Development and Performance of CosmicGuard System for Environmental Radiological Analysis

T3.1 – P17

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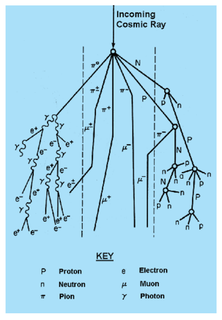
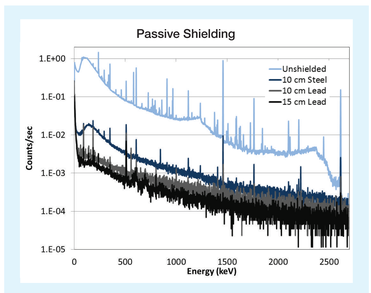
INTRODUCTION

Gamma spectrometry laboratories often analyze environmental samples with low radionuclide content. The determination of low level activities of radionuclides by gamma-spectrometry systems with a high-purity germanium (HPGe) is widely used for different experimental investigations due to its excellent energy resolution and its high efficiency. A major challenge that low-counting systems face is the high background signals which can mask the events from a sample or increase the uncertainty of peaks that are found. The background gamma radiation around the detector can be derived from several sources, and the detector should be placed inside a shield to reduce the background effect. A primary contributor to the gamma-ray background is terrestrial radiation resulting from naturally occurring radiological materials (NORM). The background induced from NORM can be considerably reduced by shielding. Another source of background is caused by highly penetrating cosmic rays passing through the shielding and interacting with the detector which produces a characteristic continuum response in a spectral histogram. Cosmic-ray-induced background is suppressed by means of an active shield device consisting of plastic scintillating plate and anti-coincidence electronic system. This can reduce the detector background by a factor of 3, improve detection sensitivity, and reduce the count time required to achieve a lower Minimum Detectable Activity (MDA). The aim of this research was to show the contribution of the cosmic ray to the detector background, the methodology available to reduce it, and the performance of the CANBERRA CosmicGuard system.

BACKGROUND SOURCES

- The background on the gamma spectrometer originates from:
  - surrounding environment
  - cosmic radiation
  - intrinsic radioactivity of the detector and its assembly
- Passive shielding is effective to suppress terrestrial radiation.
- Excluding intrinsic radiation, the remaining part is typically of cosmic origin.
  - Radiation of cosmic origin, primarily high-energy protons are continually bombarding the earth's atmosphere.
  - High-energy particles generally react in the atmosphere via spallation reactions which generate charged particles including muons.
  - Muons will pass through typical shielding materials and can produce signals in a detector.
  - The flux of muons is mainly vertical.
- Reduction of cosmic radiation is achieved by mounting a large area detector on top of a lead shield, which is providing a gating signal to reduce the background of the HPGe.
- Placing the cosmic veto detector on top of the lead shield it has shown to have the most effect to reduce the background from cosmic ray.





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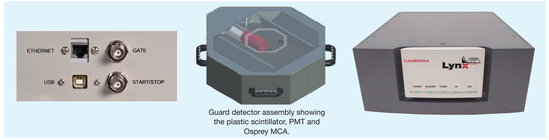
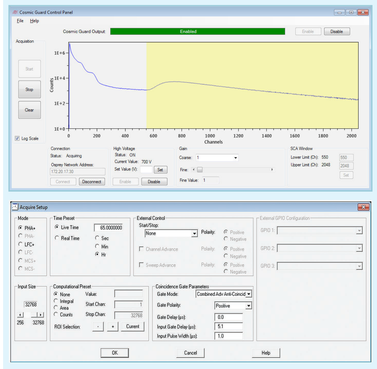
Experimental Setup: Hardware

- The gamma ray spectrometry system consisted of a HPGe detector coupled with a Lynx Multichannel Analyzer (MCA) combined with Genie 2000 V3.4.
- The detector is mounted on a vertical cryostat, directly on top of the nitrogen Dewar.
- The detector is housed in a 15 cm thick lead shield.
- A 5 cm plastic scintillator active muon guard, connected to an Osprey Digital Base MCA, is positioned on top of the lead shield.
- The output signal from the active muon guard is connected to the GATE input of the Lynx version V1.3.
- The system was acquiring simultaneously the gated and ungated spectra and both spectra were saved.



Guard detector assembly showing the plastic scintillator, PMT and Osprey MCA.

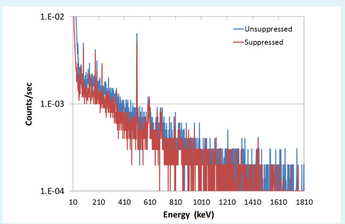
Experimental Setup: Software

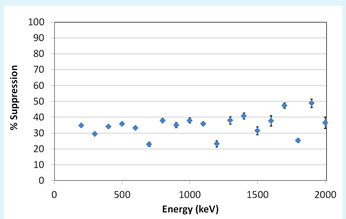


- The energy spectrum of the muons, crossing the cosmic guard, acquired with this setup.
- Within the CosmicGuard software, the Osprey output is set to the Single Channel Analyzer to produce an output signal.
- The output signal is connected to the Lynx External "GATE" input.
- Within the Genie 2000 software the coincidence gate parameters settings are configured on the Acquisition window for time correlation between the systems
  - Combined Advance Anti-Coincidence
  - Input Gate Delay (μsec)
  - Pulse Width (μsec)

Experimental Results

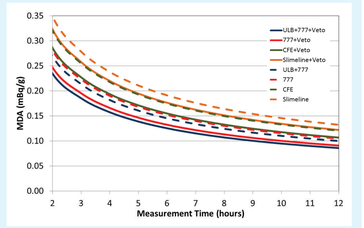
A background spectrum of the HPGe detector for the suppressed and unsuppressed events are simultaneously acquired. The background reduction factor was calculated by the ratio of the suppressed and unsuppressed measured background spectra. The background detected by the detector in the 15 cm lead shield was suppressed by a factor of 30% when the muon contribution was removed. Example of background spectra and the suppression factor acquired with a BE5030 detector inside the 15 cm lead shield is presented below.





SYSTEM PERFORMANCE

Testing was performed using the CANBERRA CosmicGuard system with a variety of shield and cryostat configurations. The improvements in the Minimum Detectable Activity (MDA) value was calculated for Cs-137 (661.7 keV) source in 1 kg soil sample on BE5030 detector in a 15 cm thick lead shield. As an example with a BE5030 detector placed in 15 cm of lead shield a MDA of 0.10 mBq/g can be achieved 2 hours faster than with a system where CosmicGuard is not used. The improved MDA value for different HPGe configurations and shield thicknesses is presented below.



The best performance of the system is observed on detector/shield combinations that make use of remote detector chambers which position the HPGe preamplifier outside the shield and also special low background shielding materials. However, benefits were seen for all configurations tested.

Shield/Cryostat	Suppression Factor with CosmicGuard
Remote Detector Chamber Ultra Low Background Hardware/ 15 cm lead shield (777)	40%
Remote Detector Chamber/15 cm lead shield	35%
Slimline Chamber Cold Finger Extension/10 cm lead shield (747)	25%
Remote Detector Chamber/15 cm lead shield	15%

CONCLUSIONS

Mirion Technologies (Canberra) Inc. has recently introduced a cosmic veto [1] system that allows users to readily retrofit shielded HPGe systems in order to gain the benefits of cosmic background reduction. The CosmicGuard system leverages modern digital signal processing, which allows users to easily configure and operate their system. This digital system acquires not only the vetoed spectra, but also the unsuppressed data, which allows for quality assurance and defendable results. Through the integration of a cosmic veto suppression system a 40% reduction in background and lower MDA can be achieved. These combined improvements can meet target MDA values in a shorter counting time.

References

[1] http://www.canberra.com/products/detectors/pdf/CosmicGuard-C48953.pdf

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