E97-110: Small Angle GDH

Experimental Status Report

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on the behalf of the Spokespeople: J.P. Chen, A. Deur, F. Garibaldi

Thesis Students: J. Singh, V. Sulkosky, and J. Yuan

and the rest of the Polarized ^{3}He Collaboration

Hall A Collaboration Meeting

CC Auditorium, January 05, 2007

GDH Sum Rule $\left(Q^2 = 0\right)$

For circularly polarized real photons ($Q^2 = 0$):

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

$$I^{\rm n}_{GDH} = -233\ \mu{\rm b} \ \ \& \ \ I^{^3{\rm He}}_{GDH} = -498\ \mu{\rm b}$$

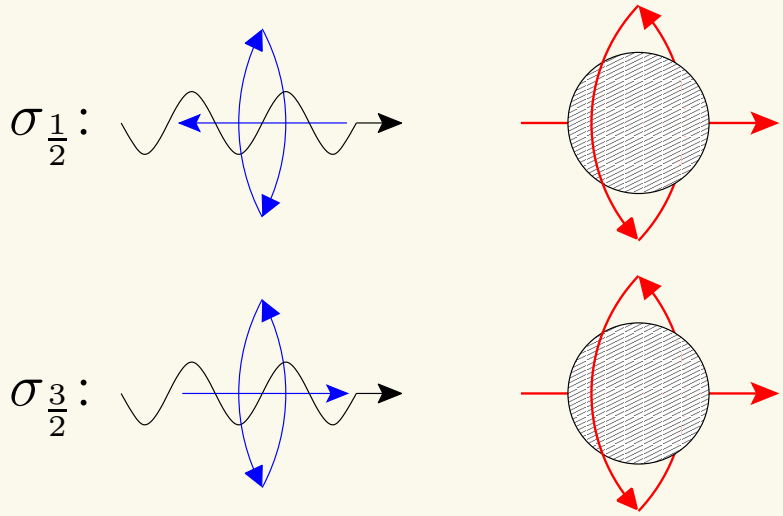
This sum rule relates the real photoabsorption cross section difference to the anomalous part of the target magnetic moment κ.

Causality $\rightarrow$ Dispersion Relation

Unitarity $\rightarrow$ Optical Theorem

Lorentz & Gauge Invariance $\rightarrow$

$\rightarrow$ Low Energy Theorem



Generalized Integral for $S = 1/2$

When the integrand is generalized to $Q^2 > 0$:

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

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

...the integral can form a sum rule proportional to the virtual photon Compton Amplitude $S_1(\nu, Q^2)$ [see for example: X. Ji & J. Osbourne J. Phys. G: Nucl. Part. Phys. 27, 127 (2001)], which can be calculated over the full Q^2 range using different theoretical tools.

This versatile experimental observable provides a bridge from the non-perturbative region to perturbative region of QCD!

Experimental Highlights

- Proposal Title: The GDH Sum Rule and the Spin Structure of ^{3}He and the Neutron Using Nearly Real Photons
- A polarized ^{3}He nucleus "stands in" as a polarized neutron.
- Detected only the scattered electron at 6^o and 9^o using the right septum magnet and the standard Hall A HRS package.
- ^{3}He target cells were specifically designed and constructed to minimize radiative corrections.
- We have data for both longitudinal (parallel) and tranverse (perpendicular) target polarizations.
- Contamination from the glass and Nitrogen are subtracted using data from reference cell runs for each kinematic.
- Measured "double" polarized cross sections and asymmetries for inclusive electron scattering from a polarized ^{3}He target.

Beamline and Target Tasks

Beamline

1. BCM Calibration (T. Holmstrom)
2. BPM and Raster Calibration (V. Sulkosky)
3. Beam Energy by Run - First Pass (J. Singh)
4. Bleedthrough Parameterization (T. Holmstrom)
5. Beam Polarization by Run - First Pass (J. Singh)

Target

1. Target Glass Thickness (J. Singh)
2. Target Setting by Run (J. Singh)
3. **Target Density by Run (J. Singh, V. Nelyubin, X. Zhan)**
4. **Glass and N_2 Dilution (X. Zhan)**
5. **Target Polarization by Run - Nextish to Final Pass (J. Singh)**

Spectrometer Tasks

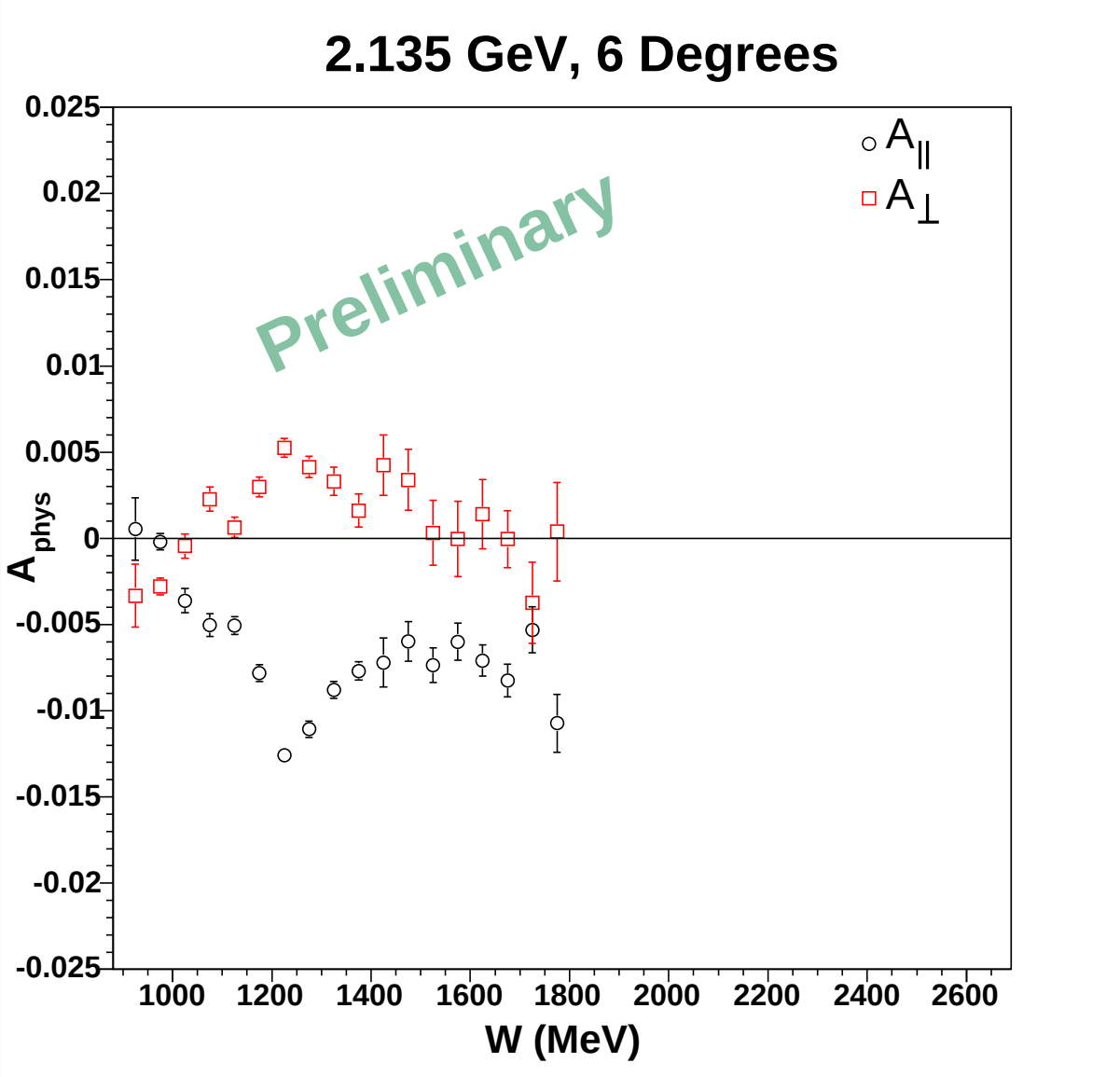
1. PID Calibrations (H. Lu, J. Yuan)
2. Optics (V. Sulkosky, N. Liyanage)
3. Momentum Setting by Run (J. Singh)
4. **PID/Cut Efficiencies - First Pass (V. Sulkosky)**
5. **Acceptance at 6 degrees - Finishing Up! (V. Sulkosky)**
6. **VDC Multitrack Analysis - In Progress (J. Yuan, S. Dhamija)**

Analysis

1. False Asymmetry Crosscheck (T. Holmstrom)
2. Background Studies: Quick Check (A. Deur, S. Dhamija)
3. Helicity Decoding (V. Sulkosky)
4. **Junk/Problem Runs Identification - Ongoing (All)**
5. **Scalar Quantities by Run (T. Holmstrom, H. Lu, V. Sulkosky)**
6. **Carbon Elastic Cross Sections - First Pass (V. Sulkosky)**
7. **He-3 Inelastic Asymmetries - First Pass (V. Sulkosky)**
8. **Background Studies: GEANT - On Hold (A. Beck, A. Deur)**
9. **Background Studies: Single Arm Monte Carlo (T. Holmstrom)**
10. **He-3 Inelastic Cross Sections - In Progress (V. Sulkosky)**
11. **Radiative Corrections - Just Started (J. Singh, R. Feuerbach)**

He-3 Inelastic Asymmetries

No Radiative Corrections!



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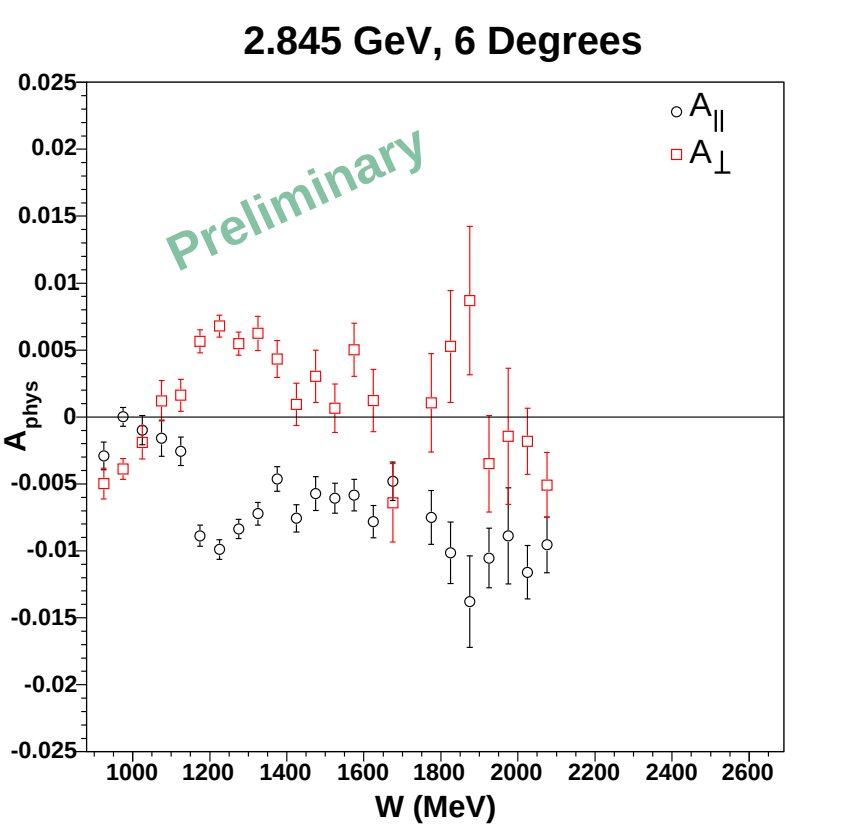

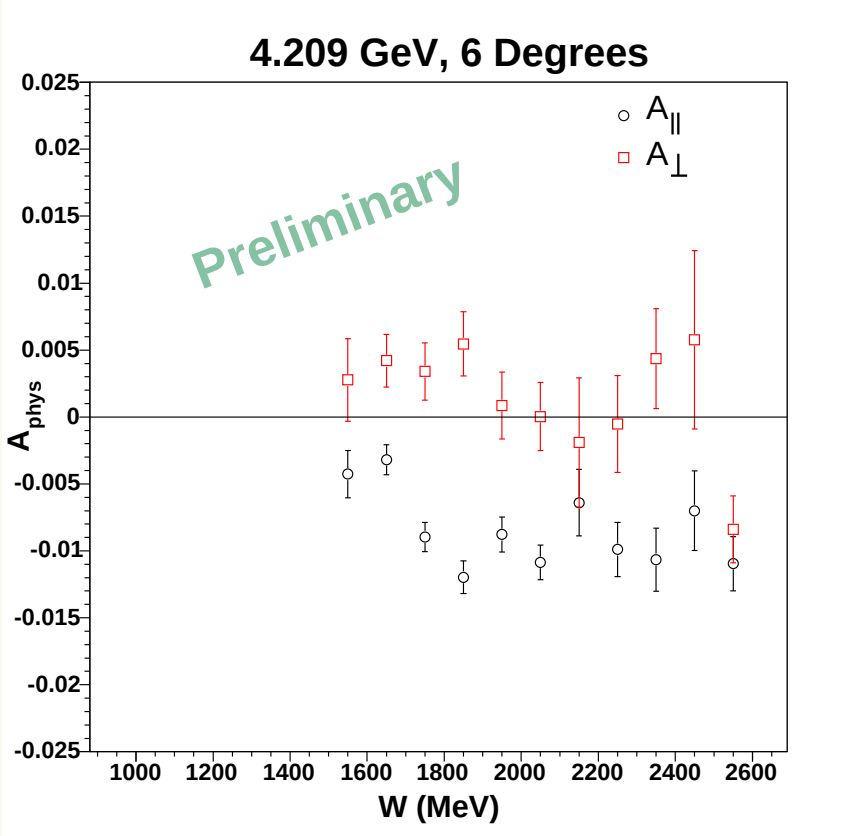

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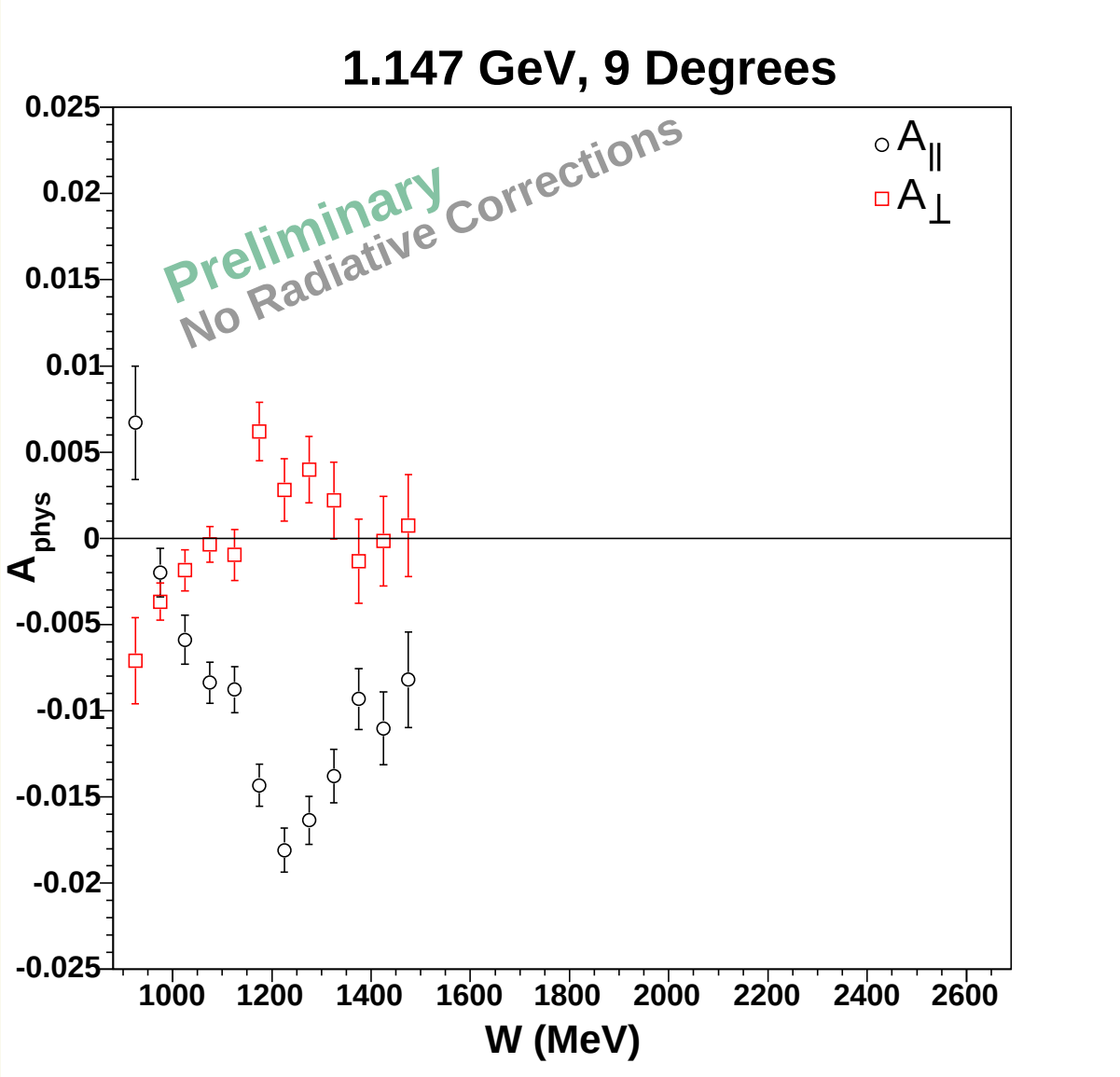

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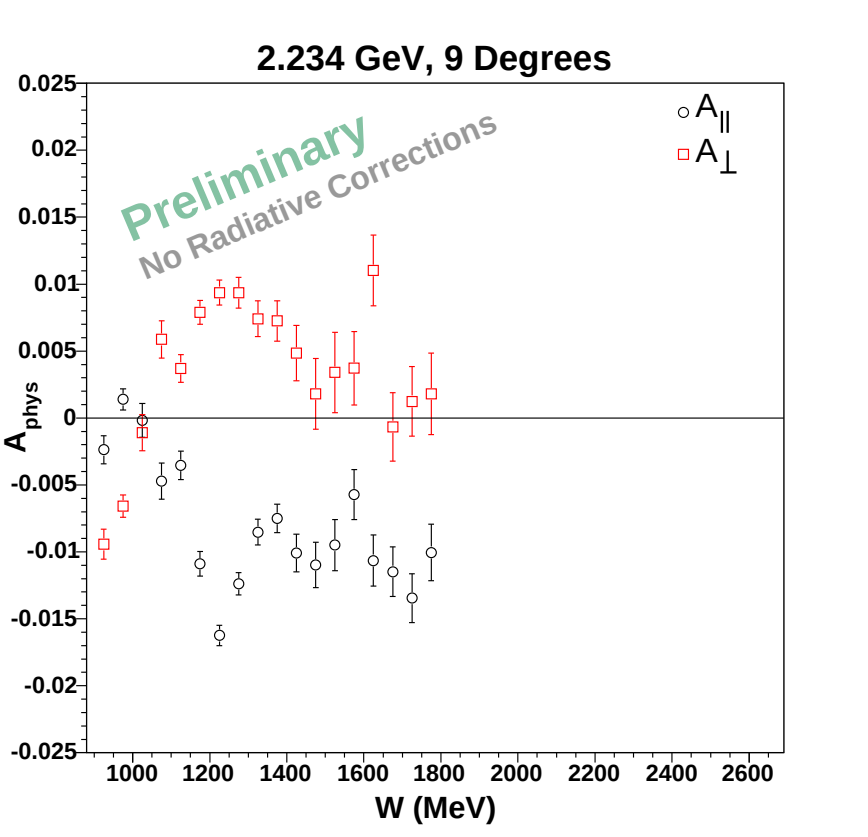

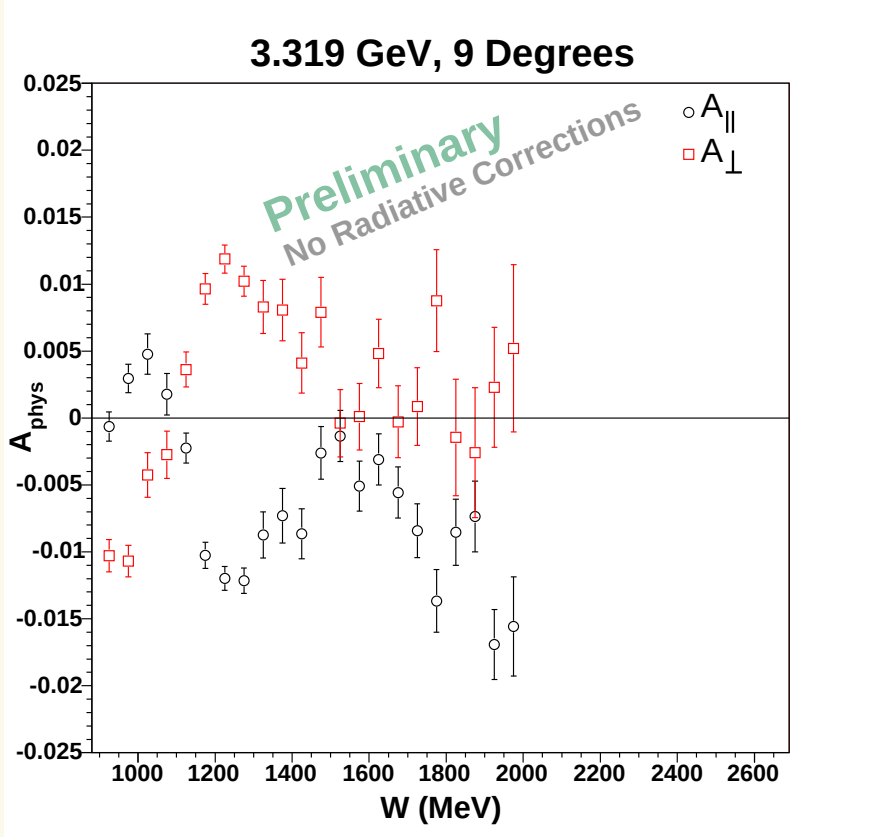

He-3 Inelastic Asymmetries

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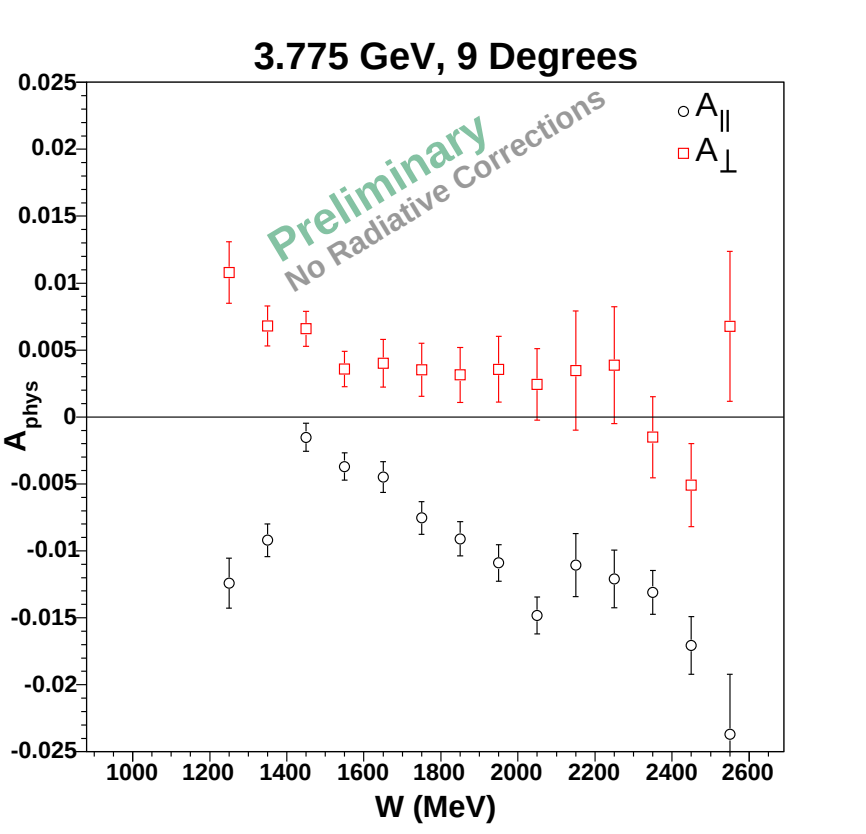
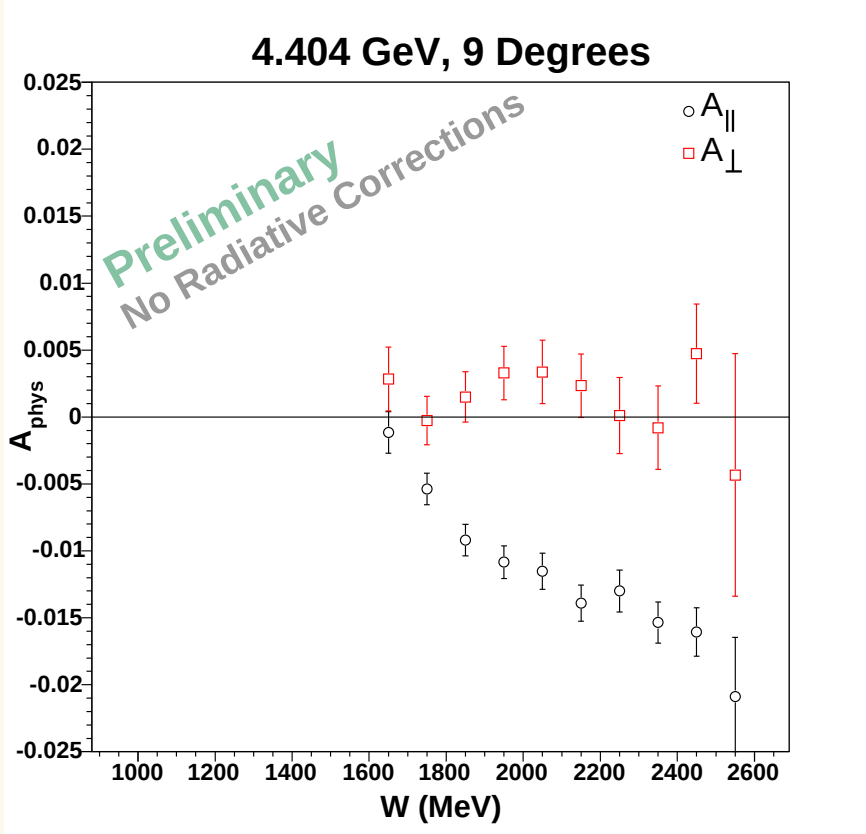
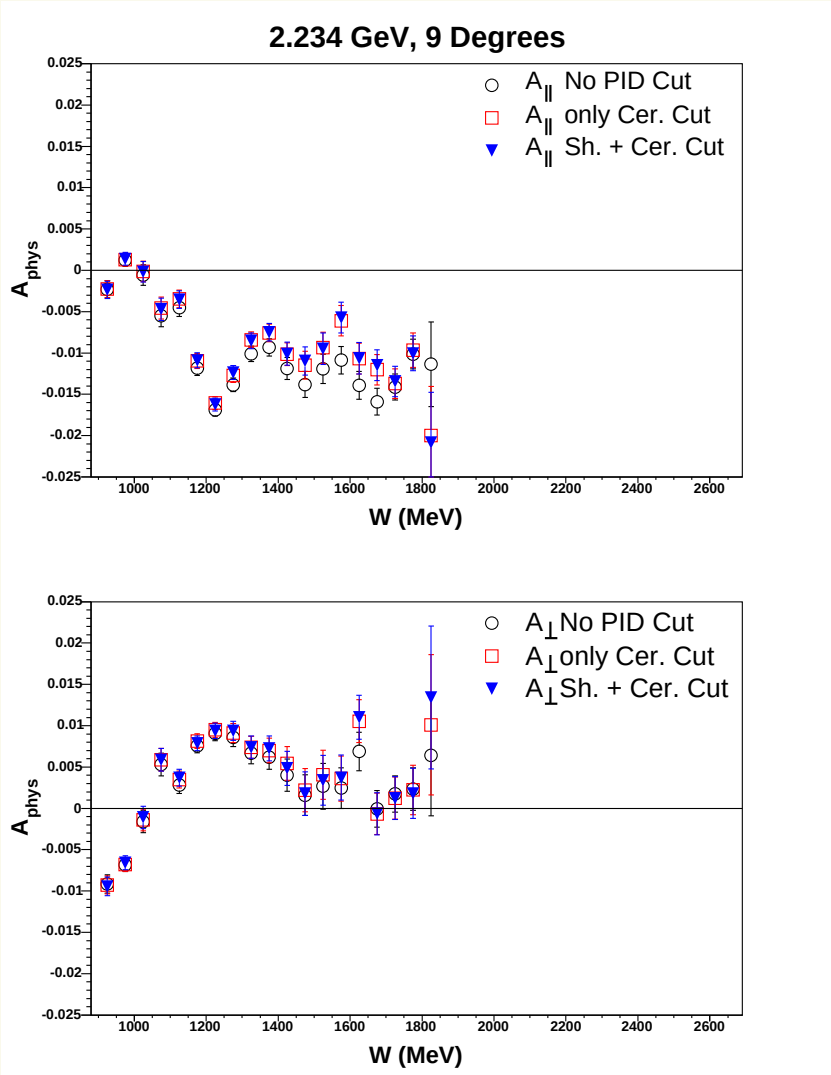
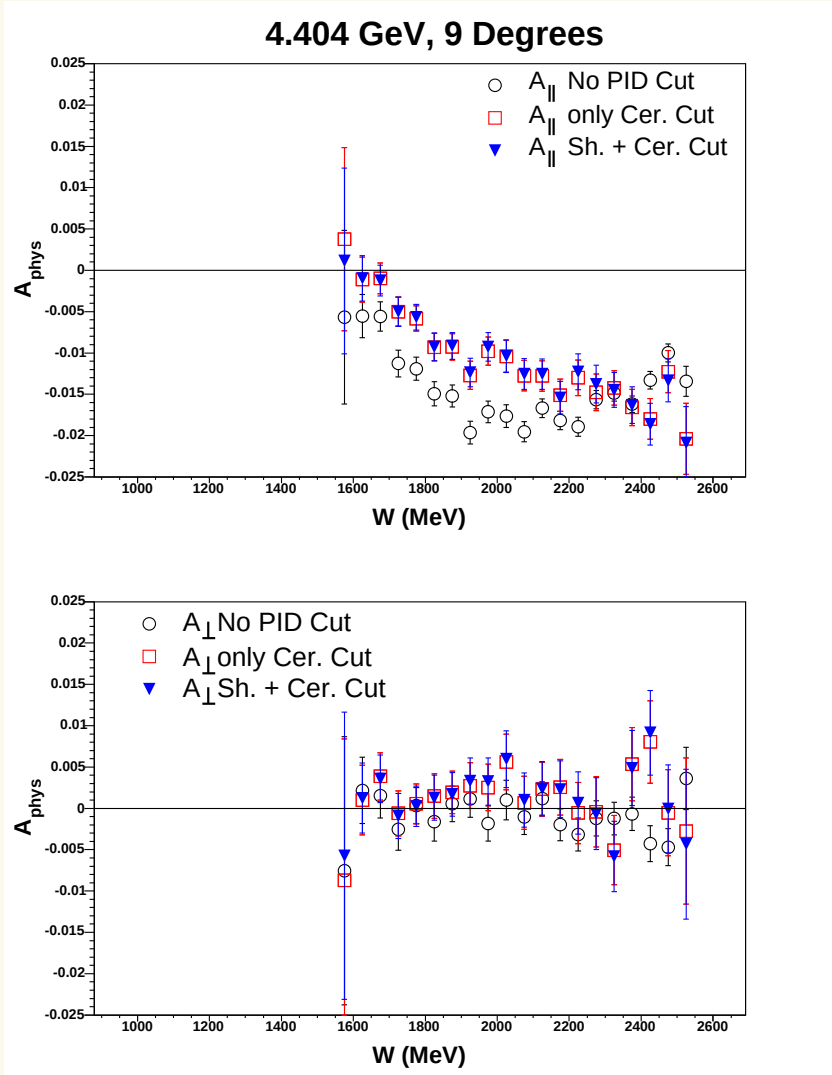




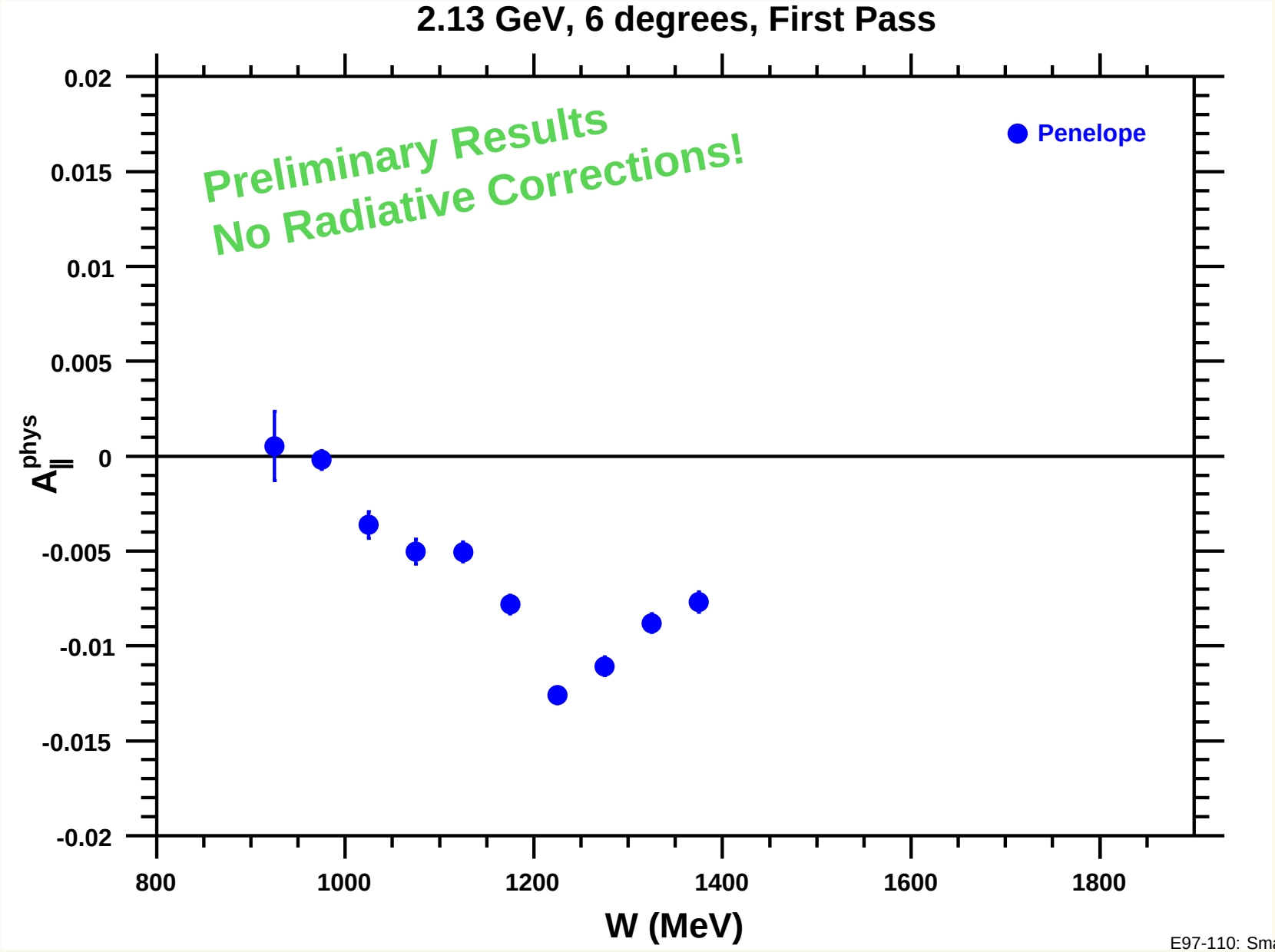
PID Cut Study

No Radiative Corrections!





Cell Comparison



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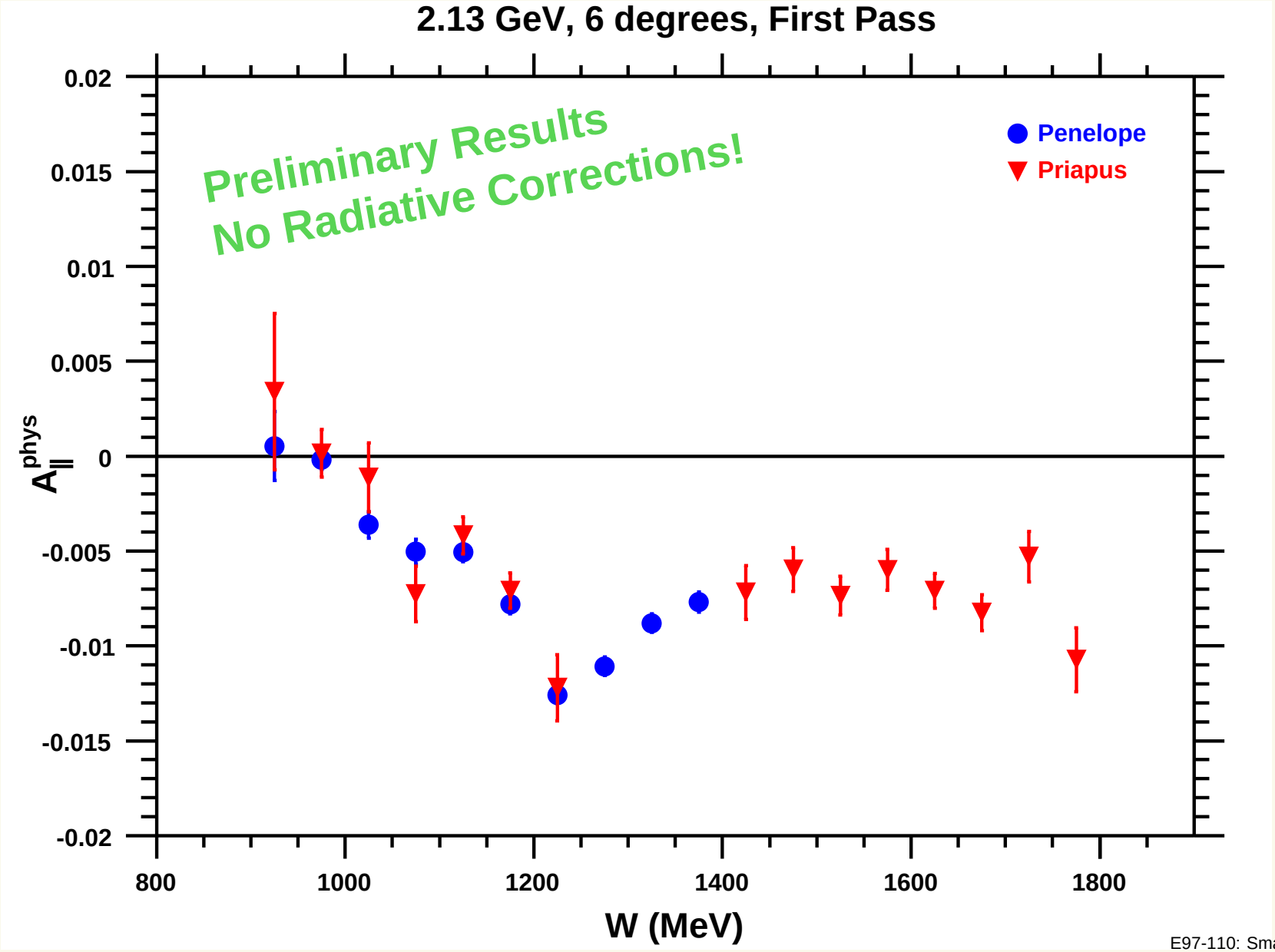
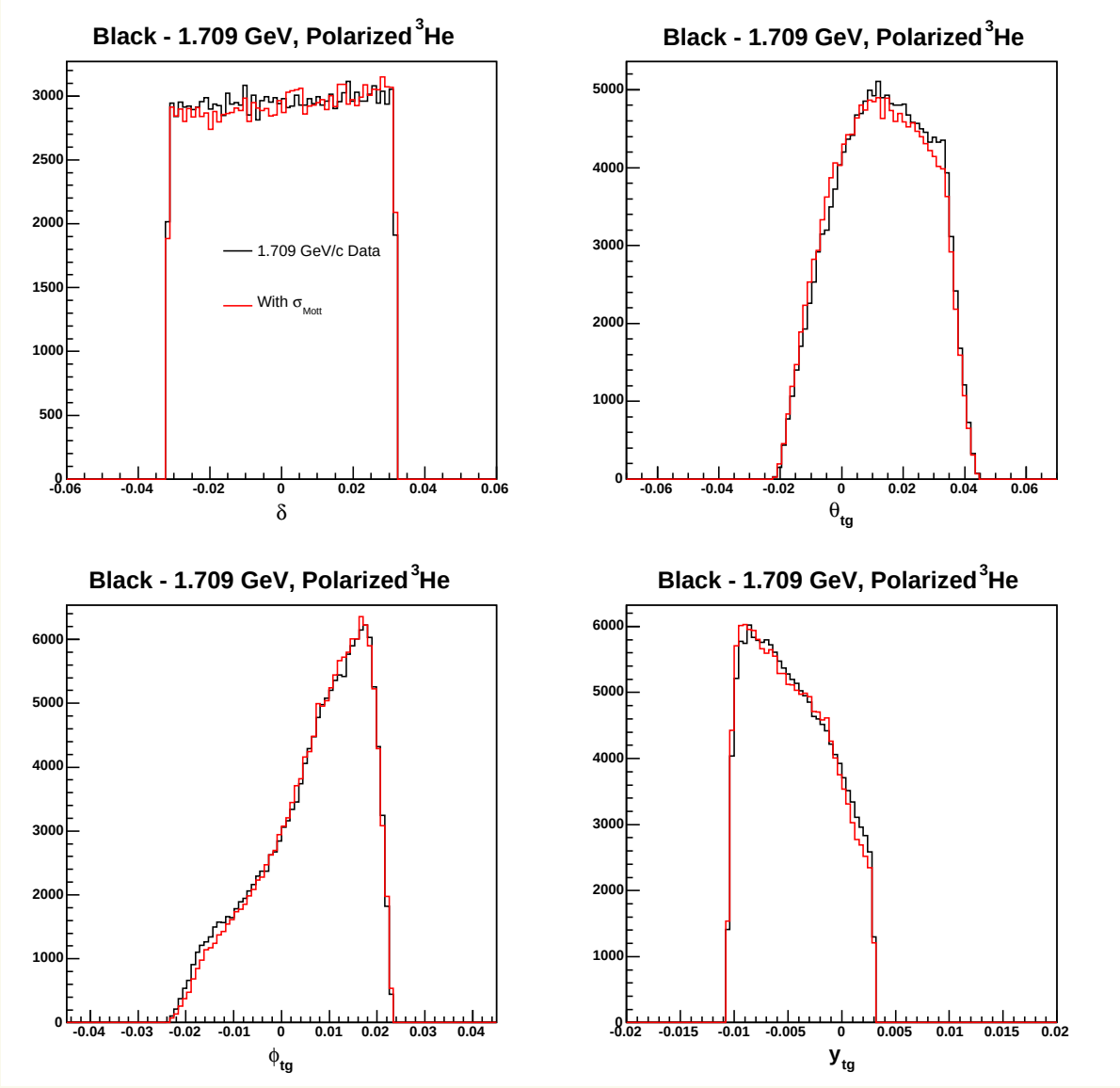


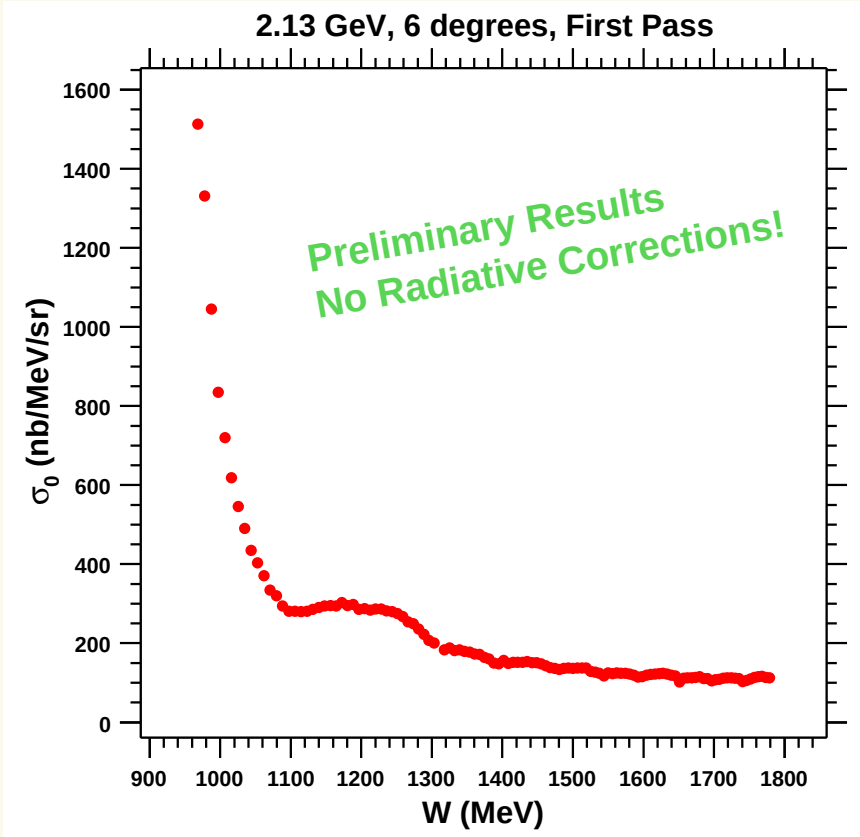
Acceptance at 6 degrees

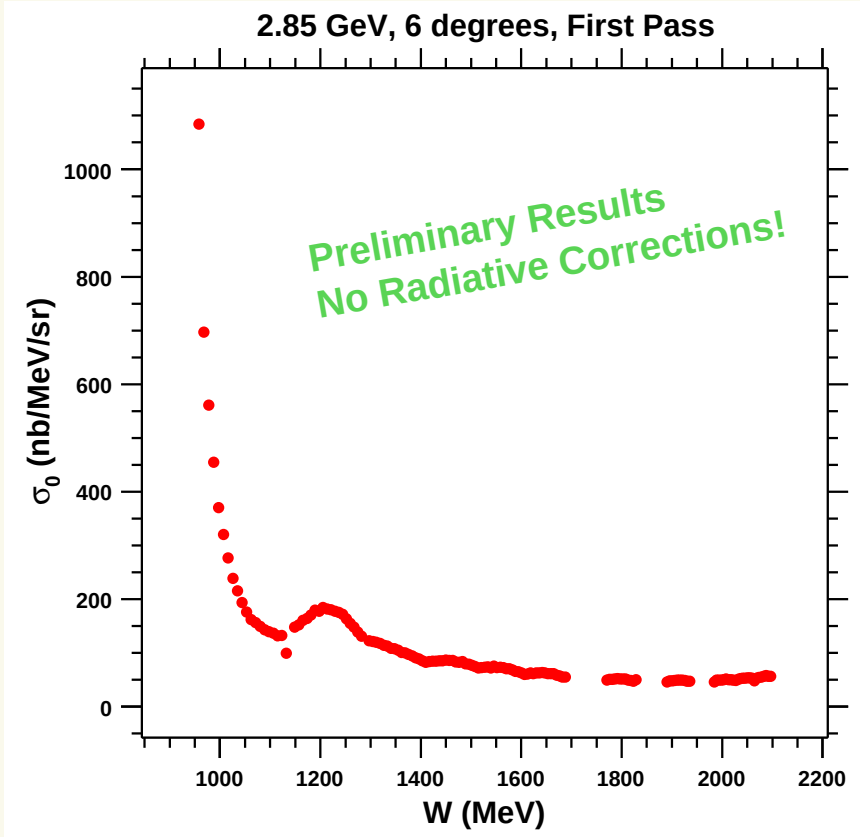
Black is Data and Red is Monte Carlo



He-3 Inelastic Cross Sections

No Radiative Corrections! AND we clearly still have some acceptance issues...





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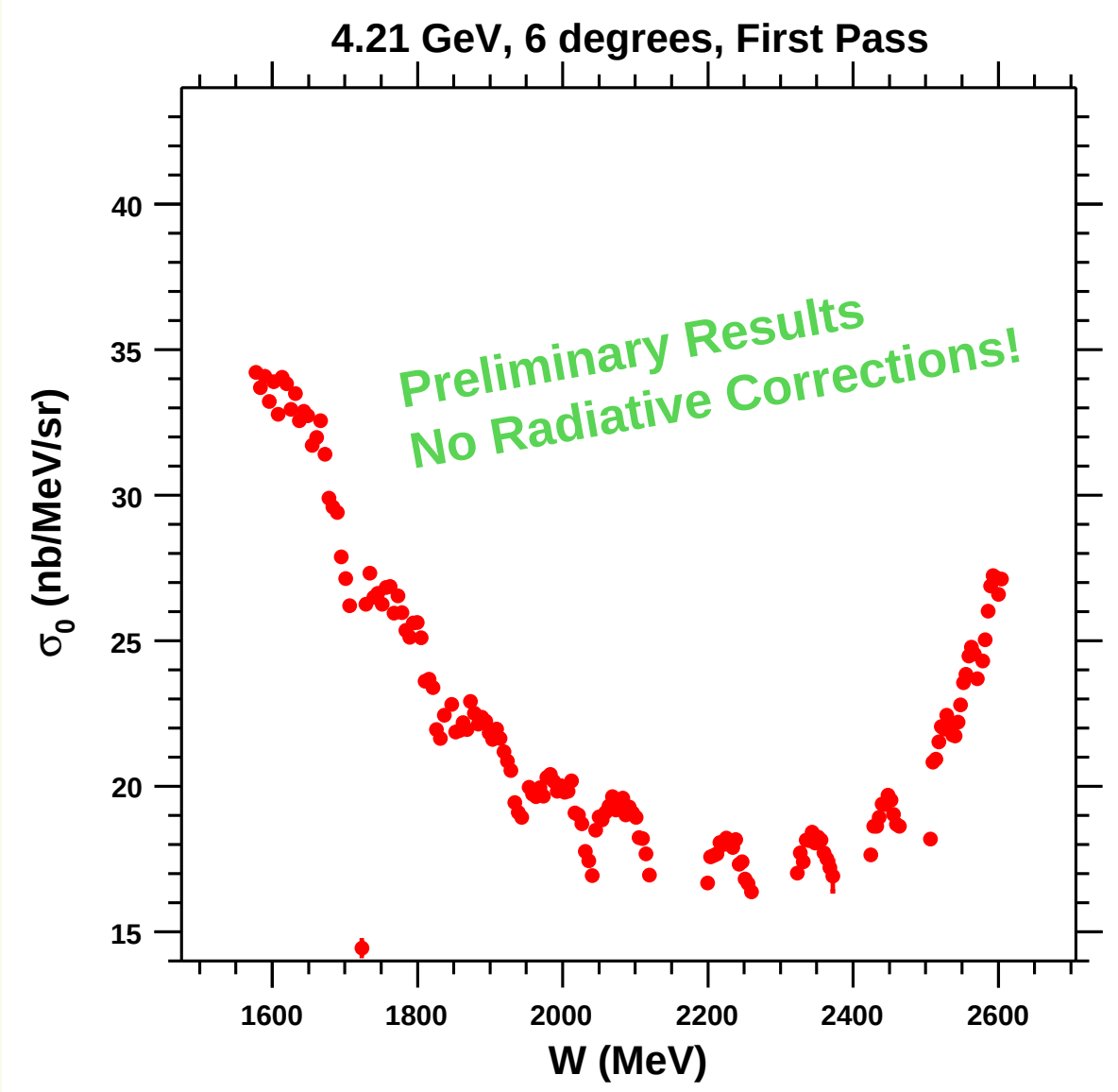
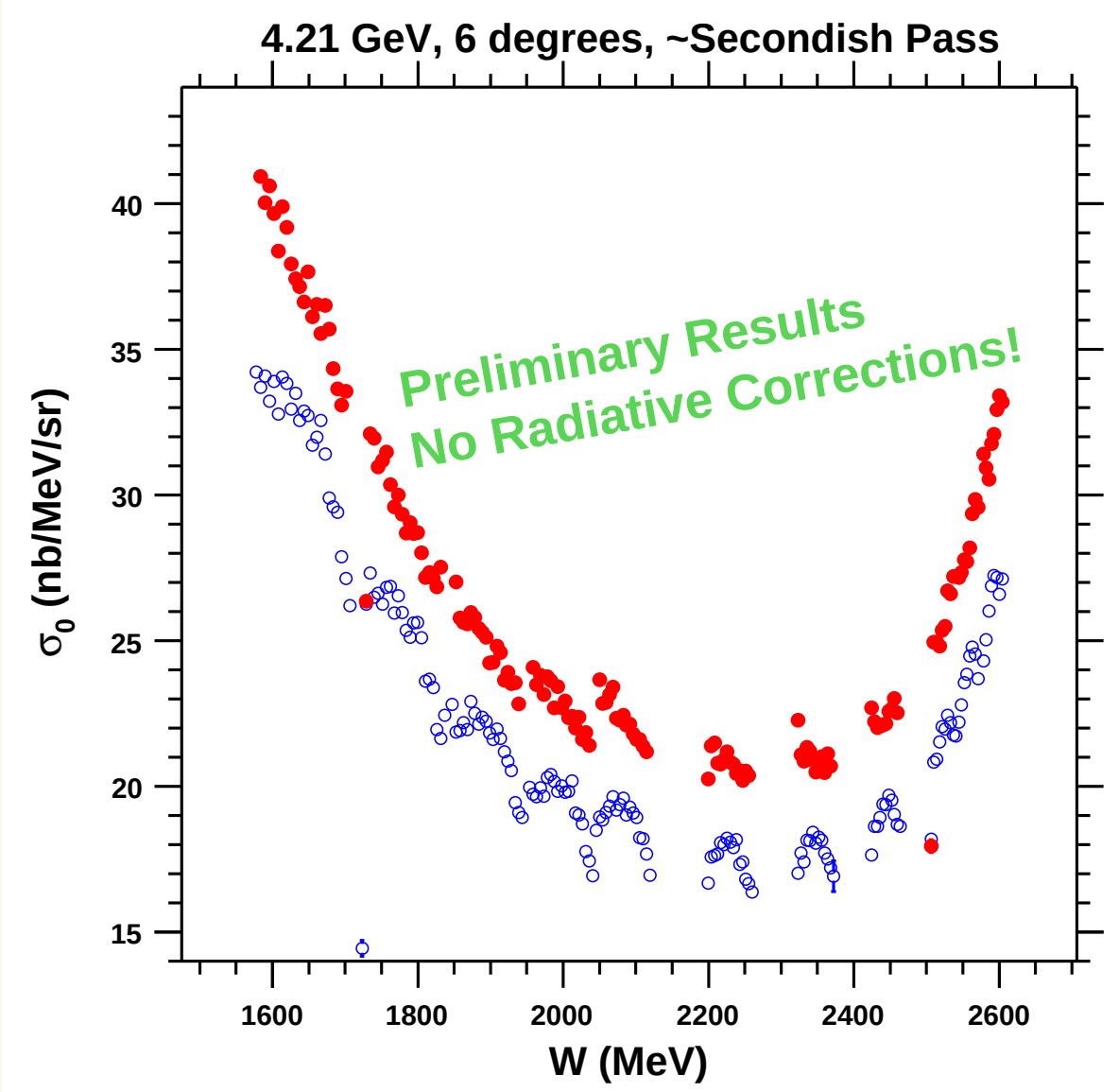


He-3 Inelastic Cross Sections

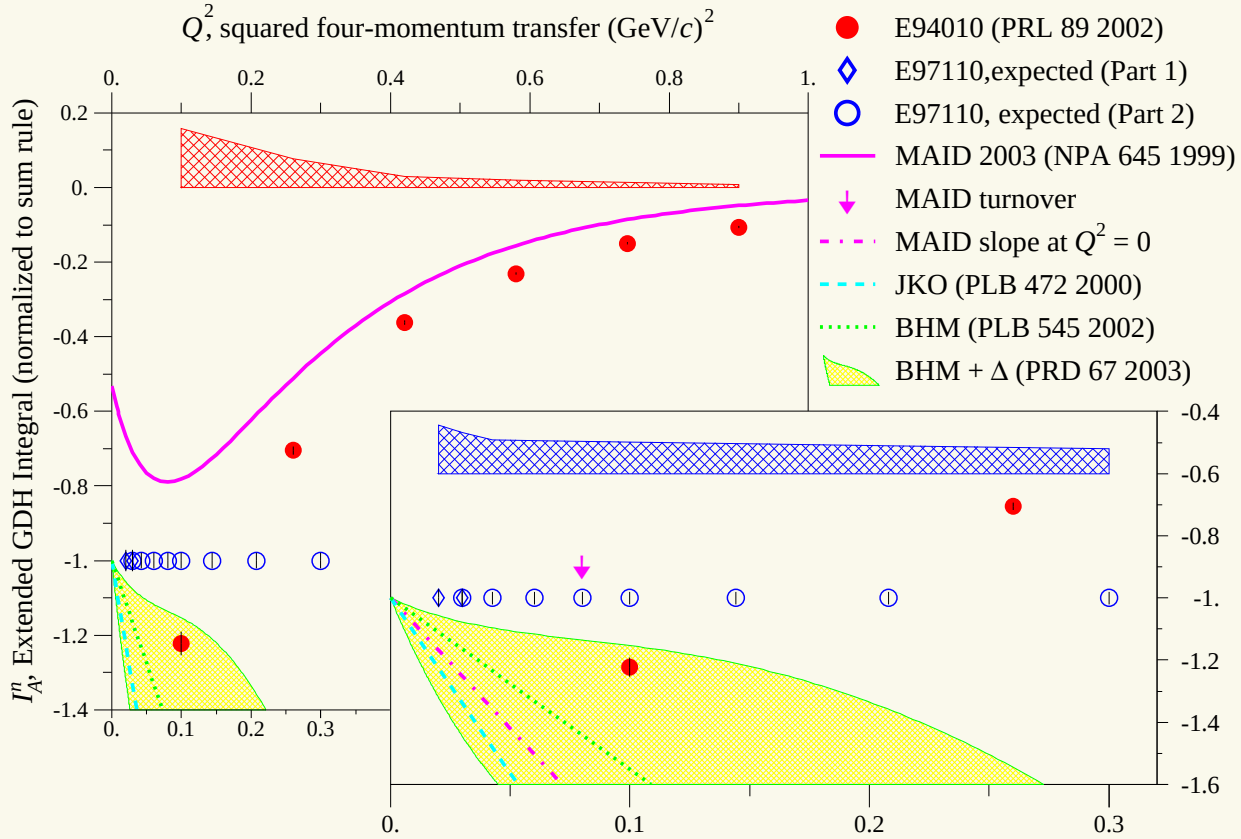
...but we're making progress



Summary: Expected Results

This data set complements the E94010 data set below $Q^2 = 0.10\ \mathrm{GeV}^2$ with improved precision.

1. Turnover?
2. Slope at low Q^2?
3. Extrapolation to the real photon point ($Q^2 = 0$)?



In addition, we will also extract the moments of the spin structure functions and forward spin polarizabilities.

Summary of Major Tasks

Recent or Current Tasks:

1. VDC Multitrack Analysis - In Progress (J. Yuan, S. Dhamija)
2. Background Studies: SAMC (T. Holmstrom)
3. He-3 Inelastic Asymmetries - First Pass (V. Sulkosky)
4. Acceptance at 6 degrees - Finishing Up! (V. Sulkosky)
5. He-3 Inelastic Cross Sections - In Progress (V. Sulkosky)
6. Radiative Corrections - In Progress (J. Singh, R. Feurbach)

Upcoming Tasks

1. Acceptance at 9 degrees (V. Sulkosky)
2. Finalize Beam and Target Polarimetry (J. Singh)
3. He-3 Elastic Analysis (J. Singh)
4. Forming the GDH Integral, etc. (V. Sulkosky, A. Deur)

Summary: Expected Results