The Hall C Spin Program at JLab

KARL J. SLIFER

University of Virginia

FOR THE RSS COLLABORATION

We discuss the preliminary results of the Resonant Spin Structure (RSS) experiment and outline future spin-dependent measurements in JLab's experimental Hall C.

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1 Resonant Spin Structure

The Resonant Spin Structure (RSS) collaboration[1]) has performed an inclusive measurement of the spin asymmetries of the Proton and Deuteron in the resonance region, using a longitudinally polarized 5.7 GeV electron beam in conjunction with a polarized solid ammonia target in JLab's Hall C. The target could be polarized longitudinally and transversely, allowing extraction of both spin-dependent structure functions g_1 and g_2 at $< Q^2 > \approx 1.3$ GeV^2. This data will provide a test of polarized duality and allow an examination of higher twist effects in the Proton. In these proceedings, we report only on the Proton studies.

1.1 Experiment

The RSS experiment ran in Jefferson Lab's Hall C. During typical run conditions, a 100 nA beam of longitudinally polarized (69%) 5.7 GeV electrons was incident on the University of Virginia (UVA) polarized NH_3 target. The incident beam was rastered over the face of the target cell to limit depolarization and beam heating effects. The High Momentum Spectrometer (HMS) was stationed at 13.15 degrees to inclusively measure scattered electrons. The HMS was outfitted with a series of scintillator planes and drift chambers for tracking and to provide the data acquisition trigger. A gas Čerenkov and lead glass calorimeter were used for particle identification. Two spectrometer momentum settings of 4.7 and 4.1 GeV allowed us to cover the resonance region up to an invariant mass W of approximately 1.9 GeV. The elastic reaction was also measured due to the large momentum acceptance. The kinematic coverage, which is displayed in Fig. 1, resulted in an average Q^2 of about 1.3 GeV^2.

[1]) JLab E01-006, O. A. Rondon-Aramayo and M. Jones spokespersons. U. Basel, Florida International U., Hampton U., U. Massachusetts, U. Maryland, Mississippi S. U., North Carolina A&T U., U. of N. C. at Wilmington, Norfolk State U., Old Dominion U., S. U. New Orleans, U. of Tel-Aviv, JLab, U. of Virginia, Virginia P. I. & S. U., Yerevan Physics I.

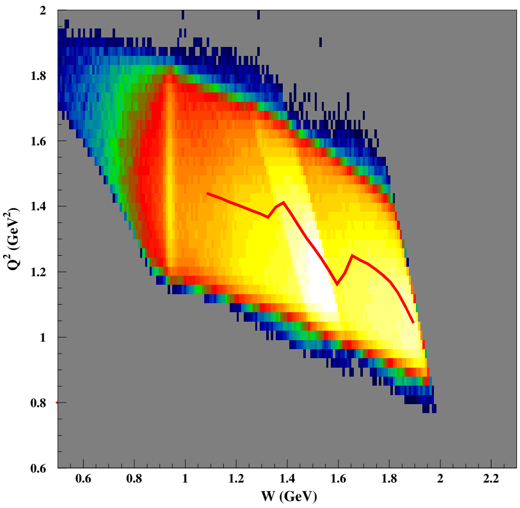

Fig. 1. Kinematic coverage of RSS. The solid line signifies the statistically weighted average.

The polarized target (see Fig. 2) operates on the principle of Dynamic Nuclear Polarization to enhance the low temperature (1K), high magnetic field (5T) polarization of the ammonia by microwave pumping. The 3 cm long target cells were typically polarized to 66-71%.

The basic measured quantity was an asymmetry defined as:

$$A = \frac{1}{fP_bP_t}\frac{1}{C_N f_{RC}}A_{raw} + A_{RC} \tag{1}$$

where P_b, and P_t represent the beam and target polarization, f is the dilution factor, which arises from the presence of unpolarized material in the target, and A$_{raw}$ is the raw counts asymmetry measured when the beam helicity was flipped at 30 Hz, while the target polarization was held fixed. C_N is a correction for the small residual polarization of Nitrogen in NH_3, and the remaining terms, known as radiative corrections, account for the radiation of photons by the incoming and scattered electrons.

From $A_\parallel$ and $A_\perp$, we can obtain the virtual photon asymmetries as follows:

$$A_1 = \frac{C}{D}\Big(A_\parallel - dA_\perp\Big)$$
$$A_2 = \frac{C}{D}\Big(c'A_\parallel + d'A_\perp\Big) \tag{2}$$

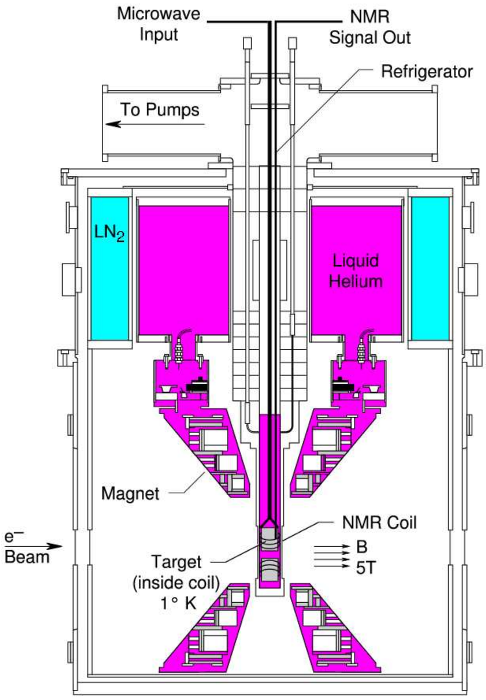

Fig. 2. The polarized target.

where $C = 1/(1+\eta c')$; $\eta = \varepsilon\sqrt{Q^2}/(E-\varepsilon E')$; $c' = \eta(1+\varepsilon)/(2\varepsilon)$; $D = (1 - \varepsilon E'/E)/(1+\varepsilon R)$ is the virtual photon depolarization factor; $d' = 1/\sqrt{2\varepsilon/(1+\varepsilon)}$; and $d = \eta d'$.

And finally, the spin dependent structure functions are given by:

$$g_1 = \frac{F_1}{1+\gamma^2}\left[A_1 + \gamma A_2\right]$$
$$g_2 = -\frac{F_1}{1+\gamma^2}\left[A_1 - 1/\gamma A_2\right] \tag{3}$$

where $\gamma = Q/\nu$. Recent fits [1] to Hall C inclusive inelastic $e-p$ data were used as input for F_1 and R.

Bloom and Gilman [3] first made note of the curious empirical fact that the unpolarized structure function F_2 measured in the resonance region averages to the value measured in DIS. The phenomenon has been classified in terms of global duality, in which the entire resonance region is considered and in terms of local duality, in which individual resonances are selected. Unpolarized local duality first observed by Bloom and Gilman, has been confirmed [4] at JLab for the F_2 structure function. Observation of duality in the polarized structure functions would imply that duality is the result of fundamental properties in the nucleon, and not simply a fortunate coincidence. If local duality works for all structure functions, it may possibly be used to illuminate experimentally inaccessable kinematic regions.

1.2 Results

In Fig. 3, we display the physcis asymmetries of Eq. 1 as a function of invariant mass. The $\Delta(1232)$ is clearly visible, along with several higher mass resonances in both the parallel and perpendicular asymmetry. The preliminary systematic uncertainty on the measured asymmetries is approximately 6%.

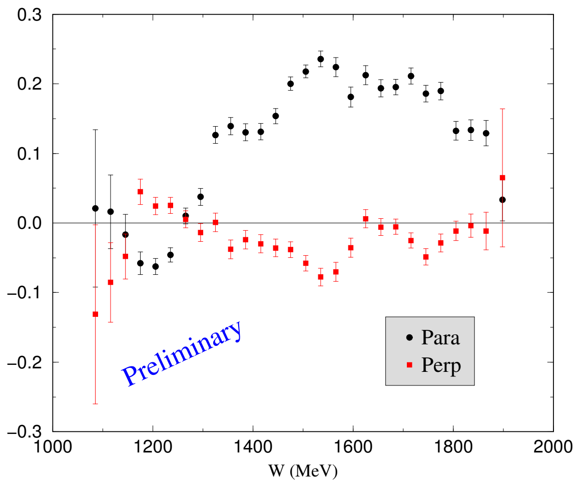

Fig. 3. Proton physics asymmetries as a function of W.

The spin structure function g_1 is plotted in Fig. 4 as a function of the Bjorken scaling variable. Several resonant peaks are again visible, and we compare to several parton distribution functions [2]. The g_2 structure function is an excellent quantity for studying higher twist effects and so to explore quark-gluon interactions in the nucleon. It is shown in Fig. 5, along with the MAID model [5] prediction and previous SLAC data [6].

In Fig. 6, the virtual photon spin asymmetry A_1 is compared to previous mea-

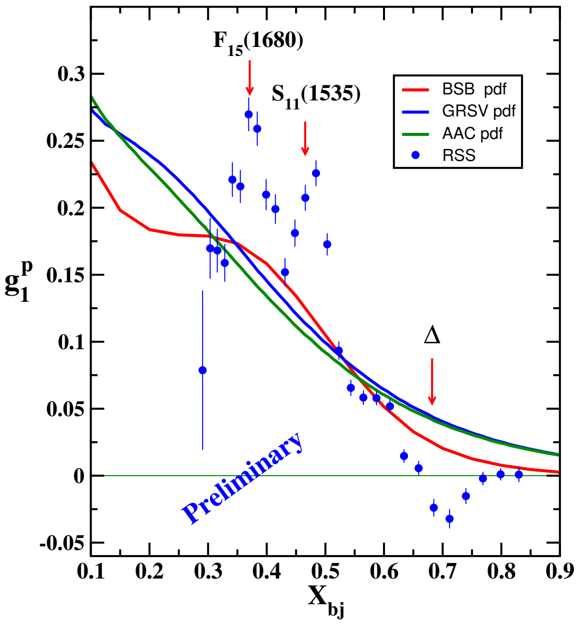

Fig. 4. The g_1 structure function compared to several parton distribution functions [2].

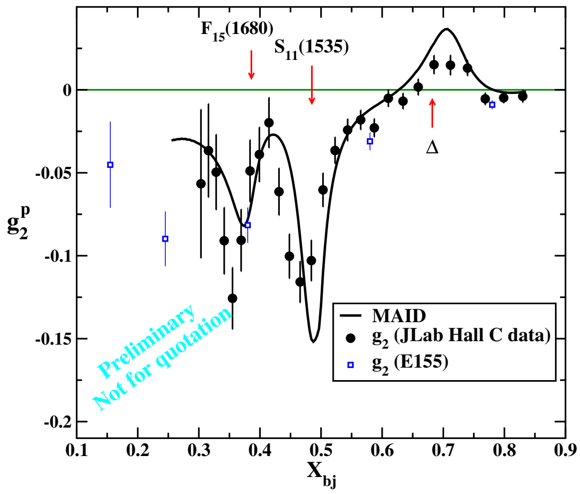

Fig. 5. The g_2 structure function compared to results from E155 [6] and the MAID [5] model.

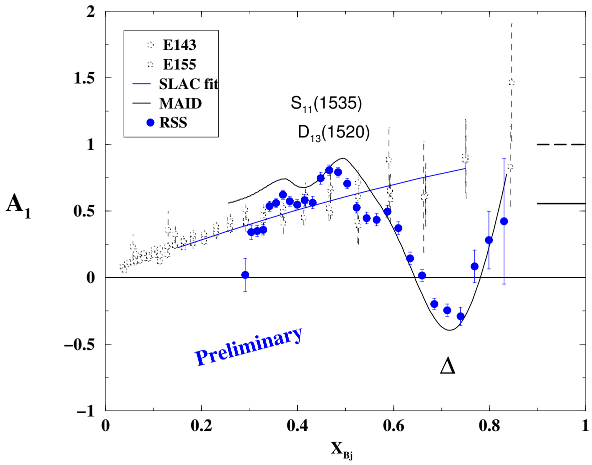

Fig. 6. Spin asymmetry A_1 compared to E143 [8], E155 [7] and the MAID [5] model.

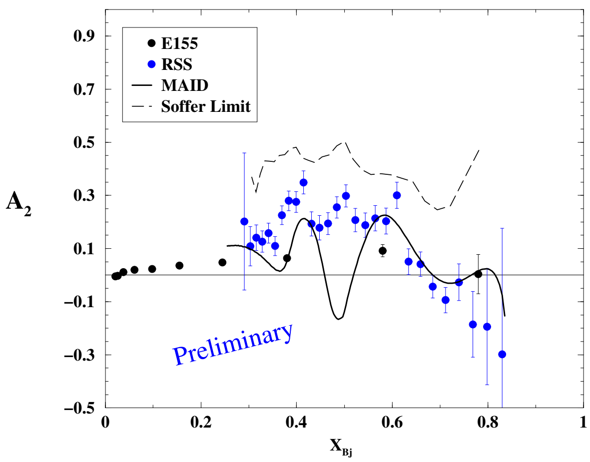

Fig. 7. Spin asymmetry A_2 compared to E155 [6], and the MAID [5] model. Also shown is the Soffer limit [9] for A_2.

surements [7, 8]. The resonance results oscillate about the DIS results hinting strongly at the existence of polarized duality. Finally, in Fig. 7, we compare the A_2 asymmetry to SLAC results [6] at much higher Q^2. The asymmetry obeys the positivity constraint of the Soffer limit [9] for the entire measured region.

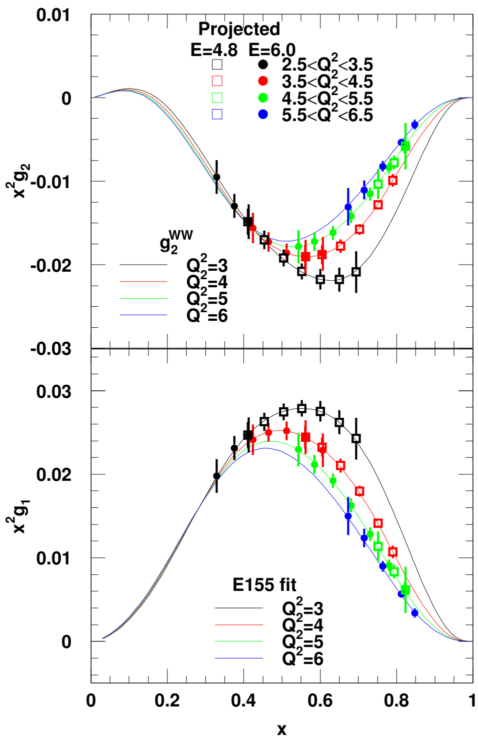

Fig. 8. Expected SANE precision for g_1 and g_2.

2 Future experiments

The Spin Asymmetries of the Nucleon Experiment[2]) (SANE) aims to study the x and Q^2 dependence of the Proton spin structure function $g_2(x, Q^2)$ and spin asymmetry $A_1(x, Q^2)$ for $2.5 < Q^2 < 6.5$ GeV^2 and for $0.3 < x < 0.8$. This will allow an examination of twist-3 effects and a test of polarized duality for $W > 1.4$ GeV. The UVA polarized target will be utilized, along with the newly designed βeta detector. βeta has three major subsystems: a lucite hodoscope, a lead glass calorimeter, and a gas Čerenkov. This large acceptance device (194 msr) will be

[2]) JLab E03-109, O. A. Rondon-Aramayo, Z.-E. Meziani, S. Choi spokespersons. U. Basel, Florida International U., Hampton U. , IHEP Protvino, Kent State, Norfolk S. U. , N.C A&T U., Rensselaer Polytechnic, St. Norbert, Temple U., JLab, U. of Virginia, William & Mary, Yerevan Physics I.

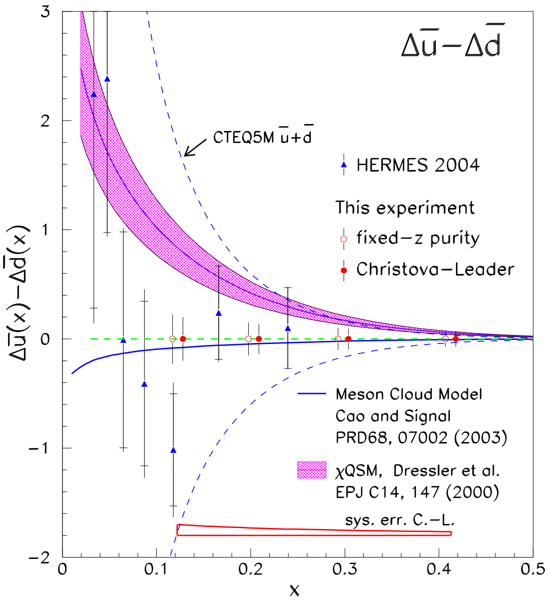

Fig. 9. Expected Semi-SANE precision for $\Delta\overline{u}(x) - \Delta\overline{d}(x)$.

used to overcome the rapidly falling count rate at the selected kinematics. The expected precision for the spin structure functions can be seen in Fig. 8.

The Semi-Inclusive Spin Asymmetries on the Nucleon Experiment[3]) (Semi-Sane) will measure the Proton and Deuteron semi-inclusive longitudinal spin asymmetries, detecting the scattered electron and either a $\pi^{\pm}$ or $K^{\pm}$ pair in the Q^2 range of 1.2–3.1 GeV^2, for $0.12 < x < 0.43$. This will enable a spin flavor decomposition and allow the examination of any deviation from factorization by comparison with the inclusive asymmetry A_1^N. The precision obtained should allow for a clear observation of whether the polarized sea is asymmetric. See Fig. 9.

3 Summary

We have presented preliminary results from the Resonant Spin Structure experiment which will allow a test of polarized duality in the Proton. The SANE experiment will measure $A_{\parallel}$ and $A_{\perp}$ in inclusive scattering from the Proton using a large acceptance detector (βeta) in the DIS region. And Semi-SANE will test the

[3]) JLab E04-113, P. Bosted, D. Day, X. Jiang and M. Jones spokespersons. Argonne, Duke U., Florida International U., HamptonU. , U. of Kentucky, Maryland U., Massachusetts U., Rensselaer Polytechnic I., Norfolk U., Old Dominion U., U. of Regina, Rutgers, Temple U. , JLab, U. of Virginia, William & Mary, Yerevan Physics I.

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validity of factorization and study the polarized sea by measuring the semi-inclusive reactions $p(e, e')h$ and $d(e, e')h$ for $h = \pi^{\pm}, K^{\pm}$.

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