E97-110 Status Report

Vincent Sulkosky
The College of William and Mary

Hall A Collaboration Meeting
December 05^{th}, 2005

Spokespersons: J.P. Chen, A. Deur, F. Garibaldi

Ph. D. Students: J. Singh, V. Sulkosky, J. Yuan

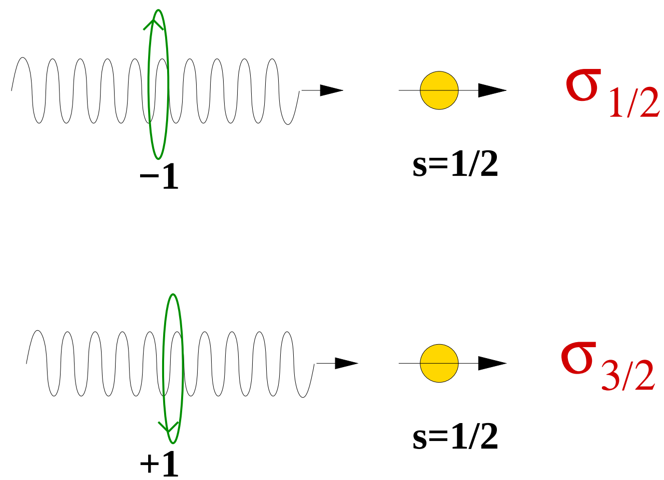
Experiment E97-110

The ^{3}He and the Neutron Generalized GDH Sum Rule at Low Q^2

- Measurements:
  - Polarized cross sections and asymmetries for $^3\overrightarrow{\mathrm{He}}(\vec{e},e')X$
  - Precise measurement of generalized GDH integral at low Q^2 (0.02 to 0.3 $(\mathrm{GeV})^2$)
- Aspects of the experiment:
  - Electrons detected at scattering angles of 6° and 9° using the right septum magnet.
  - Average beam polarization = 74.7% from Møller and 74.9% from Compton.
  - Average target polarization $\sim$ 39% (NMR and EPR).

GDH Sum Rule ($Q^2 = 0$)

- Circularly polarized photon incident on a longitudinally polarized spin-$\frac{1}{2}$ target
- $\sigma_{\frac{1}{2}}$ ($\sigma_{\frac{3}{2}}$) photo-production cross sections



$$I_{\rm GDH} = \int_{\nu_0}^{\infty} (\sigma_{\frac{1}{2}} - \sigma_{\frac{3}{2}}) \frac{d\nu}{\nu} = -\frac{2\pi^2 \alpha \kappa^2}{M^2}$$

$$= -496\ \mu\text{b} \quad ({}^3\text{He})$$

$$= -233.2\ \mu\text{b} \quad (\text{neutron})$$

Generalized GDH Integral ($Q^2 > 0$)

$$I(Q^2) \;=\; \int_{\nu_0}^{\infty} \left[\frac{K(\nu,Q^2)}{\nu}\right] \left[\sigma_{\frac{1}{2}}(\nu,Q^2) - \sigma_{\frac{3}{2}}(\nu,Q^2)\right] \frac{d\nu}{\nu}$$

$$K(\nu,0) = \nu$$

- Replaces the photo-production cross sections with the corresponding electro-production cross sections.
- Related to the virtual photon Compton Amplitudes $S_1(\nu,Q^2)$ and $S_2(\nu,Q^2)$.
- The experimentally measured quantity can be compared to theoretical predictions over the whole Q^2 range.
- Provides a bridge from the the non-perturbative region to the perturbative region of QCD.

Analysis Overview and Status

- Experimental run database (J. Singh)
- Beamline:
  - Beam polarimetry (T. Holmstrom)
  - Current, bleedthrough, beam position (T. Holmstrom and V. Sulkosky)
  - Raster calibration (V. Sulkosky)
- Spectrometer optics (V. Sulkosky) [N. Liyanage]
- Elastic analysis (J. Singh)
- Background studies (A. Deur and S. Dhamija) [A. Beck]

Green: Analysis Completed

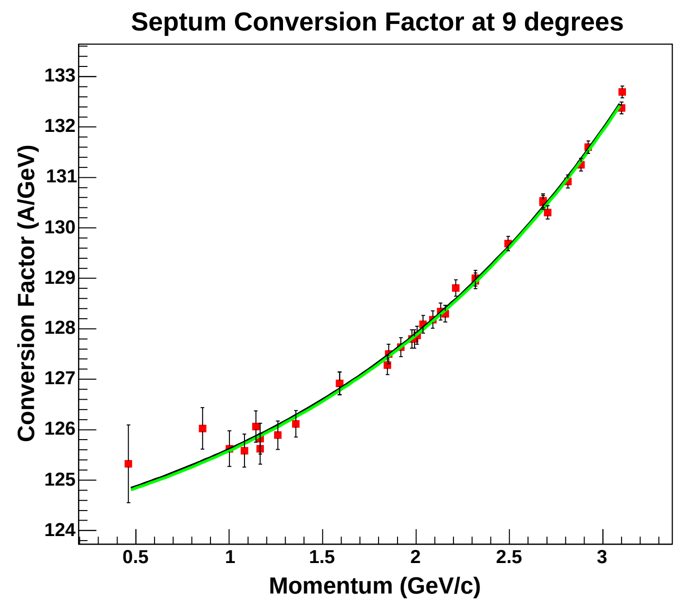
Orange: Analysis Underway or Partially Completed

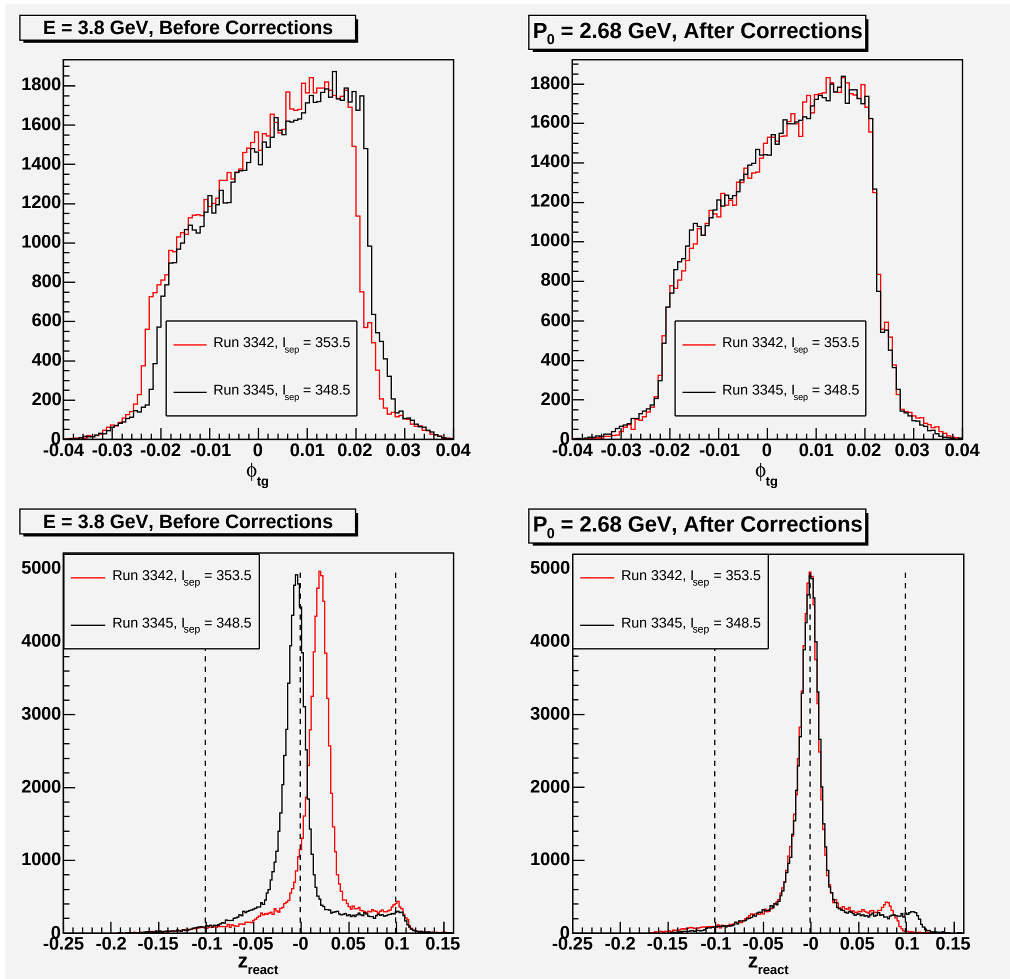
Blue: From Online Analysis

- Detectors:
  - Particle Identification (PID) (J. Yuan and H. Lu)
  - Wire Chambers (VDC) (S. Dhamija and J. Yuan) [H. Lu]
  - Scintillators (J. Singh)[H. Lu]
- Spectrometer Acceptance (V. Sulkosky)
- N_2 Dilution (X. Zhan)[USTC]
- Scaler Analysis: charge asymmetry and deadtime (J. Yuan and T. Holmstrom)
- False Asymmetry (T. Holmstrom)
- Target (J. Singh, P. Solvignon and V. Sulkosky)
- Physics Analysis, extract physics quantities, systematic errors
  (J. Singh, V. Sulkosky and J. Yuan)[USTC]
- Radiative Corrections (T. Averett)

Spectrometer Optics

- Optimization completed.
- A prescription was developed to interpolate between optimized settings due to shifts seen in the reconstructed target quantities.
- A technical note on the spectrometer optics study has been written.

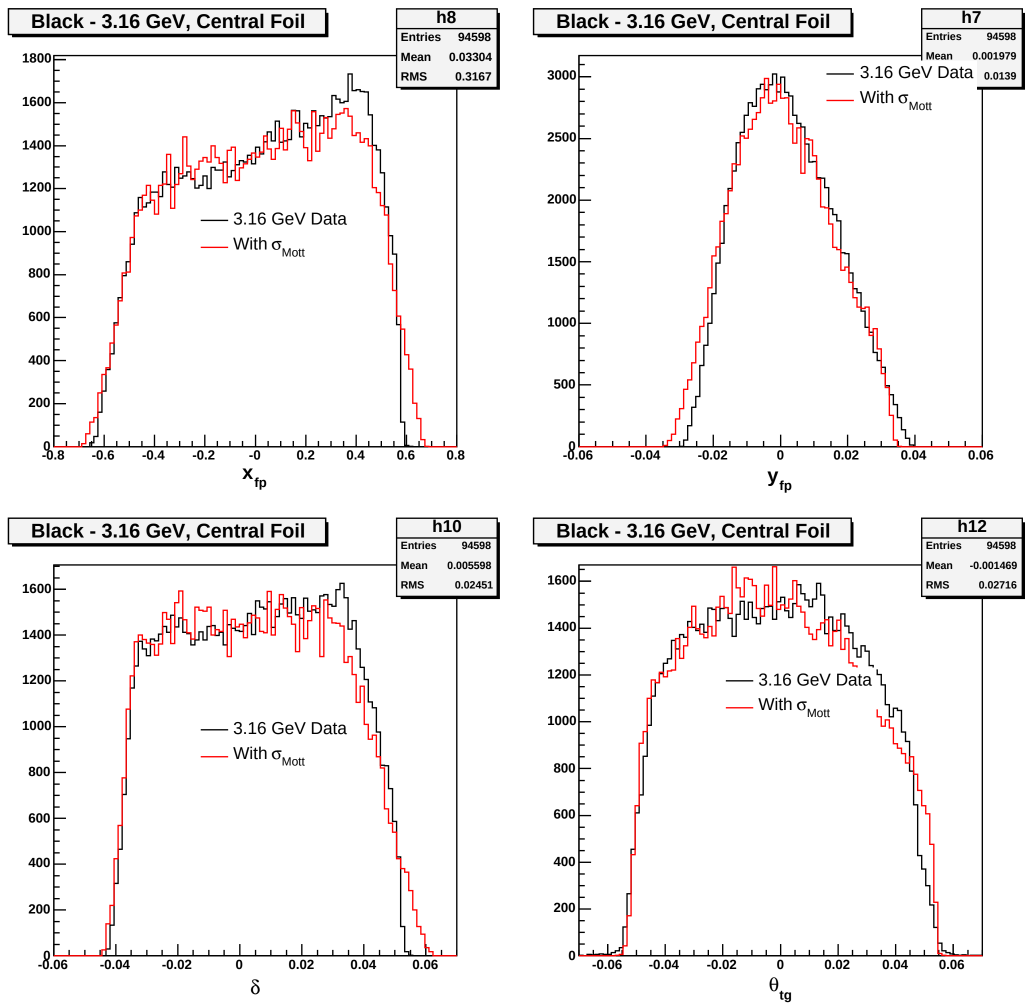




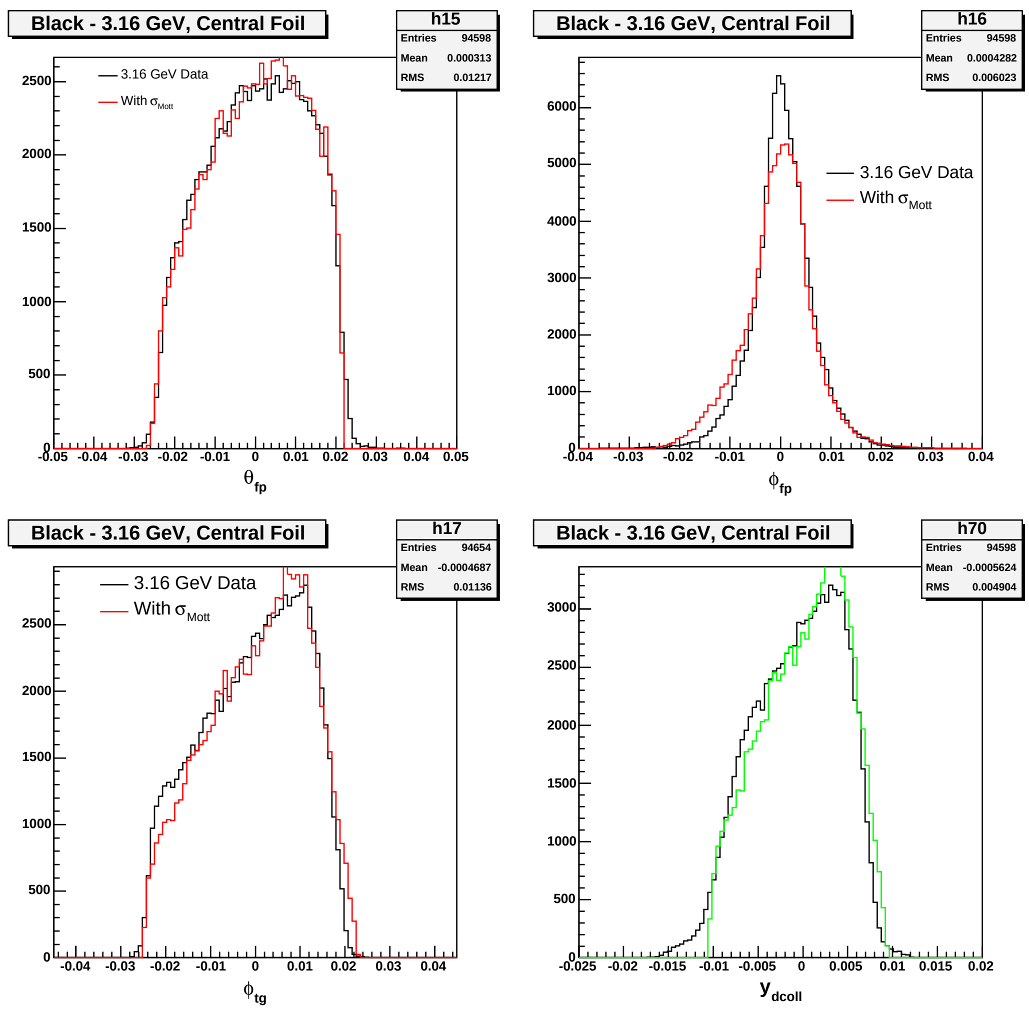
E = 3.8 GeV, Before Corrections
P0 = 2.68 GeV, After Corrections
Run 3342, Isep = 353.5
Run 3345, Isep = 348.5
ϕtg
zreact

Spectrometer Acceptance

- Modified existing code to include the septum magnet.
  - Uses right arm transfer functions (J. LeRose).
  - Added the bore cooler used during the experiment.
  - Reduced the Q3 aperture radius (28 cm).
- Weighted simulation by σ_{Mott}.
- Obtained reasonable agreement with white spectrum data at 6°.



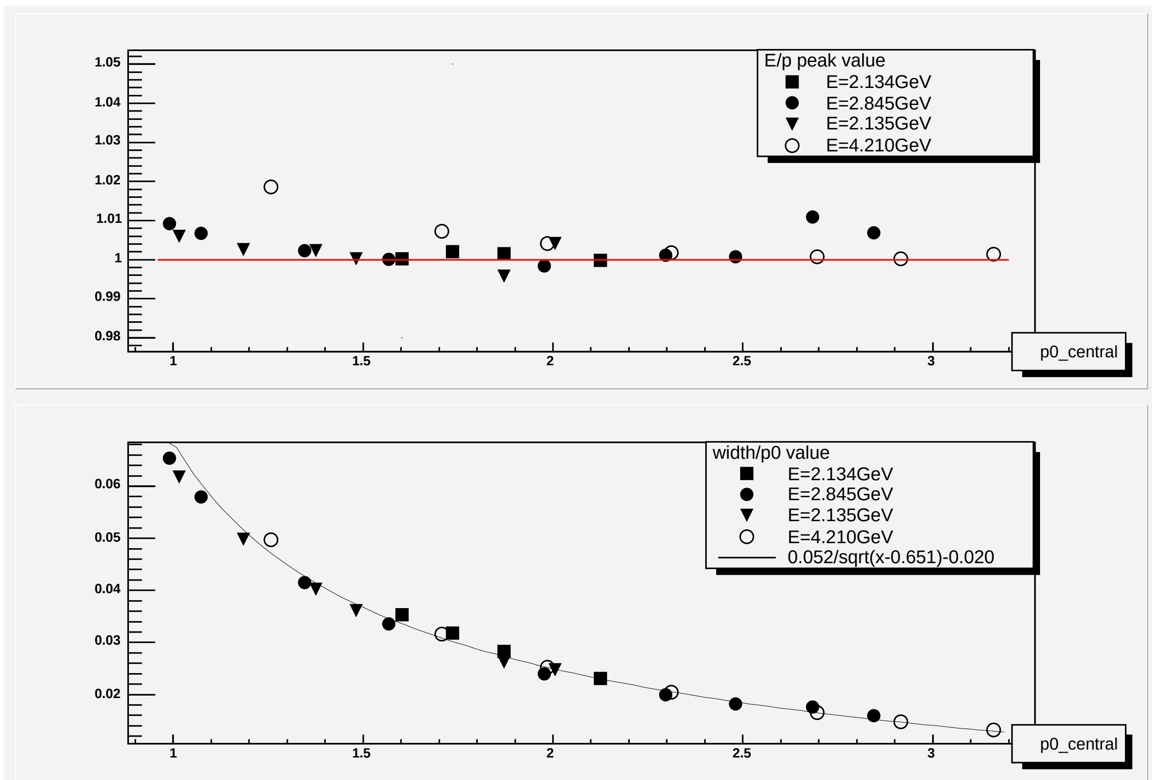
- Black: Data and Red: simulation weighted by σ_{Mott}.



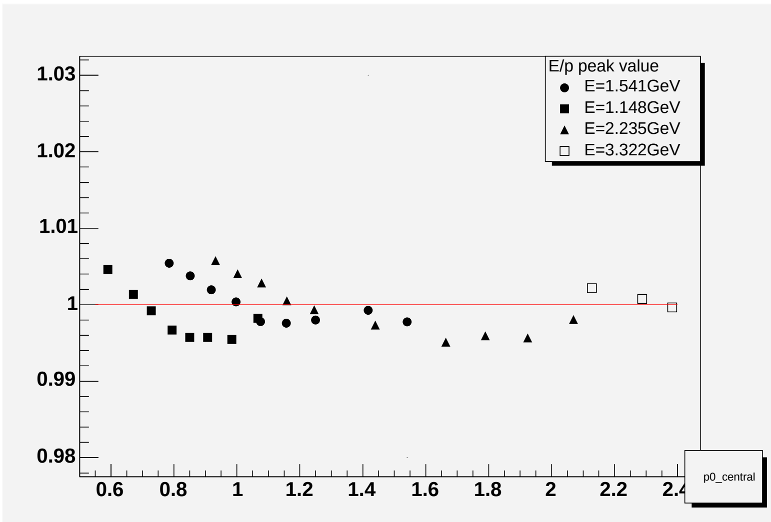
Black - 3.16 GeV, Central Foil
h15
Entries 94598
Mean 0.000313
RMS 0.01217
3.16 GeV Data
With σ_{Mott}
θ_{fp}
Black - 3.16 GeV, Central Foil
h16
Entries 94598
Mean 0.0004282
RMS 0.006023
3.16 GeV Data
With σ_{Mott}
ϕ_{fp}
Black - 3.16 GeV, Central Foil
h17
Entries 94654
Mean -0.0004687
RMS 0.01136
3.16 GeV Data
With σ_{Mott}
ϕ_{tg}
Black - 3.16 GeV, Central Foil
h70
Entries 94598
Mean -0.0005624
RMS 0.004904
y_{dcoll}

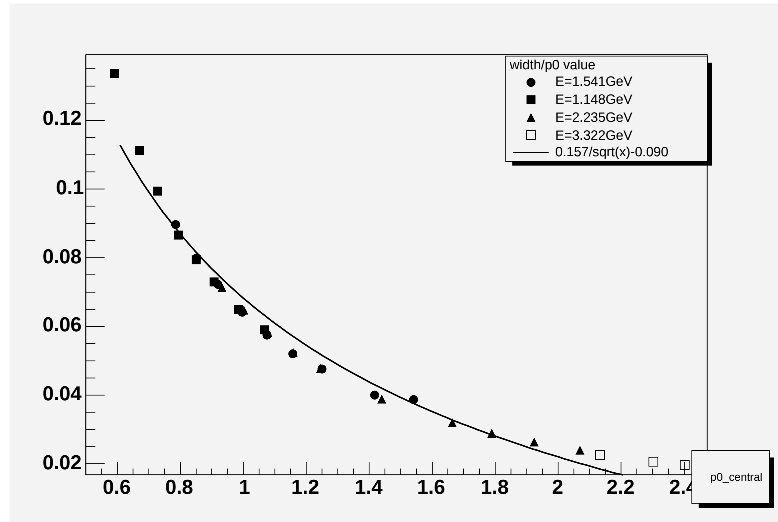
PID Calibration

- Second period PID calibration checked by H. Lu (USTC).
- First period mostly completed (H. Lu).



First Period PID

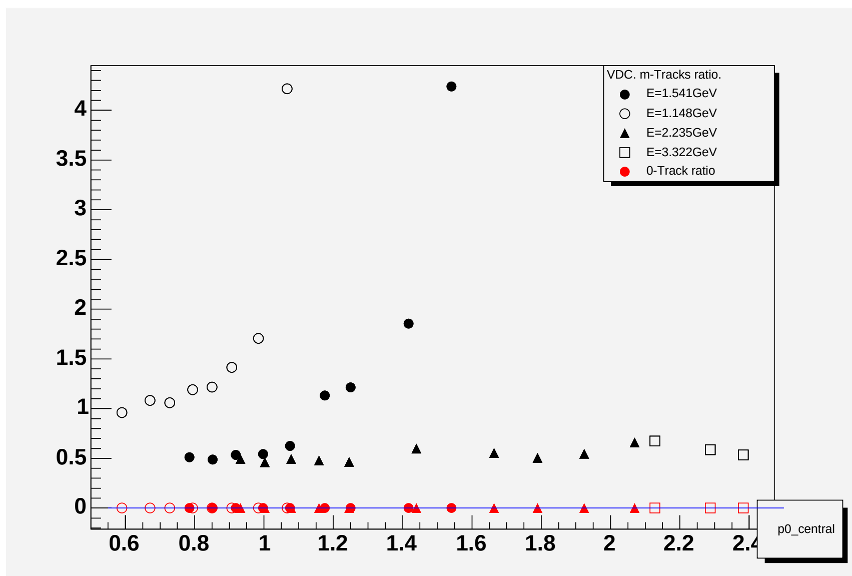




- Shower detector efficiency: $>$ 99.3% both periods
- Shower cut efficiency: $>$ 99% both periods
- Cerenkov detector efficiency: $>$ 99.5%
- Cerenkov cut efficiency: $>$ 99.5%

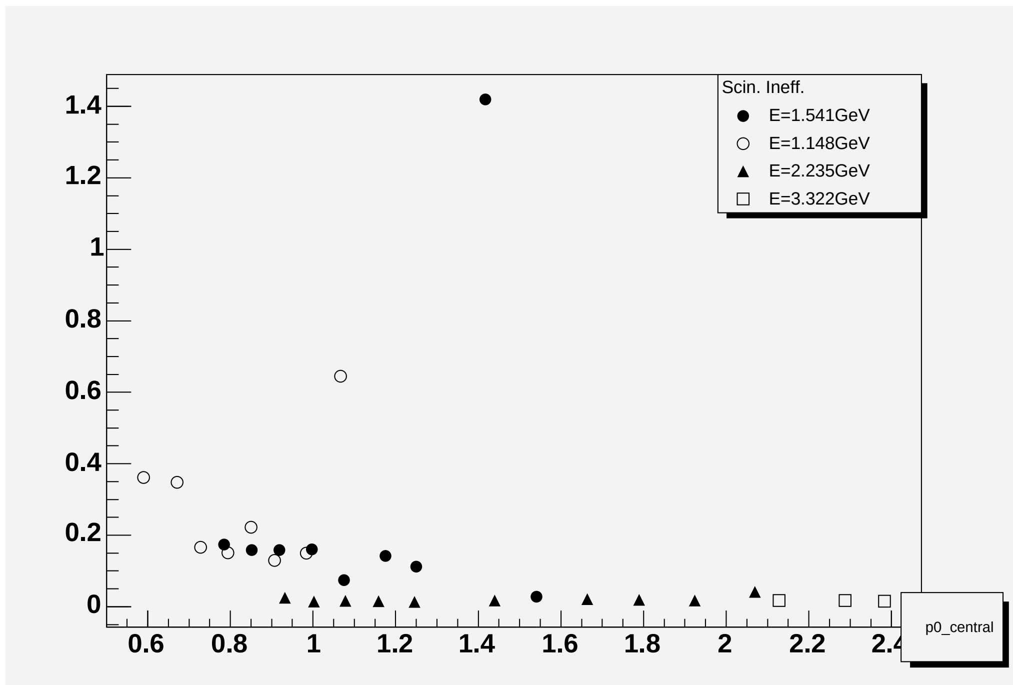
VDC Efficiency

- VDC multi-track event study (H. Lu and S. Dhamija).
- Second period, N_2 elastic data contain about 15–20% multi-track events.
- PID cuts reduce multi-track events by a factor of 2–3 (first period).

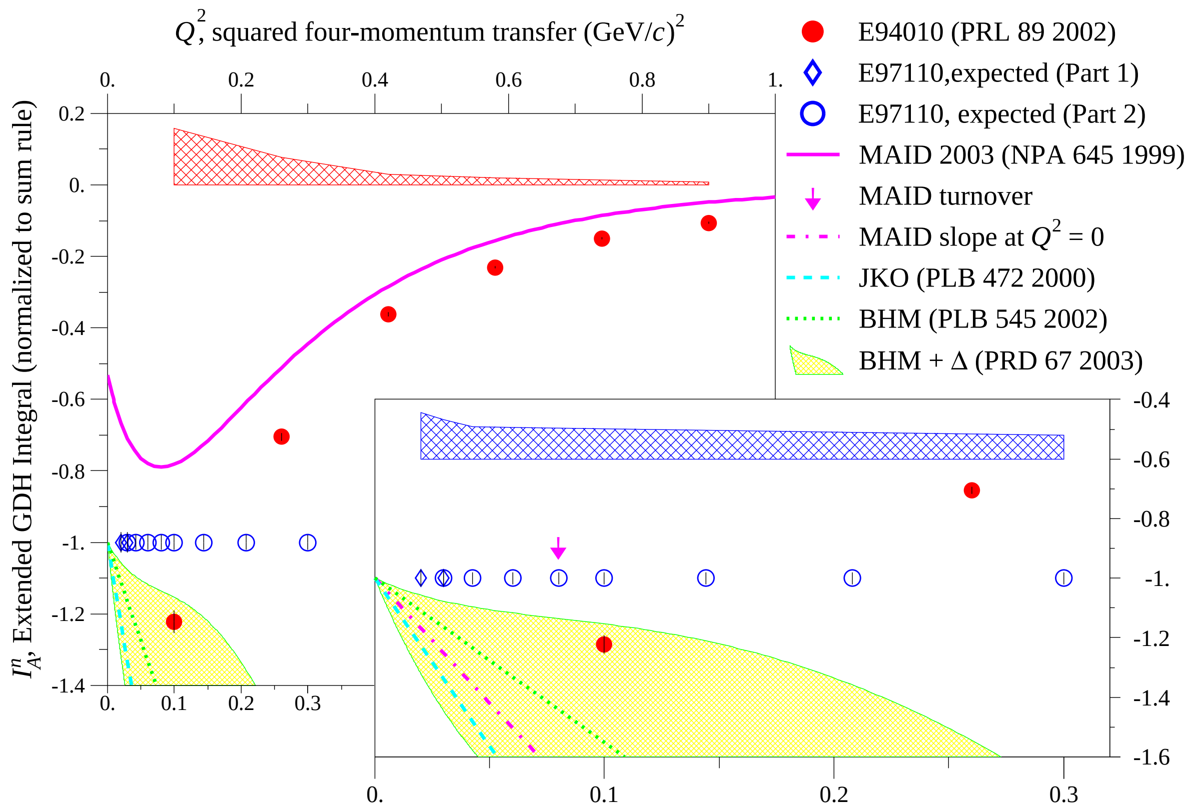


Trigger Efficiency

$$\eta_{\text{scint}} = \frac{T_2}{T_1+T_2}$$



Expected Results



Integral normalized to 233.2 μb

Summary and Plan

- Summary:
  - Measurements of the extended GDH integral will:
    - Determine the slope of the generalized GDH integral and test the dynamics of χPT.
    - Extrapolate to $Q^2 = 0$.
  - Data complements E94010 data set below $Q^2 = 0.10$ GeV^2 with improved precision.
  - Learn more about the spin structure of ^{3}He and the neutron.
  - Extract the moments of the spin structure functions and the forward spin polarizabilities.

- Analysis is underway, concentrating on the second run period.
  - Checking first run period optics with elastic data (Liyanage).
  - PID calibration mostly completed both periods (USTC).
  - Spectrometer acceptance study (Sulkosky).
- Near Term Plan:
  - Elastic analysis (Singh)
  - Scaler analysis and VDC efficiency (Yuan)
  - Scintillator analysis (Singh and Lu)
- Long Term Plan:
  - First run period analysis by USCT group (already underway)
  - Target Analysis
  - Asymmetries and cross sections
  - Radiative corrections