2004 Annual Review Report

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For my Ph. D. research, I have been working to study the spin structure of the neutron with the Polarized ^{3}He Collaboration at Jefferson Lab (JLab). The Gerasimov-Drell-Hearn (GDH) sum rule was originally derived for real photon absorption (corresponding to Q^2=0) and has been generalized to finite Q^2. The Hall A polarized ^{3}He target was used for experiment E97-110, the GDH Sum Rule and the Spin Structure of ^{3}He and the Neutron using Nearly Real Photons, to measure the generalized GDH integral. The goals of the experiment are to perform a precise measurement of the generalized GDH integral and the moments of the neutron spin structure functions in order to study their Q^2 dependence between 0.02 and 0.3 (GeV/c)^2. This Q^2 range will allow us to extrapolate to the real photon point for ^{3}He and the neutron. Furthermore the low Q^2 predictions of Chiral Perturbation Theory and its limits of applicability can be tested. The measurements will provide new constraints on understanding the ^{3}He and neutron spin structure. The acquisition of data was completed in August of 2003 using the Jefferson Lab high polarization continuous-wave electron beam, the Hall A polarized ^{3}He target, and the new Hall A septum magnet, which allows measurements at forward angles of 6 and 9 degrees.

During the past year, I primarily worked on the spectrometer optics optimization for the second run period. The optics matrix elements are used to reconstruct the interaction vertex at the target from the coordinates of the detected particles at the focal plane via a transport matrix. Even though the matrix elements have been optimized over the full momentum range of both spectrometers, the addition of the septum magnet required a careful study of the target reconstruction. To perform the optimization, elastic data is acquired by scattering electrons from a stack of carbon foils to cover the transverse position acceptance (y_{tg}) at the target. A sieve slit collimator provides well-defined horizontal and vertical positions, which aids in the in-plane (ϕ_{tg}) and out-of-plane (θ_{tg}) angular optimization. In addition, a momentum scan is performed with and without the sieve slit around the elastic peak varying the momentum between +4% and -4% in steps of 2%.

Early in the optimization process, it became clear that changes to the optimization code were required for further improvement of the reconstruction. Some of the changes made to the code were to optimize individual peaks from the sieve slit rather than columns for the in-plane angle, to split the angular optimization into separate optimizations for the in-plane and out-of-plane angles, and to ensure that unoptimized target variables were not used in the optimization process. Some of the additional challenges discovered and faced during the process included events from the upstream carbon foil passing through the NMR coils and asymmetries in the focal plane variables that cannot be corrected with a finite number of matrix elements. For the events that passed through the pick-up coils, their momentum was shifted from the elastic peak. This effect is only a concern at low energy for the 6° data. At high energy and for the 9° data, the effect is not as important. In order to adequately optimize the upstream foil, I used a loose momentum cut with tight cuts on the sieve slit peaks. The asymmetries in the focal plane variables were more difficult to address.

Unfortunately I spent a lot of time trying to optimize the effect the asymmetries in the focal plane variables caused in the target variables. The asymmetries manifested themselves in the target region as a shift in the central row of the sieve slit data, which decreased with increasing ϕ_{tg}. This also had an effect on the y_{tg} reconstruction as a similar shift. There was also a clear position dependence in the shift. The downstream foil reconstruction was almost perfect, but the central foil and the upstream foil had a kink in the first two columns for the ϕ_{tg} reconstruction. After some discussion with John LeRose, the Hall A magnet expert, it was concluded that the effect was probably caused by a gap in the septum magnet coils resulting in a weaker field along the center of the θ_{tg} acceptance. The downstream foil is better reconstructed, since the tracks for this foil pass further away from the edge of the septum magnet aperture. Whereas the tracks for the central and upstream foil pass along the edge of the magnet's aperture. The effect for the 9° data was expected to be smaller and was found to be the case.

After I finished optimization for the first energy, I checked the reconstruction at the other elastic settings and found the reconstruction was less than adequate. So I then optimized the remaining settings for the 6° data and then the settings at 9°. After completing the optimization, there were still a few things that needed to be finalized. These final projects included fixing the shift in the central row, checking the optimization at 3 Gev for 9°, and creating a database prescription to correct for shifts between the elastic data sets. The second of these has been completed, and a correction was found that fixed the majority of the shift in the central row. This correction involved adding absolute value terms to the optimization process. The asymmetry in the focal plane was similar to an absolute value in the out-of-plane angle θ_{fp}. By adding these terms, I was able to remove the effect for the inner columns in the ϕ_{tg} reconstruction, and reduce the effect for the first column by half.

Though the majority of the past year was spent optimizing the database, significant progress in the NMR analysis for the Spin-Duality experiment was also made. I have attended and presented my work at the GDH2004 symposium and at the 58th Scottish Universities Summer School in Physics (SUSSP58). At the moment I am currently correcting the distortions in the ϕ_{tg} and y_{tg} reconstruction but will not optimize the first run period database, since a colleague from UVA is working on it. Soon I will begin the spectrometer acceptance study as well as the target polarization analysis for E97-110. Once the acceptance is finished, my work will proceed to the data analysis for the GDH integral. I have also advised the students working on the next polarized ^{3}He experiment. In the next month, I plan to begin writing my dissertation with a defense date for my Ph. D. in late 2005 or early 2006.