DAQ of UITF 200 keV Mott Polarimeter

New 200 keV Mott DAQ

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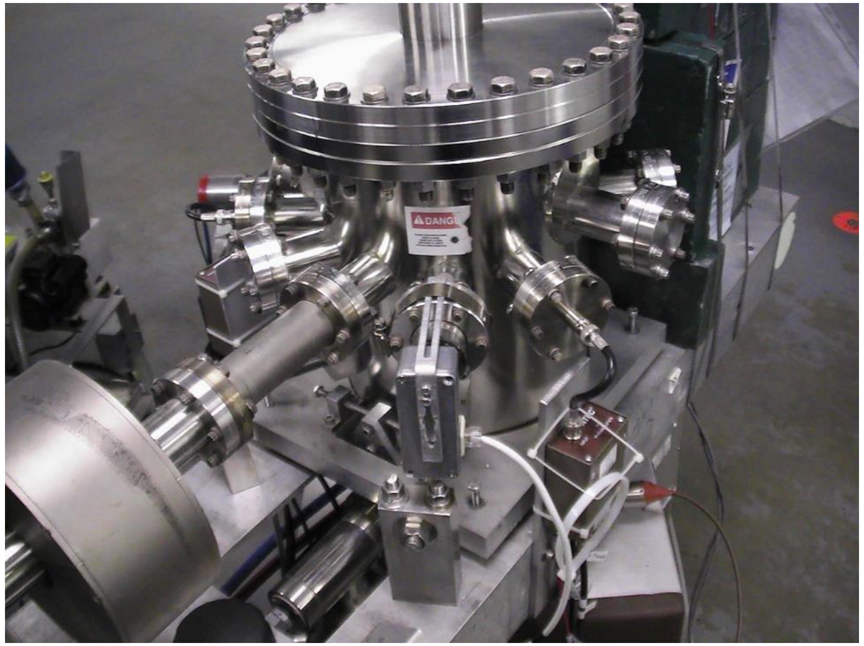
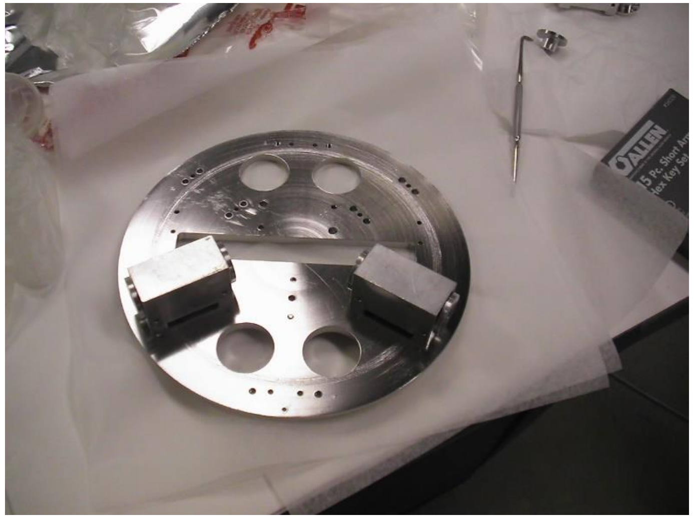
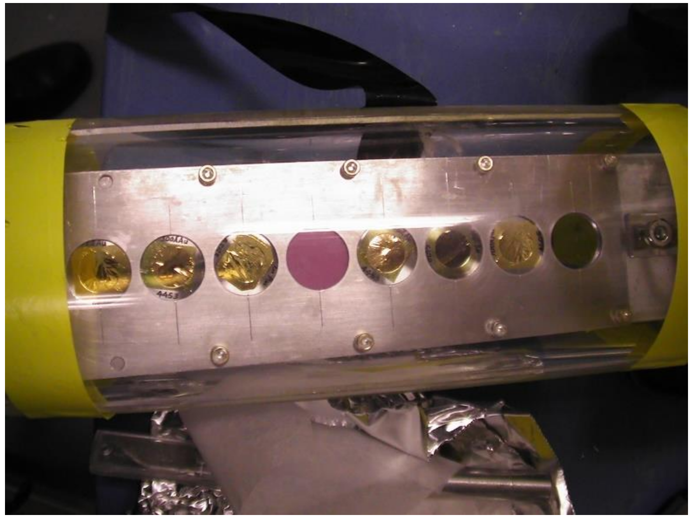
Tuesday, September 29, 2020

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),

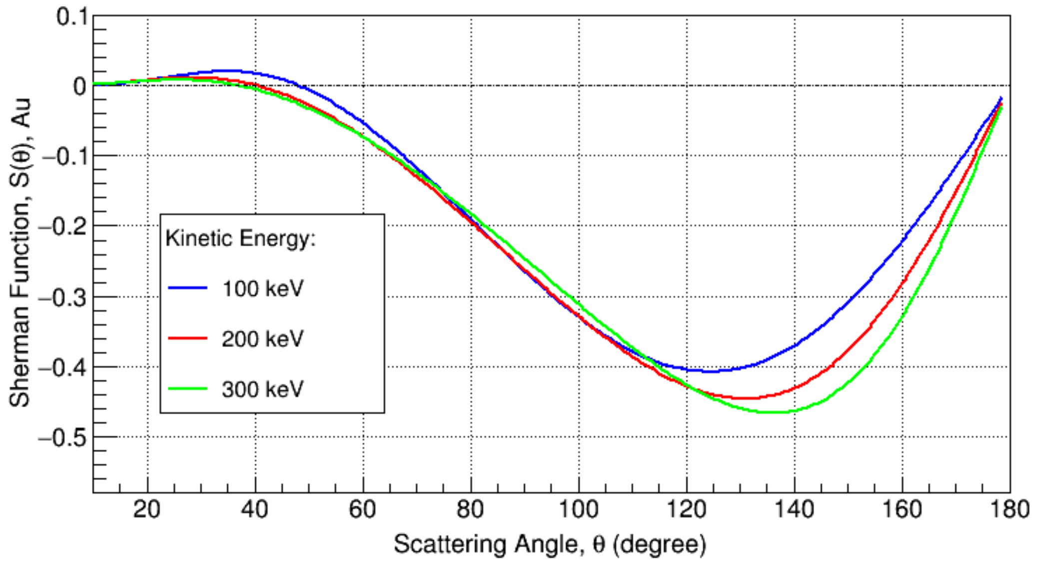
$$x_2 = \sqrt{\frac{N_L^{\uparrow} N_R^{\uparrow}}{N_L^{\downarrow} N_R^{\downarrow}}}$$

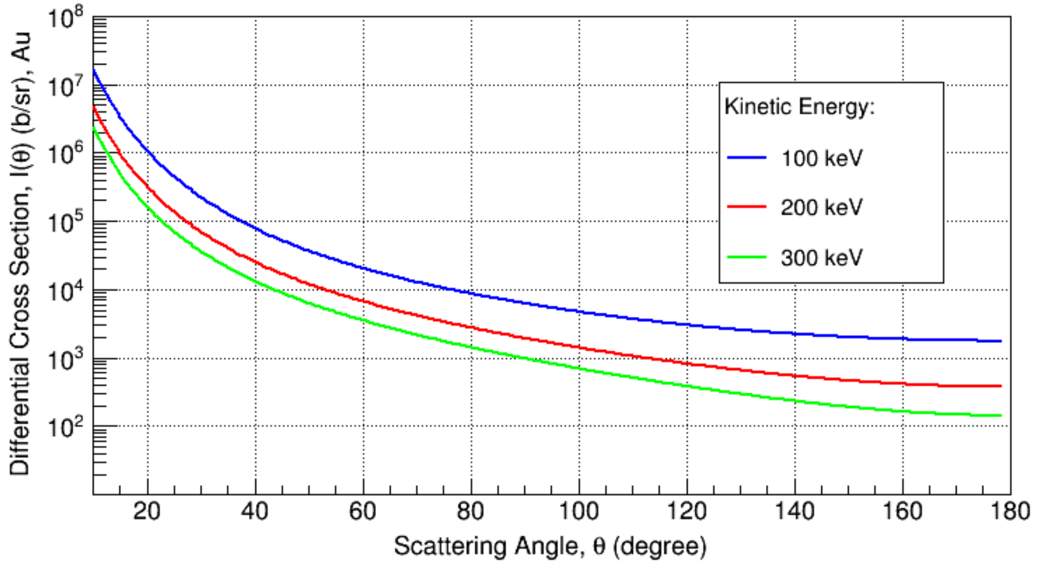
  - Then, the Instrumental Asymmetry (*A2*),

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

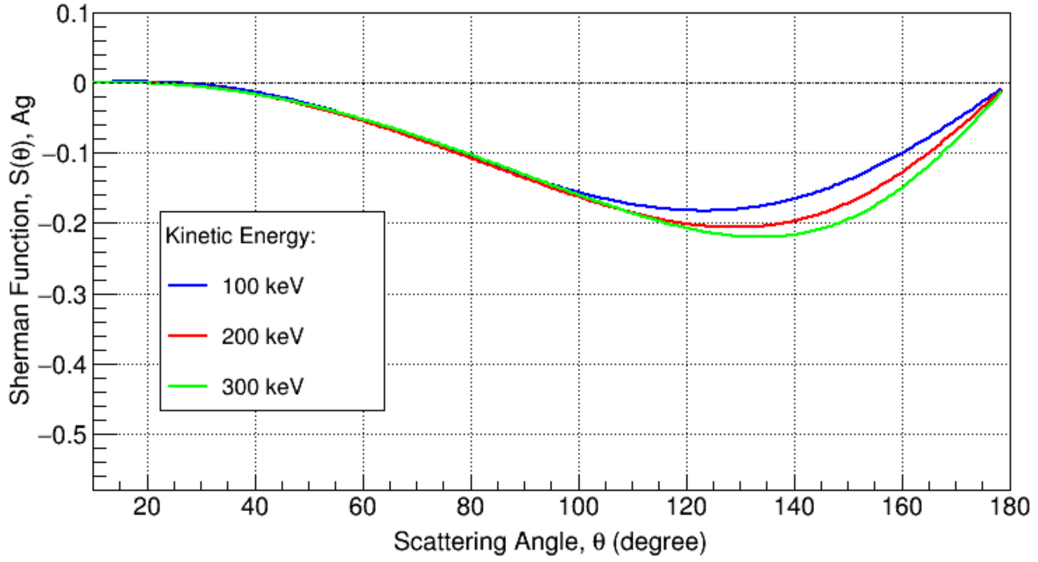
- This measures asymmetries from beam current and target thickness but cancels detector efficiency and solid angle

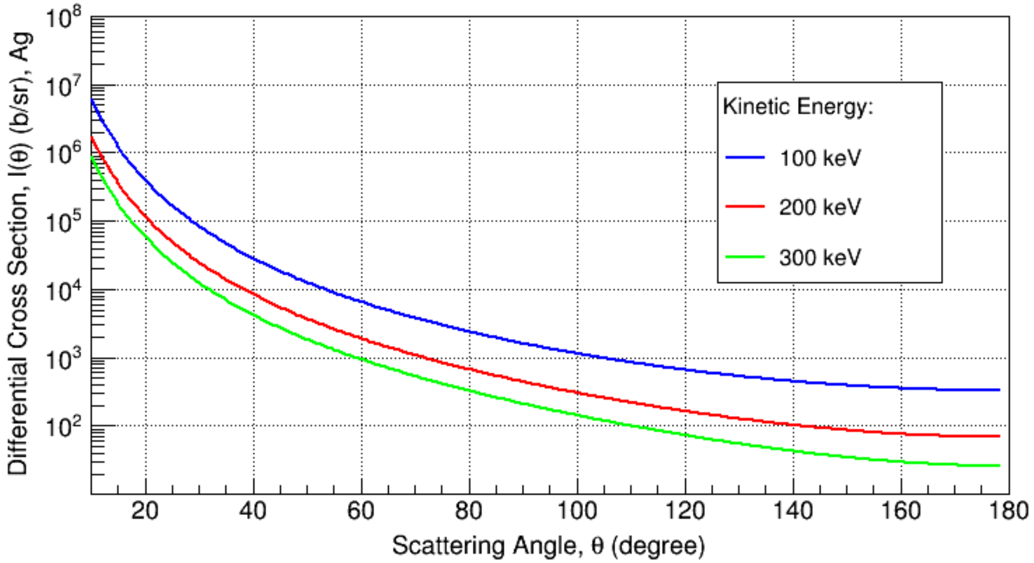
Sherman Function and Differential Cross Section, Au





Sherman Function and Differential Cross Section, Ag



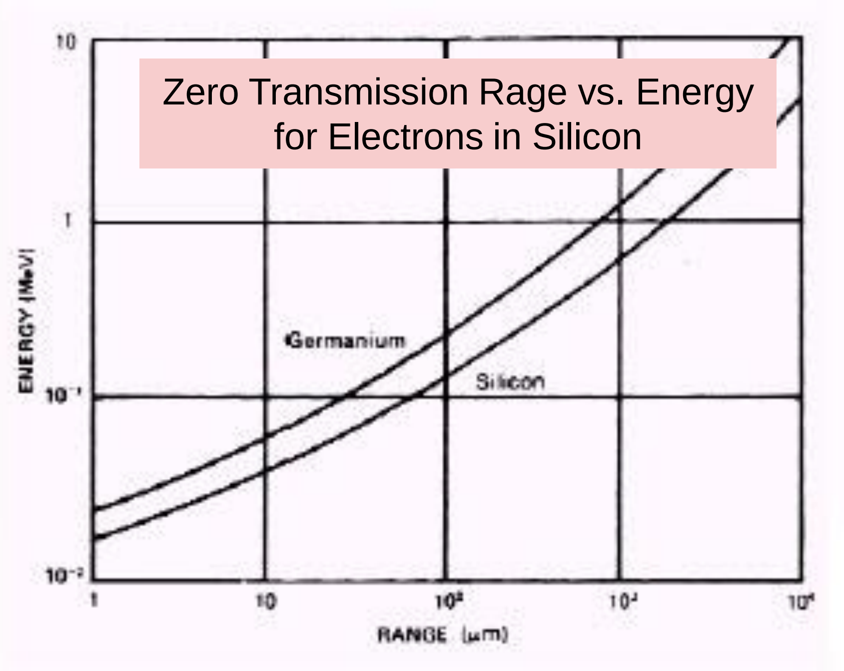


200 keV	S(130˚)	DCS (b/sr)
Au	-0.446	659
Ag	-0.206	128

ORTEC Detectors

- (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 (FWHM, α =13 keV, $\beta = 7$ keV)
  - B Mount
  - Detector size of 50 mm^2
  - Depletion Depth (Range) of 1000 um for energies $\leq$ 500 keV
  - Bias Voltage: +115 V

- (2) ORTEC ULTRA Detectors (BU-012-050-100):
  - Ion-Implanted Silicon Charged Particles Detectors
  - Ultra-thin entrance window (500 A) for optimum energy resolution (FWHM, α =12 keV , $\beta = 6$ keV)
  - B Mount
  - Detector size of 50 mm^2
  - Depletion Depth (Range) of 100 um for energies $<$ 200 keV
  - Bias Voltage: +50 V



ORTEC Electronics

- (1) ORTEC 710 Quad High Voltage Bias Supply (1 - 1000 V)
- (2) ORTEC 142A Preamplifier for detector input capacitance 0 to 100 pF (conversion gain 45 mV/MeV)
- (2) ORTEC 142B Preamplifier for detector input capacitance 100 to 400 pF (conversion gain 20 mV/MeV)
- (2) ORTEC Model 590A Amplifier and Timing Single-Channel Analyzer (SCA)
- (2) ORTEC Model 570 Amplifier

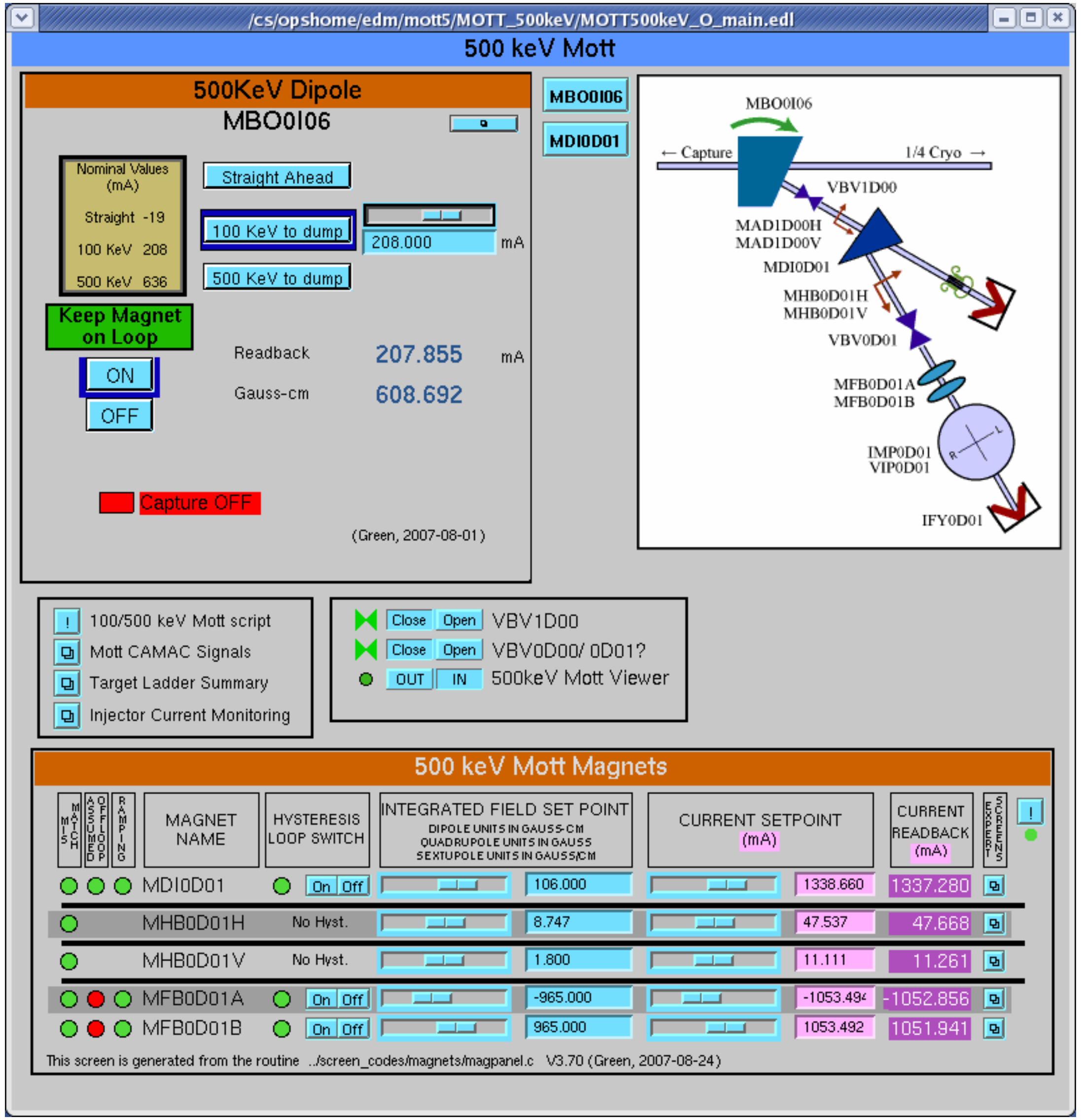
Single-Channel Analyzer (SCA)

- 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

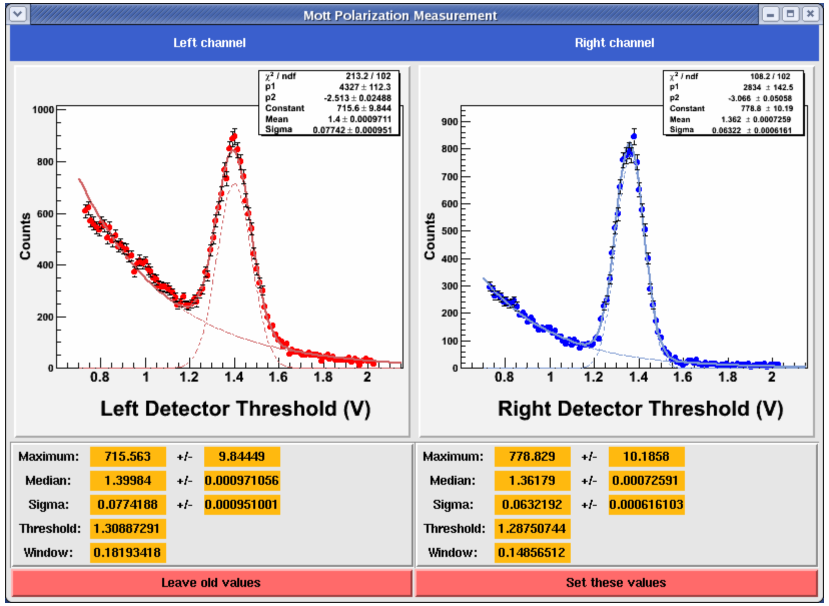
- Amp Out:
  - Energy output (Amplified: x5 to x1250)
  - Connect to fADC

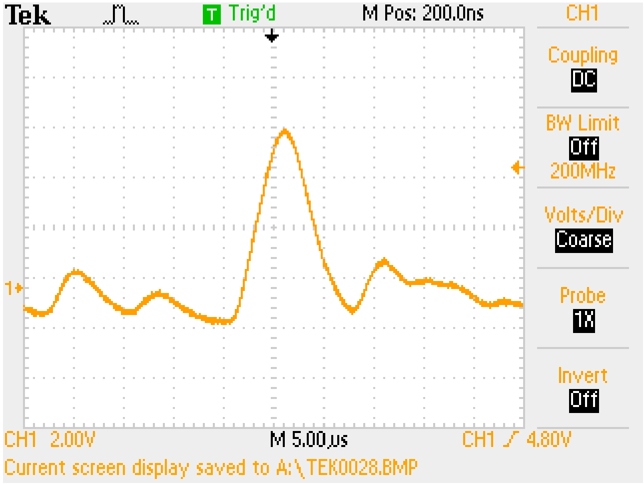
Summer 2008 Test at CEBAF Injector

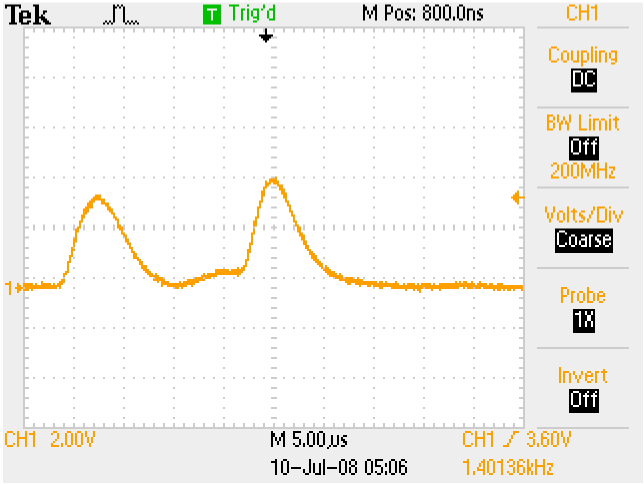
100 / 500 keV


/cs/opshome/edm/mott5/MOTT_500keV/MOTT500keV_O_main.edl
500 keV Mott
500KeV Dipole
MBO0I06
Nominal Values (mA)
Straight -19
100 KeV 208
500 KeV 636
Straight Ahead
100 KeV to dump
500 KeV to dump
208.000 mA
Keep Magnet on Loop
ON
OFF
Readback 207.855 mA
Gauss-cm 608.692
Capture OFF
(Green, 2007-08-01)
MBO0I06
MDI0D01
← Capture
1/4 Cryo →
VBV1D00
MAD1D00H
MAD1D00V
MDI0D01
MHB0D01H
MHB0D01V
VBV0D01
MFB0D01A
MFB0D01B
IMP0D01
VIP0D01
IFY0D01
100/500 keV Mott script
Mott CAMAC Signals
Target Ladder Summary
Injector Current Monitoring
Close Open VBV1D00
Close Open VBV0D00/ 0D01?
OUT IN 500keV Mott Viewer
500 keV Mott Magnets
MAGNET NAME
HYSTERESIS LOOP SWITCH
INTEGRATED FIELD SET POINT
DIPOLE UNITS IN GAUSS-CM
QUADRUPOLE UNITS IN GAUSS
SEXTUPOLE UNITS IN GAUSS/CM
CURRENT SETPOINT (mA)
CURRENT READBACK (mA)
MDI0D01 On Off 106.000 1338.660 1337.280
MHB0D01H No Hyst. 8.747 47.537 47.668
MHB0D01V No Hyst. 1.800 11.111 11.261
MFB0D01A On Off -965.000 -1053.494 -1052.856
MFB0D01B On Off 965.000 1053.492 1051.941
This screen is generated from the routine ../screen_codes/magnets/magpanel.c V3.70 (Green, 2007-08-24)


accelerator site
500 KEV MOTT


Mott Polarization Measurement
Left channel
Right channel
Counts
Left Detector Threshold (V)
Right Detector Threshold (V)
Maximum: 715.563 +/- 9.84449
Median: 1.39984 +/- 0.000971056
Sigma: 0.0774188 +/- 0.000951001
Threshold: 1.30887291
Window: 0.18193418
Maximum: 778.829 +/- 10.1858
Median: 1.36179 +/- 0.00072591
Sigma: 0.0632192 +/- 0.000616103
Threshold: 1.28750744
Window: 0.14856512
Leave old values
Set these values





Left Detector

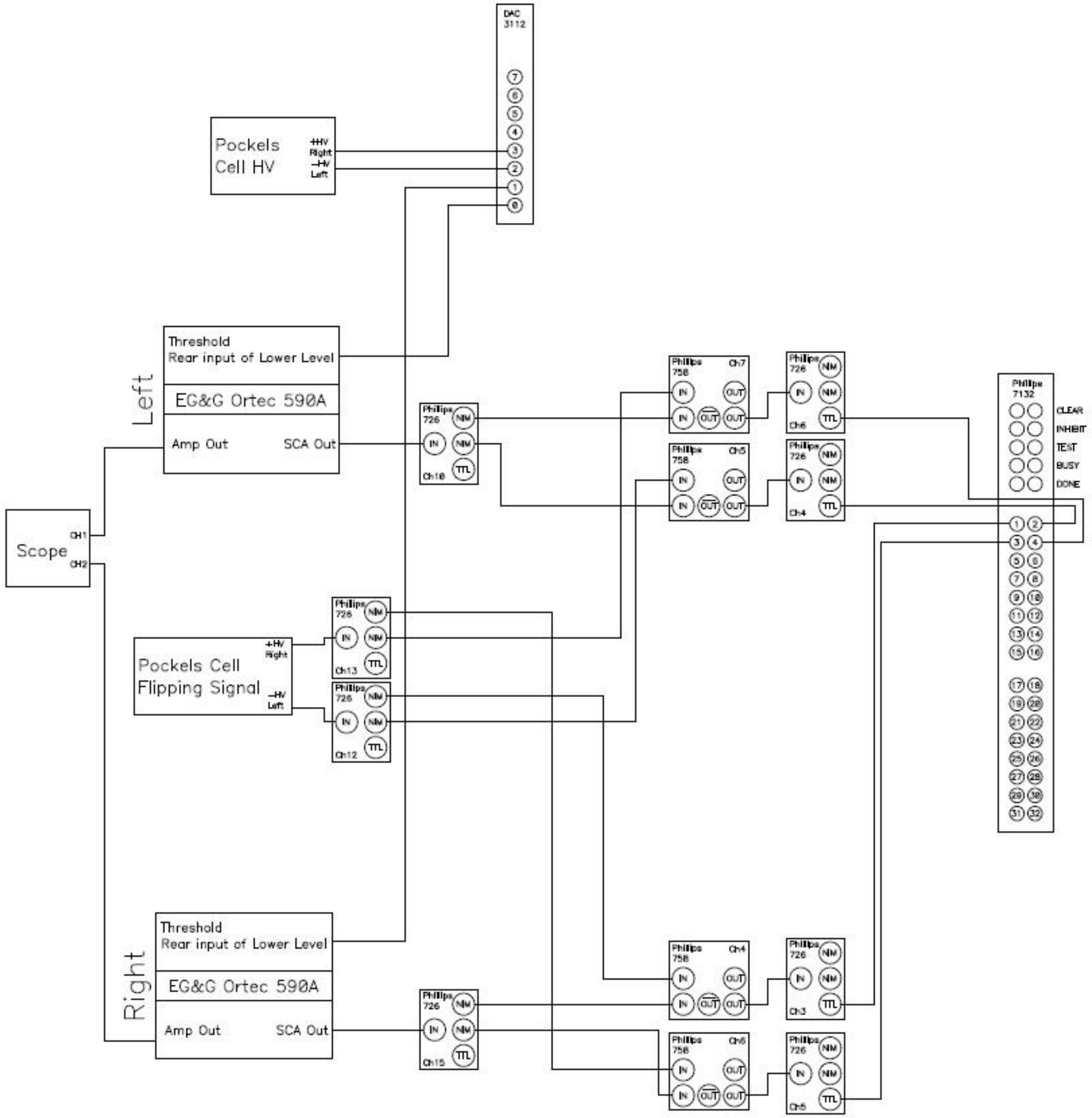
Right Detector

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

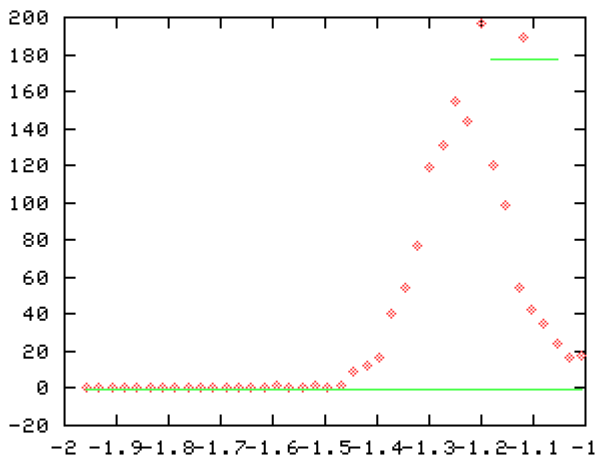
Left Preamp T Output

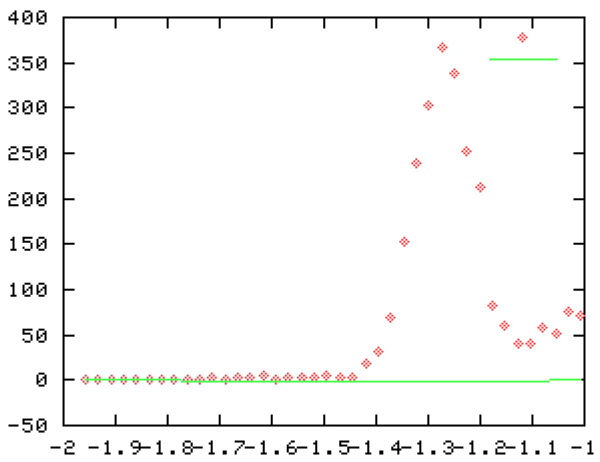
Right Preamp T Output

The old 100 keV DAQ

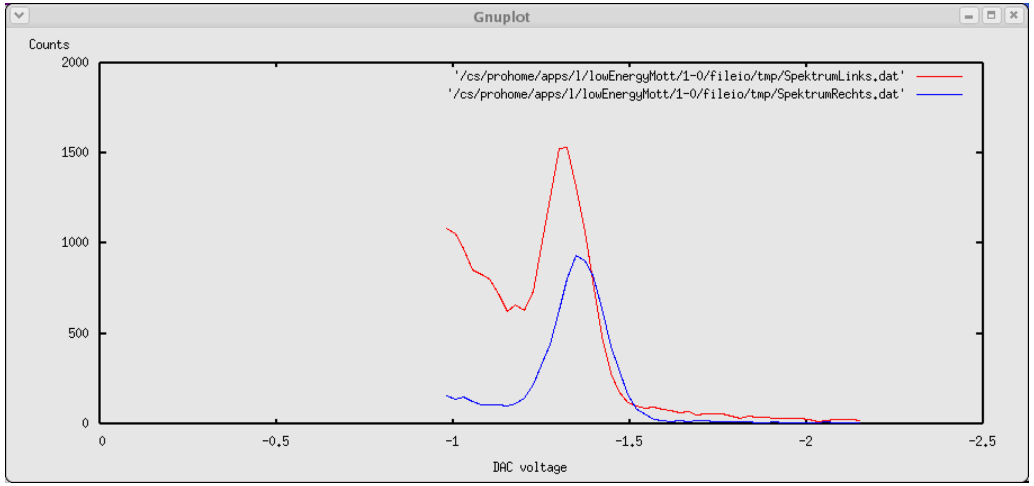


100 keV, ITS Cave

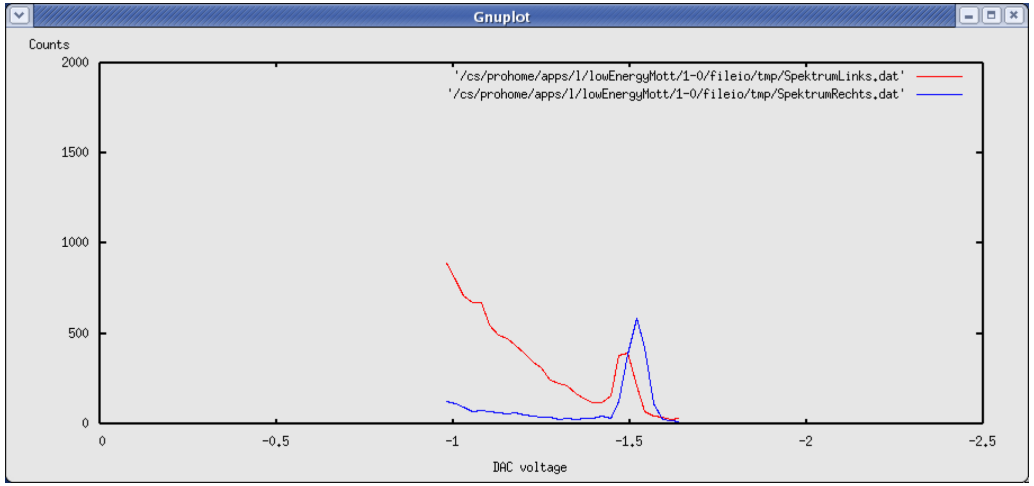




100 keV, CEBAF Tunnel



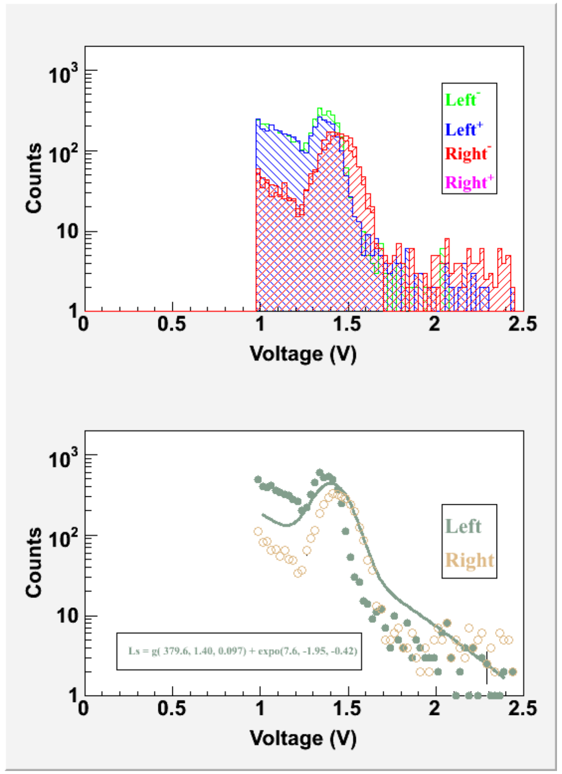
500 keV, CEBAF Tunnel

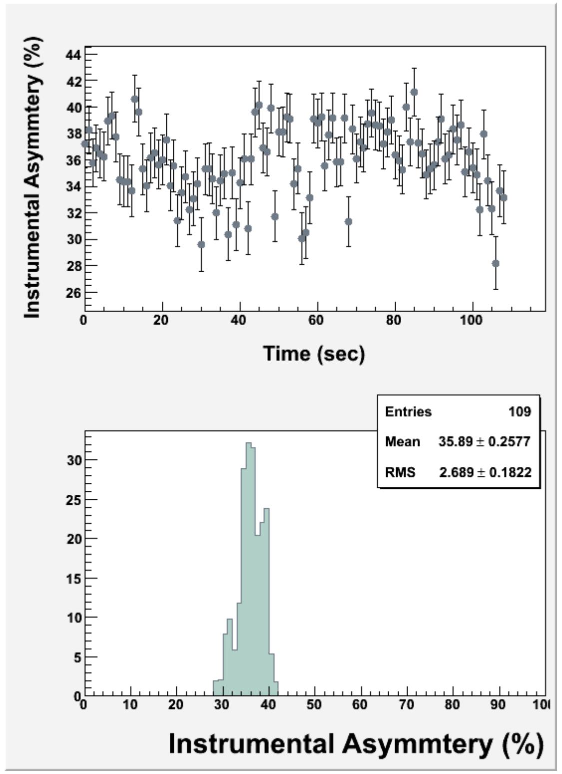


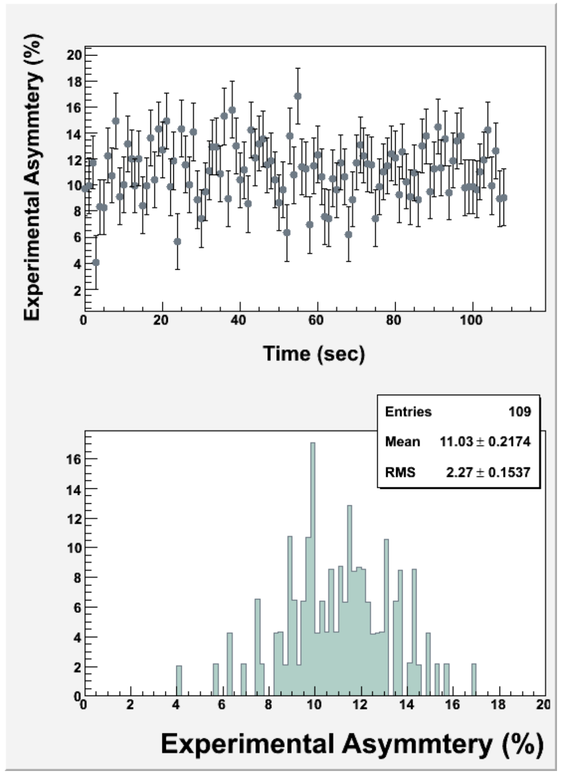
Asymmetry Data (100 keV, 300n A)

- ✓ 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
- ✓ HWien = 90 degrees, MFB0D01A = -964 G-cm, MFB0D01B = 1013 G-cm

P = 31.3 % (Bulk GaAs)



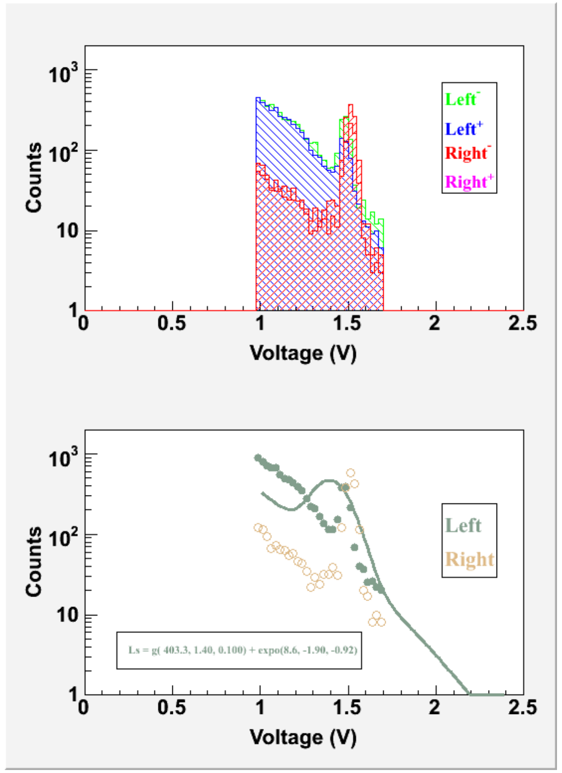


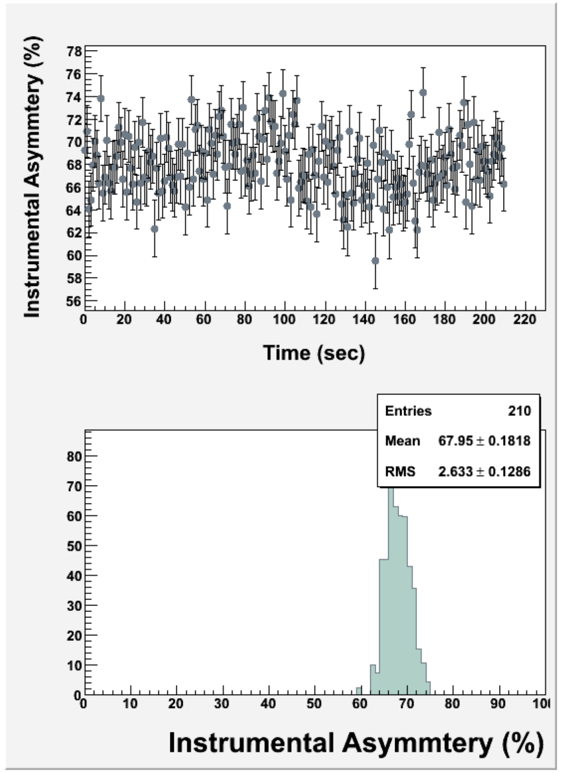


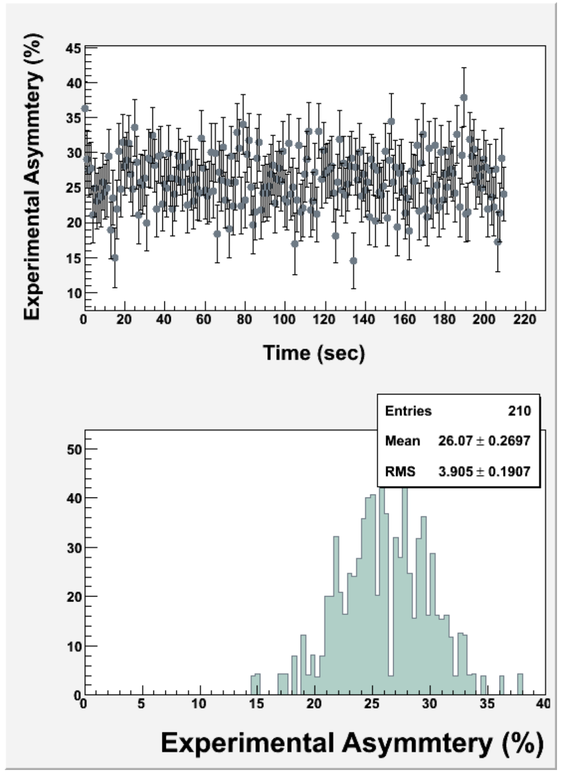
Asymmetry Data (500 keV, 300n A)

- ✓ 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
- ✓ HWien = 90 degrees, MFB0D01A = -2369 G-cm, MFB0D01B = 2369 G-cm

P = 67.7 % (Super Lattice GaAs)







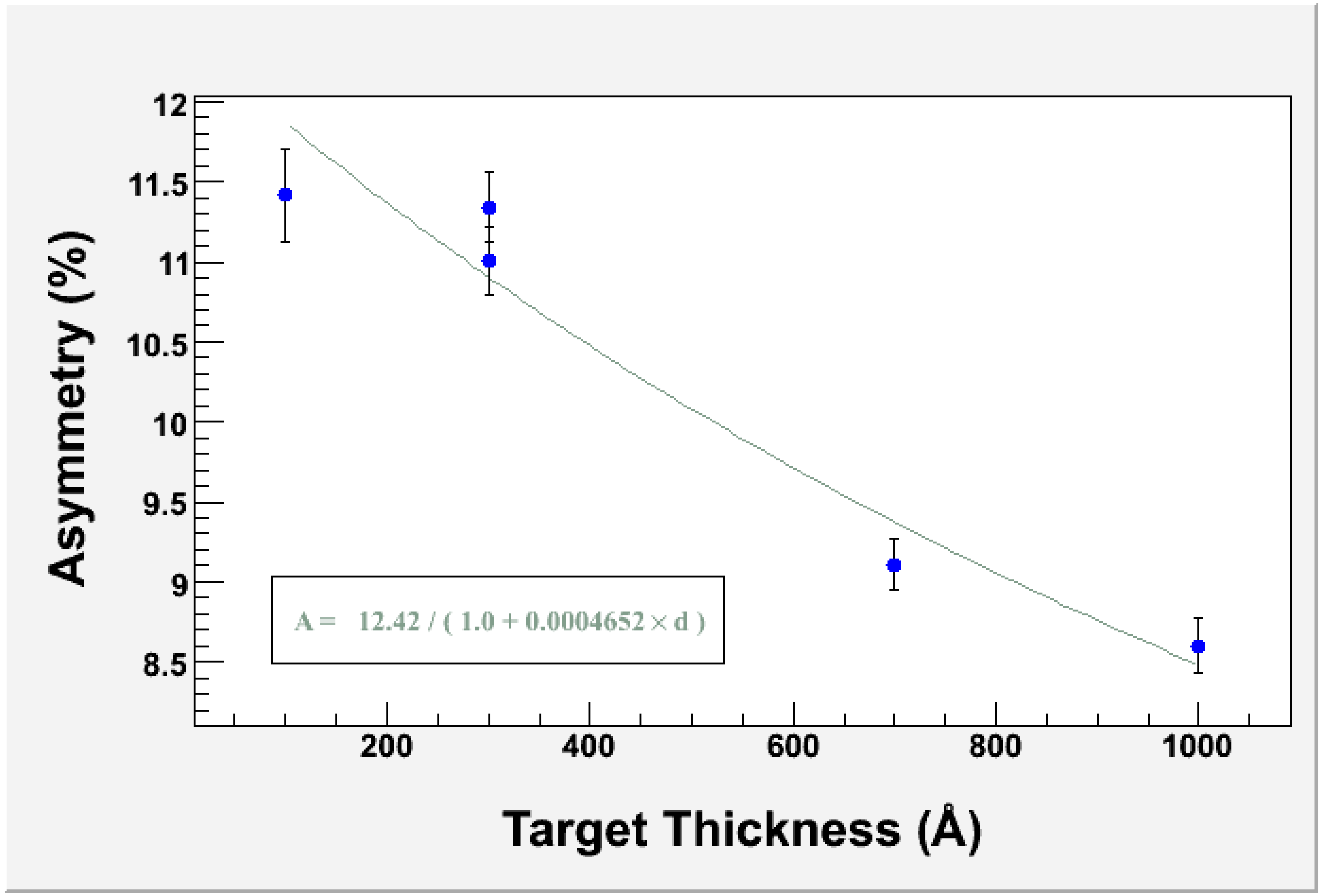
Target Thickness Extrapolation

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

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

- 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



Design of
UITF 200 keV Mott Polarimeter

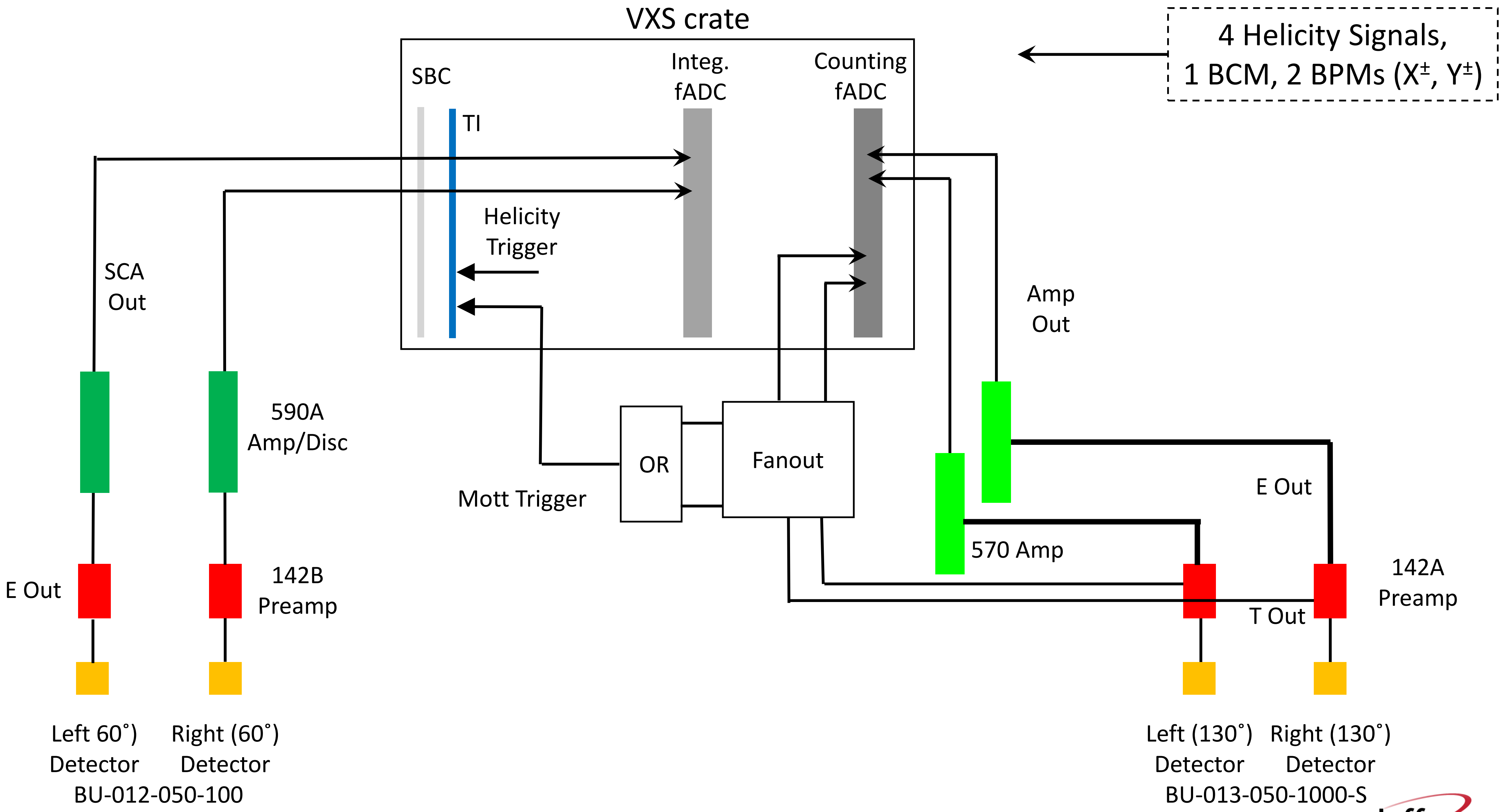
Jefferson Lab

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



DAQ Readouts

- Mott Trigger:
  - Counting fADC
  - Integ. fADC
- Helicity Trigger:
  - Integration fADC

Signals to DAQ

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

- Signals to Integration fADC (helicity-gated):
  - (2) SCA Out
  - (4) Helicity Signals
  - (1) BCM
  - (8) 2 BPMs ($X^{\pm}$, $Y^{\pm}$)

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 with 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

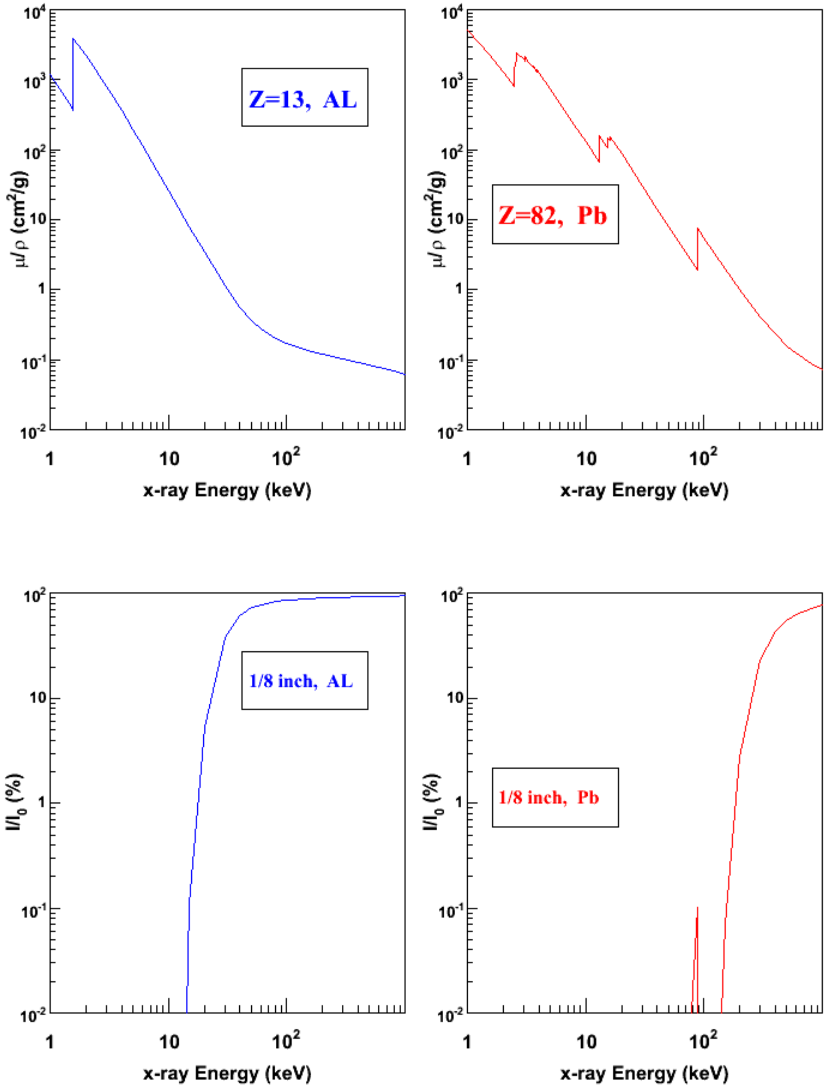
- Viewer and a thru hole

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, …

- (4) 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 cave, male in service rack

- (2) E 142B preamp 93-ohm cable, RG62A/U BNC, male connectors
- (2) 142B preamp power cable, 9-pin D connectors (amphenol 17-10090), female cave, male in service rack