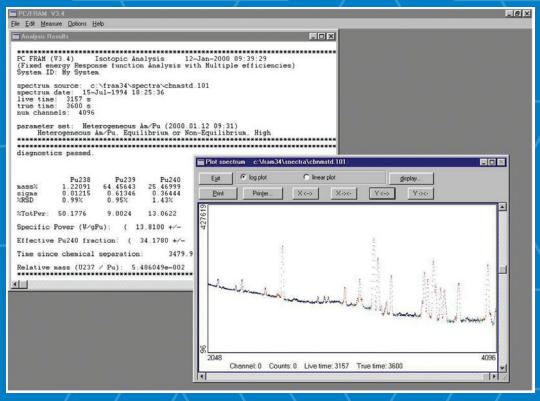
MIRION
TECHNOLOGIES

FRAM™ Multi

Fixed Energy Response Function Analysis with Multiple Efficiency



FRAM Multi is an advanced gamma spectroscopy solution for accurate, efficient and relative isotopic abundances determination of plutonium, uranium, and other actinides in nuclear measurement applications. Designed for both laboratory and field use, it combines robust algorithms, broad detector compatibility, and automated workflows to deliver reliable, auditable results for waste management, safeguards, fuel cycle, military, and research customers.

Compatible with high-resolution high-purity germanium (HPGe), cadmium zinc telluride (CZT), and lanthanum bromide ($LaBr_3$) detectors, FRAM Multi software delivers accurate determination of isotopic composition—even in complex, shielded, or unknown samples.

FEATURES

- **Accurate Isotopic Abundance Determination:** Reliable analysis for relative isotopic concentration of plutonium, uranium, and actinides - even in complex or shielded samples
- **Detector Support:** Compatible with HPGe, $LaBr_3$, and CZT detectors for lab and field use
- **Automated & Efficient Workflows:** Built-in diagnostics, adaptive analysis, and batch automation minimize manual steps and errors
- **Advanced Spectrum Processing:** Combine, shift, broaden, and subtract spectra for robust results; includes instantaneous simulation and real-time acquisition
- **Empirical and Physical Efficiency:** Delivers fast, calibration-free efficiency via empirical model. For even greater accuracy, a physical model can be applied to optimize geometry for complex and unknown sources.
- **Editable Parameter Sets:** Expanded analysis options for complex samples, delivering greater flexibility and improved accuracy

FRAM Multi leverages advanced spectrum processing and enhanced isotopic algorithms, along with two efficiency approaches: an empirical, efficiency-independent model and a physics-based efficiency calibration method for unknown sources. These capabilities enable accurate analysis across diverse sample types—including heterogeneous materials—supporting waste management, safeguards, fuel cycle operations, and research.

In nuclear safeguards, FRAM Multi complements neutron coincidence counting and calorimetry, providing reliable gamma spectrometry results that support total plutonium mass determination and regulatory compliance.

Designed for ease-of-use, the software accepts multiple spectrum formats (including IEEE N42) and supports both drag-and-drop loading and command-line batch runs. Results can be exported to detailed CSV files that include key metrics, uncertainties, isotope ratios, and time stamps for traceability. Reproducibility is supported through parameter management, while role-based access limits sensitive functions, and built-in documentation reduces the amount of training needed.

Table 1: Material Types Measured with FRAM Multi

^{240}Pu (2% – 95%) of total plutonium	^{235}U/Pu mixed (MOX) ratios from 0.005 – 35	^{234}U, ^{235}U, ^{238}U relative abundances, (no plutonium present), 0.2 to >97% ^{235}U
^{241}Pu – ^{237}U (non equilibrium)	^{243}Am – ^{239}Np	^{238}Pu (80%)
Am/Pu in heterogeneous combinations	^{244}Cm	Materials in shielded or heavy-walled containers (≥13 mm Pb for plutonium, ≥16 mm steel for uranium)
^{241}Am (0.01% to >50%)	^{237}Np	–

MEASUREMENT PRINCIPLES

Core Analytical Approach

FRAM Multi analyzes photopeaks in gamma-ray spectra collected by HPGe, CZT, or $LaBr_3$ detectors. These spectra contain signals from key isotopes such as plutonium-241, americium-241, uranium-235, and neptunium-237. By combining this spectral information, FRAM Multi calculates isotopic ratios that are independent of sample size, shape, composition, measurement geometry, or container type. Results are derived solely from spectral data and fundamental nuclear properties—no calibration with standards is required.

FRAM Multi introduces advanced physical models that account for container thickness, absorber materials, and isotopic activity. These models are integrated into the algorithm to compute relative efficiencies and activities, enhancing reliability—especially for complex or unknown samples. For quality assurance, physical reference sources may optionally be used to validate or benchmark results, complementing FRAM Multi's algorithmic approach.

Advanced Spectrum Processing and Algorithms

FRAM Multi delivers robust, reliable isotopic analysis through a suite of advanced spectrum processing techniques and enhanced algorithms, designed to handle even the most complex or heterogeneous nuclear samples.

Spectrum Processing Capabilities

- **Summing, shifting, broadening, and background subtraction:** These techniques enable accurate analysis of complex or overlapping gamma signals, improving statistical reliability across diverse sample types.
- **Sophisticated background models:** Quadratic and step background options further enhance fitting accuracy for challenging spectra.

Algorithmic Enhancements

- **Peak correction:** Includes summed peak correction for U-235 and X-ray region analysis.
- **Multiplet deconvolution:** Sophisticated fitting algorithms separate overlapping gamma peaks.
- **Automatic U/Pu ratio determination:** Utilizes fluorescence X-rays, especially beneficial for MOX samples.
- **Correlation options supported:**
  - Pu-238/U-234 correlation
  - Pu-242 and U-236
  - Pu-238, Pu-240, and U-234
- **Efficiency-independent analysis:** Calculates isotopic ratios without requiring absolute efficiency calibration.

Calibration and Curve Fitting

- **Physical model-based efficiency calibration:** With configurable absorber and thickness constraints provided by users, ensures consistent reproducible measurements across detector types (HPGe, $LaBr_3$, CZT) and energy ranges.
- **Expanded tail fitting and FWHM filtering:** Improves measurement precision.
- **Editable parameter sets:** Includes advanced peak and shape/tail fitting, customizable isotope database, ROI selection and display, calibration diagnostics, sample type and interference testing, and systematic error management.

Handling Heterogeneous Samples

- **Multiple efficiency feature:** Enables reliable analysis of samples where americium-241 and plutonium are not homogeneously distributed (e.g., pyrochemical residues), as well as mixtures of solids and powders.
- **Auto-analysis function:** Automatically applies alternative parameter sets for extreme heterogeneity or high americium content, maintaining precision and reliability.

Analysis, Data Acquisition, and Workflow Automation

- **Integrated analysis and acquisition:** Offers simple control of compatible data acquisition hardware, spectrum display, and result visualization.
- **Hardware compatibility:** Supports Mirion spectrometry devices (DSA-LX®, Lynx® II, Osprey®, and Aegis™) and reads data from HPGe, CZT, and $LaBr_3$ detectors in standard formats (CNF, SPE, N42).
- **Batch processing and command-line operation:** Enables automated workflows for high-throughput environments. FRAM Multi can be executed within Genie™ analysis sequences via command-line calls, allowing integrated acquisition and analysis as part of a fully automated workflow. Mirion offers services to develop custom Genie sequence logic for user applications, ensuring seamless automation and efficient data handling.
- **Automated diagnostics and adaptive analysis:** Built-in rule-based tests (shielding detection, sample heterogeneity assessment, isotope ratio checks, peak consistency analysis) ensure each sample is evaluated under optimal conditions, minimizing manual intervention.

Performance Outputs

FRAM Multi provides precise isotopic fractions for quality control and process measurements. For nuclear safeguards, it calculates:

- **Effective Specific Power (Pu_{eff}, W/g Pu):** Used for calorimetry measurements.
- **Effective ^{240}Pu Fraction ($^{240}Pu_{eff}$):** Used for neutron coincidence counter measurements.

Performance ranges for HPGe, $LaBr_3$, and CZT detectors are detailed in Table 2.

MEASUREMENT HARDWARE

Data Acquisition Capabilities

FRAM Multi provides straightforward control for data acquisition. Users can set presets, start and stop spectrum acquisition, and save spectra in multiple formats—including CNF, MCA, SPE and TXT (compatible with Mirion and IAEA standards). Note: Genie software also supports reading N42 files. The software features auto format detection and supports drag-and-drop file loading for added convenience.

Supported Hardware

FRAM Multi works seamlessly with Mirion MCA devices such as DSA-LX, Lynx II, and Osprey, and can read and analyze data from HPGe, CZT, and $LaBr_3$ fixed or portable detectors (including Aegis™ and SPIR-Ace™ models).

Detector Simulation

The software includes an MCA emulator for spectrum display during acquisition and supports spontaneous data collection. Additionally, FRAM Multi offers instantaneous simulation MCA, enabling rapid generation of spectra from master files for comparative analysis.

Configuration Tools

The MCA setup is defined using the Genie MID Editor Setup Wizard, which guides users through a simple selection process to configure the MCA. For more complex requirements, the MCA Input Definition Editor can be used to customize the configuration.

- If the front-end electronics are not programmable, the MID Editor Setup Wizard or the MID Editor itself is usually sufficient for configuration, allowing FRAM Multi to operate as a stand-alone analysis package.
- If the front-end electronics are programmable, configuration must be completed using Genie software, as FRAM Multi does not provide controls for these adjustments.

Automation and Efficiency

FRAM Multi supports command-line batch processing, including batch command execution via the new /L command, enabling automated and efficient data analysis workflows for high-throughput environments. The software also supports IEEE N42 multi-spectrum files for advanced data handling.

Security and Access Control

FRAM Multi incorporates robust password protection and administrator-level access control to safeguard system settings and analysis parameters. Users must log in with authorized credentials, and access is governed by four privilege levels: Administrator, Power User, Normal User, and Limited User. Administrators can create and manage user accounts, assign privileges, and restrict access to sensitive configuration options, ensuring secure and compliant operation in controlled environments.

SYSTEM REQUIREMENTS & ORDERING INFORMATION

FRAM Multi requires the installation of Genie 4.0 or higher versions, and is compatible with Windows 11 and Windows 10 operating systems.

FRAM Multi is compatible to all versions of Genie 4.0 and above. See table for ordering information.

For the Genie subscription license, once Genie expires, FRAM Multi will continue to function but will not be capable of acquiring data in CNF format.

Mirion can provide additional services to develop a customized FRAM–Genie analysis workflow that enhances accuracy for user specific applications.

FRAM MULTI ORDERING INFORMATION	
PRODUCT CODE	**DESCRIPTION**
S575C	FRAM Multi software
S575U	FRAM Multi upgrade bundle from FRAM v5.2
S575CT	FRAM Multi 2-day training is available and is highly recommended for new and current users.

GENIE ORDERING INFORMATION	
PRODUCT CODE	**DESCRIPTION**
Genie-Multi	Genie Spectroscopy Suite for Multi-Input Applications
Genie-Single	Genie Spectroscopy Suite for Single Input Applications
GenieLite-Multi	Genie Basic Spectroscopy for Multi-Input Applications
GenieLite-Single	Genie Basic Spectroscopy for Single-Input Applications

Table 2: Typical Ranges of FRAM Measurement Characteristics

	HPGe	CZT	$LaBr_3$
Measurement Time	10 min to 1 hr	~15 min (typical)	~15 min (typical)
Sample Size	100 mg to many kg (limited by criticality)	100 mg to many kg (limited by criticality)	100 mg to many kg (limited by criticality)
Precision (Relative standard deviation)	Pu_{eff} – 0.2% to 0.5% $^{240}Pu_{eff}$ – 0.8% to 3.0%	Pu_{eff}: ~0.5–1.5% $^{240}Pu_{eff}$: ~2–6%	
Bias	Pu_{eff} – <0.3% $^{240}Pu_{eff}$ – <1.0% Individual isotopes – <1.0% (^{238}Pu to ^{241}Pu)	Individual Pu isotopes and Am-241: <1.0% Individual U isotopes: 0.85–25.1%	Individual Pu isotopes and Am-241~0.07 to ~12.5; Individual U isotopes: ~0.99 to ~27.4

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