Neutron Spin Structure in the Resonance Region

and

Quark-Hadron Duality

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HUGS
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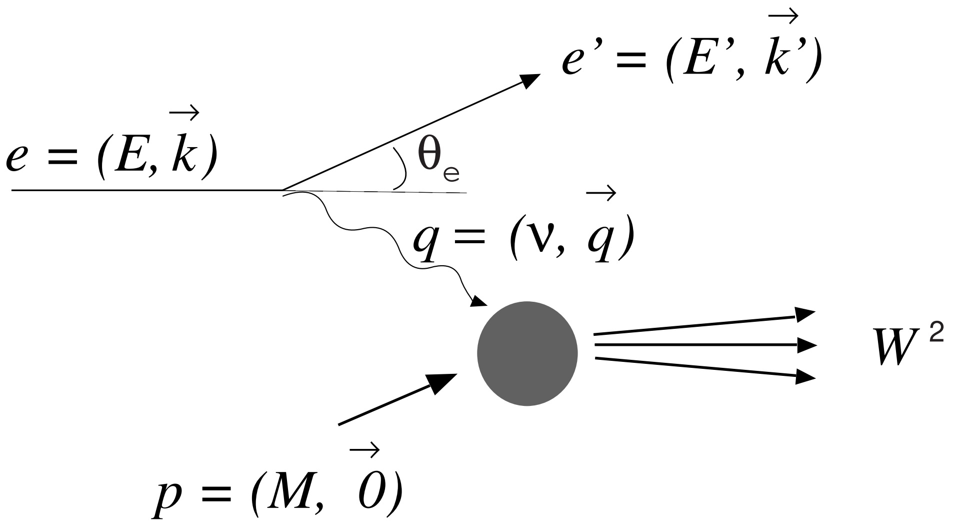
Inclusive Electron Scattering



- 4-momentum transfer of the virtual photon:

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

- Invariant mass squared:

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

- Bjorken variable:

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

Structure Functions

Unpolarized case:

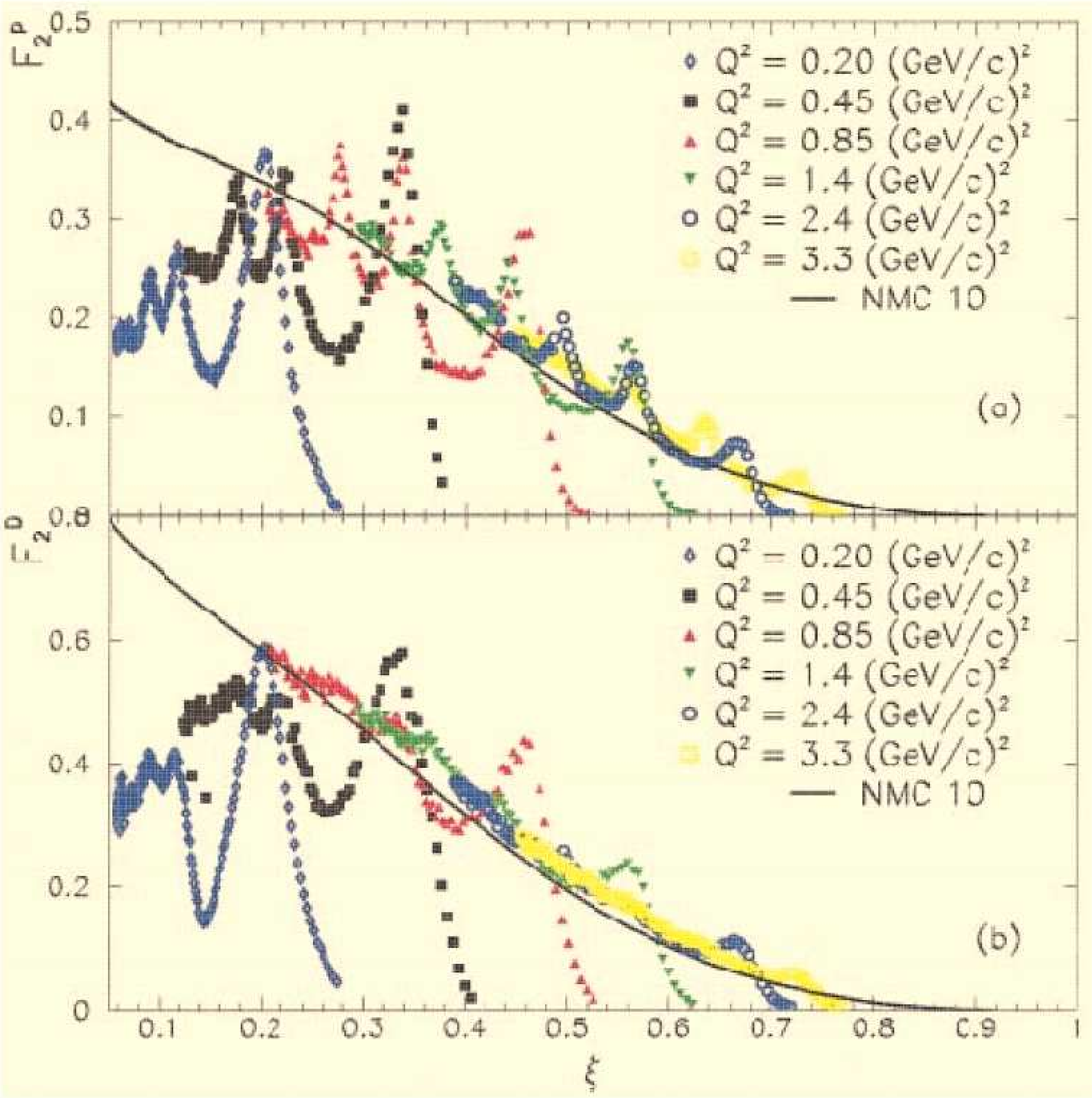
$$\frac{d^2\sigma}{d\Omega dE'} = \sigma_{Mott}\left[\frac{1}{\nu}F_2(x,Q^2) + \frac{2}{M}F_1(x,Q^2)\tan^2\frac{\theta}{2}\right]$$

Polarized case:

$$\frac{d^2\sigma_{\uparrow\Uparrow}}{d\Omega dE'} - \frac{d^2\sigma_{\uparrow\Downarrow}}{d\Omega dE'} = \frac{4\alpha^2 E'}{\nu E Q^2}\left[(E + E'\cos\theta)g_1(x,Q^2) - 2Mx g_2(x,Q^2)\right]$$

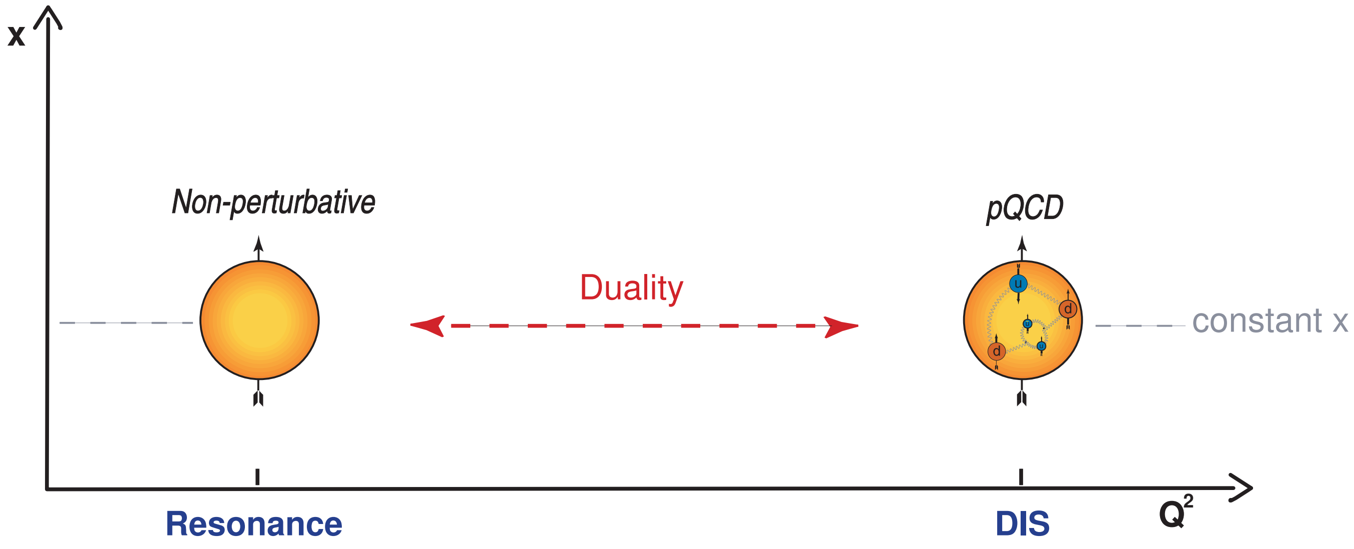
$$\frac{d^2\sigma_{\uparrow\Rightarrow}}{d\Omega dE'} - \frac{d^2\sigma_{\uparrow\Leftarrow}}{d\Omega dE'} = \frac{4\alpha^2 E'}{\nu E Q^2}\sin\theta\left[g_1(x,Q^2) + \frac{2ME}{\nu}g_2(x,Q^2)\right]$$

Hall C results for the unpolarized structure function F_2



→ Resonances average to DIS scaling curve.

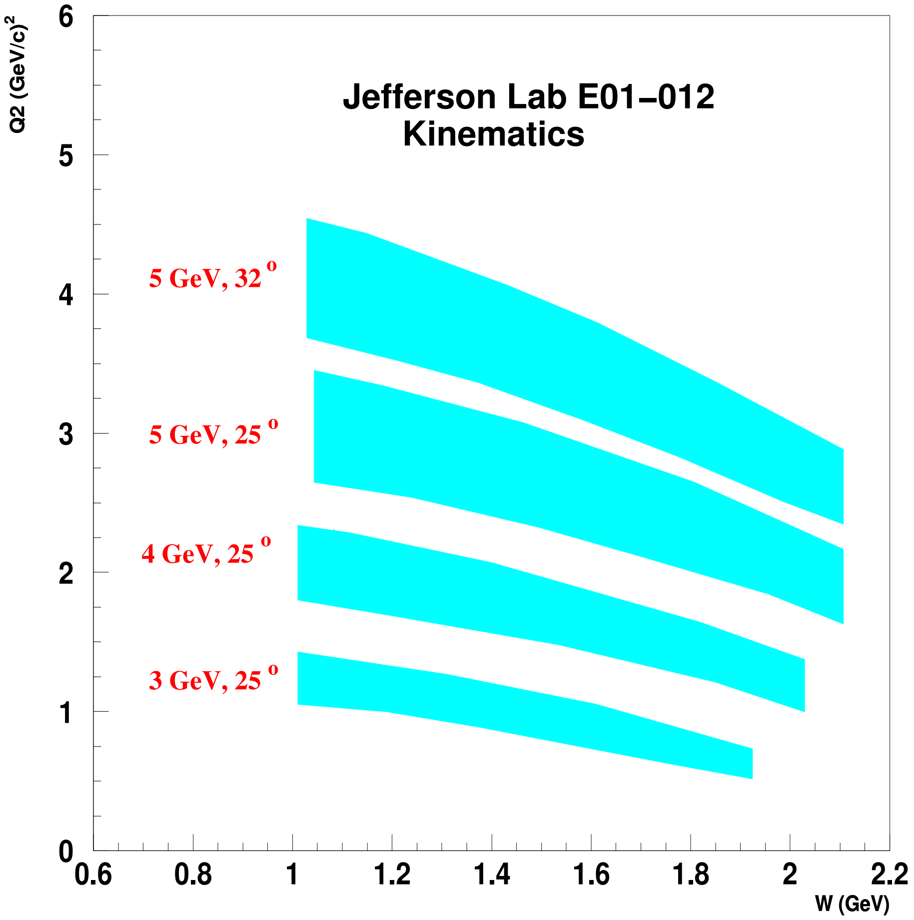
Quark-Hadron Duality



In the OPE, QCD moments of the structure functions are organized in powers of $1/Q^2$:

- $\rightarrow$ leading terms: scaling of the structure functions due to free quark scattering.
- $\rightarrow$ higher twist terms: interations between quarks and gluons $\Rightarrow$ confinement dynamics.

The E01-012 experiment

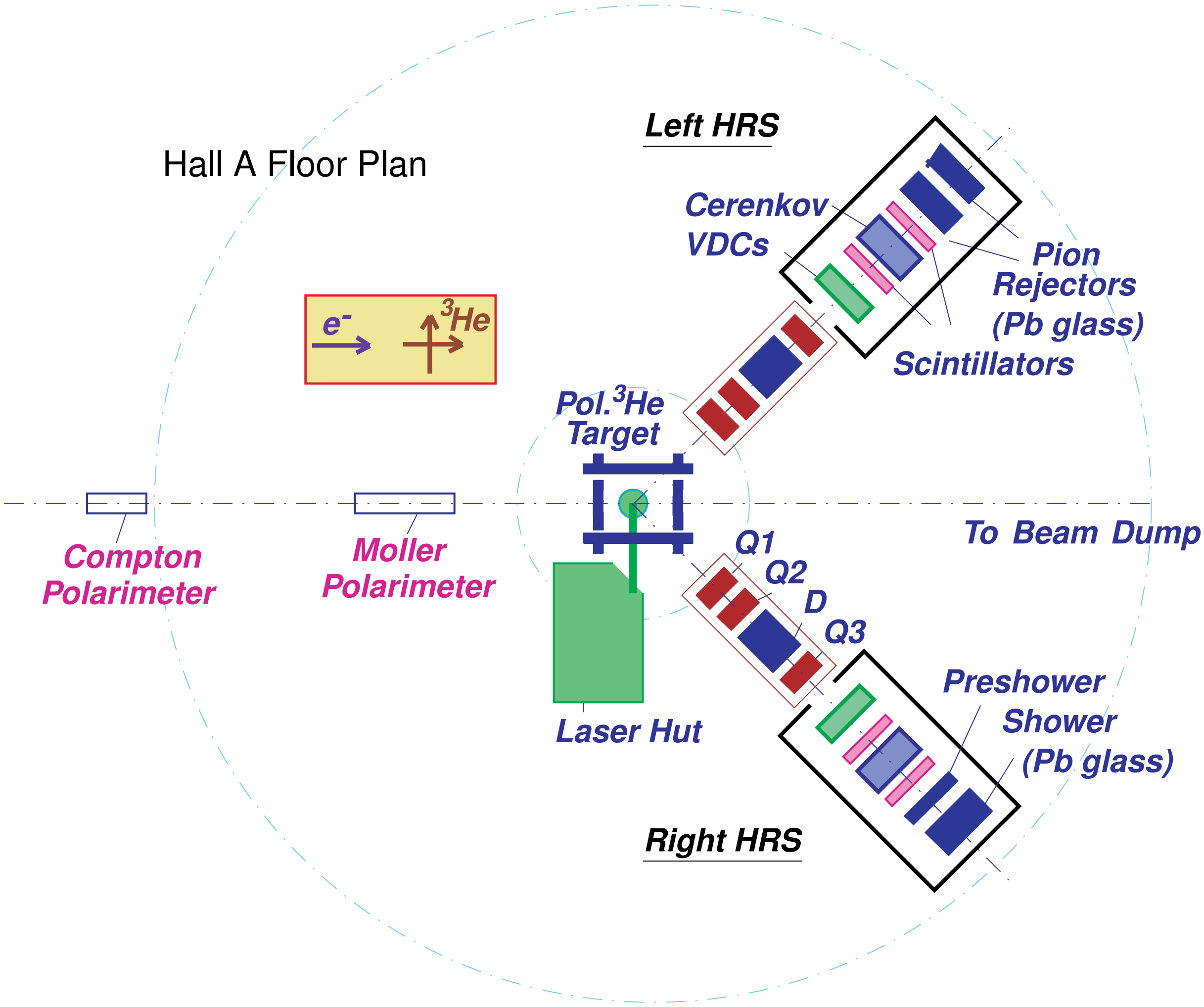


- → Ran successfully in January-February 2003.
- → Kinematic coverage from $1 < Q^2 < 3.2$ $(\mathrm{GeV/c})^2$ and cover all the resonance region.
- → Measurement of g_1^n and A_1^n with polarized ^{3}He target.
- → Overlap with E94-010 data that measured g_1^n at $Q^2 < 1.0$.
- → Will be compared with DIS data up to $x = 0.6$ where data already exist.

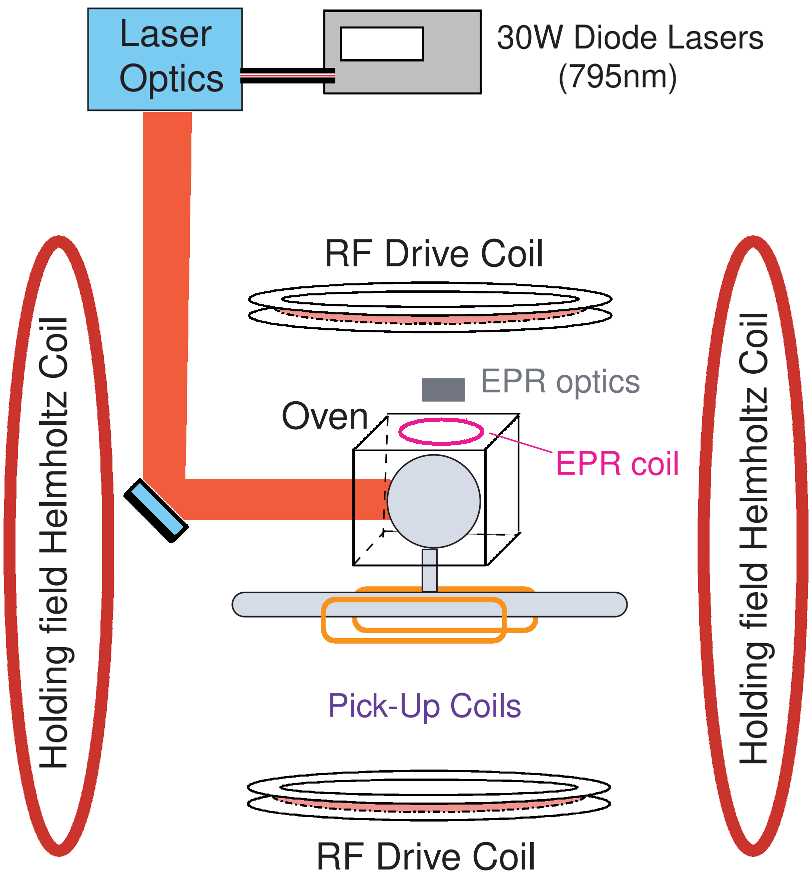
The Experimental Setup

- Jefferson Lab polarized electron beam

- Hall A High Resolution Spectrometers



The Polarized ^{3}He Target System



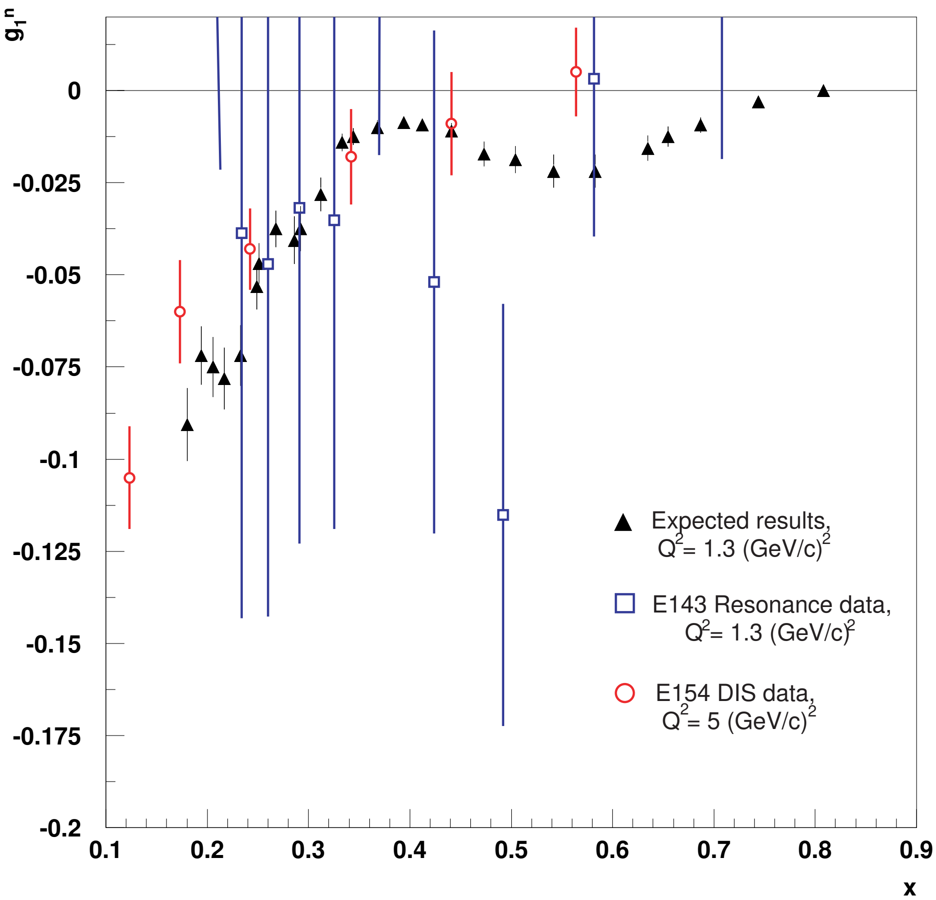
→ Highest polarized luminosity: 10^{36} s^{-1} cm^{-2}

→ 40 cm long, density $\sim$ 10 atm. Polarization in beam about 35%

→ Longitudinal and transverse orientations

→ Two independent polarimetries: NMR and EPR

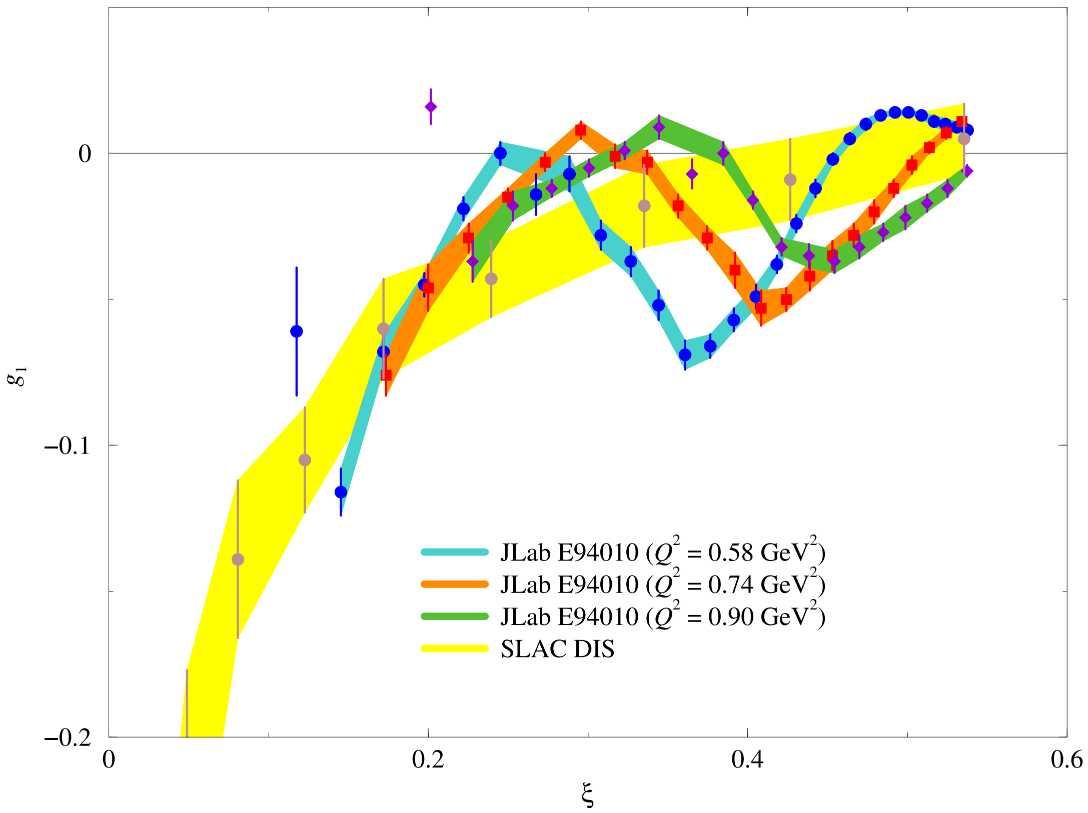
E01-012 expected results



→ We measured g_1 at eight Q^2 settings.

→ Our data are expected to be an order of magnitude better than previous data.

Hint of Duality in Spin Structure Function g_1^n



→ E94-010: high precision measurement of g_1^n in the resonance region to get GDH integral.

→ g_1^n plotted as a function of Nachtmann scaling variable:

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

Outlook

- → Experiment is completed and analysis is in progress.
- → E01-012 data combined with proton data will be a test of spin-flavor dependence of duality.
- → Results from E94-010 show a hint of Quark-Hadron Duality.
- → Quark-Hadron Duality, if observed, can be a powerful tool to study high x behavior.
- → Quark-Hadron Duality might help us understand the confinement of quarks in protons and neutrons.