A Fabry-Perot Cavity for HALL A Compton Polarimeter Upgrade

By: Botao Jia Duke University
botaoj@jlab.org

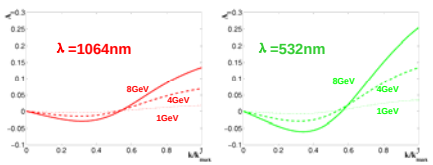
Jefferson Lab

Review

At Jefferson Lab the electron beam polarization in Hall A is measured by using a Compton polarimeter in which the electron beam is scattered from the phontons trapped in a high finesse Fabry-Perot cavity.

Upgrade Motivation

The upcoming Pb Radius Experiment demands polarization measurement of a lower energy (0.85 GeV) electron beam at **1% accuracy**, which can not be achieved by the IR (**1064 nm**) laser Compton Polarimeter presently operating in Hall A. The upgrade will employ a green (**532 nm**) laser cavity with higher intra cavity power to reduce the measurement uncertainty as well as increase the figure of merit.



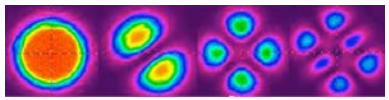
$$\frac{\Delta P_e}{P_e} \propto \frac{1}{A_L}$$

The Fabry-Perot Cavity

Why we need a laser cavity ?

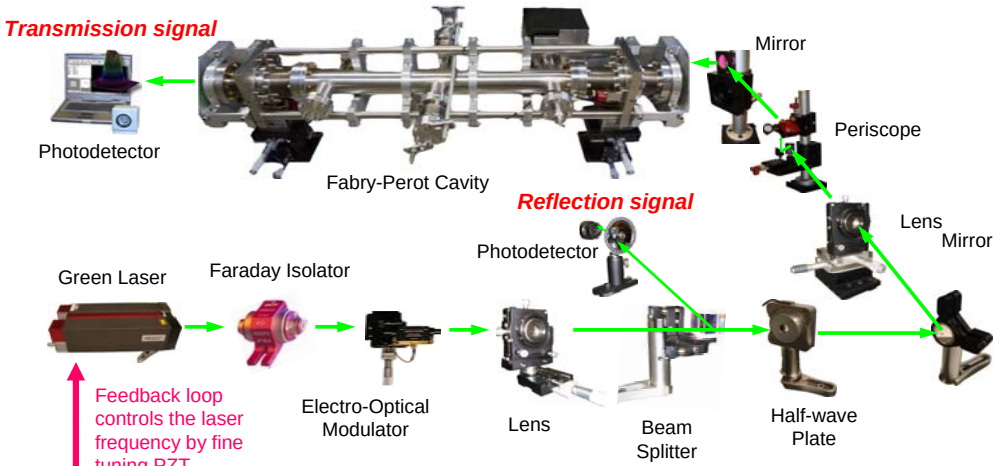
The function of the cavity is to amplify the power of the outside continous wave laser by a large factor so that "a high density photon target" can be built inside the cavity to increase the luminosity significantly. To maintain a constant resonance at TEM_{00} mode is a necessity, which is so called “lock”.

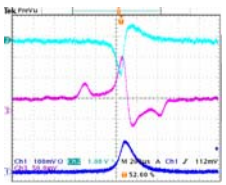
Transverse Intensity Modes of the Laser in the Cavity



TEM_{00} TEM_{01} TEM_{11} TEM_{12}

How to lock the laser to the cavity ?





The well-known **Pound-Drever Hall (PDH)** feedback loop is applied to continuously tune the laser frequency to follow the variations in cavity length so that the cavity can always operate at its resonance peak.

Challenge

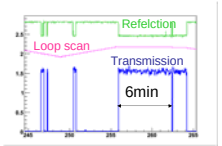
Cavity Specifications

Intra cavity power	1.5 kW
Gain	15,000
Length	0.85 m
Finesse	**49,000**
Mirror Reflectivity	**99.9936%**

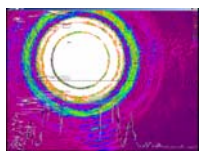
For such high cavity mirror reflectivity, even if the cavity length changes by several **angstroms**, the lock can be totally lost. This requires a high resolution piezo-electric transducer and an accurate feedback control loop which are able to follow the cavity change in the rang of several times of hydrogen radius.

Summary

- Minutes level locking has been achieved. The longest record so far is 6 minutes by using testing mirrors.
- Hours level locking is under development.



Locking monitored via Epics



Snapshot of the intra cavity laser beam mode during lock