Designing and Simulating Wavelength Shifter Geometry in an Active Helium Target

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Final Report

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Scalar polarizabilities are fundamental characteristics closely related to the internal structure of nucleons. While the polarizabilities of the proton have been well studied, the neutron remains elusive due to the lack of a free-neutron target. Based at the Institute for Nuclear Physics in Germany, the A2 Collaboration has proposed a new active helium target filled with helium isotopes that would allow better access to the neutron. This design would allow for the collection of scintillation light within the active volume, which would reduce backgrounds. The blast of photons emitted from each collision are in the vacuum ultraviolet, while the silicon photomultipliers used only detect in the $200 - 900$ nm range. Thus, a wavelength shifting material is needed. This research examines potential configurations of wavelength shifting fibers to be placed within the target and simulates the light collection and output of each design. Monte Carlo and Geant4 simulations were carried out to compare scintillation light collection between prototypes. Once the target is built, the neutron scalar polarizabilities can be applied to help explain quantum chromodynamics in the non-perturbative region.

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Based in Germany, the A2 Collaboration is a nuclear physics research group that aims to experimentally determine specific nucleon polarization observables via Compton scattering. These fundamental characteristics, called polarizabilities, are determined by colliding real photons with nuclei and detecting the final state of the photons. While the polarizability results for the proton are well established, the neutron remains unsatisfactory. It was proposed that a new Active Helium target filled with helium isotopes would allow better access to the neutron. This design would allow for the collections of scintillation light within the active volume, which would reduce backgrounds. The firework of photons emitted from each collision are in the vacuum ultraviolet, while the silicon photomultipliers used detect in the 200 – 900 nm range. Thus, a wavelength shifting material is needed. This research examines potential configurations of wavelength shifting fibers to be placed within the target and simulates the light collection and output of each design.

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Nucleon Polarizability Extraction via Compton Scattering - Meg Morris (Mount Allison University)

The A2 collaboration at the Institute for Nuclear Physics in Mainz, Germany, is experimentally determining the polarizabilities of nucleons in the grand pursuit of better understanding the strong interaction between quarks and gluons. Precise measurement of the neutron scalar polarizabilities has been a long-standing challenge due to the lack of a free-neutron target. Lead by the University of Glasgow and the Mount Allison University groups of the A2 collaboration, preparations have begun to test a recent theoretical model with a high-pressure, active helium target with the hope of determining these elusive quantities with small statistical, systematic, and model-dependent errors. Apparatus testing, including the evaluation of new photomultiplier tubes and a study of the effect of nitrogen concentrations on detector response, and background-event simulations have been carried out with the full experiment projected to run in 2015. Once determined, these values can be applied to help understand quantum chromodynamics in the non-perturbative region.