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Review of the Physics of Semiconductor Detectors

Historically, semiconductor detectors were conceived as solid-state ionization chambers. To obtain a high-electric-field, low-current, solid-state device for detection and possibly spectroscopy of ionizing radiation, conduction counters (highly insulating diamond crystals) were first used. However, such crystals were quickly rejected because of poor charge collection characteristics resulting from the deep trapping centers in their bandgap. After the highly successful development of silicon (Si) and germanium (Ge) single crystals for transistor technologies, the conduction-counter concept was abandoned, and silicon and germanium ionizing radiation detectors were developed by forming rectifying junctions on these materials. A semiconductor detector is a large silicon or germanium diode of the p-n or p-i-n type operated in the reverse bias mode.

At a suitable operating temperature (normally ~300 K for silicon detectors and ~85 K for germanium detectors), the barrier created at the junction reduces the leakage current to acceptably low values. Thus an electric field can be applied that is sufficient to collect the charge carriers liberated by the ionizing radiation.

Detailed information on the physics of semiconductor detectors and their fabrication is available in the literature.[1] Some of the more useful basic concepts are summarized in the following sections.

Interaction of Ionizing Radiation with Semiconductor Detectors

A brief review of some fundamental concepts relating to the interaction of ionizing radiation with matter must precede a description of the operating characteristics of semiconductor detectors.

Heavy Charged Particles

Heavy charged particles lose energy by Coulomb interaction with the electrons and the nuclei of the absorbing materials. The collision of heavy charged particles with free and bound electrons results in the ionization or excitation of the absorbing atom, whereas the interaction with nuclei leads only to a Rutherford scattering between two types of nuclei. Thus the energy spent by the particle in electronic collisions results in the creation of electron-hole pairs, whereas the energy spent in nuclear collisions is lost to the detection process.

The concepts of specific ionization loss dE/dx and of range R can be used to summarize the interaction of heavy charged particles in semiconductor detectors when nuclear collisions are unimportant. The specific ionization loss measures the amount of energy lost by the particle per unit-length of its track; the range indicates how deeply the particle penetrates the absorbing material. Figure 1 shows the stopping power as a function of the energy, and Fig. 2 shows the range as a function of the energy in silicon and in germanium for alpha particles, protons, and deuterons.

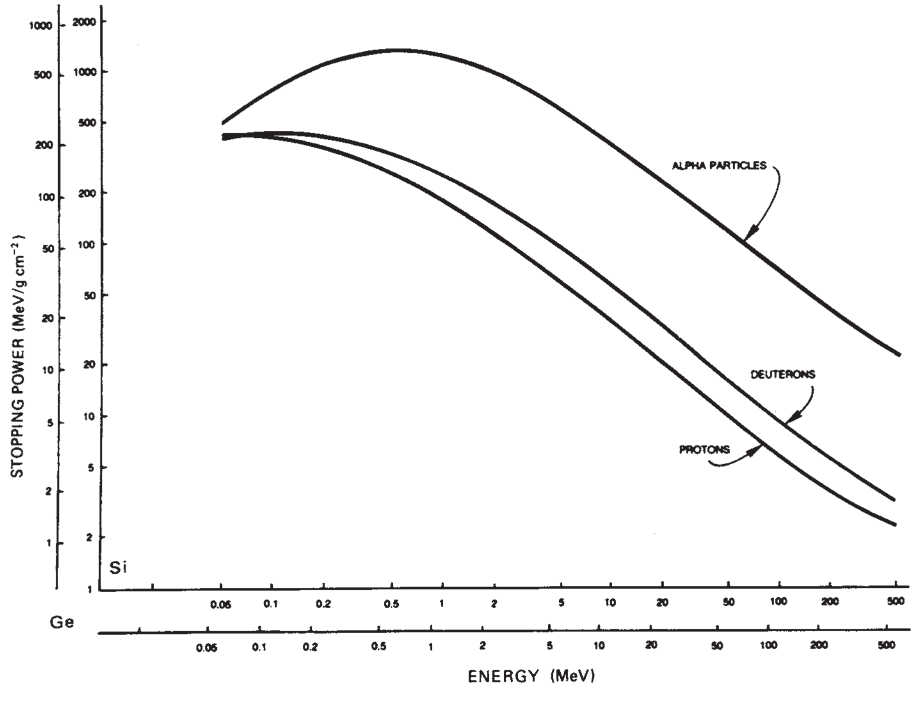

Fig. 1. Stopping Power vs. Energy for Protons, Deuterons, and Alpha Particles in Si and Ge.

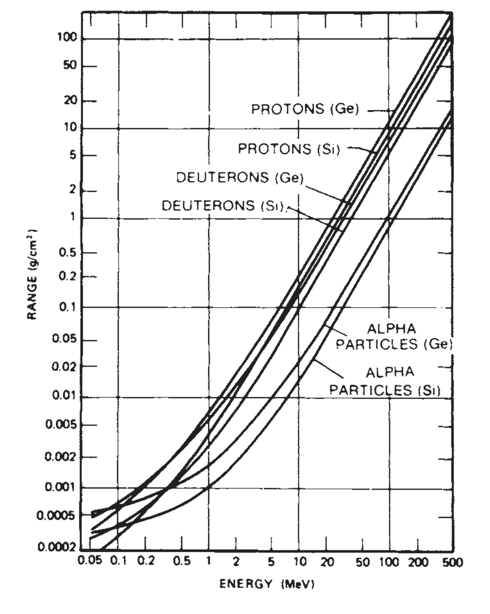

Fig. 2. Proton, Deuteron, and Alpha Particle Ranges in Si and Ge.

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Nuclear collisions can become an important part of the energy loss process, especially in the case of heavy ions and fission fragments. The theory describing this process is too complicated for a brief summary. We refer the reader to specialized literature such as the IEEE Transactions on Nuclear Science and the references footnoted here.[1, 2]

Finally, it should be mentioned that channeling effects (the steering of charged particles in open regions in the lattice) can reduce the specific ionization loss. Again, we refer the reader to the referenced literature for details on this particular phenomenon.[1, 2]

Electrons

The interaction of electrons with matter is similar to the interaction of heavy particles, with the following differences:

1. Nuclear collisions are not part of the interaction because of the very light electron mass.
2. At energies higher than a few MeV, radioactive processes (bremsstrahlung) must be considered in addition to the inelastic electron collision.
3. Again because of their light mass, electrons are so intensely scattered that their trajectory in the material is a jagged line; therefore, the concept of range as previously used cannot be applied. Rather, the concept of zero-transmission range is introduced. This is done by means of absorption experiments, which permit definition of the absorber thickness resulting in zero-electron transmission at a given energy. Figure 3 shows the zero-transmission range as a function of energy in silicon and germanium.

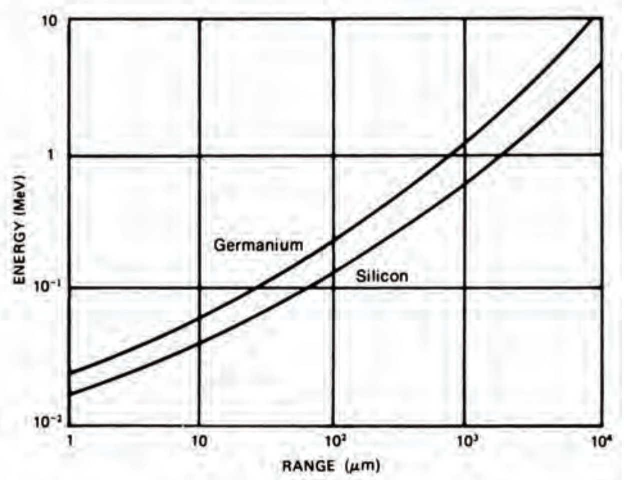

Fig. 3. Zero Transmission Range vs. Energy for Electrons in Si and Ge.

Gamma and X Rays

The interaction of ionizing electromagnetic radiation with matter is different from the processes previously mentioned, and the concept of ranges and specific ionization loss cannot be applied. Only the three most important absorption processes are considered: the photoelectric effect, the Compton effect, and the pair-production effect. The corpuscular description of electromagnetic radiation is the most appropriate for these effects, as one photon in a well-collimated beam of N_o photons disappears at each interaction. The attenuation of the photon beam can be described by a simple exponential law

$$N = N_o \exp(-\mu x), \qquad (1)$$

where N is the remaining photons in the beam after traversing distance x, and the absorption coefficient µ is the sum of three terms due to the three above-mentioned processes.

In the photoelectric interaction, the photon ejects a bound electron from an atom. All of the photon energy, $h\upsilon$, is given to the atom, which ejects the electron with an energy $h\upsilon - E_1$, where E_1 is the binding energy of the electron. The excited atom then releases energy E_1 by decaying to its ground state. In this process, the atom releases one or more photons (and possibly an electron, called an Auger electron). The cross section of the photoelectric effect increases rapidly with the atomic number Z and decreases with increasing energy.

The Compton effect is essentially an elastic collision between a photon and an electron; during this interaction, the photon gives a fraction of its energy to the electrons, and its frequency υ is therefore decreased. The cross section for this effect decreases with increasing energy, but the decrease is less rapid than for the photoelectric effect.

In the pair-production effect, a high-energy photon near a nucleus gives up its energy to produce an electron-positron pair. The photon energy goes into the rest-mass energy and the kinetic energy of the electron-positron pair. The minimum energy necessary for this effect is set by elementary relativistic considerations at the value of 1.022 MeV, an amount equivalent to two electron rest masses. The cross section P for

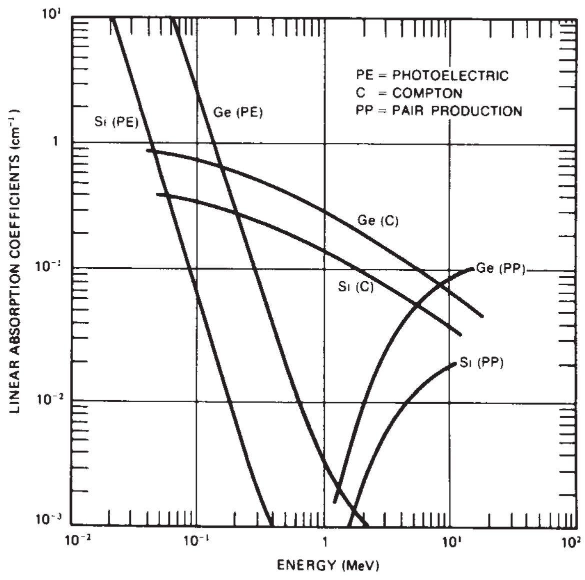

Fig. 4. Linear Absorption Coefficients vs. Gamma-Ray Energy for Si and Ge.

pair production increases with energy. Up to energies of 10 MeV, the P/Z ratio remains constant with energy.[2] At higher energies, the cross section starts to decrease for increasing values of the atomic number.

Figure 4 summarizes values of the linear absorption coefficients of the above-mentioned effects as a function of gamma-ray energy for silicon and germanium.

Creation of Electron-Hole Pairs in Semiconductor Detectors by Ionizing Radiation

Average Energy Necessary to Create an Electron-Hole Pair

The energy lost by ionizing radiation in semiconductor detectors ultimately results in the creation of electron-hole pairs. Details of the processes through which incoming radiation creates electron-hole pairs are not well known, but the average energy ε necessary to create an electron-hole pair in a given semiconductor at a given temperature is independent of the type and the energy of the ionizing radiation. The values of ε are: 3.62 eV in silicon at room temperature; 3.72 eV in silicon at 80 K, and 2.95 eV in germanium at 80 K.

Since the forbidden bandgap value is 1.115 eV for silicon at room temperature and is 0.73 eV for germanium at 80 K, it is clear that not all the energy of the ionizing radiation is spent in breaking covalent bonds. Some of it is ultimately released to the lattice in the form of phonons.

The constant value of ε for different types of radiation and for different energies contributes to the versatility and flexibility of semiconductor detectors for use in nuclear spectroscopy. The low value of ε compared with the average energy necessary to create an electron-ion pair in a gas (typically 15 to 30 eV) results in the superior spectroscopic performance of semiconductor detectors.

The Fano Factor

If all of the energy lost by ionizing radiation in a semiconductor were spent breaking covalent bonds in the detector's sensitive volume, no fluctuations would occur in the number of electron-hole pairs produced by ionizing radiation of a given energy. At the other extreme, if that energy entering the semiconductor detector that is partitioned between breaking covalent bonds and lattice vibrations or phonon production were completely uncorrelated, Poisson statistics would apply.

The variance in the number of electron-hole pairs n would then be $\langle n\rangle^2 = n$. In fact, neither of these suppositions simulates reality. As the incoming ionizing radiation gives up energy, a large shower of hot electrons is created. After many generations, the energy of these hot electrons gets close to the ionization energy necessary to create an electron-hole pair in the semiconductor detector, so that there are several possible competing mechanisms for energy loss. Thus the Fano factor F is introduced to modify the more familiar Poisson relation for this case. The equation for the variance can be written as

$$\langle n_o\rangle^2 = F\,\langle n\rangle^2 = Fn\,. \qquad (2)$$

In the case where there are no fluctuations in the number of electron-hole pairs, F would be zero; in the case where Poisson statistics apply, F would be equal to 1. Since the energy necessary to create electron-hole pairs in semiconductor detectors is much smaller than that of the incoming ionizing radiation, it can be concluded that F is closer to zero than to 1. The true value of F for silicon and germanium is still unknown; the conflicting theories on the subject do not lead to experimentally distinguishable results. However, by assuming a value of 0.1 for F in both silicon and germanium, satisfactory agreement with measured results is found in most cases.

By assuming a value of 0.1 for the Fano factor, the following formula gives the germanium detector resolution at LN_2 temperature:

$$\Delta E = 1.27\sqrt{E} \qquad (3)$$

with E measured in eV.

ΔE must be summed in quadrature with the FWHM keV noise ΔN in order to obtain the measured energy resolution ΔE_S:

$$\Delta E_S = \sqrt{(\Delta E)^2 + (\Delta N)^2} \qquad (4)$$

The value of F for silicon at room temperature is of little interest because, in such conditions, other factors than fundamental statistics dominate energy resolution values. These simple formulas show that, as expected from the better statistics due to the lower value of ε, when the energy resolution is dominated by the detector contribution, germanium detectors have an advantage over silicon detectors.

Pulse Formation Process

The equivalent circuit of a semiconductor detector operated as a spectrometer is shown in Fig. 5. In most cases, effects of high resistance of the reverse-biased junction are negligible. If a zero-electric-field radiation-insensitive region is present in the detector, its impedance (a parallel RC combination) appears in series with the circuit and is indicated in Fig. 5 by the impedance Z. The impedance also accounts for any resistance (or resistance-capacitance combination) appearing in series with the contacts.

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When semiconductor detectors are used as spectrometers, they are invariably connected to a charge-sensitive (integrating) preamplifier with a high dynamic input capacitance. The charge-sensitive preamplifier integrates on its feedback capacitance the current signal delivered by the detector and feeds the resulting voltage signal to the filter amplifier (main amplifier). The time behavior of the current signal at the input of the charge-sensitive preamplifier is determined by the current signal's shape and by the effect of the equivalent circuit shown in Fig. 5. The effect of the equivalent circuit is usually either negligible or easily calculated, whereas detailed considerations on the charge collection process in the detector are needed to calculate the induced current signal I(t).

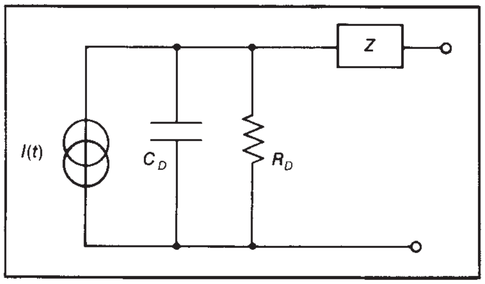

Fig. 5. Equivalent Circuit of Semiconductor Detector. Where I(t) is the current generator; C_D is the capacitance of the depletion region; R_D is the resistance of the depletion region; and Z is the series impedance.

Charge Collection Process and the Resulting Induced Current Signal

The current delivered by the signal generator I(t) is induced on the contacts of the detector by the motion of the charge carriers created by the ionizing radiation. Therefore, the first problem in determining I(t) is calculating the motion of the charge carriers in the detector's electric field. When this problem is solved, the induced charge can be calculated by electrostatic considerations.

The charge carriers created by the ionizing radiation drift to the contacts of opposite polarity, following the lines of force of the electric field established by the applied voltage. In the case of heavily ionizing particles such as fission fragments, the drift process does not begin immediately due to the creation of the charge cloud.

The electric field $\mathbf{E}(\mathbf{r})$ in the detector can be calculated from known quantities: applied bias voltage, detector geometry, and resistivity of the bulk material. Once the electric field is known, the motion of a charge carrier created at a given point $\mathbf{r}_0$ of the detector volume can be calculated by using the values for the drift velocity $\mathbf{V}_d$ as a function of the electric field $\mathbf{E}$ given in the referenced literature. Thus the differential equation

$$\frac{d\mathbf{r}}{dt} = \mathbf{V}_d[\mathbf{E}(\mathbf{r})] \qquad (5)$$

can be written for every charge carrier and can be solved if the initial positions $\mathbf{r}_0$ are known only when the charge carriers are created along a well-defined track (heavy charged particles). In the case of beta, x, and gamma radiation, the only information on $\mathbf{r}_0$ values is of statistical nature. The integration of Eq. (5) leads to $\mathbf{r}(t)$ for every created charge carrier. The charge induced by every carrier can then be calculated by electrostatic considerations. For instance, in the case of a detector with plane parallel contacts and a field $\mathbf{E}(x)$ across a distance W, the charge induced by a carrier q moving along a length Δx in the direction of the field is given by

$$\Delta q = q\frac{\Delta x}{W} \qquad (6)$$

independently of the shape of $\mathbf{E}(x)$. Equations (5) and (6) (or the appropriate induction equation) yield the contribution to I(t) of every single charge carrier and, by integration over all the created charge carriers, the total I(t) function.

Rise Time

The rise time T_t of the pulse generated by a semiconductor detector can be measured at the output of a charge-sensitive preamplifier. If the preamplifier is sufficiently fast, T_t is determined by the following factors:

1. The charge collection time T_R ,

2. The rise time of the detector equivalent circuit, in most cases a negligible quantity, and

3. The plasma time.

In most cases T_R is the dominant factor. Although a precise calculation of T_R can be quite complex, the order of magnitude of T_R can be easily obtained by the following formulas:

$$T_R \cong W \times 10^{-7}\text{s} \qquad (7)$$

for silicon detectors at room temperature, and

$$T_R \cong W \times 10^{-8}\text{s} \qquad (8)$$

for germanium detectors at LN_2 temperature.

In these formulas, W is the thickness of the depletion region measured in mm. For silicon detectors and for planar HPGe detectors, the value of W is provided with each detector. For coaxial Ge detectors, W is the radius of the cylinder (specified in the detector instruction manual).

The formulas given above are indicative only of orders of magnitude and do not give exact values.

The previous discussion did not consider trapping effects, which result in a loss of charge to the collection process and consequent distortion of the shape of the peak as observed with a multichannel analyzer.

Trapping Effects

Trapping of a charge carrier in a semiconductor occurs when the carrier is captured by an impurity or imperfection center and is temporarily lost to any charge transport process. In semiconductor detectors, it is useful to introduce the quantity τ^+ (mean free drift time):

$$\tau^+ = (N_t \, \sigma \, V_{th})^{-1} \qquad (9)$$

where

N_t = density of trapping centers,

σ = trapping cross section,

V_{th} = thermal velocity.

Note that τ^+ does not ordinarily coincide with the classical lifetime in photoconductivity theories. This is because in photoconductivity the traps are generally filled, while in a depleted detector, the traps are generally empty.

The trapped charge carrier can be reemitted in the relevant band and take part again in the charge transport process. The average time spent by a carrier in a trap is called the mean detrapping time τ_D and is strongly temperature dependent:

$$\tau_D = C \exp\left(\frac{-E_\tau}{KT}\right) \qquad (10)$$

where

C = a constant,

E_τ = activation energy of the trap,

K = Boltzmann's constant,

T = absolute temperature.

If the mean detrapping time is of the same order of magnitude as, or larger than, the electronic shaping constants, the charge carrier is lost to the charge collection process or is collected with significantly reduced efficiency. The result is poor energy resolution and peak tailing. On the other hand, if the mean detrapping time is orders of magnitude shorter than the charge collection time due to drift of the carriers, then the trap has no effect on the charge collection process. For this reason, normally used dopants such as Li, P, B, and Ga, which are shallow donors or acceptors, do not act as traps.

It can be shown that to first-order approximation, the efficiency of collection of a charge carrier subjected to trapping with a mean free drift time τ^+ is given by

$$\eta = 1 - \left(\frac{T_R}{2\tau^+}\right) \qquad (11)$$

where η is the collected fraction of the created charge.

In a modern germanium gamma-ray spectrometer the charge collection efficiency is of the order of 0.999, and as T_R is of the order of 10^{-7} s, then τ^+, according to Eq. (11), is of the order of 10^{-4} s.

As typical values of V_{th} and σ are 10^7 cm·s^{-1} and 10^{-13} cm^2 respectively, the maximum concentration of trapping centers permissible in the detector is of the order of 10^{10} cm^{-3}, corresponding to approximately 1 for every 10^{12} atoms of germanium.

Plasma Effects

Of particular interest in heavy-ion spectroscopy are plasma effects. In silicon charged-particle detectors heavy charged particles produce a dense cloud of electron-hole pairs into which the electric field, created by the applied bias voltage, cannot penetrate at the onset. Only when the cloud has been sufficiently dispersed by bipolar diffusion will the charge carriers begin to drift under the influence of the electric field. This phenomenon has the following effects:

1. A delay is generated between the creation of the electron-hole pairs (which can be considered instantaneous) and the appearance of the rising edge of the charge pulse in the detector. This delay results in an additional component to the time jitter of the signal delivered by the detector.
2. The rise time of the charge signal from the detector is slowed down; this also increases the value of the time jitter.
3. Because of the existence of a dense cloud of charge in an initially zero-electric-field region, charge carriers can recombine, with consequent loss of pulse amplitude. This phenomenon is unimportant in the detection of light particles, gamma, or x rays because the probability of carrier recombination in a semiconductor region with a high electric field is negligible.

For further information on this subject see ORTEC's application note AN-40, "Heavy-Ion Spectroscopy with Surface Barrier Detectors" available on the website.

[1] *Radiation Detection and Measurement* (2nd Edition) by Glenn F. Knoll, New York: John Wiley and Sons, 1989, and *Semiconductor Detectors*, edited by G. Bertolini and A. Coche, North Holland Publishing Co., 1968 (distributed in the U.S. by American Elsevier Publishing Co.), New York City.

[2] F.S. Goulding and R.H. Pehl, "Semiconductor Detectors," Section IIIA, *Nuclear Spectroscopy and Reactions*, J. Cerny, Ed. Academic Press (1974).

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Introduction to Charged-Particle Detectors

Silicon Charged-Particle Detector Manufacturing

Table 1 summarizes the major physical properties of silicon. To produce silicon charged-particle detectors, ORTEC employs both ion-implantation and surface-barrier technologies. The two processes are complementary in that each technique is best for manufacturing certain types of detectors. Fig. 1 (A and B) shows simplified representations of the two manufacturing processes.

There are several advantages to using ion implantation:

(a) A thinner and more rugged front contact; better energy resolution for some alpha spectroscopy applications

(b) Lower electronic noise

(c) Higher geometric efficiency for some alpha spectroscopy applications

(d) Operation to 60°C and bakeout at 200°C.

Table 1

Atomic density, atoms/cm^3	4.96 X 10^{22}
Mass density, g/cm^3	2.33
Dielectric coefficient	12
Energy gap, eV	1.115
Average energy per electron-hole pair, eV/pair	3.62 at 300 K 3.76 at 80 K
Mobility, cm^2 · V^{-1} · s^{-1}	
Electron	1350 (2.1 X 10^9 T$^{-2.5}$)
Hole	480 (2.3 X 10^9 T$^{-2.7}$)

The advantage of surface barrier technology is that it allows production of transmission detectors as thin as 10 µm or as thick as several mm (see Selection Chart).

ORTEC also manufactures deep, lithium-drifted silicon [Si(Li)] detectors for special applications.

Depletion Depth, Capacitance, Leakage Current, Electronic Noise, and Energy Resolution

Depletion Depth and Capacitance

Silicon detectors are reverse-biased diodes with parallel, planar electrodes and therefore have the capacitance of the corresponding parallel-plate capacitor. The electric field in the detector, however, is not constant but decreases linearly from the contact at which the p-n junction is made to the end of the depletion region (Fig. 2).

The nomograph in Fig. 3 shows the depth **W** of the depletion region as a function of the bias voltage applied to the detector and the resistivity of the silicon material. For a given value of bias, the depletion depth increases with increasing resistivity, and

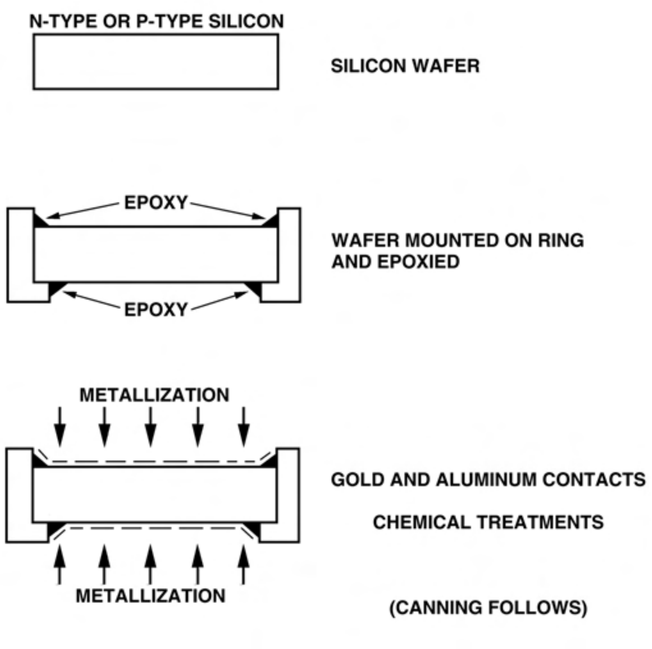

Fig. 1(A). Simplified Diagram of Surface Barrier Si Detector Manufacturing.

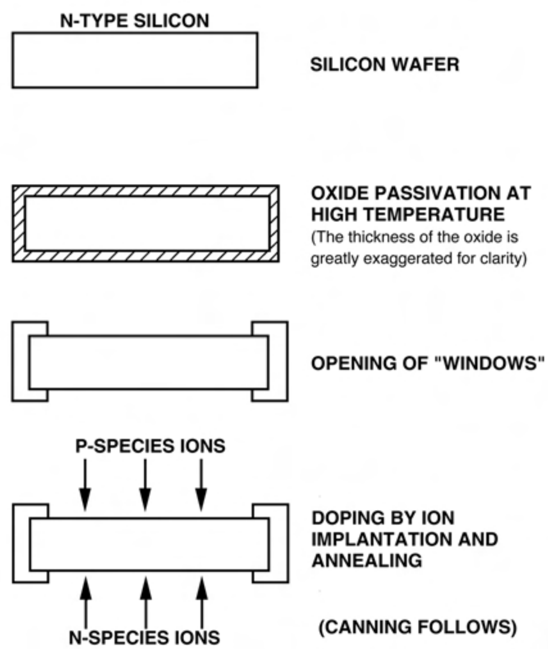

Fig. 1(B). Simplified Diagram of Ion-Implanted Si Detector Manufacturing.

Introduction to Charged-Particle Detectors

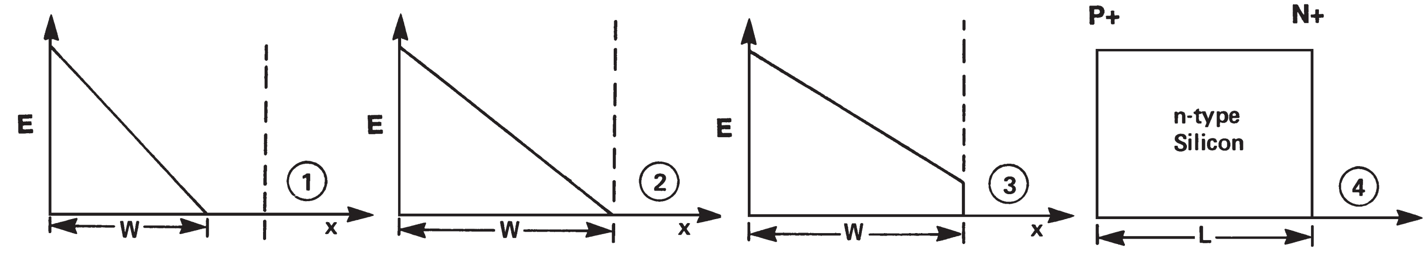

Fig. 2. Representation of Electric Field E in Silicon Surface Barrier Detectors.

correspondingly, the slope of the electric field in Fig. 2 decreases with increasing material resistivity, that is, as the silicon material behaves more and more like an insulator. If, as shown in Fig. 2, **L** is the overall thickness of the silicon slice, the detector is totally depleted when **W = L**.

The nomograph of Fig. 3 also shows the "specific capacitance" (capacitance per unit area) of silicon detectors for any given value of **W**. A detector's capacitance can be read directly from this nomograph once the active area has been determined.

The value of the capacitance is of interest because the effective electronic noise of preamplifiers used with silicon detectors increases with increasing capacitance values (Fig. 4). The electronic noise increase per unit capacitance increase is called the preamplifier's "slope."

Leakage Current

A silicon detector, just like any reverse-biased silicon diode, has a temperature dependent leakage current. At room temperature, ion-implanted detectors, such as the ULTRA Series, have a leakage current in the range of {D/100} X {~1–10 nA/cm^2 active area}, where D is the depletion thickness in microns; surface barrier detectors, on the other hand, have leakage current an order of magnitude higher, in the range of {D/100} X {~20 to 100 nA/cm^2}. As shown in Fig. 5, the leakage current is a strong function of the detector temperature and detector type.

The value of the leakage current is of interest, because, as shown in Fig. 5, the electronic noise increases with increasing leakage current.

Energy Resolution and Noise

A typical nuclear electronic chain is shown in Fig. 6. For alpha spectroscopy such electronics have long been available in NIM format; e.g., the SOLOIST or 576A, or more recently in a completely integrated, computer controlled multi-input system, the OCTÊTE-Plus.

The warranted energy resolution is measured in keV FWHM using a thin-window, 5.486-MeV ^{241}Am alpha particle point source placed at a distance from the detector equal to at least twice the detector diameter. The time constant in the main amplifier is also indicated: ORTEC uses 0.5 µsec pulse width at half the maximum pulse height for surface barrier detectors and 1 µsec for ULTRA detectors. The electronic noise of the detector is measured with the chain of

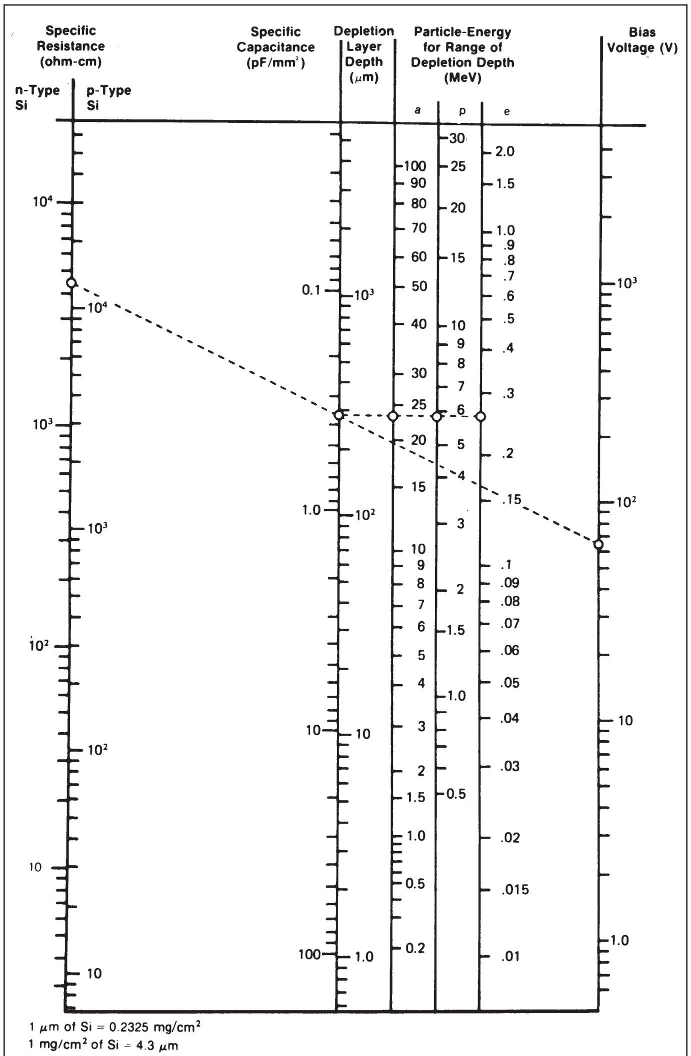

Fig. 3. Silicon Detector Parameters Nomograph. [Similar to Nomogram reported by J. L. Blankenship, *IEEE Trans. Nucl. Sci.* **NS7** (2–3), 190–195 (1960).]

A straight edge intersecting the center vertical line at the required depletion depth will give combinations of resistivity and detector bias that may be used to achieve that depth. (Shown, for example, is the voltage that must be applied to a 13,000 Ω-cm p-type or 4500 Ω-cm n-type silicon detector to stop a 23-MeV alpha, a 6-MeV proton, or a 250-keV electron within the depletion depth.)

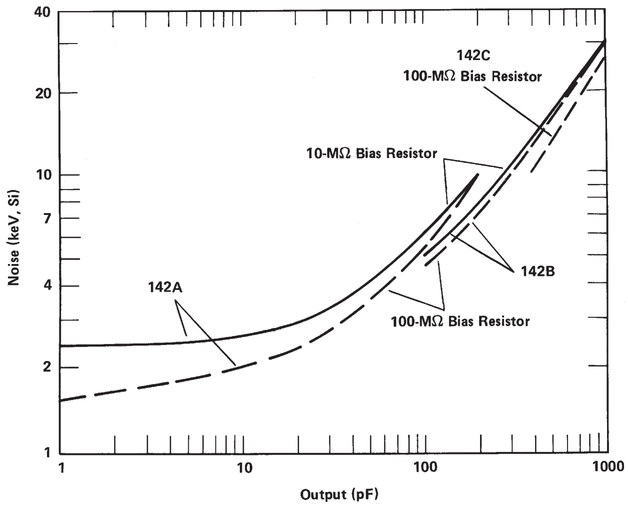

Fig. 4. Typical Noise Data for Model 142 Preamplifiers.
(Using ORTEC Shaping Amplifier with 0.5-μs shaping time constant.)

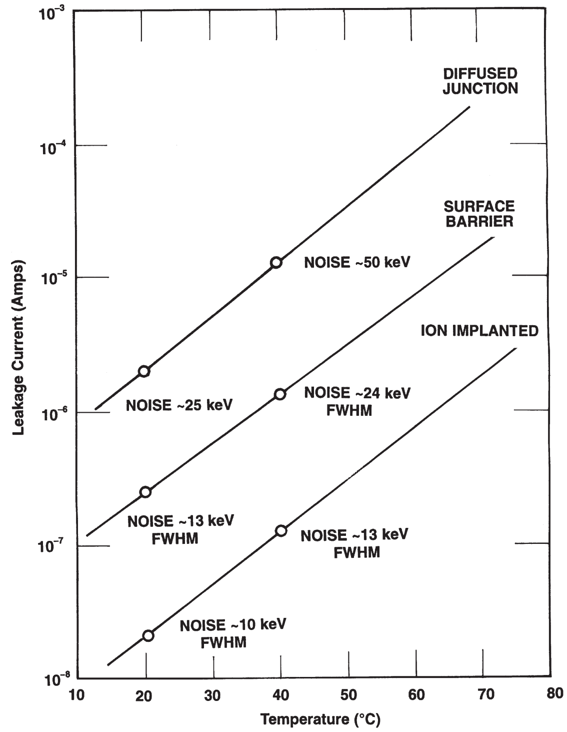

Fig. 5. Leakage Current and Noise vs. Temperature for 3 Types of Si Charged-Particle Detectors.

Fig. 6, with an electronic pulser replacing the alpha source. This noise has historically been referred to as the "Beta resolution" because when the detector is used with very low specific ionization particles such as conversion electrons (Fig. 7), the energy resolution is approximately equal to the noise. The energy resolution, measured as described above, depends on a number of factors; the most important are:

a) Electronic noise due to the detector leakage current and capacitance. This noise component can be minimized by choice of preamplifier and by optimum amplifier time constant selection. The time constant is preset at its optimum value in all ORTEC alpha spectrometers.

b) Electronic noise due to the bias resistor. This noise component increases with decreasing values of the bias resistor. Typically, the value of the bias resistor is sufficiently high to make this component negligible. However, at elevated detector temperatures, it may become necessary to decrease the value of the bias resistor, with a concomitant noise increase.

c) Energy loss and straggling in the detector entrance window . This factor is important when striving for high geometrical efficiency with the alpha source positioned as close as possible to the detector entrance contact. In this situation, alpha particles emitted perpendicular to the detector front contact pass through the entrance dead layer specified in the following summary table and, therefore, undergo the minimum energy loss; alpha particles that enter the front contact at an angle pass through a thicker dead layer, thereby losing more energy in the contact. The energy resolution is thus degraded.

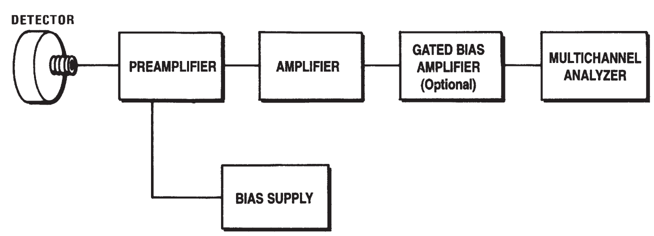

Fig. 6. Typical System for Charged-Particle Spectroscopy.

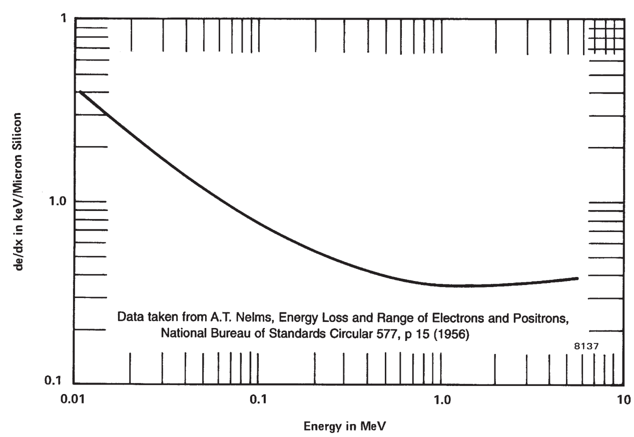

Fig. 7. Specific Energy Loss for Electrons in Silicon.
NOTE: Channeling of ions between crystal planes can result in significant variations from the data shown here.

Introduction to Charged-Particle Detectors

Effects of Operating Temperature on Noise and Energy Resolution

ULTRA ion-implanted detectors, used primarily for alpha spectroscopy, are generally operated at room temperature. When optimum resolution is required, it is useful to reduce the detector noise by operation at low temperature. This is best accomplished by using surface barrier detectors instead of ULTRA detectors. The noise and energy resolution of surface barrier detectors can be substantially decreased by operating below room temperature, down to approximately –60°C. Below that temperature no further improvement is obtained because, with the leakage now ≈pA, the noise is dominated by the preamplifier noise and the detector capacitance, the latter, of course, not being a function of temperature. Figs. 8 and 9 show typical electronic noise and energy resolution measurements obtained with surface barrier detectors.

With ion-implanted ULTRA detectors, the noise is substantially lower at all temperatures, making them a clear choice at higher temperatures. The energy resolution **increase** that can be expected with ULTRAs at elevated temperature is approximately 15–20 keV FWHM at 60°C.

In some rare cases it is of interest to operate silicon detectors at temperatures below that of LN_2, even down to <4 K. For such applications surface barrier detectors mounted with special cryogenic epoxy should be used. Totally depleted surface barrier detectors can be operated at such temperatures without adverse effects.[1,2]

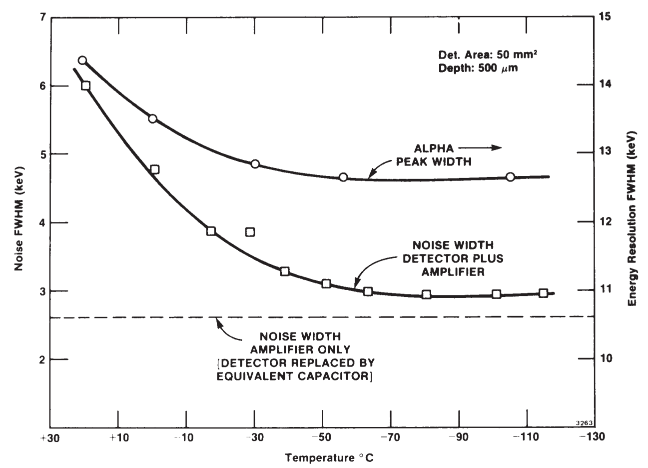

Fig. 8. Detector Noise and Alpha Energy Resolution as a Function of Temperature.

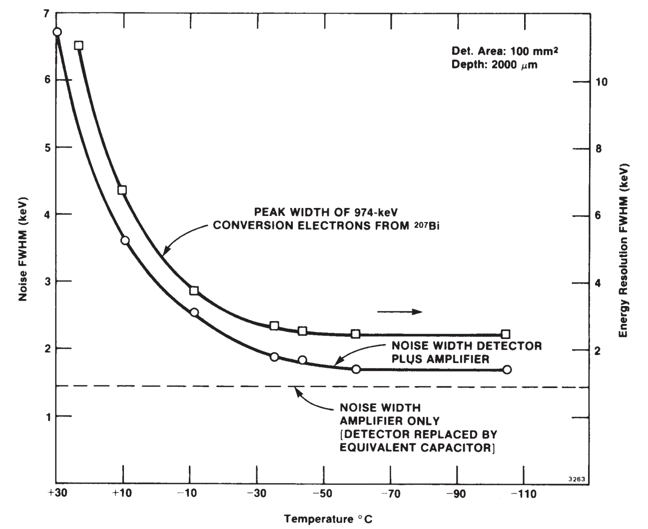

Fig. 9. Detector Noise and Electron Energy Resolution as a Function of Temperature.

Selecting the Appropriate Si Detector for Your Application

Alpha Spectroscopy

The detectors of choice for alpha spectroscopy are ULTRAs with a depletion depth of ≥100 microns and ULTRA-AS detectors for ultra-low background applications. Many established installations are equipped with reliable Ruggedized (R-Series) Surface Barrier Detectors. As these require negative bias, the U Series are not a direct replacement in alpha spectrometer units. (All other ORTEC charged-particle detectors require positive bias.)

The reasons why the ULTRA and ULTRA-AS lines are widely used in alpha spectroscopy are the following:

- Alpha spectroscopists with low activity samples often position samples as close as possible to the front detector contact. As noted above, the thin (500 Å silicon equivalent) window results in optimal energy resolution.
- The front contact is cleanable. (This is also true of R-Series Surface Barrier Detectors, but not of other surface barrier detectors.)
- The type of edge passivation used with ULTRA Series Detectors permits positioning the sample as close as 1 mm from the detector entrance contact; the minimum distance with surface barrier detectors is 2.5 mm. As, in many cases, the efficiency of the detector depends strictly on geometrical factors, ULTRA detectors provide higher efficiency than surface barrier detectors.
- The low leakage current results in low noise, also contributing to good energy resolution.

An issue of particular importance in alpha spectroscopy is the need to perform **low-background** measurements. As health physics regulations become more stringent, it is becoming increasingly important to be able to analyze samples with extremely low activity. Measurements performed at ORTEC have confirmed that the ultimate limit to the low- background performance of silicon detectors, when manufactured and packaged with special materials and following strict cleaning procedures, is associated with the omnipresent **cosmic radiation**. This limit in the energy range from 3–8 MeV is 0.05 counts/hr/10^{-2} cc of active volume. This means that for a 450 mm^2 active area, 100-μm thick, low- background ULTRA-AS (AS denotes low background), a background counting rate of about 6 counts/day is expected. **To achieve such a low level, one must take exquisite care both concerning previous or present vacuum chamber contamination and in detector handling procedures.**

To minimize cosmic ray interactions, ULTRA-AS series are made as thin as possible, consistent with achieving good resolution. As natural alpha particles have a range not exceeding 30 microns in silicon, it would seem that a depletion depth not exceeding 30 microns should be sufficient. It would be were it not for the fact that such a high-capacitance detector would display excessive noise. A depletion depth close to 100 microns provides the best tradeoff.

Some alpha spectroscopists employ an alpha recoil avoidance package to reduce the tendency for a gradual increase of background contamination on the detector surface. Information on this package is contained in the description of the ORTEC RCAP-2 system.

For rough spectroscopy and for simple counting applications (as in continuous air monitors), ORTEC offers the ruggedized ULTRA CAM line. ULTRA CAM detectors are light tight and moisture resistant.

Beta Spectroscopy and Counting

A key concern when selecting a silicon detector for room temperature beta spectroscopy or counting is the generation of a sufficiently large signal to well exceed the detector beta resolution. For example, 1 MeV electrons, which are minimum ionizing particles, deposit only 0.4 keV/micron of silicon (Fig. 7). The average energy loss in a 100-µm thick detector is 40 keV. As the threshold of the discriminator must be set 2.5 times above the beta resolution (noise), the beta resolution of the detector must be well below 15 keV FWHM to obtain meaningful data.

High quality beta spectroscopy cannot be obtained with room temperature silicon detectors. ORTEC offers a number of solutions:

- A complete Si(Li) detector-cryostat-preamplifier package, the BETA-X, for optimum energy resolution
- Thick, coolable silicon detectors (A- or L-Series).

Nuclear and Atomic Physics

The selection of appropriate detectors for nuclear and atomic physics is experiment dependent. Here are responses to frequently asked questions on this subject:

Q. Which detectors should be used for heavy-ion spectroscopy?

Because of the short, highly-ionized track of heavy ions, detectors with high electric field at the front contact (Fig. 2) are best. The F-Series Detectors have a warranted minimum electric field of 20,000 V/cm at the front contact.

Q. Which detectors and what techniques should be applied for low-energy ion and charged-particle spectroscopy?

For ions or particles in the energy range from 0 to 50 keV, one should cool both the detector and the first stage of the preamplifier. See "Detection Of Low Energy Heavy Particles With Silicon Barrier Detectors" by J.A. Ray and C.F. Barnett, IEEE Trans on Nuc. Sci. Vol NS-16, N1 (1969), pp. 82–86. An example of the results given in this paper is the spectrum shown in Fig. 10.

Q. Which detectors and what techniques should be applied for fast timing?

A silicon detector used for fast timing must have a high and uniform electric field throughout the depletion depth. Totally depleted detectors, such as an ULTRA or a high field partially depleted detector, capable of withstanding overbias should be used (Fig. 2). With particles in the MeV range and above, subnanosecond FWHM timing values are achievable (Ref: T.J. Paulus, et. al., IEEE NS-24, N1-1977).

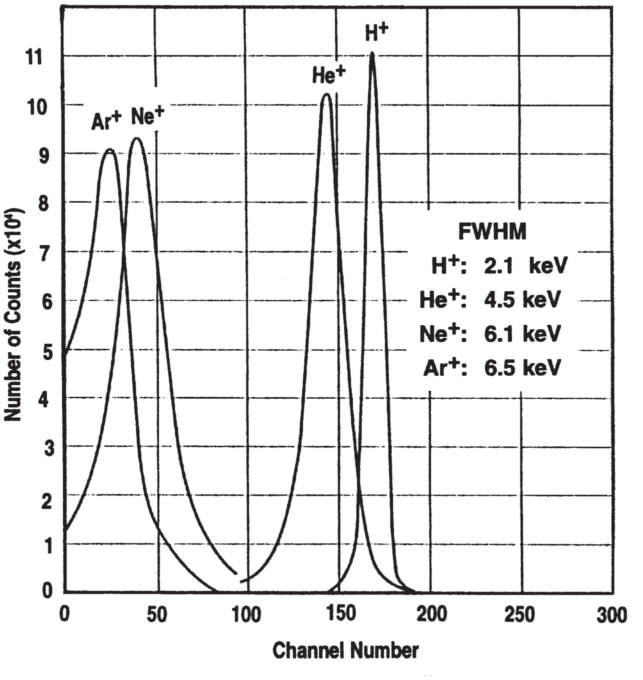

Fig. 10. The Pulse Height Spectrum of 40 keV H^+, He^+, Ne^+, and Ar^+ Ions from a 7 mm^2 Detector (700 µm Depletion Depth, 20 kΩ-cm Resistivity).

Introduction to Charged-Particle Detectors

Radiation Damage

Table 2 shows threshold doses for radiation damage with different types of charged particles.

The symptoms of radiation damage are: higher leakage current/noise followed by peak broadening and, sometimes, double peaking. In order to prolong the usable "life" of a detector in a radiation field causing damage, the detector must be kept cold (any cooling below room temperature helps; ideally the detector should be cooled to –60°C).

Table 2. Effects of Radiation Damage in Silicon Detectors.

Threshold Doses (particles/cm^2)				
Electrons	Fast Neutrons	Protons	Alpha Particles	Fission Fragments
10^{13}	10^{12}	10^{10}	10^{9}	10^{8}

Parameters Affecting Performance Characteristics

Many parameters affect the performance of silicon charged-particle detectors. A description of the major parameters follows.

Area

The sensitive area is important because it affects both efficiency and energy resolution. When a low-intensity radiation source is used or when an accurate particle count is required (within the count-rate limits of the system), a large-area detector is desirable. However, since detector capacitance and electronic noise are proportional to the area, smaller detectors give much better resolution. Selecting the right detector size requires a compromise between efficiency and resolution.

Sensitive Depth

For energy spectrometry each output pulse must be generated with an amplitude proportional to the energy of the charged particle. Therefore, for these common applications the detector's sensitive depth must be sufficient to completely absorb all the particle energy (Fig. 3). As the sensitive depth increases, the detector capacitance C_D decreases, and this results in a decrease in preamplifier noise. However, the increase in sensitive depth also increases the sensitive volume of the detector, and this may increase the detector leakage-current-noise contribution. Minimum total system noise is obtained by matching the capacitance of the detector to the appropriate preamplifier.

In applications involving spectrometry of heavy charged particles, rather large electric fields are required to ensure complete charge collection and to ensure linearity and optimum resolution. Consequently, for heavy-ion or fission-fragment spectrometry the maximum sensitive depth is established by the need for large electric fields.

For high-resolution timing applications, in which the rise time of the information pulse must be very short, the charge transit distances have to be kept as small as possible and large electric fields maintained. In such cases, the sensitive depth may be restricted by the need for very precise timing information and occasionally by the need to discriminate against unwanted background.

Capacitance

The major effects of detector capacitance are its influence on the noise contribution from the preamplifier and its deterioration of the preamplifier rise time. In applications that require low total noise, it is necessary to minimize the capacitance C_D by restricting the active area and/or by optimizing the sensitive depth. Stray capacitance from cables, connectors, etc., must be added to the detector capacitance to establish the total capacitive load that determines the preamplifier contribution to the noise, and therefore must be minimized.

Electric-Field Strength

The minimum electric-field strength required for complete charge collection (i.e., optimum resolution and response linearity) depends on the mass (specific ionization density) of the charged particle being analyzed, with the more massive particles requiring higher field strengths. For charged particles (alpha particles or lighter), this minimum field is attained by meeting the required resolution specifications. For heavy-ion (fission-fragment) detectors, however, and for very thin totally depleted detectors, in which the resolution cannot be routinely tested, the minimum specified electric-field strength has been established by experimental data obtained during actual use in the field. In applications requiring very high-resolution timing, it is desirable to keep the average field strength as large as possible, consistent with optimum noise and sensitive depth.

Breakdown Voltage

For a given resistivity material the breakdown voltage of the diode establishes an upper limit on the electric-field strength and on the depletion depth. ORTEC does not use breakdown voltage as a basic specification, because it is redundant if the sensitive depth, noise, resolution, and/or field strength are specified.

Reverse-Leakage Current

A large reverse-leakage current results in detector noise and excessive voltage drop across the bias supply resistor (R_b).* Since a quantitative relation between the detector leakage current and noise can be established only through a detailed knowledge of the origins of all current components, detector noise performance has been selected by ORTEC as the basic performance specification. Detectors whose leakage currents would produce excessive voltage drops across R_b are rejected by our quality-control standards. All ORTEC detectors are furnished with detailed data on their original leakage current so that this information may be used for troubleshooting and for estimates of the drop anticipated across R_b.

Silicon detectors made with ion-implantation and silicon-dioxide-passivated technologies have leakage current values substantially lower than surface barrier detectors of the same geometrical dimensions.

Detector Noise

Noise sources in the detector and the preamplifier introduce a dispersion that broadens a pulse-height spectrum of mono-energetic particles. Noise is customarily specified in terms of FWHM (full width half maximum) broadening of a mono-energetic peak. The detector and the preamplifier are separate and independent sources of noise, and the total system noise is equal to the square root of the sum of the squares of the individual noise contributions. Noise specifications for ORTEC detectors include the total noise width for the detector and standard ORTEC electronics at a temperature of 21 ±1°C. These noise widths and actual resolutions therefore can be guaranteed only when the contribution from any other electronics does not exceed that from the appropriate ORTEC electronics.

Energy Resolution

The noise-broadening effect previously mentioned establishes a lower limit on the energy resolution (FWHM) of any given detector-preamplifier combination. However, factors such as statistical effects, imperfect charge collection, and variations in energy lost in the dead layer of the source and of the detector can cause additional broadening of the peak; their relative contribution is a strong function of the mass of the incident particle. For beta particles, the resolution is nearly always determined solely by the electronic noise broadening. For alpha particles, the ultimate resolution (with no significant contribution from noise) appears to be less than 10 keV. For very heavy ions such as ^{127}I, the typical resolution for nonchanneled particles is about 1 MeV.

Pulse Rise Time

The pulse rise time associated with any ionizing event is a complex function of the mass, energy, range, and orientation of the ionizing particle; the detector parameters (depletion depth, electric-field strength, diode series resistance, and sensitive area); and the characteristics of the associated electronics. Pulse rise times for typical ORTEC charged-particle detectors range from the order of one nanosecond to tens of nanoseconds. The charge collection time in silicon detectors at room temperature is ~100 ns/mm. In many experiments requiring nanosecond or subnanosecond time resolution, good energy resolution is also desired, usually resulting in a need for compromises in detector parameters. Consequently, this high-resolution-time requirement, together with all other relevant experimental information, should be specified at time of first inquiry.

Stacked Detectors

For some applications, such as ($\Delta E/\Delta x$)(E) mass deter-minations and telescopic arrays, the energy range of the analyzed particles requires more depth than is provided by a single detector. Two or more detectors can then be combined so that the energy of the particle is totally absorbed in the detectors. The sum of the output pulses from the detectors will be proportional to the energy of the particle. For these applications the effective dead layer is the sum of the front and back dead layers (approximately equal to the electrode thickness) of all the detectors except the last one in the stack. For the last detector, only the front dead layer is considered. (Although all the detectors preceding the last one must be totally depleted, the last one need not be.) Quantitative, independent evaluation of this dead-layer thickness is supplied with each detector.

Parallel Connection of Two or More Detectors

In applications that require unusually large areas of sensitive depths, it is desirable to connect several detectors in parallel to the same preamplifier. In these circumstances, the total noise contribution to the energy resolution broadening can be determined by the following procedure:

The individual contributions of detector noise (total noise less preamplifier noise) are added by the mean-squares process:

$$N_{d,t}^2 = N_{d,1}^2 + N_{d,2}^2 + \cdots + N_{d,i}^2 \qquad (1)$$

where $N_{d,t}$ is the total noise contribution from the detectors and $N_{d,i}$ is the contribution of the ith detector.

*Resistor, usually located in the preamplifier, has a value of 10 MΩ.

The total capacitive load on the preamplifier is obtained by summing the detector capacitances and the stray capacitance:

$$C_t = C_{d,i} + C_{d,2} + \cdots + C_s = C_s + \sum_i C_{d,i} \qquad (2)$$

where C_t is the total load, $C_{d,i}$ is the capacitance of the ith detector, and C_s is the total stray capacitance, including that from cables, connectors, interconnections, etc. The value of C_t and the appropriate curve for preamplifier noise versus input capacitance are used to determine the preamplifier contribution to the noise. The total noise broadening is then obtained from

$$N_t^2 = N_{d,t}^2 + N_A^2 \qquad (3)$$

where N_t is the total noise width and N_A is the preamplifier's contribution to the noise.

Charged-Particle Detector Multiplexing

Often in low-level counting applications, multiple spectrometers are employed to keep up with large numbers of low-level samples to be counted. Because these are low- or ultra-low-level applications, count rates are extremely low. For this reason, it is possible to employ a multiplexed system, where a gated multiplexer-router is used to send pulses from multiple detectors to separate memory segments in an MCA system. This can lead to substantial cost savings. The more advanced of these systems provide for independent start, stop, and preset of the multiplexed inputs. Examples of such configurations from ORTEC are the 920E NIM MCB which provides 16 inputs and can connect directly to Ethernet, and the OCTÊTE-Plus, which is a complete integrated spectrometer with 8 complete chains including vacuum chamber, and the capacity to connect an additional eight existing vacuum chambers, making a very cost-effective system expansion.

Thickness Uniformity

Inadequate thickness uniformity of totally depleted ΔE detectors has undoubtedly been responsible for many disappointing experiments. A 10-MeV ^{4}He particle incident on a 50-µm-thick silicon detector will lose approximately 5.9 MeV in traversing the detector. The rate of energy loss (dE/dx) of the exiting particle, however, will be about 160 keV/µm. This means that a detector thickness variation of 1 µm would cause an energy spread of 160 keV, which is many times greater than the detector resolution for particles that are completely absorbed in the detector. Considerations such as these show that precise control over the thickness uniformity of a device is highly desirable for many experiments. ORTEC uses an exclusive mechanical electrochemical wafer-polishing process that produces damage-free surfaces that are optically flat and parallel. By testing the wafers with optical interference techniques and by profiling the thickness of each wafer with an x-ray transmission technique, ORTEC ensures that each silicon wafer meets stringent thickness-uniformity specifications before being accepted as a planar totally depleted surface barrier detector (D Series). The measured mean detector thickness and uniformity are given on the Quality Assurance Data Sheet that accompanies each D Series detector.

Channeling and Crystal Orientation

The channeling of ions between crystal planes can produce significant differences in the rate of energy loss (and total range) between channeled and unchanneled ions. For very heavy ions this same effect can produce pronounced differences in the pulse-height linearity and energy resolution. Consequently, the silicon wafers for ORTEC totally-depleted and standard heavy-ion detectors are cut from the parent crystal at an angle that has been carefully selected to minimize channeling effects. Silicon charged-particle detectors that are cut at specific orientations are available on special order.

Test Data and General Information

Alpha Resolution

Alpha resolution is specified as the maximum peak width for a standard alpha source measured at one-half the peak height (FWHM) expressed in keV. The total system alpha resolution is measured and warranted for 5.486-MeV alphas from ^{241}Am with an ORTEC preamplifier chosen to be consistent with the detector capacitance and an ORTEC amplifier using equal differential and integral time constants as follows:

0.5 µs for A, B, C, F, L, and R Series;

1.0 µs for ULTRA, ULTRA-AS, and ULTRA CAM.

For totally depleted B Series detectors with ≤500-µm thicknesses, the alpha resolution is measured through the exit (low-field strength) contact, and >500-µm detectors measured with alpha particles through the front contact. The D and F Series are not warranted for alpha resolution but are warranted for system noise with suitable ORTEC electronics. Unless specified otherwise, resolution measurements are performed and warranted at 21 ±1°C.

Beta Resolution (System Noise)

The system noise width guaranteed maximum FWHM (which approximates beta resolution) is listed for each type of detector. Unless specified otherwise, measurements are performed and warranted at 21 ±1°C.

Electrons (beta particles) are, to a first approximation, sufficiently light to cause zero energy loss in the entrance window of silicon detectors. The beta energy resolution of silicon detectors is thus determined by the electronic noise of the detector and preamplifier; hence, the interchangeable "beta resolution/system noise" terminology.

Discriminator Threshold Setting

When silicon detectors are used as beta spectrometers, the threshold of the lower-level discriminator in the electronics must be set at 2.5 times the "beta resolution" to avoid spurious noise counts. Because the specific ionization of electrons is very low (e.g., 0.35 keV/μm for minimum ionizing betas), it is often necessary to cool silicon detectors used as beta spectrometers. (Detectors with cryogenic epoxy must be special-ordered.) When this is done, the electronic noise caused by the detector leakage current is eliminated and the detector becomes equivalent to a pure capacitor. The electronic noise of the system can then be easily calculated from the noise vs. capacitance characteristics of the preamplifier.

[1] M. Martini, T.A. McMath, I.L. Fowler, "The Effects of Operating Temperature on the Behavior of Semiconductor Detectors," *IEEE Trans. on Nucl. Sci.*, Vol. NS-17, No. 3, pp. 139–148 (1970).

[2] C. Canali, M. Martini, G. Ottaviani, A. Alberigi-Quaranta, "Measurement of the Average Energy per Electron-Hole Pair Generation in Silicon between 5 and 320 K," *IEEE Trans. on Nucl. Sci.*, Vol. NS-19, N4, pp. 9–19 (1972).

Introduction to Charged-Particle Detectors

ORTEC Charged-Particle Detector Data Summary and Selection Chart

Series	Chief Application	Starting Material	Range of Active Area (mm^2)	Range of Active Thickness (μm)	Warranted Operating Temperature Range*	Diode Structure	Nominal Structure** Stopping Power of Wndows	
							Entrance	Exit
ULTRA†	High-resolution, high-efficiency alpha and beta spectroscopy	Si	25–3000	100–500	+60°C to –196°C (LN_2)	Implanted Boron — N-type Si Implanted As Partial Depletion	500 Å Si	
ULTRA AS†	Ultra-low background high-efficiency alpha spectroscopy	Si	300–1200	100	+60°C to –196°C (LN_2)	Implanted Boron — N-type Si Implanted As Partial Depletion	500 Å Si	
ULTRA CAM†	Alpha and beta continuous air monitoring (counting in adverse environment)	Si	300–2000	100 (Deeper detector requires special order)	+60°C to –196°C	Implanted Boron — N-type Si Implanted As Partial Depletion	N/A	
A	High-Resolution charged-particle spectroscopy (Nuclear Physics and Chemistry-Space Physics)	Si	25–450	1000–5000	+25°C to –30°C‡	Gold — N-type Si Aluminum Partial Depletion	800 Å Si	
B	Particle identification, telescopes of detectors (Nuclear Physics and Chemistry-Space Physics)	Si	50–450	150–5000	+25°C to –30°C‡	Gold — N-type Si Aluminum Total Depletion	800 Å Si	2250 Å Si
C	Backscattering from a collimated source or beam target-angular correlation measurements (Nuclear Physics)	Si	50–450	100–1000	25°C to –30°C‡	Gold — N-type Si Aluminum Partial Depletion	800 Å Si	2250 Å Si
D	Time-of-flight measurements with heavy ions (Nuclear Physics)	Si	10–450	15–100	10°C to 25°C	Gold — N-type Si Aluminum Total Depletion Planar	800 Å Si	2250 Å Si
F	Heavy-ion spectroscopy (Nuclear Physics)	Si	100–900	≥60	+25°C to –30°C‡	Gold — N-type Si Aluminum Partial Depletion High Field Strength	800 Å Si	
L	Medium-energy proton (25 MeV) and other charged-particle energy spectroscopy	Si (Lithium compensated)	25–200	5000	+25°C to –196°C (LN_2)	Gold — Lithium Compensated P-type Si Lithium (diffused)	2000 Å Si	
P	Simultaneous measurement of charged-particle energy and position (Nuclear Physics)	Si	8 x 47	100–1000	+25°C to –30°C‡	Implanted Boron — N-type Si Aluminum Partial Depletion	3200 Å Si	
R	Charged-particle spectroscopy operable in air and ambient light	Si	50–2000	100–500	+25°C to –30°C‡	Aluminum — P-type Si Gold Partial Depletion	2300 Å Si	
Beta-X§	High-resolution beta spectroscopy	Si (Lithium compensated)	80	5000	–196°C (LN_2)	Gold — Lithium Compensated — P-type Si Lithium (diffused)	2000 Å Si	

** Measured with 5.486-MeV natural alpha particles.
† ULTRA series detectors are manufactured by ion-implantation silicon-dioxide passivated technologies. Versions bakeable at 200°C available on special order.
‡ Available with special cryogenic mount capable of cycling down to LN_2 temperature.
§ The Beta-X detector is offered in a sealed cryostat.

Specifications subject to change
040810

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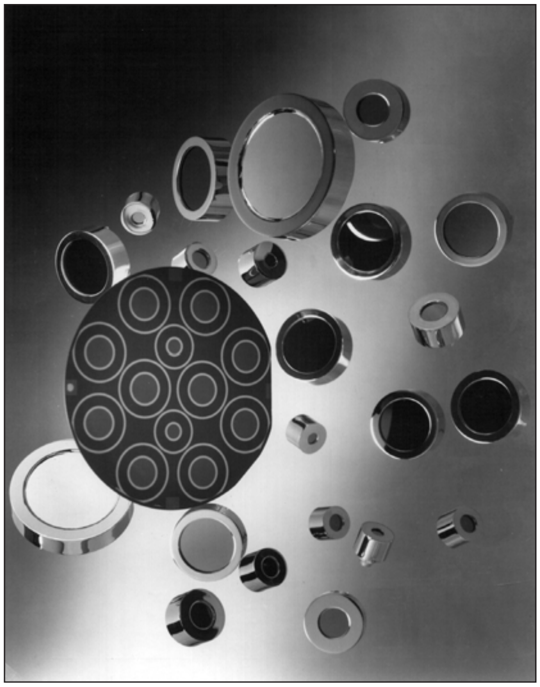
ULTRA and ULTRA AS

Ion-Implanted-Silicon Charged-Particle Detectors

ULTRA

- **The standard for charged-particle detector spectroscopy.**
- **Ultra-thin entrance contact for optimum energy resolution.**
- **High geometric efficiency due to close detector-to-can spacing.**
- **Rugged and reliable.**
- **Gold-plated cans for contacts that last a lifetime.**
- **Advanced surface passivation for total device stability.**
- **ORTEC quality and reliability.**
- **Bakeable at 200°C (require special order).**



ULTRA-AS

- **Low-background version for alpha spectroscopy.**

ULTRA ion-implanted-silicon detectors for alpha and beta spectroscopy are the most advanced charged-particle detectors ever produced. They possess the reliability that has made ORTEC the sole supplier to NASA of silicon detectors for space applications.

Both the entrance and the back contact are ion implanted. The entrance contact is an extremely thin (~500 Å) boron implantation. Since no epoxies are used to mount the ULTRA detectors, the distance between the silicon surface and the top of the mounting can is <1 mm; this provides maximum geometric efficiency. The rugged front contact, easily cleaned with a solvent-moistened cotton swab, is impervious to finger contact.

ULTRA detectors have **gold**-plated mounting cans. The superior electrical conductivity of gold, which can never oxidize, makes it the choice versus stainless steel or aluminum. Gold contacts last a lifetime. An advanced surface passivation that covers the critical silicon dioxide layer guarantees absolute device stability.

The extremely low leakage current permits specifying the energy resolution at a 1-μs amplifier time constant.

Low-background ULTRA-AS detectors are made with special low-background materials and have an optimized depletion thickness to minimize background counts from cosmic rays. All ORTEC Alpha Spectrometers (Alpha Aria, Alpha Duo, Alpha Ensemble, 576A, and SOLOIST) are equipped with either ULTRA-AS detectors or R-Series, Ruggedized Surface Barrier Detectors. All these spectrometers, when equipped with a 450 mm^2 detector, have a warranted background performance of ≤24 counts per day, over the 3- to 8-MeV energy range.

The dimensions of the ULTRA and ULTRA-AS detector mounting cans, identical to those of the corresponding size A or R Series detectors, ensure that ULTRA detectors will fit perfectly in any application where A or R Series detectors are being used now.

*Extensive care regarding detector and chamber cleanliness can result in background count levels as low as 0.05 counts/hr/cm^2 of active area, corresponding to 6 counts/24 hours, for a 450 mm^2 active area.

**U Series detectors are not a direct replacement in alpha spectrometer units for R Series detectors. R Series detectors require negative polarity bias, whereas all other ORTEC charged-particle detectors require positive bias.

ULTRA and ULTRA AS

Ion-Implanted-Silicon Charged-Particle Detectors

Ordering Information

ULTRA **Specify B, C or "Blind" T** Mount.**

Active Area (mm²)	Guaranteed Maximum Resolution* (keV FWHM)		Minimum Depletion Depth 100 µm	Guaranteed Maximum Resolution* (keV FWHM)		Minimum Depletion Depth 300 µm	Guaranteed Maximum Resolution* (keV FWHM)		Minimum Depletion Depth 500 µm
	α	β	Model No.	α	β	Model No.	α	β	Model No.
25	12	6	U-012-025-100	11	5	U-011-025-300	11	5	U-011-025-500
	14	8	U-014-025-100	13	7	U-013-025-300	12	6	U-012-025-500
50	12	6	U-012-050-100	11	5	U-011-050-300	11	5	U-011-050-500
	14	8	U-014-050-100	13	7	U-013-050-300	13	7	U-013-050-500
100	13	7	U-013-100-100	12	6	U-012-100-300	12	6	U-012-100-500
	15	9	U-015-100-100	14	8	U-014-100-300	14	8	U-014-100-500
150	14	9	U-014-150-100	13	8	U-013-150-300	12	7	U-012-150-500
	16	10	U-016-150-100	15	9	U-015-150-300	14	9	U-014-150-500
300	16	11	U-016-300-100	15	10	U-015-300-300	14	9	U-014-300-500
	19	14	U-019-300-100	18	13	U-018-300-300	17	12	U-017-300-500
450	17	12	U-017-450-100	16	11	U-016-450-300	15	10	U-015-450-500
	21	16	U-021-450-100	20	15	U-020-450-300	19	14	U-019-450-500
600	22	17	U-022-600-100	21	16	U-021-600-300	20	15	U-020-600-500
	24	19	U-024-600-100	23	18	U-023-600-300	22	17	U-022-600-500
900	27	22	U-027-600-100	25	20	U-025-900-300	23	18	U-023-900-500
	33	28	U-033-900-100	30	25	U-030-900-300	28	23	U-028-900-500
1200	35	30	U-035-1200-100	30	25	U-030-1200-300	28	23	U-028-1200-500
	42	37	U-042-1200-100	37	32	U-037-1200-300	35	30	U-035-1200-500
2000	50	45	U-050-2000-100	40	35	U-040-2000-300	35	30	U-035-2000-500
	58	53	U-058-2000-100	48	43	U-048-2000-300	43	38	U-043-2000-500
3000	60	55	U-060-3000-100	55	50	U-055-3000-300	50	45	U-050-3000-500
	70	65	U-070-3000-100	65	60	U-065-3000-300	60	55	U-060-3000-500

* First three digits of Model No. indicate total system resolution FWHM for ^{241}Am, 5.486-MeV alphas, using standard ORTEC electronics and 1-µs shaping time constants.
** "Blind" T Mount available only for 300, 450 and 600-mm² ULTRAs, except by special order.

ULTRA-AS **Specify B, C or "Blind" T** Mount**

~100 µm active depth to minimize cosmic background

Active Area (mm²)	Alpha Resolution* (keV FWHm @5.486 MeV)	Model No.
300	19	U-019-300-AS
450	20	U-020-450-AS
490	20	U-020-490-AS
600	24	U-024-600-AS
900	29	U-029-900-AS
1200	37	U-037-1200-AS

* First three digits of Model No. indicate total system resolution FWHM for ^{241}Am, 5.486-MeV alphas, using standard ORTEC electronics and 1-µs shaping time constants.
** "Blind" T Mount available only for 300, 450 and 600-mm² ULTRA-AS, except by special order.

To Order:

Add the appropriate letter **prefix** for the mounting desired.

Example: **BU**-016-300-100 or **TU**-016-300-100.**

ULTRA and ULTRA AS

Ion-Implanted-Silicon Charged-Particle Detectors

Mounting Arrangements

B Microdot connector on the rear of the can.

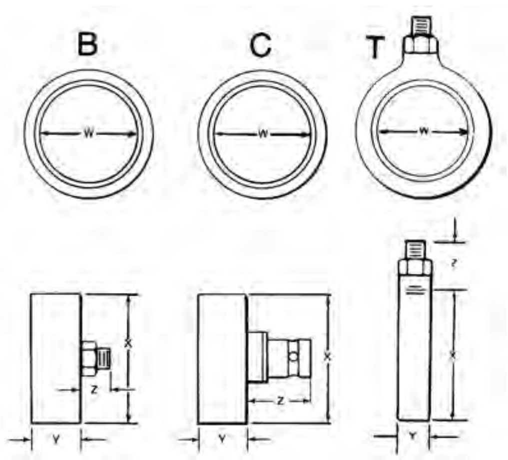
C BNC connector on the rear of the can.

T Microdot on the side of the can; without adjustable screws. Available only for 300-, 450-, and 600-mm² detectors, except by special order.

For ULTRA or ULTRA-AS detectors in 576A Alpha Spectrometer modules having a horizontal sample tray, only one side of the can has an opening.

V, W, X, Y, and Z dimensions are given in millimeters.

§Built into a Microdot connector only.



Detector Size (mm²)	W (Nominal)	Type B Rear Microdot			Type C Rear BNC			Type T § Transmission Mount		
		X	Y	Z	X	Y	Z	X	Y	Z
025	5.6	16.7	12.3	7.1	16.7	12.3	15.9	19.4	7.9	9.9
050	8.0	16.7	12.3	7.1	16.7	12.3	15.9	19.4	7.9	9.9
100	11.3	23.6	12.3	7.1	23.6	12.3	15.9	26.1	7.9	9.9
150	13.8	23.6	12.3	7.1	23.6	12.3	15.9	26.1	7.9	9.9
300	19.5	28.6	12.3	7.1	28.6	12.3	15.9	31.6	7.9	9.9
450	23.9	32.0	12.3	7.1	32.0	12.3	15.9	34.8	7.9	9.9
490	25.0	33.4	12.3	7.1	33.4	12.3	15.9			
600	27.6	36.1	12.3	7.1	36.1	12.3	15.9	38.4	7.9	9.9
900	33.9	45.2	12.3	7.1	45.2	12.3	15.9			
1200	40.0	48.8	12.3	7.1	48.8	12.3	15.9			
2000	51.0	65.5	12.3	7.1	65.5	12.3	15.9			
3000	62.0	76.2	12.3	7.1	76.2	12.3	15.9			
Tol.	±0.5	±0.3	±0.3	±0.3	±0.3	±0.3	±0.3	±0.3	±0.3	±0.3

Specifications subject to change
040810

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AMETEK® ADVANCED MEASUREMENT TECHNOLOGY

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ULTRA CAM

Ion-Implanted-Silicon Detector for Continuous Air Monitoring

- **Alpha and beta continuous air monitoring (counting in adverse environment).**
- **Rugged and reliable.**
- **Ion-implanted front contact.**
- **Protective polymer front-contact coating.**
- **Low bias voltage.**
- **Advanced surface passivation for total device stability.**

Continuous air monitoring (CAM) instrumentation is used for counting, or rough-spectroscopy, of alpha particles from filters used with continuous air monitors. ULTRA CAM detectors set a new standard for silicon detectors for this purpose.

Since CAM instruments must work in air, exterior light, and under uncontrolled ambient conditions, the entrance contact of the ULTRA CAM detectors is coated with both an aluminum evaporation and a thin polymer film for protection against adverse environmental conditions, such as high humidity.

ULTRA CAM detectors have active areas ranging from 300 to 2000 mm^2. They operate at low voltage (+15 to 24 volts). This means that a separate HV supply is not required; the NIM +24 volt supply can be used for application of bias.

ULTRA CAM detectors are designed for use in air and are not suitable for use in a vacuum. These sealed detectors should not be put into a vacuum.

*U Series detectors are not a direct replacement in alpha spectrometer units for R Series detectors. R Series detectors require negative polarity bias, whereas all other ORTEC charged-particle detectors require positive bias.

Ordering Information

Supplied with B Mount unless otherwise specified.

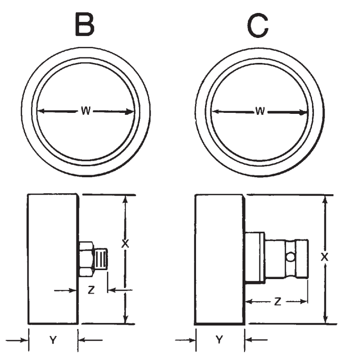
Active Area (mm^2)	Minimum Depletion Depth 100 µm* Model No.
300	U-CAM-300
450	U-CAM-450
490	U-CAM-490
600	U-CAM-600
900	U-CAM-900
1200	U-CAM-1200
2000	U-CAM-2000

*Deeper detectors available on special order.

Mounting Arrangements

B Microdot connector on the rear of the can.
C BNC connector on the rear of the can.
W, X, Y, and Z dimensions are given in millimeters.

Detector Size (mm^2)	W (Nominal)	Type B Rear Microdot			Type C Rear BNC		
		X	Y	Z	X	Y	Z
300	19.5	28.6	12.3	7.1	28.6	12.3	15.9
450	23.9	32.0	12.3	7.1	32.0	12.3	15.9
490	25.0	33.4	12.3	7.1	33.4	12.3	15.9
600	27.6	36.1	12.3	7.1	36.1	12.3	15.9
900	33.9	45.2	12.3	7.1	45.2	12.3	15.9
1200	40.0	48.8	12.3	7.1	48.8	12.3	15.9
2000	51.0	65.5	12.3	7.1	65.5	12.3	15.9
Tol.	±0.5	±0.3	±0.3	±0.3	±0.3	±0.3	±0.3



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A Series

Partially Depleted Silicon Surface Barrier Detectors

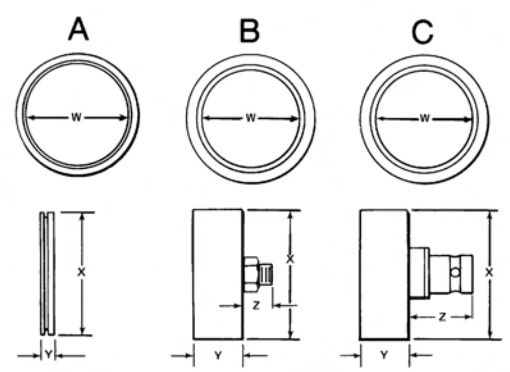
Main Application: High-resolution charge-particle spectroscopy.

Supplied with B Mount unless otherwise specified.

Active Area (mm²)	Guaranteed Maximum Resolution (keV)**		Minimum Depletion Depth 1000 µm	Guaranteed Maximum Resolution (keV)**		Minimum Depletion Depth 1500 µm§	Guaranteed Maximum Resolution (keV)**		Minimum Depletion Depth 2000 µm§
	α	β	Model No.	α	β	Model No.	α	β	Model No.
25	13 14	6 6	A-013-025-1000 A-014-025-1000	14 16	9 11	A-014-025-1500 A-016-025-1500	16	11	A-016-025-2000
50	14 15	7 8	A-014-050-1000 A-015-050-1000	16 18	11 13	A-016-050-1500 A-018-050-1500	17	12	A-017-050-2000
100	14 15	7 8	A-014-100-1000 A-015-100-1000	17 19	12 14	A-017-100-1500 A-019-100-1500	18	13	A-018-100-2000
150	15 16	9 10	A-015-150-1000 A-016-150-1000	18 20	13 15	A-018-150-1500 A-020-150-1500	19	14	A-019-150-2000
300	17 18	13 14	A-017-300-1000 A-018-300-1000	20 23	15 18	A-020-300-1500 A-023-300-1500	22	17	A-022-300-2000
450	18 19	13 14	A-018-450-1000 A-019-450-1000	21 26	16 21	A-021-450-1500 A-026-450-1500			

** First three digits of Model No. indicate total system resolution FWHM for ^{241}Am, 5.486-MeV alphas, using standard ORTEC electronics and 0.5-µs shaping time constants. Beta resolution approximated by pulse generator width FWHM.

§ Requires special order.



Rectangular Detectors

Partially depleted and totally depleted rectangular detectors are available on special request.

Special Configurations

Special configuration charged-particle detectors are available on special request.

Mounting Arrangements

A This is a "ring mount"; i.e., the silicon wafer is offered on its ring without output connectors. This infrequently used arrangement is available on special request.

B Microdot connector on the rear of the can.

C BNC connector on the rear of the can.

Dimensions are given in millimeters.

For detectors 1500 or 2000 µm deep, add 1.5 mm to the Y dimension.

Detector Size (mm²)	W (Nominal)	Type A Mount		Type B Rear Microdot			Type C Rear BNC		
		X	Y	X	Y	Z	X	Y	Z
025	5.6	15.2	3.7	16.7	12.3	7.1	16.7	12.3	15.9
050	8.0	15.2	3.7	16.7	12.3	7.1	16.7	12.3	15.9
100	11.3	22.0	3.7	23.6	12.3	7.1	23.6	12.3	15.9
150	13.8	22.0	3.7	23.6	12.3	7.1	23.6	12.3	15.9
300	19.5	27.1	3.7	28.6	12.3	7.1	28.6	12.3	15.9
450	23.9	30.5	3.7	32.0	12.3	7.1	32.0	12.3	15.9
Tol.	±0.5	±0.3	±0.3	±0.3	±0.3	±0.3	±0.3	±0.3	±0.3

Specifications subject to change
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B Series

Totally Depleted Silicon Surface Barrier Detectors

Main Application: Particle identification, telescopes of detectors, any type of ΔE measurements. In addition to ΔE/Δx experiments, the uniformly high field of B Series detectors makes them the best choice for rise-time discrimination or for precision timing experiments. These detectors are also useful in any experiment where an A Series detectors is used; B Series detectors are preferable if radiation damage is likely.

Supplied with T Mount unless otherwise specified.

Active Area (mm²)	Guaranteed Maximum Resolution (keV)**		Depletion Depth 150 µm Range: 125–175 µm	Depletion Depth 200 µm Range: 176–225 µm	Depletion Depth 250 µm Range: 226–275 µm	Depletion Depth 300 µm Range: 276–350 µm	Depletion Depth 400 µm Range: 351–450 µm
	α	β	Model No.	Model No.	Model No.	Model No.	Model No.
50	15 16	6 7	B-015-050-150 B-016-050-150	B-015-050-200 B-016-050-200	B-015-050-250 B-016-050-250	B-015-050-300 B-016-050-300	B-015-050-400 B-016-050-400
150	17 18	9 10	B-017-150-150 B-018-150-150	B-017-150-200 B-018-150-200	B-017-150-250 B-018-150-250	B-017-150-300 B-018-150-300	B-017-150-400 B-018-150-400
300	19 20	12 15	B-019-300-150 B-020-300-150	B-019-300-200 B-020-300-200	B-019-300-250 B-020-300-250	B-019-300-300 B-020-300-300	B-019-300-400 B-020-300-400
450	23 24	17 19	B-023-450-150 B-024-450-150	B-023-450-200 B-024-450-200	B-023-450-250 B-024-450-250	B-023-450-300 B-024-450-300	B-023-450-400 B-024-450-400

Active Area (mm²)	Guaranteed Maximum Resolution (keV)**		Depletion Depth 500 µm Range: 451–550 µm	Depletion Depth 700 µm Range: 650–750 µm	Depletion Depth 1000 µm Range: 950–1050 µm	Guaranteed Maximum Resolution (keV)**		Depletion Depth 1500 µm§ Range: 1450–1550 µm
	α	β	Model No.	Model No.	Model No.	α	β	Model No.
50	15 16	8 9	B-015-050-500 B-016-050-500	B-015-050-700 B-016-050-700	B-015-050-1000 B-016-050-1000	17 19	12 14	B-017-050-1500 B-019-050-1500
150	17 18	9 10	B-017-150-500 B-018-150-500	B-017-150-700 B-018-150-700	B-017-150-1000 B-018-150-1000	19 21	14 16	B-019-150-1500 B-021-150-1500
300	19 20	13 14	B-019-300-500 B-020-300-500	B-019-300-700 B-020-300-700	B-019-300-1000 B-020-300-1000	21	16	B-021-300-1500
450	21 23	16 18	B-021-450-500 B-023-450-500	B-021-450-700 B-023-450-700	B-021-450-1000 B-023-450-1000	24	19	B-024-450-1500

Active Area (mm²)	Guaranteed Maximum Resolution (keV)**		Depletion Depth 2000 µm§ Range: 1950–2050 µm
	α	β	Model No.
50	18	13	B-018-050-2000
150	20	15	B-020-150-2000
300	23	18	B-023-3000-2000
450	26	21	B-026-450-2000

* All standard totally depleted detectors are cut off-axis from the parent crystal at a specific angle that will minimize ion channeling. Supplied in T Mount unless specified otherwise by appropriate letter prefix. Other areas and depths available on special order.

** First three digits of Model No. indicate total system resolution FWHM for ^{241}Am, 5.486-MeV alphas, using standard ORTEC electronics and 0.5-µs shaping time constants. Beta resolution approximated by pulser width FWHM.

§ Requires special order.

Mounting Arrangements

A This is a "ring mount"; i.e., the silicon wafer is offered on its ring without output connectors. This infrequently used arrangement is available on special request.

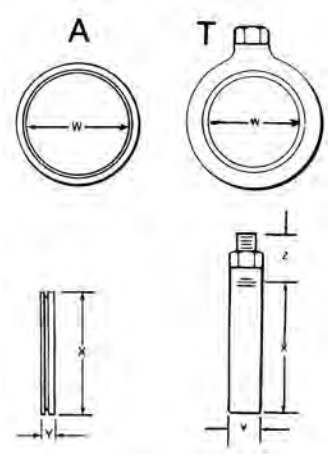
T Microdot on the side of the can; without adjustable screws. (Open back.)

Dimensions are given in millimeters.

§ Built into a Microdot connector only.

For detectors 1500 or 2000 µm deep, add 1.5 mm to the Y dimension.

Detector Size (mm^2)	W (Nominal)	Type A Mount		Type T § Transmission Mount		
		X	Y	X	Y	Z
050	8.0	15.2	3.7	19.4	7.9	9.9
150	13.8	22.0	3.7	26.1	7.9	9.9
300	19.5	27.1	3.7	31.6	7.9	9.9
450	23.9	30.5	3.7	34.8	7.9	9.9
Tol.	±0.5	±0.3	±0.3	±0.3	±0.3	±0.3



Specifications subject to change
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C Series

Annular Partially Depleted Silicon Surface Barrier Detectors

Main Application: Backscattering from a collimated source or beam target; angular correlation measurements.

Supplied with T Mount unless otherwise specified.

Total Area Including 4-mm-diam. Hole (mm^2)	Guaranteed Maximum Resolution (keV)**		Minimum Depletion Depth 100 µm	Minimum Depletion Depth 300 µm	Minimum Depletion Depth 500 µm	Guaranteed Maximum Resolution (keV)**		Minimum Depletion Depth 1000 µm
	α	β	Model No.	Model No.	Model No.	α	β	Model No.
50	17	9	C-017-050-100	C-017-050-300	C-017-050-500	18	10	C-018-050-1000
150	19	12	C-019-150-100	C-019-150-300	C-019-150-500	20	12	C-020-150-1000
300	21	14	C-021-300-100	C-021-300-300	C-021-300-500	22	15	C-022-300-1000
450	25	20	C-025-450-100	C-025-450-300	C-025-450-500	25	20	C-025-450-1000

* Supplied in T Mount unless specified otherwise by appropriate letter prefix; 4-mm hole is standard, 6- or 8-mm hole or other areas and depths available on special order.

** First three digits of Model No. indicate total system resolution FWHM for ^{241}Am, 5.486-MeV alphas, using standard ORTEC electronics and 0.5-µs shaping time constants. Beta resolution approximated by pulse generator width FWHM.

Mounting Arrangements

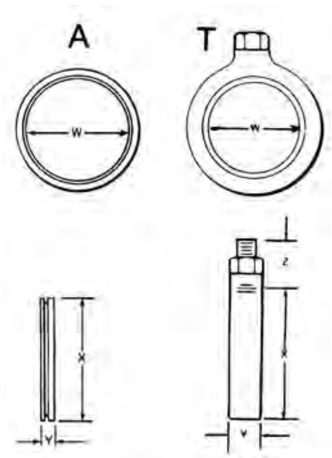
A This is a "ring mount"; i.e., the silicon wafer is offered on its ring without output connectors. This infrequently used arrangement is available on special request.

T Microdot on the side of the can; without adjustable screws. (Open back.)

Dimensions are given in millimeters.

§ Built into a Microdot connector only.

Detector Size (mm^2)	W (Nominal)	Type A Mount		Type T § Transmission Mount		
		X	Y	X	Y	Z
050	8.0	15.2	3.7	19.4	7.9	9.9
150	13.8	22.0	3.7	26.1	7.9	9.9
300	19.5	27.1	3.7	31.6	7.9	9.9
450	23.9	30.5	3.7	34.8	7.9	9.9
Tol.	±0.5	±0.3	±0.3	±0.3	±0.3	±0.3



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D Series

Planar Totally Depleted Silicon Surface Barrier Detectors

Main Application: Time-of-Flight measurements with heavy ions.

Unless specified otherwise, supplied in E Mount for 10–25 µm thickness; in T Mount for >25 µm thickness.

Active Area (mm^2)	Maximum Thickness Variation (µm)	Depletion Depth 15 µm Range 7-15 µm	Depletion Depth 25 µm Range 15.1-25 µm	Depletion Depth 40 µm Range 25.1-40 µm	Depletion Depth 50 µm Range 40.1-65 µm	Depletion Depth 75 µm Range 65.1-85 µm	Depletion Depth 100 µm Range 85.1-110 µm
		Model No.	Model No.	Model No.	Model No.	Model No.	Model No.
10	±0.5	D-020-010-15					
50	±0.5	D-035-050-15	D-035-050-25	D-020-050-40	D-015-050-50	D-015-050-75	D-015-050-100
150	±1.0		D-060-150-25	D-035-150-40	D-030-150-50	D-030-150-75	D-025-150-100
300	±1.0		D-095-300-25	D-055-300-40	D-045-300-50	D-040-300-75	D-030-300-100
450	±3.0		D-100-450-25	D-090-450-40	D-070-450-50	D-060-450-75	D-060-450-100

* All standard totally depleted detectors are cut off-axis from the parent crystal at a specific angle that will minimize channeling. Larger areas available on special order. Other areas and depths available on special order.

** First three digits of Model No. indicate total system noise width measured with standard ORTEC electronics and 0.5-µs shaping time constants. Noise width is given for the smallest thickness (largest capacitance) in each range and specified nominal area. For high-capacitance units, performance depends on actual thickness and area.

Mounting Arrangements

A This is a "ring mount"; i.e., the silicon wafer is offered on its ring without output connectors. This infrequently used arrangement is available on special request. For 40 µm to 100 µm detectors.

E This is a special type of transmission mount in which four screws can be carefully adjusted to avoid excessive pressure on particularly fragile silicon wafers. For 15 µm to 25 µm detectors.

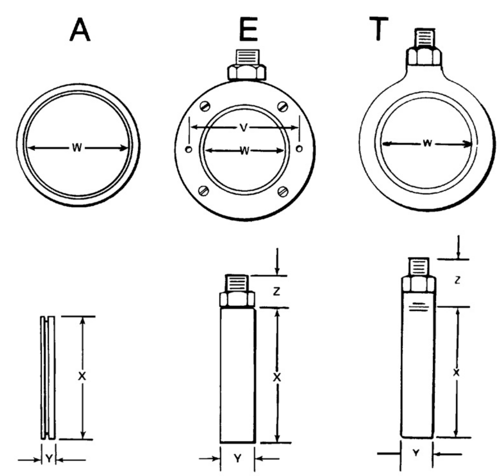
T Microdot on the side of the can; without adjustable screws. (Open back.) For 40 µm to 100 µm detectors.

Dimensions are given in millimeters.

**E Mounts may be disassembled by removing screws. V dimension provides distance between mounting holes that are 1.7 mm in diameter and suitable for 0.080 screws.

§ Built into a Microdot connector only.

Detector Size (mm^2)	W (Nominal)	Type A Mount		Type E** Demountable Transmission				Type T § Transmission Mount		
		X	Y	X	Y	Z	V	X	Y	Z
050	8.0	15.2	3.7	25.1	7.7	7.0	18.2	19.4	7.9	9.9
150	13.8	22.0	3.7	31.9	7.7	7.0	25.0	26.1	7.9	9.9
300	19.5	27.1	3.7	37.1	7.7	7.0	30.1	31.6	7.9	9.9
450	23.9	30.5	3.7	40.2	7.7	7.0	33.3	34.8	7.9	9.9
Tol.	±0.5	±0.3	±0.3	±0.5	±0.3	±0.3	±0.3	±0.3	±0.3	±0.3



Specifications subject to change
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F Series

Heavy-Ion Partially Depleted Silicon Surface Barrier Detectors

Main Application: Heavy-Ion spectroscopy.

Supplied with B Mount unless otherwise specified.

Active Area (mm^2)		Max Noise (keV)	Close Mount (≤0.050 in.) ≥60 µm Partially Depleted Model No.
100		18	F-018-100-60
300		23	F-023-300-60
400		28	F-028-400-60
600		33	F-033-600-60
900		35	F-035-900-60

* All standard heavy-ion detectors are cut off-axis from the parent crystal at a specific angle that will minimize channeling. Supplied in B Mount unless specified otherwise by the appropriate letter prefix.

** Available in annular configuration and greater depths on special order.

† Maximum field strength ≥15 kV/cm.

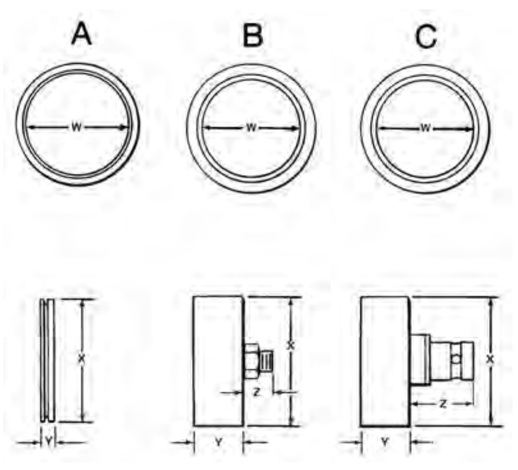
Mounting Arrangements

A This is a "ring mount"; i.e., the silicon wafer is offered on its ring without output connectors. This infrequently used arrangement is available on special request.

B Microdot connector on the rear of the can.

C BNC connector on the rear of the can.

Dimensions are given in millimeters.



Detector Size (mm^2)	W (Nominal)	Type A Mount		Type B Rear Microdot			Type C Rear BNC		
		X	Y	X	Y	Z	X	Y	Z
100	11.3	22.0	3.7	23.6	12.3	7.1	23.6	12.3	15.9
300	19.5	27.1	3.7	28.6	12.3	7.1	28.6	12.3	15.9
400	22.6	30.5	3.7	32.0	12.3	7.1	32.0	12.3	15.9
600	27.6	34.1	3.7	36.1	12.3	7.1	36.1	12.3	15.9
900	33.9	43.2	3.7	45.2	12.3	7.1	45.2	12.3	15.9
Tol.	±0.5	±0.3	±0.3	±0.3	±0.3	±0.3	±0.3	±0.3	±0.3

Specifications subject to change
050409

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L Series

Room-Temperature Lithium-Drifted Silicon Detector

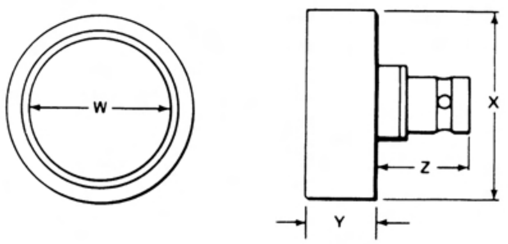
The L Series meets a persistent need of high-energy physicists for up to 5-mm-thick Si detectors that can completely stop 25-MeV protons, 100-MeV alphas, or other highly penetrating particles. These devices have good radiation-damage-resistance characteristics. They are supplied in an L Mount unless otherwise specified. The transmission-type mount is available on special request. Warranty is one year at room temperature.

Active Area (mm^2)	Guaranteed Maximum Resolution		Active Depth (mm)	Model No.
	α	β		
25	35	30	5	L-035-025-5
75	40	35	5	L-040-075-5
200	45	40	5	L-045-200-5

Mounting Arrangements

L BNC connector on the back of the can.
Dimensions are given in millimeters.

Model No.	Dimensions (mm)			
	W	X	Y	Z
L-035-025-5	6.0	16.7	15.2	15.9
L-040-075-5	10.0	23.5	15.2	15.9
L-045-200-5	16.0	23.5	15.2	15.9
Tol.	±0.5	±0.3	±0.3	±0.3



Specifications subject to change
031010

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AMETEK® ADVANCED MEASUREMENT TECHNOLOGY

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P Series

Position Sensitive Ion-Implanted Silicon Detectors

Main Application: Simultaneous measurement of charged-particle energy and position.

Supplied with P Mount only.

Active Area Dimensions (mm)			Guaranteed Maximum Resolution		Position Resolution (mm)	Minimum Depletion Depth 100 µm	Minimum Depletion Depth 500 µm	Minimum Depletion Depth 1000 µm
W	L		α	β		Model No.	Model No.	Model No.
8	47		55	45	0.5	P-055-0847-100	P-055-0847-500	P-055-0847-1000

Supplied with side-mounted Microdot connectors. Partially depleted; totally depleted versions available on special order.

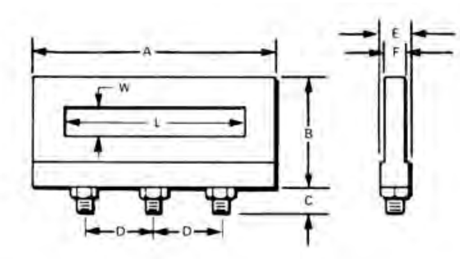
Mounting Arrangements

P Three Microdot output connectors on the side of the can.

Dimensions are given in millimeters.

Model No.	Dimensions (mm)							
	W*	L*	A	B	C	D	E	F
0847	8	47	59.6	30.2	7.1	16.5	7.6	6.1

*Tolerance on width, ±0.5 mm; tolerance on length, ±1.0 mm.
**Built into a Microdot connector only.



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R Series

Ruggedized® Partially Depleted Silicon Detectors

Main Application: Charged-particle spectroscopy in vacuum or in air with ambient light; cleanable.

Supplied with B Mount unless otherwise specified.

Active Area (mm^2)	Guaranteed Maximum Resolution (keV)**		Minimum Resolution Depth 100 µm	Minimum Resolution Depth 300 µm	Guaranteed Maximum Resolution (keV)**		Minimum Resolution Depth 500 µm
	α	β	Model No.	Model No.	α	β	Model No.
50	15 17	7 8	R-015-050-100 R-017-050-100	R-015-050-300 R-017-050-300	15 17	7 8	R-015-050-500 R-017-050-500
150	16 19	10 11	R-016-150-100 R-019-150-100	R-016-150-300 R-019-150-300	16 18	10 11	R-016-150-500 R-018-150-500
300	19 21	13 15	R-019-300-100 R-021-300-100	R-019-300-300 R-021-300-300	19 21	13 15	R-019-300-500 R-021-300-500
450	20 24	14 19	R-020-450-100 R-024-450-100	R-020-450-300 R-024-450-300	20 24	14 18	R-020-450-500 R-024-450-500
600	25 33	17 28	R-025-600-100 R-033-600-100	R-025-600-300 R-033-600-300	25 33	19 29	R-025-600-500 R-033-600-500
900	30 40	25 35	R-030-600-100 R-040-600-100	R-030-600-300 R-040-600-300	30 53	25 48	R-030-900-500 R-053-900-500
2000	50 60	45 55	R-050-2000-100 R-060-2000-100	R-050-2000-300 R-060-2000-300	50 80	45 75	R-050-2000-500 R-080-2000-500

* Supplied in B Mount unless specified otherwise by the appropriate letter prefix. Other areas, depths, and configurations available on special order.

** First three digits of Model No. indicate total system resolution FWHM for ^{241}AM, 5.486-MeV alphas, using standard ORTEC electronics and 0.5-µs shaping time constants. Beta resolution approximated by pulse generator width FWHM.

"SEE-NO-ALPHA" R Series

R Series detectors are available in a "SEE-NO-ALPHA" version. Detectors delivered will have been checked for noise, and the resolution specification is warranted. To guard against backscattering contamination, the detector will not have been exposed to an alpha source.

Active Area (mm^2)	Minimum Depletion Depth 100 µm Model No.
300	TR-SNA-300-100
450	TR-SNA-450-100
600	TR-SNA-600-100

Active Area (mm^2)	Minimum Depletion Depth 100 µm Model No.
300	BR-SNA-300-100
450	BR-SNA-450-100
600	BR-SNA-600-100
900	BR-SNA-900-100

Mounting Arrangements

A This is a "ring mount"; i.e., the silicon wafer is offered on its ring without output connectors.

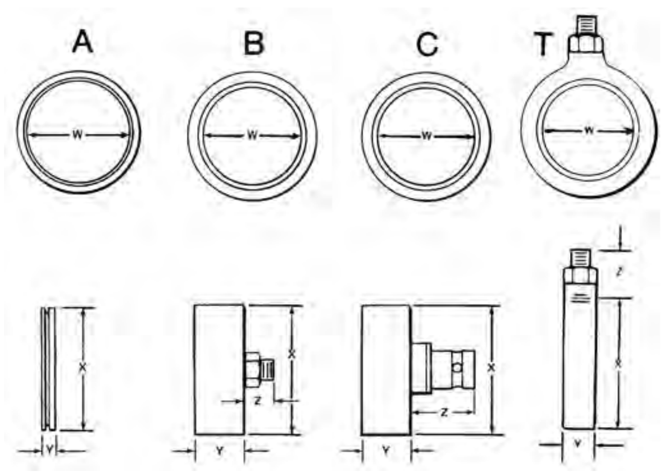
B Microdot connector on the rear of the can.

C BNC connector on the rear of the can.

T Microdot on the side of the can; without adjustable screws.

Dimensions are given in millimeters.

Detector Size (mm²)	W (Nominal)	Type A Mount		Type B Rear Microdot			Type C Rear BNC			Type T § Transmission Mount		
		X	Y	X	Y	Z	X	Y	Z	X	Y	Z
050	8.0	15.2	3.7	16.7	12.3	7.1	16.7	12.3	15.9	19.4	7.9	9.9
150	13.8	22.0	3.7	23.6	12.3	7.1	23.6	12.3	15.9	26.1	7.9	9.9
300	19.5	27.1	3.7	28.6	12.3	7.1	28.6	12.3	15.9	31.6	7.9	9.9
450	23.9	30.5	3.7	32.0	12.3	7.1	32.0	12.3	15.9	34.8	7.9	9.9
600	27.6	34.1	3.7	36.1	12.3	7.1	36.1	12.3	15.9	38.4	7.9	9.9
900	33.9	43.2	3.7	45.2	12.3	7.1	45.2	12.3	15.9			
2000	51.0			65.5	12.3	7.1	65.5	12.3	15.9			
Tol.	±0.5	±0.3	±0.3	±0.3	±0.3	±0.3	±0.3	±0.3	±0.3	±0.3	±0.3	±0.3
§Built into a Microdot connector only.												



Specifications subject to change
121907

ORTEC®

Warranty and Ordering Information

Warranty

ORTEC warrants that all Charged-Particle Detectors will be delivered free from defects in materials and workmanship and will perform in accordance with performance specifications. ORTEC makes no other warranties express or implied and specifically **NO WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE**.

ORTEC's exclusive liability for breach of the foregoing warranty is limited to repairing or replacing, at ORTEC's option, defective items returned at Buyer's expense within the following warranty periods:

A Series	one year
B Series	one year
C Series	one year
D Series (>25 µm thick)	one year
D Series (≤25 µm thick)	three months
F Series	three months
L Series	one year
P Series	one year
R Series	one year
ULTRA/ULTRA CAM/ULTRA-AS	one year

In the event Charged-Particle Detectors have been subject to mishandling, abuse, radiation damage, or the failure to adhere to the use and handling precautions contained in the manual furnished with the detector, no warranty coverage will be afforded.

ORTEC's liability on any claim of any kind, including negligence, for loss or damages arising out of, connected with, or resulting from this agreement, or from the performance or breach thereof, or from the manufacture, sale, delivery, resale, repair, or use of any item or services covered by or furnished under any agreement shall in no case exceed the price allocable to the item or service or part thereof which gives rise to the claim. In the event ORTEC fails to manufacture or deliver items other than standard products that appear in ORTEC's catalog, ORTEC's exclusive liability and Buyer's exclusive remedy shall be release of the Buyer from the obligation to pay the purchase price. **IN NO EVENT SHALL ORTEC BE LIABLE FOR SPECIAL OR CONSEQUENTIAL DAMAGES**.

Ordering Information

To order the detector most suitable for your particular needs, select the model number of the detector desired and add the appropriate letter **prefix** for the mounting desired. The model numbers for all series of detectors consist of four components: the letter indicates the series; the first three digits indicate:

1. The maximum room-temperature alpha resolution in keV FWHM for the Series A, B, C, L, P, R, ULTRA, ULTRA CAM, and ULTRA-AS.
2. The maximum total system noise width in keV FWHM for the D and F Series Detectors.

The next group of digits indicates the minimum active area in mm^2. Note that:

1. The area indicated for the C Series includes the 4-mm-diameter hole.
2. In the P Series, this group contains four digits that are the width and the length of the rectangular active region. The last three digits indicate the depletion depth.

Example: BU-012-100-300 is an ULTRA Partially Depleted detector in a **B** Mount with a rear Microdot connector with:

- <**12** keV alpha resolution
- **100**-mm^2 active area
- ≥**300**-µm depletion depth.

This sample detector would be shipped with a standard rear Microdot connector (B Mount). If a rear BNC connector (C Mount) were desired, the model number should be designated: **CU-012-100-300**.

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A-576 A-PAD

Preamplifier, Amplifier, Discriminator with Bias Supply

- **Complete alpha spectroscopy chain in a one-wide NIM module**
- **Includes preamplifier, amplifier, bias supply, and discriminator**
- **Lowest cost per input for non-NIM vacuum chambers**
- **Spectroscopy and gross counting outputs**
- **Front-panel-selectable energy ranges**
- **Integral test pulse generator**

The ORTEC Model A-576 A-PAD is a single-wide NIM module for performing alpha spectroscopy and counting when used in conjunction with a silicon surface barrier detector. The instrument includes a variable detector bias supply, a preamplifier, a shaping and stretching amplifier, a biased amplifier, a test pulse generator, and a discriminator (Fig. 1).

The detector bias supply and the amplifier have selectable polarity so that the A-PAD can be used with any charged-particle silicon semiconductor detector. Examples are the ORTEC ULTRA ion-implanted Si detectors and Ruggedized® Si surface barrier detectors.

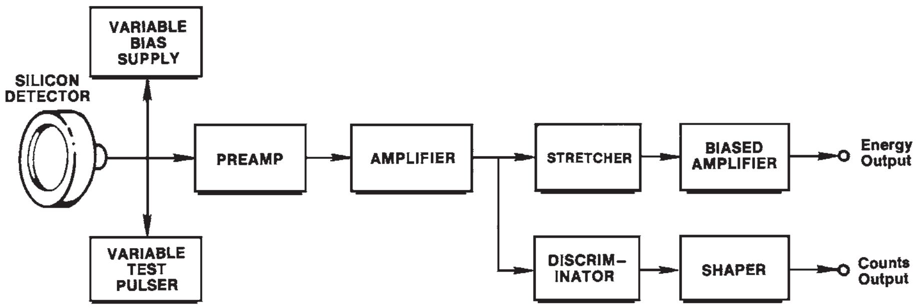

Fig. 1. Block Diagram of A-PAD A-576 Alpha Spectrometer.

Specifications subject to change
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BETA-X

Cooled Spectrometer

- **Excellent spectroscopy for up to 2-MeV electrons and 20-keV x rays**
- **4-1/2-in. ConFlat® flange permits insertion of a source or connection to a beam tube**
- **Contains reliable 10-mm diameter, 5-mm thick Si(Li) device**
- **Room temperature storage**
- **High-voltage shutoff protection**

When conversion electron spectroscopy or determination of a beta decay end point is the objective, room temperature silicon detectors are often unsatisfactory because of their relatively high noise level (an 80-mm^2 detector has about 7 keV FWHM noise). To minimize the noise, both the detector and the first stage of the preamplifier must be cooled. Considerable expertise is required to deal with the subtle technologies involved.

The problems are solved with ORTEC's cooled BETA-X Spectrometer. It contains a 10-mm diameter, 5-mm deep Si(Li) detector coupled to a noise-optimized cryogenic electronic front end. An easy-to-operate valve gives access to the cryostat vacuum. The front flange can be opened for connection to an experiment chamber or a beam tube. A beryllium window in the front flange makes the BETA-X Spectrometer a useful tool for x-ray spectroscopy (Fig. 1) and permits measuring noise and x-ray resolution without opening the front flange.

Using the BETA-X Spectrometer requires familiarity with vacuum equipment. The vacuum system must be absolutely oil free (via a well trapped diffusion pump or a cryogenic pump) and should provide a vacuum of 10^{-5} torr or better. Because the detector responds to light of any frequency, there must be no light leaks.

The electron energy resolution is limited, at low energies, by the thickness of the entrance contact on the Si(Li) detector (equivalent to approximately 2000 Å of silicon) and, at high energies, by the thickness and density of the material supporting the source and any source window thickness.

Beta and electron spectroscopy is feasible from 20 keV to 3 MeV.

The BETA-X is equipped with a pulsed optical feedback (POF) cryogenic streamline preamplifier and high-voltage filter combination optimized for the specific application. This includes high-voltage shutoff to protect the detector from FET failures.

Specifications

PREAMPLIFIER PERFORMANCE

TEST INPUT One 18-in. RG174 coaxial cable with female BNC connector.

HIGH-VOLTAGE BIAS INPUT One 18-in. RG59 coaxial cable with female SHV connector.

OUTPUTS Two 18-in. RG174 coaxial cables with female BNC connectors.

CABLE DRIVE CAPABILITY AND TERMINATION Test Input terminated in 93 Ω; outputs are series terminated in 93 Ω and may drive terminated and unterminated 93 Ω coaxial cables (RG62 recommended). Termination recommended for cable lengths greater than 50 ft.

RISE TIME Pulse rise time typically 25 ns; actual rise time to nuclear event depends on detector characteristics.

MAXIMUM OUTPUT Maximum pulse output to a single event is –10 V.

MAXIMUM ENERGY RATE 4000 MeV/s.

NONLINEARITIES Integral and differential, <±0.05% over 90% of the dynamic range of the preamplifier.

BIAS VOLTAGE High-voltage filter capable of supplying needs of detector up to 5000 V bias.

TEMPERATURE INSTABILITY
≤±50 ppm/°C over 0°C to +50°C recommended operating temperature range.

POWER REQUIREMENTS Typically +24 V, 50 mA; –24 V, 25 mA.

MECHANICAL

VALVE OUTPUT CONNECTION 1/2-in. OD tube.

GASKETS Provided for connection to user's system.

*The POF does not "lock up" or saturate at high count rates, unlike resistor-feedback designs. At ultra-high count rates with the POF, throughput is limited by reset pulse rates. 4000 MeV/s is an estimate of maximum "useable" energy rate.

®Trademarked by Varian.

BETA-X

Cooled Spectrometer

ELECTRICAL

CABLE PACK BETA-X is provided with a standard cable pack containing: signal cable and test pulse cable (both RG62A/U, 93 Ω BNC), high-voltage cable (RG59A/U, 75 Ω SHV female), and a preamplifier power cable (9-pin D connector, male). Supplemental or extra cable and connector options are available on request.

AUTOMATIC, HIGH-VOLTAGE SHUTOFF The cryostat contains a temperature sensing element attached to the cooling path. The sensing element connects to a hybrid monitoring circuit, which is incorporated into the preamplifier electronics. An output cable from the preamplifier is connected to the remote shutdown input on the rear panel of the ORTEC Model 659 Detector Bias Supply. This supply is designed to reduce the detector bias voltage to zero if the remote shutdown input's center contact is provided with a low-impedance (<30 Ω) path to ground. The monitoring circuit in the preamplifier provides this condition if the detector temperature becomes too high. Although no alarm is provided, the bias supply meter will indicate zero voltage, and system noise will greatly increase after shutoff occurs. For the unit to be operational, preamplifier power must be provided through the power cable.

The automatic shutoff should be placed in operation before attempting to apply bias to the detector. Thus the circuit will also prevent the accidental application of bias to a detector which has not yet reached operating temperature.

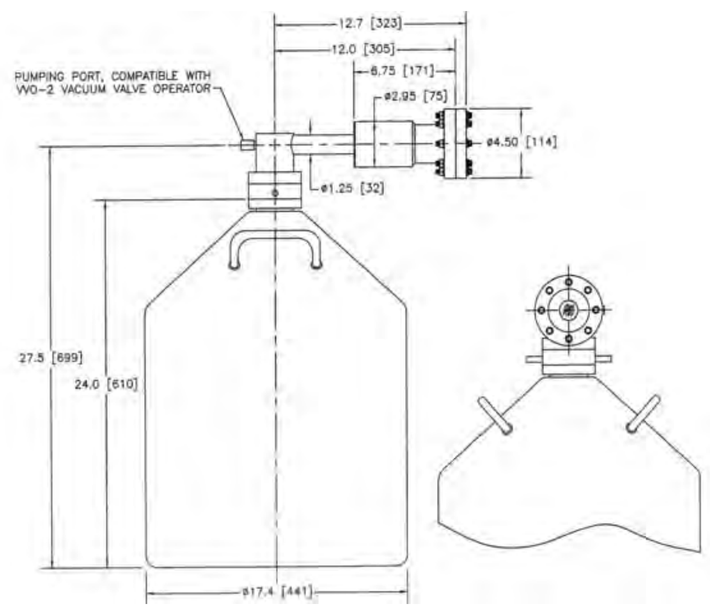

Fig. 1. Si(Li) Electron and X-Ray Spectrometer.

References

1. C.T. Prevo and J.L. Cate, "A Practical Solid State Beta Spectrometer," *Nucl. Instrum. Methods* **55**, 173–176 (1967).

2. R.E. Wood, P. Venugapala Rao, O.H. Puckett, and J.M. Palms, "Si(Li) Spectrometers for Electrons and Low Energy Photons," *Nucl. Instrum. Methods* **94**, 245–252 (1971).

3. I. Amad and F. Wagner, "A Simple Cooled Si(Li) Electron Spectrometer," *Nucl. Instrum. Methods* **116**, 465–469 (1974).

Ordering Information

To order, specify:

Model	**Description**
SLB-10490	BETA-X Spectrometer. Includes CFG-B-SH Pumpable SH Cryostat and DWR-B-30 30-Liter Dewar

Radiation Type	Energy (keV)	Warranted Energy Resolution (eV) FWHM	Max. Energy Rate (meV/s)	Max. Single Pulse Energy (MeV)
^{55}Fe X-Ray	5.9	490	130,000	10
^{57}Co Conversion Electrons	115	1000	130,000	10
^{207}Bi Conversion Electrons	976	3500*	130,000	10
*This figure was obtained with a source deposited on aluminum, causing peak broadening due to backscattering. It is expected that with an accelerator beam or with conversion electrons from a thin source, the energy resolution will be ~2 keV FWHM at 1 MeV.				

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AMETEK® ADVANCED MEASUREMENT TECHNOLOGY

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807

Vacuum Chamber

- **For routine alpha/beta counting**
- **Convenient and durable**
- **Sample-to-detector distance easily set and measured**
- **Can be used for beta-gamma coincidence measurements**
- **Single valve for pumping and venting**

The ORTEC Model 807 Vacuum Chamber is designed for routine alpha/beta counting applications using a semiconductor radiation detector and a radioactive sample. Two examples of the many applications possible with this convenient and durable chamber are its use in educational laboratories to demonstrate detectors and counting principles, and in radiological laboratories for smear counting.

The detector is mounted in the center of the chamber cover, and the sample is mounted on one of three support rods at a preselected distance from the detector. This design makes it possible to establish and measure the detector-to-sample distance before the assembly is placed in the chamber. Because of easy access, the detector can be changed without the detector being touched. Another convenience is that the support rods on the sample mounting can be used as legs to support the cover when it is out of the chamber.

An opening in the wooden base allows an effective-geometry gamma detector to be placed against the bottom of the thin stainless steel chamber for beta-gamma coincidence measurements. In this application, an extension cable is used to mount the semiconductor detector close to the chamber base.

Since the vacuum pump and vent functions are combined in a single valve, the vacuum pump does not have to be turned off while the samples are being changed. A quarter turn of the valve opens the chamber to vacuum while sealing off the vent passage.

The Model 807 is both functional and attractive, with its main housing made of stainless steel and mounted on a varnished wood base. The valve is nickel-plated and has a 0.09 cm (0.25 in.) hose connector for the vacuum line. (NOTE: A Welch 1402, or larger, mechanical pump with proper inter-connecting base is recommended for use with this chamber.)

The photograph also shows a measurement scale attached to a leg of the chamber cover. The scale measures the sample-to-detector distance.

807

Vacuum Chamber

Specifications

MATERIALS Aluminum, chrome-plated brass, stainless steel, and wood base.

DETECTOR-TO-SAMPLE DISTANCE Variable up to ~12.7 cm (~5 in.).

CONNECTOR Female BNC outside, Microdot male inside.

WEIGHT

Net 1.1 kg (2.5 lb).

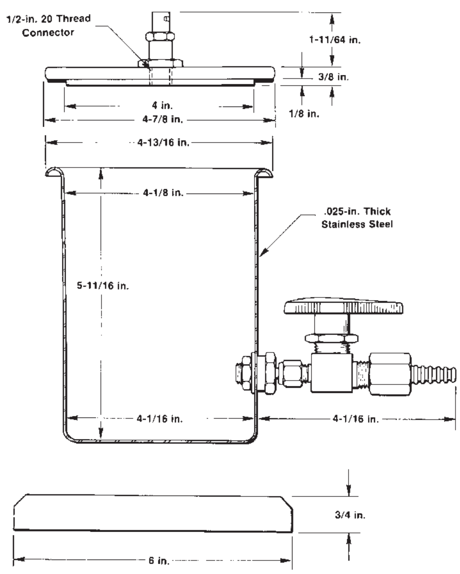
Shipping 2.0 kg (4.5 lb).

DIMENSIONS Overall dimensions are: 21.0 cm (8.25 in.) high X 15.24 cm (6.0 in.) diameter at base [vacuum shutoff valve projects 8.25 cm (3.25 in.) beyond base diameter]. Inside chamber dimensions are: 14.45 cm (5.69 in.) deep X 10.48 cm (4.125 in.) wide at the mouth of the chamber.

Ordering Information

To order, specify:

Model	Description
807	Vacuum Chamber



Model 807 Vacuum Chamber

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808

Vacuum Chamber

- **For quick and convenient measurement of environmental samples with charged-particle detectors**
- **Superior design and construction**
- **Accommodates extra large samples**
- **Easily adjustable and repeatable sample-detector geometry**
- **Low-background sample holders**
- **Compatible with any ORTEC charged-particle detector equipped with a Microdot® connector**
- **Front-opening hinged door**
- **Three-way, high-quality, "Pump", "Hold", and "Vent" vacuum valve**
- **Compatible with the ORTEC ALPHA-PPS-115 (or -230) Portable Pumping Station**

The ORTEC Model 808 Vacuum Chamber provides a quick and convenient way to measure the alpha and beta activity of environmental samples. It accommodates a wide range of sizes of samples and detectors. The chamber can accept sample trays measuring up to 10.8 X 14 cm (4-1/4 X 5-1/2 in.), with nominal sample size 10 cm (4 in.) in diameter.

The precise, internal, rack mounting structure ensures repeatable detector/sample geometry. A front-opening, hinged door permits easy access for inserting and removing samples and detectors.

A wide variety of charged-particle detectors fitted with a Microdot® S-93 connector can be used. Typically, one would use ORTEC ion implanted or surface-barrier detectors in a B mount; also suitable in certain applications are detectors in E or T mounts.

The sample holder trays are made of special low-background materials. The chamber is equipped with a hermetic electrical feedthrough that provides a male connection to a Microdot S-93 for ready installation of a silicon charged-particle detector and preamplifier.

A 3-inch hook-and-loop fastener is provided for connecting the preamplifier to the rear panel.

The ORTEC Model ALPHA-PPS-115 (or -230) Portable Pumping Station is an excellent choice for use with the Model 808 Vacuum Chamber.

Specifications

CONTROLS

PUMP/HOLD/VENT Front-panel position control for venting or pumping the vacuum chamber. A hold position independently isolates both the pump and the chamber.

OUTPUTS

DETECTOR Rear-panel BNC connector provides for connection from the detector mounted in the vacuum chamber to the preamplifier, which can be mounted to the Model 808 rear panel with a hook-and-loop fastener that is provided with the instrument.

VACUUM Rear-panel vacuum pump connector (Swagelok® connector for 3/8-in. OD tubing) for connecting the Model 808 Vacuum Chamber to a vacuum pump.

808

Vacuum Chamber

ELECTRICAL AND MECHANICAL

WEIGHT
Shipping 9 kg (20 lb).
Net 4.37 kg (9 lb 10 oz) with trays and holder.

DIMENSIONS
Cabinet 20.9 cm (8-1/4 in.) wide by 26 cm (10-1/4 in.) high by 34.3 cm (13-1/2 in.) deep.
Chamber 11.4 cm (4-1/2 in.) wide by 16 cm (6-3/16 in.) high by 15.7 cm (6-3/16 in.) deep.
Sample Trays 10.8 cm (4-1/4 in.) wide by 14 cm (5-1/2 in.) long. Nominal sample size up to 10.2 cm (4 in.). Without tray holder, holds sample sizes up to 4-1/2 in.

Related Equipment

The Portable Pumping Station, Model ALPHA-PPS-115 (or -230), consists of a cart-mounted, rotary direct-drive mechanical vacuum pump to which is attached an anti-backstreaming trap, a thermocouple vacuum gauge, and flexible bellows tubing with appropriate termination for connecting directly to the Model 808 Vacuum Chamber. The Pumping Station requires no assembly.

Ordering Information

To order, specify:

Model	Description
808	Vacuum Chamber
ALPHA-PPS-115	Pumping Station (115-V ac version)
ALPHA-PPS-230	Pumping Station (230-V ac version)

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Am-1

Ultra-Thin Window Alpha Source

For the convenience of our customers, ORTEC offers alpha particle sources for energy calibration of charged-particle detectors and spectrometers. They are carefully manufactured to ensure source integrity while providing minimum self-absorption. Two types of sources are available: a source calibrated to within 1% of the absolute disintegration rate, and a less expensive uncalibrated version. The calibrated source is useful primarily for absolute activity and efficiency measurements. The uncalibrated version is an ideal source of nearly monoenergetic alpha particles for spectrometer calibration.

CALIBRATED ^{241}Am SOURCE ORTEC Am-1C

Isotopically pure ^{241}Am of 0.1-µCi nominal activity is electrodeposited on platinum and is calibrated to within 1% of the absolute disintegration rate. The energy spectrum from ^{241}Am contains alphas of 5.486 MeV (85%), 5.443 MeV (12.8%), and others <2% each.

UNCALIBRATED ^{241}Am SOURCE ORTEC Am-1U

This source is identical to the one described above, except that it has not been calibrated.

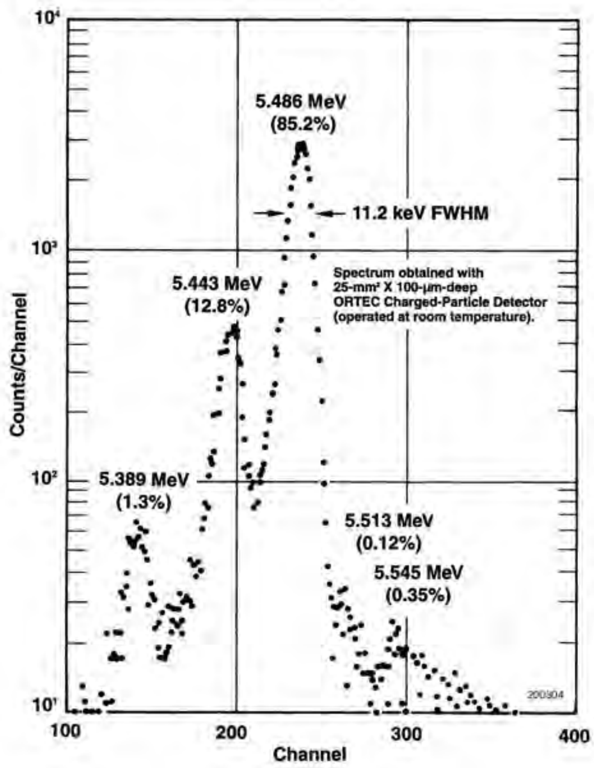
Specifications

The alpha sources are electrodeposited on 0.127-mm-thick, 12.7-mm-diam. platinum foil. The active source diameter is nominally 3 mm, and equivalent source thickness is <8 keV. The source holder is stainless steel, 6.35 mm thick and 17.46 mm in outside diameter. USA users must have an NRC and/or Agreement State License with provisions for type and quantity of isotope involved. **A copy of this license**, authorizing the possession of the source ordered, must accompany an order for these ORTEC sources.

Ordering Information

To order, specify:

Model	Description
Am-1C	Calibrated ^{241}Am Source
Am-1U	Uncalibrated ^{241}Am Source



Typical ^{241}Am Spectrum Obtained with an ORTEC Partially-Depleted Detector.

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AMETEK® ADVANCED MEASUREMENT TECHNOLOGY

High-Purity Germanium (HPGe) Detector Manufacturing

For 50 years ORTEC has been responsible for most major innovations in silicon charged-particle and germanium gamma-ray detectors (see Timetable). ORTEC was the first company to develop its own germanium crystal growth technology. The ensuing availability of the world's best detector-grade germanium has made ORTEC the world's primary supplier of high-purity germanium detectors.

The production of ORTEC HPGe photon detectors involves complex manufacturing processes. The description of these processes in this section emphasizes the tangible benefits to both customer and manufacturer of having crystal and detector manufacturing plus quality control "under one roof."

Timetable of ORTEC Innovations in Semiconductor Radiation Detectors

Silicon Surface Barrier detectors	1961
Ge(Li) Lithium-Drifted detectors	1965
Si(Li) Lithium-Drifted detectors (X-ray)	1968
Ge(Li) LEPS Low-Energy Planar detectors	1973
In-House Ge(Li) material	1973
HPGe LEPS with First Ion-Implanted Contact	1975
High-Purity Coaxial Germanium detectors	1976
In-House HPGe material	1977
N-Type Germanium detectors (GAMMA-X)	1978
HPGe Well detectors	1979
Streamline cryostat	1979
Portable HPGe detector (Gamma Gage)	1979
Low-Energy Coaxial (LO-AX) detector	1979
DUET BGO-HPGe and "Golf Club" detectors	1983
Electrically Cooled HPGe detector	1985
70% Efficiency P-type HPGe detector	1986
70% Efficiency N-type HPGe detector	1987
PopTop Transplantable detector	1987
80% Efficiency P-type HPGe detector	1987
100% Efficiency P-type HPGe detector	1988
150% Efficiency P-type HPGe detector	1992
175% Efficiency P-type HPGe detector	1994
IGLET-X Soft X-Ray detector	1994
"Safeguards Tuned" HPGe detector	1998
X-COOLER low-cost electrically cooled detector	2000
200% Efficiency P-type HPGe detector	2000
SMART-1 Authenticated HPGe detector	2001
PROFILE Series GEM HPGe detector	2001
trans-SPEC HPGe Spectrometer	2004
Interchangeable Detector Moduel (IDM)	2007
trans-SPEC-DX-100 HPGe Spectrometer	2009
Micro-trans-SPEC Portable HPGe Spectrometer	2009

Process

The many steps required to convert polycrystalline germanium into a gamma-ray spectrometer are depicted in Fig. 1. The description of these steps follows the flow of germanium through the process, some steps being more intricate than others.

The initial starting material, electronic grade polycrystalline germanium "metal" (because of its metallic appearance), is zone refined in a quartz "boat" having a pyrolytic graphite coating. A zone refiner uses the principle that most impurities concentrate in the liquid phase as the material begins to freeze. The rf heating coils of the zone refiner melt a small section of the germanium ingot or bar held in the quartz boat.

The rf coils are slowly moved along the length of the ingot, causing the liquefied portion beneath the coils to move also. Thus, the ingot is continuously melting at the advancing solid-liquid interface and freezing at the receding interface. The impurities tend to remain in the molten section and hence are "swept" to one end of the ingot by this process. This "sweeping" operation is repeated many times, until the impurities are concentrated at one end of the ingot. This end is then removed, leaving the remaining portion much purer than the original starting material. Figure 2 shows a three-coil zone refiner in operation. The improvement or reduction in impurity concentration actually realized is about a factor of 100 or more at the completion of this process. Figure 3 shows a zone-refined ingot. The tapered end contains the high concentration of impurities and is cut off. The impurity concentration of the remaining portion is then determined by a Hall effect measurement, and the ingot is sliced into pieces suitable for loading into the crystal-growing equipment.

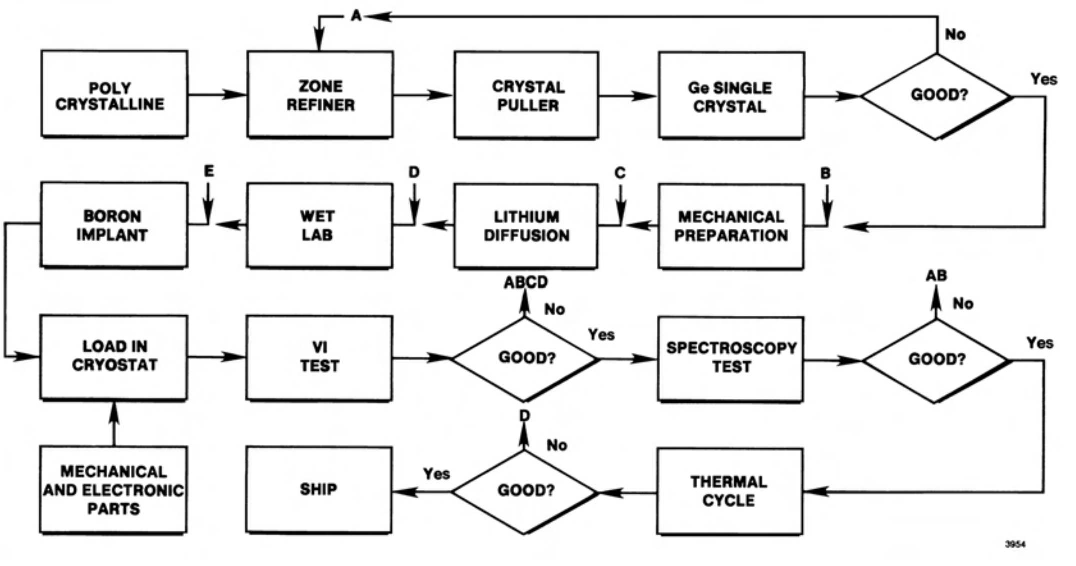

Fig. 1. Germanium Detector Manufacturing Process.

High-Purity Germanium (HPGe) Detector Manufacturing

Large single crystals of germanium are grown using the Czochralski technique, which is schematically illustrated by Fig. 4. A precisely cut seed crystal is dipped into the molten germanium and then withdrawn slowly, while maintaining the temperature of the melt just above the freezing point. The rate of crystal withdrawal and temperature of the melt are adjusted to control the growth of the crystal.

Figure 5 shows a crystal during the growth process. High-purity germanium crystals suitable for detector fabrication are almost always grown in a quartz crucible under a hydrogen atmosphere. Near the completion of the growth process, the crystal is tapered gradually at the tail to minimize thermal strain. It is imperative that the crystal be grown to the exhaustion of the melt, because germanium both wets quartz and expands on freezing. The valuable quartz crucible might be fractured if any germanium were left after completion of the crystal growth.

After the crystal is grown and cooled, it is mounted in a Plaster-of-Paris cast for slicing. Figure 6 depicts a mounted crystal during the slicing process. The completed crystal is cut by an ORTEC-designed string saw that causes virtually no damage to the crystal. A slurry of water and silicon carbide is pulled along by a wire, resulting in a sawing action. Sections of the crystal from both top and bottom are checked by Hall effect measurements to determine the impurity concentration and type (n or p). On the basis of the Hall effect results, that part of the crystal which contains detector-grade material is selected. The rejected material is returned to the zone refining operation.

The section of crystal which has both adequate purity and crystallographic perfection for coaxial detector fabrication is then ground perfectly cylindrical. The edge at one end is beveled to a radius ("bulletized") to improve charge collection and timing performance. Figure 7 illustrates the grinding operation. Afterwards, a hole is machined into the unbeveled end so that the central contact of the device may be made later. The detector subsequently is hand lapped all over to remove damage caused by the machining processes.

A lithium diffusion to form the n^+ contact is then performed over the entire outer surface except the flat, unbeveled end for p-type coaxial detectors and on the "walls" of the central hole for n-type coaxial detectors. This lithium-diffused layer is about 600-µm thick. After the lithium diffusion operation, the detector is lapped once more, chemically polished, and a surface protective coating applied. The coating is amorphous germanium hydride deposited by a sputtering process, similar to that described by Hansen, *et al.,* (Ref. 1). Next, the p^+ contact is formed by the ion implantation of boron ions. This last step completes the fabrication process for the coaxial detector element itself. Figure 8 shows schematically the structure of both p-type and n-type coaxial detectors.

At this point the detector is ready to be mounted in a cryostat. The basic function of a cryostat is to cool the germanium detector to its near-liquid-nitrogen operating temperature. For best performance the first stage of the preamplifier is also cooled to low temperature, the entire cold assembly being maintained by the cryostat under high vacuum for both thermal insulation and protection of the internal components from contamination. Figure 9 shows the construction of a typical cryostat system. Cryosorption material (such as selected zeolite or activated charcoal) is used as a residual gas getter or pump to maintain the vacuum for long periods of time. After being loaded into the cryostat, the detector is tested for several parameters, including leakage current and energy resolution. If the device fails a test, it is returned to some previous stage of the process. Another important cryostat design consideration is allowing for the convenient positioning of the detector element. This usually means that a copper cooling rod, needed to conduct the heat from the detector element, is routed from a point outside the dewar to the liquid nitrogen inside the dewar. All of the cryostat materials around the detector should be as low Z as possible to reduce photon scatter. Hence, aluminum, magnesium, beryllium, Teflon, and Mylar are used whenever possible.

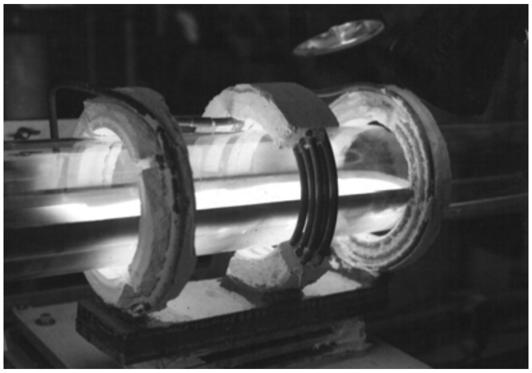

Fig. 2. A 3-Coil Zone Refiner.

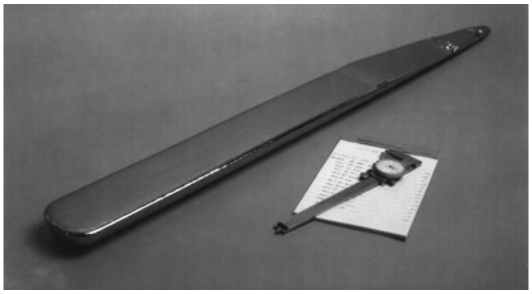

Fig. 3. A Zone-Refined Ingot.

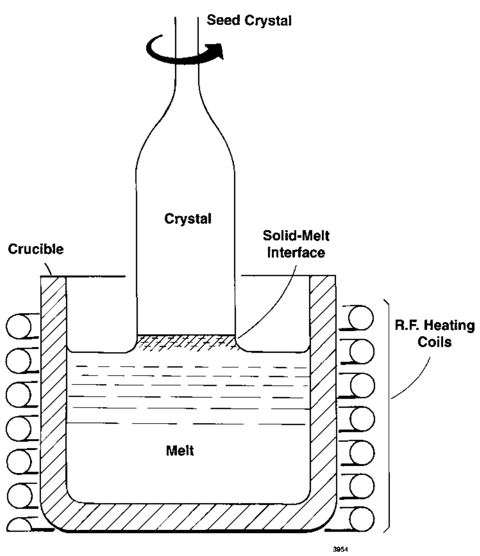

Fig. 4. Czochralski Technique Schematic.

High-Purity Germanium (HPGe) Detector Manufacturing

Because many of the steps in the manufacturing process (Fig. 1) have less than a 100% yield, a detector element may spend an extended time in a "loop" before being shipped.

The Past and the Future

When ORTEC started production of germanium detectors in the late 60's, a detector of 5% relative efficiency (compared to a 3" x 3" NaI detector) with 3-keV energy resolution at 1.33 MeV was considered typical. In 1975 the "VIP 10" offered 10% efficiency at 2 keV. In 1980 the Ge(Li) technology in use was obsoleted by high purity germanium detectors which could be cycled to room temperature. Recently detectors with 170% efficiency and <2 keV resolution have been produced.

ORTEC pioneered these technologies and others, such as GAMMA-X coaxial detectors, streamline cryostats, and PopTop transplantable detector capsules.

Development work toward larger crystals, application-matched performance parameters, ultra-low background cryostats, and exceptional reliability continues. We welcome suggestions for new, more application-tuned detectors.

References

1. W.L. Hansen, E.E. Haller, and G.S. Hubbard, "Protective Surface Coatings on Semiconductor Nuclear Radiation Detectors," *IEEE Trans. on Nucl. Sci.* **NS**-27, No. 1, 1980.

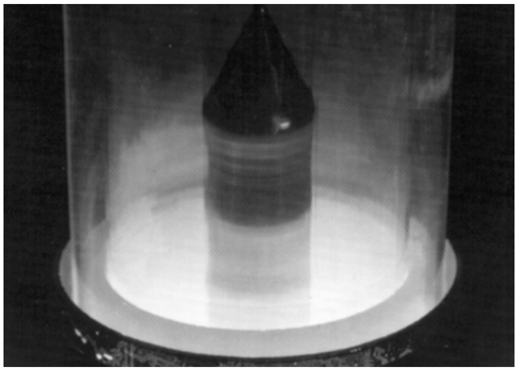

Fig. 5. A Germanium Crystal Being Grown.

Fig. 6. A Mounted Crystal Being Sliced.

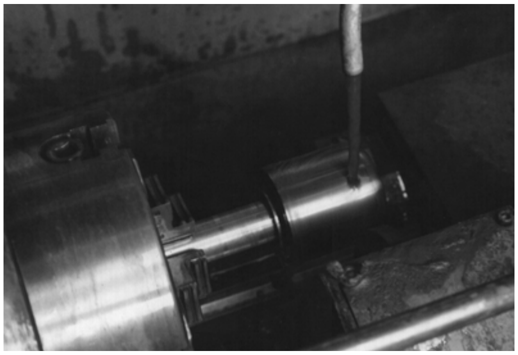

Fig. 7. Grinding the Germanium Crystal.

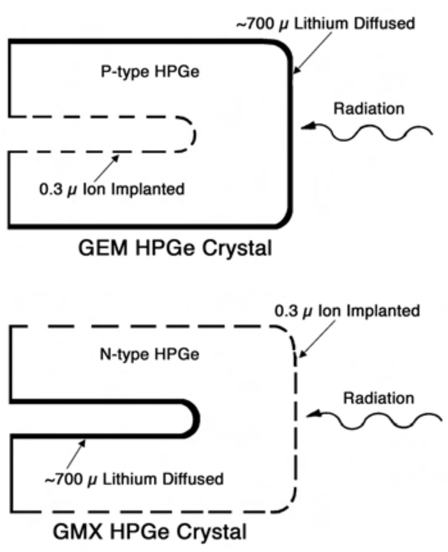

Fig. 8. Schematic of Both P-Type and N-Type Coaxial Detectors.

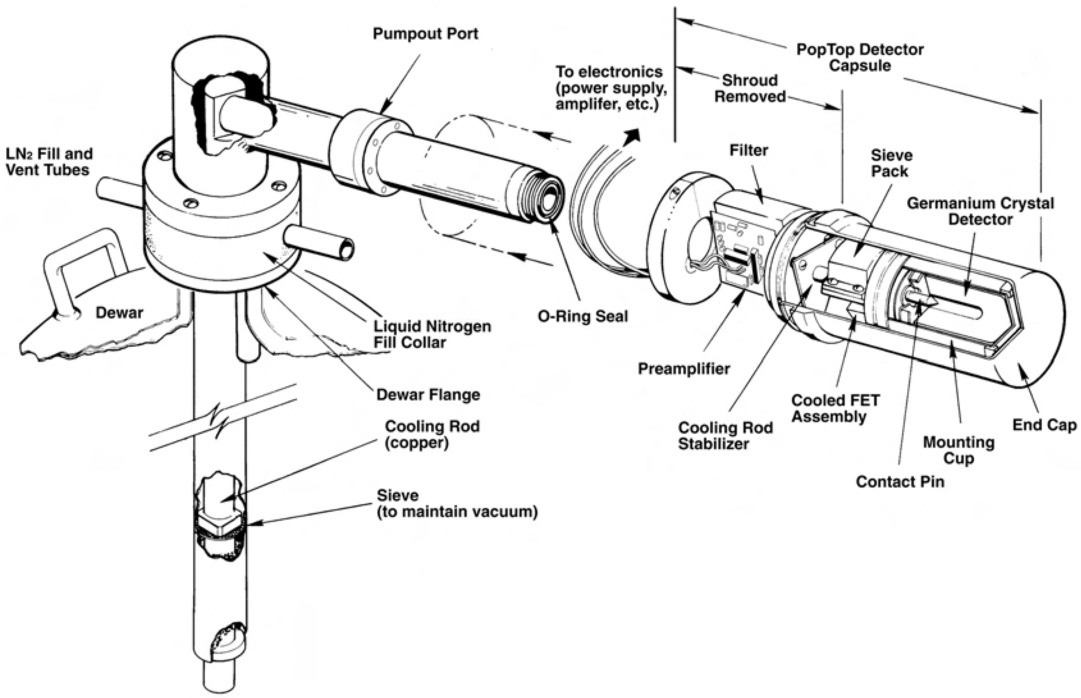

Fig. 9. Exploded View of PopTop Detector Capsule with Horizontal Dipstick Cryostat and 30-Liter Dewar.

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Introduction to Photon Detectors

ORTEC offers a complete line of semiconductor photon detectors for the nuclear spectroscopist working in the energy range from <1 keV to above 10 MeV. To lower the leakage current and enhance the “noise,” ORTEC photon detectors are designed to operate at near-liquid-nitrogen temperature. A photon detector (Fig. 1) consists of:

(a) A detector element mounted, in most systems, inside the vacuum enclosure of its PopTop capsule. The detector element is either a Si(Li) or an HPGe device (planar or coaxial).

(b) A charge-sensitive preamplifier and a HV filter, with accompanying cable pack. The first stage of the preamplifier is also mounted inside the vacuum enclosure to ensure proper cooling for optimum noise and reliability. The second stage of the preamplifier and the HV filter are part of the PopTop assembly but reside outside the vacuum enclosure to which they are connected by vacuum feedthroughs.

(c) A dipstick cryostat and a 30-liter LN_2 dewar, or a combination cryostat-dewar assembly, or a cryostat that is electrically cooled.

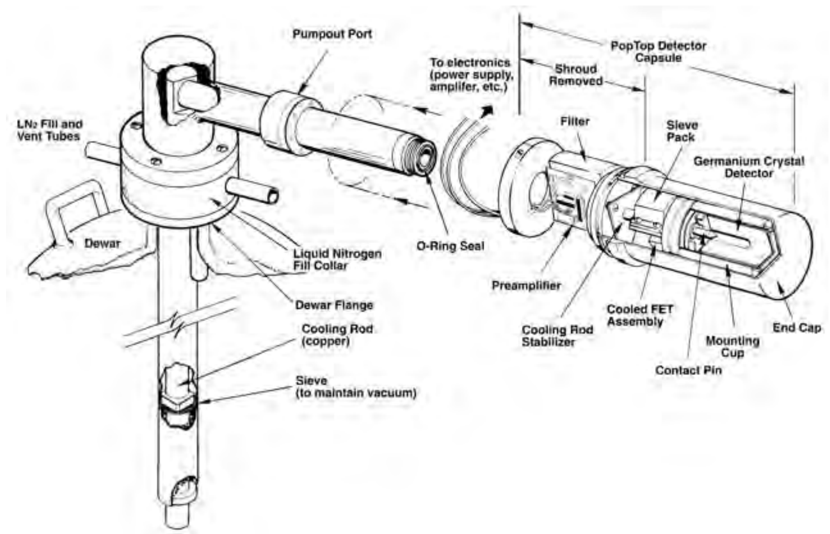


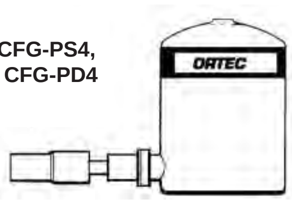
Fig. 1. Exploded View of PopTop Detector Capsule with Horizontal Dipstick Cryostat and 30-Liter Dewar.

Some Helpful Terms

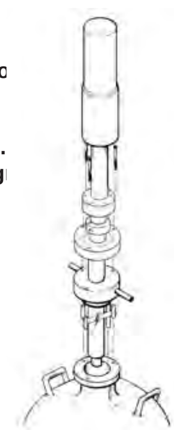
CRYOSTAT
(vacuum enclosure that provides a path to cool the detector)

DEWAR
(vacuum container for LN_2)

BUCKET DEWAR
(used with CFG-SL, CFG-PS, CFG-PS4, CFG-SJ, CFG-SD, CFG-PD, or CFG-PD4 assemblies)



DIPSTICK
Having a cryostat that “dips” intc the LN2 dewar (refers to the CFG-PV-1, CFG-PV4, CFG-PH-2, CFG-PH4, CFG-SV, and CFG-SH). Other cryostats/dewars are integ



ELECTRONIC SHROUD
(electrical shield for preamplifier and HV filter)

POPTOP CAPSULE
(contains the crystal or detector element, preamplifier, and HV filter)

Some Key Dimensional Data for PopTop Capsules

- Thickness of endcap walls: 1.3-mm Al for 70-mm endcap diameters; 1-mm Al for 82.5-, 95- and 108-mm diameters
- Thickness of front window by endcap diameter:
  Al: 1.3-mm for 70-mm, 1-mm for 82.5- and 95-mm;
  1.5-mm for 108-mm
  Carbon Fiber: 0.76-mm nominal
  Be: 0.5-mm for 70- and 82.5-mm; 0.76-mm for 95-mm
- Thickness of detector element mount cup walls: 0.5-mm Al
- Thickness of the small section of the mounting cup where the screws that hold the detector in the cup are located (not shown in the drawing): 1.5-mm Al
- Thickness of mounting cup front window (GAMMA-X, GLP, SLP, or LO-AX): 0.13-mm aluminized Mylar
- Distance between the front window of the endcap and the front contact of the detector: 3- to 4-mm nominal for coaxial and LO-AX detectors, 7-mm nominal for planar detectors
- Largest possible diameter detector that can be accommodated in the 70-mm outer-diameter (OD) endcap: 59 mm
- Largest possible diameter detector that can be accommodated in the 82.5-mm OD endcap: 70 mm
- Largest possible diameter detector that can be accommodated in the 95-mm OD endcap: 82 mm
- Largest possible diameter detector that can be accommodated in the 108-mm OD endcap: 94 mm

As shown in Fig. 2, the flexibility of the PopTop concept allows you to switch a “capsule” from one cooling assembly to another without pumps, heater tapes, or other equipment.

All ORTEC detectors are warranted for 12 months. ORTEC provides service for most photon detector repairs in Europe and the Far East. Full service for all repairs is provided at the Oak Ridge, Tennessee factory.

The PopTop Advantage

With the exception of certain special detectors, ORTEC’s photon detectors are mounted in a PopTop capsule, offering unique flexibility and reliability. In particular, the LN_2-free X-COOLER II may be used and the PopTop easily exchanged for service.

PopTop™ Transplantable Detector Capsule

(U.S. PATENT 4,851,684)

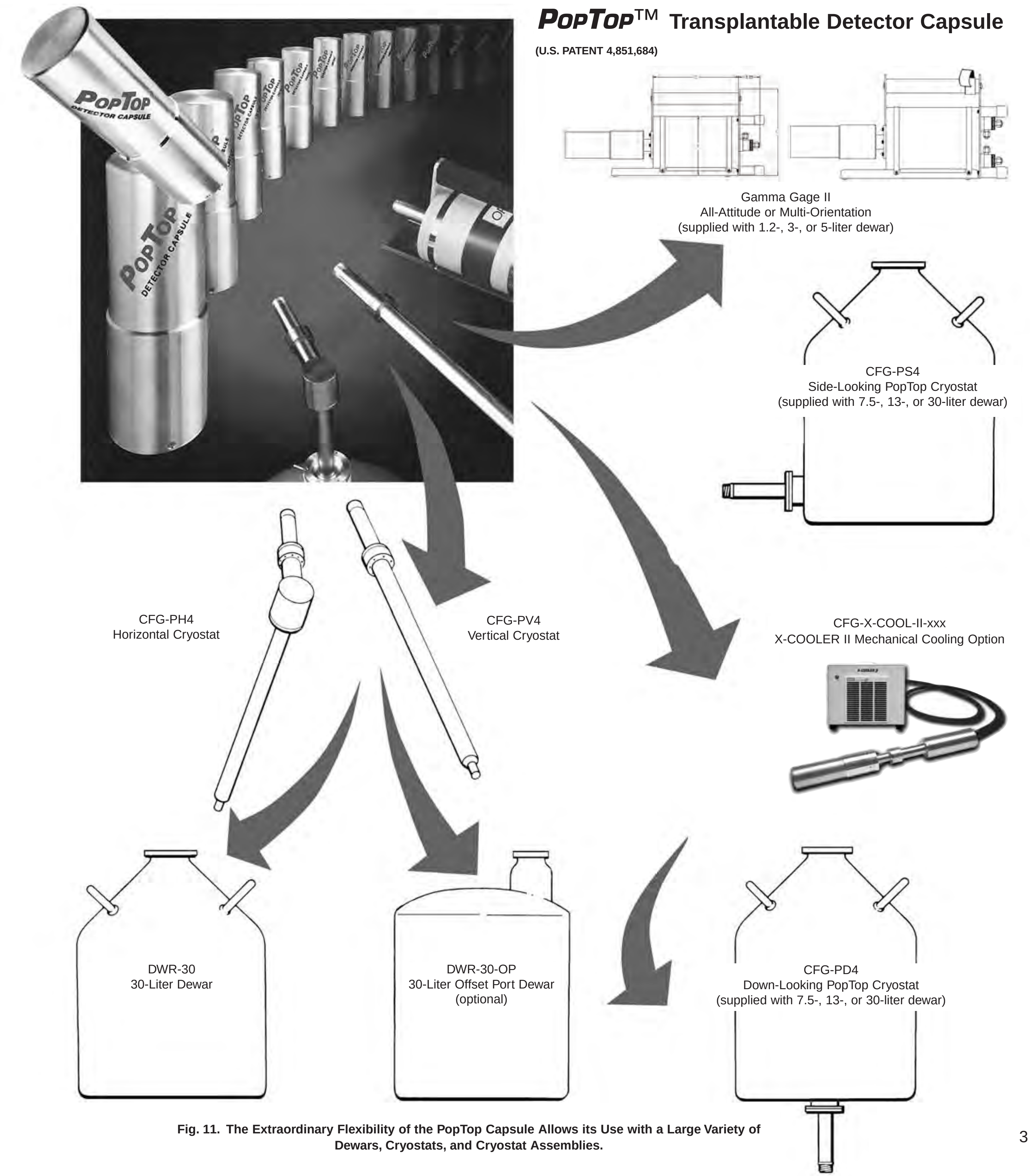


Fig. 11. The Extraordinary Flexibility of the PopTop Capsule Allows its Use with a Large Variety of Dewars, Cryostats, and Cryostat Assemblies.

PopTop Capsule*

The innovative PopTop capsule is the core of the instrument. Its sealed and self-pumping cryogenic enclosure contains the detector element and the front end of the preamplifier, consisting of a cooled FET and resistor (resistive feedback) or junction transistor (transistor-reset active feedback). The rest of the preamplifier and a HV filter, electrically connected by vacuum feedthroughs, are also part of the capsule.

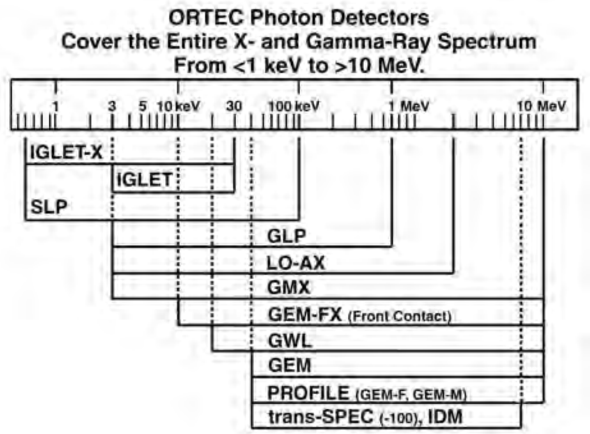


Fig. 1. ORTEC Detectors Cover the Entire Spectrum from <1 keV to >10 MeV.

Detector Element

The detector element establishes the energy range and efficiency for useful x- or gamma-ray spectroscopy (Fig. 1).

The principles of operation of the HPGe and Si(Li) detectors described in this section are described in Reference 1.

As shown in Fig. 2, the detector element is cooled from the outer or the front contact to which the HV is applied. The thermal connection between the cooling rod and the detector mounting cup is made with aluminum oxide, which is both a good thermal conductor and a good electrical insulator. The minimum distance between the endcap (which is at room temperature and ground potential) and the detector cup (which must be maintained at 85–100 K and to which HV is applied) is determined by field emission and thermal emissivity considerations.

The detector element contact at ground potential is connected to the input stage of the "front-end" electronics (see Fig. 3).

The Detector Shape Advantage

All ORTEC coaxial HPGe detectors are shaped as true right-circular cylinders with a deep hole (central contact) and "bulletized" front "corners." This precise machining of the crystals results in detectors with superior peak shape and timing characteristics.

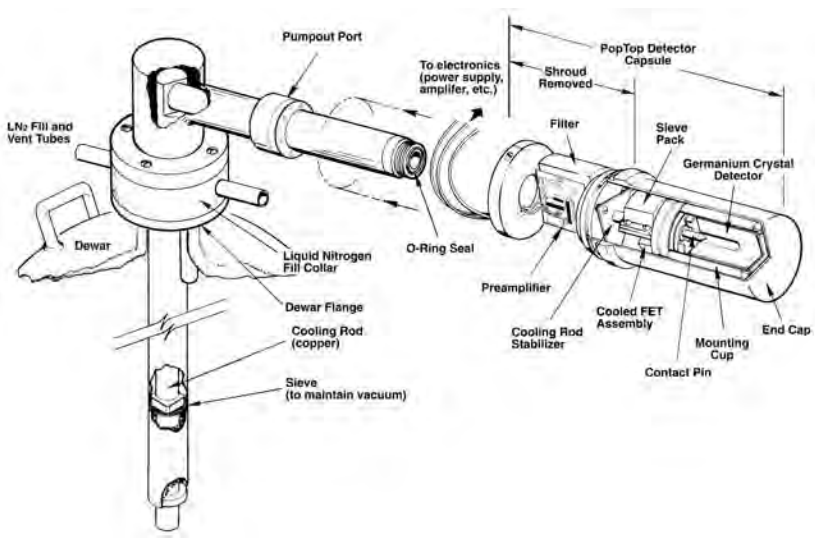


Fig. 2. Exploded View of PopTop Detector Capsule with Horizontal Dipstick Cryostat and 30-Liter Dewar.

"Front-End" Electronics

The front-end electronics (Fig. 3) include the input field-effect transistor (FET) and the feedback element of the charge-sensitive preamplifier. The feedback element comprises a capacitor and a resistor (passive feedback) or a transistor (active feedback). Preamplifiers with active feedback, such as the transistor-reset preamplifier (TRP), are used for achieving ultra-high count rates.

A temperature-sensing element, also located in the cryogenic vacuum enclosure, automatically shuts off the HV power supply if the detector temperature begins to rise. The front-end electronics are enclosed in the cryogenically-cooled enclosure to minimize electronic noise. Both the input FET and the feed-back element have optimum noise characteristics at ~120 K.

Preamplifiers Used with HPGe and Si(Li) Detectors

With the exception of the front-end electronics, both the sealed HV filter and charge-sensitive hybridized preamplifier circuitry are assemblies located behind the detector within the PopTop capsule (Fig. 2). They are outside the vacuum chamber and are at room temperature.

***U.S.A. Patent No. 4,851,684**

Photon Detector Assembly

Table 1. Some Basic Properties of Silicon and Germanium.*	Si	Ge
Atomic number	14	32
Density (300 K); g·cm^{-3}	2.33	5.33
Atoms; cm^{-3}	4.96 X 10^{22}	4.41 X 10^{22}
Dielectric constant	12	16
Forbidden energy gap (300 K); eV	1.115	0.665
Forbidden energy gap (0 K); eV	1.165	0.746
Electron mobility (300 K); cm^2·V^{-1}·s^{-1}	1350	3900
Hole mobility (300 K); cm^2·V^{-1}·s^{-1}	480	1900
Electron mobility (77 K); cm^2·V^{-1}·s^{-1}	2.1 X 10^4	3.6 X 10^4
Hole mobility (77 K); cm^2·V^{-1}·s^{-1}	1.1 X 10^4	4.2 X 10^4
Carrier saturation velocity; cm·s^{-1} (300 K)	8.2 X 10^6	5.9 X 10^6
Carrier saturation velocity; cm·s^{-1} (77 K)	10^7	9.6 X 10^6
Energy per hole-electron pair (300 K); eV	3.62	(not applicable)
Energy per hole-electron pair (77 K); eV	3.76	2.96

*All ORTEC semiconductor photon detectors are made of either germanium or lithium-drifted silicon.

The very long time constant of the HV filter ensures that the voltage is applied gradually to the detector. This protects the FET from voltage spikes. When cold, any modern HPGe detector from ORTEC may have the full bias voltage switched on without risking damage to the FET.

Some additional observations about preamplifiers used with Photon [HPGe or Si(Li)] Detectors (See Fig. 3): all are of the “charge sensitive” type, and all have the “front-end” cryogenically cooled for lowest electronic noise and energy resolution. Three different feedback mechanisms are used:

1) The simplest and most common is “resistive feedback.” In this case the feedback circuit contains a resistor and a capacitor in parallel.

2) For coaxial detectors used at high count rates (>75 kcps) the feedback circuit contains a junction transistor, switched on when the voltage at the gate of the input FET exceeds a certain threshold voltage. This resets the input FET gate voltage to zero. This type of preamplifier is called a transistor-reset preamplifier (TRP).

3) For small detectors (IGLET, IGLET-X, SLP, GLP), electronically equipped for optimum resolution below 50 keV, the feedback circuit contains an LED (light-emitting diode) which rezeros the voltage at the gate of the input FET via a mechanism similar to that of the TRP, but using light instead of an electronic switch. Ultra-low noise performance is achieved with this type of preamplifier [Pulsed Optical Feedback (POF)] because the feedback resistance is infinite (in contrast to resistive feedback), and the capacitance on the gate of the input FET is not increased by the addition of the collector-to-ground capacitance of a junction transistor (as with the TRP). Very high feedback resistance and very low capacitance are the keys to low noise performance.

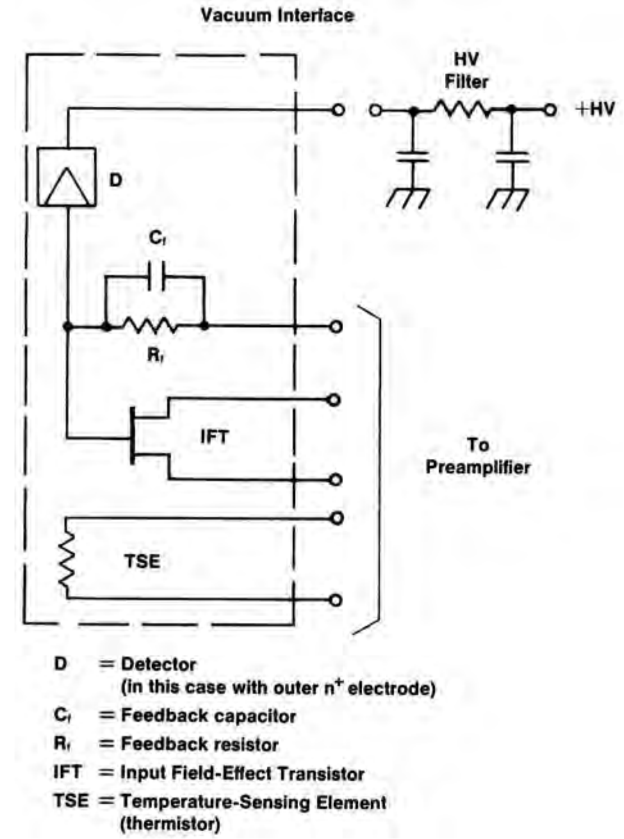


Fig. 3. Simplified Electronic Diagram Showing the Detector and the “Front End” of the Preamplifier in a Cryogenically Cooled Ge or Si(Li) Detector. The feedback element may be either a resistor or instead an electronic switch that resets the FET gate voltage to zero whenever a given threshold voltage is reached.

Table 2. Energy Rate of Preamplifiers Supplied with Photon Detectors.

Preamplifier Type	Detector Type	Maximum Energy Rate (MeV Sec^{-1})
Resistive Feedback	GEM, GMX, LO-AX, GLP (25, 32, 36 mm) GLP (6, 10, 16 mm)	145,000 4,000 2,200
Transistor Reset (Order “Plus”)	GEM, GMX	1,000,000
Pulsed Optical Feedback (Order “POF”)	IGLET, IGLET-X, SLP, GLP, SLB (6, 10, 16 mm)	4,000*
Modified For HCR (Resistive Feedback)	All GLPs	10,000

*The POF does not "lock up" or saturate at high count rates, unlike resistor-feedback designs. At ultra-high count rates with the POF, throughput is limited by reset pulse rates. 4000 MeV/s is an estimate of maximum "useable" energy rate.

Photon Detector Assembly

All new ORTEC resistive-feedback preamplifiers (Model A250 Series) require only 1 watt of power, which is 50% less than previous ORTEC preamps. This makes the new preamplifiers ideal for demanding portable applications such as Safeguards. The transistor-reset preamplifier ("Plus" option) requires ~1.8 watts of power.

Automatic HV Shutdown

If the system is warmed up with bias on, the automatic HV shutdown feature protects the input FET and the critical detector surfaces. ORTEC uses a thermistor on the mount, not the detector element itself, to sense the onset of warmup.

Cable Pack

Unless otherwise specified at time of order, each ORTEC detector is supplied with a single, captive cable bundle 3 ft in length and terminating into individual in-line connectors:

Signal out 93-Ω BNC
Timing out 93-Ω BNC
Test in 93-Ω BNC
HV in 75-Ω Male
Preamp power 9-pin D female

A mating cable pack of individual conductors, 10 ft in length is provided for connections to supporting electronic systems.

Two alternative cabling arrangements are offered:

1. "M-1 style" all cables except high voltage are carried in a single cryostat-mounted LEMO connector. HV is carried via SHV male connector. Includes standard 10 ft length single cable bundle carrying all connectors. This is ordered by appending "**-M**" to the detector specification for coaxial detectors >30% relative efficiency only.

2. SMART-1 Intelligent Detector option.

SMART-1 Intelligent Detector Option

SMART-1 is an option on all GEM, GMX, and GLP detectors. The option integrates a microprocessor controlled module with the detector assembly. The module, controlled via an RS-232 link from the MCA, provides the HV bias for the detector element and provides state of health information on the following detector functions:

Preamplifier ±12, ±24 V
Detector element temperature
Detector high voltage on/off/set/read
Detector overload status
Detector shutdown status
Detector serial number (read only)
Detector authentication code (read/write)

Cryostats, Dewars, Cryostat-Dewar Assemblies, and Electrical Cooling

All ORTEC HPGe and SiLi detectors must be operated at cryogenic temperatures. Historically, the cryogen has been liquid nitrogen (LN_2). The revolutionary X-COOLER II now offers a practical, LOW COST and reliable alternative to LN_2 cooling.

Reference

1. G.F. Knoll, *Radiation Detection and Measurements* (second edition), John Wiley and Sons, New York, 1989.

ORTEC®

Categories of Photon Detectors

ORTEC has the right photon detector for a wide range of x- and gamma-ray energies. See Fig. 1 for the energy ranges of the detectors discussed in this section.

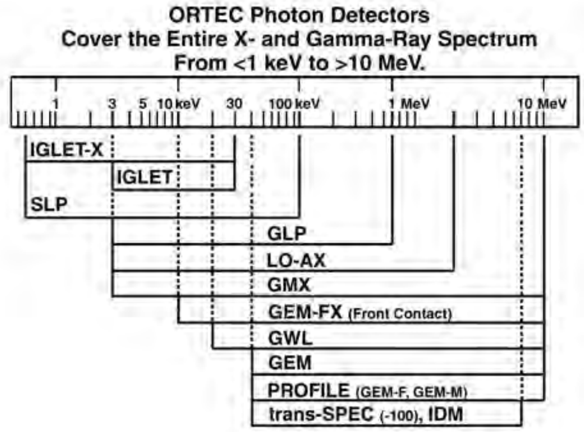


Fig. 1. ORTEC Detectors Cover the Entire Spectrum from <1 keV to >10 MeV.

GEM and GAMMA-X Coaxial Detectors

GEM and GAMMA-X (GMX) coaxial detectors maybe characterized by the following specifications:

Specifications	Coaxial Detector Type
• Relative Efficiency at 1.33 MeV	GEM and GMX
• Energy Resolution at:	
1.33 MeV	GEM and GMX
122 keV	GEM
5.9 keV	GMX
• Peak-to-Compton Ratio at 1.33 MeV	GEM and GMX
• Peak Shape at 1.33 MeV	GEM and GMX
FW.1M/FWHM	
FW.02M/FWHM	
• ^{109}Cd 22-keV/88-keV Peak Area Ratio	GMX

The new PROFILE Series GEM detectors are characterized in terms of crystal dimensions being optimized for applications such as filter paper or Marinelli beaker counting.

Efficiency as a Function of Energy

As shown in Fig. 2 (Refs. 1–3), the absolute efficiency of HPGe coaxial detectors varies with energy. The ratio of the number of counts in the full-energy photopeak to the total number of gamma rays emitted from a source is known as the absolute full-energy photopeak efficiency. This includes the effect of the solid angle subtended by the detector, and thus the source-to-detector distance. This absolute detection efficiency is a function of energy. For a gamma-ray or x-ray to be detected, the photon must transfer part or all of its energy by one of three interaction modes: photoelectric effect, Compton scattering, or pair production. For a count to occur within a nuclide's full-energy photopeak, all of the photon's energy must be deposited in the detector's active volume, either as a single photoelectric interaction or as a multiple event. At 1.33 MeV, ~80% of the full-energy counts start with a Compton interaction.

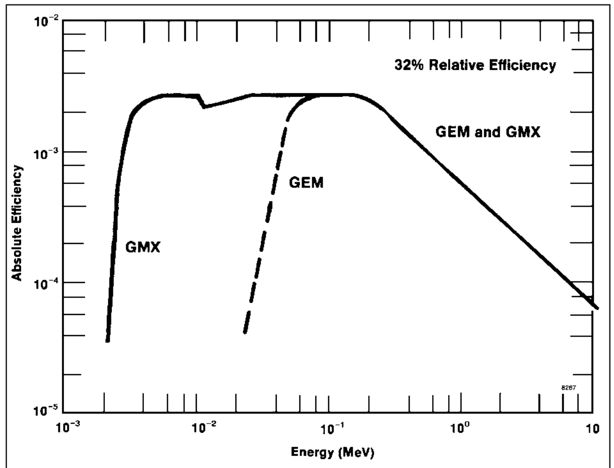


Fig. 2. Absolute Efficiency vs. Energy for 32% GEM and GAMMA-X HPGe Coaxial Detectors.

At gamma-ray and x-ray energies up to ~40 keV, the relationship of efficiency to energy is dominated by the attenuation of these photons by materials outside the detector and by any dead layers on the detector periphery. For this reason, the GEM (p-type) and GAMMA-X (n-type) detectors have different responses.

In GAMMA-X detectors, the 0.3-µm boron ion-implanted contact and thin beryllium front window allow photons of energy down to 3 keV to enter the active volume of the detector. Except for the anomaly at the 11-keV germanium absorption edge, virtually all photons up to 200 keV are detected. Above that energy, the efficiency falls off with the total absorption cross section of Ge, which is dominated by the fall-off in the photoelectric cross section (Fig. 3).

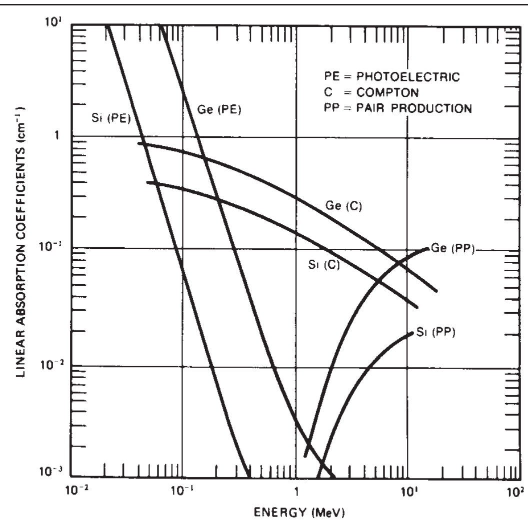


Fig. 3. Linear Absorption Coefficients vs. Gamma-Ray Energy for Si and Ge.

Due to the 700-µm-thick Li-diffused outer contact of the GEM detector, it experiences a fall-off of efficiency below ~100 keV, with almost all photons below 40 keV being absorbed in the outer dead layer. At higher energies the relationship between efficiency and energy is dominated by the average path length in the active volume of the detector. The efficiency decreases with increasing energy because the probability that the photon

Categories of Photon Detectors

will interact within the detector also decreases with energy. Because it is primarily the detector volume (and somewhat the detector dimensions) that determines this average path length, both GEM and GAMMA-X detectors have the same efficiency at high energies (Refs. 1, 2, and 3).

A useful presentation is in Figure 4 (after Vano*), which demonstrates there is little relationship between the relative efficiency at 1.33 MeV and the relative efficiency at other energies.

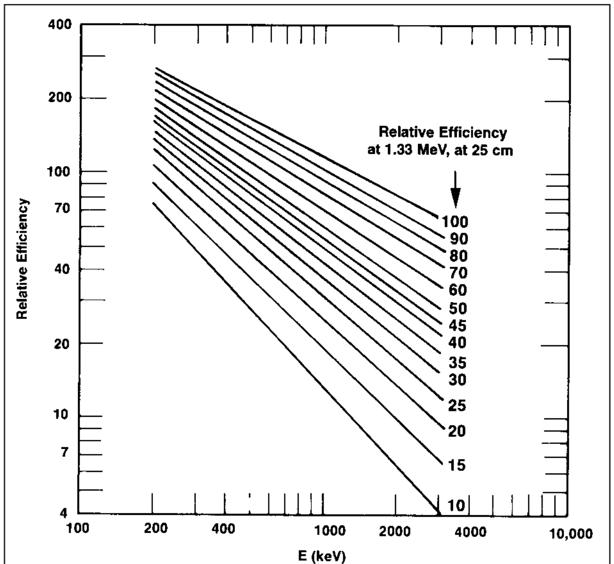


Fig. 4. Relative Efficiency as a Function of Energy for Detectors with Relative Efficiency from 10% to 100% at 1.33 MeV.

Attenuation Effects

An example of attenuation effects in external materials is shown in Table 1, the **percentage of photons transmitted through 1 mm of aluminum**, a material commonly used in detector endcaps. The relationship describing this attenuation is:

$$N = N_0 e^{-\mu x}$$

where N is the number of remaining photons in the beam of original intensity N_0 after traversing distance x, and μ is the absorption coefficient for aluminum.

Another example is the percentage of photons transmitted through 0.7 mm of germanium, which is the typical thickness of the outer contact of a GEM (p-type) detector (Table 2).

A practical example of the effects of detector dead layers on low-energy spectra is shown in Fig. 5.

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

Table 2. Percentage of Photons Transmitted, as a Function of Energy, through 0.7 mm of Germanium.

Energy (keV)	% Transmitted
20	1.5×10^{-7}
30	.6
40	10
50	29
60	47
80	70
100	81

Relative Efficiency (at 1.33 MeV)

For historical reasons, the relative detection efficiency of coaxial germanium detectors is defined at 1.33 MeV relative to that of a standard 3-in.-diameter, 3-in.-long NaI(Tl) scintillator. The measurement is performed by the method that is described in the IEEE Standard Test Procedures for Germanium Detectors for Ionizing Radiation (ANSI/IEEE 325–1996) and in the equivalent IEC standard. A National Institute of Standards ^{60}Co source with known intensity is positioned 25 cm from the endcap face, and a fixed-time count is taken for the 1.33-MeV peak. The absolute efficiency is the ratio of the number of counts in the photopeak divided by the number of gamma rays emitted from the source during the same period of time. This absolute efficiency is then divided by 1.2×10^{-3}, which is the absolute efficiency at 1.33 MeV of a standard 3-in. by 3-in. NaI(Tl) crystal 25 cm from the source. The ratio of these measurements is the basis for the relative efficiency specification of the germanium detector.

Relative efficiency, while giving a general indicator of detector performance, can be highly misleading in regards to specific geometries (e.g., filter paper or Marinelli beakers). For this reason, ORTEC offers the PROFILE Series GEM detectors with warranted crystal dimensions.

The Efficiency Advantage

Many ORTEC coaxial germanium detectors have a measured relative efficiency substantially higher than the warranted value.

The PROFILE Advantage

PROFILE Series GEM detectors offer warranted crystal dimensions, greatly increasing detection limit predictability.

*Nucl. Instrum. Methods, **23** (1975) 573–4.

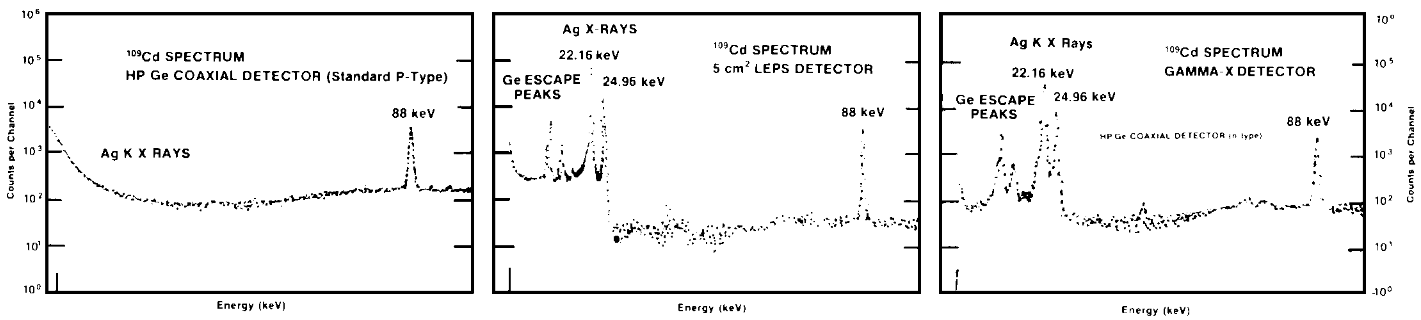


Fig. 5. ^{109}**Cd Spectrum Observed with: (a) a 10% Relative Efficiency GEM Detector; (b) a 5-cm^2 Active Area, 10-mm Active Depth HPGe LEPS Detector; (c) a 10% Relative Efficiency GAMMA-X Detector.**

Relationship of Relative Efficiency to Active Volume

As the volume of a coaxial detector increases, so does its relative efficiency (measured at 1.33 MeV). However, there is not a simple relationship between volume and relative efficiency. The efficiency increases faster with detector radius than with detector length. An approximate (**not** dimensionally correct) relationship is:

$$\text{Relative Eff (\%)} = \frac{\text{Volume (cc)}}{4.3}$$

Since the density of germanium is 5.33 g/cc, ~23 g of Ge in the finished detector is required for each “percent” of efficiency.

A more recent empirical formula relating volume to efficiency is the following (courtesy of Dr. T.L. Khoo of Argonne National Lab):

$$\text{Relative Eff (\%)} = KD^{\alpha} L^{\beta} ,$$

where D = active crystal diameter, L = crystal length, K = 2.4321, α = 2.8155, and β = 0.7785. (Diameter and length in decimeters.)

This formula illustrates how detectors of the same % relative efficiency (IEEE 325) can have very different dimensions.

Energy Resolution

The energy resolution is a measure of the detector’s ability to distinguish closely-spaced lines in the spectrum. The method used to measure the energy resolution is also described in ANSI/IEEE 325–1996.

Energy Resolution as a Function of Energy

For the energy range **up to 1.5 MeV**, the following approximate (and **not** dimensionally correct) expression is useful for predicting the resolution of a Ge detector:

$$R = (N^2 + 2E)^{1/2}$$

where R is the energy resolution (FWHM) at the energy of interest, N is the noise line width, and E is the energy of interest, with all quantities expressed in eV (**not** in keV).

For the range from 1.5 MeV to 10 MeV (as shown in Ref. 2), the expected resolution (FWHM) is *approximately* 0.08% to 0.1% of the energy of the line of interest. At the higher energies the measured resolution can be worse than this due to even minor trapping. The actual measured values depend on the quality of the Ge crystal used to manufacture the detector element, the depth of the hole in the center of the crystal, extent of shaping of the crystal’s front “corners,” and other manufacturing details. All Ge detectors are not created equal!

Energy Resolution as a Function of Temperature

Most HPGe detectors begin to show increasing leakage current and electronic noise at temperatures above ~110 K. Due to the different cooling capabilities of various cryostats, HPGe detectors normally operate at temperatures in the range from 85 to 100 K. A stable operating temperature is essential. Because E, the average energy necessary to create an electron hole-pair (see Table 3), varies with temperature at a rate of 2.53 X 10^{-4} per degree K (Ref. 4), temperature variations during a measurement result in a peak shift that degrades the energy resolution. Temperatures below 40 K may result in deterioration in energy resolution due to trapping effects.

There are several references[5,6] useful for those planning to use germanium detectors at temperatures higher or lower than the customary temperature. Because the FET that is in the first stage of the preamplifier is inside the cryostat and yet must be held at

~115 K, the use of germanium detectors at unusual operating temperatures may result in increased first-stage preamplifier noise.

Si(Li) detectors do not operate well at temperatures below 77 K.[8]

Operation in Magnetic Fields

If it is necessary to operate a germanium detector in a high magnetic field (~ several hundred millitesla) there is danger that even with a good vacuum a Penning discharge may cause surface leakage current, which will make the detector inoperable.

ORTEC can, on request, prevent such an occurrence by providing a modified detector mount which includes an insulator between the endcap wall and the detector outer contact sitting at high voltage.

Table 3. Some Basic Properties of Silicon and Germanium.*

	Si	Ge
Atomic number	14	32
Density (300 K); $g \cdot cm^{-3}$	2.33	5.33
Atoms; cm^{-3}	4.96×10^{22}	4.41×10^{22}
Dielectric constant	12	16
Forbidden energy gap (300 K); eV	1.115	0.665
Forbidden energy gap (0 K); eV	1.165	0.746
Electron mobility (300 K); $cm^2 \cdot V^{-1} \cdot s^{-1}$	1350	3900
Hole mobility (300 K); $cm^2 \cdot V^{-1} \cdot s^{-1}$	480	1900
Electron mobility (77 K); $cm^2 \cdot V^{-1} \cdot s^{-1}$	2.1×10^4	3.6×10^4
Hole mobility (77 K); $cm^2 \cdot V^{-1} \cdot s^{-1}$	1.1×10^4	4.2×10^4
Carrier saturation velocity; $cm \cdot s^{-1}$ (300 K)	8.2×10^6	5.9×10^6
Carrier saturation velocity; $cm \cdot s^{-1}$ (77 K)	10^7	9.6×10^6
Energy per hole-electron pair (300 K); eV	3.62	(not applicable)
Energy per hole-electron pair (77 K); eV	3.76	2.96

*All ORTEC semiconductor photon detectors are made of either germanium or lithium-drifted silicon.

Peak-to-Compton Ratio

The peak-to-Compton ratio, also measured in accordance with ANSI/IEEE 325–1996, is the key indicator of a detector's ability to distinguish low-energy peaks in the presence of high-energy sources. **The peak-to-Compton ratio is one of the most important and yet most often overlooked — sometimes even unspecified — measures of detector performance.** The Compton plateau results from Compton interactions in the detector in which the resulting photon, reduced in energy, escapes from the sensitive volume of the detector. The peak-to-Compton ratio is obtained by dividing the height of the 1.33-MeV peak by the average Compton plateau between 1.040 and 1.096 MeV. Again, the typical measured peak-to-Compton ratio for ORTEC detectors is substantially better than the warranted specifications. For a given value of the relative efficiency, **higher peak-to-Compton values are achieved with better values of energy resolution**. [Note: For two HPGe detector elements **having the same diameter and length**, the product of resolution (at 1.33 MeV) times the peak-to-Compton ratio is a constant; therefore, if one detector has 10% better resolution, it will have a 10% higher peak-to-Compton ratio.]

Peak Shape

In cases where two peaks have nearly identical energies (and the smaller peak is on the low-energy side of the larger peak), near-perfect Gaussian peak shape is essential to quantify the smaller peak's net area. As demands for reduced MDAs become more pervasive, excellent peak shape is increasingly important. Even when the most sophisticated software is employed to deconvolute interferences, the precision of the result and the MDA is limited by the extent of the interference of the peaks with each other.

The ratios FW.1M/FWHM (FW.1M = Full Width at One-Tenth Maximum) and FW.02M/FWHM (FW.02M = Full Width at One-Fiftieth Maximum) are excellent means of describing this shape. The theoretical Gaussian peak has a FW.1M/FWHM ratio of 1.83 and an FW.02M/FWHM ratio of 2.38. *Most ORTEC detectors have peak shapes close to these theoretical numbers.*

22-keV Peak/88-keV Peak Area

This specification quantifies the thinness of the entrance window in GAMMA-X detectors. The natural ratio of gamma rays from the 22-keV and 88-keV lines of a ^{109}Cd source is ~21:1. A GAMMA-X detector typically displays a ratio >20:1. For comparison, the ratio for a GEM (p-type) detector is ~1:100.

Timing with HPGe Coaxial Detectors

The timing performance of a coaxial detector defines its ability to distinguish between two events closely spaced in time.

Timing performance depends greatly on proper electronic setup. Table 4 shows some typical timing results measured with ORTEC detectors. The timing performance of a 61% GAMMA-X detector (with a Model 583 Constant-Fraction Discriminator threshold set at 50 keV and the energy range selected with a Model 551 Timing Single-Channel Analyzer) is as follows:

At E > 100 keV	FWHM = 5.5 ns
At E = 1.33 MeV (±50 keV)	FWHM = 3.7 ns
	FW.1M = 8.9 ns

Results obtained with large GAMMA-X detectors are shown in Table 5.

Table 4. Typical Timing Results Measured with ORTEC's Coaxial Detectors.													
					Timing Resolution (ns)								
					Mean Energy (keV) Using ^{22}Na				Mean Energy (keV) Using ^{60}Co				
Detector System	Detector Type	Efficiency (%)	Optimum Delay (ns)	Measure	150	250	350	511	511	750	950	1170	1330
1	HPGe-P	11.0	24	FWHM FW.1M	9.2 –	6.7 45.3	5.8 22.2	4.0 9.9	3.9 10.2	3.0 8.4	2.6 7.5	2.0 5.6	1.7 5.1
2	HPGe-N	19.8	23	FWHM FW.1M	12.5 84.0	8.6 33.0	7.0 18.1	4.5 10.2	4.9 11.9	3.7 8.6	3.1 7.7	2.2 5.5	2.0 4.9
3	HPGe-P	28.0	34	FWHM FW.1M	11.3 –	8.8 55.8	7.7 27.1	5.6 12.8	6.2 13.4	5.7 12.3	4.0 11.8	3.6 9.8	3.4 9.0

HPGe (IGLET, IGLET-X, GLP) and Si(Li) Planar, and LO-AX Coaxial Low-Energy Photon Spectrometers

Detectors of choice for high-resolution, low photon energies are Si(Li) (SLP Series), Planar (GLP Series), LO-AX, IGLET and IGLET-X detectors. For each of these detectors the following information is provided: active diameter, active depth, and resolution at 5.9 keV measured with optimal time constants. For GLP and LO-AX detectors an additional specification (energy resolution at 122 keV) is provided. For IGLET and IGLET-X detectors a high count rate specification 5.9 keV resolution at 100 kcps at a 0.5 µs time constant, is given.

Intrinsic Efficiency

Intrinsic (full-energy) efficiency is the probability that a photon of a given energy ε, impinging on the front of the detector will be completely absorbed by the detector element. Although the intrinsic efficiency is not a standard specification for SLP, GLP, IGLET, and IGLET-X detectors, it is a parameter of interest for GLP detectors from 3 to 100 keV, for IGLET detectors from 3 to 50 keV and down to very low energies for SLP and IGLET-X detectors.The low energy portion of the intrinsic efficiency curves for SLP and IGLET-X detectors is dominated by the beryllium window thickness. The curves in Fig. 6 show the intrinsic efficiency for SLP detectors; those in Fig. 7 show intrinsic efficiency values for GLP and IGLET detectors, and Fig. 8 the intrinsic efficiency for IGLET-X detectors in which the beryllium window thickness dominates the low energy efficiency.

Typically, SLP series detectors are "black" (total absorption) for energies up to 20 keV, while GLP series detectors are "black" for energies up to 120 keV.

Maximizing IGLET-X Efficiency for Ultra-Low-Energy X Rays

In a windowless mode of operation, IGLET-X detectors are capable of detecting photons of energy <0.5 keV. A windowless detector is supplied with a gate valve which can be opened when the detector is placed in a vacuum common to the source of the x rays. Windowless detectors are supplied with a beryllium window on the gate valve to allow a general test of the detector performance upon arrival.

At energies below 3 keV the Intrinsic Full Energy Efficiency of SLP and IGLET-X detectors is greatly reduced by x-ray absorption in the endcap window. Figure 6 displays the results obtained with Be windows of different thickness.

Table 5. Timing Data Obtained on Three High Efficiency GAMMA-X Detectors Included in the EUROGAM Array (P. Nolan, *et al.*, Internal Daresbury Report – July 1991).			
Detector	Efficiency (%)	E (keV)	FWHM (nsec)
A	69.2	50–1332 1332 779 344 122	5.8 4.3 6.8 9.0 19.0
B	80.2	50–1332 1332 779 344 122	9.2 6.7 8.7 13.3 18.1
C	70.2	50–1332 1332 779 344 122	7.2 4.7 6.0 10.6 22.2

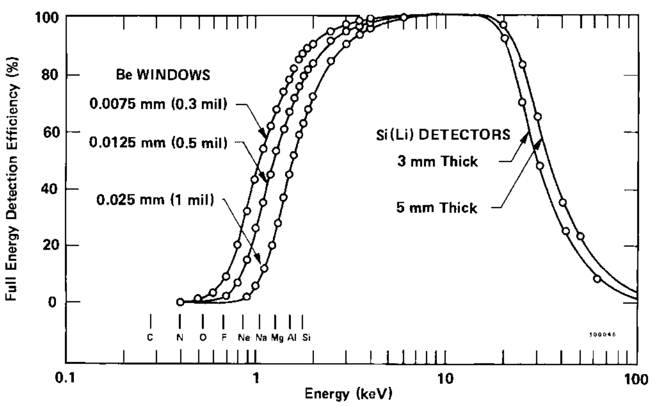


Fig. 6. Intrinsic Full-Energy Detection Efficiency for SLP Detectors as a Function of Be Window Thickness and Detector Thickness.

Categories of Photon Detectors

Timing at Low Energies with Planar Germanium Detectors

For timing measurements at energies below 150 keV planar HPGe (GLP series) detectors are the best choice. Table 6 shows results obtained with GLP detectors of 10 cm². Note: LO-AX, IGLET, or similar quasi-planar detectors are unsuitable for such measurements.

Well Detectors (GWL Series)

Well detector design maximizes efficiency for small samples. The Well detector is actually a p-type HPGe coaxial detector mounted with a large central hole facing the front of the endcap.

Historically, Well detectors have been characterized by the following parameters:

- Active volume (cc)
- Diameter (mm) of endcap well
- Depth (mm) of endcap well
- Energy resolution at 1.33 MeV (keV FWHM)
- Energy resolution at 122 keV (keV FWHM)

Efficiency of Well Detectors

Data on efficiency of Well detectors can be found in the literature (Ref. 8). Figure 9 shows a typical efficiency curve for point sources placed at the bottom of the Well.

The ORTEC Well Detector Advantage

The "blind well" approach pioneered by ORTEC puts sensitive germanium immediately under the sample, and thus increases the detector efficiency, particularly for low-energy lines.

Detector Microphonics

After more than 30 years of germanium detector production the phenomenon of microphonics is still not well understood. A back-of-the-envelope calculation leads to the false conclusion that no germanium detector will ever operate. For example, consider a metal part, such as the cup that holds the detector, which has a small, but non-zero capacitance with respect to the FET gate. Assume that sound waves, such as from a voice, induce a variation of merely 0.5 femtofarads in the value of this capacitance; the result would be a signal equivalent to 10 keV!

Although there is no IEEE standard on the measurement of the extent of microphonics, considerable work has been done in this field:

1) Special design: ORTEC has always been at the forefront in this field, for example production of a rugged detector designed for the U.S. Navy (Ref. 9). ORTEC has also provided arrays of germanium detectors for helicopter aerial surveillance.

2) Proper electronic setup: As the microphonics spectrum is primarily in the few kcps range, a high pass filter (shorter amplifier time constants and baseline restorer "on") will often improve detector performance.

3) Vibration decoupling: Users typically obtain improvement by using soft foam rubber around and under the detector.

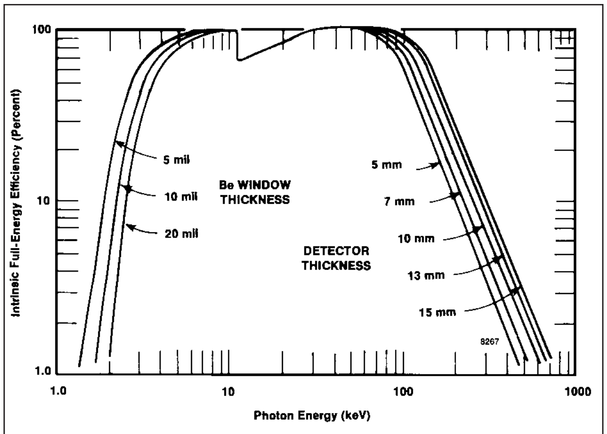


Fig. 7. Intrinsic Full-Energy Efficiency vs. Energy for GLP and IGLET Detectors as a Function of Be Window Thickness and Detector Thickness.

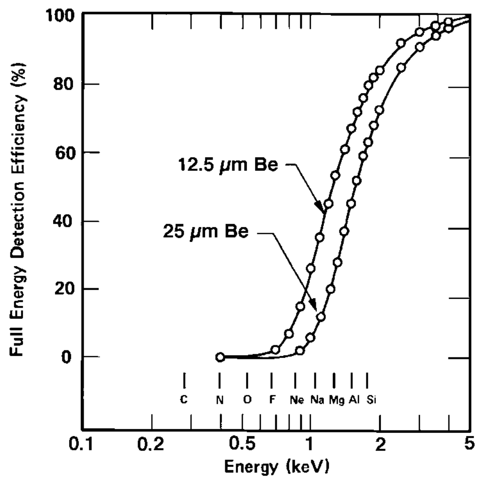


Fig. 8. IGLET-X Intrinsic Full Energy Efficiency in % vs. X-Ray Energy.

Table 6. Timing at Low Energies with 10 cm² Active Area Planar Detectors*.

Source	Energy (keV)	Time Resolution(ns)
^{22}Na	20 ±10	20 ±2
	100 ±10	8.5 ±1
	511 ±5	4.5 ±0.2
^{133}Ba	31 ±3	19 ±2
	81 ±3	Isomer
	85 ±5	11 ±1
	356 ±5	6.0 ±0.5
^{152}Eu	41 ±3	15 ±1
	122 ±5	Isomer
	125 ±5	6.5 ±0.5
	344 ±5	5.0 ±0.2
	779 ±5	3.8 ±0.3

*Data courtesy of Dr. Kim Lister, Argonne National Lab.

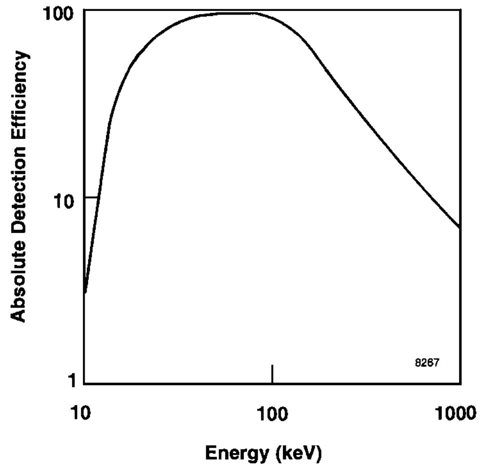


Fig. 9. Absolute Detection Efficiency vs. Photon Energy for a Typical ORTEC Well Detector.

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ORTEC®

Low-Background Germanium Gamma-Ray Detectors

Factors Affecting Low-Background Gamma Spectroscopy with HPGe Detectors

The radiation background of standard cryostats used by ORTEC for germanium detectors is lower than that required for the majority of users. Net area peak counting rates ~0.1 counts/min are typical at energies of interest. **Nonetheless, those measuring environmental samples who require the lowest MDAs in the shortest possible counting time will be best served by a large germanium detector in a low- or extra-low-background cryostat.** Coaxial detectors of efficiency from 80% to 175%, with their exceptionally high peak-to-Compton ratios (approaching 100 to 1), are also recommended (Ref. 1).

ORTEC offers a variety of low-background detector options and cryostat configurations to meet each customer's specific requirements.

There are a number of naturally-occurring radionuclides that contribute to the gamma-ray background observed by spectroscopists using a germanium detector system. Contributions from the cosmic-ray induced background, ^{40}K from building structures, and radon, can be markedly reduced by appropriate shielding (including in some cases an underground location) and flushing the shield with "aged" nitrogen. The principal sources of activity from the cryostat are the primordial emitters, ^{238}U, ^{232}Th, ^{235}U and their daughters, man-made radionuclides including ^{137}Cs fallout, and the activation product ^{60}Co. There are both full-energy photopeaks and associated Compton background from 46 to 2600 keV.

In some materials, the natural emitter chains may not be in equilibrium. Therefore, ORTEC reports the measured background at all the energies shown in Table 1.

Different spectroscopists have different "low-background" requirements and energies to which the phrase "low background" applies. Therefore, low-background cannot be rigorously defined as, for example, energy resolution at the 1.33-MeV line of ^{60}Co. For this reason various laboratories use different nomenclature and different report formats when describing measured background.

Table 1. Environmental Radionuclide Full-Energy Photopeak Energies.

Isotope (Parent Nuclide)	Energy in keV	Isotope (Parent Nuclide)	Energy in keV
U x-rays	13.0, 13.3*	^{137}Cs	661.6
^{231}U	25.6*	^{214}Bi (^{238}U)	727.2
^{137}Cs	31.8, 32.2, 36.4*	^{234m}Pa (^{238}U)	766.6
^{210}Pb (^{238}U)	46.5	^{228}Ac (^{232}Th)	911.0
^{234}Th (^{238}U)	63.3	^{228}Ac (^{232}Th)	969.0
^{234}Th (^{238}U)	92.6	^{234m}Pa (^{238}U)	1001.0
^{235}U, ^{226}Ra	185.7, 186.2	^{214}Bi (^{238}U)	1120.3
^{212}Pb (^{232}Th)	238.6	^{60}Co	1173.0
^{214}Pb (^{238}U)	295.2	^{214}Bi (^{238}U)	1238.0
^{214}Pb (^{238}U)	351.9	^{60}Co	1332.5
Cosmic	511.0	^{40}K	1460.8
^{208}Tl (^{232}Tl)	583.1	^{214}Bi (^{238}U)	1764.5
^{214}Bi (^{238}U)	609.3	^{208}Tl (^{232}Tl)	2614.5

* The lines lower than 46 keV are reported only for LO-AX and GMX detectors.

To satisfy the needs of spectroscopists, ORTEC does the following:

- Carefully selects low-background materials
- Characterizes completed HPGe detectors in a specialized low-background facility
- Produces the world's largest detectors in the lowest-background cryostats — the ultimate for gamma spectroscopy of low-level samples
- Provides with each detector an activity report of the 22 most common isotopes
- Remains current with technology for low-background materials

Environmental spectroscopists seeking to minimize MDA while maximizing sample throughput should read: *The Benefits of Using Super-Large Germanium Gamma-Ray Detectors for the Quantitative Determination of Environmental Radionuclides.*

Material Selection and Low-Background Measurements

For many years ORTEC has been selecting low-background materials such as magnesium, ultra-pure aluminum, OFHC copper, lead, stainless steel, beryllium (for windows), and charcoal (for cryopumping).

We have also established a low-background spectroscopy laboratory and a detector background-certification program. The laboratory houses two lead shields, configured to accommodate detectors in various configurations. Each shield consists of a 3-in. OFHC copper "well" surrounded by eight inches of low-radiogenic lead. The copper virtually eliminates the lead x-rays resulting from photoelectric interactions of gamma rays with the lead.

For characterizing the materials to be used for detector cryostat construction, the low-background laboratory has a graded-Z (Pb, Cu, Cd) shield containing an ultra-low-background detector. Quality control limits have been established for each type of material dependent on its location in the finished cryostat.

Each completed detector is placed in the appropriate shield. An NBS SRM 4275 source is used for calibration.

Low-Background Germanium Gamma-Ray Detectors

Then, with the source removed, a detector background spectrum is acquired for 100,000 seconds. The background spectrum is searched using a second-difference peak-search algorithm. All identified peaks are visually examined. For any peaks that are part of the list reported as “not found,” a region-of-interest (ROI) is set manually, and the net area is computed by the MCA Emulation software. Finally, a report that lists the ROI net count rates is created.

The data are reported as intensities rather than activities because the activities are a function of the geometry of the calibration, while the intensities are geometry-independent.

The logarithmic plot (Fig. 1), linear plot (Fig. 2), and low-background analysis reports (Tables 2 and 3) show, for comparison, the gamma background spectra of two GEM detectors of identical relative efficiency (56%), one in a standard cryostat and the other in an extra-low-background (Model XLB) cryostat (Fig. 3). The difference in background is substantial. The background report can be supplied, if requested, on a floppy disk, which can be used in conjunction with the ORTEC MAESTRO MCA Emulation program to visually examine the data or to plot it.

It must be emphasized that the gamma background measured in a detector cannot be better than the background in the laboratory where the detector is operated. For example, health physicists making *in vivo* measurements should be aware that the beds or chairs in which the subject is placed are generally not made of materials selected for low gamma background and, also, that the subjects being measured emit gamma rays at a rate consistent with the 40–120 nanocuries of ^{40}K normally found in the human body. Therefore, while every precaution must be taken to obtain good, reliable measurements, it is useless to strive for the “ultimate in low background” as some physics researchers operating in sophisticated underground laboratories must and can do.

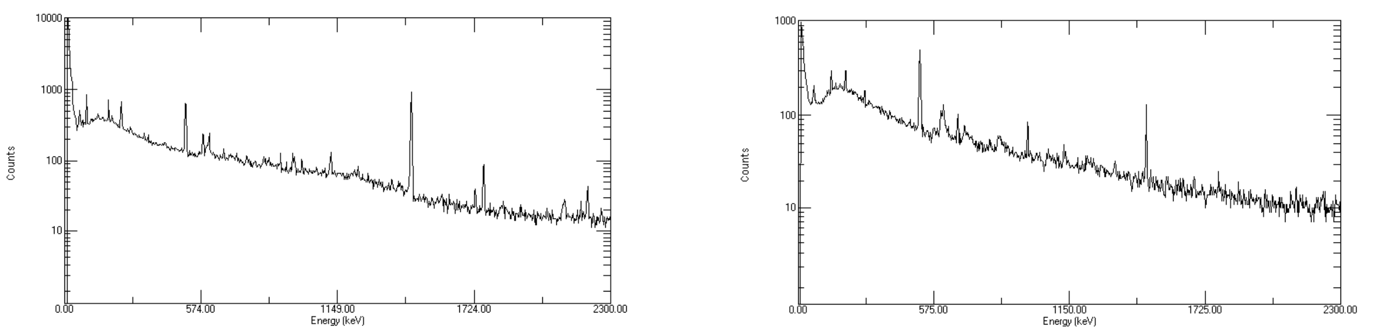


Fig. 1. Logarithmic Plots of Super High Efficiency 205% GEM Detectors in (a) Standard Cryostat and (b) LLB Cryostat.

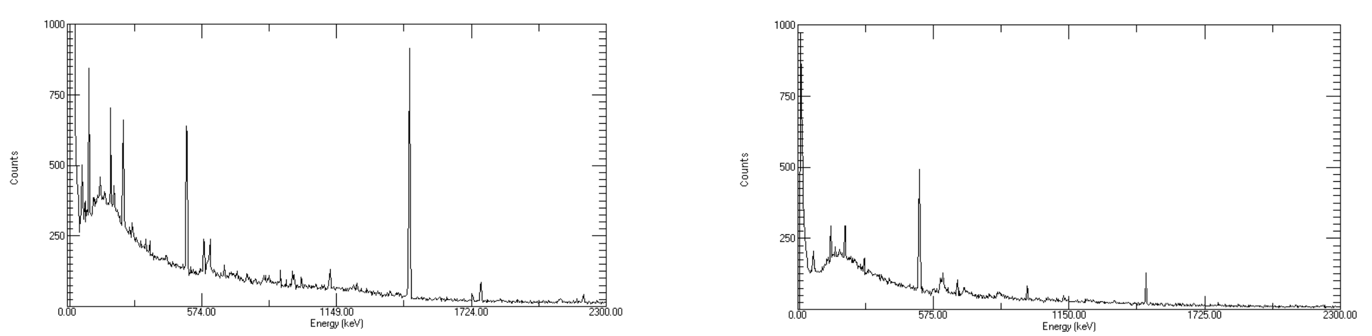


Fig. 2. Linear Plots of Super High Efficiency 205% GEM Detectors in (a) Standard Cryostat and (b) LLB Cryostat.

Table 2. Low-Background Analysis Report for "Standard" Detector.

1 LOW BACKGROUND ANALYSIS
SPECTRUM: A:P40836AN.CHN
ROI FILE: A:P40836AN.ROI
DETECTOR SERIAL NUMBER P40836A, NON LOWBACKGROUND ENDCA 205% RELATIVE EFFICIENCY
ANALYSIS AT 08:13:49 ON 17-AUG-01
MCA NUMBER: 1 SEGMENT NUMBER: 1
REALTIME 100983.20 SECS, LIVETIME 100000.00 SECS
START TIME 13:18:26 ON 09-Jul-99 0
START CHANNEL 0 LENGTH 8192
SAMPLE MULTIPLIER: 1000.0000
TOTAL CORRECTION FACTOR: 1000.0000
BACKGROUND CALCULATED AS AVERAGE OF 3 CHANNELS
ENERGY = 42.1E-02 + 28.5E-02*CHAN + .0E+00*CHAN**2

REGION	CENTROID	START	STOP	-----PEAK AREA-----		ERROR	CORRECTED
NUMBER	ENERGY(keV)	CHANNEL		GROSS	NET	NET %	CTS/KSEC
1	46.57	152	172	6442.	643.	25.5	6.43
2	63.43	210	228	6597.	1065.	14.6	10.65
3	66.55	230	236	2242	50.	139.0	.50
4	76.26	259	281	7245.	219.	84.6	2.19
5	92.82	313	335	10059.	3036.	6.3	30.36
6	139.73	477.	501	9644	557.	39.2	5.57
7	185.94	639	663	10588.	2405.	8.8	24.05
8	198.59	683	707	8563	609.	33.5	6.09
9	238.81	823	849	9801.	1831.	11.7	18.31
10	277.98	962	988	6393	318.	57.8	3.18
11	351.88	1220	1248	5338.	543	31.1	5.43
12	510.60	1772	1807	10739.	6233.	3.1	62.33
13	582.65	2027	2059	4552.	933	16.8	9.33
14	608.49	2118	2150	5240.	945.	18.0	9.45
15	661.15	2302	2332	2990	0.	.0	.00
16	668.90	2334	2363	3135.	370.	35.2	3.70
17	726.38	2532	2566	3153	219.	65.1	2.19
1	762.33	2670	2704	3118.	15.	993.1	.15
19	910.34	3174	3210	2889	583	22.5	5.83
20	961.72	3353	3383	2438.	516.	21.6	5.16
21	967.65	3385	3411	2045.	330.	29.9	3.30
22	1000.30	3490	3526	2576.	436	28.8	4.36
23	1117.27	3907	3945	2836.	230.	61.3	2.30
24	1173.92	4091	4129	2055.	86.	142.6	.86
25	1236.53	4322	4360	2187.	217.	56.3	2.17
26	1331.28	4650	4686	1384.	0.	0	.00
27	1459.02	5096	5136	11492	9859	1.5	98.59
28	1762.42	6166	6198	1384.	966	6.3	9.66
29	2201.42	7707	7734	688.	282	18.0	2.82

END OF ROI LIST

Table 3. Low-Background Analysis Report for "Low-Background" Detector.

1 LOW BACKGROUND ANALYSIS
SPECTRUM: A:P40836AL.CHN
ROI FILE: A:P40836AL.ROI
DETECTOR SERIAL NUMBER P40836A, LOW BACKGROUND ENDCAP 205% RELATIVE EFFICIENCY
ANALYSIS AT 08:01:57 ON 17-AUG-01
MCA NUMBER: 3 SEGMENT NUMBER: 1
REALTIME 100073.10 SECS LIVETIME 100000.00 SECS
START TIME 10:24:52 ON 03-Apr-00 1
START CHANNEL 0 LENGTH 16384
SAMPLE MULTIPLIER: 1000.0000
TOTAL CORRECTION FACTOR: 1000.0000
BACKGROUND CALCULATED AS AVERAGE OF 3 CHANNELS
ENERGY = 12.8E-02 + 24.7E-02*CHAN + .0E+00*CHAN**2

REGION	CENTROID	START	STOP	-----PEAK AREA-----		ERROR	CORRECTED
NUMBER	ENERGY(keV)	CHANNEL		GROSS	NET	NET %	CTS/KSEC
1	45.99	178	194	2045.	116.	75.0	1.16
2	64.20	250	266	2619.	21.	479.5	.21
3	91.98	363	379	1972	0.	0	.00
4	140.07	559	575	3511.	491.	22.4	4.91
5	184.31	735	753	3352.	36.	322.4	.36
6	198.56	795	813	3927.	630.	19.0	6.30
7	236.17	946	964	2710	0.	.0	.00
8	278.50	1119	1137	2704.	285.	35.8	2.85
9	292.57	1173	1191	2123.	17.	546.2	.17
10	348.01	1398	1418	1961.	0.	.0	.00
11	510.99	2046	2092	8939.	5837	3.1	58.37
12	545.70	2324	2346	1244.	2.	3873.7	.02
13	602.81	2429	2451	2045	0	0	0
14	609.47	2455	2477	2107.	321.	29.5	3.21
15	657.97	2658	2689	1446.	65.	145.2	.65
16	669.92	2691	2724	1889.	331.	31.3	3.31
17	727.46	2924	2966	1802.	175.	66.2	1.75
18	771.64	3084	3126	1714.	23.	518.9	.23
19	910.49	3670	3710	1208.	101.	92.7	1.01
20	962.29	3883	3911	1351.	534.	13.8	5.34
21	1001.31	4034	4074	1050.	0.	.0	.00
22	1120.57	4517	4557	1191.	0.	.0	.00
23	1173.22	4731	4771	875.	75.	105.4	.75
24	1238.71	4995	5033	856.	108.	89.7	1.08
25	1332.66	5377	5415	734.	0.	0	.00
26	1460.62	5896	5936	1939.	1252.	6.4	12.52
27	1763.73	7127	7163	455.	159.	30.0	1.59
28	2613.73	1056	810604	625.	385.	11.9	3.85

END OF ROI LIST

The data obtained at ORTEC are representative of the low-background characteristics of the detector/shield combination in our facility in Oak Ridge, Tennessee. Since background results are dependent upon the shielding, better results may be obtained in sophisticated laboratories (e.g., with active shields or in deep mines).

An example of this for a 40% GEM in a vertical XLB cryostat is shown in Table 4. The third column is from the report of the ORTEC Low-Background Facility. The fourth column contains the reported results on the same detector in a sophisticated low-background laboratory (Ref. 2). Another example is given in Table 5, which reports results obtained at the Gran Sasso National Laboratory, an Italian research facility located under 3500 meters of rock, with a resulting cosmic background reduction of a factor of 10^6. The ORTEC detector has a measured efficiency of 96%. Extraordinary precautions were taken to minimize the gamma background.*

When comparing the data in Tables 2, 3, and 4, the following considerations must be kept in mind:

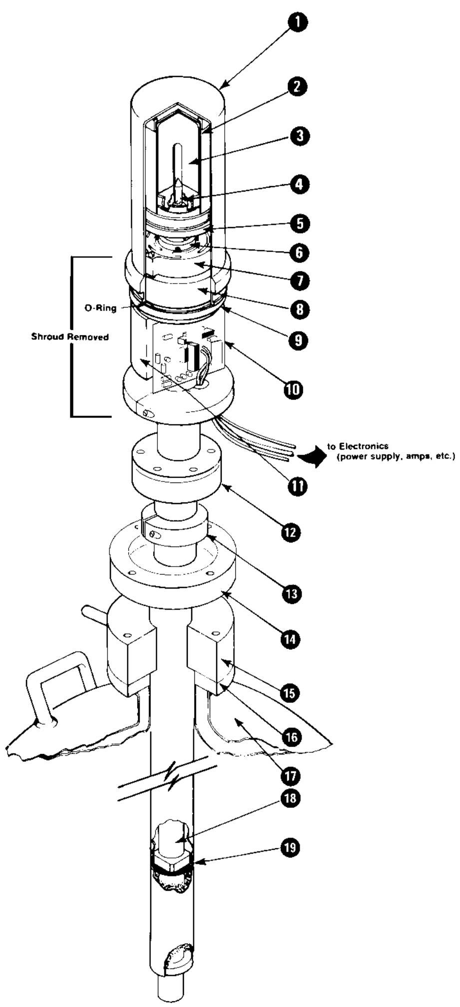
As there is no standard, laboratories use different formats for such tables; hence, the obvious differences between Tables 2 and 3 (both obtained at ORTEC) and 4 (obtained at the U.S. National Institute of Standards and Technology).

The computer printout reports energy centroids rather than the energy of the nuclides. Therefore, some interpretation is required to understand the centroid/nuclide relationship between Tables 2 and 3 and Table 1. For example, Region #1 in Table 2 (centroid at 45.72 keV) indicates the counts due to ^{210}Pb in Table 1 (46.5 keV).

When comparing gamma background data obtained from detectors with different efficiency, the difference in efficiency should be factored in, at least in an approximate (linear) way.

A less sophisticated way of characterizing low-background detectors is reporting the total counts per second in a given energy interval, typically from 100 keV to 3 MeV. A large (96% efficiency) ORTEC detector measured at Gran Sasso, the world-class Italian laboratory under a mountain, registered 100 counts per second in that energy interval.

*C.R. Arpesella, et al., "A Low Background Counting Facility at Laboratori Nazionali del Gran Sasso." (Internal Report LNGS – 92/35 July 1992).



Legend:

1 **Endcap (Ni-plated magnesium) (with low-background Be, or carbon fiber window for GAMMA-X or LO-AX)**
2 **Detector mount cup (OFHC copper or, at additional expense, ultra pure aluminum)**
3 **Germanium detector element**
4 **Pedestal nut (stainless steel)**
5 **Pedestal (OFHC copper)**
6 **Cooling rod clamp (OFHC Cu)**
7 **Thermal insulator (plastic)**
8 **Shield (virgin lead), ~2 cm thick**
9 **Cryostat flange (stainless steel, low cobalt)**
10 **Preamplifier**
11 **HV filter (with Al shroud)**
12 **Pumpout port**
13 **Cryostat clamp**
14 **Collar mounting hardware**
15 **Fill collar (RTV rubber)**
16 **Dewar flange**
17 **Dewar**
18 **Cooling rod (OFHC copper)**
19 **Cryosorption material (charcoal)**

Fig. 3. Cutaway View of Model CFG-XLB-GEM-SV.

Table 4. Comparison of ORTEC Low-Background Analysis with that in a Sophisticated Laboratory (NIST).

LOW-BACKGROUND ANALYSIS

DETECTOR SERIAL NUMBER P33P, GEM-40195,
Low Background Detector

REALTIME 100014.40 secs, LIVETIME 100000.00 secs

CENTROID ENERGY (keV)	NUCLIDE	NET Counts/1000 s (ORTEC LAB.)	NET Counts/1000 s (NIST)
53.6	^{73*}Ge	1.1	0.4
122.1	^{57*}Fe	0.33	0.3
145.3	^{238}U	0.7	Not detected
186.2	^{226}Ra	0.5	Not detected
238.6	^{212}Pb	1.3	0.5
295.2	^{214}Pb	0.9	0.4
352.0	^{214}Pb	1.5	1.0
511.03	ß+ annihilation	28	29
583.1	^{208}Tl	1.1	0.3
609.3	^{214}Bi	1.6	1.0
661.7	^{137}Cs	0.6	Not detected
727.1	^{228}Ac	0.5	Not detected
1120.0	^{214}Bi	0.6	0.3
1173.2	^{60}Co	0.3	0.6
1332.5	^{60}Co	0.1	0.6
1460.8	^{40}K	9	0.3

Table 5. Counting Rate of Main Gamma Lines for the 96% ORTEC Germanium Detector at Gran Sasso Facility. (1σ errors are indicated.)

Isotope	Energy	Counts/1000 s
^{238}U	295.2	0.22 ± 0.03
	351.9	0.44 ± 0.04
	609.3	0.33 ± 0.03
	1764	0.06 ± 0.01
^{232}Th	238.6	0.08 ± 0.02
	583.1	0.04 ± 0.01
	2614.7	0.02 ± 0.01
^{40}K	1460.7	0.09 ± 0.02
^{137}Cs	661.6	0.05 ± 0.01
^{60}Co	1173.2	0.04 ± 0.01
	1332.5	0.03 ± 0.01
^{125}Sb	427.9	
	600.6	
	635.9	
^{106}Ru	621.8	
	1050.1	

References

1. R. Keyser, T. Twomey, and S. Wagner, "Benefits of Using Super-Large Germanium Gamma-Ray Detectors for the Quantitative Determination of Environmental Radionuclides," *Radioactivity and Radiochemistry* Vol. 1, No. 2, pp. 46–56 (Spring 1990).
2. R.M. Lindstrom, *et al.*, "A Low-Background Gamma Ray Assay Laboratory for Activation Analysis," *Nucl. Instr. and Meth.*, **A299** (1990) 425–429.

Specifications subject to change
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Detectors for High-Count-Rate Applications

Both conventional analog and the more modern digital electronics (such as ORTEC's DSPEC PLUS) are covered in the following discussion. Typically, energy resolution specifications, in accordance with ANSI/IEEE Standard 325-1996, are measured with amplifier time constants that are a suitable compromise between optimum resolution and reasonable throughput (10 µs for IGLET, IGLET-X, GLP, SLP, LO-AX; 6 µs for GEM, GAMMA-X, and GWL detectors). SGD Series Safeguards detectors are designed to operate at higher count rates and are specified at 1 and 2 µs.

Several factors can affect the high-count-rate performance of Si(Li) or HPGe detector based systems. First, as the input count rate increases, it becomes necessary to decrease the time constant of the main amplifier (be it Gaussian or triangular) in order to achieve a reasonable unpiled-up output count rate. This is shown in Fig. 1 (from Ref. 1), which contains a series of plots of the equation:

$$r_o = r_i \exp(-T_D\, r_i)$$

where r_o is the unpiled output count rate, r_i is the input count rate, and T_D is the dead time or effective processing time of the amplifier.

As the input count rate increases, one must decrease the main amplifier time constant to obtain a sufficient unpiled-up output count rate. A family of curves for conventional analog electronics is shown in Figure 1.

The use of shorter time constants results in some trade-offs in energy resolution. Decreasing the time constants results in an increase in noise and a deterioration in energy resolution. An example is shown in Figure 2.

The combination of the information shown in Figure 1 and Figure 2 allows the user to make the energy count rate tradeoff most appropriate for his application. In larger detectors a short time constant may result in energy resolution degradation due to "ballistic deficit" effects. Peak shift may also appear at very high count rates and short time constants. This effect, however, cannot be described by a simple equation. Gated-integrator amplifiers are best for some applications of coaxial detectors when conventional analog electronics are used.

Data obtained with a digital electronic spectrometer such as the ORTEC DSPEC Plus or DigiDART and a small detector (IGLET-11135) are shown in Figures 3, 4, and 5. Figure 6 shows resolution data obtained with a 12% coaxial HPGe detector.

The advantages of DSPEC Plus over conventional electronics are the range of time constants, which ensures availability of the optimum one, plus a choice of digital filter functions. DSPEC Plus offers a choice of 115 rise times.

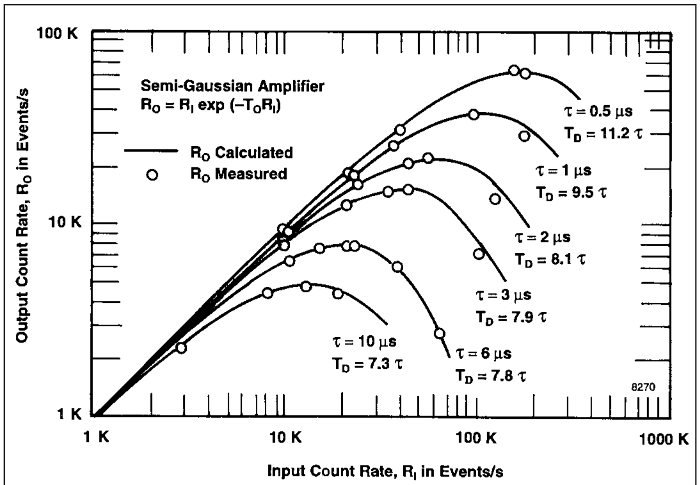

Fig. 1. A Plot of the Unpiled-Up Amplifier Output Rate as a Function of the Input Rate for Six Values of Shaping Time Constants.

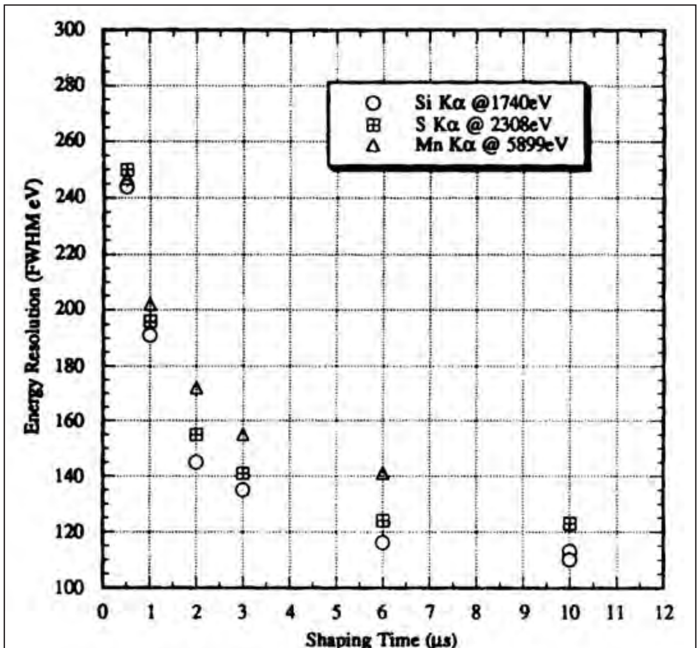

Fig. 2. Data Obtained with an IGLET-X-06135 Detector Shows Energy Resolution at 5.9 keV as a Function of Amplifier Time Constant (Ref. 15).

Other factors limiting the high-count-rate performance of photon detectors are pole-zeroing, energy rate, and performance of the preamplifier and ADC. All ORTEC digital electronics feature automatic pole-zero and optimize functions.

When using a passive feed-back element, one factor is pole zeroing in the preamplifier second stage. In fact, the impedance of this feedback element (resistor) contains reactive elements which may cause ringing and other phenomena that greatly increase the difficulty of proper pole zeroing. A transistor-reset preamplifier, TRP (see Ref. 2; Fig. 7), eliminates this problem.

Energy rate considerations in detectors with resistive feedback preamplifiers are another performance-limiting factor. In germanium at 77 K electron-hole pairs are produced at the rate of one pair for every 2.96 eV (= ε) of absorbed energy. As a consequence, if the

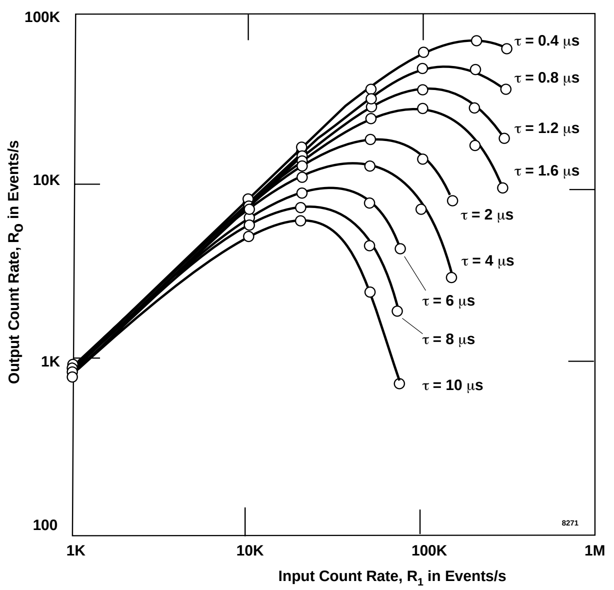

Fig. 3. Unpiled-Up Output as a Function of Count Rate at Different Time Constants. Data obtained at 5.9 keV with a DSPEC Spectrometer and an IGLET-11145.

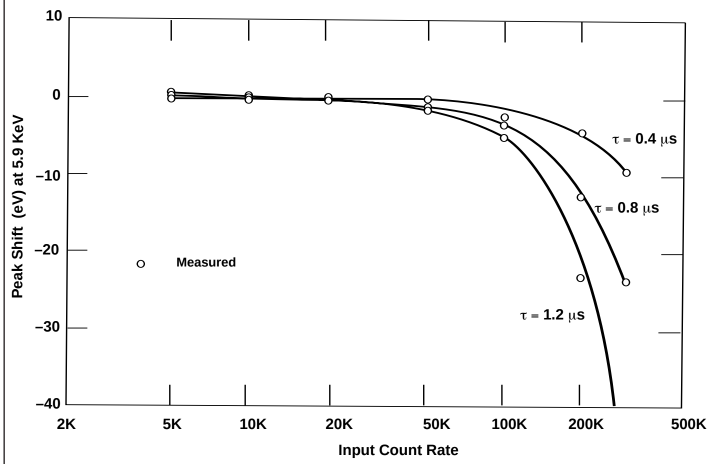

Fig. 4. Peak Stability as a Function of Count Rate at Different Time Constants. Data obtained at 5.9 keV with a DSPEC Spectrometer and an IGLET-11145.

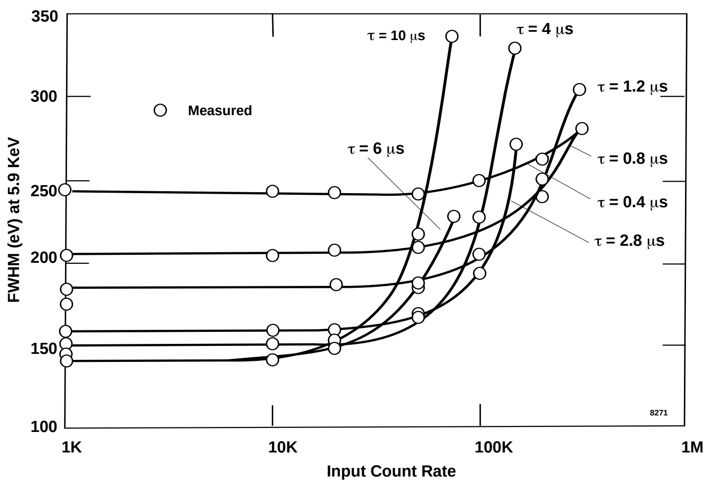

Fig. 5. Energy Resolution as a Function of Count Rate at Different Time Constants. Data obtained at 5.9 keV with a DSPEC Spectrometer and an IGLET-11145.

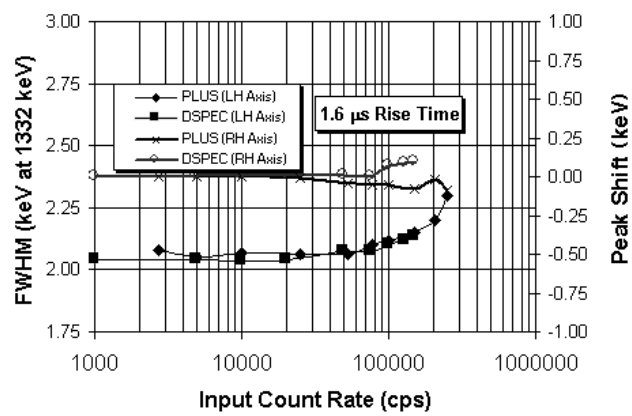

Fig. 6. Energy Resolution as a Function of Count-rate at 1.6 µs Risetime for DSPEC and DSPEC PLUS. Data taken with 12% Relative Efficiency Coaxial Detector.

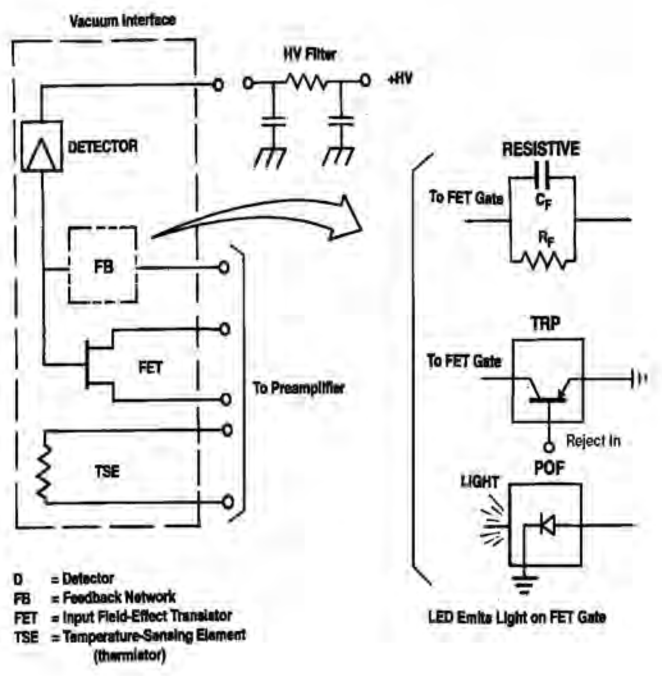

Fig. 7. Example of Electronic Diagram Showing the Detector and "Front-End" Preamplifier Components in a PopTop Capsule.

incoming radiation is absorbed by the detector at a rate of r counts per second, of average energy E, then the radiation-generated current I flowing through the Resistor R_F (Fig. 7) is given by:

$$I = r\,(E/\varepsilon) \times 1.6 \times 10^{-19} \text{ (in amperes)}.$$

The rE product is called the "energy rate" and is normally given in MeV/s. The current I causes a voltage drop IR_F across the feedback resistor R_F. If this voltage drop exceeds the dynamic range of the preamplifier, the preamplifier output becomes nonlinear. At sufficiently high energy rates the preamplifier "locks up."

Table 2. Energy Rate of Preamplifiers Supplied with Photon Detectors.

Preamplifier Type	Detector Type	Maximum Energy Rate (MeV Sec^{-1})
Resistive Feedback	GEM, GMX, LO-AX, GLP (25, 32, 36 mm) GLP (6, 10, 16 mm)	145,000 4,000 2,200
Transistor Reset (Order "Plus")	GEM, GMX	1,000,000
Pulsed Optical Feedback (Order "POF")	IGLET, IGLET-X, SLP, GLP, SLB (6, 10, 16 mm)	4,000*
Modified For HCR (Resistive Feedback)	All GLPs	10,000

*The POF does not "lock up" or saturate at high count rates, unlike resistor-feedback designs. At ultra-high count rates with the POF, throughput is limited by reset pulse rates. 4000 MeV/s is an estimate of maximum "useable" energy rate.

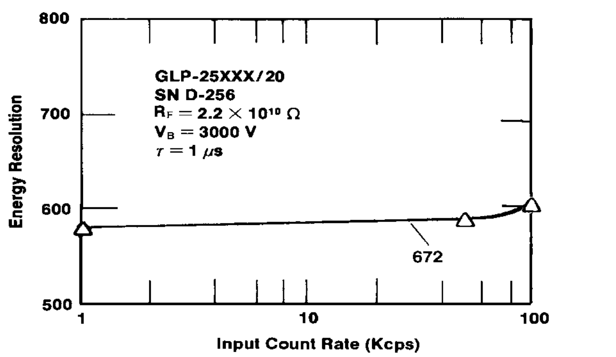

Fig. 8. Performance of a High-Count-Rate 500-mm^2 Active Area Planar HPGe Detector at 122 keV.

The feedback resistor is chosen for high count rate. Performance measured with Model 672 Amplifier. Note that the energy rate at the high end is ~10,000 MeV/s. (With a standard feedback resistor the energy rate is 4,000 MeV/s.)

Reducing the value of R_F in order to increase the energy rate results in an increase in electronic noise, thus creating a trade-off situation as in the case of amplifier time constants being decreased to increase throughput.

Table 1 lists the energy rate performance of various preamplifiers.

High Count Rate in the Energy Range 30 keV to 300 keV

GLP planar detectors, 16, 25, 32, or 36 mm in diameter with appropriately selected feedback resistors, are the instruments of choice for studying the complex gamma spectra generated by highly enriched materials in the 80- to 200-keV region.

The value of the feedback resistor (R_F) for these detectors is selected in such a way that the energy rate is maximized without a substantial degradation of the energy resolution.

These detectors are typically characterized by their high-count-rate performance at 122 keV. Figure 8 shows the performance of 500-mm^2 active area planar detectors built for these applications.

For high count rates in the energy range above 300 keV, ask for a cop the paper entitled "High Count Rate Spectroscopy with Ge Detectors: Quantitative Evaluation of the Performance of High Rate Systems."

Detectors for High-Count-Rate Applications

High Count Rate in the Energy Range <30 keV

In the energy range up to 60 keV the detectors of choice are the IGLET and the IGLET-X. For such detectors, both at low and at high count rates, the preamplifier of choice is the pulsed optical feedback, POF preamplifier.

References

1. T.H. Becker, E.E. Gross, and R.C. Trammell, "Charac-teristics of High-Rate Energy Spectroscopy System with Time-Invariant Filters," *IEEE Trans. on Nucl. Sci.* **NS**-28, No. 1 (1981) 598.
2. C.L. Britton, T.H. Becker, T.J. Paulus, and R.C. Trammell, "Characteristics of High-Rate Energy Spectroscopy Systems Using HPGe Coaxial Detectors and Time-Variant Filters," *IEEE Trans. on Nucl. Sci.* **NS**-31, No. 1, (1984) 455.

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Neutron Radiation Damage in HPGe Detectors

The effect of fast neutrons on the performance of germanium detectors is described in detail in the literature (see Ref. 1).

A summary of the results of greatest practical interest follows:

(1) HPGe coaxial and planar detectors show energy resolution degradation when bombarded with fast neutrons. The approximate threshold fluences are:

2×10^8 cm^{-2} for GEM detectors up to 20% in efficiency
1×10^7 cm^{-2} for GEM detectors up to 70% in efficiency
4×10^9 cm^{-2} for GMX detectors up to 30% in efficiency
1×10^9 cm^{-2} for GMX detectors up to 70% in efficiency
1×10^9 cm^{-2} for GLP (planar) detectors

(2) Evidence (Ref. 2) suggests that in order to achieve the highest possible resistance to neutron damage, the detector should operate at a temperature as close to 77 K as possible. Detectors in PopTop capsules typically operate at a temperature ~10 K higher than detectors in “streamline” non-PopTop cryostats. We recommend that detectors that may be exposed to significant fast neutron fluences be **ordered in streamline cryostats** that may be equipped with an internal heater and companion hardware (596A Temperature Controller) to allow in-cryostat neutron damage repair at the place of detector use.

(3) Larger detectors start showing energy resolution degradation at lower fluences than smaller detectors.

(4) The increase in resistance to neutron damage of GAMMA-X detectors vs. GEM detectors can be as high as a factor of 20 (Ref. 1). However, this increase depends on a variety of factors including detector size, configuration of electric field internal to the detector, energy spectrum of the neutrons, and probably other variables.

(5) Both GEM and GAMMA-X detectors can be repaired for neutron damage by heating for a period of time at sufficiently high temperatures. However, GAMMA-X detectors are easier to repair (lower temperatures, shorter “annealing” time). Typical annealing temperatures and duration of the annealing cycle for 30% relative efficiency detectors with severe damage are given below:

Detector	Temperature	Time
GEM	120˚C	168 hours
GMX	100˚C	24 hours

(6) Moreover, when GEM detectors are annealed, there is a significant loss in relative efficiency because of inward diffusion from the lithium outer contact. Such loss is negligible for GAMMA-X detectors because the lithium diffusion is at the inner contact where an increase of the lithium diffusion depth has little effect on the detector’s active volume.

(7) There is no known limit to the number of times that a neutron-damaged detector can be annealed if proper precautions are taken. There is no evidence of a radiation hardening effect.

(8) Slightly neutron-damaged GAMMA-X detectors show some improvement in energy resolution when cycled to room temperature. However, severely neutron-damaged GAMMA-X detectors show a catastrophic deterioration of energy resolution when cycled to room temperature. As a general rule, it is best to maintain neutron-damaged detectors at LN_2 temperature until they are annealed.

ORTEC routinely installs a heating resistor in GMX detectors which are to be used in fast neutron fields. The annealing temperature is controlled with a 596A Temperature Controller.

References

1. T.W. Raudorf, R.C. Trammell, S. Wagner, and R.H. Pehl, “Performance of Reverse Electrode HPGe Coaxial Detector After Light Damage by Fast Neutrons,” *IEEE Trans. on Nucl. Sci.* **NS**-31, No. 1 (1984) 253.
2. R.H. Pehl, Private Communication, 1990.

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How to Choose the Right Photon Detector for Your Application

Choosing the correct detector for your specific application involves many criteria. No single table or graph can uniquely specify a detector for a particular measurement. The recommendations that follow are intended to guide a user to the detector likely to be best suited for the application. (If you have questions about whether a particular detector's performance will meet your needs, we suggest that you contact your local sales representative or the ORTEC facility in Oak Ridge, Tennessee, USA.)

To choose the optimum detector to solve a particular measurement problem, several issues should be considered.

HPGe Detector Types

All HPGe radiation detectors are large, reverse-biased diodes. The germanium material can be either "P-type" or "N-type". The type depends on the concentration of donor or acceptor atoms in the crystal. To connect the diode to an electrical circuit to amplify the signal, we need to put contacts on the crystal. These electrical contacts on the crystal are a thick, lithium diffused contact, which is the N+ contact, and a thin, ion-implanted contact, which is the P+ contact. An exception is the GEM-FX detector in which the front contact has a thinner layer of lithium diffusion.

The crystal can be cut or ground to any shape. However, the electrical field inside the crystal (diode) is very important. This limits the useful shapes to a disk or a cylinder with a hollow core. The cylinders are closed at one end and called coaxial; the disks are called planar. These are shown in Fig. 1.

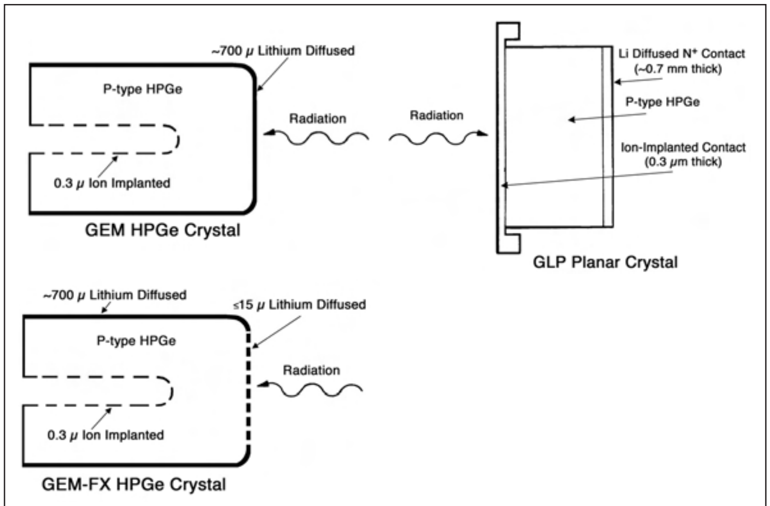

Figure 1. P-type HPGe crystal geometries.

Depending on the type of material used (N or P), the contacts are applied differently. For P-type material, the thick, lithium diffused contact is on the outer surface and the thin, ion-implanted contact is on the inside. The ORTEC name is GEM. For N-type material the contacts are reversed. The ORTEC name is GMX. Very short coaxial detectors are called LO-AX detectors. Figure 2 shows the two N-types detectors: GMX and LO-AX. Coaxial construction allows larger (deeper) detectors to be fabricated, but the large size means a higher capacitance. The higher capacitance increases the resolution, which means there is a tradeoff to be made between having the best low-energy resolution and having the highest efficiency at higher energies. The ORTEC LO-AX geometry is a semi-planar (or maybe a semi-coaxial) geometry, with a good low energy resolution and better high energy efficiency (deeper) than a planar.

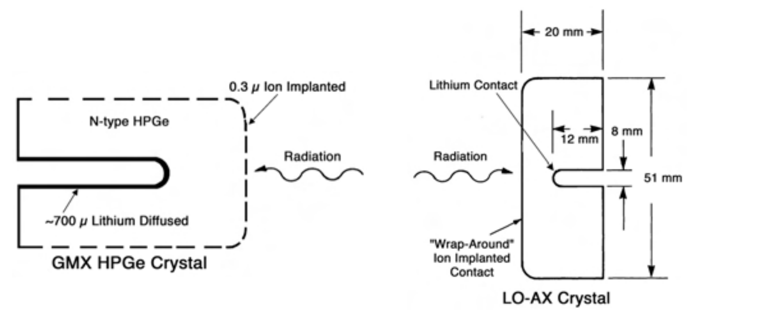

Figure 2. N-type HPGe crystal geometries.

The P-type coaxial (GEM) is the most commonly used HPGe in counting laboratories. The N-type coaxial (GMX) has extended low-energy efficiency because of the thin contact and has slightly worse resolution specifications at higher energies than a GEM. The largest GEM detectors are about 75% higher than the largest GMX. LO-AX and planar (GLP) detectors have excellent low-energy resolution, but reduced high-energy efficiency and resolution.

How Do You Select the Detector?

First, let us present some measurements made on different types of detectors to show several features. We will show you how to select the right detector for your application. The right detector is the detector that produces the most analyzable data in the shortest time for the lowest cost. Most spectroscopy problems can be solved with simple detectors. There is no need to have exotic or overly complex designs.

The Analyzable Spectrum: Good Data vs. BAD Data

"Good data" is defined as being spectral data in which the peaks of interest are well shaped and have good "signal to noise." This is a key consideration; just having more data doesn't make the data better.

One measure of the quality of a spectrum is the minimum detectable activity (MDA) of the detector system. The resolution, background and efficiency of the detector are related to the MDA. This relationship may be simply stated as (Ref. 2):

$$\text{MDA (E)} \sim \text{SQRT [R (E) B (E)]}/\varepsilon(\text{E}) \qquad \frac{\sqrt{\text{R(E) B(E)}}}{\varepsilon(\text{E})} \qquad (1)$$

How to Choose the Right Photon Detector for Your Application

The MDA varies with energy because the quantities on which it depends vary with energy. Here we have separated out all the factors in the MDA that only depend on the detector itself. The gamma rays per decay, the shield and count time affect the MDA, but will do so in the same way for all detectors.

R(E) is the energy resolution of the detector as a function of energy; B(E) is the background counts per keV (unit energy) as a function of energy and ε(E) is the absolute efficiency of the detector as a function of energy.

This simple formula is highly significant in guiding us towards the right choice of detector. Let us examine it in more detail.

You can see that the MDA is linear in efficiency, but proportional to the square root of the resolution and the background. So you would expect that the biggest detector will give the best MDA for a low-activity sample. Is it always the case that "Bigger is Better" (Ref. 3)? Yes and no! More efficiency will always improve the detection limit reached in a given count time. However, you should consider the sample to be counted:

- Does the spectrum have interferences (multiplets) in which a gamma-ray peak of interest is obscured by a peak from another nuclide? Equation 1 is correct, but the resolution of a larger detector is typically worse than the resolution of a smaller detector. This could mean that a good resolution detector will give better MDAs than a larger efficiency detector.
- Does background increase as relative efficiency increases? Certainly, as the efficiency increases, the background increases, but data from a large number of all sizes of detectors shows clearly that the background increases less rapidly than the efficiency. Thus MDA improves on larger detectors. (Fig. 3) Cosmic background will also increase with increasing detector size, but will increase no faster than efficiency and thus MDA will improve. This background is the general background in the detector when no sample activity is present. As soon as a sample source with non-zero activity is presented to the detector, this will also add to the general background in the form of source induced background.

As detectors increase in size (efficiency), the peak-to-Compton ratio (p/C) increases, (Fig. 4) which means that the ratio of source related signal to source induced background in the spectrum will increase, that is improve (Fig. 4). Figure 5 shows an example of this. Two GMX detectors were used to count the same sources in the same geometry. The peak areas for ^{241}Am and ^{137}Cs are shown. The ratios of the counts in the spectra are not as large as the stated efficiency ratio because the stated efficiency is for 1.3 MeV only. The source-induced background is higher for the larger detector (except in the 100 keV region), but the ratio of the two backgrounds is never as high as the efficiency ratio for the peaks. We talked earlier about cosmic and other non-source background. If the Compton background has been produced in the spectrum because of a dense sample matrix, a high p/C detector will not reduce this Compton background. For example, in plutonium-in-human lung measurements, a high contributor to Compton background is the natural ^{40}K gamma rays scattering from the person's bones. This cannot be reduced by the detector.

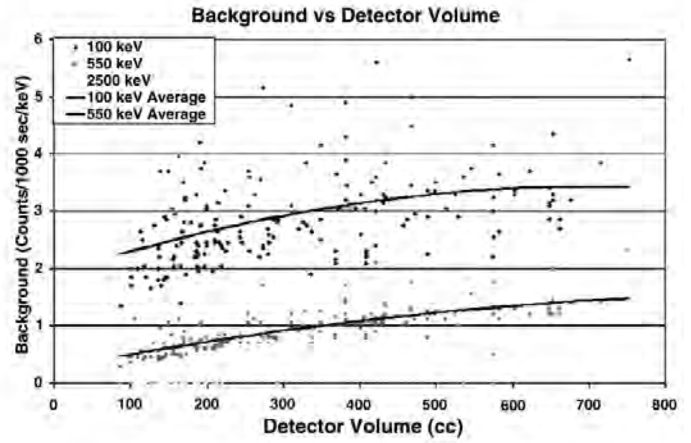

Figure 3. Background counts vs. detector volume for a large number of detectors.

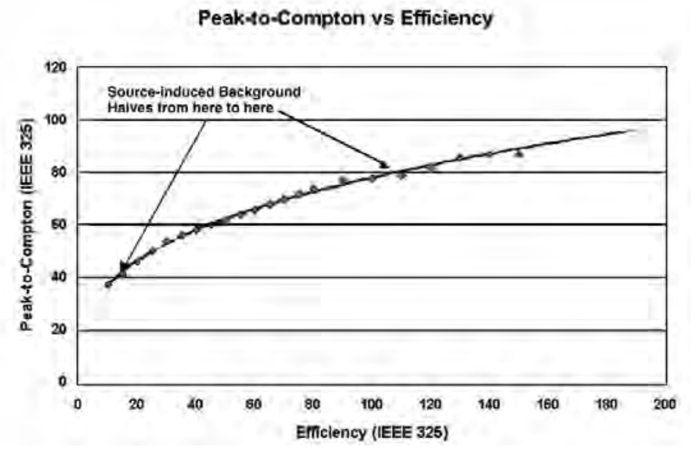

Figure 4. Peak to Compton ratio vs. relative efficiency for coaxial P-type detectors.

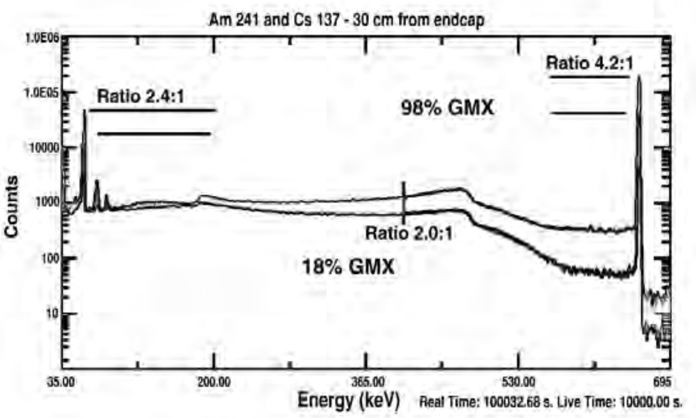

Figure 5. Comparison of ^{137}Cs/^{241}Am spectra obtained with 18 and 98% relative efficiency GMX detectors, showing the effect of increasing P:C ratio, improving MDA.

Is a More Complex Solution Likely to be a Better Solution?

Compton Suppression Systems?

The large Compton background seen in Fig. 5 is due to capturing only part of the original gamma-ray energy. Some of the remaining or lost energy actually leaves the detector. If we could capture these lost energy parts, we could reject the part of the gamma-ray energy captured in the HPGe. In a Compton Suppression System (CSS), (Fig. 6) the HPGe detector is surrounded by a NaI(Tl) annular detector which detects photons escaping from the HPGe. The signals from the HPGe and NaI are used in anticoincidence circuitry to remove the Compton background events from the primary gamma-ray spectrum. CSS systems are usually tested with ^{137}Cs, and some systems have background improvements of a factor of 5 over the p/C ratio of the detector itself.

CSS Advantages: For a given HPGe detector, a CSS will always reduce Compton background. It is also called an "active shield." It reduces the cosmic background because a cosmic ray produces events (counts) in both detectors.

CSS Disadvantages: The sample size is usually small because the sample must be placed inside the NaI annulus. The system is complex: coincidence electronics require careful adjustment and maintenance to ensure consistent performance. CSS efficiency calibration is complex because some nuclides naturally emit photons in coincidence with each other and this reduces the full-energy peak areas for these peaks as well as reducing the background. Most importantly CSS systems are expensive. It is usually better to spend your money on a larger HPGe detector, which may be less expensive, work better, and be simpler than Compton suppressing a smaller detector. Compton suppression of large detectors is not as effective (not as large an improvement) as small detectors because the large detectors already have a high p/C ratio. High p/C HPGe detectors have largely replaced CSS.

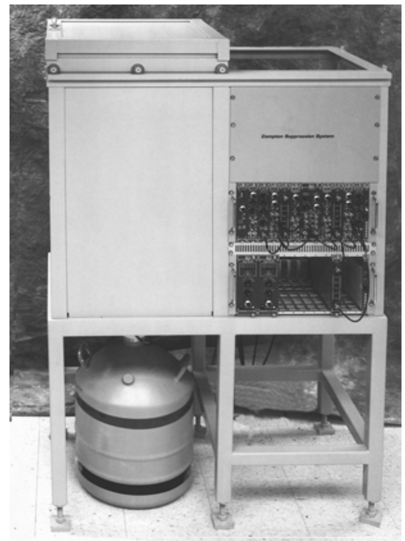

Figure 6. An ORTEC Compton Suppression System.

Detector Efficiency: ε(E)

The detector efficiency in Eq. 1 will potentially have the most effect on MDA.

The IEEE-325 definition of relative efficiency (Ref. 4) at 1.33 MeV, is not a good indicator of detector sensitivity in most of the sample geometries you want to use. It is defined at a single energy and for a point source at 2 cm distance to the detector endcap. No real samples meet this criteria except a point ^{60}Co source at 25 cm from the endcap! On the other hand, relative efficiency is often a good place to start as a general indicator of detector performance. The efficiency for various energies is shown in Figure 7.

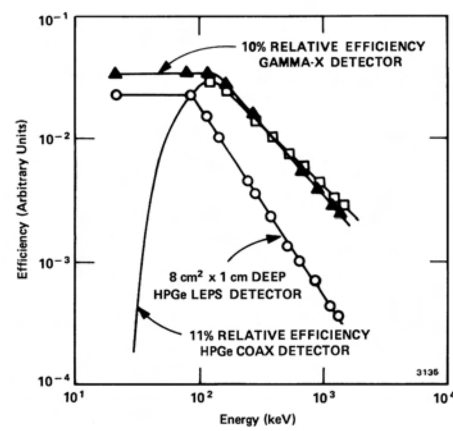

Figure 7. Point source efficiency curves for planar and coaxial detectors in arbitrary units.

In Eq. 1, ε(E) is the absolute efficiency at the specified energy. ε(E) will depend on the detector-to-sample geometry, and many other energy dependent factors, including gamma-ray absorption in matrix and detector dead layers and the intrinsic efficiency of the detector. The IEEE-325 relative efficiency is no longer a suitable indicator.

Figure 8 illustrates how three detectors can have the same IEEE-325 efficiency, yet have different efficiencies for your samples and your nuclides. All three schematically represented detectors have the same IEEE-325 relative efficiency, but for counting a flat disk-like sample (e.g., filter paper), it is obvious that the long and thin detector will have poorer geometrical efficiency than the "shorter and fatter" detectors. So if your samples are filter papers, disks or other large area containers, your best selection will be a shorter and fatter detector, such as the ORTEC PROFILE GEM. With the ORTEC PROFILE GEM series, you can specify the crystal dimensions as well as IEEE-325 relative efficiency (Ref. 7).

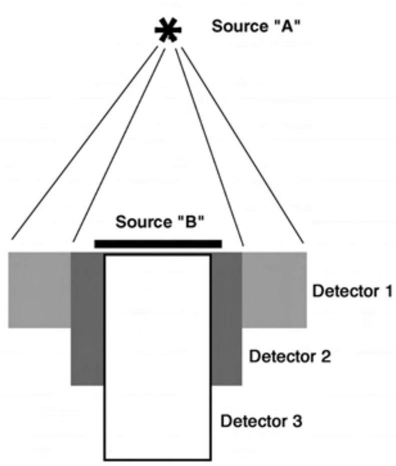

Figure 8. Three different crystal geometries, all with the same IEEE point source efficiency, but very different absolute efficiency for a puck sample on endcap.

How to Choose the Right Photon Detector for Your Application

Dead Layers, Windows and Absorption

Now you need to consider the gamma-ray range of energies to be analyzed. All materials will absorb gamma rays. The materials between the emitting nuclide and the crystal can absorb (or attenuate) the gamma-ray flux. The absorption processes are a function of energy and described by the exponential attenuation equation below:

$$I = I_0 e^{-\mu(E)\,X} \qquad (2)$$

Where I_0 is the unattenuated gamma-ray flux, I is the flux after passing through the material and μ is the linear attenuation coefficient of the absorber and x is the thickness.

This relationship determines both how deep a detector needs to be to stop the incident gamma rays and the reduction in efficiency due to the window thickness and crystal dead layer thickness. The exponential function in the equation means there is no absolute cutoff length for absorption or stopping power, so that a thin planar detector will have reduced, but not zero efficiency at high energy and a thick contact coaxial detector will have reduced and not zero efficiency at low energy. The optimum choice of detector is a tradeoff of all measurement parameters.

Figure 9 compares absolute efficiency of two detectors, one P-type (GEM) and one N-type (GMX). The crystals are of very similar diameter, but the GEM is 14 mm deeper than the GMX. As you look at the efficiency above about 150 keV, there is little difference in efficiency. The efficiency curves are diverging slightly with increasing energy because the deeper GEM crystal will stop more gamma rays. Below 150 keV, the GMX has higher efficiency and below 100 keV, the difference increases rapidly as you go down in energy. This is because the dead layer of the GEM (~700 microns) is much larger than that of the GMX (~0.3 microns). Any gamma rays stopped in the dead layer do not produce an output. At 60 keV (^{241}Am), the GMX has about 1.7 times the absolute efficiency of the GEM and a proportionately better detection limit for ^{241}Am (Eq. 1). This does not mean the GEM cannot measure ^{241}Am, it simply means that it is not as good as the GMX. The GMX however would cost significantly more, and for the measurement of higher energy gamma rays, for example, ^{137}Cs at 661 keV, is no better. Don't forget the GEM will have superior resolution and p/C, because it is a P-type and has bigger dimensions. So the GEM will have better MDA at the higher energies.

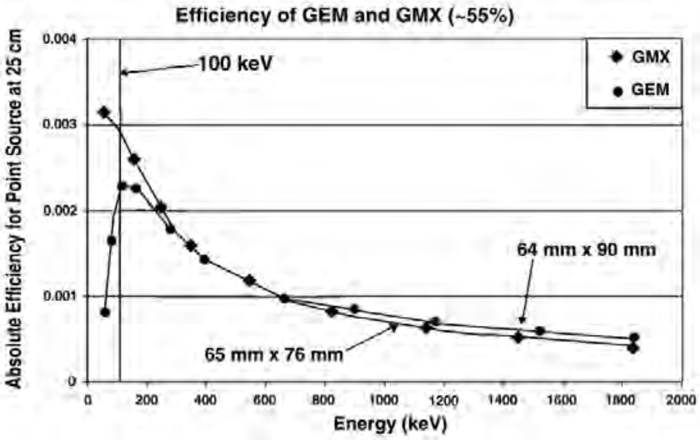

Figure 9. Comparison of absolute efficiency of an N-type (GMX) and a P-type (GEM). (Point source at 25 cm.)

Detector TYPE "Rules of Thumb"

P-type (GEM) vs. N-type (GMX, LO-AX)

~80 keV–3 MeV use a GEM (P-type) Coaxial detector. Why? The GMX has no advantage above 80 keV, costs more and may have poorer resolution.

~10 keV–3 MeV use a GMX (N-type) with a Carbon Fiber Window (60% transmission at 10 keV) Beryllium (Be) has 29% higher transmission at 10 keV, but is toxic and fragile.

~3 keV–3 MeV use a GMX (N-type) with a beryllium Window, but be careful!

Sample Presentation

Samples for gamma-ray spectrometry come in all shapes, sizes, chemical and physical forms. The activity you need to measure may be very low in a large sample, or it may be very high in a small sample or anywhere in between. The matrix of the sample may be dense and have a high atomic number, therefore making accurate measurements difficult due to attenuation of the gamma rays.

You may be able to position the sample relative to the HPGe detector in a way to optimize the spectrum gathered, and therefore the results. You may have external reasons which define or restrict the choice of how the sample is presented to the detector. Some reasons you may see are:

- A human being in a bioassay measurement is a fixed-format sample. There is no opportunity to change the presentation of the subject into another geometry.
- A wide-area, uncollimated soil survey is a very different counting geometry than a waste drum.
- While a 2 L Marinelli beaker and large detector might be the best choice, you may have already standardized on 1 L beakers, so be sure any new detector will actually fit inside your existing Marinelli beakers.

Filter vs. Bottle vs. Marinelli Beaker

Remember the MDA (Eq. 1) depends on the absolute efficiency and the absolute efficiency depends on the geometry of sample and detector. You may select the sample geometry from several different containers. Lets look at some different samples counted on a single detector. In Fig. 7, the filter paper was placed directly on the endcap and the filter active area diameter is slightly smaller than the diameter of the detector. Would a smaller diameter detector or a larger diameter detector be better for this filter paper? The best detector diameter for a disk source on endcap (that is, in "close" geometry to the crystal) is about 1.2 times the diameter of the disk (Refs. 5, 6, and 7). A larger crystal does not increase the efficiency significantly and a smaller detector reduces the efficiency. The form of the sample also has an impact on the efficiency. Three different geometries are shown in Fig. 10 and you can see the filter geometry is, by far, the best of the three examples. So if you can, you should make disk samples rather than use the larger sample containers. The 1 L bottle is a larger diameter than the filter paper.

The situation changes if you want to determine specific activity or activity per unit sample, such as µCi/kg. In such practical cases, you should consider, if it is possible to use the entire sample in that geometry. If only 1% of the sample could be put on the filter, but 100% of the sample could be put in the Marinelli beaker, then using the Marinelli beaker to count the whole sample would be more efficient over-all in terms of counts in the spectrum per unit activity in the original source.

In Fig. 11, 1 L and 2 L Marinelli beakers are compared on the same detector. It may seem at first surprising, but the 1 L beaker has a higher efficiency than the 2 L. The reason is back to simple geometry. The 1 L beaker puts a greater proportion of the sample closer to the detector. Thus 1000 Bq of activity in the 1 L beaker will produce more counts in the spectrum than 1000 Bq in the 2 L beaker. However, and it is important, if there is enough sample to fill the 2 L Marinelli, then the 2 L beaker will produce lower MDC (minimum detectable concentration MDA/volume) because of the larger sample.

Marinelli Beaker or a Bottle?

Figure 12 shows that a Marinelli beaker has about 3 times the efficiency of a bottle geometry. The Marinelli beaker utilizes the sides of the detector thereby gaining efficiency. At low energies, however the aluminum endcap wall, (replaced by beryllium or carbon fiber on the face of the GMX detector), will attenuate the gamma rays, thus reducing the advantage of the Marinelli.

What About "Wrap-Around" Geometries?

Figure 13 shows that a small disk on endcap has a higher efficiency than a sample wrapped around the curved surface of the detector. This initially surprising result can be explained as follows. Imagine a point source placed on the curved endcap surface. Directly below the source, the germanium is as close to the sample as if it is on the face of the endcap. However, when you consider gamma rays emitted at an angle, the curved surface puts the sensitive Ge further away from the source than it would be on the flat endcap face. However, as in the case of the 1 L

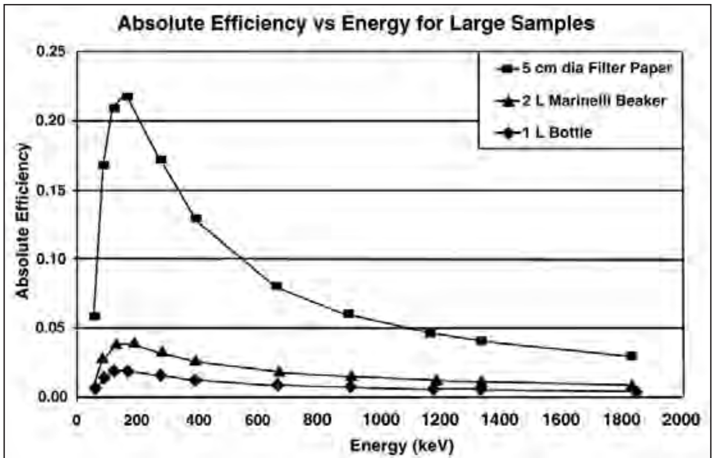

Figure 10. Filter paper, Marinelli beaker and bottle geometries compared.

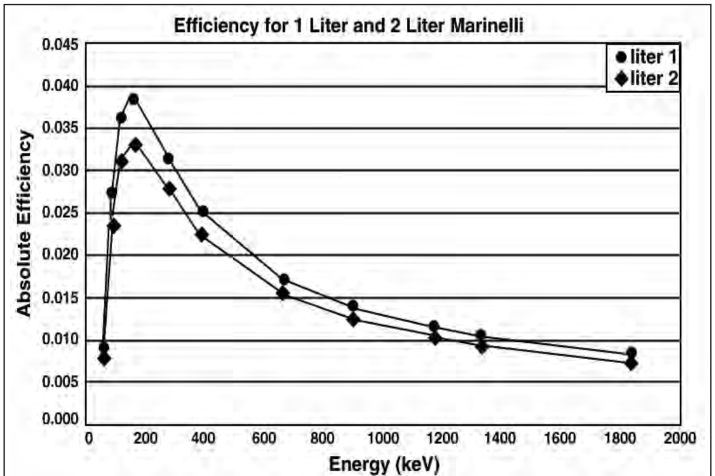

Figure 11. Comparison of 1 L and 2 L Marinelli beakers on the same detector.

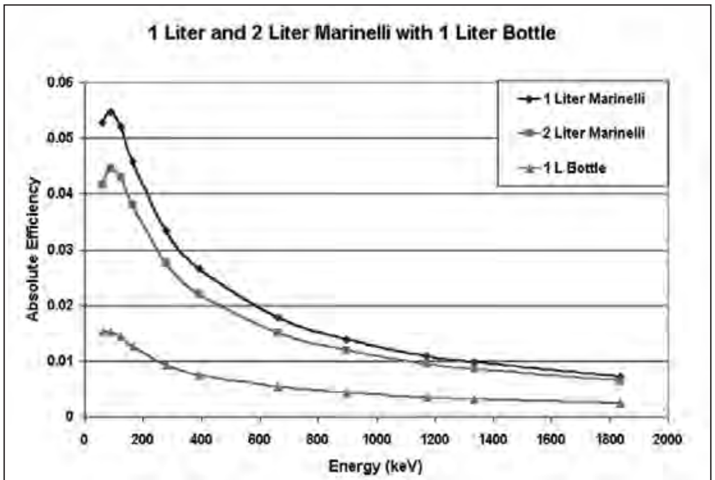

Figure 12. 1 L and 2 L Marinelli Beakers compared to 1 L bottle on endcap for a GMX detector.

and 2 L Marinellis in Fig. 12, if you can make the sample as large as the area of curved surface (much larger than the amount on the front flat surface), the curved surface has the highest efficiency in terms of counts in the spectrum per unit activity of the source. The cylindrical surface area in the detector in Fig. 10 was 15 times that of the flat disk on the end face of the crystal, which would more than offset the differences shown in the curves.

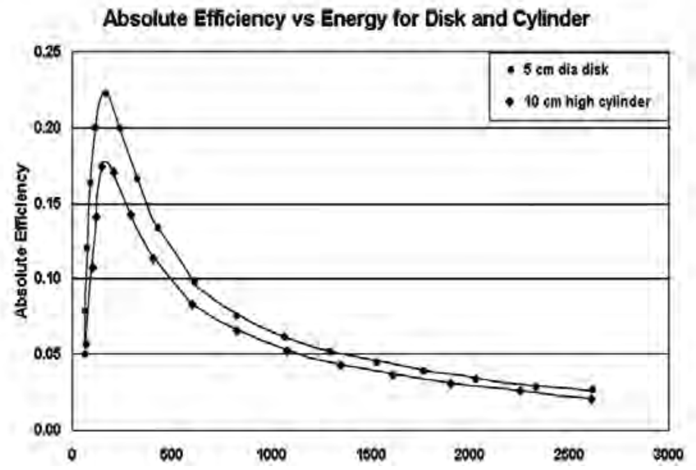

Figure 13. Disk and “wrap-around’ geometries compared.

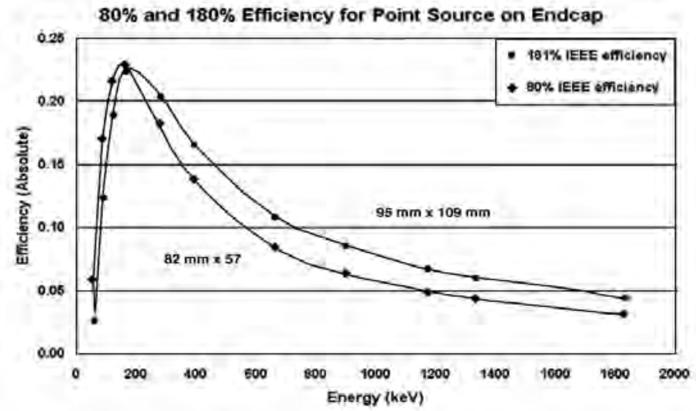

Figure 14. 81% and 181% relative efficiency detectors compared with point source geometry.

"Well" Detectors

The well detector (GWL Series) has been around for some years. A well detector has the highest geometric efficiency possible, but can only contain small samples and introduces some other complexities. The geometry is so "close" that coincident summing complicates calibration. Software can correct for coincident summing (TCC), but you must remember this if you are considering a well detector. Well detectors are for use in cases where the quantity of sample is very small, e.g., in some forensics applications.

GEOMETRY "Rules of Thumb"

- The closer the sample "activity center of gravity" is to the Ge, the higher the absolute efficiency, and the better the MDA
- The higher the absolute efficiency and the more sample counted, the better the MDA
- If all of the sample can be made into a small diameter disk on endcap, the only better geometry is a well detector
- For a disk on endcap, the crystal diameter should be at least 1.2 times the filter diameter for best efficiency

Making the correct choice not only means you get the best result, but can also save money. Look at the two detector efficiency plots shown in Fig. 14. comparing an 81% and 181% efficiency detector.

Because both detectors greatly exceed the diameter of the source, the sample-detector solid angle is large and there is no difference in efficiency at medium to low energies. At low energies, the thickness of the endcap and the dead layer make the 81% more efficient than the 181%. At medium energies, because the 81% detector is already quite long, the 181% detector has little advantage. At high energies, the larger detector will start to show real advantage (>1 MeV). Despite very similar performance in this geometry and over the energy range of 50 to 1000 keV, the purchase price of these two detectors will differ by a factor of two.

Count-Rate Considerations

In gamma spectrometry you want to obtain the best data possible. In high count-rate applications, you have many counts in the spectrum, but other issues become relevant in making the choice of detector and the system electronics.

What Count Rates are We Discussing?

- Low — Below 100 cps
- High — Above 75,000 cps input rate
- Very High — Above 100,000 cps

High and Very High Count Rates

A high-rate system must be operated at short shaping times to minimize the processing time per pulse. This will decrease the dead time and give maximum throughput. This shorter shaping time means the resolution is worse (peaks get wider) but not always significantly worse. Throughput is defined as the number of "useful" events stored in memory per second. Pulses which are too close together to be separated are called "pileup," and these can’t be used because you don’t know the separate energies of the pulses. The useful events (full energy peak area) is, of course, less than the total counts stored, but pileup events can’t be used and even degrade signal to noise ratio in the spectrum. So when you consider high count rates, you must count just the good counts not all the counts.

The HPGe detector preamplifier will ultimately limit the system performance throughput and may affect the resolution. Resistor feedback preamplifiers have a limit on the amount of charge or power they can deliver and this is called the energy-rate product. The maximum energy-rate product is specified in MeV/sec (for example, 1000 CPS at 1 MeV = 1000 MeV/sec). At rates higher than this maximum rate, the preamplifier saturates, or freezes; no more pulses come out (Ref. 8).

Standard ORTEC GEM/GMX preamplifiers have an energy-rate limit of 145,000 MeV/sec while the LO-AX/GLP preamplifiers have a limit of 4000 MeV/sec. "Modified Resistor" GLP preamplifiers can be produced for special applications (e.g., safeguards) to a limit of 10,000 MeV/sec.

An alternative to the resistor feedback is the "Plus" or Transistor Reset Preamplifier (TRP). The TRP is effectively limitless, that is >1,000,000 MeV/sec.

It is important to realize that pulsed reset preamplifiers do not saturate and are therefore an excellent choice if wide ranges of count-rate may occur (e.g., accident monitoring), but the reset process increases dead time. Thus, a reset preamplifier will produce fewer counts to memory than a resistor feedback preamplifier operating below its point of saturation.

Throughput Limited Counting

Figure 15 shows a representative system throughput curve, (Ref. 9). The shape is typical of most throughput curves. Above the point of maximum throughput, pileup losses increase and, in terms of time taken to get to a given MDA, counting above the point of maximum throughput actually increases the counting time. This is because less and less data is being stored in memory as the input count rate increases. If you can change the input count rate by changing the counting geometry in some way, then the point of maximum throughput is the best place to operate. However in some cases, e.g., post accident monitoring, wide count rate variations "wide dynamic ranges" need to be accommodated.

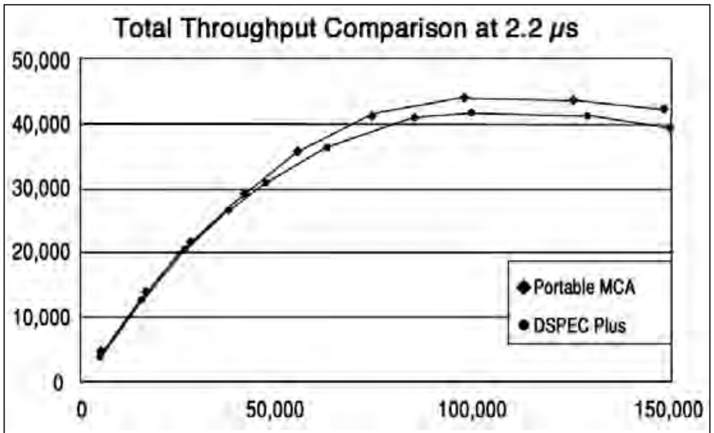

Figure 15. System throughput curves.

The combination of the digital or analog shaping time chosen, the system processing dead time per pulse and the dead time due to the reset of the preamplifier (if not resistive), defines the system maximum throughput. Misleading claims are sometimes made in commercial literature about maximum achievable throughput of various electronic systems. However, the throughput limit is determined by the amplifier settings (or digital filter settings). These settings determine the dead time and resolution. So you select the settings based on the resolution you need, and this determines the throughput you can achieve.

Getting the Best Data When the System is Throughput-Limited

By choosing the correct detector, you can improve the quality of the spectral data. You might think that choosing a small detector would give superior high count-rate performance. This might be true for certain low-energy applications where very good resolution at very short shaping times is important (Ref. 9), but this is not always the case. Recall Fig. 4. In this figure, you see that the large detector has "higher peaks and lower valleys." Thus, for throughput-limited work at intermediate to high energies, a collimated larger detector will produce better quality data than a smaller detector, even though both may have the same capability in terms of throughput to memory. The larger detector has a higher proportion of photopeak (good) events in its pulse stream than Compton background (bad) events in comparison to the smaller detector.

Figure 16 shows two spectra superimposed taken with a 120% relative efficiency and a 12% relative efficiency P-type (GEM) detector (Ref. 8). The 120% GEM was collimated to produce the same over-all count rate as the 12% GEM. Peak net areas from the 120% are almost 3 times as large as those from the 12%

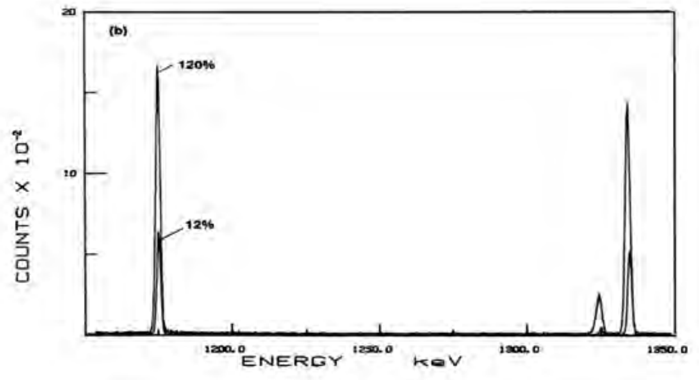

Figure 16. 12% uncollimated and 120% collimated detectors compared at the same count rate.

even though both are counting at the same count rate. Thus the 120% would have a "throughput limited MDA" almost 3 times better than that of the 12% for the same measurement time.

High Count-Rate "Rules of Thumb"

You will always have to make a trade-off between conflicting needs and performance.

- What is the "worst" tolerable resolution? This defines amplifier shaping time, and thereby throughput limits.
- Low energy only (planar)? Planar detectors can operate at short shaping times; special resistor option can trade resolution for throughput with no reset losses as in TRP.
- High energy? Consider using a collimated large coax to improve the data quality.
- Fixed high rate situation? Adjust the count rate to operate at the point of maximum throughput.
- TRP (Plus) or resistive? TRP for wide dynamic count rate ranges (no saturation), but some loss of throughput.

Low and Very Low Count Rates. Low Background Detectors.

Reduced and low background detectors are available, constructed with different degrees of low background specification. The background in the detector comes from natural emitters found in nearly all materials. By carefully selecting the materials used in the detector, these natural radionuclides can be significantly reduced. No detectors (low or otherwise) have non-mode radionuclides in the material. The background has both peaks and continuum. Ref. 11 describes the background and how to quantify it.

The Standard Options From ORTEC Are:

LB — Low Background

XLB — Low Background with lead backshield

RB — Reduced Background in PopTop

Low background (Ref. 7) options require specially selected materials, and therefore can add considerable cost to the detector. Before deciding that such a step is necessary, consider the following:

What problem are you trying to solve or mitigate? The basic principle should be removal of INTERFERENCE LINES which degrade the results. The background continuum is not usually the problem.

Examples:

In a lung burden system, the major source of background is the ^{40}K Compton background from the subject. If uranium is being measured, then some attention should be paid to removing sources of this line (including Compton-scattered events from the subject) from the spectrum.

In an In-situ measurement, the source of background is not the detector itself. You should first shield the detector from external radiation sources such as nearby containers.

Figure 17 shows the background in different detectors. If you are measuring uranium via the 186 keV line, then the reduced background PopTop or low background option rather than the standard detector is needed. This is due to uranium being present in the standard detector aluminum endcap.

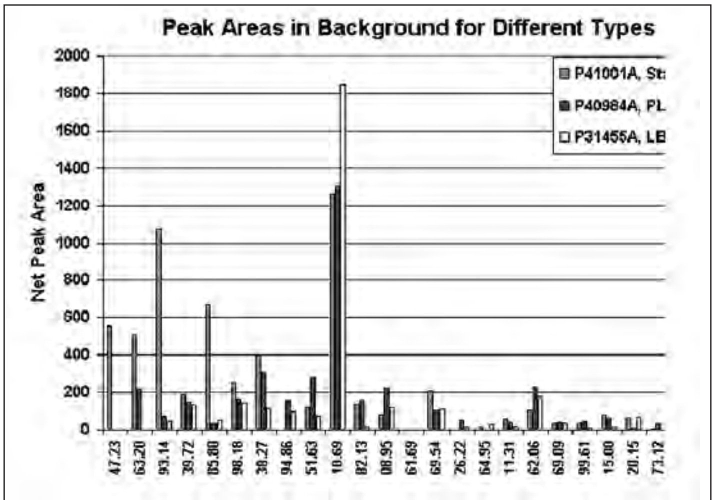

Figure 17. Low background (LB), reduced background PopTop (PLB), and standard detector.

The Cryostat

PopTop, the Versatile Cryostat Choice

ORTEC's proprietary transplantable PopTop capsule (U.S.A. Patent No. 4,851,684), attached to a companion cryostat and liquid nitrogen dewar, is the best solution for most applications. If you do choose PopTop, you will be able, inexpensively, to select more than one cryostat configuration, either now or later. If, for example, you decide on a vertical dipstick cryostat now, but decide later to use the detector both in the laboratory and in the field, you can obtain a Gamma Gage hand-held cryostat/dewar that will mate with the capsule. The capsule can be quickly attached to the Gamma Gage when going into the field, then re-attached to the vertical cryostat for use in the laboratory. PopTop LN_2 cooled detectors are field upgradeable to the X-COOLER II LN_2-Free cooling system.

Streamline (Non-PopTop) and Special Cryostats for Special Requirements

A streamline cryostat may be the best choice for certain demanding applications. For example, if ultra-low MDA is needed for particular lines that may be present in standard cryostats, the choice is an Extra-Low-Background (XLB) streamline cryostat, which has been optimized in every way for this purpose.

Streamline cryostats are routinely supplied for all low background, GWL, IGLET, and IGLET-X detectors.

For experiments in which the detector is to be subjected to intense fast neutron flux, a streamline cryostat is recommended.

ORTEC has produced many special cryostats designed to meet specific customer requirements. A noteworthy example is the array of 100 special detectors, of which 60 were "segmented," in GAMMASPHERE (Fig. 18), the largest such configuration of detectors in the world. Other specials include detectors used in balloon experiments, detector arrays flown in helicopters for gamma ray topology measurements, and internally-shielded detectors for Safeguards and post accident monitoring purposes.

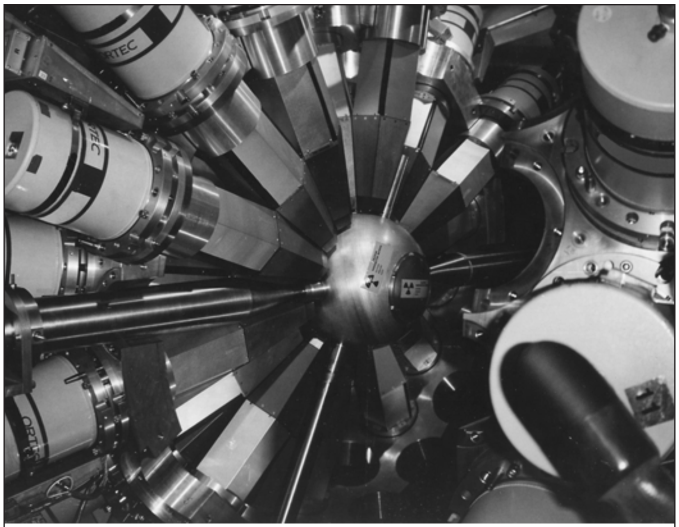

Fig. 18. View of GAMMASPHERE with Right Half Removed.

Cryostat Materials

Are the lines to be quantified the same ones (or very close to those) that are often present in cryostat materials? (See Table 1.)

If the answer is **yes**, then a Low- or Extra-Low-background detector is needed to achieve detection limits. It can be provided in a wide choice of configurations.

If the answer is **no**, consider this next: **Will the count rates of the peaks to be quantified be comparable with the Compton background counts created by the radioactive isotopes that are present at low levels in a standard cryostat?*** If the answer to this question is **yes**, observe the spectra above (taken on two 55% efficiency detectors — one low-background, one standard). This is an example of the reduction in background count rate that can be achieved with a low-background cryostat.

The low-background cryostat is substantially better than the standard one for energies below ~500 keV, somewhat better between 500 and 1500 keV, and little better above that. If your peaks of interest are below 500 keV, you should invest next in a low-background cryostat. Between 500 and 1500 keV, the low-background cryostat may help to lower the MDA, but the same amount of investment in a higher-efficiency detector will produce about the same MDA improvement. (Obtaining both the low-background cryostat and the high-efficiency detector will produce the best possible results.) For measurements of lines at energies above 1500 keV, a low-background cryostat is of little value.

Table 1. Environmental Radionuclide Full-Energy Photopeak Energies.

Isotope (Parent Nuclide)	Energy in keV	Isotope (Parent Nuclide)	Energy in keV
U x-rays	13.0, 13.3*	^{137}Cs	661.6
^{231}U	25.6*	^{214}Bi (^{238}U)	727.2
^{137}Cs	31.8, 32.2, 36.4*	^{234m}Pa (^{238}U)	766.6
^{210}Pb (^{238}U)	46.5	^{228}Ac (^{232}Th)	911.0
^{234}Th (^{238}U)	63.3	^{228}Ac (^{232}Th)	969.0
^{234}Th (^{238}U)	92.6	^{234m}Pa (^{238}U)	1001.0
^{235}U, ^{226}Ra	185.7, 186.2	^{214}Bi (^{238}U)	1120.3
^{212}Pb (^{232}Th)	238.6	^{60}Co	1173.0
^{214}Pb (^{238}U)	295.2	^{214}Bi (^{238}U)	1238.0
^{214}Pb (^{238}U)	351.9	^{60}Co	1332.5
Cosmic	511.0	^{40}K	1460.8
^{208}Tl (^{232}Tl)	583.1	^{214}Bi (^{238}U)	1764.5
^{214}Bi (^{238}U)	609.3	^{208}Tl (^{232}Tl)	2614.5

* The lines lower than 46 keV are reported only for LO-AX and GMX detectors.

How to Choose the Right Photon Detector for Your Application

Cryostat Choice for Ultra-Low-Level Measurements

There are two popular cryostat configurations often chosen for ultra-low MDA. They are (a) the J configuration, which makes it possible to shield the dewar, much of the cryostat, and the cryosorption material from the detector element, and (b) the HJ configuration, which, in addition, allows the preamplifier to be shielded from the detector element. These are available in streamline cryostats.

Shielding

Applications that have count rates sufficiently high that the total of background counts from all sources is insignificant need neither special shielding nor a low-background detector. However, if high sample throughput and low MDA must be obtained for low-level samples, the contribution from background radiation (the outside world and the cryostat) is of definite concern.

A good quality, low-background lead shield (containing ~4 inches of low-radiogenic lead) that will accommodate the detector is essential.

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How to Choose the Right Photon Detector for Your Application

Photon Detector Applications Summary Guide

Application	Most Suitable Detector(s)
Synchrotron light studies; Soft x-ray (fusion) research	IGLET, IGLET-X, SLP, GLP
PIXE	SLP, IGLET, IGLET-X
Large environmental samples with complex spectra	GEM, GEM-F, GEM-M, GMX, (low-background recommended)
Environmental samples on filter media, dishes or bottles	GEM-F, GEM-FX, GEM, GMX
Small environmental samples	GWL (low-background recommended)
High-grade fissile materials	SGD, SGD-GEM
Neutron activation analysis	GMX (PLUS option recommended)
Post-accident monitoring	GEM (PLUS option recommended)
Compton-suppressed gamma spectroscopy	GMX, GEM (based on range of energy interest)
Sea or airborne surveillance	Micro-trans-SPEC, trans-SPEC-DX-100, IDM
Lung monitoring	Actinide-85
Measurements in-beam or near fast-neutron fields	GMX (special internal heater for in-situ neutron damage anneal recommended)
Waste assay	Micro-trans-SPEC, trans-SPEC-DX-100, GEM, GMX
Freight/Border Security	Micro-Detective, Detective-EX, Detective-DX, IDM
In-Situ environmental spectroscopy	Micro-trans-SPEC, trans-SPEC-DX-100, GEM, GMX

Photon Detector Selection Guide

Type of ORTEC Detector	Geometry	Window Thickness (μm)	Useful Energy Range	Material	Standard* Sizes	Standard* Energy Resolutions	Standard* Peak to Compton	Standard Peak Shapes		Warranted Temperature Cyclable
								FW.1M/FWHM	FW.02M/FWHM	
GEM	Closed-End Coaxial	600	40 keV–10 MeV	P-type HPGe	10%–150% Efficiency	175–240 keV @ 1.33 MeV	37:1–90:1	1.90–2.00	2.65–3.10	Yes
PROFILE GEM	Closed-End Coaxial	600	40 keV–10 MeV	P-type HPGe	60–90 mm	675–1300 eV @122 keV 1.85–2.3 keV @1.33 keV	40:1–90:1	1.90–2.00	2.65–3.10	Yes
GMX	Thin Window Coaxial	0.3 Ion Implanted	3 keV–10 MeV	N-type HPGe	10%–100% Efficiency	1.90–2.65 keV @1.33 MeV	38:1–64:1	1.90–2.30	2.65–3.30	Yes
GWL	Well	0.3 Ion Implanted	10 keV–10 MeV	P-type HPGe	Up to 400 cc Active Volume	2.10–2.30 keV @1.33 MeV 1.20–1.40 keV @ 122 keV				Yes
GLP	Planar	0.3 Ion Implanted	3 keV–300 keV	P-type HPGe	6–36 mm Diameter	165–385 eV @ 5.9 keV 480–595 eV @ 122 keV				Yes
LO-AX	Short Thin-Window Coaxial	0.3 Ion Implanted	3 keV–1 MeV	N-type HPGe	36–70 mm Diameter	300–495 eV @ 5.9 keV 585–720 eV @ 122 keV				Yes
SLP	Planar	0.1	1 keV–30 keV	Lithium Drifted Silicon	4–16 mm Diameter	160–250 eV @ 5.9 keV				Yes
IGLET	Special	0.1	3 kev–>60 keV	P-type HPGe	6–16 mm Diameter	135–160 eV @ 5.9 keV				Yes
IGLET-X	Special	<0.1	<1 keV–>60 keV	P-type HPGe	6–16 mm Diameter	135–160 eV @ 5.9 keV				Yes

*Detectors of different size, resolution, peak/Compton ratio, and peak shape are available on special order.

ORTEC®

PINS-GMX

Portable Isotopic Neutron-Spectroscopy GAMMA-X Detector

The **P**ortable **I**sotopic **N**eutron-**S**pectroscopy GAMMA-X (PINS-GMX) detector was created from a joint development of ORTEC and the Idaho National Engineering Laboratory* (INEEL) in response to the growing worldwide need to determine *in situ* the specific nature of the contents of a variety of containers of munitions or potential chemical weapons. Such applications require a detector with high resolution over a large range of energy, portability, neutron damage resistance, reliability, and ease of use. The performance of the PINS-GMX detector has been verified in real-world use by the U.S. Army. The detector is a component of the ORTEC PINS System (brochure available on request).

- High purity germanium (HPGe) detector with high-neutron damage resistance characteristics.
- Relative efficiency >40% for 1.33-MeV gamma ray of ^{60}Co, relative to a 3-in. x 3-in. NaI(Tl) crystal at a 25-cm source-to-detector distance.
- Rugged 0.3-microns thick boron implant contact on all outer surfaces.
- Rugged all aluminum endcap with front window thickness of ≤1 mm.
- Detector crystal to endcap front distance ≤5 mm.
- Horizontal concentric type preamplifier.
- Preamplifier outputs capable of driving 150 feet of coaxial cable without measurable degradation to the pulse shape or resolution.
- Minimum operating bias of –3000 volts, and typically operates at bias between –4000 and –5000 volts.
- All attitude portable style cryostat and dewar providing adequate cooling in any orientation if any liquid nitrogen is in the dewar.
- Dewar capacity of 1.2 liters liquid nitrogen, with nominal 20-hour holding time.
- High-rate indicator for excessive count rate.
- Internal temperature sensor providing necessary signal for high-voltage shutdown in the event of accidental warm up.
- A sensor is incorporated into the cryostat in such a way that if the detector warms up, a logic signal to gate off the high-voltage power supply will be generated.
- Can be safely thermal cycled to room temperature.

*CRADA 93-ST-12

PINS-GMX

Portable Isotopic Neutron-Spectroscopy
GAMMA-X Detector

Specifications

- Resolution:
  - FWHM: ≤1.95 keV at 1.33 MeV
  - FWTM: ≤3.90 keV at 1.33 MeV
  - FWFM: ≤5.85 keV at 1.33 MeV
  - Peak-to Compton (pC) ratio: >55:1
  - FWHM: ≤825 eV at 88 keV
  - FWHM ≤750 eV at 22 keV
  - Peak area ratio from ^{109}Cd at 22-keV to 88-keV >7
  - Ratio of 2.6-MeV to 1.33-MeV FWHM resolutions <1.5
- The FWHM of a time spectrum taken with the detector and an 1-in. x 1-in. plastic scintillator with an energy window 100 keV wide and constant-fraction timing:

Energy Window Centroid (keV)	FWHM (Nanoseconds)
150	≤15.0
250	≤12.0
350	≤8.5
511	≤6.5
1170	≤3.0

- Capable of operating at energy rates >50,000 MeV/sec without preamplifier lockup and without deterioration in resolution beyond that contributed by the main amplifier

Ordering Information

Model No.	Description
PINS-GMX	GAMMA-X Detector for PINS-2 System. Includes CFG-MG4-1.2 Dewar/Cryostat and SMART-1 option for negative bias detector.

Options

B/PFA-1.2L	Bayonet Pressure Fill
DWR-S/F	Storage Fill Dewar

Specifications subject to change
030210

ORTEC®

ACTINIDE-85

HPGe Lung Monitor Detector

- **85-mm diameter and 30-mm thick HPGe detector optimized for Actinide Bioassay measurements.**
- **Large frontal active area with excellent photon sensitivity for photon energies above 10 keV.**
- **Warranted Energy Resolution (FWHM) equal to or better than 600 eV at 14.4 keV.**
- **Warranted Energy Resolution (FWHM) equal to or better than 650 eV at 122 keV.**
- **Warranted Energy Resolution (FWHM) equal to or better than 1.9 keV at 1332 keV.**
- **Warranted Peak to Compton ratio >55:1.**
- **FW 0.1M/FWHM typically <2.0, FW0.2M/FWHM typically <2.9.**
- **Can be used with X-COOLER II Mechanical Cooler.**

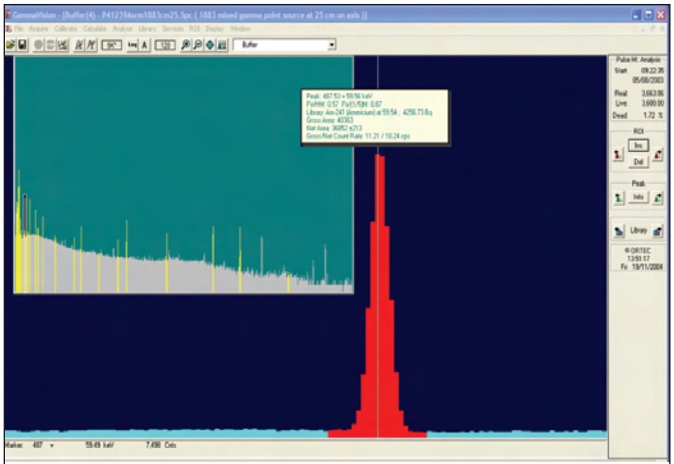


Figure 1. Mixed Isotope Spectrum from ACTINIDE-85 Detector. 59 keV Am-241 Peak Expanded.

ACTINIDE-85 is a high-resolution, high-purity germanium detector designed specifically for lung burden and whole body counting applications. It is based on the PROFILE FX-85, which employs a proprietary thin radiation entrance window (~10 microns Ge equivalent), in order to maximize low-energy efficiency.

The unique detector design combines large area and excellent energy resolution across a wide range of energy, with excellent peak shape, so important in analysis of complex spectra. The result is excellent sensitivity for the detection of small amounts of actinides such as uranium, plutonium, and americium, as well as higher energy fission products and naturally-occurring radioisotopes, in a distributed source such as the human lung.

The large frontal area (>54 sq cm) of ACTINIDE-85 provides high geometrical detection efficiency and superior resolution performance in the lower energy range of actinides such as Pu, Am and U, below around 400 keV, while the crystal depth of 30 mm means good stopping power and excellent relative efficiency at higher energies. The excellent warranted energy resolution at 1.33 MeV, combined with exceptionally good peak shapes, means that the ACTINIDE-85 is the ideal detector solution for analysis of fission products as well.

In lung burden measurements, large diameter detectors allow better coverage of the lung; with ACTINIDE-85, critically important energy resolution is maintained. The special mechanical construction of the cryostat allows two, three, or four ACTINIDE-85 detectors to be placed very close to each other and in contact with the subject. This configuration gives the maximum possible detector efficiency for human lungs. The detector cryostat is made of selected and qualified low background material, based not only on radioactive background characteristics, but also on long-term reliability. The detector endcap is made of an ultra-low background, high-strength carbon fiber composite which provides greater than 85% transmission for photon energy above 15 keV and nearly 100% transmission for photon energy above 20 keV. To further assure and verify low background quality, each detector is placed inside a graded-Z shielding and a background spectrum is taken for 100,000 seconds after assembly. This spectrum is delivered with the detector.

Positioning

ORTEC ACTINIDE-85 detectors may be ordered in a variety of configurations to meet a variety of requirements for lung burden, body burden, and whole-body counting programs. ORTEC lung burden assessment systems allow independent detector positioning which provide for optimum detector placement and measurement efficiency. In general, positioning mechanisms should be made of carefully screened low-background materials and designed for ease of use and reliability.

Cryostat and Dewar

The standard ACTINIDE-85 is supplied with a 3.5L "high fill" dewar. Which provides a typical holding time of 48 hrs.

X-COOLER II Mechanical Cooling Option

The ORTEC X-COOLER II can be employed as an alternative to liquid nitrogen to cool the ACTINIDE-85 detector.

The use of LN_2 is costly, time consuming, and (of particular concern for lung burden assessment) is potentially hazardous. In addition, the presence of LN_2 can be intimidating to personnel. X-COOLER II is a proven, economical alternative to LN_2 for whole-body counting. It can be shown that the savings in LN_2 alone will mean that the investment in the X-COOLER II is recovered in a timescale as short as one year.

ACTINIDE-85

HPGe Lung Monitor Detector

Specifications

Model	Crystal Dimensions[1]		Energy Resolution (FWHM)[2,3]				Peak Shape[2]				
	Diameter Nominal	Length Minimum	14.4 keV Warranted (eV)	46 kev Typical (eV)	@122 keV Warranted (eV)	@1.33 MeV Warranted (keV)	FW.1M/ FWHM Typical	FW.02M/ FWHM Typical	P:C Warranted	Nominal Relative Efficiency %	Endcap Diameter mm
ACT85	85	30	600	625	650	1.90	2.00	2.90	55	50	108

[1]Smaller crystal dimensions are available. Contact your ORTEC Sales Representative or the Main Factory.

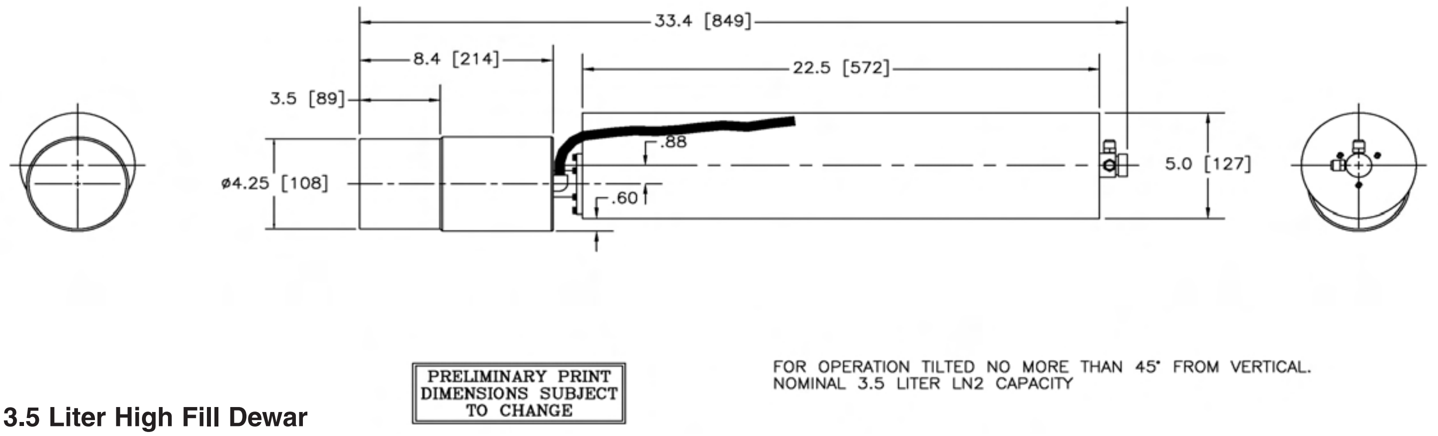
[2]FWHM = Full Width at Half Maximum; FW0.1M = Full Width at One-tenth Maximum; FW.02M = Full Width at One-Fiftieth Maximum; total system resolution for a source at 1000 counts per second measured in accordance with ANSI/IEEE Std. 325-1996, using ORTEC standard electronics.

[3]Measured at optimum shaping time using ORTEC analog or digital electronics.

[4]The proprietary contact employed by the ACTINIDE-85 detector offers exceptionally high transmission at energies below 40 keV. Some instability in transmission may occur below 20 keV if stored uncooled at room temperature for extended periods of time (20–25°C or above). It is therefore recommended that the ACTINIDE-85 detector be kept cold, limiting the exposure to elevated ambient storage temperatures for applications which demand minimally varying efficiency below 20 keV.

Ordering Information

Model	Description
ACT85	ACTINIDE-85 detector, CFG-GG-LB-C-108 low-background cryostat with Carbon Fiber endcap and DWR-3.5HF high-fill dewar.
B/PFA-HF	Bayonet Pressure Fill Adapter for the DWR-3.5HF.
ACT85P4-RB	ACTINIDE-85 detector in reduced background PopTop capsule with Carbon Fiber endcap for use with X-COOLER II
Options	
-SMP	SMART-1 detector option for positive bias detector, add "-SMP" to the model number [e.g., ACT85-SMP or ACT85P4-RB-SMP].



3.5 Liter High Fill Dewar

Specifications subject to change
092408

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AMETEK® ADVANCED MEASUREMENT TECHNOLOGY

ORTEC®

Detector Preamplifier Options

Ultra-High Count-Rate Preamplifier (PLUS Option)

The Ultra-High Count-Rate Preamplifier (transistor-reset preamplifier) which may be ordered as the “PLUS” Option, is available for GEM or GAMMA-X detectors. This preamplifier, which can handle input count rates up to 1,000,000 counts/s at 1 MeV, offers the added benefit of having no feedback resistor.

PLUS Option Ordering Information

Place the word PLUS after the GEM, GMX model number. *Example:* To order a 40% GAMMA-X (GMX) detector with resolution specification 1.95 keV, specify GMX40P4-76-**PLUS**.

NOTE: For the best results at low energies with small planar Ge detectors, a Pulsed-Optical-Feedback (POF) preamplifier is recommended. Call the factory for details.

SMART-1 “Intelligent” Detector Option and Detector Interface Module (DIM)

SMART-1 is a significant advance in the operation of HPGe detectors and is a major enhancement to data and chain-of-custody integrity. It is supported by the digiDART, DSPEC jr 2.0, and DSPEC pro revolutionary, small sized, low power, DIGITAL nuclear multichannel analyzer systems. Both instruments are designed primarily with the needs of HPGe-detector gamma-ray spectrometry in mind. The SMART-1 HPGe detector has the high voltage included, so none of the instruments require an external high-voltage power supply. The SMART-1 HPGe detector monitors and reports on vital system functions. Also, the SMART-1 identification serial number can be read by the instrument. For more security it can save authentication codes and report the code at a later time.

ORTEC SMART-1 HPGe Detectors monitor the following conditions:

- Preamplifier +24 and +12 V values (read-only)
- Detector element temperature (read-only)
- Detector high voltage value (read-only)
- Detector high voltage state (on/off)
- Detector overload state (read-only)
- Detector HV shutdown state (read-only)
- Detector serial number (read-only)
- Detector authentication code (read/write)

These parameters are displayed as required on the LCD display of the attached instrument or computer, local or remote.

SMART-1 Physical

The SMART-1 is housed in a rugged ABS molded plastic enclosure. The SMART-1 is permanently attached to the detector endcap via a molded-strain-relieved sealed cable. This eliminates the possibility that the detector will suffer severe damage from moisture leaking into high-voltage connectors. The SMART-1 can be positioned in any convenient place and does not interfere with shielding or other mounting hardware.

The Detector Interface Module (DIM)

For older, non-ORTEC or non-SMART-1 detectors, the DIM is used to supply the HV for the detector. The DIM is provided in the same convenient housing as the SMART-1, but with flying leads (HV, Bias Supply Shutdown, Energy Output, Preamplifier Power, and Inhibit Output) to connect to the HPGe detector. The DIM does NOT provide SMART-1 functionality to a non-SMART-1 detector. It supplies HV and preamplifier power as well as providing warm-up protection for he HPGe detector.

The following DIMs support non-SMART-1 detector systems:

• **DIM-POSGE** For any non-SMART-1 positive-bias, HPGe detector. Includes short leads with mating connectors for connecting to existing detector cabling.

• **DIM-NEGGE** For any non-SMART-1 negative-bias, HPGe detector. Includes short leads with mating connectors for connecting to existing detector cabling.

• **DIM-POSNAI** For any positive-bias NaI detector. Includes short leads with mating connectors for connecting to existing detector cabling.

Detector Preamplifier Options

DIM Specifications

Dimensions: The DIM is shaped for easy mounting; the maximum dimensions (including mounting lugs) are 12 cm x 8.2 cm x 3.3 cm (4.7 in. x 3.2 in. x 1.3 in.)

Weight: <240 gm (0.5 lb.)

Performance

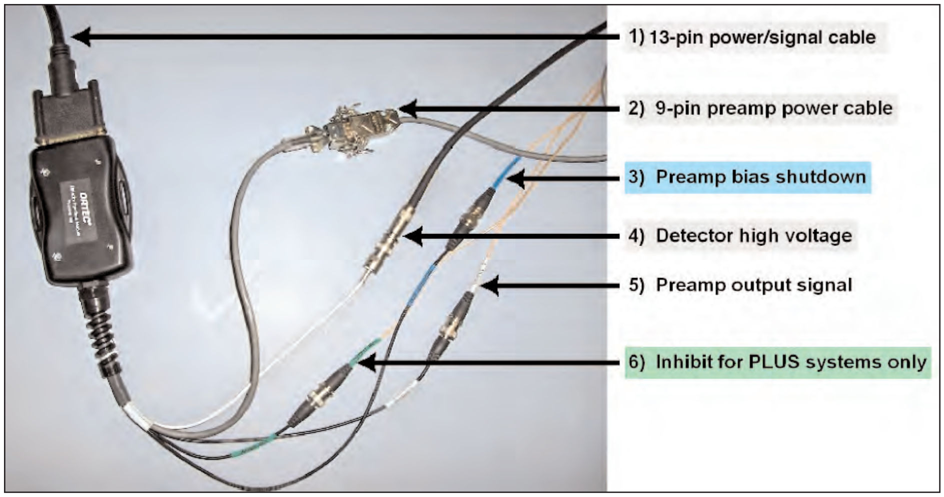
DIM-POSGE Output 0 +5 kV, 100 MΩ impedance

DIM-NEGGE Output 0 –5 kV, 100 MΩ impedance

DIM-POSNAI 0 +1800 V, 600 µA below 1000 V, 300 µA maximum above 1000 V

DIM Connectors

Multi-Pin connector for attachment to instrument (mating cable is provided with instrument)



DIM-POSGE and DIM-NEGGE (these connectors will mate directly with most standard HPGe detectors)

- Preamplifier Power: 9-PIN D female 1 W maximum (+12 V,1 2 V, +24 V, 24 V, 2 GND)
- Analog In: BNC male
- Bias Shutdown In: BNC male
- Bias Out: SHV (HV) female
- TRP Inhibit Out/Coincidence Gate In: BNC male (function is software selected)

DIM-POSNAI

- Preamplifier Power: 9-PIN D female 1 W maximum (+12 V, 12 V, +24 V, 24 V, 2 GND)
- Analog In: BNC male
- Bias Out: SHV (HV) female
- Coincidence Gate In: BNC male

DIM-296 Option for 14 Pin PMT NaI Detectors

The DIM-296 option is an alternative to the DIM-POSNAI for NaI detectors with a standard 14-Pin base. The DIM-296 is a 296 ScintiPack with a single cable connection, ten feet in length for direct connection to the instrument.

- For scintillation detectors employing 10-stage PMTs that fit standard 14-pin sockets
- Convenient, single-cable connection direct to instrument
- Internal, adjustable, high-voltage bias supply eliminates high-voltage cables
- Active bias network minimizes peak shifts at high counting rates
- Low power consumption (240 mW) for portable applications

Specifications subject to change
042308

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AMETEK® ADVANCED MEASUREMENT TECHNOLOGY

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Gamma Gage II
Portable Cryostat/Dewar

- Standard holding times in the range of 1–5 days[1]
- Available in all-attitude and compact multi-orientation dewar types
- Lightweight: <11 lbs for 24-hour holding time version
- Available for all GEM, GMX, SLP or GLP detectors
- Automatic high-voltage shutdown and high count-rate indicator
- PopTop or Streamline versions

Gamma Gage II represents a series of engineering improvements over the highly successful Gamma Gage of which many thousands are deployed daily in portable high resolution spectroscopy applications. These improvements have been implemented specifically in response to requests from users of the original Gamma Gage.

Gamma Gage II is intended for most any situation in which it is necessary to "take the instrument to the sample." Examples of such measurements are found in many waste assay and site characterization measurements, as well as nuclear materials holdup, and portable safeguards isotopic ratio measurements. In some cases, a Gamma Gage dewar is an excellent solution when space/weight is at a premium, for example, in Whole Body Counting applications or in some multi-detector research applications, although increasingly, electrical cooling is a viable alternative in these.

The integral LN_2 dewar is available in a variety of hold times to suit the measurement constraints on size/weight and holding time.

A Tale of Two Dewars

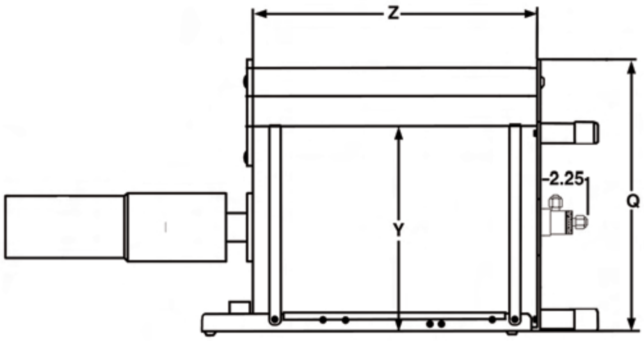
Two dewar type options on Gamma Gage II allow a choice between complete all-attitude no-spill operation and no-spill operation in a slightly restricted range of attitudes from a more compact dewar, the MOD dewar.

The definition of an all-attitude dewar is, apart from the inevitable venting of boil-off liquid nitrogen during use, the liquid refrigerant cannot escape from the dewar while the detector is in use, regardless of the orientation ("attitude") of the dewar. This is achieved by the relatively simple expedient of making the single fill-vent tube extend to the geometrical center of the LN_2 reservoir. Thus whatever the orientation of the dewar, the fill/vent tubes are above the level of the liquid. The dewar is never more than 50% full.

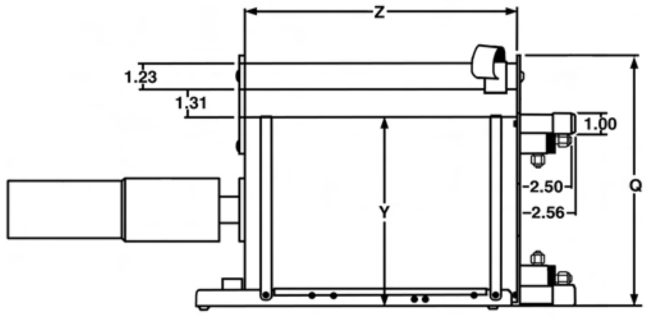
In some situations, the constraint on size is more important, and a dewar which may be filled completely is required, even at the expense of having to restrict the range of movement allowed without some venting of refrigerant. The MOD (multi-orientation dewar) option allows this. It may be operated pointing vertically upward, downward or horizontally. Table 1 gives the choice criteria between all-attitude and MOD dewar types; the basic tradeoff is between minimum size/weight for a given holding time and avoidance of loss of liquid refrigerant.

Table 1. Multi-Orientation Dewar vs. All-Attitude Dewar

	MOD	**All-Attitude**
Ease of filling with a funnel	More difficult and slower than all-attitude	Fills Easily
Ease of filling with a pressurized source	Equal	
Storage/Fill Dewar	Not compatible	Easily used with S/F dewar
Size	Smaller (all of the volume is utilized for LN)	Larger (only half the dewar volume is utilized for LN)
Dry Weight (Same LN_2 Capacity)	Smaller dewar equals lighter weight	Larger dewar equals heavier weight (~4 lbs.)
Spill Possibilities	LN is Easily Spilled by moving dewar	Very Difficult to make LN spill out of ports
Rotation About Center Axis	Causes pressurization of dewar and consequent leakage of refrigerant	No LN is spilled
Rotation on Longitudinal Axis (Tilting Up or Down)	Only 180° operation in one plane	No LN is spilled



All-Attitude Dewar



Multi-Orientation (MOD) Dewar

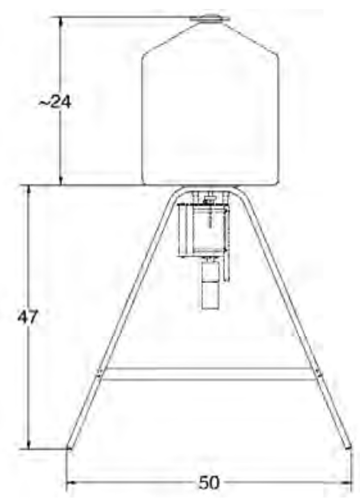
Dewar Type							
	Designation		All-Attitude			Multi-Orientation (MOD)	
	LN2 Volume> Hold Time[1]>		1.2L 1 Day[1]	3L 2 Days[1]	5L 4 Days[1]	3L 2 Days[1]	7L 5 Days[1]
	Unit	Tolerance					
Q	mm (in.)	±13 ±0.5	229 (9.0)	302 (11.9)	302 (11.9)	229 (9.0)	302 (11.9)
Y	mm (in.)	±5 ±0.2	157 (6.2)	229 (9.0)	229 (9.0)	157 (6.2)	229 (9.0)
Z	mm (in.)	±5 ±0.2	229 (9.0)	267 (10.5)	419 (16.5)	292 (11.5)	320 (12.6)

[1]Hold times are approximate for standard non-PopTop cryostats in 2.75" diameter size endcap only. Hold time for PopTop cryostats and special cryostats may vary. Actual hold times may vary depending on specific dewar, cryostat, and detector.

Gamma Gage II Fill Options

Both the all-attitude and MOD versions of the Gamma Gage II are supplied with fill funnels to allow manual filling in a HORIZONTAL orientation. (The MOD dewar cannot be filled in vertical orientation.) Both dewar types are compatible with the ORTEC manual and automatic LN_2 fill systems.

The all-attitude version may be filled in a vertical orientation or kept "at the ready" by attachment to the DWR S/F "mother cow" long term storage dewar.



DWR S/F

Specifications subject to change
120909

ORTEC®

CryoSecure™

Security System for Electrically-Cooled HPGe Detectors

- **Microprocessor controlled**
- **Protection against possible failure due to power outage**
- **Wide selection of restarting time intervals**
- **LED indicators show system status at a glance**
- **Battery backup**

When germanium detectors are cooled with an electromechanical cooler, such as the EC-III from ORTEC, there is a small possibility of an ac power failure causing detector damage. The supposed mechanism is that following the power failure, the system starts warming toward room temperature, and during the warmup, residual gases are released by the molecular sieve. If, before the system is completely warmed up, the ac power is restored, some of the gas is gettered by the detector element, which is then the coldest object in the vacuum assembly. The condensed gases may short circuit the reverse-biased detector junction and thereby cause voltage breakdown. For this reason, many users of electromechanical coolers prefer the detector to warm completely to room temperature after a power failure. CryoSecure ensures that this occurs, thus avoiding possible detector failure.

The CryoSecure Compressor Power Controller allows the operator to control the following time intervals:

- The “holding time” (4 selectable values) after an ac failure before allowing the Controller to go in the warming mode
- The “warmup time” (4 selectable values), which is the time the compressor is unpowered as the detector warms to room temperature
- The “cooling time with bias off” (16 selectable values), the Controller waits after restarting the compressor, before allowing reapplication of the detector bias voltage.

Once the desired time intervals are set, CryoSecure operates automatically under microprocessor control. Designed for worldwide use, CryoSecure operates with input from 100 V ac to 240 V ac, 47 to 63 Hz.

A rear-panel connector block incorporates a fuse holder and the input power connector. An international standard IEC power connector permits the use of power cords and plugs that meet local electrical standards. Output to the compressor, controlled by a solid-state relay, is provided via a mating rear-panel connector. The internal microprocessor-controlled circuit detects ac failure, measures its duration, and determines an appropriate response based on user settings. During the power failure, an internal battery supplies power to CryoSecure for continued operation (nominally 24 hours). Front-panel LED indicators allow monitoring of the controller status:

- **AC Power** AC on, the battery is being charged, the cooler is operating normally.
- **Holding** System is maintained on hold after a power failure.
- **Warming** System is in a warmup mode.
- **Bias OFF** Detector bias voltage is shut down.
- **Mains Fail** AC power has been interrupted.

A front-panel, two-position rocker switch turns the power on or off and a push-button Initialize switch allows the user to select the sequence of operation.

CryoSecure™

Security System for Electrically-Cooled HPGe Detectors

Specifications

PERFORMANCE

INPUT AC VOLTAGE The CryoSecure can accommodate input voltages of 100 V ac to 240 V ac at 47 to 63 Hz.

INPUT CURRENT Typically 7.5 A rms when connected to a 600-watt compressor.

CIRCUIT PROTECTION The input ac power line is protected with a 10-A fuse incorporated into the AC POWER input connector.

INPUTS

AC POWER Rear-panel, international standard IEC power connector, type CEE-22, accepts power cables wired according to local electrical standards. A power cable is shipped with the CryoSecure.

BIAS SHUTDOWN Rear-panel BNC connector accepts Bias Shutdown signal from detector. During normal operation, this signal is passed through a relay contact to allow bias voltage to be applied to the detector. During a Holding State, Warming State, or Cooling State, the Bias Shutdown signal is interrupted preventing bias from being applied to the detector.

OUTPUTS

COMPRESSOR Rear-panel, type NEMA 5-15R AC, provides ac mains voltage to the compressor. A solid-state switch in series controls on/off operation of the compressor.

BIAS SHUTDOWN Rear-panel BNC connector provides Bias Shutdown signal to the detector.

CONTROLS

POWER Front-panel rocker switch turns power on or off.

INITIALIZE Front-panel push-button switch begins system operation, and allows the customer to manually cycle through the operating sequences.

HOLD TIME Internal printed wiring board (PWB)-mounted rotary switches (qty. 2) allow user to set the amount of time the CryoSecure waits after a mains power failure, before entering the Warming State.

WARMING TIME Internal PWB-mounted rotary switches (qty. 2) allow the user to set the amount of time the CryoSecure waits after a mains power failure before restarting the compressor.

BIAS OFF Internal PWB-mounted rotary switch allows the user to set the amount of time the CryoSecure waits after restarting the compressor, before allowing the detector bias voltage to be applied.

DEEP DISCHARGE PROTECTION In the event of a long-term power failure, or if the ac mains are turned off for an extended period of time, an internal relay will disconnect the internal circuity from the internal backup battery before the battery discharges. When ac power is restored, the system will resume normal operation and the battery will be recharged.

INDICATORS

AC POWER Front-panel LED indicates presence of ac mains voltage.

BIAS OFF Front-panel LED indicates the bias supply has been shut down.

WARMING Front-panel LED indicates CryoSecure is in the warming phase.

HOLDING Front-panel LED indicates CryoSecure is in the holding phase.

MAINS FAIL Front-panel LED indicates ac mains has failed. CryoSecure is operating from the internal battery.

ELECTRICAL AND MECHANICAL

WEIGHT

Net 2.6 kg (5.8 lb).

Shipping 3.2 kg (7.0 lb).

DIMENSIONS 21.5 cm (8.4 in.) W x 26 cm (10.2 in.) D x 10.2 cm (4.0 in.) H. Aluminum enclosure.

Ordering Information

To order, specify:

Model	Description
CRYOSECURE	Compressor Power Controller

Specifications subject to change
092507

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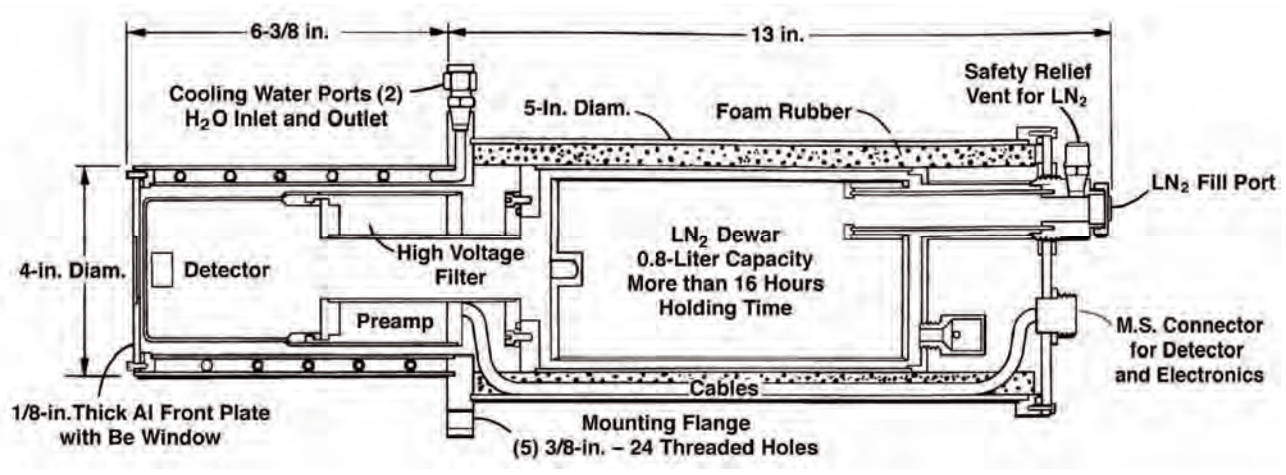
PGM-1
Pipe Gage Monitor

- **Compact (6-1/2 in. x 20 in. maximum dimensions)**
- **Lightweight detector/dewar package 8–10 lb stainless steel shroud 25 lb aluminum shroud ~12 lb**
- **1/4 in. Swagelock fittings for cooling end cap (optional)**
- **Foam-rubber insulation reduces shock**
- **External connections for in-situ LN_2 refilling**
- **Military specification electrical connections**
- **Water resistant**
- **Available with Be or Al end cap**

The ORTEC Pipe Gage Monitor (PGM-1) is designed to monitor fluid/vapor density in nuclear reactor coolant piping. Other applications include activated corrosion products monitoring, activation analysis of sulphur in coal slurry, and and stack monitoring. In applications requiring high-resolution gamma-ray spectroscopy, such as reactor coolant pipe monitoring, a high-purity germanium (HPGe) detector may be desirable. However, all germanium detectors require liquid nitrogen (LN_2) cooling to operate. A special dewar (thermos vessel) was designed to fit the compact space requirements.

The reactor coolant pipe is subject to temperatures of up to 650°F within 0.5 inches of the detector window. To ensure adequate cooling protection under this environment, a cooling coil is built into the stainless steel end cap to circulate cold water as required. This small but rugged package is bolted to the coolant pipe via a flange.

The liquid nitrogen is refilled periodically through a separate automated filling system attached to the rear of the housing. The holding time of the LN_2 dewar is more than 16 hours. Electrical connections (preamp power, detector, H.V. bias, H.V. cutoff, amplifier output, test pulser input) to and from the detector package are made through a military specification connector. This compact (approximately 20-in. in length and 6-1/2 in. in diameter maximum) rugged detector package can be operated either indoors or outdoors.



Detailed Illustration of the ORTEC Pipe Gage Monitor (PGM-1)

Specifications subject to change
110207

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AMETEK® ADVANCED MEASUREMENT TECHNOLOGY

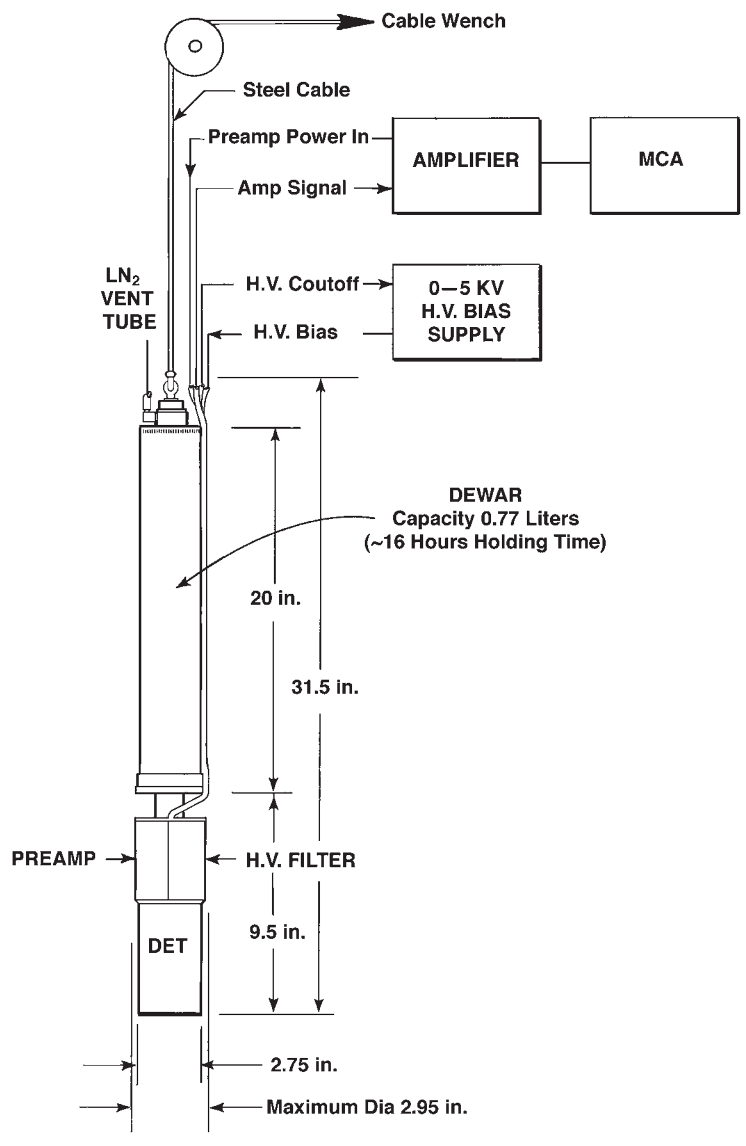
SHP-1
Shallow Hole Probe

- **Compact size (~31.5-in. long and 2.95-in. diameter)**
- **Weight ~12 lb**
- **Can withstand 100% humidity, noncondensing**
- **~16 hour LN_2 holding time**
- **Available with GEM, GMX or GLP types**
- **100-ft operating depth**
- **Rugged eye hook for cable rigging**

The ORTEC Shallow Hole Probe (SHP-1) is designed for surveying shallow bore holes in and around mine and mill tailing dumps and land fills, formerly utilized nuclear materials facilities, and other waste management sites. In the waste management application, high-resolution spectroscopy is desired, dictating the use of a high-purity germanium (HPGe) photon detector. All germanium detectors require liquid nitrogen (LN_2) cooling to operate. A special compact dewar (thermos vessel) was designed to supply 0.77 liters of LN_2 providing approximately 16-hours holding time during operation. This compact system has a maximum diameter of 2.95 in. (O.D.), which makes it ideal for shallow-depth bore-hole logging in 3 in. diameter (I.D.) pipes, casings, holes, etc. The entire length of the SHP-1 is approximately 31.5 in. including detector, H.V. filter, preamp, cooling cryostat and dewar.

The dewar vessel is offset to allow the electronic support cables to pass within the 2.95-in. maximum diameter. A rugged eye hook, attached to the top of the LN_2 fill port, provides the necessary steel cable attachment to enable the entire system to be dropped into a 3 in. diameter hole to depths of 100 feet. Electronic cables and and an LN_2 vent tube are fixed to the steel cable which is then attached to the surface mobile support van.

All ORTEC HPGe detector types can be supplied in the SHP cryostat.



Detailed Illustration of the ORTEC Shallow-Hole Probe (SHP-1)

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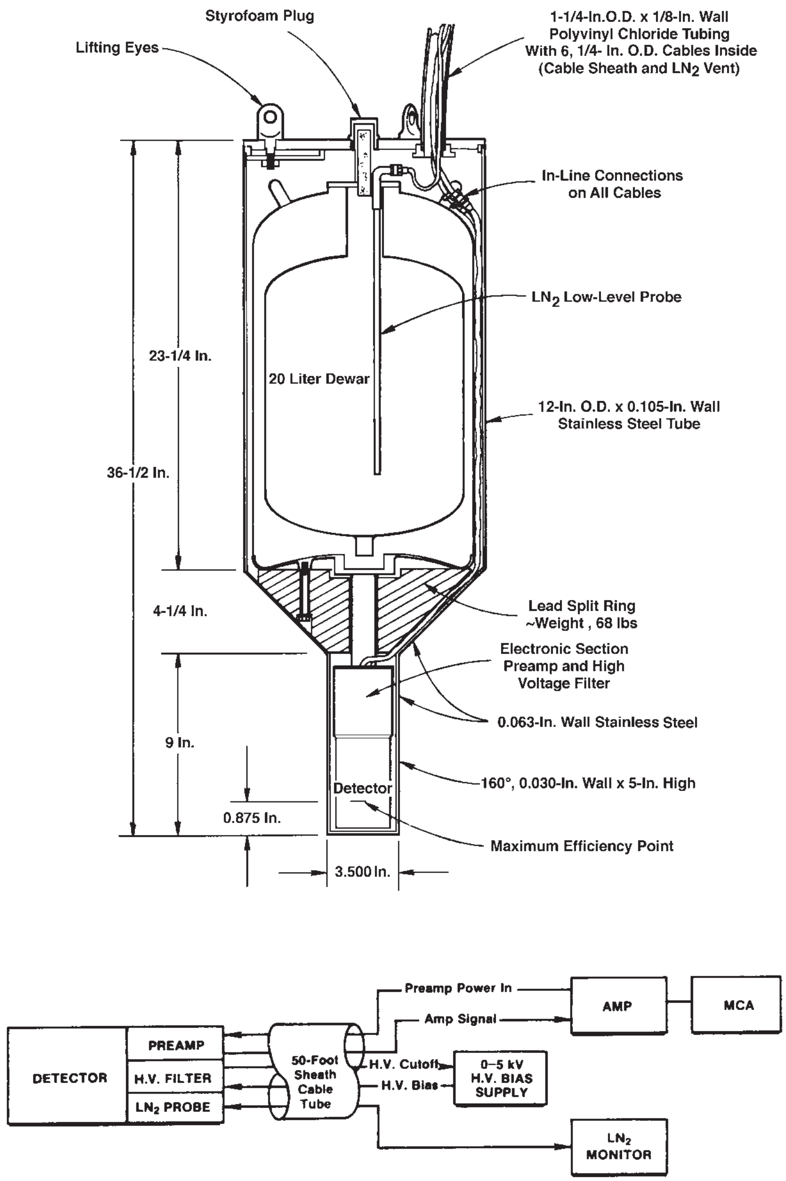
SPD-1
Submergible Photon Detector

- **Compact size (~37-in. long and 12-in. diameter)**
- **Weight ~100 lbs**
- **Totally waterproof, submergible**
- **LN_2 refillable without opening the shroud cover**
- **Split-ring lead shield for shielding and negative buoyancy**
- **HPGe coaxial detector**
- **Preamp, H.V. filter, LN_2 level probe, and H.V. cutoff protection included**
- **30-foot operating depth**
- **Stainless steel shroud for easy cleaning and decontamination**
- **Thin (30 mil) side window in shroud to enable low energy photon (≥50 keV) spectroscopy**

The ORTEC Submergible Photon Detector (SPD-1) is designed for nuclear fuel element scanning in storage pools. The SPD-1 is useful in other simular applications that require a totally waterproof, submergible photon detector for shallow depth pools. In the fuel element scanning application, high-resolution spectroscopy is desired, dictating the use of a High-Purity Germanium (HPGe) Photon Detector. As with all germanium detectors, liquid nitrogen (LN_2) cooling is required for operation. A special compact LN_2 dewar (thermos vessel) supplies 20 liters of LN_2 during operation. The dewar can be refilled at the surface of the pool without removing the waterproof shroud cover. Operating time of the SPD-1, before LN_2 refilling is required, is approximately 12 to 14 days. An LN_2 low level alarm and high-voltage (H.V.) cutoff circuitry monitor and protect the system.

The compact (approximately 37-in long x 12-in. diameter) stainless steel shroud contains the HPGe detector element, cryogenic package, 20-liter LN_2 dewar, LN_2 level probe, preamplifier, H.V. filter, and lead shield. The split-ring lead shield is provided behind the detector element to shield from contaminated water in the pool and also to provide negative buoyancy to the system. The stainless steel package has three lifting eyes and can be easily cleaned or decontaminated. The particular system shown was designed for pool depths up to 30 feet. Polyvinyl chloride tubing is used to carry the electrical cables to and from the detector package and to vent the LN_2 to the pool surface. A thin (30 mil) side window is provided in the stainless steel shroud to enable low energy photons (down to 50 keV) to enter the detector package.

SPD-1
Submergible Photon Detector



Detailed Illustration of the ORTEC Submergible Photon Detector (SPD-1)

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AWM-1
Actinide Wound Monitor

- **Locates and quantifies Pu, Am, and U in tissue**
- **Excellent energy and position resolution**
- **Provides lateral and depth location**
- **Lightweight**
- **Customer-responsive design**
- **Ergonomically engineered for easy handling in clinical situations**

ORTEC's Model AWM-1 Actinide Wound Monitor is designed to accurately locate actinides embedded in body tissue, so that they may be removed surgically. The instrument's design is based on specific suggestions from a leading radioisotope fabricating and reprocessing facility.

Energy Resolution and Position Information

The instrument contains a rugged, reliable, 6-mm diameter, 5-mm deep HPGe planar detector which provides excellent energy resolution and position information. By using Ge rather than Si, the ratios of intensities of the gamma-ray lines can be compared to those of the L x-rays (13 to 17 keV) to obtain information on the depth of the actinides.

Ergonomic Design

The ergonomic design of the instrument ensures optimum convenience in clinical situations. The construction and placement of the handle permit the user to operate the instrument for extended periods of time with little hand or arm fatigue. The one-hour supply of liquid nitrogen in the 0.06-liter dewar provides ample time for completion of most clinical procedures.

Personnel Safety and Equipment Protection

Safety of the patient and the operator is assured by an all-attitude dewar. Liquid nitrogen cannot be released from the dewar regardless of its orientation. A red LED on the top of the instruments warns if the radiation level being measured is high enough to drive the preamplifier out of its linear range. If the liquid nitrogen supply is exhausted while the detector is operational, an internal sensor cuts off the high voltage supply to protect the instrument from damage.

Instant Operation

A special 25-liter storage fill dewar supplied with the AWM-1 keeps the instrument filled with liquid nitrogen and ready to use.

Specifications

Performance

WARRANTED ENERGY RESOLUTION* AT 5.9 keV 180 eV FWHM.

WARRANTED ENERGY RESOLUTION* AT 122 keV 599 eV FWHM.

DETECTOR ELEMENT ACTIVE DIAMETER 6 mm.

DETECTOR ELEMENT ACTIVE DEPTH 5 mm.

BERYLLIUM WINDOW THICKNESS 0.13 mm.

INSTRUMENT WEIGHT 4 pounds.

Electrical

TEST INPUT One 18-inch RG174 coax cable with female BNC connector.

HIGH VOLTAGE BIAS INPUT One 18-inch RG59 coax cable with female SHV connector.

OUTPUTS Two 18-inch RG174 coax cables with female BNC connectors.

CABLE DRIVE CAPABILITY AND TERMINATION

Test Input Terminated in 93 Ω.

Outputs Series terminated in 93 Ω.

Drive Capability May drive terminated or unterminated 93-Ω coax cables (RG62 recommended). Termination recommended for cable lengths greater than 50 feet.

AWM-1
Actinide Wound Monitor

CONVERSION GAIN Normally 1.7 mV/keV (Ge), negative output pulse signal.

MAXIMUM PULSE OUTPUT TO A SINGLE EVENT –10 V.

MAXIMUM ENERGY RATE 2500 MeV/s.

NONLINEARITIES Integral and differential, <0.05% over 90% of the dynamic range of the preamplifier.

BIAS ISOLATION High-voltage filter can supply detector up to 2500 V bias.

TEMPERATURE INSTABILITY 50 ppm/°C over 0 to +50°C recommended operating temperature range.

POWER REQUIREMENTS +24 V at 50 mA, typical; –24 V at 25 mA, typical.

CABLE PACK Standard cable pack contains signal, test pulse, high-voltage shut down, and preamplifier overrange cables (all RG59A/U, 93-Ω BNC); a high-voltage cable (RG59A/U, 75-Ω SHV female); and a preamplifier power cable (9-pin connector, male).

AUTOMATIC HIGH-VOLTAGE SHUT-DOWN Cryostat section contains a temperature-sensing element attached to the cooling path. The sensing element is connected to a hybrid monitoring circuit in the preamplifier. An output cable is connected to the remote shutdown input on the rear panel of the ORTEC Model 659 Detector Bias Supply.

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*Energy resolution measured with an ORTEC Model 672 Amplifier at 6 µs shaping time constant.

Specifications subject to change
061008

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AMETEK® ADVANCED MEASUREMENT TECHNOLOGY

Detector Shielding

Choice of Detector Shielding

For low-level counting of samples, shielding of the detector to reduce ambient background radiation is essential. Many materials are used in shield designs, lead being the most common because of its high atomic number and density. Pre-World War II steel is used in some designs.

The thickness chosen for the principal shielding material depends on the required attenuation of gamma rays of a specific energy. For environmental applications covering the energy range from 0 to 2 MeV, 4 in. of lead is sufficient. Figure 1 shows the half-thickness values vs energy for commonly used shielding materials. For lead, the half-thickness for a 1 MeV gamma ray is 0.85 cm, which means that a 1-MeV gamma ray passing through 10 cm (4 in.) of lead will be attenuated by a factor of 3200; a 2-MeV gamma ray, by a factor of 175. These attenuation factors are adequate for most applications. Still greater thicknesses provide additional attenuation of gamma rays, but also increase the probability of undesired cosmic-ray interaction within the shield. Beyond 4 to 5 in. of lead, the background will actually increase because of this effect. Figure 2, showing the fraction remaining of photons incident on the shield, leads to the same conclusions.

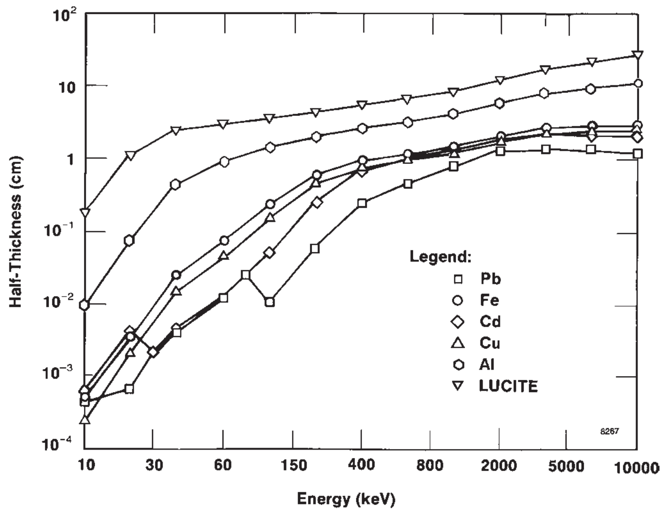


Fig. 1. Half-Thickness Values vs. Energy for Commonly Used Shielding Materials.

Figure 1 also shows that the half-thickness does not increase significantly at energies above 2 MeV, so that the conclusions for shield thickness also apply to prompt gamma measurements up to 10 MeV.

For some applications, the reduction of the lead K x ray is desirable. A graded-Z shield may be used for this purpose. The graded-Z shield works by providing materials with decreasing atomic numbers toward the detector in order to absorb the lead x ray photoelectrically and emit a secondary x ray of lower energy. Typical graded-Z shields use lead-cadmium-copper as the shielding materials. The required thickness of the cadmium and copper may be determined by examining Fig. 1 and noting the half-thickness values in those materials at the energies of interest.

For example, 0.3 mm is the half-thickness of cadmium at 80 keV (Pb K x rays); therefore, 10 half-thicknesses (3 mm) would reduce the peak by a factor of 1000. The copper is used to absorb the cadmium x rays at 22 keV and emit lower-energy x rays at about 3 keV. The half-thickness of copper for 20-keV photons is 0.03 mm and for 80-keV photons is 1 mm; so 0.3 mm would attenuate the 22-keV photons by a factor of 1000, but would also provide an additional 20% attenuation at 80 keV. Commercially available graded-Z liner thicknesses vary, but typical specifications are 0.02 in. (0.5 mm) for the Cd liner and 0.62 in. (1.57 cm) for the Cu liner. These dimensions would result in a 100-fold decrease in the Pb x rays and essentially complete attenuation (2×10^{16}) for the Cd x rays.

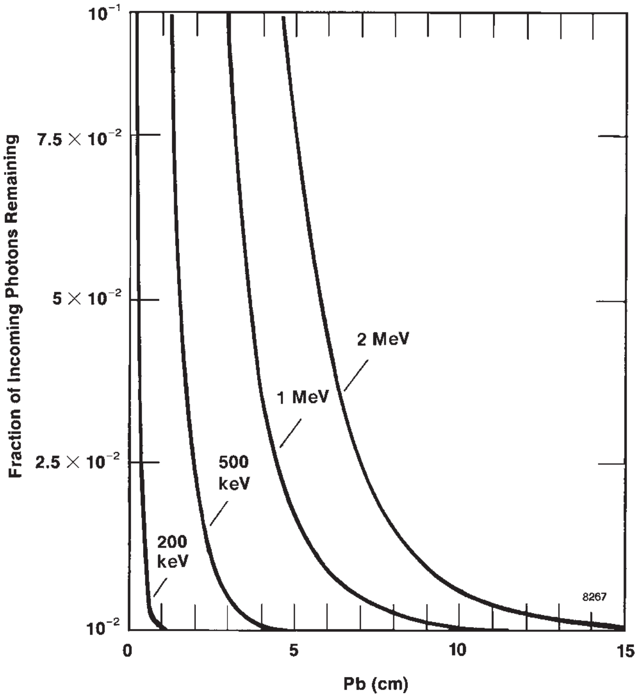


Fig. 2. Photon Attenuation as a Function of Pb Shield Thickness for Various Energies.

Other materials, such as Al and Lucite, are sometimes used in graded-Z shields used with x-ray detectors. Use of the graded-Z shield will result in higher backscatter effects within the shield and may actually reduce the detection limit for nuclides with principal peaks within the backscatter peak energies.

For the primary shielding material, both the graded-Z liner and the support structure should be constructed from materials with concentrations of radioactive nuclides as low as possible.

For even lower-level measurements, active shielding methods provide additional enhancement of signal-to-background ratio. These methods should be considered if passive shielding alone will not provide the required measurement sensitivity.

ORTEC®

HPLBS Series

High-Performance, Low-Background Shields and Accessories for Ge Detectors

ORTEC's high-performance, low-background Ge detector shields feature the highest quality workmanship and the best materials available. They include features which have evolved over years of experience in lead shield design. Options that make the shield easier to use also ensure continued smooth operation.

All ORTEC high-performance, low-background lead shields feature an 11-in.-diam x 16-in.-deep cavity, suitable for accommodating even 4-liter Marinelli beakers. A graded liner of copper and tin is provided for the suppression of lead x-rays. The bulk shielding material is certified Doe Run virgin lead (4-in.-thick). The support stand and shield jacket are made from low-carbon steel. All external surfaces are finished in a durable, attractive textured polyurethane. Internal (copper and lead) surfaces are polished and coated with a clear-acrylic lacquer to minimize tarnishing of the copper liner and prevent human exposure to lead.

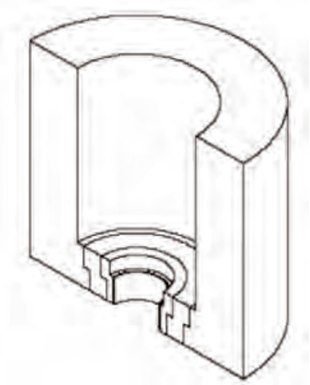
With each ORTEC HPLBS, the following are supplied:

1. Rigid support stand
2. Installation and maintenance manual
3. Touch-up paint
4. Assembly tools
5. Lifting eyes and lid restraint brackets
6. Two heavy-duty, wood pallet/crate sets suitable for overseas shipping

HPLBS1 Shield

The bottom port on the shield includes two nested inserts that allow multiple fit options to the bottom port. The bottom through-hole is 3.5-inches. This can be increased to a 5-inch through-hole by removing the center insert. A second insert makes up almost the entire bottom of the lead shield providing a 9-inch through-hole when removed. The model LFT1 and can be used to remove the larger bottom insert from the shield should this be required. The LFT1 is not included with the HPLBS1; it must be ordered separately.

It is not expect to remove this larger insert; however, it is provided for possible changes that may be required for the customers' specifications. This 42-lb. insert can be removed and machined locally or shipped back to ORTEC for replacement and/or modification if needed without having the entire shield machined on-site or replaced.



Nested Ports

The cutaway sketch shows the two nested ports that are now supplied with the model HPLBS1.

The HPLBS1 shield is designed to accommodate ORTEC cryostat "vertical dipstick" models CFG-PV-1 and CFG-SV or the X-COOLER II.

Close fitting plugs for the 3.5-inch through hole may be ordered as an option with the HPLBS1. Two standard models are available, PLG1 and PLG2.

PLG1 fits inside the 3.5-inch bottom port and closely around a vertical "dipstick" cryostat.

PLG2 is a split plug that fits inside the 3.5-inch bottom port and closely around the X-COOLER cold head. The X-COOLER systems require a split plug in order to fit between the larger capsule and cold head diameter. The two piece design allows the larger detector capsule to be positioned inside the shield and the PLG2 installed around the X-COOLER cold head.

HPLBS1F Front-Loading Shield

The HPLBS1F Shield is similar to the HPLBS1 Shield function, material, and appearance with the additional benefit of a hinged front door to allow easy access to the sample chamber. The bottom through-hole is 3.5-inches and can accommodate the PLG1 and PLG2. It does not include the nested inserts for larger through-hole sizes.

Specifications of Models HPLBS1 and HPLBS1F

SHIELDED CAVITY DIMENSIONS 28-cm i.d. x 40-cm high (11-in. i.d. x 16-in. high).

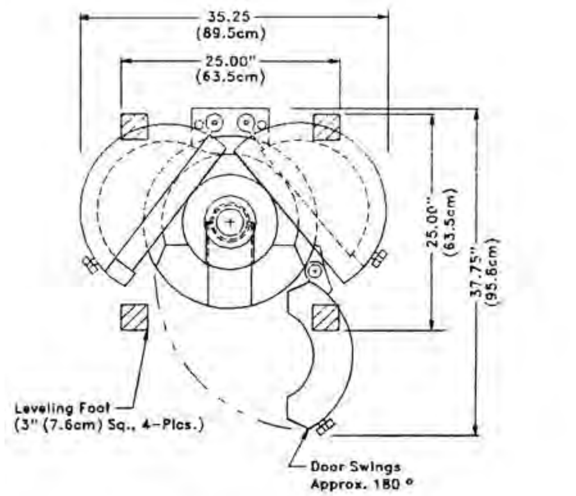
SHIELDING TYPE Solid-cast virgin lead with steel casing and graded-Z liner.

SHIELDING SPECIFICATIONS
9.5 mm (3/8 in.) low-carbon steel casing
101 mm (4 in.) certified Doe Run lead
0.5 mm (0.02 in.) tin sheet liner
1.6 mm (0.064 in.) soft-copper sheet liner

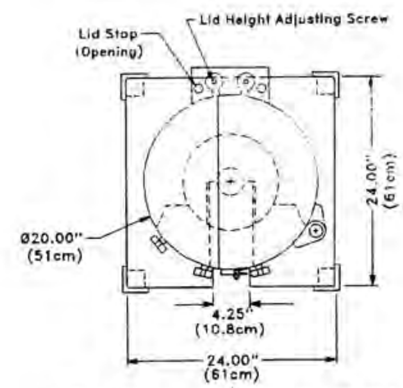
SUPPORT STAND MATERIAL Low-carbon steel square tubing and plate.

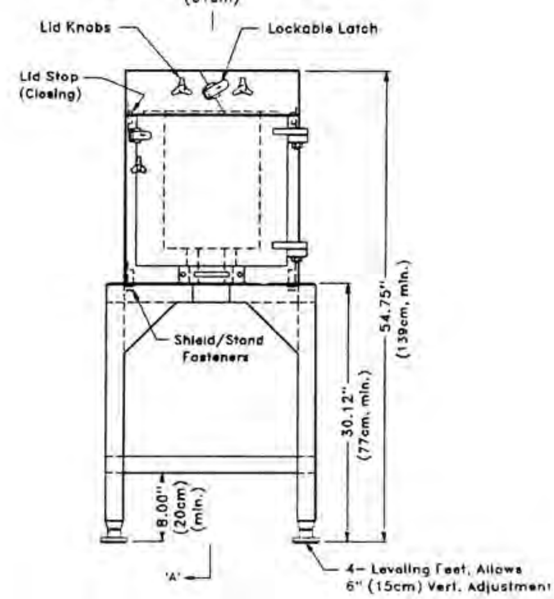
WEIGHT
Total Assembled 1,134 kg (2,500 lb).
Shipping 1,270 kg (2,800 lb).

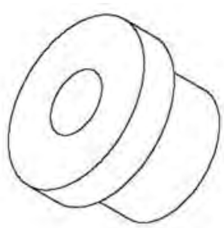
EXTERNAL DIMENSIONS
Shield 51-cm diameter x 63-cm high (20-in. diameter x 24-5/8-in. high).
Stand 61-cm square x 77-cm high (minimum) [24-in. square x 30-1/8-in. high (minimum)].
Assembled Height 139 cm (minimum) to 154 cm (maximum) [54-3/4 in. (minimum) to 60-3/4 in. (maximum)].



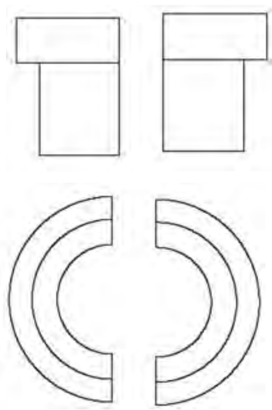
Top View With Lids And Front Door Opened
Floor Loading: 70 Lbs./sq.in. (5Kg/sq.cm)



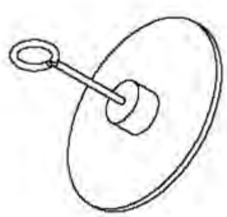




PLG1



PLG2



LFT1

HPLBS2F

The HPLBS2F Shield is similar to the HPLBS1F, in that it combines front loading with the split-top shield. It differs, however, in that it is designed for use with an ORTEC "J" Type cryostat Model CFG-SJ or CFG-HJ. A compact design results in the need for only 2-ft x 4-ft floor space [61-cm x 117-cm], plus clearance for opening of lids and the front door.

Specifications

SHIELDED CAVITY DIMENSIONS 28-cm i.d. x 40-cm high (11-in. i.d. x 16-in. high).

SHIELDING TYPE Solid-cast virgin lead with steel casing and graded-Z liner.

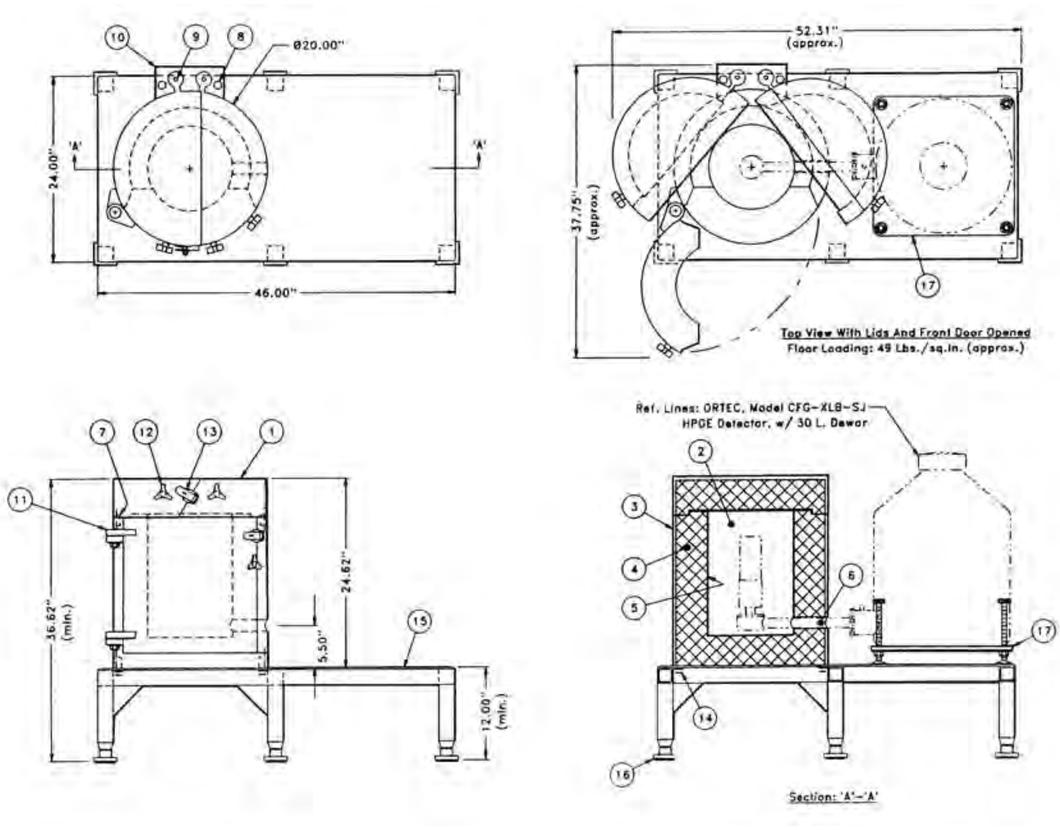
SHIELDING SPECIFICATIONS
9.5 mm (3/8 in.) low-carbon steel casing
101 mm (4 in.) certified Doe Run lead
0.5 mm (0.02 in.) tin sheet liner
1.6 mm (0.064 in.) soft-copper sheet liner

SUPPORT STAND MATERIAL Low-carbon steel square tubing and plate.

DETECTOR ACCESS SLOT WIDTH 4.5 cm (1-3/4 in.).

WEIGHT
Total Assembled 1,134 kg (2,500 lb).
Shipping Weight 1,270 kg (2,800 lb).

EXTERNAL DIMENSIONS
Shield 51-cm diameter x 63-cm high (20-in. diameter x 24-5/8-in. high).
Stand 61 cm x 117 cm x 77-cm high (minimum) [24 in. x 46 in. x 12-in. high (minimum)].
Assembled Height 94 cm (minimum) to 109 cm (maximum) [37 in. (minimum) to 43 in. (maximum)].



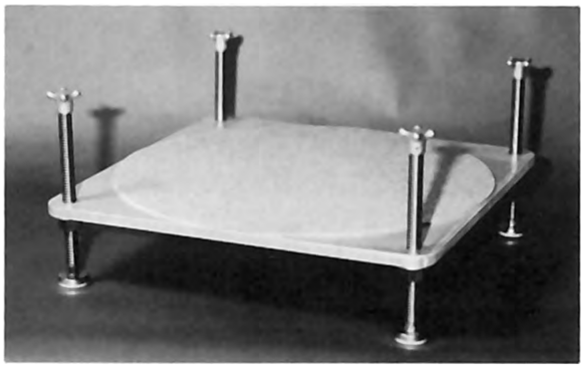
Legend

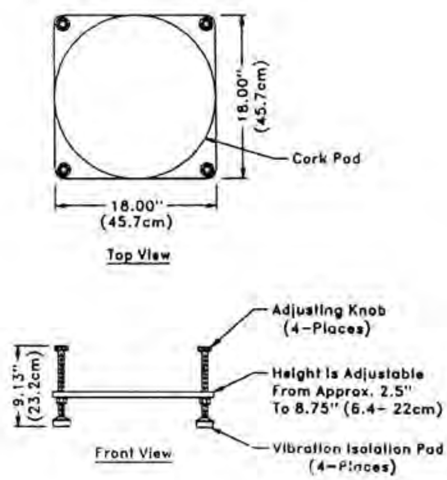
1. Model LSSJ-1116 Low background lead shield
2. Shielded cavity: 11" i.d. x 16" tall
3. Steel casing: 3/8" thick, low carbon
4. Cast virgin lead: 4" thick (minimum)
5. Sample cavity liner: .020" Cd and .064" Cu
6. Detector coldfinger slot with cable way
7. Lid stop (closing)
8. Lid stop (opening)
9. Adjusting screw, lid height
10. Enclosure, lid pivot mechanism
11. Front-door pivot hinge
12. Knob for front door and lids
13. Lockable latch for front door and lids
14. Shield to table fasteners
15. Low carbon steel support stand
16. Leveling foot (3" square) allows 6" vertical adj
17. Model DS-30, dewar stand (optional extra)

Accessories for HPLBS1 and HPLBS1F

DS30 Dewar Leveling Stand

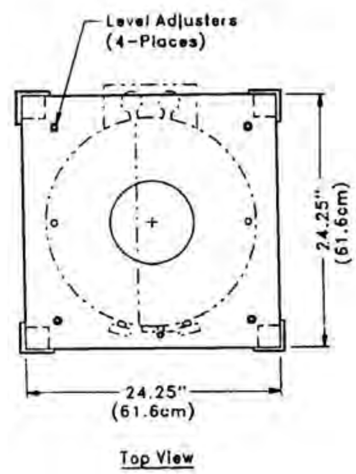
Provides up to 15 cm (6 in.) of vertical height adjustment; features vibration isolation pads to minimize detector microphonics.

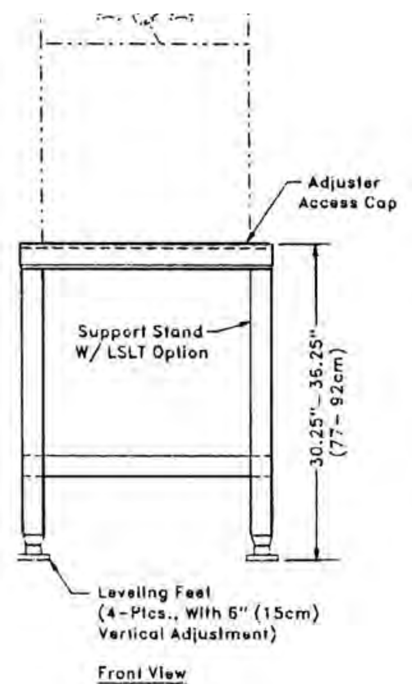




LSLT Table-Top Leveling Option

LSLT allows extremely precise adjustment of the leveling of the HPLBS1 Shield. Leveling is performed at table top height using a single hex-key wrench. It can compensate for floor deviations as great as 16 mm in a 61-cm square (5/8 in. in a 24-in. square). When correctly adjusted, the Model LSLT allows the biparting lids of the shield (when unlatched) to swing slowly and gently to the fully open position, and stay there allowing full SAFE access to the counting chamber.





Specifications subject to change
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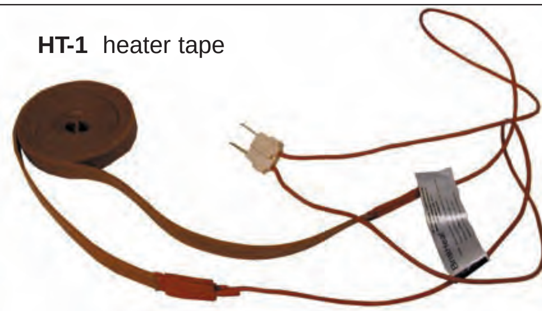
Photon Detector Accessories

469 For use of ORTEC detectors with other manufacturer's HV supplies equipped with shutdown circuitry with HV-on in open circuit condition and HV-off in short circuit condition.

HT-1 heater tape

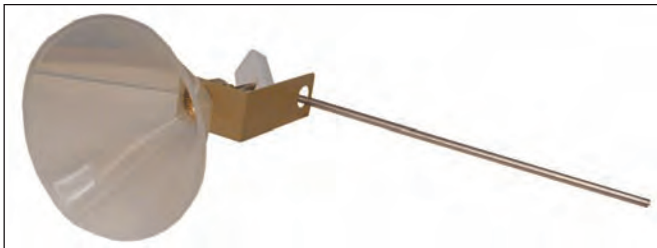


4-in. Cooling Rod Extension; used on dipstick detectors. Includes indium foil gasket.

CRE-1 for 1.25" dia.

CRE-2 for 1.5" dia.

STD-1 220V/110V step down transformer.



Fill Funnel for filling portable dewars are provided with portable detector systems with different length fill tubes according to the dewar size.

596A temperature controller for internal heating elements inside special cryostats.

810292 or "Sieve Pill" pumping agent for the PopTop vacuum interface.

SENSADPTR needed to connect a vent line to the multi-orientation (MOD) dewars.

496 used to control the temperature of heater tapes. **496-1** includes the 496 and HT-1. **496-2** includes the 496, HT-1, and STD-1.

PFB-MOD3L and **PFB-MOD7L** pressure fill adapters for the respective sized multi-orientation dewars.

B/PFA-1.2, **3.0**, **5.0**, or **HF** used to pressure fill portable dewars with respective volumes.

Photon Detector Accessories

NTC/30 (pictured) used for pressure filling the 30L bucket style dewar. Models **NTC/7.5B**, **NTC/13**, and **NTC/15B** are for respective dewar sizes.

TL-3, **6**, **9**, **12**, **15**, **18**, **21**, and **24** liquid nitrogen transfer lines supplied in respective lengths (ft.)

VL-6, **9**, **12**, **15**, **18**, **21**, **24**, and **30** vent lines for liquid nitrogen filling supplied in respective lengths (ft.)

PTPA is one of two items needed to adapt the model VVO-2 to access the vacuum in PopTop capsules.

PTVSO is one of two items needed to adapt the model VVO-2 to access the vacuum in PopTop capsules.

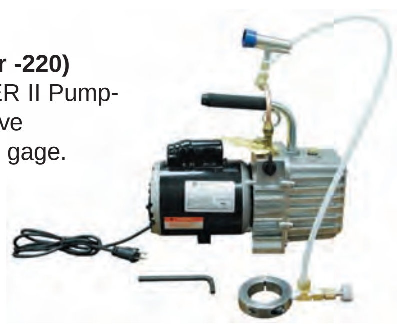
VVO-1 adapts the VVO-2 to access the vacuum in Non-PopTop cryostats.

VVO-2 vacuum valve operator and the ORTEC tooling for any ORTEC vacuum connection. (May require adapters.)

X-COOL-STAND

EC-III-RACKMOUNT or **X-COOL-RACKMOUNT** made with slightly different bolt circle sizes.

X-COOL-PK-115 (or -220)
Complete X-COOLER II Pump-Out Kit including valve operator, pump, and gage.



Photon Detector Accessories

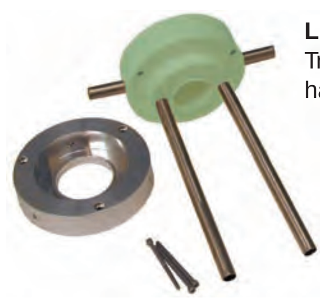
LNP-30D-2 Probe for use with 729A; used on dipstick cryostat CFG-PH-2, CFG-PH4, or large diameter CFG-PV4. Center hole diameter is 1.5 in.
LNP-30D-3 Probe for use with 729A; used on all dipstick cryostats except CFG-PH-2, CFG-PH4, or large diameter CFG-PV4. Center hole diameter is 1.25 in.

LNP-7D Probe for use with 729A; fits standard 7.5-liter and 13 liter bucket (SL, PS, PS4) type dewars. **LNP-30B** is longer with a slightly different lid.

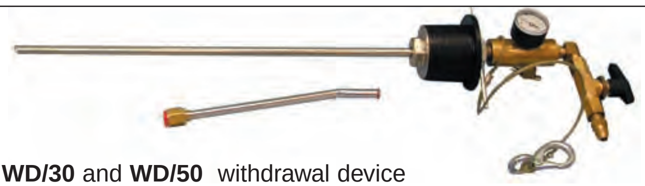
LNTC1.25 1.25” Liquid Nitrogen Transfer Collar.

LNTC1.5 1.5” Liquid Nitrogen Transfer Collar.

LNTC1.25WH 1.25” Liquid Nitrogen Transfer Collar with mounting hardware.



LNTC1.5WH 1.5” Liquid Nitrogen Transfer Collar with mounting hardware.



WD/30 and **WD/50** withdrawal device supplied in respective dewar size.

Clamp for Vertical "Dipstick" Cryostat

803586 for 1.25" ID

803908 for 1.5" ID

ISO-CART
Mobile Shielded Waste Assay System

ORTEC®

729A

Liquid Nitrogen Level Monitor

Liquid Nitrogen Level Monitor (Model 729A)

- **Prevents loss of data**
- **Avoids thermal cycling of older HPGe detectors**
- **For HPGe coaxial, LEPS, and Si(Li) systems**
- **Sounds alarm when liquid nitrogen level is low**
- **Available with a variety of thermistor probes**
- **Battery backup**
- **Totally fail-safe**

The ORTEC Model 729A Liquid Nitrogen Level Monitor is a single-width module (NIM-standard) designed to serve as an accessory on HPGe coaxial (GEM and GMX), LEPS, Si(Li), and old Ge(Li) detectors in the field.

There are two uses for the 729A: (1) for customers whose applications will not tolerate detector warmup, (e.g., unacceptable loss of experimental data); (2) guarding against thermal cycling older HPGe detectors.

When used with the appropriate probe, the monitor will sound an alarm long before the detector can warm up as a result of loss of liquid nitrogen in the dewar. The level of liquid nitrogen is sensed by a thermistor probe in the dewar. When the liquid nitrogen falls below a safe level (approximately 1/4 of the dewar capacity), an alarm sounds and a red light on the front panel of the control module flashes a warning.

The module is totally fail-safe with a battery backup in case of power failure and an audible, flashing alarm that sounds if: (1) bin power is shut off, (2) the sensor is broken, (3) the sensor is disconnected, or (4) an attempt is made to remove the module from the bin.

Impedance considerations do not permit using the detector's internal, high-voltage shutdown and the Model 729A together. A 3.66 m (12 ft) BNC coaxial cable for connecting the probe to the Model 729A is included.

Specifications

CONTROLS

TEST/NORM-OPER/HV DISABLED Front-panel toggle switch permits normal operation when set at its center position. The switch can be set at Test to check for response of the warning indications and is spring loaded to return to the Norm-Oper position. The switch can be set at HV Disabled to provide the interlock output signal that clamps the Model 659 output at zero; this setting does not affect the alarm circuit.

BALANCE ADJ Rear-panel screwdriver control adjusts the sensitivity level of the sensor and bridge circuit to determine the alarm threshold. When ordered as an integral part of a detector system, this is preset at the factory.

SHIP/USE Internal slide switch accessible through the side panel. Set at Ship, the alarm circuit is not activated unless power is applied to the module. Set at Use, with no probe connected, the alarm circuit is activated as intended when power is applied to the module, providing the internal batteries are not removed. The alarm is also activated when power is not furnished from the bin to the module.

INPUT

SENSOR Rear-panel BNC connector accepts the cable from the sensing element.

OUTPUTS

INTERLOCK OUTPUT Rear-panel BNC connector for cable to the Remote Shutdown connector on the detector bias supply module such as the ORTEC Model 659. Clamps high-voltage power supply output to zero when alarm condition is present or when front-panel switch is set at HV Disabled.

AUDIO ALARM Warning buzzer mounted at the center of the front panel sounds when the alarm circuit is activated.

ALARM HV DISABLED Flashing red light on front panel indicates that the alarm circuit is activated.

HV ENABLE Red monitor light on front panel indicates that the signal through the interlock output permits operation of the Model 659 Detector Bias Supply.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +12 V, 100 mA; + 24 V, 20 mA, –24 V, 20 mA. (Furnished from NIM-standard bin and power supply.)

Two internal nickel-cadmium rechargeable battery cells provide battery backup against power failure; the Model 729A is normally furnished with the cells installed unless otherwise indicated.

WEIGHT
Net 1.4 kg (3.1 lb).
Shipping 3 kg (7 lb).

DIMENSIONS NIM-standard single-width module 3.43 X 22.13 cm (1.35 X 8.714-in. front panel) per DOE/ER-0457T.

INCLUDED ACCESSORIES

A 3.66 m (12 ft) BNC coaxial cable for connecting the probe to the Model 729A is included.

Ordering Information

To order, specify Model 729A, Liquid Nitrogen Level Monitor.

SEPARATE ACCESSORIES

PROBES: The appropriate probe for the particular cryostat/dewar combination must be ordered separately.

C-24-12 CABLE: RG-62A/U 93-Ω Cable with two BNC male plugs; 12-ft. length

Custom built probes and different length cable available on special request.

LNP-30D-2 Probe for use with 729A; used on dipstick cryostat CFG-PH-2 or CFG-PH4 only. Center hole diameter is 1.5 in.
LNP-30D-3 Probe for use with 729A; used on all dipstick cryostats except CFG-PH-2 or CFG-PH4. Center hole diameter is 1.25 in.

LNP-7D Probe for use with 729A; fits standard 7.5-liter and 13 liter bucket (SL, PS, PS4) type dewars. **LNP-30B** is longer with a slightly different lid.

Specifications subject to change
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905 Series
NaI(Tl) Scintillation Detectors

A gamma ray interacting with a scintillator produces a pulse of light that is converted to an electric pulse by a photomultiplier tube (PMT). The PMT consists of a photocathode, a focusing electrode, and 10 or more dynodes that multiply the number of electrons striking at each dynode. A chain of resistors typically located in a plug-in tube base assembly biases the anode and dynodes. Complete assemblies including the scintillator and PMT are available.

The properties of a scintillation material required to produce a good detector are transparency, availability in large size, and large light output proportional to gamma-ray energy. Few materials have good properties for detectors. Thallium-activated sodium iodide [NaI(Tl)] and cesium iodide [CsI(Tl)] crystals are commonly used, as well as a wide variety of plastics. CsI(Tl) and plastics have much faster light decay times than NaI(Tl) and are primarily used for timing applications.

The high Z of iodine in NaI(Tl) crystals result in high efficiency for gamma-ray detection. Resolution for a 3-inch diameter by 3-inch length crystal is typically about 7% for ^{137}Cs and slightly worse for larger sizes. The light decay time constant for a NaI(Tl) crystal is about 0.23 µs. Typical charge-sensitive preamplifiers translate this into an output voltage pulse with a rise-time of about 0.5 µs. Fast coincidence measurements cannot achieve the very short resolving times that are possible for plastic scintillators, especially at low gamma-ray energies.

The Model 905 Series offers various sizes of Nal(TI) detectors. These detectors are assembled and supplied to ORTEC by several companies that specialize in the manufacture of Nal(TI) detectors.

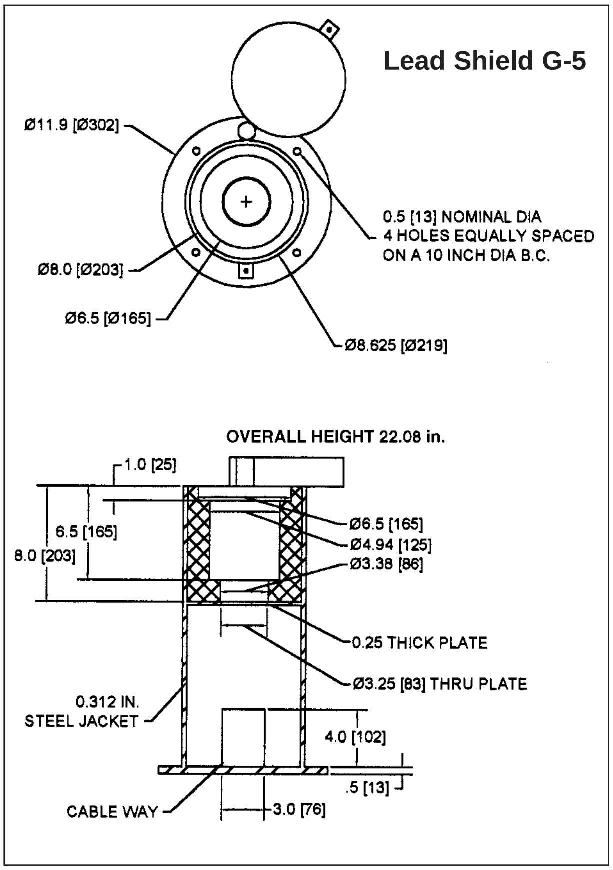
Typical efficiencies given as a percentage for a 1-µCi ^{137}Cs source centered at a distance of 10-cm:

905-1 (1” x 1”): 0.17 @0.5 MeV and 0.09 @2.0 MeV

905-3 (2” x 2”): 0.75 @0.5 MeV and 0.45 @2.0 MeV

905-4 (3” x 3”): 2.00 @0.5 MeV and 1.30 @2.0 MeV

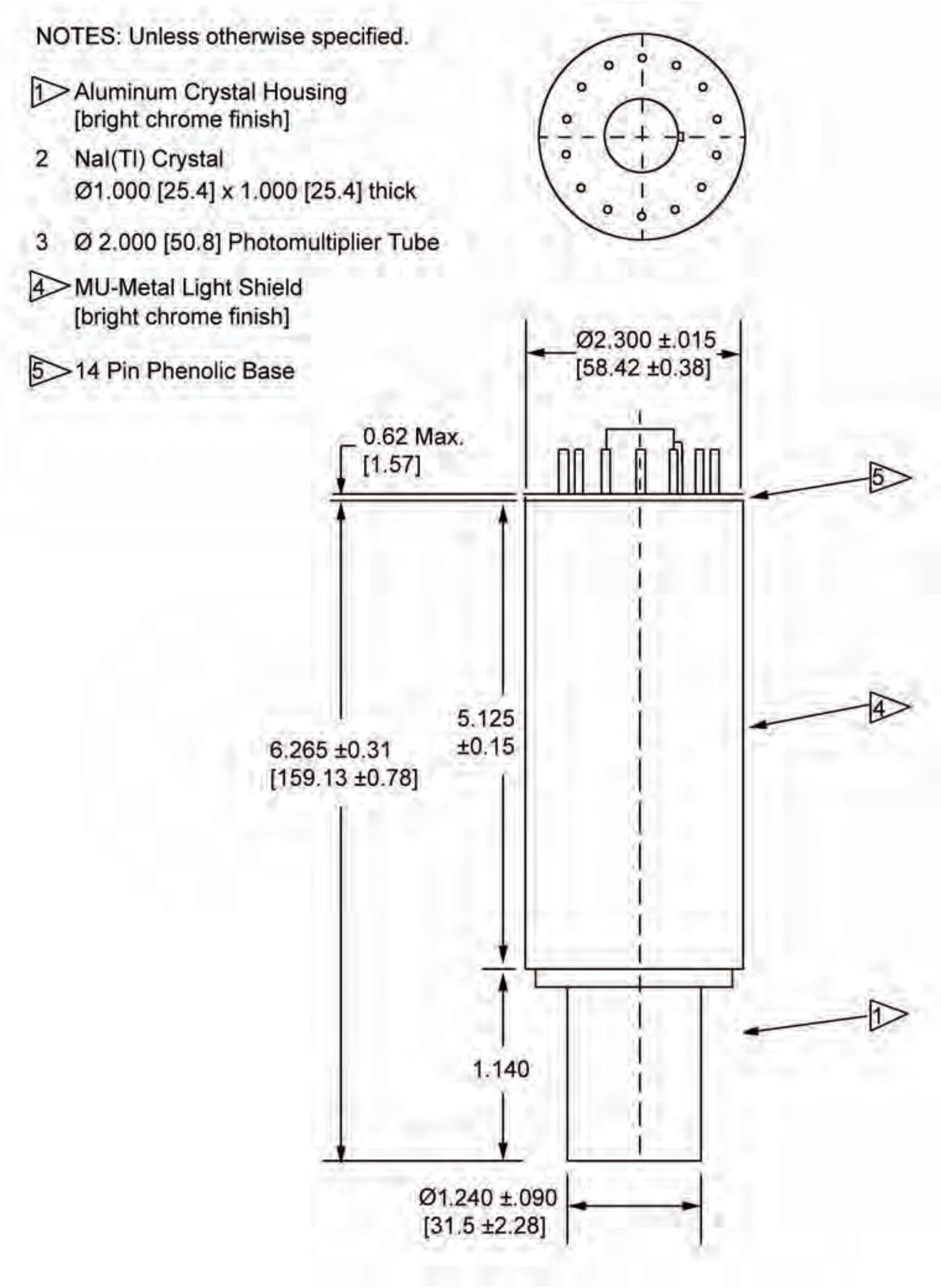
NOTE: Special sizes and configurations such as Wells, Thin-Window X-Ray, Thyroid Counters, and Large Slabs are available on special order.



Ordering Information

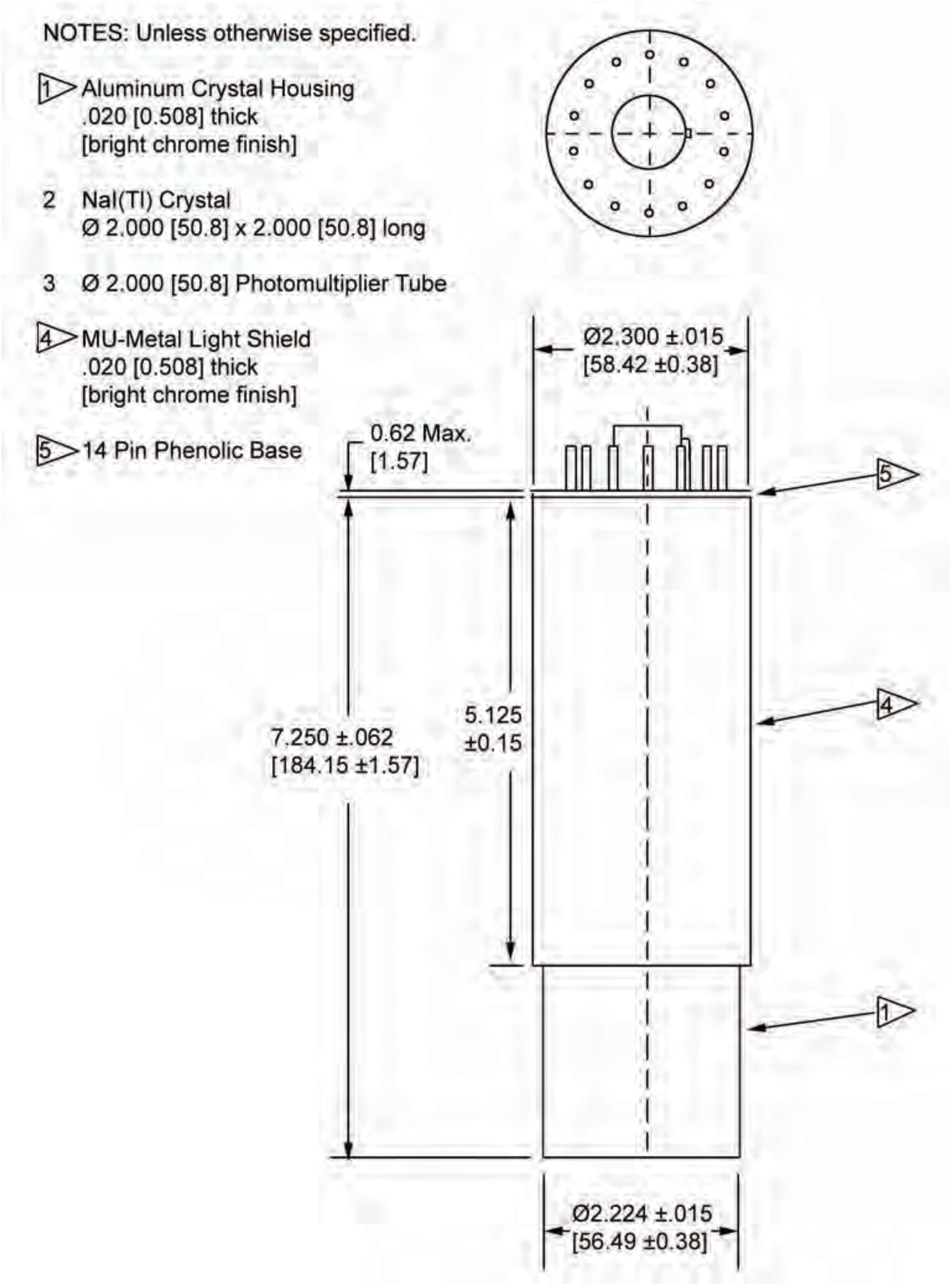
Model	Description
905-1	NaI Scintillation Detector, 1- x 1-in. crystal, 2-in. PMT
905-3	NaI Scintillation Detector, 2- x 2-in. crystal, 2-in. PMT
905-4	NaI Scintillation Detector, 3- x 3-in. crystal, 3-in. PMT
Lead Shield G-5	Table top lead shield with cable-way. A clamp mechanism is provided to hold the Detector/PMT assembly in place with room for any of the ORTEC PMT bases to be coupled to the PMT (see drawing). Shipping weight: 300 lbs.

905-1 NaI Scintillation Detector, 1- x 1-in. crystal, 2-in. tube



NOTE: Dimensions are subject to slight variation depending on the original manufacturer.

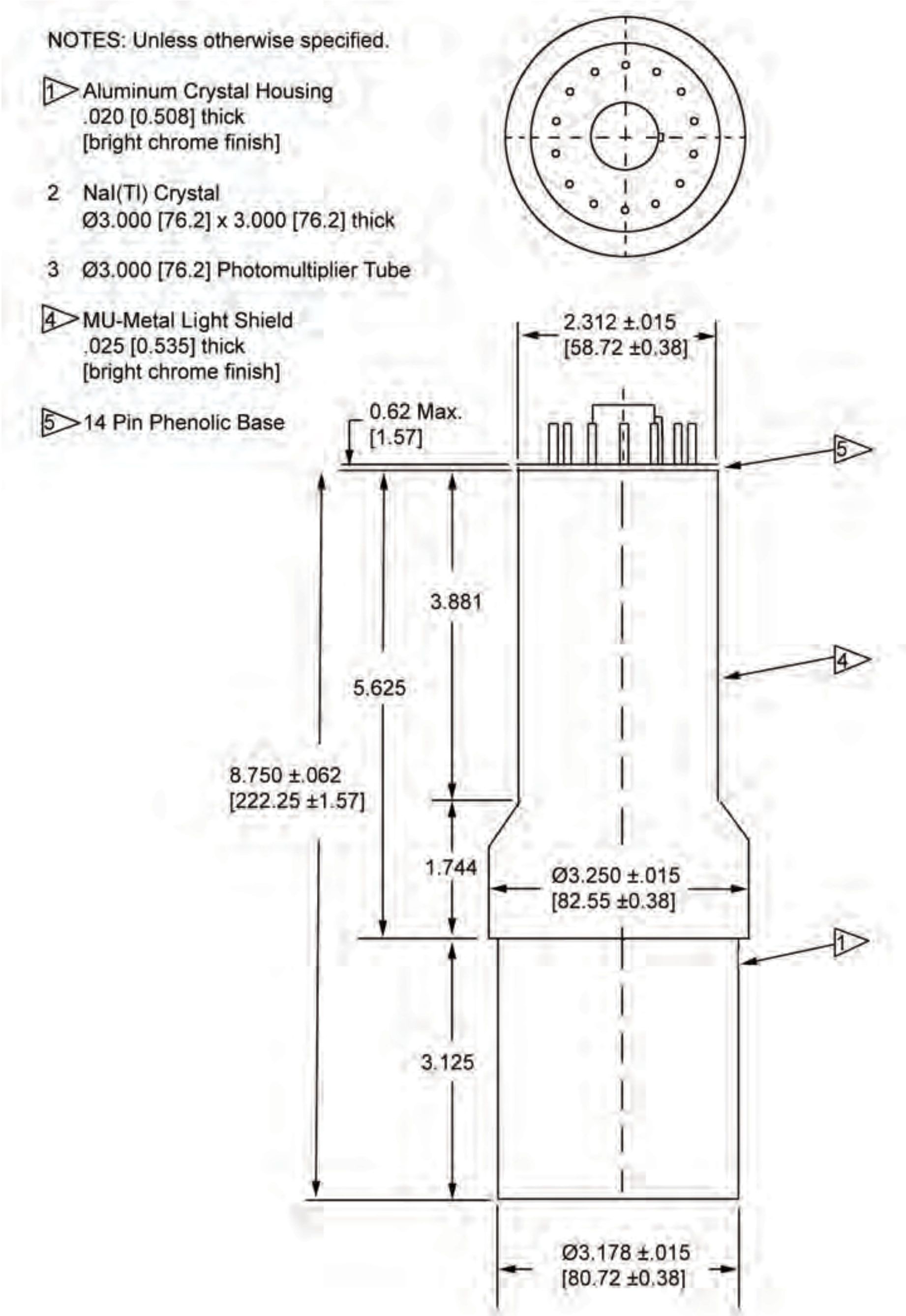
905-3 NaI Scintillation Detector, 2- x 2-in. crystal, 2-in. tube



NOTE: Dimensions are subject to slight variation depending on the original manufacturer.

905 Series
NaI(Tl) Scintillation Detectors

905-4 NaI Scintillation Detector, 3- x 3-in. crystal, 3-in. tube



NOTE: Dimensions are subject to slight variation depending on the original manufacturer.

Specifications subject to change
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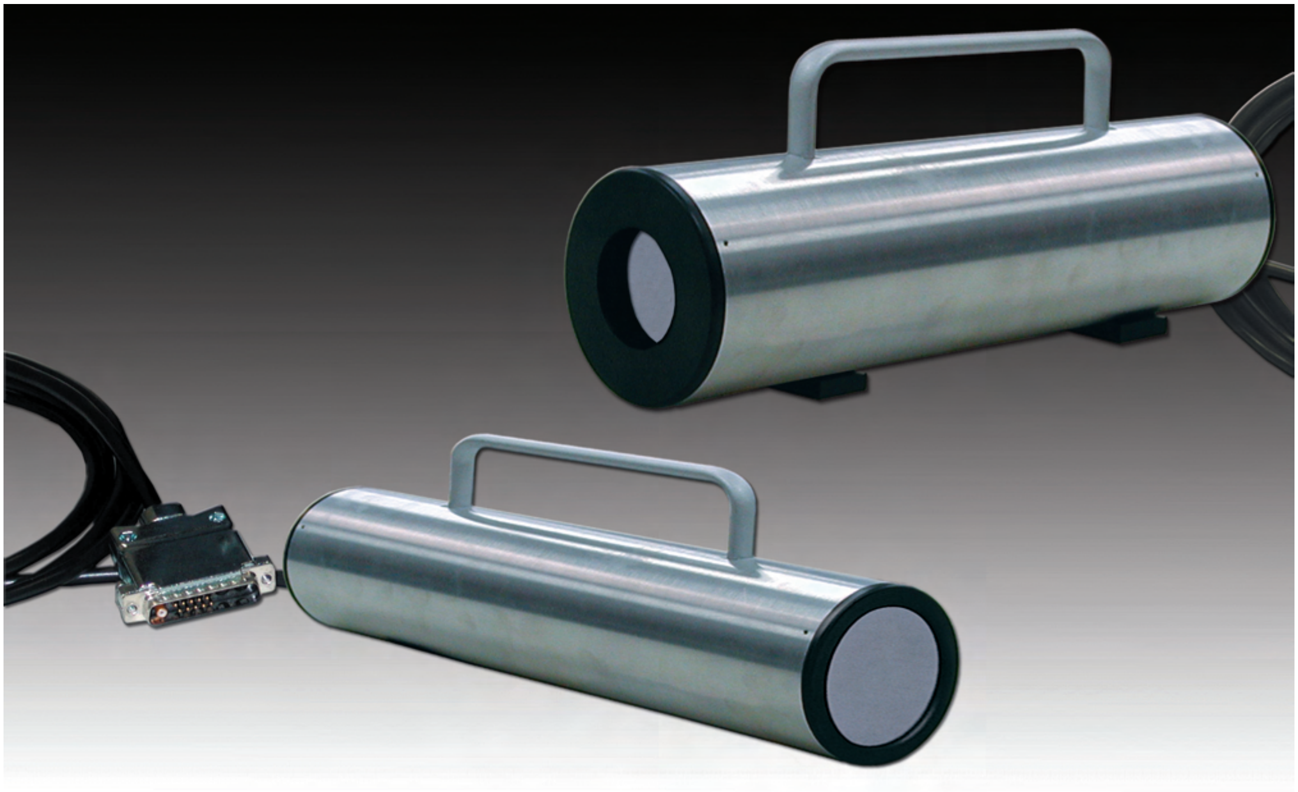
2BY2/2BY2-DD
3BY3/3BY3-DD
Integral NaI(Tl) Detector

Complete Rugged NaI Detector Probes for In-Field Gamma Spectroscopy Measurements



- Rugged integrated NaI detectors in tough aluminum housing — available in 2" x 2" and 3" x 3" sizes.
- Integral preamplifier and high voltage (HV) for convenience and safety.
- Low power consumption (240 mW), ideal for portable applications.
- Single-cable connections for most applications.
- 2BY2-DD and 3BY3-DD available for use with ORTEC digiDART and digiDART-LF.

Everything You Need in One Compact Package

2BY2 or 3BY3 is a complete NaI(Tl) probe, ready to go to work in your application. Each models contains a NaI(Tl) crystal (2" x 2" or 3" x 3") with photomultiplier tube (PMT) and a PMT base with integral preamplifier and HV supply securely encased in a compact aluminum housing.

Ultra Low Power; the End of Bulky, External, HV Supplies

The model 296 ScintiPack™ PMT base includes a low-power, adjustable high-voltage supply, an active bias network, and a charge-sensing preamplifier. Incorporating the bias supply in the PMT base eliminates high voltage cable connections to bulky, external, HV supplies. The ACTIVE bias network permits high-rate operation with minimal peak shift. ScintiPack's ultra-low power consumption (240 mW) makes it attractive for portable applications.

Single-Cable Operation

A single cable supplies power to the preamplifier and the HV supply as well as the signal out of the preamplifier. For the "-DD" versions, the connection is direct to the digiDART or digiDART-LF (also other ORTEC DSP spectrometers). An optional break-out cable can be used with the model 2BY2 or 3BY3 should you want the signal on a BNC output connector.

2BY2/2BY2-DD
3BY3/3BY3-DD
Integral NaI(Tl) Detector

Electrical and Mechanical

Power Required

2BY2 or 3BY3 +12 V at 20 mA. Supplied via a captive power cord terminated in a standard preamplifier power plug (9-pin D connector). Power cord length is nominally 3 m or 10 ft. The preamplifier power plug is compatible with standard preamplifier power connectors provided on most nuclear spectroscopy amplifiers. The preamplifier output signal is delivered on pin-3 of the connector. An optional signal break-out adapter is available for extracting the preamplifier output signal at the power connector.

2BY22-DD or 3BY3-DD Power is provided by the digiDART or digiDART-LF.

Net Weight

2BY2 or 2BY2-DD 2.5 kg (5.5 lb)

3BY3 or 3BY3-DD 4 kg (8.8 lb)

Shipping Weight

2BY2 or 2BY2-DD 4.6 kg (10 lb)

3BY3 or 3BY3-DD 4.6 kg (10 lb)

Dimensions

2BY2 and 2BY2-DD 35.5 cm (14 in.) long x 7.62 cm(3 in.) diameter

3BY3 and 3BY3-DD 38.9 cm (15.3 in.) long x 10.2 cm (4 in.) diameter

Optional Accessories

296-ADAPT Signal Break-Out Adapter Connects to the end of the power cable of the 2BY2 or 3BY3 and separates the preamplifier signal cable from the preamplifier power cable. The adapter 9-pin D connector plugs into the standard preamplifier power connector on the rear of most spectroscopy amplifiers. The 60 cm preamplifier signal cable from the adapter terminates in a male BNC connector for connection to the input of a spectroscopy amplifier.

C-24-12 93 Ω, Coaxial Cable connects the preamplifier output to an amplifier input.

Ordering Information

Model	Description
2BY2	Integrated 2" x 2" NaI(Tl) Detector
3BY3	Integrated 3" x 3" NaI(Tl) Detector
296-ADAPT	Signal Break-Out Adapter. For use with 2BY2 or 3BY3.
C-24-12	RG62A/U, 93 Ω cable with two BNC male plugs; 12-ft. length. For use with 2BY2 or 3BY3.
2BY2-DD	Integrated 2" x 2" NaI(Tl) Detector for use with digiDART or digiDART-LF.
3BY3-DD	Integrated 3" x 3" NaI(Tl) Detector for use with digiDART or digiDART-LF

Specifications subject to change
090309

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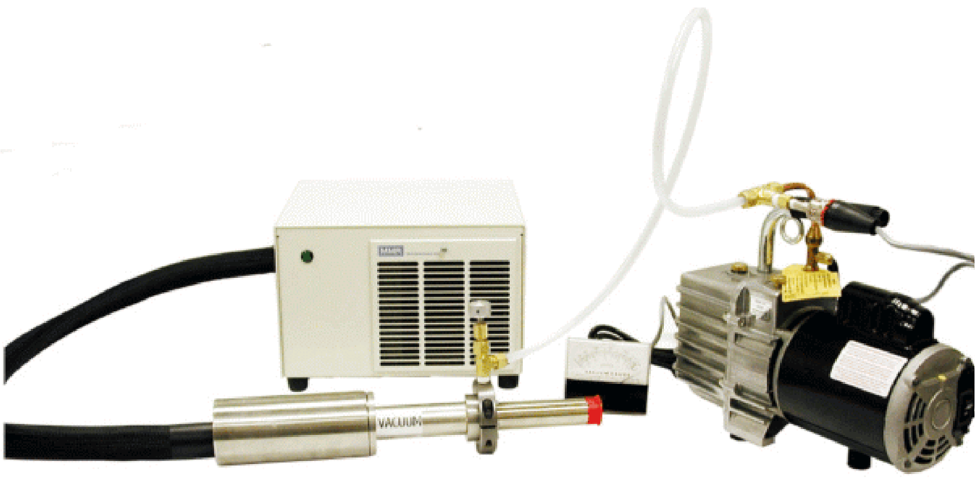
AMETEK®
ADVANCED MEASUREMENT TECHNOLOGY

VACUUM PUMPING PROCEDURE for the
X-COOLER HEAT EXCHANGER/CRYOSTAT

I. Introduction

The X-Cooler's cryostat-heat exchanger uses molecular sieve to maintain their internal vacuum for proper thermal transfer. Molecular sieve by design has tremendous capacity to pump gases. After a period of several months, due to permeation and out gassing, these gases may accumulate in such volume to prevent proper thermal transfer. This condition may be evident by moisture accumulation on the heat exchanger-cryostat and/or decreased cooling capacity. In such cases it may become necessary to vacuum pump the exchanger-cryostat.



X-Cooler and vacuum pumping system

Evacuation of the cryostat should only be performed by qualified field service personnel. This procedure outlines the proper procedure and equipment that must be used.

***Note: It is not necessary to remove the detector capsule from the cryostat for this procedure**

II. Equipment:

Complete X-Cooler Pump-out Kit contains: Pump-out Valve Operator, Vacuum Pump and Gage:

·**110V/60Hz Model part number:** X-Cool-PK-110

·or

·**220V/50Hz Model part number;** X-Cool-PK-220

If you have a suitable vacuum pump then you will only need the Pump-out Valve Operator.

- **"Pump-out valve operator" part number:** X-Cool-PK-ADPT

(Includes valve operator, clamp and 2ea socket head screws)

III. Pumping The Cryostat

Preparing the pump station: The pump station should be situated where it will not be in a high traffic area or in an area where tampering could occur. The cryostat should be positioned within easy reach of the pump connection so that the minimum stress on connections is applied while pumping is achieved.

Preparing the cryostat: The detector must be completely warm prior to pumping the X-Cooler cryostat. Turn off the X-Cooler and allow at least 24 hours for the detector to warm to room temperature.

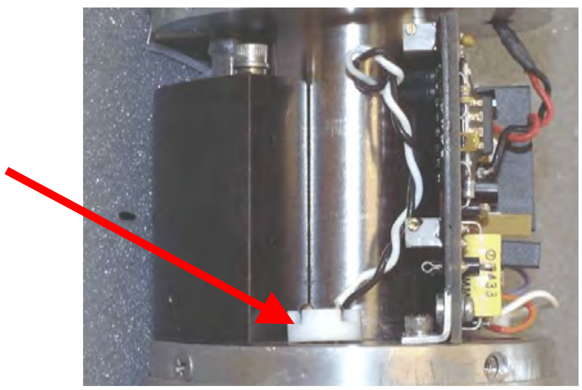
1. To determine detector temperature:

¨ To insure the detector is warm, the thermal element (T/E) must be measured.

¨Remove the shroud that covers the detector electronics by removing the phillips head screws.

¨ Slide the shroud toward the end of the capsule to allow for full access to the detector electronics.

Find the white Teflon feedthrough connection next to the HV Filter.

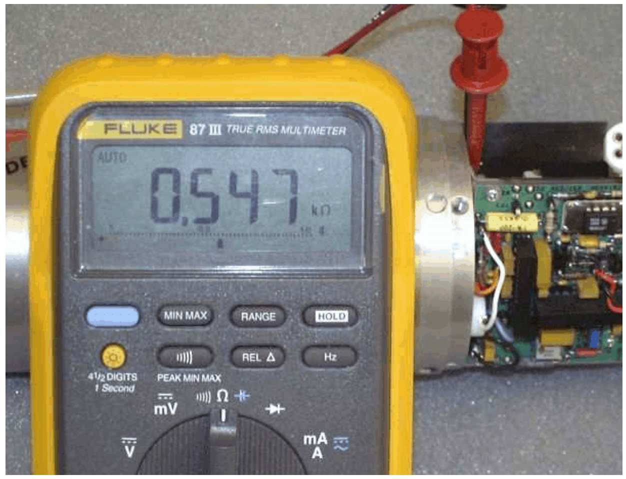


¨*Note connector orientation for reconnection. The black and white wires connect to the internal temperature element.

Carefully remove the Teflon connection from the T/E pins. The T/E pins are in a glass mount. If excessive force is used when removing the Teflon connection the pins can bend possibly causing a vacuum leak. Pull the Teflon connection straight off from the pins with NO side motion. The connection should come off with minimal effort.

- Connect an ohmmeter to the two pins, which correspond to the black and white wires.

- The resistance measurement for a warm detector should be greater than 535 Ohms.



- The measurement shown above is typical of a detector at a room temperature of 75^{O}F (24^{O}C).

- **Note:** If the T/E is less than 535 ohms, allow additional time for the detector to warm until the proper reading is achieved.

2. Connecting the pumpout adapter:

- Locate the pumpout port on the heat exchanger's cryostat. It has a small brass vacuum plug. If you are not certain please contact the ORTEC Customer Service department for assistance.

3. Attach the pumpout valve operator to the cryostat:

- Remove the 2 allen screws (1/4”) from the two halves of the Pump-out valve clamp.
- Using the operator’s knurled knob engage the threads in the brass vacuum plug by rotating the valve shaft CW, as in the figure.

- Now tighten the 2 allen screws proportionally to maintain an equal gap on both sides of the clamp. <u>Do not over tighten</u>, use only enough force to compress the o-ring.

Note equal gap on both sides of clamp.

Note uneven gap on both sides of clamp.

- Ensure the compression nut is finger tight to seal the Pump-out Valve Operator.

*Never pull the handle out unless it is positive that the shaft is not connected to the vacuum plug or that the vacuum pump is running and a vacuum has been established. Doing so would vent the cryostat to room air, which could contaminate the internal surfaces.

- **Starting the vacuum pump and placing the cryostat under vacuum** Energize the pump and wait for the system to stabilize to a pressure of at least 10^{-3} Torr. Then pull the Pump-out Valve Operator handle out until the handle stops to open the vacuum plug. To ensure the vacuum plug does not reseat during pumping prop open the valve handle. (A piece of Tygon tubing can be split down the side and slipped around the handle shaft.)
- **Allow the cryostat to remain on the pump for a minimum of 30 minutes.**

6. Removing the cryostat from the vacuum after vacuum restoration:

- Push the Valve Operator handle in until it stops, indicating proper vacuum plug seating. The handle should be almost flush with the compression nut.

- Unscrew the Valve Operator handle from the vacuum plug. To insure the successful disconnection of the Valve Operator handle from the vacuum plug, continue to unscrew the Valve Operator handle with slight inward pressure until the threads can be felt "popping' against each other. One pop for one full rotation after threads are fully disconnected.

- De-energize the pump to allow for venting.

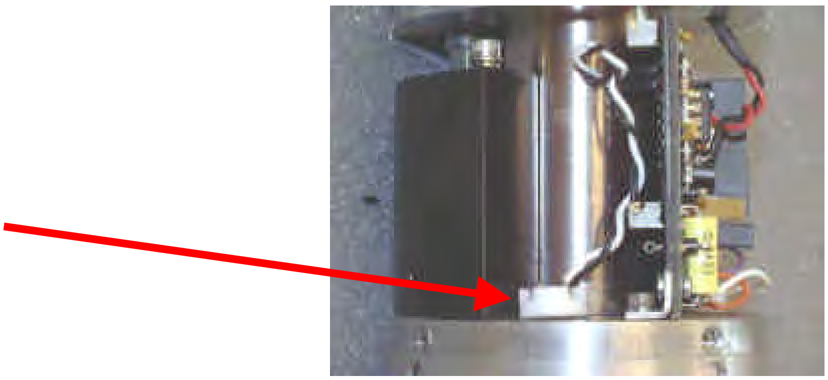
*Never pull the handle out unless it is positive that the shaft is not connected to the vacuum plug or that the vacuum pump is running and a vacuum has been established. Doing so would vent the cryostat to room air, which could contaminate the internal surfaces.

- Remove the pumpout adapter.
- The compressor should sit for two hours after being moved this allows any oil to settle. The X-Cooler is now ready to be started and cool the detector.
- Monitor the X-Cooler cool down by observing the temperature change of the T/E.
- The X-Cooler may take up to 24 hours to cool.
- Nominal T/E reading of a cold detector is approximately 155 Ohms.
- The Bias Shutdown circuit is set at 196 Ohms, therefore the T/E must read less then 196 Ohms.

- If the T/E reading is not less than 196 Ohms at the end of the 24-hour cool down period, a mechanical fault is present. Contact the ORTEC Customer Service department for further assistance.
- When finished monitoring the detector cool down, disconnect the ohmmeter.

7. Reinstalling the shroud:

- Reconnect the T/E Teflon connector. The Teflon connector is flat on one edge, this allows it to fit closely to the HV Filter. Verify proper placement of the Teflon connector.



- Slide the shroud up over the electronics.

- Locate the HV Filter Ground Wire and place it into the grove in the shroud clamp.

- Line up the screw holes in the shroud, detector capsule and shroud clamp.
- Install screws in the shroud clamp first. This makes installation of screws in the detector capsule easier.

ORTEC®

X-COOLER™ II

The Next Generation in HPGe Detector Cooling Technology

More Powerful than Ever!

Replace Liquid Nitrogen with the X-COOLER II

- More Powerful than Ever
- No Limit to Detector Size
- For HPGe Detectors within a Wide Range of Gamma Spectroscopy Applications
- Compatible with All ORTEC HPGe Detector Types
- Lightweight and Compact Design
- Low Power Operation (less than 400 W)
- Field Replaceable: Retrofits to Existing Detectors and is Easily Maintained
- Cool HPGe Detectors Anywhere There's Electricity!
- No Dewar Filling Operations
- No LN_2 Safety Hazard
- No Bulky Storage Tanks or Unwieldy Plumbing Systems
- A Truly Economical Alternative to Liquid Nitrogen

X-COOLER™ II ORTEC®

*….Available Exclusively from **ORTEC***

Now There is No Limit to the Size of Detector that can be Cooled by Mechanical Cooling. . .

There is virtually no limit to the HPGe laboratory applications that can be optimized by mechanical cooling with the X-COOLER II. This exciting product extends the capability of mechanical cooling to any size detector!

That's right. . . any size detector!

The use of LN_2 has truly become a thing of the past!

. . . and you'll save money, time, and operating costs!

The annual cost of running an X-COOLER II can actually be less than that of an LN_2-cooled detector.

A Variety of Detector Options

X-COOLER II is designed to work with any ORTEC detector available in PopTop configurations. Degradation of resolution performance is guaranteed to be less than 10% for energies less than 500 keV, and no degradation will be observed above 500 keV.

Light on Cost, Weight and Size!

X-COOLER II is not only inexpensive to purchase and operate, but it is smaller and lighter than other devices of this type. The compact design boasts a footprint of less than one square foot (or 930 cm^2), stands 11" (28 cm) tall, and weighs less than 36 pounds (16.4 kg). This compares very favorably to the previous generation of mechanical coolers.

Field Replaceable

Reliability and ease of service are essential to any mechanical cooling system for HPGe detectors. X-COOLER II systems employ the ORTEC patented[1] PopTop™ detector capsule technology. While the design life of the X-COOLER II is greater than five years, there is always the possibility of failure of any mechanical system. Because of the unique PopTop design of ORTEC detectors, an X-COOLER II can be replaced in the field, without special tools or procedures. After the detector has returned to room temperature, a new X-COOLER II can be installed in less than 10 minutes. The detector does not have to be returned to the factory to replace a faulty mechanical cooling system.

Retrofittable

The X-COOLER II can be retrofit in the field to existing PopTop detectors. Simply warm the existing detector, unscrew the capsule from the LN_2 cryostat, and couple onto the X-COOLER II.

You'll be up and running in no time!

Proven Technology

Traditional mechanical coolers fail because oil from the compressor mixes with the refrigerant, migrating to the heat exchanger and clogging it, thus causing the detector to warm up. The X-COOLER II's patented design cleans the oil out of the refrigerant continuously. Similar coolers using this design have logged over 38,000 hours (more than 4-1/4 years) of operation without failure... and still going.

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[1] U.S. Patent No. 4,851,684

Specifications

Resolution: Coaxial detector specifications are warranted to *no* degradation above 500 keV and less than 10% degradation of the warranted and published LN_2 specifications at less than 500 keV. Planar detector specifications are warranted to no degradation above 500 keV and less than 20% degradation of the warranted and published LN_2 specifications at less than 500 keV.

Mechanical:

Dimensions:

Compressor: 12.5" W x 12.5" D x 11" H
(31.8 cm x 31.8 cm x 28 cm)

Cold Head Length with Detector Capsule attached:
Standard: 23.25" (59 cm)
Oversize: 24.5" (62.3 cm)
Ultra: 25.5" (64.8 cm)

Weight:

Compressor: 36 lbs. (16.4 kg).
Cold Head: 11 lbs. (5 kg) not including capsule.

Noise: Less than 70 dB at 1 meter.

Input Power: 110–120 V ac, 57–63 Hz or 220–240 V ac, 47–53 Hz (input power must be selected by choosing the appropriate model number, see ordering information).

Power Consumption: <500 W during initial cool down. <400 W during normal operation.

Connector Hose: 10 ft. gas hose connected between compressor box and cold head assembly is included. Longer lengths available on special request. Contact the factory for more information and pricing on other hoses.

Refrigerant: Mixed gas, CFC-free refrigerant. MSDS available on request.

CE Approved

Environmental

Ambient Temperature: 5–30°C (40–85°F).

Relative Humidity: 5–95% non-condensing.

Ordering Information

Model	Description
CFG-X-COOL-II-115	X-COOLER II with PopTop connector using 110–120 V ac, 60 Hz Input Power
CFG-X-COOL-II-230	X-COOLER II with PopTop connector using 220–240 V ac, 50 Hz Input Power
X-COOL-STAND	Omnidirectional Cold Head Stand (ideal when replacing 30 L dewar dipstick type cryostats)
X-COOL-RACKMOUNT	Cold Head Rackmount Bracket
CRYOSECURE	Programmable Compressor Power Controller (ensures that detector is fully warmed before commencing cooldown after power failure)
X-COOL-UPS-115	30 minute backup power system (1440 VA) for maintaining Mains power to the X-COOLER II during brief power outages. Input/Output power: 110–120 V ac, 60 Hz.
X-COOL-UPS-230	30 minute backup power system (1440 VA) for maintaining Mains power to the X-COOLER II during brief power outages. Input/Output power: 220–240 V ac, 50 Hz.
X-COOL-PK-115	Complete X-COOLER II Pumpout Kit. Includes valve operator, pump and gauge. Requires 110–120 V ac, 60 Hz Input Power.
X-COOL-PK-220	Complete X-COOLER II Pumpout Kit. Includes valve operator, pump and gauge. Requires 220–240 V ac, 50 Hz Input Power.
X-COOL-PK-ADPT	X-COOLER II Pumpout Kit Adapter Only.
X-COOL-FILTER	Replacement filters (pkg. of 12).

Specifications subject to change
101206

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HPGe Detectors for Harsh Environments (HE)

High-Reliability Gamma Spectroscopy in Harsh Environment Conditions

- Corrosion resistant
- Impervious to moisture
- Unaffected by dust and grit
- No loss in sensitivity

Introduction

Increasingly, methods are being developed in a variety of fields in which the advantages of high resolution germanium gamma ray detectors produce great improvements to measurement quality. Increased desire for “real time” results and reduction in labor cost is driving the measurement “out of the lab and into the process”. Examples may be found in homeland security, nuclear safeguards, and in both nuclear and non nuclear “in plant” industrial processes. Developments in the field of neutron generators are creating a demand for portable and transportable assay systems based on neutron activation analysis techniques.

Germanium Detectors have historically been hyper-sensitive and hyper-fragile. . . until now.

By exploiting the benefits of new materials and carefully re-engineering the electronics portion of the HPGe detector capsule, ORTEC has achieved a step up in HPGe detector reliability and robustness, surprisingly with no loss (actually often a gain!) in sensitivity to low energy gamma rays.

The -HE Option

All ORTEC GEM and GMX series HPGe detectors in PopTop capsules of 76 mm diameter or larger can be supplied in this new format.

The -HE Option Features

- Rugged carbon fiber detector capsule endcap, corrosion resistant but with high transmission of low energy gamma-rays
- Sealed electronics housing featuring an innovative, replaceable desiccant pack which ensures that the electronics stays 100% dry and indicates when it needs to be replaced.

Ordering Information

The -HE option is available for all GEM and GMX series HPGe detectors in PopTop capsules of 76 mm diameter or larger.

To order, simply specify “-HE” at the end of the detector model number.

Example: GMX60P4-83-HE or GEM30P4-76-HE.

For an additional desiccant pack, order model HE-DP.

Specifications subject to change.
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576A
Dual Alpha Spectrometer

- **Two independent alpha-spectroscopy channels**
- **Each channel includes vacuum chamber, sample holder, detector, bias supply, preamplifier, amplifier, biased amplifier, test pulser, and discriminator**
- **Separate energy range selections for each channel: 3–5, 4–6, or 5–7 MeV and 3–7, 4–8, or 5–9 MeV**
- **Choice of either vertical or horizontal sample holder**
- **Available with ULTRA™ or Ruggedized™ detector areas of 300 mm^2, 450 mm^2, or 600 mm^2**

The Model 576A Dual Alpha Spectrometer is a self-contained, double-wide NIM module that contains two independent alpha-spectroscopy channels. Each channel includes a vacuum chamber, a choice of either a vertical or horizontal sample holder, and ORTEC ULTRA low-background, ion-implanted silicon detector or a Ruggedized low-background surface barrier detector (300-mm^2, 450-mm^2, or 600-mm^2 detectors are available), a detector bias supply, a preamplifier, a shaping and stretching amplifier, a biased amplifier, a test pulser, and a discriminator (Fig.1). The unit is factory calibrated, and no further adjustments are necessary.

By a simple jumper selection on the side panel and a front-panel energy range switch, each channel can be set so that the output range represents energies from 3 to 5, 4 to 6, or 5 to 7 MeV in the 2-MeV position; and from 3 to 7, 4 to 8, or 5 to 9 MeV in the 4-MeV position. Another simple jumper selection sets the internal pulser signal at the center of the appropriate range (Fig.2).

Together with a vacuum pump and a multichannel analyzer, the Model 576A provides a complete reliable, easy-to-operate, low-level dual alpha spectroscopy system. Eight- or sixteen-channel alpha spectroscopy systems can easily be configured by utilizing the ORTEC Model 920E 16-Input Multichannel Buffer.

The special ULTRA or Ruggedized low-background detectors supplied with each Model 576A Dual Alpha Spectrometer have been processed through the standard ORTEC quality control procedures. To eliminate the possibility of low-level alpha contamination, these detectors have not been exposed to alpha particles. Instead, alpha resolution is measured on a representative sample of detectors from each batch of ULTRA or Ruggedized low-background detectors produced to ensure that the specified alpha resolution is met. The alpha resolution and noise resolution are measured in accordance with IEEE Standard 300-1998. (Ruggedized detectors are tested at a 0.5 μs amplifier shaping time constant, ULTRA detectors at 1.0 μs).

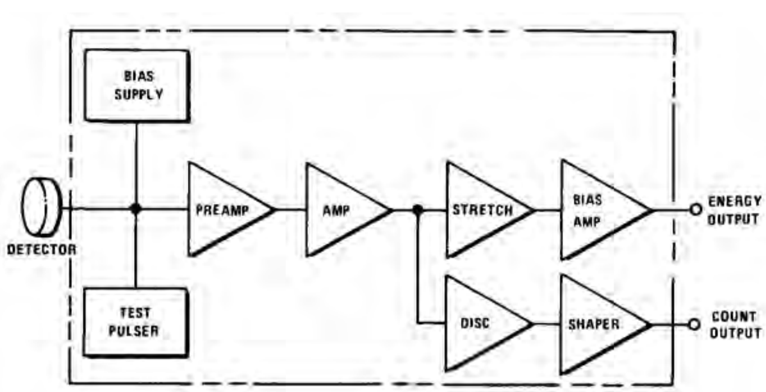


Fig. 1. Simplified Block Diagram of One Channel of the Model 576A Dual Alpha Spectrometer.

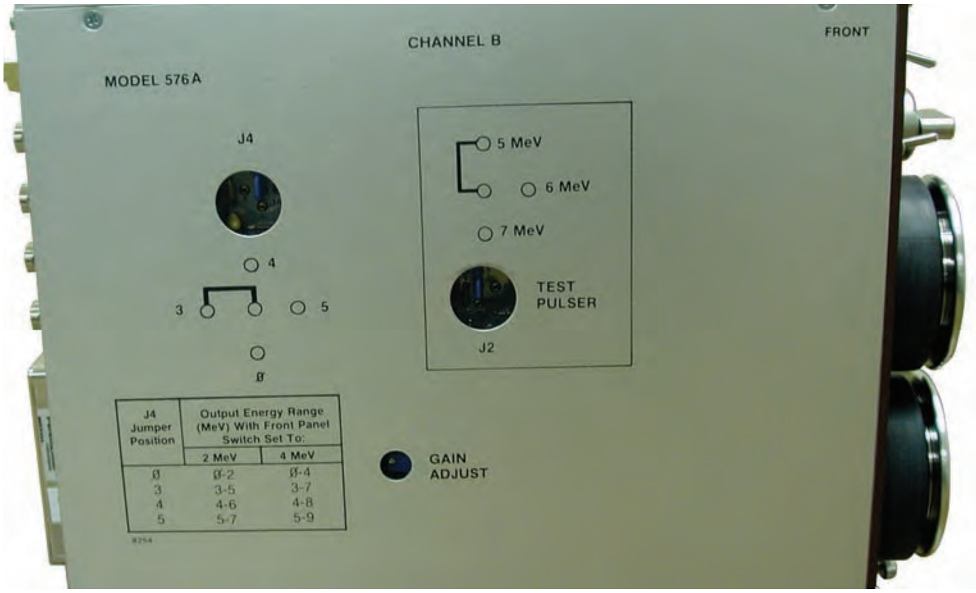


Fig. 2. Side Panel Energy Range and Test Pulser Selection.

Specifications

PERFORMANCE

SYSTEM NOISE ≤24 keV FWHM for 300- and 450-mm^2 detectors and ≤35 keV FWHM for 600-mm^2 detectors (at 22°C).

BACKGROUND† <30 counts/day above 3.0 MeV (measured from COUNT output) with 300- and 450-mm^2 active area, both R-Series and ULTRA detectors; and <40 counts/day for 600-mm^2 active area, both with R-Series and ULTRA detectors.

SAMPLE SIZE Up to 3.8 cm (1.5 in.) diameter planchets or filter paper for vertical sample holder; up to 2.54 cm (1.0 in.) diameter for horizontal sample holder.

SAMPLE SPACING Adjustable from 1 to 15 mm from detector housing for vertical sample holder. Either 1 or 5 mm from detector housing for horizontal sample holder.

ENERGY RANGES Separately selectable for each channel: 3 to 5 MeV, 3 to 7 MeV, 4 to 6 MeV, 4 to 8 MeV, 5 to 7 MeV, or 5 to 9 MeV. Limited operation from 0 to 2 MeV or 0 to 4 MeV.

NONLINEARITY <±0.1% of full-scale energy (5, 6, 7, 8, or 9 MeV as selected) in accordance with IEEE Standard No. 301-1988.

ELECTRONIC SYSTEM INSTABILITY ≤±0.15% of full-scale energy for 22°C in accordance with IEEE Standard No. 301-1988.

DETECTOR VOLTAGE SUPPLIES Fixed at 50 V to preamplifier section; polarity individually selectable on printed wiring board (PWB) for each channel. The Model 576A is shipped with the bias polarity positive when equipped with ULTRA detectors, and negative when equipped with Ruggedized detectors.

PULSER 50 ppm/°C; rate ~100 counts/s.

CONTROLS

VACUUM FACILITY Rear-panel vacuum pump connector for connection to roughing pump or vacuum manifold; Swagelok® connector for 1/4-in. O.D. tubing.

PUMP/VENT Two-position, front-panel valve control selects either the vacuum line or atmospheric pressure for both chambers.

DETECTOR VOLTAGE On/Off toggle switch with LED indicator on front panel controls power to both detector voltage supplies.

PULSER (OPERATE/TEST) Front-panel toggle switch turns on both pulsers for Test and turns off both pulsers for Operate.

RANGE Front-panel, two-position toggle switch. Allows selection of an energy span of 2 MeV or 4 MeV above biased amplifier energy level selected by PWB jumper J4.

576A

Dual Alpha Spectrometer

BIAS ENERGY LEVEL Front-panel trim potentiometers marked A and B allow adjustment of energy zero for each channel. Range of adjustment is about 100 keV.

ENERGY RANGE PWB jumpers (J4) allow selection of lower end of energy range as either 0, 3, 4, or 5 MeV. Jumpers are accessible through side panels.

TEST PULSER PWB jumpers (J2) allow selection of internal pulser energies of 5 MeV, 6 MeV, or 7 MeV. Jumpers are accessible through side panels.

GAIN PWB-mounted potentiometers accessible through the side panels for gain adjustment if exact matching of gain of multiple channels is desired.

OUTPUTS

CHANNEL A ENERGY 0.1 to 10 V positive pulses representing an energy span of 2 MeV or 4 MeV above selected biased amplifier lower level (0, 3, 4, or 5 MeV); stretched for MCA compatibility except for the 0 to 2 MeV range of operation.

CHANNEL B ENERGY Same as Channel A Energy characteristics.

CHANNEL A COUNT A positive NIM logic pulse is furnished for each alpha above 2.7 MeV; can be used for gross counting or for MCA subgroup routing.

CHANNEL B COUNT Same as Channel A Count characteristics.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +12 V, 115 mA; –12 V, 75 mA; +24 V, 165 mA; –24 V, 70 mA; 117 V ac, 60 mA.

DIMENSIONS NIM-standard double-width module 6.90 x 22.13 cm (2.70 x 8.714 in.) per DOE/ER-0457T.

WEIGHT

Net 2.4 kg (5.2 lb)
Shipping 3.3 kg (7.3 lb)

Ordering Information

Model No.	Description
576A-XXXV	576A module without Detectors; Vertical Sample Holder
576-XXXH	576A module without Detectors; Horizontal Sample Holder

When purchasing detectors separately, please indicated "for use with Model 576A Dual Alpha Spectrometer" on your purchase order, and specify the geometrical configuration desired (vertical or horizontal). Detector extraction tools are **not** supplied with this model.

with ULTRA-AS Detectors

576A-300UV	Vertical 576A module with two 300-mm^2 ULTRA-AS
576A-450UV	Vertical 576A module with two 450-mm^2 ULTRA-AS
576A-600UV	Vertical 576A module with two 600-mm^2 ULTRA-AS
576A-300UH	Horizontal 576A module with two 300-mm^2 ULTRA-AS
576A-450UH	Horizontal 576A module with two 450-mm^2 ULTRA-AS
576A-600UH	Horizontal 576A module with two 600-mm^2 ULTRA-AS

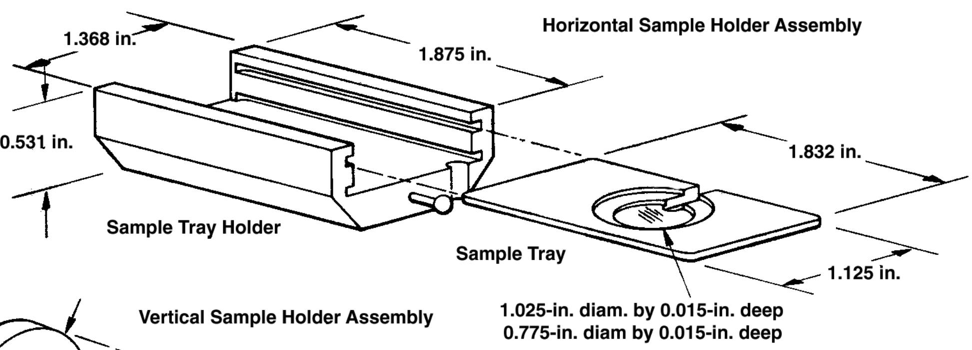
with Ruggedized Detectors

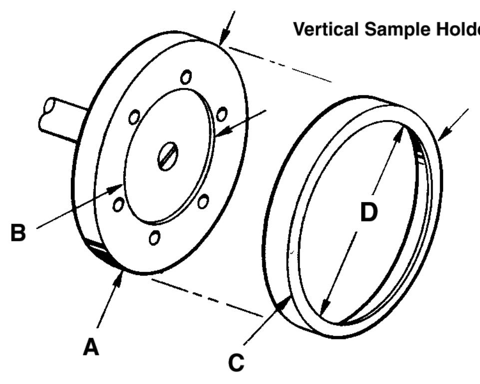
576A-300RV	Vertical 576A module with two R-Series (300 mm^2, 100 µm deep)
576A-450RV	Vertical 576A module with two R-Series (450 mm^2, 100 µm deep)
576A-600RV	Vertical 576A module with two R-Series (600 mm^2, 100 µm deep)
576A-300RH	Horizontal 576A module with two R-Series (300 mm^2, 100 µm deep)
576A-450RH	Horizontal 576A module with two R-Series (450 mm^2, 100 µm deep)
576A-600RH	Horizontal 576A module with two R-Series (600 mm^2, 100 µm deep)

- Vertical models include two 576-SHAV-K sample holder assembly kits (unless other sample holders are requested) and one 576-DETV detector extraction tool.
- Horizontal models include two 576-HTH horizontal sample tray holders, two 576-HT horizontal sample trays, and one 576-DETH detector extraction tool.

Accessories and Sample Holder Assemblies

576-DETH	Horizontal Detector Extraction Tool
576-DETV	Vertical Detector Extraction Tool
576-HTH	Horizontal Sample Tray Holder
576-HT	Horizontal Sample Tray
576-OVC	Spare O-Rings
576-SHAV-S	Customized Sample Holder
576-SHAV-K	Sample Holder Kit (includes 576-SHAV-1, 576-SHAV-2, 576-SHAV-4, and 576-SHAV-5)
576-SHAV-1	Vertical Sample Holder (for use with 1" x 0.025" thick flat metal planchet)
576-SHAV-2	Vertical Sample Holder (for use with 1.25" x 0.025" thick flat metal planchet)
576-SHAV-3	Vertical Sample Holder (for use with 25-mm filter paper)
576-SHAV-4	Vertical Sample Holder (for use with 37-mm filter paper)
576-SHAV-5	Vertical Sample Holder (for use with .75" x 0.025" thick flat metal planchet)
576-VCD	Vacuum Chamber Door





Model No.	Sample Holder Dimensions (Diameter) A	B	Retaining Ring Dimensions (Diameter) C	D
576-SHAV-1	1.500	1.010	1.555	0.910
576-SHAV-2	1.500	1.260	1.555	1.160
576-SHAV-3	1.000	No C Bore	1.055	0.890
576-SHAV-4	1.500	No C Bore	1.555	1.390
576-SHAV-5	1.000	0.765	1.055	0.670

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ORTEC®

Low-Background Cryostats with Carbon Fiber Endcaps for Coaxial Detectors

Low-Background Just Got Better!

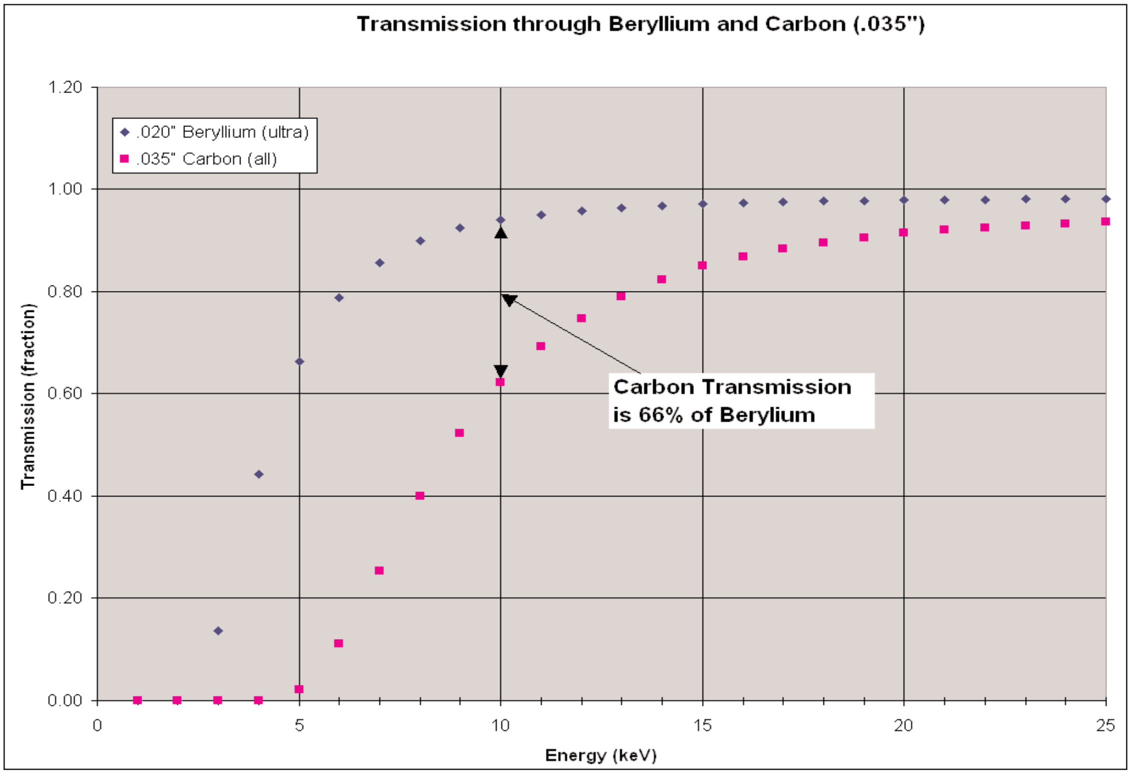
Carbon Fiber

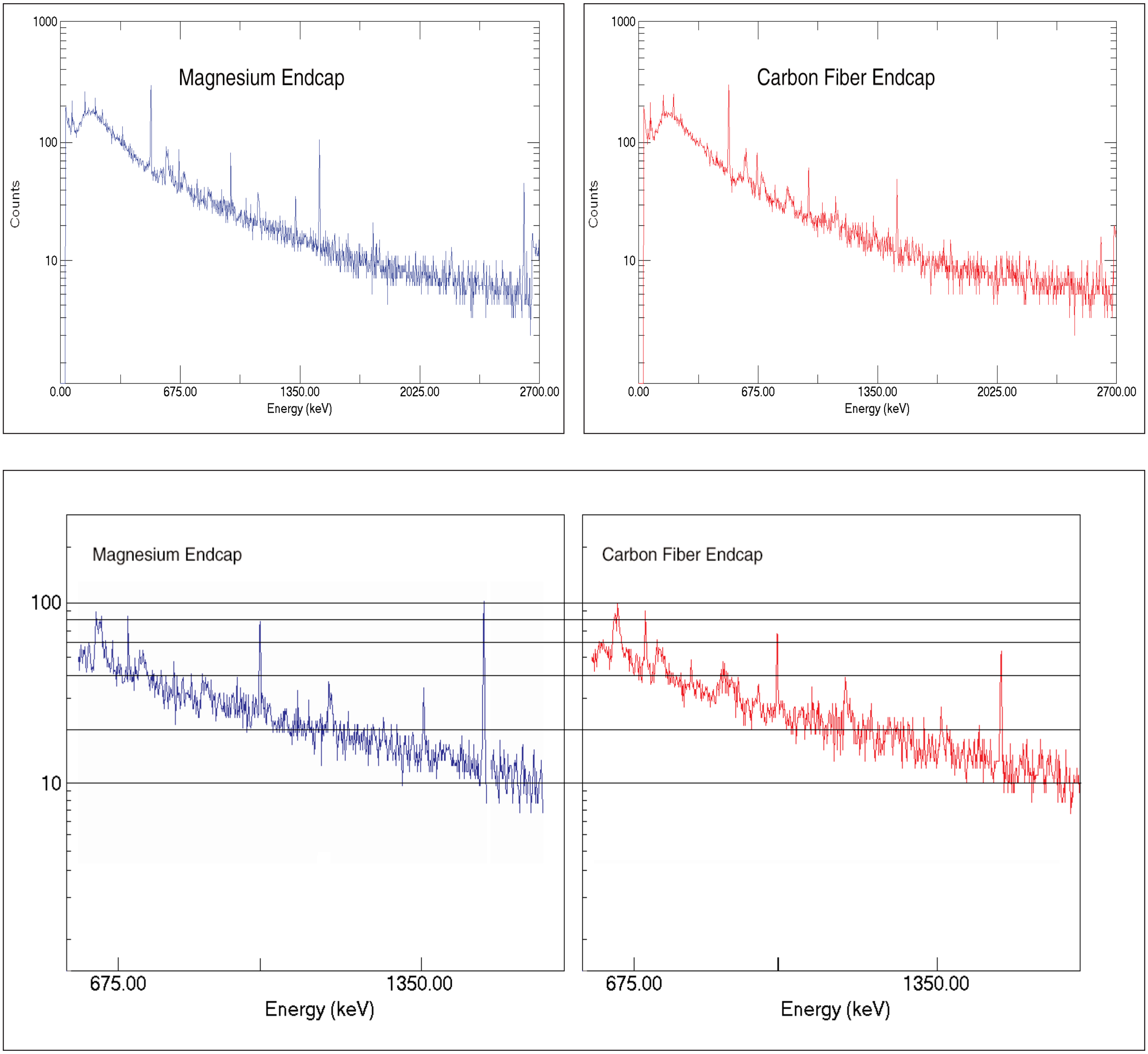
- **is as strong as Al, Mg, and Cu**
- **creates less background**
- **does not corrode**
- **can detect energies less than 10 keV** (see comparison chart)

A monolithic endcap made of Carbon Fiber is now available for ORTEC Low-Background detectors. This lower background material allows for lower Minimum Detectable Activity (MDA) for a specific counting time, which provides another step in increasing sample throughput in low-background counting applications. The lower Z of Carbon Fiber provides a low-energy window without the additional background found in most alloys (see transmission chart).

Beryllium windows in copper endcaps are available for Low-Background detectors where lower energy efficiencies are needed.

Carbon Fiber, unlike Beryllium, is non-toxic and can be cleaned with most laboratory solvents such as methanol, trichloroethylene, and acetone. Soap and water may also be used. Abrasive cleaners should not be used.





100,000 second live time spectra of two similar efficiency Low Background GEM detectors, one with a Magnesium endcap and one with a Carbon Fiber endcap. These background spectra were taken in a standard lead shield.

Specifications subject to change
051309

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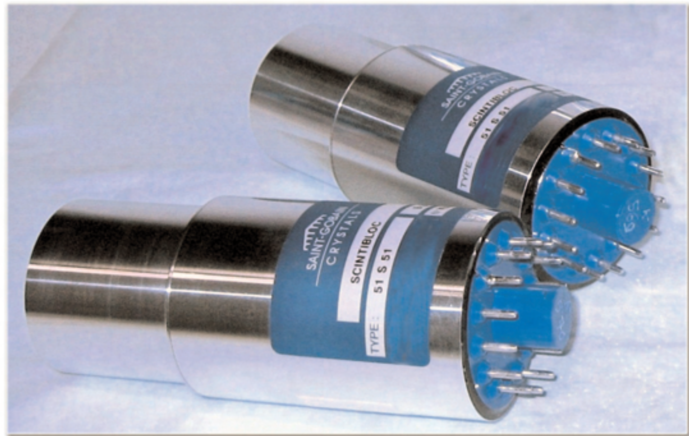
Lanthanum Bromide

Scintillation Detectors

New Generation Inorganic Scintillators:

- **High Light output, and fast decay time output pulse.**
- **Better energy resolution and stability than NaI(Tl).**
- **Higher maximum throughput at high input count rates.**



Lanthanum Bromide, or LaBr3(Ce), sometimes simply (and incorrectly) referred to as "LaBr", is one of the new generation of inorganic scintillation gamma-ray detectors. LaBr detectors exhibit improved resolution and faster light decay time.

When used with the latest ORTEC digital electronics, these detectors provide improved resolution, pulse shape, and temperature stability compared to NaI(Tl) types. As a convenience to our customers, ORTEC is pleased to offer various LaBr detector models.

Crystals sizes for the spectroscopy systems range from 1 x 1-in. to 3 x 3-in.

Improved Resolution and Efficiency

As shown in Figure 1, LaBr provides better resolution performance over NaI(Tl) systems by approximately a factor of 2. Note that neither the NaI(Tl) detectors nor the lanthanum bromide detectors can approach the resolution of a HPGe detector.

The efficiency for LaBr is about 1.3 times that of NaI(Tl) for the same volume and the decay time constant is slightly more than 10% of the NaI detector decay time (see Table 1). On the basis of photoelectron yield, LaBr has higher efficiency and temperature stability than NaI(Tl).

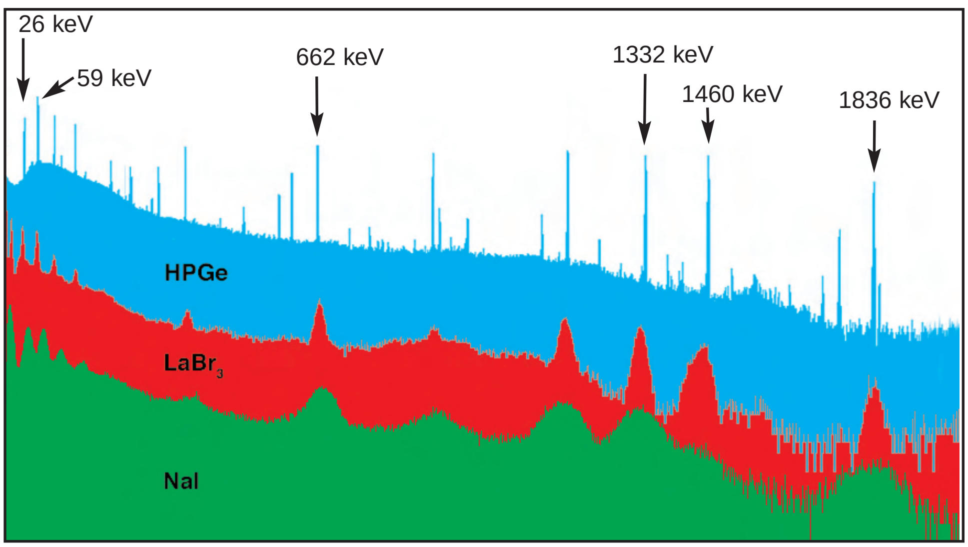


Figure 1. Comparison for $LaBr_3$(Ce), NaI(Tl), and HPGe spectra.

High Count Rate Compatibility

Lanthanum bromide detectors can operate over wide dynamic ranges of count rate with little variation in energy resolution.

Figures 2 and 3 show high rate performance of a LaBr detector with an ORTEC digiBASE.

The digiBASE shows minimal resolution degradation over a wide range of count rates.

Table. 1. Comparison of Critical Parameter for Lanthanum Bromide Detectors.

Detector Type	Resolution @662 keV (%)	Density (g/cc)	Photoelectron Yield Relative to NaI	Primary Decay Time (μsec)
$LaBr_3$(Ce)	2.8—4.0	5.29	130	0.026
NaI(Tl)	7	3.7	100	0.230
HPGe	0.2 (1.3 keV)	5.35	N/A	N/A

Lanthanum Bromide

Scintillation Detectors

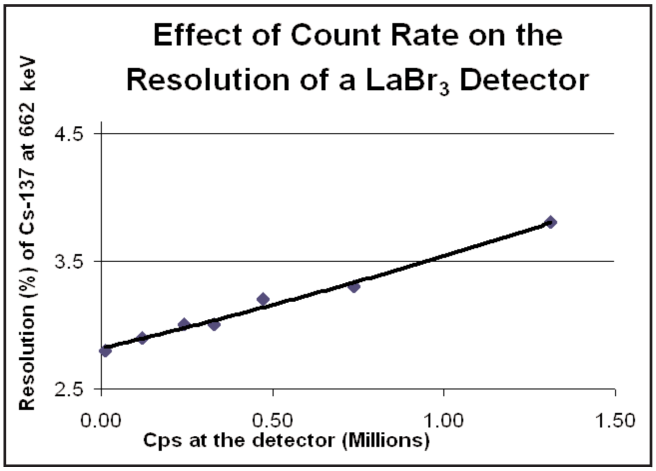


Figure 2.

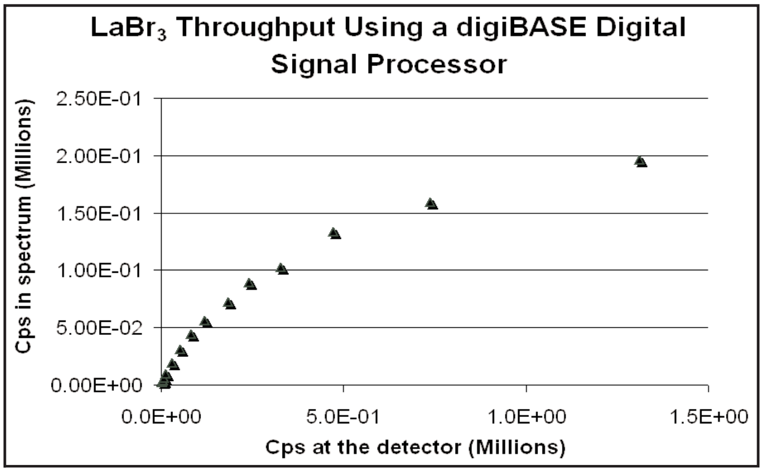


Figure 3.

Spectroscopy Electronics for LaBr

Lanthanum bromide crystals are generally supplied ready mounted on a PMT in the form of an integrated assembly. Many options are available to develop a complete spectroscopy system.

Electronics	PMT Base/Preamp	Amplifier	MCB	HVPS	Comments
digiBASE or digiBASE-E	Included in digiBASE and digiBASE-E	Included in digiBASE and digiBASE-E	digiBASE or digiBASE-E	included in digiBASE and digiBASE-E	simplest system — requires computer
digiDART or digiDART-LF with DIM-296	Included in digiDART-296 and DD-LF-296	Included in digiDART-296 and DD-LF-296	digiDART-296 or DD-LF-296	included in digiDART-296 and DD-LF-296	portable applications with or without computer
NIM solution with 296 ScintiPack PMT Base HVPS	296	NIM amplifier*	MCB**	included in PMT Base	requires NIM BIN/PWR and computer
NIM solution with 276 Preamplifier PMT Base	276	NIM amplifier*	MCB**	556	requires NIM BIN/PWR and computer
NIM solution with 266 PMT Base and 113 Preamplifier	266 + 113	NIM amplifier*	MCB**	556	requires computer

*Choice of NIM amplifier: 855, 575, 570A, 590A, 671, 672, 572A.
**Choice of MCB: EASY-MCA-2k, EASY-MCA-8k, 919E, 926-M32-USB, 921E, 920E.

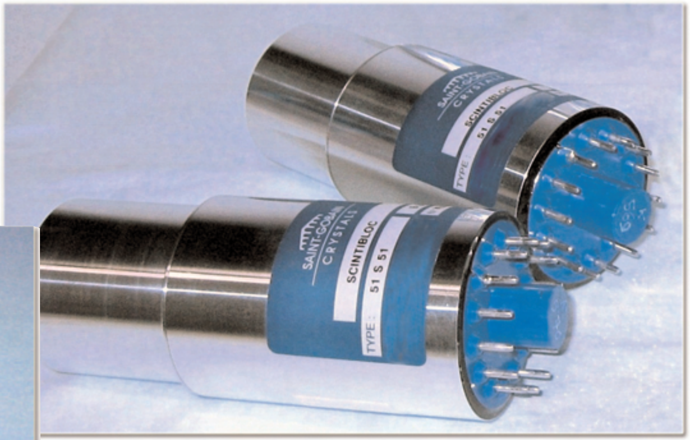
Dimensions and Weights

Model	Base OD	PMT OD	Detector Housing OD	Detector Housing Length	Overall Length	Net Weight	Shipping Weight
LABR-1X1	57 mm 2.2 in	44.5 mm 1.8 in	30.4 mm 1.2 in	26.1 mm 1.0 in	143 mm 5.6 in + pins	~.06 lb	5 lb
LABR-1.5X1.5	58.7 mm 2.3 in	58.7 mm 2.3 in	43.1 mm 1.7 in	39 mm 1.5 in	151.5 mm 6.0 in + pins	~1 lb	5 lb
LABR-2X2	58.7 mm 2.3 in	58.7 mm 2.3 in	55.8 mm 2.2 in	51.5 mm 2.0 in	164 mm 6.5 in + pins	~1.5 lb	5 lb
LABR-3X3	58.7 mm 2.3 in	58.7 mm 2.3 in	82.5 mm 3.2 in	157 mm 6.2 in	194 mm 7.6 in + pins	~2 lb	5 lb

Ordering Information

Model	Description
LABR-1X1	$LaBr_3$(Ce) scintillation detector, 1 x 1-in. crystal with 1.5-in. diameter 14-pin PMT; resolution 3.5% guaranteed. St. Gobain Part No. 2-4-7174.
LABR-1.5X1.5	$LaBr_3$(Ce) scintillation detector, 1.5 x 1.5-in. crystal with 2-in. diameter 14-pin PMT; resolution 3.0% target. St. Gobain Part No. 2-4-6115.
LABR-2X2	$LaBr_3$(Ce) scintillation detector, 2 x 2-in. crystal with 2-in. diameter 14-pin PMT; resolution 3.5% target. St. Gobain Part No. 2-4-6288.
LABR-3X3	$LaBr_3$(Ce) scintillation detector, 3 x 3-in. crystal with 3-in. diameter 14-pin PMT; resolution 3.5% target. St. Gobain Part No. 2-4-7175.

Lanthanum Bromide
Scintillation Detectors



Specifications subject to change
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AMETEK® ADVANCED MEASUREMENT TECHNOLOGY

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SMART-1 and SMART-INTERFACE

- **An Intelligent High Voltage Supply for HPGe Detectors**
- **Provides Detector State-of-Health (SOH) Information**
- **Security Function Allows Use of Authentication Codes**
- **Rugged Housing to Protect Electronics**

The SMART-1 option for ORTEC HPGe detectors is a major enhancement to operational quality assurance and to data and chain-of-custody integrity. It is supported directly through MAESTRO-32 software which is supplied with the digiDART, digiDART-LF, DSPEC-jr-2.0, DSPEC-LF, and DSPEC-Pro revolutionary, small sized, low power, digital nuclear multichannel analyzer systems. For other multichannel analyzers, the SMART-INTERFACE provides the same control as the SMART-1.

The SMART-1 HPGe detector includes the high voltage supply, so an external high voltage power supply is not required. The SMART-1 HPGe detector monitors and reports on vital system functions and the SMART-1 identification serial number can be read by the instrument. For more security it can save authentication codes and report the code at a later time.

ORTEC SMART-1 HPGe detectors monitor the following conditions:

- Preamplifier +24 and +12 V values (read-only)
- Detector element temperature (read-only)
- Detector high voltage value (read-only)
- Detector high voltage state (on/off)
- Detector overload state (read-only)
- Detector HV shutdown state (read-only)
- Detector serial number (read-only)
- Detector authentication code (read/write)

These parameters are displayed as required on the LCD display of the attached instrument or computer (local or remote).

SMART-1 Physical

The SMART-1 is housed in a rugged ABS molded plastic enclosure. The SMART-1 is permanently attached to the detector endcap via a molded, strain-relieved sealed cable. This eliminates the possibility that the detector will suffer severe damage from moisture leaking into the high voltage connectors. The SMART-1 can be positioned in any convenient place and does not interfere with shielding or other mounting hardware.

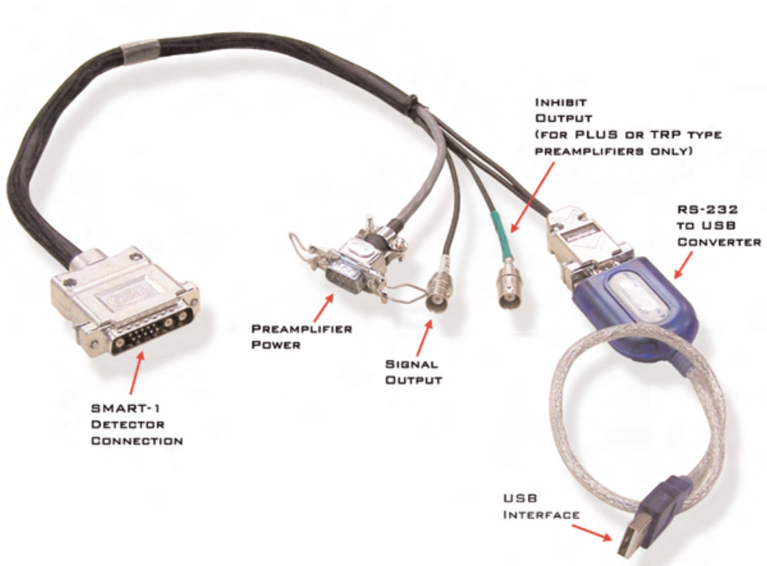
SMART-1 and SMART-INTERFACE

SMART-INTERFACE for Other MCA Types

SMART-INTERFACE allows the SMART-1 detector technology to be used with virtually any MCA — even analog.

SMART-INTERFACE provides communications between the ORTEC SMART-1 detector and an analog amplifier with any MCA or a Digital Signal Processor that cannot directly connect to the SMART-1. Easy to use software is provided to access the SMART-1 detector's State-of-Health (SOH) data and control the high voltage.

The SMART-INTERFACE is supplied with one detector output signal cable, one inhibit output signal cable [for use with -PLUS or Transistor Reset Preamplifiers (TRP)], one preamplifier power cable for an ORTEC preamplifier power supply, one preamplifier power cable to connect to another manufacturer's preamplifier power supply, a USB extension cable for connection to a PC and software to control the high voltage and display the detector SOH data.



SMART-INTERFACE Software

To start the SMART-INTERFACE software, click the Window's Start button, then "ORTEC SMART-INTERFACE." Note, the software is initially minimized to the system tray. To terminate the SMART-INTERFACE software, right click the SMART-INTERFACE icon and click "Shut Down."

To see the SMART-INTERFACE dialogue box, click the SMART-INTERFACE icon in the system tray.

SMART-INTERFACE Dialogue Box

HV On/Set Turns on the bias voltage to the detector and sets the HV to the target voltage. The user enters the target volts in the "Target" box.

Actual Displays the voltage applied to the detector.

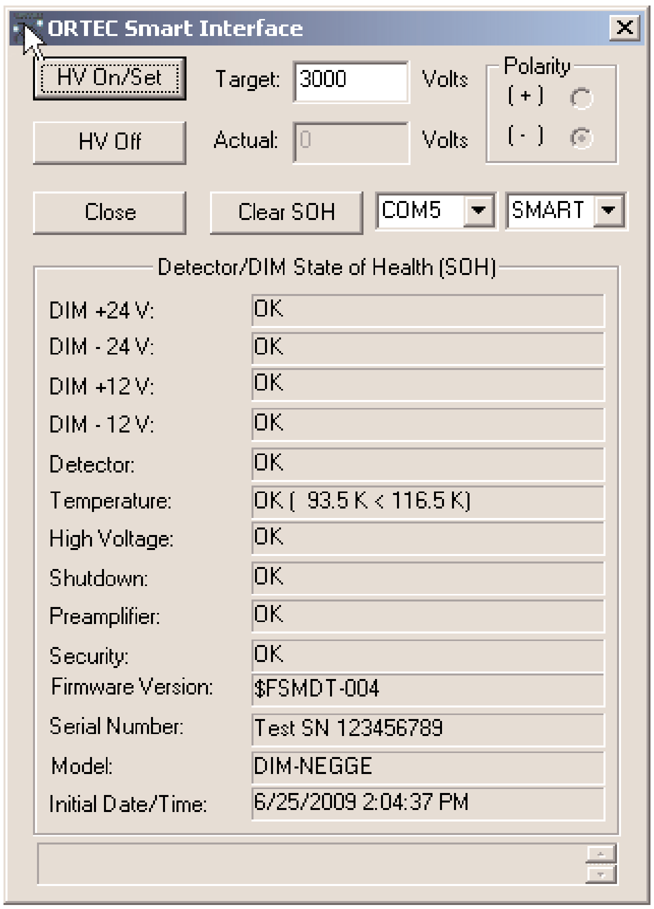
HV Off Turns off bias voltage to the detector.

Close Closes the dialogue box for the SMART-INTERFACE software. Note, this does not cease operations for the SMART-INTERFACE software.

Clear SOH Clears the data from the Detector/DIM State-of-Health (SOH) chart and resets the Initial Date/Time to the current date and time.

Drop-Down Menu (Left) Selects the COM port that will be used to control the SMART-INTERFACE.

Drop-Down Menu (Right) Indicates the bias shutdown logic that is being used. This should always be set to SMART for use with a SMART-1 detector.

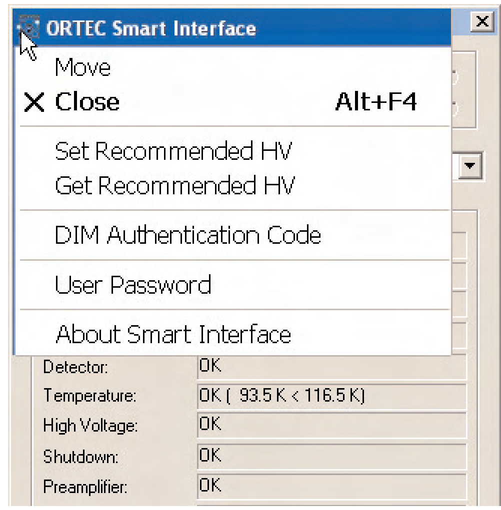


SMART-Interface Dialogue Box.

SMART-1 and SMART-INTERFACE

SMART-INTERFACE Controls Menu

Access the SMART-INTERFACE controls menu by clicking on the upper left corner of the SMART-INTERFACE dialogue box. A drop-down menu will appear.



SMART-Interface Controls Menu.

SMART-INTERFACE Controls

Move Moves the dialogue box.

Close (ALT+F4) Closes the dialogue box

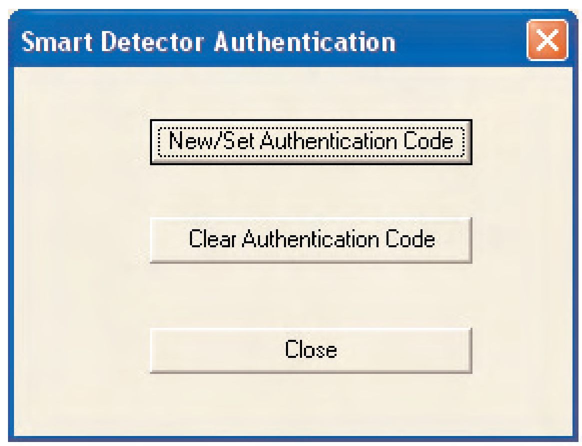
Set Recommended HV Allows the user to enter a value for the bias (normally the recommended value from the SMART-1 detector QAD sheet).

Get Recommended HV Acquires the value entered by the user in the Set Recommended HV step and applies this value to the "Target" box of the SMART-INTERFACE dialogue box.

DIM Authentication Code Allows the user to change or delete the authentication code.

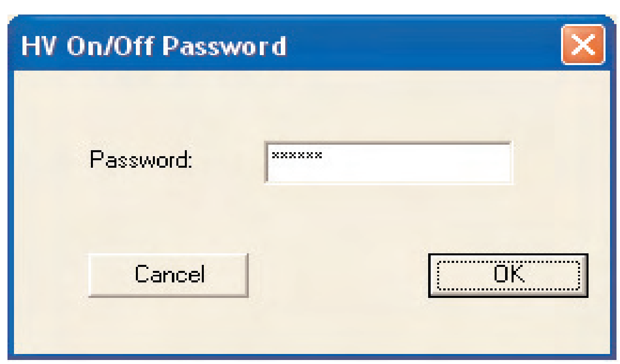
User Password Opens the Manage User Password dialogue box and allows setting or deleting password protection of the HV On/Off function and provides a means of changing the password. Note, the default password is "ORTEC".

Setting the HV On/Off is password protected by default. If the "HV On/Off without Password" box is not checked in the Manage User Password dialogue box, the HV On/Off Password dialogue box will appear.



DIM Authentication Code.

User Password.



HV On/Off Password.

SMART-1 and SMART-INTERFACE

SMART-INTERFACE Specifications

Preamplifier Power 9-pin D connector provides ±12 V and ±24 V power to the preamplifier and high voltage supply. Two 12 ft (3.6 m) preamplifier power cables are provided, one for ORTEC connections and one for another manufacturer.

Signal Output Supplies the voltage pulse from the preamplifier suitable for input to a spectroscopy shaping amplifier or a Digital Signal Processor. 100-Ω impedance. A 12 ft (3.6 m) BNC cable is provided.

Inhibit Output A logic signal is provided during the reset time from a -Plus type (Transistor Reset) preamplifier. 1 kΩ impedance. A 12 ft (3.6 m) BNC cable is provided.

USB Interface Converts the RS232 interface to USB and provides a USB connection to a PC. Interface circuit is powered by the USB. A 10 ft (3 m) USB extension cable is provided.

Weight Net 2 lbs. (0.9 kg) Shipping 3 lbs. (1.4 kg)

Ordering Information

Model	Description
-SMP	Positive Bias SMART-1 detector option, add "-SMP" to the detector model number [e.g., GEM75P4-95-SMP or GME75-95-SMP].
-SMN	Negative Bias SMART-1 detector option, add "-SMN" to the detector model number [e.g., GMX70P4-95-SMN or GMX70-95-SMN].
SMART-INTERFACE	Provides communication between the ORTEC SMART-1 detector and an analog amplifier with MCA or a Digital Signal Processor that cannot directly connect to the SMART-1.

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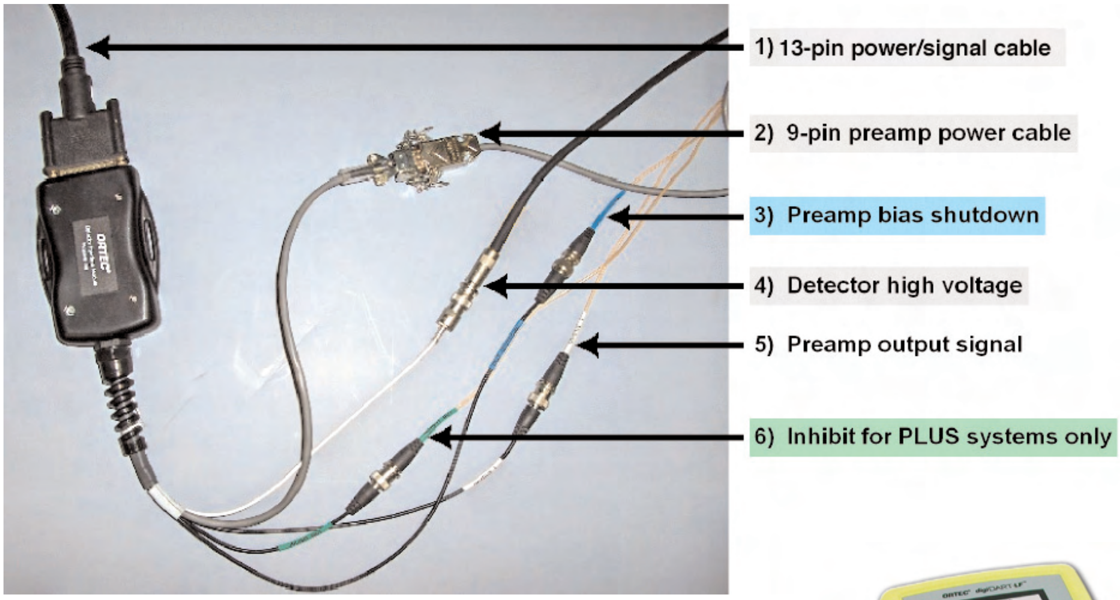
Detector Interface Module (DIM)

- **Provides High Voltage for HPGe or NaI Detectors**
- **Single Cable Connectivity for DSP Systems**
- **<310 grams for Portable Systems**
- **High Impact ABS Plastic Housing**

For older, non-ORTEC or non-SMART-1 detectors, the Detector Interface Module (DIM) is used to supply HV and preamplifier power as well as providing warm-up protection for the HPGe detector. The DIM is provided in a high impact ABS plastic housing with flying leads with mating connectors (HV, Bias Supply Shutdown, Energy Output, Preamplifier Power, and Inhibit Output) to connect to the existing detector cabling.

The following DIMs support non-SMART-1 detector systems:

- **DIM-POSGE** For any non-SMART-1 positive-bias, HPGe detector.
- **DIM-NEGGE** For any non-SMART-1 negative-bias, HPGe detector.
- **DIM-POSNAI** For any positive-bias NaI detector.



DIM-296 Option for 14 Pin PMT NaI Detectors

The DIM-296 option is an alternative to the DIM-POSNAI for NaI detectors with a standard 14-Pin base. The DIM-296 is a 296 ScintiPack with a single cable connection, ten feet in length for direct connection to the instrument.

- For scintillation detectors employing 10-stage PMTs that fit standard 14-pin sockets
- Convenient, single-cable connection direct to instrument
- Internal, adjustable, high-voltage bias supply eliminates high-voltage cables
- Active bias network minimizes peak shifts at high counting rates
- Low power consumption (240 mW) for portable applications

Detector Interface Module (DIM)

Specifications

Dimensions

DIM 12 cm x 8.2 cm x 3.3 cm (4.7 in. x 3.2 in. x 1.3 in.)

DIM-296 5.6 cm (2.2 in.) diameter x 17 cm (6.7 in.) length

Weight

DIM Net <240 gm (0.5 lb.) Shipping 1.21 kg (2.6 lb.)

DIM-296 Net 0.5 kg (1.1 lb) Shipping 1.2 kg (2.6 lb)

Performance

DIM-POSGE Output 0 +5 kV, 100 MΩ impedance.

DIM-NEGGE Output 0 –5 kV, 100 MΩ impedance.

DIM-POSNAI 0 +1800 V, 600 µA below 1000 V, 300 µA maximum above 1000 V.

Connectors

DIM-POSGE and DIM-NEGGE

- Preamplifier Power: 9-PIN D female 1 W maximum (+12 V,12 V, +24 V, 24 V, 2 GND)
- Analog In: BNC male
- Bias Shutdown In: BNC male
- Bias Out: SHV (HV) female
- TRP Inhibit Out/Coincidence Gate In: BNC male (function is software selected)

DIM-POSNAI

- Preamplifier Power: 9-PIN D female 1 W maximum (+12 V,12 V, +24 V, 24 V, 2 GND)
- Analog In: BNC male
- Bias Out: SHV (HV) female
- Coincidence Gate In: BNC male

Ordering Information

Model	Description
DIM-POSGE	Detector interface module for non-SMART positive bias HPGe detector. Contact factory for use with -Plus option detector.
DIM-NEGGE	Detector interface module for non-SMART negative bias HPGe detector. Contact factory for use with -Plus option detector.
DIM-POSNAI	Detector interface module for positive bias NaI detector
DIM-296	296 ScinitPack High-Rate PMT Base for use with digiDart, digiDART-LF, DSPEC jr 2.0, DSPEC LF, or DSPEC Pro.

Specifications subject to change
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GEM Series Coaxial HPGe Detector Product Configuration Guide

P-type Coaxial HPGe Detectors for High Performance Gamma Spectroscopy in the Energy Range of ~40 kev and Up.

The majority of gamma spectroscopy applications such as those found in counting laboratories involve the energy range ~40 keV upward. ORTEC GEM and Profile Series GEM detectors are designed to cover this energy range. The Profile GEM-FX Series extends this lower energy cut off to 10 keV and above. (A separate guide is available for the Profile GEM Series.)

All GEM Series feature:

- Efficiencies to 150%, higher on request.
- Excellent energy resolution and peak symmetry..
- Specified crystal dimensions in Profile models.
- SMART bias options.
- Harsh Environment (-HE) option.
- Low-background carbon fiber endcap options.
- PLUS preamplifier option for ultra-high-rate applications.
- Huge configuration flexibility: PopTop, Streamline and mechanically cooled options.

ORTEC offers GEM Series HPGe detectors with relative efficiencies[1] from 10% to 150% and beyond. The detectors are manufactured from ORTEC-grown germanium crystals processed in our advanced manufacturing facility in Oak Ridge, TN. The detectors are fabricated from P-type germanium with an outer contact of diffused Li and an inner contact of ion-implanted boron.

ORTEC maintains a large stocklist of GEM detectors. Some of these have "super specifications," that is, a warranted energy resolution better than the usual GEM warranted specifications.

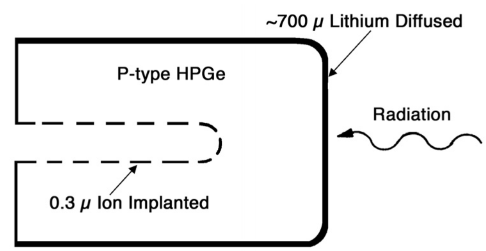


Fig. 1. Configuration of GEM Coaxial Germanium Crystal.

The Following Specifications are Provided for each GEM Detector

- Energy resolution full-width half-maximum (FWHM) at 1.33-MeV and optimum shaping time.
- Relative Photopeak efficiency at 1.33 MeV.
- Peak-to-Compton ratio at 1.33 MeV.
- Peak shape ratio for the full-width tenth-maximum to the full-width half-maximum at 1.33 MeV.
- Energy resolution at 122 keV at optimum shaping time.

Configuration Guidelines

PopTop or Streamline (non-PopTop) Configuration

The essence of a PopTop detector system is that the HPGe detector element cryostat, preamplifier, and high voltage filter are housed in a detector "capsule" which is then attached to an appropriate cryostat (Figure 2.)

In so called Streamline systems, the detector capsule in NOT demountable. Detector capsule and cryostat share the same vacuum. In configuration terms, this requires a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap. A cryostat must always be ordered with a Streamline capsule, because they are integral.

The actual PopTop capsule has its own vacuum. It can be mounted on any of the available cryostats, cryostat/dewar combinations, or the X-COOLER II mechanical cooling system.

[1]By convention, HPGe detectors are characterized by "relative efficiency". Relative efficiency is defined as the efficiency of a point Co-60 source at 25 cm from the face of a standard 3-inch x 3-inch right circular cylinder NaI(Tl) detector. "IEEE Test Procedures for Germanium Detectors for Ionizing Radiatio," ANSI/IEEE Standard 325-1986.

GEM Series Coaxial HPGe Detector
Product Configuration Guide

Steps to Configure Your ORTEC HPGe Detector

1) Configure the Detector Model

- Capsule type (PopTop or Streamline)
- Ge Crystal efficiency and specifications
- Endcap and window
- Mount
- Preamplifier
- High Voltage Filter
- Cable Package

Options are available for the detector model that can change specific materials used in the construction of the detector endcap, cup, and mount. Preamplifier options are also available.

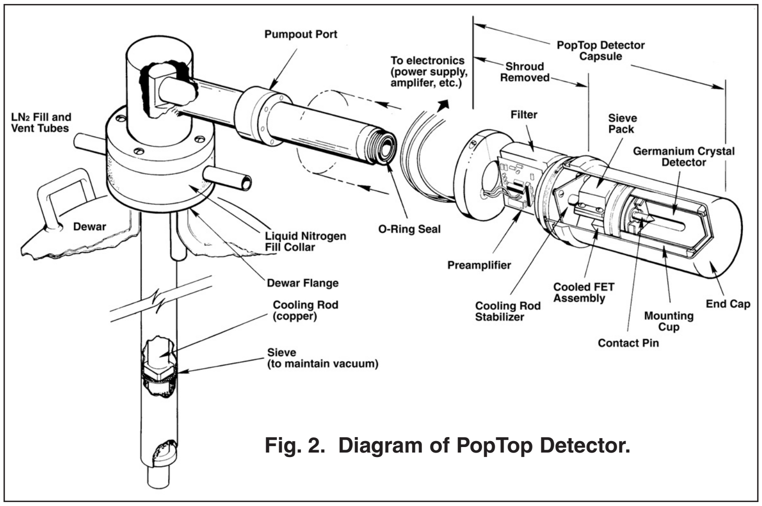


Fig. 2. Diagram of PopTop Detector.

2) Configure the Cryostat/Dewar Model

- Vertical Dipstick style (separate Dewar)
- Horizontal Dipstick style (separate Dewar)
- Portable with all-position or multi-position cryostat/dewar models
- Downlooking designed to be oriented with the detector pointing down
- Sidelooking designed to be oriented with the detector horizontal at the bottom of the dewar
- "J" configurations designed with the detector attached near the bottom of the dewar and a right angle bend in the cryostat orienting the detector to look up.

A cryostat and dewar or other cooling device are required for operation.

If a PopTop detector has been selected, you can choose a PopTop style cryostat, cryostat/dewar combination or the X-COOLER II mechanical cooler.

If a Streamline detector has been selected, you must choose a cryostat or cryostat/dewar model for the detector to be mounted on and vacuum sealed. The cryostat or cryostat/dewar combination diameter must match the endcap diameter of the selected detector.

Fig. 3. -HE Detector Option (Carbon Fiber Endcap).

Detector Options

Harsh Environment Option (-HE)

The Harsh Environment option is a rugged carbon fiber endcap with a sealed electronics housing featuring a replaceable desiccant pack which ensures that the electronics stay 100% dry and indicates when it needs to be replaced.

GEM series detectors in PopTop capsules of 76 mm diameter or larger can be supplied with this option.

Ultra-High Count-Rate Preamplifier Option (-PL)

The Ultra-High Count-Rate Preamplifier (transistor-reset preamplifier), which can handle input count rates up to 1,000,000 counts/s at 1 MeV, offers the added benefit of having no feedback resistor.

Fig. 4. SMART-1 Detector Interface Module.

SMART-1 Option (-SMP)

The SMART-1 option monitors and reports on vital system functions, and can save authentication codes and report the code at a later time. It has the high voltage included, so none of the instruments require an external high-voltage power supply.

The SMART-1 is housed in a rugged ABS molded plastic enclosure and is permanently attached to the detector endcap via a molded-strain-relieved sealed cable. This eliminates the possibility that the detector will suffer severe damage from moisture leaking into high-voltage connectors. The SMART-1 can be positioned in any convenient place and does not interfere with shielding or other mounting hardware.

Remote Preamplifier Option (-HJ)

This option allows all the preamplifier and high voltage connections to be outside a shield and removes the preamplifier and high voltage filter from the "line-of-sight" to the Ge crystal. For low background applications, this option eliminates any possible preamplifier or high voltage filter components that may add to the background inside a shield.

Low-Background Carbon Fiber Endcap Options (-RB, -LB-C, and -XLB-C)

Carbon Fiber is as strong as Al, Mg, and Cu, creates less background, does not corrode, and can detect energies less than 10 keV.

This lower background material allows for lower Minimum Detectable Activity (MDA) for a specific counting time, which provides another step in increasing sample throughput in low-background counting applications. The lower Z of Carbon Fiber provides a low-energy window without the additional background found in most alloys. See Figures 5 and 6 for transmission characteristics of the Be and carbon fiber windows.

Carbon Fiber, unlike Beryllium, is non-toxic and can be cleaned with most laboratory solvents such as methanol, trichloroethylene, and acetone. Soap and water may also be used. Abrasive cleaners should not be used.

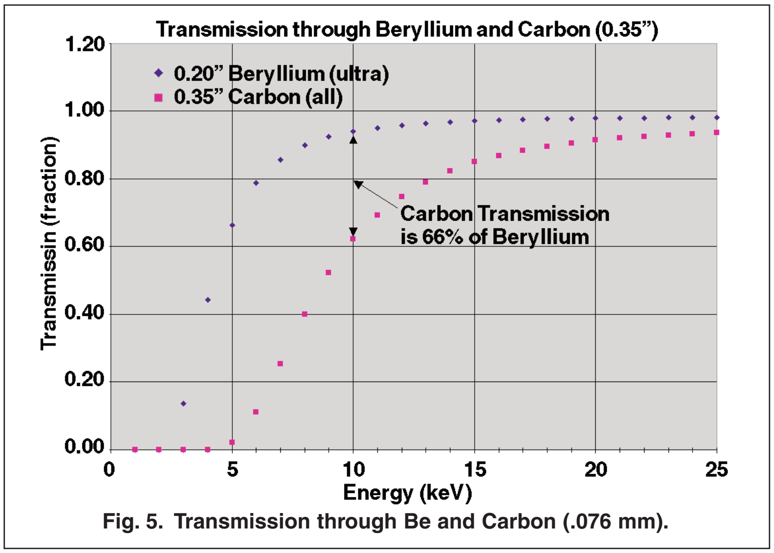


Fig. 5. Transmission through Be and Carbon (.076 mm).

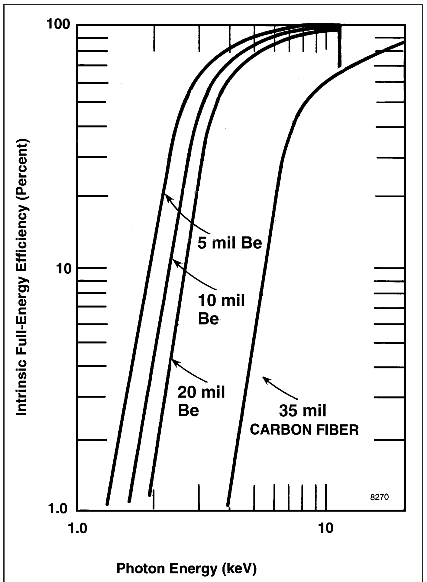


Fig. 6. Low Energy Gamma and X-Ray Transmission of Be and Carbon Fiber Windows.

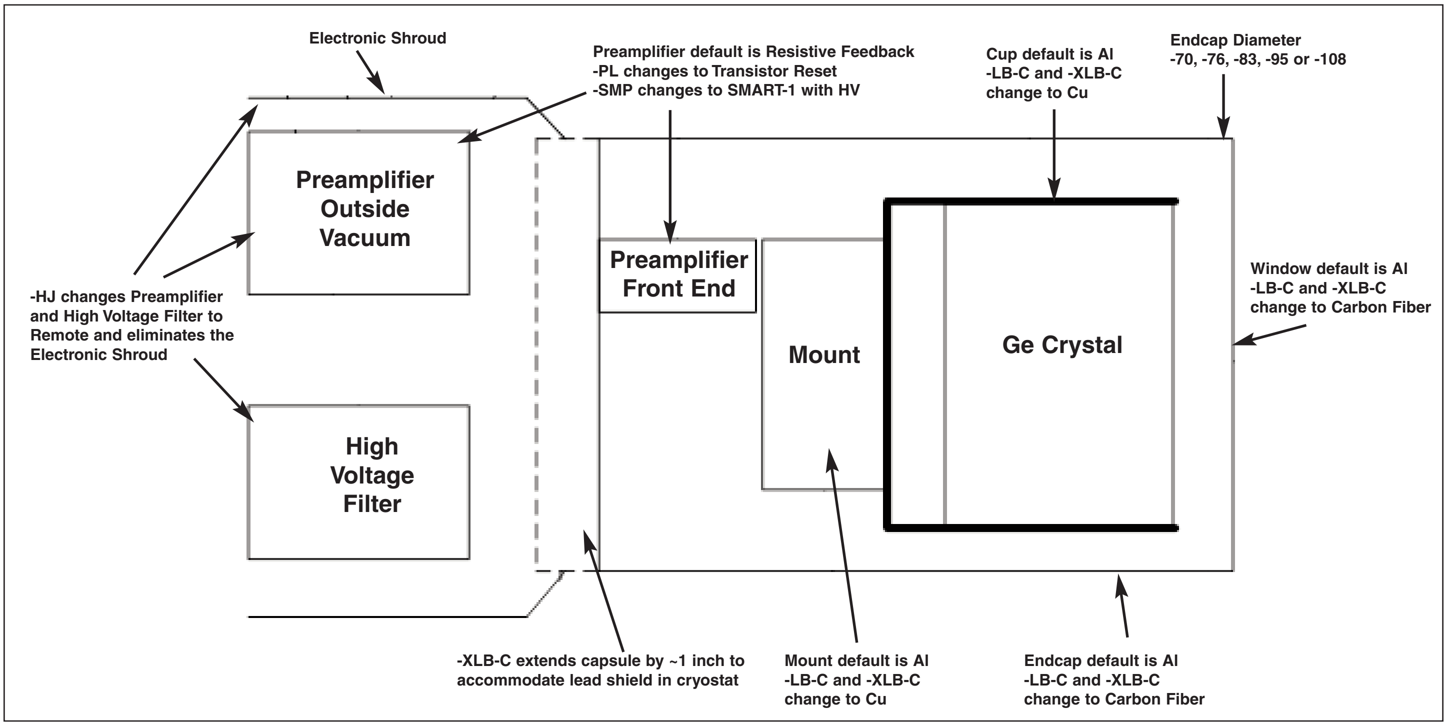
Defining the Detector Model

• See ordering information for option compatibility.

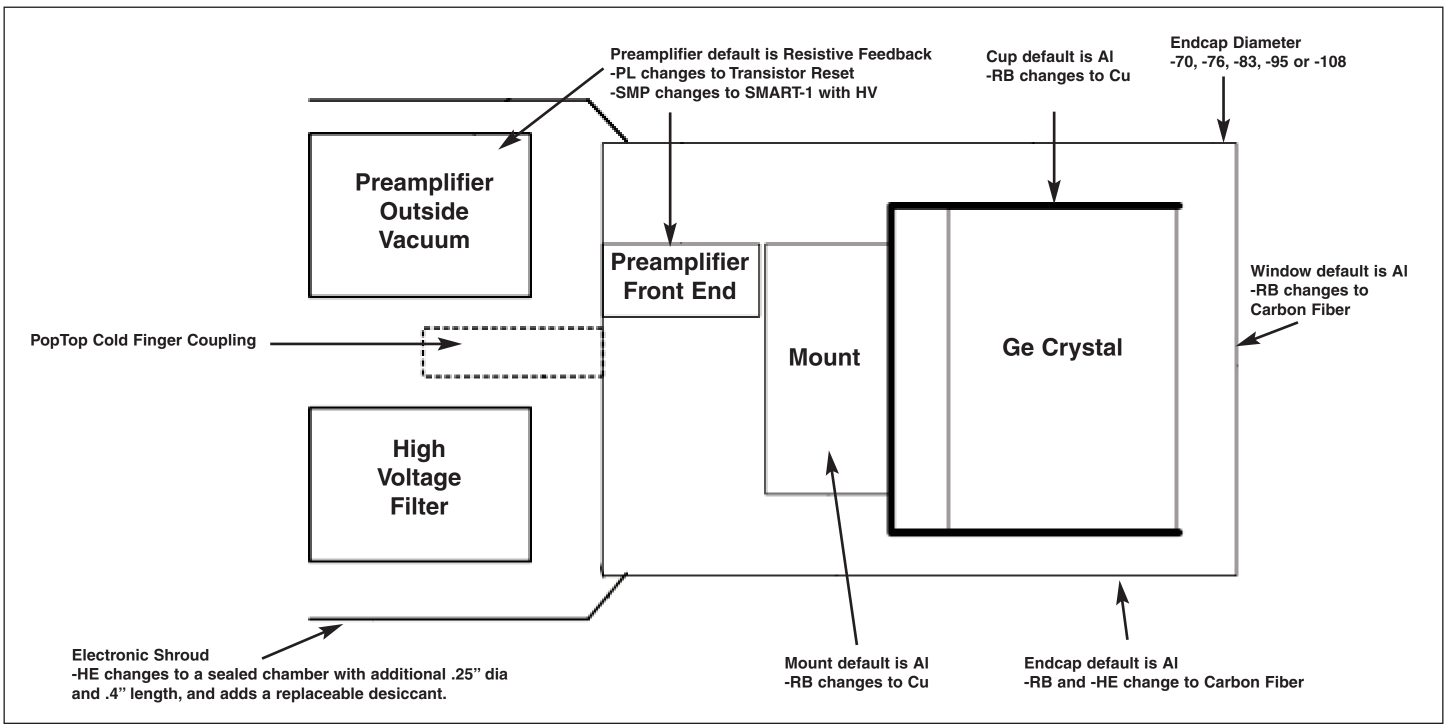
Base Model (example)	PopTop or Streamline	Endcap Diameter	Window Option (if required)	Preamplifier Option (if required)	High Voltage Option (if required)
GEM10	P4 (PopTop) (Streamline)	-70 -76 -83 -95 -108	-RB -HE -LB-C -XLB-C	-PL -HJ	-SMP

GEM Series Coaxial HPGe Detector
Product Configuration Guide

Streamline Detector Capsule

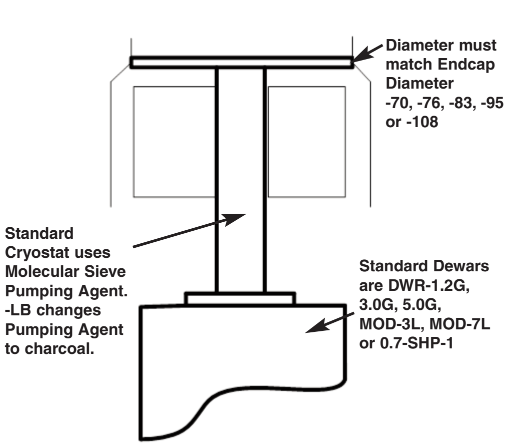


PopTop Detector Capsule

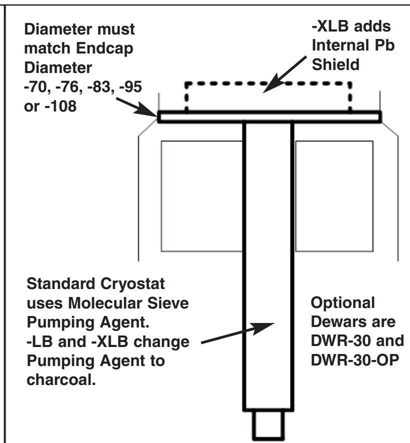


Streamline Cryostat and Cryostat/Dewar Assemblies

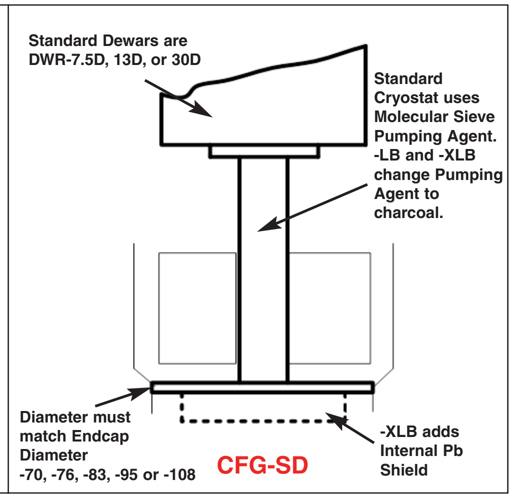
Streamline systems (detector capsule and cryostat) share the same vacuum, requiring a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap.



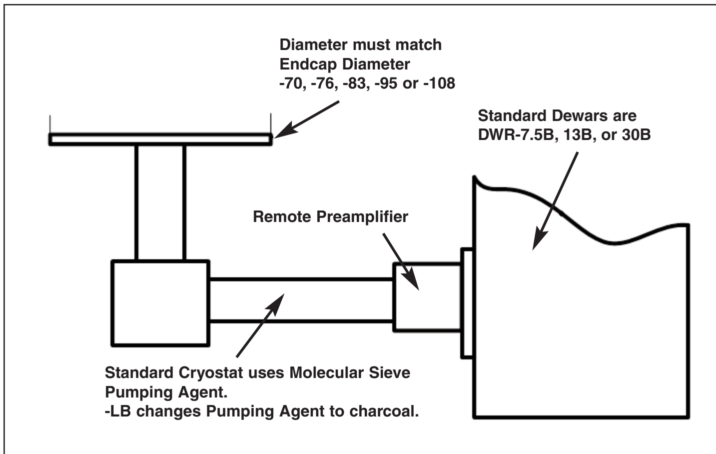
CFG-GG



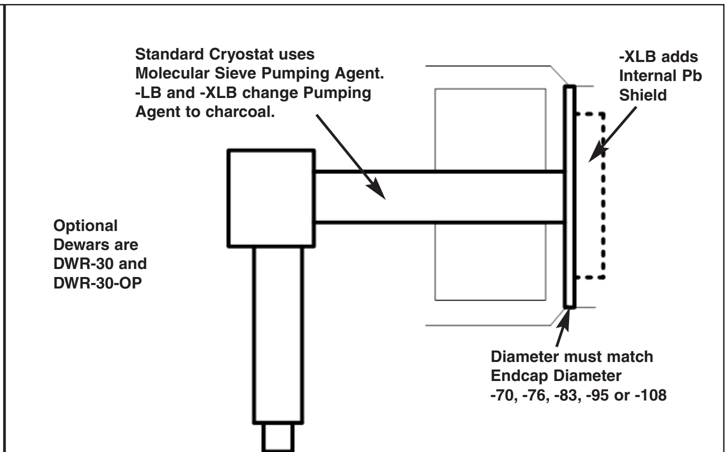
CFG-SV



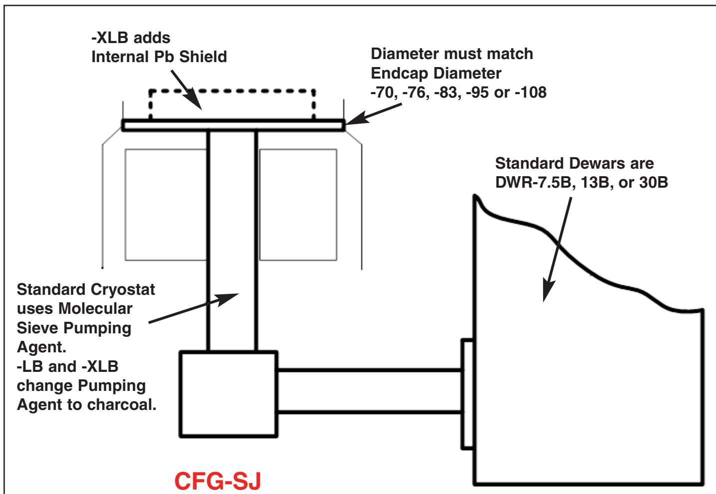
CFG-SD



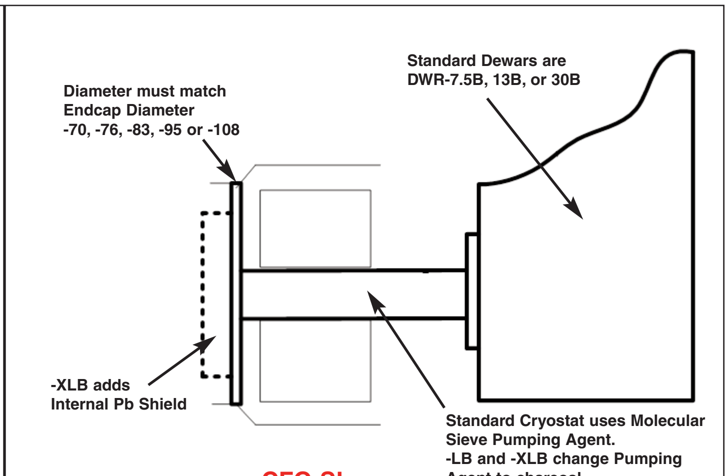
CFG-HJ



CFG-SH



CFG-SJ



CFG-SL

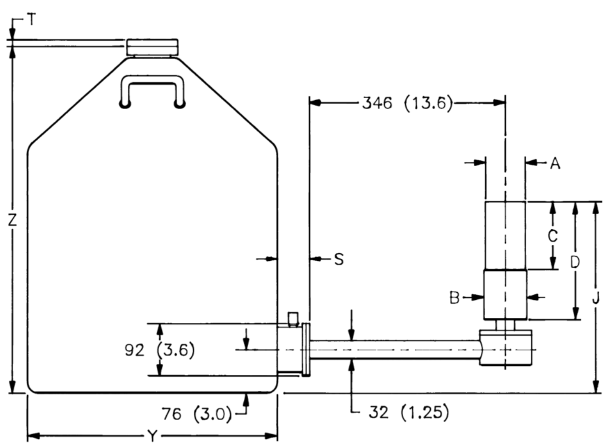
PopTop and Streamline Dimensional Data

Streamline systems (detector capsule and cryostat) share the same vacuum, requiring a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap. A cryostat must be ordered with a Streamline capsule.

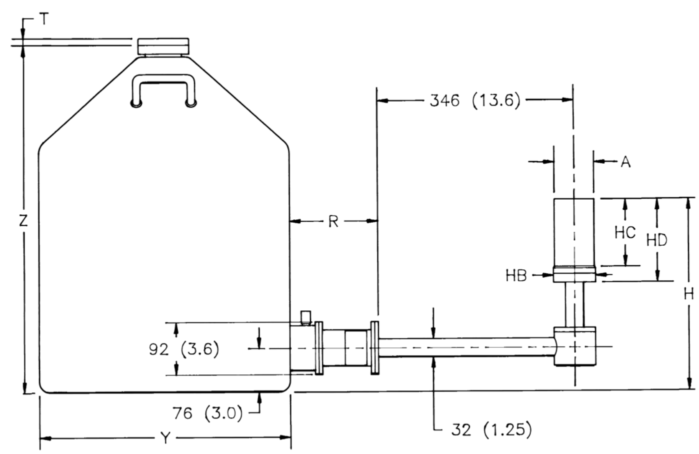
The PopTop capsule contains a vacuum unto itself. It can be mounted on any of the available cryostats, cryostat/dewar combinations, or the X-COOLER II mechanical cooling system.

The cryostat and dewar drawings that follow are to be used in conjunction with the accompanying tables of dimensions.

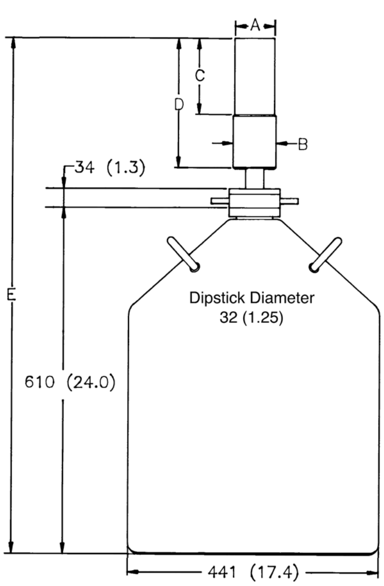
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



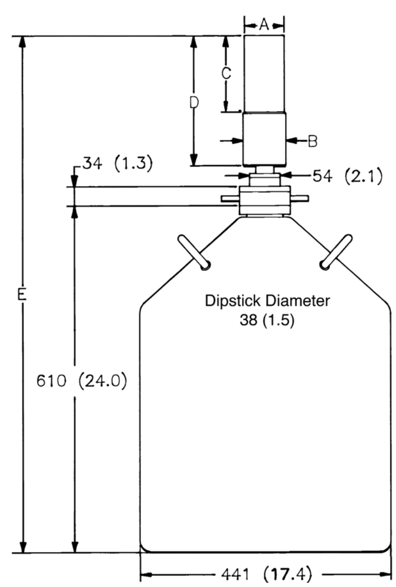
CFG-SJ, DWR-30B (or -13B or -7.5B)



CFG-HJ, DWR-30B (or -13B or -7.5B)

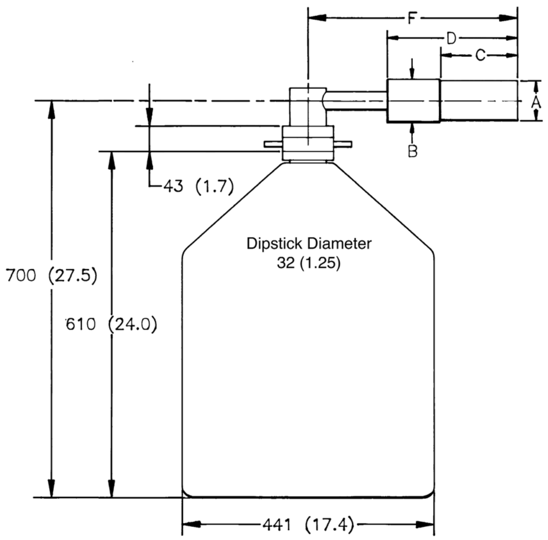


CFG-SV, DWR-30

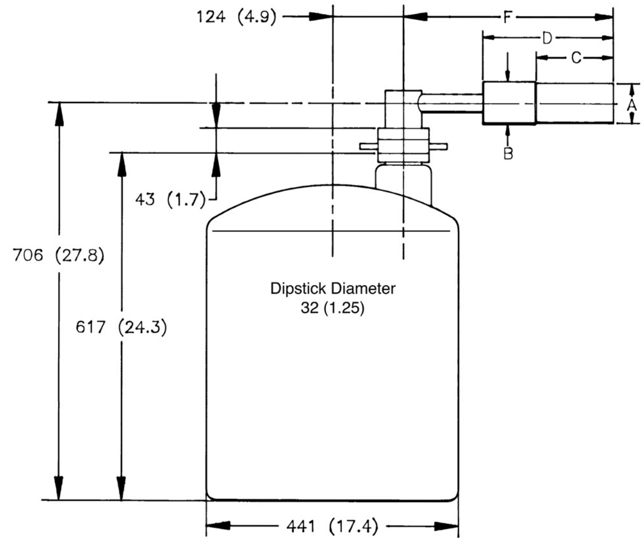


CFG-PV4, DWR-30

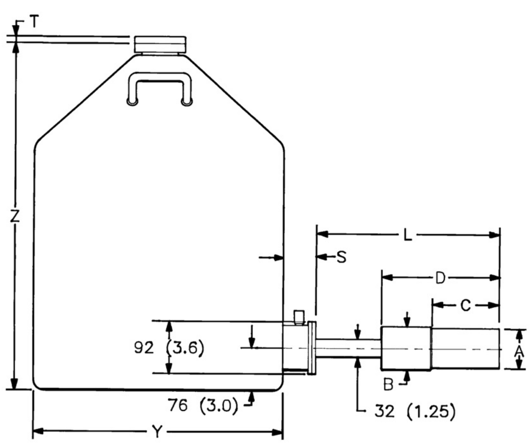
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



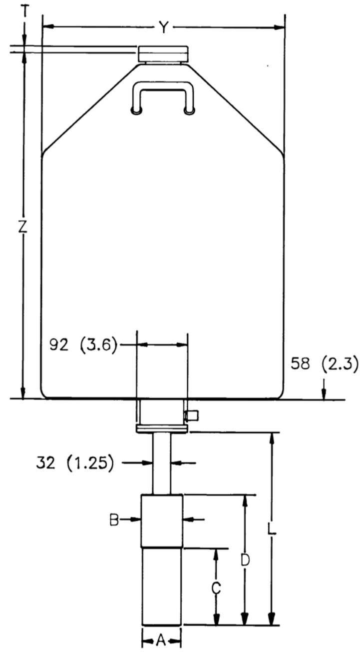
CFG-SH, DWR-30



CFG-SH, DWR-30-OP

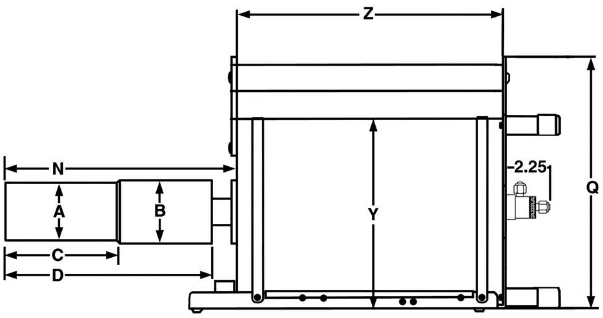


CFG-PS4-30 (or -13 or -7.5)
or
CFG-SL, DWR-30B (or -13B or -7.5B)

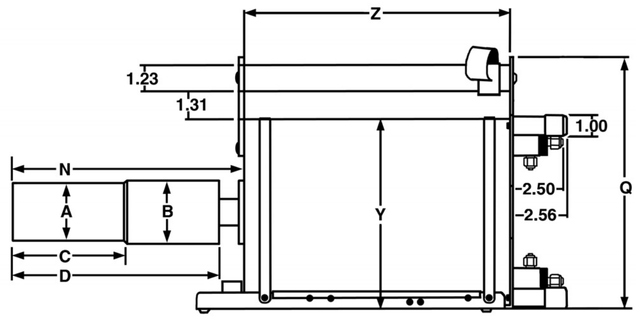


CFG-PD4-30 (or -13 or -7.5)
or
CFG-SD, DWR-30D (or -13D or -7.5D)

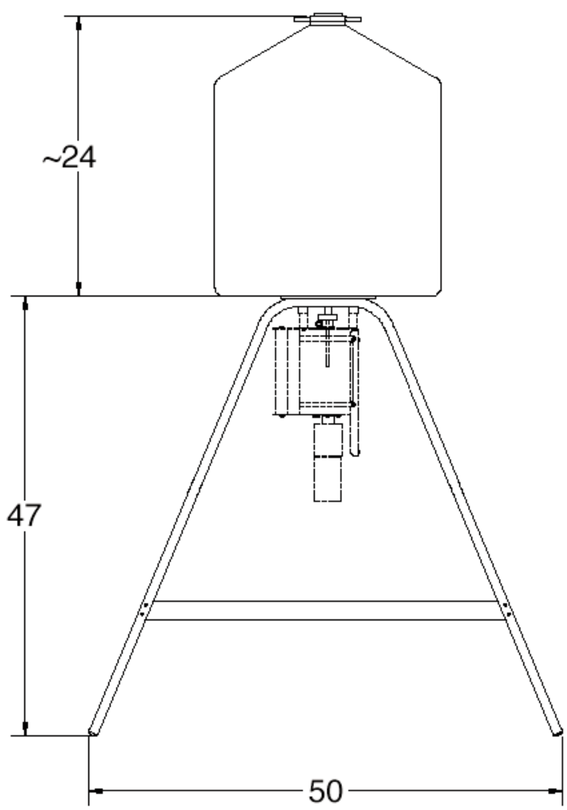
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



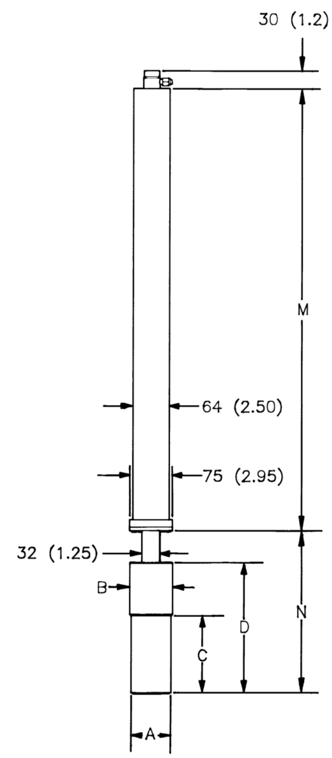
CFG-PG4-1.2 (or -3 or -5)
or
CFG-GG, DWR-1.2G (or -3.0G, -5.0G)



CFG-PMOD4-3 (or -7)
or
CFG-GG, DWR-MOD3L (or -MOD7L)

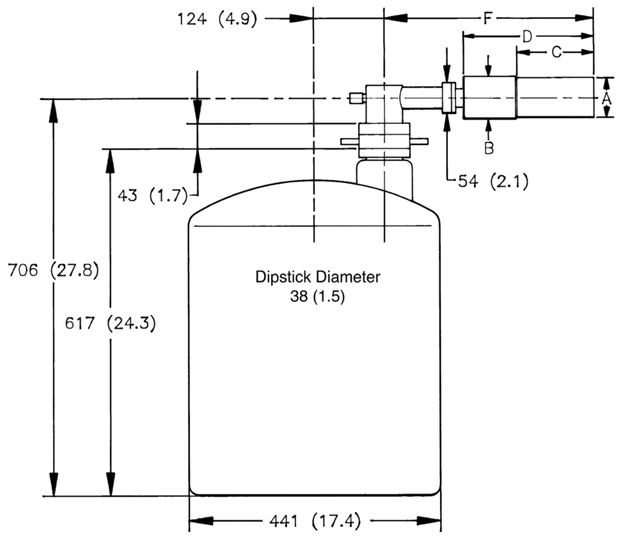


DWR-S/F

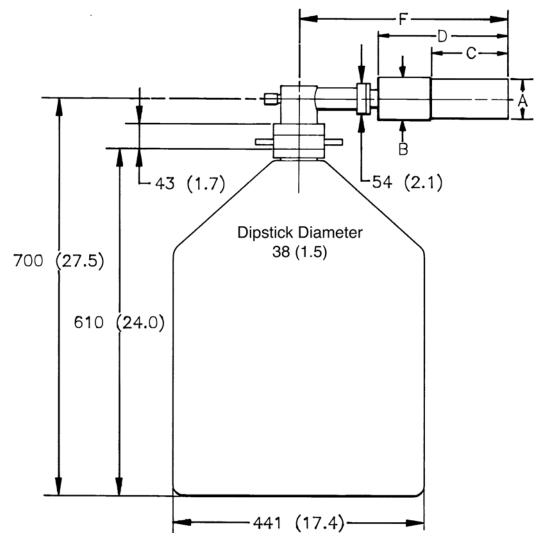


CFG-PSHP4
or
CFG-GG, DWR-0.7-SHP-1

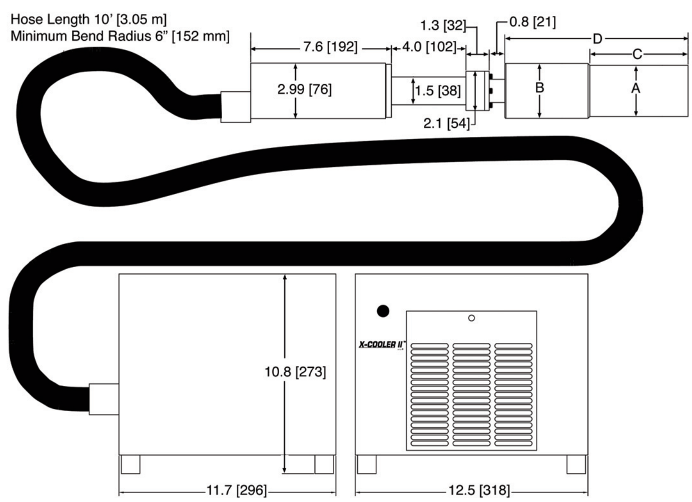
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



CFG-PH4, DWR-30-OP



CFG-PH4, DWR-30



CFG-X-COOL-II

GEM Series Coaxial HPGe Detector Product Configuration Guide

GEM Endcap Diameter and Window

Note that there is an “overlap” of coaxial detector efficiency versus endcap diameter. For example, a 25–35% efficiency detector, depending on diameter, may fit in either a -70, -76 or -83 size endcap. The endcap size must be specified by adding the endcap Model (-xx) to the Detector Model (e.g., GEM25-76 or GEM25P4-70).

If this, or any other dimension is critical, please specify at time of order.

Endcap Model (dia. mm)	**-70**	**-76**	**-83**	**-95**	**-108**
Endcap Diameter (in)	2.75	3.00	3.25	3.75	4.25
Efficiency	0–35%	25–45%	25–65%	60–110%	120–150%
Thickness of Al Window	1 mm	1 mm	1 mm	1.5 mm	1.5 mm
Thickness of CF Window	.9 mm nominal	.9 mm nominal	.9 mm nominal	.9 mm nominal	.9 mm nominal

PopTop GEM Detector Dimensions

- Dimensions are for reference only and subject to change.
- If dimensional constraints are critical, contact the factory.

Endcap Model (dia. mm)			-70	-76	-83	-95	-108
% Efficiencies available in this endcap size			0–35	25–45	25–65	60–110	120–150
Dim.	Unit	Tol.					
A	mm (in)	0.3 (0.01)	70 (2.75)	76 (3.0)	83 (3.25)	95 (3.75)	108 (4.25)
B	mm (in)	0.3 (0.01)	75 (2.95)	88 (3.45)	88 (3.45)	100 (3.95)	113 (4.45)
C	mm (in)	5 (0.2)	134 (5.3)	165 (6.4)	168 (6.6)	193 (7.6)	207 (8.2)
D	mm (in)	8 (0.3)	250 (9.8)	282 (11.2)	282 (11.2)	309 (12.2)	323 (12.7)
E	mm (in)	18 (0.7)	947 (37.3)	982 (38.6)	982 (38.6)	1007 (39.7)	1019 (40.1)
F	mm (in)	10 (0.4)	396 (15.6)	429 (16.9)	429 (16.9)	455 (17.9)	469 (18.5)
L	mm (in)	10 (0.4)	338 (13.3)	371 (14.6)	371 (14.6)	396 (15.6)	412 (16.2)
M	mm (in)	8 (0.3)	790 (31.1)	X X	X X	X X	X X
N	mm (in)	10 (0.4)	278 (10.9)	312 (12.3)	312 (12.3)	338 (13.3)	348 (13.7)

Streamline GEM Detector Dimensions

- Dimensions are for reference only and subject to change.
- If dimensional constraints are critical, contact the factory.

			Standard or LB					XLB				
Endcap Model (dia. mm)			-70	-76	-83	-95	-108	-70	-76	-83	-95	-108
% Efficiencies available in this endcap size			0–35	25–45	25–65	60–110	120-150	0–35	25–45	25–65	60–110	120-150
Dim.	Unit	Tol.										
A	mm (in)	0.3 (0.01)	70 (2.75)	76 (3.0)	83 (3.25)	95 (3.75)	108 (4.25)	70 (2.75)	76 (3.0)	83 (3.25)	95 (3.75)	108 (4.25)
B	mm (in)	0.3 (0.01)	75 (2.95)	88 (3.45)	88 (3.45)	100 (3.95)	113 (4.45)	75 (2.95)	88 (3.45)	88 (3.45)	100 (3.95)	113 (4.45)
C	mm (in)	5 (0.2)	134 (5.3)	131 (5.1)	134 (5.3)	160 (6.3)	197 (7.8)	160 (6.3)	157 (6.1)	160 (6.3)	185 (7.3)	197 (7.8)
D	mm (in)	8 (0.3)	246 (9.7)	259 (10.2)	259 (10.2)	284 (11.2)	322 (12.7)	272 (10.7)	284 (11.2)	284 (11.2)	310 (12.2)	322 (12.7)
E	mm (in)	18 (0.7)	916 (36.1)	932 (36.7)	932 (36.7)	957 (37.7)	995 (39.2)	941 (37.1)	958 (37.7)	958 (37.7)	983 (38.7)	995 (39.2)
F	mm (in)	10 (0.4)	368 (14.5)	381 (15.0)	381 (15.0)	406 (16.0)	445 (17.5)	394 (15.5)	406 (16.0)	406 (16.0)	432 (17.0)	445 (17.5)
H	mm (in)	18 (0.7)	351 (13.8)	364 (14.3)	364 (14.3)	390 (15.3)	428 (16.9)	X X	X X	X X	X X	X X
HB	mm (in)	0.3 (0.1)	73 (2.9)	85 (3.4)	85 (3.4)	98 (3.9)	111 (4.4)	X X	X X	X X	X X	X X
HC	mm (in)	5 (0.2)	134 (5.3)	135 (5.3)	135 (5.3)	160 (6.3)	199 (7.8)	X X	X X	X X	X X	X X
HD	mm (in)	10 (0.4)	162 (6.4)	175 (6.9)	175 (6.9)	200 (7.9)	238 (9.4)	X X	X X	X X	X X	X X
J	mm (in)	10 (0.4)	380 (15)	393 (15.5)	393 (15.5)	418 (16.5)	456 (18)	405 (16)	418 (16.5)	418 (16.5)	444 (17.5)	456 (18)
L	mm (in)	10 (0.4)	338 (13.3)	351 (13.8)	351 (13.8)	376 (14.8)	414 (16.3)	363 (14.3)	376 (14.8)	376 (14.8)	401 (15.8)	414 (16.3)
M	mm (in)	8 (0.3)	516 (20.3)	X X	X X	X X	X X	516 (20.3)	X X	X X	X X	X X
N	mm (in)	10 (0.4)	278 (11)	292 (11.5)	292 (11.5)	318 (12.5)	355 (14)	305 (12)	318 (12.5)	318 (12.5)	243 (13.5)	355 (14)

Gamma Gage and Side-Looking Dewar Dimensions

- Dimensions are for reference only and subject to change.
- If dimensional constraints are critical, contact the factory.

			Cryostat/Dewar or Dewar Type							
			CFG-PG4 and DWR-x.xG			CFG-PMOD4 and DWR-MOD-xL		CFG-PS4, CFG-PD4, DWR-xxB and DWR-xxD		
			VOLUME			VOLUME		VOLUME		
Dim.	UNIT	TOL. ±	1.2L	3L	5L	3L	7L	7.5L	13L	30L
Q	mm (in)	13 (0.5)	229 (9.0)	302 (11.9)	302 (11.9)	229 (9.0)	302 (11.9)	X X	X X	X X
R	mm (in)	10 (0.4)	X X	X X	X X	X X	X X	174 (6.9)	174 (6.9)	155 (6.1)
S	mm (in)	7.6 (0.3)	X X	X X	X X	X X	X X	77 (3.0)	77 (3.0)	60 (2.3)
T	mm (in)	5 (0.2)	X X	X X	X X	X X	X X	10 (0.4)	10 (0.4)	13 (0.5)
Y	mm (in)	5 (0.2)	157 (6.2)	229 (9.0)	229 (9.0)	157 (6.2)	229 (9.0)	224 (8.8)	307 (12.1)	442 (17.4)
Z	mm (in)	5 (0.2)	229 (9.0)	267 (10.5)	419 (16.5)	292 (11.5)	320 (12.6)	452 (17.8)	429 (16.9)	610 (24.0)

Example Model Numbers

Streamline Configuration

GEM10-70	10% efficiency GEM detector with 70-mm diameter endcap.
CFG-GG-70	Portable Gamma Gage cryostat with matching 70-mm diameter flange.
DWR-1.2G	1.2 liter all-position dewar for Gamma Gage cryostat.
GEM35-76-SMP	35% efficiency GEM detector with 76-mm diameter endcap and SMART-1 preamplifier and high voltage supply.
CFG-SD-76	Down-looking cryostat with matching 76-mm diameter flange.
DWR-7.5D	7.5 liter down-looking dewar.
GEM50-83-HJ	50% efficiency GEM detector with 83-mm diameter endcap and remote preamplifier and high voltage filter.
CFG-HJ-83	“J” configuration cryostat with matching 83-mm diameter flange, and remote fittings for the preamplifier and high voltage filter.
DWR-30B	30 liter side-looking dewar for “HJ” cryostat.
GEM70-95-LB-C-PL	70% efficiency GEM detector with 95-mm diameter low-background carbon fiber endcap, and Plus preamplifier.
CFG-SV-LB-95	Vertical “dipstick” style cryostat with matching 95-mm diameter flange and low-background charcoal pumping agent.
DWR-30	30 liter top port dewar that accepts “dipstick” style cryostats.

PopTop Configuration

GEM10P4-70	10% efficiency GEM detector with 70-mm diameter endcap.
CFG-PG4-1.2	Portable Gamma Gage cryostat with 1.2 liter all-position dewar.
GEM35P4-76-SMP	35% efficiency GEM detector with 76-mm diameter endcap and SMART-1 preamplifier and high voltage supply.
CFG-PD4-7.5	Downlooking cryostat with 7.5 liter dewar.
GEM50-83-HE	50% efficiency GEM detector with 83-mm diameter carbon fiber endcap with sealed preamplifier and high voltage filter.
CFG-PG4-3	Portable Gamma Gage cryostat with 3 liter all-position dewar.
GEM50P4-83-RB-SMP	50% efficiency GEM detector with 83-mm diameter reduced background carbon fiber endcap and SMART-1 preamplifier and high voltage supply.
CFG-PV4	Vertical “dipstick” style cryostat.
DWR-30	30 liter top port dewar that accepts “dipstick” style cryostats.

GEM Series Coaxial HPGe Detector
Product Configuration Guide

Ordering Information

- For Streamline, remove the “P4” from the model number.
- Endcap Diameter must be specified, see Endcap Diameter.
- 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. The FW.02M/FW.1M specification is typical, not warranted.
- If dimensional considerations are critical, contact factory.
- Cryostat and dewar or other cooling device are not included with detector and are required for operation.
- A cryostat must be ordered with a Streamline detector.
- Monte Carlo drawing included.

Model No.	Efficiency (%)	Resolution @122 keV (keV)	Resolution @1.33 MeV (keV)	Peak-to-Compton Ratio	Peak Shape FW.1M\ FWHM	Peak Shape FW.02M/ FWHM typical	Endcap Diameter (mm)
GEM150P4	150	1.30	2.3	90:1	2.0	3.1	-108
GEM140P4	140	1.30	2.2	90:1	2.0	3.1	-108
GEM130P4	130	1.30	2.1	90:1	2.0	3.1	-108
GEM120P4	120	1.30	2.1	86:1	2.0	3.1	-108
GEM110P4	110	1.30	2.1	85:1	2.0	3.0	-95
GEM100P4	100	1.20	2.1	83:1	2.0	3.0	-95
GEM90P4	90	1.20	2.0	80:1	2.0	3.0	-95
GEM80P4	80	1.10	2.0	77:1	2.0	3.0	-95
GEM75P4	75	1.10	2.0	77:1	2.0	3.0	-95
GEM70P4	70	1.00	2.0	75:1	2.0	3.0	-95
GEM65P4	65	1.00	1.95	73:1	1.9	3.0	-83, -95
GEM60P4	60	1.00	1.95	70:1	1.9	3.0	-83, -95
GEM55P4	55	1.00	1.90	67:1	1.9	2.8	-83
GEM50P4	50	0.90	1.90	66:1	1.9	2.6	-83
GEM45P4	45	0.90	1.90	64:1	1.9	2.6	-76, -83
GEM40P4	40	0.87	1.85	64:1	1.9	2.6	-76, -83
GEM35P4	35	0.85	1.85	62:1	1.9	2.6	-70, -76, -83
GEM30P4	30	0.85	1.85	60:1	1.9	2.6	-70, -76, -83
GEM25P4	25	0.82	1.85	56:1	1.9	2.6	-70, -76, -83
GEM20P4	20	0.82	1.80	52:1	1.9	2.6	-70
GEM15P4	15	0.82	1.80	46:1	1.9	2.6	-70
GEM10P4	10	0.80	1.75	41:1	1.9	2.6	-70

GEM Detector Options

-RB PopTop Only. Reduced background PopTop capsule with Carbon Fiber endcap, add “-RB” to the model number. Not compatible with -HE option.

-HE PopTop Only. Harsh Environment Option for PopTop detectors 76 mm and larger, add “-HE” to the model number. Not compatible with -RB option.

-PL PLUS Ultra-high-count-rate Preamplifier, add “-PL” to the model number. Not compatible with -HJ option.

-SMP SMART-1 detector option for positive bias detector, add “-SMP” to the model number. Not compatible with -HJ option.

-LB-C Streamline Only. Low-Background Detector with Carbon Fiber Endcap, add “-LB-C” to the model number. Requires selection of a Low-Background LB cryostat.

-XLB-C Streamline Only. Extra-Low-Background Detector with Carbon Fiber Endcap, add “-XLB-C” to the model number. Requires selection of a Low-Background XLB cryostat. Not compatible with -HJ option.

-HJ Streamline Only. Remote preamplifier and high voltage filter for use with HJ type cryostat, add “-HJ” to the model number. Requires selection of HJ cryostat. Not compatible with -PL, -SMP, or -XLB-C options.

GEM PopTop Cryostats and Dewars

• Dewar included except where marked *.

Model No.	Description
CFG-MG4-1.2G	Gamma Gage Cryostat with 1.2-liter Dewar, Pistol Grip handle and mounting holes to fit the M-1-T1 Tripod (for 83 mm or smaller endcaps)
CFG-PD4-7.5	Down-looking Cryostat with 7.5-liter Dewar
CFG-PD4-13	Down-looking Cryostat with 13-liter Dewar
CFG-PD4-30	Down-looking Cryostat with 30-liter Dewar
CFG-PG4-1.2	Gamma Gage Cryostat with 1.2-liter Dewar (for 83 mm or smaller endcaps) (not compatible with -HE option)
CFG-PG4-3	Gamma Gage Cryostat with 3-liter Dewar
CFG-PG4-5	Gamma Gage Cryostat with 5-liter Dewar
CFG-PH4	Horizontal Cryostat (Dipstick type). Includes LNTC1.5WH. Dewar not included.* Choose DWR-30 or DWR-30-OP.
CFG-PMOD4-3	Gamma Gage Cryostat with 3-liter Multi-Orientation Dewar
CFG-PMOD4-7	Gamma Gage Cryostat with 7-liter Multi-Orientation Dewar
CFG-PS4-7.5	Side-Looking Cryostat with 7.5-liter Dewar
CFG-PS4-13	Side-Looking Cryostat with 13-liter Dewar
CFG-PS4-30	Side-Looking Cryostat with 30-liter Dewar
CFG-PSHP4	Down-Looking Shallow-Hole Probe with 0.7-liter Dewar
CFG-PV4	Vertical Cryostat (Dipstick type). Includes LNTC1.5WH. Dewar not included.* Choose DWR-30 or DWR-30-OP.
DWR-30	30-liter Dewar
DWR-30-OP	30-liter Offset-Port Dewar
DWR-S/F	Storage Fill Dewar for CFG-PG4-X
CFG-X-COOL-II-115	X-COOLER II with PopTop connector using 110-120 V ac, 60 Hz Input Power
CFG-X-COOL-II-230	X-COOLER II with PopTop connector using 220-240 V ac, 50 Hz Input Power

GEM Series Coaxial HPGe Detector Product Configuration Guide

GEM Streamline Cryostats

- Select dewar from GEM Streamline Dewars. Dewar included except where marked*.
- Append matching Detector Endcap Size designation to cryostat model: -70, -76, -83, -95, -108 [e.g., CFG-SJ-95 for GEM75-95 or CFG-SL-XLB-76 for GEM25-76-XLB-C]

Model No.	Description
CFG-GG	Gamma Gage Cryostat Dewar
CFG-HJ	J-type Cryostat with Remote Preamp and Dewar. (for -HJ option only)
CFG-SD	Down-Looking Cryostat with Dewar
CFG-SH	Horizontal Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
CFG-SJ	J-type Cryostat with Dewar
CFG-SL	Side-Looking Cryostat with Dewar
CFG-SV	Vertical Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
LOW-BACKGROUND	
CFG-GG-LB	Low-Background Gamma Gage Cryostat with Dewar
CFG-HJ-LB	Low-Background J-type Cryostat with Remote Preamp and Dewar. (for -HJ option only)
CFG-SD-LB	Low-Background Down-Looking Cryostat with Dewar
CFG-SH-LB	Low-Background Horizontal Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
CFG-SJ-LB	Low-Background J-type Cryostat with Dewar
CFG-SL-LB	Low-Background Side-Looking Cryostat with Dewar
CFG-SV-LB	Low-Background Vertical Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
CFG-SD-XLB	Extra-Low-Background Down-Looking Cryostat with Dewar
CFG-SH-XLB	Extra-Low-Background Horizontal Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
CFG-SJ-XLB	Extra-Low-Background J-type Cryostat with Dewar
CFG-SL-XLB	Extra-Low-Background Side-Looking Cryostat with Dewar
CFG-SV-XLB	Extra-Low-Background Vertical Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*

GEM Streamline Dewars

For Cryostat	Choose	Description	
CFG-GG	DWR-1.2G	1.2-liter All-Orientation Dewar	Included with Cryostat
	DWR-3.0G	3.0-liter All-Orientation Dewar	Included with Cryostat
	DWR-5.0G	5.0-liter All-Orientation Dewar	Included with Cryostat
	DWR-MOD-3L	3-liter Multi-Orientation Dewar	Included with Cryostat
	DWR-MOD-7L	7-liter Multi-Orientation Dewar	Included with Cryostat
	DWR-0.7-SHP-1	0.7-liter Shallow-Hole Probe Dewar	Included with Cryostat
	DWR-S/F	Storage/Fill Dewar for DWR-XG	
CFG-HJ, SJ, SL	DWR-7.5B	7.5-liter Side-Looking Dewar	Included with Cryostat
	DWR-13B	13-liter Side-Looking Dewar	Included with Cryostat
	DWR-30B	30-liter Side-Looking Dewar	Included with Cryostat
CFG-SD	DWR-7.5D	7.5-liter Down-Looking Dewar	Included with Cryostat
	DWR-13D	13-liter Down-Looking Dewar	Included with Cryostat
	DWR-30D	30-liter Down-Looking Dewar	Included with Cryostat
CFG-SV, SH	DWR-30-OP	30-liter Offset-Port Dewar	
	DWR-30	30-liter Dewar	

Specifications subject to change
072910

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GLP Series Planar HPGe Low-Energy Detector Product Configuration Guide

- Excellent energy resolution in the 3 to 300 keV range
- Active area from 30 to 1000 mm^2
- PopTop flexibility
- Unequaled timing performance
- Detectors larger than 36-mm diameter available
- Available with special feedback resistor for high-rate applications
- POF preamplifier option for superior energy resolution and high count rate at low energies

The ORTEC GLP Series Planar Low-Energy Photon Spectrometer (LEPS) is a small-area, high-purity germanium photon spectrometer for use in applications over the energy range from 3 to ~300 keV.

Available in diameters from 6 to 36 mm, the LEPS offers exceptional energy resolution for low and intermediate energies. At low energies in nuclear structure physics GLP detectors are irreplaceable because of their excellent timing performance (see Table 1).

A cross sectional drawing of a 16-mm LEPS is shown in Figure 1.

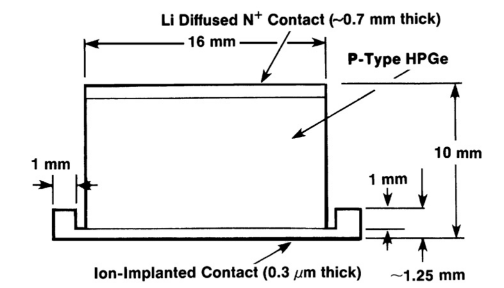


Fig. 1. 16-mm Diameter, 10-mm Deep GLP Detector.

Table 1. Timing at Low Energies with 10 cm^2 Active Area Planar Detectors*.

Source	Energy (keV)	Time Resolution(ns)
^{22}Na	20 ±10 100 ±10 511 ±5	20 ±2 8.5 ±1 4.5 ±0.2
^{133}Ba	31 ±3 81 ±3 85 ±5 356 ±5	19 ±2 Isomer 11 ±1 6.0 ±0.5
^{152}Eu	41 ±3 122 ±5 125 ±5 344 ±5 779 ±5	15 ±1 Isomer 6.5 ±0.5 5.0 ±0.2 3.8 ±0.3

*Data courtesy of Dr. Kim Lister, Argonne National Lab.

The Following Specifications are Provided for Each Model GLP Detector

- Active crystal diameter and depth.
- Energy resolution at 5.9 keV photons from ^{55}Fe at optimum shaping time unless the window material prohibits this energy.
- Energy resolution at 122 keV photons from ^{57}Co at optimum shaping time.

Configuration Guidelines

PopTop or Streamline (non-PopTop) Configuration

The essence of a PopTop detector system is that the HPGe detector element cryostat, preamplifier, and high voltage filter are housed in a detector "capsule" which is then attached to an appropriate cryostat (Figure 2.)

In so called Streamline systems, the detector capsule in NOT demountable. Detector capsule and cryostat share the same vacuum. In configuration terms, this requires a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap. A cryostat must always be ordered with a Streamline capsule, because they are integral.

The actual PopTop capsule has its own vacuum. It can be mounted on any of the available cryostats, cryostat/dewar combinations, or the X-COOLER II mechanical cooling system.

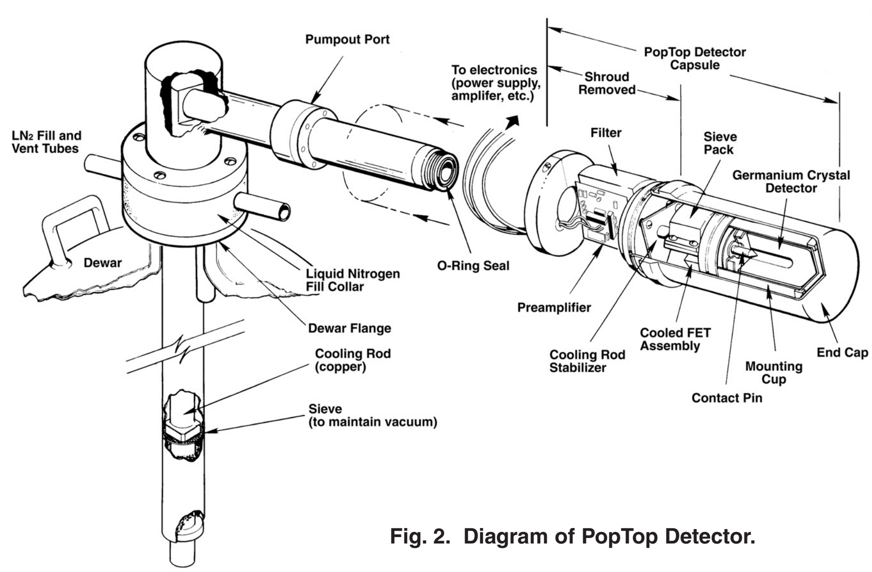


Fig. 2. Diagram of PopTop Detector.

GLP Series Planar
HPGe Low-Energy Detector
Product Configuration Guide

Steps to Configure Your ORTEC HPGe Detector

1) Configure the Detector Model

- Capsule type (PopTop or Streamline)
- Ge Crystal dimensions and specifications
- Endcap and window
- Mount
- Preamplifier
- High Voltage Filter
- Cable Package

Options are available for the detector model that can change specific materials used in the construction of the detector endcap, cup, and mount. Preamplifier options are also available.

2) Configure the Cryostat/Dewar Model

- Vertical Dipstick style (separate Dewar)
- Horizontal Dipstick style (separate Dewar)
- Portable with all-position or multi-position cryostat/dewar models
- Downlooking designed to be oriented with the detector pointing down
- Sidelooking designed to be oriented with the detector horizontal at the bottom of the dewar
- "SJ" configuration designed with the detector attached near the bottom of the dewar and a right angle bend in the cryostat orienting the detector to look up.

A cryostat and dewar or other cooling device are required for operation.

If a PopTop detector has been selected, you can choose a PopTop style cryostat, cryostat/dewar combination or the X-COOLER II mechanical cooler.

If a Streamline detector has been selected, you must choose a cryostat or cryostat/dewar model for the detector to be mounted on and vacuum sealed. The cryostat or cryostat/dewar combination diameter must match the endcap diameter of the selected detector.

Detector Options

SMART-1 Option (-SMN)

The SMART-1 option monitors and reports on vital system functions, and can save authentication codes and report the code at a later time. It has the high voltage included, so none of the instruments require an external high-voltage power supply.

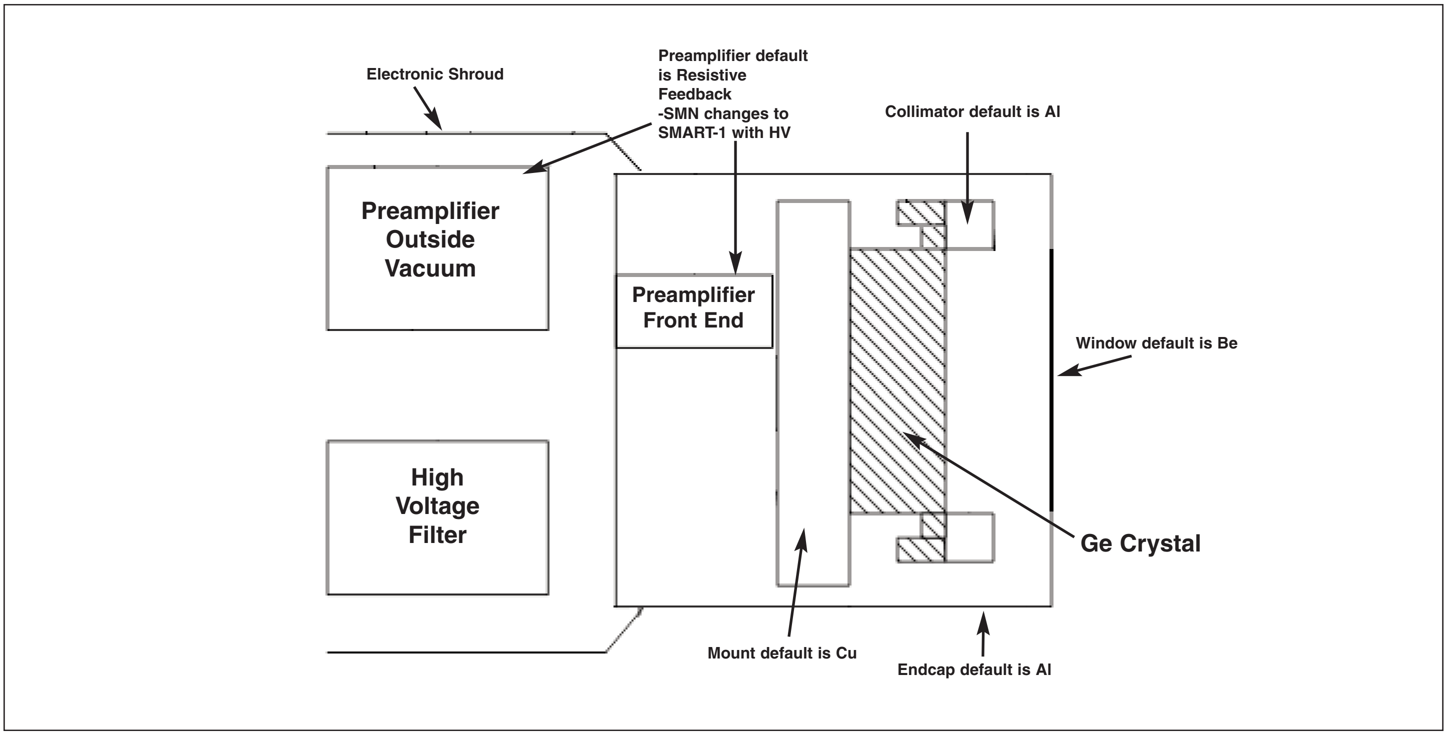
The SMART-1 is housed in a rugged ABS molded plastic enclosure and is permanently attached to the detector endcap via a molded-strain-relieved sealed cable. This eliminates the possibility that the detector will suffer severe damage from moisture leaking into high-voltage connectors. The SMART-1 can be positioned in any convenient place and does not interfere with shielding or other mounting hardware.

SMART-1 Detector Interface Module.

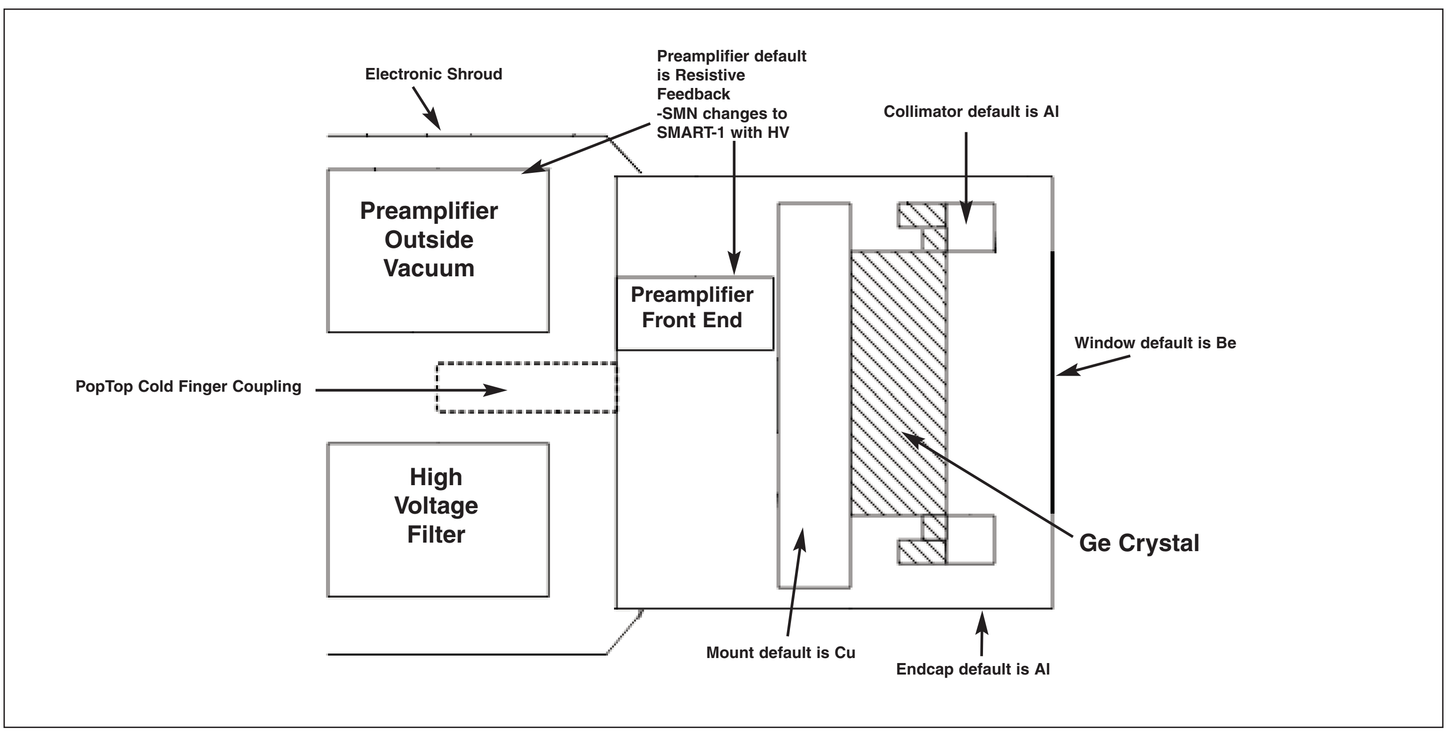
Defining the Detector Model

Base Model (example)	PopTop or Streamline	High Voltage Option (if required)
GLP-061695/05	P4 (PopTop) (Streamline)	-SMN

Streamline Detector Capsule



PopTop Detector Capsule



GLP Series Planar
HPGe Low-Energy Detector
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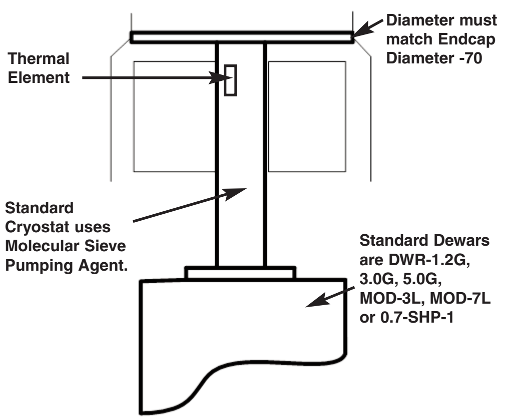
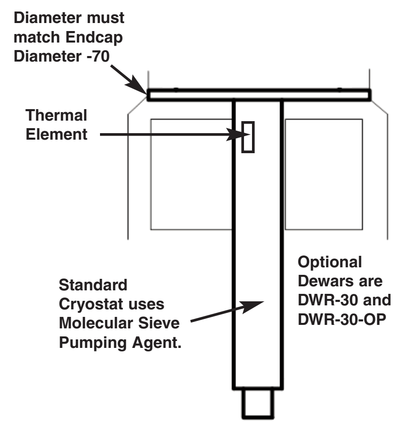
Streamline Cryostat and Cryostat/Dewar Assemblies

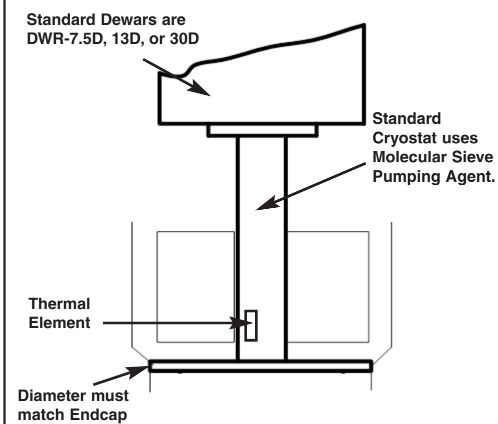
Streamline systems (detector capsule and cryostat) share the same vacuum, requiring a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap.



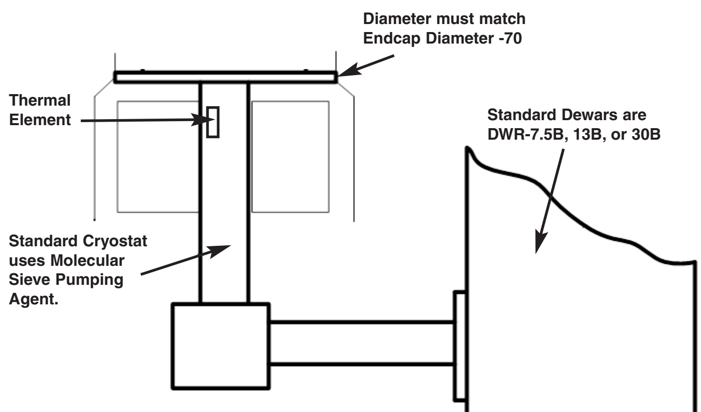
CFG-LP-GG



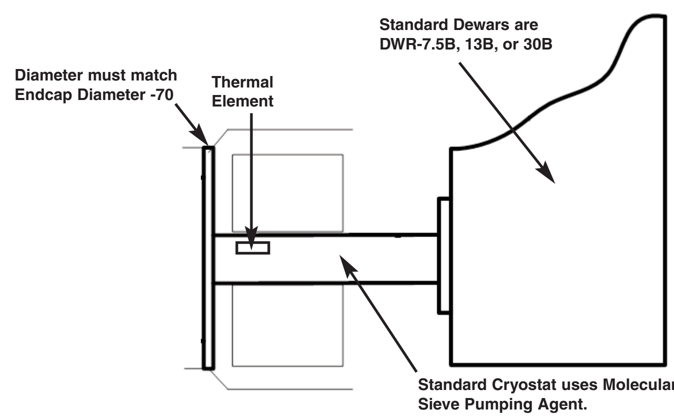
CFG-LP-SV



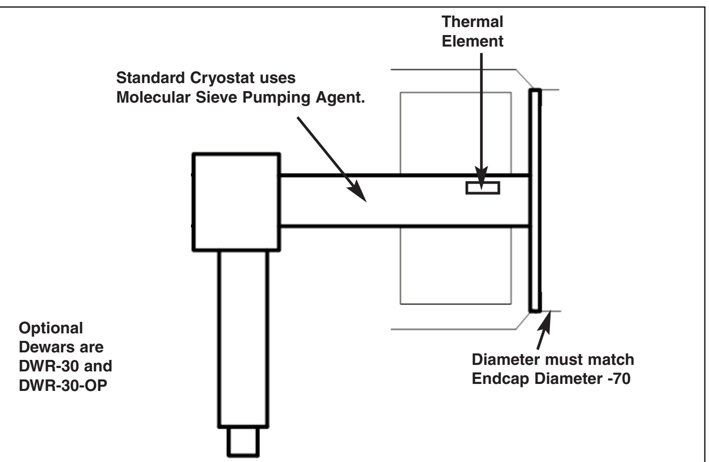
CFG-LP-SD



CFG-LP-SJ



CFG-LP-SL



CFG-LP-SH

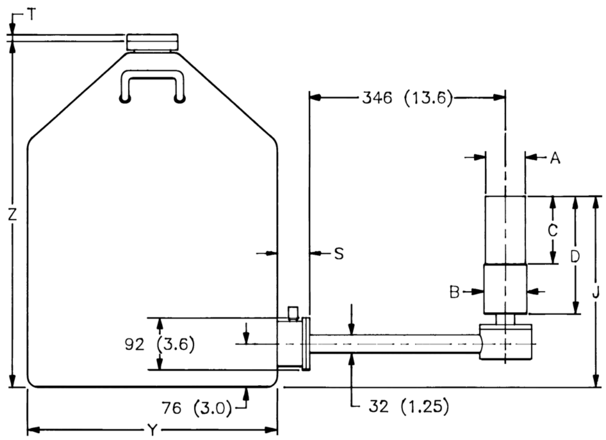
PopTop and Streamline Dimensional Data

Streamline systems (detector capsule and cryostat) share the same vacuum, requiring a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap. A cryostat must be ordered with a Streamline capsule.

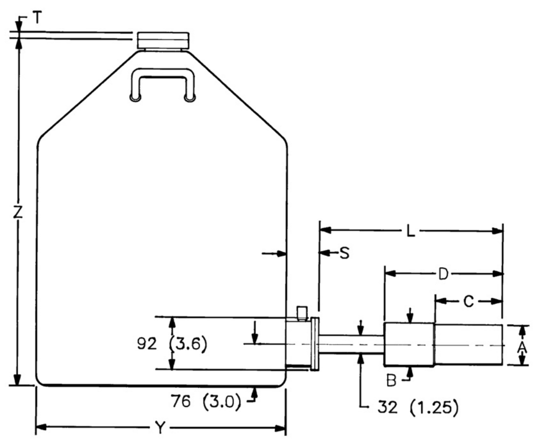
The PopTop capsule contains a vacuum unto itself. It can be mounted on any of the available cryostats, cryostat/dewar combinations, or the X-COOLER II mechanical cooling system.

The cryostat and dewar drawings that follow are to be used in conjunction with the accompanying tables of dimensions.

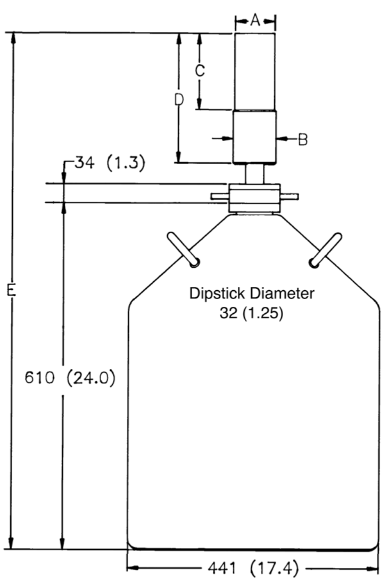
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



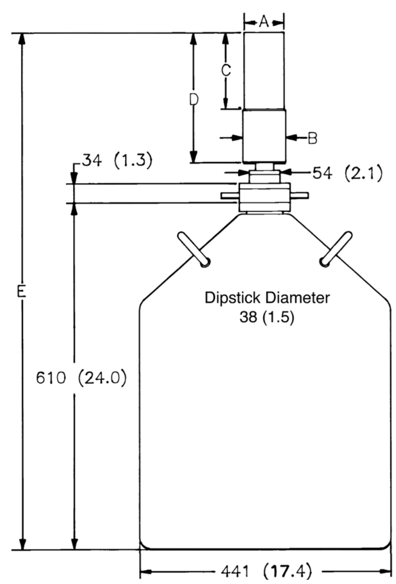
CFG-LP-SJ, DWR-30B (or -13B or -7.5B)



CFG-PS4-30 (or -13 or -7.5)
or
CFG-LP-SL, DWR-30B (or -13B or -7.5B)

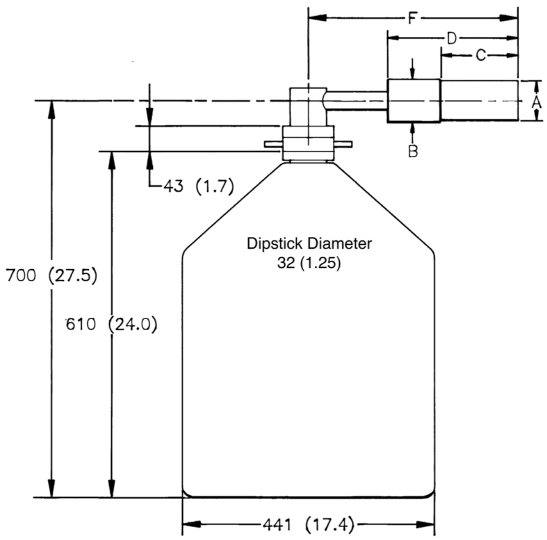


CFG-LP-SV, DWR-30

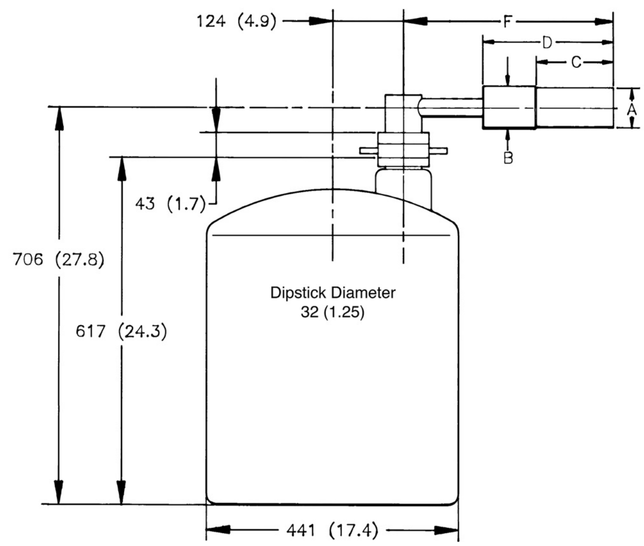


CFG-PV4, DWR-30

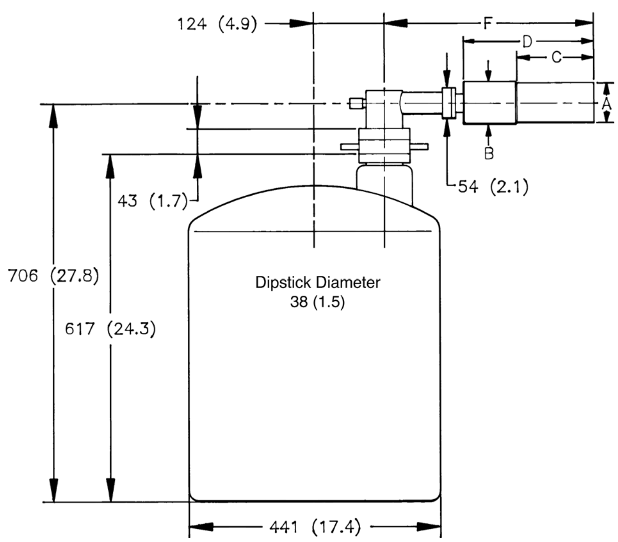
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



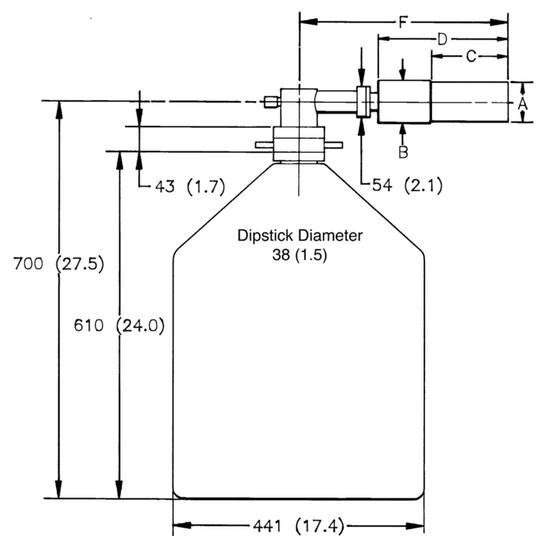
CFG-LP-SH, DWR-30



CFG-LP-SH, DWR-30-OP

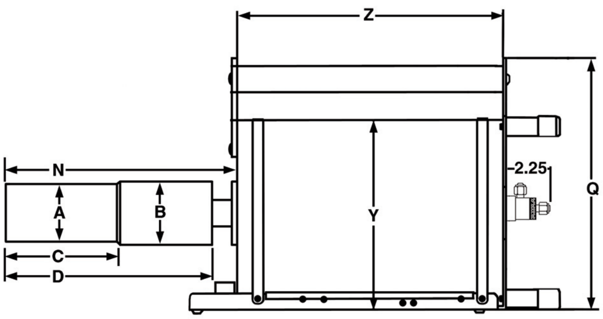


CFG-PH4, DWR-30-OP

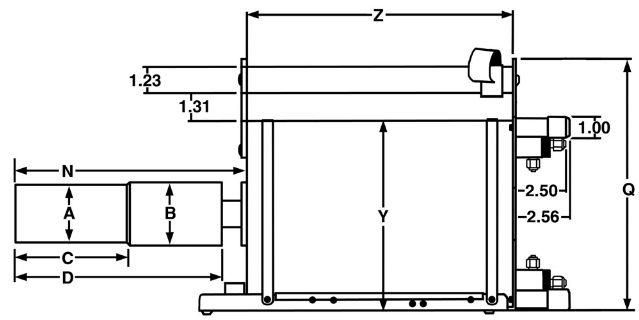


CFG-PH4, DWR-30

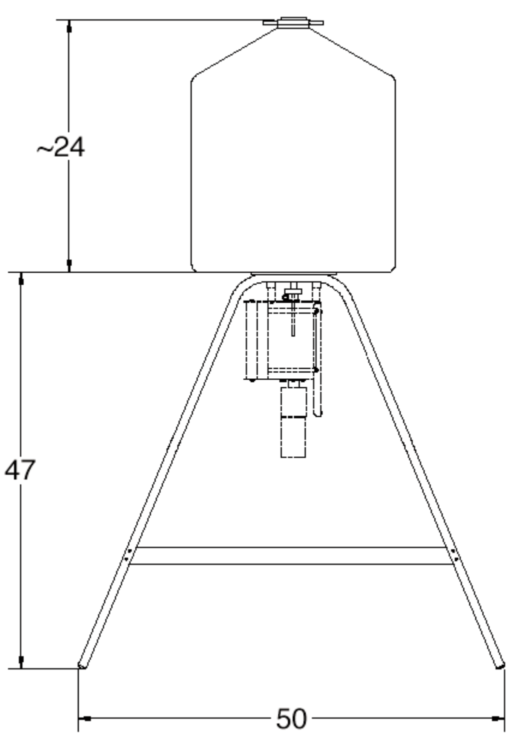
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



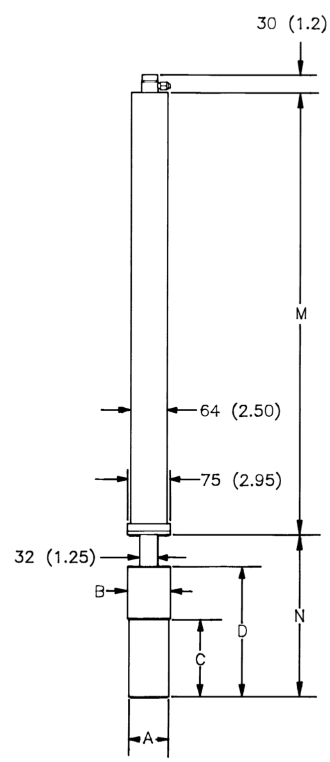
CFG-PG4-1.2 (or -3 or -5)
or
CFG-LP-GG, DWR-1.2G (or -3.0G, -5.0G)



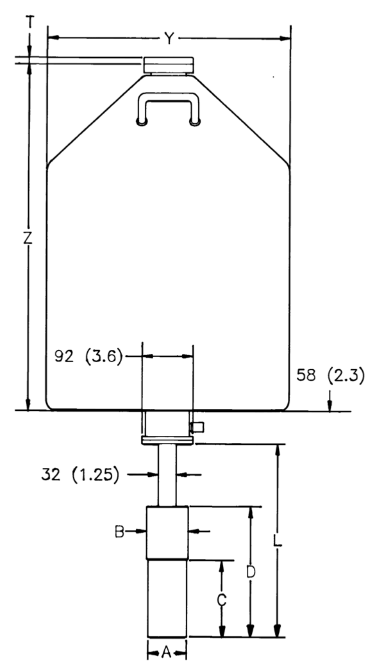
CFG-PMOD4-3 (or -7)
or
CFG-LP-GG, DWR-MOD3L (or -MOD7L)



DWR-S/F



CFG-PSHP4
or
CFG-LP-GG, DWR-0.7-SHP-1



CFG-PD4-30 (or -13 or -7.5)
or
CFG-LP-SD, DWR-30D (or -13D or -7.5D)

GLP Series Planar
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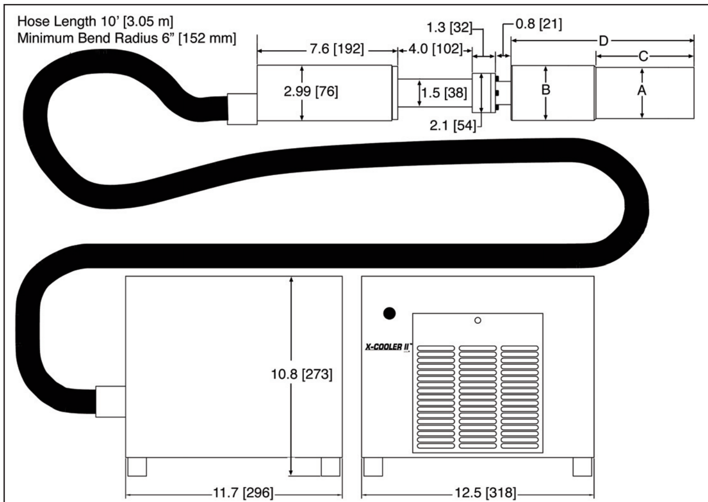


CFG-X-COOL-II

GLP Detector Dimensions

- Dimensions are for reference only and subject to change.
- If dimensional constraints are critical, contact the factory.

Dim.	Unit	Tol.	PopTop	Streamline
A	mm (in)	0.3 (0.01)	70 (2.75)	70 (2.75)
B	mm (in)	0.3 (0.01)	75 (2.95)	75 (2.95)
C	mm (in)	5 (0.2)	135 (5.3)	71 (2.8)
D	mm (in)	8 (0.3)	250 (9.8)	182 (7.2)
E	mm (in)	8 (0.3)	947 (37.3)	854 (33.6)
F	mm (in)	18 (0.7)	396 (15.6)	305 (12.0)
J	mm (in)	10 (0.4)	X X	318 (12.5)
L	mm (in)	18 (0.7)	338 (13.3)	274 (10.8)
M	mm (in)	10 (0.4)	790 (31.1)	X X
N	mm (in)	8 (0.3)	278 (10.9)	215 (8.5)

Gamma Gage and Side-Looking Dewar Dimensions

- Dimensions are for reference only and subject to change.
- If dimensional constraints are critical, contact the factory.

			Cryostat/Dewar or Dewar Type							
			CFG-PG4 and DWR-x.xG			CFG-PMOD4 and DWR-MOD-xL		CFG-PS4, CFG-PD4, DWR-xxB and DWR-xxD		
			VOLUME			VOLUME		VOLUME		
Dim.	UNIT	TOL. ±	1.2L	3L	5L	3L	7L	7.5L	13L	30L
Q	mm (in)	13 (0.5)	229 (9.0)	302 (11.9)	302 (11.9)	229 (9.0)	302 (11.9)	X X	X X	X X
S	mm (in)	7.6 (0.3)	X X	X X	X X	X X	X X	77 (3.0)	77 (3.0)	60 (2.3)
T	mm (in)	5 (0.2)	X X	X X	X X	X X	X X	10 (0.4)	10 (0.4)	13 (0.5)
Y	mm (in)	5 (0.2)	157 (6.2)	229 (9.0)	229 (9.0)	157 (6.2)	229 (9.0)	224 (8.8)	307 (12.1)	442 (17.4)
Z	mm (in)	5 (0.2)	229 (9.0)	267 (10.5)	419 (16.5)	292 (11.5)	320 (12.6)	452 (17.8)	429 (16.9)	610 (24.0)

Example Model Numbers

Streamline Configuration

GLP-06165/05	6-mm diameter, 5-mm deep GLP planar detector with 70-mm diameter endcap.
CFG-LP-GG-70	Portable Gamma Gage cryostat with matching 70-mm diameter flange.
DWR-1.2G	1.2 liter all-position dewar for Gamma Gage cryostat.
GLP-36385/10	36-mm diameter, 10-mm deep GLP detector with 70-mm diameter endcap.
CFG-LP-SD-70	Downlooking cryostat with matching 70-mm diameter flange.
DWR-7.5D	7.5 Liter downlooking dewar for downlooking cryostat.
GLP-16195/10-SMN	16-mm diameter, 10-mm deep GLP detector with 70-mm diameter endcap and SMART-1 preamplifier and high voltage supply.
CFG-LP-SV-70	Vertical “dipstick” style cryostat with matching 70-mm diameter flange.
DWR-30	30 liter top port dewar that accepts “dipstick” style cryostats.

PopTop Configuration

GLP-36360/13P4-SMN	36-mm diameter, 13-mm deep GLP detector with 70-mm diameter endcap and SMART-1 preamplifier and high voltage supply.
CFG-PG-3	Portable Gamma Gage cryostat with 3 liter all-position dewar.
GLP-10180/07P4	10-mm diameter, 7-mm deep GLP detector with 70-mm diameter endcap.
CFG-PD4-7.5	Downlooking cryostat with 7.5 liter dewar.

GLP Series Planar
HPGe Low-Energy Detector
Product Configuration Guide

Ordering Information

- For Streamline, remove the "P4" from the model number.
- If dimensional considerations are critical, contact factory.
- Cryostat and dewar or other cooling device are not included with detector.
- Cryostat and dewar or other cooling device are required for operation.
- A cryostat must be ordered with a Streamline detector.

Model No.	Active Diameter (mm)	Dimensions		Energy Resolution FWHM		Endcap Diameter (mm)	Be Window Thickness (mm)
		Area (mm^2)	Depth (mm)	@5.9 keV (eV)	@122 keV (eV)		
GLP-06165/05P4	≥6	≥28	≥5	≤165	≤480	70	0.13
GLP-10180/07P4	10	80	7	180	485	70	0.13
GLP-16195/10P4	16	200	10	205	525	70	0.13
GLP-25325/10P4	25	500	10	325	550	70	0.25
GLP-25300/13P4	25	500	13	300	545	70	0.25
GLP-32355/10P4	32	800	10	355	580	70	0.25
GLP-32340/13P4	32	800	13	340	570	70	0.25
GLP-36385/10P4	36	1000	10	385	595	70	0.25
GLP-36360/13P4	36	1000	13	360	585	70	0.25

GLP Detector Options

-SMN	SMART-1 detector option for negative bias detector, add "-SMN" to the model number.

GLP PopTop Cryostats and Dewars

- Dewar included except where marked *.

Model No.	Description
CFG-PD4-7.5	Down-looking Cryostat with 7.5-liter Dewar
CFG-PD4-13	Down-looking Cryostat with 13-liter Dewar
CFG-PD4-30	Down-looking Cryostat with 30-liter Dewar
CFG-PG4-1.2	Gamma Gage Cryostat with 1.2-liter Dewar
CFG-PG4-3	Gamma Gage Cryostat with 3-liter Dewar
CFG-PG4-5	Gamma Gage Cryostat with 5-liter Dewar
CFG-PH4	Horizontal Cryostat (Dipstick type). Includes LNTC1.5WH. Dewar not included.* Choose DWR-30 or DWR-30-OP.
CFG-PMOD4-3	Gamma Gage Cryostat with 3-liter Multi-Orientation Dewar
CFG-PMOD4-7	Gamma Gage Cryostat with 7-liter Multi-Orientation Dewar
CFG-PS4-7.5	Side-Looking Cryostat with 7.5-liter Dewar
CFG-PS4-13	Side-Looking Cryostat with 13-liter Dewar
CFG-PS4-30	Side-Looking Cryostat with 30-liter Dewar
CFG-PSHP4	Down-Looking Shallow-Hole Probe with 0.7-liter Dewar
CFG-PV4	Vertical Cryostat (Dipstick type). Includes LNTC1.5WH. Dewar not included.* Choose DWR-30 or DWR-30-OP.
DWR-30	30-liter Dewar
DWR-30-OP	30-liter Offset-Port Dewar
DWR-S/F	Storage Fill Dewar for CFG-PG4-X
CFG-X-COOL-II-115	X-COOLER II with PopTop connector using 110-120 V ac, 60 Hz Input Power
CFG-X-COOL-II-230	X-COOLER II with PopTop connector using 220-240 V ac, 50 Hz Input Power

GLP Streamline Cryostats

• Select dewar from GLP Streamline Dewars. Dewar included except where marked*.

Model No.	Description
CFG-LP-GG-70	Gamma Gage Cryostat Dewar
CFG-LP-SD-70	Down-Looking Cryostat with Dewar
CFG-LP-SH-70	Horizontal Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
CFG-LP-SJ-70	J-type Cryostat with Dewar
CFG-LP-SL-70	Side-Looking Cryostat with Dewar
CFG-LP-SV-70	Vertical Cryostat with (Dipstick type). Includes LNTC1.25WH. Dewar not included.*

GLP Streamline Dewars

For Cryostat	Choose	Description	
CFG-LP-GG	DWR-1.2G	1.2-liter All-Orientation Dewar	Included with Cryostat
	DWR-3.0G	3.0-liter All-Orientation Dewar	Included with Cryostat
	DWR-5.0G	5.0-liter All-Orientation Dewar	Included with Cryostat
	DWR-MOD-3L	3-liter Multi-Orientation Dewar	Included with Cryostat
	DWR-MOD-7L	7-liter Multi-Orientation Dewar	Included with Cryostat
	DWR-0.7-SHP-1	0.7-liter Shallow-Hole Probe Dewar	Included with Cryostat
	DWR-S/F	Storage/Fill Dewar for DWR-XG	
CFG-LP-SJ, SL	DWR-7.5B	7.5-liter Side-Looking Dewar	Included with Cryostat
	DWR-13B	13-liter Side-Looking Dewar	Included with Cryostat
	DWR-30B	30-liter Side-Looking Dewar	Included with Cryostat
CFG-LP-SD	DWR-7.5D	7.5-liter Down-Looking Dewar	Included with Cryostat
	DWR-13D	13-liter Down-Looking Dewar	Included with Cryostat
	DWR-30D	30-liter Down-Looking Dewar	Included with Cryostat
CFG-LP-SV, SH	DWR-30-OP	30-liter Offset-Port Dewar	
	DWR-30	30-liter Dewar	

ORTEC®

GMX Series Coaxial HPGe Detector Product Configuration Guide

GAMMA-X: N-type Coaxial HPGe Detectors for High-Performance Gamma Spectroscopy in the Energy Range of ~3 keV and Upward

The GAMMA-X detector is a coaxial Germanium (Ge) detector with an ultra-thin entrance window. While most coaxial detectors have entrance windows from 500- to 1000-µm thick, the entrance window of the GAMMA-X detector is a 0.3-µm-thick, ion-implanted contact, extending the lower range of useful energies to around 3 keV. Ion implantation results in a totally stable contact which will not deteriorate with repeated cycling. Moreover, N-type HPGe detectors have been shown to be resistant to damage by fast neutrons.

All GAMMA-X Series detectors feature:

- Efficiencies to 100%, higher on request.
- Spectroscopy from 3 keV to 10 MeV.
- ULTRA thin boron ion implanted radiation window, ideal for Compton Suppression systems.
- Neutron damage resistant; user self-repair neutron damage option.
- Excellent energy resolutona nd peak symmetry.
- SMART bias option.
- Harsh Environment (-HE) option.
- Be window supplied with protective cover; Al or carbon fiber window option available at no additional charge.
- Low-background carbon fiber endcap option.
- PLUS preamplifier option for ultra-high-rate applications.
- Huge configuration flexibility, PopTop, Streamline, and mechanically cooled options.

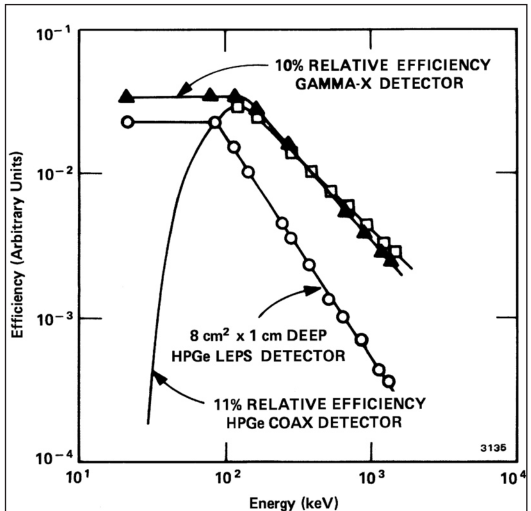


Fig. 1. Comparison of the Efficiency-Energy Curve of the LEPS, HPGe Coaxial, and GAMMA-X Detectors.

GAMMA-X Series detectors are manufactured from ORTEC- grown germanium crystals processed in our advanced manufacturing facility in Oak Ridge, TN. The detectors are fabricated from N-type germanium with an inner contact of diffused Li and an outer, ultra thin, contact of ion-implanted boron.

The wide energy range of application of the GAMMA-X detector is illustrated in Figure 1 which compares the relative efficiencies of a GAMMA-X, a GEM (P-type coaxial), and a GLP planar detector. The GAMMA-X detector, uniquely, demonstrates excellent efficiency at both high and low energies.

ORTEC offers GMX Series HPGe detectors with relative efficiencies from 10% to 100% and beyond.

ORTEC maintains a large stocklist of HPGe detectors. Some of these have "super specifications," that is, a warranted energy resolution better than the usual warranted specifications.

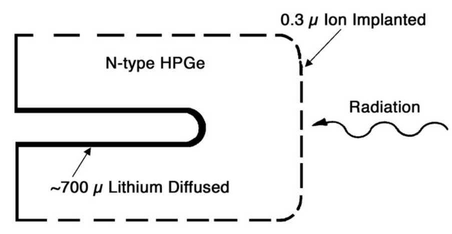


Fig. 2. Configuration of GMX Coaxial Germanium Crystal.

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 is 20.

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

22-keV Peak/88-keV Peak Area

This specification quantifies the thinness of the entrance window in GAMMA-X detectors. The natural ratio of gamma rays from the 22-keV and 88-keV lines of a ^{109}Cd source is ~21:1. A GAMMA-X detector typically displays a ration >20:1.

GMX Series Coaxial HPGe Detector Product Configuration Guide

Beryllium Window

GMX detectors in 70-mm (2.75-in.) or 76-mm (3-in.) diameter endcaps (10 to ~35%) are supplied with 51-mm (2-in.) diameter Be windows. GMX detectors in 83-mm (3.25-in.) diameter endcaps (~30 to 65%) are supplied with 64-mm (2.5-in.) diameter Be windows. These windows are 0.020-in. thick and have a transmission coefficient of ~95% at 5.9-keV. Detectors in 95-mm (3.75-in.) diameter endcaps (~60 to 100%) receive a 84-mm (3.3-in.) diameter Be window that is 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.

Neutron Damage Resistance

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 3, 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.

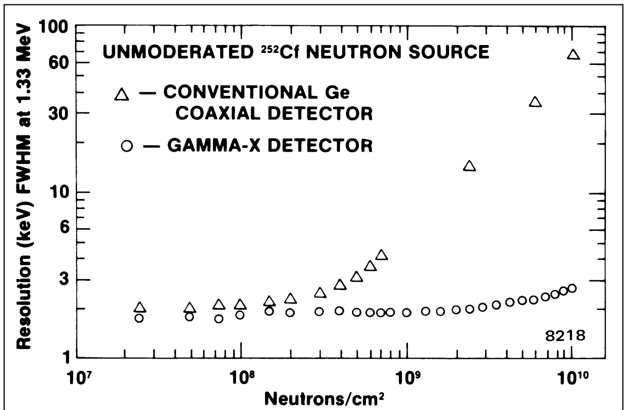


Fig. 3. Effect of Neutron Fluence on the Energy Resolution (FWHM) of the 1332-keV ^{60}Co Line for Both Conventional and Reverse-Electrode Configuration Ge Coaxial Detectors. (Electronic noise has not been subtracted).

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.

The Following Specifications are Provided for each GMX Detector

- Energy resolution at 1.33-MeV photons from ^{60}Co at optimum shaping time.
- Relative Photopeak efficiency for a ^{60}Co 1.33-MeV peak.
- Peak-to-Compton ratio for a ^{60}Co 1.33-MeV peak.
- Peak shape ratio for the full-width tenth-maximum to the full-width half-maximum for a ^{60}Co 1.33-MeV peak.
- Energy resolution at 5.9-keV photons from ^{55}Fe at optimum shaping time unless the window material prevents detection at this energy.

[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).

Configuration Guidelines

PopTop or Streamline (non-PopTop) Configuration

The essence of a PopTop detector system is that the HPGe detector element cryostat, preamplifier, and high voltage filter are housed in a detector “capsule” which is then attached to an appropriate cryostat (Figure 4.)

In so called Streamline systems, the detector capsule in NOT demountable. Detector capsule and cryostat share the same vacuum. In configuration terms, this requires a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap. A cryostat must always be ordered with a Streamline capsule, because they are integral.

The actual PopTop capsule has its own vacuum. It can be mounted on any of the available cryostats, cryostat/dewar combinations, or the X-COOLER II mechanical cooling system.

Steps to Configure Your ORTEC HPGe Detector

1) Configure the Detector Model

- Capsule type (PopTop or Streamline)
- Ge Crystal efficiency and specifications
- Endcap and window
- Mount
- Preamplifier
- High Voltage Filter
- Cable Package

Options are available for the detector model that can change specific materials used in the construction of the detector endcap, cup, and mount. Preamplifier options are also available.

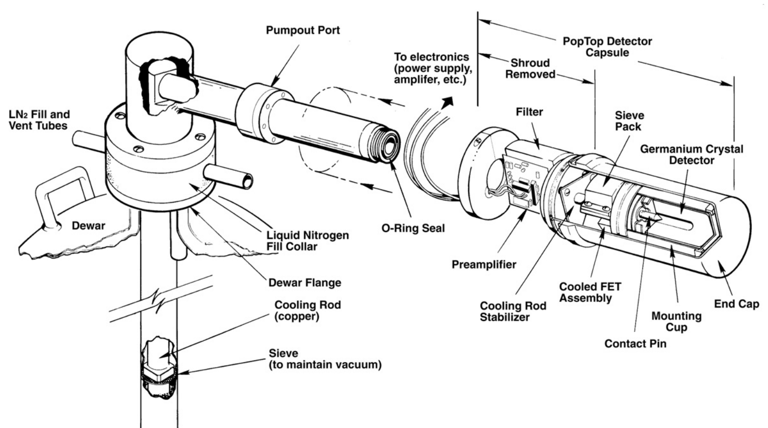


Fig. 4. Diagram of PopTop Detector.

2) Configure the Cryostat/Dewar Model

- Vertical Dipstick style (separate Dewar)
- Horizontal Dipstick style (separate Dewar)
- Portable with all-position or multi-position cryostat/dewar models
- Downlooking designed to be oriented with the detector pointing down
- Sidelooking designed to be oriented with the detector horizontal at the bottom of the dewar
- “J” configurations designed with the detector attached near the bottom of the dewar and a right angle bend in the cryostat orienting the detector to look up.

A cryostat and dewar or other cooling device are required for operation.

If a PopTop detector has been selected, you can choose a PopTop style cryostat, cryostat/dewar combination or the X-COOLER II mechanical cooler.

If a Streamline detector has been selected, you must choose a cryostat or cryostat/dewar model for the detector to be mounted on and vacuum sealed. The cryostat or cryostat/dewar combination diameter must match the endcap diameter of the selected detector.

Detector Options

Aluminum Window Option (-A)

An all aluminum endcap can be chosen if the energies of interest exceed 20 keV. See Table 1 for the transmission data for Al.

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

[1]By convention, HPGe detectors are characterized by “relative efficiency”. Relative efficiency is defined as the efficiency of a point Co-60 source at 25 cm from the face of a standard 3-inch x 3-inch right circular cylinder NaI(Tl) detector. “IEEE Test Procedures for Germanium Detectors for Ionizing Radiatio,” ANSI/IEEE Standard 325-1986.

GMX Series Coaxial HPGe Detector
Product Configuration Guide

Ultra-High Count-Rate Preamplifier Option (-PL)

The Ultra-High Count-Rate Preamplifier (transistor-reset preamplifier), which can handle input count rates up to 1,000,000 counts/s at 1 MeV, offers the added benefit of having no feedback resistor.

Harsh Environment Option (-HE)

The Harsh Environment option is a rugged carbon fiber endcap with a sealed electronics housing featuring a replaceable desiccant pack which ensures that the electronics stay 100% dry and indicates when it needs to be replaced.

GMX series detectors in PopTop capsules of 76 mm diameter or larger can be supplied with this option.

Fig. 5. -HE Detector Option (Carbon Fiber Endcap).

SMART-1 Option (-SMN)

The SMART-1 option monitors and reports on vital system functions, and can save authentication codes and report the code at a later time. It has the high voltage included, so none of the instruments require an external high-voltage power supply.

The SMART-1 is housed in a rugged ABS molded plastic enclosure and is permanently attached to the detector endcap via a molded-strain-relieved sealed cable. This eliminates the possibility that the detector will suffer severe damage from moisture leaking into high-voltage connectors. The SMART-1 can be positioned in any convenient place and does not interfere with shielding or other mounting hardware.

Fig. 6. SMART-1 Detector Interface Module.

Remote Preamplifier Option (-HJ)

This option allows all the preamplifier and high voltage connections to be outside a shield and removes the preamplifier and high voltage filter from the "line-of-sight" to the Ge crystal. For low background applications, this option eliminates any possible preamplifier or high voltage filter components that may add to the background inside a shield.

Carbon Fiber Window Option (-CW)

A carbon fiber window is available for energies greater than about 8 keV. While this window does not pass all the lower energies, carbon fiber has lower Z than Al and does not have any of the hazards associated with Be. See Figures 7 and 8 for transmission data for carbon fiber.

Low-Background Carbon Fiber Endcap Options (-RB, -LB-C, and -XLB-C)

Carbon Fiber is as strong as Al, Mg, and Cu, creates less background, does not corrode, and can detect energies less than 10 keV.

This lower background material allows for lower Minimum Detectable Activity (MDA) for a specific counting time, which provides another step in increasing sample throughput in low-background counting applications. The lower Z of Carbon Fiber provides a low-energy window without the additional background found in most alloys. See Figures 7 and 8 for transmission characteristics of the Be and carbon fiber windows.

Low-Background Be/Cu Endcap Options (-RB-B, -LB-B, and -XLB-B)

If the ultimate in low energies is required, a low-background, high purity Be window can be installed in a Cu endcap to minimize the background and still allow energies as low as 3-keV through the front window of the detector.

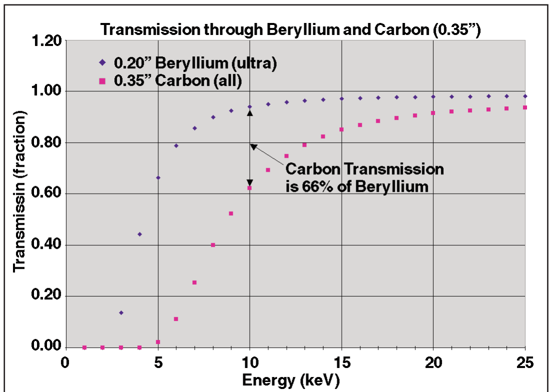


Fig. 7. Transmission through Be and Carbon (.076 mm).

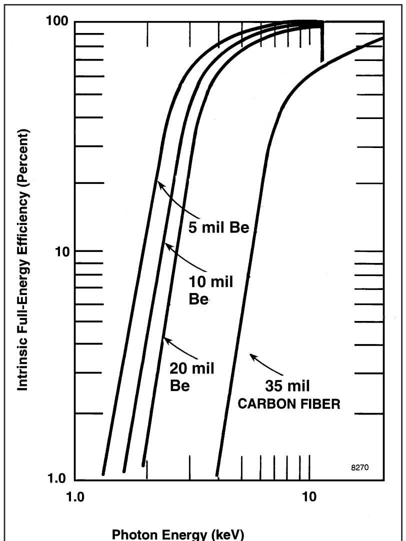


Fig. 8. Low Energy Gamma and X-Ray Transmission of Be and Carbon Fiber Windows.

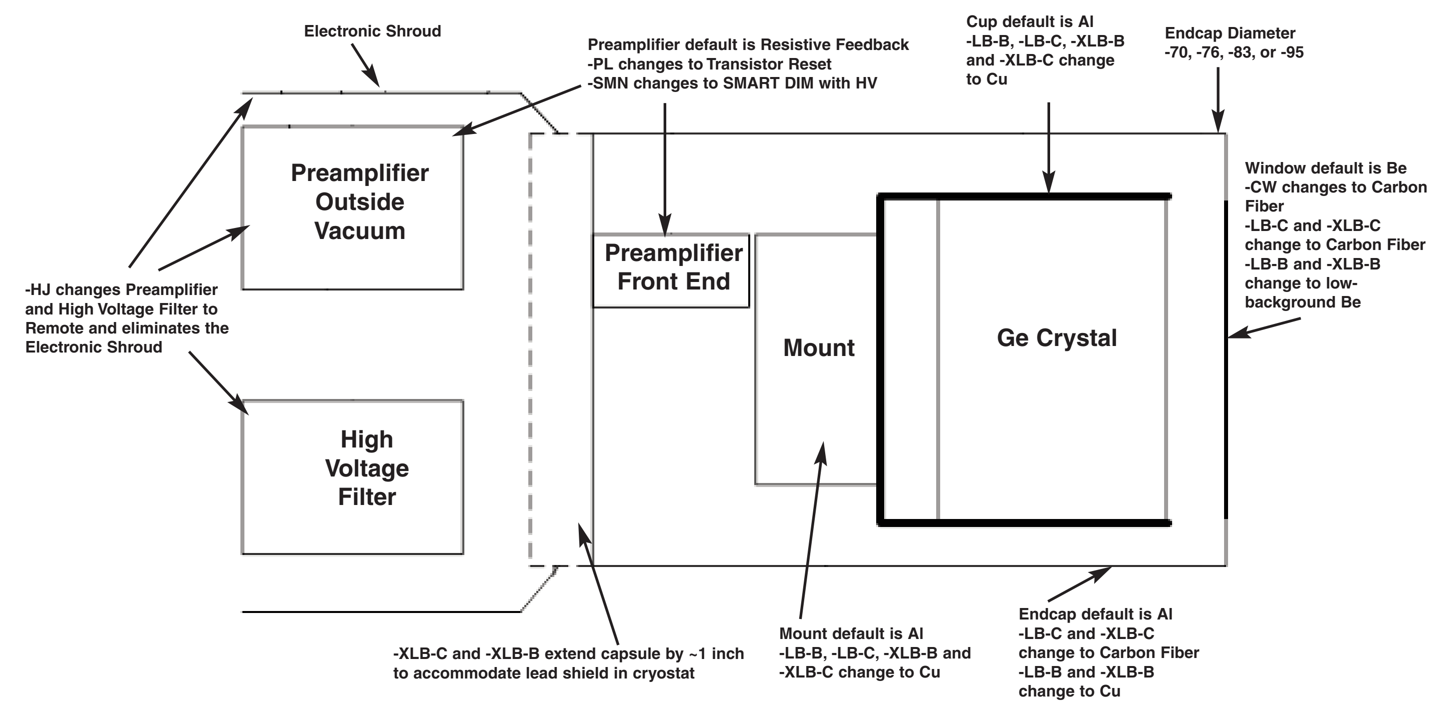
Defining the Detector Model

• See ordering information for option compatibility.

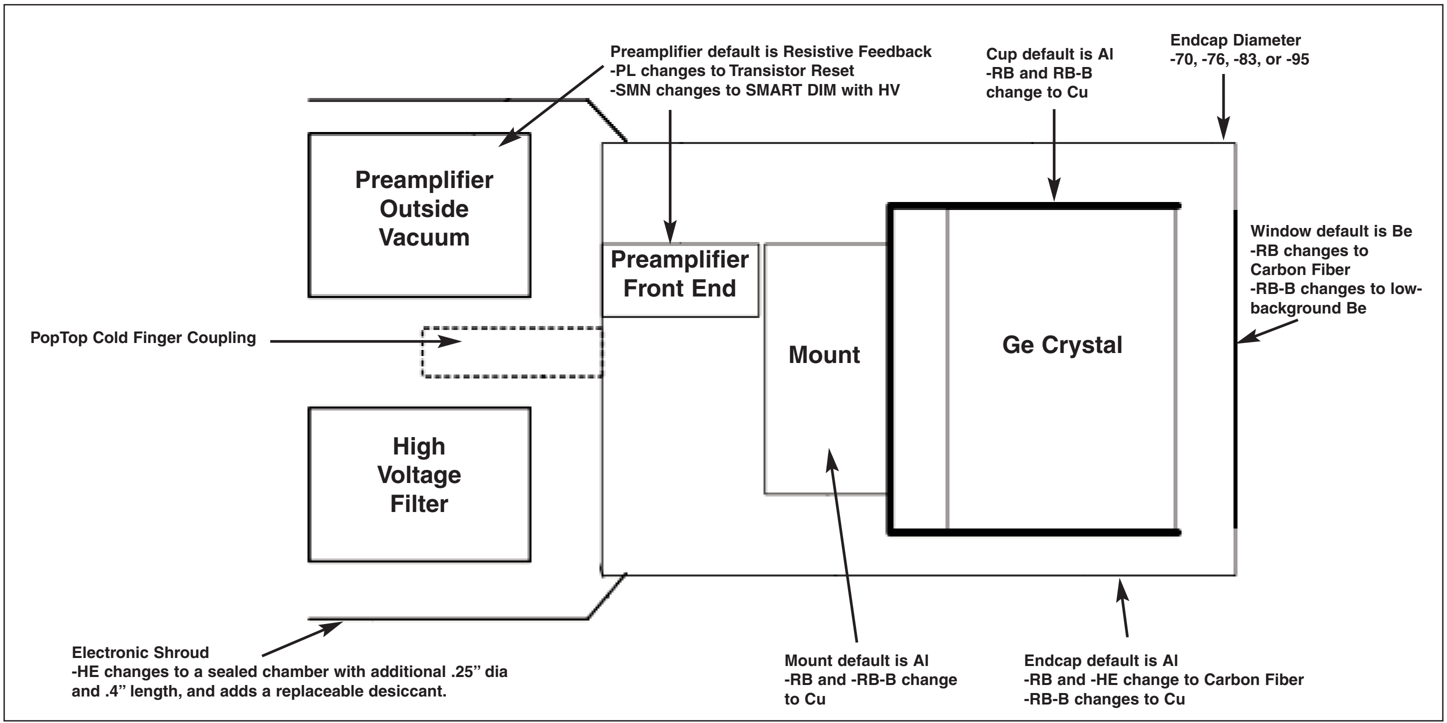
Base Model (example)	PopTop or Streamline	Endcap Diameter	Window Option (if required)	Preamplifier Option (if required)	High Voltage Option (if required)
GMX10	P4 (PopTop) (Streamline)	-70 -76 -83 -95	-RB -RB-B -HE -A -CW -LB-B -LB-C -XLB-B -XLB-C	-PL -HJ	-SMN

GMX Series Coaxial HPGe Detector
Product Configuration Guide

Streamline Detector Capsule

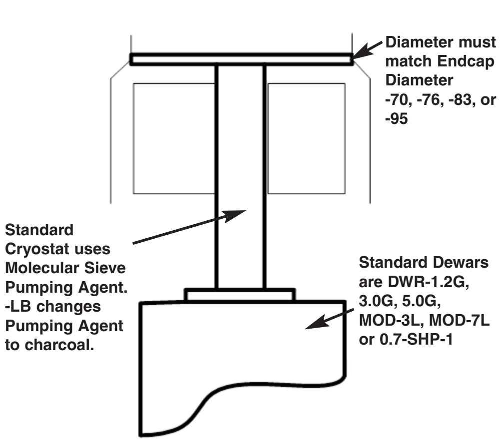


PopTop Detector Capsule

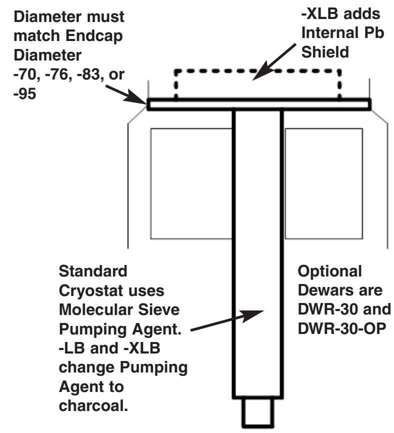


Streamline Cryostat and Cryostat/Dewar Assemblies

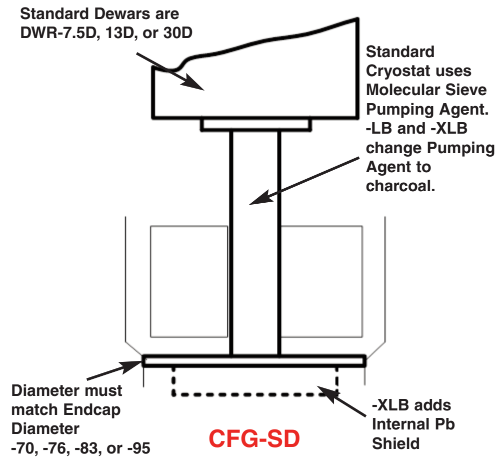
Streamline systems (detector capsule and cryostat) share the same vacuum, requiring a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap.



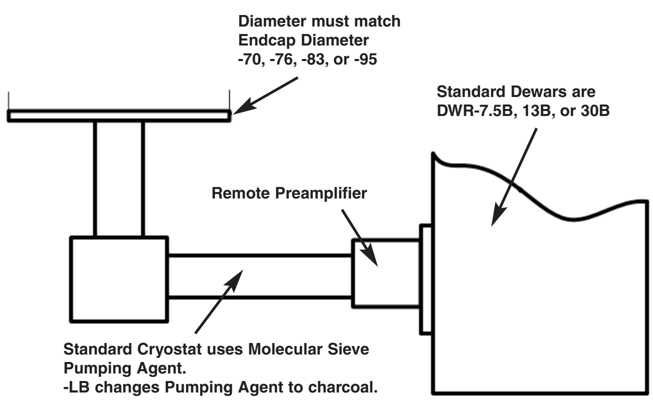
CFG-GG



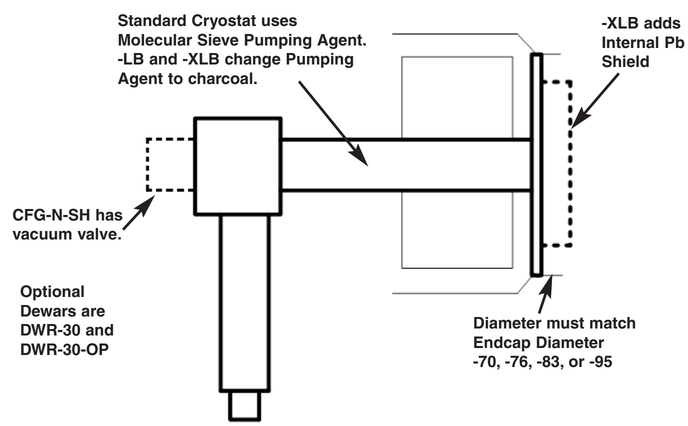
CFG-SV



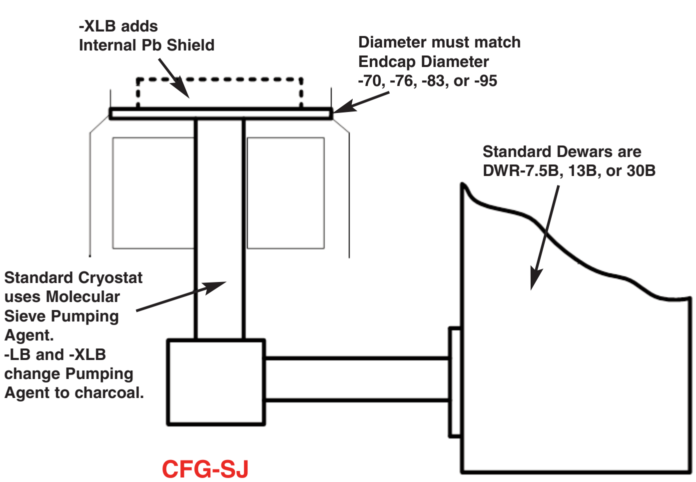
CFG-SD



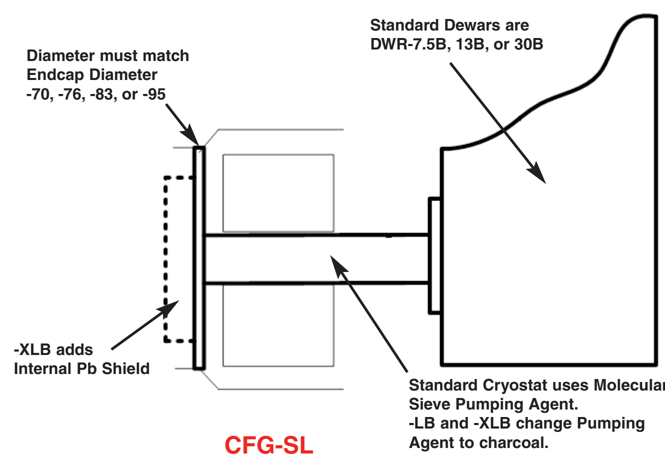
CFG-HJ



CFG-SH or CFG-N-SH



CFG-SJ



CFG-SL

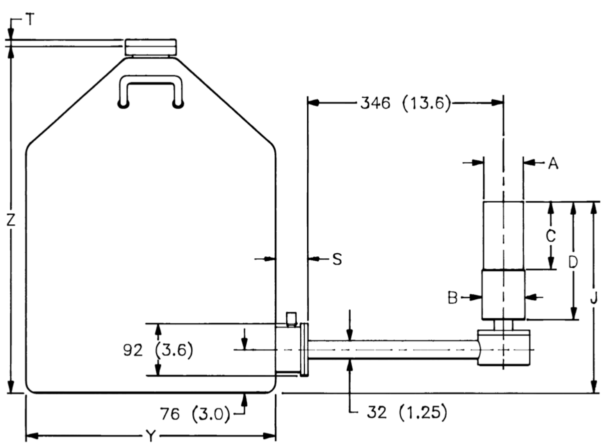
PopTop and Streamline Dimensional Data

Streamline systems (detector capsule and cryostat) share the same vacuum, requiring a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap. A cryostat must be ordered with a Streamline capsule.

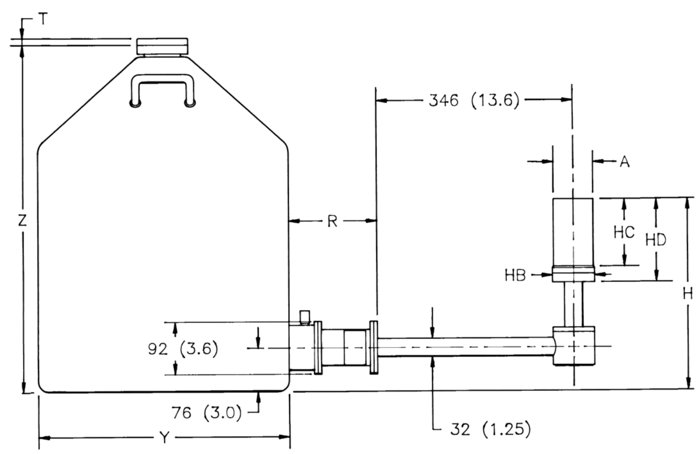
The PopTop capsule contains a vacuum unto itself. It can be mounted on any of the available cryostats, cryostat/dewar combinations, or the X-COOLER II mechanical cooling system.

The cryostat and dewar drawings that follow are to be used in conjunction with the accompanying tables of dimensions.

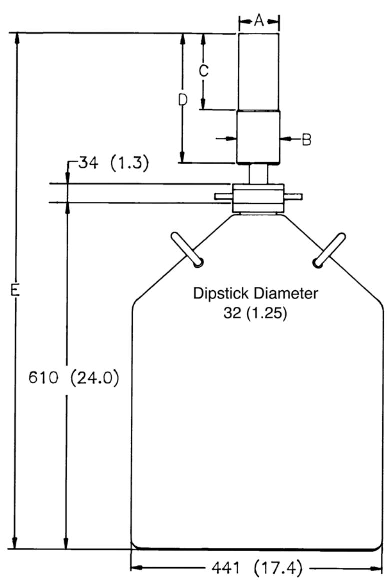
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



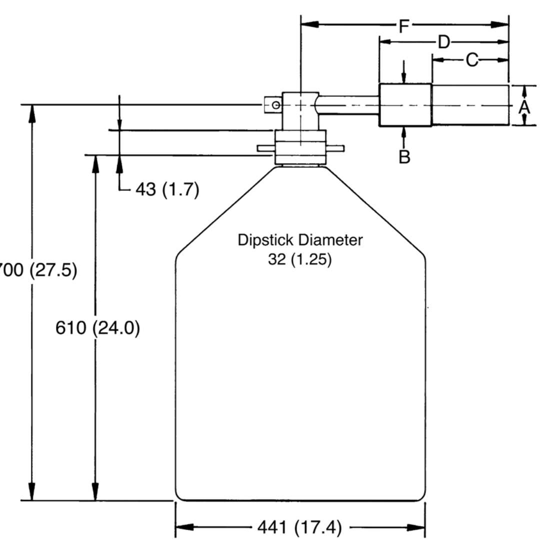
CFG-SJ, DWR-30B (or -13B or -7.5B)



CFG-HJ, DWR-30B (or -13B or -7.5B)

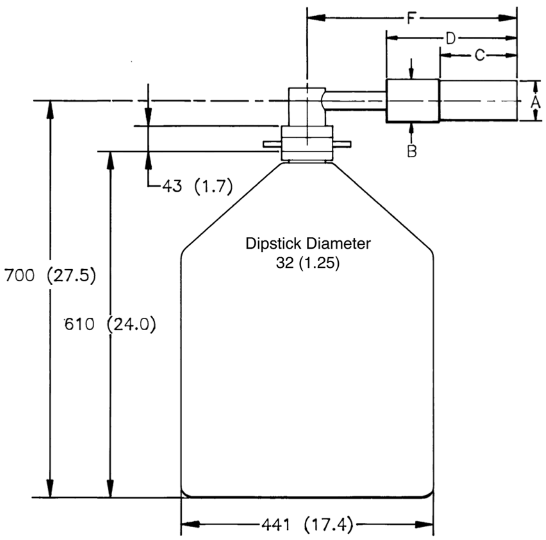


CFG-SV, DWR-30

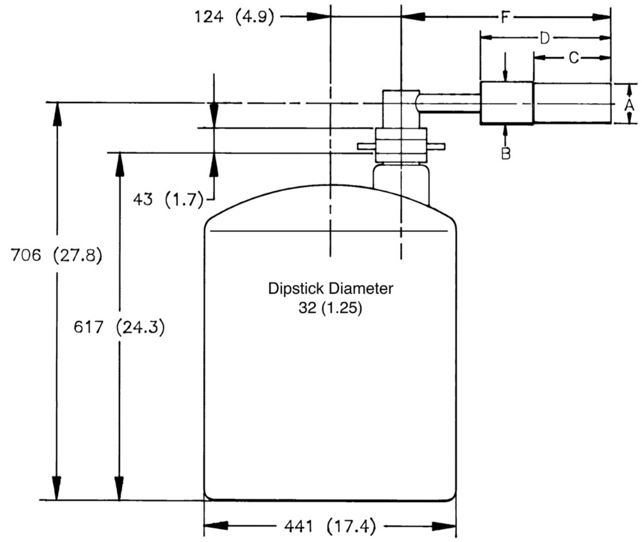


CFG-N-SH, DWR-30

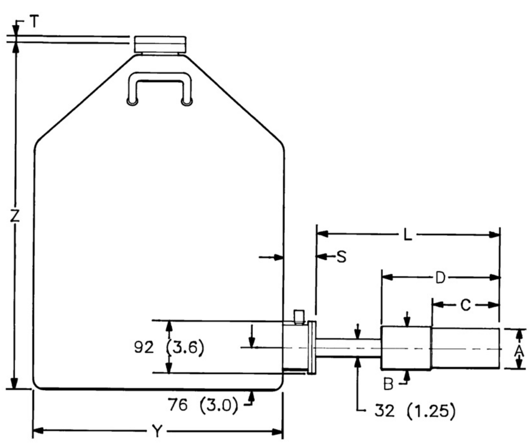
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



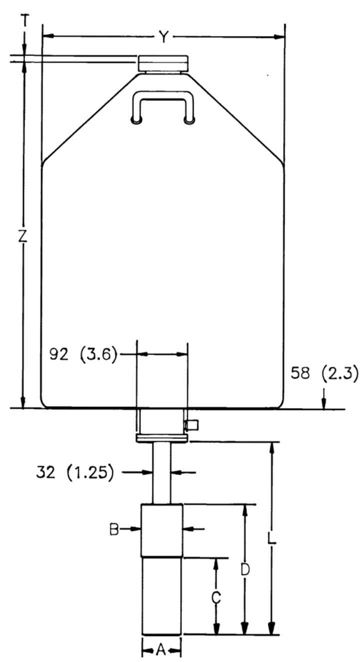
CFG-SH, DWR-30



CFG-SH, DWR-30-OP

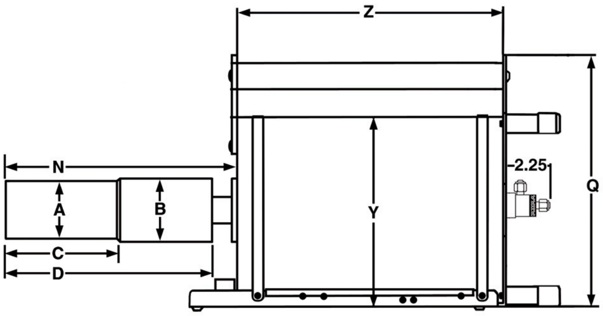


CFG-PS4-30 (or -13 or -7.5)
or
CFG-SL, DWR-30B (or -13B or -7.5B)

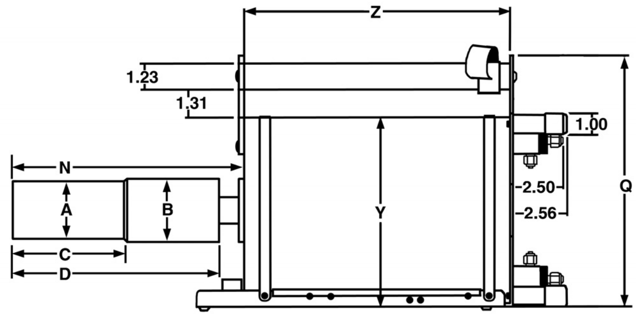


CFG-PD4-30 (or -13 or -7.5)
or
CFG-SD, DWR-30D (or -13D or -7.5D)

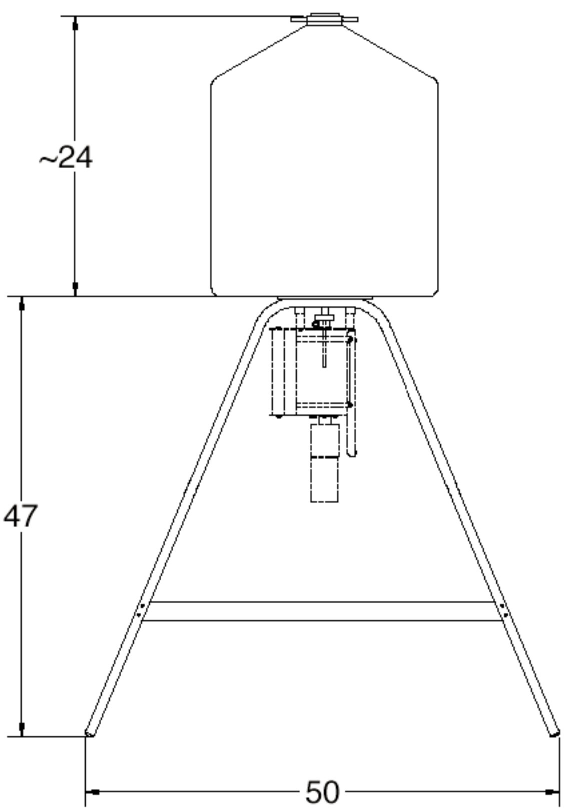
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



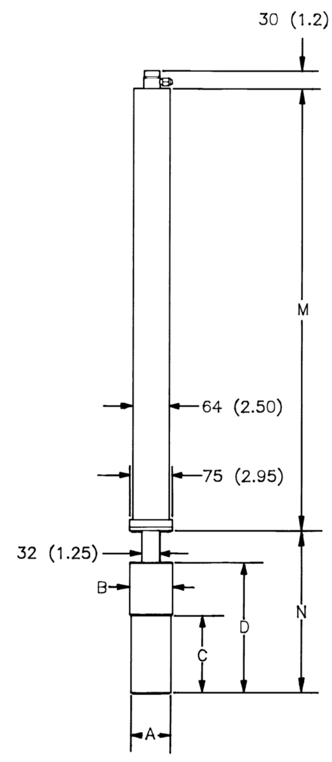
CFG-PG4-1.2 (or -3 or -5)
or
CFG-GG, DWR-1.2G (or -3.0G, -5.0G)



CFG-PMOD4-3 (or -7)
or
CFG-GG, DWR-MOD3L (or -MOD7L)

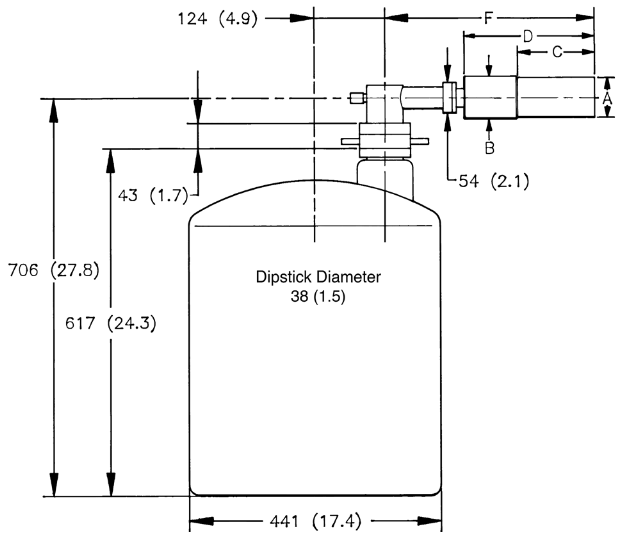


DWR-S/F

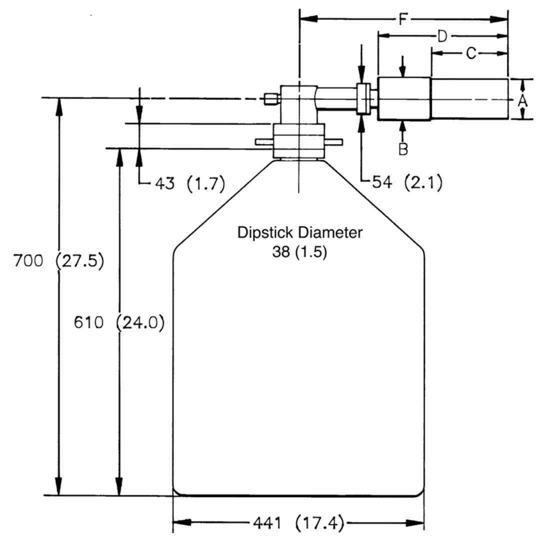


CFG-PSHP4
or
CFG-GG, DWR-0.7-SHP-1

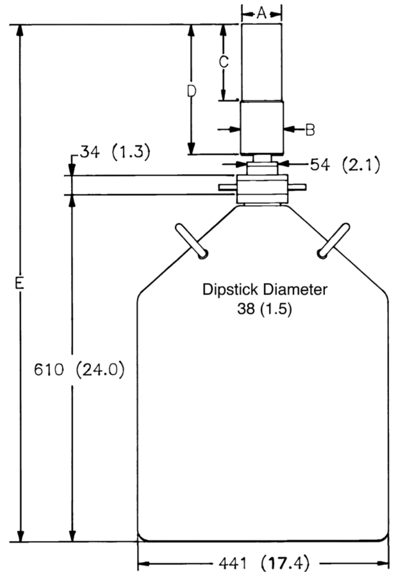
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



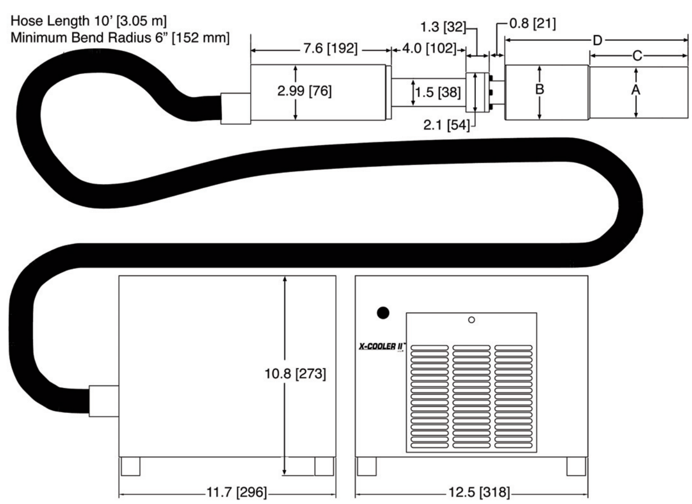
CFG-PH4, DWR-30-OP



CFG-PH4, DWR-30



CFG-PV4, DWR-30



CFG-X-COOL-II

GMX Series Coaxial HPGe Detector
Product Configuration Guide

GMX Endcap Diameter and Window

Note that there is an "overlap" of coaxial detector efficiency versus endcap diameter. For example, a 25–35% efficiency detector, depending on diameter, may fit in either a -70, -76 or -83 size endcap. The endcap size must be specified by adding the endcap Model (-xx) to the Detector Model (e.g., GMX25-76 or GMX25P4-70).

If this, or any other dimension is critical, please specify at time of order.

Endcap Model (dia. mm)	**-70**	**-76**	**-83**	**-95**
Endcap Diameter (in)	2.75	3.00	3.25	3.75
Efficiency	0–35%	25–45%	25–60%	60–100%
Thickness of Al Window	1 mm	1 mm	1 mm	1.5 mm
Thickness of CF Window	.9 mm nominal	.9 mm nominal	.9 mm nominal	.9 mm nominal
Thicknesso f Be Window	.5 mm	.5 mm	.5 mm	.76 mm

PopTop GMX Detector Dimensions

- Dimensions are for reference only and subject to change.
- If dimensional constraints are critical, contact the factory.

Endcap Model (dia. mm)			-70	-76	-83	-95
% Efficiencies available in this endcap size			0–35	25–45	25–65	60–110
Dim.	Unit	Tol.				
A	mm (in)	0.3 (0.01)	70 (2.75)	76 (3.0)	83 (3.25)	95 (3.75)
B	mm (in)	0.3 (0.01)	75 (2.95)	88 (3.45)	88 (3.45)	100 (3.95)
C	mm (in)	5 (0.2)	134 (5.3)	165 (6.4)	168 (6.6)	193 (7.6)
D	mm (in)	8 (0.3)	250 (9.8)	282 (11.2)	282 (11.2)	309 (12.2)
E	mm (in)	18 (0.7)	947 (37.3)	982 (38.6)	982 (38.6)	1007 (39.7)
F	mm (in)	10 (0.4)	396 (15.6)	429 (16.9)	429 (16.9)	455 (17.9)
L	mm (in)	10 (0.4)	338 (13.3)	371 (14.6)	371 (14.6)	396 (15.6)
M	mm (in)	8 (0.3)	790 (31.1)	X X	X X	X X
N	mm (in)	10 (0.4)	278 (10.9)	312 (12.3)	312 (12.3)	338 (13.3)

Streamline GMX Detector Dimensions

- Dimensions are for reference only and subject to change.
- If dimensional constraints are critical, contact the factory.

			Standard or LB				XLB			
Endcap Model (dia. mm)			-70	-76	-83	-95	-70	-76	-83	-95
% Efficiencies available in this endcap size			0–35	25–45	25–65	60–110	0–35	25–45	25–65	60–110
Dim.	Unit	Tol.								
A	mm (in)	0.3 (0.01)	70 (2.75)	76 (3.0)	83 (3.25)	95 (3.75)	70 (2.75)	76 (3.0)	83 (3.25)	95 (3.75)
B	mm (in)	0.3 (0.01)	75 (2.95)	88 (3.45)	88 (3.45)	100 (3.95)	75 (2.95)	88 (3.45)	88 (3.45)	100 (3.95)
C	mm (in)	5 (0.2)	134 (5.3)	131 (5.1)	134 (5.3)	160 (6.3)	160 (6.3)	157 (6.1)	160 (6.3)	185 (7.3)
D	mm (in)	8 (0.3)	246 (9.7)	259 (10.2)	259 (10.2)	284 (11.2)	272 (10.7)	284 (11.2)	284 (11.2)	310 (12.2)
E	mm (in)	18 (0.7)	916 (36.1)	932 (36.7)	932 (36.7)	957 (37.7)	941 (37.1)	958 (37.7)	958 (37.7)	983 (38.7)
F	mm (in)	10 (0.4)	368 (14.5)	381 (15.0)	381 (15.0)	406 (16.0)	394 (15.5)	406 (16.0)	406 (16.0)	432 (17.0)
H	mm (in)	18 (0.7)	351 (13.8)	364 (14.3)	364 (14.3)	390 (15.3)	X X	X X	X X	X X
HB	mm (in)	0.3 (0.1)	73 (2.9)	85 (3.4)	85 (3.4)	98 (3.9)	X X	X X	X X	X X
HC	mm (in)	5 (0.2)	134 (5.3)	135 (5.3)	135 (5.3)	160 (6.3)	X X	X X	X X	X X
HD	mm (in)	10 (0.4)	162 (6.4)	175 (6.9)	175 (6.9)	200 (7.9)	X X	X X	X X	X X
J	mm (in)	10 (0.4)	380 (15)	393 (15.5)	393 (15.5)	418 (16.5)	405 (16)	418 (16.5)	418 (16.5)	444 (17.5)
L	mm (in)	10 (0.4)	338 (13.3)	351 (13.8)	351 (13.8)	376 (14.8)	363 (14.3)	376 (14.8)	376 (14.8)	401 (15.8)
M	mm (in)	8 (0.3)	516 (20.3)	X X	X X	X X	516 (20.3)	X X	X X	X X
N	mm (in)	10 (0.4)	278 (11)	292 (11.5)	292 (11.5)	318 (12.5)	305 (12)	318 (12.5)	318 (12.5)	243 (13.5)

Gamma Gage and Side-Looking Dewar Dimensions

• Dimensions are for reference only and subject to change.
• If dimensional constraints are critical, contact the factory.

			Cryostat/Dewar or Dewar Type							
			CFG-PG4 and DWR-x.xG			CFG-PMOD4 and DWR-MOD-xL		CFG-PS4, CFG-PD4, DWR-xxB and DWR-xxD		
			VOLUME			VOLUME		VOLUME		
Dim.	UNIT	TOL. ±	1.2L	3L	5L	3L	7L	7.5L	13L	30L
Q	mm (in)	13 (0.5)	229 (9.0)	302 (11.9)	302 (11.9)	229 (9.0)	302 (11.9)	X X	X X	X X
R	mm (in)	10 (0.4)	X X	X X	X X	X X	X X	174 (6.9)	174 (6.9)	155 (16.1)
S	mm (in)	7.6 (0.3)	X X	X X	X X	X X	X X	77 (3.0)	77 (3.0)	60 (2.3)
T	mm (in)	5 (0.2)	X X	X X	X X	X X	X X	10 (0.4)	10 (0.4)	13 (0.5)
Y	mm (in)	5 (0.2)	157 (6.2)	229 (9.0)	229 (9.0)	157 (6.2)	229 (9.0)	224 (8.8)	307 (12.1)	442 (17.4)
Z	mm (in)	5 (0.2)	229 (9.0)	267 (10.5)	419 (16.5)	292 (11.5)	320 (12.6)	452 (17.8)	429 (16.9)	610 (24.0)

Example Model Numbers

Streamline Configuration

GMX10-70	10% efficiency GMX detector with 70-mm diameter endcap.
CFG-GG-70	Portable Gamma Gage cryostat with matching 70-mm diameter flange.
DWR-1.2G	1.2 liter all-position dewar for Gamma Gage cryostat.
GMX35-76-A-SMN	35% efficiency GMX detector with 76-mm diameter endcap, Al window, and SMART-1 preamplifier and high voltage supply.
CFG-SD-76	Downlooking cryostat with matching 76-mm diameter flange.
DWR-7.5D	7.5 liter downlooking dewar for downlooking cryostat.
GMX50-83-HJ	50% efficiency GMX detector with 83-mm diameter endcap, remote preamplifier and high voltage filter.
CFG-HJ-83	"J" configuration cryostat with remote fittings for the preamplifier and high voltage filter.
DWR-30B	30 liter side port dewar for "HJ" cryostat.
GMX70-95-LB-C-PL	70% efficiency GMX detector with 95-mm diameter low background carbon fiber endcap, and Plus preamplifier.
CFG-SV-LB-95	Vertical "dipstick" style cryostat with matching 95-mm flange and low background charcoal pumping agent.
DWR-30	30 liter top port dewar that accepts "dipstick" style cryostats.

PopTop Configuration

GMX10P4-70	10% efficiency GMX detector with 70-mm diameter endcap.
CFG-PG4-1.2	Portable Gamma Gage cryostat with 1.2 liter all-position dewar.
GMX35P4-76-SMN	35% efficiency GMX detector with 76-mm diameter endcap and SMART-1 preamplifier and high voltage supply.
CFG-PD4-7.5	Downlooking cryostat with 7.5 liter dewar.
GMX50-83-HE	50% efficiency GMX detector with 83-mm diameter carbon fiber endcap with sealed preamplifier and high voltage filter.
CFG-PG4-3	Portable Gamma Gage cryostat with 3 liter all-position dewar.
GMX50P4-83-RB-SMN	50% efficiency GMX detector with 83-mm diameter reduced background carbon fiber endcap, and SMART-1 preamplifier and high voltage supply.
CFG-PV4	Vertical "dipstick" style cryostat.
DWR-30	30 liter top port dewar that accepts "dipstick" style cryostats.

GMX Series Coaxial HPGe Detector
Product Configuration Guide

Ordering Information

- For Streamline remove the "P4" from the model number.
- Endcap Diameter must be specified, see Endcap Diameter.
- 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.
- If dimensional considerations are critical, contact factory.
- Cryostat and dewar or other cooling device are not included with detector.
- Cryostat and dewar or other cooling device are required for operation.
- A cryostat must be ordered with a Streamline detector.
- Monte Carlo drawings included.

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 (mm)	Be Window Thickness (mm)
GMX10P4	10	600	1.80	40:1	1.9	2.6	-70	0.51
GMX15P4	15	635	1.85	44:1	1.9	2.6	-70	0.51
GMX20P4	20	650	1.90	48:1	1.9	2.8	-70	0.51
GMX25P4	25	690	1.90	48:1	1.9	2.8	-70, -76, -83	0.51
GMX30P4	30	715	1.90	52:1	1.9	2.8	-70, -76, -83	0.51
GMX35P4	35	730	1.95	55:1	2.0	3.0	-70, -76, -83	0.51
GMX40P4	40	760	2.0	59:1	2.0	3.0	-76, -83	0.51
GMX45P4	45	800	2.1	60:1	2.0	3.0	-76, -83	0.51
GMX50P4	50	800	2.2	58:1	2.0	3.0	-83	0.51
		(keV FWHM)						
GMX60P4	60	1.10	2.3	56:1	2.0	3.0	-83, -95	0.51, 0.76
GMX70P4	70	1.10	2.3	60:1	2.0	3.0	-95	0.76
GMX80P4	80	1.10	2.3	63:1	2.0	3.0	-95	0.76
GMX90P4	90	1.20	2.4	64:1	2.1	3.1	-95	0.76
GMX100P4	100	1.20	2.5	64:1	2.2	3.2	-95	0.76

GAMMA-X Detector Options

-RB — PopTop Only. Reduced background PopTop capsule with Carbon Fiber endcap, add “-RB” to the model number. Not compatible with -HE option.

-RB-B — PopTop Only. Reduced background PopTop capsule with Be window in Cu endcap, add “-RB-B” to the model number. Not compatible with -HE option.

-HE — PopTop Only. Harsh Environment Option for PopTop detectors 76 mm and larger, add “-HE” to the model number. Not compatible with -RB or -RB-B option. This option deletes the 5.9-keV resolution specification.

-PL — PLUS Ultra-high-count-rate Preamplifier, add “-PL” to the model number. Not compatible with -HJ option.

-SMN — SMART-1 detector option for negative bias detector, add “-SMN” to the model number. Not compatible with -HJ option.

-A — Aluminum endcap (no Be) at no extra charge, add “-A” to the model number. This option deletes the 5.9-keV resolution specification.

-CW — Carbon Fiber Window (0.9 mm thick) at no extra charge, add “-CW” to the model number. This option deletes the 5.9-keV resolution specification.

-LB-B — Streamline Only. Low-Background Detector with Be window in Cu endcap, add “-LB-B” to the model number. Requires selection of a Low-Background LB cryostat.

-LB-C — Streamline Only. Low-Background Detector with Carbon Fiber Endcap, add “-LB-C” to the model number. Requires selection of a Low-Background LB cryostat. This option deletes the 5.9-keV resolution specification.

-XLB-B — Streamline Only. Extra-Low-Background Detector with Be window in Cu endcap, add “-XLB-B” to the model number. Requires selection of a Low-Background XLB cryostat. Not compatible with -HJ option.

-XLB-C — Streamline Only. Extra-Low-Background Detector with Carbon Fiber Endcap, add “-XLB-C” to the model number. Requires selection of a Low-Background XLB cryostat. This option deletes the 5.9-keV resolution specification. Not compatible with -HJ option.

-HJ — Streamline Only. Remote preamplifier and high voltage filter for use with HJ type cryostat, add “-HJ” to the model number. Requires selection of HJ cryostat. Not compatible with -PL, -SMN, -XLB-B, or -XLB-C options.

GAMMA-X PopTop Cryostats and Dewars

• Dewar included except where marked *.

Model No.	Description
CFG-MG4-1.2G	Gamma Gage Cryostat with 1.2-liter Dewar, Pistol Grip handle and mounting holes to fit the M-1-T1 Tripod (for 83 mm or smaller endcaps)
CFG-PD4-7.5	Down-looking Cryostat with 7.5-liter Dewar
CFG-PD4-13	Down-looking Cryostat with 13-liter Dewar
CFG-PD4-30	Down-looking Cryostat with 30-liter Dewar
CFG-PG4-1.2	Gamma Gage Cryostat with 1.2-liter Dewar (for 83 mm or smaller endcaps) (not compatible with -HE option)
CFG-PG4-3	Gamma Gage Cryostat with 3-liter Dewar
CFG-PG4-5	Gamma Gage Cryostat with 5-liter Dewar
CFG-PH4	Horizontal Cryostat (Dipstick type). Includes LNTC1.5WH. Dewar not included.* Choose DWR-30 or DWR-30-OP.
CFG-PMOD4-3	Gamma Gage Cryostat with 3-liter Multi-Orientation Dewar
CFG-PMOD4-7	Gamma Gage Cryostat with 7-liter Multi-Orientation Dewar
CFG-PS4-7.5	Side-Looking Cryostat with 7.5-liter Dewar
CFG-PS4-13	Side-Looking Cryostat with 13-liter Dewar
CFG-PS4-30	Side-Looking Cryostat with 30-liter Dewar
CFG-PSHP4	Down-Looking Shallow-Hole Probe with 0.7-liter Dewar
CFG-PV4	Vertical Cryostat (Dipstick type). Includes LNTC1.5WH. Dewar not included.* Choose DWR-30 or DWR-30-OP.
DWR-30	30-liter Dewar
DWR-30-OP	30-liter Offset-Port Dewar
DWR-S/F	Storage Fill Dewar for CFG-PG4-X
CFG-X-COOL-II-115	X-COOLER II with PopTop connector using 110-120 V ac, 60 Hz Input Power
CFG-X-COOL-II-230	X-COOLER II with PopTop connector using 220-240 V ac, 50 Hz Input Power

GMX Series Coaxial HPGe Detector Product Configuration Guide

GAMMA-X Streamline Cryostats

- Select dewar from GAMMA-X Streamline Dewars. Dewar included except where marked*.
- Append matching Detector Endcap Size designation to cryostat model: -70, -76, -83, -95 [e.g., CFG-SJ-95 for GMX70-95 or CFG-SL-XLB-83 for GMX25-83-XLB-B]

Model No.	Description
CFG-GG	Gamma Gage Cryostat Dewar
CFG-HJ	J-type Cryostat with Remote Preamp and Dewar. (for -HJ option only)
CFG-SD	Down-Looking Cryostat with Dewar
CFG-SH	Horizontal Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
CFG-N-SH	Horizontal Cryostat with vacuum valve (Dipstick type). Includes LNTC1.25WH. Dewar not included.* Requires model VV02 and model 496-1 (110 V/60 Hz) or model 496-2 (220 V/50 Hz).
CFG-SJ	J-type Cryostat with Dewar
CFG-SL	Side-Looking Cryostat with Dewar
CFG-SV	Vertical Cryostat with (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
LOW-BACKGROUND	
CFG-GG-LB	Low-Background Gamma Gage Cryostat with Dewar
CFG-HJ-LB	Low-Background J-type Cryostat with Remote Preamp and Dewar. (for -HJ option only)
CFG-SD-LB	Low-Background Down-Looking Cryostat with Dewar
CFG-SH-LB	Low-Background Horizontal Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
CFG-SJ-LB	Low-Background J-type Cryostat with Dewar
CFG-SL-LB	Low-Background Side-Looking Cryostat with Dewar
CFG-SV-LB	Low-Background Vertical Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
CFG-SD-XLB	Extra-Low-Background Down-Looking Cryostat with Dewar
CFG-SH-XLB	Extra-Low-Background Horizontal Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
CFG-SJ-XLB	Extra-Low-Background J-type Cryostat with Dewar
CFG-SL-XLB	Extra-Low-Background Side-Looking Cryostat with Dewar
CFG-SV-XLB	Extra-Low-Background Vertical Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*

GAMMA-X Streamline Dewars

For Cryostat	Choose	Description	
CFG-GG	DWR-1.2G	1.2-liter All-Orientation Dewar	Included with Cryostat
	DWR-3.0G	3.0-liter All-Orientation Dewar	Included with Cryostat
	DWR-5.0G	5.0-liter All-Orientation Dewar	Included with Cryostat
	DWR-MOD-3L	3-liter Multi-Orientation Dewar	Included with Cryostat
	DWR-MOD-7L	7-liter Multi-Orientation Dewar	Included with Cryostat
	DWR-0.7-SHP-1	0.7-liter Shallow-Hole Probe Dewar	Included with Cryostat
	DWR-S/F	Storage/Fill Dewar for DWR-XG	
CFG-HJ, SJ, SL	DWR-7.5B	7.5-liter Side-Looking Dewar	Included with Cryostat
	DWR-13B	13-liter Side-Looking Dewar	Included with Cryostat
	DWR-30B	30-liter Side-Looking Dewar	Included with Cryostat
CFG-SD	DWR-7.5D	7.5-liter Down-Looking Dewar	Included with Cryostat
	DWR-13D	13-liter Down-Looking Dewar	Included with Cryostat
	DWR-30D	30-liter Down-Looking Dewar	Included with Cryostat
CFG-SV, SH, N-SH	DWR-30-OP	30-liter Offset-Port Dewar	
	DWR-30	30-liter Dewar	

ORTEC®

GWL Series Coaxial HPGe Detector Product Configuration Guide

For Analysis of Small, Low-Activity Samples

- High absolute counting efficiency for small samples
- Active Volumes to 400 cc
- Unique ion-implanted blind well
- Resolution specified with source inside the well
- Spectroscopy from 10 keV to 10 MeV
- Near 4 π geometry
- Extra-large well (1.55 x 4.0 cm) standard

ORTEC's High-Purity Germanium (HPGe) Well Detectors offer high absolute counting efficiency for radiochemical analysis and low-level gamma-ray spectroscopy. The unique ion-implanted detector well has an ultra-thin dead layer (only 0.3 µm thick), and therefore provides the most extensive useful energy range (10 keV to 10 MeV). Unlike other Well detectors that have a hole all the way through the germanium crystal, ORTEC's Well Detectors have a "blind hole" with at least 5 mm of active germanium at the bottom of the hole (Fig. 1). This near 4 π geometry provides the maximum absolute counting efficiency available. The large well (1.55-cm-diameter and 4.0-cm-long) accommodates an extensive range of sample sizes. Like all of ORTEC's HPGe photon detectors, the HPGe Well detector may be stored or cycled repeatedly to room temperature without performance degradation.

As specified in ANSI/IEEE Std. 325-1996, the resolution is measured with a point source inside the well, 1 cm from the bottom. Measurements of resolution outside the well can be deceiving.

A typical curve of absolute efficiency in the well vs. photon energy is shown in Fig. 2.

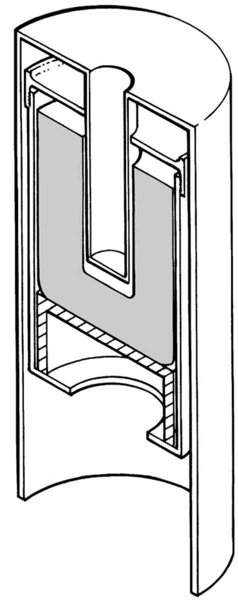


Fig. 1. Simplified Isometric View of HPGe Well Detector Cryostat.

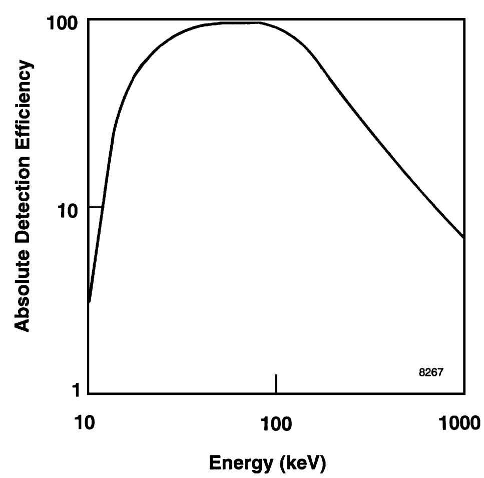


Fig. 2. Absolute Detection Efficiency in the Well vs. Photon Energy. [If a well detector is used as a general-purpose coaxial detector (a use not recommended by ORTEC), its relative efficiency at 25 cm can be determined from the equation on page 58.]

The Following Specifications are Provided for Each Model GWL Detector

- Energy resolution at 1.33-MeV photons from ^{60}Co at optimum shaping time.
- Acitve Ge volume and well tube diameter.
- Energy resolution at 122 keV photons from ^{57}Co at optimum shaping time.

GWL Series Coaxial HPGe Detector
Product Configuration Guide

Configuration Guidelines

Streamline (non-PopTop) Configuration

In so called Streamline systems, the detector capsule in NOT demountable. Detector capsule and cryostat share the same vacuum. In configuration terms, this requires a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap. A cryostat must always be ordered with a Streamline capsule, because they are integral.

Steps to Configure Your ORTEC HPGe Detector

1) Configure the Detector Model

- Ge Crystal active volume and well tube diameter
- Endcap and window
- Mount
- Preamplifier
- High Voltage Filter
- Cable Package

Options are available for the detector model that can change specific materials used in the construction of the detector endcap, cup, and mount. Preamplifier options are also available.

2) Configure the Cryostat/Dewar Model

- Vertical Dipstick style (separate Dewar)
- Sidelooking designed to be oriented with the detector horizontal at the bottom of the dewar
- “J” configurations designed with the detector attached near the bottom of the dewar and a right angle bend in the cryostat orienting the detector to look up.

A cryostat and dewar or other cooling device are required for operation.

You must choose a cryostat or cryostat/dewar model for the detector to be mounted on and vacuum sealed. The cryostat or cryostat/dewar combination diameter must match the endcap diameter of the selected detector.

Detector Options

Remote Preamplifier Option (-HJ)

This option allows all the preamplifier and high voltage connections to be outside a shield and removes the preamplifier and high voltage filter from the “line-of-sight” to the Ge crystal. For low background applications, this option eliminates any possible preamplifier or high voltage filter components that may add to the background inside a shield.

Low-Background Options (-LB-AWT, and -XLB-AWT)

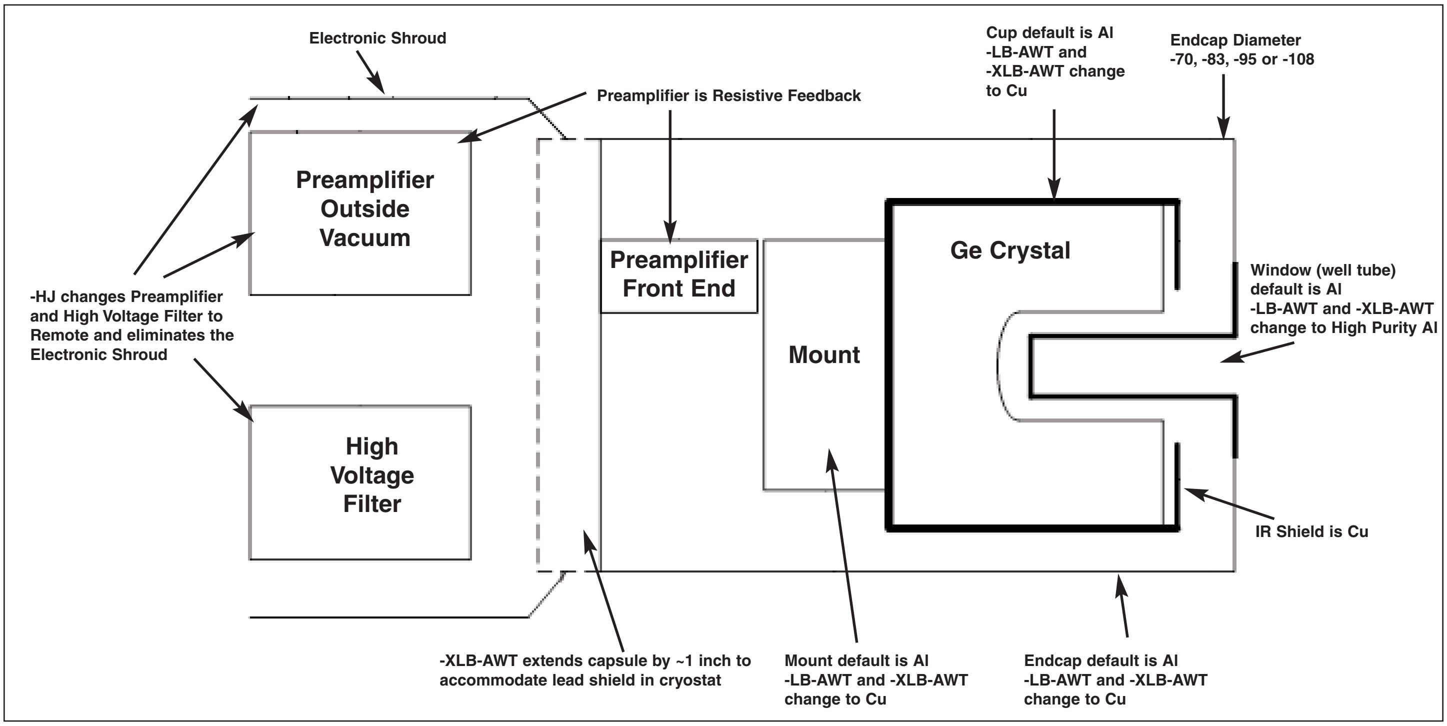
Low-background GWL detectors are supplied with oxygen-free high conductivity (OFHC) copper endcaps with low-background high purity aluminum well tubes of 0.02 inch wall thickness.

Defining the Detector Model

- See ordering information for option compatibility.

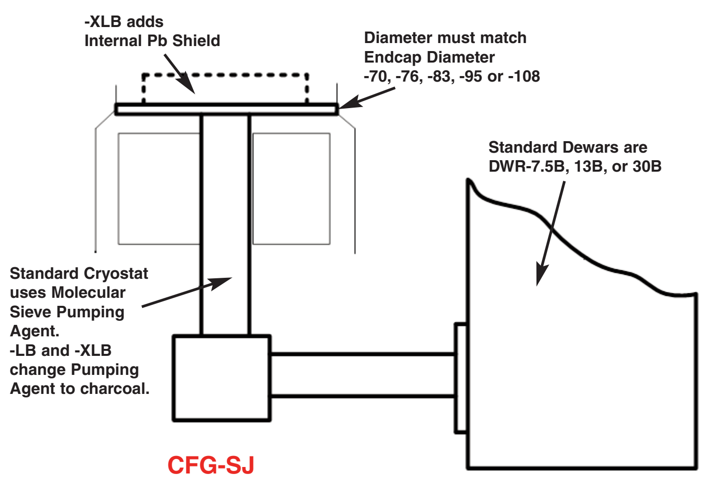
Base Model (example)	Well Option (if required)	Preamplifier Option (if required)
GWL-90-15	-LB-AWT -XLB-AWT	-HJ

Streamline Detector Capsule

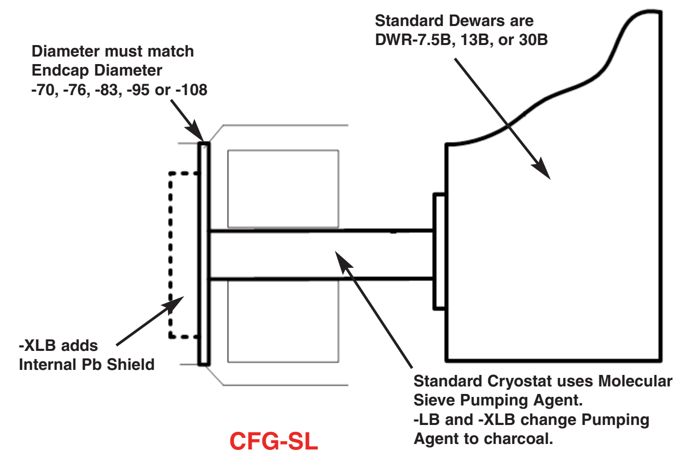


Streamline Cryostat and Cryostat/Dewar Assemblies

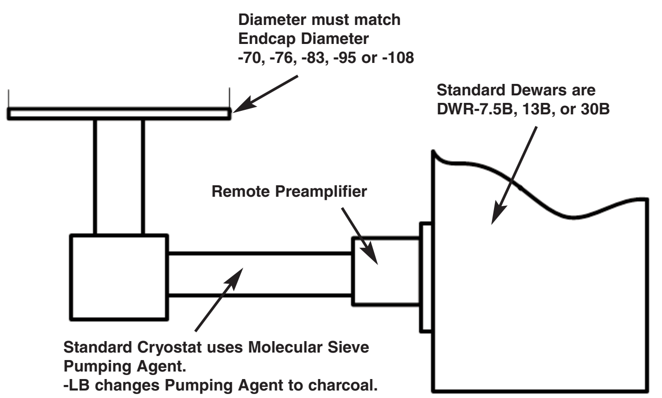
Streamline systems (detector capsule and cryostat) share the same vacuum, requiring a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap.



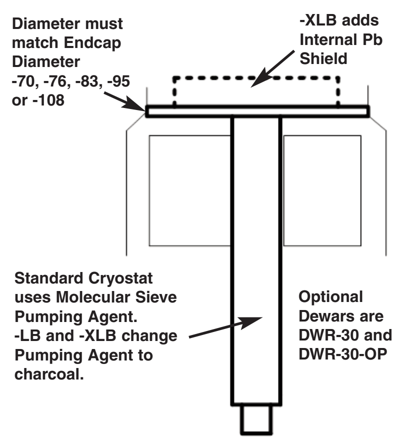
CFG-SJ



CFG-SL



CFG-HJ



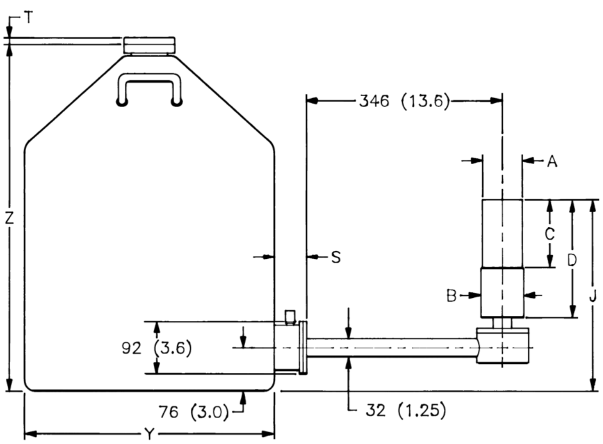
CFG-SV

Streamline Dimensional Data

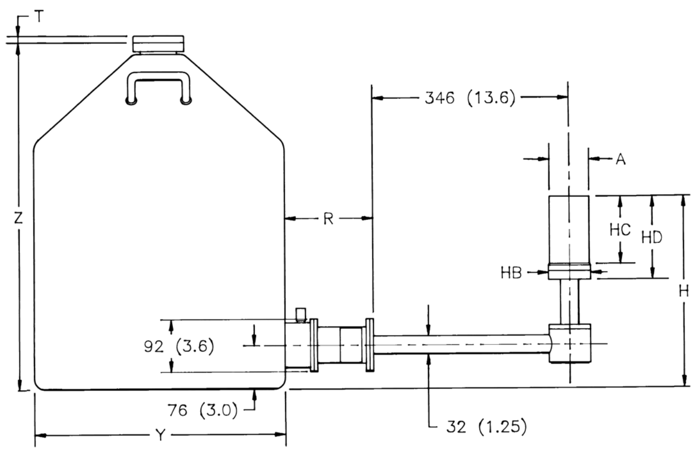
Streamline systems (detector capsule and cryostat) share the same vacuum, requiring a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap. A cryostat must be ordered with a Streamline capsule.

The cryostat and dewar drawings that follow are to be used in conjunction with the accompanying tables of dimensions.

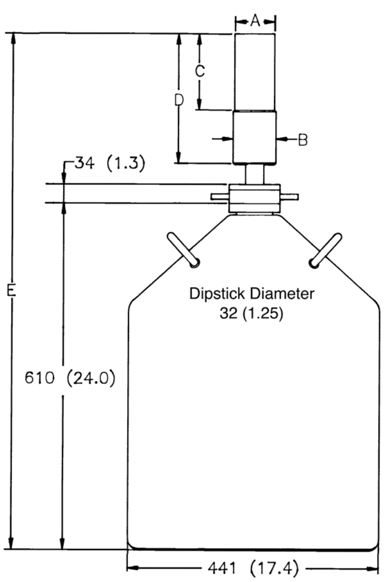
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



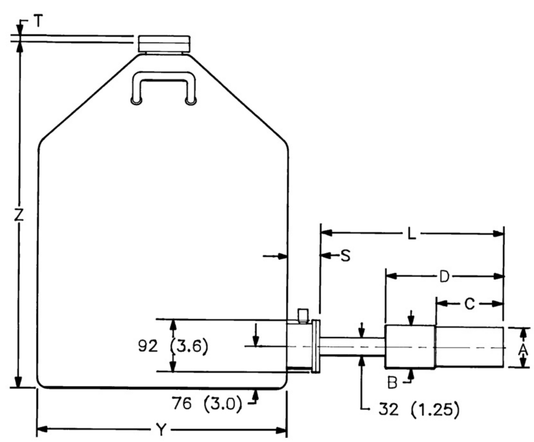
CFG-SJ, DWR-30B (or -13B or -7.5B)



CFG-HJ, DWR-30B (or -13B or -7.5B)



CFG-SV, DWR-30



CFG-SL, DWR-30B (or -13B or -7.5B)

GWL Series Coaxial HPGe Detector Product Configuration Guide

GWL Detector Dimensions

- Dimensions are for reference only and subject to change.
- If dimensional constraints are critical, contact the factory.

			Standard or LB				XLB			
	Endcap Model (dia. mm)		-70	-83	-95	-108	-70	-83	-95	-108
Dim.	Unit	Tol.								
A	mm (in)	0.3 (0.01)	70 (2.75)	83 (3.25)	95 (3.75)	108 (1.25)	70 (2.75)	83 (3.25)	95 (3.75)	108 (1.25)
B	mm (in)	0.3 (0.01)	75 (2.95)	88 (3.45)	100 (3.95)	113 (4.45)	75 (2.95)	88 (3.45)	100 (3.95)	113 (4.45)
C	mm (in)	5 (0.2)	134 (5.3)	122 (4.8)	134 (5.3)	134 (5.3)	160 (6.3)	147 (5.8)	160 (6.3)	160 (6.3)
D	mm (in)	8 (0.3)	246 (9.7)	246 (9.7)	258 (10.2)	258 (10.2)	272 (10.7)	272 (10.7)	284 (11.2)	284 (11.2)
E	mm (in)	18 (0.7)	916 (36.1)	919 (36.2)	932 (36.7)	932 (36.7)	941 (37.1)	945 (37.2)	957 (37.7)	957 (37.7)
H	mm (in)	18 (0.7)	352 (13.8)	352 (13.8)	364 (14.3)	364 (14.3)	X X	X X	X X	X X
HB	mm (in)	0.3 (0.1)	73 (2.9)	85 (3.3)	99 (3.9)	111 (4.4)	X X	X X	X X	X X
HC	mm (in)	5 (0.2)	134 (5.3)	122 (4.8)	135 (5.3)	135 (5.3)	X X	X X	X X	X X
HD	mm (in)	10 (0.4)	162 (6.4)	162 (6.4)	175 (6.9)	175 (6.9)	X X	X X	X X	X X
J	mm (in)	10 (0.4)	380 (15)	380 (15)	393 (15.5)	393 (15.5)	405 (16)	405 (16)	418 (16.5)	418 (16.5)
L	mm (in)	10 (0.4)	338 (13.3)	338 (13.3)	350 (13.8)	350 (13.8)	363 (14.3)	363 (14.3)	376 (14.8)	376 (14.8)

Example Model Numbers

GWL-120-10	120 cc active volume GWL detector with 10-mm diameter well tube and 70-mm diameter endcap.
CFG-SV-70	Vertical “dipstick” style cryostat to fit 70-mm diameter endcap.
DWR-30	30 liter top port dewar that accepts “dipstick” style cryostats.
GWL-300-15-LB-AWT	300 cc active volume GWL detector with 15-mm diameter high purtiy Al (low-background) well tube and 95-mm diameter Cu endcap.
CFG-SL-LB-95	Sidelooking cryostat and dewar to fit 95-mm diameter endcap with low background charcoal pumping agent.
DWR-13B	13 liter sidelooking dewar.
GWL-450-10-XLB-AWT	450 cc active volume GWL detector with 10-mm diameter high purity Al (low-background) well tube with 108-mm diameter Cu endcap.
CFG-SJ-XLB	“J” type cryostat with lead shield and low-background charcoal pumping agent.
DWR-30B	30 liter side looking dewar.

Ordering Information

- GWL-120 is standard order and delivery, all other are special order only.
- If dimensional considerations are critical, contact factory.
- Cryostat and dewar or other cooling device are not included with detector and are required for operation.
- A cryostat must be ordered with a Streamline detector.

Model No.	Volume Nominal (cc)	Well Tube Diameter (mm)	Well Tube Depth (mm)	Energy Resolution FWHM @1.33 MeV (keV)	Energy Resolution FWHM @122 keV (keV)	Endcap Diameter (mm)
GWL-90-10	90	10	40	2.10	1.2	70
GWL-90-15	90	15.5	40	2.30	1.4	70
GWL-110-10	110	10	40	2.10	1.2	70
GWL-110-15	110	15.5	40	2.30	1.4	70
GWL-120-10	120	10	40	2.10	1.2	70
GWL-120-15	120	15.5	40	2.30	1.4	70
GWL-130-10	130	10	40	2.10	1.2	70
GWL-130-15	130	15.5	40	2.30	1.4	70
GWL-150-10	150	10	40	2.10	1.2	83
GWL-150-15	150	15.5	40	2.30	1.4	83
GWL-170-10	170	10	40	2.10	1.2	83
GWL-170-15	170	15.5	40	2.30	1.4	83
GWL-190-10	190	10	40	2.10	1.2	83
GWL-190-15	190	15.5	40	2.30	1.4	83
GWL-220-10	220	10	40	2.10	1.2	95
GWL-220-15	220	15.5	40	2.30	1.4	95
GWL-250-10	250	10	40	2.10	1.2	95
GWL-250-15	250	15.5	40	2.30	1.4	95
GWL-280-10	280	10	40	2.15	1.2	95
GWL-280-15	280	15.5	40	2.30	1.4	95
GWL-300-10	300	10	40	2.15	1.2	95
GWL-300-15	300	15.5	40	2.30	1.4	95
GWL-350-10	350	10	40	2.15	1.2	95
GWL-350-15	350	15.5	40	2.30	1.4	95
GWL-400-10	400	10	40	2.15	1.2	108
GWL-400-15	400	15.5	40	2.30	1.4	108
GWL-450-10	450	10	40	2.15	1.2	108
GWL-450-15	450	15.5	40	2.30	1.4	108

GWL Detector Options

-LB-AWT Low-Background Detector with OFHC Cu Endcap and High Purity Al Well Tube, add “-LB-AWT” to the model number. Requires selection of a Low-Background LB cryostat.

-XLB-AWT Extra-Low-Background Detector with OFHC Cu Endcap and High Purity Al Well Tube, add “-XLB-AWT” to the model number. Requires selection of a Low-Background XLB cryostat. Not compatible with -HJ option.

-HJ Remote preamplifier and high voltage filter for use with HJ type cryostat, add “-HJ” to the model number. Requires selection of HJ cryostat. Not compatible with -XLB-AWT option.

GWL Series Coaxial HPGe Detector Product Configuration Guide

GWL Streamline Cryostats

- Select dewar from GWL Streamline Dewars. Dewar included except where marked*.
- Append matching Detector Endcap Size designation to cryostat model: -70, -83, -95, -108 [e.g., CFG-SJ-95 for GWL-280-15 or CFG-SL-XLB-83 for GWL-170-10-XLB-AWT]

Model No.	Description
CFG-HJ	J-type Cryostat with Remote Preamp and Dewar. (for -HJ option only)
CFG-SJ	J-type Cryostat with Dewar
CFG-SL	Side-Looking Cryostat with Dewar
CFG-SV	Vertical Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
LOW-BACKGROUND	
CFG-HJ-LB	Low-Background J-type Cryostat with Remote Preamp and Dewar. (for -HJ option only)
CFG-SJ-LB	Low-Background J-type Cryostat with Dewar
CFG-SL-LB	Low-Background Side-Looking Cryostat with Dewar
CFG-SV-LB	Low-Background Vertical Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
CFG-SJ-XLB	Extra-Low-Background J-type Cryostat with Dewar
CFG-SL-XLB	Extra-Low-Background Side-Looking Cryostat with Dewar
CFG-SV-XLB	Extra-Low-Background Vertical Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*

GWL Streamline Dewars

For Cryostat	Choose	Description	
CFG-HJ, SJ, SL	DWR-7.5B	7.5-liter Side-Looking Dewar	Included with Cryostat
	DWR-13B	13-liter Side-Looking Dewar	Included with Cryostat
	DWR-30B	30-liter Side-Looking Dewar	Included with Cryostat
CFG-SV	DWR-30-OP	30-liter Offset-Port Dewar	
	DWR-30	30-liter Dewar	

Specifications subject to change
072910

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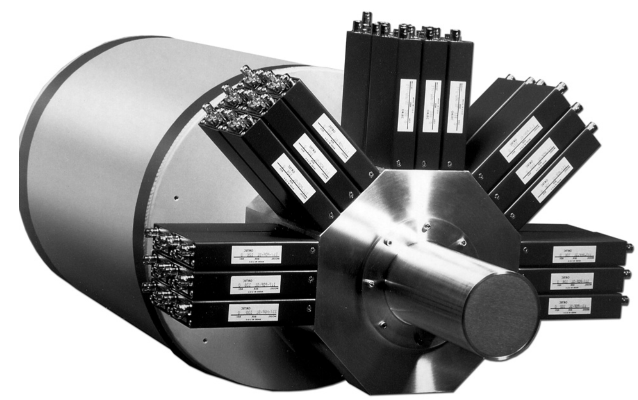
IGLET and IGLET-X HPGe Detectors for Low and Very-Low Energy X Rays Product Configuration Guide

- **135 eV resolution for 5.9 keV x rays**
- **Ultra-thin detector window for spectroscopy to <0.5 keV in windowless cryostats**
- **Excellent resolution at ultra-high count rates**
- **Wide acceptance angle: active area up to 200 mm^2**
- **Peak-to-tail ratio >1000 — ideal for PIXE**
- **Far superior to Si(Li) detectors**
- **Ideal choice for PIXE, XAFS, XRF, and Fusion**
- **Custom designed XAFS arrays**
- **Complete analog or digital electronics available**



IGLET and IGLET-X detectors provide state-of-the-art energy resolution at energies up to 30 keV. For the lowest energies the IGLET-X is the detector of choice, with a front contact so thin that spectroscopy may be performed even below 0.5 keV. In many applications the low energy limit of the IGLET-X is established by the cryostat window. The IGLET's lower energy limit is 3 keV.

Due to the superior intrinsic energy resolution of germanium vs. silicon, the IGLET-X and IGLET are better than Si(Li) detectors for most applications. Another advantage of IGLET and IGLET-X detectors over Si(Li) detectors is the result of a special low-capacitance geometry that yields minimal electronic noise despite the relatively large active area.

Because many applications present conflicting demands for high-count-rate operation and excellent energy resolution, an advanced Pulsed Optical Feedback (POF) preamplifier is incorporated. Resolution specifications are given at 5.9 keV at 100,000 cps with a 0.5 µs amplifier time constant. Throughput curves at various time constants are shown in Figure 1. Energy resolution vs. shaping time is displayed in Figure 2.

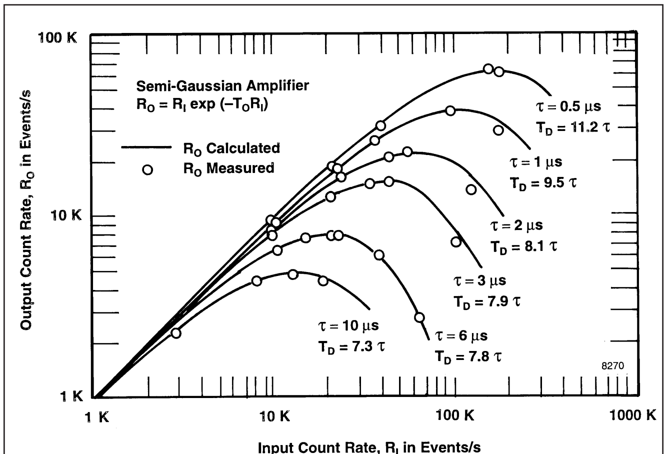


Fig. 1. A Plot of the Unpiled-Up Amplifier Output Rate as a Function of the Input Rate for Six Values of Shaping Time Constants.

IGLET-X™ HPGe Detector for Very-Low-Energy X Rays

The IGLET-X is a unique germanium detector especially designed for x-ray spectrometry in PIXE, XAFS, and XRF applications. The large active area combined with the high density of germanium (vs. silicon) yields a high efficiency detector for x-ray energies from <500 eV (in a windowless cryostat) to >60 keV.

IGLET-X delivers high peak-to-tail ratios and Gaussian peak shapes, even at energies below 500 eV (in a windowless cryostat). Excellent energy resolution may be achieved even at count rates of 100,000 cps and above.

With a resolution of **135 eV** for a 6-mm-diameter, 6-mm-deep detector and **145 eV** for a 11-mm-diameter, 10-mm-deep detector, the IGLET-X detector provides substantially better resolution than is possible with conventional planar or modified planar detector geometries. With an IGLET-X detector in a windowless system, resolution of less than 110 eV, with perfectly Gaussian peak shape, has been reported for the oxygen $K_{\alpha 1}$ line (at 525 eV). (Fig. 3)[6]

Another feature of the IGLET-X is a well-collimated, sharply defined entrance contact, which provides a high acceptance angle without peak distortion, a key issue for PIXE.

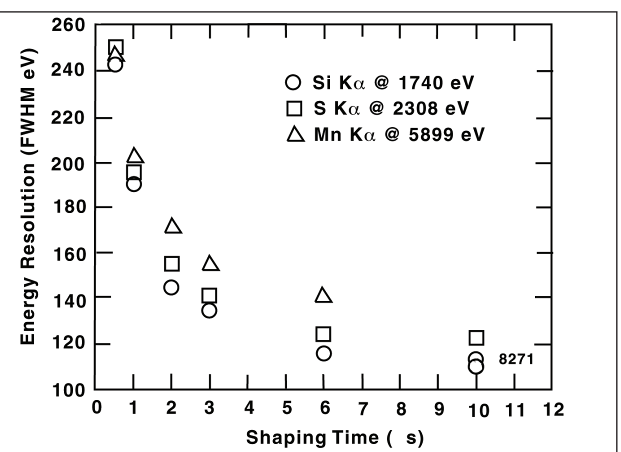


Fig. 2. Energy Resolution of Mn Kα, S Kα, and Si Kα Lines as a Function of Amplifier Shaping Time Constants for a 6-mm Diameter IGLET-X.

IGLET and IGLET-X
HPGe Detectors for Low and Very-Low Energy X Rays
Product Configuration Guide

IGLET™ HPGe Detector for Low-Energy X Rays

The IGLET detector geometry results in substantially better resolution than is achievable with Ge planar detectors. By virtue of a proprietary detector-element geometry and an advanced reset-feedback preamplifier, the IGLET offers unmatched performance from 3 keV to 30 keV, the energy range for XAFS measurements at synchrotron light sources. Furthermore, the IGLET has unmatched warranted performance at 100,000 cps, thus ensuring full exploitation of the extreme brightness of x-ray beams at the newest facilities.

Cryostat Windows

While the IGLET detector element entrance window establishes 3 keV as a lower limit for the useful energy range, the IGLET-X low energy capability is limited only by the cryostat window. ORTEC offers thin Be windows with the performance shown in Fig. 4.

Through even ultra-thin beryllium windows, there is little transmission of <1-keV photons. There is a practical, reliable method of achieving excellent resolution at energies as low as the carbon K_α line at 277 eV (Fig. 5)[6]. The answer is a windowless system, for which the experimenter must control the cleanliness of the vacuum, such as a CFG-JIMG cryostat outfitted with a gate valve. It should be noted that a good vacuum, free of impurities, is then needed in the x-ray source. Although ORTEC does not warrant any detector which has been opened, reliable operation can be obtained with a clean vacuum.

At energies below 3 keV the Full Energy Detection Efficiency of IGLET-X detectors is dominated by x-ray absorption in the endcap window. Figure 6 shows the results obtained with Be windows of different thickness.

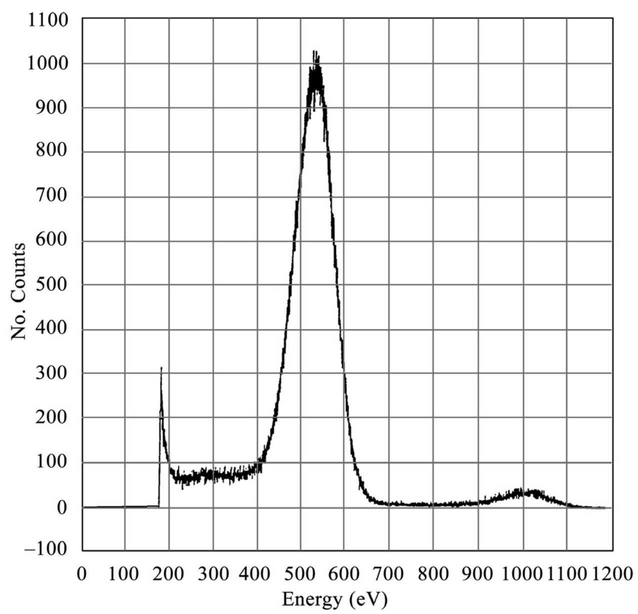


Fig. 3. Pulse Height Distribution of Oxygen *K*α Line (109 eV FWHM @ 525 eV).

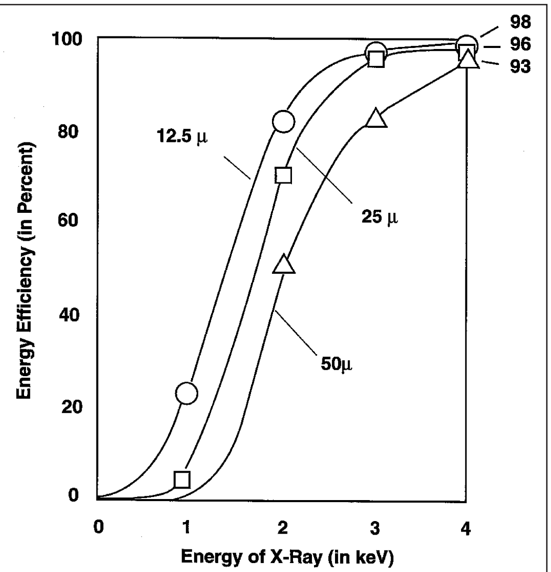


Fig. 4. Full Energy Detection Efficiency (%) with Be Windows of Different Thickness: 12.5 μm for IGLET-X-06135, 25 μm for IGLET-X-11145, and 50 μm for IGLET-X-16160.

Individual Detector or Multiple-Detector Arrays

The IGLET and IGLET-X detectors are available either as individual detectors in an individual cryostat or in multiple-detector arrays.

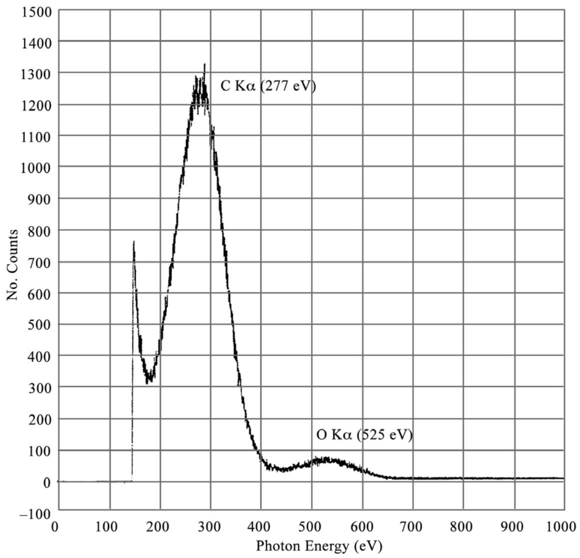


Fig. 5. Pulse Height Distribution of Carbon *K*α Line (118 eV FWHM @ 277 eV).

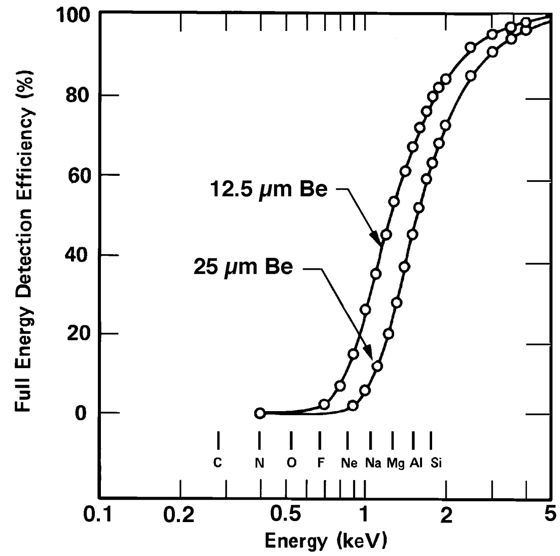


Fig. 6. IGLET-X Full Energy Detection Efficiency in Percent vs. X-Ray Energy.

Configuration Guidelines

Streamline (non-PopTop) Configuration

In so called Streamline systems, the detector capsule in NOT demountable. Detector capsule and cryostat share the same vacuum. In configuration terms, this requires a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap. A cryostat must always be ordered with a Streamline capsule, because they are integral.

Steps to Configure Your ORTEC HPGe Detector

1) Configure the Detector Model

- Ge Crystal dimensions and specifications
- Endcap and window

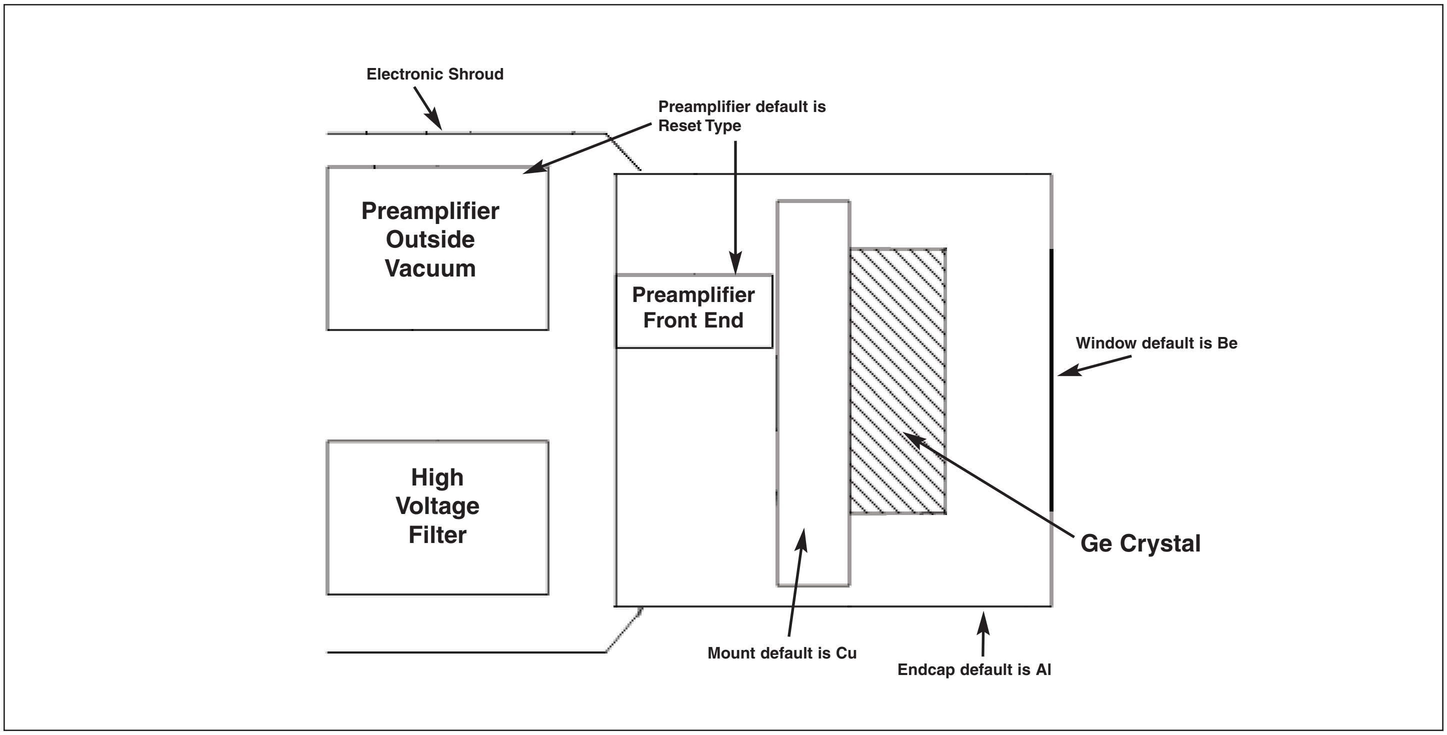
2) Configure the Cryostat/Dewar Model

- Vertical Dipstick style (separate Dewar)
- Horizontal Dipstick style (separate Dewar)
- Portable with all-position or multi-position cryostat/dewar models
- Downlooking designed to be oriented with the detector pointing down
- Sidelooking designed to be oriented with the detector horizontal at the bottom of the dewar
- "J" configuration designed with the detector attached near the bottom of the dewar and a right angle bend in the cryostat orienting the detector to look up.

A cryostat and dewar or other cooling device are required for operation.

You must choose a cryostat or cryostat/dewar model for the detector to be mounted on and vacuum sealed. The cryostat or cryostat/dewar combination diameter must match the endcap diameter of the selected detector.

Streamline Detector



JIM Cryostat/Dewar Assemblies

Both IGLET and IGLET-X detectors are available in all standard ORTEC cryostats. IGLET detectors are also available in the cryostat-dewar assemblies shown in Fig. 7. For spectroscopy on extremely small targets, these JIM series cryostats with their small diameter, are the best choice. (Not available for IGLET-X.)

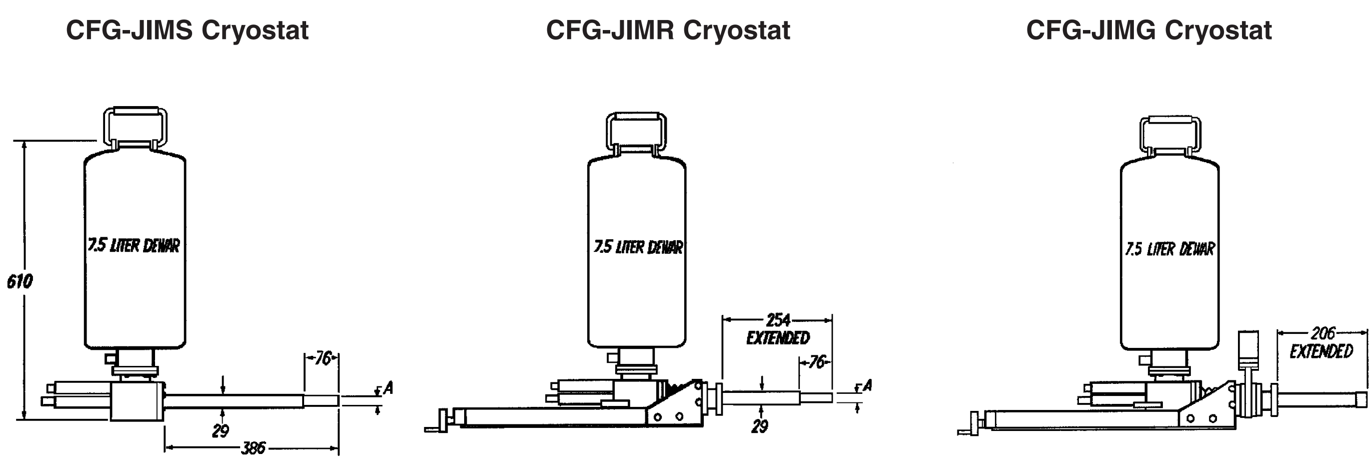
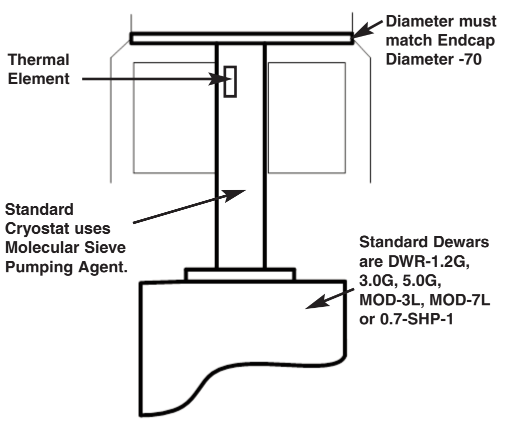


Fig. 7. CFG-JIMS, CFG-JIMR, and CFG-JIMG Cryostat Types for IGLET Detectors.

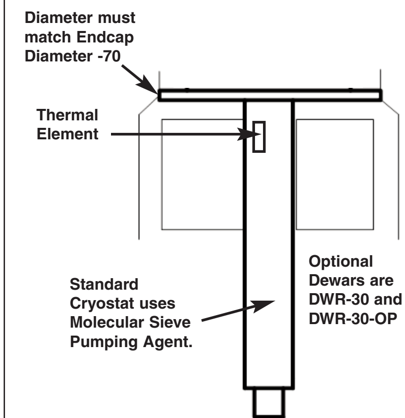
Active Diameter (mm)	06	11	16
"A" Dimension (mm)	19	22	29

Streamline Cryostat and Cryostat/Dewar Assemblies

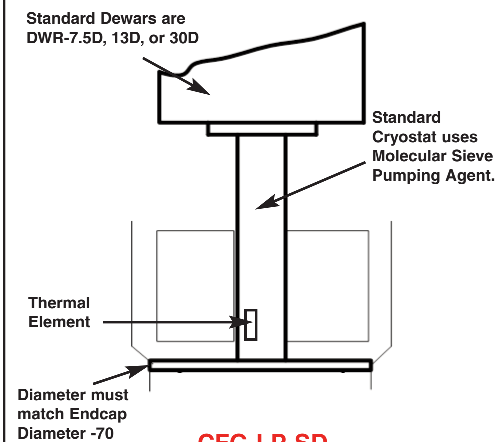
Streamline systems (detector capsule and cryostat) share the same vacuum, requiring a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap.



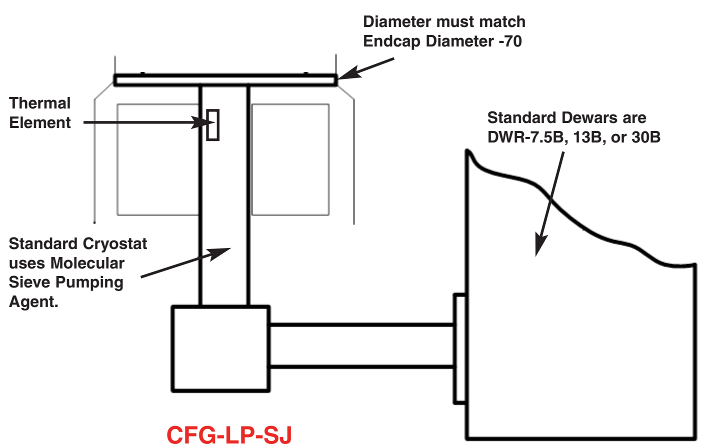
CFG-LP-GG



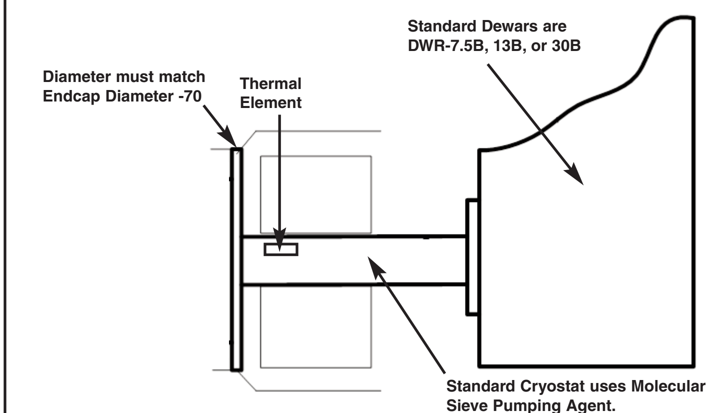
CFG-LP-SV



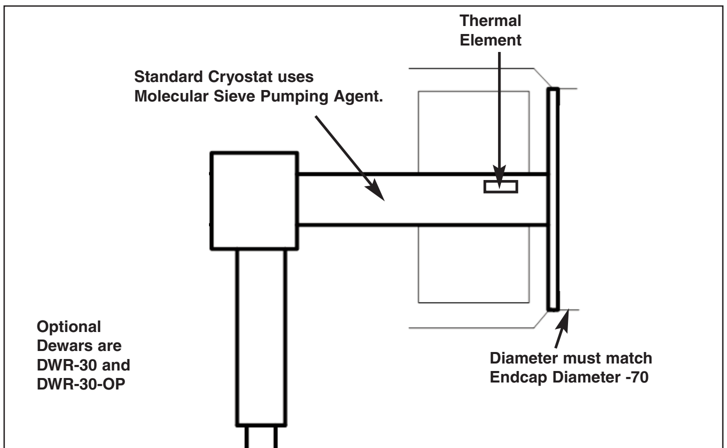
CFG-LP-SD



CFG-LP-SJ



CFG-LP-SL



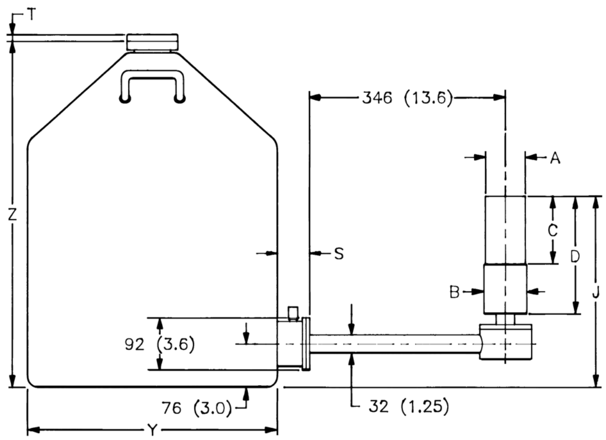
CFG-LP-SH

Streamline Dimensional Data

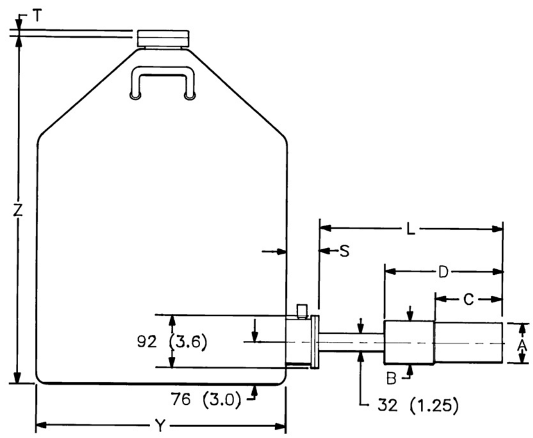
Streamline systems (detector capsule and cryostat) share the same vacuum, requiring a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap. A cryostat must be ordered with a Streamline capsule.

The cryostat and dewar drawings that follow are to be used in conjunction with the accompanying tables of dimensions.

Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



CFG-LP-SJ, DWR-30B (or -13B or -7.5B)



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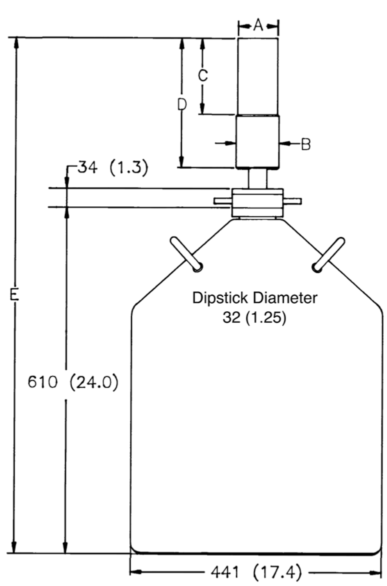
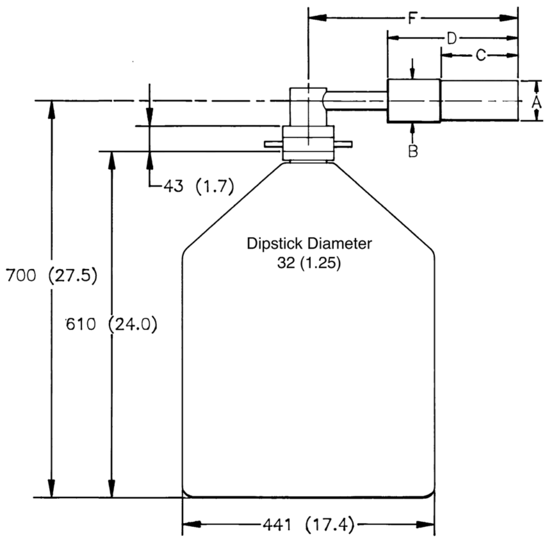
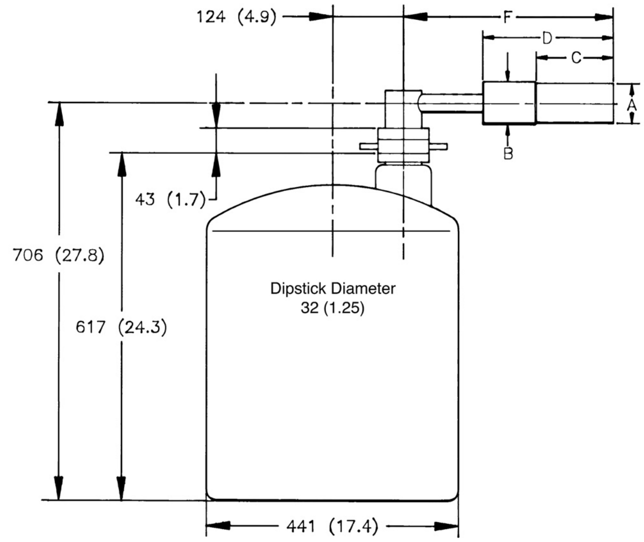


CFG-LP-SV, DWR-30

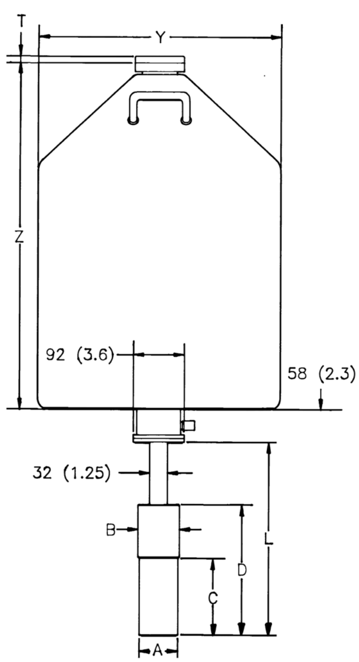
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



CFG-LP-SH, DWR-30

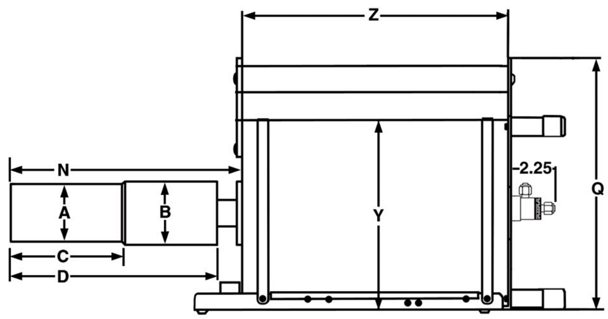


CFG-LP-SH, DWR-30-OP

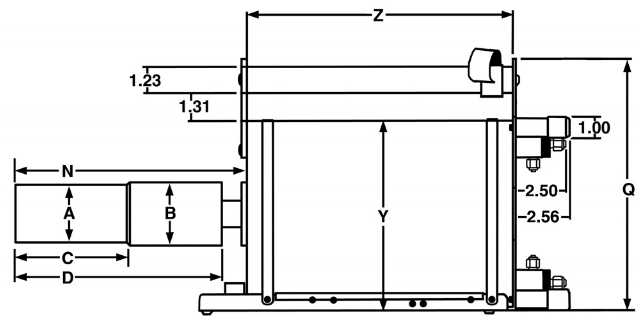


CCFG-LP-SD, DWR-30D (or -13D or -7.5D)

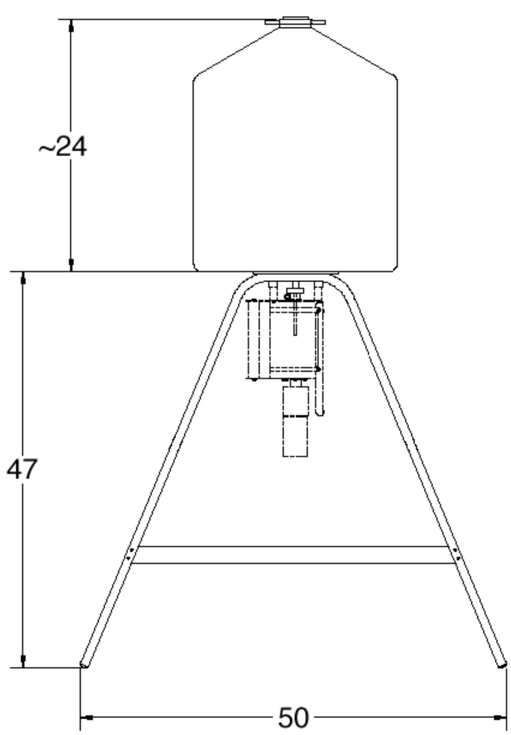
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



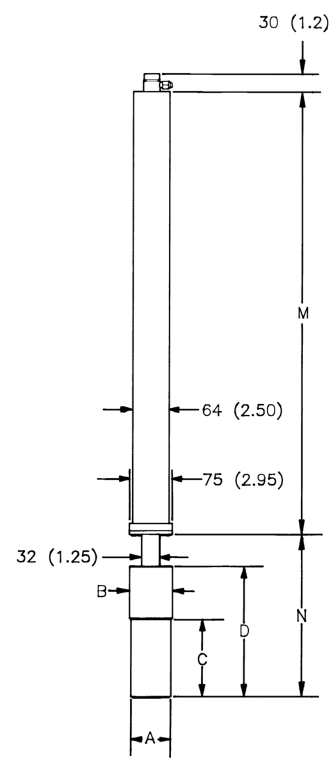
CFG-LP-GG, DWR-1.2G (or -3.0G, -5.0G)



CFG-LP-GG, DWR-MOD3L (or -MOD7L)



DWR-S/F



CFG-LP-GG, DWR-0.7-SHP-1

IGLET and IGLET-X Detector Dimensions

- Dimensions are for reference only and subject to change.
- If dimensional constraints are critical, contact the factory.

Dim.	Unit	Tol.	Streamline
A	mm (in)	0.3 (0.01)	70 (2.75)
B	mm (in)	0.3 (0.01)	75 (2.95)
C	mm (in)	5 (0.2)	71 (2.8)
D	mm (in)	8 (0.3)	182 (7.2)
E	mm (in)	8 (0.3)	854 (33.6)
F	mm (in)	18 (0.7)	305 (12.0)
J	mm (in)	10 (0.4)	318 (12.5)
L	mm (in)	18 (0.7)	274 (10.8)
M	mm (in)	10 (0.4)	X X
N	mm (in)	8 (0.3)	215 (8.5)

Gamma Gage and Side-Looking Dewar Dimensions

- Dimensions are for reference only and subject to change.
- If dimensional constraints are critical, contact the factory.

			Cryostat/Dewar or Dewar Type							
			DWR-x.xG			DWR-MOD-xL		DWR-xxB and DWR-xxD		
			VOLUME			VOLUME		VOLUME		
Dim.	UNIT	TOL. ±	1.2L	3L	5L	3L	7L	7.5L	13L	30L
Q	mm (in)	13 (0.5)	229 (9.0)	302 (11.9)	302 (11.9)	229 (9.0)	302 (11.9)	X X	X X	X X
R	mm (in)	10 (0.4)	X X	X X	X X	X X	X X	174 (6.9)	174 (6.9)	155 (6.1)
S	mm (in)	7.6 (0.3)	X X	X X	X X	X X	X X	77 (3.0)	77 (3.0)	60 (2.3)
T	mm (in)	5 (0.2)	X X	X X	X X	X X	X X	10 (0.4)	10 (0.4)	13 (0.5)
Y	mm (in)	5 (0.2)	157 (6.2)	229 (9.0)	229 (9.0)	157 (6.2)	229 (9.0)	224 (8.8)	307 (12.1)	442 (17.4)
Z	mm (in)	5 (0.2)	229 (9.0)	267 (10.5)	419 (16.5)	292 (11.5)	320 (12.6)	452 (17.8)	429 (16.9)	610 (24.0)

IGLET and IGLET-X
HPGe Detectors for Low and Very-Low Energy X Rays
Product Configuration Guide

Example Model Numbers

Streamline Configuration

IGLET-06135	6-mm diameter, 6-mm thick IGLET detector with 70-mm diameter endcap.
CFG-LP-GG-70	Portable Gamma Gage cryostat with matching 70-mm diameter flange.
DWR-1.2G	1.2 liter all-position dewar for Gamma Gage Cryostat.
IGLET-X-11145	11-mm diameter, 10-mm deep IGLET-X detector with 70-mm diameter endcap.
CFG-LP-SD-70	Downlooking cryostat with matching 70-mm diameter flange.
DWR-7.5D	7.5 Liter downlooking dewar for downlooking cryostat.
IGLET-16160	16-mm diameter, 10-mm deep IGLET detector with 70-mm diameter endcap.
CFG-JIMS-7.5	Sidelooking, 7.5-liter bucket dewar, small diameter cryostat and endcap.

Ordering Information

- If dimensional considerations are critical, contact factory.
- Cryostat and dewar or other cooling device are not included with detector.
- Cryostat and dewar or other cooling device are required for operation.
- A cryostat must be ordered with a Streamline detector.

Model No.	Be Window Thickness (μm)	Active Diameter (mm)	Active Depth (mm)	Warranted Resolution @5.9 keV, 10 μs 1000 cps	Warranted Resolution @5.9 keV, 0.5 μs 100,000 cps
IGLET-06135	13	6	6	135 eV	250 eV
IGLET-11145	25	11	10	145 eV	270 eV
IGLET-16160	50	16	10	160 eV	280 eV
IGLET-X-06135	13	6	6	135 eV	250 eV
IGLET-X-11145	25	11	10	145 eV	270 eV
IGLET-X-16160	50	16	10	160 eV	280 eV

IGLET and IGLET-X Streamline Cryostats

• Select dewar from IGLET and IGLET-X Streamline Dewars. Dewar included except where marked*.

Model No.	Description
CFG-LP-GG-70	Gamma Gage Cryostat Dewar
CFG-LP-SD-70	Down-Looking Cryostat with Dewar
CFG-LP-SH-70	Horizontal Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
CFG-LP-SJ-70	J-type Cryostat with Dewar
CFG-LP-SL-70	Side-Looking Cryostat with Dewar
CFG-LP-SV-70	Vertical Cryostat with (Dipstick type). Includes LNTC1.25WH. Dewar not included.*

IGLET and IGLET-X Streamline Dewars

For Cryostat	Choose	Description	
CFG-LP-GG	DWR-1.2G	1.2-liter All-Orientation Dewar	Included with Cryostat
	DWR-3.0G	3.0-liter All-Orientation Dewar	Included with Cryostat
	DWR-5.0G	5.0-liter All-Orientation Dewar	Included with Cryostat
	DWR-MOD-3L	3-liter Multi-Orientation Dewar	Included with Cryostat
	DWR-MOD-7L	7-liter Multi-Orientation Dewar	Included with Cryostat
	DWR-0.7-SHP-1	0.7-liter Shallow-Hole Probe Dewar	Included with Cryostat
	DWR-S/F	Storage/Fill Dewar for DWR-XG	
CFG-LP-SJ, SL	DWR-7.5B	7.5-liter Side-Looking Dewar	Included with Cryostat
	DWR-13B	13-liter Side-Looking Dewar	Included with Cryostat
	DWR-30B	30-liter Side-Looking Dewar	Included with Cryostat
CFG-LP-SD	DWR-7.5D	7.5-liter Down-Looking Dewar	Included with Cryostat
	DWR-13D	13-liter Down-Looking Dewar	Included with Cryostat
	DWR-30D	30-liter Down-Looking Dewar	Included with Cryostat
CFG-LP-SV, SH	DWR-30-OP	30-liter Offset-Port Dewar	
	DWR-30	30-liter Dewar	

IGLET Streamline Cryostats with Small Diameter Endcap and Dewar

• Not available for IGLET-X.
• Dewar included.

Model No.	Description
CFG-JIMS-7.5	Sidelooking, 7.5 liter bucket dewar, small diameter cryostat and endcap.
CFG-JIMR-7.5	Sidelooking, 7.5 liter bucket dewar, small diameter cryostat and endcap with retractable slide and bellows.
CFG-JIMG-7.5	Sidelooking, 7.5 liter bucket dewar, small diameter cryostat and endcap with retractable slide and bellows, and high vacuum gate valve.

Literature

Visit the ORTEC website for the following papers:

1. "On the Use of a High-Purity-Ge Detector for PIXE Spectrometry on Geological Material" by R.D. Vis, Free University of Amsterdam, Faculty of Physics and Astronomy. (This paper conclusively shows that, for most PIXE applications, Ge detectors [such as ORTEC IGLET-X] advantageously replace Si(Li) detectors.)

2. "A Soft X-Ray Solid-State Detector for Beamline 3.4. Part 2: Detector Characterization for Photon Energies Below 1 keV" by A.D. Smith and R.C. Farrow. (This paper shows how to obtain spectra down to energies down to the C K alpha line <300 keV.)

3. "A Solid-State Detector for Soft Energy Extended X-Ray Absorption Fine Structure Measurements" by A.D. Smith, G.E. Derbyshire, R.C. Farrow, A. Sery (DRAL U.K.) and T. W. Raudorf and M. Martini (ORTEC), Rev. Sci. Instruments 66 (2) February 1995. (This paper expands on the subject covered in reference #2.)

Specifications subject to change
072910

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LO-AX Low-Energy Photon Detector Product Configuration Guide

The LO-AX provides optimum peak-to-background ratio from 10 to 400 keV on large-area samples. It is also ideal for *in vivo* actinide monitoring using L x rays.

- Large active area
- 36-, 51-, 60-, and 70-mm diameter available
- Ideal for *in vivo* actinide monitoring
- Excellent for uranium monitoring
- PopTop flexibility
- ULTRA-thin rugged Ion-implanted pointer contact sensitive at front and sides

The LO-AX is a large active area, "short" coaxial detector which supplies the best possible energy resolution for the energy range from 3 to 400 keV.

A typical application for the LO-AX is *in vivo* quantitative actinide monitoring. This measurement, frequently performed in the past using phoswich scintillation counters, is now routinely performed using a LO-AX, usually in a low-background cryostat.

The LO-AX detector element length, about one-half that of the diameter (Fig. 1), provides a special, low-capacitance coaxial geometry. The result is 370-eV energy resolution at 5.9 keV for the 51-mm diameter LO-AX detector. **Typical measured resolution for 13- to 17-keV x rays is ~400 eV.** Higher efficiency is available with the 60-mm and 70-mm-diameter LO-AX detectors.

Because of their good energy resolution at low energies LO-AX detectors, particularly in low-background cryostats, are ideal for quantifying plutonium. In most laboratories 70-mm diameter LO-AX have become the detector of choice because of their higher efficiency and sensitivity. An additional benefit of the 70-mm detector is a net reduction in Compton background due to the increased probability that a high energy event will experience a multiple interaction in the larger detector, and thus generate a count in a channel well above the Pu peak.

The LO-AX detector's wide energy range results in high efficiency for the quantification of uranium.

The LO-AX is equipped with an automatic, high-voltage shutdown capability.

LO-AX detectors are available with a choice of Be or carbon fiber window. Transmission data is shown in Fig. 2.

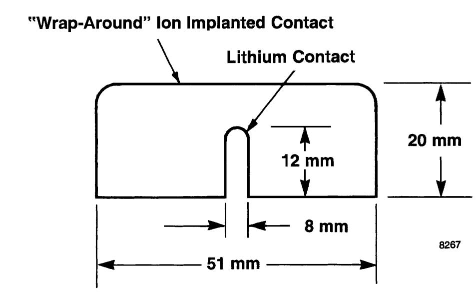


Fig. 1. Dimensional Drawing of the 51-mm-Diameter LO-AX Detector Element.

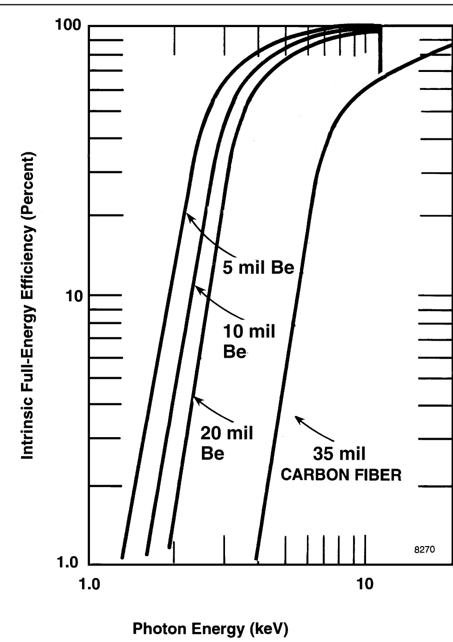


Fig. 2. Low Energy Gamma and X-Ray Transmission of Be and Carbon Fiber Windows.

The Following Specifications are Provided for each LO-AX Detector

- Active crystal diameter and depth.
- Energy resolution at 5.9 keV photons from ^{55}Fe at optimum shaping time unless the window material prohibits this energy.
- Energy resolution at 122 keV photons from ^{57}Co at optimum shaping time.

Configuration Guidelines

PopTop or Streamline (non-PopTop) Configuration

The essence of a PopTop detector system is that the HPGe detector element cryostat, preamplifier, and high voltage filter are housed in a detector “capsule” which is then attached to an appropriate cryostat (Figure 3.)

In so called Streamline systems, the detector capsule in NOT demountable. Detector capsule and cryostat share the same vacuum. In configuration terms, this requires a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap. A cryostat must always be ordered with a Streamline capsule, because they are integral.

The actual PopTop capsule has its own vacuum. It can be mounted on any of the available cryostats, cryostat/dewar combinations, or the X-COOLER II mechanical cooling system.

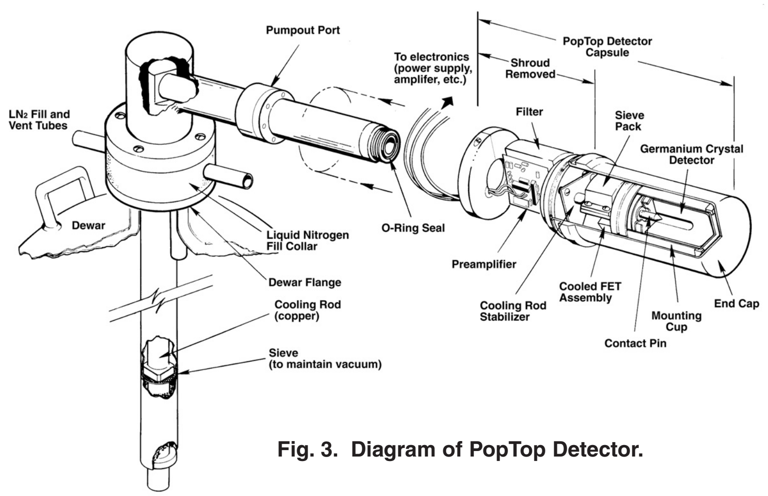


Fig. 3. Diagram of PopTop Detector.

Steps to Configure Your ORTEC HPGe Detector

1) Configure the Detector Model

- Capsule type (PopTop or Streamline)
- Ge Crystal dimensions and specifications
- Endcap and window
- Mount
- Preamplifier
- High Voltage Filter
- Cable Package

Options are available for the detector model that can change specific materials used in the construction of the detector endcap, cup, and mount. Preamplifier options are also available.

2) Configure the Cryostat/Dewar Model

- Vertical Dipstick style (separate Dewar)
- Horizontal Dipstick style (separate Dewar)
- Portable with all-position or multi-position cryostat/dewar models
- Downlooking designed to be oriented with the detector pointing down
- Sidelooking designed to be oriented with the detector horizontal at the bottom of the dewar
- “J” configuration designed with the detector attached near the bottom of the dewar and a right angle bend in the cryostat orienting the detector to look up.

A cryostat and dewar or other cooling device are required for operation.

If a PopTop detector has been selected, you can choose a PopTop style cryostat, cryostat/dewar combination or the X-COOLER II mechanical cooler.

If a Streamline detector has been selected, you must choose a cryostat or cryostat/dewar model for the detector to be mounted on and vacuum sealed. The cryostat or cryostat/dewar combination diameter must match the endcap diameter of the selected detector.

Detector Options

SMART-1 Option (-SMN)

The SMART-1 option monitors and reports on vital system functions, and can save authentication codes and report the code at a later time. It has the high voltage included, so none of the instruments require an external high-voltage power supply.

The SMART-1 is housed in a rugged ABS molded plastic enclosure and is permanently attached to the detector endcap via a molded-strain-relieved sealed cable. This eliminates the possibility that the detector will suffer severe damage from moisture leaking into high-voltage connectors. The SMART-1 can be positioned in any convenient place and does not interfere with shielding or other mounting hardware.

Fig. 4. SMART-1 Detector Interface Module.

Carbon Fiber Window Option (-CW)

A carbon fiber window is available for energies greater than about 8 keV. While this window does not pass all the lower energies, carbon fiber has lower Z than Al and does not have any of the hazards associated with Be. See Figures 5 and 6 for transmission data for carbon fiber.

Low-Background Carbon Fiber Endcap Options (-RB, -LB-C, and -XLB-C)

Carbon Fiber is as strong as Al, Mg, and Cu, creates less background, does not corrode, and can detect energies less than 10 keV.

This lower background material allows for lower Minimum Detectable Activity (MDA) for a specific counting time, which provides another step in increasing sample throughput in low-background counting applications. The lower Z of Carbon Fiber provides a low-energy window without the additional background found in most alloys. See Figures 5 and 6 for transmission characteristics of the Be and carbon fiber windows.

Low-Background Be/Cu Endcap Options (-RB-B, -LB-B, and -XLB-B)

If the ultimate in low energies is required, a low-background, high purity Be window can be installed in a Cu endcap to minimize the background and still allow energies as low as 3-keV through the front window of the detector.

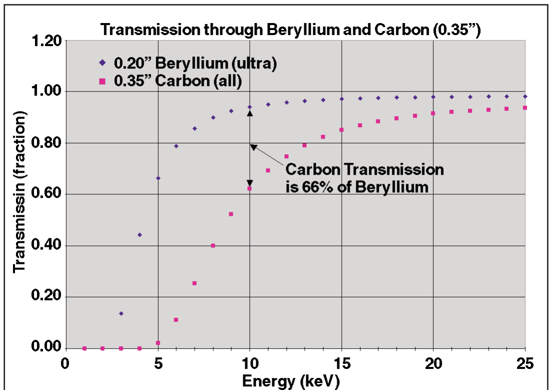


Fig. 5. Transmission through Be and Carbon (.076 mm).

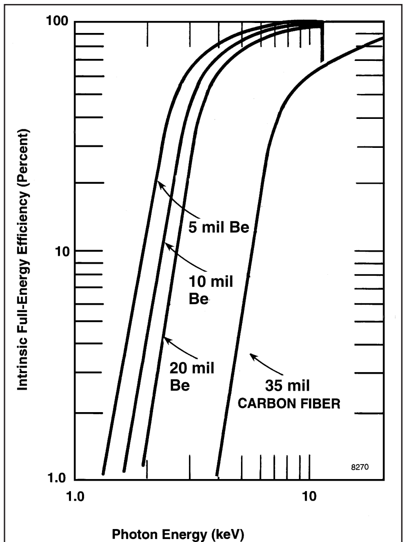


Fig. 6. Low Energy Gamma and X-Ray Transmission of Be and Carbon Fiber Windows.

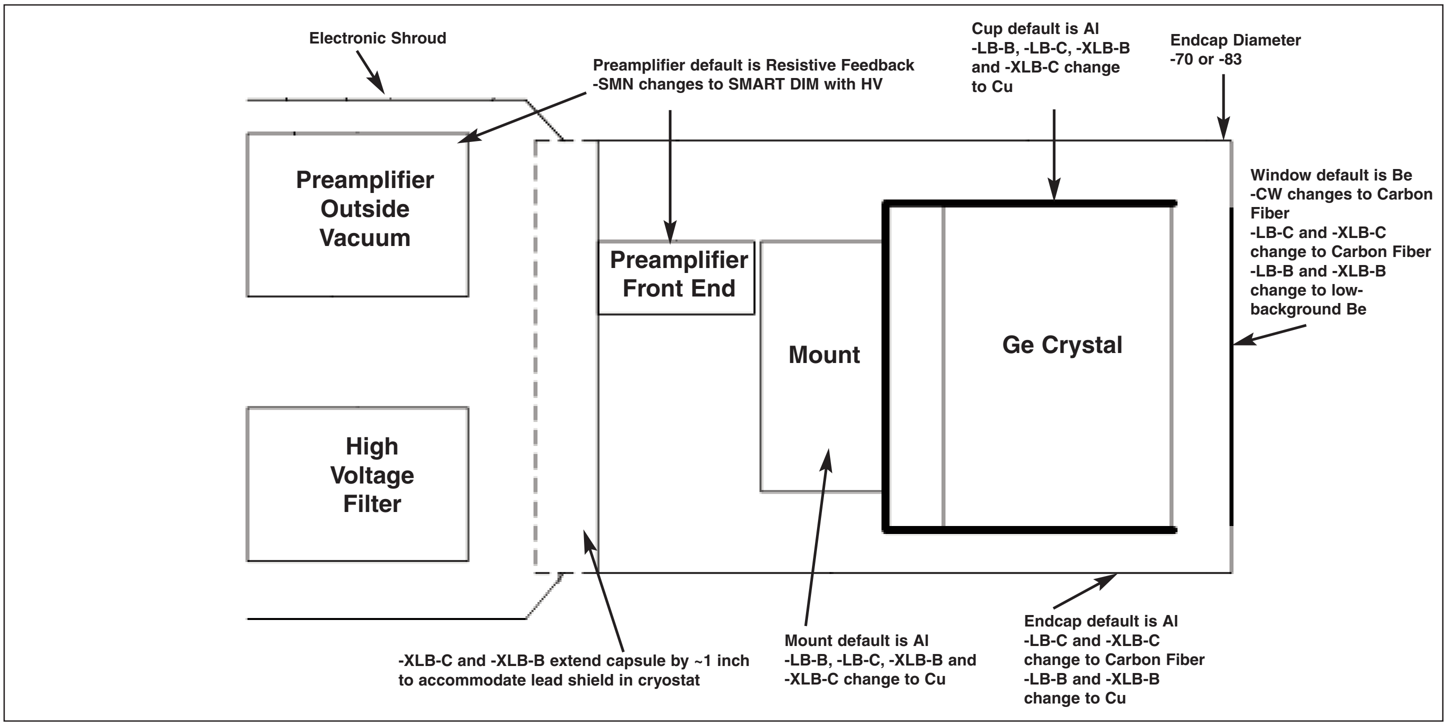
Defining the Detector Model

• See ordering information for option compatibility.

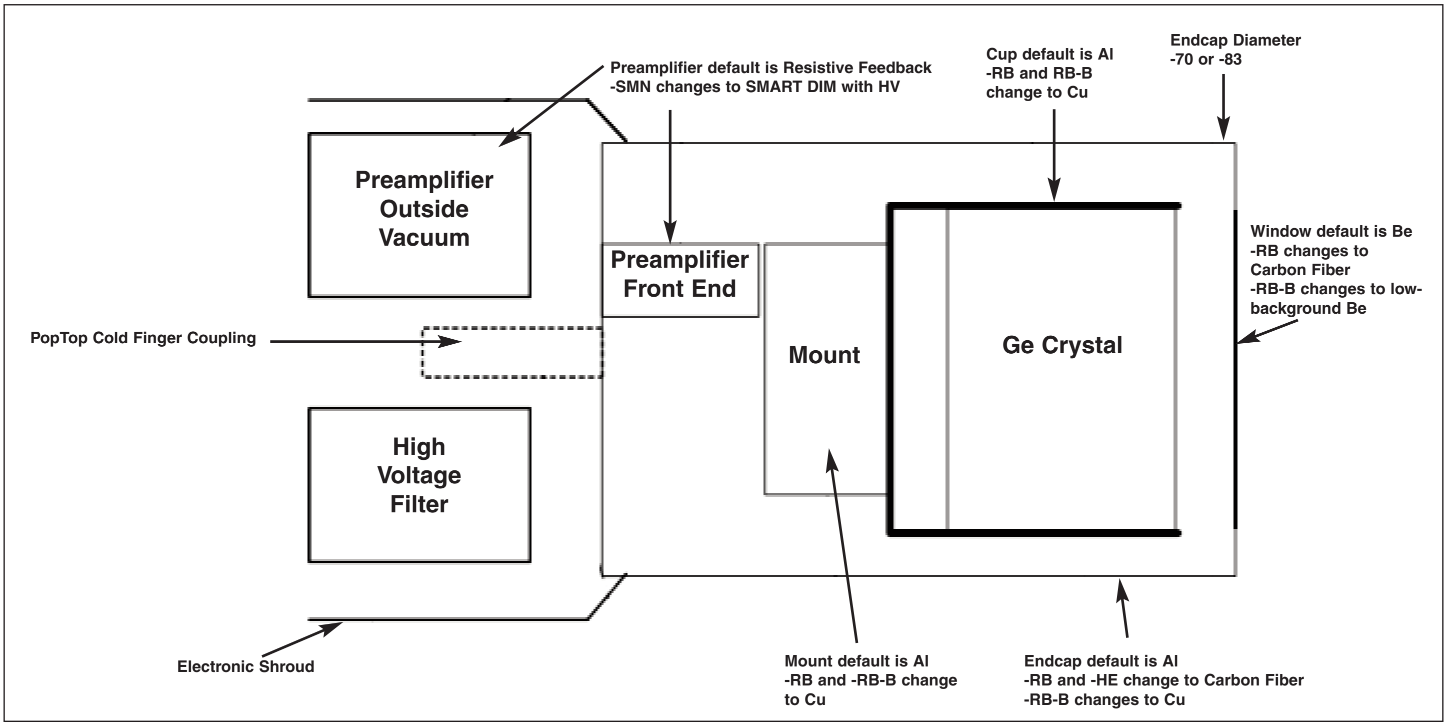
Base Model (example)	PopTop or Streamline	Window Option (if required)	High Voltage Option (if required)
LX-36300-15	P4 (PopTop) (Streamline)	-RB -RB-B -CW -LB-B -LB-C -XLB-B -XLB-C	-SMN

LO-AX Low-Energy Photon Detector
Product Configuration Guide

Streamline Detector Capsule

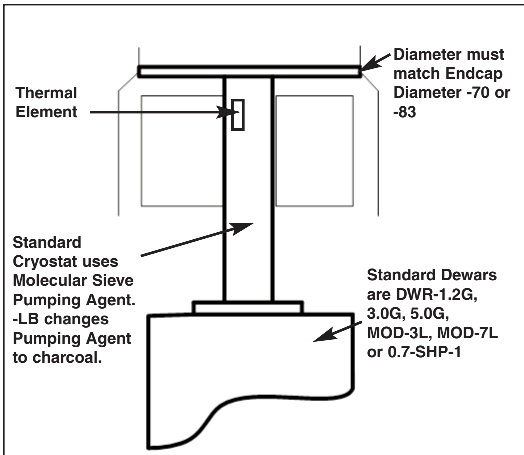


PopTop Detector Capsule

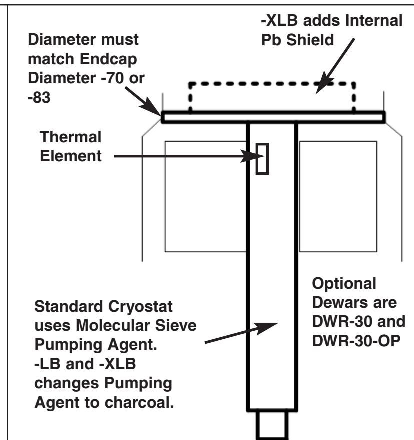


Streamline Cryostat and Cryostat/Dewar Assemblies

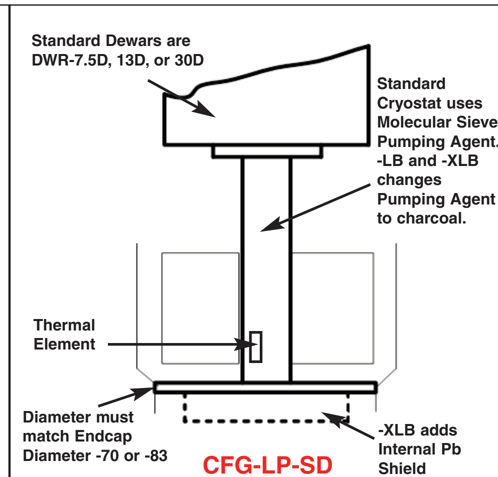
Streamline systems (detector capsule and cryostat) share the same vacuum, requiring a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap.



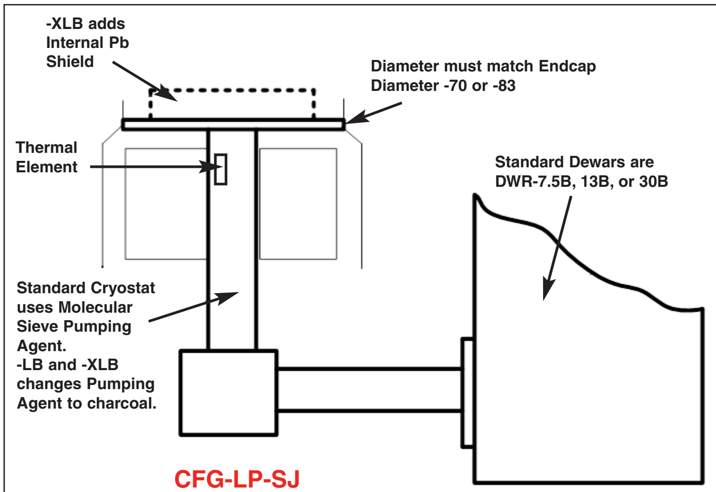
CFG-LP-GG



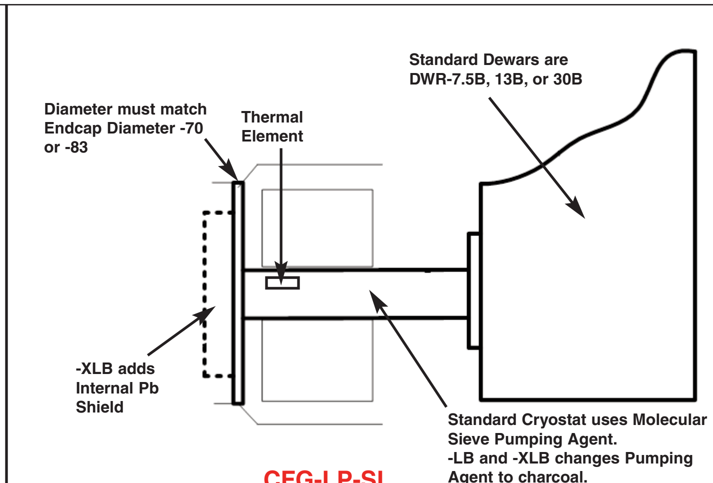
CFG-LP-SV



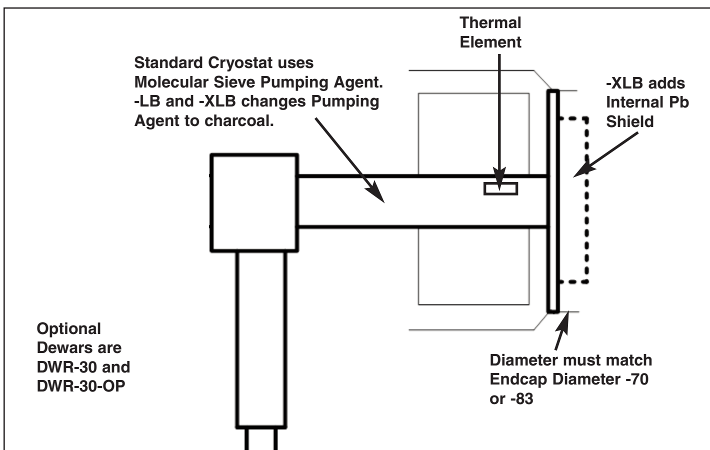
CFG-LP-SD



CFG-LP-SJ



CFG-LP-SL



CFG-LP-SH

LO-AX Low-Energy Photon Detector
Product Configuration Guide

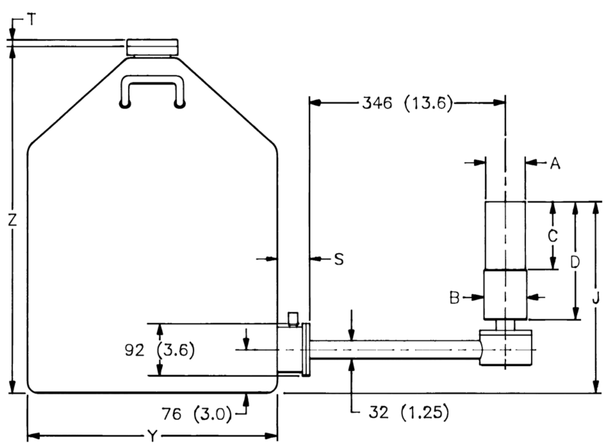
PopTop and Streamline Dimensional Data

Streamline systems (detector capsule and cryostat) share the same vacuum, requiring a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap. A cryostat must be ordered with a Streamline capsule.

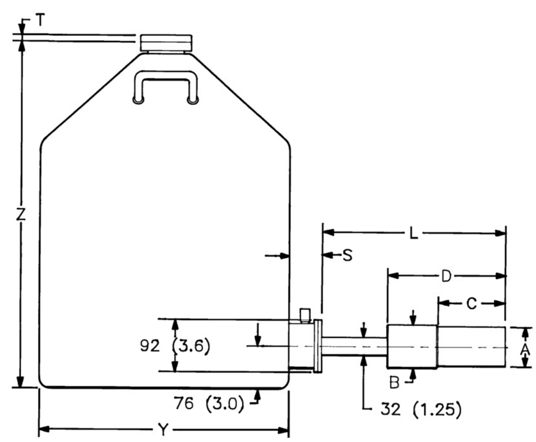
The PopTop capsule contains a vacuum unto itself. It can be mounted on any of the available cryostats, cryostat/dewar combinations, or the X-COOLER II mechanical cooling system.

The cryostat and dewar drawings that follow are to be used in conjunction with the accompanying tables of dimensions.

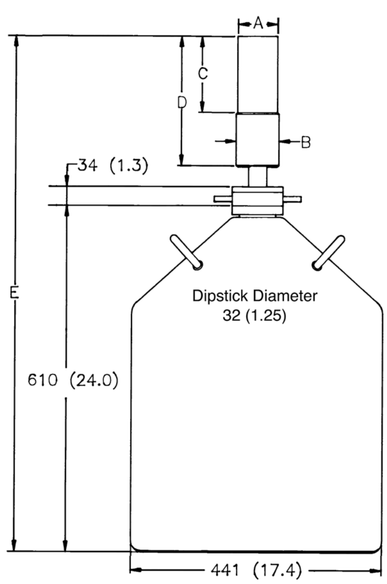
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



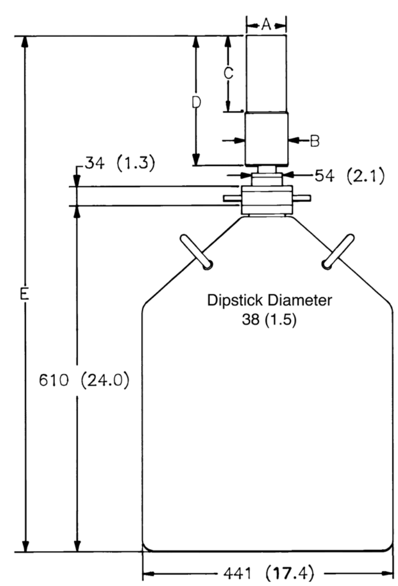
CFG-LP-SJ, DWR-30B (or -13B or -7.5B)



CFG-PS4-30 (or -13 or -7.5)
or
CFG-LP-SL, DWR-30B (or -13B or -7.5B)

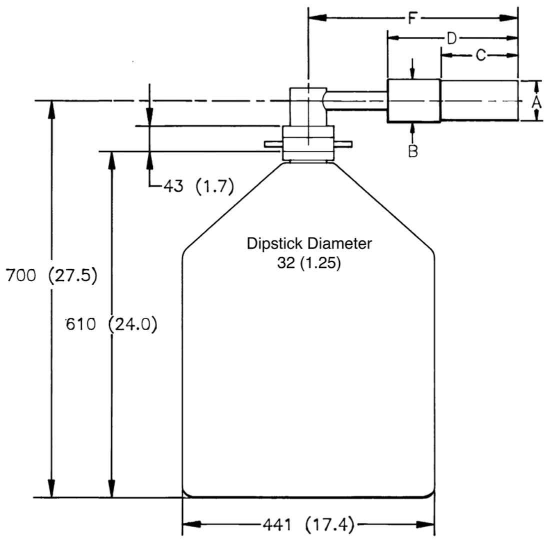


CFG-LP-SV, DWR-30

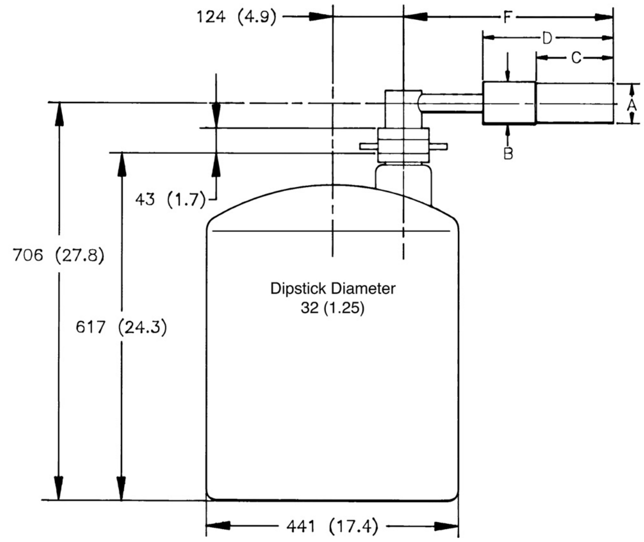


CFG-PV4, DWR-30

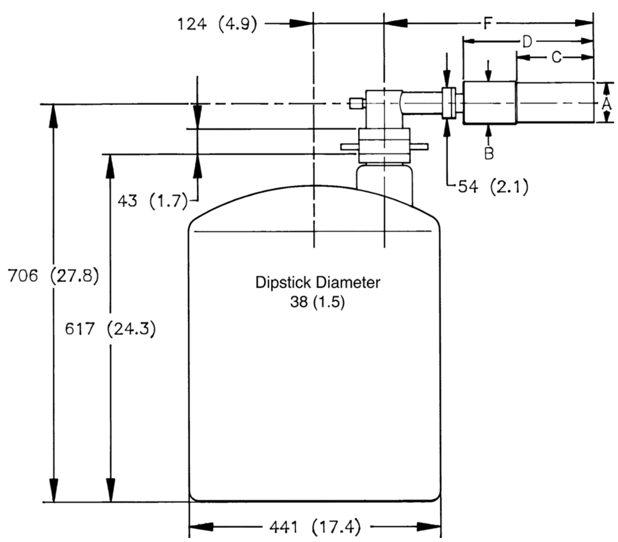
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



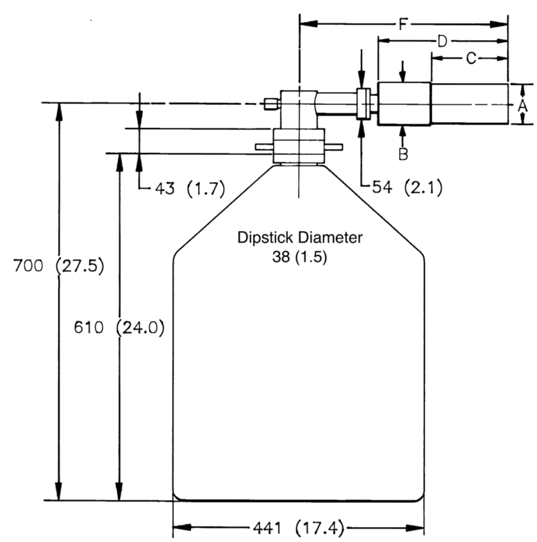
CFG-LP-SH, DWR-30



CFG-LP-SH, DWR-30-OP



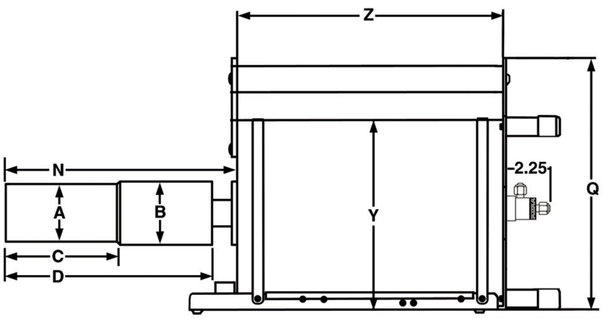
CFG-PH4, DWR-30-OP



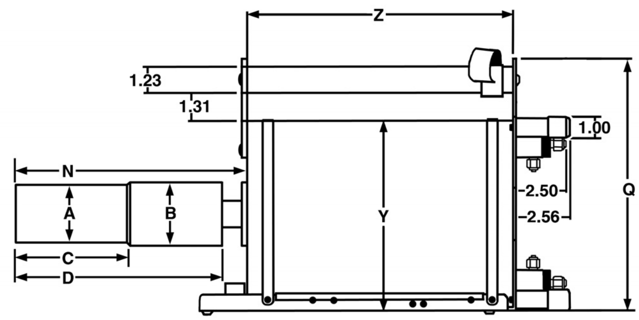
CFG-PH4, DWR-30

LO-AX Low-Energy Photon Detector
Product Configuration Guide

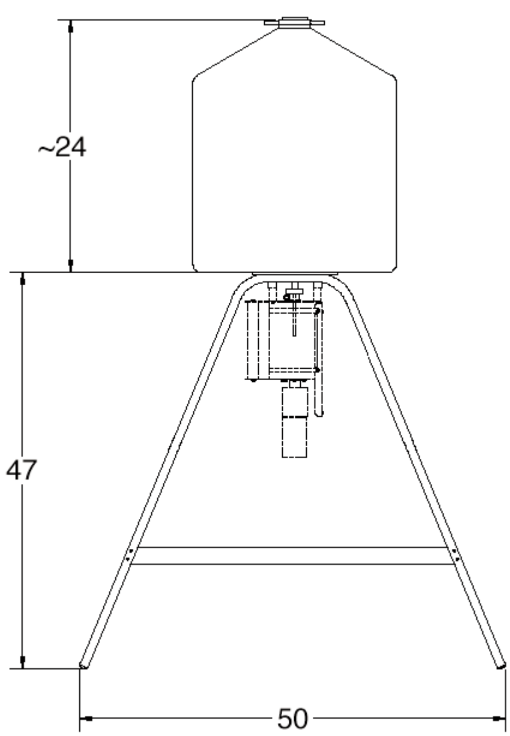
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



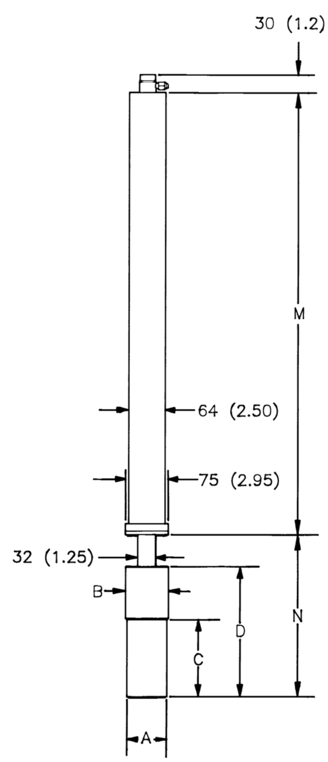
CFG-PG4-1.2 (or -3 or -5)
or
CFG-LP-GG, DWR-1.2G (or -3.0G, -5.0G)



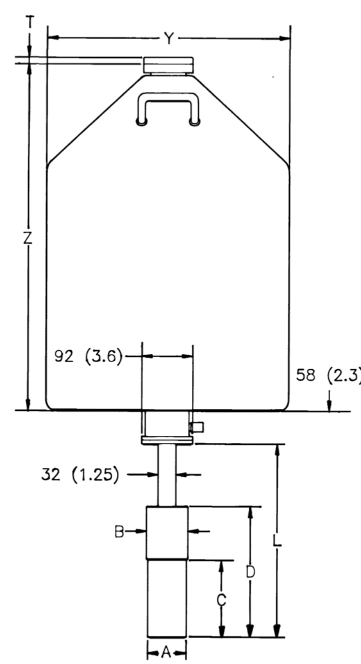
CFG-PMOD4-3 (or -7)
or
CFG-LP-GG, DWR-MOD3L (or -MOD7L)



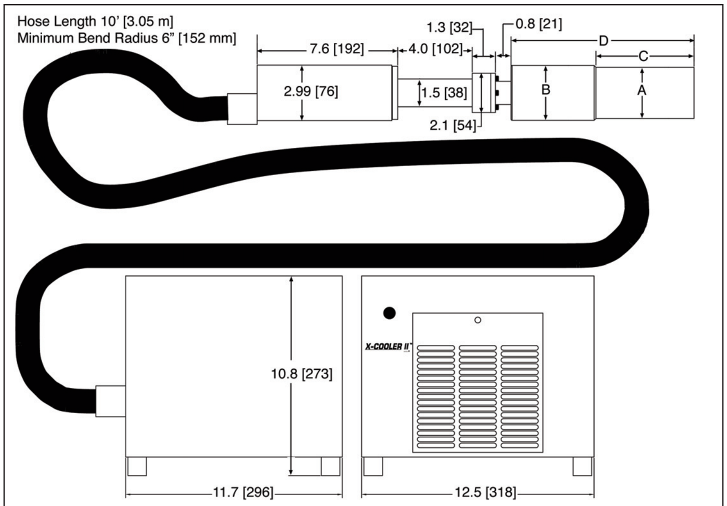
DWR-S/F



CFG-PSHP4
or
CFG-LP-GG, DWR-0.7-SHP-1



CFG-PD4-30 (or -13 or -7.5)
or
CFG-LP-SD, DWR-30D (or -13D or -7.5D)



CFG-X-COOL-II

LO-AX Detector Dimensions

- Dimensions are for reference only and subject to change.
- If dimensional constraints are critical, contact the factory.

			PopTop		Streamline			
					Standard or LB		XLB	
			Endcap Diameter		Endcap Diameter		Endcap Diameter	
Dim.	Unit	Tol.	36/51 mm	60/70 mm	36/51 mm	60/70 mm	36/51 mm	60/70 mm
A	mm (in)	0.3 (0.01)	70 (2.75)	83 (3.25)	70 (2.75)	83 (3.25)	70 (2.75)	83 (3.25)
B	mm (in)	0.3 (0.01)	75 (2.95)	88 (3.45)	75 (2.95)	88 (3.45)	75 (2.95)	88 (3.45)
C	mm (in)	5 (0.2)	134 (5.3)	168 (6.6)	134 (5.3)	134 (5.3)	160 (6.3)	160 (6.3)
D	mm (in)	8 (0.3)	250 (9.8)	282 (11.2)	246 (9.7)	259 (10.2)	272 (10.7)	284 (11.2)
E	mm (in)	8 (0.3)	947 (37.3)	982 (38.6)	916 (36.1)	932 (36.7)	941 (37.1)	958 (37.7)
F	mm (in)	18 (0.7)	396 (15.6)	429 (16.9)	368 (14.5)	381 (15.0)	394 (15.5)	406 (16.0)
J	mm (in)	10 (0.4)	X X	X X	380 (15)	393 (15.5)	405 (16)	418 (16.5)
L	mm (in)	18 (0.7)	338 (13.3)	371 (14.6)	338 (13.3)	351 (13.8)	363 (14.3)	376 (14.8)
M	mm (in)	10 (0.4)	790 (31.1)	X X	516 (20.3)	X X	516 (20.3)	X X
N	mm (in)	8 (0.3)	278 (10.9)	312 (12.3)	278 (11)	292 (11.5)	305 (12)	318 (12.5)

LO-AX Low-Energy Photon Detector Product Configuration Guide

Gamma Gage and Side-Looking Dewar Dimensions

• Dimensions are for reference only and subject to change.
• If dimensional constraints are critical, contact the factory.

			Cryostat/Dewar or Dewar Type							
			CFG-PG4 and DWR-x.xG			CFG-PMOD4 and DWR-MOD-xL		CFG-PS4, CFG-PD4, DWR-xxB and DWR-xxD		
			VOLUME			VOLUME		VOLUME		
Dim.	UNIT	TOL. ±	1.2L	3L	5L	3L	7L	7.5L	13L	30L
Q	mm (in)	13 (0.5)	229 (9.0)	302 (11.9)	302 (11.9)	229 (9.0)	302 (11.9)	X X	X X	X X
R	mm (in)	10 (0.4)	X X	X X	X X	X X	X X	174 (6.9)	174 (6.9)	155 (16.1)
S	mm (in)	7.6 (0.3)	X X	X X	X X	X X	X X	77 (3.0)	77 (3.0)	60 (2.3)
T	mm (in)	5 (0.2)	X X	X X	X X	X X	X X	10 (0.4)	10 (0.4)	13 (0.5)
Y	mm (in)	5 (0.2)	157 (6.2)	229 (9.0)	229 (9.0)	157 (6.2)	229 (9.0)	224 (8.8)	307 (12.1)	442 (17.4)
Z	mm (in)	5 (0.2)	229 (9.0)	267 (10.5)	419 (16.5)	292 (11.5)	320 (12.6)	452 (17.8)	429 (16.9)	610 (24.0)

Example Model Numbers

Streamline Configuration

LX-60450-30	60-mm diameter, 30-mm deep LO-AX detector with 83-mm diameter endcap.
CFG-SD-83	Downlooking cryostat with matching 83-mm diameter flange.
DWR-7.5D	7.5 Liter downlooking dewar for downlooking cryostat.
LX-70450-30-CW	70-mm diameter, 30-mm deep LO-AX detector with 83-mm diameter endcap and carbon fiber window.
CFG-SJ-83	"J" configuratiion cryostat with matching 83-mm diameter flange.
DWR-30B	30 liter side port dewar for "J" configuration cryostat.
LX-60450-30-LB-B	60-mm diameter, 30-mm deep LO-AX detector with 83-mm diameter endcap and low background Be window in Cu endcap.
CFG-LP-SV-83-LB	Vertical "dipstick" style cryostat with matching 83-mm diameter flange and low background charcoal pumping agent.
DWR-30	30 liter top port dewar that accepts "dipstick" style cryostats.

PopTop Configuration

LX-36300-15-SMN	36-mm diameter, 15-mm deep LO-AX detector with 70-mm diameter endcap and SMART-1 preamplifier and high voltage supply.
CFG-PV4	Vertical "dipstick" style cryostat.
DWR-30	30 liter top port dewar that accepts "dipstick" style cryostats.
LX-51370-20-RB-B	51-mm diameter, 20-mm deep LO-AX detector with 70-mm diameter Cu endcap and Be window.
CFG-PD4-7.5	Downlooking cryostat with 7.5 liter dewar.
LX-51370-20-RB	51-mm diameter, 20-mm deep LO-AX detector with 70-mm diameter carbon fiber endcap.
CFG-PG4-3.0	Portable Gamma Gage cryostat with 3 liter all-position dewar.

LO-AX Low-Energy Photon Detector
Product Configuration Guide

Ordering Information

- For Streamline, remove the "P4" from the model number.
- If dimensional considerations are critical, contact factory.
- Cryostat and dewar or other cooling device are not included with detector.
- Cryostat and dewar or other cooling device are required for operation.
- A cryostat must be ordered with a Streamline detector.

Model No.	Detector Diameter (mm)	Dimensions		Energy Resolution FWHM		Endcap Diameter (mm)	Be Window Thickness (mm)
		Area (mm^2)	Depth (mm)	@5.9 keV (eV)	@122 keV (eV)		
LX-36300-15P4	36	1000	15	300	550	70	0.5
LX-51370-20P4	51	2000	20	370	625	70	0.5
LX-60450-30P4	60	2800	30	450	700	83	0.5
LX-70450-30P4	70	3800	30	450	725	83	0.5

LO-AX Detector Options

-RB PopTop Only. Reduced background PopTop capsule with Carbon Fiber endcap, add "-RB" to the model number. Not compatible with -HE option.

-RB-B PopTop Only. Reduced background PopTop capsule with Be window in Cu endcap, add "-RB-B" to the model number. Not compatible with -HE option.

-SMN SMART-1 detector option for negative bias detector, add "-SMN" to the model number.

-CW Carbon Fiber Window (0.9 mm thick) at no extra charge, add "-CW" to the model number. This option deletes the 5.9-keV resolution specification.

-LB-B Streamline Only. Low-Background Detector with Be window in Cu endcap, add "-LB-B" to the model number. Requires selection of a Low-Background LB cryostat.

-LB-C Streamline Only. Low-Background Detector with Carbon Fiber Endcap, add "-LB-C" to the model number. Requires selection of a Low-Background LB cryostat. This option deletes the 5.9-keV resolution specification.

-XLB-B Streamline Only. Extra-Low-Background Detector with Be window in Cu endcap, add "-XLB-B" to the model number. Requires selection of a Low-Background XLB cryostat.

-XLB-C Streamline Only. Extra-Low-Background Detector with Carbon Fiber Endcap, add "-XLB-C" to the model number. Requires selection of a Low-Background XLB cryostat. This option deletes the 5.9-keV resolution specification.

LO-AX PopTop Cryostats and Dewars

- Dewar included except where marked *.

Model No.	Description
CFG-PD4-7.5	Down-looking Cryostat with 7.5-liter Dewar
CFG-PD4-13	Down-looking Cryostat with 13-liter Dewar
CFG-PD4-30	Down-looking Cryostat with 30-liter Dewar
CFG-PG4-1.2	Gamma Gage Cryostat with 1.2-liter Dewar
CFG-PG4-3	Gamma Gage Cryostat with 3-liter Dewar
CFG-PG4-5	Gamma Gage Cryostat with 5-liter Dewar
CFG-PH4	Horizontal Cryostat (Dipstick type). Includes LNTC1.5WH. Dewar not included.* Choose DWR-30 or DWR-30-OP.
CFG-PMOD4-3	Gamma Gage Cryostat with 3-liter Multi-Orientation Dewar
CFG-PMOD4-7	Gamma Gage Cryostat with 7-liter Multi-Orientation Dewar
CFG-PS4-7.5	Side-Looking Cryostat with 7.5-liter Dewar
CFG-PS4-13	Side-Looking Cryostat with 13-liter Dewar
CFG-PS4-30	Side-Looking Cryostat with 30-liter Dewar
CFG-PSHP4	Down-Looking Shallow-Hole Probe with 0.7-liter Dewar
CFG-PV4	Vertical Cryostat (Dipstick type). Includes LNTC1.5WH. Dewar not included.* Choose DWR-30 or DWR-30-OP.
DWR-30	30-liter Dewar
DWR-30-OP	30-liter Offset-Port Dewar
DWR-S/F	Storage Fill Dewar for CFG-PG4-X
CFG-X-COOL-II-115	X-COOLER II with PopTop connector using 110-120 V ac, 60 Hz Input Power
CFG-X-COOL-II-230	X-COOLER II with PopTop connector using 220-240 V ac, 50 Hz Input Power

LO-AX Low-Energy Photon Detector
Product Configuration Guide

LO-AX Streamline Cryostats

- Select dewar from LO-AX Streamline Dewars. Dewar included except where marked*.
- Append matching Detector Endcap Size designation to cryostat model: -70, -83 [e.g., CFG-LP-SJ-70 for LX-36300-15 or CFG-LP-SL-XLB-83 for LX-70450-30-XLB-B]

Model No.	Description
CFG-LP-GG	Gamma Gage Cryostat Dewar
CFG-LP-SD	Down-Looking Cryostat with Dewar
CFG-LP-SH	Horizontal Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
CFG-LP-SJ	J-type Cryostat with Dewar
CFG-LP-SL	Side-Looking Cryostat with Dewar
CFG-LP-SV	Vertical Cryostat with (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
LOW-BACKGROUND	
CFG-LP-GG-LB	Low-Background Gamma Gage Cryostat with Dewar
CFG-LP-SD-LB	Low-Background Down-Looking Cryostat with Dewar
CFG-LP-SH-LB	Low-Background Horizontal Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
CFG-LP-SJ-LB	Low-Background J-type Cryostat with Dewar
CFG-LP-SL-LB	Low-Background Side-Looking Cryostat with Dewar
CFG-LP-SV-LB	Low-Background Vertical Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
CFG-LP-SD-XLB	Extra-Low-Background Down-Looking Cryostat with Dewar.
CFG-LP-SH-XLB	Extra-Low-Background Horizontal Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
CFG-LP-SJ-XLB	Extra-Low-Background J-type Cryostat with Dewar
CFG-LP-SL-XLB	Extra-Low-Background Side-Looking Cryostat with Dewar
CFG-LP-SV-XLB	Extra-Low-Background Vertical Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*

LO-AX Streamline Dewars

For Cryostat	Choose	Description	
CFG-LP-GG	DWR-1.2G	1.2-liter All-Orientation Dewar	Included with Cryostat
	DWR-3.0G	3.0-liter All-Orientation Dewar	Included with Cryostat
	DWR-5.0G	5.0-liter All-Orientation Dewar	Included with Cryostat
	DWR-MOD-3L	3-liter Multi-Orientation Dewar	Included with Cryostat
	DWR-MOD-7L	7-liter Multi-Orientation Dewar	Included with Cryostat
	DWR-0.7-SHP-1	0.7-liter Shallow-Hole Probe Dewar	Included with Cryostat
	DWR-S/F	Storage/Fill Dewar for DWR-XG	
CFG-LP-SJ, SL	DWR-7.5B	7.5-liter Side-Looking Dewar	Included with Cryostat
	DWR-13B	13-liter Side-Looking Dewar	Included with Cryostat
	DWR-30B	30-liter Side-Looking Dewar	Included with Cryostat
CFG-LP-SD	DWR-7.5D	7.5-liter Down-Looking Dewar	Included with Cryostat
	DWR-13D	13-liter Down-Looking Dewar	Included with Cryostat
	DWR-30D	30-liter Down-Looking Dewar	Included with Cryostat
CFG-LP-SV, SH	DWR-30-OP	30-liter Offset-Port Dewar	
	DWR-30	30-liter Dewar	

Specifications subject to change
072910

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ADVANCED MEASUREMENT TECHNOLOGY

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High-Performance Germanium Coaxial Detectors for Safeguards and Non-Destructive Assay Product Configuration Guide

- **Specifically designed to meet the demanding requirements of isotopic ratio software codes used in Safeguards and NDA.**
- **Excellent resolution is maintained over a wide range of count rates, enhancing measurement flexibility.**
- **Available in a full range of crystal diameters.**
- **Extensive range of cryostats with multi-orientation dewar options for applications requiring portability.**
- **Compatible with all existing Safeguards multichannel analyzers.**

The precise measurement of isotopic ratios required in Safeguards and non-destructive assay (NDA) applications places a severe demand on the techniques of gamma-ray and x-ray spectroscopy. Figure 1 demonstrates the complexity of the 90–130 keV region of a typical Pu spectrum. (The choice of energy region(s) for analysis depends specifically on the sample type and origin and the material matrix.

National laboratory software codes[1] written to obtain highly accurate isotopic ratios, must deal with these spectra to analyze low-energy and/or high-energy regions in which groups of peaks are located close together. Each code requires exceptional system resolution and stability in order to achieve accurate unfolding of these regions.

Recent safeguards development trends have led to a growing requirement of isotopic ratio determinations involving higher energy gamma-rays. Such needs spring from the need to measure attenuated samples, such as those found in waste assay and in certain homeland security applications. Software codes such as PC/FRAM and MGAHI[2] can now determine Pu isotopic ratios from the higher energy regions of the spectrum. As a consequence, it is desirable to produce HPGe detectors that offer improved higher energy performance, while maintaining the excellent resolution characteristics required in such applications.

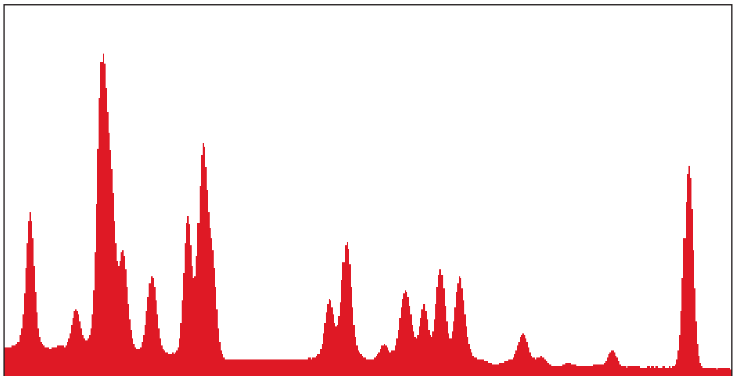


Fig. 1. The 90 to 130 keV region of a typical plutonium spectrum.

The ORTEC Safeguards series include both coaxial and planar geometry detectors, specifically designed to meet the demands of the applications software used for isotopic ratio determination, have been developed to strike an optimum balance between low-energy resolution and high-energy efficiency.

SGD series detectors are compatible with ALL conventional MCA types, although optimum performance will be obtained when used with the ORTEC Digital Signal Processing Spectrometers.

All SGD detectors feature the following:

- Choice of fixed, portable, and custom cryostats, including the latest MOD multi-orientation dewar option.
- Robust aluminum end-cap
- Streamline preamplifier assembly
- LN_2-Free option

The latest low-power resistive feedback preamplifier with "no ring" output, suitable for use with all existing types of MCA systems. Power consumption less than 25 mA at ±12 and ±24 V.

Application Considerations

For samples in thick walled containers, or when significant matrix attenuation is present, it may be necessary to use a higher energy region of the spectrum to perform the analysis. In these cases, the SGD-GEM detectors, which are coaxial or semi-coaxial, have been developed to strike an optimum balance between low-energy resolution and high-energy efficiency.

The SGD-GEM-5050P4 is the "traditional" coaxial detector for use with PC/FRAM[3] in a wide variety of cases, including the measurement of UF6 cylinders.

The SGD-GEM-5030P4 has a semi-planar geometry and can be used as a more practical substitute for "telescope" detectors which have traditionally been used with the codes TRIFID and MGA in so-called "two-detector" mode. Recent improvements in crystal and preamplifier technologies have made it possible to gather both high- and low-energy spectra SIMULTANEOUSLY with a single SGD-GEM-5030P4 detector.

The SGD-GEM-6560P4 has been produced specifically to provide a large-area detector, which meets the resolution requirements of the FRAM code, and has good high-energy efficiency and a large detection area.

The Following Specifications are Provided for each SGD-GEM Detector

- Energy resolution at 1.33 MeV photons from ^{60}Co and 122 keV photons from ^{57}Co at 6 µs shaping time and 1 kcps.
- Energy resolution at 1.33 MeV photons from ^{60}Co an 122 keV photons from ^{57}Co at 2 µs shaping time and 1 kcps.
- Energy resolution at 1.33 MeV photons from ^{60}Co and 122 keV photons from ^{57}Co at 2 µs shaping time and 30 kcps.
- Peak shape ratio for the full width tenth maximum to the full width half maximum for ^{60}Co 1.33 MeV peak at 6 µs shaping and 1 kcps.
- Peak shape ratio for the full width fiftieth maximum to the full width half maximum for ^{60}Co 1.33 MeV peak at 6 µs shaping and 1 kcps.

Configuration Guidelines

PopTop or Streamline (non-PopTop) Configuration

The essence of a PopTop detector system is that the HPGe detector element cryostat, preamplifier, and high voltage filter are housed in a detector “capsule” which is then attached to an appropriate cryostat (Figure 2.)

In so called Streamline systems, the detector capsule in NOT demountable. Detector capsule and cryostat share the same vacuum. In configuration terms, this requires a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap. A cryostat must always be ordered with a Streamline capsule, because they are integral.

The actual PopTop capsule has its own vacuum. It can be mounted on any of the available cryostats, cryostat/dewar combinations, or the X-COOLER II mechanical cooling system.

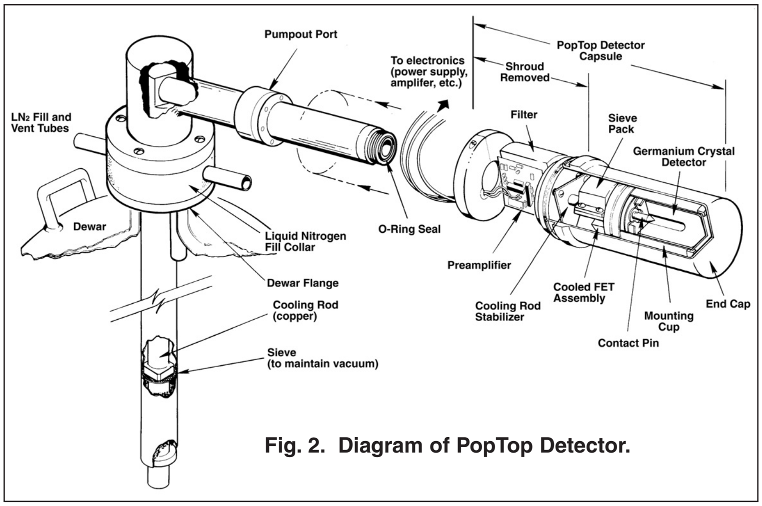


Fig. 2. Diagram of PopTop Detector.

[1]Specifically these codes are: FRAM from Los Alamos National Laboratory; MGA from Lawrence Livermore National Laboratory and TRIFID from Rocky Flats Plant.
[2]MGAHI is now included in the MGA-B32 suite of software available from ORTEC.
[3]See for example LA-UR-98-2007 Los Alamos reprint "Test and Evaluation of FRAM Isotopic Analysis Code for Euratom Applications", T.E. Sampson et al. Paper presented at the 1999 INMM, Phoenix, AZ.

Steps to Configure Your ORTEC HPGe Detector

1) Configure the Detector Model

- Capsule type (PopTop or Streamline)
- Ge Crystal dimensions and specifications
- Endcap and window
- Mount
- Preamplifier
- High Voltage Filter
- Cable Package

Preamplifier options are available.

2) Configure the Cryostat/Dewar Model

- Vertical Dipstick style (separate Dewar)
- Horizontal Dipstick style (separate Dewar)
- Portable with all-position or multi-position cryostat/dewar models
- Downlooking designed to be oriented with the detector pointing down
- Sidelooking designed to be oriented with the detector horizontal at the bottom of the dewar
- "J" configurations designed with the detector attached near the bottom of the dewar and a right angle bend in the cryostat orienting the detector to look up.

A cryostat and dewar or other cooling device are required for operation.

If a PopTop detector has been selected, you can choose a PopTop style cryostat, cryostat/dewar combination or the X-COOLER II mechanical cooler.

If a Streamline detector has been selected, you must choose a cryostat or cryostat/dewar model for the detector to be mounted on and vacuum sealed. The cryostat or cryostat/dewar combination diameter must match the endcap diameter of the selected detector.

Detector Options

SMART-1 Option (-SMP)

The SMART-1 option monitors and reports on vital system functions, and can save authentication codes and report the code at a later time. It has the high voltage included, so none of the instruments require an external high-voltage power supply.

The SMART-1 is housed in a rugged ABS molded plastic enclosure and is permanently attached to the detector endcap via a molded-strain-relieved sealed cable. This eliminates the possibility that the detector will suffer severe damage from moisture leaking into high-voltage connectors. The SMART-1 can be positioned in any convenient place and does not interfere with shielding or other mounting hardware.

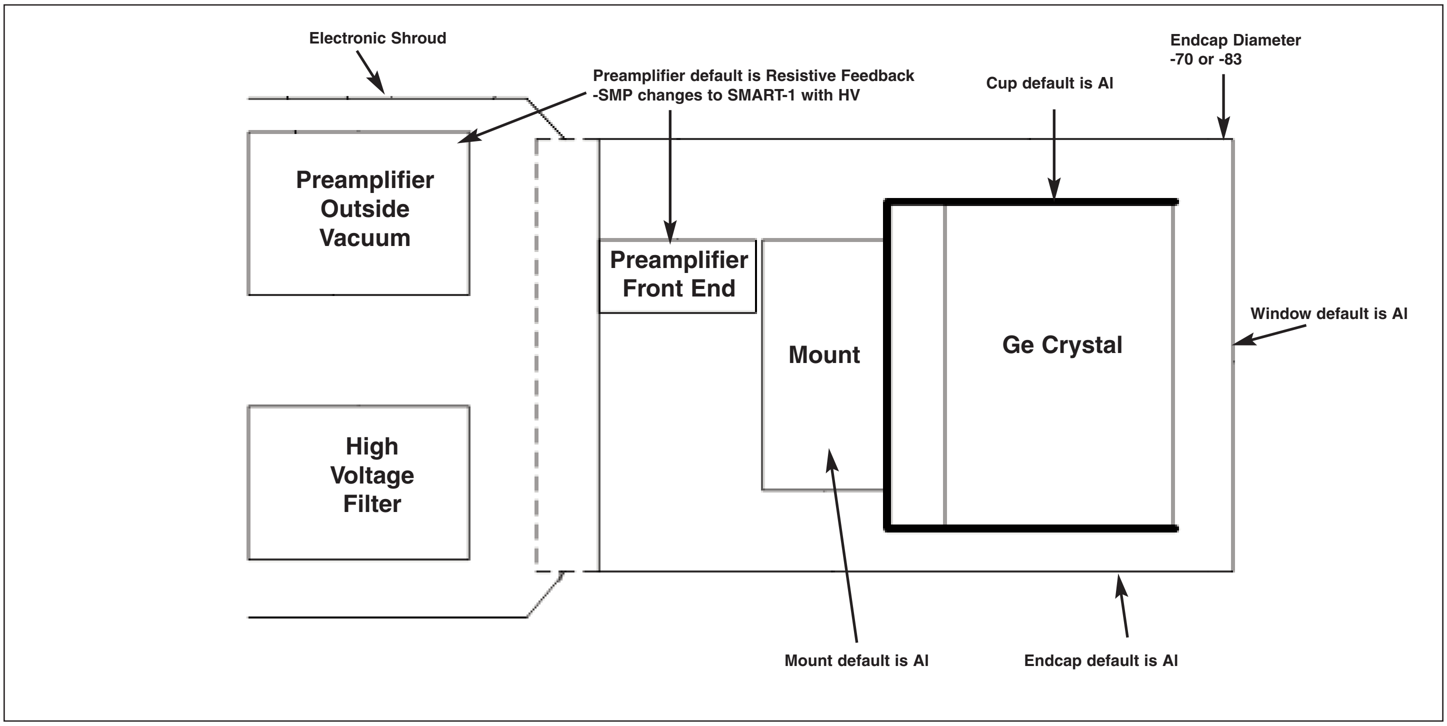
SMART-1 Detector Interface Module.

Defining the Detector Model

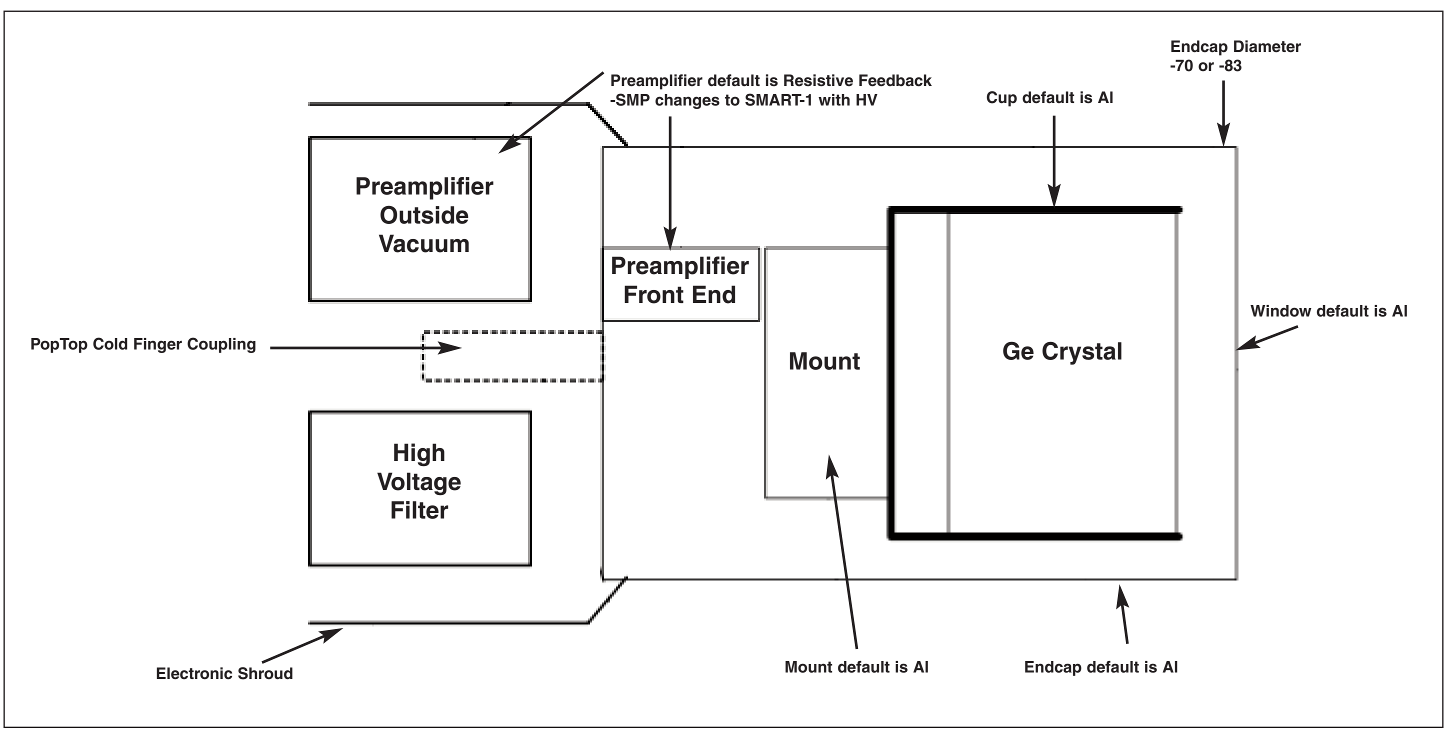
- See ordering information for option compatibility.

Base Model (example)	PopTop or Streamline	High Voltage Option (if required)
SGD-GEM-3165	P4 (PopTop) (Streamline)	-SMP

Streamline Detector Capsule

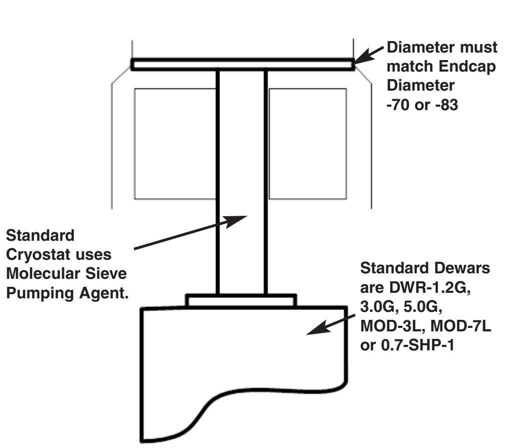


PopTop Detector Capsule

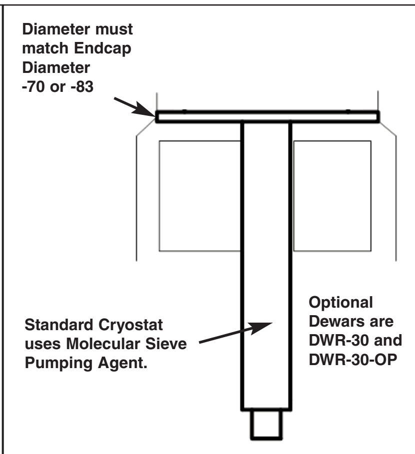


Streamline Cryostat and Cryostat/Dewar Assemblies

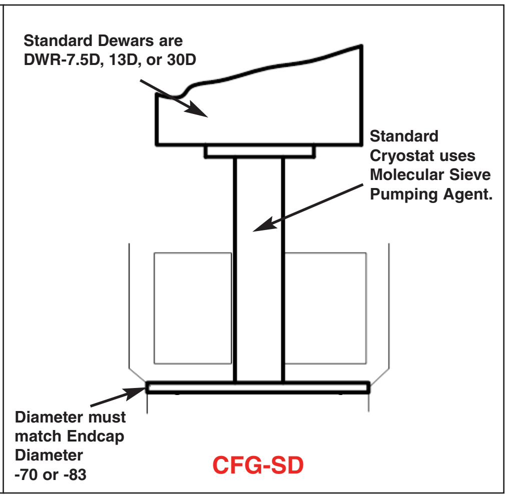
Streamline systems (detector capsule and cryostat) share the same vacuum, requiring a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap.



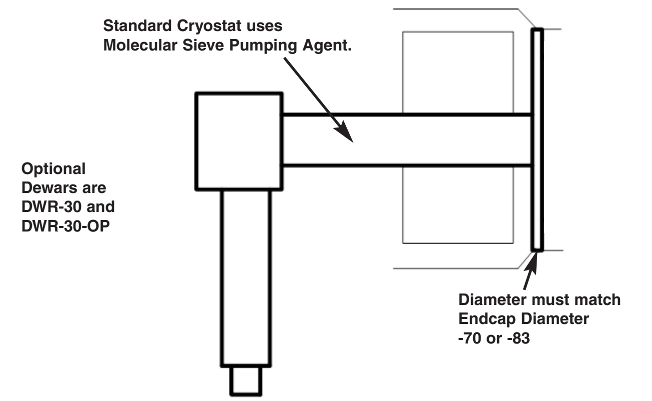
CFG-GG



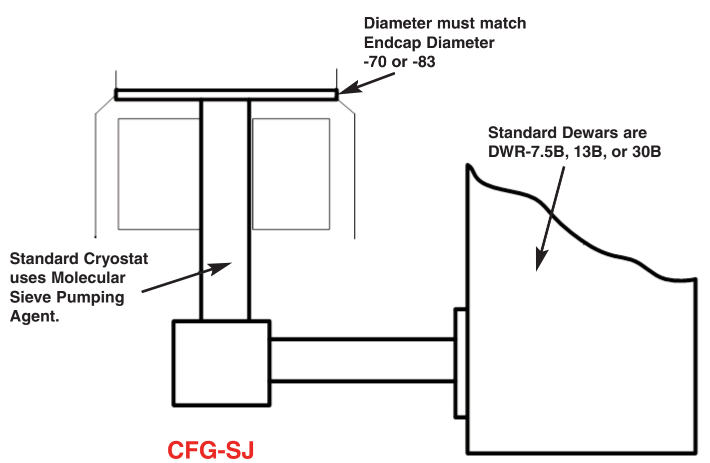
CFG-SV



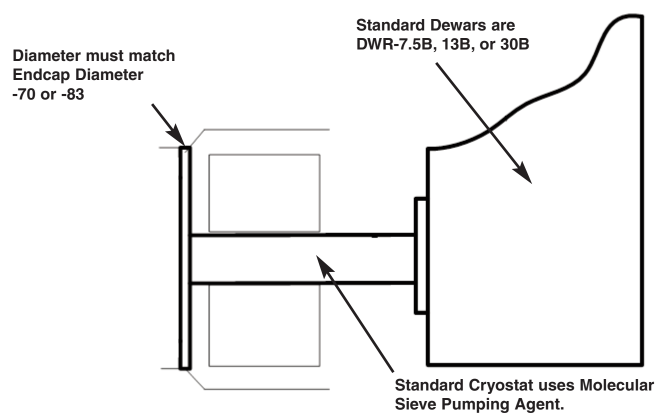
CFG-SD



CFG-SH



CFG-SJ



CFG-SL

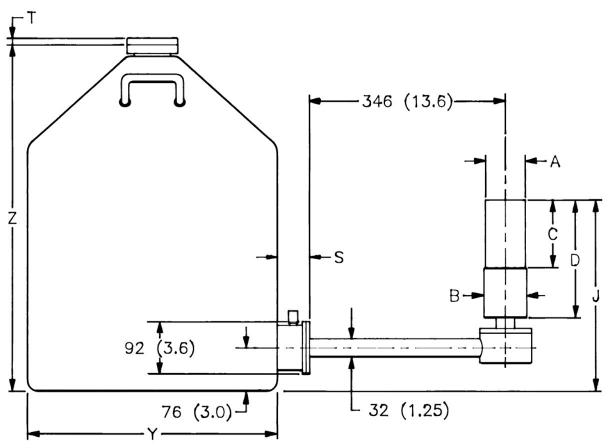
PopTop and Streamline Dimensional Data

Streamline systems (detector capsule and cryostat) share the same vacuum, requiring a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap. A cryostat must be ordered with a Streamline capsule.

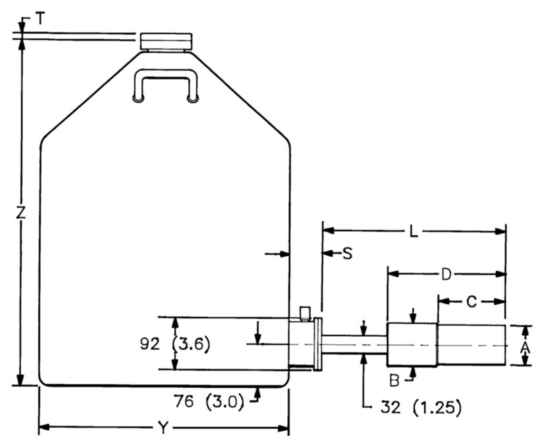
The PopTop capsule contains a vacuum unto itself. It can be mounted on any of the available cryostats, cryostat/dewar combinations, or the X-COOLER II mechanical cooling system.

The cryostat and dewar drawings that follow are to be used in conjunction with the accompanying tables of dimensions.

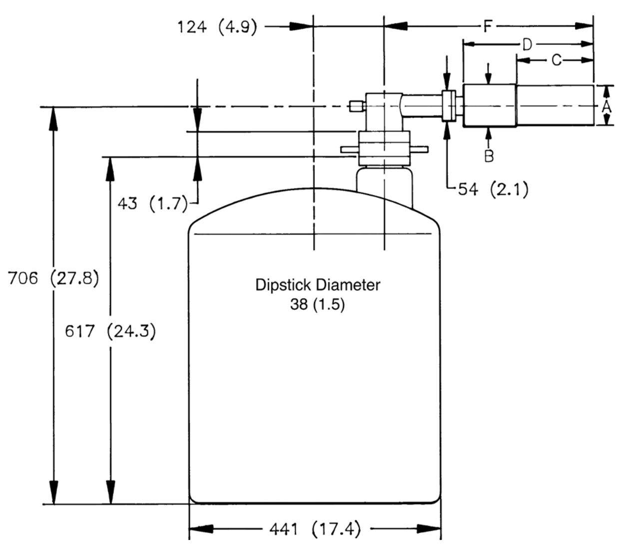
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



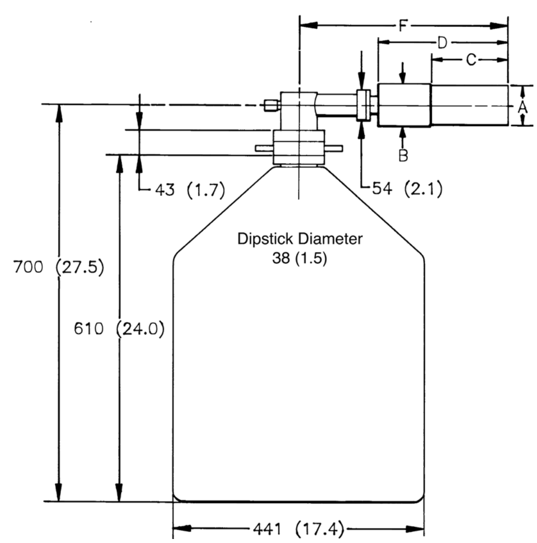
CFG-SJ, DWR-30B (or -13B or -7.5B)



CFG-PS4-30 (or -13 or -7.5)
or
CFG-SL, DWR-30B (or -13B or -7.5B)

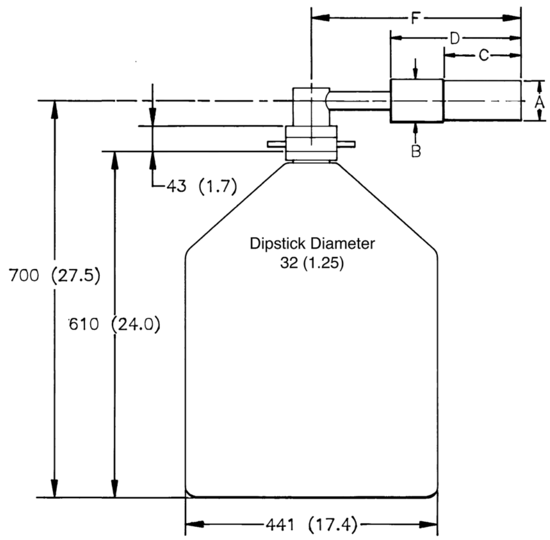


CFG-PH4, DWR-30-OP

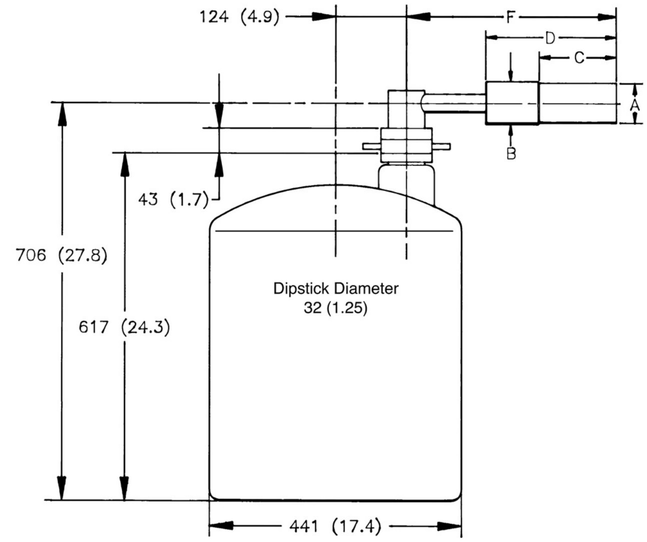


CFG-PH4, DWR-30

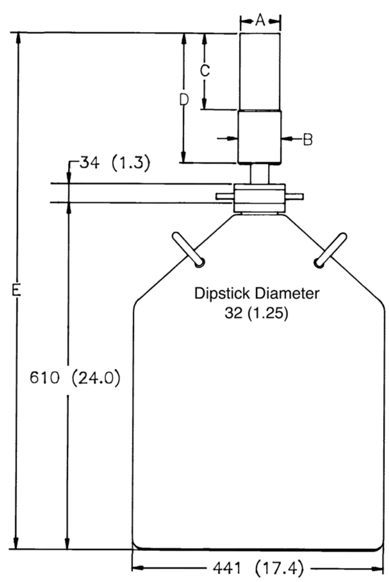
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



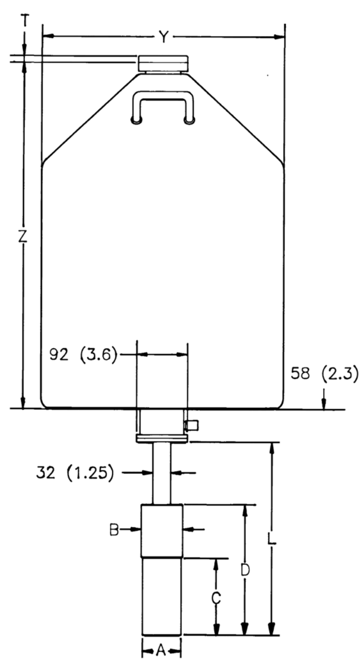
CFG-SH, DWR-30



CFG-SH, DWR-30-OP

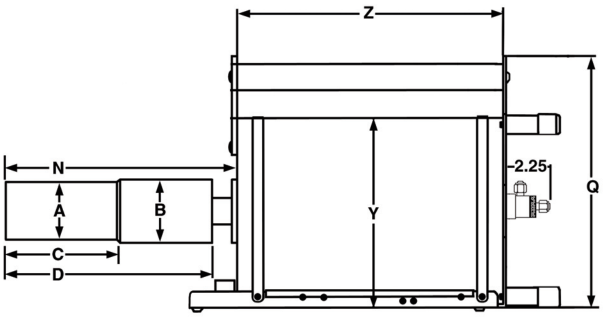


CFG-SV, DWR-30

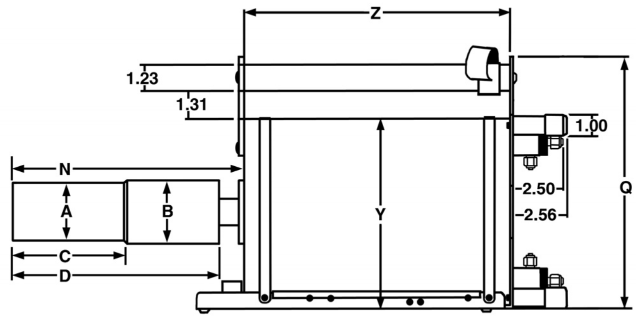


CFG-PD4-30 (or -13 or -7.5)
or
CFG-SD, DWR-30D (or -13D or -7.5D)

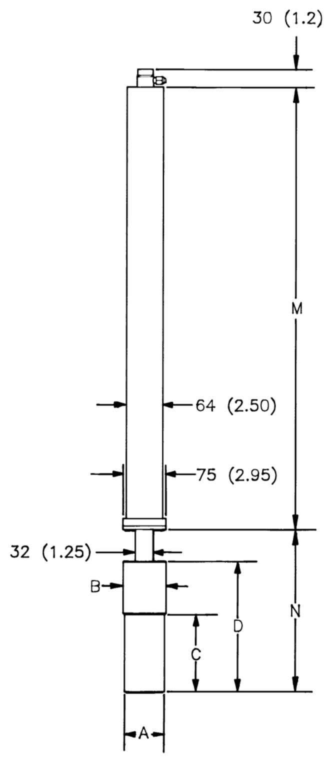
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



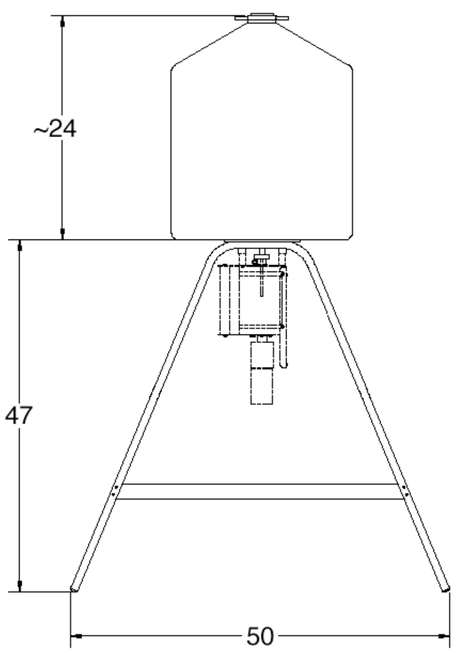
CFG-PG4-1.2 (or -3 or -5)
or
CFG-GG, DWR-1.2G (or -3.0G, -5.0G)



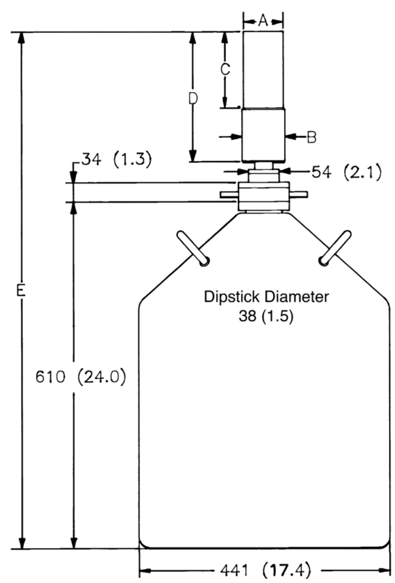
CFG-PMOD4-3 (or -7)
or
CFG-GG, DWR-MOD3L (or -MOD7L)



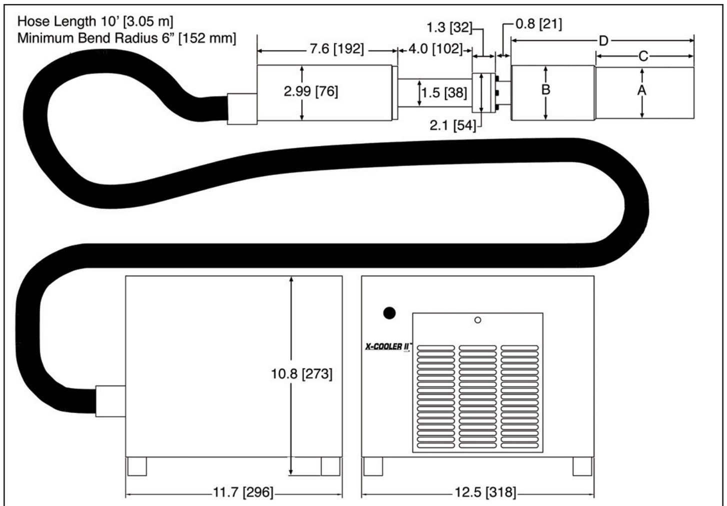
CFG-PSHP4
or
CFG-GG, DWR-0.7-SHP-1



DWR-S/F



CFG-PV4, DWR-30



CFG-X-COOL-II

PopTop SGD-GEM Detector Dimensions

- Dimensions are for reference only and subject to change.
- If dimensional constraints are critical, contact the factory.

Endcap Model (dia. mm)			-70	-83
Dim.	Unit	Tol.		
A	mm (in)	0.3 (0.01)	70 (2.75)	83 (3.25)
B	mm (in)	0.3 (0.01)	75 (2.95)	88 (3.45)
C	mm (in)	5 (0.2)	134 (5.3)	168 (6.6)
D	mm (in)	8 (0.3)	250 (9.8)	282 (11.2)
E	mm (in)	18 (0.7)	947 (37.3)	982 (38.6)
F	mm (in)	10 (0.4)	396 (15.6)	429 (16.9)
L	mm (in)	10 (0.4)	338 (13.3)	371 (14.6)
M	mm (in)	8 (0.3)	790 (31.1)	X X
N	mm (in)	10 (0.4)	278 (10.9)	312 (12.3)

Streamline SGD-GEM Detector Dimensions

- Dimensions are for reference only and subject to change.
- If dimensional constraints are critical, contact the factory.

Endcap Model (dia. mm)			-70	-83
Dim.	Unit	Tol.		
A	mm (in)	0.3 (0.01)	70 (2.75)	83 (3.25)
B	mm (in)	0.3 (0.01)	75 (2.95)	88 (3.45)
C	mm (in)	5 (0.2)	134 (5.3)	134 (5.3)
D	mm (in)	8 (0.3)	246 (9.7)	259 (10.2)
E	mm (in)	18 (0.7)	916 (36.1)	932 (36.7)
F	mm (in)	10 (0.4)	368 (14.5)	381 (15.0)
H	mm (in)	18 (0.7)	351 (13.8)	364 (14.3)
HB	mm (in)	0.3 (0.1)	73 (2.9)	85 (3.4)
HC	mm (in)	5 (0.2)	134 (5.3)	135 (5.3)
HD	mm (in)	10 (0.4)	162 (6.4)	175 (6.9)
J	mm (in)	10 (0.4)	380 (15)	393 (15.5)
L	mm (in)	10 (0.4)	338 (13.3)	351 (13.8)
M	mm (in)	8 (0.3)	516 (20.3)	X X
N	mm (in)	10 (0.4)	278 (11)	292 (11.5)

Gamma Gage and Side-Looking Dewar Dimensions

- Dimensions are for reference only and subject to change.
- If dimensional constraints are critical, contact the factory.

			Cryostat/Dewar or Dewar Type							
			CFG-PG4 and DWR-x.xG			CFG-PMOD4 and DWR-MOD-xL		CFG-PS4, CFG-PD4, DWR-xxB and DWR-xxD		
			VOLUME			VOLUME		VOLUME		
Dim.	UNIT	TOL. ±	1.2L	3L	5L	3L	7L	7.5L	13L	30L
Q	mm (in)	13 (0.5)	229 (9.0)	302 (11.9)	302 (11.9)	229 (9.0)	302 (11.9)	X X	X X	X X
R	mm (in)	10 (0.4)	X X	X X	X X	X X	X X	174 (6.9)	174 (6.9)	155 (16.1)
S	mm (in)	7.6 (0.3)	X X	X X	X X	X X	X X	77 (3.0)	77 (3.0)	60 (2.3)
T	mm (in)	5 (0.2)	X X	X X	X X	X X	X X	10 (0.4)	10 (0.4)	13 (0.5)
Y	mm (in)	5 (0.2)	157 (6.2)	229 (9.0)	229 (9.0)	157 (6.2)	229 (9.0)	224 (8.8)	307 (12.1)	442 (17.4)
Z	mm (in)	5 (0.2)	229 (9.0)	267 (10.5)	419 (16.5)	292 (11.5)	320 (12.6)	452 (17.8)	429 (16.9)	610 (24.0)

Example Model Numbers

Streamline Configuration

SGD-GEM-3615	3% efficiency SGD-GEM detector with 70-mm diameter endcap.
CFG-GG-70	Portable Gamma Gage cryostat with matching 70-mm diameter flange.
DWR-1.2G	1.2 liter all-position dewar for Gamma Gage cryostat.
SGD-GEM-5050-SMP	25% efficiency SGD-GEM detector with 70-mm diameter endcap and SMART-1 preamplifier and high voltage supply.
CFG-SD-70	Down-looking cryostat with matching 76-mm diameter flange.
DWR-7.5D	7.5 liter down-looking dewar.

PopTop Configuration

SGD-GEM-3615P4	3% efficiency SGD-GEM detector with 70-mm diameter endcap.
CFG-PG4-1.2	Portable Gamma Gage cryostat with 1.2 liter all-position dewar.
SGD-GEM-5050P4-SMP	25% efficiency GEM detector with 70-mm diameter endcap and SMART-1 preamplifier and high voltage supply.
CFG-PD4-7.5	Downlooking cryostat with 7.5 liter dewar.

Ordering Information

- For Streamline, remove the “P4” from the model number.
- If dimensional considerations are critical, contact factory.
- Cryostat and dewar or other cooling device are not included with detector and are required for operation.
- A cryostat must be ordered with a Streamline detector.
- Monte Carlo drawing included.

Model No.	Active Diameter (mm)	Minimum Thickness (mm)	Nominal Relative Efficiency	Energy	Warranted Resolution (keV) @1 kcps (6 µs)	@1 kcps (2 µs)	@30 kcps (2 µs)	Warranted FW.1M/FWHM @ <1 kcps (6 µs)	Warranted FW.02M/FWHM @<1 kcps (6 µs)	Endcap Diameter
SGD-GEM-3615P4	36	15	30	122 keV 1.33 MeV	610 eV 1.65 keV	630 eV 1.75 keV	650 eV 2.00 keV	1.9	2.6	70
SGD-GEM-5030P4	50	30	15	122 keV 1.33 MeV	650 eV 1.70 keV	690 eV 1.85 keV	750 eV 2.05 keV	1.9	2.6	70
SGD-GEM-5050P4	50	50	25	122 keV 1.33 MeV	750 eV 1.75 keV	880 eV 1.95 keV	890 eV 2.10 keV	1.9	2.6	70
SGD-GEM-6560P4	65	60	50	122 keV 1.33 MeV	800 eV 1.80 keV	935 eV 2.05 keV	960 eV 2.15 keV	1.9	2.6	83

SGD-GEM Detector Options

-SMP SMART-1 detector option for positive bias detector, add “-SMP” to the model number.

SGD-GEM PopTop Cryostats and Dewars

- Dewar included except where marked *.

Model No.	Description
CFG-PD4-7.5	Down-looking Cryostat with 7.5-liter Dewar
CFG-PD4-13	Down-looking Cryostat with 13-liter Dewar
CFG-PD4-30	Down-looking Cryostat with 30-liter Dewar
CFG-PG4-1.2	Gamma Gage Cryostat with 1.2-liter Dewar
CFG-PG4-3	Gamma Gage Cryostat with 3-liter Dewar
CFG-PG4-5	Gamma Gage Cryostat with 5-liter Dewar
CFG-PH4	Horizontal Cryostat (Dipstick type). Includes LNTC1.5WH. Dewar not included.* Choose DWR-30 or DWR-30-OP.
CFG-PMOD4-3	Gamma Gage Cryostat with 3-liter Multi-Orientation Dewar
CFG-PMOD4-7	Gamma Gage Cryostat with 7-liter Multi-Orientation Dewar
CFG-PS4-7.5	Side-Looking Cryostat with 7.5-liter Dewar
CFG-PS4-13	Side-Looking Cryostat with 13-liter Dewar
CFG-PS4-30	Side-Looking Cryostat with 30-liter Dewar
CFG-PSHP4	Down-Looking Shallow-Hole Probe with 0.7-liter Dewar
CFG-PV4	Vertical Cryostat (Dipstick type). Includes LNTC1.5WH. Dewar not included.* Choose DWR-30 or DWR-30-OP.
DWR-30	30-liter Dewar
DWR-30-OP	30-liter Offset-Port Dewar
DWR-S/F	Storage Fill Dewar for CFG-PG4-X
CFG-X-COOL-II-115	X-COOLER II with PopTop connector using 110-120 V ac, 60 Hz Input Power
CFG-X-COOL-II-230	X-COOLER II with PopTop connector using 220-240 V ac, 50 Hz Input Power

High-Performance Germanium Coaxial Detectors for Safeguards and Non-Destructive Assay Product Configuration Guide

SGD-GEM Streamline Cryostats

- Select dewar from SGD-GEM Streamline Dewars. Dewar included except where marked*.
- Append matching Detector Endcap Size designation to cryostat model: -70 or -83.

Model No.	Description
CFG-GG	Gamma Gage Cryostat Dewar
CFG-SD	Down-Looking Cryostat with Dewar
CFG-SH	Horizontal Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
CFG-SJ	J-type Cryostat with Dewar
CFG-SL	Side-Looking Cryostat with Dewar
CFG-SV	Vertical Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
LOW-BACKGROUND	
CFG-GG-LB	Low-Background Gamma Gage Cryostat with Dewar
CFG-SD-LB	Low-Background Down-Looking Cryostat with Dewar
CFG-SH-LB	Low-Background Horizontal Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
CFG-SJ-LB	Low-Background J-type Cryostat with Dewar
CFG-SL-LB	Low-Background Side-Looking Cryostat with Dewar
CFG-SV-LB	Low-Background Vertical Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
CFG-SD-XLB	Extra-Low-Background Down-Looking Cryostat with Dewar
CFG-SH-XLB	Extra-Low-Background Horizontal Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
CFG-SJ-XLB	Extra-Low-Background J-type Cryostat with Dewar
CFG-SL-XLB	Extra-Low-Background Side-Looking Cryostat with Dewar
CFG-SV-XLB	Extra-Low-Background Vertical Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*

SGD-GEM Streamline Dewars

For Cryostat	Choose	Description	
CFG-GG	DWR-1.2G	1.2-liter All-Orientation Dewar	Included with Cryostat
	DWR-3.0G	3.0-liter All-Orientation Dewar	Included with Cryostat
	DWR-5.0G	5.0-liter All-Orientation Dewar	Included with Cryostat
	DWR-MOD-3L	3-liter Multi-Orientation Dewar	Included with Cryostat
	DWR-MOD-7L	7-liter Multi-Orientation Dewar	Included with Cryostat
	DWR-0.7-SHP-1	0.7-liter Shallow-Hole Probe Dewar	Included with Cryostat
	DWR-S/F	Storage/Fill Dewar for DWR-XG	
CFG-SJ, SL	DWR-7.5B	7.5-liter Side-Looking Dewar	Included with Cryostat
	DWR-13B	13-liter Side-Looking Dewar	Included with Cryostat
	DWR-30B	30-liter Side-Looking Dewar	Included with Cryostat
CFG-SD	DWR-7.5D	7.5-liter Down-Looking Dewar	Included with Cryostat
	DWR-13D	13-liter Down-Looking Dewar	Included with Cryostat
	DWR-30D	30-liter Down-Looking Dewar	Included with Cryostat
CFG-SV, SH	DWR-30-OP	30-liter Offset-Port Dewar	
	DWR-30	30-liter Dewar	

Specifications subject to change
072910

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High-Performance Germanium Planar Detectors for Safeguards and Non-Destructive Assay Product Configuration Guide

- **Specifically designed to meet the demanding requirements of isotopic ratio software codes used in Safeguards and NDA.**
- **Excellent resolution is maintained over a wide range of count rates, enhancing measurement flexibility.**
- **Available in a full range of crystal diameters.**
- **Extensive range of cryostats with multi-orientation dewar options for applications requiring portability.**
- **Compatible with all existing Safeguards multichannel analyzers.**

The precise measurement of isotopic ratios required in Safeguards and non-destructive assay (NDA) applications places a severe demand on the techniques of gamma-ray and x-ray spectroscopy. Figure 1 demonstrates the complexity of the 90–130 keV region of a typical Pu spectrum. (The choice of energy region(s) for analysis depends specifically on the sample type and origin and the material matrix.

National laboratory software codes[1] written to obtain highly accurate isotopic ratios, must deal with these spectra to analyze low-energy and/or high-energy regions in which groups of peaks are located close together. Each code requires exceptional system resolution and stability in order to achieve accurate unfolding of these regions.

Recent safeguards development trends have led to a growing requirement of isotopic ratio determinations involving higher energy gamma-rays. Such needs spring from the need to measure attenuated samples, such as those found in waste assay and in certain homeland security applications. Software codes such as PC/FRAM and MGAHI[2] can now determine Pu isotopic ratios from the higher energy regions of the spectrum. As a consequence, it is desirable to produce HPGe detectors that offer improved higher energy performance, while maintaining the excellent resolution characteristics required in such applications.

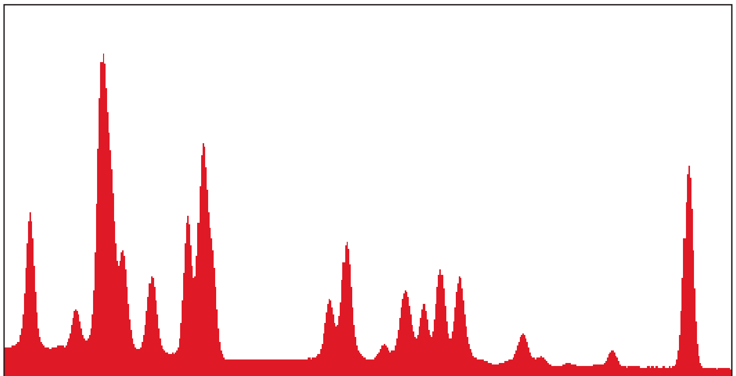


Fig. 1. The 90 to 130 keV region of a typical plutonium spectrum.

The ORTEC Safeguards series include both coaxial and planar geometry detectors, specifically designed to meet the demands of the applications software used for isotopic ratio determination, have been developed to strike an optimum balance between low-energy resolution and high-energy efficiency.

SGD series detectors are compatible with ALL conventional MCA types, although optimum performance will be obtained when used with the ORTEC Digital Signal Processing Spectrometers.

All SGD detectors feature the following:

- Choice of fixed, portable, and custom cryostats, including the latest MOD multi-orientation dewar option.
- Robust aluminum end-cap
- Streamline preamplifier assembly
- LN_2-Free option

The latest low-power resistive feedback preamplifier with "no ring" output, suitable for use with all existing types of MCA systems. Power consumption less than 25 mA at ±12 and ±24 V.

Application Considerations

For safeguards accountancy measurements involving the verification of declared materials values, the sample is usually presented in a pure form in a purpose-designed thin-walled container. This occurs with routine safeguards inspection programs, when a portable system is employed.

The Following Specifications are Provided for each SGD Detector

- Active crystal diameter and depth.
- Energy resolution at 122 keV photons from ^{57}Co at 1 kcps and optimum shaping time.
- Energy resolution at 122 keV photons from ^{57}Co at 50 kcps with 1 µs shaping time.
- Shape specifications for Full Width Tenth Maximum (FWTM) to Full Width Half Maximum (FWHM) and Full With Fiftieth Maximum (FWFM) to FWHM at <50 kcps for 122 keV photons from ^{57}Co.

Configuration Guidelines

PopTop or Streamline (non-PopTop) Configuration

The essence of a PopTop detector system is that the HPGe detector element cryostat, preamplifier, and high voltage filter are housed in a detector “capsule” which is then attached to an appropriate cryostat (Figure 2.)

In so called Streamline systems, the detector capsule in NOT demountable. Detector capsule and cryostat share the same vacuum. In configuration terms, this requires a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap. A cryostat must always be ordered with a Streamline capsule, because they are integral.

The actual PopTop capsule has its own vacuum. It can be mounted on any of the available cryostats, cryostat/dewar combinations, or the X-COOLER II mechanical cooling system.

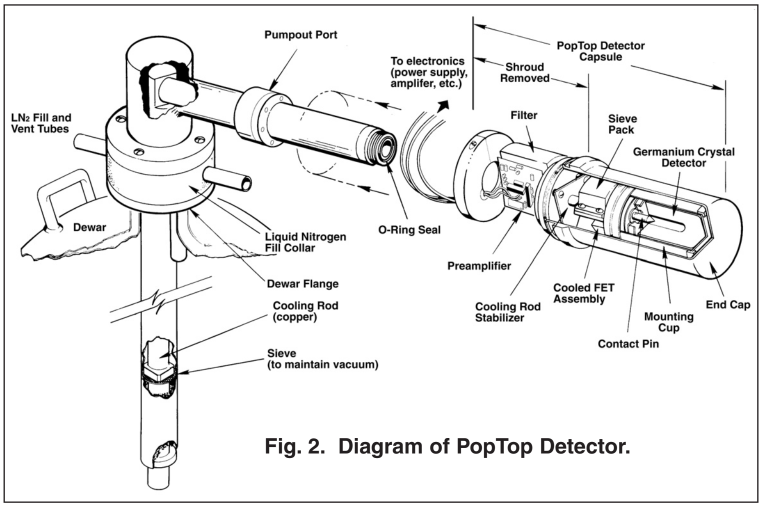


Fig. 2. Diagram of PopTop Detector.

Steps to Configure Your ORTEC HPGe Detector

1) Configure the Detector Model

- Capsule type (PopTop or Streamline)
- Ge Crystal dimensions and specifications
- Endcap and window
- Mount
- Preamplifier
- High Voltage Filter
- Cable Package

Preamplifier options are available.

[1]Specifically these codes are: FRAM from Los Alamos National Laboratory; MGA from Lawrence Livermore National Laboratory and TRIFID from Rocky Flats Plant.
[2]MGAHI is now included in the MGA-B32 suite of software available from ORTEC.

2) Configure the Cryostat/Dewar Model

- Vertical Dipstick style (separate Dewar)
- Horizontal Dipstick style (separate Dewar)
- Portable with all-position or multi-position cryostat/dewar models
- Downlooking designed to be oriented with the detector pointing down
- Sidelooking designed to be oriented with the detector horizontal at the bottom of the dewar
- "J" configuration designed with the detector attached near the bottom of the dewar and a right angle bend in the cryostat orienting the detector to look up.

A cryostat and dewar or other cooling device are required for operation.

If a PopTop detector has been selected, you can choose a PopTop style cryostat, cryostat/dewar combination or the X-COOLER II mechanical cooler.

If a Streamline detector has been selected, you must choose a cryostat or cryostat/dewar model for the detector to be mounted on and vacuum sealed. The cryostat or cryostat/dewar combination diameter must match the endcap diameter of the selected detector.

Detector Options

SMART-1 Option (-SMN)

The SMART-1 option monitors and reports on vital system functions, and can save authentication codes and report the code at a later time. It has the high voltage included, so none of the instruments require an external high-voltage power supply.

The SMART-1 is housed in a rugged ABS molded plastic enclosure and is permanently attached to the detector endcap via a molded-strain-relieved sealed cable. This eliminates the possibility that the detector will suffer severe damage from moisture leaking into high-voltage connectors. The SMART-1 can be positioned in any convenient place and does not interfere with shielding or other mounting hardware.

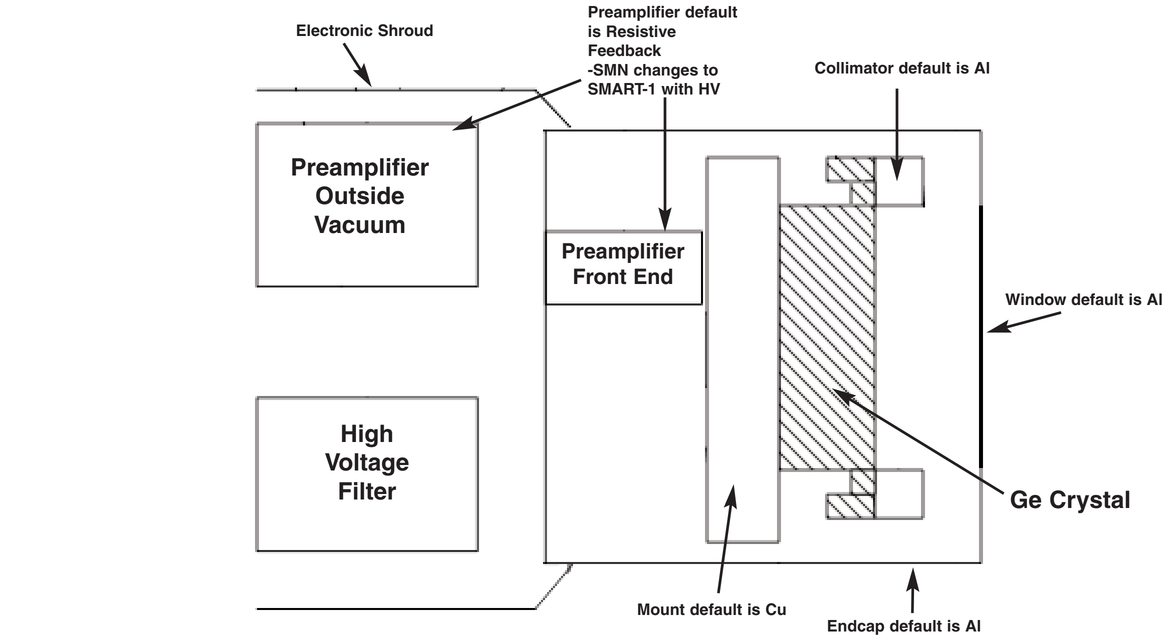
SMART-1 Detector Interface Module.

Defining the Detector Model

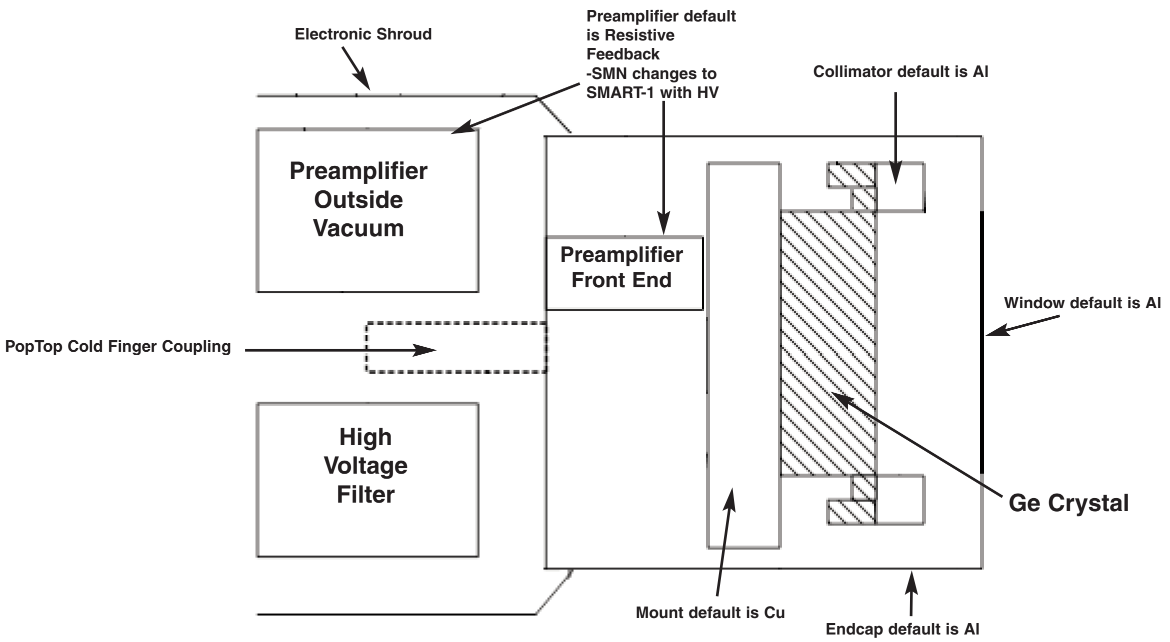
• See ordering information for option compatibility.

Base Model (example)	PopTop or Streamline	High Voltage Option (if required)
SGD-16550	P4 (PopTop) (Streamline)	-SMN

Streamline Detector Capsule

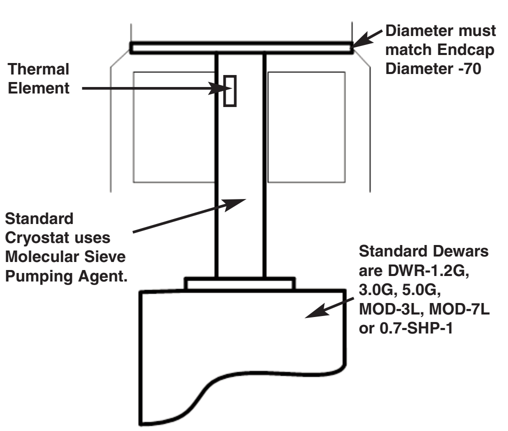


PopTop Detector Capsule

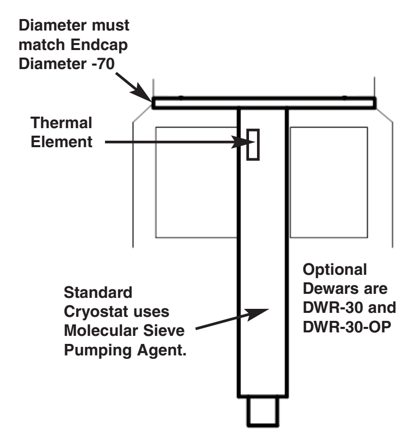


Streamline Cryostat and Cryostat/Dewar Assemblies

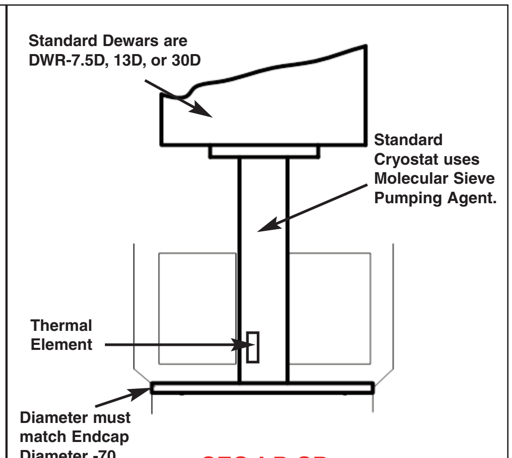
Streamline systems (detector capsule and cryostat) share the same vacuum, requiring a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap.



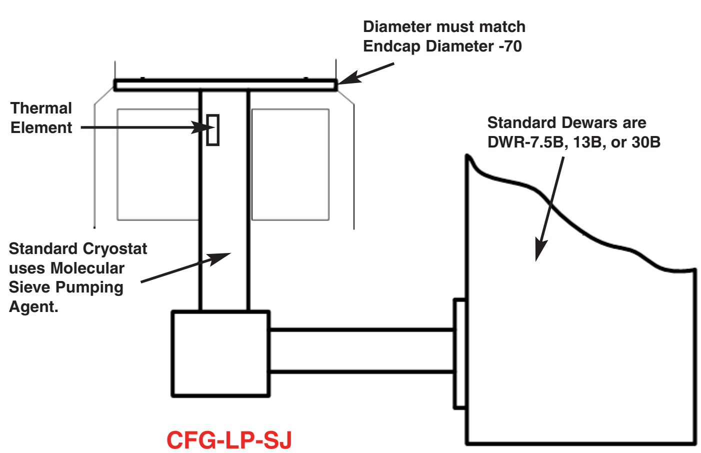
CFG-LP-GG



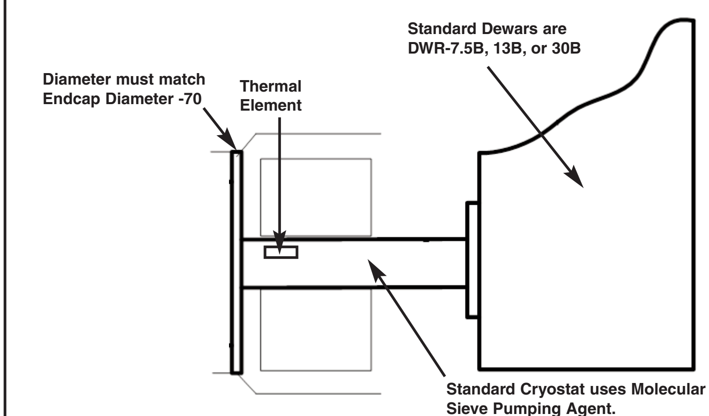
CFG-LP-SV



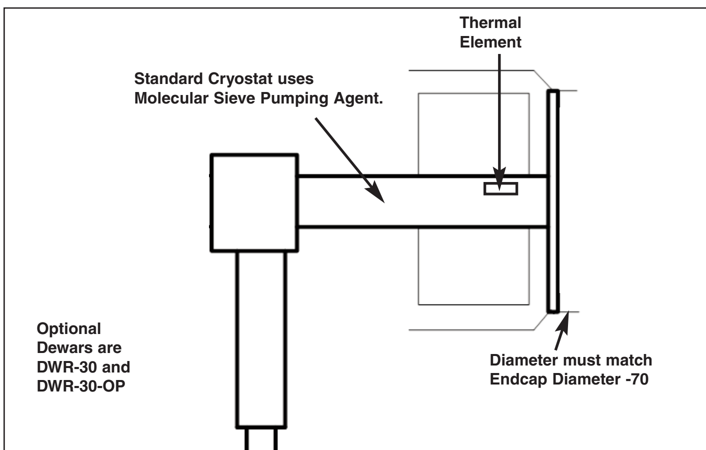
CFG-LP-SD



CFG-LP-SJ



CFG-LP-SL



CFG-LP-SH

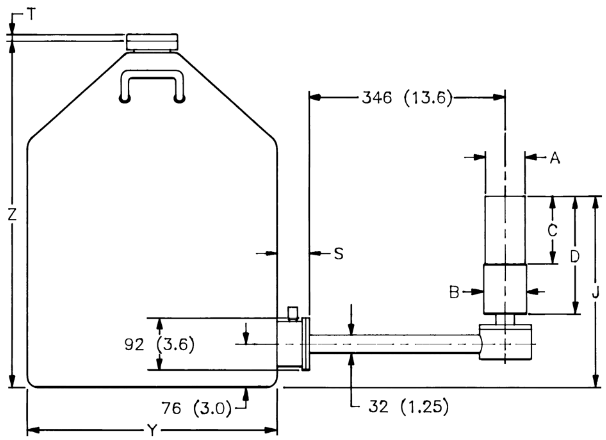
PopTop and Streamline Dimensional Data

Streamline systems (detector capsule and cryostat) share the same vacuum, requiring a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap. A cryostat must be ordered with a Streamline capsule.

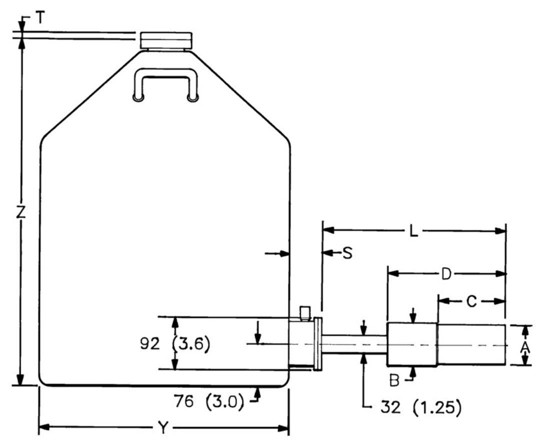
The PopTop capsule contains a vacuum unto itself. It can be mounted on any of the available cryostats, cryostat/dewar combinations, or the X-COOLER II mechanical cooling system.

The cryostat and dewar drawings that follow are to be used in conjunction with the accompanying tables of dimensions.

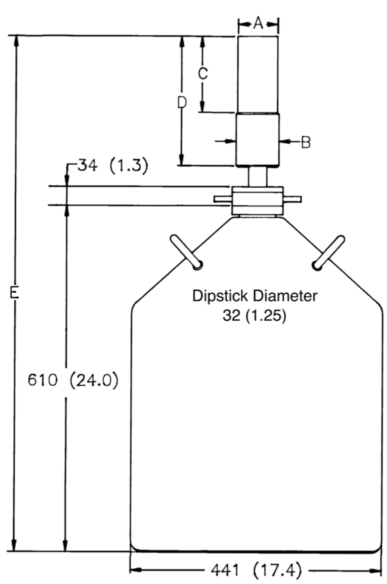
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



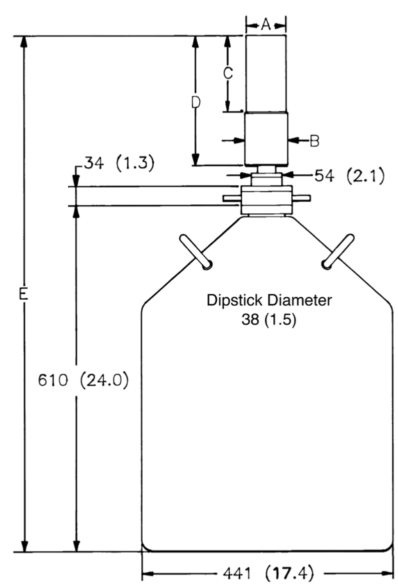
CFG-LP-SJ, DWR-30B (or -13B or -7.5B)



CFG-PS4-30 (or -13 or -7.5)
or
CFG-LP-SL, DWR-30B (or -13B or -7.5B)

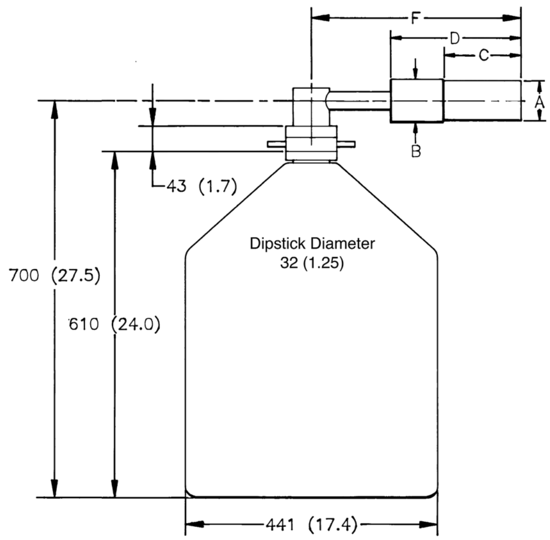


CFG-LP-SV, DWR-30

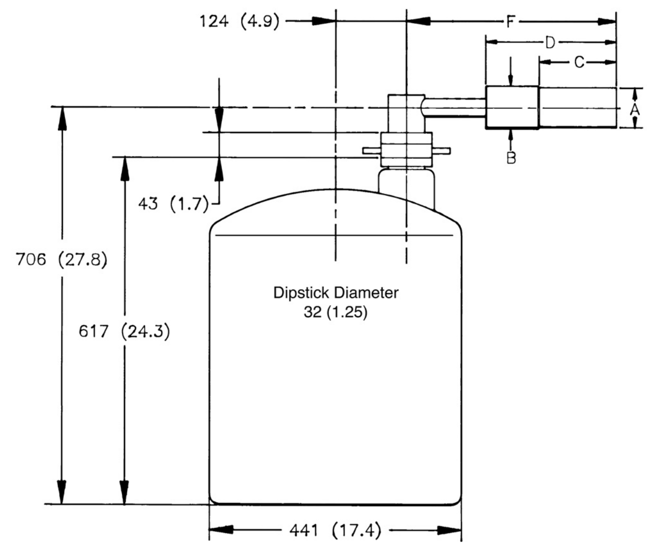


CFG-PV4, DWR-30

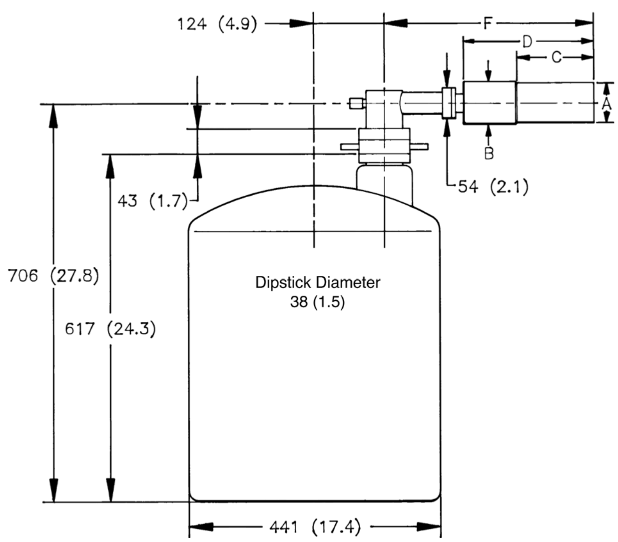
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



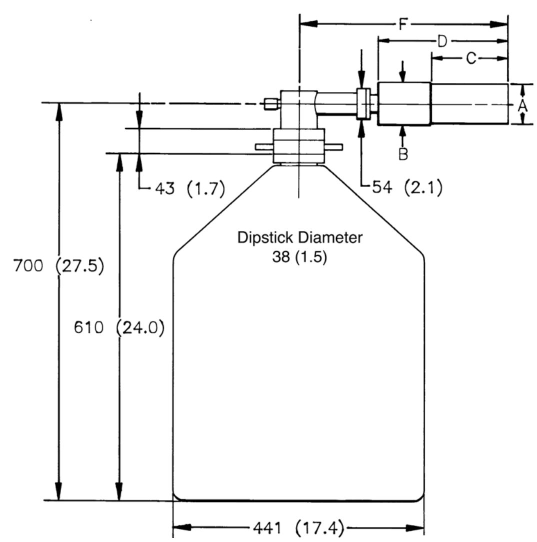
CFG-LP-SH, DWR-30



CFG-LP-SH, DWR-30-OP

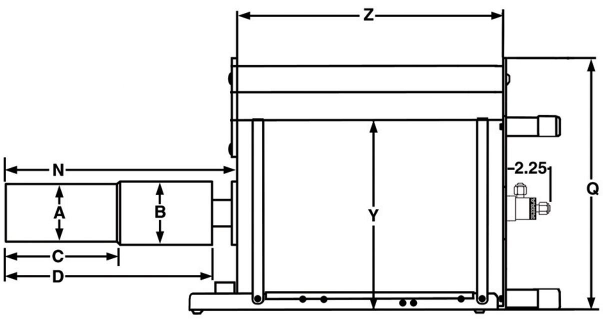


CFG-PH4, DWR-30-OP

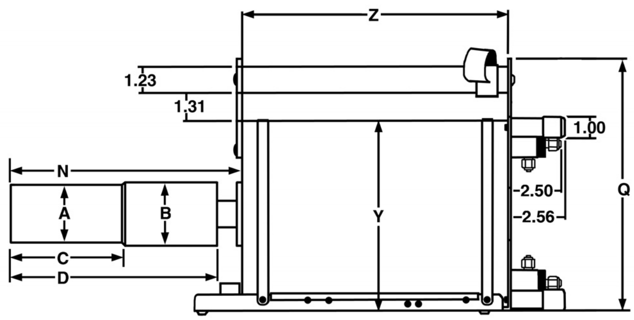


CFG-PH4, DWR-30

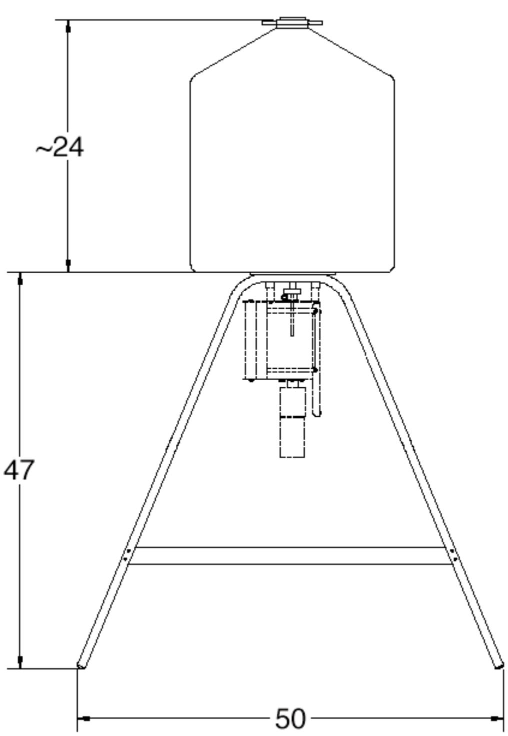
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



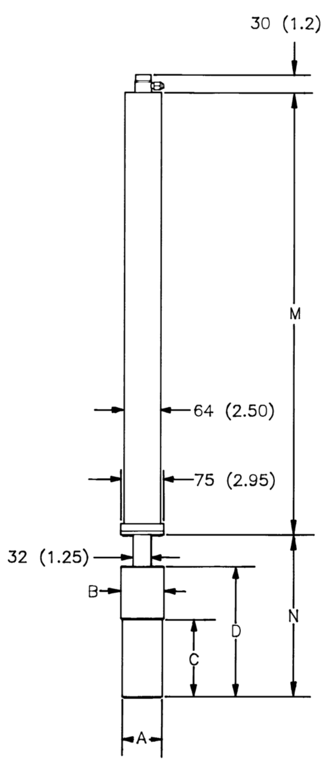
CFG-PG4-1.2 (or -3 or -5)
or
CFG-LP-GG, DWR-1.2G (or -3.0G, -5.0G)



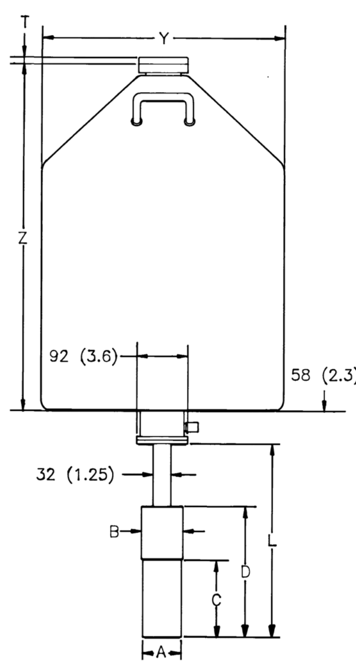
CFG-PMOD4-3 (or -7)
or
CFG-LP-GG, DWR-MOD3L (or -MOD7L)



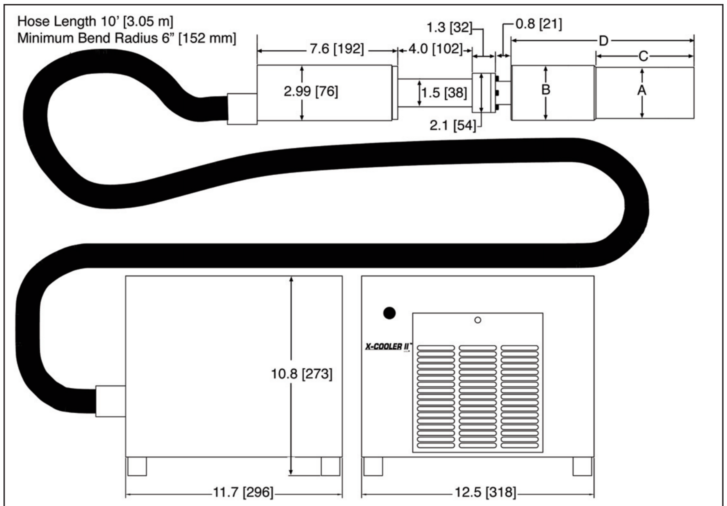
DWR-S/F



CFG-PSHP4
or
CFG-LP-GG, DWR-0.7-SHP-1



CFG-PD4-30 (or -13 or -7.5)
or
CFG-LP-SD, DWR-30D (or -13D or -7.5D)



CFG-X-COOL-II

SGD Detector Dimensions

- Dimensions are for reference only and subject to change.
- If dimensional constraints are critical, contact the factory.

Dim.	Unit	Tol.	PopTop	Streamline
A	mm (in)	0.3 (0.01)	70 (2.75)	70 (2.75)
B	mm (in)	0.3 (0.01)	75 (2.95)	75 (2.95)
C	mm (in)	5 (0.2)	135 (5.3)	71 (2.8)
D	mm (in)	8 (0.3)	250 (9.8)	182 (7.2)
E	mm (in)	8 (0.3)	947 (47.3)	854 (33.6)
F	mm (in)	18 (0.7)	396 (15.6)	305 (12.0)
J	mm (in)	10 (0.4)	X X	318 (12.5)
L	mm (in)	18 (0.7)	338 (13.3)	274 (10.8)
M	mm (in)	10 (0.4)	790 (31.1)	X X
N	mm (in)	8 (0.3)	278 (10.9)	215 (8.5)

Gamma Gage and Side-Looking Dewar Dimensions

- Dimensions are for reference only and subject to change.
- If dimensional constraints are critical, contact the factory.

			Cryostat/Dewar or Dewar Type							
			CFG-PG4 and DWR-x.xG			CFG-PMOD4 and DWR-MOD-xL		CFG-PS4, CFG-PD4, DWR-xxB and DWR-xxD		
			VOLUME			VOLUME		VOLUME		
Dim.	UNIT	TOL. ±	1.2L	3L	5L	3L	7L	7.5L	13L	30L
Q	mm (in)	13 (0.5)	229 (9.0)	302 (11.9)	302 (11.9)	229 (9.0)	302 (11.9)	X X	X X	X X
R	mm (in)	10 (0.4)	X X	X X	X X	X X	X X	174 (6.9)	174 (6.9)	155 (6.1)
S	mm (in)	7.6 (0.3)	X X	X X	X X	X X	X X	77 (3.0)	77 (3.0)	60 (2.3)
T	mm (in)	5 (0.2)	X X	X X	X X	X X	X X	10 (0.4)	10 (0.4)	13 (0.5)
Y	mm (in)	5 (0.2)	157 (6.2)	229 (9.0)	229 (9.0)	157 (6.2)	229 (9.0)	224 (8.8)	307 (12.1)	442 (17.4)
Z	mm (in)	5 (0.2)	229 (9.0)	267 (10.5)	419 (16.5)	292 (11.5)	320 (12.6)	452 (17.8)	429 (16.9)	610 (24.0)

Example Model Numbers

Streamline Configuration

SGD-16550	16-mm diameter, 15-mm deep SGD planar detector with 70-mm diameter endcap.
CFG-LP-GG-70	Portable Gamma Gage cryostat with matching 70-mm diameter flange.
DWR-1.2G	1.2 liter all-position dewar for Gamma Gage cryostat.
SGD-16550-SMN	16-mm diameter, 15-mm deep SGD detector with 70-mm diameter endcap and SMART-1 preamplifier and high voltage supply.
CFG-LP-SV-70	Vertical “dipstick” style cryostat with matching 70-mm diameter flange.
DWR-30	30 liter top port dewar that accepts “dipstick” style cryostats.

PopTop Configuration

SGD-16550P4-SMN	16-mm diameter, 15-mm deep SGD detector with 70-mm diameter endcap and SMART-1 preamplifier and high voltage supply.
CFG-PG-3	Portable Gamma Gage cryostat with 3 liter all-position dewar.
SGD-16550P4	16-mm diameter, 15-mm deep SGD detector with 70-mm diameter endcap.
CFG-PD4-7.5	Downlooking cryostat with 7.5 liter dewar.

Ordering Information

- For Streamline, remove the "P4" from the model number.
- Available with internal shielding, contact the factory for details.
- If dimensional considerations are critical, contact factory.
- Cryostat and dewar or other cooling device are not included with detector.
- Cryostat and dewar or other cooling device are required for operation.
- A cryostat must be ordered with a Streamline detector.

Model No.	Active Diameter (mm)	Thickness (mm)	Warranted Resolution (eV) @ 122 keV		Warranted FW.1M/FWHM @≤50 kcps	Warranted FW.02M/FWHM @≤50 kcps
			@1 kcps (6 μs)	@50 kcps (1 μs)		
SGD-16550P4	16	15	550	615	1.87	2.50

SGD Detector Options

-SMN	SMART-1 detector option for negative bias detector, add "-SMN" to the model number.

SGD PopTop Cryostats and Dewars

- Dewar included except where marked *.

Model No.	Description
CFG-PD4-7.5	Down-looking Cryostat with 7.5-liter Dewar
CFG-PD4-13	Down-looking Cryostat with 13-liter Dewar
CFG-PD4-30	Down-looking Cryostat with 30-liter Dewar
CFG-PG4-1.2	Gamma Gage Cryostat with 1.2-liter Dewar
CFG-PG4-3	Gamma Gage Cryostat with 3-liter Dewar
CFG-PG4-5	Gamma Gage Cryostat with 5-liter Dewar
CFG-PH4	Horizontal Cryostat (Dipstick type). Includes LNTC1.5WH. Dewar not included.* Choose DWR-30 or DWR-30-OP.
CFG-PMOD4-3	Gamma Gage Cryostat with 3-liter Multi-Orientation Dewar
CFG-PMOD4-7	Gamma Gage Cryostat with 7-liter Multi-Orientation Dewar
CFG-PS4-7.5	Side-Looking Cryostat with 7.5-liter Dewar
CFG-PS4-13	Side-Looking Cryostat with 13-liter Dewar
CFG-PS4-30	Side-Looking Cryostat with 30-liter Dewar
CFG-PSHP4	Down-Looking Shallow-Hole Probe with 0.7-liter Dewar
CFG-PV4	Vertical Cryostat (Dipstick type). Includes LNTC1.5WH. Dewar not included.* Choose DWR-30 or DWR-30-OP.
DWR-30	30-liter Dewar
DWR-30-OP	30-liter Offset-Port Dewar
DWR-S/F	Storage Fill Dewar for CFG-PG4-X
CFG-X-COOL-II-115	X-COOLER II with PopTop connector using 110-120 V ac, 60 Hz Input Power
CFG-X-COOL-II-230	X-COOLER II with PopTop connector using 220-240 V ac, 50 Hz Input Power

High-Performance Germanium Planar Detectors for Safeguards and Non-Destructive Assay Product Configuration Guide

SGD Streamline Cryostats

• Select dewar from SGD Streamline Dewars. Dewar included except where marked*.

Model No.	Description
CFG-LP-GG-70	Gamma Gage Cryostat Dewar
CFG-LP-SD-70	Down-Looking Cryostat with Dewar
CFG-LP-SH-70	Horizontal Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
CFG-LP-SJ-70	J-type Cryostat with Dewar
CFG-LP-SL-70	Side-Looking Cryostat with Dewar
CFG-LP-SV-70	Vertical Cryostat with (Dipstick type). Includes LNTC1.25WH. Dewar not included.*

SGD Streamline Dewars

For Cryostat	Choose	Description	
CFG-LP-GG	DWR-1.2G	1.2-liter All-Orientation Dewar	Included with Cryostat
	DWR-3.0G	3.0-liter All-Orientation Dewar	Included with Cryostat
	DWR-5.0G	5.0-liter All-Orientation Dewar	Included with Cryostat
	DWR-MOD-3L	3-liter Multi-Orientation Dewar	Included with Cryostat
	DWR-MOD-7L	7-liter Multi-Orientation Dewar	Included with Cryostat
	DWR-0.7-SHP-1	0.7-liter Shallow-Hole Probe Dewar	Included with Cryostat
	DWR-S/F	Storage/Fill Dewar for DWR-XG	
CFG-LP-SJ, SL	DWR-7.5B	7.5-liter Side-Looking Dewar	Included with Cryostat
	DWR-13B	13-liter Side-Looking Dewar	Included with Cryostat
	DWR-30B	30-liter Side-Looking Dewar	Included with Cryostat
CFG-LP-SD	DWR-7.5D	7.5-liter Down-Looking Dewar	Included with Cryostat
	DWR-13D	13-liter Down-Looking Dewar	Included with Cryostat
	DWR-30D	30-liter Down-Looking Dewar	Included with Cryostat
CFG-LP-SV, SH	DWR-30-OP	30-liter Offset-Port Dewar	
	DWR-30	30-liter Dewar	

Specifications subject to change
120409

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ORTEC®

SLP Series Silicon Lithium-Drifted Planar Low-Energy X Ray Detector Product Configuration Guide

For x-ray spectroscopy with a nuclear accelerator, radioactive source, or x-ray tube.

- Premium performance spectroscopy from 1 keV to 30 keV
- Superior resolution performance at low and high count rates
- Multi-detector arrays available for use at fusion facilities
- Thin Be window
- High peak-to-background ratio
- PopTop flexibility

ORTEC SLP Series Lithium-Drifted Silicon X-Ray Detectors provide the spectroscopist with a highly sensitive, premium performance research tool for detecting x rays from a nuclear accelerator, radioactive source, or x-ray tube. The energy range of detection (Fig. 1) is from 30 keV down to 1 keV, depending on the thickness of the beryllium window.

The x-ray detector consists of a lithium-drifted silicon crystal and a cryogenically-cooled-FET, a high-gain, low-noise hybridized preamplifier in a PopTop capsule with a thin Be entrance window. The ORTEC Si(Li) detector crystal is manufactured under an exclusive process. Special techniques for lithium drifting result in a negligible detector element dead layer whose characteristics will not change even if the detector is stored at room temperature.

The SLP Series Si(Li) detector provides exceptional resolution performance. A pulsed optical feedback preamplifier having and energy rate in excess of 4000 MeV/s* is supplied with the SLP Series detectors.

An ultra-thin Be window (either 0.3 mil and 0.5 mil) is an option.

SLP detectors have an exclusive high-rate indicator and high-voltage shutdown protection feature. If the LN_2 supply is exhausted and the detector begins to warm while high voltage is applied, the high voltage will automatically shut off, thus protecting the FET from damage.

As a single element or in multiple detector arrays (Figs. 2 and 3), the SLP Series has become an important tool in soft x-ray spectroscopy in fusion research. Please contact the factory or your local sales representative for specific information on these applications.

An SLP PopTop detector consists of:

(a) A Si(Li) detector element (Fig. 4) mounted, in most systems, inside the vacuum enclosure of its PopTop capsule.

(b) A charge-sensitive preamplifier and a HV filter, with accompanying cable pack. The first stage of the preamplifier is also mounted inside the vacuum enclosure to ensure proper cooling for optimum noise and reliability. The second stage of the preamplifier and HV filter are part of the PopTop assembly but reside outside the vacuum enclosure to which they are connected by vacuum feedthroughs.

(c) A dipstick cryostat with a 30-liter LN_2 dewar or a combination cryostat-dewar assembly.

*The POF does not "lock up" or saturate at high count rates, unlike resistor-feedback designs. At ultra-high count rates with the POF, throughput is limited by reset pulse rates. 4000 MeV/s is an estimate of maximum "useable" energy rate.

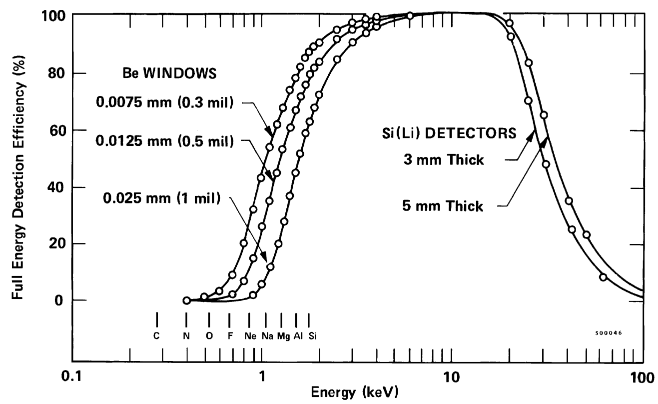


Fig. 1. Detection Efficiency vs. Be Window Thickness on Low-Energy Curve and vs. Crystal Thickness on High-Energy Curve.

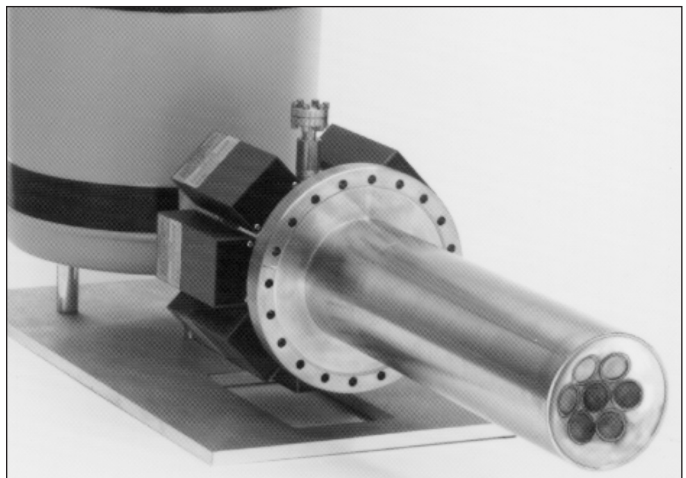


Fig. 2. Array, Comprising Seven Tightly-Packed 6-mm-diam Si(Li) Detectors, Used at Synchrotron Light Source.

Fig. 3. Examples of Multiple Detector Arrays for Soft X-Ray Spectroscopy. Note the three Be windows in each endcap. Three Si(Li) detectors share a common cryostat in each of the systems shown.

SLP Series Silicon Lithium-Drifted Planar
Low-Energy X Ray Detector
Product Configuration Guide

The Following Specifications are Provided for Each Model GLP Detector

- Active crystal diameter and depth.
- Energy resolution at 5.9 keV photons from ^{55}Fe at optimum shaping time unless the window material prohibits this energy.

Configuration Guidelines

PopTop or Streamline (non-PopTop) Configuration

The essence of a PopTop detector system is that the HPGe detector element cryostat, preamplifier, and high voltage filter are housed in a detector "capsule" which is then attached to an appropriate cryostat (Figure 4.)

In so called Streamline systems, the detector capsule in NOT demountable. Detector capsule and cryostat share the same vacuum. In configuration terms, this requires a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap. A cryostat must always be ordered with a Streamline capsule, because they are integral.

The actual PopTop capsule has its own vacuum. It can be mounted on any of the available cryostats, cryostat/dewar combinations, or the X-COOLER II mechanical cooling system.

Steps to Configure Your ORTEC HPGe Detector

1) Configure the Detector Model

- Capsule type (PopTop or Streamline)
- Ge Crystal dimensions and specifications
- Endcap and window
- Mount
- Preamplifier
- High Voltage Filter
- Cable Package

2) Configure the Cryostat/Dewar Model

- Vertical Dipstick style (separate Dewar)
- Horizontal Dipstick style (separate Dewar)
- Portable with all-position or multi-position cryostat/dewar models
- Downlooking designed to be oriented with the detector pointing down
- Sidelooking designed to be oriented with the detector horizontal at the bottom of the dewar
- "J" configuration designed with the detector attached near the bottom of the dewar and a right angle bend in the cryostat orienting the detector to look up.

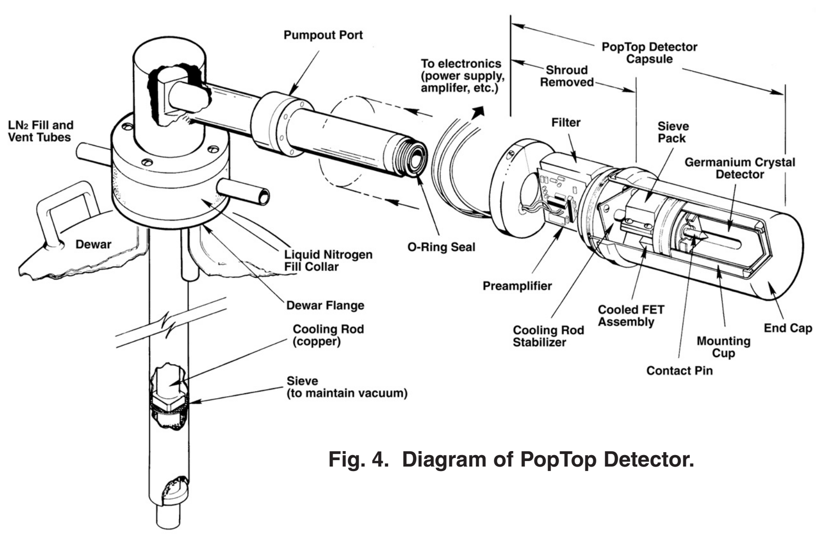


Fig. 4. Diagram of PopTop Detector.

A cryostat and dewar or other cooling device are required for operation.

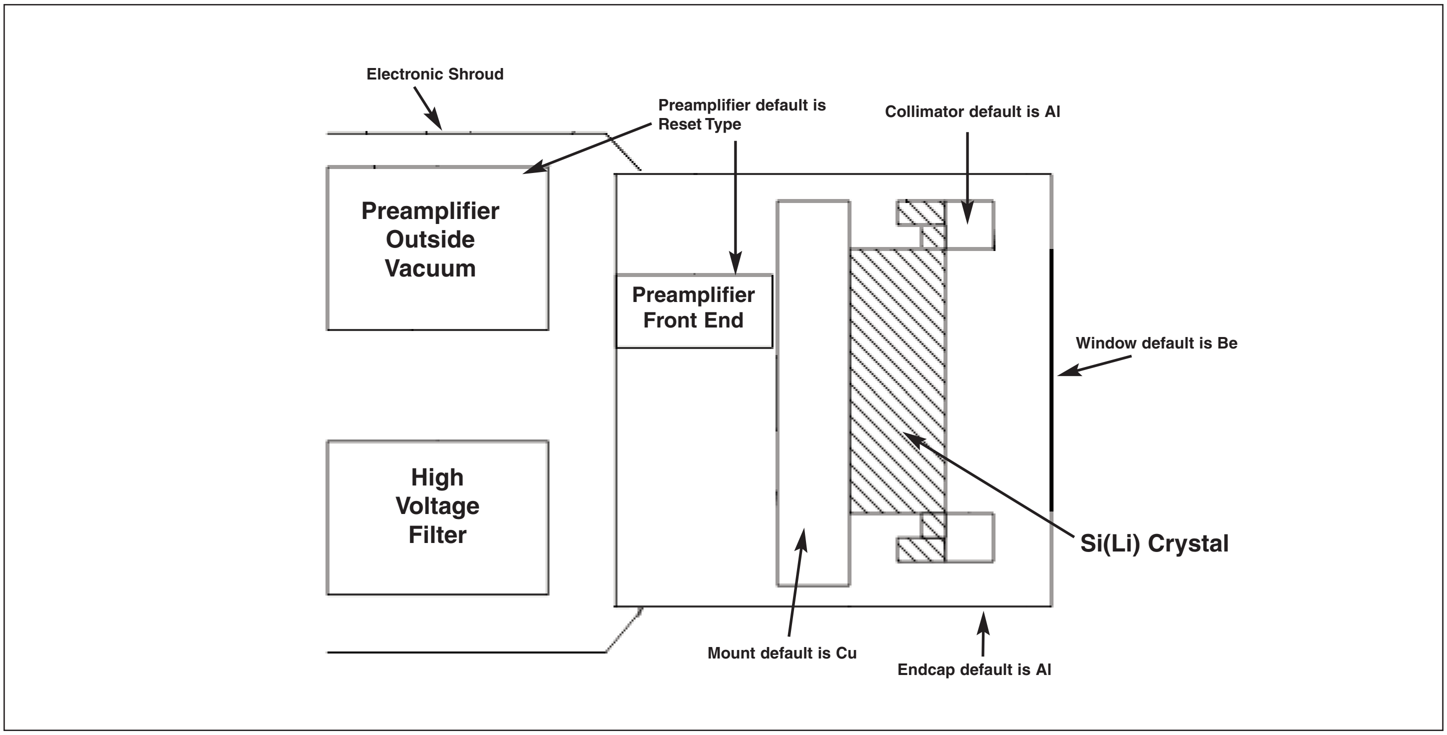
If a PopTop detector has been selected, you can choose a PopTop style cryostat, cryostat/dewar combination or the X-COOLER II mechanical cooler.

If a Streamline detector has been selected, you must choose a cryostat or cryostat/dewar model for the detector to be mounted on and vacuum sealed. The cryostat or cryostat/dewar combination diameter must match the endcap diameter of the selected detector.

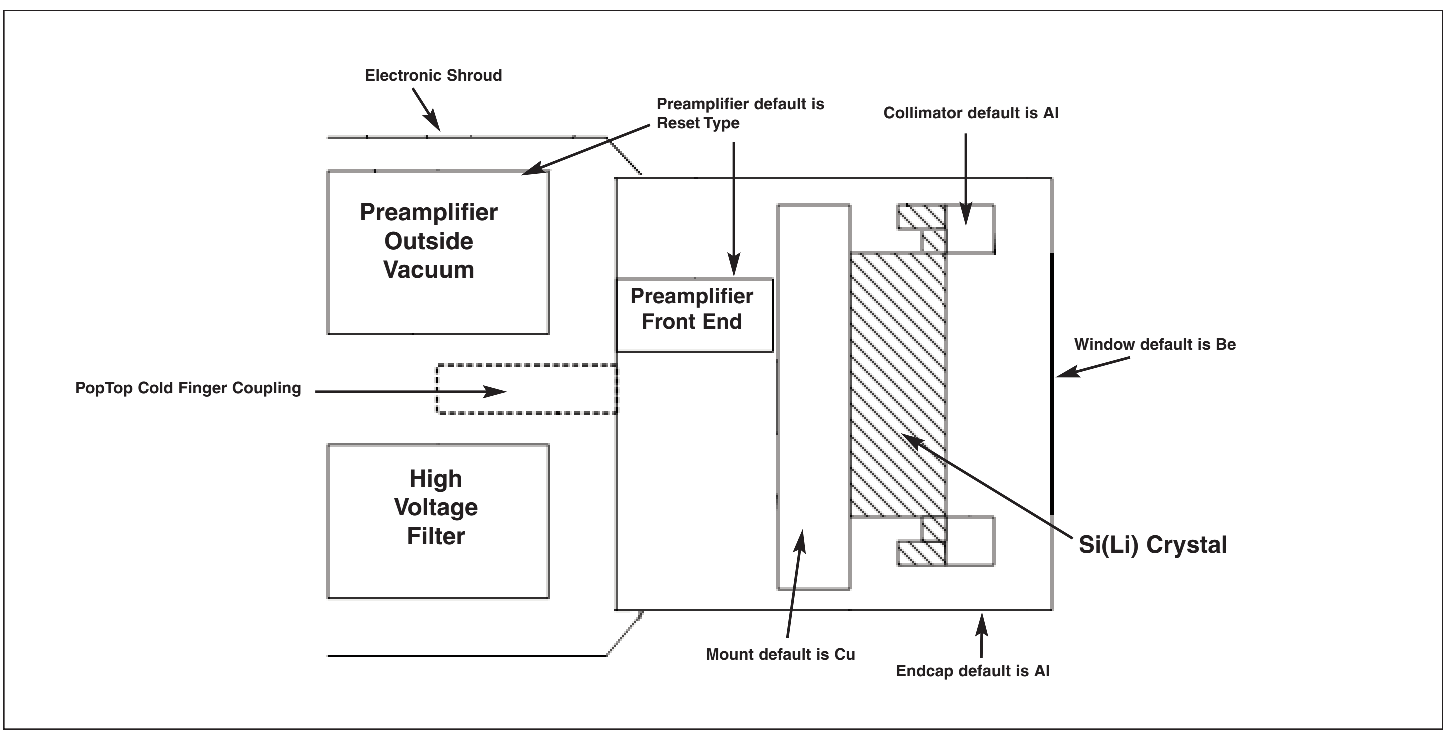
Defining the Detector Model

Base Model (example)	PopTop or Streamline
SLP-06165	P (PopTop) (Streamline)

Streamline Detector Capsule



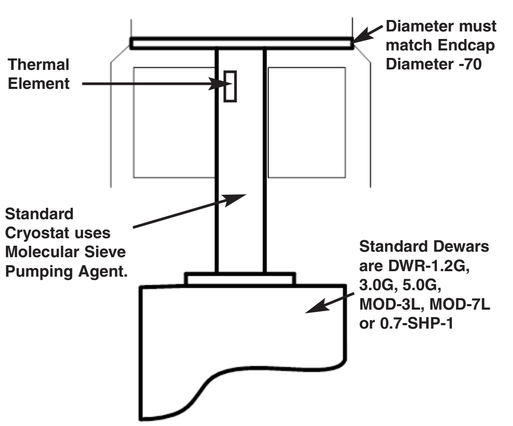
PopTop Detector Capsule



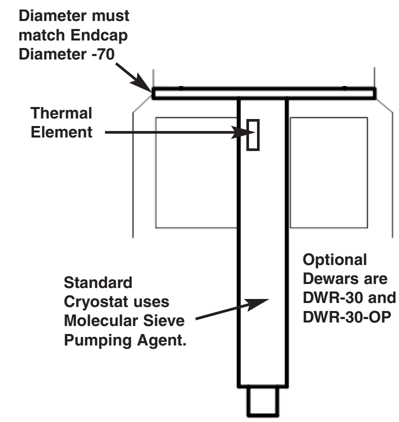
SLP Series Silicon Lithium-Drifted Planar Low-Energy X Ray Detector Product Configuration Guide

Streamline Cryostat and Cryostat/Dewar Assemblies

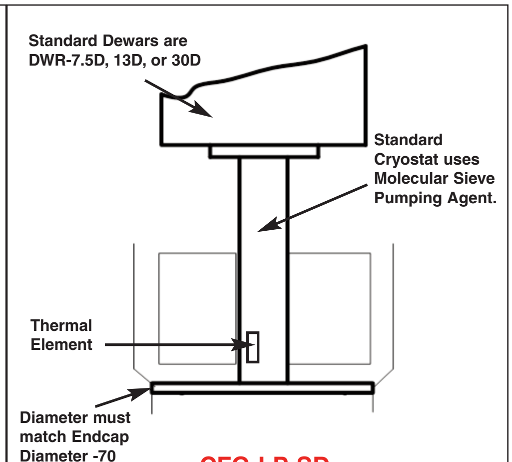
Streamline systems (detector capsule and cryostat) share the same vacuum, requiring a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap.



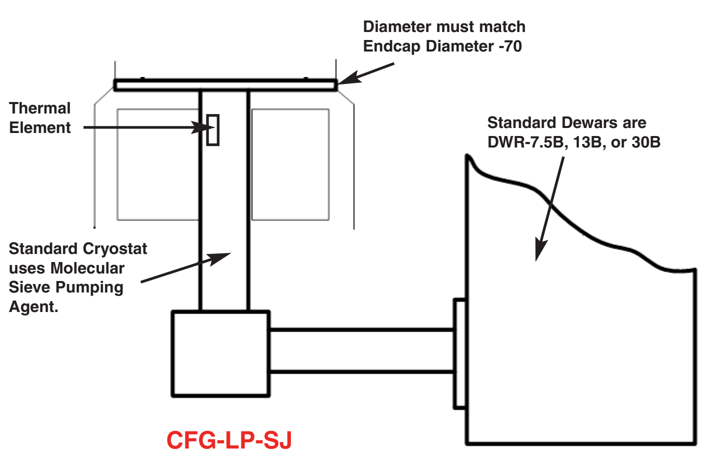
CFG-LP-GG



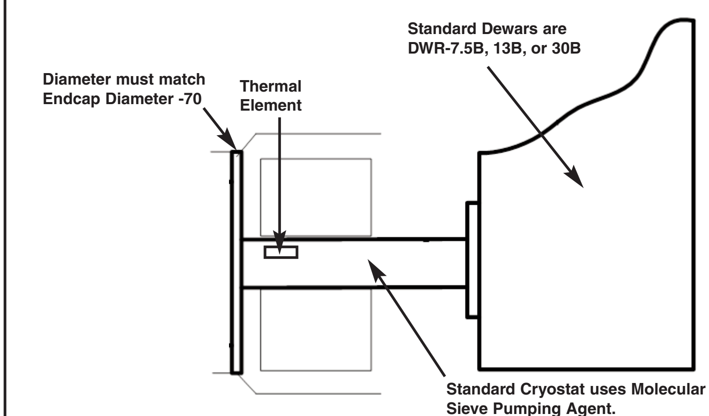
CFG-LP-SV



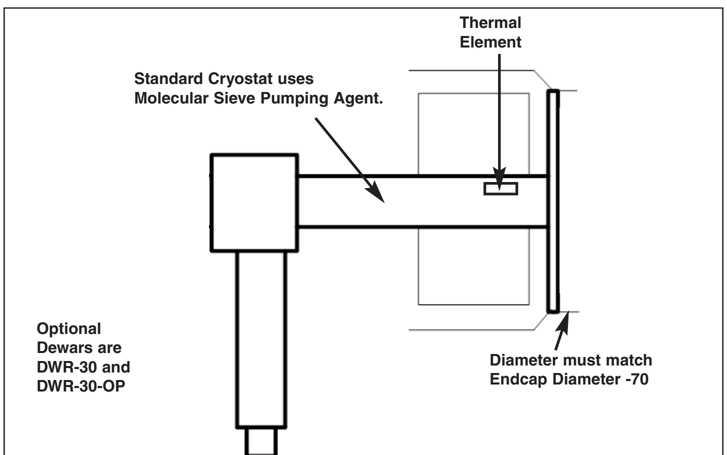
CFG-LP-SD



CFG-LP-SJ



CFG-LP-SL



CFG-LP-SH

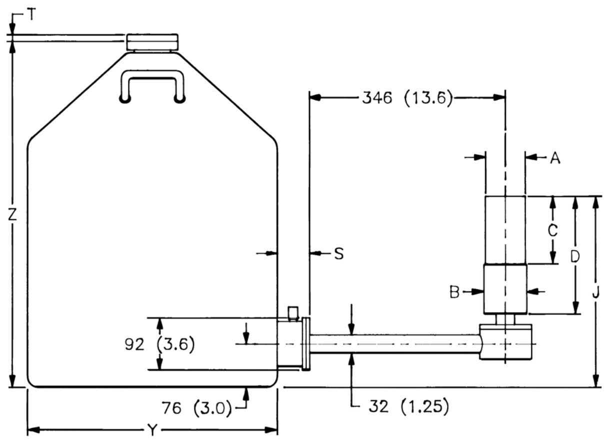
PopTop and Streamline Dimensional Data

Streamline systems (detector capsule and cryostat) share the same vacuum, requiring a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap. A cryostat must be ordered with a Streamline capsule.

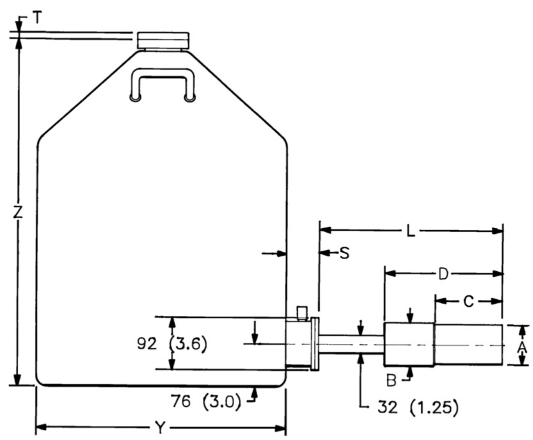
The PopTop capsule contains a vacuum unto itself. It can be mounted on any of the available cryostats, cryostat/dewar combinations, or the X-COOLER II mechanical cooling system.

The cryostat and dewar drawings that follow are to be used in conjunction with the accompanying tables of dimensions.

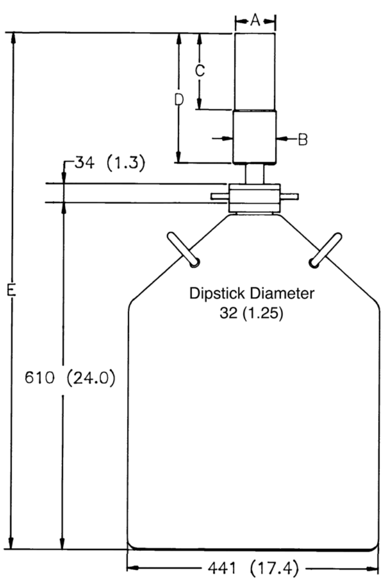
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



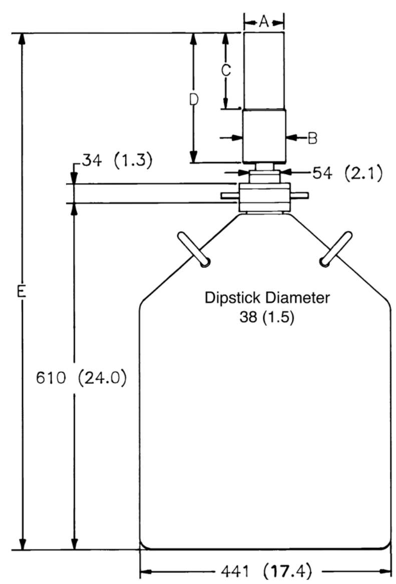
CFG-LP-SJ, DWR-30B (or -13B or -7.5B)



CFG-PS4-30 (or -13 or -7.5)
or
CFG-LP-SL, DWR-30B (or -13B or -7.5B)



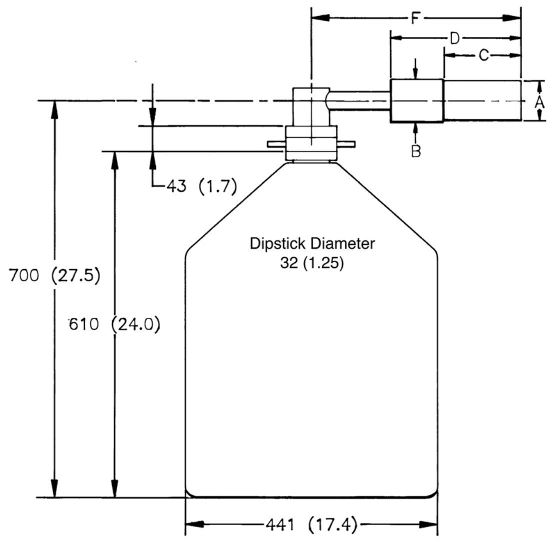
CFG-LP-SV, DWR-30



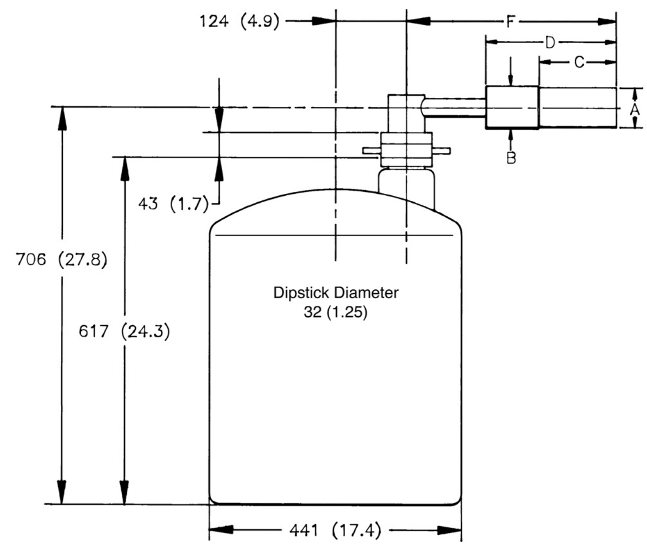
CFG-PV4, DWR-30

SLP Series Silicon Lithium-Drifted Planar Low-Energy X Ray Detector Product Configuration Guide

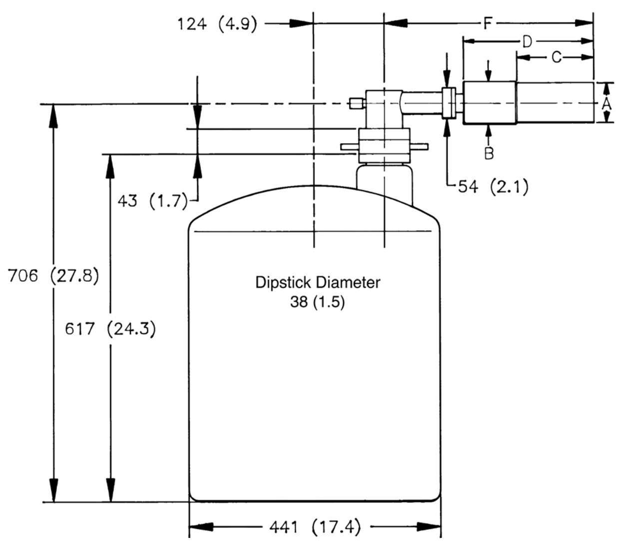
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



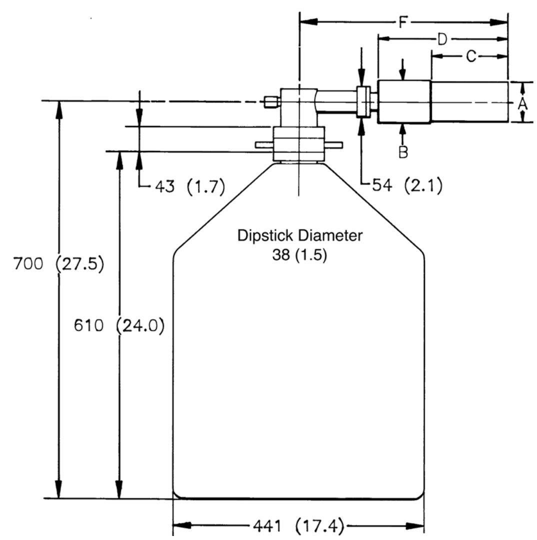
CFG-LP-SH, DWR-30



CFG-LP-SH, DWR-30-OP

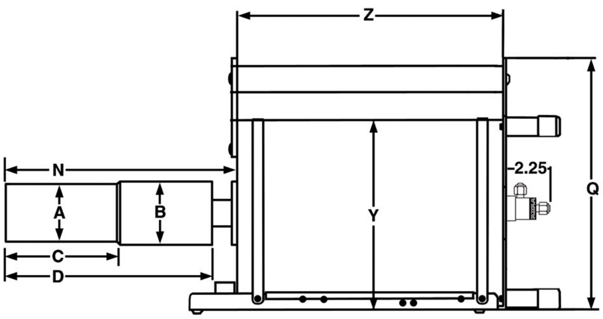


CFG-PH4, DWR-30-OP

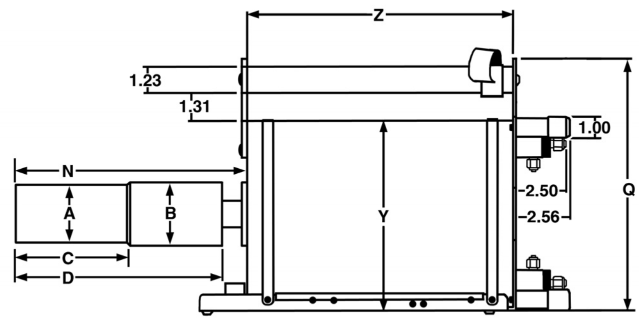


CFG-PH4, DWR-30

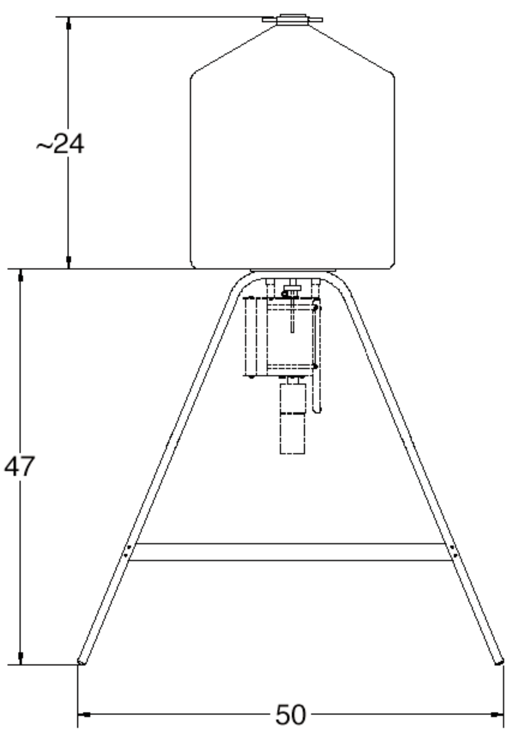
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



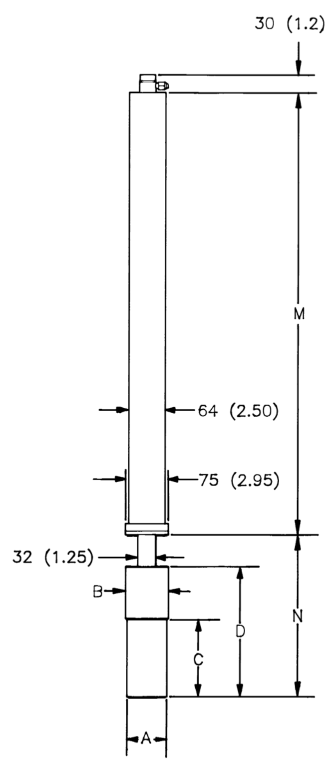
CFG-PG4-1.2 (or -3 or -5)
or
CFG-LP-GG, DWR-1.2G (or -3.0G, -5.0G)



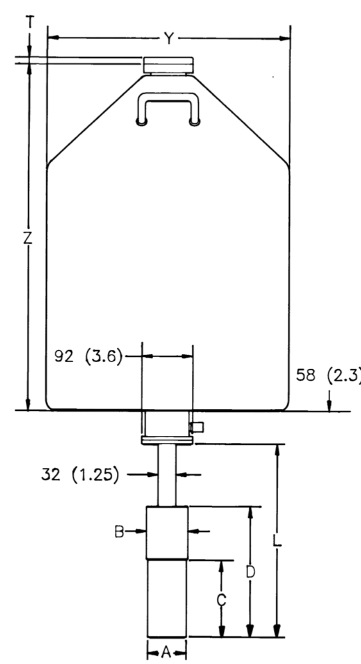
CFG-PMOD4-3 (or -7)
or
CFG-LP-GG, DWR-MOD3L (or -MOD7L)



DWR-S/F



CFG-PSHP4
or
CFG-LP-GG, DWR-0.7-SHP-1



CFG-PD4-30 (or -13 or -7.5)
or
CFG-LP-SD, DWR-30D (or -13D or -7.5D)

SLP Series Silicon Lithium-Drifted Planar
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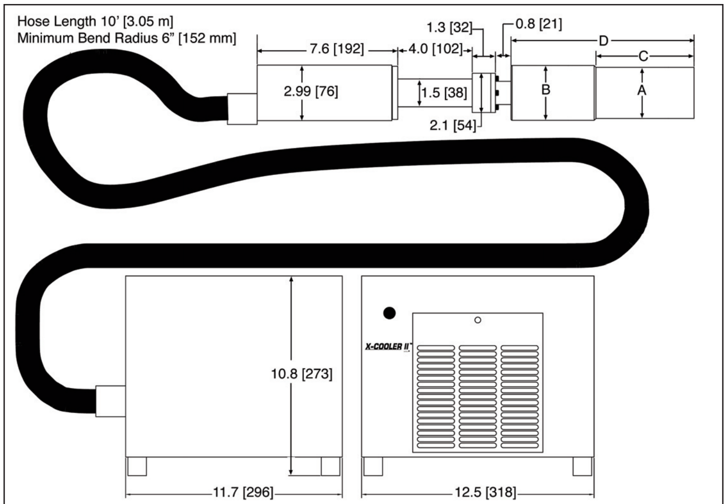


CFG-X-COOL-II

SLP Detector Dimensions

- Dimensions are for reference only and subject to change.
- If dimensional constraints are critical, contact the factory.

Dim.	Unit	Tol.	PopTop	Streamline
A	mm (in)	0.3 (0.01)	70 (2.75)	70 (2.75)
B	mm (in)	0.3 (0.01)	75 (2.95)	75 (2.95)
C	mm (in)	5 (0.2)	135 (5.3)	71 (2.8)
D	mm (in)	8 (0.3)	250 (9.8)	182 (7.2)
E	mm (in)	8 (0.3)	947 (37.3)	854 (33.6)
F	mm (in)	18 (0.7)	396 (15.6)	305 (12.0)
J	mm (in)	10 (0.4)	X X	318 (12.5)
L	mm (in)	18 (0.7)	338 (13.3)	274 (10.8)
M	mm (in)	10 (0.4)	790 (31.1)	X X
N	mm (in)	8 (0.3)	278 (10.9)	215 (8.5)

Gamma Gage and Side-Looking Dewar Dimensions

- Dimensions are for reference only and subject to change.
- If dimensional constraints are critical, contact the factory.

			Cryostat/Dewar or Dewar Type							
			CFG-PG4 and DWR-x.xG			CFG-PMOD4 and DWR-MOD-xL		CFG-PS4, CFG-PD4, DWR-xxB and DWR-xxD		
			VOLUME			VOLUME		VOLUME		
Dim.	UNIT	TOL. ±	1.2L	3L	5L	3L	7L	7.5L	13L	30L
Q	mm (in)	13 (0.5)	229 (9.0)	302 (11.9)	302 (11.9)	229 (9.0)	302 (11.9)	X X	X X	X X
S	mm (in)	7.6 (0.3)	X X	X X	X X	X X	X X	77 (3.0)	77 (3.0)	60 (2.3)
T	mm (in)	5 (0.2)	X X	X X	X X	X X	X X	10 (0.4)	10 (0.4)	13 (0.5)
Y	mm (in)	5 (0.2)	157 (6.2)	229 (9.0)	229 (9.0)	157 (6.2)	229 (9.0)	224 (8.8)	307 (12.1)	442 (17.4)
Z	mm (in)	5 (0.2)	229 (9.0)	267 (10.5)	419 (16.5)	292 (11.5)	320 (12.6)	452 (17.8)	429 (16.9)	610 (24.0)

Example Model Numbers

Streamline Configuration

SLP-16220	16-mm diameter, 5-mm deep SLP planar detector with 70-mm diameter endcap.
CFG-LP-GG-70	Portable Gamma Gage cryostat with matching 70-mm diameter flange.
DWR-1.2G	1.2 liter all-position dewar for Gamma Gage cryostat.
SLP-06165	6-mm diameter, 5-mm deep SLP detector with 70-mm diameter endcap.
CFG-LP-SD-70	Downlooking cryostat with matching 70-mm diameter flange.
DWR-7.5D	7.5 Liter downlooking dewar for downlooking cryostat.

PopTop Configuration

SLP-16220P	16-mm diameter, 5-mm deep SLP detector with 70-mm diameter endcap.
CFG-PG-3	Portable Gamma Gage cryostat with 3 liter all-position dewar.
GLP-06165P	6-mm diameter, 5-mm deep SLP detector with 70-mm diameter endcap.
CFG-PD4-7.5	Downlooking cryostat with 7.5 liter dewar.

Ordering Information

- For Streamline, remove the “P” from the model number.
- If dimensional considerations are critical, contact factory.
- OPT-0.3 = 8 µm (0.0003-in) thick Be (ultra-thin) unsupported window.
- OPT-0.5 = 13 µm (0.005-in) thick Be window.
- Cryostat and dewar or other cooling device are not included with detector.
- Cryostat and dewar or other cooling device are required for operation.
- A cryostat must be ordered with a Streamline detector.

Model No.	Active Diameter (mm)	Thickness (mm)	Area (mm^2)	Energy Resolution FWHM (eV) @ 5.9 keV	Endcap Diameter (mm)	Be Window Thickness (µm)
SLP-04160P	≥4	5	≥12.5	≤160	70	25
SLP-04160P-OPT-0.3	≥4	5	≥12.5	≤160	70	7.6
SLP-04160P-OPT-0.5	≥4	5	≥12.5	≤160	70	13
SLP-06165P	6	5	28	165	70	25
SLP-06165P-OPT-0.5	6	5	28	165	70	13
SLP-10180P	10	5	80	180	70	25
SLP-16220P	16	5	200	220	70	50

SLP Series Silicon Lithium-Drifted Planar Low-Energy X Ray Detector Product Configuration Guide

SLP PopTop Cryostats and Dewars

• Dewar included except where marked *.

Model No.	Description
CFG-PD4-7.5	Down-looking Cryostat with 7.5-liter Dewar
CFG-PD4-13	Down-looking Cryostat with 13-liter Dewar
CFG-PD4-30	Down-looking Cryostat with 30-liter Dewar
CFG-PG4-1.2	Gamma Gage Cryostat with 1.2-liter Dewar
CFG-PG4-3	Gamma Gage Cryostat with 3-liter Dewar
CFG-PG4-5	Gamma Gage Cryostat with 5-liter Dewar
CFG-PH4	Horizontal Cryostat (Dipstick type). Includes LNTC1.5WH. Dewar not included.* Choose DWR-30 or DWR-30-OP.
CFG-PMOD4-3	Gamma Gage Cryostat with 3-liter Multi-Orientation Dewar
CFG-PMOD4-7	Gamma Gage Cryostat with 7-liter Multi-Orientation Dewar
CFG-PS4-7.5	Side-Looking Cryostat with 7.5-liter Dewar
CFG-PS4-13	Side-Looking Cryostat with 13-liter Dewar
CFG-PS4-30	Side-Looking Cryostat with 30-liter Dewar
CFG-PSHP4	Down-Looking Shallow-Hole Probe with 0.7-liter Dewar
CFG-PV4	Vertical Cryostat (Dipstick type). Includes LNTC1.5WH. Dewar not included.* Choose DWR-30 or DWR-30-OP.
DWR-30	30-liter Dewar
DWR-30-OP	30-liter Offset-Port Dewar
DWR-S/F	Storage Fill Dewar for CFG-PG4-X
CFG-X-COOL-II-115	X-COOLER II with PopTop connector using 110-120 V ac, 60 Hz Input Power
CFG-X-COOL-II-230	X-COOLER II with PopTop connector using 220-240 V ac, 50 Hz Input Power

SLP Streamline Cryostats

• Select dewar from SLP Streamline Dewars. Dewar included except where marked*.

Model No.	Description
CFG-LP-GG-70	Gamma Gage Cryostat Dewar
CFG-LP-SD-70	Down-Looking Cryostat with Dewar
CFG-LP-SH-70	Horizontal Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
CFG-LP-SJ-70	J-type Cryostat with Dewar
CFG-LP-SL-70	Side-Looking Cryostat with Dewar
CFG-LP-SV-70	Vertical Cryostat with (Dipstick type). Includes LNTC1.25WH. Dewar not included.*

SLP Streamline Dewars

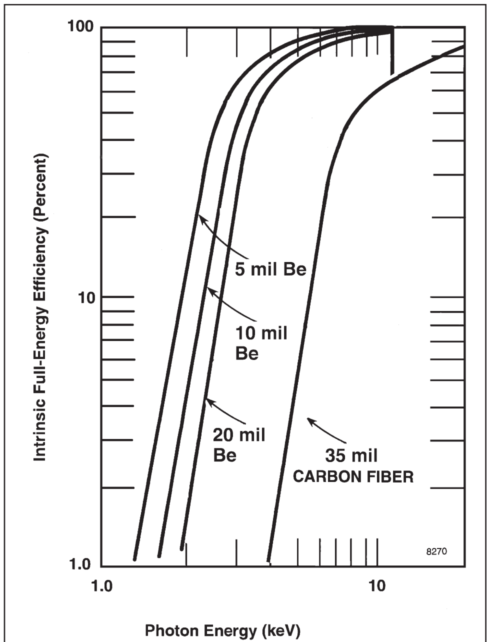
For Cryostat	Choose	Description	
CFG-LP-GG	DWR-1.2G	1.2-liter All-Orientation Dewar	Included with Cryostat
	DWR-3.0G	3.0-liter All-Orientation Dewar	Included with Cryostat
	DWR-5.0G	5.0-liter All-Orientation Dewar	Included with Cryostat
	DWR-MOD-3L	3-liter Multi-Orientation Dewar	Included with Cryostat
	DWR-MOD-7L	7-liter Multi-Orientation Dewar	Included with Cryostat
	DWR-0.7-SHP-1	0.7-liter Shallow-Hole Probe Dewar	Included with Cryostat
	DWR-S/F	Storage/Fill Dewar for DWR-XG	
CFG-LP-SJ, SL	DWR-7.5B	7.5-liter Side-Looking Dewar	Included with Cryostat
	DWR-13B	13-liter Side-Looking Dewar	Included with Cryostat
	DWR-30B	30-liter Side-Looking Dewar	Included with Cryostat
CFG-LP-SD	DWR-7.5D	7.5-liter Down-Looking Dewar	Included with Cryostat
	DWR-13D	13-liter Down-Looking Dewar	Included with Cryostat
	DWR-30D	30-liter Down-Looking Dewar	Included with Cryostat
CFG-LP-SV, SH	DWR-30-OP	30-liter Offset-Port Dewar	
	DWR-30	30-liter Dewar	

ORTEC®

Low-Background Germanium Gamma-Ray Detectors

ORTEC can provide all GEM, GMX, LO-AX, and GWL detectors in low-background configurations, including SGD and PROFILE series GEMS.

The principles of the approach to reducing the background in a HPGe detector operate in two directions: reduction of the background intrinsic to the materials used to make the detector, and secondly reduction of the amount of radiation from any such materials which reach the detector element itself.



Intrinsic Full-Energy Efficiency of GAMMA-X or LO-AX Detectors Equipped with Carbon Fiber or Beryllium Windows.

ORTEC Low-Background Detector Materials

- Standard endcaps for low-background GEM and GMX detectors without Be windows are Carbon Fiber. Carbon fiber endcap thickness for low-background detectors is 0.035". Low-background GWL detectors have oxygen-free high conductivity (OFHC) copper endcaps with low-background high purity aluminum well tubes of 0.02" wall thickness.
- If lower energies are required, copper endcaps with low-background Be windows are standard for low-background GMX and LO-AX detectors. The Be window is 0.020" thick for up to 3-1/4" endcaps and 0.030" thick for 3-1/2" endcaps.
- Detector internals (cup, cooling rod, cooling rod clamp and pedestal) are made of OFHC Copper for standard low-background detectors.
- Activated Charcoal is used as the cryo pump, having lower background than sieve.
- Detector flange is made of low cobalt steel.
- XLB option includes a 2 cm thick aged lead back shield between the preamplifier/HV and crystal.

Low-Background Options for Streamline Detectors

The LB option is constructed as described above.

The XLB option offers an improvement (in most cases) over the LB, by the introduction of the aged lead back shield behind the crystal. (There are instances in which the absence of the lead back shield is preferable, such as when the secondary Pb x rays may create more background at the energy of interest than the additional background present due to the lead back shield's absence.)

Low-Background Options for PopTop Detectors

The RB option is essentially the same construction as the LB, but the sieve pack in the capsule is retained in order to provide adequate pumping. The detector is shielded from the sieve by an OFHC copper cup.

The RB-B option provides a Be window in a Cu endcap instead of the Carbon Fiber endcap (for GMX and LO-AX detectors only).

LB Series HJ Cryostat Configuration

The popular HJ configuration is a side-looking cryostat with the preamplifier and high-voltage filter next to the dewar and thus remote from the detector; therefore, the lead back shield immediately behind the detector is unnecessary. Generally, this is the optimum configuration for shielding the detector element from the dewar, the cryogenic pumping material, the preamplifier, and much of the cryostat.

Factors Affecting Low-Background Gamma Spectroscopy with HPGe Detectors

The radiation background of standard cryostats used by ORTEC for germanium detectors is lower than that required for the majority of users. Net area peak counting rates ~0.1 counts/min are typical at energies of interest. Nonetheless, those measuring environmental samples who require the lowest MDAs in the shortest possible counting time will be best served by a large germanium detector in a LB or XLB cryostat. Coaxial detectors of efficiency from 80% to 175%, with their exceptionally high peak-to-Compton ratios (approaching 100 to 1), are also recommended (Ref. 1).

There are a number of naturally-occurring radionuclides that contribute to the gamma-ray background observed by spectroscopists using a germanium detector system. Contributions from the cosmic-ray induced background, ^{40}K from building structures, and radon, can be markedly reduced by appropriate shielding (including in some cases an underground location) and flushing the shield with "aged" nitrogen. The principal sources of activity from the cryostat are the primordial emitters, ^{238}U, ^{232}Th, ^{235}U and their daughters, man-made radionuclides including ^{137}Cs fallout, and the activation product ^{60}Co. There are both full-energy photopeaks and associated Compton background from 46 to 2600 keV.

In some materials, the natural emitter chains may not be in equilibrium. Therefore, ORTEC reports the measured background at all the energies shown in Table 1.

Different spectroscopists have different "low-background" requirements and energies to which the phrase "low-background" applies. Therefore, low-background cannot be rigorously defined as, for example, energy resolution at the 1.33-MeV line of ^{60}Co. For this reason various laboratories use different nomenclature and different report formats when describing measured background.

To satisfy the needs of spectroscopists, ORTEC does the following:

- Carefully selects low-background materials
- Characterizes completed HPGe detectors in a specialized low-background facility
- Produces the world's largest detectors in the lowest-background cryostats — the ultimate for gamma spectroscopy of low-level samples
- Provides with each detector an activity report of the 22 most common isotopes
- Remains current with technology for low-background materials. Environmental spectroscopists seeking to minimize MDA while maximizing sample throughput should read: The Benefits of Using Super-Large Germanium Gamma-Ray Detectors for the Quantitative Determination of Environmental Radionuclides.
- For customers that require special configurations, ORTEC can work with the user to supply various materials or utilize customer supplied materials where possible.

Table 1. Environmental Radionuclide Full-Energy Photopeak Energies.

Isotope (Parent Nuclide)	Energy in keV	Isotope (Parent Nuclide)	Energy in keV
U x-rays	13.0, 13.3*	^{137}Cs	661.6
^{231}U	25.6*	^{214}Bi (^{238}U)	727.2
^{137}Cs	31.8, 32.2, 36.4*	^{234m}Pa (^{238}U)	766.6
^{210}Pb (^{238}U)	46.5	^{228}Ac (^{232}Th)	911.0
^{234}Th (^{238}U)	63.3	^{228}Ac (^{232}Th)	969.0
^{234}Th (^{238}U)	92.6	^{234m}Pa (^{238}U)	1001.0
^{235}U, ^{226}Ra	185.7, 186.2	^{214}Bi (^{238}U)	1120.3
^{212}Pb (^{232}Th)	238.6	^{60}Co	1173.0
^{214}Pb (^{238}U)	295.2	^{214}Bi (^{238}U)	1238.0
^{214}Pb (^{238}U)	351.9	^{60}Co	1332.5
Cosmic	511.0	^{40}K	1460.8
^{208}Tl (^{232}Tl)	583.1	^{214}Bi (^{238}U)	1764.5
^{214}Bi (^{238}U)	609.3	^{208}Tl (^{232}Tl)	2614.5

* The lines lower than 46 keV are reported only for LO-AX and GMX detectors.

Low-Background Spectroscopy Laboratory and Detector Background Certification Program

Low-background detectors are measured in the ORTEC Low-Background Test Facility, and a certificate is provided reporting the intensity of the lines listed in Table 1.

As a result of the differences in altitude and the extent of radioactivity in materials near to the detector, the background that will be observed at your location may be lower or higher than that measured in the ORTEC Low-Background Test Facility.

The ORTEC Low-Background Test Facility houses two lead shields, configured to accommodate detectors in various configurations. Each shield consists of a 3 inch OFHC copper "well" surrounded by eight inches of low-radiogenic lead. The copper virtually eliminates the lead x-rays resulting from photoelectric interactions of gamma rays with the lead.

For characterizing the materials to be used for detector cryostat construction, the low-background laboratory has a graded-Z (Pb, Cu, Cd) shield containing an ultra-low-background detector. Quality control limits have been established for each type of material dependent on its location in the finished cryostat.

Each completed detector is placed in the appropriate shield and calibrated.

Then, with the source removed, a detector background spectrum is acquired for 100,000 seconds. The background spectrum is searched using a second-difference peak-search algorithm. All identified peaks are visually examined. For any peaks that are part of the list reported as "not found," a region-of-interest (ROI) is set manually, and the net area is computed by the MCA Emulation software. Finally, a report that lists the ROI net count rates is created.

The data are reported as intensities rather than activities because the activities are a function of the geometry of the calibration, while the intensities are geometry-independent.

The logarithmic plot (Fig. 1), linear plot (Fig. 2), and low-background analysis reports (Tables 2 and 3) show, for comparison, the gamma background spectra of two GEM detectors of identical relative efficiency (56%), one in a standard cryostat and the other in an extra-low-background (XLB) cryostat (Fig. 3). The difference in background is substantial. The background report can be supplied on disk if requested, and can be used in conjunction with the ORTEC MAESTRO MCA Emulation program to visually examine the data or to plot it.

It must be emphasized that the gamma background measured in a detector cannot be better than the background in the laboratory where the detector is operated. For example, health physicists making in vivo measurements should be aware that the beds or chairs in which the subject is placed are generally not made of materials selected for low gamma background and, also, that the subjects being measured emit gamma rays at a rate consistent with the 40–120 nanocuries of ^{40}K normally found in the human body. Therefore, while every precaution must be taken to obtain good, reliable measurements, it is useless to strive for the "ultimate in low-background" as some physics researchers operating in sophisticated underground laboratories must and can do.

The data obtained at ORTEC are representative of the low-background characteristics of the detector/shield combination in our facility in Oak Ridge, Tennessee. Since background results are dependent upon the shielding, better results may be obtained in sophisticated laboratories (e.g., with active shields or in deep mines).

An example of this for a 40% GEM in a vertical XLB cryostat is shown in Table 4. The third column is from the report of the ORTEC Low-Background Facility. The fourth column contains the reported results on the same detector in a sophisticated low-background laboratory (Ref. 2). Another example is given in Table 5, which reports results obtained at the Gran Sasso National Laboratory, an Italian research facility located under 3500 meters of rock, with a resulting cosmic background reduction of a factor of 10^6. The ORTEC detector has a measured efficiency of 96%. Extraordinary precautions were taken to minimize the gamma background.*

When comparing the data in Tables 2, 3, and 4, the following considerations must be kept in mind:

As there is no standard, laboratories use different formats for such tables; hence, the obvious differences between Tables 2 and 3 (both obtained at ORTEC) and 4 (obtained at the U.S. National Institute of Standards and Technology).

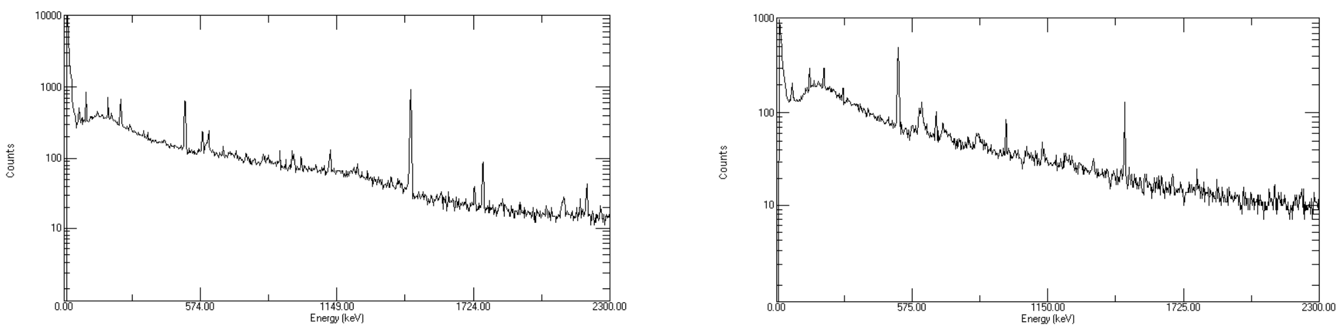


Fig. 1. Logarithmic Plots of Super High Efficiency 205% GEM Detectors in (a) Standard Cryostat and (b) LLB Cryostat.

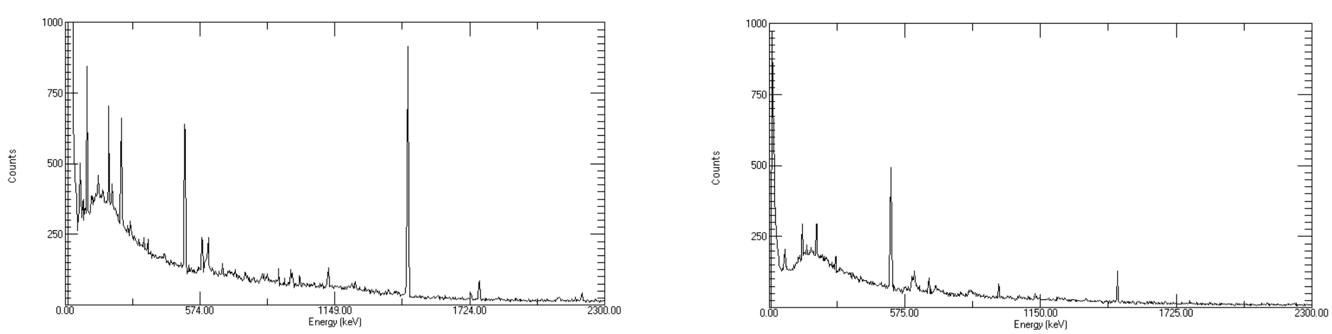


Fig. 2. Linear Plots of Super High Efficiency 205% GEM Detectors in (a) Standard Cryostat and (b) LLB Cryostat.

Low-Background Germanium Gamma-Ray Detectors

The computer printout reports energy centroids rather than the energy of the nuclides. Therefore, some interpretation is required to understand the centroid/nuclide relationship between Tables 2 and 3 and Table 1. For example, Region #1 in Table 2 (centroid at 45.72 keV) indicates the counts due to ^{210}Pb in Table 1 (46.5 keV).

When comparing gamma background data obtained from detectors with different efficiency, the difference in efficiency should be factored in, at least in an approximate (linear) way.

A less sophisticated way of characterizing low-background detectors is reporting the total counts per second in a given energy interval, typically from 100 keV to 3 MeV. A large (96% efficiency) ORTEC detector measured at Gran Sasso, the world-class Italian laboratory under a mountain, registered 100 counts per second in that energy interval.

*C.R. Arpesella, et al., "A Low Background Counting Facility at Laboratori Nazionali del Gran Sasso." (Internal Report LNGS – 92/35 July 1992).

Table 2. Low-Background Analysis Report for "Standard" Detector.

1 LOW BACKGROUND ANALYSIS
SPECTRUM: A:P40836AN.CHN
ROI FILE: A:P40836AN.ROI
DETECTOR SERIAL NUMBER P40836A; NON LOWBACKGROUND ENDCA 205% RELATIVE EFFICIENCY
ANALYSIS AT 08:13:49 ON 17-AUG-01
MCA NUMBER: 1 SEGMENT NUMBER: 1
REALTIME 100983.20 SECS, LIVETIME 100000.00 SECS
START TIME 13:18:26 ON 09-Jul-99 :0
START CHANNEL 0 LENGTH 8192
SAMPLE MULTIPLIER: 1000.0000
TOTAL CORRECTION FACTOR: 1000.0000
BACKGROUND CALCULATED AS AVERAGE OF 3 CHANNELS
ENERGY = 42.1E-02 + 28.5E-02*CHAN + .0E+00*CHAN**2

REGION NUMBER	CENTROID ENERGY(keV)	START CHANNEL	STOP CHANNEL	------PEAK AREA------ GROSS	NET	ERROR NET %	CORRECTED CTS/KSEC
1	46.57	152	172	6442.	643.	25.5	6.43
2	63.43	210	228	6597.	1065.	14.6	10.65
3	66.55	230	236	2242.	50.	139.0	.50
4	76.26	259	281	7245.	219.	84.6	2.19
5	92.82	313	335	10059.	3036.	6.3	30.36
6	139.73	477	501	9644.	557.	39.2	5.57
7	185.94	639	663	10588.	2405.	8.8	24.05
8	198.59	683	707	8563.	609.	33.5	6.09
9	238.81	823	849	9801.	1831.	11.7	18.31
10	277.98	962	988	6393.	318.	57.8	3.18
11	351.88	1220	1248	5338.	543.	31.1	5.43
12	510.60	1772	1807	10739.	6233.	3.1	62.33
13	582.65	2027	2059	4552.	933.	16.8	9.33
14	608.49	2118	2150	5240.	945.	18.0	9.45
15	661.15	2302	2332	2990.	0.	.0	.00
16	668.90	2334	2363	3135.	370.	35.2	3.70
17	726.38	2532	2566	3153.	219.	65.1	2.19
1	762.33	2670	2704	3118.	15.	993.1	.15
19	910.34	3174	3210	2889.	583.	22.5	5.83
20	961.72	3353	3383	2438.	516.	21.6	5.16
21	967.65	3385	3411	2045.	330.	29.9	3.30
22	1000.30	3490	3526	2576.	436.	28.8	4.36
23	1117.27	3907	3945	2836.	230.	61.3	2.30
24	1173.92	4091	4129	2055.	86.	142.6	.86
25	1236.53	4322	4360	2187.	217.	56.3	2.17
26	1331.28	4650	4686	1384.	0.	0	.00
27	1459.02	5096	5136	11492.	9859.	1.5	98.59
28	1762.42	6166	6198	1384.	966.	6.3	9.66
29	2201.42	7707	7734	688.	282.	18.0	2.82

END OF ROI LIST

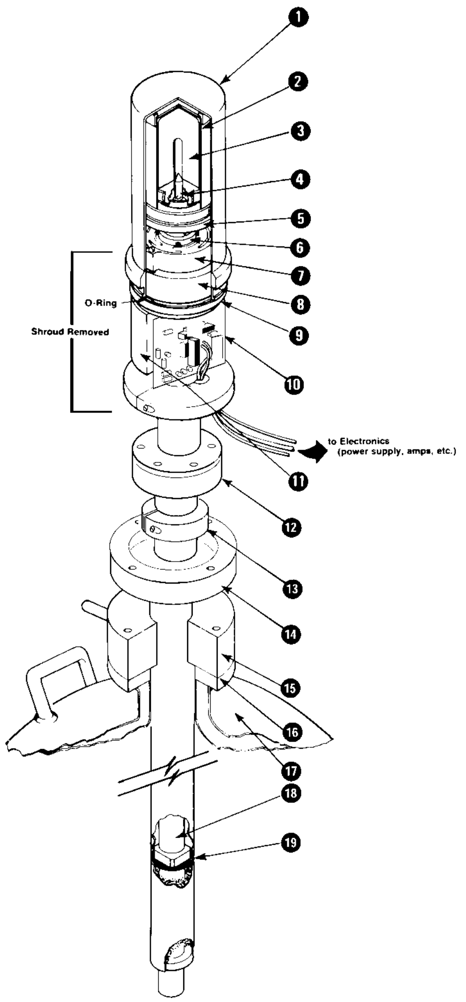
Table 3. Low-Background Analysis Report for "Low-Background" Detector.

1 LOW BACKGROUND ANALYSIS
SPECTRUM: A:P40836AL.CHN
ROI FILE: A:P40836AL.ROI
DETECTOR SERIAL NUMBER P40836A; LOW BACKGROUND ENDCAP 205% RELATIVE EFFICIENCY
ANALYSIS AT 08:01:57 ON 17-AUG-01
MCA NUMBER: 3 SEGMENT NUMBER: 1
REALTIME 100073.10 SECS, LIVETIME 100000.00 SECS
START TIME 10:24:52 ON 03-Apr-00:1
START CHANNEL 0 LENGTH 16384
SAMPLE MULTIPLIER: 1000.0000
TOTAL CORRECTION FACTOR: 1000.0000
BACKGROUND CALCULATED AS AVERAGE OF 3 CHANNELS
ENERGY = 12.8E-02 + 24.7E-02*CHAN + .0E+00*CHAN**2

REGION NUMBER	CENTROID ENERGY(keV)	START CHANNEL	STOP	------PEAK AREA------ GROSS	NET	ERROR NET %	CORRECTED CTS/KSEC
1	45.99	178	194	2045.	116.	75.0	1.16
2	64.20	250	266	2619.	21.	479.5	.21
3	91.98	363	379	1972.	0.	0	.00
4	140.07	559	575	3511.	491.	22.4	4.91
5	184.31	735	753	3352.	36.	322.4	.36
6	198.56	795	813	3927.	630.	19.0	6.30
7	236.17	946	964	2710	0.	.0	.00
8	278.50	1119	1137	2704.	285.	35.8	2.85
9	292.57	1173	1191	2123.	17.	546.2	.17
10	348.01	1398	1418	1961.	0.	.0	.00
11	510.99	2046	2092	8939.	5837.	3.1	58.37
12	545.70	2324	2346	1244.	2.	3873.7	.02
13	602.81	2429	2451	2045.	0	0	0
14	609.47	2455	2477	2107.	321.	29.5	3.21
15	657.97	2658	2689	1446.	65.	145.2	.65
16	669.92	2691	2724	1889.	331.	31.3	3.31
17	727.46	2924	2966	1802.	175.	66.2	1.75
18	771.64	3084	3126	1714.	23.	518.9	.23
19	910.49	3670	3710	1208.	101.	92.7	1.01
20	962.29	3883	3911	1351.	534.	13.6	5.34
21	1001.31	4034	4074	1050.	0.	.0	.00
22	1120.57	4517	4557	1191.	0.	.0	.00
23	1173.22	4731	4771	875.	75.	105.4	.75
24	1238.71	4995	5033	856.	108.	69.7	1.08
25	1332.66	5377	5415	734.	0.	0	.00
26	1460.62	5896	5935	1939.	1252.	6.4	12.52
27	1763.73	7127	7163	455.	159.	30.0	1.59
28	2613.73	1056	810604	625.	385.	11.9	3.85

END OF ROI LIST

Low-Background Germanium Gamma-Ray Detectors



Legend:

1 **Endcap (Ni-plated magnesium) (with low-background Be, or carbon fiber window for GAMMA-X or LO-AX)**

2 **Detector mount cup (OFHC copper or, at additional expense, ultra pure aluminum)**

3 **Germanium detector element**

4 **Pedestal nut (stainless steel)**

5 **Pedestal (OFHC copper)**

6 **Cooling rod clamp (OFHC Cu)**

7 **Thermal insulator (plastic)**

8 **Shield (virgin lead), ~2 cm thick**

9 **Cryostat flange (stainless steel, low cobalt)**

10 **Preamplifier**

11 **HV filter (with Al shroud)**

12 **Pumpout port**

13 **Cryostat clamp**

14 **Collar mounting hardware**

15 **Fill collar (RTV rubber)**

16 **Dewar flange**

17 **Dewar**

18 **Cooling rod (OFHC copper)**

19 **Cryosorption material (charcoal)**

Fig. 3. Cutaway View of Model CFG-SV-XLB.

References

1. R. Keyser, T. Twomey, and S. Wagner, "Benefits of Using Super-Large Germanium Gamma-Ray Detectors for the Quantitative Determination of Environmental Radionuclides," *Radioactivity and Radiochemistry* Vol. 1, No. 2, pp. 46–56 (Spring 1990).
2. R.M. Lindstrom, *et al.*, "A Low-Background Gamma Ray Assay Laboratory for Activation Analysis," *Nucl. Instr. and Meth.*, **A299** (1990) 425–429.

Table 4. Comparison of ORTEC Low-Background Analysis with that in a Sophisticated Laboratory (NIST).

LOW-BACKGROUND ANALYSIS

DETECTOR SERIAL NUMBER P33P, GEM-40195, Low Background Detector

REALTIME 100014.40 secs, LIVETIME 100000.00 secs

CENTROID ENERGY (keV)	NUCLIDE	NET Counts/1000 s (ORTEC LAB.)	NET Counts/1000 s (NIST)
53.6	^{73*}Ge	1.1	0.4
122.1	^{57*}Fe	0.33	0.3
145.3	^{238}U	0.7	Not detected
186.2	^{226}Ra	0.5	Not detected
238.6	^{212}Pb	1.3	0.5
295.2	^{214}Pb	0.9	0.4
352.0	^{214}Pb	1.5	1.0
511.03	ß+ annihilation	28	29
583.1	^{208}Tl	1.1	0.3
609.3	^{214}Bi	1.6	1.0
661.7	^{137}Cs	0.6	Not detected
727.1	^{228}Ac	0.5	Not detected
1120.0	^{214}Bi	0.6	0.3
1173.2	^{60}Co	0.3	0.6
1332.5	^{60}Co	0.1	0.6
1460.8	^{40}K	9	0.3

Table 5. Counting Rate of Main Gamma Lines for the 96% ORTEC Germanium Detector at Gran Sasso Facility. (1σ errors are indicated.)

Isotope	Energy	Counts/1000 s
^{238}U	295.2	0.22 ± 0.03
	351.9	0.44 ± 0.04
	609.3	0.33 ± 0.03
	1764	0.06 ± 0.01
^{232}Th	238.6	0.08 ± 0.02
	583.1	0.04 ± 0.01
	2614.7	0.02 ± 0.01
^{40}K	1460.7	0.09 ± 0.02
^{137}Cs	661.6	0.05 ± 0.01
^{60}Co	1173.2	0.04 ± 0.01
	1332.5	0.03 ± 0.01
^{125}Sb	427.9	
	600.6	
	635.9	
^{106}Ru	621.8	
	1050.1	

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Alpha Suite

All-In-One Integrated Alpha Spectrometers

With the introduction of the Alpha Suite range of integrated Alpha Spectrometers, ORTEC is able to address the needs of ANY counting laboratory, large or small, upgrading or just starting out. The ORTEC Alpha Suite consists of a single channel NIM, (the Alpha Aria), a dual channel benchtop system, (the Alpha Duo), and modular 2, 4, 6, or 8 input "Alpha Ensemble" systems for use in a rack or on a shelf. The latest advanced digital design, together with a modular mechanical approach, aligns value and performance with unparalleled configuration flexibility. Any of these spectrometers may be added to existing ORTEC systems simply by installing the latest drivers included with the instrument.

Alpha Suite

All-In-One Integrated Alpha Spectrometers

All Alpha Suite models feature the following:

• A complete instrument requiring vacuum, power and connection to a PC only

• Simple and fast USB 2.0 connection to computer

• Internal advanced DIGITAL MCA

• Digital Spectrum Stabilizer

• Calibration Pulser

• Computer controlled HV Supply

• High Quality Nickel-plated Brass Vacuum chamber, easily decontaminated

• Alpha Recoil protection system (optional)

• Compatibility with all previous ORTEC Alpha Spectrometer Systems

Alpha Aria

• Single channel

• 2 wide NIM module

• Manual vacuum control

• USB connectivity

• Recoil Protection Option

Many Counting Laboratories still use NIM instrumentation. The Alpha Aria requires only that a dual NIM slot be available to add it to an existing system. A simple to operate PUMP/HOLD/VENT control is mounted on the front panel.

Alpha Duo

• Dual channel, USB connectivity

• Neat, benchtop enclosure, small foot print

• Computer controlled chamber pressure monitoring and venting

• Inexpensive recoil protection option

• Can be upgraded as part of an Ensemble configuration

The Alpha Duo is conveniently packaged in a benchtop enclosure, requiring a vacuum connection, power, and a USB connection to the PC, only.

Alpha Ensemble

• Rack mounted or benchtop configuration of 1, 2, 3, or 4 Alpha Duo modules

• Initially 2, 4, 6 or 8 channels; expand with ALPHA-DUO-M1 modules, easily added in minutes

• Computer controlled chamber pressure monitoring and venting

• Inexpensive recoil protection option

The Alpha Ensemble is available in 2-, 4-, 6-, or 8-input models. Empty slots in the chassis are covered by easily removed blank panels. Expansion couldn't be easier. The ALPHA-DUO-M1 enclosure-less version of the Alpha Duo simply slides into any available space in the chassis, and after making a few simple connections, is ready for use. In the event of a contamination problem, a complete Alpha Duo unit is easily removed from an Ensemble, and the vacuum line is easily isolated with supplied hardware.

Alpha Suite Hardware

Vacuum Chambers

Each Alpha Suite member incorporates one or more high-quality modular vacuum chambers. These individually cast brass chambers are nickel plated for corrosion protection and ease of decontamination, and can be isolated and removed if necessary without affecting the operation of other chambers.

The chambers are sealed with a high-performance O-ring secured in a cleanly-machined groove in the face of each chamber.

Vacuum Chamber Capability and Flexibility

Samples sizes from 13 mm to 51 mm in diameter, with 4 mm to 44 mm detector spacing are accommodated.

ORTEC ULTRA-AS silicon ion implanted and R Series ruggedized surface barrier detectors with surface areas from 300 mm^2 to 1200 mm^2 are easily accommodated.

Electronics

Each Alpha Suite sample chamber is served by its own bias supply, preamplifier, DIGITAL SIGNAL PROCESSOR based (MCA) and pulser.

In the Alpha Ensemble configuration, an internal USB hub provides connection via a single cable to the user's PC. Each detection system has individual digital offset and conversion gain settings for maximum flexibility. Each detector operates independently with completely adjustable energy ranges from 0 to 10 MeV.

Recoil Protection System (optional)

Recoil protection is provided through the use of reverse biased sample holders and through the careful control of the vacuum pressure.

Alpha Aria models: The RCAP option includes a biased sample holder and a Granville-Philips gauge with solenoid vacuum controller.

Alpha Duo and Alpha Ensemble models: Addition of the biased sample holders are all that is required, the pressure control is built into every model (common to both chambers in a dual module).

Alpha Suite

All-In-One Integrated Alpha Spectrometers

Alpha Suite Software

MAESTRO-32 MCA Emulation Software (brochure on request)

MAESTRO-32 MCA software is included with Alpha Aria, Alpha Duo and Alpha Ensemble.

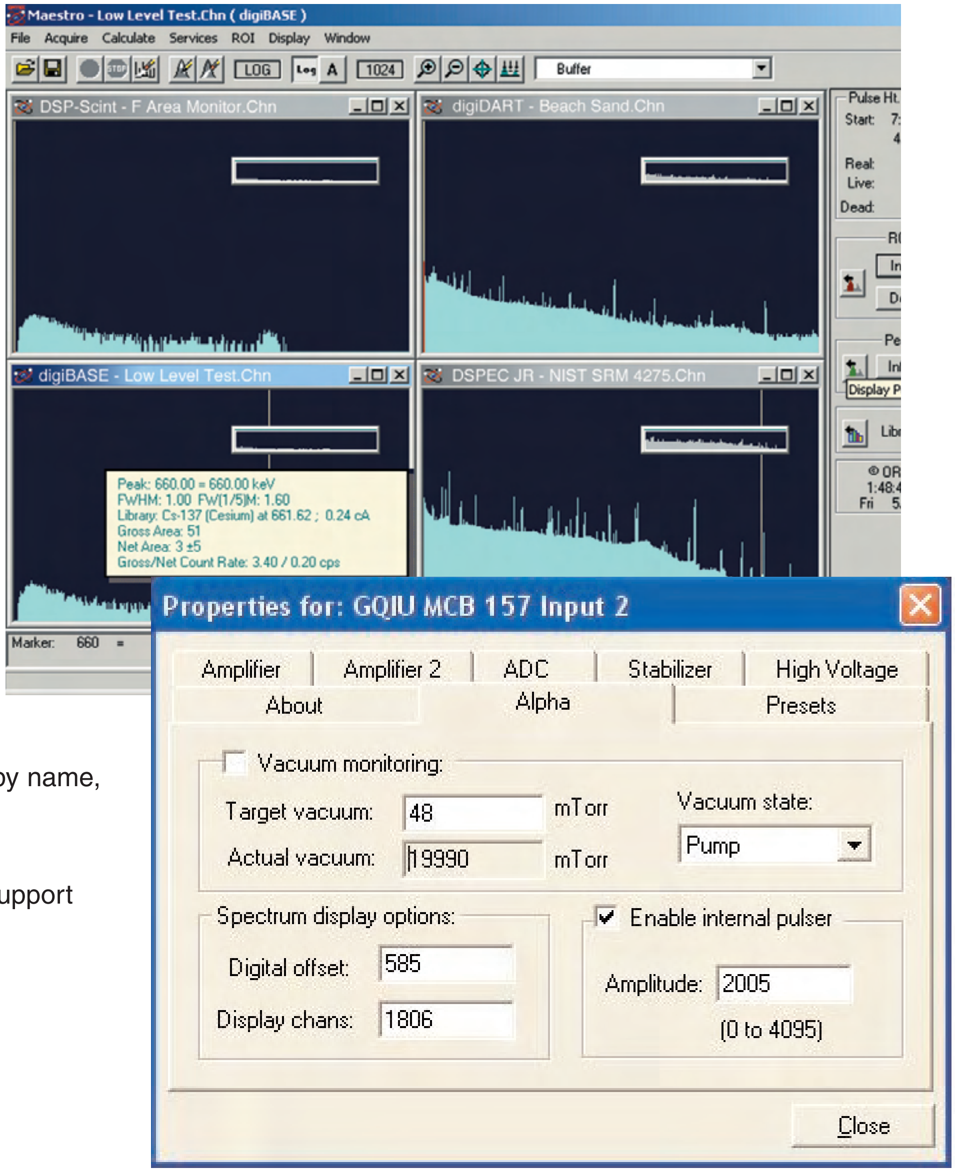
With the addition of a vacuum pump (and NIM Bin in the case of the Alpha Aria) all you need do is hook the spectrometer to your PC with a USB cable. The MAESTRO-32 MCA emulation software is included with all members of the Alpha Suite.

MAESTRO-32 utilizes the Windows 2000/XP Professional or VISTA operating systems, dialog protocols using the latest Windows standards, and on-online and context-sensitive help. MAESTRO-32 uses the common Windows Explorer dialogs for importing and exporting files. No advanced training or programming skills are required.

MAESTRO-32 is a CONNECTIONS-32 product, providing advanced connectivity features within the Windows Network environment.

MAESTRO-32 features include:

- MCA Emulation for Alpha Suite and other ORTEC MCA hardware
- Multi-Detector Interface
- Seamless Networking for Remote Detectors Systems
- Secure Data with Personal Password Protection
- Advance Peak Analysis features
- Complete Interactive Control of all MCB Hardware features, including Alpha Duo and Alpha Ensemble vacuum controls
- Mariscotti fast peak search, with nuclide identification by library lookup
- Activity, net and gross areas (with uncertainty), centroid and shape for peaks
- Data protection with "detector locking" by name, not by workstation
- Comprehensive JOB STREAMING
- Integrated Local Area Network (LAN) support



AlphaVision-32 Quantitative Analysis Software (option, brochure on request)

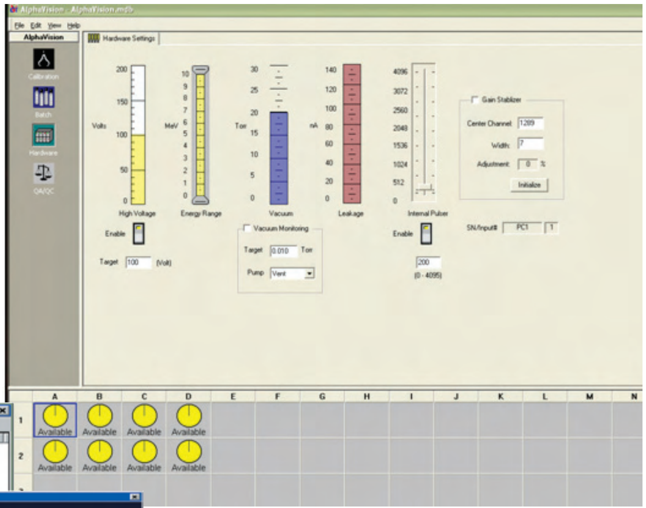
AlphaVision-32 is the ORTEC data management and analysis software for alpha spectroscopy in the "production environment". The design of such a solution requires that it be as easy as possible to make the "same" analysis over and over with replicate samples, but with built-in flexibility for a wide variety of sample types. AlphaVision-32 incorporates flexibility in analysis methods and reporting formats, industry standard data structures and connectivity to LIMS systems, as well as the ability to control multiple (up to 256) detector systems from a single screen operating in the Windows 2000/XP environment.

While the flexibility of AlphaVision-32 is immense, a set-and-forget design philosophy means that this flexibility is not a hindrance to simple routine operation. According to current Windows convention, the analysis processes are easily customized using a batch "wizard". Once this has been done, analysis sequences are initiated at the click of a mouse.

Complete Sample Management

Key AlphaVision-32 features include:

- Powerful detector control and status for up to 256 detectors on a single display
- Intuitive "point and click" operations for all features; familiar Windows menu and command operations
- "Set and Forget" analysis setups for reliable, consistent analyses
- Dynamic detector, chamber, calibration, and process QA monitoring
- Integrated online help with built-in searchable index
- Flexible reporting capability through Access and Seagate Crystal Reports®
- Unique count-to-MDA preset capability
- Mutiple dilution options:
    - Add tracer to whole sample; analyze whole sample
    - Add tracer to whole sample; analyze aliquot
    - Add tracer to whole sample and make up to 2 dilutions
    - Add tracer to aliquot and analyze aliquot



Alpha Suite Hardware Specifications Common to All Models

VACUUM CHAMBER

Cast brass, nickel-plated for ease of decontamination. Each chamber is supplied with one ENS-ST-1 sample tray, others may be ordered as accessories.

Maximum Sample Size: 51 mm (2.030 in.).

Maximum Sample-to-Detector Spacing: 44 mm, in increments of 4 mm.

Maximum Detector Size: 1200 mm^2.

High-Performance O-Ring Seal: Spare package of 10 seals (ORTEC part OCT-CG) included.

Detector Connector Type: Rear Microdot (ORTEC B mount).

Vacuum Manifold Connector: 0.25” Swagelock tube fitting for Alpha Aria and Alpha Duo, NW25 for Alpha Ensemble.

Vacuum Pump Requirements: Rotary vacuum pump, 6.7 CFM (190 L/min) displacement, with oil mist trap. The ORTEC ALPHA-PPS-115 (or -230) is available for this application.

SYSTEM PERFORMANCE

Based on use with a BU-017-450-100 ULTRA™ Series detector with a good-quality ^{241}Am point source.

Energy Resolution: ≤20 keV (FWHM) with a detector-to-source spacing equal to the detector diameter.

Detector Efficiency: ≥25% is achievable with close detector-to-source spacing.

Background: Above 3 MeV, ≤1 count/hour based on a BU-020-450-AS detector.

ELECTRONICS PERFORMANCE

Bias Supply

Range: 0 ±100 V, 10 µA; voltage can be read by the computer.

Bias: Computer controlled, adjustable in 1 V increments.

Pos/Neg: Polarity can be selected independently with PWB slide switches (factory set for positive bias voltage).

Enable/Disable: By computer control.

Indicator: Front-panel, red LED for each channel shows if the bias is on.

Calibration Pulser

Range: 0 to 10 MeV.

Pulser: Computer controls the internal pulser amplitude with 12 bit (2.5 keV) level settings; set to a nominal 7-MeV pulse when shipped.

Amplitude Drift: <50 ppm/°C.

Long Term Drift: <0.005% of full scale / 24 hours at constant temperature.

ON/OFF: Computer controlled.

Indicator: Front-panel, BIAS red LED flashes when pulser is on.

Detector Current Monitor

Range: 0 to 10,000 nA; read by computer.

Display Resolution: 3 nA.

Preamplifier

Shaping: 1 µs unipolar, dc restored.

Pos/Neg: Polarity can be selected independently with PWB slide switches.

Digital MCA

Conversion Gain: Software-selectable as 256, 512, 1024, 2048, or 4096, independent for each segment.

Fine Gain: Software-selectable range from 0.25 to 1.

Digital Offset: Software-selectable range from 0 to conversion gain setting (4096 max) in 1 channel increments.

Display Channels: Software-selectable range from 0 to (conversion gain – digital offset).

Conversion Time Per Event: <2 µs dead time.

Gain Instability: ≤150 ppm/°C.

Digital Spectrum Stabilizer: Controlled via computer.

Dead-Time Correction: Extended live-time correction according to the Gedcke-Hale method.

Software Controls

ADC LLD: Computer controlled from 0 to 100% full scale.

ADC ULD: Computer controlled from 0 to 100% full scale.

Indicators (front panel)

ADC BUSY: Red LED flashes once for each digitized pulse.

Presets

Real Time/Live Time: Multiples of 20 ms.

Region of Interest: Peak count/Integral count.

Data Overflow: Terminates acquisition when any channel exceeds 231^{-1}.

Interface Connectors

USB 2.0 Rear panel standard “B” type USB connector.

COMPUTER PREREQUISITES

Any computer capable of running any of the following operating systems: Windows 2000/XP or VISTA.

Model Specific Hardware Specifications

Alpha Aria

A single alpha spectroscopy channel in a NIM chassis. Each unit includes a variable detector bias supply (switchable positive or negative), a preamplifier, and a test pulse generator with variable amplitude.

Vacuum Control: 3-position Pump/Vent/Hold valve, front-panel mounted.

Recoil Protection (RCAP) option: Includes biased sample holder and Granville-Philips gauge with solenoid vacuum controller.

ELECTRICAL AND MECHANICAL

Dimensions: 2.7 in. W x 11.9 in. D x 8.7 in. H in a double-wide NIM chassis.

Net Weight: 1.9 kg (4.2 lb).

Shipping Weight: 2.3 kg (7.3 lb).

Power Input: NIM power. +6 V @ 315 mA, +12 V @ 50 mA, –12 V @ 75 mA, +24 V @ 50 mA.

Power Consumption: 5 W input power.

Operating Environment: 0° to 50°C. Up to 95% relative humidity, non-condensing.

Alpha Duo

Benchtop dual alpha spectrometer with two alpha spectroscopy channels. Each unit includes a vacuum gauge, variable detector bias supply (switchable positive or negative), preamplifier, test pulse generator with variable amplitude, and a leakage current monitor.

Vacuum Control: Via computer for each Alpha Duo module.

Vacuum Gauge Range: 10 mTorr to 20 Torr, read by computer.

Recoil Protection (RCAP): Built-in pressure controller, requires addition of optional biased sample holders only.

RCAP Contoller Range: 10 mTorr to 20 Torr, read by computer. Regulation Target Pressure ±10%

ELECTRICAL AND MECHANICAL

Dimensions: 10.1 in. W x 14.4 in. D x 6.0 in. H enclosure.

Net Weight: 3.9 kg (8.5 lb).

Shipping Weight: 5.0 kg (11.0 lb).

Power Input: 120/240 V ac, 50/60 Hz.

Power Consumption: 10 W input power.

Operating Environment: 0° to 50°C. Up to 95% relative humidity, non-condensing.

Alpha Ensemble

A modular alpha spectroscopy system with configurations of 2, 4, 6, or 8 total chambers. Each alpha spectroscopy module includes a vacuum gauge, variable detector bias supply (switchable positive or negative), preamplifier, test pulse generator with variable amplitude, self-controlled RCAP, and a leakage current monitor. Configurations of less than 8 can be expanded through the use of ALPHA-DUO-M1 dual modules. Each Alpha Duo dual module has a separate vacuum control within an Alpha Ensemble configuration.

The Alpha Ensemble may be either rack mounted or left in the table-top mounting enclosure in which it is supplied.

Vacuum Control: Via computer for each dual module installed.

Vacuum Gauge Range: 10 mTorr to 20 Torr, read by computer.

Recoil Protection (RCAP): Built-in pressure controller, requires addition of optional biased sample holders only.

RCAP Contoller Range: 10 mTorr to 20 Torr, read by computer. Regulation Target Pressure ±10%.

ELECTRICAL AND MECHANICAL

Dimensions: 19.0 in. W x 19.4 in. D x 10.7 in. H enclosure.

Net Weight (with 8 complete chambers): 26.6 kg (58.4 lb).

Shipping Weight (with 8 complete chambers): 29.5 kg (65.0 lb).

Power Input: 120/240 V ac, 50/60 Hz.

Power Consumption: 50 W input power.

Operating Environment: 0° to 50°C. Up to 95% relative humidity, non-condensing.

Each instrument is supplied with a full set of blank panels a needed to cover unoccupied expansion space.

Ordering Information: How to order your Alpha Suite product.

Step 1. Choose one or more Alpha Spectrometers. Each spectrometer includes one ENS-ST-1 sample tray per chamber. More may be ordered from the accessories list below.

Model	Description
ALPHA-ARIA	Single input NIM spectrometer. Includes MAESTRO-32 MCA Emulation Software.
ALPHA-DUO	Dual input benchtop spectrometer. Includes one each of all four sample trays, package of 10 chamber door o-rings, MAESTRO-32 MCA Emulation Software, and USB cable.
ALPHA-ENSEMBLE-2	2 input benchtop spectrometer, expandable to 8 inputs. Includes one each of all four sample trays, package of 10 chamber door o-rings, MAESTRO-32 MCA Emulation Software, and USB cable.
ALPHA-ENSEMBLE-4	4 input benchtop spectrometer, expandable to 8 inputs. Includes one each of all four sample trays, package of 10 chamber door o-rings, MAESTRO-32 MCA Emulation Software, and USB cable.
ALPHA-ENSEMBLE-6	6 input benchtop spectrometer, expandable to 8 inputs. Includes one each of all four sample trays, package of 10 chamber door o-rings, MAESTRO-32 MCA Emulation Software, and USB cable.
ALPHA-ENSEMBLE-8	8 input benchtop spectrometer. Includes one each of all four sample trays, package of 10 chamber door o-rings, MAESTRO-32 MCA Emulation Software, and USB cable.

Step 2. For each spectrometer chosen, specify type and quantity of detectors from the list below:

ENS-U300	300 mm^2 low-background ULTRA-AS detector for Alpha Suite spectrometer, installed and system tested. Order BU-019-300-AS for uninstalled detectors).
ENS-U450	450 mm^2 low-background ULTRA-AS detector for Alpha Suite spectrometer, installed and system tested. Order BU-020-450-AS for uninstalled detectors).
ENS-U490	490 mm^2 low-background ULTRA-AS detector for Alpha Suite spectrometer, installed and system tested. Order BU-020-490-AS for uninstalled detectors).
ENS-U600	600 mm^2 low-background ULTRA-AS detector for Alpha Suite spectrometer, installed and system tested. Order BU-024-600-AS for uninstalled detectors).
ENS-U900	900 mm^2 low-background ULTRA-AS detector for Alpha Suite spectrometer, installed and system tested. Order BU-029-900-AS for uninstalled detectors).
ENS-U1200	1200 mm^2 low-background ULTRA-AS detector for Alpha Suite spectrometer, installed and system tested. Order BU-037-1200-AS for uninstalled detectors).
ENS-R300	300 mm^2 low-background Ruggedised detector for Alpha Suite spectrometer, installed and system tested. Order BR-SNA-300-100 for uninstalled detectors).
ENS-R450	450 mm^2 low-background Ruggedised detector for Alpha Suite spectrometer, installed and system tested. Order BR-SNA-450-100 for uninstalled detectors).
ENS-R600	600 mm^2 low-background Ruggedised detector for Alpha Suite spectrometer, installed and system tested. Order BR-SNA-600-100 for uninstalled detectors).
ENS-R900	900 mm^2 low-background Ruggedised detector for Alpha Suite spectrometer, installed and system tested. Order BR-SNA-900-100 for uninstalled detectors).

STEP 3. Specify options and accessories if needed:

ALPHA-PPS-115	Portable Pump Station, 115 V.
ALPHA-PPS-230	Portable Pump Station, 230 V.
ENS-ST-1	Sample Tray, fits 3/4 and 1 inch samples.
ENS-ST-2	Sample Tray, fits 1/2 and 7/8 inch samples.
ENS-ST-3	Sample Tray, fits 1.25 and 1.5 inch samples.
ENS-ST-4	Sample Tray, fits 1.75 and 2 inch samples.
ENS-ST-KK	Set of Sample Trays, one each of all four (1/2 through 2 inch).
ENS-CG	Chamber Door O-Rings, package of 10.
ENS-RACKMOUNT	19” Rackmount Kit installed onto Ensemble.
RCAP-ST	Biased Sample tray assembly for recoil protection use. (One per chamber required.)
A36-B32	AlphaVision-32 Alpha Analysis Software (primary single use license).
A36-N32	AlphaVision-32 Network Copy (for networked systems in addition to the first).

How to order EXPANSION Modules for Alpha Ensemble:

Step 1. Choose one or more Dual Alpha Ensemble Expansion Modules (max 8 chambers per Alpha Ensemble chassis):

ALPHA-DUO-M1	Dual input Alpha Ensemble expansion spectrometer.

Step 2. Choose suitable options and accessories as described above.

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PROFILE Coaxial HPGe Photon Detector
Product Configuration Guide

- **"Application-Matched" P-type HPGe Detectors, optimized for specific sample types, gamma energy ranges and measurement geometries.**
- **Know how your new HPGe detector will perform before you buy it!**
- **Best absolute efficiency for the given IEEE standard relative efficiency in your counting geometry.**
- **Warranted Crystal Dimensions ensure measurement performance.**
- **Reproducible dimensions mean reproducible performance. . . no surprises.**
- **Full range of PopTop Cryostats and options.**

PROFILE GEM detectors are a first in germanium detectors; a range of detectors from which you can choose the best solution for your application from specified crystal dimensions. Nominal relative efficiency specifications are provided in order to help relate relative efficiency to terms of crystal dimensions. The resolution is measured according to the IEEE standard. If a particular PROFILE series detector is available from the ORTEC detector stocklist, then the ACTUAL MEASURED specifications may be inspected before purchase.

F-Series PROFILE GEM Detectors

F-Series PROFILE detectors employ "over-square" (diameter > length) coaxial structures. For a given relative (IEEE) efficiency, the F-Series represents the "best use" of the germanium material in terms of producing the maximum absolute counting efficiency for on-endcap or "close geometry" extended samples, such as:

- Point sources on-endcap
- Filter Paper Samples on-endcap
- Samples presented in bottles and pots on-endcap
- Bio-Assay applications (e.g., lung monitoring)
- Waste Drum monitoring

In addition, the over-square geometry helps improve low-energy resolution by reduced crystal capacitance.

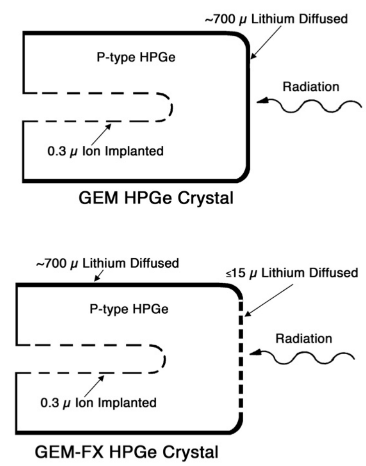


Figure 1. P-type HPGe crystal geometries.

FX-Series PROFILE GEM Detectors

- All the advantages of the F-Series PROFILE detector with an ULTRA-thin Entrance Window.
- Excellent warranted performance specifications

FX-Series PROFILE GEM detectors employ a proprietary thin entrance window in order to improve low energy efficiency. The FX-series can extend the useful energy range down to 10 keV and below, which maintains the excellent peak shape and resolution characteristics of the PROFILE series.

Figure 2 shows absolute efficiency curves for a 70 mm diameter x 15 mm length source on endcap for an 85 mm diameter GEM-FX8530, compared to a GEM80 76 mm diameter x 87 mm length.[1] Note the much higher absolute efficiency of the FX85 at all energies below 160 keV. At 59 keV, the FX is SIX times more efficient, and below that the efficiency of the GEM80 falls off due to the thick (~700 µm) contact. The FX detector has an ultra thin contact (~10 µm Ge) allowing good transmission at 22 keV and below.

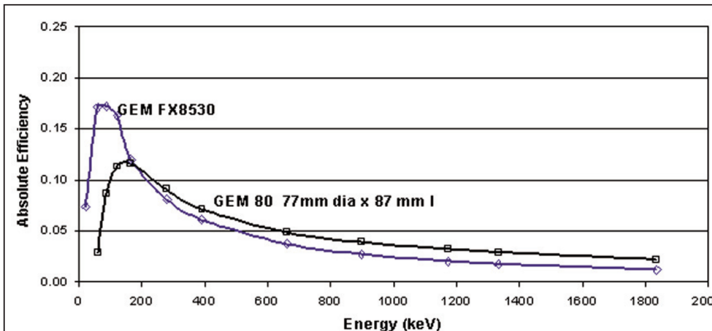


Figure 2. Absolute Efficiency vs. Energy for a 15 mm thick x 70 mm dia. disk on endcap, FX85 and 80% coax compared.

Figure 3 shows similar spectra from the three detectors compared, in the energy range up to ~130 keV. The spectra are taken from a mixed isotope calibration source. In all cases, the cursor is centered on the 59 keV ^{241}Am peak. To the right is the 88 keV peak from ^{109}Cd. In both the GEM-FX and the GMX, the thin entrance window clearly transmits the low-energy gammas in the 22–24 keV region. These peaks are entirely absent from the spectrum of the GEM80, even though the 88 keV is visible.

[1]Data taken from "The Evaluation of True Coincidence Summing Effect on CTBTO-Type Sample Geometry," R.M. Keyser, ORTEC. Presented at IEEE Nuclear Science Symposium, Portland, Oregon, October 19–25, 2003.

PROFILE Coaxial HPGe Photon Detector Product Configuration Guide

General Guidelines for Choosing an F-Series or FX-Series PROFILE GEM Detector

For a close or on-endcap sample, the detector diameter should ideally exceed the sample diameter by 20% or more. Beyond 30% the gain in efficiency is small. Another point, often missed, is if the detector diameter exceeds the sample diameter by 20% or more, then any errors due to irreproducibility of sample position will be minimal.

When budget limits are considered, first select the largest diameter up to the optimum diameter, then specify a deeper detector to further increase the absolute efficiency, specifically at higher energies. For samples to be counted in geometries similar to those listed above, choose an F-Series PROFILE detector with a diameter 20% (or more) larger than the sample to ensure the highest absolute efficiency for a given relative (IEEE) efficiency. Over-square detectors can often achieve better low-energy resolution than longer, smaller diameter detectors of the same relative efficiency.

M-Series PROFILE GEM Detectors

The M-Series detectors are designed specifically to provide optimum geometry for use with Marinelli beakers. These are made with the endcap diameter "filled with crystal" and the length slightly longer than the diameter, which maximizes the overall absolute efficiency for a Marinelli beaker. This is the most common beaker where the well diameter is equal to its length.

General Guidelines for Choosing an M-Series PROFILE GEM Detector

Choosing the optimum M-Series detector for use with a specific Marinelli beaker could not be easier: simply choose the detector with the tightest fit inside the Marinelli beaker well!

An F-Series detector may be used in a Marinelli geometry, but will have a lower efficiency than an M-Series of the same diameter. Correspondingly, an M-Series detector may be used as a substitute for an F-Series in an on-endcap type of geometry. For the same diameter, the M-Series will give slightly higher efficiency (improvement increasing with increasing energy).

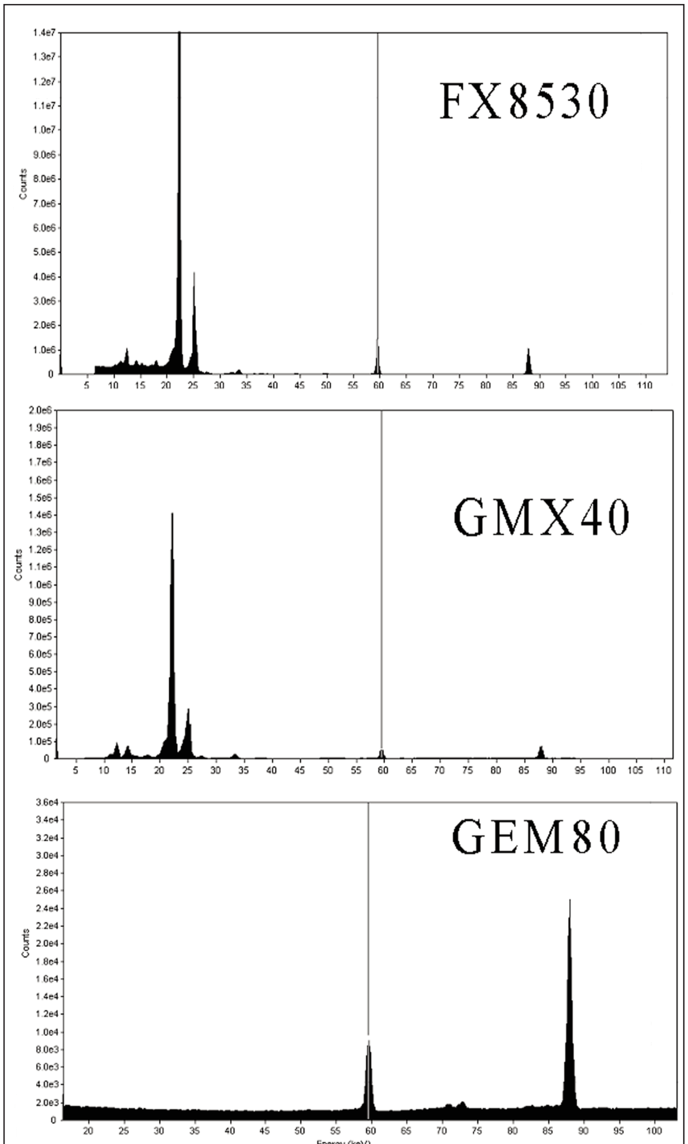


Figure 3. Three Detectors Compared.

Overall Guidelines on the Choice of PROFILE Series GEM

Source Energy	Marinelli Beaker Sources	Near Point Sources	Far Point Sources	Small Extended Sources	Large Extended Sources*
5 to 200	N/A	LO-AX	LO-AX	LO-AX	LO-AX
10 to 1500	GMX	PROFILE FX	PROFILE FX	PROFILE FX	PROFILE FX
10 to 3000	GMX	GMX	GMX	GMX	GMX
50 to 200	PROFILE M	PROFILE F	PROFILE F	PROFILE F	PROFILE F
200 to 1500	PROFILE M	PROFILE F	PROFILE F	PROFILE F	PROFILE F
1500 to 3000	PROFILE M	PROFILE M	PROFILE M	PROFILE M	PROFILE M
above 3000	GEM	GEM	GEM	GEM	GEM

*For extended sources; including filters, bottles, and Petri dishes, the detector diameter should be ≥1.2 x sample diameter for best results.

If high-energy emitters dominate when the nuclides of primary interest are at lower energies, the higher peak to compton ratio of a deeper detector may result in improved detection limits for the lower energy emitters.

The Following Specifications are Provided for Each PROFILE Series Detector

- Energy resolution at 1.33-MeV photons from ^{60}Co at optimum shaping time.
- Active dimensions.
- Nominal values for relative efficiency are given (not a specification).
- Peak-to-Compton ratio for ^{60}Co 1.33-MeV peak.
- Nominal values for peak shape ratio for the full-width tenth-maximum to the full-width half-maximum for ^{60}Co 1.33-MeV peak are given (not a specification).
- Energy resolution at 122-keV photons from ^{57}Co at optimum shaping time for the GEM-F and GEM-M.
- Energy resolution at 122-keV photons and 14.4-keV photons from ^{57}Co at optimum shaping time for the GEM-FX.
- Energy resolution at 46-keV photons from ^{210}Pb at optimum shaping time for the GEM-FX.

Configuration Guidelines

PopTop or Streamline (non-PopTop) Configuration

The essence of a PopTop detector system is that the HPGe detector element cryostat, preamplifier, and high voltage filter are housed in a detector "capsule" which is then attached to an appropriate cryostat (Figure 4.)

In so called Streamline systems, the detector capsule in NOT demountable. Detector capsule and cryostat share the same vacuum. In configuration terms, this requires a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap. A cryostat must always be ordered with a Streamline capsule, because they are integral.

The actual PopTop capsule has its own vacuum. It can be mounted on any of the available cryostats, cryostat/dewar combinations, or the X-COOLER II mechanical cooling system.

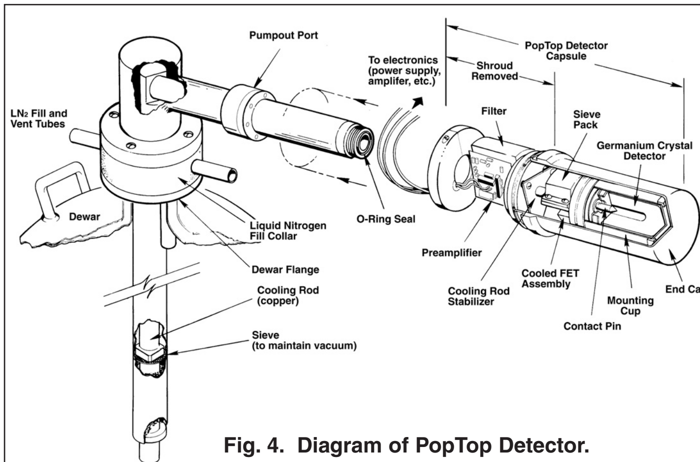


Fig. 4. Diagram of PopTop Detector.

Steps to Configure Your ORTEC HPGe Detector

1) Configure the Detector Model

- Capsule type (PopTop or Streamline)
- Ge Crystal dimensions and specifications
- Endcap and window
- Mount
- Preamplifier
- High Voltage Filter
- Cable Package

Options are available for the detector model that can change specific materials used in the construction of the detector endcap, cup, and mount. Preamplifier options are also available.

2) Configure the Cryostat/Dewar Model

- Vertical Dipstick style (separate Dewar)
- Horizontal Dipstick style (separate Dewar)
- Portable with all-position or multi-position cryostat/dewar models
- Downlooking designed to be oriented with the detector pointing down
- Sidelooking designed to be oriented with the detector horizontal at the bottom of the dewar
- "J" configurations designed with the detector attached near the bottom of the dewar and a right angle bend in the cryostat orienting the detector to look up.

A cryostat and dewar or other cooling device are required for operation.

If a PopTop detector has been selected, you can choose a PopTop style cryostat, cryostat/dewar combination or the X-COOLER II mechanical cooler.

If a Streamline detector has been selected, you must choose a cryostat or cryostat/dewar model for the detector to be mounted on and vacuum sealed. The cryostat or cryostat/dewar combination diameter must match the endcap diameter of the selected detector.

PROFILE Coaxial HPGe Photon Detector Product Configuration Guide

Detector Options

Harsh Environment Option (-HE)

The Harsh Environment option is a rugged carbon fiber endcap with a sealed electronics housing featuring a replaceable desiccant pack which ensures that the electronics stay 100% dry and indicates when it needs to be replaced.

PROFILE series detectors in PopTop capsules of 83 mm diameter or larger can be supplied with this option.

Fig. 5. -HE Detector Option (Carbon Fiber Endcap).

Ultra-High Count-Rate Preamplifier Option (-PL)

The Ultra-High Count-Rate Preamplifier (transistor-reset preamplifier), which can handle input count rates up to 1,000,000 counts/s at 1 MeV, offers the added benefit of having no feedback resistor.

SMART-1 Option (-SMP)

The SMART-1 option monitors and reports on vital system functions, and can save authentication codes and report the code at a later time. It has the high voltage included, so none of the instruments require an external high-voltage power supply.

The SMART-1 is housed in a rugged ABS molded plastic enclosure and is permanently attached to the detector endcap via a molded-strain-relieved sealed cable. This eliminates the possibility that the detector will suffer severe damage from moisture leaking into high-voltage connectors. The SMART-1 can be positioned in any convenient place and does not interfere with shielding or other mounting hardware.

Fig. 6. SMART-1 Detector Interface Module.

Remote Preamplifier Option (-HJ)

This option allows all the preamplifier and high voltage connections to be outside a shield and removes the preamplifier and high voltage filter from the "line-of-sight" to the Ge crystal. For low background applications, this option eliminates any possible preamplifier or high voltage filter components that may add to the background inside a shield.

Low-Background Carbon Fiber Endcap Options (-RB, -LB-C, and -XLB-C)

Carbon Fiber is as strong as Al, Mg, and Cu, creates less background, does not corrode, and can detect energies less than 10 keV.

This lower background material allows for lower Minimum Detectable Activity (MDA) for a specific counting time, which provides another step in increasing sample throughput in low-background counting applications. The lower Z of Carbon Fiber provides a low-energy window without the additional background found in most alloys. See Figures 7 and 8 for transmission characteristics of the Be and carbon fiber windows.

Carbon Fiber, unlike Beryllium, is non-toxic and can be cleaned with most laboratory solvents such as methanol, trichloroethylene, and acetone. Soap and water may also be used. Abrasive cleaners should not be used.

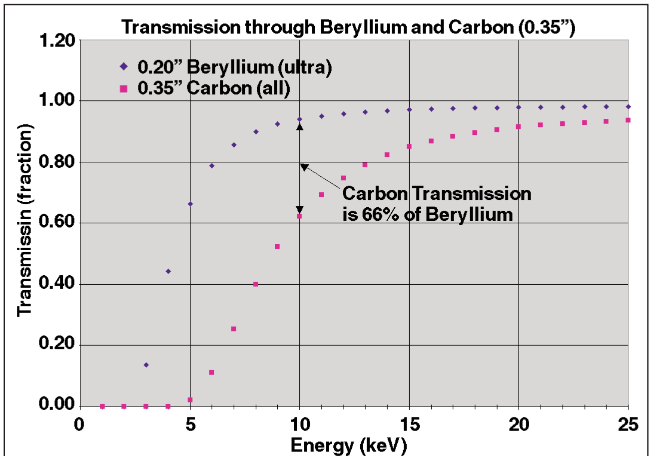


Fig. 7. Transmission through Be and Carbon (.076 mm).

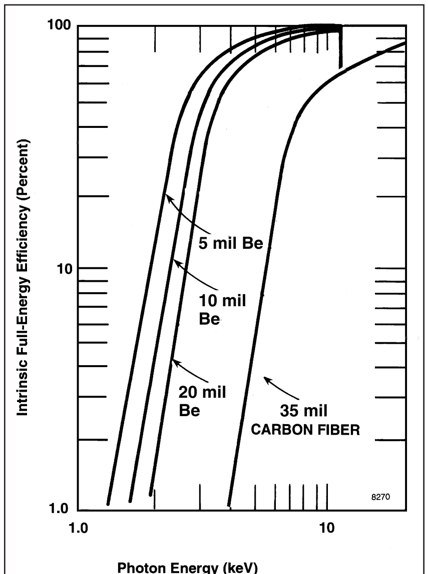


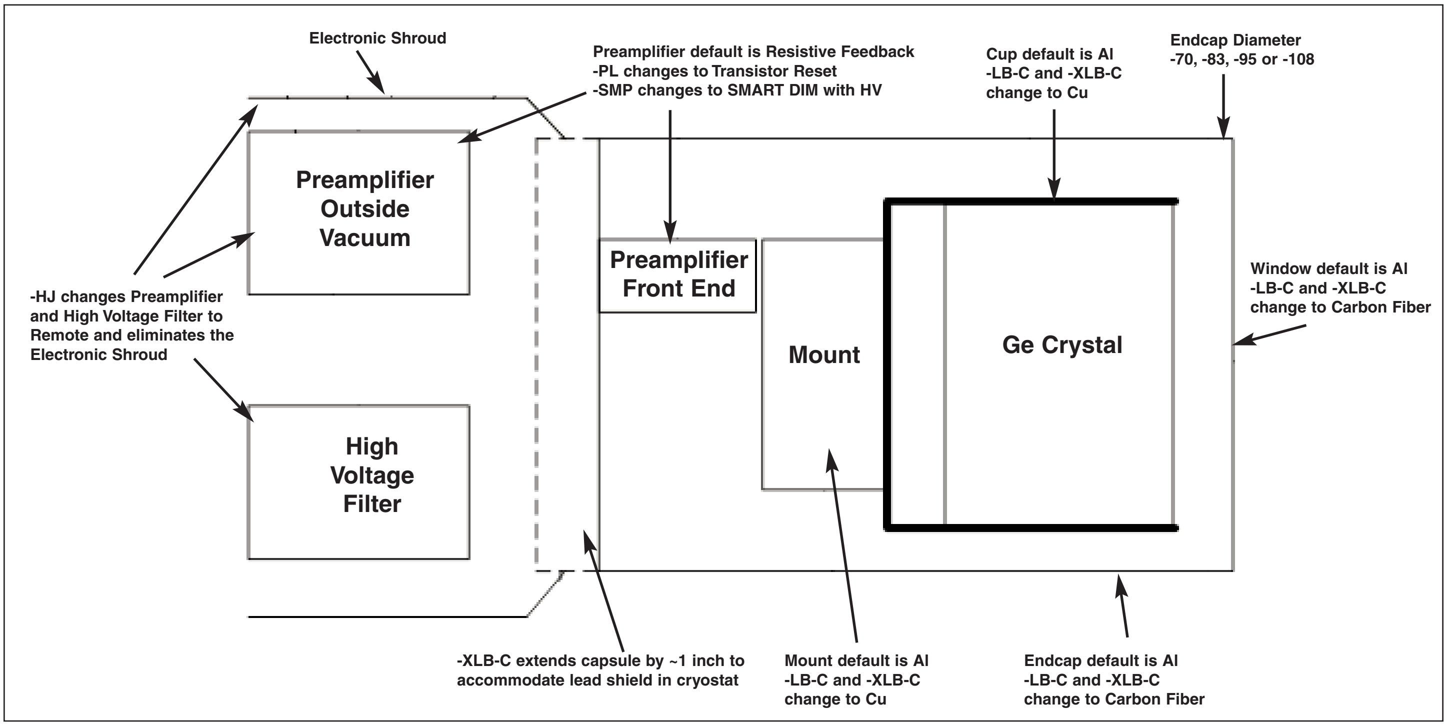
Fig. 8. Low Energy Gamma and X-Ray Transmission of Be and Carbon Fiber Windows.

Defining the Detector Model

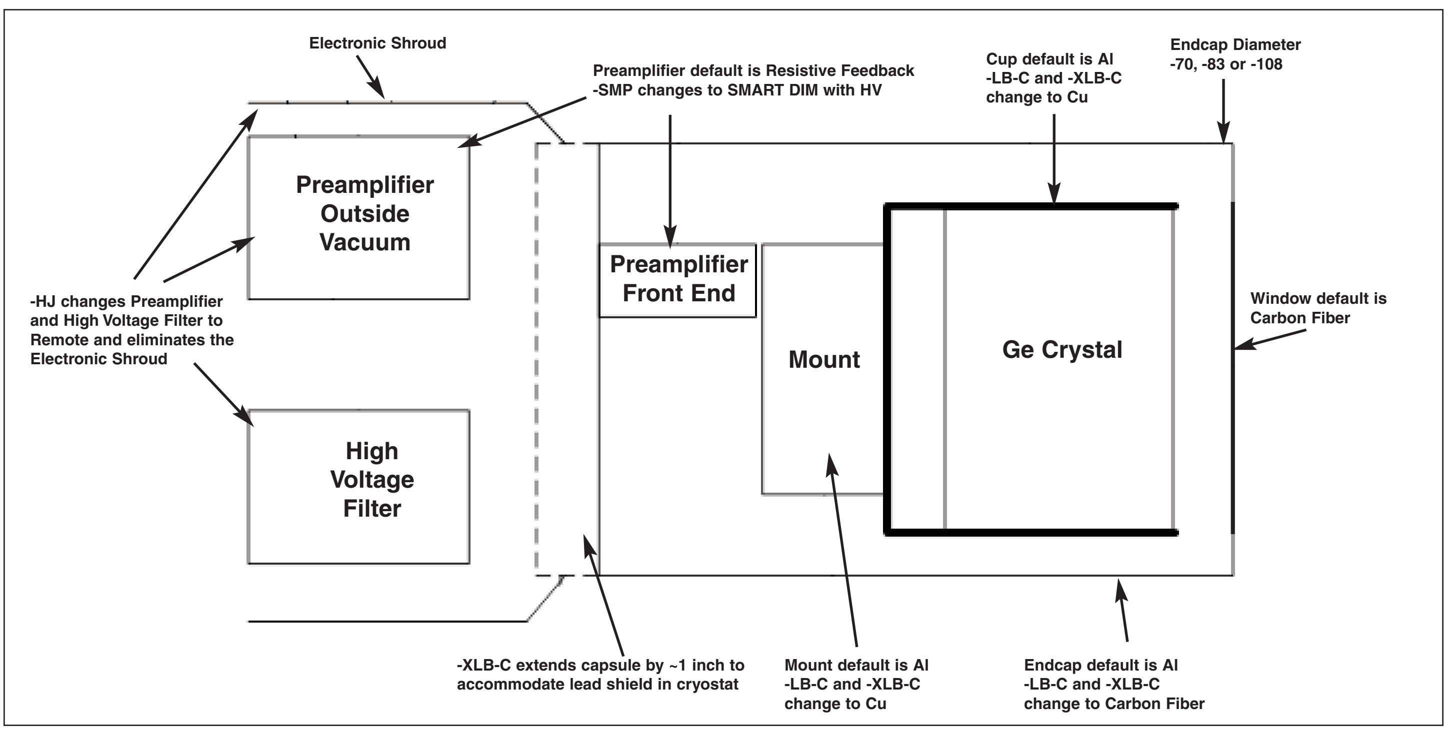
• See ordering information for option compatibility.

Base Model (example)	PopTop or Streamline	Window Option (if required)	Preamplifier Option (if required)	High Voltage Option (if required)
GEM-M5970	P4 (PopTop) (Streamline)	-RB -HE -LB-C -XLB-C	-PL -HJ	-SMP

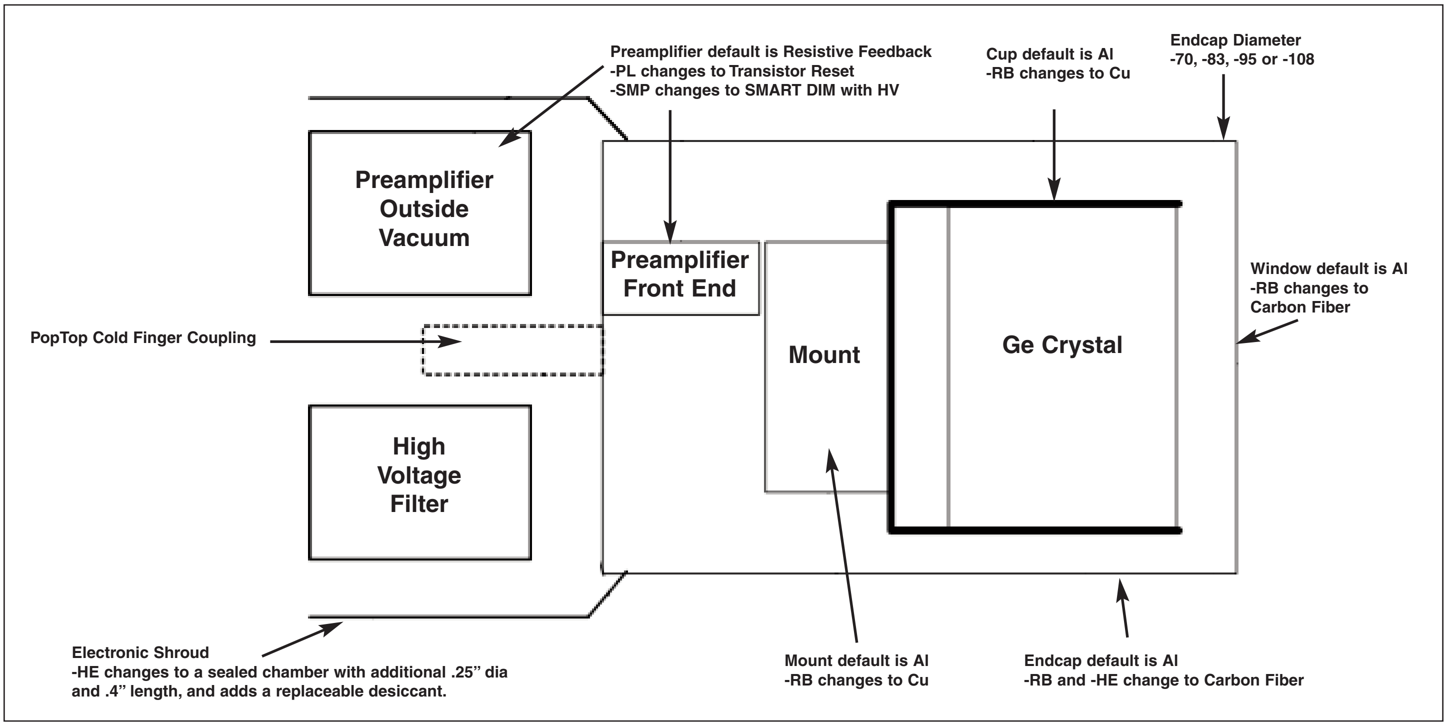
Streamline GEM-F and GEM-M Detector Capsule



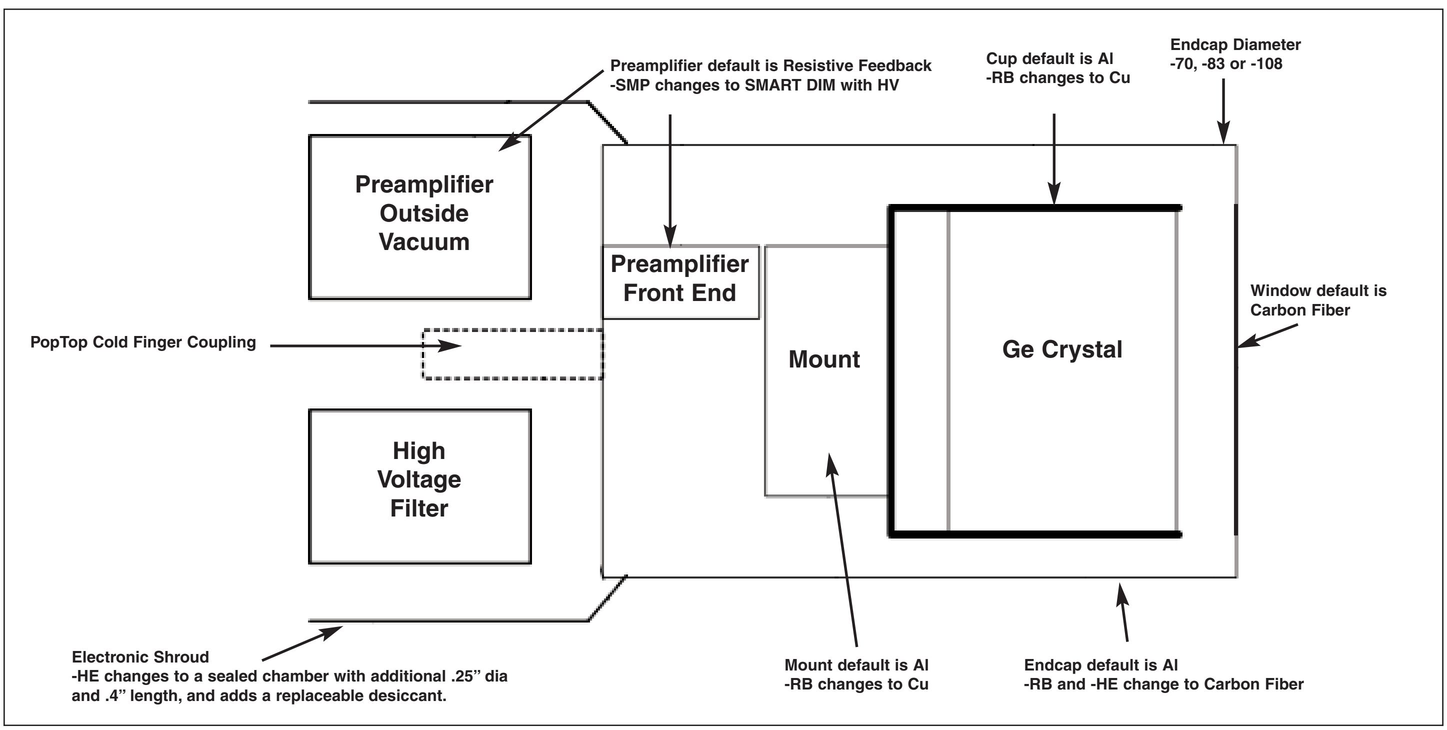
Streamline GEM-FX Detector Capsule



PopTop GEM-M and GEM-F Detector Capsule

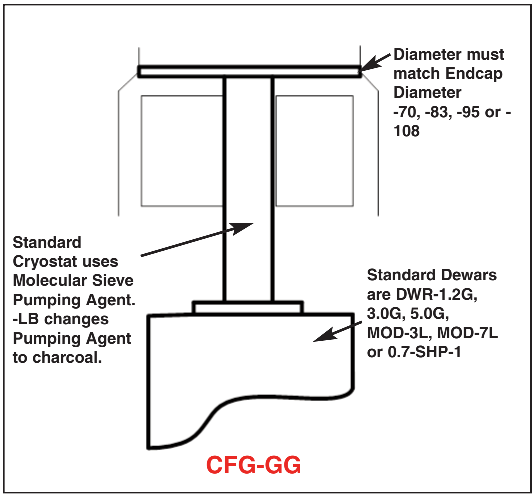


PopTop GEM-FX Detector Capsule

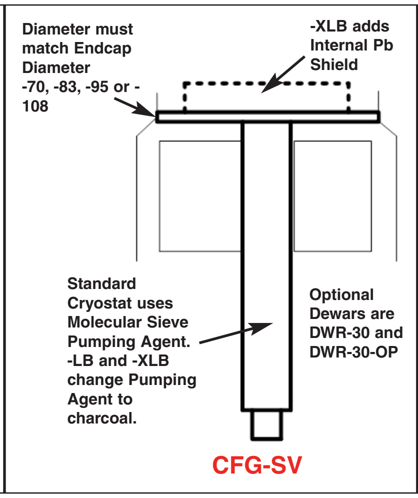


Streamline Cryostat and Cryostat/Dewar Assemblies

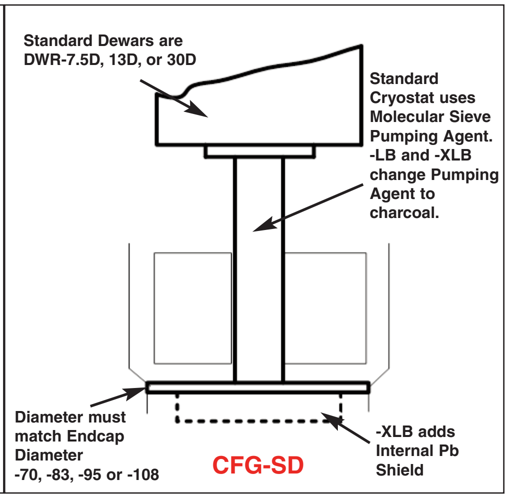
Streamline systems (detector capsule and cryostat) share the same vacuum, requiring a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap.



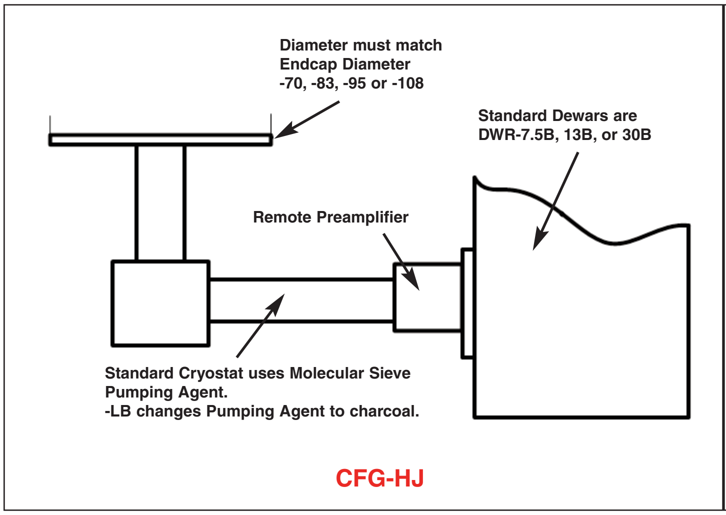
CFG-GG



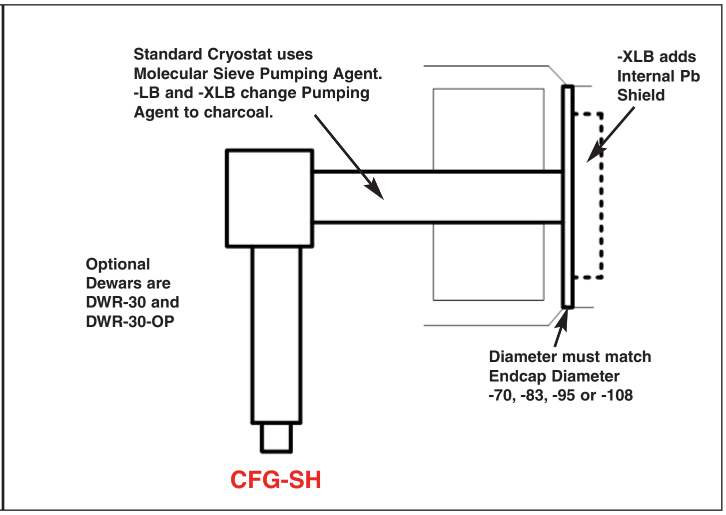
CFG-SV



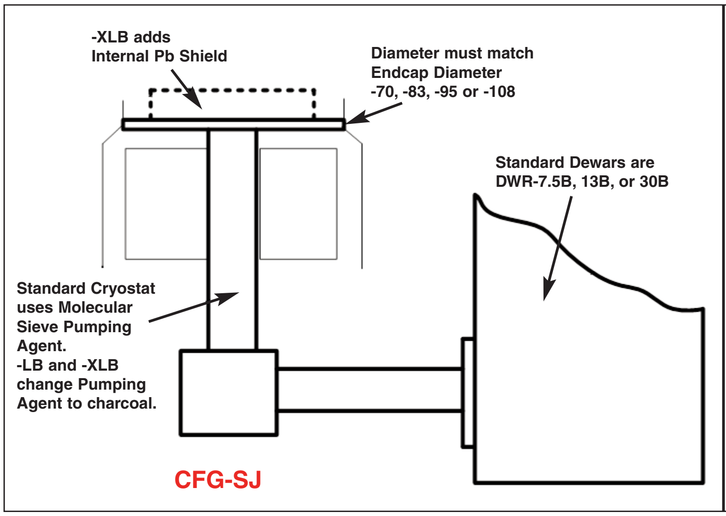
CFG-SD



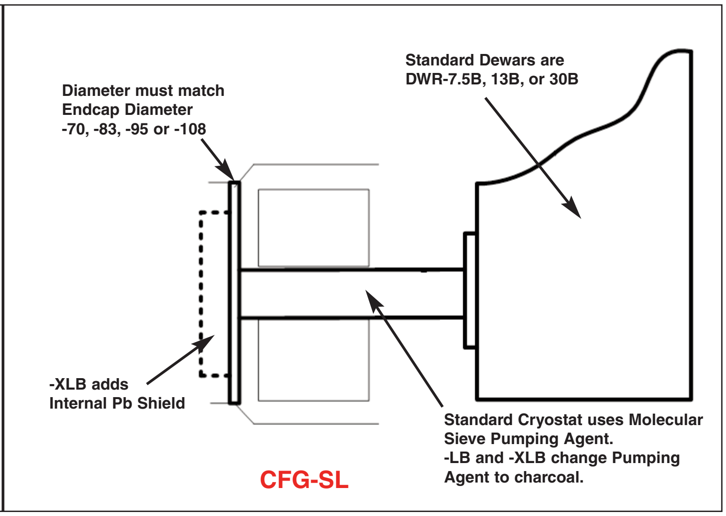
CFG-HJ



CFG-SH



CFG-SJ



CFG-SL

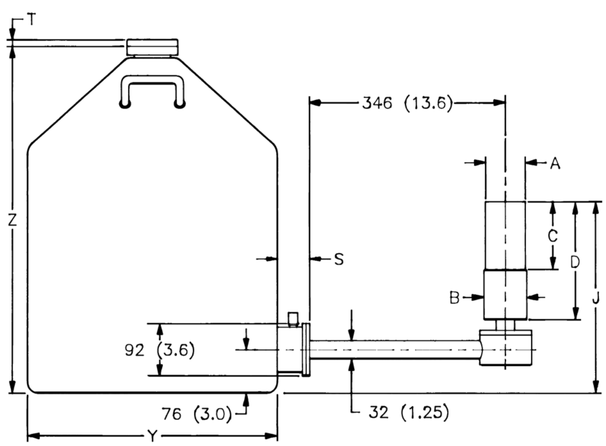
PopTop and Streamline Dimensional Data

Streamline systems (detector capsule and cryostat) share the same vacuum, requiring a cryostat or cryostat/dewar selection with the cryostat having a matching diameter to the capsule endcap. A cryostat must be ordered with a Streamline capsule.

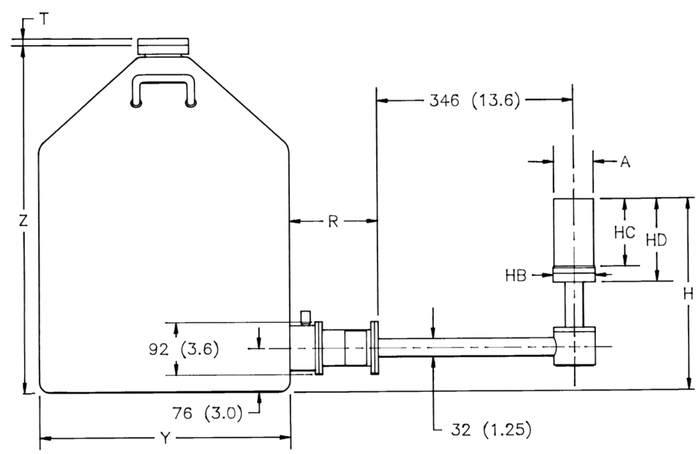
The PopTop capsule contains a vacuum unto itself. It can be mounted on any of the available cryostats, cryostat/dewar combinations, or the X-COOLER II mechanical cooling system.

The cryostat and dewar drawings that follow are to be used in conjunction with the accompanying tables of dimensions.

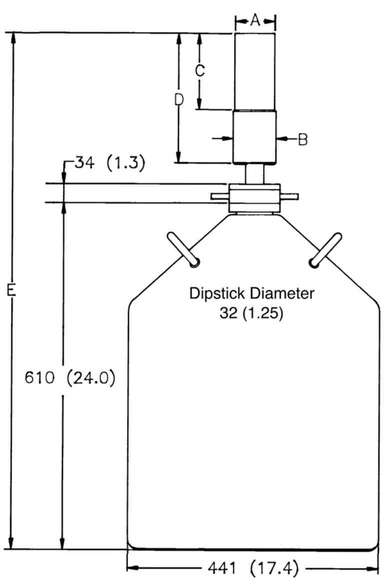
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



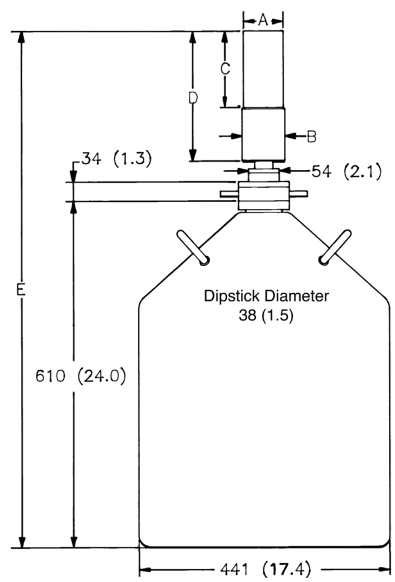
CFG-SJ, DWR-30B (or -13B or -7.5B)



CFG-HJ, DWR-30B (or -13B or -7.5B)

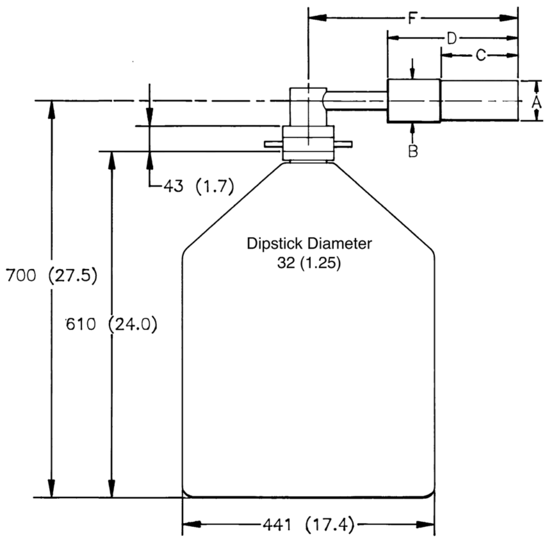


CFG-SV, DWR-30

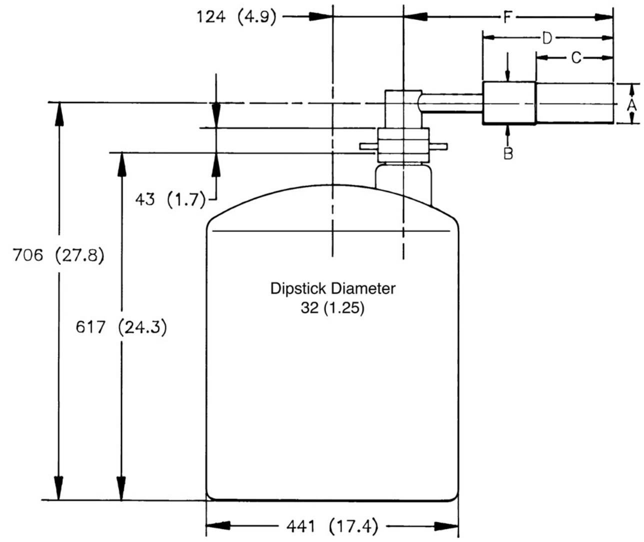


CFG-PV4, DWR-30

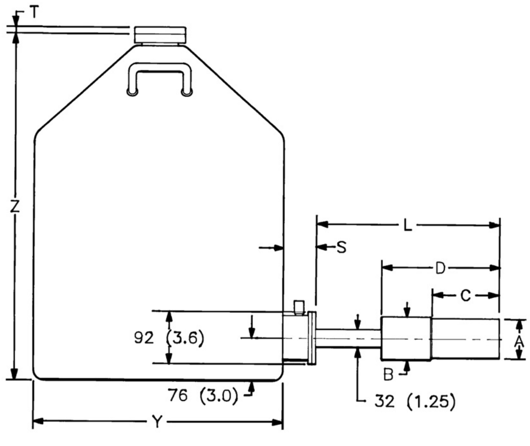
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



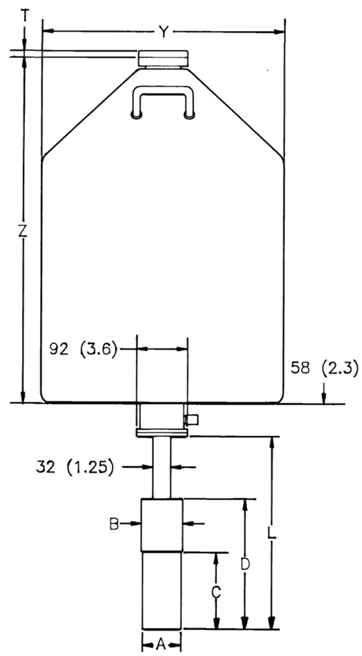
CFG-SH, DWR-30



CFG-SH, DWR-30-OP

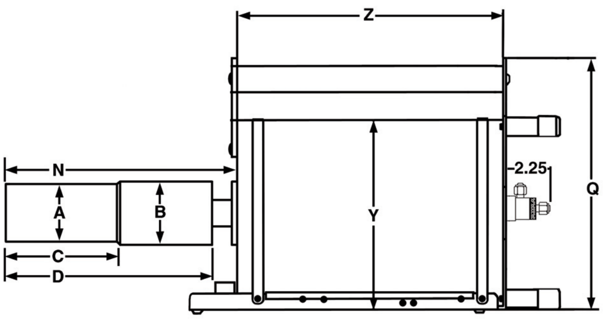


CFG-PS4-30 (or -13 or -7.5)
or
CFG-SL, DWR-30B (or -13B or -7.5B)

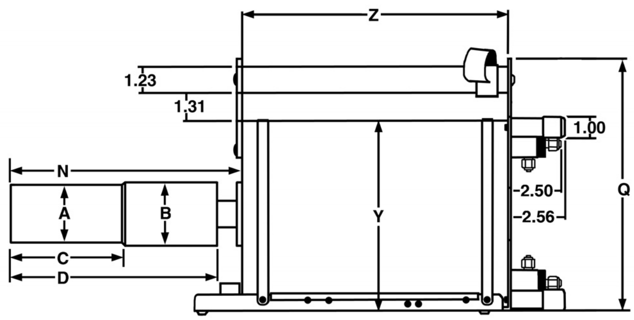


CFG-PD4-30 (or -13 or -7.5)
or
CFG-SD, DWR-30D (or -13D or -7.5D)

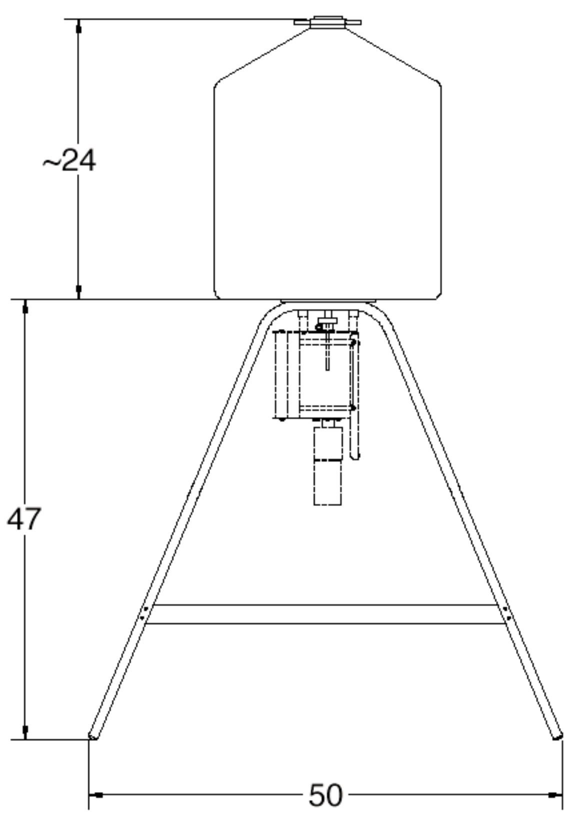
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



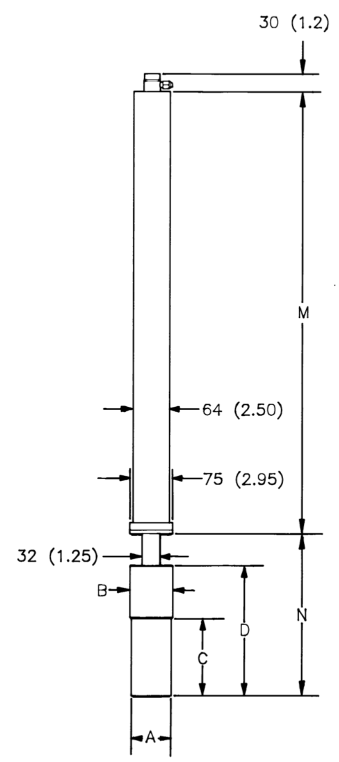
CFG-PG4-1.2 (or -3 or -5)
or
CFG-GG, DWR-1.2G (or -3.0G, -5.0G)



CFG-PMOD4-3 (or -7)
or
CFG-GG, DWR-MOD3L (or -MOD7L)

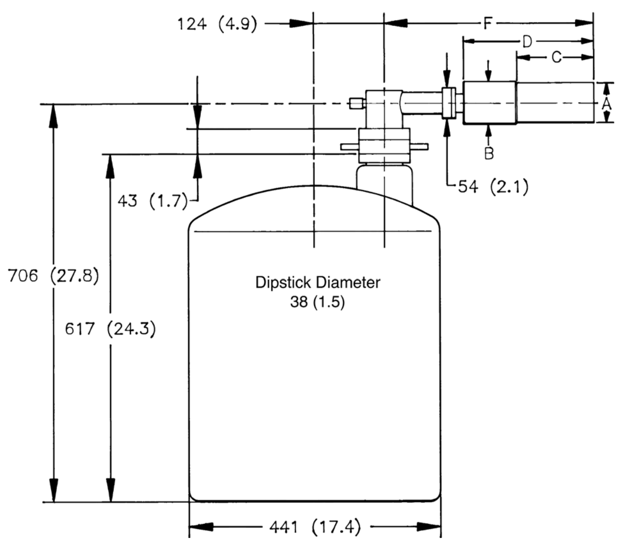


DWR-S/F

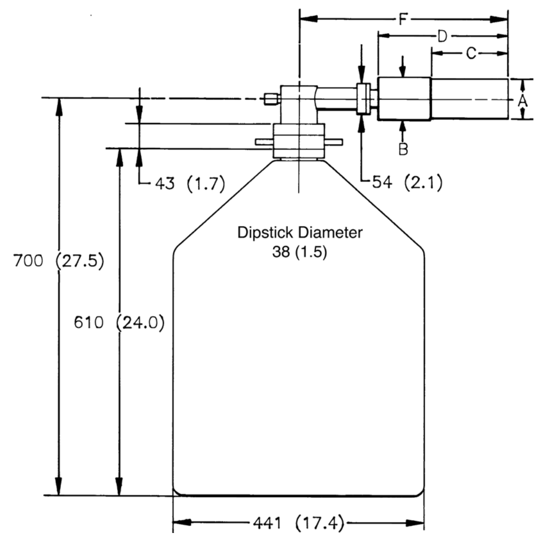


CFG-PSHP4
or
CFG-GG, DWR-0.7-SHP-1

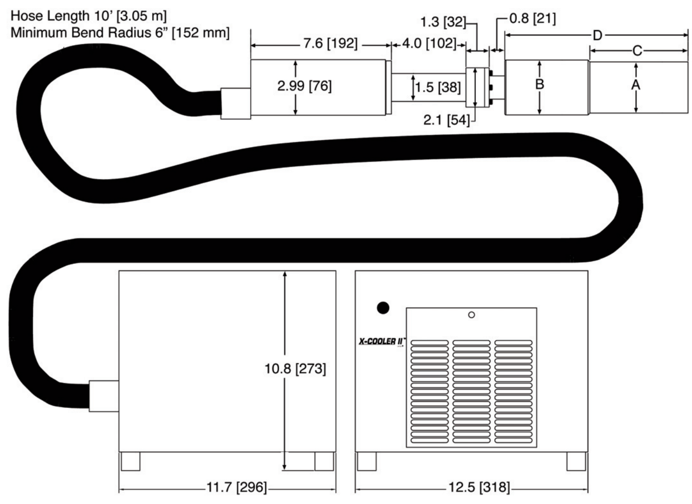
Note: Cryostat/Dewar drawings are NOT to scale, see tables that follow for complete dimensions.



CFG-PH4, DWR-30-OP



CFG-PH4, DWR-30



CFG-X-COOL-II

PopTop PROFILE Series Detector Dimensions

- Dimensions are for reference only and subject to change.
- If dimensional constraints are critical, contact the factory.

Endcap Model (dia. mm)			-70	-83	-95	-108
Dim.	Unit	Tol.				
A	mm (in)	0.3 (0.01)	70 (2.75)	83 (3.25)	95 (3.75)	108 (4.25)
B	mm (in)	0.3 (0.01)	75 (2.95)	88 (3.45)	100 (3.95)	113 (4.45)
C	mm (in)	5 (0.2)	134 (5.3)	168 (6.6)	193 (7.6)	207 (8.2)
D	mm (in)	8 (0.3)	250 (9.8)	282 (11.2)	309 (12.2)	323 (12.7)
E	mm (in)	18 (0.7)	947 (37.3)	982 (38.6)	1007 (39.7)	1019 (40.1)
F	mm (in)	10 (0.4)	396 (15.6)	429 (16.9)	455 (17.9)	469 (18.5)
L	mm (in)	10 (0.4)	338 (13.3)	371 (14.6)	396 (15.6)	412 (16.2)
M	mm (in)	8 (0.3)	790 (31.1)	X X	X X	X X
N	mm (in)	10 (0.4)	278 (10.9)	312 (12.3)	338 (13.3)	348 (13.7)

Streamline PROFILE M and F Series Detector Dimensions

- Dimensions are for reference only and subject to change.
- If dimensional constraints are critical, contact the factory.

			Standard or LB				XLB			
Endcap Model (dia. mm)			-70	-83	-95	-108	-70	-83	-95	-108
Dim.	Unit	Tol.								
A	mm (in)	0.3 (0.01)	70 (2.75)	83 (3.25)	95 (3.75)	108 (4.25)	70 (2.75)	83 (3.25)	95 (3.75)	108 (4.25)
B	mm (in)	0.3 (0.01)	75 (2.95)	88 (3.45)	100 (3.95)	113 (4.45)	75 (2.95)	88 (3.45)	100 (3.95)	113 (4.45)
C	mm (in)	5 (0.2)	134 (5.3)	134 (5.3)	160 (6.3)	197 (7.8)	160 (6.3)	160 (6.3)	185 (7.3)	197 (7.8)
D	mm (in)	8 (0.3)	246 (9.7)	259 (10.2)	284 (11.2)	322 (12.7)	272 (10.7)	284 (11.2)	310 (12.2)	322 (12.7)
E	mm (in)	18 (0.7)	916 (36.1)	932 (36.7)	957 (37.7)	995 (39.2)	941 (37.1)	958 (37.7)	983 (38.7)	995 (39.2)
F	mm (in)	10 (0.4)	368 (14.5)	381 (15.0)	406 (16.0)	445 (17.5)	394 (15.5)	406 (16.0)	432 (17.0)	445 (17.5)
H	mm (in)	18 (0.7)	351 (13.8)	364 (14.3)	390 (15.3)	428 (16.9)	X X	X X	X X	X X
HB	mm (in)	0.3 (0.1)	73 (2.9)	85 (3.4)	98 (3.9)	111 (4.4)	X X	X X	X X	X X
HC	mm (in)	5 (0.2)	134 (5.3)	135 (5.3)	160 (6.3)	199 (7.8)	X X	X X	X X	X X
HD	mm (in)	10 (0.4)	162 (6.4)	175 (6.9)	200 (7.9)	238 (9.4)	X X	X X	X X	X X
J	mm (in)		380 (15)	393 (15.5)	418 (16.5)	456 (18)	405 (16)	418 (16.5)	444 (17.5)	456 (18)
L	mm (in)	10 (0.4)	338 (13.3)	351 (13.8)	376 (14.8)	414 (16.3)	363 (14.3)	376 (14.8)	401 (15.8)	414 (16.3)
M	mm (in)	8 (0.3)	516 (20.3)	X X	X X	X X	516 (20.3)	X X	X X	X X
N	mm (in)	10 (0.4)	278 (11)	292 (11.5)	318 (12.5)	355 (14)	305 (12)	318 (12.5)	243 (13.5)	355 (14)

Streamline PROFILE FX Series Detector Dimensions

- Dimensions are for reference only and subject to change.
- If dimensional constraints are critical, contact the factory.

			Standard or LB			XLB		
Endcap Model (dia. mm)			-70	-83	-108	-70	-83	-108
Dim.	Unit	Tol.						
A	mm (in)	0.3 (0.01)	70 (2.75)	83 (3.25)	108 (4.25)	70 (2.75)	83 (3.25)	108 (4.25)
B	mm (in)	0.3 (0.01)	75 (2.95)	88 (3.45)	113 (4.45)	75 (2.95)	88 (3.45)	113 (4.45)
C	mm (in)	5 (0.2)	89 (3.5)	84 (3.3)	96 (3.8)	115 (4.5)	109 (4.3)	121 (4.8)
D	mm (in)	8 (0.3)	202 (7.9)	208 (8.2)	220 (8.7)	227 (8.9)	234 (9.2)	246 (9.7)
E	mm (in)	18 (0.7)	875 (34.4)	881 (34.7)	898 (35.4)	900 (35.4)	907 (35.7)	923 (36.4)
F	mm (in)	10 (0.4)	324 (12.8)	330 (13)	343 (13.5)	349 (13.8)	356 (14)	368 (14.5)
H	mm (in)	18 (0.7)	307 (12.1)	313 (12.3)	326 (12.9)	X X	X X	X X
HB	mm (in)	0.3 (0.1)	73 (2.9)	85 (3.3)	111 (4.36)	X X	X X	X X
HC	mm (in)	5 (0.2)	91 (3.6)	85 (3.3)	97 (3.8)	X X	X X	X X
HD	mm (in)	10 (0.4)	117 (4.9)	124 (4.9)	137 (5.4)	X X	X X	X X
J	mm (in)	10 (0.4)	336 (13.2)	342 (13.5)	355 (14)	361 (14.2)	367 (14.5)	380 (15)
L	mm (in)	10 (0.4)	293 (11.5)	300 (11.8)	312 (12.3)	319 (12.6)	325 (12.8)	338 (13.3)
N	mm (in)	10 (0.4)	234 (9.2)	240 (9.5)	253 (10)	259 (10.2)	266 (10.5)	279 (11)

Gamma Gage and Side-Looking Dewar Dimensions

- Dimensions are for reference only and subject to change.
- If dimensional constraints are critical, contact the factory.

			Cryostat/Dewar or Dewar Type							
			CFG-PG4 and DWR-x.xG			CFG-PMOD4 and DWR-MOD-xL		CFG-PS4, CFG-PD4, DWR-xxB and DWR-xxD		
			VOLUME			VOLUME		VOLUME		
Dim.	UNIT	TOL. ±	1.2L	3L	5L	3L	7L	7.5L	13L	30L
Q	mm (in)	13 (0.5)	229 (9.0)	302 (11.9)	302 (11.9)	229 (9.0)	302 (11.9)	X X	X X	X X
R	mm (in)	10 (0.4)	X X	X X	X X	X X	X X	174 (6.9)	174 (6.9)	155 (16.1)
S	mm (in)	7.6 (0.3)	X X	X X	X X	X X	X X	77 (3.0)	77 (3.0)	60 (2.3)
T	mm (in)	5 (0.2)	X X	X X	X X	X X	X X	10 (0.4)	10 (0.4)	13 (0.5)
Y	mm (in)	5 (0.2)	157 (6.2)	229 (9.0)	229 (9.0)	157 (6.2)	229 (9.0)	224 (8.8)	307 (12.1)	442 (17.4)
Z	mm (in)	5 (0.2)	229 (9.0)	267 (10.5)	419 (16.5)	292 (11.5)	320 (12.6)	452 (17.8)	429 (16.9)	610 (24.0)

Example Model Numbers

Streamline Configuration

GEM-M5970	59 mm x 70 mm GEM-M detector with 70-mm diameter endcap.
CFG-GG-70	Portable Gamma Gage cryostat with matching 70-mm diameter flange.
DWR-1.2G	1.2 liter all-postition dewar for Gamma Gage cryostat.
GEM-F8250-SMP	82 mm x 50 mm GEM-F detector with 95-mm diameter endcap and SMART-1 preamplifier and high voltage supply.
CFG-SD-95	Downlooking cryostat with matching 95-mm diameter flange.
DWR-7.5D	7.5 liter downlooking dewar for downlooking cryostat.
GEM-FX7025-HJ	70 mm x 25 mm GEM-FX detector with 83-mm diameter endcap and remote preamplifier and high voltage filter.
CFG-HJ-83	"J" configuratiion cryostat with remote fittings for the preamplifier and high voltage filter.
DWR-30B	30 liter side port dewar for "HJ" cryostat.
GEM-F5930-LB-C-PL	59 mm x 30 mm GEM-F detector with 70-mm diameter low-background carbon fiber endcap, and Plus preamplifier.
CFG-SV-70-LB	Vertical "dipstick" style cryostat with matching 70-mm endcap and low background charcoal pumping agent.
DWR-30	30 liter top port dewar that accepts "dipstick" style cryostats.

PopTop Configuration

GEM-M5970P4	59 mm x 70 mm GEM-M detector with 70-mm diameter endcap.
CFG-PG4-1.2	Portable Gamma Gage cryostat with 1.2 liter all-position dewar.
GEM-M8295P4-SMP	82 mm x 95 mm GEM-M detector with 95-mm diameter endcap and SMART-1 preamplifier and high voltage supply.
CFG-PD4-7.5	Downlooking cryostat with 7.5 liter dewar.
GEM-FX7025P4-HE	70 mm x 25 mm GEM-FX detector with 83-mm diameter carbon fiber endcap with sealed preamplifier and high voltage filter.
CFG-PG4-3	Portable Gamma Gage cryostat with 3 liter all-position dewar.
GEM-M7080P4-RB-SMP	70 mm x 80 mm GEM-M detector with 83-mm diameter reduced background carbon fiber endcap and SMART-1 preamplifier and high voltage supply.
CFG-PV4	Vertical "dipstick" style cryostat.
DWR-30	30 liter top port dewar that accepts "dipstick" style cryostats.

PROFILE Coaxial HPGe Photon Detector Product Configuration Guide

PROFILE Series GEM Detector Ordering Information

- For Streamline remove the "P4" from the model number.
- If dimensional considerations are critical, contact factory.
- Cryostat and dewar or other cooling device are not included with detector.
- Cryostat and dewar or other cooling device are required for operation.
- A cryostat must be ordered with a Streamline detector.
- GEM-M????P4 is an M-series PROFILE detector optimized for use with Marinelli Beakers: Choose the largest diameter which will fit within the Marinelli well.
- GEM-F????P4 is an F-series PROFILE detector optimized for “close geometry” samples such as filters, Petri dishes, and bottles. If possible, choose a crystal diameter >20% larger than your sample.
- GEM-FX????P4 is an FX-Series PROFILE Detector optimzed for the same geometries as the F-Series, but with thin contact and carbon fiber window for use down to below 15 keV.
- Monte Carlo drawing included with GEM-F and GEM-M detectors.

	Crystal Dimension		Energy Resolution (FWHM)				Peak Shape				
Model No.	Actual Diameter (+0/–2 mm)	Actual Length Minimum	14.4 keV Warr. (eV)	46 keV Typical (eV)	@122 keV Warr. (eV)	@1.33 MeV Warr. (keV)	FW.1M/ FWHM Typical	FW.02M/ FWHM Typical	P:C Warr.	Nominal Relative Efficiency %	Endcap Dia. (mm)
GEM-M5970P4	59	70			900	1.90	1.90	2.65	62	38	70
GEM-F5930P4	59	30			675	1.85	1.90	2.65	40	20	70
GEM-M7080P4	70	80			950	1.95	2.00	3.00	75	66	83
GEM-F7040P4	70	40			750	1.95	1.90	2.65	50	40	83
GEM-M8295P4	82	95			1300	2.10	2.00	3.10	85	115	95
GEM-F8250P4	82	50			850	2.10	2.00	3.00	62	60	95
GEM-M94100P4	94	100			1300	2.30	2.00	3.10	90	175	108
GEM-FX5825P4	58	25	485	500	650	1.80	1.90	2.65	35	15	70
GEM-FX7025P4	70	25	575	575	650	1.90	1.95	2.75	40	20	83
GEM-FX8530P4	85	30	600	625	700	1.90	2.00	2.90	55	50	108

PROFILE Detector Options

-RB	PopTop Only. Reduced background PopTop capsule with Carbon Fiber endcap, add “-RB” to the model number. Not compatible with -HE option.
-HE	PopTop Only. Harsh Environment Option for PopTop detectors 76 mm and larger, add “-HE” to the model number . Not compatible with -RB option.
-PL	PLUS Ultra-high-count-rate Preamplifier, add “-PL” to the model number. Not compatible with FX series or -HJ option.
-SMP	SMART-1 detector option for positive bias detector, add “-SMP” to the model number. Not compatible with -HJ option.
-LB-C	Streamline Only. Low-Background Detector with Carbon Fiber Endcap, add “-LB-C” to the model number. Requires selection of a Low-Background LB cryostat.
-XLB-C	Streamline Only. Extra-Low-Background Detector with Carbon Fiber Endcap, add “-XLB-C” to the model number. Requires selection of a Low-Background XLB cryostat. Not compatible with -HJ option.
-HJ	Streamline Only. Remote preamplifier and high voltage filter for use with HJ type cryostat, add “-HJ” to the model number. Requires selection of HJ cryostat. Not compatible with -PL, -SMP, or -XLB-C options.

Notes

[1]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.

[2]Measured at optimum shaping time using ORTEC analog or digital electronics.

[3]The proprietary contact employed in the FX-Series detectors offers exceptionally high transmission at energies below 40 keV. Some instability in transmission may occur below 20 keV if stored (uncooled) at room temperature for extended time periods (20–25°C or above). It is therefore recommended to keep FX-Series detectors cold, limiting the exposure to elevated ambient storage temperatures for applications which demand minimally varying efficiency below 20 keV.

PROFILE PopTop Cryostats and Dewars

• Dewar included except where marked *.

Model No.	Description
CFG-PD4-7.5	Down-looking Cryostat with 7.5-liter Dewar
CFG-PD4-13	Down-looking Cryostat with 13-liter Dewar
CFG-PD4-30	Down-looking Cryostat with 30-liter Dewar
CFG-PG4-1.2	Gamma Gage Cryostat with 1.2-liter Dewar (for 83 mm or smaller endcaps) (not compatible with -HE option)
CFG-PG4-3	Gamma Gage Cryostat with 3-liter Dewar
CFG-PG4-5	Gamma Gage Cryostat with 5-liter Dewar
CFG-PH4	Horizontal Cryostat (Dipstick type). Includes LNTC1.5WH. Dewar not included.* Choose DWR-30 or DWR-30-OP.
CFG-PMOD4-3	Gamma Gage Cryostat with 3-liter Multi-Orientation Dewar
CFG-PMOD4-7	Gamma Gage Cryostat with 7-liter Multi-Orientation Dewar
CFG-PS4-7.5	Side-Looking Cryostat with 7.5-liter Dewar
CFG-PS4-13	Side-Looking Cryostat with 13-liter Dewar
CFG-PS4-30	Side-Looking Cryostat with 30-liter Dewar
CFG-PSHP4	Down-Looking Shallow-Hole Probe with 0.7-liter Dewar
CFG-PV4	Vertical Cryostat (Dipstick type). Includes LNTC1.5WH. Dewar not included.* Choose DWR-30 or DWR-30-OP.
DWR-30	30-liter Dewar
DWR-30-OP	30-liter Offset-Port Dewar
DWR-S/F	Storage Fill Dewar for CFG-PG4-X
CFG-X-COOL-II-115	X-COOLER II with PopTop connector using 110-120 V ac, 60 Hz Input Power
CFG-X-COOL-II-230	X-COOLER II with PopTop connector using 220-240 V ac, 50 Hz Input Power

PROFILE Coaxial HPGe Photon Detector
Product Configuration Guide

PROFILE Streamline Cryostats

- Select dewar from PROFILE Streamline Dewars. Dewar included except where marked*.
- Append matching Detector Endcap Size designation to cryostat model: -70, -83, -95, -108 [e.g., CFG-SJ-95 for GEM-F8250 or CFG-SL-XLB-83 for GEM-FX7025-XLB-C]

Model No.	Description
CFG-GG	Gamma Gage Cryostat Dewar
CFG-HJ	J-type Cryostat with Remote Preamp and Dewar. (For -HJ option only.)
CFG-SD	Down-Looking Cryostat with Dewar
CFG-SH	Horizontal Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
CFG-SJ	J-type Cryostat with Dewar
CFG-SL	Side-Looking Cryostat with Dewar
CFG-SV	Vertical Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
LOW-BACKGROUND	
CFG-GG-LB	Low-Background Gamma Gage Cryostat with Dewar
CFG-HJ-LB	Low-Background J-type Cryostat with Remote Preamp and Dewar. (For -HJ option only.)
CFG-SD-LB	Low-Background Down-Looking Cryostat with Dewar
CFG-SH-LB	Low-Background Horizontal Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
CFG-SJ-LB	Low-Background J-type Cryostat with Dewar
CFG-SL-LB	Low-Background Side-Looking Cryostat with Dewar
CFG-SV-LB	Low-Background Vertical Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
CFG-SD-XLB	Extra-Low-Background Down-Looking Cryostat with Dewar
CFG-SH-XLB	Extra-Low-Background Horizontal Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*
CFG-SJ-XLB	Extra-Low-Background J-type Cryostat with Dewar
CFG-SL-XLB	Extra-Low-Background Side-Looking Cryostat with Dewar
CFG-SV-XLB	Extra-Low-Background Vertical Cryostat (Dipstick type). Includes LNTC1.25WH. Dewar not included.*

PROFILE Streamline Dewars

For Cryostat	Choose	Description	
CFG-GG	DWR-1.2G	1.2-liter All-Orientation Dewar	Included with Cryostat
	DWR-3.0G	3.0-liter All-Orientation Dewar	Included with Cryostat
	DWR-5.0G	5.0-liter All-Orientation Dewar	Included with Cryostat
	DWR-MOD-3L	3-liter Multi-Orientation Dewar	Included with Cryostat
	DWR-MOD-7L	7-liter Multi-Orientation Dewar	Included with Cryostat
	DWR-0.7-SHP-1	0.7-liter Shallow-Hole Probe Dewar	Included with Cryostat
	DWR-S/F	Storage/Fill Dewar for DWR-XG	
CFG-HJ, SJ, SL	DWR-7.5B	7.5-liter Side-Looking Dewar	Included with Cryostat
	DWR-13B	13-liter Side-Looking Dewar	Included with Cryostat
	DWR-30B	30-liter Side-Looking Dewar	Included with Cryostat
CFG-SD	DWR-7.5D	7.5-liter Down-Looking Dewar	Included with Cryostat
	DWR-13D	13-liter Down-Looking Dewar	Included with Cryostat
	DWR-30D	30-liter Down-Looking Dewar	Included with Cryostat
CFG-SV, SH	DWR-30-OP	30-liter Offset-Port Dewar	
	DWR-30	30-liter Dewar	

Specifications subject to change
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