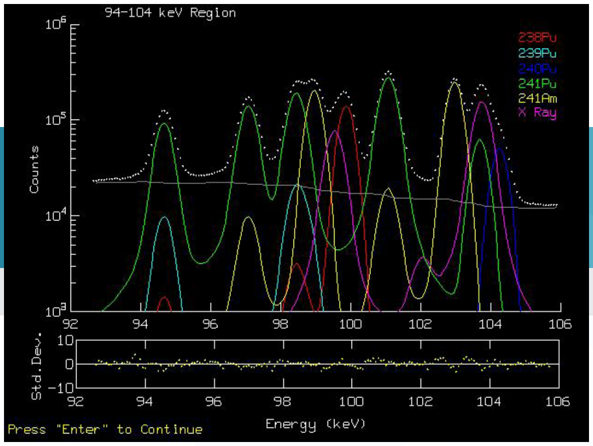
MIRION TECHNOLOGIES

Radiation Safety. **Amplified.**

MGA

Multi-Group Analysis Software



Nuclear | Healthcare | Homeland Security & Defense | Labs and Education | Industrial and Manufacturing

KEY FEATURES

- Determines relative plutonium isotopic abundances in nondestructive assay applications
- Determines the relative amounts of certain other non-plutonium actinides
- Optimized for spectra collected with HPGe detectors which are optimized for high resolution at low energies over a wide range of count rates
- Incorporates a sophisticated peak fitting and multiplet deconvolution algorithm to improve the accuracy in samples with complex isotope mixtures
- Requires no efficiency calibration for matrix density, thickness or container characteristics
- Operates in either one or two detector mode
- Integrated into CANBERRA waste and safeguards instruments to perform a sophisticated analysis with minimal operator interaction
- Developed in collaboration with top experts in non-destructive safeguards applications and hardened for waste and security applications
- Offers “Waste” and “Unusual Isotopics” analysis modes

DESCRIPTION

The determination of relative plutonium isotopic concentrations through non-destructive assay is a fundamental requirement in most waste management and safeguards applications. Yet, complex samples, varying container shapes and materials, and other complications have historically made it one of the more difficult measurements.

Multi-Group Analysis (MGA) was designed to improve the accuracy of these measurements over traditional methods. In addition to the primary application of measuring Pu isotopics, MGA can be used to determine other actinides such as ^{235}U, ^{238}U, ^{237}Np and ^{241}Am as well.

More recently, CANBERRA has added its exclusive enhancements to improve the measurement results obtained under the difficult conditions encountered in Waste and Decommissioning & Decontamination (D&D) applications. These applications often result in low-activity, low-counting statistics spectra typified by measurements on large containers. Additional enhancements have simplified or eliminated the numerous setup and calibration steps necessary with earlier MGA versions and other methodologies. Thus it can be used in a broader range of applications involving routine, repetitive measurements.

For standard 8K spectra the MGA analysis is based on the spectral information available in the 0-600 keV range of the energy spectrum. (When only 4096 channels are available the operating range is from 0-300 keV.) The primary analysis in both cases is performed using the multiplet region at 94-104 keV. While this region is the best choice for gamma line intensity (and consequently detection sensitivity) for several of the plutonium isotopes, it is a very complex region because it also consists of gamma ray peaks from plutonium progeny as well as numerous x-rays. In order to unfold this complex multiplet region, MGA automatically adjusts the energy and peak shape calibration for each spectrum using peaks that are characteristic of all plutonium samples – 59 keV, 129 keV, and 208 keV. The characteristic plutonium lines at 129 keV and 208 keV are always required to be present. For special cases where the low-energy region is not available for analysis (if the Pu sample is stored in a Pb-lined container for example), a ‘high-energy-only’ option exists to force the analysis. A two-detector mode is available as well, if added information from regions above 600 keV is desired in the analysis.

CANBERRA

MGA internally develops an intrinsic efficiency curve based on several energy lines from three isotopes. The efficiency curve takes into account the physical processes that affect the observable gamma ray intensities at different energies, such as the detector efficiency as a function of energy, and gamma ray attenuation in absorbing materials between the sample and the detector as well as within the plutonium sample itself. Using the energy, shape and intrinsic efficiency information, MGA calculates a response spectrum consisting of peak energies (positions), relative peak intensities, and an accurate peak shape of each peak in the 94-104 keV peak region. Accommodation is made for the Gaussian broadening of gamma ray peaks and the Lorentzian shape of the x-ray peaks. Isotopic concentrations are directly calculated for all Pu isotopes, except ^{242}Pu which is derived from the other isotopes.

ANALYSIS FEATURES

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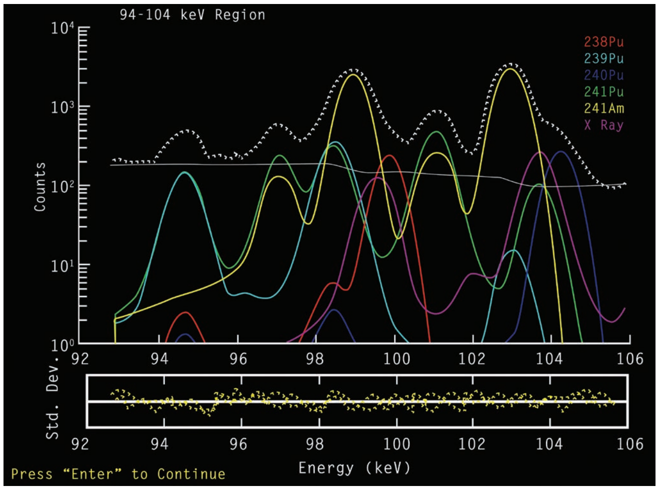
DETECTOR CHOICE

To ensure the high-quality results required of Safeguards applications the typical detector of choice in the acquisition of isotopics spectra is the CANBERRA LEGe detector due to its exceptional low energy peak shape and resolution characteristics over a wide range of count rates. The recommended value for energy resolution is less than 525 eV at an energy of 122 keV. Measurement experience has shown that the analysis will provide good results even with resolutions up to 600 eV, but the results should be reviewed in these cases. In waste and in-situ applications, however, the use of detectors larger in volume than LEGe detectors are commonplace. Coaxial or BEGe detectors are typically used in applications where thick container walls or dense matrix contents limit the low-energy information available. In these cases MGA examines and evaluates three high energy regions of the spectrum to supplement available information from the low-energy spectrum. With BEGe detectors an improved resolution of better than ~700 eV at 122 keV should be requested.



Sample spectrums from a waste measurement.

WASTE AND UNUSUAL SPECTRA

In addition MGA offers a “Waste and Unusual Spectra” mode that modifies some of the internal requirements of the code in order to handle poorer-quality spectra (see figure this page) that would not otherwise pass the stringent test criteria. There is also an “Unusual Isotopics” mode for use when one or more of the Pu isotopes cannot be detected in the spectra. This is expected of samples with high 238Pu abundance or other “isotopically pure” samples. In cases where these extended applications are selected the results must typically be scrutinized in greater detail.

SPECIFICATIONS

REQUIREMENTS

- Genie™ 2000 MultiGroup Analysis V10 is supported under the following Operating Systems: Windows® XP Professional Edition SP3; Windows Vista® Professional/ Enterprise Edition. SP2; Windows 2000 Server 2003 R2. Compliance testing was also performed utilizing 32-bit Microsoft® Windows 7.
- MGA V10 requires Genie 2000 installation and can be installed using Genie 2000 Version 3.1, but V3.2 or higher versions are required for qualified compatibility.
- MGA V10 is distributed only in the English language.
- The Stand-Alone and Genie versions of MGA should not be run simultaneously on the same datasource.
- The detector choice should be a CANBERRA LEGe detector with resolution better than 525 eV at an energy of 122 keV.

ORDERING INFORMATION

- Model # S508C – Multi Group Analysis V10.
- Model # S500C – Genie 2000 V3.2.1 or higher.

PERFORMANCE

Results from tests on CBNM standards are shown in Table 1. Excellent agreement is obtained between MGA results and the declared values. For waste applications, the accuracies are dependent on the waste matrix, the amount of plutonium present, and the count time used; achievable accuracies are typically in the 20-30% range. Several test results are published in scientific literature and are available in the public domain.

Table 1. Comparison of MGA Results with Declared Values of CBNM Standards
(Typical results when using good instruments and proper measurement procedures.)

CBNM Source	^{238}Pu		^{239}Pu		^{240}Pu		^{241}Pu		^{242}Pu †		^{241}Am	
	Declared	% Diff	Declared	% Diff	Declared	% Diff	Declared	% Diff	Declared	% Diff	Declared	% Diff
93	0.01	–7.79 (6.7)	93.49	0.02 (0.06)	6.31	–0.29 (0.91)	0.15	-2.21 (0.85)	0.04	0.00 (1.00)	0.18	-1.42 (0.78)
84	0.07	–1.74 (1.0)	84.57	0.01 (0.08)	14.24	0.01 (0.44)	0.76	–0.69 (0.37)	0.36	0.00 (1.00)	0.48	-0.85 (0.40)
70	0.82	0.01 (0.6)	74.41	–0.01 (0.22)	18.56	0.15 (0.75)	4.11	–0.40 (0.54)	2.11	0.00 (1.00)	2.61	–0.89 (0.52)
61	1.16	0.26 (0.7)	63.67	–0.19 (0.37)	25.86	0.43 (0.73)	5.04	0.07 (0.61)	4.27	0.00 (1.00)	3.21	0.23 (0.59)

Counting time: 600 seconds
Measurement uncertainty (%) in parentheses

† ^{242}Pu declaration values used

REFERENCES

1. R. Gunnink, *MGA: A Gamma-Ray Spectrum Analysis Code for Determining Plutonium Isotopic Abundances*, Vol. I, LLNL, Ca. UCRL-LR-103220, 1990.
2. S. Croft, A. Bosko, R. Gunnink, S. Philips, D. Anteck, and B. Morales, *Recent Enhancements to the Computer Code MGA for the Determination of the Relative Isotopic Composition of Plutonium from Gamma-Ray Spectra*, Proceedings of the 29th ESARDA Annual Meeting, Aix en Provence, France (2007).
3. A. Bosko, S. Croft, and S. Philips, *Plutonium Isotopic Analysis using FALCON 5000®: A Portable HPGe based Nuclear Identifier*, Proceedings of the 49th Annual Meeting of the Institute of Nuclear Materials Management, Nashville, TN (2008).
4. S. Croft, A. Bosko, R. Gunnink, S. Philips, J. Lamontagne, M. Koskelo, R. McElroy, *MGAv10: The Latest Evolution in the Multi-Group Analysis Code*, Proceedings of the 12th International Conference on Environmental Remediation and Radioactive Waste Management, Liverpool, UK (2009).