**ABSTRACT**

The Compton polarimeter at Jefferson Lab’s experimental Hall A provides continuous, non-invasive measurement of electron beam polarization via electron photon scattering. The electron beam passing through the polarimeter intercepts a green laser light stored in a Fabry-Perot cavity. Scattered electrons are detected in an electron detector while back scattered photons are detected in a GSO crystal calorimeter. For an accurate beam polarization measurement, the laser polarization inside the Fabry-Perot cavity must be well known. We have performed studies to optimize the laser polarization inside the cavity and to know it precisely.

**FROM ASYMMETRIES TO POLARIZATION**

- The Cross section of Compton scattering is different for right and left circularly polarized electrons on polarized photons. 
  \[ A_{\text{meas}} = \frac{p_x}{p_z} A_{\text{compton}} \]
  
  - We use this asymmetry to calculate beam polarization.
  \[ A_{\text{meas}} = p_x p_A \]
  
  Where, \( p_x \) is laser/electron beam polarization

**DETERMINATION OF CAVITY BIREFRINGENCE**

- To measure cavity birefringence we prepare known input states & measure the polarization after the 2nd cavity mirror.
  \[ P_{\text{final}} = M_{\text{cav}} P_{\text{initial}} \]
  
  - Due to geometrical locking-servo constrains we had to use a non polarizing beam splitter (NPBS).
  
  - Unfortunately NPBS has some birefringence so must be characterized.

**HALL A COMPTON SETUP**

- Four dipole magnets bend electron beam through a chicane.
- Electron beam collides with green laser locked to a Fabry-Perot optical cavity.
- Detect scattered electrons and backscattered photons separately.

**FABRY-PEROT CAVITY**

- Fabry-Perot cavity is a resonator which consists of two high reflective mirrors that form a standing light waves between them.
- Due to constructive interferences, the laser power circulating in the cavity will be enhanced with respect to the laser power coupled to it.

**COMPTON LASER SYSTEM**

- Narrow line width 1064 nm seed laser
- Fiber amplifier
- PPLN doubling crystal
- High gain Fabry-Perot cavity
- Polarization manipulation/ monitoring optics

**LASER POLARIZATION**

- Optical reversibility allows configuring system to give 100% DOCP at the cavity.
- Scanning combination of half & quarter wave plates and monitoring the reflected power, we can build a model for the entrance function → developed during Qweak

- Unlike Qweak when locking the cavity we saw backreflected light from cavity increasing implying possible polarization change between cavity locked and unlocked.
  
  Evidence for Cavity Birefringence in Hall A Fabry-Perot Cavity

**NPBS CHARACTERIZATION**

- Measured stokes parameters of light transmitted through NBPS for several initial states.
- The laser polarization was set to left and right circular, horizontal, vertical and +/- 45 deg.
- Linear and measured stokes parameters using rotating QWP + fixed polarizer technique.

**CAVITY BIREFRINGENCE**

- While doing the QWP/HWP scans we came across another interesting mystery → depolarization in the air at high cavity power.
- We continue the polarization study at low power due to this effect.
- Performed scans for different QWP/HWP states.
- Used the NPBS inverted matrix to infer the initial polarization before the NPBS from measured stokes parameters.

**TESTING CAVITY DOCP MODEL**

- With cavity birefringence and entrance function, can predict DOCP in cavity and determine optimum settings for left and right circular polarization.
  \[ P_{\text{cav}} = M_{\text{cav}} M_{\text{p}} P_{\text{initial}} \]
- Ran PREX-II & CREX experiments at these optimal positions.
- Model of polarization in cavity can be tested using asymmetry data from polarimeter.
- From the preliminary data we can see a good agreement (data under analysis).

**SUMMARY**

- We use a Fabry-Perot cavity for Compton polarimetry measurements at Jefferson Lab hall A.
- Laser polarization inside the cavity is a key source of systematic uncertainty that must be controlled.
- Previous technique of measuring the polarization suffers from birefringence changes due to mechanical stresses.
- We have a new technique to determine the laser polarization inside a Fabry-Perot cavity which measures the cavity birefringence directly.
- Tested the model of cavity polarization with asymmetry data taken during PREX-II & CREX running
- Good agreement with data to model.