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PC/FRAM, Version 3.2

User Manual

February 23, 1999

Los Alamos
NATIONAL LABORATORY

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PC/FRAM, Version 3.2

User Manual

1. Introduction

This section contains general information about the PC/FRAM program, the prerequisites for running that program, and the contents of the distribution kit.

1.1. General

This manual describes the use of version 3.2 of the PC/FRAM plutonium isotopic analysis software developed in the Safeguards Science and Technology Group, NIS-5, Nonproliferation and International Security Division, Los Alamos National Laboratory. The software analyzes the gamma ray spectrum from plutonium-bearing items and determines the isotopic distribution of the plutonium, ^{241}Am content, and concentration of other isotopes in the item. The software can also determine the isotopic distribution of uranium isotopes in items containing only uranium.

The body of this manual describes the generic version of the code. Special facility-specific enhancements, if they apply, will be described in the appendices. The information in this manual applies equally well to version 3.3, which has been licensed to ORTEC.

The software can analyze data that is stored in a file on disk. It understands several storage formats including Canberra's S100 format, ORTEC's 'chn' and 'spc' formats, and several ASCII text formats. The software can also control data acquisition using an MCA and then store the results in a file on disk for later analysis or analyze the spectrum directly after the acquisition. The software currently only supports the control of ORTEC MCB's. Support for Canberra's Genie-2000 Spectroscopy Systems will be added in the future. Support for reading and writing CAM files will also be forthcoming.

A versatile parameter file database structure governs all facets of the data analysis. User editing of the parameter sets allows great flexibility in handling data with different isotopic distributions, interfering isotopes, and different acquisition parameters such as energy calibration, and detector type.

1.2. Audience

This manual is intended for the system supervisor or the local user who is to be the resident expert. Excerpts from this manual may also be appropriate for the system operator who will routinely use the instrument.

1.3. Other Documentation

Various manuals for commercially available electronic and computer components of the data acquisition and analysis system may be required to support other aspects of data acquisition and analysis. These manuals are supplied only if the PC/FRAM software is delivered as part of a complete data acquisition system.

1.4. Conventions Used in this Document

The pictures in this document were captured on a system running Windows NT version 4.0.

Most of the text and all of the headings in this document are written with the Times New Roman font.

Names of the menu choices will be written within the text in bold using the Arial Rounded MT font, for example, **File**, **Edit**, **Measure**, **Analyze**, etc.

Placing a vertical bar between the individual choices will denote a sequence of menu selections. For example, choose the **File | Open** option.

Directory and file names will be written in bold using the Courier New font, for example, `c:\pcfram` and `pcfram.ini`.

Text that is reproduced from a text file will be written using the Courier New font.

Text that is displayed on the screen either as a message, a dialog box title, or prompt for a control within a dialog box will be written in bold using the Arial Rounded MT font.

Key combinations are indicated with a plus sign, e.g. Shift+Tab or Ctrl+F4.

1.5. Definitions and Acronyms

CAM	Configuration Access Method
CPU	Central Processing Unit
DLL	Dynamic Link Library.
FRAM	Fixed energy, Response function Analysis with Multiple efficiencies. Also, a word of Scandinavian origin meaning "forward" or "onward."
FWHM	Full Width at Half Maximum.
MCA	Multi-Channel Analyzer.
MCB	Multi-Channel Buffer.
NIM	Nuclear Instrumentation Module.
Parameter Set	The group of parameters, constants, and text strings that govern all facets of the analysis. Each parameter set is stored in the PC/FRAM database during analysis.
Parameter File	A parameter set may be exported as ASCII text to a DOS disk file. This disk file is called a parameter file. It has a default file extension of .pst.
PC	Personal Computer, an IBM (or compatible) computer with an Intel-based CPU.
RAM	Random Access Memory.
UMCBI	Unified MCB Interface.

1.6. New Features in Version 3.2

The users familiar with version 2.2 of PC/FRAM will note the following new features and upgrades in version 3.2.

1. **32-bit.** This is a 32-bit version of FRAM. It is designed to run under Windows 95, Windows 98, and Windows NT.

2. **New user interface.** The user interface now has a 3-D look and feel similar to what is used in Windows 95.
3. **New Measure Menu.** There is a new option under the Measure menu called Analyze Data. This combines and replaces the old Analyze | Single Spectrum and Analyze | Autocycle options.
4. **Bi-lingual support.** There is a new option called Language under the Options menu. It allows the user to choose one of two languages to be used when displaying information on the screen. The character strings to be displayed are stored in one of two language files. Currently we support English and Russian as the two languages. But this can be easily extended to other European languages.
5. **New Database format.** The analysis parameters are stored in a database using a different format. This format is not compatible with previous versions of FRAM. The distribution kit does not contain an "empty" database as it did for version 2.2. The new version of PC/FRAM creates the necessary files when it is first executed.
6. **New results display.** The results are displayed in a different type of window.

1.7. System Requirements

PC/FRAM is designed to run best on an IBM (or compatible) PC with a Pentium processor running at a speed of 200 MHz or greater. PC/FRAM has run successfully on lower end machines and machines with a slower CPU.

A math coprocessor is required.

The PC should have at least 32 MB of RAM

The program requires a minimum of 4Mb of free space on the disk. In order to have room for saving spectra and results, the system disk should have several hundred Mb of space.

The system must have a 3.5" diskette drive.

The system must be running under Microsoft Windows 95, Windows 98, or Windows NT.

1.8. Distribution Kit

The distribution kit for PC/FRAM consists of three diskettes.

Diskette #1 contains a batch file (`install.bat`) for installing PC/FRAM, a self-extracting compressed file (`fram.exe`) containing all the necessary files for running PC/FRAM, and a text file (`readme.txt`) containing instructions for installing PC/FRAM. These instructions are reproduced below.

Diskette #2 contains a collection of fonts with Cyrillic character support in case you need to "Russify" your American computer. Instructions for doing so are found in the file `readme.txt`.

Diskette #3 contains an electronic copy of this User Manual and a collection of special parameter sets. The information for each parameter set is stored in textual form in a separate file.

```
Instructions for installing PC/FRAM version 3.2

1.  All the files will be placed in a directory "c:\fram32".
If you already have such a directory, you are advised to
rename it.

2.  Place diskette #1 into the appropriate drive.
Click on the Start button in the lower left-hand corner of the
```

screen. Then select the Run... option. Type a:\install then click on the OK button.

3. The batch file install.bat will be executed within a special DOS window. When the installation is complete, you will need to close this window.

Instructions for "Russifying" your American computer if you are running Windows 95 or Windows 98

1. Copy all the font files from Diskette #2 to the folder c:\fram32\fonts

2. Close Windows and startup in DOS-mode.
The prompt "C:WINDOWS>" will appear.

3. Type the command "cd fonts" and press the Enter key.
The prompt "C:\WINDOWS\FONTS>" will appear.

4. Type the command "mkdir savefon" and press the Enter key.

5. Type the command "attrib -h -s *.fon" and press the Enter key.

6. Type the command "copy *.fon savefon*.*" and press the Enter key.

7. Type the command "copy c:\fram30\fonts*.fon *.*" and press the Enter key. The message "Overwrite 8514FIX.FON (Yes/No/All)?" will appear. Type A and press the Enter key.

8. Type the command "attrib +h +s *.fon" and press the Enter key.

9. Type the command "cd .." and press the Enter key.

10. Type the command "win" and press the Enter key.

1.9. Configuration

There is a configuration file, `pcfram.ini` that contains much of the default information needed for running PC/FRAM. It contains information of a general nature such as the maximum size of spectral data arrays, default path names, the type of MCA to expect, and the template for reporting dates. All the information in this file can be accessed and modified within the PC/FRAM program. The file is in text format and can be edited directly by using Windows Notepad or Wordpad programs.

The language files provide some configuration information with regard to the display of character strings. They specify the font to be used for displaying strings in various situations. This file is also in text form and can be easily edited.

The user authorization file contains a list of authorized users, their passwords (in encrypted form), and the level of access granted to each. The information in this file can be modified by means of the **Edit | User List** option (cf. Section 3.4.8).

2. Getting Started

This section describes the steps required for installing and configuring PC/FRAM for the first time. These initial actions seldom require any changes once the software is in operation. In this section references are made to other sections of the manual that contain more detailed information.

2.1. Before Running PC/FRAM

The first step is to install the software. Then you need to consider several issues connected with customizing the software.

2.1.1. Installing Software

Please read the instructions for installing PC/FRAM. If you already have a directory labeled `c:\fram32` you are advised to rename it to something else. The batch file that does the installation creates a directory by this name along with several subdirectories and then copies some files to the main directory.

Follow the instructions by invoking the batch file `install.bat` on diskette #1 of the distribution kit. Then close the DOS window and remove the installation diskette. PC/FRAM is now installed on your system!

Before you every run PC/FRAM, there are several questions you should ask. Do you need to change the default fonts used for displaying text on the screen? Do you need to establish a different working directory? Do you want a shortcut, or icon, for invoking the program?

2.1.2. Selecting Fonts

The distribution kit provides support for either English or Russian. This is done by storing all the character strings in a language file. English strings are found in the file `pcfram.1st` while Russian strings are found in the file `pcfram.2nd`. The names of the fonts to be used for displaying strings are retrieved from the corresponding language file. There are four different situations where strings can be displayed. The first and most important is the display of text in the menus and in each of the dialog boxes. The second is the display of the results of an analysis in a special text window. The third is the display of titles within a special plot window. The fourth is the printing of text on your system printer. Four lines in each language file specify the font to be used in each of these situations. The following is a copy of the lines in `pcfram.1st` that specify the default fonts used for displaying text in English.

```
szFonDialog,"MS Sans Serif,10"
szFonDisplay,Courier
szFonPlot,MS Sans Serif
szFonPrint,"Courier,8"
```

In the Russian language file, the default font specified for printing is FixHelvDL (with a size of 10) instead of Courier. If you are going to run PC/FRAM in English, the default fonts will work just fine. However, if you want to run PC/FRAM in Russian you must do one of two things. The first alternative is to change these fonts so that they support Cyrillic characters. See the section 2.1.3 for information on how to do this. The second alternative is to edit the language file so as to specify a different font. The next paragraph contains information helpful in doing this.

The information in a language file is divided into several groups. Each individual piece of information in a group is a line that consists of an identifier followed by a comma then followed by a text string.

The four lines reproduced above serve as an example. In the "font" section the text string following the comma will be the name of the font to use. The language file is in text format, so you can edit this file with Notepad or Wordpad and substitute another font name for the one provided for you. Remember that the font with the name you supply must be installed on your system. If this is not the case, PC/FRAM will use a default system font.

2.1.3. "Russifying" Your Computer

The system fonts that come with American computers do not have support for Cyrillic characters. If you want to have a Russian version of PC/FRAM that utilizes the common system fonts, you will need to replace your system fonts with ones that do support Cyrillic characters. To do this, follow the instructions in the file `readme.txt` that is reproduced in section 1.8.

2.1.4. Changing the Working Directory

If you move the PC/FRAM files to a different directory or rename the working directory to something else, use Notepad or Wordpad to edit the configuration file, `pcfram.ini`. You need to modify the following four lines by replacing `c:\fram32` with the path name of the new directory.

```
mcb_log_path = "c:\fram32\mcberr.log"
pcfram_path = "c:\fram32\"
save_spectrum_path = "c:\fram32\spectra"
save_results_path = "c:\fram32\results"
```

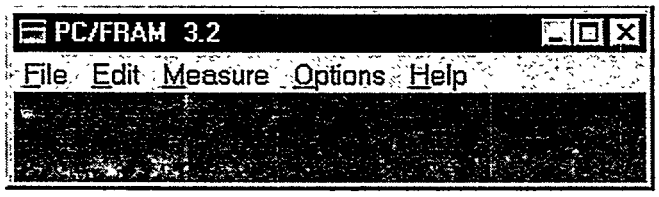
You could also accomplish this from within PC/FRAM by invoking the **Edit | General Defaults** option. See section 3.4.2 for more details on using this option.

2.1.5. Creating an Icon

You can create a shortcut to PC/FRAM by using Explorer to locate the file `fram32.exe` in the working directory. Select this file then drag it to the desktop. Now use the right mouse button to click on this icon. Choose the Rename option from the menu. Use the keyboard to enter "PC FRAM V3.2" then press the Enter key.

2.2. Running PC/FRAM for the first time

Run PC/FRAM by double clicking on its icon that was established during the installation procedure. The first time you run PC/FRAM two information dialog boxes will appear. The first will tell you that a user authorization file was created for you. The second will tell you that a database was created for you. Eventually, the following window will appear on the screen.



2.2.1. Main Menu Overview

Presented below is a brief description of the functions provided by PC/FRAM's main menu.

File This menu allows you to open a spectral data file and read it into memory and to save spectral data into a file on disk. It also allows you to exit from PC/FRAM.

Edit This menu allows you to edit the parameters in the parameter sets, to establish default values for various dialog boxes, and to establish passwords and access rights for different users.

Measure This menu allows you to acquire a spectrum from a multi-channel analyzer under the control of the PC/FRAM program. This could be followed by an analysis of the spectrum collected. These operations require the installation of the appropriate hardware and its associated software drivers. This option also allows you to analyze spectra from a disk file or a series of disk files.

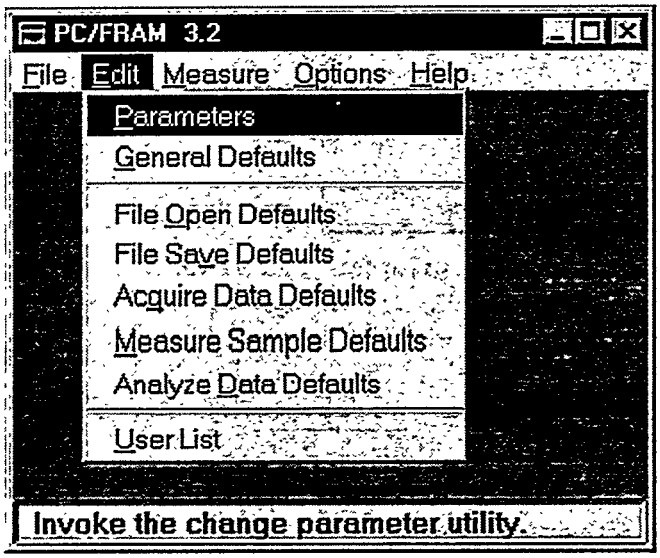
Options This menu allows you to view a display of the spectral data being analyzed or opened by the program. It also allows you to display, region by region, the calculated background and fit to the net data for the last spectrum analyzed. You can also choose to view the relative efficiency curve and its fitting residuals while another suboption permits you to print the results of the last analysis at any desired print level. You can also retrieve the results files from previously analyzed spectra as well as run a program that updates and decay corrects a plutonium isotopic distribution. There is also an option for choosing one of two languages to be used for the display of information on the screen.

Help This menu allows you to see a screen with the name and version number of the program along with copyright information.

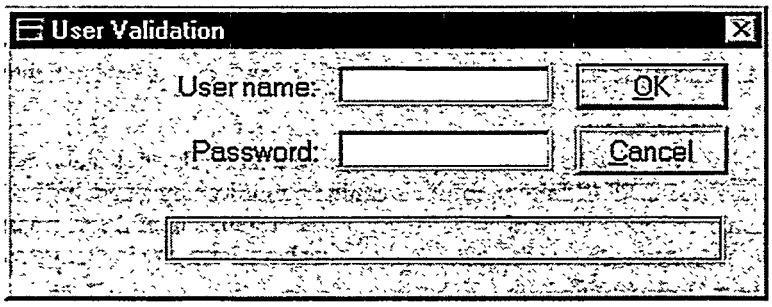
2.2.2. Importing Parameter Sets

When PC/FRAM is run for the very first time an "empty" database is created. It is very important that you populate the database with some parameter sets. The distribution kit comes with several sets of analysis parameters each in its own text file. These files all have an extension of ".pst". These parameter sets and their applicability are described in Appendix C. The following procedure shows you how to import one or more of these parameter sets into the database.

From PC/FRAM's main menu select the **Edit | Parameters** option.

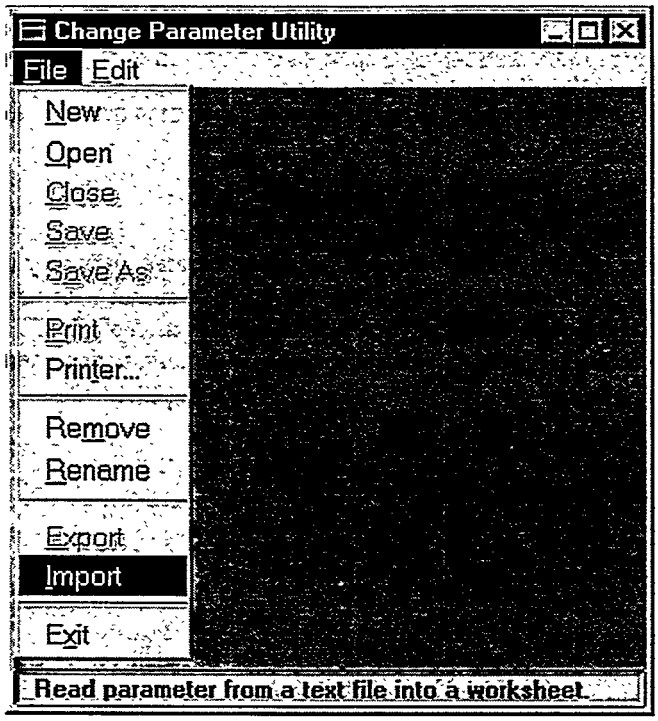


A dialog box entitled **User Validation** will appear on the screen.

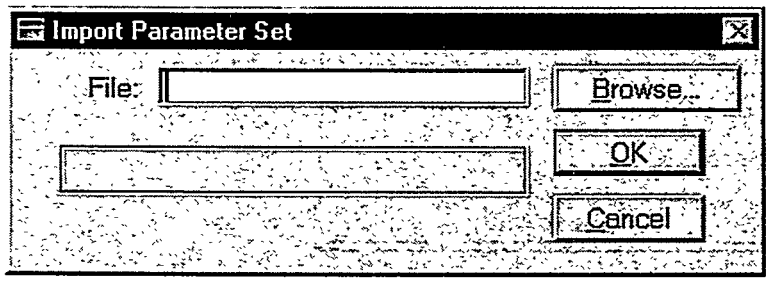


Click on the **OK** button to dismiss this dialog box. A password is not required because the user authorization file created by FRAM contains a record with a "null" user name and a "null" password (cf. Section 3.4.8).

You will now be in the **Change Parameter Utility**, and it has its own menu. From this menu select the **File | Import** option.

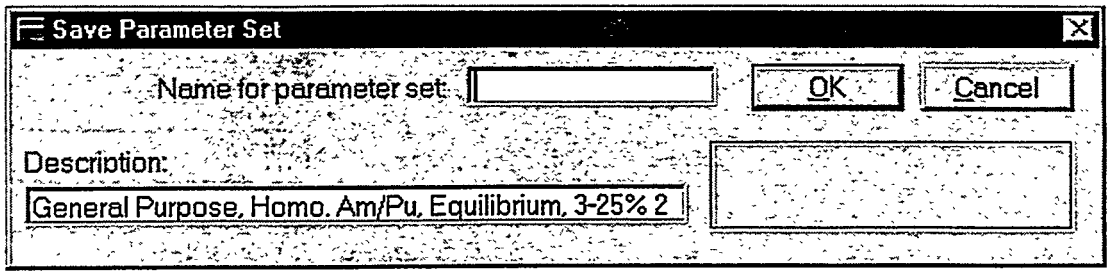


A dialog box entitled **Import Parameter Set** will appear on the screen.



Click on the **Browse...** button. Windows will activate the standard **File Open** dialog box. Use it to select one of the parameter set files supplied with the distribution kit. Note that during installation all the parameter sets on the distribution diskette were copied to the subdirectory

`c:\fram32\paramset`. Now click on the **OK** button to dismiss the **File Open** dialog box. The dialog box entitled **Import Parameter Set** will reappear. Click on the **OK** button to dismiss this dialog box. Another dialog box entitled **Save Parameter Set** will appear on the screen. The picture below serves as an example.



Fill in the name you wish to use to identify the parameter set. The name may be any combination of alphanumeric characters (up to 30). Names longer than 18 characters may not be displayed fully in some of the dialog boxes. You may also change the description that is associated with the parameter set, but this is not recommended. Then click on the **OK** button. An information dialog box will appear telling you that the parameter set has been saved. Either click on the **OK** button or wait 5 seconds for the dialog boxes to disappear.

If you want to import another parameter set, choose the **File | Close** option, then repeat the preceding steps starting with the selection of the **File | Import** option. See section 4.1.10 for more information on importing parameter sets into the database.

Select the **File | Exit** option return to PC/FRAM's main menu.

2.2.3. Setting General Defaults

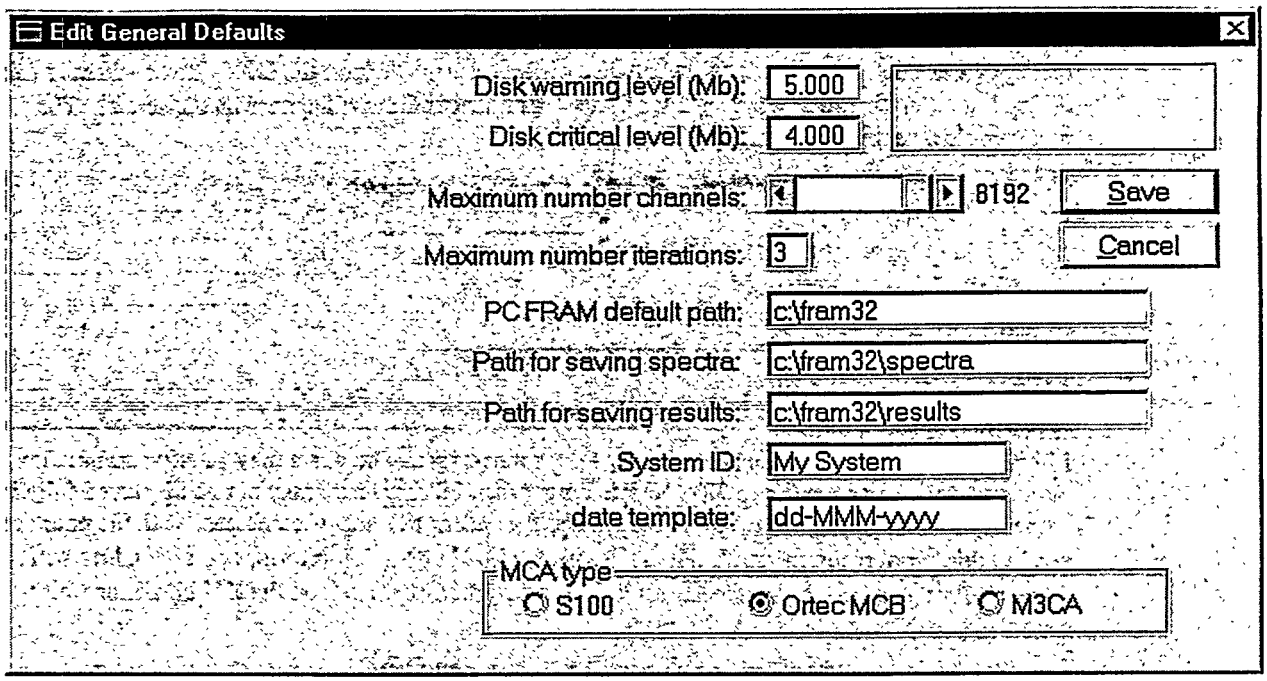
You also need to make sure that the general defaults are set properly. From PC/FRAM's main menu select the **Edit | General Defaults** option. A dialog box entitle **User Validation** will appear on the screen. Click on the **OK** button to dismiss this dialog box.

A dialog box entitled **Edit General Defaults** will appear on the screen. The following picture will serve as an example. The information in this window proved the default settings. You may change any of these to suit your own situation. The picture below shows the dialog box that appears in version 3.2. In version 3.3, licensed to ORTEC, the set of radio buttons at the bottom is replaced by a single button with the title 'Default MCB'.

You should change the system ID to something more meaningful.

You should choose the MCA type to match the hardware on your system.

You might want to change the date template if you are used to displaying dates in a different manner. The template provided specifies dates with a two-digit day followed by a dash followed by a three-character month abbreviation followed by a dash followed by a four-digit year. You must specify a four-digit year in your template. See section 3.4.2 for more information about modifying fields in this dialog box.



2.2.4. Setting Passwords

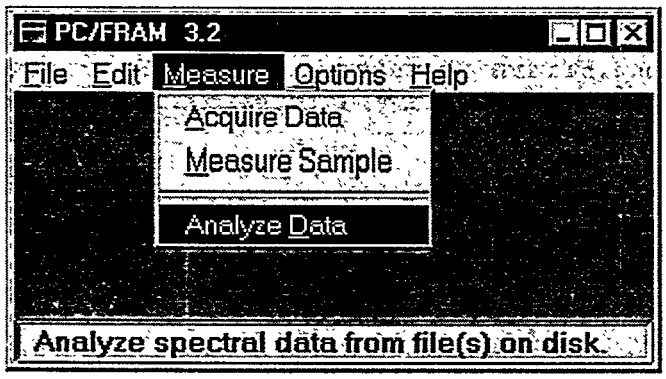
When PC/FRAM is run for the very first time, a user authorization file is created with four default user records. These are described in section 3.4.8. If for some reason you need to modify these or if you need to add other user records, select the **Edit | User List** from PC/FRAM's main menu. A dialog box entitled **User Validation** will appear on the screen. You need to enter the name and password of a user that has Manager privileges. Then click on the **OK** button to dismiss this window.

A table will appear on the screen. It will display information about all the user records that are in the user authorization file. You may edit the information in this table to reflect your own situation. Then click on the **OK** button to dismiss the dialog box and have the changes take effect. See section 3.4.8 for more information on how to modify the information in this table.

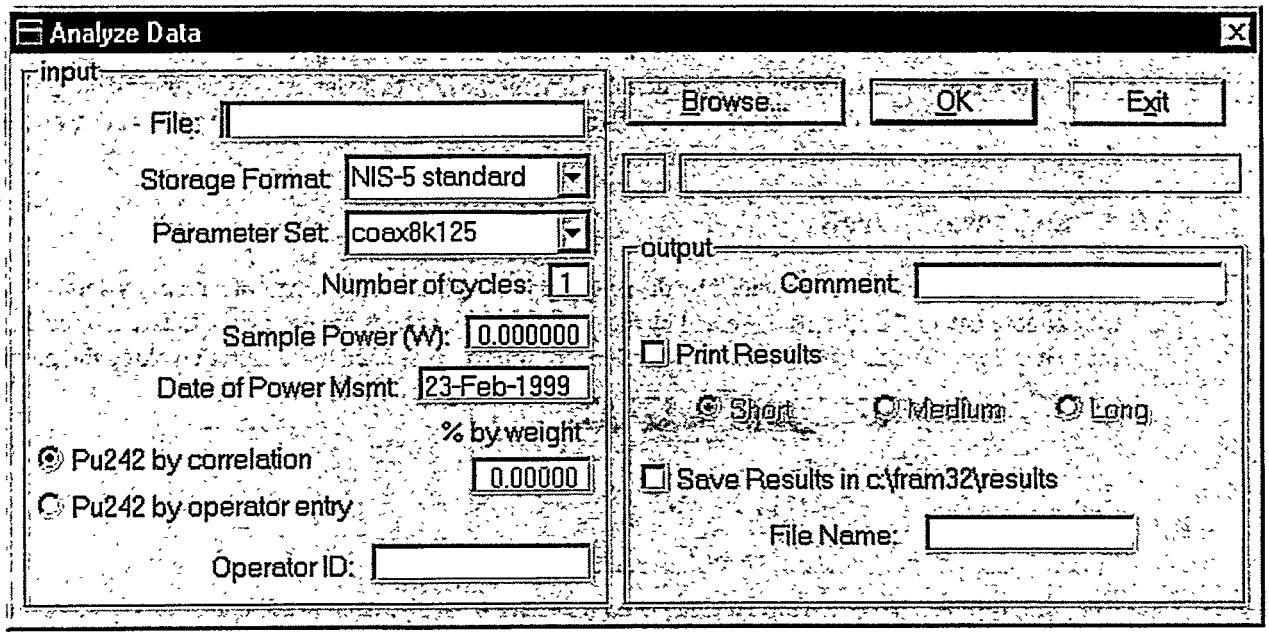
2.3. Analyzing Spectral Data

The following procedure shows how to analyze a spectrum stored in a disk file. It is assumed that you have already imported the appropriate parameter sets into the database.

Choose the **Measure | Analyze Data** option.



The **Analyze Data** dialog box will appear on the screen. The initial settings of the parameters may vary depending on how the default parameters have been set.



In the **Input** section, enter the filename in the **File:** box or click on the **Browse...** button to find the filename for the spectrum to be analyzed.

Choose the **Storage Format** from the pull down list or keep the default.

Choose the **Parameter Set** from the pull down list or keep the default.

This completes the minimum required information to analyze data from a disk file. The short output that appears on the screen will be described later. If you want a printout of the results, check the **Print Results** box in the **Output** section and select the **Short** radio button.

The **Sample Power** box in the **Input** section is used only if you wish to analyze a spectrum from an item previously measured in a calorimeter. Otherwise you ignore and leave the default value of zero alone.

For uranium analyses both the **Sample Power** and the **Pu242** by correlation entries should be ignored.

To proceed with the analysis click on the OK button. Just below this button you will see information about the analysis as it progresses. When the analysis is done, a summary of the results will be displayed on the screen in a special text window. An example of a results window is shown in section 3.6.4. To dismiss this window you need to click on the **X** in the upper right hand corner of the window or press the key combination Ctrl+F4.

> **NOTE!** With appropriate use of defaults, an analysis can be initiated with only two data entries – **File** and **Operator ID**.

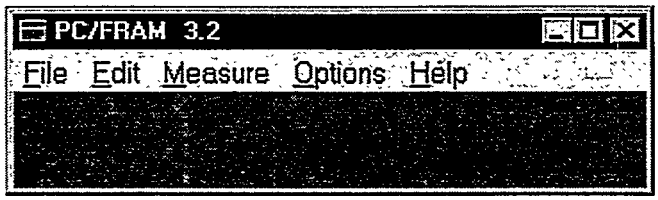
3. Operations Reference

3.1. Startup

To invoke the program from the desktop, double-click on the icon that was established during the installation procedure. The alternative to use Explorer to locate the file `fram32.exe` in your working directory and then double clicking on that entry.

3.2. Software Controls

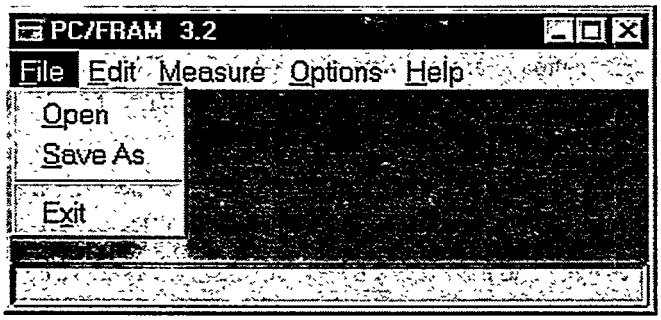
The major software controls provided by the program are implemented in terms of a menu system. You may choose any of the options presented by the menus. These options are grouped into five top-level menu headings. The following is the top-level menu structure presented to you after invoking the program.



The main features of the five top-level menu options have been discussed in section 2.2.1. The sections below describe these options in detail.

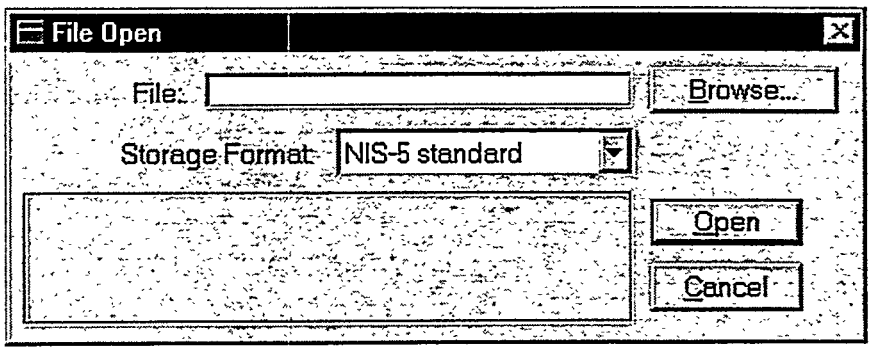
3.3. File

The File menu can be expanded by clicking on the word File with the mouse or by pressing the key combination Alt+F. The following picture shows the options available under the File menu.



3.3.1. File | Open

This option allows you to read spectral data from a disk file into memory. The following dialog box will appear on the screen.



File: Enter the specification (including path, name, and extension) for the file to be opened. You may click on the **Browse...** button and use the standard Windows dialog to search for the file to be opened.

Storage Format: You must select the data storage format of the selected file from the choices given. If the wrong format is chosen an error message will appear when the program attempts to read the data from the file.

Open Click on this button to open the specified data file. If there is an error in opening the file, a message will appear in the large box at the bottom of the window. If the file is opened successfully, the **Cancel** button will be renamed to **Exit**. Information about the spectrum will also appear in the large status box at the bottom of the window.

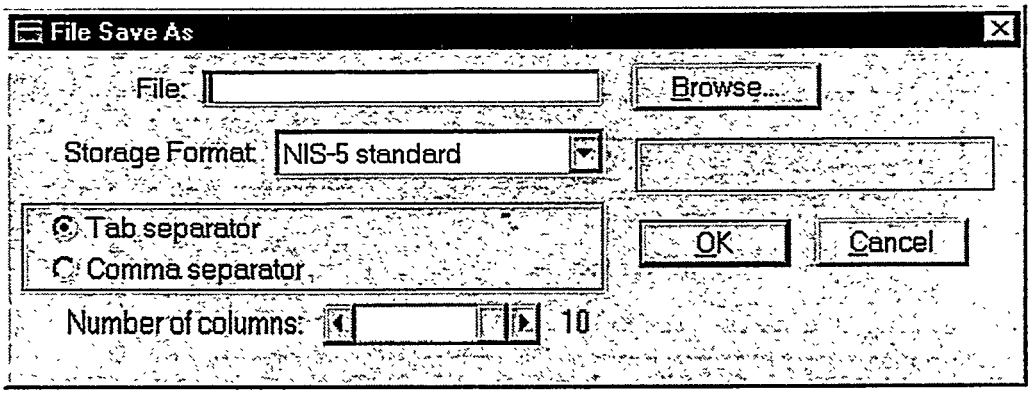
Cancel/Exit Click on this button to exit from the dialog box and return to PC/FRAM's main menu.

If you choose the ORTEC 'spc' storage format, a message box will appear on the screen asking you if you want to load the parameter values stored in the file into memory. If you answer yes, an active worksheet will be created and filled with that parameter information. A flag will also be set indicating that there is an active worksheet open. The effect is the same as if you had opened a parameter set and chosen the **Edit | Postpone Editing** option. See sections 3.3.3 and 4.2.6 for the consequences of this.

After opening a file, you can plot the spectrum by choosing the **Plot Spectrum** option from the **Options** menu or perhaps save the data in a disk file using a different format with the **Save As** option. The principle uses of these options are to preview spectra before analysis and to convert among data formats.

3.3.2. File | Save As

This option allows you to write spectral data from memory to a disk file. It brings up the following dialog box.



File: Enter the specification (including path, name, and extension) for the file where the spectral data will be stored. You may click on the **Browse...** button and use the standard Windows dialog to search for a file name.

Storage Format: You must select the data storage format of the selected file from the choices given. If you want the spectral data stored in text form, choose the ASCII storage format. In this case, you need to specify the character used in separating entries in each row. You also need to specify how many columns you want.

OK Click on this button to store the spectral data.

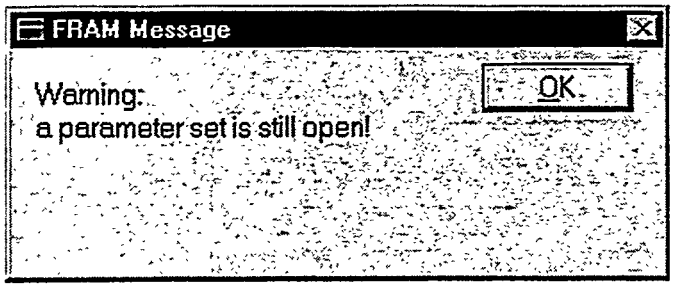
Cancel Click on this button to exit from the dialog box and return to PC/FRAM's main menu without saving the spectral data.

If you choose the ORTEC 'spc' storage format, a dialog box entitle 'FRAM Parameter Sets' will appear on the screen. If you want to store parameter set information with the spectral data, select the name of the parameter set then click on the OK button. If you do not want to store any parameter information with the data, click on the Cancel button.

The **Save As** option allows you to use the program as a data format translation utility, especially useful because of the flexible ASCII formatting allowed. For example, selecting **ASCII** and one column causes the data to be written in a way that allows you to import it into a spreadsheet program.

3.3.3. File | Exit

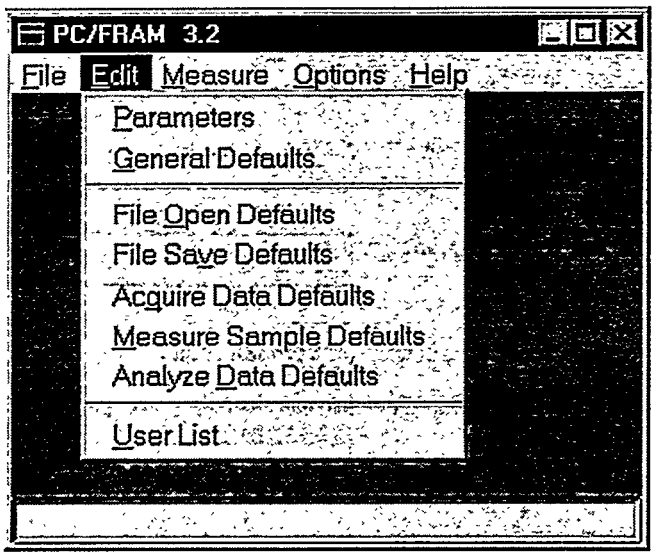
This option closes the PC/FRAM code and returns you to the Windows Desktop. There are two alternatives to closing PC/FRAM. You may click on the **X** in the upper right hand corner of the window. You may also click on the small box in the upper left-hand corner of the window to bring up a small system menu and then choose the **Close** option. None of these options will succeed if you had opened a parameter set in the Change Parameter Utility and then chosen the **Postpone Editing** option. Instead the following message will appear on the screen.



In this case you must get back into the Change Parameter Utility and exit in the normal way.

3.4. Edit

The Edit menu can be expanded by clicking on the word **Edit** with the mouse or by pressing the key combination Alt+E. The following picture shows the options available under the **Edit** menu.



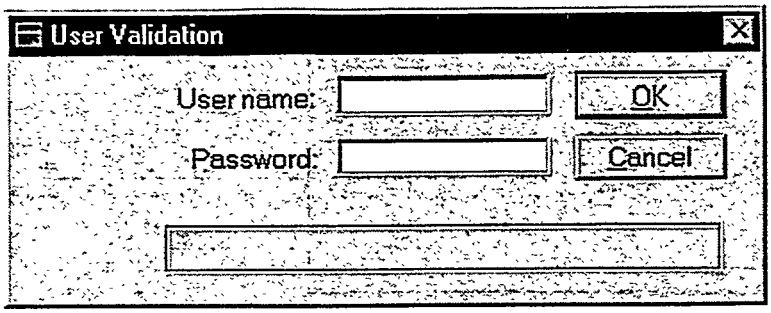
3.4.1. Edit | Parameters

NOTE! This password-protected option controls all the analysis parameters and their default values. This option will be discussed in detail in the Change Parameter Utility, section 5, in this manual.

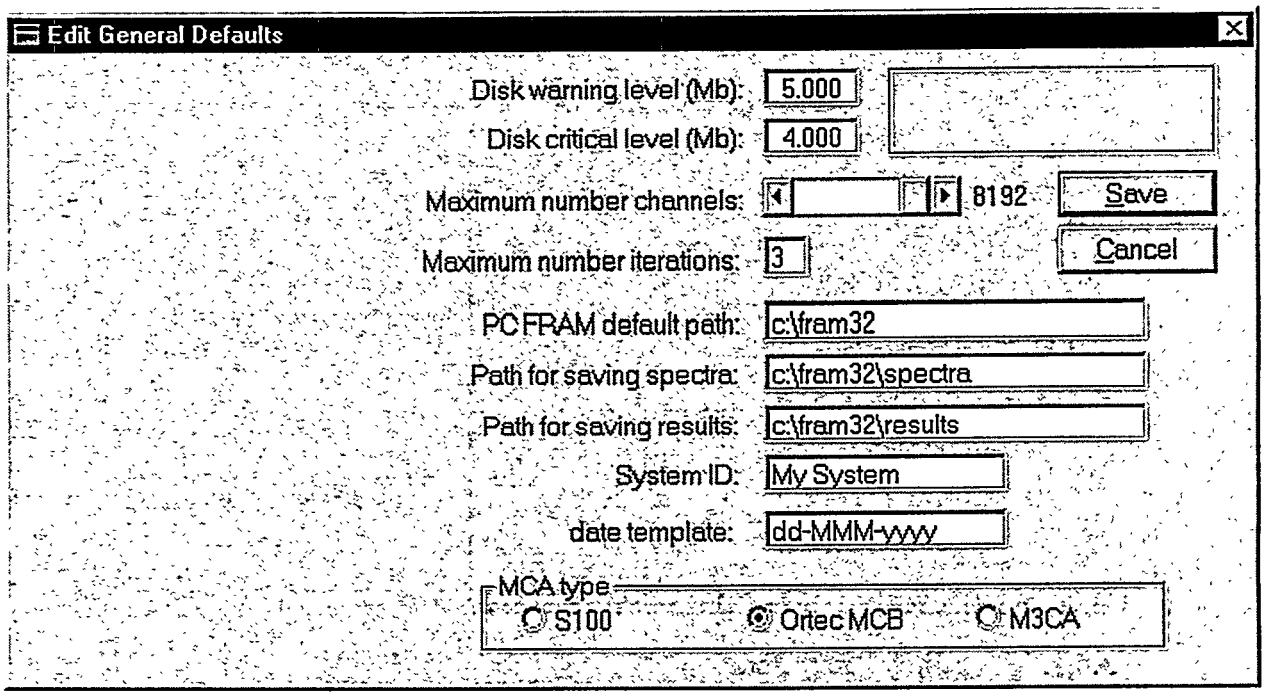
3.4.2. Edit | General Defaults

General defaults refers to the configuration parameters which govern the environment in which this program runs. They are stored in the configuration file, `pcfram.ini`. This option allows you to view and modify these parameters.

This option is protected by the password mechanism (see section 3.4.8). A dialog box entitled **User Validation** will first appear on the screen.



Enter the **User Name** and **Password** of an account, which has been, granted supervisory access and then click on the **OK** button. If access is permitted, the General Defaults will appear in a dialog box just like the one below. You may now edit their values. The picture below shows the dialog box that appears in version 3.2. In version 3.3, licensed to ORTEC, the group box labeled 'MCA type' along with the enclosed set of radio buttons is replaced by a single button with the title 'Default MCB'.



Disk warning level (Mb): This is the level of free space, in megabytes, on the disk below which warning messages will appear before new space is allocated for the creation of output files.

Disk critical level (Mb): This is the level of free space, in megabytes, on the disk below which error messages appear and no new space is allocated for the creation of output files.

Maximum number channels: The value displayed is set with the horizontal scroll bar. You may analyze spectra with fewer channels than the setting, but not more. This is usually set to 8192.

Maximum number iterations: The background, relative efficiency, peak area, and isotopic results calculations are repeated or iterated. Leave the setting at 3.

PC FRAM default path: This is the path to the PC FRAM directory. A default path is provided when the software is installed. If you change this path, you must create or make sure the appropriate directory exists. The program does not create the directory from this option.

Path for Saving Spectra: This is the path for storing spectral data files. A default path is provided when the software is installed. If you change this path, you must create or make sure the appropriate directory exists. The program does not create the directory from this option.

Path for Saving Results: This is the path for storing results files. A default path is provided when the software is installed. If you change this path, you must create or make sure the appropriate directory exists. The program does not create the directory from this option.

System ID: This is a user-specified name (with a maximum of 59 characters) describing the computer/measurement system. It is used as identification on the printed output.

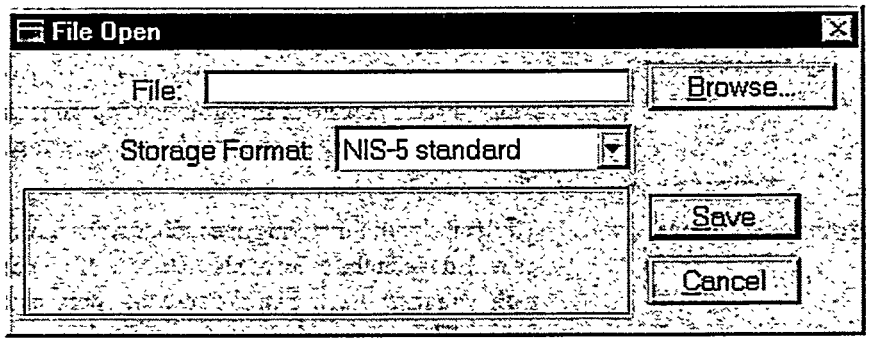
date template: You may enter a custom template to be used for displaying dates. The default template shown above specifies a two-digit day followed by a dash followed by a three-character month abbreviation followed by a dash followed by a four-digit year. In this template, a lowercase 'd' represents day of the month, a lowercase 'm' represents month of the year as a digit, an uppercase 'M' represents month of the year as a character, and a lowercase 'y' represents the year. Other characters in the template are reproduced without interpretation.

> **Note!** It is required that you specify a four-digit year in your date template.

MCA Type: Select the radio button corresponding to type of MCA connected to your system. If your choice ORTEC MCB, a dialog box will appear with a list of the MCB's available to the system; choose one of these. If you select any of the other buttons, the error message "This MCA type is not implemented" will appear in the upper right-hand corner of the window. If your system is used for analysis only, with no data acquisition control, the choice of MCA type is irrelevant.

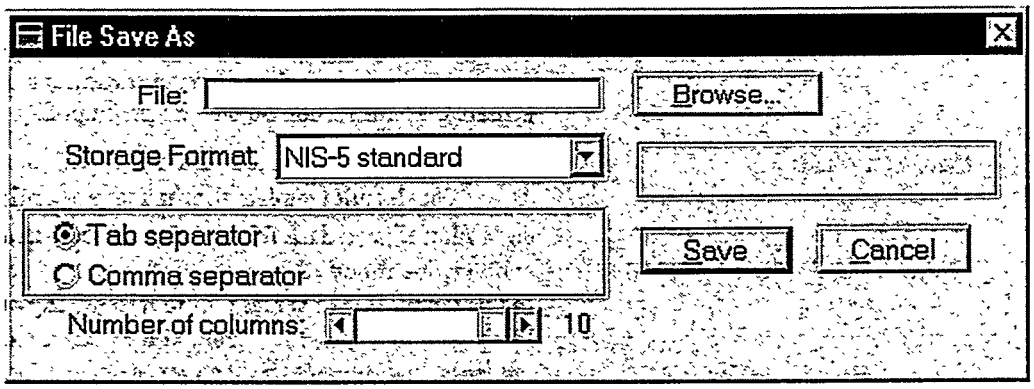
3.4.3. Edit | File Open Defaults

The dialog box, which appears, is a replica of the one that appears when you select the **Open** option under the **File** menu. The only difference is that the **OK** button is labeled **Save**. You may modify any information in this dialog box. If you then click on the **Save** button, these values become the defaults any time this dialog box is invoked again.



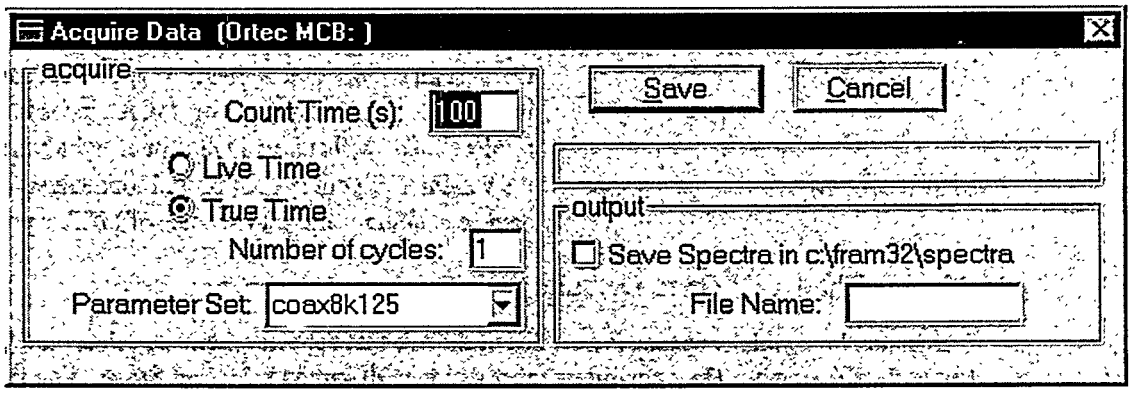
3.4.4. Edit | File Save Defaults

The dialog box, which appears, is a replica of the one that appears when you select the **Save As** option under the **File** menu. The only difference is that the **OK** button is labeled **Save**. You may modify any information in this dialog box. If you then click on the **Save** button, these values become the defaults any time this dialog box is invoked again.



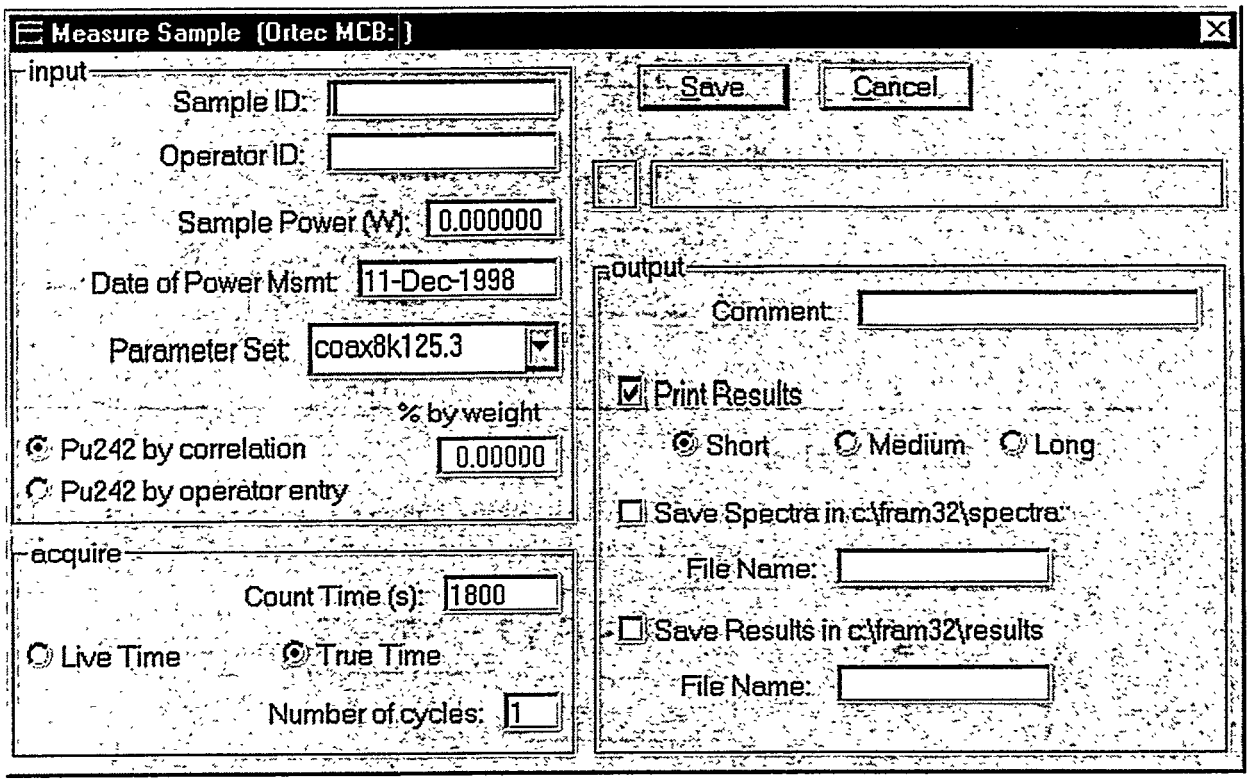
3.4.5. Edit | Acquire Data Defaults

The dialog box, which appears, is a replica of the one that appears when you select **Acquire Data** option under the **Measure** menu. The only difference is that the **OK** button is labeled **Save**. You may modify any information in this dialog box. If you then click on the **Save** button, these values become the defaults any time this dialog box is invoked again.



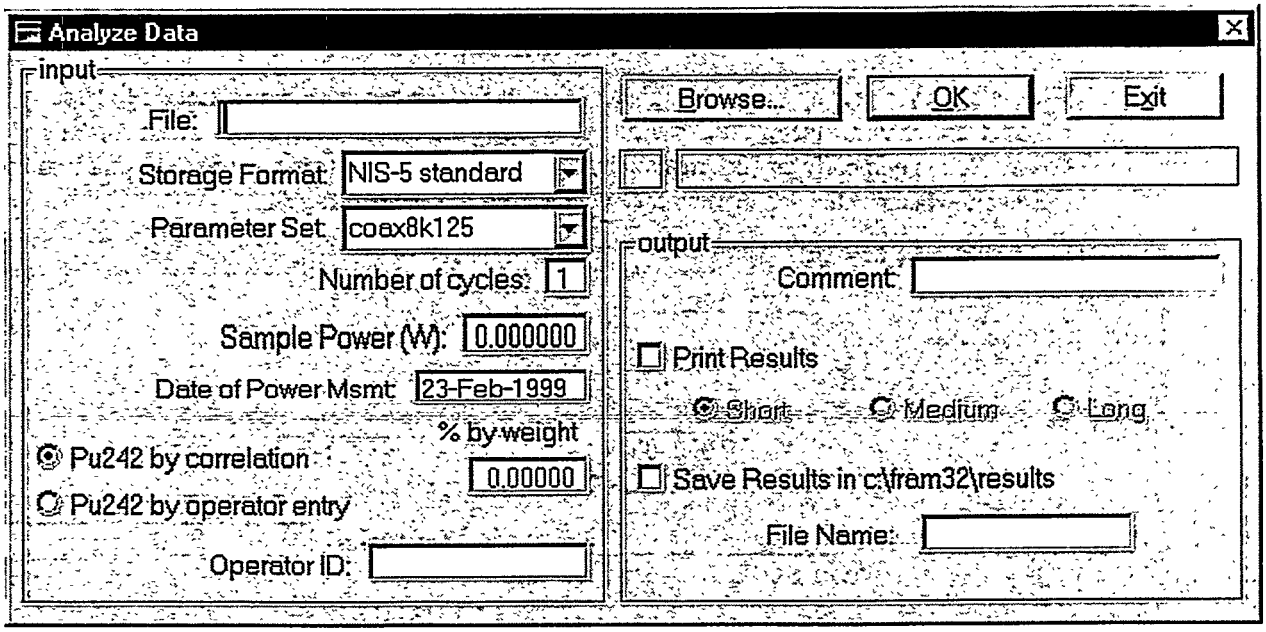
3.4.6. Edit | Measure Sample Defaults

The dialog box, which appears, is a replica of the one that appears when you select the **Measure Sample** option under the **Measure** menu. The only difference is that the **OK** button is labeled **Save**. You may modify any information in this dialog box. If you then click on the **Save** button, these values become the defaults any time this dialog box is invoked again.



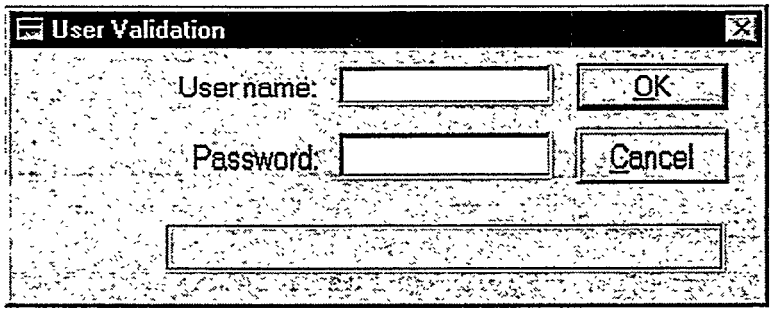
3.4.7. Edit | Analyze Data Defaults

The dialog box, which appears, is a replica of the one that appears when you select **Analyze Data** option under the **Measure** menu. The only difference is that the **OK** button is labeled **Save**. You may modify any information in this dialog box. If you then click on the **Save** button, these values become the defaults any time this dialog box is invoked again.

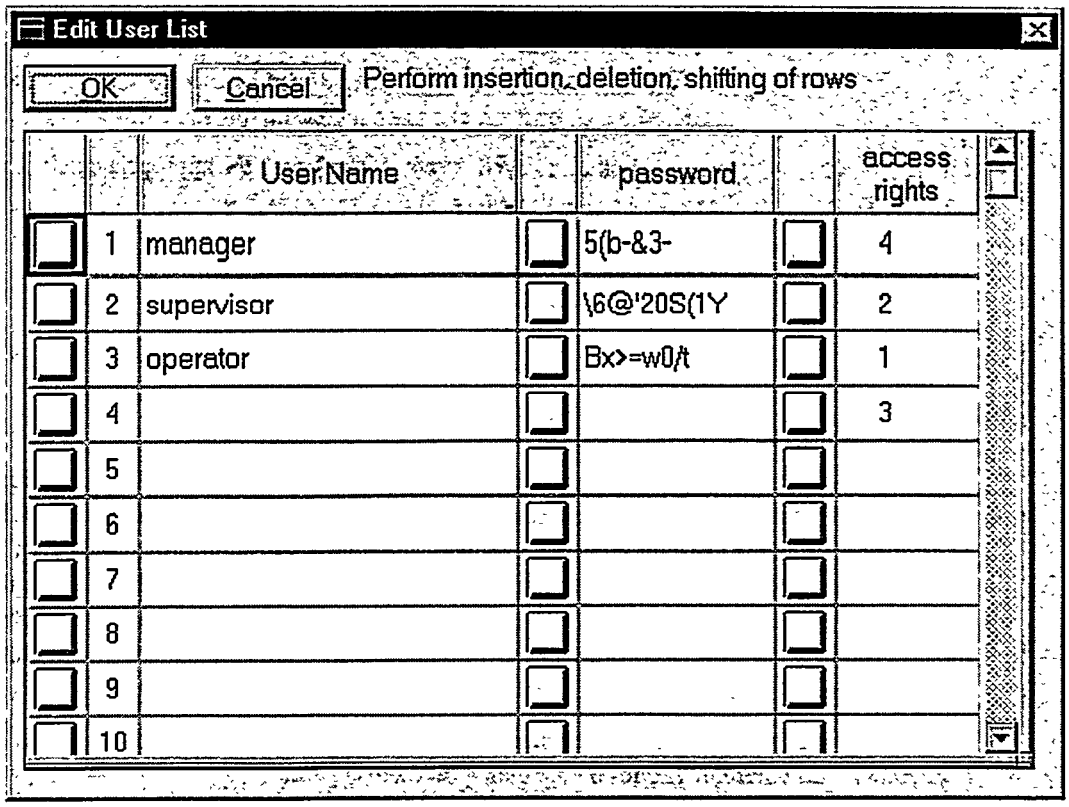


3.4.8. Edit | User List

This option allows you to view and modify the information about the user accounts that is stored in the User Authorization File. This option is protected by the password mechanism. The following dialog box will first appear.



Enter the **User Name** and **Password** of an account that has been granted access to the user list then click on the **OK** button. If access is permitted, a table similar to the one below will appear on the screen



When the table first appears, the focus is placed on the **OK** button. Pressing the Tab key shifts the focus to the **Cancel** button. You can use the mouse to select a cell in the table by clicking on it. If you do, a dark black border will appear around that cell. You can now navigate between cells by using the Tab, Shift+Tab, ←, →, ↑, and ↓ keys. You can use the vertical scroll bar at the right of the screen to view more of the table. Clicking on a cell with a yellow box in it will cause an auxiliary dialog box to appear on the screen.

The first column displays an index, which serves as a row number for the table.

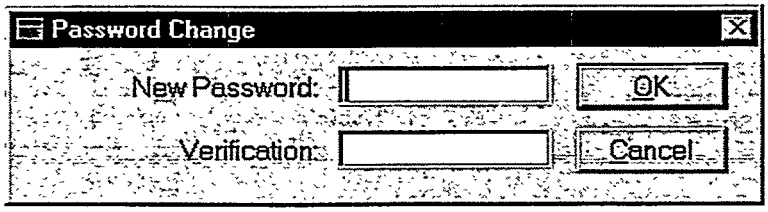
User Name This column contains the name associated with each user account. You can replace the contents of a cell in this column by selecting the cell then typing in new characters into that cell.

password This column contains the encrypted password associated with each user account. You cannot change the contents of a cell in this column directly. You must click on the yellow button to the left of the cell you want to change. An auxiliary dialog box will appear which will allow you to change the password.

access rights This column indicates what access rights are granted to each user. You cannot change the contents of a cell in this column directly. You must click on the yellow button to the left of the cell you want to change. An auxiliary dialog box will appear which will allow you to change the access rights. There are three levels of access rights designated as manager, supervisor, and operator. Operator rights have a value of 1, supervisor rights have a value 2, and manager rights have a value of 4. These access rights may be combined. If this is done, the number in this column will be the sum of the values associated with the individual rights used in the combination

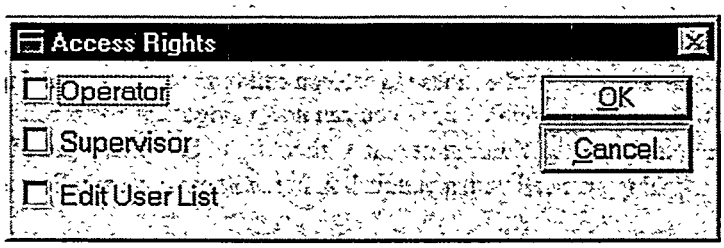
Row Operations: Rows may be added, deleted, or shifted in the user list. See section 4.2.2.1 for information on doing this. When editing the user list, the **Move this row up** and **Move this row down** commands can be used to rearrange the rows. See section 4.2.2.2 for instructions on increasing the number of rows in this table.

To modify a user's password, click on the yellow box to the left of the appropriate cell in the **password** column. The following dialog box will appear.



Enter the new password in the box labeled **New Password** then enter the exact same password in the box labeled **Verification**. The passwords are case sensitive and the typed characters will be echoed as asterisks. Click the **OK** button. If the passwords do not match, an information box will appear with the error message **Passwords do not match**. In this event click on the **OK** button to dismiss the box, and try again. When the password entry is successful, the above dialog box will disappear and the encryption of the new password will show up in the cell. If you click the **Cancel** button to abort this operation and return to the table, the old password remains intact.

To modify a user's access rights, click on the yellow box to the left of the appropriate cell in the **access rights** column. The following dialog box will appear.



Check the boxes on the left for the access rights that you want to grant to the user. You may check more than one box. Then click on the **OK** button to dismiss this dialog box and return to the user list. The number in the access rights column will reflect the new access rights that you chose. If you click on the **Cancel** button in the dialog box shown above, it will disappear and the old access rights will remain in effect.

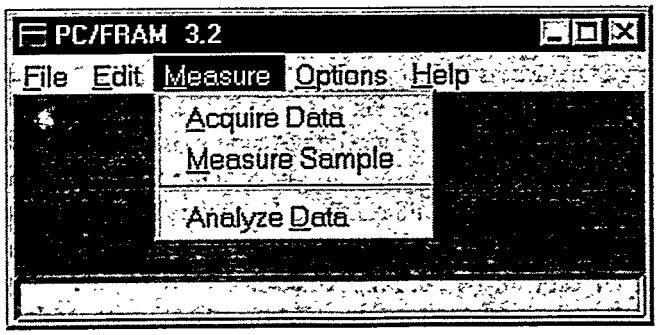
The user authorization file contains a list of authorized users, their passwords (in encrypted form), and the level of access granted to each. The following records are present in this file when first created

Name	Password	Access Level
manager	manager	Manager (can edit list of users)
supervisor	supervisor	Supervisor (can edit parameters & defaults)
operator	operator	Operator
"null"	"null"	Supervisor (can edit parameters & defaults)

where "null" means a string with no characters in it. The picture of the user list shown above reflects these default settings.

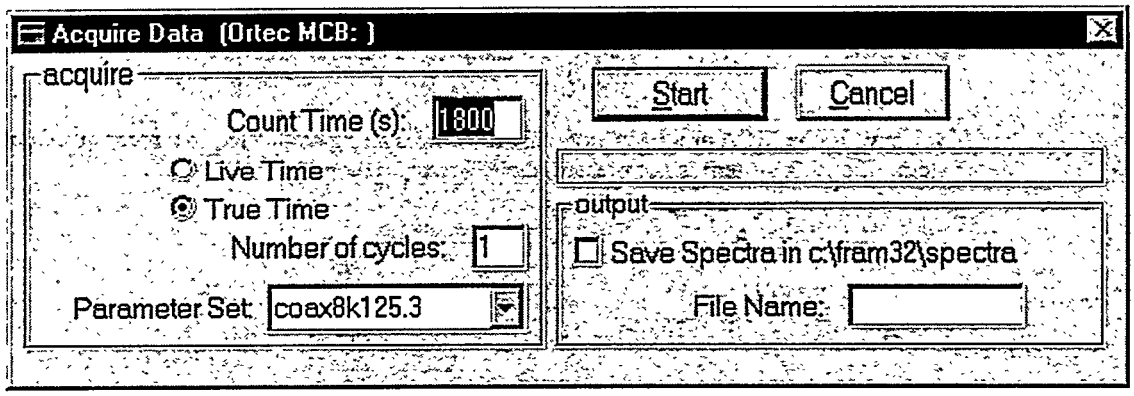
3.5. Measure

The Measure menu can be expanded by clicking on the word **Measure** with the mouse or by pressing the key combination Alt+M. Two options in this menu control acquisition of the spectral data with subsequent analysis (**Measure Sample**) and without analysis (**Acquire Data**). The third option (**Analyze Data**) allows you to analyze spectral data that is stored in a file on disk.



3.5.1. Measure | Acquire Data

This option controls all aspects of a data acquisition with data storage, but no analysis. The following dialog box will appear on the screen. Its defaults are set under the **Acquire Data Defaults** option in the **Edit** menu. Its title reflects the type of MCA chosen in the **General Defaults** option under the **Edit** menu.



Acquire

Count time (s): Enter the data acquisition time in seconds.

Live Time The amount of time during which the analyzer is actively engaged in counting pulses from the detector/preamplifier. The time during which the analyzer is unable to count pulses is referred to as "dead time".

True Time The elapsed clock time during the data acquisition. This is the sum of the live time and the dead time.

Number of Cycles: Enter the number (between 1 and 99) of repeated data acquisition and storage cycles. More than one cycle is typically called an Autocycle. The acquisitions will be repeated without operator intervention.

Parameter Set: You must select a named set of analysis parameters from the list of the parameter sets in the database. This is used for display purposes during acquisition.

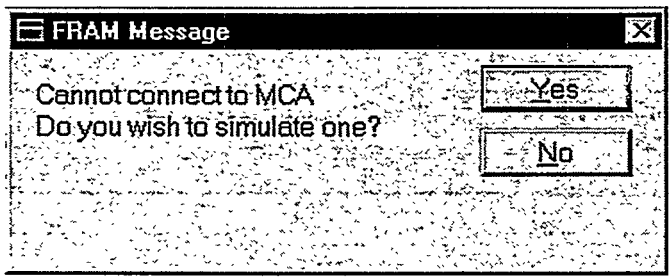
Output

Save Spectra ... Check this box if you want the spectral data saved to disk. The path to the storage directory is given. The file name for the spectral data should be a legal DOS file name with a maximum of 8 characters. If the measurement is an autocycle (**Number of Cycles** > 1) the last two characters of the extension to the file name will be replaced by a two-digit cycle number. If you do not supply an extension, the letter **s** will be used for the first character. The default path shown above the box is set during installation and may be changed in the **General Defaults** option under the **Edit** menu. The data storage format will be determined by the type of MCA connected to your system. If the MCA is a Canberra S100, the format will be the S100 format. If the MCA is a LANL M^3CA, the format will be the NIS-5 Standard. If the MCA is an ORTEC MCB the format will be the ORTEC 'chn' format in version 3.2 and the ORTEC 'spc' format in version 3.3.

Start Click on this button to start the measurement. It will invoke the MCA emulator.

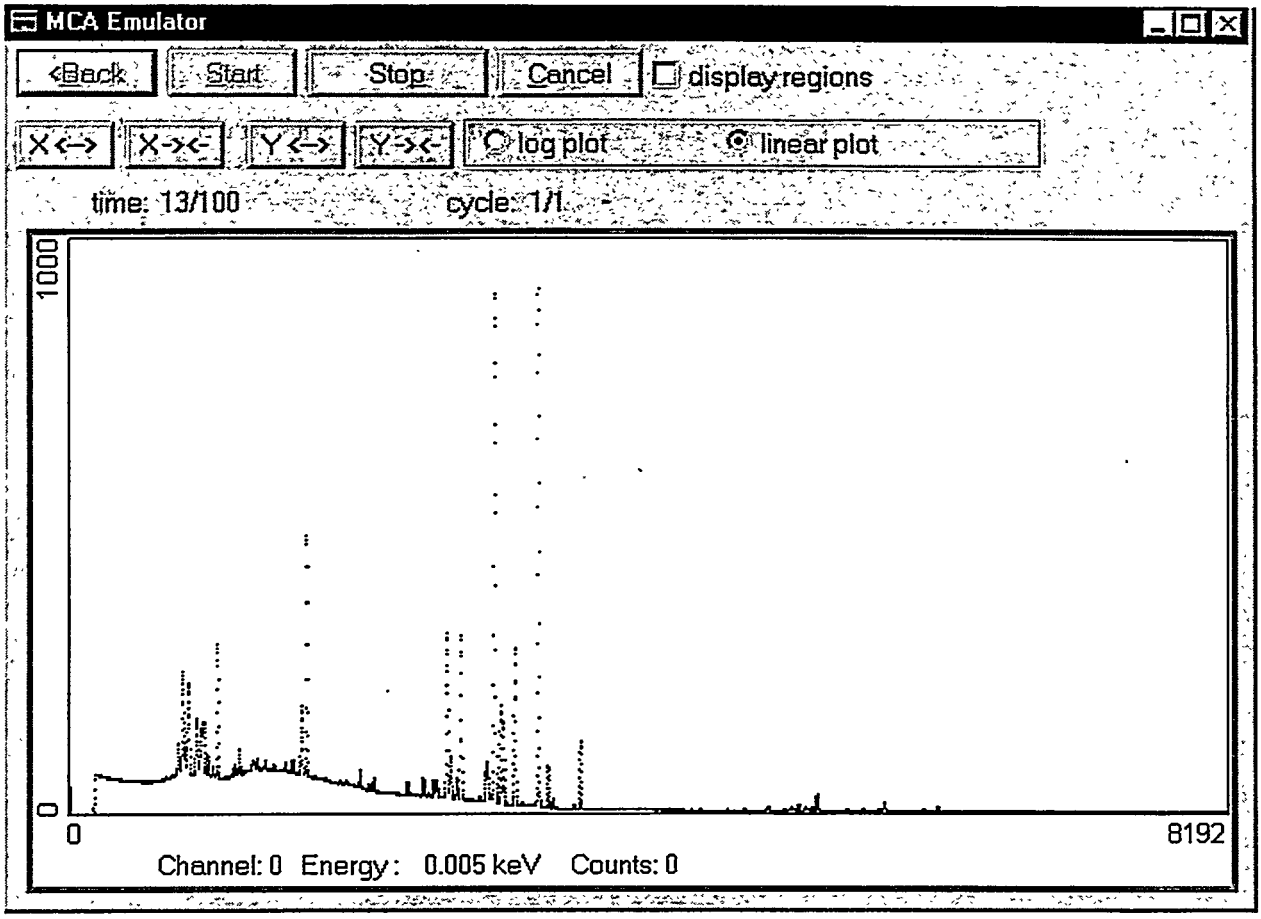
Cancel Click on this button to cancel the measurement and return to FRAM's main menu.

If you invoke the MCA emulator, note that it requires being connected to a recognized data acquisition system. If such a system is not present, the following dialog box will appear.



Answering **No** causes the **Measure Sample** dialog box to disappear. FRAM's main menu will then become active again. Answering **Yes** allows for simulation of a live acquisition using an existing spectral data file. This file must contain spectral data stored ORTEC's 'chn' format. The purpose of this simulation is for development and testing purposes.

If you are connected to a recognized MCA or if you have chosen to simulate one, the window shown below will appear on the screen. This window can be maximized, minimized, and even resized to a larger window if the size of the screen permits.



< Back Click on this button to return to the Measure Sample dialog box. This button is initially disabled and can only be enabled by stopping the acquisition of data.

Start Click on this button to restart the acquisition of data. This button is initially disabled. It is enabled when the stop button is pushed.

Stop Click on this button to stop the acquisition of data. After doing so, this button will be disabled until the start button is pushed.

Cancel Click on this button to cancel the acquisition of data, to return to the Measure Sample dialog box, and to continue with the analysis of the data that has already been acquired.

display regions Check this box to have the regions specified in the parameter set displayed. The background points will be shown in green while the peak regions will be shown in red.

X <—> Click on this button to increase the scale horizontally. In order for this to be effective, you must first select the plot window by clicking inside of it with the mouse.

X –><– Click on this button to decrease the scale horizontally. In order for this to be effective, you must first select the plot window by clicking inside of it with the mouse.

Y <—> Click on this button to increase the scale vertically. In order for this to be effective, you must first select the plot window by clicking inside of it with the mouse.

Y –><– Click on this button to decrease the scale vertically. In order for this to be effective, you must first select the plot window by clicking inside of it with the mouse.

log plot Click on this radio button to display the data on a log scale.

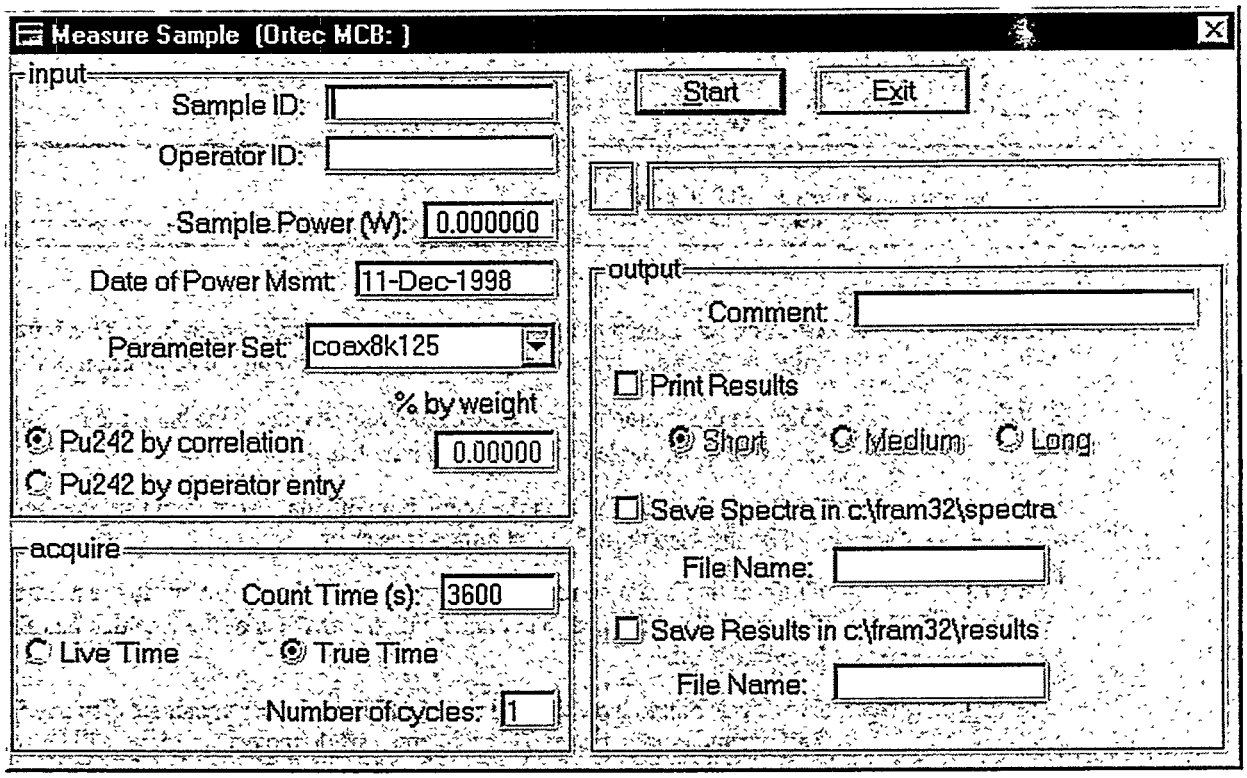
linear plot Click on this radio button to display the data on a linear scale.

time: This displays the elapsed time and the preset time.

cycle: This displays the current cycle number and the number of cycles requested.

3.5.2. Measure | Measure Sample

This option governs all aspects of a sample measurement including operator and sample identification, data acquisition, data analysis, output, and spectral data and results file generation. The following dialog box will appear on the screen. Its defaults are set under the **Measure Sample Defaults** option in the **Edit** menu.



input

Sample ID: You must enter a character string (up to 15 characters in length) identifying the sample being measured.

Operator ID: You must enter a character string (up to 15 characters in length) identifying the operator of the system.

Sample Power (watts): Enter the wattage from a previous calorimeter measurement. If no calorimeter measurement is available or if the sample is uranium, leave the sample power box at 0.0. If you enter the wattage and date, PC/FRAM will calculate and display the sample's total plutonium mass on the date of the calorimetry measurement.

Date of Power Msmt: Enter the date of the calorimeter measurement. This must conform to the date format as displayed. The **date template** string controls how dates are displayed, and you can change this in the **Edit | General Defaults** option.

Parameter Set: You must select a named set of analysis parameters from the list of the parameter sets in the database.

Pu242: Choose whether Pu242 is to be calculated by a correlation or whether a known value (in units of wt% relative to total plutonium) is to be entered by the operator. The correlation used is of the form

$$Pu242 = A*[(Pu238)^B * (Pu239)^C * (Pu240)^D * (Pu241 + Am241)^E]$$

where the constants A, B, C, D, and E are Application Constants in the selected parameter set and are entered or changed in the Change Parameter Utility. Ignore these entries for uranium measurements.

acquire

Count time (s): Enter the data acquisition time in seconds. Choose either live time or true time.

Number of Cycles: Enter the number of repeated data acquisition-data storage-data analysis cycles (a number between 1 and 99) to be repeated without operator intervention. More than one cycle is typically called an Autocycle.

output

Comment: Enter a comment (a character string up to 59 characters in length) that is reproduced on the output. Comments are optional.

Print Results Check the **Print Results** box if you wish to have the output automatically printed at the end of each analysis. You must then choose the level of detail (**Short, Medium,** or **Long**) desired in the output. Details of the various outputs will be presented later but the general features are these.

Short yields a half page printout, giving the final plutonium (or uranium) isotopic fractions, errors, specific power in Watts/gPu, $^{240}Pu_{eff}$ fraction, Time since Chemical Separation, and ratios of other designated isotopes to plutonium.

Medium yields a seven or eight page output containing, in addition to a complete short output; results of the internal calibration of FWHM, energy, and peak shape; complete diagnostics relating to energy calibration, FWHM calibration, shape calibration, and interferences; goodness of fit results for each region; results from relative efficiency curve fitting; final activity ratios for all isotopes; a summary of peak areas, relative efficiencies, and heterogeneity factors for all peaks; and diagnostic checks on the sample type.

Long adds a complete channel-by-channel summary of the fitting results for each region to the medium output. A long output may be 25-30 pages in length depending on the characteristics of the parameter set and the number of regions analyzed.

Save Spectra ...

Check this box if you want the spectral data saved to disk. The file name for the spectral data should be a legal DOS file name with a maximum of 8 characters. If the measurement is an autocycle (**Number of Cycles** > 1) the last two characters of the extension to the file name will be replaced by a two-digit cycle number. If you do not supply an extension, the letter **s** will be used for the first character. The default path shown above the box is set during installation and may be changed in the **General Defaults** option under the **Edit** menu. The data storage format will be determined by the type of MCA connected to your system. If the MCA is a Canberra S100, the format will be the S100 format. If the MCA is a LANL M^3CA, the format will be the NIS-5 Standard. If the MCA is an ORTEC MCB the format will be the ORTEC 'chn' format in version 3.2 and the ORTEC 'spc' format in version 3.3.

Save Results ...

Check this box if you wish to save the results of an assay in the indicated directory. A results file is a complete record of the entire analysis, essentially a text file containing a long printout. The file name for the spectral data should be a legal DOS file name with a maximum of 8 characters. If the measurement is an autocycle (**Number of Cycles** > 1) the last two characters of the extension to the file name will be replaced by a two-digit cycle number. If you do not supply an extension, the letter **r** will be used for the first character. The default path shown above the box is set during installation and may be changed in the **General Defaults** option under the **Edit** menu. This file can be viewed on the monitor by choosing the **Display Results** option in the **Options** menu. The use of this feature is intended mainly for debugging and development work. A typical results file takes nearly 100kb of disk space.

As an additional quality assurance feature, a copy of the parameter set used in the analysis is appended to the results file.

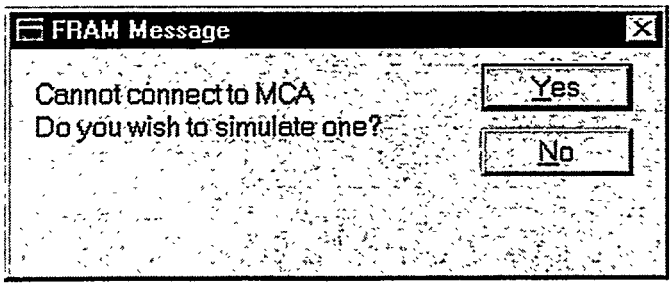
Start

Click on this button to start the measurement. It will invoke the MCA emulator.

Exit Click on this button to cancel the measurement and return to PC/FRAM's main menu.

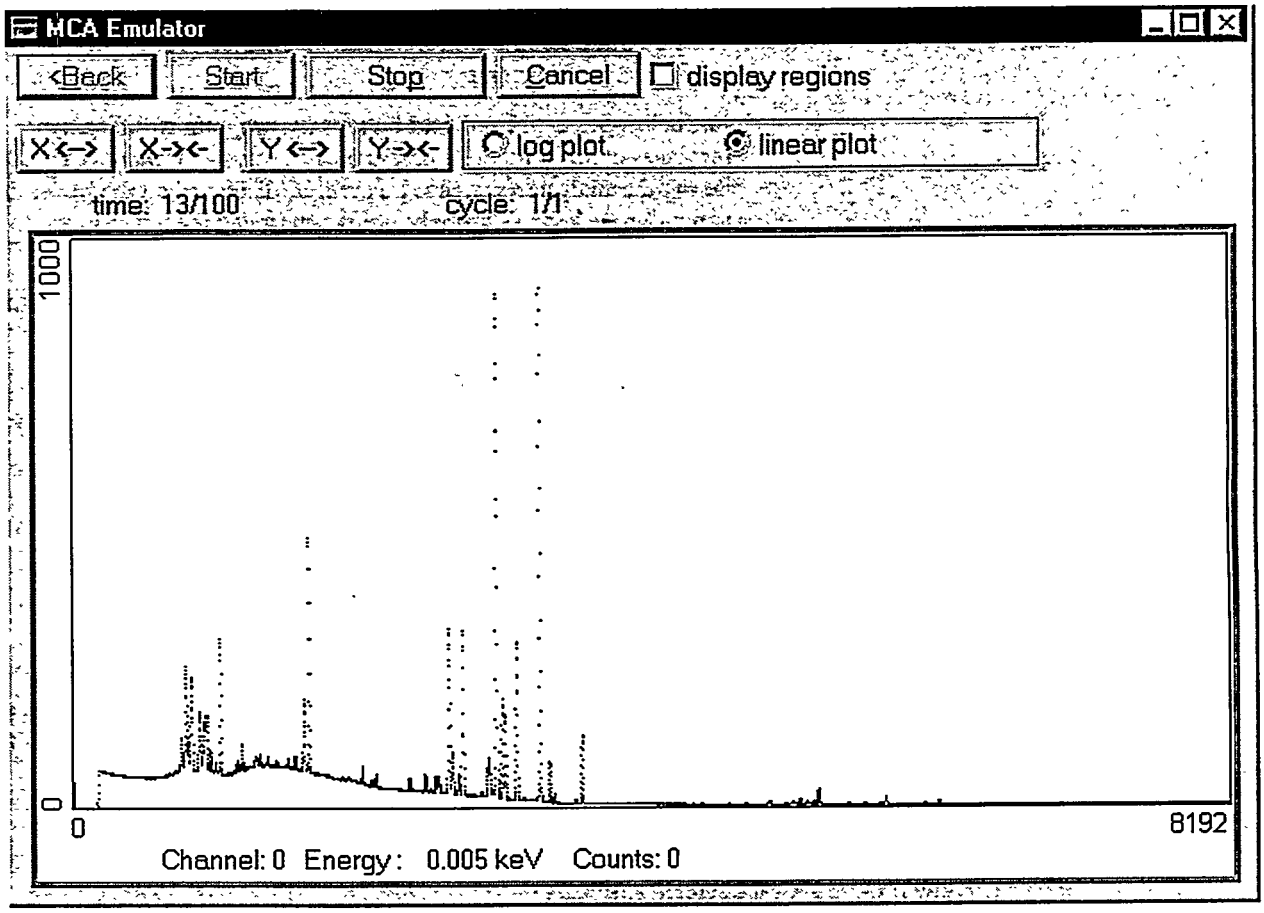
"status" Just below the **Start** and **Exit** buttons the program will display messages concerning the progress of the analysis. If there is an error during the analysis a message box will be displayed on the screen and you will be asked to choose between continuing the analysis or terminating the analysis.

If you invoke the MCA emulator, note that it requires being connected to a recognized data acquisition system. If such a system is not present, the following dialog box will appear.



Answering **No** or **Cancel** causes the **Measure Sample** dialog box to disappear; FRAM's main menu will then become active again. Answering **Yes** allows for simulation of a live acquisition using an existing spectral data file stored in the ORTEC's 'chn' format. The purpose of this simulation is for development and testing purposes.

If you are connected to a recognized MCA or if you have chosen to simulate one, the following window will appear on the screen. This window can be maximized, minimized, and even resized to a larger window if the size of the screen permits.



< Back	Click on this button to return to the Measure Sample dialog box. This button is initially disabled and can only be enabled by stopping the acquisition of data.
Start	Click on this button to restart the acquisition of data. This button is initially disabled. It is enabled when the stop button is pushed.
Stop	Click on this button to stop the acquisition of data. After doing so, this button will be disabled until the start button is pushed.
Cancel	Click on this button to cancel the acquisition of data, to return to the Measure Sample dialog box, and to continue with the analysis of the data that has already been acquired.
display regions	Check this box to have the regions specified in the parameter set displayed. The background points will be shown in green while the peak regions will be shown in red.
X <—>	Click on this button to increase the scale horizontally. In order for this to be effective, you must first select the plot window by clicking inside of it with the mouse.
X –><–	Click on this button to decrease the scale horizontally. In order for this to be effective, you must first select the plot window by clicking inside of it with the mouse.

Y <—> Click on this button to increase the scale vertically. In order for this to be effective, you must first select the plot window by clicking inside of it with the mouse.

Y –><– Click on this button to decrease the scale vertically. In order for this to be effective, you must first select the plot window by clicking inside of it with the mouse.

log plot Click on this radio button to display the data on a log scale.

linear plot Click on this radio button to display the data on a linear scale.

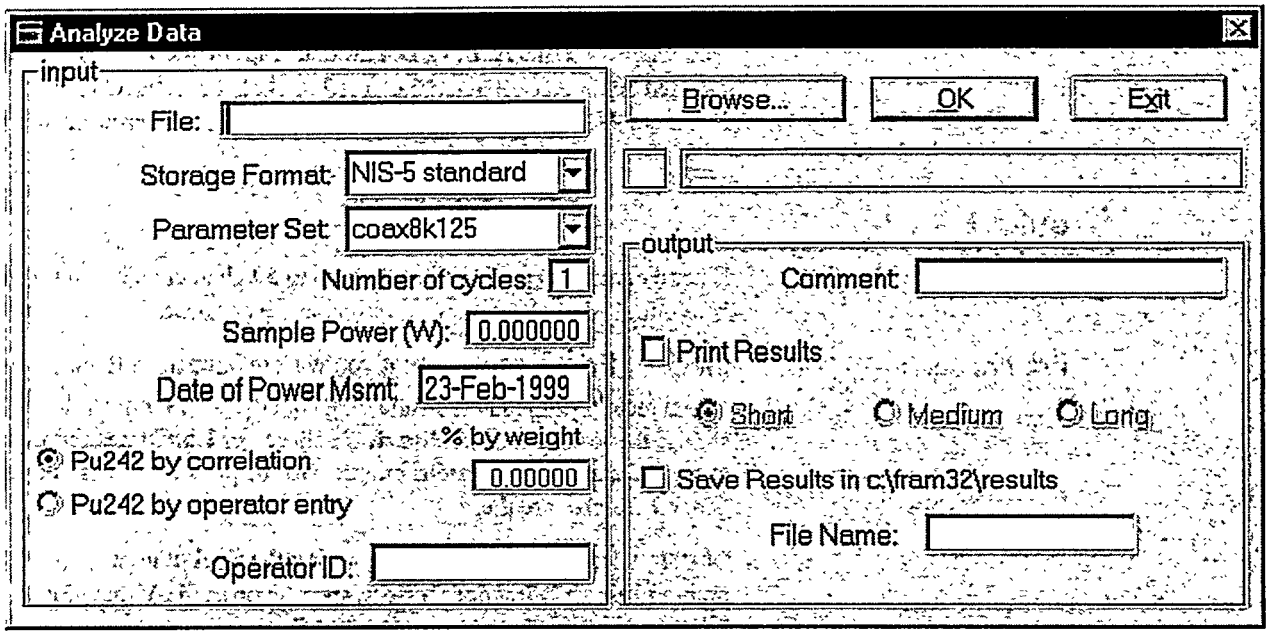
time: This displays the elapsed time and the preset time.

cycle: This displays the current cycle number and the number of cycles requested.

When the acquisition is done, this window disappears and the Measure Sample dialog box returns. At this point the spectrum will be analyzed. The results of the analysis will be automatically displayed on the screen. An example of a results window is shown in section 3.6.4. To dismiss this window you need to click on the **X** in the upper right hand corner of the window or press the key combination Ctrl+F4.

3.5.3. Measure | Analyze Data

This option allows you to analyze spectral data files stored on disk. The following dialog box will appear on the screen. Its defaults are set under the **Analyze Data Defaults** option in the **Edit** menu.



input

File: Enter the file to be analyzed, including complete path and extension. You may click on the **Browse...** button and use the standard Windows dialog to search for the file to be opened.

Storage Format: You must select the data storage format of the selected file from the choices given. If the wrong format is chosen an error message will

appear in the upper right hand corner of the dialog box when the program attempts to read the data from the file.

Parameter Set: You must select an analysis parameter set from the choices given. They represent the sets that currently exist in the database. If you select an inappropriate parameter set, you may encounter difficulties in the analysis.

Number of Cycles: The number of files with sequential filename extensions to be analyzed starting with the file entered above.

Sample Power (watts): Enter the wattage from a previous calorimeter measurement. If no calorimeter measurement is available or if the sample is uranium, leave the sample power box at 0.0. If you enter the wattage and date, PC/FRAM will calculate and display the sample's total plutonium mass on the date of the calorimetry measurement.

Date of Power Msmt: Enter the date of the calorimeter measurement. This must conform to the date format as displayed. The **date template** string controls how dates are displayed, and you can change this in the **Edit | General Defaults** option.

Pu242: Choose whether Pu242 is to be calculated by a correlation or whether a known value (in units of wt% relative to total plutonium) is to be entered by the operator. The correlation used is of the form

$$Pu242 = A*[(Pu238)^B * (Pu239)^C * (Pu240)^D * (Pu241 + Am241)^E]$$

where the constants A, B, C, D, and E are Application Constants in the selected parameter set and are entered or changed in the Change Parameter Utility. Ignore these entries for uranium measurements.

output

Comment: Enter a comment (a character string up to 59 characters in length) that is reproduced on the output. Comments are optional.

Print Results Check the **Print Results** box if you wish to have the output automatically printed at the end of each analysis. You must then choose the level of detail (**Short, Medium,** or **Long**) desired in the output. Details of the various outputs will be presented later but the general features are these.

Short yields a half page printout, giving the final plutonium (or uranium) isotopic fractions, errors, specific power in Watts/gPu, $^{240}Pu_{eff}$ fraction, Time since Chemical Separation, and ratios of other designated isotopes to plutonium.

Medium yields a seven or eight page output containing, in addition to a complete short output; results of the internal calibration of FWHM, energy, and peak shape; complete diagnostics relating to energy calibration, FWHM calibration, shape calibration, and interferences; goodness of fit results for each region; results from relative efficiency

curve fitting; final activity ratios for all isotopes; a summary of peak areas, relative efficiencies, and heterogeneity factors for all peaks; and diagnostic checks on the sample type.

Long adds a complete channel-by-channel summary of the fitting results for each region to the medium output. A long output may be 25-30 pages in length depending on the characteristics of the parameter set and the number of regions analyzed.

Save Results ...

Check this box if you wish to save the results of an assay in the indicated directory. A results file is a complete record of the entire analysis, essentially a text file containing a long printout. The file name for the spectral data should be a legal DOS file name with a maximum of 8 characters. The default path shown above the box is set during installation and may be changed in the **General Defaults** option under the **Edit** menu. The use of this feature is intended mainly for debugging and development work. A typical results file takes nearly 100kb of disk space.

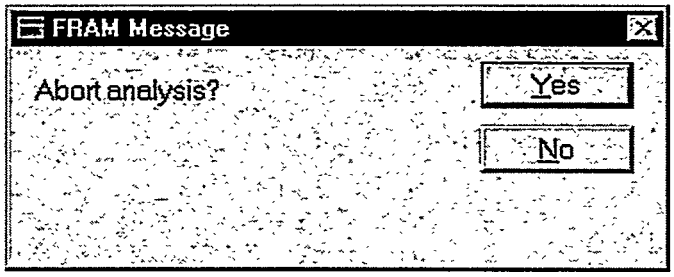
As an additional quality assurance feature, a copy of the parameter set used in the analysis is appended to the results file.

OK

Click on this button to start the analysis. If you had chosen the ORTEC 'spc' storage format, a message box will appear on the screen asking whether you want to load parameter set information from the data file. If you answer yes, the parameter set information in the data file will be loaded into memory and used to perform the analysis. If you answer no, the parameter set you selected from the drop-down list will be retrieved from the database and used to perform the analysis.

Exit

Click on this button to cancel the analysis and return to FRAM's main menu. If you click on this button while the analysis is in progress, the following dialog box will appear on the screen.



When it does, you must verify whether you wish to abort the analysis or have it continue.

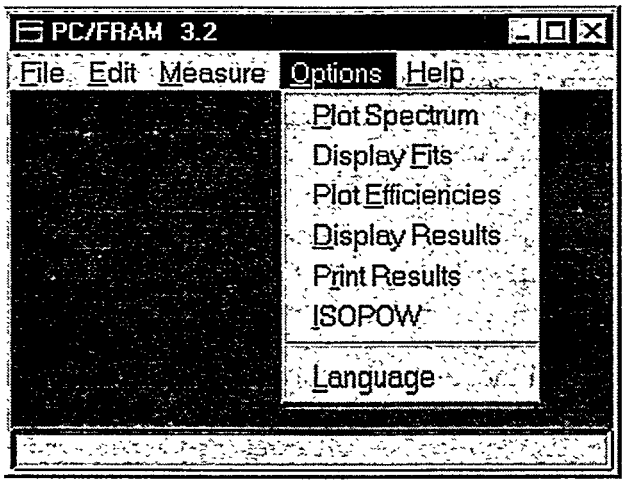
"status"

Just below the **OK** and **Exit** buttons the program will display messages concerning the progress of the analysis. If there is an error during the analysis a message box will be displayed on the screen and you will be asked to choose between continuing the analysis or terminating the analysis.

When the analysis is done, the Analyze Data dialog box will disappear and the results of the analysis will be automatically displayed on the screen. An example of a results window is shown in section 3.6.4. To dismiss this window you need to click on the **X** in the upper right hand corner of the window or press the key combination Ctrl+F4.

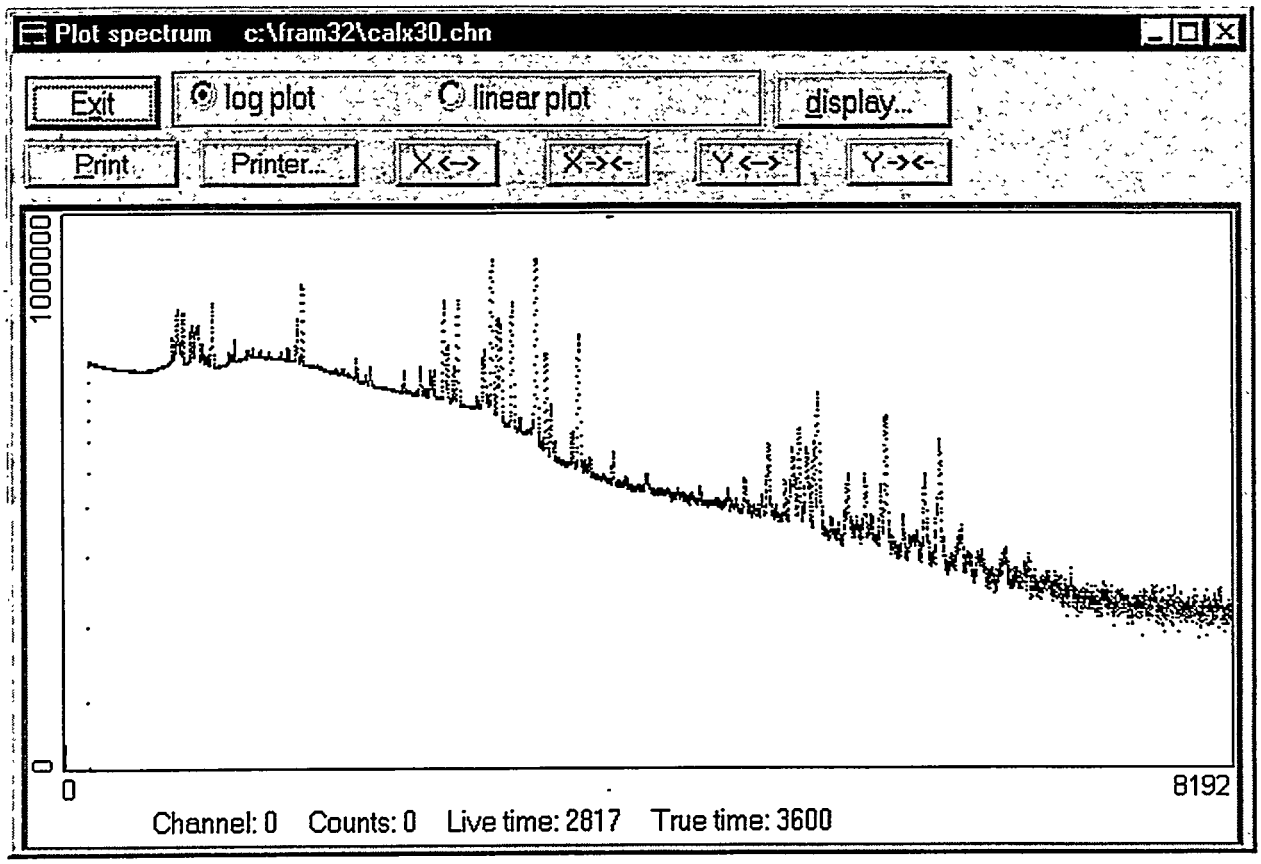
3.6. Options

The Options menu can be expanded by clicking on the word **Options** with the mouse or by pressing the key combination Alt+O. This menu controls a variety of utility functions that allow you to easily examine the quality of the analysis. You can view the spectral data and fits. You can display the results on the screen at any chosen print level. You can print the results at any chosen print level. You can decay correct the isotopic composition of any sample.



3.6.1. Options | Plot Spectrum

This option allows you to view the raw spectral data from within the PC/FRAM program in a flexible display format similar to that of a multi-channel analyzer. You may examine data in the office without needing the multi-channel analyzer hardware and software to carry out the viewing functions. The following window will appear on the screen. This window can be maximized, minimized, and even resized to a larger window if the size of the screen permits.



The spectrum plotted is either the last spectrum that was analyzed or a spectrum that was opened under the **Open** option in the **File** menu depending on whichever action was the most recent.

The first click in the spectrum window selects the window and makes it active. A thick border around the window denotes an active window. If the window is active the next click of the cursor places a cursor cross hair in the spectrum at the x coordinate of the cursor. The cursor may be moved through the spectrum with the ← and → keys. The cursor location and channel counts are displayed at the bottom of the window.

Exit	Click on this button to return to PC/FRAM's main menu.
log plot	Click on this radio button to display the data on a log scale.
linear plot	Click on this radio button to display the data on a linear scale.
display...	Click on this button to see the choices for spectrum overlays. This option is explained below.
Print	Click on this button to send a copy of this spectral plot to the printer.
Printer...	Click on this button to bring up a standard Windows dialog box, which allows you to modify the properties of your printer.
X <—>	Click on this button to increase the scale horizontally. In order for this to be effective, you must first select the plot window by clicking inside of it with the mouse. When this is selected a horizontal scroll bar appears at the bottom of the screen. You can use this along with the arrow keys to scroll through the spectrum.

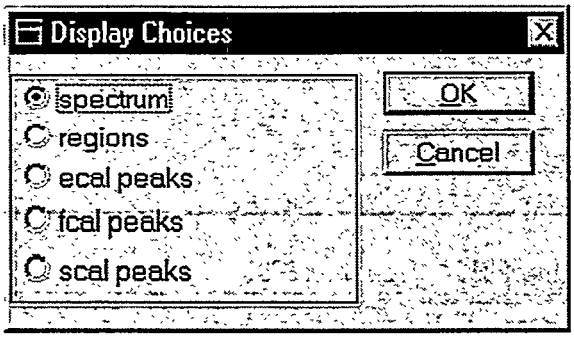
X –><– Click on this button to decrease the scale horizontally. In order for this to be effective, you must first select the plot window by clicking inside of it with the mouse.

Y <—> Click on this button to increase the scale vertically. In order for this to be effective, you must first select the plot window by clicking inside of it with the mouse. When this is selected a vertical scroll bar appears on the right of the screen.

Y –><– Click on this button to decrease the scale vertically. In order for this to be effective, you must first select the plot window by clicking inside of it with the mouse.

Display Choices

Click on the **display...** button and the following dialog box will appear on the screen. The five radio buttons at the left of the screen control what is plotted in addition to the spectrum itself. Select one of the radio buttons then click on the **OK** button.



spectrum Only the spectrum will be displayed.

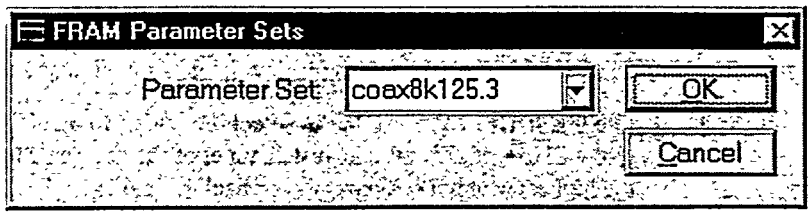
regions Select this radio button to highlight the peak and background regions from a selected parameter set on the plotted spectrum. You will be asked to choose a parameter set. The peak regions will be displayed in red and the background regions of interest will be displayed in green. This allows you to judge the appropriateness of the region data for the chosen parameter set. For example, you might scan through the spectrum and note whether the defined background regions of interest truly represent the background continuum and are not on top of an unexpected peak. Furthermore, the default energy calibration in the parameter set is used to calibrate the x-axis. Both the channel number and energy of the cursor now appear at the bottom of the plot window

ecal peaks Select this radio button to highlight the peaks that are designated to determine the energy calibration. You will be asked to choose a parameter set. The region where the peak is expected will be highlighted in red.

fcal peaks Select this radio button to highlight the peaks that are designated to determine the full width at half-maximum calibration. You will be asked to choose a parameter set. The region where the peak is expected will be highlighted in red.

scal peaks Select this radio button to highlight the peaks that are designated to determine the shape calibration for the contribution of the tailing on the low energy side of each peak. You will be asked to choose a parameter set. The region where the peak is expected will be highlighted in red.

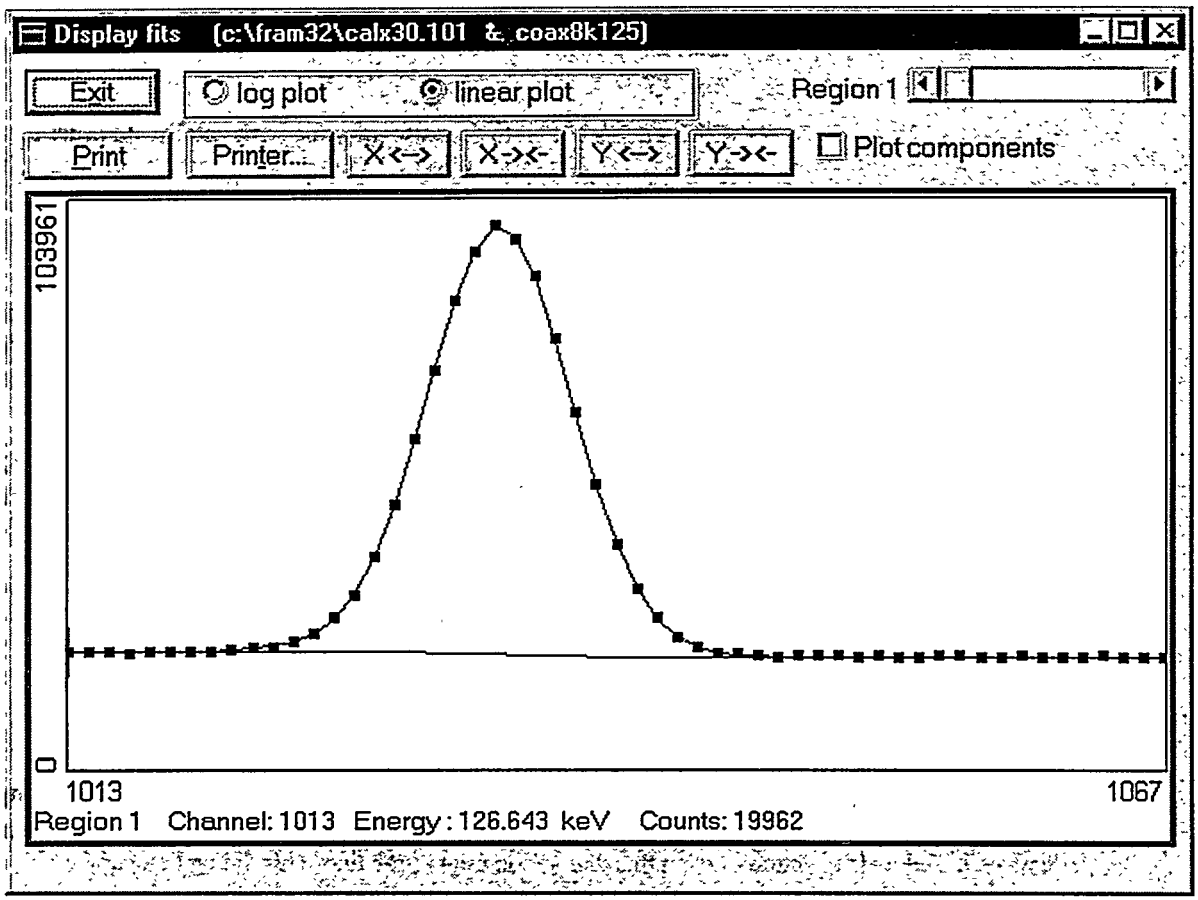
If you select any of the buttons except **spectrum**, the following dialog box will appear on the screen.



Select a parameter set from the list of parameter sets that are present in the database then click on the **OK** button.

3.6.2. Options | Display Fits

This option allows you to display the fitting results still in memory from the most recent spectrum analyzed. Below is a sample of the dialog box that appears on the screen. This dialog box can be maximized, minimized, and even resized to a larger one if the size of the screen permits.

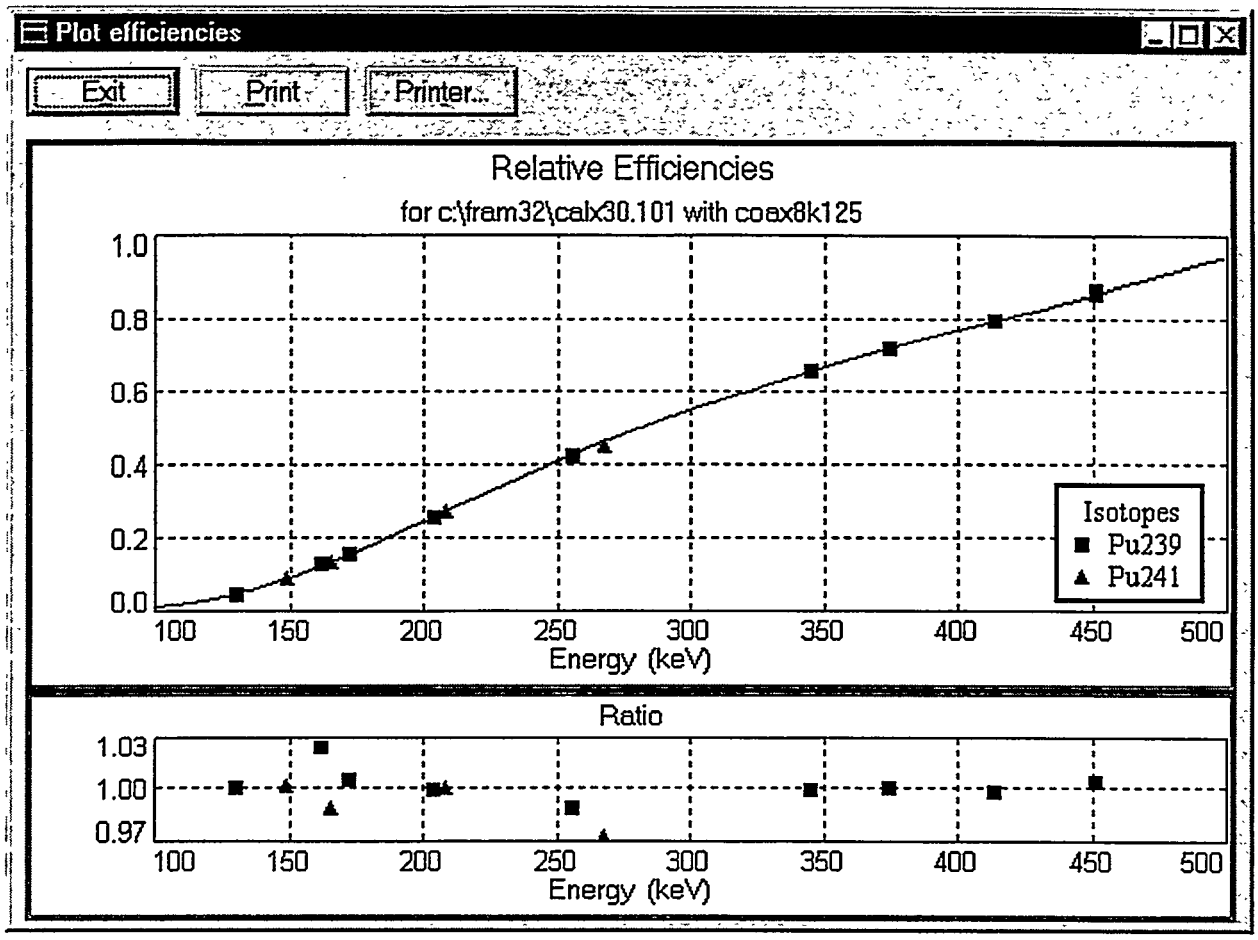


On a color monitor, the peak fit is in red and the background fit is in green. The display controls work in the same manner as described for the **Plot Spectrum** option. The first click in the spectrum window selects the window and makes it active. A thick border around the window denotes an active window. If the window is active the next click of the cursor places a cursor cross hair in the spectrum at the x coordinate of the cursor. The cursor may be moved through the spectrum with the ← and → keys. The cursor location (in channels and in energy) is displayed at the bottom of the window along with the channel counts.

Exit	Click on this button to return to PC/FRAM's main menu.
log plot	Click on this radio button to display the data on a log scale.
linear plot	Click on this radio button to display the data on a linear scale.
Region	Use this horizontal scroll bar to select the region to be displayed. The plot will extend from the lowest channel of the region or background to the highest channel of the region or background.
Print	Click on this button to send a copy of this plot to the printer.
Printer...	Click on this button to bring up a standard Windows dialog box, which allows you to modify the properties of your printer.
X <—>	Click on this button to increase the scale horizontally. In order for this to be effective, you must first select the plot window by clicking inside of it with the mouse. When this is selected a horizontal scroll bar appears at the bottom of the screen. You can use this along with the arrow keys to scroll through the spectrum. There will be no response to this button if fewer than 128 channels are being displayed in the plot window.
X –><–	Click on this button to decrease the scale horizontally. In order for this to be effective, you must first select the plot window by clicking inside of it with the mouse. Once the maximum number of channels for the region is displayed, clicking this button will have no effect on the display.
Y <—>	Click on this button to increase the scale vertically. In order for this to be effective, you must first select the plot window by clicking inside of it with the mouse. When this is selected a vertical scroll bar appears on the right of the screen.
Y –><–	Click on this button to decrease the scale vertically. In order for this to be effective, you must first select the plot window by clicking inside of it with the mouse.
Plot components	Check this box to have each individual peak contributing to the response function in this region plotted.

3.6.3. Options | Plot Efficiencies

Selection of this option produces a screen plot of the relative efficiency data points and the fit of the relative efficiency curve to them. At the bottom of the screen the ratio of the fit and the data points is displayed. Below is a picture of what this dialog box might look like. This dialog box can be maximized, minimized, and even resized to a larger one if the size of the screen permits.



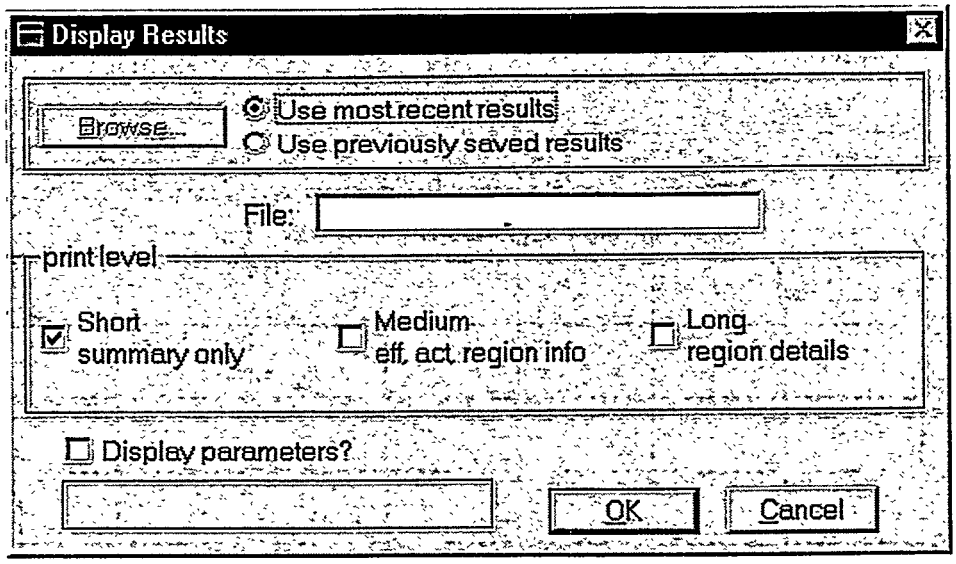
Exit Click on this button to return to PC/FRAM's main menu.

Print Click on this button to send a copy of this plot to the printer.

Printer... Click on this button to bring up a standard Windows dialog box, which allows you to modify the properties of your printer.

3.6.4. Options | Display Results

This option allows you to display, on the screen, the results from the most recent analysis still in memory from any previously saved results file. The following dialog box will appear on your screen.



Use most recent results	Click this radio button to have the results of the most recent analysis displayed on the screen.
Use previously saved results	Click this radio button to have the results of a previously saved analysis displayed on the screen. If you select this choice, the **Browse...** button will be activated.
Browse...	Click this radio button to invoke the standard Windows dialog box for opening a file. If you use this dialog to select a file, its path and name will appear in the **File:** edit box.
File:	If you have chosen to use previously saved results, please enter the name of the file containing the results that you wish to display. You may use **the Browse...** button to help you select a file.
print level	Choose one of the three print levels: Short, Medium, or Long.
Display parameters?	Check this box if you want to have a listing of the parameter set displayed at the end of the results.
OK	Click on this button to have the results displayed in a special text window.
Cancel	Click this button to cancel the display and return to PC/FRAM's main menu.

A display of results using a short printout is shown below.

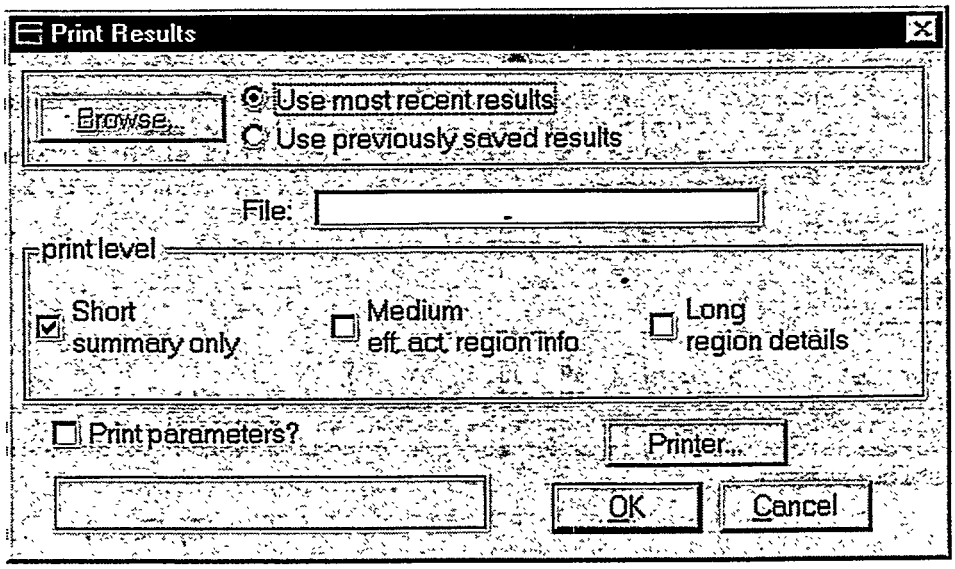
Analysis Results

```
*****************************************************************************
PC FRAM (V3.2)      Isotopic Analysis      31-Aug-1998 08:04:18
(Fixed energy Response function Analysis with Multiple efficiencies)
System ID:

spectrum source:  c:\fram32\cbnmstd.I01
spectrum date:  15-Jul-1994 16:25:36
live time:  3157 s
true time:  3600 s
num channels:  4096

parameter set:  widerange6 (1998.08.31 07:39)
    General Purpose, Homo. Am/Pu, Equilibrium, 3-25% 240
*****************************************************************************
*****************************************************************************
diagnostics passed.

                                                    (By Corr)   (ug/gPu)

              Pu238       Pu239       Pu240       Pu241       Pu242       Am241
mass%       1.18569    63.25856    25.12757     5.33509     5.09307    28247.4
sigma        .01688      .88229      .44008      .07456     1.34159      402.8
%RSD        1.42%       1.39%       1.75%       1.40%      26.34%       1.43%

%TotPwr:  51.2025      9.2834     13.5404      1.3846       .0449     24.5440

Specific Power (W/gPu):    (  13.1431 +/-    .1120)e-003  (  0.85%)

Effective Pu240 fraction:  (  36.6718 +/-   2.2968)e-002  (  6.26%)

Time since chemical separation:      3232.48   +/-   7.79   days   (  0.24%)

*****************************************************************************
```

To dismiss the text window you need to click on the **X** in the upper right hand corner of this window or press the key combination Ctrl+F4.

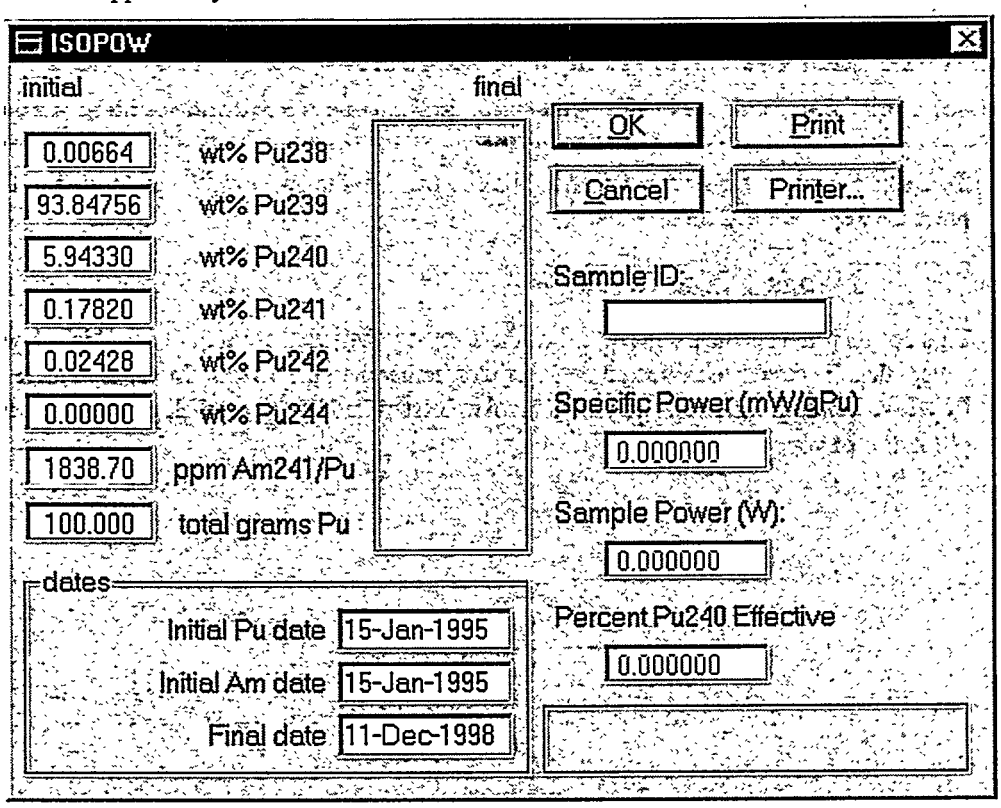
3.6.5. Options | Print Results

This option provides the same choices as the **Display Results** option discussed in section 3.6.4 except that the results are directed to the printer, rather than the screen. In addition there is a **Printer...** button which allows you to invoke the standard Windows dialog box for modifying the properties of your printer.



3.6.6. Options | ISOPOW

This option allows you to decay correct the isotopic ratios, including ^{241}Am, of a plutonium sample from any arbitrary date to any other date, either forward or backward in time. The following dialog box will appear on your screen.



In the **initial** column, you need to enter the starting values of the Pu isotopic ratios in wt%, the ^{241}Am ratio in parts per million with respect to total Pu, and the total amount of Pu in grams, if known.

Default values are provided from the most recent analysis. If the total amount of Pu is not known, a nominal value of 100 will suffice. Decay-corrected values for all these quantities will appear in the **final** column.

Initial Pu date — Enter the date of the values in the column labeled **initial**. The date format is governed by the template string specified in the **Edit | General Defaults** option.

Initial Am date — Enter the date of the ^{241}Am value in the column labeled **initial**. This date may be different from that for the Pu isotopic. The date format is governed by the template string specified in the **Edit | General Defaults** option.

Final date — Enter the final date for decay correcting the ratios. The date format is governed by the template string specified in the **Edit | General Defaults** option.

OK — Click on this button to perform the decay corrections. The results for the **Final date** will appear in the column labeled **final**. The sum of the initial Pu isotopic ratios will appear in the status box in the lower right hand corner of the window. If this sum deviates from 100% by more than 1%, an error message will appear in this box, and you should check the initial values.

Print — Click on this button to print out the results of the decay corrections.

Cancel — Click on this button to dismiss the 'ISOPOW' dialog box and return to PC/FRAM's main menu.

Printer... — Click on this button to bring up a standard Windows dialog box, which allows you to modify the properties of your printer.

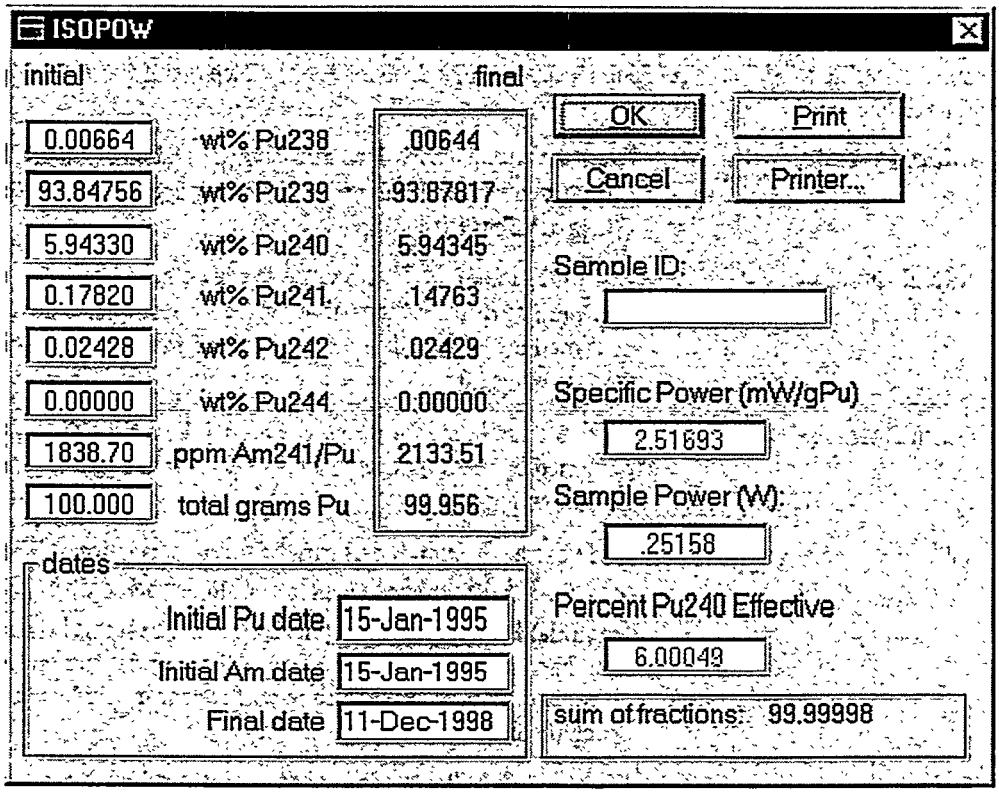
Sample ID — Enter a string of up to 15 characters which will identify the sample. This string will appear on a print out if you click on the **Print** button. Otherwise it is ignored.

Specific Power — This box will be filled in with the computed value of the specific power for the sample on the final date. The units are milliWatts per gram of Pu.

Sample Power — This box will be filled in with the computed value for the total power of the sample (in Watts) on the final date based on the value for the total grams of Pu. It is the product of the specific power and the final value for the total amount of Pu.

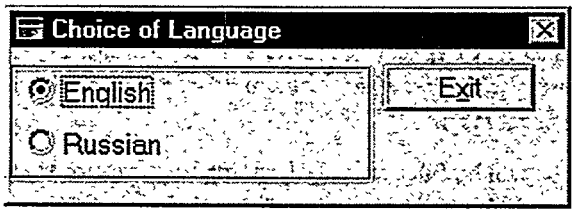
Percent Pu240 Effective — This box will be filled in with the computed value for the effective ^{240}Pu fraction.

Shown below is an example of what gets displayed after the decay-correction calculations.

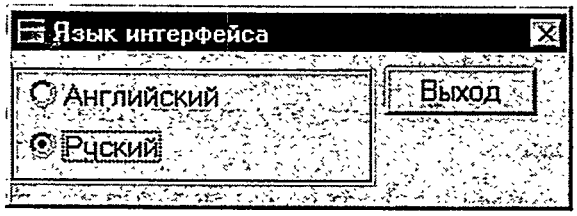


3.6.7. Options | Language

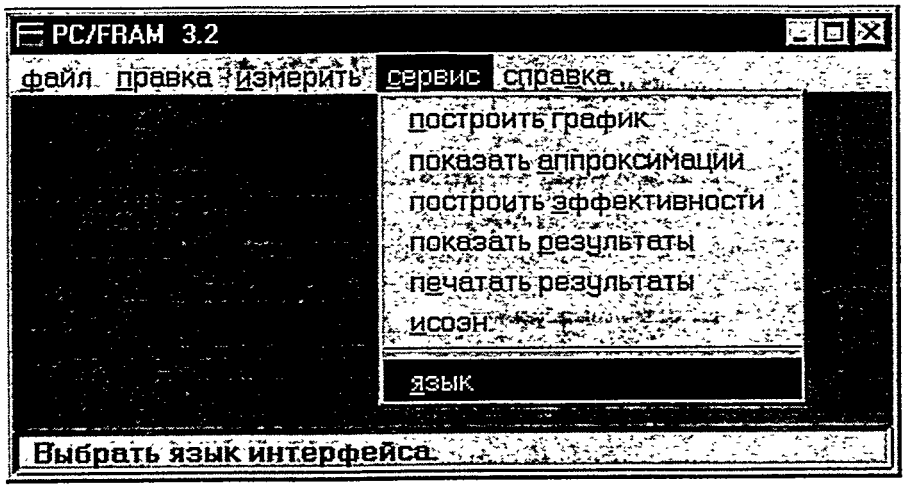
This option allows you to select one of two languages for displaying information on the screen. The following dialog box will appear on the screen.



The distribution kit comes with support for two languages, English and Russian. These are the two choices that are present in the dialog box above. If you select the radio button labeled **Russian**, the dialog box will change to the following.



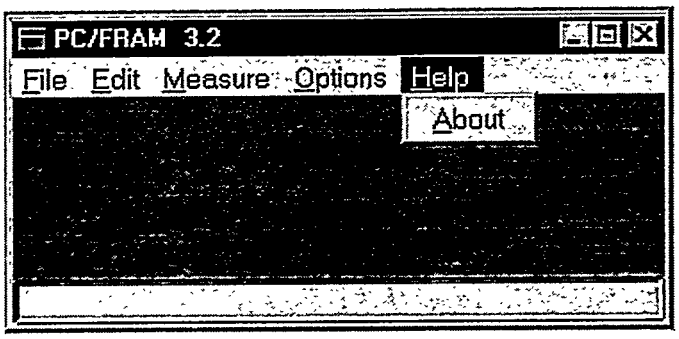
If you click on the "**Exit**" button, the user interface henceforth will be in Russian. The menus, the dialog boxes, the display of analysis results, and the printouts of analysis results will all be in Russian. If you exit the program and restart PC/FRAM, the interface will again be in Russian. You can change back to English by selecting the "**Options | Language**" option as shown below.



When the dialog box for choice of language appears on the screen, select "**English**" and click on the **Exit** button.

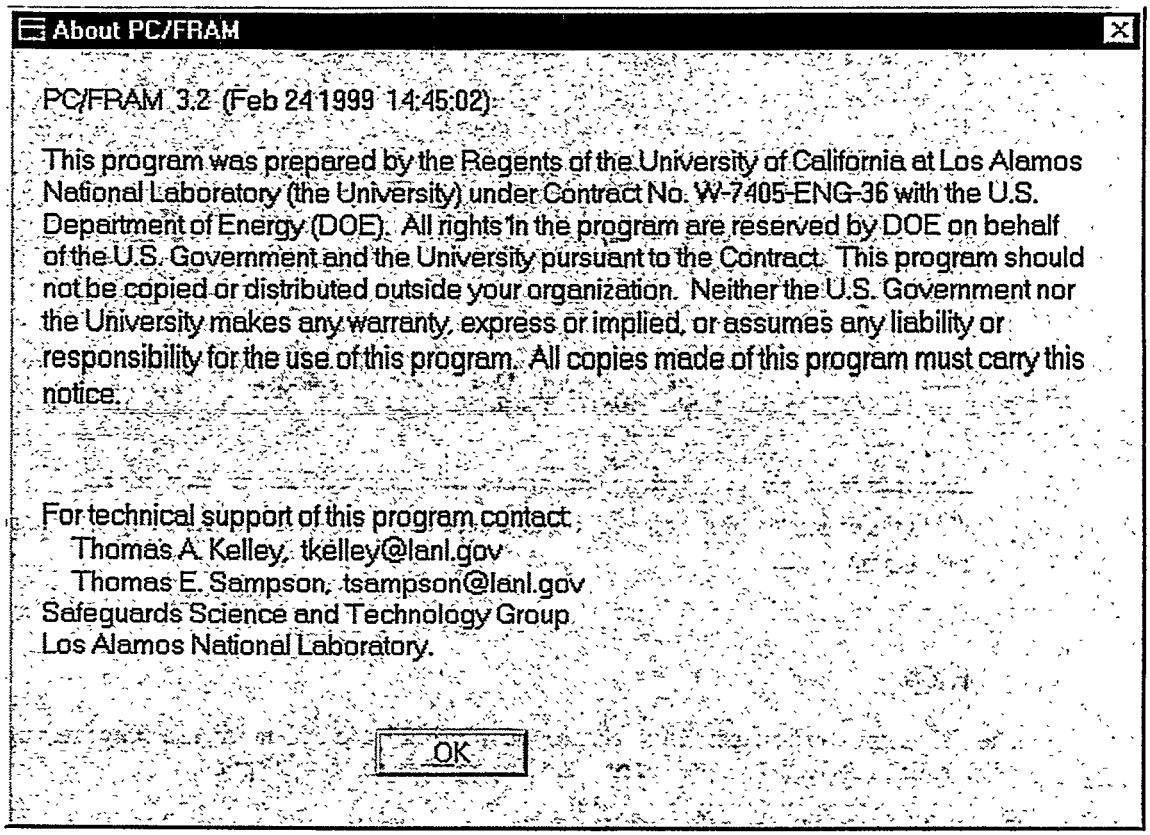
3.7. Help

The Help menu can be expanded by clicking on the word **Help** with the mouse or by pressing the key combination Alt+H. At the present time the Help menu has only one option.



3.7.1. Help | About

The **About** option under **Help** in the main menu displays a screen with the name, version number, and release date for this product along with copyright information.


About PC/FRAM
PC/FRAM 3.2 (Feb 24 1999 14:45:02)
This program was prepared by the Regents of the University of California at Los Alamos National Laboratory (the University) under Contract No. W-7405-ENG-36 with the U.S. Department of Energy (DOE). All rights in the program are reserved by DOE on behalf of the U.S. Government and the University pursuant to the Contract. This program should not be copied or distributed outside your organization. Neither the U.S. Government nor the University makes any warranty, express or implied, or assumes any liability or responsibility for the use of this program. All copies made of this program must carry this notice.
For technical support of this program contact:
Thomas A. Kelley, tkelley@lanl.gov
Thomas E. Sampson, tsampson@lanl.gov
Safeguards Science and Technology Group
Los Alamos National Laboratory.
OK

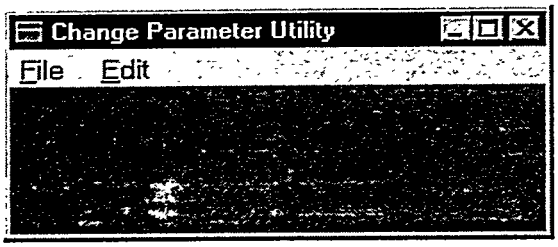
4. Change Parameter Utility

The Change Parameter Utility gives you access to all the parameters that control an analysis. A complete group of parameters necessary for an analysis is called a **Parameter Set.** All parameter sets are stored in a single database, which resides in the default PC/FRAM directory.. This utility allows you to augment the database with a new parameter set, delete a parameter set from the database, or modify the values in any parameter set. The utility also allows you to export the information in a parameter set to a text file and subsequently import that information back into the database. This allows for sharing of parameter sets between different PC/FRAM systems.

Each parameter set has a name; however, it does NOT have to conform to the DOS conventions for file names.

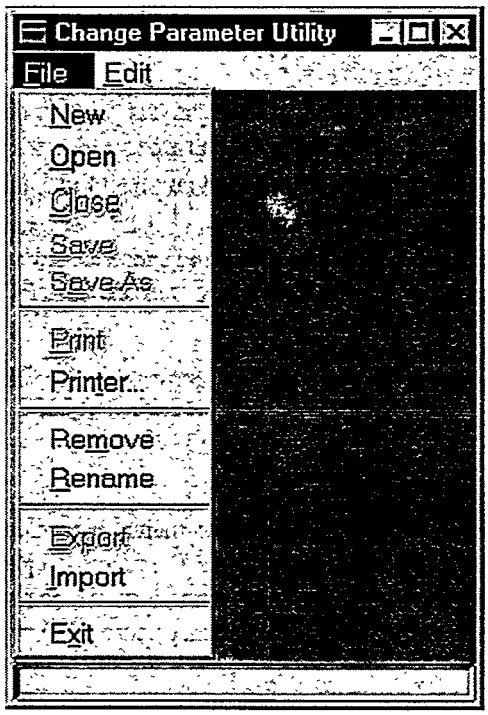
The Change Parameter utility is password protected.

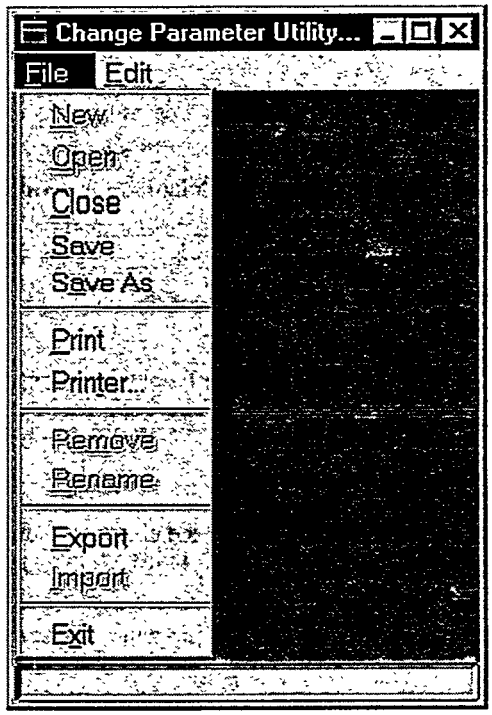
Startup Instructions To enter the change parameter utility select **Edit** from the main menu, then select the **Parameters** option. Once the **User Validation** screen is correctly completed with the name and password of an account which has been granted supervisory access, the title of the application window will change to **Change Parameter Utility** and a new menu system will become active. Below is a picture of what you will see.



4.1. File

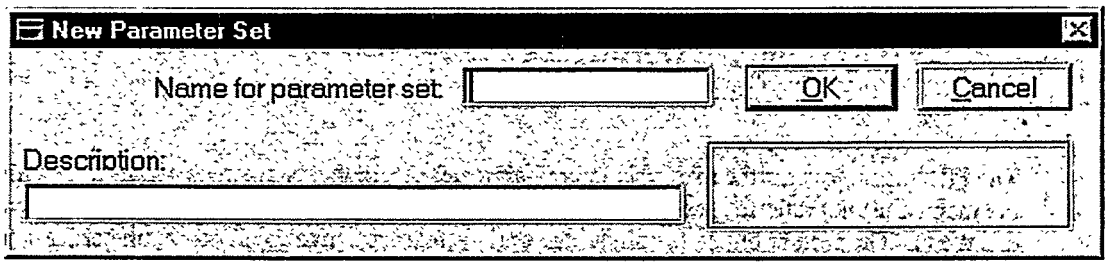
The **File** menu governs the manipulation of parameter sets in the parameter set database. The word File in the menu does not refer to spectral data files. The following pictures illustrate the options available under this menu. The picture on the left shows the options that are active when no parameter has been opened. The picture on the right shows the options that are active only when a parameter has been opened.





4.1.1. File | New

This option allows you to create a new parameter set that will initially be empty. The following dialog box will appear on the screen.



Name for parameter set: Enter a name (up to 30 characters in length) for the new parameter set. The string may be any combination of characters, including spaces.

Description: Enter a description for the new parameter set. This serves as a short description of the type of spectral data this parameter set is designed to handle. This string of characters must fit within the edit box.

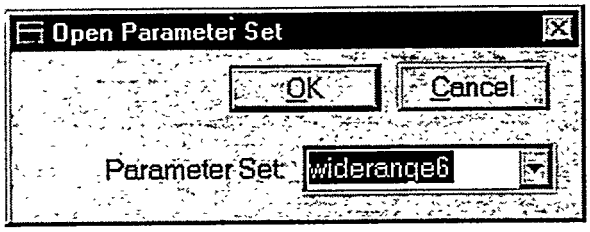
OK Click on this button to create the new parameter set and dismiss this dialog box. If you did not enter a name, an error message will appear in the status box in the lower right-hand corner of the window. If you entered a name that matches the name of another parameter set in the database, an error message will appear in the same status box.

Cancel Click on this button to dismiss the dialog box without creating a new parameter set.

The parameter set can be edited as soon as it is created, but will not exist in the database until it is saved using the **Save** or **Save as** option. Instead of creating a completely new parameter set, you may find it easier to follow these steps: 1) open an existing parameter set or import an existing parameter file, 2) save it with a new name using the **Save as** option, 3) close the existing parameter set, then 4) open the parameter set with the new name. You are now ready to edit the new parameter set.

4.1.2. File | Open

This option allows you to open an existing parameter set and read it into memory, either for editing, or for use as a basis for a new parameter set as described above. The following dialog box will appear on the screen.



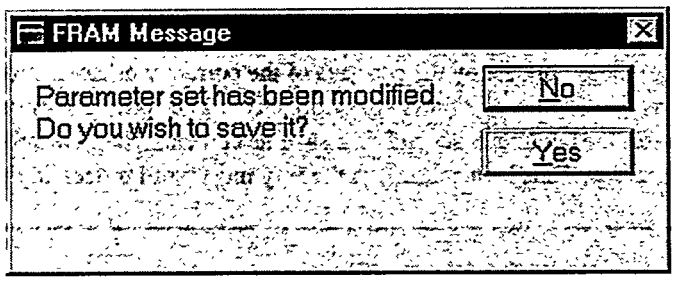
Parameter Set: Select one of the parameter set from the drop-down list. These are the parameter sets that currently reside in the database.

OK Click on this button to open the selected parameter set and dismiss this dialog box. Opening a parameter set causes its information to be transferred from the database to a worksheet in memory. After a parameter set is opened, its name will be displayed in the title bar of the window. Only one parameter can be open at any one time.

Cancel Click on this button to dismiss the dialog box without opening any parameter set.

4.1.3. File | Close

This option will erase the contents of the current worksheet and remove the name from the window's title bar. If the contents of the worksheet have been altered, the following message box will appear on the screen.



No Click on this button to dismiss the dialog box without saving the changes in the current worksheet to the database.

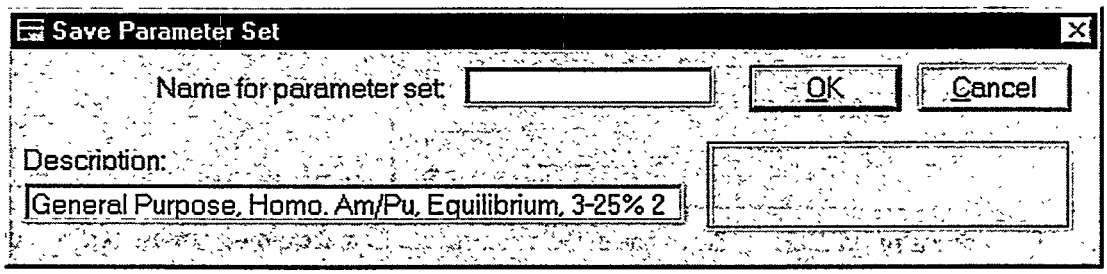
Yes Click on this button to dismiss the dialog box and have the changes in the current worksheet saved in the database.

4.1.4. File | Save

This option writes the contents of the worksheet to the database replacing the old records for this parameter set with new ones. The contents of the worksheet remain unaltered.

4.1.5. File | Save As

This option makes a copy of the current worksheet and writes it to the database as a parameter set with the name and description specified by you. The following dialog box will appear on the screen.



Name for parameter set: Enter a name (up to 30 characters in length) for the new parameter set. The string may be any combination of characters, including spaces.

Description: Enter a description for the new parameter set. This serves as a short description of the type of spectral data this parameter set is designed to handle. This string of characters must fit within the edit box.

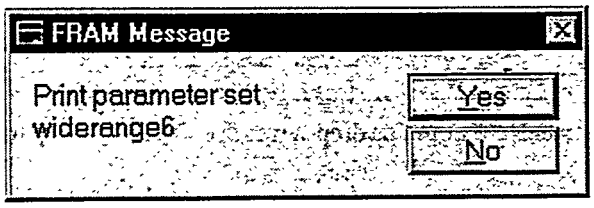
OK Click on this button to save the parameter set and dismiss this dialog box. If the name you gave matches the name of a parameter set already in the database a message box will appear on the screen with the message: **This parameter set already exists in the database. Do you want to continue?** If you click on the **Yes** button, the current worksheet will replace that parameter set in the database. If you click on the **No** button, the save operation will be cancelled.

Cancel Click on this button to dismiss the dialog box without saving the worksheet in the database.

NOTE! Saving a worksheet with a new name creates a copy of that worksheet in the database with that name. This operation does not destroy the contents of the current worksheet nor change the name associated with the parameter set information in the worksheet. The "old" parameter set is still "active". If you continue to edit the parameter set and then save its contents, the new information will be stored in the "old" parameter set. This is in contrast to the way most word processing programs work

4.1.6. File | Print

This option will write the contents of the worksheet to a text file and then have that file printed on the system printer. The following dialog box will appear on the screen.



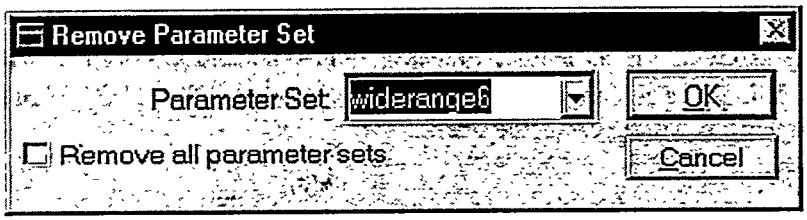
Yes Click on this button to dismiss this dialog box and have the information printed.

No Click on this button to dismiss this dialog box without printing the information.

An example of a printout is shown in section 4.3 of this manual.

4.1.7. File | Remove

This option removes all the information in a single parameter set from the database. This option can also be used to remove all the information from the database. That would result in the creation of a new database with no parameter sets in it.



Parameter Set: Select the parameter set from this drop-down list. These are the parameter sets that currently reside in the database.

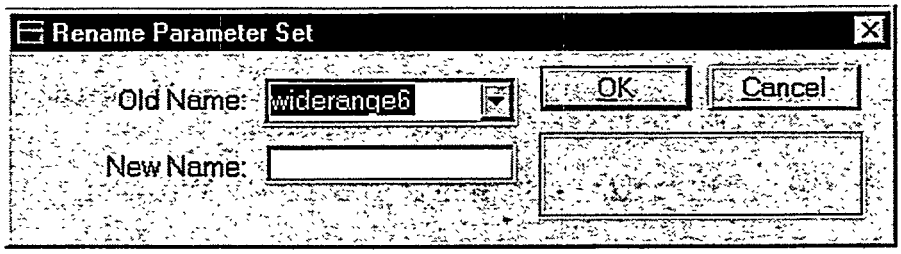
Remove all parameter sets Check this box if you want to delete all the parameter sets and create a new database.

OK Click on this button to dismiss the dialog box and remove the selected parameter set. If you chose to remove all the parameter sets, a message box will appear on the screen with the message: **This will destroy all the data in the database. Do you want to continue?** Click on the **Yes** button to create the new database. Click on the **No** button to cancel the operation.

Cancel Click on this button to dismiss the dialog box without changing the database.

4.1.8. File | Rename

This option allows you to change the name of a parameter set in the database. The following dialog box will appear on the screen.



Old Name: Select the parameter set from this drop-down list. These are the parameter sets that currently reside in the database.

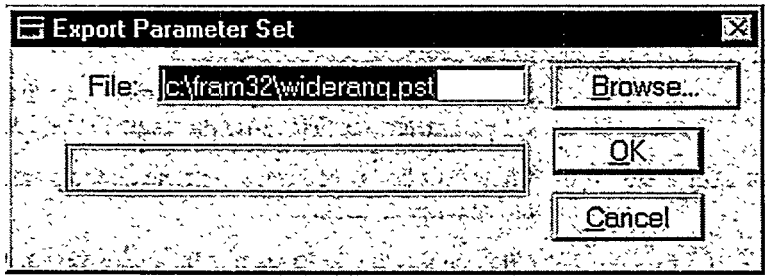
New Name: Enter a name (up to 30 characters in length) for the parameter set. The string may be any combination of characters, including spaces.

OK Click on this button to dismiss the dialog box and have the parameter set renamed. If you specify a new name that matches the name of another parameter set in the database, and error message will appear in the status box in the lower right-hand corner of the window.

Cancel Click on this button to dismiss the dialog box without renaming the parameter set.

4.1.9. File | Export

This option takes the contents of the current worksheet, formats the information, then writes it to a text file on the disk. This can be used to transfer parameter sets between different PC/FRAM systems. The following dialog box will appear on the screen.



File: Enter the name of the file, including complete path and extension, where the parameter set information will be stored. The default file name appearing in the box is constructed by taking the first eight characters of the parameter set name followed by an extension of **.pst**. The directory is the default PC/FRAM directory.

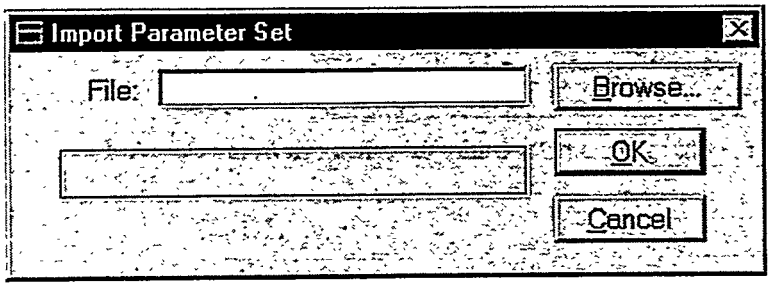
Browse... Click on this button to invoke the standard Windows dialog for opening a file.

OK Click on this button to dismiss the dialog box and have the parameter set information stored in textual form.

Cancel Click on this button to dismiss the dialog box without save the parameter set information.

4.1.10. File | Import

This option reads the information present in a text file resulting from a previous **Export** command and places it in the current worksheet. The following dialog box will appear on the screen.



File: Enter the name of the file, including complete path and extension, where the parameter set information is stored.

Browse... Click on this button to invoke the standard Windows dialog for opening a file.

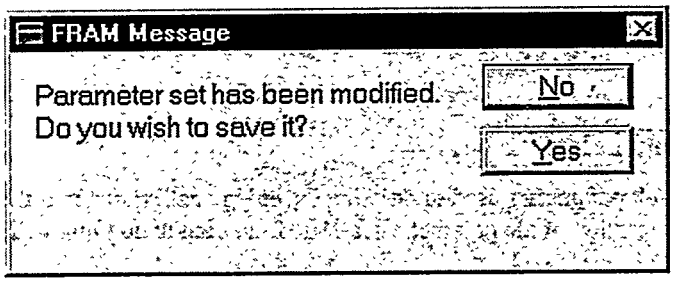
OK Click on this button to dismiss the dialog box and have the parameter set information retrieved from the text file.

Cancel Click on this button to dismiss the dialog box without retrieving the parameter set information.

NOTE! A parameter file that has been imported into the worksheet in memory must be saved into the database with the **Save As** command to preserve it as a parameter set.

4.1.11. File | Exit

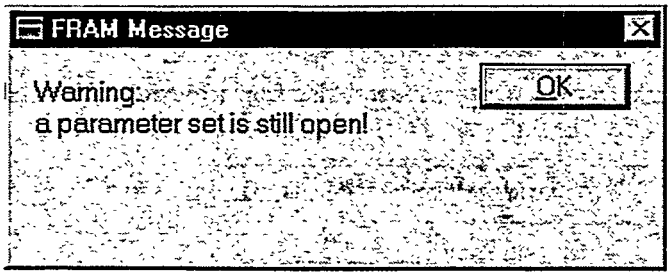
This option destroys the window and returns control to the main PC/FRAM menu unless the worksheet has been changed. In this case, the following dialog box will appear on the screen.



Yes Click on this button to dismiss this dialog box and have the information saved.

No Click on this button to dismiss this dialog box without saving the information.

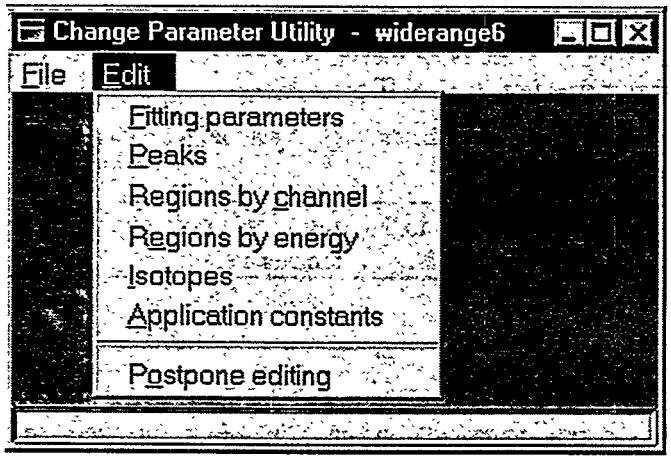
If the worksheet was changed and you attempt to exit from PC/FRAM by clicking on the **X** in the upper right-hand corner of the window or by double clicking on the small box in the upper left hand corner of the window, the following message will appear on the screen.



You must exit from the Change Parameter Utility first, then exit from PC/FRAM.

4.2. Edit

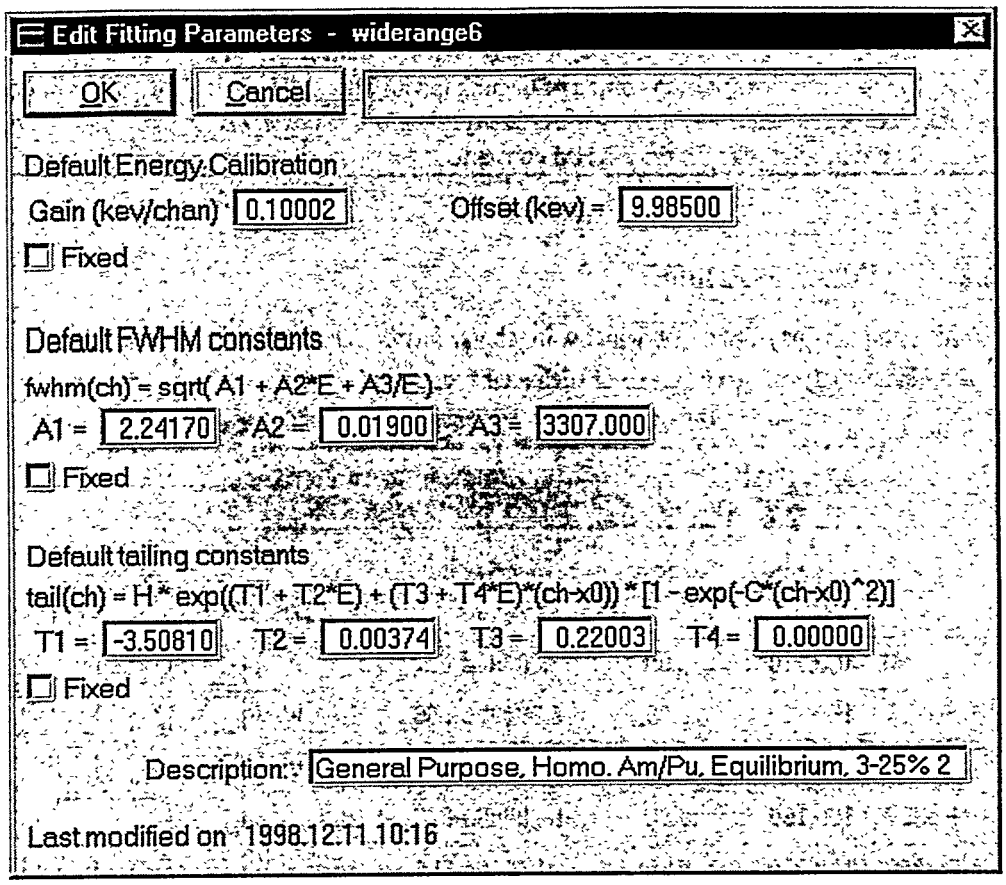
The choices that appear when the **Edit** option in the menu is selected refer to various groups of parameters in the open parameter set. These choices are illustrated in the picture below.



In order to view and/or edit any of the values in a parameter set, one must first place that information in the worksheet. This is accomplished via the **Open** or the **Import** options under the **File** menu option.

4.2.1. Edit | Fitting Parameters

This option displays the default parameters used to describe the energy calibration and the peak shapes. It also displays a description of the parameter set. The following dialog box will appear on the screen.



The software is fairly tolerant regarding these initial values. Appropriate starting values for use here may be obtained from the medium (or long) printouts from a successful analysis. The starting values that are provided with the existing parameter sets should be adequate for nearly all purposes.

It is important that the **Default Energy Calibration** constants be accurate. This enables the code to find the peaks selected for the final energy calibration and to convert from channel number to energy for setting region boundaries. The default energy calibration should predict the actual peak positions to within 10 channels.

The **Default FWHM constants** use a formula with the final result **fwhm(ch)** in units of channels whereas the input energy values are in keV. The parameters above are for a good resolution planar detector at a gain of 0.1 keV/channel. The first two terms in the formula for **fwhm(ch)** are physics based, while the last term is an empirical correction to account for the observation that many curves of $FWHM^2$ vs. energy deviate from a straight line at low energy.

The Default tailing constants describe an exponential tail on the low energy side of the peak and allow for both the amplitude and slope of the tail to be a linear function of *energy*. We have observed that these tail parameters are not easily parametrized, with their observed behavior depending on the type of detector and even the detector manufacturer. Therefore we typically set the constant T4 to zero and use the customary form where the amplitude is a linear function of *energy* and the slope is a constant.

NOTE! One may encounter conditions where good peaks, for the internal calibration of the shape parameters, are not available in the spectrum. The program allows you to fix the parameters at their default values, which can be obtained from a previous analysis with good statistical precision. This

may be the best procedure for very weak spectra with poor counting statistics. If the parameters are to be fixed, it is best to obtain the fixed values from a spectrum acquired under conditions as near as possible to those from the acquisition of the unknown. The FWHM constants, in particular, will be count rate dependent. *We find it very useful to fix the tailing constants for poor quality spectra.* It is usually not necessary to fix the FWHM constants.

4.2.2. Edit | Peak Info

This option displays, in a new window in tabular form, necessary information about the peaks to be used in an analysis. An example of such a table appears below.

Edit Peak Information - widerange6

OK | Cancel | Perform insertion, deletion, shifting of rows

		isotope	peak energy	line width	branching ratio	fix area to	sum area with	used for eff	used for act	used for ecal	used for fcal	used for scal
☐	13	Am241	150.110	0.00	7.20000e-007	11	0	☐	☐	☐	☐	☐
☐	14	Pu238	152.720	0.00	8.98300e-006	0	0	☐	☒	☐	☐	☐
☐	15	Pu241	159.955	0.00	6.80300e-008	19	0	☐	☐	☐	☐	☐
☐	16	Pu239	160.190	0.00	6.20000e-008	18	0	☐	☐	☐	☐	☐
☐	17	Pu240	160.308	0.00	3.84200e-006	0	0	☐	☒	☐	☐	☐
☐	18	Pu239	161.482	0.00	1.18400e-006	0	0	☒	☒	☐	☐	☐
☐	19	Pu241	164.597	0.00	4.54100e-007	0	0	☒	☒	☒	☒	☒
☐	20	Am241	164.597	0.00	6.26000e-007	19	19	☐	☒	☐	☐	☐

When the table first appears, the focus is placed on the **OK** button. Pressing the Tab key shifts the focus to the **Cancel** button. You can use the mouse to select a cell in the table by clicking on it. If you do, a dark black border will appear around that cell. You can now navigate between cells by using the Tab, Shift+Tab, ←, →, ↑, and ↓ keys. You can replace the contents of a selected cell by typing new characters into that cell. You can edit the string in a cell by first double clicking on that cell to select the entire string inside that cell and then clicking again to establish the position of the cursor. While you are editing the string in a cell you can use the ← and → keys to move around in the cell; the ↑ and ↓ keys will be inactive. You can exit the cell by pressing the Tab key or the Enter key. You may use the vertical scroll bar at the right of the screen to view more of the table.

The first column displays an index for each gamma ray that serves as a row number for the table.

isotope This column displays the name of the gamma ray's assigned **isotope** in the form **XXnnn** where XX is the standard two letter abbreviation for the isotope and **nnn** is its atomic mass number. A peak does not have to have an isotope assignment; this column may be left blank. This is sometimes done for unidentified interference peaks that are left free in the fitting. A peak without an assigned isotope must be a free

peak and can not be used as a reference for fixing another peak. An unassigned peak may be used for energy, shape, and FWHM calibrations.

peak energy

This column displays the energy of each gamma ray in keV. The starting values for most of the gamma ray energies have been taken from the work of Gunnink, Evans, and Prindle, "A Reevaluation of the Gamma-Ray energies and Absolute Branching Intensities of ^{237}U, ^{238,239,240,241}Pu, and ^{241}Am," Lawrence Livermore Laboratory report UCRL-52139, October 1976. Some of the values have been adjusted from the published data because the adjusted values gave better fits. It is appropriate to adjust published values if it improves the fitting results. Because energy calibrations are done on a piecewise linear basis, system nonlinearity and the exact choice of energy calibration peaks may force this adjustment. One can use **Display Fits** under **Options** in PC/FRAM's main to examine the peak fits to see if this is necessary.

line width

This column displays the line width in eV of x-ray peaks. We have not tested x-ray fitting with this version of PC/FRAM. This column should be filled with zeros.

branching ratio

This column displays the branching ratio of each gamma ray which is the fraction of all decays of the assigned isotope that yield the gamma ray in question. For parent-daughter gamma rays, you should consider all branches between the parent and daughter if you wish the daughter to represent the parent. For example, the ^{237}U branching ratios for gamma rays at 164, 208, 267 keV and other energies, are the product of the branching ratio of the decay of ^{237}U to ^{237}Np and the alpha decay branching fraction of 2.46e-5 for the decay of ^{241}Pu to ^{237}U. These gamma rays are labeled as ^{241}Pu in the widerange6 parameter set example because of the assumed decay equilibrium between ^{241}Pu and ^{237}U.

Fixing and summing of peak areas

Columns six through nine display information about how the peaks are used in the analysis.

fix area to

This column indicates when a peak area is to be determined by ratio of relative efficiency, branching ratio, and activity from a second peak rather than being determined as a free parameter in the response function fitting. Such a process is used to extract interfering peaks from a complex of several peaks by reference to a more easily determined peak nearby. Peaks fixed to another peak in the same region are used together in a composite response function. Peaks that are fixed to another peak outside the region are subtracted or stripped from the net count array before the response function fitting is performed. An example is shown in the previous window. Peaks 15-17 form an unresolved complex containing the important ^{240}Pu peak at 160.308 keV (peak 17). The closeness of the three peaks might yield

inaccurate results from the response function fitting process if all three peaks were free. Therefore, we use peak 18 at 161.482 keV as part of the ^{239}Pu response function to determine the ^{239}Pu peak at 160.190 keV and use peak 19 at 164.597 (in a different region) to strip the 159.955 keV peak from the complex. The stripping process leaves only data from the 160.308 keV peak and the ^{239}Pu peaks to be fitted with two response functions. Peaks fixed to other peaks should not be used for activity peaks. Enter the peak number of the peak to be fixed to or a zero if the peak is free.

sum area with

This column indicates which peaks are to be used together in the final determination of activity ratios. Here we sum the areas of the coenergetic peaks, typically from ^{241}Pu-^{237}U and ^{241}Am, (see peaks 19 and 20 in previous window, for example) in the least squares equations allowing the resolution of the components in the least squares process. Enter the peak number of the peak to be summed with or a zero if the peak is not summed.

used for eff

This column designates the peaks to be used in the relative efficiency curve calculation. One typically chooses a series of strong peaks from a single isotope that spans the range of the analysis. Peaks from other isotopes can also be included, although, because of normalization, additional isotopes must have two or more peaks to contribute. The principal isotope in the relative efficiency calculation is usually the first isotope in the isotope list (see later discussion on the isotope list). We usually use ^{239}Pu and ^{241}Pu-^{237}U peaks for the relative efficiency curve in the 120-450 keV range. If you want to use the peak in the efficiency calculation and the box is empty, click on the box to place a check in it. If you do not want to use the peak in the efficiency calculation and the box is checked, click on the box to remove the check.

used for act

This column designates the peaks to be used in the calculation for relative activity. We do not use all of the peaks from a given isotope for relative activity determination. Only the strongest peaks will contribute significantly in the weighted least squares process used. Also, we do not use peaks that have been fixed to other peaks in this analysis because the fixed peaks are not independent. If you want to use the peak in the activity calculation and the box is empty, click on the box to place a check in it. If you do not want to use the peak in the activity calculation and the box is checked, click on the box to remove the check.

Internal Calibration Peaks

The last three columns indicate the selection of peaks used for the internal calibrations. It is not necessary for these peaks to belong to a particular isotope, or to have any isotope name at all. These peaks typically are clean, single, well-resolved peaks with good statistics. While different peaks may be used for these calibrations, one usually uses many of the same peaks for all the calibrations.

used for ecal

This column indicates the selection of peaks used for the energy calibration. While any peak in the list may be used, the peak should be strong, have good counting statistics, a well-defined peak position, a well-known energy, and be free from neighboring interferences over the range from 75% of the peak maximum on the low energy side to 25% of the maximum on the high energy side. At a minimum, two energy calibration peaks are needed. When more peaks are used, the calibration is a piecewise linear calibration between adjacent calibration peaks. If you want to use the peak in the internal energy calibration and the box is empty, click on the box to place a check in it. If you do not want to use the peak in the internal energy calibration and the box is checked, click on the box to remove the check.

used for fcal

This column designates the peaks to be used for the full-width-at-half-max (FWHM) vs. energy calibration. The peaks used for this internal calibration need to have the same characteristics as those used for the energy calibration. At least three FWHM peaks must be specified. If you want to use the peak in the internal FWHM calibration and the box is empty, click on the box to place a check in it. If you do not want to use the peak in the internal FWHM calibration and the box is checked, click on the box to remove the check.

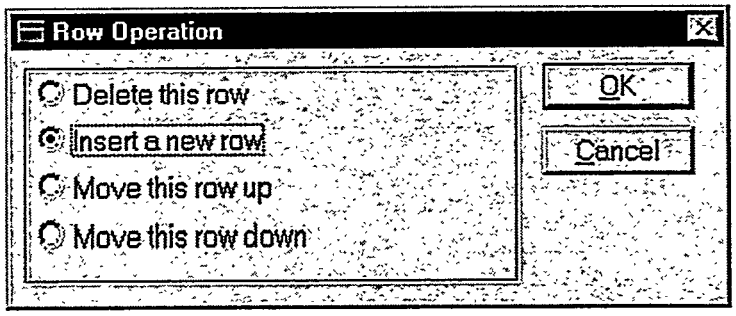
used for scal

This column designates the peaks to be used for the shape calibration, (the determination of the peak tailing parameters). The peaks used must be free of interferences in the range from 0.5 FWHM to 1.5 FWHM on the low energy side of the peak. If you want to use the peak in the internal shape calibration and the box is empty, click on the box to place a check in it. If you do not want to use the peak in the internal shape calibration and the box is checked, click on the box to remove the check.

If a sufficient number of high quality peaks are not available for **ecal, fcal, or scal**, those parameter values may be fixed at the default values. Do this by invoking the Change Parameter Utility, opening the appropriate parameter set, then selecting the **Edit, Fitting Parameters** option. In the window that comes up, click on the appropriate check box on the left-hand side, which is labeled **Fixed**.

4.2.2.1. Row Operations

In this table, you may add, delete, or shift the rows. Click on the yellow box to the left of a row number. The following dialog box will appear.



If you click on the **Cancel** button, this window will disappear and the rows will remain the same. If you want to change the rows, click on one of the radio buttons, then on the **OK** button. Note that inserting a new row is the default action. If you insert a new row, remember that it is inserted **above** the row selected. If any of these row operations cannot be performed, a message box will appear on the screen with the appropriate error message.

Editing the peak list is special since the code will automatically reorder the peaks by energy when you exit the table. This means that using the **Move this row up** and **Move this row down** options will have no effect in the end.

NOTE! To change the database, you must click the **OK** button to preserve the changes made on the screen into the worksheet. Then you must choose the **Save** option from the **File** menu to write the contents of the worksheet into the database.

4.2.2.2. Expanding the Number of Rows Displayed

You may reach a point during a process of entering many new rows where the table is full and no new rows may be added. The vertical scroll bar will not scroll to give you any more empty rows. To obtain more empty rows, you need to close the table, save it to the database, close the parameter set, and then reopen the parameter set. Every time the parameter set is opened the table is given ten empty rows in addition to the rows already in use. You should follow these instructions.

1. Click on the **OK** button to close the table window and save the changes.
2. Choose the **File | Save** option to store the worksheet information into the database.
3. Choose the **File | Close** option to close the current worksheet. If you neglected to save the worksheet in step 2, you will be prompted to save any changes at this point.
4. Choose the **File | Open** option. Then in the dialog box entitled 'Open Parameter Set' select the same parameter set. Now when you choose an edit option that displays a table in table form, your table will have ten additional blank rows at the bottom.

4.2.3. Edit | Regions by channel & Edit | Regions by energy

Selection of these options opens a new window displaying in tabular form all the information about the regions (groupings of peaks) to be used in an analysis. Region parameters are displayed in channels or energy units, depending upon the chosen option. An example of pair of such tables (by channel and by energy) appears below.

Edit Region Information (by channel) - widerange6

OK Cancel Perform insertion, deletion, shifting of rows

	region start	region end	BKG #1 start	BKG #1 end	BKG #2 start	BKG #2 end	BKG #3 start	BKG #3 end	BKG #4 start	BKG #4 end	background type
1	1140	1203	1164	1171	1207	1214	1225	1232	0	0	linear step
2	1180	1203	1168	1173	1209	1214	1227	1232	0	0	linear step
3	1310	1408	1298	1302	1304	1308	1323	1327	1409	1413	linear step
4	1418	1436	1412	1417	1438	1443	0	0	0	0	linear
5	1533	1566	1524	1528	1566	1570	1570	1574	0	0	linear step
6	1490	1522	1487	1492	1524	1529	0	0	0	0	linear
7	1588	1622	1582	1587	1623	1628	0	0	0	0	linear

Edit Region Information (by energy) - widerange6

OK Cancel Perform insertion, deletion, shifting of rows

	region start	region end	BKG #1 start	BKG #1 end	BKG #2 start	BKG #2 end	BKG #3 start	BKG #3 end	BKG #4 start	BKG #4 end	background type
1	124.00	130.30	126.40	127.10	130.70	131.40	132.50	133.20	0.00	0.00	linear step
2	128.00	130.30	126.80	127.30	130.90	131.40	132.70	133.20	0.00	0.00	linear step
3	141.00	150.80	139.80	140.20	140.40	140.80	142.30	142.70	150.90	151.30	linear step
4	151.80	153.60	151.20	151.70	153.80	154.30	0.00	0.00	0.00	0.00	linear
5	163.30	166.60	162.40	162.80	166.60	167.00	167.00	167.40	0.00	0.00	linear step
6	159.00	162.20	158.70	159.20	162.40	162.90	0.00	0.00	0.00	0.00	linear
7	168.80	172.20	168.20	168.70	172.30	172.80	0.00	0.00	0.00	0.00	linear
8	202.00	204.70	201.80	202.20	204.70	205.10	0.00	0.00	0.00	0.00	linear

When the table first appears, the focus is placed on the **OK** button. Pressing the Tab key shifts the focus to the **Cancel** button. You can use the mouse to select a cell in the table by clicking on it. If you do, a dark black border will appear around that cell. You can now navigate between cells by using the Tab, Shift+Tab, ←, →, ↑, and ↓ keys. You can replace the contents of a selected cell by typing new characters into that cell. You can edit the string in a cell by first double clicking on that cell to select the entire string inside that cell and then clicking again to establish the position of the cursor. While

you are editing the string in a cell you can use the ← and → keys to move around in the cell; the ↑ and ↓ keys will be inactive. You can exit the cell by pressing the Tab key or the Enter key. You may use the vertical scroll bar at the right of the screen to view more of the table.

The first column displays an index for each region, which serves as a row number for the tables. The start and end of each region are displayed in the next two columns. The start and end of each of four background regions are displayed in the next 8-columns. The units of the display are channels or energy (keV), depending on the chosen option. The shape of the background continuum to be extrapolated underneath the peaks in the region is displayed in the last column.

These boundaries may be displayed in either energy units (keV) or channel units. The software converts between the two using the default energy calibration. The example directly above shows the display in energy units. The values are always stored in the database in energy units. A switch in energy calibration will update the **Region Info (channels)** the next time the option is brought up.

NOTE! The default energy calibration can be changed by choosing the **Edit | Fitting Parameters** option. It is important that this energy calibration be as accurate as possible.

When the table first appears, the focus is placed on the **OK** button. Pressing the Tab key shifts the focus to the **Cancel** button. You can use the mouse to select a cell in the table by clicking on it. If you do, a dark black border will appear around that cell. You can now navigate between cells by using the Tab, Shift+Tab, ←, →, ↑, and ↓ keys. You can replace the contents of a selected cell by typing new characters into that cell. You can edit the string in a cell by first double clicking on that cell to select the entire string inside that cell and then clicking again to establish the position of the cursor. While you are editing the string in a cell you can use the ← and → keys to move around in the cell; the ↑ and ↓ keys will be inactive. You can exit the cell by pressing the Tab key or the Enter key. You may use the vertical scroll bar at the right of the screen to view more of the table.

Up to four different "sub regions" labeled **BKG #1** through **BKG #4** can be used to define the background continuum underneath the region. The background regions may be placed anywhere in the spectrum, inside or outside the peak region. The placement of the background regions must be done carefully with full cognizance of interferences that may appear in other spectra to be analyzed with the same parameter set. The wide intensity variation of peaks from ^{241}Am must especially be recognized in this regard.

NOTE! The selection of the proper parameters for the peak and background regions may be the most important set up feature in the code.

Region Numbers: Regions are analyzed in the order they are presented in the table. The regions need not be in order of energy and, indeed, it is sometimes desirable to have them out of order so a region having a peak that a second region fixes to is analyzed first. Note the discussion in Appendix A. The regions are not reordered when the window is reentered.

Background Type: Click on the arrow at the right hand side of this box to display a list of the permissible background types. Select one of the eight choices in the list. Here is a brief description of the background types.

none	no background subtraction
flat	a straight line with zero slope
linear	a sloping straight line
quadratic	use with care as poor background ROI choices may produce an unphysical background
exponential	gives a mildly curving background
flat step	a smoothed step function with zero slope at the ends
linear step	a smoothed step function superimposed on a sloping straight line
bilinear step	a linear step with different sloping straight lines allowed above and below the region (use with care)
reference	not applicable to PC/FRAM

To judge the appropriateness of a particular background form for a particular region, perform an analysis using this parameter set, then use the **Display Fits** option under **Options** on the main PC/FRAM menu to view the computed backgrounds.

Row Operations: Rows may be added, deleted, or shifted in the region list. See section 4.2.2.1 for information on doing this. When editing the region information, the **Move this row up** and **Move this row down** commands can be used to rearrange the regions. See section 4.2.2.2 for instructions on increasing the number of rows in this table.

NOTE! To change the database, you must click the **OK** button to preserve the changes made on the screen into the worksheet. Then you must choose the **Save** or the **Save As** option from the **File** menu in the Change Parameter utility to write the contents of the worksheet into the database.

4.2.4. Edit | Isotopes

Selecting this option opens a new window and displays in tabular form all the necessary information about the isotopes to be used in an analysis. An example of such a table appears below.

Edit Isotope Information - widerange6

OK | Cancel | Perform insertion, deletion, shifting of rows

		isotope	half-life	units	mass	power (mW/g)	pu240 coefficient	efficiency function
	1	Pu239	2.41190e+004	years	239.05220	1.92880	0.0000	1
	2	Pu241	1.43480e+001	years	241.05690	3.41120	0.0000	1
	3	Am241	4.33600e+002	years	241.05679	114.20000	0.0000	1
	4	Pu238	8.77400e+001	years	238.04961	567.57000	2.5200	1
	5	Pu240	6.56400e+003	years	240.05380	7.08240	1.0000	1
	6	Pu242	3.76300e+005	years	242.05874	0.11590	1.6800	1
	7			years				
	8			years				

When the table first appears, the focus is placed on the **OK** button. Pressing the Tab key shifts the focus to the **Cancel** button. You can use the mouse to select a cell in the table by clicking on it. If you do, a dark black border will appear around that cell. You can now navigate between cells by using the Tab, Shift+Tab, ←, →, ↑, and ↓ keys. You can replace the contents of a selected cell by typing new characters into that cell. You can edit the string in a cell by first double clicking on that cell to select the entire string inside that cell and then clicking again to establish the position of the cursor. While you are editing the string in a cell you can use the ← and → keys to move around in the cell; the ↑ and ↓ keys will be inactive. You can exit the cell by pressing the Tab key or the Enter key. You may use the vertical scroll bar at the right of the screen to view more of the table.

The first column displays an index for each isotope, which serves as a row number for the table.

isotope This column displays the name of the **isotope** in the form **XXnnn** where **XX** is the standard two letter abbreviation for the isotope and **nnn** is its atomic mass number. The first isotope in the list is important because all the other isotopes ratios are calculated relative the first one. Thus, in the example above, the fundamental isotopic ratios calculated by the code are $^{241}Pu/^{239}Pu$, $^{241}Am/^{239}Pu$ ... $^{237}U/^{239}Pu$. (Actually ^{242}Pu is calculated from a correlation, in a manner different from the calculation of the other ratios. However, its presence is still needed in the isotope list for its required constants.)

half-life The values of the **half-life** used are those from ANSI N15.22-1987, American National Standard for Nuclear Materials -- Plutonium-Bearing Solids--Calibration Techniques for Calorimetric Assay.

units This is a read only field. The half-life units must always be "years".

mass The Atomic Mass in AMUs.

power (mW/g) This is the specific power of the isotope in milliWatts/g isotope used for interpretation of calorimetry results. The values also come from ANSI N15.22-1987.

pu240 coefficient This parameter is the coefficient multiplying the isotope mass in the expression for ^{240}Pu effective mass, (or effective fraction) used to interpret neutron coincidence counting. Currently accepted values are highlighted below.

$$^{240}Pu_{eff}(mass) = \mathbf{2.52}*^{238}Pu(mass) + \mathbf{1.00}*^{240}Pu(mass) + \mathbf{1.68}*^{242}Pu(mass)$$

efficiency function A different **efficiency function** is given to isotopes in a different matrix or isotopes that suffer different attenuation at the same gamma energy than the first isotope in the list. The number of efficiency functions is not limited, but we only have experience with two functions.

Row Operations: Rows may be added, deleted, or shifted in the isotope list. See section 4.2.2.1 for information on doing this. When editing the isotope information, the **Move this row up** and **Move this row down** commands can be used to rearrange the isotopes. See section 4.2.2.2 for instructions on increasing the number of rows in this table.

NOTE! To change the database, you must click the **OK** button to preserve the changes made on the screen into the worksheet. Then you must choose the **Save** or the **Save As** option from the **File** menu in the Change Parameter utility to write the contents of the worksheet into the database.

4.2.5. Edit | Application Constants

Selecting this option opens a new window and displays in tabular form all the information about the application constants to be used in an analysis. These constants, for the most part, govern the diagnostic tests performed in PC/FRAM. These tests are flexible and can be added, deleted, or customized to suit specific measurement conditions.

An example of such a table appears below.

Edit Application Constants - widerange6

OK | Cancel | Perform insertion, deletion, shifting of rows

	name	value
1	pu242_correlation	.994
2	num_ecal	2
3	ecal_energy[1] (keV)	129.294
4	ecal_channel[1]	1193.00
5	ecal_limit[1] (channels)	.25
6	ecal_energy[2] (keV)	413.714
7	ecal_channel[2]	4037.12
8	ecal_limit[2] (channels)	.25
9	num_fwhmcal	2

When the table first appears, the focus is placed on the **OK** button. Pressing the Tab key shifts the focus to the **Cancel** button. You can use the mouse to select a cell in the table by clicking on it. If you do, a dark black border will appear around that cell. You can now navigate between cells by using the Tab, Shift+Tab, ←, →, ↑, and ↓ keys. You can replace the contents of a selected cell by typing new characters into that cell. You can edit the string in a cell by first double clicking on that cell to select the entire string inside that cell and then clicking again to establish the position of the cursor. While you are editing the string in a cell you can use the ← and → keys to move around in the cell; the ↑ and ↓ keys will be inactive. You can exit the cell by pressing the Tab key or the Enter key. You may use the vertical scroll bar at the right of the screen to view more of the table.

The first column displays an index for each application constant, which serves as a row number for the table.

name This column contains a string, which is the name of the application constant. The program, when searching for a constant name examines only the characters in the column up to the first blank. You may append other information such as assumed units to the name as long as there is one or more blanks separating the two.

value This column contains a string which can be decoded into the value for that constant.

Row Operations: Rows may be added, deleted, or shifted in the application constants list. See section 4.2.2.1 for information on doing this. When editing the application constants information, the **Move this row up** and **Move this row down** commands can be used to rearrange the constants. See section 4.2.2.2 for instructions on increasing the number of rows in this table.

Many of the constant names have indices. You are permitted to test as many peaks or quantities as desired. The indices *must* be entered in braces [...]. Parentheses will not work.

Tests may be added to or deleted from the list to suit the analysis characteristics of the specific parameter set.

A description of the permitted **Application constant** names follows.

pu242_correlation The correlation constant A in the expression for the ^{242}Pu correlation, which has the form

$$^{242}Pu = A*[(^{238}Pu)^B * (^{239}Pu)C^B * (^{240}Pu)^D * (^{241}Pu + ^{241}Am)^E]$$

The units are mass fraction. Am-241 is added back to the ^{241}Pu as shown before the correlation is calculated. This correlation can be tailored to most any of the specific models that have been published in the literature.

pu238_exponent The value of B in the ^{242}Pu correlation above.

pu239_exponent The value of C in the ^{242}Pu correlation above.

pu240_exponent The value of D in the ^{242}Pu correlation above.

pu241_exponent The value of E in the ^{242}Pu correlation above.

FRAM_SUMMARY_TYPE Tailors the summary or short printout for plutonium or uranium analyses. Acceptable values are **PLUTONIUM** or **URANIUM**. This test is case sensitive so use uppercase entries as shown.

num_ecal The number of peaks to be checked for peak centroid position. This check assures that the energy calibration has been maintained. Failure is usually not a problem unless the peaks are so far out of position that the internal energy calibration routine can not find them.

ecal_energy[.] The energy in keV of a peak to be checked for peak centroid position. This energy should appear in the peak list.

ecal_channel[.] The channel number including decimal fractions, if desired, of the peak centroid for the peak at **ecal_energy [.]**.

ecal_limit[.] The allowable deviation in channels of the observed peak position of the peak at **ecal_energy** from its specified location at **ecal_channel**. If the observed peak centroid position is outside the region from location minus limit to location plus limit, a warning message will be printed.

Example: The acceptable peak positions for **ecal_energy[1]** at 129.294 keV lie between channels 1192.75 and 1193.25 in the above table.

Edit Application Constants - widerange6

OK Cancel Perform insertion, deletion, shifting of rows

	name	value
9	num_fwhmcal	2
10	fcal_energy[1] (keV)	129.294
11	fcal_limit[1] (eV)	630.
12	fcal_energy[2] (keV)	413.714
13	fcal_limit[2] (eV)	1080.
14	num_tailfract	2
15	scal_energy[1] (keV)	129.294
16	scal_limit[1] (percent)	4.0

num_fwhmcal The number of peaks to be checked for Full Width at Half Maximum (FWHM). This test is usually performed to see that the detector resolution is within reasonable bounds.

fcal_energy[.] The energy in keV of a peak to be checked for FWHM. This energy should appear in the peak list.

fcal_limit[.] The FWHM of the peak at **fcal_energy[.]** must be less than this limit, in eV or a warning message will be printed.

num_tailfract The number of peaks to be used to check for the percentage of the total peak area falling in the tail. This test is performed to look for possible neutron damage causing excessive peak tailing.

scal_energy[.] The energy in keV of a peak to be checked for its tailing percentage. This energy should appear in the peak list.

scal_limit The percentage of the total peak area permitted to fall under the tail. A warning message will be printed if the tail percentage is greater than this number.

Edit Application Constants - widerange6

OK Cancel Perform insertion, deletion, shifting of rows

	name	value
19	num_intf	3
20	intf_1st_energy[1] (keV)	185.720
21	intf_2nd_energy[1] (keV)	203.545
22	intf_limit[1] (ratio)	.050
23	intf_msg[1]	** possible presence of U235 **
24	intf_1st_energy[2] (keV)	228.140
25	intf_2nd_energy[2] (keV)	203.545
26	intf_limit[2] (ratio)	.025

num_intf

The number of interference peaks to be checked. Interference peaks are peaks that are somewhat likely to appear in a spectrum but are not accounted for in the parameter set. Their presence, when not accounted for in the parameter set, may bias the analysis.

intf_1st_energy[.]
intf_2nd_energy[.]
intf_limit[.]
intf_2nd_energy[.].
intf_limit[.].
intf_msg[.]

To check for the presence of an interference peak we search for the peak at **intf_1st_energy[.]** and ratio its gross area including background to that of an expected peak at **intf_2nd_energy[.].** The peak area ratio must be less than **intf_limit[.].**The peak at **intf_2nd_energy[.]** must be in the peak list. The **intf_limit[.]**'s are set empirically. When a peak interference is found, the text from **intf_msg[.]** is printed. The message should be less than 80 characters

If this diagnostic is triggered one should visually examine the spectrum and, if necessary, reanalyze the spectrum with another parameter set, which includes the appropriate interference peaks.

Edit Application Constants - widerange6

OK Cancel Perform insertion, deletion, shifting of rows

	name	value
32	num_samptype	2
33	type_1st_peak[1] (pk. no.)	12
34	type_2nd_peak[1] (pk. no.)	19
35	type_lower_limit[1] (ratio)	0.96
36	type_upper_limit[1] (ratio)	1.04
37	type_msg[1]	Possible non-equilibrium or heterogeneous sample.
38	type_1st_peak[2] (pk. no.)	5
39	type_2nd_peak[2] (pk. no.)	44

num_samptype
type_1st_peak[.]
type_2nd_peak[.]
type_lower_limit[.]
type_upper_limit[.]
type_msg[.]

The type test checks peak activity ratios and can be used for various diagnostic tests. An activity ratio is the isotopic activity for the **type_1st(2nd)_peak[.]** ratioed to the activity for the first isotope in the isotope list. When this activity ratio is formed for two type peaks and ratioed, one has formed a ratio between the activities found from the two type peaks. This ratio must be between **type_lower_limit[.]** and **type_upper_limit[.]** or the **type_msg[.]** will be printed.

Example: From the parameter set **Edit Application Constants** listing above we note from row 34 that the 1st peak being compared is peak no. 12 in the peak list which is a ^{241}Pu peak at 148.6 keV. From row line 35 we see that the 2nd peak being compared is peak no. 19 at 164.6 keV from the ^{237}U daughter of ^{241}Pu. If the ratio of the activities found from these two peaks is outside the range from 0.96 to 1.04, the warning message **Possible non-equilibrium or heterogeneous sample** is printed.

Example: The second comparison is between peak 5, ^{241}Am at 125.3 keV with that of peak 44, ^{241}Am at 335.4 keV. If the activity ratio of these two peaks is not in the range from 0.93 to 1.07, the message **Possible heterogeneous (Am/Pu) sample** is printed. The reason is that the Am gamma rays may be suffering different attenuation than the plutonium gamma rays.

The structure of this test is flexible enough that you may find applications other than those illustrated.

fix_bad_bkg

This parameter can be set to **TRUE** or **FALSE**. It controls whether the background fitting is redone with an alternate function if the program senses that an unphysical background has been calculated. The default value is **TRUE** which means that the backgrounds are automatically recalculated even if this parameter is omitted from the Application

Constants list. For example, a linear step background (section 4.2.3) applied to a region with a positively sloping background continuum will produce unphysical smoothed steps for the calculated background. The program will recalculate the background with a linear background if the **fix_bad_bkg** parameter is **TRUE** or if the **fix_bad_bkg** parameter is omitted from the list. If the **fix_bad_bkg** parameter is **FALSE** the designated background fit is not changed.

> **NOTE!** To change the database, you must click the **OK** button to preserve the changes made on the screen into the worksheet. Then you must choose the **Save** option from the **File** menu to write the contents of the worksheet into the database.

4.2.6. Edit | Postpone Editing

This option returns control immediately to FRAM's main menu, keeping the open parameter set active. You may perform an analysis or any other activity and then return to the editing of this set by selecting the **Parameters** option in the **Edit** menu. Whenever you postpone the editing and choose a menu option that requires the selection of a parameter set, you will be forced to use the one that is active. If you try to exit FRAM, you will be reminded that a parameter set is still open. You must close the editing session before exiting from FRAM.

4.3. Parameter Set Listing

The contents of a parameter set may be listed by:

1. Enter the Change Parameter Utility by choosing **Edit**, then **Parameters** from the main PC/FRAM menu. Correctly complete the **User Validation** screen.
2. Open the desired parameter set by choosing **Open** under the **File** menu in the **Change Parameter Utility** window.
3. Choose **Print** under the **File** menu to print the parameter set on the printer.

A printer listing of the parameter set **widerange6** follows.

```
Parameter set:  widerange6
 Description: Planar, .1 keV/ch, Homo. Am/Pu, Equilib. 3-25% 240
 Printed: 14-Dec-1995 16:49:42     Last modified: 14-Dec-1995 16:32:36


 Initial values of calibration constants:
     GAIN        =  0.100020 kev/channel
     ZERO offset =  9.985000 kev
 These constants are FREE; they will be redetermined.

 Initial FWHM constants for formula:
     FWHM(ch) = SQRT (A1 + A2*E + A3/E)

     A1 = 2.241700 (ch**2)
     A2 = 0.019000 (ch**2/kev)
     A3 = 3307.000000 (ch**2*kev)
```

```
These constants are FREE; they will be redetermined.

Initial tailing constants for formula:
TAIL(J) = HT*EXP[(T1 + T2*E)+(T3 + T4*E)*(J-X0)]*[1 - EXP(-0.4*C*(J-X0)**2)]

    T1 = -3.508100 ()
    T2 = 0.003740 (1/kev)
    T3 = 0.220030 (1/channel)
    T4 = 0.000000 (1/channel**2)
These constants are FREE; they will be redetermined.
```

Peak Parameters for widerange6

pk	rg	iso-tope	peak energy	line width	branching ratio	fix area to	sum area with	used for eff	used for act	used for ecal	used for fcal	used for scal
1	0	Am241	122.994	0.00	1.000e-005	5	0	N	N	N	N	N
2	0	Pu239	123.620	0.00	1.970e-007	6	0	N	N	N	N	N
3	1	Pu239	124.510	0.00	6.130e-007	6	0	N	N	N	N	N
4	1	Pu239	125.210	0.00	5.210e-007	6	0	N	N	N	N	N
5	1	Am241	125.292	0.00	4.190e-005	0	0	N	Y	N	N	N
6	2	Pu239	129.294	0.00	6.260e-005	0	0	Y	Y	Y	Y	Y
7	3	Pu239	141.657	0.00	3.200e-007	9	0	N	N	N	N	N
8	3	Pu239	143.350	0.00	1.730e-007	9	0	N	N	N	N	N
9	3	Pu239	144.211	0.00	2.840e-006	0	0	N	Y	N	N	N
10	3	Pu239	146.077	0.00	1.190e-006	9	0	N	N	N	N	N
11	3	Am241	146.557	0.00	4.610e-006	0	0	N	N	N	N	N
12	3	Pu241	148.567	0.00	1.832e-006	0	0	Y	Y	Y	Y	N
13	3	Am241	150.110	0.00	7.200e-007	11	0	N	N	N	N	N
14	4	Pu238	152.720	0.00	8.983e-006	0	0	N	Y	N	N	N
15	6	Pu241	159.955	0.00	6.803e-008	19	0	N	N	N	N	N
16	6	Pu239	160.190	0.00	6.200e-008	18	0	N	N	N	N	N
17	6	Pu240	160.308	0.00	3.842e-006	0	0	N	Y	N	N	N
18	6	Pu239	161.482	0.00	1.184e-006	0	0	Y	Y	N	N	N
19	5	Pu241	164.597	0.00	4.541e-007	0	0	Y	Y	Y	Y	Y
20	5	Am241	164.597	0.00	6.260e-007	19	19	N	Y	N	N	N
21	5	Am241	165.930	0.00	2.320e-007	0	0	N	N	N	N	N
22	7	Am241	169.567	0.00	1.630e-006	0	0	N	N	N	N	N
23	7	Pu239	171.372	0.00	1.085e-006	0	0	Y	Y	N	N	N
24	0	Pu239	179.190	0.00	6.310e-007	0	0	N	N	N	N	N
25	0		187.960	0.00	0.000e+000	0	0	N	N	N	N	N
26	0	Pu239	189.320	0.00	7.870e-007	0	0	N	N	N	N	N
27	0	Pu239	195.660	0.00	1.090e-006	0	0	N	N	N	N	N
28	0	Pu239	196.870	0.00	3.700e-008	0	0	N	N	N	N	N
29	8	Pu239	203.545	0.00	5.570e-006	0	0	Y	Y	N	N	N
30	9	Pu241	208.000	0.00	5.250e-006	0	0	Y	Y	Y	Y	Y
31	9	Am241	208.000	0.00	7.540e-006	30	30	N	Y	N	N	N
32	10	Pu239	255.380	0.00	7.925e-007	0	0	Y	Y	N	N	N
33	11	Pu239	263.930	0.00	2.610e-007	0	0	N	N	N	N	N
34	11		264.850	0.00	0.000e+000	0	0	N	N	N	N	N
35	11	Pu239	265.700	0.00	1.580e-008	33	0	N	N	N	N	N
36	11	Pu241	267.540	0.00	1.793e-007	0	0	Y	Y	Y	Y	N
37	11	Am241	267.540	0.00	2.630e-007	36	36	N	Y	N	N	N
38	12	Pu239	311.740	0.00	2.580e-007	49	0	N	N	N	N	N
39	12		311.878	0.00	0.000e+000	0	0	N	N	N	N	N
40	14	Pu241	332.387	0.00	2.935e-007	0	0	N	Y	N	N	N
41	14	Am241	332.387	0.00	1.450e-006	40	40	N	Y	N	N	N
42	14	Pu239	332.845	0.00	5.060e-006	49	40	N	Y	N	N	N

43	14	Pu241	335.422	0.00	2.354e-008	0	0	N	Y	N	N	N
44	14	Am241	335.422	0.00	4.830e-006	43	43	N	Y	N	N	N
45	14	Pu239	336.096	0.00	1.134e-006	49	43	N	Y	N	N	N
46	14		337.720	0.00	0.000e+000	0	0	N	N	N	N	N
47	13		340.450	0.00	0.000e+000	0	0	N	N	N	N	N
48	13	Pu239	341.495	0.00	6.620e-007	49	0	N	N	N	N	N
49	13	Pu239	345.011	0.00	5.593e-006	0	0	Y	Y	Y	Y	Y
50	15	Pu239	367.036	0.00	8.650e-007	0	0	N	N	N	N	N
51	15	Pu239	368.536	0.00	9.030e-007	50	0	N	N	N	N	N
52	15	Pu241	368.605	0.00	1.034e-008	0	0	N	Y	N	N	N
53	15	Am241	368.605	0.00	2.120e-006	52	52	N	Y	N	N	N
54	15	Pu241	370.934	0.00	2.672e-008	0	0	N	Y	N	N	N
55	15	Am241	370.934	0.00	5.200e-007	54	54	N	Y	N	N	N
56	16		372.450	0.00	0.000e+000	0	0	N	N	N	N	N
57	16	Pu239	375.042	0.00	1.570e-005	0	0	Y	Y	Y	Y	N
58	16	Am241	376.590	0.00	1.330e-006	0	0	N	N	N	N	N
59	17	Pu239	380.170	0.00	3.050e-006	0	0	N	Y	N	N	N
60	17	Pu239	382.743	0.00	2.587e-006	0	0	N	Y	N	N	N
61	17	Am241	383.740	0.00	2.820e-007	0	0	N	N	N	N	N
62	18	Am241	390.540	0.00	5.900e-008	0	0	N	N	N	N	N
63	18	Pu239	392.545	0.00	1.934e-006	64	0	N	Y	N	N	N
64	18	Pu239	393.120	0.00	3.609e-006	0	0	N	Y	N	N	N
65	19	Pu239	411.150	0.00	6.800e-008	66	0	N	Y	N	N	N
66	19	Pu239	413.712	0.00	1.489e-005	0	0	Y	Y	Y	Y	Y
67	19		414.870	0.00	0.000e+000	0	0	N	N	N	N	N
68	19		415.760	0.00	0.000e+000	0	0	N	N	N	N	N

Peak infomation summary for widerange6

Peaks used for efficiency determination:

	energy	isotope	eff fn.
6	129.29	Pu239	1
12	148.57	Pu241	1
18	161.48	Pu239	1
19	164.60	Pu241	1
23	171.37	Pu239	1
29	203.55	Pu239	1
30	208.00	Pu241	1
32	255.38	Pu239	1
36	267.54	Pu241	1
49	345.01	Pu239	1
57	375.04	Pu239	1
66	413.71	Pu239	1

Peaks used for relative activity determination:

	energy	isotope
5	125.29	Am241
6	129.29	Pu239
9	144.21	Pu239
12	148.57	Pu241
14	152.72	Pu238
17	160.31	Pu240
18	161.48	Pu239
19	164.60	Pu241
20	164.60	Am241
23	171.37	Pu239
29	203.55	Pu239
30	208.00	Pu241
31	208.00	Am241

32	255.38	Pu239
36	267.54	Pu241
37	267.54	Am241
40	332.39	Pu241
41	332.39	Am241
42	332.85	Pu239
43	335.42	Pu241
44	335.42	Am241
45	336.10	Pu239
49	345.01	Pu239
52	368.61	Pu241
53	368.61	Am241
54	370.93	Pu241
55	370.93	Am241
57	375.04	Pu239
59	380.17	Pu239
60	382.74	Pu239
63	392.55	Pu239
64	393.12	Pu239
65	411.15	Pu239
66	413.71	Pu239

Peaks used for energy calibration:

	energy	isotope
6	129.29	Pu239
12	148.57	Pu241
19	164.60	Pu241
30	208.00	Pu241
36	267.54	Pu241
49	345.01	Pu239
57	375.04	Pu239
66	413.71	Pu239

Peaks used for fwhm calibration:

	energy	isotope
6	129.29	Pu239
12	148.57	Pu241
19	164.60	Pu241
30	208.00	Pu241
36	267.54	Pu241
49	345.01	Pu239
57	375.04	Pu239
66	413.71	Pu239

Peaks used for shape calibration:

	energy	isotope
6	129.29	Pu239
19	164.60	Pu241
30	208.00	Pu241
49	345.01	Pu239
66	413.71	Pu239

Region Parameters in kev. for widerange6

region	region	BKG #1	BKG #1	BKG #2	BKG #2	BKG #3	BKG #3	BKG #4	BKG #4	background

	start	stop	start	stop	start	stop	start	stop	start	stop	type
1	124.0	130.3	126.4	127.1	130.7	131.4	132.5	133.2	0.0	0.0	linear step
2	128.0	130.3	126.8	127.3	130.9	131.4	132.7	133.2	0.0	0.0	linear step
3	141.0	150.8	139.8	140.2	140.4	140.8	142.3	142.7	150.9	151.3	linear step
4	151.8	153.6	151.2	151.7	153.8	154.3	0.0	0.0	0.0	0.0	linear
5	163.3	166.6	162.4	162.8	166.6	167.0	167.0	167.4	0.0	0.0	linear step
6	159.0	162.2	158.7	159.2	162.4	162.9	0.0	0.0	0.0	0.0	linear
7	168.8	172.2	168.2	168.7	172.3	172.8	0.0	0.0	0.0	0.0	linear
8	202.0	204.7	201.8	202.2	204.7	205.1	0.0	0.0	0.0	0.0	linear
9	206.7	209.3	204.9	205.6	209.9	210.6	211.6	212.3	0.0	0.0	linear step
10	254.2	256.5	252.7	253.1	253.7	254.1	256.7	257.1	0.0	0.0	linear step
11	262.7	269.0	261.2	261.5	262.2	262.5	269.1	269.4	270.1	271.4	linear step
12	310.4	313.1	309.3	309.8	313.8	314.3	0.0	0.0	0.0	0.0	linear
13	339.6	346.6	327.7	328.2	328.6	329.1	347.5	348.0	348.7	349.2	flat step
14	330.2	338.6	327.7	328.2	328.6	329.1	347.5	348.0	348.7	349.2	flat step
15	365.6	372.0	363.2	363.7	364.0	364.5	385.2	385.7	385.9	386.4	flat step
16	372.1	377.8	363.2	363.7	364.0	364.5	385.2	385.7	385.9	386.4	flat step
17	378.4	384.2	363.2	363.7	364.0	364.5	385.2	385.7	385.9	386.4	flat step
18	389.5	394.7	387.5	387.9	388.4	388.8	396.5	396.9	397.3	397.7	flat step
19	409.9	417.0	408.1	408.8	409.0	409.7	417.5	418.2	0.0	0.0	flat step

Region Parameters in channels for widerange6

	region start	region stop	BKG #1 start	BKG #1 stop	BKG #2 start	BKG #2 stop	BKG #3 start	BKG #3 stop	BKG #4 start	BKG #4 stop	background type
1	1140	1203	1164	1171	1207	1214	1225	1232	0	0	linear step
2	1180	1203	1168	1173	1209	1214	1227	1232	0	0	linear step
3	1310	1408	1298	1302	1304	1308	1323	1327	1409	1413	linear step
4	1418	1436	1412	1417	1438	1443	0	0	0	0	linear
5	1533	1566	1524	1528	1566	1570	1570	1574	0	0	linear step
6	1490	1522	1487	1492	1524	1529	0	0	0	0	linear
7	1588	1622	1582	1587	1623	1628	0	0	0	0	linear
8	1920	1947	1918	1922	1947	1951	0	0	0	0	linear
9	1967	1993	1949	1956	1999	2006	2016	2023	0	0	linear step
10	2442	2465	2427	2431	2437	2441	2467	2471	0	0	linear step
11	2527	2590	2512	2515	2522	2525	2591	2594	2601	2614	linear step
12	3004	3031	2993	2998	3038	3043	0	0	0	0	linear
13	3295	3365	3177	3182	3186	3191	3374	3379	3386	3391	flat step
14	3202	3285	3177	3182	3186	3191	3374	3379	3386	3391	flat step
15	3555	3619	3531	3536	3539	3544	3751	3756	3758	3763	flat step
16	3620	3677	3531	3536	3539	3544	3751	3756	3758	3763	flat step
17	3683	3741	3531	3536	3539	3544	3751	3756	3758	3763	flat step
18	3794	3846	3774	3778	3783	3787	3864	3868	3872	3876	flat step
19	3998	4069	3980	3987	3989	3996	4074	4081	0	0	flat step

Isotope Parameters for widerange6

	name	half-life	units	mass	power (mw/g)	pu240 coef.	eff function
1	Pu239	2.41190e+004	years	239.0522	1.9288	0.00	1

2	Pu241	1.43480e+001	years	241.0569	3.4112	0.00	1
3	Am241	4.33600e+002	years	241.0568	114.2000	0.00	1
4	Pu238	8.77400e+001	years	238.0496	567.5700	2.52	1
5	Pu240	6.56400e+003	years	240.0538	7.0824	1.00	1
6	Pu242	3.76300e+005	years	242.0587	0.1159	1.68	1

Application Specific Constants for widerange6

name	value
pu242_correlation	.994
pu238_exponent	0.
pu239_exponent	-2.0
pu240_exponent	1.0
pu241_exponent	1.0
FRAM_SUMMARY_TYPE	PLUTONIUM
num_ecal	2
ecal_energy[1] (keV)	129.294
ecal_channel[1]	1193.00
ecal_limit[1] (channels)	.25
ecal_energy[2] (keV)	413.714
ecal_channel[2]	4037.12
ecal_limit[2] (channels)	.25
num_fwhmcal	2
fcal_energy[1] (keV)	129.294
fcal_limit[1] (eV)	630.
fcal_energy[2] (keV)	413.714
fcal_limit[2] (eV)	1080.
num_tailfract	2
scal_energy[1] (keV)	129.294
scal_limit[1] (percent)	4.0
scal_energy[2] ((keV)	413.714
scal_limit[2] (percent)	15.0
num_intf	3
intf_1st_energy[1] (keV)	185.720
intf_2nd_energy[1] (keV)	203.545
intf_limit[1] (ratio)	.050
intf_msg[1]	** possible presence of U235 **
intf_1st_energy[2] (keV)	228.140
intf_2nd_energy[2] (keV)	203.545
intf_limit[2] (ratio)	.025
intf_msg[2]	** possible presence of Np239 **
intf_1st_energy[3] (keV)	311.890
intf_2nd_energy[3] (keV)	345.011
intf_limit[3] (ratio)	2.000
intf_msg[3]	** possible presence of Np237 **
num_samptype	2
type_1st_peak[1] (pk. no.)	12
type_2nd_peak[1] (pk. no.)	19
type_lower_limit[1] (ratio)	0.96
type_upper_limit[1] (ratio)	1.04
type_msg[1]	Possible non-equilibrium or heterogeneous sample.
type_1st_peak[2] (pk. no.)	5
type_2nd_peak[2] (pk. no.)	44
type_lower_limit[2] (ratio)	0.94
type_upper_limit[2] (ratio)	1.06
type_msg[2]	Possible heterogeneous (Am/Pu) sample.
fix_bad_bkg	TRUE

5. Output Listings

Three levels of printer output (**Short, Medium,** and **Long**) are available to users on a system with a printer. These three print levels are inputs in dialog boxes associated with the **Measure | Measure Sample** option and the **Measure | Analyze Data** option. A screen copy of the short printout is sent to the monitor after each analysis no matter what print level is selected.

Under the **Options** menu, you can print or display results from the latest analysis or a previously saved results file at any of the above levels.

5.1. Short Output

A typical short output is shown below.

```
*****************************************************************************
PC FRAM (V3.2)      Isotopic Analysis      12-Jan-1999 15:06:52
(Fixed energy Response function Analysis with Multiple efficiencies)
System ID: My system

spectrum source: Test (ORTEC MCB: )
spectrum date:  12-Jan-1999 15:06:42
live time:  2817 s
true time:  3600 s
num channels:  8192

parameter set:  coax8k125 (1999.01.12 07:38)
    Coax .125 kev/ch, Homo. Am/Pu, Equ., 3-25% Pu240,<460 keV
spectrum file:  c:\fram32\spectra\Test.ssp
results file:  c:\fram32\results\Test.res
*****************************************************************************
*****************************************************************************
diagnostics passed.

                                                        (By Corr)   (ug/gPu)

             Pu238      Pu239      Pu240      Pu241      Pu242      Am241
mass%       .00672   93.79265    5.99797     .17806     .02458     1846.3
sigma       .00110     .15581     .15601     .00036     .00614       32.1
%RSD      16.39%      0.17%      2.60%      0.21%     25.01%      1.74%

%TotPwr:   1.5336    72.6827    17.0671      .2440      .0011     8.4713

Specific Power (W/gPu):    (   2.4889 +/-    .0135)e-003  (  0.54%)

Effective Pu240 fraction:  (   6.0562 +/-    .1560)e-002  (  2.58%)

Time since chemical separation:      5429.97   +/-  68.16   days   (  1.26%)

*****************************************************************************
*****************************************************************************
  total Pu:    403.082 g
  sample power:    1.0000 W
  specific power:    2.4808 mW/gPu
  date: 28-Feb-1998
*****************************************************************************
```

Header Block Information The first information printed is information about the sample, measurement system, measurement conditions, and data storage information.

`diagnostics passed` A report from any failed diagnostic tests as established in the Application Constants list is appended here. The report includes the value of the tested parameter and the limits compared against.

`Pu242` This is labeled as `(By Corr)` from the correlation specified in the Application Constants in the parameter set used for the analysis, or `(OpEntry)` as entered by you in the dialog box for the **Measure** options.

`Am241` This isotopic ratio is expressed as μg/gPu or ppm with respect to the total plutonium. Multiply this value by 10^{-4} to convert to mass percent.

`mass%` The isotopic percentage by weight relative to total plutonium.

`sigma` The absolute uncertainty representing one standard deviation propagated from counting statistics, closely representing the standard deviation that is observed from repeated measurements.

`% RSD` The relative standard deviation expressed as a percentage. It is calculated as `(sigma/mass%)*100`

`%TotPwr` The percentage of the total power (Watts) from the sample that is contributed by the indicated isotope. It is calculated from the known Watts/gram for each isotope weighted by the measured fraction of that isotope in the sample. This parameter is listed only for information purposes.

`Specific Power (W/gPu)` The sum over all heat producing isotopes of the product of the Watts/gram for each isotope times the measured isotope fraction in the sample. It is used to interpret a calorimetry measurement of the total sample power in Watts.

`Effective Pu240 fraction` 2.52*mass%(Pu238) + 1.00*mass%(Pu240) + 1.68*mass%(Pu242)
This parameter is used to interpret neutron coincidence counting measurements of Effective Pu240 mass in terms of total plutonium mass. The coefficients in this equation are entered as **pu240 coef.** through the **Edit | Isotopes** option in the Change Parameter Utility.

Note the exponents on the `Specific Power:` and `Effective Pu240 fraction:`. The uncertainties for these quantities are absolute (within the first parentheses) and one relative standard deviation expressed as a percentage (in the second parentheses).

`Time since chemical separation` The time in days since the last chemical separation of ^{241}Am and ^{237}U from the sample. It is calculated from the equation

time(days) = 7819.176*ln(0.9669335*R + 1)

where R is the ^{241}Am/^{241}Pu abundance ratio.

Calorimetry Report (optional) If you enter a calorimeter wattage and date in the dialog box associated with the **Measure | Measure Sample** or the **Measure | Analyze Data** option, we append a report of the total plutonium mass in the sample as of the date of the calorimetry measurement. If a calorimetry wattage is not entered, this report is not printed.

5.2. Medium Output

A medium printout shown below appends about a half dozen pages before ending with the short printout previously shown. Description of some of the features of this output follows the example. The short output that is normally at the end of the medium output is not shown here.

```
*****************************************************************************
PC FRAM (V3.2)      Isotopic Analysis      12-Jan-1999 15:06:52
(Fixed energy Response function Analysis with Multiple efficiencies)
System ID: My system

spectrum source: Test (ORTEC MCB: )
spectrum date:  12-Jan-1999 15:06:42
live time:  2817 s
true time:  3600 s
num channels:  8192

parameter set:  coax8k125 (1999.01.12 07:38)
    Coax .125 kev/ch, Homo. Am/Pu, Equ., 3-25% Pu240,<460 keV
*****************************************************************************

Table used for energy calibration:

       centroid      energy
---------------------------
  1    1034.213     129.294
  2    1188.432     148.567
  3    1316.732     164.597
  4    1664.000     208.000
  5    2140.408     267.540
  6    2760.013     345.011
  7    3000.379     375.042
  8    3309.668     413.712
  9    3611.813     451.474

*****************************************************************************

FWHM parameter in the formula:
    fwhm = SQRT( A1 + A2*E + A3/E )

    A1 = 4.695017e+001      sigma = 8.652252e+000
    A2 = 1.473442e-001      sigma = 1.564259e-002
    A3 = 4.008763e+002      sigma = 9.807882e+002

   Qfit =  6.792e+000    R**2 =   .97798   Cond =  7.260e+005

                                 interp.   fitted
         energy    centroid       fwhm      fwhm     error   formula    ratio
-------------------------------------------------------------------------------
  1     129.294    1034.221     8.3996    8.3096     .42%    8.3127    .9996
  2     148.567    1188.375     8.5242    8.3889    1.41%    8.4580    .9918
  3     164.597    1316.651     8.9219    8.9181    2.13%    8.5812   1.0392
  4     208.000    1664.021     8.9762    8.9242     .27%    8.9176   1.0007
  5     345.011    2760.024     9.8625    9.8780     .27%    9.9472    .9930
  6     413.712    3309.683    10.5373   10.4648     .11%   10.4344   1.0029
  7     451.474    3611.845    10.7840   10.5934     .28%   10.6939    .9906

*****************************************************************************

Shape parameters in the formula:
    log(tail[j]/hght/roll_off) = (T1+T2*E) + (T3+T4*E)*(x-x0)

    T1 = -2.035781e+000      sigma = 0.000000e+000
    T2 = -2.430535e-003      sigma = 0.000000e+000
```

```
    T3 = 2.187396e-001      sigma = 0.000000e+000
    T4 = 0.000000e+000      sigma = 0.000000e+000

   Qfit =  6.792e+000    R**2 =   .97798   Cond =  7.260e+005

         energy            amp          slope
-----------------------------------------------
  1     129.294  9.536585e-002  2.187396e-001
  2     164.597  8.752421e-002  2.187396e-001
  3     208.000  7.876139e-002  2.187396e-001
  4     345.011  5.645324e-002  2.187396e-001
  5     451.474  4.358228e-002  2.187396e-001

*****************************************************************************

Calibration Diagnostics:

check energy calibration:
  1 at   208.000 kev, centroid =  1663.994 [ 1663.500 < ? <  1664.500]
  2 at   662.456 kev, centroid =  5299.119 [ 5297.900 < ? <  5300.900]

check fwhm calibration:
  3 at   413.714 kev, fwhm =   1304.3 ev [? <   1500.0]

check shape calibration:
  4 at   413.714 kev, tail fraction =    .43% [? <   5.00%]

check for interferences:
  5 (  185.719,  203.545) peak area ratio =  1.446e-002 [? <   .050]
  6 (  228.140,  203.545) peak area ratio =  1.035e-003 [? <   .025]
  7 (  311.887,  345.011) peak area ratio =  9.839e-002 [? <  2.000]


*****************************************************************************

Results of efficiency calculations:

     coefficient      error
     -----------      -----
    2.72059e+001    2.52286e-001   (Pu239)
   -2.06876e-002    1.36124e-002   (1/E**2)
    1.87696e+000    8.18336e-001   (log(E))
    1.38282e+000    7.73372e-001   (log(E)**2)
    5.56068e-001    3.06374e-001   (log(E)**3)
    1.15415e+000    5.44325e-003   (Pu241)

   Qfit =  4.634e+000    R**2 =   .99985   Cond =  2.783e+004

    pk  isotope  energy       area    error   branch      log(A/Br) predicted  exp(dif)
    --  -------  ------       ----    -----   ------      ---------------------  --------
 1   6    Pu239  129.294     712347   0.16%  6.2600e-005   23.155    23.155    .9998
 2  12    Pu241  148.567     134405   0.62%  1.8320e-006   25.018    25.016   1.0021
 3  18    Pu239  161.482      39913   2.09%  1.1840e-006   24.241    24.216   1.0247
 4  19    Pu241  164.597      50424   1.67%  4.5410e-007   25.433    25.445    .9878
 5  23    Pu239  171.372      44924   1.86%  1.0850e-006   24.446    24.441   1.0053
 6  24    Pu239  203.545     392456   0.25%  5.5700e-006   24.978    24.979    .9986
 7  25    Pu241  208.000    1244624   0.11%  5.2500e-006   26.191    26.191   1.0003
 8  27    Pu239  255.380      92027   0.76%  7.9250e-007   25.477    25.488    .9891
 9  31    Pu241  267.540      70437   0.91%  1.7930e-007   26.696    26.725    .9715
10  44    Pu239  345.011    1020602   0.11%  5.5930e-006   25.929    25.930    .9993
11  52    Pu239  375.042    3149942   0.06%  1.5700e-005   26.024    26.023   1.0012
12  61    Pu239  413.712    3292167   0.06%  1.4890e-005   26.121    26.123    .9986
13  64    Pu239  451.474     456620   0.15%  1.8900e-006   26.210    26.206   1.0039

 isotope     beta
```

```
-------      ----
 Pu239     0.00000
 Pu241     0.00000
 Am241     0.00000
 Pu238     0.00000
 Pu240     0.00000
 Pu242     0.00000
*****************************************************************************
```

Results of activity calculations:

isotope ratio	activity ratio	mass ratio	error
Pu239/Pu239	1.00000e+000	1.00000e+000	0.03%
Pu241/Pu239	3.16485e+000	1.89850e-003	0.12%
Am241/Pu239	1.08588e-001	1.96852e-003	1.74%
Pu238/Pu239	1.97943e-002	7.17056e-005	16.39%
Pu240/Pu239	2.33997e-001	6.39493e-002	2.77%
Pu242/Pu239	0.00000e+000	0.00000e+000	>99.99%

Qfit = 1.467e+001 R**2 = .99998 Cond = 1.798e+308

Individual ratios:

pk	isotope	energy	area	error	activity ratios	mass ratios
6	Pu239	129.294	712347	0.16%	9.99899e-001	9.99899e-001
9	Pu239	144.211	55907	1.38%	9.79444e-001	9.79444e-001
18	Pu239	161.482	39913	2.09%	1.02476e+000	1.02476e+000
23	Pu239	171.372	44924	1.86%	1.00537e+000	1.00537e+000
24	Pu239	203.545	392456	0.25%	9.98625e-001	9.98625e-001
27	Pu239	255.380	92027	0.76%	9.89116e-001	9.89116e-001
44	Pu239	345.011	1020602	0.11%	9.99398e-001	9.99398e-001
52	Pu239	375.042	3149942	0.06%	1.00125e+000	1.00125e+000
54	Pu239	380.170	628651	0.14%	1.01396e+000	1.01396e+000
55	Pu239	382.743	536128	0.15%	1.01232e+000	1.01232e+000
59	Pu239	393.120	758668	0.12%	9.98978e-001	9.98978e-001
61	Pu239	413.712	3292167	0.06%	9.98603e-001	9.98603e-001
64	Pu239	451.474	456620	0.15%	1.00397e+000	1.00397e+000
12	Pu241	148.567	134405	0.62%	3.17817e+000	1.90650e-003
19	Pu241	164.597	50424	1.67%	3.13283e+000	1.87930e-003
25	Pu241	208.000	1244624	0.11%	3.17257e+000	1.90314e-003
31	Pu241	267.540	70437	0.91%	3.08096e+000	1.84818e-003
35	Pu241	332.387	155879	0.41%	3.04175e+000	1.82466e-003
38	Pu241	335.422	13991	3.50%	3.36637e+000	2.01939e-003
47	Pu241	368.605	7245	6.15%	3.56222e+000	2.13688e-003
49	Pu241	370.934	17632	2.62%	3.33205e+000	1.99880e-003
5	Am241	125.292	43282	1.74%	1.09964e-001	1.99346e-003
20	Am241	164.597	2365	1.61%	1.06589e-001	1.93227e-003
26	Am241	208.000	60817	0.06%	1.07941e-001	1.95678e-003
32	Am241	267.540	3515	0.83%	1.04824e-001	1.90028e-003
36	Am241	332.387	26201	0.34%	1.03490e-001	1.87609e-003
39	Am241	335.422	97670	4.10%	1.14534e-001	2.07631e-003
48	Am241	368.605	50539	6.82%	1.21198e-001	2.19711e-003
50	Am241	370.934	11674	2.58%	1.13367e-001	2.05514e-003
14	Pu238	152.720	4677	16.39%	1.98051e-002	7.17448e-005
17	Pu240	160.308	29354	2.77%	2.34125e-001	6.39842e-002

****

Summary of peak information:

pk	isotope	energy	area	error	eff	hfac	mass ratios		
1	Am241	122.994	0	>99.99%	.0847	1.0000	0.0000e+000	F	
2	Pu239	123.620	0	>99.99%	.0874	1.0000	0.0000e+000	F	
3	Pu239	124.510	5570	0.10%	.0912	1.0000	9.9535e-001	F	
4	Pu239	125.210	3142	0.10%	.0944	1.0000	9.9612e-001	F	
5	Am241	125.292	43282	1.74%	.0947	1.0000	1.9935e-003	A	
6	Pu239	129.294	712347	0.16%	.1138	1.0000	9.9990e-001	EA	QWT
7	Pu239	141.657	5775	1.31%	.1843	1.0000	9.7893e-001	F	
8	Pu239	143.350	3309	1.31%	.1953	1.0000	9.7929e-001	F	
9	Pu239	144.211	55907	1.38%	.2009	1.0000	9.7944e-001	A	
10	Pu239	146.077	24897	1.35%	.2135	1.0000	9.7971e-001	F	
11	Am241	146.557	10680	7.01%	.2168	1.0000	1.9368e-003		
12	Pu241	148.567	134405	0.62%	.2308	1.0000	1.9065e-003	EA	QW
13	Am241	150.110	1861	7.06%	.2418	1.0000	1.9373e-003	F	
14	Pu238	152.720	4677	16.39%	.2609	1.0000	7.1745e-005	A	
15	Pu241	159.955	6418	1.67%	.3166	1.0000	1.8803e-003	F	
16	Pu239	160.190	2156	1.99%	.3185	1.0000	1.0249e+000	F	
17	Pu240	160.308	29354	2.77%	.3195	1.0000	6.3984e-002	A	
18	Pu239	161.482	39913	2.09%	.3289	1.0000	1.0248e+000	EA	
19	Pu241	164.597	50424	1.67%	.3544	1.0000	1.8793e-003	EA	QWT
20	Am241	164.597	2365	1.61%	.3544	1.0000	1.9323e-003	AFS	
21	Am241	165.930	1258	63.42%	.3655	1.0000	2.6883e-003		
22	Am241	169.567	7018	11.40%	.3963	1.0000	1.9696e-003		
23	Pu239	171.372	44924	1.86%	.4118	1.0000	1.0054e+000	EA	
24	Pu239	203.545	392456	0.25%	.7055	1.0000	9.9862e-001	EA	
25	Pu241	208.000	1244624	0.11%	.7472	1.0000	1.9031e-003	EA	QWT
26	Am241	208.000	60817	0.06%	.7472	1.0000	1.9568e-003	AFS	
27	Pu239	255.380	92027	0.76%	1.1740	1.0000	9.8912e-001	EA	
28	Pu239	263.930	32182	1.93%	1.2455	1.0000	9.8999e-001		
29		264.850	0	>99.99%	1.2530	1.0000	0.0000e+000		
30	Pu239	265.700	1971	1.84%	1.2600	1.0000	9.9000e-001	F	
31	Pu241	267.540	70437	0.91%	1.2750	1.0000	1.8482e-003	EA	Q
32	Am241	267.540	3515	0.83%	1.2750	1.0000	1.9003e-003	AFS	
33	Pu239	311.740	41404	0.11%	1.6078	1.0000	9.9808e-001	F	
34		311.887	57088	1.00%	1.6088	1.0000	0.0000e+000		
35	Pu241	332.387	155879	0.41%	1.7460	1.0000	1.8247e-003	A	
36	Am241	332.387	26201	0.34%	1.7460	1.0000	1.8761e-003	AFS	
37	Pu239	332.845	883974	0.11%	1.7490	1.0000	9.9884e-001	FS	
38	Pu241	335.422	13991	3.50%	1.7655	1.0000	2.0194e-003	A	
39	Am241	335.422	97670	4.10%	1.7655	1.0000	2.0763e-003	AFS	
40	Pu239	336.096	200500	0.11%	1.7698	1.0000	9.9900e-001	FS	
41		337.720	4426	10.92%	1.7801	1.0000	0.0000e+000		
42		340.450	5329	8.93%	1.7974	1.0000	0.0000e+000		
43	Pu239	341.495	119333	0.06%	1.8039	1.0000	9.9924e-001	F	
44	Pu239	345.011	1020602	0.11%	1.8258	1.0000	9.9940e-001	EA	QWT
45	Pu239	367.036	169478	0.36%	1.9578	1.0000	1.0007e+000		
46	Pu239	368.536	177716	0.36%	1.9665	1.0000	1.0008e+000	F	
47	Pu241	368.605	7245	6.15%	1.9669	1.0000	2.1369e-003	A	
48	Am241	368.605	50539	6.82%	1.9669	1.0000	2.1971e-003	AFS	
49	Pu241	370.934	17632	2.62%	1.9803	1.0000	1.9988e-003	A	
50	Am241	370.934	11674	2.58%	1.9803	1.0000	2.0551e-003	AFS	
51		372.449	5455	8.21%	1.9890	1.0000	0.0000e+000		
52	Pu239	375.042	3149942	0.06%	2.0038	1.0000	1.0012e+000	EA	Q
53	Am241	376.590	42031	1.04%	2.0126	1.0000	2.8465e-003		
54	Pu239	380.170	628651	0.14%	2.0327	1.0000	1.0140e+000	A	
55	Pu239	382.743	536128	0.15%	2.0471	1.0000	1.0123e+000	A	
56	Am241	383.740	5138	7.15%	2.0527	1.0000	1.6091e-003		
57	Am241	390.540	0	>99.99%	2.0902	1.0000	0.0000e+000		
58	Pu239	392.525	405930	0.10%	2.1010	1.0000	9.9897e-001	F	

```
 59    Pu239  393.120     758668   0.12%  2.1043   1.0000   9.9898e-001    A
 60    Pu239  411.150      14944   0.01%  2.2006   1.0000   9.9865e-001     F
 61    Pu239  413.712    3292167   0.06%  2.2140   1.0000   9.9860e-001   EA    QW
 62           414.870      26175   1.16%  2.2201   1.0000   0.0000e+000
 63           415.760      18493   1.50%  2.2247   1.0000   0.0000e+000
 64    Pu239  451.474     456620   0.15%  2.4064   1.0000   1.0040e+000   EA    QWT

Efficiencies are divided by  1.0e+011
E - this peak is used to determine relative efficiencies.
A - this peak is used to determine relative activities.
F - this peak is fixed to another peak.
S - this peak is summed with another peak.
Q - this peak is ued to determine the energy calibration.
W - this peak is used to determine the fwhm calibration.
T - this peak is used to determine the shape calibration.

*****************************************************************************

Check sample types:

  1 (  148.567,   164.597)  mass ratio =  1.014e+000 [  .950 < ? <  1.050]
  2 (  125.292,   335.422)  mass ratio =  9.601e-001 [  .930 < ? <  1.070]
```

Table used for energy calibration:

This table lists the centroid in channels of the peaks designated as energy calibration peaks. The energy calibration is a piecewise linear calibration between adjacent pairs of energy calibration peaks.

FWHM parameters in formula:

In the table displaying the results of the FWHM fitting, the heading `width` gives the FWHM from a simple linear interpolation and is used only as a check on the other values. `fwhm` lists the values from the FWHM fitting which are input to a least squares fit to obtain the formula. `formula` gives the value from the formula and fitted parameters `A1...A3`. The formula values are used in the response function fitting. `ratio` is `fwhm` divided by `formula`. The units of the formula coefficients are such that FWHM is in channels when E (energy) is in keV.

Shape parameters in formula:

We customarily set `T4` to zero in the expression for parametrizing the energy dependence of the tailing parameters.

Calibration Diagnostics:

This section displays the results from some of the diagnostic tests set up in the Application Constants dialog. If any of these tests fail, the complete diagnostic will be displayed on the short output listing.

Results of efficiency calculations:

The coefficients correspond to the constants in the expression for the relative efficiency given in Appendix A. The first coefficient represents the first isotope in the isotope list. All relative activity calculations are

performed relative to this isotope. `predicted` is the fitted value of `log(A/Br)` where `A` is the peak area and `Br` is the branching ratio and `ratio` is `log(A/Br)/predicted`.

The `Qfit` value will seldom be near unity (even though it is in this example) because the empirical relative efficiency formula is not an exact match for the physical processes governing the shape of the relative efficiency curve.

`beta` will be nonzero only for isotopes declared in the isotope list to have a different relative efficiency curve from that for the first isotope.

Results of Activity Calculation:

This section gives the calculated results for the fundamental quantities computed in PC/FRAM

PC/FRAM may be used to measure isotopic ratios other than from plutonium. While a dedicated printout format can be designated for uranium (Application Constants FRAM_SUMMARY_TYPE, URANIUM) no such formal output exists at this time for other than uranium and plutonium. The final answers for measured isotopic ratios for samples without uranium or plutonium would be obtained here.

The remainder of this section shows the individual activity ratios for each peak designated as an activity peak. All the peaks for a given isotope should have the same activity ratio, within statistical uncertainties, for all gamma rays. A peak consistently out of conformance with others from the same isotope may indicate the need for a branching ratio adjustment or close examination of the fitting parameters in that region. It could also indicate the presence of an unidentified interference.

Summary of Peak Information:

This section presents the final peak areas and uncertainties (`error` at the one RSD level), scaled relative efficiency values (`eff`), and the heterogeneity factor (`hfac` = exp(β/E)). `mass ratios` are given for all peaks whether or not they were designated as an activity peak. The letter codes at the right are keyed at the bottom of the section.

Check Sample Types:

Displays the results from some of the diagnostic tests set up in the Application Constants dialog. If any of these tests fail, the complete diagnostic will be displayed on the short output listing. The tests listed in this section can diagnose nonequilibrium ^{241}Pu-^{237}U decay and Am/Pu heterogeneity.

Short output

A **Medium** printout ends with the short output on the last page. This is not shown here.

5.3. Long Printout

A long printout inserts a `Summary of the Results for each Region` into the **Medium** printout previously shown. This section displays statistical parameters from the response function fit to each region. Normally one expects `Qfit` to be near unity for a good fit. For very intense peaks `Qfit` will often be >> 1 representing our inability to perfectly model the peak shape within counting statistics. R^2

will be near unity for a good fit. **Cond** is a parameter that describes the nearness to singularity of the inverted matrix. The larger the number, the more nearly the matrix is to being singular. This section also provides information about each of the peaks in the given region. The following information is listed: peak index, name of the associated isotope, energy, centroid, full-width at half-max, tailing amplitude, tailing slope, area, error associated with the area, the group index of the peak, and the area factor. Each free peak is assigned a unique group index while the other peaks are assigned the group index of the free peak that they are fixed to. The area factors are the weights assigned to the functional form of each peak when constructing a composite response for all the peaks in a single group.

```
*******************************************************************************

Summary of the results for each region:

-------------------------------------------------------------------------------
region 1  from channel 1021 to 1048     (  127.600 kev to   131.000 kev)
-------------------------------------------------------------------------------

   total net counts =     710519.6
   Qfit =  1.020e+000     R**2 =    .99990    Cond =  1.000e+000

pk isotope   energy centroid   fwhm  tamp  tslp       area  error  fn  factor
-- -------   ------ --------   ----  ----  ----       ----  -----  --  ------
 6   Pu239  129.294 1034.221  8.312  .095  .218     712523   0.16%  1  1.0000

-------------------------------------------------------------------------------
region 2  from channel 992 to 1048      (  124.000 kev to   131.000 kev)
-------------------------------------------------------------------------------

   total net counts =     761288.6
   Qfit =  6.348e-001     R**2 =    .99992    Cond =  1.502e+000

pk isotope   energy centroid   fwhm  tamp  tslp       area  error  fn  factor
-- -------   ------ --------   ----  ----  ----       ----  -----  --  ------
 3   Pu239  124.510  995.932  8.277  .096  .218       5570   0.10%  2   .0078
 4   Pu239  125.210 1001.534  8.282  .096  .218       3142   0.10%  2   .0044
 5   Am241  125.292 1002.190  8.283  .096  .218      43282   1.74%  1  1.0000
 6   Pu239  129.294 1034.221  8.312  .095  .218     712347   0.16%  2  1.0000

-------------------------------------------------------------------------------
region 3  from channel 1126 to 1208     (  140.800 kev to   151.000 kev)
-------------------------------------------------------------------------------

   total net counts =     232897.9
   Qfit =  6.198e-001     R**2 =    .99793    Cond =  1.386e+000

pk isotope   energy centroid   fwhm  tamp  tslp       area  error  fn  factor
-- -------   ------ --------   ----  ----  ----       ----  -----  --  ------
 7   Pu239  141.657 1133.140  8.405  .092  .218       5775   1.31%  1   .1032
 8   Pu239  143.350 1146.687  8.418  .092  .218       3309   1.31%  1   .0591
 9   Pu239  144.211 1153.576  8.424  .091  .218      55907   1.38%  1  1.0000
10   Pu239  146.077 1168.508  8.439  .091  .218      24897   1.35%  1   .4453
11   Am241  146.557 1172.348  8.442  .091  .218      10680   7.01%  2  1.0000
12   Pu241  148.567 1188.375  8.458  .091  .218     134405   0.62%  3  1.0000
13   Am241  150.110 1200.782  8.469  .090  .218       1861   7.06%  2   .1742

-------------------------------------------------------------------------------
region 4  from channel 1213 to 1232     (  151.600 kev to   154.000 kev)
```

```
-------------------------------------------------------------------------------

   total net counts =      4359.0
   Qfit =  4.213e-001    R**2 =    .67055   Cond =  1.000e+000

pk isotope   energy centroid   fwhm  tamp  tslp       area  error  fn  factor
-- -------   ------ --------   ----  ----  ----       ----  -----  --  ------
14   Pu238  152.720 1221.672  8.489  .090  .218       4677  16.39%  1  1.0000

-------------------------------------------------------------------------------
region 5  from channel 1305 to 1335     (  163.100 kev to   166.900 kev)
-------------------------------------------------------------------------------

   total net counts =     53226.7
   Qfit =  3.365e-001    R**2 =    .99595   Cond =  1.131e+000

pk isotope   energy centroid   fwhm  tamp  tslp       area  error  fn  factor
-- -------   ------ --------   ----  ----  ----       ----  -----  --  ------
19   Pu241  164.597 1316.651  8.581  .087  .218      50424   1.67%  1  1.0000
20   Am241  164.597 1316.732  8.581  .087  .218       2365   1.61%  1   .0469
21   Am241  165.930 1327.397  8.591  .087  .218       1258  63.42%  2  1.0000

-------------------------------------------------------------------------------
region 6  from channel 1270 to 1300     (  158.700 kev to   162.500 kev)
-------------------------------------------------------------------------------

   total net counts =     70444.3
   Qfit =  6.353e-001    R**2 =    .98754   Cond =  1.288e+000

pk isotope   energy centroid   fwhm  tamp  tslp       area  error  fn  factor
-- -------   ------ --------   ----  ----  ----       ----  -----  --  ------
15   Pu241  159.955 1279.579  8.545  .088  .218       6418   1.67%  0   .1272
16   Pu239  160.190 1281.459  8.547  .088  .218       2156   1.99%  2   .0540
17   Pu240  160.308 1282.404  8.548  .088  .218      29354   2.77%  1  1.0000
18   Pu239  161.482 1291.800  8.557  .088  .218      39913   2.09%  2  1.0000

-------------------------------------------------------------------------------
region 7  from channel 1348 to 1382     (  168.500 kev to   172.700 kev)
-------------------------------------------------------------------------------

   total net counts =     52026.6
   Qfit =  4.227e-001    R**2 =    .99142   Cond =  1.042e+000

pk isotope   energy centroid   fwhm  tamp  tslp       area  error  fn  factor
-- -------   ------ --------   ----  ----  ----       ----  -----  --  ------
22   Am241  169.567 1356.497  8.619  .086  .218       7018  11.40%  1  1.0000
23   Pu239  171.372 1370.939  8.633  .086  .218      44924   1.86%  2  1.0000

-------------------------------------------------------------------------------
region 8  from channel 1614 to 1641     (  201.800 kev to   205.100 kev)
-------------------------------------------------------------------------------

   total net counts =    390594.8
   Qfit =  7.147e-001    R**2 =    .99980   Cond =  1.000e+000

pk isotope   energy centroid   fwhm  tamp  tslp       area  error  fn  factor
-- -------   ------ --------   ----  ----  ----       ----  -----  --  ------
24   Pu239  203.545 1628.355  8.883  .079  .218     392456   0.25%  1  1.0000

-------------------------------------------------------------------------------
```

```
region 9  from channel 1646 to 1686     (  205.800 kev to   210.800 kev)
-------------------------------------------------------------------------------

   total net counts =   1306174.8
   Qfit =  2.998e+000    R**2 =   .99990   Cond =  1.000e+000

pk isotope   energy centroid   fwhm  tamp  tslp       area  error  fn  factor
-- -------   ------ --------   ----  ----  ----       ----  -----  --  ------
25   Pu241  208.000 1664.021  8.917  .078  .218    1244624   0.11%  1  1.0000
26   Am241  208.000 1664.000  8.917  .078  .218      60817   0.06%  1   .0488

-------------------------------------------------------------------------------
region 10  from channel 2031 to 2055     (  253.900 kev to   256.899 kev)
-------------------------------------------------------------------------------

   total net counts =     91378.9
   Qfit =  7.903e-001    R**2 =   .99780   Cond =  1.000e+000

pk isotope   energy centroid   fwhm  tamp  tslp       area  error  fn  factor
-- -------   ------ --------   ----  ----  ----       ----  -----  --  ------
27   Pu239  255.380 2043.110  9.281  .070  .218      92027   0.76%  1  1.0000

-------------------------------------------------------------------------------
region 11  from channel 2101 to 2156     (  262.600 kev to   269.500 kev)
-------------------------------------------------------------------------------

   total net counts =    106675.7
   Qfit =  8.923e+001    R**2 =   .99705   Cond =  1.798e+308

pk isotope   energy centroid   fwhm  tamp  tslp       area  error  fn  factor
-- -------   ------ --------   ----  ----  ----       ----  -----  --  ------
28   Pu239  263.930 2111.523  9.346  .068  .218      32182   1.93%  1  1.0000
29          264.850 2118.884  9.353  .068  .218          0 >99.99%  2  1.0000
30   Pu239  265.700 2125.686  9.359  .068  .218       1971   1.84%  1   .0612
31   Pu241  267.540 2140.408  9.373  .068  .218      70437   0.91%  3  1.0000
32   Am241  267.540 2140.408  9.373  .068  .218       3515   0.83%  3   .0499

-------------------------------------------------------------------------------
region 12  from channel 2481 to 2510     (  310.100 kev to   313.700 kev)
-------------------------------------------------------------------------------

   total net counts =     56576.2
   Qfit =  9.217e-001    R**2 =   .99433   Cond =  1.000e+000

pk isotope   energy centroid   fwhm  tamp  tslp       area  error  fn  factor
-- -------   ------ --------   ----  ----  ----       ----  -----  --  ------
33   Pu239  311.740 2493.915  9.704  .061  .218      41404   0.11%  0   .0405
34          311.887 2495.091  9.705  .061  .218      57088   1.00%  1  1.0000

-------------------------------------------------------------------------------
region 13  from channel 2714 to 2778     (  339.300 kev to   347.300 kev)
-------------------------------------------------------------------------------

   total net counts =   1144747.9
   Qfit =  1.557e+000    R**2 =   .99991   Cond =  2.180e+000

pk isotope   energy centroid   fwhm  tamp  tslp       area  error  fn  factor
-- -------   ------ --------   ----  ----  ----       ----  -----  --  ------
42          340.450 2723.535  9.914  .057  .218       5329   8.93%  1  1.0000
43   Pu239  341.495 2731.893  9.921  .056  .218     119333   0.06%  2   .1169
44   Pu239  345.011 2760.024  9.947  .056  .218    1020602   0.11%  2  1.0000
```

```
-------------------------------------------------------------------------------
region 14  from channel 2642 to 2712     (  330.300 kev to   339.000 kev)
-------------------------------------------------------------------------------

   total net counts =    298544.4
   Qfit =  1.268e+000    R**2 =   .99829   Cond =  1.154e+001

pk isotope   energy centroid   fwhm  tamp  tslp       area  error  fn  factor
-- -------   ------ --------   ----  ----  ----       ----  -----  --  ------
35   Pu241  332.387 2659.048  9.855  .058  .218     155879   0.41%  1  1.0000
36   Am241  332.387 2659.048  9.855  .058  .218      26201   0.34%  1   .1680
37   Pu239  332.845 2662.711  9.858  .058  .218     883974   0.11%  0   .8661
38   Pu241  335.422 2683.321  9.877  .057  .218      13991   3.50%  2  1.0000
39   Am241  335.422 2683.321  9.877  .057  .218      97670   4.10%  2  6.9809
40   Pu239  336.096 2688.712  9.882  .057  .218     200500   0.11%  0   .1964
41          337.720 2701.701  9.894  .057  .218       4426  10.92%  3  1.0000


-------------------------------------------------------------------------------
region 15  from channel 2922 to 2983     (  365.300 kev to   372.900 kev)
-------------------------------------------------------------------------------

   total net counts =    437264.6
   Qfit =  1.980e+000    R**2 =   .99928   Cond =  7.455e+000

pk isotope   energy centroid   fwhm  tamp  tslp       area  error  fn  factor
-- -------   ------ --------   ----  ----  ----       ----  -----  --  ------
45   Pu239  367.036 2936.300 10.105  .053  .218     169478   0.36%  1  1.0000
46   Pu239  368.536 2948.306 10.116  .053  .218     177716   0.36%  1  1.0486
47   Pu241  368.605 2948.858 10.116  .053  .218       7245   6.15%  2  1.0000
48   Am241  368.605 2948.858 10.116  .053  .218      50539   6.82%  2  6.9757
49   Pu241  370.934 2967.499 10.133  .053  .218      17632   2.62%  3  1.0000
50   Am241  370.934 2967.499 10.133  .053  .218      11674   2.58%  3   .6621
51          372.449 2979.633 10.144  .052  .218       5455   8.21%  4  1.0000


-------------------------------------------------------------------------------
region 16  from channel 2984 to 3025     (  373.000 kev to   378.100 kev)
-------------------------------------------------------------------------------

   total net counts =   3193027.8
   Qfit =  1.031e+001    R**2 =   .99992   Cond =  3.447e+000

pk isotope   energy centroid   fwhm  tamp  tslp       area  error  fn  factor
-- -------   ------ --------   ----  ----  ----       ----  -----  --  ------
52   Pu239  375.042 3000.379 10.162  .052  .218    3149942   0.06%  1  1.0000
53   Am241  376.590 3012.761 10.173  .052  .218      42031   1.04%  2  1.0000


-------------------------------------------------------------------------------
region 17  from channel 3026 to 3086     (  378.200 kev to   385.800 kev)
-------------------------------------------------------------------------------

   total net counts =   1172914.7
   Qfit =  4.389e+000    R**2 =   .99978   Cond =  1.916e+000

pk isotope   energy centroid   fwhm  tamp  tslp       area  error  fn  factor
-- -------   ------ --------   ----  ----  ----       ----  -----  --  ------
54   Pu239  380.170 3041.394 10.199  .051  .218     628651   0.14%  1  1.0000
55   Pu239  382.743 3061.973 10.217  .051  .218     536128   0.15%  2  1.0000
56   Am241  383.740 3069.947 10.224  .051  .218       5138   7.15%  3  1.0000
```

```
-------------------------------------------------------------------------------
region 18  from channel 3115 to 3170     (  389.400 kev to   396.300 kev)
-------------------------------------------------------------------------------

   total net counts =   1170181.9
   Qfit =  1.024e+003    R**2 =   .99987   Cond =  1.798e+308

pk isotope   energy centroid   fwhm  tamp  tslp       area  error  fn  factor
-- -------   ------ --------   ----  ----  ----       ----  -----  --  ------
57   Am241  390.540 3124.335 10.272  .050  .218          0 >99.99%  1  1.0000
58   Pu239  392.525 3140.211 10.286  .050  .218     405930   0.10%  2   .5350
59   Pu239  393.120 3144.970 10.290  .050  .218     758668   0.12%  2  1.0000


-------------------------------------------------------------------------------
region 19  from channel 3274 to 3345     (  409.200 kev to   418.100 kev)
-------------------------------------------------------------------------------

   total net counts =   3354384.1
   Qfit =  1.946e+001    R**2 =   .99996   Cond =  6.546e+000

pk isotope   energy centroid   fwhm  tamp  tslp       area  error  fn  factor
-- -------   ------ --------   ----  ----  ----       ----  -----  --  ------
60   Pu239  411.150 3289.176 10.416  .048  .218      14944   0.01%  1   .0045
61   Pu239  413.712 3309.683 10.434  .047  .218    3292167   0.06%  1  1.0000
62          414.870 3318.933 10.442  .047  .218      26175   1.16%  2  1.0000
63          415.760 3326.054 10.448  .047  .218      18493   1.50%  3  1.0000


-------------------------------------------------------------------------------
region 20  from channel 3592 to 3628     (  449.000 kev to   453.500 kev)
-------------------------------------------------------------------------------

   total net counts =    456331.6
   Qfit =  2.335e+000    R**2 =   .99985   Cond =  1.000e+000

pk isotope   energy centroid   fwhm  tamp  tslp       area  error  fn  factor
-- -------   ------ --------   ----  ----  ----       ----  -----  --  ------
64   Pu239  451.474 3611.845 10.693  .043  .218     456620   0.15%  1  1.0000


*******************************************************************************
```

Appendix A. Analysis Methods

The analysis of a gamma-ray pulse-height spectrum by the PC/FRAM code can be conveniently described in two parts, 1) The Internal Calibration, 2) The Analysis of the spectral data

The discussion below assumes that the spectral data is in computer memory.

A.1. Internal Calibration

The internal calibration uses selected peaks in the spectrum under analysis to provide an internal calibration of energy vs. channel, FWHM vs. channel, and peak shape (tailing parameters) vs. channel. This means that the analysis does not depend on parameters determined from other measurements that may have been taken with different conditions of count rate, resolution, or electronic adjustment. The internal calibration is performed with the same unknown spectrum that is under analysis.

There may be special cases where the spectral quality or the absence of strong peaks to use for calibration precludes using the unknown spectrum for its own peak calibrations. In these cases one can fix the peak calibration parameters to their initial values in the parameter set. The appropriate portion of the internal calibration is bypassed in this case.

A.1.1. Energy Calibration:

The first portion of the internal calibration procedure calibrates energy vs. channel number from a list of peaks, usually strong singlets, in the parameter set. A piecewise linear calibration between pairs of peaks is used for the energy calibration. The peaks are located using the default gain (keV/ch) and zero (keV at channel 0) in the parameter set. The algorithm locates the peak at the maximum count found in a region of 10 channels on either side of the default peak position. This position is found using the default gain and zero.

The centroid is found using a least squares fit of a quadratic function to the logarithm of the counts. If there is an error in the calculation the peak is not used in the calibration. Calibration outside the range of the peaks in the parameter set is extrapolated from the nearest two points.

A.1.2. Initial Background:

A background is now calculated for all peak regions defined in the parameter set using the background shape for each region that is specified in the parameter set.

A.1.3. FWHM Calibration:

The full width at half maximum (FWHM) of the FWHM peaks in the parameter set is calculated from the net data after a channel by channel subtraction of the initial background. The FWHM is calculated from a least-squares fit of a quadratic to logarithm of the net counts. The fit is over a range of channels in which the counts exceed 75% of the peak maximum on the low-energy side and exceed 25% of the peak maximum on the high-energy side. This fit also yields the peak centroid and if there is a match with an energy calibration peak (very likely) the centroid of the energy calibration peak is updated.

The FWHM as a function of energy used in calculating the response function of an arbitrary fitted peak is found from a least squares fit to the function

$$FWHM(E) = SQRT[A_1 + (A_2 * E) + A_3/E]$$

A.1.4. Shape /Tail Calibration

The shape of a gamma-ray peak in the spectrum is described by a central Gaussian component with a single exponential tail on the low energy side of the peak.

$$Y(J) = Ht*exp[\alpha*(J - x_0)^2] + Tail(J)$$

where

Y(J) is the net count in channel J

Ht is the peak height at the peak centroid x_0

$\alpha = 2.77259/FWHM^2$ the peak width parameter

and the tailing parameter Tail(J) is given by

$$Tail(J) = Ht*exp[(T1+T2*E) + (T3+T4*E)*(J-x_0)] * [1 - exp(-0.4*\alpha*(J-x_0)^2]$$

Here we have allowed both the amplitude and slope of the tailing function to be a function of energy. In practice we set T4 to zero reducing the number of unknowns to three. After subtracting the Gaussian portion of the peak (known because we have calibrations for energy and FWHM), we combine the data from all the FWHM peaks on the low energy side of the peak from 0.5 to 1.5 FWHMs from the peak center to determine the slope and amplitude constants in a least squares fit.

At this point we have completed the internal calibration and have all the parameters necessary to calculate the shape of a gamma ray peak at any location in the spectrum.

A.2. Analysis of the Spectral Data

The analysis proceeds on a region-by-region basis in the order that the regions are presented in the parameter set. The program makes three passes or iterations through all the regions. The regions are generally analyzed in order of increasing energy, however, if a region has a peak fixed to a second peak outside of the region, it is desirable to analyze the second region first so all peaks fit in a given region use the most current data. You do this ordering when constructing the regions in the parameter set.

The analysis starts by subtracting the background to get the net counts in a region. The background for the first iteration is available from the initial background calculation done during the calibration phase.

These are the steps taken during each iteration of the analysis phase:

A.2.1. Calculate Peak Areas

For each of the regions defined in the parameter set being used, perform the following:

Establish the start of the region, the end of the region, and the number of peaks in the region.

Make sure that a background has been calculated for the region that uses all the latest information.

Allocate enough dynamic memory for a least squares fitting of the response functions. Then initialize all the arrays used in this analysis. In particular, set the values of the output array to the net counts in the region.

Construct a set of response functions by examining each peak that contributes to this region. There will be as many response functions as there are free peaks in the region, and each one of the response functions will have the form

$$\sum_i f_i R_i(x)$$

where each R_i is a unit area function describing the shape of a photo peak and f_i is the associated area factor. One of the terms in this sum will correspond to a given free peak; its area factor is set to one. The other terms in the sum will correspond to peaks, which are fixed to this free peak. If peak i is fixed to peak j, the area factor will be

$$f_i = (Br_i/BR_j)(RE_i/RE_j)(RA_i/RA_j)$$

where BR = branching ratio, RE = relative efficiency, and RA = relative activity. This defines the ratio of the area of peak i to the area of peak j. The relative activity is the ratio of the activity of the given isotope to that of the first isotope in the isotope list in the parameter set. The relative activity ratio above is set to unity for the first iteration.

If a peak in the region is fixed to one outside the region, its photo peak function R(x) is multiplied the product of the area factor and the previously determined area of that other peak. These values are then subtracted from the values in the output array. Thus, this peak is effectively stripped off or removed from the spectrum.

Compute the final weights to be used in the least squares fitting.

Perform the weighted least squares fitting of the response fingerprints for the free peaks to the adjusted (adjusted for stripped peaks) net counts. If the area of any of the peaks turn out to be negative, perform another least-squares analysis, forcing them to be zero this time around. The coefficients resulting from the analysis will be the areas of the free peaks.

Calculate the predicted responses and save for display and output.

Calculate from the coefficients the areas of all the peaks and appropriate values for their errors.

If this is not the last iteration, use the results so far to update the background offsets.

A.2.2. Calculate Relative Efficiencies

From the parameter set determine how many peaks are to be used in calculating the relative efficiency curve. This will be the number of data points used in the least-squares analysis.

Determine the number of isotopes, N, represented by the above peaks. Determine the number of efficiency functions, M, represented by these isotopes. The number of parameters used in the least squares analysis will be 5 + (N-1) + (M-1).

Set up the arrays for a least-squares analysis.

The design matrix is constructed to reflect the model

$$ln(Area/BR) = c_1 + c_2/E^2 + c_3(lnE) + c_4(lnE)^2 + c_5(lnE)^3 + c_i + c_j/E$$

where E is the energy in MeV. Each c_i is associated with isotopes beyond the first one; i ranges in value from 6 to 5+(N-1). Each c_j is associated with an efficiency function beyond the first one; j ranges in value from 6+(N-1) to 5+(N-1)+(M-1)

Each weight is set to the reciprocal of the square of the relative error in the associated peak area.

Each output array value is the logarithm of the associated peak area divided by its branching ratio.

Perform the least-squares analysis.

For every peak in the parameter set, compute a relative efficiency by using the first 5+(N-1) terms in the above model. In addition, if a peak is associated with an isotope which is assigned an efficiency function other than one, compute its heterogeneity factor, $h = \exp(c_j/E)$, then multiply its relative efficiency by h.

A.2.3. Calculate Relative Activities

From the parameter set determine how many peaks are to be used in calculating the relative activities. This will be the number of data points used in the least-squares analysis. The number of parameters will be the number of isotopes in the parameter set.

Set up the arrays for a least-squares analysis.

The design matrix is constructed to reflect the model

$$Area = \sum_i c_i \sum_j (BR_j)(RE_j)$$

where the outer sum ranges over the isotopes and the inner sum includes the peak belonging to that isotope and any other peaks summed with it.

The weights are the reciprocals of the sum of the squares of the errors associated with the peak areas.

The outputs are the areas of the peaks.

Perform the least-squares analysis. The resulting coefficients are the relative activities. From these and the half lives and atomic masses of the isotopes, compute relative masses for each isotope.

A.2.4. Calculate Isotopic Fractions

After the third iteration is complete the final relative masses (relative to the first isotope in the isotope list) are combined to give the absolute isotopic fractions without ^{242}Pu. The fractions are renormalized accounting for ^{242}Pu computed by correlation or fixed by operator entry. Non Pu isotopes are quantified relative to total Pu when analyzing Pu-bearing samples. For samples (except uranium only) containing no plutonium the final results are the relative masses themselves.

Auxiliary results such as effective specific power and effective ^{240}Pu fraction are computed from the plutonium isotopic fractions and appropriate constants in the parameter set.

Appendix B. Files for PC FRAM

This appendix describes all the important files associated with PC/FRAM.

B.1. Input Files

This section describes all the files that are created external to the software but are used by the software.

B.1.1. pcfram.ini

Configuration file: This file is provided in the distribution kit. Initially it contains a minimal amount of information about the system. Every time the general defaults are modified and saved, however, this file gets overwritten with the most recent settings.

This file is also used to store default responses for all the major dialog boxes presented to you when invoking menu options. Every time these defaults are modified and saved, this file gets overwritten with the most recent values.

Reprinted below is an example of what is contained in this file:

```
/*  pcfram.ini     configuration file for PC FRAM  */

[general]
disk_low = 5
disk_critical = 4
language_choice = 1
max_channels = 8192
max_iterations = 3
mca_type = "ORTEC"
mcb_det_id = 1
mcb_det_desc = ""
mcb_log_errors = 1
mcb_log_path = "c:\fram32\mcberr.log"
pcfram_path = "c:\fram32"
save_spectrum_path = "c:\fram32\spectra"
save_results_path = "c:\fram32\results"
system_id = "My System"
date_template = "dd-MMM-yyyy"
m3ca_high_voltage = 0

[file_open]
filespec = ""
format_index = 1

[file_save]
filespec = ""
format_index = 1
separator = 0
num_cols = 10

[autocycle]
num_cycles = 1
filespec = ""
format_index = 0
pu242_opentry = 0
pu242_weight = 0
```

```
operator_id = ""
save_results = 0
results_file = ""
print_results = 0
print_level = 1
pset_name = ""
sample_power = 0
sample_date = ""

[acquire]
count_time = 60
live_time = 1
num_cycles = 1
pset_name = ""
save_spectrum = 0
spectrum_file = ""

[measure]
sample_id = ""
operator_id = ""
comment = "
pu242_opentry = 0
pu242_weight = 0
sample_power = 0
sample_date = "9"
count_time = 100
live_time = 0
num_cycles = 1
print_results = 0
print_level = 1
pset_name = ""
save_spectrum = 0
spectrum_file = ""
save_results = 0
results_file = ""
```

B.1.2. **pcfprms.con**

Database file: this file contains all the records storing information about the application constants for each parameter set.

B.1.3. **pcfprms.fit**

Database file: this file contains all the fitting parameters for each parameter set.

B.1.4. **pcfprms.iso**

Database file: this file contains all the records storing information about the isotopes for each parameter set.

B.1.5. **pcfprms.pks**

Database file: this file contains all the records storing information about the gamma-ray peaks for each parameter set.

B.1.6. pcfprms.rgs

Database file: this file contains all the records storing information about the regions of interest for each parameter set.

B.1.7. Parameter files

Each of these files contains a sample set of parameters. Each one is a text file and has an extension of ".pst". In order to get the information in a file into the database, you need to make use of the import option in the change parameter utility.

B.1.8. Language files

The character strings that are displayed on the screen or sent to the printer are stored in either the primary language file, pcfram.1st or the secondary language file pcfram.2nd. The distribution kit contains a pair of these files with English strings in the primary language file and Russian strings in the secondary language file. Each line that identifies a string consists of a name beginning with sz then a comma, then the corresponding string. A string that consists of several parts will be enclosed within quotation marks.

Reprinted below is a listing of what is contained in the primary language file in the distribution kit.

```
[general],
szCpuTitle,Change Parameter Utility
szFirstLanguage,English
szFramTitle,PC/FRAM
szMonthsInYear,JanFebMarAprMayJunJulAugSepOctNovDec
szNotImplemented,Not implemented.
szSecondLanguage,Russian

[dialogs],
szDbxAbort,Abort
szDbxAcquire,acquire
szDbxAm241Fraction,ppm Am241/Pu
szDbxAmStartDate,Initial Am date
szDbxARTitle,Analysis Results
szDbxBack,<&Back
szDbxBrowse,&Browse...
szDbxCancel,&Cancel
szDbxCEATitle,Edit Application Constants
szDbxCECTitle,Edit Region Information (by channel)
szDbxCEETitle,Edit Region Information (by energy)
szDbxCEFTitle,Edit Fitting Parameters
szDbxCEITitle,Edit Isotope Information
szDbxCEPTitle,Edit Peak Information
szDbxCFATitle,Save Parameter Set
szDbxCFETitle,Export Parameter Set
szDbxCFITitle,Import Parameter Set
szDbxCFMTitle,Remove Parameter Set
szDbxCFNTitle,New Parameter Set
szDbxCFOTitle,Open Parameter Set
szDbxCFRTitle,Rename Parameter Set
szDbxCheckSum,checksum:
szDbxCommaSeparator,Comma separator
szDbxComment,Comment:
szDbxContinue,&Continue
szDbxCountTime,Count Time (s):
```

```
szDbxCycle,cycle:
szDbxDate,Date
szDbxDates,dates
szDbxDateTemplate,date template:
szDbxDefaultPath,PC FRAM default path:
szDbxDeleteRow,Delete this row
szDbxDescription,Description:
szDbxDFTitle,MCB - Dummy File
szDbxDiagnosticPrint,Diagnostic information
szDbxDiscard,Discard
szDbxDiskCritical,Disk critical level (Mb):
szDbxDiskWarning,Disk warning level (Mb):
szDbxDisplay,&display...
szDbxDisplayPrms,Display parameters?
szDbxDspEcalPeaks,ecal peaks
szDbxDspFcalPeaks,fcal peaks
szDbxDspRegions,regions
szDbxDspScalPeaks,scal peaks
szDbxDspSpectrum,spectrum
szDbxDspTitle,Display Choices
szDbxEGTitle,Edit General Defaults
szDbxEnergyCalibration,Default Energy Calibration
szDbxExit,E&xit
szDbxFcalA1,A1 =
szDbxFcalA2,A2 =
szDbxFcalA3,A3 =
szDbxFile,File:
szDbxFileName,File Name:
szDbxFinal,final
szDbxFinalDate,Final date
szDbxFixed,Fixed
szDbxFOTitle,File Open
szDbxFSTitle,File Save As
szDbxFwhmFormula,fwhm(ch) = sqrt( A1 + A2*E + A3/E )
szDbxFwhmPrms,Default FWHM constants
szDbxGain,Gain (kev/chan) =
szDbxHATitle,About PC/FRAM
szDbxHLTitle,Choice of Language
szDbxInitial,initial
szDbxInput,input
szDbxInsertRow,Insert a new row
szDbxIsoSum,sum of fractions
szDbxLastModified,Last modified on
szDbxLinearPlot,linear plot
szDbxLiveTime,Live Time
szDbxLoadPrms,Do you want to load parameter information from the file?
szDbxLogPlot,log plot
szDbxLong,Long
szDbxLongPrint,Long -\region details
szDbxM3CATitle,M3CA defaults
szDbxManager,Edit User List
szDbxMATitle,Acquire Data
szDbxMaxChans,Maximum number channels:
szDbxMaxIter,Maximum number iterations:
szDbxMCA,MCA
szDbxMCATitle,MCA Emulator
szDbxMcaType,MCA type
szDbxMcbDefault,Default MCB
szDbxMcbDetector,MCB detector:
```

```
szDbxMcbLogErrors,Log errors
szDbxMcbLogFile,Log file:
szDbxMCBTitle,MCB defaults
szDbxMDTitle,Analyze Data
szDbxMedium,Medium
szDbxMediumPrint,Medium -\eff, act, and peak info
szDbxMMTitle,Measure Sample
szDbxMoveRowDown,Move this row down
szDbxMoveRowUp,Move this row up
szDbxMsgTitle,FRAM Message
szDbxNegative,negative
szDbxNewName,New Name:
szDbxNewPassword,New Password:
szDbxNext,&Next>
szDbxNo,&No
szDbxNumChan,Number of channels
szDbxNumCols,Number of columns:
szDbxNumCycles,Number of cycles:
szDbxODTitle,Display Results
szDbxOETitle,Plot efficiencies
szDbxOFTitle,Display fits
szDbxOITitle,ISOPOW
szDbxOK,&OK
szDbxOldName,Old Name:
szDbxOpen,&Open
szDbxOperator,Operator
szDbxOperatorID,Operator ID:
szDbxOPTitle,Plot spectrum
szDbxORTitle,Print Results
szDbxOutput,output
szDbxParameterSet,Parameter Set:
szDbxPassword,Password:
szDbxPlotComponents,Plot components
szDbxPolarity,Polarity:
szDbxPositive,positive
szDbxPowerDate,Date of Power Msmt:
szDbxPrint,&Print
szDbxPrinter,Prin&ter...
szDbxPrintLevel,print level
szDbxPrintPrms,Print parameters?
szDbxPrintPset,Print parameter set
szDbxPrintResults,Print Results
szDbxPsetName,Name for parameter set:
szDbxPsetTitle,FRAM Parameter Sets
szDbxPu238Fraction,wt% Pu238
szDbxPu239Fraction,wt% Pu239
szDbxPu240Effective,Percent Pu240 Effective
szDbxPu240Fraction,wt% Pu240
szDbxPu241Fraction,wt% Pu241
szDbxPu242Correlation,Pu242 by correlation
szDbxPu242Fraction,wt% Pu242
szDbxPu242Opentry,Pu242 by operator entry
szDbxPu242Weight,% by weight
szDbxPu244Fraction,wt% Pu244
szDbxPuStartDate,Initial Pu date
szDbxRegion,Region
szDbxRegionNum,Region number
szDbxRegions,display regions
szDbxRemoveAll,Remove all parameter sets
```

```
szDbxResultsPath,Path for saving results:
szDbxROTitle,Row Operation
szDbxSampleID,Sample ID:
szDbxSamplePower,Sample Power (W):
szDbxSave,&Save
szDbxSaveResults,Save Results in
szDbxSaveSpectra,Save Spectra in
szDbxScalT1,T1 =
szDbxScalT2,T2 =
szDbxScalT3,T3 =
szDbxScalT4,T4 =
szDbxShort,Short
szDbxShortPrint,Short -\summary only
szDbxSimulateMca,Cannot connect to MCA\Do you wish to simulate one?
szDbxSpecificPower,Specific Power (mW/gPu)
szDbxSpectraPath,Path for saving spectra:
szDbxStart,&Start
szDbxStatus,status
szDbxStop,Sto&p
szDbxStorageFormat,Storage Format:
szDbxSupervisor,Supervisor
szDbxSystemID,System ID:
szDbxTabSeparator,Tab separator
szDbxTailFormula,tail(ch) = H * exp((T1 + T2*E) + (T3 + T4*E)*(ch-x0)) * [1 -
exp(-C*(ch-x0)^2)]
szDbxTailPrms,Default tailing constants
szDbxTime,time:
szDbxTotalPu,total grams Pu
szDbxTrueTime,True Time
szDbxUATitle,Access Rights
szDbxUETitle,Edit User List
szDbxUPTitle,Password Change
szDbxUseRecent,Use most recent results
szDbxUserName,User name:
szDbxUseSaved,Use previously saved results
szDbxUVTitle,User Validation
szDbxVerify,Verification:
szDbxVoltage,High Voltage:
szDbxXZoomIn,X <-->
szDbxXZoomOut,X -><-
szDbxYes,&Yes
szDbxYZoomIn,Y <-->
szDbxYZoomOut,Y -><-
szDbxZero,Offset (kev) =

[errors],
szErrAbortFram,Abort analysis?
szErrAccessDenied,Access denied.
szErrAlreadyFixed,Another peak is fixed to this one.
szErrAlreadySummed,Another peak is summed with this one.
szErrAnalyze,Do you want to continue with the rest of the analyses?
szErrBadBkg,Suspicious BKG for region
szErrBkgFail,Failed to calculate BKG for region
szErrCancel,analysis cancelled by user.
szErrCancelBrowse,Browse was canceled.
szErrContinue,Do you want to continue?
szErrCreateDb,New database created.
szErrCreateUaf,User authorization file created.
szErrDataRead,Cannot read this data file.
```

```
szErrDataSave,Cannot save this spectrum.
szErrDiskLow,Warning:\Disk space is low.
szErrDspEffFail,Cannot display efficiencies.\There is no data.
szErrDspFitFail,Cannot display fits.\There is no data.
szErrDuplicatePset,This parameter set already exists in database.
szErrFileCreate,Cannot create file
szErrFileOpen,Cannot open file
szErrFor,for
szErrFreeSpace,free space (Mb):
szErrFwhmFail,Failed to calculate FWHM for peak
szErrImport,Error while importing parameter set.
szErrInternal,**Internal error in FRAM**
szErrInvalidInput,**Invalid input for FRAM**
szErrInvalidPswd,Invalid password.
szErrInvAmDate,invalid start date for Am
szErrInvDate,invalid final date
szErrInvPeakCh,**Invalid peak channel**
szErrInvPeakFwhm,Invalid FWHM for peak
szErrInvPeakRegion,Invalid region for peak
szErrInvPuDate,invalid start date for Pu
szErrInvPwrDate,invalid date for sample power
szErrInvSum,invalid isotopic fractions
szErrInvTailSlope,Invalid slope for tail at energy
szErrInvTemplate,Invalid date template
szErrLoadCon,Cannot load application constants into memory.
szErrLoadFit,Cannot load fitting parameters into memory.
szErrLoadIso,Cannot load isotope parameters into memory.
szErrLoadPks,Cannot load peak parameters into memory.
szErrLoadPrms,Cannot load parameter set into memory.
szErrLoadRgs,Cannot load region parameters into memory.
szErrLsqFail,Failure in least squares calculations.
szErrNewDatabase,New database (with no parameters) created.
szErrNoDiskSpace,Insufficient disk space on
szErrNoDrive,No disk drive in the path
szErrNoFileName,File name is missing.
szErrNoMca,This MCA type is not implemented.
szErrNoMcb,No MCB detector!
szErrNoMemory,Insufficient memory available.
szErrNoMorePsets,There is no room for any more parameter sets.
szErrNoPeaks,No peaks found in spectrum.
szErrNoPsetName,Parameter set name is missing.
szErrNoPsets,There are no parameter sets in the database.
szErrNoRegPeak,No peaks in region
szErrNoSampleID,Sample ID is missing.
szErrNoSpectrum,Warning:\there is no spectral data in memory.
szErrNoUser,No such user name in list.
szErrOutputFiles,FRAM output files.
szErrPrint,**print error**
szErrPsetModified,Parameter set has been modified.\Do you wish to save it?
szErrPsetNotOpened,Cannot open parameter set:
szErrPsetNotSaved,Cannot save parameter set:
szErrPsetOpen,Warning:\a parameter set is still open!
szErrPsetRemoved,Removed parameter set:
szErrPsetSaved,Parameter set saved as:
szErrPswdMatch,passwords do not match.
szErrReadUaf,Cannot read user authorization file.
szErrRemoveAll,This will destroy all the data\in the database.
szErrResFail,Failure in computing response function.
szErrResultsFile,results file.
```

```
szErrRowDelete,Cannot delete this row.
szErrRowInsert,Cannot insert a row.
szErrRowMoveDown,Cannot move this row down.
szErrRowMoveUp,Cannot move this row up.
szErrSaveData,Do you wish to save the data\that has accumulated?
szErrSpecfitFail,Failed to create specfit.dbi
szErrSpectraFile,spectral data file.
szErrTailFail,Failed to calculate tail -'will use defaults.
szErrTooFewPeaks,Not enough peaks - will use defaults.

[fonts],
szFonDialog,"MS Sans Serif,10"
szFonDisplay,Courier
szFonLanguage,English
szFonPlot,MS Sans Serif
szFonPrint,"Courier,8"

[help messages],
szHlpAppconName,Name of this application constant
szHlpAppconNum,Index number for this application constant
szHlpAppconValue,Value for this application constant
szHlpBkg1EndCh,Final channel of the first background
szHlpBkg1EndEn,Final energy of the first background
szHlpBkg1StartCh,Starting channel of the first background
szHlpBkg1StartEn,Starting energy of the first background
szHlpBkg2EndCh,Final channel of the second background
szHlpBkg2EndEn,Final energy of the second background
szHlpBkg2StartCh,Starting channel of the second background
szHlpBkg2StartEn,Starting energy of the second background
szHlpBkg3EndCh,Final channel of the third background
szHlpBkg3EndEn,Final energy of the third background
szHlpBkg3StartCh,Starting channel of the third background
szHlpBkg3StartEn,Starting energy of the third background
szHlpBkg4EndCh,Final channel of the fourth background
szHlpBkg4EndEn,Final energy of the fourth background
szHlpBkg4StartCh,Starting channel of the fourth background
szHlpBkg4StartEn,Starting energy of the fourth background
szHlpBkgType,Which type of background do you want to fit?
szHlpBranch,Branching ratios (gammas per disintegration)
szHlpCpuEA,Edit the application constants.
szHlpCpuEC,Edit the region information (by channel).
szHlpCpuEE,Edit the region information (by energy).
szHlpCpuEF,Edit the fitting parameters.
szHlpCpuEI,Edit the isotope information.
szHlpCpuEO,Postpone the edit session.
szHlpCpuEP,Edit the peak information.
szHlpCpuFA,Write parameter info into database as a new set.
szHlpCpuFC,Destroy the current worksheet.
szHlpCpuFE,Write parameter info in worksheet into a text file.
szHlpCpuFI,Read parameter from a text file into a worksheet.
szHlpCpuFM,Remove a parameter set from the database.
szHlpCpuFN,Create a new worksheet.
szHlpCpuFO,Read a parameter set from the database into a worksheet.
szHlpCpuFP,Send parameter info in worksheet to the system printer.
szHlpCpuFR,Rename a parameter set in the database.
szHlpCpuFS,Write parameter info from worksheet back into database.
szHlpCpuFX,Exit Change Parameter Utility and return to FRAM's menu.
szHlpEA,Modify defaults for the analyze data dialog.
szHlpEditPassword,Change the password for this user
```

```
szHlpEditRights,Change the access rights for this user
szHlpEffFn,"Efficiency function number (1,2,...)"
szHlpEG,Modify the general default settings.
szHlpEM,Modify defaults for the measure sample dialog.
szHlpEnergy,Gamma-ray energy in kev
szHlpEO,Modify defaults for the file open dialog.
szHlpEP,Invoke the change parameter utility.
szHlpEQ,Modify defaults for the acquire data dialog.
szHlpES,Modify defaults for the analyze spectrum dialog.
szHlpEU,Modify the list of authorized users.
szHlpEV,Modify defaults for the file save dialog.
szHlpFixTo,Which peak is this peak's area fixed to? (0 for none)
szHlpFO,Read spectral data from file.
szHlpFP,Print contents of this window.
szHlpFS,Save spectral data in file.
szHlpFT,Invoke the dialog for setting printer properties.
szHlpFX,Terminate this program.
szHlpHA,Display version and copyright information.
szHlpHalfLife,Half-life of this isotope
szHlpHL,Choose the language for screen displays.
szHlpIsotope,Isotope name (xxnnn)
szHlpIsotopeNum,Index number for this isotope
szHlpLineWidth,Intrinsic line width in ev (for X-rays)
szHlpMA,Collect data using MCA.
szHlpMass,Exact mass of this isotope (amu)
szHlpMD,Analyze spectral data from file(s) on disk.
szHlpMM,Collect data using MCA then analyze the spectrum.
szHlpOD,Display results of analysis.
szHlpOE,Plot efficiency curve for the most recent analysis.
szHlpOF,Plot fit results of the most recent analysis.
szHlpOI,Perform isotopic decay corrections.
szHlpOP,Plot most recent spectrum.
szHlpOR,Print results of analysis.
szHlpPassword,Encrypted password for this user
szHlpPeakNumber,Index number for this peak
szHlpPower,Specific power of this isotope (mW/g)
szHlpPu240Coef,Coefficient used to compute effective Pu240 mass
szHlpRegionEndCh,Final channel of the region
szHlpRegionEndEn,Final energy of the region
szHlpRegionNumber,Index number for this region
szHlpRegionStartCh,Starting channel of the region
szHlpRegionStartEn,Starting energy of the region
szHlpRights,Encoded value of the access rights for this user
szHlpRowOperation,"Perform insertion, deletion, shifting of rows"
szHlpSumWith,Which peak is this peak's area summed with? (0 for none)
szHlpUnits,"Units used for the half-life (days,years)"
szHlpUseForAct,Use this peak to construct activity ratios?
szHlpUseForEcal,Use this peak for an internal energy calibration?
szHlpUseForEff,Use this peak to construct efficiency functions?
szHlpUseForFcal,Use this peak for an internal FWHM calibration?
szHlpUseForScal,Use this peak for an internal shape calibration?
szHlpUserName,Name of the user (maximum of 20 characters)
szHlpUserNum,Index number for this user

[menus],
szMenCpuE,&Edit
szMenCpuEA,&Application constants
szMenCpuEC,Regions by &channel
szMenCpuEE,R&egions by energy
```

```
szMenCpuEF,&Fitting parameters
szMenCpuEI,&Isotopes
szMenCpuEO,P&ostpone editing
szMenCpuEP,&Peaks
szMenCpuF,&File
szMenCpuFA,S&ave As
szMenCpuFC,&Close
szMenCpuFE,&Export
szMenCpuFI,&Import
szMenCpuFM,Re&move
szMenCpuFN,&New
szMenCpuFO,&Open
szMenCpuFP,&Print
szMenCpuFR,&Rename
szMenCpuFS,&Save
szMenCpuFT,Prin&ter...
szMenCpuFX,E&xit
szMenE ,&Edit
szMenEA,Analyze &Data Defaults
szMenEG,&General Defaults
szMenEM,&Measure Sample Defaults
szMenEO,File &Open Defaults
szMenEP,&Parameters
szMenEQ,Ac&quire Data Defaults
szMenEU,&User List
szMenEV,File Sa&ve Defaults
szMenF ,&File
szMenFO,&Open
szMenFS,&Save As
szMenFX,E&xit
szMenH ,&Help
szMenHA,&About
szMenM ,&Measure
szMenMA,&Acquire Data
szMenMD,Analyze &Data
szMenMM,&Measure Sample
szMenO ,&Options
szMenOD,&Display Results
szMenOE,Plot &Efficiencies
szMenOF,Display &Fits
szMenOI,&ISOPOW
szMenOL,&Language
szMenOP,&Plot Spectrum
szMenOR,P&rint Results

[pcfram],
szPcfCalcAct,calculate activities.
szPcfCalcEff,calculate efficiencies.
szPcfCheckCal,check calibrations.
szPcfDone,analysis done.
szPcfEnergyCal,energy calibration.
szPcfFwhmCal,fwhm calibration.
szPcfIsotopics,determine isotopic composition.
szPcfIteration,iteration
szPcfPreviewSpectrum,preview spectrum.
szPcfRegion,region
szPcfSetupPeaks,setup peak information.
szPcfSetupRegion,setup region
szPcfSetupRegions,setup region information.
```

```
szPcfShapeCal,shape calibration.

[plots],
szPltChannel,Channel
szPltCounts,Counts
szPltEnergy,Energy
szPltEnergyUnits,keV
szPltFor,for
szPltIsotopes,Isotopes
szPltLiveTime,Live time
szPltRatio,Ratio
szPltRegion,Region
szPltRelEff,Relative Efficiencies
szPltTrueTime,True time
szPltWith,with

[printouts],
szPrtA,this peak is used to determine relative activities.
szPrtActData,Data used for activity calculations
szPrtActivity,activity
szPrtActResults,Results of activity calculations
szPrtAm241Units,(ug/gPu)  // abbreviation for micrograms per gram Pu
szPrtAmp,amp  // abbreviation for amplitude
szPrtAmplitude,amplitude
szPrtArea,area
szPrtAt,at
szPrtBeta,beta
szPrtBkg,bkg  //abbreviation for background
szPrtBkgs,BKG's  // abbreviation for backgrounds
szPrtBranch,branch  //abbreviation for branching ratio
szPrtCentroid,centroid
szPrtChan,chan  //abbreviation for channel
szPrtChannel,channel
szPrtCheckEcal,check energy calibration
szPrtCheckFcal,check fwhm calibration
szPrtCheckInterferences,check for interferences
szPrtCheckSample,Check sample types
szPrtCheckScal,check shape calibration
szPrtCoefficient,coefficient
szPrtComment,comment
szPrtDate,date
szPrtDays,days
szPrtDiagPassed,diagnostics passed.
szPrtDiagTitle,Calibration Diagnostics
szPrtDiff,diff  //abbreviation for difference
szPrtDiffSigma,diff/sigma  //abbreviation for difference divided by sigma
szPrtE,this peak is used to determine relative efficiencies.
szPrtEcalFixed,Energy calibration fixed with
szPrtEcalTitle,Table used for energy calibration
szPrtEff,eff  // abbreviation for efficiency
szPrtEffData,Data used for efficiency calculations
szPrtEffDiv,Efficiencies are divided by
szPrtEffResults,Results of efficiency calculations
szPrtEnergy,energy
szPrtError,error
szPrtEV,ev
szPrtExpDif,exp(dif)  // abbreviation for exponential of the difference
szPrtF,this peak is fixed to another peak.
szPrtFactor,factor
```

```
szPrtFail,fail
szPrtFcalFormula,FWHM = SQRT( A1 + A2*E + A3/E )
szPrtFcalTitle,FWHM parameter in the formula
szPrtFitCts,fit cts  //abbreviation for fitted counts
szPrtFitted,fitted
szPrtFitTo,Fitting to region
szPrtFn,fn  // abbreviation for function
szPrtFormula,formula
szPrtFrom,from
szPrtFwhm,fwhm
szPrtGain,gain
szPrtHfac,hfac  //abbreviation for heterogeneity factor
szPrtIndRatios,Individual ratios
szPrtInterp,interp.  // abbreviation for interpolated
szPrtIsopowResults,ISOPOW Results
szPrtIsotope,isotope
szPrtKEV,kev
szPrtLiveTime,live time
szPrtLogABr,log(A/Br)  //logarithm of area divided by branching ratio
szPrtMass,mass
szPrtMassPct,mass%
szPrtMassRatio,mass ratio
szPrtMassUnits,g
szPrtNetCts,net cts  //abbreviation for net counts
szPrtNoSepTime,cannot compute time since chemical separation
szPrtNumChan,num channels
szPrtOperatorID,Operator ID
szPrtPass,pass
szPrtPeak,peak
szPrtPeakAreaRatio,peak area ratio
szPrtPeakSummary,Summary of peak information
szPrtPk,pk  // abbreviation for peak
szPrtPowerUnits,W
szPrtPredicted,predicted
szPrtPrmFixed,these parameters have been fixed
szPrtPset,parameter set
szPrtPu240Eff,Effective Pu240 fraction
szPrtPu242Correlation,(By Corr) // abbreviation: by correlation
szPrtPu242Default,(Default)
szPrtPu242Opentry,(OpEntry)  // abbreviation: operator entry
szPrtQ,this peak is ued to determine the energy calibration.
szPrtRatio,ratio
szPrtRatios,ratios
szPrtRegion,region
szPrtRegionSummary,Summary of the results for each region
szPrtRelMass,Relative mass
szPrtResultFile,results file
szPrtRSD,%RSD    //abbreviation: % relative standard deviation
szPrtS,this peak is summed with another peak.
szPrtSamplePower,sample power
szPrtSaveFile,spectrum file
szPrtScalFormula,log(tail(x)/height/roll_off) = (T1+T2*E) + (T3+T4*E)*(x-x0)
szPrtScalTitle,Shape parameters in the formula
szPrtSeconds,s
szPrtSepTime,Time since chemical separation
szPrtSigma,sigma
szPrtSlope,slope
szPrtSource,spectrum source
szPrtSpecDate,spectrum date
```

```
szPrtSpecificPower,specific power
szPrtSpecPower,Specific Power (W/gPu)
szPrtSPowerUnits,mW/gPu
szPrtSumCts,Sum of the fitted counts
szPrtSystemID,System ID
szPrtT,this peak is used to determine the shape calibration.
szPrtTailFrac,tail fraction
szPrtTamp,tamp  //abbreviation for tail amplitude
szPrtTitle1,Isotopic Analysis
szPrtTitle2,(Fixed energy Response function Analysis with Multiple
efficiencies)
szPrtTo,to
szPrtTotal,total
szPrtTotalCounts,total net counts
szPrtTotalPower,%TotPwr
szPrtTotalPu,total Pu
szPrtTrueTime,true time
szPrtTslp,tslp  //abbreviation for tail slope
szPrtW,this peak is used to determine the fwhm calibration.
szPrtWeight,weight
szPrtZero,zero

[tables],
szTblBkgEnd1,BKG\#1\end
szTblBkgEnd2,BKG\#2\end
szTblBkgEnd3,BKG\#3\end
szTblBkgEnd4,BKG\#4\end
szTblBkgStart1,BKG\#1\start
szTblBkgStart2,BKG\#2\start
szTblBkgStart3,BKG\#3\start
szTblBkgStart4,BKG\#4\start
szTblBkgType,background\type
szTblBranch,branching\ratio
szTblEffFn,efficiency\function
szTblFixTo,fix\area\to
szTblHalfLife,half-life
szTblIsotope,isotope
szTblLineWidth,line\width
szTblMass,mass
szTblName,name
szTblPassword,password
szTblPeakEnergy,peak\energy
szTblPower,power\(mW/g)
szTblPu240Coef,pu240\coefficient
szTblRegionEnd,region\end
szTblRegionStart,region\start
szTblRights,access\rights
szTblSumWith,sum\area\with
szTblUnits,units
szTblUseForAct,used\for\act
szTblUseForEcal,used\for\ecal
szTblUseForEff,used\for\eff
szTblUseForFcal,used\for\fcal
szTblUseForScal,used\for\scal
szTblUserName,User Name
szTblValue,value

[copyright],
szHACR01,"This program was prepared by the Regents of the University of"
```

```
szHACR02," California at Los Alamos National Laboratory (the University) under"
szHACR03," Contract No. W-7405-ENG-36 with the U.S. Department of Energy (DOE)."
szHACR04,"  All rights in the program are reserved by DOE on behalf of the U.S."
szHACR05," Government and the University pursuant to the Contract.  This program"
szHACR06," should not be copied or distributed outside your organization."
szHACR07,"  Neither the U.S. Government nor the University makes any warranty,"
szHACR08," express or implied, or assumes any liability or responsibility for the"
szHACR09," use of this program.  All copies made of this program must carry"
szHACR10," this notice."
szHATS01,"For technical support of this program contact:"
szHATS02,"     Thomas A. Kelley,  tkelley@lanl.gov"
szHATS03,"     Thomas E. Sampson,  tsampson@lanl.gov"
szHATS04,"Safeguards Science and Technology Group"
szHATS05,"Los Alamos National Laboratory."
```

B.2. Output Files

This section describes all the files that are generated by the software that are intended to be used by other software.

B.2.1. saved spectra

When spectral data is stored, it is written to a binary file in the storage format specified by you. If the data is saved from the 'acquire data' option or the 'measure sample' option and the number of cycles was set to one, the name of the file specified by you will be used. If the number of cycles was set to something larger than one and you specify a name with no extension, the file name will be used, but an extension of ".snn" will be supplied where nn will be replaced by the cycle number. If, in the latter case, you supply a name with an extension, the first character of the extension will be used and it will be appended with the cycle number.

B.2.2. saved results

When the results of an analysis are stored, they will be stored in a text file. If the results are saved from the **Measure | Analyze Data** option or the **Measure | Measure Sample** option and the number of cycles was set to one, the name of the file you specified will be used. If the results are saved from either of these options and the number of cycles was set to something larger than one and you specified a name with no extension, that file name will be used, but with an extension of ".rnn" where nn will be replaced by the cycle number. If, in the latter case, you supplied a name with an extension, the first character of the extension will be used and the cycle number will be appended to it.

B.3. Internal Files

In this section we describe all the files created by and used by the software for internal operations.

B.3.1. `pcfram.uaf`

The user authorization file. This contains information about the users, their passwords, and the authorizations granted to them.

B.3.2. `pcfram.dbi`

The results of every analysis are stored in this file. This file is overwritten whenever a new analysis is performed. This file is used when you ask for a display of the results of the last analysis.

B.3.3. `specfit.dbi`

The results of the fitting process during every analysis are stored in this file. This file is overwritten whenever a new analysis is performed. This file is used when you ask for a display of the fits achieved in the last analysis.

B.3.4. `pcfpset.dbi`

This file stores, in text form, the values of the analysis parameters that were last retrieved from the database.

Appendix C. PC/FRAM Parameter Set Descriptions

The versatility of the PC/FRAM code allows it to be used with parameter sets tailored for different applications. Descriptions of some of the parameter sets in use at Los Alamos follow. They are meant to be illustrative rather than inclusive and any specific distribution of the code may not include all the files below. Parameter sets may be found on diskette 3 of the PC/FRAM distribution. Other parameter sets, not listed here, tailored to specific user applications, may also be available.

Both the DOS filename and the customary parameter set name used at Los Alamos are given for each parameter set. The "customary parameter set name" may be changed when the file is imported or the parameter set may be renamed within the PC/FRAM program. It is suggested, however, that the Customary Parameter Set Name be retained, or, if not, that careful records be retained of the relation between the parameter set name and the parameter file name. Of course, the parameters may also be changed for the specific application at hand.

New parameter sets, especially for coaxial detector analysis, are under development. Contact the authors for current information regarding versions of available parameter sets.

C.1. Parameter Sets for Planar Detectors

Parameter sets for planar detectors were the first developed and used for the FRAM code. For historical reasons, these parameter sets were developed for a gain of 0.1 keV/ch and with an offset of 10 keV (zero channel = 10 keV). Planar detector parameter sets are now available with a gain of 0.105 keV/channel with zero offset. These are applicable to a wide range of ADC types including successive approximation ADCs with only 4000 channels of useful data

A planar detector parameter set with Default Gain of 0.1 keV/ch and a Default Offset of 10 keV can be easily changed to a Gain of 0.105 keV/ch with and Offset of zero by the following:

Enter the Change Parameter Utility and **Open** the parameter set to be changed. **Save As** to a new name for the new parameter set. **Close** the old parameter set and **Open** the newly named parameter set. Select **Edit | Fitting Parameters** and under the **Default Energy Calibration** change the **Gain** to 0.105 and the **Offset** to 0.0.

The only other changes required are to change the channel numbers in the centroid test to match the new default energy calibration. Select **Edit | Application Constants** and change **ecal_channel[i]** to values appropriate for the new default energy calibration.

Typical planar detector specifications are 16 mm dia. by 13 mm deep with a low rate resolution at 122 keV of ≤ 510 eV. Larger planar detectors with 122keV low rate resolution ≤ 570 eV may also be used. There is little experience with yet poorer resolution planar detectors. We strongly encourage the use of detectors with the best possible resolution.

Planar detectors have been most widely used with a shaping time constant of 1μs, triangular shaping at count rates up to 40 kHz in conventional analog amplifiers.

DOS Filename	Customary Parameter Set Name at Los Alamos
wr6.pst	**widerange6**
Applicability	General purpose use for nearly all isotopically homogeneous plutonium-bearing items. Requires Am/Pu homogeneity and ^{241}Pu-^{237}U equilibrium.
Detector type:	planar
Default Gain:	0.1 keV/ch, Default Offset: 10 keV
No. of channels:	4096 (10-420 keV)
^{240}Pu range tested:	2-38%
Interference tests:	^{235}U, ^{237}Np,^{243}Am-^{239}Np
Sample tests:	^{241}Am/Pu heterogeneity, Nonequilibrium ^{241}Pu-^{237}U
Comments:	Standard planar detector parameter set for general purpose use. Used for many years at Los Alamos

DOS Filename	Customary Parameter Set Name at Los Alamos
wr6105.pst	**widerange6.105**
Applicability	General purpose use for nearly all isotopically homogeneous plutonium-bearing items. Requires Am/Pu homogeneity and ^{241}Pu-^{237}U equilibrium. Same as widerange6 but with zero offset and gain = 0.105 keV/ch
Detector type:	planar
Default Gain:	0.105 keV/ch, Default Offset: 0.0 keV
No. of channels:	4096 (0-430 keV)
^{240}Pu range tested:	2-38%
Interference tests:	^{235}U, ^{237}Np,^{243}Am-^{239}Np
Sample tests:	^{241}Am/Pu heterogeneity, Nonequilibrium ^{241}Pu-^{237}U
Comments:	Standard planar detector parameter set for general purpose use. Used for many years at Los Alamos.

DOS Filename	Customary Parameter Set Name at Los Alamos
hetero6.pst	**hetero6**
Applicability	Planar detector for isotopically heterogeneous (Am/Pu) residues. Either equilibrium or non-equilibrium ^{241}Pu-^{237}U.
Detector type:	planar
Default Gain:	0.1 keV/ch, Default Offset: 10 keV
No. of channels:	4096 (10-420 keV)
^{240}Pu range tested:	4-8%

Interference tests: ^{235}U, ^{237}Np, ^{243}Am-^{239}Np

Sample tests: None

Comments: Uses a second relative efficiency curve for ^{241}Am. Works best for Am > 2000 ppm. Used to analyze pyrochemical residues with known Am/Pu heterogeneities. Developed starting with widerange6.

DOS Filename	Customary Parameter Set Name at Los Alamos
moxplnr.pst	**mox_planar**

Applicability: Planar detector for mixed uranium/plutonium oxides (MOX) with ^{235}U/Pu ratios less than ~ 0.3. General purpose use for isotopically homogeneous plutonium and/or MOX-bearing items. Requires Am/Pu homogeneity and ^{241}Pu-^{237}U equilibrium.

Detector type: planar

Default Gain: 0.10 keV/ch, Default Offset: 10.0 keV

No. of channels: 4096 (10-420 keV)

^{240}Pu range tested: 6-16%

Interference tests: ^{237}Np, ^{243}Am-^{239}Np

Sample tests: ^{241}Am/Pu heterogeneity, Nonequilibrium ^{241}Pu-^{237}U

Comments: It is applicable for ^{235}U/Pu ratios at least as high as 0.3. Biases in the ^{235}U/Pu ratio may be present if the two oxides have different particle sizes. For ^{235}U/Pu ratios higher than ~0.3, use the **eupu** parameter set.

DOS Filename	Customary Parameter Set Name at Los Alamos
eupuplnr.pst	**eupu_planar**

Applicability: Planar detector for mixed uranium/plutonium oxides (MOX) with ^{235}U/Pu ratios greater than ~ 0.3. General purpose use for isotopically homogeneous plutonium and/or MOX-bearing items. Requires Am/Pu homogeneity and ^{241}Pu-^{237}U equilibrium.

Detector type: planar

Default Gain: 0.10 keV/ch, Default Offset: 10.0 keV

No. of channels: 4096 (10-420 keV)

^{240}Pu range tested: 6%

Interference tests: ^{237}Np, ^{243}Am-^{239}Np

Sample tests: ^{241}Am/Pu heterogeneity, Nonequilibrium ^{241}Pu-^{237}U

Comments: It is applicable for ^{235}U/Pu ratios greater than 0.15, used for mixed uranium/plutonium oxides with higher ^{235}U/Pu ratios than the **mox_planar** parameter set. Biases in the ^{235}U/Pu ratio may be present if the two oxides have different particle sizes. For ^{235}U/Pu ratios lower than ~0.3, use the **mox_planar** parameter set.

C.2. Parameter Sets for Coaxial Detectors

Parameter sets for coaxial detectors were developed to tackle problems requiring measurements at higher energies where the low efficiency of planar detectors does not allow them to be useful. These measurement problems mainly involve situations where the measured item is placed in a thick-walled container or shielding for personnel protection has been placed in the container. This attenuates the lower energy gamma rays (typically those below 200-300 keV) that are often used in plutonium analysis.

Parameters for coaxial detectors have also been developed allowing plutonium analysis starting at ~120 keV, the same range as planar detectors. A coaxial detector can also be used for isotopic analysis of samples containing only uranium.

Standard measurements with a coaxial detector use 8192 channels with a gain of 0.125 keV/channel and no offset (spanning a range of 0-1024 keV). This allows the user to measure plutonium in the energy range from 120-450 keV and 200-800 keV as well as uranium from 0-1024 keV without changing electronics settings.

Coaxial detectors with an approximate 25% relative efficiency and a low rate energy resolution of <1.75 keV at 1332 keV and < 750 eV at 122 keV have been widely used in these applications.

Coaxial detectors have been most widely used with a shaping time constant of 2μs, triangular shaping at count rates up to 30 kHz in conventional analog amplifiers.

DOS Filename	Customary Parameter Set Name at Los Alamos
coax8k3.pst	**coax8k125.3**
Applicability	General purpose use for nearly all isotopically homogeneous plutonium-bearing items Requires Am/Pu homogeneity and ^{241}Pu-^{237}U equilibrium. Analyzes gamma rays from 120-450 keV from unshielded or lightly shielded (< ~2 cm steel) items.
Detector type:	coaxial
Default Gain:	0.125 keV/ch, Default Offset: 0.0 keV
No. of channels:	8192 (0-1024 keV)
^{240}Pu range tested:	2-38%
Interference tests:	^{235}U, ^{237}Np, ^{243}Am-^{239}Np
Sample tests:	^{241}Am/Pu heterogeneity, Nonequilibrium ^{241}Pu-^{237}U
Comments:	Standard coaxial detector parameter file for general purpose plutonium use. Use **shieldcoax4.2** for samples with more shielding where gamma rays < 200 keV are not present.

DOS Filename	Customary Parameter Set Name at Los Alamos
sc42.pst	**shieldcoax4.2**
Applicability	General purpose use for nearly all isotopically homogeneous plutonium-bearing items. Requires Am/Pu homogeneity and ^{241}Pu-^{237}U equilibrium. Analyzes gamma rays from 200-800 keV from unshielded or shielded (tested up to 6 mm lead, capability is probably greater than this) items.
Detector type:	coaxial
Default Gain:	0.125 keV/ch, Default Offset: 0.0 keV
No. of channels:	8192 (0-1024 keV)
^{240}Pu range tested:	2-38%
Interference tests:	^{235}U, ^{237}Np, ^{243}Am-^{239}Np
Sample tests:	^{241}Am/Pu heterogeneity, Nonequilibrium ^{241}Pu-^{237}U
Comments:	A slight modification of these parameters has been tested on data taken with 13 mm of lead, analyzing gamma rays from 300-800 keV.

DOS Filename	Customary Parameter Set Name at Los Alamos
uloenr.pst	**U125_Coax_LowEnrch**
Applicability	General purpose use for low enriched uranium (up to approximately 50% ^{235}U), no plutonium. Measures ^{234}U, ^{235}U, and ^{238}U fractions. Assumes ^{238}U-^{234}Pa equilibrium. Works best for enrichments < 20%.
Detector type:	coaxial
Default Gain:	0.125 keV/ch, Default Offset: 0.0 keV
No. of channels:	8192 (0-1024 keV)
^{235}U range tested:	0.2-70%
Interference tests:	none
Sample tests:	none
Comments:	Coincidence summing losses cause measurement results to be distance dependent for samples closer than about 5 cm to detector. Use of data acquisition systems with only 8000 channels of useful data require change of default energy calibration to a gain of 0.130 keV/channel.

Parameter Set Name at Los Alamos

uhienr.pst **U125_Coax_HiEnrch**

Applicability	General purpose use for high-enriched uranium (> 20 % ^{235}U), no plutonium. Measures ^{234}U, ^{235}U, and ^{238}U fractions. Assumes ^{238}U-^{234}Pa equilibrium. Works best for enrichments >20%. Requires the presence of ^{228}Th gamma rays in the spectrum for best analysis.
Detector type:	coaxial
Default Gain:	0.125 keV/ch, Default Offset: 0.0 keV
No. of channels:	8192 (0-1024 keV)
^{235}U range tested:	10-99%
Interference tests:	none
Sample tests:	none
Comments:	Coincidence summing losses causes measurement results to be distance dependent for samples closer than about 5 cm to detector although this effect is less severe than for the low enriched parameters.. Use of data acquisition systems with only 8000 channels of useful data require change of default energy calibration to a gain of 0.130 keV/channel. Uses ^{228}Th gamma rays in the relative efficiency curve. A known problem is the severe underestimation of the statistical error of the final results.

Appendix D. ASCII File Description

You can save spectral data in a text file by selecting the **Save as** option then choosing ASCII as the storage format. When doing this, you then must choose either a tab separator or a comma separator. You must also choose the number of columns that are to be "printed".

The first 45 lines of such a text file are shown on the next page. This was produced by opening the file CBNM93B.101 and then saving it as a text file. The tab separator was chosen, and the number of columns was chosen to be 1. The resulting text file was opened with Microsoft Word, ver. 4.0 and then the first page was printed.

The first line in the output file displays the name of the file in which the data resides. The next two lines display information that is usually found in the header portion of the spectral data file. In the second line, between the commas, are numbers representing the date and time associated with that spectrum. The numbers, in order, indicate the year, month, day, hour, minute, second, millisecond, and time zone offset. The third line indicates the live time and true time used in collecting the spectral data. The fourth line is blank. The fifth line consists of the string "ch" followed by the separator character followed by the string "counts." The remaining lines present the spectral data with a channel number followed by one or more columns of channel counts. Each of the columns in these lines is separated by the special separator character chosen by you (either tab or comma). The channel number at the left will be the channel number for the first column of counts. If there are 8 columns of counts, for example, the channel numbers will increase in increments in 8.

When you choose to open a data file and selects ASCII as the storage format, PC/FRAM attempts to read the header information: date, time, live time, and true time. If this fails, it proceeds to the spectral data. Thus, the header information in lines 1-3 need not be present in the file. But **the line with the strings "ch" and "counts" must be present.** PC/FRAM looks for the character between these two strings and assumes that this will be the delimiter between each column of numbers in the succeeding lines. As the channel counts are being read the channel numbers actually read are checked against what they ought to be in order to ensure the integrity of the data.

```
Spectral data from  C:\PCFRAM\CBNM93B.101
94,07,15,14,09,44,0000,0
Live time:  3389     True time:  3600

ch     counts
0      0
1      0
2      12148
3      12067
4      12076
5      11987
6      11889
7      12064
8      12169
9      12630
10     12637
11     12839
12     12974
13     12892
14     12761
15     12875
16     12859
17     12775
18     12643
19     12832
20     12798
21     12489
22     12769
23     12609
24     12719
25     12775
26     12574
27     12718
28     12581
29     12464
30     12562
31     12534
32     12665
33     12661
34     12785
35     12476
36     12674
37     12584
38     12549
39     12627
40     12410
41     12741
42     12299
43     12756
44     12448
45     12548
```

Appendix E. Facility Specific Information

E.1. Introduction

This appendix contains general information that may be used to assist in the operation of a PC/FRAM data acquisition system in cases where the system has not been provided by Los Alamos and also contains specific information for one commonly used configuration. As such, the illustrations and descriptions are meant to be illustrative and are not intended to exclude other implementations of data acquisition systems that perform to the same standard as illustrated here.

E.2. System Interconnections

Typical electronic system interconnections of a PC/FRAM system are shown on the next page for a specific installation. While the illustration is for a specific system, other components may also be suitable as long as the data acquisition formats are compatible with those supported by PC/FRAM. Because support for various data formats may change with time, please call the authors for information on current support

The main features of the data acquisition systems we have implemented to date are

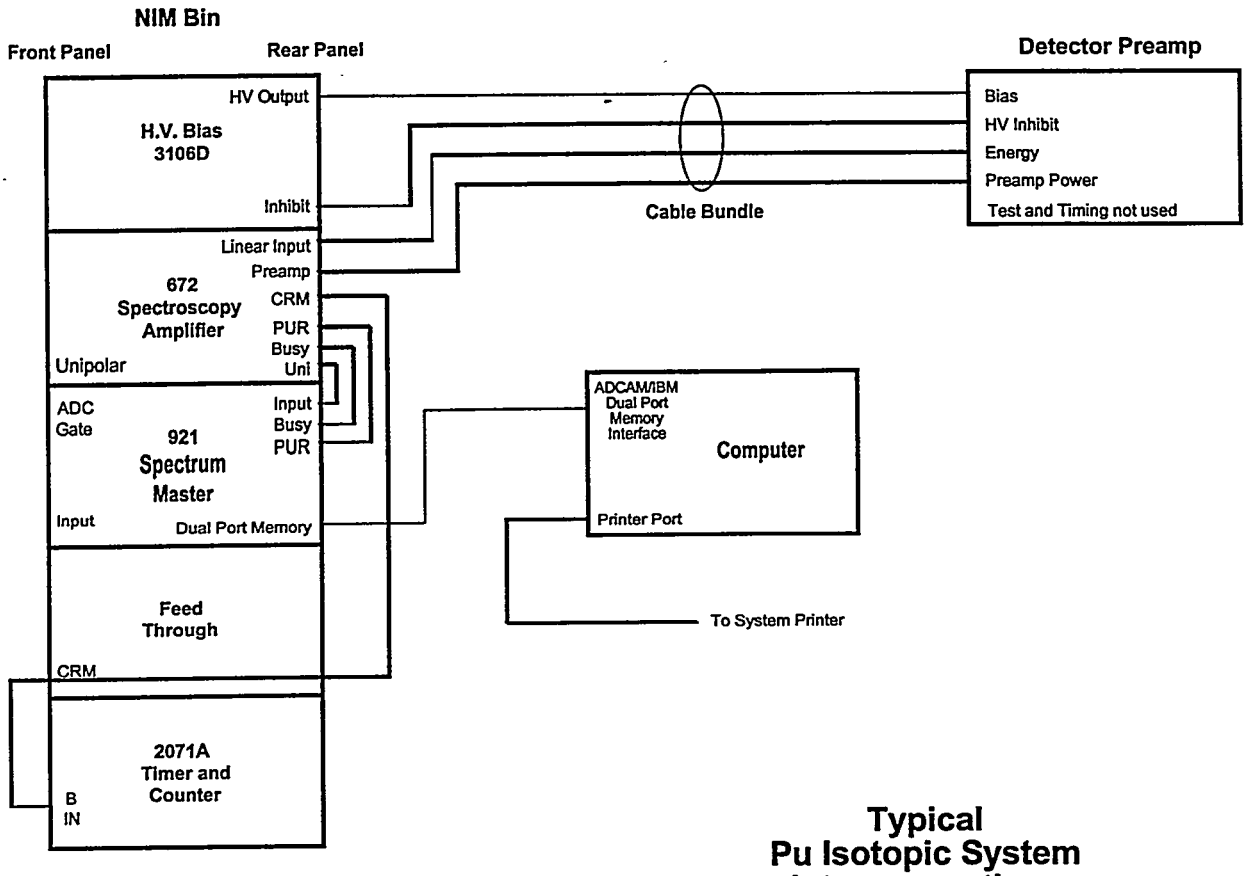
* High quality spectroscopy amplifier with baseline restoration, pulse pileup rejection, automatic Pole-Zero, and available shaping time constants in the range from 1-3 microseconds.
* Fast Analog-to-Digital Converter (450 MHz Wilkinson or < 7 μsec fixed)
* Counter-Timer
* Digital Gain and Zero Stabilization

The last two features are not required but increase the assurance of adequate data quality and are highly recommended.

We have also implemented FRAM with integral digital spectroscopy systems, e.g. ORTEC DSPEC, which incorporate, in digital form, all of the above components (excluding the counter-timer). Information obtained to date indicates that the digital systems outperform their NIM module equivalents.

The instruments shown on the next page, as representative of a NIM-based data acquisition system, consist of standard NIM modules from Canberra (3106D, 2071A) and ORTEC (672, 921) contained in a standard Nuclear Instrumentation Module (NIM) bin (ORTEC 4001C bin and 4002D power supply or equivalent). Other combinations of modules of equivalent quality may be used. The MCA shown (921 Spectrum Master) is one of the MCA's supported by PC/FRAM. The figure on the next page illustrates how these modules may be connected.

Typical System Interconnections



Typical Pu Isotopic System Interconnections

E.3. System Settings

A description of some typical system settings for plutonium measurements for an 8192 channel, single coaxial detector system is given on the next page. The maximum count rate for the coaxial detector system settings on the next page is recommended to be about 30 kHz. The digital stabilizer settings for both uranium and plutonium are shown. The first settings at 208 and 662.4 keV are recommended because you can measure most shielded as well as unshielded samples without making any changes. Optional settings for plutonium when measuring and analyzing data in the 120-450 keV region are also given.

The other widely-used option, a single planar detector system, uses 4096 channels at 0.1 keV/channel with a 10 keV offset (or 0.105 keV/channel with zero offset in 4000 channels) collecting data from 10-420 keV (0-420 keV) for plutonium measurements. This gain and offset is historical, allowing an easy conversion of channel number to energy, and is not required. A slightly lower gain of about 0.105 keV/channel with zero offset would also work. The planar detector system typically uses a 1μs, triangular shaping time constant, with zero stabilization at 129 keV and gain stabilization at 413.7 keV for plutonium. Its maximum count rate is usually limited to < 40 kHz.

Typical System Settings

(Coaxial detector, 8K ch, 0.125 keV/channel)

H. V. Power Supply

Kilovolts	(see detector requirements)
Polarity:	positive (for most coaxial detectors, check to be sure)
Voltage dial:	(as appropriate)

ORTEC 672 Spectroscopy Amplifier

Coarse Gain:	20
Fine Gain:	approx. 11.0
Uni Shaping:	Triangle
PZ:	Auto
Shaping Time:	2
BLR Rate:	Auto
Input:	Norm, +

ADC

Gain:	8K
Range:	8K
Offset:	0

Digital Stabilizer

Zero

Peak:	1664 (208 keV) plutonium
Peak:	1034 (129 keV) plutonium (optional)
Peak:	1486 (186 keV) uranium

Gain

Peak:	5299 (662.4 keV) plutonium
Peak:	3310 (413.7 keV) plutonium (optional)
Peak:	8008 (1001 keV) uranium

E.4. Adjustments for Energy Calibration

The energy calibration should be set at 0.125 keV/channel have a zero offset (channel 0 = 0.0 keV) for a single coaxial detector system. If this calibration should be disturbed, it may be reset with the following procedure. (The example is for a coaxial detector with a 0.125 keV/channel gain.)

1. Acquire a spectrum with the digital stabilizer turned off using a source with a wide range of gamma ray energies up to 1 MeV. A plutonium source is suitable, as is a combination of common radioisotope sources, such as ^{133}Ba plus ^{137}Cs. Use the MCA emulator for the acquisition without the PC/FRAM software running.

2. Calculate the correct peak positions for several gamma rays from the sample (or source). The correct peak positions are calculated by using the known energy of the gamma ray peaks and dividing by 0.125.

$$\text{peak position in channels} = \text{Peak Energy(keV)}/(0.125\ \text{keV/channel})$$

3. Use the gain controls on the amplifier to adjust the highest energy peak (preferably in the upper third of the spectrum) to its proper peak position.

4. Use the zero control on the ADC to adjust the lowest energy peak (preferably in the lower quarter of the spectrum) to its proper peak position.

5. Iterate on these adjustments, as they are interdependent, until the two peaks are within approximately one channel of their desired location.

6. When these adjustments are complete, you may turn the stabilizer on.

E.5. Other Manuals

In addition to this manual, the system's individual modules will have their own manuals. Consult these manuals for instructions on setting up and using the individual system components.

E.6. Data Acquisition Considerations

Filters

Measurements on plutonium-bearing items usually need filters attached to the front of the detector end cap. The purpose of the filters is to attenuate the very strong 59.5 keV gamma ray from ^{241}Am, nearly always present in plutonium. If this peak is too intense random summing with x-rays and gamma rays around 100 keV will disturb the spectrum in the 150-170 keV range. Filters are usually made from Cd or Sn. We find that 2 mm of Cd is sufficient for nearly all plutonium samples and while thinner filters may be used for some items, we find it most convenient to use the same thickness for all items. A rule of thumb is that the height of the 59.5 keV gamma ray from ^{241}Am should be attenuated to approximately the same intensity as or lower than the intensity of the gamma rays and x rays in the 100 keV region. Thinner filters may be used for uranium although all uranium measurements should use at least a 0.8 mm thick Cd (or equivalent) filter. Often a thick container (e.g. UF_6 cylinders) provides its own filter.

Shaping Time Constants

The choice of amplifier shaping time constants in systems with analog amplifiers is always a tradeoff between throughput and resolution. Most HPGe detectors exhibit their best resolution when operated at a time constant around 6 μs. This time constant is too long to use with plutonium measurements because throughput suffers unacceptably. The compromises that we suggest are to use 2 μs, triangular shaping for coaxial detector measurements and 1 μs triangular shaping for planar detector measurements. You may make measurements of resolution and throughput vs. incoming count rate to view these tradeoffs and make your own choices. For systems without a counter/timer you may make percent dead time your independent variable. We suggest maximum counting rates of 40 kHz under these conditions for planar detectors and 30 kHz for coaxial detectors.

Shielding

Isotopic measurements must be made with full recognition of the existing background conditions with shielding being supplied for the detector under most all measurement conditions. FRAM is used best with significant shielding, especially when carrying out measurements that need high-energy gamma ray analysis. Shielding thicknesses of 5 cm of lead are routinely used.

Appendix F. Test File Data

The following table gives the accepted isotopic values and some sample and data acquisition parameters for the test spectra enclosed with the manual.

Appendix G. Technical Support

Questions, comments, and trouble reports for this program should be directed to:

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