ABSTRACT

Experiment E158 at SLAC will make the first measurement of parity violation in Møller scattering. The left-right cross-section asymmetry in the elastic scattering of a 45-GeV polarized electron beam with unpolarized electrons in a liquid hydrogen target will be measured to an accuracy of better than 10⁻⁶, with the expected Standard Model asymmetry being approximately 10⁻⁷. An intense circularly polarized laser beam for the photocathode electron source is required with the ability to quickly switch between left and right polarization states with minimal left-right asymmetries in the parameters of the electron beam. This laser beam is produced by a unique SLAC-designed, flashlamp-pumped, Ti:Sapphire laser. We present this laser system design and initial results from the recent commissioning run.

Optical Pulse Shaping

A polarizer pair and a Pockels cell are used to ‘slice’ out a 370ns pulse from the ~20 µs long Flash:Ti laser pulse. Slicing occurs at the amplitude jitter minimum region. The ‘Slice’ pockels cell is also used for intensity control. A second Pockels cell (TOPS) with fast electronics and polarizer allows for shaping of the pulse profile. A trapezoidal pulse shape is needed to achieve a flat energy profile in the electron beam due to beam loading effects.

Helicity Control

A pair of Pockels cells (CP and PS with 45° relative orientation of their fast axes) can generate arbitrary elliptical polarization and are used to generate circularly polarized light of either helicity at the photocathode. The "Asymmetry Inverter" inverts the spatial profile and angle of the laser beam leaving the polarization optics, providing a means of cancelling helicity-correlated systematics introduced by the CP and PS cells. The half-wave plate reverses the sign of the laser beam’s helicity, providing another means of systematics cancellation. The "Intensity Asymmetry" (IA) Pockels cell can be pulsed differently for left and right helicity pulses. It is used for a feedback on the helicity-correlated intensity asymmetry. The "Piezomirror" is mounted on 3 piezoelectric stacks such that its angle can be adjusted differently for left and right helicity pulses.

Performance of Helicity Feedbacks

Integrated helicity-correlated intensity asymmetry and position difference feedback results for ~8hrs of data. Smooth curves represent expected error bars for 1/N2 scaling. Feedbacks compensate for statistical noise, causing integrated asymmetry to converge to zero faster than with statistical scaling alone.

E158 uses a strained-lattice GaAs photo - cathode. The quantum efficiency depends on the orientation of linear polarization of the incident light. Significant charge asymmetries result from the cathode’s analyzing power coupled with small asymmetries in linear polarization for the ‘left’ and ‘right’ laser beams. The linear polarization can be adjusted by small changes to the CP or PS offset voltages. Optimizing these voltages for best laser circular polarization typically yields 1000ppm charge asymmetries. The CP and PS voltages are tuned to reduce this asymmetry to less than 100ppm. The Intensity Asymmetry feedback with the IA cell is then used to further reduce the asymmetry to << than 1ppm.

Results are currently limited by statistics acquired. "Intensity asymmetry" provides a means of cancelling helicity-correlated systematics provided by the CP and PS cells. The "Piezomirror" is mounted on 3 piezoelectric stacks such that its angle can be adjusted differently for left and right helicity pulses. The mirror’s angle is adjusted by a piezoelectric stack. The "Intensity Asymmetry" (IA) Pockels cell can be pulsed differently for left and right helicity pulses. It is used for a feedback on the helicity-correlated intensity asymmetry. The "Piezomirror" is mounted on 3 piezoelectric stacks such that its angle can be adjusted differently for left and right helicity pulses. The mirror’s angle is adjusted by a piezoelectric stack. The "Intensity Asymmetry" (IA) Pockels cell can be pulsed differently for left and right helicity pulses.