

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 vast 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<sup>1</sup>. 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 <sup>60</sup>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 800:1 are achieved. This results in a reduction in background of greater than a factor of 10 and in MDA by a factor of more than 3.

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<sup>1</sup>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:

- HPGe outer contact
- HPGe crystal cup
- HPGe endcap
- Air or other materials between HPGe endcap and shield housing
- Shield detector housing

### ***What Characteristics to Choose***

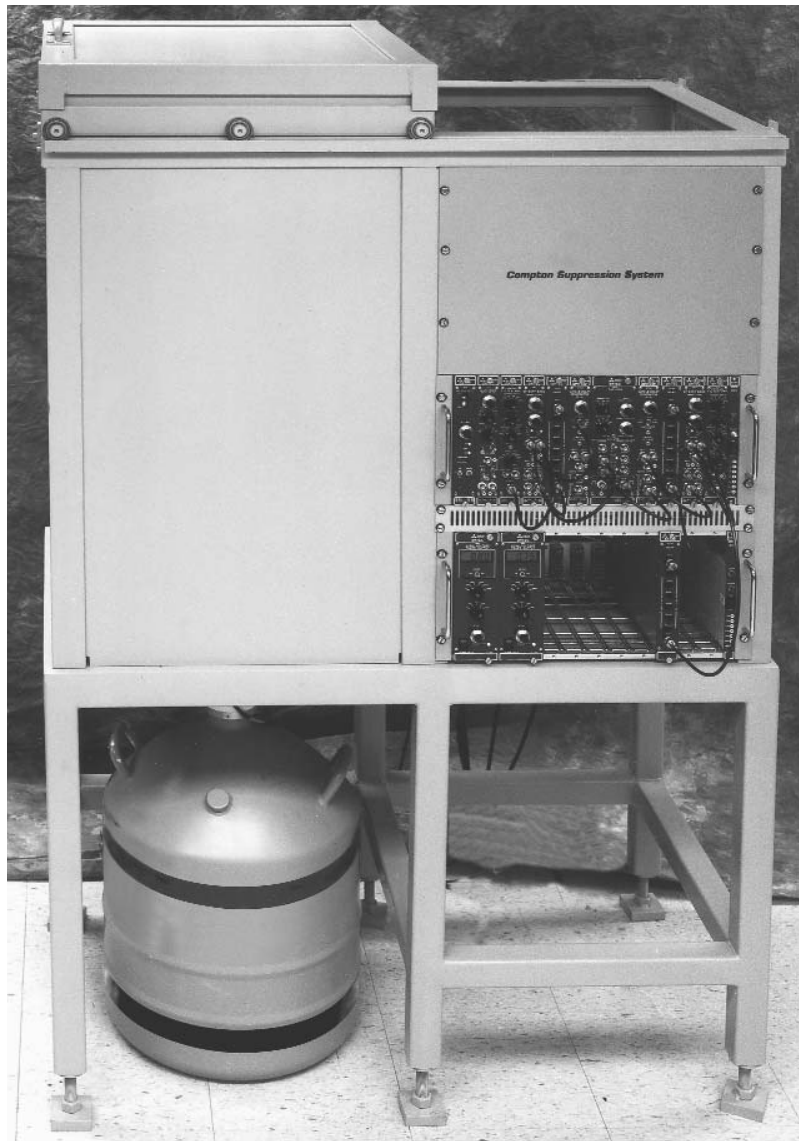
A properly selected HPGe detector for a Compton-Suppression System should have the following characteristics:

1. Thin outer contact
2. Low density cup
3. Low density endcap
4. HPGe crystal diameter as large as possible to fit into the endcap
5. Endcap diameter to fit within the annulus of the NaI detector

Characteristic No. 1 is accomplished by using an ORTEC Gamma-X detector which uses N-type germanium with an outer contact of 0.3 microns of boron.

ORTEC uses a 0.5 mm thick, low-background aluminum cup in fabricating its standard detectors to fulfill the requirements of Characteristic No. 2.

Endcaps of 1.5 mm thick low-background aluminum with carbon fiber windows are used in standard detectors thus meeting the requirements of Characteristic No. 3.



**ORTEC Standard Compton-Suppression System**

# HPGe Detectors for Compton-Suppression Counting Systems

Choosing the right crystal for the endcap is essential to fulfill Characteristic No. 4. In a typical oversize endcap (82-1/2 mm diameter), a detector up to 70 mm diameter may be used. This equates to a Gamma-X detector having a relative efficiency of 60–75%.

Characteristic No. 5 can be accommodated at the time of ordering the NaI annulus as most of these can be custom fit to the specifications from ORTEC.

## ***What Characteristics NOT to Choose***

Given the characteristics above, the following should be avoided for detectors used in a Compton-Suppression System:

- 1. Standard P-Type detectors:** P-type detectors, like the GEM, have a thick outer contact (~600 microns of Lithium). This contact is three orders of magnitude larger than a Gamma-X's and thus the probability of a gamma ray being stopped in this contact (and lost from the suppression) increases substantially.
- 2. Extended range P-type detectors:** Unfortunately, extended range P-type detectors only have a thin contact on front. This means that the majority of the crystal is surrounded with a thick lithium contact, and thus should not be used in a Compton-Suppression System for the same reason as a standard P-type.
- 3. Magnesium endcaps:** Magnesium has a higher mass absorption coefficient than aluminum and therefore increases the probability that a photon will interact with the endcap and not enter the NaI annulus and thus should be avoided.
- 4. 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.
- 5. Copper endcaps:** As with the copper cups, copper endcaps used in some environmental low-background detector systems should be avoided.

Those familiar with low-background detectors will notice that items 3, 4, and 5 in the list above 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.

# HPGe Detectors for Compton-Suppression Counting Systems

## Ordering Information

The following list of standard detectors should be considered ideal in Compton-Suppression Systems. For a complete system including specially designed lead shield, timing electronics, suppression shield detector, and HPGe detector, contact the factory.

Model	Efficiency	FHWM @ 1332 keV	P-to-C
GMX-60230	60%	2.30 keV	56:1
GMX-70230	70%	2.30 keV	60:1

**Notes:** Above detectors can be ordered with a reduced background PopTop® capsule configuration by adding "-PLB-C-S" to the Model Number. Consult factory about the reduced background system Peak-to-Compton ratio.

Specifications subject to change  
013105

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