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... for a brighter future

E01-012: Spin Duality Status report

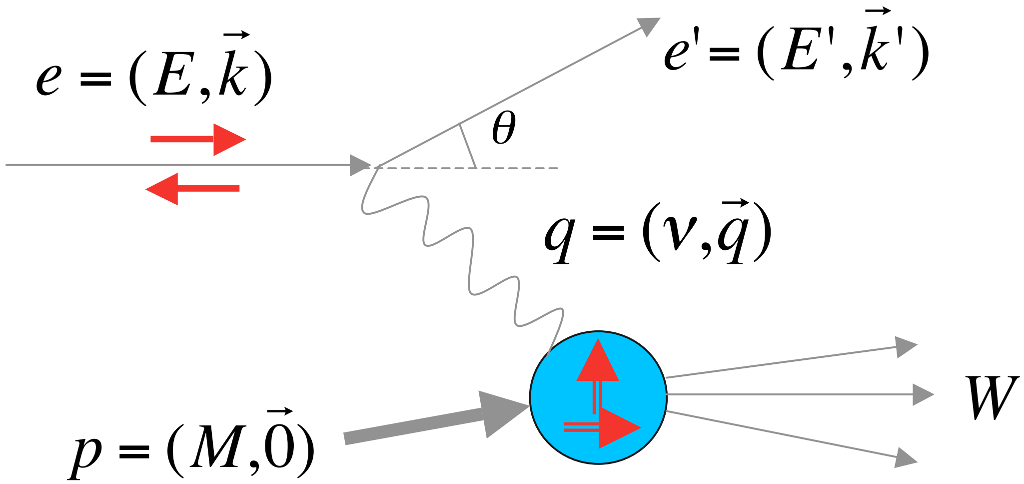
Patricia Solvignon

Argonne National Laboratory

For E01-012 collaboration

Hall A collaboration meeting
December 12-14, 2007

Inclusive electron scattering



<u>4-momentum transfer squared</u>

$$Q^2 = -q^2 = 4EE'\sin^2\tfrac{\theta}{2}$$

<u>Invariant mass squared</u>

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

<u>Bjorken variable</u>

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

Unpolarized case

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

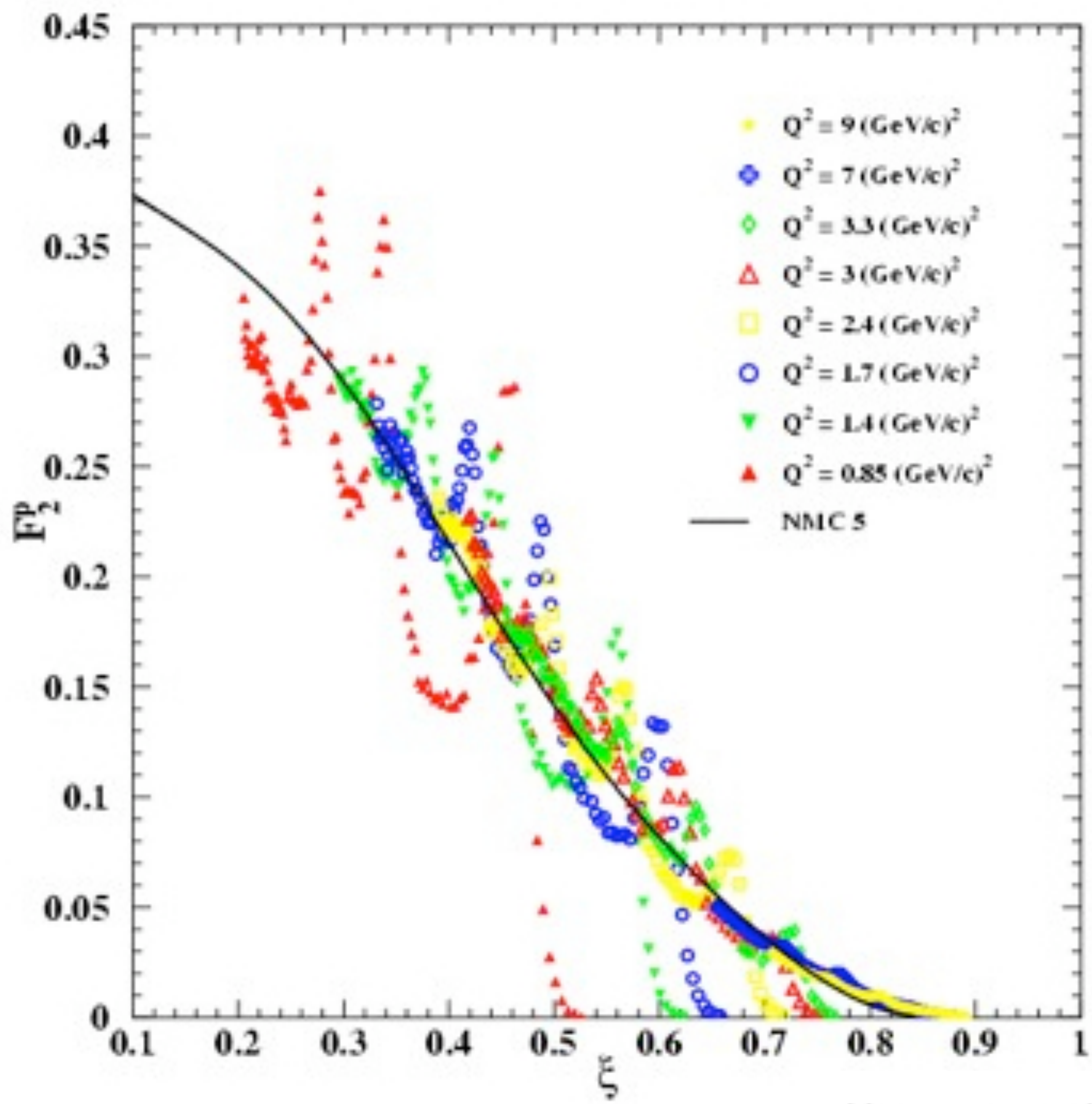
Polarized case

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

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

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
- Global and Local duality are observed for F_2

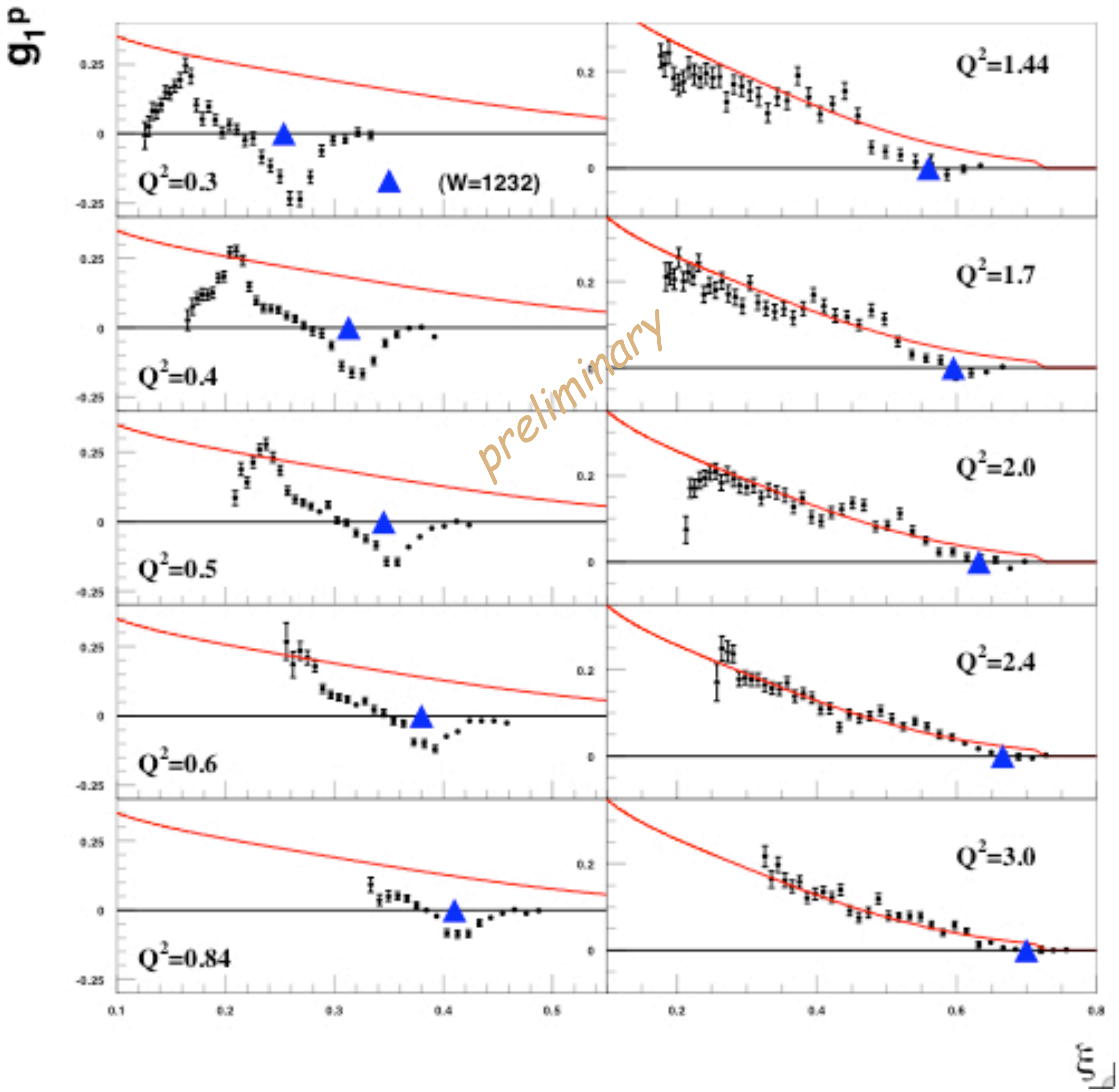


I. Niculescu et al., PRL 85 (2000) 1182

World data

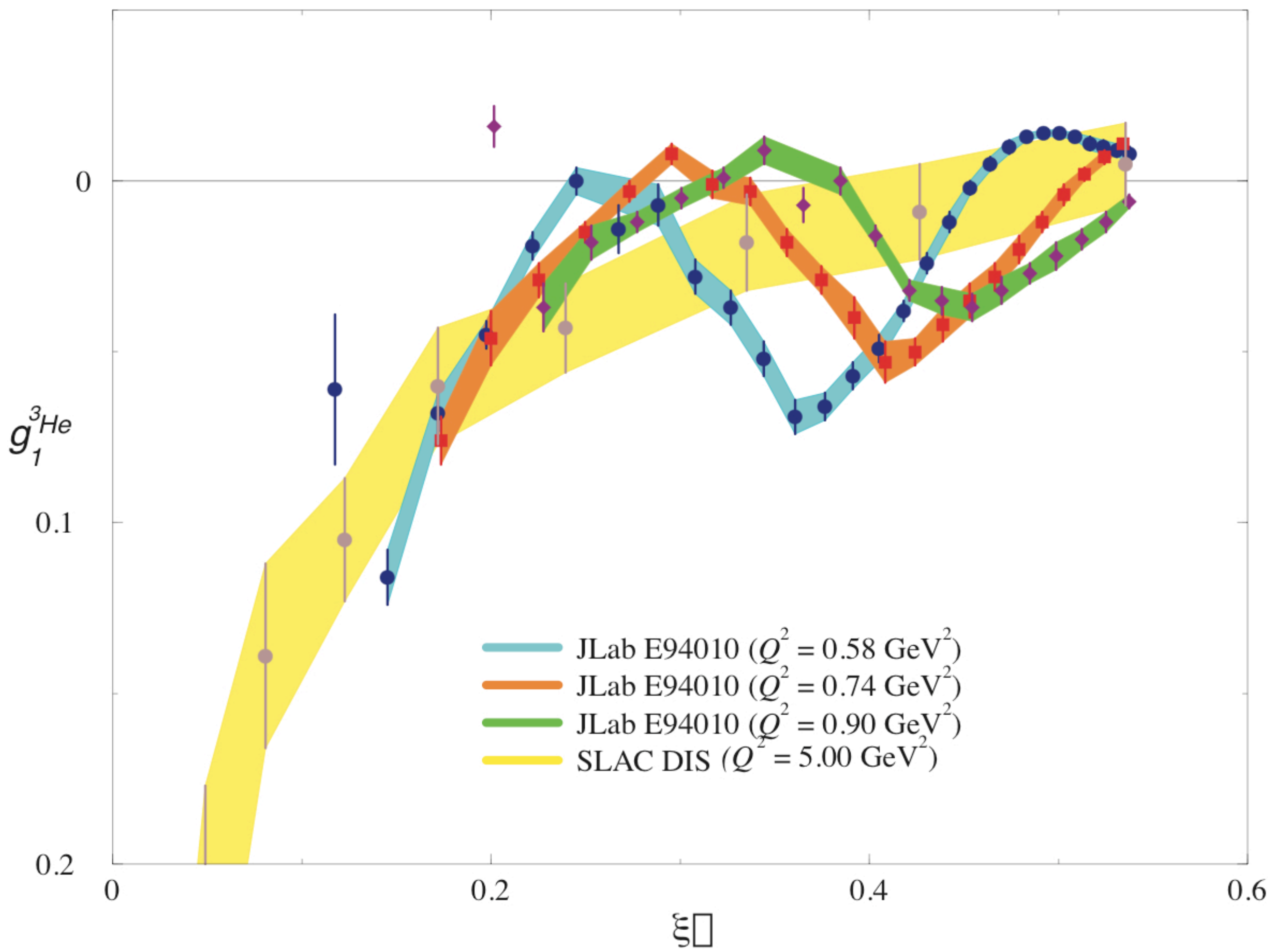
Jlab Hall B for g_1^p

From DIS 2005 proceedings



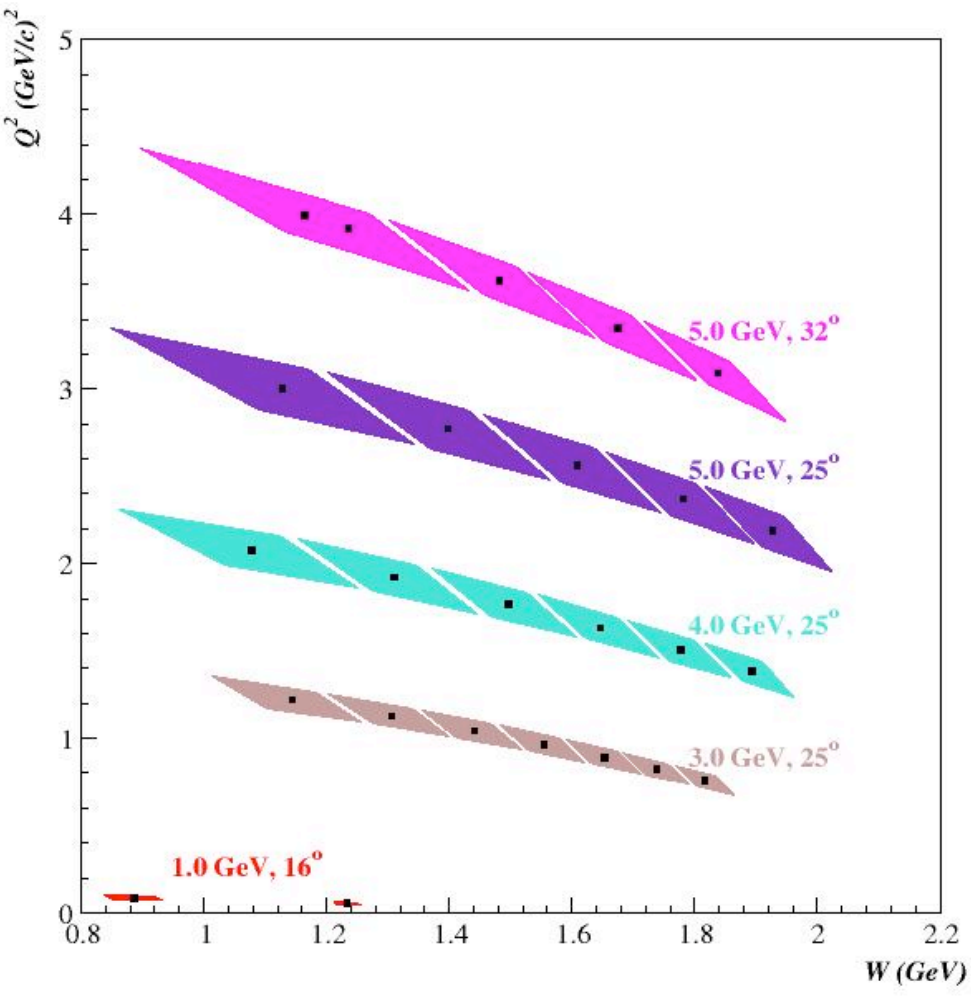
World data

Indication of duality from Jlab Hall A for g_1^{3He}



The experiment E01-012

- Ran in Jan.-Feb. 2003
- Inclusive experiment: $^3\vec{He}(\vec{e},e')X$
  - ➢ Polarized electron beam:
    $70 < P_{beam} < 85\%$
  - ➢ Hall A in standard equipment:
    - ↪ HRS in symmetric configuration
    - ↪ PID performance $\pi/e < 10^{-4}$
  - ➢ Pol. ^{3}He target (para and perp):
    $\langle P_{targ} \rangle = 37\%$
- Measured polarized cross section differences
- Form g_1 and g_2 for ^{3}He



↪ **Test of spin duality on the neutron (^{3}He)**

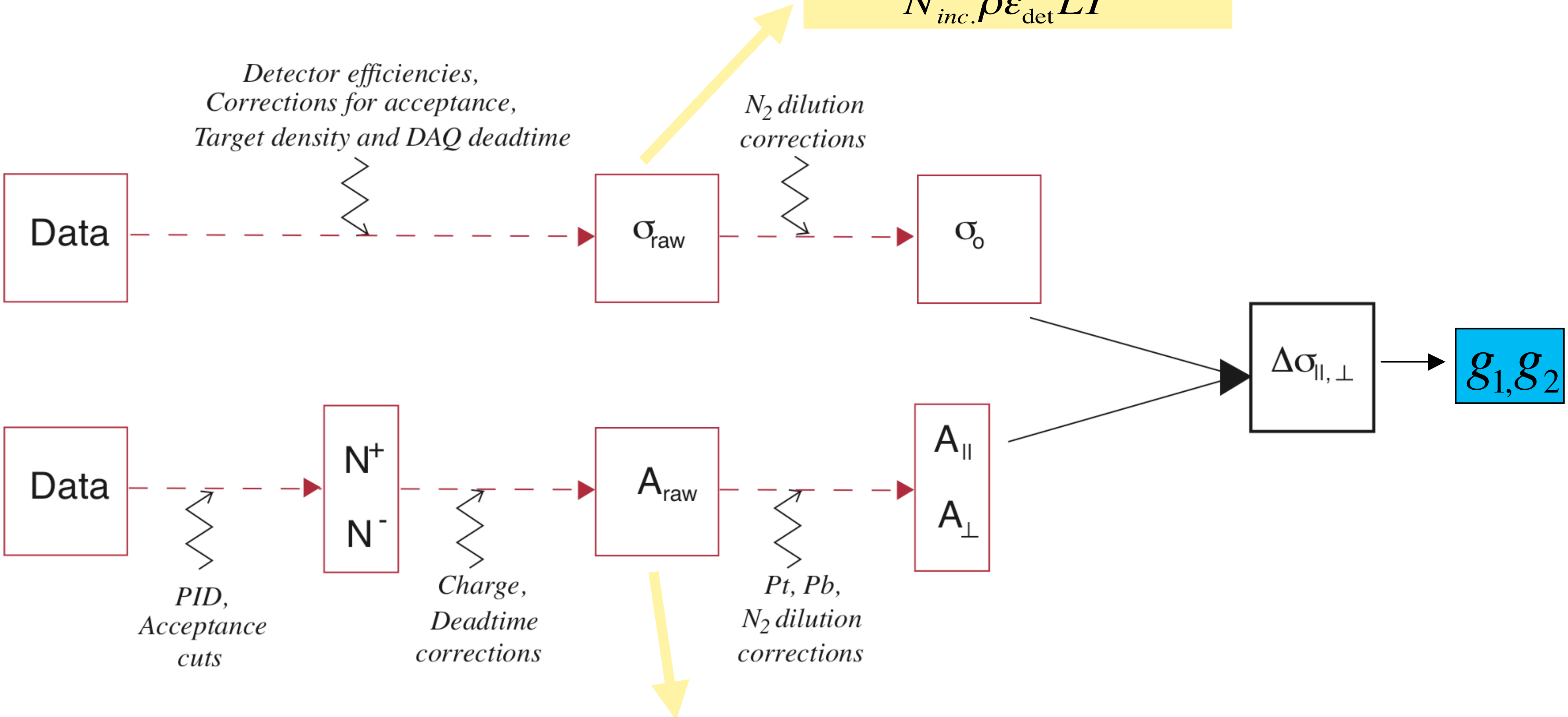
The E01-012 Collaboration

K. Aniol, T. Averett, W. Boeglin, A. Camsonne, G.D. Cates, G. Chang, J.-P. Chen, Seonho Choi, E. Chudakov, B. Craver, F. Cusanno, A. Deur, D. Dutta, R. Ent, R. Feuerbach, S. Frullani, H. Gao, F. Garibaldi, R. Gilman, C. Glashausser, O. Hansen, D. Higinbotham, H. Ibrahim, X. Jiang, M. Jones, A. Kelleher, J. Kelly, C. Keppel, W. Kim, W. Korsch,K. Kramer, G. Kumbartzki, J. LeRose, R. Lindgren, N. Liyanage, B. Ma, D. Margaziotis, P. Markowitz, K. McCormick, Z.-E. Meziani, R. Michaels, B. Moffit, P. Monaghan, C. Munoz Camacho, K. Paschke, B. Reitz, A. Saha, R. Sheyor, J. Singh, K. Slifer, P. Solvignon, V. Sulkosky, A. Tobias, G. Urciuoli, K. Wang, K. Wijesooriya, B. Wojtsekhowski, S. Woo, J.-C. Yang, X. Zheng, L. Zhu

and the Jefferson Lab Hall A Collaboration

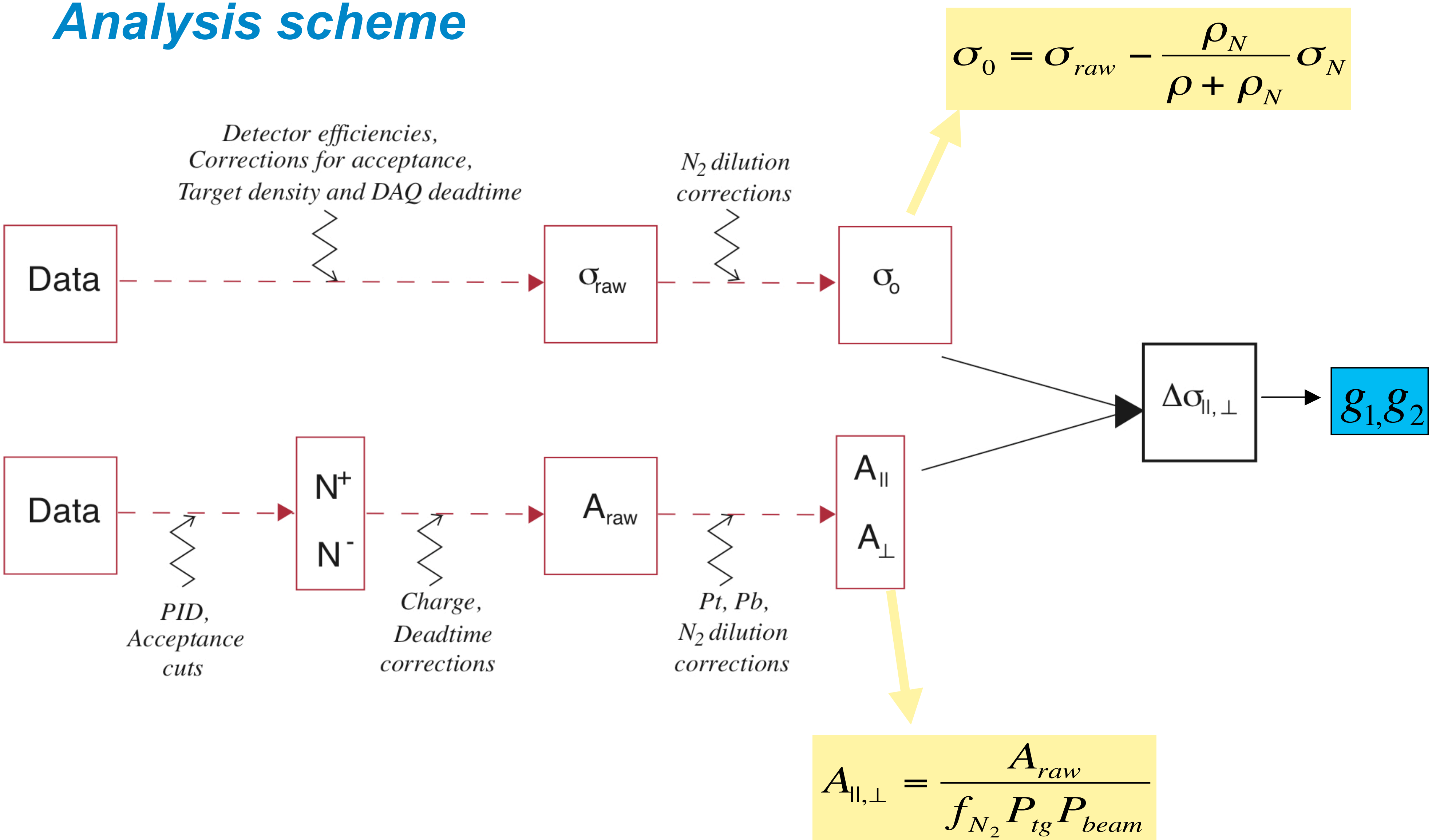
Analysis scheme

$$\sigma_0 = \frac{N_{cuts}}{N_{inc.}\rho\varepsilon_{det}LT} * Acc.$$

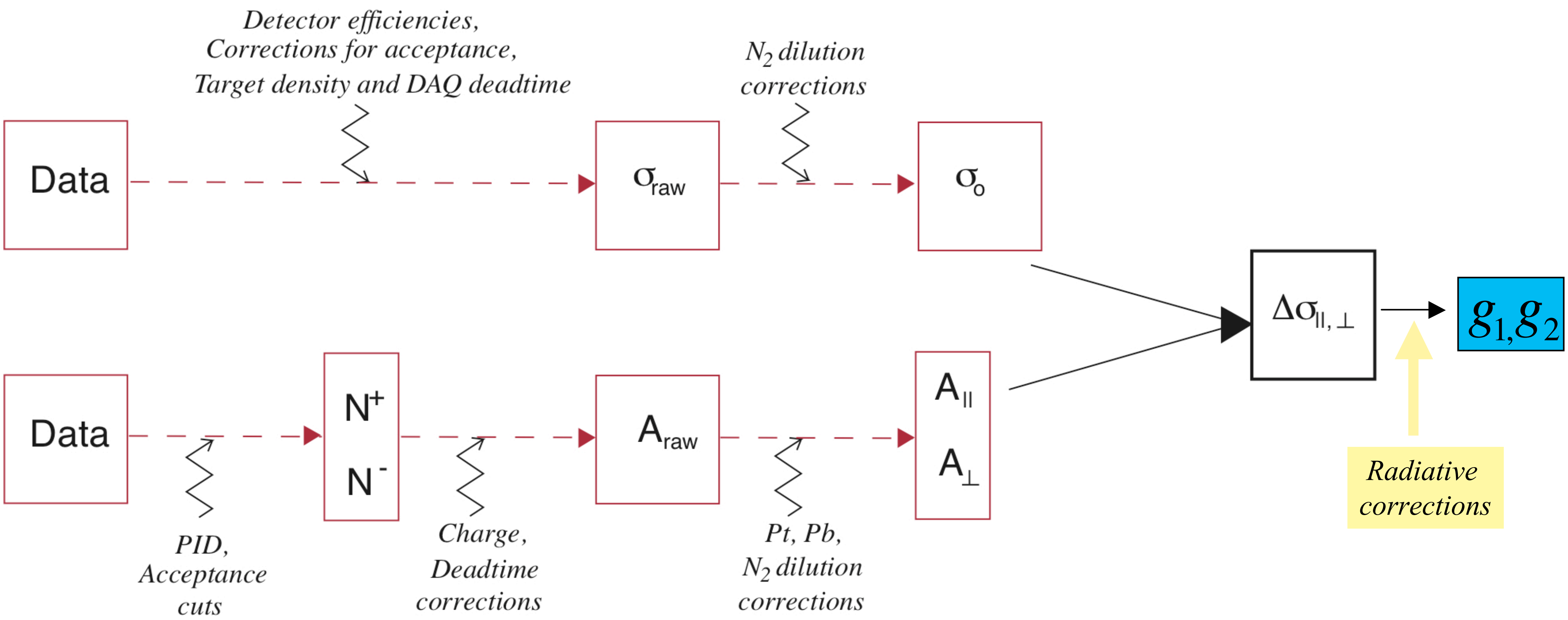


$$A_{\parallel,\perp} = \frac{\dfrac{N^+}{Q^+LT^+} - \dfrac{N^-}{Q^-LT^-}}{\dfrac{N^+}{Q^+LT^+} + \dfrac{N^-}{Q^-LT^-}}$$

Analysis scheme

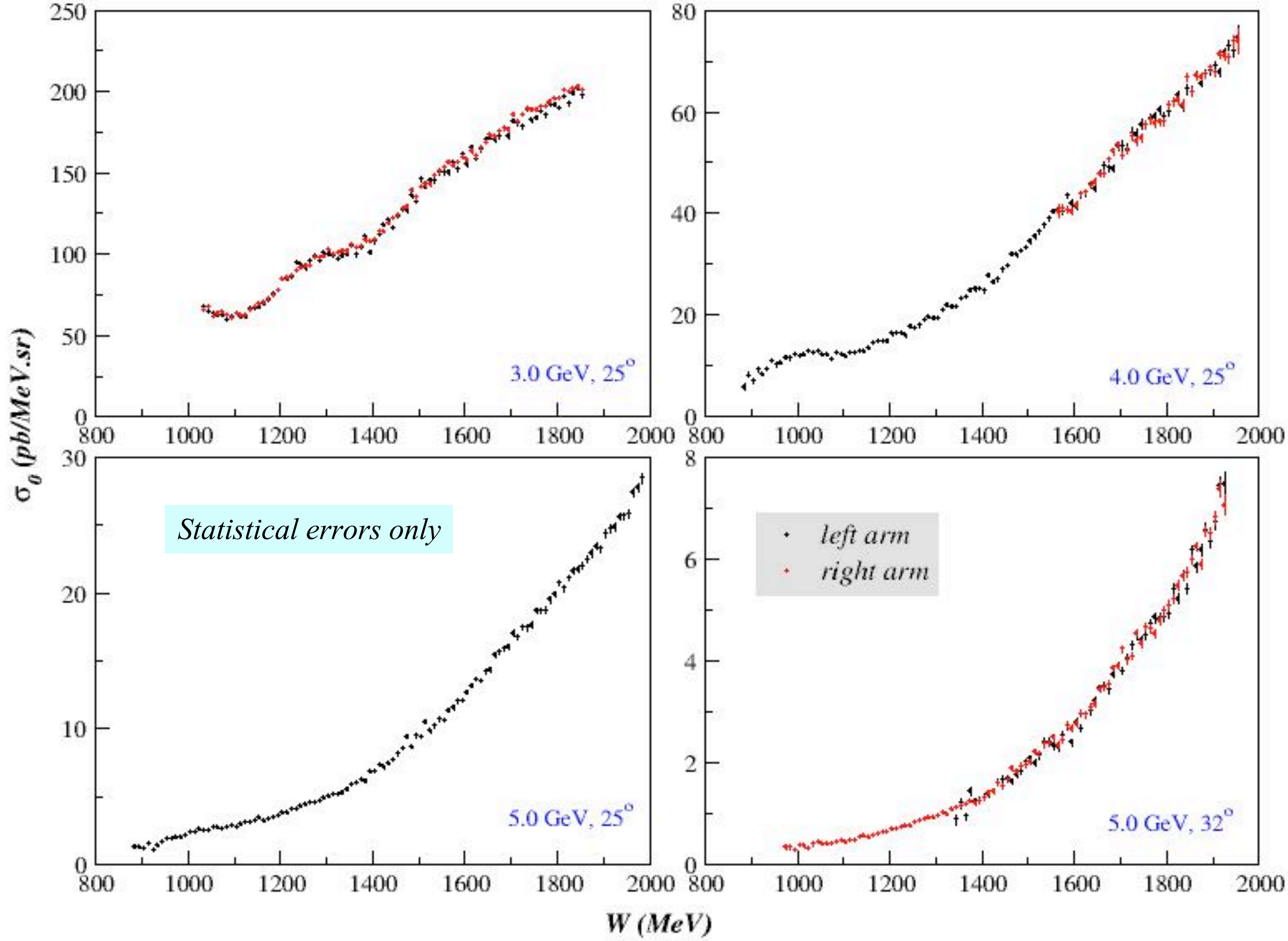


Analysis scheme

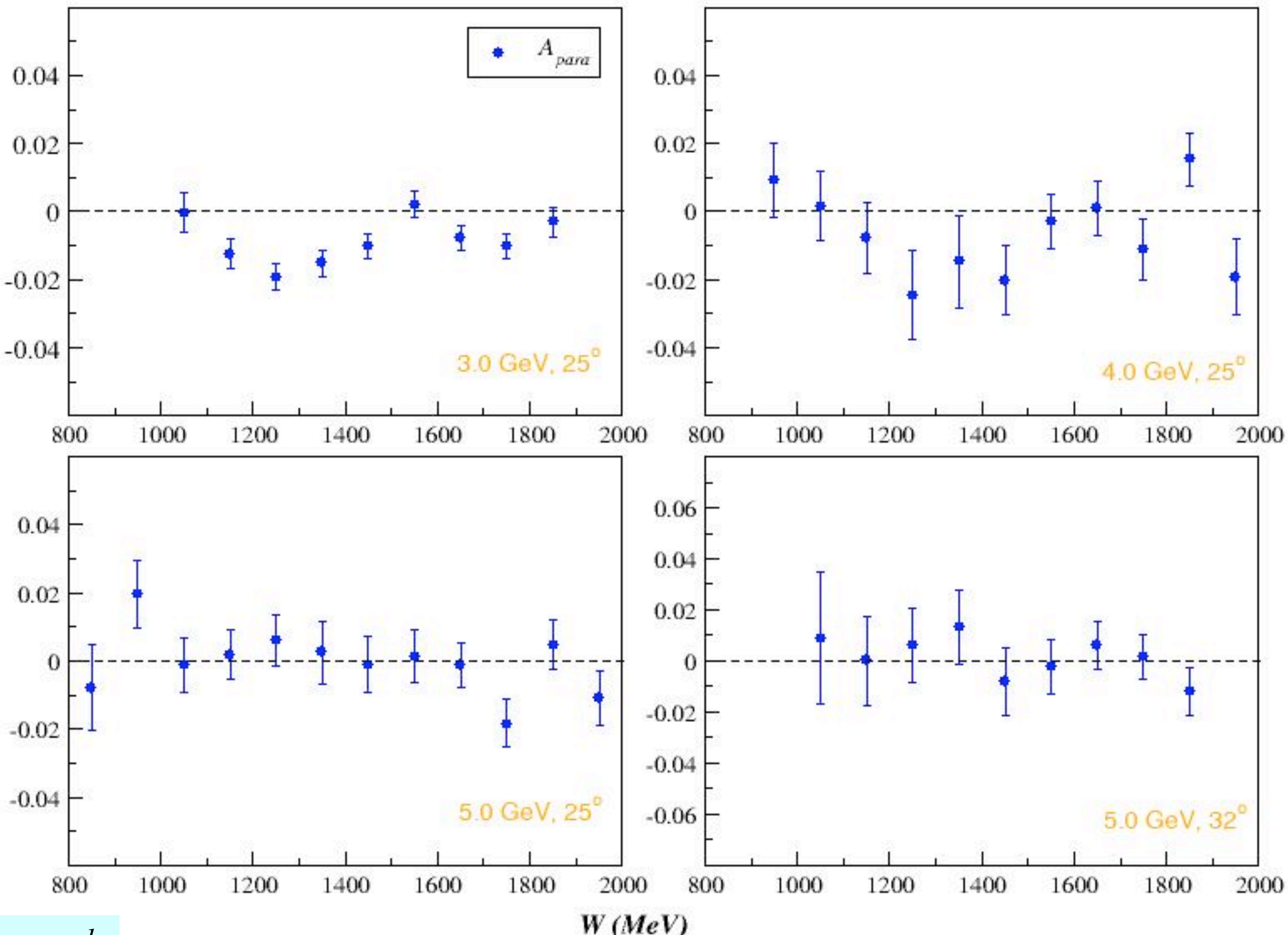


Unpolarized cross sections

Agreement between both HRS better than 2%

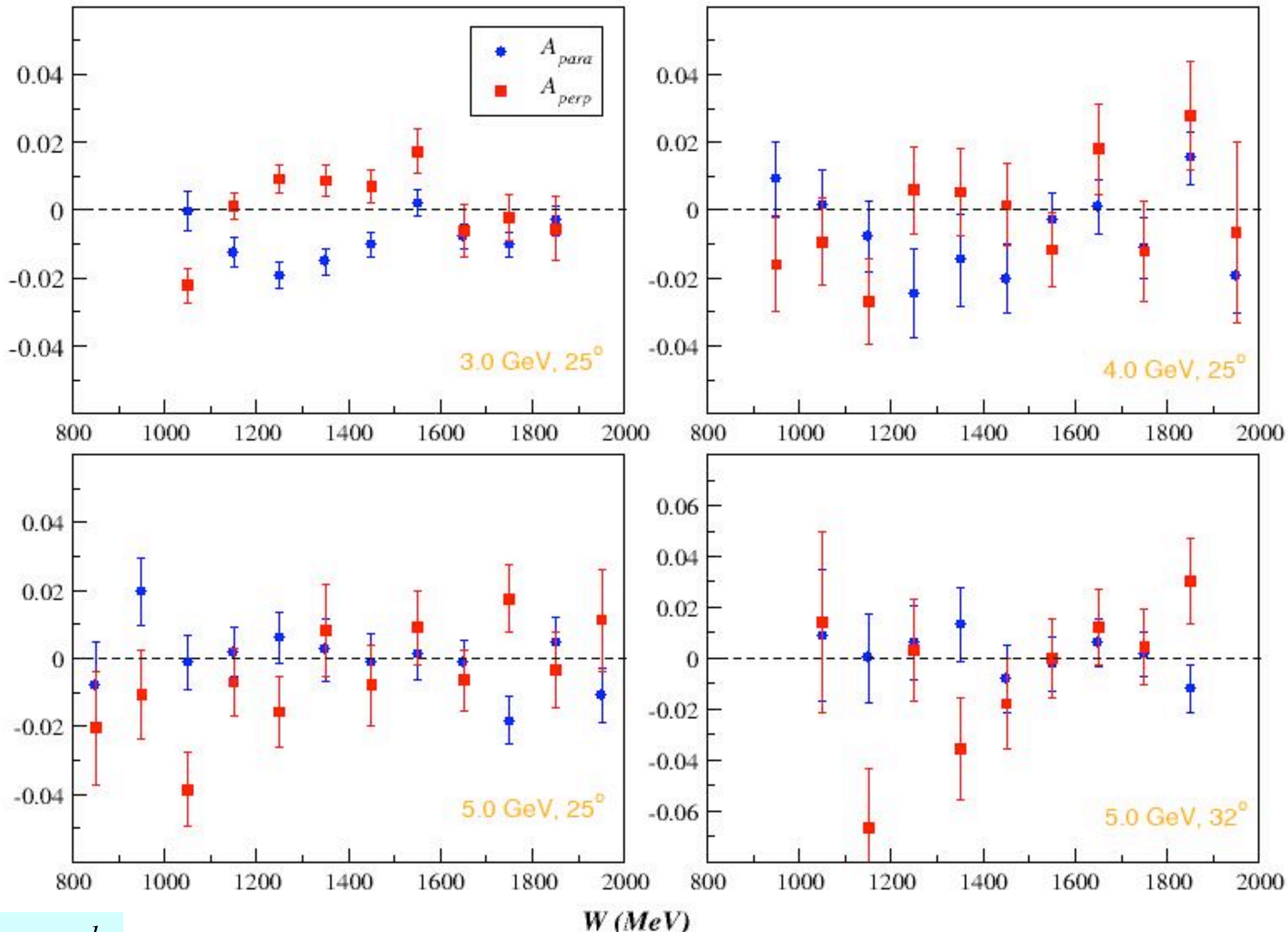


Asymmetries



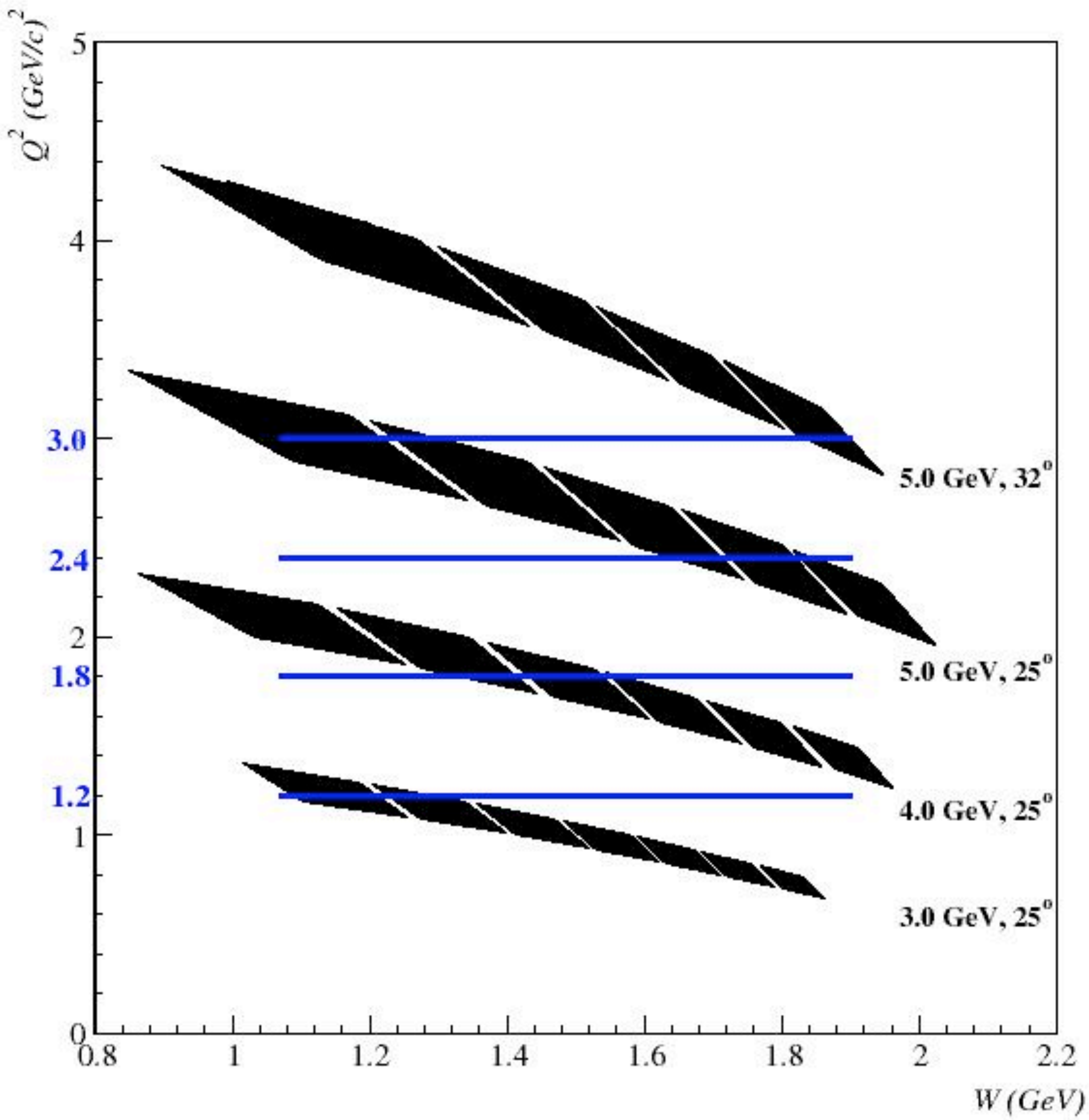
Statistical errors only

Asymmetries

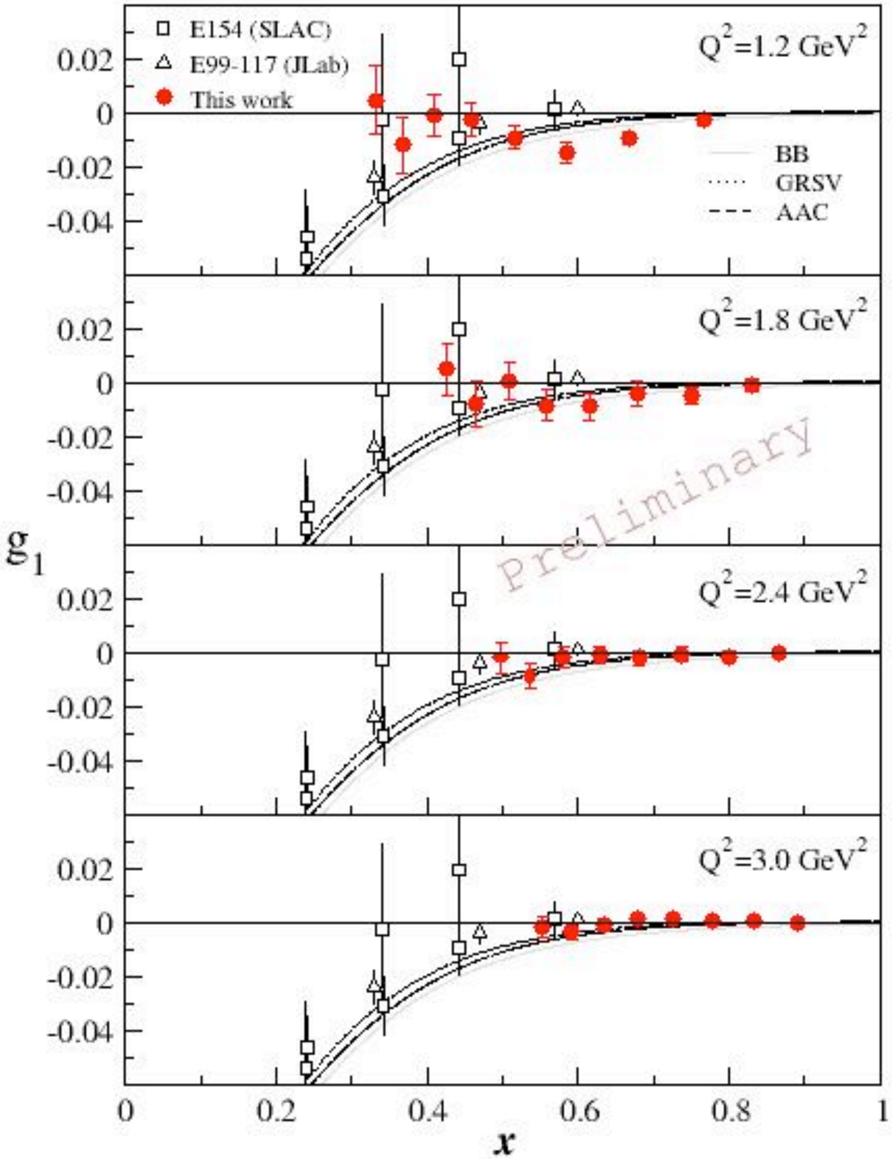


Statistical errors only

From constant E to constant Q^2



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



Test of duality on the neutron and ^{3}He

Used method defined by N. Bianchi, A. Fantoni and S. Liuti on g_1^p

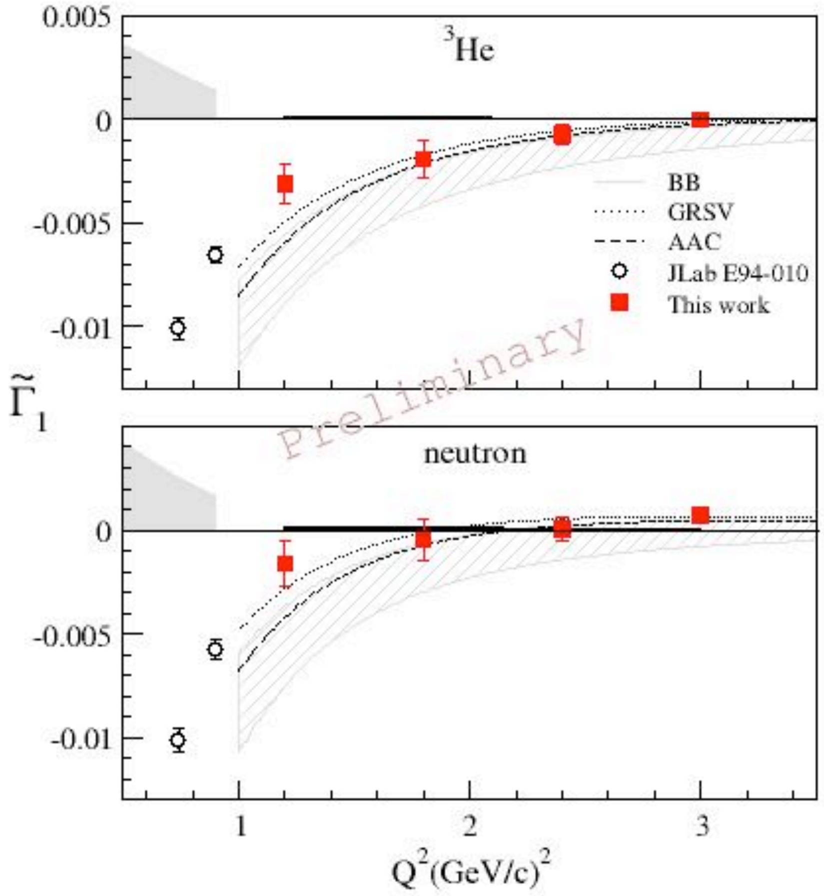
PRD 69 (2004) 014505

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

$$\tilde{\Gamma}_1^{res} = \int_{x_{min}}^{x_{max}} g_1^{res}(x,Q^2)dx \qquad \tilde{\Gamma}_1^{dis} = \int_{x_{min}}^{x_{max}} g_1^{dis}(x,Q^2)dx$$

If $\tilde{\Gamma}_1^{res} = \tilde{\Gamma}_1^{dis}$ **$\Rightarrow$ duality is verified**

g_1 in the resonance region



Extract the neutron from effective polarization equation:

$$\tilde{\Gamma}_1^{\,^3He} = P_n \tilde{\Gamma}_1^{n} + 2P_p \tilde{\Gamma}_1^{p}$$

P_n=86%
P_p=-2.8%

In progress

- 1st paper in preparation

Global duality on g_1 for ^{3}He and neutron, A_1^{3He}

APS/123-QED

Quark-Hadron Duality on the Neutron (^{3}He) Spin Structure

DRAFT

P. Solvignon[19], N. Liyanage[20], J.-P. Chen[10], Seonho Choi[19], K. Aniol[3], T. Averett[21], W. Boeglin[7] A. Camsonne[2], G.D. Cates[20], G. Chang[13], E. Chudakov[10], B. Craver[20], F. Cusanno[9], A. Deur[10,20], D. Dutta[4], R. Ent[10], R. Feuerbach[10], S. Frullani[9], H. Gao[4], F. Garibaldi[9], R. Gilman[10,17], C. Glashausser[17], O. Hansen[10], D. Higinbotham[10], H. Ibrahim[16], X. Jiang[17], M. Jones[10], A. Kelleher[21], J. Kelly[13], C. Keppel[8,10], W. Kim[12], W. Korsch[11], K. Kramer[21], G. Kumbartzki[17], J. LeRose[10], R. Lindgren[20], B. Ma[15], D. Margaziotis[3], P. Markowitz[7], K. McCormick[17], Z.-E. Meziani[20], R. Michaels[11], B. Moffit[21], P. Monaghan[15], C. Munoz Camacho[5], K. Paschke[14], B. Reitz[10], A. Saha[10], R. Sheyor[18], J. Singh[20], K. Slifer[19], V. Sulkosky[21], A. Tobias[20], G. Urciuoli[9], K. Wang[20], K. Wijesooriya[4], B. Wojtsekhowski[10], S. Woo[12], J.-C. Yang[6], X. Zheng[1], L. Zhu[15]
(and The Jefferson Lab Hall A Collaboration)

[1] *Argonne National Laboratory, Argonne, IL 60439*
[2] *Université Blaise Pascal et CNRS/IN2P3 LPC, 63177 Aubière Cedex, France*
[3] *California State University, Los Angeles, CA 90032*
[4] *Duke University, Durham, NC 27708*
[5] *CEA Saclay, DAPNIA/SPhN, F-91191 Gif sur Yvette, France*
[6] *Chungnam National University, Taejon 305-764 Korea*
[7] *Florida International University, Miami, FL 33199*
[8] *Hampton University, Hampton, Virginia 23187*
[9] *Institute Nazionale di Fisica Nucleare, Sezione Sanitá, 00161 Roma, Italy*
[10] *Thomas Jefferson National Accelerator Facility, Newport News, VA 23606*
[11] *University of Kentucky, Lexington, KY 40506*
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[19] *Temple University, Philadelphia, PA 19122*
[20] *University of Virginia, Charlottesville, VA 22904*
[21] *College of William and Mary, Williamsburg, VA 23187*

(Dated: June 14, 2007)

We present results on a dedicated experiment to study quark-hadron duality in spin structure functions of the neutron and ^{3}He using a polarized ^{3}He target in the four momentum transfer range from 1.0 to 3.6 (GeV/c)^2. We observed the onset of global duality for the structure function g_1 for $1.2 < Q^2 < 1.8$ (GeV/c)^2 in both ^{3}He and the neutron. We have also formed the photon-nucleus asymmetry A_1 for ^{3}He and found no strong Q^2-dependence above 2.6 (GeV/c)^2 hinting for a DIS-like behavior.

PACS numbers: 13.60.Hb, 13.88.+e, 14.20.Dh

Lepton-nucleon scattering experiments have provided a window into the partonic sub-structure of the nucleon and helped establish Quantum Chromodynamics (QCD) as the fundamental theory governing the strong interaction. A very important subset of these experiments have probed the nucleon spin structure using polarized lepton beams and polarized targets.

In high-energy lepton-nucleon scattering, the lepton interacts with the nucleon by exchanging a virtual photon with one of the quarks in the nucleon. This process is characterized by two variables, Q^2 and x. The quantity Q^2 is the four-momentum squared for the exchanged virtual photon, and $x = Q^2/(2M\nu)$ (M is the mass of the nucleon and ν is the energy transfer), is the Bjorken scaling variable. The invariant masses W of the virtual photon-nucleon system is related to Q^2 and x through $W^2 = M^2 + Q^2/x - Q^2$. The scattering cross section is parametrized in terms of two unpolarized structure functions (F_1 and F_2) and two polarized structure functions (g_1 and g_2). These structure functions are related to the polarized and unpolarized parton distribution functions in the nucleon. Another observable that provides a direct insight into the polarized quark distributions in the nucleon is the Virtual Photon Asymmetry, A_1, which is approximately equal to the ratio of the polarized and unpolarized structure functions, g_1/F_1.

In the Deep Inelastic Scattering (DIS) region, at large values of Q^2 and W, the electron scatters off an asymp-

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Checking statistical fluctuations

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- Then extraction of:

  d_2^n

  BC sum rule

  A_2^n

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