Genie™ 2000 Spectroscopy Software

Customization Tools

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Table of Contents

Preface

The Genie™ 2000 Customization Tools Manual contains specialized material for advanced users, such as how to customize a Report Template to your needs, definitions of the Genie CAM parameters, Genie algorithm descriptions, error codes, and several chapters devoted to technical material specific to ISOCS™ and LabSOCS™ Calibration Software.

Chapter 1, *Report Module and Template Files*. The Template Report System's output is controlled by an ASCII template file, which contains all report format information. This chapter describes the report commands used in a template, with examples of many of them.

Chapter 2, *CAM Files*. Among the types of data that have to be stored when a sample is counted are: the spectrum itself, elapsed timing information, the description of the sample, calibration information, and so forth. This chapter discusses the CAM (Configuration Access Method) parameters used to store all of these data types.

Chapter 3, *Genie Algorithms*. This chapter lists and fully describes the algorithms used by Genie Spectroscopy Software including all of its options.

Chapter 4, *Genie-2000 Error Codes* Errors returned from components of the software environment conform to the notations described in this chapter.

Chapter 5, *LabSOCS/ISOCS Error Codes*. This listing of error codes and their corresponding messages is included as an aid to troubleshooting problems that may occur in data entry and/or other operations.

The remaining chapters are devoted to the optional LabSOCS and ISOCS mathematical calibration packages.

1. Report Module and Template Files

The Genie Spectroscopy Software Template Report System is designed for complete flexibility in report outputs, an approach which has several advantages:

- Establish different report types for different applications.
- Define ‘detail’ and ‘summary’ formats for various users, reviewers, permanent records, and so forth.
- Output data to file in a format defined by you. This allows data to be transferred to other programs that can accept ASCII input data, such as spreadsheets, databases and user written programs.

To accomplish this, the Template Report System’s output is controlled by an ASCII template file, which contains all report format information, such as Column and Row Headings, Text Messages, and Numerical and Alphanumeric Formats. Arithmetic Manipulation, Logic Tests and Variable Processing can also be handled within reports.

Report templates can be divided into sections for those times when you want to print less than a complete report. This chapter describes the definition and setup of a template file, several examples of which are included here and with the Genie distribution. And “Modifying a Template File”, on page 30, shows how a report template can easily be modified for a specific situation.

Command Index

$IF	Begin conditional processing of template lines.	4
$NOFF	Prevents generation of formfeeds in the report.	10
$NP	Start a new page (form feed) with the page heading defined by $PHn.	10
$PHn	Defines the page heading to be printed at the top of each page.	11
$REC	Fetch record-oriented values.	7
$REM	Defines a comment line in the report template	2
$SEC	Define the beginning of a report section.	3
$SET[E|A|S|M|D]	Set a report variable to a value.	3
$SETDS	Selects the datasource from which the data is to be fetched for a report.	9
$TBL	Fetch tabular entry values.	8

Template Command Descriptions

This section lists the detailed descriptions and syntax of each of the supported Commands.

$REM

The $REM command specifies a comment line within the report template file.

Syntax

Parameters

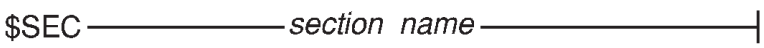
text	A comment string (syntax is not checked).

$SEC

The $SEC command specifies the beginning of a section of the Template file and assigns a name to it. A user requested report can specify which section, by name, is to be included in the report. Note that the first eight characters of a section name must be different from any other section name in the same template file.

The user (via either the Report batch command or a Report step in an analysis sequence) has the option of producing a report on *all* sections. In this case, each $SEC encountered will reinitialize the Composite and Array report variables, the page headers PH1-9, and the General Purpose report variables IV1-99, FV1-99 and SV1-99, as described in “Report Module Initialization” on page 20.

Syntax



Parameters

section name	The name of a section within the Template file.

$SET[E | A | S | M | D]

The $SET[E | A | S | M | D] command assigns or changes the value of a General Purpose Report Variable (page 12) to be used later in the report

$SETE sets a General Purpose Report Variable equal to the specified argument value

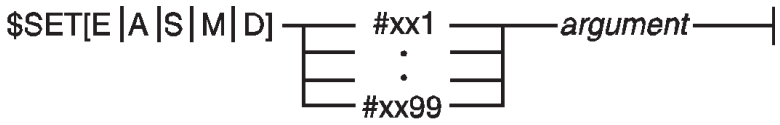
$SETA sets the General Purpose Report Variable equal to its current value plus the value of the specified argument

$SETS sets the General Purpose Report Variable equal to its current value minus the value of the specified argument

$SETM sets the General Purpose Report Variable equal to its current value multiplied by the value of the specified argument

$SETD sets the General Purpose Report Variable equal to its current value divided by the value of the specified argument.

Syntax



Where xx can be IV or FV for any $SET command and can also be SV for the $SETE command.

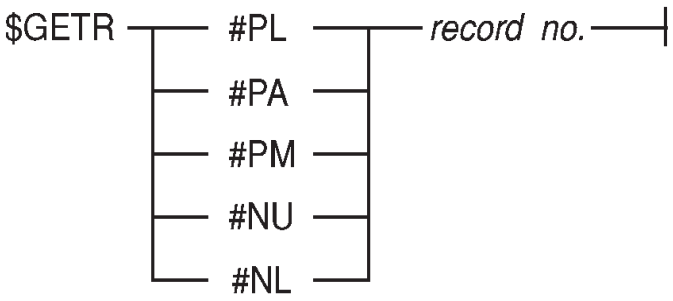
Parameters

argument	The value to be applied during the $SET[E|A|S|M|D] (see "Argument Description" on page 17).

$GETR

The $GETR command specifies that a Composite Report Variable (page 13) is to be initialized with data read from the datasource being reported on.

Syntax



Parameters

record no.	The record number from which the CAM data will be read. Note that this parameter can only be represented as a #IV1 through #IV99 general purpose report variable or as a short value 'n'.

$IF

Several "if" commands are available, which are used to determine whether a block of report lines ending with the $ENDIF command should be processed. Any of these "if" commands can be followed by the $ELSE command as a further condition.

Note there is a limit of 10 nested $IFxxx conditions within Genie 2000 templates.

General Syntax

$IF, $IFNOT

Takes one argument (defined on page 17). If the argument is non-zero (or zero in the case of $IFNOT), the block of report lines between this command and the next $ENDIF or $ELSE command is processed.

Parameters

argument	The value that is evaluated to determine whether or not to process the lines between this command and the next $ENDIF command.

$IFEQ

Compares two arguments (defined on page 17). If the two arguments are identical, the block of report lines between this command and the next $ENDIF or $ELSE command is processed. Note that neither argument may be a string value.

Parameters

argument1 argument2	The two values that are compared to determine whether or not to process the lines between this command and the next $ENDIF command.

$IFEQSI, $IFEQSS

These commands compare two arguments (defined on page 17) of type string. The longer string is compared to the shorter string. If they match, up to the length of the shorter string, the block of report lines between this command and the next $ENDIF command is processed. The string comparison is either case insensitive ($IFEQSI) or case sensitive ($IFEQSS).

Parameters

argument1 argument2	The strings that are compared to determine whether or not to process the lines between this command and the next $ENDIF command.

$IFGE, $IFGT, $IFLE, $IFLT, $IFNE

These commands take two arguments (defined on page 17). If the arguments compare as specified (≥, >, ≤, <, and ≠, respectively), the block of report lines between this command and the next $ENDIF command is processed. Note that neither argument may be a string value.

Parameters

argument1 argument2	The values that are compared to determine whether or not to process the lines between this command and the next $ENDIF command.

$ELSE

The $ELSE command executes the command(s) between it and the next $ENDIF command if the preceding $IF command fails.

Syntax

Parameters

None

$ENDIF

The $ENDIF command specifies the end of a conditional processing section of report template lines.

Syntax

$BT

The $BT command specifies the beginning of a table of report lines to be repeated a specified number of times (via argument value).

Note there is a limit of 5 nested tables.

Syntax

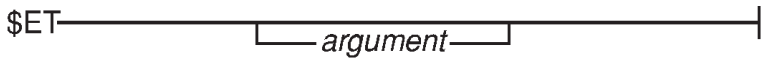
Parameters

argument	A short value. The number of times the report lines should be repeated (see “Argument Description” on page 17).

$ET

The $ET command specifies the end of a table of report lines.

Syntax



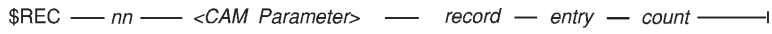
Parameters

argument	A short value. The number of times the loop counter should be incremented. If not specified the loop counter will be incremented by one each time ‘ET’ is executed. ‘ET’ will compare its internal counter to the ‘BT’ loop count after incrementing. If the internal count is greater than ‘BT’ count the table is terminated.

$REC

The $REC command fetches record-oriented values for the specified CAM parameter into the specified record type of Array Report Variable (page 14).

Syntax



Parameters

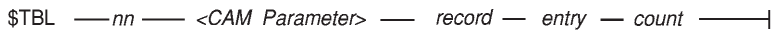
nn	A value of 1 to 10 indicating the specific record type of Array Report Variable (page 14) in which the fetched data will be stored.
CAM Parameter	The name of a CAM parameter whose value will be read as part of the list definition.
record	The record number from which the specified list data will be fetched. Note that this parameter can only be represented as a #IV1 through #IV99 general-purpose report variable or as a short value ‘n’.
entry	The entry number from which the specified list data will be fetched. Note that this parameter can only be represented as a #IV1 through #IV99 general-purpose report variable or as a short value ‘n’.

count	The number of tabular entries that are to be fetched (typically derived by using the ENTCNT report filter). Note that this parameter can only be represented as a #IV1 through #IV99 general-purpose report variable or as a short value ‘n’.

$TBL

The $TBL command fetches tabular entry values for the specified CAM parameter into the specified table type of Array Report Variable (page 14).

Syntax



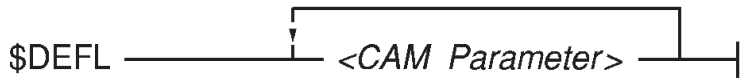
Parameters

nn	A value of 1 to 10 indicating the specific table type of Array Report Variable (page 14) in which the fetched data will be stored).
CAM Parameter	The name of a CAM parameter whose value will be read as part of the list definition.
record	The record number from which the specified list data will be fetched. Note that this parameter can only be represented as a #IV1 through #IV99 general-purpose report variable or as a short value ‘n’.
entry	The entry number from which the specified list data will be fetched. Note that this parameter can only be represented as a #IV1 through #IV99 general-purpose report variable or as a short value ‘n’.
count	The number of tabular entries that are to be fetched (typically derived by using the ENTCNT report filter). Note that this parameter can only be presented as a #IV1 through #IV99 general-purpose report variable or as a short value ‘n’.

$DEFL

The $DEFL command defines the members of a list definition. The list definition can then be used to read a set of CAM variables into a list type of Array Report Variable (page 14). Up to 20 CAM parameters may be specified in one list definition; only one list definition can exist at a time.

Syntax



Parameters

CAM Parameter	The name of a CAM parameter whose value will be read as part of the list definition.

$GETL

The $GETL command fetches the values of the current list definition into the specified list type of Array Report Variable (page 14).

Syntax

Parameters

nn	A value of 1 to 10 indicating the specific list type of Array Report Variable (page 14) in which the fetched data will be stored.
record	The record number from which the specified list data will be fetched. Note that this parameter can only be represented as a #IV1 through #IV99 general-purpose report variable or as a short value ‘n’.
entry	The entry number from which the specified list data will be fetched. Note that this parameter can only be represented as a #IV1 through #IV99 general-purpose report variable or as a short value ‘n’.

$SETDS

The $SETDS command selects the datasource from which the data is to be fetched for a report.

Syntax

Parameters

nn	A number, from 1 to 35, indicating which datasource the report's data is to be fetched from. The number must have already been defined (either via the Report job command's /NAMEnn qualifier or via PARS-ing the name into the appropriate CAM_T_ALTINPUTnn parameter). If 'nn' has not been defined, then any data items reported on for that datasource will show up as ??? on the report. Note that this parameter can be represented as either a #IVnn general purpose report variable or as a short value 'nn'.

$NOFF

The $NOFF command prevents generation of formfeeds in this section of the report. This is useful when generating a report which is to be imported into a database or a spreadsheet.

Syntax

Parameters

None

$NP

The $NP command specifies that a new page will start here. A form feed will be generated followed by any Page Heading lines specified by the last encountered $PHn command(s) (see "$PHn" on page 11). The Fixed Function report variable PAGENUM will automatically be incremented each time a new page is started. If no parameter is specified, a new page is unconditionally started. A report page is defined as 60 lines, with a new page automatically being generated when that line count is reached.

Syntax

Parameters

argument	This argument is used as follows: if the number of lines remaining on the page is less than this argument value (60 - LINENUM + 1 < argument), then a new page is generated (see “Argument Description” on page 17).

$PHn

Each $PHn command ($PH1-$PH9) specifies the contents of a Page Heading line to be printed at the top of each page. If a defined page header line, such as $PH2, has a higher number than an undefined page header line, such as $PH1, the undefined lines are treated as blank lines when the report is generated. The entire heading is followed by a blank line. If no page header lines are defined, the report will contain no header and the trailing blank line will be suppressed. Note that $PH is the same as $PH1 and that a null $PH ($PHn="") sets that heading line to “undefined”.

Syntax

Parameters

text	Any combination of alphabetic and/or numeric characters.
format	The format for the inserted argument (see “Format Description” on page 18).
argument	The definition of the argument to be inserted into the line according to the format (see “Argument Description” on page 17).

Report Variables and Filters

There are four types of predefined Report Variables: Fixed Function, General Purpose, Composite, and Array. The Fixed Function Report Variables are automatically initialized at the start of the Report Module. Their contents cannot be changed with the $SET[E|A|S|M|D] command; however, they can be used as arguments in a Template Report Line.

The General Purpose Report Variables are available for storing and reporting variables. Their contents can be changed with the $SET[E|A|S|M|D] command and they can be used as arguments in a Template Report Line.

The Composite Report Variables are available for fetching predefined blocks of information from a datasource in a single, efficient read operation.

The Array Report Variables are available for fetching user-defined blocks of information from a datasource in a single efficient read operation.

Report filters are pre-defined, internal functions that can be used to generate and/or return values based on their dedicated purpose.

Fixed Function Report Variables

The Fixed Function Report Variables are automatically initialized at the start of the Report Module and they can be used as arguments in a Template Report Line.

The Fixed Function Report Variables are as follows:

PAGENUM	A report variable for keeping track of the current Page Number. This variable is automatically set to the CAM parameter CAM_L_PAGENUM at the start of the Report Module. It is automatically incremented by one at the start of each new page.
DATETIME	A report variable for the current date/time. This variable is automatically set to the computer's current date/time at the start of the Report Module. Its value can not be changed during the report.
FILENAME	The fully specified path name of the datasource being reported on. Its value cannot be changed during the report.

General Purpose Report Variables

There are several types of general purpose report variables: #IV1 through #IV99 are of type long (four byte); #FV1 through #FV99 are of type double (double precision floating point); #SV1 through #SV99 are of type string, each of which can be up to 255 characters in length.

You may use these variables for storing and reporting anything within the limits of their type. They can be set and changed with the $SET[E|A|S|M|D] command (see "Argument Description" on page 17). The values of these variables can be reported in a Template Report Line (see "Template Report Line Description" on page 16).

Composite Report Variables

The Template Report System includes five (5) Composite Report Variables for performing reads on predefined blocks of data stored in a CAM file. These variables are initialized by using the $GETR report command. Each variable contains a list of data components as described below; each component represents a CAM parameter as described in Appendix 2, *CAM Files* (Genie 2000 documents) or in the *Genie-VMS Programmer's Guide* (Genie-VMS documents).

The five available variables are described below. Each variable includes its components and their numbers.

#PL (Peak Locate Information)

1. PSLOCCENT
2. PSDLOCCENT
3. PSENERGY
4. PSDENERGY
5. PSSIGNIF

#PA (Peak Area Information)

1. PSLEFT
2. PSPWIDTH
3. PSCENTRD
4. PSDCENTRD
5. PSENERGY
6. PSDENERGY
7. PSORIGAREA
8. PSORIGERR
9. PSBACKGND
10. PSDBACK
11. PSFIT
12. PSKVAL
13. PSPPFIT
14. PSPFITROI
15. PSPFITCONV
16. PSPPADONE
17. PSPMULT

#PM (Miscellaneous Peak Information)

1. PSENERGY
2. PSORIGAREA
3. PSORIGERR
4. PSAREA
5. PSDAREA
6. PSEFF
7. PSEFERR
8. PSAMBBACK
9. PSDAMBBACK
10. PSPTCRATIO
11. PSCTSS
12. PSCERR
13. PSFWHM
14. PSDFWHM
15. PSPFIT
16. PSPPADONE
17. PSPMULT

#NU (General Nuclide Information)

1. NCLNAME
2. NCLSBHDR
3. NCLCONFID
4. NCLWTMEAN
9. NCLMDA
10. NCLFFDECAY
11. NCLFIDENT
12. NCLFSHORTHL

5. NCLWTMERR
6. NCLHLFLIFE
7. NLCHLFERR
8. NCLHLFUNITS
13. NCLFINTFREJ
14. NCLFKEYOUT
15. NCLFNORPTMDA

#NL (Nuclide Energy Line Information)

1. NLENERGY
2. NLENGERR
3. NLABUN
4. NLABUNERR
5. NLPEAK
6. NLACTVTY
7. NLERR
8. NLMDA
9. NLEFFICIENCY
10. NLEFFERR
11. NLFKEYLINE
12. NLFFINTERF

Example 1 illustrates using the $GETR command to initialize the General Nuclide Information composite report variable, #NU, by reading information from record 2 in the datasource.

Example 1

```
$SETE #IV1 2
$GETR #NU #IV1
```

Example 2 illustrates how to output a line in a report using the #NU composite report variable.

Example 2

```
“Nuclide    Weighted Mean       Half Life”
“Name       Activity            (|AAAA)” #NU8
“”
“|AAAAAAAA                      |FFF.FFF
|FFF.FF” #NU1 #NU4 #NU6
```

Note that when used for output purposes, the composite report variables take on the form #XX*nn* where *nn* indicates the component number within the specified composite report variable.

Array Report Variables

The Template Report System includes three (3) types of Array Report Variables for performing reads on user-defined blocks of data stored in a datasource:

#TBL1 through #TBL10	Table type of Array Report Variable; used for fetching tabular entry data from the datasource. These variables are initialized by using the $TBL command.

#REC1 through #REC10	Record type of Array Report Variable; used for fetching record-oriented data from the datasource. These variables are initialized by using the $REC command.
#LIS1 through #LIS10	List type of Array Report Variable; used for fetching a list of data from the datasource. These variables are initialized by using the $GETL command.

Notes

1. When these variables are used for output purposes, the Array Report Variables take the form *#TTTnn(mm)*, where *TTT* is the type name (TBL, REC, or LIS), *nn* is the number of the Array Report Variable (1-10), and *mm* is the number of the array member to be used. For example, if the $TBL command is used to fetch 50 tabular entries into table variable number 3, then #TBL3(15) refers to the 15th tabular entry value.

2. The $REC and $TBL array variables cannot be used as arguments with the $SETE, $IFEQSI and $IFEQSS commands.

3. If any parameter was not successfully read from the configuration file, all of the parameters in the array will be printed as question marks (????).

Report Filters

Report filters are pre-defined internal functions which perform a dedicated function; they will always return a value that can be used just like any other command line argument (see “Argument Description” on page 17). The following filters are defined:

RECCNT — This filter returns the count of records for the specified CAM parameter name. Syntax is:

RECCNT(CAM parameter)

ENTCNT — This filter returns the number of tabular entries for the specified CAM parameter name. Syntax is:

ENTCNT(CAM parameter,#IVnn)

where #IVnn represents the CAM record number to be used when the specified CAM parameter is of the record tabular variety.[1]

SPECDATA — This filter returns spectral data for a given channel. Syntax is:

SPECDATA (#IVnn)

where #IVnn represents the channel number.

String Constants

Alphanumeric string constants in the form ‘abcd’ can be used for assignment to string variables via the $SETE command (see “Argument Description” on page 16). They can also be used in $IF string comparison statements.

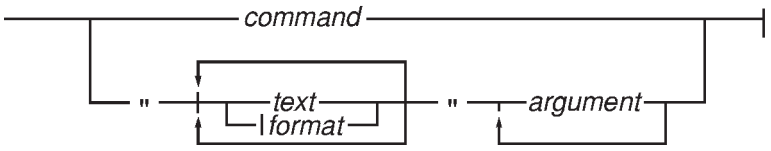
Report Template Description

The Template for a report is made up of line definitions as described in the following subsections.

Template Report Line Description

The Template for a report line is defined as follows:

Syntax



Parameters

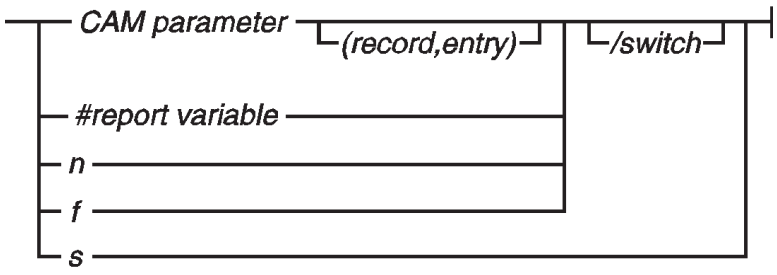
command — Any report template Command (see “Template Command Descriptions” on page 2 for command syntax details).

1. For a complete listing of CAM parameters, refer to the *CAM Files* appendix in the Genie 2000 Customization Tools Manual or to the *Spectroscopy Applications Programmer's Guide* in the Model 48-0198 Genie-VMS Manual.

Argument Description

An Argument for a report line is defined as follows:

Syntax



Parameters

CAM parameter	The name of a CAM parameter whose value is to be inserted into the report.
record	The record number for the CAM record parameter. Note that this parameter can only be represented as a #IV1 through #IV99 general-purpose report variable or as a short value ‘n’.
entry	The entry number for the CAM tabular parameter. Note that this parameter can only be represented as a #IV1 through #IV99 general-purpose report variable or as a short value ‘n’.
report variable	The name of a report variable whose value is to be inserted into the report (see “Report Variables and Filters” on page 11).
n	A long value.
f	A double floating point value.
s	A string constant in the form ‘abcd’, which can be assigned to a string variable (via $SETE) or used in $IF string comparison statements. Note that ‘s’ does not take a switch.
switch	Allows modification of the argument preceding the switch.

/TF – A switch that allows text conversion based on a test for zero/non-zero. The form is as follows:

/TF=true-text:false-text

/EM – A switch that allows the argument to be multiplied by internal variable ERRMULT (page 21) for purposes of uncertainty reporting (for example, for reporting other than one sigma). The form is as follows:

/EM

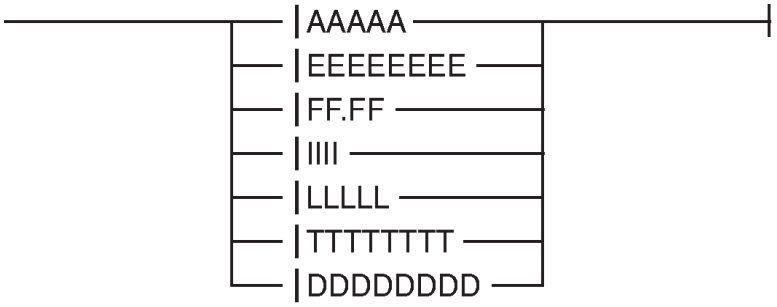
/MU – A switch that allows the argument to be multiplied by the specified general purpose floating point report variable (to convert units for instance). The form is as follows:

/MU=#FVnn

Format Description

A Format for a report argument is defined as follows:

Syntax



Parameters

Ala	Alphanumeric output. The alphanumerics are left justified with the number of characters being equal to the number of A's plus one (for the 'l').
Ele	Exponential floating point output. The output is of the form [-]b.dddE[sign]eee where the form of 'b.ddd' is calculated as follows:

If the number of E's (including the |) < 8:

then ** Parsing error **

If the number of E's (excluding the |) ≥ 8:

then the number of b's is always 1

and the number of d's = (number of E's) – 7

Note that the '|' is a place holder for a minus sign.

Examples: |EEEEEEEEE → [-]b.ddE[sign]ddd

|EEEEEEEEEEE → [-]b.ddddE[sign]ddd

F|f Floating point output. The output is of the form:

[-]bbb.ddd where the form of 'bbb.ddd' is calculated as follows:

If the number of F's (including the '.' and the |) < 3:

then ** Parsing error **

If the number of F's (excluding the '.' and the |) ≥ 3:

then the number of b's = the number of f's before the '.'

and the number of d's = the number of f's after the '.'

Note that the '|' is a place holder for a minus sign.

Examples: |F.F → [-]b.d

|FFFFFF.FFF → [-]bbbbbb.ddd

I|i Signed long decimal output. The output is right justified in the field with the number of digits being equal to the number of I's plus one (for the '|').

L|l	Unsigned long decimal output. The output is right justified in the field with the number of digits being equal to the number of L's plus one (for the 'l').
T|t	Time
D|d	Date.

Report Module Description

The Report Module is a module that is used by various applications (for example, the Gamma Spectroscopy Analysis application, REPORT batch command). Similar to analysis modules, this module has three parts:

1. The report module routine.
2. A dialog resource representing the setup screen for parameters used by the report module.
3. The dialog procedure which processes the setup screen dialog.

Report Module Initialization

At the time the Report Module is started (report module entry point is invoked), several internal report variables and Fixed Function Report Variables are initialized.

LINENUM	The internal report variable LINENUM is initialized to the value of the CAM parameter CAM_L_LINENUM. This is then incremented at the end of each line and tested against LINEPPAGE (lines/page) to determine if a new page should be generated. Whenever a new page occurs, LINENUM will be set to zero.
LINEPPAGE	The internal report variable LINEPPAGE is initialized to the value that is the current default of the system-defined printer (initial implementation will be set to 60 lines). LINENUM is compared to this at the end of every line to determine if a new page should be generated.
PAGENUM	The Fixed Function Report Variable PAGENUM is initialized to the value of the CAM parameter CAM_L_PAGENUM. This is then incremented whenever a new page occurs.

DATETIME	The Fixed Function Report Variable DATETIME is initialized to the computer's current date/time.
IV1-99	The General Purpose Integer Report Variables IV1 through IV99 are initialized to 0.
FV1-99	The General Purpose Floating Point Report Variables FV1 through FV99 are initialized to 0.0.
SV1-99	The General Purpose String Report Variables SV1 through SV99 are initialized to “”* (null string).
PH1-99	The page headers are initialized to “undefined”.
ERRMULT	This variable is used as a multiplier for uncertainty correction when the EM switch (page 18) is specified for an argument. The internal report variable ERRMULT is initialized to the value of the CAM parameter CAM_F_SIGMA, when the report is invoked from an analysis sequence. It is set to ACGARG1 for each report step when invoked as part of an analysis sequence.

The Composite and Array Report Variables are also initialized, to 0, “”, or undefined, as appropriate.

Report Module – Error Handling

The report module will generate errors that fall into one of three categories as follows:

INIT	This class of error results in no report data being written to the report disk file (for example, the report file is neither created or appended). The report module will return an appropriate ULONG error code detailing the exact error. Errors in this category include “template file not found”; “report template section not found”, and so forth.
PARSE	This class of error is a result of “compilation errors” detected by the report module at the time the specified report template section is scanned for syntax. The report file will be created/appended ONLY with error messages describing the exact syntax problems (includes line and argument numbers). The report module will also return an appropriate ULONG error code for this type of error. Errors in this category include “illegal command”; “$IF specified with no corresponding $ENDIF”, and so forth.

FORMAT — This class of error occurs as the report data is actually being formatted for writing to the created/appended report disk file. There are three types of error that will be shown in the report at the point which they occur. They are:

1. If a value can't be printed in the number of characters allowed by the format, it is replaced by asterisks (****) (that is, a value of 12345 with a |III format)

2. If a value type can't be printed as the format type, it is replaced with octothorps (####) (that is, a double value with a |AAAA format)

3. If a CAM parameter was not successfully read from the CAM (.CNF) file, it is replaced with question marks (????).

Report Module – Datasource Handling

The report module is capable of reporting data for up to 24 datasources. The names of all the datasources (except for the specified input datasource) are fetched from the CAM parameters CAM_T_ALTINPUT2 through CAM_T_ALTINPUT24. The CAM parameter CAM_L_NUMALTINPS is used to fetch the number of the highest alternate input datasource name used.

For example, the following report job command invocation:

```
REPORT C:\GENIE2K\CAMFILES\NBSSTD.CNF
/NAME3=C:\GENIEP2K\CAMFILES\NBSSTD1.CNF …
```

will store the datasource name C:\GENIE2K\CAMFILES\NBSSTD1.CNF into the CAM parameter CAM_T_ALTINPUT3 and the value 3 into the CAM parameter CAM_L_NUMALTINPS. Note that the CAM parameter CAM_T_ALTINPUT2 is undefined and will not be used.

Report Template File Example and Description

An example of a typical report template file follows, with line numbers which refer to the line-by-line explanation of the details; the line numbers are not part of the template file.

1. $SEC NID_Std

2. $PH1 "NID Report |DDDDDD |TTTTTTTTTT Page |I"

   #datetime #datetime #pagenum

3. $NP 57
4. “”
5. $IF NIDFNID
6. “**********”
7. “** N U C L I D E I D E N T I F I C A T I O N R E P O R T **”
8. “**********”
9. “”
10. “ Sample Title: |AAAAAAAAAAAAAAAAAAAAA” STITLE
11. “ Nuclide Library Used: |AAAAAAAAAAAAAAAAAAAAAAAAAAAAAA” EXPLIB
12. “”
13. “ Nuclide ID Energy Yield Activity Activity”
14. “ Name Confidence (keV) (%) (uCi/ |AAA Uncertainty” SUNITS
15. “”
16. $SETE #IV1 1
17. $BT RECCNT(NCLNAME)
18. $GETR #NU #IV1
19. $IF #NU11
20. $SETE #IV2 0
21. $SETE #IV3 NCLLINE(#IV1,1)

```
22. $SETE #IV4 1

23. $BT ENTCNT(NCLLINE,#IV1)

24. $GETR #NL #IV3

25. $IFNOT #IV2

26. $IF #NL5

27. “      |AAAAAAA   |F.FFF   |FFFF.FF|A   |FF.FF     |EEEEEEEEEE
    |EEEEEEEEEE”    #NU1 #NU3 #NL1 #NL5/TF=*: #NL3 #NL6 #NL7/EM

28. $ELSE

29. “   AAAAAAA  F.FFF   FFFF.FF A  FF.FF” #NU1 #NU3
    #NL1 #NL5/TF=*: #NL3

30. $ENDIF

31. $ENDIF

32. $IF #IV2

33. $IF #NL5

34. “                FFFF.FF A  FF.FF   EEEEEEEEEE   EEEEEEEEEE”  #NL1
    #NL5/TF=*: #NL3 #NL6 #NL7/EM

35. $ELSE

36. “                FFFF.FF A  FF.FF” #NL1 #NL5/TF=*" #NL3

37. $ENDIF

38. $ENDIF

39. $SETE #IV2 1

40. $SETA #IV4 1

41. $SETE #IV3 NCLLINE(#IV1,#IV4)
```

42. $ET

43. $ENDIF

44. $SETA #IV1 1

45. $ET

46. $ENDIF

1. Define the beginning of the section NID_Std. Everything from here on until another $SEC command is encountered or end-of-file will be processed by the report system when this section is specified.

2. Define the page header used by this report whenever a new page is generated. Note that CAM parameters as well as Fixed Function Report Variables have been specified.

3. Perform a new page (formfeed) if
(60 – CAM_L_LINENUM + 1) < 57.

4. Blank line appears on report.

5. Beginning of conditional block. Everything between this line and the $ENDIF on line 46 will be processed if a nuclide identification was performed.

6. Output this line as is.

7. Output this line as is.

8. Output this line as is.

9. Blank line appears on report.

10. Output this line with the format replaced with the CAM parameter value CAM_L_STITLE (up to 24 characters).

11. Output this line with the format replaced with the CAM parameter value CAM_L_EXPLIB (up to 32 characters).

12. Blank line appears on report.

13. Output line as is.

14. Output this line with the format replaced with the CAM parameter value CAM_L_SUNITS (up to 4 characters).

15. Blank line appears on report.

16. Set General Purpose Report Variable #IV1 to 1. This variable will be used as the counter for nuclides.

17. Begin definition of a table of data (equivalent to a DO WHILE there is data to report on). Note that the CAM parameter 'NCLNAME' will define (via the RECCNT filter) the length of the table.

18. Initialize the Composite Report Variable #NU with data from the current nuclide record (defined by #IV1).

19. Start of another conditional processing block. Everything between this line and the $ENDIF on line 43 will be processed if the current nuclide has been identified.

20. Set General Purpose Report Variable #IV2 to 0. This variable is used as a flag to print out the nuclide name for only the first line of the nuclide.

21. Set General Purpose Report Variable #IV3 to the record number of the first energy line for the nuclide currently being processed. Energy lines are record-oriented CAM parameters stored as a separate class from the nuclide names. Each nuclide name record contains tabular entries that point (using record numbers) to the energy lines associated with that nuclide.

22. Set General Purpose Report Variable #IV4 to 1. This variable is used as an energy line counter for the nuclide being processed.

23. Begin definition of a table of data (equivalent to a DO WHILE there is data to report on). Note that the CAM parameter 'NCLLINE' will define (via the ENTCNT filter) the length of the table. As can be seen, the flow of this report is controlled by two tables: the outer table is the number of nuclides (see line 7) and the inner table is the number of energy lines for each nuclide.

24. Initialize the Composite Report Variable #NL with data from the current nuclide energy line record (defined by #IV3).

25. Start of another conditional processing block. Everything between this line and the $ENDIF on line 31 will be processed if this is the first line of the nuclide (#IV2 equal to 0).

26. Start of another conditional processing block. Everything between this line and the $ELSE on line 28 will be processed if this line of the nuclide was matched to a peak in the spectrum.

27. Output the line with the formats replaced by their respective arguments. Note that the Composite Report Variables #NU and #NL are used by specifying the appropriate component.

28. Start of the other “half” of the conditional processing block. Everything between this line and the $ENDIF on line 30 will be processed if this line of the nuclide was *not* matched.

29. Output the line with the formats replaced by their respective arguments. Note that the Composite Report Variables #NU and #NL are used by specifying the appropriate component.

30. End of conditional processing block started on line 26.

31. End of conditional processing block started on line 25.

32. Start of another conditional processing block. Everything between this line and the $ENDIF on line 38 will be processed if this is not the first line of the nuclide (#IV2 not equal to 0).

33. Start of another conditional processing block. Everything between this line and the $ELSE on line 35 will be processed if this line of the nuclide was matched to a peak in the spectrum.

34. Output the line with the formats replaced by their respective arguments. Note that the Composite Report Variables #NU and #NL are used by specifying the appropriate component.

35. Start of the other “half” of the conditional processing block. Everything between this line and the $ENDIF on line 38 will be processed if this line of the nuclide was *not* matched.

36. Output the line with the formats replaced by their respective arguments. Note that the Composite Report Variables #NU and #NL are used by specifying the appropriate component.

37. End of conditional processing block started on line 33.

38. End of conditional processing block started on line 32.

39. Set the General Purpose Report Variable #IV2 to 1. This is setting the flag which indicates that the first line of the nuclide has been reported.

40. Add 1 to the General Purpose Report Variable #IV4 each time through the energy table.

41. Set the General Purpose Report Variable #IV3 to the record no. of the next energy line for the nuclide being processed.

42. End the energy line table definition. Lines 24-41 will be repeated until there are no more energy lines for the nuclide being processed.

43. End of conditional processing block started on line 19.

44. Add 1 to the General Purpose Report Variable #IV1 each time through the nuclide table.

45. End the nuclide table definition. Lines 17-44 will be repeated until there are no nuclides left to be processed.

46. End the conditional processing block started on line 5.

Sample Report

The following shows a portion of the output of a report generated by the report system using this template where nuclide identification has already been performed on the CAM file.

NID Report 2-27-92 1:24:25 PM Page 1

****

** NUCLIDE IDENTIFICATION REPORT **

****

Sample Title: GENIE Spectrum No. 1

Nuclide Library Used: C:\GENIE2K\CAMFILES\DEMOLIB.NLB

Nuclide Name	Id Confidence	Energy keV	Yield (%)	Activity (uCi/unit)	Activity Uncertainty
K-40	0.998	1460.81*	0.67	1.870E-01	9.588E-03
CO-57	1.000	122.06*	85.51	2.893E-02	8.912E-04
		136.48*	10.60	3.089E-02	3.583E-03
CO-06	1.000	1173.22*	100.00	1.027E-01	1.623E-03
		1332.49*	100.00	1.039E-01	1.917E-03
SE-75		0.281	96.73	3.41	
		121.11	16.70	1.898E-01	5.848E-03
		136.00	59.20	7.089E-03	8.222E-04
		198.60	1.45		
		264.65	59.80		
		279.53*	25.20	9.869E-02	3.743E-03
		303.91	1.32		
		400.65	11.40		
SR-85	0.992	513.99*	99.27	7.964E-02	2.163E-03
Y-88	0.998	898.02*	14.00	1.946E-00	3.734E-02
		1836.01	99.38	2.981E-00	9.384E-03
CD-109	0.996	88.03*	3.72	3.783E-01	2.379E-02
SN-113	255.12	1.93			
		391.69*	64.90	6.535E-02	1.916E-03
CS-134	0.756	563.23	8.38		
		569.32	15.43		
		604.70*	97.60	6.689E-03	4.220E-04
		795.84*	85.40	1.078E-02	7.537E-04

Modifying a Template File

As an example of template modification, we'll look at how the standard report template file (ANALYSIS.TPL or ND_SYSMSG:ANALYSIS.TPL) was modified to report Bq instead of µCi.

To modify the file, Canberra used an ASCII editor to search the report template file for the "Standard Nuclide Identification" section, where the activities are reported in µCi/unit, which is the fixed activity unit saved in the CAM files. To report activities in Bq/unit, the µCi/unit value has to be multiplied by 37000. This multiplication can be defined in the template file using the /MU= switch (see "Argument Description" on page 17 for details).

The following steps show how the "Nuclide Identification Template" section ($SEC NID_Std) was modified to report the activity in Becquerels.

1. The $SEC NID_Std section of the file was found. A few lines below the report title "NUCLIDE IDENTIFICATION REPORT", the line which starts with

   " Name Confidence (keV)

   was located and (|AA/|AAA) was replaced with (|Bq/|AAA).

2. A few lines later is a line which reads

   $SETE #IV8 RECCNT(NCLNAME)

   Four lines were added here:

   ```
   $REM uCi ==> Bq - multiply by 37000
   $SETE #FV1 37000
   $SETE #FV2 #FV1
   $SETM #FV2 SIGMA
   ```

3. The line which reads `$IF #LIS2(2)` was located.

4. Then in the *next* line, the statement `#LIS2(4)` was modified to read:

   #LIS2(4)/MU=#FV1

5. In the same line, the statement `#LIS2(5)/EM` was modified to read:

   #LIS2(5)/MU=#FV2

6. Several lines farther on, another line which starts with:

   " Name Confidence (keV)

   was located and (lAA/lAAA) was replaced with (lBq/lAAA).

As a result of these modifications, the activity argument expressed in µCi/unit is multiplied by variable #FV1, which is the conversion factor 37000, and the activity uncertainty argument expressed in µCi/unit is multiplied by variable #FV2, which is #FV1 multiplied by Sigma.

Similar modifications were made in the "Interference Corrected Nuclide Identification" section (`$SEC NID_Intf`) and the "Nuclide MDA Report" section (`$SEC MDA`).

Using New or Modified Report Template Files in VMS

This section applies only to Genie-VMS systems. If you are using a Genie 2000 system, this section does not apply to you.

The default report template file is ND_SYSMSG:ANALYSIS.TPL. It is pointed to by the system logical name ND_REPORT_TEMPLATE. If you create a new report template, or create a modified version of ANALYSIS.TPL in one of your own directories, you can tell the template report engine which template file to use in two ways:

1. Define ND_REPORT_TEMPLATE as a process (or group) logical name to point to your template file; the template report engine will then use your template file instead of the default one. For example, if you have created a new template file in your login directory, define ND_REPORT_TEMPLATE to point to it:

   ```
   DEFINE ND_REPORT_TEMPLATE  SYS
                  $LOGIN:MYTEMPLATE.TPL
   ```

2. Explicitly specify the name of the template file when setting up to run the template report engine in the Genie-ESP analysis sequence file editor. If the name of the template is blank in the setup dialog, the template file pointed to by ND_REPORT_TEMPLATE will be used. The advantage of explicitly specifying the name in the setup dialog is that a different template file can be used in each invocation of the template report engine in the setup file (if ND_REPORT_TEMPLATE is redefined, as in step 1, that file is always used).

For Example

1. Copy the default template file to your working directory with a new name:

   ```
   COPY ND_REPORT_TEMPLATE  MY.TPL
   ```

2. Edit your template file to make changes or add user defined new reports as new sections to your new template file. You are limited to three USERDEF reports.

$SEC USERDEF1	(instructions for the first user defined report)
$SEC USERDEF2	(instructions for the second user defined report)
$SEC USERDEF3	(instructions for the third user defined report)

3. To use your new user defined reports or modified reports:

   a. Redefine the logical name ND_REPORT_TEMPLATE to point to your new template file giving the full directory specification. e.g.

      ```
      Define ND_REPORT_TEMPLATE  $USER:
             [ND_SC_CUSTOM]MY.TPL
      ```

      or if you are using ASE/GUI, enter the full file name for the report template file.

   b. Edit your analysis sequence file and add rows to run your new reports at the appropriate places in the sequence.

      ```
      REPORT, USERDEF1, NO, YES, etc.
      REPORT, USERDEF2, NO, YES, etc.
      REPORT, USERDEF3, NO, YES, etc.
      ```

      Run the analysis sequence file

      ```
      NDANALYZE/ANALYSIS=MY.ASF MY.CNF
      ```

Note: If you are running the analysis sequence files from a PROcount environment, the logical name ND_LIST_DEST is defined and this logical name will determine where the output from the template reports will be written. To generate the reports to the screen, this logical should be defined as sys$output. If the logical name is not defined then the screen and file options in the sequence file determine where the output is generated.

Enhanced Report Commands

Enhanced report templates allow you to design reports with more flexibility in overall layout design. You can change the font's face, size, attributes and color, the margins, text alignment, and include images into a report. The enhanced reports are processed in two steps.

- In the first step, Genie uses the template file to retrieve data from a datasource and produce a report (RPT) file.
- In the second step, the RPT file, containing the enhanced report commands, will be used to render an image of the final report.

Only a small set of the enhanced commands, $ETEMPLATE, $IMAGE, $VP, $SCRIPLET and $ENP, are processed in the first step. The remaining enhanced commands, listed below, are processed in the second step. For these commands to be interpreted correctly in the second step, they must appear in quotes in the template file.

Command	Meaning
$FONT	//Font (font family and size)
$FONTB	//Font Bold
$FONTC	//Font Color
$FONTF	//Font Family
$FONTI	//Font Italics
$FONTS	//Font Size
$FONTU	//Font Underline
$FONTSO	//Font Strikeout
$ALIGNMENT	//Text Alignment
$MARGIN	//Page Margins
$ORIENTATION	//Page Orientation
$TABDEF	//Table Definition
$TABHD1	//Table Header 1
$TABHD2	//Table Header 2

Command	Meaning
$TABATT	//Table Attributer
$TABLN	//Table Line of data
$TABEND	//Table End

$ETEMPLATE

For enhanced reports, the first line after the $SEC name must be the $ETEMPLATE command. This tells the report processor that the report needs the additional step of rendering the enhanced report commands. If the $ETEMPLATE command is not included or is not on the first line after the $SEC command, the enhanced commands will appear in the report.

Page Breaks

In enhanced reports, the page breaks are determined by the margins. The default margins are: left=70, top=40, right=2100, and bottom=2750, measured in tenths of a millimeter. When writing a line of report text, if the text would print beyond the right margin, the text is truncated. If the text would print beyond the bottom margin, a page break is triggered and the text will continue on the next page. This differs from the non-enhanced report generation in that the lines are not counted to determine the page size. Instead, the page is defined by a measurement. This is necessary because the size of any line can change with the size of a font or included image.

As part of the new paging control, the page number must be included in the enhanced command processing, the second processing step. Thus, the #PAGENUM command should be placed in quotes in the header string. An added feature of the enhanced command is the #NUMPAGES command. It allows the total number of pages to be shown in a report. The #NUMPAGES command should also be in a quoted string, so a header command might look like this:

```
$PH "Test report header          Page #PAGENUM of #NUMPAGES"
```

Note: In enhanced reports, the header commands will be processed to the point that any substitutions are replaced with values, i.e. date or time, then rewritten to the report file for the enhanced processing to use. All enhanced commands will appear with [brackets] around their parameters in the RPT file.

$IMAGE

The $IMAGE command allows you to include an image file in a report. Supported file formats are BMP, EMF, GIF, JPG, PCX, PNG, TIFF and WMF. The command takes the image's path and file name, in single quotes, and, optionally, an image width and/or height, measured in tenths of a millimeter.

```
$IMAGE 'C:\GENIE2K\REPFILES\Nbsstd.bmp' 1250
```

If the height and width parameters are omitted, the image will be embedded in its existing size. If one of the parameters is included, the image's aspect ratio will be used to calculate the other parameter. If both parameters are included, the aspect ratio will not be used; the image will be embedded using the specified values.

When the report is generated, the image files will be embedded in the report file.

$SCRIPLET

The $SCRIPLET command allows the execution of custom code during report generation, using Component Object Model (COM) objects, which can be created in Visual Basic script and Java script, or any language that supports creating COM components. COM objects can be uniquely defined by two attributes: the class factory identifier and the interface identifier. Therefore, we can identify a COM interface by its class factory identifier also known as the programmatic identifier, ProgId, and interface identifier known as the method. The report script COM components must be located in the \GENIE2k\Scripts directory. When a script is executed, the report file will be closed before the script executes and when the script completes the report file will be reopened and positioned at the end of the file before continuing with the report template file.

```
$SCRIPLET PROGID value, METHOD value
```

Parameters

PROGID	This is the programmatic identifier of the interface to execute (required).
METHOD	This parameter defines the name of the method to execute (required).

When the template engine encounters the $SCRIPLET command, it will create an instance of the interface and execute the method.

When creating scripts for use with the $SCRIPLET command, a specific parameter convention is expected for user created script method(s). There are two parameters: (hDSC), the ICamDatasource interface, and (RptName), a string which is the report file name. The method specified in the $SCRIPLET command should be expecting these parameters. The ICamDatasource interface can be used to access the currently open datasource.

Example

```
function RunItNow(hDSC, RptName)
    Dim oFSO
    Dim oFile
    Dim oFile2
    Dim oRFmt
    Dim lFS

    Set oRFmt = CreateObject("Canberra.ReportFormatter.1")
    Set oFSO = CreateObject("Scripting.FileSystemObject")
    Set oFile = oFSO.OpenTextFile(RptName, 8, false)

    oFile.Write "DS camName = " & hDSC.Information(camName) ' camName
    oFile.Write vbCrLf

    ' calculate encoded image size
    Set oFile2 = oFSO.GetFile("c:\genie2k\repfiles\SpecPlot.bmp")
    lFS = Fix((oFile2.Size / 3 ) + .7)

    oFile.Write "$IMAGE [c:\genie2k\repfiles\SpecPlot.bmp, 1253, 0, "
                                    & CStr(lFS) & "]"
    oFile.Write vbCrLf
    oFile.Close

    oRFmt.EncodeImage RptName, "c:\genie2k\repfiles\SpecPlot.bmp"

    Set oFSO = Nothing
    Set oFile = Nothing
    Set oFile2 = Nothing
    Set oRFmt = Nothing
    Set lFS = Nothing

    DoItNow = "Temporary Value"
    RptFileName = RptName
end function
```

In this script example, the report file is opened then the datasource name is written to the report file. Next, the script calculates the encoded image size and writes out a final $IMAGE command. Then a method, EncodeImage, of the ReportFormatter control is called to encode the image into the report file.

$VP

The $VP (Vertical Pitch) command, sets the height of the following text lines, measured in tenths of a millimeter.

If the $VP command is not present, the default value of 43 will be used, a pitch of 6 lines per inch (lpi), corresponding to the default font size of 12 points.

If $VP is present and is set to a value of 0 (zero), the current font height will be used to determine the pitch.

If $VP is present and is set to any value other than zero (0), that line pitch will be used, regardless of the font size, until another $VP value is encountered.

$ENP

The $ENP, the enhanced new page command, defines the relative location of a page break in tenths of a millimeter.

If the $VP command is present without a value, a page break is inserted.

If the $VP command is present and its value is other than zero (0), and the remaining page height to the bottom margin is less than that value, a page break is inserted.

$ALIGNMENT

The $ALIGNMENT command is used to set the text alignment. Because this is a string embedded command, its parameter must be placed in brackets.

The alignment values are [left], [center] and [right].

```
"$ALIGNMENT[CENTER]"
```

The specified alignment remains in effect until it is changed.

$MARGIN

The $MARGIN command sets the non-printing area of a report. Because this is a string embedded command, its parameters must be placed in brackets.

The default margins are [70, 40, 2100, 2750] for left, top, right and bottom, respectively. These numbers are in tenths of a millimeter, measured from the top left corner of the page.

$ORIENTATION

The $ORIENTATION command orients the report either vertically (portrait) or horizontally (landscape). Because this is a string embedded command, its parameter must be placed in brackets.

```
"$ORIENTATION[LANDSCAPE]"
```

The specified orientation remains in effect until it is changed.

$FONT

The $FONT command sets the font family and size in the same command. The first parameter is the name of the TrueType font, in single quotes, and the second parameter is the font size in points. Because this is a string embedded command, the parameters must be placed in brackets.

The default font is Courier New and the default font size is 12 points.

```
"$FONT ['Times New Roman' 10]"
```

$FONTF

The $FONTF command sets the font family (typeface). Because this is a string embedded command, its parameter must be placed in brackets.

```
"$FONTF [Impact]"
```

The default font is Courier New.

$FONTS

The $FONTS command sets the current font size in points. Because this is a string embedded command, its parameter must be placed in brackets.

```
"$FONTS[14]"
```

The default font size is 12 points.

$FONTB

The $FONTB command turns the bold font attribute ON or OFF. Because this is a string embedded command, its parameter must be placed in brackets.

```
"$FONTB[ON]bolded text$FONTB[OFF]"
```

Because the bold attribute remains on until turned off, $FONTB[OFF] should always be specified before the end of the report. Otherwise bolding will carry over to the next report when multiple reports are generated.

$FONTC

The $FONTC command sets the color of the text; it does not affect the color of the lines used in tables. The specified color remains in effect until it is changed. Because this is a string embedded command, its parameter must be placed in brackets.

```
"$FONTC [color]"
```

The available colors are: Black, DkGray, Gray, LtGray, White, DkRed, Red, LtRed, DkOrange, Orange, LtOrange, DkYellow, Yellow, LtYellow, DkGreen, Green, LtGreen, HiGreen, BlueGreen, Olive, Brown, DkBlue, Blue, LtLtBlue, HiBlue, Cyan, DkPurple, Purple, Magenta.

$FONTI

The $FONTI command sets the font italic attribute ON or OFF. Because this is a string embedded command, its parameter must be placed in brackets.

```
"$FONTI[ON]some italic text$FONTI[OFF]"
```

Because the bold attribute remains on until turned off, $FONTI[OFF] should always be specified before the end of the report. Otherwise italicizing will carry over to the next report when multiple reports are generated.

$FONTU

The $FONTU command sets the font underline attribute ON or OFF. Because this is a string embedded command, its parameter must be placed in brackets.

```
"$FONTU[ON]underlined text$FONTU[OFF]"
```

Because the underline attribute remains on until turned off, $FONTU[OFF] should always be specified before the end of the report. Otherwise underlining will carry over to the next report when multiple reports are generated.

$FONTSO

The $FONTSO command sets the font strikeout attribute ON or OFF. Because this is a string embedded command, its parameter must be placed in brackets.

```
"$FONTSO[ON]struck out text$FONTSO[OFF]"
```

Because the strikeout attribute remains on until turned off, $FONTSO[OFF] should always be specified before the end of the report. Otherwise strikeout will carry over to the next report when multiple reports are generated.

Table Commands for Enhanced Reports

The table commands in enhanced reports are slightly different from those used in unenhanced reports. By default, enhanced reports are drawn in a box grid of lines around each table cell. These lines can be turned off by using an embedded flag command to set the pen size (PS) to 0.

“Example Enhanced Table” on page 41 illustrates the enhanced table commands.

$TABDEF

The $TABDEF command defines the number of columns and the width of each column measured in tenths of a millimeter. The first $TABDEF parameter is the number of columns in the table. The remaining parameters define the width of each column in the table.

If all the column widths are defined, the total of the column widths is the table width. If no column widths are defined, column widths are determined by dividing the printable page width by the number of columns.

If several, but not all, column widths are defined, the given widths are used and the remaining space to the margin is divided between the remaining undefined columns.

$TABHD1 and $TABHD2

These two table header commands define the first and second line of table column headers. Because this is a string embedded command, its parameter must be placed in brackets, and the individual column headers enclosed in single quotes.

```
"$TABHD1 [‘[PS 1]’ ‘[CE]Peak’ ‘Centroid’ ‘Centroid’ ‘Energy’ ‘Peak’]"
"$TABHD2 [‘ ’ ‘No.’ ‘Channel’ ‘Uncertainty’ ‘(keV)’ ‘Significance’]"
```

$TABATT

The $TABATT command defines the attributes for each column using embedded flags. Because this is a string embedded command, its parameters must be placed in brackets and the individual column headers enclosed in single quotes.

```
"$TABATT ['[B]' '[I]' '[IO]' '[BO]'"
```

In this example bold is turned on in the first column. This attribute will remain in effect until it is turned off in the fourth column. This example causes the first through third columns to be bold, the second column to be bold italic and the fourth column to be nonitalic (roman) unbolded.

$TABLN

The $TABLN command defines a line of table data. Because this is a string embedded command, its parameters must be placed in brackets and the individual column data enclosed in single quotes. As seen in the example below, the unenhanced report is being used to generate the enhanced table line data. The basic table does the data formatting into the output string and the enhanced report is rendering the data into an enhanced report.

$TABEND

The $TABEND command defines the end of the enhanced report table.

Example Enhanced Table

```
"$MARGIN [200 40 2100 2550]$TABDEF [6 75 200 350 350 350 350]"
"$TABHD1 ['[PS 1] ' '[CE]Peak' 'Centroid' 'Centroid' 'Energy' 'Peak']"
"$TABHD2 [' ' 'No.' 'Channel' 'Uncertainty' '(keV)' 'Significance']"
$SETE #IV1 1
$SETE #IV5 15
$REC 1 PSLOCCENT 1 0 #IV2
$REC 2 PSDLOCCENT 1 0 #IV2
$REC 3 PSENERGY 1 0 #IV2
$REC 4 PSSIGNIF 1 0 #IV2
$REC 5 PSPADJPEAK 1 0 #IV2
$BT #IV2
$IF #REC5(#IV1)
$SETE #SV1 '?'
$ELSE
$SETE #SV1 "
$ENDIF
```

```
$IF #REC2(#IV1)
"$TABLN ['[B]|A' '[BO]|II' '|FFFF.FF' '|FF.FFFF' '|FFFF.FF' '|FFF.FF']"
                                                #SV1 #IV1 #REC1(#IV1) #REC2(#IV1)
#REC3(#IV1) #REC4(#IV1)
$ELSE
"$TABLN ['[B]|A' '[BO]|II' '|FFFF.FF' ' <NA> ' '|FFFF.FF' ' <NA> ']"
                                          #SV1 #IV1 #REC1(#IV1) #REC3(#IV1)
$ENDIF
$SETA #IV1 1
$ET
"$TABEND"
"$MARGIN[70 40 2100 2750]"
```

In this example, the unenhanced table is used to generate lines for enhanced table line code; i.e., “$TABLN [‘|A’ ‘|II’ ‘|FFFF.FF’ ‘|FF.FFFF’ ‘|FFFF.FF’ ‘|FFF.FF’]” #SV1 #IV1 #REC1(#IV1) #REC2(#IV1) #REC3(#IV1) #REC4(#IV1)

Embedded Flags for Enhanced Reports

To reduce development time, enhanced reports let you embed flags for some of the most common functions in the text you want to output. These embedded flags are enclosed in [brackets]. The “[” can only be interpreted at the first position in the string. All following characters will be interpreted as flag-settings, until a “]” is encountered. A “[[” sequence will be interpreted as one “[” that will be printed.

For Example:
To print the text “Hello, World!” in bold and italic, the string you’ll supply to one of the text-output functions would be:

“[B I]Hello, World!”

The next line will turn the bold and italic font off:

“[BO IO]”

Line Characteristic Flags

Each flag can be given in a long or a short form and are not case sensitive. Some flags must be followed by one or more numeric parameters.

The following embedded flags can be used to change the characteristics of the lines used in enhanced report tables. For example, if you don’t want lines around your report, set the PenSize to 0.

PenSize, PS <pensize>
Sets the pensize, where <pensize> is the size of the pen in tenths of a millimeter.

PenColor, PC <color-name>
Sets the pencolor to the named color , where <color-name> is one of the following color strings:
Black, DkGray, Gray, LtGray, White, DkRed, Red, LtRed, DkOrange, Orange, LtOrange, DkYellow, Yellow, LtYellow, DkGreen, Green, LtGreen, HiGreen, BlueGreen, Olive, Brown, DkBlue, Blue, LtLtBlue, HiBlue, Cyan, DkPurple, Purple, Magenta.

PenColorRGB, PCRGB <red> < green> <blue>
Sets the pencolor to RGB colors, where <red> < green> <blue> are the RGB color values.
Example: “PCRGB 200 210 30"

PSSolid, PSS
Sets the pen to the solid drawing mode.

PSDash, PSDA
Sets the pen to the dash drawing mode.

PSDot, PSDO
Sets the pen to the dot drawing mode.

PSDashDot, PSDADO
Sets the pen to dash-dot drawing mode.

PSDashDotDot, PSDADODO
Sets the pen to the dash-dot-dot drawing mode.

Font Attribute Flags

The next group of embedded flags are related to font attributes, font family, size, color, alignment, bold, underline, italic, and strikeout.

‘ [it’s a single quote!]
Use the font specified within single quotes. Example: [‘Arial’]

FONTS, S <FONTS>
Sets the FONTS, where <FONTS> is the size of the font in points (NOT 1/10mm!).

Color, C <color-name>
Sets the text color, where <color-name> is one of the color-strings above.

ColorRGB, RGB <red> < green> <blue>
Sets the text color with RGB-values of <red> < green> <blue>.

Justified, J
Sets the text alignment to justified.

Right, R
Sets the text alignment to right.

Left, L
Sets the text alignment to left.

Center, CE
Sets the text alignment to centered.

Bold, B
Sets the font setting to bold.

BoldOff, BO
Sets the font setting to bold off.

Underline, U
Sets the font setting to underlined.

UnderlineOff, UO
Sets the font setting to underlined off.

Italic, I
Sets the font setting to italic.

ItalicOff, IO
Sets the font setting to italic off.

StrikeOut, ST
Sets the font setting to strikeout.

StrikeOutOff, STO
Sets the font setting to strikeout off.

Page Break Flags

The remaining embedded flags are related to the automatic page break.

AutoBreak, A
Sets the AutoPageBreak-Mode to ON.
Auto Break is activated. An Auto Break will happen if y > VBOTTOMMARGIN.
Remaining text is broken onto the next page(s) with the following coordinates:

AutoBreakOff, AO
Sets the AutoPageBreak-Mode to OFF.
Same behavior as AUTO_BREAK_ON (limited positioning / rendering to the bottom of the output rectangle is active), but remaining text is NOT broken onto next page(s). It is cut instead.

AutoBreakNoLimits, ANL
Sets the AutoPageBreak-Mode to NO LIMITS.
Remaining text is NOT broken onto the next page(s), it can be placed anywhere on the paper with no limits.

AutoBreakFull, AF
Sets the AutoPageBreak-Mode to FULL.
Auto Break is activated. An Auto Break will happen if y > VBOTTOMMARGIN.
Remaining text is broken onto the next page.

2. CAM Files

Among the types of data that have to be stored when a sample is counted are: the spectrum itself, elapsed timing information, the description of the sample, calibration information, and so forth. In addition, if you analyze the data, the results of the analyses must be stored.

All of these data types are stored in a single place: a CAM file. Access to the data is controlled by subroutines called the Configuration Access Method.

No longer do you have to keep track of multiple files (calibration, data, library, results, header, and so forth) to recreate an analysis. In the Genie family of products, all of this data is stored in a single file, so that you can be confident that full sample records are available.

Additionally, CAM Files allow you to access data by parameter name. If you need to extract particular information, for special programs for example, you can do so without specific knowledge of physical data structures: You simply access the data by name.

A CAM file contains two kinds of data: parameters and spectral data. A parameter is a single number or text string, such as preset real time or the sample identification string, with each parameter being given a symbolic code by which it can be accessed. Spectral data is an array of 32-bit integers.

Configuration Data and Parameters

The different kinds of data which make up a configuration are separated into “classes” of information. The data composing each class of information is considered to be relatively independent of the data in other classes.

The classes of information are acquisition setup parameters, geometry parameters, sample parameters, and so forth. A configuration is a collection of data of various classes, which is stored in “parameter blocks”. In general, there will be only one block of a particular class per configuration.

New applications may require new classes of information and may require different kinds and formats of information for existing classes. Therefore, each class is grouped into “types”, which serve to identify the contents and format of data in a block.

In general, programs will know only about information classes, not the types within a class.[1]

The basic unit of configuration data is the “parameter”. (Spectral data is considered separately). Each parameter is referenced by a symbolic name or numeric code, and has a particular data type (such as longword integer, floating point, text string). Examples of parameters are the elapsed live time, the energy calibration quadratic factor, and the sample identification string.

For some information classes, such as peak search results, the characteristics of the data demands that parameters be repeated over and over. Therefore, parameters can be grouped into “records”, and the records can be repeated as many times as need be (for peak search results, once for each peak found). This process can be carried one step further, where parameters can be grouped within records into “tabular entries”. An example of this is in the nuclide library, where each record represents one nuclide; for each nuclide, there are tabular entries describing the energy lines associated with that nuclide. Thus, to completely specify a “record tabular” parameter, one would have to indicate the parameter name or code, the record number, and the tabular entry number. (Parameters which are not contained in records or tabular entries are called “common” parameters).

Spectral data access is handled through a separate mechanism, since it is generally accessed in bulk amounts. A particular channel is specified by its channel number (starting from 1) and its row number (for dual parameter spectra; this terminology replaces the old term “groups” in this context). Spectral data is always treated as 32-bit signed integers.

Creating a Configuration

A configuration can be created in one of three ways using Genie 2000/Genie-PC software:

1. Via the MID Editor Save function (this is how hardware datasources are created).

2. Via the FILECNVT command.

3. Via the MOVEDATA command.

1. Though some classes of data in this chapter are not supported by Genie 2000/Genie-PC software, they are included here for completeness and for consistency with Genie-VMS documents.

Initial Parameters

Whenever a configuration is created, a set of CAM operating parameters is automatically initialized with the following default values, many of which are common to all detectors types and some of which are dependent on the specific detector type.

Values Common to All Detector Types

CAM Parameter	Value
CAM_L_BYTES	4
CAM_L_ROWS	1
CAM_L_GROUPS	1
CAM_L_ECFENCAL	1
CAM_L_ECFFWCAL	1
CAM_L_ECFT1CAL	1
CAM_L_ECALTERMS	0
CAM_L_ITERATIONS	10
CAM_L_PEAKSTART	1
CAM_L_PASTART	1
CAM_L_MSCHANS	19
CAM_L_NBACKTERMS	2
CAM_L_PRGAINSHFT	1
CAM_L_MAXGAINPASS	10
CAM_L_NSIGMA	1
CAM_L_SHOWROIS	1
CAM_L_DOUNKSRCH	1
CAM_L_CURSORCH	1
CAM_L_RPTFSCREEN	1
CAM_L_RPTFNEWFILE	1
CAM_L_PEAKEND	65535
CAM_L_PAEND	65535
CAM_F_FWHMCONST	50.0
CAM_F_SQUANT	1.0
CAM_F_SENSITVTY	3.0
CAM_F_CHISENSITVTY	4.0

CAM_F_RSENSITVTY	4.0
CAM_F_SECSENS	1.75
CAM_F_SUMSENSITVTY	1.0
CAM_F_SQUANTMULT	1.0
CAM_F_OVERWIND1	0.3
CAM_F_OVERWIND2	0.3
CAM_F_REJMDASIG	2.5
CAM_F_REJMDACONST	3.0
CAM_F_UNIDCONST	6.0
CAM_F_HALFLIFERAT	8.0
CAM_F_ABUNDANLIM	75.0
CAM_F_WTMLIMIT	3.0
CAM_F_MDACONFID	5.0
CAM_F_ACTIVMULT	1.0
CAM_F_CONFID	0.3
CAM_F_SIGMA	1.0
CAM_F_MDAADDCONST	2.71
CAM_F_MDAMULTCONST	3.29
CAM_T_ECALTYPE	POLY
CAM_T_SUNITS	Unit
CAM_T_ROIPSTYP	Net
CAM_T_GAINSHIFT	AUTO
CAM_T_WEIGHTING	Derived
CAM_T_ACTIVUNITS	µCi
CAM_F_PRFWHMPKLEFT	2.0
CAM_F_PRFWHMPKRGHT	2.0
CAM_F_PRFWHMPKMULT	5.0
CAM_F_UNIDREJ	3.0
CAM_F_DCSAMPDIST	0.5

Values Dependent on the Detector Type

CAM Parameter	Alpha	NaI	Ge
CAM_L_BACKGNDCHNS	0	4	4
CAM_L_PRNBKCHN	0	4	4
CAM_L_USEAVRG	1	0	0
CAM_F_ECSLOPE[2]	10000.0	2048.0	2048.0
CAM_F_ECALCNV	1000.0	1.0	1.0
CAM_F_FWHMOFF	25.0	-7.0	1.0
CAM_F_FWHMSLOPE	0.0	2.0	0.03
CAM_F_ECALTOL	25.0	30.0	1.5
CAM_F_VARECALTOL	1.0	0.75	1.5
CAM_F_GSENSITVTY	35.0	35.0	10.0
CAM_F_AREAWIND1	1.0	1.0	2.5
CAM_F_AREAWIND2	1.5	1.5	3.0
CAM_F_INTFWIND1	1.5	1.5	3.0
CAM_F_INTFWIND2	2.5	2.5	4.0
CAM_F_BACKREJ	1.0	1.0	0.0
CAM_F_VARREJ	1.0	1.0	0.0
CAM_F_GAINREJ	0.005	0.005	0.0001
CAM_F_UNIDETOL	0.5	0.5	1.5
CAM_F_TOLERANCE	20.0	20.0	1.0
CAM_F_VPWIDTH	3.0	1.2	3.0
CAM_F_VARTOLERANCE	0.5	0.5	1.0
CAM_T_EXPLIB[3]	ALPHA.NLB	STDLIB.NLB	STDLIB.NLB
CAM_T_PEAKLIB[3]	ALPHA.NLB	STDLIB.NLB	STDLIB.NLB
CAM_T_REPTEMPLATE[3]	ALPHA.TPL	ANALYSIS.TPL	ANALYSIS.TPL
CAM_T_ECALUNITS	MeV	keV	keV
CAM_T_FWCALTYPE	CONSTANT	SQRT	SQRT
CAM_T_EFFTYPE	AVERAGE	DUAL	DUAL

2. This number is divided by the number of channels in the configured ADC.
3. These include the full path name, found using the proper environment variable.

CAM_T_ROIPSBTYP	NONE	STEP	STEP
CAM_T_RPTSECTNAME	µCi_Report	HEADER	HEADER
CAM_L_PRUSEVBKCHN	0	1	1

Configuration Parameter Descriptions

Configuration parameters are described in the following sections, one section per information class. The classes described are:

1. Acquisition parameters. This class describes the setup of the configuration's electronics, contains calibration information, and describes the current state of the configuration.

2. Sample parameters. This class describes the sample, or whatever is being measured.

3. Geometry parameters. This class describes the relationship between the sample and the detector system (for instance, efficiency).

4. Processing parameters. This class describes how the data is to be processed, and some of the results of that processing.

5. Data. This class actually contains the spectral data acquired.

6. Peak Search results. This class describes the results of the peak search analysis.

7. NID results. Actually two classes of information (one for nuclides and one for energy lines), these classes both describe the nuclides searched for by NID, and contain the results of the analysis.

8. Display parameters. This class describes how the data is displayed.

9. Certificate parameters. This class contains the information that describes a certificate file.

10. Calibration Results parameters. These two classes of information are used to store intermediate data (energy/channel pairs, etc.) used to calculate the calibration equations.

11. Analysis Control parameters. This class describes the contents of Analysis Sequence Files.

12. QA File parameters. These two classes of information are used to described both the definitions (QA Parameter Definitions) and actual QA data (QA Results) stored in a Genie QA file.

13. Miscellaneous parameters. There are numerous other classes of information that are used to store application specific (e.g. Whole Body Counting, Safeguards systems) sets of parameters and data.

Each parameter's symbolic code is listed with a brief description. The symbolic codes all have a standard format:

CAM_type_name

where "name" is the name of the parameter, and "type" specifies the returned type of the parameter, as given below:

B – byte

W – word (INTEGER*2)

L – longword (INTEGER*4)

Q – quadword

F – floating point (REAL*4)[4]

D – double precision floating point (REAL*8)

G – G format double precision floating point (REAL*8)

X – date/time (both absolute and delta).

T – character string (CHARACTER*n)

For example, the elapsed live time parameter has the symbolic code CAM_X_ELIVE. The "X" specifies that the parameter is a date-time stamp. "ELIVE" is the name of the parameter. The energy calibration offset parameter is identified by CAM_F_ECOFFSET. The "F" specifies that the parameter is a F format floating point number (REAL*4); "ECOFFSET" is the name of the parameter.

4. Floating point values are stored in DEC format.

Flag Parameters

A number of parameters are “flag words”: each bit in the parameter has a particular meaning. For example, the first bit in the preset mode flags parameter (CAM_L_PMODE) means that acquisition should terminate after running for a certain amount of live time. Each of these bits in the flag words have a symbolic code, with the format:

CAM_M_flagname_bitname

Where “flagname” identifies the flag word and “bitname” identifies the bit in that word.

Individual Parameters

Many of these flags can also be accessed as individual parameters; this is especially useful in editors. In the CAM Parameters listings, each individual parameter is shown in brackets below its flag parameter. For example:

CAM_M_PMOD_LIVE [CAM_L_PMLIVE]	Terminate on preset livetime

Acquisition Parameters

The acquisition parameter block is composed of common parameters relating to the entire configuration, and a number of records, each record describing an input ADC to the configuration. The symbolic name for this class is CAM_CLS_ACQP.

Common Parameters

CAM_T_CTITLE	Configuration title (32 characters) (see note 1 on page 75)
CAM_T_CPNAME	Configuration physical name (32 characters)
CAM_T_ACQMOD	Acquisition mode (PHA+, PHA–, MCS+, etc.) (4 chars)
CAM_L_CMASK	Coincidence mask
CAM_L_BYTES	Bytes/channel
CAM_L_CHANNELS	Channels/row
CAM_L_ROWS	Number of rows
CAM_L_GROUPS	Number of groups
CAM_L_EXTRA	Number of extra bytes/channel

CAM_F_ASAMPDIST	Shelf-detector distance (mm)
CAM_L_PMODE	Preset mode flags
CAM_M_PMOD_LIVE [CAM_L_PMLIVE]	Terminate on preset livetime
CAM_M_PMOD_REAL [CAM_L_PMREAL]	Terminate on preset real time
CAM_M_PMOD_SWEEPS [CAM_L_PMSWEEPS]	Terminate on preset sweeps
CAM_M_PMOD_TOTALS [CAM_L_PMTOTALS]	Terminate on preset totals
CAM_M_PMOD_LEVEL [CAM_L_PMLEVEL]	Terminate on preset level
CAM_M_PMOD_AREA [CAM_L_PMAREA]	Terminate on preset net area
CAM_M_PMOD_PERR [CAM_L_PMPERR]	Terminate on preset percent error
CAM_F_ACQAIRTEMP	Air temperature (°C)
CAM_X_PREAL	Preset real time
CAM_X_PLIVE	Preset live time
CAM_X_MAXPLIVE	Maximum preset live time (used by “count to minimum MDA” applications)
CAM_L_PTOTAL	Preset total counts
CAM_L_PSWEEPS	Preset sweeps
CAM_L_PLEVEL	Preset level
CAM_L_PTSCHAN	Preset total area start channel
CAM_L_PTSROW	Preset total area start row
CAM_L_PTECHAN	Preset total area end channel
CAM_L_PTEROW	Preset total area end row
CAM_F_PAREA	Preset net area

CAM_F_PPERR	Preset net area % error
CAM_F_PNETENG	Preset net counts energy
CAM_F_DWELL	MCS dwell time (seconds)
CAM_F_ECOMP	Elapsed computational preset
CAM_L_ESWEEPS	Elapsed sweeps
CAM_L_ACQPHYSADDR	Acquisition memory address
CAM_Q_TOTALEVENTS	Total number of events (MPA only)
CAM_L_PARAMSEVENT	Parameters (words) per event
CAM_L_AGROUP	Current acquire group
CAM_L_ACQINTVEC	Interrupt vector (/4)
CAM_T_ACQOPNAME	Name of person who acquired spectrum (32 characters) (see note 1 on page 75)
CAM_L_BACKGNDCHNS	Channels used for display background
CAM_F_DTLIMIT	Deadtime limit (%); used by stack monitor if DODTTEST is true
CAM_L_ACQNUMMEAS	Number of replicate measurements requested
CAM_L_ACQNUMMEASA	Number of replicate measurements actually performed
CAM_L_DSCOPESFAC	Digital scope smoothing factor (1-32)

CAM_L_ACQMFLGS	Acquisition mode flags
CAM_M_ACQMF_WAITACQCOMP [CAM_L_WAITACQCOMP]	Wait for acquisition complete
CAM_M_ACQMF_DETNOTAVAIL [CAM_L_DETNOTAVAIL]	Detector not available
CAM_M_ACQMF_DETHASSC [CAM_L_DETHASSC]	Detector associated with serial sample changer
CAM_M_ACQMF_SCMANUAL [CAM_L_SCMANUAL]	Sample changer in manual mode
CAM_M_ACQMF_SCIGNORETO [CAM_L_SCIGNORETO]A +	Ignore sample changer timeout

CAM_M_ACQMF_MEETMDA [CAM_L_MEETMDA]	Count until required MDAs are met
CAM_M_ACQMF_DODTTEST [CAM_L_DODTTEST]	Perform deadtime limit test
CAM_M_ACQMF_SCAN [CAM_L_ACQFSCAN]	This is a scanning detector
CAM_M_ACQMF_SEG [CAM_L_ACQFSEG]	This is a segmented detector
CAM_M_ACQMF_MSS [CAM_L_ACQFMSS]	MSS data is collected for this detector
CAM_M_ACQMF_TRANS [CAM_L_ACQFTRANS]	This data includes transmission peaks
CAM_M_ACQMF_COLLIMATOR [CAM_L_ACQFCOLLIMAT]	This counter has a selectable collimator/ geometry
CAM_M_ACQMF_AUTOCOL [CAM_L_ACQFAUTOCOL]	Automatic collimator
CAM_M_ACQMF_SEPSEG [CAM_L_ACQFSEPSEG]	Segments are separated (vs. adjacent)
CAM_M_ACQMF_DOSEDONE [CAM_L_WACQDOSEDONE]	Dosimeter assay has been performed
CAM_M_ACQMF_HELSCAN [CAM_L_WACQHELSCAN]	Do helical scan
CAM_M_ACQMISGAMMA [CAM_L_ACQMF_ISGAMMA]	NDA 2000 gamma target
CAM_M_ACQMISNEUT [CAM_L_ACQMF_ISNEUT]	NDA 2000 neutron target
CAM_M_ACQMF_ISDDAMCS	NDA 2000 DDA/MCS target
CAM_M_ACQMF_ISQUANTG	NDA 2000 Quantitative gamma results file
CAM_M_ACQMF_ISMEASISO	NDA 2000 Measured isotopics results file

CAM_L_ASTATUS	Acquisition status flags
CAM_M_ASTF_ACQUIRE [CAM_L_ACQUIRE]	Acquisition state (on-true/off-false)

CAM_M_ASTF_CCFEMOD [CAM_L_ASTFCCFEMOD]	Module modified during acquisition
CAM_M_ASTF_BADCAL [CAM_L_ASTFBADCAL]	Bad calibration data in configuration
CAM_M_ASTF_CCERR [CAM_L_ASTFCCERR]	Computer controlled NIM error
CAM_M_ASTF_RAMBACK [CAM_L_ASTFRAMBACK]	RAM is battery backed-up (Inspector only)

Sample Changer Parameters

CAM_T_SCADDRESS	ICB address for sample changer (14 characters)
CAM_T_CHANGERTYPE	Sample changer type (8 characters)
CAM_T_CHANGERID	Sample changer serial number (8 characters)
CAM_L_SCHANGER	Sample changer status
CAM_L_SCMAXSAMPLES	Sample changer capacity (samples)
CAM_L_PLCHERROR	PLC hard error register
CAM_L_PLCSERROR	PLC soft error register
CAM_L_PLCOOSREASON	PLC out-of-service register

Neutron Shift Register (JSR-12) Parameters

CAM_L_SRHVPS	HVPS voltage
CAM_F_SRGATEWIDTH	Gate width (µs)
CAM_F_SRPREDELAY	Predelay (µs)
CAM_X_SRCOUNTTIME	Preset cycle count time
CAM_X_SRPRESETTIME	Total preset count time (SRPRESETTIME/SRCOUNTTIME measurement cycles will be made)
CAM_T_SRGAMDETNAME	Name of the gamma detector associated with the neutron detector (16 characters)
CAM_T_SRADDRESS	Address (or device name) of the shift register (10 characters)

CAM_T_SRIDENT	Identification/serial number of the shift Register (16 characters)

Power Management Parameters

(Inspector only)

CAM_T_PWRMTYPE	Power Management module type (8 characters)
CAM_T_PWRMID	Power Management module identification (8 characters)
CAM_L_PWRMSTBYDELY	Standby delay time (minutes)
CAM_L_ACQSTRTDELAY	Acquisition start delay time (seconds)
CAM_T_PWRMMODE	Power Management mode (Full, Save, AC) (4 characters)
CAM_L_PWRMBATTERY	Number of battery selected
CAM_T_PWRMBATA	Battery A status (Low, etc.) (4 characters)
CAM_T_PWRMBATB	Battery B status (4 characters)
CAM_F_PWRMBATAVOLT	Battery A voltage
CAM_F_PWRMBATBVOLT	Battery B voltage
CAM_L_PWRMFLAGS	Power management flags
CAM_M_PWRM_BATS [CAM_L_PWRMFBATS]	Both batteries are discharged to the warning level
CAM_M_PWRM_COMM [CAM_L_PWRMFCOMM]	Communications between the MCA and the Power Manager have failed
CAM_M_PWRM_BATSEL [CAM_L_PWRMFBATSEL]	Battery select: True=A, False=B
CAM_M_PWRM_RESET [CAM_L_PWRMFRESET]	The MCA has undergone a power reset
CAM_M_PWRM_FAULT [CAM_L_PWRMFFAULT]	± 12 V supply fault

Segmented Gamma Scanner Parameters

CAM_L_WACQNSEG	Highest segment number (stored as UBYTE)

CAM_L_WACQSKIPSEGS	Number of initial segments to skip
CAM_F_WACQSEGWIDTH	Segment width (mm)
CAM_F_WACQSEGCTIME	Segment count time (seconds)
CAM_F_WACQTRCTIME	Transmission count time (seconds)
CAM_F_WACQOFFSET	Starting position from drum bottom (mm)
CAM_F_WACQSTEPLEN	Steps/mm
CAM_T_WACQADDRESS	Motor controller device address (12 characters)
CAM_T_WACQMCTYPE	Motor controller type (8 characters)
CAM_T_WACQROTSPEED	Rotation speed (rpm)
CAM_L_ACQFWACQREAL	Flag in ACQMFLGS: count times are real times (default is live times)
CAM_T_WACQPASSMODE	SGS pass mode: “One pass with”, “One pass without”, “Two pass” (16 chars)
CAM_F_WACQDELTA	Increments in mm to move scanning platform per position
CAM_L_WACQNPOS	Number of scan platform positions
CAM_L_WACQPOS	Scan platform position
CAM_L_WACQDET	Relative detector number
CAM_L_WACQTRANSRC	Transmission source number (0-n)
CAM_L_WACQCOLPOS	Collimator/geometry position (0-n)
CAM_L_WACQSEGMENT	Current segment number
CAM_F_WACQAVEDOSE	Average dosimeter reading (µSv/hr)
CAM_F_WACQMAXDOSE	Maximum dosimter reading (µSv/hr)
CAM_F_WACQAVEDOSED	Average reading from “distant” dosimeter
CAM_F_WACQMAXDOSED	Maximum reading from “distant” dosimeter
CAM_L_WACQSEGVIEWS	Number of TGS views per segment
CAM_L_WACQSEGCELLS	Number of TGS cells per segment
CAM_L_ATGSSCANMODE	TGS scanning mode: 0=traverse starts at edge of item, 1=traverse starts at center of item

Neutron Generator Parameters

CAM_F_AZETARATE	Neutron generator pulse rate (Hz)

Dose Calibration Parameters

CAM_F_ADBIFACA	Dose-by-isotope calibration factor A. These factors are used by the dose-by-isotope calculation engine: dose = net cps * (A + B*e + C*e^2 + D*e^3 + E*e^4), where e is the photopeak energy in keV.
CAM_F_ADBIFACB	Dose-by-isotope calibration factor B
CAM_F_ADBIFACC	Dose-by-isotope calibration factor C
CAM_F_ADBIFACD	Dose-by-isotope calibration factor D
CAM_F_ADBIFACE	Dose-by-isotope calibration factor E
CAM_F_AFSDFACA	Full-spectrum dose low-energy curve calibration factor A. The form of the full-spectrum dose low-energy equation is dose = A*e + B*e^2 + C*e^3 + D*e^4, where e is the average spectrum energy in keV.
CAM_F_AFSDFACB	Full-spectrum dose low-energy curve calibration factor B
CAM_F_AFSDFACC	Full-spectrum dose low-energy curve calibration factor C
CAM_F_AFSDFACD	Full-spectrum dose low-energy curve calibration factor D
CAM_F_AFSDFACE	Full-spectrum dose high-energy curve calibration factor E. The form of the full-spectrum dose high-energy equation is dose = E * e^F.
CAM_F_AFSDFACF	Full-spectrum dose high-energy curve calibration factor F
CAM_F_AFSDFACG	Full-spectrum dose calibration calibration crossover energy, in keV: below this energy, the low-energy equation will be used; at or above this energy, the high-energy equation will be used.
CAM_F_APMNOMTHRESH	Nominal threshold
CAM_F_APMHYSTFAC	Hysteresis factor

Vendor Spare Common Acquisition Parameters

CAM_F_CHSP*n*	Hardware spare parameter *n*, where *n* is 1 to 5

User Spare Common Acquisition Parameters

CAM_F_ASP*n*	User spare floating value *n*, where *n* is 1 to 3

Common Tabular Parameters

CAM_X_ASTIME	Acquisition start time (see note 2 on page 75)
CAM_X_EREAL	Elapsed real time (see note 2 on page 75)
CAM_X_ELIVE	Elapsed live time (see note 2 on page 75)

Record Parameters

High Voltage Power Supply Parameters

CAM_T_HVPSADDRESS	ICB address for high voltage supply (10 characters)
CAM_T_HVPSTYPE	Type (8 characters)
CAM_T_HVPSID	HVPS serial number (8 characters)
CAM_F_VOLTAGE	HVPS high voltage setting
CAM_F_HVPSVOLTLIM	HVPS voltage limit
CAM_F_HVPSRANGE	HVPS range (+ or – and value) (Inspector only)
CAM_F_HVPSLEAKAGE	Leakage current (nA) (Alpha Analyst only)
CAM_L_HVPSFLAGS	HVPS flags
CAM_M_HVPSF_OVLE [CAM_L_HVPSFOVLE]	Overload latch enable
CAM_M_HVPSF_INHLE [CAM_L_HVPSFINHLE]	Inhibit latch enable
CAM_M_HVPSF_LVINH [CAM_L_HVPSFLVINH]	5 V/12 V inhibit

CAM_M_HVPSF_POL [CAM_L_HVPSFPOL]	Output polarity
CAM_M_HVPSF_INH [CAM_L_HVPSFINH]	Inhibit
CAM_M_HVPSF_OV [CAM_L_HVPSFOV]	Overload
CAM_M_HVPSF_STAT [CAM_L_HVPSFSTAT]	Status (on/off)
CAM_M_HVPSF_ONLINE [CAM_L_HVPSFONLINE]	HVPS on-line
CAM_M_HVPSF_OVINRES [CAM_L_HVPSFOVINRES]	HVPS inhibit/overload reset
CAM_M_HVPSF_ATTEN [CAM_L_HVPSFATTEN]	Module attention required
CAM_M_HVPS_FAULT [CAM_L_HVPSFAULT]	HVPS fault
CAM_M_HVPSF_ALARMS [CAM_L_HVPSFALARMS]	S5000 HV alarms enable
CAM_M_HVPSF_SHUTDN [CAM_L_HVPSFSHUTDN]	S5000 HV shut down

CAM_L_HVPSVFLAGS	HVPS verification failure flags field
CAM_M_HVPSVF_ID [CAM_L_HVPSVFID]	ID verification failure
CAM_M_HVPSVF_VOLT [CAM_L_HVPSFVOLT]	Voltage verification failure
CAM_M_HVPSVF_OVLE [CAM_L_HVPSVFOVLE]	Overload latch enable verification failure
CAM_M_HVPSVF_INHLE [CAM_L_HVPSVFINHLE]	Inhibit latch enable verification failure
CAM_M_HVPSVF_LVINH [CAM_L_HVPSVFLVINH]	5 V/12 V inhibit verification failure
CAM_M_HVPSVF_POL [CAM_L_HVPSVFPOL]	Output polarity verification failure

CAM_M_HVPSVF_STAT [CAM_L_HVPSVFSTAT]	Status verification failure

Amplifier Parameters

CAM_T_AMPADDRESS	ICB address for amplifier (10 characters)
CAM_T_AMPTYPE	Amplifier type (8 characters)
CAM_T_AMPID	Amplifier serial number (8 characters)
CAM_T_PRAMPTYPE	Preamplifier type (RC, TRP) (8 characters)
CAM_F_AMPGAIN	Amplifier gain
CAM_F_AMPHWGAIN*n*	Hardware dependent amp gain *n*, where *n* is 1 to 3
CAM_T_AMPSHAPEMODE	Amplifier shaping mode (8 characters)
CAM_L_AMPPZ	Amplifier pole/zero
CAM_T_AMPBLRTYPE	Base-line restoration type (SYM, ASYM) (8 characters)
CAM_T_AMPDTCTYPE	Dead-time control type (Normal, LFC) (8 characters)
CAM_F_AMPTC	Amplifier time constant (µs)
CAM_F_AMPTC	Amplifier time constant (seconds)
CAM_F_AMPPENERGY	Pulser energy (MeV) (Alpha Analyst only) “Pulser energy”
CAM_F_AMPPGAIN	Pulser energy vs. value slope (Alpha Analyst only) “Pulser gain”
CAM_F_AMPPOFFSET	Pulser offset
CAM_F_AMPFILTERRT	DSP Filter Rise Time
CAM_F_AMPFILTERFT	DSP Filter Flat Top duration
CAM_T_AMPFDMODE	DSP Fast Discriminator Mode
CAM_F_AMPFD	DSP Fast Discriminator Setting
CAM_F_AMPPURG	DSP PUR Guard Setting
CAM_L_AMPLTTRIM	Live time correction adjustment
CAM_F_AMPICR	Incoming count rate

CAM_L_AMPINPUTCTRL	S5000 input control mode: 0 = preamp, 1 = amplifier, 2 = ADC
CAM_F_AMPDISCRIM	S5000 discriminator
CAM_L_AMPFLAGS	Amplifier mode flags (front panel switches)
CAM_M_AMPF_DIFF [CAM_L_AMPFDIFF]	Differential (vs. normal) input
CAM_M_AMPF_NEGPOL [CAM_L_AMPFNEGPOL]	Negative (vs. positive) polarity
CAM_M_AMPF_COMPINH [CAM_L_AMPFCOMPINH]	Complement inhibit polarity
CAM_M_AMPF_PUREJ [CAM_L_AMPFPUREJ]	Pileup rejection enable/disable
CAM_M_AMPF_ONLINE [CAM_L_AMPFONLINE]	Amplifier on-line
CAM_M_AMPF_MOTRBUSY [CAM_L_AMPFMOTRBUSY]	Amplifier motor busy
CAM_M_AMPF_PZBUSY [CAM_L_AMPFPZBUSY]	Amplifier pole/zero adjust busy
CAM_M_AMPF_ATTEN [CAM_L_AMPFATTEN]	Module attention required
CAM_M_AMPF_PZSTART [CAM_L_AMPFPZSTART]	Start auto pole/zero adjust
CAM_M_AMPF_PZFAIL [CAM_L_AMPFPZFAIL]	Auto pole/zero adjust failed
CAM_M_AMPF_MOTRFAIL	Amplifier motor has failed
CAM_M_AMPF_INPATT [CAM_L_AMPFINPATT]	Input attenuator enabled (Inspector only)
CAM_M_AMPF_INHTRP [CAM_L_AMPINHTRPMOD]	TRP Inhibit mode (off=Auto, on=Manual) (DSP only)
CAM_M_AMPF_PULSER [CAM_L_AMPFPULSER]	Pulser enabled (Alpha Analyst only) “Pulser”
CAM_L_LLDAUTOMODE	LLD Mode: Auto vs. Manual (bit in CAM_L_AMPFLAGS: CAM_M_AMPF_AUTOMODE)

CAM_L_GAINATTMODE	Gain Attenuator on/off (bit in CAM_L_AMPFLAGS: CAM_M_AMPF_ATTMODE)
CAM_L_AMPVFLAGS	Amplifier verification failure flags field
CAM_M_AMPVF_ID [CAM_L_AMPVFID]	ID verification failure
CAM_M_AMPVF_PRAMPT [CAM_L_AMPVFPRAMPT]	Preamp type verification failure
CAM_M_AMPVF_HWGAIN*n* [CAM_L_AMPVFHWGAIN*n*]	HW gain *n* verification failure, where *n* is 1 to 3
CAM_M_AMPVF_SHAPEM [CAM_L_AMPVFSHAPEM]	Shaping mode verification failure
CAM_M_AMPVF_PZ [CAM_L_AMPVFPZ]	Pole/zero verification failure
CAM_M_AMPVF_BLRTYPE [CAM_L_AMPVFBLRTYPE]	Base-line restore type verification failure
CAM_M_AMPVF_DTCTYPE [CAM_L_AMPVFDTCTYPE]	Dead-time control type verification failure
CAM_M_AMPVF_TC [CAM_L_AMPVFTC]	Time constant verification failure
CAM_M_AMPVF_NEGPOL [CAM_L_AMPVFNEGPOL]	Negative polarity verification failure
CAM_M_AMPVF_COMPINH [CAM_L_AMPVFCOMPINH]	Complement inhibit verification failure
CAM_M_AMPVF_PUREJ [CAM_L_AMPVFPUREJ]	Pileup rejection verification failure
CAM_M_AMPVF_DIFF [CAM_L_AMPVFDIFF]	Differential input verification failure

Gain Device

CAM_T_GAINADDRESS	ICB address for the gain device (10 chars)
CAM_T_GAINTYPE	Gain device type (8 chars)
CAM_T_GAINID	Gain device serial number (8 chars)

CAM_F_GAININHIBIT	Gain inhibit setting (microseconds) (put with other GAINxxx parameters)

Filter Device

CAM_T_FLTADDRESS	ICB address for the filter device (10 chars)
CAM_T_FLTTYPE	Filter device type (8 chars)
CAM_T_FLTID	Filter device serial number (8 chars)

Digital Spectrum Stabilizer Parameters

CAM_T_DSSADDRESS	ICB address for DSS (10 characters)
CAM_T_DSSTYPE	DSS type (8 characters)
CAM_T_DSSID	DSS serial number (8 characters)
CAM_F_DSSWIN1AR	Analog range window 1
CAM_F_DSSWIN2AR	Analog range window 2
CAM_T_DSSWIN1MODE	Window 1 mode (OFF, ON, HOLD) (4 characters)
CAM_T_DSSWIN2MODE	Window 2 mode (OFF, ON, HOLD) (4 characters)
CAM_L_STABWIN1C	Stabilization window 1 centroid channel
CAM_L_STABWIN1R	Stabilization window 1 range (channels)
CAM_L_STABWIN1S	Stabilization window 1 spacing (channels)
CAM_L_STABWIN2C	Stabilization window 2 centroid channel
CAM_L_STABWIN2R	Stabilization window 2 range (channels)
CAM_L_STABWIN2S	Stabilization window 2 spacing (channels)
CAM_F_STABRATE	Stabilization rate for window 1 (in seconds)
CAM_F_STABRATE2	Stabilization rate for window 2 (in seconds)
CAM_F_STABCORR1	Window 1 correction factor
CAM_F_STABCORR2	Window 2 correction factor
CAM_L_DSSEVMULT1	Window 1 event multiplier factor
CAM_L_DSSEVMULT2	Window 2 event multiplier factor

CAM_F_DSSZERORATIO	Zero window ratio
CAM_F_DSSGAINRATIO	Gain window ratio
CAM_L_DSSFLAGS	DSS flags
CAM_M_DSSF_W1RNG [CAM_L_DSSFRNGWIN1]	Use NaI range for window 1
CAM_M_DSSF_W2RNG [CAM_L_DSSFRNGWIN2]	Use NaI range for window 2
CAM_M_DSSF_OVERRNG [CAM_L_DSSFOVERRNG]	Overrange
CAM_M_DSSF_OVERRNG1 [CAM_L_DSSFOVERRNG1]	Window 1 overrange
CAM_M_DSSF_OVERRNG2	Window 2 overrange

Loss-Free-Counting Module Parameters

CAM_T_LFCADDRESS	ICB address for LFC (10 characters)
CAM_T_LFCTYPE	LFC module type (8 characters)
CAM_T_LFCID	LFC module serial number (8 characters)
CAM_L_LFCFLAGS	LFC module flags field

MCS/MSS Module Parameters

CAM_T_MCSTYPE	MCS type (8 characters)
CAM_T_MCSID	MCS serial number (8 characters)
CAM_T_MCSADDRESS	Address of MCS/DMSS on the ICB
CAM_L_MCSINPUT	DMSS input number
CAM_L_MCSGROUPS	Number of MSS groups
CAM_F_MCSSCANWSIZE	Scan window
CAM_F_MCSSCANSTART	Scan start
CAM_F_MCSSCANEND	Scan end
CAM_F_MCSLLD	SCA LLD
CAM_F_MCSULD	SCA ULD

CAM_L_MCSFLAGS	MCS flags field
CAM_M_MCSF_EXTCLOCK [CAM_L_MCSEXTCLOCK]	External (vs. internal) clock
CAM_M_MCSF_DATA1ST [CAM_L_MCSDATA1ST]	Put MSS data first
CAM_M_MCSF_EXTADV [CAM_L_MCSEXTADV]	External (vs. internal) advance
CAM_M_MSCF_SWMODE [CAM_L_MSCFSWMODE]	If 0, the MCS unit adds the results of the current sweep to each channel; if 1, the channel contents are replaced
CAM_M_MSCF_EXTSTART [CAM_L_MSCFEXTSTART]	Enable external start (DSA 2000)
CAM_M_MSCF_EXTSTOP [CAM_L_MSCFEXTSTOP]	Enable external stop (DSA 2000)
CAM_M_MSCF_SWDONE [CAM_L_MSCFSWDONE]	If 1, the final sweep was completed; if 0, the final sweep was partial

Multiplexer Parameters

CAM_T_MUXTYPE	Multiplexer type (8 characters)
CAM_T_MUXID	Multiplexer serial number (8 characters)
CAM_L_FIRSTMUXINP	Number of mux input for group 1
CAM_T_MUXMODE	Multiplexer mode (8 characters)
CAM_L_MUXINPUTS	Number of multiplexer inputs
CAM_L_MUXFLAGS	Multiplexer flags field
CAM_M_MUXF_DEPMUX [CAM_L_MUXFDEPMUX]	Dependent (vs. independent) multiplexer

ADC Parameters

CAM_T_ADCADDRESS	ICB address for ADC (10 characters)
CAM_T_ADCTYPE	ADC Type (8 characters)
CAM_T_ADCID	ADC serial number (8 characters)

CAM_L_ADCRANGE	ADC range
CAM_L_ADCOFFSET	ADC offset
CAM_T_ADCACQMODE	ADC acquisition mode (PHA, SVA) (8 characters)
CAM_T_ADCPNAME	ADC physical name (31 characters)
CAM_L_CNVGAIN	Conversion gain
CAM_F_LLD	Lower level discriminator
CAM_F_THRESHOLD	ADC LLD threshold
CAM_F_ULD	Upper level discriminator
CAM_F_ZERO	Zero
CAM_F_STROBE	Strobe timing (seconds)
CAM_L_ADCFLAGS	ADC mode flags
CAM_M_ADCF_ANTIC [CAM_L_ADCFANTIC]	Anti-coincidence mode
CAM_M_ADCF_LATEC [CAM_L_ADCFLATEC]	Late (vs. early) coincidence mode
CAM_M_ADCF_DELPK [CAM_L_ADCFDELPK]	Delayed (vs. auto) peak detect
CAM_M_ADCF_CIMCAIF [CAM_L_ADCFCIMCAIF]	CI (vs. ND) ADC interface
CAM_M_ADCF_NONOV [CAM_L_ADCFNONOV]	Non-overlap transfer mode
CAM_M_ADCF_ONLINE [CAM_L_ADCFONLINE]	ADC on-line
CAM_M_ADCF_LTCPUR [CAM_L_ADCFLTCPUR]	LTC/PUR signal
CAM_M_ADCF_ATTEN [CAM_L_ADCFATTEN]	Module attention required
CAM_M_ADCF_AMPINTERNAL [CAM_L_AMPINTERNAL]	Use internal amplifier (Inspector only)

CAM_L_ADCVFLAGS	ADC verification failure flags field
CAM_M_ADCVF_ID [CAM_L_ADCVFID]	ID verification failure
CAM_M_ADCVF_RANGE [CAM_L_ADCVFRANGE]	Range verification failure
CAM_M_ADCVF_OFFSET [CAM_L_ADCVFOFFSET]	Offset verification failure
CAM_M_ADCVF_ACQMODE [CAM_L_ADCVFACQMODE]	Acquisition mode verification failure
CAM_M_ADCVF_CNVGAIN [CAM_L_ADCVFCNVGAIN]	Conversion gain verification failure
CAM_M_ADCVF_LLD [CAM_L_ADCVFLLD]	LLD verification failure
CAM_M_ADCVF_ULD [CAM_L_ADCVFULD]	ULD verification failure
CAM_M_ADCVF_ZERO [CAM_L_ADCVFZERO]	Zero verification failure
CAM_M_ADCVF_ANTIC	Anti-coincidence verification failure
CAM_M_ADCVF_LATEC	Late coincidence mode verification failure
CAM_M_ADCVF_DELPK	Delayed peak detect verification failure
CAM_M_ADCVF_NONOV	Non-overlap transfer verification failure
CAM_M_ADCVF_LTCPUR	LTC/PUR signal verification failure

Multichannel Analyzer Parameters

CAM_T_MCATYPE	MCA type (8 characters)
CAM_T_MCAHWVERSION	MCA Hardware version (8 characters)
CAM_T_MCAID	MCA serial number (8 characters)
CAM_L_ALARMCOUNTS	Alarm counts (Alpha Analyst only)
CAM_X_ALARMTIME	Alarm elapsed time (Alpha Analyst only)
CAM_L_MCAFLAGS	MCA alarm parameter flags

CAM_M_MCAF_CRARMED [CAM_L_MCAFCRARMED]	Count rate alarm armed (Alpha Analyst only)

Energy Calibration Parameters

CAM_T_ECALTYPE	Energy calibration type (8 characters)
CAM_X_ECALTIME	Energy calibration time
CAM_L_ECALTERMS	Number of terms in energy calibration polynomial
CAM_F_ECOFFSET	Energy calibration offset
CAM_F_ECSLOPE	Energy calibration slope
CAM_F_ECQUAD	Energy calibration quadratic term
CAM_F_ECALFAC1	Energy calibration cubic term
CAM_F_ECALFAC2	Energy calibration 4th order term
CAM_F_ECALFAC3	Energy calibration 5th order term
CAM_T_ECALUNITS	Energy calibration units (16 characters)
CAM_F_ECALCHISQ	Energy calibration Chi square
CAM_F_ECALCNV	Energy calibration conversion factor
CAM_L_ECALFLAGS	Calibration flags field
CAM_M_ECF_ENCAL [CAM_L_ECFENCAL]	Perform energy calibration? (Y/N)
CAM_M_ECF_FWCAL [CAM_L_ECFFWCAL]	Perform FWHM calibration? (Y/N)
CAM_M_ECF_T1CAL [CAM_L_ECFT1CAL]	Perform low energy tail calibration? (Y/N)
CAM_M_ECF_T2CAL [CAM_L_ECFT2CAL]	Perform tail two calibration? (Y/N)
CAM_M__PULSER [CAM_L_ECFPULSER]	Calibration includes pulser data

Peak Shape Calibration Parameters

CAM_T_FWCALTYPE	FWHM calibration type (8 characters)

CAM_X_SCALTIME	Shape calibration time
CAM_F_FWHMOFF	FWHM offset: square root equation
CAM_F_FWHMSLOPE	FWHM slope: square root equation
CAM_F_FWHMCHISQ	Square-root FWHM calibration Chi square
CAM_F_C1FWHM	FWHM polynomial offset
CAM_F_C2FWHM	FWHM polynomial slope
CAM_F_C3FWHM	FWHM polynomial quadratic coefficient
CAM_F_FWPOLYCHISQ	Polynomial FWHM calibration Chi square
CAM_F_C1TAIL1	Low energy tail offset
CAM_F_C2TAIL1	Low energy tail slope
CAM_F_TAIL1CHISQ	Low energy tail fit chi-square
CAM_F_C1TAIL2	Additional tail offset
CAM_F_C2TAIL2	Additional tail slope
CAM_F_TAIL2CHISQ	Additional tail fit chi-square
CAM_F_FWHMCONST	Constant FWHM; Alpha Spec only (channels)

Special Purpose Calibration Parameters

CAM_F_FW511	FWHM of 511 keV peak
CAM_F_T1511	Low energy tail of 511 keV peak
CAM_F_T2511	Additional tail of 511 eV peak
CAM_F_FWREF	FWHM of reference peak
CAM_F_T1REF	Low energy tail of reference peak
CAM_F_T2REF	Additional tail of reference peak

Pulse Pileup Calibration Parameters

CAM_F_PILEUP	Pulse pileup correction factor

Reference Peak Correction Calibration

CAM_F_AREFENG	Reference peak energy

CAM_F_AREFRATE	Reference peak rate
CAM_F_ADREFRATE	Error in reference peak rate
CAM_X_AREFDATE	Reference rate measurement date
CAM_X_AREFHLF	Reference nuclide half life
CAM_T_AREFHLFUNITS	Reference nuclide half life units (1 character)
CAM_F_ATGSREFRATE	Reference peak count rate for TGS analysis

User Spare Acquisition Parameters

CAM_F_ASP4	User spare floating value 4
CAM_F_ASP5	User spare floating value 5
CAM_T_ASPSTR	User spare string (32 characters)

Alternate Linear Energy Calibration Parameters

CAM_F_ECALLCOF	Linear energy calibration offset
CAM_F_ECALLCSL	Linear energy calibration slope

Vacuum Device Parameters

CAM_T_VACDEVTYPE	Vacuum Type (8 chars)
CAM_T_VACADDRESS	Vacuum device address (12 characters)
CAM_T_VACDEVID	Vacuum device ID (serial number) (12 characters)
CAM_F_VACAIRTHICK	Air thickness ($\mu g/cm^2$) “Air Thickness”
CAM_F_VACPRESSET	Vacuum pressure setting (Torr) “Acquire On”
CAM_F_VACPRESREAD	Vacuum pressure reading “Pressure”
CAM_F_VACMINTHRESH	Vacuum minimum threshold “Bias Off”
CAM_F_VACMAXTHRESH	Vacuum maximum threshold “Bias On”
CAM_T_VACVALVE	Valve state (8 chars) “Valve”
CAM_T_VACSTATUS	Status (8 characters)
CAM_L_VACFLAGS	Vacuum device flags

CAM_M_VACF_REGULATED [CAM_L_VACFREG]	Pressure regulated

MGAU Calibration

CAM_F_ENRICHCAL93	MGAU 93 keV calibration factor
CAM_F_ENRICHCAL186	MGAU 186 keV calibration factor

Miscellaneous Parameters

CAM_L_UPPERGATE	Upper gate (ND76DP only)
CAM_T_MIDPATH	MID path name (16 characters)
CAM_T_DETNAME	Detector name (16 characters)
CAM_F_ACQDETVOL	Detector volume (cm^3)
CAM_F_ACQDETDIAM	Detector diameter (cm)
CAM_F_ACQDETWIDTH	Detector height/width
CAM_F_ACQDETTC	Detector time constant
CAM_F_ACQDETDEPTH	Detector depth (mm)
CAM_F_ACQMGAEFSL	MGA efficiency slope
CAM_F_ACQMGAEFCV	MGA efficiency curvature
CAM_T_DETTYPE	Detector type (ie, NaI, HPGe, Alpha, etc.) (8 characters)
CAM_T_DETENGTYPE	Detector type: Low-energy vs. Normal (8 characters) (put this after DETTYPE)
CAM_T_ACQINPUTID	Detector ID (serial number) (12 characters)
CAM_T_CHAMBERSTAT	Chamber status (8 characters)
CAM_F_DETTEMP	Detector temperature
CAM_T_DETID	Detector serial number (12 characters)

Record Tabular Entry Parameters

CAM_L_ECALLCCH	Linear energy calibration channel
CAM_F_ECALLCDE	Linear energy calibration delta E

CAM_F_DET*n*PERCENTS	Percent of counts from detector *n* in summed spectra, where *n* is 1 to 8

Notes

1. The CTITLE and ACQOPNAME parameters actually use the same physical space in the configuration. Therefore a given application should use one or the other, but not both, of these parameters.

2. When accessing acquisition time data in a file, the tabular entry number should be set to the number of the group whose time information is desired (currently, either 1 or 2).

3. The parameters WGRUMASS, WGRUMASSERR, WNRUMASS, WNRUMASSERR, MCRUMASS, MCRUMASSERR, WNRPUMDAERR, WNRISOMDAERR, WGRTMUMDAERR, WDRISOMDAERR and MCRISOMDAERR cannot be accessed by their names, only by symbolic code. They can be accessed via programming in languages, such as C, not by utilities such as GETPARS, PARS, and FDS files (on PC platforms), or PARS, PARS/GUI, and FPL files (on VMS platforms).

Sample Parameters

All sample parameters are common parameters. The symbolic name for this class is CAM_CLS_SAMP.

Common Parameters

CAM_T_STITLE	Sample title (64 characters)
CAM_T_SIDENT	Sample identification (16 characters)
CAM_T_STYPE	Sample type (16 characters)
CAM_T_SGEOMTRY	Sample geometry (16 characters)
CAM_T_SLOCTN	Sample location (32 characters)
CAM_F_SQUANT	Sample quantity
CAM_F_SQUANTERR	Error in sample quantity
CAM_T_SUNITS	Sample units (16 characters)
CAM_F_SUNITSCF	Sample units conversion factor (used in NDA 2000 to convert from kg to report quantity units)

CAM_X_SDEPOSIT	Sample deposition start date/time
CAM_X_STIME	Sample deposition end date / sample time
CAM_F_SSYSERR	Random sample error (%)
CAM_F_SSYSTERR	Non-random sample error (%)
CAM_F_SONFLOW	Flow rate at start of sample collection
CAM_F_SOFFFLOW	Flow rate at end of sample collection
CAM_F_SPRES	Sample pressure
CAM_F_STEMP	Sample temperature
CAM_F_SPOWER	Reactor percent power
CAM_T_SCOLLINIT	Initials of sample collector (4 characters)
CAM_T_SCOLLNAME	Name of sample collector (24 characters)
CAM_T_SANALNAME	Name of sample analyst (24 characters)
CAM_L_SAMPNUM	Sample number
CAM_T_SAMPLEPT	Sample point (32 characters)
CAM_T_SDESC*n*	Sample description *n* (64 characters), where *n* is 1 to 4
CAM_F_SSTVACPRES	Start vacuum pressure (psig)
CAM_F_SENDVACPRES	End vacuum pressure (psig)
CAM_T_SAMPLERID	Sampler identification (16 characters)
CAM_T_SSHELF	Shelf name (8 characters)
CAM_T_SREASON	Reason for sample collection (64 characters)
CAM_T_SRWP	Radiation work permit number (16 characters)
CAM_F_SCOLEFF	Sample collection efficiency (fraction)
CAM_F_STRACEAMT	Tracer quantity (used in alpha spectroscopy)
CAM_T_SBATCHID	Batch ID (16 characters)

Plant/Site Parameters

CAM_L_SSTATION	Station code for multi-site utilities

CAM_T_SPLTNAME	Plant name (32 characters)
CAM_L_SREACTORUNIT	Reactor unit number
CAM_F_SMWT	Megawatts thermal of reactor

Air Sampling Parameters

CAM_T_SASID	Air sample identification (16 characters)
CAM_T_SRWPLIST	RWP/SRWP list (96 characters)
CAM_X_SCOVSTART	Coverage period start date
CAM_X_SCOVEND	Coverage period end date
CAM_T_SSURVID	Survey Identification (16 characters)
CAM_X_SSURVDATE	Survey date
CAM_T_SSURVLOC	Survey location code (16 characters)
CAM_T_SSURVENT	Person entering survey data (24 characters)

WBC-Related Sample Parameters

CAM_F_SPARTSIZE	Inhalation particle size (um)
CAM_T_SEMPNAME	Subject name (32 characters)
CAM_T_SEMPID	Subject ID (12 characters)
CAM_T_SEMPLOYER	Employer name (32 characters)
CAM_T_SJOBCODE	Job code (32 characters)
CAM_T_SSEX	Subject gender (male/female/unknown) (8 characters)
CAM_X_SBIRTHDATE	Subject's birthdate
CAM_T_SFREQUENCY	Frequency of count (16 characters)
CAM_T_STLDNUM	TLD number (5 characters)
CAM_T_SWBCID	WBC ID (5 characters)
CAM_T_SSTHGT	WBC chair seat height (5 characters)
CAM_T_SFTBPOS	WBC chair front-to-back position (5 chars)
CAM_T_STHYPOS	WBC chair thyroid position (5 characters)

CAM_X_SUPTKDAT	Uptake date/time
CAM_T_SOPINIT	Operator's initials (4 characters)
CAM_F_SHEIGHT	Subject height (inches or cm)
CAM_F_SWEIGHT	Subject weight (pounds or kg)
CAM_F_SCWT	Subject chest wall thickness (cm); this parameter is also used for the sample density value (in g/cm^3) for waste assay applications
CAM_F_SCWTERROR	Uncertainty in CWT
CAM_F_SU235ENRICH	% U-235 enrichment
CAM_F_SWBCCR*n*	WBC count rate *n*, where *n* is 1 to 8

Waste Assay Parameters

CAM_F_SWCONTEW	Container empty weight
CAM_F_SWCONTGW	Container gross weight
CAM_F_SWCONTNW	Container net weight
CAM_F_SWCONTNWERR	Error in net weight
CAM_F_SWCONTVOL	Container volume (liters)
CAM_F_SWCONTVOLERR	Error in volume
CAM_F_SWCONTUDENS	User-entered density (kg/L)
CAM_T_SWCONTSHAPE	Container shape (16 characters)
CAM_F_SWCONTLEN	Container box length or drum diameter (m)
CAM_F_SWCONTHEIGHT	Container height (m)
CAM_F_SWCONTGCF	Container geometric correction factor
CAM_T_SWCONTMATRIX	Container matrix (16 characters)
CAM_F_SWCONTFULL	% full
CAM_T_SLENUNITS	Sample length units
CAM_F_SLENCONV	Length units conversion factor
CAM_T_SWTUNITS	Sample weight units
CAM_F_SWTCONV	Weight units conversion factor

CAM_T_SVOLUNITS	Sample volume units
CAM_F_SVOLCONV	Volume units conversion factor
CAM_T_SCTRNAME	Counter Name (8 characters)
CAM_T_SCTRDESC	Counter Description (32 characters)
CAM_T_SARRNAME	Arrangement Name (8 characters)
CAM_T_SARRDESC	Arrangement Description (32 characters)
CAM_T_SGRPNAME	Group Name (8 characters)
CAM_T_SGRPDESC	Group Description (32 characters)
CAM_T_SINFOFDS	Sample Information parameter edit file (16 characters)
CAM_T_SINFOTYPE	Sample Information type (16 characters)
CAM_L_SINFOSEQ	Sample Demographics sequence number
CAM_T_SPROCTYPE	Analysis Processing type (16 characters) [individual/cal check/etc.]
CAM_T_SAMPASF1	Standard Analysis Sequence file name (16 characters)
CAM_T_SAMPASF2	Bulk Analysis Sequence File Name (16 characters)
CAM_L_SFREPPLT	Include plot in output report (part of CAM_L_SFLAGS longword)
CAM_L_SUNITTYPE	Type of units used where 0: English; 1: Metric
CAM_T_SNODENAME	Node name of the system the sample was collected on (64 characters)

User Spare Sample Parameters

CAM_T_SSPRSTR*n*	User spare string *n* (16 characters), where *n* is 1 to 11
CAM_T_SSPBSTR1	User spare “big” string 1 (64 characters)
CAM_X_SSPTIME	User spare date-time
CAM_X_SSPDTIME	User spare elapsed time
CAM_X_SSPDTIME*n*	User spare elapsed time *n*, where *n* is 2 to 8

CAM_L_SSPI*n*	User spare integer value *n*, where *n* is 1 to 16
CAM_F_SSP*n*	User spare floating value *n*, where *n* is 2 to 32

Alpha Analyst Parameters

CAM_T_SELEMENT	Sample element description (32 chars)
CAM_T_SMATRIX	Sample matrix description (32 chars)
CAM_T_SPROTOCOL	Sample processing protocol description (32 chars)
CAM_T_SSTATUS	Sample status (8 chars)
CAM_T_SPROTOFILE	Protocol file name (96 chars)
CAM_L_SMATRIXNUM	Sample matrix number
CAM_L_SELEMENTNUM	Sample element number
CAM_L_SGEOMNUM	Sample geometry number
CAM_F_EXTCHEMYIELD	Externally calculated sample recovery factor
CAM_F_EXTCHEMYERR	Error in externally calculated sample recovery factor
CAM_F_CONTROLVOL	Volume (in mL) of control

Sample Flags Fields

CAM_L_SFLAGS	Sample flags field
CAM_M_SF_SP1 [CAM_L_SFSP1]	Flags bit 0
CAM_M_SF_SP2 [CAM_L_SFSP2]	Flags bit 1
CAM_M_SF_SP3 [CAM_L_SFSP3]	Flags bit 2
CAM_M_SF_SP4 [CAM_L_SFSP4]	Flags bit 3
CAM_V_SF_SHOWER [CAM_L_SFSHOWER]	Shower taken before count? (Y/N)
CAM_M_SF_SPECIAL [CAM_L_SFSPECIAL]	Special clothing? (Y/N)

CAM_M_SF_CHAMSPEC [CAM_L_SFCHAMSPEC]	Chamber specific processing
CAM_M_SF_INTERRUPT [CAM_L_SFINTERRUPT]	Was interrupted
CAM_M_SF_ABORTED [CAM_L_SFABORTED]	Was aborted
CAM_M_SF_CALCOUNT [CAM_L_SFCALCOUNT]	Count was for calibration purposes

Geometry Parameters

The geometry parameters block contains a number of records, each containing an efficiency calibration. The symbolic name for this class is CAM_CLS_GEOM. The first record contains the calibration to be used in calculation of efficiency by efficiency correction, NID and MDA analysis algorithms. The remaining records, if any, represent efficiency at specific chest-wall thicknesses or item densities.

Record Parameters

CAM_X_DCALTIME	Detector efficiency calibration time
CAM_T_EFOPNAME	Operator who performed efficiency calibration (24 characters)
CAM_T_EFAPNAME	Name of efficiency approver (24 characters)
CAM_X_EFAPDATE	Date of efficiency approval
CAM_T_DETSTATUS	Detector status (32 characters)
CAM_T_EFCALVERS	Efficiency calibration version (16 characters)
CAM_X_LASTCALD	Date of previous calibration
CAM_T_SHELF	Shelf identification (1 character)
CAM_T_GEOMETRY	Geometry identification (16 characters)
CAM_T_DETECTOR	Detector identification (16 characters)
CAM_T_CHAIR	Chair identification (16 characters)
CAM_F_DCREFDIST	Geometry reference distance
CAM_F_DCSAMPDIST	Actual geometry distance

CAM_T_EFFTYPE	Efficiency model to be used in analysis: SPLINE, EMPIRICAL, AVERAGE, DUAL or LINEAR (8 characters)
CAM_T_ISOCSFILE	ISOCS calibration file name (96 characters)
CAM_T_DETYP	Detector type: Ge, NaI, LEPS, … (8 characters)
CAM_F_CWTORDENSI	Chest wall thickness or density
CAM_F_CWTORDENSIER	Uncertainty in chest wall thickness or density
CAM_L_DCALFLAGS	Detector calibration flags
CAM_M_DCAL_USEAVRG	Use average efficiency (used for Alpha Spec)
CAM_M_DCAL_USEEMPEFF [CAM_L_USEEMPEFF]	Use EMPIRICAL calibration function
CAM_M_DCAL_USELUNGCNT	Use multi-record lung counting calibration data. There is one record per calibration energy: with the tabular entries being chest wall thickness, efficiency, uncertainty triplets.
CAM_M_DCAL_GEOMNOTAPP [CAM_L_GEOMNOTAPP]	Geometry not approved

WBC and Lung Counter Parameters

CAM_F_SCANST	Scan start position
CAM_F_SCANEND	Scan end position
CAM_F_LCENERGY	Calibration energy (keV)
CAM_F_LCCONST	Constant term which multiplies exponential
CAM_F_LCEXP	Exponential coefficient
CAM_F_LCGOF	Fit linear correlation coefficient

Empirical Efficiency Model Calibration Parameters

CAM_L_EMPDEGREE	Degree of EMPIRICAL polynomial (0-5)
CAM_F_DCALFAC1	EMPIRICAL scaling parameter

CAM_F_DCALFAC2	EMPIRICAL efficiency factor 2 (constant)
CAM_F_DCALFAC3	EMPIRICAL efficiency factor 3 (linear)
CAM_F_DCALFAC4	EMPIRICAL efficiency factor 4 (quadratic)
CAM_F_DCALFAC5	EMPIRICAL efficiency factor 5 (cubic)
CAM_F_DCALFAC6	EMPIRICAL efficiency factor 6 (4th order)
CAM_F_DCALFAC7	EMPIRICAL efficiency factor 7 (5th order)
CAM_F_EMPCHISQ	EMPIRICAL fit reduced chi-square
CAM_F_EFFAVERR	Average error in empirical efficiency fit

Alpha Spectroscopy Efficiency Calibration Parameters

CAM_F_AVRGEFF	Average efficiency
CAM_F_AVRGEFFERR	Uncertainty in average efficiency

Dual Polynomial Efficiency Model Calibration Parameters

CAM_F_CROSSOVER	Polynomial crossover energy
CAM_L_DLDEGREE	Degree of low energy polynomial (0-3)
CAM_L_DHDEGREE	Degree of high energy polynomial (0-5)
CAM_F_DLCALFAC1	Dual: Low energy offset
CAM_F_DLCALFAC2	Dual: Low energy slope
CAM_F_DLCALFAC3	Dual: Low energy quadratic term
CAM_F_DLCALFAC4	Dual: Low energy cubic term
CAM_F_DLCALFAC5	Dual: Low energy 4th order term
CAM_F_DLCALFAC6	Dual: Low energy 5th order term
CAM_F_DLCALCHI	Low energy fit chi-square
CAM_F_DHCALFAC1	Dual: High energy offset
CAM_F_DHCALFAC2	Dual: High energy slope
CAM_F_DHCALFAC3	Dual: High energy quadratic term
CAM_F_DHCALFAC4	Dual: High energy cubic term
CAM_F_DHCALFAC5	Dual: High energy 4th order term

CAM_F_DHCALFAC6	Dual: High energy 5th order term
CAM_F_DHCALFAC7	Dual: High energy 6th order term
CAM_F_DHCALFAC8	Dual: High energy 7th order term
CAM_F_DHCALFAC9	Dual: High energy 8th order term
CAM_F_DHCALFAC10	Dual: High energy 9th order term
CAM_F_DHCALCHI	High energy fit chi-square
CAM_G_LERRMAT*n*	Dual: Low energy error matrix *n*, where *n* is 1 to 11
CAM_G_HERRMAT*n*	Dual: High energy error matrix *n*, where *n* is 1 to 19

Linear Efficiency Model Calibration Parameters

CAM_L_LNDEGREE	Linear: Polynomial degree (0-9)
CAM_F_LNCHISQ	Linear: Reduced fit chi-square
CAM_F_LNCALFAC1	Linear: Offset
CAM_F_LNCALFAC2	Linear: Slope
CAM_F_LNCALFAC3	Linear: Quadratic term
CAM_F_LNCALFAC4	Linear: Cubic term
CAM_F_LNCALFAC5	Linear: 4th order term
CAM_F_LNCALFAC6	Linear: 5th order term
CAM_F_LNCALFAC7	Linear: 6th order term
CAM_F_LNCALFAC8	Linear: 7th order term
CAM_F_LNCALFAC9	Linear: 8th order term
CAM_F_LNCALFAC10	Linear: 9th order term
CAM_G_LNERRMAT*n*	Linear: Error matrix *n*, where *n* is 1 to 19

User Spare Geometry Parameters

CAM_F_DSP1	User spare floating value 1
CAM_F_DSP2	User spare floating value 2

Record Tabular Entry Parameters

CAM_F_DENERGY	Energy (keV) or chest wall thickness (cm); see the CAM_M_DCAL_USELUNGCNT flag
CAM_F_DEFF	Computed efficiency
CAM_F_DEFFERR	Uncertainty in efficiency
CAM_F_DEFFEFAC	Efficiency interpolation error (EMPIRICAL only)
CAM_L_DEFFPTID	Data point source ID
CAM_F_DEFFCOICF	Cascade summing correction factor
CAM_F_DEFFCOICFERR	Uncertainty in cascade summing correction factor
CAM_L_DEFFFLAGS	Efficiency point flags:
CAM_M_DEFF_CSCDONE [CAM_L_DEFFCSCDONE]	Cascade summing correction has been done for this energy

Processing Parameters

This processing parameters block is designed for standard single parameter NID applications and contains analysis parameters for many applications. The symbolic name for this class is CAM_CLS_PROC.

Common Parameters

CAM_L_PROCFLAGS	Processing flags
CAM_M_PROC_FIT [CAM_L_PRFIT]	Fit singlets (peak search)
CAM_M_PROC_ALPHA [CAM_L_DOALPHA]	Use Alpha peak search
CAM_M_PROC_NOSMOOTH	Don’t smooth data (Alpha peak search)
CAM_M_PROC_CRITLEVEL [CAM_L_CRITLEVEL]	Do critical level test (peak search)
CAM_M_PROC_PROPAGATE [CAM_L_PROPAGATE]	Propagate all errors

CAM_M_PROC_VARDT [CAM_L_PRVARDT]	Do variable dead-time correction
CAM_M_PROC_COLLTIME [CAM_L_PRCOLLTIME]	Do collection time decay correction
CAM_M_PROC_DOLIBEFF [CAM_L_DOLIBEFF]	Do library-based efficiency
CAM_M_PROC_KEYLINE [CAM_L_PRKEYLINE]	Perform key-line analysis
CAM_M_PROC_LLDCONST [CAM_L_PRLLDCONST]	Include k^2 term in LLD equation
CAM_M_PROC_CALCMDA [CAM_L_PRCALCMDA]	Compute a posteriori MDA
CAM_M_PROC_CALCWGT	Use fitted spectrum for weighting factors (Alpha-M)
CAM_M_PROC_THRSHFT	Perform a threshold shift (Alpha-M)
CAM_M_PROC_ANALCNT	Perform geometry analysis (WBC only)
CAM_M_PROC_INCREP	Include geometry in report (WBC only)
CAM_M_PROC_GAINSHFT [CAM_L_PRGAINSHFT]	Perform gain shift correction (Gamma-M)
CAM_M_PROC_SYSERRDTL [CAM_L_PRSYSERRDTL]	Include systematic error in detection limits
CAM_M_PROC_REFCORR [CAM_L_PRREFCORR]	Perform reference peak correction
CAM_M_PROC_USEVARETOL [CAM_L_USEVARETOL]	Use FWHM variable energy tolerance
CAM_M_PROC_DOSCOLEFF [CAM_L_DOSCOLEFF]	Do collection efficiency correction
CAM_M_PROC_DOCHEMYIELD [CAM_L_DOCHEMYIELD]	Do chemical yield correction
CAM_M_PROC_MGAFIXCD [CAM_L_PRMGAFIXCD]	Use fixed cadmium thickness? (Y/N) (MGA only)
CAM_M_PROC_MGAFIXPU [CAM_L_PRMGAFIXPU]	Use fixed plutonium thickness? (Y/N) (MGA only)
CAM_M_PROC_MGASAM241 [CAM_L_PRMGASAM241]	Freshly separated ^{241}Am ? (Y/N) (MGA only)

CAM_M_PROC_MGAUSELOW [CAM_L_PRMGAUSELOW]	Use 38-59 keV region (^{241}Am sep.)? (Y/N) (MGA only)
CAM_M_PROC_MGAUPRES [CAM_L_PRMGAUPRES]	Uranium present in sample? (Y/N) (MGA only)
CAM_M_PROC_SHOWROIS [CAM_L_SHOWROIS]	Display regions-of-interest? (Y/N)
CAM_M_PROC_DOUSERPL [CAM_L_PRDOUSERPL]	Perform user peak locate? (Y/N)
CAM_M_PROC_FWHMREJ [CAM_L_PRFWHMREJ]	Perform FWHM based rejection of singlets? (Y/N) [standard peak search only]
CAM_M_PROC_FIXFWHM [CAM_L_PRFIXFWHM]	Fix FWHM to calibration value during fitting? (Y/N)

CAM_L_PROCFLAGS2	More processing flags
CAM_M_PROC2_ROIMCA [CAM_L_SHOWROIMCA]	Interactive peak fit: filter by ROIs
CAM_M_PROC2_ENERGYFLTR [CAM_L_ENERGYFLTR]	Interactive peak fit: filter by energy
CAM_M_PROC2_NUCLFLTR [CAM_L_NUCLFLTR]	Interactive peak fit: filter by nuclide name
CAM_M_PROC2_CHISQFLTR [CAM_L_CHISQFLTR]	Interactive peak fit: filter by chi-square
CAM_M_PROC2_FWRATFLTR [CAM_L_FWRATFLTR]	Interactive peak fit: filter by FWHM ratio
CAM_M_PROC2_MLTPLTFLTR [CAM_L_MLTPLTPKFLTR]	Interactive peak fit: filter multiplets only
CAM_M_PROC2_NOFLTR [CAM_L_NOFLTR]	Interactive peak fit: no filter
CAM_M_PROC2_ERRREJ [CAM_L_PRERRREJ]	Perform % error rejection in NID
CAM_M_PROC2_MRLREJ [CAM_L_PRMRLREJ]	Perform minimum report level rejection in NID
CAM_M_PROC2_MINMDA [CAM_L_PRMINMDA]	Report minimum MDAs

CAM_M_PROC2_RPTCL [CAM_L_PRRPTCL]	Report critical level
CAM_M_PROC2_USEMDACONSTS [CAM_L_USEMDACONSTS]	Use “user-specified” MDA constants
CAM_M_PROC2_DOUNKSRCH [CAM_L_DOUNKSRCH]	Do Gamma-M “unknown” peaks search
CAM_M_PROC2_DISACQDECAY [CAM_L_DISACQDECAY]	Disable decay during acquisition time correction
CAM_M_PROC2_N1.5UTBC [CAM_L_PRNONEUTBC]	Disable neutron background correction
CAM_M_PROC2_NEUTDOMC [CAM_L_PRNEUTDOMC]	Do neutron multiplication correction
CAM_M_PROC2_MGAFIXPB [CAM_L_PRMGAFIXPB]	Fix lead thickness (MGA only)
CAM_M_PROC2_MGAAMHETRO [CAM_L_PRMGAAMHETRO]	Am-241 is heterogenous (MGA only)
CAM_M_PROC2_DOINTERF [CAM_L_PRDOINTERF]	Perform Interference correction (Used by ABACOS-Plus)
CAM_M_PROC2_AIST2G [CAM_L_PRNEUTAIST2G]	Use T^2G instead of A in calculation of reals rate (used neutron filter engines)
CAM_M_PROC2_CLRB4ACQ [CAM_L_PRCLRB4ACQ]	Clear data before starting acquisition (Genie 2000/Genie-PC only)
CAM_M_PROC2_NEUTUSETOT [CAM_L_PRNEUTUSETOT]	Use Total counts rather than Reals in Pu mass and MDA calculations
CAM_M_PROC2_NEUTFITZZ [CAM_L_PRNEUTFITZZ]	Constrain Pu mass curves to go through 0,0
CAM_M_PROC2_NEUTMLT1OK [CAM_L_PRNEUTMLT1OK]	The neutron multiplication factor will be allowed to be less than 1 (but greater than 0); normally, the factor must be greater than or equal to 1
CAM_M_PROC2_USEROIFILE [CAM_L_PRUSEROIFILE]	For ROI-driven peak searches, indicates that the ROIs should be read from the file indicated by the ROIFILE parameter. By default, the ROIs are read from the configuration being analyzed

CAM_M_PROC2_REJECT0PKS [CAM_L_PRREJECT0PKS]	Indicates that peaks with 0 area are to be rejected (this flag is not supported by all peak search algorithms)
CAM_M_PROC2_VARYLTAIL [CAM_L_PRVARYLTAIL]	Indicates that the low energy tail may be varied during multiplet fitting
CAM_M_PROC2_ADDPKRES [CAM_L_PRADDPKRES]	Used by some peak searches: indicates that peaks found are to be added to those found by previous searches (the default is to overwrite previous peak results)
CAM_L_PRLEVUSEMDA	Flag to indicate whether MDA should be used in level calculations/summing
CAM_L_PRLEVBOUNDS	Flag to indicate whether activity or upper level used in calculations
CAM_L_PRDORESID	Flag to enable/disable residual search

CAM_L_PROCFLAGS3	Still more processing flags
CAM_M_PROC3_DOMDATEST [CAM_L_PRDOMDATEST]	Perform MDA test during NID
CAM_M_PROC3_USEVBKCHN [CAM_L_PRUSEVBKCHN]	Use variable FWHM for continuum determination
CAM_M_PROC3_USEVPWIDTH [CAM_L_PRUSEVPWIDTH]	Use variable VPWIDTH parameter for MDA ROI calculations
CAM_M_PROC3_MGAALWAYS [CAM_L_PRMGAALWAYS]	Best of MGA/NID: always use MGA
CAM_M_PROC3_COMBAVE [CAM_L_PRCOMBAVE]	NID Combiner: do an average instead of a sum
CAM_M_PROC3_SSNOSHIFT [CAM_L_PRSSNOSHIFT]	Shift/Sum engine: don’t do gain shift
CAM_M_PROC3_SSNOLTCORR [CAM_L_PRSSNOLTCORR]	Shift/Sum engine: don’t do live time correction
CAM_M_PROC3_SSSERIAL [CAM_L_PRSSSERIAL]	Shift/Sum engine: do live time correction in serial mode
CAM_M_PROC3_MGANOABORT [CAM_L_PRMGANOABORT]	MGA and MGAU only: return success status except for I/O related errors
CAM_M_PROC3_MGAUUSEMGA [CAM_L_PRMGAUUSEMGA]	MGAU only: perform no processing if valid MGA results are already present

CAM_M_PROC3_NOREFPEAK [CAM_L_PRNOREFPEAK]	Disable reference peak correction (“new” reference peak engine only)
CAM_M_PROC3_NOBACKCOR [CAM_L_PRNOBACKCOR]	Disable background subtraction (“new” reference peak engine only)
CAM_M_PROC3_COMBAVENOW [CAM_L_PRCOMBAVENOW]	NID results combination engine: Combine using non-weighted average
CAM_M_PROC3_MGAUMGAOUT [CAM_L_PRMGAUMGAOUT]	MGAU should output results compatible with MGA
CAM_M_PROC3_NEUTMULTI [CAM_L_NEUTMULTI]	Perform multiplicity analysis
CAM_M_PROC3_NEUTDOALHAI [CAM_L_NEUTDOALPHA]	Perform known alpha multiplicity analysis
CAM_M_PROC3_NEUTDOMFACT [CAM_L_NEUTDOMFACT]	Perform known multiplication multiplicity analysis
CAM_M_PROC3_NEUTDOEFF [CAM_L_NEUTDOEFF]	Perform known efficiency multiplicity analysis
CAM_M_PROC3_NEUTDOEALHAI [CAM_L_NEUTDOEALPHA]	Perform known efficiency and alpha multiplicity analysis
CAM_M_PROC3_NEUTDOEMFACT [CAM_L_NEUTDOEMFACT]	Perform known efficiency and multiplication multiplicity analysis
CAM_M_PROC3_NEUTDOSDTAV [CAM_L_NEUTDOSDTAVG]	Compute singles, doubles, and triples using sample mean
CAM_M_PROC3_PRNEUTDOMCD [CAM_L_PRNEUTDOMCD]	Use MC doubles mass calibration
CAM_M_PROC3_PRNEUTUSERE [CAM_L_PRNEUTUSERE]	Use reals mass calibration
CAM_M_PROC3_NEUTUSEKEFF [CAM_L_NEUTUSEKEFF]	Use K-norm efficiency to compute mass

CAM_L_PROCFLAGS4	Still more processing flags again
CAM_M_PROC4_LROIBYENG [CAM_L_PRLROIBYENG]	Load ROIs by energy
CAM_M_PROC4_FORCEROI [CAM_L_PRFORCEROI]	Flag used by Simple Library Driven to tell engine to generate ROIs based on FWHM

CAM_M_PROC4_CHECKADJPK [CAM_L_PRCHECKADJPK]	Check for adjacent peaks
CAM_M_PROC4_NOMCONSTT [CAM_L_PRNOMCONSTT]	Disable multiplicity consistency test
CAM_M_PROC4_CHKFIDUTST [CAM_L_PRCHKFIDUTST]	True if the “fiducial peaks” test is to be performed
CAM_M_PROC4_DOAUTOWST [CAM_L_PRDOAUTOWST]	Perform Automated Waste Analysis
CAM_M_PROC4_HZFRACKNWM [CAM_L_PRHZFRACKNWN]	High-Z fractions are known
CAM_M_PROC4_DOMGAVCHCK [CAM_L_PRDOMGAVCHCK]	Perform MGA and MGAU results validity test (enables execution of the MGA Validity Check analysis engine)
CAM_M_PROC4_DOTMUWIPP [CAM_L_PRDOTMUWIPP]	Perform TMU and WIPP calculations (used by NDA 2000)
CAM_M_PROC4_ADDEFFERR [CAM_L_PRADDEFFERR]	Include chi-square in efficiency error
CAM_M_PROC4_NOTRCLAMP [CAM_L_PRNOTRCLAMP]	Do not clamp transmission ratio to minimum transmission value. Instead, reject transmission peaks whose ratio is at or below the minimum
CAM_M_PROC4_TRBKGSUB [CAM_L_PRTRBKGSUB]	Subtract item background from transmission data. This option can be used with two-pass transmission data to subtract the contribution of the transmission nuclide in the item from the transmission pass data
CAM_M_PROC4_DOCOLLAR [CAM_L_PRDOCOLLARAN]	Do neutron collar analysis
CAM_M_PROC4_DOACTMULT [CAM_L_PRDOACTMULT]	Do active multiplicity analysis

Peak Search Processing Parameters

CAM_F_SENSITVTY	Sensitivity
CAM_F_GSENSITVTY	Gaussian sensitivity
CAM_F_FWHMREJRATIO	Measured/Expected FWHM rejection threshold
CAM_L_ITERATIONS	Maximum number of iterations

CAM_L_PEAKSTART	Peak search start channel
CAM_L_PEAKEND	Peak search end channel
CAM_F_LOCSMTH	Peak location smoothing factor (FWHM)
CAM_F_MULTSMTH	Multiplet search smoothing factor (FWHM)
CAM_L_PASTART	Peak analysis start channel
CAM_L_PAEND	Peak analysis end channel
CAM_F_PRFWHMPKMULT	Number of expected FWHMs to search in determining whether a peak is in a multiplet
CAM_F_PRFWHMPKLEFT	Limit in FWHMs of peak left boundary search
CAM_F_PRFWHMPKRGHT	Limit in FWHMs of peak right boundary search
CAM_F_PRMINPEAKSEP	Minimum peak separation (in terms of FWHM)
CAM_L_PRNBKCHN	Number of average background channels
CAM_F_PRVBKCHN	Variable continuum channels (FWHM)
CAM_F_PRVROIWIDTH	Multiplier applied to FWHM when Simple Library driven engine is generating ROIs

Hypermet Peak Search Processing Parameters

CAM_F_CHISENSITVTY	Chi square sensitivity
CAM_F_RSENSITVTY	Residuals sensitivity

Singlet Peak Search Processing Parameters

CAM_L_MSCHANS	Median width for smoothing function
CAM_F_SECSENS	Secondary sensitivity

Alpha Peak Search Processing Parameters

CAM_F_SUMSENSITVTY	Sum sensitivity cutoff

ROI Peak Search Processing Parameters

CAM_T_ROIPSTYP	Computation Mode: GROSS or NET

CAM_T_ROIPSBTYP	Background type: LINEAR or STEP

Gamma-M Peak Search Processing Parameters

CAM_F_AREAWIND1	Phase 1: Area window (FWHM)
CAM_F_AREAWIND2	Phase 2: Area window (FWHM)
CAM_F_INTFWIND1	Phase 1: Interference window (FWHM)
CAM_F_INTFWIND2	Phase 2: Interference window (FWHM)
CAM_F_OVERWIND1	Phase 1: Overlap window (FWHM)
CAM_F_OVERWIND2	Phase 2: Overlap window (FWHM)
CAM_L_NBACKTERMS	Number of background terms (0-2)
CAM_F_BACKREJ	Background rejection factor
CAM_F_VARREJ	Peak height variance rejection factor
CAM_L_PRGAINSHFT	Perform gain shift? (Y/N)
CAM_L_MAXGAINPASS	Maximum number of gain passes
CAM_F_GAINREJ	Gain shift rejection factor
CAM_F_REJMDASIG	MDA rejection sigma
CAM_F_REJMDACONST	MDA rejection constant
CAM_F_UNIDETOL	Unidentified line energy tolerance
CAM_F_UNIDREJ	Unidentified line rejection factor
CAM_F_UNIDCONST	Unidentified line constant

Calibration Processing Parameters

CAM_F_ECALTOL	Energy calibration energy tolerance
CAM_F_VARECALTOL	Energy calibration variable tolerance (FWHM)
CAM_F_ECALSMOOTH	NaI Init calib smoothing factor (FWHM)

Alpha-M Processing Parameters

CAM_F_SQUANTMULT	Sample quantity multiplier

CAM_T_GAINSHIFT	Gain shift type: NONE, AUTO or ITER (4 characters)
CAM_T_WEIGHTING	Weighting type: NONE, COUNTS or DERIVED (7characters)
CAM_F_SIGMAREJ	N-sigma rejection coefficient
CAM_L_CALCWGT	Weights based on derived data?
CAM_L_THRSHFT	Perform threshold shift?

MGA Processing Parameters

CAM_F_MGAFCDABS	Fixed cadmium absorber thickness (this value is overridden by the value specified in the neutron detector data block)
CAM_F_MGAFPUABS	Fixed plutonium absorber thickness (this value is overridden by the value specified in the neutron sample processing parameters data block)
CAM_T_MGAPU242TYP	^{242}Pu calc. method (Decl/Old/New) (12 characters)
CAM_F_MGADECPU242	Declared ^{242}Pu abundance fraction (this value is overridden by the value specified in the neutron declaration block)
CAM_X_MGARCTOCHEM	Reactor exit to chemical sep. time (this value is overridden by the value specified in the neutron declaration block)
CAM_T_PRMGAANALTYP	Analysis type (8 characters); STD or SOL (for solutions)
CAM_L_PRMGANSPEC	Number of spectra to analyze; this should be 1 unless a high energy spectral file is available, when it should be a 2. The high energy spectral file should have the same name as the low energy file, except with a CN2 extension.
CAM_F_PRMGAMINCNTS	Total spectral counts required for MGA to operate
CAM_F_PRMGALEDETLM	Low energy spectrum (129 and 208 keV peaks) detection limit uncertainty (%)
CAM_F_PRMGAHEDETLM	High energy spectrum (208 and 414 keV peaks) detection limit uncertainty (%)

CAM_F_PRMGAUCALFAC	MGAU calibration factor
CAM_T_PRMGAREFNUCL	Best of MGA/NID: reference nuclide name (8 characters)
CAM_L_PRMGAUMODE	MGAU processing mode: 0=standard, 1=enrichment meter with unknown Fe thickness, 2=enrichment meter, 3=enrichment meter calibration with unknown Fe, 4= enrichment meter calibration with known Fe
CAM_F_PRMGAU235FCT	MGAU ^{235}U fluorescence factor
CAM_F_PRMGAU238FCT	MGAU ^{238}U fluorescence factor
CAM_F_PRMGAUFE	MGAU Fe thickness (mm)
CAM_F_PRMGAUFEDENS	MGAU Fe density
CAM_F_PRMGAUAL	MGAU Al thickness
CAM_L_PRMGAU186SR	MGAU maximum search range (channels) for 186 keV peak
CAM_F_PRMGAU93PKRT	MGAU minimum 93 keV peak height-to-background ratio
CAM_F_PRMGAU208SEN	MGAU 208 keV peak sensitivity
CAM_F_PRUENRICH	Uranium enrichment (%)
CAM_F_PRUENRICHERR	error in Uranium enrichment
CAM_F_PRMGAU122FW	Max permissible FWHM (keV) at 122 keV
CAM_X_PRAMSEPLIMIT	Maximum Am separation time
CAM_F_PRMGAMAXNQF	Maximum fit value
CAM_F_PRMAX122FWHM	Maximum 122 keV FWHM (for validity test; in eV)
CAM_F_PRMAXMGAPUER	Maximum error in ^{240}Pu effective (in percent)
CAM_T_PRMGAAVEPEAK	Used in MGA Results Averaging engine: Nuclide whose primary gamma determines results weighting (Pu-239, Pu-241, U-235) (8 characters)
CAM_F_PRMAXDT	Maximum allowed deadtime (in percent)
CAM_F_PRMINPU239	Minimum allowed Pu-239 abundance

CAM_F_PRMAXPU239	Maximum allowed Pu-239 abundance
CAM_T_PRFIDUPEAKS	Space, tab, or comma separated list of fiducial photopeak energies
CAM_F_PRMAXRPVSDTD	Maximum allowed percent difference between reference peak deadtime vs. MCA deadtime
CAM_F_PRMAXFIDUFIT	Maximum allowed fiducial peak fit
CAM_T_PRCFFIDUPEAKS	List of fiducial peak energies for Cf-252; values are separated by comma, space, or tab (32 characters)
CAM_T_PRCMFIDUPEAKS	List of fiducial peak energies for Cm-244; values are separated by comma, space, or tab (32 characters)

Nuclide ID Processing Parameters

CAM_F_TOLERANCE	Energy tolerance
CAM_F_VARTOLERANCE	Variable energy tolerance (FWHM)
CAM_F_HALFLIFERAT	Half-life ratio
CAM_F_ABUNDANLIM	Abundance limit (%)
CAM_L_MPCTYPE	MPC type to be reported
CAM_F_WTMLIMIT	Limit for WT mean test
CAM_F_VPWIDTH	Variable peak width
CAM_F_MDACONFID	% confidence level for MDA
CAM_L_NSIGMA	N sigma error to report
CAM_T_ACTIVUNITS	Units of activity (for NID report, 16 chars)
CAM_F_ACTIVMULT	Activity conversion factor (from μCi)
CAM_F_CONFID	NID confidence index threshold
CAM_F_SIGMA	Report uncertainty multiplier
CAM_T_BUILDUPTYPE	Activity build-up type (DEPOSIT or IRRAD)
CAM_L_PRCSCTYPE	Determines if Cascade summing correction is to be performed: 0 for no, 1 for yes

WBC-Specific Processing Parameters

CAM_T_DOSEUNITS	Dose reporting units (8 chars)
CAM_F_WBCDOSECOMIT	ICRP-2 dose commitment period (years)
CAM_F_DOSEMULT	Dose conversion factor (from mrem)
CAM_F_WBCDIL	Derived investigation level (% of ALI)
CAM_T_PSTYPE	Peak search type: STANDARD, LIBRARY, SINGLET, ROI or GAMMA-M
CAM_L_ANALCNT	Sum/Shift during count? (Y/N)
CAM_L_INCREP	Include in report? (Y/N)
CAM_T_LIBNAME	Library to be used for analysis
CAM_F_PWARNFIT	Warning level for fit value
CAM_F_PWARNACT	Warning level for activity
CAM_F_DOSETIME	Dose commitment time (years)

Interactive Peak Search Processing Parameters

CAM_T_PLOTSCALE	Plot scaling (LIN, LOG, SQRT) (4 characters)
CAM_F_ENERGYPKFLTR	Select the peak region closest to this energy
CAM_F_CHISQPKFLTR	Select multiplets with chi-square values greater than this value
CAM_F_FWRATPKFLTR	Select peak regions whose ratio of measured to expected FWHM exceeds this value
CAM_T_NUCLPKFLTR	Select peak regions associated with this nuclide (12 characters)

User Spare Processing Parameters

CAM_F_PRSP*n*	User spare floating value *n*, where *n* is 1 to 3
CAM_F_PRSSP*n*	User spare string *n* (16 characters), where *n* is 1 to 3

Reference Peak Processing Parameters

CAM_F_REFENG	Reference peak energy

CAM_F_REFRATE	Reference peak rate
CAM_F_DREFRATE	Uncertainty in reference peak rate
CAM_X_REFDATE	Reference rate measurement date
CAM_X_REFHLF	Half-life of reference nuclide
CAM_T_REFHLFUNITS	Units for reference nuclide half-life

Neutron Analysis Parameters

Coincidence Analysis

CAM_T_PRPUMUNITS	Neutron analysis mass units string (16 characters)
CAM_F_PRPUMCF	Conversion factor between external mass units and grams
CAM_F_PRNEUTSFTMLL	Totals filter lower rate limit
CAM_F_PRNEUTNSIGMA	Totals filter rejection value (in standard deviations)
CAM_F_PRNEURNSIGMA	Reals filter (in standard deviations)
CAM_F_NEUTT2GTMLL	T^2G filter lower rate limit
CAM_F_NEUTT2GNSIG	T^2G filter (in standard deviations)
CAM_F_PRNEUTT2GPLM	T^2G filter precision test limit (%)
CAM_T_PRNEUTISOSRC	Isotopics to use in Pu mass calculation (DECLARED or MEASURED) (8 characters)
CAM_L_PRNERRMLIM	Number of neutron measurements at or above which the measured standard deviation is used instead of the computed error. If this value is 0, the computed error is always used.
CAM_T_PRNEFFTYPE	Type of reals-to-mass calibration curve: POLYNOMIAL, POWER, EXPONENTIAL, RATIONAL (16 characters)
CAM_X_PRNEUTPRDATE	Mass/isotopics prediction date
CAM_F_PRNBKGARAT	Background rates adjustment factor

CAM_F_PRNSETIMEADJ	Neutron cycle time adjustment factor (CAM_F_NACQSETIME, the neutron cycle time, is set to this value times CAM_X_SRCOUNTTIME, if this value is non-zero).

Multiplicity Analysis

CAM_F_PRNMFLOWLIM	Upper multiplicity parameter limit
CAM_F_PRNMFHIGHLIM	Lower multiplicity parameter limit
CAM_F_PRNEUTALPHA	Known alpha value for multiplicity analysis
CAM_F_PRNEUTALPHER	Uncertainty in known alpha
CAM_F_PRNEUTMFACT	Known multiplication value for multiplicity analysis
CAM_F_PRNEUTMFACER	Uncertainty in the known multiplication
CAM_F_PRNEUTEFF	Known efficiency value
CAM_F_PRNEUTEFFER	Uncertainty in known efficiency
CAM_F_PRONESNSIGMA	Ones rate filter n-sigma limit

Automated Waste Analysis Parameters

CAM_F_PRAASLRGLIM	AAS Large Limit
CAM_F_PRAWAHZLIM	High-Z mass limit (kg) determines what is considered HZ
CAM_F_PRCMCFNSIGMA	Cm/Cf Significance limit – N*Sigma – used for determining if Cm, Cf, or Pu from Cm/Cf analysis is significant
CAM_F_PRONESTOTLIM	Ones Rate Totals limit, if totals rate is then Ones rate anal is suitable
CAM_F_PRTRUNTOTLIM	Truncation Totals Rate limit
CAM_F_PRAWAP240LIM	^{240}Pu Effective Mass cutoff for KM, and Trun analysis

Waste Assay Parameters

CAM_T_PRVOLUNITS	Volume units (8 characters)
CAM_F_PRVOLCF	Volume units conversion factor (should be initialized to 1 for liters)

CAM_T_PRDENSUNITS	Density units (8 characters)
CAM_F_PRDENSCF	Density units conversion factor (should be initialized to 1 for kg/L)
CAM_F_PRDPRATERLIM	Differential peak ratio error limit
CAM_F_PRTRRATERLIM	Transmission ratio error limit
CAM_F_PRP2AFAILOVR	Peak to average failover ratio
CAM_T_PRCOMBMATMOD	Combined matrix correction engine mode (8 characters)
CAM_F_PRT2AFAILOVR	Transmission to average density failover ratio
CAM_F_PRMINTRANS	Minimum transmission ratio (%)
CAM_F_PRMATRIXZ1	Matrix element 1 Z
CAM_F_PRMATRIXZ1FR	Proportion of element 1 (as a fraction) in the matrix
CAM_F_PRMATRIXZ2	Matrix element 2 Z
CAM_F_PRMATRIXZ2FR	Proportion of element 2
CAM_F_PRMATRIXZ3	Matrix element 3 Z
CAM_F_PRMATRIXZ3FR	Proportion of element 3

Miscellaneous Parameters

CAM_L_PARENTWDGT	Widget/handle to parent window (used in GUI Interactive Peak Fit)
CAM_L_SHELLHNDL	Presentation Manager shell handle (used in OS/2 Interactive Peak Fit)
CAM_T_SADCHAR	Sample Analysis Database character (12 characters)
CAM_F_PRTRACERAMT	Amount of tracer added to samples

Action Level Parameters

CAM_F_PRLEV1ALARM1	Sum action level 1 alarm level 1
CAM_F_PRLEV1ALARM2	Sum action level 1 alarm level 2
CAM_F_PRLEV2ALARM1	Sum action level 2 alarm level 1

CAM_F_PRLEV2ALARM2	Sum action level 2 alarm level 2

Shift/Sum Processing Parameters

CAM_L_PRSHIFTSTART	Start channel in source spectra of data to be Shift/Summed
CAM_L_PRSHIFTCHANS	Number of channels from source spectra to be Shift/Summed
CAM_T_PRSSLTCTYPE	Live time correction mode: REFERENCE, or FIXED (16 characters)

Non-Uniformity Detection Analysis Parameters

CAM_F_PRNUDSENERG	Energy of line (in keV) of transmission source which marks matrix nonuniformity
CAM_T_PRNUDSNUCL	Name of nuclide which marks source non-uniformity (8 characters)

K-Edge Processing Parameters

CAM_F_PRKEDBLIMLL	Start energy of lower continuum window (keV)
CAM_F_PRKEDBLIMLU	End energy of lower continuum window (keV)
CAM_F_PRKEDBLIMUL	Start energy of upper continuum window (keV)
CAM_F_PRKEDBLIMUU	End energy of upper continuum window (keV)
CAM_F_PRKEDREF1ENG	Reference peak 1 energy (keV)
CAM_F_PRKEDREF2ENG	Reference peak 2 energy (keV)
CAM_F_PRKEDNORMENG	Normalization energy (keV)
CAM_T_PRKEDELEMNT1	Name of element 1 (16 characters)
CAM_T_PRKEDELEMNT2	Name of element 2 (16 characters)
CAM_F_PRKEDMUNORM1	Mu of normalization energy of element 1 (cm^2/gr)
CAM_F_PRKEDMUNORM2	Mu of normalization energy of element 2 (cm^2/gr)

CAM_F_PRKEDDCL235	Default declared U-235 enrichment (%)
CAM_F_PRKEDDPUAWT	Default declared Pu atomic weight (grams/mole)
CAM_F_PRKEDDNORMV	Default K-edge normalization value
CAM_F_PRKEDKEDE1	Energy of k-edge for element 1 (keV)
CAM_F_PRKEDKEDE2	Energy of k-edge for element 2 (keV)
CAM_F_PRKEDFTLL1	Start energy of lower fitting window for element 1 (keV)
CAM_F_PRKEDFTLU1	End energy of lower fitting window for element 1 (keV)
CAM_F_PRKEDFTUL1	Start energy of upper fitting window for element 1 (keV)
CAM_F_PRKEDFTUU1	End energy of upper fitting window for element 1 (keV)
CAM_F_PRKEDFTLL2	Start energy of lower fitting window for element 2 (keV)
CAM_F_PRKEDFTLU2	End energy of lower fitting window for element 2 (keV)
CAM_F_PRKEDFTUL2	Start energy of upper fitting window for element 2 (keV)
CAM_F_PRKEDFTUU2	End energy of upper fitting window for element 2 (keV)

Self-Absorption Correction Parameters

CAM_T_SABSEQTYPE	The type of equation to use (FULL or PARTIAL self-absorption; 8 characters)
CAM_L_SABSMINPK	The minimum number of peaks to use for fitting
CAM_F_SABSBETAM	The minimum acceptable value for the parameter beta
CAM_F_SABSALPHAM	The minimum acceptable value for the parameter alpha

TMU Analysis Parameters

General

CAM_F_PRLLWLIM	LLW decision limit
CAM_F_PRMAXFGE	Maximum FGE allowed; expert review required if this value is exceeded
CAM_F_PRWCFAC	Uncertainty multiplication factor in LLW decision equation
CAM_L_PRMMOVERRIDE	Multi-modality Results selection override: allows the automatic selection of which results to use to be overridden: 0 = use automatic selection, 1 = passive neutron, 2 = quantitative gamma, 3 = DDA, 4 = passive neutron Pu + quantitative gamma U
CAM_T_PRTMUISOSRC	Isotopics actually used by TMU analysis (written by TMU engines; 8 characters, either “Measured” or “Declared”)
CAM_F_PRDDASSCTOFF	DDA self-shielding cutoff (grams FGE)
CAM_F_PRGUDDACTOFF	Gamma Uranium DDA assay cutoff (grams U)
CAM_F_PR240RSCTOFF	^{240}Pu effective mass review cutoff (grams)
CAM_F_PRGFDDACTOFF	Gamma FGE DDA assay cutoff (grams FGE)
CAM_F_PR240SSCTOFF	^{240}Pu effective mass self-shielding cutoff (grams)

Gamma TMU

CAM_F_PR414129LIM	Maximum allowed ratio of the ^{239}Pu – 414 keV activity to 129 keV activity
CAM_F_PRGMATRIXERR	1-sigma relative uncertainty in matrix correction measurement (this value is empirically determined)
CAM_F_PRLUMPFAC1	Lump uncertainty factor equation coefficient 1
CAM_F_PRLUMPFAC2	Lump uncertainty factor equation coefficient 2
CAM_F_PRMAXGPUMASS	Maximum allowed total Pu mass
CAM_F_PRMINGPU239	Minimum allowed ^{239}Pu mass (g)
CAM_F_PRMAXGPU239	Maximum allowed ^{239}Pu mass

CAM_F_PRMAXGUMASS	Maximum allowed total U mass
CAM_F_PRMAXGU233	Maximum allowed ^{233}U mass
CAM_F_PRMAXGU235	Maximum allowed ^{233}U mass
CAM_F_PRGRMAXFAC1	R_{max} equation offset coefficient
CAM_F_PRGRMAXFAC2	R_{max} equation slope coefficient
CAM_F_PRGRMAXFAC3	R_{max} equation quadratic coefficient
CAM_F_PRGRMINFAC1	R_{min} equation offset coefficient
CAM_F_PRGRMINFAC2	R_{min} equation slope coefficient
CAM_F_PRGRMINFAC3	R_{min} equation quadratic coefficient
CAM_F_PRMAXDENSITY	Maximum suggested item density
CAM_F_PRMINAMRATIO	Maximum ^{241}Am/^{239}Pu activity ratio
CAM_F_PRMINNPRATIO	Maximum ^{237}Np/^{239}Pu activity ratio
CAM_F_PRISOCPUNSIG	Maximum allowed difference (in sigma) between measured and declared ^{239}Pu, ^{240}Pu, and ^{235}U
CAM_F_PRISOCAMNSIG	Maximum allowed difference (in sigma) between measured and declared ^{241}Am

Passive Neutron TMU

CAM_F_PRAASCORERR	1-sigma additional relative error in Add-a-Source correction factor
CAM_F_PRNMAXMFAC1	Maximum multiplication equation slope
CAM_F_PRNMAXMFAC2	Maximum multiplication equation offset
CAM_F_PRHZREALS	Increase in reals rate per gram of high-Z material
CAM_F_PRAASCFCTOF1	Add-a-Source correction factor “warning level”
CAM_F_PRAASCFCTOF2	Add-a-Source correction factor “alarm level”
CAM_F_PRAASERRLIM	Add-a-Source correction factor error limit
CAM_F_PRNMAXRMIN	Maximum value for R_{min}
CAM_F_PRNMINRMAX	Minimum value for R_{max}

CAM_F_PRNRMAXFAC1	R_{max} equation offset
CAM_F_PRNRMAXFAC2	R_{max} equation slope
CAM_F_PRNRMINFAC1	R_{min} equation offset
CAM_F_PRNRMINFAC2	R_{min} equation slope
CAM_F_PRMAXNCYCREJ	Upper limit (in %) of cycles rejected
CAM_F_PRMAXNALPHA	Maximum value for alpha

DDA TMU Analysis Parameters

CAM_F_PRDDATMUMCA	Matrix correction error factor a
CAM_F_PRDDATMUMCB	Matrix correction error factor b
CAM_F_PRDDATMUMCC	Matrix correction error factor c
CAM_F_PRDDAMAXRMIN	Maximum value for R_{min}
CAM_F_PRDDAMINRMAX	Maximum value for R_{max}
CAM_F_PRDDATMUPTA	Rmin calibration factor a
CAM_F_PRDDATMUPTB	Rmin calibration factor b
CAM_F_PRDDATMUPTC	R_{max} calibration factor a
CAM_F_PRDDATMUPTD	R_{max} calibration factor b
CAM_F_PRDDATMUSSA	Self-shielding error calibration factor a
CAM_F_PRDDATMUSSB	Self-shielding error calibration factor a
CAM_F_PRDDATMUSSM0	Self-shielding calibration reference mass

DDA Processing Parameters

CAM_F_PRDDAFLEGLLM	Lower rate limit for chamber early gate flux monitor (cps)
CAM_F_PRDDAFLEGHLM	Upper rate limit for chamber early gate flux monitor (cps)
CAM_F_PRDDADEFMI	Default moderator index
CAM_F_PRDDADEFAI	Default absorption index
CAM_F_PRDDAMAXMI	Maximum moderator index
CAM_F_PRDDAMINMI	Minimum moderator index

CAM_F_PRDDATHRMI	Threshold moderator index
CAM_F_PRDDAMINAI	Minimum absorption index
CAM_F_PRDDATHRAI	Threshold absorption index
CAM_F_PRDDADEFAMCF	Default (supplied) active matrix correction factor

TGS Processing Parameters

Collimator and Geometry Parameter

CAM_L_PRTGSCOLTYPE	Collimator type: 0 = Circular Collimator and Detector 1 = Rectangular Collimator, Square Detector 2 = Rectangular Collimator,Circular Detector 3 = Diamond Collimator, Circular Detector 4 = Variable Collimator, Circular Detector
CAM_F_PRTGSCOLLEN	Collimator length (cm)
CAM_F_PRTGSCOLDIST	Collimator distance (cm)
CAM_F_PRTGSCOLWDTH	Collimator width (cm)
CAM_F_PRTGSCOLHGT	Collimator height (cm)
CAM_F_PRTGSDETDIAM	Detector diameter (cm)
CAM_F_PRTGSCOLTRIM	Trim width (cm)
CAM_F_PRTGSCOLLOFF	Left offset (cm)
CAM_F_PRTGSLAYERCO	Layer coupling

Analysis Parameters

CAM_F_PRTGSAREDAMP	ART emission damping factor
CAM_L_PRTGSAREITER	ART emission iterations
CAM_F_PRTGSAREMAXV	ART emission maximum voxel value
CAM_F_PRTGSAREMINV	ART emission minimum voxel value
CAM_L_PRTGSEMEITER	EM emission iterations
CAM_F_PRTGSEMEMINV	EM emission minimum voxel value
CAM_F_PRTGSARTDAMP	ART transmission damping factor

CAM_L_PRTGSARTITER	ART transmission iterations
CAM_F_PRTGSARTMAXV	ART transmission maximum voxel value
CAM_F_PRTGSARTMINV	ART transmission minimum voxel value
CAM_F_PRTGSMINTCPS	Minimum transmission rate (cps)
CAM_L_PRTGSMETHOD	Emission fit method flags (for SET METHOD)
CAM_L_PRTGSMFEMFIT	Do EM full drum fit
CAM_L_PRTGSMFARFIT	Do ART full drum fit
CAM_L_PRTGSMFL0ZSI	Force layer 0 to have a zero s-image
CAM_L_PRTGSMFNNLSU	In EM fits, make the NNLS pre-image the upper limit
CAM_L_PRTGSMFUNILF	Use uniform layer fit
CAM_L_PRTGSMFUSEAR	Use ART transmission fit, not NNLS
CAM_L_PRTGSMFAREFL	ART emission flags (for SET ART_S_CODE)
CAM_L_PRTGSAEFNLB	No lower bound in image
CAM_L_PRTGSAEFNUB	No upper bound in image
CAM_L_PRTGSAEFUCIM	Use current image as starting point
CAM_L_PRTGSAEFRAND	Random cycle order
CAM_L_PRTGSAEFNOCT	No convergence test
CAM_L_PRTGSAEFSMIN	Use s-image as lower bound
CAM_L_PRTGSAEFSMAX	Use s-image as upper bound
CAM_L_PRTGSMFARTFL	ART transmission flags (for SET ART_U_CODE)
CAM_L_PRTGSATFNLB	No lower bound in image
CAM_L_PRTGSATFNUB	No upper bound in image
CAM_L_PRTGSATFUCIM	Use current image as starting point

CAM_L_PRTGSATFRAND	Random cycle order
CAM_L_PRTGSATFNOCT	No convergence test
CAM_L_PRTGSATFSMIN	Use u-image as lower bound
CAM_L_PRTGSATFSMAX	Use u-image as upper bound

Display Parameters

The display parameters block is composed of common display parameters and variable length region records, one region per record. Each region record contains tabular entries, each with a channel and a row parameter. Normally, two entries will be present, which represents single parameter regions. The symbolic name for this class is CAM_CLS_DISP.

Common Parameters

CAM_T_DISPMODE	Display mode (LOG, LIN, ALOG, ALIN)
CAM_L_DISPFLAGS	Display flags
CAM_M_DISP_DISPTHRESHMD [CAM_L_DISPTHRESHMD]	Display thresholds (MPA display only)
CAM_M_DISP_DISPTRANSPAR [CAM_L_DISPTRANSPAR]	Display in transparent mode (MPA display only)
CAM_L_DISPSCH	Display start channel
CAM_F_DISPSCHEN	Display start channel energy
CAM_L_DISPSROW	Display start row
CAM_F_DISPSROWEN	Display start row energy
CAM_L_DISPECH	Display end channel
CAM_F_DISPECHEN	Display end channel energy
CAM_L_DISPEROW	Display end row
CAM_F_DISPEROWEN	Display end row energy
CAM_L_DISPSCOUNT	Display start count
CAM_L_DISPECOUNT	Display end count

CAM_L_DISPGROUP	Display group
CAM_L_DISPCRATE	Display count rate (counts/second)
CAM_Q_DISPTCOUNT	Display total counts
CAM_Q_DISPNETCOUNT	Display net counts
CAM_Q_DISPBKGCOUNT	Display background counts
CAM_L_LMARKCH	Left marker channel
CAM_F_LMARKCHEN	Left marker channel energy
CAM_L_LMARKROW	Left marker row
CAM_F_LMARKROWEN	Left marker row energy
CAM_L_RMARKCH	Right marker channel
CAM_F_RMARKCHEN	Right marker channel energy
CAM_L_RMARKROW	Right marker row
CAM_F_RMARKROWEN	Right marker row energy
CAM_L_CURSORCH	Cursor channel
CAM_F_CURSORCHEN	Cursor channel energy
CAM_L_CURSORROW	Cursor row
CAM_F_CURSORROWEN	Cursor row energy
CAM_L_DISPTILT	Display tilt (degrees)
CAM_L_DISPROT	Display rotation (degrees)
CAM_L_DISPBOXTOP	Expansion box top (ND9900 only)
CAM_L_DISPBOXBOT	Expansion box bottom
CAM_L_DISPBOXLEFT	Expansion box left edge
CAM_L_DISPBOXRIGHT	Expansion box right edge
CAM_L_DISPUPDRATE	Display update delay (centiseconds)
CAM_L_SCRNSAVER	Screen saver timeout (ND9900 only)
CAM_T_LDROIFILE	Loaded ROI file (96 characeters)

User Spare Display Parameters

CAM_F_DISSP1	User spare 1
CAM_F_DISSP2	User spare 2
CAM_T_DISSTR*n*	Display spare string *n* (20 characters), where *n* is 1 to 6

MPA Display Parameters

CAM_L_DISPTHRESH*n*	Threshold *n* upper limit, where *n* is 0 to 6
CAM_L_DISPTCOLOR*n*	Threshold *n* color, where *n* is 0 to 7
CAM_L_DISPBOXFRONT	Expansion box start row
CAM_L_DISPBOXBACK	Expansion box back row

Record Parameters

CAM_L_RGNTYPE	Region type

Record Tabular Entry Parameters

CAM_L_RGNSTART	Region start
CAM_L_RGNEND	Region end
CAM_F_RGNSTARTEN	Region start energy
CAM_F_RGNENDEN	Region end energy

Each region of interest is one record; the type of the region is defined by RGNTYPE. Single parameter regions of interest will have one tabular entry: the start channel of the region is RGNSTART; the end channel is RGNEND. Multiparameter regions of interest have more than one tabular entry, each defining a X,Y coordinate with RGNSTART and RGNEND, respectively.

Peak Search Results

The peak search results block contains several common parameters, and a number of records, each of which represents a peak. The symbolic name for this class is CAM_CLS_PEAK.

Note: These calibration parameters are not used by the “new” reference peak engine; its calibration parameters are kept in acquisition parameters.

Common Parameters

CAM_L_PSFLAGS	Peak search processing flags
CAM_M_PSF_PEAKANAL [CAM_L_PSFPEAKANAL]	Peak analysis done
CAM_M_PSF_PILEUP [CAM_L_PSFPILEUP]	Pulse pileup correction done
CAM_M_PSF_SPLIN [CAM_L_PSFSPLIN]	Efficiency computation done
CAM_M_PSF_ENBACK [CAM_L_PSFENBACK]	Ambient background subtraction done
CAM_M_PSF_NAAINTF [CAM_L_PSFNAAINTF]	NAA interference correction done
CAM_M_PSF_SETEFF [CAM_L_PSFSETEFF]	NAA SETEFF done
CAM_M_PSF_REAGENT	Reagent background subtraction done
CAM_M_PSF_NUDSDONE [CAM_L_PSNUDSDONE]	NUDS (Non-Uniformity Detection Software) done
CAM_M_PSF_NUDSMCL [CAM_L_PSNUDSMCL]	NUDS could not find the transmission peak in one spectrum
CAM_M_PSF_NUDSMNF [CAM_L_PSNUDSMNF]	NUDS count not find the transmission peak in any spectrum
CAM_M_PSF_NUDSSCL [CAM_L_PSNUDSSCL]	NUDS could not find the source peak in one spectrum
CAM_M_PSF_NUDSSNF [CAM_L_PSNUDSSNF]	NUDS could not find the source peak in any spectrum
CAM_T_PSNUDSVERS	NUDS version (16 characters)
CAM_L_PSNUDSERROR	NUDS error code: provides additional diagnostic information if NUDS cannot analyze the data; allowed range: 0 through 255
CAM_M_PSF_REFPEAK [CAM_L_PSREFPEAK]	Reference peak correction done (set when reference peak correction successfully performed)
CAM_M_PSF_REFPEAKERR [CAM_L_PSREFPEAKERR]	Error in reference peak correction (set if reference peak correction could not be performed)

CAM_M_PSF_ASTMSUMDONE [CAM_L_PSASTMSUMDON]	ASTM summing engine done
CAM_M_PSF_VCHECK [CAM_L_PSFVCHECK]	Set when Spectrum Validity Check engine has executed
CAM_M_PSF_VCHECKRVW [CAM_L_PSFVCHECKRVW]	Set if all Spectrum Validity tests fail and therefore the data should be reviewed
CAM_M_PSF_VCHECKREF [CAM_L_PSFVCHECKREF]	Set if the Spectrum Validity reference peak test failed
CAM_M_PSF_VCHECKFID [CAM_L_PSFVCHECKFID]	Set if the Spectrum Validity fiducial peaks test failed
CAM_M_PSF_VCHECKMDT [CAM_L_PSFVCHECKMDT]	Set if the Spectrum Validity Check reference peak vs. MCA deadtime comparison failed

CAM_X_PPELIVE	Pileup corrected live time
CAM_X_PSBKASTIME	Acquisition start time (background spectrum)
CAM_X_PSBKELIVE	Elapsed live time (background spectrum)
CAM_X_PSDATE	Date/time peak search performed
CAM_X_PADATE	Date/time peak analysis performed
CAM_F_REFPKRATIO	Reference peak ratio
CAM_F_DREFPKRAT	Uncertainty in reference peak ratio
CAM_F_PSUDFWRATIO	User defined FW ratio: 0.1 for FWTM, …
CAM_T_PEAKVERS	Peak search version (16 characters)
CAM_T_PKANALVERS	Peak analysis version (16 characters)
CAM_T_PILEUPVERS	Pulse pileup version (16 characters)
CAM_T_SPLINVERS	Efficiency calculation version (16 characters)
CAM_T_ENBACKVERS	Background subtraction version (16 characters)
CAM_T_REAGENTVERS	Reagent background subtraction version (16 characters)
CAM_L_PSGROUP	Searched group number (always 1)
CAM_T_NAAINTFVERS	NAA INTERF version (16 characters)

CAM_F_PSCHEMYIELD	Chemical yield
CAM_F_PSDCHEMYIELD	Error in chemical yield
CAM_F_PSNUDSMRATL	NUDS matrix nonuniformity ratio (longitudinal)
CAM_F_PSNUDSMCSQL	NUDS matrix nonuniformity chi-square (longitudinal)
CAM_F_PSNUDSMRATV	NUDS matrix nonuniformity ratio (vertical)
CAM_F_PSNUDSMCSQV	NUDS matrix nonuniformity chi-square (vertical)
CAM_F_PSNUDSSRATL	NUDS source nonuniformity ratio (longitudinal)
CAM_F_PSNUDSSCSQL	NUDS source nonuniformity chi-square (longitudinal)
CAM_F_PSNUDSSRATV	NUDS source nonuniformity ratio (vertical)
CAM_F_PSNUDSSCSQV	NUDS source nonuniformity chi-square (vertical)
CAM_L_PSREFPKAERR	Reference peak analysis error code (0 if none)
CAM_F_PRREFPKETOL	Reference peak analysis energy tolerance (used by the “new” reference peak engine only)

Record Parameters

CAM_L_PSITER	Number of iterations
CAM_L_PSAGANLINE	AGA: record number of energy line
CAM_F_PSCENTRD	Peak centroid
CAM_F_PSDCENTRD	Uncertainty in centroid
CAM_F_PSENERGY	Peak energy
CAM_F_PSDENERGY	Uncertainty in energy
CAM_L_PSLEFT	Peak left channel
CAM_L_PSPWIDTH	Peak region width (channels) [Can also be accessed as CAM_L_PSWIDTH]
CAM_F_PSBACKGND	Continuum background counts

CAM_F_PSDBACK	Uncertainty in continuum background
CAM_F_PSFWHM	Peak Full-Width at Half-Maximum
CAM_F_PSDFWHM	Uncertainty in FWHM
CAM_F_PSAREA	Peak area
CAM_F_PSDAREA	Uncertainty in peak area
CAM_F_PSORIGAREA	Original peak area (uncorrected)
CAM_F_PSORIGERR	Uncertainty in original peak area
CAM_F_PSCTSS	Counts/second
CAM_F_PSCERR	% error in area and counts/second
CAM_F_PSEFF	Efficiency
CAM_F_PSEFERR	Absolute error in efficiency
CAM_F_PSFIT	Reduced chi-square for fit
CAM_L_PSBKCHAN	Number of average background channels
CAM_F_PSLOCCENT	Peak location centroid
CAM_F_PSDLOCCENT	Uncertainty in peak location centroid
CAM_F_PSTAIL1	Low energy tail
CAM_F_PSDTAIL1	Uncertainty in low energy tail
CAM_F_PSTAIL2	Additional tail
CAM_F_PSDTAIL2	Uncertainty in additional tail
CAM_F_PSSIGNIF	Peak significance
CAM_F_PSGROSS	Gross counts in peak region
CAM_F_PSAMBBACK	Ambient background subtracted from net area
CAM_F_PSDAMBBACK	Uncertainty in ambient background
CAM_F_PSFWXM	User defined FWxM
CAM_F_PSDFWXM	Uncertainty in user defined FWxM
CAM_F_PSPTCRATIO	Peak/compton ratio
CAM_F_PSKVAL	Peak significance value (“k”)

CAM_F_PSAGAGCF	AGA: gain correction factor
CAM_F_PSAGAGCFERR	AGA: gain correction factor error
CAM_F_PSGAINSHFT	% gain shift from library energy (Gamma-M only)
CAM_T_PSFITENGNAME	Peak fit engine name (8 characters)
CAM_T_PSBACKTYPE	Background type (1 character: S for step, L for linear)
CAM_L_PSLBACKST	Start channel of left background region
CAM_L_PSLBACKEN	End channel of left background region
CAM_L_PSRBACKST	Start channel of right background region
CAM_L_PSRBACKEN	End channel of right background region
CAM_F_PSPEAKATTN	Attenuation factor
CAM_F_PSPEAKATTNER	Error in peak attenuation
CAM_F_PSORIGEFF	Original efficiency
CAM_F_PSORIGEFFER	Error in original efficiency
CAM_F_PSRBACK	Reagent background subtracted from net area
CAM_F_PSDRBACK	Uncertainty in reagent background
CAM_F_PSACCPS	Attenuation corrected count rate (calculated by ASTM sum algorithm)
CAM_F_PSCPSERR	error in attenuated count rate (calculated by ASTM sum algorithm)
CAM_F_PSCRITLEVEL	Critical level
CAM_L_PSPFLG	Peak flags
CAM_M_PSP_KNOWN [CAM_L_PSPKNOWN]	Known peak (set by NID)
CAM_M_PSP_PFIT [CAM_L_PSPPFIT]	Peak is first of a fitted group (if a singlet is fit, then PFIT should be set and MULT should be off)
CAM_M_PSP_MULT [CAM_L_PSPMULT]	Peak is part of a multiplet

CAM_M_PSP_ENBACK [CAM_L_PSPENBACK]	Ambient background subtracted from peak area
CAM_M_PSP_MANADD [CAM_L_PSPMANADD]	Peak was manually added
CAM_M_PSP_MANDEL [CAM_L_PSPMANDEL]	Peak was manually deleted
CAM_M_PSP_MANEDIT [CAM_L_PSPMANEDIT]	Peak was manually edited
CAM_M_PSP_ABERR [CAM_L_PSPABERR]	Peak aberrations are present
CAM_M_PSP_REFPK [CAM_L_PSPREFPK]	Reference peak
CAM_M_PSP_FITROI [CAM_L_PSPFITROI]	Invalid fit region-of-interest
CAM_M_PSP_FITCONVERGE [CAM_L_PSPFITCONV]	Invalid fit convergence
CAM_M_PSP_PARANGEL [CAM_L_PSPPARANGEL]	Left limit clipped by PASTART
CAM_M_PSP_PARANGER [CAM_L_PSPPARANGER]	Right limit clipped by PAEND
CAM_M_PSP_PADONE [CAM_L_PSPPADONE]	Peak analysis has been performed
CAM_M_PSP_EFFINT [CAM_L_PSPEFFINT	Interpolated efficiency data (lung counting only)
CAM_M_PSP_VARYENG [CAM_L_PSPVARYENG]	Peak centroid was allowed to vary
CAM_M_PSP_VARYAREA [CAM_L_PSPVARYAREA]	Peak area was allowed to vary
CAM_M_PSP_VARYFWHM [CAM_L_PSPVARYFWHM]	Peak FWHM was allowed to vary
CAM_M_PSP_VARYLTAIL [CAM_L_PSPVARYLTAIL]	Peak low tail was allowed to vary
CAM_M_PSP_VARYHTAIL [CAM_L_PSPVARYHTAIL]	Peak high tail was allowed to vary
CAM_M_PSP_FROMLIBR	Peak energy came from a library

CAM_M_PSP_REAGENT [CAM_L_PSPREAGENT]	Net area was corrected for reagent background
CAM_L_PSTNIDDONE	Tentative NID performed
CAM_M_PSP_ADJPEAK [CAM_L_PSPADJPEAK]	An adjacent peak may have affected this peak's results
CAM_M_PSF_REAGENT [CAM_L_PSFREAGENT	Reagent background processed flags
CAM_M_PSP_TRACERPK [CAM_L_PSPTRACERPK]	Tracer peak? (Y/N)

User Spare Peak Search Parameters

CAM_F_PSSP1	User spare
CAM_F_PSSP2	User spare

More Peak Search

A parameter class CAM_CLS_MOREPEAK, contains the results of Tentative NID. Each record in this class corresponds with a peak record in the peak search results class, and contains the names of the nuclide associated with that peak.

Common Parameters

CAM_T_PMTNIDVERS	Tentative NID engine version (16 characters)

Record Tabular Parameters

CAM_T_PMNCLNAME	Name of nuclide associated with peak (12 characters)

Certificate Parameters

The certificate parameters block contains three common parameters, and a record for every energy line described in a standard source's calibration certificate. The symbolic name for this class is CAM_CLS_CERTIF.

Common Parameters

CAM_T_CTFNAME	Certificate title

CAM_X_CTFDATE	Certificate date
CAM_F_CTFQUANT	Certificate quantity
CAM_F_CTFECNVFAC	Certificate energy conversion factor
CAM_T_CTFEUNITS	Certificate energy units
CAM_T_CTFASTMMATRX	Matrix description (32 characters)
CAM_T_CTFASTMMATER	Material description (64 characters)
CAM_T_CTFIMAGEFILE	Name of file containing scanned image of source certificate paperwork (128 characters)

Record Parameters

CAM_T_CTFNUCL	Nuclide name
CAM_F_CTFENER	Line energy (keV)
CAM_X_CTFHLFLIFE	Half life
CAM_T_CTFHLFUNITS	Half life units
CAM_X_CTFHLFERR	Uncertainty in half life
CAM_F_CTFRATE	Emission rate (gammas or alphas/sec/unit quantity)
CAM_F_CTFERROR	% uncertainty in emission rate
CAM_F_CTFABUN	% abundance
CAM_F_CTFASTMMASS	Declared mass (grams)
CAM_F_CTFASTMMERR	Error in declared mass
CAM_L_CTFAGAUSED	AGA: this line was used by AGA
CAM_L_CTFFLAGS	Certificate parameter flags
CAM_M_CTF_NOASKINI [CAM_L_CTFNOASKINI]	CAL/INITIAL will not use this line
CAM_M_CTF_TRACER [CAM_L_CTFTRACER]	This is a tracer line (alpha spectroscopy)

Energy/FWHM Calibration Results Parameters

The calibration results block contains a common parameter which describes the calibration analysis version, and a number of records which store information about each energy/centroid channel/FWHM point which is quantified at calibration time.

Please note that the offset and coefficients of the energy and FWHM calibrations are stored in the acquisition parameters block (CAM_CLS_ACQP). Also note that the detector efficiency calibration's energy/efficiency pairs and empirical fit parameters are stored in the geometry parameters block (CAM_CLS_GEOM).

The symbolic name for this parameter block is CAM_CLS_CALRESULTS.

Common Parameters

CAM_T_CALVERS	Calibrate version/ID (16 characters)
CAM_T_ECOPNAME	Operator for last energy calibration (24 characters)
CAM_L_CURRPEAK	Current peak record of interest

Record Parameters

CAM_F_CALENERGY	Calibration energy
CAM_F_CALCENTROID	Computed centroid
CAM_F_CALCENTERR	Uncertainty in centroid
CAM_F_CALFWHM	Computed FWHM
CAM_L_CALFLAGS	Energy calibration flags field
CAM_M_ERF_POORFIT [CAM_L_ERFPOORFIT]	Poor fit during energy calibration? (Y/N)
CAM_M_ERF_511PEAK [CAM_L_ERF511PEAK]	511 keV peak? (Y/N)
CAM_M_ERF_REFPEAK [CAM_L_ERFREFPEAK]	Reference peak? (Y/N)

Shape Calibration Results Parameters

The shape calibration results block contains a common parameter which describes the shape calibration analysis version, and a number of records which store information about each energy/FWHM/tail point which is quantified at calibration time.

Please note that the offset and coefficients of the FWHM and tail calibrations are stored in the acquisition parameters block (CAM_CLS_ACQP). Also note that the detector efficiency calibration's energy/efficiency pairs and empirical fit parameters are stored in the geometry parameters block (CAM_CLS_GEOM).

The symbolic name for this parameter block is CAM_CLS_SHAPECALRES.

Common Parameters

CAM_T_SCALVERS	Calibrate version/ID (16 characters)
CAM_T_SCOPNAME	Operator for last shape calibration (24 characters)

Record Parameters

CAM_F_SCENERGY	Shape calibration energy
CAM_L_SCSTART	ROI start channel
CAM_L_SCEND	ROI end channel
CAM_F_SCFWHM	Computed FWHM
CAM_F_SCFWHMERR	Uncertainty in FWHM
CAM_F_SCTAIL1	Computed low energy tail
CAM_F_SCTAIL1ERR	Uncertainty in low energy tail
CAM_F_SCTAIL2	Computed additional tail
CAM_F_SCTAIL2ERR	Uncertainty in additional tail
CAM_L_SCFLAGS	Shape calibration flags field
CAM_M_SCF_POORFIT [CAM_L_SCFPOORFIT]	Poor fit during shape calibration? (Y/N)
CAM_M_SCF_511PEAK [CAM_L_SCF511PEAK]	511 keV peak? (Y/N)

CAM_M_SCF_REFPEAK [CAM_L_SCFREFPEAK]	Reference peak? (Y/N)

Nuclide Library and Results

The same format is used for nuclide libraries and results. The nuclide identification process fills in information in the nuclide library. There are actually two classes of information associated with nuclide libraries and results: nuclides, and lines. There can be three types of the nuclide information class: Standard Nuclide Identification (NID), Neutron Activation Analysis (NAA), and Whole Body Counting (WBC). There can be two types of the energy line information class: NID/WBC, or NAA.

The fact that the nuclides and lines are associated by nuclide and line numbers (rather than names and energies) speeds access but requires that when nuclides or lines are deleted or inserted by the nuclide editor, the editor scans all the entries in the other class and correct the associated entry numbers. For this reason, it is strongly recommended that records *not* be added or deleted by user programs.

The symbolic definitions for these classes are CAM_CLS_NUCL and CAM_CLS_NLINES.

Nuclide Common Parameters

CAM_T_NCLTITLE	Title of nuclide library (64 characters)
CAM_L_NIDFLAGS	NID processing flags
CAM_M_NIDF_NID [CAM_L_NIDFNID]	Nuclide identification done
CAM_M_NIDF_MDA [CAM_L_NIDFMDA]	Detection limits computed
CAM_M_NIDF_INTERF [CAM_L_NIDFINTERF]	Interference correction done
CAM_M_NIDF_WTMEAN [CAM_L_NIDFWTMEAN]	Weighted mean done
CAM_M_NIDF_NFLUX	FLUX done
CAM_M_NIDF_NAA	NAA done
CAM_M_NIDF_SETABUN	NAA set abundance to 100% done
CAM_M_NIDF_WBCDOSE	WBCDOSE done

CAM_M_NIDF_EBAR [CAM_L_NIDFEBAR]	E-bar done
CAM_M_NIDF_PMTORSO	%MPOB based on lower torso MPOB
CAM_M_NIDF_PMLUNGS	%MPOB based on lung MPOB
CAM_M_NIDF_WBCICRP30	ICRP30 done
CAM_M_NIDF_VARDTCORR [CAM_L_NIDFVARDT]	Variable dead time correction done
CAM_M_NIDF_PROPAGATE	(Not currently used)
CAM_M_NIDF_NIDCOMB [CAM_L_NIDFNIDCOMB]	NID Combiner done
CAM_M_NIDF_MGANID [CAM_L_NIDFMGANID]	Best of MGA/NID done
CAM_M_NIDF_CRECOV [CAM_L_NIDFCRECOVDN]	Chemical recovery analysis done
CAM_M_NIDF_MGANIDP [CAM_L_NIDFMGANIDP]	MGA/NID combiner performed combination
CAM_M_NIDF_ASTMMASS [CAM_L_ASTMMASSDONE]	ASTM Mass calculation done
CAM_M_NIDF_ACTADJ [CAM_L_NIDFACTADJ]	Flag indicating activity correction performed
CAM_M_NIDF_ACTLVL [CAM_L_NIDFACTLVL]	Flag indicating action level calculation performed
CAM_M_NIDF_LV1CONC [CAM_L_NIDLEVEL1CON]	Level 1 activity/concentration flag
CAM_M_NIDF_LV2CONC [CAM_L_NIDLEVEL2CON]	Level 2 activity/concentration flag
CAM_M_NIDF_CSCDONE [CAM_L_NIDFCSCDONE]	Cascade summing corrector done
CAM_M_NIDF_PDCDONE [CAM_L_NIDFPDCDONE]	Parent-daughter correction performed
CAM_M_NCLF_ACT1ALRM1 [CAM_L_NCLACT1ALRM1]	Action level 1 alarm 1 triggered
CAM_M_NCLF_ACT1ALRM2 [CAM_L_NCLACT1ALRM2]	Action level 1 alarm 2 triggered

CAM_M_NCLF_ACT2ALRM1 [CAM_L_NCLACT2ALRM1]	Action level 2 alarm 1 triggered
CAM_M_NCLF_ACT2ALRM2 [CAM_L_NCLACT2ALRM2]	Action level 2 alarm 2 triggered
CAM_L_NIDFLACE	Flag specifying whether LACE was processed on this file
CAM_L_NLAGAUSED	AGA: this line was used by AGA
CAM_T_NIDVERS	NID version (16 characters)
CAM_T_MDAVERS	MDA version (16 characters)
CAM_T_INTERFVERS	INTERF version (16 characters)
CAM_T_WTMEANVERS	WTMEAN version (16 characters)
CAM_T_MGANIDVERSN	Best of MGA/NID versionn (16 characters)
CAM_T_NIDCOMBVERSN	NID Combiner version (16 characters)
CAM_T_NCLCSCVRS	Cascade summing corrector version (16 characters)
CAM_T_NCLPDCVERS	Parent-daughter correction algorithm version (16 characters)
CAM_L_LIBFLAGS	Nuclide library flags field
CAM_M_LIBF_NOSORT [CAM_L_LIBFNOSORT]	Nuclide library is not sorted
CAM_T_NCLMPCLAB*n*	MPC report label *n* (16 characters), where *n* is 1 to 8
CAM_T_NCLMPC*n*AU	MPC-*n* activity units (8 characters), where *n* is 1 to 8
CAM_T_NCLMPC*n*QU	MPC-*n* sample quantity units (8 characters), where *n* is 1 to 8
CAM_F_NCLMPC*n*QCF	MPC-*n* sample quantity conversion factor, where *n* is 1 to 8

CAM_L_NCLMPCFLAGS	MPC flags field. The flags in NCLMPCFLAGS are available as individual parameters
CAM_L_NCLMPCSQF*n*	Non-standard quantity units for MPC-*n*, where *n* is 1 to 8
CAM_L_NCLPT20SQF	Non-standard quantity units for 10CFR20 concentration
CAM_F_DEQACTI	Dose equivalent iodine (µci/unit)
CAM_F_DEQACTXE	Dose equivalent xenon (µci/unit)
CAM_T_ACTADJVERS	Activity correction engine version (16 characters)
CAM_T_ACTLVLVERS	Action level engine version (16 characters)
CAM_L_NCLPUNKNOWN	Number of unidentified/unused peak search results
CAM_G_NCLSUMACT	Sum of activities (µCi)
CAM_F_NCLLEV1SUM	Sum of relative level 1 values
CAM_F_NCLLEV2SUM	Sum of relative level 2 values
CAM_F_NCLLEV1UCONV	Level 1 unit conversion value
CAM_F_NCLLEV2UCONV	Level 2 unit conversion value
CAM_T_NCLLEV1UNITS	Level 1 units (8 characters)
CAM_T_NCLLEV2UNITS	Level 2 units (8 characters)
CAM_L_NUMFOUND	Total number of nuclides identified
CAM_L_ASTMMASSANAE	Error code from ASTM mass calculation engine
CAM_F_NCLCTRLRECOV	Recovery (absolute value) of control
CAM_T_NCLCONTROLDS	Control sample description (32 characters)
CAM_L_NCLSABSCE	Error code from last self-absorption calculation
CAM_T_LACEVERS	LACE Version string, stores current version of LACE

Record parameter (per nuclide)

CAM_F_NCLOSRELDIF	% difference (between original sample and duplicate)
CAM_X_NCLCOOLDATE	Worst case cool down date (calculated by action level engine)

NAA-Specific Common Parameters

CAM_T_NFLUXVERS	NFLUX version
CAM_T_NAAVERS	NAA version
CAM_F_ELTNFLUX	Thermal neutron flux
CAM_F_ELENFLUX	Epithermal neutron flux
CAM_F_ELFNFLUX	Fast neutron flux
CAM_X_ELIRTIME	Irradiation duration
CAM_T_ELSUNITS	Sample units
CAM_X_ELSTIME	Irradiation date-time
CAM_X_ELSDATE	Synonymous with CAM_X_ELSTIME

WBC Counting Common Parameters

CAM_T_WBCDVERS	WBC Dose version (16 characters)

Record Parameters (All Applications)

CAM_T_NCLNAME	Nuclide name (8 characters; 12 for NAA)
CAM_T_NCLPARENT	Name of parent nuclide (8 characters)
CAM_T_NCLDAUGHT	Name of daughter nuclide (8 characters)
CAM_F_NCLPARENTRAT	Parent-to-daughter decay ratio
CAM_F_NCLPARENTRER	Uncertainty in parent-to-daughter ratio
CAM_T_NCLSBHDR	Nuclide type (16 characters; 12 for NAA)
CAM_X_NCLHLFLIFE	Half life
CAM_X_NCLHLFERR	Half life uncertainty

CAM_T_NCLHLFUNITS	Half life report units (2 characters; Y, D, M or S)
CAM_F_NCLMPC	Maximum permissible concentration 1
CAM_F_NCLMPC*n*	Maximum permissible concentration *n*, where *n* is 2 to 8
CAM_F_NCLDACD	DAC – clearence day (µCi/ml)
CAM_F_NCLDACW	DAC – clearence week (µCi/ml)
CAM_F_NCLDACY	DAC – clearence year (µCi/ml)
CAM_T_NCLDACTYPE	DAC type to be used (D/W/Y)
CAM_F_NCLBETA	Average beta energy (MeV/dis)
CAM_F_NCLGAMMA	Average gamma energy (MeV/dis)
CAM_F_NCLMAC	Mass absorption coefficient
CAM_F_NCLATMMASS	Atomic mass
CAM_G_NCLMDA	MDA (µCi/unit)
CAM_F_NCLMDAERR	Error in MDA
CAM_F_MDABKGND	Background calculated by MDA
CAM_F_NCLABNLIM	Nuclide dependent abundance limit (%)
CAM_F_NCLAFRAC	Percent of total abundance
CAM_G_NCLDECAY	Activity decay factor (= 1.0)
CAM_F_NCLDECAYERR	Relative error in decay factor
CAM_G_NCLWTMEAN	Weighted mean activity
CAM_G_NCLWTMERR	Error in WTM activity
CAM_G_NCLORGWTM	Original weighted mean activity (NCLWTMEAN may be adjusted by activity correction engines)
CAM_G_NCLORGWTMER	Error in original weighted mean activity
CAM_F_NCLCONFID	Computed confidence index
CAM_F_NCLEQUFAC	Nuclide equivalence factor
CAM_G_NCLSUMACT	Sum of activities (for EBAR)

CAM_F_NCLSUMACTERF	Fractional error in NCLSUMACT
CAM_L_NCLKEY	Entry number of key line
CAM_F_NCLMRL	Minimum reporting level (µCi)
CAM_F_NCLERRREJ	% error rejection level
CAM_F_NCLMDAENG	Energy used for MDA computation
CAM_F_NCLECAD	Effluent concentration air days (µCi/cc)
CAM_F_NCLECAW	Effluent concentration air weeks (µCi/cc)
CAM_F_NCLECAY	Effluent concentration air years (µCi/cc)
CAM_T_NCLECATYPE	Effluent concentration air type (1 character: is D, W, or Y for days, weeks, or years)
CAM_F_NCLECWD	Effluent concentration water days (µCi/cc)
CAM_F_NCLECWW	Effluent concentration water weeks (µCi/cc)
CAM_F_NCLECWY	Effluent concentration water years (µCi/cc)
CAM_T_NCLECWTYPE	Effluent concentration water type (1 character: is D, W, or Y for days, weeks, or years)
CAM_F_NCLRSD	Release to sewers days (µCi/cc)
CAM_F_NCLRSW	Release to sewers weeks (µCi/cc)
CAM_F_NCLRSY	Release to sewers years (µCi/cc)
CAM_T_NCLRSTYPE	Release to sewers type (1 character: is D, W, or Y for days, weeks, or years)
CAM_T_NCLPT20AU	Activity units string for 10CFR20 concentrations (8 characters)
CAM_T_NCLPT20QU	Quantity units string for 10CFR20 concentrations (8 character)
CAM_F_NCLPT20QCF	10CFR20 quantity units conversion factor (used only if the “non-standard quantity units” flag is set)
CAM_T_NCLRESSRC	Source of nuclide results (4 characters); used only in gamma waste assay applications
CAM_F_NCLSPECACT	Activity to mass conversion factor (g/µCi)
CAM_F_NCLRPTLEV	Reporting level (activity/unit)

CAM_F_NCLMETMDA	MDA to be met (activity/unit)
CAM_X_NCLCOOLDATEN	Cool down date (calculated by action level engine)
CAM_L_NCLFLAGS	Nuclide flags
CAM_M_NCLF_FDECAY [CAM_L_NCLFFDECAY]	Nuclide failed decay test
CAM_M_NCLF_FABUN [CAM_L_NCLFFABUN]	Nuclide failed abundance test
CAM_M_NCLF_IDENT [CAM_L_NCLFIDENT]	Nuclide identified by NID
CAM_M_NCLF_MDA [CAM_L_NCLFMDA]	Detection limit computed. (Note: this flag being set does not imply that the nuclide was not identified; check the IDENT flag!)
CAM_M_NCLF_KEYOUT [CAM_L_NCLFKEYOUT]	Key-line is outside spectral area
CAM_M_NCLF_SHORTHL [CAM_L_NCLFSHORTHL]	Half life is too short for MDA calculation
CAM_M_NCLF_INTFREJ [CAM_L_NCLFINTFREJ]	Nuclide rejected by interference abundance test. (Note: This flag is set after an energy line is rejected by interference which as a result forces the nuclide to fail the nuclide abundance test. Setting this flag also implies that the NCLF_FABUN flag is set and the NCLF_IDENT flag is cleared.)
CAM_M_NCLF_FWTMEAN [CAM_L_NCLFWTMEAN]	Nuclide failed weighted mean test. (Note: This flag is set when all energy lines of a nuclide are rejected *and* the key-line was not identified by NID. An energy line is rejected if it was not identified by NID, was rejected by an interference engine, was rejected by weighted mean because of an interference *or* was rejected by weighted mean because it failed the n-sigma test. Setting this flag also implies that the NCLF_IDENT flag is cleared.)
CAM_M_NCLF_NOAUTO [CAM_L_NCLFNOAUTO]	No automatic act/MDA transfer (SADS only)

CAM_M_NCLF_NORPTMDA [CAM_L_NCLFNORPTMDA]	Don't report an MDA (NID only)
CAM_M_NCLF_SUBHEAD	[Not currently used]
CAM_M_NCLF_FLUX	Use absolute or FLUX method to compute concentration (NAA only)
CAM_M_NCLF_RPTMDA	Report an MDA (WBC only)
CAM_M_NCLF_MREJECT [CAM_L_NCLFMREJECT]	Nuclide was manually rejected
CAM_M_NCLF_MACCEPT [CAM_L_NCLFMACCEPT]	Nuclide was manually accepted
CAM_M_NCLF_MEDIT [CAM_L_NCLFMEDIT]	Nuclide was manually edited
CAM_M_NCLF_VARDTCORR [CAM_L_NCLFVARDT]	Nuclide was variable dead time corrected
CAM_M_NCLF_NOEBAR [CAM_L_NCLFNOEBAR]	Don't use in E-bar calculation
CAM_M_NCLF_EBAR [CAM_L_NCLFEBAR]	An E-bar has been computed
CAM_M_NCLF_UNRESINT [CAM_L_NCLFUNRESINT]	Nuclide contains an unresolved interference
CAM_M_NCLF_ERRREJ [CAM_L_NCLFERRREJ]	Nuclide was rejected by % error test
CAM_M_NCLF_MRLREJ [CAM_L_NCLFMRLREJ]	Nuclide was rejected by minimum reporting level test
CAM_M_NCLF_SABSDONE [CAM_L_NCLSABSDONE]	Self-absorption correction done for this nuclide
CAM_M_NCLF_PDCORRDN [CAM_L_NCLFPDCORRDN]	Parent-daughter correction has been applied to this nuclide
CAM_M_NCLF_NCLFUSETRU [CAM_L_NCLFUSETRU]	Include this nuclide in TRU activity calculation
CAM_M_NCLF_USETAA [CAM_L_NCLFUSETAA]	Include this nuclide in total alpha activity calculation
CAM_M_NCLF_WIPP [CAM_L_NCLFWIPP]	This nuclide is of interest to TMU

CAM_M_NCLF_USEASFID [CAM_L_NCLFUSEASFID]	This is the fiducial nuclide for gamma TMU
CAM_M_NCLF_USEISO [CAM_L_NCLFUSEISO]	Use isotopic ratios to calculate TMU activity for this nuclide
CAM_M_NCLF_LACED [CAM_L_NCLLCPROC]	LACE has processed this nuclide
CAM_L_NCLLCKEYREJ	LACE rejected nuclide for key-line processing
CAM_L_NCLLCSINGREJ	LACE rejected nuclide due to single line criteria
CAM_L_NCLFHAZNUCL	This nuclide contributes to 95% of total activity; this flag is set by the Gamma TMU engine

CAM_L_NCLFLAGS2	More nuclide flags
CAM_M_NCLF2_PT20DAYS [CAM_L_NCLPT20DAYS]	Report DAC Days values
CAM_M_NCLF2_PT20WEEKS [CAM_L_NCLPT20WEEKS]	Report DAC Weeks values
CAM_M_NCLF2_PT20YEARS [CAM_L_NCLPT20YEARS]	Report DAC Years values
CAM_M_NCLF2_PT20EAD [CAM_L_NCLPT20EAD]	Report Effluent Air Days values
CAM_M_NCLF2_PT20EAW [CAM_L_NCLPT20EAW]	Report Effluent Air Weeks values
CAM_M_NCLF2_PT20EAY [CAM_L_NCLPT20EAY]	Report Effluent Air Years values
CAM_M_NCLF2_PT20EWD [CAM_L_NCLPT20EWD]	Report Effluent Water Days values
CAM_M_NCLF2_PT20EWW [CAM_L_NCLPT20EWW]	Report Effluent Water Weeks values
CAM_M_NCLF2_PT20EWY [CAM_L_NCLPT20EWY]	Report Effluent Water Years values
CAM_M_NCLF2_PT20RSD [CAM_L_NCLPT20RSD]	Report Sewers Days values

CAM_M_NCLF2_PT20RSW [CAM_L_NCLPT20RSW]	Report Sewers Weeks values
CAM_M_NCLF2_PT20RSY [CAM_L_NCLPT20RSY]	Report Sewers Years values

CAM_T_NCLGRPNAME	Group Name (8 characters)
CAM_F_NCLLEVEL1	Calculated level 1
CAM_F_NCLLEVEL2	Calculated level 2
CAM_F_NCLACTLEVEL1	Action level 1 value
CAM_F_NCLACTLEVEL2	Action level 2 value
CAM_F_NCLADJFAC*n*	Activity correction factor number *n*, where *n* is 1 to 3
CAM_F_NCLERRADJ	Error adjustment factor
CAM_T_NCLOBSERVED	Name of observed nuclide
CAM_G_NCLNSAWTM	Weighted mean activity before self-absorption correction
CAM_G_NCLNSAWTME	Error on weighted mean activity before self-absorption correction
CAM_L_SABSNPKFIT	Number of peaks used in fit
CAM_F_NCLSABSBETA	Fit parameter beta
CAM_F_NCLSABSBETAE	Error on beta
CAM_F_NCLSABSALPHA	Fit parameter alpha
CAM_F_NCLSABSALPHE	Error on alpha
CAM_F_NCLPEFAC	^{239}Pu equivalent activity factor (converts nuclide activity to ^{239}Pu equivalent activity)
CAM_F_NCLFGEFAC	Fissile gram equivalent factor (converts nuclide mass to ^{239}Pu FGE)
CAM_F_NCLSPECPWR	Specific power (watts/gram)
CAM_F_NCLDOTADJFAC	DOT hazard level factor; see 49CFR173.435
CAM_F_NCLLCKEYOFF	Key Line equation, offset (a_0)
CAM_F_NCLLCKEYOFFE	Key Line equation, offset uncertainty

CAM_F_NCLLCKEYSLO	Key Line equation, first order coefficient - slope (a_1)
CAM_F_NCLLCKEYSLOE	Key Line equation, uncertainty in slope
CAM_F_NCLLCWMOFF	Weighted Mean equation, offset (a_0)
CAM_F_NCLLCWMOFFE	Weighted Mean equation, offset uncertainty
CAM_F_NCLLCWMSLO	Weighted Mean equation, first order coefficient - slope (a_1)
CAM_F_NCLLCWMSLOE	Weighted Mean equation, uncertainty in slope

User Spare Nuclide Parameters

CAM_F_NCLSP*n*	User spare floating value *n*, where *n* is 1 to 6

NAA-Specific Nuclide Parameters

CAM_F_NCLATMWGT	Atomic weight (Note: this parameter is a duplicate of NCLATMMASS)
CAM_F_NCLCRSEC	Cross section 1 (barns)
CAM_F_NCLCRSEC1	Cross section 2 (barns)
CAM_F_NCLCRSEC2	Cross section 3 (barns)
CAM_T_NCLFLUX	Cross section 1 type (T, E or F)
CAM_T_NCLFLUX1	Cross section 2 type (T, E or F)
CAM_T_NCLFLUX2	Cross section 3 type (T, E or F)
CAM_F_NCLCONC	Concentration
CAM_F_NCLCONCERR	Uncertainty in concentration
CAM_T_NCLCONCUNITS	Concentration units
CAM_F_NCLPFRAC	Parent abundance fraction
CAM_L_NCLFFLUX	Use FLUX method to compute concentration

WBC Nuclide Parameters

ICRP2 Parameters

CAM_L_NCLRPTMDA	List MDA on LONG report
CAM_X_NCLHLEFFTH	Thyroid effective half-life

CAM_X_NCLHLEFFLU	Lungs effective half-life
CAM_X_NCLHLEFFLT	Torso effective half-life
CAM_X_NCLHLEFFWB	Whole body effective half-life
CAM_X_NCLHLEFFCO	Critical organ effective half-life
CAM_T_NCLHLUNTH	Thyroid half-life report units
CAM_T_NCLHLUNLU	Lungs half-life report units
CAM_T_NCLHLUNLT	Torso half-life report units
CAM_T_NCLHLUNWB	Whole body half-life report units
CAM_T_NCLHLUNCO	Critical organ half-life report units
CAM_F_NCLMPBTH	Thyroid max permissible burden (Bq)
CAM_F_NCLMPBLU	Lungs max permissible burden (Bq)
CAM_F_NCLMPBLT	Torso max permissible burden (Bq)
CAM_F_NCLMPBWB	Whole body max permissible burden (Bq)
CAM_F_NCLAVGSTH	Thyroid average S′ (rem/µCi-day)
CAM_F_NCLAVGSLU	Lungs average S′ (rem/µCi-day)
CAM_F_NCLAVGSLT	Torso average S′ rem/µCi-day)
CAM_F_NCLAVGQ50TH	Thyroid average Q50 (µCi-day/µCi)
CAM_F_NCLAVGQ50LU	Lungs average Q50 (µCi-day/µCi)
CAM_F_NCLAVGQ50LT	Torso average Q50 (µCi-day/µCi)
CAM_F_NCLFRUPTH	Thyroid fractional uptake
CAM_F_NCLFRUPLU	Lungs fractional uptake
CAM_F_NCLFRUPLT	Torso fractional uptake
CAM_F_NCLFRUPWB	Whole body fractional uptake
CAM_F_NCLADLMTTH	Thyroid administrative limit in %
CAM_F_NCLADLMTLU	Lungs administrative limit in %
CAM_F_NCLADLMTLT	Torso administrative limit in %
CAM_F_NCLADLMTWB	Whole body administrative limit in %

CAM_F_NCLINPOWARN1	INPO activity warning level 1 (µCi)
CAM_F_NCLINPOWARN2	INPO activity warning level 2 (µCi)
CAM_F_NCLOBMPBTH	Thyroid calculated % MPB
CAM_F_NCLOBMPBLU	Lungs calculated % MPB
CAM_F_NCLOBMPBLT	Torso calculated % MPB
CAM_F_NCLMPCHRTH	Thyroid calculated MPC-Hr
CAM_F_NCLMPCHRLU	Lungs calculated MPC-Hr
CAM_F_NCLMPCHRLT	Torso calculated MPC-Hr
CAM_F_NCLD50TH	Thyroid 50-year dose commitment (rem)
CAM_F_NCLD50LU	Lungs 50-year dose commitment (rem)
CAM_F_NCLD50LT	Torso 50-year dose commitment (rem)
CAM_F_NCLICRP2F2	ICRP-2 F2 value
CAM_F_NCLEFAEPD	Effective absorbed energy/disintegration (MeV)
CAM_F_NCLORGMASS	Critical organ mass (grams)
CAM_T_NCLORGNAME	Critical organ name (16 characters)

ICRP30 Parameters

CAM_T_NCLSOLCLASS	Solubility class (D, W or Y)
CAM_F_NCLALI	Annual limit on intake (Bq)
CAM_F_NCLINTAKE	Computed intake (µCi)
CAM_F_NCLRATE1	A11 to A12 transfer rate (/day)
CAM_F_NCLRATE2	A15 to A19 transfer rate (/day)
CAM_F_NCLRATE3	A16 to A19 transfer rate (/day)
CAM_F_NCLRATE4	A17 to A19 transfer rate (/day)
CAM_F_NCLRATE5	A18 to A19 transfer rate (/day)
CAM_F_NCLRATE6	A12 to A15 transfer rate (/day)
CAM_F_NCLRATE7	A12 to A16 transfer rate (/day)
CAM_F_NCLRATE8	A12 to A17 transfer rate (/day)

CAM_F_NCLRATE9	A12 to A18 transfer rate (/day)
CAM_L_NCLINTDET	[Not currently used]
CAM_F_NCLDAC	Derived air concentration (Bq/m^3)
CAM_F_NCLCDE	Committed dose equivalent (Sv/Bq-Intake)
CAM_F_NCLWCDE	Weighted committed dose equivalent (Sv/Bq-Intake)

Record Tabular Entry Parameters

CAM_L_NCLLINE	Line number associated with nuclide

Energy Line Parameters

Common Parameters

CAM_T_NLECUNITS	Library energy units
CAM_F_NLECCNVFAC	Library energy conversion factor

Record Parameters

CAM_F_NLENERGY	Line energy
CAM_F_NLENGERR	Uncertainty in energy
CAM_F_NLABUN	Percent abundance
CAM_F_NLABUNERR	Error in abundance
CAM_L_NLPEAK	Peak number for this line[5]
CAM_G_NLACTVTY	Decay corrected activity in µCi/unit
CAM_G_NLERR	Error estimate (in µCi/unit)
CAM_F_NLEFFICIENCY	Efficiency at line energy
CAM_F_NLEFFERR	Error in efficiency
CAM_G_NLMDA	Minimum detectable activity
CAM_G_NLMDAERR	Error in MDA
CAM_F_NLMDABKGND	MDA background

5. If the parameter CAM_L__NLPEAK_ has a non-zero value, then the energy line has been positively identified.

CAM_G_NLDETLIMIT	Detection limit (LD)
CAM_L_NLNUCL	Nuclide number associated with this line
CAM_F_NLMDABKGNDER	Error in background counts (NLMDABKGND)
CAM_F_NLMDANET	Net counts in the region
CAM_F_NLMDANETERR	Error in net counts
CAM_F_NLMDADECLVL	Decision level (in counts)
CAM_L_NLMDALREGST	Start channel of the left background region
CAM_L_NLMDALREGEND	End channel of the left background region
CAM_L_NLMDARREGST	Start channel of the right background region
CAM_L_NLMDARREGEND	End channel of the right background region
CAM_F_NLCOICF	Coincidence summing correction factor
CAM_F_NLDCOICF	Uncertainty in summing correction factor
CAM_F_NLLCWMRAT	LACE output: ratio of line activity to nuclide weighted mean activity
CAM_F_NLLCWMRATERR	LACE output: uncertainty in ratio of line activity to nuclide weighted mean activity
CAM_F_NLLCKLRAT	LACE output: ratio of line activity to nuclide key line activity
CAM_F_NLLCKLRATERR	LACE output: uncertainty in ratio of line activity to nuclide key line activity
CAM_L_NLFLAGS	Energy line parameter flags
CAM_M_NLF_PHOTO [CAM_L_NLFPHOTO]	This is a photopeak
CAM_M_NLF_KEYLINE [CAM_L_NLFKEYLINE]	This is the key line
CAM_M_NLF_ACCSUM [CAM_L_NLFACCSUM]	This is an accidental sum line
CAM_M_NLF_COINSUM [CAM_L_NLFCOINSUM]	This is a coincident sum line

CAM_M_NLF_BACKGND [CAM_L_NLFBACKGND]	This is a background line
CAM_M_NLF_BCKSCTR [CAM_L_NLFBACKSCTR]	This is a backscatter line
CAM_M_NLF_COMPTON [CAM_L_NLFCOMPTON]	This is a Compton edge
CAM_M_NLF_SESC [CAM_L_NLFSESC]	This is a single escape line
CAM_M_NLF_DESC [CAM_L_NLFDESC]	This is a double escape line
CAM_M_NLF_FWTMEAN [CAM_L_NLFWTMEAN]	Line rejected by weighted mean n-sigma test
CAM_M_NLF_WTMINTREJ	Line rejected by weighted mean interference test
CAM_M_NLF_FINTERF [CAM_L_NLFFINTERF]	Line rejected by interference test. (Note: for interfering nuclides this means that the interference correction was made to the interfered line and, therefore, this line has no more statisical information for the interfering nuclide. For interfered nuclides, this means that when the correction was made the resulting area was less than 0.0 (or the critical level if the critical level test is being done), so the line is rejected.)
CAM_M_NLF_ELOUT	Energy line is outside spectral area
CAM_M_NLF_MDA	MDA value calculated
CAM_M_NLF_OUTOFRNG	Energy line not within peak search energy range
CAM_M_NLF_USEBCK [CAM_L_NLFUSEBCK]	Forced MDA was calculated using background counts
CAM_M_NLF_COIAPPLIED [CAM_L_NLCOIAPP]	Coincidence summing applied to this line
CAM_M_NLF_COINOTINVLVD [CAM_L_NLCOINOTI]	Not involved in cascade
CAM_M_NLF_NOUSEWTM [CAM_L_NLFNOUSEWTM]	Don’t use this line in weighted mean calculation

CAM_M_NLF_LACED [CAM_L_NLFLACED]	LACE has processed this line

User Spare Energy Line Parameters

CAM_F_NLSP1	User spare

NAA Specific Energy Line Parameters

Standards

CAM_F_NLCONST	NAA “constant”
CAM_F_NLCONSTERR	Uncertainty in NAA “constant”
CAM_F_NLSUMWGTDATA	Sum of weighted constants
CAM_F_NLSUMWGTS	Sum of weights

Samples or Unknowns

CAM_F_NLCONC	Computed Concentration
CAM_F_NLCONCERR	Uncertainty in concentration
CAM_T_NLCONCUNITS	Concentration units (4 characters)

Interfering Nuclide List Parameters

The interfering nuclide list parameter block contains a record for every pair of nuclides which potentially interfere with each other. The symbolic name for this class is CAM_CLS_INTERF.

Record Parameters

CAM_T_INTERFRED	Interfered nuclide name (8 characters)
CAM_T_INTERFRING	Interfering nuclide name (8 characters)

Interference Specific Parameters

CAM_F_INTERFCP	Energy of clean peak
CAM_F_INTERFIP	Energy of interfered peak
CAM_F_INTERFRAT	Interfered/clean peak ratio

CAM_F_INTERFRATERR	Absolute error in ratio

Interfering Nuclide Results Parameters

The interfering nuclide results parameter block contains a record for every pair of nuclides which interfere with each other. The symbolic name for this class is CAM_CLS_INTRES.

Record Parameters

CAM_T_INTREDN	Interfered nuclide name (8 characters)
CAM_F_INTREDL	Energy of interfered peak
CAM_T_INTRINGN	Interfering nuclide name (8 characters)
CAM_F_INTRINGL	Energy of interfering peak
CAM_L_INTRFLAGS	Interference flags [No flags currently used]

NAA Run Descriptor Parameters

The run descriptor parameter block contains three common parameters, and a record for each sample. The symbolic name for this class is CAM_CLS_NAARDF.

Common Parameters

CAM_T_RDFSUNITS	Sample units (16 characters)
CAM_T_RDFUNKNL	Unknown element library (32 characters)
CAM_X_RDFSDATE	Sample date
CAM_F_RDFTNFLUX	Thermal neutron flux (neutrons/cm^2/sec)
CAM_F_RDFENFLUX	Epithermal neutron flux (neutrons/cm^2/sec)
CAM_F_RDFFNFLUX	Fast neutron flux (neutrons/cm^2/sec)
CAM_F_RDFIRTIME	Irradiation duration

Record Parameters

CAM_T_RDFSTYPE	Sample type: Standard or Unknown (1 character)

CAM_T_RDFCNFNAME	Data configuration name (32 characters)
CAM_T_RDFNLIBNAME	Element library name (32 characters)
CAM_T_RDFILIBNAME	Interference library name (32 characters)
CAM_T_RDFSIDENT	Sample identification (16 characters)
CAM_T_RDFSTITLE	Sample title (64 characters)
CAM_F_RDFSQUANT	Sample quantity
CAM_X_RDFRSDATE	Sample date
CAM_X_RDFRIRTIME	Irradiation duration
CAM_L_RDFGRPNUM	Unknown sample group number
CAM_T_RDFUSRSTR1	User spare string number 1 (8 characters)

NaI (Alpha-M) Standard File Parameters

The run descriptor parameter block contains three common parameters, and a record for each standard. The symbolic name for this class is CAM_CLS_NAISTD.

Common Parameters

CAM_T_SFEBACK	Background configuration name (32 characters)
CAM_T_SFEACTUNITS	Units of activity in standards file (16 characters)
CAM_F_SFEACTMULT	Units to μCi conversion factor

Record Parameters

CAM_T_SFENUCLIDE	Standard nuclide name (8 characters)
CAM_T_SFECONFIG	Standard configuration name (32 characters)
CAM_X_SFEHLFLIFE	Half-Life of standard nuclide
CAM_T_SFEHLFUNITS	Half-Life units (8 characters)
CAM_G_SFEACTVTY	Activity of standard (SFEACTUNITS)
CAM_X_SFEDATE	Activity reference date

Scanning WBC Setup Parameters

The scanning whole body counting setup parameter block contains all of the parameters necessary to setup the motor/controller used for a scanning WBC application. All parameters in this block are common parameters. The symbolic name for this class is CAM_CLS_SCANWBC.

Common Parameters

CAM_T_SWBCSERPORT	Serial port connected to controller (16 Characters)
CAM_T_SWBCCTLR	Controller type: Modulynx or Slo-Syn (16 Characters)
CAM_T_SWBCTYPE	Type of whole body counter: Standup or Bed (16 characters)
CAM_F_SWBCLENGTH	Total scan length (in.)
CAM_F_SWBCPULINCH	Pulses/inch
CAM_F_SWBCSTRTSPD	Starting speed (in./sec)
CAM_F_SWBCACCEL	Acceleration (in./sec/sec)
CAM_F_SWBCHOMESPD	Home speed (in./sec)
CAM_F_SWBCMAXSPD	Maximum speed (in./sec)
CAM_F_SWBCHOME	Home position (in.)
CAM_F_SWBCINMCS	Inches/MCS channel
CAM_F_SWBCMANSPD	Manual operation speed: Slo-Syn only (in./sec)
CAM_L_SWBCDIR	Direction of scan (+1 / -1)

Security Parameters

The security parameters block contains a record for each user account against which access controls are to be applied. The use of this block is very application specific. The symbolic name for this class is CAM_CLS_SECURITY.

Record Parameters

CAM_T_SECENTNAME	Name or Initials to be entered (16 characters)

CAM_T_SECFULLNAME	Name or Initials to be transferred (24 characters)
CAM_T_SECPASSWORD	Password (16 characters)
CAM_L_SECMASK	Security bit mask
CAM_L_SECBIT*n*	Security mask bit *n*, where *n* is 0 to 26
CAM_L_SECLEVEL	Security level (Genie 2000/Genie-PC only)
CAM_M_SEC_BIT*n*	Security bit *n*, where *n* is 0 to 26

Analysis Control Parameters

The analysis control parameter block contains parameters which can be used in command procedures (such as PROcount or ABACOS-PLUS) to control the analysis flow for an application. The parameters include the "type" of analysis to be performed, the nuclide library to be used for nuclide analysis, the destination of hard-copy reports, etc.

This block may also define a sequence of analyses and reports to be executed. The sequence, one analysis or report per record (see below), is executed by the NDANALYZE and Genie-ESP Analyze applications. The symbolic name for this class is CAM_CLS_ANALCNTL.

WBC-Specific Analysis Control Parameters

Common Parameters

CAM_T_WBCOUNTER	Name of whole body counter (24 characters)
CAM_T_EXPICRP	ICRP2 or ICRP30 analysis? (2/30) (4 characters)
CAM_T_EXPHCOUT	Destination of hard-copy reports: Printer or Disk? (P/D) (10 characters)
CAM_T_EXPTITLE	Experiment title (40 characters)
CAM_T_EXPCONTROL	Control certificate filename (96 characters)
CAM_X_EXPPLIVE	Preset live time

CAM_X_EXPPREAL	Preset real time
CAM_X_EXPMAXPLIVE	Maximum preset live time
CAM_L_EXPPTOTAL	Preset total counts
CAM_L_EXPPTSCHAN	Preset total counts start channel
CAM_L_EXPPTECHAN	Preset total counts end channel
CAM_F_EXPPAREA	Preset net area
CAM_F_EXPPERR	Preset percent error
CAM_F_EXPPNETENG	Preset area energy
CAM_L_EXPPSWEEPS	Preset sweeps
CAM_L_EXPPLEVEL	Preset level
CAM_L_EXPPMODE	Preset mode flags
CAM_L_EXPPMLIVE	Preset live time mode
CAM_L_EXPPMREAL	Preset real time mode
CAM_L_EXPPMSWEEPS	Preset sweeps mode
CAM_L_EXPPMAREA	Preset area mode
CAM_L_EXPPMLEVEL	Preset level mode
CAM_L_EXPPMPERR	Preset error mode
CAM_T_EXPDDFNAME	Name of detector definition file (32 characters)
CAM_T_EXPDSTUNITS	Distance units: inches or cm (4 characters)
CAM_F_EXPDSTMULT	Inches to UNITS conversion factor
CAM_L_EXPNUMDISP	Number of spectral displays
CAM_L_EXPPSTYPE	NDA 2000: Indicates the type of peak search to be executed (0=none, 1=2nd difference, 2=simple library, 3=Gamma-M, 4=user-defined)
CAM_L_EXPNIDTYPE	NDA 2000: Indicates the type of NID to be executed (0=none, 1=NID with interference, 2=NID without interference)

CAM_L_EXPISOTYPE	NDA 2000: Indicates the type of isotopic analysis to be executed (0=none, 1=MGA and MGA/U)
CAM_L_EXPATTCORTYP	NDA 2000: Attenuation correction algorithm type (0=none, 1=transmission, 2=differential peak)
CAM_L_EXPNUTYPE	NDA 2000: Non-uniformity algorithm type (0=none, 1=NUDS, 2=NUCS)
CAM_L_EXPPNIDTYPE	NDA 2000: type of post-NID processing to be performed (0=none, 1=Pu Self-Absorption)
CAM_L_EXPFLAGS	Analysis control flags
CAM_M_EXPF_REPMDA [CAM_L_EXPREPMDA]	Report MDAs? (Y/N)
CAM_M_EXPF_AUTOSAV [CAM_L_EXPAUTOSAV]	Store spectra on disk? (Y/N)
CAM_M_EXPF_AUTOREP [CAM_L_EXPAUTOREP]	Generate hard-copy report? (Y/N)
CAM_M_EXPF_BACKSUB [CAM_L_EXPBACKSUB]	Subtract ambient background? (Y/N)
CAM_M_EXPF_ROIS [CAM_L_EXPROIS]	Set regions-of-interest? (Y/N)
CAM_M_EXPF_REPPK [CAM_L_EXPREPPK]	Include post-NID peak search report? (Y/N)
CAM_M_EXPF_REPPLT [CAM_L_EXPREPPLT]	Include spectral plot on report? (Y/N)
CAM_M_EXPF_REPWBP [CAM_L_EXPREPWBP]	Include whole body peak search report? (Y/N)
CAM_M_EXPF_REPDOSE [CAM_L_EXPREPDOSE]	Generate dose report? (Y/N)
CAM_M_EXPF_AFDOSE [CAM_L_EXPAFDOSE]	Perform dose calculation? (Y/N)
CAM_M_EXPF_DOWTM [CAM_L_EXPDOWTM]	Perform weighted mean calculation? (Y/N)

CAM_M_EXPF_REP10CFR [CAM_L_EXPREP10CFR]	Report 10CFR20 values?
CAM_T_PEAKASF	Analysis sequence file to use for efficiency calibration (96 characters)
CAM_T_NIDLIB	Tentative NID library (96 characters)
CAM_L_EXPPFLAGS	Parameter prompting flags field
CAM_M_EXPPF_B*n* [CAM_L_EXPPFB*n*]	Prompting flags bit *n*, where *n* is 0 to 31
CAM_L_EXPPFLAGS1	Parameter prompting flags field 1
CAM_L_EXPPF1SP*n*	Prompting flags bit *n*, where *n* is 0 to 4
CAM_L_EXPRFLAGS	Report generation flags field
CAM_M_EXPRF_PEAK [CAM_L_EXPRFPEAK]	Generate peak search report? (Y/N)
CAM_M_EXPRF_EFF [CAM_L_EXPRFEFF]	Generate efficiency report? (Y/N)
CAM_M_EXPRF_ACT [CAM_L_EXPRFACT]	Generate activity report? (Y/N)
CAM_M_EXPRF_SUM [CAM_L_EXPRFSUM]	Generate summary report? (Y/N)
CAM_M_EXPRF_PROP [CAM_L_EXPRFPROP]	Generate propagate report? (Y/N)
CAM_M_EXPRF_UNK [CAM_L_EXPRFUNK]	Generate unidentified lines report? (Y/N)
CAM_M_EXPRF_REJ [CAM_L_EXPRFREJ]	Generate rejected nuclides report? (Y/N)
CAM_M_EXPRF_INT [CAM_L_EXPRFINT]	Generate interference report? (Y/N)
CAM_M_EXPRF_MDA [CAM_L_EXPRFMDA]	Generate detection limit report? (Y/N)

CAM_M_EXPRF_MPC [CAM_L_EXPRFMPC]	Generate MPC report? (Y/N)
CAM_M_EXPRF_POST [CAM_L_EXPRFPOST]	Generate post-NID peak search report? (Y/N)
CAM_M_EXPRF_BRF [CAM_L_EXPRFBRF]	Generate brief report? (Y/N)
CAM_M_EXPRF_FMPC [CAM_L_EXPRFFMPC]	Generate fractional MPC report? (Y/N)
CAM_M_EXPRF_EQV [CAM_L_EXPRFEQV]	Generate nuclide equivalence report? (Y/N)
CAM_M_EXPRF_TRL [CAM_L_EXPRFTRL]	Generate report trailer? (Y/N)
CAM_M_EXPRF_SP*n* [CAM_L_EXPRFSP*n*]	Spare report flag *n*, where *n* is 1 to 15

CAM_T_EXPPLTDEV	Name of hard-copy plotting device (16 characters)
CAM_T_EXPCERT	Name of certificate file (96 characters)
CAM_T_SAMPFPL	FPL to be used for sample input screen (96 characters)
CAM_T_GUISAMPFPL	GUI FPL to be used for sample input screen (96 characters)
CAM_T_PEAKLIB	Name of peak search library (96 characters)
CAM_T_EXPBACK	Name of ambient background configuration (96 characters)
CAM_T_NEUTBACKFILE	Name of the neutron background configuration (96 characters)
CAM_T_EXPLIB	Name of NID nuclide library (96 characters)
CAM_T_EXPINT	Name of interference library (96 characters)
CAM_T_SAMPLOG	Name of sample log file (96 characters)
CAM_T_QAFILE	Name of quality assurance file (96 characters)
CAM_T_ALPHMSTDS	Name of Alpha-M standards file (96 characters)

CAM_T_SADFILE	Name of sample analysis database file (96 characters)
CAM_T_ROIFILE	Name of ROI file used by some ROI-driven peak location algorithms (82 characters)
CAM_T_REAGENTFILE	Name of reagent background spectrum file (96 characters)
CAM_T_KEDREFSPEC	K-edge reference (i.e., sample blank) spectrum file name (96 characters)
CAM_T_TRANSFILE	Name of the transmission spectral data file (96 characters)
CAM_T_MACFILE	Name of the mass attenuation curve file (96 characters)
CAM_T_MGAHIGHFILE	Name of high energy spectrum for MGA (if this name is blank, and CAM_L_PRMGANSPEC is 2, then the file with the same name as the input file but with a CN2 extension will be used) (96 characters)
CAM_T_MGAUCALFILE	MGAU enrichment calibration file
CAM_T_EXPHDR1	Name of header file 1 (96 characters)
CAM_T_EXPHDR2	Name of header file 2 (96 characters)
CAM_T_REPTEMPLATE	Report template file (96 characters)
CAM_T_RPTSECTNAME	Report or report section name (16 characters)
CAM_L_RPTFLAGS	Report flags field
CAM_M_RPTF_SCREEN [CAM_L_RPTFSCREEN]	Send report to screen
CAM_M_RPTF_DISK [CAM_L_RPTFDISK]	Send report to disk
CAM_M_RPTF_PRINTER [CAM_L_RPTFPRINTER]	Queue disk file to printer after report complete
CAM_M_RPTF_PAGE1 [CAM_L_RPTFPAGE1]	Start this report on page 1
CAM_M_RPTF_NEWPAGE [CAM_L_RPTFNEWPAGE]	Start this report on new page

CAM_M_RPTF_NEWFILE [CAM_L_RPTFNEWFILE]	Create new file for report (i.e., do not append)
CAM_M_RPTF_ANAL0 [CAM_L_RPTFANLA0]	General purpose engine flag
CAM_L_PAGENUM	Running page number
CAM_L_LINENUM	Running line number
CAM_L_EXPAFLAGS	Analysis flags field
CAM_M_EXPAF_EFF [CAM_L_EXPAFEFF]	Perform efficiency calculation? (Y/N)
CAM_M_EXPAF_BS [CAM_L_EXPAFBS]	Perform ambient background subtraction? (Y/N)
CAM_M_EXPAF_PP [CAM_L_EXPAFPP]	Perform pulse pileup correction? (Y/N)
CAM_M_EXPAF_NID [CAM_L_EXPAFNID]	Perform nuclide identification? (Y/N)
CAM_M_EXPAF_INT [CAM_L_EXPAFINT]	Perform interference correction? (Y/N)
CAM_M_EXPAF_WTM [CAM_L_EXPAFWTM]	Perform weighted mean computation? (Y/N)
CAM_M_EXPAF_DTL [CAM_L_EXPAFDTL]	Perform detection limit computation? (Y/N)
CAM_M_EXPAF_DOSE [CAM_L_EXPAFDOSE]	Include dose on WBC reports? (Y/N)
CAM_T_ACBATCHQ	Name of processing BATCH queue
CAM_T_ACARCHNAME	Name of archived configuration
CAM_T_ACARGS*n*	Arguments parameter *n*, where *n* is 1 to 4
CAM_L_CACLARG*n*	Integer argument parameter *n*, where *n* is 1 to 2
CAM_G_CACGARG1	Arguments DP float parameter 1
CAM_L_NUMALTINPS	Number of alternate inputs

CAM_T_ALTINPUT*n*	Alternate input *n* (96 characters), where *n* is 1 to 49
CAM_T_MEASISOFILE	Name of measured isotopics file (96 characters)
CAM_T_QUANTGFILE	Name of file that contains nuclide identification results. If blank, the current datasource must contain them.
CAM_T_PASSIVENFILE	Passive neutron coincidence data and results file (96 characters)
CAM_T_DDAFILE	Active DDA data and analysis results file (96 characters)
CAM_T_PDDAFILE	Passive data and analysis results file (96 characters)
CAM_T_NSHLDMCSFILE	DDA shielded detector MCS spectrum
CAM_T_NBAREMCSFILE	DDA bare detector MCS spectrum
CAM_T_NFLUXMONFILE	DDA flux monitor MCS spectrum
CAM_T_NBARRMONFILE	DDA barrel monitor MCS spectrum
CAM_T_TGSEROIFILE	TGS emission ROI definition file name
CAM_T_TGSTROIFILE	TGS transmission ROI definition file name
CAM_T_TGSTMAXFILE	TGS transmission calibration measurement file name
CAM_T_CONTATTFILE	Container attenuation calibration file name (96 characters)
CAM_T_NEUTACTBKGFL	Active well background file (AmLi source only)
CAM_T_ACTIVENFILE	Active well assay file (AmLi source plus item)
CAM_T_AGATRUESRC	Source of true values for AGA (16 characters)
CAM_L_AGACONVERGE	Enable AGA double-pass mode
CAM_L_AGAITERLIMIT	AGA iteration limit
CAM_L_AGAADJZERO	Enable AGA zero adjust
CAM_F_AGAMAXGAIN	AGA maximum gain deviation

CAM_L_AGADOINITQA	Do AGA initial Q/A transfer
CAM_L_AGADOFINQA	Do AGA final Q/A transfer
CAM_X_AGASTARTTIME	AGA start time
CAM_L_AGAITERDONE	Number of AGA iterations
CAM_T_AGASTATUS	AGA status (64 characters)
CAM_F_AGAAMPGAIN	AGA amp gain
CAM_F_AGAADCZERO	AGA ADC zero
CAM_F_AGATOLFACTOR	AGA tolerance factor
CAM_F_AGAECOFFSET	AGA energy cal offset
CAM_F_AGAECSLOPE	AGA energy cal slope
CAM_F_AGAECQUAD	AGA energy cal quadratic
CAM_F_AGAECALFAC1	AGA energy cal cubic
CAM_F_AGAECALFAC2	AGA energy cal 4th order coeff
CAM_F_AGAECALFAC3	AGA energy cal 5th order coeff
CAM_L_AGAUSEASF	Use ASF in AGA gain evaluation
CAM_L_AGADONE	AGA done
CAM_F_AGARELCRIT	AGA reliability criterion
CAM_L_AGAACCEPTED	AGA results accepted

Record Parameters

CAM_T_ACENGNAME	Name of analysis module (16 characters)
CAM_T_ACTARG*n*	Analysis module string argument *n* (32 characters), where *n* is 1 to 3
CAM_T_ACTEMPLATE	Report template file name (96 characters)
CAM_G_ACGARG*n*	Analysis module DP floating argument *n*, where *n* is 1 to 3
CAM_L_ACLARG*n*	Analysis module integer argument *n*, where *n* is 1 to 3

CAM_L_ACFLAGS	Analysis module flags field
CAM_M_RPTF_SCREEN [CAM_L_ACFSCREEN]	Send report to screen
CAM_M_RPTF_DISK [CAM_L_ACFDISK]	Send report to disk
CAM_M_RPTF_PRINTER [AM_L_ACFPRINTER]	Queue disk file to printer after report complete
CAM_M_RPTF_PAGE1 [CAM_L_ACFPAGE1]	Start this report on page 1
CAM_M_RPTF_NEWPAGE [CAM_L_ACFNEWPAGE]	Start this report on new page
CAM_M_RPTF_NEWFILE [CAM_L_ACFNEWFILE]	Create new file for report (i.e., do not append)
CAM_M_RPTF_ANAL0 [CAM_L_ACFANAL0]	General purpose engine flag

QA Parameter Definition Parameters

The quality assurance parameter definition parameters is composed of a set of parameters which describe a data item to be transferred from a spectral data configuration to a quality assurance configuration. Each record in this parameter block describes one such data item. The symbolic name for this class is CAM_CLS_QAPDR.

Record Parameters

CAM_X_PENTRY	Parameter definition entry time
CAM_X_PEDIT	Parameter definition last time edited
CAM_T_PNAME	Parameter name (16 characters)
CAM_T_PERRNAME	Parameter name for uncertainty (16 characters) [used if STDERROR flag is set]
CAM_T_PERRTYPE	Error type (ABSOLUTE, RELATIVE or PERCENT) (8 characters)
CAM_T_PDESC	Parameter description (32 characters)
CAM_L_PPARIND	Tabular entry index for parameter value
CAM_T_PUNITS	Reporting units (16 characters)

CAM_F_PCNVFCTR	Reporting units conversion factor
CAM_T_PPTYPE	Parameter type (GENERIC, PEAK, NUCLIDE, LINE, BCKGND or MANUAL) (8 characters)
CAM_T_PPTYPEDESC	Parameter type description (16 characters)
CAM_T_PNUCLIDE	Nuclide name (16 characters) [used if parameter type is NUCLIDE or LINE]
CAM_F_PENERGY	Line energy [used if parameter type is PEAK or LINE]
CAM_L_PSCHAN	Gross counts start channel [used if parameter type is BCKGND]
CAM_L_PECHAN	Gross counts end channel [used if parameter type is BCKGND]
CAM_F_PINVEST	Investigation sigma level [used if SAMPLE or USER flags are set]
CAM_F_PACTION	Action sigma level [used if SAMPLE or USER flags are set]
CAM_X_PSTARTDATE	Statistics start date [used if SAMPLE flag is set]
CAM_X_PENDDATE	Statistics end date [used if SAMPLE flag is set]
CAM_F_PSDMEAN	Sample-driven mean [used if SAMPLE flag is set] (this value is recomputed each time a report is generated)
CAM_F_PSDSTDEV	Sample-driven standard deviation [used if SAMPLE flag is set] (this value is recomputed each time a report is generated)
CAM_F_PBIASTRUE	“True” parameter value [used if BIAS flag is set]
CAM_X_PBIASSTDATE	Bias test start date
CAM_X_PBIASENDATE	Bias test end date
CAM_F_PUDMEAN	User-driven mean [used if USER flag is set]
CAM_F_PUDSTDEV	User-driven standard deviation [used if USER flag is set]

CAM_F_PLOLIM	Lower limit for parameter value [used if BOUNDARY flag is set]
CAM_F_PUPLIM	Upper limit for parameter value [used if BOUNDARY flag is set]
CAM_L_PSTARTREC	Start report results record number
CAM_L_PENDREC	End report results record number
CAM_L_PNMEANSMPLS	or Trend test: test for last N samples above or below mean
CAM_L_PMSLOPESMPLS	For Trend test: test for last M samples with increasing or decreasing slope
CAM_L_PDFLAGS	Parameter definition flags field
CAM_M_PDF_STDERROR [CAM_L_PDFSTDERROR]	Parameter has associated uncertainty
CAM_M_PDF_BOUNDARY [CAM_L_PDFBOUNDARY]	Perform (by default) upper/lower bounds test
CAM_M_PDF_SAMPLE [CAM_L_PDFSAMPLE]	Perform (by default) sample-driven N-Sigma test
CAM_M_PDF_USER [CAM_L_PDFUSER]	Perform (by default) user-driven N-Sigma test
CAM_M_PDF_BIAS [CAM_L_PDFBIAS]	Perform (by default) bias test
CAM_M_PDF_BSINV [CAM_L_PDFBSINV]	Multi-measurement bias investigation flag (computed at time of report)
CAM_M_PDF_BSACT [CAM_L_PDFBSACT]	Multi-measurement bias action flag (computed at time of report)
CAM_M_PDF_DOBOUND [CAM_L_PDFDOBOUND]	Do bounds test
CAM_M_PDF_DOSAMPLE [CAM_L_PDFDOSAMPLE]	Do sample-driven test
CAM_M_PDF_DOUSER [CAM_L_PDFDOUSER]	Do user-defined test
CAM_M_PDF_DOBIAS [CAM_L_PDFDOBIAS]	Do bias test

CAM_M_PDF_TREND [CAM_L_PDFTREND]	Perform trend test
CAM_M_PDF_DOTREND [CAM_L_PDFOTREND]	Do Trend Test in the Full Report

QA Results Parameters

The quality assurance results parameters is composed of a set of parameters which describe a particular quality assurance measurement. Each record in this parameter block describes one such measurement. Listed in [ ] after each parameter is the spectral configuration parameter which is copied to it during the transfer process. The symbolic name for this class is CAM_CLS_QARREC.

Record Parameters

CAM_X_RMEASR	Measurement time for results record [CAM_X_ASTIME] (Note: Results records will be sorted by this measurement time field).
CAM_X_RENTRY	Results record entry time
CAM_X_REDIT	Results record last edited time
CAM_T_RSAMPID [CAM_T_SIDENT]	Sample identification (16 characters)
CAM_X_RDEPTIME [CAM_X_SDEPOSIT]	Sample deposition time
CAM_T_RBUILDUPTYPE [CAM_T_BUILDUPTYPE]	Build-up type (8 characters)
CAM_X_RSDATE [CAM_X_STIME]	Sample date
CAM_X_RELTIME [CAM_X_ELIVE]	Elapsed live time
CAM_X_RERTIME [CAM_X_EREAL]	Elapsed real time
CAM_F_RSQUANT [CAM_F_SQUANT]	Sample quantity
CAM_T_RSUNITS [CAM_T_SUNITS]	Sample quantity units (16 characters)

CAM_T_RANALYST [CAM_T_SANALNAME]	Name of sample analyst (24 characters)
CAM_L_RRFLAGS	Results record flags field
CAM_M_RRF_REJECT	Entire record has been rejected
CAM_M_RRF_TBIAS [CAM_L_PDFTBIAS]	Bias trend alarm flag
CAM_M_RRF_TSLOPE [CAM_L_PDFTSLOPE]	Slope trend alarm flag
CAM_M_RRF_TBIAS [CAM_L_RRFTBIAS]	Last N samples exhibit a positive or negative bias trend
CAM_M_RRF_TSLOPE [CAM_L_RRFTSLOPE]	Last M samples exhibit monotonically increasing or decreasing trend

Tabular Entry Parameters

CAM_F_RVALUE	Parameter value (Note: all integers and double precision values are converted to single precision floats at transfer time)
CAM_F_RDVALUE	Parameter uncertainty (Note: all integers and double precision values are converted to single precision floats at transfer time)
CAM_L_RVFLAGS	Parameter value flags [2 bytes only]
CAM_M_RVF_STORED [CAM_L_RVFSTORED]	Parameter has been stored
CAM_M_RVF_EDITED [CAM_L_RVFEDITED]	Parameter has been edited
CAM_M_RVF_REJECT [CAM_L_RVFREJECT]	Parameter has been rejected
CAM_M_RVF_RECREJ [CAM_L_RVFRECREJ]	Parameter has been rejected as part of a record rejection
CAM_M_RVF_SDINV [CAM_L_RVFSDINV]	Sample-driven investigation flag (computed at time of report)
CAM_M_RVF_SDACT [CAM_L_RVFSDACT]	Sample-driven action flag (computed at time of report)

CAM_M_RVF_UDINV [CAM_L_RVFUDINV]	User-driven investigation flag (computed at time of report)
CAM_M_RVF_UDACT [CAM_L_RVFUDACT]	User-driven action flag (computed at time of report)
CAM_M_RVF_LUABV [CAM_L_RVFLUABV]	Bounds above flag (computed at time of report)
CAM_M_RVF_LUBLW [CAM_L_RVFLUBLW]	Bounds below flag (computed at time of report)
CAM_M_RVF_BSINV [CAM_L_RVFBSINV]	Bias investigation flag (computed at time of report)
CAM_M_RVF_BSACT [CAM_L_RVFBSACT]	Bias action flag (computed at time of report)

MGA Results Parameters

The MGA results parameter block is composed of a series of common and record parameters which summarize the results of a Multi-Group Analysis (MGA). The symbolic name for this class is CAM_CLS_MGARESULTS.

Common Parameters

CAM_L_MGAFLAGS	MGA results flags field. These flags are available as individual parameters
CAM_L_MGADONE	MGA results have been generated
CAM_L_MGAERR*nn*	MGA error *nn* occurred, where *nn* is 01 to 31
CAM_L_MGAFLAGS2	Additional MGA results flags
CAM_L_MGAERR*nn*	MGA error *nn* occurred, where *nn* is 32 to 42
CAM_M_MGAF2_DECAYDONE	Isotopics combination has decay-corrected measured isotopics
CAM_T_MGAVERSION	MGA version information (16 characters)
CAM_L_MGATYPE	Indicates the type of MGA analysis: 0 for standard MGA, 1 for MGAU

CAM_F_PUTHICK	Plutonium thickness (g/cm^2)
CAM_F_CDTHICK	Cadmium thickness (g/cm^2)
CAM_F_QFIT	Fit chi-square
CAM_F_NQFIT	Normalized fit chi-square
CAM_F_UTOPU	U/Pu ratio (from fluorescence x-rays)
CAM_F_DUTOPU	Uncertainty in U/Pu ratio
CAM_F_AMTOPU241	$^{241}Am/^{241}Pu$ weight ratio
CAM_F_DAMTOPU241	Uncertainty in $^{241}Am/^{241}Pu$ weight ratio
CAM_X_AMSEPTIME	Time since Am separation
CAM_X_DAMSEPTIME	Uncertainty in time since Am separation
CAM_X_USEPTIME	Time since U separation
CAM_F_PU240EFF	^{240}Pu effective
CAM_F_DPU240EFF	Uncertainty in ^{240}Pu effective
CAM_F_FWHM122	FWHM for 122 keV peak (eV)
CAM_F_FWHM208	FWHM for 209 keV peak (eV)
CAM_L_MFAM243NP239	$^{243}Am/^{239}Np$ present?
CAM_F_PU241TOPU239	$^{241}Pu/^{239}Pu$ ratio
CAM_F_PUXRFINT	Plutonium X-ray fluorescence intensity
CAM_F_PUDXRFINT	Uncertainty in plutonium X-ray fluorescence intensity
CAM_F_MGATOTSPOW	Total specific power (mW/g)
CAM_F_DTOTSPOW	Uncertainty in total specific power
CAM_F_MGAPUSCONC	Pu solution concentration
CAM_F_MGAPUCERR	Error in Pu solution concentration
CAM_F_MGAPUSCFAC	Pu solution concentration correction factor
CAM_F_MGAZR95CONC	^{95}Zr concentration
CAM_F_MGAZR95CERR	Error in ^{95}Zr concentration
CAM_F_MGANB95CONC	^{95}Nb concentration

CAM_F_MGANB95CERR	Error in ^{95}Nb concentration
CAM_F_MGARU103CONC	^{103}Ru concentration
CAM_F_MGARU103CERR	Error in ^{103}Ru concentration
CAM_F_MGARU106CONC	^{106}Ru concentration
CAM_F_MGARU106CERR	Error in ^{106}Ru concentration
CAM_F_MGACS137CONC	^{137}Cs concentration
CAM_F_MGACS137CERR	Error in ^{137}Cs concentration
CAM_F_MGACE144CONC	^{144}Ce concentration
CAM_F_MGACE144CERR	Error in ^{144}Ce concentration
CAM_F_MGATOTCOUNTS	Total number of counts in low energy spectrum
CAM_T_MGALEFILE	Low energy spectrum file name (name only; 32 characters)
CAM_T_MGAHEFILE	High energy spectrum file name (name only; 32 characters)
CAM_X_MGAHELIVE	High energy spectrum live time
CAM_X_MGAHEREAL	High energy spectrum real time
CAM_L_MGAU235REC	^{235}U results record number
CAM_L_MGANP237REC	^{237}Np results record number
CAM_L_MGAU238REC	^{238}U results record number
CAM_L_MGAAM243REC	^{243}Am results record number
CAM_F_MGAAM100ABN	^{241}Am abundance relative to ^{239}Pu based on 100 keV region analysis (hetrogenous ^{241}Am only; otherwise, will be 0)
CAM_F_MGAAM100ABNE	% error in ^{241}Am abundance relative to ^{239}Pu based on 100 keV region analysis
CAM_F_MGAAM300ABN	^{241}Am abundance relative to ^{239}Pu based on 300 keV region analysis (hetrogenous ^{241}Am only; otherwise, will be 0)
CAM_F_MGAAM300ABNE	% error in Am-241 abundance relative to ^{239}Pu based on 300 keV region analysis

CAM_F_MGAAM600ABN	^{241}Am abundance relative to ^{239}Pu based on 600 keV region analysis (hetrogenous ^{241}Am only; otherwise, will be 0)
CAM_F_MGAAM600ABNE	% error in Am-241 abundance relative to ^{239}Pu based on 600 keV region analysis
CAM_F_MGA100600DIF	Percent difference between the ^{241}Am abundance relative to ^{239}Pu based on the 100 keV region analysis and the 600 keV region analysis (hetrogenous Am-241 only; if homogenous, is set to 0)
CAM_F_MGAAMSTDD	Result of heterogenous ^{241}Am calculation; if homogenous, is set to 0
CAM_F_MGAAMBETA	Result of heterogenous ^{241}Am calculation; if homogenous, is set to 0
CAM_F_MGAERR*x*	Error amplification value *x*, where *x* is A to CAM_L_MGAVCHECK
	Validity tests failed: one flag per test
CAM_L_MGAVCHECK0	Validity test 0 (Q < MAX Q)
CAM_L_MGAVCHECK1	Validity test 1 (122 keV FWHM too large)
CAM_L_MGAVCHECK2	Validity test 2 (dead time too large)
CAM_L_MGAVCHECK8	Validity test 8 (MGA only; Am separation time too large)
CAM_L_MGAVCHECK9	Validity test 9 (only; ^{240}Pu error too large)
CAM_L_MGAVCHECK10	Validity test 10 (only; ^{239}Pu out of valid range)
CAM_L_MGAVCHECK16	Validity test 16 (only; ^{235}U out of valid range)

Record Parameters

CAM_T_VARNAME	MGA variable (isotope) name (16 characters)
CAM_L_VARNUMBER	MGA variable (isotope) number (16 characters)
CAM_F_RELABN	Relative abundance
CAM_F_DRELABN	Uncertainty in relative abundance

CAM_F_DRELABNR	Uncertainty in relative abundance ratio
CAM_F_WGTPCTM	Weight % at measurement time
CAM_F_DWGTPCTM	Uncertainty in weight % at measurement time
CAM_F_WGTPCTD	Weight % at declaration time
CAM_F_DWGTPCTD	Uncertainty in weight % at declaration time
CAM_F_MGAPRWEIGHT	Weight % at prediction time (PRNEUTPRDATE); this is calculated by the neutron decay correction engine, not MGA itself
CAM_F_MGAPRWTERR	Error in predicted weight %
CAM_F_SPECPWR	Specific power
CAM_F_MGA241RELABN	Abundance relative to Pu-241
CAM_F_MGA241RAE	Error (%) abundance relative to Pu-241
CAM_G_VCVM*n*	Var/ matrix column *n*, where *n* is 1 to 16
CAM_L_MGAISOFLAGS	Isotope Flags
CAM_L_MGAISODECL	True if this isotope came from declared isotopics

Neutron Acquisition and Results

The Neutron Acquisition and Results block contains two types of data

1. Neutron acquisition data, which is stored as a series of records, each of which is the total, real, and accidental counts data from a single neutron shift register measurement. These measurements will be filtered and converted to mean rates by filter analysis engines.

   All analyses take the measurement date from the first measurement record (whether rejected or not).

2. Neutron analysis results data, which consists of the averaged and filtered neutron acquisition data, and the calculated Plutonium mass. Various intermediate analysis results values are also stored.

   All mass values are as of the measurement date (see note 1, above).

The symbolic name for this class is CAM_CLS_NEUTACQ.

General Information

CAM_L_NACQFLAGS	Neutron analysis flags (these indicate what analyses have been performed)
CAM_M_NACQF_ACTIVEU [CAM_L_NACQACTIVEU]	Active uranium well assay
CAM_M_NACQF_CHKSUM	Consistency check engine
CAM_M_NACQF_SDTCALC	Singles, doubles, and triples engine
CAM_M_NACQF_NMULTI	Multiplicity data has been acquired
CAM_M_NACQF_TFILTERED	Neutron data has been filtered by a Totals filter
CAM_M_NACQF_RFILTERED	Neutron data has been filtered by a Reals filter
CAM_M_NACQF_T2G	Neutron data has been filtered by a T^2G filter
CAM_M_NACQF_NEUTRONICS	Neutronics analysis (i.e., Pu mass) has been performed
CAM_M_NACQF_CFCMDET [CAM_L_NACQFCFCMDET]	Set if the californium/curium detection engine executed successfully
CAM_M_NACQF_CFDET [CAM_L_NACQFCFDET]	Set if ^{252}Cf was detected
CAM_M_NACQF_CMDET [CAM_L_NACQFCMDET]	Set if ^{244}Cm was detected
CAM_M_NACQF_AASCFTH [CAM_L_NACQFAASCFTH]	Add-a-Source correction factor was above the calibration range
CAM_M_NACQF_AWADONE [CAM_L_NACQFAWADONE]	Automated waste assay analysis was done
CAM_M_NACQF_AASCFTL [CAM_L_NACQFAASCFTL]	Add-a-Source correction factor was below the calibration range
CAM_M_NACQF_CFAVL [CAM_L_NACQFCFAVL]	Cf has been quantified (via neutron analysis)
CAM_M_NACQF_CFMAVL [CAM_L_NACQFCMAVL]	Cm has been quantified (via neutron analysis)

CAM_M_NACQF_PUMTH [CAM_L_NACQFPUMTH]	Validity test: NCC Pu mass was above calibration range
CAM_M_NACQF_PUMTL [CAM_L_NACQFPUMTL]	Validity test: NCC Pu mass was below calibration range
CAM_M_NACQF_ONESDONE [CAM_L_NACQONESDONE]	Ones Engine has been executed and produced a mass
CAM_M_NACQF_CRRDONE [CAM_L_NACQFCRRDONE]	Cosmic Ray Rejection Algorithm has been executed and produced a mass
CAM_M_NACQF_CMCFDONE [CAM_L_NACQCMCFDONE]	Cm/Cf engine has been executed and produced a mass
CAM_M_NACQF_ONESFILT	Ones rate filter engine executed
CAM_M_NACQF_TRIPFILT	Triples rate filter engine executed
CAM_M_NACQF_MULTINOROOTS	No roots found in multiplicity analysis
CAM_M_NACQF_COINNOROOTS	No roots found in coincidence analysis
CAM_M_NACQF_MULTI2ROOTS	More than one root found in multiplicity analysis
CAM_M_NACQF_COIN2ROOTS	More than one root found in coincidence analysis

CAM_T_NACQFILTER	The type and revision(s) of the filter engines that have been performed (44 characters)
CAM_T_NACQNEUTENG	The type and revision of the neutronics analysis engine (16 characters)
CAM_L_NACQFAWASTAT	Automated waste assay analysis status: 0 if successful
CAM_T_NACQANALYST	The name of the neutronics analyst (16 characters)
CAM_T_NACQNORMVERS	The type and version of the K-factor calculation engine (16 characters)
CAM_T_NACQAASVERS	Add-a-Source correction engine version (16 characters)
CAM_T_NACQISOSRC	Isotopics used in analysis (12 characters; will be either “Declared” or “Measured”)

Filter Engine Results

CAM_F_NACQMEANTOT	Mean totals rate (counts/second)
CAM_F_NACQMEANTERR	Computed 1-sigma error in mean totals rate
CAM_F_NACQMTSTDD	Measured standard deviation of mean totals rate
CAM_F_NACQMEANREAL	Mean reals rate (counts/second)
CAM_F_NACQMEANRERR	Computed 1-sigma error in mean reals rate
CAM_F_NACQCALCWR	Reals error weighting factor (W)
CAM_F_NACQMRSTDD	Measured standard deviation of mean reals rate
CAM_F_NACQMEANACC	Mean accidentals rate (counts/second)
CAM_F_NACQMASTDD	Measured standard deviation of mean accidentals rate
CAM_F_NACQAVGSGL	Mean singles rate
CAM_F_NACQAVGSERR	Error in singles rate
CAM_F_NACQAVGDBL	Mean doubles rate
CAM_F_NACQAVGDERR	Error in doubles rate
CAM_F_NACQAVGTPL	Mean triples rate
CAM_F_NACQAVGTERR	Error in triples rate
CAM_L_NACQUNREJM	Number of unrejected measurements
CAM_F_NACQTMEASTIM	Total elapsed time of unrejected measurements
CAM_L_NACQNT2GREJ	Number of measurements rejected by T^2G filter
CAM_L_NACQNTOTREJ	Number of measurements rejected by totals filter
CAM_L_NACQNREALREJ	Number of measurements rejected by reals filter
CAM_F_NACQONESTIME	Total elapsed time for unrejected ones measurements
CAM_L_NACQONESREJ	Number of measurements rejected by Ones filter

CAM_L_NACQNCHKREJ	Number of consistency check rejected runs

Measurement Correction Results

CAM_F_NACQMEANDTT	Deadtime-corrected mean totals rate (counts/second)
CAM_F_NACQMEANDTTE	1-sigma error in deadtime-corrected mean totals rate
CAM_F_NACQMEANDTR	Deadtime-corrected mean reals rate (counts/second); see note below
CAM_F_NACQMEANDTRE	1-sigma error in deadtime-corrected mean reals rate
CAM_F_NACQMEANBCT	Normalized/background-corrected mean totals rate (counts/second); see note below
CAM_F_NACQMEANBCTE	1-sigma error in normalized/background-corrected mean totals rate
CAM_F_NACQMEANBCR	Normalized/background-corrected mean reals rate (counts/second)
CAM_F_NACQMEANBCRE	1-sigma error in normalized/background-corrected mean reals rate
CAM_F_NACQMCREALS	Multiplication-corrected mean reals rate (counts/second)
CAM_F_NACQMCREALER	1-sigma error in multiplication-corrected mean reals rate
CAM_F_NACQAVGCSGL	Measurement correction singles
CAM_F_NACQAVGCDBL	Measurement corrected doubles
CAM_F_NACQAVGCTPL	Measurement corrected triples
CAM_F_NACQAVGCSER	Error in measurement corrected singles
CAM_F_NACQAVGCDER	Error in measurement corrected doubles
CAM_F_NACQAVGCTER	Error in measurement corrected triples
CAM_F_NACQAVGCSDC	Singles-Doubles covariance
CAM_F_NACQAVGCSTC	Singles-Triples covariance
CAM_F_NACQAVGCDTC	Doubles-Triples covariance

CAM_F_NACQMCDBLS	Multiplication corrected doubles rate
CAM_F_NACQMCDBLSER	Error in multiplicity corrected doubles rate
CAM_F_NACQAVGONES	Mean Ones Rate
CAM_F_NACQAVGONEER	Error in the mean ones rate
CAM_F_NACQAVGTRNS	Mean Filtered Truncated Singles Rate
CAM_F_NACQAVGTRNSE	Error in the Mean Filtered Truncated Singles Rate
CAM_F_NACQAVGTRND	Mean Filtered Truncated Doubles Rate
CAM_F_NACQAVGTRNDE	Error in the Mean Filtered Truncated Doubles Rate
CAM_F_NACQAVGTRNT	Mean Filtered Truncated Triples Rate
CAM_F_NACQAVGTRNTE	Error in the Mean Filtered Truncated Triples Rate
CAM_F_NACQAVGCONE	Measurement corrected ones rate
CAM_F_NACQAVGCOER	Error in the measurement corrected ones rate
CAM_F_NACQAVGCTRNS	Measurement corrected truncated Singles rate
CAM_F_NACQAVGCTSE	Error in the Measurement corrected truncated Singles rate
CAM_F_NACQAVGCTRND	Measurement corrected truncated Doubles rate
CAM_F_NACQAVGCTDE	Error in the Measurement corrected truncated Doubles rate
CAM_F_NACQAVGCTRNT	Measurement corrected truncated Triples rate
CAM_F_NACQAVGCTTE	Error in the Measurement corrected truncated Triples rate
CAM_F_NACQAVGCTSDC	Measurement Corrected Truncated Singles Doubles CoVariance
CAM_F_NACQAVGCTSTC	Measurement Corrected Truncated Singles Triples CoVariance
CAM_F_NACQAVGCTDTC	Measurement Corrected Truncated Doubles Triples CoVariance

Standard Coincidence Analysis Results

CAM_F_NACQSFACTOR	S-factor
CAM_F_NACQSFACERR	Error in S factor
CAM_F_NACQALPHA	Alpha
CAM_F_NACQMFACTOR	M-factor
CAM_F_NACQPU240EFF	^{240}Pu effective mass (grams)
CAM_F_NACQPU240ERR	1-sigma estimated error (i.e., counting statistics error only) in ^{240}Pu effective mass
CAM_F_NACQPU240NER	1-sigma normal error (i.e., including all sources of error) in ^{240}Pu effective mass
CAM_F_NACQPUMASS	Plutonium mass (grams)
CAM_F_NACQPUMEERR	1-sigma estimated error (i.e., counting statistics error only) in Pu mass
CAM_F_NACQPUMNERR	1-sigma normal error (i.e., including all sources of error) in Pu mass
CAM_F_NACQPUMDIFF	% difference between measured and declared Pu mass: 100*(declared-measured)/declared
CAM_F_NACQPUMNSDIF	1-sigma difference between measured and declared Pu mass
CAM_F_NACQPREDPUM	Predicted Pu mass (grams); this is the calculated Pu mass decay corrected to the prediction date (PRNEUTPRDATE)
CAM_F_NACQPREDPUME	Error in predicted Pu mass
CAM_F_NACQPUMATDT	Pu mass (grams) as of the declared Pu mass date (NDCLPUMDATE)
CAM_F_NACQPUMEATDT	Error in Pu mass as of the declaration date
CAM_F_NACQMDA	^{240}Pu MDA (grams)
CAM_F_NACQMDAERR	Error in ^{240}Pu MDA
CAM_F_NACQ239FEG	^{239}Pu fissile gram equivalent (FEG) n
CAM_F_NACQ239FEGER	^{239}Pu FEG error
CAM_F_NACQ239EQACT	^{239}Pu equivalent activity (Ci)
CAM_F_NACQ239EQAER	^{239}Pu equivalent activity error

CAM_F_NACQDHEAT	Decay heat
CAM_F_NACQDHEATER	Decay heat error
CAM_F_NACQAACTVTY	Alpha activity
CAM_F_NACQAACTER	Alpha activity error

Multiplicity Analysis Results

CAM_F_NACQMALPHA	Alpha value based on multiplicity analysis
CAM_F_NACQMALPHAER	Alpha value error
CAM_F_NACQMMFACT	Multiplication value based on multiplicity analysis
CAM_F_NACQMMFACTER	Multiplication value error
CAM_F_NACQMPU240EF	Effective mass based on multiplicity analysis
CAM_F_NACQMPU240NE	Measured effective mass error based on multiplicity analysis
CAM_F_NACQMPU240ER	Estimated effective mass error based on multiplicity analysis
CAM_F_NACQMPUMASS	Total Pu mass based on multiplicity analysis
CAM_F_NACQMPUMNERR	Error in total Pu mass based on multiplicity analysis
CAM_F_NACQMPUMEERR	Estimated error in total Pu mass based on multiplicity analysis
CAM_F_NACQPREDMPU	Predicted Pu mass based on multiplicity analysis
CAM_F_NACQPREDMPUE	Error in predicted Pu mass based on multiplicity analysis
CAM_F_NACQMPUMDIFF	Percent difference in Pu Mass based on multiplicity analysis
CAM_F_NACQMPUNSDIF	One sigma difference in Pu mass based on multiplicity analysis
CAM_F_NACQM239FEG	^{239}Pu FEG (from multiplicity)
CAM_F_NACQM239FEGE	Error in ^{239}Pu FEG (from multiplicity)
CAM_F_NACQM239EQAC	^{239}Pu equivalent activity (from multiplicity)

CAM_F_NACQM239EQAE	Error in ^{239}Pu equivalent activity (from multiplicity)
CAM_F_NACQMDHEAT	Decay heat (from multiplicity)
CAM_F_NACQMDHEATER	Error in Decay heat (from multiplicity)
CAM_F_NACQMAACTVTY	Alpha activity (from multiplicity)
CAM_F_NACQMAACTER	Error in Alpha activity (from multiplicity)

Waste Analysis Results

CAM_F_NACQFPU240EF	^{240}Pu effective mass
CAM_F_NACQFPU240ER	1-sigma absolute uncertainty in ^{240}Pu effective mass
CAM_F_NACQFPUMASS	Pu mass
CAM_F_NACQFPUMERR	1-sigma absolute uncertainty in Pu mass
CAM_F_NACQFMDA	^{240}Pu effective MDA
CAM_F_NACQFMDAERR	1-sigma absolute error in ^{240}Pu MDA

Ones Rate Analysis Results

CAM_F_NACQPU240ONE	^{240}Pu effective mass from Ones rate analysis, non-multiplication corrected
CAM_F_NACQP240ONER	^{240}Pu effective mass error from Ones rate analysis, non-multiplication corrected
CAM_F_NACQTDBL240	^{240}Pu effective mass from truncated doubles rate
CAM_F_NACQTDBL240E	Error in ^{240}Pu effective mass from truncated doubles rate
CAM_F_NACQTDBLMDA	^{240}Pu effective MDA from truncated doubles rate
CAM_F_NACQTDBLMDAE	E in ^{240}Pu effective MDA from truncated doubles rate (note: this parameter is not accessable via parameter name)
CAM_L_NACQONESSTAT	Ones engine status flag; 0=success
CAM_F_NACQONESMDA	Ones Rate ^{240}Pu effective mass MDA

CAM_F_NACQONESMDAE	Ones Rate ^{240}Pu effective mass MDA uncertainty

Cosmic Ray Rejection Analysis Results

CAM_L_NACQFCRRSTAT	Cosmic Ray Rejection engine status; 0 = successful
CAM_F_NACQNTHZMASS	Matrix mass
CAM_F_NACQNTHZMER	Matrix mass uncertainty Non-Truncated – 1 sigma
CAM_F_NACQCRNT240	^{240}Pu Effective mass from Cosmic Rejection Analysis – Non-Truncated
CAM_F_NACQCRNT240E	1-sigma absolute uncertainty in ^{240}Pu Effective mass from Cosmic Rejection Analysis – Non-Truncated
CAM_F_NACQNTCRMDA	Non-Truncated Cosmic Ray Rejection ^{240}Pu Effective mass MDA
CAM_F_NACQNTCRMDAE	Non-Truncated Cosmic Ray Rejection ^{240}Pu Effective mass MDA uncertainty
CAM_F_NACQTHZMASS	Matrix mass Truncated
CAM_F_NACQTHZMER	Matrix mass uncertainty Truncated – 1 sigma
CAM_F_NACQCRT240	^{240}Pu Effective mass from Cosmic Rejection Analysis – Truncated
CAM_F_NACQCRT240E	1-sigma absolute uncertainty in ^{240}Pu Effective mass from Cosmic Rejection Analysis – Truncated
CAM_F_NACQTCRMDA	Truncated Cosmic Ray Rejection ^{240}Pu Effective mass MDA
CAM_F_NACQTCRMDAE	Truncated Cosmic Ray Rejection ^{240}Pu Effective mass MDA uncertainty

Cm/Cf Analysis Results

CAM_L_NACQCMCFSTAT	Cm/Cf Engine status; 0 = successful
CAM_F_NACQCMCF240	^{240}Pu effective mass from Cm/Cf analysis
CAM_F_NACQCMCF240E	Error in ^{240}Pu effective mass from Cm/Cf analysis

CAM_F_NACQCMMASS	Cm mass
CAM_F_NACQCMMASSER	Error in Cm mass
CAM_F_NACQCFMASS	Cf mass
CAM_F_NACQCFMASSER	Error in Cf mass
CAM_F_NACQCMCFMDA	^{240}Pu effective MDA from Cm/Cf analysis
CAM_F_NACQCMCFMDAE	^{240}Pu effective MDA uncertainty from Cm/Cf analysis

Coincidence Collar Analysis Results

CAM_F_NACQCLRCF1	Source decay correction factor
CAM_F_NACQCLRCF1ER	Uncertainty in source decay correction factor
CAM_F_NACQCLRCF2	Poison rod correction factor
CAM_F_NACQCLRCF2ER	Uncertainty in poison rod correction factor
CAM_F_NACQCLRCF3	Heavy metal correction factor
CAM_F_NACQCLFCF3ER	Uncertainty in heavy metal correction factor
CAM_F_NACQCLRMASS	Neutron collar mass
CAM_F_NACQCLRMASSE	Uncertainty in neutron collar mass

Active Multiplicity Analysis Results

CAM_F_NACQACPLNG	Coupling
CAM_F_NACQACPLNGER	Uncertainty in coupling
CAM_F_NACQAFMASS	Active fissile mass (g)
CAM_F_NACQAFMASSER	Uncertainty in active fissile mass
CAM_F_NACQASNGLSC	Singles scattering
CAM_F_NACQASNGLSCE	Uncertainty in singles scattering

Record Parameters

CAM_L_NACQSFLAGS	Measurement flags
CAM_M_NACQSF_TREJECT [CAM_L_NACQSREJECT]	Rejected by Totals filter

CAM_M_NACQSF_RREJECT [CAM_L_NACQSRREJECT]	Rejected by Reals filter
CAM_M_NACQSF_T2GREJECT [CAM_L_NACQST2GREJ]	Rejected by T^2G filter
CAM_M_NACQSF_CHKREJECT [CAM_L_NACQSCHKREJ]	Rejected by checksum test
CAM_M_NACQSF_CHKREJECT [CAM_L_NACQSFCHKREJ]	Consistency check reject mask
CAM_M_NACQSF_ONESREJECT [CAM_L_NACQSONESREJ]	Run rejected by the ones rate filter

CAM_X_NACQSTIME	Time of this measurement
CAM_F_NACQSETIME	Elapsed time of this measurement (seconds)
CAM_F_NACQSTOTALS	Total counts
CAM_F_NACQSREALS	Real counts
CAM_F_NACQSACC	Accidental counts
CAM_F_NACQSDOUBLES	Uncorrected Doubles counts
CAM_F_NACQSTRIPLES	Uncorrected Triples counts
CAM_F_NACQSONES	Ones counts
CAM_F_NACQSTRUNSGL	Truncated Singles counts
CAM_F_NACQSTRUNDBL	Truncated Doubles counts
CAM_F_NACQSTRUNTPL	Truncated Triples counts
CAM_L_NACQSSCALER1	Contents of first auxiliary scaler. The auxiliary scalers are supported only for the JSR-14 shift register. In the JSR-14's 2150 emulation mode, the scalers are read and reset for each measurement cycle. In the JSR-12 emulation mode, the scalers are read only on the last measurement cycle.
CAM_L_NACQSSCALER2	Contents of second auxiliary scaler

Note: Prior to mass calculations, the reals and totals rates must be corrected. There are three corrections done, in the following order: 1) deadtime correction; 2) background correction; 3) normalization. However, common analysis codes perform these corrections in two steps. The descriptions of the corrected rates above (NACQMEANDTT, NACQMEANBCT, etc.), are accurate for LANL-derived algorithms.

CEA-derived algorithms perform the rate correction slightly differently: deadtime correction and background correction are performed in one step, and normalization is done as one step. CEA algorithms store the result of their deadtime/background correction in the parameters labeled “deadtime corrected”, and the result of their normalization in the parameters labeled “normalized/background corrected”.

In all cases, the end result of the three corrections is stored in parameters labeled “normalized/background corrected”.

Neutron Declaration Data

The Neutron Declaration Data block contains isotopic declaration and mass information. This information is compared against the results of neutronics analysis to generate “measured vs. declared” reports.

Isotopic abundances (actually entered as weight %) are stored one isotope per record; the name of the isotope should be entered in a standard format (i.e., Pu-242, PU-242, etc.) so that it can be properly identified by neutronics analysis.

The symbolic name for this class is CAM_CLS_NEUTDECL.

Common Parameters

CAM_T_NDCLTITLE	Declaration title (64 characters)
CAM_T_NDCLIDENT	Declaration ID (16 characters)
CAM_T_NDCLPUMUNITS	Mass units string (by default, grams) (8 characters). This string (and the following conversion factor) may optionally be used by editors and reports to convert between external mass units and internal mass units (always grams).
CAM_F_NDCLPUMCF	Conversion factor between mass report units and grams (in units/gram)
CAM_T_NDCLSTYPE	Name of the sample type of the material described by this declaration (16 characters)
CAM_X_NDCLPUDATE	Pu isotopics date

CAM_T_NDCLPUSRC	Pu isotopics source (16 characters)
CAM_X_NDCLAMDATE	Am isotopics date
CAM_T_NDCLAMSRC	Am isotopics source (16 characters)
CAM_X_NDCLR2CSTIME	The time between removal from the reactor and chemical separation
CAM_X_NDCLPUMDATE	Pu mass declaration date
CAM_F_NDCLPUMASS	Pu mass (grams)
CAM_F_NDCLPUMASSER	Error in Pu mass
CAM_F_NDCLWGTFCTR	Pu weight to mass conversion factor; NDCLPUMASS is always multiplied by this value to convert a Pu weight to a Pu mass
CAM_F_NDCLDCPUM	Decay-corrected Pu mass (grams) (calculated by neutronics analysis)
CAM_F_NDCLDCPUMERR	Error in decay-corrected Pu mass (calculated by neutronics analysis)
CAM_F_NDCLPRPUM	Predicted Pu mass (grams), decay-corrected to the prediction date (PRNEUTPRDATE)
CAM_F_NDCLPRPUMERR	Error in the predicted Pu mass
CAM_F_NDCLUMASS	Declared U mass (grams) as of the U declaration date
CAM_F_NDCLUMASSERR	Uncertainty in the declared U mass
CAM_F_NDCLTREALS	True (known) reals rate; if non-zero, this value is used in the calculation of the proposed normalization constant.
CAM_F_NDCLTREALSER	Error in the true reals rate
CAM_F_NDCLREFV	Sample reals rate correction factor (used in the computation of the reals rate for Pu standards)
CAM_T_NDCLNAME	Declaration name utilized by the database (8 characters)
CAM_L_ NDCLTYPE	Declaration type enumeration utilized to identify the declaration type (4 integers)
CAM_X_NDCLUDATE	Declared U isotopics date

CAM_X_NDCLOIDATE	Declared “other isotopes” (that is, other than Pu, U, and Am) date

These parameters are used only in ANCC applications:

CAM_F_NDCLPOISFRAC	Poison fraction (%)
CAM_F_NDCLPOISFRER	uncertainty in poison fraction
CAM_L_NDCLFUELRODS	Total number of fuel rods (including poison rods)
CAM_L_NDCLPOISRODS	Number of poison rods
CAM_L_NDCLFLAGS	Declaration Flags
CAM_L_NDCLFVCISOOK	Declaration has been verified against measured isotopics
CAM_L_NDCLFVCISONG	Declaration does not match measured isotopics
CAM_L_NDCLFCFPRES	^{252}Cf may be present
CAM_L_NDCLFCMPRES	^{244}Cm may be present

Record Parameters

CAM_T_NDCLISONAME	Isotope name (16 characters)
CAM_F_NDCLWEIGHT	Weight %
CAM_F_NDCLWEIGHTER	Error in weight %
CAM_F_NDCLDCWEIGHT	Decay-corrected weight % (calculated by neutronics analysis; decay corrected to the neutron acquisition date)
CAM_F_NDCLDCWTERR	Error in decay-corrected weight %
CAM_F_NDCLPRWEIGHT	Predicted weight %; this is the declared weight % decay-corrected to the prediction date (PRNEUTPRDATE)
CAM_F_NDCLPRWTERR	Error in predicted weight %

Neutron Detector Data

The Neutron Detector Efficiency Data block contains data for a neutron detector which are not dependent on the type of sample (data which is dependent on both the type of sample and a particular detector is stored in the Neutron Sample-dependent Detector Data block).

The symbolic name for this class is CAM_CLS_NEUTDET.

Common Parameters

CAM_T_NDETNAME	Detector name (16 characters)
CAM_X_NDETCALDATE	Calibration date
CAM_T_NDETANALYST	Calibration analyst's name
CAM_F_NDETK1	Normalization factor [K]
CAM_F_NDETK1ERR	Error in normalization factor
CAM_F_NDETPROPK1	Proposed normalization constant (computed by the neutronics engine)
CAM_F_NDETPROPK1ER	Error in proposed normalization constant
CAM_F_NDETK1DIFF	1-sigma difference between the current and proposed normalization constants
CAM_F_NDETDTCF1	Totals deadtime correction factor 1
CAM_F_NDETDTCF2	Totals deadtime correction factor 2
CAM_F_NDETDTCF3	Reals deadtime correction factor 1 [A]
CAM_F_NDETDTCF4	Reals deadtime correction factor 2 [B]
CAM_F_NDETENSRO0	Ensslin ρ_0
CAM_F_NDETCDTHICK	Cadmium absorber thickness (g/cm^2)
CAM_F_NDETDIEAWAY	Detector dieaway time (μs)
CAM_F_NDETHICDTHK	High energy cadmium thickness (mm) (MGA)
CAM_F_NDETHICDCF	High energy cadmium thickness correction factor (MGA)
CAM_F_NDETHIPBTHK	High energy detector lead thickness (mm) (MGA)

CAM_F_NDETMDELTA	Detector deadtime
CAM_F_NDETMDELTAER	The detector deadtime error
CAM_F_NDETMDBLDTCF	Doubles deadtime coefficient
CAM_F_NDETMTPLDTCF	Triples deadtime coefficient
CAM_F_NDETDBLGATEF	Doubles gate fraction
CAM_F_NDETGATEFER	Doubles gate fraction error
CAM_F_NDETTPLGATEF	Triples gate fraction
CAM_F_NDETTGATEFER	Triples gate fraction error

Neutron Sample-Dependent Detector Data

The Neutron Sample-dependent Detector Data block contains parameters which are specific to a particular neutron detector and sample type. Detector parameters which are independent of a particular sample type are stored in the Neutron Detector Data block.

There are four groups of data in this block

- The weighting factors used in computing the uncertainty in totals and reals rates.
- The coefficients for the linear equation used in converting multiplication corrected reals rates to ^{240}Pu effective mass.
- The coefficients for the quadratic equation used in converting non multiplication corrected reals rates to ^{240}Pu effective mass.
- The raw data triplets (^{240}Pu effective, reals rate, multiplication-corrected reals rate) used in generating the coefficients; these are stored as record parameters.

The symbolic name for this class is CAM_CLS_NEUTEFF.

General Information

CAM_T_NEFFDETNAME	Detector name (16 characters)
CAM_T_NEFFSTIDENT	Sample type name (16 characters)
CAM_T_NEFFSTTITLE	Sample type title (64 characters)
CAM_X_NEFFCALDATE	Calibration date

CAM_T_NEFFANALYST	Calibration analyst's name (16 characters)
CAM_T_NEFFCURVEID	Identification of the calibration curve (16 characters)
CAM_F_NEFFTUWF	Totals uncertainty weighting factor [W]
CAM_F_NEFFRUWF	Reals uncertainty weighting factor [W]
CAM_F_NEFFLOWLIM	Lower limit of mass (grams) for which these curves are valid
CAM_F_NEFFHIGHLIM	Upper limit of mass (grams) for which these curves are valid
CAM_F_NEFFRHO0	Sample-specific ρ_0
CAM_F_NEFFDIEAWAY	Sample-specific dieaway time (μs)
CAM_F_NEFFMGAHFRAC	Fraction of sample in high energy path (MGA)
CAM_F_NEFFDETEFF	Raw uncorrected detector efficiency
CAM_F_NEFFDETEFFER	Detector efficiency error
CAM_F_NEFFDETCEFF	K-normalized detector efficiency
CAM_F_NEFFDETCEFFER	Error in normalized efficiency
CAM_F_NEFFCORRFAC1	Multiplicity mass correction factor 1
CAM_F_NEFFCF1ERROR	Uncertainty in multiplicity mass correction factor 1
CAM_F_NEFFCF1PARMA	Multiplicity mass correction factor CF1 equation parameter A
CAM_F_NEFFCF1PARMB	Multiplicity mass correction factor CF1 equation parameter B
CAM_F_NEFFCF1PARMC	Multiplicity mass correction factor CF1 equation parameter C
CAM_F_NEFFCF1VARA	Multiplicity mass correction factor CF1 equation parameter A variance
CAM_F_NEFFCF1VARB	Multiplicity mass correction factor CF1 equation parameter B variance
CAM_F_NEFFCF1VARC	Multiplicity mass correction factor CF1 equation parameter C variance

CAM_F_NEFFCF1VARAB	Multiplicity mass correction factor CF1 equation parameter A,B covariance
CAM_F_NEFFCF1VARAC	Multiplicity mass correction factor CF1 equation parameter A,C covariance
CAM_F_NEFFCF1VARBC	Multiplicity mass correction factor CF1 equation parameter B,C covariance
CAM_F_NEFFCORRFAC2	Multiplicity mass correction factor 2
CAM_F_NEFFCF2ERROR	Uncertainty in multiplicity mass correction factor 2
CAM_F_NEFFCF2PARMA	Multiplicity mass correction factor 2 equation parameter A
CAM_F_NEFFCF2PARMB	Multiplicity mass correction factor 2 equation parameter B
CAM_F_NEFFCF2PARMC	Multiplicity mass correction factor 2 equation parameter C
CAM_F_NEFFCF2VARA	Multiplicity mass correction factor 2 equation parameter A variance
CAM_F_NEFFCF2VARB	Multiplicity mass correction factor 2 equation parameter B variance
CAM_F_NEFFCF2VARC	Multiplicity mass correction factor 2 equation parameter C variance
CAM_F_NEFFCF2VARAB	Multiplicity mass correction factor 2 equation parameter A,B covariance
CAM_F_NEFFCF2VARAC	Multiplicity mass correction factor 2 equation parameter A,C covariance
CAM_F_NEFFCF2VARBC	Multiplicity mass correction factor 2 equation parameter B,C covariance
CAM_L_NEFFTRUNCL	Multiplicity histogram truncation level
CAM_T_NEFFCALDBR	Mass calibration database record ID
CAM_L_NEFFFLAGS	Flags
CAM_M_NEFF_FORCETHRU0	Force fits through 0,0
CAM_M_NEFFF_CM	Cm mass calibration has been defaulted
CAM_M_NEFFF_CF	Cf mass calibration has been defaulted

CAM_M_NEFFF_AWAPU	AWA Pu mass calibration has been defaulted
CAM_M_NEFFF_HZZ1	High-Z Z1 mass calibration has been defaulted
CAM_M_NEFFF_HZZ2	High-Z Z2 mass calibration has been defaulted
CAM_M_NEFFF_PU	NCC/Multiplicity Pu mass calibration has been defaulted
CAM_M_NEFFF_U	Uranium mass calibration is present

Multiplication-Corrected Reals ^{240}Pu Calibration

CAM_F_NEFFMCOFF	Offset
CAM_F_NEFFMCOFFV	Variance in offset
CAM_F_NEFFMCSLOPE	Slope
CAM_F_NEFFMCSLOPEV	Variance in slope
CAM_F_NEFFMCCOVAR	Covariance between offset and slope
CAM_F_NEFFMCRSS	Residual squares sum
CAM_F_NEFFMCRCHI	Multiplication corrected reals mass calibration reduced chi-square

Non-Multiplication-Corrected Reals ^{240}Pu Calibration

CAM_F_NEFFNMCOFF	Offset
CAM_F_NEFFNMCOFFV	Variance in offset
CAM_F_NEFFNMCSLOPE	Slope
CAM_F_NEFFNMCSLOPV	Variance in slope
CAM_F_NEFFNMCQUAD	Quadratic
CAM_F_NEFFNMCQUADV	Variance in quadratic
CAM_F_NEFFNMCOSC	Covariance between offset and slope
CAM_F_NEFFNMCOQC	Covariance between offset and quadratic
CAM_F_NEFFNMCSQC	Covariance between slope and quadratic

CAM_F_NEFFNMCRSS	Residual squares sum
CAM_F_NEFFNMCCUB	Cubic coefficient
CAM_F_NEFFNMCCUBV	Variance for the cubic coefficient
CAM_F_NEFFNMCOCC	Covariance between the offset and cubic coefficient
CAM_F_NEFFNMCSCC	Covariance between slope and cubic coefficient
CAM_F_NEFFNMCQCC	Covariance between the quadratic and cubic coefficient
CAM_F_NEFFNMCRCHI	Reals mass calibration polynomial reduced chi-square

^{240}Pu Calibration (Power Function)

CAM_F_NEFFNMCPMAN	Power function mantissa
CAM_F_NEFFNMCPEXP	Power function exponent
CAM_F_NEFFNMCPMANV	Power function mantissa variance
CAM_F_NEFFNMCPEXPV	Power function exponent variance
CAM_F_NEFFNMCPMEC	Power function covariance
CAM_F_NEFFNMCPRSS	Power function residual
CAM_F_NEFFNMCPRCHI	Reals mass calibration power function reduced chi-square

Non-Multiplication-Corrected Reals ^{240}Pu Calibration (Exponential Function)

CAM_F_NEFFNMCEMAN	Exponential function mantissa
CAM_F_NEFFNMCEEXP	Exponential function exponent
CAM_F_NEFFNMCEMANV	Exponential function mantissa variance
CAM_F_NEFFNMCEEXPV	Exponential function exponent variance
CAM_F_NEFFNMCEMEC	Exponential function covariance
CAM_F_NEFFNMCERSS	Exponential function residual

CAM_F_NEFFNMCERCHI	Reals mass calibration exp. function reduced chi-square

Non-Multiplication-Corrected Reals ^{240}Pu Calibration (Rational Function)

CAM_F_NEFFNMCRNUM	Rational function numerator coefficient
CAM_F_NEFFNMCRDEN	Rational function denominator coefficient
CAM_F_NEFFNMCRNUMV	Rational function numerator variance
CAM_F_NEFFNMCRDENV	Rational function denominator variance
CAM_F_NEFFNMCRNDC	Rational function covariance
CAM_F_NEFFNMCRRSS	Rational function residual
CAM_F_NEFFNMCRRCHI	Reals mass calibration rational function reduced chi-square

Non-Multiplication-Corrected Totals ^{240}Pu Calibration

CAM_F_NEFFTNMCOFF	Offset
CAM_F_NEFFTNMCOFFV	Variance in offset
CAM_F_NEFFTNMCSL	Slope
CAM_F_NEFFTNMCSLV	Variance in offset
CAM_F_NEFFTNMCOSC	Covariance between offset and slope
CAM_F_NEFFTNMRCHI	Totals mass calibration reduced chi-square

Multiplication-Corrected Doubles ^{240}Pu Calibration

CAM_F_NEFFMMCSLOPE	Multiplication corrected doubles mass calibration slope coefficient
CAM_F_NEFFMMCOFF	Multiplication corrected doubles mass calibration offset coefficient
CAM_F_NEFFMMCSLOPV	Multiplication corrected doubles mass calibration slope variance
CAM_F_NEFFMMCOFFV	Multiplication corrected doubles mass calibration offset variance

CAM_F_NEFFMMCCOVAR	Multiplication corrected doubles mass calibration covariance
CAM_F_NEFFMMCRSS	Multiplication corrected doubles mass calibration residual squares sum
CAM_F_NEFFMMCRCHI	Multiplication corrected doubles mass calibration reduced chi-square

Multiplicity Ones Rate ^{240}Pu Calibration

CAM_F_NONESPUSLP	Ones Rate Slope Calibration factor for ^{240}Pu Effective
CAM_F_NONESZ1SLP	Ones Rate Matrix Slope Calibration factor for Matrix 1
CAM_F_NONESZ2SLP	Ones Rate Matrix Slope Calibration factor for Matrix 2
CAM_F_NONESPUSLPER	Ones Rate Slope Calibration factor error for ^{240}Pu Effective
CAM_F_NONESZ1SLPER	Ones Rate Matrix Slope Calibration factor error for Matrix 1
CAM_F_NONESZ2SLPER	Ones Rate Matrix Slope Calibration factor error for Matrix 2

Non-Truncated Multiplicity ^{240}Pu Calibration

CAM_F_NEFFMMCDSLP	Multiplication corrected Doubles Slope
CAM_F_NEFFMMCDSLPV	Multiplication corrected Doubles Slope variance
CAM_F_NEFFMMCTSLP	Multiplication corrected Triples Slope for ^{240}Pu Effective
CAM_F_NEFFMMCTSLPV	Multiplication corrected Triples Slope variance for ^{240}Pu Effective
CAM_F_NEFFMMCDTCOV	Multiplication corrected Doubles-Triples Covariance for ^{240}Pu Effective

Truncated Multiplicity ^{240}Pu Calibration

CAM_F_NEFFTRUNPUD	Truncated Doubles linear calibration parameter for ^{240}Pu Effective

CAM_F_NEFFTRUNPUT	Truncated Triples linear calibration parameter for ^{240}Pu Effective
CAM_F_NEFFTRUNPUDE	Truncated Doubles calibration parameter variance for ^{240}Pu Effective
CAM_F_NEFFTRUNPUTE	Truncated Triples calibration parameter variance for ^{240}Pu Effective
CAM_F_NEFFTPUDTCOV	Truncated Doubles-Triples calibration covariance for ^{240}Pu Effective

Truncated Multiplicity Spallation Calibration

CAM_F_NEFFTRUNZ1D	Truncated Doubles linear calibration parameter for matrix 1
CAM_F_NEFFTRUNZ1T	Truncated Triples linear calibration parameter for matrix 1
CAM_F_NEFFTRUNZ1DE	Truncated Doubles linear calibration parameter variance for matrix 1
CAM_F_NEFFTRUNZ1TE	Truncated Triples linear calibration parameter variance for matrix 1
CAM_F_NEFFTRUNZ1CV	Truncated Doubles Triples linear calibration parameter covariance for matrix 1
CAM_F_NEFFTRUNZ2D	Truncated Doubles linear calibration parameter for matrix 2
CAM_F_NEFFTRUNZ2T	Truncated Triples linear calibration parameter for matrix 2
CAM_F_NEFFTRUNZ2DE	Truncated Doubles linear calibration parameter variance for matrix 2
CAM_F_NEFFTRUNZ2TE	Truncated Triples linear calibration parameter variance for matrix 2

Non-Truncated Multiplicity Cm/Cf Calibration

CAM_F_NEFFCMDCAL	Curium Doubles calibration parameter
CAM_F_NEFFCMTCAL	Curium Triples calibration parameter
CAM_F_NEFFCMDCALER	Curium Doubles calibration parameter variance

CAM_F_NEFFCMTCALER	Curium Triples calibration parameter variance
CAM_F_NEFFCMDTCOV	Curium Doubles Triples calibration
CAM_F_NEFFCFDCAL	Californium Doubles calibration parameter
CAM_F_NEFFCFTCAL	Californium Triples calibration parameter
CAM_F_NEFFCFDCALER	Californium Doubles calibration parameter variance
CAM_F_NEFFCFTCALER	Californium Triples calibration parameter variance
CAM_F_NEFFCFDTCOV	Californium Doubles Triples calibration covariance

DDA Calibration

CAM_F_NEFFDDATYPE	Differential Dieaway analysis type: 0 = ^{239}Pu equivalent mass; 1 = ^{235}U equivalent mass
CAM_F_NEFFDDAZMMF	zero matrix calibration factor for equivalent mass
CAM_F_NEFFDDASAA0	Self absorption parameter zero
CAM_F_NEFFDDASAA1	Self absorption parameter one
CAM_F_NEFFDDASAA2	Self absorption parameter two
CAM_F_NEFFDDASAA3	Self absorption parameter three
CAM_F_NEFFDDAZMV00	zero matrix calibration factor variance
CAM_F_NEFFDDASV00	Self absorption parameter zero variance
CAM_F_NEFFDDASV11	Self absorption parameter one variance
CAM_F_NEFFDDASV22	Self absorption parameter two variance
CAM_F_NEFFDDASV33	Self absorption parameter three variance
CAM_F_NEFFDDAEQMLL	Lower mass limit for equivalent mass (g
CAM_F_NEFFDDAEQMHL	Upper mass limit for equivalent mass (g

Record Parameters

CAM_F_NEFFR240EM	^{240}Pu effective mass (grams)

CAM_F_NEFFR240EMER	Error in ^{240}Pu effective
CAM_F_NEFFRREALS	Reals rate (counts/second)
CAM_F_NEFFRREALSER	Error in reals rate
CAM_F_NEFFRMCREALS	Multiplication-corrected reals rate (counts/second)
CAM_F_NEFFRMCREALE	Error in multiplication-corrected reals rate
CAM_F_NEFFRTOTALS	Totals rate (counts/second)
CAM_F_NEFFRTOTALSE	Error in totals rate
CAM_T_NEFFRCNTFILE	Mass calibration count file (96 characters)
CAM_X_NEFFRCNTDATE	Mass calibration count file acquisition date

Neutron Sample Processing Parameters

The Neutron Sample Processing Parameters block contains processing parameters specific to a particular type of sample (but not dependent on a particular detector). The symbolic name for this class is CAM_CLS_NEUTSPROC.

Common Parameters

CAM_T_NSPRTITLE	Title for this sample type (64 characters)
CAM_T_NSPRIDENT	Identification string (one word) for this sample type (16 characters)
CAM_T_NSPNAME	Sample type name utilized by the database (8 characters)
CAM_L_NSPRGROUP	Sample type group enumeration utilized to identify the sample type group (4 integers)
CAM_F_NSPRAPU238MF	Alpha Pu-238 multiplication factor [K1]
CAM_F_NSPRAPU239MF	Alpha Pu-239 multiplication factor [K2]
CAM_F_NSPRAPU240MF	Alpha ^{240}Pu multiplication factor [K3]
CAM_F_NSPRAPU241MF	Alpham ^{241}Pu ultiplication factor [K4]
CAM_F_NSPRAPU242MF	Alpham ^{242}Pu ultiplication factor [K5]
CAM_F_NSPRAAM241MF	Alpha ^{241}Pu multiplication factor [K6]

CAM_F_NSPRADENFAC	Alpha denominator factor [K7]
CAM_F_NSPRAPU238DF	Alpha ^{248}Pu denominator factor [K8]
CAM_F_NSPRAPU240DF	Alpha ^{240}Pu denominator factor
CAM_F_NSPRAPU242DF	Alpha ^{242}Pu denominator factor [K9]
CAM_F_NSPRSPU238MF	S-factor ^{238}Pu multiplication factor [K11]
CAM_F_NSPRSPU240MF	S-factor ^{240}Pu multiplication factor
CAM_F_NSPRSPU242MF	S-factor ^{242}Pu multiplication factor [K12]
CAM_F_NSPRENSNMF	Ensslin neutron multiplication factor [K10]
CAM_F_NSPRENSRTC	Ensslin R/T correlation factor
CAM_F_NSPRWA	Alpha sample-type correction factor [Wa]
CAM_F_NSPRPUTHICK	Plutonium thickness (g/cm^2)
CAM_F_NSPRCFRTRAT	Californium R/T ratio level
CAM_F_NSPRMGASTEEL	Container steel thickness (mm) (MGA)
CAM_F_NSPRMGAPB	Container lead thickness (mm) (MGA)
CAM_F_NSPRMGA242C0	MGA Pu-242 multiplier constant
CAM_F_NSPRMGA242C*n*	MGA Pu-242 coefficient *n*, where *n* is 1 to 9
CAM_F_NSPK3PCFA	Poison rod correction factor A
CAM_F_NSPK3PCFAERR	Error in poison rod correction factor A
CAM_F_NSPK3PCFB	Poison rod correction factor B
CAM_F_NSPK3PCFBERR	Error in poison rod correction factor B
CAM_F_NSPK3PCFC	Poison rod correction factor C
CAM_F_NSPK3PCFCERR	Error in poison rod correction factor C
CAM_F_NSPK4HMFA	Heavy metal factor A
CAM_F_NSPK4HMFAERR	Error in heavy metal factor A
CAM_F_NSPK4HMFB	Heavy metal factor B
CAM_F_NSPK4HMFBERR	Error in heavy metal factor B
CAM_F_NSPK5MCFA	Matrix correction factor A

CAM_F_NSPK5MCFAERR	Error in matrix correction factor A
CAM_F_NSPPSVFA	Passive factor A
CAM_F_NSPPSVFAERR	Error in passive factor A
CAM_F_NSPPSVFB	Passive factor B
CAM_F_NSPPSVFBERR	Error in passive factor B
CAM_F_NSPPSVFC	Passive factor C
CAM_F_NSPPSVFCERR	Error in passive factor C
CAM_F_NSPPSVFD	Passive factor D
CAM_F_NSPPSVFDERR	Error in passive factor D
CAM_F_NSPCRFAC	Collar counter cross calibration factor
CAM_F_NSPCRFACERR	Error in collar counter cross calibration factor
CAM_X_NSPCRFACDATE	Collar counter cross calibration factor date
CAM_T_NSPRPOISDESC	Poison rod description (64 characters)
CAM_F_NSPRPOISAFAC	Poison rod absorption factor
CAM_L_NSPRFUELRODS	Number of fuel rods in reference assembly
CAM_L_NSPRFLAGS	Neutron Sample Processing Parameter Flags
CAM_M_NSPRF_UPRES [CAM_L_NSPRFUPRES]	Uranium present? (used by MGA)
CAM_M_NSPRF_THERMAL [CAM_L_NSPACTVMODE]	False=Fast Mode (cadmium); True=Thermal Mode (no cadmium)
CAM_F_NSPPU240FR	^{240}Pu spontaneous fission rate per mass
CAM_F_NSPSMOMENT(1-3)	Moments of spontaneous fission
CAM_F_NSPIMOMENT(1-3)	Moments of induced fission

DDA Parameters

CAM_F_NSPRDDAMIA0	Moderator index parameter zero
CAM_F_NSPRDDAMIA1	Moderator index parameter one

CAM_F_NSPRDDAMIA2	Moderator index parameter two
CAM_F_NSPRDDAMIA3	Moderator index parameter three
CAM_F_NSPRDDAMCFA0	Moderator correction factor parameter zero
CAM_F_NSPRDDAMCFA1	Moderator correction factor parameter one
CAM_F_NSPRDDAACFA0	Absorption correction factor parameter zero
CAM_F_NSPRDDAACFA1	Absorption correction factor parameter one
CAM_F_NSPRDDABKGSF	Background scale factor
CAM_F_NSPRDDAIBKA0	Interrogating background parameter zero
CAM_F_NSPRDDAIBKA1	Interrogating background parameter one
CAM_F_NSPRDDAEQBA0	equivalent mass bias parameter zero
CAM_F_NSPRDDAEQBA1	equivalent mass bias parameter one
CAM_F_NSPRDDAEQBA2	equivalent bias parameter two
CAM_F_NSPRDDAMIV00	Moderator index parameter zero variance
CAM_F_NSPRDDAMIV11	Moderator index parameter one variance
CAM_F_NSPRDDAMIV22	Moderator index parameter two variance
CAM_F_NSPRDDAMIV33	Moderator index parameter three variance
CAM_F_NSPRDDAMIV01	Moderator index parameter zero, one covariance
CAM_F_NSPRDDAMIV02	Moderator index parameter zero, two covariance
CAM_F_NSPRDDAMIV03	Moderator index parameter zero, three covariance
CAM_F_NSPRDDAMIV12	Moderator index parameter one, two covariance
CAM_F_NSPRDDAMIV13	Moderator index parameter one, three covariance
CAM_F_NSPRDDAMIV23	Moderator index parameter two, three covariance
CAM_F_NSPRDDAMCV00	Moderator correction factor parameter zero variance

CAM_F_NSPRDDAMCV11	Moderator correction factor parameter one variance
CAM_F_NSPRDDAMCV01	Moderator correction factor parameter zero, one covariance
CAM_F_NSPRDDAACV00	Absorption correction factor parameter zero variance
CAM_F_NSPRDDAACV11	Absorption correction factor parameter one variance
CAM_F_NSPRDDAACV01	Absorption correction factor parameter zero, one covariance
CAM_F_NSPRDDAIBV00	Interrogating background parameter zero variance
CAM_F_NSPRDDAIBV11	Interrogating background parameter one variance
CAM_F_NSPRDDAIBV01	Interrogating background parameter zero,one covariance
CAM_F_NSPRDDAMBV00	Equivalent mass bias parameter zero variance
CAM_F_NSPRDDAMBV11	Equivalent mass bias parameter one variance
CAM_F_NSPRDDAMBV22	Equivalent mass bias parameter two variance

Attenuation Correction Calibration Parameters

This parameter block describes an attenuation curve. Its symbolic code is CAM_CLS_ATTENCALIB.

Common Parameters

CAM_X_ACCCALTIME	Calibration time
CAM_T_ACCOPNAME	Analyst's name (16 characters)
CAM_T_ACCTITLE	Curve title (64 characters)
CAM_T_ACCVERSION	Calibration engine version (16 characters)
CAM_L_ACCDEGREE	μ(E) Polynomial degree (0-9) (Stored as UBYTE)
CAM_F_ACCCHISQ	Reduced fit χ^2

CAM_F_ACCCALFAC1	Offset
CAM_F_ACCCALFAC2	Slope
CAM_F_ACCCALFAC*n*	n^{th} order term, where *n* is 3 to 10
CAM_G_ACCERRMAT*n*	Error matrix *n*, where *n* is 1 to 19

Record Parameters

CAM_F_ACCENERGY	Energy (keV) for known μ(E)
CAM_F_ACCMU	Known μ(E)
CAM_F_ACCMUERR	Error in known μ(E)

Absorption Measurement Calibration/Result Parameters

This parameter block contains absorption calibration and measurement results. Results parameters are indicated by "[R]" and must be zeroed when a peak analysis is done. The block's symbolic code is CAM_CLS_ABSMEASRES.

Common Parameters

CAM_L_AMRFLAGS	Analysis flags
CAM_M_AMRF_DP [CAM_L_AMRFDP]	Differential peak attenuation done
CAM_M_AMRF_TR [CAM_L_AMRFTR]	Transmission correction done
CAM_M_AMRF_AD [CAM_L_AMRFAD]	Average density correction done
CAM_M_AMRF_COMBINED [CAM_L_AMRFCOMBINED]	Combined matrix correction done
CAM_M_AMRF_DPFOVR [CAM_L_AMRFDPFOVR]	Differential peak attempted but failed over to average density
CAM_M_AMRF_TRFOVR [CAM_L_AMRFTRFOVR]	Transmission correction attempted but failed over to average density
CAM_M_AMRF_DPREJECT [CAM_L_AMRFDPREJECT]	All differential peak pairs rejected

CAM_M_AMRF_TRREJECT [CAM_L_AMRFTRREJECT]	All transmission peaks rejected
CAM_M_AMRF_TRMIN [CAM_L_AMRFTRMIN]	Transmission was below minimum value for at least one peak
CAM_M_AMRF_DPSREJ [CAM_L_AMRFDPSREJ]	Some differential peak pairs rejected
CAM_M_AMRF_TRSREJ [CAM_L_AMRFTRSREJ]	Some transmission peaks rejected
CAM_L_AMRTRCORTYPE	Transmission correction type: 0 = standard (empty-container) mode, 1 = no-container (ASTM) mode
CAM_X_TRNCCALTIME	No-container calibration count acquisition start time
CAM_X_TRNCCNTTIME	No-container calibration count elapsed real time
CAM_T_AMRDPVERS	Differential peak engine version (16 characters)
CAM_T_AMRTRVERS	Transmission correction engine version (16 characters)
CAM_T_AMRADVERS	Average density engine version (16 characters)
CAM_T_AMRCMVERS	Combined matrix correction engine version (16 characters)
CAM_X_AMRCALTIME	Calibration time
CAM_X_AMRTRCALTIME	Transmission calibration measurement start time
CAM_X_AMRDPCALTIME	Differential peak calibration measurement start time
CAM_T_AMROPNAME	Calibration analyst's name (16 characters)
CAM_F_AMRSEG*n*CFAC	Segment *n* correction factor, where *n* is 1 to 36
CAM_F_AMRMRHOTDP	Mean ρt from differential correction
CAM_F_AMRMRHOTDPER	Error in mean ρt from differential correction

CAM_F_AMRMRHOTTR	Mean ρt from transmission correction
CAM_F_AMRMRHOTTRER	Error in mean ρt from transmission correction
CAM_F_AMRMRHOTAD	Mean ρt from average density correction
CAM_F_AMRMRHOTADER	Error in mean ρt from average density correction
CAM_F_AMRAVERHOT	Final average ρt
CAM_F_AMRAVERHOTER	Error in final average ρt
CAM_L_AMRANALERROR	Analysis error code: provides additional diagnostic information if the density correction algorithm cannot perform the correction; allowed range: 0 through 255
CAM_L_AMRTCALCNTID	Transmission calibration count sequence number
CAM_T_AMRTCDESC	Transmission calibration description (64 characters)

Record Parameters

CAM_T_AMRNUCLIDE	Nuclide name (8 characters)
CAM_T_AMRRECTYPE	Record type: DIFF or TRANS (8 characters)

Differential Peak Parameters

CAM_F_AMRENERGY1	Peak 1 energy (keV)
CAM_F_AMRENERGY2	Peak 2 energy (keV)
CAM_F_AMREPAREARAT	Empty container peak area ratio
CAM_F_AMREPRATERR	Error in empty peak area ratio
CAM_F_AMRSPAREARAT	Sample peak ½ area ratio
CAM_F_AMRSPRATERR	Error in sample peak area ratio
CAM_F_AMRRHOT	ρt
CAM_F_AMRRHOTERR	Error in ρt

Transmission Correction Parameters

CAM_F_AMRTENERGY	Peak energy

CAM_F_AMRTEAREA	Empty container peak area
CAM_F_AMRTEAREAERR	Error in empty container peak area
CAM_F_AMRTSAREA	Sample peak area
CAM_F_AMRTSAREAERR	Error in sample peak area
CAM_F_AMRTRATIO	Area ratio
CAM_F_AMRTRATIOERR	Error in area ratio
CAM_F_AMRTNAREA	No-container corrected peak area
CAM_F_AMRTNAREAERR	Error in no-container peak area
CAM_F_AMRRECTRANS	Empty container transmission
CAM_F_AMRRECTRANSE	Error in empty container transmission
CAM_X_AMRTNHL	Nuclide half life
CAM_T_AMRNTHLU	Half life units (1 character)
CAM_L_AMRRFLAGS	Transmission peak flags
CAM_M_AMRRF_REJECTED [CAM_L_AMRRFREJECT]	This transmission peak was not found or has been rejected
CAM_M_AMRRF_MINIMUM [CAM_L_AMRRFMINIMUM]	This transmission peak transmission ratio was below the minimum and was set to the minimum

Differential Peak Absorption Correction Calibration / Results

These parameters store the calibration and analysis results for the differential peak absorption correction engine, which calculates density (ρt) based on the differential absorption of pairs of photopeaks. This class replaces the differential peak data stored in Absorption Measurement Calibration/Results class. The symbolic name for this class is CAM_CLS_DIFFPEAK.

Common Parameters

CAM_L_DIFPFLAGS	Flags
CAM_M_DIFPF_DONE	Differential peak correction has been performed

CAM_F_DIFPRHOTDP	ρt from differential peak
CAM_F_DIFPRHOTDPER	Error in differential peak ρt
CAM_F_DIFPRHOTAD	ρt from average density
CAM_F_DIFPRHOTADER	Error in average density ρt
CAM_T_DIFPVERS	Differential peak correction engine version
CAM_X_DIFPCALTIME	Date/time when differential peak calibration was created
CAM_T_DIFPOPNAME	Calibration analyst
CAM_F_DIFPAVERHOT	Average ρt
CAM_F_DIFPAVERHOTE	Error in average ρt
CAM_T_DIFPCDESC	Calibration description (64 characters)
CAM_L_DIFPCALCNTID	Calibration count sequence number

Record Parameters

CAM_T_DIFPNUCLIDE	Nuclide name
CAM_F_DIFPENERGY1	Energy 1
CAM_F_DIFPENERGY2	Energy 2
CAM_F_DIFPEPRAT	Empty container (i.e., reference) peak ratio
CAM_F_DIFPEPRATERR	Error in empty container peak ratio
CAM_F_DIFPSPRAT	Sample (i.e., unknown) peak ratio
CAM_F_DIFPSPRATERR	Error in sample peak ratio
CAM_F_DIFPRHOT	ρt
CAM_F_DIFPRHOTERR	Error in ρt

Safeguards Parameters

The safeguards parameter block is composed of common parameters relating to the entire safeguards system, and a number of records, each record describing an input (a Data Acquisition System) to the system. The symbolic name for this class is CAM_CLS_SFGSETUP.

Common Parameters

CAM_T_SFGFAC	Facility name (64 characters)
CAM_T_RAWNAME1	Device/directory for primary raw data file (96 characters)
CAM_T_RAWNAME2	Device/directory for secondary raw data file (96 characters)
CAM_T_EMQNAME	Device/directory for event manager queue file (96 characters)
CAM_T_AMQNAME	Device/directory for alarm manager queue files (96 characters)

DAS Parameters

CAM_X_DASCMDTMR	DAS command timer
CAM_X_DASACKTMR	DAS acknowledge timer
CAM_X_DASTRNTMR	DAS data transmission timer
CAM_X_DASLFADUR	DAS “look-for” acknowledge duration
CAM_X_DASACKFRQ	DAS acknowledge check frequency
CAM_X_DASRTLTMR	DAS timer after retry limit reached
CAM_X_DASMPDEL	DAS main process delay
CAM_X_DASFSFTMR	DAS timer after one file service failure
CAM_X_DASCSFTMR	DAS timer after complete file service failure
CAM_X_SWWTDOGTO	Software watchdog timeout

HDC Parameters

CAM_T_UIDIR	UIP / HDC command directory
CAM_L_MAXDDPSIZE	Maximum DDP size (bytes)
CAM_L_NUMEVCOMP	Number of events before EMQ compression
CAM_X_HDCTIMEOUT	HDC timeout period
CAM_L_RETRYLIMIT	Retry limit
CAM_X_HDCHIBER	HDC loop hibernation time

AMP Parameters

CAM_X_AMPHIBER	AMP loop hibernation time

EMP Parameters

CAM_X_EMPHIBER	EMP loop hibernation time
CAM_L_EMQRDMAX	Maximum number of measurements before calling APP
CAM_X_EMPWAITDEL	Maximum wait for companion data

UIP Parameters

CAM_X_BACKSRCINT	UIP background search interval

Neutron Analysis Parameters

CAM_F_ALP238MULT	Alpha computation Pu-238 multiplication factor (n1)
CAM_F_ALP239MULT	Alpha computation Pu-239 multiplication factor (n2)
CAM_F_ALP240MULT	Alpha computation ^{240}Pu multiplication factor (n3)
CAM_F_ALP241MULT	Alpha computation ^{241}Pu multiplication factor (n4)
CAM_F_ALP242MULT	Alpha computation ^{242}Pu multiplication factor (n5)
CAM_F_ALPAMMULT	Alpha computation ^{241}Am multiplication factor (n6)
CAM_F_ALPDENMULT	Alpha computation denominator multiplier (d)
CAM_F_S238MULT	S computation ^{238}Pu multiplication factor (P)
CAM_F_S240MULT	S computation ^{240}Pu multiplication factor (Q)
CAM_F_S242MULT	S computation ^{242}Pu multiplication factor (R)
CAM_F_CFRTRATIO	Californium reals/totals ratio threshold
CAM_F_A238MULT	Alpha computation ^{238}Pu denominator factor
CAM_F_A240MULT	Alpha computation ^{240}Pu denominator multiplication factor

CAM_F_A242MULT	Alpha computation ^{242}Pu denominator multiplication factor

Record Parameters

DAS Parameters

CAM_T_DASID	DAS identification (16 characters)
CAM_T_DASLOC	DAS location (16 characters)
CAM_L_JSRVOLT	JSR-12 high voltage
CAM_L_JSRGWIDTH	JSR-12 gate width (microseconds)
CAM_F_JSRPREDEL	JSR-12 pre-delay (microseconds)
CAM_X_JSRCNTTIM	JSR-12 count time
CAM_F_ADCZERO	ADC zero (± 3% of full scale)
CAM_F_ADCULD	ADC ULD (% of full scale)
CAM_F_ADCLLD	ADC LLD (% of full scale)
CAM_T_FILESVCE1	Primary DAS-to-Host file service (96 characters)
CAM_T_FILESVCE2	Secondary DAS-to-Host file service (96 characters)
CAM_T_GAMMADEF	Gamma configuration default file (96 characters)
CAM_L_DASGAMMAMEM	Number of gamma memory pages
CAM_L_DASNEUTMEM	Number of neutron memory pages
CAM_L_DASSENSORMEM	Number of sensor memory pages

EMP Parameters

CAM_F_QCENERGY	Quality control energy
CAM_F_EMPGQCETOL	Gamma QC energy tolerance
CAM_F_CENTLLIM	QC centroid lowerlimit
CAM_F_CENTULIM	QC centroid upperlimit
CAM_F_FWHMLLIM	QC FWHM lower limit

CAM_F_FWHMULIM	QC FWHM upper limit
CAM_F_FWTMLLIM	QC FWTM lower limit
CAM_F_FWTMULIM	QC FWTM upper limit
CAM_L_EMPNSTEVOB	Standard number of objects per event
CAM_X_EMPNSTOPDUR	Standard duration of stop
CAM_F_EMPNMINGROW	Minimum growth of totals count rate
CAM_X_EMPNMINDUROB	Minimum duration of neutron object
CAM_X_EMPNMAXDUROB	Maximum duration of neutron object
CAM_X_EMPNMAXGAPOB	Maximum gap between two neutron objects
CAM_X_EMPGAMMAXDUR	Maximum duration of gamma object
CAM_X_EMPGAMMAXGAP	Maximum gap between two gamma objects
CAM_F_EMPMATCHTOL	Object match tolerance (0-1)
CAM_L_EMPGIDSTCH	Inter-DAS gamma check start channel
CAM_L_EMPGIDENCH	Inter-DAS gamma check end channel
CAM_F_EMPGIDTOL	Inter-DAS gamma check tolerance (n-sigma)
CAM_F_EMPNIDTOL	Inter-DAS neutron check tolerance (n-sigma)
CAM_F_EMPNPHIT	Totals sigma multiplier
CAM_F_EMPNPHIR	Reals sigma multiplier
CAM_F_EMPNPHIA	Accidentals sigma multiplier
CAM_F_EMPNPHIT2G	T^2G sigma multiplier

ASDEM Parameters

CAM_X_MAXCOUNT	Maximum “uncompressed” count period (tmax)
CAM_L_DASMINPTS	Minimum number of measurements included in neutron global packet (N)
CAM_F_DASNEPT	Neutron event page’s test threshold (h)
CAM_F_DASNEPDP	Neutron event page’s test damping parameter (delta)

CAM_F_DASNBPT	Neutron background page's test threshold (h-star)
CAM_F_DASNBPDP	Neutron background page's test damping parameter (delta-star)
CAM_L_DASMTTPTS	Number of points used for MTT (r)
CAM_F_DASMTTTHR	MTT test threshold (beta)
CAM_L_DASVMTTPTS	Number of points used for MTT verification (r-prime)
CAM_F_DASVMTTTHR	MTT verification test threshold (beta-prime)
CAM_L_DASSTBPTS	Number of points used for stability test (r-star)
CAM_L_DASSTBXPTS	Number of extra points used in stability test (q)
CAM_F_DASSTBMULT	Stability test multiplier (alpha)
CAM_F_DASBCMPMULT	Multiplier used in background comparison test
CAM_L_DASTMAXPTS	Number of statistics points used after tmax (na)
CAM_F_DASSIGMULT	Sigma estimate multiplier (phi)
CAM_L_DASGSTART	Gamma background sum start channel
CAM_L_DASGEND	Gamma background sum end channel
CAM_X_DASGCNTTIM	Gamma statistics count time
CAM_L_DASGMINPTS	Minimum number of measurements included in gamma global packet (N)
CAM_F_DASGEPT	Gamma event page's test threshold (h)
CAM_F_DASGEPDP	Gamma event page's test damping parameter (delta)
CAM_F_DASGDTT	Gamma event acquisition start/end dead time threshold (%)
CAM_L_DASGTMAXPTS	Number of statistics points used after gamma tmax
CAM_F_DASGSIGMULT	Gamma sigma estimate multiplier (phi)

Neutron Detector Parameters

CAM_F_NEFFMULT	Neutron efficiency multiplier
CAM_F_DNEFFMULT	Uncertainty in neutron efficiency multiplier
CAM_F_DETDTDEL1	Detector dead time totals correction factor 1
CAM_F_DETDTDEL2	Detector dead time totals correction factor 2
CAM_F_DETDTDEL3	Detector dead time reals correction factor 1
CAM_F_DETDTDEL4	Detector dead time reals correction factor 2

Neutron Analysis Parameters

CAM_F_ENSROZERO	Ensslin Rho zero factor
CAM_F_ENSNEUTMULT	Ensslin neutron multiplicity factor (KE)
CAM_F_ENSRTCORR	Reals/Totals Correlation

Generic Flags Parameters

CAM_L_DASFLAGS	DAS flags field
CAM_M_DASF_COMPRESS [CAM_L_DASFCOMPRESS]	Compress neutron data
CAM_M_DASF_USENEUT [CAM_L_DASFUSENEUT]	Acquire neutron data
CAM_M_DASF_USEGAMMA [CAM_L_DASFUSEGAMMA]	Acquire gamma data
CAM_M_DASF_USESENS [CAM_L_DASFUSESENS]	Acquire sensor data
CAM_M_DASF_USESWD [CAM_L_DASFUSESWD]	Use software watchdog
CAM_M_DASF_PRIMARY [CAM_L_DASFPRIMARY]	Primary DAS
CAM_M_DASF_CCADC [CAM_L_DASFCCADC]	Computer controlled ADC
CAM_M_DASF_SUMGAM [CAM_L_DASFSUMGAM]	Sum gamma spectra from adjacent objects

Special Uses Parameters

The “special uses” parameter block contains both common and record type parameters. This block is used by Canberra for custom software packages and is also available for customer use. The symbolic name for this class is CAM_CLS_SPECIAL.

Common Parameters

CAM_L_SUCINT*n*	Common Integer *n*, where *n* is 1 to 8
CAM_F_SUCREAL*n*	Common Real *n*, where *n* is 1 to 8
CAM_T_SUCSTRING1	Common String 1 (255 characters)
CAM_T_SUCSTRING2	Common String 2 (255 characters)
CAM_T_SUCSTRING3	Common String 3 (255 characters)
CAM_T_SUCSTRING4	Common String 4 (255 characters)
CAM_T_SUCSTRING5	Common String 5 (16 characters)
CAM_T_SUCSTRING6	Common String 6 (16 characters)
CAM_T_SUCSTRING7	Common String 7 (16 characters)
CAM_T_SUCSTRING8	Common String 8 (16 characters)
CAM_T_SUCSTRING9	Common String 9 (256 characters)
CAM_T_SUCSTRING10	Common String 10 (32 characters)
CAM_T_SUCSTRING11	Common String 11 (32 characters)
CAM_T_SUCSTRING12	Common String 12 (16 characters)
CAM_T_SUCSTRING13	Common String 13 (16 characters)
CAM_X_SUCDATE*n*	Common Date/Time *n*, where *n* is 1 to 3
CAM_X_SUCTIME*n*	Common elapsed time *n*, where *n* is 1 to 3
CAM_L_SUCFLAGS	Common Flags Field
CAM_M_SUCF_FLAG*n* [CAM_L_SUCFLAG*n*]	Common Flag Bit *n*, where *n* is 0 to 4

Record Parameters

CAM_L_SURINT*n*	Record Integer *n*, where *n* is 1 to 8

CAM_F_SURREAL*n*	Record Real *n*, where *n* is 1 to 12
CAM_T_SURSTRING1	Record String 1 (255 characters)
CAM_T_SURSTRING2	Record String 2 (255 characters)
CAM_T_SURSTRING3	Record String 3 (16 characters)
CAM_T_SURSTRING4	Record String 4 (16 characters)
CAM_T_SURSTRING5	Record string 5 (16 characters)
CAM_T_SURSTRING6	Record string 6 (16 characters)
CAM_T_SURSTRING7	Record string 7 (32 characters)
CAM_T_SURSTRING8	Record string 8 (32 characters)
CAM_T_SURSTRING9	Record string 9 (32 characters)
CAM_T_SURSTRING10	Record string 10 (32 characters)
CAM_T_SURSTRING11	Record string 11 (64 characters)
CAM_T_SURSTRING12	Record string 12 (64 characters)
CAM_X_SURTIME*n*	Record elapsed time *n*, where *n* is 1 to 4
CAM_X_SURDATE*n*	Record date/time *n*, where *n* is 1 to 4
CAM_L_SURFLAGS	Record Flags Field
CAM_M_SURF_FLAG*n* [CAM_L_SURFLAG*n*]	Record Flag Bit *n*, where *n* is 0 to 6

MCS Parameters

The MCS data block is composed of common parameters used to define the overall operation of the software MCS function and record parameters which define the ROIs being monitored. The actual MCS data is stored as normal spectral data. The symbolic name for this class is CAM_CLS_MCSDATA.

Common Parameters

CAM_F_MCSCDWELL	Dwell time
CAM_T_MCSCDSRC	Dwell source (4 characters – LIVE/REAL/EXTN)

CAM_L_MCSCCHANS	Number of MCS channels
CAM_L_MCSCCACHESIZ	Number of MCS advances to cache before flush to disk
CAM_L_MCSCFLAGS	MCS flags longword
CAM_L_MCSCEXTADV	External advance flag
CAM_L_MCSCCPSALRM	Alarm level (cps) exceeded
CAM_L_MCSCPTIMEX	Processing time exceeded dwell time

Record Parameters

CAM_T_MCSCRGNDESC	Region description string (32 characters)
CAM_F_MCSCRSTART	Start of region (in keV)
CAM_F_MCSCREND	End of region (in keV)
CAM_F_MCSCCPSLEV	Alarm level (cps)
CAM_F_MCSCGAIN	MCS Gain term
CAM_F_MCSCOFFSET	MCS Offset term
CAM_T_MCSCUNITS	MCS units (4 characters)
CAM_L_MCSCRFLAGS	Region flags longword
CAM_L_MCSCNET	Gross (0) or Net (1) counts

K-Edge Calibration Parameters

The K-Edge Calibration parameters block contains calibration information for a K-Edge instrument station. The symbolic name for this class is CAM_CLS_KEDCAL.

CAM_T_KCDESCRIP	Calibration description (64 characters)
CAM_X_KCCALTIME	Calibration time
CAM_F_KCDELMU1	Delta mu for element 1 across the k-edge
CAM_F_KCDELMU2	Delta mu for element 2 across the k-edge

CAM_F_KCDELMU12	Delta mu for element 1 across element 2 k-edge
CAM_F_KCDELMU21	Delta mu for element 2 across element 1 k-edge
CAM_F_KCDELMUX1	Delta mu for element 1 at the k-edge
CAM_F_KCDELMUX2	Delta mu for element 2 at the k-edge
CAM_F_KCPATHLEN	Path length/diameter of sample container (cm)
CAM_T_KCANALYST	Calibration analyst's name (16 characters)

K-Edge Analysis Results Parameters

The K-Edge Analysis Result parameters block contains the analysis results from a single assay performed by a K-Edge instrument. Results from both k-edge and XRF detectors are stored. The symbolic name for this class is CAM_CLS_KEDRES.

CAM_L_KRFLAGS	K-edge analysis results flags
CAM_M_KRF_KEDDONE [CAM_L_KRFKEDDONE]	K-edge analysis done
CAM_T_KRANALVERS	Analysis engine(s) version (64 characters)
CAM_T_KRPROTOCOL	Analysis protocol (64 characters)
CAM_F_KRREFCH1	Reference peak 1 channel
CAM_F_KRREFCH2	Reference peak 2 channel
CAM_F_KRCONC1	Element 1 concentration (g/L)
CAM_F_KRCONC1ERR	Error in element 1 concentration
CAM_F_KRCONC2	Element 2 concentration (g/L)
CAM_F_KRCONC2ERR	Error in element 2 concentration
CAM_F_KRXCONC1	Extrapolated element 1 concentration (g/L)
CAM_F_KRXCONC1ERR	Error in extrapolated element 1 concentration
CAM_F_KRXCONC2	Extrapolated element 2 concentration (g/L)
CAM_F_KRXCONC2ERR	Error in extrapolated element 2 concentration

CAM_F_KRACONC1	Average element 1 concentration (g/L)
CAM_F_KRACONC1SD	Standard deviation of average element 1 concentration
CAM_F_KRACONC2	Average element 2 concentration (g/L)
CAM_F_KRACONC2SD	Standard deviation of average element 2 concentration
CAM_F_KRCONC1RAT	Ratio of reference concentration to measured concentration for element 1
CAM_F_KRCONC1RATER	Error in ratio of reference concentration to measured concentration for element 1
CAM_F_KRCONC2RAT	Ratio of reference concentration to measured concentration for element 2
CAM_F_KRCONC2RATER	Error in ratio of reference concentration to measured concentration for element 2
CAM_F_KRKED1CH	1st element's k-edge position (in channels)
CAM_F_KRKED2CH	2nd element's k-edge position (in channels)
CAM_F_KRREF1FWHM	FWHM (in keV) of reference peak 1
CAM_F_KRREF2FWHM	FWHM (in keV) of reference peak 2
CAM_F_KRTOTALCPS	Total count rate (cps)
CAM_F_KRHVCUTOFF	HVPS cutoff energy (keV)
CAM_F_KRSPNORMFAC	Spectrum normalization factor
CAM_F_KRTEMPCORFAC	Temperature correction factor
CAM_F_KRROI1OFF	ROI 1 fit offset
CAM_F_KRROI1OFFERR	Error in ROI 1 fit offset
CAM_F_KRROI1SLOPE	ROI 1 fit slope
CAM_F_KRROI2OFF	ROI 2 fit offset
CAM_F_KRROI2OFFERR	Error in ROI 2 fit offset
CAM_F_KRROI2SLOPE	ROI 2 fit slope
CAM_F_KRROI3OFF	ROI 3 fit offset
CAM_F_KRROI3OFFERR	Error in ROI 3 fit offset

CAM_F_KRROI3SLOPE	ROI 3 fit slope
CAM_F_KRROI4OFF	ROI 4 fit offset
CAM_F_KRROI4OFFERR	Error in ROI 4 fit offset
CAM_F_KRROI4SLOPE	ROI 4 fit slope

Neutron Multiplicity Data

This class records multiplicity data acquired from neutron shift registers. The data from each measurement run or cycle is contained in a record. At the start of each record are the reals and accidentals counts based on the multiplicity histogram, and the raw totals of the histogram. Then there are record tabular entries for each non-zero bin of the multiplicity histogram. There should be a one-to-one relationship between the records in this block and the records in the Neutron Acquisition/Results block. The symbolic name for the class is CAM_CLS_NEUTMULTI.

Common Parameters

CAM_L_NMULTFLAGS	Multiplicity flags
CAM_M_NMULTF_INT [CAM_L_NMULTINT]	Bin data stored as integer values in CAM_L_NMULTBINVAL; otherwise, probability values are stored in CAM_F_NMULTPROB
CAM_L_NMULTTRUNCL	Multiplicity histogram truncation level

Record Parameters

CAM_F_NMULTACCS	Accidentals count based on the multiplicity histogram
CAM_F_NMULTRAS	Reals+accidentals count based on the multiplicity histogram
CAM_F_NMULTATOT	Accidentals multiplicity histogram total
CAM_F_NMULTRATOT	Reals+accidentals multiplicity histogram total
CAM_F_NMULTRATRUNC	Fraction of the total area remaining in the reals+accidentals histogram after truncation
CAM_F_NMULTATRUNC	Fraction of the total area remaining in the accidentals histogram after truncation

Record Tabular Parameters

CAM_F_NMULTPROB	The probability of multiplicity *I* (note that either NMULTPROB or NMULTBINVAL are used, depending on NMULTINT)
CAM_L_NMULTBINVAL	Multiplicity bin *i* value
CAM_L_NMULTBINNO	The i^{th} multiplicity histogram bin number

Add-a-Source Calibration Parameters

This class describes the results of an Add-a-Source calibration for an active neutron counter. For a description of the Add-a-Source technique, see the Genie Neutron Assay Software Technical Reference Manual. The symbolic name for this class is CAM Class CAM_CLS_AASCALIB.

Common Parameters

CAM_L_AASFLAGS	Add-a-Source Flags
CAM_L_AASCALDONE [CAM_M_AASF_CALDONE]	Add-a-source calibration done
CAM_M_AASF_NSIGREJ [CAM_L_AASNSIGREJ]	Add-a-Source correction factor failed due to N-sigma rejection
CAM_M_AASF_FAILED [CAM_L_AASFAILED]	Add-a-Source correction failed
CAM_M_AASF_NOAASFILE [CAM_L_AASNOASSFILE]	AAS file not found
CAM_M_AASF_NOREFFILE [CAM_L_AASNOREFFILE)]	AAS reference file not found
CAM_M_AASF_CFLTUNITY [CAM_L_AASCFLTUNITY)]	AAS CF less than unity
CAM_M_AASF_CFCLAMPED [CAM_L_AASCFCLAMPED]	AAS CF clamped to unity
CAM_M_AASF_LOWHIGHLIM [CAM_L_AASLOWHIGHLM]	AAS perturbation lower than lower lim or higher than high limit
CAM_X_AASCALDATE	Add-a-source calibration date
CAM_T_AASANALYST	Calibration analyst's name (16 characters)

CAM_T_AASDETNAME	Counter name (16 characters)
CAM_T_AASCURVEID	Calibration curve ID (16 characters)
CAM_T_AASCONTAINER	Container name (for which this calibration is valid) (16 characters)
CAM_F_AASREAAZERO	Reals calibration polynomial offset
CAM_F_AASREAAONE	Reals calibration polynomial slope
CAM_F_AASREAATWO	Reals calibration polynomial quadratic
CAM_F_AASREAATHREE	Reals calibration polynomial cubic
CAM_F_AASTOTAZERO	Totals calibration polynomial offset
CAM_F_AASTOTAONE	Totals calibration polynomial slope
CAM_F_AASTOTATWO	Totals calibration polynomial quadratic
CAM_F_AASTOTATHREE	Totals calibration polynomial cubic
CAM_F_AASREAVAR00	Reals calibration offset error
CAM_F_AASREAVAR11	Reals calibration slope error
CAM_F_AASREAVAR22	Reals calibration quadratic error
CAM_F_AASREAVAR33	Reals calibration cubic error
CAM_F_AASREAVAR01	Reals calibration offset and slope covariance
CAM_F_AASREAVAR02	Reals calibration offset and quadratic covariance
CAM_F_AASREAVAR12	Reals calibration slope and quadratic covariance
CAM_F_AASREAVAR13	Reals calibration slope and cubic covariance
CAM_F_AASREAVAR23	Reals calibration quadratic and cubic covariance
CAM_F_AASTOTVAR00	Totals calibration offset error
CAM_F_AASTOTVAR11	Totals calibration slope error
CAM_F_AASTOTVAR22	Totals calibration quadratic error
CAM_F_AASTOTVAR33	Totals calibration cubic error
CAM_F_AASTOTVAR01	Totals calibration offset and slope covariance

CAM_F_AASTOTVAR02	Totals calibration offset and quadratic covariance
CAM_F_AASTOTVAR03	Totals calibration offset and cubic covariance
CAM_F_AASTOTVAR12	Totals calibration slope and quadratic covariance
CAM_F_AASTOTVAR13	Totals calibration slope and cubic covariance
CAM_F_AASTOTVAR23	Totals calibration quadratic and cubic covariance
CAM_F_AASTLOWLIM	Totals calibration low mass limit
CAM_F_AASTHIGHLIM	Totals calibration high mass limit
CAM_F_AASRLOWLIM	Reals calibration low mass limit
CAM_F_AASRHIGHLIM	Reals calibration high mass limit
CAM_F_AASREAARCHI	Reals calibration reduced chi-square
CAM_F_AASTOTARCHI	Totals calibration reduce chi-square
CAM_T_AASHZEFFDBR	High-Z efficiency calibration database record ID
CAM_T_AASHZBCKDBR	High-Z background calibration database record ID
CAM_T_AASCALDBR	Add-a-Source calibration database record
CAM_F_AASREFTOT	AaSreferencetotalsrate
CAM_F_AASREFTOTER	AaSreferencetotalsrateerror
CAM_F_AASREFREAL	AaSreferencerealsrate
CAM_F_AASREFREALER	AaSreferencerealsrateerror
CAM_X_AASREFSTIME	AaSreferenceacquisitiondate
CAM_F_AASDCREFTR	Decay-corrected reference totals rate
CAM_F_AASDCREFTRE	Error in decay-corrected reference totals rate
CAM_F_AASDCREFRR	Decay-corrected reference reals rate
CAM_F_AASDCREFRRE	Error in decay-corrected reference reals rate
CAM_F_AASXHZBFELIN	High-Z Background triples mass calibration linear term for iron (cps/kg)

CAM_F_AASXHZBFEV11	High-Z Background triples mass calibration variance for iron (cps/kg)
CAM_F_AASXHZBPBLIN	High-Z Background triples mass calibration linear term for lead (cps/kg)
CAM_F_AASXHZBPBV11	High-Z Background triples mass calibration variance for lead (cps/kg)
CAM_F_AASHZBFERXCV	High-Z Background Doubles Triples mass calibration for iron (cps/kg)
CAM_F_AASREALSCF	Add-a-Source reals correction factor
CAM_F_AASREALSCFER	Uncertainty in reals correction factor
CAM_F_AASREALSCFZ	Reals correction factor to the Z power
CAM_F_AASTOTLSCF	Add-a-Source totals correction factor
CAM_F_AASTOTLSCFER	Uncertainty in totals correction factor

Record Parameters

CAM_F_AASREACALXR	Reals absorption perturbation
CAM_F_AASTOTCALXR	Totals absorption perturbation
CAM_F_AASREACALXRE	Error in reals absorption perturbation
CAM_F_AASTOTCALXRE	Error in totals absorption perturbation
CAM_F_AASREACALYR	Reals volume perturbation
CAM_F_AASTOTCALYR	Totals volume perturbation
CAM_F_AASREACALYRE	Error in reals volume perturbation
CAM_F_AASTOTCALYRE	Error in totals volume perturbation
CAM_T_AASRPNTFILE	Add-a-source calibration point file (96 characters)
CAM_X_AASRPNTDATE	Add-a-source calibration point file date
CAM_T_AASREFFILE	AAS reference drum file name (128 characters)
CAM_T_AASMATFILE	AAS matrix drum file name (128 characters)
CAM_T_VOLREFFILE	Volume reference drum file name (128 characters)

CAM_T_VOLMATFILE	Volume matrix drum file name (128 characters)

ASTM Mass Calibration Parameters

This class stores count rate to isotopic mass calibration data used by the ASTM Mass calculation engine. The information in this class describes a single combination of materials (i.e., nuclides) in a matrix. Each record in the class describes a nuclide; each record has a variable number of tabular entries, each of which indicates the measured count rate seen for a given nuclide mass. Symbolic name CAM_CLS_ASTMCAL.

Common Parameters

CAM_T_ASTMCALMATER	Material type (64 characters)
CAM_T_ASTMCALMATRX	Matrix type (32 characters)
CAM_X_ASTMCALDATE	Calibration date/time
CAM_T_ASTMCANALYST	Calibration analyst's name (16 characters)

Record Parameters

CAM_T_ASTMCNUCLIDE	Nuclide name (8 characters)
CAM_F_ASTMCENERGY	Peak energy line used for this nuclide
CAM_F_ASTMCLOMASS	Low mass limit (grams) of curve validity
CAM_F_ASTMCHIMASS	High mass limit (grams) of curve validity
CAM_F_ASTMCOFF	Calibration curve offset
CAM_F_ASTMCSLOPE	Calibration curve slope
CAM_F_ASTMCQUAD	Calibration curve quadratic term
CAM_F_ASTMCOFFVAR	Variance in calibration curve offset
CAM_F_ASTMCSLOPEV	Variance in calibration curve slope
CAM_F_ASTMCQUADVAR	Variance in calibration curve quadratic
CAM_F_ASTMCOSCOV	Calibration curve offset-slope covariance
CAM_F_ASTMCOQCOV	Calibration curve offset-quadratic covariance
CAM_F_ASTMCSQCOV	Calibration curve slope-quadratic covariance

CAM_L_ASTMCORDER	Order of the curve polynomial for this nuclide
CAM_L_ASTMCNFLAGS	Per nuclide flags
CAM_L_ASTMCFZERO	Force fit through zero

Record Tabular Entry

CAM_F_ASTMCMASS	Declared reference mass (grams)
CAM_F_ASTMCMASSERR	Error in declared mass
CAM_F_ASTMCRATE	Measured count rate
CAM_F_ASTMCRATEERR	Error in measured count rate
CAM_F_ASTMCDCRATE	Decay corrected count rate
CAM_F_ASTMCDCRATEE	Error in decay corrected count rate
CAM_L_ASTMCSEQNUM	Sequence number of the calibration measurement; if 0, the data was entered manually
CAM_L_ASTMCMFLAGS	Flags
CAM_M_ASTMCM_REJECT	This mass measurement has been rejected

Peak-to-Total Calibration

This class stores the peak-to-total calibration coefficients. The symbolic name for this class is: CAM_CLS_PTCALIB.

Common Parameters

CAM_T_PTCVERS	PT Calibration version (16 characters)
CAM_F_PTCCROSSOVER	Polynomial crossover energy
CAM_L_PTCLDEGREE	Degree of low energy polynomial
CAM_L_PTCHDEGREE	Degree of high energy polynomial
CAM_F_PTCLCALFAC1	Low energy offset
CAM_F_PTCLCALFAC2	Low energy slope
CAM_F_PTCLCALFAC3	Low energy quadratic term

CAM_F_PTCLCALFAC4	Low energy cubic term
CAM_F_PTCLCALFAC5	Low energy 4th order term
CAM_F_PTCLCALFAC6	Low energy 5th order term
CAM_F_PTCLCALCHI	Low energy fit chi-square
CAM_F_PTCHCALFAC1	High energy offset
CAM_F_PTCHCALFAC2	High energy slope
CAM_F_PTCHCALFAC3	High energy quadratic term
CAM_F_PTCHCALFAC4	High energy cubic term
CAM_F_PTCHCALFAC5	High energy 4th order term
CAM_F_PTCHCALFAC6	High energy 5th order term
CAM_F_PTCHCALFAC7	High energy 6th order term
CAM_F_PTCHCALFAC8	High energy 7th order term
CAM_F_PTCHCALFAC9	High energy 8th order term
CAM_F_PTCHCALFAC10	High energy 9th order term
CAM_F_PTCHCALCHI	High energy fit chi-square
CAM_G_PTCLERRMAT*n*	Low energy error matrix *n*, where *n* is 1 to 11
CAM_G_PTCHERRMAT*n*	High energy error matrix *n*, where *n* is 1 to 19

Record Parameters

CAM_F_PTCENERGY	PT Energy
CAM_F_PTCEFF	PT Efficiency (absolute)
CAM_F_PTCDEFF	Uncertainty in PT efficiency

Coincidence Summing Library

This class stores the basic information for each line to be considered in coincident summing correction.The symbolic name for this class is: CAM_CLS_COILIB.

Common Parameters

CAM_T_COILIBVERS	Library version

Record parameters

CAM_F_COILENERGY	Line energy
CAM_L_COILCODE	Line identifier
CAM_F_COILBRANCH	Line abundance (%)
CAM_F_COILCONVER	Internal conversion correction factor
CAM_F_COILYIELD	Line yield (%)
CAM_L_COILFLAGS	Flags
CAM_M_COILF_INVOLVED	True if involved in a cascade

Coincidence Summing Chain Library

This class contains information describing energy line cascades. The symbolic name for this class is: CAM_CLS_COICHAIN.

Record parameters

CAM_L_COICCODE	Line identifier
CAM_F_COICL0	Energy of line for which summing effect is observed
CAM_F_COICL1	Energy of line composing the summing in/out/sum chain
CAM_F_COICL2	Energy of line composing the summing in/out/sum chain
CAM_F_COICL3	Energy of line composing the summing in/out/sum chain
CAM_F_COICL4	Energy of line composing the summing in/out/sum chain
CAM_F_COICL5	Energy of line composing the summing in/out/sum chain

CAM_L_COICTYPE	Type of line: 0=summing in, 1=summing out, 2=subcascade

Passive Neutron TMU Analysis Results

These parameters store the results of TMU analysis of passive neutron assay results data. The TMU analysis essentially incorporates additional factors in the calculation of uncertainties. In addition, values required for WIPP are calculated. The symbolic name for the class is CAM_CLS_NEUTTMU.

Common Parameters

CAM_L_WNRFLAGS	Flags
CAM_L_WNRFDATAAVL	Results can be used
CAM_L_WNRFDONE	TMU analysis has been performed
CAM_L_WNRFDREVIEW	If true, expert data review is required
CAM_L_WNRRVWFLG0	Data validity test failed: Add-a-Source CF < lower calibration limit
CAM_L_WNRRVWFLG1	Data validity test failed: Add-a-Source CF > upper calibration limit
CAM_L_WNRRVWFLG2	Data validity test failed: Add-a-Source CF > upper warning level 1
CAM_L_WNRRVWFLG3	Data validity test failed: Add-a-Source CF > upper warning level 2
CAM_L_WNRRVWFLG4	Data validity test failed: ^{239}Pu calibration > upper limit
CAM_L_WNRRVWFLG5	Data validity test failed: ^{239}Pu calibration < lower limit
CAM_L_WNRRVWFLG6	Data validity test failed: Cf or Cm detected but not analyzed
CAM_L_WNRRVWFLG7	Error in Add-a-Source CF > upper limit
CAM_L_WNRRVWFLG8	Data validity test failed: too many cycles rejected
CAM_L_WNRRVWFLG9	Data validity test failed: maximum FGE exceeded

CAM_L_WNRSTATUS	Engine error status: if 0, no error
CAM_T_WNRVERSION	Engine version identification string
CAM_F_WNRBKGERR	Background effect error (1-sigma relative)
CAM_F_WNRMLTERR	Maximum multiplication error (1-sigma relative)
CAM_F_WNRPTERR	Matrix-source distribution error (1-sigma relative)
CAM_F_WNRRMIN	R_{min}
CAM_F_WNRRMAX	R_{max}
CAM_F_WNRAACT	Total alpha activity
CAM_F_WNRAACTERR	1-sigma absolute uncertainty in Total alpha activity
CAM_F_WNRTRUACT	TRU Activity
CAM_F_WNRTRUACTERR	1-sigma absolute uncertainty in TRU activity
CAM_F_WNRDHEAT	Decay heat
CAM_F_WNRDHEATERR	1-sigma absolute uncertainty in decay heat
CAM_F_WNRFGE	^{239}Pu Fissile Gram Equivalent
CAM_F_WNRFGEERR	1-sigma absolute uncertainty in FGE
CAM_F_WNRFGEMDA	FGE MDA (grams)
CAM_L_WNRWCLASS	0 if the item is considered LLW; non-zero otherwise
CAM_F_WNRPUMDA	Pu MDA (note: this is Pu, not ^{240}Pu)
CAM_F_WNRPUMDAERR	1-sigma absolute uncertainty in Pu mass MDA (see note 3 on page 75)
CAM_F_WNRPUMASS	Pu mass
CAM_F_WNRPUMASSERR	1-sigma absolute uncertainty in Pu mass
CAM_F_WNRUMASS	U mass (see note 3 on page 75)
CAM_F_WNRUMASSERR	1-sigma absolute uncertainty in U mass (see note 3 on page 75)
CAM_F_WNRPU239EA	^{239}Pu equivalent activity

CAM_F_WNRPU239EAER	1-sigma absolute uncertainty in ^{239}Pu EA

Record Parameters

There is one record per isotope.

CAM_T_WNRISONAME	Isotope name (8 characters)
CAM_F_WNRISOACT	Isotope activity
CAM_F_WNRISOACTERR	1-sigma absolute uncertainty in activity
CAM_L_WNRISOACTSRC	Source of isotope activity: 0 = none, 1 = isotopic ratio
CAM_F_WNRISOMDA	Isotope MDA
CAM_F_WNRISOMDAERR	1-sigma absolute uncertainty in the MDA (see note 3 on page 75)
CAM_F_WNRSPECACT	Isotope specific activity (µCi/g)

Gamma TMU Analysis

These parameters store the results of TMU analysis of quantitative gamma assay results data. The TMU analysis essentially incorporates additional factors in the calculation of uncertainties. In addition, values required for WIPP are calculated. The symbolic name for the class is CAM_CLS_GAMMATMU.

Common Parameters

CAM_L_WGRFLAGS	Flags
CAM_L_WGRFPDATAAVL	Set if Pu results can be used (i.e., clear if Pu results are suspect)
CAM_L_WGRFUDATAAVL	Set if U results can be used (i.e., clear if U results are suspect)
CAM_L_WGRFDONE	Set if engine has executed
CAM_L_WGRFDREVIEW	Set if expert review is suggested
CAM_L_WGRFFNIDENT	Set if NID identified the fiducial nuclide
CAM_L_WGRFPUIDENT	Set if ^{239}Pu identified
CAM_L_WGRFUIDENT	Set if ^{235}U identified

CAM_L_WGRRVWFLG0	Data validity flag: density too high
CAM_L_WGRRVWFLG1	Data validity flag: deadtime too high
CAM_L_WGRRVWFLG2	Data validity flag: ^{233}U too high
CAM_L_WGRRVWFLG3	Data validity flag: ^{235}U too high
CAM_L_WGRRVWFLG4	Data validity flag: U mass too high
CAM_L_WGRRVWFLG5	Data validity flag: 414/129 activity ratio too high
CAM_L_WGRRVWFLG6	Data validity flag: ^{239}Pu too high
CAM_L_WGRRVWFLG7	Data validity flag: Pu mass too high
CAM_L_WGRRVWFLG8	Data validity flag: spectrum validity test failed
CAM_L_WGRRVWFLG9	Data validity flag: ^{239}Pu/^{241}Am ratio too low
CAM_L_WGRRVWFLG10	Data validity flag: ^{239}Pu/^{237}Np ratio too low
CAM_L_WGRRVWFLG11	Data validity flag: maximum FGE exceeded
CAM_L_WGRFCSNOINTF	^{137}Cs interference test performed: no interference detected
CAM_L_WGRFCSAMINTF	^{137}Cs interference test performed: Am interference detected

CAM_L_WGRSTATUS	Engine error code; 0 if none
CAM_T_WGRVERSION	Engine version string (16 characters)
CAM_F_WGRSRCERR	1-sigma relative uncertainty due to source non-uniformity
CAM_F_WGRLUMPERR	1-sigma relative uncertainty due to lumps
CAM_F_WGRAACT	Total alpha activity
CAM_F_WGRAACTERR	1-sigma absolute uncertainty in total alpha activity
CAM_F_WGRTRUACT	TRU activity
CAM_F_WGRTRUACTERR	1-sigma absolute uncertainty in TRU activity

CAM_F_WGRFGE	^{239}Pu fissile gram equivalent (FGE)
CAM_F_WGRFGEERR	1-sigma absolute uncertainty in FGE
CAM_F_WGRFGEMDA	FGE MDA (grams)
CAM_F_WGRDHEAT	Decay heat
CAM_F_WGRDHEATERR	1-sigma absolute uncertainty in decay heat
CAM_F_WGRPUMASS	Pu mass
CAM_F_WGRPUMASSERR	1-sigma absolute uncertainty in Pu mass
CAM_F_WGRUMASS	U mass (see note 3 on page 75)
CAM_F_WGRUMASSERR	1-sigma absolute uncertainty in U mass (see note 3 on page 75)
CAM_F_WGRPU239EA	^{239}Pu equivalent activity (PE)
CAM_F_WGRPU239EAER	1-sigma absolute uncertainty in PE
CAM_F_WGRRMAX	The ratio of maximum system response to volume averaged response
CAM_F_WGRRMIN	The ratio of minimum system response to volume averaged response
CAM_L_WGRWCLASS	0 if the item is considered LLW; non-zero otherwise

Record Parameters

CAM_T_WGRTMUNAME	Nuclide name(8 characters)
CAM_F_WGRTMUACT	Activity
CAM_F_WGRTMUACTERR	1-sigma absolute uncertainty in activity
CAM_L_WGRTMUACTSRC	Source of isotope activity: 0 = none, 1 = isotopic ratio, 2 = gamma activity, 3 = derived activity
CAM_F_WGRTMUMDA	MDA
CAM_F_WGRTMUMDAERR	1-sigma absolute uncertainty in MDA (see note 3 on page 75)
CAM_F_WGRSPECACT	Specific activity for nuclide (µCi/g)

Multi-Modality Results Combination Parameters

This class contains the results of the multi-modality results combination engine, which combines the results of the quantitative gamma, passive neutron coincidence, and DDA TMU engines.

The symbolic name for the class is CAM_CLS_MMCOMBO

CAM_L_MCRFLAGS	Flags
CAM_M_MCRF_DONE [CAM_L_MCRFDONE]	Combination analysis has been performed
CAM_M_MCRF_REVIEW [CAM_L_MCRFREVIEW]	Expert data review is suggested
CAM_M_MCRF_RESCOMPF [CAM_L_MCRFRESCOMPF]	Results comparison test failed
CAM_L_MCRFFGEMAX [CAM_M_MCRF_MAXFGE]	Maximum FGE exceeded
CAM_M_MCRF_GFNNOTID	The fiducial nuclide was not identified by gamma analysis
CAM_T_MCRVERSION	Engine version identification (16 characters)
CAM_L_MCRSTATUS	Engine error status: if 0, no error
CAM_L_MCRINPCOMB	Data available combination
CAM_L_MCROUTCOMB	Source of results from this engine: 0 = undefined, 1 = passive neutron, 2 = quantitative gamma, 3 = DDA, 4 = passive neutron Pu + quantitative gamma U
CAM_F_MCRPUMASS	Pu mass
CAM_F_MCRPUMASSERR	1-sigma absolute uncertainty in Pu mass
CAM_F_MCRUMASS	U mass (see note 3 on page 75)
CAM_F_MCRUMASSERR	1-sigma absolute uncertainty in U mass (see note 3 on page 75)
CAM_F_MCRFGE	^{239}Pu Fissile Gram Equivalent
CAM_F_MCRFGEERR	1-sigma absolute uncertainty in FGE
CAM_F_MCRFGEMDA	FGE MDA (grams)

CAM_F_MCRTRUACT	TRU Activity
CAM_F_MCRTRUACTERR	1-sigma absolute uncertainty in TRU activity
CAM_F_MCRAACT	Total alpha activity
CAM_F_MCRAACTERR	1-sigma absolute uncertainty in Total alpha activity
CAM_F_MCRPU239EA	^{239}Pu equivalent activity
CAM_F_MCRPU239EAER	1-sigma absolute uncertainty in ^{239}Pu EA
CAM_F_MCRDHEAT	Decay heat
CAM_F_MCRDHEATERR	1-sigma absolute uncertainty in decay heat
CAM_L_MCRWCLASS	0 if the item is considered LLW; non-zero otherwise

Record Parameters

CAM_T_MCRISONAME	Isotope name (8 characters)
CAM_F_MCRISOACT	Isotope activity
CAM_F_MCRISOACTERR	1-sigma absolute uncertainty in activity
CAM_L_MCRISOACTSRC	Source of isotope activity: 0 = none, 1 = isotopic ratio, 2 = gamma activity, 3 = derived activity
CAM_F_MCRISOMDA	Isotope MDA
CAM_F_MCRISOMDAERR	1-sigma absolute uncertainty in the MDA (see note 3 on page 75)
CAM_F_MCRSPECACT	Isotope specific activity

Differential Dieaway Analysis Results Parameters

This class contains the results of Differential Dieaway Analysis (DDA); the symbolic name for the class is CAM_CLS_DDARESULTS. This is an active neutron assay technique that uses interrogating neutrons from a pulsed generator to induce fission in the measured item. The data is collected using multichannel analyzers in MCS mode.

This class is organized as follows:

- Common parameters: Store the results of the DDA mass analysis.

- Record parameters: There is one record per source of data (bare detectors, shielded detectors, chamber flux monitor, barrel flux monitor), storing the net count rate.
- Record tabular parameters: There is one tabular entry per gate, storing the gate start and end times/channels and total count rate.

Common Parameters

CAM_L_DDAFLAGS	DDA analysis Flags
CAM_M_DDAF_MASSTL [CAM_L_DDAFMASSTL]	Lower equivalent mass limit violated
CAM_M_DDAF_MASSTH [CAM_L_DDAFMASSTH]	Upper equivalent mass limit violated
CAM_M_DDAF_CRTL [CAM_L_DDAFCRTL]	Chamber early gate lower rate limit violated
CAM_M_DDAF_CRTH [CAM_L_DDAFCRTH]	Chamber early gate upper rate limit violated
CAM_M_DDAF_DONE [CAM_L_DDAFDONE]	Mass engine executed and computed a mass
CAM_M_DDAF_MITL [CAM_L_DDAFMITL]	Moderator index too low
CAM_M_DDAF_MITH [CAM_L_DDAFMITH]	Moderator index too high
CAM_M_DDAF_AITL [CAM_L_DDAFAITL]	Absorber index too low
CAM_M_DDAF_AITH [CAM_L_DDAFAITH]	Absorber index too high
CAM_L_DDASTATUS	Mass engine error status (0 = no error)
CAM_T_DDAVERSION	Mass engine version (16 characters)
CAM_F_DDAMODINDEX	Moderator index
CAM_F_DDAABSINDEX	Absorption index
CAM_F_DDAMODCF	Moderator matrix correction factor
CAM_F_DDAABSCF	Absorption matrix correction factor
CAM_F_DDAAMATRIXCF	Active matrix correction factor

CAM_F_DDAINTERRBKG	Interrogating background
CAM_F_DDAEQMASSINI	Initial equivalent fissile mass – matrix correction only
CAM_F_DDASELFABSCF	Self absorption correction factor
CAM_F_DDAEQMASSSAC	E mass corrected for self absorption
CAM_F_DDAEQMASSBC	Equivalent mass corrected for bias
CAM_F_DDAEQMASSBCE	Uncertainty in equivalent mass corrected for bias
CAM_F_DDAEQMASSMDA	Equivalent mass MDA (grams)
CAM_F_DDAPUMASS	Pu-total Mass (grams)
CAM_F_DDAPUMASSE	Uncertainty in Pu-total Mass (grams)
CAM_F_DDAUMASS	U-total Mass (grams)
CAM_F_DDAUMASSE	Uncertainty in U-total Mass (grams)
CAM_F_DDAUMASSMDA	U mass MDA (grams)
CAM_F_DDACHMBRATE	Chamber monitor net count rate
CAM_F_DDACHMBRATEE	Chamber monitor net rate error
CAM_F_DDAPUMASSE	Pu-total mass MDA (grams)
CAM_F_DDACHMBBLRAT	Barrel to chamber flux ratio (unitless)
CAM_F_DDACHMBBLRAE	Barrel to chamber flux ratio uncertainty (unitless)
CAM_F_DDACHMBBARAT	Bare to chamber flux ratio (unitless)
CAM_F_DDACHMBBARAE	Bare to chamber flux ratio uncertainty (unitless)
CAM_F_DDACHMBSHRAT	Shielded to chamber flux ratio (unitless)
CAM_F_DDACHMBSHRAE	Shielded to chamber flux ratio uncertainty ()
CAM_T_DDAISOSRC	Source of the isotopic ratios used in the analysis; either “Measured” or “Declared” (8 characters)

Record Parameters

CAM_L_DDASOURCETYP	Source type: 0 = Shielded; 1 = Bare; 2 = System; 3 = Flux Monitor; 4 = Barrel Monitor
CAM_F_DDAREALELAPS	Real elapsed time
CAM_F_DDANSRATE	Net totals rate
CAM_F_DDANSRATEERR	Net totals rate uncertainty
CAM_F_DDAINVDWELL	Inverse of MCS dwell time (s-1)
CAM_F_DDATRIGFREQ	Neutron Generator pulse frequency (active) or MCS sweep frequency (passive)

Record Tabular Parameters

CAM_L_DDAGATETYPE	Gate type: 0 = Early Gate; 1 = Late Gate
CAM_F_DDAGATEDELAY	Delay in sec for this gate
CAM_F_DDAGATEWIDTH	Gate width in sec for this gate
CAM_F_DDAGATEFSTRT	ROI Start in fractional channels for this gate
CAM_F_DDAGATEFSTOP	ROI Stop in fractional channels for this gate
CAM_L_DDAGATEISTRT	ROI Start in integral channels for this gate
CAM_L_DDAGATEISTOP	ROI Stop in integral channels for this gate
CAM_F_DDAEFFELAPS	Effective elapsed time for this gate
CAM_F_DDASRATE	Raw totals rate for this gate
CAM_F_DDASRATEERR	Raw totals rate uncertainty for this gate

Differential Dieaway TMU Results

These parameters store the results of TMU analysis of differential dieaway assay results data. The TMU analysis essentially incorporates additional factors in the calculation of uncertainties. In addition, values required for WIPP are calculated.

The symbolic name for the class is CAM_CLS_DDATMU.

Common Parameters

CAM_L_WDRFLAGS	Flags

CAM_M_WDRF_DATAAVL [CAM_L_WDRFDATAAVL]	Results can be used
CAM_M_WDRF_DONE [CAM_L_WDRFDONE]	analysis has been performed
CAM_M_WDRF_DREVIEW [CAM_L_WDRFDREVIEW]	If true, expert data review is required
CAM_M_WDRF_RVWFLG0 [CAM_L_WDRRVWFLG0]	Data review flag 0: gamma differential peak test failed
CAM_L_WDRRVWFLG5	Data review flag: maximum FGE exceeded
CAM_L_WDRSTATUS	Engine error status: if 0, no error
CAM_T_WDRVERSION	Engine version identification string (16 characters)
CAM_F_WDRDHEAT	Decay heat
CAM_F_WDRDHEATERR	1-sigma absolute uncertainty in decay heat
CAM_F_WDRFGE	^{239}Pu Fissile Gram Equivalent
CAM_F_WDRFGEERR	1-sigma absolute uncertainty in FGE
CAM_F_WDRFGEMDA	FGE MDA
CAM_F_WDREQMASSERR	1-sigma absolute error in equivalent mass
CAM_F_WDRMATRIXERR	Matrix error (1-sigma relative)
CAM_F_WDRPTERROR	Source distribution error (1-sigma relative)
CAM_F_WDREQMASSERR	1-sigma absolute error in equivalent mass
CAM_F_WDRPUMASSERR	1-sigma absolute uncertainty in Pu mass
CAM_F_WDRUMASS	U mass
CAM_F_WDRUMASSERR	1-sigma absolute uncertainty in U mass
CAM_F_WDRPU239EA	^{239}Pu equivalent activity
CAM_F_WDRPU239EAER	1-sigma absolute uncertainty in ^{239}Pu EA
CAM_F_WDRAACT	Total alpha activity
CAM_F_WDRAACTERR	1-sigma absolute uncertainty in Total alpha activity
CAM_F_WDRTRUACT	TRU Activity

CAM_F_WDRTRUACTERR	1-sigma absolute uncertainty in TRU activity
CAM_L_WDRWCLASS	0 if the item is considered LLW; non-zero otherwise
CAM_F_WDRRMAX	Maximum point source response
CAM_F_WDRRMIN	Minimum point source response

Record Parameters

There is one record per isotope.

CAM_T_WDRISONAME	Isotope name (8 characters)
CAM_F_WDRISOACT	Isotope activity
CAM_F_WDRISOACTERR	1-sigma absolute uncertainty in activity
CAM_L_WDRISOACTSRC	Source of isotope activity: 0=none, 1=isotopic ratio
CAM_F_WDRISOMDA	Isotope MDA
CAM_F_WDRISOMDAERR	1-sigma absolute uncertainty in the MDA (see note 3 on page 75)
CAM_F_WDRSPECACT	Isotope specific activity

TGS ROI Definitions

This class defines the ROIs to be used in TGS analysis. The symbolic name for the class is CAM_CLS_TGSROIDEFS.

Common Parameters

CAM_L_TROIDFLAGS	Flags
CAM_M_TROI_FTYPE [CAM_L_TROIDFTYPE]	This file contains transmission ROIs (otherwise, contains emission ROIs)
CAM_T_TROIDCOMMENT	Comments (64 characters)
CAM_X_TROIDEDITDAT	Date/time of last edit

Record Parameters (one record per ROI)

CAM_L_TROIDROITYPE	ROI type: 0 = normal, 1 = reference peak

CAM_T_TROIDNUCLIDE	Nuclide name (8 characters)
CAM_F_TROIDENERGY	Peak energy
CAM_F_TROIDFIDU	Energy of the “fiducial” ROI. When a fiducial ROI is specified (i.e., this parameter is non-zero), the mass results of the current ROI are set to the mass of the fiducial ROI scaled by the total counts of the current ROI. The value of this parameter must exactly match the TROIDENERGY value of the fiducial ROI.
CAM_F_TROIDCALFACT	Calibration factor
CAM_F_TROIDLSTART	Left ROI start energy
CAM_F_TROIDLEND	Left ROI end energy
CAM_F_TROIDPSTART	Peak ROI start energy
CAM_F_TROIDPEND	Peak ROI end energy
CAM_F_TROIDRSTART	Right ROI start energy
CAM_F_TROIDREND	Right ROI end energy

TGS ROI Results

This class contains the areas for each TGS ROI for each view; that is, in this class there will be one record per defined ROI per view. The symbolic name for the class is CAM_CLS_TGSROIRES.

Record Parameters

CAM_L_TROIRROINUMB	ROI number; this corresponds to the number of the ROI definition record
CAM_L_TROIRVIEWNUM	View number
CAM_F_TROIRLEFT	Left ROI area
CAM_F_TROIRPEAK	Peak ROI area
CAM_F_TROIRRIGHT	Right ROI area
CAM_L_TROIREREAL	Elapsed real time (in mS) for the spectrum containing this ROI

CAM_L_TROIRELIVE	Elapsed live time (in mS) for the spectrum containing this ROI
CAM_L_TROIRFLAGS	Flags
CAM_M_TROI_REFPK [CAM_L_TROIRFREFPK]	This ROI is for the reference peak
CAM_M_TROI_TRANS [CAM_L_TROIRFTRANS]	This is a transmission ROI

Voxel Data

This class contains 3-D data generated by imaging applications. Each record contains a complete 3-D data set; tabular entries contained in each record represent each data point (i.e., voxel). Three common parameters indicate the X, Y, and Z dimensions of the data sets; i.e., the number of tabular entries in each record should be X * Y * Z. The symbolic name for this class is CAM_CLS_VOXELS.

Common Parameters

CAM_L_VOXXDIM	Image X dimension
CAM_L_VOXYDIM	Image Y dimension
CAM_L_VOXZDIM	Image Z dimension

Record Parameters

CAM_L_VOXRECTYPE	Data set type. The interpretation of this field is application dependent.
CAM_T_VOXRECID1	Data set identification string (16 characters).
CAM_F_VOXRECID2	Data set identification value
CAM_F_VOXRECID3	Data set identification

Record Tabular Parameters

CAM_F_VOXVALUE	Voxel value
CAM_F_VOXVALUEUNC	Uncertainty in voxel value

3. Genie Algorithms

This chapter lists and fully describes the algorithms used by the Genie Spectroscopy Systems, including all optional software.

Energy and Shape Calibration

This section discusses the peak model definition, the least squares fit, the uncertainty estimates for the peak model parameters, and calculation of the calibration curves.

Peak Model

For the purpose of finding peaks and determining their areas, a spectroscopy program must be "taught" what the peaks look like. To do this we'll have to establish some type of a model describing the expected peak shape. Furthermore, the model has to have some free parameters that can be determined from actual measurements.

If the shape calibration is performed without any tailing (tail curves set to NONE), which is recommended for gamma peaks in a NaI spectrum, the algorithms assume a pure Gaussian shape, i.e.

$$F_i = He - \frac{(x_i - c_p)^2}{2\sigma^2} \quad (1)$$

where

F_i is the value of the peak model function at channel x_i,

H is the height of the peak,

c_p is the peak centroid, and

σ is the width of the Gaussian (approximately $\frac{FWHM}{2.355}$, where FWHM is the width of the peak at half height after the subtraction of the continuum).

If the shape calibration is performed with low energy tailing (tail curves set to LOW), which is recommended for alpha spectra and for gamma peaks in a germanium spectrum, the algorithms assume a modified Gaussian function of the form:

$$F_i = \begin{cases} He^{-\frac{(x_i - C_p)^2}{2\sigma^2}} & , X_i > C_p - T \\ He^{\frac{T(2x_i - 2C_p + T)}{2\sigma^2}} & , X_i < C_p - T \end{cases} \quad (2)$$

where T is the “joining point” of the additional tailing exponential.

The effect of the tailing parameter is illustrated in Figure 1. If the tail parameter, T, is small, the tailing is quite pronounced as shown on the left, where the Tail Parameter equals 0.3 FWHM. If the tail parameter is large, the “joining point” is further away from the center of the peak and the effect of the tail is much smaller as shown on the right, where the Tail Parameter equals 0.7 FWHM.

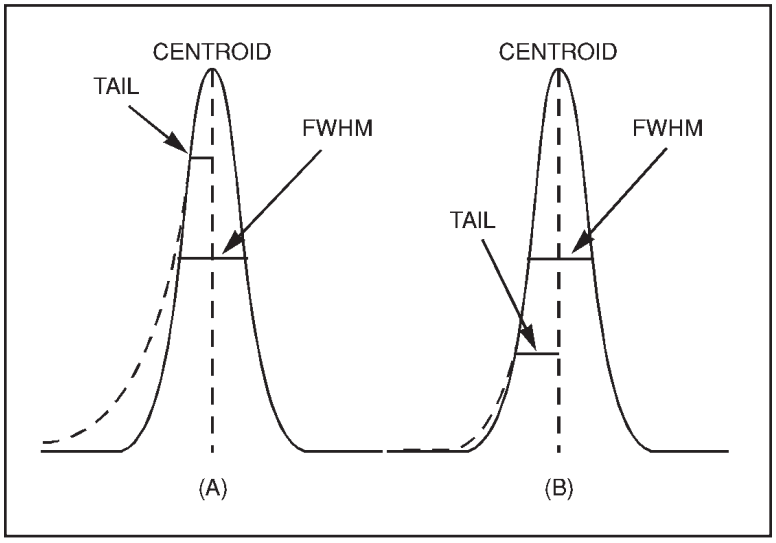


Figure 1 Illustration of Peak and Tail Parameters

In a process called the shape calibration, a number of well defined single peaks that cover the energy range of interest as evenly as possible must be chosen and the program be allowed to calculate their true centroids, their heights, their FWHMs and possibly their tail parameter values.

For alpha spectra, it may not always be possible to select singlets, in which case the peaks with the least amount deviation from a singlet should be chosen. For gamma spectra, the continuum under the peak is subtracted before calculating these parameters using a straight line or a step continuum approximation, depending on which one is in effect. When using the alpha spectroscopy analysis window, the calculations are automatically done without a continuum subtract.

For good results, each gamma calibration peak should have a net photopeak area of at least 20 000 counts.[1] For alpha spectra smaller peaks will also do.

Whether Equation (1) or Equation (2) is used for gamma spectra is determined by the type of the detector or the type of the application. For gamma spectra, selecting the linear or step continuum should be based on the expected shape of the continuum for calibration peaks. In practice, it is desirable to select calibration peaks that are on an essentially flat continuum. That way both continuum functions are essentially identical, and the one that makes more sense can be used during analysis. When using the alpha spectroscopy analysis window, there is no choice but to perform the calculations without a continuum.

Non-Linear Least Squares Fit

For each calibration, the program calculates the four (or three) free shape parameters using a non-linear least squares method.

Let us assume that we have a peak region with a set of data points (x_i,y_i), where x_i is the channel number and y_i are the counts per channel at channel x_i, and we want to "fit" a mathematical model through these data points. This means that we assume that there exists a function F, such that

$$F(x_i, \alpha_1, \alpha_2, K, \alpha_m) = y_i \tag{3}$$

where the α's are free parameters of the model to be determined from the best fit through the data points.

To determine these free parameters we use the method of least squares, which requires that the quantity

$$\chi^2 = \sum_i w_i \cdot \left[y_i - F(x_i, \alpha) \right]^2 \tag{4}$$

where w_i is the weight associated with the i^{th} data point, be a minimum.

1. "Calibration and Usage of Germanium Detectors for Measurement of Gamma-Ray Emission of Radionuclides" (1991). *ANSI Standard N42.14-1991*, American National Standards Institute.

In this formalism, if the uncertainties of the data points are not equal, each point should be weighted by $1 \diagup \sigma_i^2$, where σ_i is the standard deviation of the i^{th} data point.

For Poisson distributed data, $\sigma_i 2 = y_i$, and

$$w_i = \frac{1}{y_i} \tag{5}$$

where y_i are the counts in channel i. This is true for alpha spectroscopy, where no continuum is subtracted from the peak. In gamma spectroscopy, where we do subtract the continuum from the data points before the fit, $\sigma_i^2 \neq y_i$.

In the case of a *linear* continuum subtraction, the modified channel contents must be written as

$$y_i' = y_i - \frac{1}{n} \cdot B_1 - \frac{i \cdot (B_2 - B_1)}{n \cdot (N+1)} \tag{6}$$

and the weighting factor as

$$w_i' = \frac{1}{y_i + \frac{B_1 \cdot (N+1-i)^2 + B_2 i^2}{[n(N+1)]^2}} \tag{7}$$

where

N is the number of channels in the peak ROI,

n is the number of continuum channels on each side (currently always the same on both sides of the peak),

B_1 is the sum of counts in the continuum region to the left of the peak, and

B_2 is the sum of counts in the continuum region to the right of the peak.

In the case of a *step* continuum subtraction, the modified channel contents must be written as

$$y_i' = y_i - \frac{1}{n} \cdot B_1 - \frac{(B_2 - B_1)}{nG} \sum_{j=1}^{i} y_j \tag{8}$$

and the weighting factor must be modified to become

$$w_i' = \frac{1}{y_i + \frac{B_1 \cdot (G - P_i)^2 + B_2 \cdot P_i^2 + (B_2 - B_1)^2 \cdot P_i}{(nG)^2}} \quad (9)$$

where

G is the total sum of counts (gross) in the peak ROI,

N is the number of channels in the peak ROI,

n is the number of continuum channels on each side (currently the same on both sides),

B_1 is the sum of counts in the continuum region to the left of the peak, and

B_2 is the sum of counts in the continuum region to the right of the peak.

See also “Peak Area for Non-Fitted Single Peaks” on page 279.

For peaks having very poor statistics, Equations (7) and (9) tend to overweight channels having lower counts. It has been shown by Phillips that the use of straight statistical weighting causes an underestimation of the areas of such peaks.[2]

A better approach is to use a weighting factor that is based on an average of the number of counts in several adjacent channels. Therefore, y_i in Equations (7) and (8) is replaced with

$$y_i = \frac{y_{i-1} + 2y_i + y_{i+1}}{4} \quad (10)$$

whenever $y_i < 100$.

The quantity χ^2 defined in Equation (4) is minimized when

$$\frac{\partial \chi^2}{\partial \alpha_j} = 0 \quad (11)$$

for all α_j.

2. Phillips, G.W. (1978). *Nucl. Instr. & Meth.* 153:449.

This minimization requirement yields a set of simultaneous equations that may be solved for the α's, provided that the function $F(x_i, \alpha)$ is linear with respect to the α's.

If the function is not linear with respect to the α's, as is the case with both of our Gaussian models for a photopeak shape (with or without the tail parameter), it may be linearized by expanding it in a Taylor's series:

$$F(X,\alpha) = F_0 + \sum_{j=1}^{m} \frac{\partial F_0}{\partial \alpha_j} \delta\alpha_j + \frac{1}{2} \sum_j \sum_k \left[\frac{\partial^2 F_0}{\partial \alpha_j \partial \alpha_k} \delta\alpha_j \delta\alpha_k \right] + K \tag{12}$$

Substituting the Taylor's series expansion in Equation (12) into Equation (4) and keeping only the first order terms, the equation for χ^2 becomes

$$\chi^2 = \sum_i w_i \left[y_i - F_0 - \sum_j \frac{\partial F_0}{\partial \alpha_j} \delta\alpha_j \right]^2 \tag{13}$$

which is now linear in terms of the $\delta\alpha$'s and may be minimized with respect to them as

$$\frac{\partial \chi^2}{\partial(\delta\alpha_k)} = -2 \sum_i w_i \frac{\partial F_0}{\partial \alpha_k} \left[y_i - F_0 - \sum_j \frac{\partial F_0}{\partial \alpha_j} \delta\alpha_j \right] = 0 \tag{14}$$

In matrix notation, we now have a system of linear equations represented by

$$\bar{b} = M \cdot (\overline{\delta\alpha}) \tag{15}$$

where

$$M_{jk} = \sum_i \cdot w_i \cdot \frac{\partial F_0}{\partial \alpha_j} \cdot \frac{\partial F_0}{\partial \alpha_k} \tag{16}$$

and

$$b_k = \sum_i \cdot w_i \cdot (y_i - F_0) \cdot \frac{\partial F_0}{\partial \alpha_k} \tag{17}$$

This gives rise to an iterative procedure, generally referred to as the method of non-linear least squares.

There are many different ways of iterating towards the final solution. The Canberra iteration approach is a modified version of the method developed by Marquardt.[3] The modifications compared to the regular Marquardt algorithm enhance the convergence process and reduce the possibility of divergence with the help of a damping process. Step by step the algorithm proceeds as follows:

1. $\lambda = 0.5$

   $k = 0.9$, a damping constant

   $n = 0$, the iteration counter

   $nmax = 10$, maximum number of iterations without damping

   $nmaxd = 15$, absolute maximum number of iterations

   where λ is a multiplication factor, such that instead of solving for the matrix equation in its original form, the algorithm searches for a solution to the equation

   $$\bar{b} = M' \cdot (\overline{\delta\alpha}) \tag{18}$$

   where

   $$M'_{jk} = \begin{cases} M_{jk}\,(1+\lambda), & j = k, \\ M_{jk}, & j \neq k \end{cases} \tag{19}$$

   The program automatically determines the initial values of the α's that are supplied as input into the algorithm.

2. Compute the $\delta\alpha$'s from

   $$(\overline{\delta\alpha}) = (M')^{-1} \cdot \bar{b} \tag{20}$$

   Exit with an appropriate error, if matrix M⌈ is singular.

3. Increment iteration counter: n=n+1

3. Marquardt, D.W. (1963). *J. Soc. Indust. Appl. Math.* 11:431.

4. Set $\alpha_i n = \alpha_i^{n-1} + k(\delta\alpha)_i^{n-1}$

5. Calculate the square of the residual, $\chi 2\,(\alpha^n)$

6. If any of the α^ni is outside acceptable limits:

    a. Set the offending α's to the limit values.

    b. If n > nmax, exit with an appropriate error.

    c. Set nmax = nmax + 2; if nmax > nmaxd, set nmax = nmaxd.

    d. Set $\lambda = 5\lambda$; if $\lambda > 100$, set $\lambda = 100$; if $\lambda < 0.1$, set $\lambda = 0.1$.

    e. Set k=0.7k; if k<0.2, set k=0.2.

    f. Return to step 2.

7. If n < 2, go to step 12.

8. If n < 3, go to step 11.

9. Test if the convergence has been obtained.

10. If n > nmax, exit with error.

11. If $\chi^2\,(\alpha^n) > \chi^2\,(\alpha^{n-1}) + \varepsilon$, where $\varepsilon = 10^{-3}$ continue; otherwise the iteration is complete.

12. Set $\lambda = 0.1\lambda$, k = 1; return to step 1.

The iteration is assumed to have converged if all of the following conditions are true:

1. change in the peak position is less than 0.01 channels,

2. change in the peak width parameter, W, is less than 0.005W,

3. change in the height parameter is

    a. less than two counts, or

b. less than one-half of the standard deviation in the peak height, whichever is greater, and

4. change in the tailing parameter (if being calculated) is less than 0.5W.

If the four convergence criteria are not met, the iteration is terminated anyway, if after four or more iterations

$$\frac{|\chi^2(\alpha^{n-1}) - \chi^2(\alpha^n)|}{\chi^2(\alpha^n)} < 10^{-3} \quad (21)$$

This test indicates that although the individual parameters may still be changing, the overall fit is not improving and the process may as well be terminated.

In order to prevent "false convergence", tests are not made for convergence unless $k > 0.7$ and $\lambda < 0.05$.

Parameter Uncertainty Estimates

If the original function $F(X,\alpha)$ is a good representation of the data, the variance of α_i is given by the i^{th} diagonal element of the inverted matrix M^{-1}; that is:

$$\sigma^2_{\alpha_i} = M^{-1}_{ii} \quad (22)$$

However, when $F(X, \alpha)$ is not a good representation of the data (which can happen with experimental data), the variances can be better approximated by

$$\sigma^2_{\alpha_i} = Z \cdot M^{-1}_{ii} \quad (23)$$

where Z is the reduced χ^2 of the fit; that is,

$$Z = \frac{\chi^2_{min}}{N - M} \quad (24)$$

where

χ^2_{min} is the χ^2 from the final iteration,

N is the number of channels included in the fit,

M is the number of free parameters that were fit, and

N-M is the number of degrees of freedom (note that we must have $N \geq M+1$).

For a good fit, $Z \rightarrow 1$, and this error estimate is therefore consistent with the use of the diagonal elements of the inverted matrix for good fits.

Calculation of Calibration Curves

When the peak locations, widths, and possibly tailing parameters have been determined for each of the selected calibration peaks,[4] the calibration program determines the calibration coefficients for the following calibration polynomials:

1. Energy (E, in units of keV) as a function of channel number x:

$$E = C_0 + C_1 x + C_2 x^2 + C_3 x^3 \tag{25}$$

where C_0, C_1, C_2, and C_3 are the coefficients to be determined (parameters ECOFFSET, ECSLOPE, ECQUAD, and ECALFAC1, respectively). C_0 represents the energy offset, C_1 represents the "gain", and C_2 and C_3 account for the system non-linearity.

Only C_0 and C_1 are calculated automatically. The other coefficients will be calculated based on selections made during an interactive calibration session, provided that there are enough calibration peaks to calculate them.

At least three calibration peaks are required to calculate C_2, and at least four calibration peaks are required to calculate C_3.

2. For gamma spectra when using the gamma spectrum analysis window, peak full-width at half-maximum (FWHM in units of channels) as a function of energy

$$FWHM = \frac{F_0 + F_1\sqrt{E}}{C_1} \tag{26}$$

where E is the energy in keV, C_1 is the "gain" term from the energy calibration equation, and F_1 and F_0 are the coefficients of the FWHM equation (parameters FWHMOFF and FWHMSLOPE, respectively).

3. For gamma spectra when using the gamma spectrum analysis window, peak low-energy tailing parameter (TAIL in units of channels) as a function of energy

4. The 511 keV annihilation peak, if present, is excluded from this calculation and set aside for establishing the shape whenever a 511 keV line is found during analysis.

$$TAIL = \frac{T_0 + T_1 \cdot E}{C_1} \tag{27}$$

where TAIL is the distance from the centroid to the starting point of the low energy tail, in channels, C_1 is the "gain" coefficient from the energy calibration curve in keV/channel, and T_1 and T_0 are the coefficients of the tailing curve (parameters C1TAIL1 and C2TAIL1, respectively).

Note that energies below 100 keV are not used to calculate the peak low-energy tailing equation.

4. For alpha spectra when using the alpha spectrum analysis window, the peak FWHM as a weighted mean of the individual peak full width at half-maximum values of the calibration peaks as

$$F_{Av} = C_1 \cdot \frac{\sum_{i=1}^{n} \frac{F_i}{\sigma_{F_i}^2}}{\sum_{i=1}^{n} \frac{1}{\sigma_{F_i}^2}} \tag{28}$$

where

F_{Av} is the weighted mean FWHM (in units of keV),

n is the number of calibration points used,

F_i is the FWHM (in channels) of the i^{th} calibration peak,

σ_{F_i} is the standard deviation of F_i, and

C_1 is the "gain" term from the energy calibration equation.

5. For alpha spectra when using the alpha spectrum analysis window, the peak tailing as a weighted mean of the individual peak low energy tailing values as

$$T_{Av} = C_1 \cdot \frac{\sum_{i=1}^{n} \frac{T_i}{\sigma_{T_i}^2}}{\sum_{i=1}^{n} \frac{1}{\sigma_{T_i}^2}} \tag{29}$$

where

T_{Av} is the weighted mean tailing parameter (in units of keV),

n is the number of calibration points used,

T_i is the tailing parameter (distance from the centroid to the starting point of the low energy tail in channels) of the i^{th} calibration peak,

σ_{T_i} is the standard deviation of T_i, and

C_1 is the "gain" term from the energy calibration equation.

When using the gamma spectroscopy analysis window for gamma spectra, the order of the FWHM and TAIL curves cannot be changed. However, it is possible to edit the coefficients through the "Energy Coeff" option and set either F_1 and possibly T_1 to zero, which makes the FWHM and possibly the tailing parameter constant for the whole calibration range.

When using the alpha spectroscopy analysis window for alpha spectra, only a constant FWHM and a constant tail parameter are permitted. However, their values may be changed through the "Energy Coeff"option.

Energy Calibration Conversion for Other File Types

Genie uses a convention of the first channel in the spectrum being channel 1. Some other programs use a convention of labeling the first channel as channel 0. When converting such files to the Genie format, the conversion program uses the following equations to preserve the correct energy calibration for the converted file.

The new offset term (parameter ECOFFSET) is

$$ECOFFSET = C_0 - C_1 + C_2 - C_3 \quad (30)$$

where the C_0 through C_3 are the offset, slope, quadratic, and cubic terms of the energy calibration equation, respectively, based on the zero first channel convention.

The new slope term (parameter ECSLOPE) is

$$ECSLOPE = C_1 - 2C_2 + 3C_3 \quad (31)$$

and the new quadratic term (parameter ECQUAD) is

$$ECQUAD = C_2 - 3C_3 \quad (32)$$

Efficiency Calibration

This section discusses the peak efficiency calculation using the dual efficiency, linear efficiency, empirical efficiency and average efficiency models.

Calculation of Peak Efficiency

The peak detection efficiency at a given energy is defined as

$$\varepsilon(E) = \frac{S}{T_l \; y \; A \; K_w \; U_f} \tag{33}$$

where

$\varepsilon(E)$ is the efficiency at energy E,

S is the net peak area of the calibration peak,

T_l is the live time of the measurement,

y is the branching ratio (also called yield) of the calibration nuclide at this energy,

A is the source activity at the source reference time (certificate time),

U_f is a factor to convert the activity A from other activity units into units of Bq (if applicable), and

K_w is the decay correction factor to decay correct the activity A to the activity at the time of the start of acquisition; that is,

$$K_w = e^{-\frac{\ln(2) t_w}{T_{1/2}}} \tag{34}$$

where

t_w is decay time of the calibration source (the elapsed time between the start of the acquisition and the time at which the calibration source activities are reported, and

$T_{1/2}$ is half-life of the calibration nuclide.

In the interactive mode in the gamma and alpha spectroscopy analysis windows, the peak areas are automatically determined using the peak area calculation method and continuum function currently in effect. In the batch environment, the peak locate and area algorithms of choice may be specified as qualifiers in the command line.

The same area algorithm intended to be used during quantitative analysis should be selected for use during efficiency calibration. There are systematic differences between different area calculation models, and the only way to assure consistency of results between the calibration and analysis is to use the same algorithm.

The peak efficiency must be calculated for a set of well defined single peaks (or as close to a single peak as possible) using a standard source of the same geometry and count rate as is expected for the actual samples. Furthermore, the peaks should cover the entire energy range of interest.

Calculation of the Dual Efficiency Curve

After the peak detection efficiency has been established for each calibration peak, the detection efficiency as a function of energy can be represented in many different ways. In the gamma spectroscopy analysis window, one of the forms chosen in the Canberra software can be described by a polynomial function of the form

$$\ln(\varepsilon) = \sum_{i=0}^{n} b_i \cdot (\ln(E))^i \qquad (35)$$

where

b_i is the coefficient to be determined by the calculation,

ε is the photopeak efficiency at energy E, and

E is the photopeak energy.

This model is called the *dual* function because two separate models are supported;

1. two curves - one for the low energy region and one for the high energy region - with a single “crossover” point common to both, or

2. a single curve (a crossover of zero).

After the peak detection efficiency has been determined for each calibration peak, a weighted least squares fit is made to a polynomial expression shown in Equation (35). If the two curve approach is used, a separate fit is made in each energy region and the result is two separate curves. Figure 2 shows an example of the general shape of the efficiency curve.

The default degree of the polynomial, n, depends on the number of calibration points available as follows:

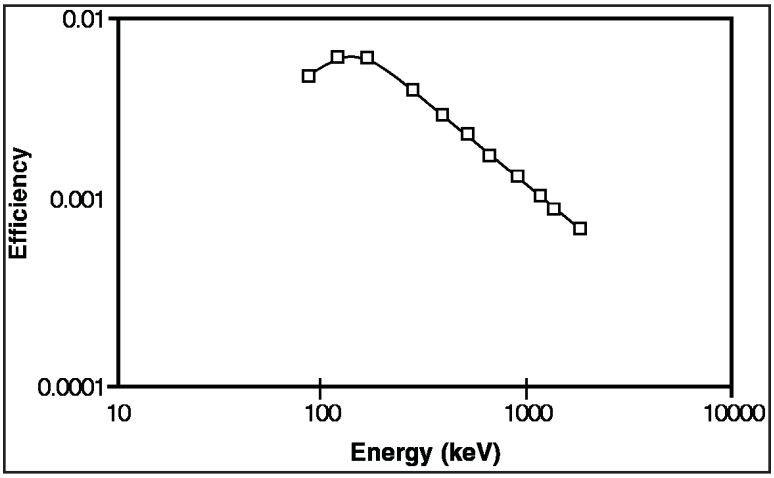


Figure 2 Typical Efficiency Curve for Ge Detectors

For E ≤ cross-over energy:

n = 5 for ten or more (high energy) calibration points.
n = 4 for eight or nine calibration points.
n = 3 for six or seven calibration points.
n = 2 for three to five calibration points.

For E ≥ cross-over energy:

n = 5 for ten or more (high energy) calibration points.
n = 4 for eight or nine calibration points.
n = 3 for six or seven calibration points.
n = 2 for three to five calibration points.

The order of the low energy curve can be changed interactively up to n=5, and the high energy curve up to n=9, provided that a sufficient number of calibration points is available.

The maximum allowed order of the calibration curve is N-1, where N is the number of calibration points in the energy region to be used. The lowest allowed order of the curve in either region is n=2.

Thus, for a two curve model, at least five calibration points are required: two below the cross-over energy, one at the cross-over energy, and two above it.

For a single curve model, at least three calibration points are required (more points are recommended).

The default order of the polynomial in the single polynomial model follows the rules for the higher energy curve of the two polynomial model.

The calibration coefficients for the two (or one) efficiency calibration curves are determined using a linear least squares method from the equation

$$M \cdot \bar{b} = \bar{V} \tag{36}$$

where

$$M_{jk} = \sum_i W_i \cdot [\ln(E_i)]^{j-1} \cdot [\ln(E_i)]^{k-1} \tag{37}$$

And

$$V_k = \sum_i W_i \cdot \ln(\varepsilon_i) \cdot [\ln(E_i)]^{k-1} \tag{38}$$

where W_i is the weighting factor of the i^{th} calibration point.

The weighting factor is the inverse of the variance of ln(ε), which is made up of two components:

1. The uncertainty in the peak area used to determine the efficiency ε.

2. The uncertainty in the calibration source activity.

The variance in efficiency, denoted by σ_ε^2 (where σ_ε is the standard deviation of ε), is obtained from the equation

$$\sigma_\varepsilon^2 = \varepsilon^2 \cdot \left[\left(\frac{\sigma_S}{S} \right)^2 + \left(\frac{\sigma_A}{A} \right)^2 \right] \tag{39}$$

where

S is the net peak area of the calibration peak in question,

σ_S is the standard deviation of the peak area,

A is the known activity of the calibration nuclide in question, and

σ_A is the standard deviation of the source activity including the uncertainty of the branching ratio.

The variance of ln(ε) is given by

$$(\sigma_{\ln \varepsilon})^2 = \left(\frac{1}{\varepsilon}\right)^2 \cdot \sigma_\varepsilon^2 \tag{40}$$

and therefore the weighting factor W_i is

$$W_i = \left(\frac{\varepsilon}{\sigma_\varepsilon}\right)^2 \tag{41}$$

The matrix equation is solved directly for the b's by inverting the matrix M, and the variances of the b's are obtained from the inverse matrix.

Use of the ln-ln relationship for the efficiency function results in a high degree of correlation between the b's. Therefore the normal method of calculating the errors for the b's from the diagonal elements of the inverse matrix cannot be used. Instead the covariance terms, expressed as

$$\text{Covar}(b_j, b_k) = (M^{-1})_{j,k} \quad , \quad k \neq j \tag{42}$$

as well as the diagonal terms are stored into the efficiency calibration results to be subsequently used for analyses. The variances and covariances are stored as double precision values to eliminate significant round-off errors due to the high degree of correlation between the b's.

If a crossover energy is in use, its value is written into the parameter CROSSOVER, otherwise the crossover parameter value is set to zero. The calibration coefficients (b's) for the low energy curve (if in use) are written into the parameters DLCALFAC1 through DLCALFAC3 since only a 2nd order curve is supported at the present time. The reduced chi-square of the fit is written into parameter DLCALCHI and the degree of the low energy polynomial into the parameter DLDEGREE.

The calibration coefficients (b's) for the high energy curve are written into the parameters DHCALFAC1 through DHCALFAC10, the reduced chi-square of the fit into parameter DHCALCHI, and the order of the high energy polynomial into the parameter DHDEGREE.

Calculation of the Linear Efficiency Curve

After the peak detection efficiency has been established for each calibration peak in the gamma spectroscopy analysis window, the detection efficiency as a function of energy can also be represented with the use of the following function

$$\log(\varepsilon) = \sum_{i=-1}^{n} a_i \cdot \left(\frac{1}{E}\right)^i \tag{43}$$

where

a_i is the coefficient to be determined by the calculation,

ε is the photopeak efficiency at energy E, and

E is the photopeak energy.

This model is called Linear because no logarithms are used for the energy side of it.

After the peak detection efficiency has been determined for each calibration peak, a weighted least squares fit is made to a polynomial expression shown in Equation (43).

The default degree of the polynomial, n, depends on the number of calibration points available as follows:

n = 5 for ten or more calibration points.
n = 4 for eight or nine calibration points.
n = 3 for six or seven calibration points.
n = 2 for three to five calibration points.

The order of the high energy curve can be changed interactively, up to n = 9, provided that a sufficient number of calibration points is available.

The maximum allowed order of the calibration curve is N-1, where N is the number of calibration points in the energy region to be used. The lowest allowed order of the curve is n=2.

Thus, at least three calibration points are required (more points are recommended).

The calibration coefficients for the efficiency calibration curve are determined using a linear least squares method from the equation

$$M \cdot \bar{a} = \overline{V} \tag{44}$$

where

$$M_{jk} = \sum_i W_i \cdot \left(\frac{1}{E}\right)^{j-1} \cdot \left(\frac{1}{E}\right)^{k-1} \tag{45}$$

and

$$V_k = \sum_i W_i \cdot \log(\varepsilon_i) \cdot \left(\frac{1}{E}\right)^{k-1} \tag{46}$$

where W_i is the weighting factor of the i^{th} calibration point.

The weighting factor is the inverse of the variance of log(ε), which is made up of two components:

1. The uncertainty in the peak area used to determine the efficiency ε.

2. The uncertainty in the calibration source activity.

The variance in efficiency, denoted by σ_ε^2 (where σ_ε is the standard deviation of ε), is obtained from the equation

$$\sigma_\varepsilon^2 = \varepsilon^2 \cdot \left[\left(\frac{\sigma_S}{S}\right)^2 + \left(\frac{\sigma_A}{A}\right)^2 \right] \tag{47}$$

where

S is the net peak area of the calibration peak in question,

σ_S is the standard deviation of the peak area,

A is the known activity of the calibration nuclide in question, and

σ_A is the standard deviation of the source activity including the uncertainty of the branching ratio.

The variance of log(ε) is given by

$$\sigma_{\log(\varepsilon)}^2 = \left(\frac{\log(e)}{\varepsilon}\right)^2 \cdot \sigma_\varepsilon^2 \tag{48}$$

and therefore the weighting factor W_i is

$$W_i = \left(\frac{\varepsilon}{\sigma_\varepsilon \cdot \log(e)}\right)^2 \tag{49}$$

The matrix equation is solved directly for the a's by inverting the matrix M, and the variances of the a's are obtained from the inverse matrix.

Use of the logarithm for the efficiency results in a correlation between the a's. Therefore, the covariance terms, expressed as

$$\mathrm{COVAR}(a_j, a_k) = (M^{-1})_{j,k} \quad , \quad k \neq j \tag{50}$$

as well as the diagonal terms, are stored into the efficiency calibration results to be subsequently used for analyses, as when the dual efficiency curve is used. The variances and covariances are stored as double precision values to eliminate any round-off errors.

The calibration coefficients (a's) for the LINEAR efficiency calibration curve are written into the parameters LNCALFAC1 through LNCALFAC10, the reduced chi-square of the fit into parameter LNCHISQ, and the order of the polynomial into the parameter LNDEGREE.

Calculation of the Empirical Efficiency Curve

After the peak detection efficiency has been established for each calibration peak in the gamma spectroscopy analysis window, the detection efficiency as a function of energy can also be represented with the use of the following function:

$$\ln(\varepsilon) = \sum_{i=0}^{n} c_i \cdot \left[\ln\left(\frac{c_a}{E} \right) \right]^i \tag{51}$$

where

c_i is the coefficient to be determined by the calculation,

ε is the photopeak efficiency at energy E,

E is the photopeak energy,

c_a is a scaling factor and calculated as $\frac{E_2 + E_1}{2}$,

E_2 is the largest calibration energy, and

E_1 is the smallest calibration energy.

This model is called Empirical for historical reasons.

After the peak detection efficiency has been determined for each calibration peak, a weighted least squares fit is made to the polynomial expression shown in Equation (51). The order of the polynomial, n, depends on the number of calibration points as follows:

n = 5 for ten or more calibration points.
n = 4 for eight or nine calibration points.
n = 3 for six or seven calibration points.
n = 2 for three to five calibration points.

The order can be changed interactively up to n=5, provided that there are enough calibration points. The maximum order is N-1 (up to 5), where N is the number of calibration points in the energy region to be used.

Thus, at least three calibration points are required (more points are recommended).

The calibration parameters for the efficiency calibration curve are determined using a linear least squares method from the equation:

$$M \cdot \bar{c} = \overline{V} \tag{52}$$

where

$$M_{jk} = \sum_i W_i \cdot \left[\ln\left(\frac{c_a}{E_i}\right) \right]^{j-1} \cdot \left[\ln\left(\frac{c_a}{E_i}\right) \right]^{k-1} \tag{53}$$

and

$$V_k = \sum_i W_i \cdot \ln(\varepsilon_i) \cdot \left[\ln\left(\frac{c_a}{E_i}\right) \right]^{k-1} \tag{54}$$

where W_i is the weighting factor of the i^{th} calibration point.

The weighting factor is the inverse of the variance of ln(ε), which is made up of two components:

1. The uncertainty in the peak area used to determine the efficiency ε.

2. The uncertainty in the calibration source activity.

The variance in efficiency, denoted by σ_ε^2, where σ_ε is the standard deviation of ε), is obtained from the equation

$$\sigma_{\varepsilon}^{2} = \varepsilon^{2} \cdot \left[\left(\frac{\sigma_S}{S} \right)^2 + \left(\frac{\sigma_A}{A} \right)^2 \right] \tag{55}$$

where

S is the net peak area of the calibration peak in question,

σ_S is the standard deviation of the peak area,

A is the known activity of the calibration nuclide in question, and

σ_A is the standard deviation of the source activity including the uncertainty of the branching ratio.

The variance of ln(ε) is given by

$$\left(\sigma_{\ln(\varepsilon)} \right)^2 = \left(\frac{1}{\varepsilon} \right)^2 \cdot \sigma_{\varepsilon}^{2} \tag{56}$$

and therefore the weighting factor W_i is

$$W_i = \left(\frac{\varepsilon}{\sigma_{\varepsilon}} \right)^2 \tag{57}$$

The matrix equation is solved directly for the c's by inverting the matrix M.

In this model, the covariance terms are not established for error propagation. Instead, the difference between the measured efficiency and the calculated efficiency (from the fitted curve) and the uncertainty of the calibration point (a combination of the source activity error and the peak area error) are added together in a root-mean-square sense to form an interpolation error value. These interpolation error values are stored into the efficiency calibration results for each calibration energy for subsequent use.

The calibration coefficients (c's) for the Empirical Efficiency Calibration curve are written into the parameters DCALFAC2 through DCALFAC7, the scaling parameter as DCALFAC1, the reduced chi-square of the fit into parameter EMPCHISQ, and the order of the high energy polynomial into the parameter EMPDEGREE.

Calculation of the Average Efficiency Curve

In the alpha spectroscopy analysis window, the efficiency is calculated as a weighted average of the individual efficiency values rather than a curve. The average efficiency is calculated as

$$\varepsilon_{Av} = \frac{\sum_{i=1}^{n} \frac{\varepsilon_i}{\sigma_{\varepsilon_i^2}}}{\sum_{i=1}^{n} \frac{1}{\sigma_{\varepsilon_i^2}}} \quad (58)$$

where

ε_{Av} is the weighted mean efficiency,

n is the number of calibration points used,

ε_i is the efficiency of the i^{th} calibration peak, and

σ_{ε_i} is the standard deviation of $\varepsilon_{i.}$

and its uncertainty is

$$\sigma_{\varepsilon_{Av}} = \sqrt{\frac{1}{\sum_{i=1}^{n} \frac{1}{\sigma_{\varepsilon_i^2}}}} \quad (59)$$

The weighted average efficiency is stored in the parameter AVRGEFF and its uncertainty into the parameter AVRGEFFERR.

Peak-to-Total Calibration

The methodology developed to correct for cascade summing effects requires the knowledge of P/T ratios at various point locations within the voluminous source. While it is desirable to use the exact P/T ratio at each point location (subsource) inside the source volume, it's rather tedious to perform such measurements. V.P. Kolotov et al.[5] have demonstrated that the P/T ratios are weakly dependent on the source-detector distance.

5. Kolotov, V.P., Atrashkevich, V.V. and Gelsema, S.J. (1996). *Journal of Radioanalytical and Nuclear Chemistry*, 210:183

They have also measured the P/T ratios at various points on the top and side of the detector endcap and shown that the P/T ratios are effectively independent of the source position. Any small variation in the P/T ratio as a function of source position will not have a significant impact on the final cascade summing correction factor[6]. It is suggested that the P/T calibration measurements be performed using a series of individual point sources located at a given source-detector distance.

Canberra recommends a set of affordable uncalibrated point sources with the following nuclides: ^{109}Cd, ^{57}Co, ^{113}Sn, ^{137}Cs, ^{54}Mn and ^{65}Zn. These are "single gamma" emitting nuclides. In addition, an ^{241}Am source may be used if necessary and if it is available. But for most applications, a valid P/T calibration curve can be generated without having to use an ^{241}Am source.

In the case of ^{109}Cd and ^{113}Sn sources, a thin absorber foil has been incorporated into the sources, in order to filter out the low energy X rays that are emitted by these nuclides. If the X rays are not filtered out, they could skew the P/T ratios at ^{109}Cd and ^{113}Sn gamma-ray energy.

If the ambient background in the counting area is not negligible, a background spectrum must be collected and used in the P/T calibration process. Another factor that could influence the P/T ratios is the presence of bulk materials near the detector, such as walls, shielding, sample holder etc. It is highly recommended that the measurement be set up away from such scattering media.

Prior to running the P/T calibration software, a peak analysis must be performed on the point source and background spectra. The P/T calibration software sets some parameters that govern the calculation of the P/T ratios. These parameters are "Extrapol. Channel" and "Avg. Window", and the number of iterations.

The "Extrapol. Channel" and "Avg. Window" parameters are used to extrapolate the counts in the continuum to the 0th channel. For example, at the default values of 20 for "Extrapol. Channel" and 4 for "Avg. Window", the software sets up a window of four channels to left and right of channel 20, determines the average number of counts per channel in this window and places the average at channel 20. The extrapolated counts to the 0th channel are determined by multiplying the average counts per channel by 20.

By performing the extrapolation to 0th channel, the software ensures that the counts due to photons that have downscattered from the main gamma ray energy are taken into account, at the same time avoiding the deleterious influence of low energy noise artifacts. The default value of 20 for the "Extrapol. Channel" will yield good P/T results for spectra that are not affected by X-ray peaks. For spectra that are in fact affected by X-ray peaks, it may be necessary to set up a higher value for the "Extrapol. Channel" parameter.

6. F. De Corte and C. Frietas. *Journal of Radioanalytical and Nuclear Chemistry*, 160:253 (1992).

The software automatically analyzes the point source spectra of “single gamma” emitting radionuclides, performing background correction and computing the P/T ratios at the gamma ray energies corresponding to the “main” peaks in the point source spectra. The software uses a special certificate file PTCAL.NLB to identify the correct gamma ray peaks from “single gamma” nuclides. Some nuclides such as ^{57}Co, ^{113}Sn, and ^{65}Zn are not strictly single gamma emitting nuclides. As a result, the P/T ratios at the main gamma ray peak energies of these nuclides are contaminated by satellite peaks. The contamination due to a satellite peak is corrected using an iterative process.

Using a chi-squared minimization technique, the P/T values at the main peak energies of the 8 nuclides are fitted by a logarithmic function.

$$\ln(P / T) = a + b \cdot \ln E_{\gamma} + c \cdot (\ln E_{\gamma})^2 + d / E_g^n \tag{60}$$

Initially, this function may not provide a good fit to the measured P/T data since 3 of the 8 data points are contaminated by satellite peaks. An iterative technique is employed to correct the “Total” value for the effect of the side peak. During the first iteration, the P/T ratio at the satellite peak energy is used to compute the satellite peak’s contribution to the continuum (Backgr). This is then subtracted from the original “Total” value.

$$\text{Backgr} = (\text{Satellite Peak Area}) \cdot \left[\frac{1}{P/T} - 1 \right] \tag{61}$$

Using this corrected “Total” value, a new P/T ratio is computed at the corresponding main peak energy. The improved set of data points is then fitted by the logarithmic function.

In the next iteration, the process is repeated with the P/T ratio at the satellite peak being obtained from the refined curve from iteration #1. As a result, the correction to the original “Total” value is improved. Thus, the P/T ratio at the main peak energy is improved and consequently, a better fit is obtained. The iterative technique described above converges very quickly. To ensure convergence for all cases, the default value of 10 iterations is recommended.

The Genie 2000 software uses the P/T calibration entries from the final iteration to plot the calibration curve. The calibration curve will be plotted in the dual mode with a cross-over energy of 122 keV (^{57}Co). A default order of 2 will be used for the high energy polynomial. This provides a linear and predictable extrapolation in the log-log scale.

Peak Locate Calculations

Genie 2000 architecture currently provides five algorithms for locating the peaks in a spectrum: “User Specified”, “Library (Simple)”, “Library (Gamma-M)”, “Unidentified 2nd Diff”, and “VMS Standard Peak Search”. Each of these methods is described in detail in the following sections. As a general rule, the “User Specified” method is best suited for an application where only specific regions of the spectrum are of interest. The “Library (Simple)” method is best suited for situation where the contents of the spectrum are well known and the energy calibration is not expected the vary from spectrum to spectrum, such as in alpha spectroscopy. The “Library (Gamma-M)” method is best suited for situations where only specific nuclides are of interest, for NaI analysis, and for situations where some tests are required to make sure that the peaks are actually present. The “Unidentified 2nd Diff” method is best suited for applications where the contents of the spectrum are not known in advance. The “VMS Standard Peak Search” method is an alternative to the Unidentified 2nd difference peak locate and Sum Non-Linear Least Squares Fit peak analysis function combination. The VMS Standard Peak Search performs a 2nd difference peak locate followed by a pure Gaussian fit peak analysis.

User Specified Peak Locate

The User Specified Peak allows regions of interest (ROIs) be specified in the spectrum display or to loaded from an external secondary ROI file for each of the peaks in question. The peak location is calculated as the geometric center of the channel contents of the ROI. With this method there are no tests to determine the absence or presence of a peak in the specified ROI. The selected ROI limits will be used as such if the area calculations are performed with the Sum/Non-Linear LSQ Method, unless the peak locate results are a combination of user-specified results and other types of peak locate results (see “Sum/Non-Linear Least Squares Fit Peak Area” on page 277277277).

If the algorithm is executed in the “add to existing results” mode (the Add to Existing Results check box in the setup screen is checked), the calculated peak locations will be merged with existing peak locations provided that they are outside the energy tolerance (fixed or variable, whichever is in effect) of an existing peak. If the Add to Existing Results check box is *not* checked, the calculated peak locations will overwrite the existing peak locations.

Executing the User Specified Peak Locate algorithm creates the Peak Search Results class of CAM parameters (if one does not already exist) and writes out the following parameters:

PEAKVERS	The name and version of the locate algorithm
PSDATE	The date and time peak locate was performed
PSLOCCENT	The peak location centroid
PSDLOCCENT	The uncertainty of peak location centroid (this is always set to 0, since no location uncertainty is calculated by this method)

PSENERGY	The peak energy
PSDENERGY	The uncertainty in the peak energy (this is always set to 0, since no energy uncertainty is calculated by this method)

Library (Simple) Peak Locate

The Library (Simple) peak locate will assign the peak locations based on the library energies. Unlike the Library (Gamma-M) algorithm, there is no erosion of the continuum, gainshift correction or MDA calculations to verify that the peaks are indeed present. All such calculations are delegated to the peak area calculations.

If the algorithm is executed in the "add to existing results" mode (the Add to Existing Results check box in the setup screen is checked), found peaks will be merged with existing results provided that they are outside the energy tolerance (fixed or variable, whichever is in effect) of an existing peak. If the Add to Existing Results check box is *not* checked, the found peak results will overwrite the existing peak results.

If the energy calibration curve is 1st order, the energy values from the library are converted to channel numbers using

$$ch = \frac{E - C_0}{C_1} \tag{62}$$

where C_0 is the offset term of a linear energy calibration and C_1 is the slope term. If the energy calibration curve is 2nd order, the energy values from the library are converted to channel numbers using

$$ch = \frac{-C_1 + \sqrt{C_1^2 + 4C_2(E - C_0)}}{2C_2} \tag{63}$$

where C_0, C_1, and C_2 are the offset term, slope, and quadratic term of the energy calibration equation, respectively. If the absolute value of the quadratic term, C_2, is less than 1×10^{-10}, it is ignored and the equation for the linear curve is used instead.

Executing the Library (Simple) Peak Locate algorithm creates the Peak Search Results class of CAM parameters (if one does not already exist) and writes out the following parameters:

PEAKVERS	The name and version of the locate algorithm
PSDATE	The date and time peak locate was performed
PSLOCCENT	The peak location centroid

PSDLOCCENT	The uncertainty of peak location centroid (this is always set to 0, since no location uncertainty is calculated by this method)
PSENERGY	The peak energy
PSDENERGY	The uncertainty in the peak energy (this is always set to 0, since no energy uncertainty is calculated by this method)

Library (Gamma-M) Peak Locate

The Library (Gamma-M) Peak Locate algorithm includes steps for determining the background continuum using an erosion technique as well as establishing the presence of both library and unknown peaks.

Peak Erosion

The Library (Gamma-M) Peak Locate and its companion Library (Gamma-M) Peak Area are based on work by East *et al*.[7] During the locate phase, the first step is the determination of the continuum background. In this step, the photopeaks are eroded until they subside into the continuum to establish a "background continuum" spectrum. In this process, the spectrum is first divided into energy bins with the spacing and width of the bins being proportional to the expected FWHM at the center of each bin. The bins are then grouped into four PLYs, with the first bin being part of ply 1, the second bin part of ply 2, the third bin part of ply 3, the fourth bin part of ply 4, the fifth bin part of ply 1, the sixth bin part of ply 2, etc.

The first step requires the determination of the number of bins, N_b, which is calculated from equation

$$N_b = \frac{CH_L \cdot F_L}{k \cdot F_M} \tag{64}$$

where

CH_L is the last channel of the spectrum,

k is an empirical multiplier,

F_L is the expected FWHM (in channels) at the last channel of the spectrum, and

F_M is the expected FWHM (in channels) at the mid-channel of the spectrum.

The empirical multiplier k is initially set to 0.4. However, if the number of bins indicated by this equation exceeds 3400, k is modified by multiplying it by 1.1, then

7. East, L.V, Phillips, R.L. and Strong, A.R. (1982). *Nucl. Instr. & Meth.* 193:147.

the calculation is repeated. If the number of bins is still greater than 3400, the modified k is again multiplied by 1.1 and the process is repeated until $N_b \leq 3400$.

After establishing a reasonable value for k, the width of each bin (in channels) is calculated as

$$Z = k \cdot \text{FWHM(channels)} \tag{65}$$

where

k is the last value arrived at to make sure that the total number of bins remains at 3400 or less, and

FWHM(channels) is evaluated from the calibration information at the low channel of the bin. For the first bin, the low channel is the first channel of the spectrum. For all other bins, the low channel is the last channel of the previous bin.

However, if the width of the bin calculated with Equation (65) is less than one channel, the width is set to one channel.

Note that the bin width does not remain constant and does not need to be a whole number of channels. The average contents of a bin is calculated as

$$B_i = \frac{\sum_k W_k Y_k}{\sum_k W_k} \tag{66}$$

where the sums range over all channels inside the bin and

W_k is the fraction of channel k inside bin i, and

Y_k are the counts in channel k.

For the low channel

W_k = 1 - (the fractional part of the low channel number),

and for the high channel

W_k = the fractional part of the high channel number.

Otherwise

$W_k = 1$.

After we have established the averages for each bin, they are modified from left to right according to the following rule

$$B'_k = \begin{cases} B_k, & \text{if } B_k < \dfrac{(B'_{k-4} + B_{k+4})}{2} \\ \dfrac{B'_{k-4} + B_{k+4}}{2}, & \text{if } B_k > \dfrac{(B'_{k-4} + B_{k+4})}{2} \end{cases} \quad (67)$$

where

B'_k is the new average in bin k, and

B_k is the old average in bin k.

The process is repeated eight times. After the eighth pass, the continuum background is constructed as

$$C_k = \text{MINIMUM}(Y_{k,} E_{1k}, E_{2k}, E_{3k}, E_{4k}) \quad (68)$$

where

C_k is the estimated continuum background in channel k,

Y_k is the original counts in channel k, and

E_{ik} is the estimate of the continuum formed for the k^{th} channel using the i^{th} ply, and defined as

$$E_{ik} = B_{k-4} + \frac{(B_k - B_{k-4})(i - ch_{k-4})}{(ch_k - ch_{k-4})} \quad (69)$$

where

B_k is the average count rate in the bin that channel k belongs to, and

ch_k is the center channel of the bin that channel k belongs to.

The continuum background spectrum is then subtracted from the original spectrum to form a net spectrum, which is used for peak fits.

Peak Fitting

The peak fits in the Library (Gamma-M) Locate are done to a peak region whose limits are defined by the AREAWIND1 parameter using a peak model consisting of a pure Gaussian,[8] i.e.

$$F_G(x_i) = he^{-\frac{(x_i - E)^2}{Z^2}} \tag{70}$$

where

h is the height of the peak,

x_i is the energy at channel i,

E is the energy of the incident gamma ray, and

Z is a measure of the peak width.

In this algorithm, we calculate the photopeak areas by fitting the Gaussian model to the data in the least squares sense, which requires that the quantity

$$\chi^2 = \sum_i W_i \left[Y_i - F(x_{i,} P_j) \right]^2 \tag{71}$$

where

W_i is the weighting factor assigned to the i^{th} data point,

Y_i is the net counts (original data minus the background continuum), and

P_j is the j^{th} parameter to be fit,

be a minimum. The quantity χ^2 will be at a minimum, if

$$\frac{\partial \chi^2}{\partial P_j} = 0 \tag{72}$$

for all P_j.

8. If the shape calibration was performed with the low energy tail included, the tail parameter will be ignored in this algorithm.

Performing a least squares fit in this manner with a Gaussian function leads to a non-linear problem, if all three parameters (h, E, and Z) are allowed to be solved for best fit. To simplify the problem, we will assume that the parameters E and Z will be fixed, with E taken from the library energy and Z from the calibration information.

If the automatic gain shift correction is enabled, we will introduce an additional term in the fitting functions that provides an estimate of any peak shifts that might be required. This additional term is given by

$$F_s(x_i) = \frac{dY_i}{dx_i} \cdot (1 + Q_0) \tag{73}$$

where

(dY_i/dx_i) is the slope of the background subtracted spectrum at channel i, and

Q_0 is the fractional shift in the peak position.

The slope of the spectrum is determined numerically from a weighted first difference, namely

$$\frac{dY_i}{dx_i} = \left(\frac{1}{2}\right)\left[\frac{Y_{i+2} + 2Y_{i+1}}{4} - \frac{2Y_{i-1} + Y_{i-2}}{4}\right] = \left[\frac{Y_{i+2} - Y_{i-2}}{8} + \frac{Y_{i+1} - Y_{i-1}}{4}\right] \tag{74}$$

where Y_i is the background subtracted data in channel i.

A small residual background may remain after the estimated continuum background has been subtracted from the pulse height spectrum, especially at low energies. In order to correct for this, we have added a straight line term to the fitting function. The complete fitting function for each peak E_j thus becomes:

$$F(x_i) = B_0 + B_1(x_i - E_j) + \frac{dY_i}{dx_i} \cdot (1 + Q_0) + H_j e^{-\frac{(x_i - E_j)^2}{Z_j^2}} \tag{75}$$

where the values determined from the fit are:

B_0 the constant background term,

B_1 the slope background term,

Q_0 the fractional shift in the peak position, and

H_j the height of the peak at E_j.

A non-zero value of Q_0 as a result of the fit indicates that the peak positions in the spectrum are not at the expected positions. If Q_0 is larger than the convergence criterion (parameter GAINREJ), then new estimates of the peak position, E_j', are determined from

$$E'_j = E_j + Q_0 \tag{76}$$

and a new fit is obtained. This is repeated until Q_0 is less than the convergence criterion, or until a maximum allowed number of fits (parameter MAXGAINPASS) have been made.

If the automatic gain shift correction is not enabled, there no additional term and Equation (75) reduces to

$$F(x_i) = B_0 + B_1(x_i - E_j) + H_j e^{-\frac{(x_i - E_j)^2}{Z_j^2}} \tag{77}$$

This equation results in a straight linear least-squares equation which is solved by matrix inversion that does not require iterations or convergence criteria. The values of the parameters MAXGAINPASS and GAINREJ are simply ignored in this mode of operation.

In both cases, if the uncertainties of the data points are not equal, the least squares method requires that each data point be weighted by $1/\sigma_i^2$ where σ_i is the standard deviation of the ith data point.

The non-subtracted, original counts per channel are Poisson distributed data, and $\sigma_i^2 = Y'_i$ making the weighting factor

$$W'_i = \frac{1}{Y'_i} \tag{78}$$

where Y'_i are the original counts in channel i.

However, since we have subtracted the continuum background from the data points before performing the fit, the remainder is not Poisson distributed, and strictly speaking, $\sigma_i^2 \neq Y_i$.

However, since a rigorous error propagation is very complicated for the erosion technique, we have elected to use Equation (78) as the weighting factor.

Unknown Peak Locate

The unknown peak locate portion of the library (Gamma-M) peak locate is a digital filter that supplements the library locations. It can be enabled or disabled through the setup options of the library (Gamma-M) peak locate. If the unknown peak locate is enabled both its results and the results from the library locations are subjected to the rejection criteria described in the next section. If the unknown peak locate is not enabled, only the library locations will be subjected to the rejection criteria described in “Peak Rejection Criteria” on page 262.

The unknown peak locate algorithm of the library (Gamma-M) peak locate averages the data over a region that is proportional to the detector resolution. This produces a quantity that is proportional to the peak area divided by the detection limit, which can be written as

$$dd_i = \frac{O_i - C_i - K_1}{K_2\sqrt{W(B_i + C_i)}} \tag{79}$$

where

O_i is the sum of counts in the filter window,

C_i is the correction term for the background variance,

B_i is the sum of background counts in the window,

W is the window width in channels,

K_1 is the unidentified rejection constant (UNIDCONST), and

K_2 is the unidentified rejection sigma (UNIDREJ).

The window width is automatically chosen as the integer part of the expected FWHM. The quantity C_i arises from the fact that the background continuum is systematically underestimated as a result of the erosion algorithm. This correction is approximated by

$$C_i = W\sqrt{\frac{B_i}{W}} \tag{80}$$

A peak is found when the quantity dd_i is greater than 1.0. Peak positions are found by looking for the maxima in each region where $dd_i > 1.0$.

Peak Rejection Criteria

A library peak is rejected from the list of valid peaks, if it is closer than OVERWIND1 times the expected FWHM of the peak to another library peak.

An unknown peak is rejected from the list of valid peaks if it is within the energy tolerance (on either side) of a library location. Such a peak is assumed to be the library peak already assigned.

A library peak or an unknown peak is rejected from the list of valid peaks, if it does not exceed the MDA rejection limit, i.e. the area has to satisfy the condition

$$A > C_1 + C_2 \sqrt{\frac{\sum_{i=E-R}^{E+R} y_i}{0.966^2}} \tag{81}$$

where

C_1 is the MDA rejection constant (REJMDACONST),

C_2 is the MDA rejection sigma (REJMDASIG),

E is the energy of the incident gamma ray,

R is $0.9 \cdot$FWHM, and

y_i is the original counts in channel i.

A library peak or an unknown peak is rejected from the list of valid peaks, if its height does not exceed the uncertainty of the height multiplied by a rejection factor, i.e. the height has to satisfy the condition

$$h^2 > F_V \cdot \sigma_h^{\,2} \tag{82}$$

where

h is the calculated height of the peak,

σ_h is the calculated uncertainty of the peak height, and

FV is the variance rejection parameter (VARREJ).

A library peak or an unknown peak is also rejected from the list of valid peaks, if the square of its height does not exceed the height of the continuum background under the peak, i.e. the peak must satisfy the condition

$$h^2 > F_B \cdot B \tag{83}$$

where

h is the calculated height of the current peak of interest,

B is the height of the continuum under the current peak of interest at the location of the peak, which includes both the eroded component and the fitted linear continuum, and

F_B is the background rejection factor (parameter BACKREJ).

Note that The Library (Gamma-M) Peak Locate has no “add to existing results” mode. It will *always* erase any existing previous peak locate results.

Executing the Library (Gamma-M) Peak Locate algorithm creates the Peak Search Results class of CAM parameters (if one does not already exist) and writes out the following parameters:

PEAKVERS	The name and version of the locate algorithm
PSDATE	The date and time peak locate was performed
PSLOCCENT	The peak location centroid
PSDLOCCENT	The uncertainty of peak location centroid (this is always set to 0, since no location uncertainty is calculated by this method)
PSENERGY	The peak energy
PSDENERGY	The uncertainty in the peak energy (this is always set to 0, since no energy uncertainty is calculated by this method)

Generalized Second Difference Method

A second difference peak locate algorithm was originally proposed by Mariscotti.[9] The original concepts were later enhanced in SAMPO [10] and SAMPO80[11]. The Canberra second difference peak locate algorithm is a slightly modified version of the SAMPO80 version.

The peak centroid is defined as

$$\text{centroid} = \frac{\sum_i i \cdot ss_i}{\sum_i ss_i} \tag{84}$$

where i is channel number, and

9. Mariscotti, M.A. (1967). *Nucl. Instr. & Meth.* 50:309.
10. Routti, J.T. and Prussin, S.G. (1969). *Nucl. Instr. & Meth.* 72:125.
11. Koskelo, M.J., Aarnio, P.A. and Routti, J.T. (1981). *Nucl. Instr. & Meth.* 190:89.

$$ss_i = \frac{dd_i}{sd_i} \tag{85}$$

The summing is done over the channels where the significance value is defined in Equation (85) is negative; that is, the centroid is defined as the weighted average of those channels.

The terms on the right hand side of Equation (85) are defined as the generalized second difference

$$dd_i = \sum_{j=-k}^{j=+k} c_j y_{i+j} \tag{86}$$

and its standard deviation

$$sd_i = \sqrt{\sum_{j=-k}^{j=+k} c_j^2 (y_{i+j})} \tag{87}$$

The counts per channel are denoted by y and the summation is done over 2k+1 channels where the number k depends on the coefficients c. The coefficients are defined as

$$c_j = \frac{100\,(j^2 - (cw)^2)}{(cw)^2} \cdot e - \frac{j^2}{2(cw)^2} \tag{88}$$

where cw is the calibrated expected Gaussian width (cw = FWHM/2.355 in units of channels).

The first coefficient c0 is always –100, and the set of coefficients is terminated at k, where the absolute value of the next coefficient would be less than one. The second coefficient is then adjusted so that the sum of the coefficients is zero.

The expected peak width value is automatically determined by the program based on the shape calibration data for the spectrum to be analyzed. Furthermore, the coefficients are recalculated every 100 channels to make sure that the peak locate algorithm is appropriate for the types of peaks expected.

The absolute value of the significance value must be above a threshold value for peaks to be considered found. The initial default value of the significance threshold is 4 (parameter SENSITVTY).

The peak locate algorithm also contains a test for peak shape. Regions where the sign of the second difference remains unchanged for too long are classified as Compton edges or other continuum features and are rejected as real peaks.

If the algorithm is executed in the "add to existing results" mode (the Add to Existing Results check box in the setup screen is checked), found peaks will be merged with existing results provided that they are outside the energy tolerance (fixed or variable, whichever is in effect) of an existing peak. If the Add to Existing Results check box is *not* checked, the found peak results will overwrite the existing peak results.

Executing the Generalized Second Difference Peak Locate algorithm creates the Peak Search Results class of CAM parameters (if one does not already exist) and writes out the following parameters:

PEAKVERS	The name and version of the locate algorithm
PSDATE	The date and time peak locate was performed
PSLOCCENT	The peak location centroid
PSDLOCCENT	The uncertainty of peak location centroid
PSENERGY	The peak energy
PSDENERGY	The uncertainty in the peak energy
PSSIGNIF	The peak significance

VMS Standard Peak Search

In this section, we will limit the discussion of the peak search program to the quantification of peak regions that contain a single photopeak.

Essential to any peak search algorithm is the reliable determination of the background underneath a photopeak. The two main contributions to the background are the ambient background in the sample chamber and the Compton background contribution from peaks with higher energies than the one being analyzed.

A third background component, due to the photopeak being analyzed, must also be considered. If one assumes that a gamma-ray can undergo at most one interaction in the detector, then the third contribution would not exist. This is because the interaction would either be a photo-electric interaction which would contribute to the spectral photopeak or a Compton interaction whose maximum energies is significantly below the photopeak. On the other hand, if the gamma-ray can undergo more than one interaction, then multiple Compton events can contribute to channels just below the photopeak. Usually only visible for photopeaks with large peak/background ratios, these multiple Compton events give rise to peaks whose background to the right of the peak is significantly lower than the background to the left of the peak. This is even allowing for any local background slope.

To account for this “step background”, the peak search uses the following analytical function for determining the background at any channel in the peak region.

$$B_i = L_{avg} + \frac{\sum_{j=L}^{i} Y_j}{\sum_{j=L}^{R} Y_j} * \left(R_{avg} - L_{avg} \right) \tag{89}$$

$$L_{avg} = \frac{\sum_{i=L-N+1}^{L} Y_i}{N} \tag{90}$$

$$R_{avg} = \frac{\sum_{i=R}^{R+N-1} Y_i}{N} \tag{91}$$

where:

i is the channel at which the background is computed,

L is the channel that defines the left limit of the peak region,

R is the channel that defines the right limit of the peak region,

N is the number of channels used in the average background calculations,

L_{avg} is the average background to the left of the peak,

R_{avg} is the average background to the right of the peak,

Y_j is the spectral contents of channel j, and

B_i is the computed background at channel I.

The value of N is equal to one half of the predicted FWHM of the peak (in channels), that is

$$N = \frac{f_0 + f_1 * \sqrt{E}}{2 * e_1} \tag{92}$$

It is further constrained to be greater than or equal to 2 and less than or equal to 5. For a standard 4096 channel Ge spectrum with ~0.5 keV/channel and a resolution of 2 keV at 1332 keV, N will be equal to 2 for the entire spectrum.

The total peak background B is simply the sum of B_i over the entire peak region.

$$B = \sum_{i=L}^{R} B_i \tag{93}$$

The gross counts in the peak region G is the sum of the individual channel contents over the entire peak region.

$$G = \sum_{i=L}^{R} Y_i \tag{94}$$

The contribution to the peak area for each channel P_i is simply the gross counts in that channel minus the background contribution to that channel.

$$P_i = Y_i - B_i \tag{95}$$

The peak area is then the sum of P_i over the entire peak region, or even more simply, the gross counts minus the background.

$$P = \sum_{i=L}^{R} P_i = G - B \tag{96}$$

And therefore the uncertainty in the peak area is given by the expression

$$\Delta P^2 = \Delta G^2 + \Delta B^2 \tag{97}$$

Under Poisson assumptions:

$$\Delta Y_i^{\,2} = Y_i \tag{98}$$

$$= \Delta G^2 = \sum_{i=1}^{N} Y_i = G$$

$$= \Delta G = \sqrt{G}$$

Assuming a linear background:

$$B = \left(L_{avg} + R_{avg}\right)\frac{W}{2 * N} = \sigma\left(L_{avg} + R_{avg}\right) \tag{99}$$

where

W is the Peak region width,

N is the Number of average background channels, and

$L_{AVG} + R_{AVG}$ equals the Gross counts sums of N channels to Left and Right of region.

$$\sigma = \frac{W}{(2 * N)} \tag{100}$$

Std errorprop:

$$\Delta B^2 = \sigma^2 \left(\Delta L_{avg}{}^2 + \Delta R_{avg}{}^2 \right) \tag{101}$$

Substituting equation (98) into (101), we obtain:

$$\Delta B^2 = \sigma^2 * \left(\sum_{i}^{Left} Y_i + \sum_{i}^{Right} Y_i \right) \tag{102}$$

Substituting the above into equation (118) in the “Critical Level” on page 275 gives form of critical level.

This reduces to

$$\Delta P^2 = G + \left[\frac{W}{2 * N} \right] * B \tag{103}$$

where

W is the width (in channels) of the peak region = R – L + 1 and

N is the number of channels used to determine L_{avg} and R_{avg}

In order to determine the centroid channel C (and hence the energy) of a peak in the spectrum, the peak search uses a first moment calculation.

$$C = L + \frac{\sum_{i=L}^{R} (i - L) * P_i}{P} \tag{104}$$

Example Peak Search Calculations

As an example, consider the 1173 keV peak in the NBSSTD data file. For each channel in the peak region, the following Table 1 lists the channel number, the channel contents, the background contribution and the area contribution. The last two columns were computed using equations (89) and (95).

Table 1 Peak Search Calculations

Channel #	Y_i Contents	B_i Background	P_i Area
2532	86	—	—
2533	85	85.50252	– 0.50252
2534	92	85.50524	6.494759
2535	99	85.50817	13.49183
2536	110	85.51143	24.48857
2637	113	85.51477	27.48523
2538	118	85.51827	32.48173
2539	111	85.52156	25.47844
2540	134	85.52552	48.47448
2541	250	85.53292	164.4671
2542	469	85.54681	383.4532
2543	821	85.57112	735.4289
2544	1449	85.61402	1363.386
2545	2255	85.68079	2169.319
2546	2747	85.76212	2661.238
2547	2787	85.84464	2701.155
2548	2154	85.90842	2068.092
2549	1336	85.94798	1250.052
2550	692	85.96847	606.0315
2551	327	85.97815	241.0219
2552	179	85.98345	93.01655
2553	110	85.98671	24.01329
2554	88	85.98931	2.010689
2555	92	85.99204	6.007965
2556	95	85.99485	9.005152
2557	85	85.99736	– 0.99736
2558	89	86.00000	3.00000

Table 1 Peak Search Calculations			
Channel #	**Y_i Contents**	**B_i Background**	**P_i Area**
2559	83	—	—
Totals	16887	2229.407	14657.59

To illustrate a background computation, we must first compute the average background to the left and right of the peak region. For our 1173 keV region we have:

L = 2533

R = 2558

N = 2

L_{avg}

R_{avg}

Substituting these values into equation (89) we obtain

$$B_i = 85.5 + \frac{\sum_{j=2533}^{i} Y_j}{\sum_{j=2533}^{2558} Y_j} * (86 - 85.5) \tag{105}$$

Hence the equation for the background at any channel *i* is

$$B_i = 85.5 + \frac{\sum_{j=2533}^{i} Y_j}{16887} * (0.5) \tag{106}$$

As an example, let's calculate the background at channel 2539. Substituting i=2539, we obtain

$$B_{2539} = 85.5 + \frac{\sum_{j=2533}^{2539} Y_j}{16887} * (0.5)(19) \tag{107}$$

$$B_{2539} = 85.5 + \frac{85 + 92 + 99 + 110 + 113 + 118 + 111}{16887} * (0.5)$$

$$B_{2539} = 85.5215$$

The background at any other channel in the region is computed in a similar fashion. If the background values are plotted against their channel numbers, the "step" background becomes very apparent as shown in Figure 3.

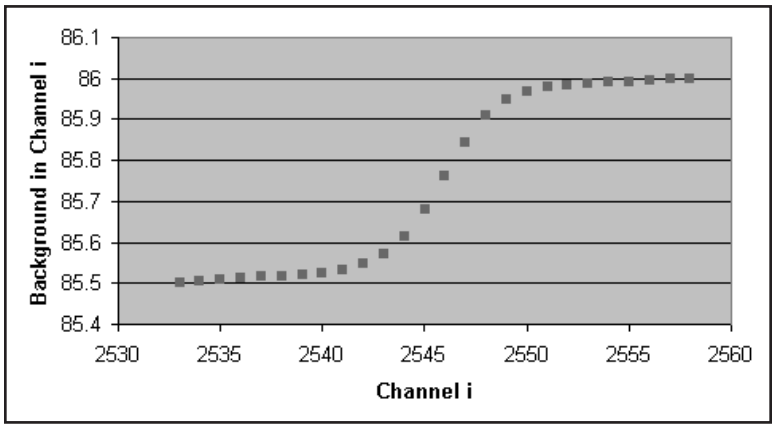


Figure 3 Example of Background Channel vs Channel Numbers

Once the total background is computed, it is a simple task to compute the net peak area. As shown in Table 1.

G = 16887

B = 2229.407

P = G – B = 14657.593

The uncertainty in the peak area is given by

$$\Delta P^2 = 16887 + \left[\frac{2558 - 2533 + 1}{2 * 2}\right] * 2229.407 \tag{108}$$

$$\Delta P = 177.1388$$

or the percent error is

$$\%\text{error} = \frac{\Delta P}{P} * 100 = \frac{177.1388}{14657.593} * 100 = 1.208\% \tag{109}$$

Finally the centroid is calculated by plugging the values from the table into equation (104).

$$C = 2533 + \frac{\left(0 * -0.5025 + 1 * 6.4947 + 2 * 13.4918 + \ldots + 24 * -0.9973\right)}{14657.593} \qquad (110)$$

$$C = 2546.288$$

The following report lists the peak search results for all peaks found in the NBSSTD configuration using the listed parameter.

```
Peak Analysis Report            6/7/02    9:45:33 AM            Page  1

********************************************************************************
*******           P E A K    A N A L Y S I S    R E P O R T           *******
********************************************************************************

       Configuration Title:
       Spectrum Title:              GENIE-PC Spectrum No. 1
       Peak Analysis Performed on:  6/7/02    9:45:32 AM
       Peak Analysis From Channel:     50    To Channel:     4096
       Peak Search Sensitivity:      5.00    Gaussian Sensitivity: 10.00
       Max Iterations: 10  Fit Singlets: No  Critical Level Test: No
       Use Fixed FWHM: No  FWHM Reject:  No  FWHM Reject Ratio:  0.00
       Peak Fit Engine Name: NDSTD           Continuum Type: STEP

   Pk IT  Energy      Area   Bkgnd  FWHM Channel   Left  PW  Cts/Sec  %err   Fit

    1  0    87.87     8789   14914  1.42  170.06    165  12 2.20E+00   3.0   0.0
    2  0   121.99    17824   15867  1.41  244.76    239  12 4.46E+00   1.6   0.0
    3  0   136.41     2355   12013  1.37  276.33    272  10 5.89E-01   9.0   0.0
    4  0   165.88     8965   12901  1.50  340.86    335  13 2.24E+00   2.8   0.0
    5  0   238.49     1252    5996  1.38  499.86    495  10 3.13E-01  12.8   0.0
    6  0   255.27      670    6360  1.53  536.60    532  11 1.67E-01  23.4   0.0
    7  0   279.20     9162    7719  1.50  588.98    581  15 2.29E+00   2.3   0.0
    8  0   295.19      824    5061  1.70  624.00    619  11 2.06E-01  17.1   0.0
    9  0   352.06     1149    4660  1.68  748.52    743  12 2.87E-01  12.3   0.0
   10  0   391.76    11966    5164  1.61  835.45    828  15 2.99E+00   1.6   0.0
   11  0   514.07    10522    4252  1.71 1103.25   1097  12 2.63E+00   1.6   0.0
   12  0   583.35      665    2694  1.97 1254.93   1250  11 1.66E-01  15.6   0.0
 M 13  2   604.83     1784    2850  1.69 1301.98   1295  24 4.46E-01   6.2   1.1
 m 14  2   609.49     1209    2994  1.83 1312.17   1295  24 3.02E-01   9.6   1.1
   15  0   661.67     9335    4196  1.80 1425.42   1419  15 2.33E+00   1.8   0.0
   16  0   795.92     2117    2204  1.72 1720.37   1712  16 5.29E-01   5.4   0.0
   17  0   813.91      728    2076  1.91 1759.76   1752  15 1.82E-01  14.1   0.0
   18  0   898.00    32797    3549  2.01 1943.88   1934  20 8.20E+00   0.7   0.0
   19  0   911.10      702    2050  1.78 1972.57   1965  16 1.76E-01  14.9   0.0
   20  0  1120.41      368    1101  2.43 2430.87   2426  11 9.21E-02  18.3   0.0
   21  0  1173.13    14658    2229  2.20 2545.29   2533  26 3.66E+00   1.2   0.0
 M 22  5  1325.41      595    1380  3.75 2879.73   2870  35 1.49E-01  15.1   3.4
 m 23  5  1332.40    12678    1055  2.45 2895.03   2870  35 3.17E+00   1.1   3.4
   24  0  1460.85     2388    1155  2.51 3175.27   3158  18 5.97E-01   3.9   0.0
   25  0  1764.22      246     258  2.06 3840.53   3834  18 6.16E-02  16.4   0.0
   26  0  1835.89    18046     376  2.76 3997.44   3983  30 4.51E+00   0.8   0.0

M = First peak in a multiplet region
m = Other peak in a multiplet region
F = Fitted singlet

Errors quoted at  1.000 sigma
```

Gaussian Fit Weighting Factors

While the details of the Gaussian fitting process is beyond the scope of this manual, a note regarding the channel specific weighting factor used during the fit is appropriate at this time.

The data set that is fit to a Gaussian function (actually to the log of a Gaussian function) is:

$$X = \ln(Y - B - O) \tag{111}$$

where

Y is the raw spectral contents at a channel,

B is the computed background at a channel, and

O is the contribution of other peaks in a multiplet region at the same channel (O = 0 for single peak regions).

The weighting factor used in the fitting process is given by:

$$W = \frac{1}{\Delta X^2} \tag{112}$$

Fitted data:

$$X = \ln(Y - B - O) \tag{113}$$

$$\Delta X^2 = \Delta Y^2 \left(\frac{2X}{2Y}\right)^2 + \Delta B^2 \left(\frac{2X}{2B}\right)^2 + \Delta O^2 \left(\frac{2X}{2O}\right)^2 \tag{114}$$

$$\frac{2X}{2Y} = \frac{2}{2Y}\ln(Y - B - O) = \frac{-1}{Y - B - O}$$

$$\frac{2X}{2B} = \frac{2}{2B}\ln(Y - B - O) = \frac{-1}{Y - B - O}$$

$$\frac{2X}{2O} = \frac{2}{2O}\ln(Y - B - O) = \frac{-1}{Y - B - O}$$

$$\Delta X^2 = \frac{\Delta Y^2}{(Y - B - O)^2} + \frac{\Delta B^2}{(Y - B - O)^2} + \frac{\Delta O^2}{(Y - B - O)^2} = \frac{\Delta Y^2 + \Delta B^2 + \Delta O^2}{(Y - B - O)^2} \tag{115}$$

$$W = \frac{1}{\Delta X^2} = \frac{(Y - B - O)^2}{\Delta Y^2 + \Delta B^2 + \Delta O^2} = \frac{(Y - B - O)^2}{(Y + B + O)} \quad (116)$$

Critical Level Test

After a peak is found and quantified, an optical critical level test is (optionally) applied. This test determines whether the peak area found is significant relative to the Compton continuum underneath it.

The methodology used in this engine is based on that developed by L. A. Currie[12]; where the net peak area computed by the engine is compared to Currie's critical level L_C:

$$L_C = k\sqrt{B + \Delta B^2} \quad (117)$$

where:

k is the confidence level (1.645 if 95% confidence level is used),

B is the Compton continuum under "peak", and

ΔB is the 1-sigma uncertainty in B.

If the peak area P is less than L_C, it is statistically consistent with a zero true signal at the confidence level chosen, and therefore, the peak is rejected. If the peak area is greater than L_C, it is statistically inconsistent with a zero true signal at the confidence level chosen, and therefore the peak is *not* rejected.

Substituting the general definition of ΔB from the previous section, we obtain:

$$L_C = k\sqrt{B + \sigma^2\left(\sum_{i}^{Left} Y_i + \sum_{i}^{Right} Y_i\right)} \quad (118)$$

where

$$\sigma = \frac{W}{2 * N} \quad (119)$$

12. L.A. Currie, (1968). Limits for Qualitative Detection and Quantitative Determination. *Analytical Chemistry*. 40:586.

W is the width of the peak region,

N is the number of average background channels, and

Y_i is the raw spectral contents in channel i.

Simplifying this equation:

$$L_C = k\sqrt{B(1+\sigma)} \quad (120)$$

Peak Area Calculations

The Genie 2000/Genie-PC architecture currently provides two different algorithms for calculating peak areas in a spectrum: “Library (Gamma-M)” and “Sum/Non-Linear LSQ Fit”. Each of these methods is described in detail in the following. As a general rule, the “Library (Gamma-M)” method is best suited for situations where only specific nuclides are of interest, and for NaI analysis. The “Sum/Non-Linear LSQ Fit” algorithm is best suited for Ge analysis and when the spectrum contents are unknown, but can also be used for NaI analysis.

Note that the peak area calculations should always be done using the same area calculation method that was used during the efficiency calibration.

Library (Gamma-M) Peak Area

The Library (Gamma-M) Peak Area algorithms include steps for defining the background continuum using the erosion technique, as well as calculating the peak areas and their uncertainties.

Peak Erosion

The first step in the Library (Gamma-M) Peak Area is the determination of the continuum background. In this step, the photopeaks are eroded until they subside into the continuum to establish a “background continuum” spectrum in the same way as it is done during the Library (Gamma-M) Peak Locate. A more detailed description of the algorithm can be found under “Peak Erosion”, on page 256.

Peak Area

The peak area is calculated using a linear least squares fit algorithm (with a gain shift, if it is enabled). There is no difference between the peak fitting algorithms used in the Library (Gamma-M) Peak Locate and the Library (Gamma-M) Peak Area except that the parameters AREAWIND2, OVERWIND2, and INTFWIND2, instead of AREAWIND1, OVERWIND1, and INTFWIND1 are used. A more detailed description of the fitting and peak rejection rules can be found under “Peak Fitting” on page 259 and “Peak Rejection Criteria” on page 262.

The area of each photopeak is calculated from the best fit. The area under a Gaussian is given by

$$A = hZ\sqrt{\pi} \tag{121}$$

where

h is the height of the peak, and

Z is a measure of the peak width ($Z^2 = 2\sigma^2$, where σ is the Gaussian width).

Peak Area Uncertainty

The uncertainty of a peak area is estimated as

$$\sigma_{area} = \sqrt{\left(\frac{A}{h}\right)^2 \sigma_h^2 + \sum_i \left(\frac{f_i A_i}{h_i}\right)^2 \sigma_{h_i^2}} \tag{122}$$

where

A is the area of the peak of interest,

h is the calculated height of the peak of interest,

σ_h is the calculated uncertainty of the peak height of the peak of interest,

Ai is the area of the ith interfering peak,

hi is the calculated height of the i^{th} interfering peak,

σ_{hi} is the calculated uncertainty of the peak height of the i^{th} interfering peak, and

f_i is the fraction of the i^{th} peak area that lies within the AREAWIND2 window of the peak of interest.

The peak location uncertainty and peak width uncertainty are assumed to be zero for all peaks.

Sum/Non-Linear Least Squares Fit Peak Area

The Sum/Non-Linear Least Squares Fit Peak Area algorithm includes calculations for defining the limits of the peak region, as well as calculating the peak areas and their uncertainties for either singlets or multiplets.

Determination of Peak Region Limits

If the area calculations are preceded by a "User Specified" peak locate, the ROIs marked in the spectrum display or loaded from an external ROI file are used as is for the peak area calculations. The sum/non-linear least squares area algorithm will treat each of the ROIs as a singlet. No multiplet analysis is performed no matter how close to each other the ROIs may be, or even if the ROIs overlap.

If the area calculations are preceded by either of the library peak locates or the unidentified 2nd difference peak locate, the ROI limits are determined automatically before executing the area calculation algorithms. This automatic method of determining the ROI limits will also make the determination whether adjacent peaks are going to be analyzed as two singlets or a multiplet. The rules are as follows.

The centroid results from the peak locate phase are checked from the smallest to the largest. Each consecutive peak is compared to its neighbor to the right to see if a multiplet should be formed. If peaks i and i+1 satisfy the following condition, they are considered to part of a multiplet

$$C_{i+1} - C_i < n_W \cdot W \tag{123}$$

where

C_{i+1} is the centroid of peak i+1 (in units of channels),

C_i is the centroid of peak i (in units of channels),

w is the expected FWHM at peak i (in units of channels), and

n_w is the user selectable separation parameter (PRFWHMPKMULT).

When a 2-peak multiplet is found, the next interpeak distance from peak i+1 to peak i+2 is checked the same way until the condition is no longer satisfied.

Each singlet or multiplet peak region is then analyzed for its left and right boundaries. X-point averages are computed for each channel starting at the peak centroid minus 0.8 FWHM. The value of X is 5 channels if the expected peak width is less than or equal to 5. Otherwise, X is set to the smallest odd integer which is greater than or equal to the expected peak width.

The left boundary of a region is the first channel to the left of the first peak of the multiplet (or the only peak of a singlet) where the X-point average reaches a minimum, up to a distance of $n_L \cdot w$, or to the beginning of the spectrum plus (X-1)/2 channels; whichever is greater. n_L is the user selectable parameter (PRFWHMPKLEFT) that defines the maximum extension of the region to the left.

The right boundary of a region is the first channel to the right of the last peak of the multiplet (or the only peak of a singlet) where the X-point average reaches a minimum, up to a distance of $n_R \cdot w$, or to the end of the spectrum minus (X-1)/2 channels; whichever is greater. n_R is the user selectable parameter (PRFWHMPKRGHT) that defines the maximum extension of the region to the right.

After the ROI determination completes the calculation of the boundaries of the ROI, the number of continuum background channels to be used to the left and right of the peak ROI is then determined. In one mode, the number of channels is fixed at a particular number throughout the spectrum. If the variable continuum is enabled, the number of channels used at each ROI will be calculated based on the FWHM at the mid-point of the ROI rounded off to the nearest integer. If the rounded off number is less than one (1), one channel will be used. The FWHM multiplier is user selectable.

Up to 16 peaks are allowed in a multiplet. Up to 512 channels are allowed in a single ROI. If the algorithm finds a multiplet region that is larger than 16 peaks and/or 512 channels, the region is automatically broken into a smaller multiplet region at the lowest valley between the peaks.

Peak Area for Non-Fitted Single Peaks

The net peak area for a single peak is calculated as follows.

$$S = G - B \tag{124}$$

where

S is the net peak area,

G is the sum of gross counts in the peak ROI, and

B is the continuum.

A linear continuum, B, illustrated in Figure 4, is calculated from the sample spectrum using the equation

$$B = \left(\frac{N}{2n}\right)(B_1 + B_2) \tag{125}$$

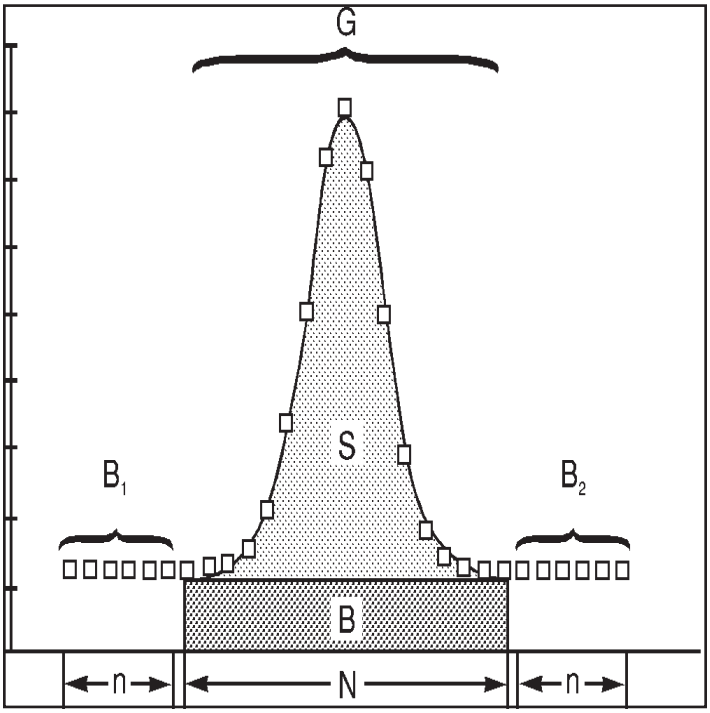


Figure 4 Parameters Used in a Linear Continuum Calculation

where

N is the number of channels in the peak ROI,

n is the number of continuum channels on each side (currently the same on both sides),

B_1 is the sum of counts in the continuum region to the left of the peak, and

B_2 is the sum of counts in the continuum region to the right of the peak.

A step continuum, B, illustrated in Figure 5, is calculated from the sample spectrum using the equation.

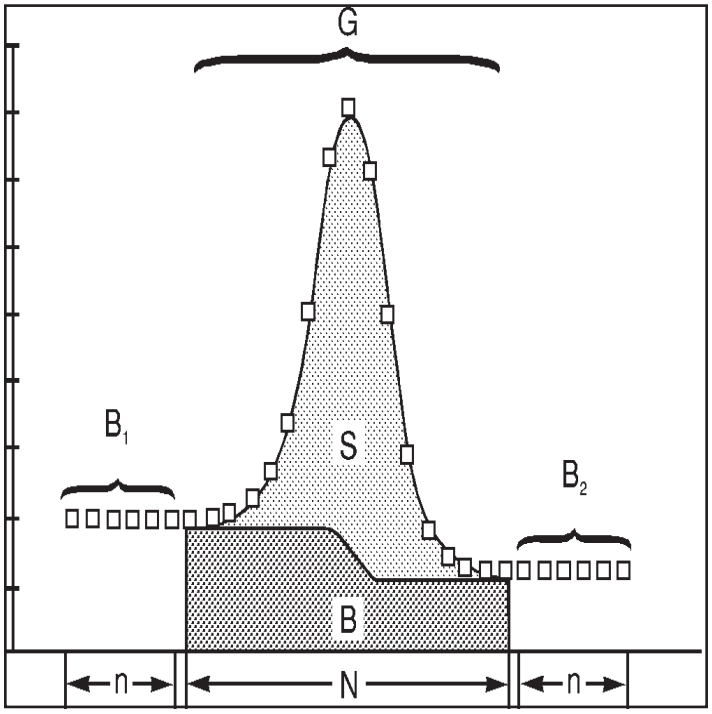


Figure 5 Parameters Used in a Step Continuum Calculation

$$B = \sum_{i=1}^{N} \left(\frac{B_1}{n} + \frac{(B_2 - B_1)}{nG} \sum_{j=1}^{i} y_j \right) \tag{126}$$

where

y_i is the counts per channel in channel i,

G is the total sum of counts (gross) in the peak ROI,

N is the number of channels in the peak ROI,

n is the number of continuum channels on each side (currently the same on both sides),

B_1 is the sum of counts in the continuum region to the left of the peak, and

B_2 is the sum of counts in the continuum region to the right of the peak.

Equation (126) can also be written as

$$B = \frac{N}{n} B_1 + \frac{(B_2 - B_1)}{nG} \sum_{i=1}^{N} \sum_{j=1}^{i} y_j \tag{127}$$

or (using a shorter notation for the partial sums P_i)

$$B = \frac{N}{n} B_1 + \frac{(B_2 - B_1)}{nG} \sum_{i=1}^{N} P_i \tag{128}$$

where

$$P_i = \sum_{j=1}^{i} Y_j \tag{129}$$

Peak Area Uncertainty for Non-fitted Single Peaks

The standard deviation (at one sigma) of the net peak area is calculated from the equation

$$\sigma_S = \sqrt{\sigma_G^2 + \sigma_B^2} \tag{130}$$

In order to establish σB , let us consider a function, F, which is some combination of counts in several channels

$$F = f(y_1, y_2, ..., y_n) \tag{131}$$

where $y_1, \leq, y_n$ are counts in n channels.

Assuming that the y_i's are uncorrelated, which is the case in gamma spectroscopy, the estimate of the variance of F is given by[13]

$$\sigma_F^2 = \left(\frac{\partial f}{\partial y_1}\right)^2 \sigma_{y_1}^2 + \left(\frac{\partial f}{\partial y_2}\right)^2 \sigma_{y_2}^2 + K + \left(\frac{\partial f}{\partial y_n}\right)^2 \sigma_{y_n}^2 \tag{132}$$

Using this relationship, the variance of a *linear* continuum becomes

$$\sigma_B^2 = \left(\frac{N}{2n}\right)^2 \sigma_{B_1}^2 + \left(\frac{N}{2n}\right)^2 \sigma_{B_2}^2 \tag{133}$$

where

13. A proof of this may be found in a variety of textbooks that discuss error propagation. In the exact case, the covariances must be included. However, the covariance terms vanish, if the N_i's are uncorrelated, as is the case in gamma spectroscopy.

σ^2_{B1} is the variance of B_1, and

σ^2_{B2} is the variance of B_2.

Making use of the properties of Poisson distributed quantities, and combining the terms, equation (133) can be written as

$$\sigma_B^2 = \left(\frac{N}{2n}\right)^2 (B_1 + B_2) \tag{134}$$

Since G is also Poisson distributed, the uncertainty for the net peak area (with a *linear* continuum) can be written as

$$\sigma_s = \sqrt{G + \left(\frac{N}{2n}\right)^2 (B_1 + B_2)} \tag{135}$$

Using the same approach, the variance of a *step* continuum becomes

$$\sigma_B^2 = \left(\frac{\partial B}{\partial B_1}\right)^2 \sigma^2_{B_1} + \left(\frac{\partial B}{\partial B_2}\right)^2 \sigma^2_{B_2} + \left(\frac{\partial B}{\partial G}\right)^2 \sigma^2_G + \sum_{i=1}^{N} \left(\frac{\partial B}{\partial P_i}\right)^2 \sigma^2_{P_i} \tag{136}$$

which reduces to

$$\sigma_B^2 = \frac{1}{(nG)^2}\left[\left(NG - \sum P_i\right)^2 B_1 + \left(\sum P_i\right)^2 B_2 + (B_2 - B_1)^2 \left(\sum P_i\right)^2 \left(\frac{1}{G} + \frac{1}{\sum P_i}\right) \right] \tag{137}$$

Therefore, the uncertainty for the net peak area (with a *step* continuum) can be written as

$$\sigma_s = \sqrt{G + \frac{1}{(nG)^2}\left[\left(NG - \sum P\right)^2 B_1 + \left(\sum P\right)^2 B_2 + (B_2 - B_1)^2 \left(\sum P\right)^2 \left(\frac{1}{G} + \frac{1}{\sum P}\right) \right]} \tag{138}$$

Peak Area for Multiplets and Fitted Singlets

The peak areas for multiplets and fitted singlets are calculated using the same non-linear least squares techniques explained in "Non-Linear Least Squares Fit" on page 231. During the peak area calculations, the number of peaks can be higher than one, and the FWHM and tailing parameter values are either fixed or variable depending on the selected options.

Since the various peak locate algorithms allow peaks to be placed where no peaks actually exist, the matrix equation in the case of peak fitting may not always be solvable. To make sure that the algorithm does not even attempt to solve an impossible set of equations, this peak area algorithm includes a test to make sure that the matrix from the fit is not singular. We have chosen a technique that assumes that the matrix is symmetric, since a least squares method always results in a symmetric matrix.

First, we use the QL algorithm and the Householder Method[14] to compute the eigenvalues through successive transformations of the tridiagonal fit matrix until a diagonal matrix is obtained. The QL algorithm is defined by

$$A_T^{(i+1)} = Q^{(i)T} A_T^{(i)} Q^{(i)} \quad , \quad \text{for } i = 1 K\, n \tag{139}$$

where $A_T(i)$ is the tridiagonal matrix at iteration i and $Q^{(i)}$ is the orthogonal matrix at iteration i. The orthogonal matrix, $Q^{(i)}$, and tridiagonal matrix, $A_T(i)$, for iteration i=1 are obtained by the Householder Method. The iteration is continued until iteration n where a diagonal matrix is obtained at which time the eigenvalues of A are along the diagonal of $A_T(n)$. If the iteration counter reaches n=30 without producing a diagonal matrix, the L_∞ method to determine the properties of the fit are used instead (see below).

When the eigenvalues can be calculated they are used to calculate the following condition number:[15]

$$K(A) = \frac{\max\limits_{1 \le i \le n} |\lambda_i|}{\min\limits_{1 \le i \le n} |\lambda_i|} \tag{140}$$

If

$$\log_{10}(K(A)) > 16.0 \tag{141}$$

14. W.H. Press, B. P. Flannery, S. A. Teukolsky and W. T. Vetterline, "Numerical Recipes in C", 2nd Ed., Cambridge University Press, 1992.
15. Y. Bar-Shalom and X-R. Li, "Estimation and Tracking: Principles, Techniques, and Software", Artech House, Inc., 1993.

the matrix may be ill-conditioned, badly scaled, or nearly singular. The algorithm then deletes the smallest peak from a multiplet (in terms of peak height) and recomputes the fit until the matrix is no longer singular. If the last or only peak in the ROI still produces a singular matrix, it is deleted from the peak records and the calculation moves to the next region.

If the eigenvalues of the matrix cannot be computed, the algorithm calculates the L_∞ norm for both A and A^{-1}. The L_∞ norm[16] of A is defined as

$$|| A ||_\infty = \max_{1 \le i \le n} \sum_{j=1}^{n} | a_{ij} | \tag{142}$$

and the L_∞ norm of A^{-1} as

$$|| A^{-1} ||_\infty = \max_{1 \le i \le n} \sum_{j=1}^{n} | b_{ij} | \tag{143}$$

where b_{ij} are the individual values of matrix A^{-1}. In this case the condition number is defined as

$$K(A) = || A ||_\infty || A^{-1} ||_\infty \tag{144}$$

Again, if

$$\log_{10} (K(A)) > 16.0 \tag{145}$$

the matrix may be ill-conditioned, badly scaled, or nearly singular. The algorithm deletes the smallest peak from a multiplet (in terms of peak height) and recomputes the fit until the matrix is no longer singular. If the last or only peak in the ROI still produces a singular matrix, it is deleted from the peak records and the calculation moves to the next region.

16. R. L. Burden and J. D. Faires, “Numerical Analysis”, 4th Ed., PWS-KENT Publishing Company, 1989.

In addition to testing that the matrix to be inverted is not ill-conditioned, a multiplet fit has a constraint in the peak movements during the iteration that may remove peaks from the peak list. In previous algorithms, peaks in a multiplet were prevented from ever exchanging places (in energy or channel location), but no peaks were ever removed, even if the iteration placed two peaks at the same location. In the Sum/Non-Linear LSQ Fit algorithm, peaks which are already within the energy tolerance after the peak locate, and peaks which would be moved inside the energy tolerance by the iterative multiplet fit are deleted from the results. For best results, the multiplet is refit with the remaining peaks, or treated as a singlet if only one peak remains.

After the multiplet (or singlet) envelope has been fitted with the best fit, the areas of the individual peaks within the multiplet (or the single peak) are determined by numerical integration over the ROI using the fit function and the fit parameters for the individual peak in the fitted multiplet.

In each case, the peak area may be expressed by

$$P_a = A_g + A_\tau \tag{146}$$

where

A_g is the area under the Gaussian portion, which is defined as

$$A_g = \int_{c_P - \tau}^{R_e} He \frac{-(x - c_p)^2}{2\sigma^2} dx \tag{147}$$

and

A_t is the area under the tail portion, which is defined as

$$A_\tau = \int_{R_s}^{c_p - \tau} He \frac{\tau(2x - 2c_p + \tau)}{2\sigma^2} dx \tag{148}$$

The area under the tail portion can be calculated by solving for the integral of equation (148) in closed form.

The area under the Gaussian portion, A_G, is calculated using the Gauss-Quadrature integration technique.[17]

17. W. H. Press, S. A. Teukolsky, W. T. Vetterling, B. P. Flannery. “Numerical Recipes in C”, in *The Art of Scientific Computing Second Edition*. Cambridge: Cambridge University Press. (1992)

Note that both when setting up the matrix to be inverted, as well as when calculating the area, any peak within the energy tolerance of 511 keV is treated in a special way.

If the 511 keV peak has been calibrated separately for its shape (the parameter FW511 is non-zero), the calibrated shape is used in setting up the matrix for a peak at around 511 keV. If the 511 keV peak has not been calibrated for its shape separately, the FWHM of any peak within the energy tolerance of 511 keV is automatically assumed to be 1.5 times the expected FWHM from the calibration curve.

After the multiplet or singlet envelope has been fitted with the best fit, the algorithm checks to see if the fitted peak area (or the sum of the fitted peak areas for a multiplet) is very different from the simple sum area of the peak (or peaks). If the fitted peak area is more than 150% or less than 50% of the sum area (of the single peak or of the whole multiplet envelope), the area of the single peak is automatically calculated as a simple sum. In the case of a multiplet, the areas of the individual peaks within the multiplet are determined by apportioning the total multiplet area based on the peak height and peak width of each component. In the case of a two-component multiplet, for example, the areas A_1 and A_2 of the two components are given by

$$A_1 = \frac{P_1 \sigma_1 A_t}{P_1 \sigma_1 + P_2 \sigma_2} \qquad (149)$$
$$A_2 = A_t - A_1$$

where

A_t is the total multiplet area,

P_1 is the height of peak one.

σ_1 is the Gaussian width of peak one,

P_2 is the height of peak two,

σ_2 is the Gaussian width of peak two.

In general, the area of the i^{th} component of a multiplet is given by

$$A_i = \frac{P_i \sigma_i A_t}{\sum_{k}^{N} P_k \sigma_k} \qquad (150)$$

Where N is the number of peaks in the multiplet.

The continuum reported for each peak in a multiplet is calculated by integrating the selected background function (linear or step) over a virtual ROI around the eventual peak centroid which is determined using the following rules. The left limit boundary, R_L, and the right limit boundary, R_R, are set as

$$R_L = C_p - 1.5 \cdot F, \qquad \text{when } T > 1.2 \cdot F \tag{151}$$

$$R_L = C_p - 1.12 \cdot \frac{F^2}{T} - \frac{T}{2}, \qquad \text{when } T < 1.2 \cdot F \tag{152}$$

and

$$R_R = C_p + 1.5 \cdot F \tag{153}$$

respectively, and where F is the FWHM of the peak (in units of channels), T is the tailing parameter of the peak (in units of channels), and C_p is the peak centroid. However, if the calculations using these equations would assign either boundary to a value that is outside the actual ROI limits of the multiplet, the boundary will automatically be assigned to be the ROI limit of the multiplet.

Peak Area Uncertainty for Multiplets and Fitted Singlets

The parameters which have an uncertainty which must be propagated into the uncertainty are: H, c_p, t, and s.

Note that some of the parameters which are used during the uncertainty analysis are defined in the integration limits. Using the Leibnitz Theorem,[18] we get:

$$\frac{d}{dx}\left(\int_{g(x)}^{h(x)} f(x, y)dy \right) = f(x, h(x)) \frac{dh(x)}{dx} - f(x, g(x)) \frac{dg(x)}{dx} + \int_{g(x)}^{h(x)} \frac{\partial f(x, y)}{\partial x} dy \tag{154}$$

Using this Theorem, the uncertainty in the peak area is calculated by:

18. J. Spanier, K. B. Oldham. *An Atlas of Functions*. Hemisphere Publishing Corp., New York (1987)

$$\sigma^2(P_{A)} = \left(\frac{\partial P_A}{\partial c_p}\right)^2 \sigma^2(c_p) + \left(\frac{\partial P_A}{\partial H}\right)^2 \sigma^2(H) + \left(\frac{\partial P_A}{\partial \sigma}\right)^2 \sigma^2(\sigma) + \left(\frac{\partial P_A}{\partial \tau}\right)^2 \sigma^2(\tau) \quad (155)$$
$$+ 2\left(\left(\frac{\partial P_A}{\partial c_p}\right)\left(\frac{\partial P_A}{\partial H}\right)\sigma(c_p, H) + \left(\frac{\partial P_A}{\partial c_p}\right)\left(\frac{\partial P_A}{\partial \tau}\right)\sigma(c_p, \tau) + \left(\frac{\partial P_A}{\partial c_p}\right)\left(\frac{\partial c_p}{\partial \sigma}\right)\sigma(c_p, \sigma)\right)$$
$$+ 2\left(\left(\frac{\partial P_A}{\partial H}\right)\left(\frac{\partial P_A}{\partial \tau}\right)\sigma(H, \tau) + \left(\frac{\partial P_A}{\partial H}\right)\left(\frac{\partial P_A}{\partial \sigma}\right)\sigma(H, \sigma) + \left(\frac{\partial P_A}{\partial \sigma}\right)\left(\frac{\partial P_A}{\partial \tau}\right)\sigma(\sigma, \tau)\right)$$

Substituting the peak equation into the above equation we get:

$$\sigma^2(P_A) = \left(\frac{\partial A_G}{\partial c_p} + \frac{\partial A_\tau}{\partial c_p}\right)^2 \sigma^2(c_p) + \left(\frac{\partial A_G}{\partial H} + \frac{\partial A_\tau}{\partial H}\right)^2 \sigma^2(H) \quad (156)$$
$$+ \left(\frac{\partial A_G}{\partial \tau} + \frac{\partial A_\tau}{\partial \tau}\right)^2 \sigma^2(\tau) + \left(\frac{\partial A_G}{\partial \sigma} + \frac{\partial A_\tau}{\partial \sigma}\right)^2 \sigma^2(\sigma)$$
$$+ 2\left(\left(\frac{\partial A_G}{\partial c_p} + \frac{\partial A_\tau}{\partial c_p}\right)\left(\frac{\partial A_G}{\partial \tau} + \frac{\partial A_\tau}{\partial \tau}\right)\sigma(c_{p,}\tau)\right)$$
$$+ 2\left(\left(\frac{\partial A_G}{\partial c_p} + \frac{\partial A_\tau}{\partial c_p}\right)\left(\frac{\partial A_G}{\partial H} + \frac{\partial A_\tau}{\partial H}\right)\sigma(c_{p,}H)\right)$$
$$+ 2\left(\left(\frac{\partial A_G}{\partial c_p} + \frac{\partial A_\tau}{\partial c_p}\right)\left(\frac{\partial A_G}{\partial \sigma} + \frac{\partial A_\tau}{\partial \sigma}\right)\sigma(c_{p,}\sigma)\right)$$
$$+ 2\left(\left(\frac{\partial A_G}{\partial H} + \frac{\partial A_\tau}{\partial H}\right)\left(\frac{\partial A_G}{\partial \tau} + \frac{\partial A_\tau}{\partial \tau}\right)\sigma(H, \tau)\right)$$
$$+ 2\left(\left(\frac{\partial A_G}{\partial H} + \frac{\partial A_\tau}{\partial H}\right)\left(\frac{\partial A_G}{\partial \sigma} + \frac{\partial A_\tau}{\partial \sigma}\right)\sigma(H, \sigma)\right)$$
$$+ 2\left(\left(\frac{\partial A_G}{\partial \sigma} + \frac{\partial A_\tau}{\partial \sigma}\right)\left(\frac{\partial A_G}{\partial \tau} + \frac{\partial A_\tau}{\partial \tau}\right)\sigma(\sigma, \tau)\right)$$

where the partial derivatives for the Gaussian portion of the area, A_G, are given by:

$$\frac{\partial A_G}{\partial H} = \frac{A_G}{H} \quad (157)$$

$$\frac{\partial A_G}{\partial \tau} = He^{\frac{-\tau^2}{2\sigma^2}} \tag{158}$$

$$\frac{\partial A_G}{\partial \sigma} = \int_{c_p - \tau}^{R_e} H\left(\frac{(x - c_p)^2}{\sigma^3}\right) e^{\frac{-(x - c_p)^2}{2\sigma^2}} dx \tag{159}$$

$$\frac{\partial A_G}{\partial c_p} = \int_{c_p - \tau}^{R_e} H\left(\frac{(x - c_p)}{\sigma^2}\right) e^{\frac{-(x - c_p)^2}{2\sigma^2}} dx - He^{-\frac{\tau^2}{2\sigma^2}} \tag{160}$$

$$\frac{\partial A_G}{\partial c_p} = -h * e^{-\frac{(R_e - c_p)^2}{2\sigma^2}} \tag{161}$$

Note that the partial derivative with respect to the peak width, σ, can not be evaluated directly. However, this integral can be evaluated using numerical techniques, which is what we have chosen to do in the code.

The partial derivatives for the tail portion of the area, A_t, are given by:

$$\frac{\partial A_\tau}{\partial H} = \frac{A_\tau}{H} \tag{162}$$

$$\frac{\partial A_\tau}{\partial \tau} = \frac{-A_\tau}{\tau} - \frac{H}{\tau}\left(\tau e^{\frac{-\tau^2}{2\sigma^2}} + (R_s - c_p + \tau) e^{\frac{\tau(2R_s - 2c_p + \tau)}{2\sigma^2}}\right) \tag{163}$$

$$\frac{\partial A_\tau}{\partial \sigma} = \frac{2A_\tau}{\sigma} + \frac{H}{\sigma}\left(\tau e^{\frac{-\tau^2}{2\sigma^2}} + (2R_s - c_p + \tau) e^{\frac{\tau(2R_s - 2c_p + \tau)}{2\sigma^2}}\right) \tag{164}$$

$$\frac{\partial A_\tau}{\partial c_p} = He^{\frac{\tau(2R_s - 2c_p + \tau)}{2\sigma^2}} \tag{165}$$

If the peak apportioning mechanism is invoked during the area calculation, the variance in the area of the i^{th} component in a multiplet is given by:

$$\sigma^2_{A_i} = \left(\frac{\sigma_i A_t \left(\sum P_k \sigma_k - P_i \sigma_i \right)}{\left(\sum P_k \sigma_k \right)^2} \right)^2 \sigma^2_{P_i} + \left(\frac{P_i \sigma_i}{\sum P_k \sigma_k} \right)^2 \sigma^2_{A_t} + \sum_{j \neq i} \left(\frac{P_i \sigma_i A_t \sigma_j}{\left(\sum P_k \sigma_k \right)^2} \right)^2 \sigma_{P_j^2} \quad (166)$$

where

σ^2_{At} is the variance of A_t ,

σ_k is the Gaussian width of peak k,

σ_i is the Gaussian width of peak i,

σ^2_{Pl} is the variance of the height of peak 1,

-
-
-

σ^2_{Pn} is the variance of the height of the n^{th} peak.

In the case of a single peak, the variance is simply calculated the same way that it is calculated in the simple sum method.

Residual Search

If the residual search is enabled, for each peak region (ROI), the residuals will be searched for all residual values that exceed the residual threshold. A new peak will be added at the highest residual which also satisfies the proximity clause, i.e. it is at least the minimum peak separation distance away from an existing peak location.

If the residual does not exceed the residual threshold at any channel within the ROI or the residual does exceed the threshold at some channel(s) but the location is too close to an existing peak no peak will be added.

If the residual does exceed the threshold at one or more locations which are more than the minimum peak separation distance away from an existing peak, a peak will automatically be added to the location of the highest such residual (one peak at a time). The algorithm will then re-establish the ROI limits. In doing so, the previous ROI will also be considered since it may now need to be fitted together with the current ROI. After the ROI has been re-established the residual search is repeated until no more peaks need to be added. The residual search is then performed on the next ROI until no more ROIs are left in the spectrum.

In combining ROIs, logic has been built into the system to recognize a situation where the total number of peaks in the current ROI and the previous ROI exceeds the maximum that the algorithm can handle (currently 16) and not try to re-fit such a region as a single region. If a region which would have more than 16 peaks must be broken up, it is done at the lowest valley that provides two regions, each less than 16 peaks.

No Critical Level testing (page 66) is performed while peaks are being added based on a residual search. The Critical Level test (if enabled) is performed only after a particular peak ROI has been completely processed.

Note that it is not wise to set the residual search threshold and/or the proximity threshold very low. If a peak is added too close to an existing peak, the peak area results are likely to be unreliable.[19,20] If the residual threshold is set too low, the algorithm will spend a lot of time adding and quantifying peaks that will promptly be removed by the Critical Level test. The default for the residual threshold is 6 and the default for the peak separation parameter (proximity factor) 1 FWHM.

Critical Level Testing

Peak areas may be subjected to a Critical Level test. A Critical Level, L_C, is based on the maximum acceptable confidence level k_α, together with the standard deviation, σ_0, of a null net signal and mathematically defined as

$$L_C = k_\alpha \sigma_0 \tag{167}$$

If the Critical Level test *is* in effect, an observed signal, S, must exceed L_C to be accepted as a valid peak area result. Areas not exceeding L_C are simply ignored.

If the Critical Level test *is not* in effect all peak areas regardless of their size are accepted as valid results and saved. This includes negative areas, if the peak area calculation so indicates.

For more information on how the Critical Level is derived, see “MDA Calculations” on page 324.

With this algorithm the Critical Level test is applied separately for each peak regardless of whether it is a singlet or part of a multiplet.

19. Koskelo, M. J. and Mercier, M. T. Nucl. Instr. & Meth. A299 (1990) 318.
20. M. T. Mercier and M. J. Koskelo, J. Radioanal. & Nucl. Chem. 160 (1992) 233.

Peak Area Corrections

If appropriate, the peak areas can be corrected for random summing and subtraction of the environmental background.

Reference Peak Correction

The purpose of a reference peak correction algorithm is to use a reference peak in the spectrum (of a known count rate) to normalize the areas of all other peaks in the spectrum. The reference source can be either an electronic pulser or an external stationary source. The concepts presented here are general purpose concepts that are applicable to either type of a reference source.

If both a reference peak correction and an environmental background subtract are to be applied, the reference peak correction must always be applied first. This algorithm provides both of these corrections in the proper order.

Reference Peak Correction Factor

If a peak is found at the reference energy (REFENG) within the energy tolerance currently in effect, the calculations will proceed as described here. If a peak is not found at the reference energy, an error will be produced.

First, the algorithm will calculate the reference peak ratio as

$$K = \frac{C_0 \cdot e^{-\frac{\ln(2) t_w}{T_{1/2}}}}{C_m} \tag{168}$$

where

t_w is the elapsed time between the reference rate measurement date/time (REFDATE) and the start of acquisition date/time (ASTIME).[21]

$T_{1/2}$ is the half-life of the reference nuclide (REFHLF),

C_0 is the known count rate of the reference source (REFRATE) on the reference date, and

C_m is the current observed count rate of the reference source (PSCTSS for the identified reference peak).

21. Note that the decay correction is only applicable for a stationary source. No decay correction is required for an electronic pulser.

The uncertainty associated with the nuclide half-life is usually negligible in relation to the acquisition time and there is no uncertainty associated with the elapsed time. Therefore, the uncertainty of the reference peak ratio is calculated as

$$\sigma_K = K \cdot \sqrt{\left(\frac{\sigma_{C_0}}{C_0}\right)^2 + \left(\frac{\sigma_{C_m}}{C_m}\right)^2} \tag{169}$$

where

σ_{C_0} is the uncertainty of the reference rate (DREFRATE), and

σ_{C_m} is the uncertainty of the observed count rate of the reference peak, which is calculated as

$$\sigma_{C_m} = \frac{\text{PSCERR}}{100} \cdot \text{PSCTSS} \tag{170}$$

Corrected Peak Areas

After the reference peak ratio has been established, the current net peak area will be corrected for each peak in the spectrum as follows

$$S' = K \cdot S \tag{171}$$

where

S' is the net peak area (PSAREA) after this correction,

S is the net peak area (PSAREA) before this correction, and

K is the calculated reference peak ratio (REFPKRATIO).

The uncertainty of the net area after this correction, $\sigma_{S'}$, is calculated as

$$\sigma_{S'} = S' \cdot \sqrt{\left(\frac{\sigma_S}{S}\right)^2 + \left(\frac{\sigma_K}{K}\right)^2} \tag{172}$$

where

σ_S is the uncertainty of the net peak area before the correction (PSDAREA), and

σ_K is the uncertainty of the reference peak ratio (DREFPKRAT).

For each peak in the spectrum the current net counts per second will be corrected as follows

$$R' = K \cdot R \tag{173}$$

where

R' is the net counts per second (PSCTSS) after this correction,

R is the net peak area (PSCTSS) before this correction, and

K is the calculated reference peak ratio (REFPKRATIO).

The uncertainty of the net count rate after this correction, $\sigma_{R'}$, is calculated as

$$\sigma_{R'} = R' \cdot \sqrt{\left(\frac{\sigma_R}{R}\right)^2 + \left(\frac{\sigma_K}{K}\right)^2} \tag{174}$$

where

σ_R is the uncertainty of the net peak count rate before the correction, and

σ_K is the uncertainty of the reference peak ratio (DREFPKRAT).

Subtraction of Peak Environmental Background

There are three steps in the peak environmental background subtract: peak area calculation, peak area uncertainty and critical level testing.

Net Peak Area Calculation

If an environmental background subtraction is performed using the standard background subtract method, the corrected net peak area for a general case is calculated as

$$S = R \cdot (G - B) - I \tag{175}$$

where

G are the gross counts in the peak ROI,

B is the continuum subtracted from the gross counts to produce the net area,

R is the correction factor for random summing (set to 1, if no reference peak correction is applied), and

I is the number of counts above the continuum that are due to the environmental background.

The environmental background interference is calculated as

$$I = \frac{T_s}{T_b} \cdot I_b \tag{176}$$

where

T_s is the live time of the sample spectrum,

T_b is the live time of the background spectrum, and

I_b is the net peak area of the peak in the background spectrum (also corrected for random summing, if applicable, although it is usually not required).

The net peak area corrected for both the continuum and the environmental background interference can thus be written as

$$S = R \cdot \left(G - \left(\frac{N}{2n} \right) (B_1 + B_2) \right) - \frac{T_s}{T_b} \cdot I_b \tag{177}$$

The net peak area in the background spectrum, I_b, must be available from a separate analysis performed on the background spectrum and can be defined as

$$I_b = R_b \cdot (G_b - B_b) \tag{178}$$

where

G_b is the gross signal of the background peak in the background spectrum, and

B_b is the continuum of the peak in the background spectrum, and

R_b is the reference peak correction factor for the background spectrum (if applicable, else set to 1).

The continuum in the background spectrum is calculated from the equation

$$B_b = \left(\frac{N}{2n} \right) \left(B_1^{(b)} + B_2^{(b)} \right) \tag{179}$$

where

N is the number of channels in the background peak ROI,

n is the number of continuum channels on each side,

B_1^b is the sum of counts in the low energy continuum region, and

B_2^b is the sum of counts in the high energy continuum region.

Peak Area Uncertainty

With an environmental background subtract in effect, Equation (130) transforms into

$$\sigma_S = \sqrt{\sigma_G^2 + \sigma_B^2 + \sigma_I^2} \tag{180}$$

Using the formalism shown in Equation (132), the variance of the background interference, σ_I^2, can be calculated as

$$\sigma_I^2 = \left(\frac{T_s}{T_b}\right)^2 \sigma_{I_b}{}^2 \tag{181}$$

Substituting Equations (134) and (181) into Equation (180) we get

$$\sigma_S = \sqrt{G + \left(\frac{N}{2n}\right)^2 (B_1 + B_2) + \left(\frac{T_s}{T_b}\sigma_{I_b}\right)^2} \tag{182}$$

where

$$\sigma_{I_b} = \sqrt{G_b + \left(\frac{N}{2n}\right)^2 \cdot (B_1^{(b)} + B_2^{(b)})} \tag{183}$$

Critical Level Testing

If the Critical Level Test is enabled, a peak will be deleted from the list of valid peaks if its area no longer passes the Critical Level Test after the environmental background subtract has been performed.

If the Critical Level Test is not enabled, peaks will not be deleted from the list of valid peaks, even if their areas end up being zero or negative after the environmental background subtract has been performed.

Note that in the interactive environment, the Critical Level Test is enabled/disabled in the peak area setup screen and will automatically remain in effect for the remainder of the analysis phases.

For more information on how the Critical Level is derived, see “MDA Calculations” on page 324.

Subtraction of Alpha Environmental Background

There are three steps in the alpha environmental background subtract: net peak area, peak area uncertainty and critical level test.

Net Peak Area Calculation

For the more common situations in alpha spectroscopy, where the background does not have peaks in it, the following steps will be performed:

1. The end points of each ROI in the sample spectrum are first translated into energy units using the energy calibration equation of the current sample spectrum.

2. The ROI energy limits are then translated back into channel units, using the energy calibration equation of the background spectrum, and rounded off to the nearest whole channel. If the ROI is completely outside the spectrum, the background area for the ROI will be set to zero. If the ROI is partially outside the spectrum, the background area will be calculated based on the channels that are within the spectrum.

3. The raw background counts are calculated as the sum of counts within the ROI in the background spectrum.

4. For singlets, the net peak area of the sample spectrum is calculated as the sum of all counts in the ROI in the sample spectrum minus the sum of raw background counts normalized for count time.

5. For multiplets, the only way to perform a reasonable environmental background subtract is to perform an area calculation on the background spectrum, then subtracting the background peak by peak in the usual way. Therefore, if an alpha background subtract is attempted, and the algorithm detects the presence of a multiplet, it will simply abort with an error message indicating that the regular background subtract should be used.

The corrected net peak area for a general case is calculated as

$$S = G - I \tag{184}$$

where

G are the gross counts in the peak ROI, and

I are the gross counts in the equivalent ROI in the background spectrum corrected for the live time ratio; that is

$$I = \frac{T_s}{T_b} \cdot I_b \tag{185}$$

where

T_s is the live time of the sample spectrum,

T_b is the live time of the background spectrum, and

I_b are the gross counts in the equivalent ROI in the background spectrum.

The net peak area corrected for the environmental background interference can thus also be written as

$$S = G - \frac{T_s}{T_b} \cdot I_b \tag{186}$$

Peak Area Uncertainty

With an environmental background subtract in effect, the equation for the net peak area uncertainty transforms into

$$\sigma_S = \sqrt{\sigma_G^2 + \sigma_I^2} \tag{187}$$

where the variance of the background interference, σ_I^2, can be calculated as

$$\sigma_I^2 = \left(\frac{T_s}{T_b}\right)^2 \sigma_{I_b^2} \tag{188}$$

where we have taken advantage of the fact that the gross counts in the background spectrum I_B are Poisson distributed. Substituting these into the equation for peak area uncertainty we get

$$\sigma_S = \sqrt{G + \left(\frac{T_s}{T_b}\right)^2 I_b} \tag{189}$$

Critical Level Test

If the Critical Level Test is enabled, a peak will be deleted from the list of valid peaks if its area no longer passes the Critical Level Test after the environmental background subtract has been performed.

If the Critical Level Test is *not* enabled, peaks will not be deleted from the list of valid peaks, even if their areas are zero or negative after the environmental background subtract has been performed.

Reagent Blank Correction

The reagent blank correction algorithm uses the tracer peak in the spectrum to subtract a certain amount from the other peaks in the spectrum.

If both a reagent blank correction and an environmental background subtract are to be applied, the environmental background subtract correction must always be applied first.

The Reagent Blank Correction Factors

As the current sample spectrum is analyzed for peaks, if a peak is found at an energy that is within the energy tolerance of the tracer peak in the reagent blank file, the calculations will proceed as described here. If a matching tracer peak is not found, an error will be produced.

First, the algorithm will calculate the ratios of the areas of all of the peaks to the area of the tracer peak in the reagent blank spectrum as

$$K_i = \frac{N_i}{N_t} \tag{190}$$

where N_t is the peak area of the tracer peak, and N_i is the area of the i^{th} peak. Note that this calculation can be performed on all peaks, since the ratio for the tracer peak will simply be one.

For the time being, it is assumed that the reagent blank measurement has been made reasonably recently compared to the current sample measurement, so that the ratios will be valid for both the sample and the reagent blank.

The uncertainty of each of the peak ratios is calculated as

$$\sigma_{K_i} = K_i \cdot \sqrt{\left(\frac{\sigma_{N_t}}{N_t}\right)^2 + \left(\frac{\sigma_{N_i}}{N_i}\right)^2} \tag{191}$$

where

σ_{N_t} is the uncertainty of the tracer area N_t, and

σ_{N_i} is the uncertainty of the i^{th} peak N_i.

Corrected Peak Areas

After the peak ratios have been established from the reagent blank spectrum, the peak areas of the sample spectrum will be corrected for each peak (not the tracer peak) as follows

$$N'_i = N_i - K_i \cdot N_t \tag{192}$$

where

N'_i is the peak area after this correction,

N_i is the peak area before this correction,

K_i is the calculated reagent blank correction for this peak, and

N_t is the peak area of the tracer peak in the sample spectrum.

The uncertainty of the peak area after this correction, σ_{Ni}', is calculated as

$$\sigma_{N_i}' = \sqrt{\sigma_{N_i}^2 + N_t^2 \cdot \sigma_{K_i}^2 + K_i^2 \cdot \sigma_{N_t}^2} \tag{193}$$

where

σ_{N_i} is the uncertainty of the peak area before the correction,

σ_{K_i} is the uncertainty of the peak ratio, and

σ_{N_t} is the uncertainty of the peak area of the tracer peak.

For each peak in the spectrum, the current net counts per second will be corrected as follows

$$R'_i = \frac{N'_i}{T_s} \tag{194}$$

where

N'_i is the peak area after this correction, and

T_s is the live time of the sample spectrum (in seconds).

The uncertainty of the count rate after this correction, $\sigma_{R_i}{}'$, is calculated as

$$\sigma_{R'_i} = \frac{\sigma_{N'_i}}{T_s} \tag{195}$$

where

$\sigma_{N'_i}$ is the uncertainty of the net peak area after the correction,

T_s is the live time of the sample spectrum (in seconds).

Critical Level Test

If the Critical Level Test is enabled, a peak will be deleted from the list of valid peaks if its area no longer passes the Critical Level Test after the reagent blank background subtract has been performed.

If the Critical Level Test is *not* enabled, peaks will not be deleted from the list of valid peaks, even if their areas are zero or negative after the reagent blank background subtract has been performed.

Efficiency Correction

The efficiency correction calculation means obtaining an efficiency and its uncertainty for each of the found peaks. Efficiency corrections can be made with any of the available models: Dual, Linear, Empirical, Average, or Tracer.

Efficiency Correction Using the Dual Curve

The efficiency from the Dual Efficiency Calibration Curve is calculated as

$$\varepsilon = e^{\left(\sum_{i=0}^{n} b_i \cdot (\ln(E))^i \right)} \tag{196}$$

where the b's are the parameters determined for the curve at the time of the efficiency calibration.

The variance of the efficiency, σ_ε^2, is calculated as

$$\sigma_\varepsilon^2 = \varepsilon^2 \sum_n \sum_m (\ln(E))^{n-1} (\ln(E))^{m-1} (M^{-1})_{n,m} \tag{197}$$

which can also be presented in the form

$$\begin{aligned} \sigma_\varepsilon^2 &= \varepsilon^2 \sum_n (\ln(E))^{2n-2} \sigma_{b_n}^2 \\ &+ \varepsilon^2 \cdot \sum_n \sum_m (\ln(E))^{n-1} (\ln(E))^{m-1} \mathrm{COVAR}(b_n, b_m), n \neq m \end{aligned} \tag{198}$$

where

$$\mathrm{COVAR}(b_n, b_m) = (M^{-1})_{n,m} \ , \ n \neq m \tag{199}$$

and

$$(M^{-1})_{n,m} \tag{200}$$

is the inverse of the matrix resulting from the least squares determination of the efficiency calibration coefficients b_n.

Efficiency Correction Using the Linear Curve

The efficiency from the Linear Efficiency Calibration Curve is calculated as

$$\varepsilon = 10^{\left(\sum_{i=-1}^{n} a_i \cdot \left(\frac{1}{E} \right)^i \right)} \tag{201}$$

where the a's are the parameters determined for the curve at the time of the efficiency calibration.

The variance of the efficiency, σ_ε^2, is calculated as

$$\sigma_{\varepsilon}^{2} = \left(\frac{\varepsilon}{\log(e)}\right)^{2} \sum_{n} \sum_{m} \left(\frac{1}{E}\right)^{n-1} \left(\frac{1}{E}\right)^{m-1} (M^{-1})_{n,m} \tag{202}$$

which can also be presented in the form

$$\sigma_{\varepsilon}^{2} = \left(\frac{\varepsilon}{\log(e)}\right)^{2} \cdot \sum_{n} \left(\frac{1}{E}\right)^{2n-2} \sigma_{a_n}^{2} + \left(\frac{\varepsilon}{\log(e)}\right)^{2} \cdot \sum_{n} \sum_{m} \left(\frac{1}{E}\right)^{n-1} \left(\frac{1}{E}\right)^{m-1} \text{Covar}(a_n, a_m),\ n \neq m \tag{203}$$

where

$$\text{Covar}(a_n, a_m) = (M^{-1})_{n,m} \ , \ n \neq m \tag{204}$$

and

$$(M^{-1})_{n,m} \tag{205}$$

is the inverse of the matrix resulting from the least squares determination of the efficiency calibration coefficients a_n.

Efficiency Correction Using the Empirical Curve

The efficiency from the Empirical Efficiency Calibration Curve is calculated as

$$\varepsilon = e^{\left(\sum_{i=0}^{n} c_i \cdot \left(\ln\left(\frac{c_a}{E}\right)\right)^{i}\right)} \tag{206}$$

where the c's are the parameters determined for the curve at the time of the efficiency calibration.

The standard deviation of the efficiency, σ_{ε}, is calculated as

$$\sigma_{\varepsilon} = \Delta\varepsilon_{E1} + \frac{\Delta\varepsilon_{E2} - \Delta\varepsilon_{E1}}{E_2 - E_1} \cdot (E - E_1) \tag{207}$$

where

E is the energy at which the efficiency is being computed,

E_1 is the nearest calibration energy below energy E,

E_2 is the nearest calibration energy above energy E,

$\Delta\varepsilon_{E1}$ is the interpolation uncertainty at energy E1, and

$\Delta\varepsilon_{E2}$ is the interpolation uncertainty at energy E_2.

For energies less than E_1 and greater than E_2, the standard deviation is set equal to $\Delta\varepsilon_{E1}$ and $\Delta\varepsilon_{E2}$, respectively.

Efficiency Correction Using Average Efficiency

In Alpha Spectroscopy work, all peaks have the same counting efficiency. Efficiency correction with the Average Efficiency model simply consists of copying the known average efficiency to the peak record of each found peak.

Efficiency Correction Using a Tracer

In alpha spectroscopy work, a straight counting efficiency is often not sufficient to determine the activities in the sample. To establish the loss of sample material during the chemical processes that are part of the sample preparation, it is customary to add a tracer (a known amount of a suitable radionuclide) into the sample at the beginning of the sample preparation. The efficiency calculated from the observed signal of the tracer peak is a combination of the chemical recovery factor and the counting efficiency. In this text, the term effective efficiency is used for this combined efficiency.

Effective Efficiency

For alpha spectra, the effective efficiency from a tracer peak is calculated as

$$\varepsilon_{eff} = \frac{N_t}{R\,K\,T} \tag{208}$$

where

N_t is the net area of the tracer peak (corrected for background, if the background subtract is enabled),

R is the known emission rate of the tracer per sample (in units of 1/s),

K is the decay correction factor for any decay during the spectrum acquisition and between the time the sample acquisition was started and the tracer reference date/time, and

T is the acquisition live time (in seconds).

The factor K is a composite of two correction factors

$$K = K_c \cdot K_W \tag{209}$$

where

K_c is the correction factor for the tracer nuclide decay during spectrum acquisition:

$$K_c = \frac{T_{1/2}}{\ln(2)\, t_c} \left(1 - e - \frac{\ln(2)\, t_c}{T_{1/2}} \right) \tag{210}$$

where

$T_{1/2}$ is the half-life of the tracer nuclide, and

t_c is the elapsed real clock time during the measurement (in the same time units as $T_{1/2}$), and

K_w is the correction factor for the tracer nuclide decay from the tracer reference date/time to the start of the spectrum acquire:

$$K_w = e - \frac{\ln(2)\, t_w}{T_{1/2}} \tag{211}$$

where t_w is the elapsed clock time from the tracer reference time/date to the beginning of the spectrum acquire (in the same time units as $T_{1/2}$).

The uncertainty of the effective efficiency is calculated as

$$\sigma_{\varepsilon_{eff}} = \varepsilon_{eff} \cdot \sqrt{\left(\frac{\sigma_{N_t}}{N_t}\right)^2 + \left(\frac{\sigma_R}{R}\right)^2 + \left(\frac{\sigma_K}{K}\right)^2} \tag{212}$$

where

σ_{N_t} is the uncertainty of the net area of the tracer peak,

σ_R is the uncertainty of the emission rate of the tracer (in units of 1/s), and

σ_K is the uncertainty due to the decay correction factors, which is defined as

$$\sigma_K = K \cdot \sqrt{\left(\frac{\sigma_{K_c}}{K_c}\right)^2 + \left(\frac{\sigma_{K_w}}{K_w}\right)^2} \tag{213}$$

The uncertainty of the decay correction factor, K_c, is calculated as

$$\sigma_{K_c} = \left(\frac{1 + K_c}{T_{1/2}}\right)\sigma_{T_{1/2}} \tag{214}$$

The uncertainty of the decay correction factor, K_w, is calculated as

$$\sigma_{K_W} = \frac{K_W \cdot \ln(2) \cdot t_W}{(T_{1/2})^2} \cdot \sigma_{T_{1/2}} \tag{215}$$

Chemical Recovery Factor for an Unknown Sample

If a counting efficiency value is available and tracer information is provided, the algorithm will calculate a chemical recovery factor as

$$R_c = \frac{N_t}{R\,K\,T_l\,\varepsilon} \tag{216}$$

where

N_t is the net area of the tracer peak,

R is the known emission rate of the tracer per sample (in units of 1/s),

K is the decay correction factor for any decay during the spectrum acquisition and between the time the sample acquisition was started and the tracer reference date/time,

T_l is the live time of the collect (in seconds), and

ε is the counting efficiency.

The uncertainty of the chemical recovery factor is calculated as

$$\sigma_{R_c} = R_c \sqrt{\left(\frac{\sigma_{N_t}}{N_t}\right)^2 + \left(\frac{\sigma_R}{R}\right)^2 + \left(\frac{\sigma_K}{K}\right)^2 + \left(\frac{\sigma_\varepsilon}{\varepsilon}\right)^2} \quad (217)$$

where all the terms have been defined above except σ_ε, which is defined as the uncertainty of the counting efficiency.

If the counting efficiency is not available in the datasource being analyzed, the chemical recovery factor and its error are not calculated and the associated parameters are set to zero.

If the sample does not contain a tracer, this algorithm can also be executed in the "Simple Efficiency" mode which will merely copy the known single counting efficiency value and its error into the peak search records.

Chemical Recovery Factor for a Control Sample

The Alpha Efficiency Correction algorithm has been enhanced to calculate the chemical recovery of a Control Sample. This can be a separate step within an ASF. The setup screen within the ASF asks for a certificate for the control isotope and the amount of control added to the sample in mL (milliliters). The Control Certificate must contain the control peak energy and associated activity concentration per milliliter.

The activity of "control isotope" (normally of the same actinide, but a different isotope than the tracer) is first calculated by the normal method. The value of the calculated activity will then be compared to the actual value within the control certificate value to calculate the chemical recovery of the Control Sample. This recovery value (in absolute format) will be transferred to the appropriate CONTROL.QAF for the element/matrix pair defined in the sample protocol.

$$\text{Control recovery} = \frac{A_m}{A_c} \quad (218)$$

where

A_m = Measured activity of the Control Sample

A_c = Certified activity of the Control Sample

where A_c is calculated as

$$A_c = \frac{E \cdot V_c}{C_f \cdot Q \cdot D} \quad (219)$$

E = Activity concentration from the Control Certificate

V_c = Volume of the Control added to the sample aliquot

C_f = Conversion factor from Bq to µCi

Q = Sample quantity

D = Decay correction for the Control Isotope

Manually Entered Chemical Recovery Factor

The Alpha Efficiency Correction algorithm also includes the capability to handle a manually entered chemical recovery factor. If the efficiency correction mode has been selected to be "simple counting efficiency" but the chemical recovery factor is greater than zero, the algorithm automatically calculates an effective efficiency, e_{eff}, based on the counting efficiency and the chemical recovery factor as

$$\varepsilon_{eff} = \varepsilon \cdot R_c \tag{220}$$

where ε is the "normal" counting efficiency and R_c is the user entered chemical recovery factor (fraction, not a percentage). The uncertainty of the effective efficiency is defined as

$$\sigma_{\varepsilon_{eff}} = \varepsilon_{eff} \sqrt{\left(\frac{\sigma_\varepsilon}{\varepsilon}\right)^2 + \left(\frac{\sigma_{R_c}}{R_c}\right)^2} \tag{221}$$

This effective efficiency will be used by the nuclide identification and MDA algorithms automatically.

Nuclide Identification and Activity Calculation

Basic Calculations

The nuclide identification uses a matrix formalism similar to the one developed in SAMPO80[22] which is based on the ideas originally presented by Gunnink.[23] This formalism takes into account all lines of a nuclide entered into the analysis library with their proper branching ratios.

22. Koskelo, M.J., Aarnio, P.A. and Routti, J.T. (1981). *Nucl. Instr. & Meth.* 190:89.
23. Gunnink, R. and Niday, J.B. (1972). *University of California Lawrence Livermore Laboratory Report UCRL-51061*.

At first the program builds a matrix of possible identifications by comparing each nuclide in the analysis library against the observed peaks. Only nuclides that pass the following criteria are accepted into the matrix:

1. The library nuclide must have at least one gamma energy within the user-selected energy tolerance of an observed peak. For each gamma energy of a library nuclide that is within the energy tolerance of an observed gamma peak, the nuclide confidence value (which starts out as 1.0) is multiplied by the following penalty function:

$$f(\Delta E_i) = e^{\left(-\frac{0.16}{ETOL^2} \cdot \frac{(\Delta E_i)^2 \, y_i}{\sum_i y_i} \right)} \tag{222}$$

   where

   ETOL is the user-selected energy tolerance (fixed or variable, whichever is in effect),

   ΔE_i is the difference between the reference energy and the measured energy for the i^{th} peak,

   0.16 is an empirical constant which currently cannot be changed, and

   y_i is the branching ratio of the i^{th} peak.

2. If at least one matching energy has been found, the confidence index is further reduced as follows

$$\text{Index}' = \text{Index} - 1.6 \cdot \frac{\sum_j^n y_j \cdot w(E_j) \cdot \delta(MDA)_j}{\sum_i^N y_i \cdot w(E_i)} \tag{223}$$

   where

   n is the number of energy lines from the library for this nuclide that did not have a matching observed peak in the spectrum (to within the energy tolerance in effect),

   N is the total number of peaks in the library for this nuclide,

   y_i is the branching ratio of the i^{th} peak, and

1.6 is an empirical constant which currently cannot be changed, and

δ(MDA) is dependent on whether the MDA test is enabled or not.

If the MDA test is disabled, δ(MDA) is always 1. If the MDA test is enabled

$$\partial(\mathrm{MDA})_j = \begin{cases} 1, & \text{if } P_j \geq \mathrm{MDA}_j \\ 0, & \text{if } P_j < \mathrm{MDA}_j \end{cases} \tag{224}$$

where

P_j is the expected area of a peak at energy E_j calculated from the first peak match, and

MDA_j is the MDA (in units of peak area) calculated at energy E_j for a peak that was not observed.

The weighting factors $w(E_j)$ are calculated as

$$w(E_j) = \sqrt{\varepsilon} \cdot e^{-\mu(E_j)\rho t} \tag{225}$$

where

ε is the efficiency at gamma energy E_j excluding the correction due to attenuation,

$\mu(E_j)$ is the mass attenuation (in units of cm^2/g) at gamma energy E_j, and

ρt is the average density of the material times its thickness (effective mass per area of the sample in units of g/cm^2).

It will be assumed that the mass attenuation will be described in the form of a polynomial curve in the ln-ln domain, which has been established through a separate setup procedure. That is, the equation for the mass attenuation curve is assumed to be of the form

$$\ln(\mu(E)) = \sum_{i=0}^{n} f_i \cdot (\ln(E))^i \tag{226}$$

where f_i are empirically determined coefficients.

Note that if the attenuation correction has not been performed, ρt will be undefined (= 0) and the weighting factor automatically reduces to just using the efficiency.

3. Finally the confidence index is multiplied by the decay time penalty function

$$g(\Delta t) = e^{\left(-P_1 \left(\frac{\Delta t}{T_{1/2}}\right)^2\right)} \quad (227)$$

where

P_1 is an empirically chosen constant (currently 5.1E-03) which currently cannot be changed. It has been chosen to reduce the confidence index to 0.3 (the default acceptance threshold) based on this penalty alone, if the sample has decayed more than approximately 15 half-lives of the possible identified nuclide. This is done to remove from the calculations nuclides with too short a half-life to be probable.

Δt is the elapsed time from the sample taking time to the start of the measurement, and

$T_{1/2}$ is the half-life of the nuclide.

Nuclides which pass through these three tests with a confidence index greater than the user-selected threshold will be classified as identified. The result is a matrix of the form shown in Figure 6. In this example, the first peak in the spectrum has been identified to belong to nuclide number five, the second peak to nuclides one and two, etc. The third and the eight peaks have not been identified at all.

During the plain nuclide identification, the nuclide activities for each of the energy lines are calculated without taking some of this information into account. For example, the activity of nuclide one for its first energy line that matches with the second observed peak in the spectrum is calculated as if the identification for nuclide two did not exist at all.

For nuclide two the calculation of activity is done as if the identification for nuclide one did not exist at all, etc. How much of peak two is actually explained by the two nuclides can only be determined by an interference correction algorithm which is explained in “Activity Corrections” on page 318.

The activity per unit volume (or mass) of the sample, C, on the sample date (decay corrected) for each energy line in the library that has been matched with a line in the spectrum is calculated as

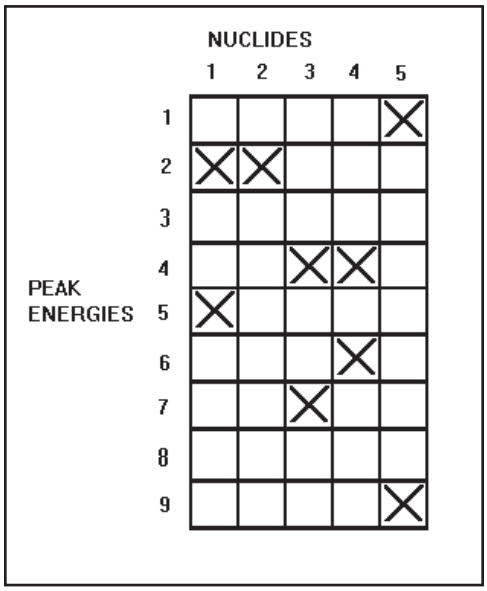


Figure 6 Indentification Matrix

$$C = \frac{S}{V \varepsilon' y T_l U_f K_c K_w} \tag{228}$$

where

S is the net peak area,

Note: If the peak area is exactly zero, the activity and activity uncertainty are calculated using a net peak area value of 1. After calculating the activity uncertainty, the activity is set to zero to correspond to the zero net area.

V is the sample volume (or mass),

ε' is the attenuation corrected efficiency, i.e.

$$\varepsilon' = \varepsilon \cdot e^{-\mu(E)\rho t} \tag{229}$$

where

ε is the non-attenuation corrected detection efficiency at the peak energy in question.

Note that if the attenuation correction has not been performed $\varepsilon' = \varepsilon$. If the attenuation correction has been performed, the efficiency value stored in the peak search results is the already corrected efficiency, ε'.

$\mu(E)$ is the mass attenuation (in units of cm^2/g) at gamma energy E,

ρt is the average sample mass per unit area,

y is the branching ratio of the peak energy,

T_l is the live time of the collect in seconds,

U_f is the conversion factor required to have the activity in μCi (the fixed internal storage unit),

K_c is the correction factor for the nuclide decay during counting,[24] namely

$$K_c = \frac{T_{1/2}}{\ln(2)\, t_c}\left[1 - e^{-\frac{\ln(2)\, t_c}{T_{1/2}}}\right] \tag{230}$$

where

$T_{1/2}$ is the half-life of the nuclide in question, and

t_c is the elapsed real clock time during the measurement (in the same time units as $T_{1/2}$).

K_w is the correction factor for the nuclide decay from the time the sample was obtained to the start of the collect, namely

$$K_w = e^{-\frac{\ln(2) t_w}{T_{1/2}}} \tag{231}$$

where t_w is the elapsed clock time from the time the sample was taken to the beginning of the measurement (in the same time units as $T_{1/2}$).

A slightly different calculation is used for samples where the sample material is collected or accumulated over a finite period of time. Such samples include air filters and activation samples.

For *air filter samples*, the decay corrected activity is calculated as

24. If the sample is measured while it is being accumulated, the decay correction during acquisition should not be performed. For such situations, this decay correction can be disabled.

$$C = \frac{S}{V \varepsilon' y T_l U_f K_c K_w K_s} \tag{232}$$

which is equivalent to Equation (228) except for the additional correction factor, K_s, for decay during the sampling time, which is defined as

$$K_s = \frac{T_{1/2}}{\ln(2)\, t_s} \left[1 - e^{-\frac{\ln(2)\, t_s}{T_{1/2}}} \right] \tag{233}$$

where t_s is the sampling time.

For *irradiated samples* the decay corrected activity (saturation activity) is calculated as

$$C = \frac{S}{V \varepsilon' y T_l U_f K_c K_w K_i} \tag{234}$$

which is equivalent to Equation (228), except for the additional correction factor, K_i, for decay during the irradiation, which is defined as

$$K_i = 1 - e^{-\frac{\ln(2)\, t_i}{T_{1/2}}} \tag{235}$$

where

t_i is the irradiation time.

The random uncertainty of the activity, C, is calculated as

$$\sigma_C = C \cdot \sqrt{\left(\frac{\sigma_R}{100}\right)^2 + \left(\frac{\sigma_S}{S}\right)^2 + \left(\frac{\sigma_V}{V}\right)^2 + \left(\frac{\sigma_{\varepsilon'}}{\varepsilon'}\right)^2 + \left(\frac{\sigma_y}{y}\right)^2 + \left(\frac{\sigma_K}{K}\right)^2} \tag{236}$$

where

σ_R is the user defined random uncertainty (%),

σ_S is the uncertainty of the net peak area S,

σ_V is the uncertainty of the sample quantity V,

$\sigma_{\varepsilon'}$ is the uncertainty of the effective efficiency, which is defined a3

$$\sigma_{\varepsilon'} = \varepsilon' \cdot \sqrt{(\sigma_\varepsilon \,/\, \varepsilon)^2 + (\rho t \cdot \sigma_{\mu(E)})^2 + (\mu(E) \cdot \sigma_{\rho t})^2} \tag{237}$$

where ε is the non-attenuation corrected detection efficiency at the peak energy in question, σ_ε is its uncertainty, $\mu(E)$ is the mass attenuation (in units of cm^2/g) at gamma energy E, $\sigma_{\mu(E)}$ is its uncertainty, $\rho\tau$ is the average sample mass per unit area, and $\sigma_{\rho t}$ is its uncertainty.

σ_y is the uncertainty of the branching ratio y, and

σ_K is the uncertainty of the composite decay correction factor K,

which for buildup type “None” is defined as

$$\sigma_K = K \cdot \sqrt{\left(\frac{\sigma_{K_c}}{K_c}\right)^2 + \left(\frac{\sigma_{K_w}}{K_w}\right)^2} \tag{238}$$

for buildup type “Deposition” as

$$\sigma_K = K \cdot \sqrt{\left(\frac{\sigma_{K_c}}{K_c}\right)^2 + \left(\frac{\sigma_{K_w}}{K_w}\right)^2 + \left(\frac{\sigma_{K_s}}{K_s}\right)^2} \tag{239}$$

and for buildup type “Irradiation” as

$$\sigma_K = K \cdot \sqrt{\left(\frac{\sigma_{K_c}}{K_c}\right)^2 + \left(\frac{\sigma_{K_w}}{K_w}\right)^2 + \left(\frac{\sigma_{K_i}}{K_i}\right)^2} \tag{240}$$

The composite decay correction factor itself is defined as

$$K = K_C \cdot K_W \cdot K_X \tag{241}$$

where K_c is defined in Equation (230), K_w is defined in Equation (231), and K_x is 1 for buildup type “None”, defined by Equation (233) for buildup type “Deposition”, and by Equation (235) for buildup type “Irradiation”.

The uncertainty of the decay correction factor, K_c, is calculated as

$$\sigma_{K_c} = \left| K_c - e^{\frac{-tc\ln(2)}{T\frac{1}{2}}} \right| \cdot \frac{\sigma_{T\frac{1}{2}}}{T\frac{1}{2}} \tag{242}$$

The uncertainty of the decay correction factor, K_w, is calculated as

$$\sigma_{K_W} = \frac{K_W \cdot \ln(2) \cdot t_W}{(T\frac{1}{2})^2} \cdot \sigma_{T\frac{1}{2}} \tag{243}$$

The uncertainty of the decay correction factor, K_s, is calculated as

$$\sigma_{K_s} = \left| K_s - e^{\frac{-ts\ln(2)}{T\frac{1}{2}}} \right| \cdot \frac{\sigma_{T\frac{1}{2}}}{T\frac{1}{2}} \tag{244}$$

The uncertainty of the decay correction factor, K_i, is calculated as

$$\sigma_{K_i} = \frac{\left(1 - K_i\right) \cdot \ln(2) \cdot t_i}{(T\frac{1}{2})^2} \cdot \sigma_{T\frac{1}{2}} \tag{245}$$

In all cases, if the branching ratio uncertainty, σ_y, and/or the half-life uncertainty, $\sigma_{T\frac{1}{2}}$ are not available, they are set to zero.

Note that the effective efficiency and its uncertainty are simply taken from the PSEFF and PSEFERR parameters. They are composite effective efficiency values only if a separate attenuation correction algorithm has been executed prior to the nuclide identification phase and it has modified the contents of these two parameters.

Also note that if the net area of the ROI is zero, the efficiency, abundance and decay correction factor uncertainties are *not* included in the random uncertainty of the activity calculation.

And finally, the *total* uncertainty of the activity, C, is calculated as

$$\sigma_{C(T)} = \sigma_C + \frac{\sigma_{sys} \cdot C}{100} \tag{246}$$

where σ_{sys} is the user defined systematic uncertainty (%).

Example Calculations

For the ^{137}Cs 661 keV line of the example file NBSSTD.CNF, the calculation can be illustrated as follows:

$$K_c = \frac{9.521 \cdot 10^8}{\ln(2) \cdot 4020} \cdot 1 - e\left(- \frac{\ln(2) \cdot 4020}{9.521 \cdot 10^8} \right) = 0.999998537 \quad (247)$$

and

$$K_w = e\left(- \frac{\ln(2) \cdot 6328800}{9.521 \cdot 10^8} \right) = 0.995440311 \quad (248)$$

and

$$C = \frac{9384.9}{1.0 \cdot 1.7601 \cdot 10^{-3} \cdot 0.8512 \cdot 4000 \cdot 37000 \cdot 0.999998537 \cdot 0.99540311} = 4.252 \cdot 10^{-2} \quad (249)$$

which is what the program reports as the decay corrected ^{137}Cs activity in μCi/unit.

The uncertainty of the activity, C, is calculated as

$$\sigma_C = 4.252 \cdot 10^{-2} \cdot \sqrt{\left(\frac{175.35}{9384.9}\right)^2 + \left(\frac{3.9570 \cdot 10^{-5}}{1.7601 \cdot 10^{-3}}\right)^2 + \left(\frac{0.23}{85.12}\right)^2} = 1.248E-03 \quad (250)$$

Activity Corrections

In the Nuclide Identification with Interference Correction algorithm, the interference calculation is invoked after the regular identification. During the interference calculation the identified nuclides are searched for possible interference sets.

An interference set is defined as two or more nuclides with at least one common peak that the peak search and area calculation phases have not been able to resolve into multiple peaks. The activities of such nuclides are calculated as a solution to a linear least squares equation.

For interference sets that include energy lines, where one of the interfering lines has been marked as “do not include in weighted mean calculations”, and the other(s) not, all lines will be included in the calculations, ignoring the setting of the flag.

The activity of a nuclide which is not part of an interference set is calculated as a weighted average of the activities calculated for each one of its peaks. However, the lines that have been marked as “do not include in weighted mean calculations” in the nuclide library will be excluded from this weighted average. The activity of a nuclide with only one peak and no interference from other nuclides is calculated from its single peak. If the only peak of a nuclide has been marked as “do not include in weighted mean calculations”, the flag will be ignored.

Taking an example identification result shown in Figure 7, if none of the energies of the identified nuclides have the “do not include in weighted mean calculations” flag set, it is clear that nuclides one and two form an interference set because they share the second observed peak in the spectrum. The same thing applies to nuclides three and four. Nuclide five does not form an interference set with any other nuclide but it has more than one identified line.

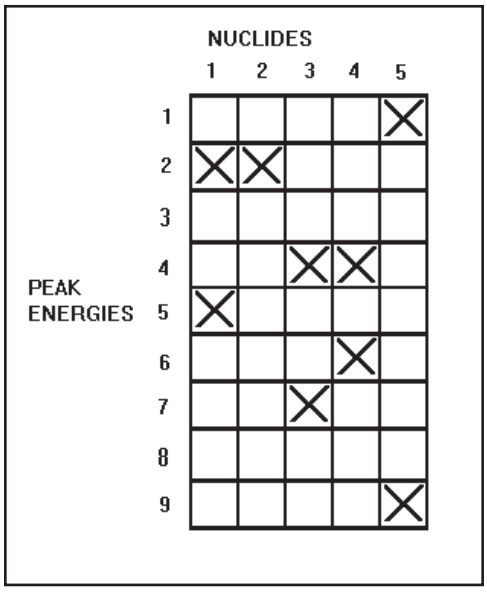


Figure 7 Indentification Matrix

If both the first energy line of nuclide three and the first energy line of nuclide four have the “do not include in weighted mean calculations” flag set, the second interference set ceases to be an interference set and each nuclide will be reported with an activity calculated from the remaining energy line.

The weighted average activity for a nuclide with a single identified energy and no interferences is calculated as described in Equation (228).

The weighted average activity for a nuclide with multiple energies but no interferences is calculated as:

$$C_{Av} = \frac{\sum_{i=1}^{N} \frac{C_i}{\sigma_{C_i}^2}}{\sum_{i=1}^{N} \frac{1}{\sigma_{C_i}^2}} \quad (251)$$

where

C_{Av} = decay corrected weighted average activity,

N = number of nuclide energies identified and not marked as “do not include in weighted mean calculations”,

C_i = the decay corrected activity of the i^{th} energy,

σ_{Ci} is the standard deviation of C_i.

The uncertainty of the weighted average activity from multiple lines is calculated as

$$\sigma_{C_{Av}} = \sqrt{\frac{1}{\sum_{i=1}^{N} \frac{1}{\sigma_{C_i^2}}}} \quad (252)$$

The weighted average activity for a situation where an interference condition exists is calculated by minimizing the quantity

$$\chi^2 = \sum_i \sum_j w_i \cdot (y_i - \alpha_{ij} x_j)^2 \quad (253)$$

where

w_i is the reciprocal of the combination of the area uncertainty and the efficiency uncertainty at the i^{th} observed peak,

y_i is the area of the i^{th} peak divided by its efficiency (attenuation corrected efficiency, if appropriate),

α_{ij} is the branching ratio of the j^{th} nuclide that was matched with the i^{th} peak, and

x_j is the unknown activity of the j^{th} nuclide.

In this formalism, the uncertainties of the branching ratios cannot be taken into account. The weighting factors are calculated merely as

$$w_i = \frac{1}{\sigma_S^2 + \sigma_\varepsilon^2} \tag{254}$$

where

σ_S is the standard deviation of the net peak area and

σ_ε is the standard deviation of the associated efficiency (attenuation corrected efficiency uncertainty, if appropriate).

If the Critical Level Test is enabled, a nuclide with just one peak will not be identified at all if its only peak does not pass the Critical Level Test. A nuclide with multiple lines without interferences and a nuclide with one or more lines that is part of an interference set is rejected if its activity is less than a user selectable MDA confidence factor (e.g. 1.645) times its uncertainty estimate, or if its activity is less than zero.

If the Critical Level Test is not enabled, a nuclide with multiple lines without interferences and a nuclide with one or more lines that is part of an interference set is rejected only if its activity is less than zero. The test requiring that the activity be larger than the user selectable MDA confidence factor times its uncertainty estimate is not invoked.

Note that in the interactive environment, the Critical Level Test is enabled/disabled in the peak area setup screen and will automatically remain in effect for the remainder of the analysis phases. In the batch environment, the Critical Level Test may be enabled via the PARS command at any time, or in connection with the command to perform peak area calculations. It will then normally remain in effect until specifically turned off again.

For more information on how the Critical Level is derived, see “MDA Calculations” on page 324.

Parent-Daughter Correction

Prior to executing the Parent-Daughter Correction algorithm, it is necessary to execute the "NID plus Interference Correction" analysis step on the datasource. The "NID plus Interference Correction" engine calculates the activity of each identified nuclide. Single-line activities are calculated, and the weighted average activities for each nuclide are determined by correcting for interferences. The calculated activities include a decay correction to account for the time lapse between the Acquisition Time and the Sample Time. The NID engine does this, however, by treating each nuclide as a standalone decay. That is, it does not account for parental feeding. Furthermore, Genie 2000 has other post-NID engines to correct for conditions at the time the sample spectrum was collected. These corrections must be applied before the parent-daughter correction.

The Parent-Daughter Correction algorithm loops through the identified nuclides in the datasource searching for nuclides in parent-daughter pairs. It performs corrections to the activities of the daughter nuclides – according to the logic described below – to account for possible feeding from a parent nuclide. The algorithm only treats parent-daughter pairs. It does not handle multiple generation (e.g. parent-daughter-granddaughter) nuclide chains, nor does it handle cases where a daughter has multiple parents.

The elapsed decay time between the Sample Time and the Acquisition Start Time (i.e., $T_{ASTIME} - t_{STIME}$, referred to as t_{decay}) is calculated; in addition the elapsed Acquisition Real Time, referred to as t_{real} , is obtained.

The Parent-Daughter Correction algorithm first examines each nuclide as a potential daughter. For each nuclide identified, its nuclide library record is examined to see if a parent is specified (NCLPARENT) and if the parent nuclide was identified in the sample spectrum. If no parent is specified or if the parent was not identified, no correction will be performed and the software proceeds to the next nuclide in the loop. If a parent is specified and was identified, the correction is calculated and applied to the current nuclide (i.e., the daughter). The corrected daughter activity $D_{0,Corr}$ and its uncertainty , is calculated from the uncorrected daughter activity D_0, the weighted mean parent activity P_0, and their respective uncertainties σ_{D_0} and σ_{P_0} via the equations given below. Note that the correction is applied to daughter's individual line activities as well as the daughter's weighted mean activity.

The corrected daughter activity is obtained by

$$D_{0,Corr} = D_0 - k_{PD} P_0 \frac{\lambda_D}{\lambda_D - \lambda_P} \left[\frac{\lambda_D e^{-\lambda_P t_{decay}} \left(1 - e^{-\lambda_P t_{real}}\right)}{\lambda_P e^{-\lambda_D t_{decay}} \left(1 - e^{-\lambda_D t_{real}}\right)} - 1 \right] = D_0 - C \tag{255}$$

The uncertainty in this quantity is given by

$$\sigma^2_{D_{0,Corr}} = \sigma^2_{D_0} + \left(\sigma_{k_{PD}} \frac{\partial D_{0,Corr}}{\partial k_{PD}}\right)^2 + \left(\sigma_{P_0} \frac{\partial D_{0,Corr}}{\partial P_0}\right)^2 + \left(\sigma_{\lambda_p} \frac{\partial D_{0,Corr}}{\partial \lambda_P}\right)^2 + \left(\sigma_{\lambda_D} \frac{\partial D_{0,Corr}}{\partial \lambda_D}\right)^2 \quad (256)$$

where

$$\frac{\partial D_{0.Corr}}{\partial k_{PD}} = -\frac{C}{k_{PD}} \quad (257)$$

$$\frac{\partial D_{0,corr}}{\partial P_0} = -\frac{C}{P_0} \quad (258)$$

$$\frac{\partial D_{0,corr}}{\partial \lambda_P} = k_{PD} P_0 \left[\frac{\lambda_P}{\left(\lambda_D - \lambda_P\right)^2} \left(\frac{\lambda_D e^{-\lambda_P t_{decay}} \left(1 - e^{\lambda_P t_{real}}\right)}{\lambda_P e^{-\lambda_D t_{decay}} \left(1 - e^{\lambda_D t_{real}}\right)} - 1 \right) + \frac{\lambda_D}{\left(\lambda_D - \lambda_P\right)} \left(\frac{\lambda_D e^{-\lambda_P t_{decay}} \left(1 - e^{\lambda_P t_{real}}\right)}{\lambda_P e^{-\lambda_D t_{decay}} \left(1 - e^{\lambda_D t_{real}}\right)} \right) \left(\frac{t_{real} e^{-\lambda_P t_{real}}}{1 - e^{-\lambda_P t_{real}}} - \frac{1}{\lambda_P} - t_{decay} \right) \right] \quad (259)$$

$$\frac{\partial D_{0,corr}}{\partial \lambda_D} = k_{PD} P_0 \left[\frac{-\lambda_P}{\left(\lambda_D - \lambda_P\right)^2} \left(\frac{\lambda_D e^{-\lambda_P t_{decay}} \left(1 - e^{-\lambda_P t_{real}}\right)}{\lambda_P e^{-\lambda_D t_{decay}} \left(1 - e^{-\lambda_D t_{real}}\right)} - 1 \right) + \frac{\lambda_D}{\left(\lambda_D - \lambda_P\right)} \left(\frac{\lambda_D e^{-\lambda_P t_{decay}} \left(1 - e^{-\lambda_P t_{real}}\right)}{\lambda_P e^{-\lambda_D t_{decay}} \left(1 - e^{-\lambda_D t_{real}}\right)} \right) \left(\frac{-t_{real} e^{-\lambda_D t_{real}}}{1 - e^{-\lambda_D t_{real}}} + \frac{1}{\lambda_D} + t_{decay} \right) \right] \quad (260)$$

In the above expressions, k_{PD} is the branching ratio (abundance) from the parent to the daughter. This is obtained from the NCLPARENTRAT parameter from the *daughter's* NID record. The uncertainty in the branching ratio is obtained from the NCLPARENTRER parameter from the daughter's NID record. λ_D and λ_P are the decay parameters for the daughter and parent, respectively. These are calculated from each nuclide's half-life via $\lambda = \ln 2 / t_{1/2}$.

The algorithm then makes a second pass through the list of identified nuclides, this time examining each as a potential parent. If the nuclide has a daughter defined in the NCLDAUGHT parameter of its nuclide library record, but the specified daughter was *not* found in the sample spectrum, an activity record is created for the daughter and its activity is calculated and stored. To do this, the above equations are used, but since the daughter was not originally found in the spectrum, the uncorrected daughter activity is assumed to be 0. As in the first pass, the corrected activity is calculated for both the daughter's individual lines as well as for its mean activity. Note that by assuming 0 for the uncorrected daughter activity, the above expression yields a corrected activity that is less than 0 in the case where the Acquisition Start Time occurs after the Sample Time (i.e., $t_{decay} > 0$).

In both passes, if the algorithm changes a nuclide's activity, this fact is flagged by setting that nuclide's NCLFPDCORRDN flag. This flag is used in the reporting template to indicate that the reported activity has been corrected.

MDA Calculations

This discussion of the MDA algorithms includes a section on the general theory as well as two specific implementations: Currie MDA and KTA MDA.

General Theory

A Minimum Detectable Activity (MDA) can be calculated for both the radionuclides which have not been found in the spectrum, as well as for those that have been found. The methods developed by Currie are widely accepted and used as a basis for this.[25]

25. Currie, L.A. (1968) *Anal. Chem.* 40:586.

Currie's method is based on two important concepts: a Critical Level, L_C, below which a net signal cannot *reliably* be detected, and a Detection Limit, L_D, the smallest net signal that can *reliably* be quantified, as shown in Figure 8.

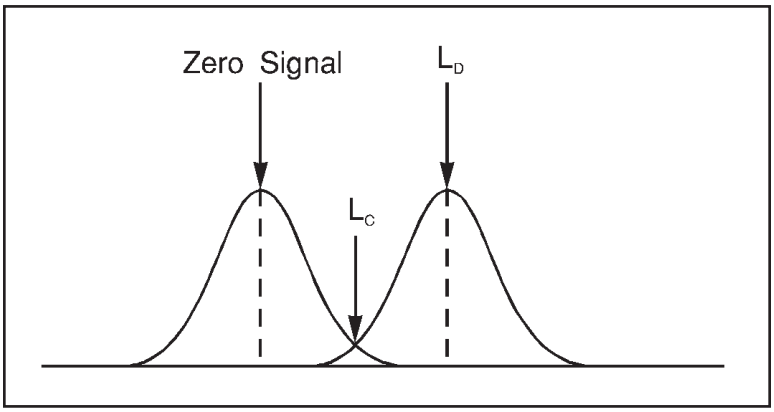


Figure 8 Illustrating the L_C and L_D Concepts

The quantity L_C can be considered to be the detection sensitivity, and the quantity L_D the lower limit of detection for a given measurement situation. These quantities are fundamentally different, and, in general, $L_D > L_C$.

The discussion that follows here closely follows the concepts presented by Currie as it applies to the analysis of gamma-ray spectra.

Let us first define the following concepts:

Interference

The net peak area of the photopeak of interest in a separate background measurement, due to environmental activity, detector contamination, and so forth.

Interference must be determined from a separate measurement with no sample and the quantities associated with it are:

I = measured interference net peak area,

σ_I = standard deviation of I, and

σ_I^2 = variance of I.

Tracer Interference (Alpha Spectroscopy)

The net peak area of the photopeak of interest due to the presence of a tracer nuclide.

Tracer interference must be determined from a separate reagent blank (also called preparation blank) measurement with no sample and the quantities associated with it are:

I_T = measured interference net peak area,

σ_{I_T} = standard deviation of I_T, and

$\sigma^2_{I_T}$ = variance of I_T.

Continuum

The "non-peaked" continuum under the photopeak of interest due to Compton scattering, and so forth.

Continuum must be determined from the sample measurement and the quantities associated with it are:

B = calculated continuum under the peak,

σ_B = standard deviation of B, and

σ^2_B = variance of B.

Gross Signal

The total sum of counts in the region of interest due to interference, continuum, and the activity of the nuclide of interest. This quantity is sometimes also called the integral area.

Gross signal must be determined from the sample measurement and the quantities associated with it are:

G = gross sum of the photopeak region (in gamma spectroscopy G = S+B+I; in alpha spectroscopy G = S+I_T+I),

σ_G = standard deviation of G, and

σ^2_G = variance of G.

Net Peak Area

The photopeak area due to the activity of interest only (this is called the "net signal" by Currie).

The net peak area (also called the observed net signal) must be determined from the sample measurement and the quantities associated with it are:

S = observed net signal (in gamma spectroscopy S = G-B-I = (S+B+I)-B-I, in alpha spectroscopy S = G-I_T-I = (S+I_T+I)-I_T-I). If S is exactly zero, a value of 1 is used as the observed net signal to calculate the forced activity and activity uncertainty.

μ_S = "true" net signal,[26]

σ_S = standard deviation of S, and

σ_S^2 = variance of S.

Note that there is an important distinction between continuum and the two different types of interference:

1. The continuum is determined from the sample measurement at the same time as the gross signal (for example, using counts on either side of a photopeak),

2. The interference is determined by a separate measurement, and is, in fact, a net area resulting from some background activity or contamination.

3. The tracer contamination is determined both from a separate reagent blank measurement and the sample measurement. The ratio of the contamination to the amount of tracer is determined from the reagent blank measurement. The actual amount in the sample measurement is then calculated from this ratio and the net area of the tracer peak in the sample spectrum.

There are two fundamental aspects associated with the detection of peaks:

1. given an observed net signal, deciding if it is real, and

2. given a specified measurement, estimating the minimum true signal, μ_S, that would yield an observed net signal, S, which would be detected.

The first decision is an *a posteriori* decision as to whether an observed signal is real. The second decision is an *a priori* estimate of what size net signal would be detectable.

This decision process is subject to two kinds of errors:

1. deciding that a signal is present when it is not (error of the first kind), with a probability α, and

26. In counting experiments, S is an experimental determination (or estimate) of μs, which is not observable except at the limit of an infinite number of measurements.

2. failing to decide a signal is present when it is (error of the second kind), with a probability β.

The quantities $1-\alpha$ and $1-\beta$ are often called the confidence levels for not making errors of the first kind and the second kind, respectively.

The maximum acceptable value of α, together with the standard deviation, σ_0, of the observed net signal when $\mu_S = 0$, establish the Critical Level, L_C, upon which decisions may be based. This means that an observed signal, S, must exceed L_C to be detected.

Once L_C has been defined, the Detection Limit, L_D, may be established by specifying L_C along with the acceptable level, β, for the error of failing to recognize a real signal, and the standard deviation, σ_D, associated with the net signal when its real value, μ_S, is equal to L_D.

The significance of this particular form of the definition is that it allows the determination of the smallest true signal which may be detected with a probability $1-\beta$, with a built-in protection level, α, against falsely concluding that a null observation represents a real signal.

Mathematically, the Critical Level is given by

$$L_C = k_\alpha \sigma_0 \tag{261}$$

and the Detection Limit by

$$L_D = L_C + k_\beta \sigma_D \tag{262}$$

where k_α and k_β are abscissas of the Normal (Gaussian) distribution corresponding to probability levels $1-\alpha$ and $1-\beta$ (or "confidence levels").

Normally one would accept equal probabilities for errors of the first and the second kind. In that case, $\alpha = \beta$ and $k_\alpha = k_\beta = k$. Representative values of k are given in Table 2. Note that if one is willing to accept a 50% decision error, then $L_D = L_C = 0$.

In gamma-ray spectroscopy, the signals are counts from a radiation detector which are governed by the Poisson distribution (ignoring any systematic effects). If the number of counts is sufficiently large, the Poisson distribution may be approximated by the Normal (Gaussian) distribution, and the k values given in Table 2 are applicable.

Furthermore, the signal mean values and variances may be estimated using the normal error propagation rules to establish approximate levels of confidence and significance.

In gamma spectroscopy the observed net signal is S = G-B-I, and its variance can be calculated as:

Table 2 Confidence Levels and k Values

α	**1-β**	**k**
0.001	0.999	3.090
0.005	0.995	2.756
0.010	0.990	2.326
0.025	0.975	1.960
0.050	0.950	1.645
0.100	0.900	1.282
0.200	0.800	0.842
0.250	0.750	0.675
0.300	0.700	0.525
0.400	0.600	0.254
0.500	0.500	0.000

$$\sigma_S^2 = \sigma_G^2 + \sigma_B^2 + \sigma_I^2 \tag{263}$$

Since the gross signal is Poisson distributed, its variance is the value itself and Equation (263) can be written as

$$\sigma_S^2 = \mu_G + \sigma_B^2 + \sigma_I^2 \tag{264}$$

where μ_G is the true total gross area of the photopeak.

Substituting the components that μ_G consists of, Equation (264) can be written as

$$\sigma_S^2 = (\mu_S + \mu_B + \mu_I) + \sigma_B^2 + \sigma_I^2 \tag{265}$$

where

μ_S is the true net signal,

μ_B is the true continuum, and

μ_I is the true background interference.

As an approximation, the observed signals may be used in place of the unobservable true values. We then get

$$\sigma_S^2 \approx (S + B + I) + \sigma_B^2 + \sigma_I^2 \tag{266}$$

If the true net signal is null ($\mu_S = 0$), the variance of the net signal becomes

$$\sigma_0^2 = (\mu_B + \mu_I) + \sigma_B^2 + \sigma_I^2 \tag{267}$$

When the true net signal is equal to the Detection Limit, that is, $\mu_S = L_D$, the variance of the net signal becomes:

$$\sigma_D^2 = (L_D + \mu_B + \mu_I) + \sigma_B^2 + \sigma_I^2 \tag{268}$$

Using the definitions for L_C and L_D, and setting $k_\alpha = k_\beta = k$, we get

$$L_C = k\sigma_0 = k\sqrt{\mu_B + \mu_I + \sigma_B^2 + \sigma_I^2} \tag{269}$$

and

$$L_D = L_C + k\sqrt{L_D + \sigma_0^2} \tag{270}$$

Solving Equations (269) and (270) for L_D, one obtains

$$L_D = k^2 + 2L_C \tag{271}$$

As an example for alpha spectroscopy, let us assume that the background spectrum has been measured for a different amount of time than the sample spectrum (this is often the case). The “true” background is thus defined as

$$\mu_B = \frac{T_s}{T_B} S_B \tag{272}$$

where

T_s is the live time of the sample spectrum,

T_B is the live time of the background spectrum, and

S_B is the net peak in the equivalent peak in the background spectrum.

The standard deviation of the "true" background is defined as

$$\sigma_B = \sqrt{\left(\frac{T_s}{T_B}\right)^2 \sigma_{S_B^2}} = \frac{T_S}{T_B} \cdot \sigma_{S_B} \quad (273)$$

The "true" tracer interference and its variance can be calculated from the reagent blank spectrum. For a tracer peak the interference is always zero. For a non-tracer peak, the tracer interference is calculated as

$$\mu_{I_T} = \frac{S_I(R,B)}{S_T(R,B)} S_T(S,B) \quad (274)$$

where

$S_I(R,B)$ is the net signal of the non-tracer peak in the *reagent blank* spectrum (background subtracted),

$S_T(R,B)$ is the net signal of the tracer peak in the *reagent blank* spectrum (background subtracted), and

$S_T(S,B)$ is the net signal of the tracer peak in the *sample* spectrum (background subtracted).

The net signal of a non-tracer peak in a reagent blank spectrum is calculated as

$$S_I(R,B) = S_I(R) - \frac{T_R}{T_B} S_B \quad (275)$$

Where

$S_I(R)$ is the peak area of the non-tracer peak in the reagent blank spectrum (not background subtracted),

S_B is the peak area of the equivalent peak in the background spectrum,

T_R is the live time of the reagent blank spectrum, and

T_B is the live time of the background spectrum.

The uncertainty is calculated as

$$\sigma_{S_I\,(R,B)} = \sqrt{\sigma_{S_I\,(R)}{}^2 + \left(\frac{T_R}{T_B}\right) 2\,\sigma_{s_b}{}^2} \tag{276}$$

The net signal of the tracer peak in the reagent blank spectrum is calculated the same way, i.e.

$$S_T\,(R,B) = S_T\,(R) - \frac{T_R}{T_B} S_B \tag{277}$$

where

$S_T(R)$ is the peak area of the tracer peak in the reagent blank spectrum (not background subtracted).

The uncertainty is calculated as

$$\sigma_{S_T\,(R,B)} = \sqrt{\sigma_{S_T\,(R)}{}^2 + \left(\frac{T_R}{T_B}\right)^2 \sigma_{S_B^2}} \tag{278}$$

The net signal of the tracer peak in the sample spectrum is calculated the same way, i.e.

$$S_T(S,B) = S_T(S) - \frac{T_S}{T_B} S_B \tag{279}$$

where

$S_T(S)$ is the peak area of the tracer peak in the sample spectrum (not background subtracted).

Its uncertainty is calculated as

$$\mathrm{Yu}\sigma_{S_T}\,(S,B) = \sqrt{\sigma^2_{S_T\,(S)} + \left(\frac{T_S}{T_B}\right)^2 \sigma_{S_B^2}} \tag{280}$$

The standard deviation of the "true" tracer interference is calculated as

$$\sigma I_T = \mu I_T \cdot \sqrt{\left(\frac{\sigma S_I\,(R,B)}{S_I\,(R,B)}\right)^2 + \left(\frac{\sigma S_T\,(R,B)}{S_T\,(R,B)}\right)^2 + \left(\frac{\sigma S_T\,(S,B)}{S_T\,(S,B)}\right)^2} \tag{281}$$

These conclusions are reached on the basis of statistical calculations performed for a measured spectrum and result in a Detection Limit in terms of counts. They can be extended to the related physical quantity, such as activity, by means of the appropriate calibration factor(s).

In gamma spectroscopy, the term used to describe the Detection Limit in units of activity is commonly called the Minimum Detectable Activity (MDA). When calculated per unit mass (or volume), MDA is defined as

$$MDA = \frac{L_D}{T_l\,\varepsilon'\,y\,V\,K_c\,K_w\,K_x\,C_f\,U_f} \tag{282}$$

where

T_l is the collection live time in seconds,

ε' is the attenuation corrected efficiency, i.e.

$$\varepsilon' = \varepsilon \cdot e(-\mu(E)\rho t) \tag{283}$$

where

ε is the non-attenuation corrected detection efficiency at the peak energy in question,

$\mu(E)$ is the mass attenuation (in units of cm^2/g) at gamma energy E,

ρt is the average sample mass per unit area,

Note that if the attenuation correction has not been performed, $\varepsilon' = \varepsilon$. In alpha spectroscopy, ε' is typically the effective efficiency calculated from the tracer peak and includes both the attenuation and sample preparation losses.

y is the branching ratio of the gamma energy under consideration,

V is the mass (or volume) of the sample,

C_f is the sample mass conversion factor (or volume conversion factor, such as a dilution factor) to translate the calculated activity values to the original sample mass, if the measured mass is only a portion of the real mass (if applicable).

U_f is the unit conversion factor from Bq to the selected unit of activity for reporting (if applicable).[27]

K_c is the correction factor for the nuclide decay during counting, namely

$$K_c = \frac{T_{1/2}}{\ln(2)\, t_c} \left[1 - e \left(- \frac{\ln(2)\, t_c}{T_{1/2}} \right) \right] \tag{284}$$

where

$T_{1/2}$ is the half-life of the nuclide in question, and

t_c is the elapsed real clock time during the measurement (in the same time units as $T_{1/2}$).

K_w is the correction factor for the nuclide decay from the time the sample was obtained to the start of the collect,

$$K_w = e \left(- \frac{\ln(2)\, t_w}{T_{1/2}} \right) \tag{285}$$

where

t_w is the elapsed clock time from the time the sample was taken to the beginning of the measurement (in the same time units as $T_{1/2}$).

K_x is the correction factor K_s (see Equation 188) for decay during sample accumulation for air filter samples, or K_i (see Equation 190) for decay during irradiation for irraditated samples, and 1 for all other types of samples.

The attenuation factor $\mu(E)$ is assumed to be available in the form

$$\mu(E) = e \left(\sum_{i=0}^{n} f_i \cdot (\ln(E))^i \right) \tag{286}$$

where f_i are fitted parameters at the time the curve is established from published attenuation data, and n is the order of the function eventually decided on during a calibration procedure.

27. Since live time is specified in seconds, the equations presented here produce an MDA value in disintegrations per second (= Bq).

Note that for nuclides which have multiple gamma energies, a separate MDA value can be calculated for each energy. The lowest of the values will be assigned as the nuclide MDA value.

This MDA calculation, if done for an empty shield or a blank, is what the U.S. NRC calls LLD in the latest revision of Regulatory Guide 4.16.[28]

The uncertainty of the MDA is calculated as

$$\sigma_{MDA} = MDA \cdot \sqrt{\left(\frac{\sigma_R}{100}\right)^2 + \left(\frac{\sigma_V}{V}\right)^2 + \left(\frac{\sigma_{\varepsilon'}}{\varepsilon'}\right)^2 + \left(\frac{\sigma_y}{y}\right)^2 + \left(\frac{\sigma_K}{K}\right)^2} \quad (287)$$

where

σ_R is the user defined random uncertainty (%),

σ_V is the uncertainty of the sample quantity V,

$\sigma_{\varepsilon'}$ is the uncertainty of the effective efficiency, which is defined as

$$\sigma_{\varepsilon'} = \varepsilon' \cdot \sqrt{(\sigma_\varepsilon / \varepsilon)^2 + (\rho t \cdot \sigma_{\mu(E)})^2 + (\mu(E) \cdot \sigma_{\rho t})^2} \quad (288)$$

where

ε is the non-attenuation corrected detection efficiency at the peak energy in question

σ_ε is its uncertainty, $\mu(E)$ is the mass attenuation (in units of cm^2/g) at gamma energy E,

$\sigma_{\mu(E)}$ is its uncertainty

ρt is the average sample mass per unit area, and

$\sigma_{\rho t}$ is its uncertainty.

σ_y is the uncertainty of the branching ratio y, and

σ_K is the uncertainty of the composite decay correction factor K, which for buildup type “None” is defined as

28. \'93Measuring, Evaluating and Reporting Radioactivity in Releases of Radioactive Materials in Liquid and Airborne Effluents from Nuclear Fuel Processing and Fabrication Plants\'94 (December, 1985). *U.S. Nuclear Regulatory Commission Regulatory Guide 4.16*.

$$\sigma_K = K \cdot \sqrt{\left(\frac{\sigma_{K_c}}{K_c}\right)^2 + \left(\frac{\sigma_{K_w}}{K_w}\right)^2} \tag{289}$$

and for buildup type “Deposition”, is defined as

$$\sigma_K = K \cdot \sqrt{\left(\frac{\sigma_{K_c}}{K_c}\right)^2 + \left(\frac{\sigma_{K_w}}{K_w}\right)^2 + \left(\frac{\sigma_{K_s}}{K_s}\right)^2} \tag{290}$$

and for buildup type “Irraditation”, is defined as

$$\sigma_K = K \cdot \sqrt{\left(\frac{\sigma_{K_c}}{K_c}\right)^2 + \left(\frac{\sigma_{K_w}}{K_w}\right)^2 + \left(\frac{\sigma_{K_i}}{K_i}\right)^2} \tag{291}$$

The composite decay correction factor itself is defined as

$$K = K_c \cdot K_w \cdot K_x \tag{292}$$

In all cases, if the branching ratio uncertainty, σ_y, and/or the half-life uncertainty, $\sigma_{T_{1/2}}$ are not available, they are set to zero.

The uncertainty of the unattenuated efficiency depends on the Efficiency Calculation method used. It is calculated as explained in the text describing the selected method in “Efficiency Correction”, starting on page 302.

The uncertainty of the average sample density $\sigma_{\rho t}$ is normally available in the data file as a result of the attenuation correction calculations. If not, a zero uncertainty for the average sample density will be assumed.

The variance of the attenuation factor is calculated from the fitted function that describes it as a function of energy as:

$$\sigma_\mu(E)^2 = (\mu(E))^2 \sum_n \sum_m (\ln(E))^{n-1} (\ln(E))^{m-1} (M^{-1})_{n,m} \tag{293}$$

which can also be presented in the form

$$\sigma^2_{\mu(E)} = (\mu(E))^2 \sum_n (\ln(E))^{2n-2} \sigma_{f_n^2} + (\mu(E))^2 \cdot \sum_n \sum_m (\ln(E))^{n-1} (\ln(E))^{m-1} \text{COVAR}(f_n, f_m), n \neq m \quad (294)$$

where

$$\text{COVAR}(f_n, f_m) = (M^{-1})_{n,m}, n \neq m \quad (295)$$

and

$$(M^{-1})_{n,m} \quad (296)$$

is the inverse of the matrix resulting from the least squares determination of the coefficients f_n.

However, Equation (282) is still subject to some interpretation. The Genie 2000 environment currently offers two alternative algorithms for MDA calculations. These two algorithms are explained in the following two sections.

Currie MDA

In the Currie MDA algorithm, the detection limit L_D is calculated using

$$L_D = k^2 + 2L_C \quad (297)$$

which is then translated into MDA using Equation (282). In calculating the detection limit, the continuum is based on data on each side of the peak region for peaks that were found. It is based on the equivalent of the peak region itself for peaks that were not found.

For example, for a found peak with the *linear* continuum model in effect, the continuum is calculated as:

$$\mu_B \approx B = \left(\frac{N}{2n}\right)(B_1 + B_2) \quad (298)$$

where

N is the number of channels in the peak region,

n is the number of channels on each side of the peak region used for the determination of the continuum counts,

B_1 is the sum of counts in the n channels to the left of the peak region, and

B_2 is the sum of counts in the n channels to the right of the peak region.

For an example on how to calculate the continuum with the *step* continuum model, see "Peak Area for Non-Fitted Single Peaks" on page 279.

For peaks that had a background interference component subtracted (if background subtract was done), setting $\mu_1 = I$ and including the background component, the equation for L_C becomes

$$L_C = k\sqrt{B + \left(\frac{T_s}{T_b}\right) I_b + \left(\frac{N}{2n}\right)^2 (B_1 + B_{2)} + \left(\frac{T_s}{T_b}\right)^2 \sigma_{I_b}{}^2} \quad (299)$$

where

B is the value of the continuum subtracted,

I_b is net peak area of the background measurement,

T_s is the live time of the sample measurement, and

T_b is the live time of the separate background measurement.

This equation is used as a Critical Level test criterion at 95% confidence level. If the net peak area is less than L_C, then a "not detected" decision is made. If the net peak area is greater than L_C, then a "detected" decision is made.

This test is commonly applied to any peaks located by a peak locate method. However, Canberra's algorithms also provide the possibility of analyzing spectra without subjecting the peaks to this test.

Not using the Critical Level test is particularly important when the statistics are very poor. The equation described above is not truly valid for small values of continuum and interference because its derivation uses a mixture of properties from both the Normal and the Poisson distributions. At small values of continuum and interference, the Poisson distribution is no longer well approximated by the Normal distribution. Other statistical methods, which are beyond the scope of this document, must then be used to determine whether the observed signal is real or not.

For the peaks that were not found, the program assigns the ROI limits based on the following rules:

1. For each energy in the library that does not have a matching observed peak in the spectrum, we calculate the expected location of such an energy in channels using the energy calibration information.

2. We then calculate the expected FWHM at the expected peak location based on the FWHM calibration information.

3. If the variable ROI width is disabled, the left boundary of the region-of-interest is calculated as the integer portion of the expected peak location minus the integer part of four times the FWHM (in channels) plus2 channels.

4. If the variable ROI width is disabled, the right boundary of the region-of-interest is calculated as the integer portion of the expected peak location plus the integer portion of four times the FWHM (in channels) minus 2 channels.

5. If the variable ROI width is enabled, the boundaries of the ROI that the MDA background calculation is based on are simply calculated as ± *x* FWHM, from the expected location of an unidentified peak, where *x* is a user selectable multiplier. The variable ROI parameter (VPWIDTH) will be initialized to 3.0 for germanium spectra and to 1.2 for NaI spectra for compatibility with older versions of the software. Since the efficiency calibration assumes that a full peak is included, a multiplier of less than 0.8 is not be permitted. This minimum roughly guarantees that the efficiency values calculated from the efficiency curve are valid without modifications.

If the Currie MDA is executed with “Use variable MDA constants” enabled, instead of Equation (297), it uses equation

$$L_D = C_0 + C_1\sigma_0 \tag{300}$$

where C_0 is the user selected Add Constant, C_1 is the user selected Multiplier Constant and σ_0 is the variance of a null net signal as defined in Equation (267). Please note that by selecting C_0=k2=2.71 and C_1=2k=3.29 this calculation is equivalent to the “normal” Currie MDA calculation at 95% confidence level.

KTA MDA

In the KTA MDA algorithm (required by the German authorities), the detection limit L_D is defined as

$$L_D = 0.5(2k)^2 + 2L_c \tag{301}$$

All other equations are used as described starting on page 324 for the regular MDA algorithm.

If the variable ROI width is disabled, the program assigns the ROI limits as ± 1.25 times the expected FWHM for a total ROI width of 2.5 FWHM for peaks that were not identified. For peaks that are identified, the MDA background is calculated using the continuum that is subtracted from under the peak, whatever its ROI width happens to be.

If the variable ROI width is enabled, the boundaries of the ROI that the MDA background calculation is based on are simply calculated as ± *x* FWHM, from the expected location of an unidentified peak, where *x* is a user selectable multiplier. The variable ROI parameter (VPWIDTH) will be initialized to 4.0 for germanium spectra and to 1.2 for NaI spectra for compatibility with older versions of the software. Since the efficiency calibration assumes that a full peak is included, a multiplier of less than 0.8 is not be permitted. This minimum roughly guarantees that the efficiency values calculated from the efficiency curve are valid without modifications.

In algorithm versions 2.2 and earlier, enabling the variable ROI width has no effect on peaks that are identified. Their MDA background is calculated from the continuum under the peak regardless of its width. Starting with V2.3, enabling the variable ROI width calculates the MDA background for peaks that were identified using only the portion of the continuum that is included in a region around the peak of ± *x* FWHM, where *x* is the user selectable multiplier.

If the KTA MDA is executed with “Use variable MDA constants” enabled, instead of Equation (301), it uses

$$L_D = C_0 + C_1\sigma_0 \tag{302}$$

where C_0 is the user selected Add Constant, C_1 is the user selected Multiplier Constant and σ_0 is the variance of a null net signal as defined in Equation (267). Please note that by selecting C_0=k2=5.42, and C_1=2k=3.29, this calculation is equivalent to the “normal” KTA MDA calculation at 95% confidence level.

MDA Calculation Examples

Using the 569 keV line of ^{134}Cs as a calculation example, one obtains

$$K_c = \frac{6.507 \cdot 10^7}{\ln(2) \cdot 4020} \cdot 1 - e\left(-\frac{\ln(2) \cdot 4020}{6.507 \cdot 10^7}\right) = 0.999978589 \tag{303}$$

and

$$K_w = e\left(-\frac{\ln(2) \cdot 6328800}{6.507 \cdot 10^7}\right) = 0.934805799 \tag{304}$$

Currie Calculation

With the Currie algorithm

$$L_D = 1.645^2 + 2 \cdot 1.645 \cdot \sqrt{2 \cdot 7548} = 406.9344 \quad (305)$$

where 7548 is the sum of counts in channels 1210-1238 centered around the expected peak location of 569.315 keV. Inserting this into the MDA equation, we get

$$\begin{aligned} MDA &= \frac{406.9344}{4000 \cdot 2.0357 \cdot 10^{-3} \cdot 0.1543 \cdot 1.0 \cdot 0.999978589 \cdot 0.934805799 \cdot 1.0 \cdot 1.0 \cdot 37000} \\ &= 9.36 \cdot 10^{-3}\ \mu Ci \,/\, unit \end{aligned} \quad (306)$$

which corresponds to the result given by the program.

The Currie MDA for a nuclide that has been identified can be illustrated with the 661 keV line of ^{137}Cs as follows:

$$L_D = 1.645^2 + 2 \cdot 1.645 \cdot \sqrt{5809.1 + 124.71^2} = 483.5605 \quad (307)$$

where 5809.1 and 124.71 are the continuum subtracted from under the identified peak and the uncertainty of the continuum, respectively. Inserting this into the MDA equation, we get

$$\begin{aligned} MDA &= \frac{483.5605}{4000 \cdot 1.7601 \cdot 10^{-3} \cdot 0.8512 \cdot 1.0 \cdot 0.999998537 \cdot 0.99540311 \cdot 37000} \\ &= 2.191 \cdot 10^{-3}\ \mu Ci \,/\, unit \end{aligned} \quad (308)$$

which does correspond to the result given by the program.

KTA Calculation

With the KTA algorithm

$$L_D = 0.5(2 \cdot 1.645)^2 + 2 \cdot 1.645 \cdot \sqrt{2 \cdot 2968} = 258.8916 \quad (309)$$

where 2968 is the sum of counts in channels 1219-1229 (± 1.25 FHWM) centered around the expected peak location of 569.315 keV. Inserting this into the MDA equation, we get

$$\mathrm{MDA} = \frac{258.8916}{4000 \cdot 2.0357 \cdot 10^{-3} \cdot 0.1543 \cdot 1.0 \cdot 0.999978589 \cdot 0.934805799 \cdot 1.0 \cdot 1.0 \cdot 37000} \quad (310)$$
$$= 5.96 \cdot 10^{-3}\ \mu\mathrm{Ci} \,/\, \mathrm{unit}$$

which corresponds to the result given by the program.

Activities for Unidentified Nuclides

For nuclides that were not identified, and for which the NOMDA flag has *not* been set, the MDA algorithm will also calculate an activity for each energy line. The ROI limits will be first assigned using the normal rules described at the end of “MDA” on page 324. If the ROI created in this manner does not overlap with an ROI created during a normal peak analysis, if it totally encompasses such an existing ROI, or if it is totally encompassed by such an existing ROI, it will be used as is. If the ROI only partially encompasses an ROI created during the peak analysis, its end points will be modified to not overlap with the existing ROI before use.

Using this ROI for the unidentified energy, the MDA engine will calculate a normal singlet net peak area and its uncertainty using the singlet peak area calculation method.

The activity per unit volume (or mass) of the sample is calculated from this net peak area as:

$$C = \frac{S}{V\,\varepsilon'\,y\,T_l\,U_f\,K} \quad (311)$$

where

S is the net peak area,

Note: If the peak area is exactly zero, the activity and activity uncertainty are calculated using a net peak area value of 1. After calculating the activity uncertainty, the activity is set to zero to correspond to the zero net area.

V is the sample volume (or mass),

ε' is the effective efficiency at the peak energy (may include an attenuation correction),

y is the branching ratio of the peak energy, and

U_f is the conversion factor required to have the activity in μCi (the fixed internal storage unit),

T_l is the live time of the collect in seconds, and

K is the composite decay correction factor due to decay during acquisition, from the sample deposition date/time to the beginning of the acquisition, and for decay during sample accumulation for filter samples or during irradiation for irradiated samples.

Each of these terms and the error propagation are explained in more detail in “Nuclide Identification and Activity Calculation” on page 309.

Cascade Summing Correction

Most cases of radioactive decay of a parent nuclide to the ground state of its daughter occur with the emission of several γ or X-ray photons in a cascade. If two γ rays with different energies are emitted in a cascade in a nuclear decay, and they are detected within the resolving time of the system, the two γ rays are said to be detected in true coincidence. The detector accumulates the sum total of the energy deposited by the two gammas. As a result, events are lost (summing-out) or gained (summing-in) from the Full Energy Peak (FEP) of the gamma ray of interest, and any activity determination based on the FEP will be in error. It is therefore, necessary to correct the FEP for true coincidence effects. Figure 9 shows an example of the cascade phenomenon.

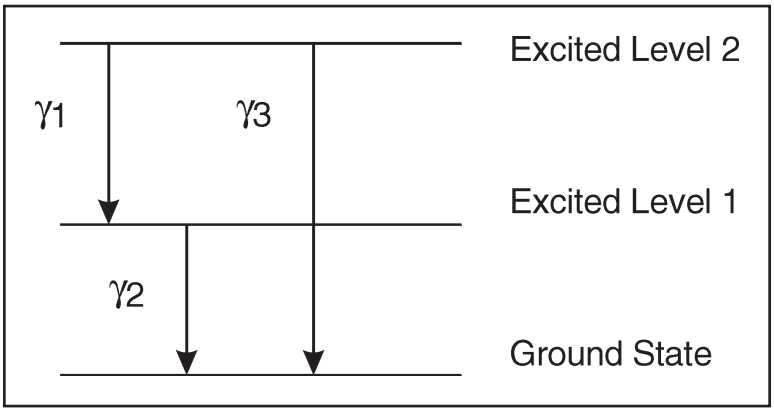


Figure 9 Cascading Gamma Rays

In the above example, a FEP measurement of γ_1 or γ_2 suffers from losses due to cascade summing, whereas, the FEP from γ_3 suffers from cascade summing gains. It must be noted that cascade summing losses are not just limited to the counts appearing in the sum peak. Rather, the detector may accumulate the full energy deposition from γ_1 (γ_2) and a partial energy deposition from γ_2 (γ_1) resulting in a count being lost from the FEP of γ_1 (γ_2). Thus it becomes necessary to determine the *total efficiency* of the cascading gamma rays in order to correct for cascade summing losses.

It must be noted that the phenomenon of cascade summing or true coincidence is geometry dependent, and not count rate dependent.

Cascade Summing Theory

The true coincidence correction factor, COI, of a voluminous source is computed as follows. The voluminous source is first divided into a large number of equal volume subsources. A point location is selected within each subsource using a pseudo-random sequence. The true coincidence correction factor at each of these point locations is calculated and then integrated to determine the overall correction factor for the entire source.

The total efficiency of the detector, ε_t, is required to compute the true coincidence correction factor. For a point source, the total efficiency at a given gamma ray energy may be computed, provided the full peak efficiency ε_p and the peak-to-total ratio (P/T) are known.

$$\varepsilon_t = \frac{\varepsilon_p}{P/T} \tag{312}$$

The true coincidence correction for the gamma ray of interest, A, is given by the equation,

$$COI_A = (1 - L_A) \cdot (1 - S_A) \tag{313}$$

where L_A is the probability of summing out and S_A is the probability of summing in. These probabilities are the sum of the partial probabilities calculated for individual decay chains involving the gamma line of interest

$$L_A = \sum_{j=1}^{n} L_{A,j} \tag{314}$$

$$S_A = \sum_{j=1}^{n} S_{A,j} \tag{315}$$

Summing in Probability

F. De Corte and C. Frietas[29] give the following equation for computing the summing-in probability for a cascade consisting of three components, A = $\gamma_1+\gamma_2+\gamma_3$

$$S_A = \frac{Y_1}{Y_A} a_2 c_2 a_3 c_3 \frac{\varepsilon_{p,1}\varepsilon_{p,2}\varepsilon_{p,3}}{\varepsilon_{p,A}} \quad (316)$$

The quantities Y, a, and c are respectively, the absolute gamma ray yield, the branching ratio, and the internal conversion correction factor. The internal conversion correction factor c is computed as $1/(1+\alpha)$ where α is the Internal Conversion coefficient.

The absolute gamma ray yield, Y, is the number of gamma rays of a given energy emitted per decay. The branching ratio "a" is the emission probability of a particular gamma ray during a nuclear transition from a given excited level. The Internal Conversion coefficient α is defined as the ratio of the number of electrons to the number of gamma rays emitted during a nuclear transition from a given excited level.

To obtain the summing-in probability for a cascade involving only two gammas, the quantities related to the third gamma (subscript 3) should be excluded. From Equation (316) it follows that for cascade chains with more than 3 gammas, the summing-in probability would become negligible since it involves the product of peak efficiencies.

The computation of summing out probability is much more complicated. The appropriate equation to be used in the computations depends upon the type of the decay scheme. Some examples of formulae used in the software are given below[30]. These expressions correspond to 5 different decay chains, with the gamma ray of interest being present at a different point in each chain. The decay chains involve gamma rays cascading through 5 energy levels indicated by 0,1,2,3, and 4. These expressions involve 15 coefficients, each coefficient being the product of terms involving nuclear decay parameters Y, a, and c. The software computes these coefficients, multiplies the coefficients with the appropriate total efficiency values (teff[i]) and sequentially sums the products to determine the summing-out probability.

29. F. De Corte and C. Frietas. *Journal of Radioanalytical and Nuclear Chemistry*, 160:253 (1992).
30. F. De Corte and C. Frietas. *Journal of Radioanalytical and Nuclear Chemistry*, 160:253 (1992).

Chain: $0(A) \rightarrow 1 \rightarrow 2 \rightarrow 3 \rightarrow 4$, where A is the gamma ray of interest.

a[l]*c[l]*teff[l]+a[l]*a[2]*c[2]*teff[2]+
a[l]*a[2]*a[3]*c[3]*teff[3]+a[l]*a[2]*a[3]*a[4]*c[4]*teff[4]–
a[l]*a[2]*c[l]*c[2]*teff[l]*teff[2]–
a[l]*a[2]*a[3]*c[l]*c[3]*teff[l]*teff[3]–
a[l]*a[2]*a[3]*a[4]*c[l]*c[4]*teff[l]*teff[4]–
a[l]*a[2]*a[3]*c[2]*c[3]*teff[2]*teff[3]–
a[l]*a[2]*a[3]*a[4]*c[2]*c[4]*teff[2]*teff[4]–
a[l]*a[2]*a[3]*a[4]*c[3]*c[4]*teff[3]*teff[4]+
a[l]*a[2]*a[3]*c[l]*c[2]*c[3]*teff[l]*teff[2]*teff[3]+
a[l]*a[2]*a[3]*a[4]*c[l]*c[2]*c[4]*teff[l]*teff[2]*teff[4]+
a[l]*a[2]*a[3]*a[4]*c[l]*c[3]*c[4]*teff[1]*teff[3]*teff[4]+
a[l]*a[2]*a[3]*a[4]*c[2]*c[3]*c[4]*teff[2]*teff[3]*teff[4]–
a[1]*a[2]*a[3] *a[4] *c[1]*c[2]*c[3] *c[4]*teff[l]*teff[2]*teff[3]*teff[4]

Chain: $0 \rightarrow 1(A) \rightarrow 2 \rightarrow 3 \rightarrow 4$, where A is the gamma ray of interest

a[l]*c[l]*y[0]/y[l]* teff[0]+a[2]*c[2]*teff[2]+
a[2]*a[3]*c[3]* teff[3]+a[2]*a[3]*a[4]*c[4]* teff[4]–
a[l]*a[2]*c[l]*c[2]*Y[0]/Y[l]* teff[0]*teff[2]–
a[l]*a[2]*a[3]*c[l]*c[3]*y[0]/y[l]* teff[0]*teff[3]–
a[l]*a[2]*a[3]*a[4]*c[l]*c[4]*y[0]/y[l]* teff[0]*teff[4]–
a[2]*a[3]*c[2]*c[3]* teff[2]*teff[3]–
a[2]*a[3]*a[4]*c[2]*c[4]* teff[2]*teff[4]–
a[2]*a[3]* a [4]*c[3]*c[4]* teff[3]*teff[4]+
a[l]*a[2]*a[3]*c[l]*c[2]*c[3]*y[0]/y[l]* teff[0]*teff[2]*teff[3]+
a[l]*a[2]*a[3]*a[4]*c[l]*c[2]*c[4]*y[0]/y[l]* teff[0]*teff[2]*teff[4]+
a[l]*a[2]*a[3]*a[4]*c[l]*c[3]*c[4]*y[0]/y[l]* teff[0]*teff[3]*teff[4]+
a[2]*a[3]*a[4]*c[2]*c[3]*c[4]* teff[2]*teff[3]*teff[4]–
a[l]*a[2]*a[3]*a[4]*c[l]*c[2]*c[3]*c[4]*Y[0]/Y[l]* teff[0]*teff[2]*teff[3]*teff[4]

Chain: $0 \rightarrow 1 \rightarrow 2(A) \rightarrow 3 \rightarrow 4$, where A is the gamma ray of interest

a[l]*c[l]*teff[l]+a[l]*a[2]*c[2]*teff[2]+
a[l]*a[2]*a[3]*c[3]*teff[3]+a[l]*a[2]*a[3]*a[4]*c[4]*teff[4]–
a[l]*a[2]*c[l]*c[2]*teff[l]*teff[2]–
a[l]*a[2]*a[3]*c[l]*c[3]*teff[l]*teff[3]–
a[l]*a[2]*a[3]*a[4]*c[l]*c[4]*teff[l]*teff[4]–
a[l]*a[2]*a[3]*c[2]*c[3]*teff[2]*teff[3]–
a[l]*a[2]*a[3]*a[4]*c[2]*c[4]*teff[2]*teff[4]–
a[l]*a[2]*a[3]*a[4]*c[3]*c[4]*teff[3]*teff[4]+
a[l]*a[2]*a[3]*c[l]*c[2]*c[3]*teff[l]*teff[2]*teff[3]+
a[l]*a[2]*a[3]*a[4]*c[l]*c[2]*c[4]*teff[l]*teff[2]*teff[4]+
a[l]*a[2]*a[3]*a[4]*c[l]*c[3]*c[4]*teff[1]*teff[3]*teff[4]+
a[l]*a[2]*a[3]*a[4]*c[2]*c[3]*c[4]*teff[2]*teff[3]*teff[4]–
a[1]*a[2]*a[3] *a[4] *c[1]*c[2]*c[3] *c[4]*teff[l]*teff[2]*teff[3]*teff[4]

Chain: $0 \rightarrow 1 \rightarrow 2 \rightarrow 3(A) \rightarrow 4$, where A is the gamma ray of interest

a[l]*a[2]*a[3]*c[3]*y[0]/y[3]*teff[0]+a[2]*a[3]*c[3]*y[l]/y[3]*teff[l]+
a[3]*c[3]*y[2]/y[3]*teff[2]+a[4]*c[4]*teff[4]–
a[l]*a[2]*a[3]*c[l]*c[3]*Y[0]/y[3]*teff[0]*teff[l]–
a[l]*a[2]*a[3]*c[2]*c[3]*y[0]/y[3]*teff[0]*teff[2]
a[l]*a[2]*a[3]*a[4]*c[3]*c[4]*y[0]/y[3]*teff[0]*teff[4]–
a[2]*a[3]*c[2]*c[3]*y[l]/y[3]*teff[l]*teff[2]–
a[2]*a[3]*a[4]*c[3]*c[4]*y[l]/y[3]*teff[l]*teff[4]–
a[3]*a[4]*c[3]*c[41*y[2]/y[3]*teff[2]*teff[4]+
a[l]*a[2]*a[3]*c[l]*c[2]*c[3]*y[0]/y[3]*teff[0]*teff[l]*teff[2]+
a[l]*a[2]*a[3]*a[4]*c[l]*c[3]*c[4]*y[0]/y[3]*teff[0]*teff[l]*teff[4]+
a[l] *a [2] *a [3] *a[4] *c[2] *c[3] *c[4] *y[0] /y[3] *teff[0] *teff[2] *teff [4] +
a[2]*a[3]*a[4]*c[2]*c[3]*c[4]*y[l]/y[3]*teff[l]*teff[2]*teff[4]–
a[l]*a[2]*a[3]*a[4]*c[l]*c[2]*c[3]*c[4]*y[0]/y[3]*teff[0]*teff[l]*teff[2]*teff[4]

Chain: $0 \rightarrow 1 \rightarrow 2 \rightarrow 3 \rightarrow 4(A)$, where A is the gamma ray of interest

a[l]*a[2]*a[3]*a[4]*c[4]-y[0]/y[4]*teff[0]+a[2]*a[3]*a[4]*c[4]*y[l]/y[4]*teff[l]+
a[3]*a[4]*c[4]*y[2]/y[4]*teff[2]+a[4]*c[4]*y[3]/y[4]*teff[3]–
a[l]*a[2]*a[3]*a[4]*c[3]*c[4]*y[0]/y[4]*teff[0]*teff[3]–
a[l]*a [2]*a[3]*a[4]*c[2]*c[4]*y[0] /y[4]*teff[0]*teff[2]–
a[l]*a[2]*a[3]*a[4]*c[l]*c[4]*y(0]/y[4]-teff[0]*teff[l]–
a[2]*a[3]*a[4]*c[2]*c[4]*y[l]/y[4]*teff[l]*teff[2]–
a[2]*a[3]*a[4]-c[3]*c[4]*y[l]/y[4]*teff[l]*teff[3]–
a[3]*a[4]*c[3]*c[4]*y[2]/y[4]*teff[2]*teff[3]+
a[l]*a[2]*a[3]*a[4]*c[l]*c[2]*c[4]*y[0]/y[4]*teff[0]*teff[l]*teff[2]+
a[1]*a[2]*a[3]*a[4]*c[l]*c[3]*c[4]*y[0]/y[4]*teff[0]*teff[l]*teff[3]+
A[l]*a[2]*a[3]*a[4]*c[2]*c[3]*c[4]*y[0]/y[4]*teff[0]* teff[2]*teff[3]+
a[2]*a[3]*a[4]*c[2]*c[3]-c(4)-y[l]/y[4]*teff[l]*teff[2]*teff[3]–
a[l]*a[2]*a[3]*a[4]*c[l]*c[2]*c[3]*c[4]*y[0]/y[4]*teff[0]*teff[l]*teff[2]*teff[3]

To compute the cascade summing correction factors, Genie 2000 V2.0 uses information from five different specialized databases. These databases contain data regarding (1) nuclides and gamma lines that are free from cascade summing effect, (2) decay parameters such as branching ratio, internal conversion correction factor, and absolute yield % for nuclides and gamma lines that are susceptible to cascade summing effects, (3) the energies of gamma lines in summing out decay chains, (4) the energies of gamma lines in summing-in decay chains, and (5) the energies of gamma lines involved in sub-cascades. The decay parameters in the Canberra database are based on the NuDat database of the National Nuclear Data Center (NNDC). The information from the five databases has been condensed into a single library. The information contained in the coincidence library file is quite comprehensive, and updates will be made by Canberra Industries as and when necessary.

Subcascades

In several cases of nuclear decay, it is possible that the decay scheme includes more than one subcascade, all of which decay to a common level. In other words, there may be a fragment of a decay chain, which is common to two or more decay chains. For example, the 244 keV line emitted by ^{152}Eu is common to the following decay chains or subcascades.

$$1213 \Rightarrow 244 \Rightarrow 122$$

$$1005 \Rightarrow 244 \Rightarrow 122$$

$$926 \Rightarrow 244 \Rightarrow 122$$

$$296 \Rightarrow 867 \Rightarrow 244 \Rightarrow 122$$

$$657 \Rightarrow 244 \Rightarrow 122$$

$$719 \Rightarrow 244 \Rightarrow 122$$

$$444 \Rightarrow 244 \Rightarrow 122$$

From the above list, it is evident that the decay chain fragment 244 $\Rightarrow$ 122 occurs seven times. Therefore, in order to avoid overestimating the summing out probability for this fragment of the decay chain, it is necessary to decrease the total summing out probability for six subcascades that involve the transition 244 $\Rightarrow$ 122. So, for the 244 keV line, the final value of summing out probability can be written as follows.

$$L_{244} = \sum_{i=1}^{7} L_i - 6 \times L_{244 \rightarrow 122} \tag{317}$$

A subcascade may be situated at any place in a decay chain (at the beginning, in the middle, or at the end), but it must include the gamma ray of interest.

Estimation of True Coincidence Corrections for Voluminous Sources

The following discussion about the computation of true coincidence correction for voluminous sources is based on the work of V.P. Kolotov et al.[31] The total activity of a radionuclide based on the FEP measurement of an emitted gamma ray "g" may be written as follows.

$$A = \frac{N_{p,g}}{\varepsilon_g \cdot y_g} \tag{318}$$

In Equation (318), the quantity $N_{p,g}$ is the measured full energy peak count rate of the gamma line g, ε_g is the full energy peak efficiency of the whole source, and y_g is the yield of the gamma line.

The voluminous source is divided into "n" subsources of equal volumes. The activity of the i^{th} subsource is given by,

$$A_i = \frac{N_{p,g}}{e_g \cdot y_g \cdot n} \tag{319}$$

The contribution of the i^{th} subsource to the measured count rate can be written as follows.

$$N_{(p,g)i} = A_i \cdot y_g \cdot \varepsilon_{g,i} \tag{320}$$

The quantity A_i is the activity of the i^{th} subsource, and $\varepsilon_{g,i}$ is the full energy peak efficiency of the i^{th} subsource. Substituting for A_i from Equation (319), the expression for the partial count rate from the i^{th} subsource can be written as,

$$N_{(p,g)i} = \frac{\left(N_{p,g} \cdot \varepsilon_{g,i}\right)}{\left(\varepsilon_g \cdot n\right)} \tag{321}$$

Knowing the peak count rate for each subsource, and assuming that the peak efficiencies and P/T ratios for each gamma line within a given subsource are constant, it is possible to compute the coincidence correction ($COI_{g,i}$) for each subsource. The correction for the whole source may be obtained by summation.

$$N'_{p,g} = \sum_{i=1}^{n} \frac{N_{p,g} \cdot \varepsilon_{g,i}}{\varepsilon_g \cdot n \cdot COI_{g,i}} = \frac{N_{p,g}}{\varepsilon_g \cdot n} \sum_{i=1}^{n} \frac{\varepsilon_{g,i}}{COI_{g,i}} \tag{322}$$

31. V.P. Kolotov, V.V. Atrashkevich, S.J. Gelsema. *Journal of Radioanalytical and Nuclear Chemistry*, 210:183 (1996).

The quantity $N'_{p,g}$ is the peak count rate corrected for cascade summing or true coincidence effects.

The overall true coincidence correction for the voluminous source is,

$$COI_g = \frac{N_{p,g}}{N'_{p,g}} \tag{323}$$

Therefore, from Equation (322), the overall correction factor is given by,

$$COI_g = \frac{\varepsilon_g \cdot n}{\sum_{i=1}^{n} \frac{\varepsilon_{g,i}}{COI_{g,i}}} \tag{324}$$

In the limit of infinitesimally small subsource volume, the summation in equation (324) can be replaced by volume integration

$$COI_g = \frac{\varepsilon_g}{\iiint_V \frac{\varepsilon_{g,(xyz)}}{COI_{g,(xyz)}} dxdydz} \tag{325}$$

where

$$\varepsilon_g = \iiint_V \varepsilon_{g,(xyz)}\, dxdydz \tag{326}$$

The peak efficiency $\varepsilon_{g,i}$ of each subsource inside the voluminous source is calculated using Canberra's ISOCS methodology. The ISOCS method uses mathematical techniques to compute the full energy peak efficiencies of a germanium detector for practically any source geometry. The method requires that the germanium detector be ISOCS characterized before being used for efficiency calculations.

For the purposes of computing cascade summing corrections, a set of generic ISOCS detector characterizations has been provided with Version 2.0 of the Genie 2000 software. A generic detector should be chosen that closely matches the crystal diameter of the HPGe detector. For more accurate results, it is recommended that the users get their specific germanium detector characterized for ISOCS. Consult the factory for details.

Applying Cascade Summing Correction to Nuclide Activity

In Genie 2000, the computation of the cascade summing correction is set up as part of the Nuclide Identification (NID with Interference Correction) step of the analysis sequence. For each identified nuclide, each entry in the identification matrix is compared with its nuclide/energy counterpart in the coincidence library. For each match, the program determines the cascade summing correction factor and its uncertainty (parameters COI and COIERR) for the energy line. The yield of that energy line in the identification matrix is corrected by multiplying it with the cascade summing correction factor.

After the contents of the identification matrix have been adjusted, the calculation proceeds normally to calculate the line activities and their uncertainties (parameters NLACTVTY and NLERR, respectively) as well as the weighted mean activities and their uncertainties (parameters NCLWTMEAN and NCLWTMERR, respectively) with or without interference correction as the case may be.

Applying the Cascade Summing Correction to the MDA

The Minimum Detectable Activity (MDA) is determined based on the Detection Limit for a given measurement situation. The Detection Limit, as defined by Currie, is the smallest net signal that can be reliably quantified. For nuclides that emit gamma rays in a cascade, the net signal will be affected by losses or gains due to cascade summing. Therefore, the cascade correction has to be applied to the Detection Limit, and hence the MDA.

In Genie 2000, the cascade correction feature will be enabled in the Detection Limits engine set up, if and only if, the correction had been performed in the NID step. The correction factor is applied as follows. For each nuclide in the NID library, and for every gamma line listed for a given nuclide, the program evaluates whether cascade summing correction is required. If cascade correction is indeed required, the yield for gamma line is modified. Thereafter, the MDA calculation proceeds normally.

Estimated Uncertainty Due to the Cascade Correction Factor

Based on a verification and validation analysis performed by Canberra, it is estimated that the cascade correction factor introduces a systematic uncertainty of ±5% (1σ) in the final activity results. It is recommended that this additional uncertainty in the nuclide activity be propagated linearly. The uncertainty estimate is appropriate for the correction factors computed using an ISOCS/LabSOCS characterization valid for the specific HPGe detector used in the measurement. The uncertainty is characterized as systematic because the cascade correction factor tends to under-correct or over-correct the final activity results, though not in any predictable way. Even though the cascade correction introduces an additional uncertainty, the final activity results are much closer to the true activity (±5%) than if no correction is applied at all. Note that the error in nuclide activities for some typical laboratory source geometries such as filter papers could be as high as 30% due to cascade summing if no correction is applied.

Post-NID Processing Algorithm

The Action Level and Line Activity Consistency Evaluator calculations are described in this section. A interference corrected nuclide identification analysis is required for LACE and a nuclide identification and/or an MDA calculation must precede this algorithm for action level calculations.

Action Level Calculation

If the Action Level mode in the library has been set to Concentration, the "Use MDA" check box in the setup screen has not been checked, and the "Use Upper Limits" check box has not been checked, the two action level results (Level 1 = CAM_F_NCLLEVEL1 and Level 2 = CAM_F_NCLLEVEL2) for a nuclide are calculated as:

$$A_C = \frac{A_N}{A_L \cdot C_F} \tag{327}$$

where:

A_C is the calculated action level value for the nuclide (one value for level 1 and another for level 2),

A_N is the activity per unit volume (or mass) of the nuclide,

A_L is the action level for the nuclide (the level 1 value from the library for the level 1 calculation and the level 2 value from the library for the level 2 calculation),

C_F is the action level unit conversion value from the library (if one has been entered for the nuclide).

Activity Mode

If the Action Level mode in the library has been set to Activity, the "Use MDA" check box in the setup screen has not been checked, and the "Use Upper Limits" check box has not been checked, the two action level results for a nuclide are calculated as:

$$A_C = \frac{A_N \cdot Q}{A_L \cdot C_F} \tag{328}$$

where Q is the sample volume (or mass).

If the Action Level mode in the library has been set to Concentration, the "Use MDA" check box in the setup screen has been checked, and the "Use Upper Limits" check box has not been checked, the two action level results for a nuclide are calculated as:

$$A_C = \frac{MDA_N}{A_L \cdot C_F} \tag{329}$$

where MDA_N is the MDA per unit volume (or mass) of the nuclide.

If the Action Level mode in the library has been set to Activity, the "Use MDA" check box in the setup screen has been checked, and the "Use Upper Limits" check box has not been checked, the two action level results for a nuclide are calculated as:

$$A_C = \frac{MDA_N \cdot Q}{A_L \cdot C_F} \tag{330}$$

In each case, the calculated levels for each nuclide are summed and stored in parameters CAM_F_NCLLEV1SUM and CAM_F_NCLLEV2SUM, respectively.

The summed level 1 and level 2 values (CAM_F_NCLLEV1SUM and CAM_F_NCLLEV2SUM) are compared to the alarm levels settings (CAM_F_PRLEV1ALARM1 and CAM _F_PRLEV1ALARM2, for level 1 and CAM_F_PRLEV2ALARM1 and CAM_F_PRLEV2ALARM2, for level 2).

If the summed result is greater than or equal to the corresponding alarm level, a corresponding flag (CAM_L_NCLACT*n*ALRM*m*) is set indicating that the alarm level value has been reached or exceeded. In the parameter name, *n* refers to the action level (1 or 2) and *m* refers to the alarm level (1 or 2).

Cooling Time Calculation

The "cooling time", the time required for the activity of a nuclide to go below its action levels, is calculated for each nuclide that exceeds either or both of the action levels (NCLACTLEVEL1 or NCLACTLEVEL2), by

$$CT = -\ln\left(Al/Am\right) \times 1/d \tag{331}$$

where:

CT = cooling time

Al = activity limit

Am = measured activity

d = decay constant (ln(2) / half-life)

If the action level is not specified (NCLACTLEVELn = 0) or if the calculated level (NCLLEVELn) is < 1, the cooling date is set to 0. In addition to the time per isotope, the worst-case time for all the nuclides in the library is stored.

In the Action Level calculation (page 353), when the Action Level mode is Concentration and the sample quantity (SQUANT) is equal to one and the sample container net weight (SWCONTNW) is greater than one, SWCONTNW is used instead of SQUANT as the value of Q in the "Activity Mode" equation on page 353.

Upper Limits Calculation

If the Action Level mode in the library has been set to Concentration, "Use MDA" check box in the setup screen has not been checked, and the "Use Upper Limits" check box has been checked, the two action level results (Level 1 = CAM_F_NCLLEVEL1 and Level 2 = CAM_F_NCLLEVEL2) for a nuclide are calculated as:

$$A_C = \frac{A_N + \sigma_{A_N}}{A_L \cdot C_F} \tag{332}$$

where σ_{A_N} is the uncertainty of the activity per unit volume (or mass) of the nuclide.

If the Action Level mode in the library has been set to Activity, the "Use MDA" check box in the setup screen has not been checked, and the "Use Upper Limits" check box has been checked, the two action level results for a nuclide are calculated as:

$$A_C = \frac{(A_N + \sigma_{A_N}) \cdot Q}{A_L \cdot C_F} \tag{333}$$

If the Action Level mode in the library has been set to Concentration, the "Use MDA" check box in the setup screen has been checked, and the "Use Upper Limits" check box has been checked, the two action level results for a nuclide are calculated as:

$$A_C = \frac{MDA_N + \sigma_{MDA_N}}{A_L \cdot C_F} \tag{334}$$

where σ_{MDA_N} is the uncertainty of the MDA per unit volume (or mass) of the nuclide.

If the Action Level mode in the library has been set to Activity, the "Use MDA" check box in the setup screen has been checked, and the "Use Upper Limits" check box has been checked, the two action level results for a nuclide are calculated as:

$$A_C = \frac{(MDA_N + \sigma_{MDA_N}) \cdot Q}{A_L \cdot C_F} \tag{335}$$

In each case, the calculated levels for each nuclide are summed and stored in parameters CAM_F_NCLLEVEL1SUM and CAM_F_NCLLEVEL2SUM, and compared to the alarm level settings as described above.

Nuclide Results Totalization

In all modes, the algorithm sums up the number of peaks in the peak results that were not identified. This total indicates the number of "unidentified peaks" and is stored in the parameter CAM_L_NCLPUNKNOWN.

The algorithm also sums up the number of nuclides in the nuclide results table that were identified. This total number of identified nuclides is stored in the parameter CAM_L_NCLNUMFOUND.

LACE

The LACE algorithm is the calculation part of LACE and will appear under the "Post NID Processing" menu.

When launched the Lace algorithm will scan the nuclide results block of the current datasource:

1. Determine whether NID processing has been done on the datasource. NID processing must precede LACE processing.

2. Determine what kind of NID was run. NID w/Interf Correction is required for the Weighted Mean calculations.

Next, scan each nuclide record. Determine whether the nuclide was identified, if not identified then this nuclide is not processed by LACE.

For each *identified* nuclide:

1. Read all associated energy records for the nuclide and determine all identified peaks. Single-line nuclides and nuclides with zero or one identified peak are skipped.

2. Check existence of Key Line from the identified peaks.

3. Calculate for each *identified* peak:

    a. The ratio of the line activity to the Key Line activity (called Key Line ratio) if a key line exists for that nuclide.

b. The ratio of the line activity to the Weighted Mean activity (called Weighted Mean ratio) if NID w/Interf Correction was run.

c. Uncertainty of Key Line ratio, calculated as:

$$\sigma_{R\,KL} = R_{KL} \cdot \sqrt{\left(\sigma_L / C_L\right)^2 + \left(\sigma_{KL} / C_{KL}\right)^2} \tag{336}$$

where

$\sigma_{R_{KL}}$ is the uncertainty of the Key Line ratio
R_{KL} is the Key Line ratio CL is the line activity
σL is the uncertainty of the line activity
C_{KL} is the Key Line activity
σ_{KL} is the uncertainty of the Key Line activity

d. Uncertainty of Weighted Mean ratio, calculated as:

$$\sigma_{R\,WM} = R_{WM} \cdot \sqrt{\left(\sigma_L / C_L\right)^2 + \left(\sigma_{WM} / C_{WM}\right)^2} \tag{337}$$

where

$\sigma_{R_{WM}}$ is the uncertainty of the Weighted Mean ratio
R_{WM} is the Weighted Mean ratio
C_L is the line activity
σ_L is the uncertainty of the line activity
C_{WM} is the Weighted Mean activity
σ_{WM} is the uncertainty of the Weighted Mean activity

4. Calculate a best *linear* fit of Ln(ratio) vs. Ln(energy) for both Key Line and Weighted Mean ratios:

$$\ln(\text{ratio}) = A + B \cdot \ln(\text{energy})$$

Note that the Key Line fit is not done if a Key Line was not identified (see step 2 for identifying a nuclide), and Weighted Mean fit is not done if NID w/Interf Correction had not been performed (see step 2 in the second paragraph and the uncertainty of Key Line ratio in step 3c).

The χ^2 used to perform the linear fit of the data with equation (337) is:

$$\chi^2 = \sum_{i=1}^{N} \left[\frac{\ln(\text{ratio}_i) - (A + B \cdot \ln(\text{energy}_i))}{\sigma_i / \text{ratio}_i} \right]^2 \tag{338}$$

for calculated ratios and ratio uncertainties (σ's), at the N energies. The weighting factor (1/[(σ/ratio]) has been modified by the ratio to appropriately account for the log scaling. For the best fit, χ^2 must be minimized by setting the partial derivative of equation (338) with respect to A and B equal to zero. Solving for A and B yields the following equations:

$$A = \frac{\left[\sum_{i=1}^{N} \frac{(\ln(\text{energy}_i))^2}{(\sigma_i / \text{ratio}_i)^2} \right] \left[\sum_{i=1}^{N} \frac{\ln(\text{ratio}_i)}{(\sigma_i / \text{ratio}_i)^2} \right] - \left[\sum_{i=1}^{N} \frac{\ln(\text{energy}_i)}{(\sigma_i / \text{ratio}_i)^2} \right] \left[\sum_{i=1}^{N} \frac{\ln(\text{energy}_i) \cdot \ln(\text{ratio}_i)}{(\sigma_i / \text{ratio}_i)^2} \right]}{\left[\sum_{i=1}^{N} \frac{1}{(\sigma_i / \text{ratio}_i)^2} \right] \left[\sum_{i=1}^{N} \frac{(\ln(\text{energy}_i))^2}{(\sigma_i / \text{ratio}_i)^2} \right] - \left[\sum_{i=1}^{N} \frac{\ln(\text{energy}_i)}{(\sigma_i / \text{ratio}_i)^2} \right]^2} \tag{339}$$

$$B = \frac{\left[\sum_{i=1}^{N} \frac{1}{(\sigma_i / \text{ratio}_i)^2} \right] \left[\sum_{i=1}^{N} \frac{\ln(\text{energy}_i) \cdot \ln(\text{ratio}_i)}{(\sigma_i / \text{ratio}_i)^2} \right] - \left[\sum_{i=1}^{N} \frac{\ln(\text{energy}_i)}{(\sigma_i / \text{ratio}_i)^2} \right] \left[\sum_{i=1}^{N} \frac{\ln(\text{ratio}_i)}{(\sigma_i / \text{ratio}_i)^2} \right]}{\left[\sum_{i=1}^{N} \frac{1}{(\sigma_i / \text{ratio}_i)^2} \right] \left[\sum_{i=1}^{N} \frac{(\ln(\text{energy}_i))^2}{(\sigma_i / \text{ratio}_i)^2} \right] - \left[\sum_{i=1}^{N} \frac{\ln(\text{energy}_i)}{(\sigma_i / \text{ratio}_i)^2} \right]^2} \tag{340}$$

Error propagation yields the equation for the uncertainty in B:

$$\sigma_B = \sqrt{\frac{\sum_{i=1}^{N} \frac{1}{\left(\sigma_i / \text{ratio}_i\right)^2}}{\left[\sum_{i=1}^{N} \frac{1}{\left(\sigma_i / \text{ratio}_i\right)^2}\right]\left[\sum_{i=1}^{N} \frac{\left(\ln\left(\text{energy}_i\right)\right)^2}{\left(\sigma_i / \text{ratio}_i\right)^2}\right] - \left[\sum_{i=1}^{N} \frac{\ln\left(\text{energy}_i\right)}{\left(\sigma_i / \text{ratio}_i\right)^2}\right]^2}} \quad (341)$$

Finally, save results to the current datasource. The CAM parameters used to store results are described Chapter 2, *CAM Parameters*.

Control Recovery

(S509 Alpha Analysis only)
The Control Recovery algorithm calculates the chemical recovery of a control sample (tracer), using the following calculation:

$$C = \frac{A}{Ac} \quad (342)$$

where

A = activity of nuclide

Ac = certified activity of nuclide = $\frac{E \cdot Vc}{Cf \cdot Q \cdot K}$

Where

E = Activity concentration from the certificate

Vc = Volume of the control added to aliquot

Cf = conversion factor from Bq to µCi

Q = sample quantity

K = decay correction for control isotope

The result, C, is stored in the CAM Parameter CAM_F_NCLCTRLRECOV.

MCA Status Page Calculations

The algorithms for the MCA Status Page calculations, centroid, full width at half maximum (FWHM), and full width at tenth maximum (FWTM) are described in this section.

Centroid

To calculate a peak's centroid, the algorithm proceeds from the left Half Maximum point (channel below the Half Maximum value) to the right Half Maximum point, and computes

$$I_c = \frac{\Sigma(IC_i)}{\Sigma C_i} \tag{343}$$

where

C_i = absolute contents of Channel i

I = channel address relative to the left Half-Maximum point

The Peak Centroid then equals left Half-Maximum point + I_c.

FWHM and FWTM

The Full Width at Half Maximum (FWHM) and Full Width at Tenth Maximum (FWTM) algorithms calculate the current peak's width at one-half (one-tenth) of its maximum amplitude.

The current ROI determines the search limits and the background. The highest channel within this ROI, corrected for the sloped background, is located using 3-point smoothed data.

The Half Maximum value equals the counts in the highest channel (determined by a 3-point smooth) background corrected and divided by 2.

The Tenth Maximum value equals the counts in the highest channel (determined by a 3-point smooth) background corrected and divided by 10. Background is a straight line connecting the four-channel averaged end points of the ROI.

Using data in the highest channel, proceed down each side of the peak to locate the channel whose background corrected counts fall below the designated Half Maximum (Tenth Maximum) value.

The left and right FWHM (FWTM) points are the interpolated channels between the counts of the channel below the Half Maximum (Tenth Maximum) value and the counts of the channel above the Half Maximum (Tenth Maximum) value.

Smoothing the data of the wider peaks can improve the performance of the FWHM, FWTM, and Centroid calculations, but results may be misleading or insignificant if data is smoothed on narrow peaks. Therefore, raw (unsmoothed) data is used for peaks of 20 channels or less.

4. Genie-2000 Error Codes

Errors returned from software components of the software environment conform to the following notation.

Error codes are returned as 32-bit hexadecimal numbers (for example, 278e2a, see below for interpretation) where:

Bits 0 - 15: Specific error code value

Bits 16 - 19: Error class as defined below

Bits 20 - 27: Error level as defined below

Error levels (bits 20 - 27) include:

Hex 1: Hardware Protocol driver error

Hex 2: VDM Driver error

Hex 3: VDM error

Hex 4: IPC error

Hex 5: Client (SAD access routine) error

Hex 6: Application error

Error classes (bits 16 - 19) include:

Hex 0: None, specific error value is sufficient.

Hex 1: Command class.

Hex 2: Hardware class.

Hex 3: Communications class.

Hex 4: Operating system class.

Hex 5: Environment variable class.

Hex 6: Data conversion class.

Hex 7: CAM class.

Hex 8: ‘C’ runtime library class.

Given the above description, an error code such as 278e2a would indicate a VDM driver error level of the class CAM. The low order 16 bits (8e2a) denote an actual CAM error code which means ‘file already opened’. Below is a detailed list of common 32-bit error codes with the corresponding error message; a brief description of the error is presented where appropriate.

System-level errors that are considered less common, such as memory allocation errors, are presented like this:

General <level-name> Error:
Source: <a>
Class: <b>
Number: <cccc> (<ddddd>)where:

<level-name>:	Error level (such as SAD or CAM)
<a>:	Error level number (in hex)
<b>:	Error class number (in hex)
<cccc>:	Specific error code (in hex)
<ddddd>:	Specific error code (in decimal)

CAM Error Codes

CAM file access error codes will be reported as a hex number 27xxxx; common 'xxxx' codes include:

805A: Parameter not on file.

The specified CAM parameter does not exist in the datasource being accessed.

8092: Failed to find, access or open file.

809A: Error closing file.

80A2: Error reading from file.

80AA: Error writing to file.

8102: Block (class) not on file.

CAM block missing (for instance, a specified CAM class does not exist in the datasource being accessed).

8362: Number too large for storage.

8E2A: File is open and not shareable.

8E62: File already exists.

8E6A: Invalid file name.

The syntax of the specified file name is invalid (needs to be bbbbbbbb.eee).

8E7A: Destination file is open.

IPC Errors

IPC error codes will be reported as a hex number 4yxxxx (y is the particular class as described above); common ‘xxxx’ codes include:

FFFE: Timeout during communications with VDM.

FFFD: Error -3 attempting communications with VDM.

Miscellaneous communications error (most likely that the VDM is not currently running).

FFFB: No access to IPC server (no VDM running).

FFF4: Network Configuration File error.

Configuration file not found or other internal configuration file error.

FFF3: Error –13 attempting communication with VDM.

Message transaction already in progress.

–nn: Error (–nn) communicating with VDM.

VDM Errors

VDM error codes will be reported as a hex number 3yxxxx (y is the particular class as described above); common xxxx codes include:

7: A path named by an environment variable was not found.

A pathname does not exist as specified by an environment variable.

C: A required environment variable was not found by the VDM.

A system-required environment variable was not found.

13: Datasource is unknown to the VDM.

Specified detector/counter datasource is not in the Runtime Database.

17: Action disabled – datasource not verified.

19: Can’t effect change of busy datasource in Runtime Database.

21: Major verification error encountered when opening the specified detector datasource.

22: Busy but never opened.

Specified detector datasource is currently busy, but not being monitored by the VDM.

23: Minor verification error encountered when opening the specified detector datasource.

Analysis Module Errors

There are two groups of analysis module error codes: one group will be reported as a hex number in the range 61xxxx, the other as a hex number in the range E8xxxx (listing starts on page 369).

Common 61 ‘xxxx’ codes

1: Function not supported by this algorithm.

2: ROI is too small to solve.

3: Too few points for the calculation.

Not enough points were available to perform the specified calculation (for example, a third order energy calibration requires four data points).

4: Too many lines for internal arrays.

5: Equation type not supported by this algorithm.

6: Need Energy Calibration in order to proceed.

7: Need Efficiency Calibration in order to proceed.

8: Need FWHM Calibration in order to proceed.

9: Need Low Tail Calibration in order to proceed.

A: Need High Tail Calibration in order to proceed.

B: Need Peak Locate results in order to proceed.

C: Need Peak Area results in order to proceed.

D: Need Peak Search results in order to proceed.

E: Need Nuclide Library Info in order to proceed.

F: Too many nuclides for internal arrays.

10: Need DUAL Efficiency Calibration in order to proceed.

11: Setup data is invalid.

Setup parameters required for a particular algorithm are invalid (for example, a Start/Stop range of 0 to 0 would be invalid for a peak locate).

12: Expected/Calculated data is invalid.

Data resulting from previous operations (for example, live time) is invalid for this algorithm.

13: Sample data is invalid.

14: Need Efficiency Correction results in order to proceed.

15: Data invalid – Counts Per Second (for instance, area) is 0.

16: Data invalid - Efficiency is 0.

17: Need Nuclide-ID info in order to proceed.

18: No energy calibration information available.

20: Background file not found, or open error.

21: Library file not found, or open error.

23: Certificate file not found, or open error.

25: Too many peaks in the ROI.

26: No multiplets allowed in the datasource.

Acquisition Errors

The following errors are possible during acquisition:

50: Input already busy.

Energy Calibration Errors

The following errors are possible during energy calibration:

100: Singular matrix – no solution.

An error has occurred while fitting a curve to the specified points; add or delete points until a suitable set of points for a curve solution is present.

102: Couldn’t find a peak.

A peak could not be found at the specified cursor position.

103: Couldn’t fit a Gaussian to the peak.

The shape of the specified peak is poor (for instance, not a Gaussian). Typical cause is poor selection of peak via the cursor.

104: Insufficient data for required calculations.

105: Insufficient memory for dynamic variables.

Efficiency Calibration Errors

The following errors are possible during efficiency calibration:

200: No peaks in the efficiency list.

Peak Locate Errors

The following errors are possible during peak locate:

300: No nuclides in the library.

301: Mismatch in library entries.

Peak Area Analysis Errors

The following errors are possible during peak area analysis:

400: Can’t resolve peaks in a multiplet.

401: Too many peaks in the analysis range. Maximum is 350.

402: Peak Locate results were not ordered by peak centroid.

Area Correction Errors

The following errors are possible during area correction:

600: No Peak Area results in background file.

601: No Peak Search results in background file.

602: No peak found matching the tracer/reference peak.

603: Setup half-life is zero.

604: Peak has zero net counts.

650: None of the peaks were identified.

651: No efficiency calibration or tracer information found.

Activity Correction Errors

The following errors are possible during activity correction:

700: Unexpected return from interference correction.

701: Incompatible previous activity correction – rejected nuclide or line/peak link broken.

Control Recovery Error

The following error is possible during activity correction:

800: Energy line of control's nuclide could not be found.

Common E8 'xxxx' codes

8E14: Memory Allocation Error

9222: Need calibration to proceed

967A: Nuclide Library not specified

9682: Unable to open specified library

968A: Internal error – Number of channels in spectrum is zero

9692: Starting channel number is greater than end channel number

969A: Unable to write peak location results

96A2: Unable to read user ROI file flag

96AA: User specified ROI file not specified

96BA: Unable to open user specified ROI file

96B2: Bad values for ROI limits, unable to continue

96CA: No sigma value given for 2nd difference coefficients

96D2: Significance threshold value out of range or missing

96DA: Elapsed Live Time is ≤ 0

96E2: Energy or Variable FWHM tolerance is < 0

96EA: Could not fit peak(s) due to bad fit shape parameters

Geometry Composer Errors

LoadMuLibr

100 Can't open file with mu-library. Check the existence of the file pointed to by the :ATTENUATION_LIBRARY statement in file SPACE.INI.

101 Can't find predefined material in the library. The material assigned for some geometry component is absent in the connected library. Insert the desired material into the library.

102 Error while reading the attenuation library. Problem with the mu-library. The library may be corrupted; use its backup version.

103 Arrays to store attenuation coeffs. are full. Only 10 energy intervals may be used to describe the polynomial that represents the energy dependence of mass attenuation coefficient.

104 End of file with mu-library is reached, no more records exist.

Mu-Editor

500 Error while accessing of a function in LoadMuLibr.dll. The Dll may be corrupted; re-install it.

501 Cannot find LoadMuLibr.dll.

502 Error during treatment of substance composition. The old mu-library format may have been used. You may use either the construction of a new substance from elements (via chemical formula) and/or the substances prepared in the Windows version of the mu-library editor.

503 Error during conversion of the formula to the new mu-library format. While reading the DOS formatted Mu-Library the program was unable to convert a substance composition into the new format. Try to prepare this substance directly using the Windows version of the program.

504 Error in Dll (.dll) while performing the selected operation.

505 Cannot load the ISOCS path data. Either file SPACE.INI was not found or the statement :ATTENUATION_LIBRARY was not found in SPACE.INI.

506 Error while deleting a material from the library. Internal error in muedit.dll.

507 Invalid value of density. Density must be greater than 0 and less than 20.

508 Internal error while attempting to insert the material.

509 The formula is too long to be inserted into the library. You can subdivide the material composition into a few components.

510 The material ‘water’ or ‘dry air’ cannot be deleted.

511 Trying to input a string inside another substring (parenthesis).

512 Substance name coincides with an element name. The problem is corrected by adding a prefix (asterisk).

513 Name of substance coincides with an element name, correct it first.

605 Too many components, the reserved arrays are full.

609 Impossible to delete because of formula traceability. The next substance(s) refer for ‘%1’:

610 Impossible to insert because of formula traceability. The next substance(s) refer for ‘%1’:

GeomEdit

100 Not enough room between source and detector to put Absorber(s)

701 Can’t get address of DLL function

702 Can’t load DLL

703 Can’t load Material Info from library

704 The material pointed to in the template geometry is not found in the current mu-library. The material must be added before proceeding.

705 The geometry description must include a detector.

706 The detector specified in the geometry file is missing from the local file Detector.txt. Check the existence of the detector characterization file in the ISOCS directory! The geometry file refers to a detector record that has been deleted, or the current Detector.txt file has been modified.

707 Cannot append detector(s) to the Combo Box.

708 Cannot load the selected detector from file Detector.txt. Check for an appropriate record (for the selected detector) in Detector.txt.

709 A detector must be selected.

710 The number of template versions exceeds the maximum allowed. To enter a new version first delete one or more existing versions.

711 Invalid template version name.

712 The template version name is already in use.

713 Cannot open template version file. A system error occurred while opening the template version file. Version information could not be saved.

714 Cannot open the predefined beaker file. Check that the beaker file is not currently being used by another program.

715 Invalid parameter in pre-defined beaker file. The line of data must contain 7 parameters.

716 Not a valid contour ID. The ID did not correspond to one of the three types of contour (i, o or b).

717 Invalid number of parameters (less than 4)! The record structure in file describing contour.

718 Cannot load DLL with template information. When the Edit Dimensions dialog was called, the program could not load the template dll. This situation may arise when attempting to edit a .GEO file of a particular geometry template that is not available in the current GC configuration.

719 Cannot get the address of a function in the template dll. This is a system error. It may be due to a corrupted dll and may be necessary to reinstall.

720 New user template version may be based only on the default template version. A new user template version cannot be based on an existing geometry file that itself is based on a user template version. Use the version that is not marked as [user].

721 The material '%1' referenced in the geometry file is not available in the current mu-library. Please replace it with an available material or add the material to the mu-library.

722 The geometry definition contains the material '%1' which is not available in the current mu-library. Would you like to replace this material with and available one?

723 Density for the source material is missing. Mass of the source cannot be calculated.

724 Cannot load .dll.

725 Cannot get address of function in .dll. This is an internal (system) error.

726 Cannot find the bitmap containing the template drawing. The bitmap file must exist in the directory specified by the :TMPL_BITMAPS keyword in Space.ini.

727 The file containing the template drawing is not a valid bitmap (.bmp) file.

728 Cannot continue. Check the :PROGRAM keyword in Space.ini. The directory path specified by the :PROGRAM keyword is missing or invalid, or Space.ini itself may be missing.

729 Cannot retrieve the address of a function in the computational DLL. Isocs_generic.dll may be corrupted. You may need to re-install.

730 Cannot load computational DLL. Check existence of isocs_generic.dll in directory specified by the :PROGRAM keyword in Space.ini.

731 Cannot open contour description file for writing.

732 Cannot open the file containing cylindrical collimator parameters. This file is located in the directory specified by the :C_COLLIMATOR keyword in Space.ini.

733 Invalid record in collimator file.

734 Cannot open file containing under water housing parameters. This file is located in the directory specified by the :UW_HOUSING keyword in Space.ini.

735 Cannot open file containing rectangular collimator parameters. This file is located in the directory specified by the :R_COLLIMATOR keyword in Space.ini.

736 Select a collimator type first.

737 Cannot execute the operation. The collimator type must be selected first.

738 The collimator name has not been identified. The record will be saved as a new record.

739 Cannot open file to save collimator data. Check that the file is not being used by another program.

740 Please specify a name for the record: none is not valid!

741 Please confirm deletion of user version %1.

743 Versions library has been updated.

744 Please select the version to be deleted.

745 Template version has been saved.

746 Cylindrical collimator record has been successfully stored.

747 Rectangular collimator record has been successfully stored.

748 Housing record has been successfully stored.

749 Detector name is longer than 19 characters. Please make the necessary correction to the detector file. The detector is not included in the list of available detectors.

750 Please confirm deletion of the collimator record.

751 Please confirm deletion of the housing record.

752 Cannot launch MuEditor.exe. Check the existence of this file in the directory specified by the :PROGAM keyword in Space.ini.

753 Please confirm replacement of the record #%1: %2.

754 Cylindrical Collimator

755 Rectangular Collimator

756 Housing

757 Material in the string #'%1' is missing. Select the proper material from the list box or none if the geometry component is absent. In the latter case the line's data will be ignored.

758 Data Validation

759 Only positive numbers greater than 1.0E-4 mm may be entered.

760 Cannot load BMP file for plotting. The bitmap file must exist in the directory specified by the :TMPL_BITMAPS keyword in Space.ini.

Geometry Composer

100 OLE initialization failed. Make sure that the OLE libraries are the correct version.

104 Windows sockets initialization failed.

1002 Variable ‘SPACE’ is not found in the environment.

1003 File Space.ini cannot be opened.

1004 The preset path statement is not found in file Space.

1005 Cannot open file detector. with detector parameters. Check whether detector.txt is present in the directory specified by the :DETECTOR_PAR keyword in Space.ini.

1006 Error in format of file Space.ini. Check format of Space.ini: each line should have a format of keyword=path.

1007 System error while reading the detector list file.

1008 Check format of the detector list file (8 columns per line are allowed).

1009 Program cannot open templates list file (template.cnf).

1010 Templates list file (template.cnf) has an invalid format.

1011 System error while reading the templates list file (template..

1012 Cannot load the template DLL file.

1013 Cannot access exported DLL function. This is a system error which occurred when the program attempted to access the DLL.

1014 Unable to locate the geometry files directory. The program cannot locate the directory specified by the :GEOMETRY keyword in Space.ini. The results will be stored in the root directory.

1015 Cannot open ISOCS geometry (.GIS) file to store geometry description data.

1016 Directory specified by the :PROGRAM keyword in file Space.ini is invalid.

1017 Internal error in ISOCS program.

1018 Cannot open efficiency (.ECC) file generated by ISOCS.

1019 Error while reading ISOCS efficiency (.ECC) file: invalid number of columns in file.

1020 Error while reading ISOCS efficiency (.ECC) file: invalid number of energies in file.

1021 Internal error calling efficiency curve function in .dll.

1022 Error returned from efficiency curve function in .dll.

1023 Cannot load .dll. Check existence of this file in the directory specified by the :PROGRAM keyword in Space.ini.

1024 Internal error: generation failed.

1025 Error attempting to open .ECC file generated by ISOCS: cannot find :ECC_OUTPUT keyword in file Space.ini.

1026 Unrecognized file format: the file is not in a .GEO format.

1027 The function computing efficiency returned with an error.

1028 Internal system error attempting to call a function in _generic.dll.

1029 Cannot load _generic.dll.

1030 The geometry (.GEO) file was created by later version of Geometry Composer than is currently running. The program may have failed attempting to read a file. Please update your Geometry Composer.

1031 Cannot open file containing geometry data.

1032 Internal arrays for importing ISOCS geometry are full. Check the .GIS file and insure that all contained data are valid.

1033 Cannot open the Clipboard to store the template picture for export to Excel.

1034 Cannot empty the Clipboard.

1035 Unable to write template picture to the Clipboard.

1036 Do you wish to overwrite existing configuration file?

1037 Cannot open back-up copy of Space. (Space.bak).

1038 No geometry templates are available. Please check Options/Configuration menu item. Check for the existence of the template DLLs (lgt_xx.dll and igt_xx.dll) in the directory specified by the :PROGRAM keyword in Space.ini.

1039 Filename of the Computational DLL does not match its content. The file may have been renamed.

1040 Cannot find the bitmap containing the template drawing. The bitmap file must exist in the directory specified by the :TMPL_BITMAPS keyword in Space.ini.

1041 The file containing the template drawing is not a valid bitmap (.bmp) file.

1042 Program cannot run because of a missing keyword. One of the required keywords in Space.ini is missing.

1043 Cannot find the directory specified by the :GEOMETRY keyword in file Space.ini.

1044 The selected folder does not correspond to standard file storage convention. Save the file anyway?

1045 Confirm selection!

1046 Cannot create new directory.

1047 Cannot open the energy list file.

1048 Error in format of energy list file. Each line should contain two comma delimited fields: Energy and Efficiency Error.

1049 Cannot open energy list file for writing.

1050 Error while requesting information about a computational DLL.

1051 Program cannot continue: cannot find one of the required keywords in file Space.ini.

1052 Internal system error: problem calling a function in the computational DLL.

1053 Cannot load computational DLL. Check existence of DLL in directory specified by the :PROGRAM keyword in Space.ini.

1054 Cannot delete temporary file .txt. This is required in order to execute the next ISOCS computation.

1055 Cannot open temporary file to store beaker description during geometry testing.

1056 Cannot find generated file. Export to Excel is stopped.

1057 Excel is being launched...Please answer the following questions from Excel:

1058 Cannot launch ‘Excel’.

1059 Efficiency curve may be generated after saving the geometry file.

1060 Geometry test has run successfully.

1061 Geometry test has failed:

1062 Error

1063 Variable ‘SPACE’ is not found in the environment.

1064 File Space.ini cannot be opened. Check for the existence of this file in the directory specified by the SPACE environment variable.

1065 The preset statement is not found in file Space.ini.

1066 Cannot open file detector. with detector parameters. Check existence of this file in the directory specified by the :DETECTOR_PAR keyword in file Space.ini.

1067 Error in format of file Space.ini. Check format of Space.ini: each line should have a format of keyword=path.

1101 Cannot find the bitmap containing the template drawing. The bitmap file must exist in the directory specified by the :TMPL_BITMAPS keyword in Space.ini.

1102 Please select the energy to be deleted.

1103 An Efficiency Calibration Calculation (ECC) process is already running. Wait for its termination before launching another ECC process.

1104 Efficiency data points have been generated.

1105 Filename of the Template DLL does not match its content. The file may have been renamed.

1106 Temperature is below the lower temperature limit (deg C):

1107 Temperature is above the upper temperature limit (deg C):

1108 Pressure exceeds the upper pressure limit (mm Hg):

1109 ISOCS environment is not found. Program cannot run.

1110 File Space.ini or a required keyword in Space.ini was not found. The program cannot access data needed for creation of a new document. Only existing documents may be opened.

1111 Cannot move generated .ECC file from temporary to destination directory. System error number (errno)

1112 Configuration list is empty. New document cannot be created: no templates are available.

1113 Cannot update configuration. File Space.ini or the :PROGRAM keyword in space.ini was not found.

1114 You have loaded a previous version of a GEO file. To make the picture available open the Edit/Dimensions dialog and save the GEO file.

1115 Cannot create backup of template list file (template.bak). While updating the configuration the program could not rename template.cnf to ‘template.bak.

1116 Cannot update template list file (template.cnf). While updating the configuration the program could not rename the temporary copy of the template list file (template.tmp) back to the permanent file name (template.cnf).

1117 List is full. Cannot append new energy value to the list used for ECC generation. Max lines in the list is 100.

1118 % elements have been loaded.

1119 The valid energy interval is:

1120 The energy value is already in the list.

1121 The Error value is missing.

LGT_101

101	Windows sockets initialization failed.
200	Not enough room between source and detector to put Absorber(s)
	Invalid volume: upper part of beaker is not filled The data in line 4 will be reset Input correct values

LGT_104

101	Windows sockets initialization failed.
200	Not enough room between source and detector to put Absorber(s)
201	Please specify thickness of side walls
202	Please select material of side walls
203	Please specify thickness of bottom wall
204	Please select material of bottom wall

LGT_106

101	Windows sockets initialization failed.
200	Not enough room for Absorber(s)
201	Invalid volume. If you wish to change sample volume, correct the dimensions.
202	Please select material for the container.
203	Please specify thickness of container walls.

LGT_107

101	Windows sockets initialization failed.
200	Not enough room for Absorber(s)
201	Please select material for the container.
202	Please specify thickness of container walls.

LGT_108

101	Windows sockets initialization failed.
200	Detector does not fit into Marinelli beaker well. See the “Endcap INFO” frame on the dialog panel.
201	Invalid volume: upper part of beaker is not filled. The data in line 4 will be reset. Input correct values.
202	Sample is below detector plane.
203	Invalid data: only positive values are permitted.
204	Invalid data for detector well: both of them must be zero or not zero.
205	Invalid data for detector well: 3.1 must be greater than 2.1 + 4*1.1.
206	Container diameter must be greater than detector diameter.
207	Please select a material for the container.

LGT_112

101	Windows sockets initialization failed.
200	Please select a material for the beaker walls.
201	Sample volume is too large to fit into the beaker.
202	Not enough room for the sample.

LGT_12

101	Windows sockets initialization failed.
200	Please select a wall material.
201	Please specify the height of at least one of the layers: 2.1 or 3.1.

LGT_3

101	Windows sockets initialization failed.
200	Please select material for walls.

201 Please specify height of at least one of the layers: 2.1 or 3.1.

LGT_6

101 Windows sockets initialization failed.

200 Please select material for walls.

201 Please specify height of layer.

LGT_7

101 Windows sockets initialization failed.

200 Please select material for the walls.

201 Sum of shells exceeds diameter: (1.1+ 2.1) > 1.2

202 Please select material for the sample.

203 Please select material for Source-Shell.

204 Please select material for Source.

LGT_8

101 Windows sockets initialization failed.

200 Detector does not fit into Marinelli beaker well. See the “Endcap INFO” frame on the dialog panel.

201 Parameters 3.1 and 4.1 must be set in the current context.

Report Module Errors

Report module error codes will be reported as a hex number 60xxxx; common xxxx codes include:

1: Memory Allocation Error.

2: Template file not specified.

3: Report section not specified.

4: Parsing error(s) detected.

Errors have been detected during the compilation phase of generating a report. Look at the report file for a more detailed description of errors.

5: Temp. file creation error.

6: Error communicating with VDM.

7: Error during disk file access.

8: Error during CAM file access.

9: Invalid intermediate file

Find the directory named by the RTPLFILES environment variable; find a subdirectory with the base name of the template file you're using; delete the *.ITF files from that subdirectory and try again.

QA Routine Errors

Errors in the Transfer and Analyze routines will be reported as a hex number 60xxxx. Common xxxx codes include:

380: General communication failure.

381: Memory allocation error.

384: The record being transferred has the same time-stamp as one that's already on file - but there's no over-write flag.

385: No records to transfer.

386: Nuclide or Nuclide line not found.

38C: Warning that the bias test was not performed because one or more values had error = 0.

38D: Bad date range specified.

38E: Warning that not all tests were performed.

38F: Cannot transfer to hardware.

MID Editor Errors

MID Editor error codes will be reported as a hex number 3yxxxx (y is the particular class as described above); common xxxx codes include:

15: MID file <name> is loaded in the Runtime Database.

This error indicates that the specified MID file to be opened for edit is loaded in the Runtime Database. It must be unloaded before it can be edited.

19: That file defines an input which is acquiring.

This error indicates that the specified MID file cannot be unloaded because a detector defined within it is currently acquiring data.

1B: An already-loaded file has an input with the same name.

An attempt was made to load an MID file into the Runtime Database containing at least one input name that already appears in the Runtime Database. Input names must be unique within any instance of the Runtime Database.

1C: That file is not loaded.

The specified MID file to be unloaded from the Runtime Database is not currently loaded.

1D: An already-loaded file has a hardware device at the same board number or address.

An attempt was made to load an MID file into the Runtime Database containing at least one hardware device with a board number (S100) or address (AIM) that already appears in the Runtime Database. Hardware device addressing must be unique within any instance of the Runtime Database.

Input Datasource Errors

A detector datasource (or input) is made up of an MCA and various front-end devices, such as an Amplifier, an ADC, or a high-voltage power supply. The process of configuring an input via the MID Editor was discussed in Chapter 3. No actual hardware is required until you decide to use an input by opening it up in a Genie-2000 software application.

Open/Verify Errors

The system perform a verification on an input datasource when it is first opened; verification is defined as checking to make sure that the input can be communicated with and is configured as defined by the MID Editor. There are various errors that verification can determine; they are divided into three categories: fatal errors, major errors, and minor errors.

Fatal Errors

This class of error indicates that the open of the specified input datasource has failed. This error will be reflected in an appropriate error message from the various system software applications.

Busy but never open

This condition arises when the VDM, in responding to a request for opening an input, detects that the input is busy without being monitored. This can be caused by the VDM being closed and restarted (or the computer being soft-rebooted) while an input is acquiring.

Unlike the other fatal errors, the Gamma and Alpha applications will present the user with three options in handling this condition:

- Cancel the open operation.
- Proceed with the open and continue acquisition on the input datasource. Note that no verification is performed in this case.
- Proceed with the open by aborting the acquisition and verifying the input datasource.

Hardware not Available

This error is due to a failure in detecting the presence of some device that makes up the input. Some of the causes for this error include:

Incorrect board no. (S100)

Incorrect I/O address (Accuspec)

Incorrect Ethernet address (AIM)

1520 defined and not present (S100)

No response from unit (Inspector)

Owner Mismatch:

This condition indicates that the input being opened is currently “owned” by another user and cannot be accessed. This is caused when an attempt is made to open an AIM input and the AIM device is currently being accessed by another VDM; that is, another user.

Baud Rate not Supported by Serial Port Hardware

This condition indicates that the serial port hardware in the computer does not support the data transfer (baud) rate selected in the MID Editor. Try a slower rate.

Major Errors

This class of error indicates that the open of the specified input datasource has failed. Unlike a fatal error, this error class is handled differently by the Gamma and Alpha applications. Upon detecting this class of error, the applications will automatically bring up the Status screen which presents more detailed information as to the errors that were encountered. Upon exiting the Status screen, the user is directed back to the main window, just as if a fatal error occurred.

Hardware Failure

This error is returned when an open of an input detects that one of the devices comprising the input has failed. Note that this error always indicates that a device, such as ICB NIM, has notified the system software that it has failed.

Model No. Mismatch

This error is returned when an open of an input detects that one of the devices comprising the input does not match the model number as configured by the MID Editor; that is, the input was configured to include an 9641 HVPS and the open/verify process found a 9645 HVPS.

Minor Errors

This class of error indicates that the open of the specified input datasource was partially successful in that all devices comprising the input were located and communicated with; however, discrepancies were found in the actual configuration of one or more devices. In the Gamma and Alpha applications, the user will be presented with three options in handling this condition (the system job commands will treat this class of error as fatal):

1. Cancel the open operation.

2. Proceed with the open and ignore the minor error. In this case, the system software will set a “questionable data” flag in the datasource as a reminder of this error condition. The “Ready LED” will be set to YELLOW for any ICB devices defined for this input datasource.

   If the open was initiated from the Acquisition and Analysis application, its Status field will have been changed to red and its Status Report will display an asterisk (*) next to the parameter in question. When the error has been corrected, both error flags can be cleared by updating the Status Report screen.

3. Proceed with the open and accept the minor error. No “questionable data” flag is set in this case and the input datasource is updated with the conflicting parameter values. The “Ready LED” will be set to GREEN for any ICB devices defined for this input datasource.

Serial No. Mismatch

This error is returned when an open of an input detects that one of the devices comprising the input does not match the serial number detected last time it was opened and used. This error will occur when an ICB device, such as a 9641 HVPS, is removed for repair/maintenance and is replaced with another unit.

Operational Errors

After verification is performed, two additional checks, Questionable Data and Questionable Calibration, are made on the input datasource while it is being opened.

Questionable Data – This condition (indicated by CAM parameter ASTFCCERR) occurs whenever:

1. An error occurs during acquisition.

2. A minor verification error is detected during open and is ignored (see “Open/Verify Errors” on page 385).

This error is cleared by accepting the condition at open time.

Questionable Calibration – This condition (indicated by CAM parameter ASTFBADCAL) occurs whenever a hardware setting is changed. It is intended to flag the user about changes in the hardware characteristics that could potentially affect the energy/shape calibration. This error is cleared either by accepting the condition at open time or by performing a valid energy/shape calibration.

After an input datasource is opened by a system software application, the input is monitored by the VDM for any change in status. The parameters that are monitored vary, based on the input datasource; that is, on the types of devices that comprise the input. Some typical parameters that are monitored include:

- Has the device failed since open?
- Has there been a communications error since open?
- Has the device gone through a power reset since open?
- High voltage status change; for instance, inhibit or overload.
- Any readable parameters that can possibly change since open, such as the shaping time constant on a 9615 ICB Amplifier.
- RAM keepalive battery is low (Inspector only)
- Both power batteries are low (Inspector only)

The way a change in status is handled varies between system software applications:

When the Gamma or Alpha application detects a change in status, it will change the background color of the input's Status Line from white to red. This tells the user that there has been a change at the hardware level. The Status Report screen in the Acquisition and Analysis application will show an asterisk next to the changed parameter. When the error has been corrected, both error flags can be cleared by updating the Status Report screen.

The Genie-2000 WAIT command does monitor change in status during its execution. If a change is detected, the WAIT command will return to the user with an appropriate error message and error return code.

Stabilizer Window Outside Channel Limits

This error message can be triggered by one of three conditions:

1. The Centroid channel plus one half of the number of Spacing channels plus the Window width yields a channel which is greater than the number of channels in the input.

2. The Centroid channel minus one half of the number of Spacing channels minus the Window width yields a channel which is less than one.

3. The Zero Centroid channel is greater than the Gain Centroid channel.

5. LabSOCS/ISOCS Error Codes

This listing of error codes and their corresponding messages is included as an aid to troubleshooting problems that may occur in data entry and/or other operations. Extensive error testing is done in various parts of the program, especially when editing or creating geometries.

Exiting the Geometry Composer screen causes a three-part error validation routine to be called.

1. First, the GeomEdit module compares the input values to generic rules for all templates;

2. Next the values are compared to template-specific requirements for various parameters;

3. Last, a test is carried out by the computational dll for that template to make sure that the full computation will run. This is the same test that is called when using the “Check Geometry Validity” function.

The validation routine uses error messages box with different titles than standard error message.

- If title of the box is “Data Validation Error #xyz”, it means that error was detected in GeomEdit or the template dll.
- If the title of the box is “Data Validation Error [from computational module]: #xyz” it means that error was detected in the computational dll.
- If the title of the box is “Data Validation Warning: #xyz”, it comes from conditions within the template dll.

Other similar error testing is done in Mu-Editor while creating/editing materials and for ISOCS while creating/editing collimators or external housings.

There are several sets of error messages described in this chapter.

1. General errors, starting page 390.

2. Geometry composer errors, starting on page 420.

3. ISOCS multi-efficiency errors, starting on page 430.

4. ISOCS template-dependent errors, starting page 431.*

5. LabSOCS template-dependent errors, starting page 447.*

*To find template-dependent error messages, first locate the name of the template that was used, then find the error number within that template.

The error codes and their messages are presented as:

- The number of the error message.
- The text of the error message in caps.
- An explanation of the error message.

General Errors

#256 AN EFFICIENCY CALIBRATION CALCULATION (ECC) PROCESS IS ALREADY RUNNING.
WAIT FOR ITS TERMINATION BEFORE LAUNCHING ANOTHER ECC PROCESS.
This error message can appear when you try to launch the Efficiency Calibration Calculation [ECC] process before the previously launched ECC has completed. Launching two concurrent ECC processes is prohibited.

#257 CAN'T OPEN INPUT FILE WITH THE TEMPLATE DESCRIPTION.
Make sure that the template description contained in the input geometry file really exists in the current configuration.

#258 UNKNOWN TEMPLATE NAME.
An invalid template name is declared in the template geometry description file.
Make sure that you use a valid template name.

#259 TEMPLATE NAME IS MISSING.
The template name is not defined in the geometry description file.

#260 CAN'T ALLOCATE MEMORY TO READ THE FILE WITH THE TEMPLATE DESCRIPTION.
There is not enough memory to continue the program. It is a system error.

#261 FILE WITH TEMPLATE DESCRIPTION IS EMPTY.
There is no data in the template geometry description file.

#262 FILE WITH LIST OF CYLINDRICAL COLLIMATORS IS NOT FOUND.
Check the file indicated via the :C_COLLIMATOR keyword in SPACE. file.
Make sure that the :C_COLLIMATOR keyword is not missing in the "SPACE.INI" file. Then check keyword's definition, then try again This keyword should point to the full name of the file with descriptions of the cylindrical collimator parameters.

#263 FILE WITH LIST OF DETECTORS IS NOT FOUND.
Check the file indicated via the :DETECTOR_PAR keyword in SPACE.INI file.
Make sure that the :DETECTOR_PAR keyword is not missing in the "SPACE.INI" file. Then check keyword's definition, then try again This keyword should point to the full name of the file with descriptions of the detector parameters.

#264 THE DCG FILE NAME DECLARED IN THE DETECTOR ROW DESCRIPTION IS NOT FOUND.
The description of the detector parameters includes the Detector Calibration Generator [DCG] filename that is used to calculate the efficiency at the point with the arbitrary XYZ coordinates. Make sure that the pointed DCG-filename really exists.

#265 THE DETECTOR NAME IS MISSING IN THE INPUT PARAMETER FILE.
The geometry description should refer to the symbolic name of detector that is used in the measurement. Make sure that you indicate any detector name in the geometry description.

#266 THE ENERGY LIST IS EMPTY.
The geometry description should refer to the list of energies that are used to approximate the efficiency vs. energy function. Make sure you define the list of energies.

#267 NEGATIVE VALUE ENTERED FOR EITHER ENERGY OR ERROR.
The geometry description refers to the list of energies that are used to approximate the efficiency vs. energy function. Check the list of energies for negative values. Negative values are not allowed.

#268 THE ERROR ARRAY IS SHORTER THAN THE ENERGY ARRAY.
The geometry description refers to the list of energies that are used to approximate the efficiency vs. energy function. Make sure that the list contains the same number of error values as the number of energy values.

#269 THE ENERGY ARRAY IS SHORTER THAN THE ERROR ARRAY.
The geometry description refers to the list of energies that are used to approximate the efficiency vs. energy function. Make sure that the list contains the same number of energy values as the number of error values.

#270 FILE WITH LIST OF RECTANGULAR COLLIMATORS IS NOT FOUND.
Check the file indicated via the :R_COLLIMATOR keyword in SPACE. file.
Make sure that the :R_COLLIMATOR keyword is not missing in the "SPACE.INI" file. Then check keyword's definition, then try again This keyword should point to the full name of the file with descriptions of the rectangular collimator parameters.

#272 FILE WITH LIST OF HOUSINGS IS NOT FOUND.
Check the file indicated via the :UW_HOUSING keyword in SPACE. file.
Make sure that the :UW_HOUSING keyword is not missing in the "SPACE.INI" file. Then check keyword's definition, then try again This keyword should point to the full name of the file with descriptions of the underwater housing parameters.

#273 FILE NAME WITH THE PREDEFINED ENERGY LIST IS NOT FOUND.
The geometry description refers to the list of energies that are used to approximate the efficiency vs. energy function. The list of energies can be defined in two different ways. User can input energies either directly from the keyboard or by pointing to the name of the file that contains the list of energies. This error can appear when the pointed filename does not exist.

If you use the default filename, then make sure that the :PREDEFINED_ELIST keyword of SPACE.INI file points to an existing filename.

#274 THE DCG FILE FORMAT IS INCOMPATIBLE WITH THE LabSOCS/ISOCS SOFTWARE VERSION.
The description of the detector parameters includes the Detector Calibration Generator [DCG] filename that is used to calculate the efficiency at the point with the arbitrary XYZ coordinates. ISOCS software versions 1.2e and earlier will work with DCG files generated using an older methodology. ISOCS versions 3.0 and later will work with DCG files generated using a new method. The above error message can appear when the selected DCG file is damaged or when the DCG creation method is incompatible with the ISOCS software version.

#275 NOT ENOUGH ROOM FOR ABSORBER.
The space between the source and detector is not enough to accommodate the generic absorber with the specified thickness. Change the total thickness of the used generic absorber(s).

#276 DETECTOR IS BEHIND THE ABSORBER.
The above error message will appear when the definition of the detector location makes it go through the generic absorber. Change the detector location parameters and/or the total thickness of the used generic absorbers.

#277 DETECTOR IS BEHIND THE SOURCE REFERENCE PLANE.
The above error message will appear when the definition of the detector location makes it go through the source reference plane. Change the detector location parameters.

#278 NEGATIVE COLLIMATOR DIMENSION. SEE THE COLLIMATOR DESCRIPTION.
It means that the value of one or more collimator dimensions is negative.

#279 INVALID DIMENSION FOR COLLIMATOR FRONT OPENING.
An invalid parameter value was used to define the conical [pyramidal] slope of the front opening for the circular [rectangular] collimator.

#280 COLLIMATOR DOESN'T HAVE ENOUGH ROOM TO ACCOMMODATE THE DETECTOR.
The collimator was defined so that the detector can't be located inside the collimator. Change the inside dimensions of collimator.

#281 COLLIMATOR IS BEHIND THE ABSORBER.
The collimator location was defined in such a way that the collimator goes through the generic absorber. Change the detector location parameters or/and the total thickness of the used generic absorbers.

#282 COLLIMATOR IS BEHIND THE SOURCE REFERENCE PLANE.
The detector location was defined in such a way that the collimator goes through the source reference plane. Change the detector location parameters or/and the collimator dimensions.

#283 INVALID HOUSING DIMENSION. SEE THE HOUSING DESCRIPTION.
It means that the value of one or more dimensions of the underwater housing is negative or zero.

#284 HOUSING DOESN'T HAVE ENOUGH ROOM TO ACCOMMODATE THE COLLIMATOR.
The underwater housing was defined in such a way that the defined collimator can't be located inside the housing. Change the inside dimensions of the housing.

#285 HOUSING DOESN'T HAVE ENOUGH ROOM TO ACCOMMODATE THE DETECTOR.
The underwater housing was defined in such a way that the detector can't be located inside the housing. Change the inside dimensions of the housing.

#286 HOUSING IS BEHIND THE ABSORBER.
The detector location was defined in such a way that the underwater housing goes through the generic absorber. Change the housing location parameters or/and the total thickness of the used generic absorbers.

#287 HOUSING IS BEHIND THE SOURCE REFERENCE PLANE.
The detector location was defined in such a way that the underwater housing goes through the source reference plane. Change the housing location parameters.

#288 DETECTOR REFERENCE POINT IS BEHIND THE SOURCE REFERENCE PLANE.
This source-detector geometry is not allowed [parameter sd1 0]. Change the source-detector geometry so that the detector reference point is located in front of the source reference plane.

#289 SOURCE-DETECTOR DISTANCE [SD1 PARAMETER] IS UNDEFINED.
A value must be entered in the ‘sd1’ field of the source-detector row. If the ‘sd1’ field is supposed to be zero, a zero (not a blank) must be entered. The other ‘sdx’ fields may be left blank, and in those cases a blank is interpreted as a zero. As an example, an entry of sd1=0 with sd2, sd3, sd4, and sd5 left blank on the source-detector row is acceptable, and will run without any error messages.

#290 IF SOURCE-DETECTOR DISTANCE sd1=0, THEN sd4=sd2 and sd5=sd3 ARE REQUIRED.
The detector reference point is found to be on the source reference plane. To prevent indeterminacy, only source-detector locations that satisfy the criterion of sd4=sd2 and sd5=sd3 are allowed. Change the source-detector location parameters to fulfill the criterion of sd4=sd2 and sd5=sd3, if the sd1 distance is required to be zero.

#292 A NEGATIVE CONCENTRATION VALUE.
A string of the source dimension table contains a negative value for the radioactivity relative concentration. Make sure that the radioactivity relative concentration values are non-negative.

#293 NON RADIOACTIVE SAMPLE.
The radioactivity relative concentration is zero for all source layers. It means that the sample is non-radioactive. Change the radioactivity relative concentrations so that at least one of the source layers has a positive non-zero value.

#294 RADIOACTIVITY CONCENTRATION VALUE IS INDICATED FOR A SOURCE WITH ZERO OR NEGATIVE THICKNESS.
A negative source layer dimension is detected in a string of the source table. Or a layer with zero thickness has a non-zero value for the radioactivity concentration. Make sure that the source dimension table contains only non-negative values defining the layer thickness. If the zero thickness layer is used, make sure that the corresponding radioactivity concentration is zero.

#295 IMPOSSIBLE SAMPLE-DETECTOR LOCATION. CHECK BOTH THE sd4 and sd5 VALUES.
This error message can appear to prevent the system math run-time error that could occur due to rounding off while calculation of the trigonometrical functions. The probability of the appearance of this error message is negligible. But, if it appears, it means that the sd4 or/and the sd5 absolute value is too big.

#296 CAN'T OPEN THE AUXILIARY FILE: ECC_DATA.
The ECC_DATA is the auxiliary file that is used to store the intermediate information while the Efficiency Calibration Calculation [ECC] process is running. If this message appears, it means that the ECC_DATA file is damaged due to some system error. The ECC process cannot be continued.

#297 CAN'T OPEN FILE WITH THE MU-LIBRARY TO CHECK THE INDICATED MATERIALS IN THE TEMPLATE DESCRIPTION.
Most probably the materials library file has not been found. Make sure that the materials library file exists, then try again.

#298 CAN'T FIND THE 'DRYAIR' MATERIAL TO GENERATE THE HUMID AIR ATTENUATION.
ISOCS software uses the fixed material name to generate the attenuation/energy function for the humid air. This material name is expected to define the dry air chemical content. If this name doesn't exist in the materials library, then the above error message appears. Include the 'dryair' material in the materials library, then try again.

#299 CAN'T FIND THE 'WATER' MATERIAL TO GENERATE THE HUMID AIR ATTENUATION.
ISOCS software uses the fixed material name 'water' to generate the attenuation/energy function for the humid air. This material name is expected to define the water chemical content. If this name doesn't exist in the materials library, then the above error message appears. Include the 'water' material in the materials library, then try again.

#300 THE AIR TEMPERATURE VALUE IS OUT OF 0,100 C DEGREE INTERVAL.
The [-50, 100 degree of Celsius] interval is limit of the air temperature range for ISOCS software. Make sure that the value of the air temperature is within the above interval, then try again.

#301 THE AIR RELATIVE HUMIDITY VALUE IS OUT OF ,100 p.c. INTERVAL.
The [0, 100 %] interval is limit of the relative humidity range. Make sure that the value of the relative humidity is within the above interval, then try again.

#302 THE AIR BAROMETRIC PRESSURE IS TOO LOW FOR GIVEN T and RH.
Doing a model computation, user could err estimating the Barometric Air Pressure [BAP] at the given temperature and Relative Humidity [RH]. The BAP is a sum of the dry air and the Saturated Water Steam [SWS] partial pressures, where the SWS partial pressure depends on only the temperature and RH. Thus the BAP anyway may not be less than the SWS partial pressure at given T and RH. For example, the BAP may not be zero if the RH is not zero. To prevent the invalid BAP value inserted by user, software checks the inequality: BAP ≥ SWS partial pressure. If this inequality is not fulfilled, then software outputs the above message. Change the BAP value, then try again.

#303 THE AIR BAROMETRIC PRESSURE VALUE IS TOO HIGH (2000 mm Hg).
The 2000 mm.Hg. value is set as some reasonable limitation for the Air Barometric Pressure [BAP]. Make sure that the BAP value is less than the above limit, then try again.

#304 MATERIAL OR DENSITY PROBLEM. SEE THE SOURCE TABLE.
Either the material name without the density value or the density value without the material name is indicated in the table of the source description. Make sure that each material name is used with the density value, then try again.

#305 d.1 PARAMETER MAY NOT BE ZERO IF MATERIAL IS PRESENT. SEE THE SOURCE TABLE.
A material name and/or a non-zero density value is not allowed for a zero thickness layer. Make sure that both the material name and the density value are not used for the zero thickness layers, then try again.

#306 BOTH MATERIAL AND DENSITY ARE UNDEFINED. SEE THE SOURCE TABLE.
Both a material and its density are required for any non-zero thickness layer. Make sure the source, collimator, and underwater housing definitions don’t contain a non-zero thickness value without both the material name and the density value being defined. Then try again.

#307 A MATERIAL NAME USED IN THE TEMPLATE DESCRIPTION DOESN’T EXIST IN THE MATERIALS LIBRARY.
Each material name that is used in the template description should exist in the materials library. Make sure that all the used material names are valid and really exist in the materials library. Then try again.

#308 HOUSING INSIDE MATERIAL DENSITY IS ZERO.
This message can appear if an underwater housing is used. Inside material defines environment [usually air] inside the housing. The error message means that the inside material name is indicated with the density zero value. Make sure that this density value is positive, then try again.

#309 HOUSING INSIDE MATERIAL NAME DOESN'T EXIST IN LIBRARY.
This message can appear if an underwater housing is used. Inside material defines environment [usually air] inside the housing. The error message means that the indicated inside material name doesn't exist in the materials library. Make sure that the used material name is valid and really exists in the materials library. Then try again.

#310 HOUSING OUTSIDE MATERIAL DENSITY IS ZERO.
This message can appear if an underwater housing is used. Outside material defines environment [e.g. water] outside the housing. The error message means that the outside material name is indicated with the density zero value. Make sure that this density value is positive, then try again.

#311 HOUSING OUTSIDE MATERIAL NAME DOESN'T EXIST IN LIBRARY.
This message can appear if an underwater housing is used. Outside material defines environment [e.g. water] outside the housing. The error message means that the indicated outside material name doesn't exist in the materials library. Make sure that the used material name is valid and really exists in the materials library. Then try again.

#312 SAMPLE GOES THROUGH ABSORBER. CHECK THE LOCATION DISTANCES.
The source/detector location parameters are defined in such a way that the source goes through the absorber layer. Change the source/detector location parameters and/or the total thickness of the used generic absorbers.

#313 SAMPLE GOES THROUGH DETECTOR.
The source/detector location parameters are defined in such a way that the source goes through the detector. Change the source/detector location parameters.

#315 OUT OF THE CALIBRATION ENERGY OR [AND] DISTANCE REGION.
The source is located too far from the detector. And the current DCG file can't support the Efficiency Calibration Calculation [ECC] at these distances. Or the current DCG file can't support the ECC at the required energy values. Change source/detector location parameters and/or the list of energies, then try again.

#317 NOT ENOUGH MEMORY TO ALLOCATE 'SPACE.INI' FILE.
There is not enough memory to continue the program. It is a system error.

#318 CAN'T FIND THE 'SPACE' VALUE IN PROCESS ENVIRONMENT.
The ISOCS software searches for the 'SPACE' value in the process environment to determine the SPACE.INI file location. This error message means that the ISOCS software is incorrectly installed. Most probably the registry entries for the 'SPACE' value are invalid.

#319 CAN'T OPEN 'SPACE.INI' FILE.
The 'space.ini' file contains the structure of directories that are used while running the ISOCS software. The error message means that the 'space.ini' file is not found. Make sure that the 'space.ini' file really exists. If so, then most probably, the registry entries for the 'SPACE' value are invalid.

#320 THE 'SPACE.INI' FILE IS EMPTY.
The 'space.ini' file should contain the structure of directories that are used while running the ISOCS software. The error message means that the 'space.ini' file is blank.

#322 THE :SPACE_CALIBRATION KEYWORD IS MISSING IN 'SPACE.INI' FILE.
The :SPACE_CALIBRATION keyword determines the folder where the files with the DCGs are stored. Include both the :SPACE_CALIBRATION keyword and its definition in the 'space.ini' file, then try again.

#323 THE :SOURCE_PARAMETERS KEYWORD IS MISSING IN 'SPACE.INI' FILE.
In case of batch-mode of ISOCS, the :SOURCE_PARAMETERS keyword determines the folder where the files with the template geometry description are stored. Include both the :SOURCE_PARAMETERS keyword and its definition in the 'space.ini' file, then try again.

#324 THE :ATTENUATION_LIBRARY KEYWORD IS MISSING IN 'SPACE.INI' FILE.
The :ATTENUATION_LIBRARY keyword determines the folder where the files with the materials library are stored. Include both the :ATTENUATION_LIBRARY keyword and its definition in the 'space. file, then try again.

#326 THE :TABLE_KIT KEYWORD IS MISSING IN 'SPACE.INI' FILE.
The :TABLE_KIT keyword determines the folder that is used to store the intermediate data while ISOCS running. This folder is also used to store both the 'fatalerr.txt' file containing the error messages and the 'report.txt' file containing the results on the integral convergence while the ECC. Include both the :TABLE_KIT keyword and its definition in the 'space.ini' file, then try again.

#327 THE :ECC_OUTPUT KEYWORD IS MISSING IN 'SPACE.INI' FILE.
The :ECC_OUTPUT keyword determines the folder that is used to store the results on the Efficiency Calibration Calculation [ECC]. Include both the :ECC_OUTPUT keyword and its definition in the 'space.ini' file, then try again.

#328 THE :COINCIDENCE KEYWORD IS MISSING IN 'SPACE.INI' FILE.
The :COINCIDENCE keyword determines the folder that is used to store the information supporting the further computation on coincidence. Include both the :COINCIDENCE keyword and its definition in the 'space.ini' file, then try again.

#329 EITHER AN INVALID MATERIAL OR DENSITY VALUE IN DETECTOR PARAMETERS.
The description of the detector parameters uses a number of the material names. Make sure that each material name is indicated with a non-zero density value. Then try again.

#330 A MATERIAL IN DETECTOR DESCRIPTION IS NOT IN THE LIBRARY.
The description of the detector parameters uses a number of material names. The error message means that an indicated material name doesn't exist in the materials library. Make sure that all the used material names are valid and really exist in the materials library. Then try again.

#331 TEMPLATE'S NAME IS TOO LONG.
Check the file indicated via the :ISOCS_TMPL_NAME keyword in SPACE.INI file.
The file indicated via the :ISOCS_TMPL_NAME keyword is intended to store the list of the template names. The error message means that a template name length exceeds the 255 symbols limit. Change the template name, then try again.

#332 CAN'T OPEN FILE WITH THE LIST OF ISOCS TEMPLATE NAMES.
Check the full filename indicated via the :ISOCS_TMPL_NAME keyword in SPACE.INI file.
The list of the template names is stored in the file that location is indicated via the :ISOCS_TMPL_NAME keyword of 'space.ini' file. Make sure that the indicated file really exists. Then try again.

#333 THE FILE WITH THE LIST OF ISOCS TEMPLATE NAMES IS EMPTY.
Check the file indicated via the :ISOCS__NAME keyword in SPACE.INI file.
The list of the template names is stored in the file that location is indicated via the :ISOCS_TMPL_NAME keyword of 'space.ini' file. The error message means that the indicated file was blank. Restore the template names to the file,, then try again.

#334 EMPTY TEMPLATE NAME FOUND.
Check the file indicated via the :ISOCS__NAME keyword in SPACE. file.
The list of the template names is stored in the file that location is indicated via the :ISOCS_TMPL_NAME keyword of 'space.ini' file. The error message means that one of the names was found blank. Replace the blank name with a valid template name, then try again.

#335 ORDER NUMBER OF THE TEMPLATE NAME IS MISSING.
Check the file indicated via the :ISOCS_TMPL_NAME keyword in SPACE.INI file.
The list of the template names is stored in the file that location is indicated via the :ISOCS_TMPL_NAME keyword of ‘space.ini’ file. Each template name of the list goes with the order number that is intended for further use in ISOCS software. The error message means that one of the names was found without the order number. Insert the lost order number in a proper way, then try again.

#336 CAN’T OPEN ECC_DATA FILE TO RETRIEVE THE TEMPLATE PARAMETERS FROM DISK.
ISOCS uses the auxiliary ‘ECC_DATA’ file to store the template parameters in the internal representation. The error message means that the ‘ECC_DATA’ file can not be open due to some system error. The ISOCS can not be continued.

#337 ECC_DATA FILE CONTAINS AN INVALID TEMPLATE NAME.
ISOCS uses the auxiliary ECC_DATA’ file to store the template parameters in the internal representation. The error message means that the ‘ECC_DATA’ file contains an unexpected template name. Make sure that the file assigned via the :ISOCS_TMPL_NAME keyword contains the proper list of the template names. Then try again.

#338 THE NUMBER OF ITERATIONS FOR ECC INTEGRATION MUST BE GREATER THAN OR EQUAL TO 3.
The Efficiency Calibration Computation [ECC] process uses an iterative Monte-Carlo numeric integration method that doubles the number of random points at the end of every iteration. The ECC requires at least 3 iterations to estimate the convergence of the efficiency integral. Also, the maximum number of random points [N] that ISOCS can generate is 2^{20}. Thus, if random points for the first iteration [n1] is set to a value greater than 2^{18}, then for the third iteration the number of random points would exceed 2^{20}, and the above error message would appear. Change the n1 value so that the product 8*n1 product does not exceed 2^{20}.

#339 CAN’T WRITE BACK FILE FOR THE RUN+ADD MODE OF .
This error message can appear when ISOCS is applied for a multi-detector measurement system. This is the system error that could most probably indicate insufficient space on hard disk to write the file back. Program cannot be continued.

#340 CAN’T CREATE FILE TO WRITE THE ECC RESULTS.
This is the system error that could most probably indicate insufficient space on hard disk to write the ECC results. Program cannot be continued.

#341 SOME DIMENSION OF SAMPLE IS TOO SMALL. ECC CAN'T BE DONE.
Some dimension of sample is too small making the sample volume 1e-15 mm^3. To avoid the math run-time errors due to rounding while computation, the 1e-15 mm^3 has been set in ISOCS as the limit for sample volume. Change the sample dimensions, then try again.

#342 DLL FOR THE TEMPLATE INDICATED IN THE GEOMETRY DESCRIPTION FILE IS NOT FOUND.
DLL loading failed while trying to find it in the directory assigned via :PROGRAM keyword in SPACE.INI file.
Each geometry template is supported by the corresponding *n*.DLL that should be located in the directory assigned via the :PROGRAM keyword. Where *n*=1, 2, … is the order number of the geometry template. To determine the *n* value, see the list of the template names in the file assigned via the :ISOCS_TMPL_NAME keyword in 'space.ini' file. Then make sure that the DLL with that *n* exists in the directory assigned via the :PROGRAM keyword. Then try again. If the required *n*.DLL is absent, the program cannot be continued.

#343 THE CURRENT TEMPLATE DLL FAILED.
This is a system error. The program cannot be continued.

#344 THE ISOCS_PBAR.DLL IS MISSING.
DLL loading failed while trying to find it in the directory assigned via :PROGRAM keyword in SPACE.INI file.
The ISOCS_PBAR.DLL is intended to support displaying both the geometry template main parameters and the ECC progress. Make sure that the ISOCS_PBAR.DLL exists in the directory assigned via the :PROGRAM keyword. Then try again.

#345 THE :PROGRAM KEYWORD IS MISSING IN 'SPACE.INI' FILE.
The :PROGRAM keyword determines the folder that is used to store the executable programs for ISOCS. Include both the :PROGRAM keyword and its definition in the 'space.ini' file, then try again.

#346 THE :C_COLLIMATOR KEYWORD IS MISSING IN 'SPACE.INI' FILE.
The :C_COLLIMATOR keyword determines the file that is used to store the descriptions of the available cylindrical collimators. Include both the :C_COLLIMATOR keyword and its definition in the 'space. file, then try again.

#347 THE :R_COLLIMATOR KEYWORD IS MISSING IN 'SPACE.INI' FILE.
The :R_COLLIMATOR keyword determines the file that is used to store the descriptions of the available rectangular collimators. Include both the :R_COLLIMATOR keyword and its definition in the 'space. file, then try again.

#348 THE :UW_HOUSING KEYWORD IS MISSING IN ‘SPACE.INI’ FILE.
The :UW_HOUSING keyword determines the file that is used to store the descriptions of the available underwater housings. Include both the :UW_HOUSING keyword and its definition in the ‘space.ini’ file, then try again.

#349 ECC WAS INTERRUPTED DUE TO PROGRESS BAR ERROR: Can’t find ISOCS_CreateProgressBar function.
This is a system error. Program can not be continued.

#350 ECC WAS INTERRUPTED DUE TO PROGRESS BAR ERROR: Can’t find ISOCS_RefreshProgressBar function.
This is a system error. Program cannot be continued.

#351 ECC WAS INTERRUPTED DUE TO PROGRESS BAR ERROR: Can’t find ISOCS_DestroyProgressBar function.
This is a system error. Program cannot be continued.

#352 ECC WAS INTERRUPTED DUE TO PROGRESS BAR ERROR: Can’t destroy Progress Bar.
This is a system error. Program cannot be continued.

#353 ECC WAS INTERRUPTED DUE TO PROGRESS BAR ERROR: Can’t Create Progress Bar.
This is a system error. Program cannot be continued.

#354 ECC WAS INTERRUPTED DUE TO PROGRESS BAR ERROR: Can’t Refresh Progress Bar.
This is a system error. Program cannot be continued.

#355 ECC INTERRUPTED BY USER.
During the execution of the Efficiency Calibration Computation [ECC], the user has pushed the STOP button to interrupt the ECC.

#356 SPACE AVAILABLE ON DISK IS NOT ENOUGH TO WRITE COINCIDENCE CALCULATION DATA.
This error message can appear when ISOCS was run in ‘coincidence’ mode to store on hard disk the information supporting the further computation on coincidence. But, it was found during computation that the hard disk doesn’t have sufficient space for the program to continue.

#357 THE :DETECTOR_PAR KEYWORD IS MISSING IN ‘SPACE.INI’ FILE.
The :DETECTOR_PAR keyword determines the file that is used to store the descriptions of the available detectors. Include both the :DETECTOR_PAR keyword and its definition in the ‘space.ini’ file, then try again.

#358 THE :ISOCS__NAME KEYWORD IS MISSING IN ‘SPACE.INI’ FILE.
The :ISOCS_TMPL_NAME keyword determines the file that is used to store the list of the available template names. Include both the :ISOCS_TMPL_NAME keyword and its definition in the ‘space.ini’ file, then try again.

#359 ORDER NUMBER OF THE TEMPLATE NAME IS TOO BIG.
Check the file indicated via the :ISOCS_TMPL_NAME keyword in SPACE.INI file.
The list of the template names is stored in the file that location is indicated via the :ISOCS_TMPL_NAME keyword of ‘space.ini’ file. Each template name of the list goes with the order number that is intended for the further use in ISOCS software. The error message means that the order number exceeds the allowed maximum of 40. Change the invalid order number, then try again.

#360 DECLARED CYLINDRICAL COLLIMATOR NAME IS NOT FOUND.
Check the file indicated via the :C_COLLIMATOR keyword in SPACE.INI file.
The :C_COLLIMATOR keyword determines the file that is used to store the descriptions of the available cylindrical collimators. Each collimator description includes a collimator name that is used as reference to identify the required collimator in the geometry template description. The above error message means that the cylindrical collimator name indicated in the geometry template description was not found in the file containing cylindrical collimator descriptions. Make sure that the required collimator name is included in the file with the cylindrical collimator descriptions. Then try again.

#361 DECLARED RECTANGULAR COLLIMATOR NAME IS NOT FOUND.
Check the file indicated via the :R_COLLIMATOR keyword in SPACE.INI file.
The :R_COLLIMATOR keyword determines the file that is used to store the descriptions of the available rectangular collimators. Each collimator description includes a collimator name that is used as reference to identify the required collimator in the geometry template description. The above error message means that the rectangular collimator name indicated in the geometry template description was not found in the file containing rectangular collimator descriptions. Make sure that the required collimator name is included in the file with the rectangular collimator descriptions. Then try again.

#362 DECLARED HOUSING NAME IS NOT FOUND.
Check the file indicated via the :UW_HOUSING keyword in SPACE.INI file.
The :UW_HOUSING keyword determines the file that is used to store the descriptions of the available underwater housings. Each housing description includes a housing name that is used as reference to identify the required housing in the geometry template description. The above error message means that the housing name indicated in the geometry template description was not found in the file containing housing descriptions. Make sure that the required housing name is included in the file with the housing descriptions. Then try again.

#363 DECLARED DETECTOR NAME IS NOT FOUND.
Check the file indicated via the :DETECTOR_PAR keyword in SPACE.INI file.
The :DETECTOR keyword determines the file that is used to store the descriptions of the available detectors. Each detector description includes a detector name that is used as reference to identify the required detector in the geometry template description. The above error message means that the detector name indicated in the geometry template description was not found in the file with detector descriptions. Make sure that the required detector name is included in the file with detector descriptions. Then try again.

#364 THE :PREDEFINED_ELIST KEYWORD IS MISSING IN 'SPACE.INI' FILE.
The :PREDEFINED_ELIST keyword determines the file that is used to store the list of the energies that can be used as default in the ECC process. Include both the :PREDEFINED_ELIST keyword and its definition in the 'space.ini' file, then try again.

#365 TEMPLATE NAME USED IN THE GEOMETRY DESCRIPTION FILE IS TOO LONG.
Among the other parameters, the geometry template description always contains the geometry template name. The above error message means that the length of the name exceeds 255 characters. Change the name, then try again.

#366 THE NAME OF THE BEAKER DESCRIPTION FILE USED IN THE GEOMETRY FILE IS TOO LONG.
In case of the pre-defined container shape, the geometry template description may refer to the name of a file that contains the definition of the beaker contour. The above error message means that the length of the name exceeds 255 characters. Change the name, then try again.

#367 HOUSING NAME IS TOO LONG.
The geometry template description may refer to the name to identify the description of the underwater housing parameters. The above error message means that the length of the name exceeds 255 characters. Change the name, then try again.

#368 CYLINDRICAL COLLIMATOR NAME IS TOO LONG.
The geometry template description may refer to the name to identify the description of the cylindrical collimator parameters. The above error message means that the length of the name exceeds 255 characters. Change the name, then try again.

#369 RECTANGULAR COLLIMATOR NAME IS TOO LONG.
The geometry template description may refer to the name to identify the description of the rectangular collimator parameters. The above error message means that the length of the name exceeds 255 characters. Change the name, then try again.

#370 DETECTOR NAME IS TOO LONG.
The geometry template description always refers to the name to identify the description of the detector parameters. The above error message means that the length of the name exceeds 255 characters. Change the name, then try again.

#371 SYNTAX ERROR. THE NAME OF FILE WITH PREDEFINED ENERGIES IS EXPECTED AS A QUOTED STRING.
The geometry template description may refer to the name to identify the file containing the list of the predefined energies. The used filename should be quoted [the double quote symbols are required]. The above error message means the invalid syntax for the used filename. Correct the filename syntax, then try again.

#372 NAME OF FILE WITH THE PREDEFINED ENERGIES IS TOO LONG.
The geometry template description may refer to the name to identify the file containing the list of the predefined energies. The above error message means that the length of the filename exceeds 255 characters. Change the filename, then try again.

#373 INVALID LENGTH UNIT.
The geometry template description may indicate the length in any of the following units:
MM means millimeter;
CM means centimeter;
M means meter;
IN means inch;
FT means foot.
If the length unit is not indicated, the MM is used as default.
The above error means that an invalid syntax was detected for the length unit. Change the length unit definition, then try again.

#374 INVALID DENSITY UNIT.
The geometry template description may indicate the density in any of the following units:
G/CU.C means the gram per cubic centimeter;
KG/CU.M means the kilogram per cubic meter;
LB/CU.FT means the pound per cubic foot;
If the density unit is not indicated, the G/CU.C is used as default.
The above error means that an invalid syntax was detected for the density unit. Change the density unit definition, then try again.

#375 INVALID PRESSURE UNIT.
The geometry template description may indicate the air pressure in any of the following units:
MM.HG means the millimeters of the mercury column;
BAR means the 1 technical atmosphere;
IN.HG means the inches of the mercury column;
KPA means the kilopascal;
If the air pressure unit is not indicated, the MM.HG is used as default.
The above error means an invalid syntax was detected for the air pressure unit. Change the air pressure unit definition, then try again.

#376 INVALID TEMPERATURE UNIT.
The geometry template description may indicate the air temperature in units of either F [Fahrenheit degrees] or C [Celsius degrees]. If the air temperature unit is not indicated, the unit C is used as default. The above error means that an invalid syntax was detected for the air temperature unit. Change the air temperature unit definition, then try again.

#377 FILE INTENDED TO STORE THE RESULTS HAS A LONG NAME.
The geometry template description may refer to the name to identify the file that is intended to store the ECC results. The above error message means that the length of the filename exceeds 255 characters. Change the filename, then try again.

#378 FULL FILE NAME PATH IS TOO LONG.
A fully qualified file name cannot exceed 260 characters.

#601 SAMPLE IS OUT OF THE COMPLEX BOX CONTAINER. SEE THE SOURCE TABLE.
The sum of the height of the source layers is greater than the container inside height. Change the sample height or/and the inside container height, then try again.

#602 AN INVALID DIMENSION IN THE RECTANGULAR HOT SPOT. CHECK THE HOT SPOT DIMENSIONS IN SOURCE TABLE.
Upon checking the ‘complex box’ template dimensions, it was found that some dimension defining the source concentration is negative. Make sure that all parameters defining the source concentration are positive, then try again.

#603 RECTANGULAR HOT SPOT IS OUT OF CONTAINER.
Upon checking the ‘complex box’ template definition, it is found that some of the parameters that define the hot spot location make the concentrated source to be out of container. Change the concentrated source location to place it inside the container. Then try again.

#651 SAMPLE IS OUT OF THE SIMPLE BOX CONTAINER. CHECK THE SOURCE TABLE.
The sum of the height of the source layers is greater than the container inside height. Change the sample height or/and the inside container height, then try again.

#751 SAMPLE IS OUT OF THE COMPLEX CYLINDER CONTAINER. CHECK THE SOURCE TABLE.
The sum of the height of the source layers is greater than the container inside height. Change the sample height or/and the inside container height, then try again.

#752 AN INVALID DIMENSION FOR SPHERICAL HOT SPOT. CHECK THE HOT SPOT DIMENSIONS IN SOURCE TABLE.
Upon checking the ‘complex cylinder’ template dimensions, it was found that some parameter(s) defining the spherical hot spot is negative. Make sure that all parameters defining the concentrated source are positive, then try again.

#753 SPHERICAL HOT SPOT IS OUT OF CONTAINER.
Upon checking the ‘complex cylinder’ template definition, it was found that some of the parameters defining the hot spot location make the concentrated source to be out of container. Change the concentrated source location to place it inside the container. Then try again.

#801 SAMPLE IS OUT OF THE SIMPLE CYLINDER CONTAINER. CHECK THE SOURCE TABLE.
The sum of the height of the source layers is greater than the container inside height. Change the sample height or/and the inside container height, then try again.

#851 NOT ENOUGH ROOM FOR THE SPHERE TEMPLATE SOURCES.
Upon checking the ‘sphere’ template definition, it is found that the inside diameter of the shell is too small to accommodate the sources. Change the shell inside diameter and/or the shell thickness, then try again.

#901 WELL DIAMETER TOO SMALL TO FIT THE DETECTOR.
The ‘well or Marinelli beaker’ template dimensions are defined such that the detector cannot be located inside the well. Check the well diameter, the container thickness, and the horizontal detector location to fix the error. Then try again.

#902 UNDERWATER HOUSING OR COLLIMATOR IS IN CONFLICT WITH MARINELLI REFERENCE PLANE.
This error message appears if the source-detector location in the ‘well or Marinelli beaker’ template is defined such that the collimator and/or the underwater housing assembly is in conflict with the Marinelli reference plane. In ISOCS, the Marinelli reference plane is located at the bottom of the well. Check the collimator, underwater housing, and source-detector parameters to fix the error.

#951 A NEGATIVE DIMENSION VALUE IS INDICATED IN THE PIPE TEMPLATE. CHECK TABLE OF SAMPLE PARAMETERS.
Some of dimensions in the ‘pipe’ template were found to be negative. Make sure that all dimensions of the sample are positive, then try again.

#952 PIPE DIAMETER IS TOO SMALL. NOT ENOUGH ROOM FOR SOURCE No.2.
Upon checking the ‘pipe’ template dimensions it is found that the pipe inside diameter is not enough to locate source No.2. Make sure that source No.2 can be located inside the pipe, then try again.

#1001 SPHERICAL SOURCE IS OUT OF DRUM.
Upon checking the ‘special sphere’ template dimensions it was found that the drum doesn’t have enough room to include the spherical source. Change the drum inside dimensions or/and the sphere total diameter to fix the error. Then try again.

#1051 AO VALUE IS OUT OF THE [0,1] LIMIT. REENTER AO..
The message can appear if the ‘Exponential Circular Plane’ template is used. Ao is one of the parameters that define the functional form of the radioactivity distribution inside the source layer. For more details see description of the ‘Exponential Circular Plane’ template. Make sure that $Ao \leq 1$.

#1052 DMAX IS GREATER THAN SOURCE THICKNESS. REENTER DMAX.
The message can appear if the ‘Exponential Circular Plane’ template is used. Dmax is one of the parameters that defines the functional form of the radioactivity distribution inside the source layer. For more details see description of the ‘Exponential Circular Plane’ template. Make sure that the value of Dmax is less than the source thickness.

#1053 DRL VALUE MUST BE POSITIVE. REENTER DRL.
The message can appear if the ‘Exponential Circular Plane’ template is used. Dmax is one of the parameters that defines the functional form of the radioactivity distribution inside the source layer. For more details see description of the ‘Exponential Circular Plane’ template. Make sure that DRL is positive, then try again.

#1101 THE BEAKER DESCRIPTION FILE IS EMPTY.
The ‘beaker’ template may refer to a file that is intended to store the definition of a pre-defined container shape. That file was found to be blank. Make sure you use the proper file, then try again.

#1102 CAN’T OPEN THE BEAKER DESCRIPTION FILE.
The ‘beaker’ template may refer to a file that is intended to store the definition of a pre-defined container shape. The error message means that the filename cannot be found in the folder assigned via the :SOURCE_PARAMETERS keyword in the SPACE. file. Ensure that the file really exists, then try again.

#1103 TOO MANY MATERIAL NAMES ARE USED IN THE BEAKER DESCRIPTION FILE.
The ‘beaker’ template may refer to a file that is intended to store the description of a pre-defined container shape. The error message means that the beaker description uses too many material names [maximum limit is 8 different material names]. Change the beaker description taking into account this limitation, then try again.

#1104 ZERO OR NEGATIVE VALUE OF A MATERIAL DENSITY IS USED IN THE BEAKER DESCRIPTION FILE.
The ‘beaker’ template may refer to a file that is intended to store the description of a pre-defined container shape. The error message means that the beaker description contains a non-positive value to indicate a material density. Make sure that all the density values are positive, then try again.

#1105 AN INVALID ID-NAME OF FRAGMENT IS USED IN THE BEAKER DESCRIPTION FILE.
The letters O | I | B are allowed to identify the type [ID-name] of a fragment belonging to the inner | outer | boundary contour, respectively. Make sure you use proper ID-names in the beaker description. Then try again.

#1106 DEFAULT MATERIAL NAME MAY NOT BE USED IN THE 1st ROW OF THE BEAKER DESCRIPTION FILE.
The beaker description may use the default material name in any row of description except the 1st row. Define the material in the 1st row of description, then try again.

#1107 AN UNDEFINED MATERIAL NAME IS FOUND IN THE BEAKER DESCRIPTION FILE.
The beaker description may use the default material name in any row of description except the 1st row. The description syntax requires the comma symbol separating the material name even if it is defaulted. If a comma delimiter is absent, the material name is assumed to be improperly defined, causing the above error message. Make sure you use comma where the default name is desired. Then try again.

#1108 A NEGATIVE DIAMETER VALUE IS FOUND IN THE BEAKER DESCRIPTION FILE.
Among other parameters the beaker description contains the diameter values to define the fragments of the beaker contours. The error message means that the description includes a negative diameter value. Make sure you use only non-negative diameter values in the beaker description. Then try again.

#1109 DENSITY VALUE IS NOT ALLOWED IF DEFAULT MATERIAL NAME IS USED IN THE BEAKER DESCRIPTION FILE.
The beaker description may use the default material name in any row of description except the 1st row. However, a density value should not be entered if the material name in a row is indicated as default. Remove the density value for the defaulted material name. Then try again.

#1110 NEITHER A MATERIAL NAME NOR A DENSITY IS ALLOWED FOR A BOUNDARY FRAGMENT IN THE BEAKER DESCRIPTION FILE.
The beaker description may contain fragments defining inner, outer, and boundary contours. Boundary fragments may be defined only at a contour node where fragments with two different materials join. Therefore, neither a material name nor a density value is allowed in the definition of a boundary fragment. Remove the material name and/or the density value from the boundary fragment contour definition.

#1111 NUMBER OF FRAGMENTS USED IN THE BEAKER DESCRIPTION FILE EXCEEDS 200.
The ‘beaker’ template may refer to a file that is intended to store the description of a pre-defined container. The description may contain fragments defining the inner, outer, and boundary contours. The maximum number of fragments that can be used in the description is 200. Modify the description so that the number of fragments used is less than 200. Then try again.

#1116 INNER CONTOUR IS MISSING IN THE BEAKER DESCRIPTION FILE.
The beaker description may include the inner, outer, and boundary contours. While the outer contour and the boundary contour are not required to be present, it is mandatory that the inner contour be present in the description. The above error message means that no fragments belonging to the inner contour were found in the beaker description.

#1117 TOO FEW INNER CONTOUR FRAGMENTS IN THE BEAKER DESCRIPTION FILE.
The above error message means that, upon checking the beaker description, it was found that the inner contour consists of only a single fragment. At least two inner contour fragments are required to be present [the simplest conical beaker]. Change the description to fix the error, then try again.

#1118 TOO FEW OUTER FRAGMENTS IN THE BEAKER DESCRIPTION FILE.
It is possible to define a beaker with a zero wall-thickness, (.e) without an outer contour. But if the outer contour is indeed defined, then it should consist of at least 2 fragments [the simplest conical beaker]. The above error message indicates that the outer contour consists of only a single fragment.

#1119 BOUNDARY FRAGMENTS ARE NOT ALLOWED IN THE BEAKER DESCRIPTION FILE IF OUTER CONTOUR IS MISSING.
It is possible to define a beaker with a zero wall-thickness, (i.e) without an outer contour. But when the outer contour is not defined, it is not valid to define a boundary fragment, since the length of the boundary fragment would become zero. Remove the boundary fragment(s) to fix the error. Then try again.

#1120 A BOUNDARY NODE ISN'T JOINED TO ANY FRAGMENT IN THE BEAKER DESCRIPTION FILE.
The 'beaker' template may refer to file that contains the description of a pre-defined container. The description may contain definitions of inner, outer, and boundary contours. The inner, outer, and boundary contour definitions consist of fragments. A fragment is a line segment connecting two nodal points defined in the Cartesian coordinate system. The beaker description requires that each boundary fragment be joined with another [or inner, or outer, or boundary] fragment end. Change the erroneous node coordinates to fix the error. Then try again.

#1121 THE BEAKER DESCRIPTION FILE CONTAINS A BOUNDARY NODE LOCATED ON THE BEAKER SYMMETRY AXIS.
Since a boundary fragment is assumed to separate two different materials, the boundary end may not be located on the beaker rotation axis. Otherwise, the symmetrical fragments would consist of the different materials. Change the erroneous node coordinates to fix the error. Then try again.

#1122 THE BEAKER DESCRIPTION FILE CONTAINS TWO COINCIDING FRAGMENTS.
A VERTICAL BOUNDARY FRAGMENT IS ONE OF THEM.
Neither an inner nor an outer fragment is allowed to fully coincide with a boundary fragment. Note that the above error message contains a more precise definition identifying the erroneous boundary fragment as a vertical fragment. Change the erroneous fragment coordinates to fix the error. Then try again.

#1123 THE BEAKER DESCRIPTION FILE CONTAINS TWO FRAGMENTS INTERSECTING AT A NON-NODAL POINT.
It is required that none of the defined fragments intersect any other fragment at a point other than the nodal points. Change the erroneous fragment coordinates to fix the error. Then try again.

#1124 THE BEAKER DESCRIPTION FILE CONTAINS TWO COINCIDING FRAGMENTS. A BOUNDARY FRAGMENT IS ONE OF THEM.
Neither an inner nor an outer fragment is allowed to fully coincide with a boundary fragment. Change the erroneous fragment coordinates to fix the error. Then try again.

#1125 A DISCONTINUITY OF THE INNER CONTOUR IS FOUND IN THE BEAKER DESCRIPTION FILE.
It is required that all fragments of the inner contour must be joined end to end making up a continuous polygonal line that starts and ends on the beaker symmetry axis. If it is not the case, the above error message appears. Change the erroneous fragment coordinates to fix the error. Then try again.

#1126 A DISCONTINUITY OF THE OUTER CONTOUR IS FOUND IN THE BEAKER DESCRIPTION FILE.
It is required that all fragments of the outer contour must be joined end to end making up a continuous polygonal line that starts and ends on the beaker symmetry axis. If it is not the case, the above error message appears. Change the erroneous fragment coordinates to fix the error. Then try again.

#1127 THE BEAKER DESCRIPTION FILE CONTAINS INVALID DEFINITION OF MATERIALS AT A BOUNDARY FRAGMENT.
Each boundary fragment is expected to separate two different materials in the container wall. While checking the beaker description, these two materials identification is made in two different ways, namely, through the left and right end of a boundary fragment. If the identified materials at the left end don't correspond to ones identified at the right end, then the above message is generated. Make sure you identify properly the materials for both the inner and outer contour. Then try again.

#1128 A BOUNDARY NODE IS EXPECTED BETWEEN TWO INNER CONTOUR FRAGMENTS WITH DIFFERENT MATERIAL DEFINITIONS.
Two inner contour fragments are joined at a node of the inner contour. The above error message is generated if a boundary fragment is not joined at the node where two inner contour fragments with different materials are joined. Make sure you identify properly the coordinates for all the boundary fragments. Then try again.

#1129 A BOUNDARY NODE IS EXPECTED BETWEEN TWO OUTER FRAGMENTS OF THE BEAKER DESCRIPTION FILE.
Two outer contour fragments are joined at a node of the outer contour. The above error message is generated if a boundary fragment is not joined at the node where two outer contour fragments with different materials are joined. Make sure you identify properly the coordinates for all the boundary fragments. Then try again.

#1130 THE BEAKER DESCRIPTION FILE CONTAINS UNCHAINED FRAGMENT[S] IN THE INNER CONTOUR.
It is required that all fragments of the inner contour be joined end to end making up a continuous polygonal chain that starts and ends on the beaker symmetry axis. The above error message is generated if a discontinuity is detected in the chain of fragments defining the inner contour.

#1131 THE BEAKER DESCRIPTION FILE CONTAINS UNCHAINED FRAGMENT[S] IN THE OUTER CONTOUR.
It is required that all fragments of the outer contour be joined end to end making up a continuous polygonal chain that starts and ends on the beaker symmetry axis. The above error message is generated if a discontinuity is detected in the chain of fragments defining the outer contour.

#1132 THERE IS NO INNER FRAGMENT STARTING ON THE SYMMETRY AXIS.
It is required that all fragments of the inner contour be joined end to end making up a continuous polygonal chain that starts and ends on the beaker symmetry axis. When that continuous polygonal chain does not start/stop on the beaker symmetry axis, the above error message is generated. Make sure that the inner contour starts and stops on the beaker symmetry axis. Then try again.

#1133 THERE IS NO OUTER FRAGMENT STARTING ON THE SYMMETRY AXIS.
It is required that all fragments of the outer contour be joined end to end making up a continuous polygonal chain that starts and stops on the beaker symmetry axis. When that continuous polygonal chain does not start/stop on the beaker symmetry axis, the above error message is generated. Make sure that the outer contour starts and stops on the beaker symmetry axis. Then try again.

#1142 SAMPLE IS LOCATED SO THAT IT INTERSECTS DETECTOR.
The above error message is generated if a conflict is detected in the definition of the source/detector location in the ‘beaker’ template. Review the beaker description file to make sure that the inner and the outer contours are properly defined so that there is enough room for locating the detector. Or change the source/detector location parameters. Then try again.

#1143 SOURCE IS OUT OF BEAKER.
The above error message is generated if the inside height of the beaker is less than the sum of the heights of the source layers that are defined in the ‘beaker’ template. Review the beaker description file to make sure that both the inner and the outer contours are properly defined so that there is to enough room to accommodate the source layers. Or change the source height parameter, then try again.

#1144 DETECTOR IS BEHIND THE ABSORBER.
A conflict was detected between the detector location defined in the 'beaker' template and the generic absorber thickness. Change the parameters of the source/detector location or/and the total thickness of the used generic absorbers.

#1151 INVALID START-STOP ANGLES FOR THE INSIDE SOURCE. USE COUNTERCLOCKWISE DIRECTION AS POSITIVE TO INDICATE BOTH THE START AND STOP ANGLES.
The 'round tube' template description uses 'start' and 'stop' angles (in degrees)to define the limits of the inside source. Both negative and positive angle values are allowed. Positive angles are measured in the counterclockwise direction. The start angle should not be greater than the stop angle. The above error message means that in the inside source definition, the start angle is greater than the stop angle. Change the start or stop angle for the inside source definition then try again.

#1152 INVALID START-STOP ANGLES FOR THE OUTSIDE SOURCE. USE COUNTERCLOCKWISE DIRECTION TO INDICATE BOTH THE START AND STOP ANGLES.
The 'round tube' template description uses 'start' and 'stop' angles (in degrees)to define the limits of the outside source. Both negative and positive angle values are allowed. Positive angles are measured in the counterclockwise direction. The start angle should not be greater than the stop angle. The above error message means that in the outside source definition, the start angle is greater than the stop angle. Change the start or stop angle for the outside source definition then try again.

#1153 INVALID LENGTH OF THE INSIDE SOURCE.
The 'round tube' template description defines the inside source length using the distance of the right and left ends of the source relative to the right end of the tube. The above error message means that the inside source right end is farther way from the right end of the tube than the inside source left end. Fix the error, then try again.

#1154 INVALID LENGTH OF THE OUTSIDE SOURCE.
The 'round tube' template description defines the outside source length using the distance of the right and left ends of the source relative to the right end of the tube. The above error message means that the outside source right end is farther way from the right end of the tube than the outside source left end. Fix the error, then try again.

#1155 INSIDE SOURCE IS OUT OF TUBE.
The 'round tube' template description defines both the left and right ends of the inside source relative to the right end of the tube. The above error message means that the right and/or left end of the inside source exceeds the length of the tube. Fix the error, then try again.

#1156 OUTSIDE SOURCE IS OUT OF TUBE.
The ‘round tube’ template description defines both the left and right ends of the outside source relative to the right end of the tube. The above error message means that the right and/or left end of the outside source exceeds the length of the tube. Fix the error, then try again.

#1157 INVALID TUBE DIMENSION.
The ‘round tube’ template description should contain definitions of the tube wall thickness, inside diameter, and the length. Both the wall thickness and the inside diameter may not be less than zero. The tube length is required to be greater than zero. The above error message means that one or more of the above tube parameters are invalid. Fix the error, then try again.

#1158 ANGLE ABSOLUTE VALUE 360 DEGREES IS NOT ALLOWED.
The ‘round tube’ template description uses angles (in degrees) to define the limits of both inside and outside sources. Both negative and the positive angle values are allowed. Positive angles are measured in the counterclockwise direction. The absolute value of an angle must not exceed 360 degrees. Fix the error, then try again.

#1159 INVALID DIAMETER OF THE INSIDE SOURCE.
Upon checking the ‘round tube’ template description it is found that the inside source diameter is too small or has a negative value. Change the tube wall thickness and/or the tube inside diameter to fix the error. Then try again.

#1160 INVALID DIAMETER OF THE OUTSIDE SOURCE.
Upon checking the ‘round tube’ template description it is found that the outside source diameter is too small or the zero value. Change the inside diameter of the tube to fix the error. Then try again.

#1201 TEMPLATE ORIENTATION PARAMETER FOR U-CHANNEL IS MISSING.
The ‘U-channel’ can be defined in any one of four different orientations, depending on sample geometry. The error message means that the orientation parameter value is not found in the description. Insert the orientation parameter in the ‘U-channel’ template description to fix the error, then try again.

#1202 INVALID PARAMETER VALUE FOR THE U-CHANNEL TEMPLATE ORIENTATION.
THE 1,2,3, or 4 ARE ALLOWED FOR THE PARAMETER VALUE.
The ‘U-channel’template can be defined in any one of four different orientations, depending on sample geometry. The error message means that the orientation parameter value is invalid. Make sure that the proper value is used to define the orientation parameter, then try again.

#1203 SOURCE IS OUT OF U-CHANNEL.
The ‘U-channel’ template description defines both the left and right ends of any source relative to the channel right end. The above error message means that the right and/or left end of the source exceeds the length of the channel. Fix the error, then try again.

#1204 INVALID LENGTH OF SOURCE IN THE U-CHANNEL TEMPLATE.
The ‘U-channel’ template description defines both the left and right ends of any source relative to the channel right end. The above error message means that the source right end is farther away from the right end of the channel than the source left end. Fix the error, then try again.

#1205 U-CHANNEL TOP WALL IS TOO THICK.
The top wall thickness of the U-channel has been defined such that if the thickness is doubled, it is greater than the outside height of the channel. Change the top wall thickness to fix the error. Then try again.

#1206 U-CHANNEL SIDE WALL IS TOO THICK.
The side wall thickness of the U-channel has been defined such that side the thickness is greater than the channel outside width. Change the side wall thickness to fix the error, then try again.

#1207 ONE OR MORE OF THE U-CHANNEL OUTSIDE DIMENSIONS IS TOO SMALL.
One of the U-channel parameters, namely, the U-channel width, the height, or the length is either too small or has a negative value. Fix the error, then try again.

#1251 TEMPLATE ORIENTATION PARAMETER FOR L-BEAM IS MISSING.
The ‘L-beam’ template can be defined using any one of four different orientations, depending on the sample geometry. The error message means that the orientation parameter value is not found in the description. Insert the orientation parameter in the ‘L-beam’ template description to fix the error., then try again.

#1252 INVALID PARAMETER VALUE FOR L-BEAM TEMPLATE ORIENTATION.
THE 1,2,3, or 4 ARE ALLOWED FOR THE PARAMETER VALUE.
The ‘L-beam’ template can be defined using any one of four different orientations, depending on the sample geometry. The error message means that the orientation parameter value is invalid. Make sure that the proper value is used to define the orientation parameter, then try again.

#1253 SOURCE IS OUT OF L-BEAM.
The ‘L-beam’ template description defines both the left and right ends of any source relative to the right end of the beam. The above error message means that the right and/or left end of the source exceeds the length of the beam. Fix the error, then try again.

#1254 INVALID LENGTH OF SOURCE IN THE L-BEAM TEMPLATE.
The ‘L-beam’ template description defines both the left and right ends of any source relative to the right end of the beam. The above error message means that the source right end is farther away from the right end of the beam than the source left end. Fix the error, then try again.

#1255 L-BEAM BOTTOM WALL IS TOO THICK.
The thickness of the bottom wall of the L-beam bottom wall is greater than the outside height of the beam. Change the bottom wall thickness to fix the error. Then try again.

#1256 L-BEAM SIDE WALL IS TOO THICK.
The thickness of the L-beam side wall is greater than the outside width of the beam. Change the side wall thickness to fix the error. Then try again.

#1257 ONE OR MORE OF THE L-BEAM DIMENSIONS IS TOO SMALL.
One or more of the L-beam dimensions, namely, the beam width, the height, or the length is either too small or has a negative value. Fix the error then try again.

#1301 TEMPLATE ORIENTATION PARAMETER FOR H-BEAM TEMPLATE IS MISSING.
The ‘H-beam’ template can be defined in one of two different orientations, depending on the sample geometry. The error message means that the orientation parameter value is not found in description. Insert the orientation parameter in the ‘H-beam’ template description to fix the error. Then try again.

#1302 INVALID PARAMETER VALUE FOR H-BEAM TEMPLATE ORIENTATION. EITHER 1 OR 2 IS ALLOWED FOR THE PARAMETER VALUE.
The ‘H-beam’ template can be defined in one of two different orientations, depending on the sample geometry. The error message means that the orientation parameter value is invalid. Make sure that the proper value is used to define the orientation parameter. Then try again.

#1303 SOURCE IS OUT OF H-BEAM.
The ‘H-beam’ template description defines both the left and right ends of any source relative to the beam right end. The above error message means that the right and/or the left end of the source exceeds the length of the beam. Fix the error, then try again.

#1304 INVALID LENGTH OF SOURCE IN H-BEAM TEMPLATE.
The ‘H-beam’ template description defines both the left and right ends of any source relative to the beam right end. The above error message means that the source right end is farther away from the right end of the beam than the source left end. Fix the error, then try again.

#1305 H-BEAM CROSS-BAR IS TOO THICK.
The thickness of the H-beam cross-bar thickness is greater than the outside height of the beam. Change the cross-bar thickness to fix the error. Then try again.

#1306 H-BEAM SIDE WALL IS TOO THICK.
The thickness of the H-beam side wall is greater than the outside width of the beam. Change the side wall thickness to fix the error. Then try again.

#1307 ONE OR MORE OF THE H-BEAM DIMENSIONS IS TOO SMALL.
One of the H-beam parameters, namely, the width, height, or the length is either too small or has a negative value. Fix the error then try again.

#1351 SOURCE IS OUT OF RECTANGULAR TUBE.
The ‘rectangular tube’ template description defines both the left and right ends of the source relative to the right end of the tube. The above error message means that the right and/or left end of the source exceeds out the length of the tube. Fix the error, then try again.

#1352 INVALID LENGTH OF SOURCE IN THE RECTANGULAR TUBE TEMPLATE.
The ‘rectangular tube’ template description defines both the left and right ends of the source relative to the right end of the tube. The above error message means that the source right end is farther away from the right end of the tube than the source left end. Fix the error, then try again.

#1353 THE RECTANGULAR TUBE WALL IS TOO THICK.
The wall thickness of the rectangular tube has defined such that if the thickness is doubled, it is greater than either the outside width or the outside height of the tube. Change the wall thickness to fix the error. Then try again.

#1354 ONE OR MORE OF THE RECTANGULAR TUBE DIMENSIONS IS TOO SMALL.
One of the tube parameters, namely, the tube width, height, or the length is either too small or has a negative value. Fix the error then try again.

#1401 DETECTOR IS OUT OF ROOM THROUGH THE SURFACE.
In the ‘room’ template description, the source/detector location can be defined such that the detector penetrates through a non-radioactive wall of the room. But the detector must not penetrate through a radioactive wall. The above error message means that the detector is found to penetrate through a radioactive wall. Change the source-detector location parameters appropriately to fix this error. Then try again.

#1402 ONE OR MORE OF THE ROOM DIMENSIONS IS TOO SMALL.
One of the room dimensions, namely, the room width, height, or the length is either too small or has a negative value. Fix the error then try again.

#1451 SAMPLE IS OUT OF TANK CONTAINER. CHECK THE SOURCE HEIGHT.
The source height in the tank template description is greater than the inside diameter of the tank. Make sure that the source height doesn't exceed the inside tank diameter. Then try again.

#1452 ONE OR MORE OF THE SOURCE DIMENSIONS IN THE TANK TEMPLATE IS TOO SMALL.
One or more of the tank container dimensions, namely, the height or the length is either too small or has a negative value. Change the tank dimensions appropriately to fix the error then try again.

#1453 ROTATION ANGLE IS OUT OF THE [0,360] DEGREES REGION.
The source inside the tank may be rotated relative to the container location. The angle of rotation must be specified in the counterclockwise direction, and must be in units of degrees. The value of the angle is required to be in the [0, 360] degrees range. The above error message means that an invalid rotation angle value is specified in the 'tank' template description. Make sure that the rotation angle value is within the [0, 360] degrees range. Then try again.

#1454 TANK TEMPLATE ORIENTATION PARAMETER IS MISSING.
The 'tank' template can be defined in one of two different orientations, depending on the sample geometry. The error message means that the orientation parameter value is not found in description. Insert the orientation parameter in the 'tank' template description to fix the error. Then try again.

#1455 INVALID PARAMETER VALUE FOR TANK TEMPLATE ORIENTATION.
USE THE 1 or 2 FOR THE PARAMETER VALUE.
The 'tank' template can be defined in one of two different orientations, depending on the sample geometry. The error message means that the orientation parameter value is invalid. Make sure that the proper value is used to define the orientation parameter. Then try again.

#1501 SOURCE IS OUT OF THE CONE CONTAINER. CHECK THE SOURCE HEIGHT.
The source height defined in the cone template exceeds the inside height of the cone container. Make sure that the source height doesn't exceed the inside height of the cone. Then try again.

#1502 ONE OR MORE OF THE CONICAL SOURCE DIMENSIONS IS TOO SMALL.
One or more of the cone container dimensions, namely, the height or the diameter of is either too small or has a negative value. Change the cone dimensions so that to fix the error then try again.

#1503 CONE DIAMETER NEGATIVE VALUE.
The minimal diameter of the cone is found to be negative. Change the negative value to fix the error. Then try again.

Geometry Composer Errors

LoadMuLibr

100 Can't open file with mu-library. Check the existence of the file pointed to by the :ATTENUATION_LIBRARY statement in file SPACE.

101 Can't find predefined material in the library. The material assigned for some geometry component is absent in the connected library. Insert the desired material into the library.

102 Error while reading the attenuation library. Problem with the mu-library. The library may be corrupted; use its backup version.

103 Arrays to store attenuation coeffs. are full. Only 10 energy intervals may be used to describe the polynomial that represents the energy dependence of mass attenuation coefficient.

104 End of file with mu-library is reached, no more records exist.

Mu-Editor

500 Error while accessing of a function in LoadMuLibr.dll. The Dll may be corrupted; re-install it.

501 Cannot find LoadMuLibr.dll.

502 Error during treatment of substance composition. The old mu-library format may have been used. You may use either the construction of a new substance from elements (via chemical formula) and/or the substances prepared in the Windows version of the mu-library editor.

503 Error during conversion of the formula to the new mu-library format. While reading the DOS formatted Mu-Library the program was unable to convert a substance composition into the new format. Try to prepare this substance directly using the Windows version of the program.

504 Error in Dll (.dll) while performing the selected operation.

505 Cannot load the ISOCS path data. Either file SPACE. was not found or the :ATTENUATION_LIBRARY keyword was not found in SPACE.INI.

506 Error while deleting a material from the library. Internal error in muedit.dll.

507 Invalid value of density. Density must be greater than 0 and less than 20.

508 Internal error while attempting to insert the material.

509 The formula is too long to be inserted into the library. You can subdivide the material composition into a few components.

510 The material ‘water’ cannot be deleted.

511 Trying to input a string inside another substring (parenthesis).

512 Substance name coincides with an element name. The problem is corrected by adding a prefix (asterisk).

513 Name of substance coincides with an element name, correct it first.

605 Too many components, the reserved arrays are full.

609 Impossible to delete because of formula traceability. The next substance(s) refer for ‘%1’:

610 Impossible to insert because of formula traceability. The next substance(s) refer for ‘%1’:

GeomEdit

100 Not enough room between source and detector to put Absorber(s)

701 Can’t get address of DLL function

702 Can’t load DLL

703 Can’t load Material Info from library

704 The material pointed to in the template geometry is not found in the current mu-library. The material must be added before proceeding.

705 The geometry description must include a detector.

706 The detector specified in the geometry file is missing from the local file Detector.txt. Check the existence of the detector characterization file in the ISOCS directory! The geometry file refers to a detector record that has been deleted, or the current Detector.txt file has been modified.

707 Cannot append detector(s) to the Combo Box.

708 Cannot load the selected detector from file Detector.txt. Check for an appropriate record (for the selected detector) in Detector.txt.

709 A detector must be selected.

710 The number of template versions exceeds the maximum allowed. To enter a new version first delete one or more existing versions.

711 Invalid template version name.

712 The template version name is already in use.

713 Cannot open template version file. A system error occurred while opening the template version file. Version information could not be saved.

714 Cannot open the predefined beaker file. Check that the beaker file is not currently being used by another program.

715 Invalid parameter in pre-defined beaker file. The line of data must contain 7 parameters.

716 Not a valid contour ID. The ID did not correspond to one of the three types of contour (i, o or b).

717 Invalid number of parameters (less than 4)! The record structure in file describing contour.

718 Cannot load DLL with template information. When the Edit Dimensions dialog was called, the program could not load the template dll. This situation may arise when attempting to edit a .GEO file of a particular geometry template that is not available in the current GC configuration.

719 Cannot get the address of a function in the template dll. This is a system error. It may be due to a corrupted dll and may be necessary to reinstall.

720 New user template version may be based only on the default template version. A new user template version cannot be based on an existing geometry file that itself is based on a user template version. Use the version that is not marked as [user].

721 The material '%1' referenced in the geometry file is not available in the current mu-library. Please replace it with an available material or add the material to the mu-library.

722 The geometry definition contains the material '%1' which is not available in the current mu-library. Would you like to replace this material with and available one?

723 Density for the source material is missing. Mass of the source cannot be calculated.

724 Cannot load .dll.

725 Cannot get address of function in .dll. This is an internal (system) error.

726 Cannot find the bitmap containing the template drawing. The bitmap file must exist in the directory specified by the :TMPL_BITMAPS keyword in Space.ini.

727 The file containing the template drawing is not a valid bitmap (.bmp) file.

728 Cannot continue. Check the :PROGRAM keyword in Space.ini. The directory path specified by the :PROGRAM keyword is missing or invalid, or Space.ini itself may be missing.

729 Cannot retrieve the address of a function in the computational DLL. Isocs_generic.dll may be corrupted. You may need to re-install.

730 Cannot load computational DLL. Check existence of isocs_generic.dll in directory specified by the :PROGRAM keyword in Space.ini.

731 Cannot open contour description file for writing.

732 Cannot open the file containing cylindrical collimator parameters. This file is located in the directory specified by the :C_COLLIMATOR keyword in Space.ini.

733 Invalid record in collimator file.

734 Cannot open file containing under water housing parameters. This file is located in the directory specified by the :UW_HOUSING keyword in Space.ini.

735 Cannot open file containing rectangular collimator parameters. This file is located in the directory specified by the :R_COLLIMATOR keyword in Space.ini.

736 Select a collimator type first.

737 Cannot execute the operation. The collimator type must be selected first.

738 The collimator name has not been identified. The record will be saved as a new record.

739 Cannot open file to save collimator data. Check that the file is not being used by another program.

740 Please specify a name for the record: none is not valid!

741 Please confirm deletion of user version %1.

743 Versions library has been updated.

744 Please select the version to be deleted.

745 Template version has been saved.

746 Cylindrical collimator record has been successfully stored.

747 Rectangular collimator record has been successfully stored.

748 Housing record has been successfully stored.

749 Detector name is longer than 19 characters. Please make the necessary correction to the detector file. The detector is not included in the list of available detectors.

750 Please confirm deletion of the collimator record.

751 Please confirm deletion of the housing record.

752 Cannot launch MuEditor.exe. Check the existence of this file in the directory specified by the :PROGAM keyword in Space.ini.

753 Please confirm replacement of the record #%1: %2.

754 Cylindrical Collimator

755 Rectangular Collimator

756 Housing

757 Material in the string #'%1' is missing. Select the proper material from the list box or none if the geometry component is absent. In the latter case the line's data will be ignored.

758 Data Validation

759 Only positive numbers greater than 1.0E-4 mm may be entered.

760 Cannot load BMP file for plotting. The bitmap file must exist in the directory specified by the :TMPL_BITMAPS keyword in Space.ini.

Geometry Composer

100 OLE initialization failed. Make sure that the OLE libraries are the correct version.

104	Windows sockets initialization failed.
1002	Variable ‘SPACE’ is not found in the environment.
1003	File Space.ini cannot be opened.
1004	The preset path statement is not found in file Space.
1005	Cannot open file detector. with detector parameters. Check whether detector.txt is present in the directory specified by the :DETECTOR_PAR keyword in Space.ini.
1006	Error in format of file Space.ini. Check format of Space.ini: each line should have a format of keyword=path.
1007	System error while reading the detector list file.
1008	Check format of the detector list file (8 columns per line are allowed).
1009	Program cannot open templates list file (template.cnf).
1010	Templates list file (template.cnf) has an invalid format.
1011	System error while reading the templates list file (template.
1012	Cannot load the template DLL file.
1013	Cannot access exported DLL function. This is a system error which occurred when the program attempted to access the DLL.
1014	Unable to locate the geometry files directory. The program cannot locate the directory specified by the :GEOMETRY keyword in Space.ini. The results will be stored in the root directory.
1015	Cannot open ISOCS geometry (.GIS) file to store geometry description data.
1016	Directory specified by the :PROGRAM keyword in file Space.ini is invalid.
1017	Internal error in ISOCS program.
1018	Cannot open efficiency (.ECC) file generated by ISOCS.
1019	Error while reading ISOCS efficiency (.ECC) file: invalid number of columns in file.

1020 Error while reading ISOCS efficiency (.ECC) file: invalid number of energies in file.

1021 Internal error calling efficiency curve function in .dll.

1022 Error returned from efficiency curve function in .dll.

1023 Cannot load .dll. Check existence of this file in the directory specified by the :PROGRAM keyword in Space.ini.

1024 Internal error: generation failed.

1025 Error attempting to open .ECC file generated by ISOCS: cannot find :ECC_OUTPUT keyword in file Space.ini.

1026 Unrecognized file format: the file is not in a .GEO format.

1027 The function computing efficiency returned with an error.

1028 Internal system error attempting to call a function in _generic.dll.

1029 Cannot load _generic.dll.

1030 The geometry (.GEO) file was created by later version of Geometry Composer than is currently running. The program may have failed attempting to read a file. Please update your Geometry Composer.

1031 Cannot open file containing geometry data.

1032 Internal arrays for importing ISOCS geometry are full. Check the .GIS file and insure that all contained data are valid.

1033 Cannot open the Clipboard to store the template picture for export to Excel.

1034 Cannot empty the Clipboard.

1035 Unable to write template picture to the Clipboard.

1036 Do you wish to overwrite existing configuration file?

1037 Cannot open back-up copy of Space. (Space.bak).

1038 No geometry templates are available. Please check Options/Configuration menu item. Check for the existence of the template DLLs (lgt_xx.dll and igt_xx.dll) in the directory specified by the :PROGRAM keyword in Space.ini.

1039 Filename of the Computational DLL does not match its content. The file may have been renamed.

1040 Cannot find the bitmap containing the template drawing. The bitmap file must exist in the directory specified by the :TMPL_BITMAPS keyword in Space.ini.

1041 The file containing the template drawing is not a valid bitmap (.bmp) file.

1042 Program cannot run because of a missing keyword. One of the required keywords in Space.ini is missing.

1043 Cannot find the directory specified by the :GEOMETRY keyword in file Space.ini.

1044 The selected folder does not correspond to standard file storage convention. Save the file anyway?

1045 Confirm selection!

1046 Cannot create new directory.

1047 Cannot open the energy list file.

1048 Error in format of energy list file. Each line should contain two comma delimited fields: Energy and Efficiency Error.

1049 Cannot open energy list file for writing.

1050 Error while requesting information about a computational DLL.

1051 Program cannot continue: cannot find one of the required keywords in file Space.ini.

1052 Internal system error: problem calling the function in the computational DLL.

1053 Cannot load computational DLL. Check existence of DLL in directory specified by the :PROGRAM keyword in Space.ini.

1054 Cannot delete temporary file *.txt. This is required in order to execute the next ISOCS computation.

1055 Cannot open temporary file to store beaker description during geometry testing.

1056 Cannot find generated file. Export to Excel is stopped.

1057 Excel is being launched…Please answer the following questions from Excel:

1058 Cannot launch ‘Excel’.

1059 Efficiency curve may be generated after saving the geometry file.

1060 Geometry test has run successfully.

1061 Geometry test has failed:

1062 Error

1063 Variable ‘SPACE’ is not found in the environment.

1064 File Space.ini cannot be opened. Check for the existence of this file in the directory specified by the SPACE environment variable.

1065 The preset statement is not found in file Space.ini.

1066 Cannot open file detector. with detector parameters. Check existence of this file in the directory specified by the :DETECTOR_PAR keyword in file Space.ini.

1067 Error in format of file Space.ini. Check format of Space.ini: each line should have a format of keyword=path.

1101 Cannot find the bitmap containing the template drawing. The bitmap file must exist in the directory specified by the :TMPL_BITMAPS keyword in Space.ini.

1102 Please select the energy to be deleted.

1103 An Efficiency Calibration Calculation (ECC) process is already running. Wait for its termination before launching another ECC process.

1104 Efficiency data points have been generated.

1105 Filename of the Template DLL does not match its content. The file may have been renamed.

1106 Temperature is below the lower temperature limit (deg C):

1107 Temperature is above the upper temperature limit (deg C):

1108 Pressure exceeds the upper pressure limit (mm Hg):

1109 ISOCS environment is not found. Program cannot run.

1110 File Space.ini or a required keyword in Space.ini was not found. The program cannot access data needed for creation of a new document. Only existing documents may be opened.

1111 Cannot move generated file from temporary to destination directory. System error number ()

1112 Configuration list is empty. New document cannot be created: no templates are available.

1113 Cannot update configuration. File Space.ini or the :PROGRAM keyword in space.ini was not found.

1114 You have loaded a previous version of a GEO file. To make the picture available open the Edit/Dimensions dialog and save the GEO file.

1115 Cannot create backup of template list file (template.bak). While updating the configuration the program could not rename template.cnf to ‘template.bak.

1116 Cannot update template list file (template.cnf). While updating the configuration the program could not rename the temporary copy of the template list file (template.tmp) back to the permanent file name (template.cnf).

1117 List is full. Cannot append new energy value to the list used for ECC generation. Max lines in the list is 100.

1118 % elements have been loaded.

1119 The valid energy interval is:

1120 The energy value is already in the list.

1121 The Error value is missing.

1122 Cannot load DLL with template information. The program could not load the template DLL.

1123 Cannot get the address of a function in the template DLL. This is a system error.

ISOCS Multi-Efficiency Errors

1300 CANNOT FIND ECC_OUTPUT STATEMENT IN SPACE.INI FILE
Check the contents of the SPACE.INI file.

1301 ENERGY LIST OF THIS FILE DOES NOT CORRESPOND TO THE LIST OF ALREADY LOADED FILE(S)
On loading the second .ECC file into the table of files to be treated, the program checks that the list of energies for this file is exactly the same as the list of the first file (no energy tolerance is used).

1302 INVALID CONTENT OF CURRENT ECC FILE. PLEASE, GENERATE THIS FILE AGAIN
Probably the contents of the input .ECC file is corrupted; generate it again.

1303 CAN NOT OPEN DESTINATION 'MULTIEFFICIENCY' DIRECTORY
An effort to make a new daughter directory (MultiEfficiency) in ..\geometry\in-situ\ has failed.

1304 CAN NOT LOAD ECC FILE (SEE ROW MARKED BY RED)
Usually this situation happens while loading the file containing the list of ECC files. If one (or more) of .ECCfiles was erased (or moved) from the preset location, the list will contain an invalid file. The program detects this situation and marks the invalid file in red in the table with the input list.

1307 PLEASE, ENTER VALUE(S) OF WEIGHT (WEIGHTING FACTOR)
If the Weighted Average mode was selected, the Weight value must be indicated in the table.

1308 PLEASE CHECK VALUE OF 'WEIGHT'. ONLY FLOATING POINT NUMBER GREATER THAN ZERO IS ALLOWED.

1309 FILE WITH SAME NAME ALREADY EXITS. REPLACE?
This message can be seen when saving a file (table on the Input screen or .ECCfile on the Report screen).

1310 TOO LONG PARAMETER IN THE INPUT ECC LINE. THE INVALID PARAMETER IS SHOWN ON THE FOLLOWING LINE
The message is generated while reading input .ECC files. The program found that the argument is too long. The argument is detector name, template name, filename, geometry name.

1311 SAVE MULTI-EFFICIENCY RESULTS?
Message appears on exit of Report screen if MEfficiency.ECC file is not saved yet.

ISOCS Template-Dependent Errors

The error number for each set of template-dependent messages begins at 200. To find the appropriate error message, first locate the name of the template that was used, and then find its error number.

An error message may contain the symbols “%1” or “%2”. These are substitution fields, and will be replaced by a specific value when the error message is generated. Usually the fields are intended to print the number of layer (source) where a problem was detected to provide a clearer indication of the error.

Note: Some error messages are typical and are repeated in many templates. Please refer to the first appearance of the message for an additional explanation.

Template and Error Number	Error Message	Comment
igt_1 CIRCULAR_PLANE		
200	No radioactive layer is found. Set up Rel.Conc. for radioactive layer	Rel.Conc. is not set for a layer (2-11) which may be radioactive (has RelConc field)
201	Please select material for walls	Wall dimension (1.1) is selected, but not the material
202	Material for walls is selected, Please set dimension	Material is selected, but wall dimension (1.1) is not
203	Layer is marked as radioactive, set up its dimension or reset Rel.Conc. value	RelConc > 0 , but layer thickness is 0
204	Radioactive layer is defined. Select material for it	Dimension of layer and its RelConc. are defined, but a material is not selected.
205	Please select material for Absorber1 (its dimension was set)	Dimension 12.1 > 0, but material is ‘none’
206	Please select material for Absorber2 (its dimension was set)	Dimension 13.1 > 0, but material is ‘none’
207	Material for Absorber is set. Set up its thickness or replace material with ‘none’ if Absorber is really absent	Material specified, but dimension 12.1 and/or 13.1 is zero
208	Non radioactive layer is defined. Select material for it	The layer is considered as nonradioactive since its RelConc= 0, but its Material OR dimension is set
209	Non radioactive layer is defined. This layer (line %1) will be considered as absorber, not source	Warning message
igt_2 Complex_Box		
200	No radioactive layer/source is found. Set up Rel.Conc. for radioactive layer	Rel.Conc. is not set (2…6)

Template and Error Number	Error Message	Comment
201	Please select material for walls	The wall thickness is given, but not its material
202	Material for walls is selected, Please set dimension	The wall material is given, but not its thickness
203	Layer is marked as radioactive, set up its dimension or reset Rel.Conc. value	
204	Radioactive layer is defined. Select material for it	
205	Please select material for Absorber1 (its dimension was set)	
206	Please select material for Absorber2 (its dimension was set)	
207	Material for Absorber is set. Set up its thickness or replace material with ‘none’ if Absorber is really absent	
208	Non radioactive layer is defined. Select material for it	
209	Non-radioactive layer is defined. This layer (line %1) will be considered as absorber, not source	
210	Concentrated Source is set. Define all its dimensions: 6.1, 6.2, 6.3	Dimension 6.1, 6.2 or 6.3 is zero
211	Concentrated Source is set. Select material for it	All dimensions (6.1, 6.2, 6.3) are set, but the material is not specified
igt_3 SIMPLE_BOX		
200	No radioactive layer is found. Set up Rel.Conc. for radioactive layer	
201	Please select material for walls	The wall thickness is given, but not the material

Template and Error Number	Error Message	Comment
202	Material for container is selected, Please set dimension	The wall material is given, but not its thickness
203	Layer is marked as radioactive, set up its dimension or reset Rel.Conc. value	
204	Radioactive layer is defined. Select material for it	
205	Please select material for Absorber1 (its dimension was set)	
206	Please select material for Absorber2 (its dimension was set)	
207	Material for Absorber is set. Set up its thickness or replace material with ‘none’ if Absorber is really absent	
208	Non radioactive layer is defined. Select material for it	
209	Non radioactive layer is defined. This layer (line %1) will be considered as absorber, not source	
211	Layer(s) does not fit container: 2.1+ 3.1 > 1.3	
igt_4 RECTANGULAR_PLANE		
200	No radioactive layer is found. Set up Rel.Conc. for radioactive layer	
201	Please select material for walls	The wall thickness is given, but not the material
202	Material for walls is selected, Please set dimension	The wall material is given, but not its thickness
203	Layer is marked as radioactive, set up its dimension or reset Rel.Conc. value	

Template and Error Number	Error Message	Comment
204	Radioactive layer is defined. Select material for it	
205	Please select material for Absorber1 (its dimension was set)	
206	Please select material for Absorber2 (its dimension was set)	
207	Material for Absorber is set. Set up its thickness or replace material with ‘none’ if Absorber is really absent	
208	Non radioactive layer is defined. Select material for it	
209	Non radioactive layer is defined. This layer (line %1) will be considered as absorber, not source	
igt_5 COMPLEX_CYLINDER		
200	No radioactive layer/source is found. Set up Rel.Conc. for radioactive layer	
201	Please select material for walls	The wall thickness is given, but not the material
202	Material for walls is selected, Please set dimension	The wall material is given, but not its thickness
203	Layer is marked as radioactive, set up its dimension or reset Rel.Conc. value	
204	Radioactive layer is defined. Select material for it	
205	Please select material for Absorber1 (its dimension was set)	
206	Please select material for Absorber2 (its dimension was set)	

Template and Error Number	Error Message	Comment
207	Material for Absorber is set. Set up its thickness or replace material with ‘none’ if Absorber is really absent	
208	Non radioactive layer is defined. Select material for it	
209	Non radioactive layer is defined. This layer (line %1) will be considered as absorber, not source	
210	Spherical Source is set. Define its dimensions	Rel.Conc for hotspot > 0, but dimension 2.1 is 0
211	Spherical Source is set. Select material for it	(2.1 > 0) AND (Rel.Conc.2 > 0), but material is not defined
igt_6 SIMPLE_CYLINDER		
200	No radioactive layer is found. Set up Rel.Conc. for radioactive layer	
201	Please select material for walls	The wall thickness is given, but not the material
202	Material for container is selected, Please set dimension	The wall material is given, but not its thickness
203	Layer is marked as radioactive, set up its dimension or reset Rel.Conc. value	
204	Radioactive layer is defined. Select material for it	
205	Please select material for Absorber1 (its dimension was set)	
206	Please select material for Absorber2 (its dimension was set)	
207	Material for Absorber is set. Set up its thickness or replace material with ‘none’ if Absorber is really absent	

Template and Error Number	Error Message	Comment
208	Non radioactive layer is defined. Select material for it	
209	Non radioactive layer is defined. This layer (line %1) will be considered as absorber, not source	
211	Layer(s) does not fit container: 2.1+ 3.1 > 1.3	
igt_7 SPHERE		
200	No radioactive source is found. Set up Rel.Conc. for a radioactive source	
201	Please select material for shell	The wall thickness is given, but not the material
202	Material for shell is selected, Please set dimension	The wall material is given, but not its thickness
203	Source Shell is marked as radioactive, set up its dimension	
204	Source Shell is defined. Select material for it.	
205	Please select material for Absorber1 (its dimension was set)	
206	Please select material for Absorber2 (its dimension was set)	
207	Material for Absorber is set. Set up its thickness or replace material with ‘none’ if Absorber is really absent	
208	Non radioactive Source-shell is defined. Select material for it.	Dimension 2.1 > 0 AND (Rel.Conc.2 > 0), but material is not defined for source shell

Template and Error Number	Error Message	Comment
209	Non radioactive Source-shell is defined. This layer (line %1) will be considered as absorber, not source.	
211	Thickness(es) of Shell and Source Shell does not fit shell diameter: 1.1*2+ 2.1*2 > 1.2	
213	Non radioactive Source-shell is defined. Set its dimension	Dimension 2.1 > 0, but material is not set for source shell
igt_8 WELL_or_MARINELLI_BEAKER		
200	Bottom slot of Marinelli beaker does not fit detector. Look at the 'Endcap INFO' frame on the dialog panel	Dimension 1.2 < end cap diameter
201	Please select material for Liner-Side	Dimension 1.1 > 0, but material is 'none'
202	Material for Liner-Side is selected, Please set dimension	Material is selected, but dimension is not set
203	Please set up length of bottom part	Dimension 1.3 is 0
204	Please select material for Liner-End	Dimension 2.1 > 0, but material is 'none'
205	Material for Liner-End is selected, Please set dimension	Material is selected, but dimension 2.1 is 0
206	No radioactive layer is found. Set up Rel.Conc. for radioactive layer.	RelConc for both source layers is 0
207	Layer is marked as radioactive, set up its dimension or reset Rel.Conc. value	If the RelConc for a source layer (3 or 4) is non-zero, its thickness (3.1 or 4.1) must be non-zero too
208	Radioactive layer is defined. Select material for it.	Select a material for source (3 or 4) matrix
igt_9 PIPE		

Template and Error Number	Error Message	Comment
200	No radioactive source is found. Set up Rel.Conc. for radioactive source."	
201	Please select material for pipe	The wall thickness is given, but not the material
202	Material for container is selected, Please set wall thickness	The wall material is given, but not its thickness
203	Layer is marked as radioactive, set up its dimension or reset Rel.Conc. value	
204	Radioactive layer is defined. Select material for it	
205	Please select material for Absorber1 (its dimension was set)	
206	Please select material for Absorber2 (its dimension was set)	
207	Material for Absorber is set. Set up its thickness or replace material with ‘none’ if Absorber is really absent	
208	Non radioactive layer is defined. Select material for it	
209	Non radioactive layer is defined. This layer (line %1) will be considered as absorber, not source	
210	Source %1 is set. Define its dimensions: %2.(2-3)	
211	Source(s) does not fit pipe: 2.1*2 + 3.1 > 1.2	
igt_10 SPECIAL_SPHERE		
200	No radioactive layer is found. Set up Rel.Conc. for radioactive layer	

Template and Error Number	Error Message	Comment
201	Please select material for walls	The wall thickness is given, but not the material
202	Material for walls is selected, Please set dimension	The wall material is given, but not its thickness
203	Layer is marked as radioactive, set up its dimension or reset Rel.Conc. value	
204	Radioactive layer is defined. Select material for it	
205	Please select material for Absorber1 (its dimension was set)	
206	Please select material for Absorber2 (its dimension was set)	
207	Material for Absorber is set. Set up its thickness or replace material with ‘none’ if Absorber is really absent	
208	Non radioactive shell is defined. Select material for it	
209	Non radioactive shell(s) is defined. This shell (line %1) will be considered as absorber, not source	
211	Source Core is set. Select material for it	Material.3=‘none’
212	Select material for container	Material.2=‘none’
213	Non radioactive shell is defined. Set its dimension	Material for a shell was assigned, but its dimension (x.1) is missing
igt_11 EXPONENT_CIRCULAR_PLANE		
200	Ao value is out of the (0-1) limit	
201	Please select material for walls	The wall thickness is given, but not the material

Template and Error Number	Error Message	Comment
202	Material for walls is selected, Please set dimension	The wall material is given, but not its thickness
204	Please select material for Source-Layer	
205	Please select material for Absorber1 (its dimension was set)	
206	Please select material for Absorber2 (its dimension was set)	
207	Material for Absorber is set. Set up its thickness or replace material with ‘none’ if Absorber is really absent	
208	Check line %1 (set dimension should be completed with material and vice versa)	A component (dimension or material) is missing from one of the layers (1-3)
209	Please check parameters. (5.1+ 5.2) can not exceed 5.1	
igt_12 BEAKER		
200	No radioactive layer is found. Set up Rel.Conc. for radioactive layer."	
201	Please select material for walls	The wall thickness is given, but not the material
202	Material for container is selected, Please set dimension	The wall material is given, but not its thickness
203	Layer is marked as radioactive, set up its dimension or n reset Rel.Conc. value	
204	Radioactive layer is defined. Select material for it.	
205	Please select material for Absorber1 (its dimension was set)	
206	Please select material for Absorber2 (its dimension was set)	

Template and Error Number	Error Message	Comment
207	Material for Absorber is set. Set up its thickness or replace material with ‘none’ if Absorber is really absent	
208	Non radioactive layer is defined. Select material for it.	
209	Non radioactive layer is defined. This layer (line %1) will be considered as absorber, not source	
211	Layer(s) does not fit container: 2.1+ 3.1 > 1.3	
igt_13 ROUND_TUBE		
200	Please select material for walls	The wall thickness is given, but not the material
201	Material for walls is selected, Please set dimension	The wall material is given, but not its thickness
202	Invalid angle. The valid range is: –360 ≤ Angle ≤ 360)	
203	Angle 2.3 must be less than 2.4 (–360 ≤ Angle ≤ 360)	
204	Angle 3.3 must be less than 3.4 (–360 ≤ Angle ≤ 360)	
205	Please select material for Absorber1 (its dimension was set)	
206	Please select material for Absorber2 (its dimension was set)	
207	Please set up source concentration	
208	No Source is pointed (insert data 2.2 or 3.2)	
209	The contamination length exceed the tube length (1.3)	Dimension 3.2 dimension 1.3

Template and Error Number	Error Message	Comment
210	Material for Absorber is set. Set up its thickness or replace material with ‘none’ if Absorber is really absent	
igt_14 U_CHANNEL		
200	Please select material for walls	The wall thickness is given, but not the material
201	Material for walls is selected, Please set dimension	The wall material is given, but not its thickness
202	Please select material for Absorber1 (its dimension was set)	
203	Please select material for Absorber2 (its dimension was set)	
204	Please set Orientation as 1 or 2 or 3 or 4	
205	The Surface source length exceeds the object length (1.1)	If(x.2 > 1.1), where x= 2-7
206	Dimension x.1 must be less than x.2 (x=2-7)	
209	No radioactive surface is found	
210	Set dimension(s) for radioactive source	
211	Material for Absorber is set. Set up its thickness or replace material with ‘none’ if Absorber is really absent	
igt_15 L_BEAM		
200	Please select material for walls	The wall thickness is given, but not the material
201	Material for walls is selected, Please set dimension	The wall material is given, but not its thickness
202	Please select material for Absorber1 (its dimension was set)	

Template and Error Number	Error Message	Comment
203	Please select material for Absorber2 (its dimension was set)	
204	Please set Orientation as 1 or 2 or 3 or 4	
205	The Surface source length exceeds the object length (1.1)	
206	Dimension x.1 must be less than x.2 (x= 2-5)	
209	No radioactive surface is found	
210	Set dimension(s) for radioactive source	
211	Material for Absorber is set. Set up its thickness or replace material with ‘none’ if Absorber is really absent	
igt_16 H_BEAM		
200	Material for walls is selected, Please set dimension	The wall material is set but the dimension is not given
201	Invalid volume: upper part of beaker is not filled The data in line 4 will be reset Input correct values	
202	Please select material for Absorber1 (its dimension was set)	
203	Please select material for Absorber2 (its dimension was set)	
204	Please set Orientation as 1 or 2	
205	The Surface source length exceeds the object length (1.1)	
206	Dimension x.1 must be less than x.2 (x=2-7)	
209	No radioactive surface is found	

Template and Error Number	Error Message	Comment
210	Set dimension(s) for radioactive source	
211	Material for Absorber is set. Set up its thickness or replace material with 'none' if Absorber is really absent	
igt_17 RECTANGULAR_TUBE		
200	Please select material for walls	The wall thickness is given, but not the material
201	Material for walls is selected, Please set dimension	The wall material is given, but not its thickness
202	Please select material for Absorber1 (its dimension was set)	
203	Please select material for Absorber2 (its dimension was set	
205	The Surface source length exceeds the object length (1.2)	
206	Dimension x.1 must be less than x.2 (x = 2–9)	
209	No radioactive surface is found	
210	Set dimension(s) for radioactive source	
211	Material for Absorber is set. Set up its thickness or replace material with 'none' if Absorber is really absent	
igt_18 ROOM		
200	No radioactive surface is found	RelConc is zero for all surfaces (2–7)
igt_19 TANK		
200	Please select material for side wall	The wall thickness is given, but not the material

Template and Error Number	Error Message	Comment
201	Material for side wall is selected, Please set dimension	The wall material is given, but not its thickness
202	Please select material for ends walls	Material.2 is not selected
203	Material for ends walls is selected, Please set dimension	Material.2 is selected AND 2.1=0
204	Please select material for Absorber1 (its dimension was set)	
205	Please select material for Absorber2 (its dimension was set)	
206	Please set Orientation as 1 or 2	
207	No radioactive source found	RelConc.3= 0
210	Set dimension for radioactive source	Dimension 3.1 is 0
211	Material for Absorber is set. Set up its thickness or replace material with ‘none’ if Absorber is really absent	
igt_20 CONE		
200	Please select material for side wall	The wall thickness is given, but not the material
201	Material for side wall is selected, Please set dimension	The wall material is given, but not its thickness
202	Please select material for ends walls	
203	Material for ends walls is selected, Please set dimension	
204	Please select material for Absorber1 (its dimension was set)	
205	Please select material for Absorber2 (its dimension was set)	

Template and Error Number	Error Message	Comment
206	At least one dimension from 1.2, 1.3 must be set	
207	Source is out of the cone container: 1.4 < 3.1 Check the source height	
208	No radioactive source found	
210	Set dimension for radioactive source	Dimension 3.1 is 0
211	Material for Absorber is set. Set up its thickness or replace material with ‘none’ if Absorber is really absent	

LabSOCS Template-Dependent Errors

The error number for each set of template-dependent messages begins at 200. To find the appropriate error message, first locate the name of the template that was used, and then find its error number.

Template and Error Number	Error Message	Comment
Lgt_101 CYLINDER_DISK_AND_POINT		
200	Not enough room between source and detector to put Absorber(s)	Dimension (5.1+ 4.1) > 6.1
205	Please select material for Absorber1 (its dimension was set)	
206	Please select material for Absorber2 (its dimension was set)	
207	Material for Absorber is set. Set up its thickness or replace material with ‘none’ if Absorber is really absent	

Template and Error Number	Error Message	Comment
Lgt_104 SIMPLIFIED_BOX		
200	Not enough room between source and detector to put Absorber(s)	Dimension (5.1+ 4.1) > 6.1
201	Please indicate thickness of side walls	The material is given, but not the side wall thickness
202	Please select material of side walls	The side wall thickness is bottom wall is given, but not the material
203	Please indicate thickness of bottom wall	The bottom wall material is given, but not the thickness
204	Please select material of bottom wall	The bottom wall thickness is given, but not the material
205	Please select material for Absorber1 (its dimension was set)	
206	Please select material for Absorber2 (its dimension was set)	
207	Material for Absorber is set. Set up its thickness or replace material with ‘none’ if Absorber is really absent	
Lgt_106 CYLINDER_FROM_SIDE		
200	Not enough room for Absorber(s)	Dimension 5.1< (3.1+ 4.1)
201	Invalid volume. If you wish to change sample volume, correct the dimensions	It is assumed that cylinder is fully filled. This assumption may not be fulfilled if the dimensions are set and user tries to change volume
202	Please select material for the container	Thickness of the container is given, but the material is not.
203	Please indicate thickness of container walls	Container material given, but not the thickness.
205	Please select material for Absorber1 (its dimension was set)	
206	Please select material for Absorber2 (its dimension was set)	
207	Material for Absorber is set. Set up its thickness or replace material with ‘none’ if Absorber is really absent	

Template and Error Number	Error Message	Comment
Lgt_107 SIMPLIFIED_SPHERE		
200	Not enough room for Absorber(s)	Dimension 5.1< (3.1+ 4.1)
201	Please select material for container	The thickness of container is given, but not the material.
202	Please indicate thickness of container wall	The container wall material is given, but not the thickness.
205	Please select material for Absorber1 (its dimension was set)	
206	Please select material for Absorber2 (its dimension was set)	
207	Material for Absorber is set. Set up its thickness or replace material with 'none' if Absorber is really absent	
Lgt_108 SIMPLIFIED_MARINELLI_BEAKER		
200	Detector does not fit into Marinelli beaker well. See the 'Endcap INFO' frame on the dialog panel	
202	Sample is below detector plane	The sample must completely occupy the well portion of the Marinelli beaker. The error indicates that the sample level is below the detector end-cap plane.
203	Invalid data: only positive data are permitted	This error message may appear while testing the dimensions matrix
205	Invalid data for detector well: 3.1 must be greater than 2.1+4*1.1	3.1> (2.1+4*1.1)
206	Container diameter must be greater then detector diameter	
207	Please select a material for the container	
Lgt_112 SIMPLIFIED_BEAKER		
200	Please select material for beaker walls	The beaker wall thickness is given, but not the material
201	Sample volume too large to fit into beaker	

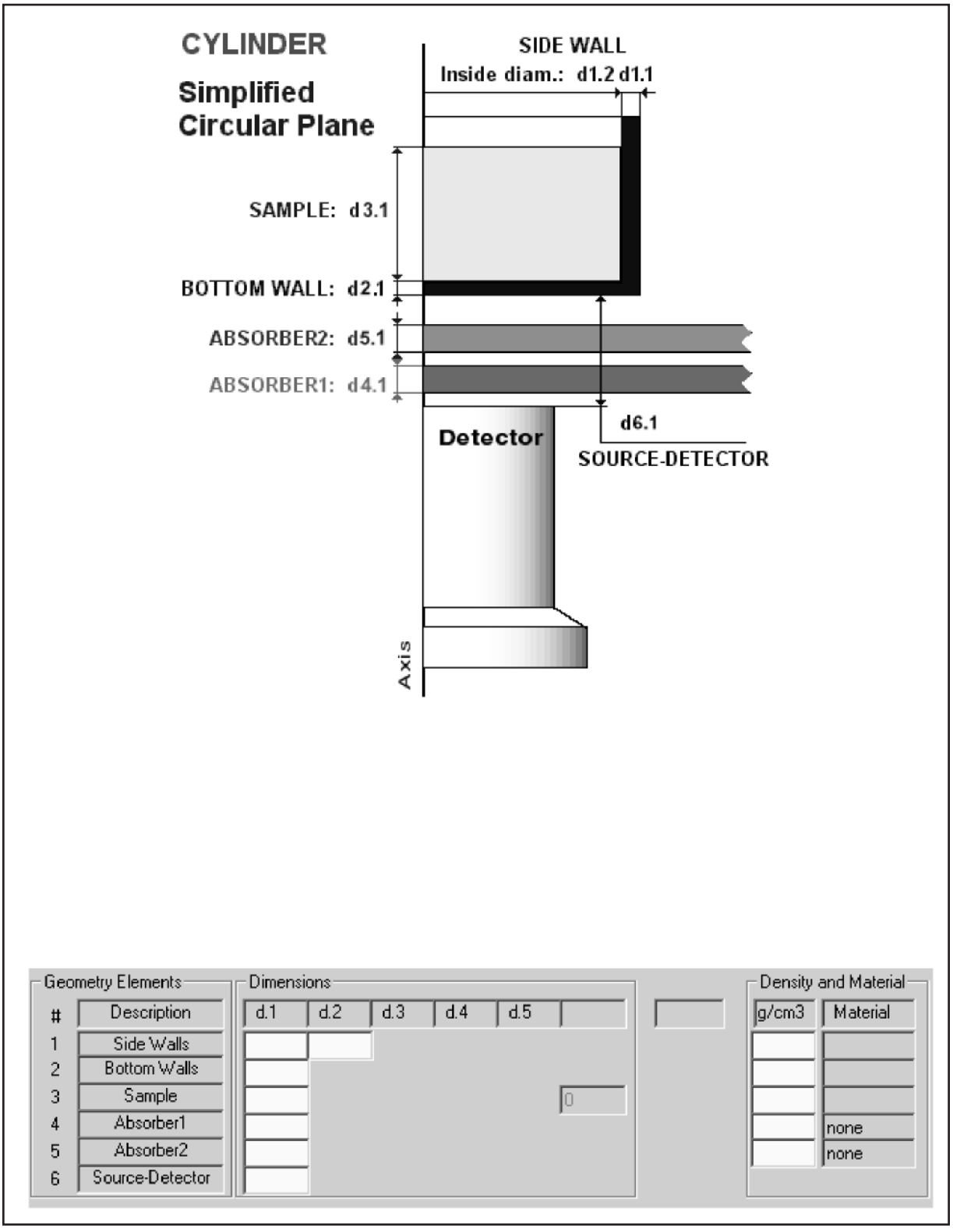
Template and Error Number	Error Message	Comment
202	Not enough room for the sample.	Dimension 2.1 > 1.4
205	Please select material for Absorber1 (its dimension was set)	
206	Please select material for Absorber2 (its dimension was set)	
207	Material for Absorber is set. Set up its thickness or replace material with ‘none’ if Absorber is really absent	
LGT_12 GENERAL_PURPOSE_BEAKER		
200	Please select a wall material	The beaker wall thickness is given, but not the material
201	“Please indicate the height of at least one of layers: 2.1 or 3.1	
205	Please select material for Absorber1 (its dimension was set)	
206	Please select material for Absorber2 (its dimension was set)	
207	Material for Absorber is set. Set up its thickness or replace material with ‘none’ if Absorber is really absent	
Lgt_8 GENERAL_PURPOSE_MARINELLI_BEAKER		
200	Detector does not fit into Marinelli beaker well. See the ‘Endcap INFO’ frame on the dialog panel	
201	Parameters 3.1 and 4.1 must be set in the current context	Not currently used

6. Standard LabSOCS Template Drawings

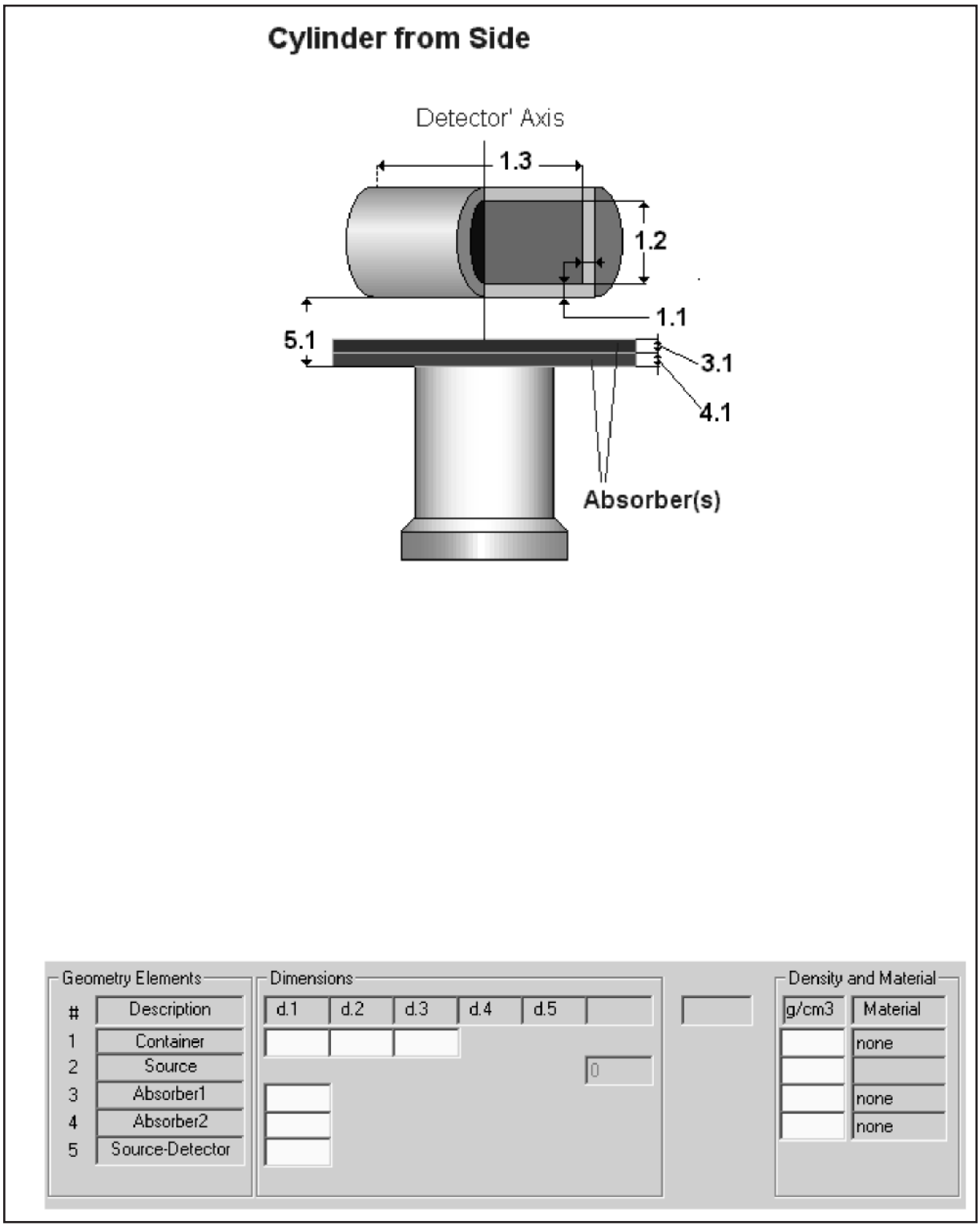
This chapter includes graphical descriptions of each of the geometries supplied with LabSOCS. Copies of these figures may be useful in recording input parameters in the field as part of a permanent record of the measurement process.

The drawings which follow are the standard sample geometries supplied with LabSOCS.

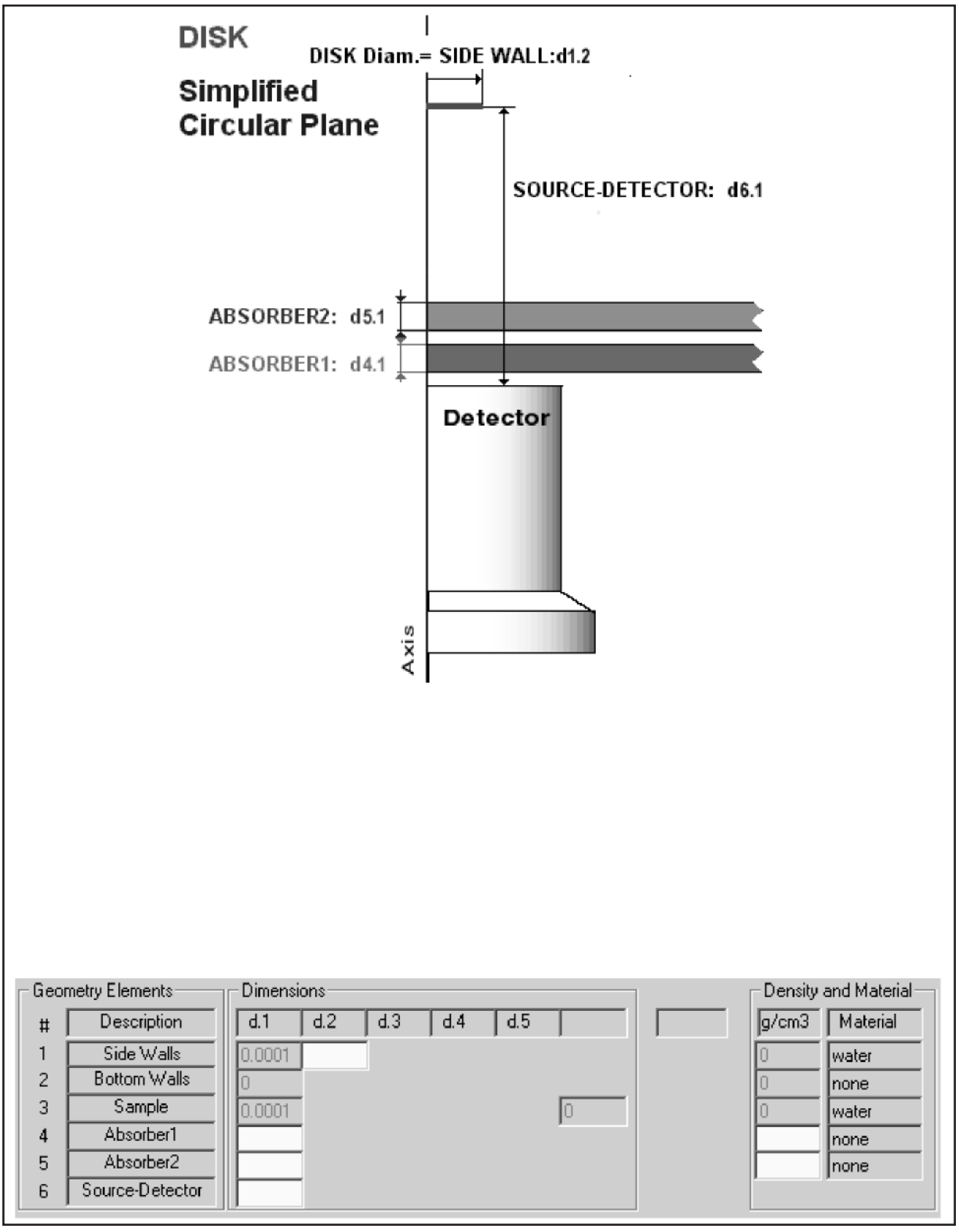
Cylinder, Simplified Circular Plane



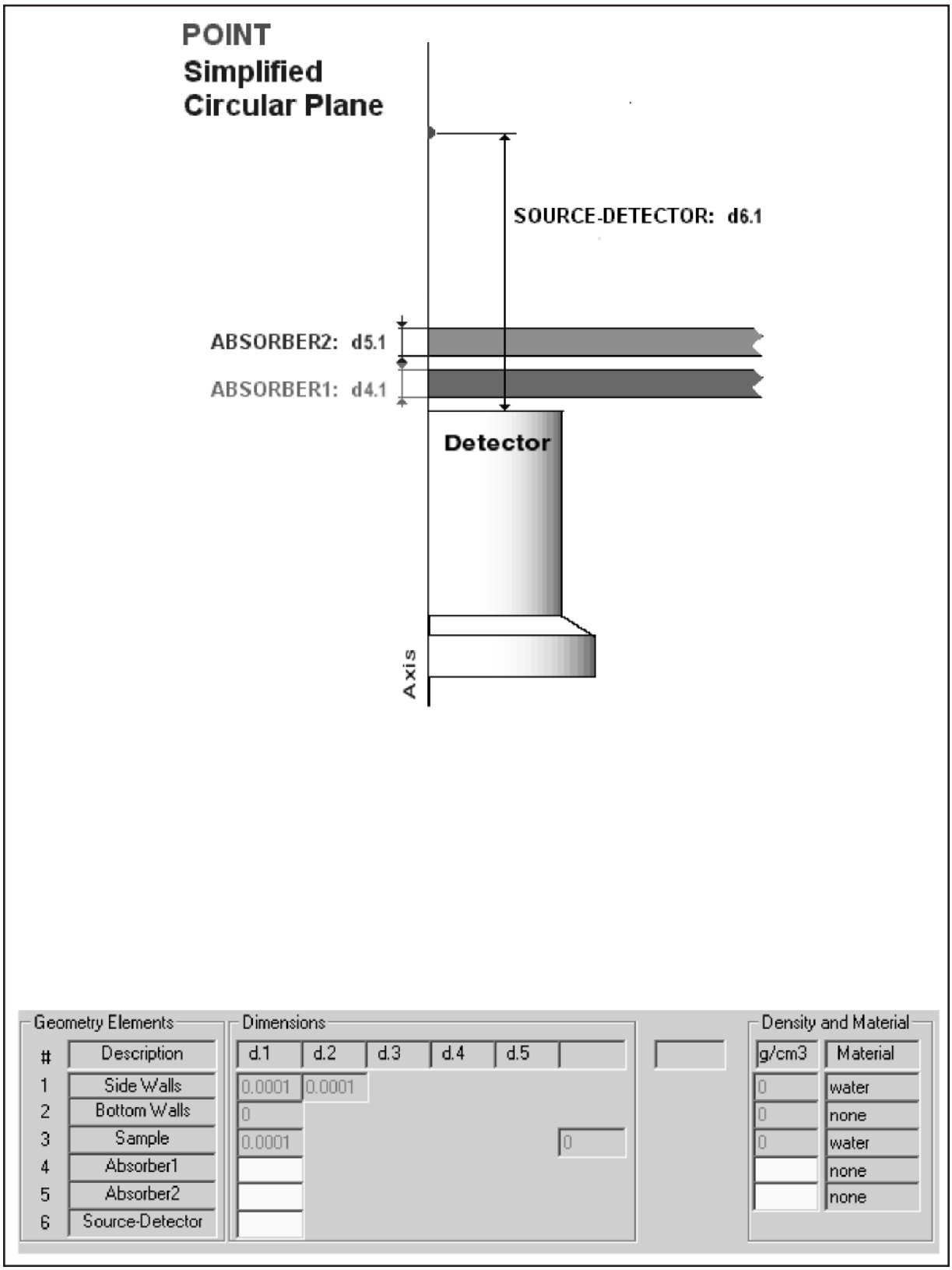
Cylinder From Side



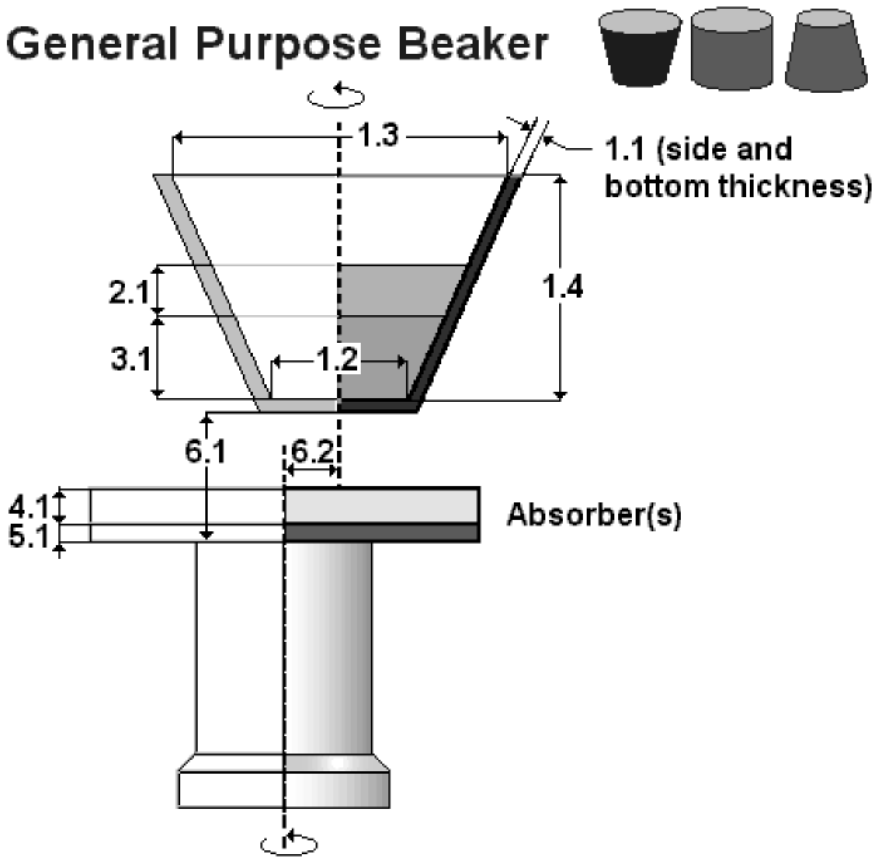
Disk, Simplified Circular Plane



Point, Simplified Circular Plane



General Purpose Beaker



Geometry Elements

#	Description
1	Beaker
2	Top Layer
3	Bottom Layer
4	Absorber1
5	Absorber2
6	Source-Detector

Dimensions

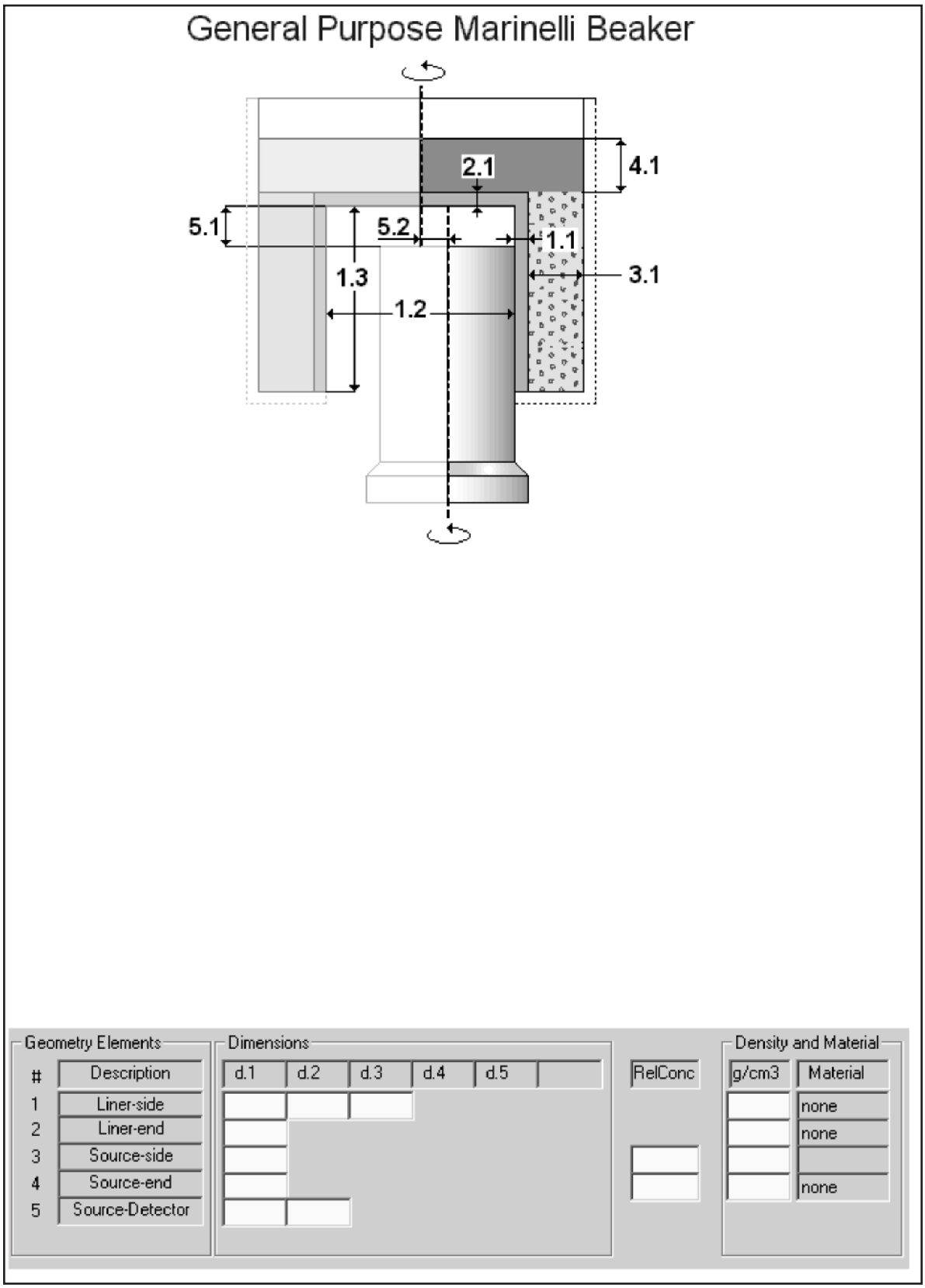
d.1	d.2	d.3	d.4	d.5	

RelConc

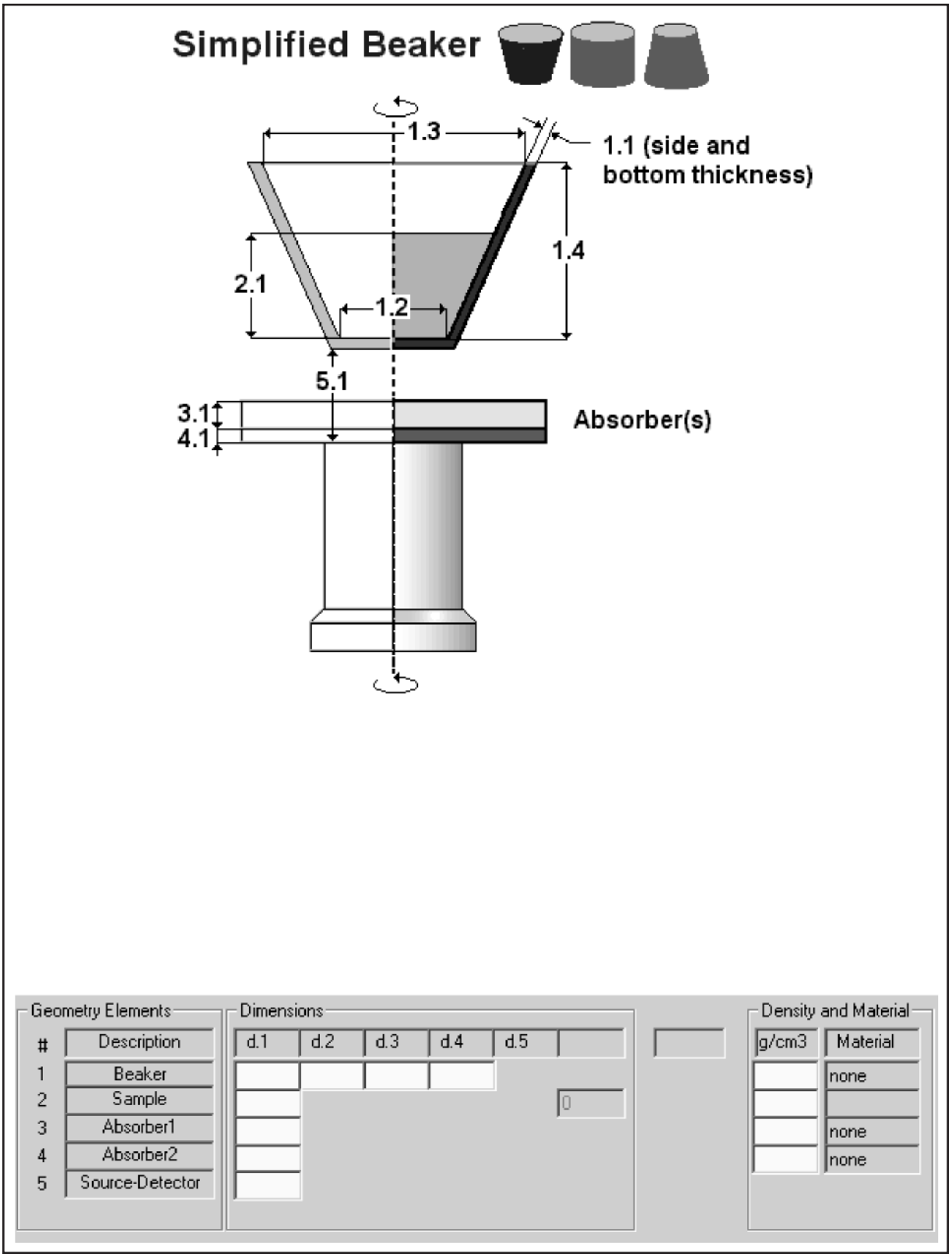
Density and Material

g/cm3	Material
	none
	none
	none
	none

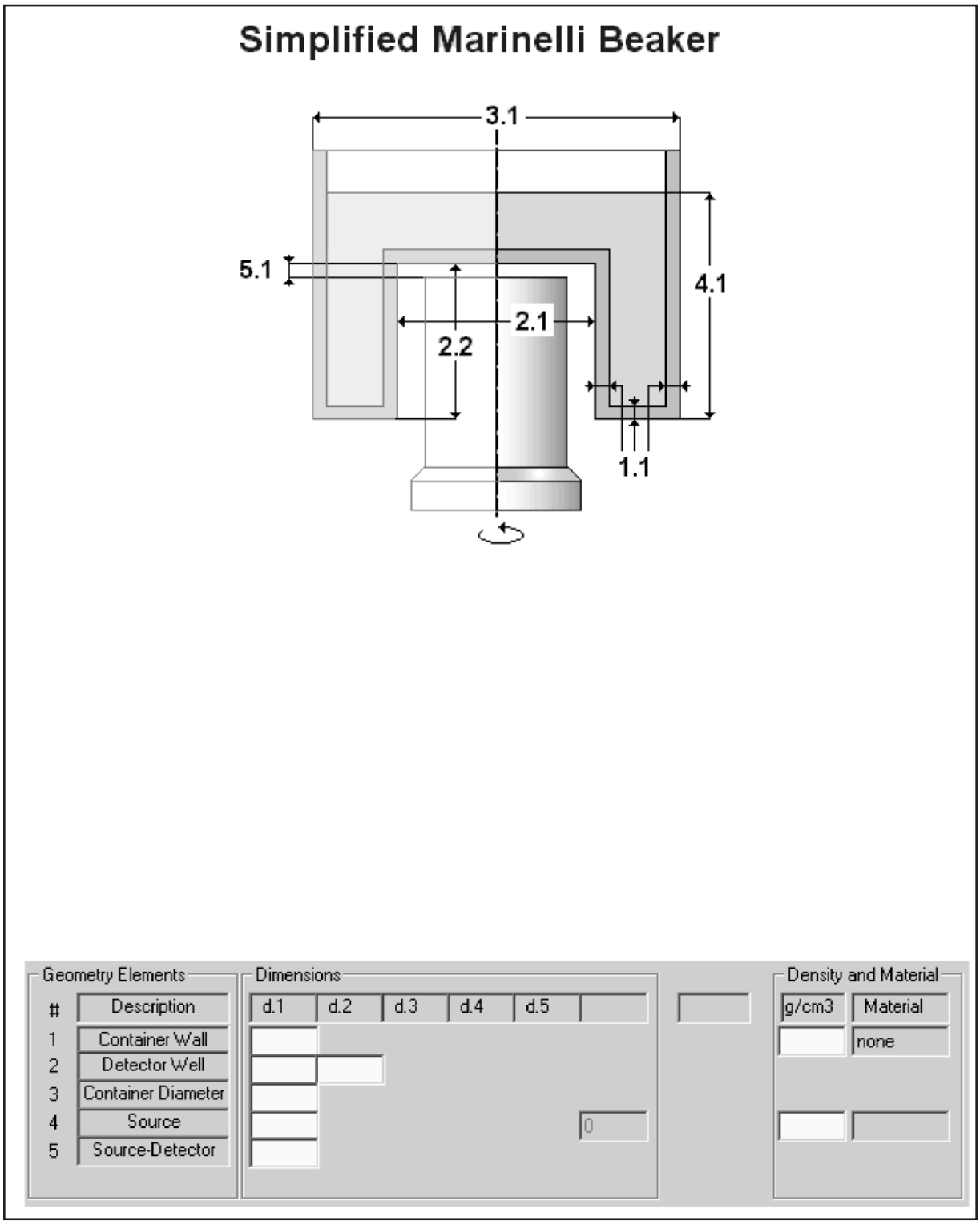
General Purpose Marinelli Beaker



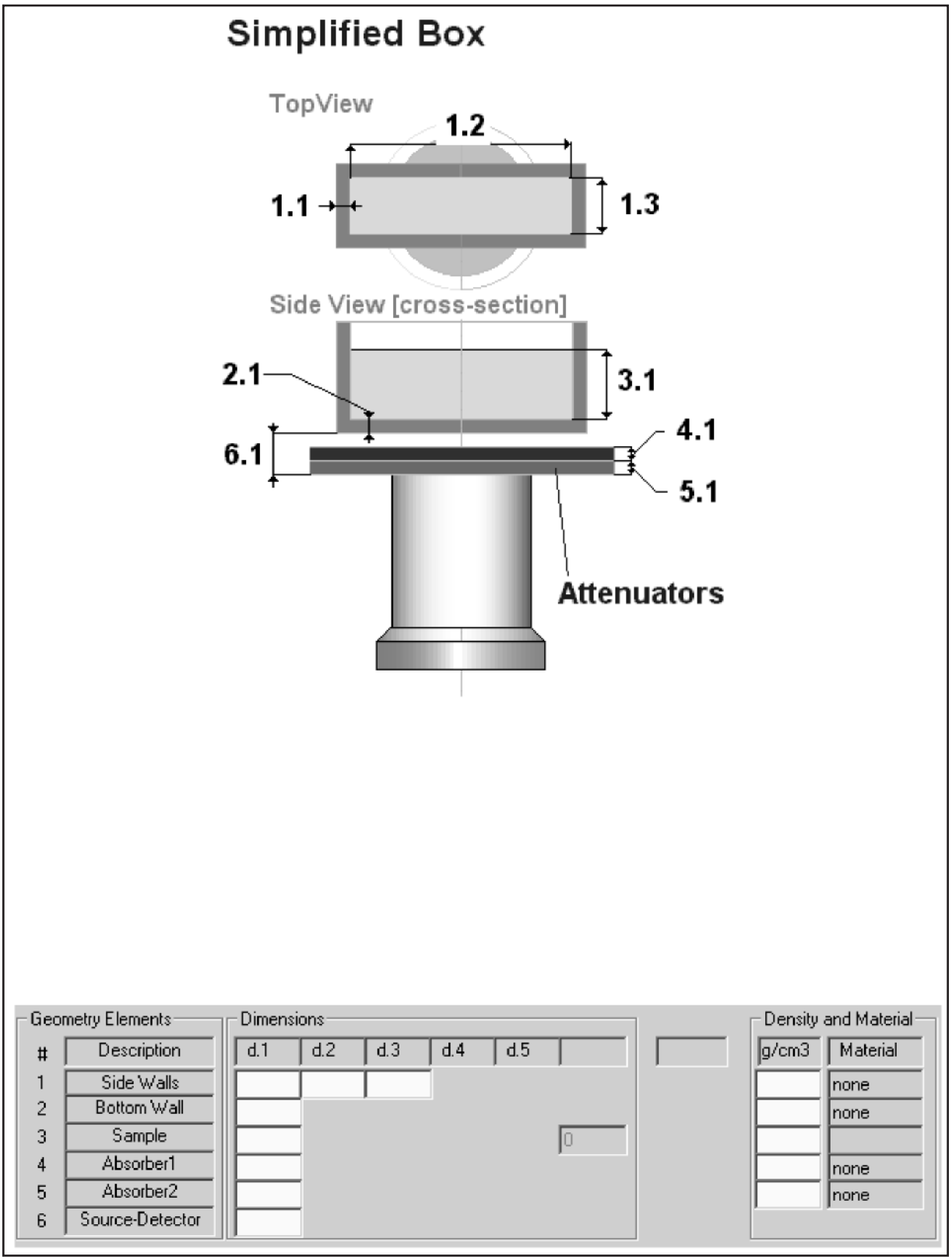
Simplified Beaker



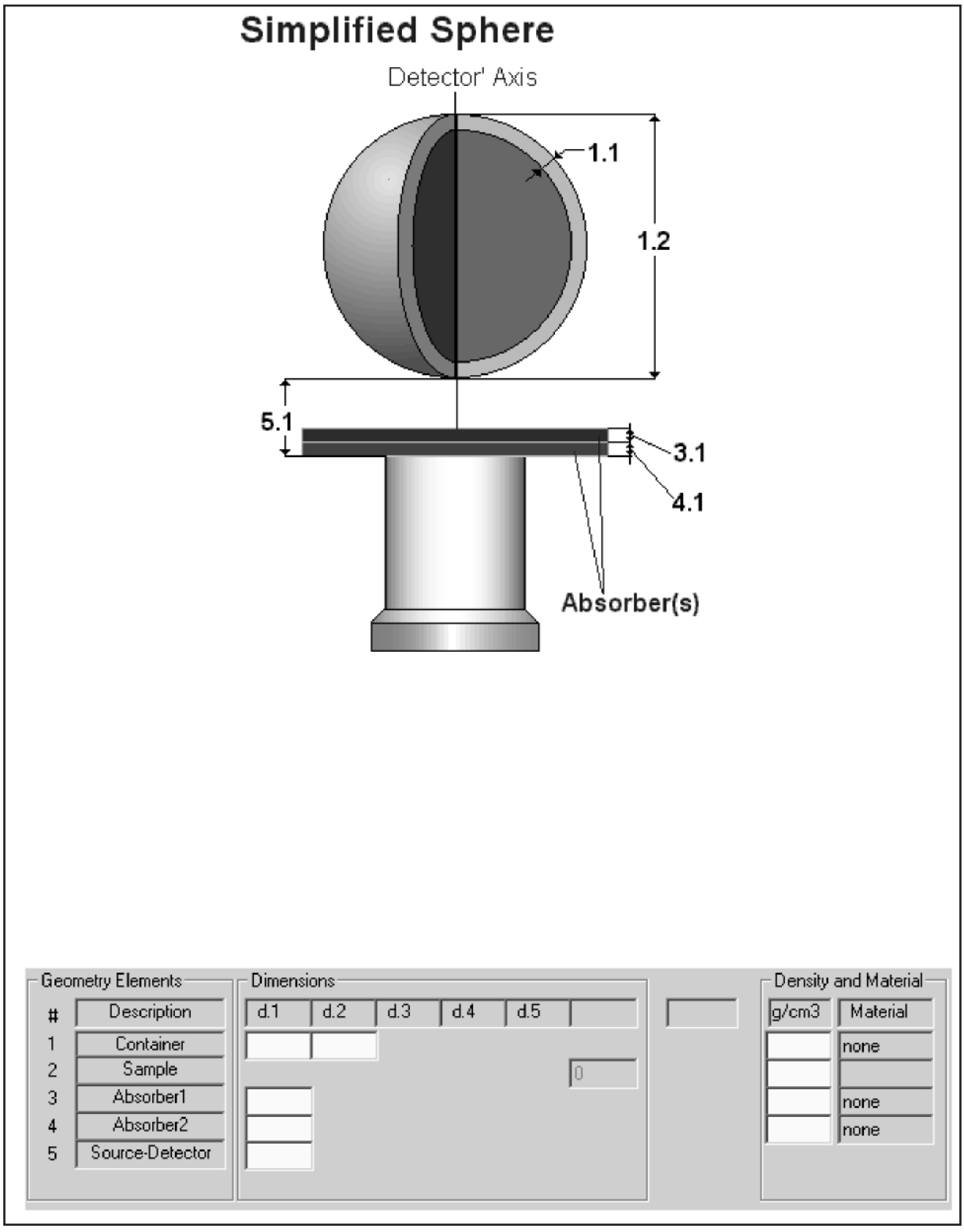
Simplified Marinelli Beaker



Simplified Box



Simplified Sphere



7. Selecting a Generic Detector Characterization

Using Genie-2000 V2.0 and later, measured nuclide activities can be corrected for cascade summing (or true coincidence) losses or gains. To compute the correction factors, the software uses a detector response characterization generated using Canberra's LabSOCS/ISOCS method. For obtaining the highest possible accuracy for cascade summing correction factors, the LabSOCS/ISOCS characterization for the specific HPGe detector should be used in the computations.

However, if a specific LabSOCS/ISOCS characterization isn't available, reasonable accuracy can be obtained by using a suitable generic detector characterization to compute the correction factors. Genie-2000 includes a set of 13 generic ISOCS/LabSOCS detector characterizations. Out of these 13 detector characterizations, 10 are coaxial detectors and three are planar detectors. Table 3 lists these detectors and their nominal dimensions.

Table 3 Generic Detector Characterizations

S. No.	Generic Detector	Diameter (mm)
1	Dia=45mm_Coaxial	45
2	Dia=50mm_Coaxial	50
3	Dia=55mm_Coaxial	55
4	Dia=60mm_Coaxial	60
5	Dia=65mm_Coaxial	65
6	Dia=70mm_Coaxial	70
7	Dia=75mm_Coaxial	75
8	Dia=80mm_Coaxial	80
9	Dia=90mm_Coaxial	90
10	Example	70
11	Dia=60mm_Planar	60
12	Dia=70mm_Planar	70
13	Dia=80mm_Planar	80

The detector named “Example” has been retained from Canberra’s LabSOCS/ISOCS/LabSOCS software distribution. The aspect ratios (Diameter/Length) of the generic coaxial listed in these detectors are in the range of 1.0 ±10%.

Correction Factor vs. Detector Diameter

Canberra has performed a sensitivity analysis to determine the effect of variations in germanium crystal diameter on the cascade summing correction factors. In this analysis, the correction factors were computed for several important nuclides such as ^{60}Co, ^{88}Y, ^{152}Eu, ^{110m}Ag, and ^{82}Br, using a counting geometry that maximized the cascade summing effect. The counting geometry was a point source at the center of the detector endcap. The correction factors were first determined for a reference detector that had been characterized using the ISOCS method. Then, for the same counting geometry and for the same set of nuclides, the cascade summing correction factors were calculated using several ISOCS characterized detectors whose dimensions were increasingly different than that of the reference detector. The correction factors obtained by using these generic detector characterizations were then compared to those obtained using the reference detector characterization. For each generic detector, the biases in the cascade summing correction factors were calculated with respect to the reference detector results.

Canberra recommends that you select a generic detector characterization with a diameter closest to that of the actual detector used in the measurements. Coaxial detector characterizations are provided in 5 mm increments of germanium diameter, except for the GC80 and the GC90, between which there is a 10 mm difference in the diameter. Selecting the appropriate detector ensures that the difference between the diameters of your detector and the generic detector is no more than ±2.5 mm.

Correction Factor vs. Detector Length

The sensitivity of cascade summing correction factors to germanium length was explored using a source geometry that maximized the length dependence. The source was essentially a thin sheet wrapped around the endcap of the HPGe detector. The length of the source was made just larger than the reference HPGe crystal length. For several nuclides of interest, the cascade summing correction factors were obtained by using several ISOCS characterized detectors whose lengths were increasingly different than that of the reference detector.

The diameters of the generic detectors were within ±2.0 mm when compared to that of the reference detector. The correction factors obtained by using these “generic” detector characterizations were then compared to those obtained using the reference detector characterization. For each generic detector, the biases in the cascade summing correction factors were calculated with respect to the reference detector results.

Based on the above analysis, it was determined that, on average, a change of ±12 mm in the crystal length resulted in a ±10% change in the cascade summing correction factor. It must be kept in mind that the estimated sensitivity is a conservative value, since it had been determined for a geometry that maximized the length dependence of the correction factors. For normal laboratory counting geometries and for HPGe detectors whose aspect ratios are not very different from unity, the cascade summing correction factors are far more sensitive to the crystal diameter than the crystal length.

Sensitivity to crystal length could become an issue if you use a planar detector in the measurements, but select a generic coaxial detector characterization (comparable Ge diameters) to compute the correction factors. Planar detectors have a large diameter, but a short length. If a planar detector is used in the measurements, it is recommended that an appropriate generic planar detector characterization be selected. Canberra provides three such generic planar characterizations, corresponding to detector diameters of 60 mm, 70 mm, and 80 mm.

Summary of Recommendations

1. For highest accuracy in cascade summing correction factors, have your specific HPGe detector characterized for LabSOCS/ISOCS. Contact the factory for details.

2. If an HPGe detector with an aspect ratio (Diameter/Length) of 1.0 ±10% is used in the measurements, select a generic LabSOCS/ISOCS characterization that corresponds to a coaxial detector nearest in diameter to that of the specific HPGe detector. Since the generic coaxial detector characterizations have been provided in diameter increments of 5 mm, an appropriately selected generic detector diameter will be within ±2.5 mm of the specific HPGe detector's diameter. This ensures that the bias in cascade summing correction factor is less than ±15%.

3. If a planar detector is used in the measurements, select an appropriate generic planar detector characterization from Table 3.

4. The bias estimates given here are conservative. The counting geometry was chosen so as to maximize the sensitivity of cascade summing correction factor to the detector diameter. It could very well be that the bias is less for your particular counting geometry. Also, for a given counting geometry, the bias varies from one nuclide to the other. And for a given nuclide, the bias in cascade summing correction factor may vary from one gamma ray to the other. Canberra has taken all of these into account in determining a conservative estimate. So, depending on the type of nuclide and the emitted gamma ray that you are considering, the bias in the cascade summing corrections may well be less than 15%. This is assuming that an appropriate generic detector characterization has been chosen (see Table 3).

5. If your application involves using a detector with an aspect ratio significantly less than 1, (i.e., the diameter is much smaller than the length), the bias in the cascade summing correction factor could be greater than 15%. In such cases, Canberra recommends that the detector be ISOCS characterized so that accurate cascade summing correction factors can be computed and applied. Please contact the factory for details on ISOCS characterization.

8. LabSOCS Complex Beaker Template

The Complex Beaker template is designed for laboratory users who require the highest degree of accuracy in their efficiency calibrations. Some containers can be modeled as simple cylinders or cones. For those containers, the Simplified_Beaker feature of the General_Purpose_Beaker template is used to define the sample container. The table in Figure 10 is used by the template to edit the source dimensions.

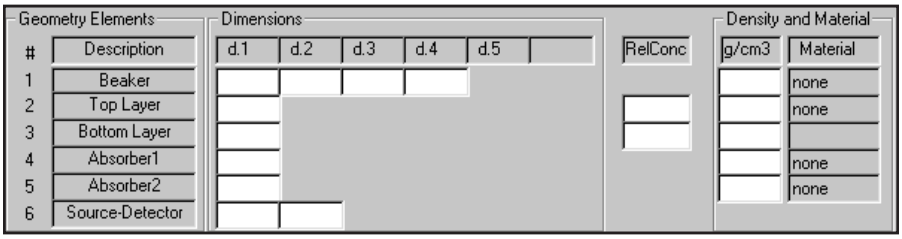


Figure 10 Beaker Template Source Dimension Table

The **Dimensions** entries in Figure 10 have the following meanings:

- Row 1, d.1 – Container side wall thickness.
- Row 1, d.2 – Inside diameter of beaker bottom.
- Row 1, d.3 – Inside diameter of beaker top.
- Row 1, d.4 – Inside height of the beaker.
- Row 2, d.1 – Height of source layer at the top.
- Row 3, d.1 – Height of source layer at the bottom.
- Rows 4-6 have the same meanings as in any other LabSOCS template.

In each row, the ‘Material’ and ‘Density’ entries must be specified. But in Row 1, a material name and a density value need to be specified only if a non-zero wall thickness is indicated for the container. The height of the source layer(s) is measured from the inner surface of the beaker bottom. Figure 11 shows a schematic diagram of a simple conical beaker in front of a germanium detector.

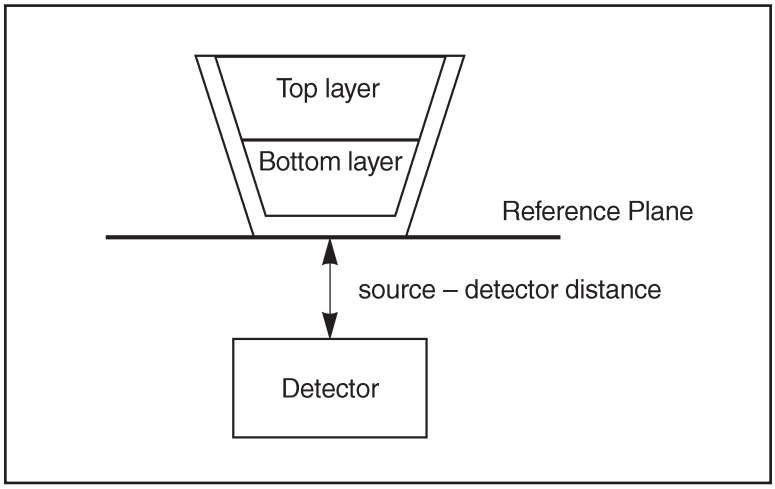


Figure 11 Schematic Diagram of the Source-Detector Geometry

The beaker is assumed to be standing over the reference plane. The Z-axis of the reference plane is required to coincide with the symmetry axis of the beaker. The detector is assumed to be located below the reference plane. The source-detector distance is measured from the beaker reference plane to the center of the plane containing the detector end cap.

Measurement Conventions

The following conventions are used in measuring distances that are input into the beaker templates.

- Every ISOCS/LabSOCS template has a reference plane, from which all detector positions are defined. For the complex beaker template, this is conventionally the surface that rests on the detector endcap, or is suspended above it.
- A line perpendicular to the reference plane is called the Z-axis. The Z-axis is assumed to be vertical [for these descriptions].
- The rotational symmetry axis of the beaker coincides with the Z-axis.
- If the beaker consists of only one source layer (either the top or the bottom), the height of the contents is defined from the lowest point of the inner contour. If both the top and the bottom source layers are present, then the bottom layer is filled from the lowest point of the inner contour, and the top layer is filled from the height where the bottom layer ends.
- The top portion of the sample is always in a plane parallel to the reference plane, perpendicular to the Z-axis.

- The detector is always located below the beaker reference plane. The source-detector distance is measured from the beaker reference plane to the center of the detector end cap, and must always be positive. However, in a source geometry such as a Marinelli Beaker, the source extends below the reference plane and surrounds the detector. Such situations are allowed if the reference plane is defined as the bottom of the Marinelli well. Then the source-detector distance can be zero (detector all the way into the Marinelli well), or can be a positive value (detector not all the way into the well).

However, most containers are neither simple cones nor true right circular cylinders with simple parallel sides, flat bottoms, and square corners. Normal sample containers were not designed for simple mathematical modeling, they were designed for ease of manufacturing, storage, and laboratory use. They have steps or other structural features in the sides, they have rounded corners, and they have concave bottoms. The Complex Beaker feature of the two Beaker templates allows you to model these complex shapes. The Complex Beaker allows the user to accurately describe the shape of most any container that is rotationally symmetric.

The Complex Beaker is selected by either of two similar templates:

- The SIMPLIFIED _BEAKER template is intended for general use. It allows definition of sample quantity by height, volume or mass.
- The GENERAL_PURPOSE_BEAKER template only allows definition of sample quantities via height, but does allow two radioactive sample layers. It also allows the sample axis and detector axis to be displaced (but parallel) by entering a value in dimension 6.2.

To select either of them, open the Geometry Composer, select the template file, then select **complex beaker** in the next dialog box that's displayed.

Displaying Beaker Drawings

Pressing the **Show Template** button will display the drawing of the selected complex beaker with explanations for the various parameters to be entered, as shown in the Wine Glass template in Figure 12. If the Detector has been selected, it will be displayed also.

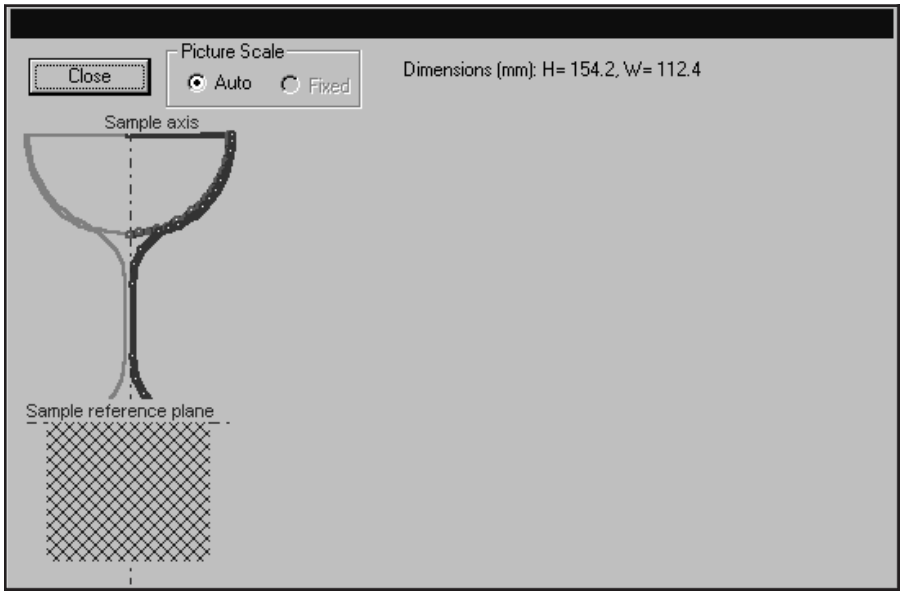


Figure 12 The Wine Glass Template (winegls.bkr).

Displaying the Specified Container Shape

The overall diameter or width (w, in mm) and height (h, in mm) is printed at the top. The inner and the outer contours are displayed, along with the nodal points. The blue circles represent the nodes of the outer contour, and the green circles represent the nodes of the inner contour.

Predefining the Container Descriptions

For any frequently used custom container, that is rotationally symmetric relative to its central axis, users have the option of predefining a customized beaker description file. This file will contain a formatted description of the container dimensions, material(s), and density value(s). The beaker description files are simple text files, to be created and edited using a standard text editor such as Notepad. Special text formatting (such as **bold** or *italicized* characters) is not permitted in these files.

All customized beaker description files must be saved with a filename extension of .BKR. The predefined *.BKR files may be stored in any folder, but for convenience they should be saved in the following directory locations:

\ISOCS\Data\Laboratory\Geometry\SIMPLIFIED_BEAKER, and

\ISOCS\Data\Laboratory\Geometry\GENERAL_PURPOSE_BEAKER.

Beaker Description File Format

Each beaker definition file must include parameters that properly specify a valid inner contour or a valid combination of inner and outer contours. A “contour” consists of a chain of contiguously connected straight-line fragments. A “fragment” is a line segment, limited by two endpoints or “nodes” with the coordinates (D1, H1) and (D2, H2). The coordinates (D1, H1) are the diameter and height respectively of the beginning node of a fragment and the coordinates (D2, H2) are the diameter and height respectively of the end node of that same fragment.

Since the coordinate D represents a ‘diameter’, it is twice the perpendicular distance of a given node from the beaker symmetry axis (the radius). D is always ≥ 0 with D=0 indicating a point on the beaker symmetry axis. The coordinate H is the ‘height’ (or perpendicular distance) of a given node relative to the beaker reference plane. For definitions of the reference plane and the coordinate system, refer to “Measurement Conventions” on page 467. For a node on the reference plane H=0. For nodes above the reference plane H is positive, while for nodes below the reference plane H is negative.

The straight-line fragments used to define the dimensions of the container are categorized as one of three types: outer contour, inner contour, and boundary. The proper fragment type must be identified for each fragment in the beaker definition file, by explicitly including the appropriate fragment “ID” code: ‘o’ (for outer contour), ‘i’ (for inner contour), and ‘b’ (for boundary). The total number of all fragments (including outer contour, inner contour, and boundary fragments) in a beaker description file cannot exceed 200.

Multiple fragments of the same type (outer contour, inner contour, or boundary) must be defined in a contiguous manner so that they form a connected chain. The fragments may be defined in a clockwise or counter-clockwise order, as long as the convention selected is maintained consistently for all chained fragments of all fragment types in the beaker definition file. (In the case of boundary fragments it is possible to define a single isolated fragment in which case the order in which the two nodes are defined does not matter.)

The text entries in a *.BKR beaker description file can include one or more lines of the following four types:

- Comment line (optional, but frequently useful)
- Outer contour fragment line (not absolutely essential, but generally used for typical containers)
- Inner contour fragment line (required)
- Boundary fragment line (required if a contour is made up of more than one material)

The following row formats are required for each text entry line in the beaker description file. Please note that commas are required as separators between entries including cases where the entry is intentionally left blank.

Required Format for Comment Lines

any characters <CRLF>

The # symbol is required as the first character in the line to identify a comment line. Comment lines are intended for documentation purposes only, and do not affect the make-up of the beaker.

Required Format for Inner and Outer Contour Fragments Lines

beginning node D_1, beginning node H_1, end node D_2, end node H_2, contour ID, material name, density <CRLF>

The parameters above must be separated by commas as shown. The “Tab” key and/or blank space(s) can be used as additional separators between these entries, if desired.

The D and H values are the diameter and height coordinates of the nodes as discussed earlier. The units for D and H are millimeters (mm). The contour ID is ‘o’ for a fragment on the outer contour and ‘i’ for a fragment on the inner contour. Both the inner and outer contour must start with a line segment that has D_1=0 and finish with a line segment that has D_2=0. So a contour must begin and end on the beaker symmetry axis.

Material names have a maximum limit of eight characters, and must be previously defined in the ISOCS/LabSOCS materials library file. Density values must be entered in units of grams per cubic centimeter (g/cc). Lines defining fragments with the same material name but different densities are considered to be fragments of two different materials. This is relevant when defining boundary fragments.

Required Format for Boundary Fragment Lines

beginning node D1, beginning node H1, end node D2, end node H2, b <CRLF>

Boundary fragment entries are required whenever the outer and/or inner contours are made up of more than one material. A boundary node must then be chosen at the point where two adjacent fragments on a contour are made up of different materials. Materials are considered different even if they have the same molecular composition but different densities (e.g. cellulos with density 0.40 g/cc is considered a different material than cellulos with density 0.50 g/cc). There is a maximum limit of eight different material/density combinations that can be included in any single beaker definition file, with each different combination separated by a properly defined boundary.

A boundary can be either a single straight-line fragment or a series of straight-line boundary fragments that are chained together in a contiguous manner. A single straight-line boundary fragment must connect a node on the outer contour with a node on the inner contour. Any boundary defined as a set of chained boundary fragments must also ultimately connect a node on the outer contour (at one endpoint of the chain) with a node on the inner contour (at the other endpoint of the chain).

Additional Text Line Format Options in Beaker Description Files

In the first text line used to define either an outer contour or an inner contour fragment, a valid material name and density value must be explicitly entered. However, in one or more subsequent outer contour and/or inner contour fragment lines, the material name and density value can be specified as identical to the previous 'default' material by leaving the entries blank provided the commas are still used as delimiters. The 'default' material will then be assumed for each fragment until the next explicit entry of a different material name and/or density value.

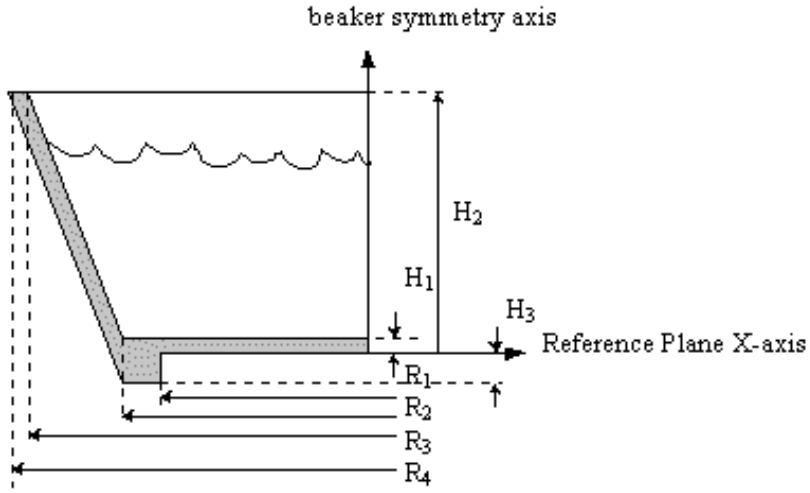
Text lines for comments, outer contour fragments, inner contour fragments, and boundary fragments can be ordered in any sequence within the beaker description file, provided that for each contour the fragments follow a contiguous chain. Grouping together all fragments of similar type is recommended, however, for ease of reviewing and making changes to the *.BKR file.

Examples of a User's File Defining a Beaker

In the following examples of beaker configuration files, the dimensions shown as 'R' in the diagrams denote the radius at which a given node is located with respect to the central axis of the container. In the *.BKR file, however, the corresponding diameter (D = 2R) must be entered rather than the radius.

Example 1

Beaker used as a typical injection molded container (axial cross section shown)



User's File Definition for the Beaker in Example 1

#a typical injection molded container

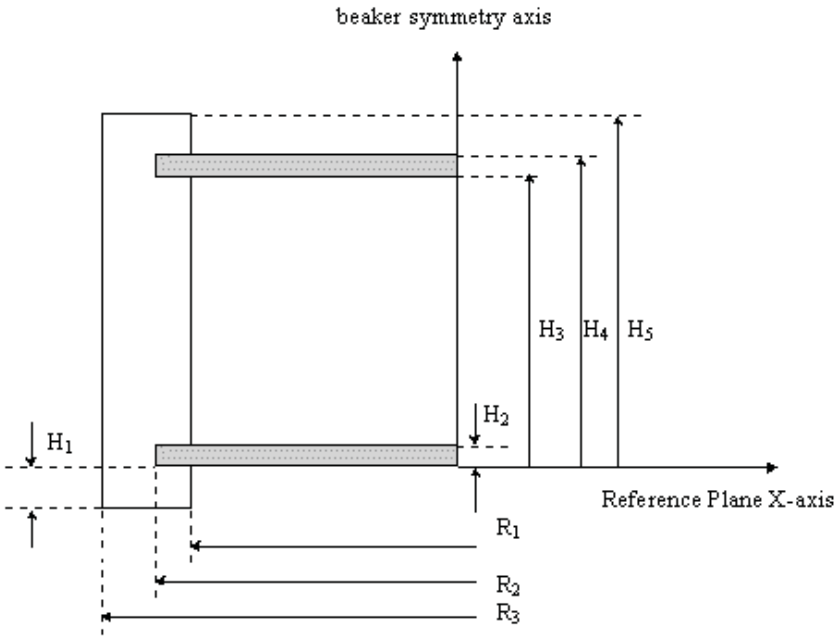
#Clockwise ordering of fragments

# Ds	Hs	De	He	Id	material name	density value
#==========						
# outer contour						
0,	0,	D_1,	0,	o,	lpolyeth,	0.92
D_1,	0,	D_1,	$-H_3$,	o,	,	
D_1,	$-H_3$,	D_2,	$-H_3$,	o,	,	
D_2,	$-H_3$,	D_4,	H_2,	o,	,	
D_4,	H_2,	0,	H_2,	o,	,	
# inner contour						
0,	H_1,	D_2,	H_1,	i,	,	
D_2,	H_1,	D3,	H_2,	i,	,	
D_3,	H_2,	0,	H_2,	i,	,	

#end of file

Example 2

Container for sampling gas/air particulate filter samplers (axial cross section shown)



User's File Definition for the Beaker in Example 2

#container for sampling gasses and air particulate filter samples

#clockwise ordering of fragment

# Ds	Hs	De	He	Id	material name	density value
# ==========						
# outer contour						
0,	0,	D_1,	0,	o,	lpolyeth,	0.92
D_1,	0,	D_1,	$-H_1$,	o,	csteel,	7.86
D_1,	$-H_1$,	D_3,	$-H_1$,	o,	,	
D_3,	$-H_1$,	D_3,	H_5,	o,	,	
D_3,	H_5,	D_1,	H_5,	o,	,	
D_1,	H_5,	D_1,	H_4,	o,	,	
D_1,	H_4,	0,	H_4,	o,	lpolyeth,	0.92
# inner contour						
0,	H_2,	D_1,	H_2,	i,	,	

D_1, H_2, D_1, H_3, i, csteel, 7.86

D_1, H_3, 0, H_3, i, lpolyeth, 0.92

boundary fragments

D_1, 0, D_2, 0, b

D_2, 0, D_2, H_2, b

D_2, H_2, D_1, H_2, b

D_1, H_3, D_2, H_3, b

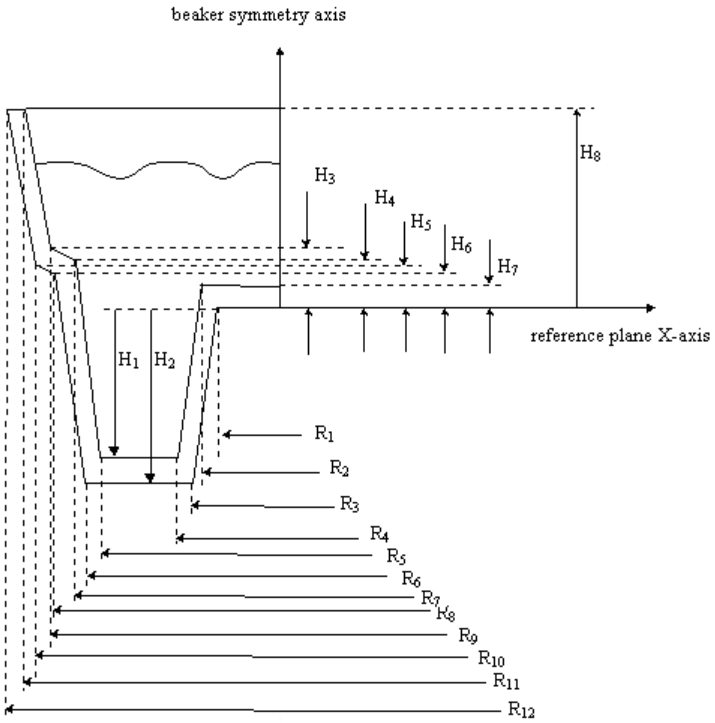
D_2, H_3, D_2, H_4, b

D_2, H_4, D_1, H_4, b

#end of file

Example 3

Complex Marinelli beaker (axial cross section shown)



User's File Definition for the Beaker in Example 3

```
# complex Marinelli beaker
#clockwise ordering of fragments
#  Db     Hb     De     He     ID     material name     density value
#  ================================================
# outer contour
   0,     0,     D1,    0,     o,     lpolyeth,         0.92
   D1,    0,     D3,    -H2,   o,     ,
   D3,    -H2,   D6,    -H2,   o,     ,
   D6,    -H2,   D8,    H6,    o,     ,
   D8,    H6,    D10,   H5,    o,     ,
   D10,   H5,    D12,   H8,    o,     ,
```

D_{12}, H_8, 0, H_8, o, ,

inner contour

0, H_7, D_2, H_7, i, ,

D_2, H_7, D_4, $-H_1$, i, ,

D_4, $-H_1$, D_5, $-H_1$, i, ,

D_5, $-H_1$, D_7, H_4, i, ,

D_7, H_4, D_9, H_3, i, ,

D_9, H_3, D_{11}, H_8, i, ,

D_{11}, H_8, 0, H_8, i, ,

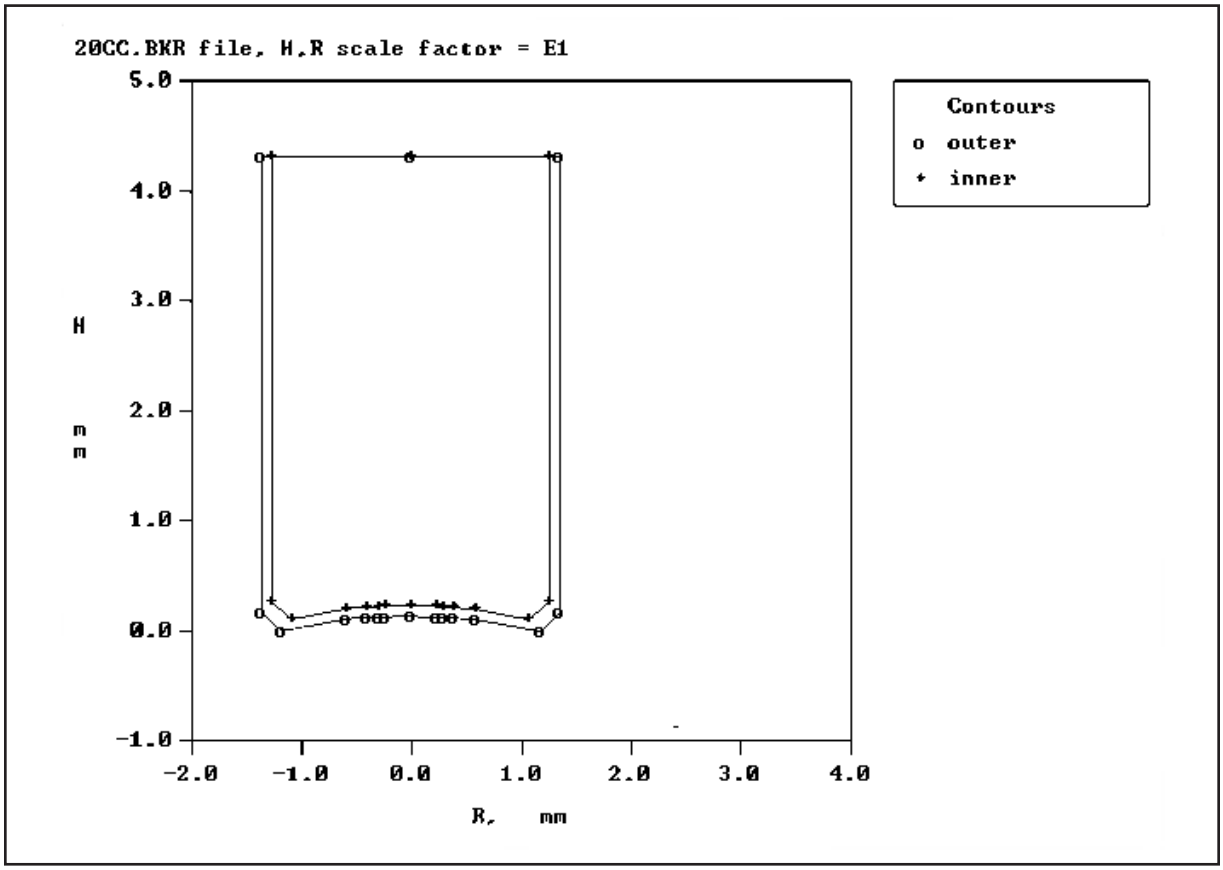
#end of file

Predefined Beaker Files

Laboratories routinely measure radioactive sources contained within standard containers. A set of six files describing six standard laboratory containers are distributed along with the LabSOCS software. The distributed beaker files are for the following containers:

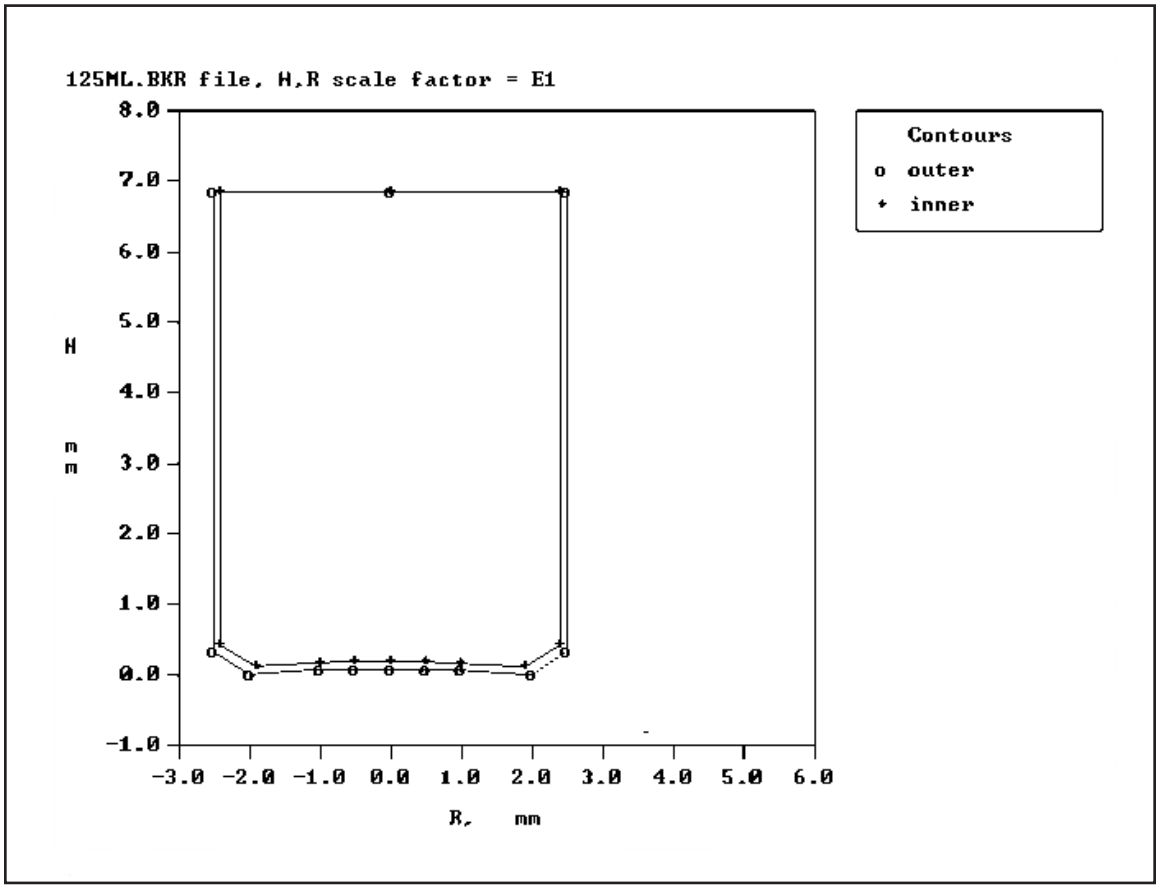
1. A 20 cc Liquid Scintillation Vial (20cc.BKR)
2. A 125 mL Nalgene Bottle (125ml.BKR)
3. A 1 liter GA-MA 130G Marinelli Beaker (130g.BKR)
4. A 1 liter GA-MA 138G Marinelli Beaker (138g.BKR)
5. A 4 liter GA-MA 430G Marinelli Beaker (430g.BKR)
6. A 500 mL GA-MA 590G Marinelli Beaker (590g.BKR)
7. A container in the shape of a wine glass to demonstrate that any rotationally symmetric, arbitrary shaped container can be described in LabSOCS (winegls.BKR).

The LabSOCS drawings for the seven containers are attached, along with information regarding the manufacturers/suppliers of these standard containers.



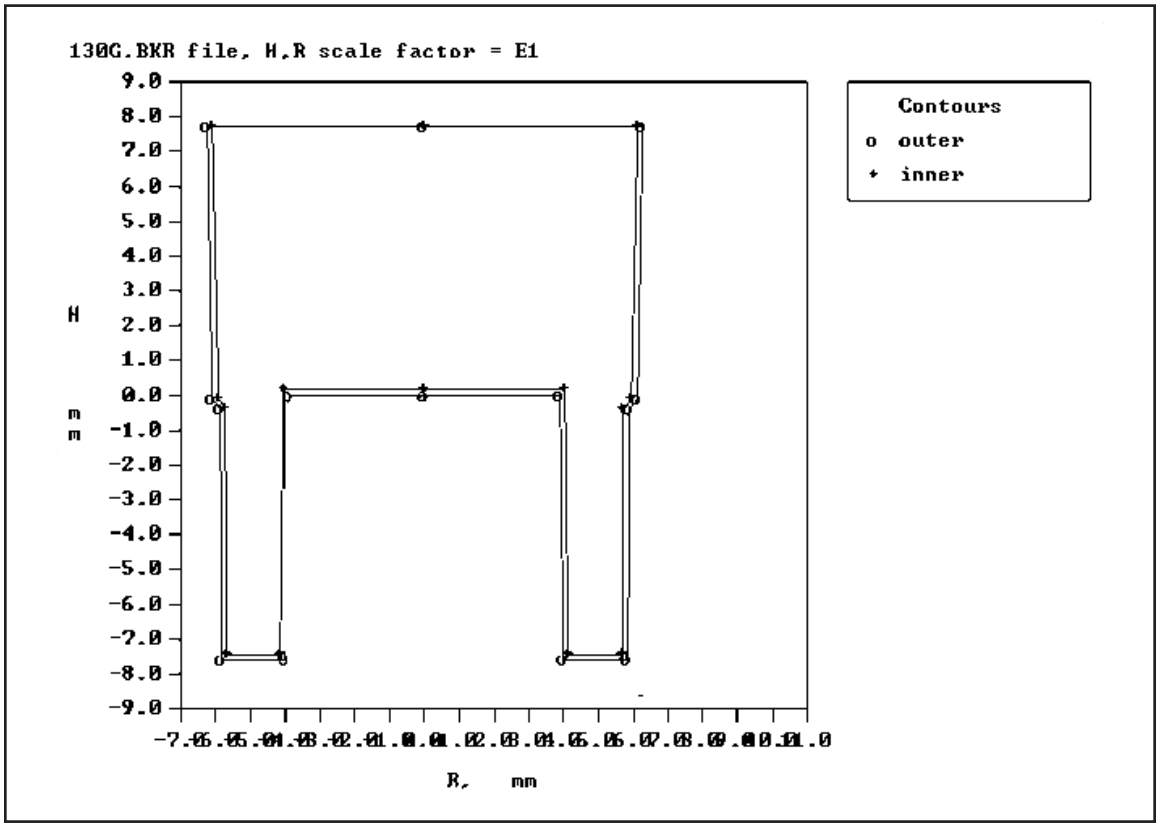
This file consists of dimensions for a 20 cc Liquid Scintillation Vial. Packard BioScience Company manufactures LSC vials of various types. The Order Number for the LSC vial shown in this drawing, is 6001085. For more information, contact:

Packard BioScience Company
800 Research Parkway
Meriden, CT 06450
Phone: (203) 238-2351



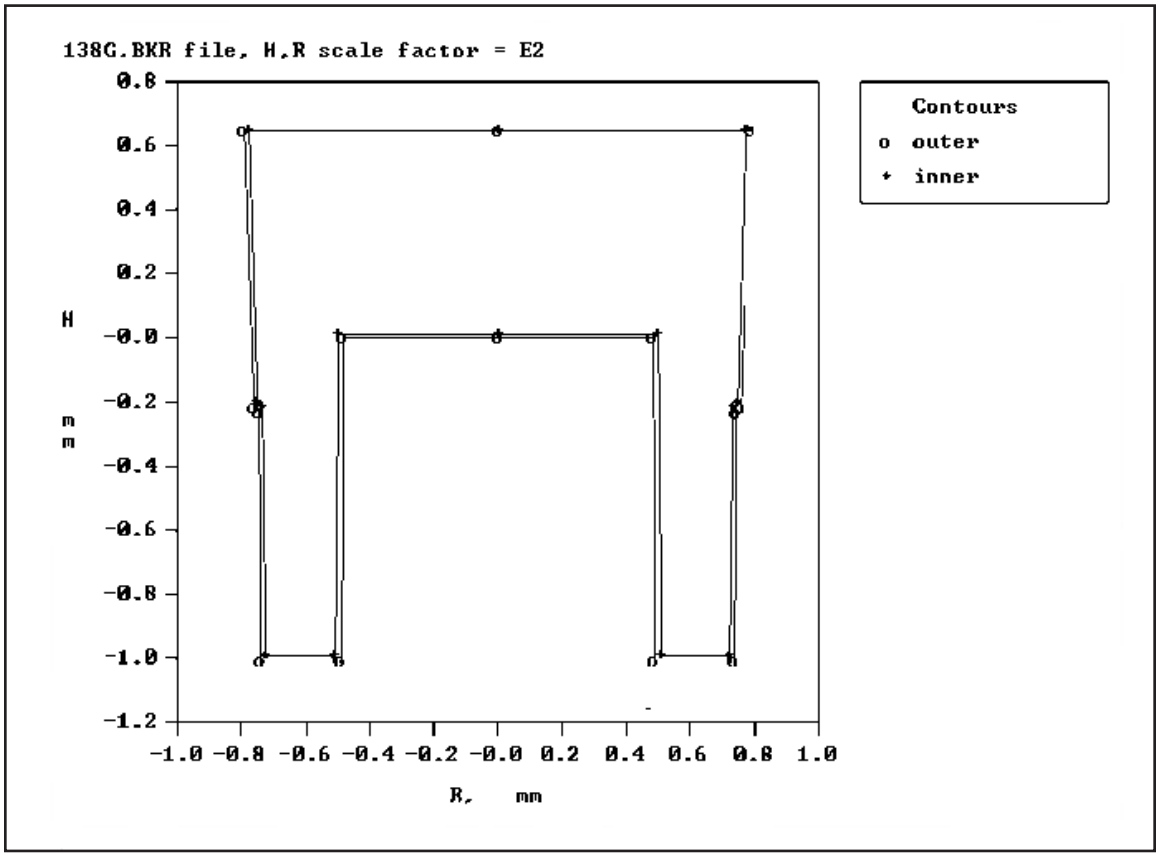
This file consists of dimensions for a 125 mL wide-mouth Nalgene bottle. The part number is 37275LK.

For more information contact a Nalgene products distributor (such as Consolidated Plastics Company, Inc., 8181 Darrow Road, Twinsburg OH 44087, 1-800-362-1000).



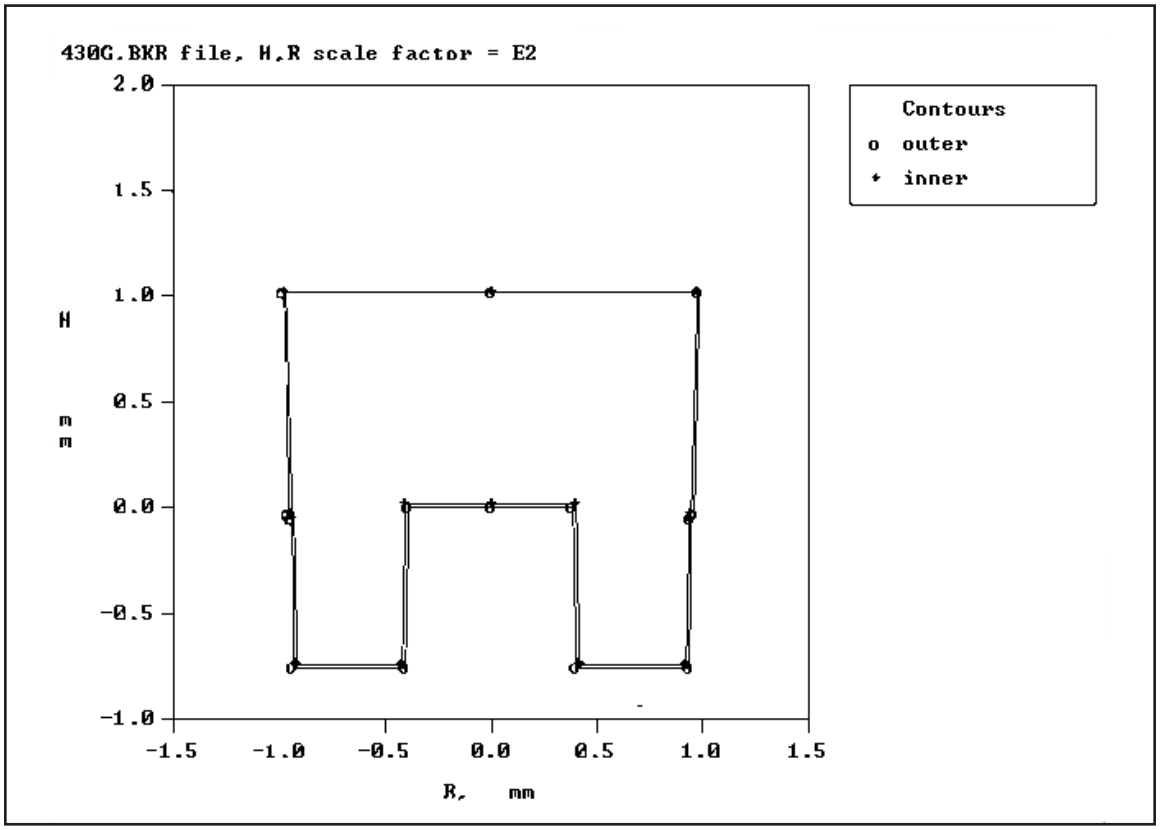
This file consists of dimensions for a 1 liter GA-MA Marinelli Beaker with a well I.D. of 77.6 mm. The container (product number 130G) is manufactured by:

GA-MA & Associates, Inc.
P.O.BOX 2918
Ocala, FL 34478-2918
Phone: (352) 687-8840



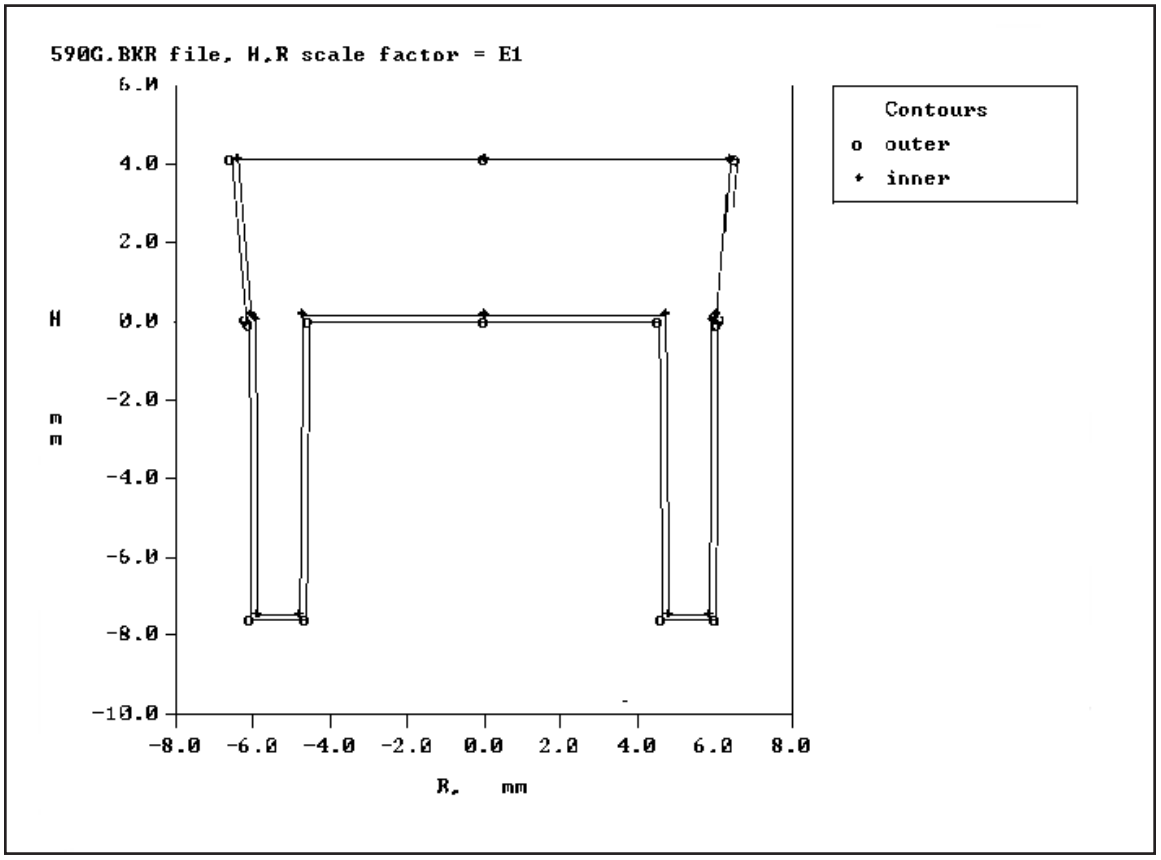
This file consists of dimensions for a 1 liter GA-MA Marinelli Beaker with a well I.D. of 96.6 mm. The container (product # 138G) is manufactured by:

GA-MA & Associates, Inc.
P.O.BOX 2918
Ocala, FL 34478-2918
Phone: (352) 687-8840



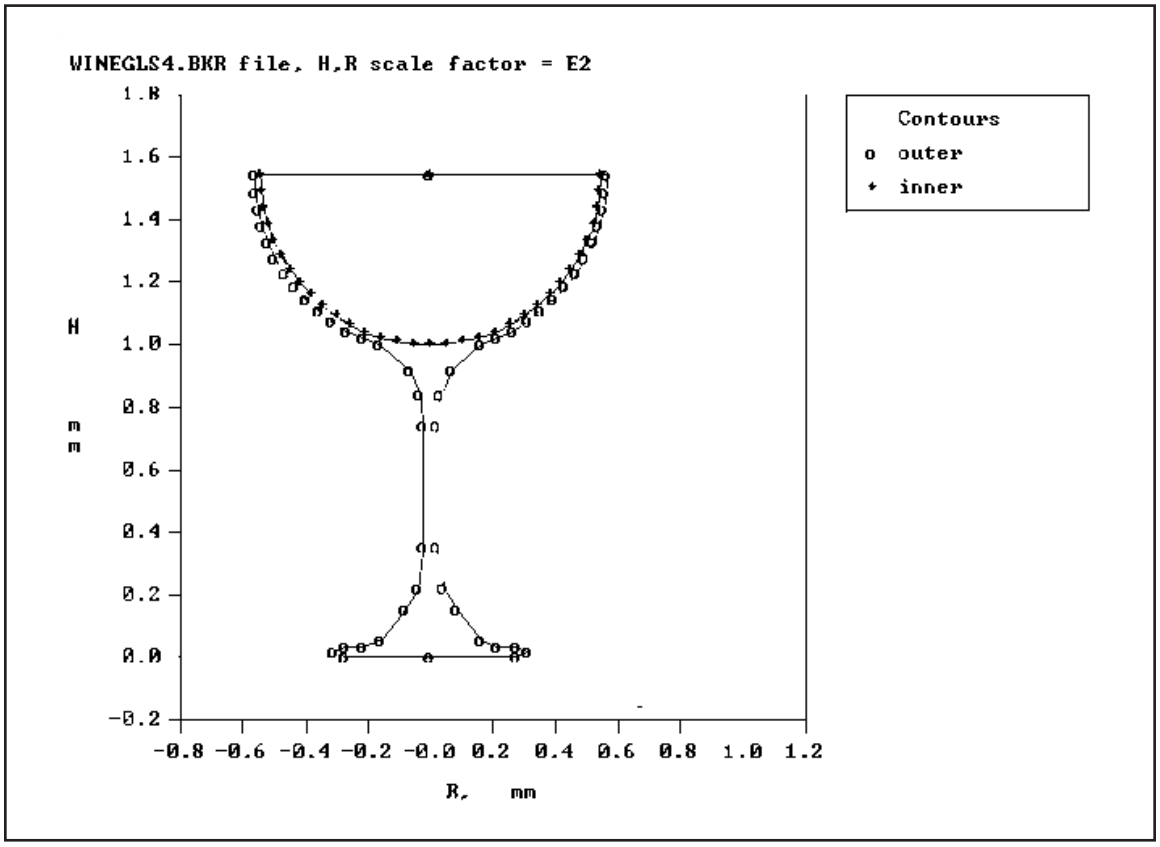
This file consists of dimensions for a 4 liter GA-MA Marinelli Beaker with a well I.D. 77.7 mm. The container (product # 430G) is manufactured by:

GA-MA & Associates, Inc.
P.O.BOX 2918
Ocala, FL 34478-2918
Phone: (352) 687-8840



This file consists of dimensions for a 500 mL GA-MA Marinelli Beaker with a well I.D. of 91.2 mm. The container (product # 590G) is manufactured by:

GA-MA & Associates, Inc.
P.O.BOX 2918
Ocala, FL 34478-2918
Phone: (352) 687-8840



This file consists of dimensions for a wine-glass shaped container. The origin is at the base of the wine glass. The LabSOCS Beaker template can be used to configure any rotationally symmetric, arbitrary shaped container.

9. LabSOCS/ISOCS Technical Notes

The following are extended explanations of some of the elements of the software.

Note: ISOCS and LabSOCS use the same software core executables. Only the templates and user interfaces are different. All statements here apply equally to both ISOCS and LabSOCS.

Technical Note 1

Technical Note 1 includes Massimetric Efficiency, the Efficiency*Area Calibration option, and the Efficiency*Length Calibration option.

Massimetric Efficiency

Traditional efficiency units are [counts per second]/[gammas per second emitted]. Select “Efficiency” if you want to use those units. The traditional units are appropriate for small samples, and where the end result desired is activity per sample.

Massimetric efficiency units are defined as [counts per second detected]/[gammas per second emitted *per gram of sample*]. Mathematically, this is the product of traditional efficiency and the mass of the sample.

With the traditional efficiency, as the sample size increases, the mass of the sample increases linearly, but the efficiency decreases from self-absorption effects and from geometrical effects. But, as long as you can measure a sample in the same geometry as you calibrated, the answer is correct. If you want to express the result in concentration [activity/gram], simply divide by the weight of the sample.

Massimetric efficiency is best used for very large [infinitely large] samples. When the efficiency is expressed this way, the efficiency asymptotically approaches a constant value as the sample becomes very large. This means that the sample is “infinitely large.” Under these conditions changes in sample size have little effect on the sample efficiency.

As an example, consider the case of *in situ* gamma spectroscopy of soil, where the detector is placed 1 meter above the ground. This data was computed with ISOCS, using a 42% coaxial detector. The soil had a constant thickness of 1.6 g/cc. the variable was the sample diameter. Figure 13 shows the traditional efficiency as a function of diameter.

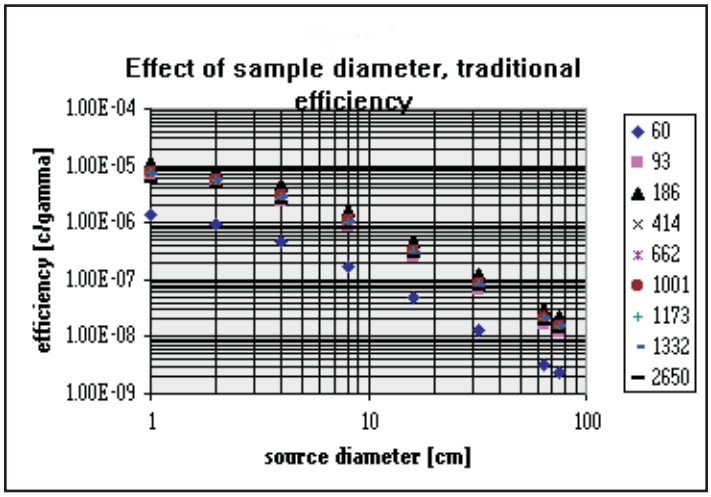


Figure 13 Effect of Sample Diameter, Traditional Efficiency

Figure 14 shows the massimetric efficiency as a function of diameter.

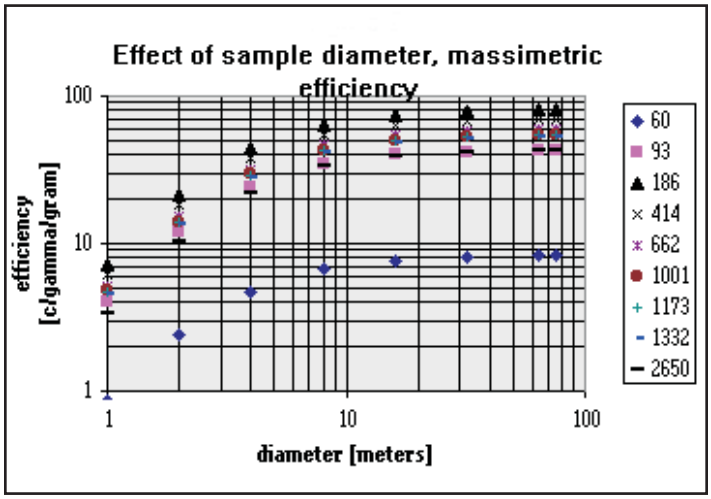


Figure 14 Effect of Sample Diameter, Mass Efficiency

Note The massimetric efficiency approaches a nearly constant value at 20 m for low energies, and 40 m for high energies. This is better illustrated in Figure 15, in which each efficiency is divided by the efficiency for the 75 m diameter source. For all diameters greater than approximately 20-40 m, the massimetric efficiency is the same.

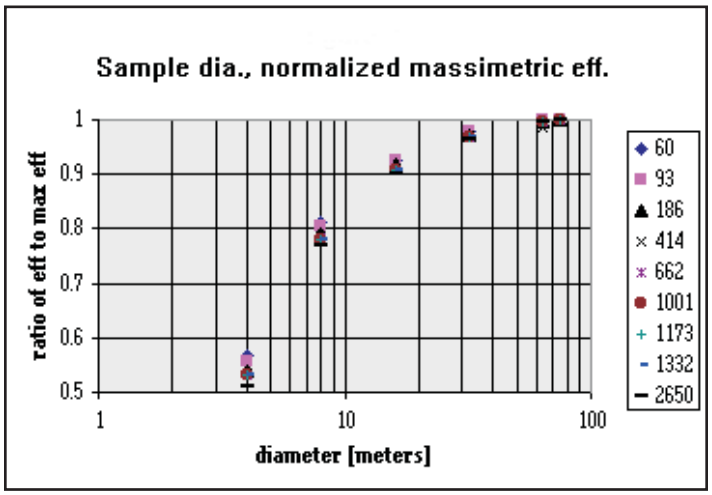


Figure 15 Sample Diameter, Normalized Massimetric Efficiency

Now, for the same *Insitu* situation, the next test holds the diameter constant at 75 m and the density constant at 1.6 g/cc, and only the sample thickness is varied. Figure 16 shows how the traditional efficiency calibration changes.

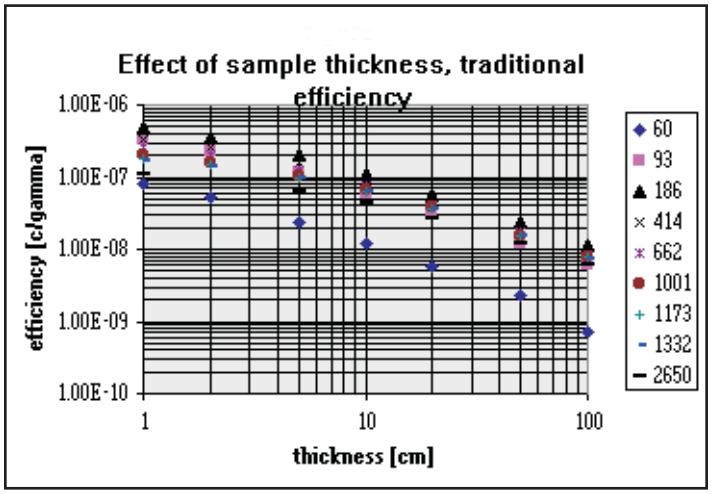


Figure 16 Effect of Sample Thickness, Traditional Efficiency

Figure 17 is the massimetric efficiency. Again, the efficiency approaches an asymptotic value at the “infinite” thickness.

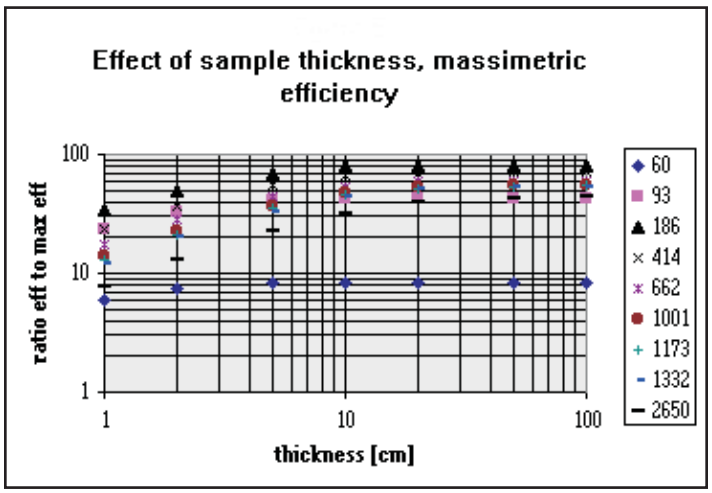


Figure 17 Effect of Sample Thickness, Massimetric Efficiency

Figure 18 is the normalized massimetric efficiency, with the data normalized to the 100 cm value. For an energy of 60 keV, infinite thickness is reached at 4-5 cm, but at 2650 keV it takes 40-50 cm.

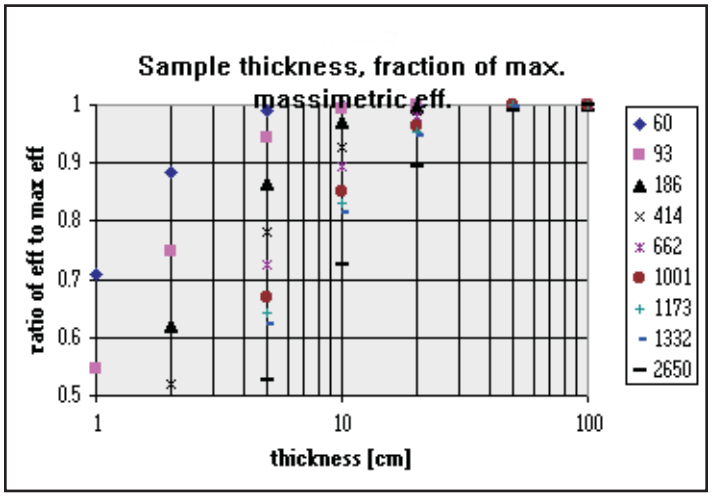


Figure 18 Sample Thickness, Fraction of Maximum Massimetric Efficiency

Finally, Figures 19 and 20 show the effects of density on the same *InSitu* counting situation. The diameter is constant at 75 m and the thickness is constant at 50 cm, while the density is varied. Again, note the large changes in the traditional efficiency, and the minimal changes in the massimetric efficiency.

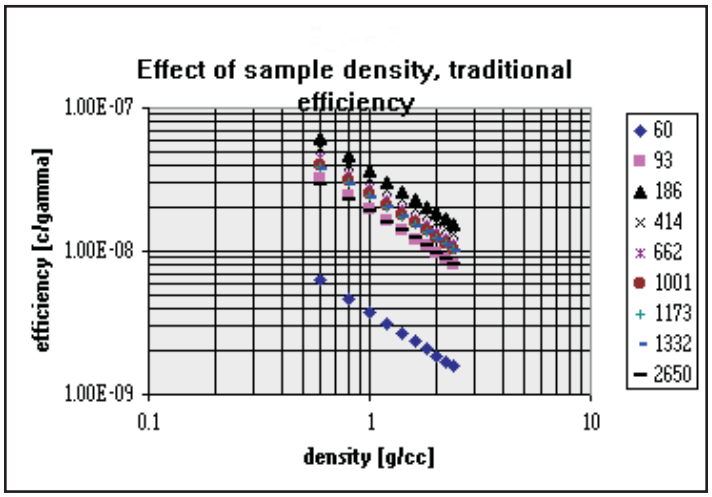


Figure 19 Effect of Sample Density, Traditional Efficiency

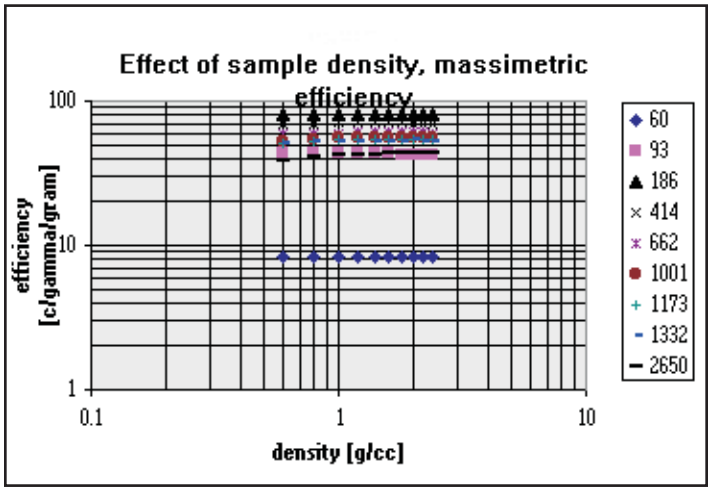


Figure 20 Effect of Sample Density, Massimetric Efficiency

Figure 21 shows the normalized massimetric efficiency, with the data normalized to 1.6 g/cc. Here, there is essentially no change in efficiency for approximately a factor of 2 change in sample density, even at high energies.

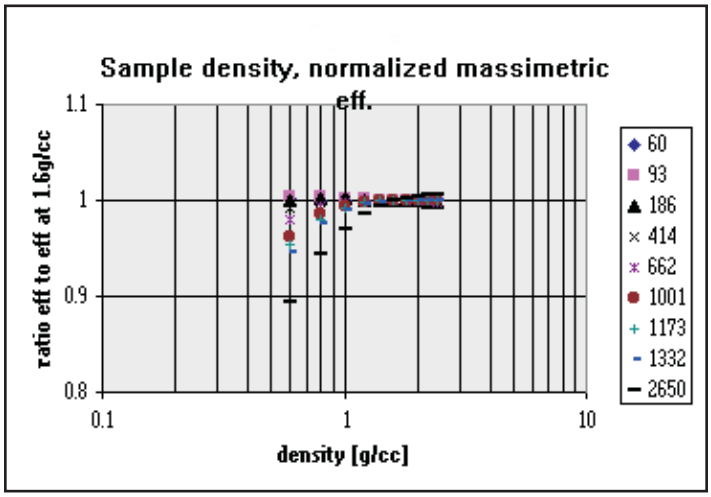


Figure 21 Sample Density, Normalized Massimetric Efficiency

Now consider the case of a Marinelli beaker. The sample under consideration is dirt, at a density of 1.6 g/cc. For the first cases, the size of the beaker was systematically increased. The internal well had fixed dimensions of 10 cm diameter and 10 cm length. The variables were the detector sidewall dimensions (i.e. the sample thickness at the side of the detector), and the sample thickness of the dirt above the endcap of the detector. Both were kept equal. The data was plotted as a function of Marinelli beaker sample mass (Figure 22).

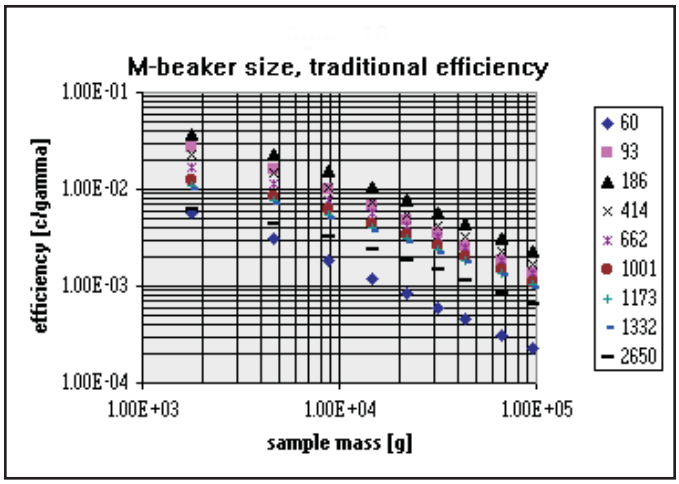


Figure 22 M-Beaker Size, Traditional Efficiency

Here, since the sample thickness is small compared to the infinite thickness, there is some variation in the massimetric efficiency, but not as much as in the traditional efficiency (Figure 23). In this example, we want to select a Marinelli beaker with the best sensitivity. And since this is an InSitu measurement project we are simulating, these measurements are done out in the field where there is plenty of dirt. But, it is really inconvenient to carefully weigh out each sample. Is that really necessary? Not if the sample chamber is optimized and if we are using massimetric efficiency calibrations.

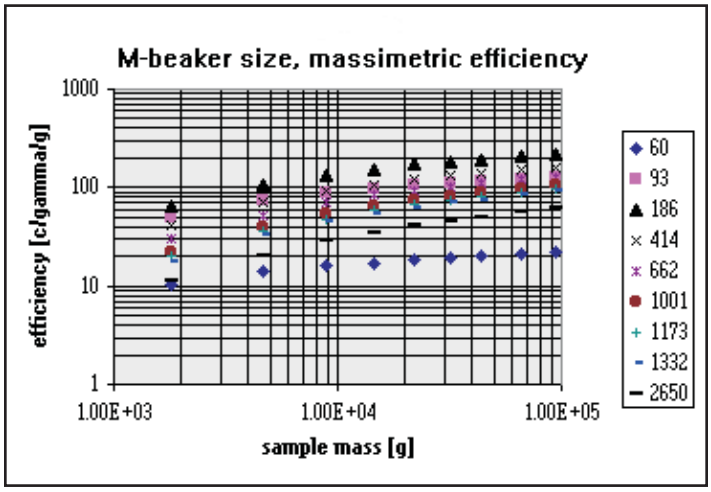


Figure 23 M-Beaker Size, Massimetric Efficiency

Figures 24 and 25 show data for a Marinelli beaker with 20 cm as the distance between the endcap and the sidewall of the container, and 20 cm as the normal fill height above the endcap. The variable is the actual fill height.

Here again, for the massimetric efficiency, there is less variation in efficiency as the container fill height is changed.

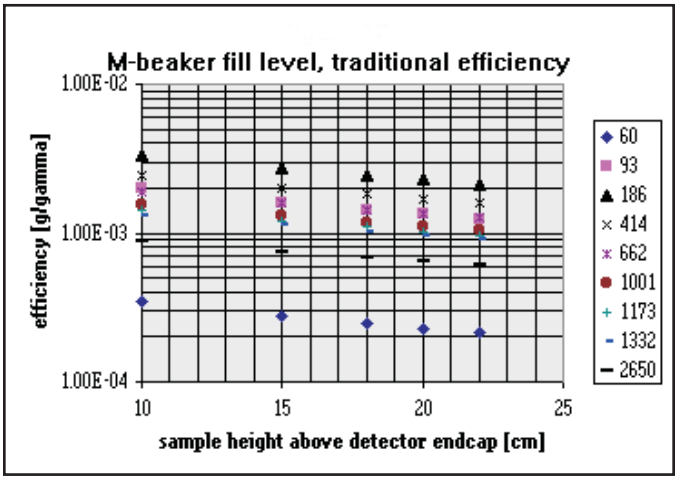


Figure 24 M-Beaker Fill Level, Traditional Efficiency

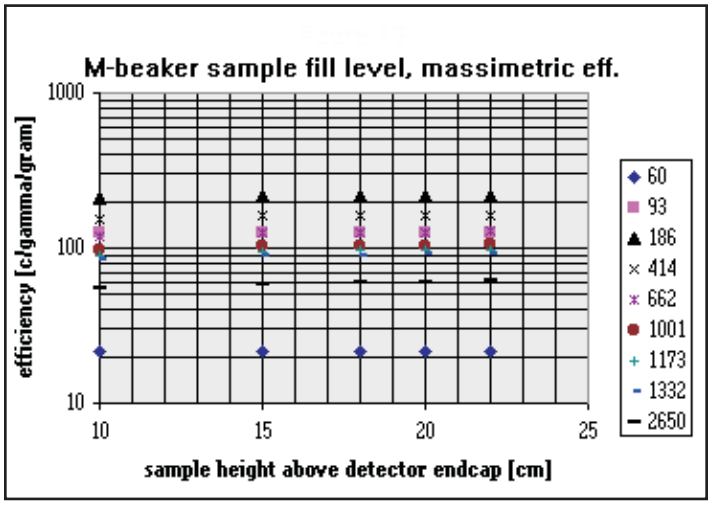


Figure 25 M-Beaker Sample Fill Level, Massimetric Efficiency

Figure 26 and 27 present the same data, but normalized to a standard “calibrated” fill height of 20 cm.

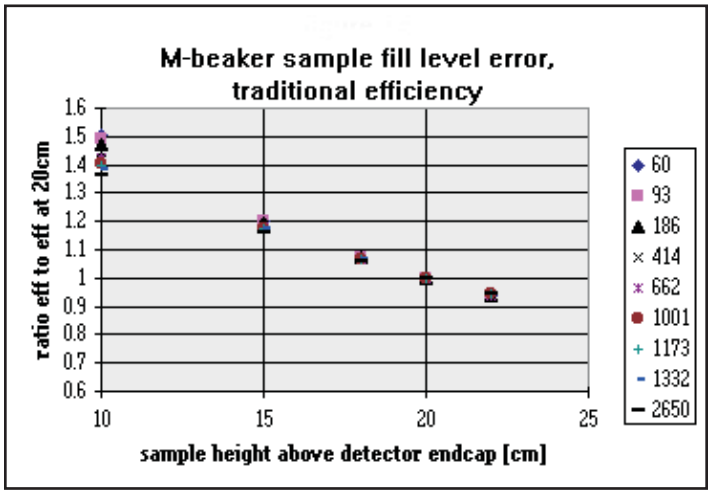


Figure 26 M-Beaker Sample Fill Level Error, Traditional Efficiency

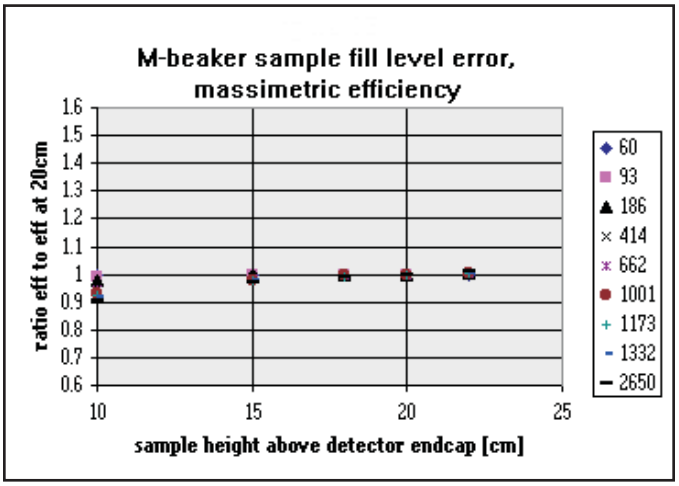


Figure 27 M-Beaker Sample Fill Level Error, Massimetric Efficiency

The Efficiency*Area Calibration Option

After the calculation is completed, the Efficiency*Area mode can be selected for creating the efficiency CAM file (Figure 28).

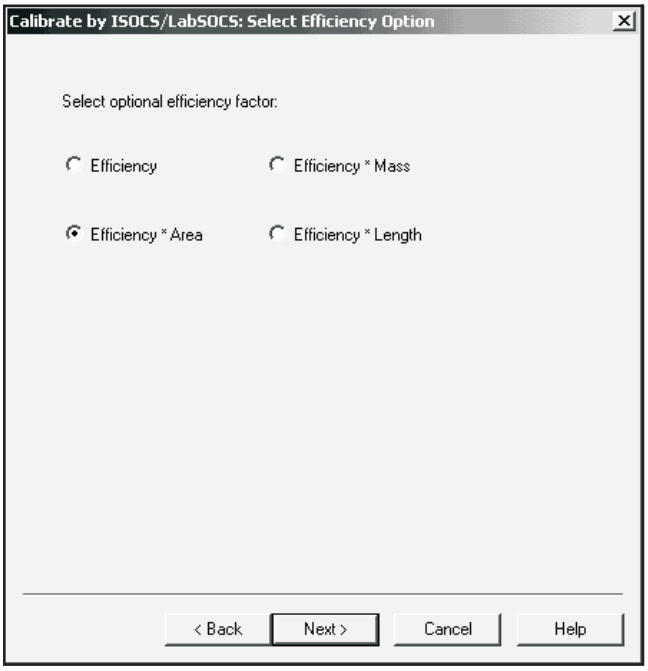


Figure 28 Select Efficiency Option

When the resulting Efficiency*Area calibration file is used in the analysis of a gamma ray spectrum, the nuclide activities will be reported in units of Activity/m^2. For example, in applications involving *in situ* soil counting, total inventory of radioactivity is usually reported in the units Activity/m^2 integrated to an "infinite" soil depth.

The product Efficiency*Area behaves in the same manner as the massimetric efficiency. As the surface area of the sample is increased, the Efficiency*Area increases initially, and as the sample area becomes infinitely large, the Efficiency*Area asymptotically reaches a constant value. As an example, an *in situ* soil counting geometry modeled using the Exponential Circular Plane template is discussed. The relaxation length of the exponential distribution was chosen to be 10 cm. The source layer thickness was set at 30cm, a value close to "infinite depth". The density of the soil matrix was set at 1.6 g/cc. The Efficiency*Area was calculated by progressively increasing the sample diameter. The results are shown in Figure 29.

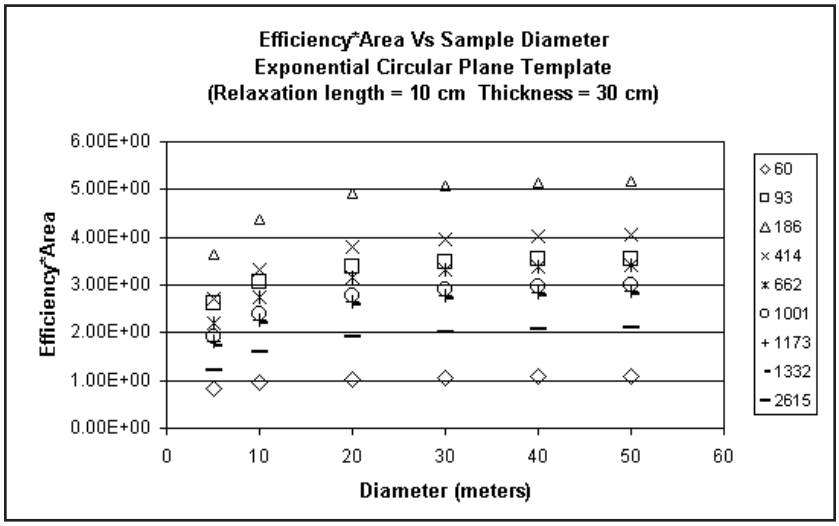


Figure 29 Efficiency*Area vs Sample Diameter

The Efficiency*Area increases initially with the sample diameter, and asymptotically approaches a constant value. Thus a value close to 30 meters can be considered to be "infinite diameter". Any further increase in the diameter results in very little change in Efficiency*Area. Also, the "infinite diameter" is smaller for lower energies than for the high energies.

Source Area Calculation

When the Efficiency*Area option is selected, the software calculates the area of the source based on the input dimensions, and multiplies it with efficiency. The formulas used by the software to calculate the source area for the various templates are given below.

Note: LabSOCS users can use the Efficiency*Area calculation mode, but should always check the displayed Area (in m^2) to see if it matches the desired value. The value can be edited if it's incorrect.

Simplified_Box (For LabSOCS)

Area=d1.2*d1.3

where d1.2 and d1.3 are the interior width and length of the box.

Simple Box (for ISOCS)

Area=d1.2*SUM(dx.1), x=2,3

where d1.2 is the length of the box
dx.1 is the height of layer x.

dx.1 is included in the SUM only if xC>0, where xC is the radioactivity concentration for layer x.

Cylinder_From_Side (for LabSOCS)

Area=d1.2*d1.3

where d1.2 is the inside diameter of the cylinder
d1.3 is the inside height of the source layer.

Simple Cylinder (for ISOCS)

Area=d1.2*SUM(dx.1), x=2,3

where d1.2 is the inside diameter of the cylinder
dx.1 is the height of the x-th source layer.

dx.1 is included in the SUM only if xC>0, where xC is the radioactivity concentration for layer x.

Simplified_Sphere (for LabSOCS) and Sphere (for ISOCS)

Area=π*D*D

where D=d1.2 - 2*d1.1
d1.1 is the wall thickness
d1.2 is the outer diameter of the sphere.

General Purpose Marinelli Beaker (for LabSOCS) and Well/Marinelli Beaker (for ISOCS)

Area=π*(d1.2+2*d1.1)*(d1.3+d2.1) + π*(d1.2+2*d1.1)*(d1.2+2*d1.1)/4

where d1.1 is the side-wall thickness of the Marinelli well
d1.2 is the inside diameter of the well
d1.3 is the depth of the well
d2.1 is the bottom wall thickness of the Marinelli well.

The first term is equal zero if the source-side is non-radioactive [3C=0]

The second term is equal zero if the source-end is non-radioactive [4C=0]

Special Sphere (for ISOCS)

Area = π*Dmin*Dmin (*sphere surface area of the minimal radioactive sphere*)

where Dmin= d3.1 in case of 3C > 0
Dmin= d3.1 + 2*d4.1 in case of 3C = 0 and 4C > 0
Dmin= d3.1 + 2*(d4.1 + d5.1) in case of 3C = 4C = 0 and 5C > 0.

Dmin= d3.1 + 2*Sum(dx.1); x = 4, ..., 10 in case of 3C = 4C =...= 9C = 0 and 10C > 0

where d3.1 is the core diameter
d4.1 is the 1st shell thickness
d5.1 is the 2nd shell thickness
.
.
d10.1 is the 7th shell thickness.

Round Tube with Internal/External Contamination (for ISOCS)

Area = π*(d1.2+2*d1.1)*d1.3 (*outside surface area of Round Tube without ends*)

where d1.1 is the side-wall thickness of the Round Tube,
d1.2 is the inside diameter of the Round Tube
d1.3 is the length of the Round Tube.

U Channel with External Contamination (for ISOCS)

Area = [(d1.2 - 2*d1.4) + 2*(d1.3 - d1.5)]*d1.1 (*inside surface area of U-channel with respect to Orientation #1*)

where d1.1 is the length of the U-channel
d1.2 is the outside width of the U-channel
d1.3 is the outside depth of the U-channel
d1.4 is the side-wall thickness of the U-channel
d1.5 is the bottom thickness of the U-channel.

L Angle with External Contamination (for ISOCS)

Area = [(d1.2 - d1.4) + (d1.3 - d1.5)]*d1.1 (*inside surface area of L-beam with respect to Orientation #1*)

where d1.1 is the length of the L-angle
d1.2 is the outside width of the L-angle
d1.3 is the outside depth of the L-angle
d1.4 is the side-wall thickness of the L-angle
d1.5 is the bottom thickness of the L-angle.

H/I Beam with External Contamination (for ISOCS)

Area = 2*[(d1.2 - d1.4) + (d1.3 - 2*d1.5)]*d1.1 (*inside surface area of H-beam with respect to Orientation #1*)

where d1.1 is the length of the H-beam
d1.2 is the outside height of the H-beam
d1.3 is the outside width of the H-beam
d1.4 is the bridge thickness of the H-beam
d1.5 is the side-wall thickness of the H-beam.

Rectangular Tube with Internal/External Contamination (for ISOCS)

Area = 2*(d1.3 + d1.4)*d1.2 (*outside surface area of Rectangular Tube without ends*)

where d1.2 is the length of the Rectangular Tube
d1.3 is the outside height of the Rectangular Tube
d1.4 is the outside width of the Rectangular Tube.

Room/Box with Internal Surface Contamination (for ISOCS)

Area = S2 + S3 + S4 + S5 + S6 + S7 (*area of the contaminated room surfaces*)

where

$$S2 = \begin{cases} d1.1*d1.2, & \text{if } 2C > 0 \\ 0, & \text{if } 2C = 0 \end{cases}$$ S2 is the room back surface

$$S3 = \begin{cases} d1.1*d1.3, & \text{if } 3C > 0 \\ 0, & \text{if } 3C = 0 \end{cases}$$ S3 is the room top surface

$$S4 = \begin{cases} d1.1 * d1.2, & \text{if } 4C > 0 \\ 0, & \text{if } 4C = 0 \end{cases}$$ S4 is the room front surface

$$S5 = \begin{cases} d1.1 * d1.3, & \text{if } 5C > 0 \\ 0, & \text{if } 5C = 0 \end{cases}$$ S5 is the room bottom surface

$$S6 = \begin{cases} d1.2 * d1.3, & \text{if } 6C > 0 \\ 0, & \text{if } 6C = 0 \end{cases}$$ S6 is the room right-side surface

$$S7 = \begin{cases} d1.2 * d1.3, & \text{if } 7C > 0 \\ 0, & \text{if } 7C = 0 \end{cases}$$ S7 is the room left-side surface

d1.1 is the length of the Room
d1.2 is the height of the Room
d1.3 is the width of the Room.

xC is the relative concentration for surface x = 2, 3, ... , 7.

Tank Partially Full of Fluid (for ISOCS)

Area = d1.2*d1.3 (*cross-section area of the tank inside volume along the tank rotation axis*)

where d1.2 is the inside diameter of the Tank
d1.3 is the inside length of the Tank.

Conical Container (for ISOCS)

Area = d3.1*(d1.2 + Dtop)/2 (*cross-section area of the source volume along the cone rotation axis*)

Where Dtop = d1.2 + d3.1*(d1.3 - d1.2)/d1.4
d1.2 is the inside bottom diameter of the Cone
d1.3 is the inside top diameter of the Cone
d1.4 is the inside height of the Cone
d3.1 is the source height.

The Efficiency*Length Calibration Option

The **Efficiency*Length Calibration** option can be used when the nuclide activities are to be reported in units of Activity/meter. As an example, a long pipe with contamination coated in its interior is discussed. The length of the pipe was increased progressively, and the Efficiency*Length was calculated. The results are shown in Figure 30.

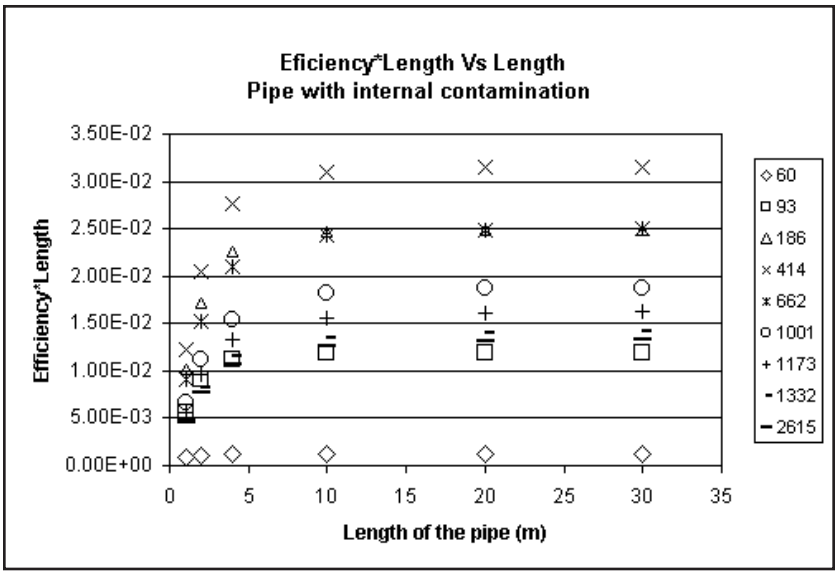


Figure 30 Efficiency*Length vs Length

The product Efficiency*Length increases initially with length, but levels off as the pipe becomes infinitely long. For lower energies, the Efficiency*Length reaches a constant value at smaller lengths than for the high energies.

Note: ISOCS does not calculate this value. A default value of 1 m is used.

Technical Note 2: LabSOCS/ISOCS Convergence Value

The LabSOCS/ISOCS efficiency calibration process is iterative. Basically, the software divides the radioactive source volume into number of voxels or volume elements(N). A source is placed in each voxel using a pseudo-random algorithm known as LPt sequence. This algorithm assures equal probability of point source location within a group of voxels, and it reaches convergence faster than a purely random point-source location algorithm. The efficiency for each of the voxels is computed at a given energy, modified by attenuation between the point and the detector, and summed with rest of the voxels. The entire process is repeated, but this time with double the number of voxels (2N). The LabSOCS/ISOCS software then repeats this process for a third time, with 4N voxels.

First, the integral efficiencies from iteration 1 with N voxels, and iteration 2 with 2N voxels are compared. The percent relative difference between the integral efficiencies for 1K and 2K voxels is given as follows.

$$\%\mathrm{DIFF1} = \frac{(\mathrm{INT}(\mathrm{N}) - \mathrm{INT}(2\mathrm{N}))}{\mathrm{INT}(2\mathrm{N})} \times 100 \quad (1)$$

Secondly, the integral efficiencies from iteration 2 (with 2N voxels) and iteration 3 (with 4N voxels) are compared. The relative difference is calculated as:

$$\%\mathrm{DIFF2} = \frac{(\mathrm{INT}(\mathrm{N}) - \mathrm{INT}(4\mathrm{N}))}{\mathrm{INT}(4\mathrm{N})} \times 100 \quad (2)$$

The LabSOCS/ISOCS software requires three convergence criteria to be satisfied, before the efficiency results can be output at a given photon energy. These are:

1. abs(%DIFF2) < % Convergence desired
2. abs(%DIFF1) < 2*(% Convergence desired)
3. abs(%DIFF2-%DIFF1) < 2*(%Convergence desired)

Criterion (1) checks whether the required % convergence has actually been reached. Criteria (2) and (3) ensure that the oscillations in the computed integral efficiency values are small. If all of the criteria are satisfied, the calculation process is halted, and the integral efficiency computed with 4N voxels is stored. LabSOCS/ISOCS will then move on to the next energy in the user_defined list.

Convergence Value

If any of the above three criteria are not satisfied, LabSOCS/ISOCS will double the number of voxels to 8N and repeat the efficiency calculation. Thus, the iterations continue until the convergence criteria are met, or, until the maximum limit for the number of voxels has been reached. In LabSOCS/ISOCS, the maximum limit for the number of voxels is 2^{20}.

When a LabSOCS/ISOCS efficiency computation is run, the % convergence value that was reached at the end of each successive iteration is displayed, and updated as the computation progresses.

The appropriate convergence value must be chosen based upon a tradeoff between computation time and accuracy. The smaller the convergence value, the better the results, and the longer the computation time. Once the maximum limit for the number of voxels is reached, setting lower values for convergence will not have any effect on the efficiencies.

Figure 31 shows the change in efficiency as a function of convergence value, for a very large volume and large diameter sample. This is a typical *in situ* soil counting application with a sample diameter of 64 meters and a thickness of 50 centimeters. The efficiency values are normalized to the efficiency at the lowest convergence value.

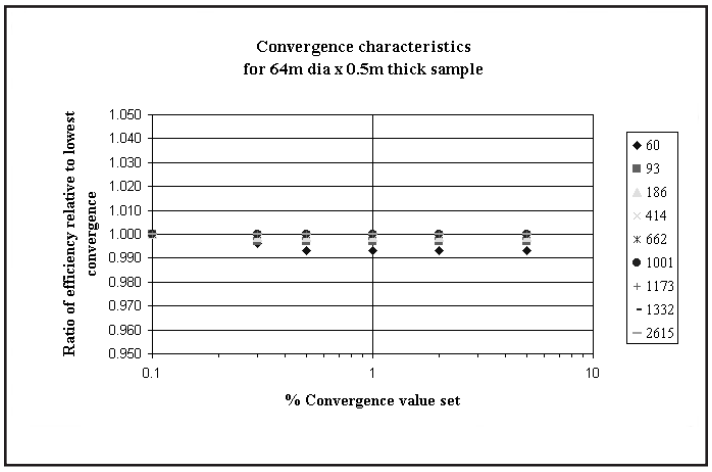


Figure 31 Convergence Characteristics for 64 m Diameter by 0.5 m Thick Sample

The data indicates that, at a convergence value of 1%, the errors in the efficiencies are less than 1%.

Figure 32 shows the convergence characteristics for a sample with a relatively small diameter of 6 meters and a large thickness of 50 meters. For this geometry, the data indicates that, at a convergence value of 1%, the errors in the efficiencies are less than 0.05%.

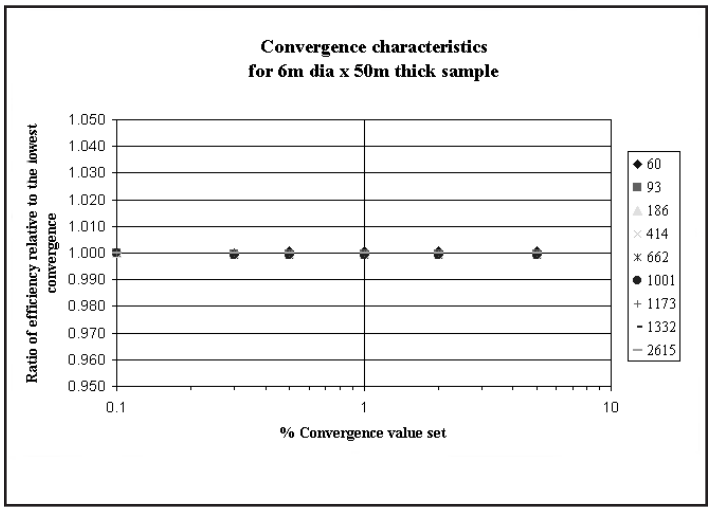


Figure 32 Convergence Characteristics for 6 m Diameter by 50 m Thick Sample

Figure 33 shows the computation time as a function of the set convergence value.

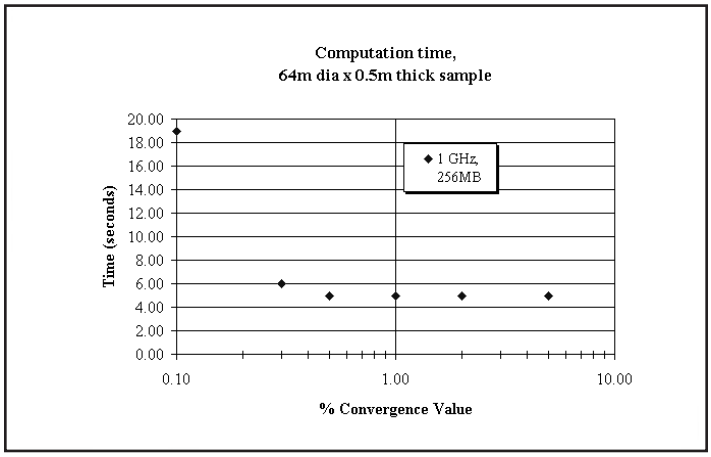


Figure 33 Convergence Characteristics for 64 m Diameter by 0.5 m Thick

The computations were performed using a computer with a 1 GHz Pentium® III processor and 256 MB RAM. No collimator was used in the calculations. From Figure 32, it is evident that even for convergence values as low as 0.1%, the computation times are less than 20 seconds.

Summary Recommendations

For most applications, it is sufficient if a convergence value of 1 percent is set. When in doubt, use a lower convergence value, and if it changes the results by more than a percent, continue to lower the convergence value further. But for large samples, and especially with collimators, the computation times will be longer; higher convergence values of 2-5% may be acceptable in order to shorten up the computation time.

Technical Note 3: Maximum Detector Reference Point Number (MDRPN)

The Maximum Detector Reference Point (MDRPN) is a parameter that can be set to increase the accuracy of LabSOCS/ISOCS computations, especially for close thick sources and for attenuators close to the detector. The software divides a radioactive source region into a large number of voxels (or volume elements). A point location is defined within each voxel, in a quasi-random fashion. From the source point within each voxel, a minimal solid angle covering the projected area of the entire active Ge cylinder is defined. A number of uniformly distributed photon pathways are defined within the solid angle, each pathway representing an equal volume part of the minimal solid angle. Thus, if there are N pathways, it means that the minimal solid angle is being divided into N equal volume parts. The number of pathways is dictated by a parameter called the Detector Reference Point Number (DRPN). The number of pathways N is related to the DRPN as follows:

$$N = 2^{DRPN} - 1$$

A weighting factor is determined for each pathway, depending upon the probability of photon absorption within the active germanium, and the photon attenuation through materials inside the detector (endcap, holder, Ge dead layers etc.). These weighting factors are then used to average the attenuation factors corresponding to the pathway lengths through all external absorbers.

At close-in geometries, the value set for MDRPN will be used by the software to calculate the number of photon pathways to be distributed. Larger the value of MDRPN, the greater the number of photon pathways. At close-in geometries, the photon path lengths vary more with angle. Larger numbers of photon pathways are required to obtain a better average for the attenuation factors, and a more accurate value for efficiency. However, a larger value of MDRPN does increase the computation time. A value of MDRPN=4 (which is the default) is found to be suitable for most applications involving close source-detector distances. In the Geometry Composer, when the MDRPN check box is enabled , the default value of 4 is set. If the MDRPN check box is disabled, the software uses a single pathway to compute the attenuation factor.

If the radioactive source is far away from the detector, the solid angle from a source voxel to the detector becomes very small. Correspondingly, the directional variation between the pathways becomes very small. Thus, only a fewer number of pathways are required to accurately determine the average attenuation factor. A small value for MDRPN (e.g. 1 or 2) may be sufficient. The software uses an intelligent algorithm to progressively decrease the Detector Reference Point Number from its maximum value to 1 at about a source-detector distance of 1 meter. Accurate results can thus be obtained within a shorter computation time.

Technical Note 4: Collimator Reference Point Number (CRPN)

This technical note applies to ISOCS only.

Technical Note 5: Effects of Photon Coherent Scattering

The three primary modes of photon interaction with matter are, photoelectric, Compton scattering and pair production. Any of these interactions will remove energy from the photon and therefore, it will not be registered in the full energy peak of the gamma spectrum. There are also some lower probability coherent scattering processes such as Thompson and Rayleigh scattering, which could affect the gamma spectrum.

When a photon undergoes coherent scattering in an absorber material, it emerges out of the process without any change in its energy. It can however, undergo a change in its direction. The scattering angle is a function of the photon energy. At lower photon energies, larger scattering angles become more probable. At higher photon energies, (1 MeV and above) coherent scattering tends to be highly peaked in the forward direction.

The coherent scattering effect either adds or removes counts from the photon full energy peak depending on how the source, the absorber and the detector are located. Consider the scenario where the source is far away from the detector, and an absorber is present between the source and the detector. Coherent scattering, even at very small angles, will result in the photon being scattered away from the detector, and thus it is removed from the full energy peak. On the other hand, if the source is located at a closer distance, a photon could undergo coherent scattering but still reach the detector and be accounted for in the full energy peak since the detector now subtends a large forward solid angle. In the case where the absorber is present at the sides of the source or the detector, a photon which otherwise would have missed the detector, could be scattered into the detector and thus be registered as a count in the full energy peak.

Correcting the full energy peak for the effects of coherent scattering is thus a complicated process. Coherent scattering is a potential problem in performing efficiency computations with very thick absorbers. Including the coherent scattering cross sections in the LabSOCS/ISOCS cross section library makes the efficiencies low, especially at low energies. Excluding the coherent scattering cross sections makes the efficiencies high, but closer to the correct results.

The effect of coherent scattering is most significant at high photon attenuations (at low/medium energies through medium/high Z absorbers). For example, at transmission levels of 0.6 through low Z absorbers such as beryllium or water, a 1–2% bias is induced in the efficiencies because of coherent scattering. At transmission levels of 0.4 through a medium Z absorber such as aluminum, the bias due to coherent scattering could be as high as 8%. For higher Z materials such as iron, at transmission levels of 1E-04, the efficiencies could be off by a factor of 2 or more, because of coherent scattering. For most LabSOCS/ISOCS applications, there are usually larger uncertainties in the overall data set, and this effect should not be very important. For very thick sources, coherent scattering still affects the heavily attenuated part of the source. But since the total efficiency is dominated by the part of the source closest to the detector, which is not heavily attenuated as the rest of the source, coherent scattering generally has a negligible effect on the peak efficiencies.

10. User-Modifiable Configuration Files

Distribution Materials Library

The file C:\GENIE2K\ISOCS\DATA\PARAMETERS\MU04_8LB.TXT contains the polynomial fit data for Mass Attenuation Coefficients for the materials in the library. These are compounds or mixtures that Canberra has created. As you create new materials, they are stored in this file. You should verify that these entries are suitable for use, and add any additional ones necessary. The library materials that are distributed with the LabSOCS software are listed in the following table.

CAUTION The density values entered into the library are from references, but are not always the exact density for the sample being measured. The user MUST assure that the density used for his efficiency computation accurately represents the sample being assayed.

Name	Definition as Entered into ISOCS/LabSOCS	Density (g/cc)	Comments
304SS	71.92FE+9.0NI+19.0CR+ 0.08C	7.81	Type 304 stainless steel (Ref. 1)
ACRYLIC	C4_H6_O2	1.17	Methylacrylate (Ref. 1)
ALUMINUM	100AL	2.7	
CELLULOS	C6_H10_O5	0.45	Used for wood, paper, etc. Wood density: (Ref. 2) Oak: 0.6–0.9 White Pine: 0.35–0.5 Yellow Pine: 0.37–0.6
CONCRETE	15.42C+35.75O+18.77SI+ 26.82CA+0.56H+2.68MG	2.35	Ordinary (2.2–2.4) (Ref. 2)
COPPER	100CU	8.96	
CSTEEL	98.93FE+0.45MN+0.62C	7.86	Common carbon hot rolled steel
DIRT1	2.2H+57.5O+8.5AL+ 26.2SI+5.6FE	1.6	ICRU Report 53 default composition, Table 3.1 (Ref. 4), *in situ* density 1.5–1.9

Name	Definition as Entered into ISOCS/LabSOCS	Density (g/cc)	Comments
DIRT2	1.1H+1.2C+55.8O+7.2AL+ 31.6SI+3.1FE	1.6	HASL-258, for EML Method *In Situ* Calibrations (Ref. 4), *in situ* density 1.5–1.9
DIRT3	10.0H+0.40N+11.4C+ 78O+0.2S	1.45	Wet organic peat, ICRU53 table 3.1 (Ref. 4), *In situ* density 1.3–1.7
DIRT4	45.2O+2.5MG+8.3AL+ 25SI+1.8K+4.1CA+0.7TI+ 0.2MN+12.2FE	1.7	Highly mineralized soil, ICRU53, Table 3.1 (Ref. 4), *In situ* density 1.6–2.0
DRYAIR	78.09N+20.97O+0.93AR+ 0.01C	0.00129	Do not delete, as this material is also used internally
DRYDIRT	49.62O+27.38SI+7.1AL+ 4.04FE+1.6MG+4.21CA+ 0.84NA+0.36H+2.37K+ 0.34TI+2.14C	1.6	Average sediment (Ref. 3), Density 1.5–1.9
EPOXY	72.1C+21.9O+6H	1.15	Analytics water standards
GERMANIUM	100GE	5.36	
GLASS	70SI_O2+15NA2_O+ 15CA_O	2.6	Common glass (Ref. 1) *in situ* density 2.4–8
HDEPOXY	14.7CA+11.8S+34.5Oc+ 3H+36C	1.6	Analytics soil standards
HPOLYETH	C2_H4	0.95	High density polyethylene
IRON	100FE	7.86	
KAPTON	C22_H10_N2_O4	1.11	
LABDIRT1	100.0DIRT1	1.25	Typical density in the lab after drying and grinding
LEAD	100PB	11.35	
LPOLYETH	C2_H4	0.92	Low density polyethylene (Ref. 2)
NAI	NA_I	3.67	Detector single crystals

Name	Definition as Entered into ISOCS/LabSOCS	Density (g/cc)	Comments
PLEXIGLS	C5_H8_O2	1.20	Plexiglass, methyl methacrylate (Ref. 1)
POLYPROP	C3_H6	0.91	Polyproplyne (Ref. 2)
POLYSTYR	C8_H8	1.06	Polystyrene (Ref. 2)
PVC	H3_C2_CL	1.40	Polyvinyl chloride (Ref. 2)
RUBBER	C10_H16_S2	1.05	
SAND	SI_O2	1.7	
TIN	100SN	7.31	
TUNGSTEN	100W	17.0	Typical density of sintered shield material (19.3 is density of pure W)
WATER	H2_0	1	Do not delete, as this material is also used internally
WOOD_OAK	CELLULOSE	0.75	Average; varies from 0.6–0.9
WOODPINE	CELLULOSE	0.50	Average; varies from 0.4–0.6
ZINC	100ZN	7.14	

References

1. Materials Handbook, 13th Edition, George S. Brady & Henry R. Clauser, McGraw-Hill, 1991.

2. Handbook of Health Physics and Radiation Health, 3rd Edition, Shlein et. al,

3. Handbook of Physics and Chemistry, 59th Edition, F-199.

4. ICRU Report 53, December 1994.

Energy List Files

The file DEFAULT.ENR consists of the default list of energies and % errors, which are loaded when LabSOCS/ISOCS is launched. This file resides in the directory C:\GENIE2K\ISOCS\DATA\ENERGY_LIST\ . The Default list of energies can be edited in the **Options | Default Parameters for New Geometry** menu option.

A series of other energy lists are distributed with the software and can be found in the same subdirectory. These files can be modified through the **Edit | Efficiency Parameters for This Geometry** menu entry. New lists may be created by saving a modified list under new file name.

The following table gives the energy values entered into the various Energy Lists distributed with the LabSOCS software.

Energies in keV in the Energy List Distribution					
Default	**Low Energy**	**High Energy**	**Wide Energy**	**Mixed Gamma +Am**	**^{241}Am+^{152}Eu**
100	50	150	50	59.4	59.5
150	60	200	60	88.03	121.78
200	70	300	70	122	244.69
300	85	500	85	165.85	344.28
500	100	750	100	391.69	411.11
700	120	1000	150	661.65	443.97
1000	150	1500	200	898.02	778.9
1400	200	2000	300	1173.22	964.34
2000	250	3000	400	1332.49	1085.91
	300	4000	600	1863.01	1112.11
	400	5000	800		1408.01
	500	6000	1000		
	750	7000	1500		
	1000		22500		
			4000		
			5500		
			7000		

Detector Parameters and Name Listings

The file C:\GENIE2K\ISOCS\DATA\PARAMETERS\DETECTOR.TXT contains the parameters for the detectors that have been characterized by Canberra, and are available for use on this system. A file similar to the one shown here is delivered with the system.

```
# Genie 2000 Generic Detector Characterizations #
================================================
Example,71.0,61.0,0,88.9,150,5,5,26,Example.par,4,
Ge,0.77,5.35, #
,,, #
AL,1.6,2.7, #
Ge,1.0,5.35, #
AL,1.03,2.7, #
AL,1.6,2.7, #
Ge,1.0937,5.35, #
AL,3.15,2.7, #
AL,5,2.7
```

-
-
-

Further entries

In the DETECTOR.TXT file, any text that follows the # symbol is considered both a comment and a continuation symbol. The labels of the parameters in the first uncommented line of the file, are as follows:

Detector_Name, Parameter_1,….Parameter_9, Characterization_file_name, MDRPN

The *.PAR file is the actual detector characterization file, and must be located in the C:\GENIE2KISOCS\DATA\DCG directory. The default value for the Maximum Detector Reference Point Number or MDRPN is stored in the DETECTOR.TXT file. Note that in the example file listed above, the default value for MDRPN is 4.

CAUTION Do not modify any other parameters in the DETECTOR.TXT file.

When new detectors are characterized by Canberra, the .PAR file must be added to the …\DCG\ directory and the new detector's information must be appended to the DETECTOR.TXT file.

Input Geometry Files

The ISOCS/LabSOCS input geometry files created by the Geometry Composer can be saved using the **Save** or **Save As** command in the **File** menu. The saved geometry files are stored in the paths:

For ISOCS

C:\GENIE2K\ISOCS\DATA\GEOMETRY\IN-SITU*name*

For LabSOCS:

C:\GENIE2K\ISOCS\DATA\GEOMETRY\LABORATORY*name*

where *name* is the name of the template upon which the geometry definition was based (e.g. SIMPLE_CYLINDER, SIMPLIFIED_MARINELLI_BEAKER, etc.). The files are stored with same name that was used when the geometry was defined and an extension of .GIS.

The user may view the geometry files using any standard Windows text editor. The input parameters in a geometry file are defined using keywords. A keyword always begins with the tilde (~) symbol and ends with the "equal to" (=) symbol, followed by the actual value of the input parameter. The keywords that define the various ISOCS parameters are given below:

Descriptor	Meaning
~1A[bsorber]=	First absorber thickness (real or integer number)
~1AM[aterial]=	First absorber material name (not more than 8 symbols)
~1AD[ensity]=	First absorber material density (real or integer number)
~2A[bsorber]=	Second absorber thickness (real or integer number)
~2AM[aterial]=	Second absorber material name (not more than 8 symbols)
~2AD[ensity]=	Second absorber material density (real or integer number)
~AP[ressure]=	Air pressure (real or integer number; the 760 is assumed as default)
~AT[emperature]=	Air temperature (real or integer number; the 20 is assumed as default)

~<N>C[oncentration]=	The n^{th} layer radioactivity concentration (real or integer number)
~COL[limator]=	Collimator name (not more than 10 symbols)
~COM[ment]=	Comment string of the ISOCS results (string of symbols)
~CON[vergence]=	Convergence value to stop integration (in %, real or integer number)
~CRPN=	Collimator reference points number (2 < integer number < 10)
~MDRPN=	Maximum detector Reference point number (2 < integer < 10)
~D<n>.<m>=	The m^{th} dimension value in the n^{th} row (real or integer number)
~<N>DEN[sity]=	The n^{th} layer material density (real or integer number)
~DES[cription]=	Description of the ISOCS results (string of symbols)
~DET[ector]=	Detector name (not more than 10 symbols)
~DU[nit]=	Density unit (g/cu.c or kg/cu.m or lb/cu.ft; the g/cu.c is the default)
~EN[ergies]=	Energies list (≤30 real [integer] numbers delimited by commas)
~ER[rors]=	Errors list (≤30 real [integer] numbers delimited by commas)
~G[eometry]=	Template type (one of the following keywords): – CIRCULAR_PLANE – COMPLEX_BOX – SIMPLE_BOX – RECTANGULAR_PLANE – COMPLEX_CYLINDER

- SIMPLE_CYLINDER
- SPHERE
- WELL_or_MARINELLI_BEAKER
- PIPE
- SPECIAL_SPHERE
- EXPONENT_CIRCULAR_PLANE
- BEAKER
- ROUND_TUBE
- U_CHANNEL
- L_BEAM
- H_BEAM
- RECTANGULAR_TUBE
- ROOM
- TANK
- CONE

~LO[op]=	Loop number to do increment (integer number)
~LU[nit]=	Length unit (MM or CM or M or IN or FT; MM is the default)
~<N>M[aterial]=	The n^{th} layer material name (not more than 8 symbols)
~MO[de]=	ECC running mode (only the A symbol which means Calc & Add)
~O[utput]=	Output file name
~RH[umidity]=	The % relative humidity of air (real or integer number; 50 is the default)
~SD<m>=	The m^{th} source-detector location parameter (real or integer number)
~PU[nit]=	Pressure unit (MM.HG or IN.HG or BAR or KPA; MM.HG is the default)

~Q[uiet]=	If this keyword has any value, any output on the screen is suppressed (keyword's value doesn't matter. But if the value is omitted, output is assumed to be on)
~TU[nit]=	Temperature unit – C or F (Celsius (default) or Fahrenheit)

A few rules regarding the keyword definitions:

1. The tilde (~) and "equal to" (=) symbols are the limits of a keyword name.
2. To identify a keyword name, it is enough if the characters outside of the square brackets alone are present. The characters inside the square brackets are optional.
3. The actual LabSOCS/ISOCS parameter value corresponding to a keyword name must be input after the "=" symbol.
4. A given keyword name and the corresponding parameter value must be present in the same row of the input file.
5. Keywords may be entered in any order.
6. Each row in the input geometry file is terminated by CRLF.
7. Both upper and lower case alphabets are acceptable for writing keyword names.
8. Any row that starts with the # symbol and terminated by CRLF is assumed to be a comment and is disregarded in the calculations.

To demonstrate the use of keyword names, an example ISOCS input geometry file is given below.

```
# ISOCS geometry file exported by 'Geometry Composer'
# The primary data are stored in file
'C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\SIMPLE_CYLINDER\Small Can.geo'
# The primary template is 'SIMPLE_CYLINDER'
#
~Geometry=SIMPLE_CYLINDER
~Description=Aluminum_Can
~Comment=Water
~Detector=Example
~Convergence_%=1.000 ~LPTN=64
~MDRPN=4 ~CRPN=4
~LUnit=mm ~PUnit=mm.Hg ~TUnit=C ~DUnit=g/cu.c
```

```
~APressure=760 ~ATemperature=22 ~RHumidity=30.0
#
~sd1=100.00
# Dimensions:
~d1.1=1.000000 ~d1.2=50.000000 ~d1.3=100.000000 ~1mater=aluminum
    ~1density=2.700000 ~1Con=0.000000
~d3.1=100.000000 ~3mater=water ~3density=1.000000 ~3Con=1.000000
~Energies_keV= 100.000, 150.000, 200.000, 300.000, 500.000, 700.000,
    1000.000, 1400.000, 2000.000, #
~Error_''= 10.0, 10.0, 8.0, 8.0, 6.0, 6.0, 4.0, 4.0, 4.0, #
~Output_Filename=Small Can.ecc
```

Index

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CANBERRA

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