JLab E-01-006
Resonances Spin Structure (*RSS*)

Precision Measurement of the Nucleon Spin Structure Functions in the Region of the Nucleon Resonances

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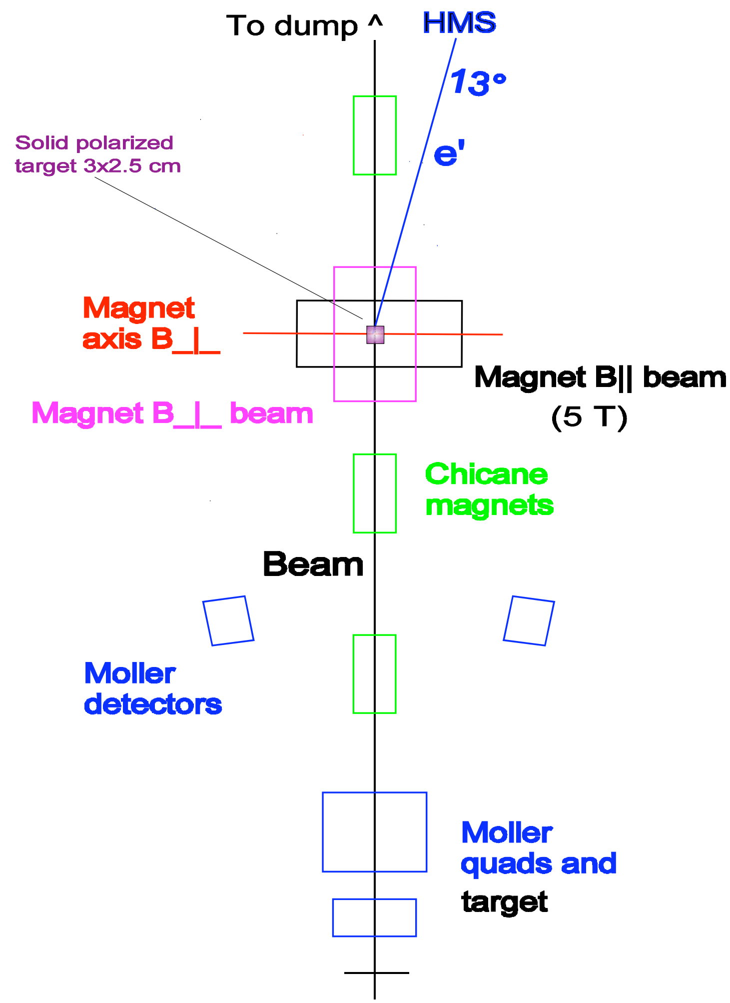
Spokesmen: Oscar A. Rondon (UVA) and Mark K. Jones (JLab)

Physics:

- Measure proton and deuteron spin asymmetries $\mathbf{A}_1(W, Q^2)$ and $\mathbf{A}_2(W, Q^2)$ at momentum transfer $Q^2 \approx 1.3$ GeV^2 and invariant mass $0.8 \leq W \leq 2$ GeV.
- Study *W* dependence, onset of polarized local duality, twist-3 effects.
- Extract asymmetries from **inclusive polarized electron scattering on polarized nuclei**.

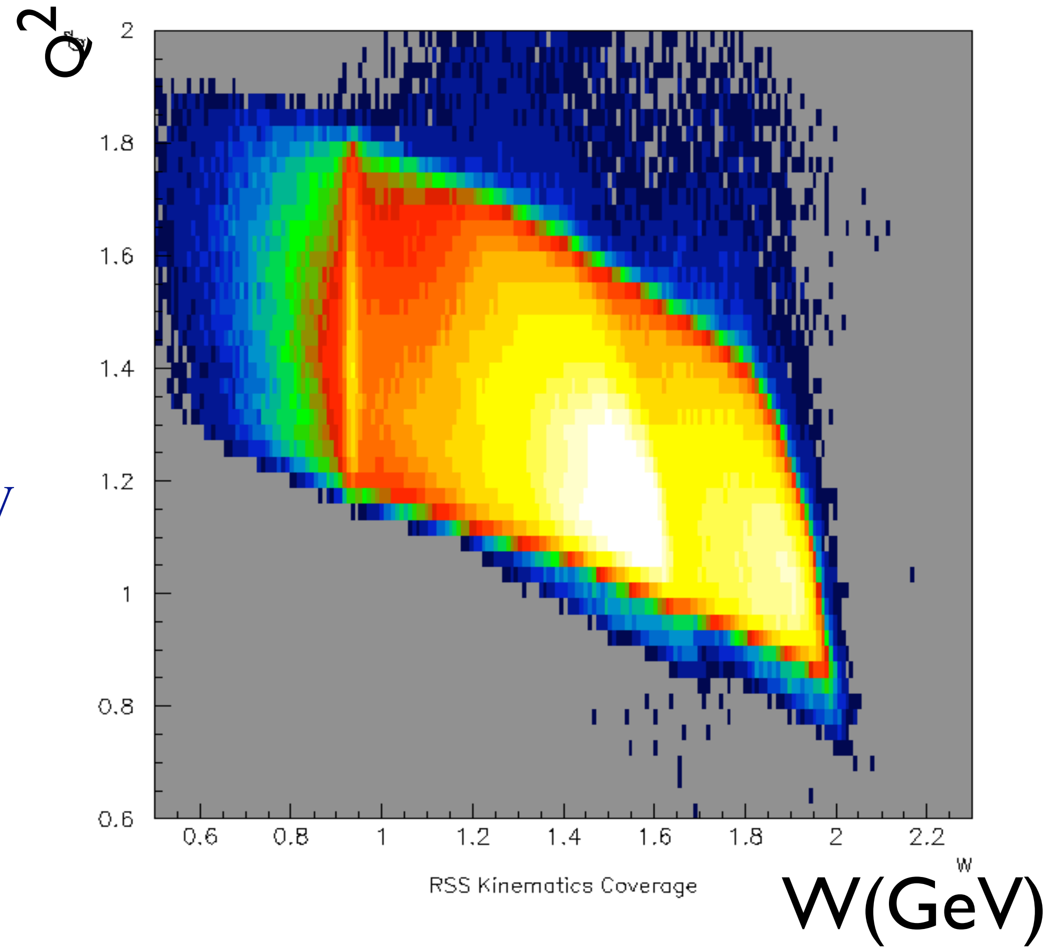
RSS technique

- Measure count asymmetries $A_{\|}$, $A_{\perp}$ on protons, deuterons
- Equipment: **Hall C**
- CEBAF polarized electron beam
  - 2 cm diameter raster at target
- Polarized ammonia target
  - Luminosity ~10^{35} Hz cm^{-2}
- High Momentum Spectrometer HMS
  - $\theta_{HMS} = -13.2°$
- Took data 1/21 to 3/3/2002
  - 160 M proton triggers
  - 350 M deuteron triggers

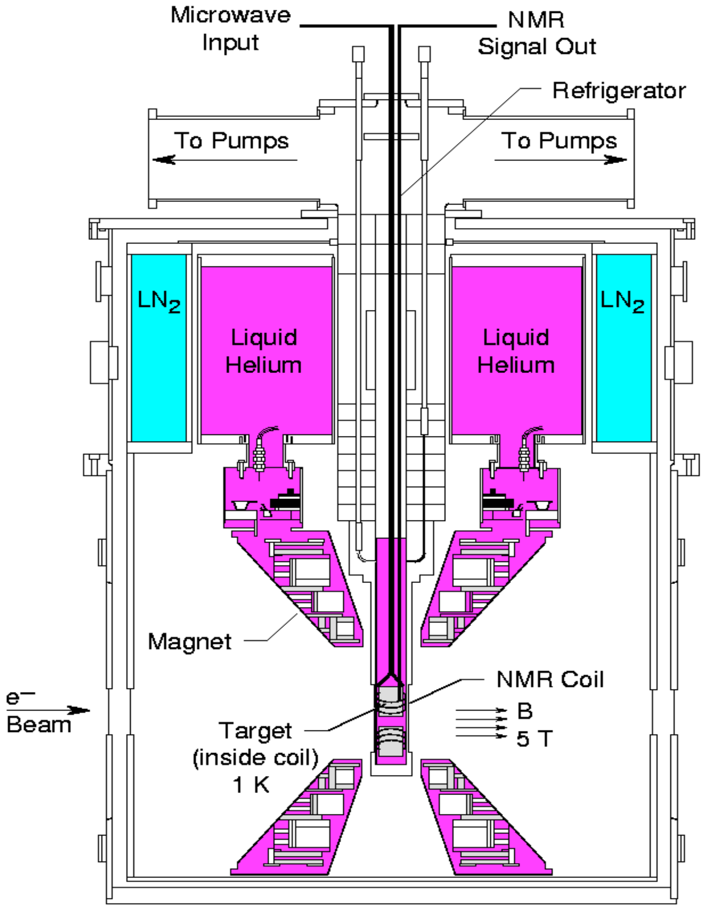


RSS kinematics

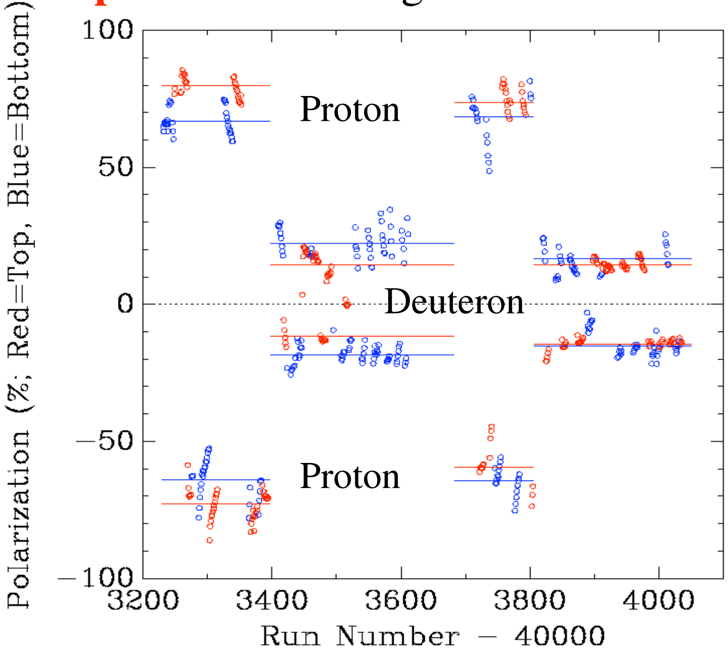
- Beam energy 5.755 GeV
- HMS angle 13.2^{o}
- HMS central momenta:
    - 4.7 GeV/c
    - 4.1 GeV/c
- Final state mass range:
    - 0.8 GeV $\leq W \leq$ 2.0 GeV
- $\langle Q^2 \rangle = 1.3\ [\mathrm{GeV/c}]^2$



Polarized Target



- Dynamic Nuclear Polarized ammonia (NH_3) and deuterated ammonia (ND_3) targets
- Carbon disks, He for normalization
- **Top** and **bottom** target cells



Measured asymmetries $A_{\parallel}$, $A_{\perp}$

$$A_{\parallel,\perp} = \frac{1}{C_N f_{RC}}\left(\frac{\epsilon}{f P_b P_t} - C_D\right) + A_{RC}$$

$$\epsilon = \frac{L-R}{L+R}$$

- L, R = charge normalized, dead time and pion corrected numbers of counts for opposite beam helicities
- P_b, P_t = beam, target polarizations
- f = dilution factor
- C_N, C_D = corrections for N in ammonia (C_D for deuterium only).
- f_{RC}, A_{RC} = radiative corrections

How to get A_1, A_2, g_1, and g_2

- Full expression for *RSS* analysis

$$A_1 = \frac{Q^2}{D'} \frac{(\nu \cot(\theta/2) + E' \sin\theta) \cos\phi \; A_{||} + E'(1+\cos\theta) A_\perp}{E' \sin\theta \cos\phi \; (Q^2 + 2E(E + E'\cos\theta))}$$

$$A_2 = \frac{\sqrt{Q^2}}{D'} \frac{(Q^2 \cot(\theta/2) - \nu E' \sin\theta) \cos\phi \; A_{||} + (Q^2 + \nu(E + E'\cos\theta)) A_\perp}{E' \sin\theta \cos\phi \; (Q^2 + 2E(E + E'\cos\theta))}$$

  - ***D'***(*E*, *E'*, θ, *R*) = depolarization factor

- Have both SA's and SF's calculated using above.

$$g_1 = \frac{F_1}{1+\gamma^2}(A_1 + \gamma A_2)$$

$$g_2 = \frac{F_1}{1+\gamma^2}(A_2/\gamma - A_1) \qquad \gamma = \sqrt{\frac{Q^2}{\nu^2}}$$

Status as of Jan. 2005

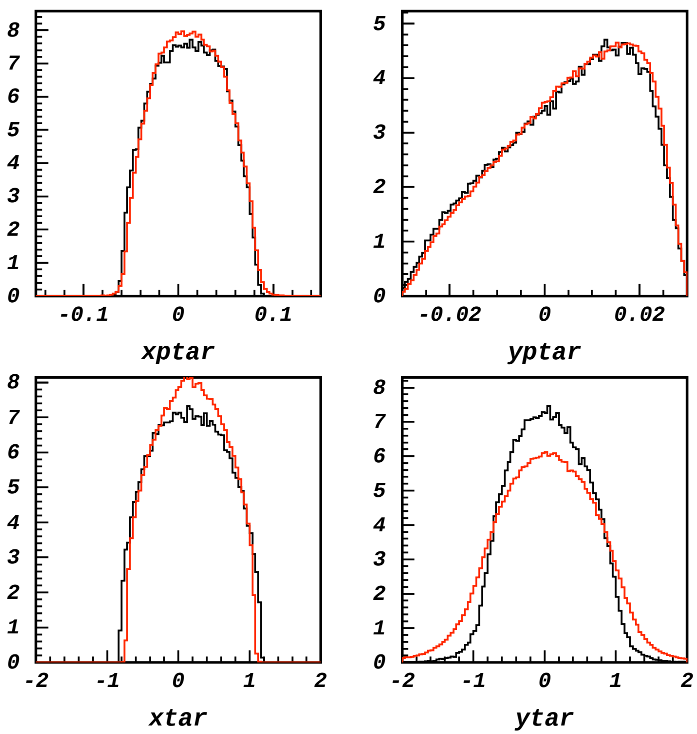
- Hallc Engine and MC upgraded (M. Jones and O. Rondon)
- Performed 2nd pass analysis (F. Wesselmann)
- Packing fractions and dilution factors for proton and deuteron (Tajima)
- Proton elastic asymmetry (M. Jones)
- Radiative Corrections (K. Slifer)

Status of Software (2nd pass)

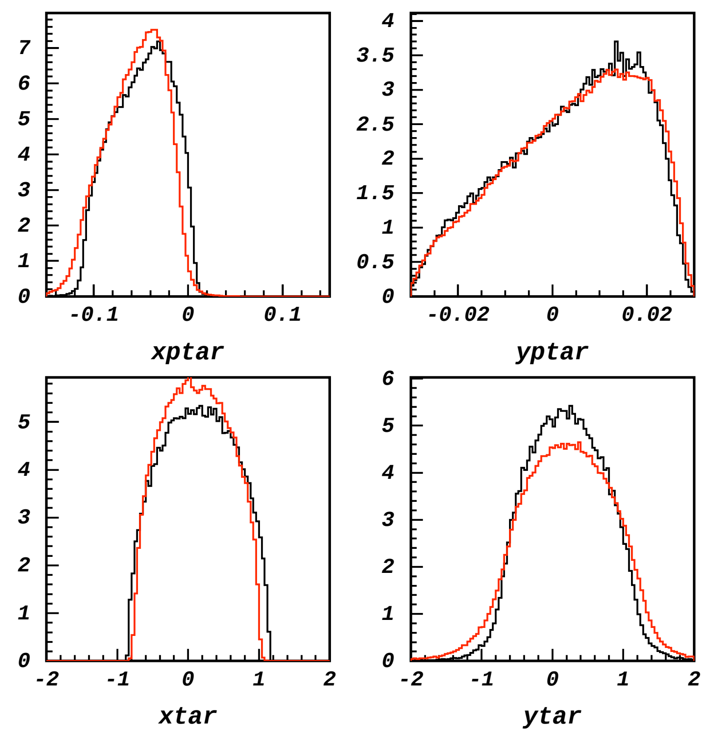
- HallC Engine
  - Added Phi dependence to target field to remove the correlation between x' and W for perp data
  - optics matrix elements have dependence on vertical positions
  - Run database has been updated
  - 2nd pass replays have been performed
- Monte Carlo (pol_hms_single)
  - Added Phi dependence to target field for perp data (→ caused shift in HMS W for perp runs)
  - HMS momentum for the perp runs were adjusted to get the correct W peaks
  - Programming errors were found and fixed
  - QFS and deuteron models improved
  - Used to obtain packing fractions and dilution factors

Target Quantity Reconstruction

NH3, // Field, 4078 MeV/c



NH3, ⊥ Field, 4078 MeV/c



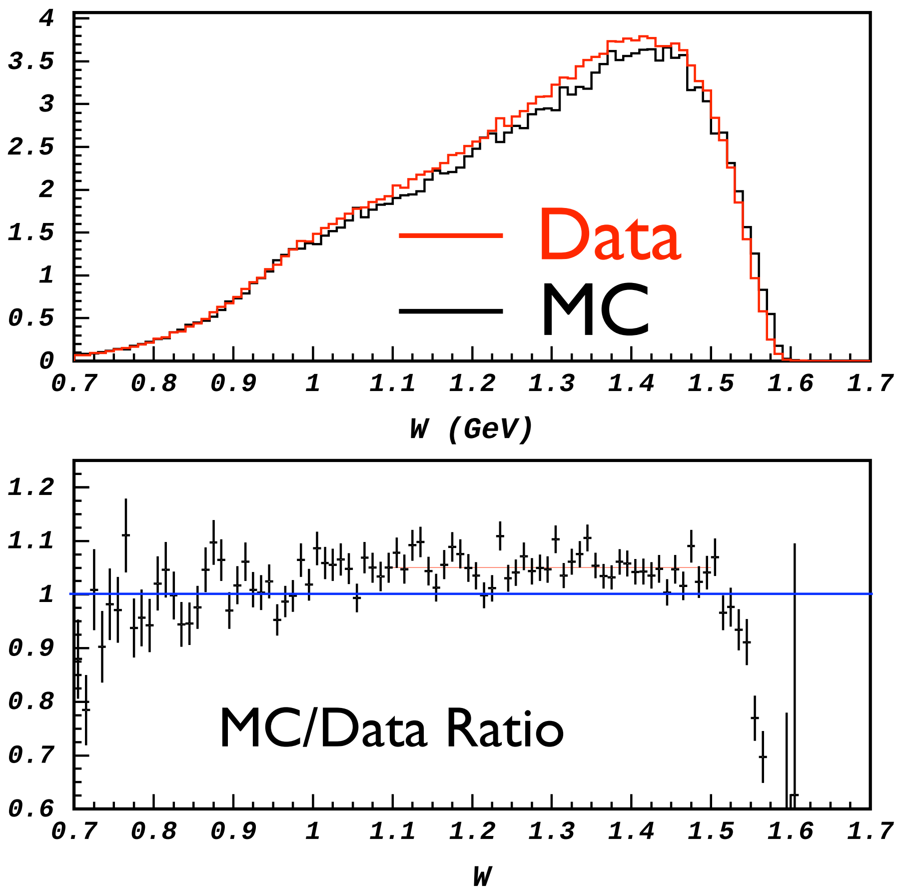
Data

MC

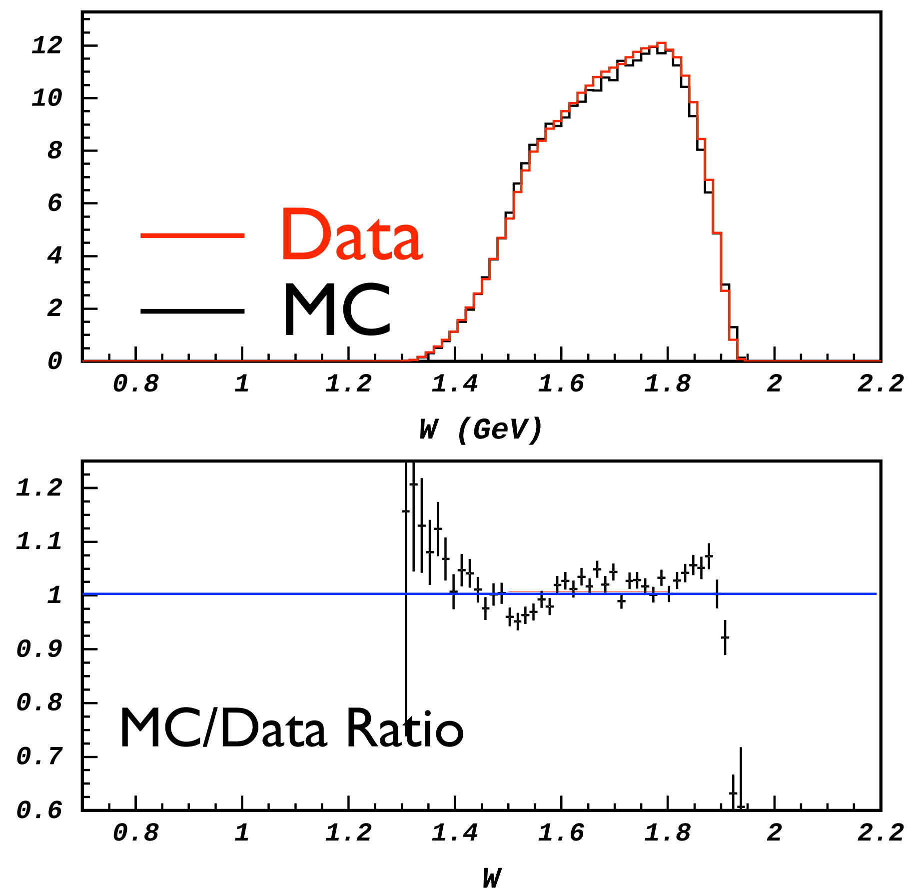
Normalization Examples

- Comparison of Carbon data with MC (// Field)

4703 MeV/c



4078 MeV/c



Normalization Examples

- Comparison of Carbon data with MC (⊥ Field)

4703 MeV/c

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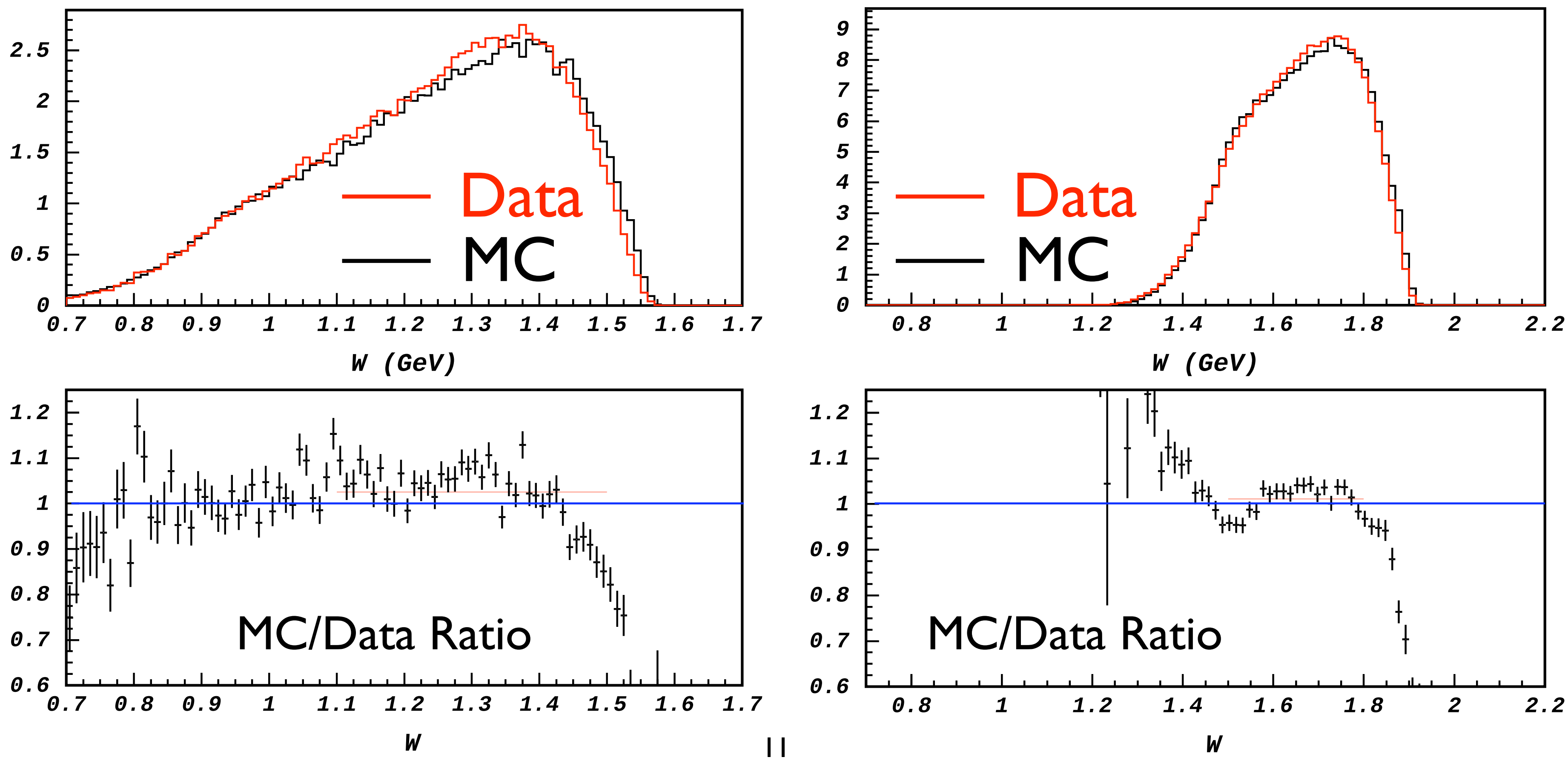
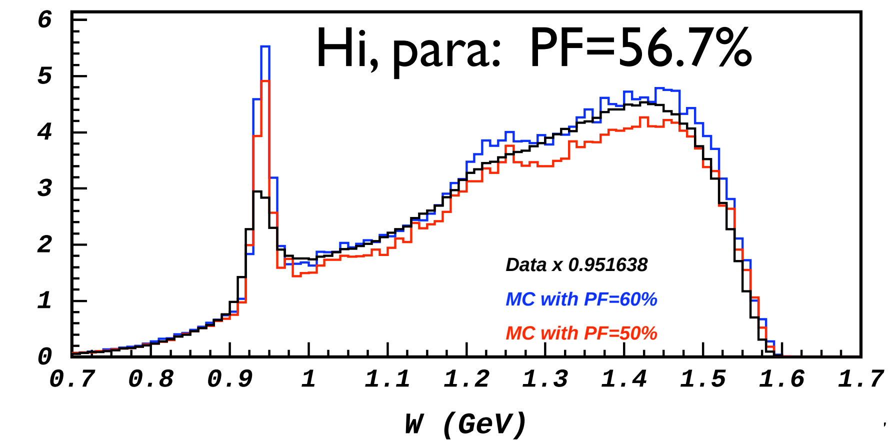
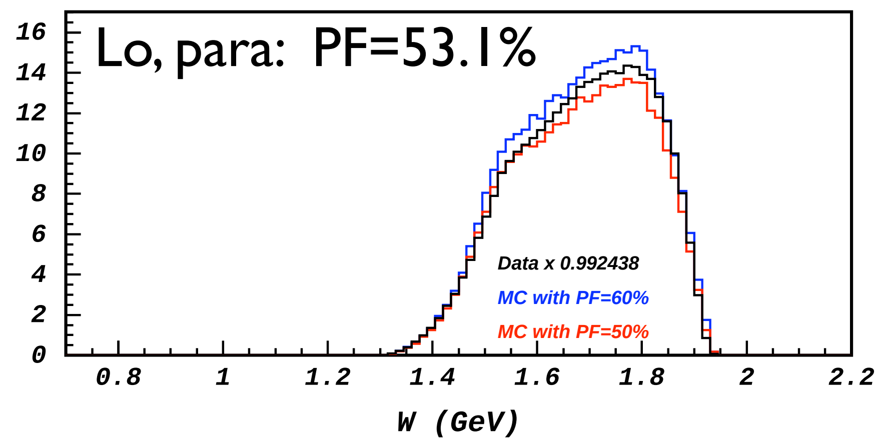
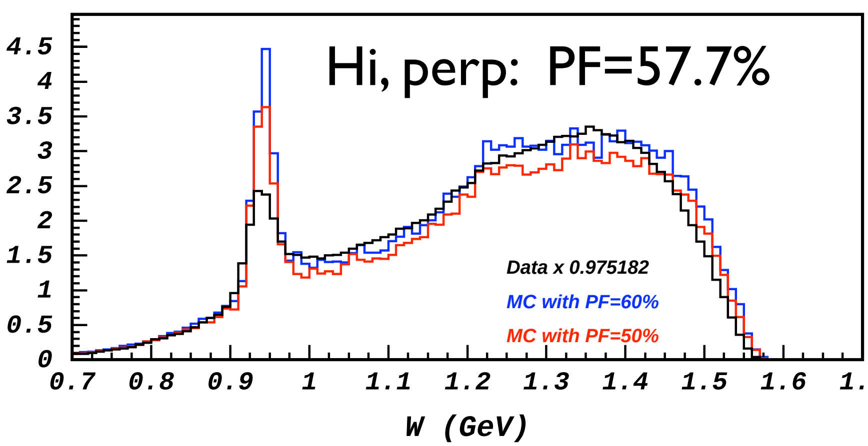


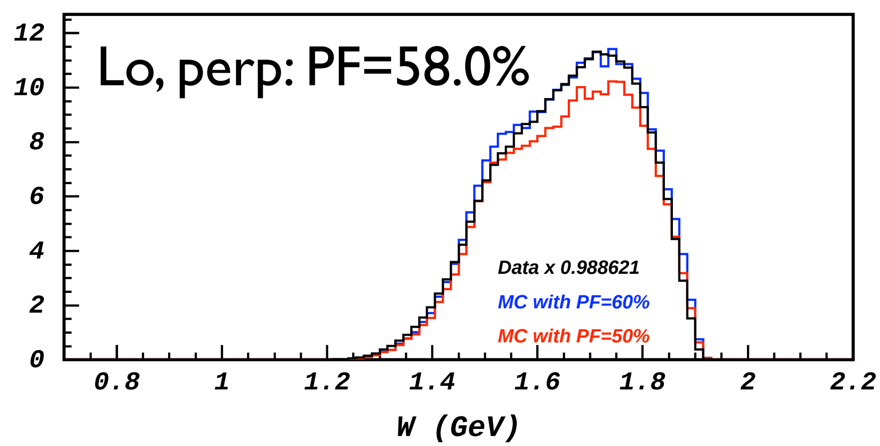
Individual cell Packing Fractions (Preliminary)

- Scale factor determined by the ratio of Carbon data to MC
- NH3, Top target (Hi: 4703MeV; Lo: 4078MeV)
- Need to determine 8 packing fractions

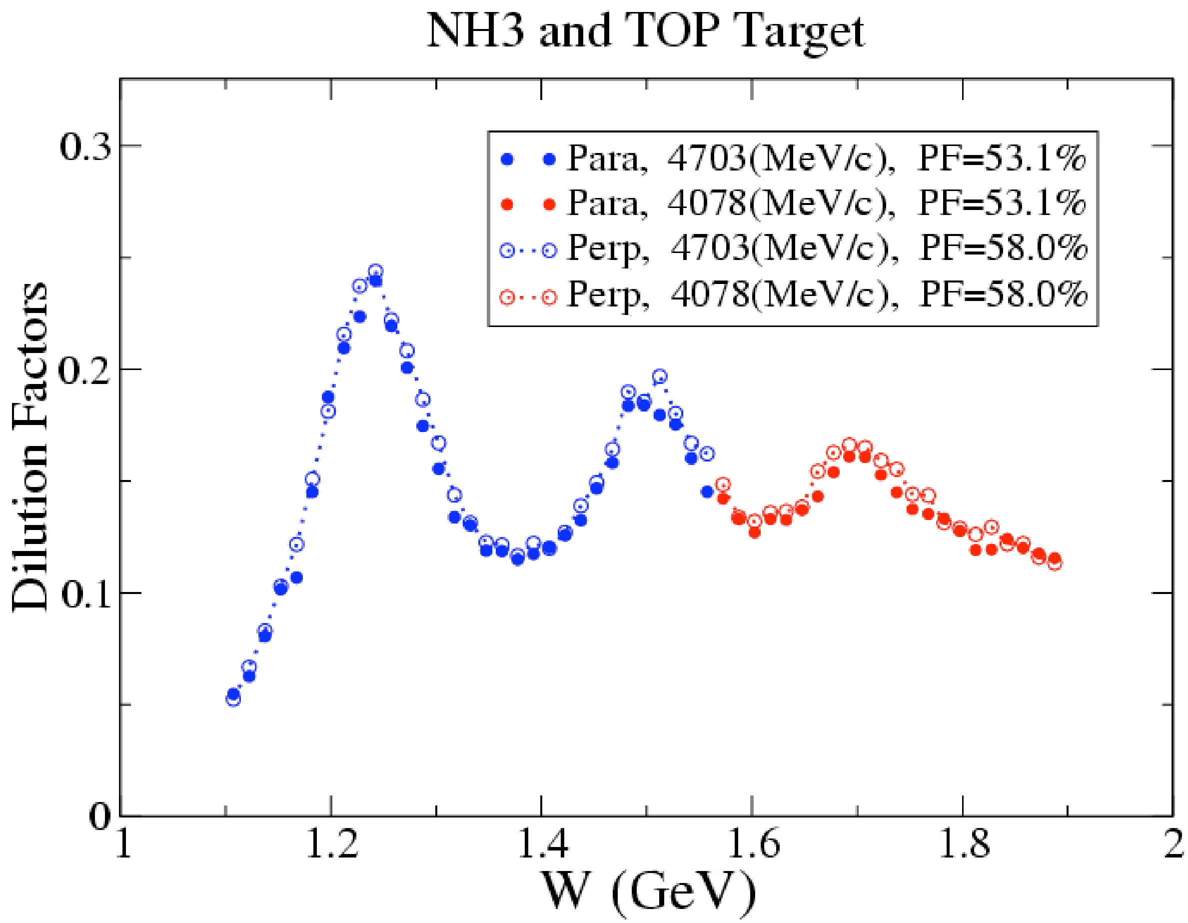








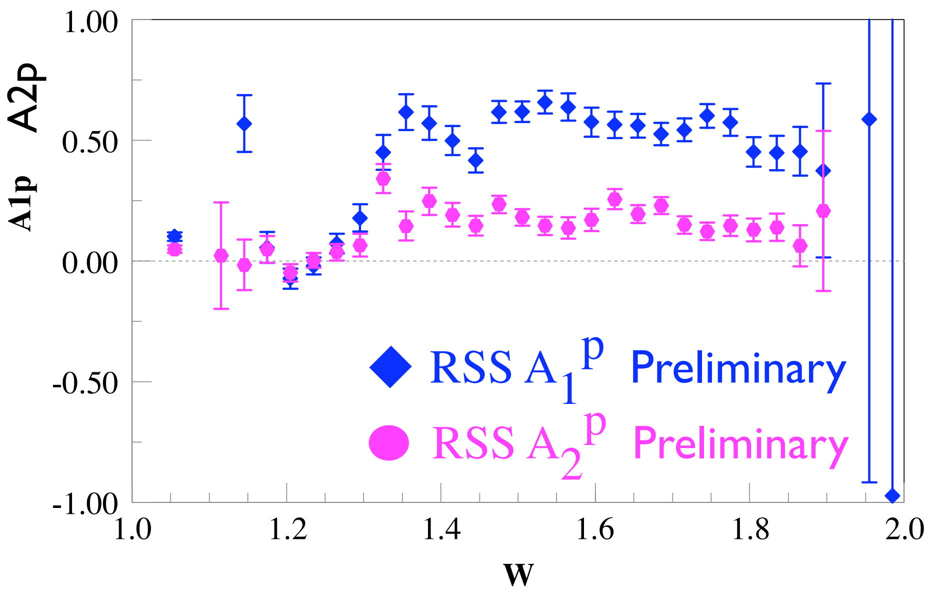
Preliminary Dilution Factors (examples)

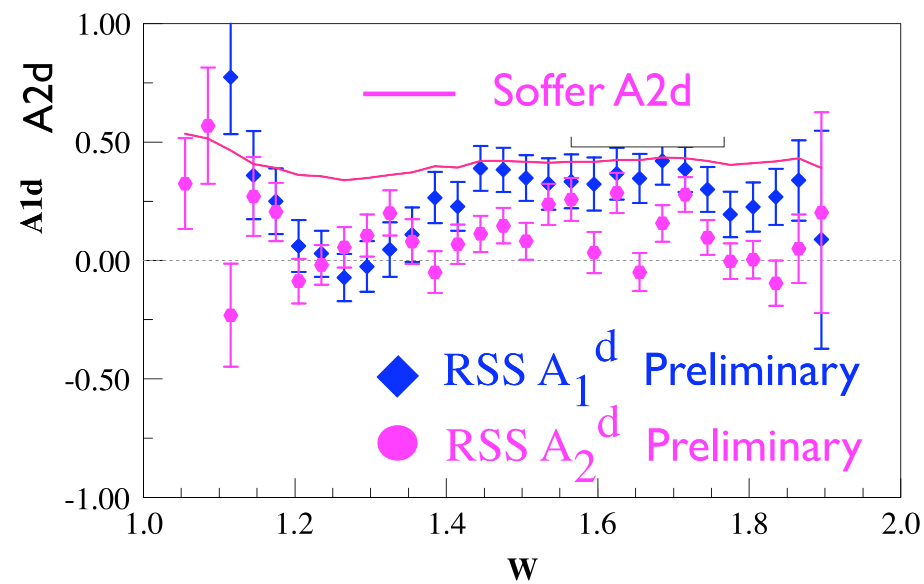


- Dilution factors (DFs) obtained for each target configuration
- The MC was run with the preliminary packing fractions, and the DFs are determined by the ratio of proton counts to the total counts (for NH3 target)

A_1^p, A_2^p, A_1^d and A_2^d (Preliminary)

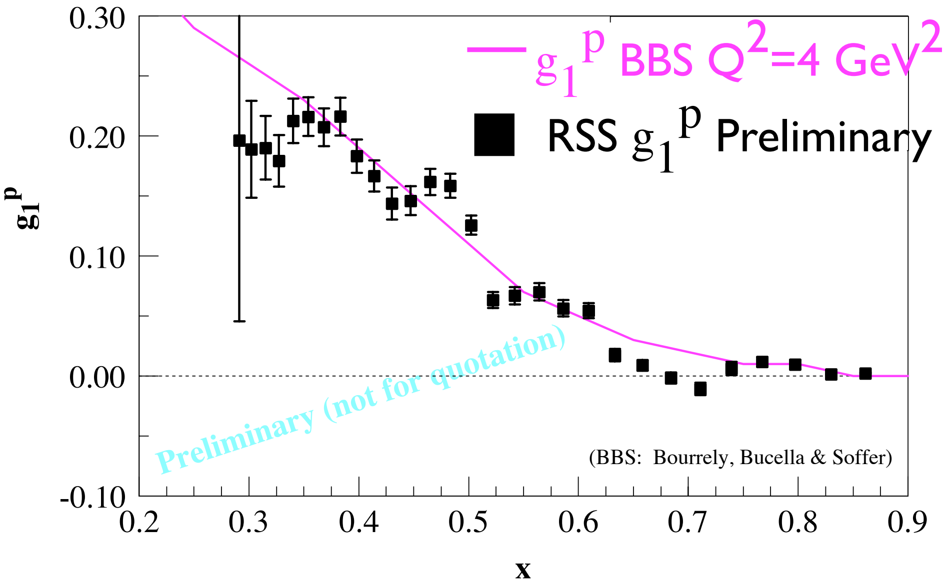
- 2nd pass results
- But the dilution factors from the 1st-pass analysis were used
- No corrections applied yet

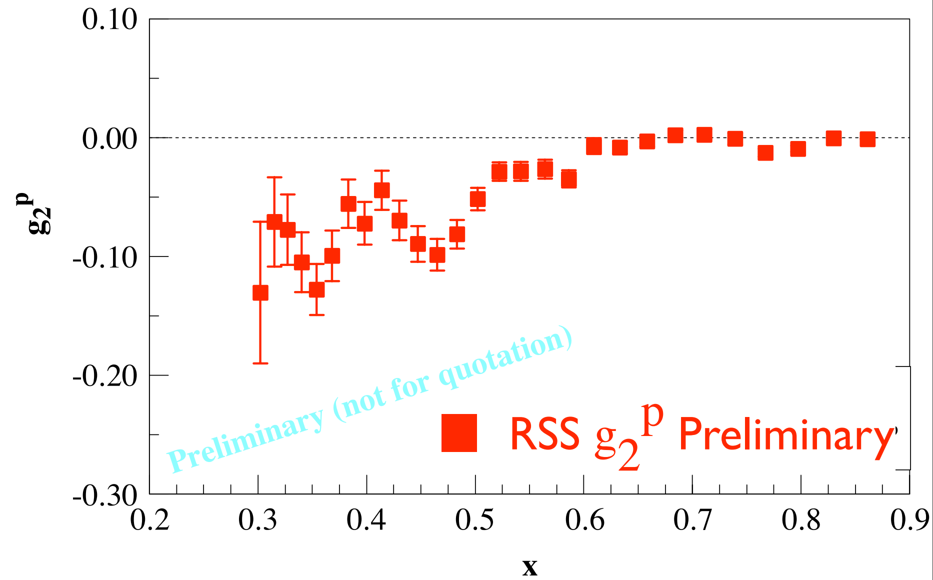




g_1^p and g_2^p (Preliminary)

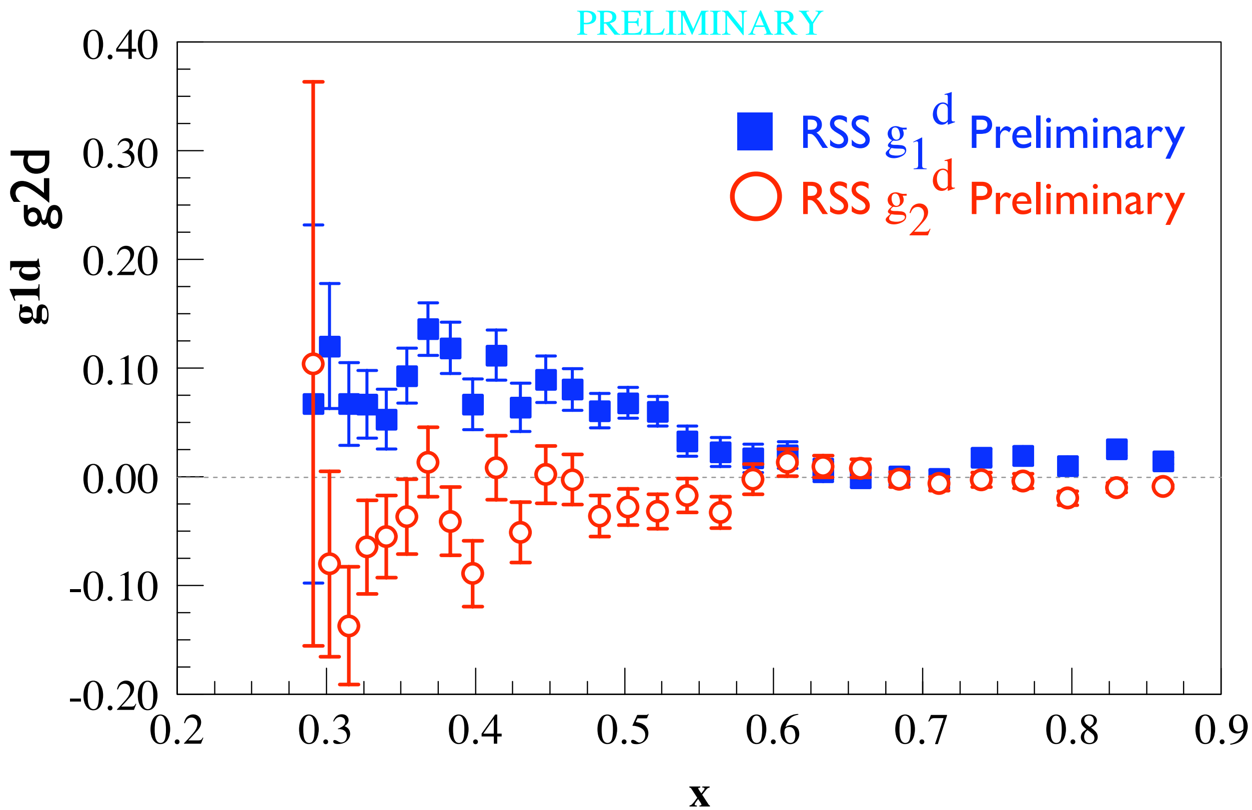
- The dilution factors from the 1st-pass analysis were used
- No corrections applied yet





g_1^d and g_2^d (Very Preliminary)

- The dilution factors from the 1st-pass analysis were used
- No corrections applied yet

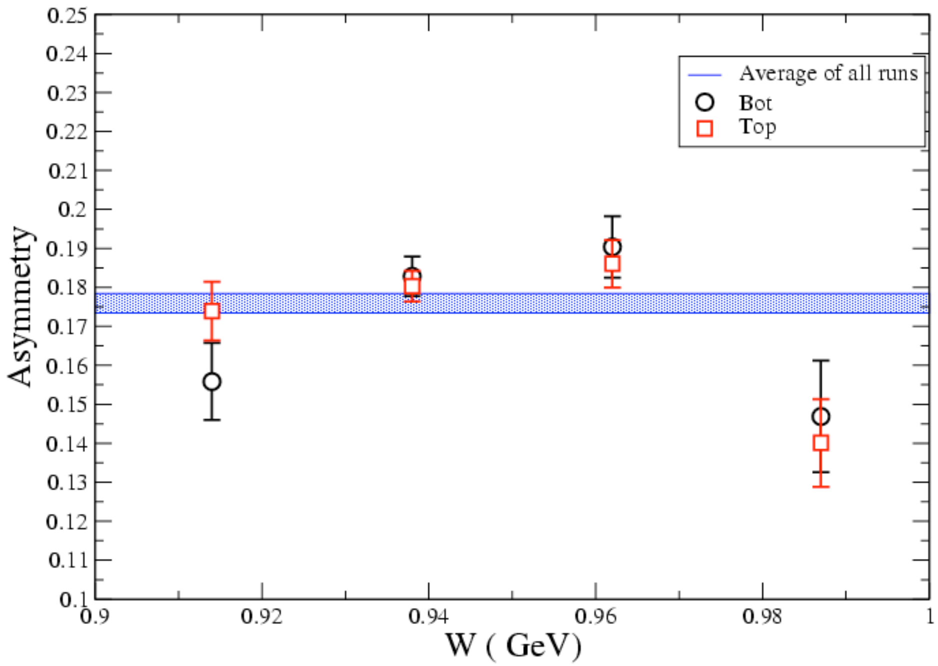


ep elastic asymmetry (Preliminary)

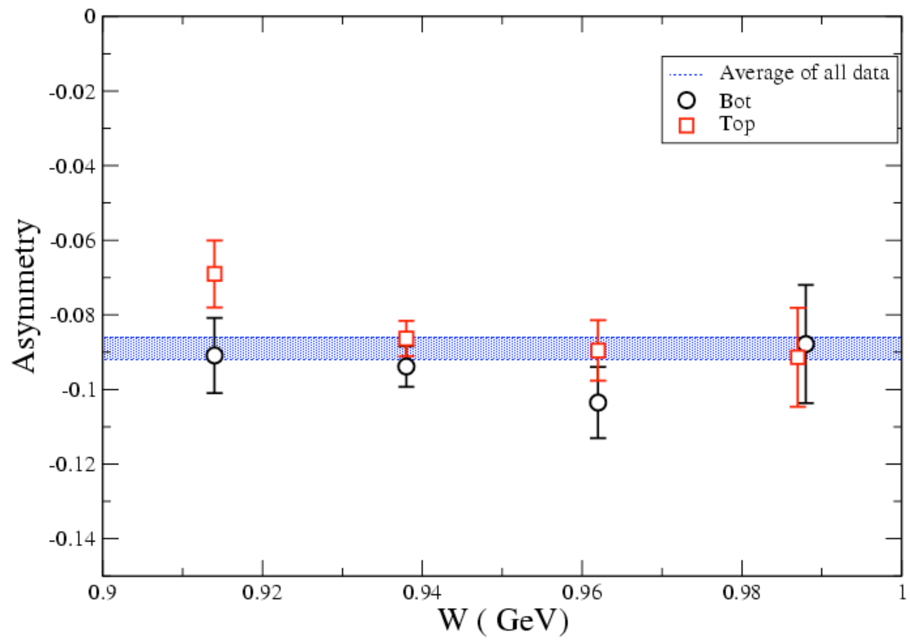
- Parallel Asymmetry (average value is 0.176±0.0024)
  The top and bottom asymmetries agree fairly well.

- Perpendicular Asymmetry (average value is -0.089±0.0028)
  The top and bottom asymmetries agree at about 2 sigmas.

Parallel target field

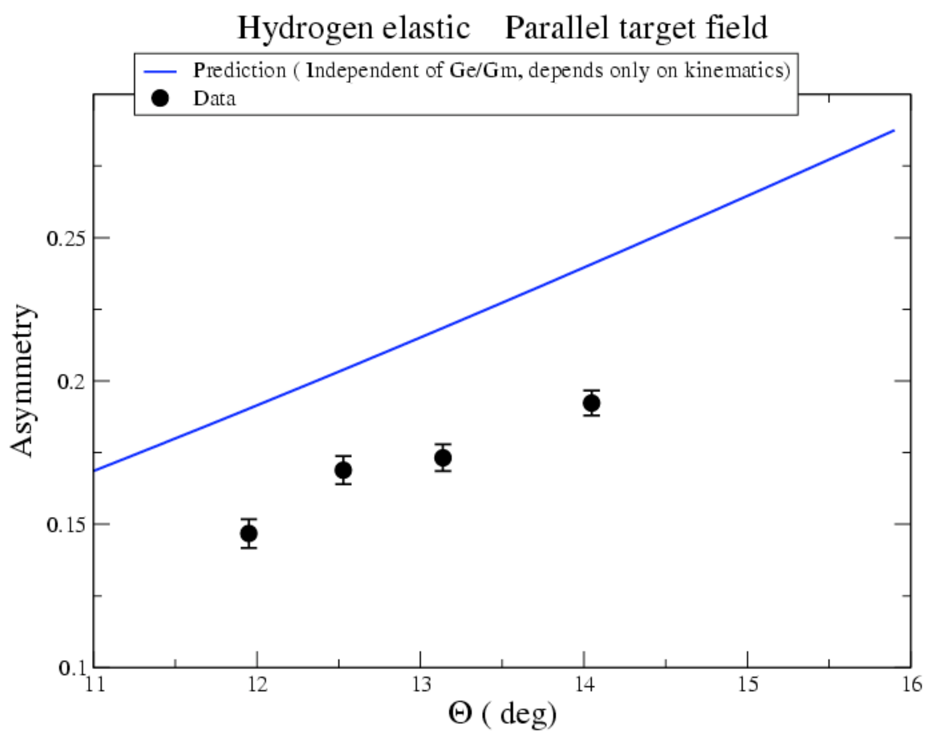


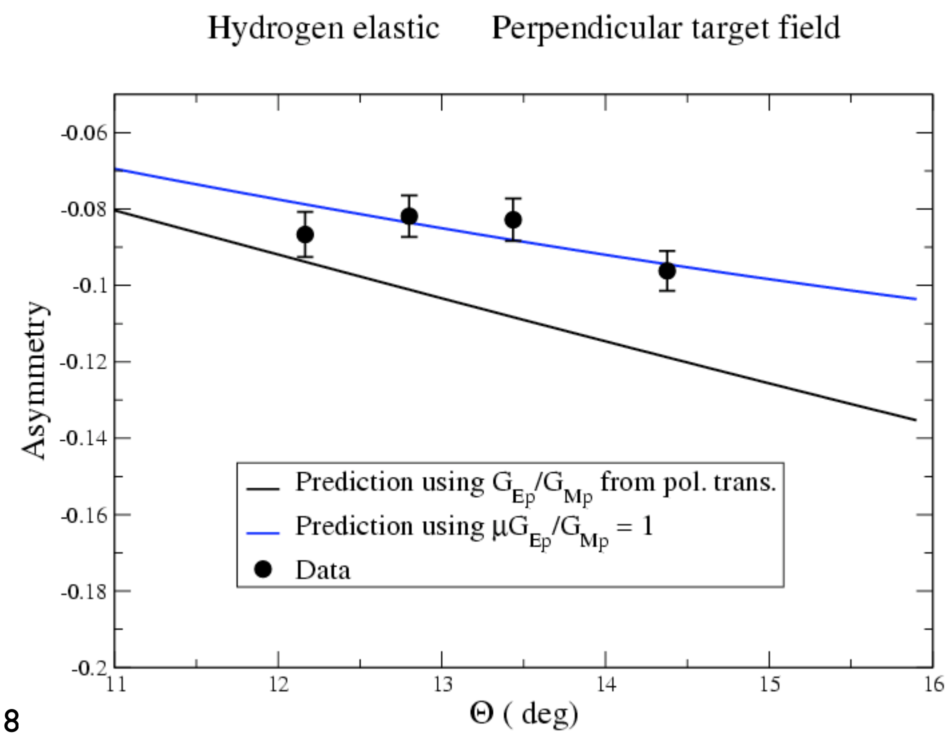
Perpendicular target field



ep elastic asymmetry (Preliminary)

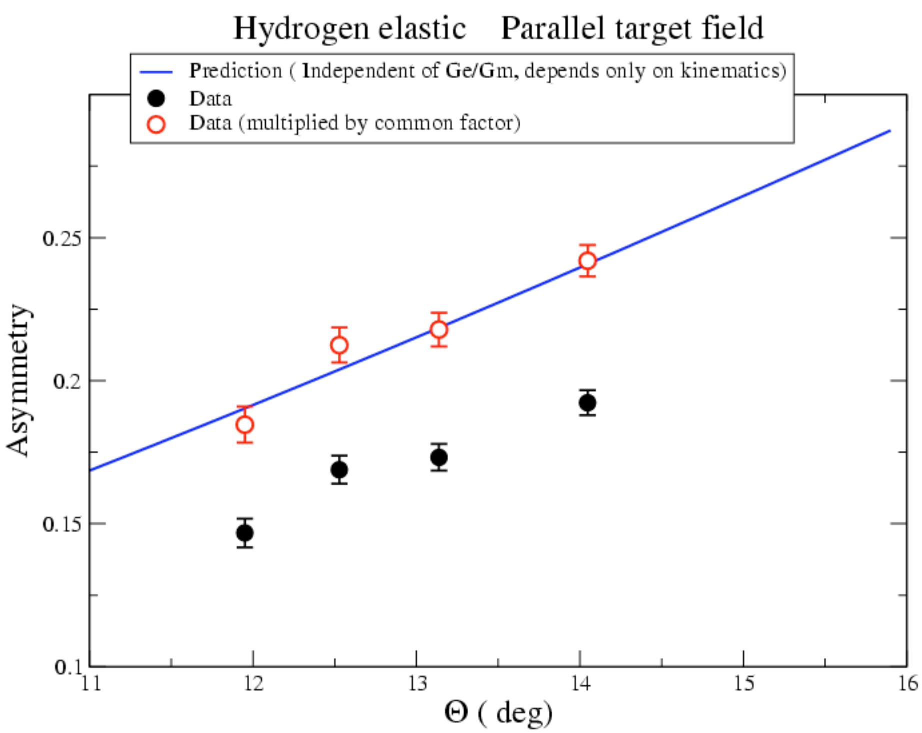
- Dependence on scattering angle (change in kinematics)
- Ratio of perp to para asymmetry agrees with the ratio of Ge/Gm from the polarization transfer.

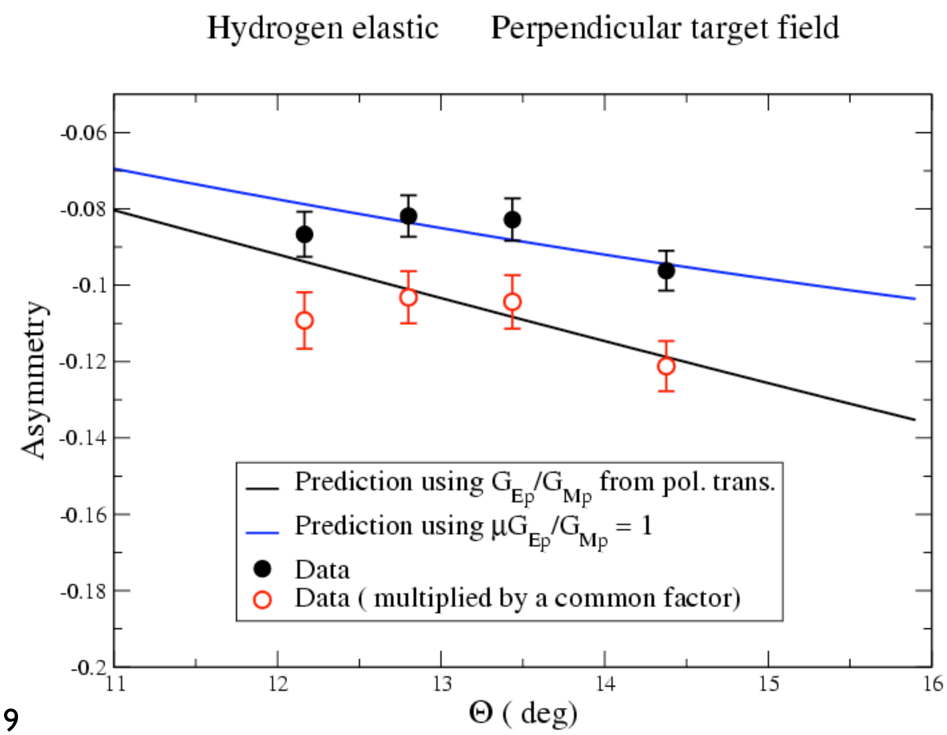




ep elastic asymmetry (Preliminary)

- Dependence on scattering angle (change in kinematics)
- Ratio of perp to para asymmetry agrees with the ratio of Ge/Gm from the polarization transfer.
- If data points are multiplied by a common factor, data agree with the predicted asymmetry assuming Ge/Gm from polarization transfer





Other things to do

- Next pass analysis (pass2a) (F. Wesselmann)
- Systematic uncertainties
- Neutron quasielastic asymmetry (Tajima)
- Corrections
    1. Radiative corrections (K. Slifer)
    2. Nitrogen asymmetry