MOLLER New RTP HV Driver – Requirement Document

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December 11, 2022

The probability of interaction of electrons with their spin aligned along the momentum direction (positive helicity) with matter (e.g., atomic electrons in the hydrogen atom, as in MOLLER) is different than that the of interaction of electrons with negative helicity where the spin direction is opposite to the momentum direction. Since under parity asymmetry (or mirror asymmetry or space inversion) a positive helicity electron becomes a negative helicity electron, the fact that the probability of interaction is different is called parity violation. The helicity of the electron beam will be changed (or flipped) by changing the circular polarization of the laser used to generate the electron from the photocathode. By flipping the laser circular polarization from right-handed to left-handed, the helicity of the electron beam is flipped. At CEBAF, we are now using a Rubidium Titanyl Phosphate (RTP) Pockels cell to achieve this. A Linearly polarized laser light passing though the RTP crystals becomes right-handed or left handed circularly polarized light depending on the HV applied to the RTP cell. The ultimate goal is to achieve a perfect polarization flip while keeping all other properties (like charge and position) of the electron beam unchanged. This is achieved by carefully aligning the cell and also making sure any information that gives the real helicity is isolated from the outside world. The leakage of the real helicity signal (e.g., changing the electrical ground level) can be picked up by other devices used by the beam or the experiment and gives a false difference if the interaction of the polarized beam.

The RTP cell and its HV driver is the most critical part of any parity violation experiment. Thus, very careful work goes into the design and operation of the cell.

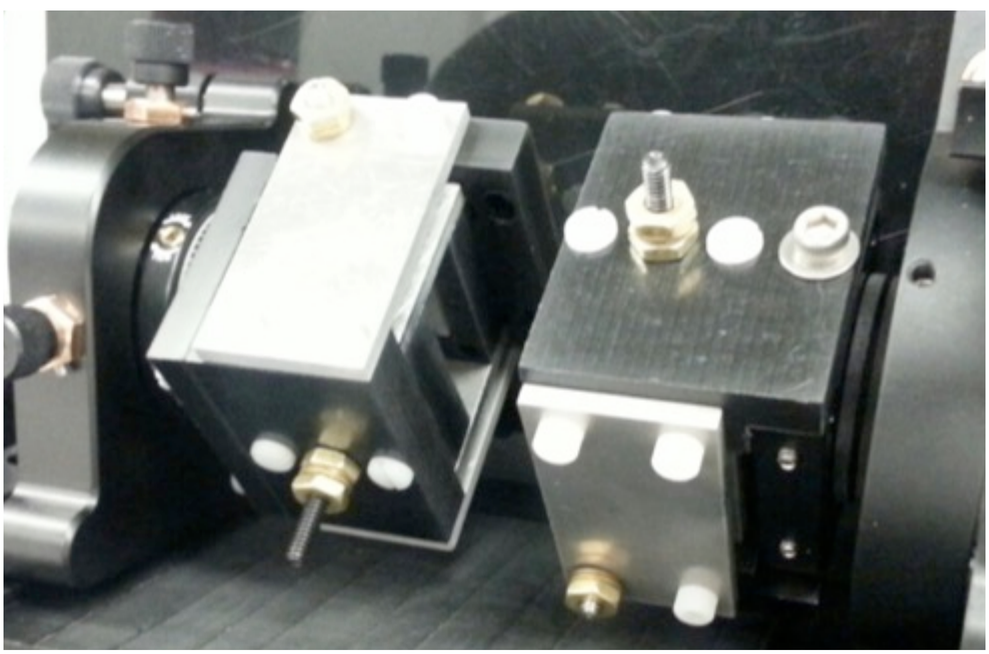
Functional requirements for HV Driver:

1. Disabled state: The driver should have an OFF state in which the controllers do not process the real-time helicity signal (or, process only in an entirely electrically isolated system). In this state, the voltages should be zero.
2. Real-time helicity: The driver should be controlled between two set points using the real-time helicity signal.
3. Electrical isolation: Great care is required to maintain security of the real-time helicity signal. The HV driver should be electrically isolated in the same manner as the helicity generator board.

4. Fast HV reversal at 2kHz.
5. Precision: Bit resolution in should be at least 0.1 V.
6. Dynamic range: each HV output should span +/-8000 V
7. Linearity: the beam deflection vs. setpoint should be linear within about 5%, so that the response measured in calibration is accurate for small excursions in operation mode.
8. Stability: the beam deflection gain vs setpoint should be stable within 5% at time scales of 1 week or more.
9. Data logging: the setpoints and state (active, disabled) should be logged and archived with about 1 second time resolution for the full length of the MOLLER run (about 4 calendar years). Alternatively, the changes and times of the changes can be logged, with that resolution.
10. 2000V supply, nominally +-800V controlled by 0-5V DAC (18bit).

RTP Crystal Properties:

The RTP cell is made up of two crystals. RTP cells generally have two crystals, transversely oriented, with 4 electrodes, 2 of which have a common ground, and use 2 HV's in switching states. The RTP cell differs from commercial cells in that, in addition to electrodes, it also has grounded side panels, and the bottom electrodes, rather than having a common ground, can be set independently. So the cell has 8 HV's : 2 crystals x 2 plates/crystal x 2 helicity states = 8.



HV Drivers:

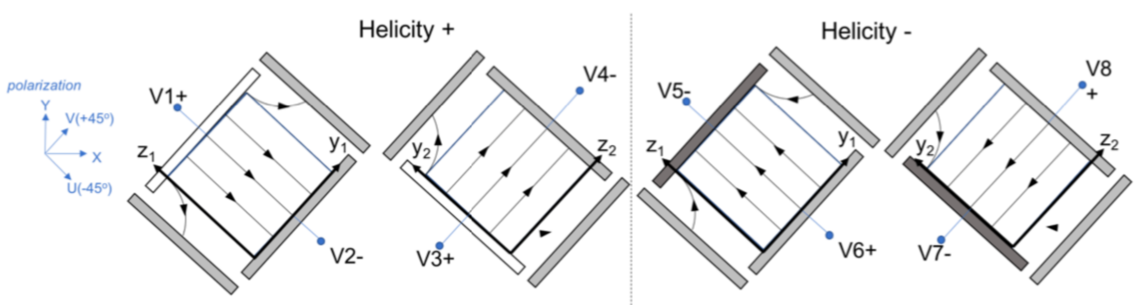
1. Existing dragon LED 8HV system
2. 2019 Design
3. New Design (with Solid-State)

Control system Fibers (5 fibers):

1. Tx and Rx for ethernet communication.

2. Both nHelicity Flip and T_Settle fibers are available at the control system. nHelicity Flip is used to control the current output to the magnets. T_Settle is not used in the control system but rather to check signals on Oscilloscope for diagnostic purposes.

3. 30 Hz PZT Booster System fiber. This system will be removed. FOpt (in Custom Mode) will be used instead.



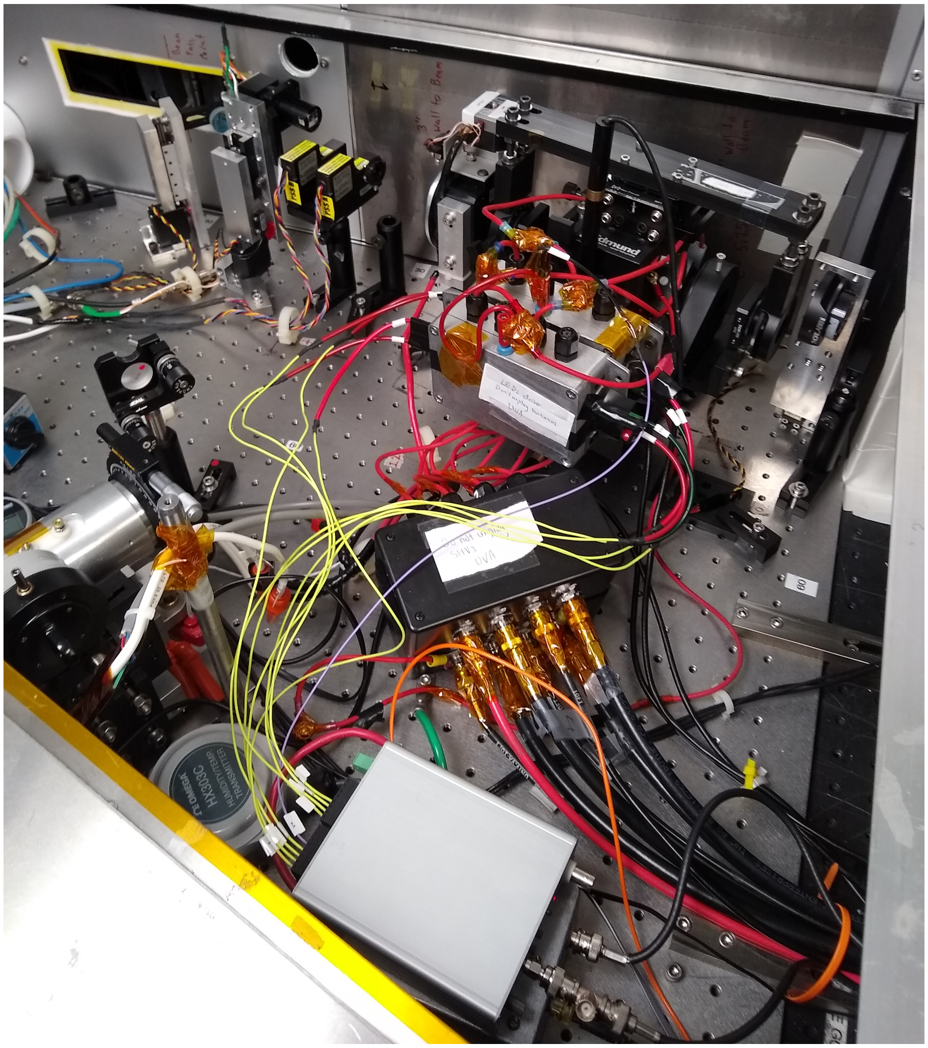
Outputs and Beam Response:

I. DAC of -8000 → 8000 gives -50 mA → 50 mA.

II. Output current can be dumped in a resistor or to power magnet

III. Slopes of about 0.1 µm/DAC in the 5 MeV region

https://wiki.jlab.org/ciswiki/index.php/RTP_Driver_@_CEBAF_Meeting_February_12,_2019



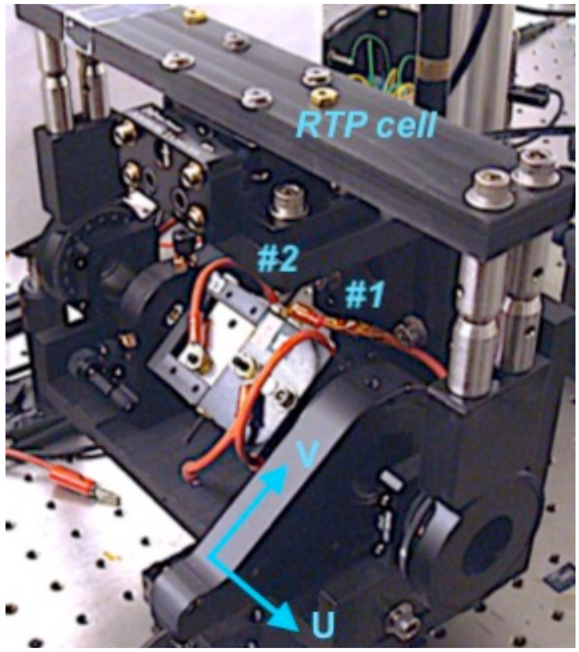
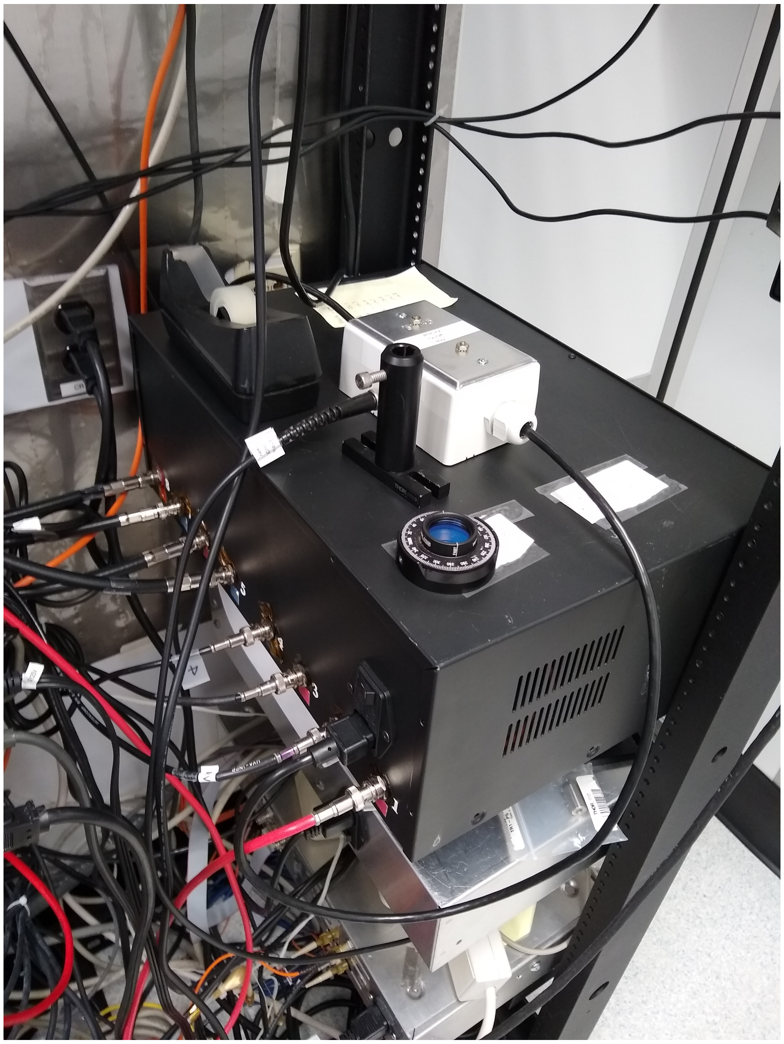


Figure 1: Helicity magnets control crate in CEBAF injector.

Figure 2: Helicity magnets control screen. For the upgrade, the "Manual Mode" will be used, too. The 30 Hz Mode was used as a PZT booster system to measure adiabatic damping in the Injector. This sys is not in use anymore. FOPT system will be used instead..



Known Problems:

1. Overshoot, Rise Time and Delay to Respond – see Figure 3.

Changes to Control System:

These are the changes to the control system:

I. Change to 16-bit DAC to reduce slopes to be about 1 nm/DAC in the 5 MeV region
II. Reduce amplifier output current from 50 mA to 5 mA (or use 50 mA amplifier with shunt resistor). DAC of -65000 → 65000 should give -5 mA → 5 mA.
III. Reduce overshoot to be less than 5% of the setpoint
IV. Increase rise time from about 4 µs to 10 µs (to reduce overshoot)