Hall A Compton Polarimeter

1 Introduction

The Hall A Compton Polarimeter provides electron beam polarization measurements in a continuous and non-intrusive manner using Compton scattering of polarized electrons from polarized photons. A schematic layout of the Compton polarimeter is shown in Fig.1. The primary features of the Compton polarimeter are:

1. A vertical magnetic chicane with four dipole magnets to transport the CEBAF electron beam to the Compton Interaction Point (CIP).

2. A high-finesse Fabry-Perot (FP) cavity serving as the photon target, located at the lower straight section of the chicane with the cavity axis at an angle of 24 mr with respect to the electron beam.

3. An electromagnetic calorimeter to detect the back-scattered photons.

4. A Silicon micro-strip electron detector to detect the recoil electrons, dispersed from the primary beam by the third dipole of the chicane.

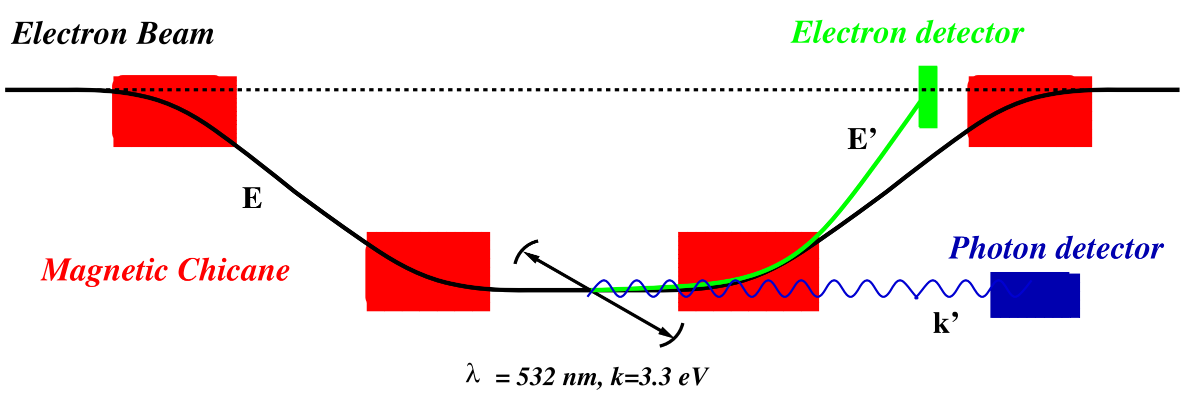

Figure 1: Schematic layout of the Compton polarimeter

The electron beam polarization is deduced from the counting rate asymmetries of the detected particles. The electron and the photon arms provide redundant measurement of the electron beam polarization.

In the recent years the Compton polarimeter has undergone a major upgrade [1] to green optics, in order to improve the accuracy of polarimetry for high precision parity violating experiments at lower beam energies. While maintaining much of the the existing infrastructure of the Saclay design, the green laser upgrade replaced the original low power 1064 nm FP cavity with a higher power 532 nm system. In addition, the electron detector, photon calorimeter, and data acquisition system were also upgraded to achieve beam polarimetry at the level of 1% accuracy, down to ∼1 GeV beam energy. The new systems have been operating successfully in Hall A beam line with several kW of cavity power for the past few years. As part of the 12 GeV upgrade of CEBAF, the Hall A Compton polarimeter has been reconfigured to accommodate the 11 GeV electron beam available to Hall A. The primary changes to the Compton Polarimeter for the 12 GeV Upgrade are:

- Reduction of the Chicane displacement from 300 to 215 mm. The change in geometry allows the 11 GeV beam to be transported through the existing dipole magnets while necessitating the raising of the two middle dipole magnets, the optics table, and the photon detector by 85 mm.

- Increase in the electron arm acceptance to allow detection of Compton edge in the electron detector with green laser photons.

- Synchrotron radiation blocker for the electron detector in the straight through beam line after the first chicane dipole.

- Suppression of synchrotron radiation background for the photon calorimeter with addition of field plates to all four dipole magnets that soften the fringe fields seen by the photon detector.

The installation of the 12 GeV Compton Polarimeter Upgrade has been completed and the new configuration commissioned during the DVCS experiment running from 2014-2016.

2 Principle of Operation

The Compton effect, light scattering off electrons, discovered by Arthur Holly Compton (1892-1962), Nobel prize in Physics, 1927, is one of the cornerstones of the wave-particle duality. Compton scattering is a basic process of Quantum Electro-Dynamic (QED), the theory of electromagnetic (EM) interactions. During 50's and 60's, the QED theoretical developments allow Klein and Nishina to compute accuratly the so-called Compton interaction cross section. Experimental physicists performed serveral experiments which are in good agerement with the predictions. This is now a well established theory, and is thus natural to use the EM interaction, such as Compton scattering, to measure experimental quantities such as polarization of an electron beam .

Many of the Hall A experiments of Jefferson Laboratory using a polarized electron beam require a measurement of this polarization as fast and accurate as possible. Unfortunately the standard polarimeters, like Møller or Mott, require the installation of a target in the beam. Therefore, the polarization measurement can not to be performed at the same time as the data taking because the beam, after the interaction with the target, is misdefined in terms of polarization, momentum and position. Another physical solution has to be found in order to permit a non-invasive polarization measurement of the beam. This is the primary motivation for Compton Polarimetry.

This physical process is well described by QED. The cross sections of the polarized electrons scattered from polarized photons as a function of their energies and scattering angle can be precisiely calculated. The cross sections are not equal for parallel and anti-parallel orientations of the electron helicity and photon polarization. The theoretical asymmetry A_{th} defined as the ratio of the difference over the sum of these two cross sections is then the analyzing power of the process. With the kinematical parameters used at JLab, the mean value of this analyzing power is of the order of few percent.

The polarization of the Jefferson Lab electron beam is flipped up to 2000 times per second. Upon interation with a laser beam of known circular polarization, an asymmetry, $A_{exp} = \frac{N^+ - N^-}{N^+ + N^-}$, in the Compton scattering events $N^\pm$ detected at opposite helicity. In the following, the events are defined as count rates normalized to the electron beam intensity within the polarization window. The electron beam polarization is extracted from this asymmetry via

$$P_e = \frac{A_{exp}}{P_\gamma A_{th}}, \tag{1}$$

where P_γ denotes the polarization of the photon beam. The measured raw asymmetry A_{raw} has to be corrected for dilution due to the background-over-signal ratio $\frac{B}{S}$, for the background asymmetry A_B and for any helicity-correlated luminosity asymmetries A_F, so that A_{exp} can be written to first order as

$$A_{exp} = \left(1 + \frac{B}{S}\right) A_{raw} - \frac{B}{S} A_B + A_F. \tag{2}$$

The polarization of the photon beam can be reversed with a rotatable quarter-wave plate, allowing asymmetry measurements for both photon states, $A_{raw}^{(R,L)}$. The average asymmetry is calculated as

$$A_{exp} = \frac{\omega_R A_{raw}^R - \omega_L A_{raw}^L}{\omega_R + \omega_L}, \tag{3}$$

where $\omega_{R,L}$ denote the statistical weights of the raw asymmetry for each photon beam polarization. Assuming that the beam parameters remain constant over the polarization reversal and that $\omega_R \simeq \omega_L$, false asymmetries cancel out such that

$$A_{exp} \quad \simeq \quad \frac{A_{raw}^R - A_{raw}^L}{2}(1 + \frac{B}{S}). \tag{4}$$

Using a specific setup, the number of Compton interactions can be measured for each incident electron's helicity state (aligned or anti-aligned with the propagation direction). These numbers are dependent on process cross sections, luminosity at the CIP and time of the experiment. To first order, assuming the time and luminosity are equal for the both electron helicity states, the counting rate asymmetry is directly proportional to the theoretical cross section asymmetry. The proportionnality factor is equal to the values of the photon circular polarization P_γ multiplied by the electron polarization P_e, so that measuring the photons polarization and experimental asymmetry, calculating theoretical asymmetry, one can deduce the electron beam polarization. One electron out of a billion is interacting with the photon beam which means 100000 interactions per second. So as only few incident electrons are interacting, these polarization measurements are completly non-invasive for the electron beam in term of positions, the orientations and the physical characterictics of the beam at the exit of the polarimeter. The backward scattering angle of the Compton photons being very small, the first priority is to separate these particles from the beam using a magnetic chicane. The energy of the backward photons will be measured by an electromagnetic calorimeter. At low energies, a single GSO crystal is used while at higher energies a higher density crystal is required. At present, a 4 block array of lead-tungstate crystals is under investigation. Both the GSO and lead-tungstate detectors are assembled and maintained by Carnegie-Mellon University. The third dipole of the chicane, coupled to the electrons detector, will be used as a spectrometer in order to measure the scattered electron momentum. To perform a quick polarization measurement, the photon flux has to be as high as possible. A Fabry-Perot Cavity, consisting of a pair of multi-layer concave mirrors with very high reflectivity, will amplify this flux to a factor greater than 10,000. The 15 meter long Compton Polarimeter has been installed in the last linear section of the arc tunnel, at the entrance of Hall A.

3 Description of Components

As shown in Fig.1, the Compton polarimeter consists of four major subsystems and associated data acquisition system. Illustrated in Fig.2 are the geometrical dimensions for the plan and elevation view of the various elements of the 12 GeV Compton polarimeter. Shown in Fig.3 is a view of the completed Compton polarimeter from the first chicane dipole end, after the 12 GeV Upgrade.

The subsystems of the Compton Polarimeter are described below:

3.1 Magnetic Chicane

The Compton magnetic chicane, illustrated in Fig.4, consists of 4 dipoles (1.5 T maximum field, 1 meter magnetic length) here after called D1,2,3,4.

(D1,D2) deflect the electrons vertically down to steer the beam through the Compton interaction point (CIP) located at the center of the optical cavity. After the CIP, the electrons are vertically up deflected (D3,D4) to reach the Hall A target. The scattered electrons are momentum analyzed by the third dipole and detected thanks to 4 planes

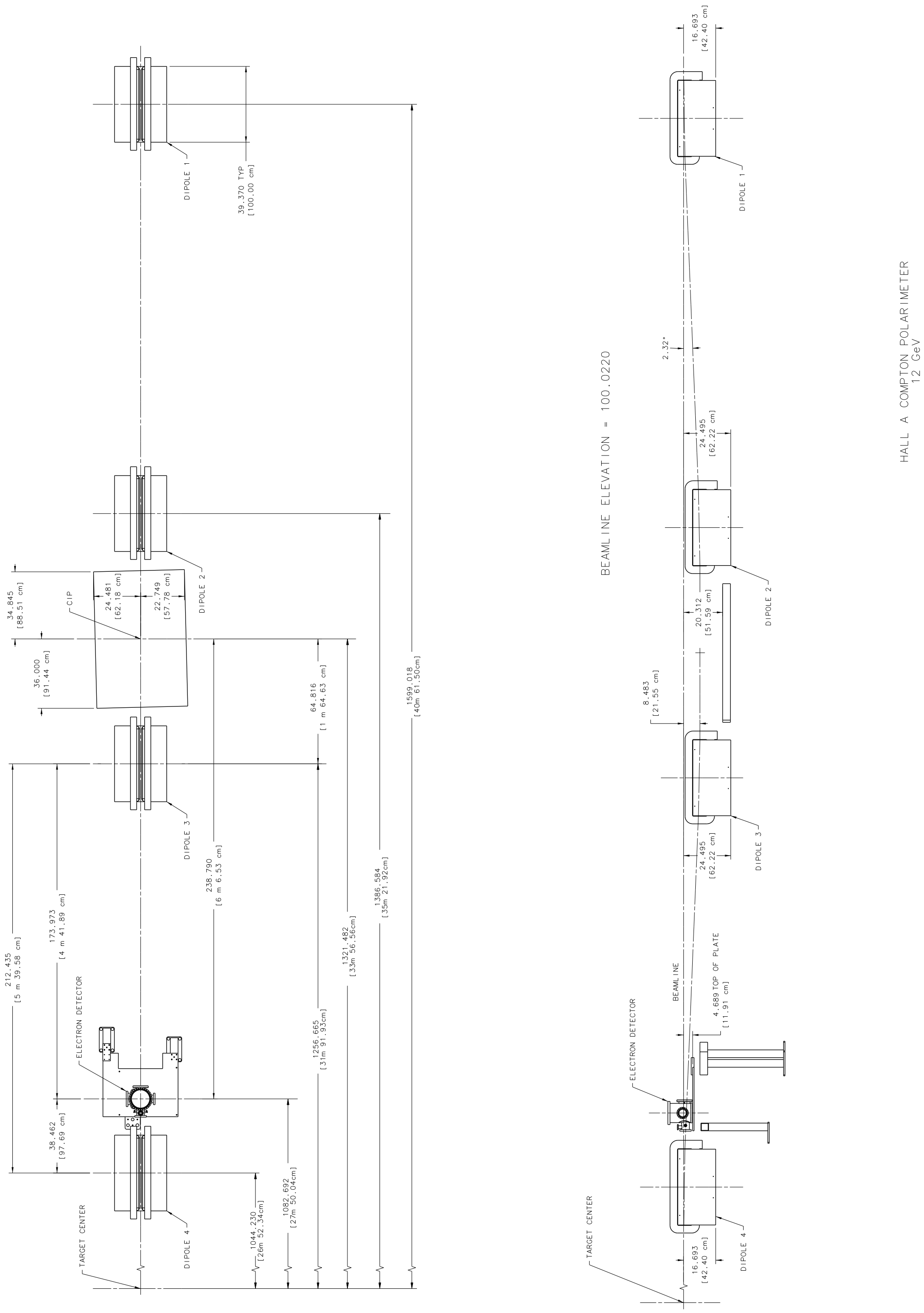

Figure 2: Plan and elevation geometrical views of the 12 GeV Compton polarimeter

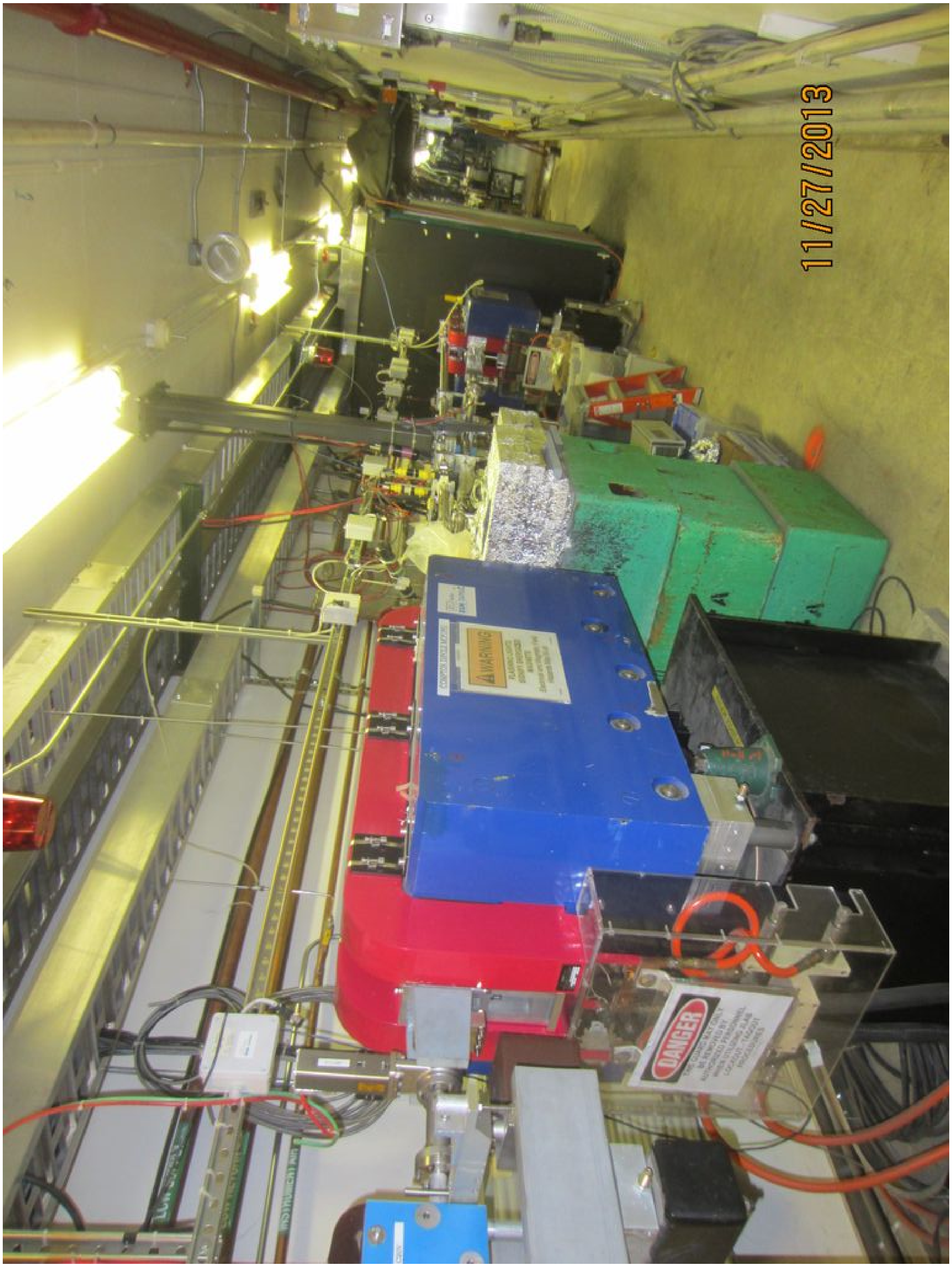

Figure 3: Image of the Compton Polarimeter viewed downstream from the fisrt chicane dipole. The laser hut containing the optical setup is in the background.

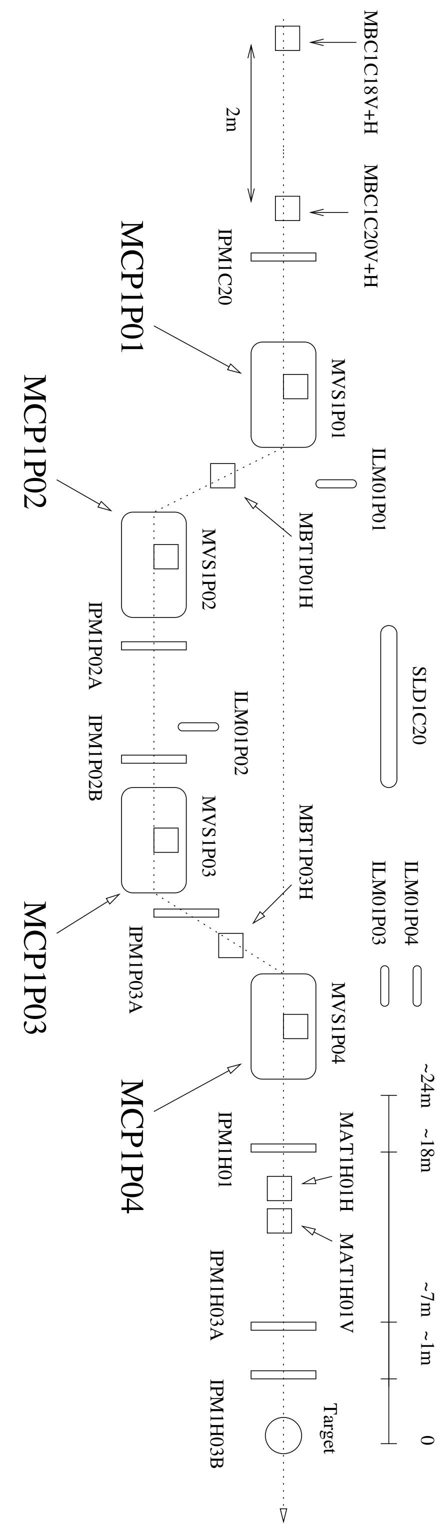

Figure 4: Schematic layout of the beamline elements along the compton chicane area.

of silicon strips. The magnetic field is scaled with the beam energy, ensuring the same vertical deflection at the CIP, up to 11 GeV electrons for 1.5 T field. The parameters of the Chicane are as follows:

- The longitudinal magnetic length on the axis of (D1,MMC1P01) and (D2,MMC1P02) is 1000 mm.
- The distance between the geometrical axis of the dipoles (D1,MMC1P01) and (D2,MMC1P02) in the longitudinal plane is 5400 mm
- The distance between the beam entry axis in (D1,MMC1P01) anfd the beam exit axis in (D2,MMC1P02) in the bending plane (vertical axis), also know as the chicane displacement, is 215 mm.
- The bending angle is 2.35°

With higher energy of the 12 GeV Upgrade, synchrotron radiation in the Compton chicane increases dramatically both in flux and energy leading to dilution of the Compton scattering signal in the detectors. The synchrotron radiation can be suppressed with the addition of passive iron plates in the fringe field region of the dipole magnets to reduce the magnetic field seen by the detectors, thus reducing synchrotron radiation background to manageable level. Shown in Fig. 5 is a schematic representation of the synchrotron radiation background and its suppression scheme. Dipole magnet D1 poses a potential source of synchrotron radiation for the electron detector via the straight-through beam line, where as D2 and D3 produce similar background for the photon detector. These radiations will be softened with the addition field plates and reduced in flux with absorbers. Dipole magnets D1-D4 have been modified with fringe field plate P1-P4. All four field plate pairs are identical in geometry, thus preserving the symmetry of the chicane as before the upgrade. New field integrals were measured after the installation of the fringe plates. The EPICS control database for the magnets have been updated with the new field maps.

A new valve, VBV1P01B, acts as the synchrotron radiation absorber for the straight through beam line. Lead and/or Iron absorbers, matched to the beam energy, are installed external to the scattered photon beam line, for the photon detector.

3.2 Optics table

A high-finesse Fabry-Perot cavity housed on a optics table serves the role of the photon target. The optical setup consists of four parts:

1. Green Laser operating at 532 nm wavelength generating up to 3 W power,
2. Input optical transport form the laser beam to the cavity to optimize laser beam size and polarization,

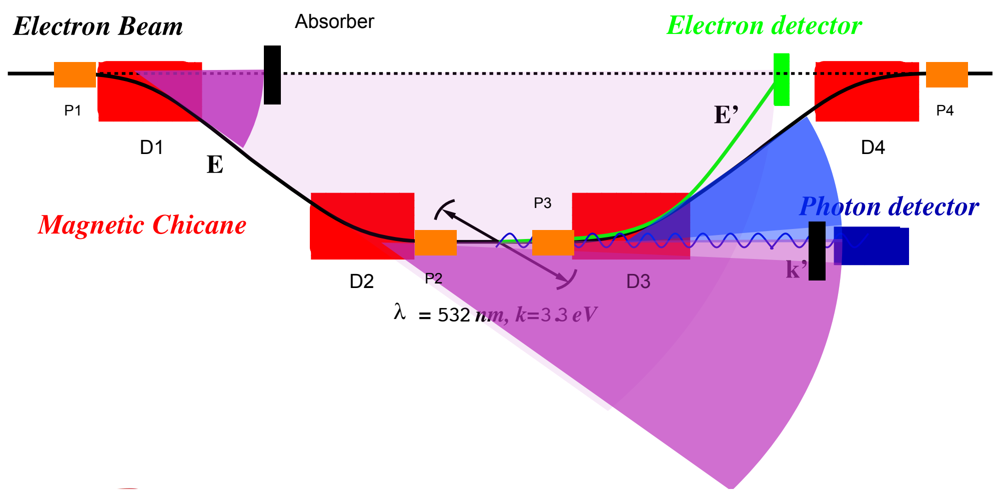

Figure 5: Illustration of synchrotron radiation suppression scheme with fringe field modifying field plates P1-P4, attached to dipole magnets D1-D4. A combination of reduced magnetic field seen by the detectors and absorbing material attenuates synchrotron radiation flux to negligible levels.

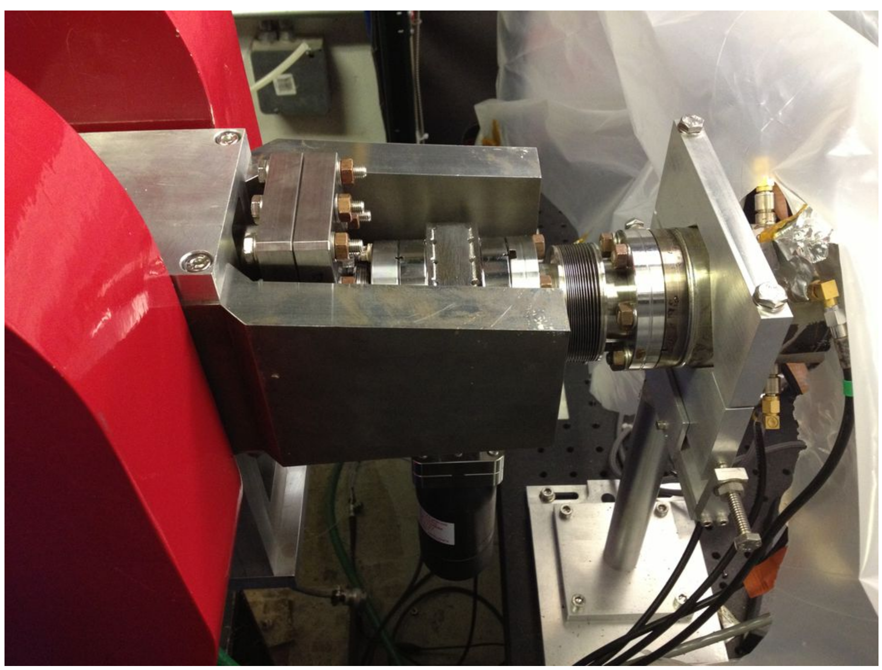

Figure 6: Field plates P2, as installed on the second chicane dipole D2. All four dipoles have identical set of field plates installed.

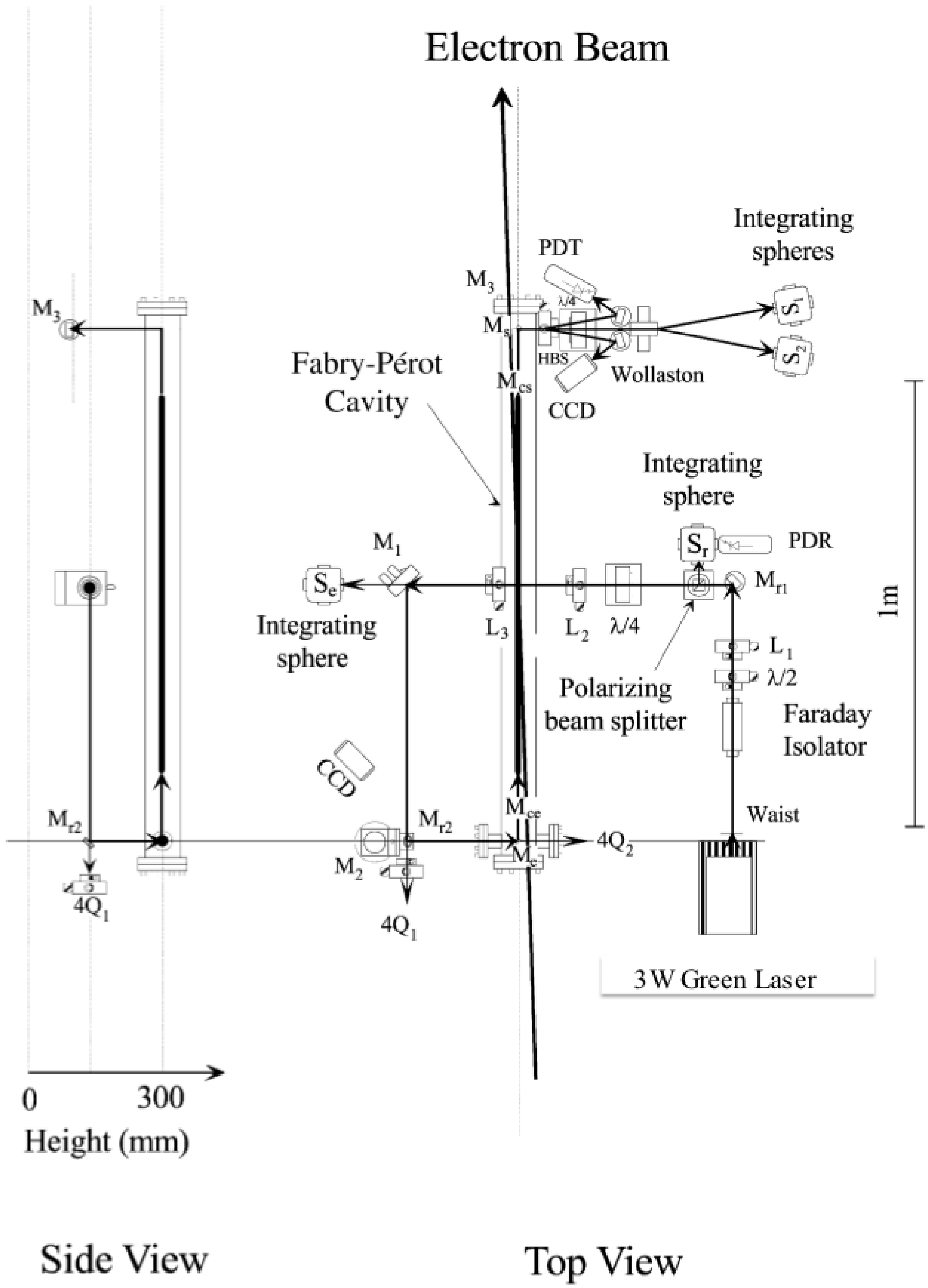

Figure 7: Optics setup of the Compton polarimeter

3. The resonant Fabry-Perot cavity that delivers more than 10 kW of circularly polarized green light
4. Optical devices to measure the circular polarization of the photons at the exit of the cavity

The layout of the optical setup is shown in Fig.7. Details of the resonant Fabry-Perot cavity for Compton polarimetry can be found here. [2]. Expert operations of the initial tuning of lasers and optics, which is beyond the scope of routine operations described in this document, is governed by a separate Laser Standard Operations Procedure [3].

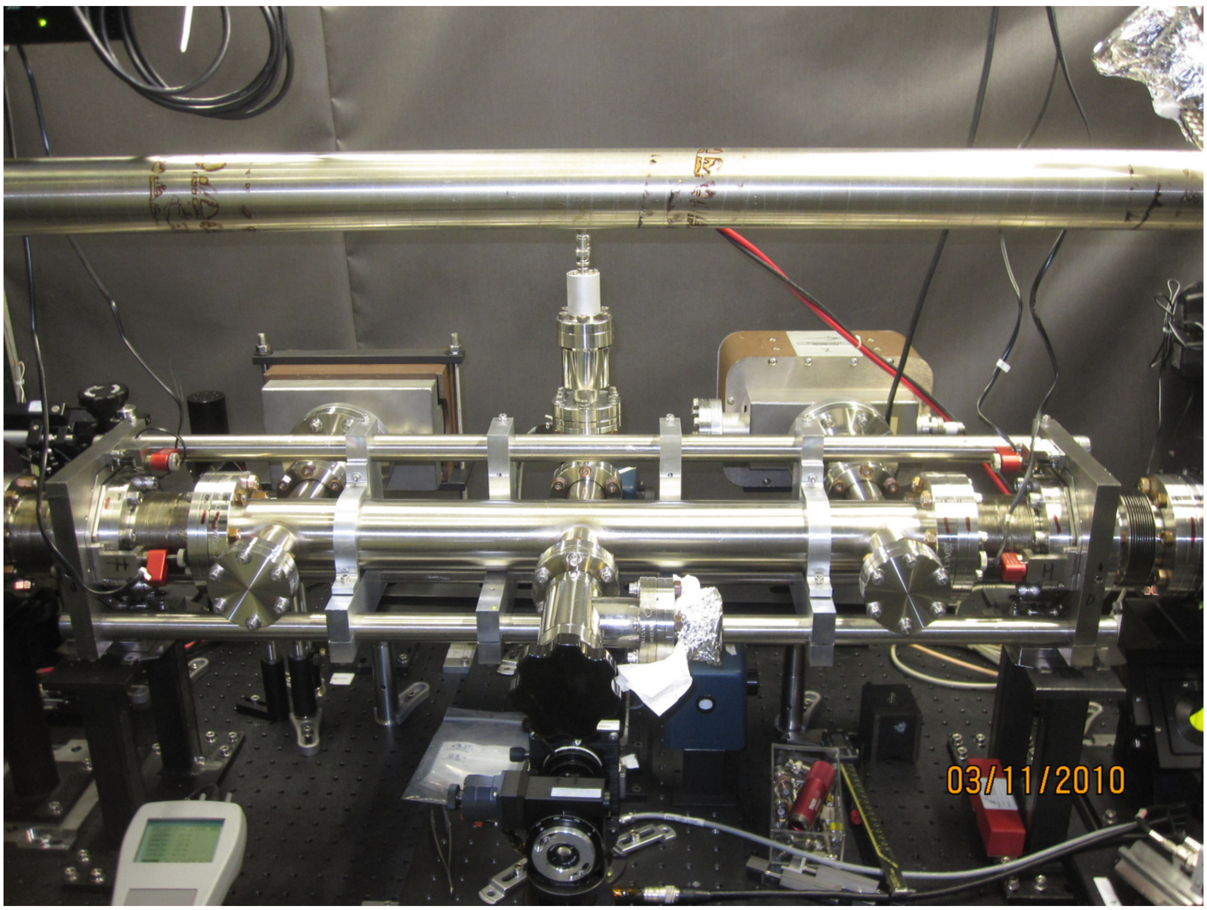

Figure 8: The new 532 nm high finesse Fabry-Perot resonating cavity installed on the optics table inside the laser hut in the Hall A Compton Polarimeter.

3.3 Photon Detector

To detect the Compton backscattered photons, an electromagnetic calorimeter is used. For low energy measurements, the calorimeter consists of a single GSO crystal, 60 mm in diameter and 150 mm in length, coupled to a single photomultiplier tube. Higher energy measurements will require a different crystal; the ideal choice is still under study, but tests have been performed most recently with a 2x2 array of lead tungstate crystals (also coupled to a single photomultiplier tube). The calorimeter is installed (Fig. 9) just behind the third dipole of the chicane. The backscattered photon are transported to the calorimeter via a telescoping beam pipe with a maximum diameter of 1.5 inch. The beam pipe is terminated with a vacuum window and a lead collimator with configurable absorbers to stop soft photons including synchrotron radiation. This configuration provides adequate acceptance from 1 to 11 GeV.

In addition, a pair of finger scintillator and iron converter combination, arranged in an XY configuration, are installed in front of the calorimeter. The entire assembly is mounted on a remote controlled motorized table with vertical and horizontal motion capabilities. The moving mechanism is used to scan for the peak of the back-scattered photons using the finger scintillators.

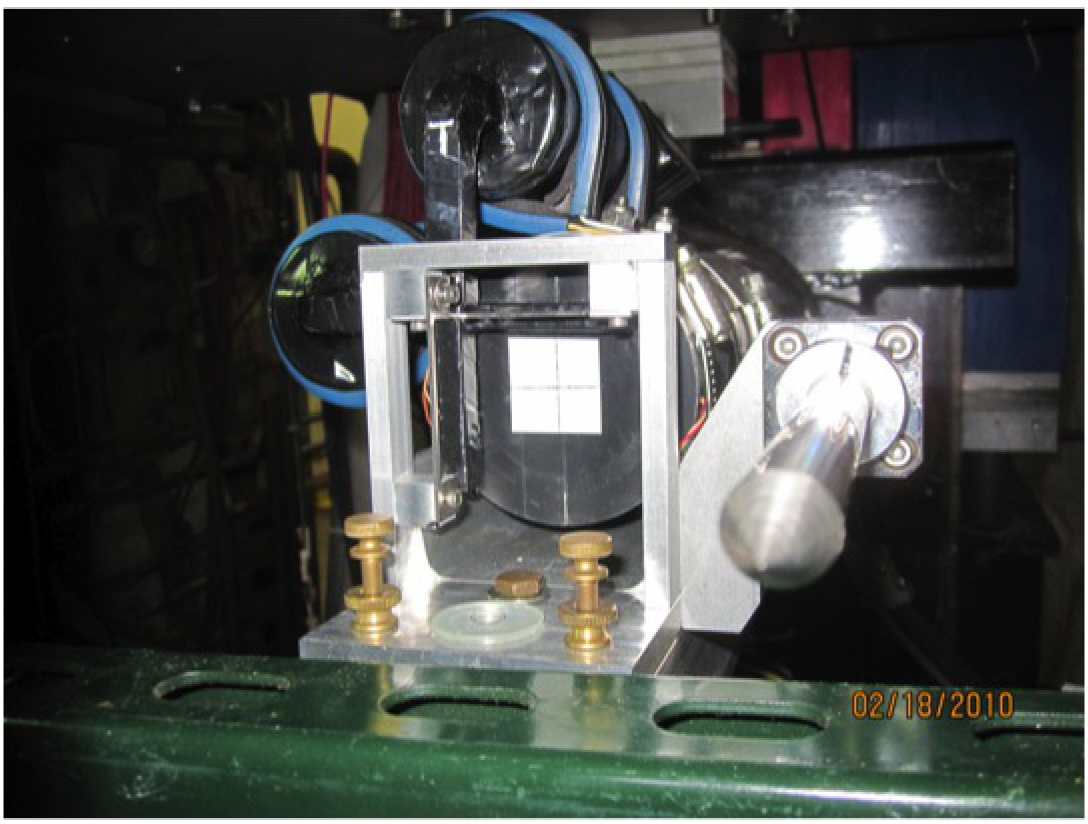

Figure 9: View of the Compton photon GSO Calorimeter.

3.4 Electron detector

The electron detector is made up of 4 planes of Silicon micro-strips composed of 192 strips each. The micro-strips have 240 μm pitch (200 μm Silicon, and 40 μm spacing), on a 500 μm thick Silicon substrate, manufactured by Canberra systems. The planes are staggered by 80 microns to allow for better resolution. Shown in Fig. 10 is a schematic view of the electron detector. The detector is mounted in a vacuum chamber on a vertically movable shaft. A motion control system moves the detector to the appropriate location for the detection of Compton scattered electrons for a given electron beam energy. The detector can be positioned as close as 4 mm to the primary electron beam in order to allow for low energy Compton polarimetery. The external view of the installed electron detector chamber in the Hall A beam line is shown in Fig. 11

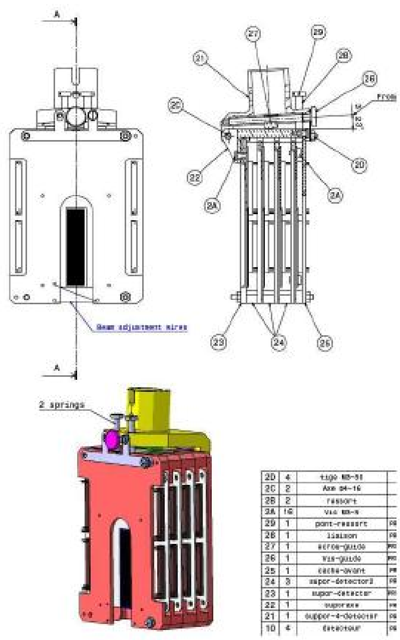

Figure 10: Schematic view of the 4-plane Silicon-mocrostrip Compton electron detector

Illustrated in Fig.11 is a view of the actual electron detector. Distance between the CIP and the first strip is 5750 mm. We recall that between the CIP and the end of the Dipole 3 is 2150 mm. For a beam of 3.362 GeV the Compton edge is at 3.170 GeV. This corresponds to a deviation of 17 mm. Thus at this energy, only one half of the Compton spectrum is covered and it extends to the 13th strip of the first plane. The trigger logic looks for a coincidence between a given number of plane in a "road" of 2 strips. For each trigger it outputs a signal check by the Polarimeter DAQ.

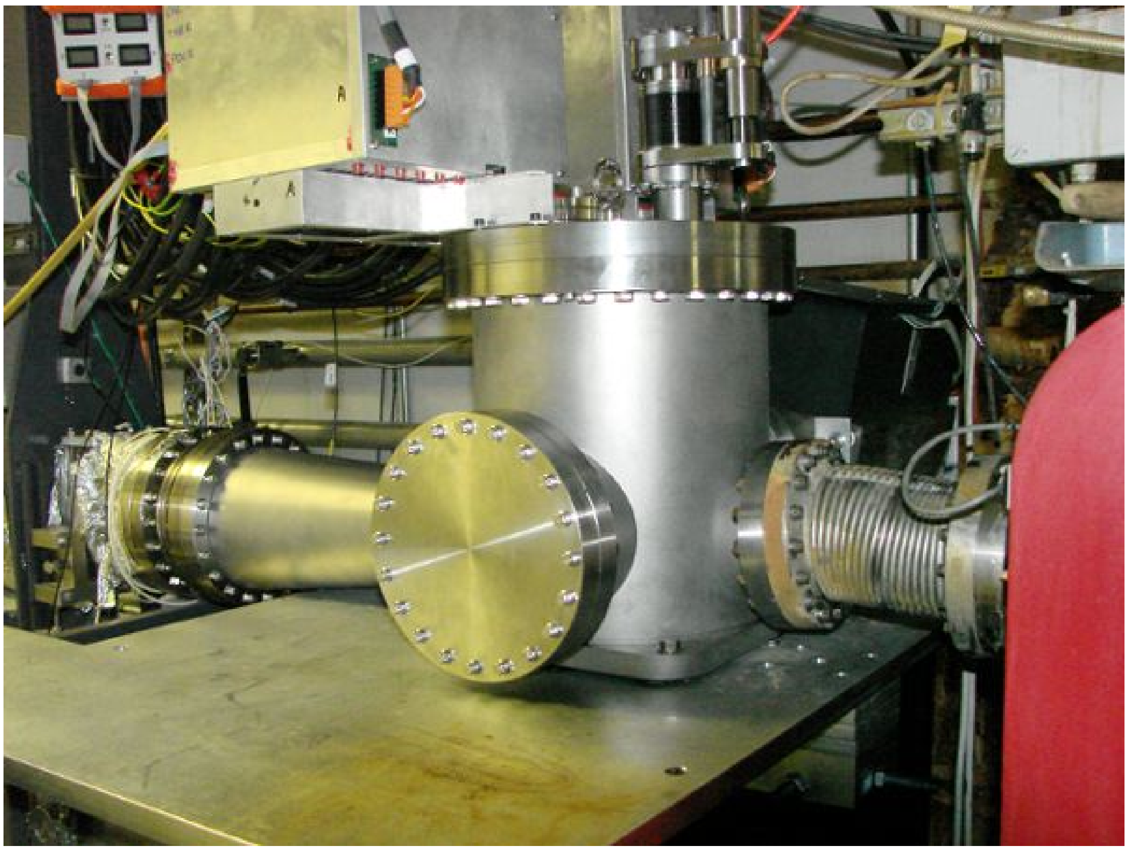

Figure 11: View of the Compton electron detector vacuum chamber installed upstream of the 4th chicane dipole. The vertical motion control system and the front end electronics are mounted on top of the chamber

3.5 Data Acquisition System

At present, the Hall A Compton polarimeter relies primarily on the "integrating mode" data acquisition developed by Carnegie Mellon University and JLab for thresholdless, readout of the integrated photon detector signal. This system is based on a Flash ADC system running at 250 MHz. It can also read out the photon detector in "sampling" mode, providing event-by-event information at lower rates.

A fast, counting DAQ for the both the electron and photon detectors is under development. This DAQ will be based on JLab-designed modules (flash ADC for the photon detector and custom logic board for the electron detector) and allow event-mode read out at up to 100 kHz. This DAQ is currently in the testing stages and not yet fully deployed.

The electronics for the Compton DAQ systems are located in two electronics racks 1H75B18 and 1H75B19in Hall A as shown in Fig.12. The data acquisition systems use CODA [5] software for online acquisition.

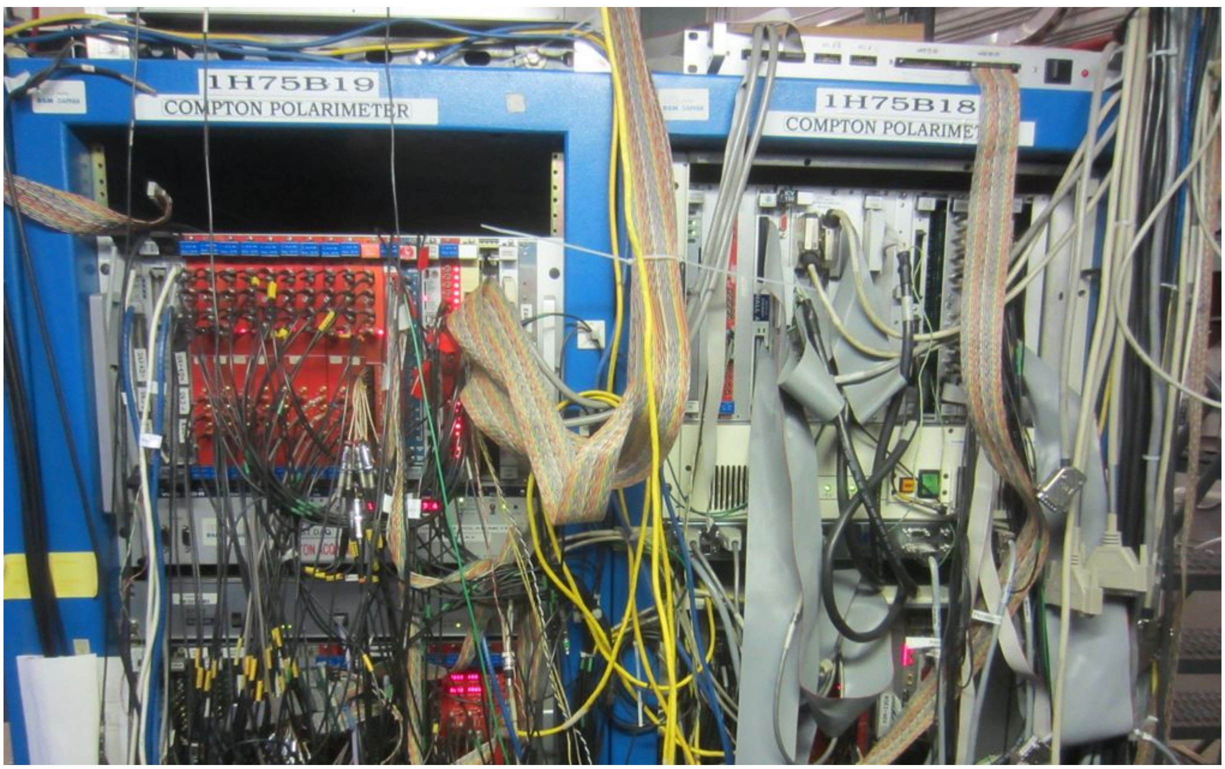

Figure 12: The Compton Polarimeter data acquisition electronics located in racks 1H75B18 and 1H75B19.

4 Operating Procedure

The main computer for the compton polarimeter operations, is compton.jlab.org located in the central isle of the Hall A counting house. A dedicated console display, labelled as Compton, is in the backroom. This machine, running RedHat Enterprise Linux, runs the compton data acquisition, analysis, and the EPICS [4] slow control system. To begin compton polarimeter activity log on to:
machine: compton.jlab.org
username: compton
password: *******(contact Dave Gaskell (6092))

All necessary environment variables are automatically defined on logon. Follow the steps below paying careful attention to ensuring that you have checked the result of each step:

4.1 DAQ Setup

- Go to the CODA desktop and open a new terminal window. Type

  $ startcoda

  All relevant CODA processes are started and you would get the **runcontrol panel**.
- Click on the **Connect** button. You will get the window shown in
- Click on the **Configure** button and you will get the run-type sub-panel
- Click on the **Run type** button and choose "**FADC_prod**" as the configuration.
- Confirm via the "**OK**" button You should see in the window below the following message "transition configure succeeded"
- Click on the "**Download**" Button
- Click "Prestart"
- Start the run by clicking on the "**Start Run**" button
  You should see the run control display Check that the following happens:

  transition Go succeeded
  the counting rates distribution
  the number of events in this run is updating
  the run status *active*
  the run number updated

- To end a run, click on End Run button to stop the acquisition and answer the questions in the end of run panel.

4.2 Cavity Setup

Choose the EPICS desktop and in a fresh terminal window and start the EDM [?] EPICS panel by executing the command:

$ NewTools

Navigate to: **EDM (HLA Main)** → **JMenu (HLA)**
From the JMenu gui, navigate to: **Hall A** → **Compton** → **Controls**
This will open the main EPICS menu for the Compton as shown in Fig.13.

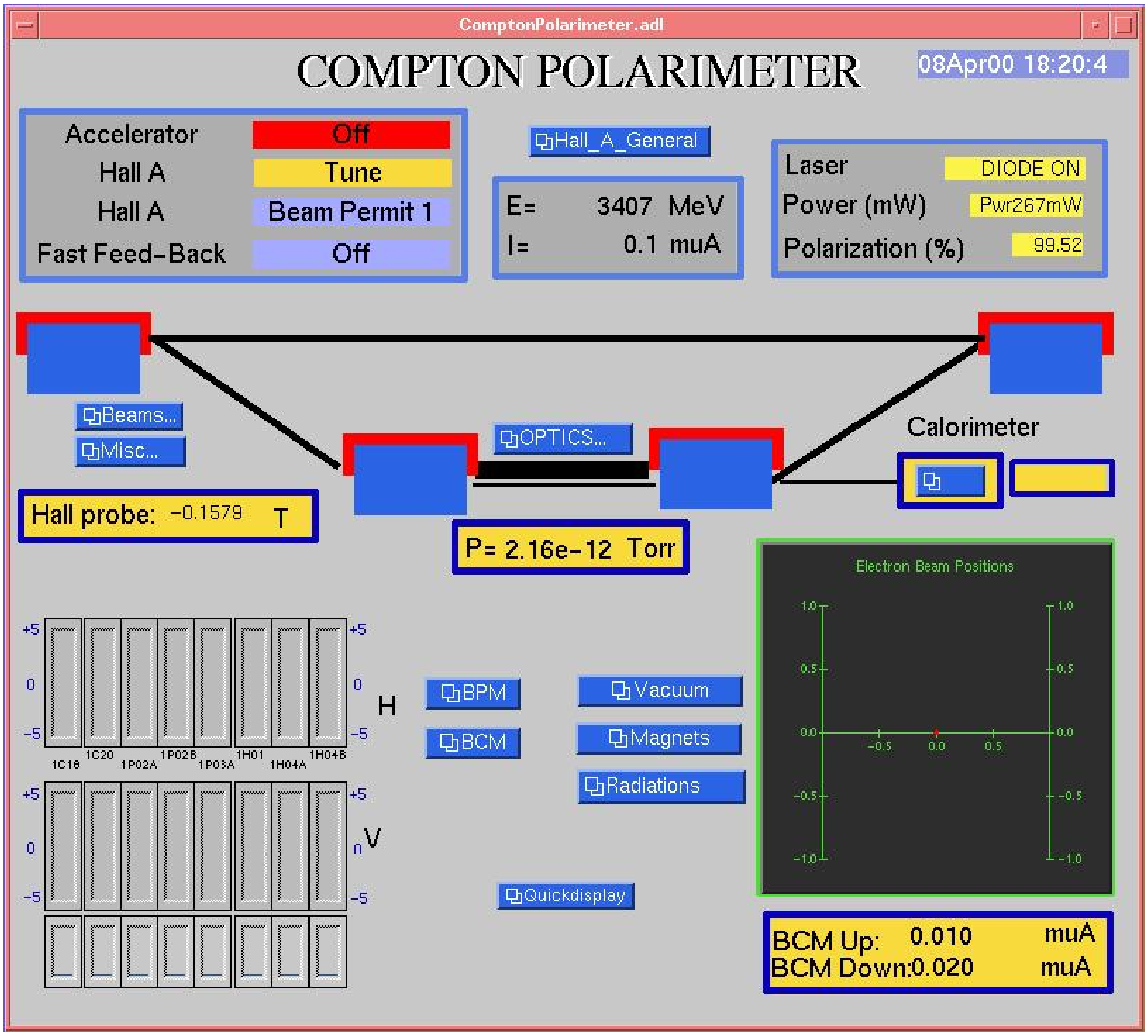

Figure 13: Compton polarimeter main EPICS control panel

On the control panel, pull the "OPTICS" menu down. Click on "Optics Table"

This will bring up the **OpticTable** EPICS control panel as shown in Fig.14. Most functions of the lasers and optical setup may be accessed remotely from this control panel.

Initial setup and calibrations of the optical setup are done by laser trained experts in the laser hut following the LSOP [3]. For an already tuned up system, routine operations may be accessed from the simpler "mini optics" control panel as shown in Fig.15 , which can be invoked as follows:

pull down the "OPTICS" menu from the main control panel. Click on "Mini Optic"

- **Switch on the laser**

  To turn the Laser On .... Click on the Laser On button.
  Check LASER STATUS and INCIDENT POWER.
  A Laser spot may blink on the CCD control TV screen
  (second from left among the 4 screens)
  and you should see a bright spot on the miror control TV screen labelled "laser."
  (see Fig.16).

  If Laser doesn't turns ON most problable problem is an interlock fault. You need an access in Hall A and check the different parts of the laser interlock around the optic table:
  Two crash buttons on the left wall, inside and outside the laser hut.

- **Lock the cavity**

  To lock the cavity click on the Servo On button shown in Fig.15. You should see the cavity locking on the CCD control TV as in Fig.17, and you should have more than 4 kW stored in the optical cavity.

  If it isn't the case, turn on the Slow Ramp and then Click on the Slow On button shown in Fig.15.

  If successful you can turn OFF the Slow Ramp button.
  Photons are now ready to meet electrons and give some Compton photons children.

  If the cavity still doesn't lock after few minutes with SERVO and Slow Ramp ON: Check the Yokogawa generator in the Compton rack (CH01B00). Frequency should be 928 kHz, Amplitude 80 mVpp and phase -4 deg. Pull down the OPTICS menu in the main epics window. Click on "Optic table" and then on "Servo". The laser servo control panel appears.Gain should be close to 167. A too high traking level in the feedback can prevent the cavity from locking. Bring the "tracking Level" cursor down to low values (0.20 - 0.40) and try to lock again with Servo and Slow Ramp on.

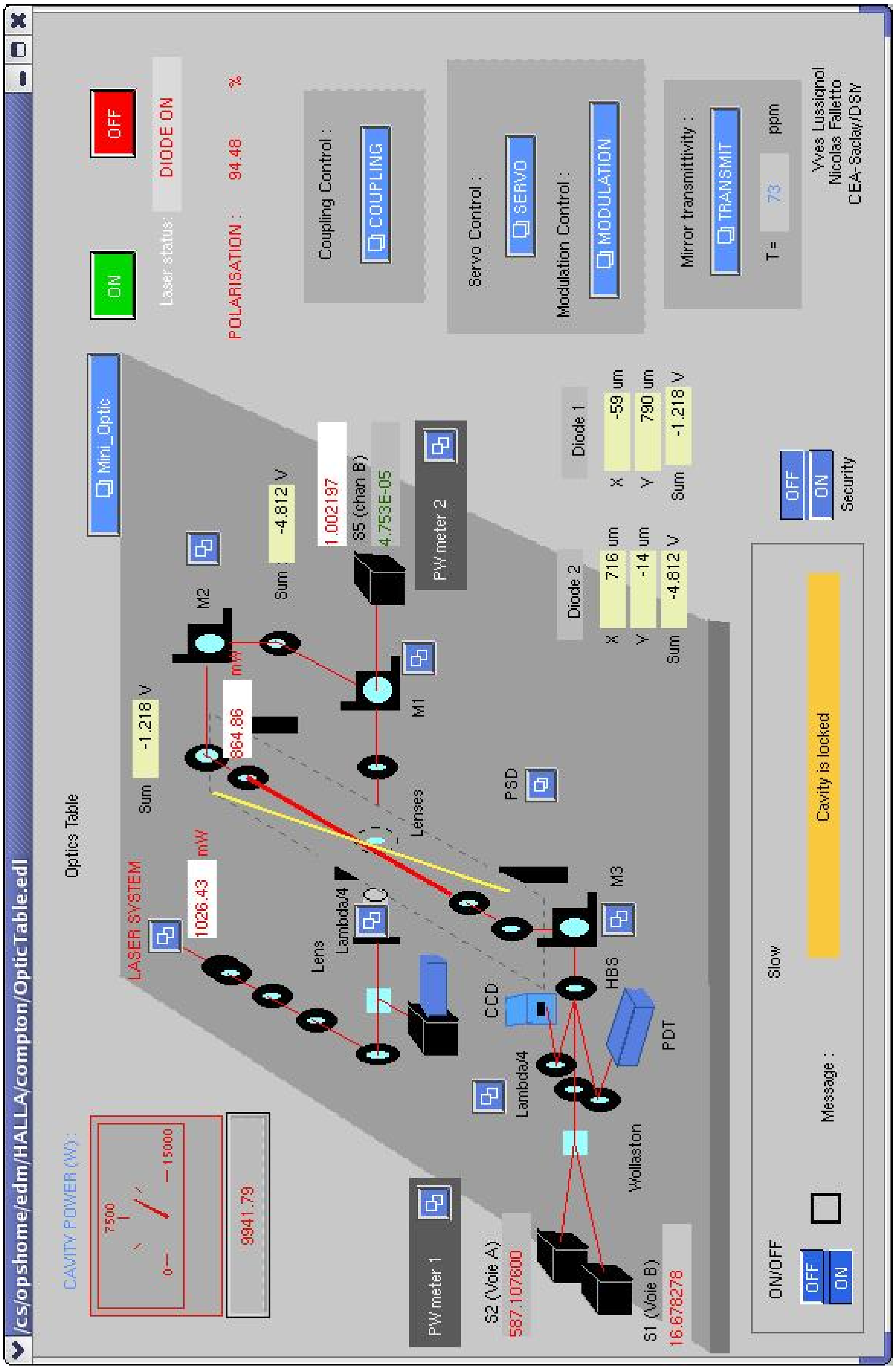

Figure 14: Compton polarimeter Optics Table EPICS control panel

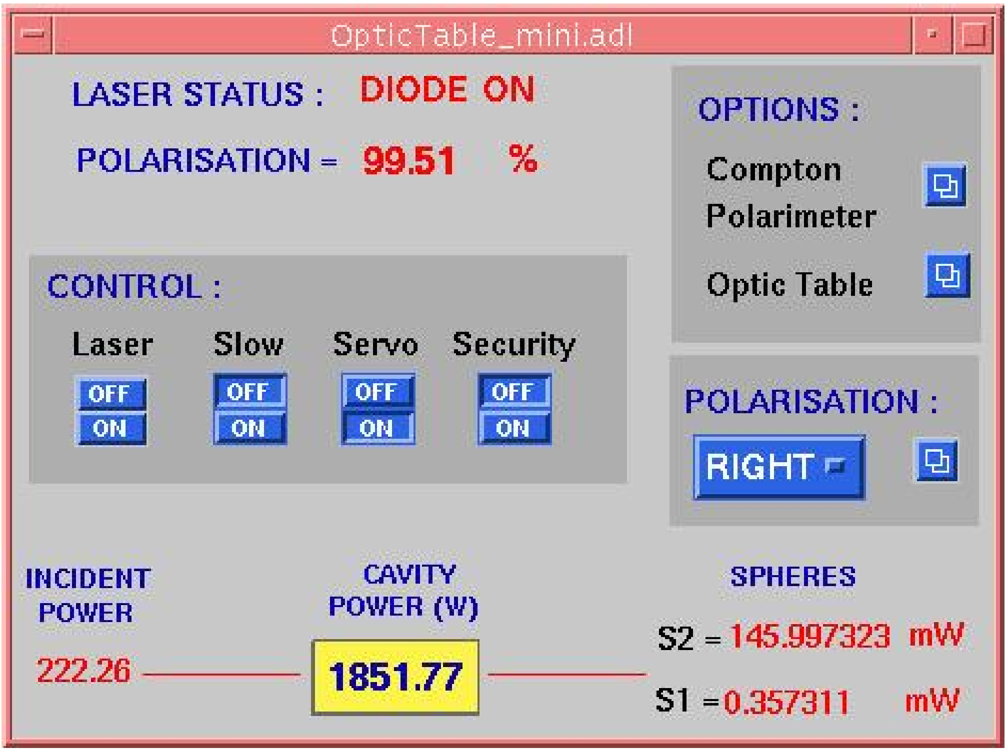

Figure 15: Compton polarimeter mini optics control panel

Figure 16: TV viewer images of laser spot

Figure 17: Compton cavity lock acquisition is indicated on the overhead Cavity Lock monitor with a steady bright green laser beam spot emanating from the exit mirror of the FP cavity

- **Unlock the Cavity**

  On the EPICS control panel, pull the "OPTICS" menu down. Click on "Mini Optic"

  To unlock the cavity, click on the Servo off button in the panel in Fig.15.

4.3 Photon Calorimeter Setup

If the HV are off, switch them on.

The cards of the COMPTON Polarimeter PMT HV are located in crate #2. The High Voltage channel for the Compton polarimeter calorimeter is in slot # 12 (channel 11), nominal high voltage is -1600 V. High voltage for 4 diagnostic detectors (on laser table) is located in slot # 9, channels 0-3; nominal HV is 1700 V.

- Login to an adaq computer as the "adev" account. Then go to the slow control directory "cd ./slowc" and invoke the Java GUI as "./hvs BEAMLINE". This pulls up a self-explanatory GUI Fig.18 which shows the state of the HV cards. One can turn the HV on and off, enable and disable specific channels, set HV values, and read back HV values and currents drawn.

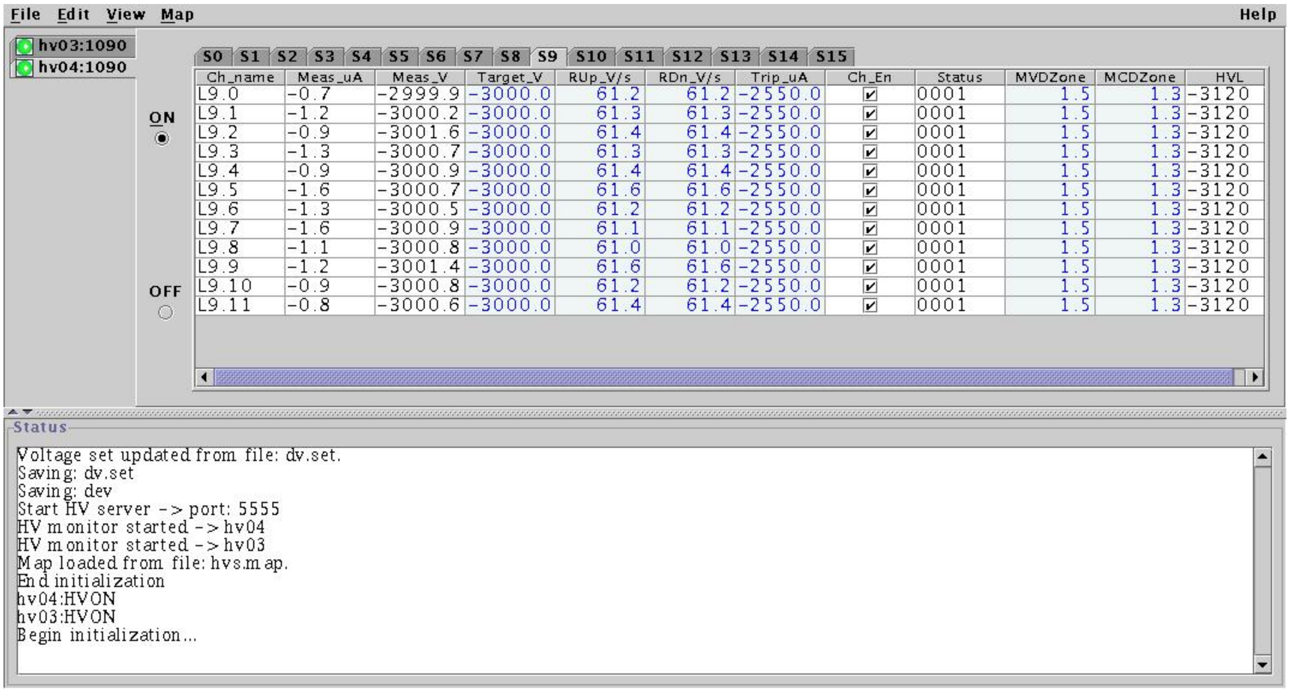

Figure 18: The java GUI for the control of the Compton Polarimeter High Voltage Channels.

4.4 Electron Detector Setup

- **Turn on the electron detector**
  The detector system needs to be powered. In hall A there is an electrical box called A-UH-B1 left of the stairs going to the tunnel. In this box, the main power switch for the electron detector is number 21 (it says electron detector on it). It must be on turned ON. In the tunnel, there is a crate attached to the wall above the electron detector Fig.19, it also needs to be turned ON. When it is ON a red LED is lit (at the right end of the crate). Below this crate there is a black electrical box controlling the displacement system. On the left side of this box it should say "Idle".

- **Slow control of the electron detector**
  To perform operations on the electron detector, go to the panel shown in Fig.20, from the main Polarimeter EPICS screen and then choose "Electron Detector". On this screen, active buttons appear in blue and readback values appear on a yellow background. To use the electron detector a high voltage (120 V) must be applied to polarize the silicon microstrips and a low voltage must be provided to the preamplifier circuit board and some threshold must be set for each plane for the detection of the signals. To do this execute the following operations :

  Turn the low voltage ON

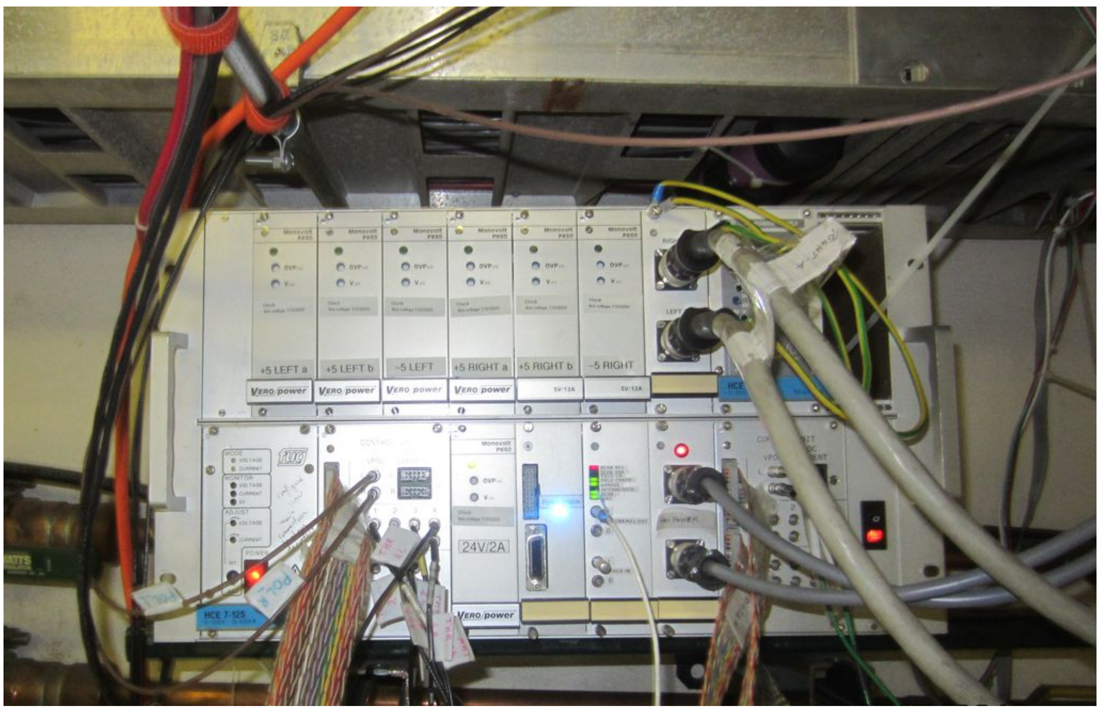

Figure 19: The Compton electron detector instrumentation crate supplying low voltage, high voltage, motion control, and FSD logic to the electron deterctor.

Turn the high voltage ON. The return value should increase gently to 120.
Set thresholds to 35. The return value should read 35.
Turn calibration OFF.

The electron detector can be put in data taking position remotely. When the detector is inserted **the chicane must be ON**, when it is being moved **the beam must be OFF too**. If it is not the case the detector will eventually be destroyed.

Click on either **GARAGE** or **COMPTON** depending on where you want to put the detector.

To make sure the detector is where you want watch the detector move on the TV screen (there is one in the Hall A counting house and one in the back room) as shown in Fig.21.

- **Switch on the the Compton chicane**

  This procedure is only performed by MCC operators.

  Before contacting MCC, ensure that the electron detector is on the **GARAGE** position. Check the status of the electron detector on the video screen.

  First of all, the Hall A Run Coordinator must request that MCC tune the beam through the Compton chicane. MCC operators have to apply the section 2 of the procedure MCC-PR-04-001 [6] . If necessary (after a long shutdown for exemple), let's remind to the operator to open valves located on the Compton line.

- **Lock once again the cavity**

4.5 CIP Scan

Perform a vertical scanning of the electron beam inside the magnetic chicane in order to find the CIP by maximizing the counting rates in the Photon detector.

In the case the crossing of the electron and Laser beams has been lost, or is not optimal, a "CIP scan" has to be performed. By stepping the magnetic field of the chicane dipoles, the beam is moved vertically. Step size should be small with respect to the laser spot size ($\tilde{1}$00 micro m). Here are some step sizes corresponding to a **25 or 100μm** vertical displacements versus typical beam energies, MCC operator are used to Gauss.cm unit:

Although the procedure is non-invasive for Hall A, let the shift leader know when you start and finish the scan.

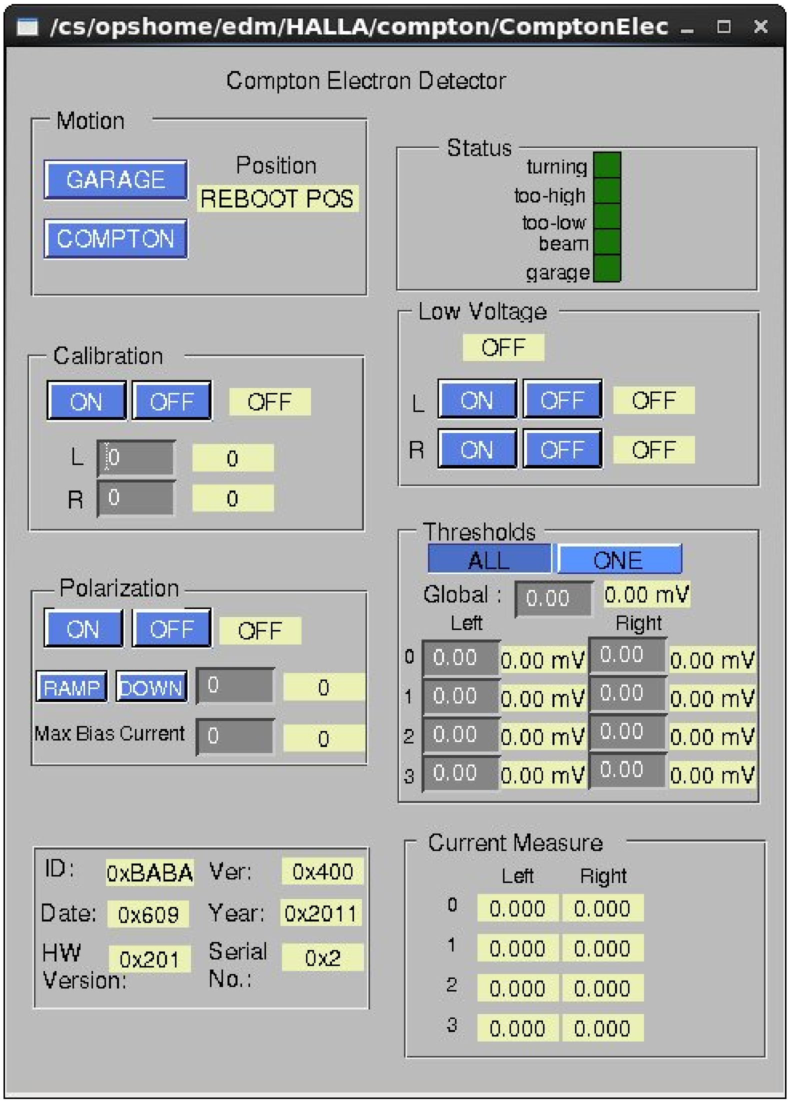

Figure 20: Compton electron detector control panel

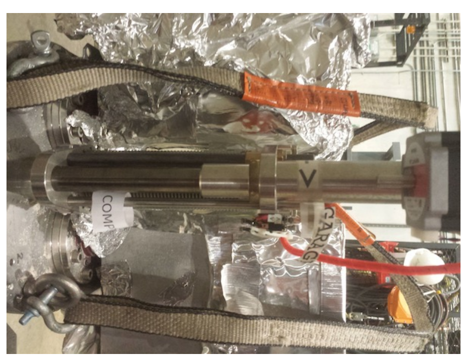

Figure 21: Compton electron detector TV viewer in the Counting House backroom

step 25μm	step 100μm	Energy
20 G.cm	80 G.cm	2.2 GeV
40 G.cm	160 G.cm	4.4 GeV
60 G.cm	240 G.cm	6.6 GeV
80 G.cm	320 G.cm	8.8 GeV
100 G.cm	400 G.cm	11.0 GeV

Table 1: Chicane CIP scan step values for various energies.

The scan is done in contact with MCC (7047) by checking the online evolution of the proton counting rate compton:RATE_G variable with **StripTool**. As a first pass, one can use bigger step size to locate the maximum and then go back to small steps to fine tune the position to determine the optimal Y-position

- **Compton Orbit Lock**
  When the CIP scan procedure is over, come back to the right Y-position and ask to the machine operator to turn on the ”Compton Orbit Lock” using the new Y-position of the beam. Then an automatic magnetic feed-back will run to keep the electron beam Y-position within 50 microns of this optimal position.

- **Beam Off**

  Request MCC operators to switch the beam off, in coordination with the Hall A Run Coordinator.

- **Insert the Electron Detector**

  First of all, the electron beam must be off (see Hall A run coordinator and call MCC operator) If it is not the case the detector will eventually be destroyed. To perform operations on the electron detector. Go to the control panel shown in Fig.20.

  Click the **COMPTON** button.

  To make sure the detector is where you want watch the detector move on the TV screen. Finally, request the MCC operators to switch the beam on.

4.6 Taking data

This is a list of check points to run Compton. It assumes the polarimeter has already been started up as described in the previous sections and that a run has just ended and you want to take a new one.

Bring up the following three screens to control the data taking:

- **EPICS screen**: slow control for the optic table + cavity, the photon and electron detectors, beam parameters.

- **Acq screen**: runcontrol.

Follow the following procedure:

- Go to the **EPICS screen**, check the cavity is loocked with $\tilde{4}$,000 Watts or more. Check that the laser is cycling on and off and that the signal to noise is reasonable.

- Go to the **Acq screen**. Start a new Compton run once every 1 or 2 hours. When starting a run, make sure that the event number is incrementing (i.e., the DAQ is not stuck).

Any comment about the running conditions, shift summary, ... are welcome to help the offline analysis. You can insert them in the Compton electronic logbook by filling up the **LogEntry window** when the run is ended. Click on **Submit** to dowload your comments in the logbook.

4.7 Turning off the compton polarimeter

- Stop the magnetic chicane

  This procedure is only performed by MCC operators.

  The Hall A Run Coordinator must request that MCC turn OFF the Compton chicane and resume normal operations.

  MCC operators have to apply the section 3 of the procedure MCC-PR-04-001 [6]. Let's remind to the operator to close valves located on the Compton line. It is very important to keep the best vacuum in the Compton line and avoid dust deposit on the high reflectivity mirrors of the cavity

- Set the electron detector to the garage position.

  Before resuming normal operations with beam the electron detector to garage position by clicking the **GARAGE** button on the control panel shown in Fig.20. Failure to do so, could result in damage to the electron detector.

  To make sure the detector is where you want it to be, watch the detector move on the TV screen (there is one in the Hall A counting house and one in the back room). At the end of its motion, the arrow on the TV screen should point to the OUT position.

- Switch off the PMT High Voltage using the HV control panel (see Fig.18).

- Unlock the cavity
  On the EPICS control panel, pull the "OPTICS" menu down.
  Click on "Mini Optic".
  To unlock the cavity, click on the Servo off button.

- Switch off the laser
  On the EPICS control panel, pull the "OPTICS" menu down.
  Click on "Mini Optic".
  To turn the Laser Off .... Click on the Laser Off button. Check LASER STATUS and INCIDENT POWER.
  The Laser spots would switch off on the CCD control TV screen

5 Safety Assessment

5.1 Magnets

Particular care must be taken while working in the vicinity of the dipole magnets of the Compton polarimeter magnetic chicane, as they can have large currents running in them producing strong magnetic fields. All four dipoles are powered in series from a common power supply. The power supply for the dipoles is located in the Beam Switch Yard Building (Building 98) with access restricted to authorized personnel only. While the power supply is capable of sourcing a maximum current of 600 A, the nominal operating current for the dipole magnets is 500 A and is not to be exceeded under normal operating conditions. All electrical connections to the magnets are covered with thick Plexiglas safety cover shields. These shields can be removed for service only by authorized personnel, with the concurrence of the Hall A work coordinator, following JLab's "Lock Out/ Tag Out" procedures.

As with any other element that can affect the path of the electron beam, the magnets are controlled by the MCC. Status of the magnets are indicated by a red light, located over each of the magnets, which is activated via a magnetic field sensitive switch placed on the coils of one of the dipoles. When the magnets are ON, these lights display a flashing red beacon indicating the presence of magnetic field; only authorized personnel for the Compton polarimeter may work in the immediate vicinity. At full excitation of the magnets, the leakage field from the magnet could exceed 5 Gauss within a six-inch boundary from the physical ends of each magnet. Access to this region by personnel with medical monitoring electronic devices and/or metallic implants is prohibited, when the magnets are ON.

5.2 Vacuum System

The Compton Polarimeter beam line elements contain thin metal bellows in several places. There is a thin vacuum window at the end of the scattered photon beam line, as well. These could rupture if struck with sharp or heavy objects accidentally, leading to an implosion. While working near these bellows or windows, protective earmuffs and safety glasses are required. Only authorized personnel for the Compton polarimeter group may work near these elements.

5.3 Lasers

The primary laser hazards in the optical table of the Compton Polarimeter are 1064 nm infra-red lasers with up to 30 W CW beam, and a 532 nm green laser up to 3 W CW power. They are housed in the tunnel in a laser hut with light barriers on all sides to isolate the laser beams from the outside world. A flashing yellow beacon installed in the tunnel indicates laser READY on ON status. Three crash buttons are provided in the tunnel for emergency shutdown of the laser. The acces doors to the laser hut are interlocked to the laser power supplies with door closure switches. In case a laser hut access door is opened accidentally, the interlock system shuts down the lasers.

All functions of the lasers are remotely controlled and personnel access to the laser hut is not necessary during routine operation of the Compton Polarimeter. However, in case of repair or maintenance work, access to the laser enclosure may be necessary. The safe operating procedure for this laser is described in Jeffeson Lab Laser Standard Operating Procedure [3] (LSOP). A copy of the LSOP is available in the tunnel wall next to the laser hut. Only personnel authorized in the LSOP with appropriate eye protection are permitted to access the laser hut. All other workers not trained for lasers, are required to disable the laser power supply following JLab's "Lock Out/ Tag Out" procedures in coordination with the Hall A Work Coordinator.

5.4 High Voltage

There are up to 25 photomultiplier tubes within the Compton photon detector module. There are also several beam diagnostic scintillation counters dispersed along the Compton Polarimeter chicane. Each tube is connected to a high voltage power supply located in the beamline instrumentation area. The maximum voltage is 3000 Volts. In addition, the electron detector is supplied with up to 350 Volts. Only SHV connectors may be used to connect the high voltage to the detectors. The high voltage supply source must be turned off prior to conecting or disconnecting the HV to the detector element being accessed for servicing purposes. Only members of the Compton group are authorized to access the detectors.

5.5 Authorized Personnel

The list of the presently authorized personnel is given in Table 2. Other individuals must notify and receive permission from the primary contact person (see Table 2) before being authorized to work on the Compton Polarimeter.

References

[1] S. Nanda and D. Lhuiellier, Conceptual Design Report for Hall A Compton Polarimeter Upgrade, https://userweb.jlab.org/~nanda/compton/HallA_

Name		Dept.	Telephone		e-mail	Comment
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Alexandre	Camsonne	JLab	5064		camsonne@jlab.org	*Alternate*
Jack	Segal	Jlab	7042	320-9977	segal@jlab.org	*Technical*

Table 2: Compton Polarimeter: authorized personnel.

Compton_Upgrade.pdf. 1

[2] http://hallaweb.jlab.org/compton/Documentation/Papers/nima4592001.pdf. 11

[3] Jeffeson Lab Laser Standard Operating Procedure for Hall A Compton Polarimeter Laser System,https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-86141/PHY-14-002-LOSP.pdf. 11, 18, 29

[4] Experimental Physics Instrumentation and Control System, http://www.aps.anl.gov/asd/controls/epics/EpicsDocumentation/WWWPages/EpicsDoc.html. 16

[5] CEBAF Online Data Acquisition, http://www.coda.org/. 15

[6] Beam tuning with the Hall ACompton Chicane, http://opsntsrv.acc.jlab.org/ops_docs/online_document_files/MCC_online_files/HallA_beam_delivery_proc.pdf

24, 27