ORTEC®

GAMMA-X HPGe Coaxial Detectors

For Compton-suppressed gamma spectroscopy, for measurements involving spectroscopy over the widest energy range, and in any situation where neutron damage is likely.

- Efficiencies to over 100%
- PopTop flexibility
- Spectroscopy from 3 keV to 10 MeV
- ULTRA thin, ultra stable boron ion implanted outer contact
- High resistance to neutron damage
- Customer-repairable for neutron damage (option)
- Excellent timing characteristics
- Ideal for Compton-suppressed gamma spectroscopy
- Be window supplied with protective cover; Al or carbon fiber window option available at no additional charge
- High-rate indicator
- PLUS preamplifier option for ultra-high-rate applications
- Automatic high-voltage shutdown protects preamplifier input FET

High- and Low-Energy Performance of the GAMMA-X Detector

The high-energy performance of a GAMMA-X detector is defined by its relative efficiency, resolution, and peak-to-Compton ratio at ^{60}Co.

The low-energy performance of this detector is defined by its resolution at 5.9 keV, its active surface area, and the detector window thickness.

The thickness of the entrance contact of the GAMMA-X detector is described by the ratio of the areas of two peaks of a readily available source. The peaks chosen are those of the 88-keV gamma rays from the ^{109}Cd and of the 22.16-keV Ag K x rays from the same source. The warranted window attenuation ratio

$$W_E = \frac{\text{peak area at 22.16 keV}}{\text{peak area at 88 keV}},$$

is 20. Obviously, the ability to see and measure the resolution accurately at 5.9 keV speaks eloquently of the thinness of the entrance window.

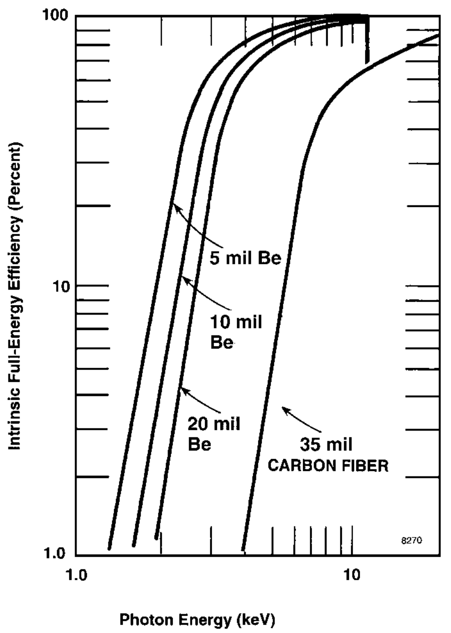

Fig. 1. Low Energy Gamma and X-Ray Transmission of Be and Carbon Fiber Windows.

Beryllium Window

Detectors supplied with 2-3/4-in.-diameter endcaps (10 to ~35%) are supplied with 2-in.-diameter Be windows; those supplied in 3-1/4-in.-diameter endcaps (~30 to 65%) are supplied with 2-1/2-in.-diameter Be windows. These windows are 0.020 in. thick and have a transmission coefficient of ~95% at 5.9 keV. (Low-background carbon fiber endcaps are optional. See Figure 1 for transmission characteristics of the Be and carbon fiber windows.) Detectors in 3-3/4-in.-diameter endcaps (~60 to 100%) receive 3.3-in.-diameter Be windows which are 0.030 in. thick.

High-Voltage Shutdown and High-Rate Indicator

GAMMA-X detectors have high-voltage shutdown and high-rate indicator protection features. If the LN_2 supply is exhausted and the detector begins to warm while high-voltage bias is applied (when using the Model 659 Bias Supply), the high voltage automatically shuts off, thus protecting the FET from damage.

This is accomplished with a temperature sensor (located on the mount behind the detector) that shuts down the high voltage before the molecular sieve can outgas and cause a dangerous high-voltage arc. Using the high-leakage current of a warming detector to shut down the high voltage can result in FET and detector damage.

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Neutron Damage Resistance

In the GEM detector, in which the outer contact is positively biased, hole collection dominates the charge collection process; in the GAMMA-X detector, electron collection is the dominant process.

Fast neutrons generate hole-trapping centers; that is, negatively charged defects that trap holes but not electrons.

Therefore, the GAMMA-X detector, in which the hole collection process is of secondary importance, is basically less sensitive to radiation damage than coaxial Ge devices in which the hole collection process is of primary importance. These theoretical considerations have been experimentally confirmed.[1]

Figure 2, a plot of the 1.33-MeV FWHM resolution as a function of fast neutron fluence for both a GAMMA-X and a GEM detector of the same efficiency, shows that the GAMMA-X detector is far more resistant to fast neutron radiation damage.[1] The detector temperature affects its radiation damage resistance to fast neutrons.

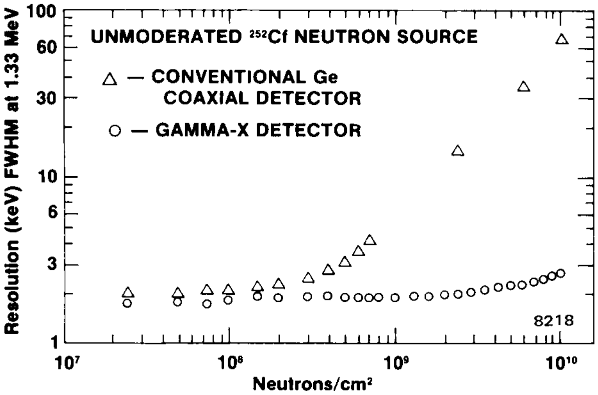

Fig. 2. Effect of Neutron Fluence on the Energy Resolution (FWHM) of the 1332-keV ^{60}Co Line for Both Conventional and Reverse-Electrode Configuration Ge Coaxial Detectors. (Electronic noise has not been subtracted).

It should be noted that **once severe radiation damage has occurred**, the "longest mileage" is obtained by avoiding cycling the detector to room temperature.[2] This is true for either p- or n-type Ge detectors. However, for slightly damaged GAMMA-X detectors (~0.1 keV degradation), cycling, or even leaving the detector warm for an extended period, will have no unfavorable effect.[3]

GAMMA-X detectors should be maintained at a temperature as close to 77 K as possible to minimize the extent of radiation damage. Therefore a streamline cryostat, with one less thermal connection, is a better choice than a PopTop for this purpose.

Customer-Neutron-Damage-Repairable Detectors

Repair of neutron-damaged GAMMA-X detectors can be performed at any of our worldwide repair facilities, or by you in your own laboratory. Contact us for information about our Customer-Neutron-Damage-Repairable GAMMA-X detectors.

[1] R.H. Pehl, N.W. Madden, J.H. Elliott, T.W. Raudorf, R.C. Trammell, and L.S. Darken, Jr., "Radiation Damage Resistance of Reverse Electrode Ge Coaxial Detectors," *IEEE Trans. Nucl. Sci.* **NS**-26, N1, 321–23 (1979).

[2] H.W. Kraner, R.H. Pehl, and E.E. Haller, "Fast Neutron Radiation Damage of High-Purity Germanium Detectors," *IEEE Trans. Nucl. Sci.* **NS**-22, N1, 149 (1975).

[3] T.W. Raudorf, R.C. Trammell, and Sanford Wagner, "Performance of Reverse Electrode HPGe Coaxial Detectors After Light Damage by Fast Neutrons," *IEEE Trans, Nucl. Sci.* **NS**-31, N1, 253 (1984).

Ordering Information

For GMX Detector in PopTop capsule, add "P4" to the model no. [e.g., GMX10P4-70]

Endcap Diameter must be specified, see Endcap Diameter Options. [e.g., GMX10-70, GMX35P4-76]

FW.02M/FWHM Specification is Typical, NOT Warranted.

Model No.	Relative Photopeak Efficiency (%)	Resolution @ 5.9 keV (eV FWHM)	Resolution @1.33 MeV (keV FWHM)	Peak-to-Compton Ratio	Peak Shape FW.1M\ FWHM	Peak Shape FW.02M/ FWHM typical	Endcap Diameter Options
GMX10	10	600	1.80	40:1	1.9	2.6	-70
GMX15	15	635	1.85	44:1	1.9	2.6	-70
GMX20	20	650	1.90	48:1	1.9	2.8	-70
GMX25	25	690	1.90	48:1	1.9	2.8	-70, -76
GMX30	30	715	1.90	52:1	1.9	2.8	-70, -76
GMX35	35	730	1.95	55:1	2.0	3.0	-70, -76
GMX40	40	760	1.95	59:1	2.0	3.0	-70, -76
GMX45	45	800	2.0	60:1	2.0	3.0	-70, -76
GMX50	50	800	2.2	58:1	2.0	3.0	-83
		(keV FWHM)					
GMX60	60	1.10	2.3	56:1	2.0	3.0	-83, -95
GMX70	70	1.10	2.3	60:1	2.0	3.0	-95
GMX80	80	1.10	2.3	63:1	2.0	3.0	-95
GMX90	90	1.20	2.4	64:1	2.1	3.1	-95
GMX100	100	1.20	2.5	64:1	2.2	3.2	-95

Options

-A	For PopTop Capsule with 1.3 mm thick Al Window, add "-A" to the model no. [e.g., GMX90P4-95-A] (see Table 1 for transmission data)
-C	Carbon Fiber Window (see Figure 1 for transmission data)
-RB	Reduced Background PopTop capsule with Carbon Fiber endcap, add -RB to the model number [e.g., GMX10P4-70-RB]
-RB-B	Reduced Background PopTop capsule with Be window in Copper endcap, add -RB-B to the model number [e.g., GMX10P4-70-RB-B]
-PLUS	Ultra-high-count-rate Preamplifier, add "-PLUS" to the model number [e.g., GMX90-95-PLUS]
SMART-1-N	SMART-1 detector option for negative bias detector. To order, add SMART-1-N as a separate line item.

*All GAMMA-X PopTop detector capsules include sealed detector element, preamplifier, high-voltage filter, and a Be window 0.02 inches thick and with diameter ≥ that of the detector element. Useful energy range is 3 keV to 10 MeV.

†FWHM = Full Width at Half Maximum; FW.1M = Full Width at One-Tenth Maximum; FW.02M = Full Width at One-Fiftieth Maximum; total system resolution for a source at 1000 counts/s measured in accordance with ANSI/IEEE Std. 325-1996, using ORTEC standard electronics.

**Typical Value. Specification is in eV for efficiencies <60% and thereafter in keV.

NOTE: For those familiar with HPGe detector specifications, you will notice that ORTEC now offers ONLY "first category" detector specifications. Recent process improvements now make this possible.

Table 1. Percentage of Photons Transmitted, as a Function of Energy, through 1 mm of Aluminum.

Energy (keV)	% Transmitted
3	0
5	0
10	8.5×10^{-2}
20	40
30	74
50	91
80	95
100	96
400	97
1000	98