

Results from Polarized Proton and Neutron Double-Polarization Experiments at LEGS

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A solid, polarized HD target has been developed for the measurement of double-polarization observables in the Δ resonance region at the Laser Electron Gamma Source (LEGS). The Strongly Polarized Hydrogen deuteride ICE target, SPHICE, combined with the high quality LEGS photon beam and the large acceptance spectrometer, SASY, provides a unique facility for studying the spin structure of the nucleon below 500 MeV.

Considerations of forward Compton scattering leads to the Gerasimov Drell-Hearn (GDH) and the forward spin polarizability, γ_0 , sum rules. Due to the Δ dominance in the helicity reaction cross sections, and the energy weighting of the integral, these sum rules are dominated by single pion production. The most general expression for the cross section on a longitudinally polarized target is a product of $\frac{d\sigma}{d\Omega}$ and a function of the three asymmetries $\Sigma(\theta; E_\gamma)$ (linear beam polarization, unpolarized target), $G(\theta; E_\gamma)$ (linear beam polarization and longitudinally polarized target), and $E(\theta; E_\gamma)$ (circular beam polarization and longitudinally polarized target). To disentangle these asymmetries from data obtained with beam polarizations less than 100% requires measurement with four linear (0° , 90° , $\pm 45^\circ$) as well as left and right circular polarizations. This is readily done at LEGS by randomly cycling the laser polarization through all six states. Data collected in this way with a longitudinally polarized $\vec{H}\vec{D}$ target permits the extraction of $\frac{d\sigma}{d\Omega}$, Σ , G and E from *both the proton and neutron simultaneously*.

SASY, the Spin-ASYmmetry detector array, determines angle, energy, and particle identity for all reactions induced by photons on hydrogen and deuterium over the entire LEGS energy range. The major calorimetry subsystems are instrumented: the crystal box (an array of 432 NaI(Tl) crystals), and a forward wall of plastic scintillator ($\approx 30\%$ neutron efficiency) and Pb-Glass Čerenkov counters. Atomic events are rejected by a gas Čerenkov at 0° and an Aerogel detector covering angles out to 30° . The space between the target cryostat and the crystal box is filled by a scintillator, azimuthally segmented in 32 sections, extending the neutron coverage to 90° .

The target used for the experiments we report here was polarized at ≈ 18 mK and 15 T for 40 days. The T_1 for \vec{H} measured in-beam (1.25 K/0.65 T) is 13 days and for \vec{D} it is 36 days. The initial polarization obtained for hydrogen was 70%. Due to the numerous tests and manipulations done on this first target, this first three day data run used an $\vec{H}\vec{D}$ target with initial in-beam polarizations of $P_H = (30 \pm 3)\%$ and $P_D = (6 \pm 1)\%$. A preliminary analysis of pion production from both the proton and neutron is presented. The helicity cross section difference for the proton is compared with the published data and with multipole analyses.