Cross-section Measurements with HRS and Septum

Vincent Sulkosky

The College of William and Mary

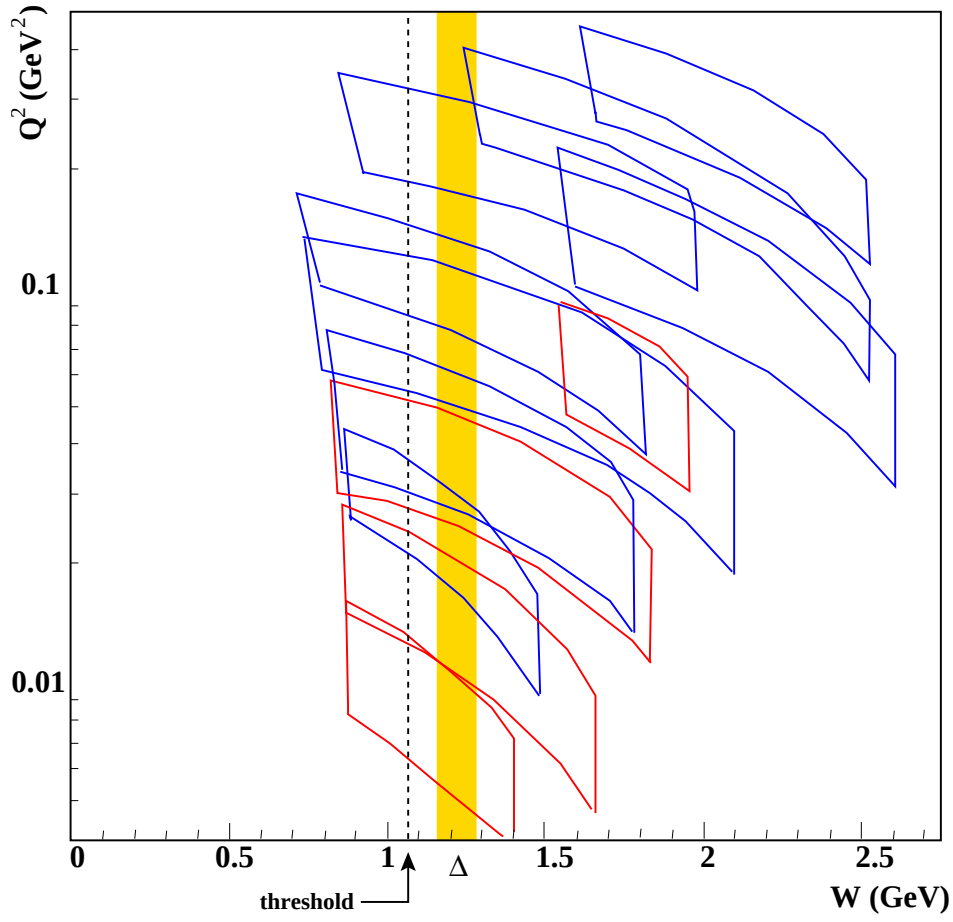
Hall A Analysis Workshop

January 6^{th}, 2007

Overview of Experiment E97-110

Precise measurement of generalized GDH integral at low Q^2, 0.02 to 0.3 GeV^2, see J. Singh's talk.

- Inclusive experiment: $^3\vec{\mathrm{He}}(\vec{e},e')X$
- Measured polarized cross section differences
- Seven different beam energies from 1.1 GeV to 4.4 GeV were used and two angles.
- The spectrometer momentum was varied from 0.5 GeV/c to 3.1 GeV/c.



Measured Observables

Asymmetries:

$$A_{\parallel,\perp} = \frac{1}{f_{\mathrm{N}_2} P_{\mathrm{tg}} P_{\mathrm{beam}}} \frac{\frac{N^+}{Q^+ LT^+} - \frac{N^-}{Q^- LT^-}}{\frac{N^+}{Q^+ LT^+} + \frac{N^-}{Q^- LT^-}}$$

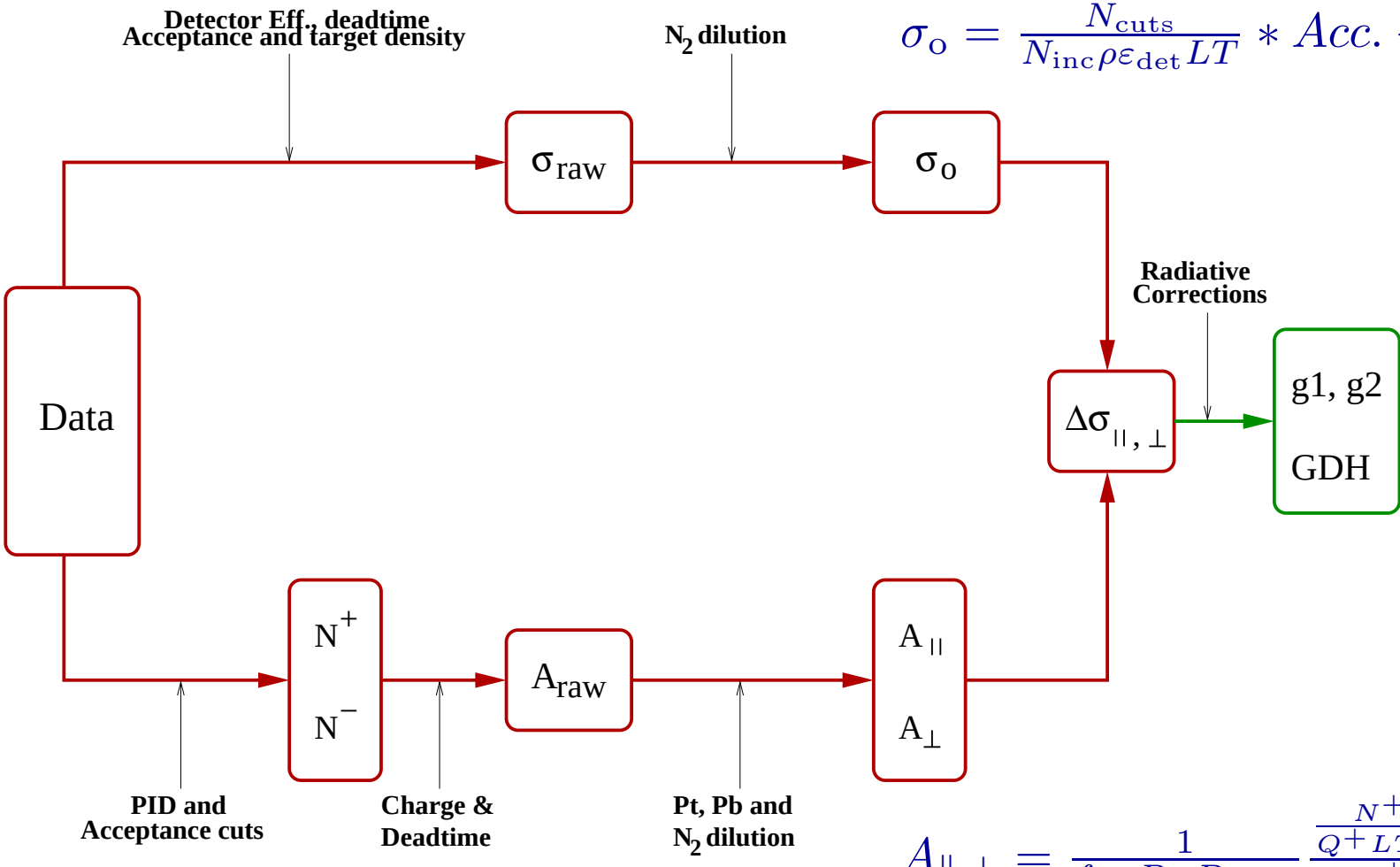
Cross-sections:

$$\sigma_{\mathrm{o}} = \frac{N_{\mathrm{cuts}}}{N_{\mathrm{inc}} \rho \varepsilon_{\mathrm{det}} LT} * Acc. - \frac{2\rho_{\mathrm{N}_2}}{\rho + \rho_{\mathrm{N}_2}} \sigma_{\mathrm{N}_2}$$

$$\Delta\sigma_{\parallel,\perp} = 2 A_{\parallel,\perp} \sigma_{\mathrm{o}} \propto g_1, g_2$$

g_1, g_2: spin dependent structure functions

Analysis Procedure



$$\sigma_o = \frac{N_{\rm cuts}}{N_{\rm inc}\rho\varepsilon_{\rm det}LT} * Acc. - \frac{2\rho_{\rm N_2}}{\rho + \rho_{\rm N_2}}\sigma_{\rm N_2}$$

$$A_{\parallel,\perp} = \frac{1}{f_{\rm N_2}P_{\rm tg}P_{\rm beam}} \frac{\frac{N^+}{Q^+LT^+} - \frac{N^-}{Q^-LT^-}}{\frac{N^+}{Q^+LT^+} + \frac{N^-}{Q^-LT^-}}$$

Spectrometer Acceptance

What is acceptance?

- The geometrical efficiency of a spectrometer.
- Acceptance is crucial in measuring absolute cross sections.

$$Acceptance = \frac{1}{\Delta\Omega\Delta E'\Delta Z}$$

Spectrometer Acceptance

What is acceptance?

- The geometrical efficiency of a spectrometer.
- Acceptance is crucial in measuring absolute cross sections.

$$Acceptance = \frac{1}{\Delta\Omega \Delta E' \Delta Z}$$

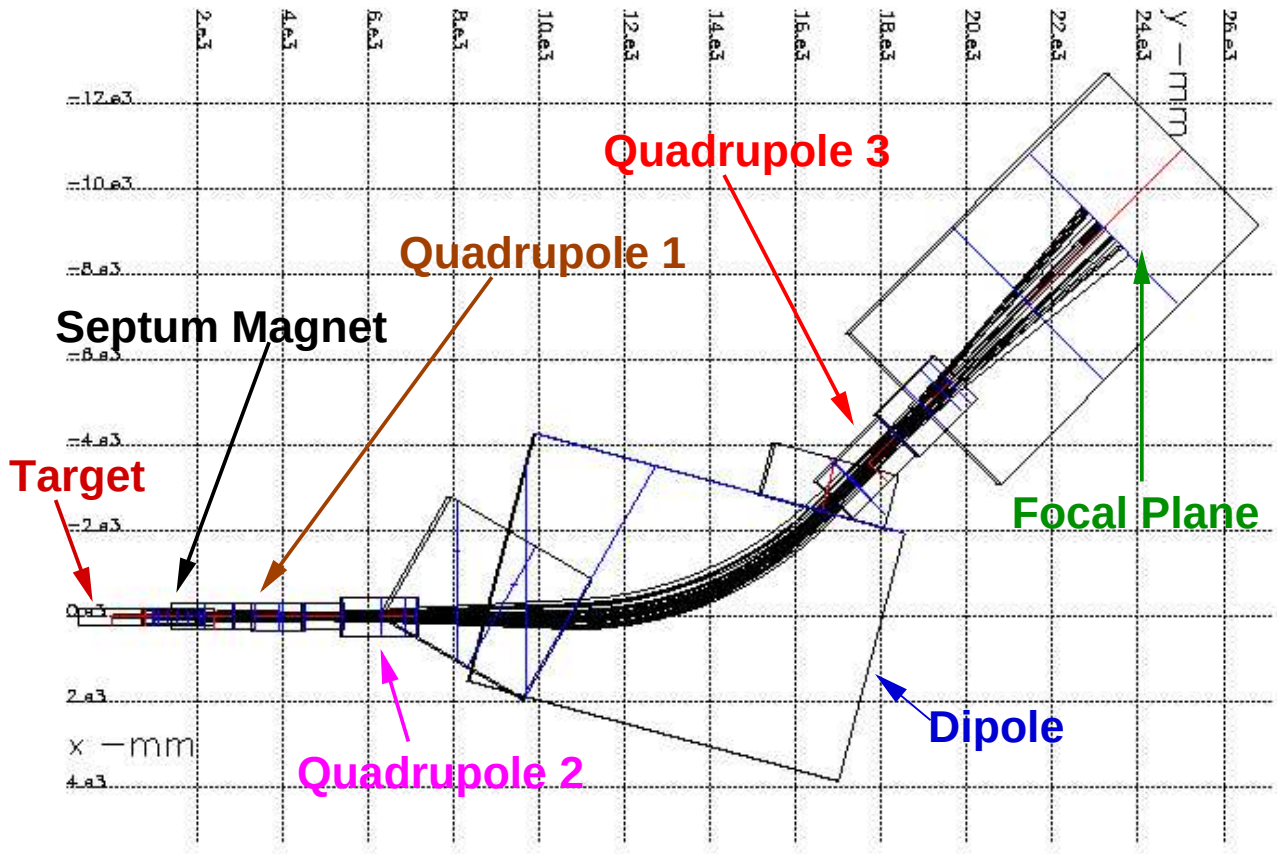
- $\Delta\Omega$ - solid angle (sr).
- $\Delta E'$ - spectrometer momentum bite (MeV/c).
- ΔZ - target length (cm).

Determining the acceptance

- The magnetic elements of the spectrometer result in a complicated acceptance shape that is dependent on the target variables.
- The acceptance shape is determined by comparing a simulation to the data.
- A ray tracing program, SNAKE, is used to generate trajectories through a model of the spectrometer.

$$\frac{1}{\Delta\Omega\Delta E'\Delta Z} = \frac{N^{\rm mc}_{\rm tot}}{N^{\rm mc}_{\rm accp}\Delta\Omega_{\rm mc}\Delta E'_{\rm mc}\Delta Z_{\rm mc}}$$

Determining the acceptance



Hall A Monte-Carlos

- *MCEEP* - standard Hall A tool.
- *SIMC* - Hall C code modified for HRS.
- *G1* - GEANT based code.
- HRS transfer functions - *SNAKE* model of the spectrometers.
- *SAMC* - Single Arm Monte-Carlo (A. Deur).

More info can be found at http://hallaweb.jlab.org/data_reduc/mc/mc.htm

Single Arm Monte-Carlo (SAMC)

- Developed by Alexandre Deur for E94-010.
- Used for inclusive ^{3}He experiments in Hall A.
- Various versions exists for different experiments.
- Most recent version adapted for use with the septum magnet.

More info can be found at http://www.jlab.org/e94010/tech_note_33.ps.gz

Single Arm Monte-Carlo (SAMC)

Includes:

- Inclusive measurements.
- Point and extended targets.
- Raster.
- Elastic radiative correction (internal + external).
- Landau Straggling.
- Multiple scattering.

More info can be found at http://www.jlab.org/e94010/tech_note_33.ps.gz

Single Arm Monte-Carlo (SAMC)

Reactions:

- Unpolarized elastic: ^{3}He, ^{4}He, Carbon, Nitrogen.
- Polarized elastic: ^{3}He.
- Polarized quasi-elastic: ^{3}He.
- Mott/phase space.

More info can be found at http://www.jlab.org/e94010/tech_note_33.ps.gz

E97-110 Experimental Setup

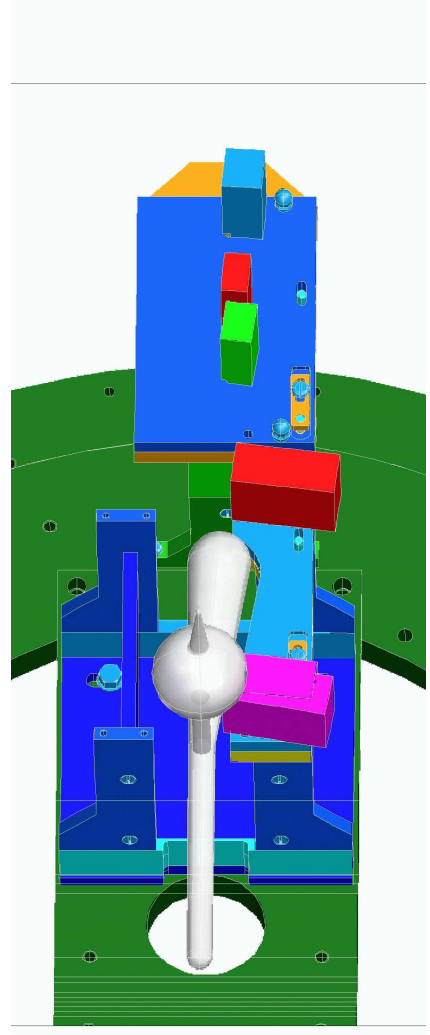
Septum magnet

- Low Q^2 requires forward angles.
- Minimum spectrometer angle is 12.5°.
- The septum magnet allows detection of electrons with scattering angles of 6° and 9°.
- Designed for the spectrometers to retain their resolution and have comparable acceptance.

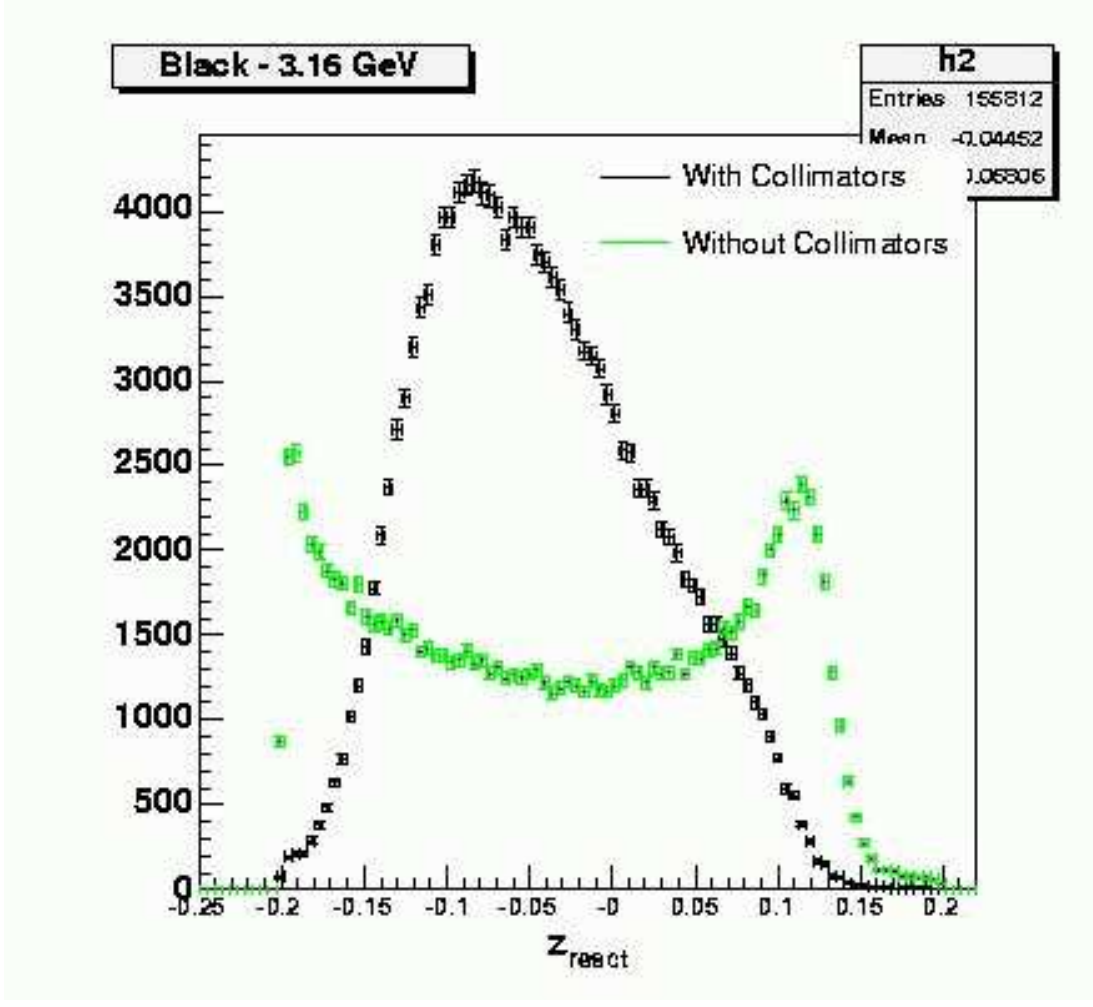
E97-110 Experimental Setup

Collimators: target and sieve slit

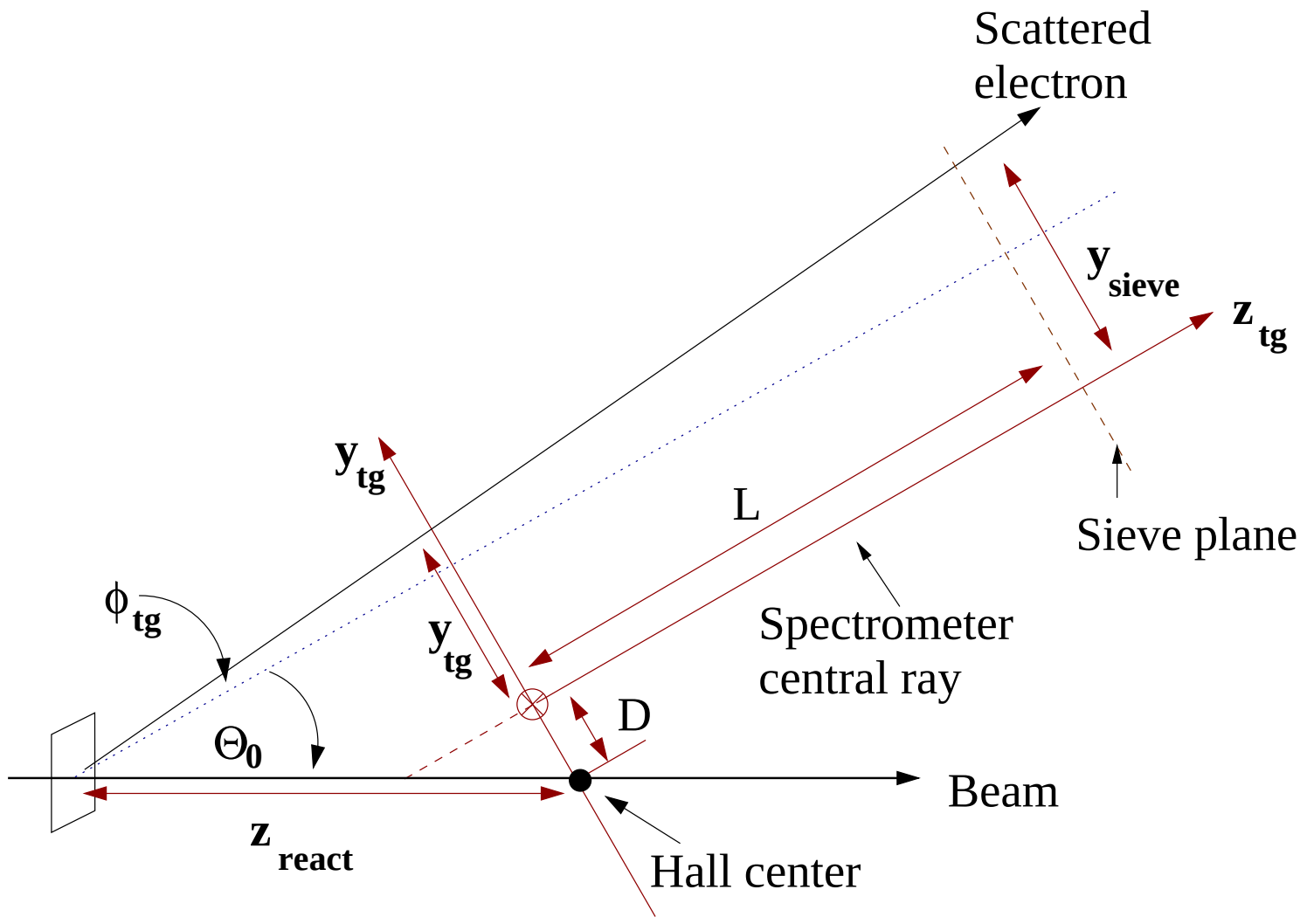
- Target collimators remove the glass windows from the acceptance.
- Three different collimator confi gurations were used.
- Sieve collimator removes background from outside the target region.
- Sieve collimator centered at sieve slit W x H = 5.5 x 9.9 cm^2.



E97-110 Experimental Setup



Target Coordinates



SAMC: Modifications and Issues

Changes for E97-110:

- Update transfer functions for septum + HRS (J. LeRose).
- Add target and sieve slit collimators.
- Use exact scattering angle formula.

$$\cos\theta_{\rm sc} = \frac{\cos\theta_0 \mp \phi_{\rm tg}\sin\theta_0}{\sqrt{1+\theta_{\rm tg}^2+\phi_{\rm tg}^2}}$$

$$\theta_{\rm sc} \approx \theta_0 \pm \phi_{\rm tg}$$

SAMC: Modifications and Issues

Changes for E97-110:

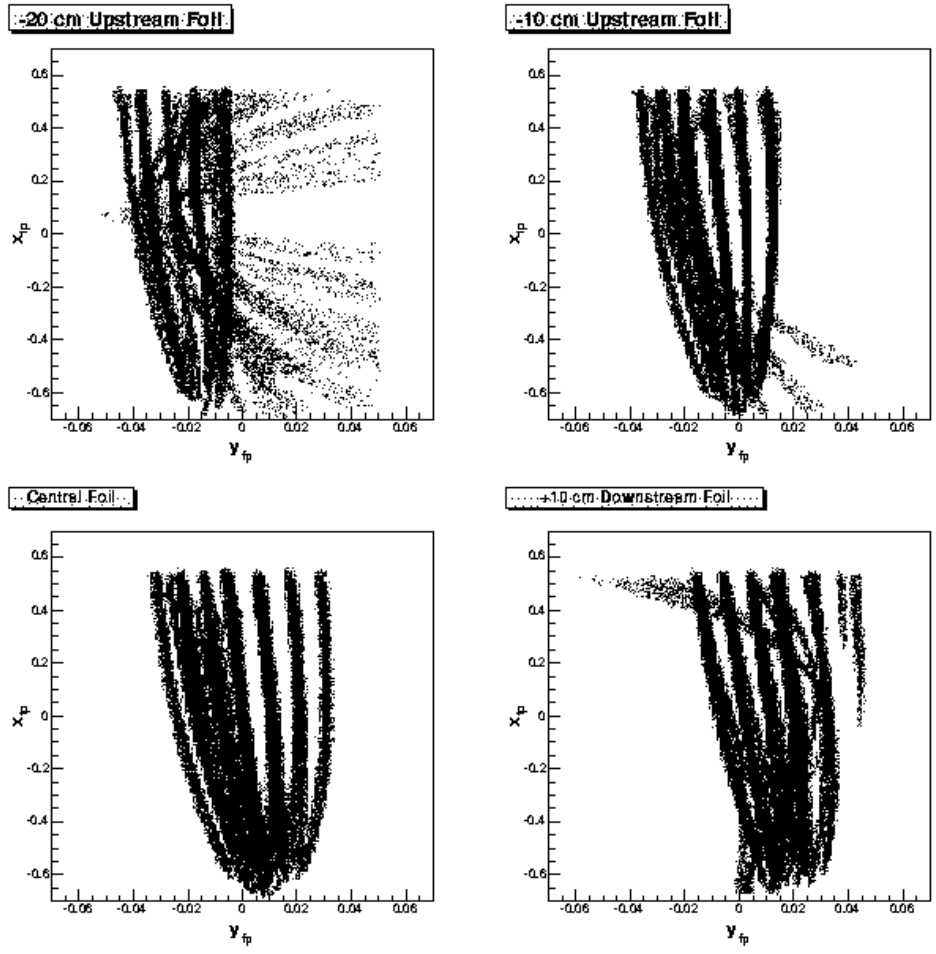
- Update transfer functions for septum + HRS (J. LeRose).
- Add target and sieve slit collimators.
- Use exact scattering angle formula.

Discovered Issues:

- Transfer functions fi t withtoo small $x_{\rm tg}$ range: $\pm$ 3 mm.
- δ acceptance is larger for model compared to data.

Issues

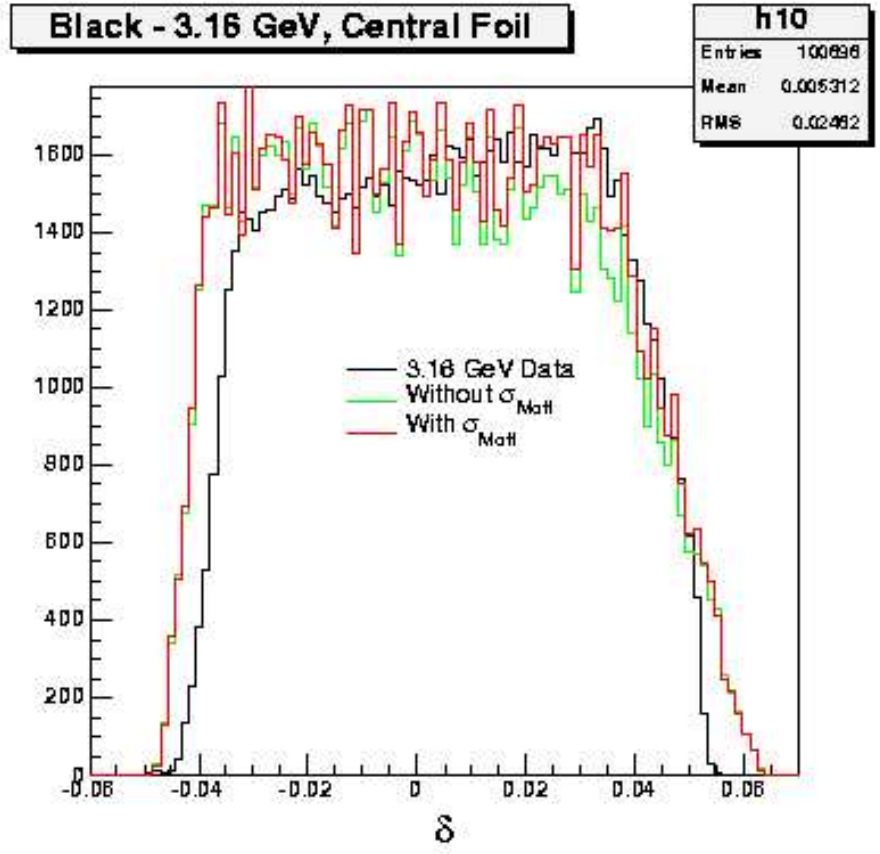
Problem: x_{tg} range



vertical axis: x_{fp} and horizontal axis: x_{fp}

Issues

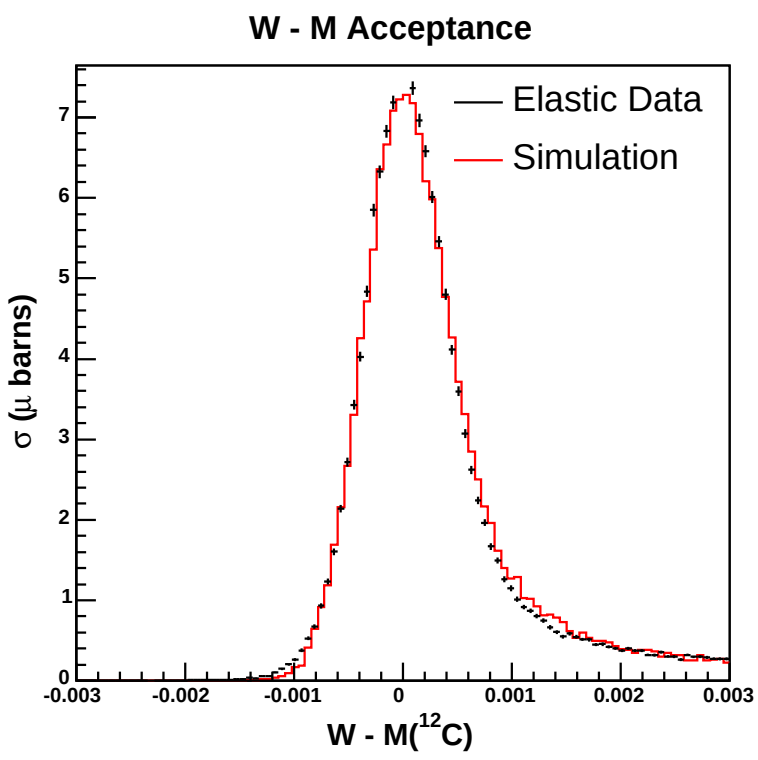
Problem: extra δ acceptance

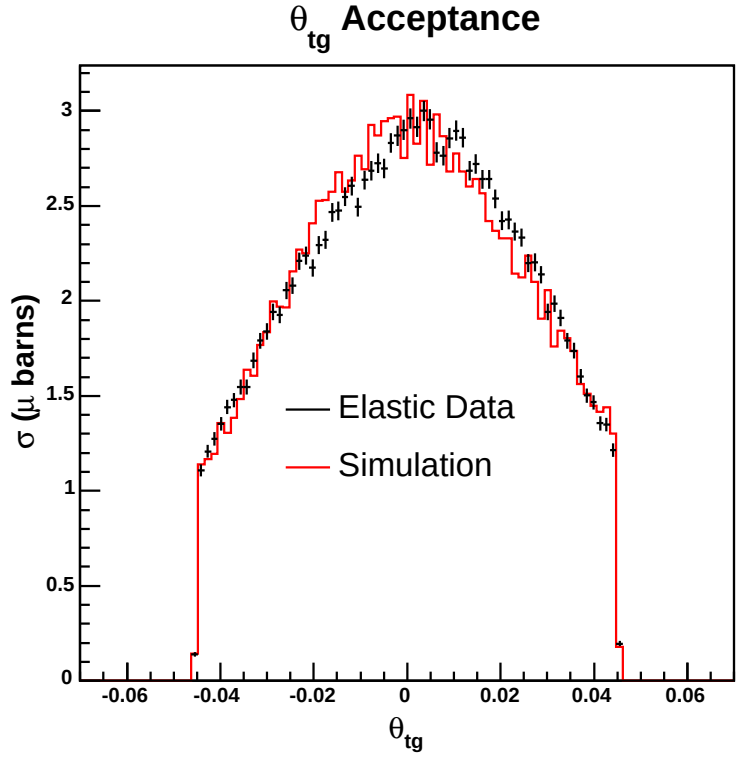


Can reduce Q3 exit aperature radius to 28 cm.

Also seen in MCEEP, see JLab-TN-01-025 by Paul Ulmer.

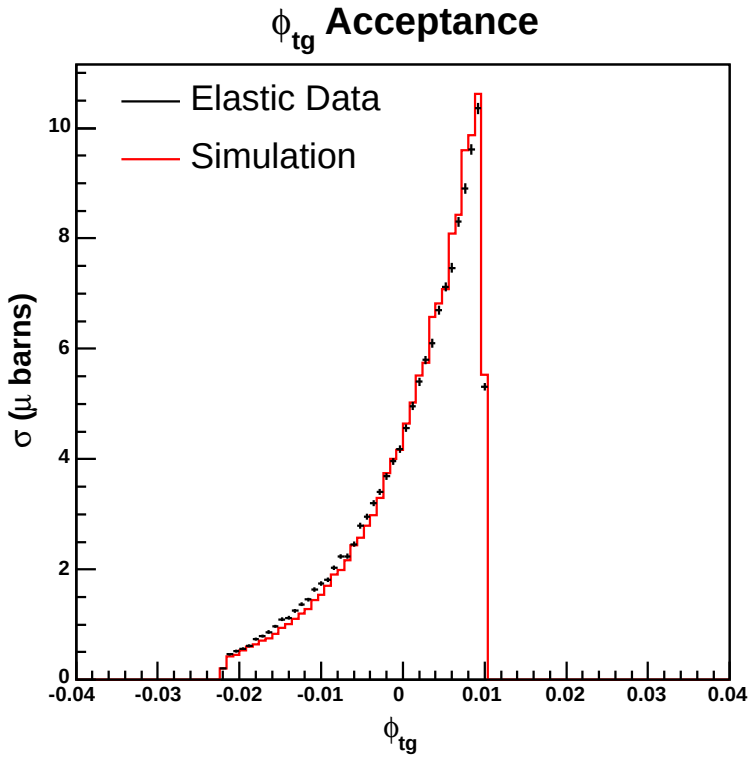
Carbon Elastic Data and MC Comparison

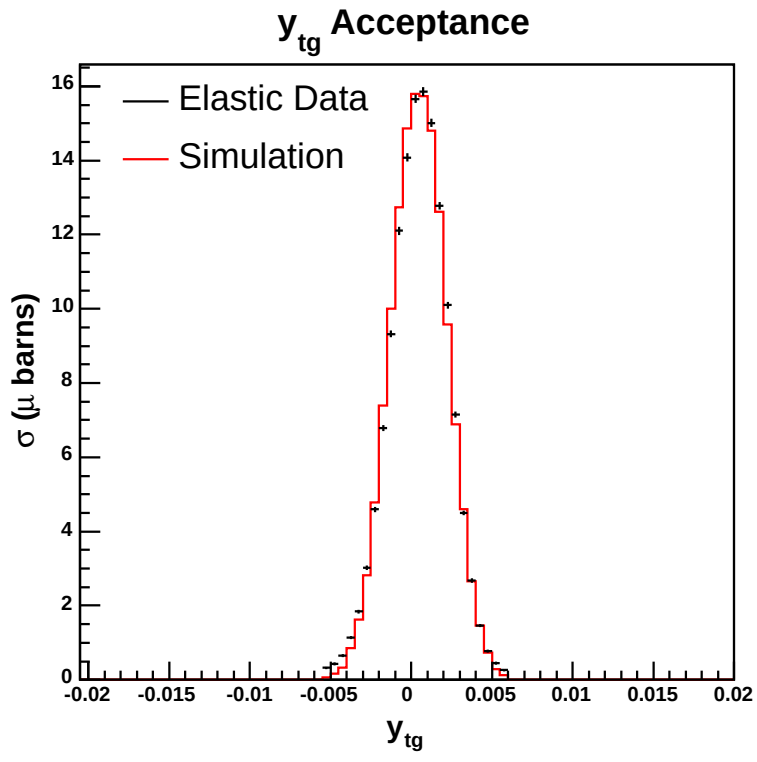




Absolute Comparison!

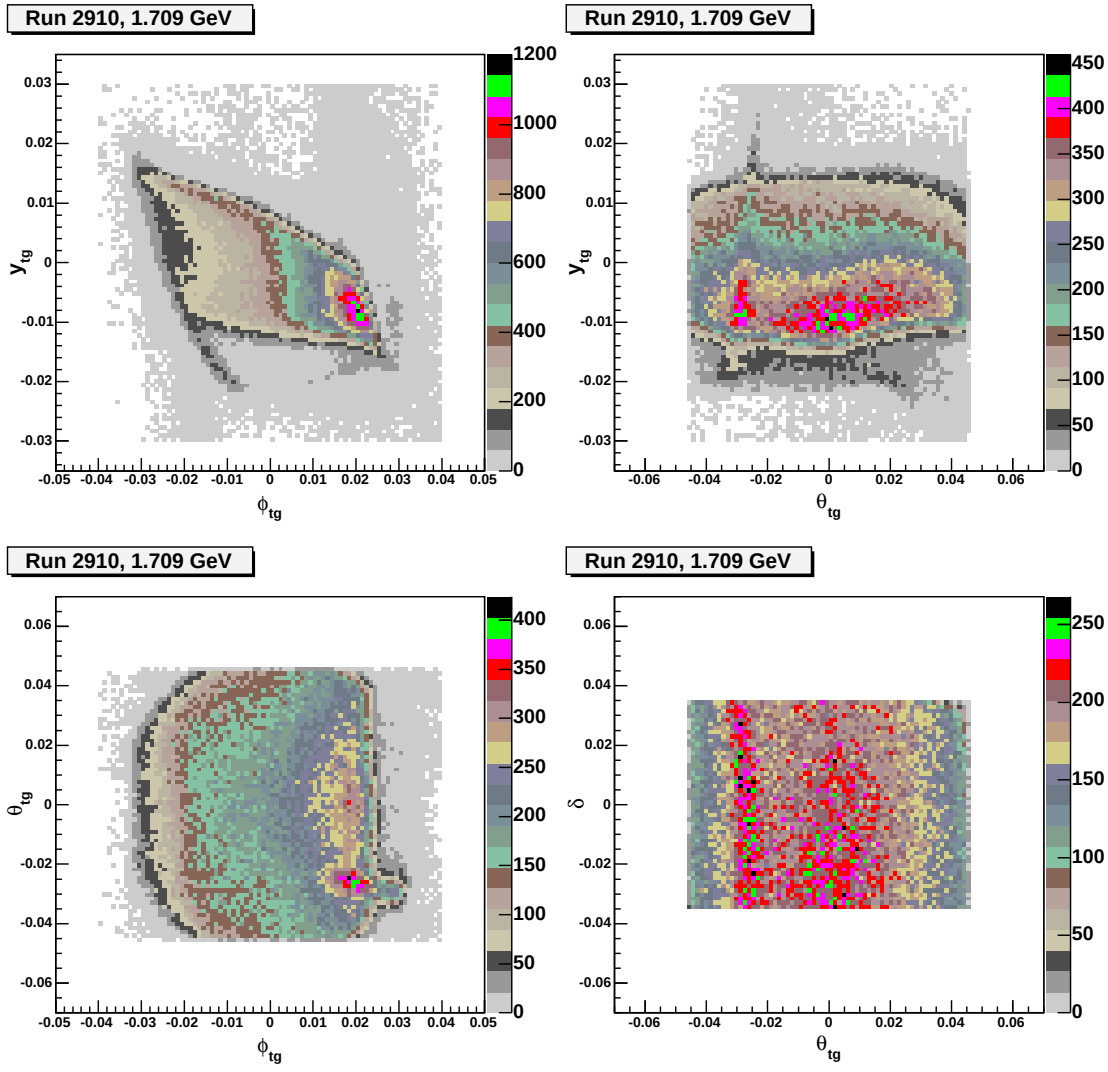
Carbon Elastic Data and MC Comparison





Absolute Comparison!

^{3}He Target Acceptance

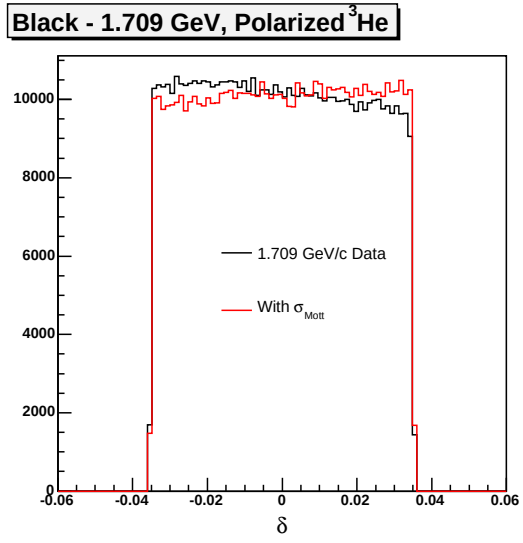


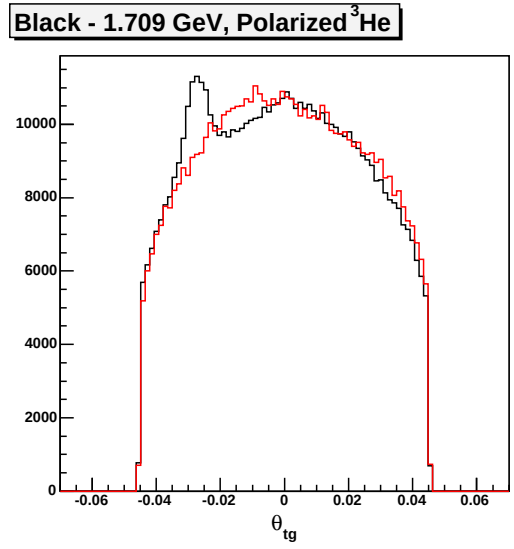
^{3}*He Target Acceptance*

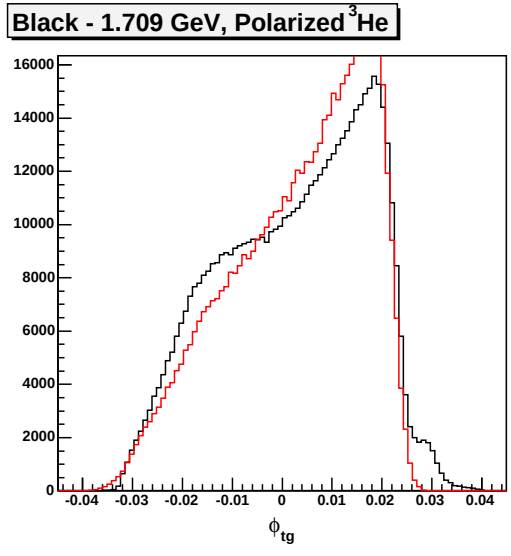
Background:

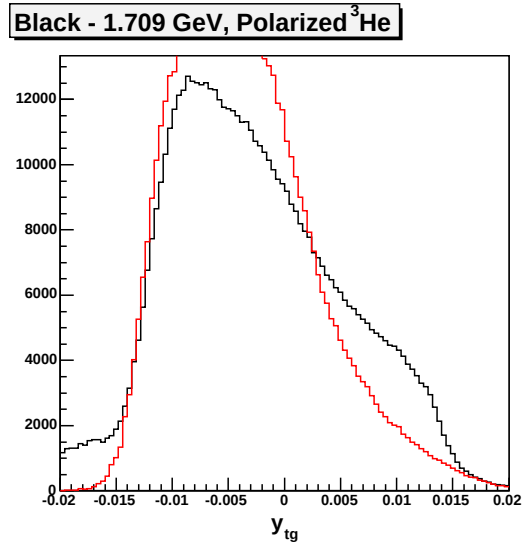
- Enhanced peak at negative $\theta_{\rm tg}$.
  - Possibly due to scrapping off the bore cooler.
  - Unfortunately leaves a hole once background is removed.
- Collimator punch-thru events.
- Both effects can be removed with tighter acceptance cuts.

^{3}He Target Acceptance

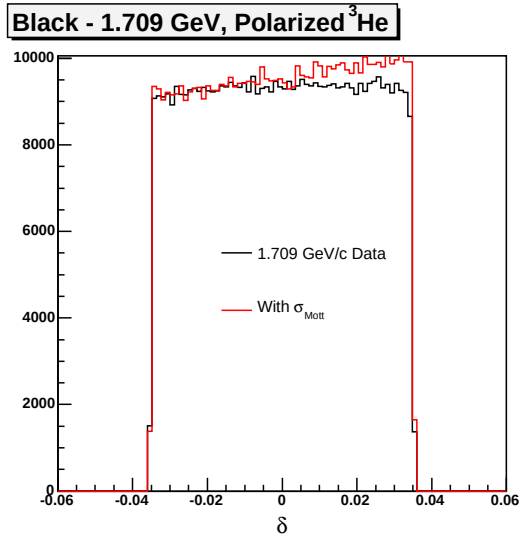


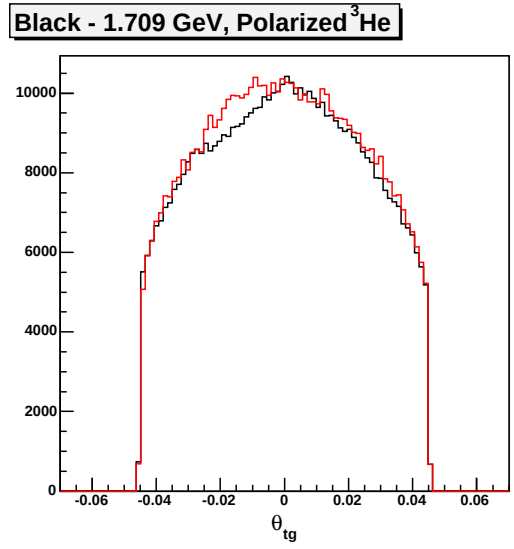


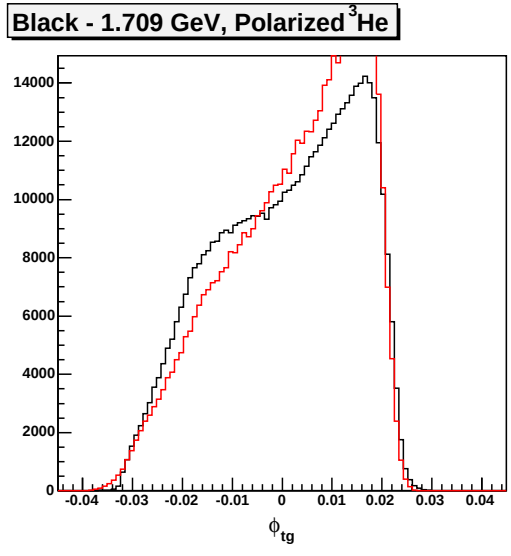


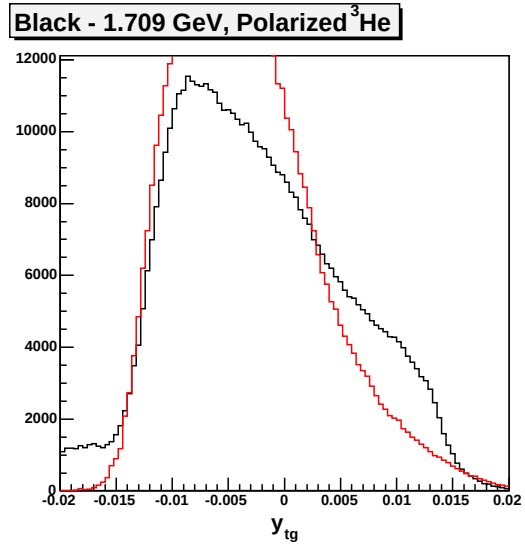


^{3}He Target Acceptance

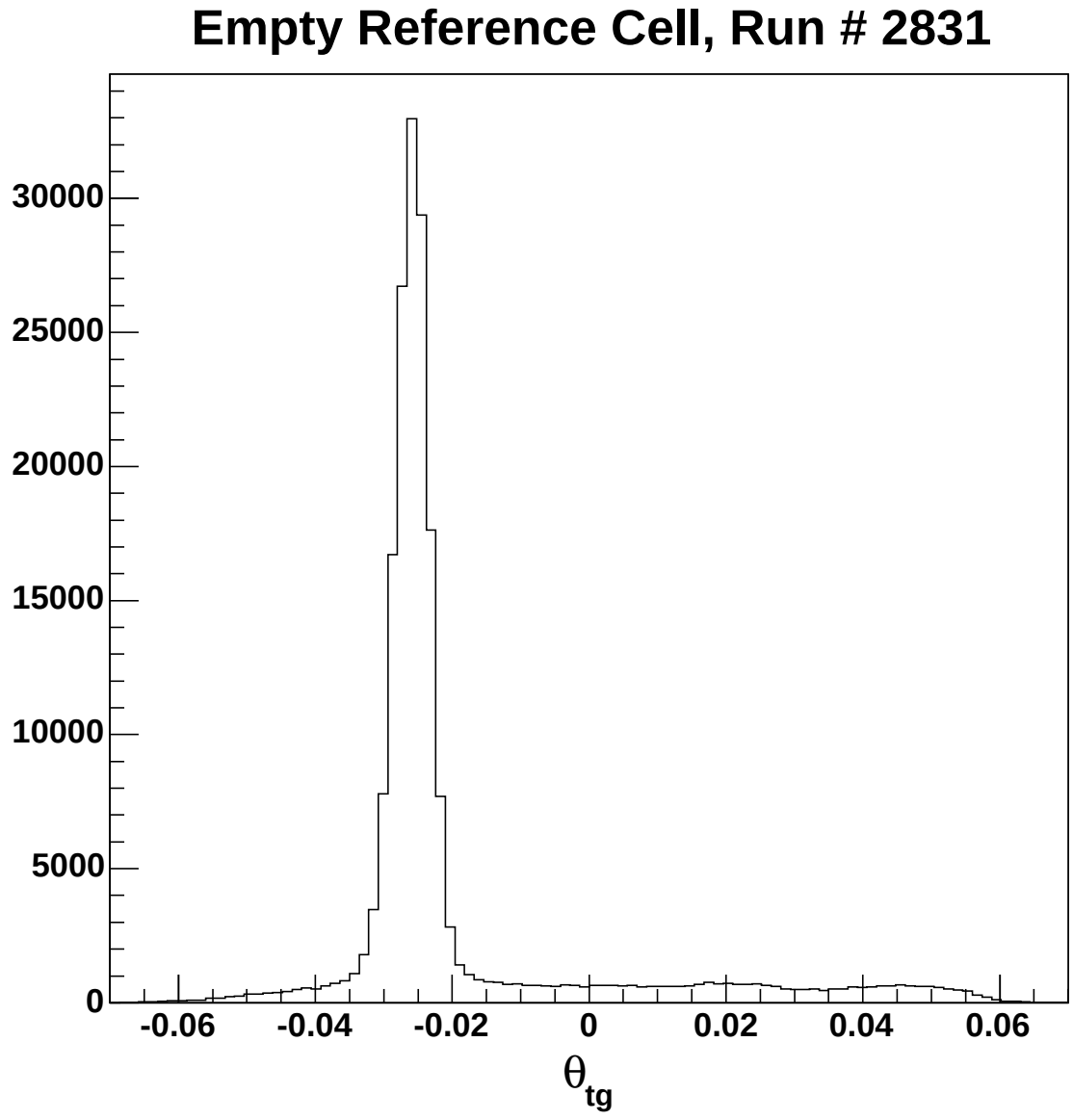




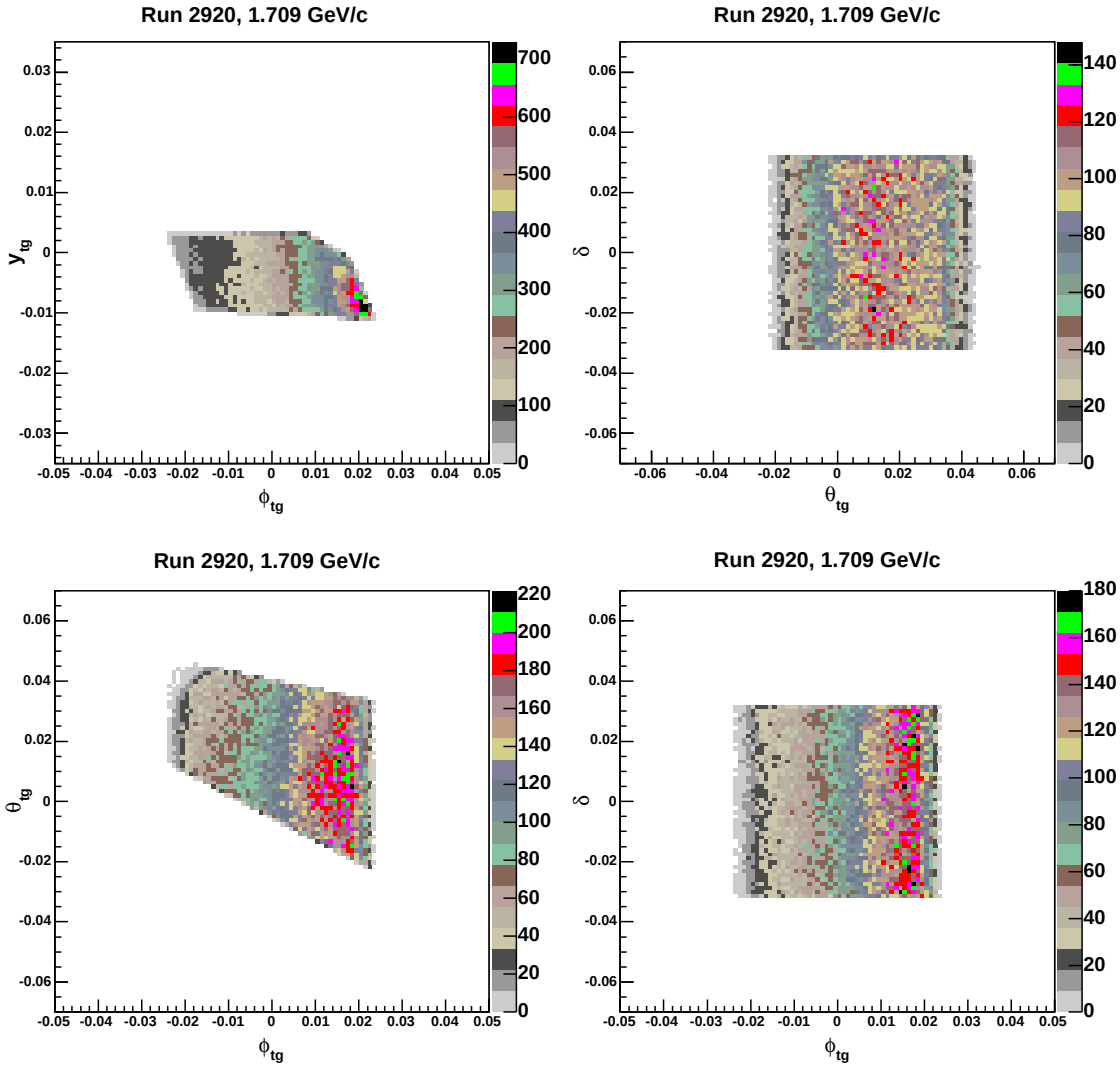




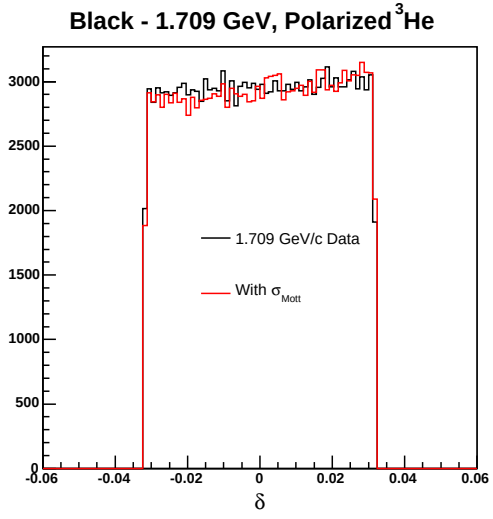
^{3}He Target Acceptance

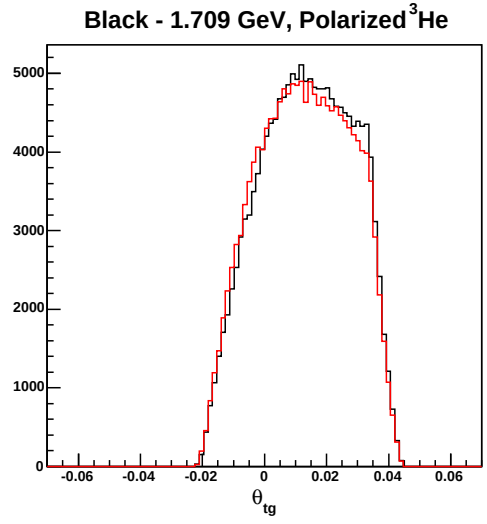


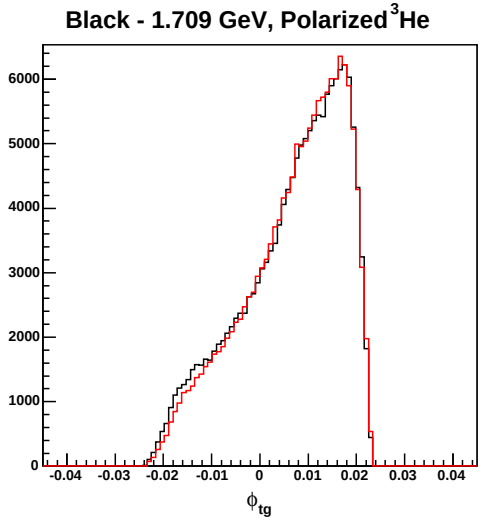
Acceptance Cuts

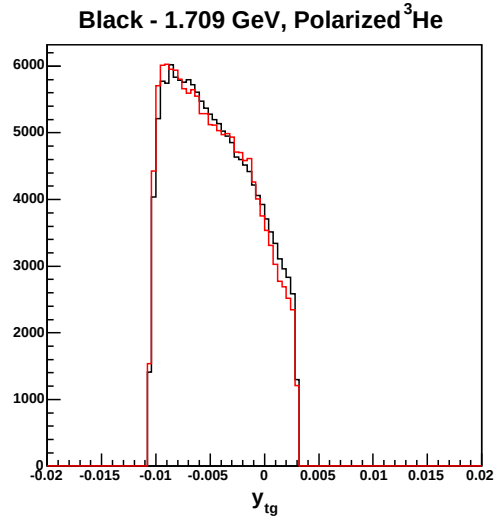


Acceptance Cuts









Remaining Items and Summary

Collimator Background

- A full simulation is underway (T. Holmstrom).
- SAMC interfaced with QFS to calculate inelastic cross-sections (K. Slifer).
- Important and necessary to extract cross-sections differences.
- If background is unpolarized, then it will cancel in the difference.
- If polarized, then a lot more work may be required.

Summary

- Acceptance determination is crucial for cross-section analyses.
- For E97-110, SAMC code was used for the spectrometer acceptance.
- Major hurdle from collimator background.

Remaining Items and Summary