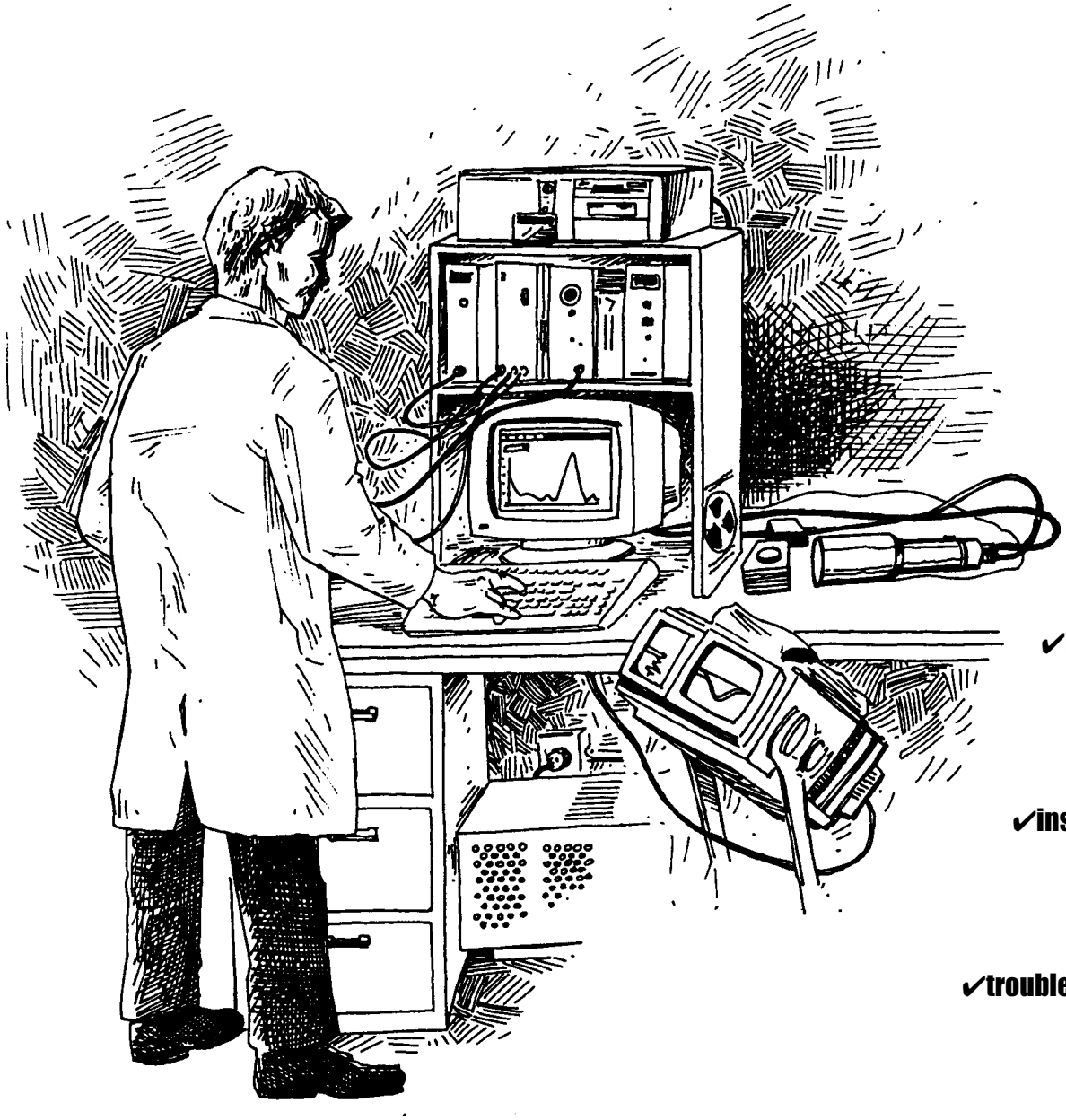
BICRON®

Scintillation Detector Operating Manual



✔handling and care

✔installation

✔troubleshooting

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Important Note on the Safe Handling of NaI(Tl) Crystal Material

A sodium iodide [NaI(Tl)] crystal is activated by the addition of a very low concentration of thallium iodide (TlI). Several years ago we asked our law firm to give us an opinion whether this product should be treated as a hazardous material for labeling purposes. A quote from their response dated November 29, 1984, follows. "We have examined the Dangerous Goods Regulations effective 1 January 1985, as promulgated by the International Air Transport Association and the Hazardous Materials Regulations promulgated by the U.S. Department of Transportation, Research and Special Programs Administration, Materials Transportation Bureau. It is our opinion, based upon our review of these materials, that your products containing sodium iodide crystals with traces of thallium iodide are not considered hazardous or poisonous."

However, thallium iodide as a pure chemical is toxic. One of our suppliers tells us that amounts of more than 1 gram per person can cause death. Another supplier states the LD-50 is 28 milligrams per kilogram body weight. On a more practical basis, there is the personnel hazard that exists from a damaged, and possibly leaking, crystal container. A thallium-activated sodium iodide crystal on average is 99.8% sodium iodide and 0.2% thallium iodide. The weight of a 2-inch diameter by 0.25 inch thick NaI(Tl) crystal is 47.24 grams including 0.094 grams of TlI. Casual contact with the small fraction of this material which might leak from a damaged container is not a serious hazard.

If a container is damaged, handle with disposable rubber gloves. Dispose of the detector materials according to local and federal regulations at an approved site. If you are unable to do so, please call Bicron's customer service for a Return Materials Authorization (RMA) number so the damaged detector can be returned to us for proper disposal.

Handling and Care of Crystal Scintillation Detectors

✔ Unpacking Instructions

CAUTION . . . DO NOT OPEN PACKAGE UNTIL DETECTOR REACHES ROOM TEMPERATURE!

If the detector package comes into the laboratory from a truck or warehouse where the temperature differs by 5°C (10°F) or more from that of the laboratory, allow the package to reach room temperature before opening. This will prevent fracturing the crystal from thermal shock. A good practice is to leave the package in the laboratory overnight before opening.

If damage to the shipping carton is apparent, ask that the carrier's agent be present when the detector is unpacked, or otherwise document the damage. Bicron cannot replace a detector damaged in shipment without this damage report.

Inspect the detector for mechanical damage, scratches, dents, etc. Check any mechanical or thermal shock indicators that may be packed with the detector.

✔ Storage and Thermal Shock

NEVER STORE THE DETECTOR NEAR A HEATING ELEMENT, SUN-WARMED SURFACE, RADIATOR OR AIR CONDITIONER!

Unless specifically designed to withstand other conditions, Bicron detectors are intended for use in a normal laboratory environment. They will operate reliably between 4°C and 43°C (40°F and 110°F), provided the rate of temperature change does not exceed 8°C (15°F) per hour.

✔ Crystal Hydration

NaI(Tl), CsF, CsI(Na) and LiI(Eu) are hygroscopic which means they are easily damaged when exposed to moisture in air at normal humidity levels. Some bare crystals can dissolve in room humidity. The hermetic seals used in these assemblies must be protected at all times. For this reason, avoid using strong organic solvents which may dissolve or soften epoxy seals. Similarly, never expose the detector to mechanical shock that may crack or chip the seals.

In NaI(Tl) crystals, hydration first appears as yellow/green spots on the surface and later as a distinct tint to the crystal. Because the hydration is yellow/green, it is an excellent absorber of blue scintillation light and will significantly degrade light output and thereby resolution. Except at low energies, counting efficiency is not normally impaired if the proper electronic adjustments are made.

In CsI(Na), hydration first deactivates the surface of the crystal. Damage produced by a small amount of hydration is not visible to the eye and does not affect resolution at high energies. At low energies, the resolution and efficiency of the detector are drastically impaired — as much as 40% up to 120 keV for a 1mm hydrated layer.

LiI(Eu) and CsF are extremely hygroscopic and even small amounts of hydration will degrade resolution and efficiency. LiI(Eu) crystals are normally a yellow/green color. Hydration will produce an overall darkening of this color until a brownish tint is discernible.

Other scintillators that are not hygroscopic are also affected by excessive moisture. CsI(pure), CsI(Tl), and BaF_2 crystal surfaces are easily damaged by drops of moisture or excessive condensation.

✔ *UV Exposure*

Ultraviolet radiation in sunlight or fluorescent lighting can produce coloration and phosphorescence in scintillation crystals. The coloration produced by UV radiation appears in the bulk of the crystal rather than the surface and is most noticeable in large crystals. For this reason, open window detectors or crystal blanks should be stored in darkness when not in use.

In NaI(Tl), the damage usually appears as a slightly muddy brown color and produces a loss of resolution. BGO is also very sensitive and its performance deteriorates quickly. BGO and NaI(Tl) should be protected from UV and should be stored in the dark. Counting efficiency is not generally impaired, though pulse height decreases and resolution increases. LiI(Eu) is extremely sensitive to UV radiation and should be stored in darkness at all times when not in use.

✔ *Light Leaks*

A light leak into the photomultiplier tube (PMT) assembly will cause continuous emission of photoelectrons from the PMT's photocathode when high voltage is on. In the D.C. current mode of operation, this will result in an increased signal that can be detected by switching the room lights on and off.

In the pulse mode of operation, light leaks can be detected by looking at the system's output with an oscilloscope. Set the sweep speed at approximately 5 µsec/cm and trigger on the smallest possible pulse (high vertical gain, but above the electronic noise level). Switch the room lights on and off again, looking for changes in the brightness of the small pulse trace.

✔ *Beryllium Windows*

As with any thin radiation entrance window, take care not to puncture or stress the beryllium windows used in many X-ray and low-energy detectors. Also, avoid touching the window surface as the mild acid from oil in fingerprints can etch through the beryllium causing a loss of hermeticity.

✔ *Cleaning and Decontamination*

We recommend using a mild detergent solution made with water for cleaning your detector. A soft sponge or lint-free cloth can be used to wipe the detector (a cotton swab is useful for cleaning wells). The cloth or swab may be moistened with methyl alcohol to remove contamination or dirt from metallic or glass surfaces.

If the detector is not hermetically sealed (e.g., some BGO and BaF_2), care should be taken that no liquid enters into the interior volume where it can wet the scintillator surface or the reflector material.

Avoid exposing the detector to acetone as it may cause chemical damage to the hermetic seals and, upon evaporation, thermal shock to the detector.

Installing Deltaline (R-Style) Detectors

In Deltaline (or R-style) detectors, the crystal is sealed by itself in a lightweight aluminum can with a single optical window. The photomultiplier tube (PMT) is normally supplied separately.

CAUTION: DO NOT EXPOSE CRYSTAL TO ULTRAVIOLET RADIATION FROM FLUORESCENT LAMPS OR SUNLIGHT.

A quick temporary package may be made by coupling the crystal to a light-shielded PMT and then wrapping the combined unit with two or more wraps of black tape from crystal container to tube, overlapping both. Note: All parts of the PMT glass bulb must be in the dark.

Optical couplings to the PMT may be made with silicone optical grease, silicone rubber pads, or other optically transparent compounds. The coupling should be as thin as is practical and free of excess compound for optimum resolution.

The PMT also should be surrounded by one or two wraps of conetic foil or other magnetic shielding. A more permanent package can be made by using a mu-metal light shield over the PMT.

To operate the PMTs, you will need a plug-on voltage divider or voltage divider/preamplifier and appropriate connecting cables. Use P-12 voltage dividers or PA-12 voltage divider/preamps with 12-pin PMT bases (1.5" PMTs) and P-14s or PA-14s with 14-pin PMTs (2", 3", 3.5" and 5"). Other plug-ons are available for other types of PMT bases. Note: Some 14-pin PMTs are only 8-stage and require a special voltage divider.

Refer to "Basic Connections" below for further installation instructions.

Installing Monoline (M-Style) and Single PMT Multiline (H-Style) Detectors

Bicron supplies a number of different detector configurations that come with a single PMT. In our Monoline (or M-style) detectors, the scintillator and PMT are mounted in the same container. Our single-PMT Multiline (or H-style) detectors feature separate, demountable scintillator and PMT housings. On request we can integrate hard-wired voltage dividers or voltage divider/preamps within these detectors. However, most detectors terminate in a phenolic PMT base with 12 or 14 connecting pins.

To install these detectors you will need a plug-on voltage divider or voltage divider/preamplifier and appropriate connecting cables. Use a P-12 voltage divider or PA-12 voltage divider/preamp with 12-pin PMT bases (1.5" PMTs) and P-14s or PA-14s with 14-pin PMTs (2", 3", 3.5" and 5"). Other plug-ons are available for other types of PMT bases.

✔ *Basic Connections*

1) Unless you have a detector with integrated voltage divider or voltage divider/preamplifier, press a plug-on voltage divider onto the PMT base. (Be sure to align the keyway before pressing.)
2) Using RG-59/U or equivalent coaxial cable, connect the positive high voltage supply (800 to 1300 volts) to the SHV (or MHV) connector as shown in *Figure 1* or *Figure 2*. The connector is marked "HV." The "SHV" can be

recognized by its overall length or the "MHV" by the inner Teflon® insulation extending higher up than that in the signal connector. See the QA Sheet supplied with your detector for a typical HV value.

3) Connect the system electronics to the BNC signal connector (marked "S") using RG-58/U or RG-59/U coaxial cable again as shown in *Figure 1* or *Figure 2*. (Cable length of less than 10 feet is recommended.)

Note: If you are using a voltage divider/preamplifier, no external preamp is required in your system electronics *(Figure 2)*. However, you will need a separate power supply to provide negative (-)24 volts through the 9-pin connector's pin 6 and ground (common) on pin 1.

Many NIM-Bin mounted amplifiers have this voltage available in a matching 9-pin connector on the unit's rear panel. If your amplifier does not have this capability, you can use an appropriate, laboratory D.C. power supply.

Figure 1

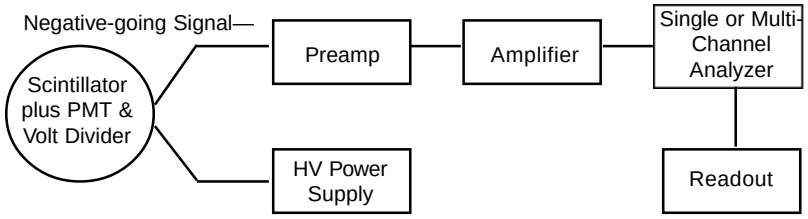
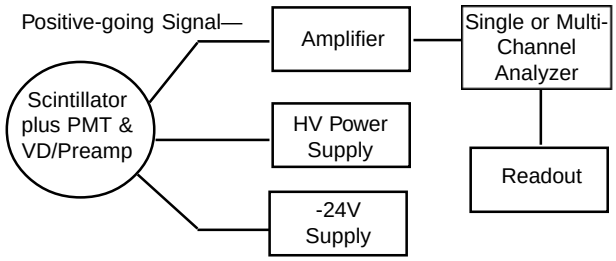


Figure 2



✔ *High Voltage*

CAUTION: The voltages applied to and the currents used with photomultiplier tubes are hazardous. Detectors must be operated at positive high voltage unless specially modified for negative high voltage operation. A detector's outer metallic housing serves as a light and electrostatic shield. For proper operation and as a necessary safety precaution, the metallic housing should be attached to a good or solid ground connection. If the PMT is operated at negative (-) high voltage, an additional electrostatic shield is attached to the PMT to prevent electrostatic degradation of the glass bulb.

Installing X-ray Probes

Bicron's 1XM.040BP and 1XMP.040B X-ray probes consist of a Deltaline X-ray detector mounted behind a collimator in a common housing with a photomultiplier tube and voltage divider in a Monoline-like configuration. The 1XMP.040B probe also has an integrated FET preamp. Each probe comes with 12 ft. long cables hard-wired to the voltage divider or preamp and terminating in appropriate connectors.

✔ *Basic Connections*

1) Connect the high voltage connector to any commercial power supply designed to provide positive high voltage to photomultiplier tubes. The connector is marked "HV." The "SHV" can be recognized by its overall length or the "MHV" by the inner Teflon® insulator extending higher up than that in the signal connector.
2) Adjust the voltage to yield the desired amplification. The Bicron QA Sheet will list a safe operating voltage. Generally, any voltage between 700 and 1400 volts will produce satisfactory performance. 1500 volts is the maximum voltage that a typical PMT can take without damage. Some PMTs can handle higher voltage. If in doubt, check the PMT manufacturer's data sheet for their specifications.
3) Connect the BNC signal connector to the system preamplifier's input as shown in *Figure 1* for the 1XM.040BP or directly to the system amplifier's input for the 1XMP.040B with FET preamp (*Figure 2*).

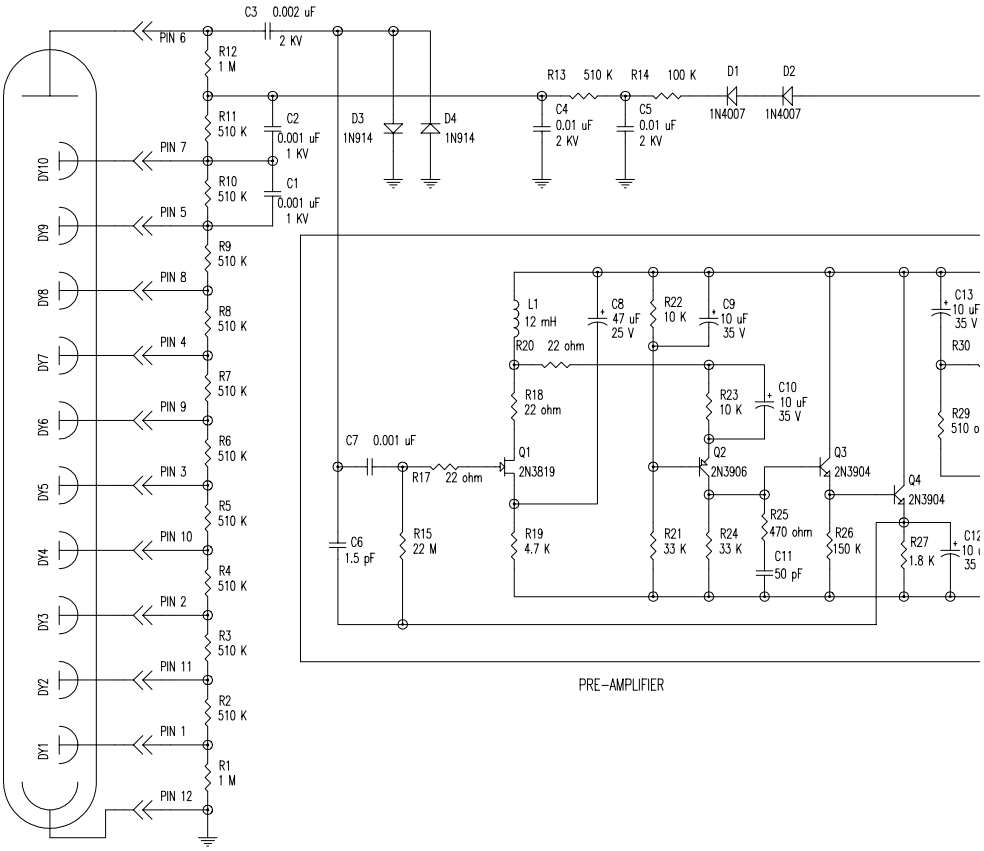
Note**: no external preamp** is required in your system electronics when using a 1XMP.040B probe.

4) If you are using a 1XMP.040B, supply negative (-)24 volts to the FET preamp through pin 6 and ground (common) through pin 1 of the 9-pin connector. Many NIM-Bin mounted amplifiers have this voltage available in a matching 9-pin connector on the unit's rear panel. If your amplifier does not have this capability, you can use an appropriate, laboratory D.C. power supply.

✔ *Positive High Voltage*

CAUTION: PROBES MUST BE OPERATED AT POSITIVE HIGH VOLTAGE UNLESS SPECIALLY MODIFIED FOR NEGATIVE HIGH VOLTAGE OPERATION.

The probe's outer metallic housing serves as a light and electrostatic shield. It is good practice to ground the metallic housing.



Schematic for X-ray Probe's Voltage Divider/I

Installing Multiple PMT Multiline (H-Style) Detectors

In Multiline (or H-style) detectors, the photomultiplier tubes are demountable by removing the socket head screws on the flange of each PMT housing. The tube may be lifted from its optical window by gently pressing and sliding or twisting the housing. **Caution: Make sure high voltage is disconnected before disassembling detector.** Silicone optical grease forms the optical coupling between PMT and window. PMTs should not be removed unless absolutely necessary because recoupling and alignment is sometimes difficult.

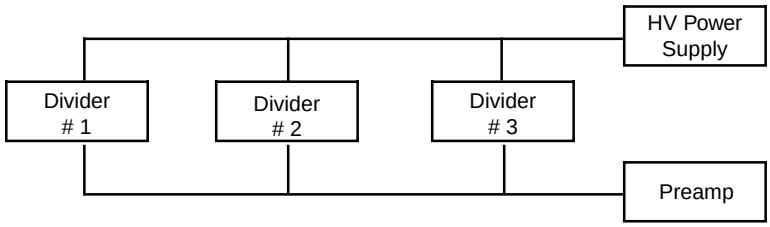
Most Multiline detectors have PMTs that terminate in a phenolic base with connecting pins. To operate these detectors you usually will need a plug-on voltage divider for each PMT. Use P-12 voltage dividers with 12-pin PMT bases (1.5" PMTs) and P-14s with 14-pin PMTs (2", 3", 3.5" and 5"). Other plug-ons are available for other types of PMT bases. Note: Some 14-pin PMTs are only 8-stage and require an appropriate 14-pin plug-on voltage divider.

When two or more PMTs are used on one detector, their signals must be summed into one signal input. Do this by connecting the plug-on voltage dividers in parallel — signal (S) to signal (S) and high voltage (HV) to high voltage (HV).

1) Press a plug-on unit onto each PMT base.
2) Using RG-58/U or RG-59/U coaxial cable, connect the positive high voltage supply (800 to 1300 volts) to the high voltage (HV) connector of each voltage divider or the network. An "SHV" connector can be recognized by the overall length or an "MHV" by the inner Teflon® insulation extending higher up than that in the signal connector. T-connectors (or a fan-out box) simplify making parallel connections (*Figure 3*). See the QA sheet supplied with your detector for a typical HV value.
3) Connect the preamplifier from the system electronics to the signal connectors (S) using RG-58/U or RG-59/U coaxial cable (and T-connectors or fan-out box, if required) again as shown in *Figure 3*. *Figure 2* shows a block diagram of a complete system.

Standard plug-on voltage dividers use SHV connectors for high voltage and BNC connectors for signal.

Figure 3



✔ *Positive High Voltage*

CAUTION: PROBES MUST BE OPERATED AT POSITIVE HIGH VOLTAGE UNLESS SPECIALLY MODIFIED FOR NEGATIVE HIGH VOLTAGE OPERATION.

The probe's outer metallic housing serves as a light and electrostatic shield. It is good practice to ground the metallic housing.

Electronic Adjustments

✔ Adjustment Potentiometers

The one turn *gain balance potentiometer* (marked "G") may be used as a variable gain adjustment to balance pulse heights from two or more phototubes. Turning it fully clockwise takes it out of the circuit and yields maximum gain. Further gain adjustment may be accomplished by changing the high voltage although extreme settings may lead to low level noise or loss in resolution. 1000 volts D.C. is usually optimum for 2", 3", 3.5" and 5" PMTs, and 900 volts for 1.5" PMTs.

The one turn *focus potentiometer* (marked "F") on P-14s and PA-14s should be adjusted to yield the best resolution (not necessarily highest pulse height). This may be accomplished by taking four spectra at quarter turn intervals on the pot and measuring the resolution of a suitable gamma-ray peak (normally the cesium-137 662 keV gamma line) at each setting. Choose the best setting by extrapolation.

✔ Balancing Procedure

For detectors with more than one PMT, the signals can be summed into a single output. Operation is then much like that of a single tube. First, each tube gain must be adjusted so that its output pulse height is identical to the other tubes on the assembly. This adjustment is called BALANCING.

1) Connect the signal cable to the counting electronics (all PMTs in parallel). For best results, balancing should be done with a multichannel analyzer. The balancing is done with all cables in place in parallel so that changes in pulse height due to cable capacitance variation is eliminated.
2) Place a source (typically 5µCi of Cs-137) on the axis of the detector at a distance of about twice the diameter of the detector. The count rate needs to be appreciably higher than background rates, but not so high as to cause electronic pile-up. A few thousand counts per second is usually adequate.
3) Set the high voltage power supply to the required voltage. Turn all voltage divider gain balance potentiometers fully clockwise to maximum gain. Examine the output of each PMT separately with a pulse height analyzer (collect a spectrum). To sample each tube, leave the HV on or connected only to the tube being checked. The signal cables should be connected to all the tubes at all times. This prevents impedance changes and, therefore, gain changes.
4) Compare the channel number or voltage (pulse) height of the gamma line from each spectrum. Leave the PMT with the lowest gain alone and adjust (reduce) the gain of the other tubes to match. Do this by incrementally turning the voltage divider gain balance potentiometer counter clockwise, collecting a spectrum, and checking the channel number for each remaining PMT in turn until their gains match that of the one with the original lowest pulse height.
5) Reconnect the HV wiring harness and apply voltage to all tubes. The tube array is now balanced at the supply voltage used in this procedure. Operation at another voltage may necessitate some rebalancing of the array, since tube gains do not track uniformly with increasing and decreasing voltages.

Performance Testing

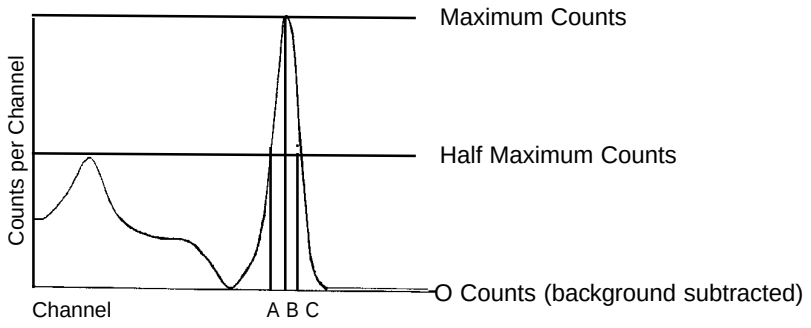
✔ *Resolution Testing*

After your detector has been installed properly, the resolution can be checked. A scintillation detector's performance is typically stated as a value of pulse height resolution, full width at half maximum (FWHM) for a particular gamma-ray peak. Although any gamma line may be used, the most frequently specified value is for the 662 keV gamma ray of cesium-137. (For an X-ray probe or detector, the most specified value is the 5.9 keV X-ray of iron-55.) Proceed as follows:

1) Apply a positive high voltage of 1000 volts D.C. (check Bicron QA sheet for appropriate value) to the phototubes, and allow 15 minutes to an hour for the gain to stabilize.
2) Uniformly irradiate the entrance face of the crystal with an appropriate radiation source (0.1 to 10.0 microcuries), but avoid high counting rates greater than about 8000 cps. If pulse pile-up or amplifier saturation occurs, the resolution value will not be a meaningful measure of detector performance. The "dead time" of the multichannel analyzer should be kept below 10%, less than 5% if possible.
3) Collect a spectrum and calculate the resolution by dividing the peak channel into the number of channels at the full width at half of the peak height.

✔ *Calculating the Resolution*

$$\text{Resolution} = \frac{\text{Channel C - Channel A}}{\text{Channel B}} \times 100\%$$



There must be adequate counts under the peak to yield good statistical accuracy--normally 5,000 counts or more in the peak channel is sufficient. Resolution values are not constant with energy. A detector having 7.5% for the cesium-137 662 keV gamma line may exhibit resolutions of 15% at 122 keV (cobalt-57) and 6% at 1172 keV (cobalt-60). As a rule of thumb, the resolution varies with one over the square root of the energy.

$$\text{Resolution} = \text{constant} \times \frac{1}{\sqrt{E}}$$

Diagnosing Crystal Scintillation Detector Problems

✔ PHR Differs from Report Values

You may experience minor discrepancies in measured pulse height resolution and the numbers reported on the test sheet for each detector. This is normal and is caused by differences in phototubes. However, should a major discrepancy become evident, contact Bicron immediately.

✔ Moisture Leaks

For hygroscopic crystals, moisture leaks produce hydration on the crystal surface and degrade resolution. Hydrate usually appears as a discoloration on or in the crystal. The effect on performance can sometimes be similar to that of a fracture. It can be distinguished from a fracture, however, because the performance degrades over an extended period of time.

✔ Crystal Fracturing

Sometimes, if a crack is not excessive and has proper orientation, it will not impair performance. However, fractured crystals usually produce asymmetrical peaks and may exhibit multiple peaks for a single gamma line. A fracture is normally stable and will not propagate. If a crack is noticed, check performance and call the factory. Note: The thin, cleaved crystals used in X-ray detectors often exhibit cleave marks. These marks look like cracks, but have no effect on detector performance.

✔ Noise

Noise in a spectrum is generally defined as the extraneous events counted near the zero energy end of the spectrum. It is nearly always a product of the photomultiplier due to spontaneous emission from the photocathode and other phenomena within the tube. It appears as a near-exponentially decreasing curve extending into the spectrum that often obscures low energy peaks. Acceptable noise level varies with the type of phototube used, but would probably be considered excessive if it extended far enough into the spectrum to obscure 15 to 20 keV X-ray peaks.

✔ Extraneous Peaks in the Spectrum

If unidentified peaks appear in your spectrum in counting times of under 60 minutes, it is unlikely they are produced by the detector. If the width of the peaks are narrower than a gamma peak of equal energy, it is certain to be a result of your electronic system. If the peak is the same width as a gamma line, look for unshielded sources near the detector.

✔ Background

Bicron crystals are grown from highly purified, low potassium salts and, in a given circumstance, will have low background. Background from the detector is usually not significant unless one hour or more counting times are taken in heavily shielded (4 to 6 inches of lead) chambers. Background spectra are complex and are the result of many sources, including cosmic rays and natural radioactivity. If background appears to be a problem, call Bicron for assistance.

▮ Troubleshooting Crystal Scintillation Detectors ▮

Problem **/ Probable Cause**	**Corrective Procedure**
No Output	
1. No radioactive source.	1. Place radioactive source near detector and check response.
2. PMT voltage is off, too high, too low or wrong polarity.	2. Refer to appropriate instrument manual or instruction sheet. Check current capacity of HV supply.
3. Defective cables or connectors.	3. Substitute known good cables. Service may be indicated - contact Bicron for instructions.
4. Short circuit or loss of vacuum in photomultiplier tube(s).	4. Substitute known good tubes if demountable. Service may be indicated - contact Bicron for instructions.
5. Wrong hook-up.	5. See Basic Connections section of this manual.
Resolution does not meet specifications	
1. Radioactive source type, location, or activity has changed.	1. Check radioactive source type, location and activity.
2. Tubes are not properly balanced.	2. Refer to balancing procedure. See QA sheet supplied with your detector for typical values.
3. Analyzer/Electronics not properly zeroed.	3. Refer to appropriate instrument manual or instruction sheets. (NOTE: Channel zero must correspond to zero pulse height or zero energy, or appropriate corrections must be made.)
4. Improper electronic pulse shape between detector and analyzer.	4. Refer to appropriate instrument manual or instruction sheets and check pulse polarity.
5. Focus potentiometer of tube(s) not adjusted correctly.	5. Adjust for maximum pulse height resolution.
6. Defective interface between crystal and photomultiplier tube.	6. Clean face plate of the detector and the tube and apply fresh optical coupling compound.
7. Defective tube or improper operating voltage.	7. Refer to appropriate instrument manual. Service may be indicated. Contact Bicron for instructions.
8. Photomultiplier tube or electronic drift during measurements.	8. Allow longer warmup. Service may be indicated. Contact Bicron for instructions.
9. Light leak in assembly.	9. Use black tape or black felt for emergency repair.
10. Cracked crystal.	10. Detector may function in an acceptable manner. If not, contact Bicron for instructions.
11. Hydrated crystal.	11. Contact Bicron for instructions.
12. UV damage to crystal.	12. Contact Bicron for instructions.
13. Various scintillators have different decay constants.	13. Adjust amplifier time constants (normally 4 times decay constant of scintillator). Check QA Report of scintillator in question.

continued...

▮ Troubleshooting Crystal Scintillation Detectors ▮

Problem **/ Probable Cause**	**Corrective Procedure**
Low Count Rate	
1. Improper electronic settings (peak not in window).	1. a) Refer to appropriate instrument manual. Check lower level discriminator, upper level discriminator and signal output by scope. b) Improper lower level discriminator setting may result in low count rate. If the LLD is set properly, refer to resolution troubleshooting.
2. Excessive dead time in electronics or pulse height analyzer.	2. Refer to appropriate instrument manual.
3. Light leak causing excessive dead time.	3. Use black tape or black felt for emergencies.
4. Cracked crystal.	4. This will probably show up as poor resolution too. Refer to resolution troubleshooting.
5. Intermittent high voltage supply.	5. Should also show up as poor resolution or drifting peak. Refer to appropriate instrument manual.
High Count Rate	
1. Lower level discriminator (or threshold) set too low. Probably below the detector noise level.	1. Reset LLD (or threshold) after checking appropriate instrument manual.
2. Tube noise too high - possible light leak.	2. Check for light leak. Use black tape or black felt for emergency repair.
3. Light leak causing excessive dead time.	3. Use black tape or black felt for emergencies.
4. Analyzer threshold too low.	4. Check appropriate manual. Check D. C. levels.
5. HV breakdown in cable(s) or voltage divider(s).	5. Service may be indicated - contact Bicron for instructions.
6. Line noise/interference.	6. Refer to appropriate instruction manual.
7. Excessive background radiation.	7. Shield detector - check for other sources - move to quiet location.
Inability to Balance Tube(s)	
1. Replacement PMT not matched to rest of set.	1. Contact Bicron if replacement PMT cannot be matched.
2. Improper operating voltage.	2. Refer to appropriate instrument manual.
3. Tube(s) have aged or deteriorated.	3. Service may be indicated - contact Bicron for instructions.
Extraneous Peaks in Spectrum	
1. Electronic overloads at preamplifier (peaks are narrower than gamma lines).	1. Refer to appropriate instrument manual.
2. Background radiation (all building materials contain trace amounts of natural uranium, thorium and potassium).	2. a) Be sure detector and surroundings are "clean." See instructions in "Handling and Care" section of this manual. b) For optimum low background, shield the detector.

The BICRON Warranty

Inorganic Scintillation Detectors

BICRON will repair or replace, at no charge, any detector which fails within a period of **two years from date of shipment** as a result of faulty construction or failure of the hermetic seal(s).

This warranty does not apply to any detector which fails as a result of rough handling, mishandling, being dropped, being submerged in water or being exposed to a non-laboratory environment. A normal laboratory environment is defined as air at normal pressure and any humidity, at a temperature between +40°F and +110°F (+4°C to +43°C) which temperature does not change at a rate greater than 15°F(8°C) per hour and which does not heat or cool any region of the detector such as to produce a temperature gradient of greater than 5°F(3°C) across the affected region.

Detector assemblies designed for use in specific applications where severe environmental conditions may be encountered carry a specific warranty. Please contact sales/customer service for further explanation of warranties.

Photomultipliers

For photomultipliers (PMTs), BICRON passes on to the customer the PMT manufacturer's warranty, which in most cases is one year.

General

This warranty applies only to the original purchaser of the detector and only to product with serial numbers still legible. This warranty does not apply to any detector whose performance fails as a result of misuse, mishandling, abuse, accident, physical damage, improper installation, exposure to vacuum, or submersion in water. This warranty does not apply if the product has been modified or altered without BICRON's express approval.

BICRON's obligation hereunder shall be limited to the repair or replacement, at our option, of any detector or any part thereof which, upon receipt and examination, proves to have been defective within the specified warranty period. BICRON is not responsible for damages of any kind including incidental or consequential damages. To the extent permitted by law, this warranty is in lieu of all other warranties, express or implied, and constitutes the fulfillment of BICRON's obligations to the purchaser.

Instructions for Returning Product to Bicron

A claim against the BICRON warranty must be made by the original purchaser within the warranty period. The purchaser must obtain a Return Materials Authorization (RMA) number from BICRON's sales/customer service organization (**440/564-2251**) prior to shipment. The RMA number must be referenced on the packing list and other documentation. All detectors being returned for warranty repair should be adequately packaged; use of original BICRON shipping material and container will help assure that no damage occurs in transit or storage. Product claimed to be defective or non-conforming must be returned to BICRON freight prepaid by the purchaser with a statement identifying the reason(s) for the return, BICRON part number and serial number. *Please ship against a return purchase order rather than a debit memo.* Product returned to BICRON that is found to be in good working order or damaged for causes not covered by this warranty will be subject to a service charge. Upon completion of repairs, detectors will be returned to the purchaser freight prepaid.

Services Available from Bicron

Bicron Direct (mail order catalog for selected organic and inorganic products, optical crystals and accessories): In the U.S. and Canada, call 1-800-887-7780 or visit our web site at www.bicrondirect.com for our free catalog!

Bicron FaxBack (data sheets, MSDS information, news releases and much more available to customers in USA and Canada): Call 1-800-892-8708 for instructions!

Bicron Web Site (data sheets, news releases, current events, etcetera): http://www.bicron.com.

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Saint-Gobain Industrial Ceramics, Inc.