Compton Analysis Progress

for the d_n^2 analysis meeting

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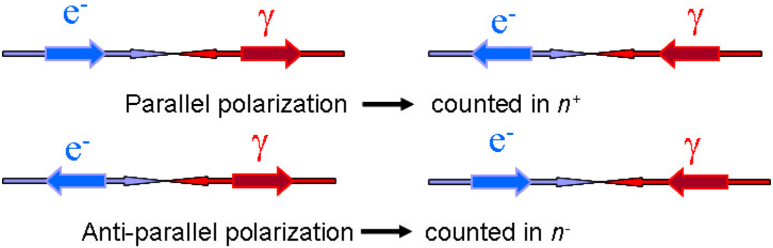
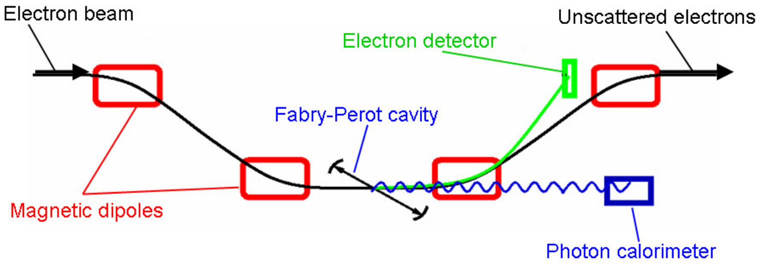
Polarimetry from Compton Scattering

- The Compton scattering ($e^-\gamma \rightarrow e^-\gamma$) cross section depends on the e^- and γ polarizations.
- We use circularly polarized laser light to exploit this sensitivity to longitudinal electron beam polarization.

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



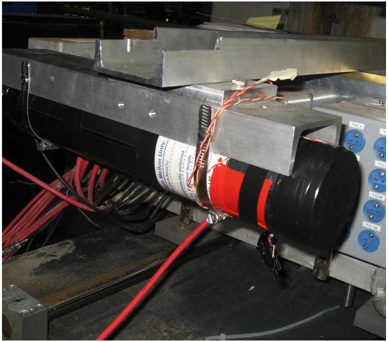
Hall A Compton Polarimeter



- Electron beam is diverted by magnetic chicane.
- Photons and electrons interact at center of Fabry-Perot cavity.
- Electron detector counts scattered electrons.
- Photon detector counts scattered photons.

Compton Hardware During d_n^2 Experiment

- Infrared laser ($\lambda = 1064$ nm)
- Fabry-Perot cavity for laser power amplification ($\bar{P} \approx 400$ W)
- New scattered-photon detector
  - GSO cylinder: 6 cm diameter, 15 cm length
  - PMT swapped out partway through d_n^2
- New scattered-electron detector (microstrips)
  - Not functional during d_n^2



Compton DAQs During d_n^2 Experiment

For nearly all of d_n^2, two Compton DAQs ran in parallel on copies of the same signal

(Original) Saclay DAQ

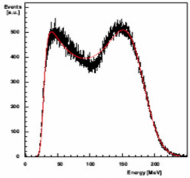
- First developed 10 years ago
- Computes asymmetry in counting rates
- Complicated system spanning 2 racks of electronics
- No real experts at JLab any more

(New) CMU DAQ

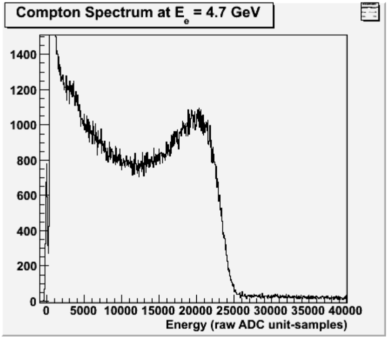
- d_n^2 run was part of its commissioning
- Computes asymmetry in energy-weighted integrated signal
- Only 2 crates (1 VME, 1 NIM)

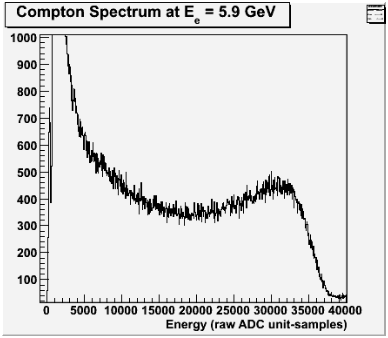
Compton Spectra

- The Compton spectrum has a distinctive shape plotted against energy
- We can confirm we have good signal by measuring the Compton spectrum with sampling data



Baylac et al., 2002





Asymmetry in Energy-Weighted Integrated Signal

- Saclay DAQ computes asymmetry in counting rates
- CMU DAQ computes asymmetry in E-weighted integrated signal S
  - Integration is over a 30-ms helicity window
  - Six different accumulators sum signals according to size, timing

$$Acc_n = N_n(\bar{P} - \bar{S}_n)$$

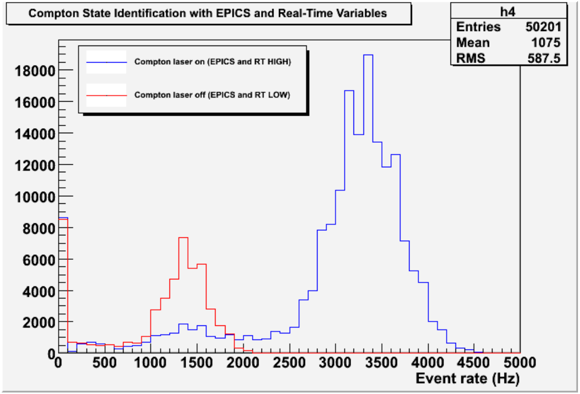
$$S_n = N_n\bar{S} = N_n\bar{P} - Acc_n$$

  - Laser-off data measures background B, which can then be removed from the Compton asymmetry

$$A_n = \frac{(S_n^+ - B_n^+) - (S_n^- - B_n^-)}{(S_n^+ - B_n^+) + (S_n^- - B_n^-)}$$

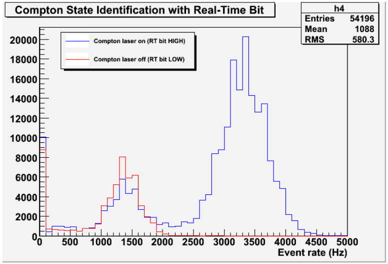
Cavity State Identification

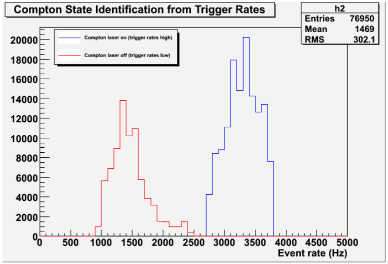
- Accurate identification of the Compton cavity state is crucial
  - Is it off? (Background measurement)
  - Is it on? (Compton events $\rightarrow$ asymmetry)
  - If it's on, are the photons left or right circularly polarized?
- Yet we discovered some systematic errors in the cavity state identification ...



Tracing Cavity State Misidentification

- Cavity on/off state can be determined from a power measurement of light transmitted through the cavity
  - EPICS variable (read every $\sim$ 1.5 seconds)
  - "Real-time" logic signal read from TIR every 30 ms
- Luckily, cavity power is also reflected in event rates ...

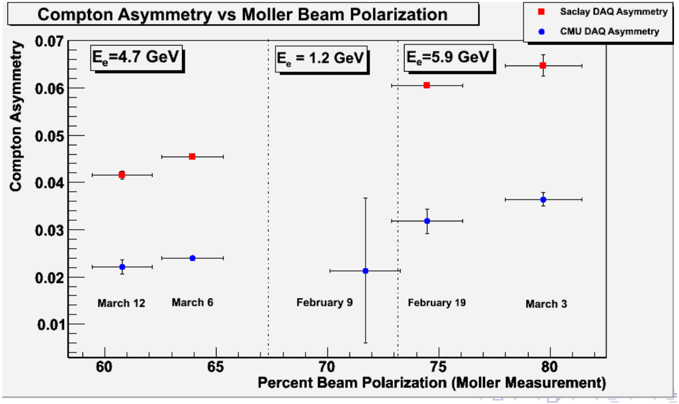




- HAPPEX-II data (2004-2005) show state misidentification in Saclay DAQ, but on a much smaller level

Comparison with Møller Data

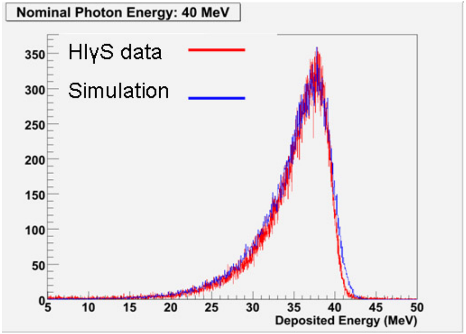
- The Compton polarimeter ($\gamma e^- \rightarrow \gamma e^-$ scattering) and Møller polarimeter ($e^- e^- \rightarrow e^- e^-$ scattering) both measure the electron beam polarization P_e
- The Compton asymmetry should be directly proportional to the Møller-measured polarization at each beam energy E_e



Detector Response Function

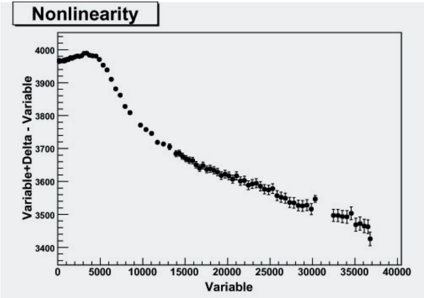
Calculating $\langle A_l \rangle$ requires the detector response function for GSO

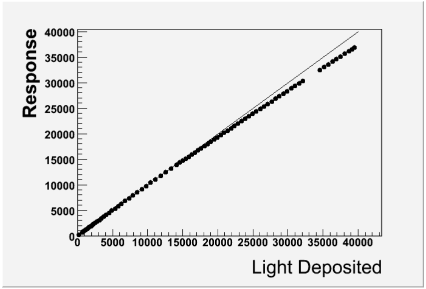
- Model GSO response with GEANT4
- Tests at HIγS in 20-40 MeV range (October 2008)
- Work on detector response continues (Matthew Oborski)



Photomultiplier Tube Linearity

- Detector response function is also affected by nonlinearities in the PMT/base
  - Gain shifts and other nonlinearities observed during running
- Megan Friend and Brian Quinn have worked on characterizing PMT nonlinearities using a pulser system





Future Work

- Report polarization histories for each d_n^2 configuration
- Translate Compton asymmetries to beam polarization
  - Finish Monte Carlo work for detector response function
  - Include analytical description of PMT nonlinearity
  - Compute analyzing power for Compton detector
- Calibrate Compton data
  - Improve asymmetry extraction from Saclay DAQ
  - Compare both sets of Compton results to each other