GMX Series

GAMMA-X® HPGe (High-Purity Germanium) Coaxial Photon Detector System

Printed in U.S.A.

ORTEC® Part Number 803409
Manual Revision G
801 South Illinois Avenue
Oak Ridge, Tennessee 37830
United States of America

0815

QUALITY ASSURANCE DATA SHEET
GMX Series HPGe GAMMA-X HPGE
(High-Purity Germanium) Coaxial Photon Detector System

Model and Serial Numbers

Detector Model No. ____________________________

Cryostat Configuration ____________________________

Dewar Model ____________________________

Preamplifier Model ____________________________

Preamplifier S/N ____________________________

H. V. Filter Model ____________________________

H. V. Filter S/N ____________________________

Important Reference Data

Ship Date ________________________

Serial No. ________________________

When calling Customer Service, always reference this Detector Serial No.

Cryogenic Information

Dewar Capacity ___________ Static Holding Time ___________ Detector Cool-Down Time ____________

Dimensions

Crystal Diameter _________________________ mm

Crystal Length _________________________ mm

End Cap to Crystal _________________________ mm

Total Active Volume _________________________ cc

Absorbing Layers

Beryllium ________________ mm

Aluminum _______________ mm

Inactive Germanium _______ mm

High Voltage Bias

Recommended Operation Bias, NEGATIVE ________________ V

Performance Specifications*

	Warranted	Measured	Amplifier Time Constant
Resolution (FWHM) at 1.33 MeV, ^{60}Co	________keV	________keV	____________us
Peak-to-Compton Ratio, ^{60}Co	________	________	____________us
Relative Efficiency at 1.33 MeV, ^{60}Co	________ %	________ %	____________us
Peak Shape (FWTM/FWHM), ^{60}Co	________	________	____________us
Peak Shape (FWFM/FWHM), ^{60}Co	________	________	____________us
Resolution (FWHM) at 122 keV, ^{57}Co	________ eV	________ eV	
Resolution (FWHM) at 5.9 keV, ^{55}Fe	________ eV	________ eV	

Other____

____

Data Certified By____________________________________Date_____________

*Measured at a nominal rate of 1000 counts/s unless otherwise specified.

CONTENTS

1. RECEIVING AND INSPECTION

1.1. General

Each ORTEC detector is shipped in a custom-built wooden crate in which the system is protected by foam. The wooden crate may be contained in a cardboard box. On the outside of each container is a set of unpacking instructions. Instructions for unpacking detector systems are given here for reference. Read these instructions before unpacking your detector. Inspect the outside of the detector crate for signs of physical damage. If any damage is found, then see Section 1.3 immediately.

Sometimes unassembled PopTop™ capsules or cryostats are shipped separately. In detector systems which have the detector attached to a dewar, the instruction manual may be packed in a separate box with other accessories which go with the system. Open these boxes first to obtain the manual.

High-purity detectors of all kinds are shipped at room temperature (without LN_2). High-purity detectors should be unpacked before filling with liquid nitrogen. IT IS IMPERATIVE THAT ANY DETECTOR SYSTEM PACKED IN FOAM BE COMPLETELY UNPACKED BEFORE FILLING. If the detector is filled while in the foam, the insulating properties of the foam, together with the tendency of any spilled liquid nitrogen to become trapped between the detector cryostat-dewar and the foam, may cause serious damage to the system. A COLD DETECTOR MUST NOT BE ENCLOSED IN THERMALLY INSULATING MATERIALS AT ANY TIME.

1.2. Unpacking Instructions

The detector is packed in a wooden crate. The top of the crate is held in place by several wood screws. Remove any external strapping which may have been placed around the crate. Remove the top from the case holding the detector. If there is a top layer of foam covering the detector, remove it also. Lift the detector out of the crate and immediately inspect it for physical damage. DO NOT ATTEMPT TO FILL A DETECTOR SYSTEM WITH LIQUID NITROGEN OR TO COOL A SYSTEM DOWN WHILE IT IS SURROUNDED BY FOAM PACKING. If any physical damage which may have occurred during shipping is discovered, see Section 1.3.

1.3. Shipping Damage

If a detector arrives with externally visible damage, DO NOT UNPACK IT. Notify the carrier and make arrangements to file a damage claim. IN ALL CASES OF SHIPPING DAMAGE, IT IS THE CUSTOMER'S RESPONSIBILITY TO FILE A DAMAGE CLAIM.

If during unpacking, concealed damage is noted, notify the carrier and file a claim. Packing materials, waybills and other such documentation should be preserved to establish claims.

Contact the ORTEC Global Service Center, 1-800-251-9750 or (865) 482-4411, for further instructions. Outside the U.S.A., contact your local ORTEC representative.

NOTICE

Before opening crate, inspect carefully for shipping damage. If damage is evident, see Section 1.3.

2. FILLING WITH LIQUID NITROGEN (LN_2)

If the detector and cryostat arrive in separate containers, refer to the "PopTop Transplantable Photon Detector Instruction Manual" for the necessary directions for assembling the detector-cryostat system. After the detector and cryostat are connected, the detector can be cooled.

Filling the dewar of a detector system with liquid nitrogen may be accomplished easily and safely. However, proper procedures must be followed to avoid personal injury or detector system damage. Please read Section 3.2 on liquid nitrogen safety as well as the following filling instructions.

In all cases, it is necessary to prevent the electronics and the outside of the cryostat from getting excessively cold. Avoid spilling liquid nitrogen on the cryostat or electronics, and vent cold gas away from the system being filled. A detector may also be damaged by filling it with liquid nitrogen while it is enclosed in thermally insulating materials (such as packing materials). NEVER FILL A DETECTOR BEFORE REMOVING IT FROM ANY INSULATING PACKING MATERIALS, ESPECIALLY IF IT IS PACKED IN FOAM. Even if a cold system is later packed in insulating materials, damage is likely to occur. A COLD DETECTOR MUST NOT BE ENCLOSED IN THERMALLY INSULATING MATERIALS AT ANY TIME. Following these precautions will prevent damage to vacuum seals or to system electronics which could occur from excessive chilling.

2.1. Bucket Dewars

Systems with bucket dewars are filled by simply removing the dewar fill cap and pouring in liquid nitrogen from the top. Care must be taken not to spill liquid nitrogen on the cryostat. If liquid nitrogen contacts a flange which contains a vacuum seal, it is possible that the seal may be breached. To prevent this, it is strongly recommended that such systems be filled by carefully pouring in the liquid nitrogen through a large metal funnel.

2.2. PG and PSHP Dewar-Cryostat Models

For detectors mounted on a PG-type dewar, a special fill funnel is included with each dewar. This funnel is used to fill the dewar with liquid nitrogen using the following procedure.

1. Remove the cap from the end of the dewar.

2. Insert the funnel into the neck of the dewar and lock the funnel in place using the plastic bar which has mating threads for the dewar neck.

3. Pour liquid nitrogen into the dewar. **Caution: When the dewar is full, liquid nitrogen will pour out of the fill tube**.

4. When the dewar is first filled, the boil off of liquid nitrogen will be excessive until the detector element is completely cooled. For this reason, the dewar will need to have additional liquid nitrogen added shortly after initial filling. (For PG 1.2, PG 0.4, and PSHP 0.7 dewars, liquid nitrogen will need to be added after approximately 30 minutes. Larger dewars can wait a maximum of 2 hours before their liquid nitrogen supplies will need replenishing.)

5. Remove the fill funnel and attach the cap to the dewar. **Caution: The cap has a pressure relief valve built into it. This valve allows the expanding gas to escape from the dewar as liquid nitrogen vaporizes. Care should be taken to avoid exposure to the escaping gases since they are at near cryogenic temperatures**.

2.3. Dipstick Cryostat Models

Before inserting a dipstick cryostat detector into a dewar, a white RTV silicone rubber collar, which is included with the detector, should be placed onto the dewar. The procedure for assembling the detector-dewar combination is outlined below.

1. Using Figure 2.1, verify that all components and hardware are in their proper place.

2. Distance "d" in Figure 2.1 should be minimized but >3/4 inch.

3. Insert the cooling rod of the cryostat into the dewar.

CAUTION

Liquid nitrogen will be forced out of the fill tubes if the dewar is full.

4. Align the screw holes and ensure that the stand off sleeves (3) have been inserted into the RTV collar.

5. Insert and tighten the three socket screws.

6. Ensure that the cryostat is level on horizontal cryostat configurations and tighten the three 5/64-inch drive Allen set screws on the locking collar.

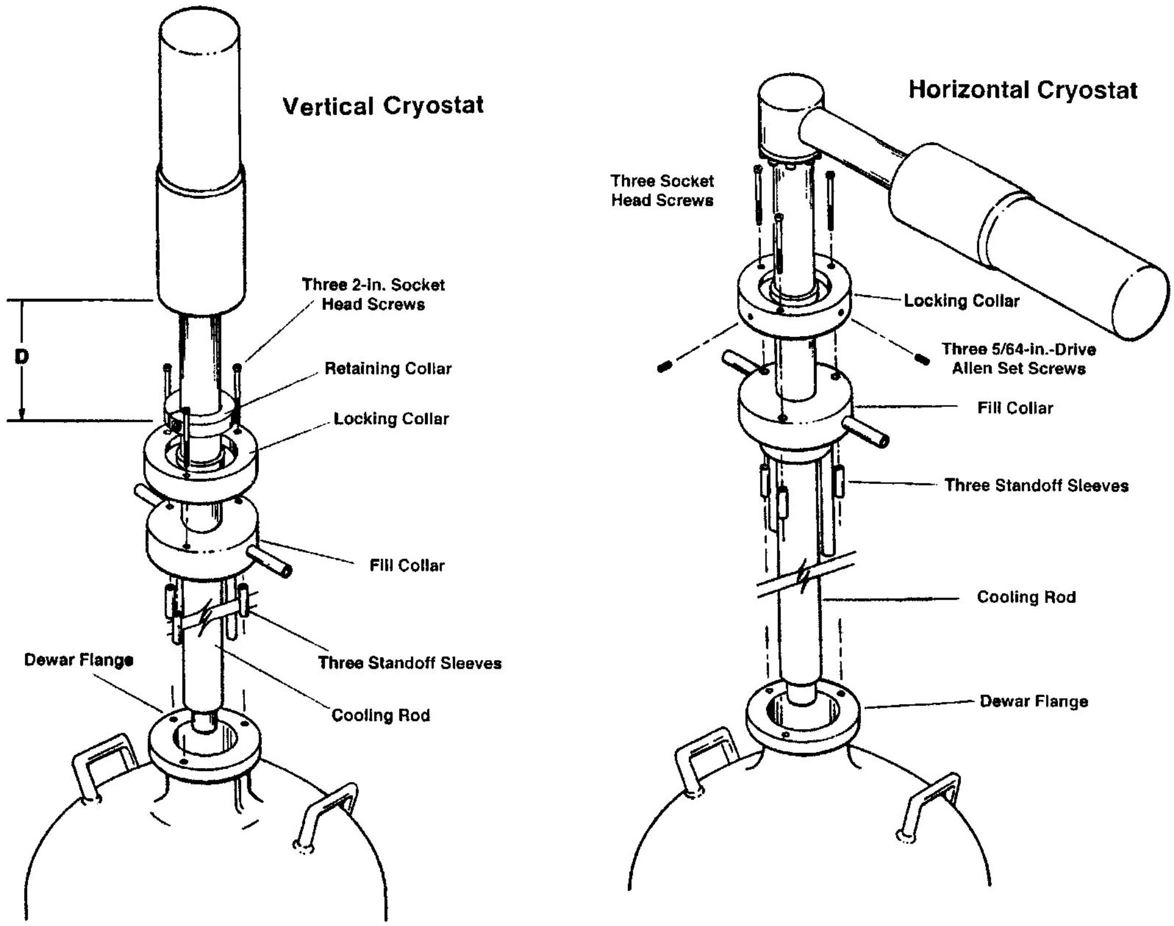


Fig. 2.1. Vertical and Horizontal Cryostat Mounting Arrangements.

The dipstick and white RTV silicone rubber collar form a gas-tight seal. The silicone collar contains two stainless steel tubes which are used for filling and gas exhaust. These tubes extend about 6 inches down into the dewar neck. In filling, liquid nitrogen enters through either tube, and the other exhaust tube will prevent the liquid level from rising within 6 inches of the dewar flange, if there are no leaks at the collar. This keeps the vacuum seal at the dewar flange from getting too cold. IT IS IMPORTANT NOT TO DAMAGE THE SILICONE RUBBER COLLAR. Do not use excessive force to attach or remove a hose from the fill tubes.

Prepare for filling the dewar by connecting the supply hose and an exhaust hose to the fill tubes in the silicone rubber collar. The exhaust hose is a 6-foot length of plastic tubing which carries cold gas and liquid overflow away from the cryostat and electronics. The connection to your liquid nitrogen supply hose is made by a short length of plastic tube.

One common filling method uses a standard 30-liter dewar of liquid nitrogen as a supply dewar (Fig. 2.2). A gas-tight fixture, which holds a metal outlet tube and a gas inlet for pressurization, is attached to the supply dewar flange. The metal outlet tube is connected to a short length of plastic tubing which serves as the supply hose. This tube carries liquid nitrogen out from the dewar bottom. Transfer is effected by pressurizing the dewar at **3 to 5 psi with dry nitrogen gas. The supply dewar or the gas inlet tube must have a pressure relief valve set at 5 psi** (see Safety Precautions in Section 3). Terminate the liquid nitrogen transfer by relieving the pressure in the supply dewar. This transfer requires only a few minutes, and it should be monitored continuously. Allow supply and exhaust hoses to thaw completely before removing them from the fill tubes.

Alternatively, a simple LN_2 fill system can be created using a funnel and a short length of plastic tube attached to one of the fill tubes. LN_2 is then poured continuously into the fill line until it overflows the exhaust tube line. Care must be taken not to spill LN_2 on the cryostat, endcap, or electronics section of the detector system.

2.4. Filling With LN_2 While Operating

It is possible that cold gas or liquid nitrogen may cause temporary moisture condensation within the electronics housing during filling. Therefore, we strongly recommend that all power be removed from the detector electronics while the dewar is being filled with liquid nitrogen. However, if this presents serious operational problems, the procedures of Sections 2.1 and 2.2 may be used while operating if care is taken to assure that cold gas or liquid does not come in contact with the electronics housing or electronic modules. Use a long plastic exhaust tube and cover the electronics with plastic sheets as needed to accomplish this. Monitor the filling process very carefully and stop immediately when the dewar is full.

2.5. Cooling Time

Due to the different types of cryostat-dewar combinations and to the different size (and, therefore, thermal mass) of different detectors, ORTEC indicates the required cooling time for every streamline and HJ detector in the Quality Assurance Data Sheet. It is extremely important not to attempt to apply H.V. bias to any detector before the recommended time. Premature application of H.V. bias may result in serious damage ("blowing" the cooled input FET) and void your warranty.

2.6. Protection Against Damage Caused by Accidental Warm Up

ORTEC provides two different methods of protection.

1. Automatic High Voltage Shutoff

Most detector cryostats built by ORTEC contain a temperature sensing element attached to the cooling path. The sensing element connects to a hybrid monitoring circuit which is incorporated into the preamplifier electronics. An output cable from the preamplifier is connected to the remote shutdown

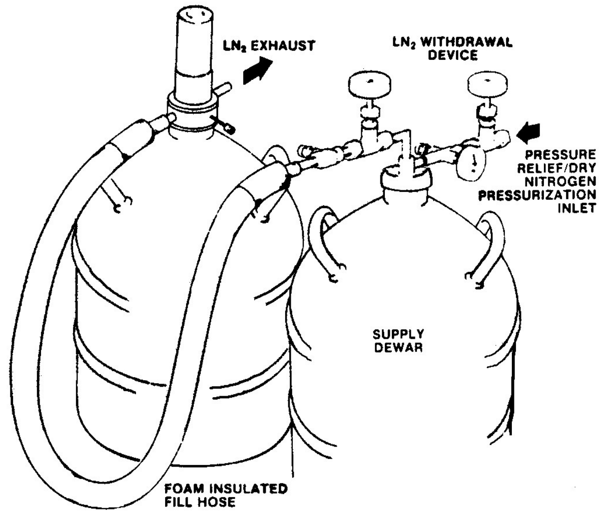


Fig. 2.2. Tubing Arrangement for Liquid Nitrogen Transfer.

input on the rear panel of an ORTEC Detector Bias Supply (Model 659, 660 or 92X). This supply is designed to reduce the detector bias voltage to zero if the remote shutdown input's center contact is provided with a low impedance (<30 ohm) path to ground. The monitoring circuit in the preamplifier provides this condition if the detector temperature becomes too high. Although no alarm is provided, the bias supply meter will indicate zero voltage and system noise will greatly increase after shutoff occurs. For the unit to be operational, preamplifier power must be provided through the power cable. After the high voltage has been automatically shut off, the bias supply switch must be turned off until the system has been filled with liquid nitrogen and completely cooled for the recommended period (see Quality Assurance Data Sheet in the front of this manual or label on detector system). **Accidental application of high voltage to a detector which is not fully cold can cause serious damage and void your warranty.**

The automatic shutoff should be placed in operation before attempting to apply bias to the detector.

2. Model 729A Liquid Nitrogen Level Monitor

The Model 729A Liquid Nitrogen Level Monitor is designed only for large dewars ($\geq$ 7.5 liter). It provides an acoustical alarm which is activated when the liquid nitrogen level descends below a set threshold in the dewar.

3. SAFETY PRECAUTIONS

3.1. High Voltage

Your detector system uses high voltage (up to 5000 V) to bias the detector element. The standard ORTEC bias supplies made for use with photon detectors are capable of delivering only very low current. However, the detector system has a high-voltage filter containing capacitors capable of delivering a dangerously high current for a brief time while being discharged (even if the bias supply has been disconnected). Such a discharge is possible at the interface between the high-voltage filter and the cryostat feedthrough or within the filter module box (on non-streamline cryostat systems). These points are not accessible unless the closed electronics shield or module box is opened. Danger should be avoided by never opening the electronics shield or module boxes except when following the explicit instructions of an authorized representative of ORTEC.

3.2. Liquid Nitrogen Safety

Users of cooled detectors should be aware of the hazards associated with the cryogenic fluid being used. Four hazards in using liquid nitrogen are high pressure gas, contact with materials, contact with personnel, and inadequate ventilation. The large expansion ratio from liquid to gas (692 to 1) can produce high pressures due to the evaporation of the liquid, if the container does not have adequate venting or pressure relief provisions. Some materials become brittle and fracture when exposed to liquid nitrogen temperatures (77 K). For advice when selecting materials for use in storing and transferring liquid nitrogen, contact ORTEC or your liquid nitrogen supplier.

Other sources of information are safety manuals such as the "CRC Handbook of Laboratory Safety," The Chemical Rubber Company, Cleveland, Ohio; and material codes such as the American Society of Mechanical Engineer's "Boiler and Pressure Vessel Code, Section VIII." In addition to possible exposure to high pressure gas, another personnel hazard is burns similar to burns from high temperature contact. Eyes are especially vulnerable to this type of exposure. It should be remembered, that although nitrogen gas is nontoxic, it is capable of causing asphyxiation by displacing air. TRANSFER LN_2 ONLY IN A WELL-VENTILATED AREA.

Liquid nitrogen is safely used everyday in factories such as ORTEC and laboratories all over the world. For safety reasons, the following precautions should be followed when working with liquid nitrogen.

A. When using the filling procedures described in Section 2.3 use only dry nitrogen gas to pressurize the supply dewar. Do not use air or oxygen because they may contain moisture and oil which could freeze and cause blockage of the filling and/or vent tube. Use a pressure relief of 5 psi on the supply dewar to avoid over-pressurization in the event of ice blockage.

B. Personnel should avoid wearing anything capable of trapping or holding spilled liquid nitrogen close to their flesh. An impervious apron or coat, cuffless trousers, and high-topped shoes are recommended. Wear safety glasses or, better yet, full-face protection. Remove all watches, rings, bracelets, or other jewelry. When gloves are used to handle containers or cold metal parts, they should be impervious and sufficiently large to be easily tossed off the hand in case of a spill.

C. Piping or transfer lines should always be constructed so as to avoid trapping liquid nitrogen in the line. Evaporation can result in pressure build-up and eventual explosion of the line. If it is not possible to empty all lines, install safety relief valves and rupture discs.

D. Vent storage containers to a well ventilated area or to the outside to avoid build-up of nitrogen gas in the work area.

3.3. Beryllium Windows and Internal Cryostat Pressure

If the detector cryostat is equipped with a beryllium window, an accidental rupture of the window will severely damage the system. Thin beryllium windows, such as those found on GLP, SLP and LO-AX Series systems, are especially fragile and can sometimes be ruptured by a light touch. The thicker beryllium windows found on GMX Series detectors are somewhat tougher, but still relatively fragile. You should avoid trouble by never allowing anything to touch a beryllium window.

If a beryllium window should rupture under normal circumstances, it will implode and personnel will normally not be exposed to flying fragments and possible injury. Avoid injury by not handling any fragments of beryllium with bare hands (tweezers are recommended).

A more dangerous situation might result if the beryllium window were to rupture outward because of a build up in cryostat pressure. This can happen if the cryostat develops a leak while cold and then warms up after the molecular sieve has absorbed a large quantity of gas. If a cold cryostat shows evidence of poor vacuum, be sure that the original plastic cover is placed over the beryllium window. (Symptoms of a poor vacuum include an unusually cold cryostat or endcap, moisture condensation or "sweating," or an outward bulge to the end window on warm-up [extreme case].) If the window cover has a hole in it, cover this hole with tape. Disconnect the system from external electronics. **Do not warm up such a cryostat or take additional action except on instruction from ORTEC. Immediately contact our ORTEC Global Service Center or, if outside the U.S.A., your local ORTEC representative.**

<u>CAUTION</u>

The inhalation of beryllium dust can lead to a chronic lung disorder called berylliosis. Beryllium has also been listed as a carcinogen, based principally on animal tests. In the event that the detector window should implode, cover the detector window with the protective cover which came with it. Tape the cover down so that none of the beryllium pieces can fall out. Contact our ORTEC Global Service Center or, if outside the U.S.A., your local ORTEC representative, for shipping instructions to return the detector for repair.

In the event that some beryllium pieces fall out of the detector, care should be taken to avoid breathing any dust or powder which may form. Pick up pieces wearing protective gloves in such a manner as to not generate any dust. Dispose of the pieces according to local or national regulation.

Every cryostat made by ORTEC has a pressure safety valve which should prevent beryllium windows from rupturing outward. However, it is remotely possible that this safeguard could fail. Therefore, you should be aware of this possibility and act with appropriate caution.

4. DETECTOR TESTING (GENERAL)

4.1. Assembling an Energy Spectroscopy System

After the dewar has been filled, allow time to assure complete cooling of the detector element. (See Quality Assurance Data Sheet for the minimum cool down time. If possible, overnight cool down is better.) The detector is then connected as part of a complete energy spectroscopy system (Fig. 4.1). Included are the detector with its attached preamplifier and high-voltage filter, a main amplifier, a count-rate meter, a pulse height analyzer, a precision pulse generator, a detector bias supply, and an oscilloscope. The preamplifier and the high voltage filter are an integral part of the detector. See Appendix A for their specifications.

Connections between the preamplifier and the detector and between the high-voltage filter and the detector are made through the cryostat vacuum feedthroughs within the electronics shield. Detector bias (operating voltage) is furnished from the detector bias supply and must be cabled to the detector's high-voltage filter. Use RG-59A/U cable, or the equivalent, with SHV connectors. The captive power cable from the preamplifier is attached to the preamp power connector on the main amplifier. The remaining connections within the spectroscopy system are made using RG-62A/U, or equivalent, with BNC connectors. In addition, connect the attenuated output from the precision pulse generator to the test input of the preamplifier, and connect the preamplifier output to a main amplifier input.

The unipolar output of the main amplifier should be connected to both the oscilloscope and the pulse height analyzer or biased amplifier (if used). A BNC Tee may be needed or separate amplifier outputs may be used.

The system should be dc-coupled all the way from the preamplifier through the pulse height analyzer, if any of the modules have optional connectors or switches to select the type of coupling, be sure that dc-coupling is used. Also be sure that the power to all equipment, including the oscilloscope, is furnished from the same ac-power source to help prevent ground loops.

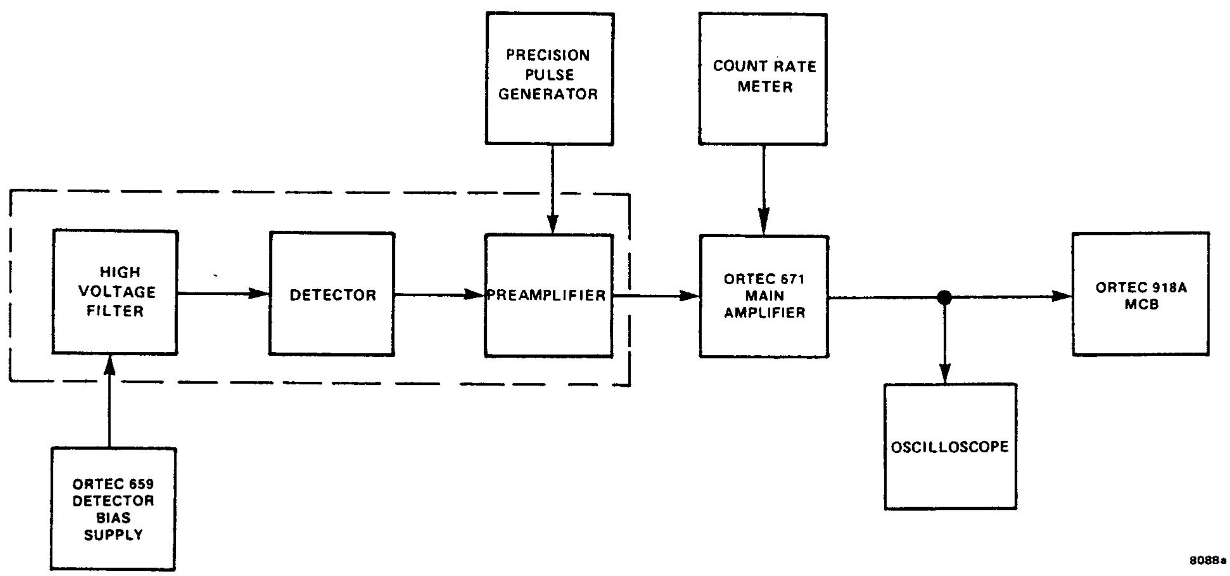


Fig. 4.1. Connection of Components in a Typical Energy Spectroscopy System. (The dashed line indicates the components included in the detector system.)

Note: High-Rate Indicator

For any dc-coupled charge-sensitive preamplifier, if the energy rate (count rate X energy product) exceeds a given level (value dependent on the particular system), the preamplifier will shut off. As the energy rate approaches this level, the detector system may suffer from excessive resolution degradation and peak shift. If the energy rate hovers around the shutoff level, the preamplifier may turn on and off intermittently. Obviously, data collected under such conditions are not reliable and corrective action should be taken.

A hybrid circuit within the preamplifier monitors the charge loop output voltage. When a condition of excessively high rate exists, an output is provided which is suitable for lighting an LED located in the preamplifier backing clamp.

4.2. Cable Termination

Connecting your system with proper cable impedance termination is important. Three general methods of termination are used. The simplest of these is a shunt termination at the receiving end of the cable. A second method is series termination at the sending end. The third method is a combination of series and shunt termination, where the cable impedance is matched both in series at the sending end and in shunt at the receiving end.

All ORTEC preamplifiers contain 93-ohm series terminations. The preamplifier of your detector system is capable of driving 500 feet of 93-ohm cable. When connected to an ORTEC amplifier (or most other modern spectroscopy amplifiers) no additional termination is required if the length of the interconnecting cable is less than 50 feet. For greater distances, terminate the amplifier input with a 100 ohm termination to ground.

The cable connecting the amplifier output to the input of the pulse height analyzer or the biased amplifier should also be properly terminated. ORTEC amplifiers have front panel outputs of <1 ohm and rear panel outputs of 93 ohm. The input of the typical pulse height analyzer or biased amplifier is 1000 ohm or more. Shunt termination at the receiving end may be achieved by using a BNC Tee connector to attach both the 93 ohm interconnecting cable and a 100 ohm terminator to the input of the receiving instrument. Series termination is provided by simply connecting the 93 ohm output of the amplifier to the input of the receiving instrument with 93 ohm cable. For the combination of series and shunt termination, the 93 ohm amplifier output is used together with the 100 ohm terminator at the input of the receiving instrument. The use of both series and shunt termination is most effective, but it is not always advised because it reduces the signal amplitude by 50%. Similar considerations apply when connecting a biased amplifier output to the input of the pulse height analyzer.

4.3. Pole-Zero and DC Output Level Adjustments

Unless the detector is tested with an amplifier with automatic pole zero, the pole zero has to be manually adjusted. The pole-zero adjustment must be made for the signal to return promptly to the baseline after each pulse. Failure to make this adjustment properly will greatly increase pulse-pileup effects and result in low or high side tailing on spectral peaks, greatly degrading high-count-rate performance.

To set the pole-zero adjustment of the main amplifier when using the detector, bring a radioactive source (^{60}Co for coaxial detectors) near the detector. Adjust the source distance to achieve a total rate between 500 and 3000 counts per second. Observe the unipolar output with an oscilloscope with enough vertical gain to allow the baseline to be observed in detail. For a pulse height of 8 to 10 V, a vertical sensitivity of 50 mV/cm is usually adequate. (See the following comments on overloading.) As amplifier gain is changed, the oscilloscope sensitivity is adjusted in inverse proportion. For the main amplifier pole-zero adjustment, the horizontal sweep time of the oscilloscope should be set to achieve a pulse width of 2 to 4 cm.

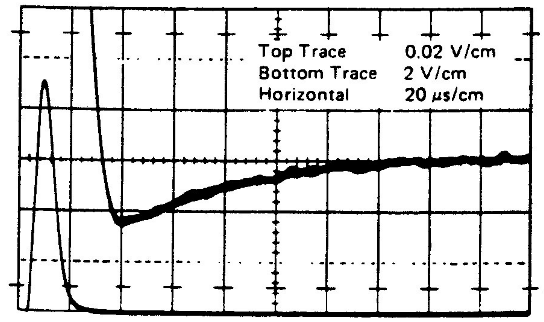
The amplifier pole-zero adjustment should be made so that the trailing edge of each pulse returns to the baseline without overshoot or undershoot (Fig. 4.2). Some older amplifiers may produce a small hump or other artifact on the trailing edge of each pulse that cannot be changed by pole-zero adjustment. In addition, some detector systems introduce a slight overshoot or other pulse tail defect that cannot be eliminated. When such artifacts or defects are present, adjust the pole-zero in such a way as to minimize the time that the signal is away from the baseline.

The oscilloscope must be dc-coupled and must not contribute distortion in the observed waveforms.

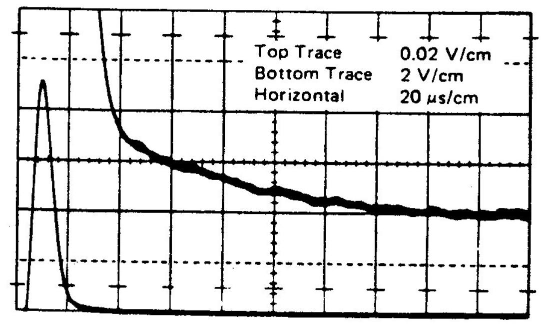
The detector system preamplifier also contains a pole-zero adjustment. To check the preamplifier pole-zero, reduce the oscilloscope sweep time until the pulse is 1 to 2 mm wide. Then look for undershoot or overshoot following each pulse. If both pole-zero adjustments are properly set, the baseline should appear smooth (little ragged appearance). Again, amplifier or detector system anomalies may produce minor defects in pulse shape which cannot be removed by pole-zero adjustment. **The preamplifier pole-zero adjustment has been properly set at the factory and should not need readjustment. However, if some adjustment becomes needed in time, please contact the ORTEC Global Service Center or your local representative.**

If the methods described herein are carefully applied, your pole-zero adjustment can be made with high accuracy. However, another method using a square-wave pulse may allow a more precise adjustment. Please refer to an ORTEC amplifier manual for the details of this method.

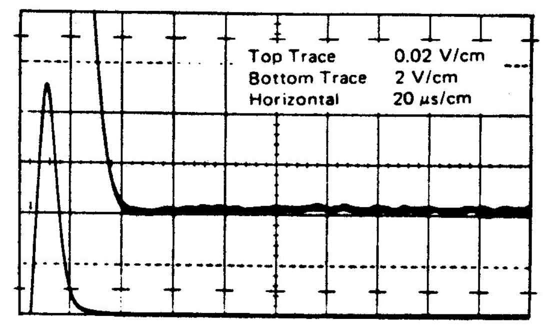
The dc-output level of the main amplifier should be set to zero. To do this, observe the amplifier output with an oscilloscope set to a sensitive vertical gain (at most, 50 mV/cm). Then ground the input of the oscilloscope and adjust the vertical height to align the trace with the center line on the measurement grid. Again look at the amplifier signal and adjust the dc level (see your amplifier manual) until the baseline of the output signal is also aligned with the center line on the oscilloscope measurement grid. The dc level is now set to zero. It is extremely important that the input signal into the analog-to-digital converter (ADC) of the pulse height analyzer has a dc level close to zero. Failure to achieve this may result in a substantial loss of counts (often manifested as an unexplained drastic efficiency loss) or in an inconveniently large energy slope intercept for the resulting spectrum. These effects depend upon the characteristics of particular analyzers.



Undercompensated Pole-Zero.



Overcompensated Pole-Zero.



Properly Adjusted Pole-Zero.

Fig. 4.2. Pole-Zero Adjustment as Seen with an Oscilloscope.

The oscilloscope must be dc-coupled and must not contribute distortion in the observed waveforms. Many oscilloscopes will overload for an 8- to 10-V signal when the vertical sensitivity is greater than 100 mV/cm. This produces an apparent defect which greatly resembles a pole-zero problem. the effect may be worse if the oscilloscope is slightly out of adjustment. Oscilloscope overload may be prevented by clipping off the top of each pulse by using the clamp circuit shown in Fig 4.3. at the oscilloscope input.

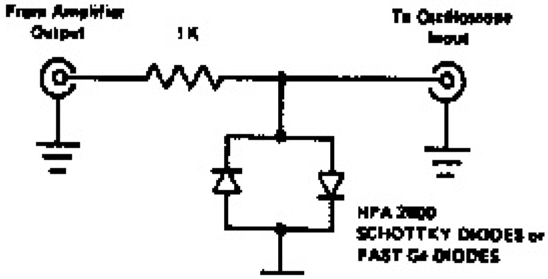


Fig. 4.3. Circuit Diagram for Clamp Network Used to Prevent Overloading the Input to the Oscilloscope Vertical Amplifier.

4.4. Common Setup Problems: Microphonics, Ground Loops, and Pickup

All detector systems will exhibit some signal response (microphonics) when subjected to excessive vibration, mechanical shock, or very loud noise. A detector system that exhibits such behavior to an excessive degree is said to be microphonic.

The preamplifier input at the gate of the input field-effect transistor (FET) is very sensitive to small current pulses. If anything electrically connected to the gate lead moves on the order of angstroms with respect to any surfaces at the high-voltage bias potential, the change in capacitance induces a current pulse that results in a substantial output signal. Vibrations of the high-voltage surfaces with respect to ground on the filter side of the detector can also produce microphonic response. Such a response is usually less significant because its magnitude is reduced by the large filter capacitor and by coupling through the relatively small detector capacitance.

There are several things that a spectroscopist should do to minimize microphonics. The detector system and its dewar should never sit directly upon a hard concrete floor or similar hard surface through which vibrations from pumps and equipment are easily transmitted. Instead, the dewar should be shock-mounted in some way. One recommended method of doing this is to set the dewar on a section of plywood which has a 1- to 2-in. piece of polyurethane foam sandwiched between it and the floor. If this much elevation of the dewar is not permissible, even a 1/4-in. piece of foam placed between the dewar and the floor will be of substantial benefit. When possible, all parts of the cryostat or dewar should be prevented from contacting vibrating objects or objects which might transmit vibrations. Loud noises in the general vicinity of an operating detector system should be avoided.

If the detector is operated in an environment which is highly conducive to microphonics, several adjustments may be made to minimize the resulting effects. The use of shorter shaping time constants (~2 microseconds) often greatly reduces microphonic signal response at the expense of increased system noise. Setting the amplifier baseline restorer to "auto" or "high" is usually helpful.

Improper system grounding can cause ground loops which may induce apparent electrical oscillations. Ground loops can result when several different electronic system components are "grounded" in different places which may be at slightly differing near-ground potentials. Make sure all components of the spectroscopy system share one effective common ground. If the building has an electrical system which is not well grounded, consult a competent electrician. Another common cause of ground loops is a poor grounding connection through faulty coaxial cable or a loose BNC connector on a cable or panel. Trace down and eliminate such problems by trial and error replacement while closely observing the resulting baseline noise on your oscilloscope.

Signal pickup can occur even in properly grounded systems. Radio frequency electromagnetic waves may be picked up from a radio station, a particle accelerator, or other sources. Although your detector system is well shielded, additional RF shielding may be useful under extreme circumstances.

Pickup over the ac power line can also be a problem. THE SYSTEM SHOULD NOT BE OPERATED ON CIRCUITS COMMON TO ELECTRIC MOTORS AND OTHER ELECTRICALLY NOISY EQUIPMENT. See an electrician about supplying an isolated power line or contact the ORTEC Global Service Center for recommendations about obtaining an appropriate ac line conditioner.

4.5. The Initial Application of Bias

Before applying bias to the detector, apply power to the other components in the system. Observe the unipolar output from the main amplifier on the oscilloscope. For preliminary testing, use a main amplifier gain of about 40 for coaxial detectors. Adjust the oscilloscope gain for a baseline width of

1 to 2 cm and observe the system noise.

A 60- or 120-Hz sine wave with superimposed noise indicates a major ground loop. This should be found and eliminated. If there is any ripple at these frequencies, it should be very small in comparison to the amplitude of the white noise. A complete inspection for smaller spurious oscillations may be made after the detector is under bias. Occasionally, the system may appear "dead" when no bias has been applied. If the application of a small amount of bias (~30 V) results in appearance of the white noise, there is no problem.
Apply about 200 V of negative bias to the detector. The noise amplitude should decrease because the detector capacitance decreases as the depletion of charge carriers begins. Application of the wrong bias polarity can cause the noise amplitude to either increase greatly or drop completely to zero and remain there. This might also occur if the detector has been damaged in shipment.

If the detector bias polarity is correct and the reaction is normal, increase the detector bias gradually in steps of about 200 V while observing the oscilloscope. The noise amplitude should normally continue to decrease down to a minimum. With the prescribed gain, the final baseline width should be about 10 to 20 mV. It is normal for the noise to completely disappear for several seconds following changes in bias voltage. During the step-wise voltage increases, if the noise disappears and does not reappear within 15 seconds, reduce the bias immediately, 100 V at a time, until the noise reappears. The detector may be tested for resolution at this reduced bias level. However, a detector problem is indicated unless your high-voltage power supply is significantly uncalibrated or the detector has not been allowed to cool completely.

When the bias voltage has been raised to that level specified in the Quality Assurance Data Sheet, the noise amplitude may have increased slightly above the minimum level noted above, but the increase should never exceed 10%. At this level of noise, any spurious oscillations or baseline disturbances due to ground loops, pickup, or microphonics should be clearly visible. Eliminate such problems before the detector system performance is evaluated. Before attempting to make definite performance measurements, allow the detector system to stabilize, with bias applied, for at least 60 minutes.

5. GAMMA-X SERIES DETECTOR PERFORMANCE MEASUREMENTS

NOTE:
All the calculations described in this Section can be performed automatically with the appropriate ORTEC software package.

5.1. FWHM Energy Resolution Measurements

1.33 MeV, ^{60}Co
Begin by making a ^{60}Co resolution measurement. Place a ^{60}Co source in front of the detector endcap. Initially set the main amplifier gain to achieve a pulse height of 8 to 9.5 V for the 1.33-MeV line as measured on an oscilloscope. Make preliminary adjustments of the pole-zero (not needed if an automatic pole-zero amplifier is used) and BLR threshold settings of your main amplifier. Adjust the source-to-detector distance to achieve a count rate of approximately 1000 counts per second.

Adjust the gain of the main amplifier and the pulse height analyzer settings (conversion gain and digital offset, if available) until the 1.17- and 1.33-MeV peaks are separated by 800 to 1000 channels. After this gain adjustment, carefully adjust the pole-zero and BLR threshold. Check to be sure that amplifier dc output levels are zero and that the entire system is dc-coupled. Use the oscilloscope to verify that the outputs from the main amplifier are within their specified linear ranges and have not suffered from any distortion. Inspect the baseline for problems such as microphonics or oscillations due to ground loops or pickup, and correct such problems before proceeding.

Accumulate a spectrum in the pulse height analyzer so that the 1.33-MeV peak has at least 50,000 counts within the half max region and a full width at half maximum (FWHM) of at least 6 channels (10 to 12 channels is preferred). The system energy slope calibration can now be made in keV/channel since both peaks are identified by channel numbers and the energy difference between the peaks is 159.3 keV. Determine the FWHM in channels interpolating to the nearest 0.01 channel. For detailed instructions, see "Determining FWHM Expressed in Channels," which follows. Multiply the FWHM in channels by the energy slope calibration in keV/channel to find the system FWHM resolution in keV. Compare this measured resolution with the Quality Assurance Data Sheet at the front of this manual. If there is a significant discrepancy, first be sure that the measurements were made at the same shaping time constant. (Refer to Section 6.3 for troubleshooting guidelines.)

5.9 keV, ^{55}Fe

For GAMMA-X detectors with beryllium windows, one of the warranted specifications is the resolution of the 5.9 keV line of ^{55}Fe (Mn X-ray). Since the resolution of a coaxial detector is not adequate to completely resolve the 5.9 keV line from the 6.5 keV line, the peak shape (FW.1M/FWHM and FW.05M/FWHM) are not very meaningful. However, the FWHM of the 5.9 line can be used as a measure of the detector's resolution in this low energy range. Since the ^{55}Fe source does not have two clearly resolved peaks which can be used for calibration purposes, the following sequence is used at the ORTEC test laboratory. The use of a pulser can also be employed for calibration if the needed radioactive sources are not available.

Place a ^{57}Co source close enough to the detector window to give a count rate of approximately 1000 cps. Adjust the main amplifier until the 122 keV line gives a 4-volt peak on an oscilloscope. Collect approximately 1000 counts in the main peak of the ^{57}Co 122 keV line. Replace the ^{57}Co source with an ^{241}Am source. Collect approximately 1000 counts in the main peak of the 60 keV line of ^{241}Am. Calculate the energy slope (eV/channel) using the 59.537 keV line of ^{241}Am and the 122.060 keV line of ^{57}Co. The two peaks should be separated by approximately 1200 channels. Clear the pulse height analyzer. Place an ^{55}Fe source close enough to the face of the detector to give approximately 1000 counts per second. Collect 10,000 counts in the main peak of the 5.9 keV line. For the suggested gain of the main amplifier, the FWHM of the ^{55}Fe peak should be between 10 and 30 channels. (However, the IEEE-recommended conditions of 6 channels FWHM and 50,000 total counts within the peak half max would be adequate.)

Calculate the peak half max in channels and, using the energy slope calculated above, calculate the FWHM energy resolution in eV. Compare this measured resolution with the Quality Assurance Data Sheet at the front of this manual. If there is a significant discrepancy, first be sure that the measurements were made at the same shaping time constant. (Refer to Section 6.3 for troubleshooting guidelines.)

Determining FWHM Expressed in Channels

These instructions assume the use of a spectroscopy system similar to that shown in Fig. 4.1. FWHM can be determined using the same principles with even simpler instrumentation (e.g., discriminators or single-channel analyzers rather than a pulse height analyzer). The determination takes more time, but with good instrumentation the results are accurate.

1. Accumulate sufficient data and halt the analyzer.

2. If necessary[1], determine the background continuum under the peak of interest so that the number of background counts in each channel is known. Obtain the net number of counts in each channel to be used by subtracting the background counts from the total counts in that channel. All subsequent steps assume that the background has been subtracted.

3. Locate the peak channel which is the channel containing the maximum number of net counts of any channel in the peak of interest.

4. Find the half maximum number of counts which is one-half of the net number of counts in the peak channel.

5. On the lower energy side of the peak, find the two adjacent channels with net numbers of counts which bracket the half maximum number.

6. Perform a linear interpolation, to 0.01 channel, to find the channel number which represents the half maximum number of counts. Record this number.

7. Determine the channel number representing the half maximum number of counts on the higher energy side of the peak using the methods of steps 5 and 6. Record this number.

8. Subtract the channel number found in step 6 from that found in step 5. The result is the FWHM expressed in channels.

5.2. Peak Width Ratios

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1 If a source is used which produces only a few lines, the background level under a higher energy peak is often small enough that it may be neglected. However, if the background level is more than 1% of the peak height, background must be subtracted when determining the FWHM.

In addition to determining the FWHM of a spectra peak, its width may also be measured at other specific heights. The full width at tenth maximum (FWTM) and full width at fiftieth maximum (FWFM) are frequently measured. From these values, the tenth-to-half ratio (FWTM/FWHM) and the fiftieth-to-half ratio (FWFM/FWHM) are calculated. These quantities are good indicators of the quality of the peak shape. Good peak shape is especially important when computer fitting is used.

The ideal peak shape is a Gaussian curve for which FWTM/FWHM = 1.82 and FWFM/FWHM = 2.38. However, for an actual spectral peak reasonable values are FWTM/FWHM $\leq$1.9 and FWFM/FWHM $\leq$2.8. At higher energies, peak shape is less influenced by electronic noise, but is sensitive to peak asymmetry or tailing caused by charge collection problems (e.g., charge trapping or the existence of weak field regions).

To obtain representative values for these peak width ratios, the pole-zero must be properly adjusted and the detector must be operated at the correct bias voltage.

5.3. Noise

Excess noise is often symptomatic of an electronics problem in the detector system or in other electronics. Therefore, it is useful to measure, and record for future reference, the noise performance of the detector system as part of the initial check-out procedure.

The spectroscopy system noise can be measured simply by using a pulse generator. If all other elements of the spectroscopy system are functioning properly, then essentially all of the measured noise is due to the detector and the preamplifier. System noise is independent of energy, unlike radiation source resolution. However, the measured noise depends strongly upon the shaping time and the method of pulse shaping used in the main amplifier. A spectral peak produced from a pulse generator input exhibits broadening only as a result of system noise. Therefore, this technique excludes broadening effects due to fluctuations in the charge generation and collection processes within the detector element.

It is helpful to precede the precision pulse generator measurement by one of the radiation source energy resolution measurements described (Section 5.1). Otherwise, a separate calibration measurement must be made using a radiation source. Do not readjust the gain or any other settings, and the same energy slope calibration determined with the radiation source will remain valid. Remove the radiation source and turn on the pulse generator. Adjust the pulse generator output to produce a peak within the spectral region of the pulse height analyzer. For a definitive measurement, acquire a spectrum until the peak channel contains at least 4000 counts. Measure the pulse generator peak FWHM in channels to the nearest 0.01 channel. Multiply this by the energy slope calibration in eV or keV per channel to obtain the FWHM system noise in energy units. A peak width of at least 6 channels at the FWHM is required for an accurate measurement. If the resulting peak is too narrow, increase the system gain, recalibrate the energy slope with a radioactive source, and repeat the measurement.

5.4. Peak-to-Compton Ratio

The measurement of the peak-to-Compton ratio is based on the same energy peak (1.33 MeV) used for the ^{60}Co resolution measurement, (Section 5.1). The ratio is the number of net counts in the 1.33-MeV peak channel divided by the average number of net counts in the channels representing the range from 1.040 through 1.096 MeV, which is part of the Compton region associated with the 1.33-MeV peak. The range of the pulse height analyzer must be adjusted to include the peak channel and the range of interest in the Compton plateau. Accumulate the spectrum until there are several thousand counts in the peak channel and then calculate the ratio based on the information in the spectrum.

Normally, the calculated peak-to-Compton ratio can be expected to match the quoted specification if the resolution specification has been met. A loss in the peak-to-Compton ratio that is not accompanied by a corresponding degradation in the energy resolution measurement is probably due to the presence of some absorbing material in the vicinity of either the detector or the source, or to ^{40}K background from the concrete walls, or to the presence of some other radiation sources. An adjacent absorbing material can increase the Compton background and can thus reduce the peak-to-Compton ratio. Any contribution of energy in the range of interest from radiation sources other than the ^{60}Co will add to the count level in the Compton region. For this measurement, be sure that the detector is at least 3 feet away from other objects and that no other radiation sources are in the vicinity of the detector.

5.5. Relative Efficiency

The detector system should be set up and adjusted in the same way as for ^{60}Co resolution measurements. The procedure used by ORTEC for efficiency measurements is defined in IEEE Standard 325-1986, "Standard Test Procedures for Germanium Gamma-Ray Detectors." This procedure must be followed exactly to achieve meaningful results.

Place a calibrated ^{60}Co point source (1% accuracy in activity) 25.0 cm from the center of the front face of the endcap on a line perpendicular to the endcap face. The current activity of this source must be calculated on the basis of the ^{60}Co decay rate. The absolute efficiency of the germanium detector for 1.33-MeV photons is measured with appropriate dead time corrections. The absolute efficiency is given by the ratio of the total counts in the 1.33-MeV peak to the total number of source disintegrations during the elapsed live time. (Live time = real time - dead time, including both amplifier and analyzer dead time.) It is suggested that at least 10,000 counts be accumulated in the 1.33-MeV peak. The ratio of the absolute germanium detector efficiency to the efficiency of a 3 X 3 NaI(Tl) scintillation detector at 25.0 cm (known to be 1.2 X 10^{-3}) is calculated. This ratio, expressed as a percentage, is given as the relative efficiency of the detector.

Relative Efficiency =

$$\frac{(\text{peak area})/[(\text{activity})(\text{live time})]}{1.2 \times 10^{-3}} \times 100$$

where

peak area = number of counts in peak,
activity = disintegrations/second,
live time = real time minus total system dead time in seconds.

When using ORTEC instrumentation, connect the amplifier BUSY OUT to the pulse height analyzer amplifier Busy input. Pulse height analyzer live time will be corrected for amplifier pulse pileup, giving results to sufficient accuracy for most efficiency determinations. If pulse pileup rejection is used, the inhibit output must also be connected to the pulse height analyzer anticoincidence gate.

6. MAINTENANCE AND TROUBLESHOOTING

6.1. Liquid Nitrogen Maintenance and Warm-Up Protection

Any GAMMA-X Series detector may be cycled between room temperature and liquid nitrogen temperature as needed. However, when the system is frequently used, it is suggested that a regular filling schedule be followed and unscheduled warm-ups be avoided. This reduces the probability that high voltage bias might be accidentally applied to a detector which is not fully cold and cause serious damage. In addition, regular filling will make any unusual increase in liquid nitrogen consumption readily apparent. An excessive liquid nitrogen loss rate indicates a vacuum problem in the cryostat or dewar.

Protection against accidental detector warm-up may be effectively accomplished by either of two methods described in Section 2.6.

When the detector system is to be kept cold, a regular filling schedule is best. Filling once a week is ideal for systems with a 30-liter dewar even though the holding time is about 2 weeks under typical laboratory conditions. This frequency will ensure an adequate supply, and there is never any doubt about whether or not it is the week for refilling. A liquid nitrogen maintenance record form and protective jacket are provided with your detector. Be aware that frequent moving of the dewar will cause some increase in liquid nitrogen loss rate. Dewars in transit are likely to have loss rates double those in laboratories.

A regular delivery schedule should be established with a supplier of liquid nitrogen. Keep the liquid nitrogen supply covered and free from contaminants at all times. When gas from an external source is used to supply filling pressure, only clean dry nitrogen should be used. Never use ordinary compressed air which contains oxygen and is likely to contain moisture and oil. Do not use oxygen or other gases which are potentially hazardous. Liquid nitrogen can condense liquid oxygen. If liquid oxygen touches a combustible material such as oil or rubber, a fire or explosion can result.

One of the recommended filling procedures (Section II) should be followed. If these methods are impractical, contact the ORTEC Global Service Center to discuss possible alternatives.

6.2. Neutron Damage

It is important for the spectroscopist to know if his detector system is or has become radiation (usually neutron) damaged. IF DAMAGE HAS OCCURRED, THERMALLY CYCLING A DETECTOR TO ROOM TEMPERATURE WILL RESULT IN DRAMATIC RESOLUTION DEGRADATION. You can postpone repair and get additional use from your neutron damaged detector by keeping it cold until unacceptable deterioration has occurred. When this point is reached, ORTEC can repair your detector promptly.

Neutron damage results in low-side tailing on higher energy peaks as a result of charge-carrier trapping by hole traps now created in the crystal (Fig. 6.1). The first indication of neutron damage is noticeable degradation of resolution above 1 MeV accompanied by little degradation below 200 keV. The system noise, as indicated by the FWHM resolution of a peak from a precision pulse generator, will be unchanged after neutron damage.

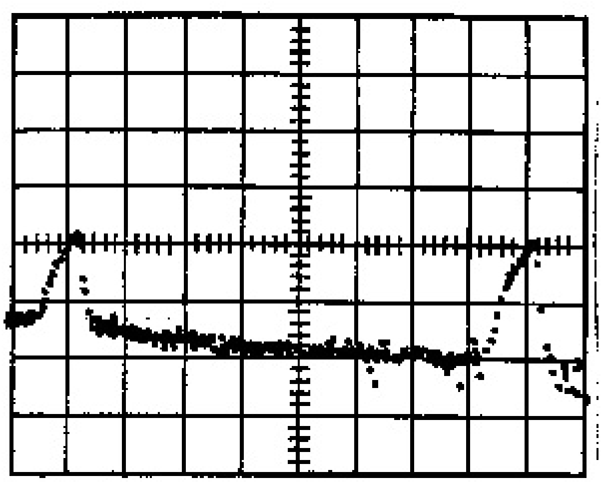

Fig. 6.1. Tailing on the Low-energy Side of 1.17- and 1.33-MeV Photopeaks due to Radiation Damage. (Semi-logarithmic scale.)

Neutron damage results from the exposure of the detector to an excessive fluence of fast neutrons. Although the threshold dose that will result in damage effects in a conventional p-type HPGe detector has been well established, it appears that fluences as low as 10^8 to 10^9 neutrons/cm^2 can cause noticeable damage in some HPGe crystals. The neutron damage resistant GMX Series (GAMMA-X) detectors can withstand approximately 25 times the neutron fluence of a conventional p-type detector before damage is evident.

6.3. Troubleshooting

Each ORTEC GAMMA-X Series Detector is guaranteed to meet all of the performance specifications listed on the "Quality Assurance Data Sheet" when the detector is used in a spectroscopy system as shown in Figure 4.1. The system should be operating in a normal laboratory environment and the main spectroscopy components (bias supply, main amplifier, and multichannel analyzer) should be those ORTEC models specified in Fig. 4.1, or their equivalent. If there appears to be a problem with the system, use the following troubleshooting procedures to identify and eliminate the difficulty.

Certain equipment and connections are required (Fig. 4.1). Review the connections of the components and the dial settings of the instruments to ensure a proper system setup. Instruction manuals of all elements of the spectroscopy system should be available to assist in determining which component of the system is causing the problem.

In detector system problem diagnosis it is important to carefully examine the main amplifier output with an oscilloscope. This will be more effective if the user is very familiar with the normal appearance of the amplifier output baseline on an oscilloscope. Regular examination of the amplifier output will provide such familiarity and may help discover problems in their early stages.

Several common problems that may arise in a germanium detector system are listed in the Troubleshooting Guide which follows. For each symptom the most probable causes are listed, and repair procedures are suggested. Use the list to help perform an organized analysis of the problem, thereby avoiding lost use of the system while trying to decide whether or not the detector is operating satisfactorily. This can usually prevent any unnecessary delays, costs, and hazards of shipping the detector to and from the factory. When a problem is identified that requires the detector to be returned to ORTEC, always summarize the symptoms observed and the tests that were performed and then call ORTEC to inform us of the details and to arrange for return and repair. In the United States, call the ORTEC Global Service Center at 1-800-251-9570 or (865) 482-4411. Elsewhere, contact the nearest ORTEC representative.

Check all power-supply voltages and the detector bias supply polarity. Set the main amplifier controls as follows:

Gain

40

Input	Negative (Streamline Cryostat System), or Positive (System with 120 Series Preamplifier)
Output	Positive
Output Range	10 V
Shaping Time	Consult Quality Assurance Data Sheet (front of manual)
BLR	Out or PZ adjust (Check to see if specified on the Quality Assurance Date Sheet.)

Connect the preamplifier output to the input of the main amplifier and connect the pulse generator output to the Test input of the preamplifier. Connect an oscilloscope and a pulse height analyzer to the unipolar output of the main amplifier. Then carefully examine the system's performance.

If the system problem is poor gamma-ray resolution, a careful study of the symptoms is needed before a diagnosis can be made. Without the presence of a radioactive source, observe the output of the amplifier (gain of 40) with an oscilloscope (50 mV/cm vertical gain). Some nuclear pulses will still be seen.

It is not abnormal to have occasional negative spikes or overload pulses followed by negative excursions. Carefully observe the nature of any other pulses or oscillations. Measure the noise of your detector system as the resolution obtained from a pulse generator spectrum (Section 5.3). A knowledge of the system resolution at both lower and higher energies is also needed. Measurements at 1.33 MeV and 122 keV are recommended. After these observations and measurements have been made, consult the Troubleshooting Guide.

TROUBLESHOOTING GUIDE

Symptom	Probable Cause	Action
1) Pulse height analyzer does not register any counts.	Pulse height analyzer not receiving pulses. Pulse height analyzer controls improperly set.	Use an oscilloscope to examine the signal input to the pulse height analyzer. If no pulses are present, see symptoms 3, 4, 5, and 6. If pulses are present at the input, see the pulse height analyzer manual and check the control settings. Be sure that the amplifier output has the proper polarity. You may be misled if the oscilloscope is accidentally set to "invert."
2) Pulse height analyzer registers background counts, but no peaks are visible.	Pulses corresponding to the spectral peaks have voltage heights outside the range of the pulse height analyzer.	Use an oscilloscope to examine the signal input to the pulse height analyzer. Adjust amplifier gain to achieve pulse heights within the input range of the pulse height analyzer. (Make sure that you know this range, which may change with pulse height analyzer settings, e.g., digital offset or conversion gain.)
3) No amplifier output for gamma-ray source or pulse generator.	Amplifier not receiving pulses.	Check preamplifier output with the oscilloscope set on 50 mV/cm vertical gain. If no output, see symptoms 5-6.
4) No amplifier output, but satisfactory preamplifier output.	Amplifier faulty or maladjusted.	Check amplifier settings and connections. Consult the amplifier manual. Replace the amplifier, if necessary.
5) No preamplifier output at recommended bias voltage.	Excessive detector leakage current biasing off the preamplifier input stage.	Decrease detector bias in steps of 100 V until output pulses are obtained. If the detector does not perform properly at a lower bias, contact the ORTEC Global Service Center (or your local ORTEC representative, if outside the U.S.A.).
6) No preamplifier output at any detector bias voltage. The baseline is virtually flat.	Power failure, preamplifier failure, blown input FET, or short inside cryostat.	Correct power supply or power cable problems. Contact the ORTEC Global Service Center (or your local ORTEC representative, if outside the U.S.A.).
7) Poor gamma-ray resolution. High noise (pulser resolution). Sinusoidal oscillations seen on the baseline with oscilloscope.	Power line noise, RF pickup, or ground loop (especially if able to synchronize to ac line with oscilloscope trigger).	Eliminate ac power line noise by isolation or filtration. Ensure that there is one effective common ground. Eliminate any breaks in the ground path—especially bad cables or connectors. If operation is in a strong RF field, consider extra shielding (Section 4.4).

Symptom	Probable Cause	Action
8) Poor gamma-ray resolution. High noise (pulser resolution). Slowly damping sinusoidal baseline oscillations.	Microphonics (see Section 4.4).	Place the system dewar on a foam pad if vibrations through the floor are a problem. Arrange other suitable shock mounting. Try using a shorter time constant (Section 4.4). Contact the ORTEC Global Service Center (or your local ORTEC representative, if outside the U.S.A.).
9) Poor gamma-ray resolution and high noise. Many negative spikes.	Breakdown of filter capacitor or high-voltage feedthrough.	Contact the ORTEC Global Service Center (or your local ORTEC representative, if outside the U.S.A.).
10) Poor gamma-ray resolution and high noise. A very ragged baseline with one or more of the following types of anomalous pulses: positive spikes, negative spikes, square positive and negative pulses.	Breakdown across the surface of the detector or an insulator.	Be sure bias voltage is not more than specified. Reduce detector bias in steps of 100 V until baseline returns to normal. If the system meets all performance requirements, it may be usable at the lower bias. If not, contact the ORTEC Global Service Center (or your local ORTEC representative, if outside the U.S.A.).
11) Poor gamma-ray resolution. No unusual pulses but a wide baseline and higher noise.	Excess detector leakage current.	Same as for symptom 10.
	Insufficient bias voltage.	Be sure that the specific bias is used. Check high- voltage bias supply for proper connections and operation. Try another bias supply. Consult your bias supply manual.
12) Poor gamma-ray resolution at 1.33 MeV or higher energy. Normal noise as measured by pulse generator resolution. Resolution at 122 keV or lower energy is much less degraded than higher energy resolution.	Neutron damage (or similar radiation damage).	If the detector is warmed up, the resolution will get much worse. DO NOT WARM UP THE DETECTOR. Neutron damage can be repaired. Contact the ORTEC Global Service Center (or your local ORTEC representative, if outside the U.S.A.).
13) Low- or high-energy side tailing and poor resolution.	Incorrect pole-zero cancellation.	See Section 4.3 for instructions.
14) Wandering peaks or multiple peaks observed.	Unstable electronics (especially main amplifier).	Check each electronic component for proper operation. Repair or replace faulty units. Check all cables and connectors (including panel connectors) for intermittent signal or ground connections.

Symptom	Probable Cause	Action
15) High loss rate of liquid nitrogen. Excessively cold cryostat with moisture condensation.*	Degradation of cryostat vacuum.	Measure liquid nitrogen loss rate by weighing (LN_2 weighs 0.807 kg/liter). For an accurate measurement, the dewar must not be moved from 2 h before the initial measurement until after the final measurement. The normal loss rate depends on cryostat/dewar configuration. Contact the ORTEC Global Service Center (or your local ORTEC representative, if outside the U.S.A.) to find out if the loss rate is abnormal. For most systems, a loss rate of more than 2.0 liter/day is excessive. For a dipstick system, the dewar loss rate (see 16) may be subtracted from the system loss rate to give the cryostat loss rate (which should not be above 1.5 liter/day).
16) High loss rate of liquid nitrogen. Excessively cold dewar with moisture condensation. Cryostat temperature normal.*	Degradation of dewar vacuum.	Check system loss rate as in 15. If cryostat is a dipstick model, place it in another dewar and measure the dewar loss rate alone. Place a stopper in the hole in the white RTV silicone collar and measure by weight as in 15. A 30-liter dewar with collar assembly should have a loss rate below 0.7 liter/day. To order a replacement dewar, contact the ORTEC Global Service Center (or your local ORTEC representative, if outside the U.S.A.).

* Note: Some systems have a common cryostat-dewar vacuum. Symptoms 15 and 16 occur simultaneously in such systems.

7. WARRANTY STATEMENT AND RETURN INSTRUCTIONS

Advanced Measurement Technology, Inc.

a/k/a/ ORTEC®, a subsidiary of AMETEK®, Inc.

Temperature Cyclable Detector Systems Warranty Statement

ORTEC warrants its Temperature Cyclable Photon Detector Systems to be free from defects in material and workmanship for a period of one year after shipment. ORTEC guarantees that the detector system will operate within the warranted specifications regardless of the number of thermal cycles between liquid nitrogen temperature and room temperature to which the system has been subjected and regardless of how long the system has been stored at room temperature during the one-year period. This warranty is subject to the following **customer obligations**:

1. The cryogenic FET has not been damaged.

2. The system has not been physically or electrically abused.

3. The detector has not been subjected to neutron damage.

4. The detector vacuum seal has not been broken by the freezing of the O-ring surfaces.

Should the detector system fail, through no fault of the customer, within the warranty period, and having at all times been handled in accordance with the above described customer obligations, it will be repaired or replaced without charge, at ORTEC's option, and will be fully warranted to within the original specifications for an extended 3-month period or the remainder of the warranty period, whichever is longer.

ORTEC's liability on any claim of any kind, including negligence, loss or damage arising out of, connected with, or from the performance or breach thereof, or from the manufacture, sale, delivery, resale, repair, or use of any item or services covered by this agreement or purchase order, shall in no case exceed the price allocable to the item or service furnished or any part thereof that gives rise to the claim. In no event shall ORTEC be liable for special or consequential damages. ORTEC makes no other warranties, expressed or implied, and specifically NO WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

Instructions for Returning a Temperature Cyclable Photon Detector System

If for any reason it becomes necessary to return a Temperature Cyclable Photon Detector System for repair or replacement, please note the following instructions and precautions regarding shipment.

1. **Contact ORTEC** Contact the nearest ORTEC representative (in the U.S. call our Global Service Center, 1-800-251-9750 or (865) 482-4411, for specific instructions and authorization for returning the detector. Any detector that is returned without prior notification having been given to ORTEC could result in loss or damage and would be automatically considered out-of-warranty.

2. **Proper Packing** If you are unfamiliar with packing a detector, please contact the nearest ORTEC representative for assistance. Poor packing could result in shipment damage that would not be covered under the ORTEC warranty or freight forwarder's insurance policy.

3. **Shipment Coordination and Communications** Detectors should be returned through the freight forwarder prepaid. For out-of-warranty repairs, the reshipment charges from ORTEC will be billed to the customer. For in-warranty repairs the reshipment charges from the factory will be paid by ORTEC. Should a detector system returned to ORTEC be found operating within specifications, the customer will be charged an inspection fee and be responsible for freight charges to and from the factory, whether in-warranty or out-of-warranty. Weekend delays in transit should be avoided; thus an early weekday shipment is recommended. ORTEC must be notified of specific details of the returning shipment (i.e., freight forwarder, air freight carrier, date, time, airway bill number, etc.) at the time of the shipment to ensure attention upon receipt at the repair facility.

The instructions and precautions stated here are to ensure proper attention in handling shipment of an expensive radiation detector. Do not be apprehensive because of these precautions. Detectors are successfully shipped all over the world when just a few precautions are followed. When in doubt about any of the above-mentioned precautions or instructions, please contact the nearest ORTEC office for assistance.

Effective Date: May 1991

This policy supersedes all previous statements regarding warranty and repair of Temperature Cyclable Detector Systems. Policy and prices subject to change without notice.

APPENDIX A.

STREAMLINE CRYOSTAT CONFIGURATION HYBRID PREAMPLIFIER AND HIGH-VOLTAGE FILTER SPECIFICATIONS

Since essentially all of the electronic specifications depend to some extent on the components within the cryostat, the following should be interpreted as resultant system specifications. Furthermore, due to the variability in these components, these specifications should be understood as typical values.

GMX Series

257N (Preamplifier) and 138 (H.V. Filter) Combination

TEST INPUT One 18-in. RG178 coax cable with female BNC connector.

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

OUTPUTS Two 18-in. RG178 coax cables with female BNC connectors. Output 2 is selectable as a normal second output or as a differential (DIFF) output signal or phantom using a printed circuit board jumper, W3.

CONVERSION GAIN Nominally 175 mV/MeV (Ge), negative output pulse signal.

RISETIME Pulser risetime typically 25 ns; actual risetime to nuclear event depends on detector characteristics.

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

MAXIMUM ENERGY RATE With standard 2000 MΩ feedback resistor, maximum average energy rate until preamp saturation is 180,000 MeV/s.

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

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

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

POWER REQUIREMENTS 1 watt nominal, +24 V, 18 mA; -24 V, 8 mA; +12 V, 24 mA; -12 V, 8 mA.

Cable Pack

Each ORTEC Photon Detector System is provided with a standard cable pack containing: signal cable and test pulse cable (both RG62A/U, 93 Ω BNC), high-voltage cable (RG59A/U, 75 Ω, SHV female), and a preamplifier power cable (9-pin D connector, male). Additional cables are supplied with various options to the detector system (e.g., remote high-voltage shutoff, remote count-rate indicator). Supplemental or extra cable and connector options are available upon request.

Automatic High-Voltage Shutoff

Detector cryostats built by ORTEC contain a temperature-sensing element attached to the cooling path. The sensing element connects to a hybrid monitoring circuit incorporated into the preamplifier electronics. An output cable from the preamplifier is connected to the Bias Shutdown input on the rear panel of the ORTEC Model 659/660 5-kV Bias Supply. This supply is designed to prevent the application of detector bias voltage if the bias shutdown cable is not connected, or if the cable is defective (open or shorted). The supply also reduces the detector bias voltage to zero if the bias shutdown input signal from the detector indicates a warm condition (+5 V dc). The monitoring circuit in the preamp provides this signal if the detector temperature becomes too high.

When a shutdown condition exists (the detector is warm or the bias shutdown cable is not connected), the bias supply display will indicate zero voltage, a front-panel Shutdown LED will turn on, and system noise will greatly increase after shutdown occurs.

For the unit to be operational, preamplifier power must be provided through the power cable. After the high voltage has been automatically shut off, the bias supply switch must be turned off until the system has been filled with liquid nitrogen and completely cooled for the recommended period (see Quality Assurance Data Sheet in the front of this manual, or the label on the detector system). **Accidental application of high voltage to a detector that is not fully cold can cause serious damage and void your warranty.**

The automatic shutoff should be placed in operation before attempting to apply bias to the detector. Thus the circuit will also prevent the accidental application of bias to a detector that has not yet reached operating temperature. This is a significant advantage over the liquid nitrogen level monitor, which is based on a temperature- sensing probe in the dewar. However, the ORTEC Model 729A Liquid Nitrogen Level Monitor provides an alarm feature that is not practical with the automatic shutoff located within the preamplifier. Also, a liquid nitrogen level monitor provides an earlier warning, allowing the addition of liquid nitrogen before the detector temperature is affected.

High-Rate Indicator

For any dc-coupled charge-sensitive preamplifier, if the energy rate (count rate × energy product) exceeds a given level (value dependent on the particular system), the preamplifier will shut off. As the energy rate approaches this level, the detector system may suffer from excessive resolution degradation and peak shift. If the energy rate hovers around the shutoff level, the preamplifier may turn on and off intermittently. Obviously, data collected under such conditions are not reliable and corrective action should be taken.

A hybrid circuit within the preamplifier monitors the charge loop output voltage. When a condition of excessively high rate exists, an output is provided suitable for lighting an LED located in the preamplifier shield.

Differential Output Signal

When long connecting cables are used between the detector/preamplifier and amplifier input, noise induced in the cable by the environment can be a problem. Amplifiers with differential input mode can be used with paired cables from the preamplifier to suppress the induced noise.

This preamplifier can be used in differential mode by moving jumper, W3, on the printed wiring board from NORM to DIFF. This makes OUTPUT 2 the differential output signal, or phantom. A second output cable must be added to the preamplifier to OUTPUT 2, which, now in the DIFF position, has its center, signal pin connected to the preamplifier ground with same value as the normal preamp output series resistor (normally 93.1 Ω). Both cables should be the same length and run next to each other.+

External Noise Impact

The detector is a highly sensitive, low noise device whose performance can be adversely affected in the presence of high level electrical or RF noise. The adverse impact of this noise will be indicated on the MCA screen by one or more of the following: elevated count rate, elevated deadtime, or resolution degradation. Once the noise source is removed, the detector output will recover to normal performance.

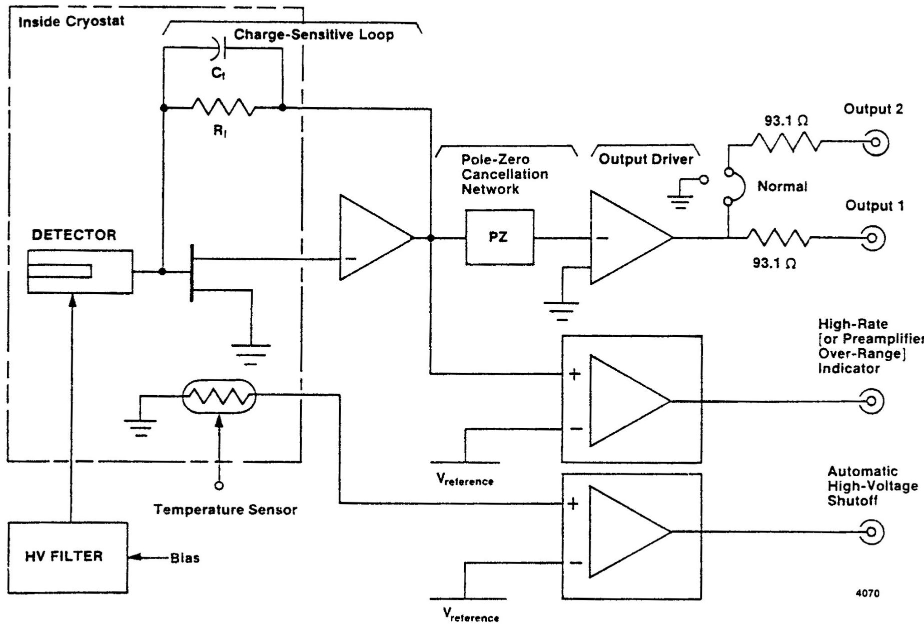

Fig. A.1. Streamline Detector System Preamplifier. Simplified Schematic with High-Rate and Automatic High-Voltage Shutoff Options.