

JLab E-01-006

Resonances Spin Structure (*RSS*)

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

U. Basel, Florida International U., Hampton U., U. Massachusetts, U. Maryland, Mississippi S. U., North Carolina A&T U., U. of N. C. at Wilmington, Norfolk S. U., Old Dominion U., S.U. New Orleans, U. of Tel-Aviv, TJNAF, U. of Virginia, Virginia P. I. & S.U., Yerevan Physics I.

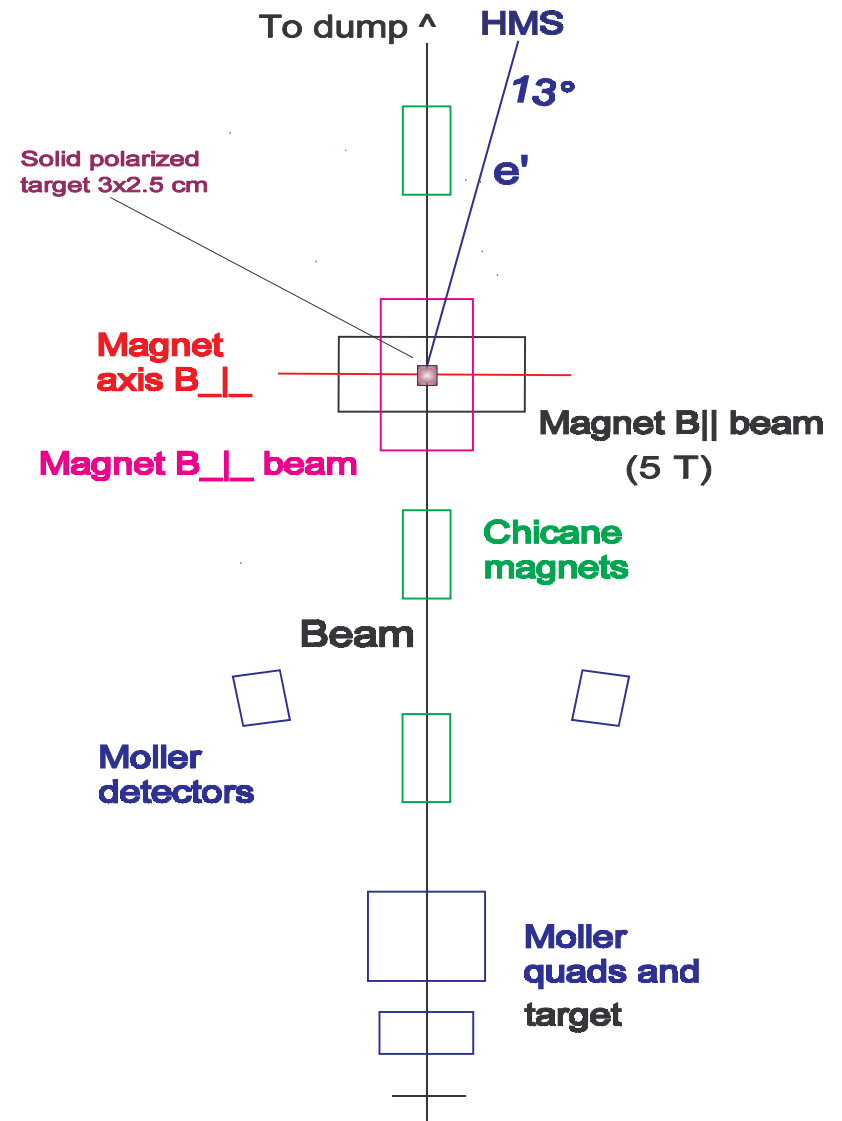
Spokesmen: Oscar A. Rondon (UVA) and Mark K. Jones (JLab)

Physics:

- Measure **proton** and **deuteron** spin asymmetries $A_1(W, Q^2)$ and $A_2(W, Q^2)$ at momentum transfer $Q^2 \approx 1.3 \text{ GeV}^2$ and invariant mass $0.8 \leq W \leq 2 \text{ GeV}$.
- Study W dependence, onset of polarized local duality, twist-3 effects.
- Extract asymmetries from **inclusive polarized electron scattering on polarized nuclei**.

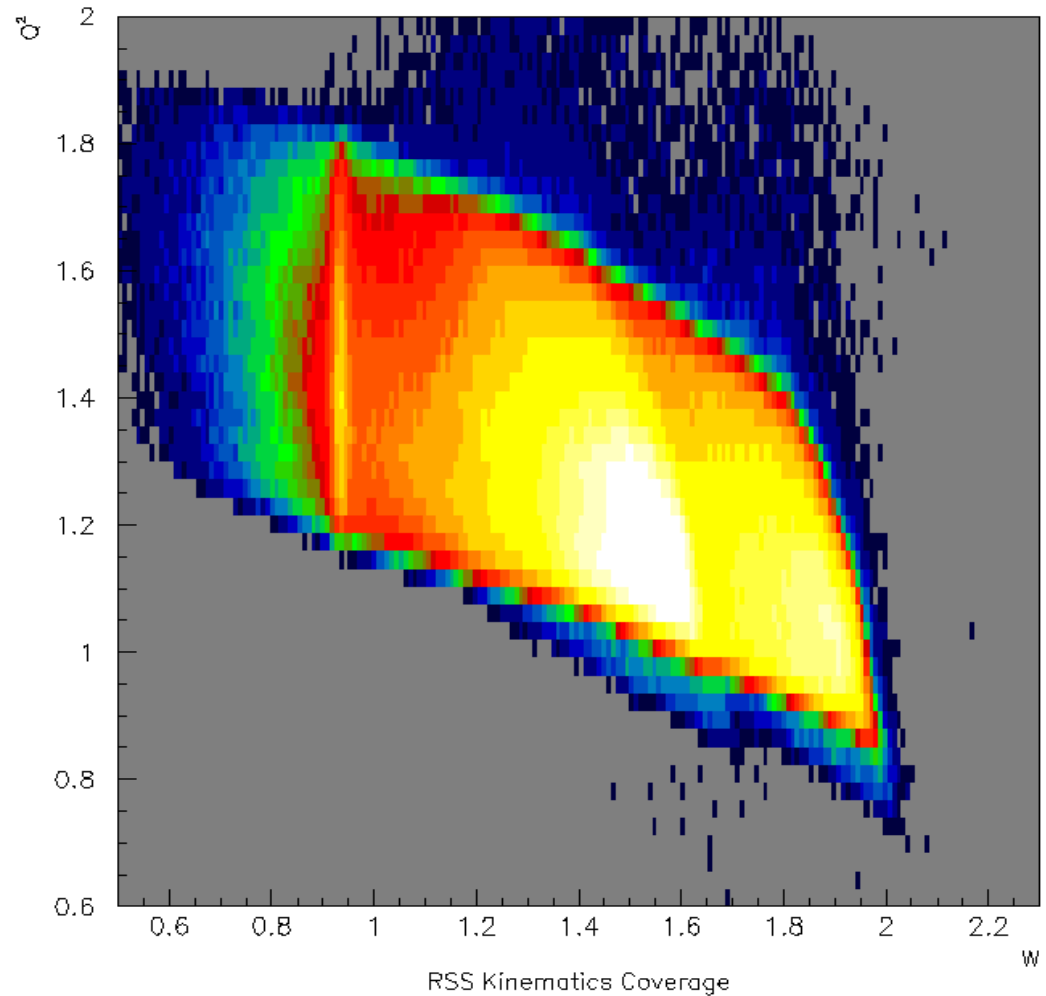
RSS technique

- Measure count asymmetries A_{\parallel} , A_{\perp} on protons, deuterons
- Equipment: **Hall C**
- CEBAF polarized electron beam
 - 2 cm diameter raster at target
- **Polarized ammonia target**
 - Luminosity $\sim 10^{35}$ Hz cm⁻²
- High Momentum Spectrometer HMS
 - $\theta_{\text{HMS}} = -13.2^\circ$
- 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 13.08°
- HMS central momenta:
 - 4.71 GeV/c
 - 4.08 GeV/c
- Final state mass range:
 - $0.8 \text{ GeV} \leq W \leq 2.0 \text{ GeV}$
- $\langle Q^2 \rangle = 1.3 \text{ [GeV/c]}^2$



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

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

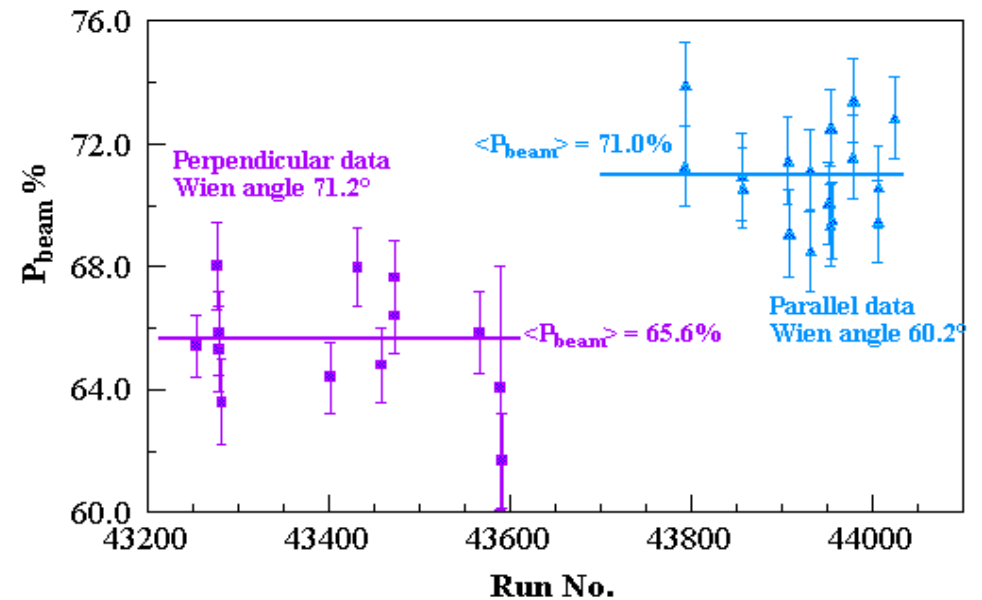
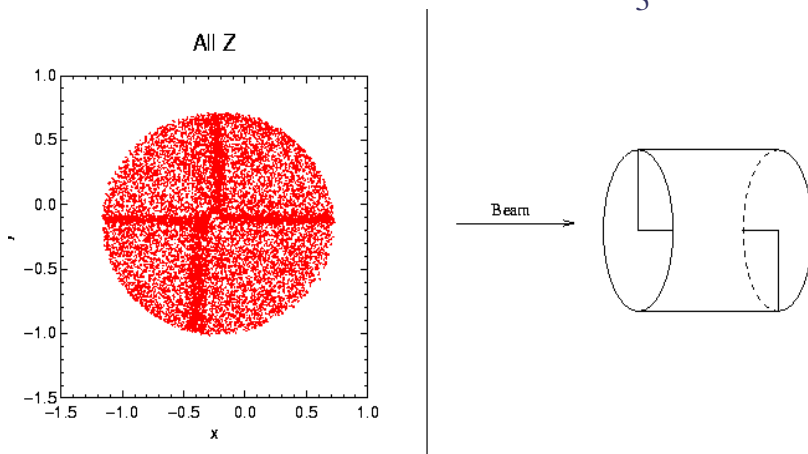
- L, R = charge normalized, dead time and pion corrected numbers of counts for opposite beam helicities
- P_b, P_t = beam, target polarizations
- f = dilution factor
- C_N, C_D = corrections for N in ammonia (C_D for deuterium only).
- f_{RC}, A_{RC} = radiative corrections

Status as of 6/03

- Preliminary measured asymmetries presented at conferences:
 - Count asymmetries
 - First pass analysis (F. Wesselmann/M. Jones)
 - Normalizations:
 - Beam polarization: off-line values after run selection (D. Gaskell/M. Jones)
 - Target polarization: v. 2 off-line polarizations (P. McKee)
 - Dilution factors: preliminary factors from MonteCarlo for nominal 50% ammonia packing fraction (H. Zhu/O. Rondon)
 - Corrections (not yet applied):
 - Radiative corrections: preliminary proton corrections (J. Yun)
 - Nitrogen asymmetry: dilution factor for $W < 900$ MeV region

Beam

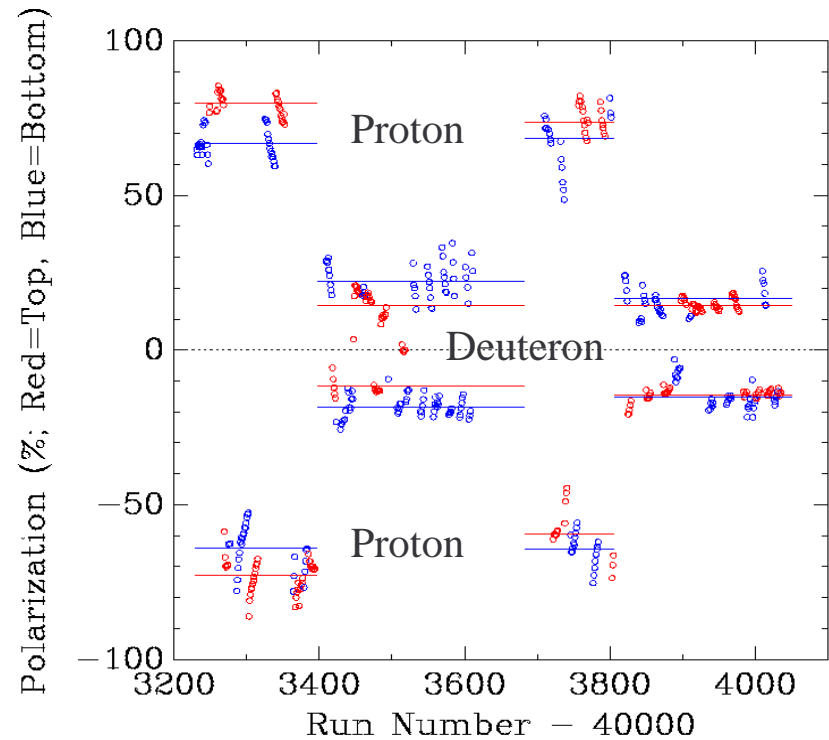
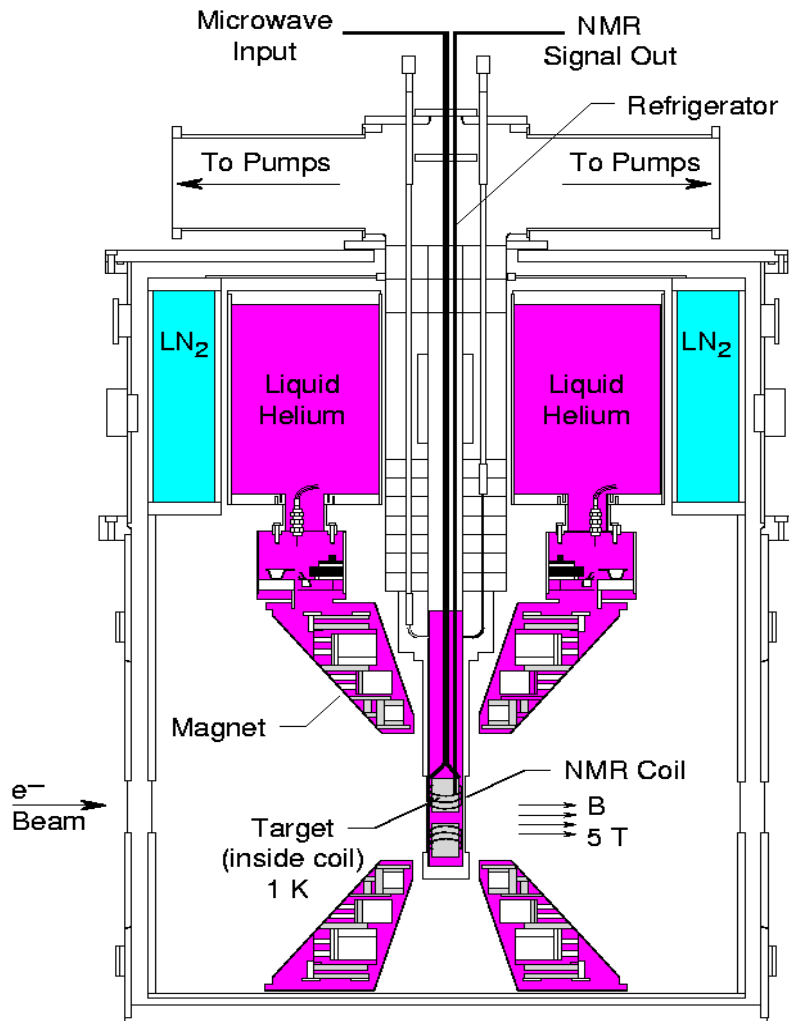
- Beam current:
 - 150 - 200 nA for ND_3 , C, He
 - 85 - 100 nA for NH_3



- Beam position at target monitored by tungsten cross hairs cell.
- Beam polarization measured with Moller spectrometer in Hall.

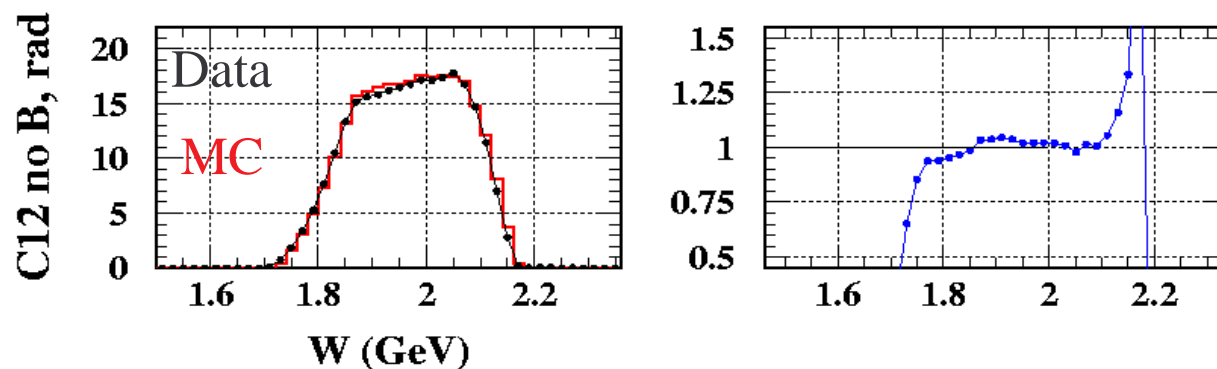
Polarized Target

- Dynamic Nuclear Polarized ammonia (NH_3) and deuterated ammonia (ND_3) targets
- Carbon disks, He for normalization

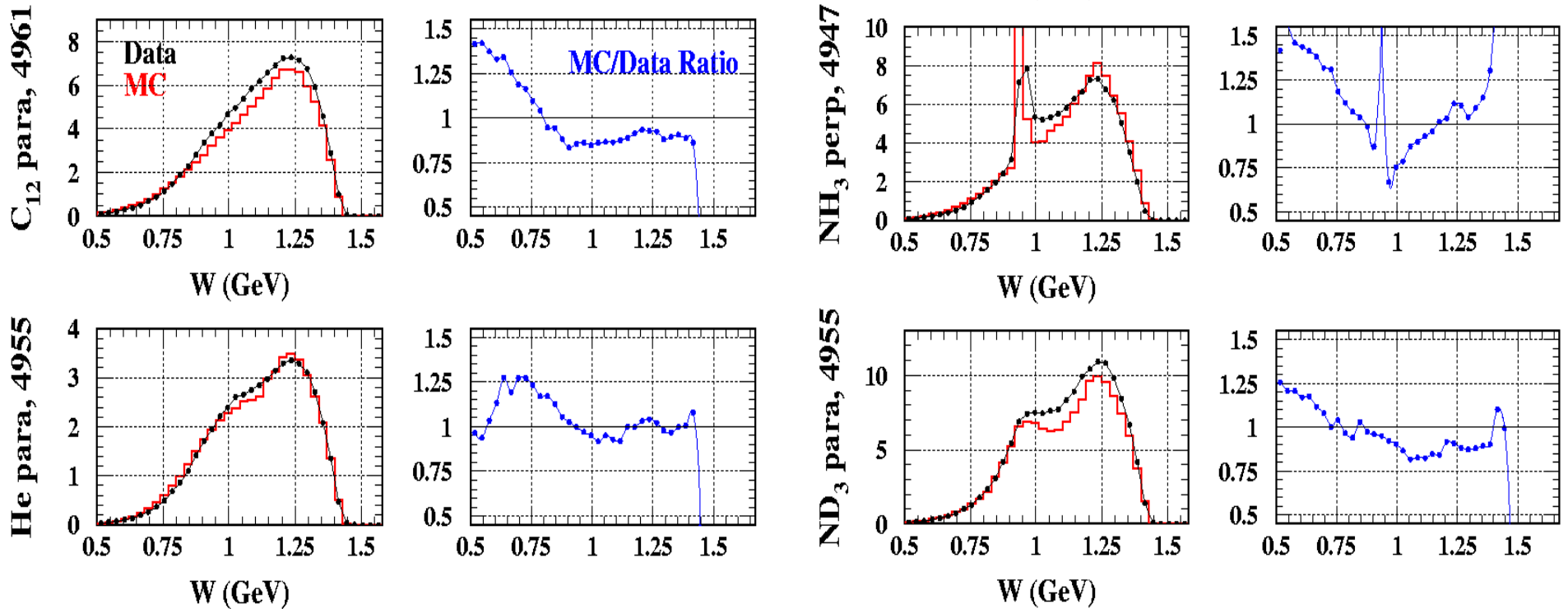


Normalization

- *Dilution factor* (contributions from N, He, etc.) modeled in Monte Carlo
 - mc_hms_single with polarized target and large raster extensions (M. Mühlbauer, 1998) – same code used in analyzer.
 - QFS Born model (O'Connell & Lightbody) modified to match *RSS*
- Normalization data taken at each kinematics on known C and He targets
- Example of Monte Carlo vs data:
 - C run 43204, target field off, 3.6 GeV/c setting, 0.91 MC/data normalization

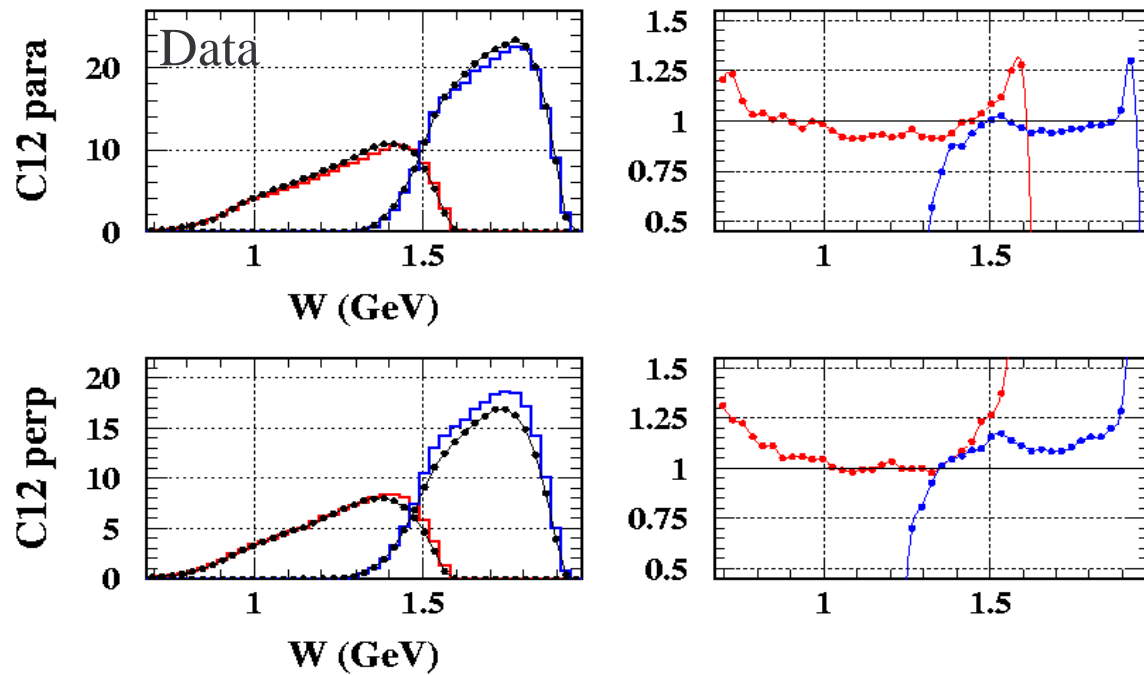


Normalization Examples



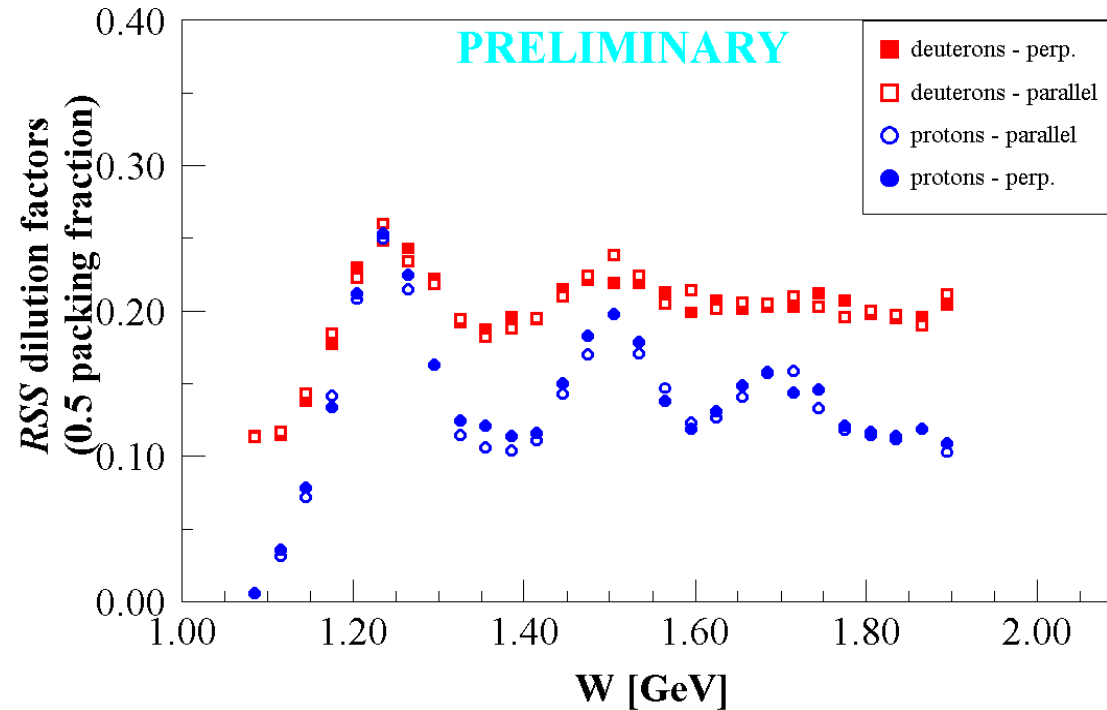
- MC /data comparison: single normalization factor for C, He
- Nominal 50% packing fraction for ammonia

More Normalization Examples



- MC /data agreement cannot be improved with modifications to Born model
- Indication of possible deeper issues, not resolved by a target field tracking bug found in 02/03

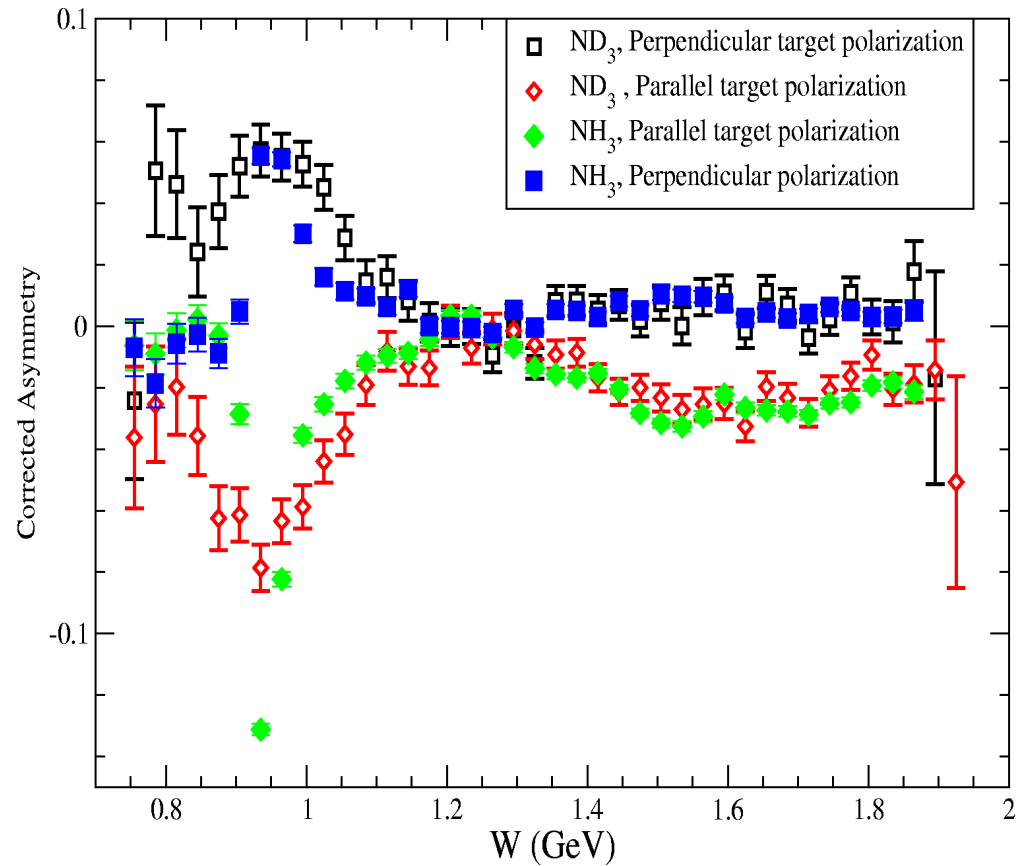
Preliminary dilution factors



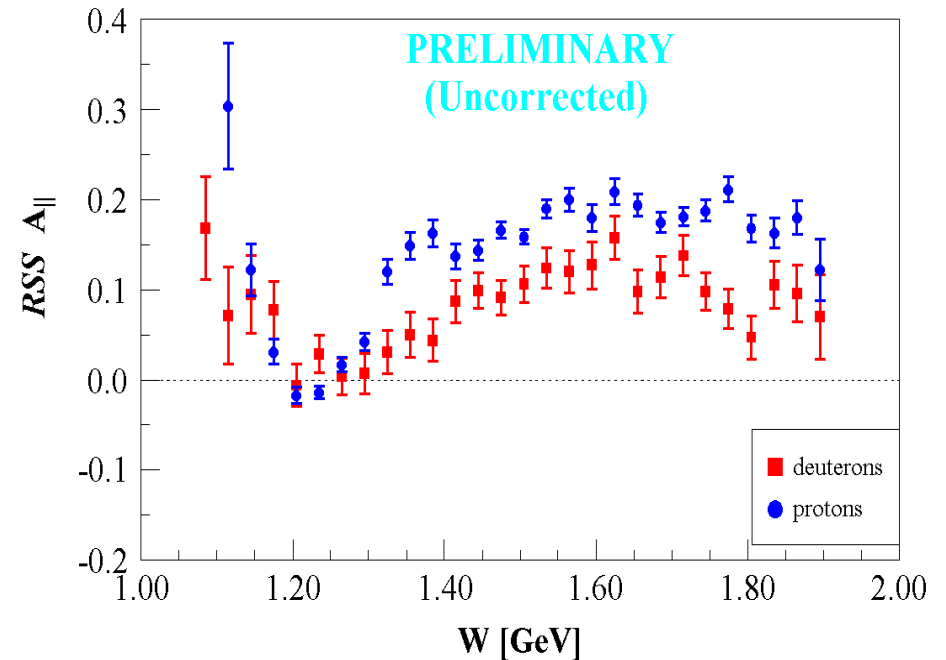
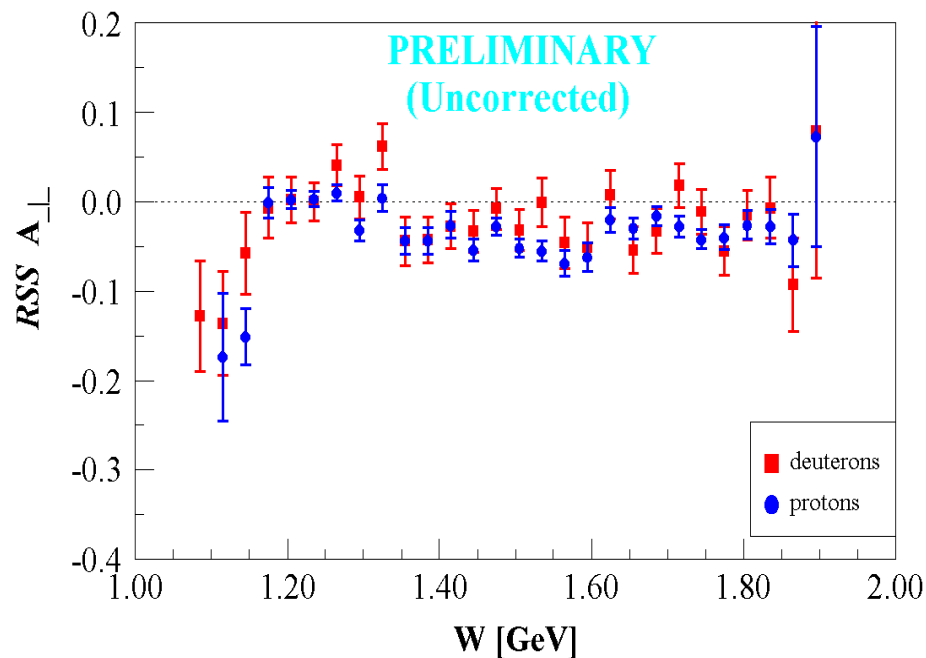
- Each target cell (8 in total) filled with specific ammonia contents (packing fraction)
- Packing fractions ~ 0.5 - ~ 0.6 determined by ratio of ammonia to C disks rates

Pass 1 counts asymmetries

- Preliminary (first pass) count asymmetries, corrected for beam, target polarizations
 - $(L-R)/[(L+R)P_b P_t]$
- Dilution factor not yet applied

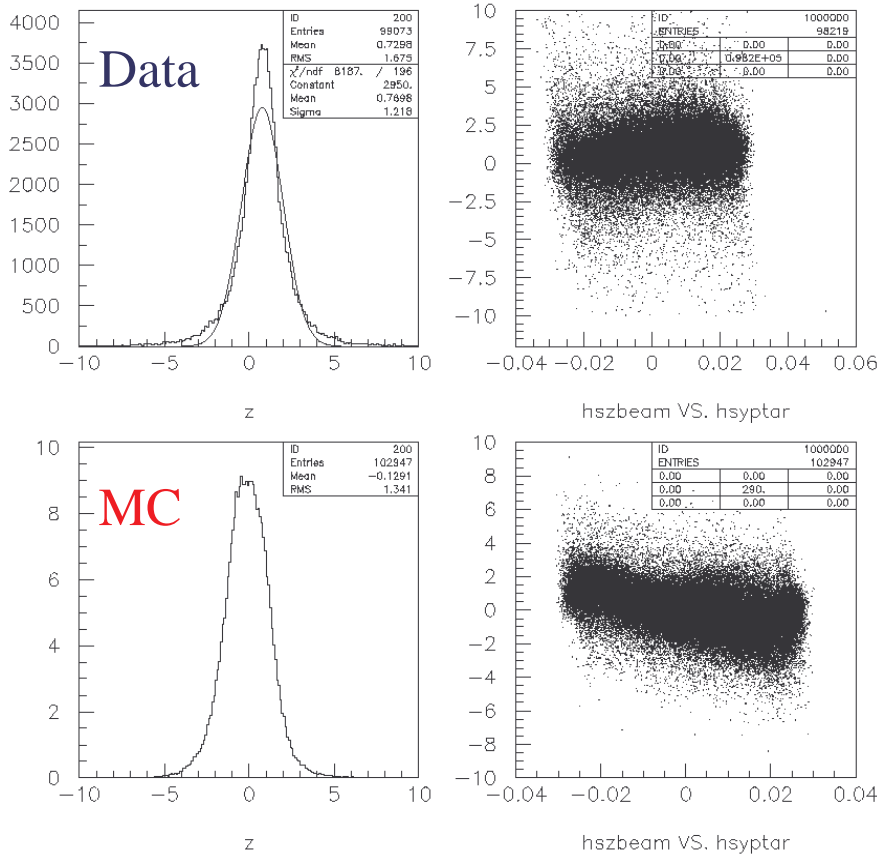


RSS Preliminary Measured Asymmetries



- Preliminary dilution factor (same packing fraction for all targets) applied in restricted range: $1.08 \text{ GeV} < W < 1.9 \text{ GeV}$
- No corrections.

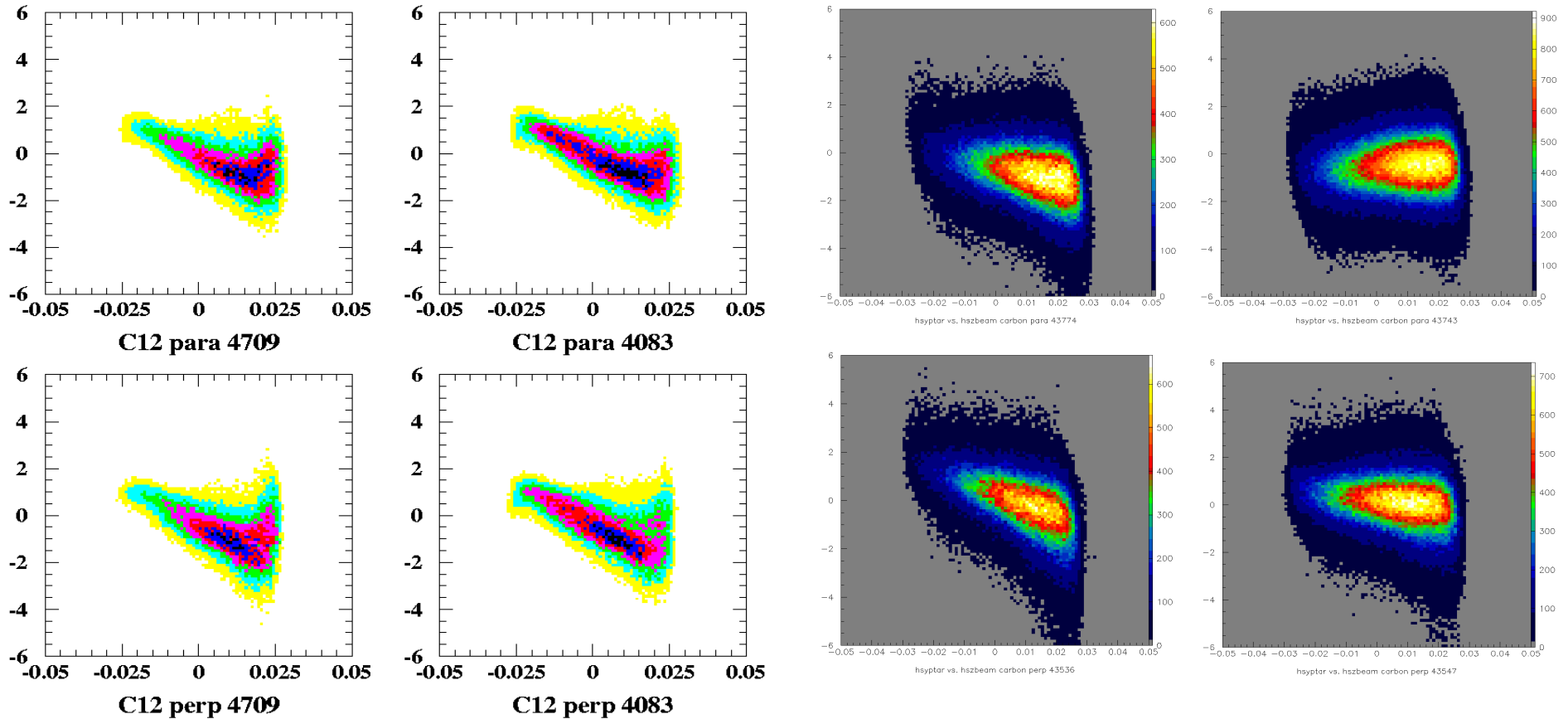
Progress since 6/03: HMS reconstruction



C run with target field off

- Residual disagreement between parallel and perpendicular data needs fix
- HMS reconstruction needs fixes to handle x (out-of-plane) offset, target field
 - Check of z ($hszbeam$) and z vs y' shows disagreement between MC and data and between data subsets
 - Eric Christy suggests origin may be inconsistent transport in iteration procedure to handle x offset
 - Reconstructed delta shift converted to x offset by successive approximations
 - Propagation of small differences in probably outdated forward and backward matrices adds up
 - MC: different initial transport to f.p.

More evidence (C runs)



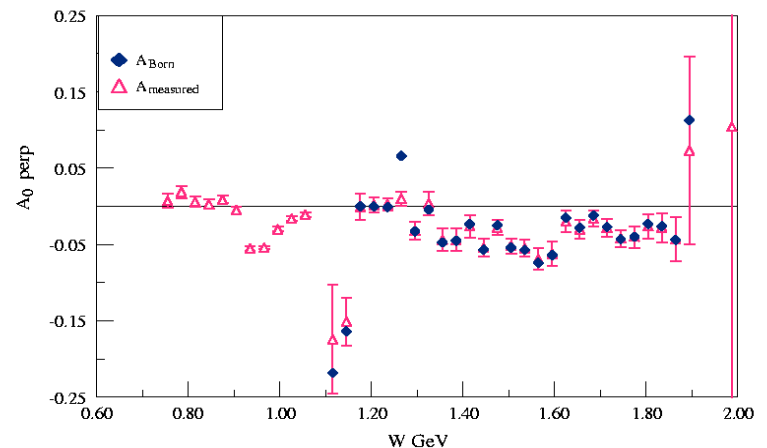
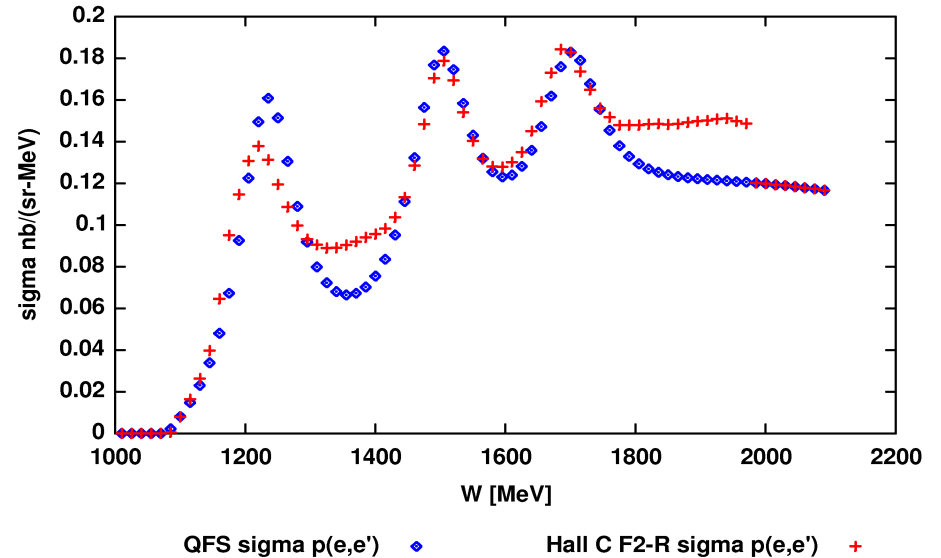
- Left: MC
- Right: data
- Low vs high central momentum z vs y' distributions very different, especially in data

Fix

- Replace iterations procedure by single step out-of-plane transport (P. McKee / M. Jones)
- Use same procedure for analyzer and MC, including MC first step
- Proper reconstruction needed before further progress
 - Required for final dilution factors and packing fractions, for proposed 3% systematic error (currently ~10%)
 - Expect better W resolution than current

Model and other improvements

- Proton Born cross section in resonances based on Hall C data
- Deuteron cross section will also be based on Hall C data
- Improved analyzer energy loss calculation
- New kinematics database for all 6 target types (J. Mellor)
- Nitrogen dilution factor (J. Mellor)
- Preliminary proton radiative corrections based on $RSS A_1, A_2$ (J. Yun)
- Target polarizations v. 3 (P. McKee)



To come

- Individual cell packing fractions and dilution factors for proton and deuteron
- Pass 2 count asymmetries
- Final off-line target polarizations
- Nitrogen and radiative corrections
- Spin asymmetries:
 - correction for out-of-plane angle
- Proton - Deuteron Spin SF's
- Neutron SF's
- Systematic errors
- Test local duality
- Proton elastic asymmetry
- Analysis Team:
 - Mark Jones
 - Paul McKee
 - Hamlet Mkrtchyan
 - Frank Wesselmann (N. S. U.)
 - Junho Yun
 - Hongguo Zhu (U. N. H.)
 - Eric Christy
 - Oscar Rondon
- Part time graduate student:
 - Jonathan Mellor

How to get A_1, A_2

- Full expression for *RSS* analysis

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

$$A_2 = \frac{\sqrt{Q^2} (Q^2 \cot(\theta/2) - \nu E' \sin \theta) \cos \phi A_{\parallel} + (Q^2 + \nu(E + E' \cos \theta)) A_{\perp}}{D' E' \sin \theta \cos \phi (Q^2 + 2E(E + E' \cos \theta))} \quad (9)$$

– $D'(E, E', \theta, R)$ = depolarization factor

- Have both SA's and SF's calculated using above.
- Not ready for release until analysis is satisfactory

