OPERATING MANUAL

XR-100CR
X-RAY DETECTOR SYSTEM

AND PX2CR POWER SUPPLY / SHAPER

Revision 7
January, 1998

CAUTION

1) **DO NOT DROP OR CAUSE MECHANICAL SHOCK TO THE XR-100CR DETECTOR**

2) **DO NOT DAMAGE** the AXRCR detector with the screw or the screw-driver if the mounting hole just below the AXRCR detector is to be used to mount the XR-100CR.

3) **DO NOT REMOVE** the red protective cap from the AXRCR detector until data is to be taken. The detector window is made from thin Beryllium (0.001 in / 25 μm thick) which is extremely brittle and can shatter very easily. Do not have any object come in contact with the window. Also, do not touch the window because the oil from the fingers will cause it to oxidize. The window cannot be repaired. If the window shatters the detector assembly must be replaced. Keep the red protective cover nearby at all times and cover the AXRCR detector when the instrument is not in use.

4) **AVOID** holding the XR-100CR in the hand. Heat from the body will increase the operating temperature of the detector and increase the leaking current. Increased leaking current in the detector will result in poor energy resolution. Keep the XR-100CR away from incandescent lamps to avoid overheating.

5) **BEST PERFORMANCE** of the XR-100CR can be achieved by mounting it by one or two of its mounting holes to a metal plate. This will increase the surface area and allow the detector to run 4 to 6 degrees colder. A colder detector will result to better energy resolution. As a rule, if the correct heat sinking has been provided, the XR-100CR should **NOT** be warm to the touch.

6) **RADIATION DAMAGE to the detector will occur if it is exposed to a high flux environment. Synchrotron Radiation Beams should be modified with attenuators before they are allowed to strike the detector or the fluorescence target. Damage to the detector will be permanent if the flux from an X-Ray Tube, a strong nuclear radiation source, or an accelerator is not attenuated.**
A RADIATION DAMAGED DETECTOR WILL NOT BE COVERED UNDER WARRANTY.

7) **PX2CR WARNING:** The Amplifier and Rise Time Discriminator (RTD) inside the PX2CR box have been carefully adjusted at the factory for maximum performance. **CHANGING THE SETTINGS TO THE AMPLIFIER AND RTD INSIDE THE PX2CR BOX WILL VOID WARRANTY.**

AMPTEK INC.
XR-100CR X-RAY DETECTOR

Date: 6/1/99
Customer: University of Washington
Country: USA
P.O. # : W863103

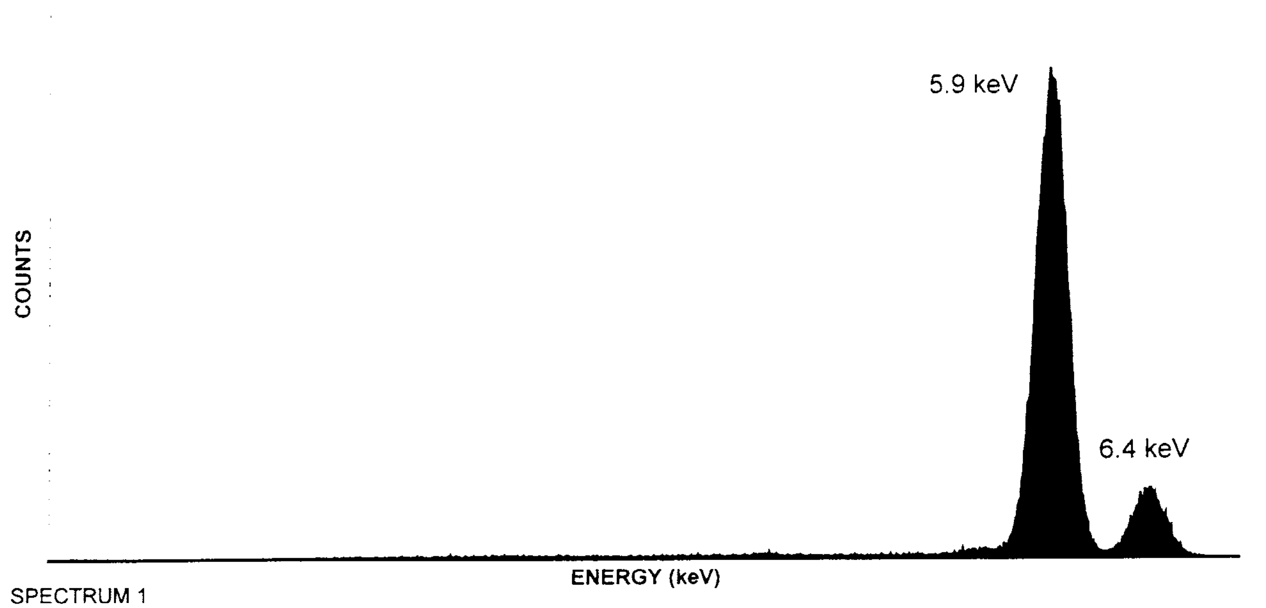
XR-100CR S/N: 2552
AXRCR S/N: 2656
PX2CR S/N: 1484

FWHM@ 5.9 keV: 210 eV @ 2,000 Cps
FWHM@ 5.9 keV: 209 eV @ 20,000 Cps
PX2CR Gain Setting: 6.0 for spectrums 1&2
Temp: 249 degrees K

Detector Size: 7mm2, 1 Be

2,000 Cps

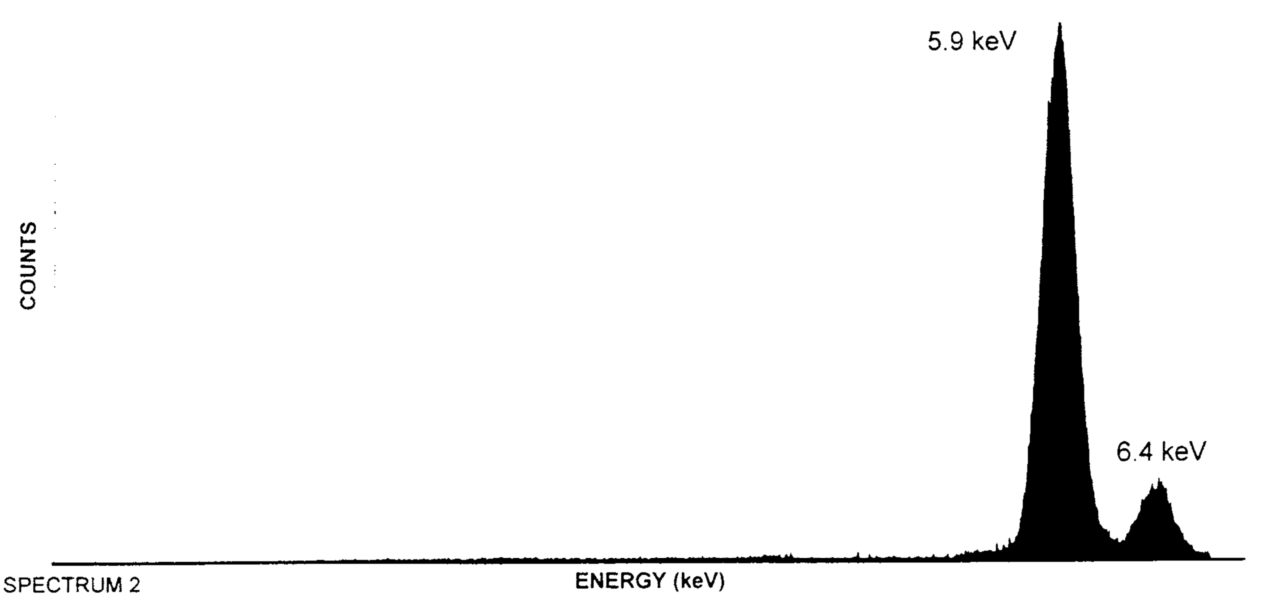
^{55}Fe SPECTRUM



SPECTRUM 1

20,000 Cps

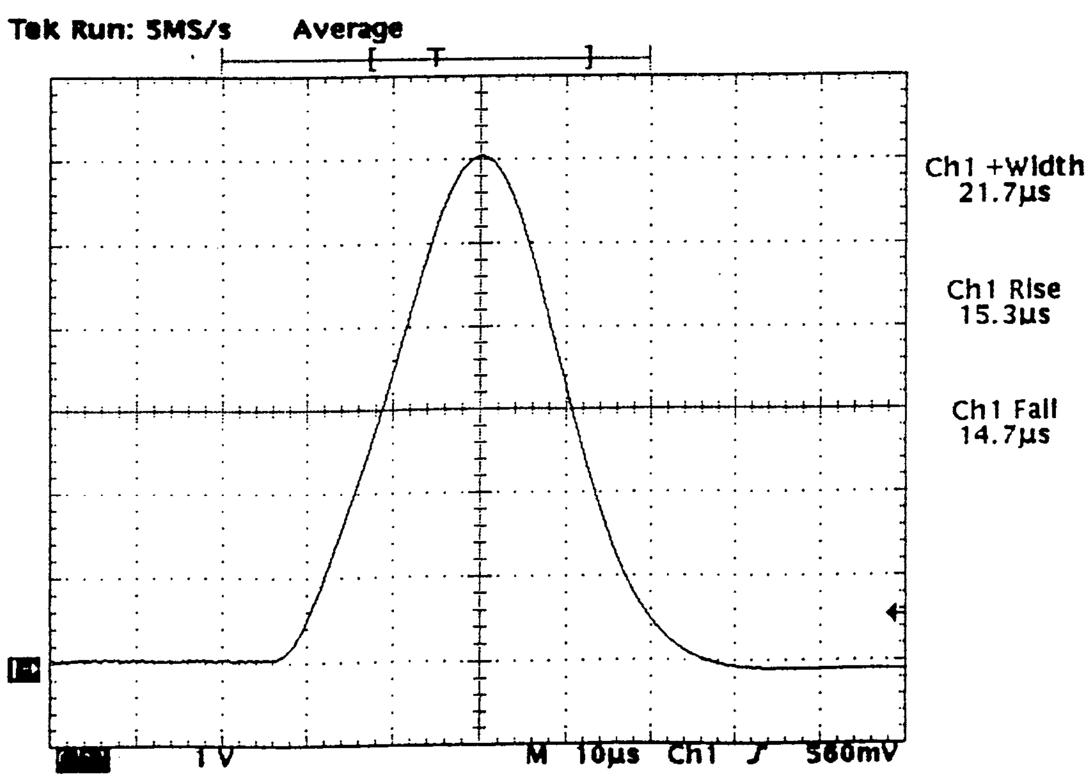
^{55}Fe SPECTRUM



SPECTRUM 2

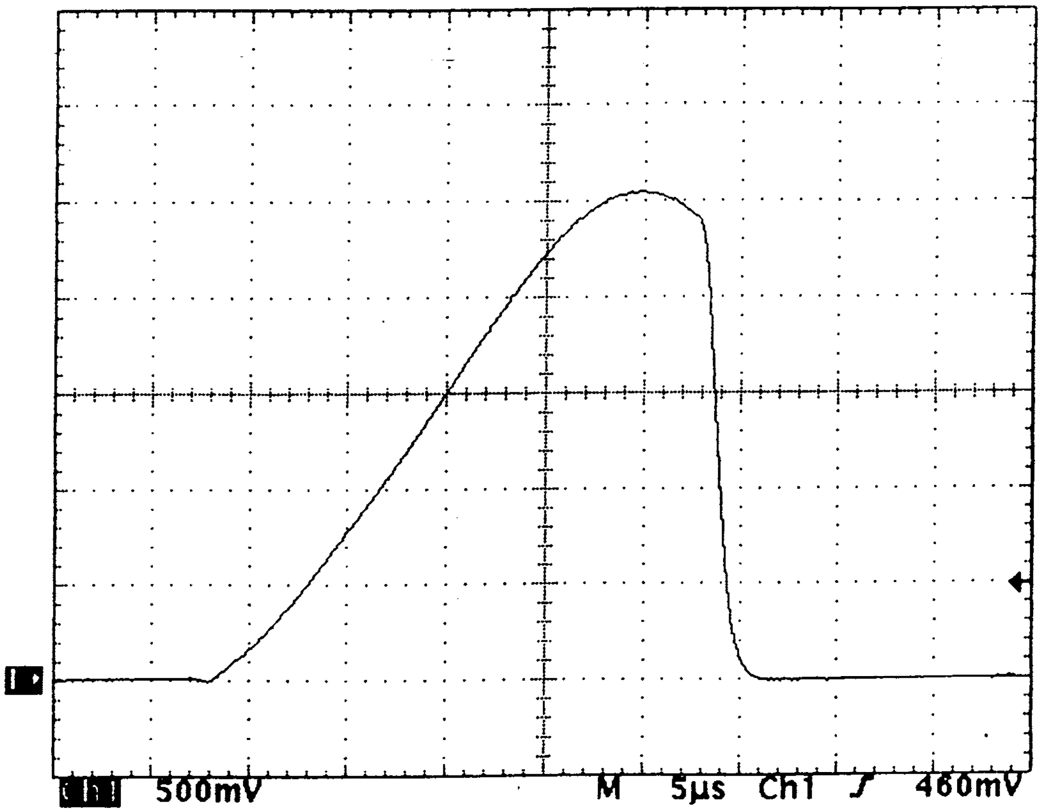
OPERATING NOTES FOR THE XR-100CR CONNECTED TO THE PX2CR

1. Turn the power to the PX2CR OFF.
2. Connect the 9-Pin D-Connector from the XR-100CR to the PX2CR.
3. Connect the Output of the XR-100CR (OUT) **directly** to the Input of the PX2CR (AMP IN) with a BNC cable. **DO NOT** terminate the cable with a 50 Ω termination.
4. Connect the Output of the PX2CR (AMP OUT) **directly** to the input of a Multichannel Analyzer (MCA). **DO NOT** terminate the cable with a 50 Ω termination.
5. Connect the +/- TEMP from the PX2CR to a μA meter.
6. Turn the AC power to the PX2CR ON via the rear panel switch.
7. Observe the μA meter. As the temperature of the cooler decreases, the μA meter will decrease from 293 μA to about 250 μA. The temperature monitor IC provides 1 μA per 1 °K. Please note: room temperature = 293 °K = 20 °C.
8. Once the temperature has stabilized (a few seconds), start taking data on the MCA. For normal operation, there is no need to monitor the temperature. **In order to avoid extraneous noise pick-up into the detector, disconnect the +/-TEMP wires from the PX2CR.** Just turn the power ON to the PX2CR, wait a few seconds and start taking data.
9. The XR-100CR can be stimulated by either an X-Ray source or through the TEST input connector. A test pulse of 20 mV will produce an output from the XR-100CR equivalent to 20 keV X-Ray.
10. PLEASE NOTE: The PX2CR Shaping Amplifier has a "triangular" fixed shaping time constant of about 12 μs, (see graph below). If a different shaping time is required, an external NIM type amplifier can be used instead. Power to the XR-100CR can be supplied through the PX2CR even if an external amplifier is used.



RISE TIME DISCRIMINATION (RTD) IN THE PX2CR AMPLIFIER

A Rise Time Discriminator circuit has been implemented in the PX2CR amplifier. See Specifications under THEORY OF OPERATION. When RTD is active (RTD switch up on the front panel), the shaped pulses are **internally gated** and only pulses corresponding to "good" X-Ray events are allowed to be sent to the MCA for analysis. The RTD internal threshold is set to about 2 keV. If energies less than 2 keV are to be detected do not use the RTD function.
The graph bellow shows the shape of the pulse when RTD is activated.



PILEUP REJECTION (PU) IN THE PX2CR AMPLIFIER

AND RESET GATE FOR THE XR-100CR

A PileUp rejection circuit has been implemented in the PX2CR amplifier. The PU Gate located in the back panel of the PX2CR produces a positive TTL pulse.
For the duration of this gate, any detected pulse must be rejected by the Multichannel Analyzer (MCA).

When using the AMPTEK MCA8000 or MCA8000A the PU Gate from the PX2CR should be connected to GATE 1 of the MCA.

The XR-100CR incorporates a RESET preamplifier. For best resolution with a reset preamplifier, the MCA should be gated OFF during the RESET interval.

In the PX2CR the RESET GATE has been combined (OR'ED) with the PU GATE. The pulse occurring during reset is approximately 2 ms in duration.

For pileup events, the PU Gate pulse goes HIGH during the rise of the PX2 Output pulse. This pulse is not useable with some MCA's, which require that the gate goes HIGH **before** the pulse in question crosses the MCA threshold. However, it is still recommended that the PU GATE be used with the PX2CR, since it will function properly as a RESET gate.

INPUT COUNT RATE (ICR) IN THE PX2CR AMPLIFIER

The Input Count Rate (ICR) pulse is provided through a rear panel BNC connector in the PX2CR amplifier. This pulse is produced from a fast low level discriminator which is set just above the noise threshold of the XR-100CR preamplifier. The ICR pulse is a positive TTL type with maximum duration of 2 μs.
DO NOT terminate this signal with 50 Ω.

When connected to a counter, the ICR counting rate corresponds to the total number of X-ray events that strike the detector. The ICR can be used together with the RTD and PU in order to calculate absolute rates.

XR-100CR / PX2CR TROUBLESHOOTING

The XR-100CR / PX2CR system has undergone extensive testing and burn-in before leaving the factory. If the performance of the system is not similar to the one recorded at the factory before shipping, please perform the following tests:

IMPORTANT:
AT ALL TIMES, BOTH CONNECTIONS, FROM THE XR-100CR TO THE PX2CR AND FROM THE PX2CR TO THE MULTICHANNEL ANALYZER (MCA), SHOULD BE MADE **DIRECTLY** AND **NOT** WITH A 50 Ω TERMINATION.

PLACE THE XR-100CR AWAY FROM THE PX2CR, AND AWAY FROM ANY COMPUTER TERMINAL OR CRT MONITOR.

1) Remove all X-Ray sources. Turn RTD **OFF.**

2) Connect the XR-100CR output to the PX2CR input. Connect the PX2CR output to a high impedance input (NOT THROUGH 50 Ω) of an oscilloscope. Look for periodic noise pick-up on the scope by changing the time-base dial on the scope back and forth. If you find any periodic signal on the scope, try to eliminate its source or place the XR-100CR away from the pick-up area. Any periodic signal detected on the scope will degrade the resolution of the XR-100CR.

If no periodic signal is present, and the system is still not performing as designed, proceed to the next step.

3) Set the gain of the PX2CR to 6.60. Connect the output of the PX2CR directly to the input of a good, wide bandwidth RMS Voltmeter. If the reading is between 50-60 mVolts RMS, the unit is normal. If the RMS reading is high and there is no periodic pick-up signal at the output of the PX2CR, then the detector has been damaged.

CONTACT THE FACTORY FOR FURTHER ASSISTANCE AND RETURN PROCEDURES

PROCEDURE TO LOWER THE HIGH VOLTAGE BIAS IN THE DETECTOR

If the detector starts to breakdown or becomes noisy, it is probably the result of increased leakage current, which may occur after exposure to accumulated radiation. The exact reason and the total radiation that will cause this increase of leakage current in the detector is very complex since it depends on the energy spectrum and intensity of radiation the detector was exposed to. Lowering the High Voltage bias from the factory set +100 Volts to 80-90 Volts can reduce the detector leakage current and improve energy resolution. Please follow the instructions below:

Open the PX2T by removing the two screws from the bottom of the case. Unplug the XR-100T from the PX2T. Turn POWER ON. CAUTION: HIGH VOLTAGE AND AC LINE VOLTAGE ARE PRESENT. DO NOT TOUCH ANYTHING INSIDE THE PX2T WITH BARE FINGERS. USE AN INSULATED SCREWDRIVER.

With a high impedance voltmeter (>1000 MOhms) measure the detector bias voltage from the outside of the PX2T at the 9-PIN D-Connector between Pins 5 and 8. It should be about +100 Volts.

Potentiometer R5 is located on the motherboard of the PX2T, in the back, just below the AC input filter. This potentiometer adjusts the high voltage to the detector. With an INSULATED screwdriver turn the potentiometer's screw counter-clockwise to reduce the voltage to the detector by about 10 volts. If a high impedance meter is not available, do not attempt to make this measurement with a low impedance (10-100 Mohm) meter. Just turn the R5 screw counter-clockwise 1/2 turn at a time. Each time R5 is turned by 1/2 turn check to see if the detector is restored to normal. High voltage to the detector can be decreased by more than 10 volts as long as the resolution of the detector is acceptable.

If this procedure succeeds, operating the detector at the highest voltage below +100 Volts without breakdown is recommended.

NOTES

ABSOLUTE MAXIMUM RATINGS:

Cooler power............+0.7 AMPS
Preamp power...........+/- 8 VOLTS
Detector Bias (HV)....+110 VOLTS

6-PIN LEMO CONNECTOR ON THE XR-100CR

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

9-PIN CABLE D-CONNECTOR TO PX2CR OR EXTERNAL POWER

Pin 1: +8 Volt Preamp Power
Pin 2: -8 Volt Preamp Power
Pin 3: 0 to +3 Volt Cooler Power @ 0.7 A max.
Pin 4: + 8 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

OPERATING NOTES FOR THE XR-100CR WITHOUT THE PX2CR

A. EQUIPMENT REQUIRED

1) Power supplies:
  * A dual tracking +/-8 VDC @ 35 mA with voltage meter & current limit.
  * A zero to +3 VDC @ 0.7 A adjustable with voltage and current meter.
  * A zero to +110 VDC adjustable @ 10 μA.

2. A zero to 400 μADC meter.

3. Shaping amplifier such as NIM standard Shaping Amplifier with an input impedance of 1 kΩ. A "triangular" type of pulse with **12 μs shaping and Base Line Restoration** will be needed to realize the resolution of the XR-100CR. Example: CANBERRA Model 2025 or 2026.

4. Oscilloscope.

5. A low energy radioactive x-ray source or tail pulse generator.

6. AC power outlet strip (preferably with surge suppression & EMI/RFI filtering).

B. CONNECTIONS and TURN-ON PROCEDURE (SEE FIGURE 1)

1. Turn all power supplies OFF. Plug all equipment to be used into one common AC power outlet strip. This will help prevent ground loops, which is crucial in getting good performance from the XR-100CR .
2. Set voltages on all power supplies to ZERO. Set current limits on all power supplies to ZERO.

3. Connect the LEMO CONNECTOR cable to the XR-100CR. Apply power to the XR-100CR through the D-CONNECTOR end of the cable according to Figure 1 and the Pin assignements given elsewhere in the manual.

4. Turn ON the +/- 8 VDC power supplies to power the charge sensitive preamplifier. Verify that both the + and - Volt outputs are between 7.5 and 8.0 Volts. NEVER EXCEED 8 VOLTS. Increase the current limit on the power supplies as required so that it can just obtain this output voltage but will not allow any excessive current to flow.

5. Set the High Voltage Supply to zero. Slowly increase voltage to be between +35 and +45 volts.

6. Attach the OUTPUT of the XR-100CR to the INPUT of the shaping amplifier. A BNC connector is provided on the rear panel of the XR-100T. The output pulses of the XR-100CR are NEGATIVE. A NIM standard shaping amplifier with an input impedance of 1 kΩ can be used. A shaping time constant of 12 μs with a "triangular" shaping and Base Line Restoration is optimum for this detector.

7. Attach the OUTPUT of the shaping amplifier to an oscilloscope. Observe that the output of the shaping amplifier is random noise. Make sure there is no repetitive signal such as the power line frequency or any type of RF signal. Any repetitive signal

observed can be traced to ground loops or RFI generated from equipment such as computer monitors. If there is any repetitive signal observed on the oscilloscope the performance of the XR-100CR will degrade significantly.

8. If the testing is to be done with a radioactive source, remove the red protective cover from the detector of the XR-100CR. Place the radioactive source in front of the AXRCR detector.

If a pulse generator is to be used follow the steps outlined below:

A. Connect the OUTPUT of the pulse generator to the BNC TEST input of the XR-100CR.

B. Set the test pulse generator to produce a 20 mV peak signal at a frequency of about 1 KHz. The rise time of the signal should be less than 100ns and the pulse width should be for about 1 ms. This will produce a pulse out of the XR-100CR equal to approximately a 20 keV X-ray event.

9. Observe pulses on the oscilloscope.

10. Connect the + terminal of the temperature monitor μA meter to the + 8 Volt supply through a 10 kΩ resistor. See Figure 1. Connect the - terminal of the meter to Pin 4 of the D-Connector in order to power the temperature monitor circuit. Observe that the reading in μA is approximately the room temperature in KELVIN degrees. (i.e. 300 μA corresponds to 300 K room temperature)

11. While observing the μA meter, slightly increase the cooler supply current until the temperature reading starts to change on the μA meter. Observe that the temperature is DECREASING. If the temperature increases, turn OFF the power supply and check the polarity of the cooler power wires. If the temperature is decreasing, increase the +3 V supply while observing the current. The current should be between +650 and +700 mA. The temperature displayed on the μA meter should decrease to about 250 K.

THE COOLER IS FRAGILE AND WILL BE PERMANENTLY DAMAGED IF EXCESSIVE CURRENT OR IF REVERSE POLARITY IS APPLIED. THE WARRANTY WILL BE VOID IF COOLER IS DAMAGED DUE TO EXCESSIVE CURRENT OR REVERSE POLARITY.

The temperature sensor has an offset associated with it. It is quite linear but it could have an offset of about 5 degrees Kelvin. Also, once the temperature on the AXRCR gets below -10 °C the performance of the XR-100CR system will not change with a temperature variation of a few degrees. Hence, accurate temperature control is not necessary.

12. Increase the + H V supply to + 100 Volts. Now the XR-100CR is fully operational.

ALWAYS INCREASE THE + H V POWER SLOWLY TO PROTECT THE INPUT FET. WHEN TURNING OFF THE XR-100CR, DECREASE THE + H V SLOWLY TO ZERO VOLTS BEFORE TURNING OFF THE XR-100CR. IF FET IS DAMAGED DUE TO HIGH VOLTAGE TRANSIENTS, THE WARRANTY WILL BE VOID.

WARRANTY

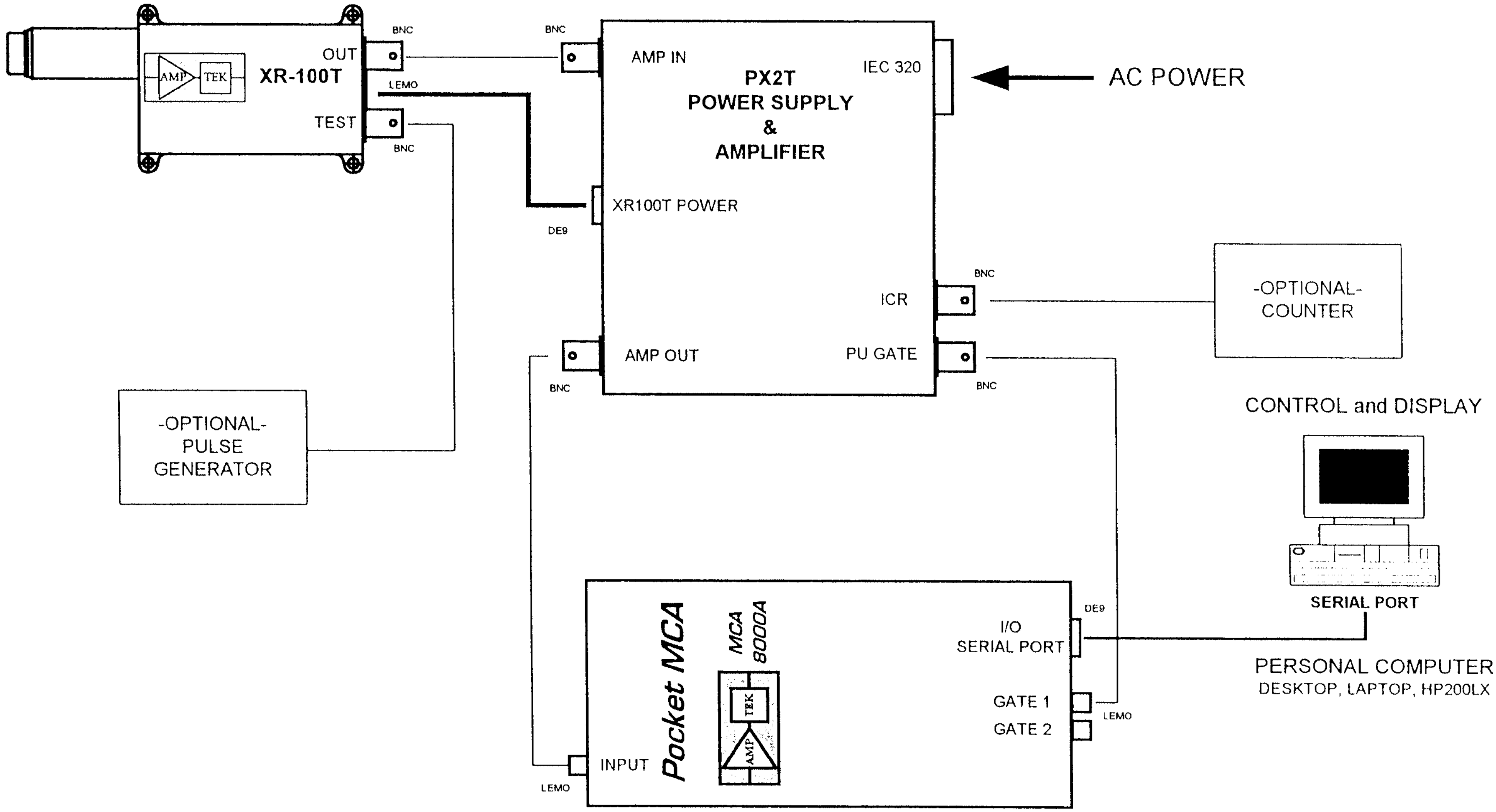
AMPTEK, INC. warrants to the original purchaser this instrument to be free from defects in materials and workmanship for a period of one year from shipment. AMPTEK, INC. will, without charge, repair or replace (at its option) a defective instrument upon return to the factory. This warranty does not apply in the event of misuse or abuse of the instrument or unauthorized alterations or repair. AMPTEK, INC. shall not be liable for any consequential damages, including without limitation, damages resulting from the loss of use due to failure of this instrument. All products returned under the warranty must be shipped prepaid to the factory with documentation describing the problem and the circumstances under which it was observed. The factory MUST be notified prior to return shipment. The instrument will be evaluated, repaired or replaced, and promptly returned if the warranty claims are substantiated. A nominal fee will be charged for unsubstantiated claims. Please include the model and serial number in all correspondence with the factory.

WARRANTY CARD

The user is asked to return the warranty card to AMPTEK, INC. promptly. Information from the warranty card will be used for mailings of **system upgrades,** future related products and application notes as they become available.

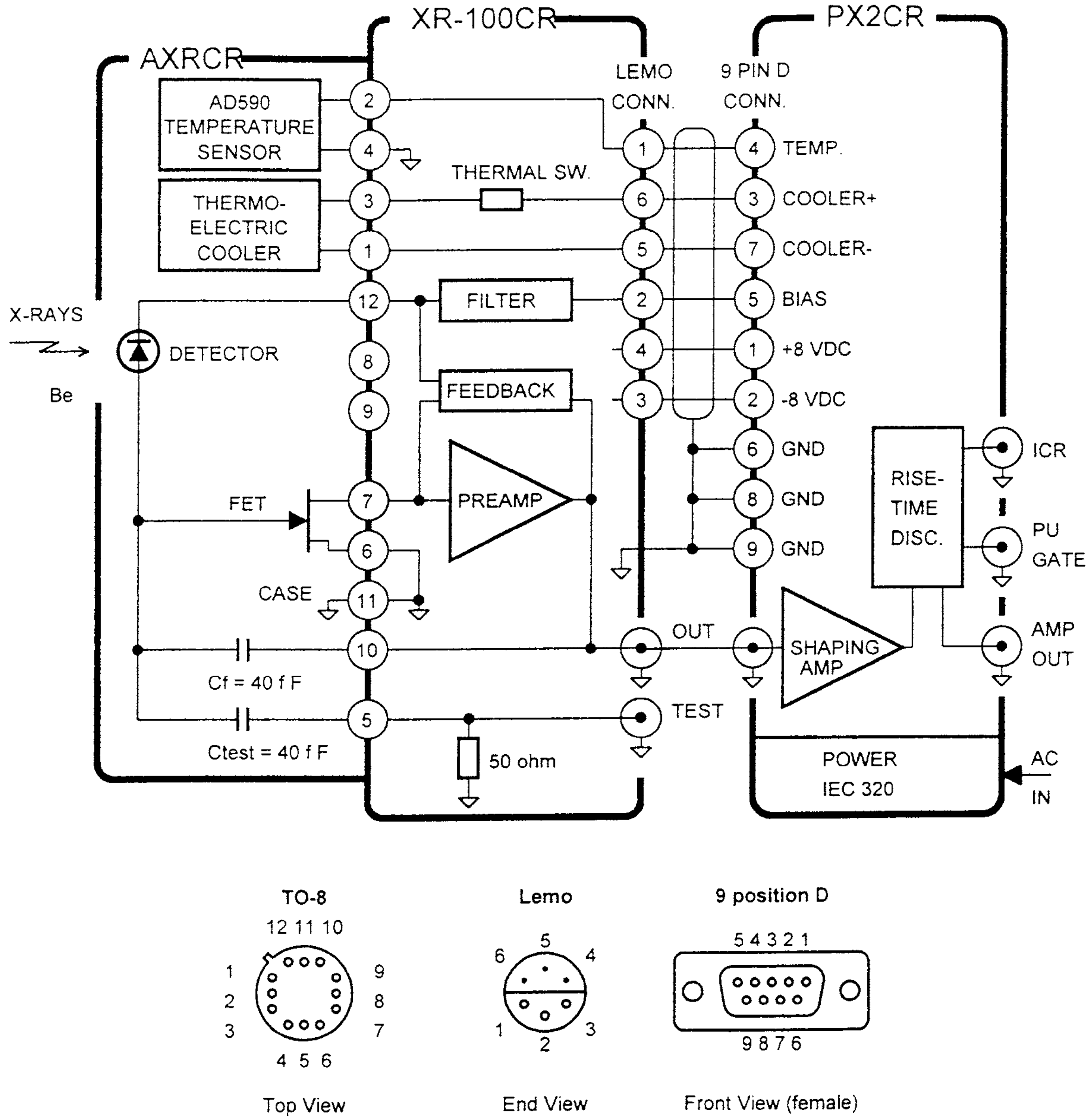
TECHNICAL QUESTIONS

Please contact the factory via FAX: (781) 275-3470, Phone: (781) 275-2242, or email: sales@amptek.com for all technical questions.



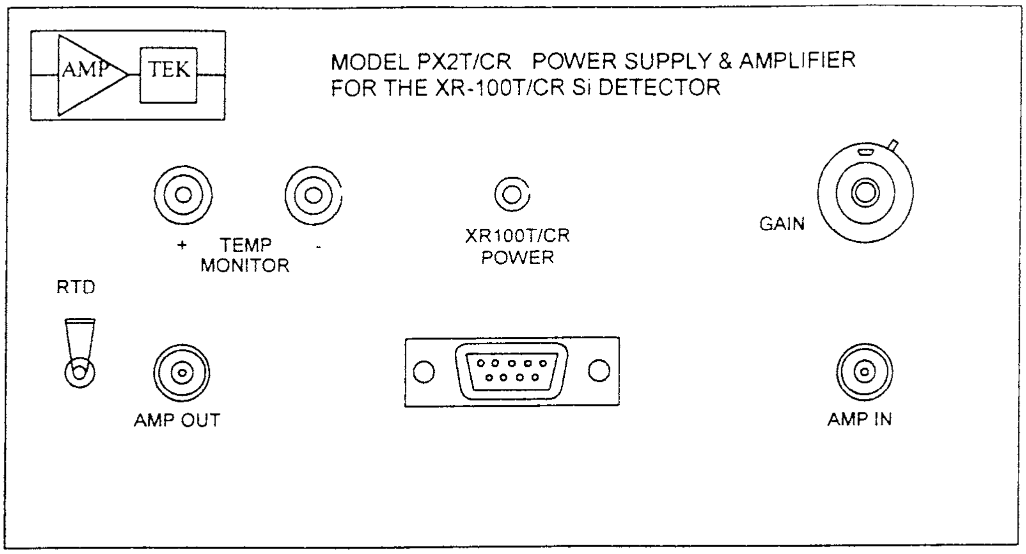
CONNECTION DIAGRAM
XR100T *TO THE* ***PX2T*** *AND* ***MCA8000A***

FILENAME
AMP103A0.VSD

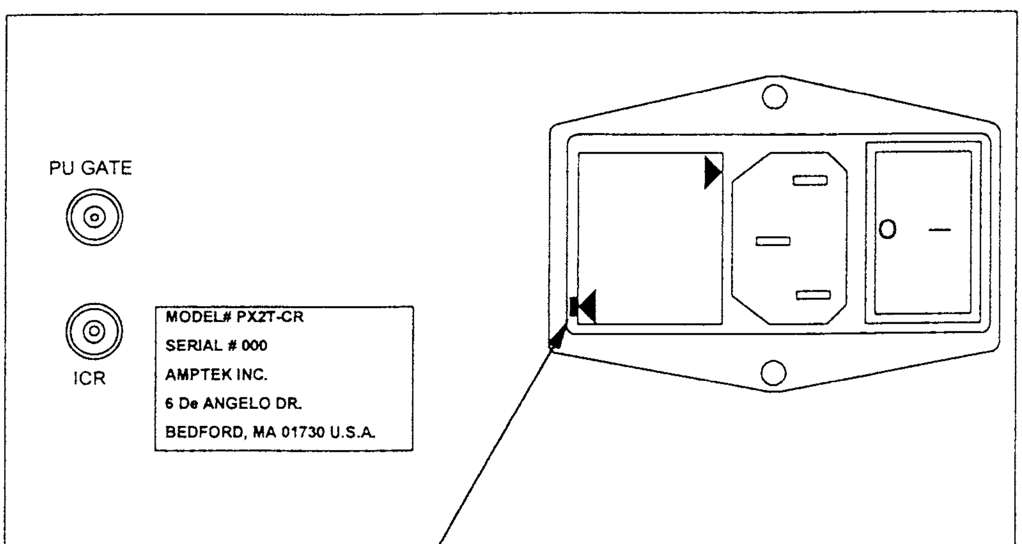


XR-100CR
PX2CR
AXRCR
AD590 TEMPERATURE SENSOR
THERMO-ELECTRIC COOLER
LEMO CONN.
9 PIN D CONN.
THERMAL SW.
TEMP.
COOLER+
COOLER-
BIAS
+8 VDC
-8 VDC
GND
GND
GND
X-RAYS
DETECTOR
Be
FILTER
FEEDBACK
PREAMP
FET
CASE
RISE-TIME DISC.
ICR
PU GATE
AMP OUT
OUT
SHAPING AMP
TEST
Cf = 40 f F
Ctest = 40 f F
50 ohm
POWER IEC 320
AC IN
TO-8
Top View
Lemo
End View
9 position D
Front View (female)

axr-041.doc



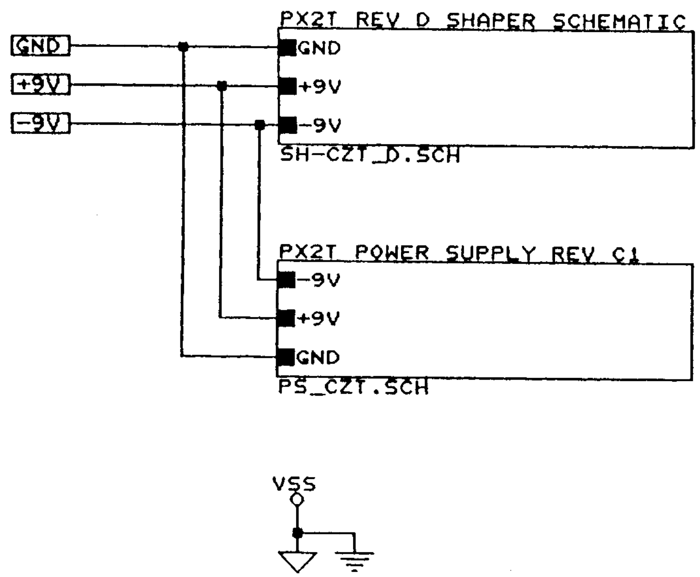
PX2T-CR FRONT PANEL



To change selected voltage: Remove fuse cartridge using a small blade screwdriver or similar tool; select desired voltage by matching arrow on fuse cartridge with indicator located on bezel (lower left corner); replace fuse cartridge *making sure the desired voltage arrow aligns with the indicator.*

PX2T-CR BACK PANEL

PCRPANELF1.doc

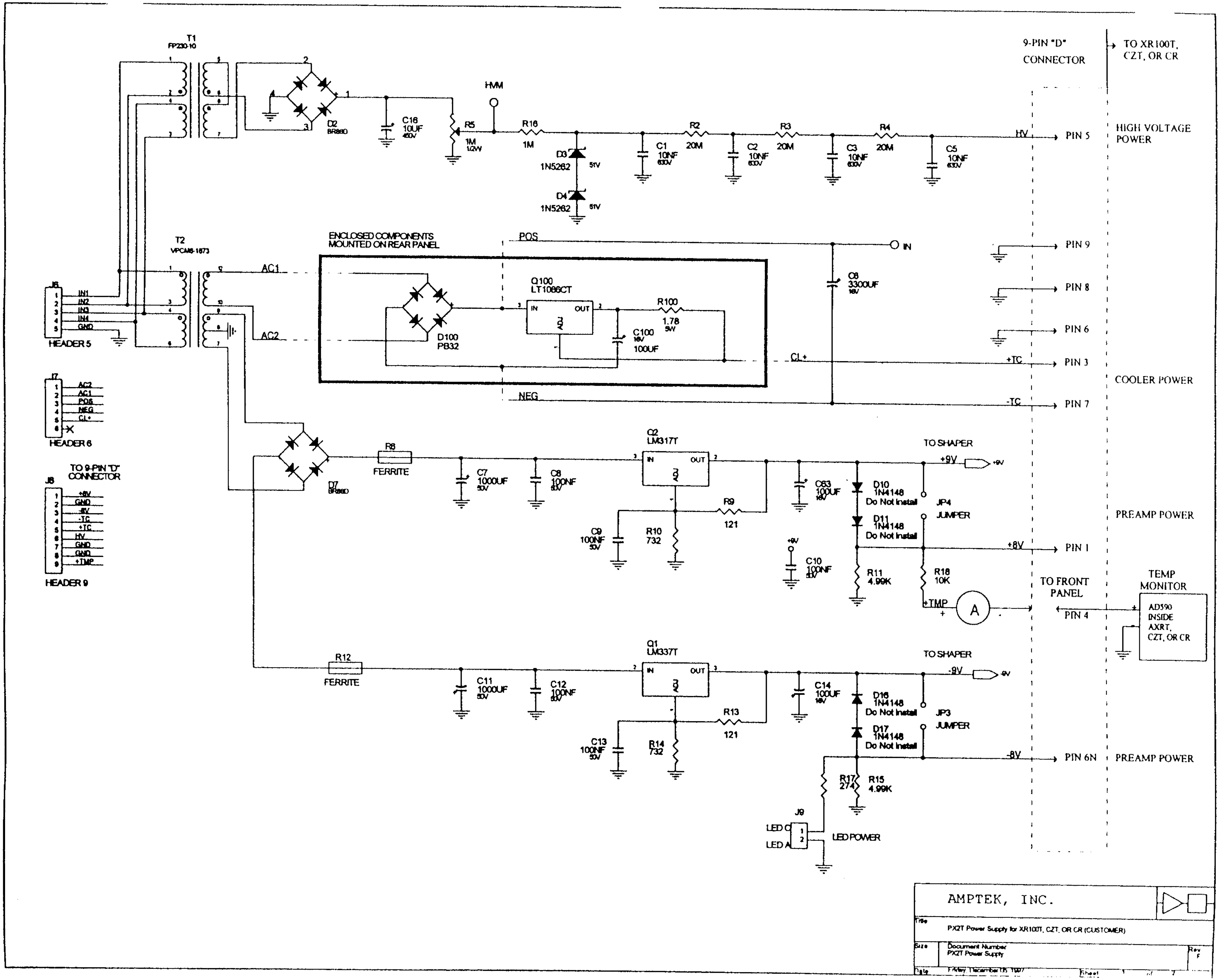


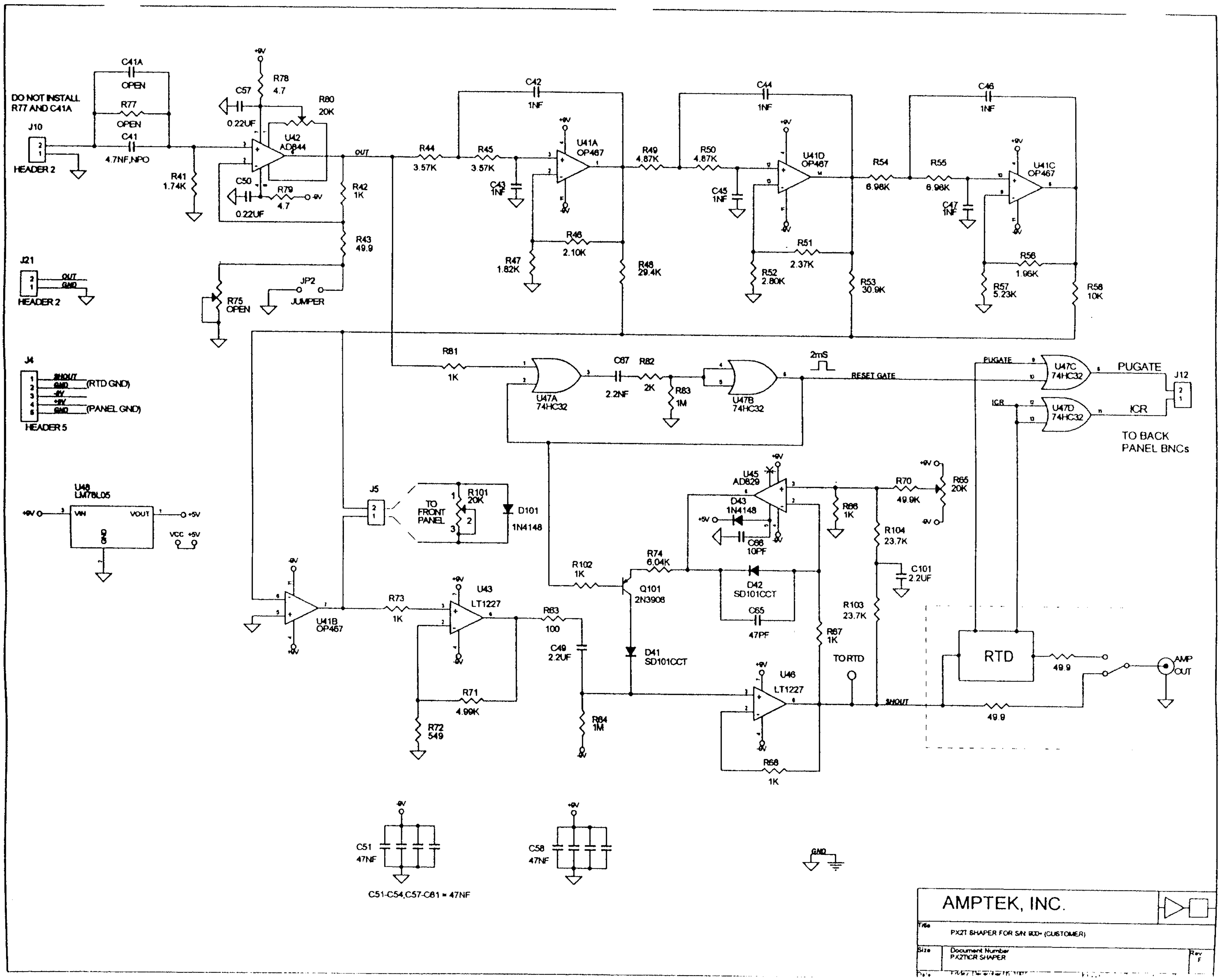
SCH : SH-CZT_D.SCH
BOM : SH-CZT_D.BOM
PCB : PX2T_C1.JOB
MFR : 3/6/96

SCH : PS_CZT.SCH
BOM : PS_CZT.BOM
PCB : PX2T_C1.JOB
MFR : 3/6/96

AMPTEK, INC.

Title PX2T/CZT POWER SUPPLY & SHAPER (PCB REV. C1)		
Size A	Document Number PX-CZT_D.SCH	REV D
Date: January 31, 1997	Sheet 1 of 3	


AMPTEK, INC.
PX2T Power Supply for XR100T, CZT, OR CR (CUSTOMER)
Document Number
PX2T Power Supply
Rev F
9-PIN "D" CONNECTOR
TO XR100T, CZT, OR CR
HIGH VOLTAGE POWER
COOLER POWER
PREAMP POWER
PREAMP POWER
TEMP MONITOR
AD590 INSIDE AXRT, CZT, OR CR
TO FRONT PANEL
PIN 5
PIN 9
PIN 8
PIN 6
PIN 3
PIN 7
PIN 1
PIN 4
PIN 6N
HV
+TC
-TC
+8V
-8V
T1 FP230-10
T2 VPCM6-1673
D2 BR88D
D7 BR88D
HVM
C16 10UF 450V
R5 1M 1/2W
R16 1M
D3 1N5262 51V
D4 1N5262 51V
C1 10NF 630V
R2 20M
C2 10NF 630V
R3 20M
C3 10NF 630V
R4 20M
C5 10NF 630V
ENCLOSED COMPONENTS MOUNTED ON REAR PANEL
POS
NEG
IN
AC1
AC2
CL+
D100 PB32
Q100 LT1086CT
R100 1.78 5W
C100 16V 100UF
C8 3300UF 16V
Q2 LM317T
Q1 LM337T
R8 FERRITE
R12 FERRITE
C7 1000UF 50V
C8 100NF 50V
C11 1000UF 50V
C12 100NF 50V
C9 100NF 50V
R10 732
R9 121
C13 100NF 50V
R14 732
R13 121
C63 100UF 16V
C14 100UF 16V
C10 100NF 50V
D10 1N4148 Do Not Install
D11 1N4148 Do Not Install
D16 1N4148 Do Not Install
D17 1N4148 Do Not Install
JP4 JUMPER
JP3 JUMPER
R11 4.99K
R18 10K
R15 4.99K
R17 274
+TMP
A
TO SHAPER
+9V
-9V
J9
LED C
LED A
LED POWER
J5
IN1
IN2
IN3
IN4
GND
HEADER 5
J7
AC2
AC1
POS
NEG
CL+
HEADER 6
TO 9-PIN "D" CONNECTOR
J8
+8V
GND
-8V
-TC
+TC
HV
GND
GND
+TMP
HEADER 9

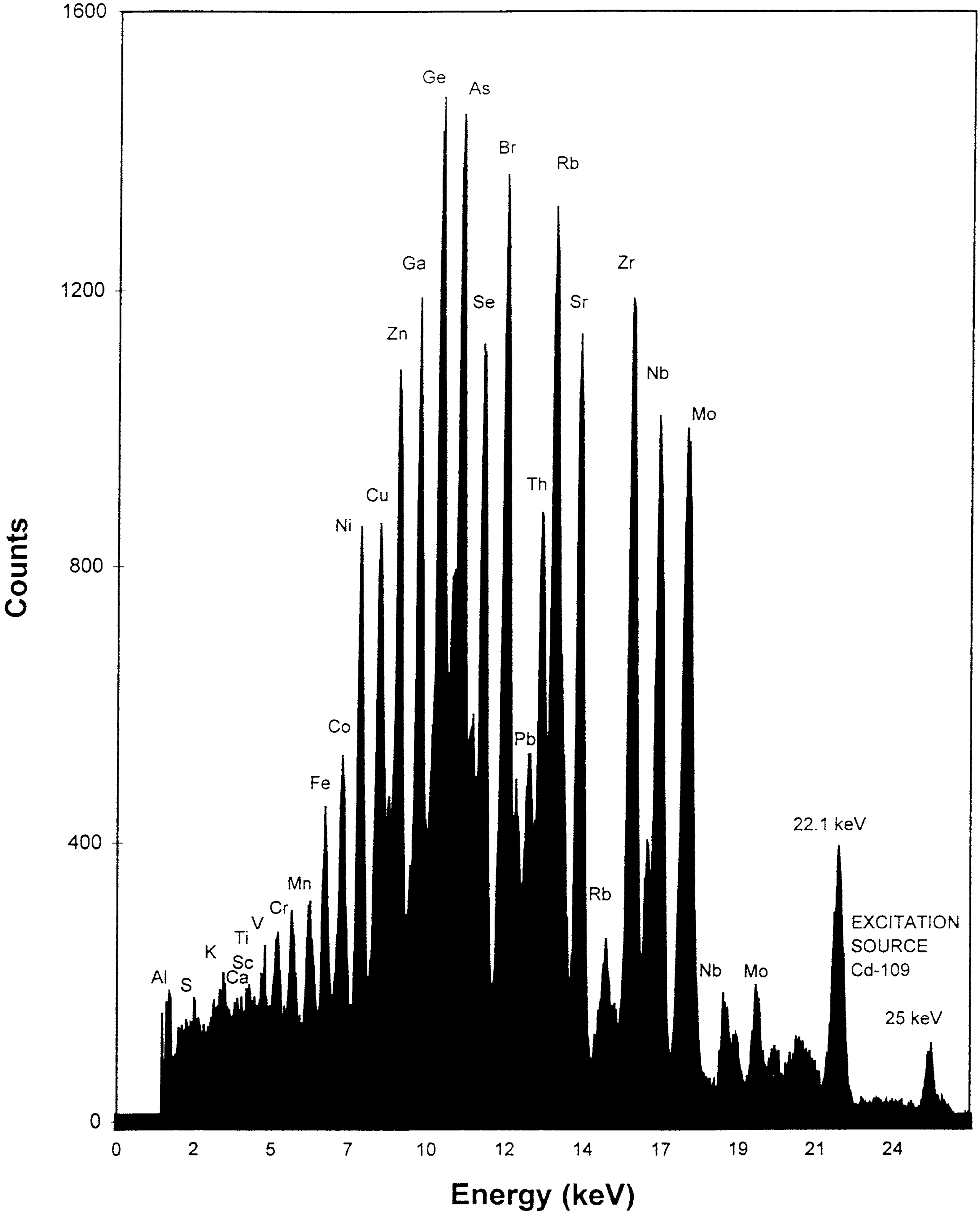


DO NOT INSTALL R77 AND C41A
J10
HEADER 2
C41A OPEN
R77 OPEN
C41 4.7NF,NPO
R41 1.74K
R78 4.7
C57 0.22UF
R80 20K
U42 AD844
C50 0.22UF
R79 4.7
OUT
R42 1K
R43 49.9
R75 OPEN
JP2 JUMPER
J21
OUT
GND
HEADER 2
J4
SHOUT
GND
-9V
+9V
GND
(RTD GND)
(PANEL GND)
HEADER 5
U48 LM78L05
VIN
VOUT
GND
+9V
+5V
VCC +5V
R44 3.57K
R45 3.57K
C42 1NF
C43 1NF
U41A OP467
R46 2.10K
R47 1.82K
R48 29.4K
R49 4.87K
R50 4.87K
C44 1NF
C45 1NF
U41D OP467
R51 2.37K
R52 2.80K
R53 30.9K
R54 6.98K
R55 6.98K
C46 1NF
C47 1NF
U41C OP467
R56 1.96K
R57 5.23K
R58 10K
R81 1K
U47A 74HC32
C67 2.2NF
R82 2K
R83 1M
U47B 74HC32
2mS
RESET GATE
PUGATE
U47C 74HC32
PUGATE
J12
ICR
U47D 74HC32
ICR
TO BACK PANEL BNCs
J5
TO FRONT PANEL
R101 20K
D101 1N4148
U41B OP467
R73 1K
U43 LT1227
R71 4.99K
R72 549
R63 100
C49 2.2UF
R64 1M
R102 1K
Q101 2N3906
R74 6.04K
D41 SD101CCT
U45 AD829
D43 1N4148
C66 10PF
D42 SD101CCT
C65 47PF
R66 1K
R67 1K
R70 49.9K
R65 20K
R104 23.7K
C101 2.2UF
R103 23.7K
TO RTD
U46 LT1227
R68 1K
SHOUT
RTD
49.9
49.9
AMP OUT
C51 47NF
C58 47NF
C51-C54,C57-C61 = 47NF
GND
AMPTEK, INC.
Title
PX2T SHAPER FOR S/N 900+ (CUSTOMER)
Size
Document Number
PX2T/CR SHAPER
Rev
F
Date

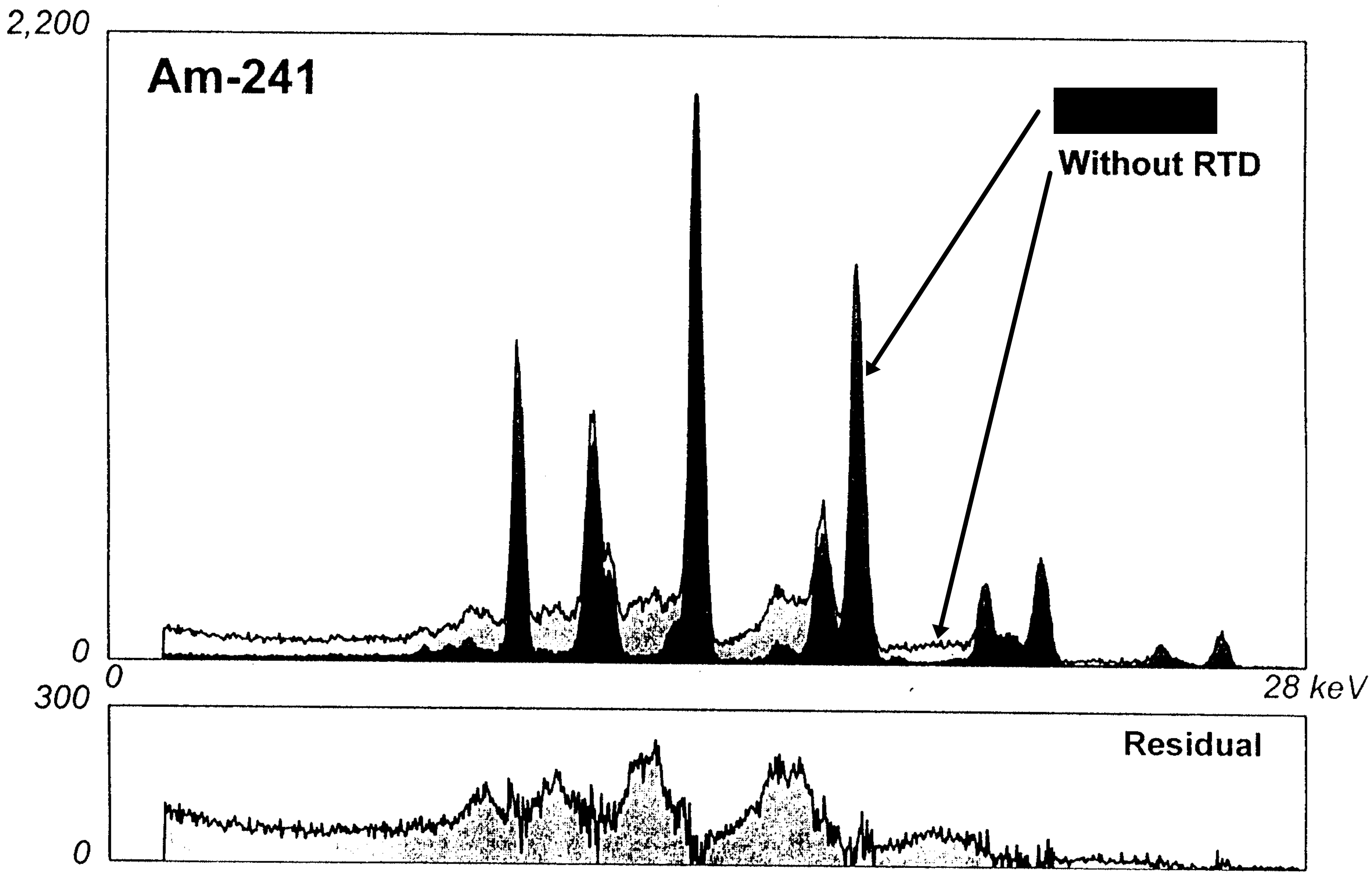
AMPTEK XR-100CR X-RAY DETECTOR

MULTI-ELEMENT FLUORESCENCE FROM Cd-109

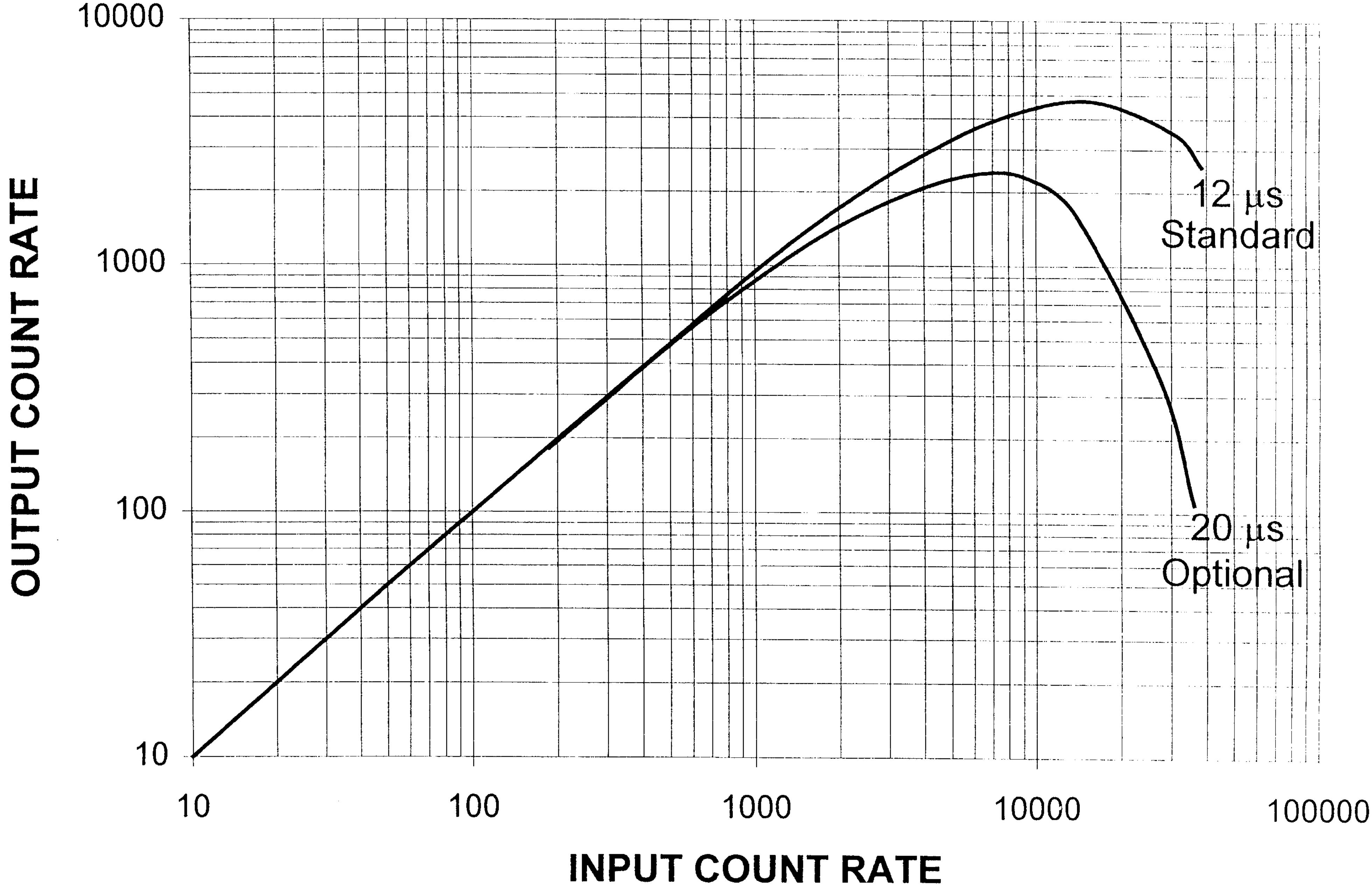
(20 µs shaping)



XR-100T Background Reduction Using Rise-Time Discrimination (RTD)



AMPTEK XR-100T/CR X-RAY DETECTOR
OUTPUT vs. INPUT RATE



APPLICATION NOTE

USE OF COLLIMATORS

X-ray events that are produced near the edges of a detector may result in partial charge collection. Hence, a typical "tail" is observed at the low energy side of an energy peak. This "tail" is often called the "Background".

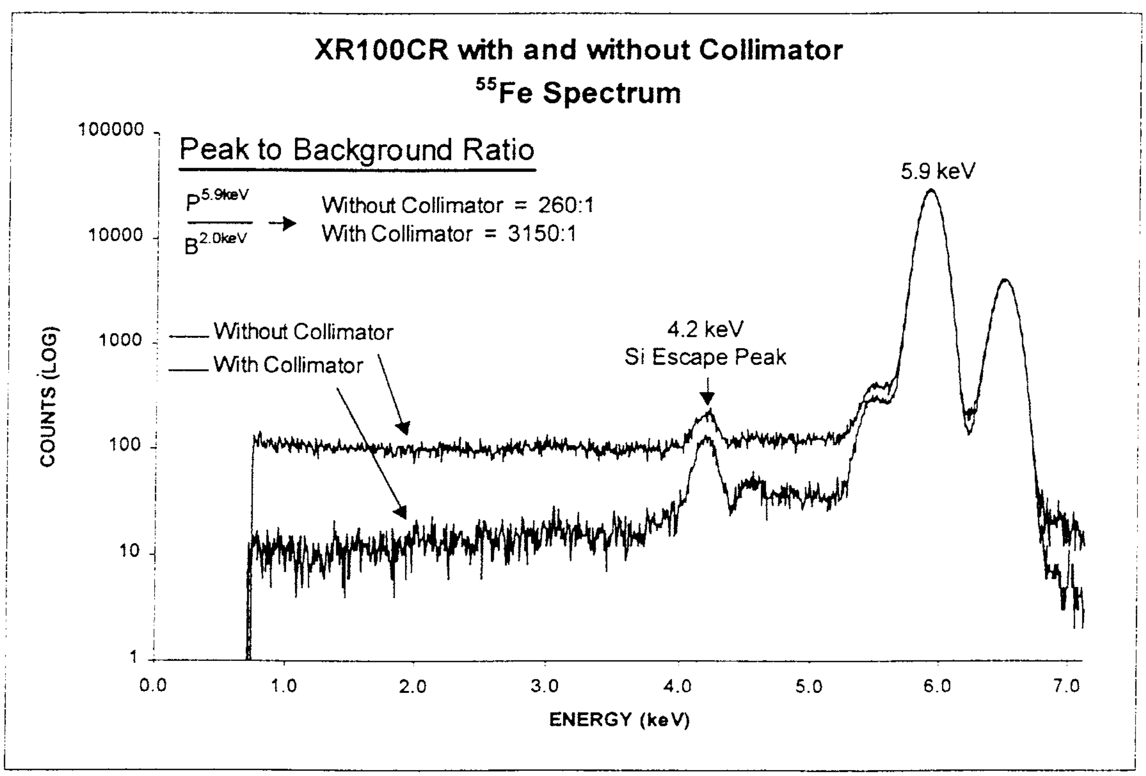
In the case of the ^{55}Fe, the ratio of the counts at the 5.9 keV peak to the counts at about 2 keV is called the "Peak to Background Ratio" (P/B).

The XR-100CR with a 7 mm^2 uncollimated detector exhibits a P/B = 260. However, the same detector with an external Aluminum collimator having a 2 mm diameter hole has a P/B = 3150. See Figure below.

The use of a collimator increases the signal to noise ratio of X-ray events that fall on the low energy tails of higher peaks, and thus, increasing the counting statistics in observing such events. As shown below, the 4.2 keV Silicon escape peak from the 5.9 keV is better defined with a collimated detector than with an uncollimated one.

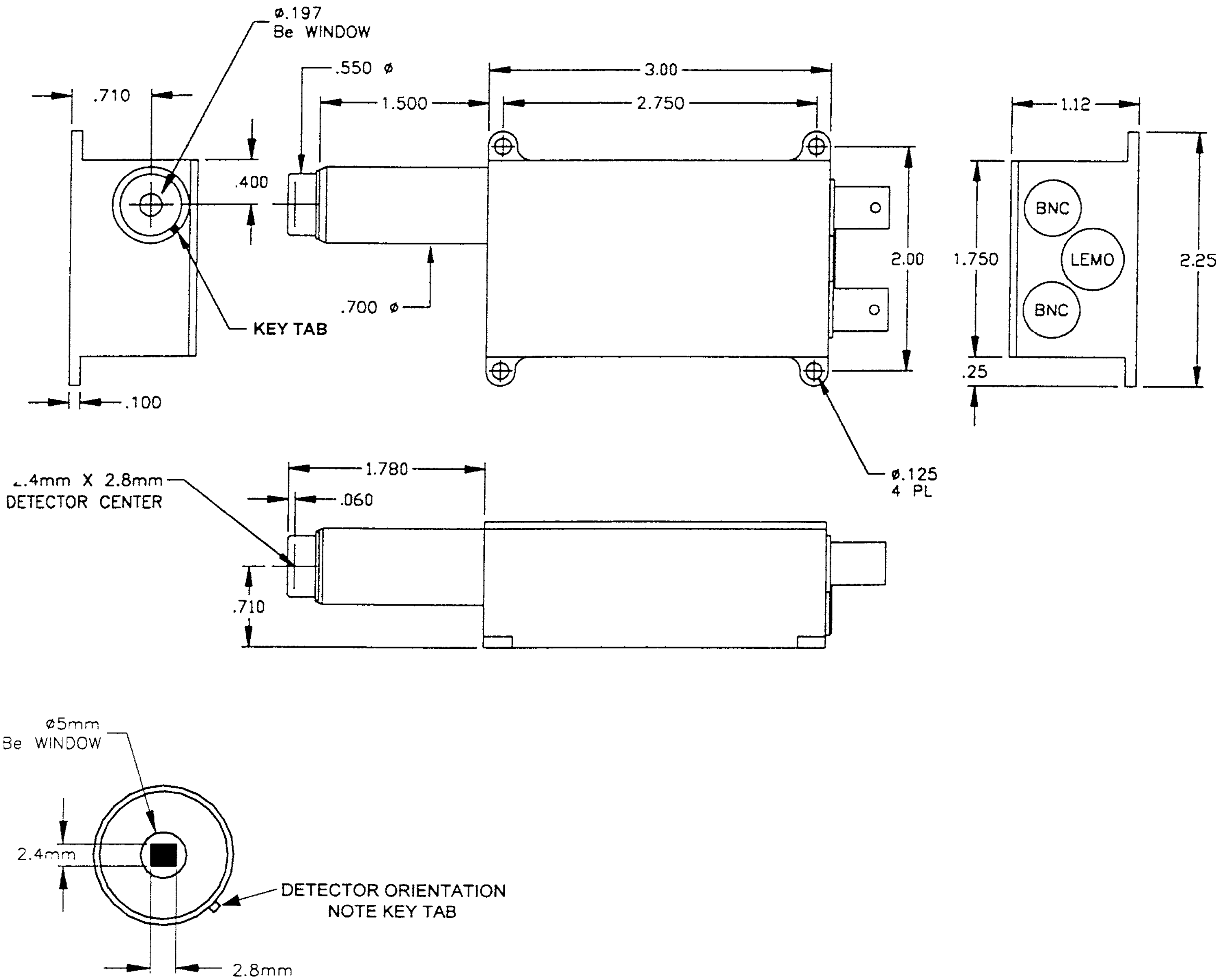
Collimators can be made from materials other than Aluminum, like Copper, Tungsten, Silver or other, provided the fluorescence peaks from the collimator material do not interfere with the anticipated measurement.

In cases where fluorescence peaks produced from the edges of collimators need to be minimized or eliminated, a multilayer collimator can be made by progressively using lower Z materials. Each layer will act as an absorber to the fluorescence peaks of the previous layer. The final layer will be of the lowest Z material whose fluorescence peaks are of low enough energy to be outside the anticipated X-ray detection range.



AMPTEK, INC.
6 DeANGELO DRIVE, BEDFORD, MA 01730-2204 U.S.A.
TEL: (617) 275-2242 **FAX:** (617) 275-3470
e-mail: sales@amptek.com **WWW:**http://www.amptek.com

XR-100CR-EX1.5 MECHANICAL DIMENSIONS



ALL DIMENSIONS ARE IN INCHES EXCEPT AS NOTED

Amptek Inc.
6 De Angelo Drive
Bedford, MA. 01730, USA
PH: 781-275-2242 FAX: 781-275-3470
e-mail: sales@amptek.com
WWW: http://www.amptek.com

Amptek K and L Emission Line Lookup Chart

XR-100CR / XR-100T-CZT / *ROVER*

X-Ray and Gamma Ray Detectors

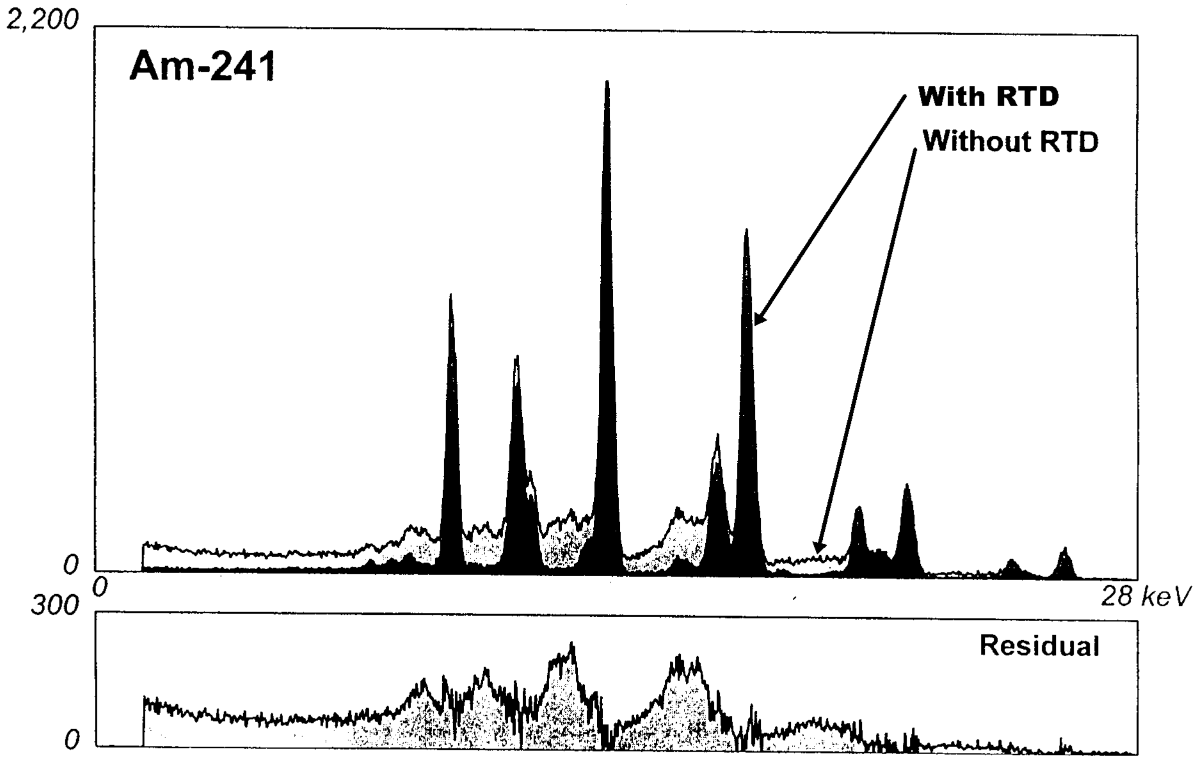
Key to Energy Values in keV

$K_{\alpha1}$ $K_{\beta1}$
Au
79
$L_{\alpha1}$ $L_{\beta1}$

Group IA	IIA	IIIB	IVB	VB	VIB	VIIB	Group VIII	Group VIII	Group VIII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
H **1**																	**He** **2**
0.052 **Li** **3**	0.110 **Be** **4**											0.185 **B** **5**	0.282 **C** **6**	0.392 **N** **7**	0.526 **O** **8**	0.677 **F** **9**	0.851 **Ne** **10**
1.04 1.07 **Na** **11**	1.25 1.30 **Mg** **12**											1.49 1.55 **Al** **13**	1.74 1.83 **Si** **14**	2.02 2.14 **P** **15**	2.31 2.46 **S** **16**	2.62 2.82 **Cl** **17**	2.96 3.19 **Ar** **18**
3.31 3.59 **K** **19**	3.69 4.01 **Ca** **20** 0.34	4.09 4.46 **Sc** **21** 0.40	4.51 4.93 **Ti** **22** 0.45 0.46	4.95 5.43 **V** **23** 0.51 0.52	5.41 5.43 **Cr** **24** 0.57 0.58	5.90 6.49 **Mn** **25** 0.64 0.65	6.40 7.06 **Fe** **26** 0.70 0.72	6.93 7.65 **Co** **27** 0.78 0.79	7.48 8.26 **Ni** **28** 0.85 0.87	8.05 8.90 **Cu** **29** 0.93 0.95	8.64 9.57 **Zn** **30** 1.01 1.03	9.25 10.26 **Ga** **31** 1.10 1.12	9.89 10.98 **Ge** **32** 1.19 1.21	10.54 11.73 **As** **33** 1.28 1.32	11.22 12.50 **Se** **34** 1.38 1.42	11.92 13.29 **Br** **35** 1.48 1.53	12.65 14.11 **Kr** **36** 1.59 1.64
13.39 14.96 **Rb** **37** 1.69 1.75	14.16 15.83 **Sr** **38** 1.81 1.87	14.96 16.74 **Y** **39** 1.92 2.00	15.77 17.67 **Zr** **40** 2.04 2.12	16.61 18.62 **Nb** **41** 2.17 2.26	17.48 19.61 **Mo** **42** 2.29 2.40	18.41 19.61 **Tc** **43** 2.42 2.54	19.28 21.66 **Ru** **44** 2.56 2.68	20.21 22.72 **Rh** **45** 2.70 2.83	21.18 23.82 **Pd** **46** 2.84 2.99	22.16 24.94 **Ag** **47** 2.98 3.15	23.17 26.09 **Cd** **48** 3.13 3.32	24.21 27.27 **In** **49** 3.29 3.49	25.27 28.48 **Sn** **50** 3.44 3.66	26.36 29.72 **Sb** **51** 3.61 3.84	27.47 30.99 **Te** **52** 3.77 4.03	28.61 32.29 **I** **53** 3.94 4.22	29.80 33.64 **Xe** **54** 4.11 4.42
30.97 34.98 **Cs** **55** 4.29 4.62	32.19 36.38 **Ba** **56** 4.47 4.83	**57 - 71**	55.76 63.21 **Hf** **72** 7.90 9.02	57.52 65.21 **Ta** **73** 8.15 9.34	59.31 67.23 **W** **74** 8.40 9.67	61.13 69.30 **Re** **75** 8.65 10.01	62.99 71.40 **Os** **76** 8.91 10.35	64.89 73.55 **Ir** **77** 9.19 10.71	66.82 75.74 **Pt** **78** 9.44 11.07	68.79 77.97 **Au** **79** 9.71 11.44	70.82 80.26 **Hg** **80** 9.99 11.82	72.86 82.56 **Tl** **81** 10.27 12.21	74.96 84.92 **Pb** **82** 10.55 12.61	77.10 87.34 **Bi** **83** 10.84 13.02	79.30 89.81 **Po** **84** 11.13 13.44	81.53 92.32 **At** **85** 11.42 13.87	83.80 94.88 **Rn** **86** 11.72 14.32
86.12 97.48 **Fr** **87** 12.03 14.77	88.46 100.14 **Ra** **88** 12.34 15.23	90.89 102.85 **Ac** **89** 12.65 15.71	93.33 105.59 **Th** **90** 12.97 16.20	95.85 108.41 **Pa** **91** 13.29 19.70	98.43 111.29 **U** **92** 13.61 17.22	101.00 114.18 **Np** **93** 13.95 17.74	103.65 117.15 **Pu** **94** 14.28 18.28	106.35 120.16 **Am** **95** 14.62 18.83	109.10 123.24 **Cm** **96** 14.96 19.39	111.90 126.36 **Bk** **97** 15.31 19.97	114.75 129.54 **Cf** **98** 15.66 20.56	117.65 132.78 **Es** **99** 16.02 21.17	120.60 136.08 **Fm** **100** 16.38 21.79	**Md** **101**	**No** **102**	**Lr** **103**	**Actinides** **90-103**
Lanthanides **57-71**		33.44 37.80 **La** **57** 4.65 5.04	34.72 39.26 **Ce** **58** 4.84 5.26	36.02 40.75 **Pr** **59** 5.03 5.49	37.36 42.27 **Nd** **60** 5.23 5.72	38.65 43.96 **Pm** **61** 5.43 5.96	40.12 45.40 **Sm** **62** 5.64 6.21	41.53 47.03 **Eu** **63** 5.85 6.46	42.98 48.72 **Gd** **64** 6.06 6.71	44.47 50.39 **Tb** **65** 6.28 6.98	45.99 52.18 **Dy** **66** 6.50 7.25	47.53 53.93 **Ho** **67** 6.72 7.53	49.10 55.69 **Er** **68** 6.95 7.81	50.73 57.58 **Tm** **69** 7.18 8.10	52.36 59.35 **Yb** **70** 7.41 8.40	54.06 61.28 **Lu** **71** 7.65 8.71	

Actinium - Ac 89
Aluminum - Al 13
Americium - Am 95
Antimony - Sb 51
Argon - Ar 18
Arsenic - As 33
Astatine - At 85
Barium - Ba 56
Berkelium - Bk 97
Beryllium - Be 4
Bismuth - Bi 83
Boron - B 5
Bromine - Br 35
Cadmium - Cd 48
Calcium - Ca 20
Californium - Cf 98
Carbon - C 6
Cerium - Ce 58
Cesium - Cs 55
Chlorine - Cl 17
Chromium - Cr 24
Cobalt - Co 27
Copper - Cu 29
Curium - Cm 96
Dysprosium - Dy 66
Einsteinium - Es 99
Erbium - Er 68
Europium - Eu 63
Fermium - Fm 100
Fluorine - F 9
Francium - Fr 87
Gadolinium - Gd 64
Gallium - Ga 31
Germanium - Ge 32
Gold - Au 79
Hafnium - Hf - 72
Helium - He 2
Holmium - Ho 67
Hydrogen - H 1
Indium - In 49
Iodine - I 53
Iridium - Ir 77
Iron - Fe 26
Krypton - Kr 36
Lanthanum - La 57
Lawrencium - Lr 103
Lead - Pb 82
Lithium - Li 3
Lutetium - Lu 71
Magnesium - Mg 12
Manganese - Mn 25
Mendelevium - Md 101
Mercury - Hg 80
Molybdenum - Mo 42
Neodymium - Nd 60
Neon - Ne 10
Neptunium - Np 93
Nickel - Ni 28
Niobium - Nb 41
Nitrogen - N 7
Nobelium - No 102
Osmium - Os 76
Oxygen - O 8
Palladium - Pd 46
Phosphorus - P 15
Platinum - Pt 78
Plutonium - Pu 94
Polonium - Po 84
Potassium - K 19
Praseodymium - Pr 59
Promethium - Pm 61
Protactinium - Pa 91
Radium - Ra 88
Radon - Rn 86
Rhenium - Re 75
Rhodium - Rh 45
Rubidium - Rb 37
Ruthenium - Ru 44
Samarium - Sm 62
Scandium - Sc 21
Selenium - Se 34
Silicon - Si 14
Silver - Ag 47
Sodium - Na 11
Strontium - Sr 38
Sulphur - S 16
Tantalum - Ta 73
Technetium - Tc 43
Tellurium - Te 52
Terbium - Tb 65
Thallium - Tl 81
Thorium - Th 90
Thulium - Tm 69
Tin - Sn 50
Titanium - Ti 22
Tungsten - W 74
Uranium - U 92
Vanadium - V 23
Xenon - Xe 54
Ytterbium - Yb 70
Yttrium - Y 39
Zinc - Zn 30
Zirconium - Zr 40

XR-100T Background Reduction Using Rise-Time Discrimination (RTD)

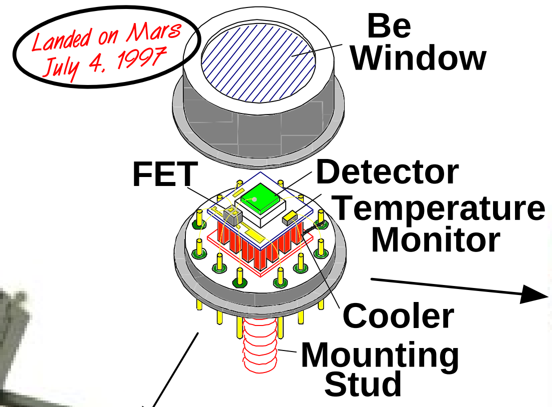


AMP TEK®

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

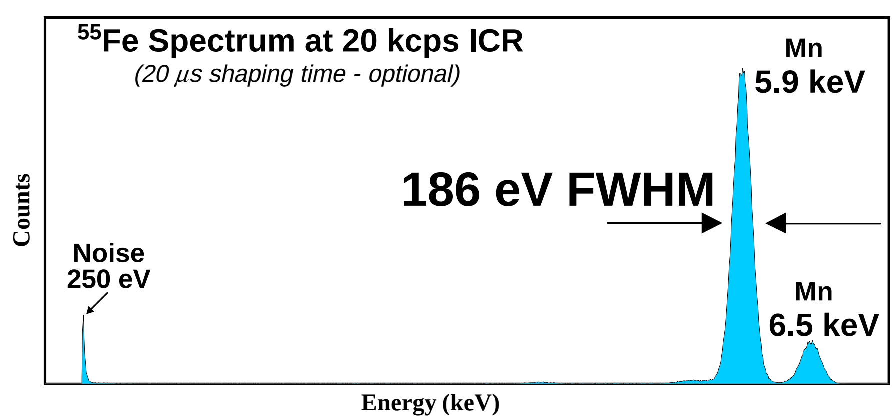
APPLICATIONS

- 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).



AMPTEK INC. 6 DE ANGELO DRIVE, BEDFORD, MA 01730-2204 U.S.A.

Tel: +1 (781) 275-2242 ***Fax:*** +1 (781) 275-3470 ***email:*** sales@amptek.com http://www.amptek.com

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*.

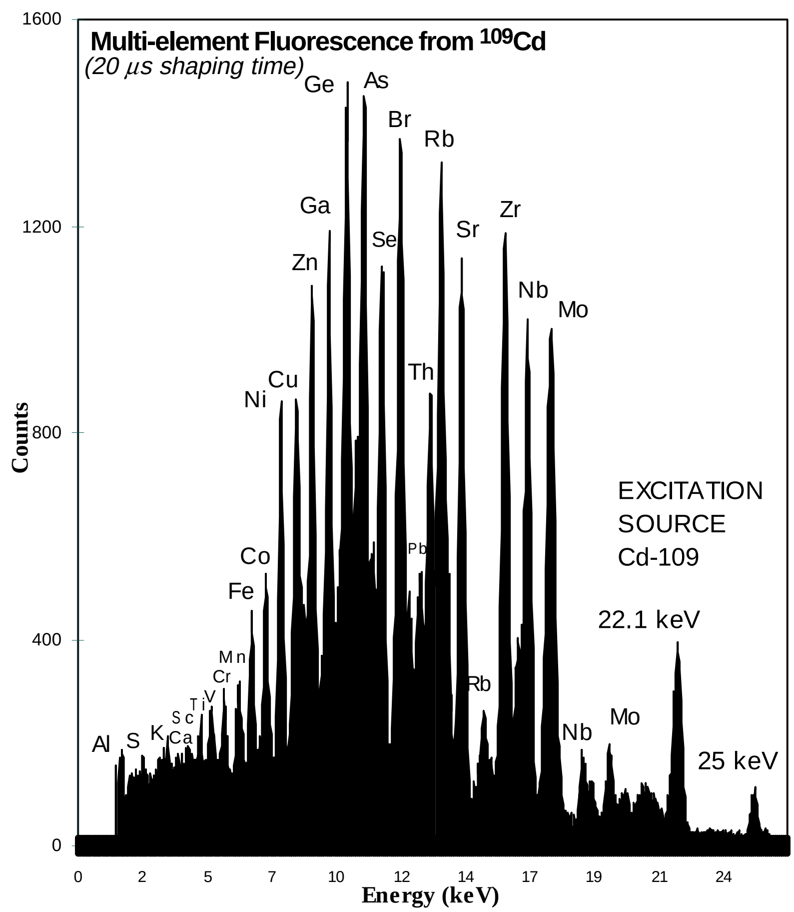


Figure 1. Sample Spectrum

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.

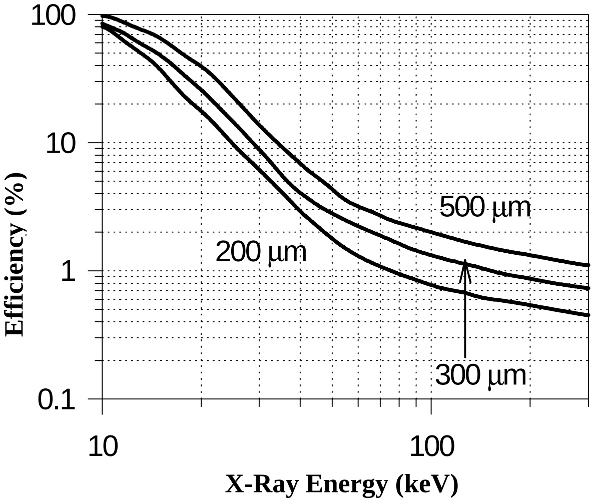


Figure 2. X-Ray Transmission through Be Windows

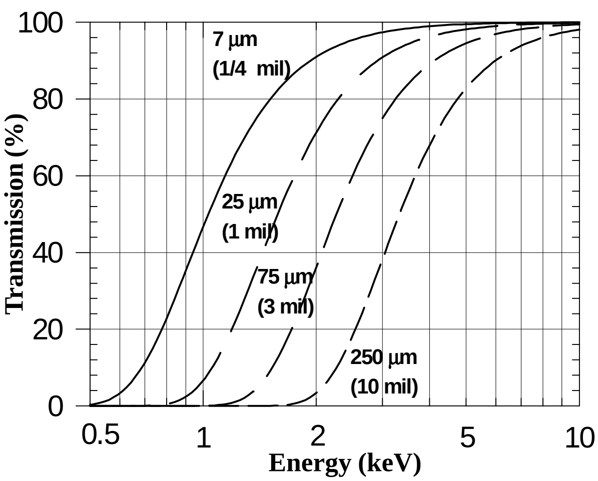


Figure 3. Detection Efficiency of Silicon Detectors

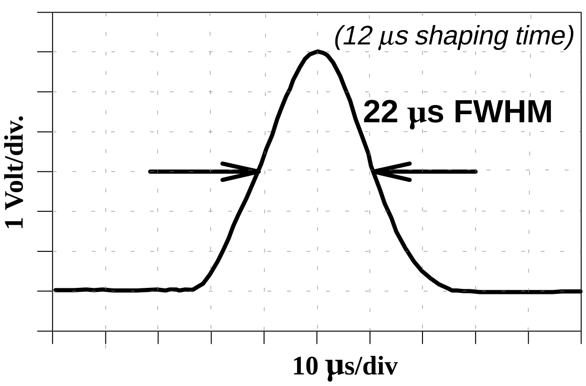


Figure 4. PX2CR Amplifier Output

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

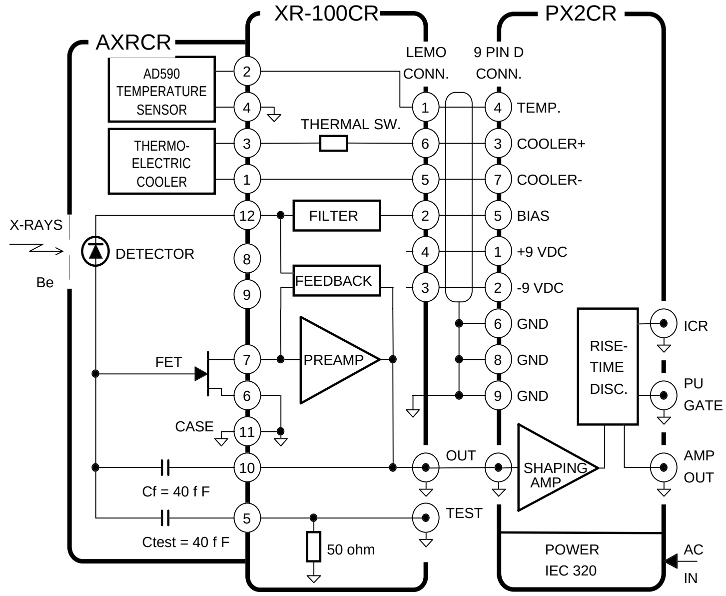


Figure 5. XR-100CR Connection Diagram

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

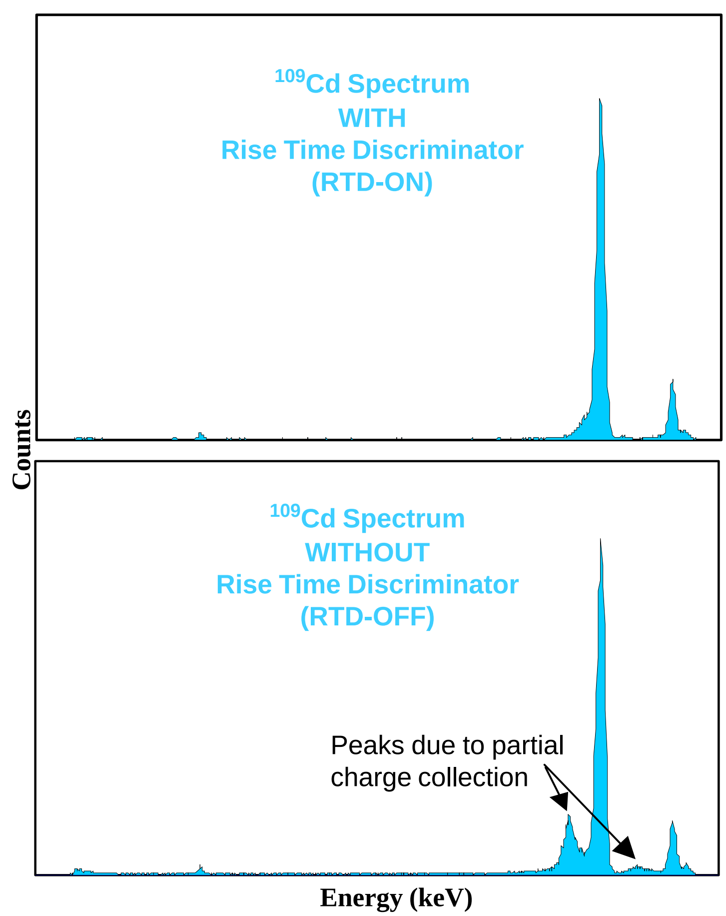


Figure 6. Comparison of ^{109}Cd Spectra WITH and WITHOUT Rise Time Discriminator (RTD)

APPLICATIONS

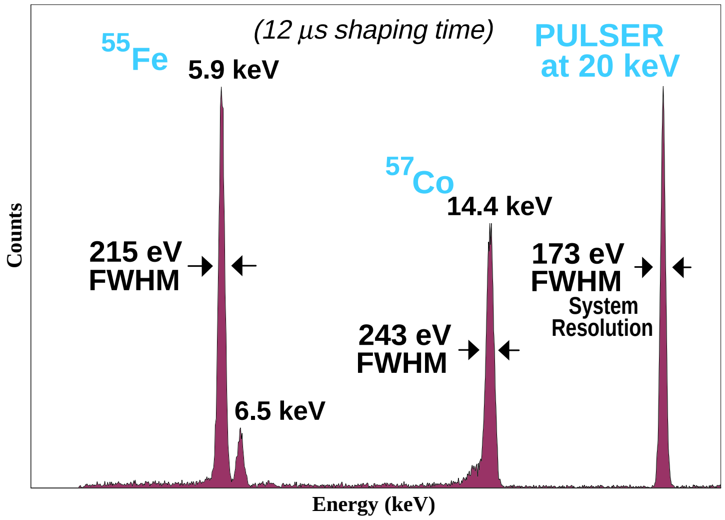


Figure 7. ^{55}Fe, ^{57}Co and Test Pulser Spectra

Figure 8. XR-100CR for Vacuum Use

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

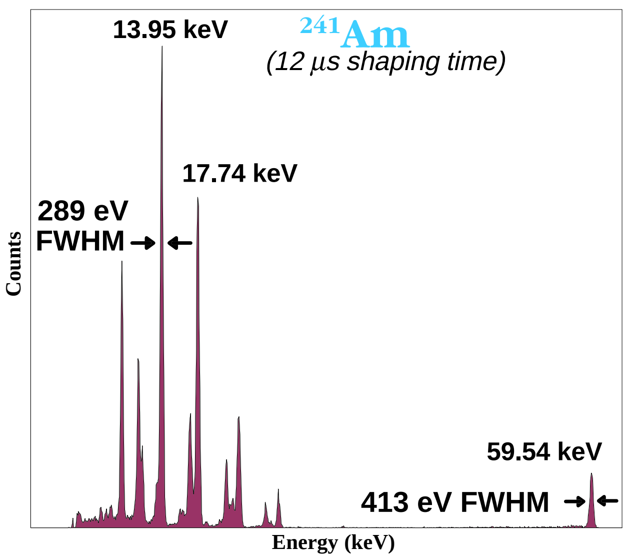


Figure 9. ^{241}Am Spectrum

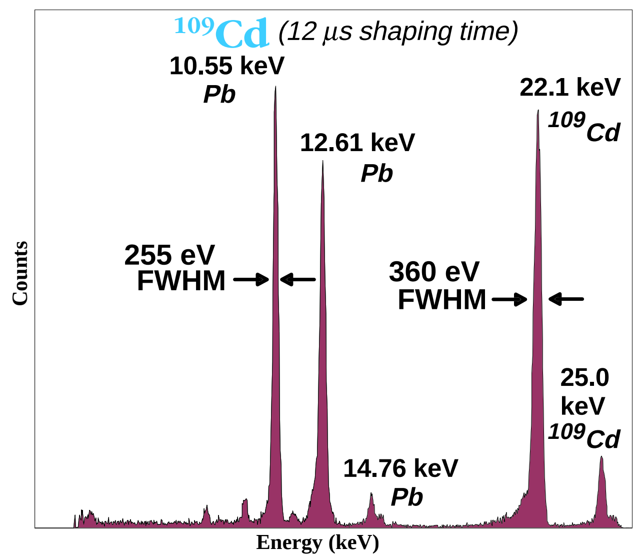


Figure 10. Lead (Pb) Fluorescence from ^{109}Cd

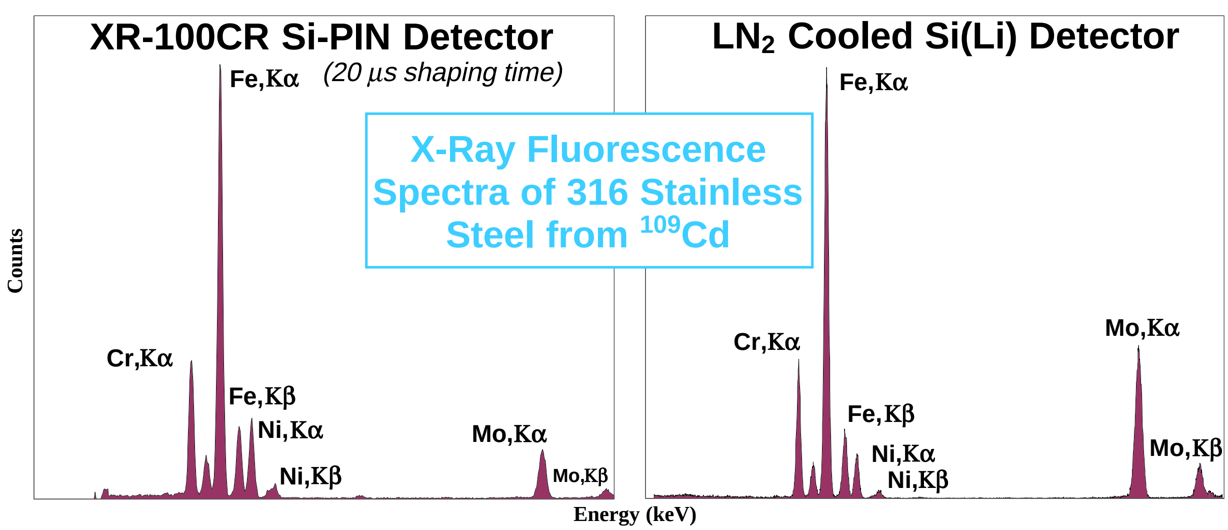


Figure 11. Amptek XR-100CR Si-PIN Detector Compared with Si(Li) Detector

XR-100CR X-RAY DETECTOR

Figure 12. XR100CR, MCA8000A, and Laptop Computer

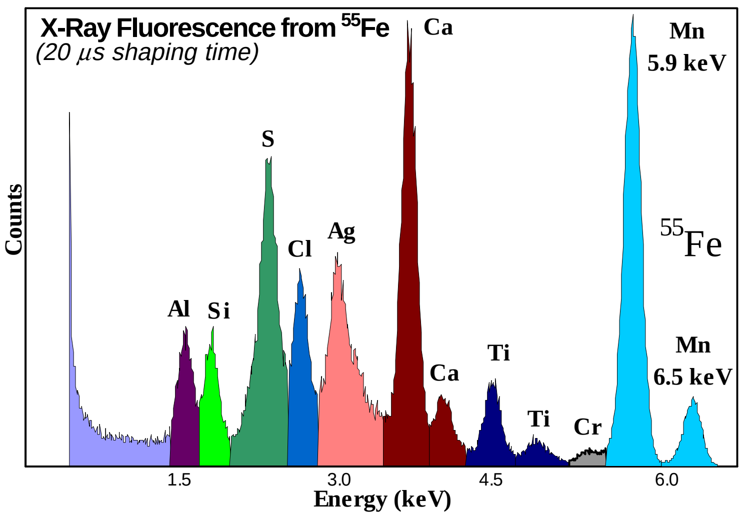


Figure 13. Sample Spectrum

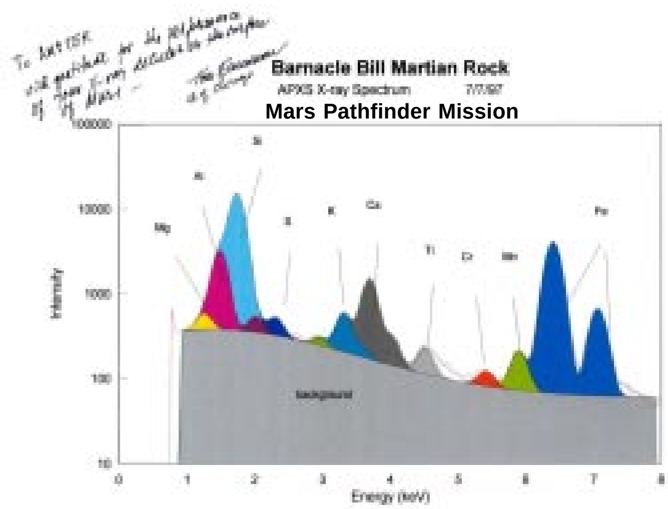


Figure 14. First X-Ray Spectrum from Mars Using XR-100T Detector, Curtesy of the University of Chicago

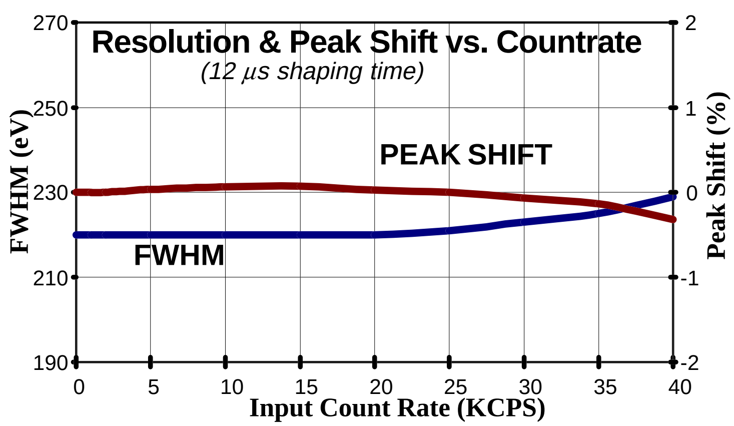


Figure 15. Resolution and Peak Shift vs. Countrate for ^{55}Fe, 5.9 keV, 12 µs Shaping

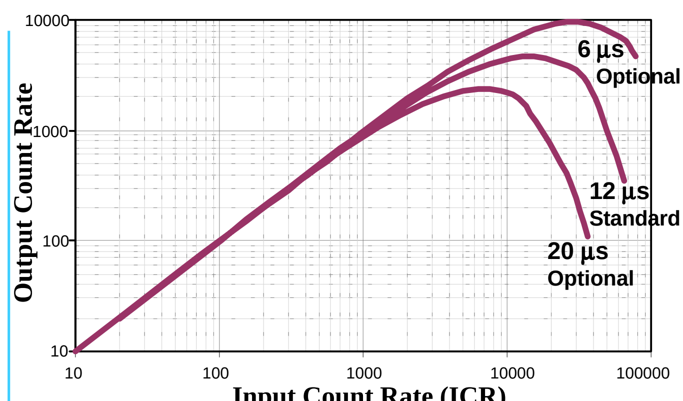


Figure 16. Output vs. Input Rate for Different Shaping Time Constants

AMP TEK ®

AMPTEK INC. 6 DE ANGELO DRIVE, BEDFORD, MA 01730-2204 U.S.A.

Tel: +1 (781) 275-2242 ***Fax:*** +1 (781) 275-3470 ***email:*** sales@amptek.com http://www.amptek.com