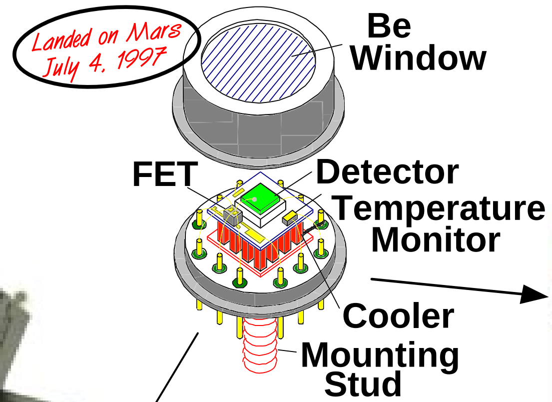
AMP TEK®

X-RAY DETECTOR

XR-100CR

All Solid State Design
No Liquid Nitrogen



FEATURES

- Si-PIN Photodiode
- Thermoelectric Cooler
- Beryllium Window
- Hermetic Package (TO-8)
- Wide Detection Range
- Easy to Operate

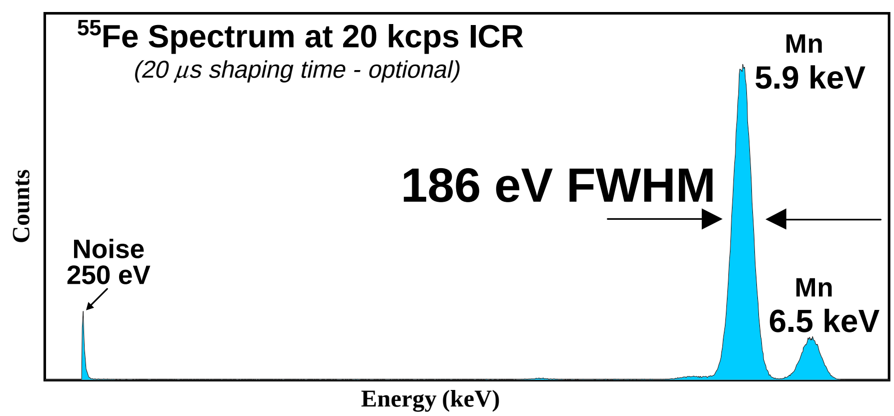
APPLICATIONS

- X-Ray Fluorescence
- Nuclear Medicine
- X-Ray Lithography
- Portable Instruments
- OEM
- Teaching & Research
- Mössbauer Spectrometers
- Space and Astronomy
- Environmental Monitoring
- Nuclear Plant Monitoring
- Archeology
- Toxic Dump Site Monitoring
- PIXE
- Process Control

Model ***XR-100CR*** is a new high performance X-Ray Detector, Preamplifier, and Cooler system which uses a thermoelectrically cooled Si-PIN Photodiode as an X-Ray detector. Also mounted on the cooler are the input FET and a novel feedback circuit. These components are kept at approximately -30°C, and can be monitored by an internal temperature sensor. The hermetic TO-8 package of the detector has a light tight, vacuum tight 1 mil (25 µm) Beryllium window to enable soft X-Ray detection.

Power to the XR-100CR is provided by the PX2CR Power Supply. The PX2CR is AC powered and includes a spectroscopy grade Shaping Amplifier. The XR-100CR/PX2CR system ensures stable operation in less than one minute from power turn-on.

The resolution for the 5.9 keV peak of ^{55}Fe is 220 eV FWHM with 12 µs shaping time constant (standard) and 186 eV FWHM with 20 µs shaping time (optional).



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THEORY OF OPERATION

X-Rays interact with silicon atoms to create an average of one electron/hole pair for every 3.62 eV of energy lost in the silicon. Depending on the energy of the incoming radiation, this loss is dominated by either the Photoelectric Effect or Compton Scattering. The probability or efficiency of the detector to "stop" an X-Ray and create electron/hole pairs increases with the thickness of the silicon. *See Figure 2*.

In order to facilitate the electron/hole collection process, a 100 Volt bias voltage is applied across the silicon. This voltage is too high for operation at room temperature, as it will cause excessive leakage, and eventually breakdown. Since the detector in the XR-100CR is cooled, the leakage current is reduced considerably, thus permitting the high bias voltage. This higher voltage decreases the capacitance of the detector, which lowers system noise.

Electron-hole pairs created by X-rays which interact with the silicon near the back contact of the detector are collected more slowly than normal events. These events result in smaller than normal charge collection and can increase the background in an energy spectrum and produce false peaks. Such events are characterized by slow risetime, and the PX2CR Amplifier incorporates a Rise Time Discrimination circuit (RTD) which prevents these pulses from being counted by the MCA. *See Figure 6*. All spectra shown in this specification were taken using RTD.

The thermoelectric cooler cools both the silicon detector and the input FET transistor to the charge sensitive preamplifier. Cooling the FET reduces its leakage current and increases the transconductance, both of which reduce the electronic noise of the system.

Since optical reset is not practical when the detector is a photodiode, the XR-100CR incorporates a novel feedback method for the reset to the charge sensitive preamplifier. The reset transistor, which is typically used in most other systems has been eliminated. Instead, the reset is done through the high voltage connection to the detector by injecting a precise charge pulse through the detector capacitance to the input FET. This method eliminates the noise contribution of the reset transistor and further improves the energy resolution of the system.

A temperature monitor chip is mounted on the cooled substrate to provide a direct reading of the temperature of the internal components, which will vary with room temperature. Below -20 °C the performance of the XR-100CR will not change with a temperature variation of a few degrees. Hence, closed loop temperature control is not necessary when using the XR-100CR at normal room temperature.

VACUUM OPERATION

The XR-100CR can be operated in air or in vacuum down to 10^{-8} Torr. There are two ways the XR-100CR can be operated in vacuum: 1) The entire XR-100CR detector and preamplifier box can be placed inside the chamber. In order to avoid overheating and dissipate the 1 Watt of power needed to operate the XR-100CR, good heat conduction to the chamber walls should be provided by using the four mounting holes. An optional Model 9DVF 9-Pin D vacuum feedthrough connector on a Conflat is available to connect the XR-100CR to the PX2CR outside the vacuum chamber. 2) The XR-100CR can be located outside the vacuum chamber to detect X-rays inside the chamber through a standard Conflat compression O-ring port. Optional Models EXV6 / EXV9 (6 or 9 inch) vacuum detector extenders are available for this application. *See Figure 8.*

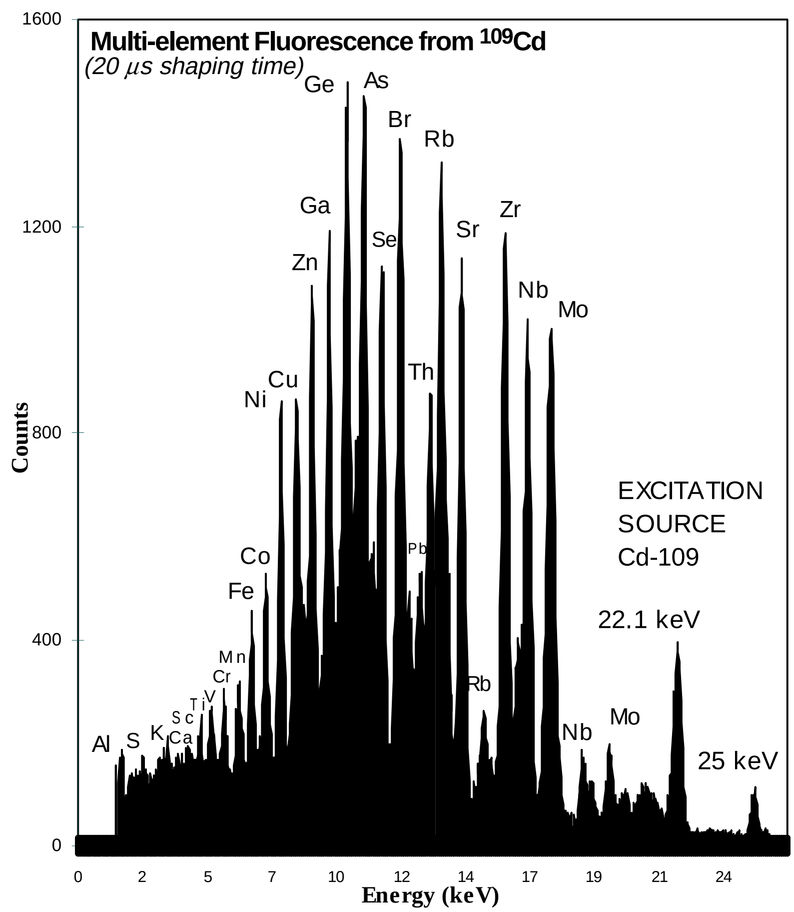

Figure 1. Sample Spectrum

Spectrum taken with Amptek MCA8000A

SPECIFICATIONS

MODEL XR-100CR

X-Ray Detector

GENERAL

Detector Type: Si-PIN
Detector Size: 2.4 x 2.8 mm (7 mm^2), standard
Silicon Thickness: 300 µm *See Figure 3.*
Energy Resolution @ 5.9 keV, ^{55}Fe
- Standard: 220 eV FWHM with 12 µs shaping time
- Optional: 186 eV FWHM with 20 µs shaping time; 280 eV FWHM with 6 µs shaping time

Background counts: <3 x 10^{-3} /s, 2 keV to 150 keV
Detector Window: Be, 1 mil thick (25 µm) *See Figure 3.*
Charge Sensitive Preamplifier: Amptek custom design with reset through the H.V. connection
Case Size: 3.75 x 1.75 x 1.13 in (9.5 x 4.4 x 2.9 cm)
Weight: 4.4 ounces (125 gm)
Total Power: <1 Watt

INPUTS

Test Input: 1 mV/keV, positive
Preamp Power: ±9 Volts @ 15 mA
Detector Power: +100 Volts @ 1 µA
Cooler Power: Current = 0.7 A maximum; Voltage = 2 Volts maximum

OUTPUTS

1) Preamplifier
- Sensitivity: 1 mV/keV
- Polarity: Negative Signal Out, 1 kΩ max. load
- Feedback: Reset through H.V. detector capacitance

2) Temperature Monitor
- Sensitivity: 1 µA corresponds to 1 °K

OPTIONS

Other detector sizes (13 mm^2 Si-PIN) and Beryllium windows (0.3 mil - 7.5 µm) are available on special order.

See also XR-100T-CZT specifications using Cadmium Zinc Telluride (CZT) detectors for high efficiency and high resolution Gamma Ray detection (1.5 keV FWHM @ 122 keV, ^{57}Co).

CONNECTORS

Preamp Output: BNC coaxial connector
Test Input: BNC coaxial connector
Other connections: 6-Pin, LEMO connector with 5 ft cable

6-PIN LEMO CONNECTOR

Pin 1: Temperature Monitor
Pin 2: + H.V. Detector Bias, +110 Volt max.
Pin 3: -9 Volt Preamp Power
Pin 4: +9 Volt Preamp Power
Pin 5: Cooler Power Return
Pin 6: Cooler Power (0 to +2.1 Volt @ 0.7 A max.)
CASE: Ground and Shield

MODEL PX2CR

Power Supply & Shaping Amplifier

GENERAL

Size: 6 x 6 x 3.5 inches (15.3 x 15.3 x 8.9 cm)
Weight: 2.5 lbs (1.15 kg)

Input AC power to the PX2CR is provided through a Standard IEC 320 plug (110/250 VAC, 50-60 Hz). *See Figure 5.*

The four (4) DC Voltages needed to operate the XR-100CR are supplied through a female 9-Pin D-Connector on the PX2CR. The Pin list to this connector is given below. The multiconductor cable which connects the PX2CR to the XR-100CR is provided with the system.

9-PIN D-CONNECTOR

Pin 1: +9 Volt Preamp Power
Pin 2: -9 Volt Preamp Power
Pin 3: 0 to +3 Volt Cooler Power @ 0.7 A max.
Pin 4: +9 Volt Temperature Monitor Power
Pin 5: +H.V. Detector Bias, +110 Volt max.
Pin 6: Ground and Case
Pin 7: Cooler Power Return
Pin 8: Ground and Case
Pin 9: Ground and Case

SHAPING AMPLIFIER

Polarity: Positive Unipolar
Shaping Time: 12 µs standard (6 µs and 20 µs optional)
Pulse Width: 22 µs. *See Figure 4.*
Shaping Type: 7 pole "Triangular" with Base Line Restoration, Pileup Rejection and Rise Time Discrimination (RTD).
Sensitivity: 0 to 1 V/keV (10 turn pot)
Gain: 0 to X1000
Gain Shift: *See Figure 16.*
Output Impedance: <1 Ω

The output pulse produced by the PX2CR Shaping Amplifier is optimum for most applications using the Si-PIN photodiode detectors, and can be connected directly to the input of a Multi-channel Analyzer (MCA). For optimum portability and versatility, use the Amptek MCA8000A "Pocket MCA" with over 16k data channels.

SIGNAL CONNECTIONS

Input from XR-100CR: Front panel BNC
Output to MCA: Front panel BNC
Pileup Rejection (PU): Rear panel BNC, Positive TTL. For the duration of this output gate, any detected pulse must be rejected by the MCA.
Input Count Rate (ICR): Rear panel BNC, Positive TTL <2 µs. When connected to a counter, the ICR countrate corresponds to the total number of X-Ray events that strike the detector.

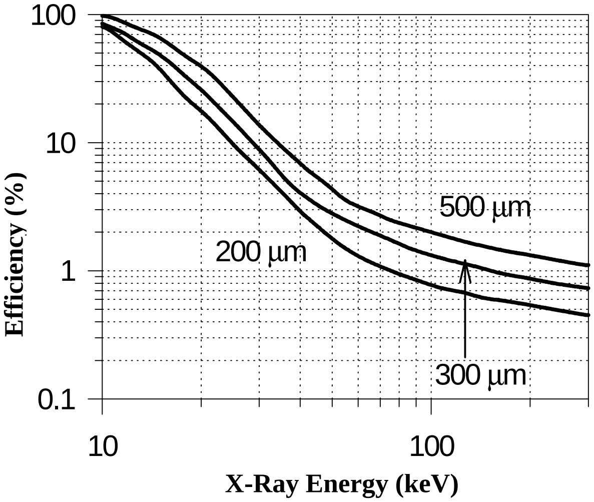

Figure 2. X-Ray Transmission through Be Windows

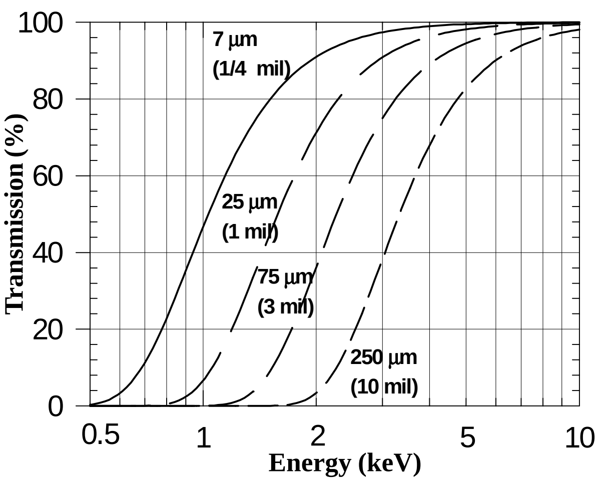

Figure 3. Detection Efficiency of Silicon Detectors

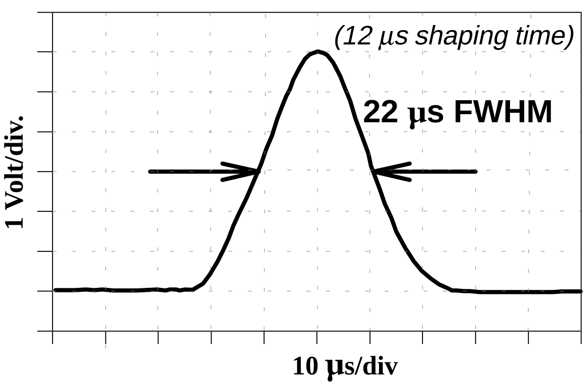

Figure 4. PX2CR Amplifier Output

Shaping Time Constant	Pulse Width
Standard 12 µs	22 µs FWHM
Optional 6 µs	15 µs FWHM
Optional 20 µs	54 µs FWHM

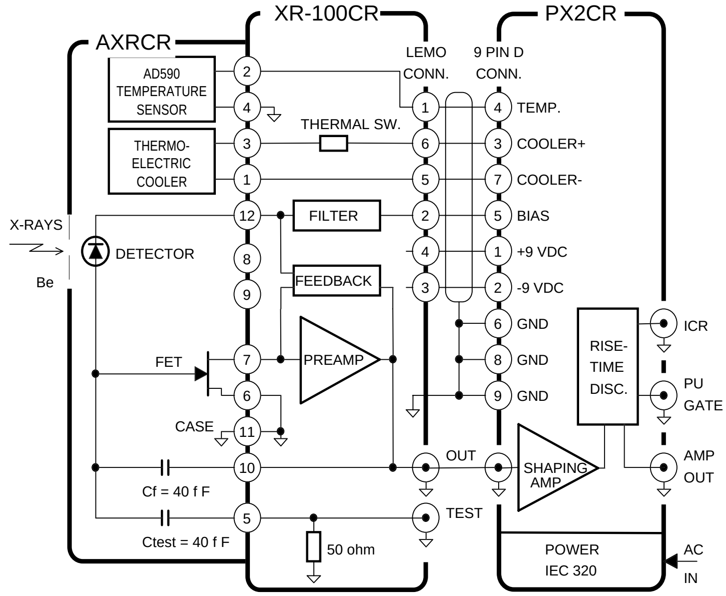

Figure 5. XR-100CR Connection Diagram

This diagram shows the internal connections between the AXRCR hybrid sensor and the electronics within the case.

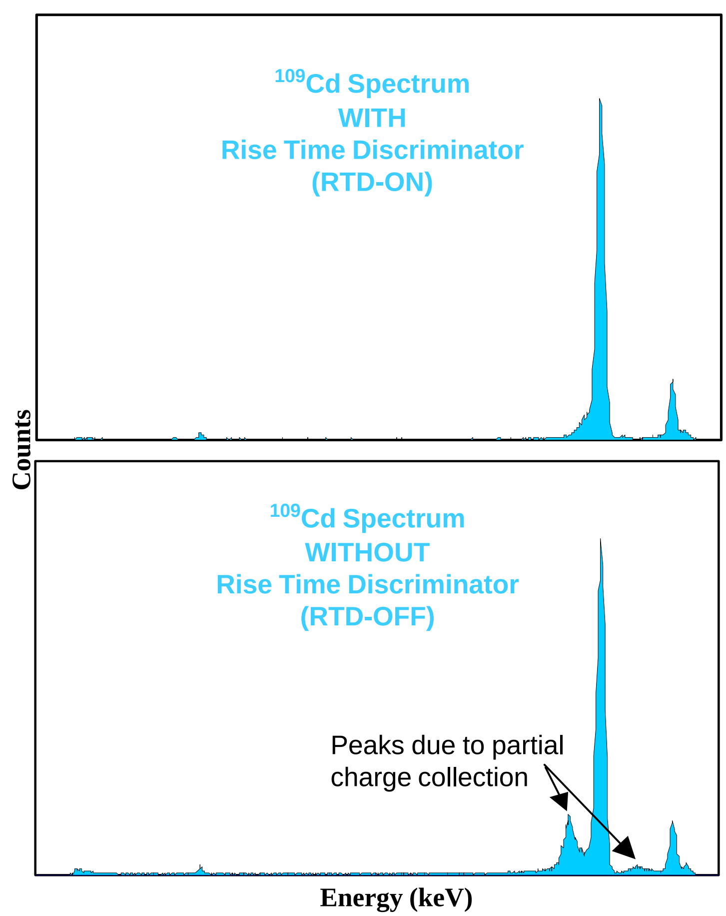

Figure 6. Comparison of ^{109}Cd Spectra WITH and WITHOUT Rise Time Discriminator (RTD)

APPLICATIONS

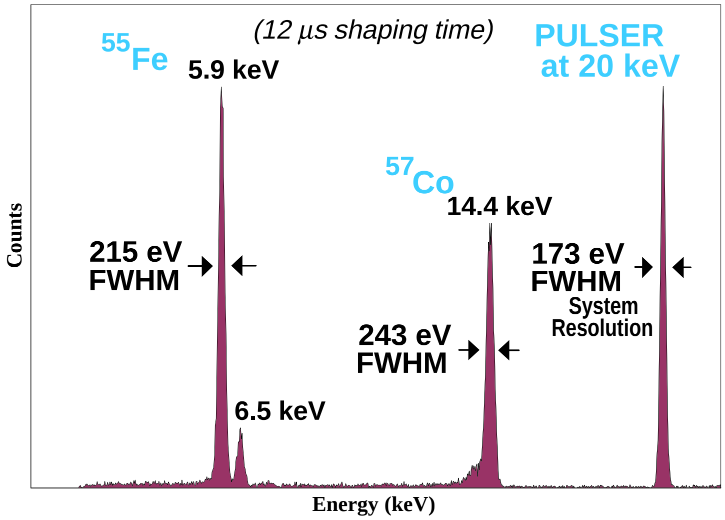

Figure 7. ^{55}Fe, ^{57}Co and Test Pulser Spectra

Figure 8. XR-100CR for Vacuum Use

Shown with optional accessories EXV6 and Conflat compression O-ring port.

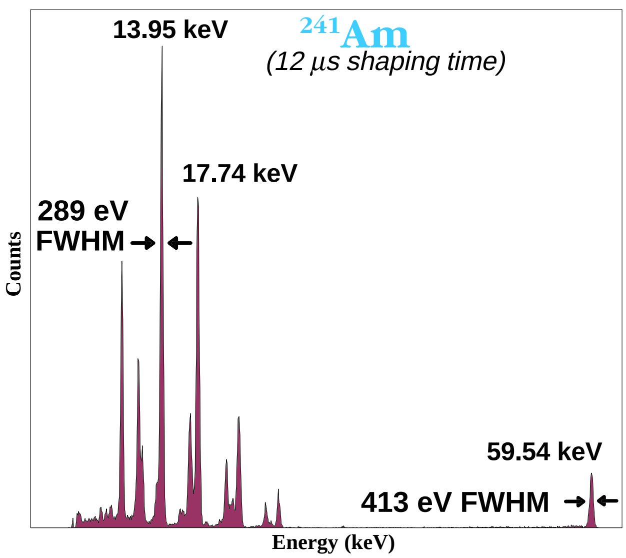

Figure 9. ^{241}Am Spectrum

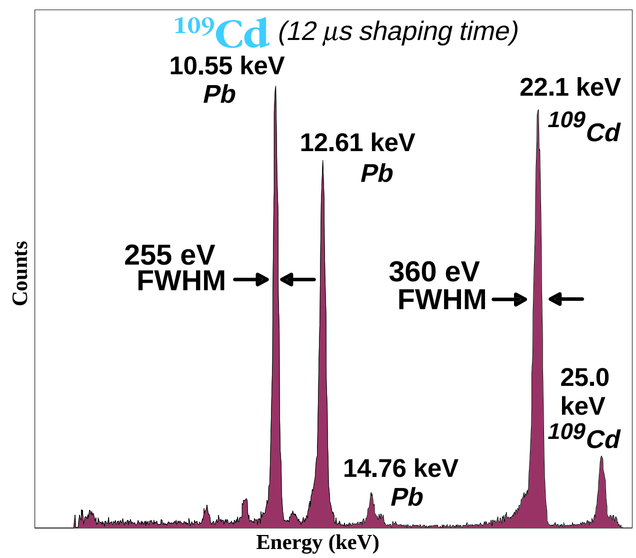

Figure 10. Lead (Pb) Fluorescence from ^{109}Cd

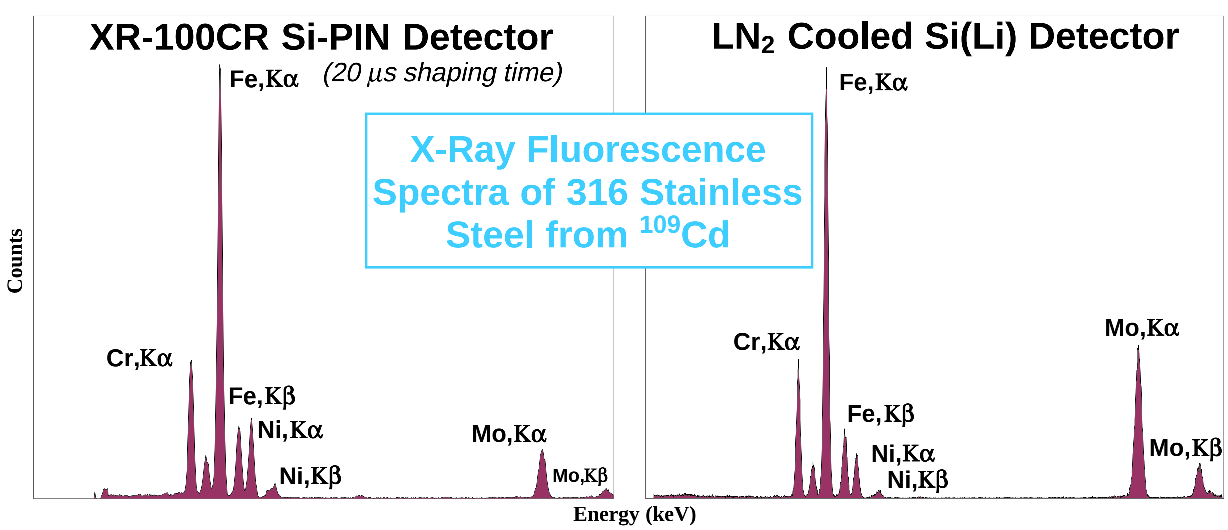

Figure 11. Amptek XR-100CR Si-PIN Detector Compared with Si(Li) Detector

XR-100CR X-RAY DETECTOR

Figure 12. XR100CR, MCA8000A, and Laptop Computer

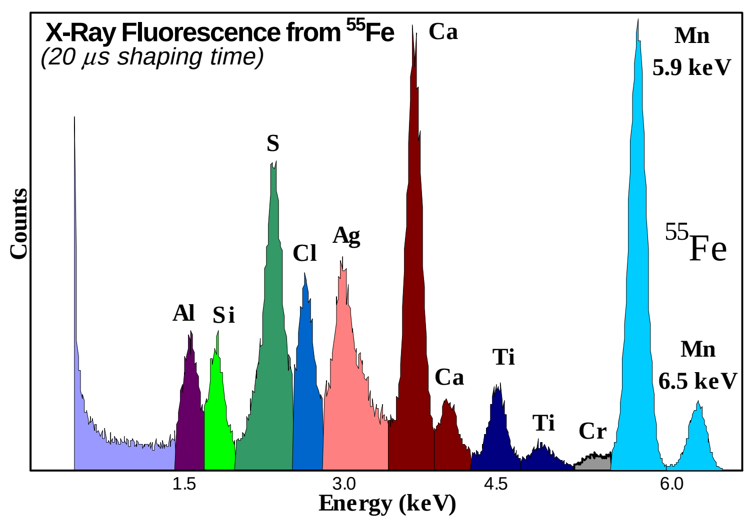

Figure 13. Sample Spectrum

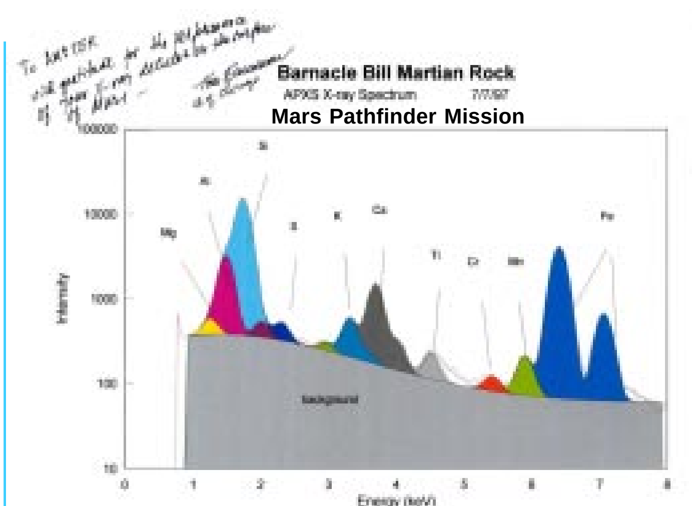

Figure 14. First X-Ray Spectrum from Mars Using XR-100T Detector, Curtesy of the University of Chicago

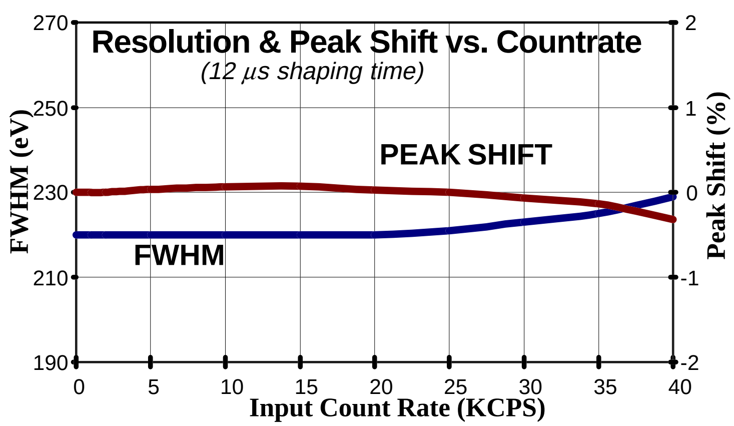

Figure 15. Resolution and Peak Shift vs. Countrate for ^{55}Fe, 5.9 keV, 12 µs Shaping

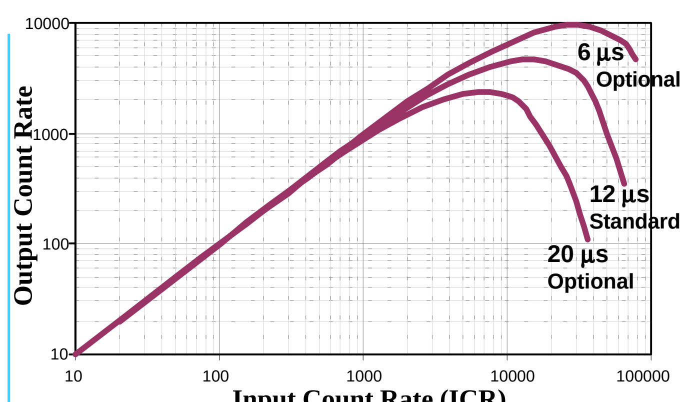

Figure 16. Output vs. Input Rate for Different Shaping Time Constants

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