Troubleshooting Crystal Scintillation Detectors

(Excerpt from the Saint-Gobain Crystals Scintillation Detector Operating Manual)

Technical Information Note
Document #518

> Diagnosing Crystal Scintillation Detector Problems

PHR Differs from Report Values –

You may experience minor discrepancies in measured pulse height resolution (PHR) 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 Saint-Gobain Crystals 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 –

Saint-Gobain crystals are grown from highly purified, low potassium salts and, in a given circumstances, 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 Saint-Gobain Crystals for assistance.

Following is a troubleshooting chart that itemizes problems and corrective procedures.

For more information on the installation of your scintillation detector, download our entire Operating Manual (SGC Scintillation Operating Manual 0304.pdf).

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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 Saint-Gobain Crystals 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 Saint-Gobain Crystals 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 Q.A 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 minimum 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 Saint-Gobain Crystals for instructions.
8. Photomultiplier tube or electronic drift during measurements.	8. Allow longer warmup. Service may be indicated. Contact Saint-Gobain Crystals 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 Saint-Gobain Crystals for instructions.
11. Hydrated crystal.	11. Contact Saint-Gobain Crystals for instructions.
12. UV damage to crystal.	12. Contact Saint-Gobain Crystals for instructions.
13. Various scintillators have different decay constants.	13. Adjust amplifier time constants (normally 4 times decay constant of scintillator). Check Q.A. Report of scintillator in question.

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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 (LLD), 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 trouble-shooting.
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 us 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 Saint-Gobain Crystals 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 us 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.

Scintillation Products
Technical Information Note

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USA

Saint-Gobain Crystals
12345 Kinsman Road
Newbury, OH 44065
Tel: (440) 564-2251
Fax: (440) 564-8047

Europe

Saint-Gobain Cristaux
104 Route de Larchant
BP 521
77794 Nemours Cedex, France
Tel: 33 (1) 64 45 10 10
Fax: 33 (1) 64 45 10 01

P.O. Box 3093
3760 DB Soest
The Netherlands
Tel: 31 35 60 29 700
Fax: 31 35 60 29 214

Japan

Saint-Gobain KK, Crystals Division
3-7, Kojimachi, Chiyoda-ku,
Tokyo 102-0083 Japan
Tel: 81 (0) 3 3263 0559
Fax: 81 (0) 3 5212 2196

China

Saint-Gobain (China) Investment Co., Ltd.
15-01 CITIC Building
19 Jianguomenwai Ave.
Beijing 100004 China
Tel: 86 (0) 10 6513 0311
Fax: 86 (0) 10 6512 9843

www.detectors.saint-gobain.com

The data presented are believed to be correct but are not guaranteed to be so.