Compton Analysis Progress

for the d_2^n analysis meeting

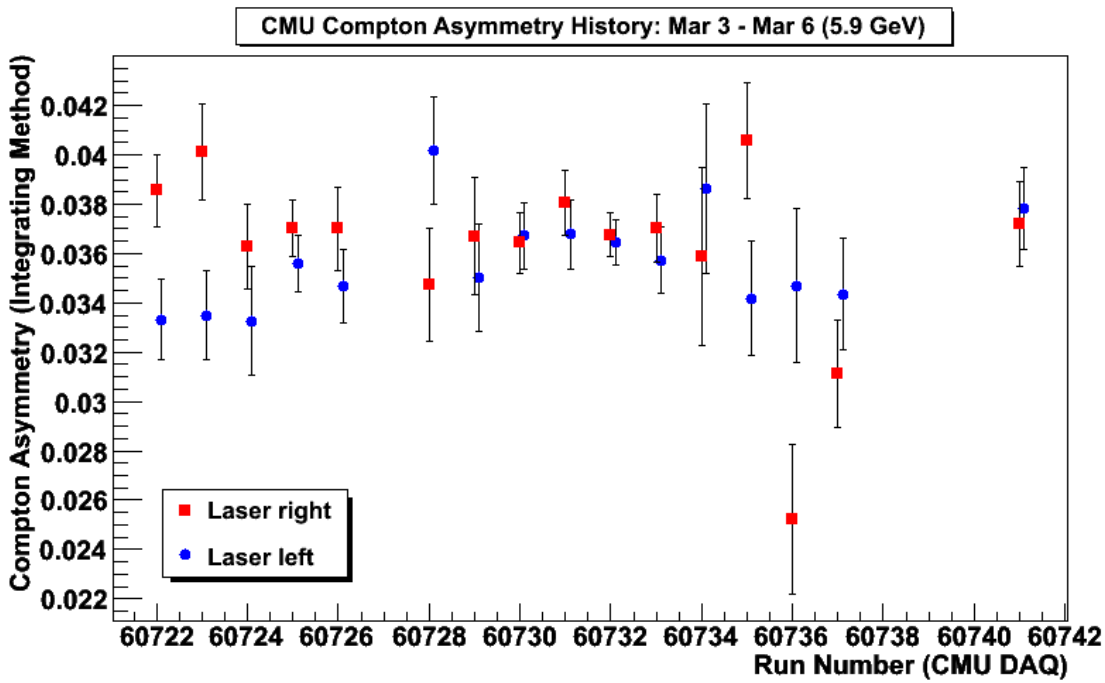
Diana Parno

Carnegie Mellon University

July 7, 2009

Compton Asymmetry Histories

- With laser-state-ID problems solved, we can generate histories of Compton asymmetries over periods of hours or days
  - Identify problems with individual runs or with our code
  - Identify trends in beam polarization (which tracks Compton asymmetry)
- For example, here are the CMU Compton asymmetries for March 3 - March 6 (5.9 GeV):



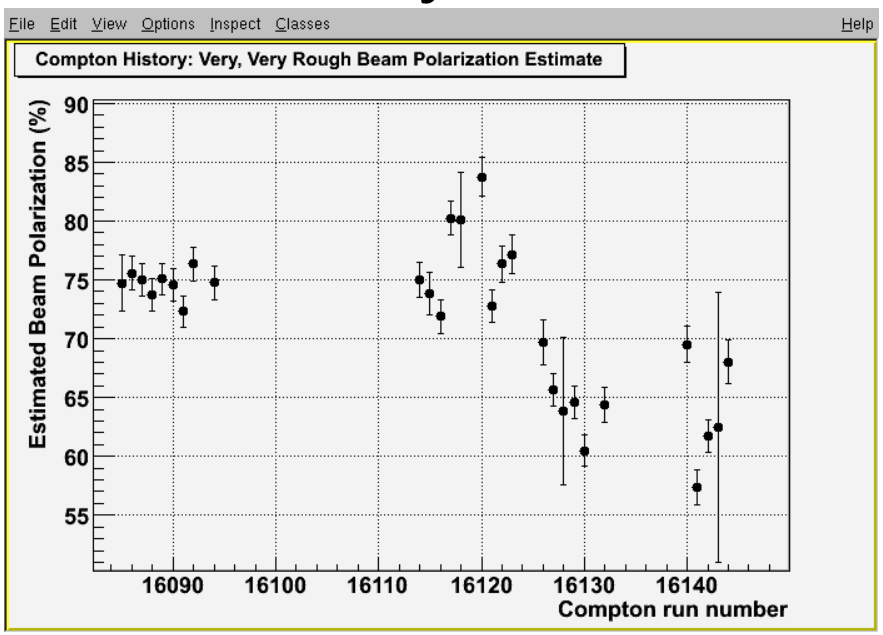
What Could Make the Laser Polarization States Different?

- Differences in cavity power
  - We have the cavity power measured in EPICS
  - However, there is an offset in the readout by design to allow easy differentiation between cavity states
  - Will need more careful study
- Differences in cavity polarization
  - Perhaps "Laser right" is 97% right-circularly polarized, while "Laser left" is only 95% left-circularly polarized
  - We have the polarization readout measured in EPICS
  - No offset in readout; simple to adjust for
- Differences in analyzing power
  - Matt Oborski is working on GEANT4 simulations
- Bad luck
  - What if the beam was off most of the run, or very trippy?
  - One polarization state might have much higher statistics than the other

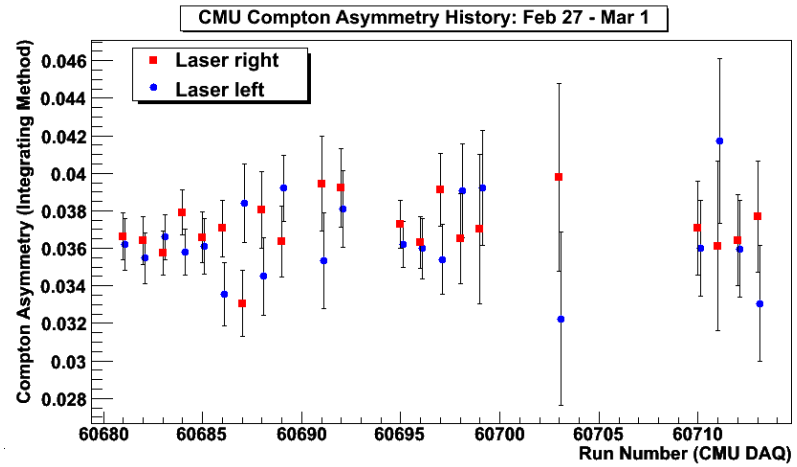
An Old Mystery

- During d_2^n, the Saclay Compton DAQ showed a precipitous drop in asymmetry on Saturday, February 28 (5.9 GeV)
- However, Hall B's Moller measurement gave the expected polarization
- We can now double-check using the CMU DAQ (same input signal)

Saclay DAQ



CMU DAQ



From Compton Asymmetry to Beam Polarization

Recall the relationship between the experimentally measured Compton asymmetry and the electron beam polarization:

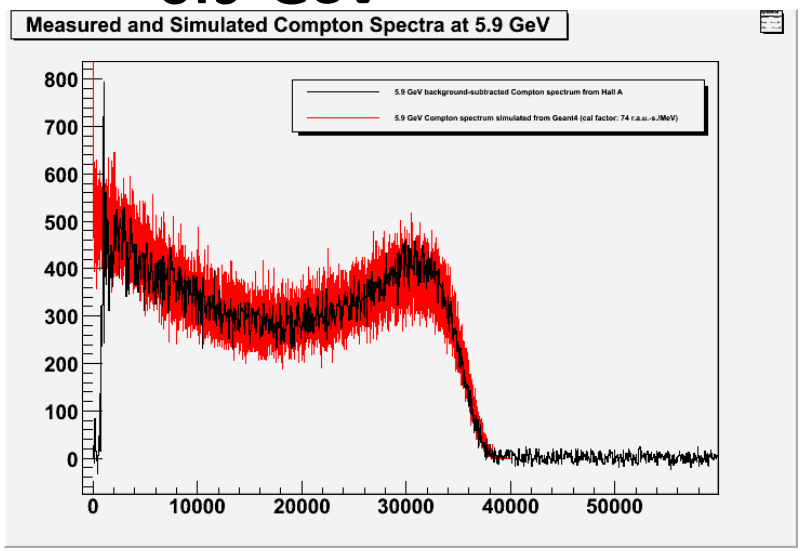
$$A_{Compton} = \frac{S^+ - S^-}{S^+ + S^-} = \langle A_l \rangle P_\gamma P_e$$

- To extract P_e, we need to understand the analyzing power $\langle A_l \rangle$:
  - Compton cross section
  - Statistics
  - Detector (and DAQ) non-linearities

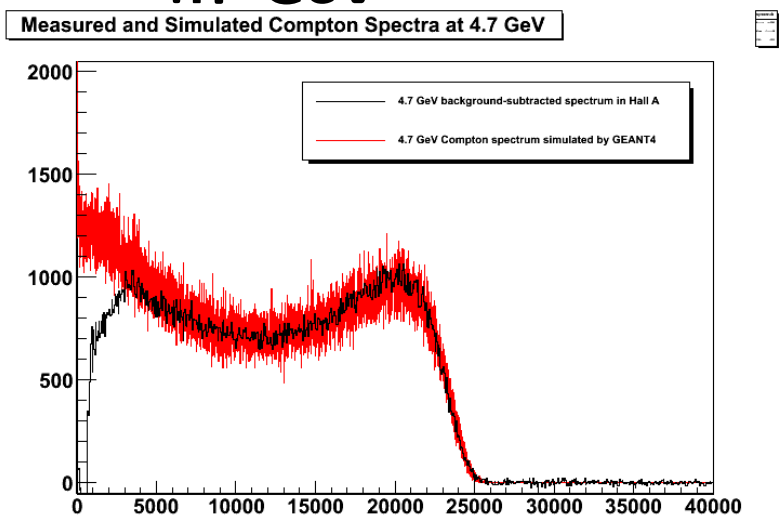
GEANT4 Simulations

- As a step toward understanding our detector, Matthew Oborski has simulated our measured Compton spectrum
  - GSO crystal (6cm diameter, 15 cm length)
  - No information from upstream (beam pipe, etc)
- We can match the simulated spectra to our empirical spectra, with a conversion factor of 74 raw-ADC-unit*samples per MeV:

5.9 GeV

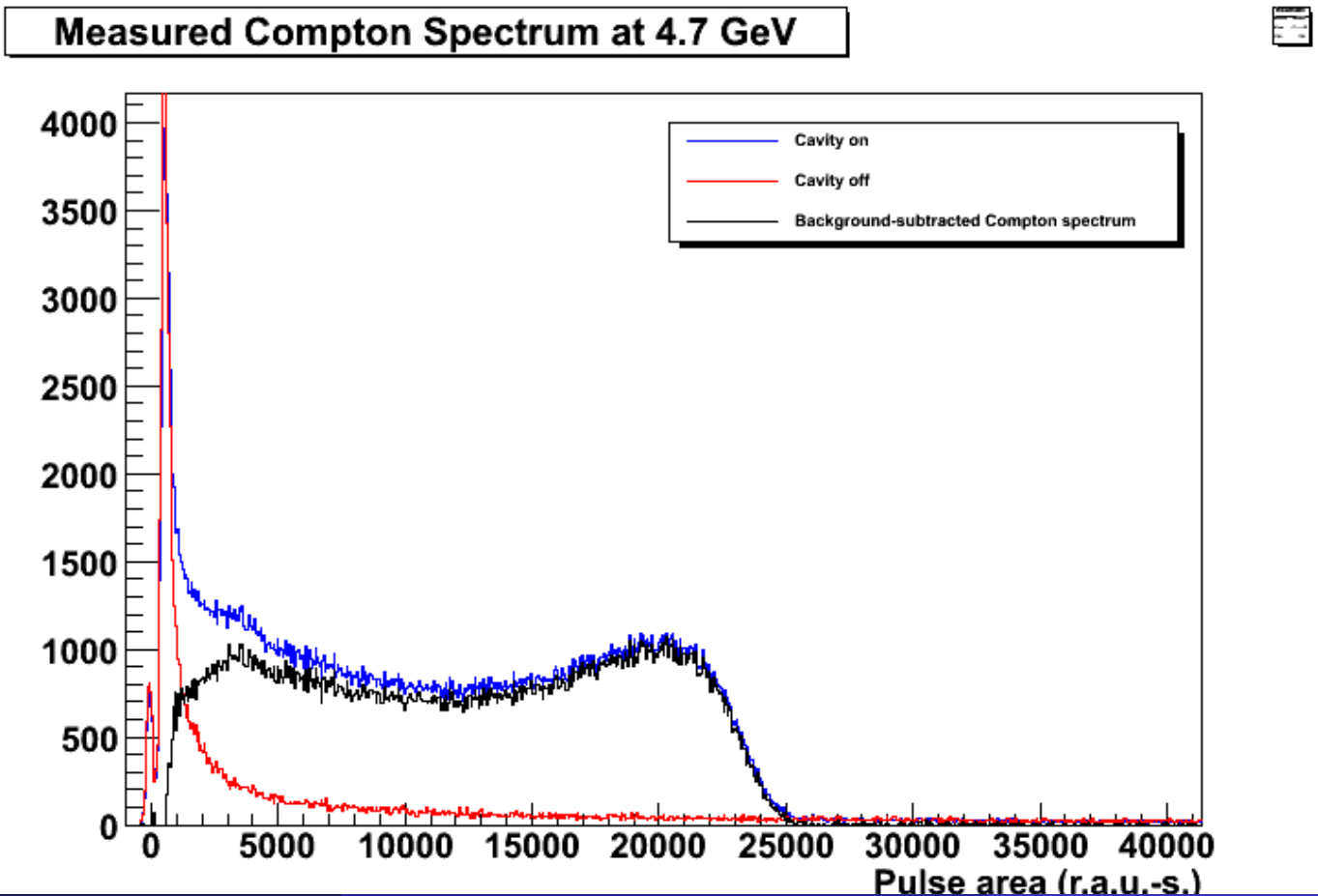


4.7 GeV



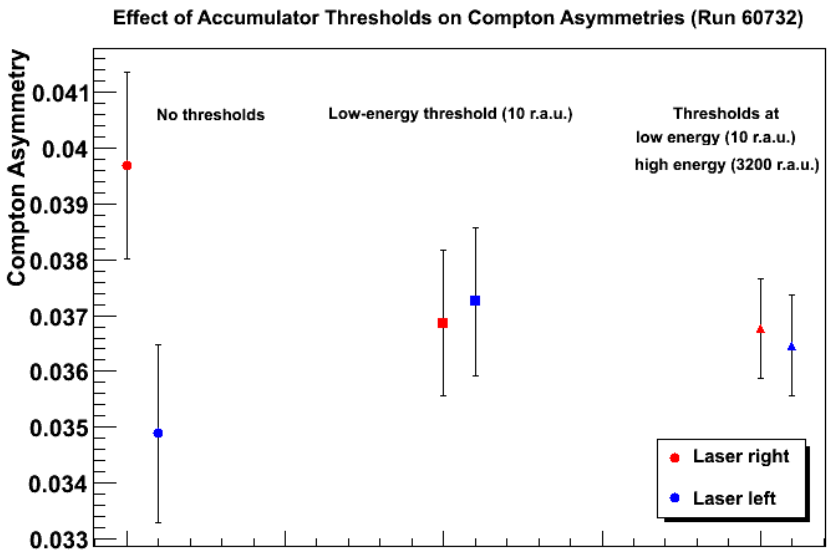
Compton Spectrum with Four-Pass Beam

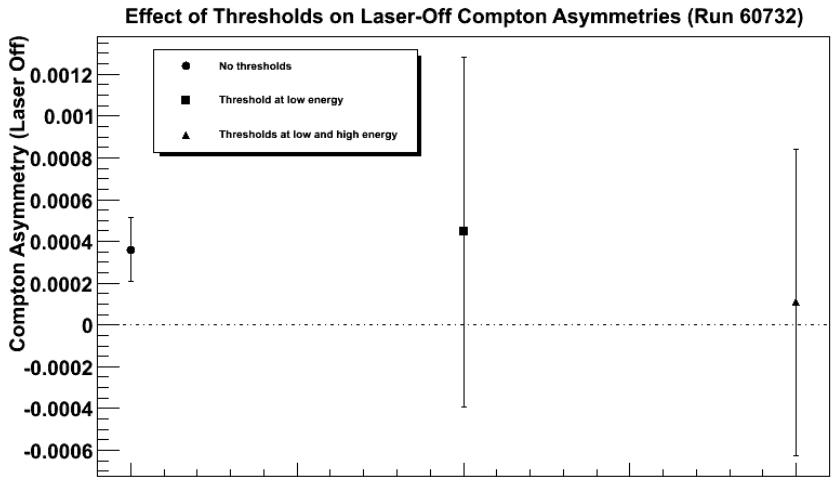
- Comparing our measured 4.7 GeV spectrum with the simulated spectrum, we see that some low-energy events seem to be missing ...
- This effect is not sensitive to changes in background subtraction, and shows up in other runs as well.



Accumulator Issues at Low Energies

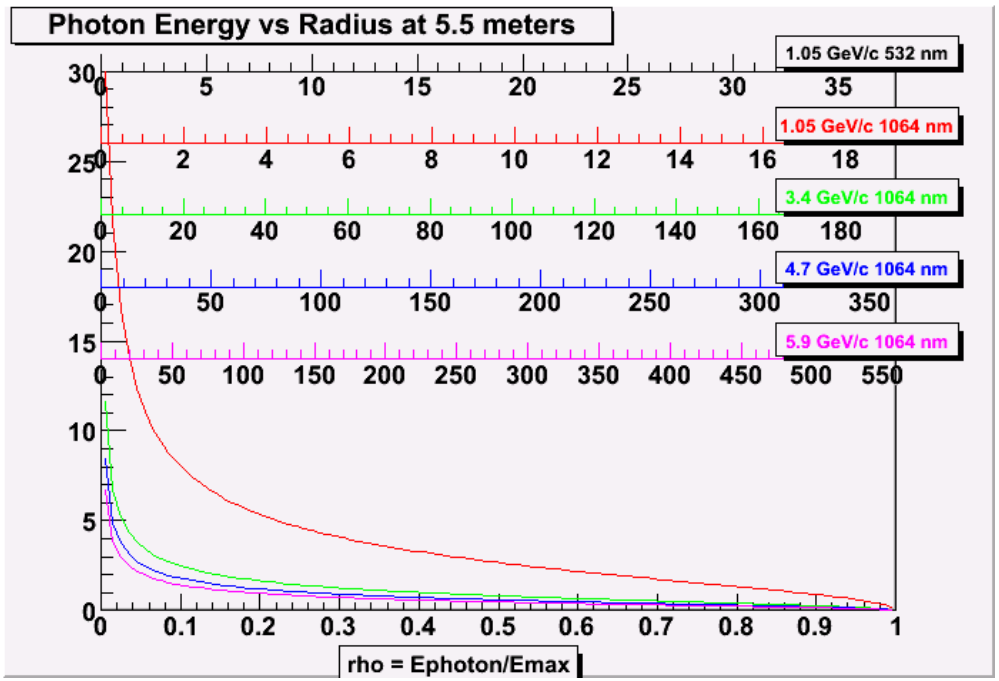
- There's more strange behavior at low energies:
  - Our threshold-less accumulator yields bizarre asymmetries
  - The asymmetries instantly clean up when we remove low-energy signal with a threshold





Possible Geometrical Explanation

- What's upstream of the photon detector?
  - Compton-scattered photons must travel 5.5 m through a 1" beam pipe
  - Beam pipe is terminated with a 1 cm window and lead collimator with 1 cm aperture
- But Compton photons scatter in a cone around the axis
- A mm-level misalignment would preferentially exclude low-energy photons



What's Next?

- Compton analysis
  - Polarimetry has 3% in d_2^n's proposed error budget
  - Still needs some work (especially understanding systematics) to get there
  - Will be moving this work to background
- BigBite optics
  - Start on an optics study similar to Xin's for Transversity