A Precision Measurement of d_2^n: Color Field Response to Nucleon Polarization

On behalf of the d2n Collaboration

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Outline

Brief Motivation

Motivation

- Nature of quark confinement remains a mystery in strong interaction physics
  - An understanding of the dynamics of quark-gluon interactions is needed
- How do we probe these quark-gluon interactions?
  - Through structure functions at intermediate $Q^2(\sim 3GeV^2)$
  - Quark-Gluon correlations are exposed
- The most interesting physics can be found in the g_2 structure function

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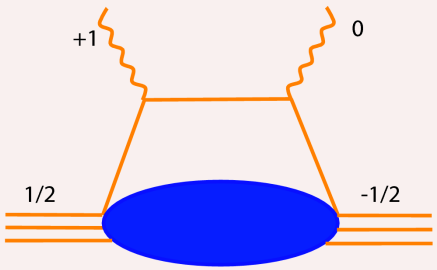
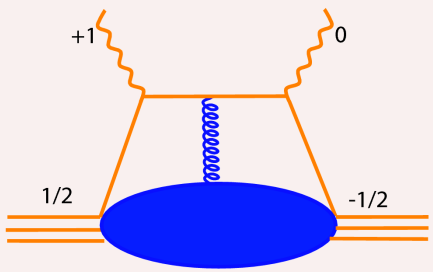
Quark-Gluon Correlation

$g2$ Structure Function

$$g_2(x, Q^2) = g_2^{WW}(x, Q^2) + \overline{g_2}(x, Q^2)$$



Leading twist = twist-2



Higher twist = twist three

Figure: QCD allows helicity exchange through two principle means

- $g(x, Q^2)_2^{WW} = -g_1(x, Q^2) + \int_x^1 g_1(y, Q^2) \frac{dy}{y}$
- $\overline{g_2}(x, Q^2) = -\int_x^1 \frac{\partial}{\partial y} \left[\frac{m_q}{M} h_T(y, Q^2) + \xi(y, Q^2) \right] \frac{dy}{y}$

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Forms of d_2^n

d_2^n Expressed in Terms of Structure Functions

$d_2^n = \int_0^1 x^2 \left[2g_1 + 3g_2\right] dx = 3\int_0^1 x^2 \overline{g_2} dx$

- Expressed in terms of measurable quantities

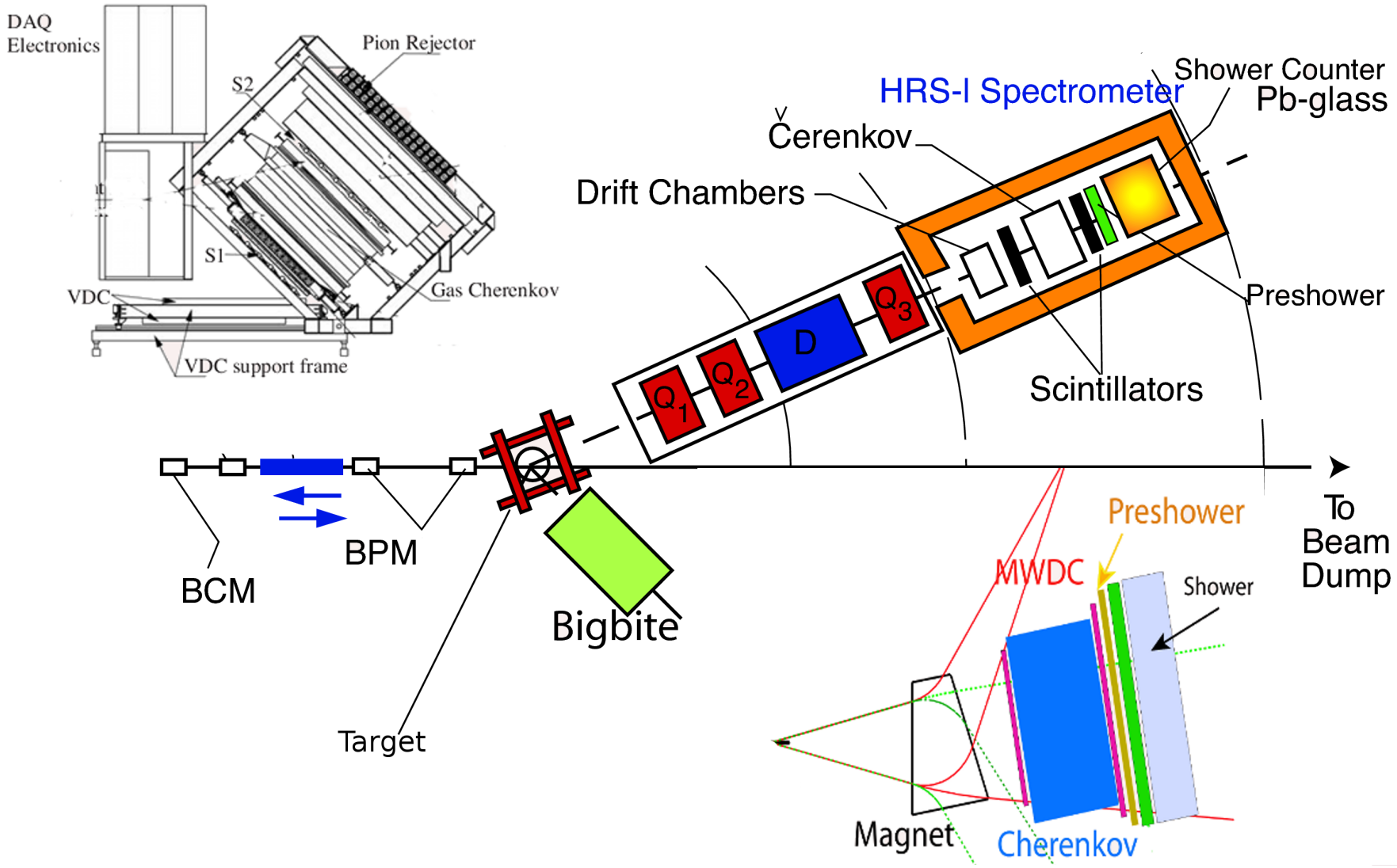
d_2^n Through OPE in Nucleon Rest Frame

$F^y(0) = -\frac{\sqrt{2}}{2P^+}\langle P,S|\overline{q}(0)G^{y+}(0)\gamma^+ q(0)|P,S\rangle = -\frac{M^2 d_2^n}{2}$

- d_2^n is averaged transverse force acting on the struck quark immediately after being struck by a virtual photon (M. Burkardt)
- Decomposition into electric and magnetic components, $F^y_{E,B}(0) \sim \chi_{E,B}$ leads to:
  - $d_2^n = \frac{1}{8}\left(\chi_E + 2\chi_B\right)$ (X. Ji)
- Shows color field response to polarized nucleon

Outline

Experimental Setup: $e^- + {}^3HE$ DIS



d_2^n Expressed in Terms of Measurable Quantities

Evaluating g_1,g_2 and Extracting d_2^n

- $g_1 = \frac{MQ^2}{4\alpha^2}\frac{y}{(1-y)(2-y)}2\sigma_0\left[A_\parallel + tan\frac{\theta}{2}A_\perp\right]$
- $g_2 = \frac{MQ^2}{4\alpha^2}\frac{y^2}{2(1-y)(2-y)}2\sigma_0\left[-A_\parallel + \frac{1+(1-y)cos\theta}{(1-y)sin\theta}A\perp\right]$
- $d_2^n = \int_0^1 \frac{MQ^2}{4\alpha^2}\frac{x^2y^2}{(1-y)(2-y)}\sigma_0\left[\left(3\frac{1+(1-y)cos\theta}{(1-y)sin\theta} + \frac{4}{y}tan\frac{\theta}{2}\right)A_\perp + \left(\frac{4}{y} - 3\right)A_\parallel\right]dx$

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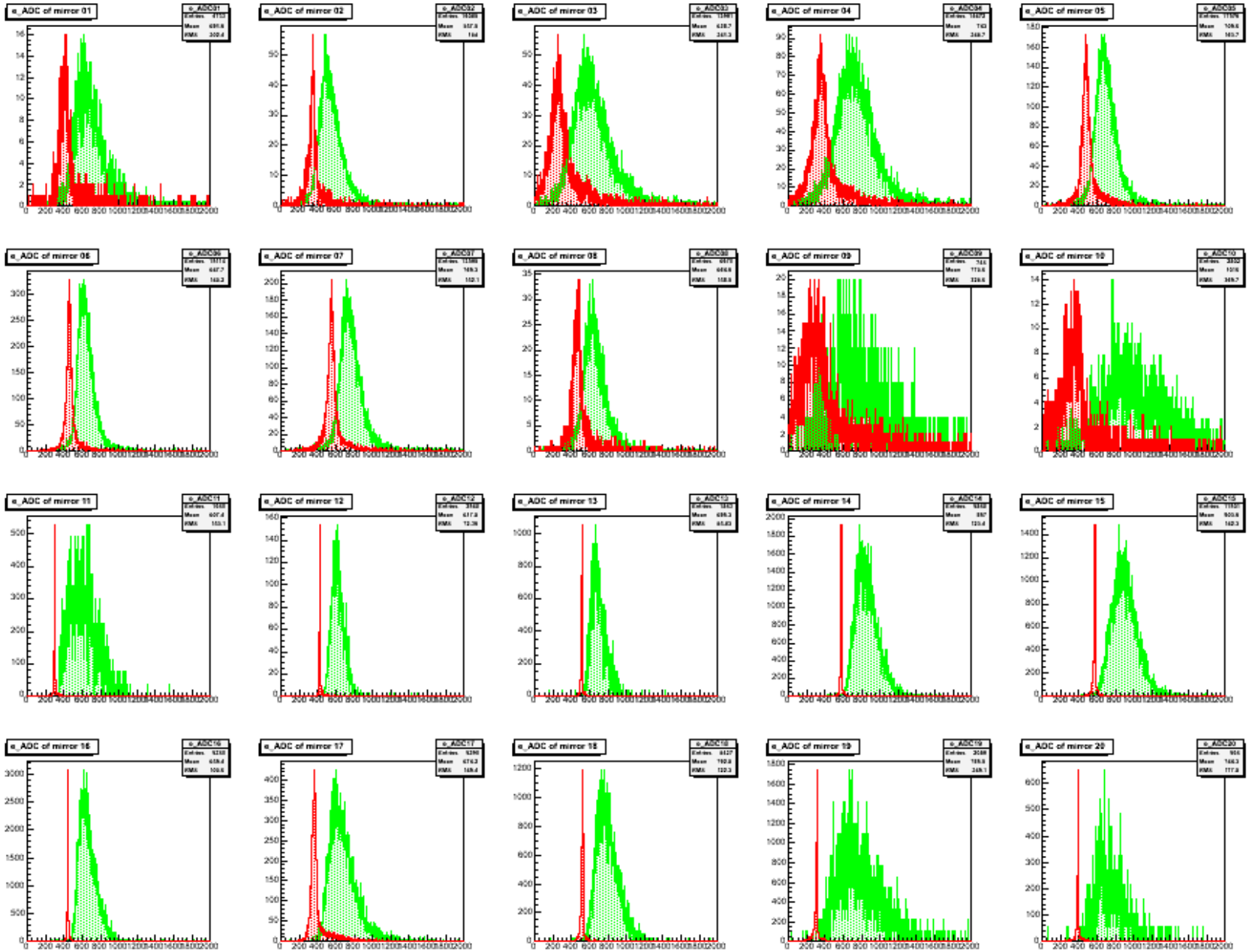
a_ADC of mirror 01
a_ADC of mirror 02
a_ADC of mirror 03
a_ADC of mirror 04
a_ADC of mirror 05
a_ADC of mirror 06
a_ADC of mirror 07
a_ADC of mirror 08
a_ADC of mirror 09
a_ADC of mirror 10
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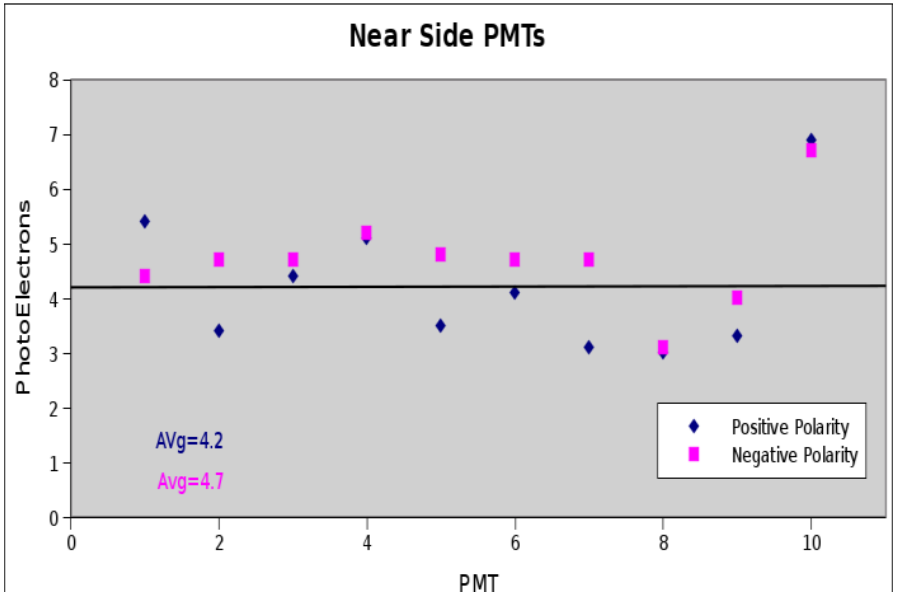

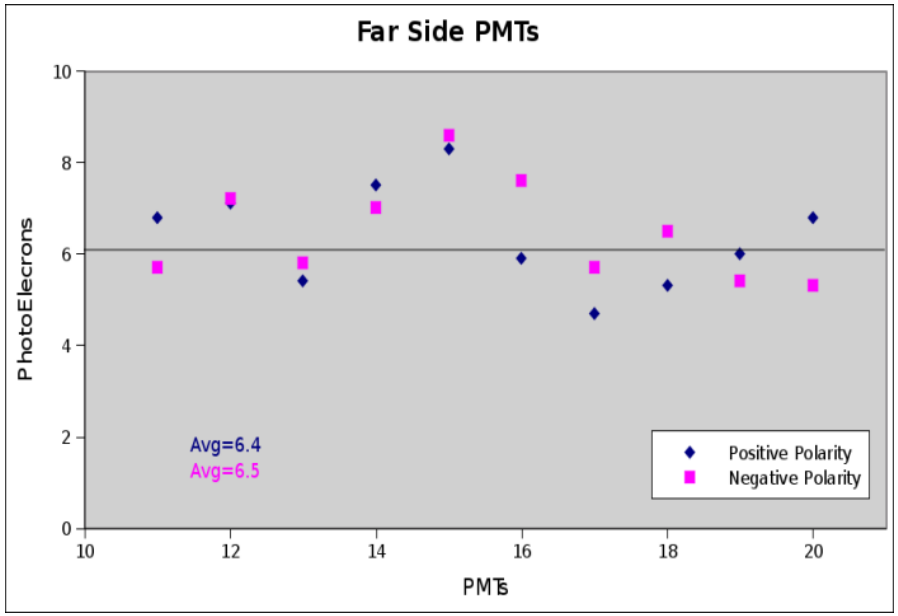

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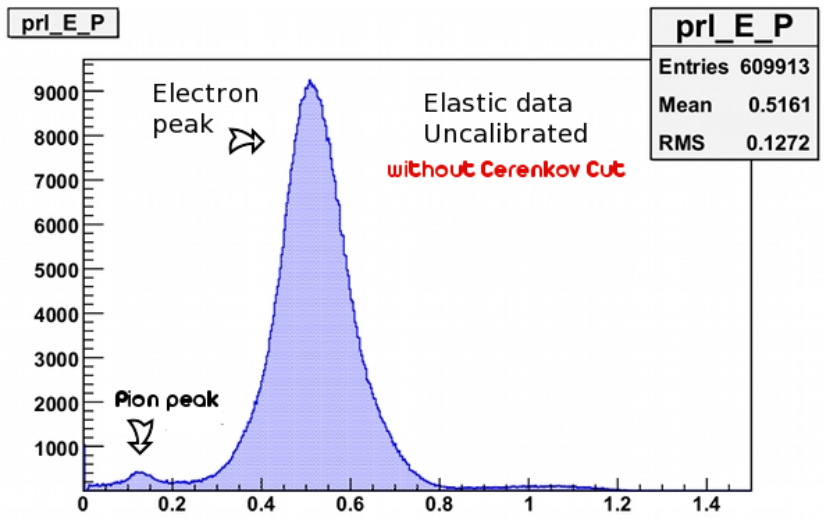
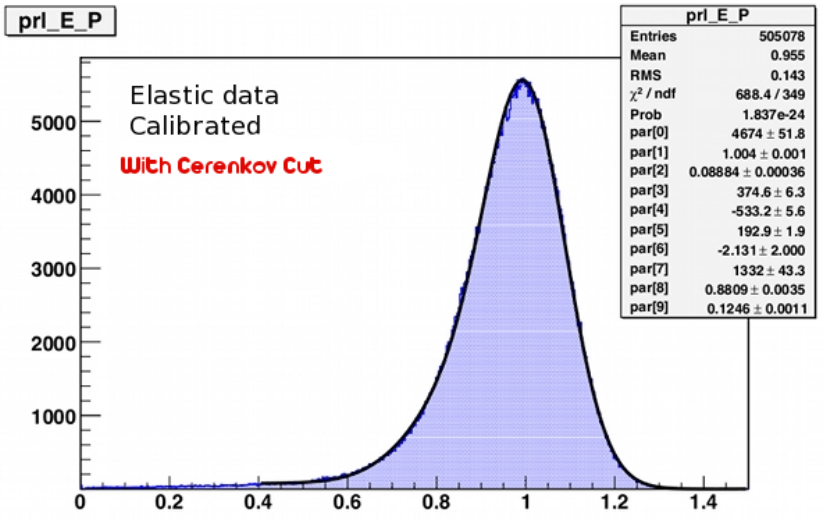
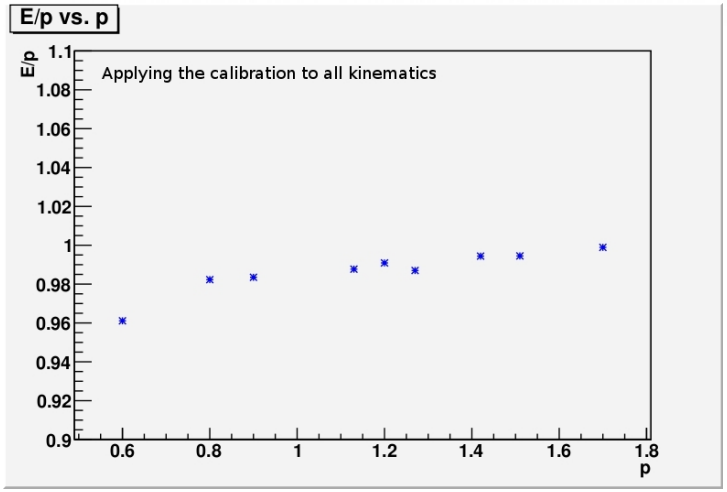
E/P Calibration







- Electron peaks aligned in ADC spectra for each layer
- Calibration consistent within 2% of elastic calibration

Figure: Plots by David Flay

Summary

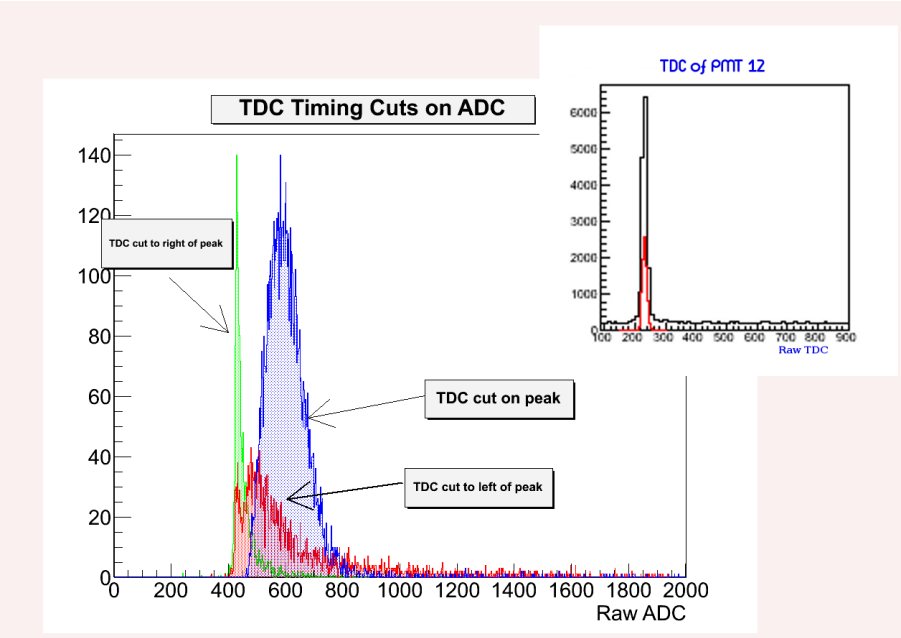
- Big Bite Cerenkov shows average of 6-8 photoelectrons
- LHRS E/p nearly finished
- For Compton progress/status see Alexandre Camsonne talk Friday 12:20pm

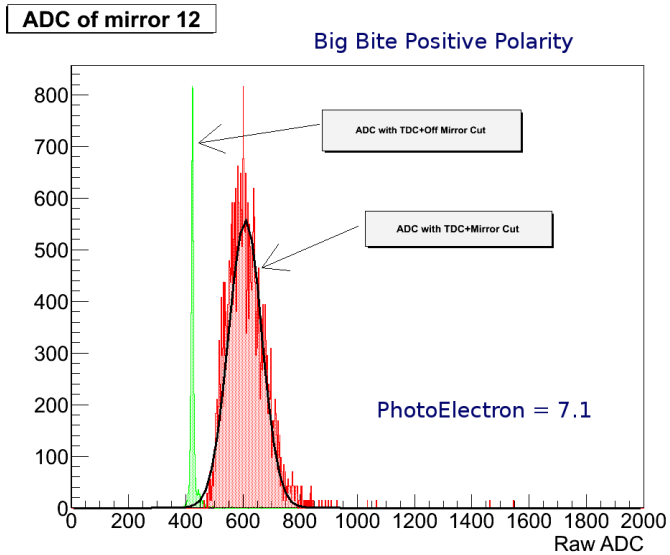
Future Work

- Finish LHRS/BB/Beamline calibrations
- Understand Systematics
- Work with elastics data
- Extract preliminary asymmetries

I Would Like to Thank...

Seonho Choi, Xiaodong Jiang, Zein-Eddine Meziani, Brad Sawatzky, The HallA Staff, The run coordinators during the experiment,the Transversity students,CMU and Temple University.


TDC Timing Cuts on ADC
TDC cut to right of peak
TDC cut on peak
TDC cut to left of peak
Raw ADC
TDC of PMT 12
Raw TDC


ADC of mirror 12
Big Bite Positive Polarity
ADC with TDC+Off Mirror Cut
ADC with TDC+Mirror Cut
PhotoElectron = 7.1
Raw ADC