E01-012: Spin Duality

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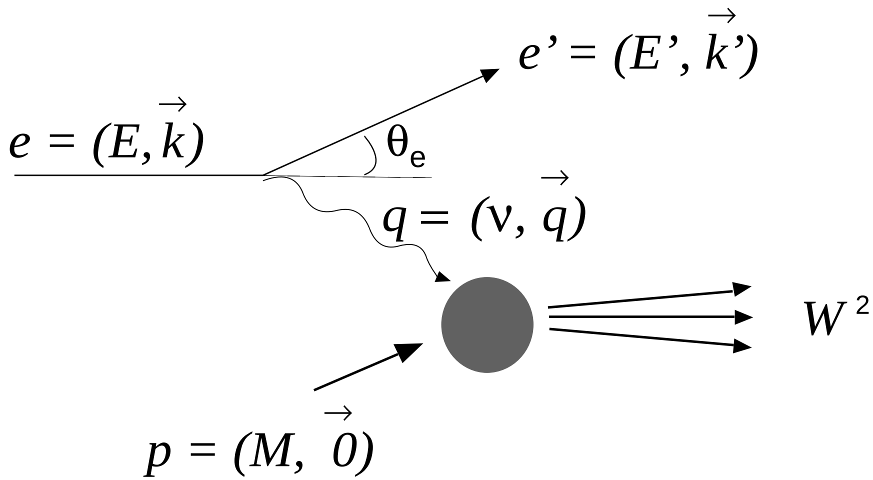
Hall A Collaboration Meeting

December 5, 2005

Inclusive scattering



Photon virtuality:

$$Q^2 = -q^2 = 4EE' sin^2 \frac{\theta_e}{2}$$

Invariant mass squared:

$$W^2 = M^2 + 2M\nu - Q^2$$

Bjorken variable

$$x = \frac{Q^2}{2M\nu}$$

Unpolarized case

$$\frac{d^2\sigma}{d\Omega dE'} = \sigma_{Mott}\left[\frac{1}{\nu}F_2(x,Q^2) + \frac{2}{M}F_1(x,Q^2)\tan^2\frac{\theta}{2}\right]$$

Polarized case

$$\frac{d^2\sigma^{\uparrow\Uparrow}}{d\Omega dE'} - \frac{d^2\sigma^{\uparrow\Downarrow}}{d\Omega dE'} = \frac{4\alpha^2 E'}{\nu E Q^2}\left[(E + E'\cos\theta)g_1(x,Q^2) - 2Mxg_2(x,Q^2)\right]$$

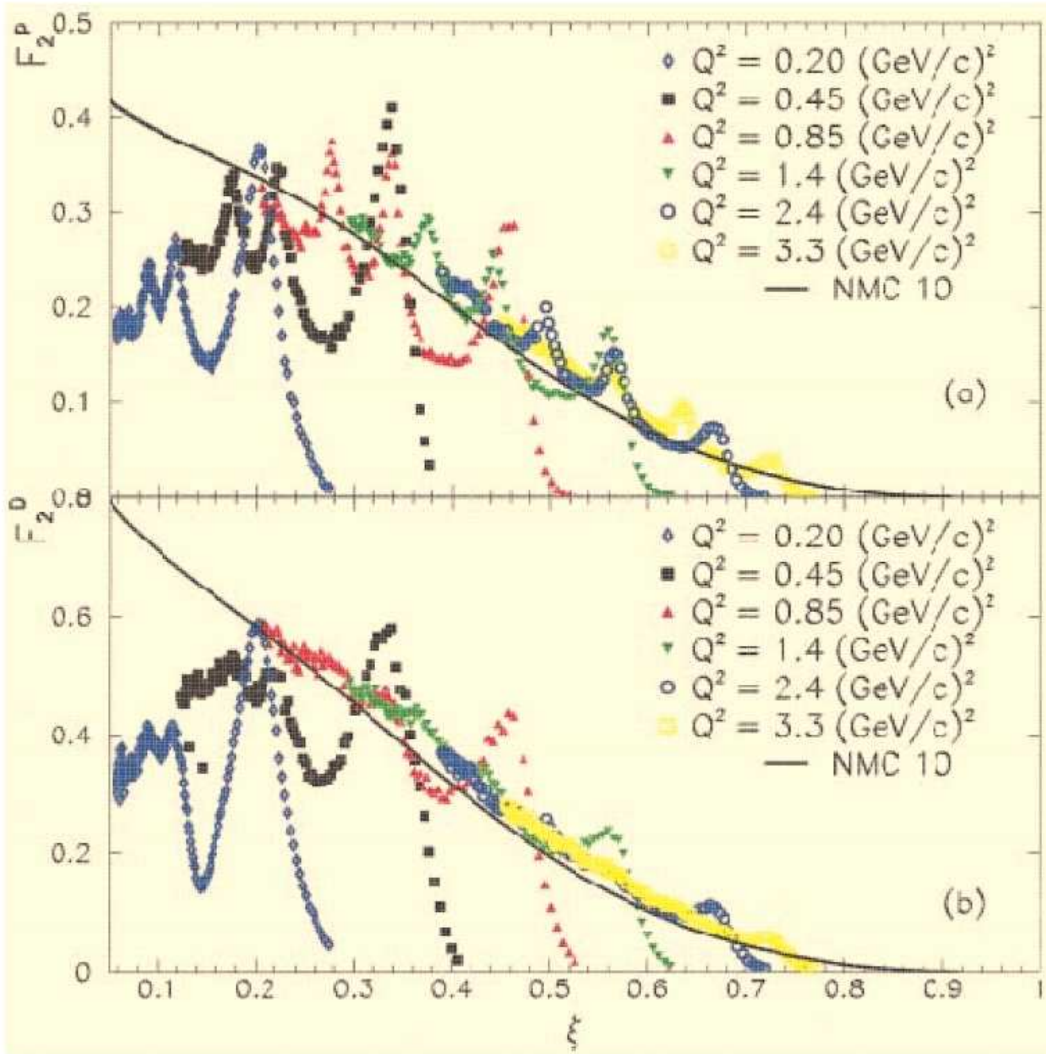
$$\frac{d^2\sigma^{\uparrow\Rightarrow}}{d\Omega dE'} - \frac{d^2\sigma^{\uparrow\Leftarrow}}{d\Omega dE'} = \frac{4\alpha^2 E'}{\nu E Q^2}\sin\theta\left[g_1(x,Q^2) + \frac{2ME}{\nu}g_2(x,Q^2)\right]$$

Quark-hadron duality

- First observed by Bloom and Gilman in the 1970's on F_2
- Scaling curve seen at high Q^2 is an accurate average over the resonance region at lower Q^2
- Confirmed in Hall C $\longrightarrow$
- Motivations:

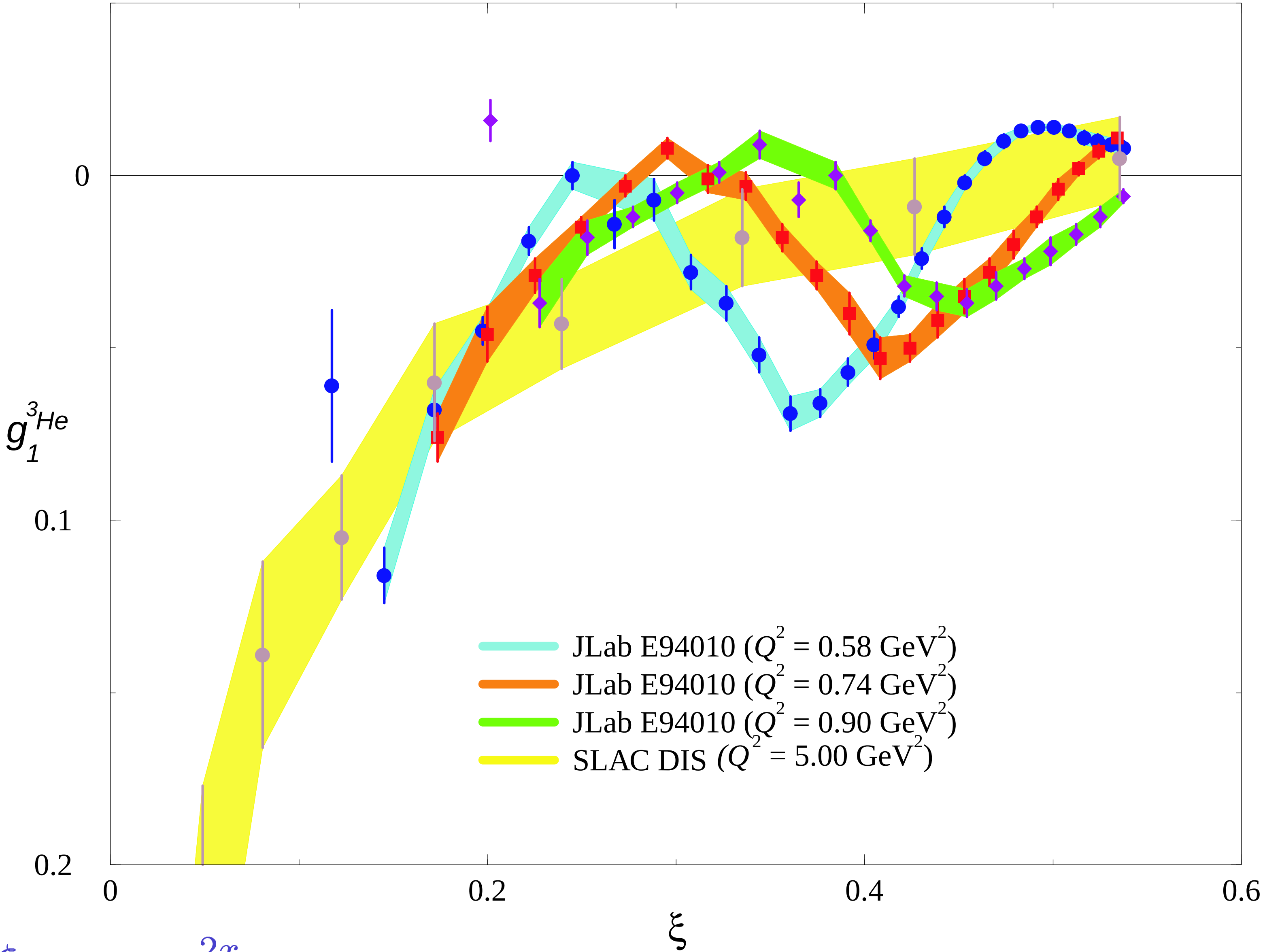
  Understand transition between quarks and hadrons

  Study of higher twists



I. Niculescu et al, PRL 85 (2000) 1182

Hint of duality



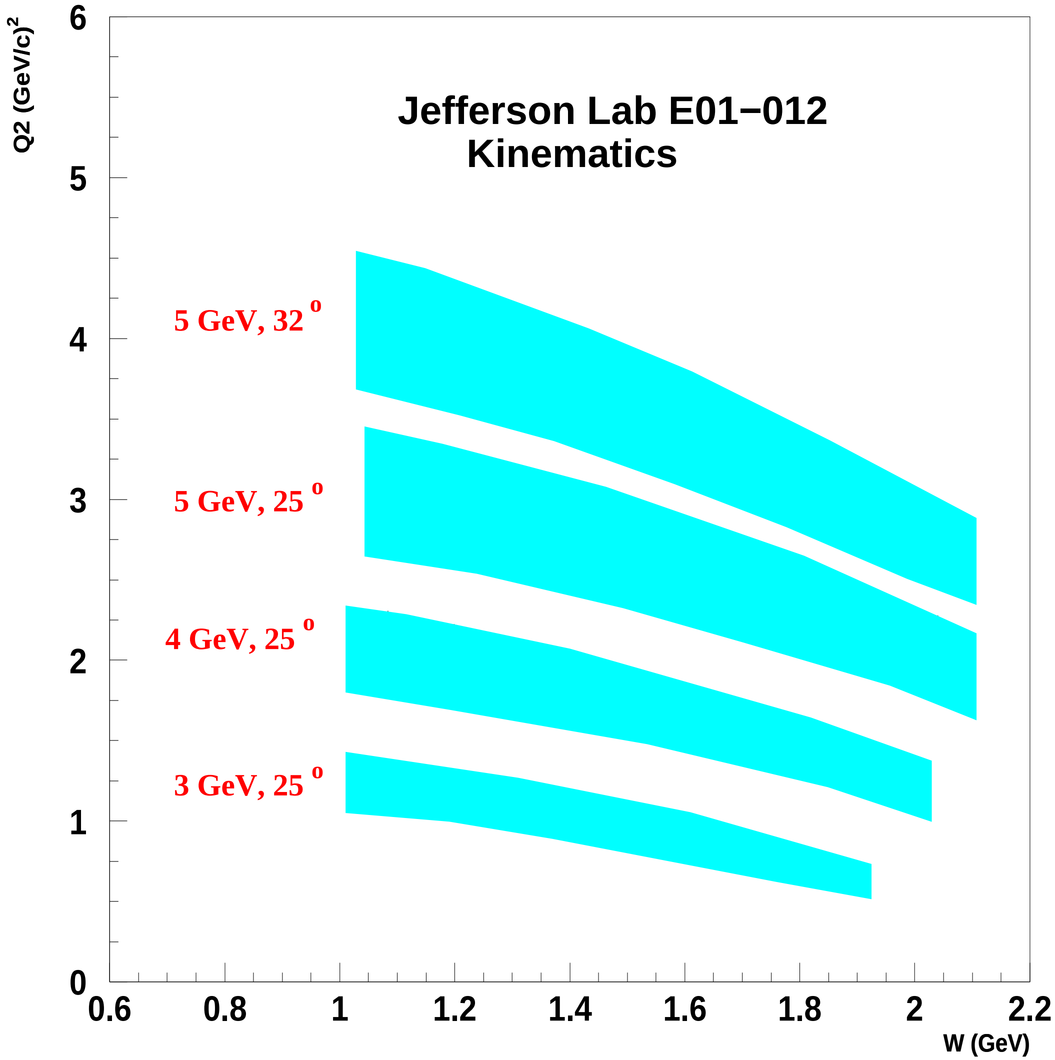
$$\xi = \frac{2x}{1+\sqrt{1+\frac{4M^2x^2}{Q^2}}}$$

Figure from Seonho Choi

The experiment E01-012

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

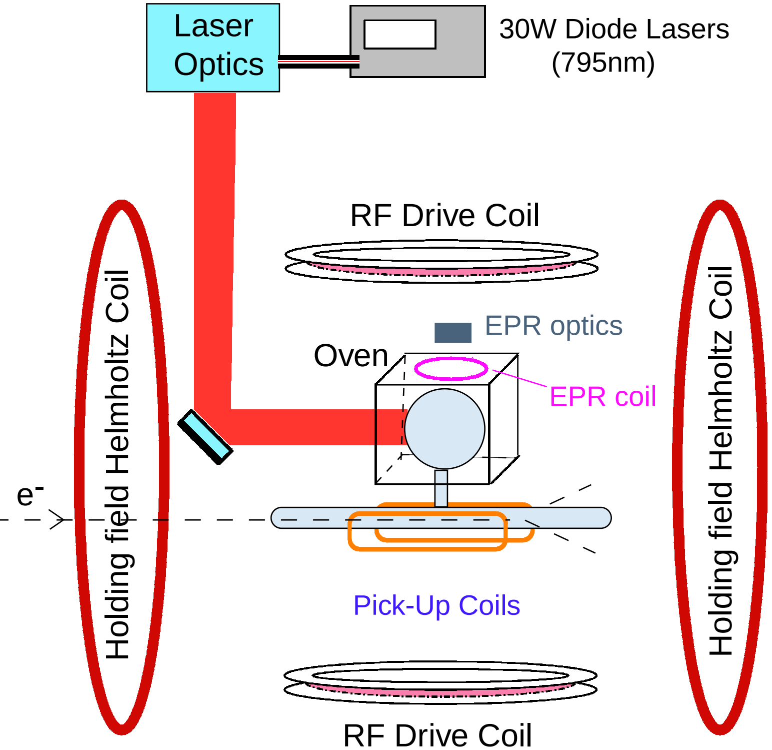
- Ran in January-February 2003
- Inclusive experiment: ${}^{3}\vec{\mathrm{He}}(\vec{e}, e')X$
- Measured polarized cross section differences and asymmetries
- Form g_1, g_2, A_1 and A_2 for ${}^{3}\mathrm{He}$
- Test of spin duality on the neutron (and ${}^{3}\mathrm{He}$)



Analysis update

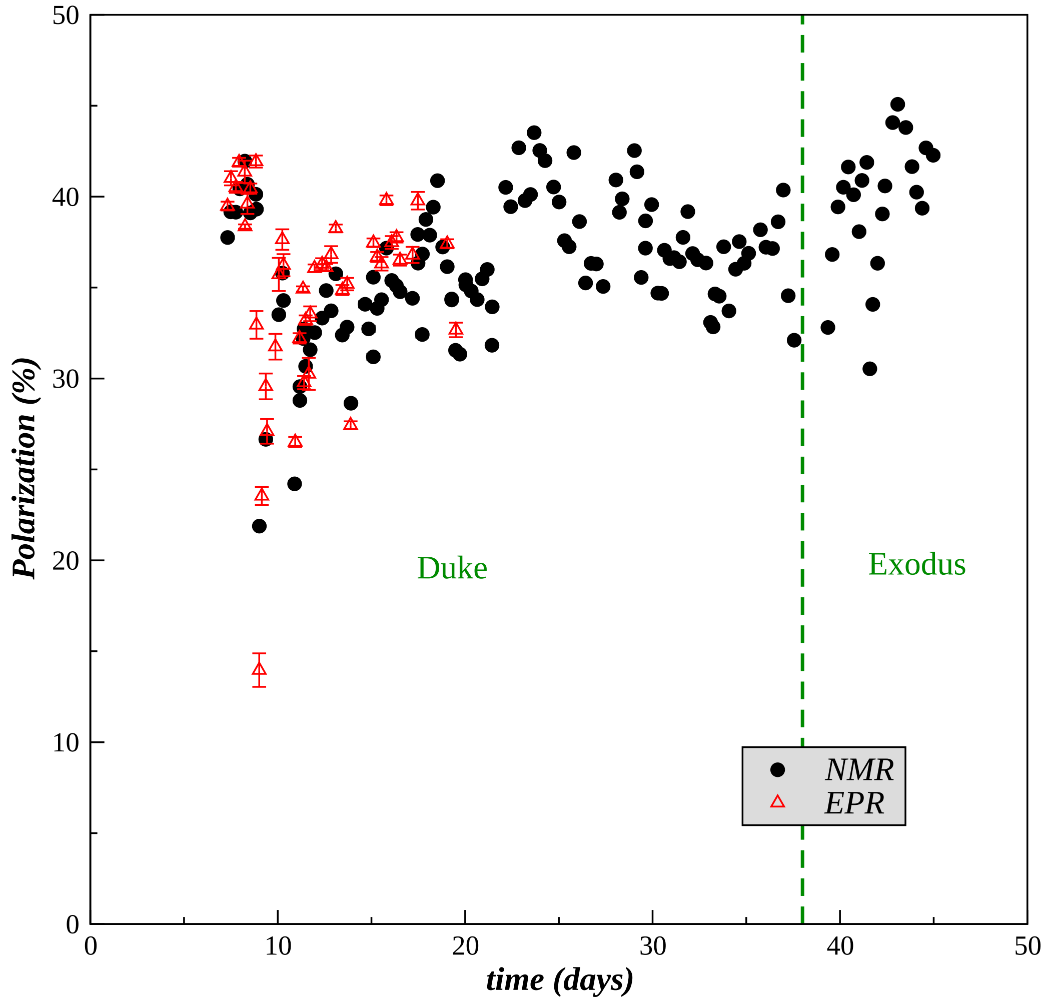
- Target polarimetry analysis in final stage (systematics).
- Detector analysis done.
- Cross sections and asymmetries near final.
- Detailed analysis of the N_2 cross sections and dilution completed.
- First pass radiative corrections completed: used E94-010 data as input model.
- Preliminary results: g_1, g_2, A_1 and A_2 on $^3\mathrm{He}$.
- Very preliminary results: Γ_1^n in the resonance region and test of global spin duality on the neutron.

Target performance



→ 2 independent polarimetries: NMR and EPR

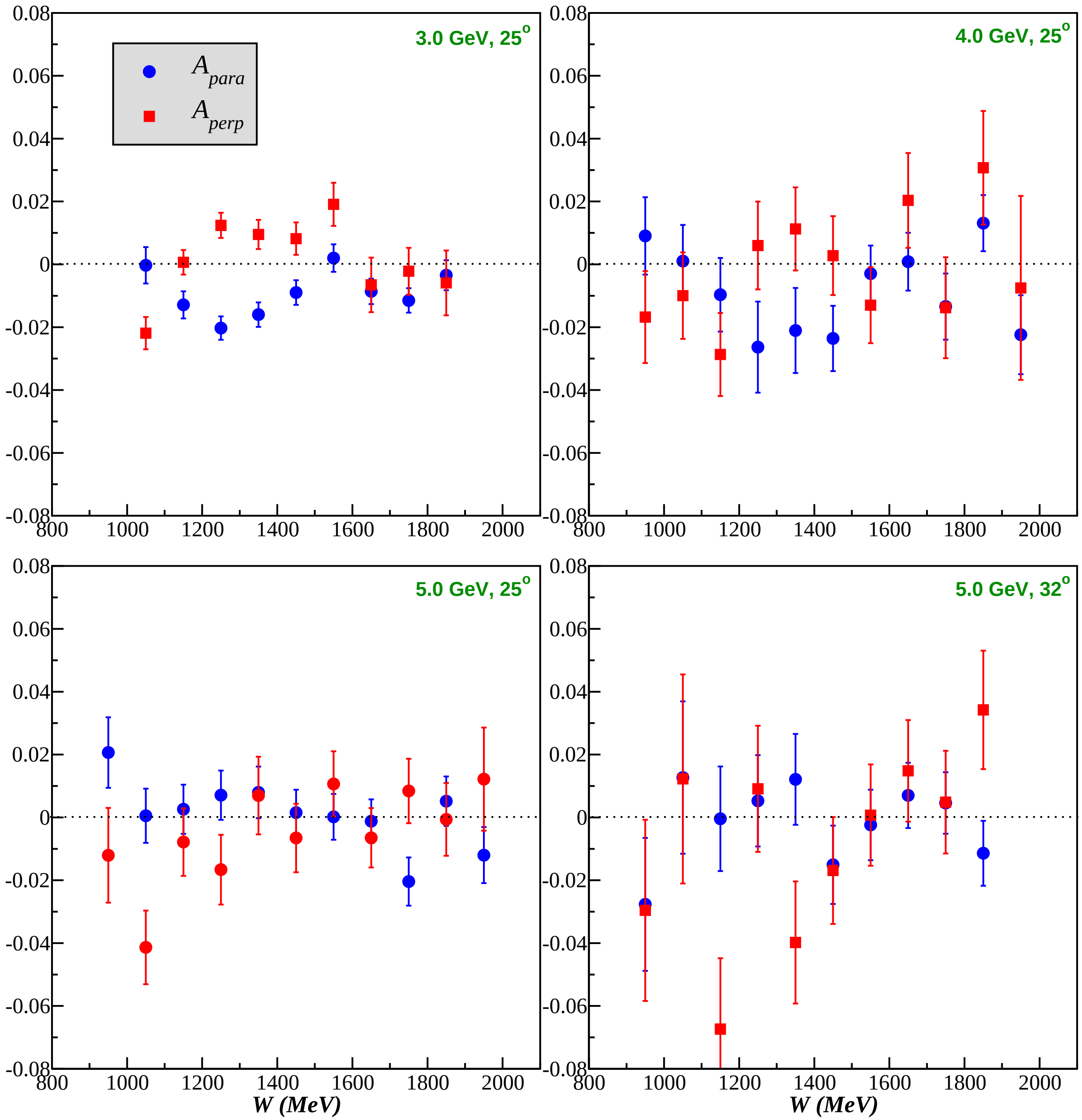
→ Longitudinal and transverse polarizations



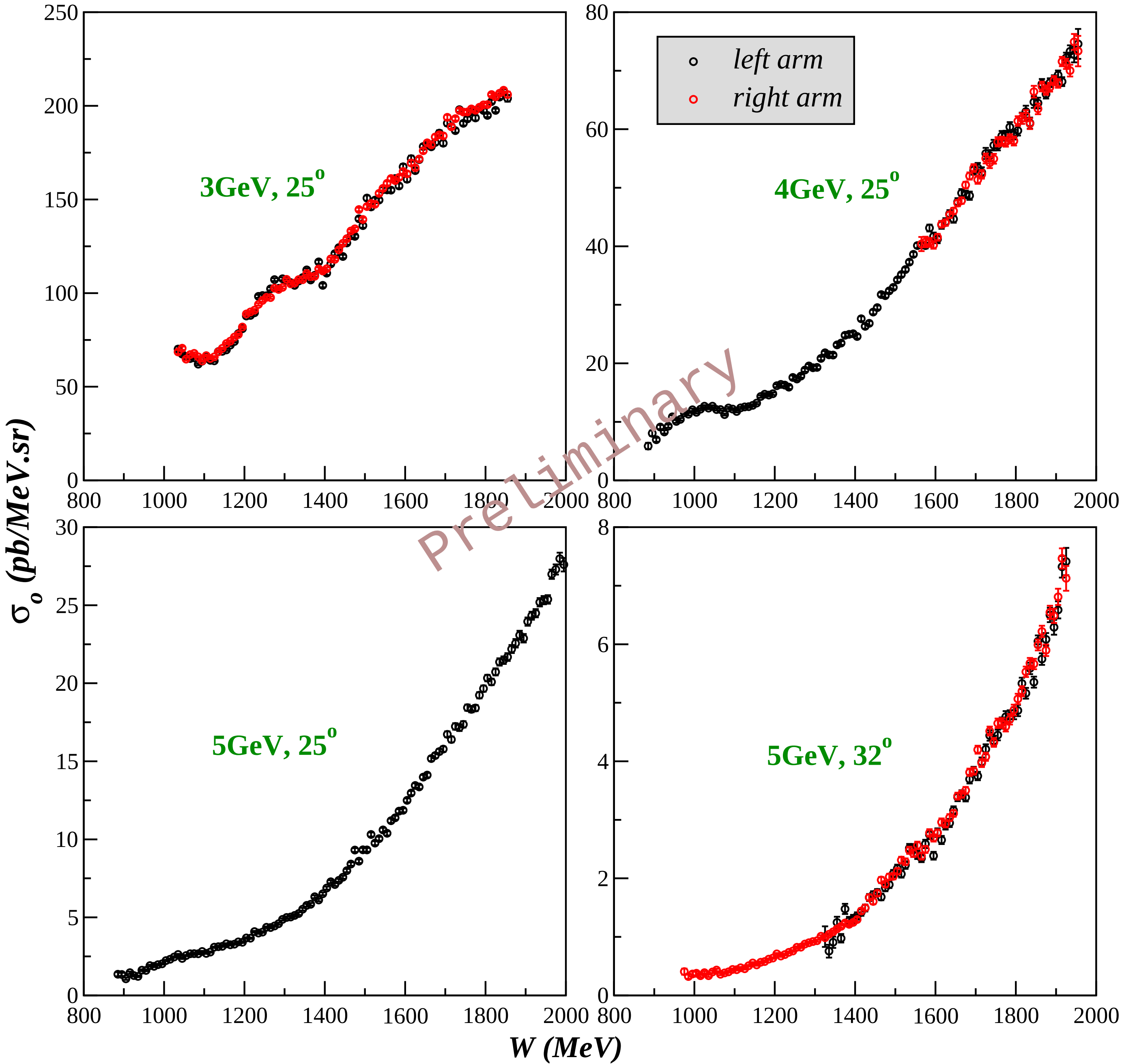
NMR analysis completed (Vince Sulkosky)

EPR analysis almost completed: still have to estimate the systematic error.

Asymmetries

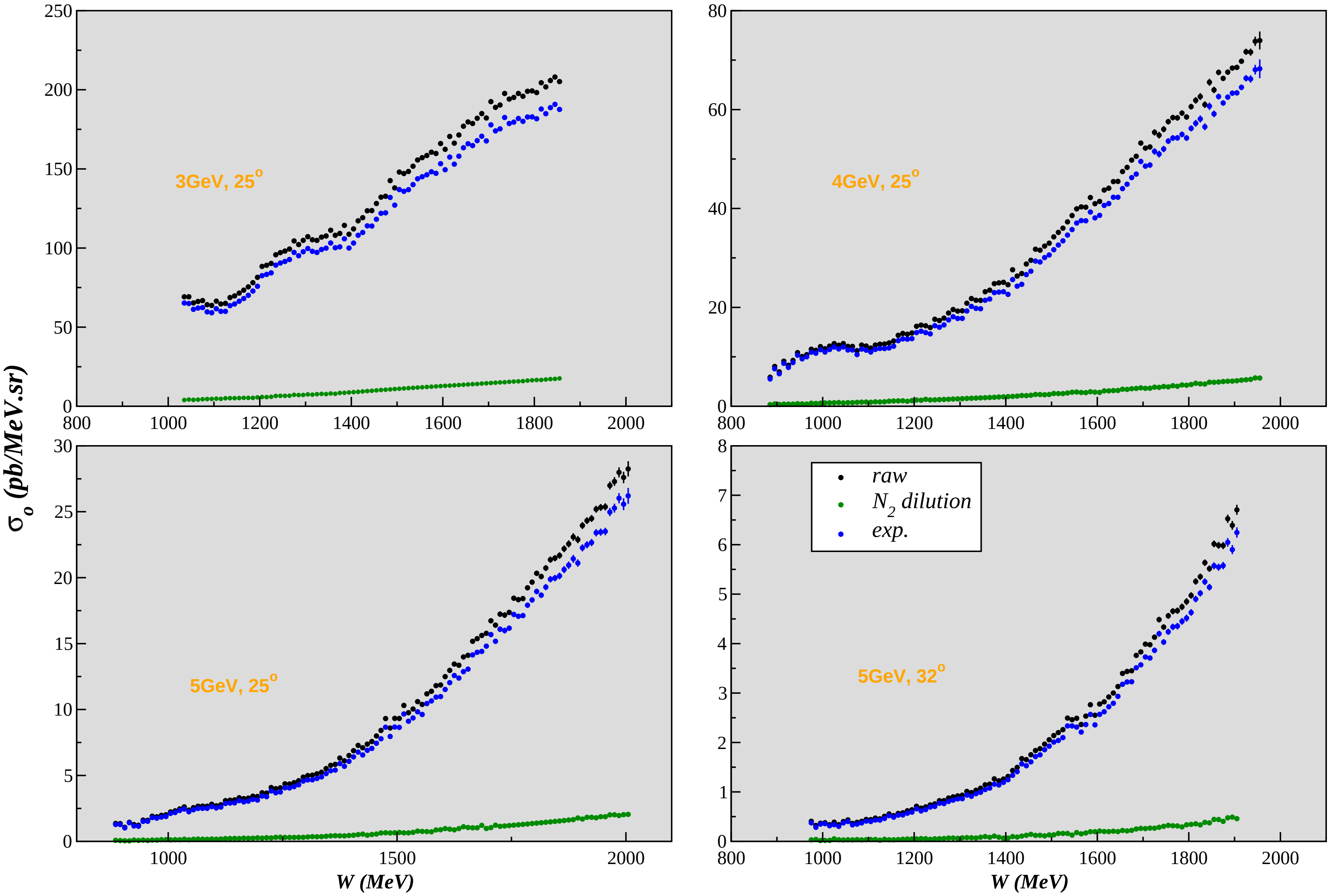


Unpolarized cross sections



Good agreement between the two HRS.

Nitrogen dilution



N_2 dilution is an 8% effect

Spin duality on Neutron and ^{3}He

$\rightarrow$ Used method defined by N. Bianchi, A. Fantoni and S. Liuti on g_1^p
PRD 69 (2004) 014505

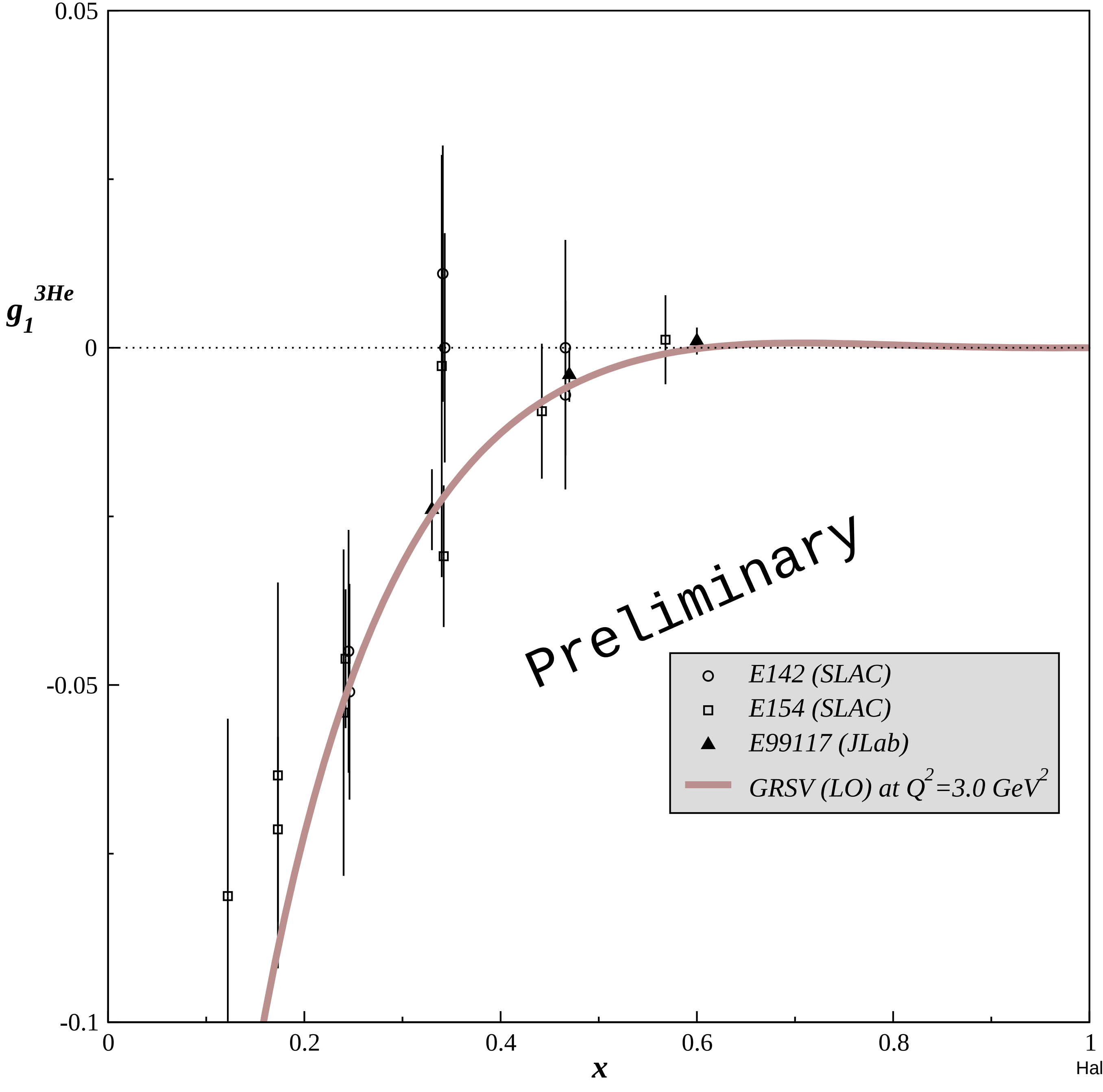
- Get g_1 at constant Q^2
- Define integration range in the resonance region in function of W
- Integrate g_1^{res} and g_1^{dis} over the same x-range and at the same Q^2

$$\tilde{\Gamma}_1^{res} = \int_{x_{min}}^{x_{max}} g_1^{res}(x, Q^2)dx \quad \text{and} \quad \tilde{\Gamma}_1^{LT} = \int_{x_{min}}^{x_{max}} g_1^{LT}(x, Q^2)dx$$

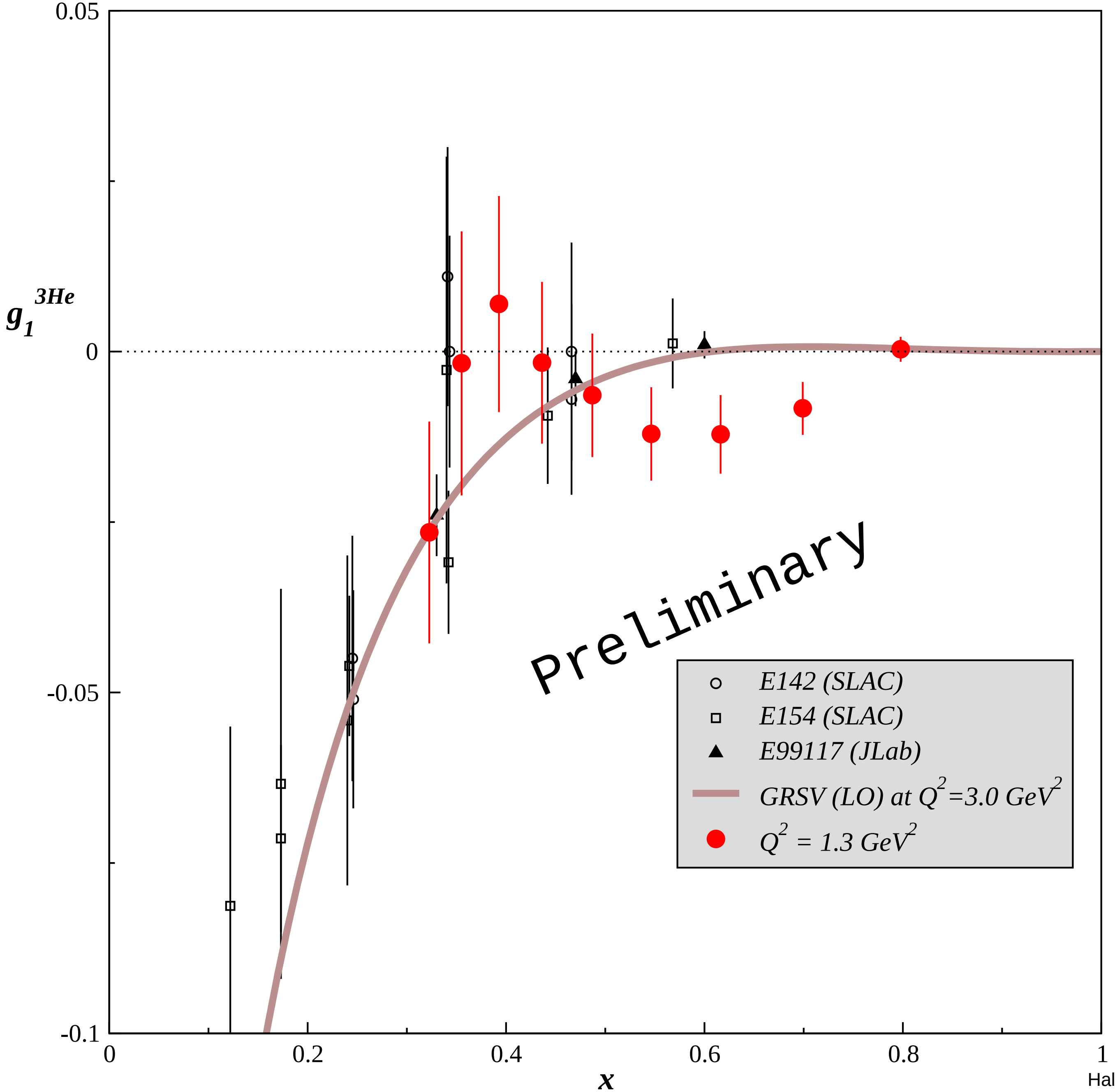
$$R^{LT} = \frac{\tilde{\Gamma}_1^{res}}{\tilde{\Gamma}_1^{LT}}$$ if unity $\Rightarrow$ duality is verifi ed.

$\Rightarrow$ Depending of the W-range chosen: test of global or local duality.

$g_1^{3\mathrm{He}}$ at constant Q^2



$g_1^{^3\mathrm{He}}$ at constant Q^2



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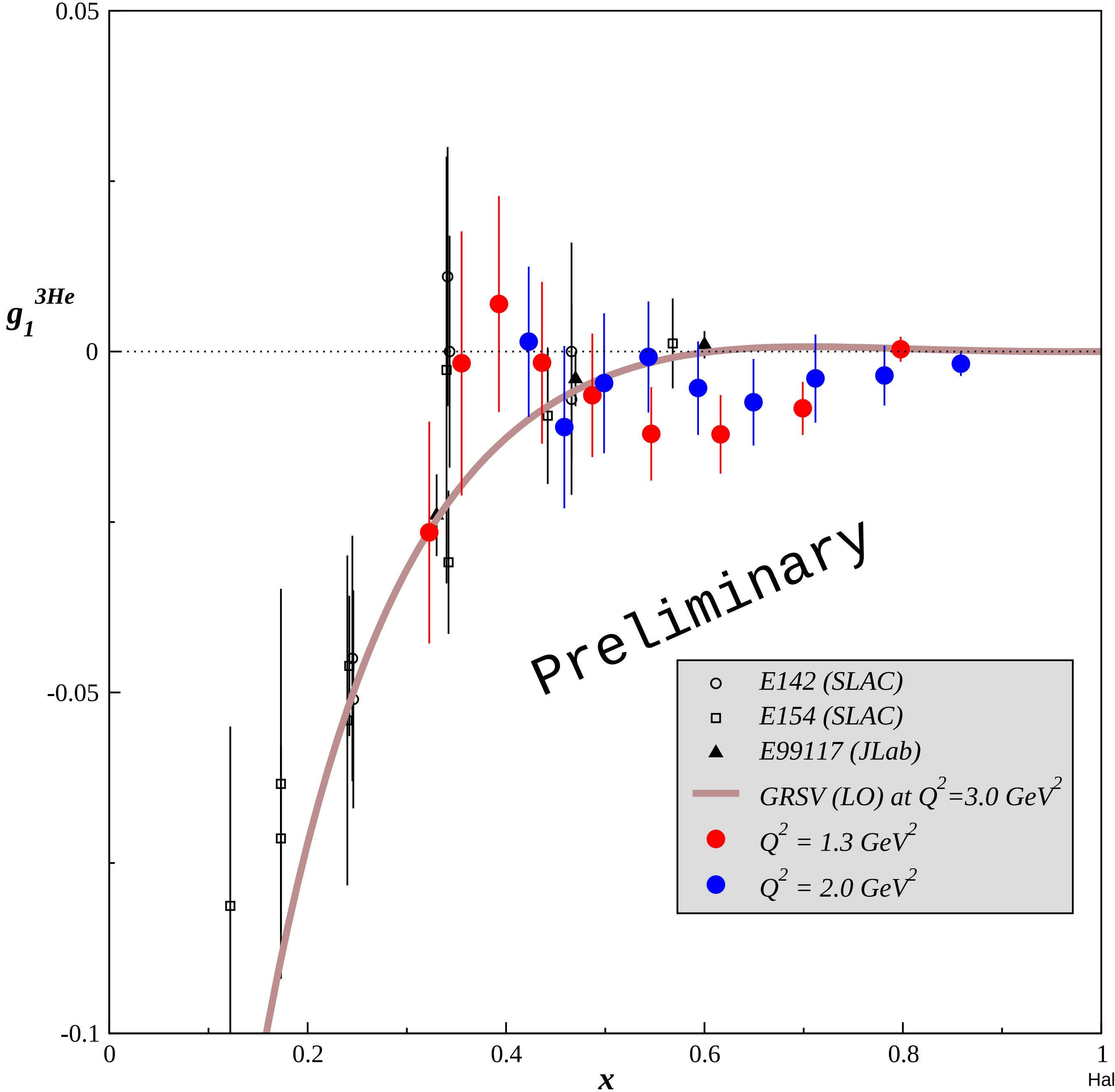
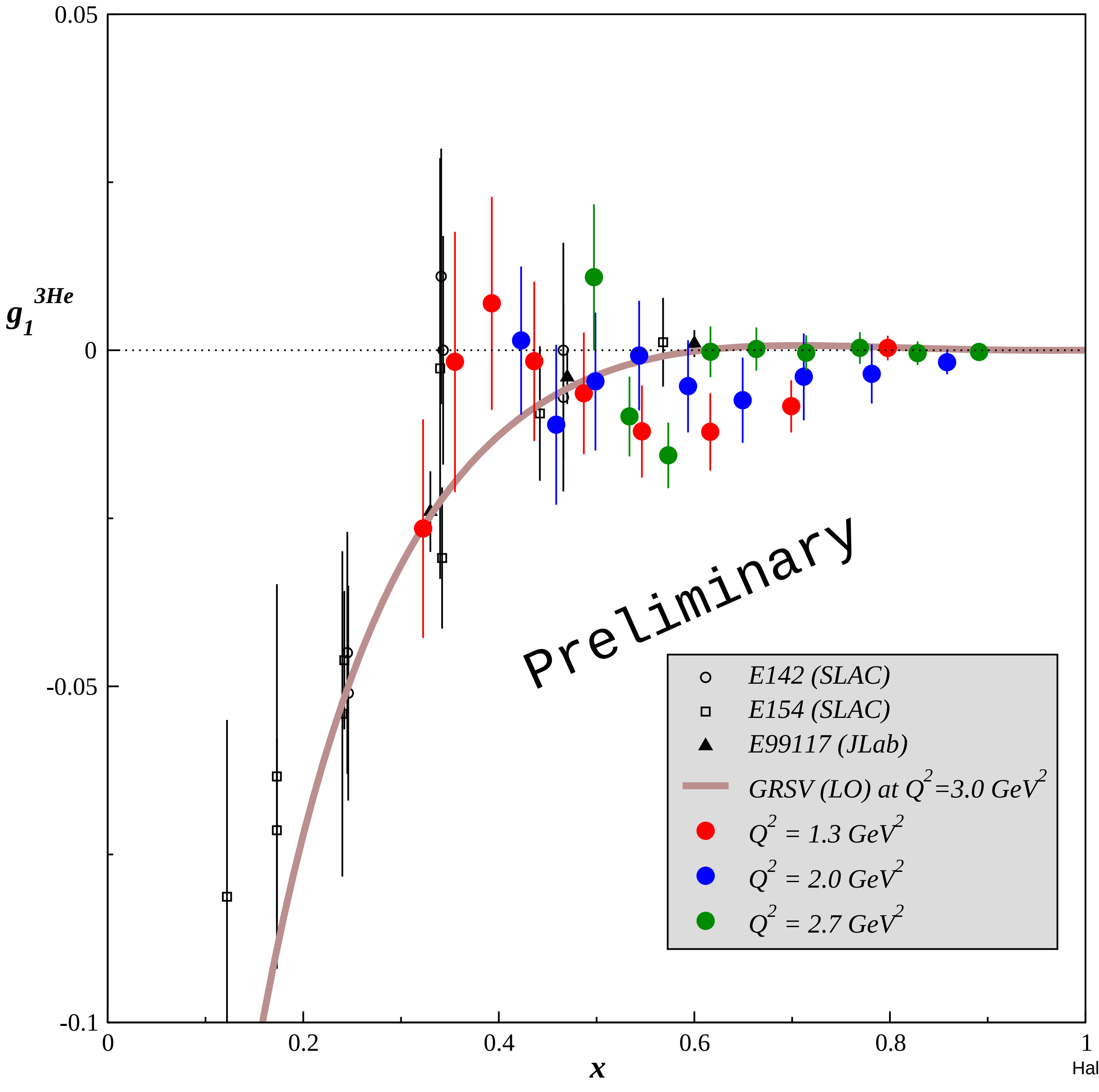
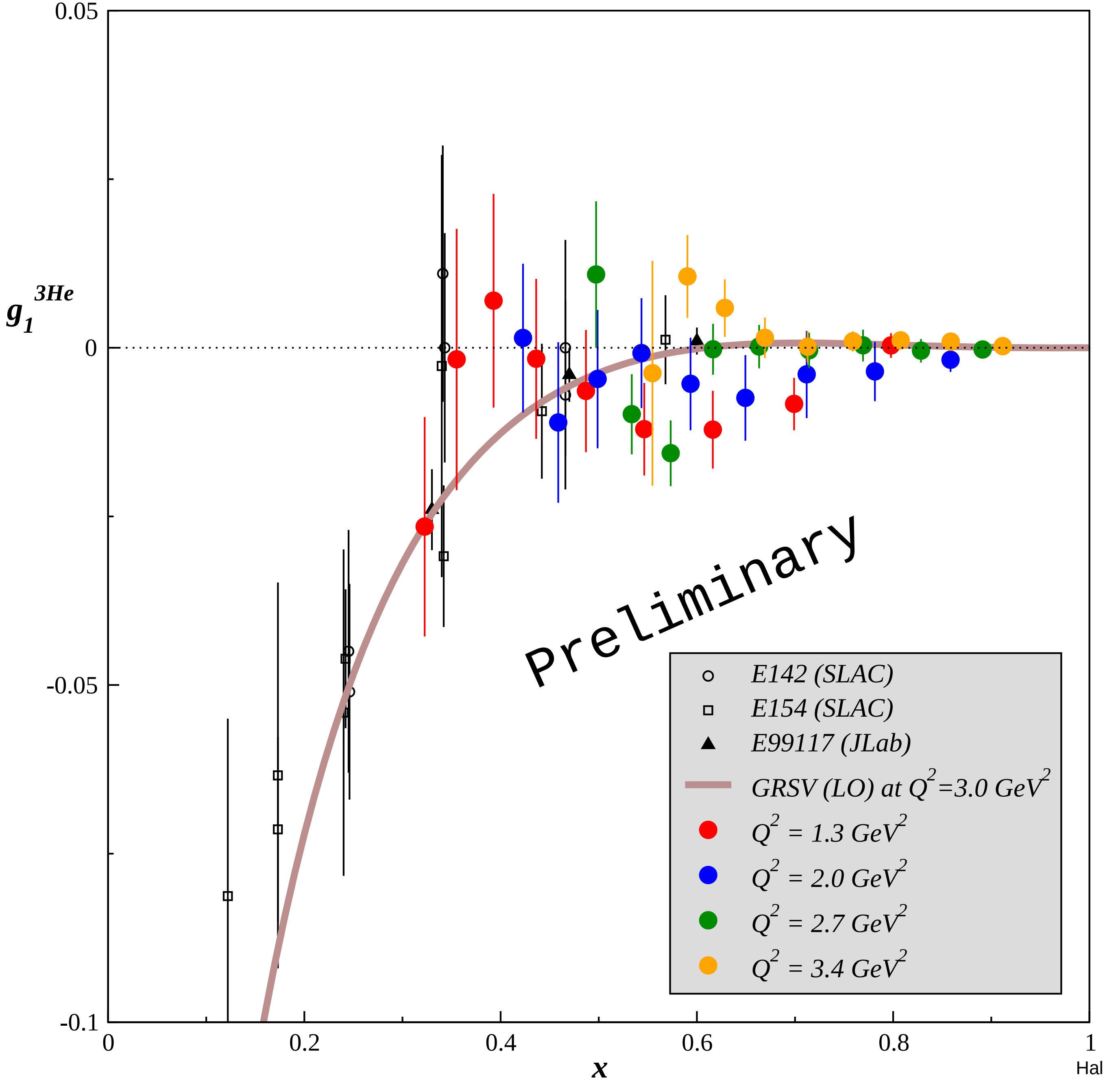


$g_1^{^3\mathrm{He}}$ at constant Q^2

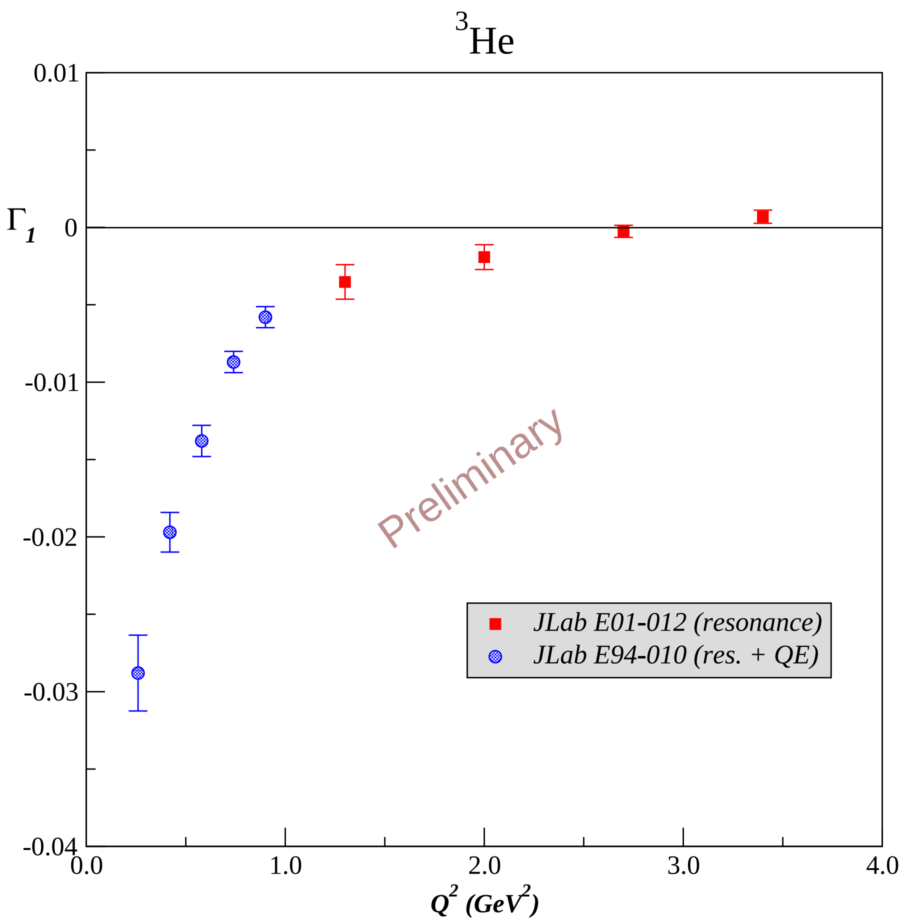


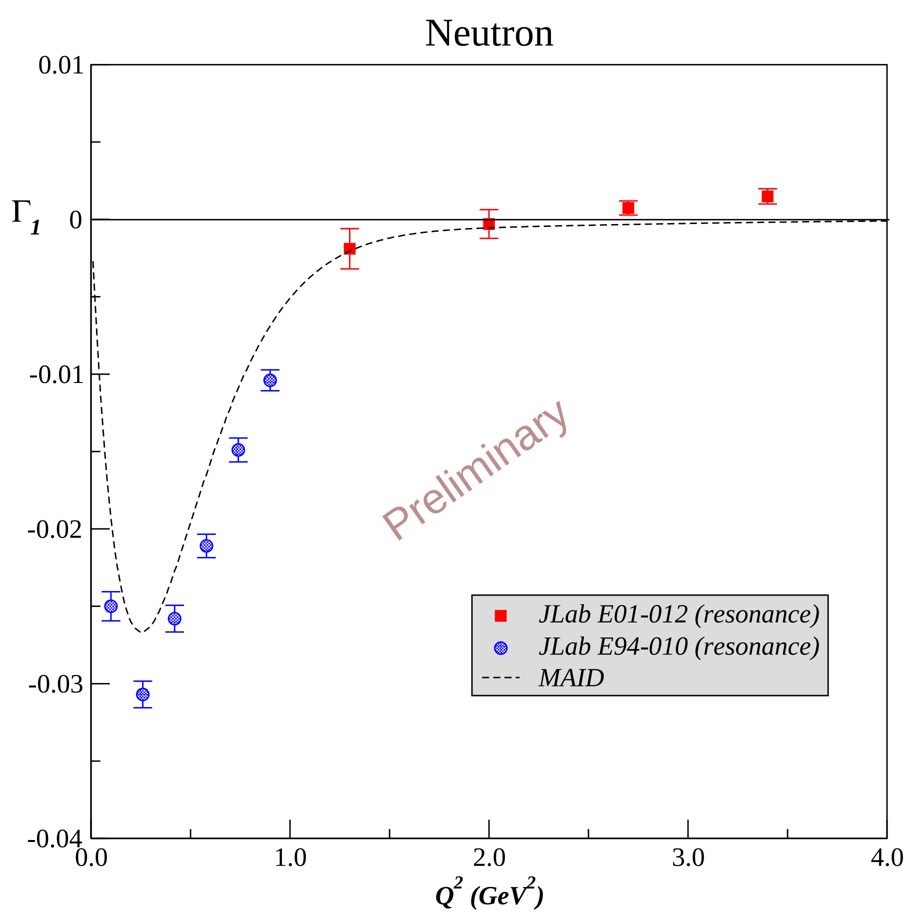
$g_1^{^3\mathrm{He}}$ at constant Q^2



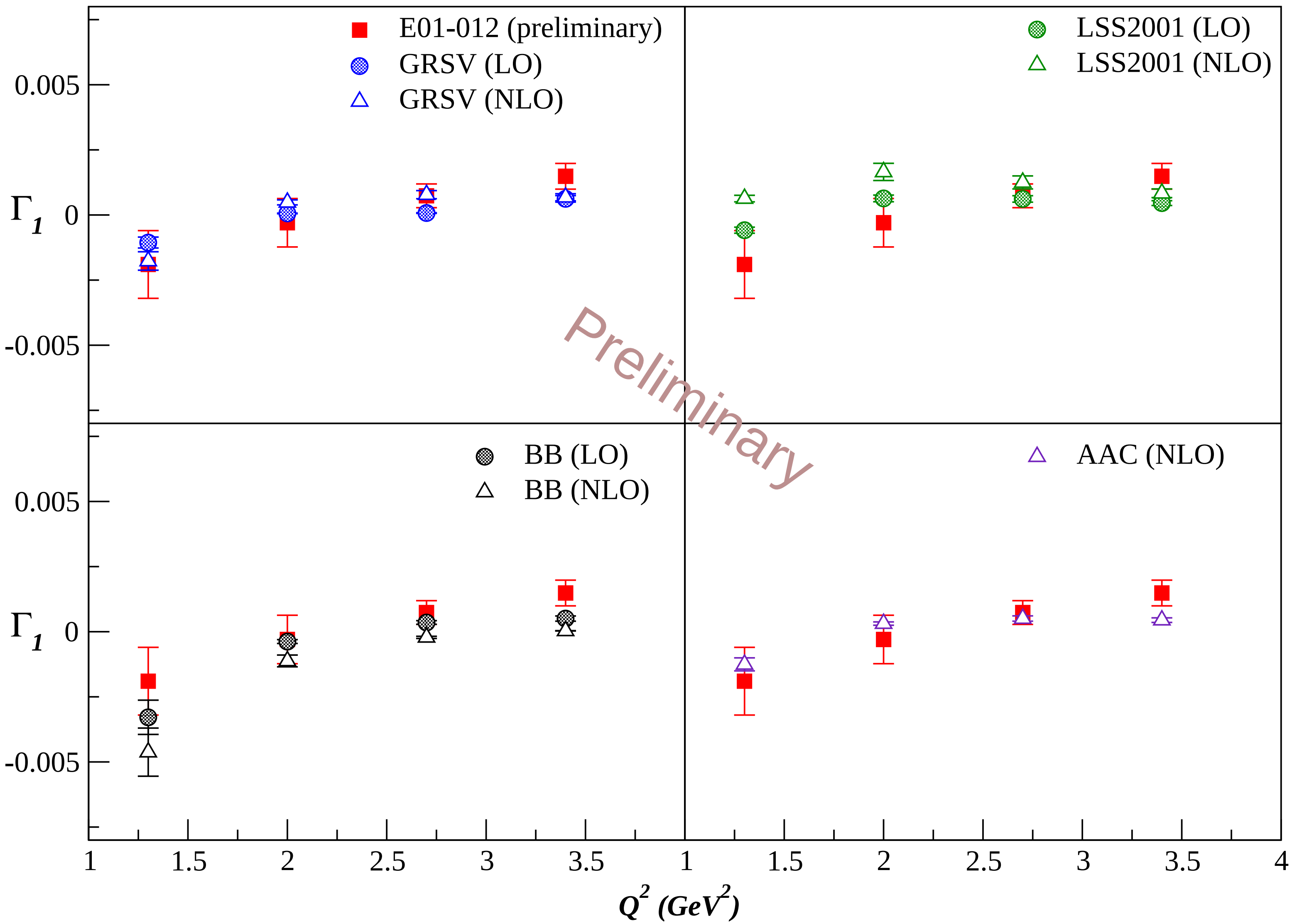
Γ_1^n in the resonance region

- Interpolate $g_1^{^3\mathrm{He}}$ to constant Q^2.
- Integrate $g_1^{^3\mathrm{He}}$ over the resonance region.
- Extract $\tilde{\Gamma}_1^n$ from $\tilde{\Gamma}_1^{^3\mathrm{He}} = P_n\,\tilde{\Gamma}_1^n + 2.0\,P_p\,\tilde{\Gamma}^p$





Test of duality



Spin asymmetries

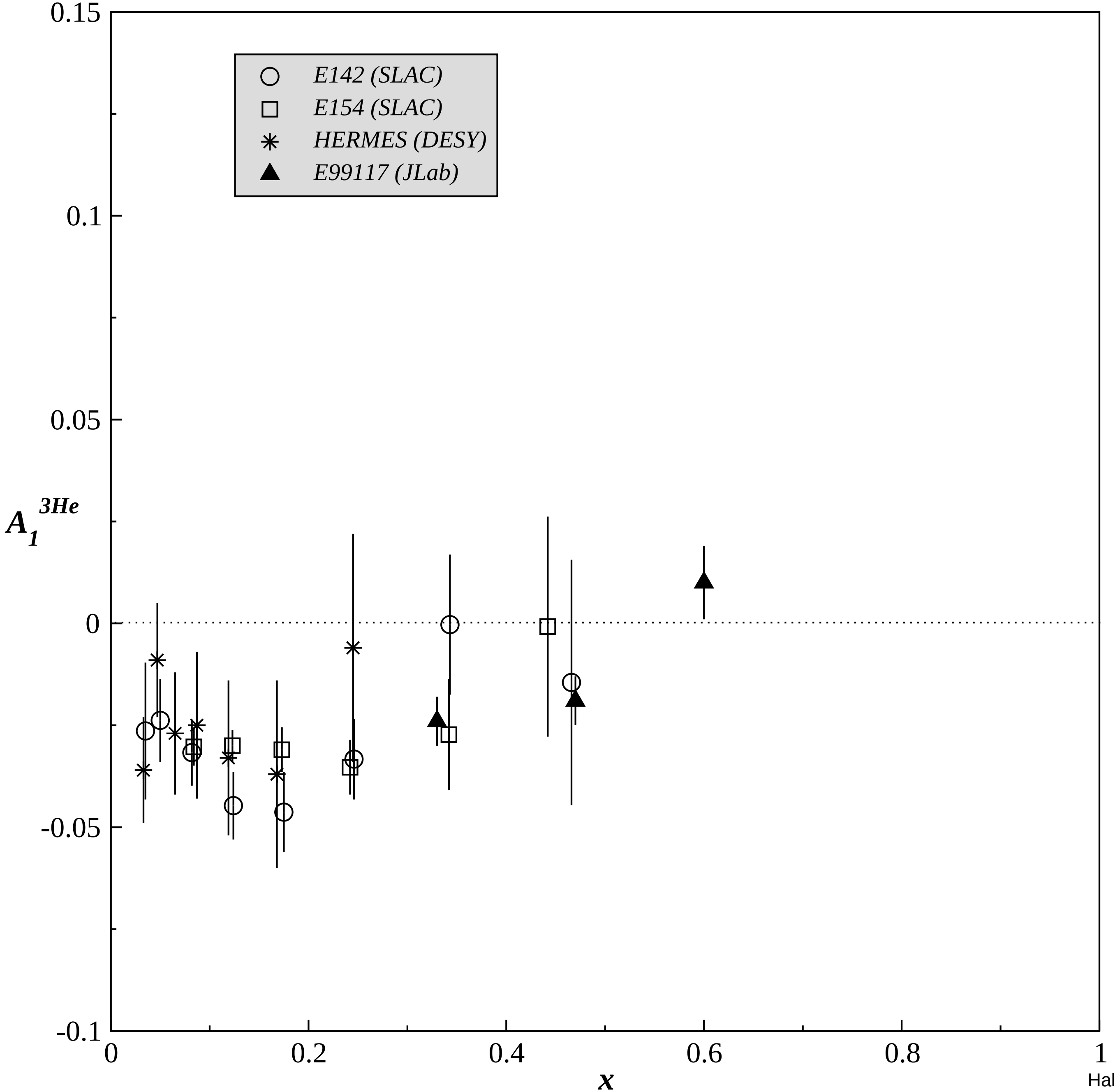
$$A_1(x, Q^2) \quad = \quad \frac{g_1(x, Q^2) - \gamma^2 g_2(x, Q^2)}{F_1(x, Q^2)}$$

$$A_2(x, Q^2) \quad = \quad \frac{\gamma\left[g_1(x, Q^2) + g_2(x, Q^2)\right]}{F_1(x, Q^2)}$$

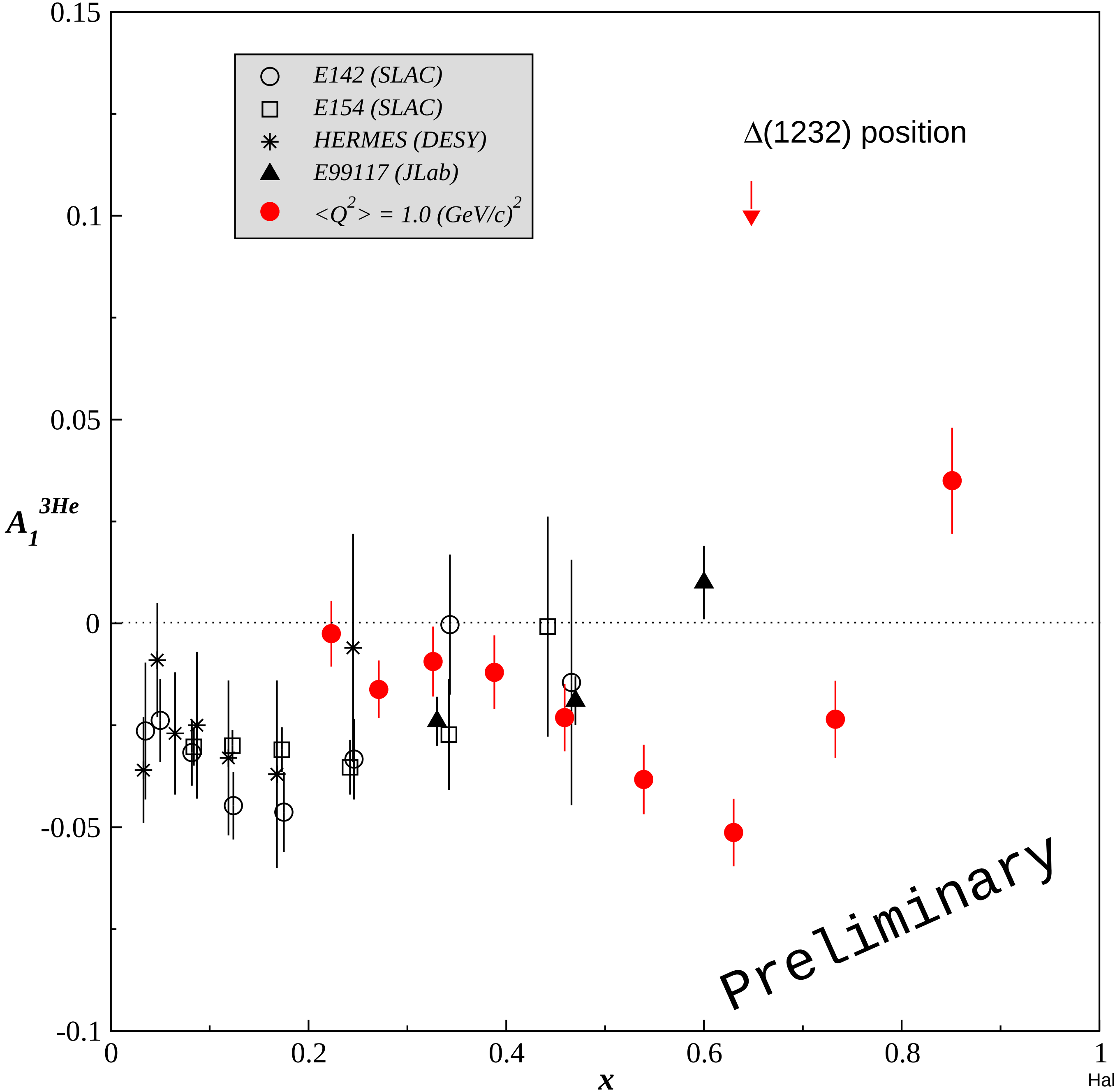
with $\gamma^2 = \frac{Q^2}{\nu^2}$.

Need model of F_1 for ^{3}He and neutron.

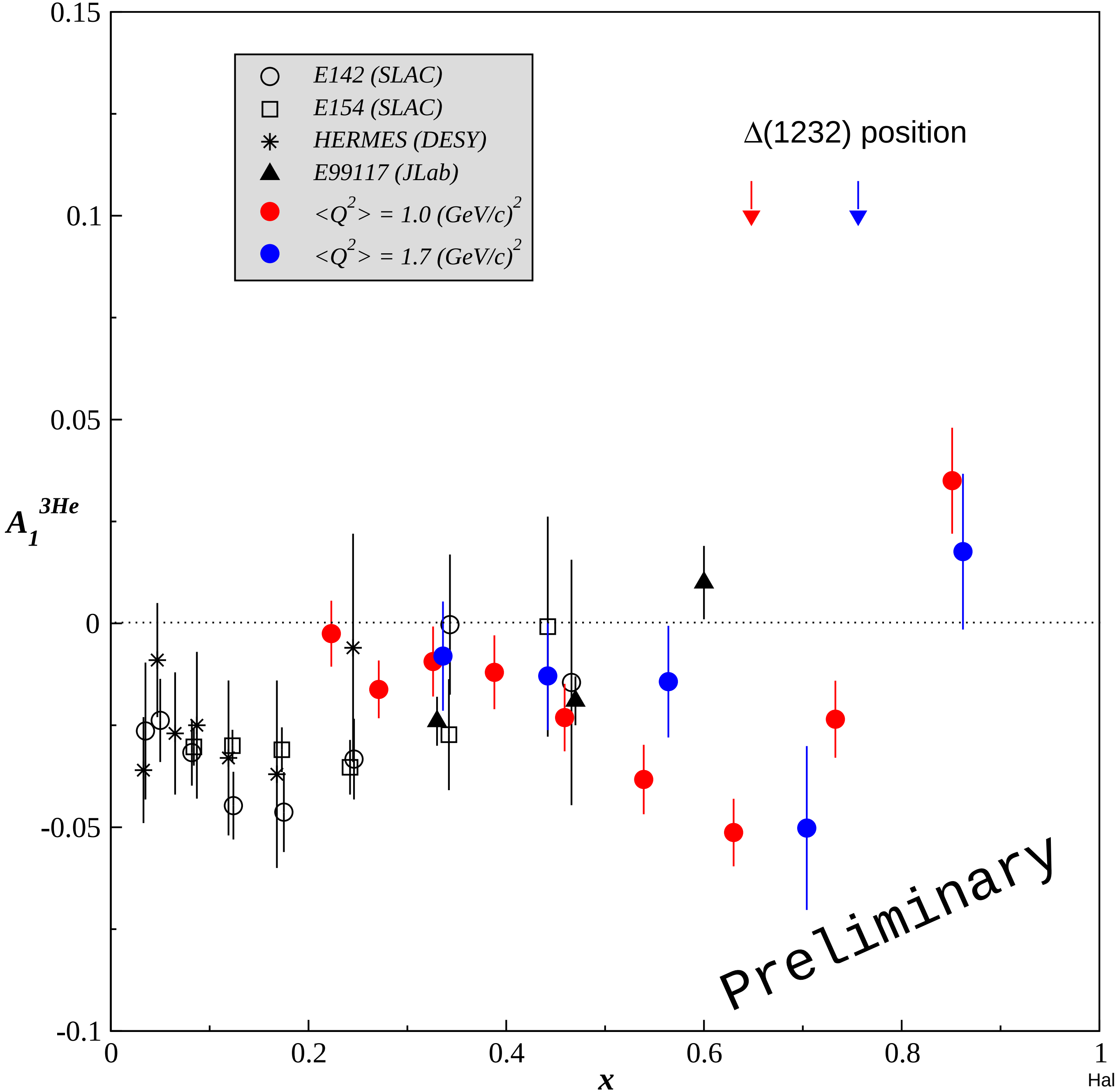
Spin asymmetry A_1



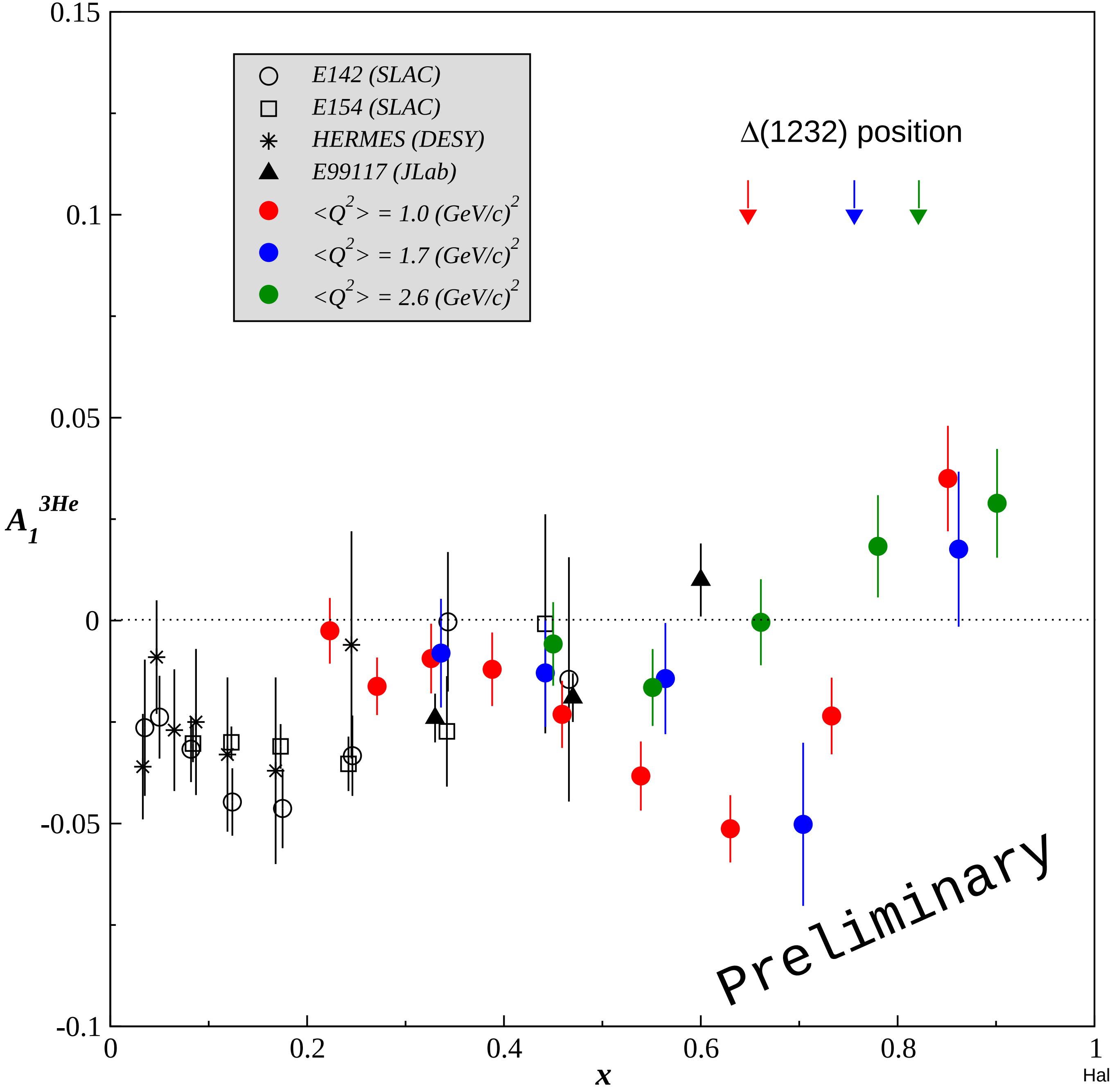
Spin asymmetry A_1



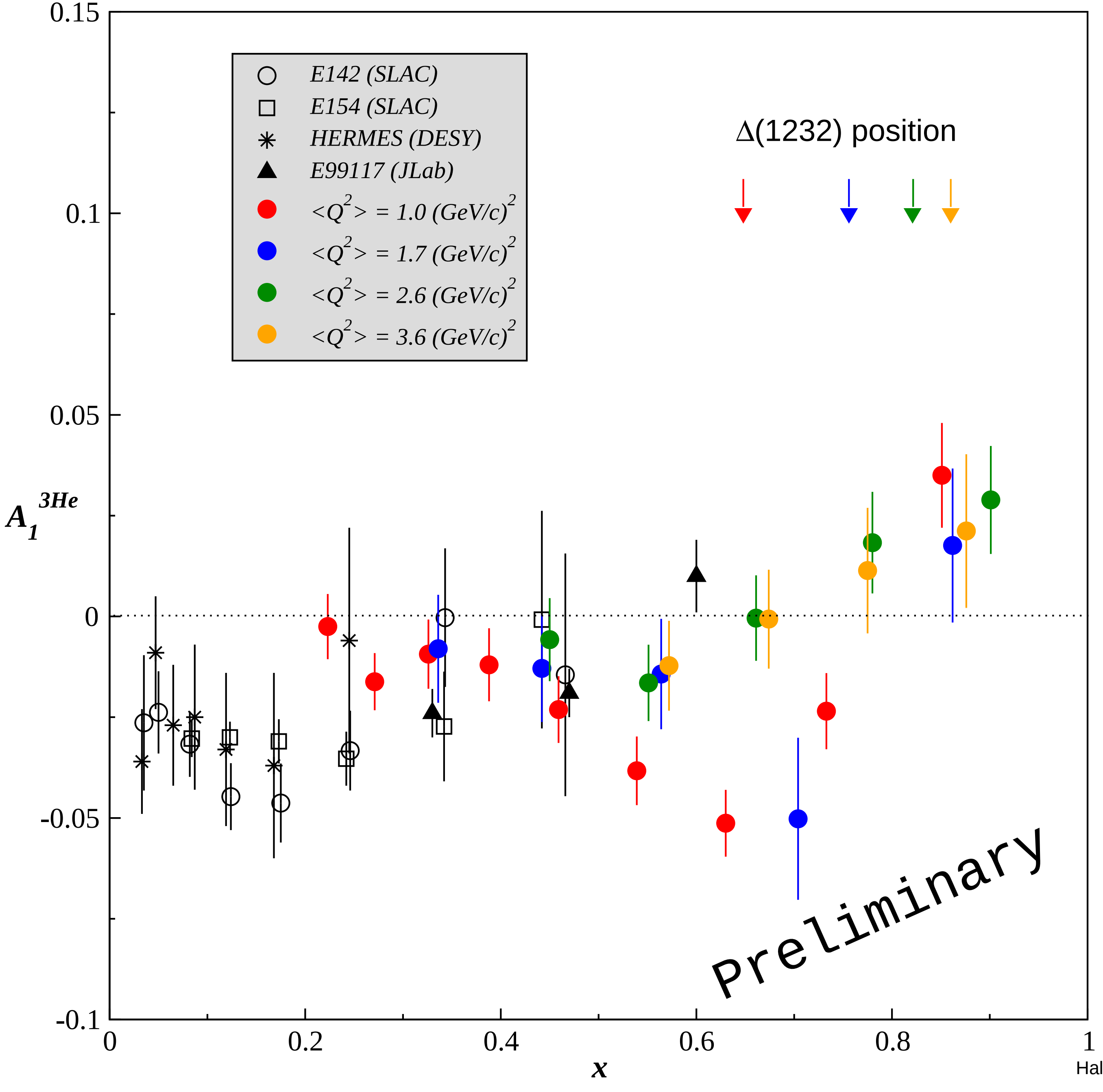
Spin asymmetry A_1



Spin asymmetry A_1



Spin asymmetry A_1



Still to do

- Finalize radiative corrections
- Neutron spin structure functions extraction from convolution approach
- Test of global and local spin duality on neutron and $^3\mathrm{He}$
- Extract moments of structure functions.
- Systematics errors