Spin Duality on the neutron (^3He)

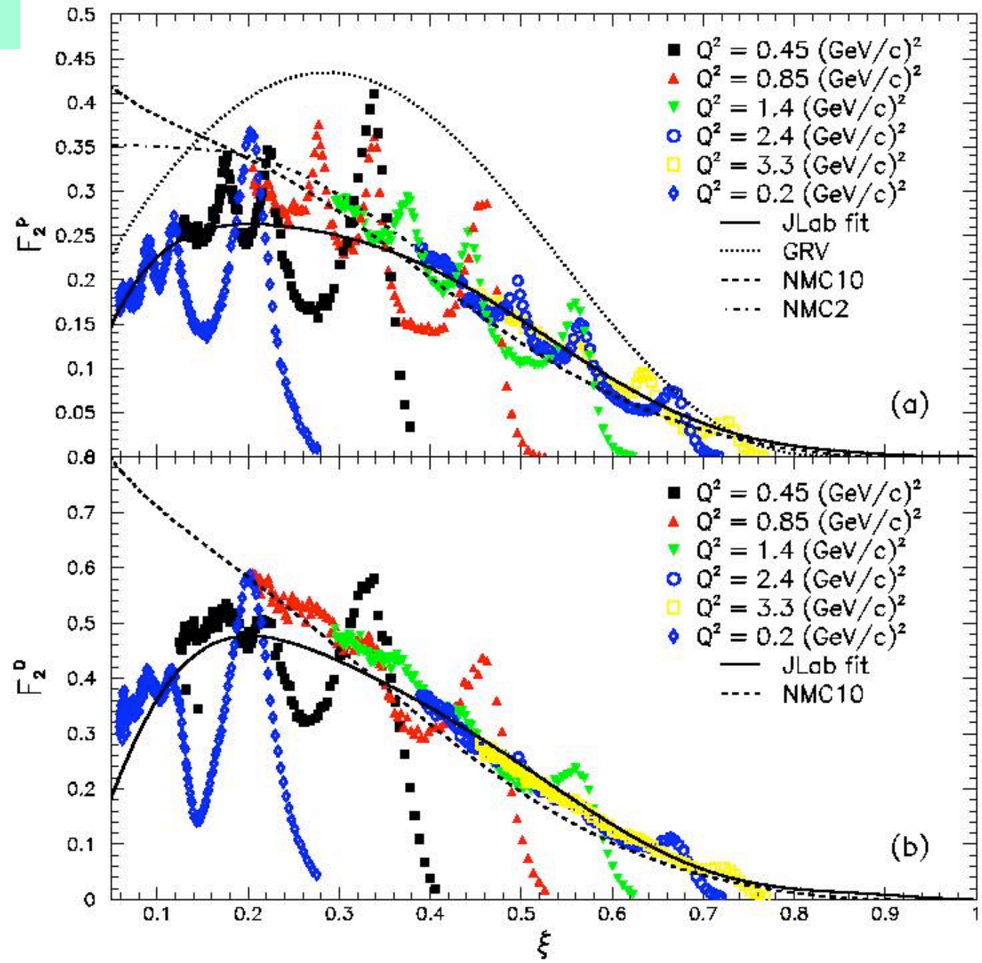
Patricia Solvignon

Thesis progress report

September 26th, 2005

Duality in unpolarized structure functions

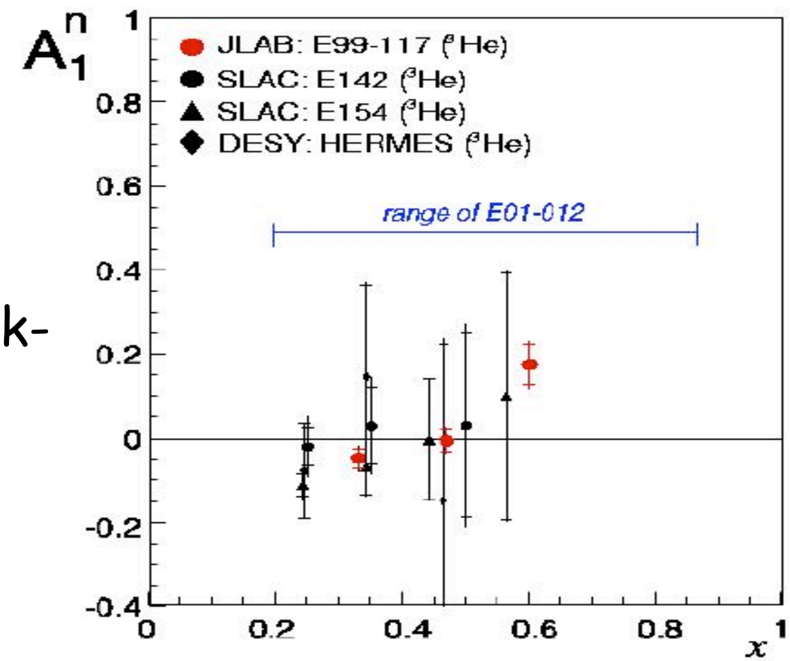
Hall C results



I. Niculescu et al., Phys. Rev. Lett. **85** (2000) 1182

Motivations

- Understand transition between partons and hadrons
- Study of higher twists
- Spin and flavor dependence of quark-hadron duality
- Access high x_{bj} region <u>if duality is demonstrated and well understood</u>



X. Zheng et al., Phys. Rev. Lett. **92** (2004) 012004

Hint of duality

E94-010 saw a hint of duality in $g_1(^3He)$

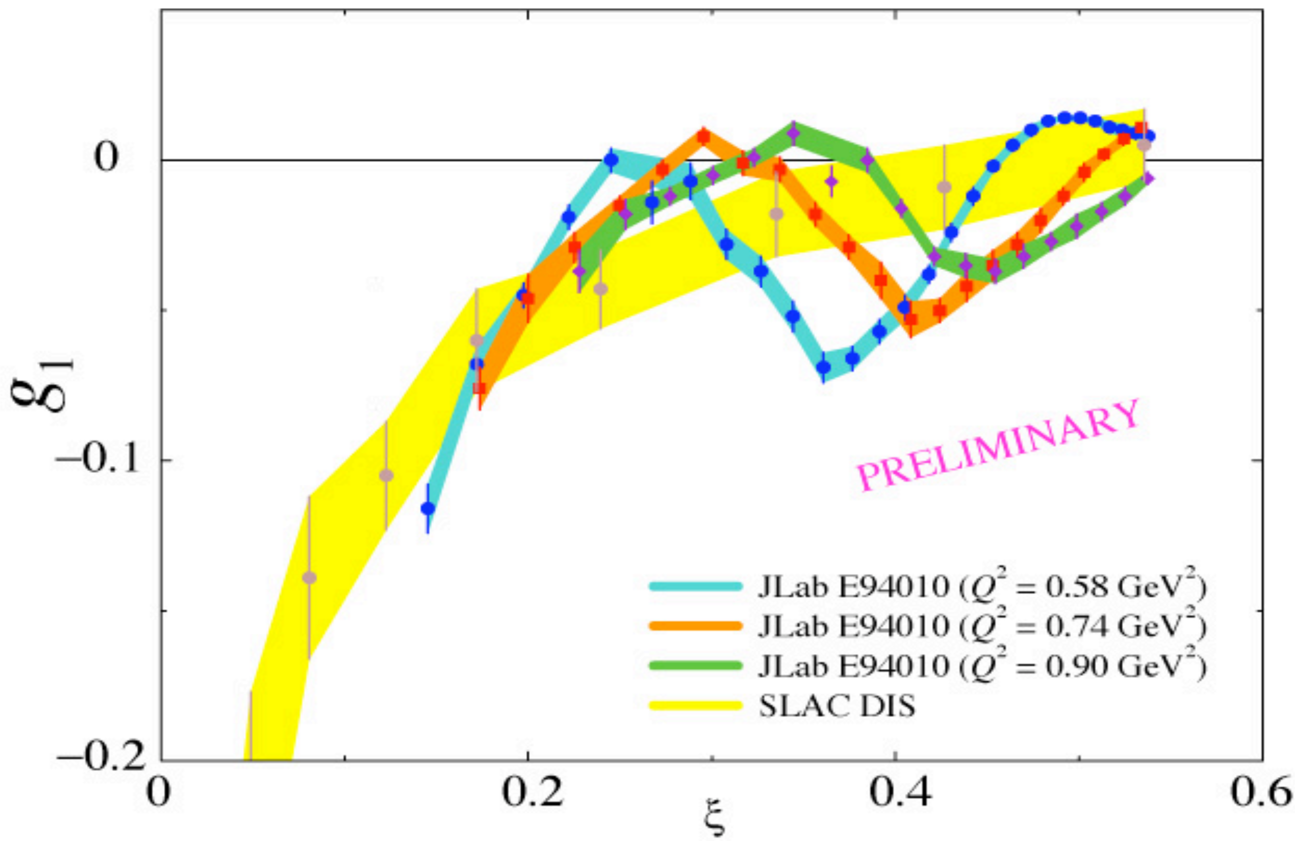
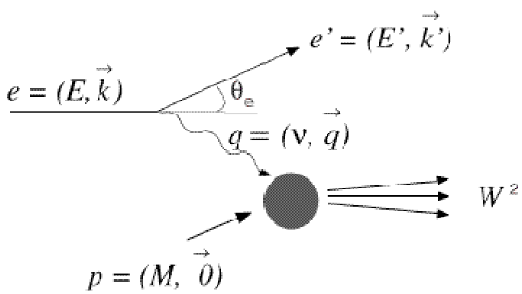


Figure from Seonho Choi

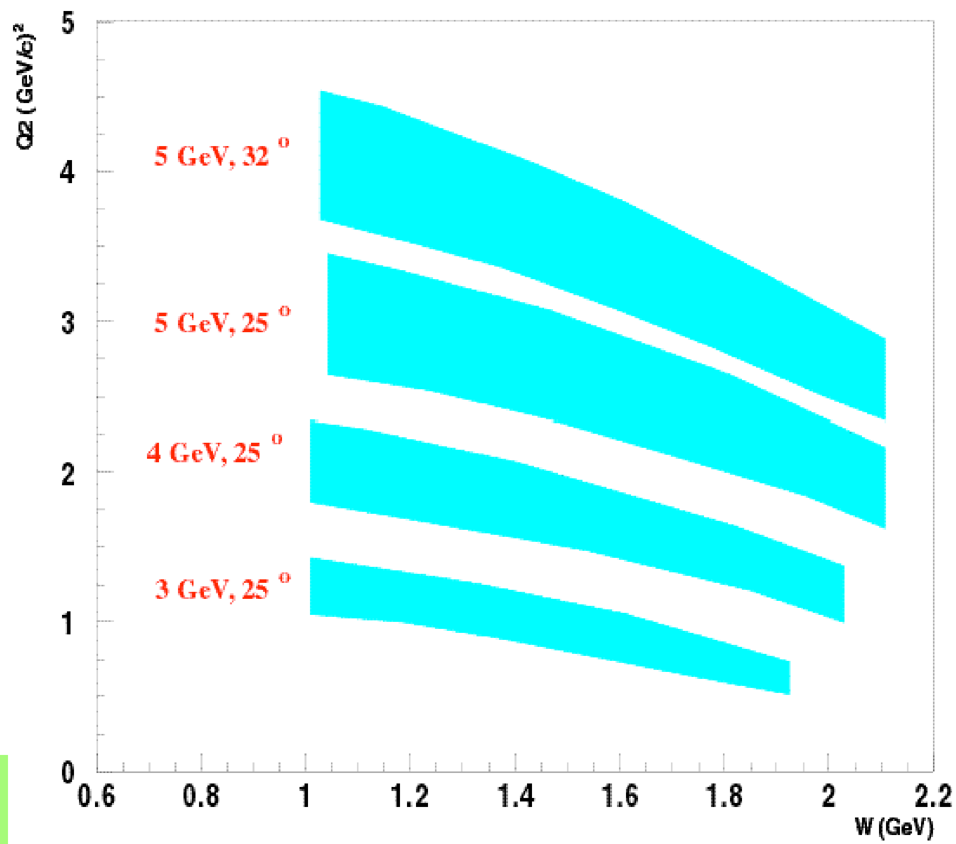
The E01-012 experiment

Spokepeople: N. Liyanage, J-P. Chen, Seonho Choi
Graduate Student: P. Solvignon

- Ran in January-February 2003
- Inclusive experiment: $^3\vec{He}(\vec{e},e')X$

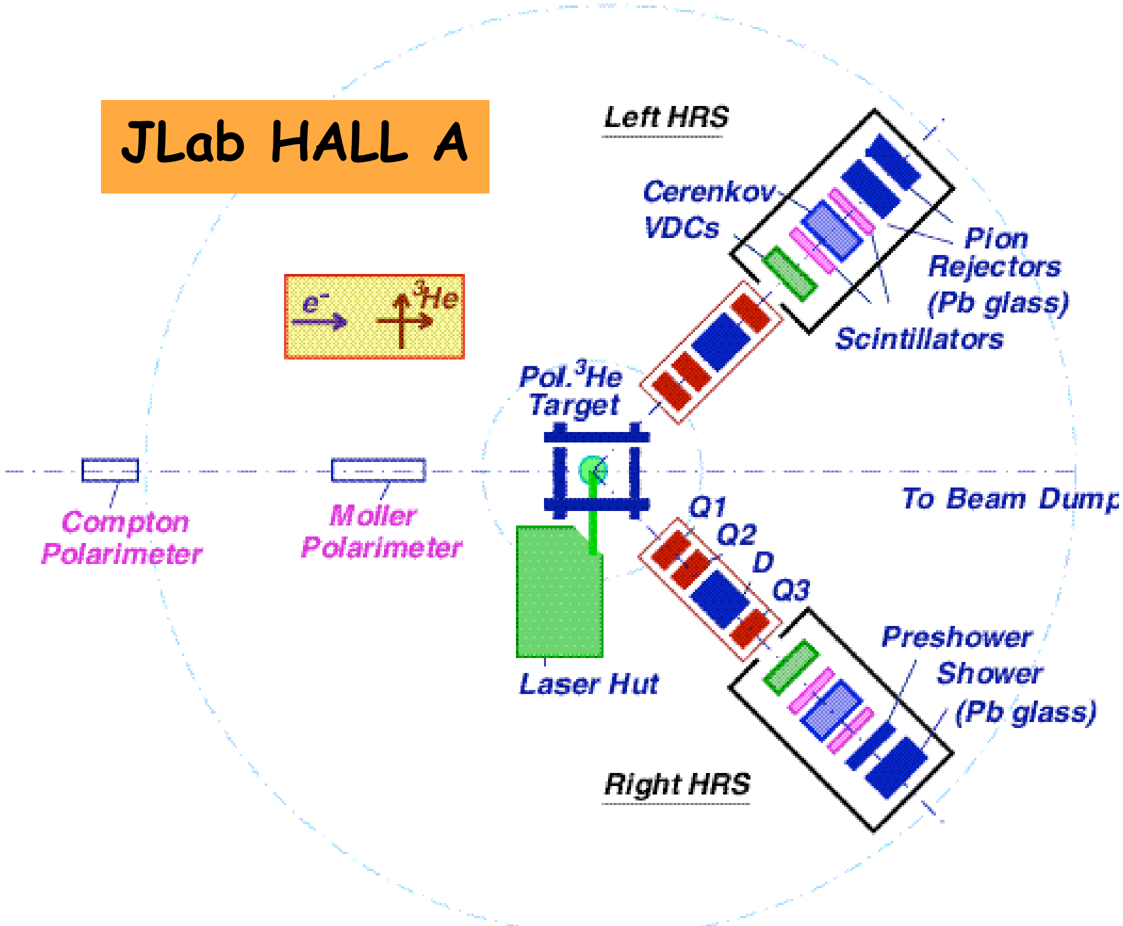


- Me -sections differences and asymmetries
- Form g_1, g_2, A_1 and A_2 for ^3He



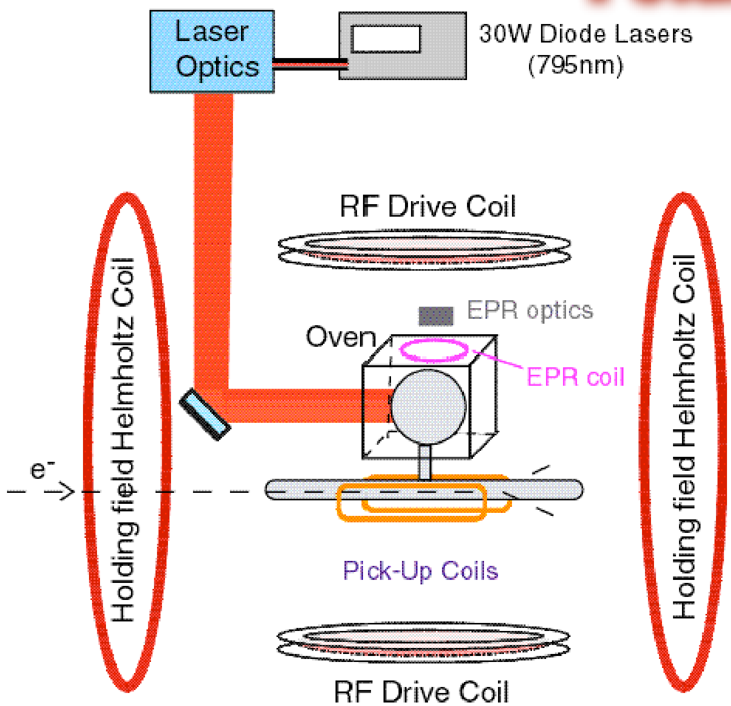
Test duality on the neutron SSF

The experimental setup



- Polarized e^- beam at 3.0, 4.0 and 5.0 GeV; $70 < P < 85\%$
- Both HRS in symmetric configuration at 25° and 32°:
  → Double statistics
  → Control systematics
- PID= Cerenkov + EM calo.
  → π/e reduced by 10^4
  → $\varepsilon(e^-) > 99\%$

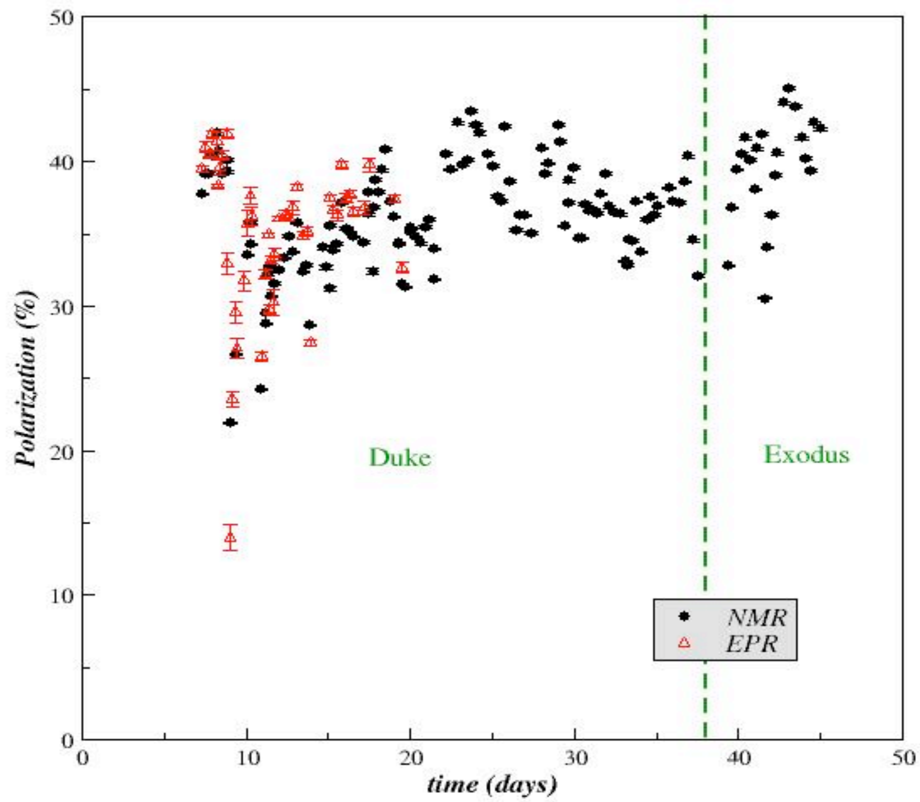
Polarized 3He target



- Longitudinal and transverse configurations
- High luminosity: 10^{36} s^{-1} cm^{-2}
- 2 independent polarimetries: NMR and EPR

→ Based on spin exchange between optically pumped Rb and ^3He

→ About 1% N_2 is added for quenching



Data analysis

Generate asymmetries and unpolarized cross sections

$$A_{//(\perp)}^{raw} = \frac{(N^+/Q^+ LT^+)-(N^-/Q^- LT^-)}{(N^+/Q^+ LT^+)+(N^-/Q^- LT^-)}$$

$$\sigma_o^{raw} = \frac{N_{cut}}{N_{inc}\, \rho_{^3He}\, \varepsilon_{det}\, LT} \, \frac{N_{trial}}{N_{acc}\, L_{targ}\, \Delta p\, \Delta\Omega}$$

Data analysis

Apply correction for nitrogen dilution

$$A_{//(\perp)}^{exp} = A_{//(\perp)}^{raw} / (f_{N_2} P_{targ} P_{beam})$$

$$\sigma_o^{exp} = \sigma_o^{raw} - 2(\rho_{N_2} / \rho_{^3He})\sigma_N$$

Data analysis

Form polarized cross section differences

$$\Delta\sigma_{//(\perp)}^{exp} = 2\, A_{//(\perp)}^{exp}\, \sigma_o^{exp}$$

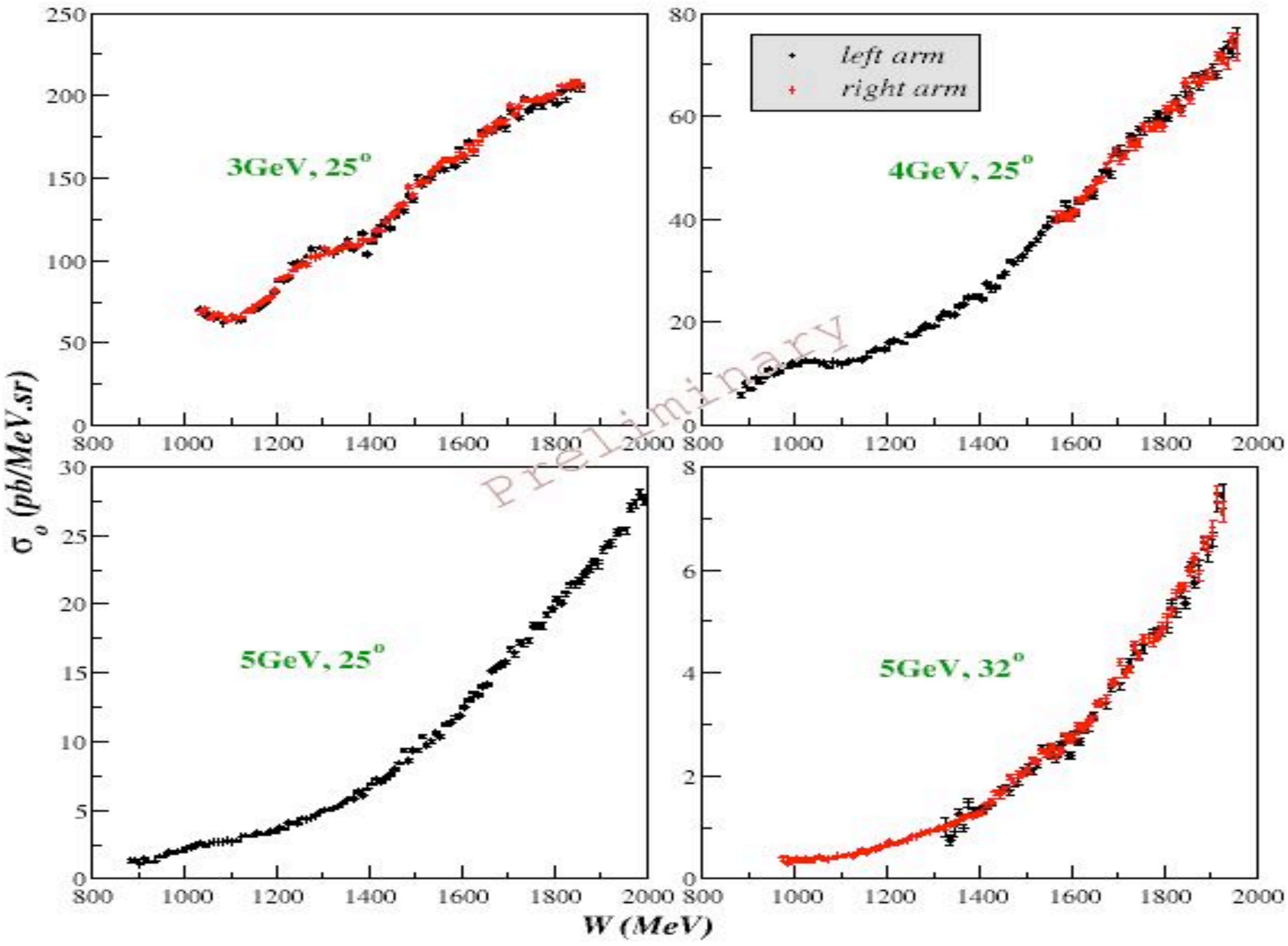
Apply radiative corrections on $\Delta\sigma_{//(\perp)}$ and σ_o

$$\Delta\sigma_{//(\perp)} = \Delta\sigma_{//(\perp)}^{exp} + R.C.$$

$$A_{//(\perp)} = \Delta\sigma_{//(\perp)} / 2\sigma_o^{born}$$

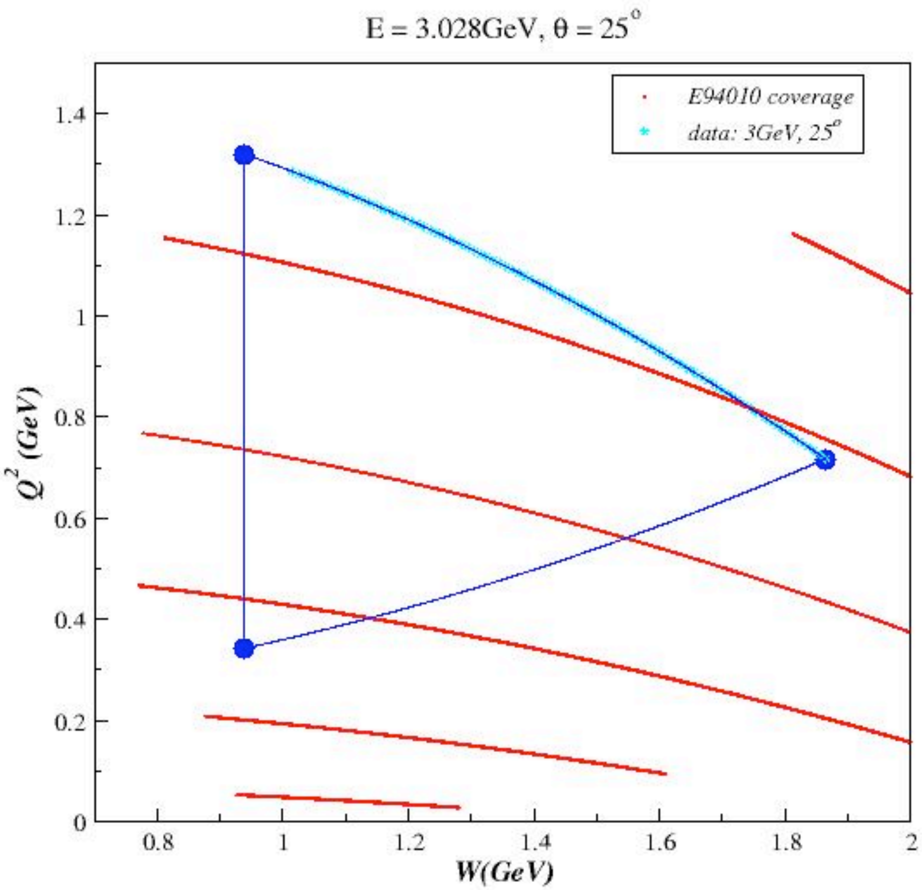
HRS cross sections comparison

Agreement between left and right arms cross sections is at 2% level.



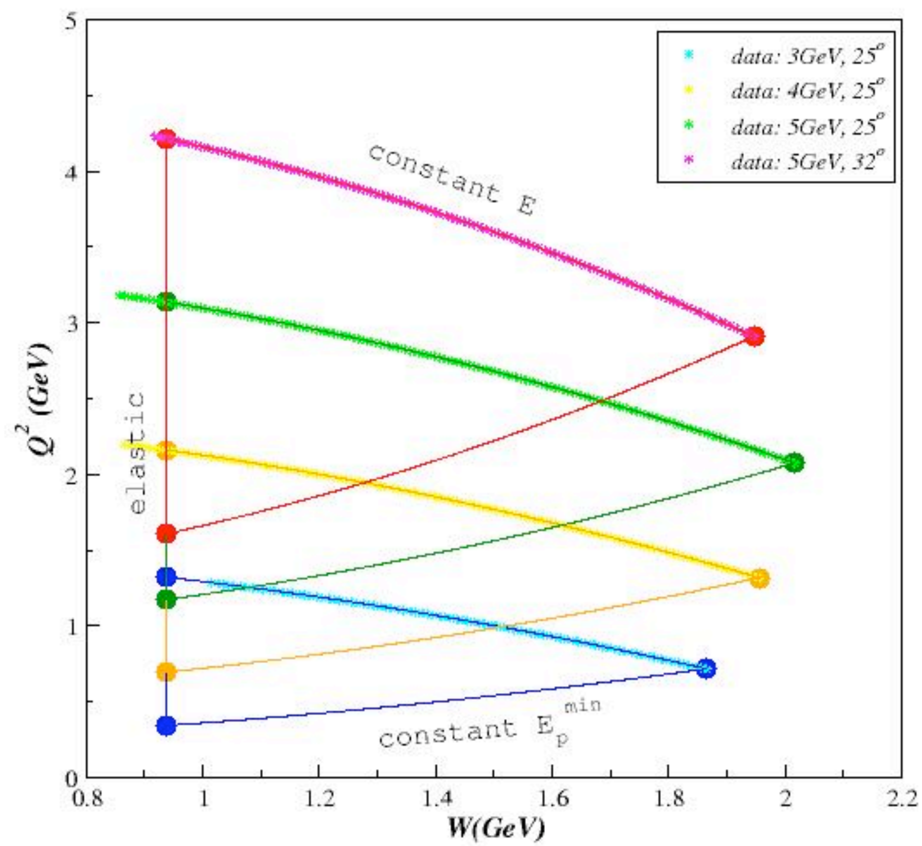
Radiative corrections

- Elastic tail negligeable at all our kinematics
- For 1st pass, used QFS as model for σ_o
- Used E94-010 spin structure functions as a model for the radiative corrections on $\Delta\sigma_{//(\perp)}$ for our lowest energy



Radiative corrections

- Elastic tail negligeable at all our kinematics
- For 1st pass, used QFS as model for σ_o
- Used E94-010 spin structure functions as a model for the radiative corrections on $\Delta\sigma_{//(\perp)}$ for our lowest energy
- Then used our own data

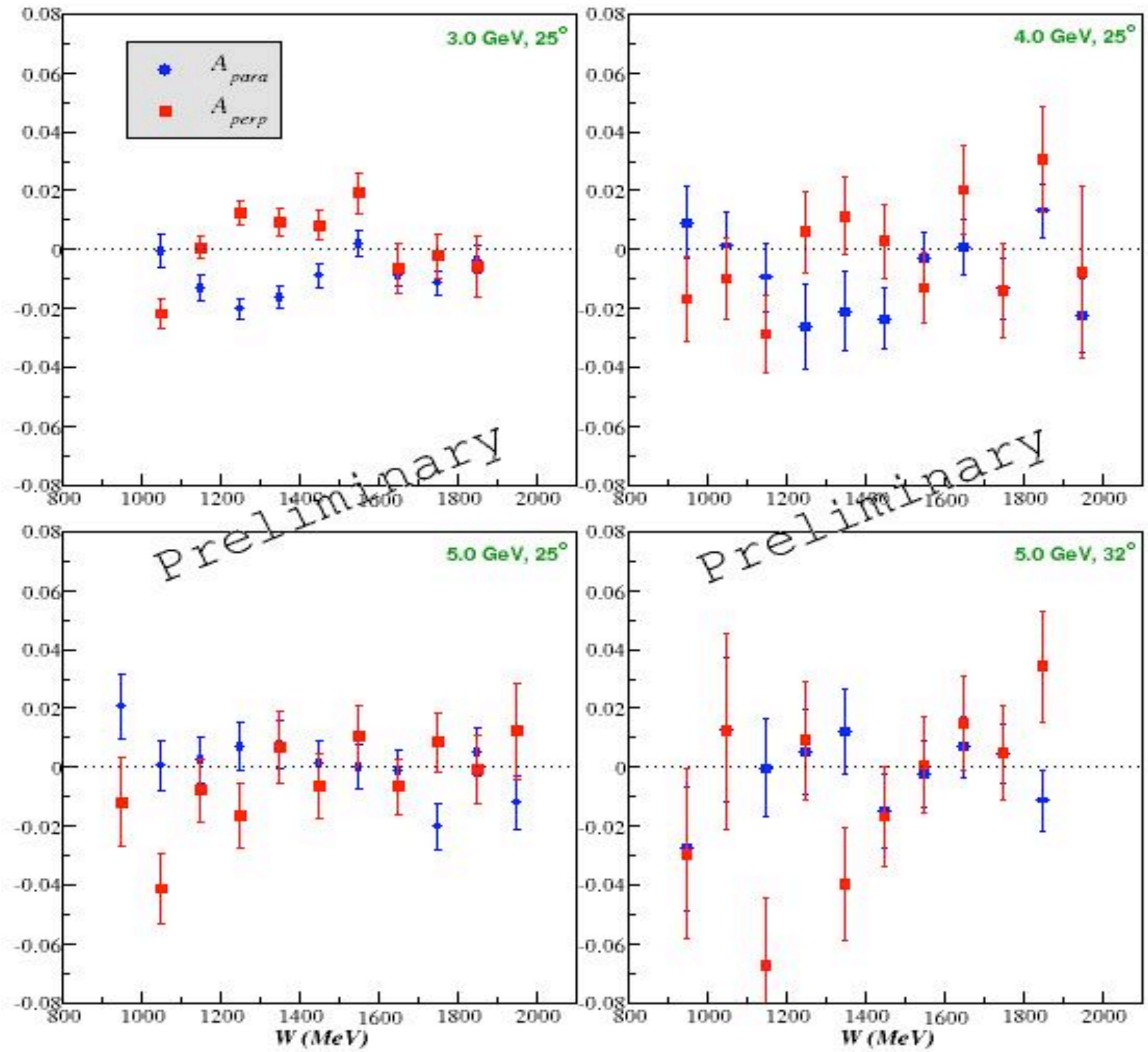


Asymmetries

N_2 dilution applied

and

1st pass radiative corrections

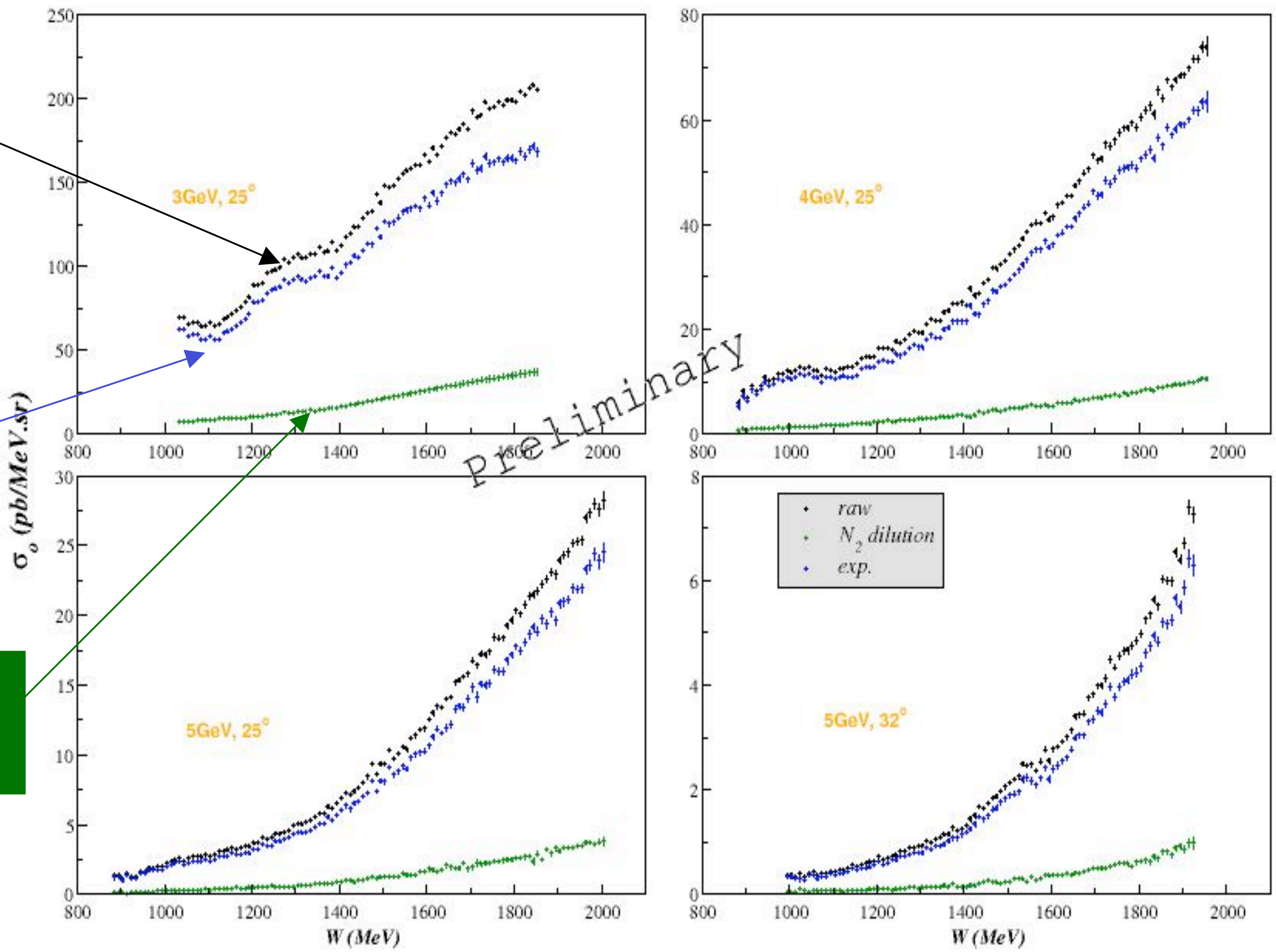


Unpolarized cross sections before R.C.

σ_{raw} with both arms combined

$\sigma_{exp} = \sigma_{raw} - \sigma_N$

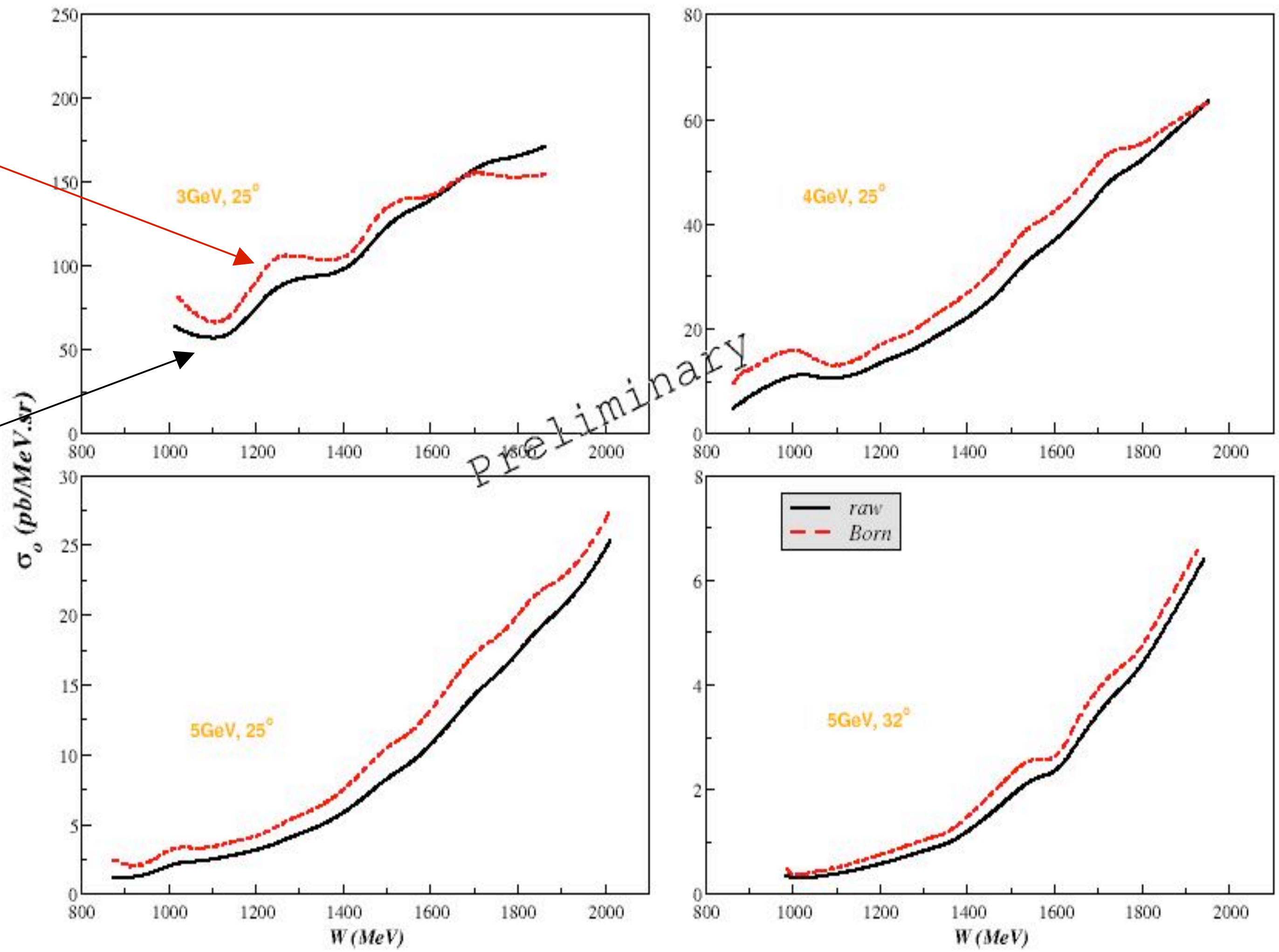
σ_N corrected for density ratio



Unpolarized Born cross sections

After R.C., we obtain σ_{born}

Smoothed σ_{exp}



Polarized structure functions

Extract g_1 and g_2 directly from our data

$$g_1 = \frac{MQ^2\nu}{4\alpha_e^2}\frac{E}{E'}\frac{1}{E+E'}\left(\Delta\sigma_{//} + \tan(\theta/2)\,\Delta\sigma_{\perp}\right)$$

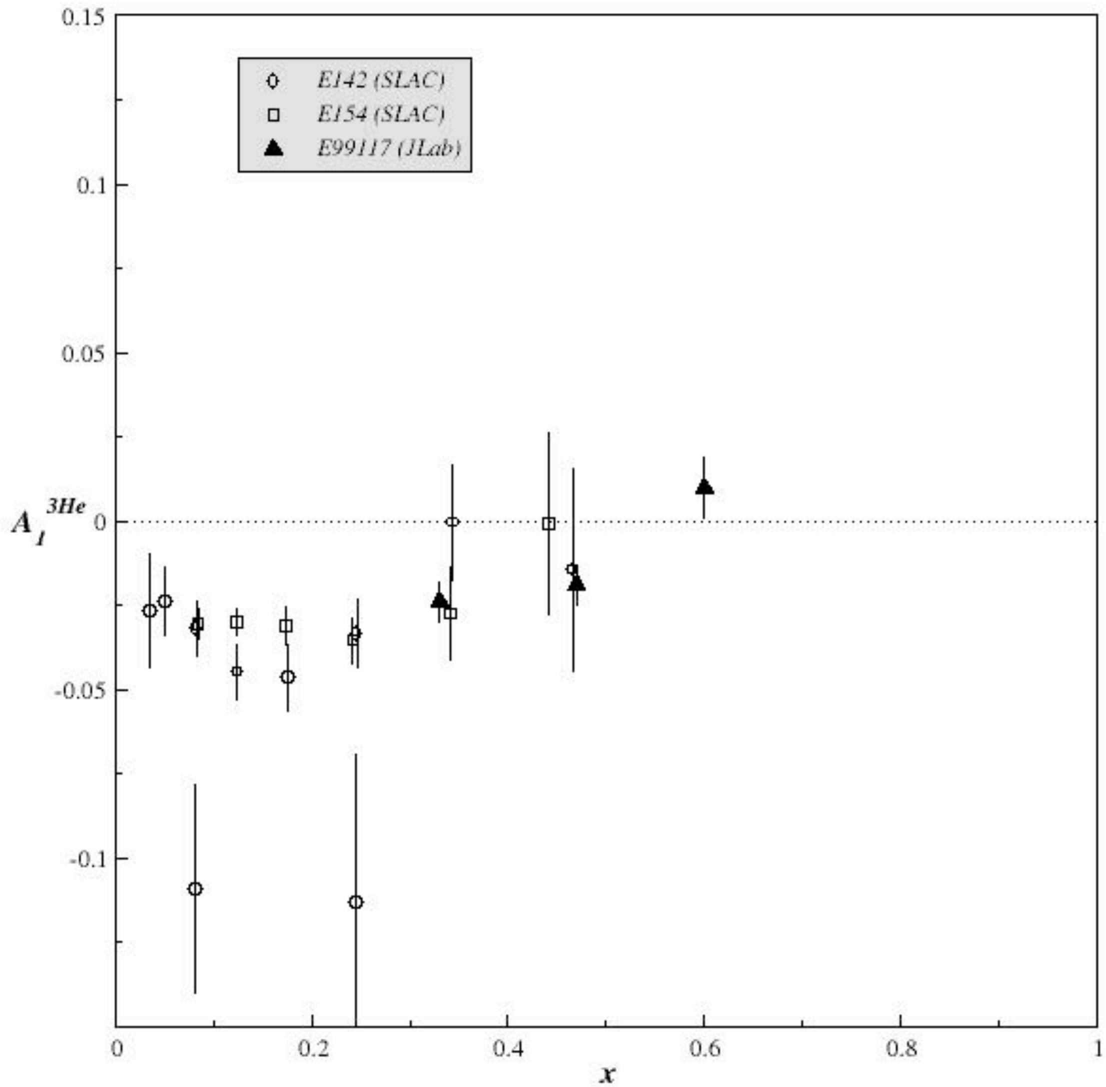
$$g_2 = \frac{MQ^2\nu^2}{4\alpha_e^2}\frac{1}{2E'(E+E')}\left(-\Delta\sigma_{//} + \frac{E+E'\cos\theta}{E'\sin\theta}\Delta\sigma_{\perp}\right)$$

Need external input of R to form A_1 and A_2

$$A_1 = \frac{A_{//}}{D(1+\eta\xi)} - \frac{\eta A_{\perp}}{d(1+\eta\xi)} \qquad A_2 = \frac{\xi A_{//}}{D(1+\eta\xi)} + \frac{A_{\perp}}{d(1+\eta\xi)}$$

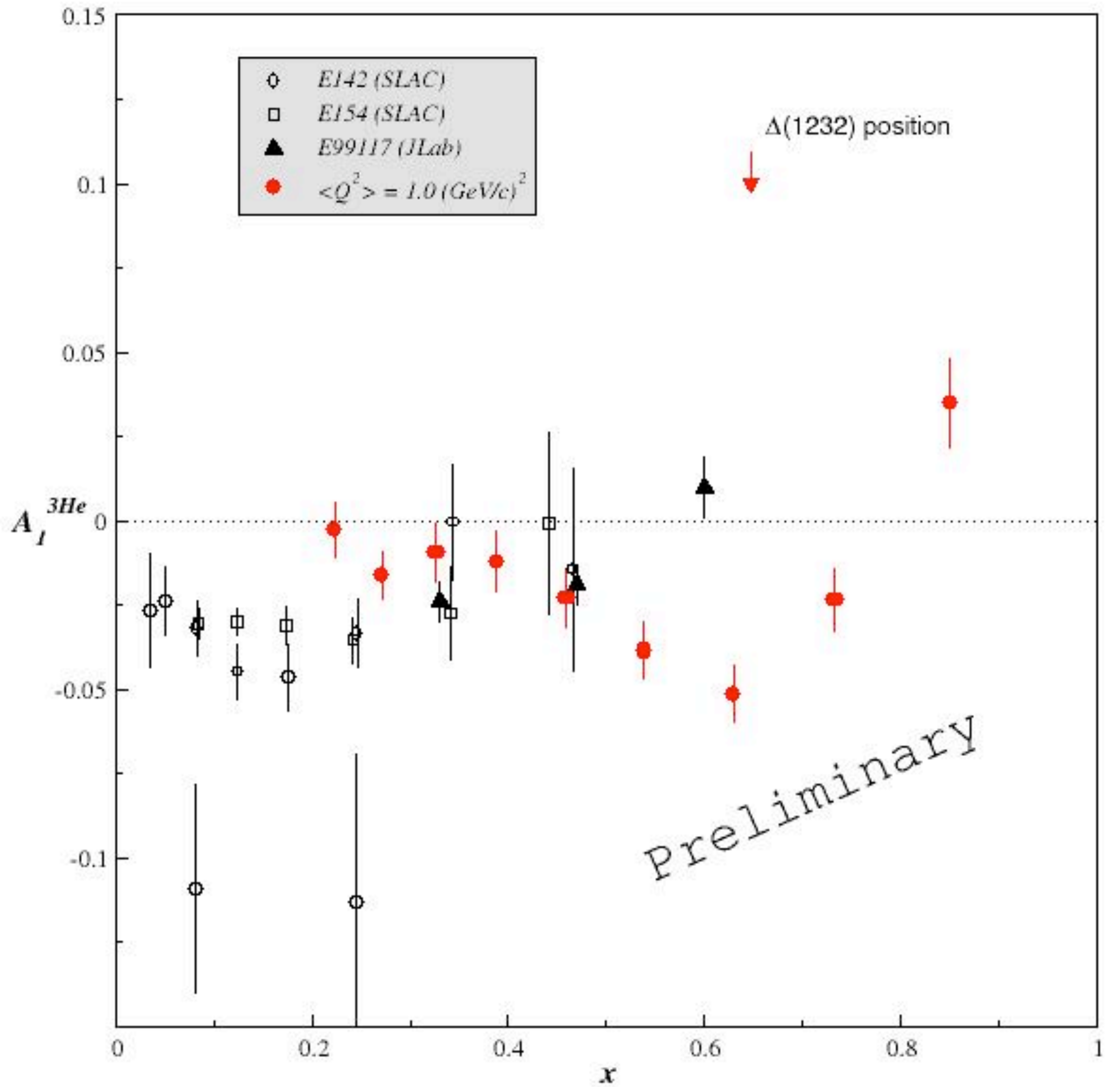
(D and d depend of R)

Spin asymmetry A1



DIS data on ^{3}He

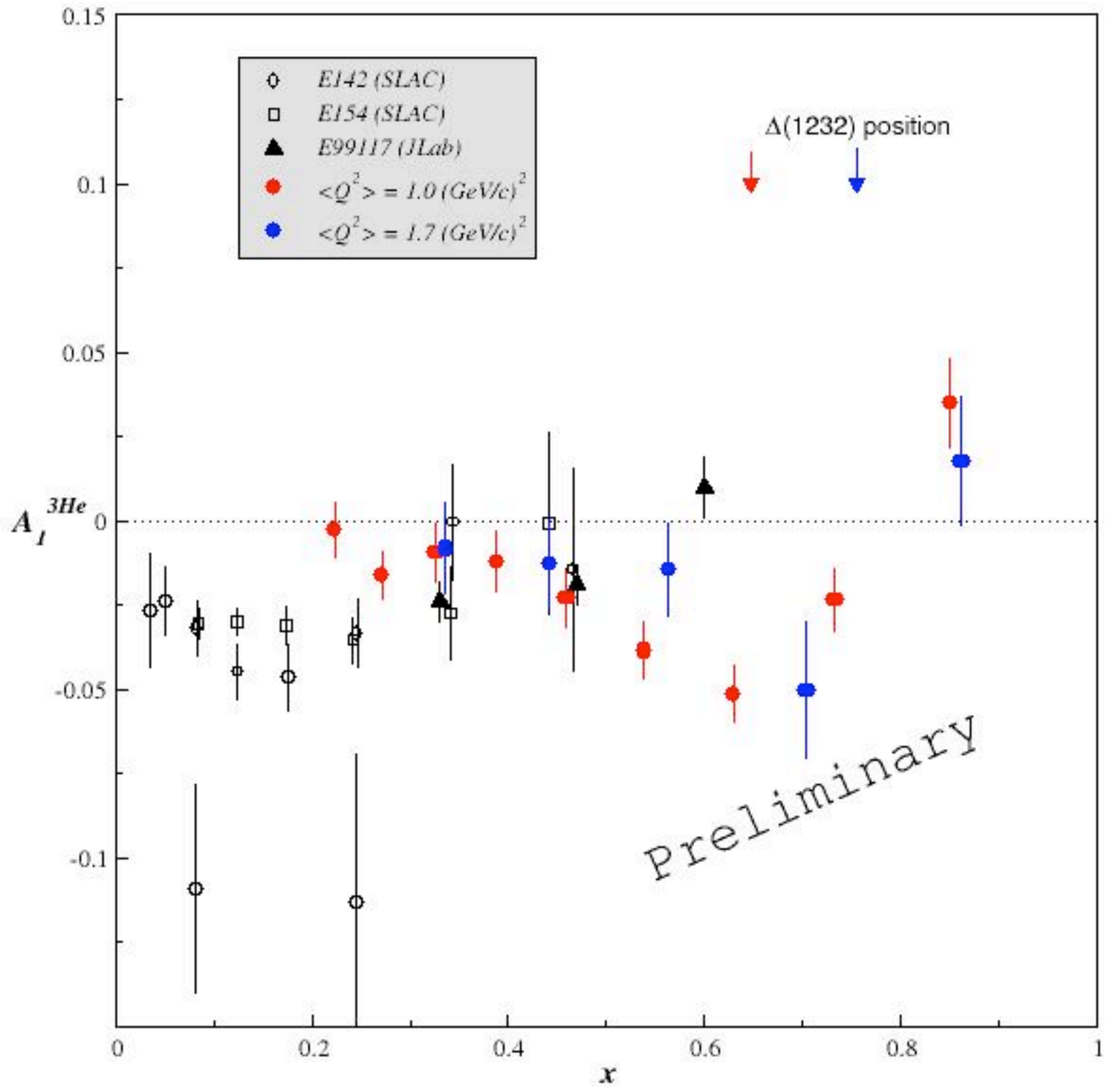
Spin asymmetry A1



A_1 is large and negative in the Δ(1232) region.

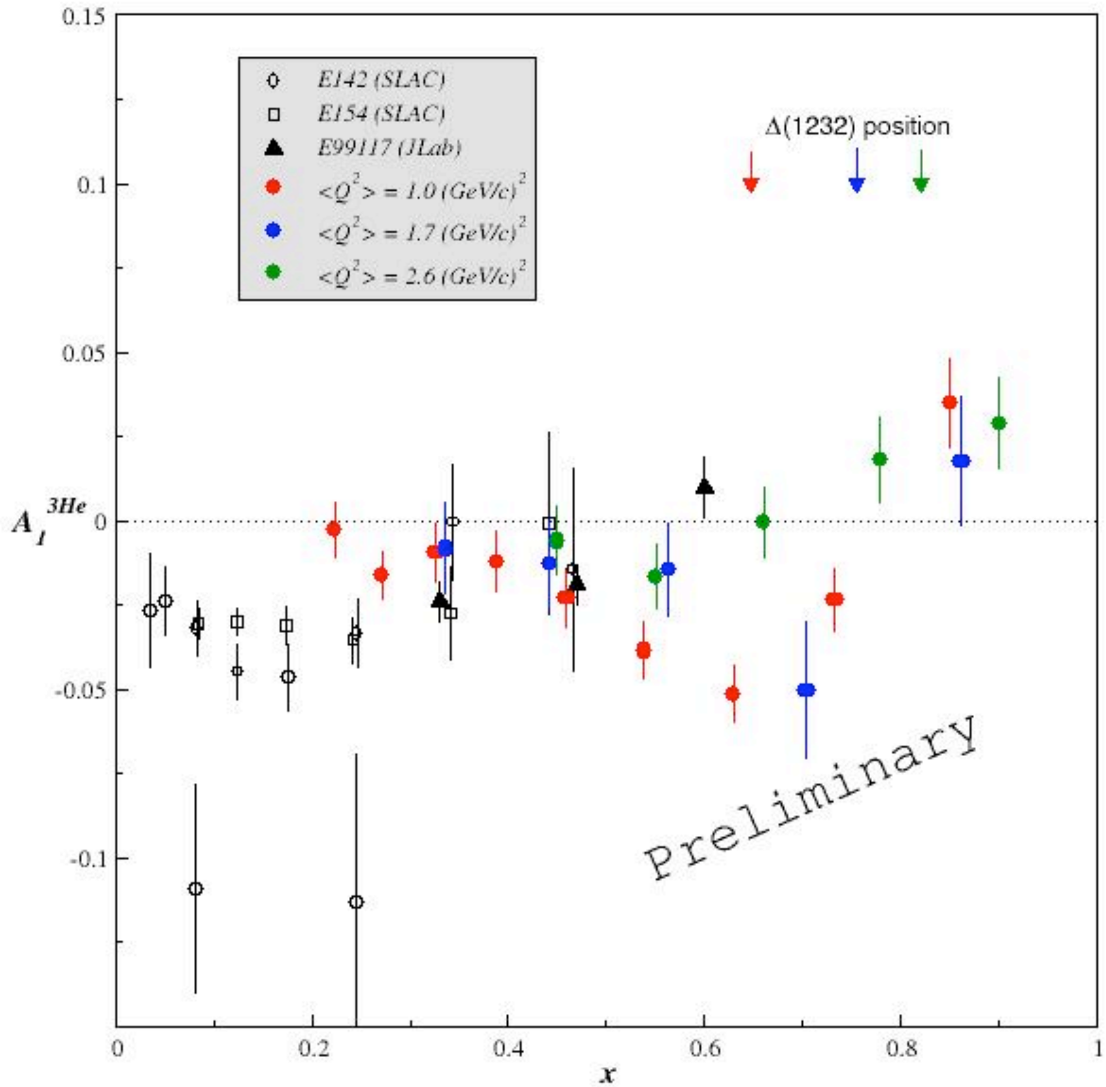
Spin asymmetry A1

A_1 is still negative in the $\Delta(1232)$ region.



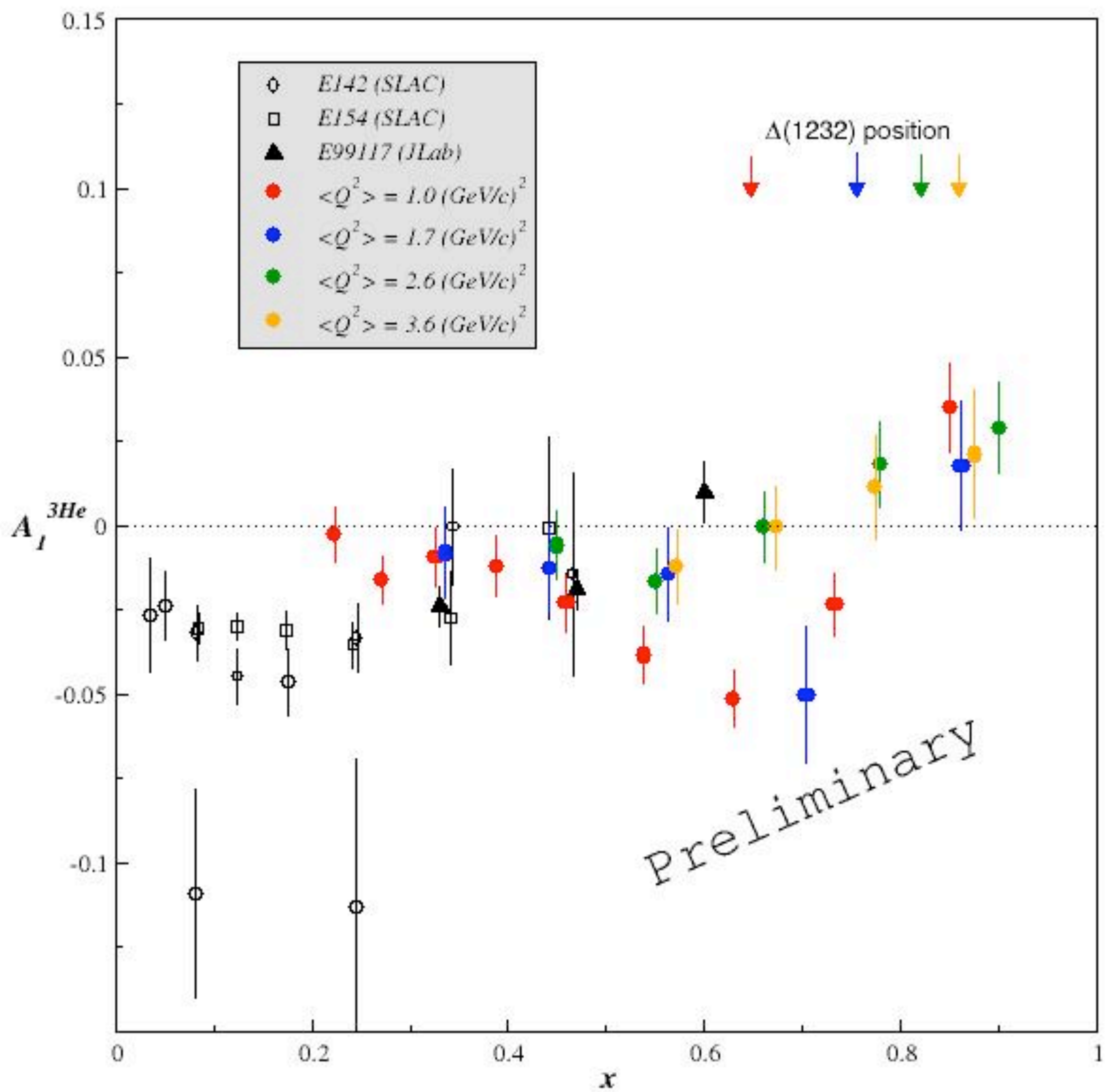
Spin asymmetry A1

The Δ(1232) vanishes while the non-resonant background is rising. A_1 becomes positive in the Δ (1232) region.

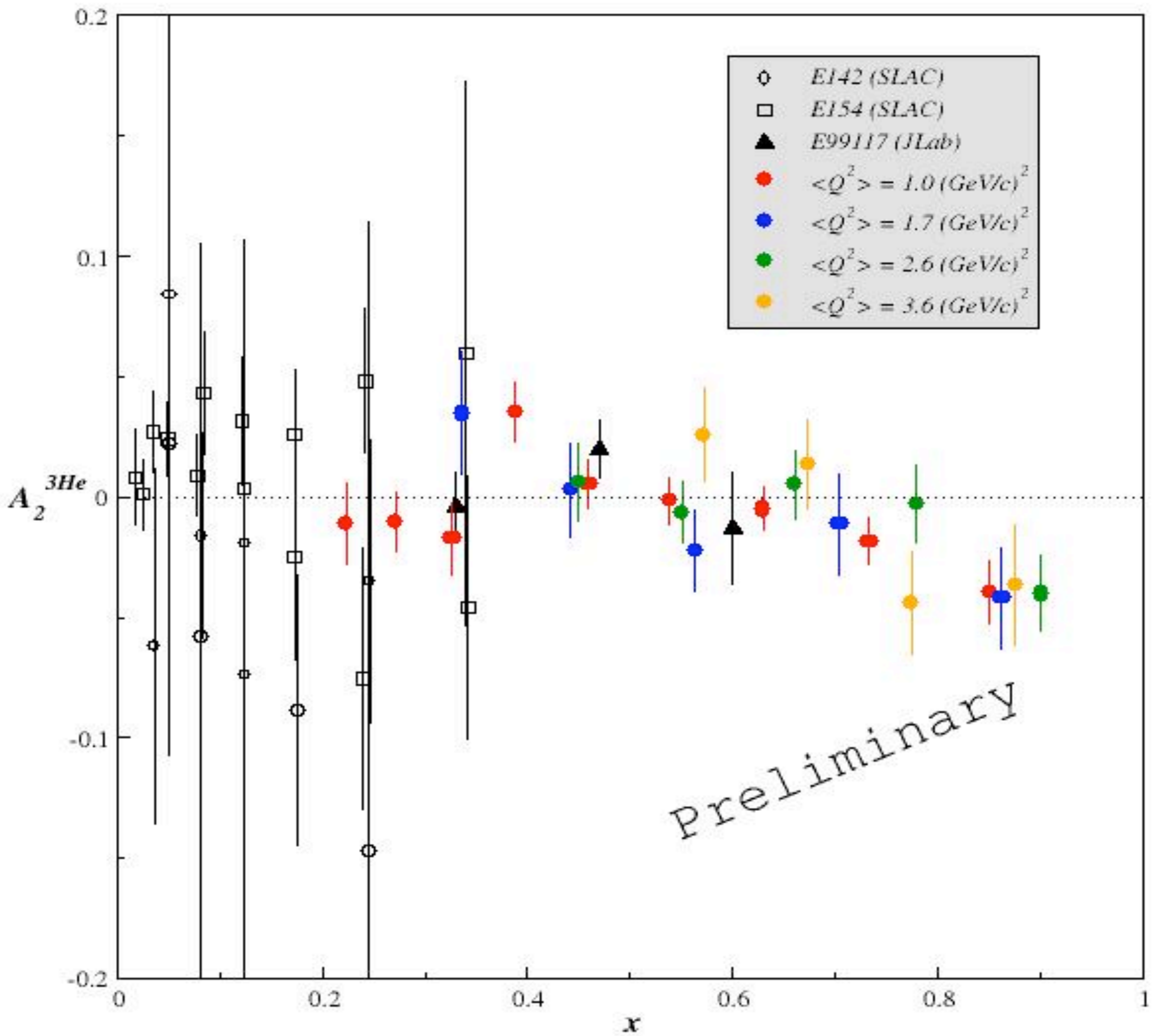


Spin asymmetry A1

The two highest Q^2 data sets agree with each other and show the same trend as DIS data.



Spin asymmetry A2



Still to do

- Finalize radiative corrections
- Extract the neutron spin structure functions
- Quantitative test of quark-hadron duality
- Extract moments of structure functions (e.g. GDH sum rule, BC sum rule)

Expected graduation: May 2006