Status Report on the Precision Measurement of d_2^n

Experiment E06-014

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Probing QCD Through Quark-Gluon Interactions

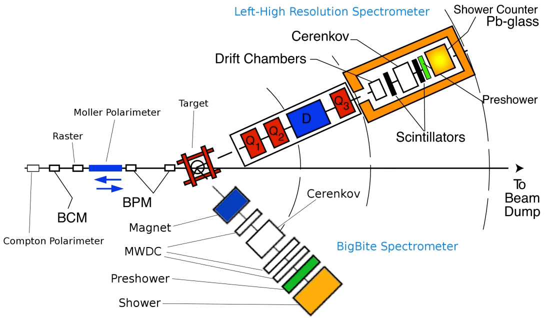
- d_2^n, the second moment of a linear combination of the spin structure functions g_1 and g_2, gives access to quark-gluon correlations

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

- There are several interesting interpretations of 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, so precision data at high x can greatly improve our picture of nucleonic quark-gluon interactions

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: measure the total unpolarized cross section σ_0
- BigBite: measure the asymmetries $A_{\parallel}$ and $A_{\perp}$

Measuring d_2^n

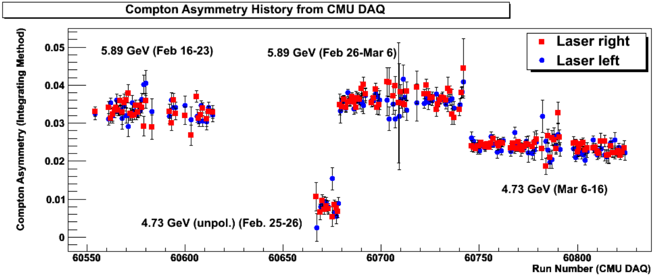
- Measure total cross section σ_0 and asymmetries $A_{\parallel}$ and $A_{\perp}$

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

- From there, we can compute the spin structure functions g_1 and g_2 – and finally, d_2^n
  - $g_1 = \frac{MQ^2}{4\alpha^2} \frac{y}{(1-y)(2-y)} 2\sigma_0 \left[A_{\parallel} + \tan\frac{\theta}{2} A_{\perp}\right]$
  - $g_2 = \frac{MQ^2}{4\alpha^2} \frac{y^2}{2(1-y)(2-y)} 2\sigma_0 \left[-A_{\parallel} + \frac{1+(1-y)\cos\theta}{(1-y)\sin\theta} A_{\perp}\right]$
- We expect a fourfold improvement in the error on d_2^n over previous measurements:
  - $\Delta d_2^n \approx 7.5 \times 10^{-4}$

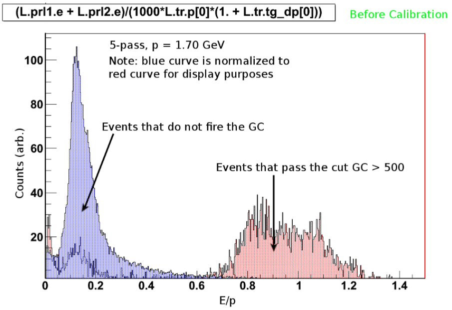
Electron Beam Polarimetry

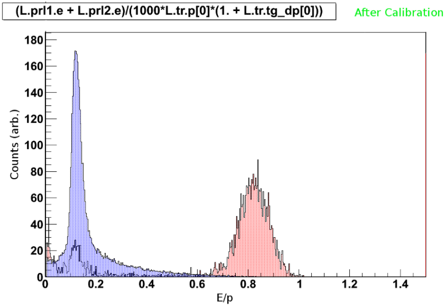
- To compute $A_{\|}$ and $A_{\perp}$, we need precise knowledge of the electron beam polarization
- Polarimetry strategies:
  - Four Moller measurements during production running
  - Commissioning of new Compton photon detector, integrating DAQ method
- We are nearly finished analyzing Compton polarization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



Gain Matching

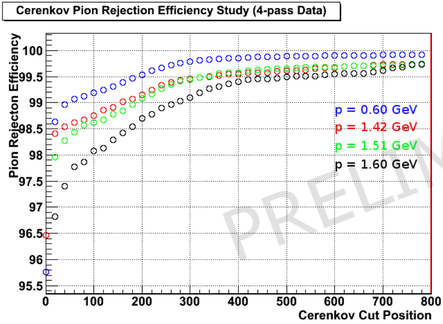
- We must gain-match our PMTs in order to make meaningful comparisons between their ADC spectra
- We have completed this work for
  - Gas Čerenkov (10 PMTs)
  - Pion rejectors (34 blocks in each of two layers)

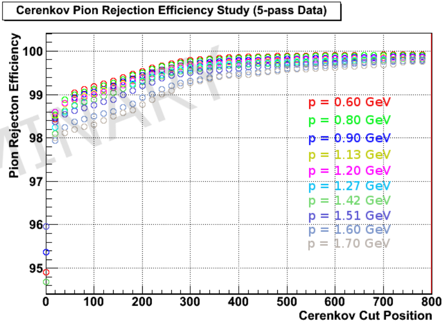




Pion Rejection Efficiency in Gas Čerenkov

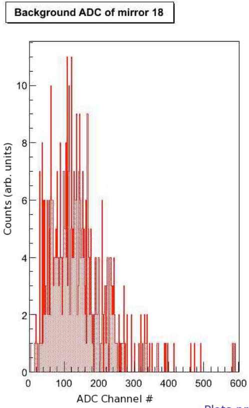
- How efficient is the LHRS gas Čerenkov at finding pions?
- It depends on the cut position in the Čerenkov and on the momentum setting
- We can compute the efficiency by testing the Čerenkov's treatment of a pion sample (selected in the pion rejector): $e = 1 - N_\pi^{Cer}/N_\pi^{PR}$

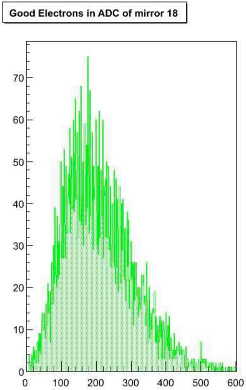




BigBite Čerenkov Calibration

- A "good electron" in a given BigBite Čerenkov PMT will have struck the corresponding mirror
- Determining whether a given track hit the right mirror gives us a sense of the background in the Čerenkov PMTs





Plots provided by M. Posik

Future Work

- Continued calibration work
  - BigBite optics
  - BigBite shower calibration
  - LHRS efficiencies (electron detection, pion rejection, cuts)
- Simulation work
  - Pion rejectors
  - Analyzing power for new Compton photon detector