ORTEC®

PC/FRAM-B32 V4.3

Plutonium and Uranium Isotopic Analysis Software

Advanced Isotopic Ratio Analysis Software for HPGe and CdTe Detector Gamma-Ray Spectra

- **Analyzes Pu, and a wide variety of heterogeneous samples containing Pu, Am, U, and other nuclides including ^{242}Pu**
- **Operates with a single HPGe or CdTe detector**
- **No calibration standards necessary**
- **Works with shielded samples**
- **Select from a large number of supplied sample/geometry conditions or add more types**
- **Dynamic selection of English or Russian Graphical-User Interface**
- **ORTEC *CONNECTIONS-32* compliant**
- **Operates on a variety of hardware platforms and is a 32-bit Windows® 2000/XP application**
- **Decay Correction for Isotopic fractions**
- **Significant enhancements over previous versions**

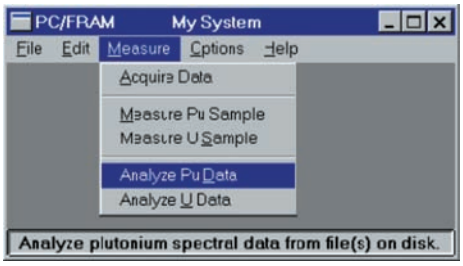

Fig. 1. PC/FRAM V4.3 Main Menu.

The PC/FRAM[1] code has been under evolutionary development at Los Alamos National Laboratory since the mid 1980s. PC/FRAM-B32 Version 4.3, is a 32-bit version for the Windows 2000/XP operating platforms. It operates within the ORTEC *CONNECTIONS-32* network spectroscopy architecture, giving greater flexibility in choice of MCA hardware.

PC/FRAM-B32 analyzes the gamma-ray spectrum taken with a germanium detector, of plutonium-bearing, uranium-bearing, or mixed items and quantifies the distribution of plutonium or uranium isotopes ^{241}Americium and other transuranic isotopes (including uranium in mixed uranium-plutonium oxides) that contribute measurable gamma rays to the spectrum can also be quantified relative to plutonium. In Version 4.3, use of CdTe (Cadmium Telluride) detectors is also supported. PC/FRAM-B32 analyzes spectra from items containing only uranium, and quantifies the uranium isotopic distribution. These measurements are performed on samples of arbitrary size, geometry, and physical and chemical composition.

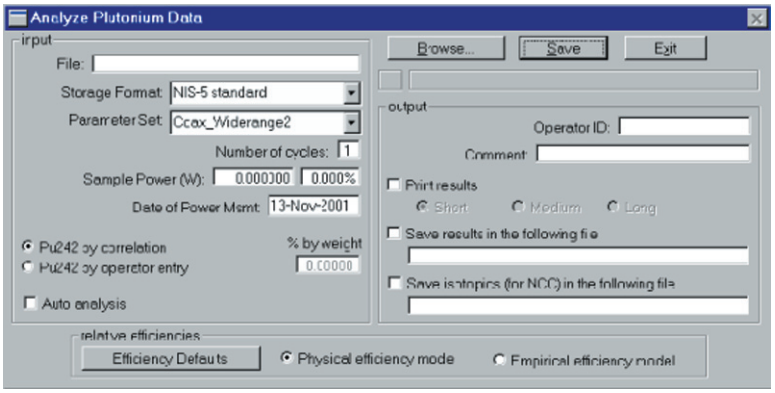

Fig. 2. Analyze Plutonium Data Dialog Box.

[1]FRAM: **F**ixed-energy **R**esponse function **A**nalysis with **M**ultiple efficiency.

Easy-to-Use Windows 2000/XP User Interface

PC/FRAM-B32 is a member of the ORTEC *CONNECTIONS-32* family of products. The user interface complies with the latest Windows conventions and is very straightforward to use. It provides control of all MCA hardware supported by *CONNECTIONS-32*. The ORTEC MAESTRO®-32 MCA Emulation program is used for hardware system setup prior to use and can be removed from the PC to secure the MCB from changes.

Bilingual Language Support

PC/FRAM-B32 has the capability of supporting two different languages. Currently English and Russian are the two languages, but this can easily be extended to other European languages.

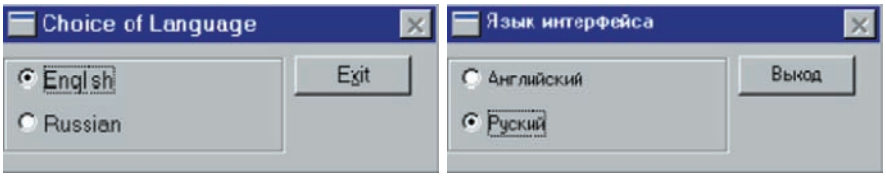

Fig. 3. Change of Language Dialog Boxes.

ORTEC *CONNECTIONS-32* Architecture

The *CONNECTIONS-32* product architecture offers a number of significant benefits: software products are truly multitasking and 32-bit spectroscopy applications, based on Windows 2000/XP. The concept is "see anything, do anything, and be anywhere using any hardware." *CONNECTIONS-32* is secure, standard, and open. Multiple *CONNECTIONS-32* applications may co-exist on a network and interface simply with custom report writers and industry-standard databases; controlling and viewing all attached spectroscopy hardware activity from any workstation. Programmer's toolkits facilitate custom development. *CONNECTIONS-32* hardware support includes all current and past ORTEC MCA devices and also an increasing number of non-ORTEC types.

PC/FRAM-B32 Analysis Capabilities

Sample Type

The versatility of PC/FRAM-B32 and its ability to analyze a wide variety of samples stems from its reliance upon generic analysis algorithms. Specific information needed to guide the analysis is encoded into a set of parameters and stored in a database. This information includes the regions and peaks to be examined, the isotopes to be used in the analysis, and special information for performing a number of diagnostic tests on the spectrum. An "analysis engine library" makes it easy to integrate into specific application situations.

Material Categories are Easily Analyzed:
- 2–38% ^{240}Pu
- 0.01–50% ^{241}Am
- Interferences from ^{243}Am-^{239}Np, ^{237}Np, and ^{244}Cm
- 80% ^{238}Pu
- Lead-shielded samples
- Heterogeneous Am/Pu
- Nonequilibrium ^{241}Pu-^{237}U
- MOX: ^{235}U/Pu from 0.005–35%
- Pu with 80–95% ^{242}Pu
- ^{235}U/^{238}U in pure U (no Pu)
- ^{235}U: ^{241}Am: Pu = 24:1:1

In an improvement over previous versions, separate dialogs now handle analysis of plutonium and uranium samples and data in Version 4.3.

Analysis Methods

PC/FRAM-B32 analyzes photopeaks from the spectrum of plutonium (or uranium) gamma rays. The spectrum contains peaks from the plutonium isotopes ^{238}Pu to ^{241}Pu, ^{241}Am, and often other isotopes such as ^{235}U or ^{237}Np. PC/FRAM-B32 combines this information to produce isotopic ratios independent of sample size, shape, physical and chemical composition, measurement geometry, and container characteristics. The results are obtained using only the spectral data and known fundamental nuclear constants. Calibration with standards is NOT necessary.

Peak Area Determination

PC/FRAM-B32 uses response function methods to determine all peak areas, fitting a Gaussian with a single exponential on the low-energy side to model the gamma-ray peak shapes and uses a Lorentzian to model x-ray peaks.

Relative Efficiency

PC/FRAM-B32 uses a separate efficiency curve for each isotope. This allows it to measure the specific power of pyrochemical residues with biases that are reduced by as much as a factor of ten from analyses that do not use multiple efficiency curves.

The multiple efficiency feature of PC/FRAM-B32 may also be used for other heterogeneous samples. The physical and chemical characteristics of the sample may not be uniform or even well known. Items may contain mixtures of solids and powders with no ill effect so long as the plutonium is isotopically uniform. Version 4.3 adds a physical model option for calculating the relative efficiencies to the previously used empirical efficiency model which is also retained.

Analysis for Isotopic Ratios

The approach used is that of finding a least squares solution to a set of linear equations involving peak areas, relative efficiency, and isotope ratios as unknowns. The method allows use of multiple peaks in the analysis with resulting improved measurement precision.

Analysis Parameters Database

The analysis parameters database is important in the power and flexibility of PC/FRAM-B32. These parameters are grouped into five categories: peak fitting parameters, gamma-ray peaks to be searched for, energy regions to be searched, isotopes to be used, and special application constants. Multiple parameter sets can be easily accommodated.

In the latest version of PC/FRAM-B32, it is possible to automatically switch, in a limited way to a more appropriate parameter set depending on analysis results.

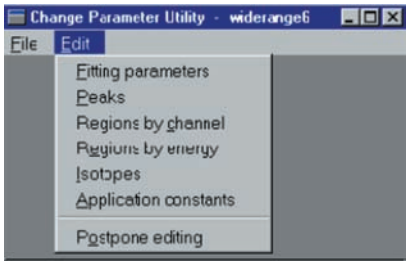

Fig. 4. Parameter Edit Menu.

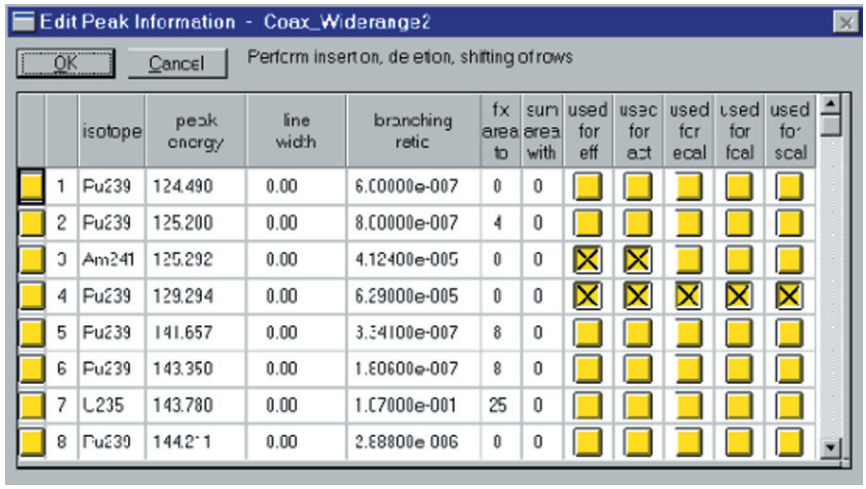

Fig. 5. Edit Peak Information Screen.

Plutonium or Uranium Analysis

A parameter set can be set up for uranium (only) spectra. In this case, different isotopic ratios are calculated and the summary is formatted differently.

Estimation of ^{242}Pu

The estimation of ^{242}Pu is done via a correlation model using an industry-standard formula with user-specified parameters. The values may be stored in any one of the parameter sets used for analysis. This model accommodates most of the commonly-proposed correlations for ^{242}Pu.

Decay Correction of Isotopic Fractions

For samples which are aged on the order of 5 years, the 14.35-year half life of ^{241}Pu can lead to a significant change in the ^{242}Pu fraction, which, if unaccounted for, can lead to (relative) errors on the order of 4% in the ^{239}Pu fraction.

PC/FRAM-B32 can decay correct the isotopic fractions of Pu and Am.

Analysis Improvements in Version 4.3

Uranium Analysis: Enhancements for uranium analysis include 1) correction for ^{234}Pa nonequilibrium, 2) correlation to predict ^{236}U, and 3) corrections for coincidence summing.

Plutonium Analysis: Complete capability for plutonium analysis in the 100-keV region and the 40-keV X-Ray region is now present.

Analysis Results Text Window

As well as printing standard reports, analysis results may be displayed in a special text window. Any of the text in this window can be "cut" and "pasted" into a Word® document or an Excel® spreadsheet.

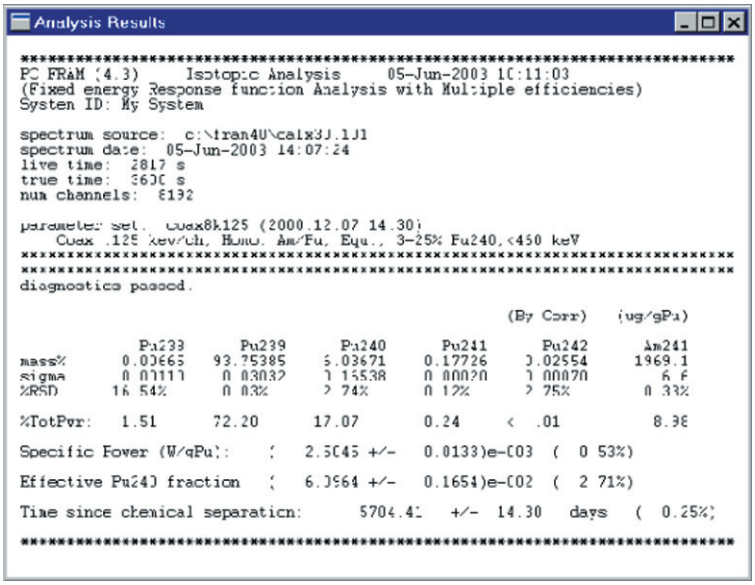

Fig. 6. Short Output Results Text Window.

Spectral Graphics

A number of plotting options within PC/FRAM-B32 are available to assist the user. The spectrum itself may be plotted and overlaid with a variety of helpful information, such as parameter files for peak and background regions; energy, peak shape, and efficiency calibration peaks; the efficiency curves themselves; and the peak fit results.

PC/FRAM-B32 Germanium Detector

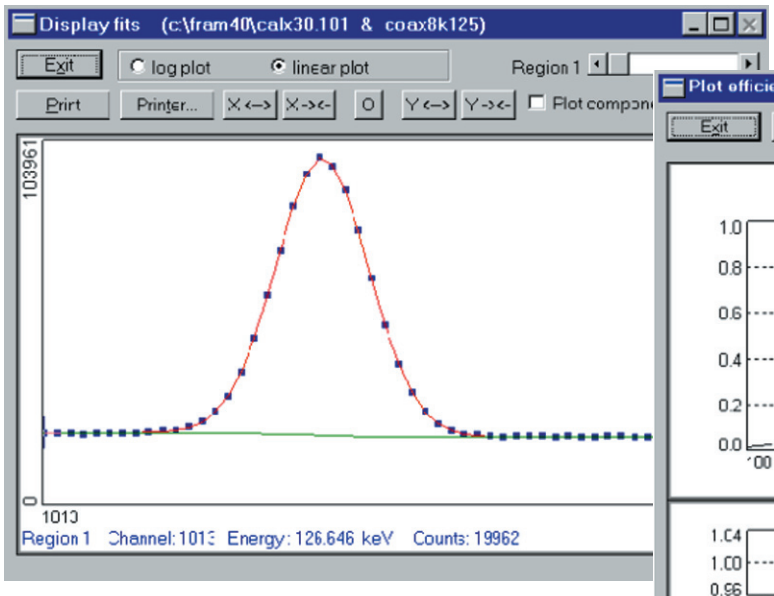

Fig. 7. Display of Peak Results.

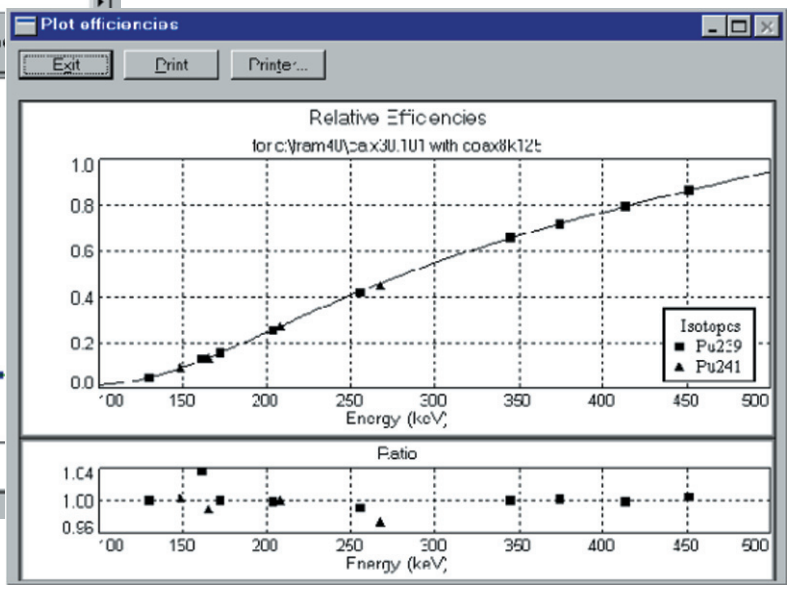

Fig. 8. Plot Efficiencies.

Requirements

PC/FRAM-B32 can perform a complete isotopic analysis using either a single planar or a single coaxial detector. The benefits of being able to operate with a single HPGe detector are obvious: cost, space, convenience, ease of use, and reliability. When used with the "traditional" single planar detector, it is used often (but not always) to collect and analyze data in the 120–420 keV range. The most widely-used energy range used in conjunction with a coaxial detector is 0–1024 keV. Various analysis modes can be used in this wide data range. If the 120–200 keV range is available, PC/FRAM-B32 will work best analyzing in the range 120–450 keV. If this is not possible (for example, if the sample is shielded or in a thick-walled container), PC/FRAM-B32 can still obtain a complete analysis using only those gamma rays above 200 keV from a single coaxial detector.

The optimum choice of detector depends on the applications expected to be encountered. A planar detector is usually the detector of choice if all measured items are unshielded or are in "thin-walled" containers. If shielded containers, thick-walled containers, or a mixture of all container types are encountered, a single coaxial detector is optimum.

The ORTEC SGD series of specifically optimized coaxial and planar geometry Safeguards HPGe detectors are highly recommended.

Password Protection and Security

An access control system within PC/FRAM-B32 stores a list of users, their passwords, and access rights granted to them. Three of the menu items are protected by this mechanism: the Parameters option in the Edit menu, the General Defaults option in the Edit menu, and the User List in the Edit menu. Thus when all these options are in operation, the user will be asked to supply a name and a password. If the security check fails, control returns to the main menu.

In addition to this, as a full 32-bit application, PC/FRAM-B32 may be run under Windows NT 4.0 providing higher level data security and access control. The ORTEC MAESTRO-32 MCA Emulator is also highly secure with password protection on all menu options.

Prerequisites

As a *CONNECTIONS-32* family member, PC/FRAM-B32 will operate correctly on any system supporting *CONNECTIONS-32* compatible hardware. This means ALL ORTEC multichannel buffers, including the latest DSPEC® Plus, DSPEC jr 2.0 and digiDART digital hardware and DART® Portable MCA, Los Alamos M^{3}CA, Rossendorf MiniMCA 166, and various Canberra, Nuclear Data, and Silena hardware systems via the EtherNIM™ MatchMaker™ module. The software will operate on any system already supporting Windows 2000/XP. PC recommendations are a minimum of a 200 MHz Pentium processor with 32 MB RAM. A math coprocessor is required.

Ordering Information

To order, specify:

Model	Description
PC/FRAM-B32	PC/FRAM-B32 Version 4.3 Safeguards Software for operation under Windows 2000/XP
PC/FRAM-G32	Documentation for PC/FRAM-B32
PC/FRAM-U32	Update for PC/FRAM-B32

LANL PC/FRAM Nuclear Safeguards Software to ORTEC

ORTEC and Los Alamos National Laboratory have entered into a licensing agreement for specialized software for nuclear safeguards applications. The license authorizes ORTEC to employ the latest version of LANL's PC/FRAM code, which analyzes HPGe detector gamma-ray spectra generated from materials containing plutonium and/or uranium, and thereby determines the isotopic distribution of the plutonium and/or uranium, the ^{241}Am content, and the concentration of certain other radioactive isotopes. The FRAM code will be integrated within ORTEC's *CONNECTIONS-32* spectroscopy environment for ease of use and reliability.

PC/FRAM-B32 V4.3

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Specifications subject to change
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