A resubmitted proposal for PAC31

Target Normal Single-Spin Asymmetry in Inclusive DIS $n^{\uparrow}(e, e')$ with a Polarized ^{3}He Target

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Abstract: We propose to measure the target normal single spin asymmetry A_N^n in inclusive deep-inelastic $n^\uparrow(e,e')$ reaction with a vertically polarized ^{3}He target during the Hall A neutron transversity experiments (E06–010) and (E06–011). The expected accuracy of our measurement is $2 \sim 4 \times 10^{-4}$ at four different Ws. The normal spin asymmetry in DIS probes helicity–flip amplitudes at the quark level related to effects beyond the leading-twist picture of DIS. In view of the predicted rapid variation of the asymmetry between 10^{-2} (exclusive) and 10^{-4} (DIS-inclusive), a measurement at this level of accuracy would be significant, allowing us to observe the predicted variation with high degree of confidence. This experiment will share the approved 29 days of 6 GeV beam time with E06–010 and E06–011. No independent beamtime is required for this measurement.

Contents

This proposal is a resubmission of P06–012, which was deferred with regret during PAC29. The report of that PAC is listed in the appendix of this document. As per the request of the PAC we have engaged theorists in understanding the target normal single spin asymmetry. Two different theory groups encouraged by our proposal of last year have studied this phenomenon; one using a partonic model and the other a constituent quark picture. Their results are discussed in this paper. Both groups feel strongly that a measurement of the target normal single spin asymmetry is of great interest.

1 Introduction

Two–photon exchange effects in eN scattering have been the subject of intense experimental and theoretical study during the last few years. In elastic scattering, two–photon exchange partly explains the discrepancy between the G_E/G_M ratio extracted using the Rosenbluth and polarization transfer methods [1,2], as was demonstrated by theoretical calculations using hadronic [3,4] and partonic [5,6] approaches to proton structure. Two–photon exchange contributions also account for important corrections to the beam helicity asymmetry measured in parity–violating electron scattering [7].

A particularly interesting two–photon exchange effect is the target normal spin asymmetry of the cross section in unpolarized *inclusive* eN scattering,

$$A_N = \frac{\sigma^{\uparrow} - \sigma^{\downarrow}}{\sigma^{\uparrow} + \sigma^{\downarrow}}. \tag{1}$$

This asymmetry is exactly zero in one–photon exchange approximation, which follows from P and T invariance and the hermiticity of the electromagnetic current operator (Christ–Lee theorem) [8]. A non–zero asymmetry arises from the interference of one–photon and two–photon exchange contributions to the electroproduction amplitudes; this can be interpreted as being due to a non–hermitean term in the effective current induced by the imaginary part of the two–photon exchange amplitude. The normal spin asymmetry thus represents a clean observable for testing two–photon exchange effects.

Recently, several theoretical studies have attempted to estimate the target normal spin asymmetry in inclusive DIS and clarify its relation to nucleon structure. Reference [9] pointed out the existence of a non-zero A_N due to two–photon exchange in a parton picture, and suggested a mechanism similar to that giving rise to the structure function $g_T = g_1 + g_2$ in polarized DIS. Reference [10] calculated the asymmetry in a constituent quark picture ("composite proton approximation"), which allows for a consistent treatment of real photon bremsstrahlung. These authors estimate A_N to be of the order 10^{-4} in inclusive DIS with 6 GeV beam energy and $Q^2 \sim$ several GeV^2, with opposite sign for proton and neutron, see Fig. 1.

The theoretical estimates of the target normal spin asymmetry suggest a very interesting situation: In *exclusive* eN scattering at large Q^2, calculations [5,6] based on GPD parameterizations of the two–photon exchange amplitude predict asymmetries of the order of $A_N \sim 10^{-2}$. In *inclusive* scattering at large Q^2 and W (Bjorken regime), however, Ref. [10] estimates the asymmetry to be of the order $A_N \sim 10^{-4}$. If this is true, it implies that in inclusive scattering the asymmetry should exhibit a very rapid fall–off with increasing missing mass, M_X. Thus, it seems that the normal spin asymmetry is a very sensitive observable for studying the "inclusive–exclusive transition" in eN scattering at large Q^2, which is intimately related to the transition from hadronic to partonic degrees of freedom.

In the helicity basis of polarization states, the target normal single spin asymmetry is related to the interference of different helicity amplitudes in the DIS cross

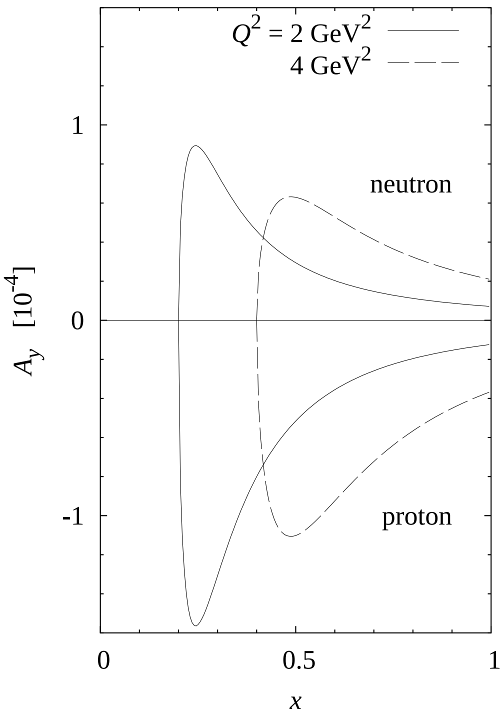

Figure 1: Theoretical predictions for DIS target normal single spin asymmetry [10].

section. In exclusive scattering at the hadronic level, it is well–known that these helicity flip amplitudes arise due to the nucleon mass and the Pauli component of the electromagnetic coupling. In inclusive scattering at the partonic level, helicity–flip amplitudes are absent for massless free quarks, and can arise only due to non-perturbative interactions (chiral symmetry breaking) or explicit quark mass effects [10]. The same effects are expected to dominate the structure function g_T, and play an important role in observables sensitive to the quark transversity distribution, $h(x)$. A measurement of the normal spin asymmetry in DIS kinematics would allow us to probe helicity–flip amplitudes at the quark level through an independent observable, which would greatly advance our understanding of these fundamental non-perturbative effects.

We propose to measure A_N^n in Hall A during the Transversity experiments E06–010 and E06–011. The combination of the high beam currents possible at Jefferson Lab, the new large acceptance BigBite spectrometer in Hall A, and the high luminosity polarized ^{3}He target is uniquely suited for a high statistics measurement of A_N^n. The expected accuracy of our measurement is $2 \sim 4 \times 10^{-4}$ at four different W values. In view of the predicted rapid variation of the asymmetry between 10^{-2} (exclusive) and 10^{-4} (deep-inclusive), a measurement at this level of accuracy would be significant, allowing us to observe the predicted variation with high degree of confidence. If the asymmetry is found to be consistent with zero, it would support the assumptions underlying the quark–level calculation of Ref.[10]. A non-zero result at this level of accuracy would signal the presence of non-perturbative effects not accounted for in the present model calculation.

The target normal spin asymmetry in DIS was previously measured in 1970 at SLAC[11], with the aim of testing time reversal (T) invariance of EM interactions using the one–photon exchange approximation (Christ–Lee theorem). The asymmetry was found to be consistent with zero at the level of 3.5%. The accuracy achieved with the proposed measurement in Hall A makes it possible to employ the asymmetry instead as a test of two–photon exchange effects in T–invariant EM interactions. We note that in the Standard Model P–conserving, T–violating effects come as weak corrections to P–violating effects, and that their magnitude is therefore expected [12] to be at least $< 10^{-8}$, significantly below the predicted two–photon exchange effect.

2 The Measurement

We purpose to measure the target normal single spin asymmetry (A_N) in Jefferson Lab Hall A using inclusive deep inelastic scattering (DIS) of a 6 GeV electron beam from a ^{3}He target polarized normal to the scattering plane. This measurement will be preformed parasitically to the neutron transversity experiments, E06-010 and E06-011 [13]. The BigBite spectrometer positioned at 30° relative to the beamline and 1.5 m from the target will be used to simultaneously measure A_N at Q^2 of 1.3, 2.0, 2.6, and 3.1 GeV^2. Based on 336 hours of running we expect a statistical uncertainty δA_N^n of 2.2, 2.7, 3.4, and 3.9 $\times$ 10^{-4} for the respective Q^2 bins. The vertically polarized ^{3}He target will be used. The target will be based on the same potassium/rubidium mixture of alkalis which was used very successful in providing high ^{3}He polarization during the recent GeN experiment (E02-013) [14].

The target will be flipped every 10–20 minutes to reduce the effect of systematic bias. To further reduce these effects a quad run structure with target flips of either $\uparrow\downarrow\downarrow\uparrow$ or $\downarrow\uparrow\uparrow\downarrow$ will be used in a randomly determined sequence. The Hall A Lumis located in the beam pipe will be used to monitor the relative luminosity. This will require the use of the Hall A parity DAQ in tandem with the BigBite DAQ. The relative beam charge will be monitored by the Hall A beam charge monitors, with standard feedback from the Hall A parity system. The beam quality requirements for a 100 ppm measurement are well within what has been achieved before for Hall A. One half of the Transversity running will be done with the target polarized in plane of the scattering angle. This data will give us a clear measure of our false asymmetries.

2.1 Kinematics, rates and statistical uncertainties

The proposed running for transversity [13] (E06–010/E06–011) will be ideal for this measurement. Half of the experiment running time will be with the target in the vertical polarization configuration. The BigBite spectrometer will be placed at a scattering angle of 30 degrees. Expected results assuming 264 hours or running and an average target polarization of 42% are shown in Table 1, where f, the dilution factor, is the fraction of scattered electrons coming from a polarized neutron. The E'-x, W-x and Q^2-x phase space for each x-bin is shown in Fig. 2. The statistical uncertainty δA_N^n will be 2.2, 2.7, 3.4, and 3.9 $\times 10^{-4}$ for the 0.14, 0.23, 0.32, and 0.41 x-bins respectively.

Table 1: Nominal kinematics for x-bin center with a beam energy of $E = 6.0$ GeV. One BigBite setting covers all the kinematics listed. f is the neutron dilution factor.

$E_0 = 6.0$ GeV, ^{3}He(e,e'). 336 hours total, $P_T = 0.42$.

$\langle x \rangle$	E′ GeV	θ_e deg.	Q^2 GeV^2	W GeV	$\Delta E'$ GeV	$d\sigma_{(e,e')}$ nb/GeV/sr	f	Rate Hz	N$_{DIS}$ 10^6	δA_N^n 10^{-4}
0.135	0.815	30.0	1.310	3.050	0.431	29.6	0.350	817.49	989.0	2.16
0.225	1.246	30.0	2.003	2.793	0.398	19.4	0.366	493.42	596.9	2.66
0.315	1.612	30.0	2.592	2.554	0.340	13.0	0.380	281.82	340.9	3.39
0.405	1.925	30.0	3.095	2.331	0.381	8.4	0.391	204.14	247.0	3.87

During E06–010 the left High Resolution Spectrometer will be looking for 2.4 GeV π^-'s. During a running period of 168 hours, 99.8 $\times 10^6$ electrons will be detected in the left arm. This data will have a Q^2 of 1.116 GeV^2, a W of 2.553 GeV, and an x of 0.165. The uncertainty δA_N^n of 6.1 $\times 10^{-4}$ will not contribute strongly to a null result, but it will provide a valuable cross-check to a non-zero result since it should have the opposite sign.

The other half of Transversity running time will be taken with the target polarization in the scattering plane of the electron either beam left or beam right. Giving this analysis matching data of similar quality and statistical error. The single spin asymmetry is $\propto (\vec{e} \times \vec{e}') \cdot \vec{S}_T$, which will be uniquely zero for this configuration. Thus only parity-violating effects such as Z Boson exchange can cause this asymmetry. This PV asymmetry should be small at these configurations. Thus any asymmetry will be a indirect measure of the systemic bias.

2.2 BigBite: A Large Acceptance electron spectrometer.

The Transversity experiments plan to use the standard BigBite electron detector package that was used by the GeN experiment (E02-013) [14]. This package includes three wire chambers, scintillator triggers, a Lead glass calorimeter, and a new Gas Cherenkov for particle identification.

The GeN experiment [14] was successfully run in spring 2006 in Hall A using the BigBite spectrometer. The new wire chambers worked well, and they should be able to handle the rate for transversity. The wire chambers provided good momentum and target z resolution as seen in Fig. 3 and Fig. 4 [17].

One new feature that will be added to the BigBite spectrometer is a Gas Cherenkov detector. This new device is critical for the d2n experiment. The design goal of this

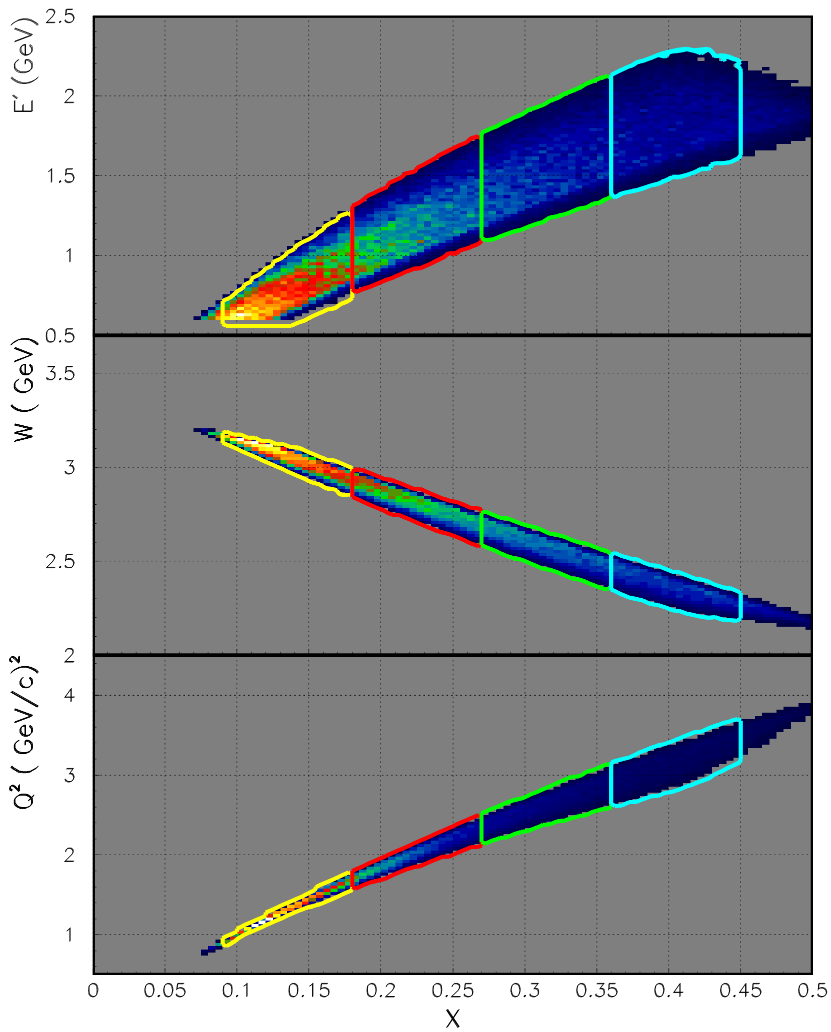

Figure 2: Available phase space in the (E', x), (Q^2, x), and (W, x) planes with each x-bin in different colors.

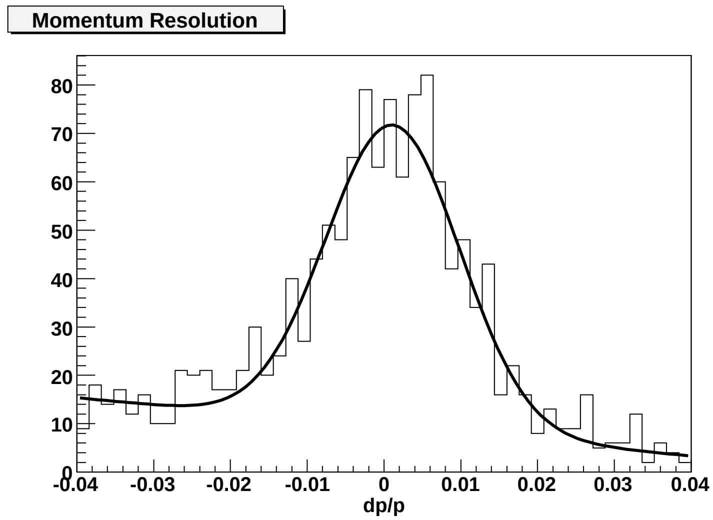

Figure 3: BigBite wire chamber momentum resolution during the GeN experiment.

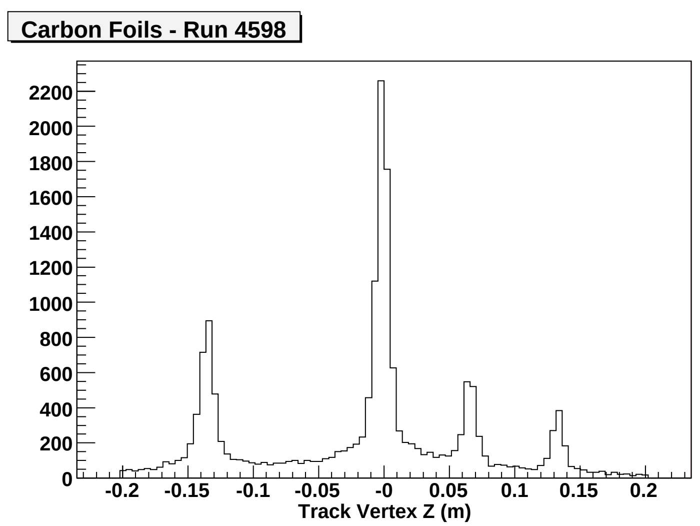

Figure 4: BigBite wire chambers target z resolution during the GeN experiment for a number of Carbon foils.

detector is a 500:1 pion rejection factor Fig. 5. The detector is fully funded and should be ready to begin assembly and commissioning July/Aug 2007.

2.3 Luminosity monitoring

The HAPPEX experiments e99-115 [15] and e00-114 [16] have completed an extended run in 2005. These experiments built 8 luminosity monitors called the Lumis. Each detector is made of Quartz with an air light guide. The monitors are placed downstream of the target within the beam pipe at a scattering angle of 7 $mrad$, see Fig. 6. The Lumis have performed very well during HAPPEX, monitoring the Luminosity to a very high precision for 30 Hz beam helicity flips.

Vertically polarized single spin ^{3}He experiments will flip the target spin in a time period of ten to twenty minutes. To study the systematic effects of the Lumis in this time window, the HAPPEX data slug 30 was examined. This slug consisted of fourteen runs, each of 56 minutes in length. The data for each run was divided into four equal length time periods. The results from all eight Lumis were summed to remove Physics effects. Each sum was divided by the value from the Hall A beam charge monitor (BCM) to cancel beam jitter. The average result was determined for each 14 minute time window. The only cut used required a non-zero beam current. The basic asymmetry assuming an ABAB sequence for all is 5×10^{-6}. To get a better handle on the systematic error a random number generator was used to randomly determine either an ABBA or BAAB pattern for each run. The 14 sequences were randomly determined 1000 times giving a root mean square of 5×10^{-5} as shown in Fig. 7. The HAPPEX data has a very large data rate so all errors should be systematic. This test has shown that the Lumis should be able to monitor the luminosity differences between target spin up and target spin down for a vertically polarized single spin ^{3}He experiments to the 5×10^{-5} level.

2.4 Trigger, data acquisition and offline event selection

The trigger used will be the same single arm electron trigger as E06–014. The addition of the Gas Cherenkov should greatly reduce the trigger rate and our deadtime corrections, which should enable running with a very low prescale factor on the trigger. The goal will be a deadtime of less then 5% to minimize our effect on Transversity experiments. The coincidence trigger rate is only a few hertz. We will require both the BigBite DAQ and the Hall A parity DAQ to run. The parity DAQ will be used to monitor the Lumis, BCMs and position differences.

2.5 The polarized ^{3}He target and density fluctuations.

The vertically polarized ^{3}He target used by E06–010/E06-011 is ideal for our measurement. The target will be an optically pumped Rubidium/Potassium hybrid mixture which was shown during GeN[14] to have a higher polarization then standard Rubidium only targets. This is due to the larger rate of spin exchange between

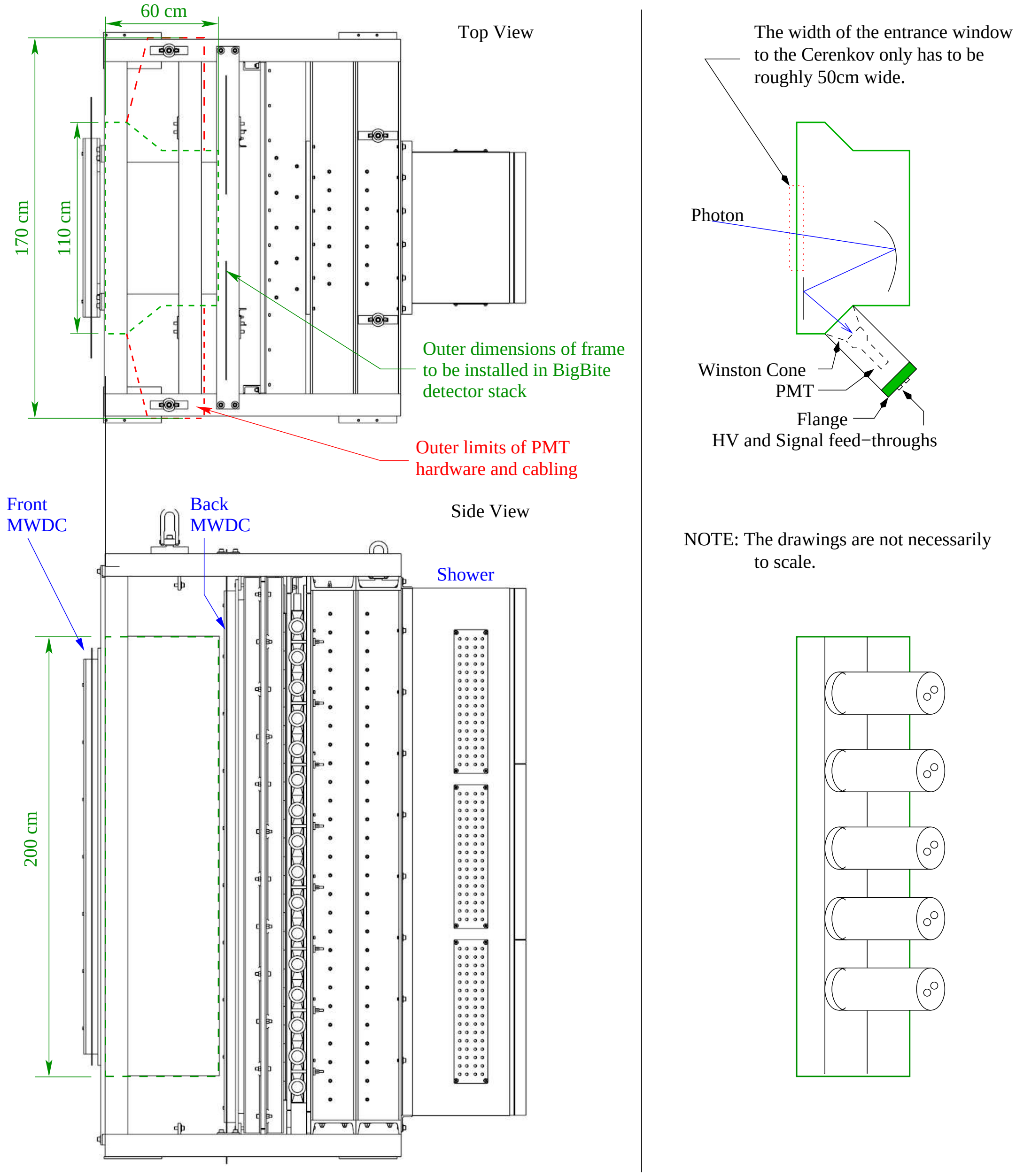

Figure 5: Current design of the E06–014 Gas Cherenkov device. The design goal of this detector is a 500:1 pion rejection factor.

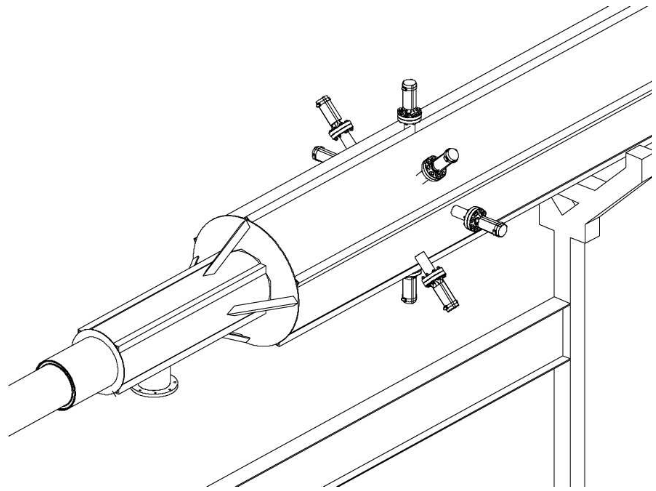

Figure 6: The Hall A Lumis in the beam pipe downstream of the target

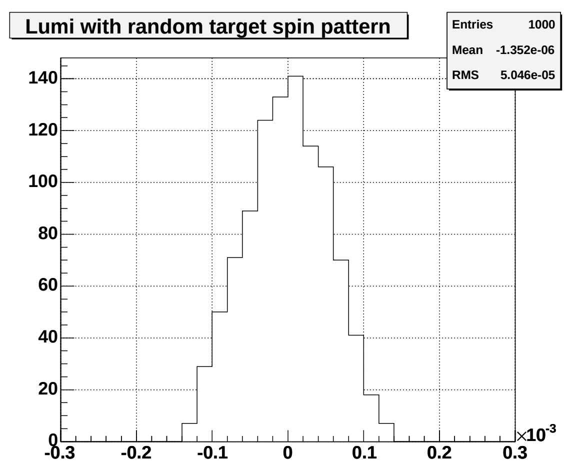

Figure 7: The Asymmetries of the Hall A Lumi sum divided by the BCM with 14 minute time windows for HAPPEX slug 30, using 1000 different random combinations of ABBA or BAAB. The very high rate of HAPPEX experiments means that the RMS is related only to the Lumi systematic error for 14 minute time windows.

Potassium and ^{3}He. To minimize systematics the target spin will be flipped frequently. The extra requirement that this experiment imposes is a strict control of target density between the spin states. While the Hall A Lumis should be able to monitor small fluctuations, we want to try to keep the Lumi asymmetry small. Since the target volume is fixed we only need to control the temperature to control density. The use of the small pumping chamber cells should keep density gradients reasonable. During the Spin Duality experiment E01-012 [22] the density asymmetry between target spin $0°$ and $180°$ with respect to the beam was found to be 8×10^{-4}. The behavior of the Lumis at various target densities will be closely monitored.

3 Expected Results

Based on full statistics we expect to improve the measurement of the DIS single spin asymmetry A_N by over two order of magnitude. We plot our results with the previous measurements versus W and x in Fig. 8 and Fig. 9. Our expected result versus x is plotted with the average of the SLAC results in Fig. 10. The systematic uncertainty should be dominated by the uncertainty in the luminosity ratio with errors similar to statistical uncertainty of δA_{phys}.

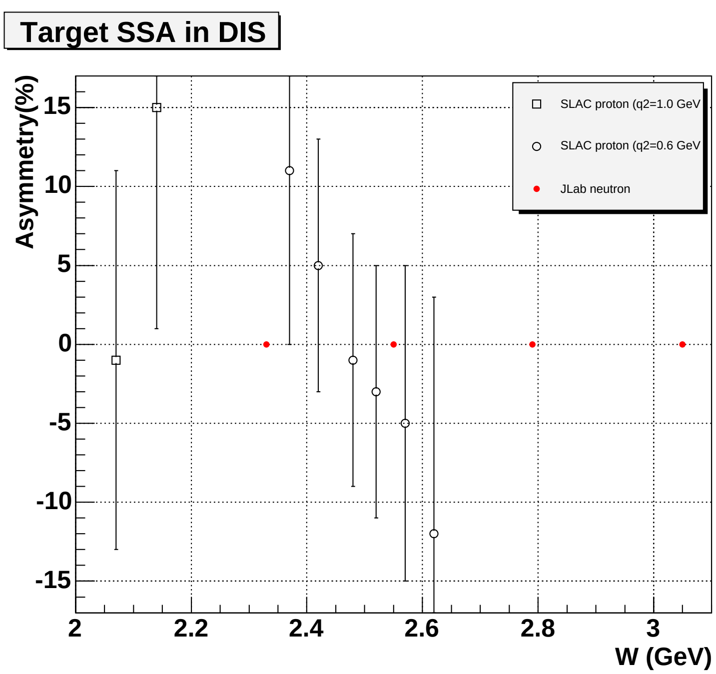

Figure 8: The normal single spin asymmetry for DIS scattering as a function of W. The open squares and circles are SLAC data on the proton at Q^2 of 1.0 GeV^2 and 0.6 GeV^2. Our expected results with a two order of magnitude improvement in statistics are shown as the solid circle.

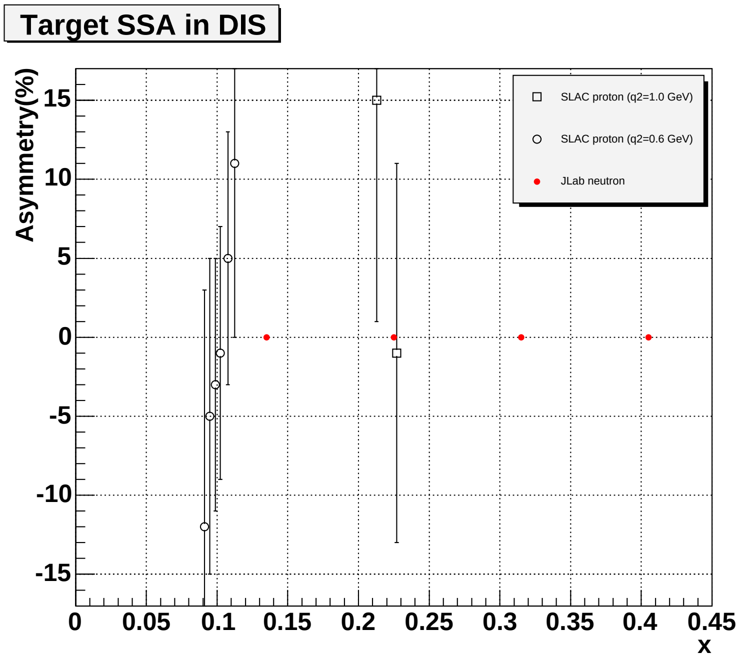

Figure 9: The normal single spin asymmetry for DIS scattering as a function of x. The open squares and circles are SLAC data on the proton at Q^2 of 1.0 GeV^2 and 0.6 GeV^2. Our expected results with a two order of magnitude improvement in statistics are shown as the solid circle.

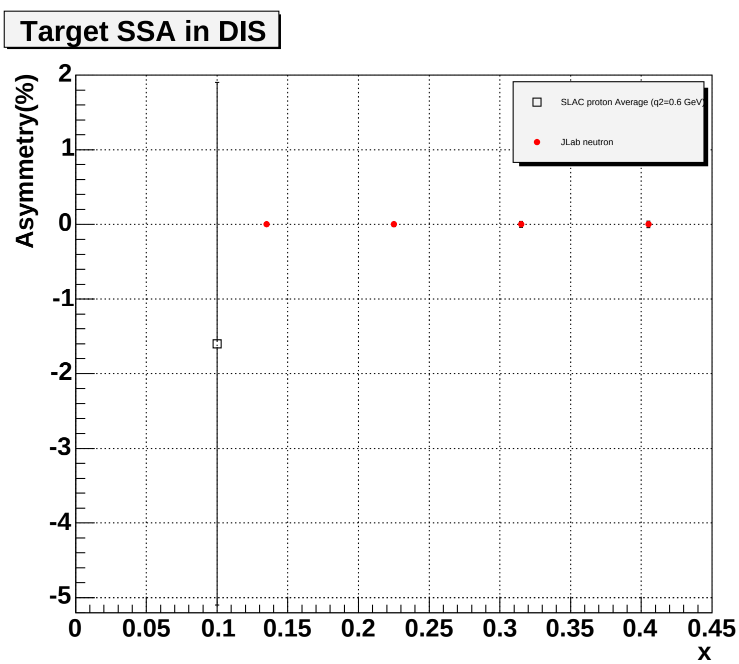

Figure 10: The normal single spin asymmetry for DIS scattering as a function of x. The open square is the average of all SLAC data on the proton at Q^2 0.6 GeV^2. Our expected results with a two order of magnitude improvement in statistics are shown as the solid circle.

3.1 Relative Luminosities

Control of systematics will be extremely important for this experiment. In particular for this measurement is knowledge of the relative luminosity. The measured asymmetry depends not only on the counting rate but also the relative luminosity as below:

$$A_{meas} = \frac{N_{\uparrow} - N_{\downarrow} \cdot \frac{\mathcal{L}_{\uparrow}}{\mathcal{L}_{\downarrow}}}{N_{\uparrow} + N_{\downarrow} \cdot \frac{\mathcal{L}_{\uparrow}}{\mathcal{L}_{\downarrow}}}, \tag{2}$$

where $N_{\uparrow}$ and $N_{\downarrow}$ are the target spin up and down counting rates and $\frac{\mathcal{L}_{\uparrow}}{\mathcal{L}_{\downarrow}}$ is the relative luminosity. The uncertainty in the luminosity ratio contributes to the asymmetry systematic by:

$$(\delta A_{meas})_{sys} = \frac{N_{\downarrow} \cdot \delta\left(\frac{\mathcal{L}_{\uparrow}}{\mathcal{L}_{\downarrow}}\right)}{N_{\uparrow} + N_{\downarrow} \cdot \frac{\mathcal{L}_{\uparrow}}{\mathcal{L}_{\downarrow}}} \cdot (1 + A_{meas}). \tag{3}$$

If we assume that that asymmetry is small, than $N_{\uparrow}/\mathcal{L}_{\uparrow} \approx \mathcal{N}_{\downarrow}/\mathcal{L}_{\downarrow}$, which leads to:

$$(\delta A_{meas})_{sys} \approx \frac{1}{2} \cdot \frac{\delta\left(\frac{\mathcal{L}_{\uparrow}}{\mathcal{L}_{\downarrow}}\right)}{\frac{\mathcal{L}_{\uparrow}}{\mathcal{L}_{\downarrow}}}. \tag{4}$$

These equations show that uncertainty of the luminosity is directly related to the final systematic uncertainty, and that we need to control the relative uncertainty. The systematic uncertainty of the HALL A Lumis is shown in Sec. 2.3 to be at the 5×10^{-5} level. Correcting for dilution and polarization leads to $(\delta A_{phys})_{sys}$ for the Luminosity to be 3.4×10^{-4}.

3.2 Target Polarization Differences

It is also possible that the polarization of the ^{3}He target will be different for spin up($\uparrow$) and spin down($\downarrow$). This difference is easy to correct, since this will be a monitored by both EPR and NMR and should be a small asymmetry.

The cross sections of the two states can be related as:

$$\sigma_{\uparrow} = \sigma_0 + P_{\uparrow}\sigma_1, \tag{5}$$

$$\sigma_{\downarrow} = \sigma_0 - P_{\downarrow}\sigma_1, \tag{6}$$

where σ_0 is the target spin independent cross section, σ_1 is the target spin dependent cross section, and $P_{\uparrow}$ and $P_{\downarrow}$ are two polarizations.

Ignoring radiative effects, the measured asymmetry is:

$$A_{meas} = \frac{\sigma_\uparrow - \sigma_\downarrow}{\sigma_\uparrow + \sigma_\downarrow} = \frac{P_\uparrow + P_\downarrow}{2} \cdot \frac{\sigma_1}{\sigma_0}. \tag{7}$$

Target polarization differences only affect the size of the asymmetry, they don't create an asymmetry. The systematic will be on the order of $A_{meas} \cdot \delta P_{\uparrow(\downarrow)}/P_{\uparrow(\downarrow)}$. Typically for ^{3}He experiments $\delta P/P \approx 4\%$, thus we will not be systematics limited from Target Polarization differences for any $A_{meas} < 6 \times 10^{-3}$.

3.3 Backgrounds

In an inclusive scattering experiment all final states are integrated over. One possible source of backgrounds come from the quasi-elastic tail. To estimate the size of the inelastic tail the unpolarized cross sections are estimated using a modified QFS program [18,19] which fits the world data and recent Jefferson Lab data. Quasi-elastic scattering (QE), the Δ resonance, the second and third resonance, two-nucleon processes (2N), elastic scattering, and deep inelastic scattering (DIS) are all simulated by the program. The cross-section versus ν is shown in Fig 11. The background from quasi-elastic rises with larger ν. For our two high x bins it is clear that the backgrounds are less then 1%, the third bin should see a background of about 5%, and the lowest x bin will have an average background of 10%. The modified Regge GPD model [20] predicts quasi-elastic single spin asymmetry A_y should have a value of 5×10^{-3} at our kinematics with 30% uncertainty. Thus we expect a correction of 5×10^{-4} for the lowest x bin, with a systematic $\delta(A_N^n) = 2 \times 10^{-4}$. The Ay experiment [21] E05-015 should test this model and could provide an improvement to these numbers.

Another source of background is pions that pass the PID cuts. We expect a pion rejection factor of 100 for the lead glass calorimeter, and a factor of 100 from the Gas Cherenkov. The π/e ratio should be less then 10:1 for our two highest x bins. Our lowest x bin will have a π/e ratio of 100. Thus we expect a pion background less then 1%. To correct for this background, we will measure the pion asymmetry by selecting a clean pion signal from our data. These events will be numerous so statistical error on the pion asymmetry should be very small. This setup of the BigBite spectrometer will be used by four different experiments allowing extensive studies of the PID performance over a wide range of operating conditions. With a conservative estimate of the PID behavior to 1%, the systematic uncertainty due to the pion background will be $\delta(A_N)_{\pi back} \approx A_\pi \cdot \delta(\pi/e)$. If $A_\pi < 1\%$, then $\delta(A_N)_{\pi back} < 1 \times 10^{-6}$ for the lowest x bin.

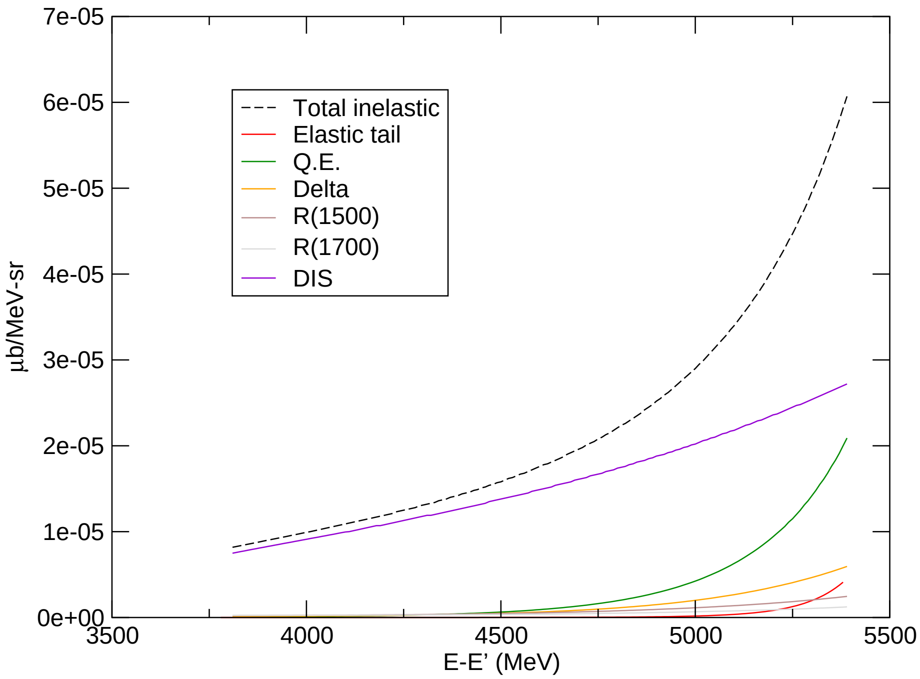

Figure 11: Radiative contributions to the total unpolarized cross-sections versus ν at $E_0 = 6.0$ GeV and $\theta = 30°$ from elastic, quasi-elastic, delta resonance, second resonance, third resonance, and deep inelastic.

3.4 Extra Systematic Studies

A series of studies will be done periodically through the run to monitor our systematics. Runs will be taken with the beam moved off center in both x_{beam} and y_{beam} to get a good understanding of position differences in the Lumis and the BigBite spectrometer. This data will be correlated with natural position differences seen during normal running. Other runs will be taken with one or two of the target pumping lasers off. This will change the density of the target and allow us to correlate density differences with response of the Lumi. Finally data will be taken at different beam currents to understand the linearity of the Lumis. Understanding of these conditions will allow us to better control small deviations that will occur naturally during production. This data will be taken at opportune times to minimize any impact on Transversity running.

3.5 Overall Systematic Cancellation

To help reduce the overall systematic uncertainties we will use a random $\uparrow\downarrow\downarrow\uparrow$ or $\downarrow\uparrow\uparrow\downarrow$ quad run structure for the target spin, where the first run in a quad will have its spin determined by a random number generator. This sequence will be blinded in the single spin asymmetry data analysis to reduce the chance for bias. The overall systematic will also be checked by analysis of the $P_{\leftarrow}$ and $P_{\rightarrow}$ data. A full analysis will be done to measure the false asymmetry and cross check our corrections.

4 Relation with other experiments

Jefferson Lab is uniquely suited for performing this experiment. The high luminosities accessible in Hall A with the polarized ^{3}He target coupled with large acceptance of the BigBite spectrometer create a strong Physics reach.

This experiment will make a long term contribution to Jefferson Lab as the corner stone target single-spin asymmetry experiment. The 12 GeV upgrade will allow parity violating DIS single spin asymmetry experiments where the target is polarized longitudinal to the beam. The DIS parity signal is expected to be $\approx 10^{-4} \times Q^2$. Follow up experiments to probe A_N at smaller W will also be of interest.

5 Beam Time Request

Our beam time requirements are outlined in Table 2. All of the time will be shared with E06–010 and E06–011. Short systematic studies studying the performance of the Hall A Lumis will be done when non-invasive to the Transversity experiments. These special systematic studies include large position difference runs and target temperature tests. We will require the standard Hall A parity charge feedback to be run during the experiment although our requirements are modest compared to a parity experiment.

Table 2: Beam time request.

	Time (Hour)
Production on Pol. ^{3}He	**672 (shared with E06–010 and E06–011)**
Reference cell runs, optics and detector check	16 (shared with E06–010 and E06–011)
Target Overhead: spin rotation, polarization measurement	32 (shared with E06–010 and E06–011)
Total Time Request	**0 (Parasitic to E06–010 and E06–011**

6 Summary

We purpose to measure the normal target single spin asymmetry A_N^n in the DIS region. Using the 29 PAC days all ready approved for E06–010 and E06–011 a measurement over a range of Q^2s at the $2 \sim 4 \times 10^{-4}$ level can be made. A few minor systematic studies can be worked into the schedule where convenient. We ask for no additional beam time. This measurement coupled with the Ay experiment is well placed to check the predicted rapid variation of the asymmetry between 10^{-2} (exclusive) and 10^{-4} (deep-inclusive),

If the asymmetry is found to be consistent with zero, it would support the assumptions underlying the quark–level calculation of Ref.[10]. A non-zero result at this level of accuracy would signal the presence of non-perturbative effects not accounted for in the present model calculation.

Acknowledgments

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Appendix

Individual Proposal Report

Proposal: PR-06-012

Scientific Rating: N/V

Title : A Parasitic Measurement During E-03-004 for Target Single-Spin Asymmetry in Inclusive DIS $n^{\uparrow}(e,e')$ Reaction on a Vertically Polarized ^{3}He Target

Spokespersons: X. Jiang, T. Averett, R. Gilman and T. Holmstrom

Motivation: The proposal is aimed at performing a measurement of inclusive transverse target single spin asymmetry, with a precision at the 5 10^{-4} level, improving by a factor 50 the precision of the previous data collected at SLAC. This measurement is related to determining the two-photon effect at the quark level. A large signal observed at this level of precision would point towards the chiral symmetry breaking, beyond the leading twist QCD picture of DIS.

Measurement and Feasibility: The time requested is only 1 day making opportunistic use of the beam time of other proposals (E-06-010 and E-06-011) approved for data taking. The experimental set-up would then basically be the one used by these experiments.
This set-up would mainly consist of a polarized high luminosity (40 cm long) ^{3}He target, and of the BigBite spectrometer for the detection of the scattered electrons. Inclusive data would be recorded. The kinematics would be the same as for the 2 other proposals: beam with a 15 μA intensity, energy of 6 GeV and 80% longitudinal polarization, BigBite set at 30°. Only the data recorded with the target polarization oriented vertically would be used to extract the signal, the other spin orientation in principle giving a zero signal could be used to determine systematic effects.
The precision of the asymmetry to be reached (100 ppm) requires beam parity quality. However the performances requested are well within those of previous parity violation experiments in Hall A. Also a fast reversal of the target polarization will be used (10-20 minutes) with a quartet structure.
The main experimental change would be the need of additional pion rejection capability in the BigBite spectrometer. It is proposed to use an aerogel Cherenkov counter which should provide an additional rejection factor of 10 in the pion rates. The inclusive rate should be kept at a level, which would not result in a dead time larger than 5% in E-06-010 and E-06-011.

Issues: The PAC has not been fully convinced by the strength of the physics case as presented in the proposal. Additional studies are requested in collaboration with theorists involved in the field of the 2-photon exchange.

Recommendation: Defer with regret

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