E97-110 Status Report

Vincent Sulkosky
The College of William and Mary

Hall A Collaboration Meeting

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

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

An Hall A collaboration experiment

Experiment E97-110

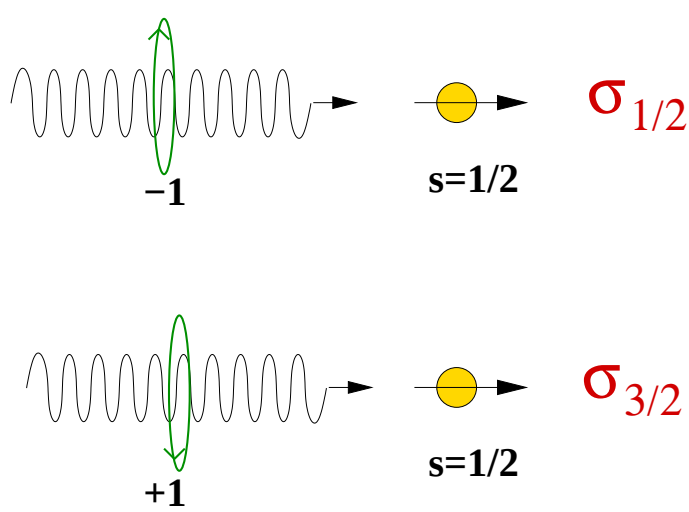
The Generalized GDH Sum Rule: Measuring the Spin Structure of ^{3}He and the Neutron using Nearly Real Photons

- Measurements:
  - $^3\vec{\mathrm{He}}(\vec{\mathrm{e}},\mathrm{e}')$X reaction
  - Polarized cross sections and asymmetries
  - Precise measurement of generalized GDH integral at low Q^2 (0.02 to 0.3 (GeV)^2)
- Aspects of the experiment:
  - The experiment ran in Spring and Summer 2003.
  - 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.
  - Three target cells used for the two run periods.

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

- Scattering of circularly polarized photon beam on longitudinally polarized spin-$\frac{1}{2}$ target.
- $\sigma_{1/2}$ ($\sigma_{3/2}$) photo-production cross sections

$$\begin{aligned} \mathrm{I}_{GDH} = \int_{\nu_0}^{\infty} (\sigma_{1/2} - \sigma_{3/2}) \frac{d\nu}{\nu} &= -\frac{2\pi^2 \alpha \kappa_{\mathrm{N}}^2}{\mathrm{M}_{\mathrm{N}}^2} \\ &= -496 \mu\mathrm{b} \\ &\quad (^3\mathrm{He}) \\ &= -233.2 \mu\mathrm{b} \\ &\quad (\mathrm{neutron}) \end{aligned}$$

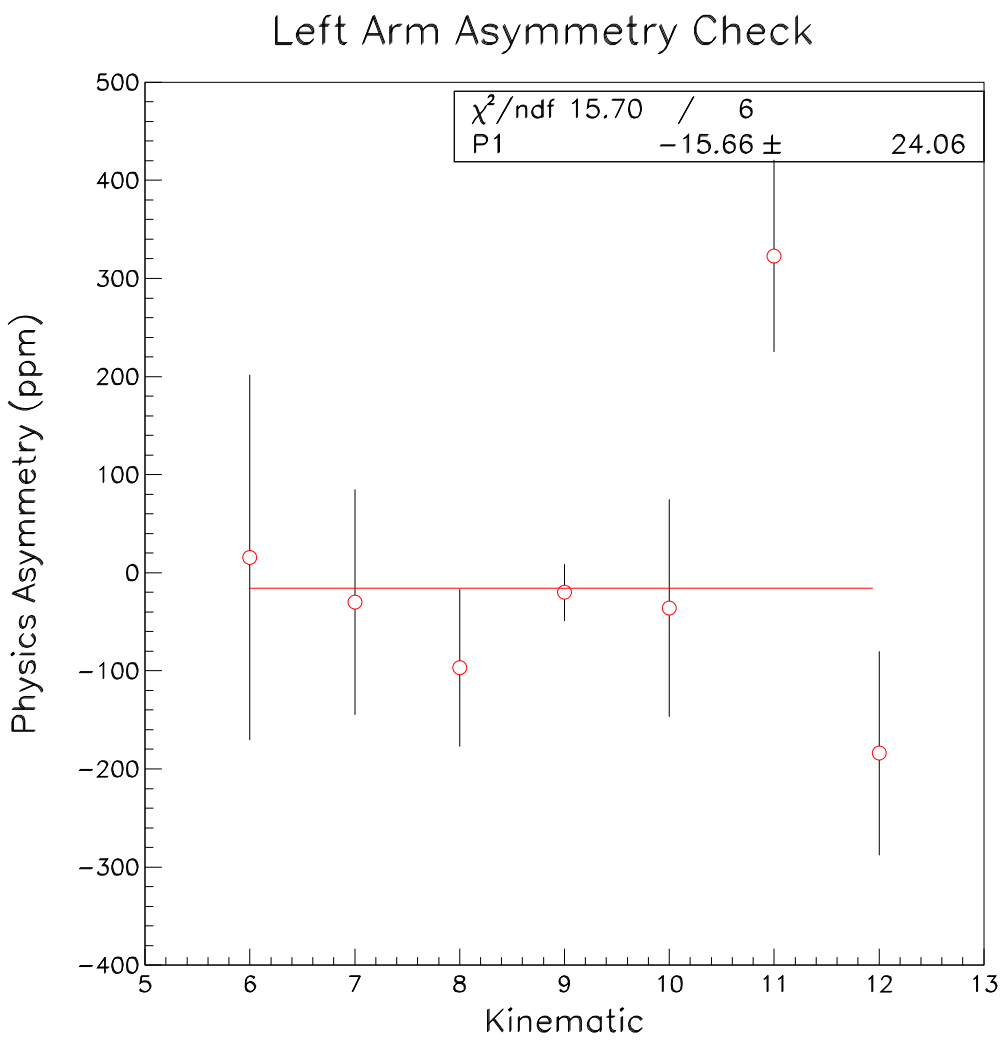


GDH at Finite Q^2

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

- Replaces the photo-production cross sections with the corresponding electro-production cross sections.
- Related to the forward Compton scattering amplitude ($S_{1(2)}$).
- Provides a bridge from the the non-perturbative region to the perturbative region of QCD.
- The experimentally measured quantity can be compared to theoretical predictions over the whole Q^2 range.

Left Arm False Asymmetry Analysis

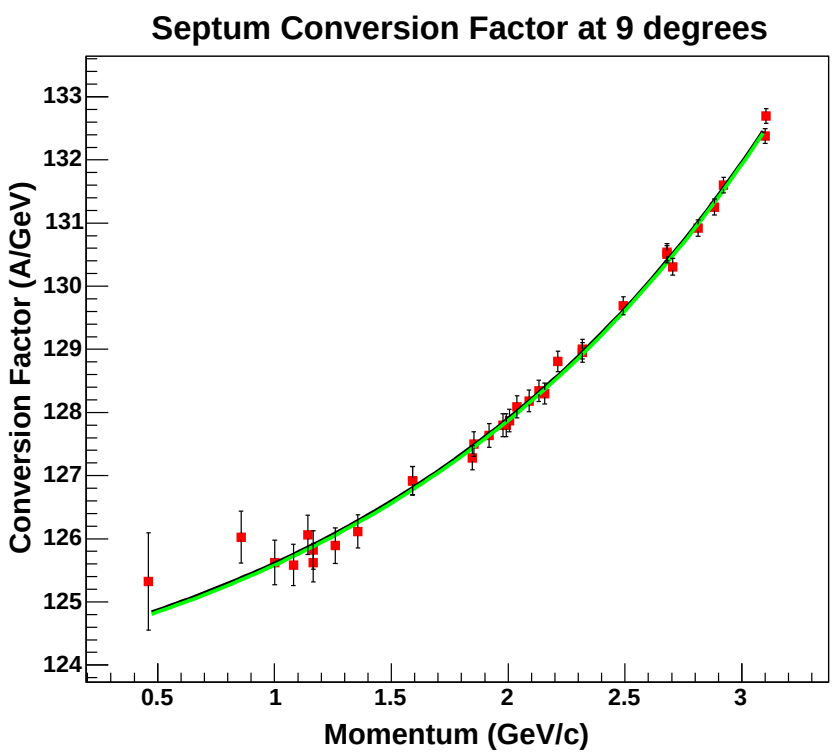


by T. Holmstrom

Database Prescription

Why Needed?

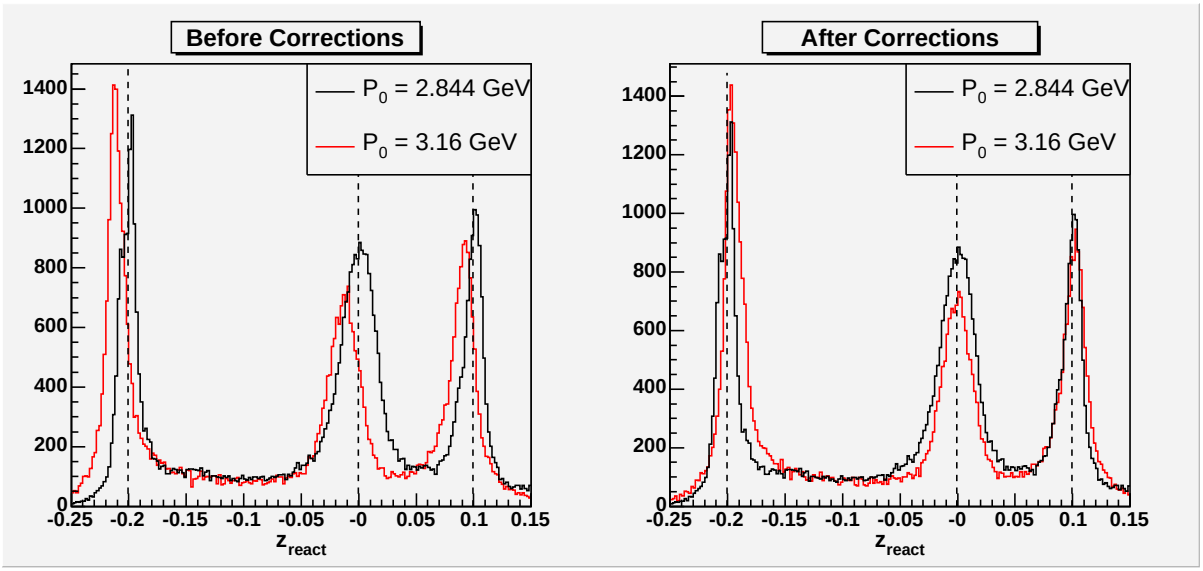
- At 6°, $I_{\mathrm{septum}} = C * P_0$, where C = 92.58 A GeV^{-1}
- At higher currents, above 200 A, the relationship is no longer linear and has an exponential shape.
  - At momenta away from the optimized settings, shifts are seen in the y_{tg} and ϕ_{tg} distributions.



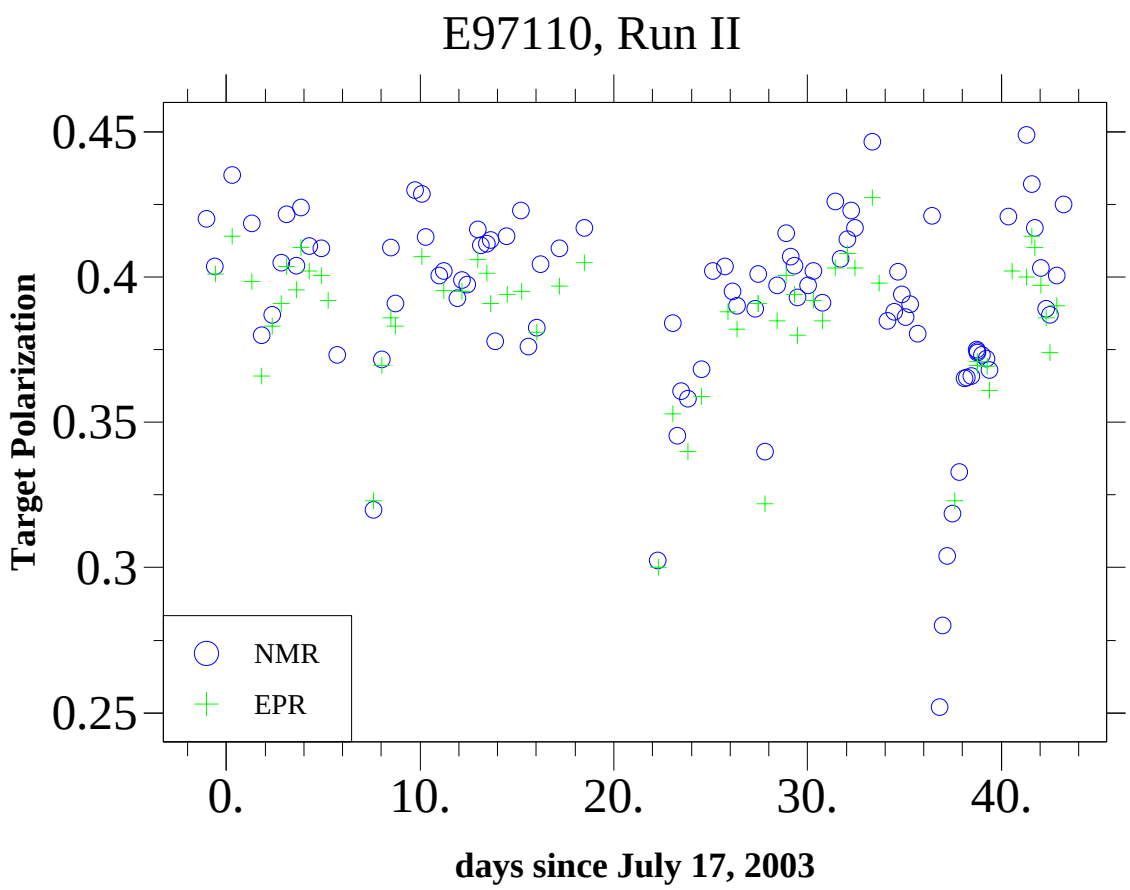
Prescription

- A prescription is needed to use the optics databases between the optimized momentum settings.
- At 6°, correction uses difference in spectrometer focal plane offets between optimized momentum settings.
- At 9°, the septum current was corrected during the run.
- However at 3.8 GeV, the current was not corrected at each momentum, so a separate correction was needed (T. Holmstrom).
- A module was written implementing the shift corrections in the Podd analyzer.

- Module was tested and works well at 6°.
- Tim Holmstrom's 9° correction still needs to be tested.



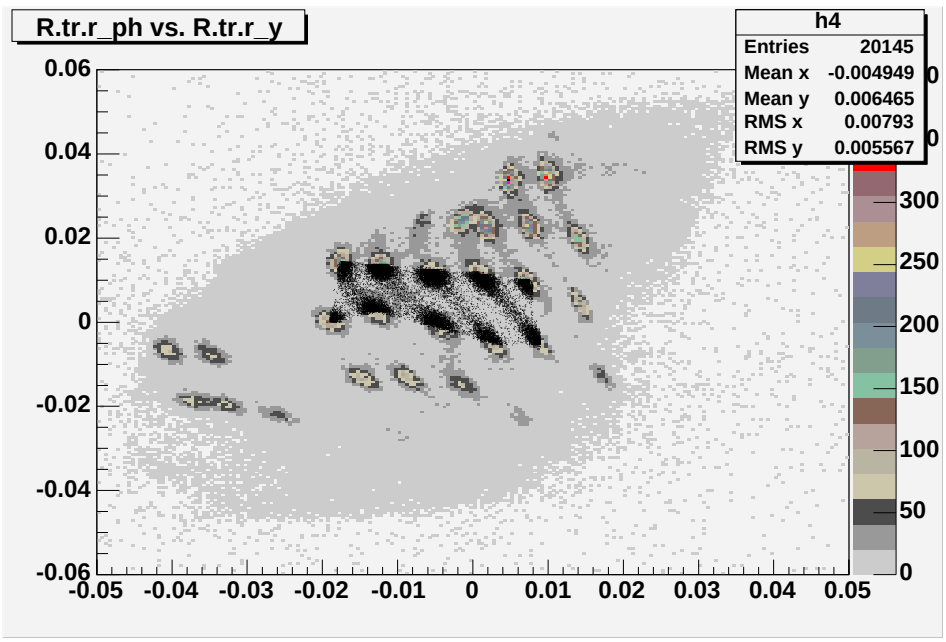
Online Target Polarizaation



P_{avg} = 38.5% (NMR and EPR)

First Run Period Optics

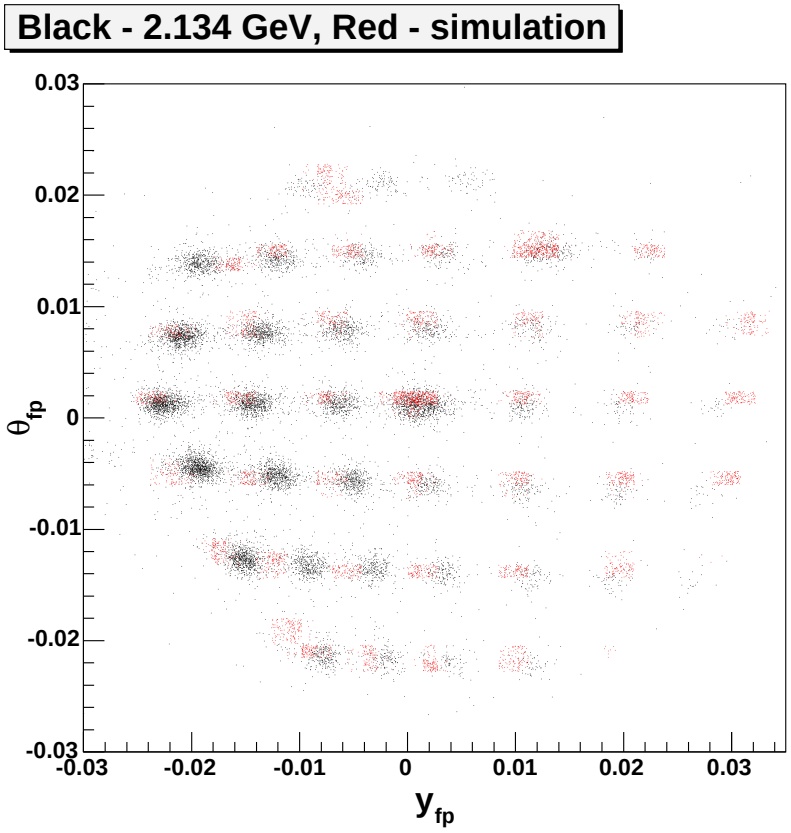
- Plan from N. Liyanage
- No reconstruction
- Define cuts at the focal plane, which depend on ϕ_{fp}, y_{fp}, and δ (x_{fp} and θ_{fp}).



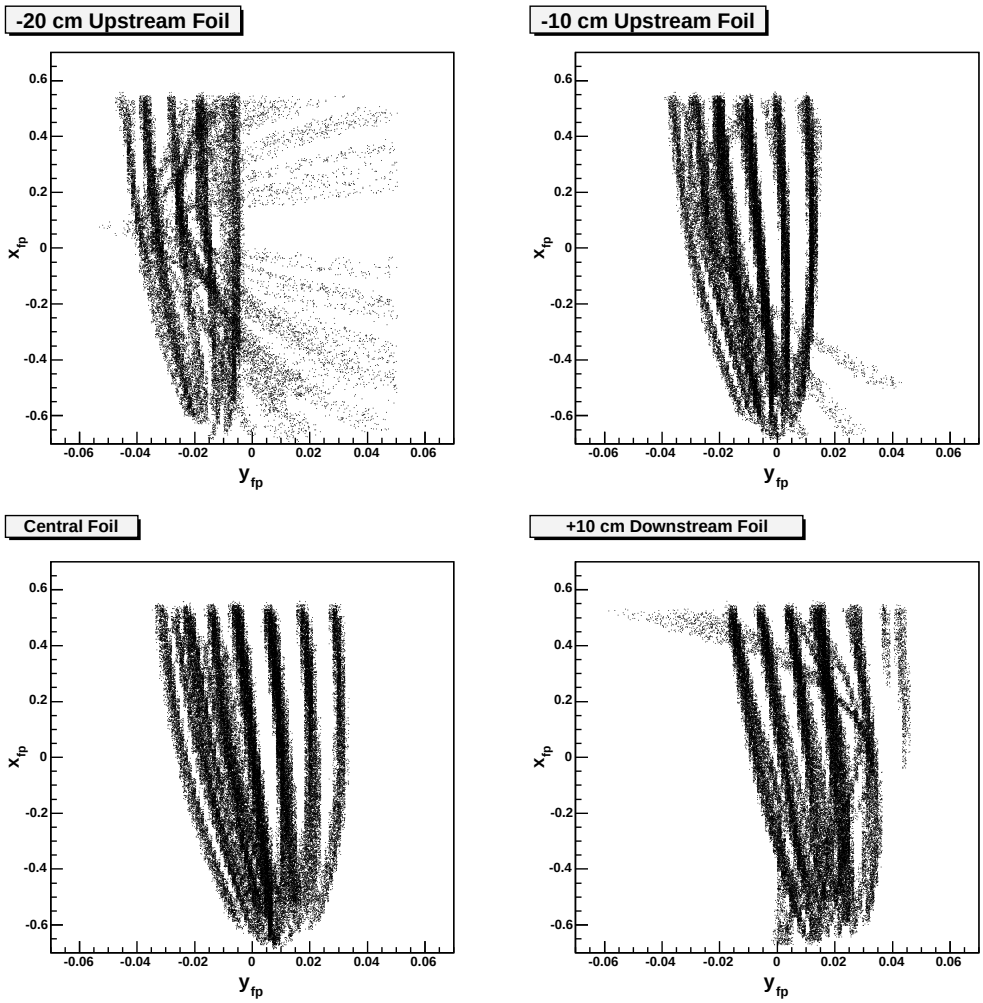
- y_{tg} acceptance determined by target collimators.
- Elastic cross section will be used to determine accuracy of acceptance.

Spectrometer Acceptance

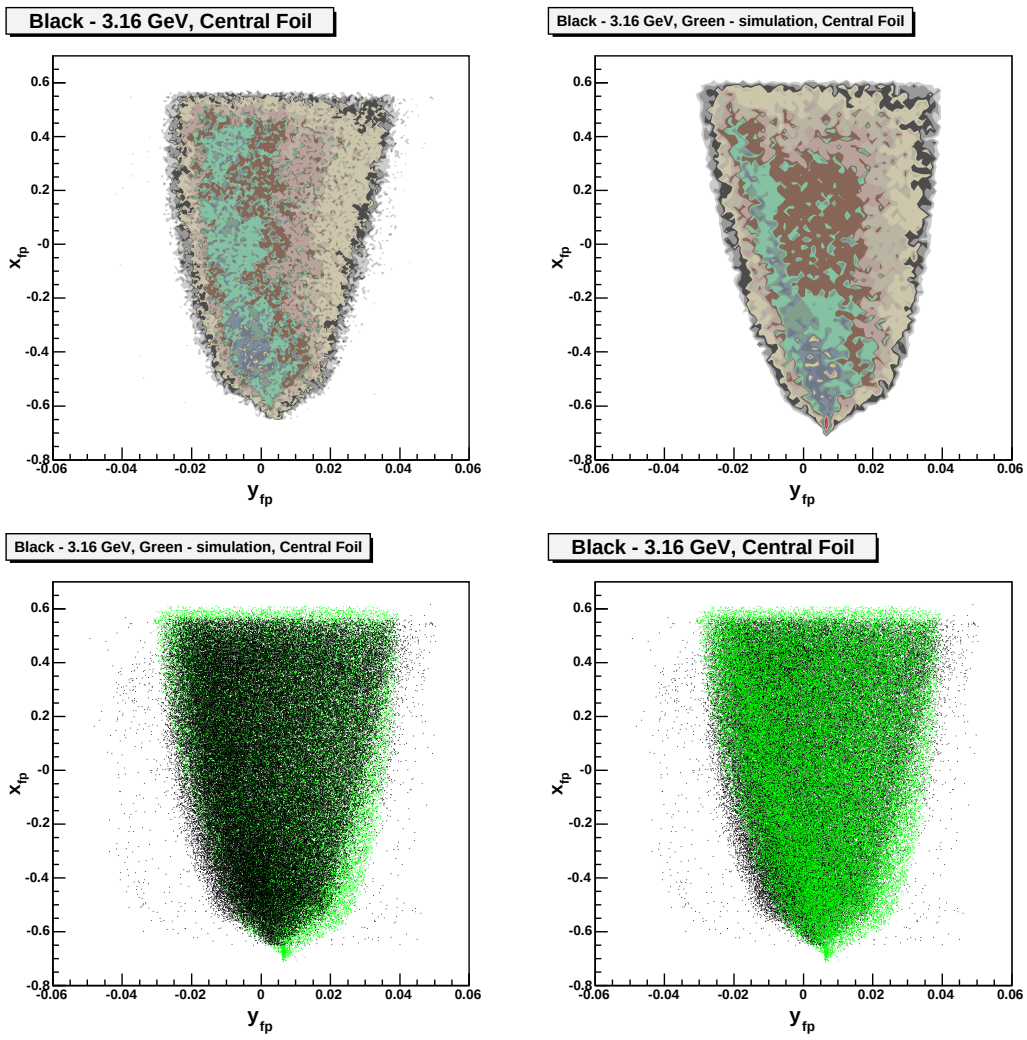
- Modified X. Jiang's Monte Carlo to include septum magnet.
  - Uses right arm transfer functions (J. LeRose).
  - Reasonable comparison between MC and sieve slit data.



- Found stray events in focal plane for extended target.
- Too small of range in x_{tg} used to fit transfer functions.
- Expanded x_{tg} range to $\pm$ 10 mm, stray events gone.

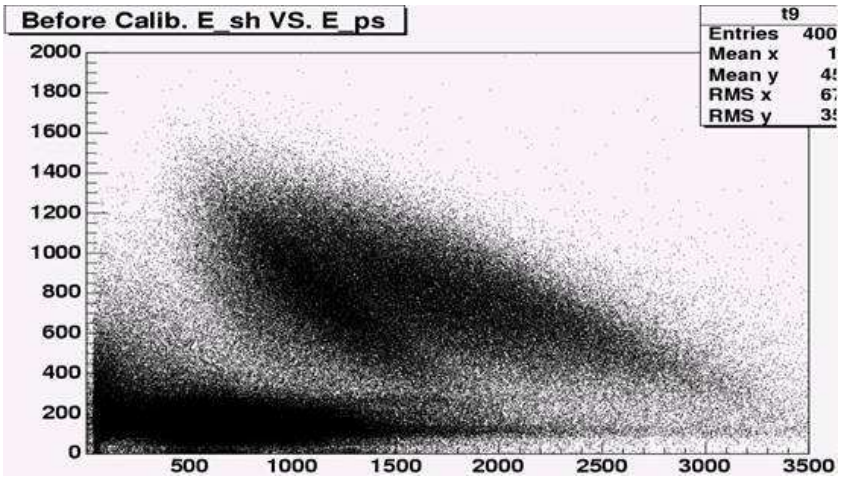


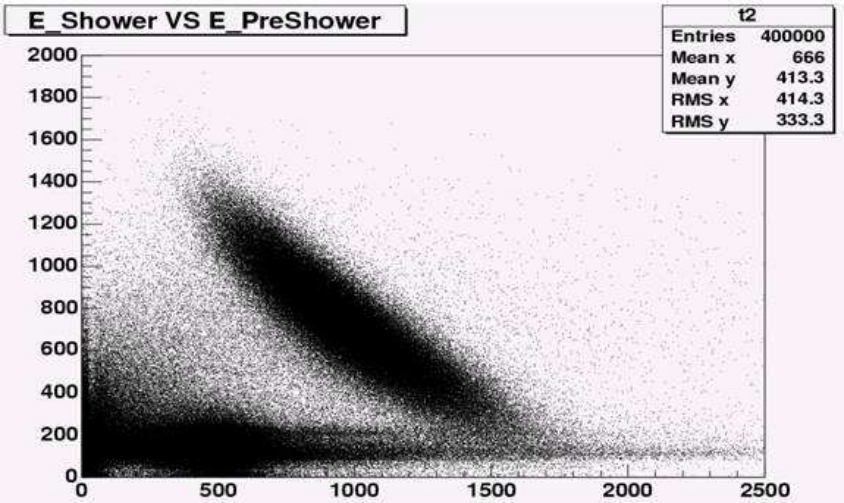
- Comparison of white spectrum with MC.
- See rotation and/or shift in data.



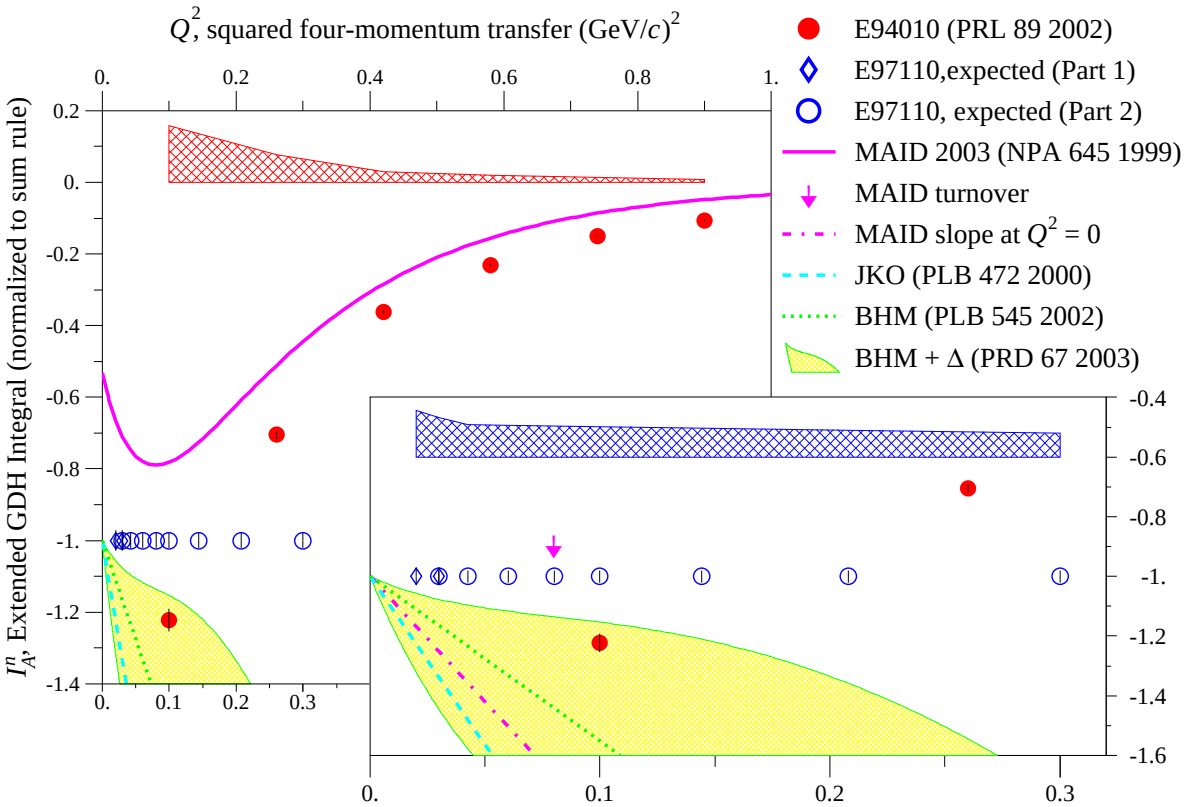
PID Calibration

- PID calibration being checked by H. Lu (USTC).
- E = 3.3 GeV, P_0 = 1.7 GeV





Expected Results



Integral normalized to 233.2 μb

Summary and Plan

- Summary:
  - Measurements of the extended GDH integral will:
    - check Chiral Perturbation Theory
    - determine where or if the slope turns over
    - allow an extrapolation to the real photon point
  - Data complements E94010 data set below Q^2 = 0.10 GeV^2 with improved precision.
  - Learn more about the structure of ^{3}He and the resonance structure of the neutron.
  - The moments of the spin structure functions and the forward spin polarizabilities will be extracted.

- Analysis is underway concentrating on the second run period.
  - Second run period optics completed at 6° and 9°.
  - PID study being checked (USTC).
  - Plan for first run period optics (Liyanage).
  - Spectrometer acceptance study underway (Sulkosky).
- Near Term Plan:
  - Elastic analysis and background studies (Singh)
  - PID study check (USTC)
  - Scaler analysis and scintillator trigger efficiency (Yuan)
  - VDC study (Dhamija)
- Long Term Plan:
  - Target Analysis
  - Asymmetries and cross sections
  - Radiative corrections
  - First run period analysis (Chinese collaboration)