The Spin Structure Function g_2(x,Q^2) and Tests of Sum Rules From SLAC E155X

Paul DePietro

American University
Representing the E155X Collaboration

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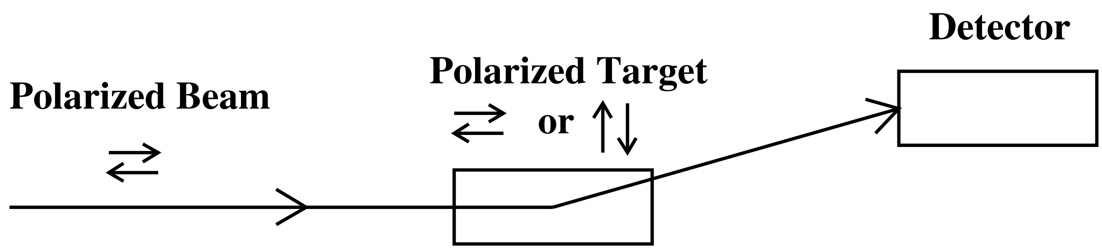
- Experimental Setup
- Spin Structure Function g_2
- Twist-3 Matrix Element d_2
- Sum Rules
- Results

Polarized Deep Inelastic Scattering



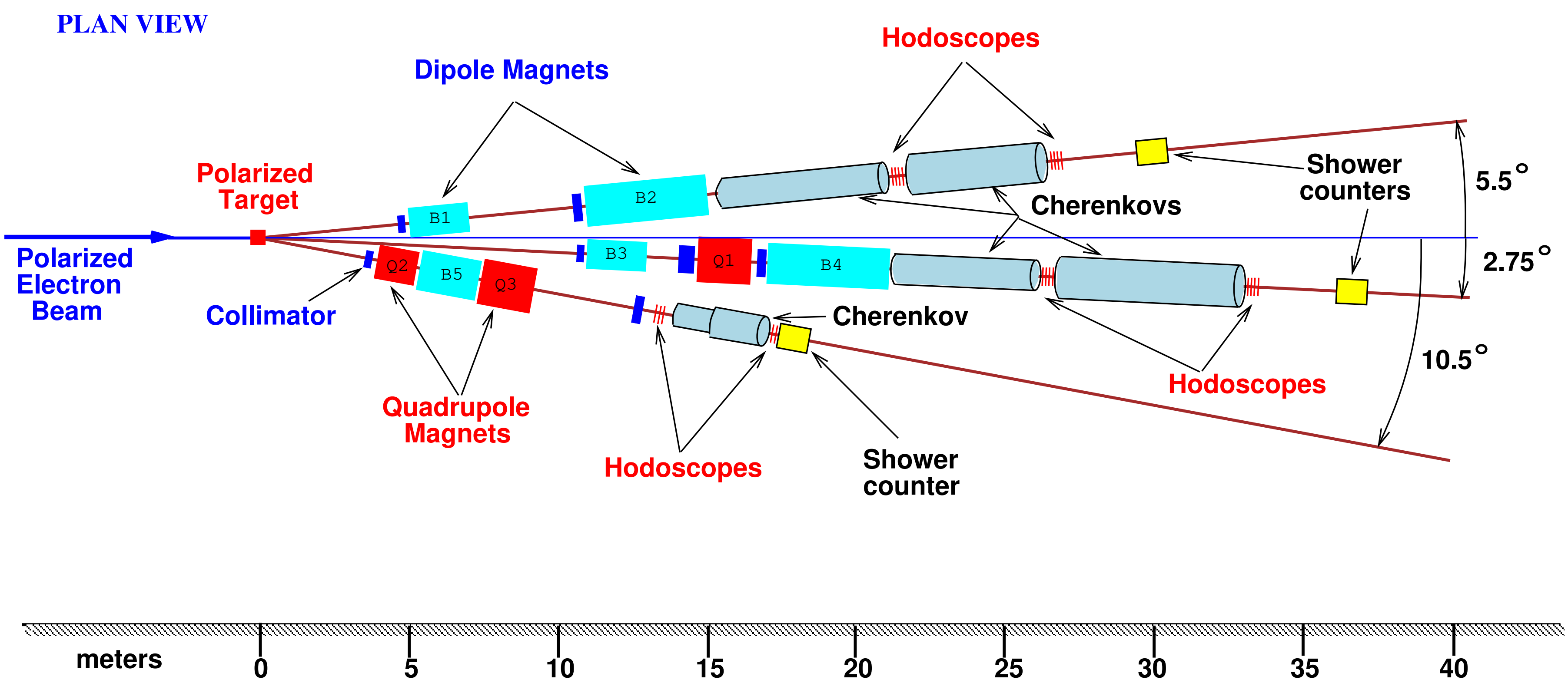
$$A_\perp = \frac{\sigma^{\downarrow\leftarrow} - \sigma^{\uparrow\leftarrow}}{\sigma^{\downarrow\leftarrow} + \sigma^{\uparrow\leftarrow}} = f_k E' \sin(\theta)\left[g_1(x,Q^2) + \frac{2E}{\nu} g_2(x,Q^2)\right]$$

- $Q^2 = 4E_oE'sin^2(\frac{\theta}{2})$: 4-momentum transfer
- $x = \frac{Q^2}{2M\nu}$: Bjorken scaling variable
- f_k includes contribution from kinematics and unpolarized structure functions
- g_1 and g_2 are the polarized structure functions.

$\rightarrow$ $A_\perp$ is more sensitive to g_2

Use measured $A_\perp$ and E155 g_1 fit to determine g_2

E155/E155X Spectrometers



$g_2(x, Q^2)$ **Structure Function**

- Wandzura-Wilczek g_2 expression (twist-2 only)

$$g_2^{WW}(x, Q^2) = -g_1(x, Q^2) + \int_x^1 \frac{dy}{y} g_1(y, Q^2)$$

- In general there are additional contributions.

$$g_2(x, Q^2) = \overbrace{g_2^{WW}(x, Q^2)}^{\text{twist-2}} - \int_x^1 \frac{\partial}{\partial y}\left(\overbrace{\frac{m}{M} h_T(y, Q^2)}^{\text{twist-2}} + \overbrace{\xi(y, Q^2)}^{\text{twist-3}}\right)\frac{dy}{y}$$

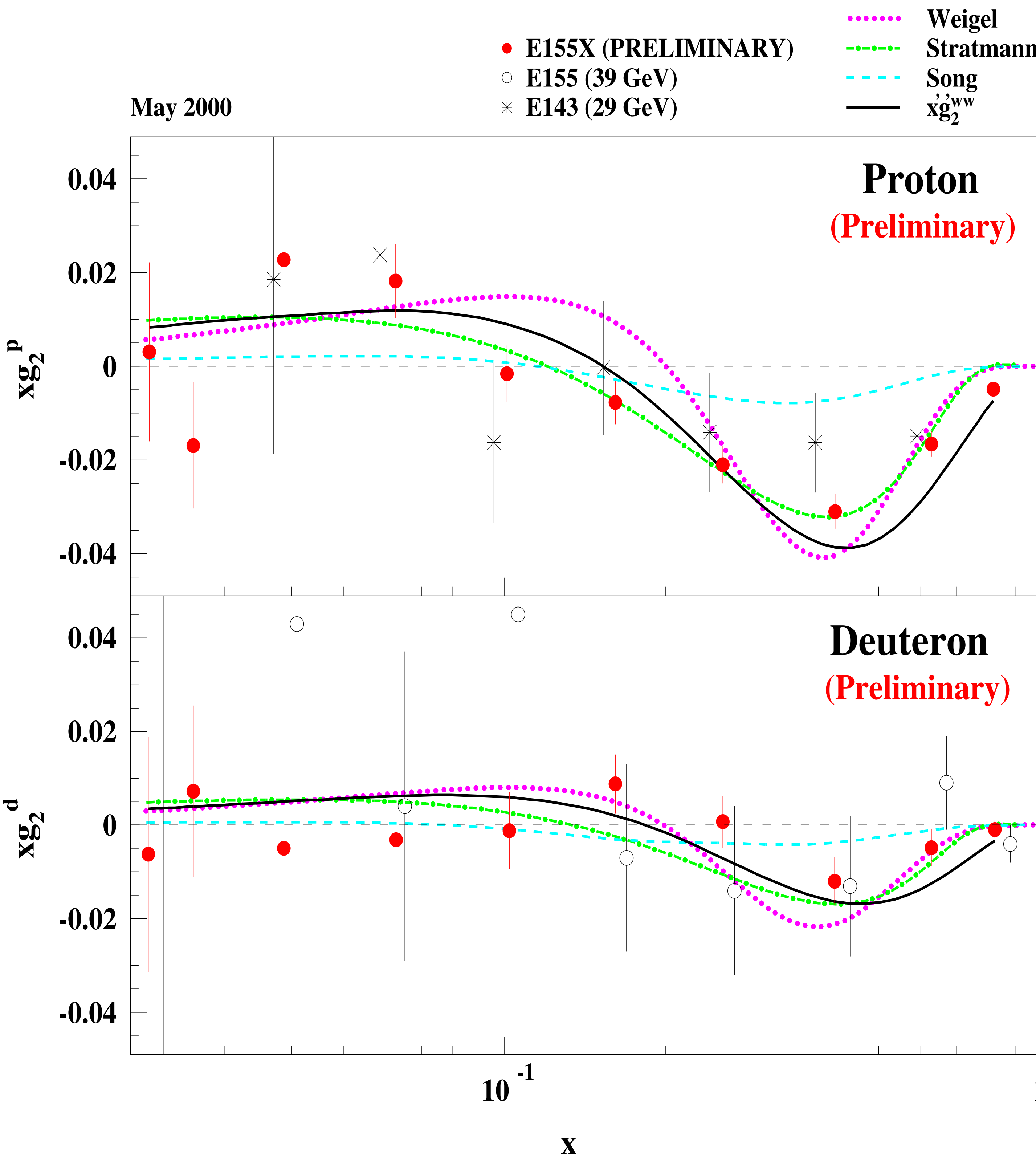
$$= g_2^{WW}(x, Q^2) + \overline{g_2}(x, Q^2)$$

- $\overline{g_2}$ includes quark-gluon correlations (ξ) inside the nucleon

- Twist-2 term (quark transverse spin distribution h_T) in $\overline{g_2}$ suppressed by $\frac{m}{M} << 1$

- By measuring g_2 precisely we can extract twist-3 matrix elements.

Preliminary Results for Q^2-averaged xg_2



Operator Product Expansion (OPE) For g_1 and g_2

OPE used in QCD to separate the physics into a perturbative piece (easily treated) and a non-perturbative piece (unknown matrix elements).

$$\Gamma_1^{(n)} = \int_0^1 x^n g_1(x,Q^2)dx = \frac{a_n}{2}, \quad n = 0, 2, 4, \ldots$$

$$\Gamma_2^{(n)} = \int_0^1 x^n g_2(x,Q^2)dx = \frac{1}{2}\frac{n}{n+1}(d_n - a_n)$$

n=2,4,...

a_n are the twist-2 and d_n are the twist-3 matrix elements.

$$d_2 = \int_0^1 x^2[2g_1(x,Q^2) + 3g_2(x,Q^2)]dx$$

$$= 3\int_0^1 x^2 \overline{g_2}(x,Q^2)dx$$

For twist-2 only: $d_2 = 0$

Sum Rules

Burkhardt-Cottingham

$$\int_0^1 g_2(x)dx = 0$$

- Derived from virtual Compton scattering dispersion relations, not OPE
- May diverge at low x if $g_2 \rightarrow \frac{1}{x^2}$ as $x \rightarrow 0$

Efremov-Leader-Teryaev

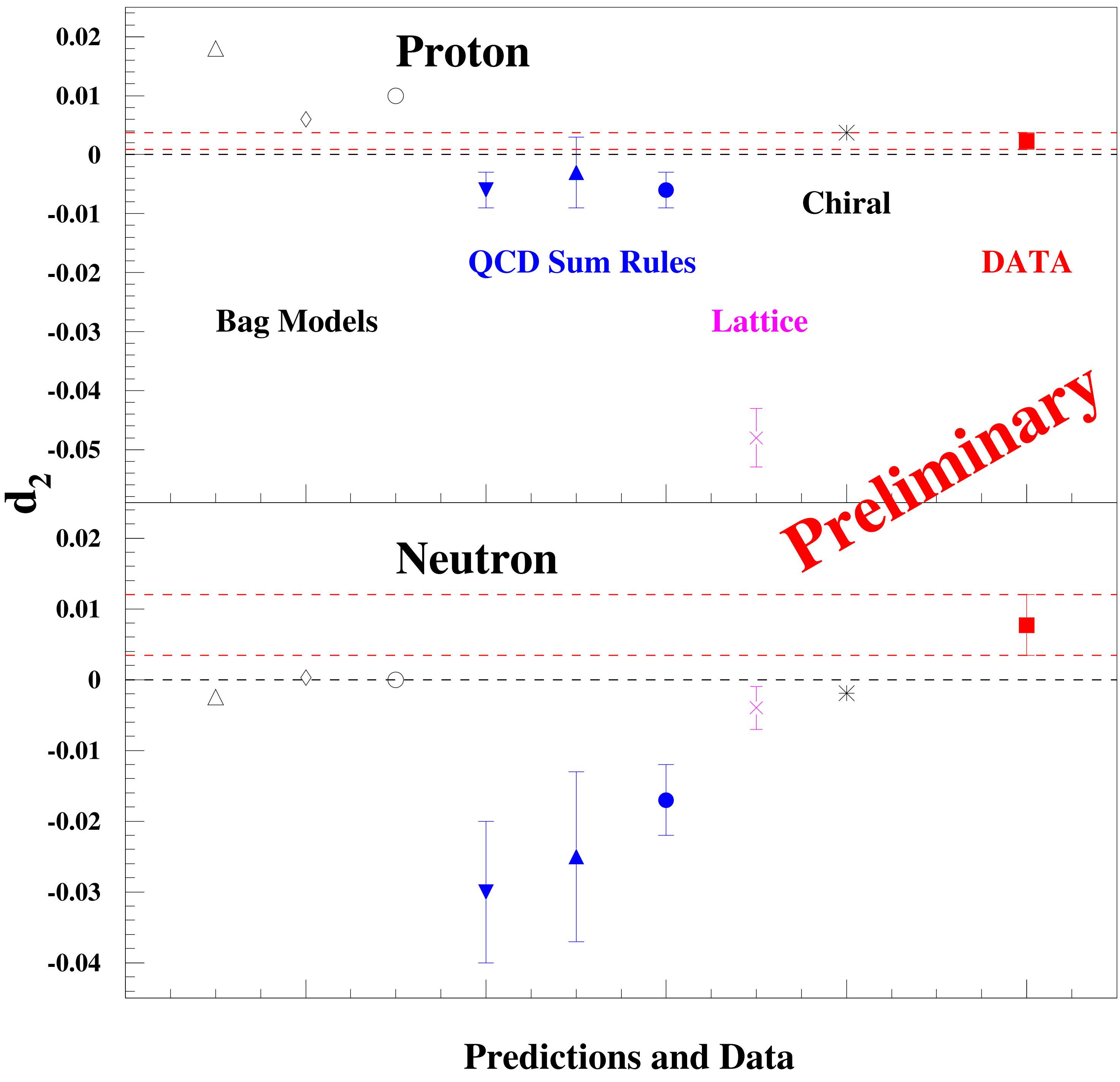
$$\int_0^1 x[g_1^V(x) + 2g_2^V(x)]dx = 0$$

- g_1^V and g_2^V are the valence contribution to g_1 and g_2
- If sea quarks are equal in proton and neutron $\Rightarrow$

$$\int_0^1 x[g_1^p(x)+2g_2^p(x)-g_1^n(x)-2g_2^n(x)]dx = 0$$

The Twist-3 d_2 Matrix Element

$$d_2 = 3\int_0^1 x^2[g_2(x,Q^2) - g_2^{WW}(x,Q^2)]dx$$



Sum Rules

Burkhardt-Cottingham

$$\int_0^1 g_2(x)dx = 0$$

	p	d
E155X Experiment:	0.006 ± 0.019	-0.013 ± 0.023
Average:	-0.001 ± 0.015	-0.006 ± 0.020

Average is taken from SLAC E143, E155, and E155X experiments

Efremov-Leader-Teryaev

$$\int_0^1 x[g_1^V(x) + 2g_2^V(x)]dx = 0$$

Average: -0.0040 ± 0.0082

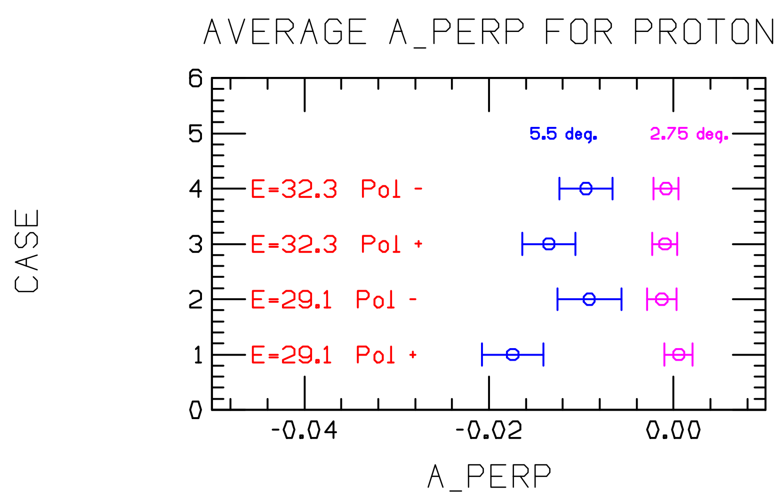
All results at Q^2=3 and $0.02 \le x \le 0.9$

Summary

- E155X uncertainties small enough to distinguish between g_2^{ww} and zero
- Analysis in progress.
- Rough agreement seen with g_2^{ww} model, bag model of Stratmann et. al.
- Twist-3 matrix element d_2 is small
- Integrals over our kinematic region ($0.02 \leq x \leq 0.9$) are consistent with BC and ELT sum rules

SYSTEMATIC CHECKS

- TARGET POLARIZATION ALIGNED (+) OR ANTI-ALIGNED (-) WITH B FIELD
- BEAM ENERGY CHANGED BY 3.2 GeV TO PRECESS SPIN BY π IN TRANSPORT LINE.
- CORRECT FOR EW ASYMMETRY (DEPENDS ONLY ON BEAM HELICITY)
- ANY REMAINING FALSE ASYMMETRIES (I.E. HELICITY-DEPENDENT BEAM POSITION) WOULD SHOW UP AS A DIFFERENCE IN AVERAGE $A_\perp$. NONE SEEN.



Q^2 DEPENDENCE

- d_2 depends logarithmically on Q^2.
- All the Integrals are at FIXED Q^2 whilst the Measurements have Q^2 and x correlated.
- For g_1 integrals, we have 'evolved' to fixed Q^2 using Q^2 dependent fits to g_1/F_1
- For g_2 we use:

  $$g_2(x, Q^2) = g_2^{WW}(x, Q^2) + \overline{g_2}(x, Q^2)$$

  and ASSUME that the Q^2 dependence of $\overline{g_2}(x, Q^2)$ is negligible.
- To calculate g_2^{WW} we utilize a global Q^2 dependent fit to A_1.

E155/E155X Spectrometers