A High Precision Mott Polarimeter at 5 MeV

[handwritten annotations: "hyphen" with arrow pointing to "High-Precision"; "Polarimetry" written above "Polarimeter" (crossed out)]

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[handwritten: "J." inserted before Gay]

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[handwritten: "Jorgensen Hall" with arrow pointing to Physics Department]

[handwritten note at right: "¿ Isn't there an earlier NIM paper on the apparatus? If so, this paper should be emphasizing the measurements, not the machine per se"]

We report on the design and performance of a Mott polarimeter optimized for operation at ~~a nominal~~ 5 MeV electron beam energy. Using beam with a 31.1875 MHz time structure from the 1497 MHz CEBAF electron injector, and incorporating time-of-flight in the electron detection, we can isolate the detected electrons that originate from the scattering foil. This background elimination results in very stable asymmetry measurements over a wide range of beam conditions and foil thicknesses. We have measured the scattering asymmetry produced by a ~ 85% transversely polarized electron beam incident on a range of gold foil thicknesses from 96 μg/cm^2 to 1.93 mg/cm^2. The statistical uncertainty of each measurement was below 0.25%. We confirmed that within this statistical precision, the measured asymmetry was unaffected by +/- 2 mm shifts in the beam position on the target, by beam current changes, and by deadtime effects over a wide range of beam currents. By extrapolation of our results to zero foil thickness we are able to confront calculations of the analyzing power – known as the Sherman function - with high precision.

[handwritten: "not true" with bracket beside the last sentences]

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Note: I have started writing on parts of this, and though I cannot write all of it on my own, I am very willing to be the "editor" to put together the final document from various contributions. Since I'm the only person without a day job, this may make some sense.

Content that must be included in the Mott polarimeter paper (not necessarily in correct order).

1. The physical construction of the polarimeter

   a. The scattering chamber, optimized for 5 MeV (i.e. 172.6° scattering angle)
   b. Internal collimation
   c. Target ladder and foils
   d. OTR viewport
   e. Beam dump, including long channel and dump magnet
   f. The detector packages (four ports)
   g. Shielding

[handwritten note at bottom: "See my earlier note. Our measurement at a given energy tells us nothing about S. Even a suite of measurements taken at varying energies only gives us indirect evidence for how well the theory is doing – through the functional form of its energy dependence."]

h. vacuum

I always liked the fact that this polarimeter allowed one to monitor the position of the beam on the target. Does this come in under d) above?

2. Detector electronics, including TOF details

3. The polarized source and injector (only basic descriptions, but including details relevant to polarization and its measurement)

   a. The gun, cathode, (including laser spot size at cathode and QE map?), and 130 kV operation (vs. original design at 100 kV?)
   b. Wien filters and solenoids
   c. The laser system, including details of 31.1875 (and 62.375) MHz operation and the IHWP
   d. Chopping, bunching, capture, and quarter cryomodule
   e. Beam monitoring and transport to polarimeter and spectrometer (including BPMs), and measured beam properties (emittance, E, dE, spot size at foil)
   f. Beam current measurements (F. cups, BCM)

4. Setup of polarization with Wien and solenoids, data collection, online analysis, and final offline analysis, including complete details of E counter spectra and TOF, event selection, etc.

5. Systematic studies (deadtime, PITA, IHWP, position change, sign of dump dipole, polarization stability measurements during run) *‖ !*

6. Details of foils used and their thickness measurement *!*

7. Experimental results – measured asymmetry versus measured foil thickness and hyperbolic fit to data

8. GEANT model of the polarimeter and its performance, including generation of a fit to the data from first principles

9. Calculated Sherman function and its uncertainties, and comparison with model and experimental data

10. Mention the spin dance and intercomparison of very different polarimeters (coupled with essentially zero polarization degradation in transport thru CEBAF)

11. Summary and Conclusions

12. Future plans (measurement with different Z foils, and at different energies)

→ needs a careful explication of uncertainties in the calculated Sherman function