DAQ of UITF 200 keV Mott Polarimeter

New 200 keV Mott DAQ

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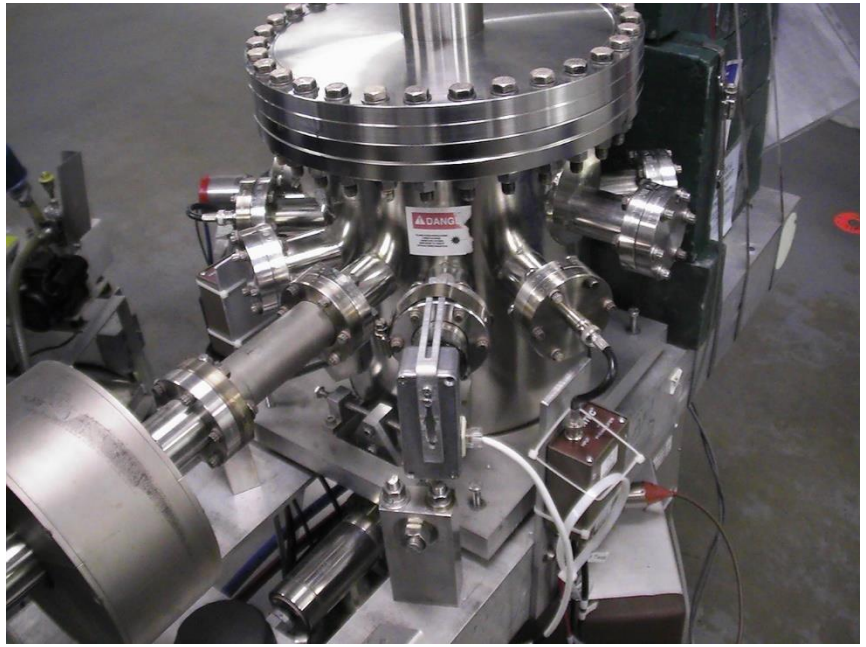
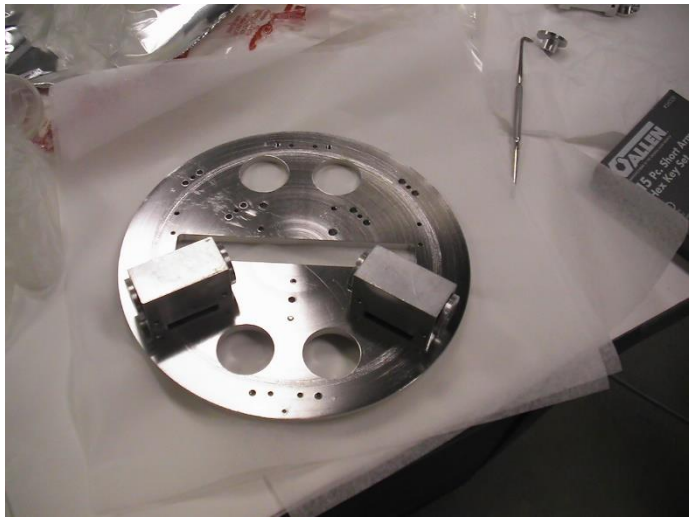
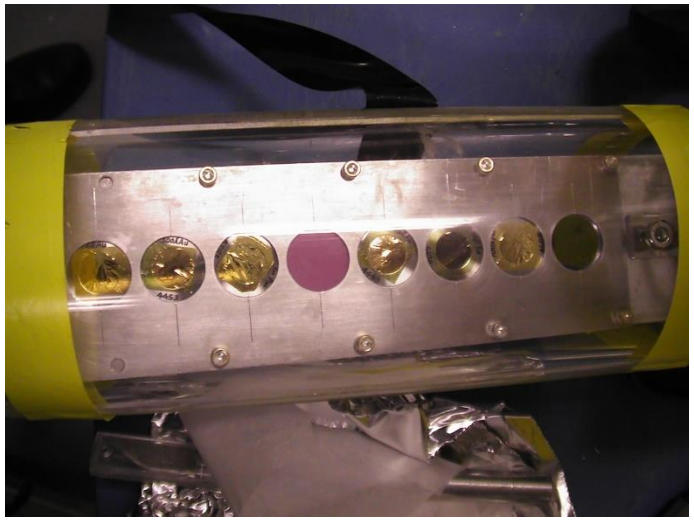
Saturday, September 26, 2020

Vacuum Chamber







Measuring Mott Asymmetry

- How to measure the Mott Asymmetry *A*?
  - For one helicity state, measure the left and right detector counting rate, $N_L^{\uparrow}$ and $N_R^{\uparrow}$
  - Flip the electron polarization, measure the counting rate again, $N_L^{\downarrow}$ and $N_R^{\downarrow}$
  - Calculate the *cross-ratio* (r),

$$r = \sqrt{\frac{N_L^{\uparrow} N_R^{\downarrow}}{N_L^{\downarrow} N_R^{\uparrow}}}$$

  - Then, the Mott Asymmetry (*A*),

$$A = \frac{1 - r}{1 + r}$$

- This cancels false asymmetries from detector efficiency, beam current, target thickness, and solid angle

Measuring Instr. Asymmetry

- How to measure the Instrumental Asymmetry A_1?
  - For one helicity state, measure the left and right detector counting rate, $N_L^{\uparrow}$ and $N_R^{\uparrow}$
  - Flip the electron polarization, measure the counting rate again, $N_L^{\downarrow}$ and $N_R^{\downarrow}$
  - Calculate the *cross-ratio* (x1),

$$x_1 = \sqrt{\frac{N_L^{\uparrow} N_L^{\downarrow}}{N_R^{\downarrow} N_R^{\uparrow}}}$$

  - Then, the Instrumental Asymmetry (*A1*),

$$A_1 = \frac{1 - x_1}{1 + x_1}$$

- This measures asymmetries from detector efficiency and solid angle but cancels beam current and target thickness

Measuring Instr. Asymmetry

- How to measure the Instrumental Asymmetry A_2?
  - For one helicity state, measure the left and right detector counting rate, $N_L^{\uparrow}$ and $N_R^{\uparrow}$
  - Flip the electron polarization, measure the counting rate again, $N_L^{\downarrow}$ and $N_R^{\downarrow}$
  - Calculate the *cross-ratio* (x2),

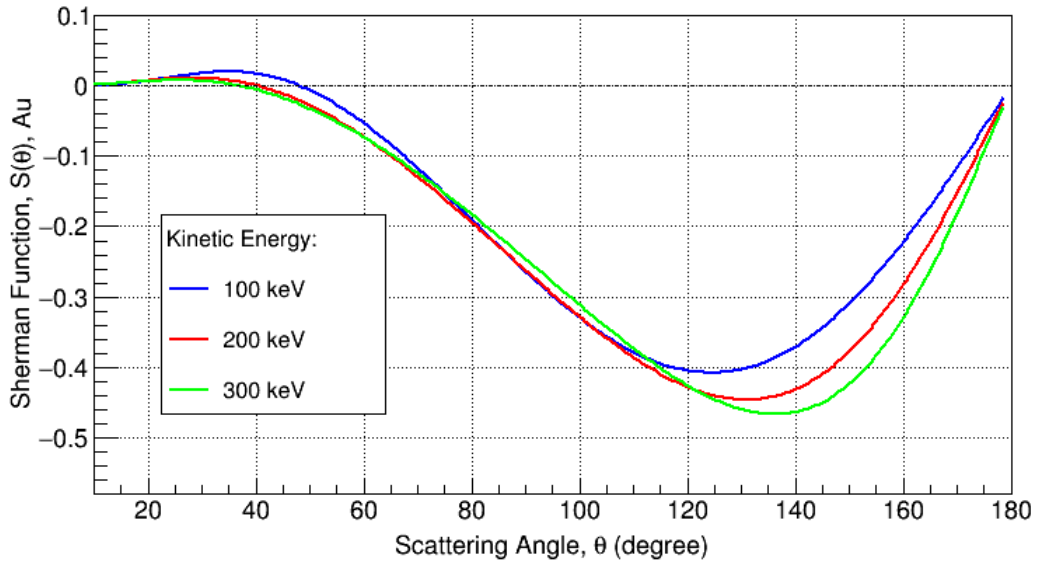
$$x_2 = \sqrt{\frac{N_L^{\uparrow} N_R^{\uparrow}}{N_L^{\downarrow} N_R^{\downarrow}}}$$

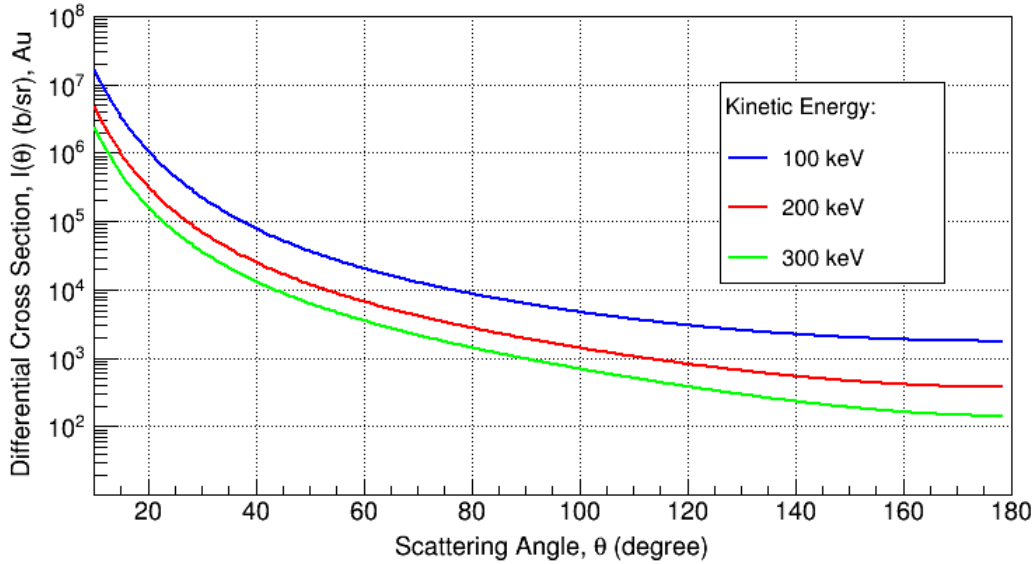
  - Then, the Instrumental Asymmetry (*A2*),

$$A_2 = \frac{1 - x_2}{1 + x_2}$$

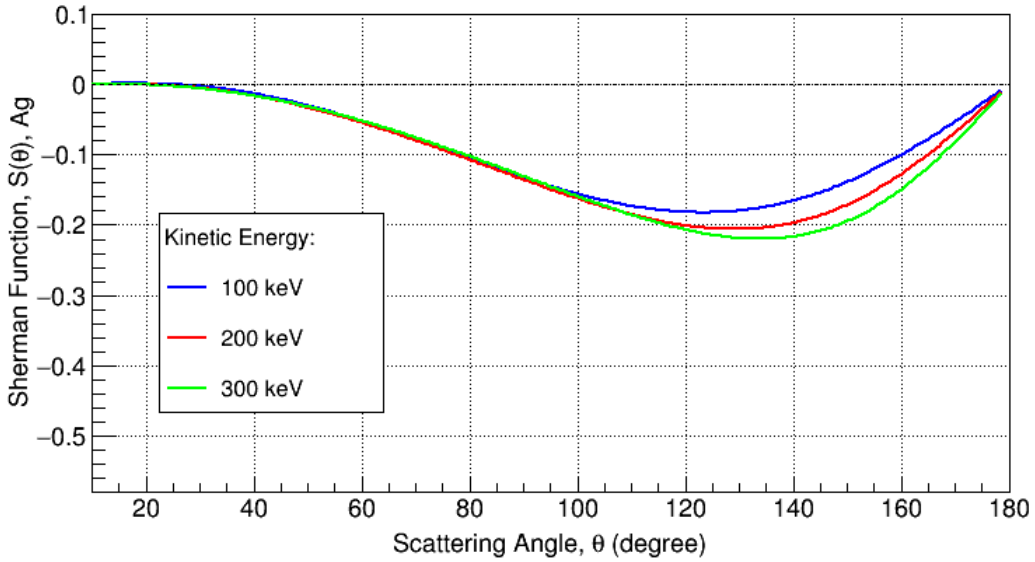
- This measures asymmetries from beam current and target thickness but cancels detector efficiency and solid angle

Sherman Function, Au

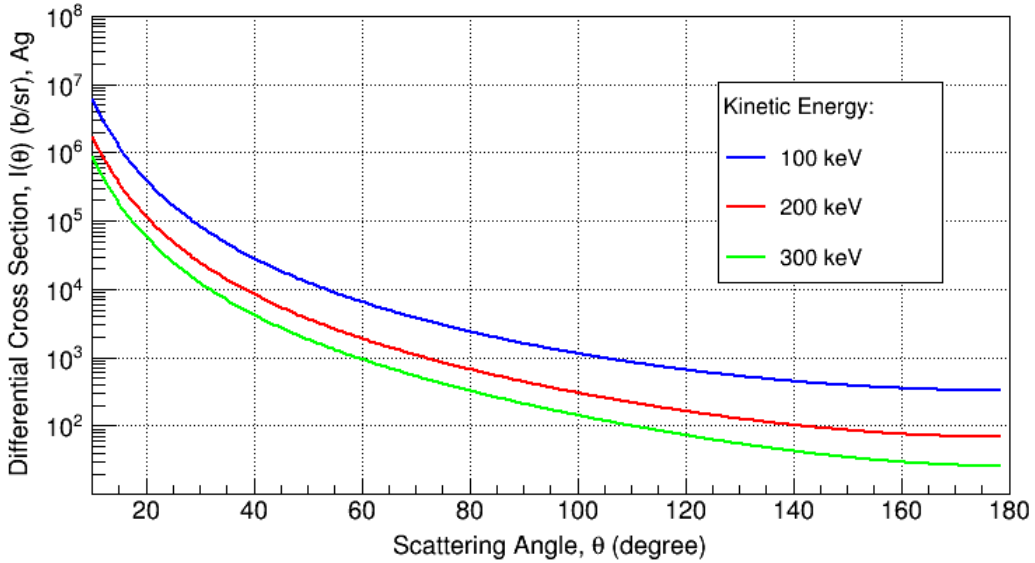




Sherman Function, Ag



200 keV	S(130˚)	DCS (b/sr)
Au	-0.446	659
Ag	-0.206	128

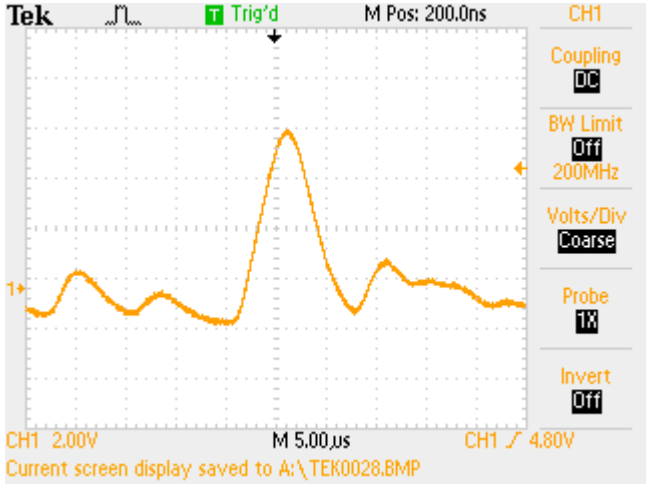


Detectors and Electronics

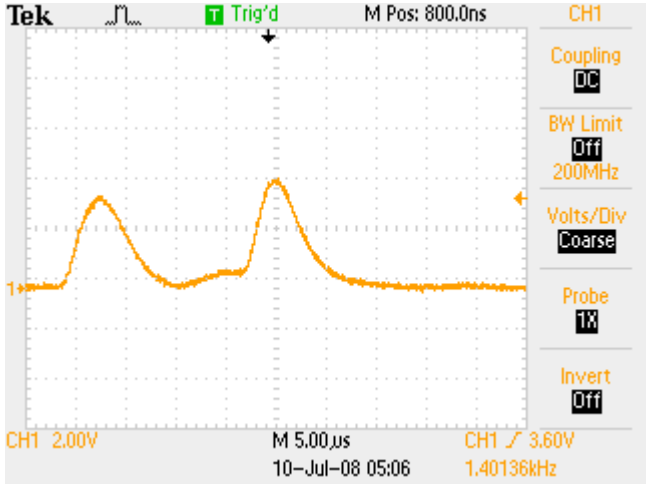
- (2) ORTEC ULTRA Detectors (BU-013-050-1000-S):
  - Ion-Implanted Silicon Charged Particles Detectors
  - Ultra-thin entrance window (500 A) for optimum energy resolution (13 keV FWHM)
  - B Mount
  - Detector size of 50 mm^2
  - Depletion Depth (Range) of 1000 um for both energies of 100 keV and 500 keV
  - Bias Voltage: +115 V

- (1) ORTEC 710 Quad High Voltage Bias Supply (1 - 1000 V)
- (2) ORTEC 142A Preamplifier (conversion gain 45 mV/MeV):
  - Energy output (connect to SCA)
  - Timing output (connect to fADC)

- (2) ORTEC Model 590A Amplifier and Timing Single-Channel Analyzer (SCA):
  - Coarse Gain: x200 for 100 keV electron, x50 for 500 keV electron
  - Fine Gain: around x2.0



Left Detector



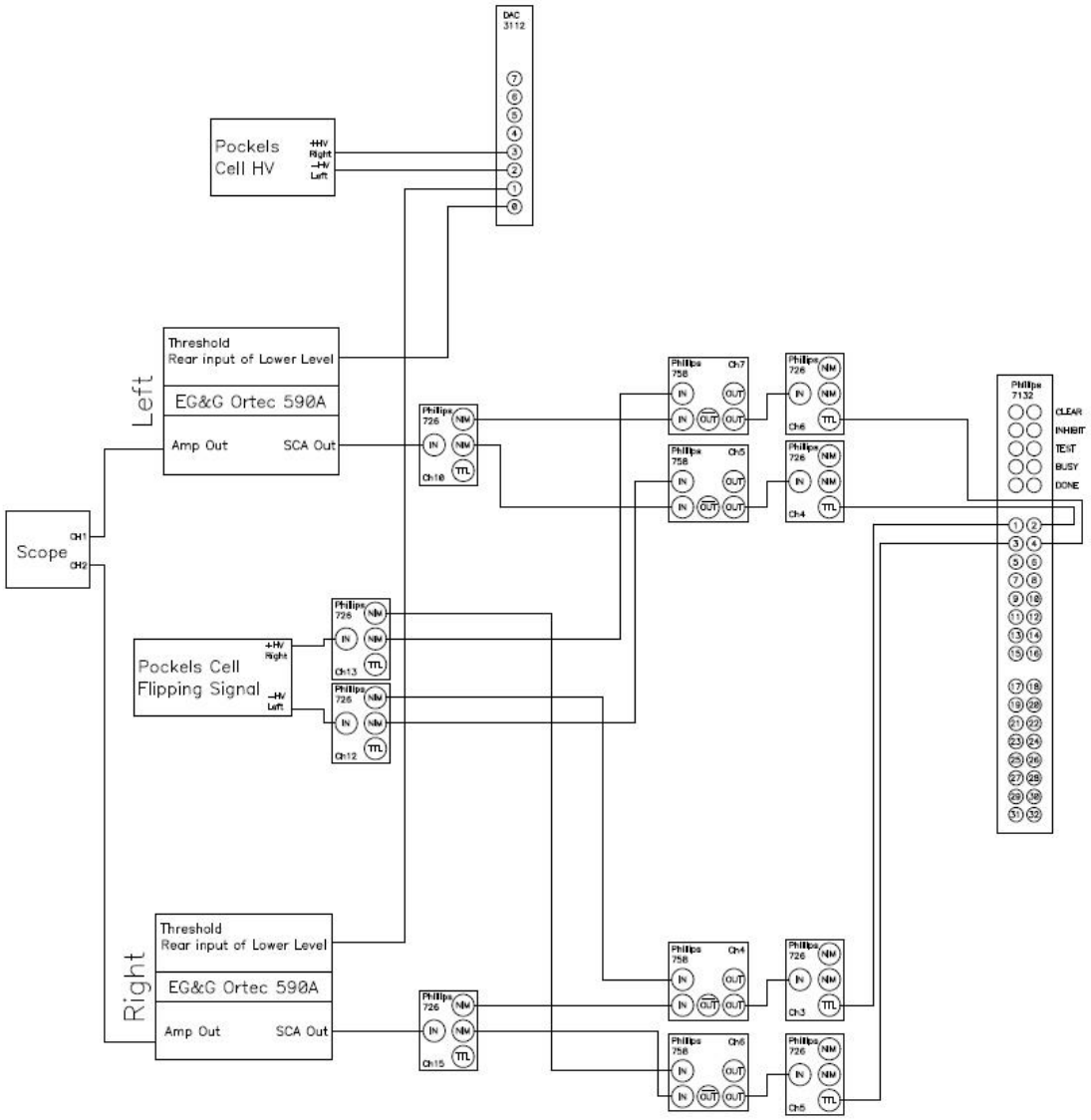
Right Detector

Note: the timing output is 50 ns wide signals with 5 ns rise time (picture pending)

Left Preamp T Output

Right Preamp T Output

The “old” 100 keV DAQ

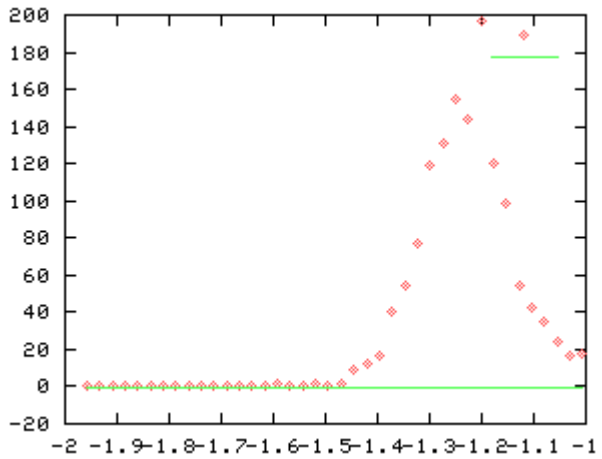


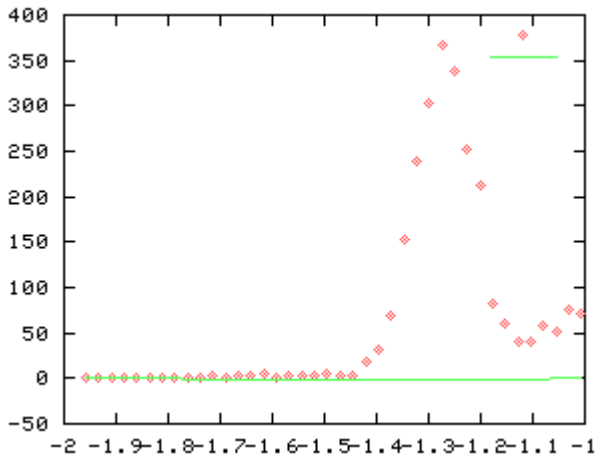
Single-Channel Analyzer (SCA)

- SCA Out:
  - Standard NIM of +5 V, 500 ns wide if the amplified signal passes the threshold of the Lower Level discriminator
  - Connect to Scaler

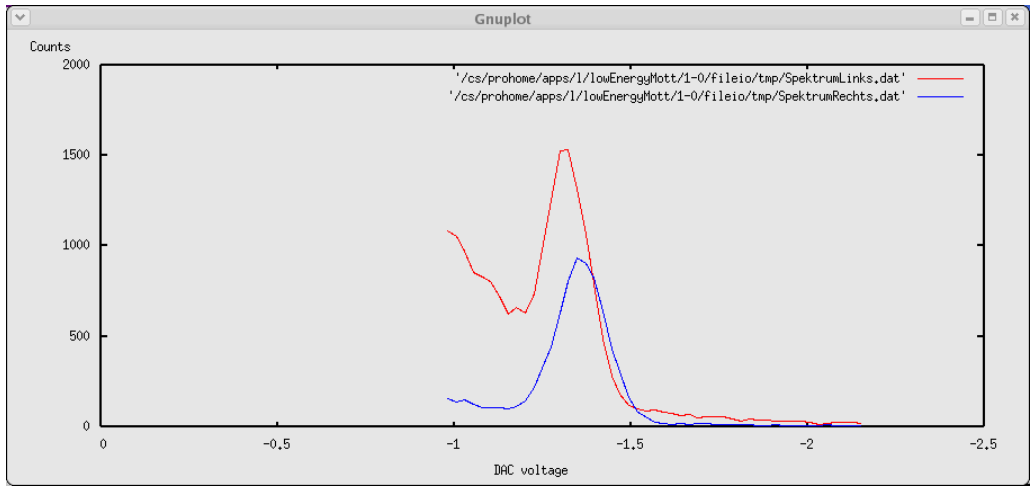
- Amp Out:
  - Energy output (Amplified: x5 to x1250)
  - Connect to fADC

100 keV, ITS Cave

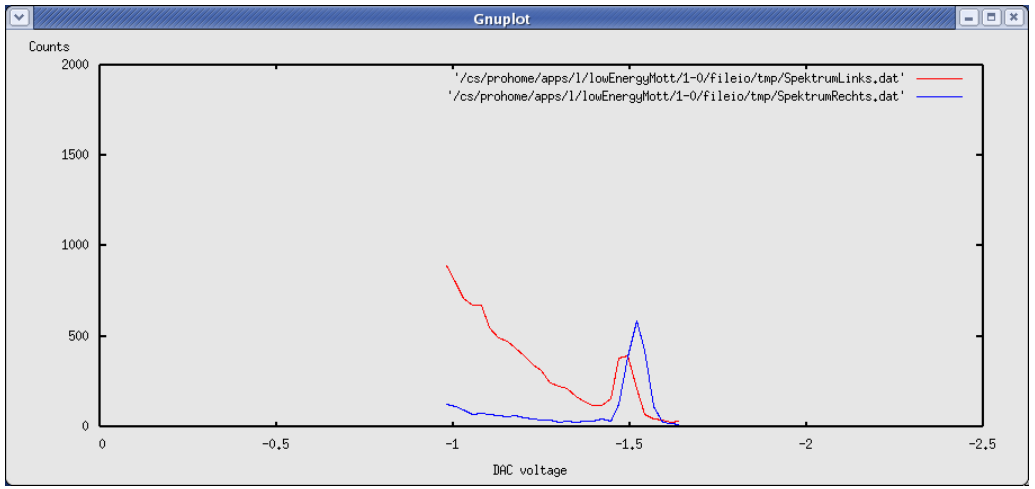




100 keV, CEBAF Tunnel



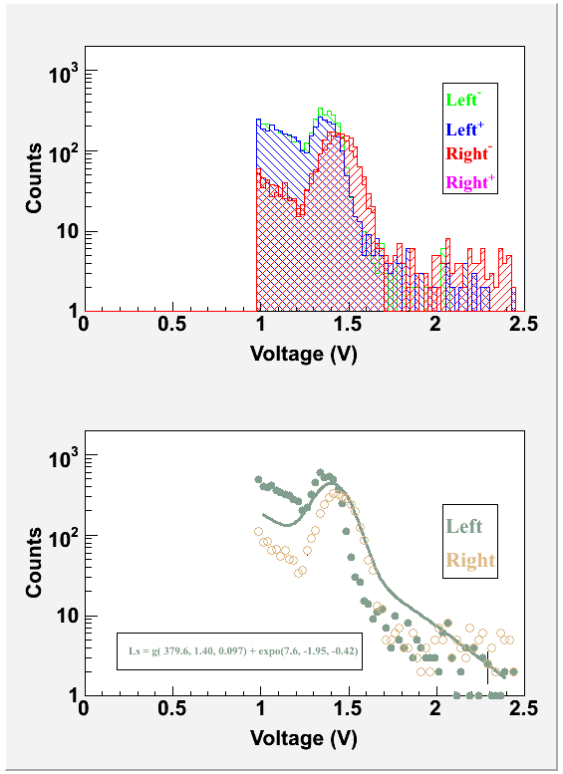
500 keV, CEBAF Tunnel

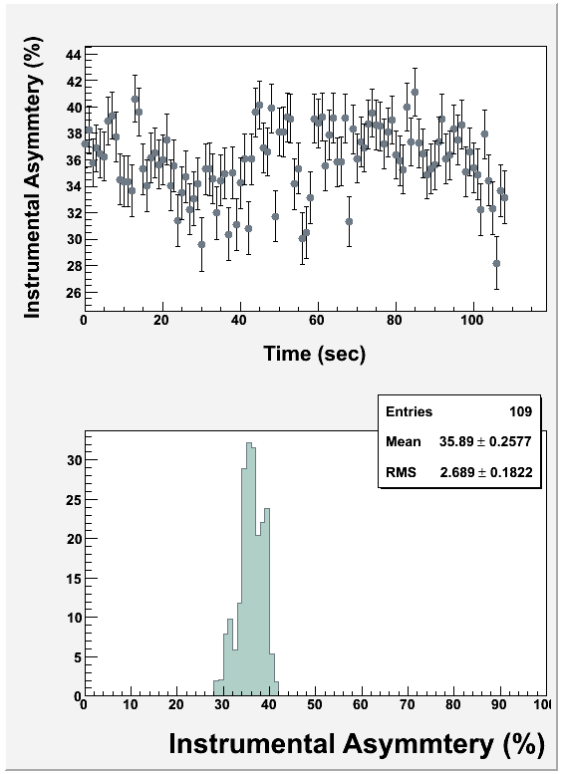


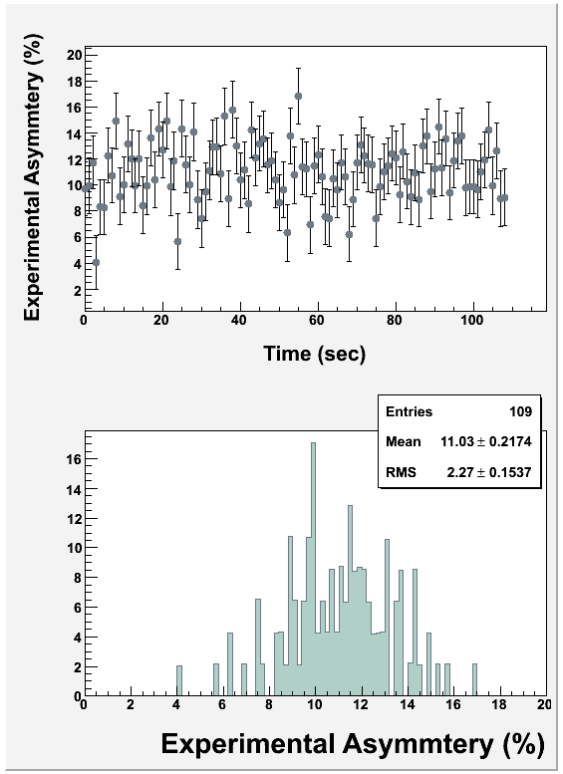
Asymmetry Data (100 keV, 300n A)

- ✓ Detectors HV +115 V
- ✓ Coarse Gain = 500, Fine Gain = 1.5
- ✓ Lower Level threshold = 1.25 V
- ✓ Window Width = 0.1 V for spectra data, = 0.5 for asymmetry data
- ✓ MFB0D01A = -964 G-cm, MFB0D01B = 1013 G-cm

P = 31.3 % (Bulk GaAs)



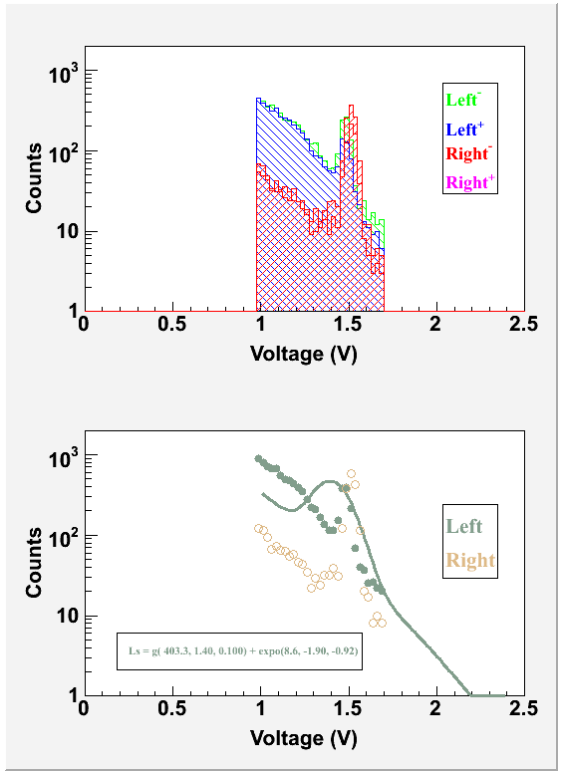


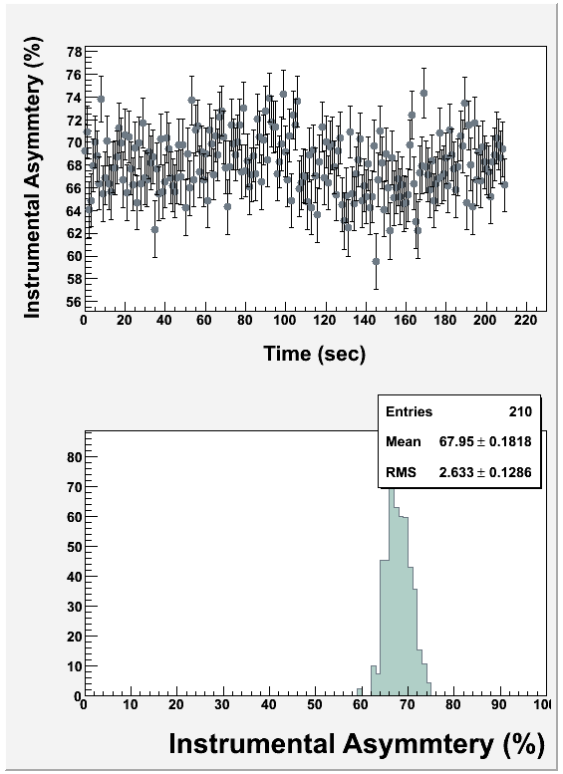


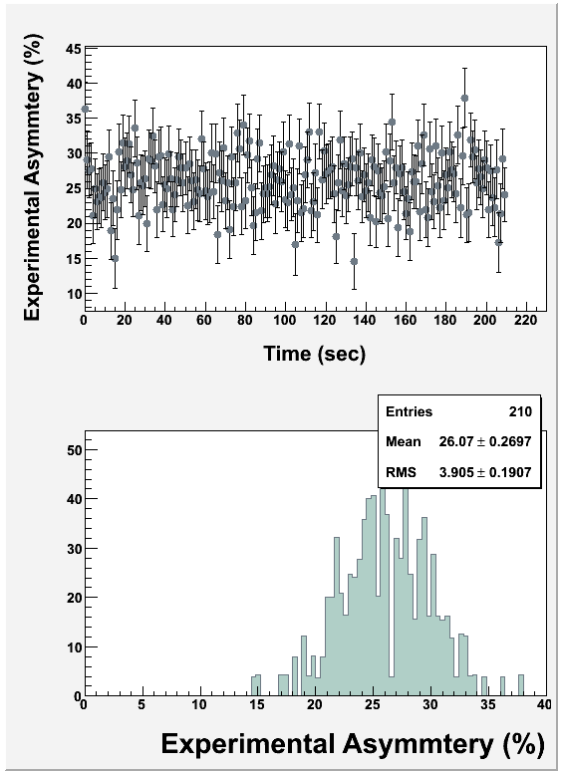
Asymmetry Data (500 keV, 300n A)

- ✓ Detectors HV +115 V
- ✓ Coarse Gain = 100, Fine Gain = 1.5
- ✓ Lower Level threshold = 1.4 V
- ✓ Window Width = 0.1 V for spectra data, = 0.3 for asymmetry data
- ✓ MFB0D01A = -2369 G-cm, MFB0D01B = 2369 G-cm

P = 67.7 % (Super Lattice GaAs)







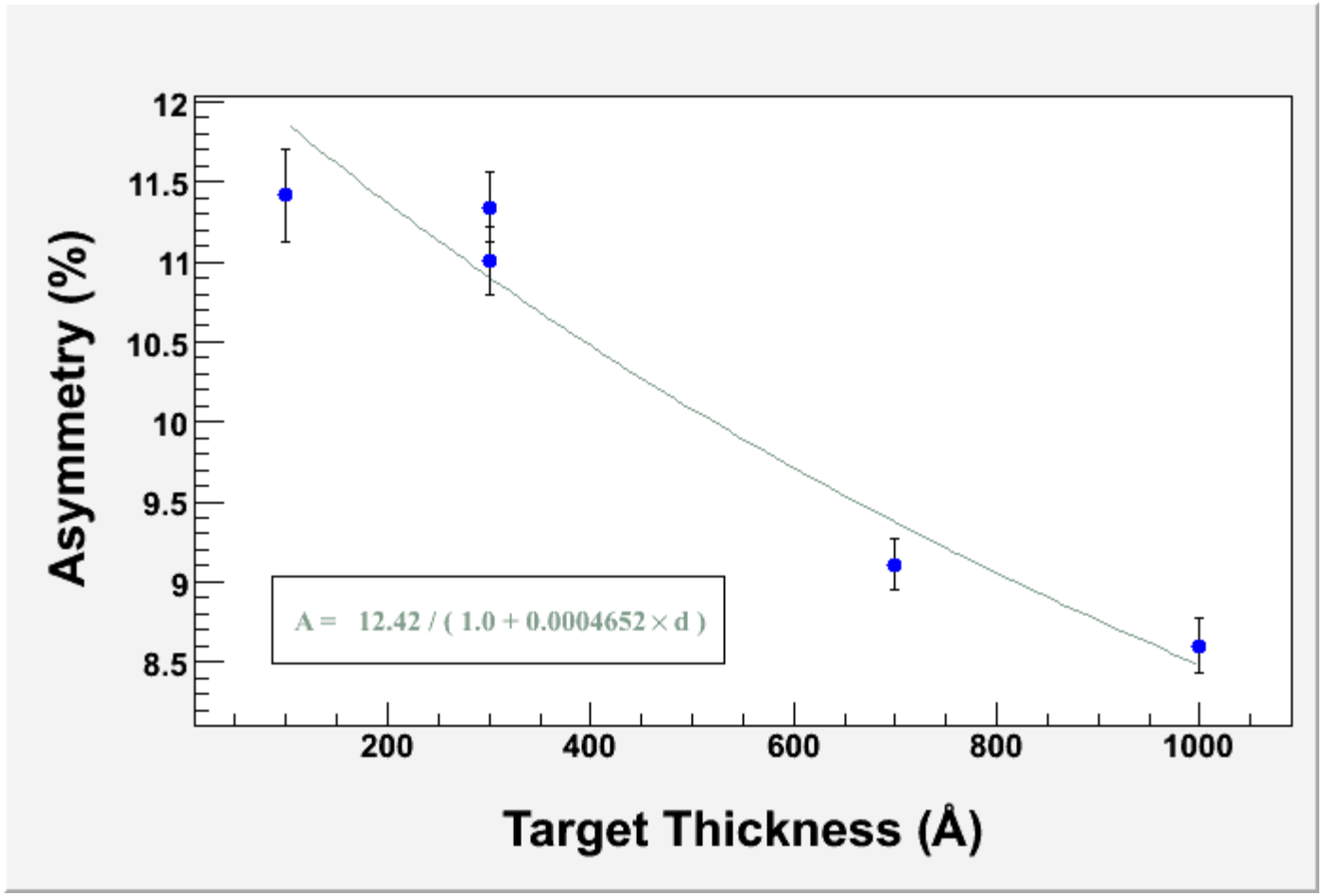
Target Thickness Extrapolation

- Single-Atom Sherman Function must be corrected for plural scattering (a few large angle scattering) in the target:

$$S_{eff}(130^\circ, d) = \frac{S_{SA}(130^\circ)}{1 + \alpha(130^\circ) \cdot d}$$

- alpha = 0.0005/A for 100 keV electrons and 0.0001/A for 500 keV electrons
- If possible, run with the thinnest target

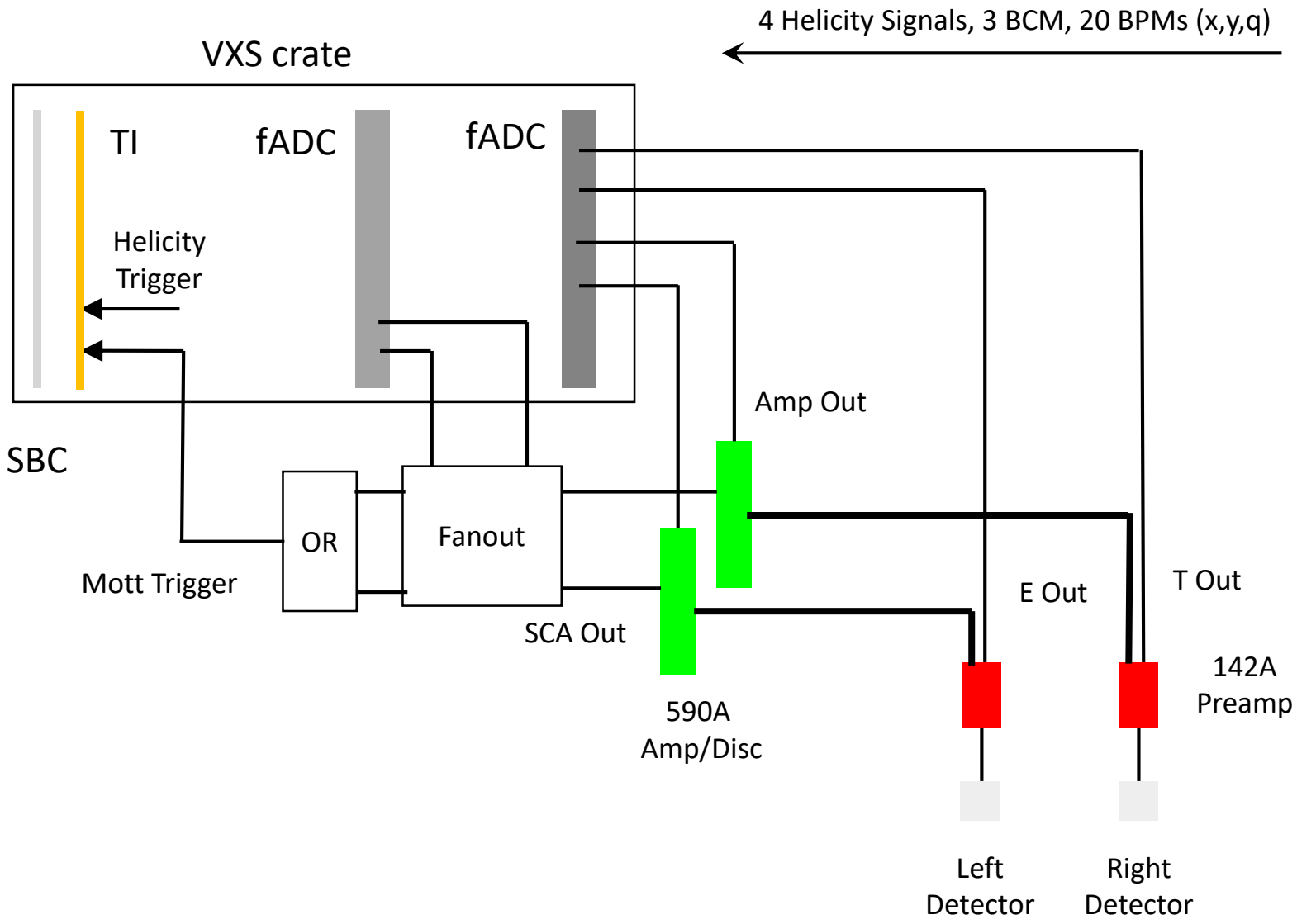
Target Thickness Scan at 100 keV



New DAQ for Mott Polarimeter

- Measure Mott asymmetry (event counting)
- Measure Charge asymmetry (per helicity)
- Measure position differences (per helicity)
- DAQ Triggers:
  - Mott Detector
  - Helicity
- DAQ Hardware:
  - VXS crate
  - XVR-16 from Abaco Single Board Computer (SBC)
  - Jefferson Lab Flash Analog-to-Digital Convertor (fADC250) (quantity = 2)
  - Trigger Interface (TI)
  - Front Panel Signal Distribution module
  - Desktop

DAQ Schematic Diagram



Signals to DAQ

- Signals to fADC:
  - (2) Amp Out
  - (2) SCA Out
  - (4) Helicity Signals
  - (2) Timing output from preamplifier

- Signals to Scaler (helicity-gated):
  - (3) BCM
  - (60) 20 BPMs (x,y,q)

- Signals to

Target and Rates

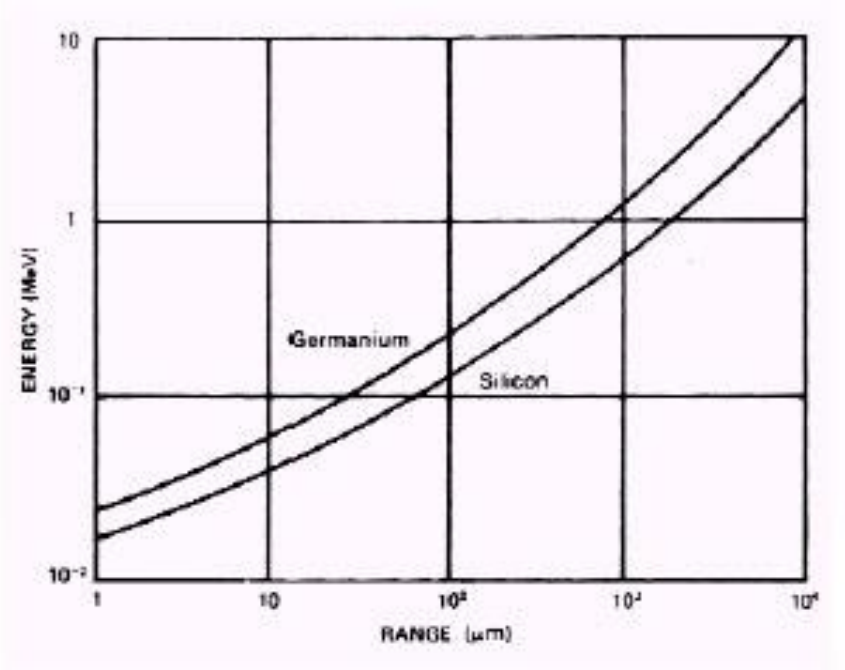
- Wien Vertical at 90˚
- Gold Targets (Z=79): 100, 300, 500 A
- Silver Targets (Z=47): 300, 500, 2000 A
- Solid angle of 0.11 msr (hole diameter of 0.02” at 1.6875”)
- Backward scattering angle of 130 degrees:

	200 keV
Au Target (A)	100
Current (nA)	50
Rate per detector(Hz)	1200
Time (s)	300

- We have a Viewer and a thru hole

Detectors

- 2 ORTEC ULTRA Detectors (BU-013-050-1000-S):
  - Ion-Implanted Silicon Charged Particles Detectors
  - Ultra-thin entrance window (500 A)
  - B Mount
  - Detector size of 50 mm^2
  - Depletion Depth (Range) of 1000 um for both energies: 100 keV & 500 keV



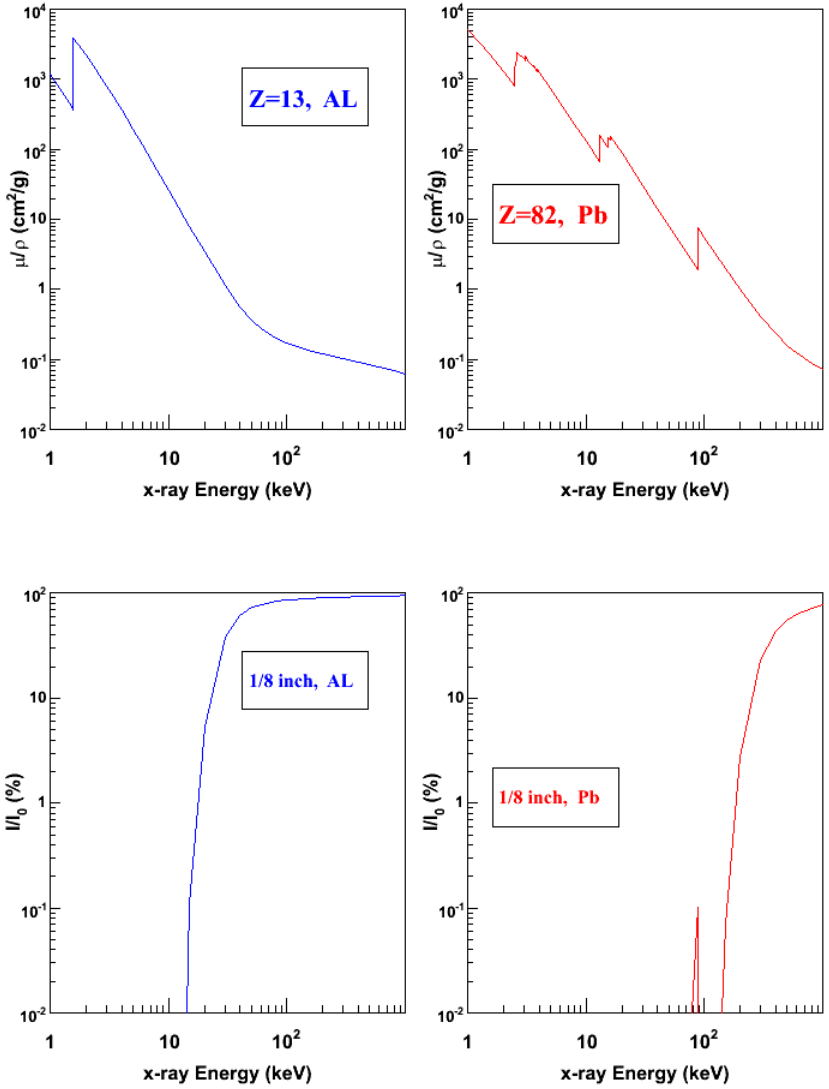
Zero Transmission Rage vs. Energy for Electrons in Silicon

Collimators

Electron Energy	Al Range (g/cm^2)	Al Range (mm)
100 keV	0.0075	0.03
500 keV	0.095	0.35

- ***Electron Shielding***: The front collimator is 1 mm thick Al. Do not change the Al Collimator.

- ***x-ray Shielding***: Add 1/8 inch lead jacket around the Al Collimator.



Cables, …

- (2) Bias cable, SHV connector, 0 - +/- 1000 V, male connectors.
- (2) E 142A preamp 93-ohm cable, RG62A/U BNC, male connectors.
- (2) T 142A preamp 50-ohm cable, RG58A/U BNC, male connectors.
- (2) Test 142A preamp 50-ohm cable, RG58A/U BNC, male connectors.
- (2) 142A preamp power cable, 9-pin D connectors (amphenol 17-10090), female in tunnel, male in ISB.