ABSTRACT

Beam Normal Single Spin Asymmetry in Forward Angle Inelastic Electron-Proton Scattering Using the Q-weak Apparatus. (December 2014)

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The Q-weak experiment in Hall-C at the Thomas Jefferson National Accelerator Facility has made the first direct measurement of the weak charge of the proton through the precision measurement of the parity-violating asymmetry in elastic electron-proton scattering at low momentum transfer. There is also a parity conserving Beam Normal Single Spin Asymmetry or transverse asymmetry (B_n) on H_2 with a $\sin(\phi)$-like dependence due to two-photon exchange. If the size of B_n is a few ppm, then a few percent residual transverse polarization in the beam, combined with small broken azimuthal symmetries in the detector, would require a few ppb correction to the Q-weak data. As part of a program of B_n background studies, we made the first measurement of B_n in the N-to-$\Delta(1232)$ transition using the Q-weak apparatus. The final transverse asymmetry, corrected for backgrounds and beam polarization, was found to be $B_n = 42.82 \pm 2.45$ (stat) $\pm$ 16.06 (sys) ppm at beam energy $E_{beam} = 1.155$ GeV, scattering angle $\theta = 8.3°$, and missing mass $W = 1.2$ GeV. B_n from electron-nucleon scattering is a unique tool to study the $\gamma^* \Delta\Delta$ form factors, and this measurement will help to improve the theoretical models on beam normal single spin asymmetry and thereby our understanding of the doubly virtual Compton scattering process.

To help correct false asymmetries from beam noise, a beam modulation system was implemented to induce small position, angle, and energy changes at the target to characterize detector response to the beam jitter. Two air-core dipoles separated by ~10 m were pulsed at a time to produce position and angle changes at the target, for virtually any tune of the beamline. The beam energy was modulated using an SRF cavity. The hardware and associated control instrumentation will be described in this dissertation. Preliminary detector sensitivities were extracted which helped

to reduce the width of the measured asymmetry. The beam modulation system also has proven valuable for tracking changes in the optics, such as dispersion at the target.