Germanium Detectors

User's Manual

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Important Safety Considerations Read Carefully

There are three potential hazards in the use and handling of Ge detectors that must be recognized and properly dealt with to avoid the risk of personal injury.

High Voltage

Ge detectors may operate at bias voltages of 5000 V dc or more. Always be sure that detectors are properly grounded (through the SHV coaxial cable ground to a properly grounded Power Supply/NIM Bin). Also use extreme caution when adjusting internal preamplifier controls to avoid contact with the high voltage circuit.

Liquid Nitrogen

LN$_2$ can cause frostbite if not handled properly. Avoid skin contact with LN$_2$ or with surfaces cooled by LN$_2$. Read “Handling Liquid Nitrogen” on page 54 for more detailed instruction on LN2 hazards.

Vacuum Failure - Overpressurization

When a cryostat exhibits signs of catastrophic vacuum failure, such as heavy moisture or ice formation on the surfaces, extremely high LN$_2$ loss rate, and so forth, the adsorber (molecular sieves or charcoal), which normally maintains vacuum, may be virtually saturated.

When allowed to warm up, the adsorber will outgas and the pressure in the cryostat will rise. Canberra cryostats and Dewars sold by Canberra have a pressure relieving seal-off valve which is designed to prevent dangerous levels of pressurization.

The pressure rise, however, can be high enough to break or break loose beryllium windows and/or end-caps. A frozen or ice clogged seal-off valve may fail to relieve pressure, resulting in dangerous levels of pressurization.

Precautions

For these reasons use extreme caution in handling cryostats with symptoms of catastrophic vacuum failure. When you do have to handle them, take the following precautions:

1. Stop using the failed unit immediately. Do not allow it to warm up until additional steps are taken to prevent damage or injury due to overpressurization.

2. Drape a heavy towel or blanket over the end-cap and point the end-cap away from personnel and equipment. If the unit is in a shield, close the shield door.

3. Call the factory for further instructions if the incident occurs during working hours.

4. If it is impractical to keep the unit cold until advice is available from the factory, keep the end-cap covered with a heavy towel or blanket and place the unit in a restricted area in a container (corrugated cardboard, for example). If the unit is in a shield, let it warm up in the shield with the door closed.

5. After the unit has warmed up, cautiously check for overpressurization (outwardly bulging end-caps or windows). If there are no signs of pressure, the unit may be shipped to the factory for repair. Consult the factory for shipping information.

1. Introduction

Germanium detectors are semiconductor diodes having a P-I-N structure in which the Intrinsic (I) region is sensitive to ionizing radiation, particularly X rays and gamma rays. Under reverse bias, an electric field extends across the intrinsic or depleted region. When photons interact with the material within the depleted volume of a detector, charge carriers (holes and electrons) are produced and are swept by the electric field to the P and N electrodes. This charge, which is in proportion to the energy deposited in the detector by the incoming photon, is converted into a voltage pulse by an integral charge-sensitive preamplifier.

Because germanium has a relatively low band gap, these detectors must be cooled in order to reduce the thermal generation of charge carriers (thus reverse leakage current) to an acceptable level. Otherwise, leakage current induced noise destroys the energy resolution of the detector. Liquid nitrogen, which has a temperature of 77 °K, is the common cooling medium for such detectors. The detector is mounted in a vacuum chamber which is attached to or inserted into a LN_2 Dewar. The sensitive detector surfaces are thus protected from moisture and other contaminants.

Although Ge detectors can be warmed up when not in use, the lithium-diffused N+ contact is not perfectly stable at room temperature. For this reason it is best to avoid extended warm time, especially for standard-electrode coaxes where the Li contact affects low energy response.

Types of Ge Detectors

Canberra makes a wide variety of detector types which are described in this instruction manual. Figure 1 illustrates the various detector geometries that are available from Canberra, and the energy range they cover. Figure 2 depicts their significant performance characteristics. Consult Chapter 2, *Detector Descriptions*, for detailed descriptions and performance ranges of each type.

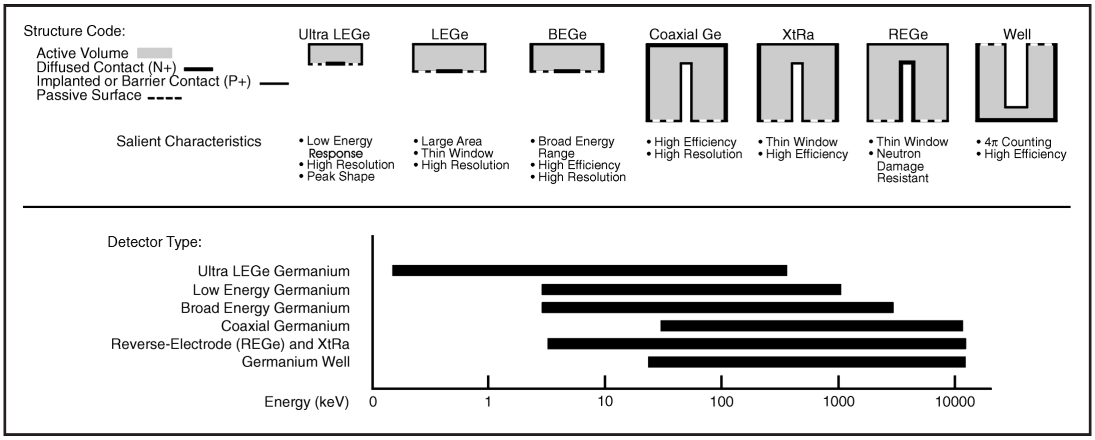


Figure 1 Detector Geometries

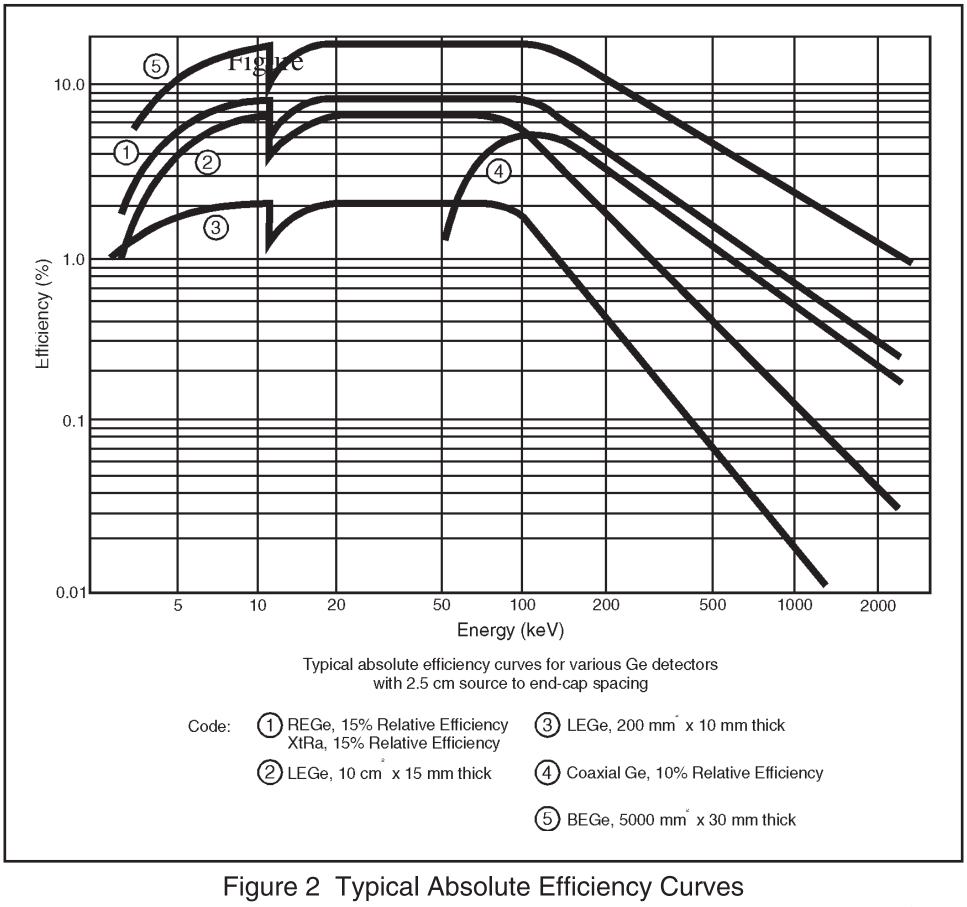


Figure 2 Typical Absolute Efficiency Curves
The notch in the efficiency curves at 11 keV is caused by excitation of the Ge K-shell by incoming photons and subsequent escape of a significant percentage of the K-shell X rays.

Cryostat

A cryostat consists of a vacuum chamber which houses the detector element plus a Dewar (double wall vacuum-insulated vessel) for the liquid nitrogen cryogen. In some cases, the detector chamber and Dewar are permanently connected. These are called “integral” cryostats. “Dipstick” cryostats have a detector vacuum chamber with a dipstick-like cold finger which is inserted into the neck of the Dewar.

The detector element is held in place by a holder, which is electrically isolated from but thermally connected to a copper cold finger. The cold finger transfers heat from the detector assembly to the liquid nitrogen reservoir. The detector holder is held in place by an anti-microphonic stabilizer. The detector holder as well as the outer vacuum jacket or “end-cap” are thin to avoid attenuation of low energy photons. The holder is generally made of aluminum and is typically 1 mm thick. The end-cap, is also generally made of aluminum. It is typically 1.5 mm thick. The detector element face is located typically 5 mm from the end-cap so caution should be used to avoid pushing the end-cap in against the detector assembly. Two popular types of cryostats are illustrated in Figure 3.

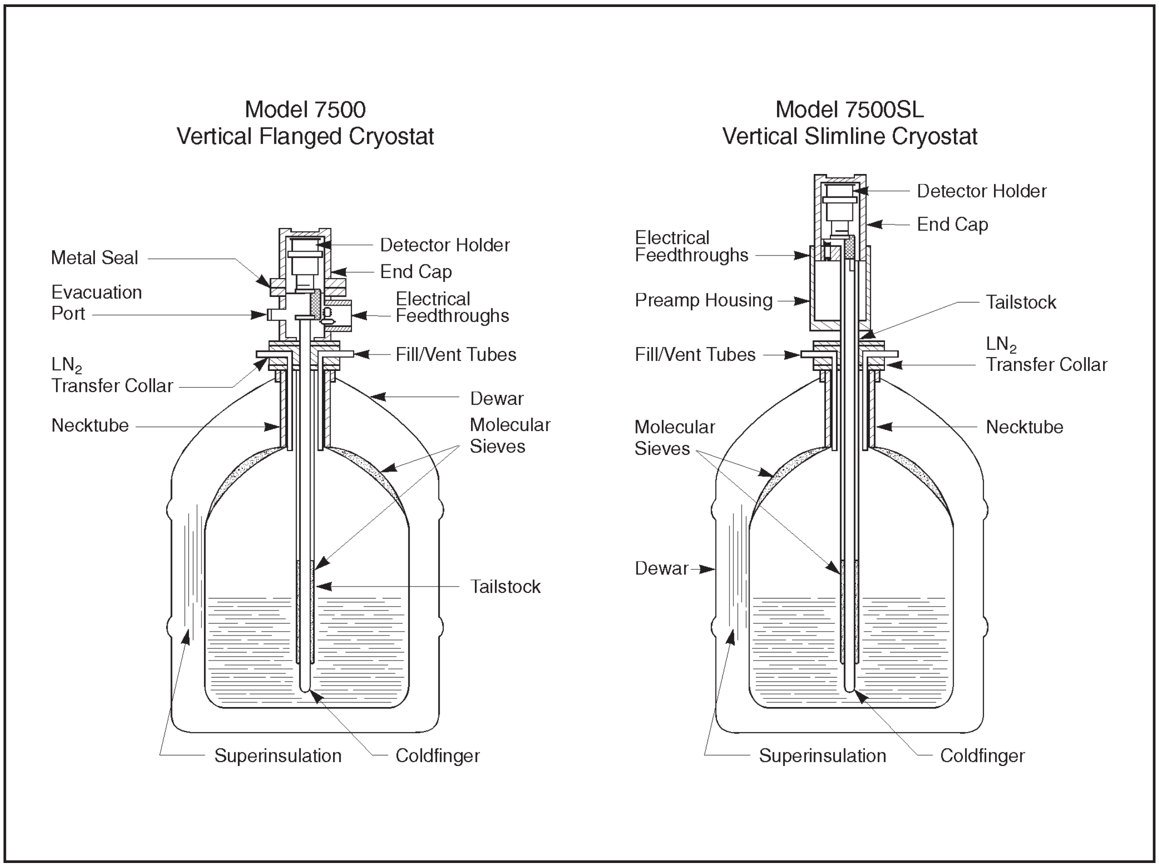


Figure 3 Two Types of Cryostat

Preamplifier Description

There are two basic types of preamplifiers in use on Ge detectors. These are charge sensitive preamplifiers that employ either dynamic charge restoration (RC feedback) or reset charge-restoration methods to discharge the integrator. The reset may be done with pulsed light from an LED (Pulsed Optical) or with a transistor switch (Transistor Reset).

RC Feedback Preamplifiers

The block diagram in Figure 4 describes the conventional RC feedback preamplifier. Charge from the detector is collected on the input node, unbalancing the first stage amplifier which has a capacitor as the feedback element (with a resistor in parallel). The amplifier balance is restored when the output changes by the amount necessary to inject the opposite charge on node A through the feedback capacitor. The transfer function is thus:

$$V_o = \frac{Q_{in}}{C_f}$$

The high value resistor (R_f) discharges the feedback capacitor (C_f) with time constant R_fC_f. The energy rate limit of the preamplifier is inversely proportional to feedback resistor value as is shown in Figure 5.

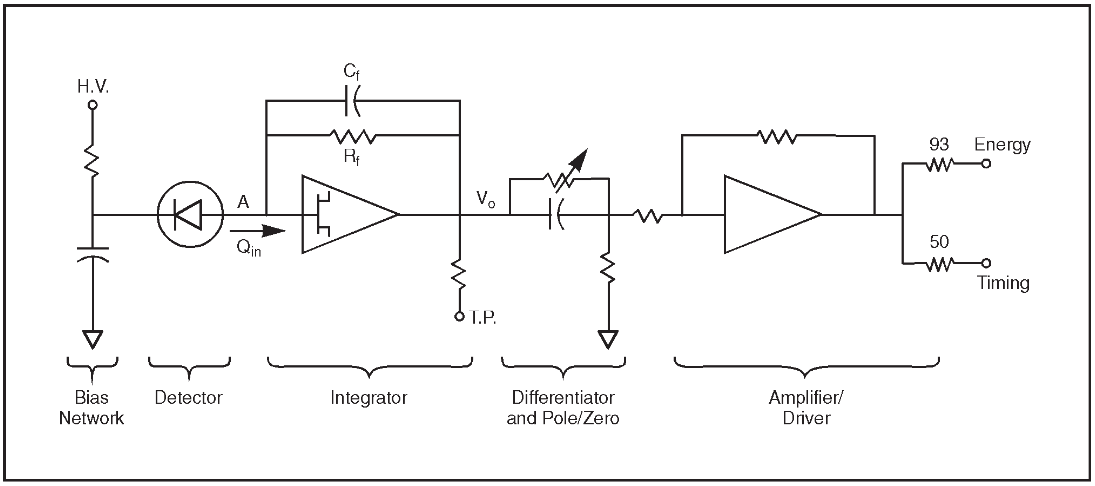
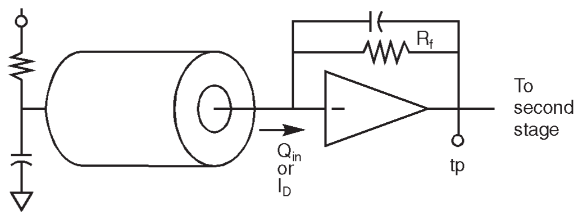


Figure 4 Typical RC Feedback Circuit

$$\text{Detector Current} = \text{Energy Rate}\left(\frac{eV}{s}\right) \times \overbrace{\frac{\text{charge (Q)}}{\text{energy (eV)}}}^{\text{Charge carriers produced by Ge per unit energy deposited} = 1/2.98} \times \underbrace{1.6 \times 10^{-19}\,\frac{\text{Coulombs}}{Q}}_{\text{Charge per charge carrier}}$$

$$\frac{\text{Detector Current (A)}}{\text{Energy Rate (MeV/s)}} = 10^{6} \times \frac{1.6 \times 10^{-19}}{2.98}$$

$$= 5 \times 10^{-14} = 0.05\ \text{pA/(MeV/s)}$$



$V_{tp} = I_D \times R_f$

Assuming $V_{tp} = 20$ V (max)

$$\text{Energy Rate Limit (MeV/s)} = \frac{400\ 000}{R\ \text{(Gigohms)}}\ \text{MeV/s}$$

For 2 Gigohms - Limit is 200 000 MeV/s

For 0.5 Gigohms - Limit is 800 000 MeV/s

Figure 5 Preamplifier Rate Limit

The output from the integrator is differentiated and passed along to an amplifier/driver which has selectable gain. The output is split and sourced with 50 and 93 ohms for the Timing and Energy outputs, respectively.

Pulsed Optical (PO) Reset Preamps

The feedback resistor in RC Preamps is a source of noise. For low energy detectors where electronic noise is a major contributor to resolution, elimination of the feedback resistor is desirable. With no feedback resistor, the preamplifier output is a step function and successive steps build up to the limit of the amplifier output range. Refer to Figure 6.

The preamplifier is then reset by firing an LED in close proximity to the FET chip discharging the FET and resetting the circuit to its initial condition. A monostable circuit generates a gating pulse of variable duration which can be used to gate off the ADC during the reset/recovery interval if necessary to reduce spurious counts in the system.

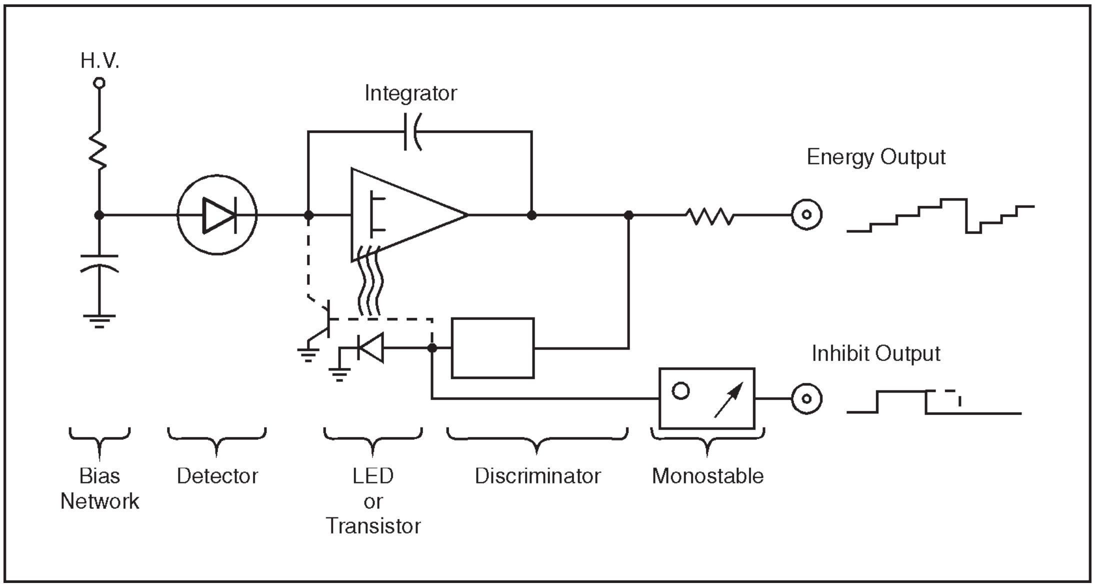


Figure 6 Pulsed Optical/Transistor Reset Preamp Circuit

Transistor Reset Preamps (TRP)

RC preamps can lock up when they are operated at high energy rates (see Figure 5). The transistor reset preamp (TRP) virtually eliminates lock-up since it is capable of discharging the integrator quickly (< 2 µs) and without long-term transients following reset. The PO preamp and the TRP have very nearly the same block diagram. Transistor reset preamps can be used with coaxial detectors and special versions of TRPs can be used with low energy detectors.

Warm Up Sensor and HV Inhibit

Newer detectors may be equipped with an internal temperature sensor and associated circuitry which can be used to disable the bias supply in case of accidental warm up of the detector. This function is also provided by a separate LN_2 monitor, such as Canberra’s Model 1786.

In either case, the reason for having such protection is as follows: When a detector warms up, the molecular sieves, which normally acts as a vacuum pump or adsorber, will release the gases that it accumulated or pumped when cold. The resultant pressure rise can lead to an electrical discharge in the high voltage circuitry within the cryostat and thus damage the FET in the preamplifier.

The Model 1786 senses the liquid nitrogen level in the Dewar and provides an advance warning so that LN_2 can be replenished before the detector begins to warm up. The internal sensor cannot react until it warms up, so while this affords adequate protection to the FET, it may not prevent down time should a refill not take place immediately.

Environmental Considerations

Germanium detectors are designed and manufactured for use indoors and for use outdoors under limited conditions, as described in the individual detector's specifications sheet. The detectors conform to Installation Category I and Pollution Degree II standards.

Temperature Range

The environmental temperature range for LN_2 cooled detectors is 5 °C to 40 °C. Electrically cooled detectors may be subject to other limits. See the relevant sections of this manual for these limitations.

Humidity Range

Up to 95% relative humidity – non-condensing. Note that Be and polymer windows are readily damaged by moisture condensation. Humidity must be controlled so that moisture does not condense on windows.

2. Detector Descriptions

This chapter will describe the characteristics of the major types of germanium detectors:

- The Ultra-LEGe Detector
- The Low Energy (LEGe) Detector
- The Coaxial (Coax) Germanium Detector
- The Reverse Electrode (REGe) Detector
- The Extended Range (XtRa) Germanium Detector
- The Ge Well Detector
- The Broad Energy Germanium (BEGe) Detector

Ultra-LEGe Detector

The Canberra Ultra-LEGe detector extends the performance range of Ge detectors down to a few hundred electron volts, providing resolution, peak shape, and peak-to-background ratios once thought to be unattainable with semiconductor detectors. The Ultra-LEGe retains the high-energy efficiency intrinsic to germanium detectors because of the high atomic number (Z) and thus covers a wider range of energies than any single-photon detector on the market.

To take full advantage of the low energy response of the Ultra-LEGe, Canberra offers the option of a polymer film cryostat window. This polymer window is a multilayer film which is supported by a ribbed silicon support structure. The film spans silicon ribs that are about 100 microns apart and 0.3 mm thick and act as a collimator accordingly. On horizontal cryostats, the support rib orientation can be chosen by designating the appropriate window model-number suffix: V for vertical ribs and H for horizontal ribs. The support structure is 80% open so the effective detector area is reduced by 20% from the total area. The total film thickness is about 3400 Å, 400 Å of which is an aluminum layer which reduces sensitivity to ambient light. Detectors having polymer windows must be operated in a darkened environment, nevertheless.

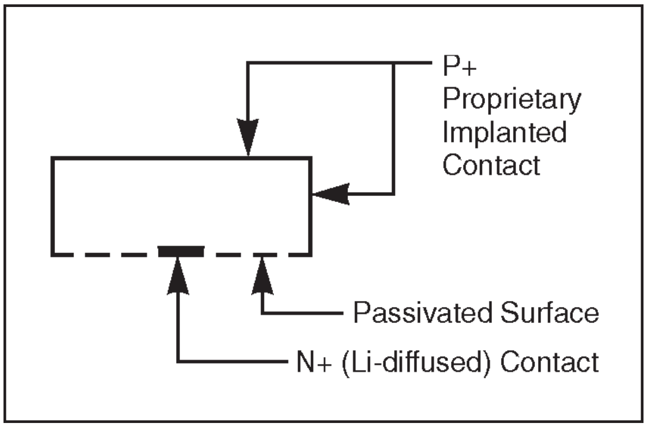


Figure 7 Ultra-LEGe Detector Cross Section

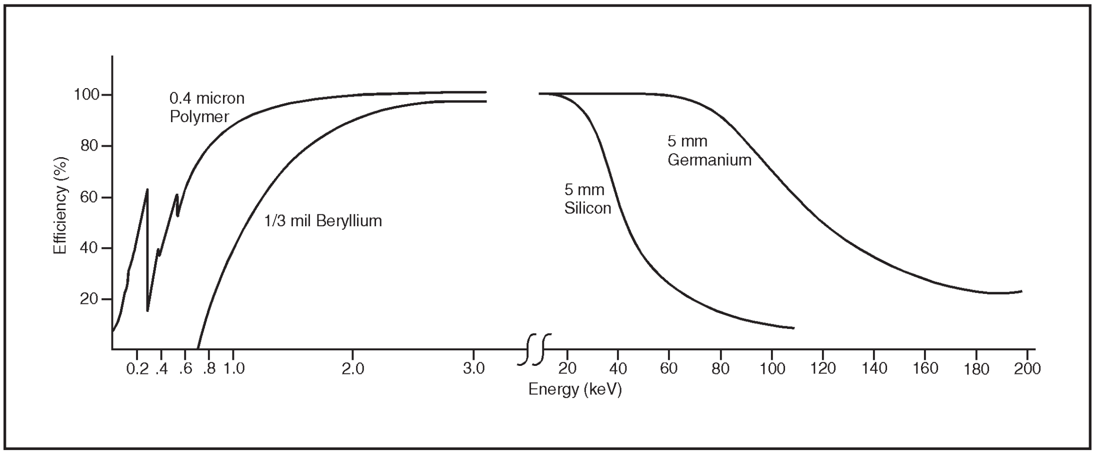


Figure 8 Comparison of Window Transmission and Detector Efficiency

Low Energy Ge Detector (LEGe)

The Low Energy Germanium Detector (LEGe) offers major advantages over conventional planar or coaxial detectors in many applications. The LEGe detector is fabricated with a thin contact on the front face. The rear is of less than full area (Figure 9). Thus the capacitance of the detector is less than that of a planar device of similar size.

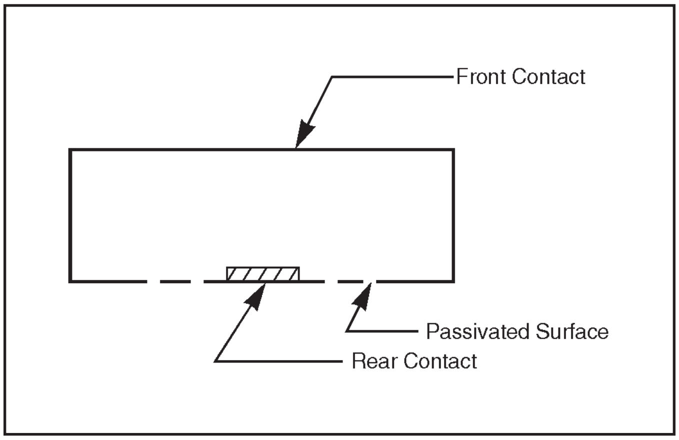


Figure 9 LEGe Detector Cross Section

Since preamplifier noise is a function of detector capacitance, the LEGe affords lower noise and consequently better resolution at low and moderate energies than any other detector geometry. Unlike grooved planar detectors, there is virtually no dead germanium beyond the active region. This, and the fact that the side surface is charge collecting rather than insulating, results in fewer long-rise time pulses with improved count rate performance and peak-to-background ratios.

The LEGe detector is available with active areas from 0.5 cm^2 to 38 cm^2 or more and with thicknesses ranging from 5 to 30 mm. The efficiency curve given in Figure 10 illustrates the performance of a typical LEGe detector.

To take full advantage of the low energy response of this intrinsically thin window detector, the LEGe is usually equipped with a thin Be window.

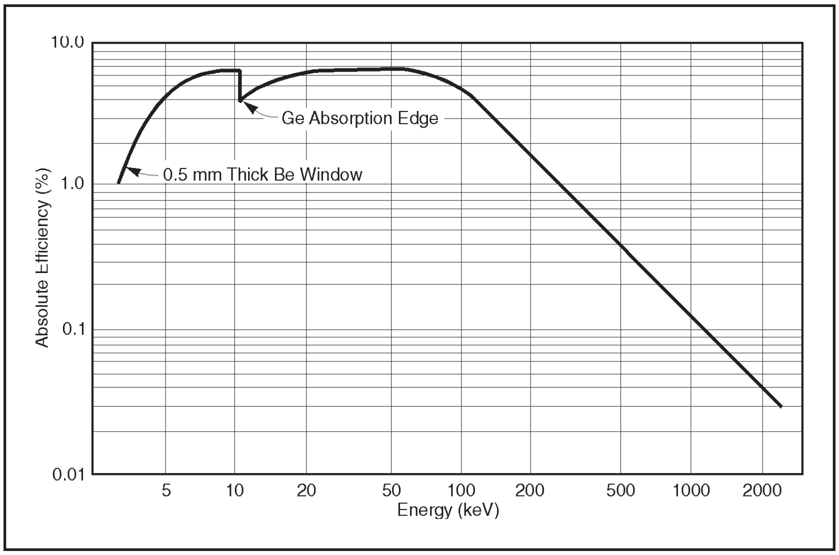


Figure 10 Model GL1015 LEGe Detector Efficiency Curve with 2.5 cm Detector-Source Spacing

Coaxial Ge Detector

The conventional coaxial germanium detector is often referred to as Pure Ge, HPGe, Intrinsic Ge, or Hyperpure Ge. Regardless of the superlative used, the detector is basically a cylinder of germanium with an n-type contact on the outer surface, and a p-type contact on the surface of an axial well (Figure 11).

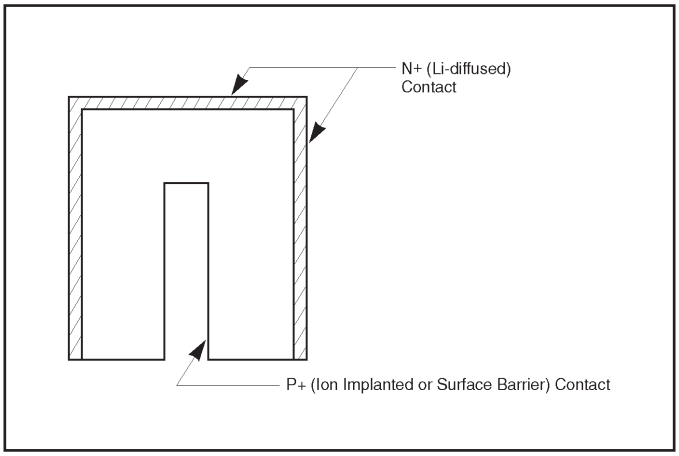


Figure 11 Coaxial Ge Detector Cross Section

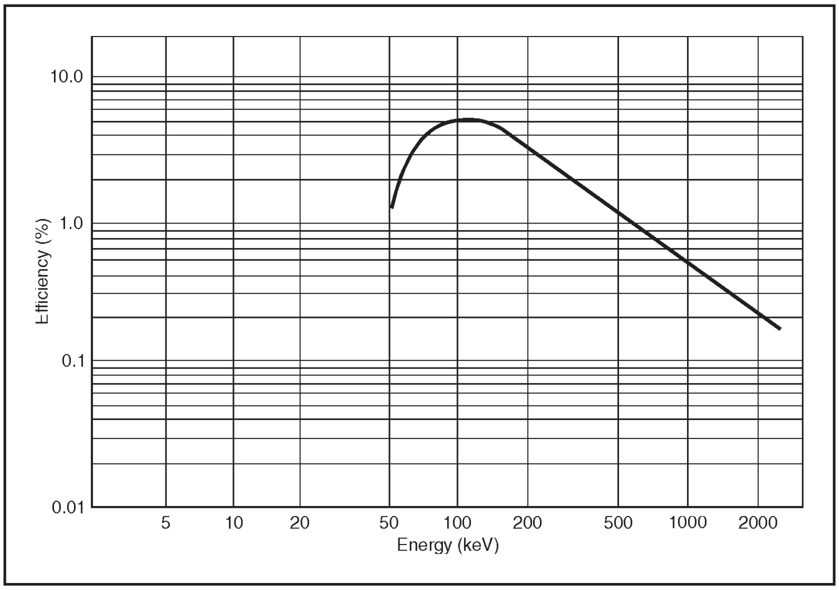


Figure 12 Model GC1020 Coaxial Detector Efficiency Curve with 2.5 Detector-Source Spacing

The germanium has a net impurity level of only about 10^{10} atoms/cc so that with moderate reverse bias, the entire volume between the electrodes is depleted, and an electric field extends across this active region. Photon interaction within this region produces charge carriers which are swept by the electric field to their collecting electrodes where a charge sensitive preamplifier converts this charge into a voltage pulse proportional to the energy deposited in the detector.

The n and p contacts or electrodes are typically diffused lithium and implanted boron respectively. The outer n-type diffused lithium contact is about 0.5 mm thick. The inner contact is about 0.3 microns thick. A surface barrier may be substituted for the ion-implanted contact with equal results.

The Canberra Coaxial Ge detector can be shipped and stored without cooling. Like all germanium detectors, however, it must be cooled when it is used to avoid excessive thermally generated leakage current. Furthermore, the lithium diffused outer contact will increase in thickness if the detector is kept warm for extended periods (months or years). This will affect the efficiency of the detector, particularly at low energies.

Reverse-Electrode Ge Detector

The Reverse-Electrode detector (REGe) is similar in geometry to other coaxial germanium detectors with one important difference. The electrodes of the REGe are opposite from the conventional coaxial detector in that the p-type electrode (ion-implanted boron) is on the outside, and the n-type contact (diffused lithium) is on the inside (Figure 13). There are two advantages to this electrode arrangement – window thickness and radiation damage resistance.

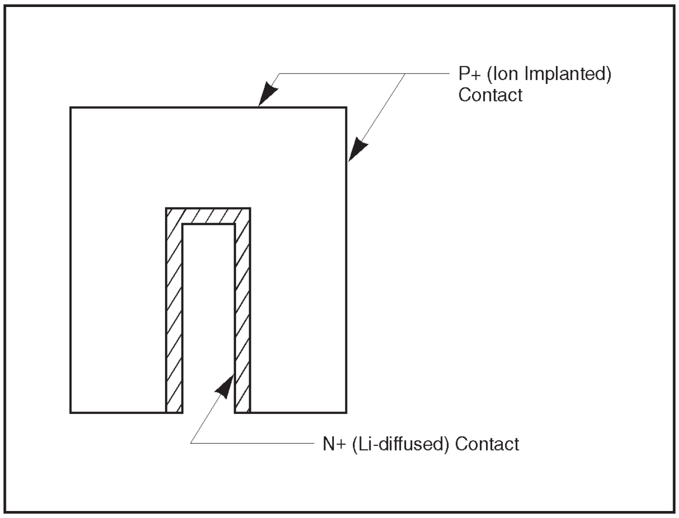


Figure 13 REGe Detector Cross Section

The ion-implanted outside contact is extremely thin (0.2 µm) compared to a lithium-diffused contact. This, in conjunction with a thin cryostat window, extends the energy response down to about 5 keV, giving this detector a dynamic range of 2000:1. Needless to say, this dynamic range exceeds the 100:1 offered by most analysis systems so the detector is unlikely to be covering the range of 5 keV to 10 MeV at once.

The radiation damage resistance properties of the REGe detector come about for the following reason. It has been found that radiation damage, principally due to neutrons or charged particles, causes hole trapping in germanium. Unlike the case of the conventional coaxial detector, holes are collected by the outside electrode of the REGe detector.

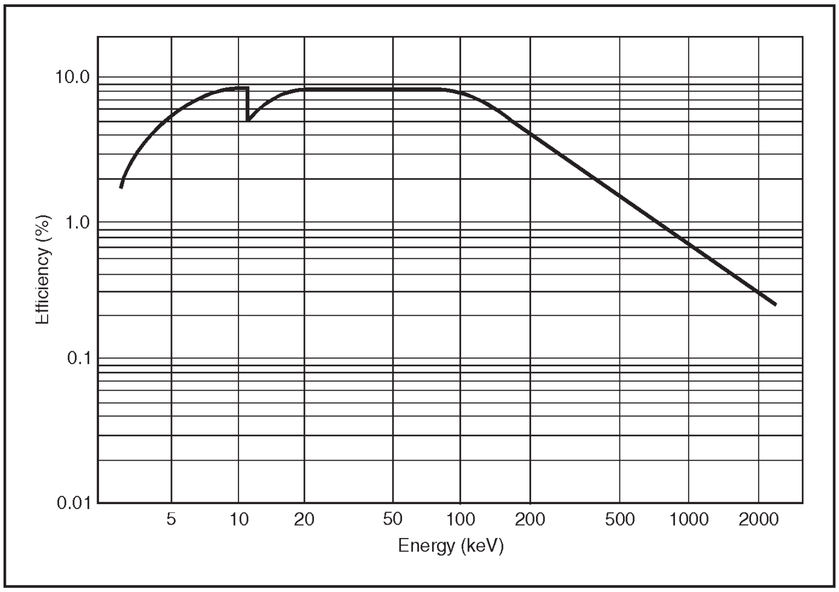


Figure 14 Model GR1520 REGe Detector Efficiency
Curve with 2.5 cm Detector-Source Spacing

Since a much greater amount of the active detector volume is situated within a given distance of the outside contact than of the inside contact, it follows that, on average, holes have less distance to travel if they are attracted to the outside contact than if they are attracted to the inside contact. With less distance to travel, they are less likely to be trapped in radiation damaged material. The extent of the improved resistance to radiation damage depends on other factors, of course, but experimental evidence suggests that the REGe detector may be l0 (ten) times as resistant to damage as conventional Coaxial Ge detectors.

Extended Range Ge Detector

The Canberra XtRa is a coaxial germanium detector having a proprietary thin-window contact on the front surface which extends the useful energy range down to 5 keV. Conventional coaxial detectors have a lithium-diffused contact typically between 0.3 and 1.0 mm thick (Figure 15).

This dead layer stops most photons below 40 keV or so, rendering the detector virtually worthless at low energies. The XtRa detector, with its exclusive thin entrance window and with a beryllium cryostat window, offers all the advantages of conventional standard coaxial detectors such as high efficiency, good resolution, and moderate cost along with the energy response of the more expensive Reverse Electrode Ge (REGe) detector.

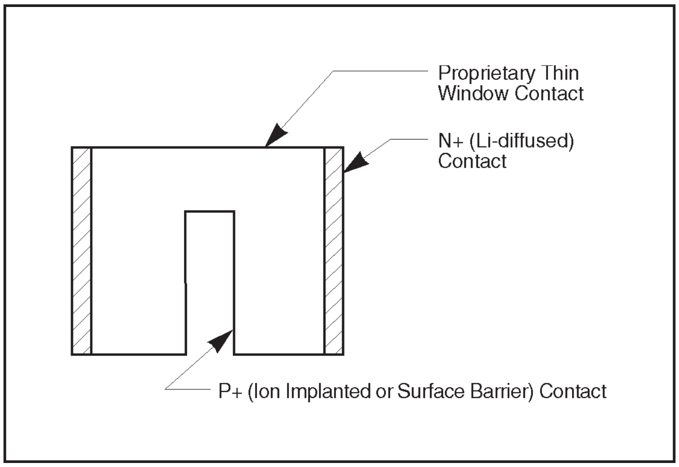


Figure 15 XtRa Detector Cross Section

The response curves (Figure 16) illustrate the efficiency of the XtRa detector compared to a conventional Ge detector. The effective window thickness can be determined experimentally by comparing the intensities of the 22 keV and 88 keV peaks from ^{109}Cd. With the standard 0.5 mm Be window, the XtRa detector is guaranteed to give a 22 to 88 keV intensity ratio of greater than 20:1.

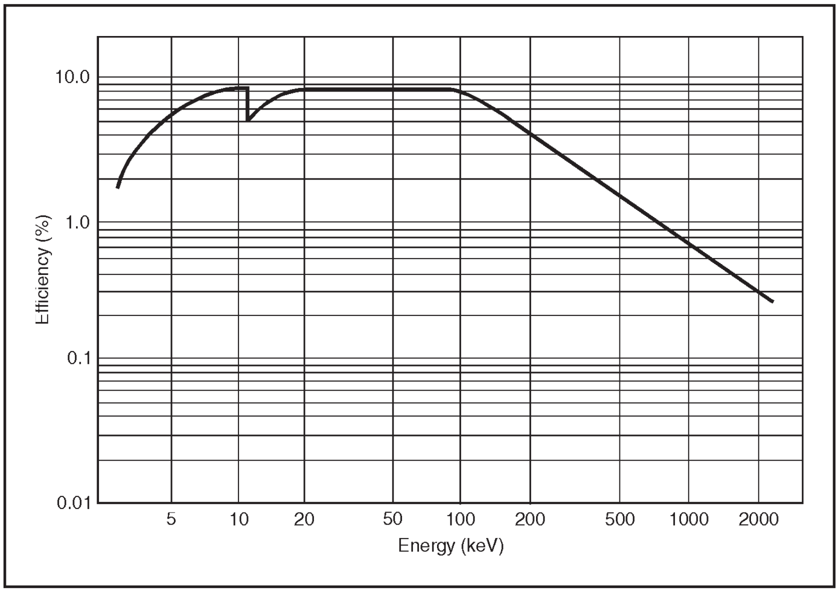


Figure 16 Model GX1520 XtRa Detector Efficiency
Curve with 2.5 cm Detector-Source Spacing

Ge Well Detector

The Canberra Germanium Well Detector provides maximum efficiency for small samples because the sample is virtually surrounded by active detector material. The Canberra Well detector is fabricated with a blind hole rather than a through hole, leaving at least 5 mm of active detector thickness at the bottom of the well. The counting geometry therefore approaches 4π.

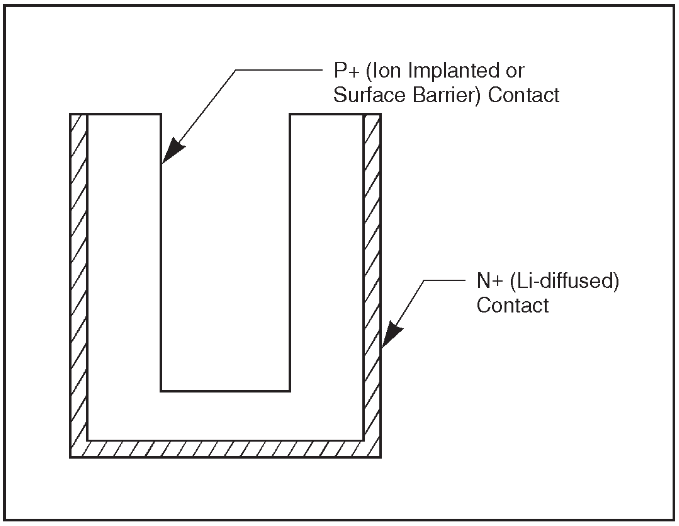


Figure 17 Ge Well Detector Cross Section

Germanium Well Detectors are made from high-purity germanium and can therefore be shipped and stored at room temperature without harm. Unlike lithium-drifted detectors, high-purity germanium detectors may be cycled repeatedly between LN^2 and room temperature with no compromise in performance.

The cryostat end cap and well are fabricated from aluminum with a thickness of 0.5 mm in the vicinity of the well. The ion-implanted or surface barrier contact on the detector element is negligibly thin compared to 0.5 mm of aluminum so these detectors have intrinsically good low energy response.

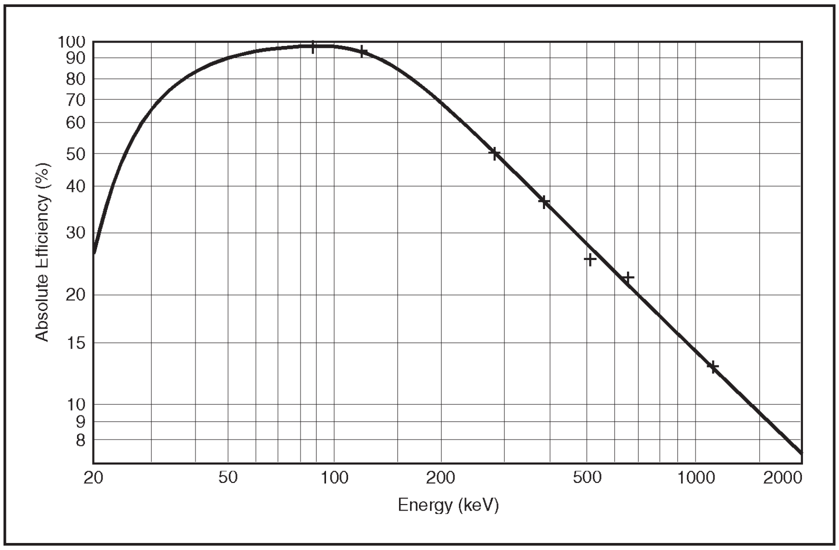


Figure 18 Model GCW2522 Ge Well Detector Efficiency

Broad Energy Ge Detector

The Canberra Broad Energy Ge (BEGe) Detector covers the energy range of 3 keV to 3 MeV. The resolution at low energies is equivalent to that of our Low Energy Ge Detector and the resolution at high energy is comparable to that of good quality coaxial detectors.

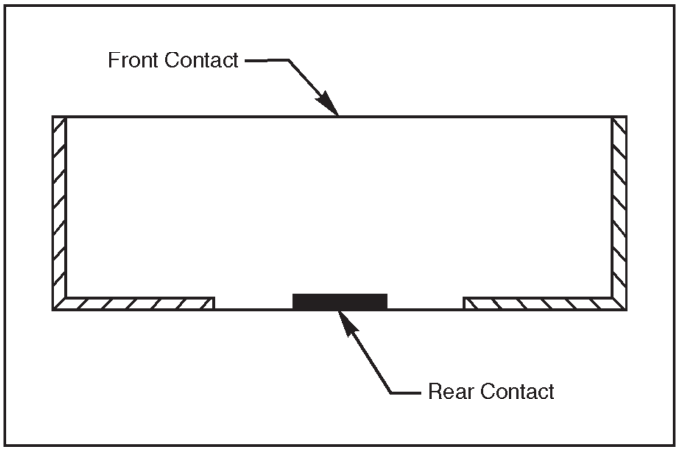


Figure 19 BEGe Detector Cross Section

Most importantly, the BEGe has a short, fat shape which greatly enhances the efficiency below 1 Me for typical sample geometries. This shape is chosen for optimum efficiency for real samples in the energy range that is most important for routine gamma analysis.

In addition to higher efficiency for typical samples, the BEGe exhibits lower background than typical coaxial detectors because it is more transparent to high energy cosmogenic background radiation that permeates above ground laboratories and to high energy gammas from naturally occurring radioisotopes such as ^{40}K and ^{208}Tl (Thorium).

In addition to routine sample counting, there are many applications in which the BEGe Detector really excels. In internal dosimetry the BEGe gives the high resolution and low background need for actinide lung burden analysis and the efficiency and resolution at high energy for whole body counting. The same is true of certain waste assay systems particularly those involving special nuclear materials.

The BEGe detector and associated preamplifier are normally optimized for energy rates of less than 40 000 MeV/sec. Charge collection times prohibit the use of short amplifier shaping time constants. Resolution is specified with shaping time constants of 4-6 microseconds typically.

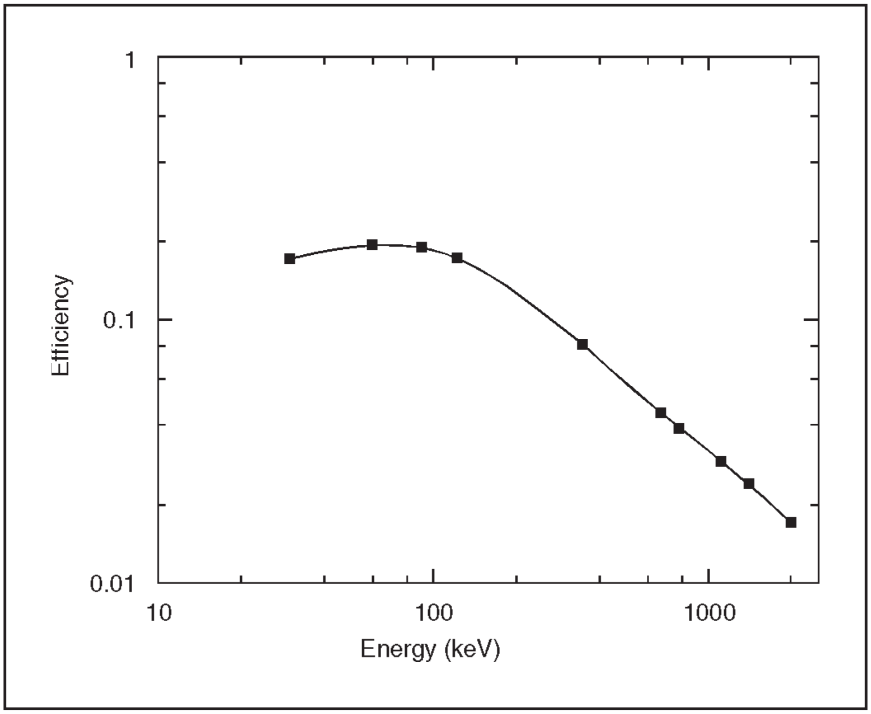


Figure 20 Absolute Efficiency of BE5030
for a Source Measuring 74 mm Diameter by 21 mm Thick
Located on the Detector End Cap

3. Cryostat Descriptions

There are five types of cryostats in two basic styles and in many sizes. This variety can be broken down as follows:

- Types: Dipstick, Integral, Electrically Cooled, Convertible
- Styles: Flanged (traditional), Slimline
- Sizes: From 1 liter capacity to 50 liter capacity
- Orientations: Horizontal, Vertical, Variable

In addition, special cryostats or variations on the above are available. Instructions for these units are covered in supplements to this manual found in the envelope on the last page if they are necessary.

Precaution Most cryostats (the 7500 and 7600 are the exceptions) are equipped with Viton O-ring Seals that are permeable to light gases such as helium. Helium is not pumped effectively by the molecular sieves or charcoal adsorber used to maintain vacuum. The epoxy used to bond beryllium, carbon composite, and polymer windows is also permeable. While permeability (as opposed to leaks) is not generally a problem (the atmospheric abundance of helium is quite low) care should be taken to avoid exposing cryostats to high concentrations of helium for extended periods.

Flanged and Slimline Styles

Refer to Figure 3 on page 5 for a description of these two cryostat styles.

Dipstick Cryostat

Dipstick cryostats consist of a detector chamber having a dipstick-like cold finger which is inserted into a liquid nitrogen Dewar for cooling. The Dewar and the detector chamber have separate vacuum systems including adsorber material which help maintain good vacuum in both over the lifetime of the product. A basic dipstick cryostat is illustrated in Figure 21.

Dipstick Dewar

Most dipstick cryostats use a 30 liter Dewar. The loss rate of the Dewar alone is typically 0.5 to 0.7 liters/day. Faulty Dewars of this type cannot be repaired but can be replaced in the field at moderate cost.

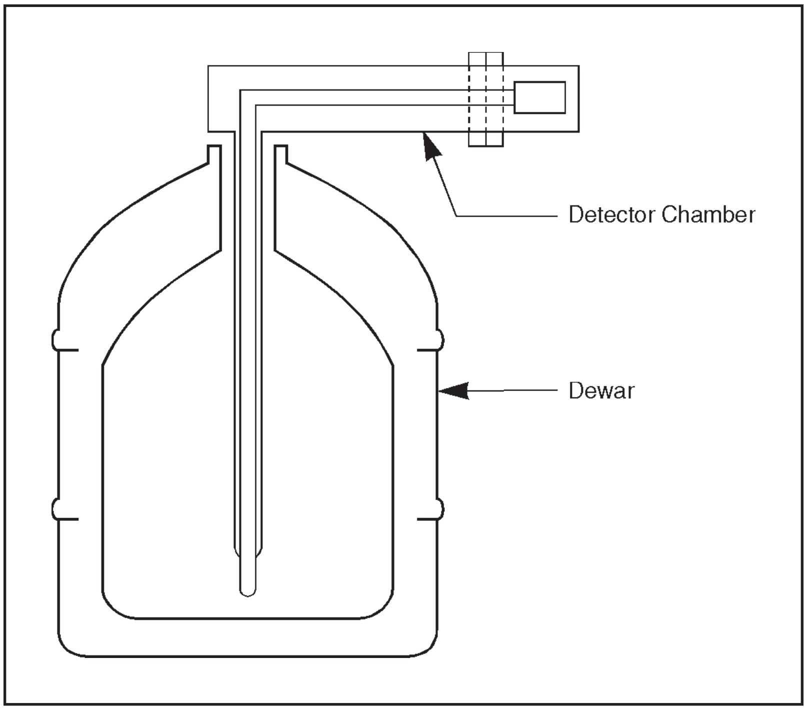


Figure 21 Typical Dipstick Cryostat Cross Section

Fill and Vent Collar

Dipstick cryostats are equipped with a silicone rubber collar which holds the dipstick in place in the Dewar neck. This collar has interchangeable tubes for fill and vent and has provisions for an LN_2 sensor of the type used with LN_2 monitors, such as the Canberra Model 1786. A clamp ring is used on some dipstick cryostats to provide mechanical stability. The clamp ring is attached to the Dewar neck by means of three screws. Two screws in the clamp ring tighten it on the dipstick. Use these screws to change the position of the dipstick. A 7/64 in. hex key wrench is supplied for this purpose.

Intergral Cryostat

Integral cryostats have a common vacuum chamber for the Dewar and detector. Unlike the dipstick type, the detector chamber and Dewar cannot be separated without breaking vacuum. A basic integral cryostat is shown in Figure 22.

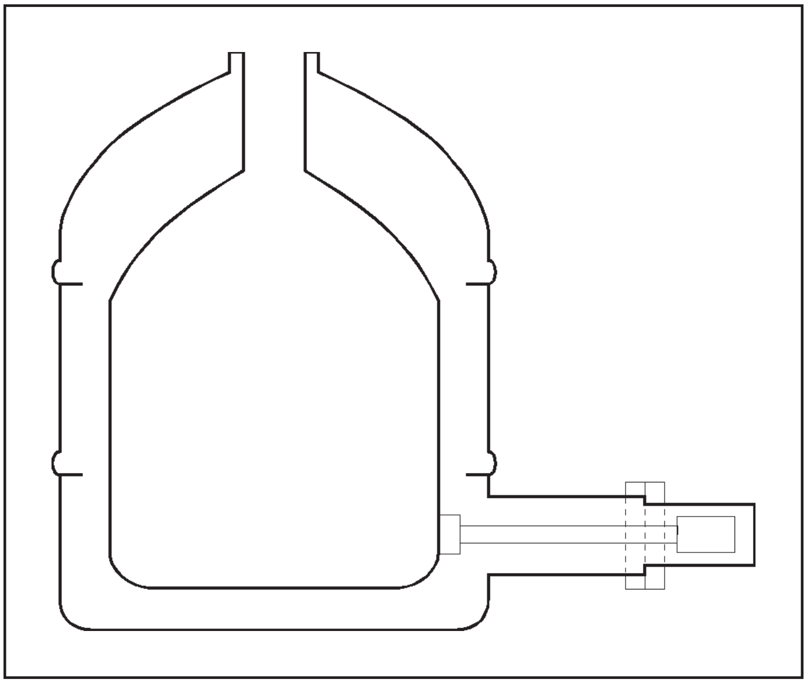


Figure 22 Typical Intergral Cryostat Cross Section

Integral Swivel-Head Cryostat

This version of the integral cryostat has a rotary vacuum seal which allows the detector chamber to be rotated 180°, affording multiple geometries without moving the cryostat or warming it up.

Rotating Seal

The rotating joint is outfitted with two O-rings to minimize the chance for leaks. The inner O-ring is under constant compression. The outer O-ring is compressed by a knurled ring nut which can be tightened to retard rotation of the head. It should not be necessary to loosen this nut to any great degree to allow rotation of the head and it would be undesirable to do so. There are mechanical stops which prevent rotation just beyond the normal 180° operating range. These stops cannot be defeated without catastrophic results.

Operation

The head can be rotated with the detector either warm or cold with the following procedure:

1. Turn off the Detector Bias and allow one minute for the bias network to discharge fully.

2. Loosen the ring nut just slightly.

3. Rotate the head to the desired orientation. Do not allow the ring nut to turn with the head.

4. Tighten the ring nut “hand tight”. Pliers or wrenches should not be necessary.

Multi-Attitude Cryostat (MAC)

Canberra's standard portable multi-attitude cryostats have twin fill/vent ports which allow the units to operate in any orientation. The arrangement of the fill and vent ports is illustrated in Figure 23. These units are available in several sizes, with holding times of one to five days.

With the detector horizontal, either tube can vent. With the detector facing down, tube one vents. With the detector facing up, tube two vents. See "Multi-Attitude Cryostats (MACs)" on page 25 for more information on the MAC.

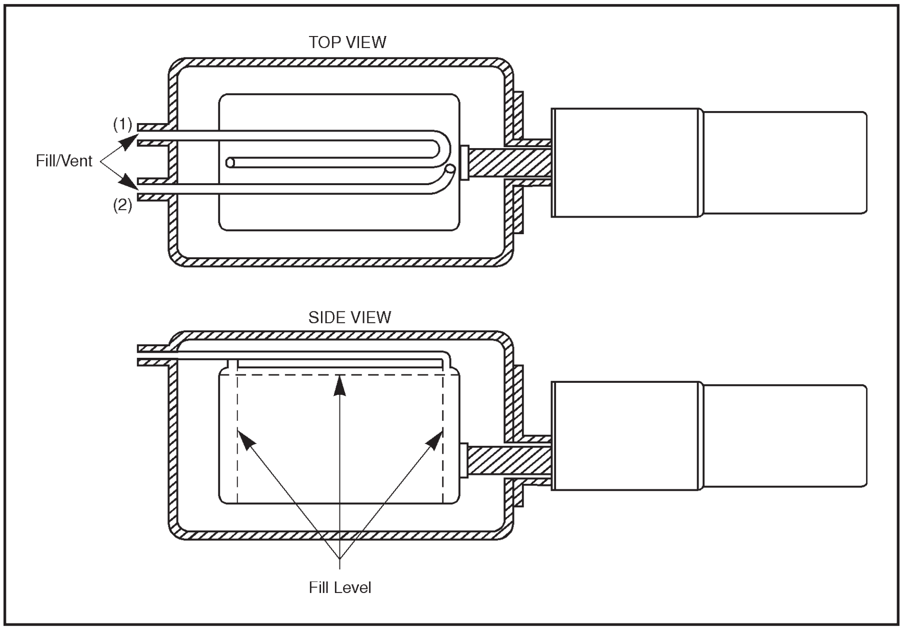


Figure 23 Typical Multi-Attitude (MAC) Cryostat Cross Section

Single Port Portable Cryostats

Portable all-attitude cryostats may also have a single port. These units have a neck tube that extends to the center of the Dewar and as long as the liquid level remains below the end of the tube (i.e., half-full maximum) the port can vent and the cryostat will work normally. For a given overall Dewar size, this type of cryostat has about one half the holding time of the standard MAC. See Figure 24 for details.

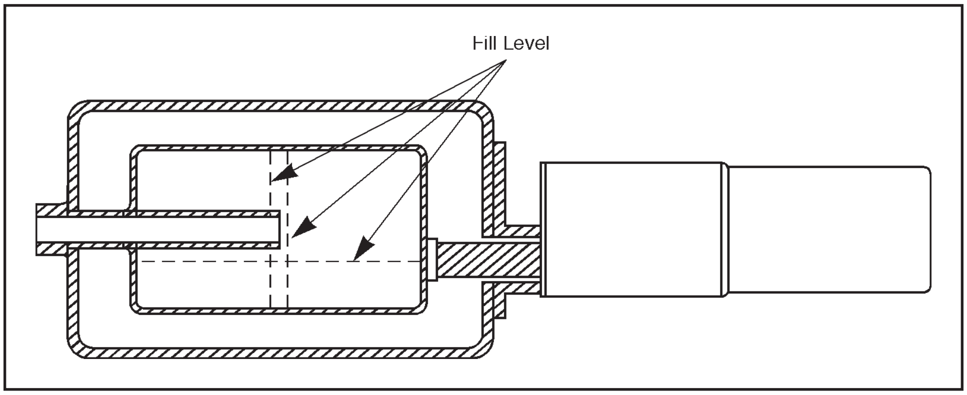


Figure 24 Typical Single Port MAC Cross Section

Detachable Cradle Assembly

The MAC is shipped with a carrying cradle which can be removed if the unit is to be installed in a fixed apparatus for any reason. To detach the cradle, remove the screws holding the rear plate to the handle and to the base, then remove the rear plate and slide the detector backwards taking care to feed the cables through the front plate along with the snout. Refer to Figure 25.

The detector cradle is equipped with a cableway fore and aft, so that the pigtail cables from the preamplifier and the extender cables supplied separately may be retained in a convenient and safe orientation. The cable retainer is a split grommet made of plastic.

To install the cables, the grommet must first be removed from the cableway. The grommet is snapped over the cable bundle and the cables are inserted in the cableway. The grommet is then pressed into the cableway with the split facing the inside.

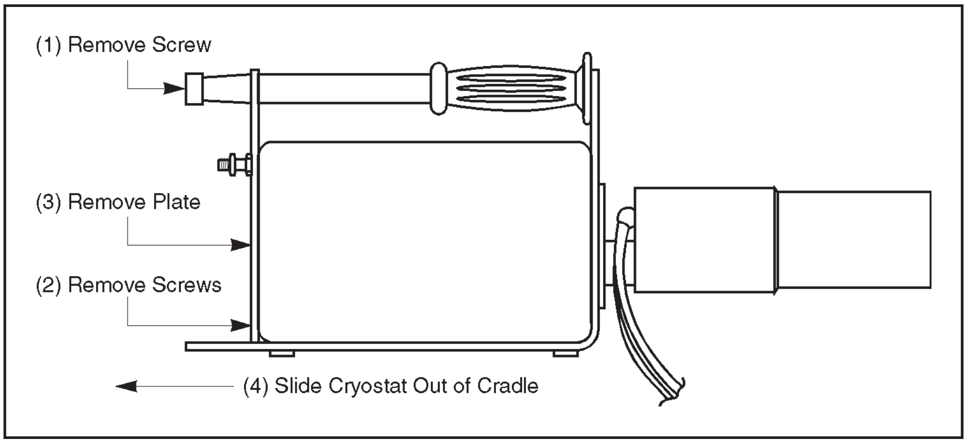


Figure 25 Cradle Assembly

The MAC cradle is also equipped with a clamp to secure the extender cable, so that they will not stress the smaller pigtail cables. This clamp, or some other means, must be employed to prevent damage to the miniature coaxial cables in the pigtail cable assembly.

Flanged versions of the MAC have a conventional (non slimline) preamplifier with bulkhead connectors which do not require strain relief.

Convertible Cryostat

The Canberra Convertible Cryostat, as the name suggests, is a cryostat which can be converted from one configuration to another without factory intervention. This is made possible by providing a sealed detector chamber which engages a cold finger receptacle. The receptacle can be built into a Dewar as in the case of portable or integral style systems, or inserted in the neck tube of a Dewar as in the case of dipstick style systems. In this way a single detector chamber may be operated with a variety of Dewars/receptacles to meet changing needs of the customer.

Principle of Operation

The detector chamber is a sealed vacuum system. The Dewar and/or dipstick assembly is also a sealed vacuum system. These sub-systems work more or less as traditional systems work. The novel aspect of the Canberra convertible cryostat is the transition coupling which joins the two sub-systems. This transition coupling involves close-fitting coaxial tubing – the inner tube being the detector chamber cold finger jacket and the outer tube being the inner wall of the receptacle. Because of the carefully chosen length and close spacing of these members, there is little heat transfer along the axis, despite the fact that the coupling operates at atmospheric pressure with one end at LN_2 temperature and the other at room temperature. The result is that convertible cryostats exhibit LN_2 loss rates only 0.1 to 0.2 liters/day above that of their conventional counterparts.

Physical Configuration

The detector chamber is shown in cross section in Figure 26. The cold finger protrudes slightly from the shroud and is surrounded by a thin-wall vacuum jacket. The chamber is evacuated and sealed by means of a seal-off valve (not shown) built into the base. Vacuum is maintained by an adsorber (not shown) attached to the cold finger assembly. The detector holder and preamplifier front end are located in the vacuum chamber but are not shown in this illustration for reasons of simplicity and clarity.

A set screw in the lug attached to the base of the detector chamber is used to hold the detector chamber firmly in place in the mating receptacle.

Dipstick Cold-Finger Receptacle

The business end of the dipstick cold-finger receptacle is also shown in cross section in Figure 26. Here you see the thin-wall vacuum jacket which receives the cold finger assembly. At the bottom of the receptacle is the copper heat sink into which the copper cold finger fits. Thermal joint compound is used to provide good thermal conduction and to prevent galling of these metal surfaces.

The dipstick assembly fits into a Dewar and is held in place by a collar assembly which has ports for LN_2 and a liquid level monitor.

The dipstick is evacuated and sealed by means of a seal-off valve which is shown. Vacuum is maintained by an adsorber located in the bottom of the dipstick assembly.

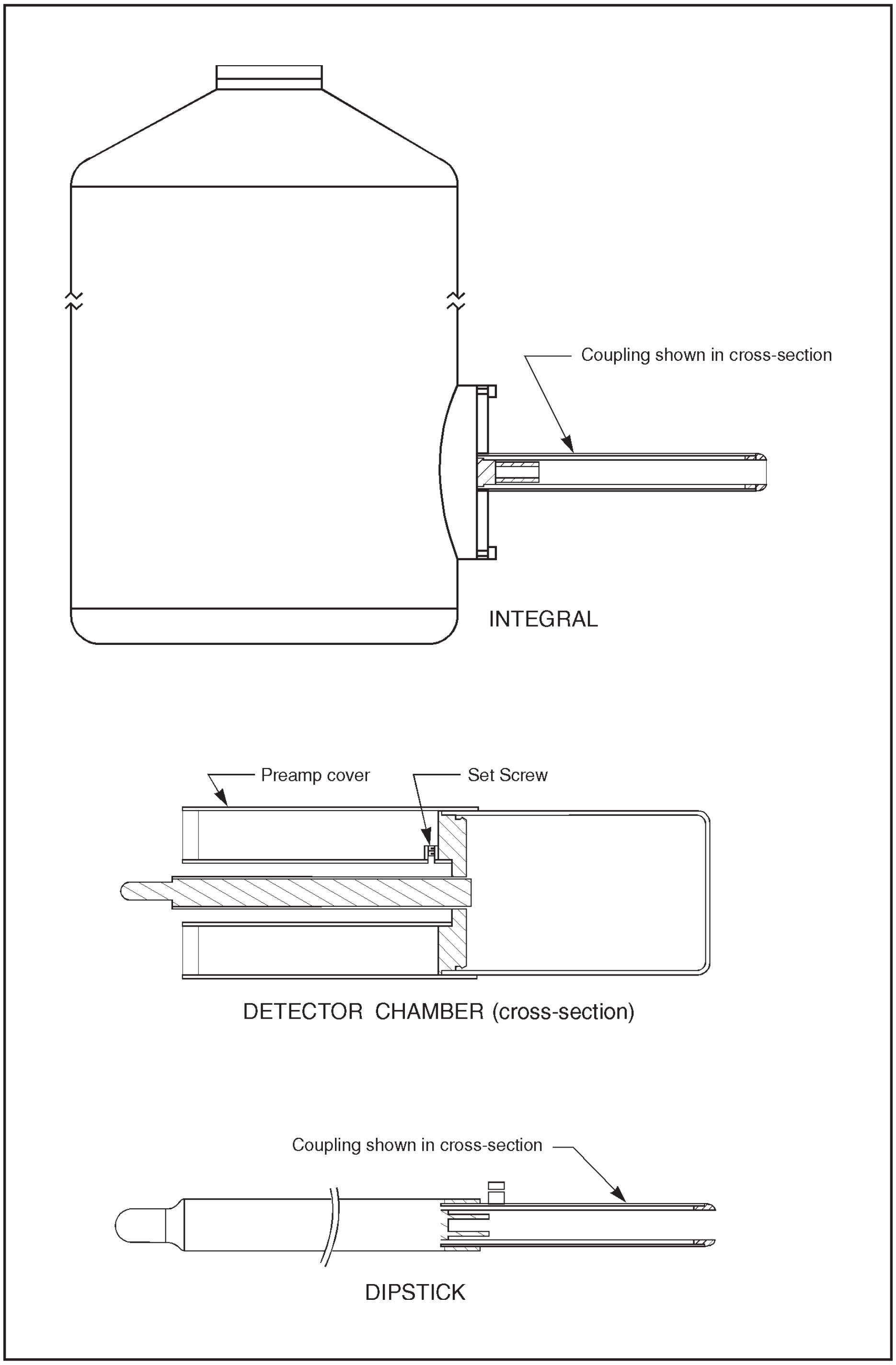


Figure 26 Convertible Cryostat

Changing Configurations

Before engaging or disengaging a detector chamber from a cryostat, both must be at room temperature. Allow the following warm-up times for various cryostat types:

Cryostat Type	Warm-up Time	Conditions
Dipstick	24 Hours	Dipstick removed from Dewar
Integral	24 Hours	Empty liquid – Dewar on side with neck plug removed
Portable	48 Hours	Empty liquid
Cryolectric	24 Hours	Power off

Disengaging Chamber

To disengage the detector chamber from the cryostat, follow these three steps. You'll need a small Phillips-head screwdriver and the $\frac{3}{32}$-inch hex key wrench supplied with the cryostat.

1. Remove screws holding preamp cover to base of preamplifier and slide cover forward exposing the base of the detector chamber.

2. Using the hex key wrench, loosen the set screw holding the detector chamber to the receptacle (see illustration).

3. Gently twist the detector chamber and pull it away from the receptacle.

Engaging Chamber

To remount the detector chamber on the cryostat, follow these seven steps. You'll need a small Phillips-head screwdriver and the $\frac{3}{32}$-inch hex key wrench supplied with the cryostat.

1. Inspect the receptacle and make sure it is both clean and dry. Use a flashlight to check the copper heat sink at the bottom of the receptacle.

2. Inspect the cold finger. Be sure it is free of burrs and dents.

5. Ensure that both the copper heat sink and the copper cold finger are coated with white thermal joint compound. The compound should coat mating copper surfaces only, not the stainless steel tubing.

4. Gently slide the capsule over the receptacle until you feel the copper parts mesh. Rotate the detector chamber back and forth to ensure good mating of the surfaces, leaving the detector chamber at the desired angle.

5. Gently tighten the set screw to lock the detector chamber in place.
6. Reinstall the preamp cover.
7. Cool the detector down and wait the prescribed time before testing.

Cryolectric Cryostat

The Canberra Cryolectric Cryostat is no longer in production. Consult the factory for information.

Freolectric Cryostat

The Canberra Freolectric Cryostat is no longer in production. Consult the factory for information.

Cryostat Options

There are wide varieties of cryostat options and features, the most common of which are described below.

Optional Windows

Most Planar, LEGe, XtRa and REGe detectors are equipped with a beryllium (Be) window to enhance sensitivity for low energy photons. Also a carbon composite window is used by Canberra as an alternative to beryllium on low background applications and polymer windows (see Figure 8 on page 11) are used on Ultra-LEGe detectors. Curves showing the transmission characteristics of various windows are shown in Figure 27.

Be Window – Care and Handling

Thin Be windows may be damaged easily. Windows of 0.25 mm (10 mils) thickness, or less, should not be touched. The window can be damaged by moisture condensation; keep it clean and dry at all times.

The detector should not be stored or operated in a humid environment. If moisture condenses on the Be window during normal operation, either the humidity is too high or the detector has a vacuum problem.

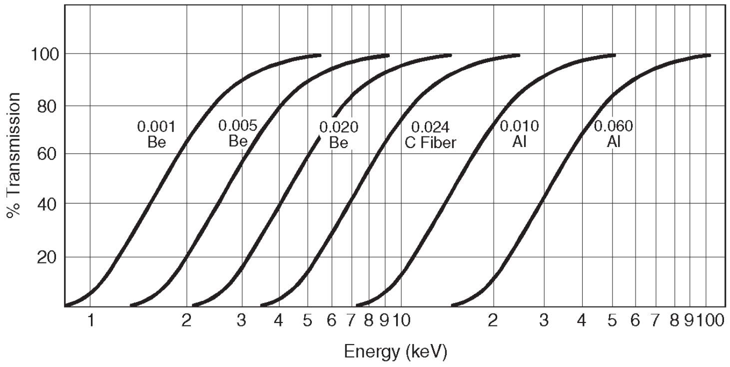


Figure 27 Window Transmission Characteristics

During cool-down or warm-up cycles when the molecular sieves outgas, some condensation may appear. This is normal. It should go away as soon as the molecular sieves repump the system.

Note: Damage to Be windows caused by physical abuse or harsh environments is not covered by the warranty.

Polymer Window – Care and Handling

Description:

The Canberra polymer window is only 3400 Å thick including 400 Å of aluminum. Considering that the polymer window is only about 1/25th as thick as 1/3 mil beryllium, it is an amazing device as it withstands atmospheric pressure and is helium leak tight. Not surprisingly, however, the window can be damaged easily if it is not handled properly and protected from the environment. Listed below are characteristics of the window as well as precautionary measures which should be taken to protect it.

The polymer window is a multilayer film supported by a ribbed silicon support structure. The film spans thin silicon ribs which are about 100 µm apart and about 0.3 mm thick. Therefore, the window exhibits a fairly tight collimation effect for photons entering at angles which are not parallel to the ribs. Also the window area is not oversized compared to the detector area so additional collimation is involved here. The ribs are about 20 µm wide so the window has about 80% “open” area.

The aluminum layer is not thick enough to block all light so the detector should be operated in the dark or in very subdued lighting. Ge detectors are very sensitive to infrared radiation and they may show effects of IR even without the presence of visible light.

Precautions:

1. Do not touch the window surface with *anything*, not even a cotton swab or soft brush. Physical abrasion can easily cause damage to the aluminum layer. It is also good to protect the window from dust and other small particles. Under certain circumstances they can abrade the surface and cause leaks.

2. Always avoid applying pressure to the ribbed side of the window (back pressure). The window is very strong when pressure is applied to the film side but very weak if pressure is applied to the ribbed side.

3. When evacuating a detector on which the window is mounted, it is best to pump down slowly to reduce the shock to the window. When venting a vacuum chamber on which the detector is mounted, you should vent very slowly to prevent flying particles from hitting and damaging the window.

4. Avoid any physical shock to the window, such as bumping or jarring the detector.

5. Never subject the window to temperatures higher than 35 °C.

6. Protect the window from moisture and from exposure to corrosive atmosphere. The aluminum layer is attacked by moisture and by acid fumes.

7. Keep the protective cover on the window whenever the detector is not in use, especially when the detector is being moved or when someone is working around the detector. Be very careful when placing test sources near the detector. This is the most common way of breaking windows in our experience.

8. If (or when) a window breaks, warm up the detector immediately and allow the inside of the detector to defrost and dry out before returning the detector to the factory for repair. This can be facilitated by removing the end cap.

Note: Damage to polymer windows is not covered by warranty.

Extended End-caps

The standard end-cap length for most Ge detectors is 7 to 10 cm (3-4 in.). Optional end-caps may reach lengths of 30 cm (12 in.) or more. Detectors so equipped may show increased cool-down time and increased microphonics because of the added cold finger and wire length between the detector and preamplifier. They also require special care in handling to avoid mechanical damage.

Remote Detector Chambers (RDC)

The remote detector chamber (RDC) option provides for external shielding just behind the detector element. The diameter and length of the neck joining the RDC to the cryostat vary depending on the application. A typical RDC configuration is shown in Figure 28.

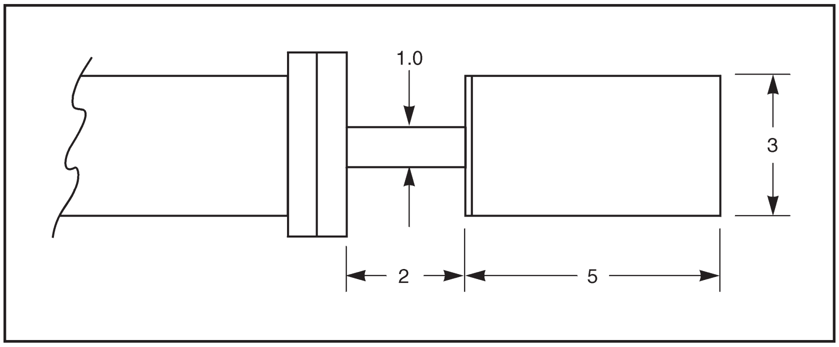


Figure 28 Typical RDC Configuration
Dimensions in inches

Cold Finger Extension

Standard Dipstick Detectors may be equipped with a cold-finger extension up to 10 cm in length. This allows the dipstick to be inserted through the floor of a shield between the detector chamber and the Dewar without sacrificing working volume of the Dewar. Such an arrangement is shown in Figure 29.

Standard Detectors are not designed to be elevated more than 10 cm (4 in.) from the Dewar neck, so the Dewar must be moved up as close as possible to the bottom of the shield.

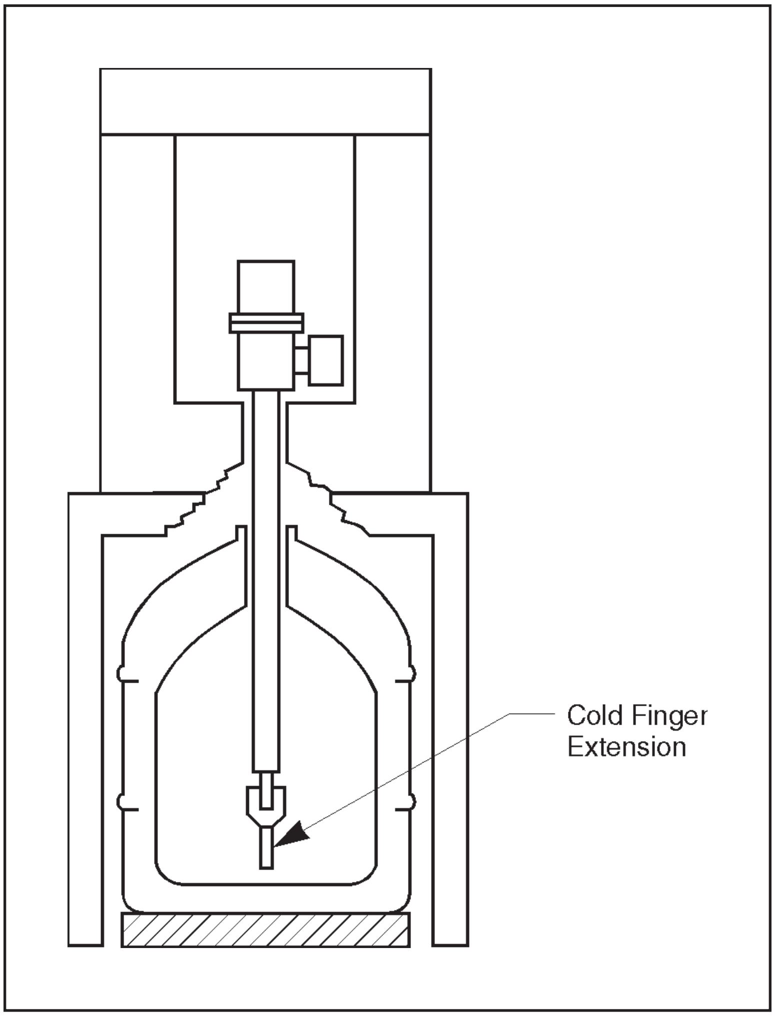


Figure 29 Cold Finger Extension

Special Preamp Hardware

To fit detectors having flanged cryostats into shields of moderate size, special preamp hardware can be used. This hardware generally provides a means of attaching the preamp to the cryostat so that the preamp protrudes a minimum amount from the detector axis.

Ultra-Low Background Materials

Although the materials used in cryostats are checked for abnormal levels of radioactive impurities, the hardware contribution to background can be improved by careful, time-consuming selection of expensive, often exotic materials. The normal materials used in cryostat construction are classified as low background. Materials that are specially selected or chosen optionally are classified as ultra-low background materials. This choice is usually negotiated with the end-user for each application.

Cryolectric II Cryostat

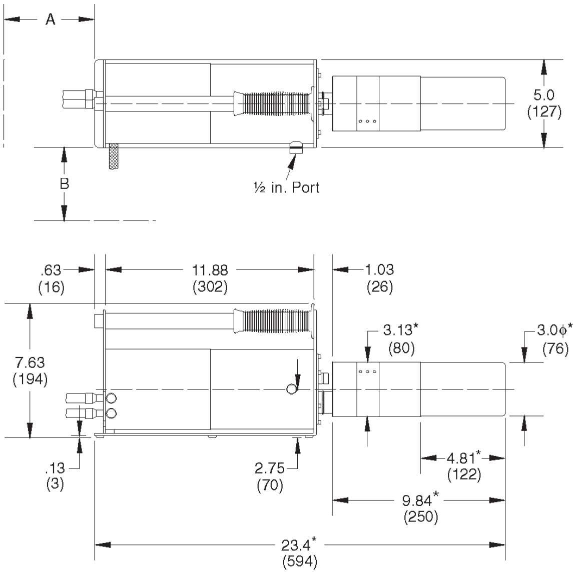
The Canberra Cryolectric II Cryostat is a refrigerating system for cooling semiconductor detectors. The system comprises a compressor which operates on electric power and a cold head which is built into a detector assembly. The compressor and cold head are connected by flexible metal refrigerant hoses. The refrigerant is a proprietary CFC-Free mixture of gases, one component of which is flammable. Each system contains less than 100 grams of the flammable component which allows it to be shipped by air freight. A manufacturers safety data sheet (MSDS) is available from Canberra for the asking. Refer to Figure 30 for more information.

Detector Assembly Description

The detector assembly comprises a detector chamber and the cold head or heat exchanger which receives the compressed refrigerant from the compressor. The detector assembly is packaged in a carrier similar to that used with our MAC (Multi-Attitude Cryostat). The refrigerant hose connections are hidden behind a metal shroud that slides over the cold head body for access.

Orientation

The detector assembly is designed to operate in any orientation. Care should be taken not to put undue stress on the refrigerant hoses. These hoses can be bent in a radius of 15 cm (6 in.) but they *must not* be twisted on their axis. Dress the lines so that they are relaxed rather than taut to avoid transmitting vibrations from the compressor the cold head.



COLD HEAD

*End-cap diameter and length shown for detectors of less than 40% efficiency.

MINIMUM WALL CLEARANCE			
HOSE CONFIG.	A	B	C
RIGHT ANGLE AT COLD HEAD	0	6.0 (152)	10.0 (254)
RIGHT ANGLE AT COMPRESSOR	6.0 (152)	0	6.0 (152)

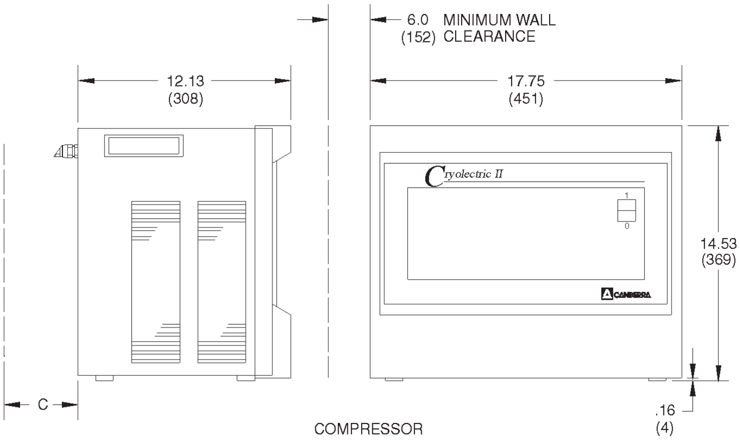


Figure 30 Cryolectric II Dimensions

Compressor Unit Description

The compressor is a sealed unit of the conventional refrigeration type. A schematic of the compressor unit is shown in Figure 31. Since cold head temperatures are very low it is important that the lubricating oil be removed from the refrigerant stream. The compressor unit has an oil separator to provide this function. Care must be exercised to keep oil from migrating to places it cannot be tolerated.

CAUTION The compressor unit must be *upright* and *level* (within 10 degrees) during operation. The compressor unit must not be tilted more than 30 degrees at any time. If the compressor unit is suspected of being tilted (during transport, for example), allow it to remain upright overnight before operating it.

Refrigerant Hoses Description

The detector assembly, the hoses, and the compressor unit are all precharged at the factory. These units may be connected together at the factory or they may be shipped separated. All fittings are self-sealing (Aeroquip Couplings) which are designed to be attached and detached without loss of refrigerant. Care must be exercised, however, as improper procedures can lead to refrigerant leaks.

Vibration Damper

A vibration damper (lead block) may be supplied to stop compressor vibration from getting to the cold head. If needed, attach the damper to the hoses near the cold head.

Unpacking, Inspection and Pressure Check

The Cryolectric II is shipped from the factory in one box. The compressor is at the bottom and the detector chamber is on top. The two are separated by foam packing material. The gas lines may or may not be connected. Lift the detector chamber and the compressor out of the box together if they are attached. Be careful not to stress the gas lines and keep the compressor unit upright at all times.

Inspect all components for damage. If there is physical damage to any of the components notify Canberra immediately.

WARNING When handling pressurized gas lines and other pressurized equipment always use eye protection. Keep the unit away from flames and sparks until it can be determined that there are no refrigerant leaks.

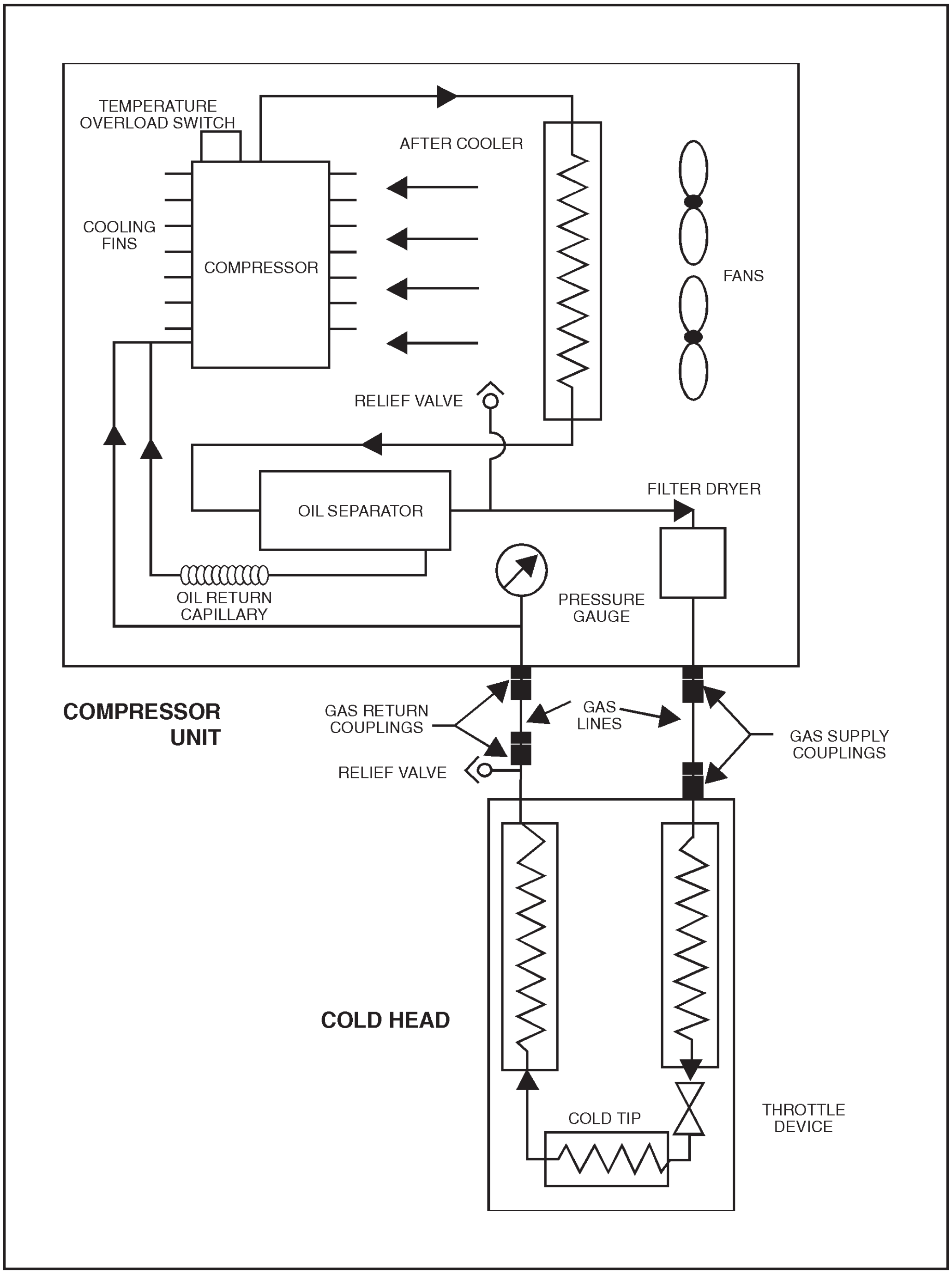


Figure 31 Cryolectric II Schematic Diagram

CAUTION Do not tip the compressor more than 30 degrees to avoid oil flow into places it doesn't belong. This can cause system contamination and compressor failure. When received it is best to allow the compressor unit to sit upright and level overnight so that any oil that may have been displaced during shipment can return to the compressor.

Note: Retain the shipping container for reuse in case the detector needs to be shipped again.

1. Check the pressure gauge on the rear of the compressor unit after all components have reached equilibrium temperature. The pressure should be within the range shown in Table 1 or Table 2.

2. The compressor unit will either be shipped from the factory set up for the voltage specified on the purchase order (in which case the voltage requirements will be listed on a tag attached to the power cord) or the compressor will have a voltage selection plug in the power connector assembly with the voltage shown in the window. The voltage choices are 100, 115, 220 and 240 V at 50-60 Hz. Remove this plug by pressing sideways on the detent. Reinstall this plug with the appropriate voltage shown in the window.

Table 1 System with Flex Lines

Gas Line Length (ft)	Gas Line Charge Pressure (psig)	Compressor Charge Press. (psig)*	System Charge Press. (psig)*
0 to 10	275	275	275
11 to 15	235	275	265
16 to 25	215	275	255
26 to 50	200	275	240

*Tolerance is +5 psig / –25 psig

Table 2 Systems with Copper Lines

Gas Line Length (ft)	Gas Line Charge Pressure (psig)	Compressor Charge Press. (psig)*	System Charge Press. (psig)*
0 to 25	275	275	275
26 to 40	250	275	270
41 to 60	225	275	260
61 to 85	210	275	250
86 to 120	200	275	240
121 to 150	190	275	235

Note: The pressure changes with ambient temperature. The data given in these tables applies at an ambient temperature of 21°C (70 °F). The pressure increases by about 1 psig/°F.

Assembly (Gas Line Attachment)

Ignore this section if the system was shipped from the factory with the gas lines attached to compressor and cold head.

WARNING When handling pressurized gas lines and other pressurized equipment, always wear eye protection.

WARNING Never apply heat to a pressurized gas line or other pressurized equipment.

CAUTION Do not crimp the gas lines. Repeated attempts to bend and reposition the gas lines can damage them.

Tools required

- 5/8 in. and ¾ in. open-end wrenches.
- torque wrench with ¾ in. crow-foot adapter

1. Decide whether the right angle hose end will be attached to the compressor unit or to the cold head. The right angle ends must be attached first, as shown in Figure 32, to ensure that they will exit the unit at the correct angle.

2. All fittings are equipped with protective dust plugs or caps. Do not remove these plugs and caps until you are ready to connect the fittings together.

3. Remove the screw beneath the plastic foot at the rear of the detector assembly and slide the shroud forward to reveal the fittings. For easier access to the fittings, particularly if the right angle fittings are used on the cold head, remove the rear plate of the carrier.

4. Place the system components in the same relative orientation (not necessarily the same places) that you wish them to have in operation. Remember the bend radius of the gas lines is about 6 inches (15 cm) minimum.

5. Remove the dust caps from the right angle hose ends and from the mating fittings.

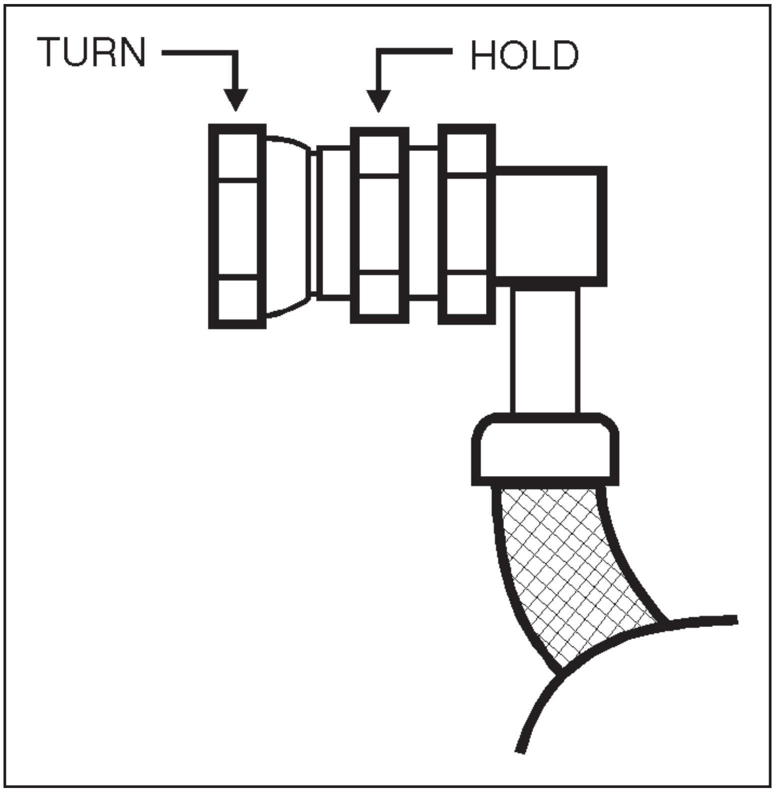


Figure 32 Connecting the Right Angle Hose End

WARNING Use caution when connecting and disconnecting the gas lines so that gas does not escape. The fittings must be properly aligned and unstressed for proper engagement. Work in a ventilated area that has no ignition sources nearby.

WARNING Use two wrenches when connecting or disconnecting gas line couplings to avoid loosening the bulkhead coupling. Gas pressure can project the coupling with considerable force.

CAUTION Check the condition of the gasket seal on the plug portion of each coupling. Be sure the gasket is in place and that both the fittings are clean and free of damage. Check the threads and remove any metal slivers or debris that could get into the seal.

Note: Keep the caps and plugs in a clean, dry container for future use. If the system is disassembled use them to protect the fittings.

6. Connect the supply and return hoses to their respective fittings using two wrenches to prevent the hose from turning. Observe the markings so as not to mix up the two lines. Tighten to 13-16 newton-meters (10-12 ft-lbs).

7. Dress the lines between the compressor and the detector assembly. Put the detector assembly in the orientation in which it will be used.

8. Remove the remaining hose plugs one at a time and attach the hoses to their respective fittings taking care not to twist the hoses. They should be relaxed - not under torsional stress. Use two wrenches to prevent twisting the hoses. Tighten to 13-16 newton-meters (10-12 ft-lbs).

9. Check the static charge pressure for the entire system and record on the first line in the chart below.

Pressure		
Date	**Static**	**Operational**

10. Lift the compressor unit and place it on 10-15 cm (4-6 in.) high blocks at either end to provide access to the bottom of the unit. (Do not tilt the compressor.) Locate three bolts heads in the bottom of the housing near the left side and remove these bolts which secure the compressor during shipment. Save these bolts for reuse in case the compressor unit is shipped again. Remove the blocks and lower the compressor to the floor.

11. The system is now ready for operation. Observe the space requirements necessary for proper ventilation of the compressor. (Figure 30 on page 37)

Operation

1. Plug the power cord into a power outlet with the appropriate voltage and current rating. To avoid ground loops this outlet should be the same one that serves the signal processing electronics which will be used with this detector.

2. Turn on the compressor.

3. After the prescribed cool-down time (see the serial/number tag on the detector), begin checking the detector in accordance with the detector instructions.

4. After several hours of operation record the operational pressure. Check it periodically for several weeks to ensure there are no leaks. The operational pressure is normally around zero psig.

Operation with Power Controller

Electrically powered detectors are subject to partial warm-up when power outages occur. The Cryolectric II will restart automatically when power is restored following an outage. If the power has been off for more than a few minutes the detector may have started to warm-up and if it is re-cooled before it warms up completely, there is a chance that the leakage current will be excessive because of outgassing of the molecular sieve and the adsorption of the outgassing product on the detector surfaces.

The fix for this condition is a complete warm-up followed by re-cooling. The Model 7901-1 Power Controller is an option which prevents automatic restart if power is off for more than a selected interval (3-30 minutes). With this option, no operator intervention is required for short outages, but for long outages manual restart is required. This means that partial warm-ups can be avoided.

Follow the instructions supplied with the Power Controller if it is to be used with the system.

Filter/Dryer

It is highly recommended that an optional Filter /Dryer be used to prevent refrigerant contamination. This will ensure more stable temperatures and less down time. Instructions are provided with the unit.

Stopping and Restarting the Compressor

Turn the power switch to off to stop the compressor.

WARNING During operation liquified refrigerant is present in the system. Never disconnect any part of the refrigerant containing system until the entire system has been turned off and has reached room temperature. Allow 8 hours for warm-up. Failure to do so can lead to over-pressurization and venting.

Like many refrigeration compressors, the 7903 many not restart properly after a short (<1 minute) power interruption. Restarting immediately may lead to a blown fuse inside the compressor or to a tripped circuit breaker near the power selector on the rear of the compressor. Refer to Figure 34, the compressor wiring diagram.

Maintenance

Typical maintenance requirements are given below.

Compressor

If the compressor is operated in a dirty environment, however, dust may accumulate on the grilles at the rear and side and the condenser may also become clogged. If this happens, use a vacuum cleaner with a brush nozzle and carefully remove the dust and dirt. Be sure the compressor is turned off and unplugged before opening the case.

Cold Head

The cold head has no moving parts and is thus expected to exhibit little wear in operation. The cold head/cryostat vacuum may deteriorate in time, however, which can prevent automatic restarting if the unit is shut down. See the next section, “Re-Evacuation Procedure” for the procedure to be used.

Incremental Gas Charge Procedure

There can be some loss of gas charge through the self-sealing fittings especially if the hoses are connected and disconnected repeatedly. If the static pressure falls below the levels (including the tolerance) listed in Tables 1 or 2, it may be necessary to replenish the refrigerant.

A simple means of topping off systems with refrigerant is available from Canberra or from the refrigerator manufacturer, Polycold, Inc. Instructions and 500 cc disposable bottles of the refrigerant with the proper fitting are available from Canberra or from the refrigerator manufacturer. If the static system pressure is above 1400 kPa (200 psig) one or two of these bottles will bring the system pressure back into the operating range.

A two-bottle kit including instructions and MSDS can be ordered by part number 25040-14. The suffix (-14) designates the type of gas. In the unlikely event that your system is charged with a different gas, the gas type is identified on a tag attached to the gas fittings at the time of delivery.

Filter/Dryer

Replace if cooling becomes erratic.

Re-evacuation Procedure

Vacuum is maintained in the Cryolectric II cold head/detector chamber by means of molecular sieves, a material which adsorbs gas molecules when cooled. Although the capacity of the molecular sieves is quite large, it releases most of the adsorbed gas when allowed to warm up as when the unit is turned off. If this gas load is excessive, the Cryolectric II may not cool down again automatically when power is restored.

Depending on the detector size, the outgassing rate, the time since manufacture, the presence of a highly conductive gas, such as helium, in the environment, and other factors, the detector may require re-evacuation. In most cases the period between re-evacuations is expected to be greater than 12 months.

Re-evacuation can be done in the field by qualified personnel using the equipment and procedures described here.

Equipment Required

This describes the minimum requirements for a vacuum pump station (Figure 33). A high vacuum pump is preferred if one is available. An LN_2 trapped helium leak detector is an ideal pump station.

- Two-stage rotary vane mechanical vacuum pump
    1. Pump speed > 25 liters/minute (0.9 cfm).
    2. Ultimate pressure < 400 kPa (3 X 10-3 torr).
- Foreline filter (to reduce backstreaming)
- Thermocouple vacuum gauge
- Flexible metal hose and manifold assembly

Evacuation Procedure

To evacuate the Cryolectric II cold head/detector chamber, follow this procedure.

1. Allow the detector to warm up completely by turning off power to the compressor 24 hours before working on the system.
2. Locate the evacuation port. It is about 16 mm diameter by 16 mm long (5/8 in. x 5/8 in.) with a red silicone rubber cover. Use port on the side of the cold head if there is one. Otherwise, use the port located on the flange behind the preamplifier. To access this port, remove the preamplifier from the head.
3. Removing the Preamplifier (only if the side port is not available).
    a. Remove the two screws holding the preamplifier cover in place and remove the cover by sliding it carefully over the end cap.
    b. Disconnect the low voltage connector (black multi-pin) and the H.V. connector (gray single-pin) from the cryostat feedthroughs.

   c. Using a hex key wrench, remove the two screws holding the preamplifier to the cryostat body. These screws are located beneath the preamplifier.

   d. Using a hex key wrench, remove the two screws holding the rear panel/clamp together.

   e. Now the preamplifier assembly can be removed.

4. Remove the evacuation port cover and clean the vacuum grease out of the port area using lint-free paper towels or swabs.

5. Attach the valve operator to the evacuation port and tighten. Do not engage the valve plug at this time.

6. With the vacuum pump connected to the valve operator by means of the flexible metal hose, as shown in Figure 33, turn on the vacuum pump and the vacuum gauge.

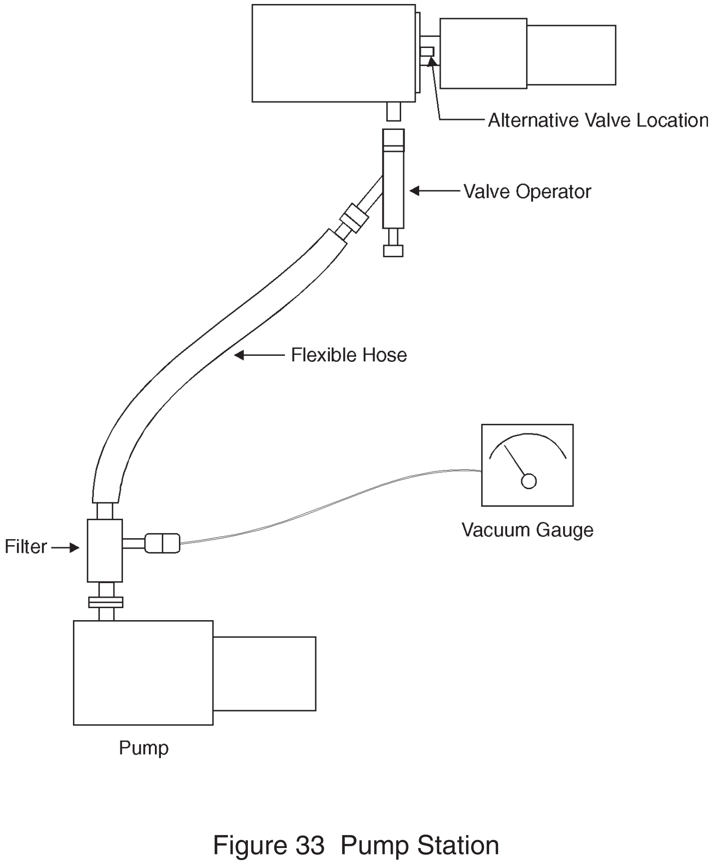


Figure 33 Pump Station

7. Observe the pressure on the vacuum gauge drop from atmospheric pressure to near zero. This should happen within five minutes or so. If it does not drop quickly or if it does not reach near zero levels, check all connections to achieve the correct performance before proceeding.

8. Engage the seal-off valve plug by pushing valve handle inward and turning it clockwise a few turns.

9. Withdraw the handle, pulling the plug out of the valve seat.

10. Watch the manifold pressure rise as the vacuum chamber is opened to the vacuum pump.

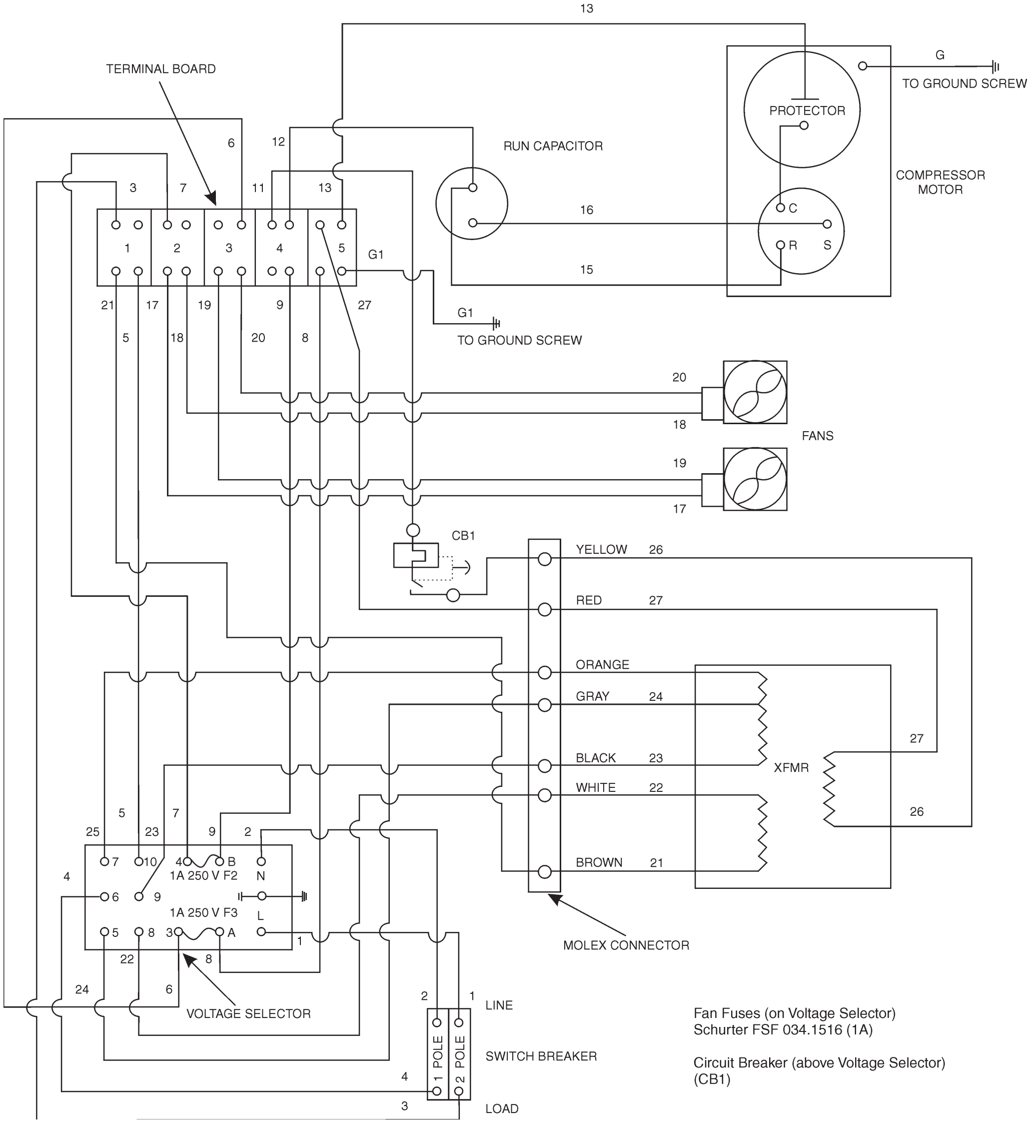
11. Continue pumping for two hours. The pumping station should exhibit no signs of a gas load after this amount of time. If it does there may be a leak requiring factory service.

12. When evacuation is complete, push the operator handle in to reseat the valve plug. Hold the handle in while turning it counterclockwise to release the plug, then pull the handle back out. (You must use your sense of touch to tell whether the plug has been released from the valve operator.)

13. Turn off the vacuum pump and vacuum gauge and detach the valve operator.

14. Fill the evacuation port with a small quantity of silicone vacuum grease.

15. Reassemble the system to restore operating conditions.



Fan Fuses (on Voltage Selector)
Schurter FSF 034.1516 (1A)

Circuit Breaker (above Voltage Selector)
(CB1)

Figure 34 Cryolectric II Compressor Wiring Diagram

4. Preamplifier Descriptions

There are several types and models of preamplifiers in use depending on the application. The typical usage is given in “Preamp Features” below.

The Preamplifier manual included in the back of this manual has information on the specific preamp used with this detector.

Preamp Features

Preamp Models	Significant Features	Detector Types
2002C, 2002CSL	Cooled FET Warm up/HV Inhibit	Coaxial, REGe, XtRa, LEGe
2008B	Pulsed Optical	Ultra-LEGe, LEGe
2002CP, 2002CPSL	Set up for low capacitance detectors	LEGe
2101P	Transistor Reset	Coaxial
2101N	Transistor Reset	REGe
2002CC	Convertible	Coaxial, REGe
2008BEF	Electronic Reset	Ultra-LeGe, LeGe

H.V. Inhibit Circuit Adjustment

If the H.V. Inhibit circuit trips and there are no other symptoms indicating a fault (low LN_2, high loss rate, coolness of cryostat, moisture accumulation, low compressor pressure (off), or high detector leakage current), the circuit may need adjustment. Portable detectors should be vertically upright for this adjustment.

Refer to LN Monitor Board Schematic Diagram.

With H.V. *off*, measure the voltage between pins 5 and 6 on comparator A1B. Adjust RV1 until the yellow LED comes on, then turn RV1 in the opposite direction until the green LED comes on. Continue until the voltage between pins 5 and 6 is 50 mV.

5. Unpacking and Repacking

When you first receive your detector, please follow the instructions in “Unpacking” for unpacking the detector. Be sure to save all packing materials for possible reshipment.

If you should ever need to return the detector to Canberra for service, please repack the detector for shipment following the instructions in "Packing for Re-Shipment”.

Unpacking

Remove the cryostat from the box by lifting it vertically by the Dewar handle(s). If the detector has been transported in a cold environment, allow it two hours to come to room temperature before proceeding. This will prevent undue moisture accumulation on sensitive parts of the system.

Remove the cord holding the dipstick to the Dewar and/or holding the plastic bag to the detector chamber. Remove the plastic bag covering the detector chamber and inspect the entire detector system for mechanical damage.

If there is evidence of shipping damage contact the carrier, file a claim for damages, and notify Canberra of the nature and extent of the damage.

Horizontal dipstick cryostats have a plastic foam pillow which cradles the horizontal detector chamber to prevent bending of the dipstick during shipment. This pillow can be removed by cutting the cord or tape securing it to the Dewar’s neck.

Packing for Re-shipment

Keep all of the packing materials with the original shipping container in case the detector should be shipped to the factory for service or elsewhere for use. We cannot be responsible for shipping damage incurred after initial delivery of the detector or if a detector is returned for in warranty service with improper packing.

Detectors properly prepared for shipment are shown in Figure 35.

Dipstick cryostats may be returned to the factory without a Dewar. In this case the dipstick must be packed carefully so it will not be damaged in shipment. Even then there is a greater chance of shipping damage because the smaller packages tend to be handled with less care, and the preferred upright orientation will not be respected.

Pack Detectors Warm

Allow detectors to warm up completely before packing in well-insulated containers. Foam in-place packing material is an excellent insulator. Cold detectors packed in this material are so well insulated that the external cryostat hardware including the sensitive vacuum seals may be cooled to a very low temperature as heat is transferred to the cold inner hardware. If the packing container is well ventilated, this should not be a problem.

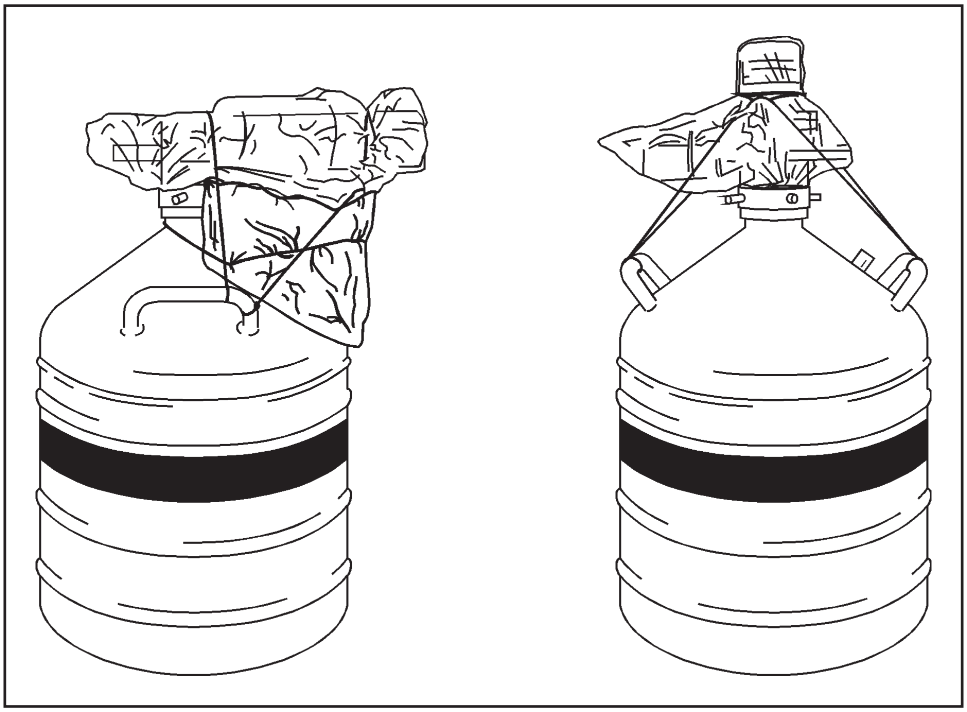


Figure 35 Detectors Prepared for Shipment

6. Filling with Liquid Nitrogen (LN$_2$)

Before attempting to fill your detector with liquid nitrogen, be sure to read and follow the Warnings and Cautionary Statements listed in “Handling Liquid Nitrogen”.

The remaining subsections deal with filling a specific type of cryostat:

- Dipstick Cryostats – refer to page 56.
- Integral Cryostats – refer to page 57.
- Multi-Attitude Cryostats – refer to page 58.

The section Temperature Cycling, on page 62, describes the precautions to be taken if it becomes necessary to temperature cycle your detector.

Handling Liquid Nitrogen

Always handle liquid nitrogen carefully! Its extremely low temperature can produce frostbite!

WARNING!

Liquid nitrogen’s temperature is minus 196 °C (77 °K).

Contact with exposed skin can cause severe frostbite!

When spilled on a surface, the LN$_2$ tends to cover the surface completely and intimately and therefore to rapidly cool a large area.

Protect Your Eyes

The gas issuing from the liquid nitrogen is also extremely cold and can produce frostbite. Delicate tissues such as those of the eyes can be damaged by an exposure to these cold gases which is too brief to affect the skin of the hands or face.

Stand clear of boiling and splashing liquid and its issuing gas. Boiling and splashing always occur when charging a warm container or when inserting warm objects into the liquid. Always perform these operations slowly to minimize boiling and splashing.

Never allow any unprotected part of your body to touch uninsulated pipes or vessels containing liquefied nitrogen: the extremely cold metal may stick fast and tear the flesh when you attempt to pull away from it.

Use tongs to withdraw objects immersed in liquid and handle the tongs and the object carefully. In addition to the hazard of frostbite or skin sticking to cold materials, objects that are soft and pliable at room temperatures usually become very hard and brittle at the temperatures of these liquids and are very easily broken.

Wear Protective Clothing

Protect your eyes with a face shield or safety goggles (safety spectacles without side shields do not give adequate protection).

Always wear gloves when handling anything that is, or may have been, in contact with liquid. Insulated gloves are recommended but leather gloves may also be used. The gloves should fit loosely so that they can be thrown off quickly if liquid should spill or splash into them.

When handling liquids in open containers, it is advisable to wear high-top shoes. Trousers (which should be cuffless if possible) should be worn outside the shoes.

Ventilate the Area

Always handle liquid nitrogen in well-ventilated areas to prevent excessive concentrations of gas.

WARNING!

High concentrations of nitrogen gas in an enclosed area can cause suffocation!

Handle liquid nitrogen only in a well ventilated area.

Never dispose of liquid in confined areas or places where others may enter. Excessive amounts of nitrogen gas in the air reduce the concentration of oxygen and can cause asphyxiation. The gas being colorless, odorless and tasteless cannot be detected by the human senses and will be inhaled as if it were air.

Cloudy Vapor

The cloudy vapor that appears when a liquefied gas is exposed to the air is condensed moisture, not the gas itself. The issuing gas is invisible.

Dipstick Cryostats

Canberra dipstick cryostats are equipped with a fill and vent collar which enables them to be filled without moving the detector chamber. The modern version of this collar is made of silicone rubber which forms a gas-tight seal between the Dewar and detector chamber. The collar is fitted with two identical, thin wall, 9.5 mm ($\frac{3}{8}$ in.) diameter stainless steel tubes, either of which may be used for filling from a storage Dewar at medium pressure, 40-80 kPa (gage) (6-12 psig). The unused tube serves as a vent for N2 gas that is evaporated during the filling operation. This tube can be fitted with a hose to direct the gas away from the sensitive preamplifier and electrical feedthrough area.

The collar is also equipped with a port for an LN2 level sensor, such as that used with a Model 1786 LN_2 Monitor.

Transfer of LN_2 from a Dewar to a cryostat by means of a low pressure withdrawal device is illustrated in Figure 36.

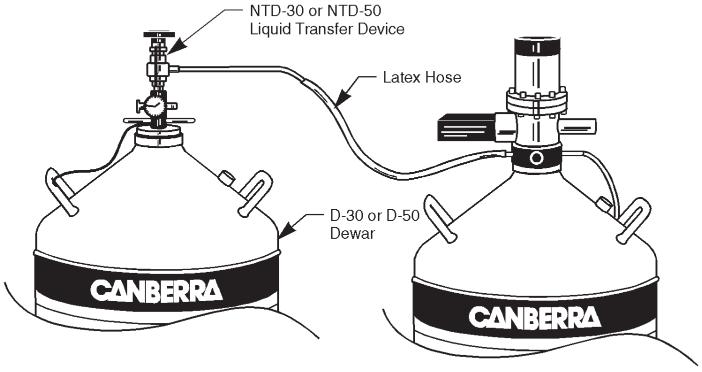


Figure 36 LN_2 Transfer

Warming Up the Dipstick Detector

Should a dipstick detector require a warm up cycle, it is best to remove the dipstick from the Dewar. Loosen the clamp ring if the cryostat is so equipped and slide the dipstick carefully upward. Keep the dipstick either vertically upright or horizontal at all times. *Never* invert a dipstick cryostat.

If the Dewar is to be emptied, first remove the silicone rubber collar and then pour the contents of the Dewar into another LN_2 container.

Check for and remove any water that may appear in the bottom of the Dewar after it warms to room temperature. The Dewar will warm much more quickly if it is turned on its side to establish convection currents.

A dipstick detector will usually warm up in 12-16 hours (overnight) if it is removed from its Dewar first.

Integral Cryostats

Integral cryostats generally have an open neck tube of 40-65 mm (1.5 to 2.5 in.) diameter. Liquid nitrogen can thus be poured directly into these cryostats or can be pumped in from a pressurized container. Be careful not to spill LN_2 on the detector chamber or the preamplifier as components therein may be damaged by the extreme cold temperatures.

The neck-plug should be replaced immediately after refilling as it will prevent ice formation in the neck tube, it will keep foreign matter from falling in, and it will increase LN_2 holding time by forcing the cold LN_2 boil-off gases to the neck-tube surface, thereby reducing heat loss by neck-tube conduction.

If an external LN_2 monitor is used with a integral cryostat, the sensor is usually wired to a BNC connector located in the neck plug. A check on the LN_2 monitor can be made by holding the LN_2 sensor tip just above liquid level until a response is obtained. The monitor must react with the sensor inside the Dewar – pulling it out to verify operation cannot guarantee proper operation because of the extreme difference in temperatures.

Warming Up the Integral Detector

Integral cryostats may be warmed up by first pouring the contents into another LN_2 container and then turning the Dewar on its side without the neck plug. In this orientation most integrals will warm up within 24 hours.

Check carefully and remove any water that may appear in the bottom of the warm Dewar. If allowed to remain, the resultant ice can cause hissing and noise in the detector system.

Multi-Attitude Cryostats (MACs)

The MAC should be filled from a source of LN_2 which is at low pressure: ≤165 kPa (gage) (24 psig). A D-50 Dewar equipped with a low pressure withdrawal device (Model NTD-50) is available from Canberra for this purpose. Standalone 160-240 liter pressurized Dewars are also available.

If liquid at high pressure is used, the vaporization that occurs when the pressure is reduced to atmospheric (flash-off) will cause a substantial amount of LN_2 to be blown through the MAC and it will be difficult if not impossible to fill it to capacity. In addition, the Dewar inner could be damaged by high pressure transfer of LN_2.

Fill and Vent Connections

Dual Port Models

The fill and vent connections are 1/8 NPT male fittings (see Figure 37). While hard fittings can be used to transfer the LN_2, it is more convenient to use flexible latex hose which simply stretches over the fittings. The hose can be forced over the hex nut and secured on both sides of the hex nut by a nylon tie-wrap or cord. The hose must not cover the entire nipple as this can lead to excess cooling of the Dewar external hardware.

CAUTION

The Fill and Vent Ports can be damaged by excessive force when attaching or detaching hoses with metal fittings.

Always use a wrench to prevent excess torque on the nipple. See Figure 37.

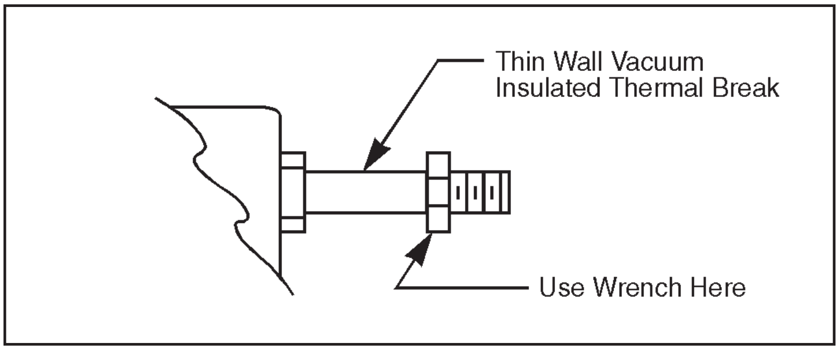


Figure 37 Fill/Vent Port Connector

The transfer line should be as short as practical, no more than 1 m (3 feet) is ideal. It should be kept away from the detector and preamplifier chamber to prevent moisture accumulation on these delicate parts. The transfer line should be insulated for the same reasons.

The vent line should be directed away from personnel to avoid injury. It should be sufficiently long to vaporize any liquid blow-by or overflow, or it should be directed into a reservoir which can contain it safely. A Dewar is a satisfactory reservoir.

Filling Orientation

The fill and vent ports exchange roles depending on the orientation of the detector. The given designators apply to the unit when it is oriented horizontally, which is recommended. When the fill and vent ports are pointing downward, the given designations also apply. However, when the ports point upward, the roles are reversed, i.e., the port designated vent is the fill port and vice versa. See Figure 38 for construction details.

Please note that the MAC does not have exactly the same LN_2 capacity in every orientation, so some spillage can occur when the unit is filled in one orientation and changed to another. This is normal.

The capacity is usually greater when the MAC is horizontal. If filled in this orientation, you can expect to lose some liquid when changing to uplooking or downlooking orientations.

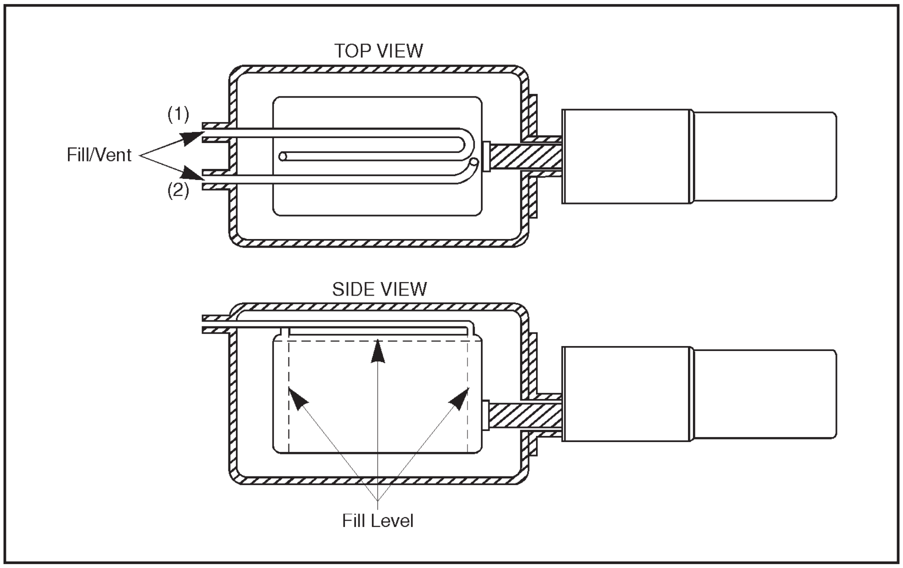


Figure 38 MAC Port Construction

Port Cover

Another effect to be aware of is percolation, which can occur if the MAC is jarred or shaken. To reduce this effect and to decrease the LN_2 loss rate in some orientations, MACs are equipped with a port cover which blocks the fill port. The cover also directs the vent gas away from the vent port, thus preventing snow or ice formation on the vent port. The right hand port should be blocked when the detector is down looking and the left hand port should be blocked when the detector is up looking. A nipple and hose are provided to direct nitrogen gas and spillover liquid away from the user.

Install the cover in the appropriate orientation when the detector is horizontal, then change the orientation. Spillage and loss rate will be minimized if you do this properly.

Single Port Models

Refer to Figure 23 on page 26 for an illustration of a single port cryostat. A single neck tube provides both fill and vent functions for this model. The cryostat includes a plug having a pressure relief valve. A secondary fixed pressure relief valve is located on the port boss.

Single port models can be pressure filled by using a 1/4 - 3/8 (6 - 9 mm) diameter tube inserted a depth of about one-half the Dewar length. An optional fill adapter is available from Canberra.

Canberra also offers a 30 liter Gravity- Feed supply Dewar for single port MACs and Big MACs. This unit provides a convenient means of keeping detectors filled and ready for use.

Cool-Down Time

Typical detectors will cool down sufficiently within 2-6 hours of filling. The LN_2 loss rate will be extraordinarily high during the cool-down period so the MAC should be topped off with LN_2 a few hours after the initial filling.

Warming Up

Dual Port MAC

A MAC can be emptied quickly by orienting it with the end-cap pointing upwards and blocking the vent port. Under this condition the boil-off gases cannot escape and will thus force most of the LN_2 out of the fill port. Use a hose to direct the LN_2 into another LN_2 container.

Because the MAC cannot be emptied as readily as can an open-mouth Dewar, the natural time required for complete warm up is quite long. To ensure that the detector undergoes a complete warm-up cycle once warm up has begun, purge the detector with dry nitrogen gas.

Do *not* purge with air or with N_2 having significant water vapor content.

To do this, the same considerations should be given to the fill and vent ports as outlined in “Fill and Vent Connection” on page 58. However, the dry nitrogen gas should be forced into the vent port rather than the fill port. An overnight purge at 3 to 5 liters/minute should be sufficient to complete the warm-up cycle. Without a purge warm up may take up to 48 hours.

Single Port MAC

The single port MAC cannot be emptied quickly because the LN_2 will not flow out regardless of the orientation. It can be forced out by inserting a 1/4 - 3/8 inch diameter tube to the full depth of the Dewar and sealing the joint between the tube and the port with the port facing upward. The pressure build-up will force the LN_2 out of the Dewar. Consult the factory for a custom-made device if needed.

Temperature Cycling

Ge detectors, unlike Ge(Li) detectors which fail on warm up, can withstand repeated and prolonged periods of room temperature storage. While it is only reasonable to expect a detector to last longer if it is kept cold at all times, with certain specific and important precautions, no serious compromise in life time will result from temperature cycling.

Temperature cycling can even be a remedy for certain problems that may occur in the use of Ge detectors. The important precautions are given below.

Turn Bias Off During Warm Up

A detector should not be allowed to warm up with bias applied. When a detector warms up, the molecular sieves outgas and pressure within the cryostat rises. If electrical discharge occurs as a result of this increased pressure, the sensitive detector surfaces and the preamplifier can be damaged. A Canberra Model 1786 LN_2 Monitor can be used to disable the bias supply when the LN_2 drops below a satisfactory level. Some detectors are equipped with a built-in Warmup Sensor/HV Inhibit circuit which provides an inhibit signal to the HV power supply.

Complete Warm Up

It can take more than 24 hours for a detector to warm up completely and several hours to cool down thoroughly. When a warm-up cycle has begun, the detector should be allowed to warm up fully before being cooled down again. Otherwise some of the residual gases that are absorbed by the detector surfaces may be frozen there. If the detector warms up completely, the molecular sieves will tend to pump the system clean when the detector is recooled. If a detector is inadvertently cooled after partial warm up, a full warm up cycle will likely restore any lost performance. A complete temperature cycle is often prescribed as a fix for performance problems.

Dipstick cryostats (removed from Dewar), Integral cryostats (on side without neck plug), and electrically cooled cryostats (power off) will warm up in 12-24 hours. MACs may take longer, especially if the LN_2 is not purged completely at the start.

Prevent Moisture Accumulation

As noted in “Turn Bias Off During Warm Up” on page 62, when a detector warms up, the molecular sieves which maintain vacuum in the cryostat outgas and pressure within the cryostat rises. Under this condition, the outside of the cryostat will be cooled by the internal hardware until it, too, reaches room temperature. Therefore, it is normal for a cryostat to be cold during warm up and to a lesser extent upon cool down (on cool down the molecular sieves usually get cold and begin pumping before the internal hardware cools down fully).

Moisture which accumulates during temperature cycling should be removed. If humidity in the environment is excessive, moisture may accumulate during normal operation. Environmental humidity should be decreased to prevent both the short term (leakage current in HV circuit/feedthrough) and long term (corrosion) effects of moisture accumulation.

Precautions – Vacuum Failure

When a cryostat exhibits signs of catastrophic vacuum failure, such as heavy moisture or ice formation on the surfaces, extremely high LN_2 loss rate, and so forth, the adsorber (molecular sieves or charcoal), which normally maintains vacuum, may be virtually saturated.

When allowed to warm up, the adsorber will outgas and the pressure in the cryostat will rise. Canberra cryostats and Dewars sold by Canberra have a pressure relieving seal-off valve which is designed to prevent dangerous levels of pressurization.

The pressure rise, however, can be high enough to break or break loose beryllium windows and/or end-caps. A frozen or ice clogged seal-off valve may fail to relieve pressure, resulting in dangerous levels of pressurization.

Precautions

For these reasons use extreme caution in handling cryostats with symptoms of catastrophic vacuum failure. When you do have to handle them, take the following precautions:

1. Stop using the failed unit immediately. Do not allow it to warm up until additional steps are taken to prevent damage or injury due to overpressurization.

2. Drape a heavy towel or blanket over the end-cap and point the end-cap away from personnel and equipment. If the unit is in a shield, close the shield door.

3. Call the factory for further instructions if the incident occurs during working hours.

4. If it is impractical to keep the unit cold until advice is available from the factory, keep the end-cap covered with a heavy towel or blanket and place the unit in a restricted area in a container (corrugated cardboard, for example). If the unit is in a shield, let it warm up in the shield with the door closed.

5. After the unit has warmed up, cautiously check for overpressurization (outwardly bulging end-caps or windows). If there are no signs of pressure, the unit may be shipped to the factory for repair. Consult the factory for shipping information.

7. Setup and Test

The significant specifications of Ge detectors are few in number, and detectors are not complex instruments, so it is possible to verify the performance of a detector with relative ease – provided that the proper equipment is available and correct procedures are used. The equipment used in conjunction with a Ge detector must be of the right type and in good working order to ensure good system performance. Likewise, the procedures must reflect the standards of the manufacturer or there will be unexplained differences in performance between tests in the factory and in the field.

Equipment Required

The Setup and Test section assumes that the test equipment listed here is available. For efficiency measurements, the ^{60}Co source should be calibrated to NIST standards.

- Ge Detector, Cryostat, and Preamplifier
- NIM Bin and Power Supply – Model 2000 or Equivalent
- Amplifier – Model 2026 or Equivalent
- MCA – with 8192 ADC Range, 4096 Memory, and Digital Readout
- Detector Bias Supply – Model 3106D, or Equivalent or Model 3102D for bias of 2000 volts or less.
- Voltmeter (Analog or 3-1/2 digit)
- Oscilloscope – 50 MHz bandwidth, 5 mV/div.
- Sources as in Table 3

Table 3 Test Sources

Detector Type	^{60}Co	^{57}C0	^{55}Fe	^{109}Cd
Coaxial	P	S		
REGe	P	S		S
XtRa	P	S		S
LEGe		S	P	
Ultra-LEGe		S	P	
Well	P	S		
BEGe	S	P		

Where P = Primary source and S = Secondary source

Test Configuration

Connect the equipment as shown in Figure 39. Use the same electrical circuit for all ac power to the system to avoid ground loops. The Bias Supply and Amplifier should be located at opposite ends of the NIM Bin, if possible, to minimize cross talk between them. Use the amplifier rear panel output (Unipolar) if the cable between Amplifier and MCA is more than 1 m (3 ft) long. The front panel output may be used with long cables only if the cable is terminated at the MCA with a 93 ohm load. Otherwise, it may oscillate.

To prevent ground loop noise from entering the system, the H.V. Input and H.V. Inhibit Output grounds are isolated. To maintain this isolation on 2002CC and 2002CSL preamps, slip the flexible sleeving included with the preamp over the BNC and SHV connector shells after connecting the cables.

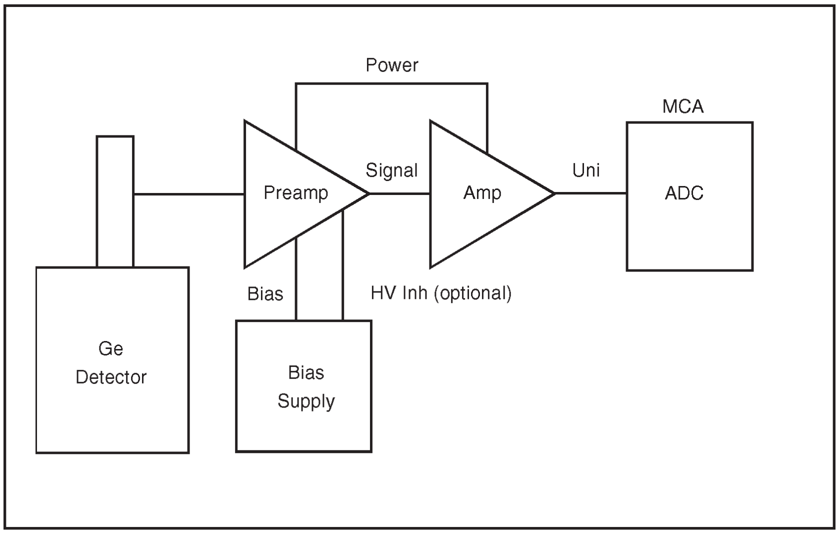


Figure 39 Test Equipment Setup

Instrument Setting

Refer to Table 4 for typical test setup settings for measuring the resolution of various detector types. Amplifier time constants for particular detectors may differ from those suggested here. Consult the detector test data sheet for specifics.

Restorer controls are normally set alike for all detector types, as follows:

Rate - AUTO

Mode - SYM

Threshold - AUTO

Consult the Amplifier Instruction Manual for further information.

Table 4 Test Setup for Resolution Measurements

Detector Type	Typical Preamp	Peak Energy	H.V. Polar.	Input* Polar.	Time Constant	ADC Gain	ADC Offset	Mem-ory	Approx. Energy/ Channel
Small LEGe	PO	5.9 keV	Neg	Pos	12 µs	2048	0	1024	7 eV
Small LEGe	RC	5.9 keV	Neg	Neg	4 µs	2048	0	1024	7 eV
LEGe	PO	122 keV	Neg	Pos	12 µs	8192	1536	1024	54 eV
Small LEGe	RC	122 keV	Neg	Neg	4 µs	8192	1536	1024	54 eV
Large LEGe	RC	5.9 keV	See data sheet		4 µs	2048	0	1024	7 eV
Large LEGe	RC	122 keV	See data sheet		4 µs	8192	1536	1024	54 eV
Coaxial	RC	122 keV	Pos	Pos	4-6 µs	8192	512	1024	91 eV
Coaxial	RC	1332 keV	Pos	Pos	4-6 µs	8192	6144	2048	163 eV
REGe	RC	122 keV	Neg	Neg	4-6 µs	8192	512	1024	91 eV
REGe	RC	1332 keV	Neg	Neg	4-6 µs	8192	6144	2048	163 eV
XtRa	RC	22/88 keV	Pos	Pos	4-6 µs	8192	0	1024	40 eV
XtRa	RC	1332 keV	Pos	Pos	4-6 µs	8192	6144	2048	163 eV
Well	RC	122 keV	Pos	Pos	2-6 µs	8192	512	1024	91 eV
Well	RC	1332 keV	Pos	Pos	2-6 µs	8192	6144	2048	163 eV
BEGe	RC	5.9 keV	See data sheet		4-8 µs	2048	0	1024	7 eV
BEGe	RC	122 keV	See data sheet		4-8 µs	8192	1536	1024	54 eV
BEGe	RC	1332 keV	See data sheet		4-8 µs	8192	6144	2048	163 eV

*Detectors with TRPs use opposite polarity.

Applying the Bias Voltage (RC Preamplifier)

Observe the amplifier output with the oscilloscope. The noise should be several hundred millivolts peak to peak, with no detector bias applied. (Use the cable that normally goes to the MCA rather than an oscilloscope probe).

Monitor the test point on the rear panel of the preamplifier with the voltmeter. It should read approximately minus (–) 1 to minus (–) 2 volts dc. Do not confuse the test input (BNC) with the test point.

Increase bias to 100 volts. The noise at the amplifier output should decrease somewhat, and the voltmeter should momentarily change before returning to its initial reading. For Detectors using positive bias, the Test Point voltage change will go negative and for detectors using negative bias, the Test Point voltage will go positive. Increase the bias now to 500 volts. The noise should be further reduced and the voltmeter should respond exactly as before.

Increase the bias in 500 volt steps to the recommended value, observing the behavior of the amplifier signal and voltmeter after each increment. The noise should remain constant after the depletion voltage is reached. The voltage at the test point should approximate that given on the test data sheet in the front of the manual.

Applying the Bias Voltage (Reset Preamplifier)

Observe the preamplifier output with the oscilloscope. If the preamplifier output is connected to the rear amplifier input, the front panel input can be connected to the oscilloscope.

With no bias applied (HV supply off), the preamp output should be about minus (–) 6 to minus (–) 12 volts for detectors requiring negative bias and plus (+) 6 to plus (+) 12 volts for detectors requiring positive bias.

Apply about 50 volts bias. The preamp output should be a sawtooth pattern, with a period stretching gradually to a second or more. Figure 40 shows the output signal for detectors having negative bias. The sawtooth is inverted for detectors requiring positive bias and for certain other preamplifier types.

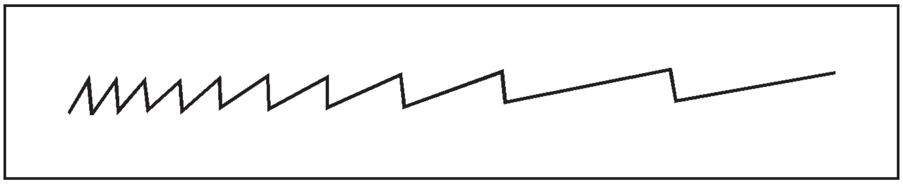


Figure 40 Sawtooth Output Signal

Increase bias gradually to the recommended operating voltage. The sawtooth pattern should repeat itself after every increment of bias. Compare the period of the sawtooth to the value shown on the test data sheet.

Fine Tuning the Amplifier

Using the amplifier settings given in Table 4 on page 67, introduce the source to the detector with the protective plastic cap removed. Observe the test voltage change if the preamp is RC type. If the preamp is the reset type, the sawtooth frequency will increase. Adjust the amplifier's coarse and fine gains to give approximately 8 volt pulses at the output.

The Pole/Zero control must be fully CCW for reset preamplifiers. With an RC preamplifier, adjust the Pole/Zero control to give the pulse shape illustrated in Figure 41.

Many oscilloscopes exhibit overload recovery problems when they are used with the high gain necessary to set Pole/Zero correctly. A Schottky clamp (Model LB1502) is available from Canberra to prevent this problem. The Schottky clamp is built into the Model 1510 Integrated Signal Processor and the Models 2025 and 2026 Spectroscopy Amplifiers.

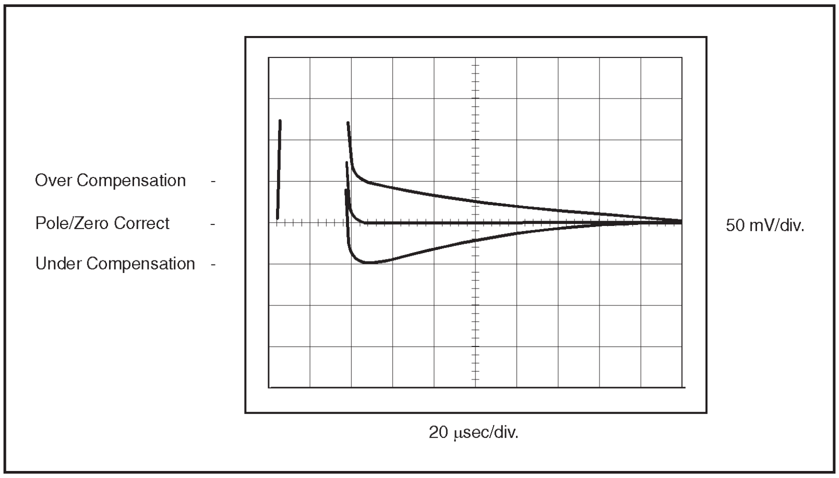


Figure 41 Pole/Zero Compensation

The Schottky clamp circuit is shown in Figure 42 for those who want to make their own.

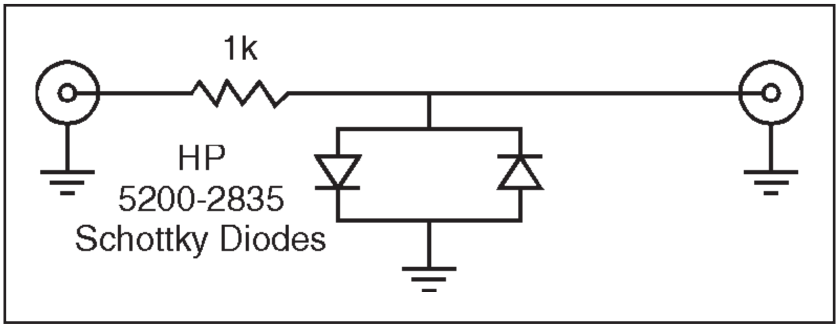


Figure 42 Schottky Clamp Circuit

Accumulating a Spectrum

With the amplifier and ADC settings, as shown in Table 4 on page 67, start a collect cycle in the MCA. Adjust the amplifier gain so that the peaks of interest are to the far right of the display (within 100 channels of the top of the memory group displayed).

After gain adjustments are complete, clear the MCA memory and accumulate a spectrum with approximately 10 000 counts in the peak channel of the peak of interest.

Calculating Resolution

Table 5 lists the peak energies of radioisotopes commonly used in calculating detector resolution.

Table 5 Peak Energies of Common Isotopes

Isotope	Peak Energies (keV)		ΔE
^{55}Fe	5.894	6.489	595.0 eV
^{57}Co	6.489	14.44	
	122.06	136.47	14.44 keV
^{109}Cd	22.1	88.0	65.9 keV
^{60}Co	1173.2	1332.5	159.30 keV

To determine the detector's resolution, collect several thousand counts in the 1332 keV peak of ^{60}Co. The procedure is identical for other radioisotopes and lines.

To determine the conversion factor, the energy per channel, find the peak centroids of the 1173.2 keV and 1332.5 keV peaks by expanding each region individually, placing the cursor by eye and recording the center channel of each peak.

Then divide the difference in keV between the two peaks by the number of channels between the peaks:

$$\frac{(1332.5 - 1173.2)\ \text{keV}}{\text{Seperation in channels(N)}} = \frac{159.3\ \text{keV}}{\text{N channel}}$$

Using the setting for the ADC previously described, the conversion factor should be in the range of 0.16 keV/channel. If it isn't, then something is set up improperly.

In this example N = 977 channels, so the conversion factor is (159.3/977) = 0.163 eV/channel, which is in the proper range.

Expand or print out the 1332 keV peak and determine the number of channels FWHM and FWTM (Full Width at Half Maximum, and Full Width at Tenth Maximum) as in Table 6.

The peak is at channel 2011, with 8512 counts. Thus Half Maximum (HM) of the peak is 8512/2 = 4256 counts; but it's not likely that there will be a channel with exactly 4256 counts in it. Therefore, it will be necessary to interpolate the data, using the following information:

a. The peak channel. That is, the channel with 8512 counts.

b. The counts in the channel just below the FWHM point on the left side of the peak (counts < 4256).

c. The counts in the channel at or just above the FWHM point on the left side of the peak (counts ≥ 4256).

d. The number of the channel in 'c' (just above FWHM on the left side of the peak).

e. The counts in the channel at or just above the FWHM point on the right side of the peak (counts ≥ 4256).

f. The number of the channel in 'e' (just above FWHM on the right side of the peak).

g. The counts in the channel just below the FWHM point on the right side of the peak (counts < 4256).

With this data, calculate the FWHM resolution as a decimal fraction using:

$$(\mathrm{f}-\mathrm{d})+\frac{\mathrm{c}-\mathrm{HM}}{\mathrm{e}-\mathrm{g}}+\frac{\mathrm{e}-\mathrm{HM}}{\mathrm{e}-\mathrm{g}}\times 0.163 \text{ keV per channel (the conversion factor)}$$

Table 6 1.33 MeV Peak Data

Channel	Data							
1992	44	51	39	61	101	156	239	423
2000	631	923	1384	1961	2898	3640	4766	5759
2008	6790	7569	8072	8512	8176	7678	6935	6152
2016	5081	4206	3305	2555	1742	1357	1012	691
2024	507	54	233	157	122	91	57	

To calculate:

Half Maximum = 8512 / 2 = 4256

$$\mathrm{FWHM} = 10 + \frac{4766 - 4256}{4766 - 3460} + \frac{5081 - 4256}{5081 - 4206} = 11.40 \text{ channels}$$

FWHM = 11.39 channels x 0.163 keV/channel = 1.686 keV

Tenth maximum is determined using the value:

$$\text{Tenth Maxium} = \frac{8512}{10} = 851$$

$$\mathrm{FWHM} = 10 + \frac{923 - 851}{923 - 631} + \frac{1012 - 851}{1012 - 691} = 21.75 \text{ channels}$$

FWTM = 21.75 channels x 0.163 keV per channel = 3.55 keV.

Peak/Compton Calculation

Coaxial detectors have Peak-to-Compton (P©) specifications which are dependent on resolution and efficiency as well as peak/shape, active to inactive material, charge collection, aspect ratio, etc.

The P© measurement must be made under the same conditions as the resolution measurements, since it uses peak height, not peak area in determining the value. The Compton Region used for P© calculations has been defined in IEEE Standard 325 for ^{60}Co as 1040 keV to 1096 keV. Therefore the formula for P© is as follows:

$$P / C = \frac{\text{Number of counts in highest channel of 1.33 MeV peak}}{\text{Average counts per channel}\left(1040 \text{ keV and } 1096 \text{ keV}\right)}$$

Efficiency Measurement

The efficiency measurement is done with the simplest, most straightforward MCA settings so as to minimize the ADC dead time (and attendant questions of live time correction) and effort required to integrate the peaks (if the MCA does not have such arithmetic capability). For these reasons, we use the 1024-channel range and memory size and no digital offset for this measurement.

Procedure

Place the source 25 cm away from the end-cap of the detector. The source should be on the end cap axis and no extraneous materials should be between the source and the detector. Appropriate allowances should be made for sources of substantial thickness.

Adjust the amplifier gain so that the 1332 keV peak is storing in the upper half of the 1024 channel memory group.

Collect a spectrum for 1000 seconds of live time. When collection is complete, integrate a symmetrical region around the 1.33 MeV peak about 10 channels wide.

Calculation

The relative efficiency is then obtained by the following formula.

$$\text{Relative efficiency} = \frac{N}{T} \times \frac{1}{R_s} \times \frac{1}{1.2 \times 10^{-3}} \times 100\%$$

Where:

N = Number of counts in 1.33 MeV peak

T = Preset Live Time

R_s = Source strength in Gamma-rays per second

$1.2 \text{ X } 10^{-3}$ = Efficiency of 3 by 3 NaI detector at 25 cm.

Background Spectrum

In conditions where background is high and might contribute to an error in the efficiency measurement a second spectrum should be accumulated in the absence of the calibrated source. The integral of background in the same region of interest about 1.33 MeV should be subtracted from the former integral before calculating the relative efficiency.

Source Calibration

NIST sources are calibrated in terms of nuclear transformations per second (NT/s) and for ^{60}Co, there is one 1.33 MeV photon emitted per nuclear transformation.

The source emission rate must be corrected for decay at least monthly, because the half life of ^{60}Co (5.27 years) implies a rate decrease of approximately 1.1% per month. Use the following formula to correct for source decay:

$$N_p = N_o \cdot e^{-(0.693)t/T}$$

Where:

N_p = present rate of emission

N_o = original rate of emission

t = elapsed time

T = half-life (5.27 years for ^{60}Co)

With a 3 in. x 3 in. NaI(TI) Detector

If no NIST or other suitable calibrated source is available, a 3 in. x 3 in. detector may be used for direct side-by-side comparisons of Ge detector efficiency.

If this approach is used, it is best to integrate the upper half of the 1.33 MeV peak and multiply by two to determine peak intensity for the NaI(TI) detector. This reduces the influence of the 1.17 MeV gamma rays on the 1.33 MeV peak.

8. Troubleshooting

There are a very limited number of Ge detector failure modes, the most common being cryostat vacuum loss. The number of things which can contribute to loss of resolution are almost limitless, however, and this is where careful diagnosis is most important.

The most important indication of the condition of a Ge detector itself, exclusive of preamplifier and other electronics problems, is reverse leakage current. The first stage of the preamplifier can be used as an electrometer to measure the leakage current of a detector.

Leakage Current must be measured as a first step in diagnosing detector performance problems!

Leakage Current Measurement

The most important indication of the condition of a Ge detector element is reverse leakage current. The so-called V-I curve can be determined by using the first stage of the preamplifier as an electrometer. A typical V-I curve for a coaxial detector is illustrated in Figure 43. The leakage current is relatively flat up to the recommended operating bias. The chart also shows the capacitance vs. bias curve, which flattens out as depletion is reached.

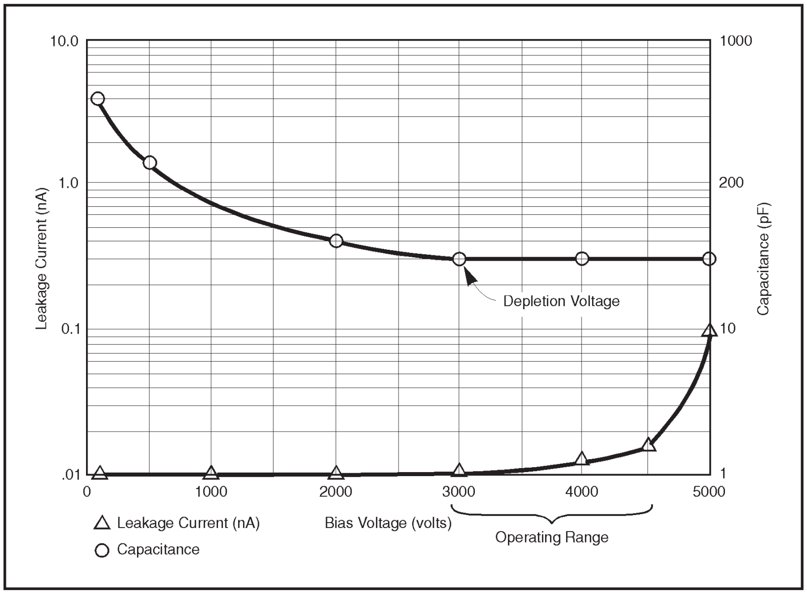


Figure 43 Typical Coaxial I-V and C-V Curves

Although the capacitance cannot be measured readily, you can observe reduced noise at the amplifier output as the capacitance is reduced with increasing bias. The noise should flatten at the point the detector becomes fully depleted provided that the leakage current is still flat at that voltage.

Resistive Feedback Preamplifier

The dc voltage at the rear panel test point is normally in the range of –0.5 to –2.0 volts. In addition to this offset, detector leakage current will cause the test point voltage to shift positive for detectors using negative bias and negative for detectors using positive bias. The transfer function is determined by the feedback resistor value. Figure 44 shows the block diagram for the RC Preamp.

Typical values and corresponding transfer functions are given below:

Detector Type	R_f (typ)	V_{tp} /I_1 (nA)
Small LEGe	1×10^{11}	100 volts/nA
Large LEGe	5×10^{10}	50 volts/nA
Coaxial	2×10^{9}	2 volts/nA

The feedback resistor value may be selected for high energy rates (lower value) or lower noise (higher value) so the above values can vary greatly from one detector to another.

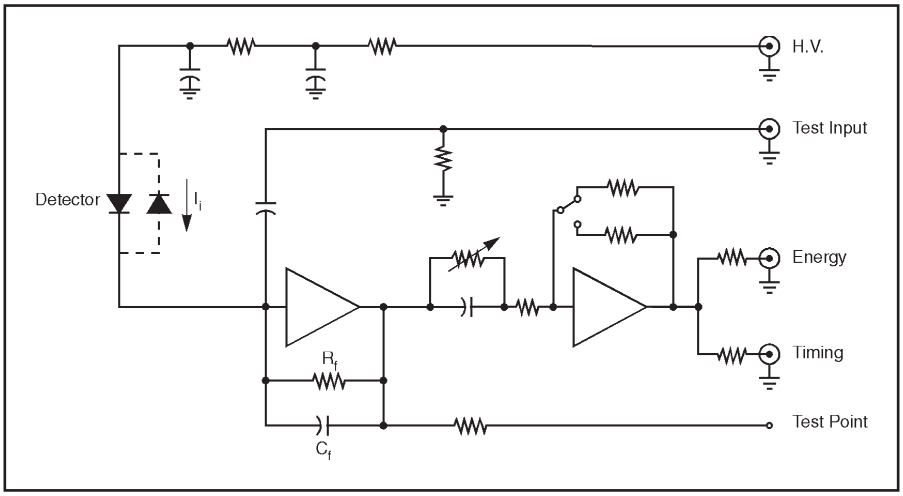


Figure 44 RC Preamplifier Block Diagram

Detected radiation results in detector current, so measurements of leakage current should be done with no radioactive sources in the presence of the detector.

The transient response to increments of voltage is momentary high current (charging the detector capacitance) returning to the normal value. This transient is greatest on the high slope part of the capacitance and observation of the transient tells a great deal about the detector. For example, no or small transient response may indicate an open HV circuit or broken contact to the detector.

Reset Preamplifiers

With a reset-type preamplifier, leakage current determines the quiescent (no sources present) preamplifier reset rate. The reset period ranges from roughly 0.1 second to 1.0 second depending on the size of the detector and on other factors, including the absolute temperature, the FET leakage current, the infrared heat load on the detector element, etc. The reset rate must be measured by using an oscilloscope on the preamplifier output. Figure 45 shows the block diagram for either a Pulsed Optical (PO) or a Transistor Reset (TRP) preamplifier.

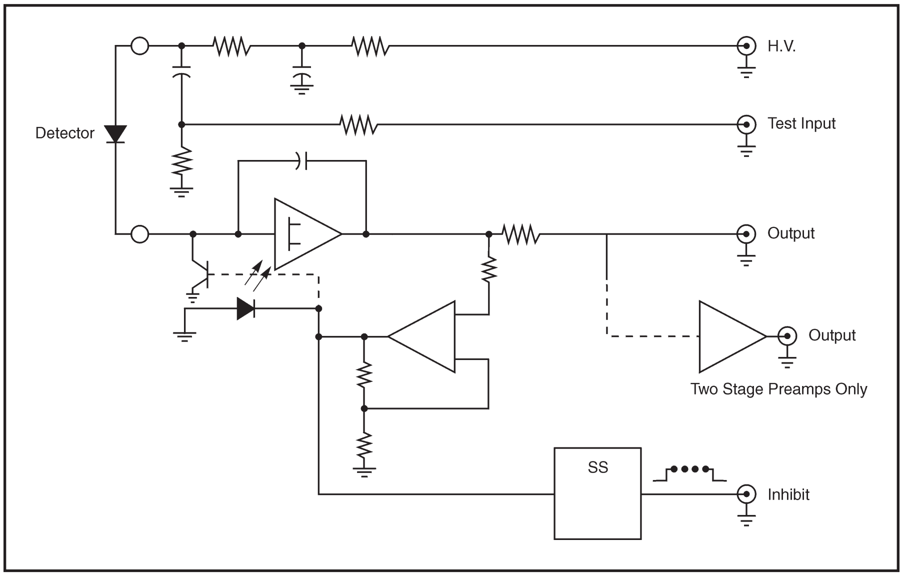


Figure 45 Reset Preamplifier Block Diagram

The transient response to movements of bias is high charging current or high momentary reset rates as indicated in Figure 46, which shows a typical transient response for detectors requiring negative bias. Sawtooth is inverted for detectors requiring positive bias or s for units having a second stage amplification.

Again, detected radiation will increase the leakage current and reset rate so make V-I measurements with no sources present.

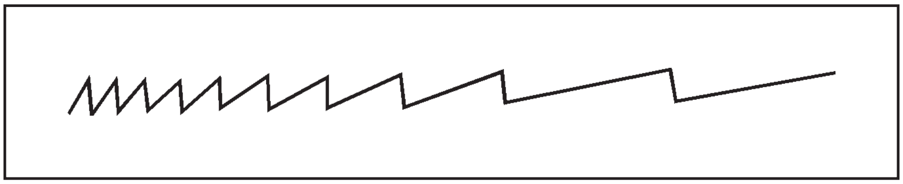


Figure 46 Typical Transient Response

Troubleshooting Symptoms and Suggestions

Most of the oscilloscope observations called for in this section are more meaningful at the amplifier output rather than at the preamplifier output. A Schottky clamp may be useful in preventing oscilloscope overload for the observation of low level signals in the presence of large signals. See “Fine Tuning the Amplifier” on page 69 for details.

No Output

– Check Power Supply Voltages.

– Check system cabling.

– Check V-I characteristics.

High Leakage Current

– Try lower bias. Detector may operate OK at lower bias.

– Detector may have been subjected to incomplete warm up cycle. Warm up completely (24 hrs) and cool down again.

Erratic Leakage Current

– Check for voltage breakdown in Preamp HV network, in the bias supply and in the HV cable.

– Dry the electrical feedthroughs with a heat gun (remove the preamplifier first to avoid damaging its components).

Poor Resolution

- Check V-I characteristic by measuring the TP voltage or reset rate as a function of detector bias.

- Check for electrical interference (periodic signals on amp output) from other equipment.

- Check ground loops (50-60 Hz noise).

  To prevent ground loop noise from entering the system, the H.V. Input and H.V. Inhibit Output grounds are isolated. To maintain this isolation on 2002CC and 2002CSL preamps, slip the flexible sleeving included with the preamp over the BNC and SHV connector shells after connecting the cables.

Microphonic Noise

- Use symmetrical restorer mode and shorter time constants to minimize effects of microphonic noise.

- Isolate the Dewar from the floor with some insulating material such as rubberized hair, foam, etc.

- Check dipstick orientation to make sure bottom of dipstick does not touch the Dewar inside. Dipstick elevation can be changed by loosening the screws in the clamp ring. These screws are recessed. A 7/64 in. hex key wrench is required.

Low Frequency Noise

- Check for Ground Loops. Make sure whole system is powered from the same electrical outlet or circuit.

High Frequency Noise

- Bias Supply typically uses 5 kHz to 20 kHz dc-dc converter. Change bias supplies if converter frequency appears as noise on preamplifier or amp output.

Peak Tailing

- Check Pole/Zero setting.

- Check HV cables and circuits. Detector may not be getting rated bias.

- Has detector been exposed to neutrons? Radiation damage causes charge collection problems.

Moisture Accumulation

- Indicates poor vacuum unless accumulation on Detector Chamber occurs only when detector is temperature cycled. Measure weight loss in 24 or 48 hour period to determine LN_2 loss rate. LN_2 weighs 0.81 kg (1.78 lb) per liter.

High LN_2 Loss Rate

- See Moisture Accumulation, above. For dipstick type detectors, substitute another Dewar and check loss rate again. Dipstick Dewars may be replaced in the field at moderate cost.

Poor Resolution at High Energy

- Neutron damage affects resolution at high energy to a greater degree than at low energy. As degradation increases, peaks develop asymmetry. Warmup following damage usually makes the resolution worse.

Noise Spikes (same polarity as signal)

- Likely caused by detector surface leakage current. Do complete thermal cycle and retest.

Noise Spikes (opposite polarity from signal)

- Breakdown in HV network, in HV feedthrough or in HVPS, cabling, etc. Check components on another system to verify. Remove preamp to dry electrical feedthrough with heat gun or clean with methanol and then dry thoroughly before reinstalling.

Peak Instability

- Most gain drift problems are associated with the main amplifier or ADC. If drift is greater than that expected from the temperature range experienced by the electronics, substitute amplifier and ADC.

- Wiring problems between detector and preamp can cause discrete peak shifts. Tap gently on detector and preamplifier assembly to induce shifts. Inspect and clean contacts between preamp and cryostat if problem exists.

Poor Resolution at High Rates

- Check amplifier Pole/Zero.

- Use appropriate amplifier shaping time constant.

- Adjust preamplifier Pole/Zero by observing amplifier output with high count rate. Set preamp P/Z for most stable baseline after first properly Pole/Zeroing the main amplifier.

Intermittent Output (pulsed-optical preamp)

– HV breakdown in cables. Unstable HV Power supply. Moisture on feedthrough HV network. All the above can cause pulsed optical preamps to lock up with output at minus (–) 6 to minus (–) 10 volts except when HV is increased momentarily.

LN_2 Siphoning from MAC

– Plug the unused port (the port not venting) with a cover.

Radiation Damage (Tailing)

– Consult factory. Radiation damage repair usually requires annealing at the factory.

Self-generated Microphonics

– Clean dipstick copper surface with abrasives. Check integral Dewars for ice crystals. Warm up and dry them thoroughly.

Noise Pickup

– Keep cables together and away from CRTs, printers, and other electrically noisy equipment.

Erratic Baseline or Amplifier Output (reset preamp)

– Be sure amplifier Pole/Zero is out: Fully counter-clockwise.

H.V. Inhibit

– If the H.V. Inhibit Indicator is on in the absence of symptoms of warm-up or poor vacuum (excessive loss rate or leakage current), the circuit may need adjustment. See “H.V. Inhibit Circuit Adjustment” on page 51.

9. System Considerations with High Resolution Detectors

This chapter describes some commonly encountered problems in achieving high resolution in routine use rather than in test setup mode and some recommendations on how to attain the best performance.

This chapter covers:

Note: Bench testing detectors for specification compliance involves setups contrived for that purpose.

System Design Considerations

High resolution spectroscopy systems require several connections involving the preamp, bias supply, and spectroscopy amplifier. Under normal operating conditions this does not present a problem, and optimal performance is achieved.

However, in some applications these interconnections are unusual in terms of environment, length, or routing. Under such conditions, systems are susceptible to oscillations or noise due to ground loops or to EMI (electromagnetic interference) from sources such as raster displays, power supplies, computers, etc. This interference will degrade the performance of most high resolution detector systems.

The Loop-Buster accessories, listed on page 87, minimize these problems without affecting cable lengths, cable routing, or system configuration.

Amplifier Shaping

The shaping time constant sets the amplifier’s frequency response. The proper choice is usually a compromise between count rate and detector noise band-width. For example, a coaxial Ge detector usually has its best results with a four microsecond shaping, but at very high count rates the pile-up effects can be reduced with a faster shaping.

The optimum time constant depends on detector characteristics (size, configuration, collection characteristics) and the incoming count rate. Table 9.1 lists optimum time constant ranges for common detectors under normal operating conditions.

Table 7 Detector Time Constants

Scintillation [NaI(Tl)]	0.5 – 1.5 µs
Gas Proportional Counters	0.5 – 2.0 µs
Silicon Surface-Barrier (SSB)	0.5 µs
Passivated Implanted Planar Silicon (PIPS)	0.5 µs – 1.0 µs
Lithium Drifted Silicon [Si(Li)]	8.0 – 24.0 µs
Low Energy Germanium	8.0 – 24.0 µs
Coaxial Germanium	4.0 – 6.0 µs

Some Canberra Amplifiers are specified by pulse width or time to peak. The equivalent shaping time constant for a unipolar amp is approximately equal to Time-to-Peak divided by 2.2.

Amplifier Noise

Amplifier noise is random in nature and is summed in quadrature (RSS) with the noise from the detector and the preamplifier. The amplifier's gain is selected so that the energy range of interest matches the ADC's full scale range. At amplifier gains less than 100, the amplifier's noise is not normally a significant factor.

Baseline Restorer

For best signal to noise performance, a direct coupled amplifier with unipolar shaping would be the best theoretical solution, but is not practical because of offset voltages in the preamplifier and amplifier. Therefore, an ac coupled amplifier is required for dc stability. But in an ac coupled amplifier, count rate changes can cause shifts in the baseline unless a bipolar pulse shaping or a baseline restorer (for unipolar shaping) is used.

A bipolar output has worse signal-to-noise ratio and count rate performance than can be obtained with a unipolar output using the same shaping time constant.

A Baseline Restorer removes the fluctuations in a unipolar amplifier by monitoring the baseline and provides drift correction to maintain a level baseline.

In most Canberra amplifiers, an Auto Threshold circuit tracks the peak of the random noise and gates the restorer off when the input being processed exceeds the threshold, thus eliminating energy pulse degradation.

ADC Conversion Gain

To calculate the location of a spectrum peak and its Full Width at Half Maximum (FWHM), at least 20 channels are required in the peak. If the peak has fewer channels, the uncertainty in the calculation will increase the computed FWHM.

The ADC Conversion Gain determines the number of elements (channels) that the input signal is divided into, which affects resolution. For a scintillation detector, a Conversion Gain of 256 or 512 is sufficient to resolve expected peaks; a higher ADC Gain can be used if the Amplifier Gain is not adequate to cover the ADC's input range.

For a Germanium detector with the 1.33 MeV ^{60}Co peak at about 90% of ADC full scale, an ADC Gain of 8192 is required to adequately determine the FWHM. With a 4096 ADC Gain, the FWHM calculation can be degraded by about 100 eV because of the granularity of the data points. This can be reduced if a sophisticated peak fitting routine is used.

System Setup Considerations

The previous factors can be analyzed prior to assembling the proper system for the intended application and are important considerations for the system design. The following are some practical points that permit a system to perform to its potential.

Pole/Zeroing

The pole/zero (P/Z) adjustment matches the amplifier to the preamplifier's tail pulse output and is extremely critical for good high count rate performance. When set properly, disturbance to following pulses is minimized. This adjustment compensates for the exponential decay time constant of the preamplifier pulse. The P/Z must be adjusted if the Amplifier Shaping is changed, but it will not change with Amplifier Gain.

For precise and optimum setting of the P/Z, an oscilloscope vertical sensitivity of 50 mV/cm should be used. However, most scopes will overload for a 10 volt input signal when the vertical sensitivity is set for 50 mV/cm, distorting the signal's recovery to the baseline.

Thus the P/Z will be incorrectly adjusted, resulting in a loss of resolution at high count rates. To prevent overloading the scope, Canberra recommends using the **Model LB1502 Schottky Clamp Box** between the amplifier's output and the scope's input.

Note that the Model 1510 Integrated Signal Processor and Models 2025 and 2026 Spectroscopy Amplifiers have a built-in Schottky clamping circuit.

Amplifier Oscillations

If the cable connecting the front panel output of the amplifier to the ADC exceeds 3 m (10 feet) in length, oscillations can occur. This is caused by the cable capacitance loading the high bandwidth output amplifier.

Most Canberra Amplifiers have a rear panel output which has 93 ohms in series to eliminate the oscillations. Most amplifiers also have internal jumpers that can put a 93 ohm resistor in series with the front panel output. In some cases where it may be necessary to use the low impedance amplifier output, a terminating resistance to ground at the load end of the cable will also eliminate the oscillation.

Vibration and Noise

Vibration transmitted to the detector and cryostat can be through the floor or mounting, as well as direct audio coupling through the air. Vibration isolators in the mounting and sound absorbing covers around the detector can reduce this problem. Shortening the amplifier shaping time constant may improve spectrometer performance in a noisy environment.

Radio Frequency Interference (RFI)

In close proximity, a radio station can sometimes be picked up by a detector. Grounding the preamplifier or cryostat may help, but this can cause ground loops, resulting in 50 or 60 Hz noise. Refer to the following Grounding subsection.

Analyzer Interference

If the detector is located within a few feet of the MCA, it can receive Electro-Magnetic Interference (EMI). In older analyzers this can be from the ferrite cores that were used as memory elements. On the more recent MCAs the display has yoke and flyback transformers that generate large magnetic fields.

The cables connected to the detector must be kept away from the CRT; definitely do not run the cables in front of the display. Some further techniques in minimizing the interference in extraordinary circumstances are covered in the following Grounding subsection.

Grounding

Grounding problems often cause poor performance from a detector. Generally the best performance is obtained when the amplifier, ADC and high voltage power supply (HVPS) are installed in the same bin, with preamp power coming from the amplifier.

Any degradation caused by preamp power circuit ground loops can be eliminated by the **Model LB1501 Ground Loop Eliminator (GLE) Preamp Power Cable**, which has a diode-interrupted ground.

The amplifier should be separated by several slots from the ADC and bias Supply. Any degradation is probably caused by EMI pickup in the signal cable from the detector's preamp to the amplifier. The **Model LB1500 Cable Transformer (CT)** provides a means to cancel signals induced in the cable.

It's not always possible to have all of the electronics in the same bin, however. Several Canberra MCAs have a built-in ADC with provisions for attaching a high voltage power supply and an external NIM amplifier. The resulting separation between the components can cause ground-loop currents. The **Model LB1503 Bias Isolation Box** provides resistive isolation in the ground circuit between the high voltage power supply and the preamp.

The final configuration to be considered is what to do when the detector is hundreds of feet away from the MCA. It's usually not practical to separate the ADC from the MCA. Therefore the amplifier and HVPS are kept near the detector and the amplified and shaped signal is brought to the ADC.

Loop-Buster Accessories

These Loop-Buster accessories are designed to minimize the interference and ground-loop problems which can be encountered in some system configurations. Refer to Figures 49 through 51 for typical system uses of the Loop Buster Accessories.

Model LB1500 Cable Transformer (CT)

The LB1500 Cable Transformer is a 93 ohm BNC cable has a ferrite core built into it. Connect it between the preamplifier and the amplifier to reduce high frequency interference. Newer amplifiers (2025, 2026, 9615) have an equivalent circuit built in.

Note: the LB1500's female BNC connector must not be allowed to touch ground.

Model LB1501 Preamp Power Cable (GLE)

The LB1501 Ground Loop Eliminator Preamp Power Cable (GLE) has a diode-interrupted ground to eliminate ground loops. It is used in place of the C1402 Preamp Power Cable supplied with the preamplifier.

Model LB1502 Schottky Clamp Box

Prevents oscilloscope overload when using high sensitivity settings for precise pole/zero adjustments. Not required with amplifiers that have a built-in limiting circuit.

Model LB1503 Bias Isolation Box

The LB1503 Bias Isolation Box provides resistive isolation in the ground circuit between high voltage power supply and preamp to reduce ground-loop induced noise.

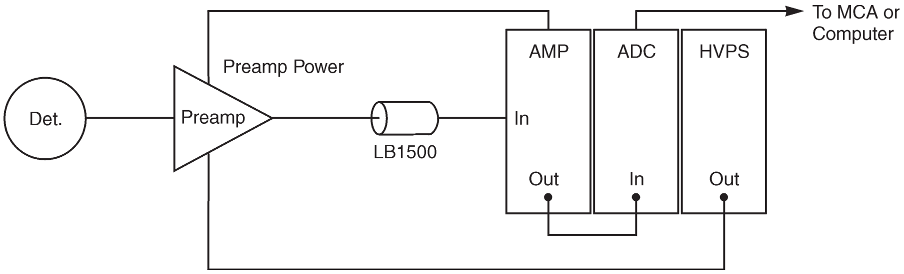


Figure 49 All Electronics in NIM Bin

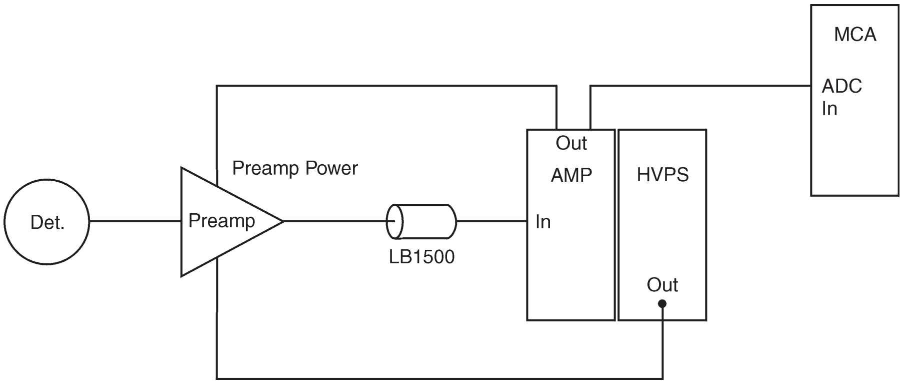


Figure 47 ADC Separated from Amp and Preamp

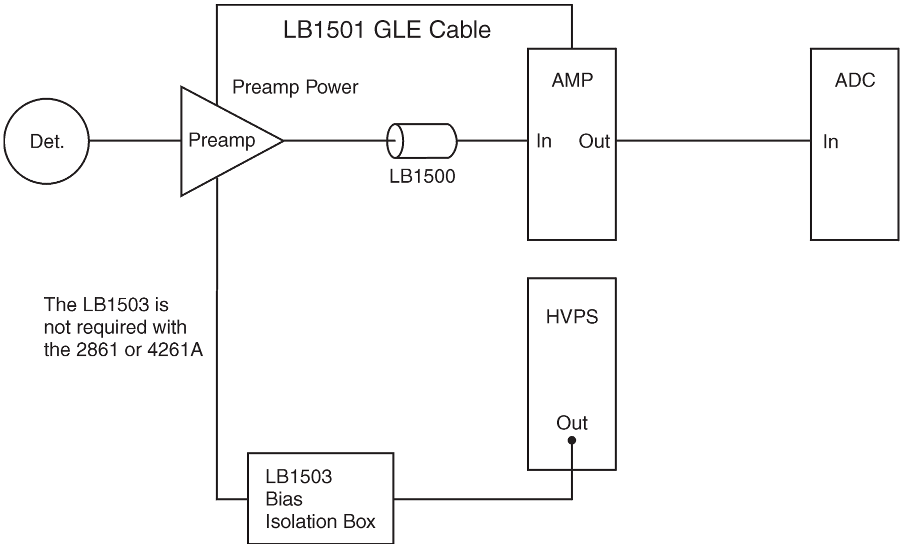


Figure 48 All Components Separated

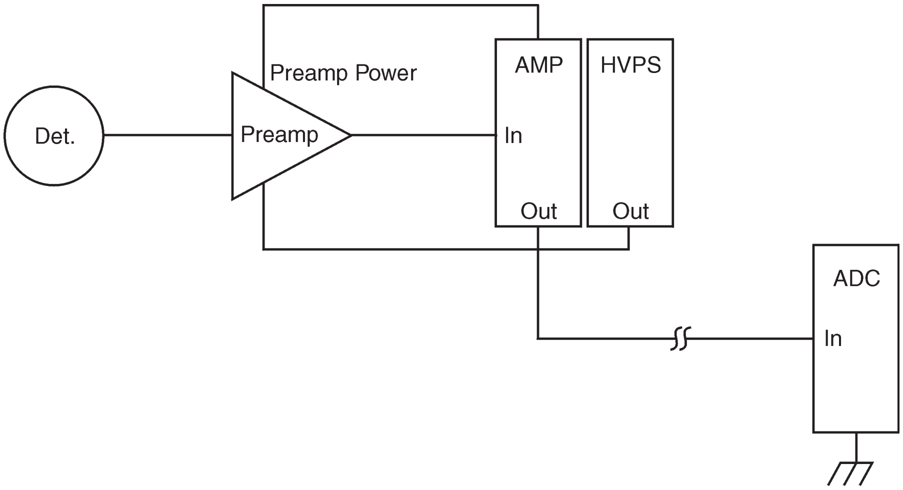


Figure 51 Single Ground

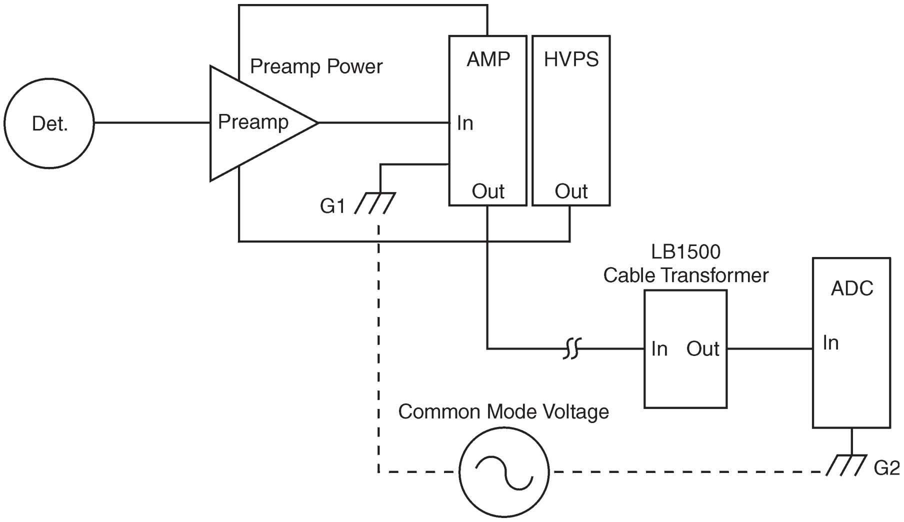


Figure 50 Ground Loop

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Warranty

Canberra (we, us, our) warrants to the customer (you, your) that for a period of ninety (90) days from the date of shipment, software provided by us in connection with equipment manufactured by us shall operate in accordance with applicable specifications when used with equipment manufactured by us and that the media on which the software is provided shall be free from defects. We also warrant that (A) equipment manufactured by us shall be free from defects in materials and workmanship for a period of one (1) year from the date of shipment of such equipment, and (B) services performed by us in connection with such equipment, such as site supervision and installation services relating to the equipment, shall be free from defects for a period of one (1) year from the date of performance of such services.

If defects in materials or workmanship are discovered within the applicable warranty period as set forth above, we shall, at our option and cost, (A) in the case of defective software or equipment, either repair or replace the software or equipment, or (B) in the case of defective services, reperform such services.

LIMITATIONS

EXCEPT AS SET FORTH HEREIN, NO OTHER WARRANTIES OR REMEDIES, WHETHER STATUTORY, WRITTEN, ORAL, EXPRESSED, IMPLIED (INCLUDING WITHOUT LIMITATION, THE WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE) OR OTHERWISE, SHALL APPLY. IN NO EVENT SHALL CANBERRA HAVE ANY LIABILITY FOR ANY SPECIAL, EXEMPLARY, PUNITIVE, INDIRECT OR CONSEQUENTIAL LOSSES OR DAMAGES OF ANY NATURE WHATSOEVER, WHETHER AS A RESULT OF BREACH OF CONTRACT, TORT LIABILITY (INCLUDING NEGLIGENCE), STRICT LIABILITY OR OTHERWISE. REPAIR OR REPLACEMENT OF THE SOFTWARE OR EQUIPMENT DURING THE APPLICABLE WARRANTY PERIOD AT CANBERRA'S COST, OR, IN THE CASE OF DEFECTIVE SERVICES, REPERFORMANCE AT CANBERRA'S COST, IS YOUR SOLE AND EXCLUSIVE REMEDY UNDER THIS WARRANTY.

EXCLUSIONS

Our warranty does not cover damage to equipment which has been altered or modified without our written permission or damage which has been caused by abuse, misuse, accident, neglect or unusual physical or electrical stress, as determined by our Service Personnel.

We are under no obligation to provide warranty service if adjustment or repair is required because of damage caused by other than ordinary use or if the equipment is serviced or repaired, or if an attempt is made to service or repair the equipment, by other than our Service Personnel without our prior approval.

Our warranty does not cover detector damage due to neutrons or heavy charged particles. Failure of beryllium, carbon composite, or polymer windows, or of windowless detectors caused by physical or chemical damage from the environment is not covered by warranty.

We are not responsible for damage sustained in transit. You should examine shipments upon receipt for evidence of damage caused in transit. If damage is found, notify us and the carrier immediately. Keep all packages, materials and documents, including the freight bill, invoice and packing list.

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