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Precision Mott Polarimetry

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High-Precision 5 MeV Mott Polarimetry at CEBAF+
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*We report on the design and performance of a Mott polarimeter optimized for a nominal 5-MeV electron beam from the CEBAF injector. The rf time structure of this beam allows the use of time-of-flight in the electron detection, making it possible to isolate those detected electrons that originate from the scattering foil, and resulting in measured scattering asymmetries which are exceptionally stable over a broad range of beam conditions, beam currents, and target foil thicknesses. In two separate series of measurements from two different photocathode electron sources, we measured the Mott scattering asymmetries produced by an approximately 86% transversely polarized electron beam incident on ten Au foils with nominal thicknesses between 50 and 1000 nm. The statistical uncertainty of the measured asymmetry from each foil is below 0.25%. Within this statistical precision, the measured asymmetry was unaffected by ±1-mm shifts in the beam position on the target, and by beam current changes and dead-time effects over a wide range of beam currents. The overall uncertainty of our beam polarization measurement, arising from the uncertainty in the value of the scattering asymmetry at zero foil thickness as determined from our fits to the measured asymmetries versus scattering foil thicknesses, the estimated systematic effects, and the (dominant) uncertainty from the calculation of the theoretical Sherman function, is 0.61%. GEANT4 calculations give results for the asymmetry versus foil thickness in good agreement with our measurements. Future measurements at different beam energies and with target foils of different atomic numbers will seek to bound uncertainties from small effects such as radiative corrections to the calculation of the polarimeter analyzing power. A simultaneous high-precision measurement of the beam polarization with a different polarimeter, AESOP (Accurate Electron Spin Optical Polarimeter), under development at the University of Nebraska, is expected to allow a high-precision comparison of our measured asymmetries with theoretical calculations of the Mott analyzing power. Finally, the improved precision of the current Mott polarimeter along with similar improvements to other Jefferson Lab GeV-energy polarimeters warrants another "Spin Dance" precision comparison of all of these polarimeters.*This work was done in collaboration with J. M. Grames1, C. K. Sinclair1, M. Poelker1, X. Roca-Maza2, M. Stutzman1, R. Sulieman1, Md. A. Mamun1,3, M. McHugh4, D. Moser1, J. Hansknecht1, B. Moffit1, and Keith Foreman5.
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