Status Report on the Precision Measurement of d_2^n

Experiment E06-014

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Probing QCD Through Quark-Gluon Interactions

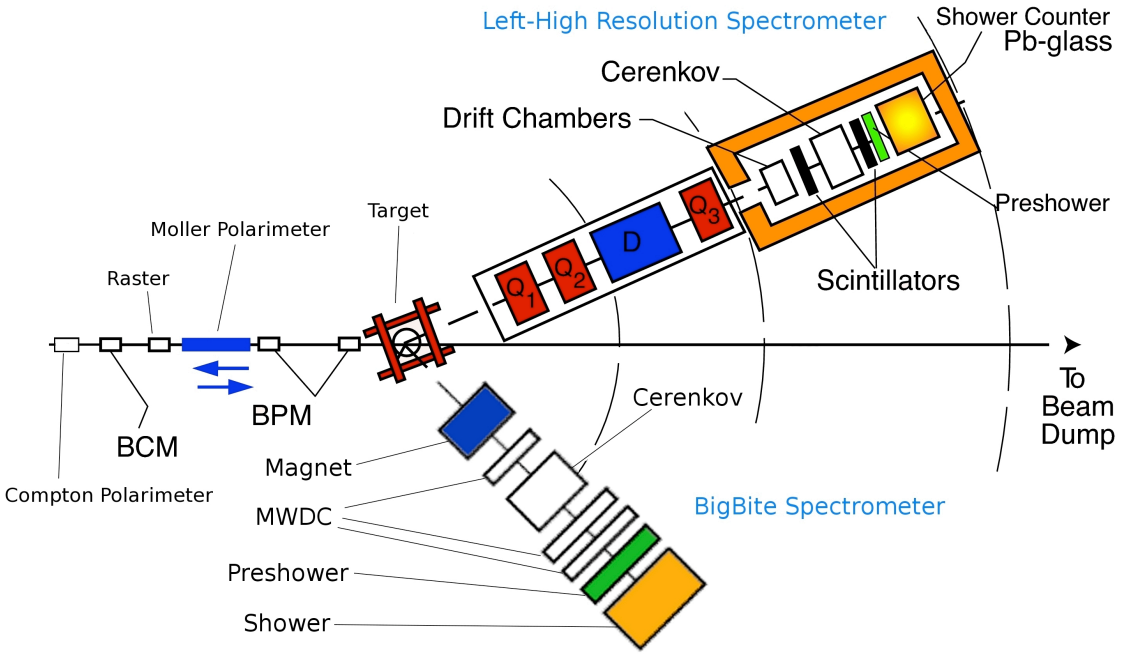
- d_2^n gives access to quark-gluon correlations

$$d_2^n(Q^2) = \int_0^1 x^2 \left(2g_1(x, Q^2) + 3g_2(x, Q^2)\right) dx$$

- How do we interpret d_2^n?
  - Color field response to polarization of a nucleon (X. Ji)
  - Averaged transverse force on a quark just after interaction with a virtual photon (M. Burkardt)
- Large-x contributions dominate d_2^n

Strategy for E06-014

- Scatter a longitudinally polarized electron beam from polarized ^{3}He
- Change the target polarization direction to measure parallel and perpendicular asymmetries
- Kinematic range: $0.2 \leq x \leq 0.7$ and $2 \leq Q^2 \leq 6$ GeV^2



- Two parallel single-arm measurements
- Left HRS: σ_0
- BigBite: $A_{\parallel}$, $A_{\perp}$

Measuring d_2^n

- Measure total cross section σ_0 and asymmetries $A_\parallel$ and $A_\perp$

$$A_\parallel = \frac{\sigma^{\downarrow\Uparrow} - \sigma^{\uparrow\Uparrow}}{2\sigma_0} \text{ and } A_\perp = \frac{\sigma^{\downarrow\Rightarrow} - \sigma^{\uparrow\Rightarrow}}{2\sigma_0}$$

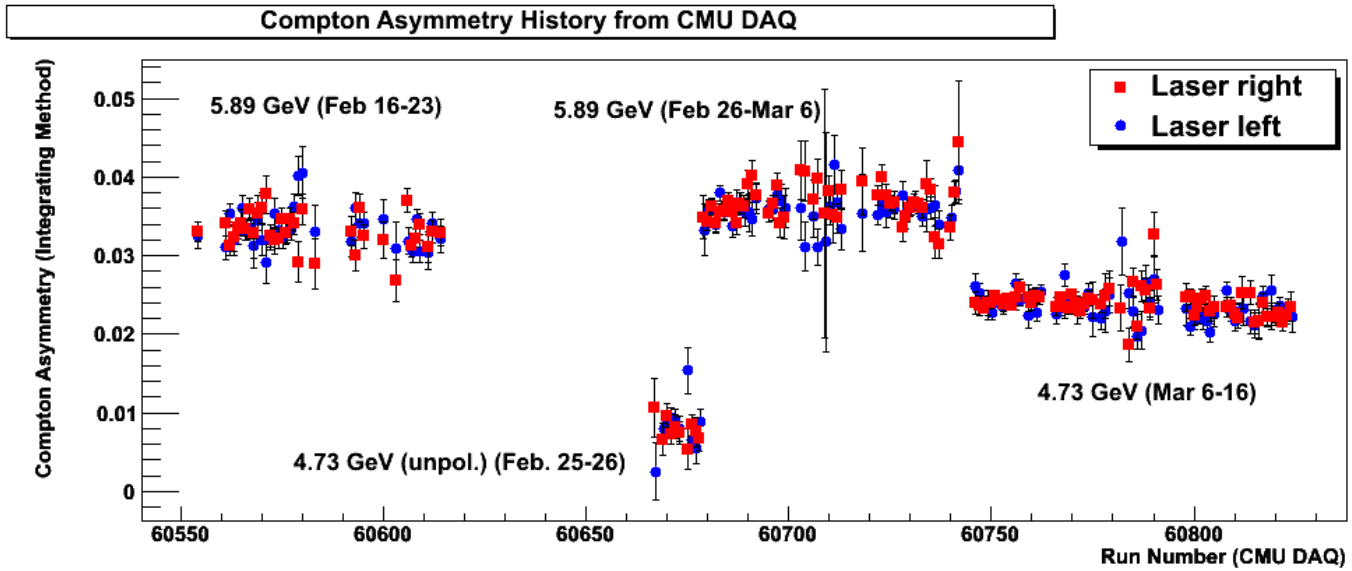
- From there, we can compute d_2^n:

$$d_2^n(Q^2) = \int_0^1 dx \quad \frac{MQ^2}{4\alpha^2} \frac{x^2 y^2}{(1-y)(2-y)} \sigma_0 \left[\left(3\frac{1+(1-y)\cos\theta}{(1-y)\sin\theta} + \frac{4}{y}\tan\frac{\theta}{2} \right) A_\perp + \left(\frac{4}{y} - 3 \right) A_\parallel \right]$$

- We can pick up the spin structure functions g_1 and g_2 along the way

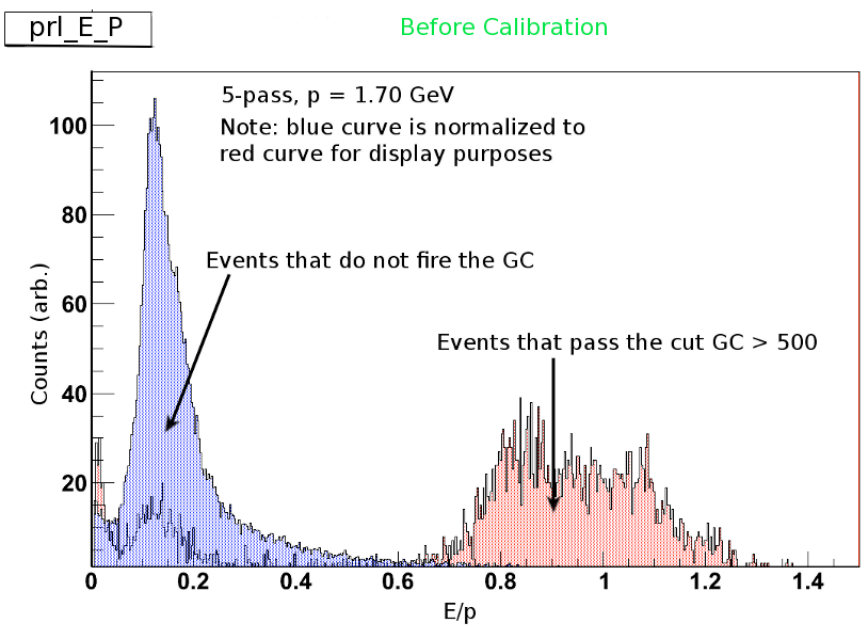
Electron Beam Polarimetry

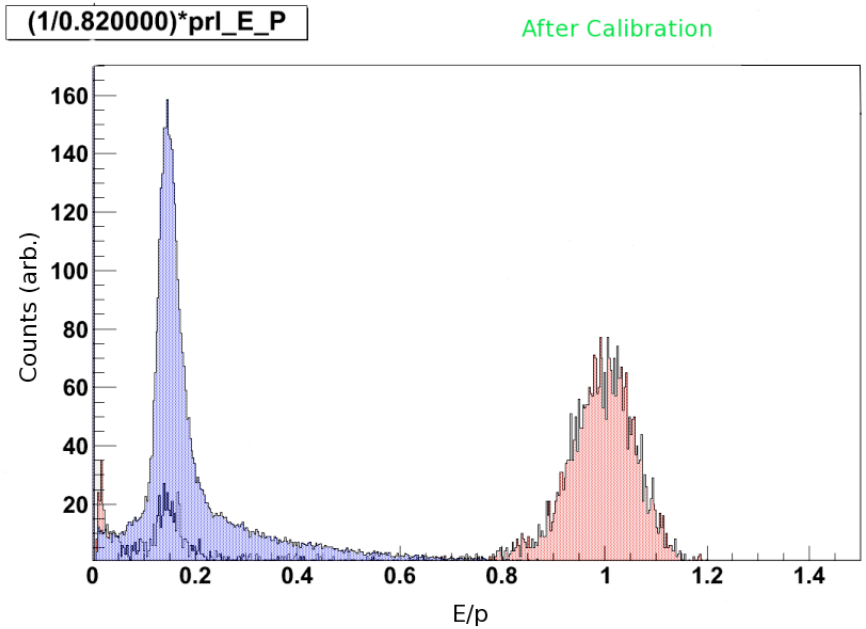
- To compute $A_{\parallel}$ and $A_{\perp}$, we need precise knowledge of the electron beam polarization
- Polarimetry strategies:
  - Four Moller measurements (1/week) during production running
  - Commissioning of new Compton photon detector, integrating DAQ
- We are nearly finished analyzing Compton polarization data from the new Carnegie Mellon DAQ



Gain Matching

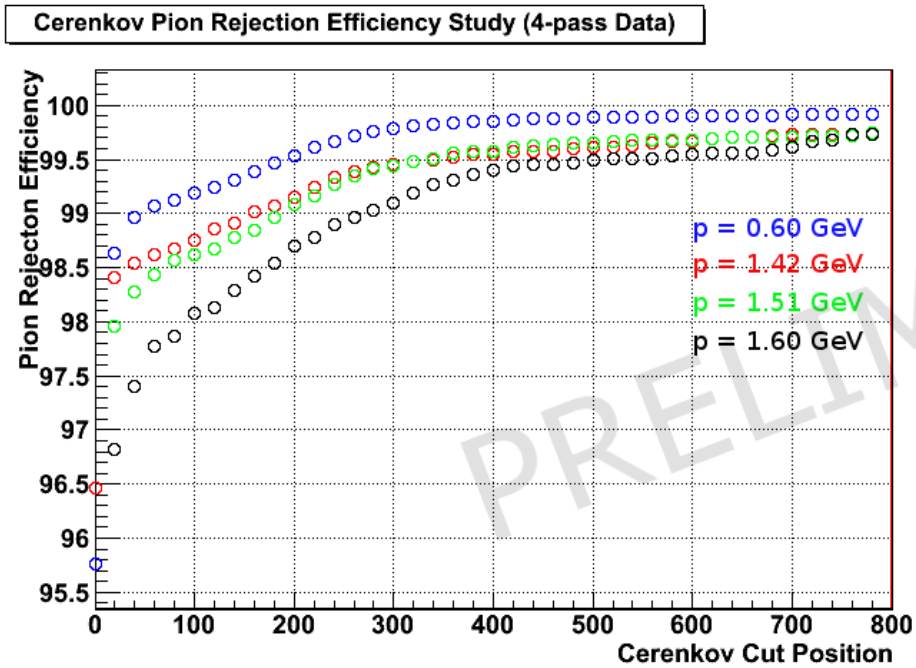
- We must gain-match our PMTs in order to make meaningful comparisons between their ADC spectra
- We have completed this work for
  - Gas Čerenkov (10 PMTs)
  - Pion rejectors (34 blocks in each of two layers)

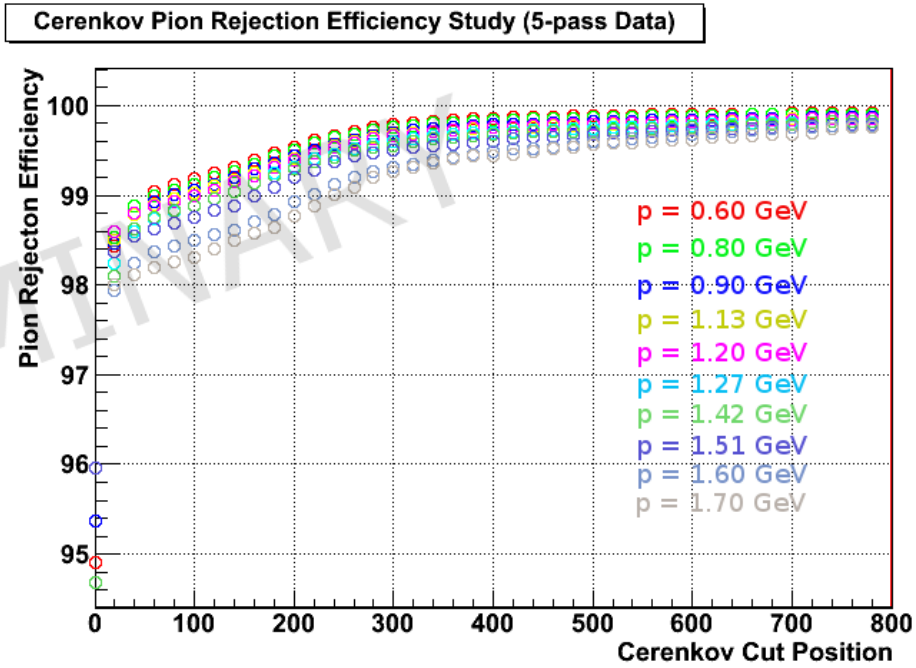




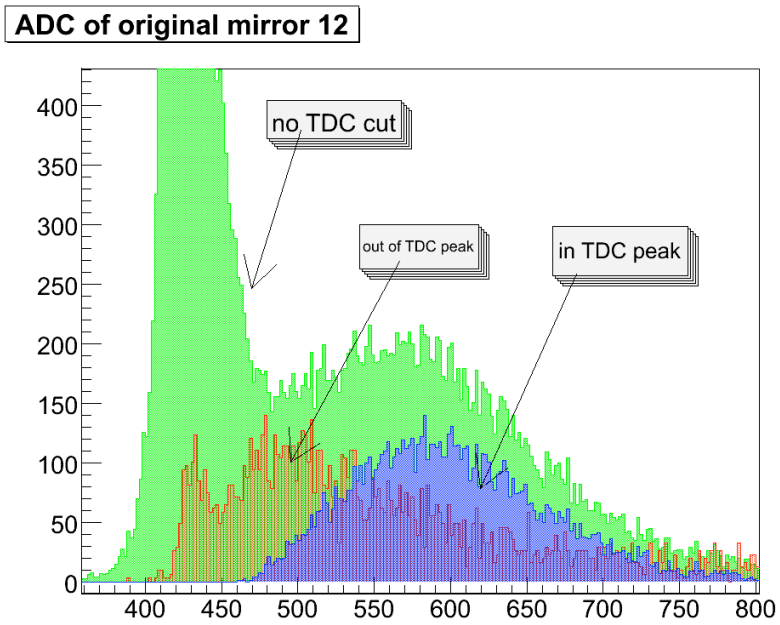
Pion Rejection Efficiency in Gas Čerenkov

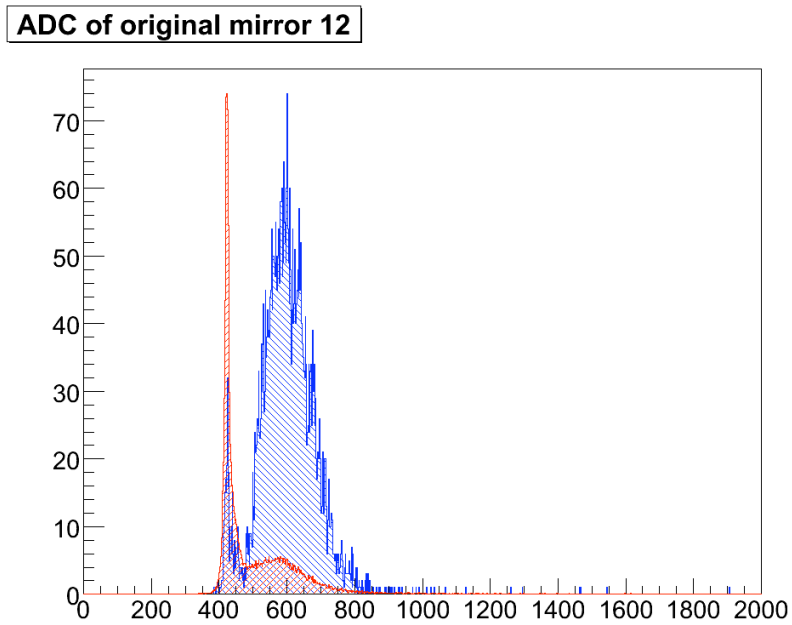
- How efficient is the LHRS gas Čerenkov at excluding pions?
- It depends on the cut position in the Čerenkov
- We can compute the efficiency by testing the Čerenkov's treatment of a pion sample (selected in the pion rejector): $e = 1 - N_{\pi}^{Cer}/N_{\pi}^{PR}$
- We're working on a simulation to understand the observed momentum dependence





"Good" Electrons in BigBite Čerenkov

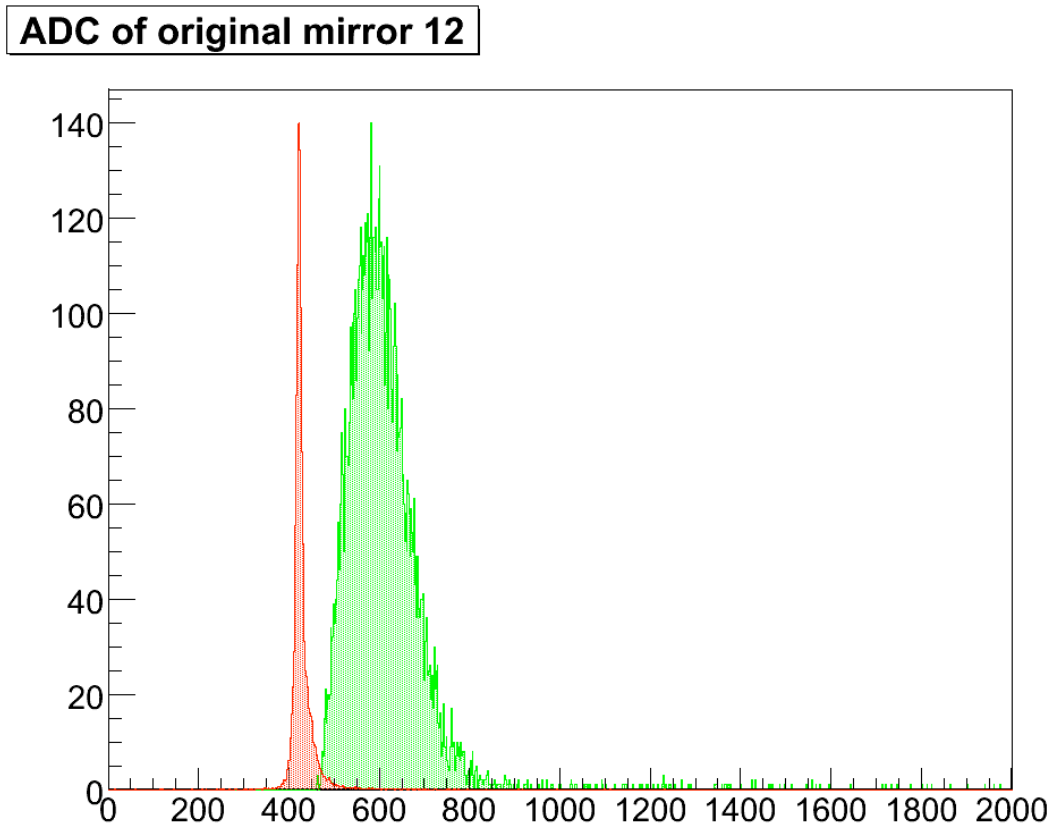




- A good electron arrives on time
  - Cut on TDC peak
- A good electron enters the PMT via the corresponding mirror
  - Cut on reconstructed track

"Good" Electrons in BigBite Čerenkov – Results

- We can get a sense of the background by cutting on off-peak timing in the TDC (red)
- Good electrons show up with both an on-peak TDC cut and a mirror cut (green)



Future Work

- Continued calibration work
  - Update analyzer Čerenkov class
  - BigBite optics
  - BigBite shower calibration
  - LHRS efficiencies (electron detection, pion rejection, cuts)
  - Target analysis
- Simulation work
  - Pion rejectors
  - Compton photon detector

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