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High Precision 5 MeV Mott Polarimeter

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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 Continuous Electron Beam Accelerator Facility (CEBAF) injector. The rf time structure of this beam allows the use of time of flight in the scattered electron detection, making it possible to cleanly 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 foil thicknesses. In two separate series of measurements from two different photocathode electron sources, we have measured the Mott scattering asymmetries produced by an approximately 86% transversely polarized electron beam incident on ten gold 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 foil, 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%. A simulation of the polarimeter using GEANT4 has confirmed that double scattering in the target foil is the sole source of the dependence of the measured asymmetry on foil thickness, and gives a result for the asymmetry versus foil thickness in good agreement with both our measurements and a simple calculation. Future measurements at different beam energies and with target foils of different atomic numbers to bound uncertainties from small effects such as radiative corrections to the calculation of the polarimeter analyzing power will also be discussed.

“High precision 5 MeV Mott polarimeter”, J. M. Grames, C. K. Sinclair, M. Poelker, X. Roca-Maza, M. L. Stutzman, R. Suleiman, Md. A. Mamun, M. McHugh, D. Moser, J. Hansknecht, B. Moffit, and T. J. Gay, *Phys. Rev. C* 102, 015501 –Published 6 July 2020

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