ORTEC®

Compton-Suppression Counting System

AMETEK®
ADVANCED MEASUREMENT TECHNOLOGY

Compton-Suppression Counting System

What's New!

- Improved Peak-to-Compton performance (1300:1 or greater).
- Increased sample height for sample volumes up to 750 mL.
- Simplified single step sample loading with compact, cylindrical shield.
- Digital electronics using advanced digital programmable timing and gating.
- Turnkey application software for easy setup, ongoing performance optimization, and spectroscopy analysis.
- Optional cosmic veto rejection add-on.

Compton-Suppression Systems are used to reduce the background continuum for low-background counting. This reduction improves the MDA and overall spectrum quality, especially for small volume samples such as air filters and petri dishes.

ORTEC has supplied dozens of Compton-Suppression Systems throughout the world to meet the demanding needs of very low background counting applications. Our experience in this field is based upon the study of a variety of HPGe detectors with a range of performance parameters in efficiency, resolution, and Peak-to-Compton values. From these studies, we have determined the combination which yields the overall best performance for these systems.

Basics of Compton-Suppression Counting

In a typical low-background system, great effort is made to reduce the inherent radioactivity in the counting system components: the detector, lead shield, and air inside the shield compartment. These low-background systems tend to focus on reducing only cosmic and natural sources of background in germanium spectroscopy systems.

Compton-suppression systems are designed to reduce the background levels observed in these typical counting systems. While low-background systems remove most of the constituents which add peaks to the spectrum, they do not address the main contributor to the background continuum: Compton-Scattering Events. Compton scattering occurs when the full energy of an incident photon is not completely absorbed by the HPGe detector and thus exits the detector leaving only part of its energy to be counted. This partial energy peak appears in a gamma-ray spectrum as a random event below the full energy peak in what is referred to as the Compton Continuum.

The ratio of the full-energy peak to the Compton Continuum is called the Peak-to-Compton (or P/C) ratio[1]. In a standard HPGe detector, it is common to have a Peak-to-Compton ratio between 40:1 and 60:1 for the 1.33 MeV peak of ^{60}Co. Larger detectors can have a P/C ratio of nearly 100:1.

Because the escaping energy is a photon, it is possible to collect that energy with another detector. This is typically done with a large crystal made of a less expensive material such as NaI, and is known as a shield detector. By correlating events in the HPGe and the shield detector with timing electronics, events counted in the shield detector can be used to reject simultaneous events in the HPGe detector. The result is a suppression of the Compton continuum. In a Compton-suppression system, Peak-to-Compton ratios in excess of 1300:1 are achieved with a 60% relative efficiency N-type HPGe detector. This results in a reduction in background of approximately a factor of 10 and in MDA by a factor of more than 3 (Fig. 1).

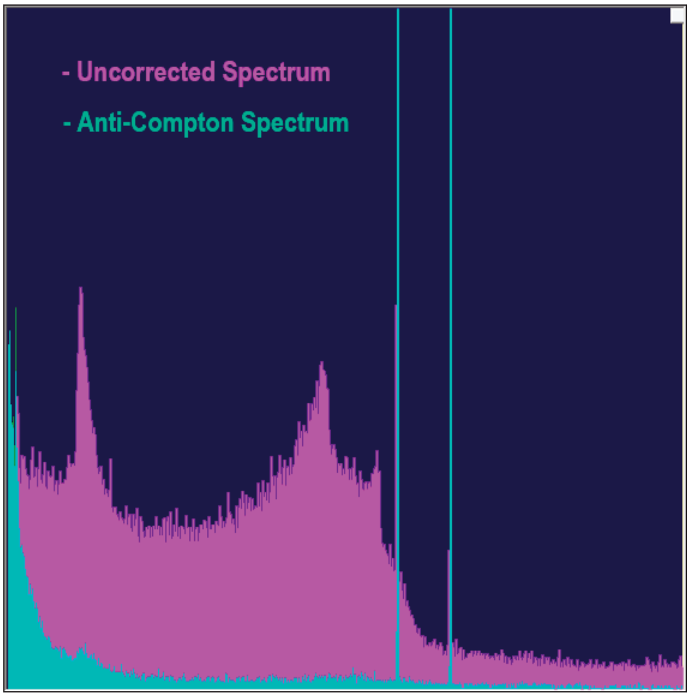

Figure 1. Peak-to-Compton Reduction with CSS

[1]As defined by ANSI/IEEE-325-1996.

Factors in Choosing HPGe Detectors for Compton Suppression

The effectiveness of a Compton-suppression system depends on the ability (efficiency) of collecting the scattered events from the HPGe detector in the shield detector. Because a photon has a probability of interaction with every material it encounters, it is necessary that there be as little material as possible between the active volume of the HPGe crystal and that of the shield crystal. Materials of concern include the following:

	What Characteristics to Choose	What Characteristics NOT to Choose
HPGe Outer Contact	**Thin outer contact:** use an ORTEC Gamma-X (GMX) detector which uses N-type germanium with an outer contact of 0.3 microns of boron	**Standard P-Type detectors:** P-type detectors, like the GEM and Profile GEM-M, have a thick outer contact (~600 microns of Lithium). This contact is three orders of magnitude larger than a Gamma-X and the probability of a gamma ray being stopped in this contact (and lost from the suppression) increases substantially. **Extended range P-type detectors:** extended range P-type detectors, like the Profile GEM-C, only have a thin contact on front. This means that the majority of the crystal is surrounded with a thick lithium contact and should not be used for the same reason as a standard P-type.
HPGe Crystal Cup	**Low density cup**: ORTEC uses a 0.5 mm thick, low-background aluminum cup in fabricating its standard detectors.	**Copper crystal cups:** The use of copper as a crystal cup should be avoided because copper has a higher density and higher mass absorption coefficient. This increases the probability that a photon will not enter the shield detector.
HPGe Endcap	**Low density endcap**: Endcaps of 1.5 mm thick Carbon Fiber or low-background aluminum with a carbon fiber window are used in standard detectors.	**Magnesium endcaps:** Magnesium has a higher mass absorption coefficient than aluminum and increases the probability that a photon will interact with the endcap and not enter the NaI annulus and should be avoided. **Copper endcaps:** As with the copper cups, copper endcaps used in some environmental low-background detector systems should be avoided.
Air or Other Materials between the HPGe endcap and shield housing	**HPGe crystal diameter as large as possible**: In a typical 83 mm diameter endcap, a detector up to 70 mm diameter may be used. This equates to a Gamma-X detector having a relative efficiency of up to 70%. Custom CSS can be made with larger N-type detector endcaps and a larger inner diameter NaI annulus.	
Shield Detector Housing	**Endcap diameter to fit within the annulus of the NaI detector:** NaI annulus can be custom fit to the specifications when ordered.	

Those familiar with low-background detectors will notice that magnesium endcaps, copper endcaps, and copper crystal cups are often used in low-background detectors. While conventional thinking would state that a Compton-Suppressed Low-Background detector would be the optimum solution for very low-background counting, this is not the case. By using these materials in detector construction, the overall effect is to reduce the capability of the Compton-Suppression System. The tradeoff can be significant.

Other Important Components of the Compton Suppression System

To capture gammas that are scattered from the HPGe detector into the NaI annulus or a plug detector in coincidence and to minimize the Compton continuum, it is very important to properly setup the electronics read-out chain. Historically, ORTEC has offered an analog readout chain using NIM based electronic components (Fig. 4). As digital electronics developed, ORTEC introduced a digital dual-MCA version. The digital version considerably simplifies gating setup both in terms of time and complexity (Fig. 5).

The digital version of the CSS significantly decreases the space needed for electronics and allows for a more compact setup with fewer components, as a result there is no need for a large NIM rack. Without the need for the NIM rack, to further minimize space efficiency, ORTEC has replaced the box style shield (Fig. 2) with a cylindrical style shield (Fig. 3) that is 4-inch (10 cm) thick lead with an inner shield height 4-inches (10 cm) taller than a typical commercial shield. The cylindrical shield is half the weight and almost half the foot print of the analog version. Additionally, the design of the top sliding door of the cylindrical shield allows the guard detector to be mounted inside the top door (Fig. 6). This novel innovation simplifies sample loading and unloading to a single step, saving time and minimizing damage that can occur to the guard detector during loading and unloading of the sample each time. Removing the guard detector from within the NaI annulus increases the sample space (Fig. 7) that can be used for measurements without sacrificing 4-π geometry and the Compton Suppression rejection performance.

Figure 2. Analog Compton Suppression System

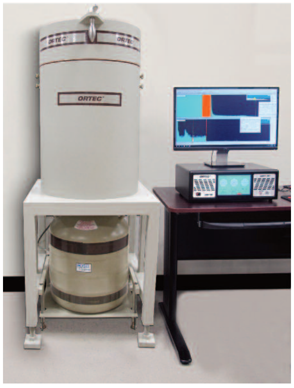

Figure 3. Digital Compton Suppression System

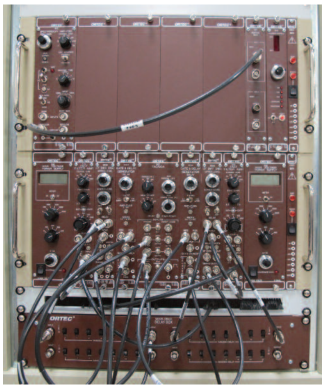

Figure 4. Analog NIM Electronics for CSS

Figure 5. Digital Dual MCA DSPEC-502A (top) and HV Power Supply for Annulus 556H (bottom)

Figure 6. Pancake detector mounted into top door of shield.

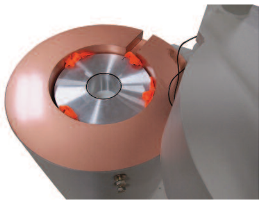

Figure 7. NaI Annulus and Lead Shield with Increased Sample Space

Specifications and Ordering Information

The table below summarizes the typical CSS option.

An optional cosmic-veto upgrade wtih a plastic scintillator is available. Contact the factory to discuss specifications and additional electronic components required.

For customized HPGe detectors (larger GMX or semi-planar HPGe detectors), annulus (larger I.D. or alternative materials (e.g. BGO)), shielding, or table, contact the factory.

Key Components	**Model CSS-D-60**
Detector	Default detector is N-type HPGe (GMX) 60% relative efficiency with 3.25” (83 mm) maximum diameter endcap, low-background Al cup, and Carbon Fiber endcap. Other detector sizes are optional up to 60% relative efficiency and up to 3.25” diameter endcap. (See individual detector specifications in the GAMMA-X brochure.)
NaI Annulus and Guard Detector	9”x9” NaI annulus with 3.5” I.D., 10.75” O.D. and FWHM @662 keV ≤11%. 6”x2” NaI plug “pancake” detector with FWHM @662 keV ≤7%.
Maximum Sample Size	3.5” diameter by 3” high (up to 750 mL).
Electronics	DSPEC-502A Digital Dual MCA with superior timing and gating performance and less than 30 minutes setup time (see DSPEC-50/502 brochure), and 556H Power Supply for NaI annulus.
Shielding	Cylindrical 4-inch (10 cm) thick reprocessed lead with Tn/Cu inner liner. Shield cavity is 11” diameter by 18” high. Optional cosmic-veto upgrade with a plastic scintillator is available.
Software	GammaVision Gamma Spectroscopy Software included. Computer is typically not included, but can be provided on request.
Guaranteed Performance P:C at 500 keV averaged background region	1300:1 or greater (with default GMX60 detector). Note: Smaller GMX detectors will have lower P:C performance.
Background Rate	0.5 cps or lower with rectangular or cylindrical shields.

Specifications subject to change
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