RECENT MEASUREMENTS WITH THE JEFFERSON LAB 5 MeV MOTT POLARIMETER*

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We report on recent experience with a 5 MeV Mott scattering polarimeter to monitor electron beam polarization in the CEBAF Injector. At 5 MeV the effective analyzing power of a 100 nm gold foil is close to the calculated single-scatter analyzing power -0.522 (at θ=172.6°). Statistical uncertainties of order 1% are achieved quickly since elastic signal rates at 2 μA CW are high. Recent chamber modifications and signal electronics changes have improved signal-to-noise. Calibration work continues. A variety of measurements are feasible which affect machine operations, polarized source development and serve the facility user community.

A Mott scattering polarimeter is installed in Jefferson Lab's Injector beam line in the 5 MeV region. [1] The design takes advantage of elastic cross-sections which allow quick polarization measurements at μA beam currents and produce only minimal multiple and plural scattering from 100 nm thick gold foils. The large analyzing power (-0.522 at $\theta = 172.6°$) and elastic event rate (1 kHz/μA on a 1.0 μm Au foil) make rapid, precise beam polarization measurements feasible.

Recent changes in the scattering chamber and beam dump have improved signal-to-noise ratio. When a 1.0 μm Au target is used, there is very clean separation between the elastic peak and the low energy background in typical pulse height spectra. The addition of time-of-flight (TOF) measurement to the signal electronics has been especially fruitful. One source of background is scattered electrons from the beam dump material located downstream of the thin target foil. A large fraction of the incident beam passes through the target foil and is dumped 1.5 m farther downstream in a dipole B-field. A fraction of the back-scattered electrons return to the foil and are detected some 11 nsec later than the elastically scattered electrons from the foil.

The rf gain-switched diode laser that drives the JLab photo-emission source was operated at 124.75 MHz to allow the TDC electronics to clearly distinguish the elastics from the beam dump background. The data acquisition electronics can be triggered to include only signals in time with the elastics. The beam polarization was measured both with and without the TOF in the trigger; little difference was recorded when using the 1.0 μm gold target foil. This implies that the background subtraction algorithm in the analysis software is fairly robust.

The 5 MeV Mott polarimeter is regularly used by Accelerator Operations staff to verify the beam polarization and the spin-axis angle before injection into the first linac. This angle is set by a 100 keV Wien filter apparatus calibrated to 1% by measuring the transverse component of the polarization for several Wien B-field settings. The curve fitted to the data is a sine function with amplitude, period and phase as free parameters to be fit. This so-called 'spin dance' can be performed while delivering beam to the experiment halls where beam polarization is measured with high energy Moller polarimeters.

There are three benefits to these measurements. First there is measured confirmation of simultaneous polarized beam delivery to three halls at different energy. Second, it is possible to deliver simultaneous longitudinal spin in the experiment halls for certain select linac energies. [2] The spin precession ΔS through any bend angle θ depends on the linac energy in γ, the electron's Lorentz factor: $\Delta S = \gamma[(g-2)/2]\theta$. Measured phase offsets in the spin dance curves can reveal errors in the linac energy of 0.2%. The third outcome is a cross-calibration of the different polarimetry methods assuming no beam depolarization in the arcs.

The beam polarization was measured 20 times using the Mott polarimeter during the HAPPEX Collaboration's one month run during which a 10 ppm parity violating asymmetry was measured in elastic scattering from a liquid hydrogen target. [3] The variations in beam polarization as a function of the quantum efficiency (QE) of the bulk GaAs wafer provide insight into the problem of photocathode aging mechanisms. One hypothesis is that ions created in the gun's residual gas bombard the GaAs and damage the crystal below the surface. [4] The increase in beam polarization which accompanies a decrease in QE due to 10-20 C charge extraction implies damage within the crystal (depth $\sim 1\ \mu$m) as opposed to surface degradation.

One procedure for calibrating the polarimeter is to perform a foil thickness extrapolation on a series of asymmetry measurements using one target material; here, gold. See Fig. 1. The four measurements were fit to the inverse function $A = A_0/(1+\alpha t)$ where t is the foil's thickness. There is little uncertainty in the calculated analyzing power for a single scattering off gold. The finite nuclear size correction for Z=82 at 5 MeV reduces the analyzing power approximately 1.2% . [5] We interpret A_0 to be the single-scatter analyzing power so diminished or -0.514. The value of α, the thickness coefficient of the inverse functional form, depends upon the scattering cross-section, angle, energy and target material. A study of 14 MeV Mott scattering polarimetry shows α=0.03 cm^2/g measured at 172° on Pb (Z=82). [6] The 5 MeV Au

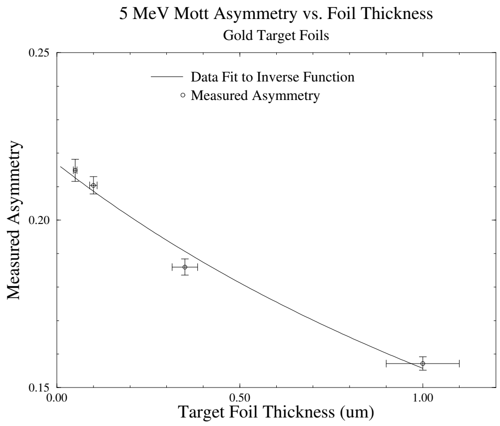

Figure 1: Measured Au asymmetry vs. Au foil thickness.

foil scattering α is 0.2 cm^2/g. This is partially explained by the lower elastic cross-section at 14 MeV compared to 5 MeV.

Similar asymmetry measurements with silver and copper foils (Z=47,29) are nearly complete. Preliminary results show good agreement with gold when scaled to the same calculated single-scattering analyzing power and to the same Moliere scattering width, w. The Moliere width scales as $[NZ(Z+1)]^{1/2}$, where N is the target thickness and Z is the atomic number. [7]

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1. J. S. Price, *et al*, Seventh International Workshop on Polarized Beams and Polarized Gas Targets AIP Proc. No. 421, eds. Roy J. Holt, Michael A. Miller, 1997, 446.
2. C. K. Sinclair, JLab Tech Notes 96-032 (1996), 97-021 (1997).
3. E. Burtin for HAPPEX, this proceedings.
4. B. Dunham, *et al*, Proceedings of the Advanced Accelerator Concepts Workshop, July 6-11, 1998, Baltimore, MD, in press.
5. P. Uginicius, *et al*, Nucl. Phys. A**158** (1970) 418.
6. D. Conti, *et al*, AIP Proc. No. 421 (1997), 326.
7. A. O. Hanson, *et al*, Phys. Rev. **84** (1951) 634.