CLAS12 Møller Operations Manual - v1.1

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I. Introduction

The CLAS12 Møller system measures the polarization of the electron beam delivered to Hall B, and this document details its operating procedures. The user interface for shift workers is shown in Fig. 1 and provides direct access to all controls and feedback that the normal operator should need, and its operating procedures are described in Section IV. Expert operations are described in Appendix A.

Note, this manual assumes acceptable beam has already been established to the tagger dump; consult the beamline manual for general procedures on establishing beam if necessary.

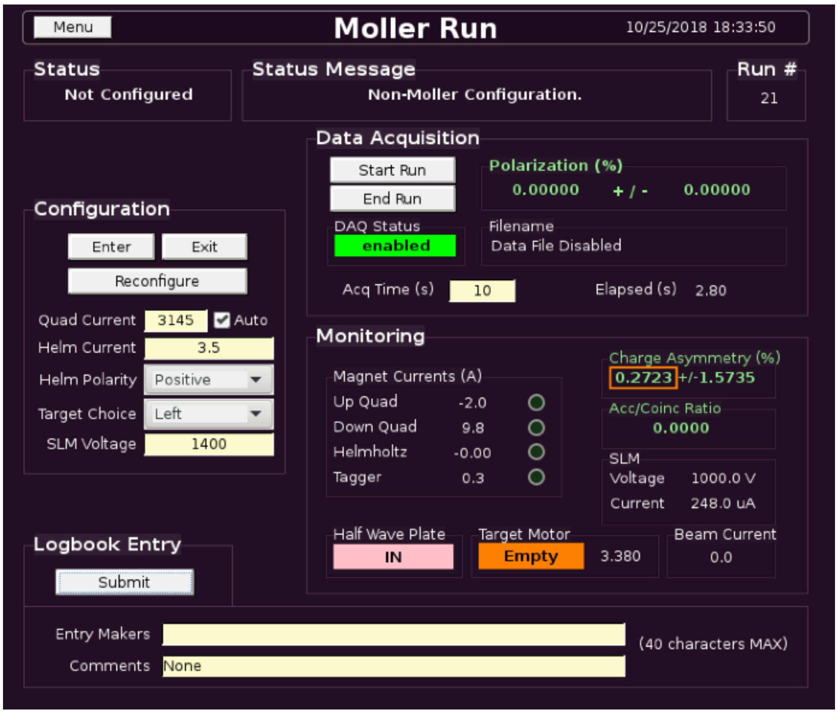

FIG. 1: The user interface for shift workers for operating a Møller run is divided into *Status*, *Configuration*, *Data Acquisition*, *Monitoring*, and *Logbook* sections. In this screenshot, the Møller system is not configured, according to the *Status* section, i.e. the setup is for non-Møller beam delivery.

II. Hardware Settings

The standard hardware settings for a Møller run are shown in Table I. These are displayed in the *Configuration* section of Figure 1 and will be used to automatically configure all hardware during the procedure in Section IV. It is the responsibility of the operator to ensure that the settings in the *Configuration* section are the desired ones before entering the Møller setup.

SLM Voltage	1400 V
Collimator Position	Blank
Target Position	Left
Helmholtz Current	$\pm$3.5 A
Quadrupole Current	
5-pass / 10.7 GeV	3145 A
3-pass / 6.4 GeV	1350 A

TABLE I: Standard hardware parameter values for the Møller setup. Live values are shown in the *Monitoring* section in Figure 1.

III. Quality Requirements

The requirements to be maintained during a Møller run, and the resulting desired error on the polarization measurement are shown in Table II. It is the responsibility of the operator to monitor these quantities to ensure a successful polarization measurement.

2C21 BPM Current	$\sim$4 nA
Beam Charge Asymmetry	$< 0.2\%$ (typical $\sim 0.1\%$)
Accidental/Coincidence Ratio	< 0.1 (typical ~ 0.05)
Final Beam Polarization Error	$< 1.5\%$ (absolute)

TABLE II: Standard quality conditions required for a Møller run. Live values are shown in the *Monitoring* and *Data Acquisition* sections in Figure 1. Note, beam polarization error depends on statistics and should gradually decrease during the run.

IV. Standard Procedures

A. Procedure Summary

The procedure for the operator with the interface in Figure 1 can be summarized in the following steps, and more details are shown on the next section.

1. **Configure:** ensure the Configuration section is set as desired
2. **Enter:** click *Enter* in the Configuration section and wait for success status
3. **Start Run:** click *Start Run* in the DAQ section
4. **Monitor:** monitor the critical parameters
5. **End Run:** click *End Run* in the DAQ section
6. **Log Entry:** click *Submit* in the Logbook Entry section
7. **Reconfigure:** (Optional)
8. **Exit:** click *Exit* in the Configuration section and wait for success status

B. Procedure Details

1. **Configure:** ensure the Configuration section of Fig. 1 is set as desired

    See Table I for standard values. Contact the Run Coordinator if uncertain.

2. **Enter:** click *Enter* in the Configuration section and wait for success status

    This will configure the system for a Møller run by initiating a sequence of actions and provide corresponding feedback in the status portion of the screen. This includes turning off all appropriate detectors' high voltage, inserting the blank collimator, energizing the quadrupoles and Helmholtz magnets, and inserting the Møller target. Success will result in "Moller Configuration Ready" in the status message.

3. **Start:** click *Start Run* in the DAQ section

    This will initiate a new Møller run, including zeroing any accumulated data, opening a new data file, incrementing the run number, and starting data acquisition.

4. **Monitor:** monitor the critical quality parameters

    This is left to the operator, described in Table II, with possible actions in Section V. Of particular importance are beam charge asymmetry below 0.2% and accidental ratio of less than 0.1, although ideally about half that. *If you cannot achieve the quality requirements, contact the Run Coordinator.*

5. **End:** click *End Run* in the DAQ section

    At this point you should have achieved the desired polarization error of 1.5% (see Table II), or just need to stop the current run and start a new one.

6. **Log Entry**: click *Submit* in the Logbook Entry section if the run was successful.

    This will submit a standardized, searchable log entry to HBLOG with a table summarizing the results and an attached data file, and requires filling the Entry Makers and Comments fields. *Note, if you want to log any screenshots associated with this Møller run, then you should navigate to this log entry and upload them as comments.*

7. **Reconfigure:** (Optional) At this point you may reconfigure the system (e.g. change the Helmholtz polarity or switch to a different target, and then click *Reconfigure*) and then start a second run (go to Step #3), or just start another run with the same configuration (go to Step #3).

8. **Exit**: click *Exit* in the Configuration section and wait for success status

    This will restore the non-Møller configuration by turning off the quadrupoles and Helmholtz and retracting the Møller target. *Note, this will not restore any detector high voltage (except the SLM) nor move the collimator.*

V. Tuning Parameters

If quality requirements are not satisfied, first check whether our hardware settings are as expected. For example, compare to the parameters earlier in this document, and also to recent satisfactory Møller runs in the logbook in case of any recent changes. *Be wary of earlier versions of this manual or the beamine manual (or very old logbook entries) you may find on the web!*

The following subsections contain information on the quality parameters and the main parameters that can affect them. Consult with the Run Coordinator and/or beamline expert if you have any uncertainty.

A. Beam Charge Asymmetry

Beam charge asymmetry is measured by the Synchrotron Light Monitor fed to a Struck scaler latching on the heliticy signals. It is located a few meters upstream of, and *completely independent of*, the Møller quadrupoles, Helmholtz, target, and Left/Right counters. Beam Charge asymmetry is affected primarily by beam characteristics from the injector and accelerator. There can be some effect from quality of the SLM performance, e.g. if voltage is far too high and the SLM is saturated, but this should generally never be the case for the normal operator.

Note that beam charge asymmetry updates with the same period as our Moller acquisition time, since it shares the same Struck scaler latched on the helicity signals for polarization measurement. So if the acquisition time is set at 60 seconds, beam charge asymmetry will only update once per minute. It can be important not to gauge the quality based on only one or two readings, but to assess based on multiple readings with stable beam. To facilitate this, one can open a strip chart to monitor beam charge asymmetry over time, or increase the acquisition time for a higher statistics reading during stable beam.

If the beam charge asymmetry is too high, the parameters that can be considered in consultation with the beamline expert:

- Beam position (BPM and harp scans)
- Beam profile (harp scans)
- Injector slit setting
- Injector attenuator settings

B. Accidentals

The accidental-coincidence ratio is measured by Møller Left/Right PMTs, downstream of the target and quadrupoles. This quantity is independent of the helicity signals and Struck scaler. Excessive accidentals can be caused by beam quality issues, e.g. bleedthrough from other halls, or non-optimal settings of our Møller system. Parameters that can be considered are the same as for beam charge asymmetry, with the addition of our Møller configuration, e.g. Left/Right PMT voltages, malfunctioning quadrupoles, or very miscalibrated target position.

VI. Run Duration

At 10 GeV, with our 2018 hardware configuration, the normal run duration to achieve 1.5% absolute error on the polarization is about 20 minutes of beam. Interruptions to beam delivery, e.g. trips, will of course increase the necessary run time.

VII. Status Values

Describe the possible values of the status variable in the top left of the screen.

Appendices

A. Expert Procedures

Note, this section may be out of date and should be ignore by shift operators.

1. Before start

- Reasonable quality beam must be already present for Hall-B
- Beam has to be terminated on the tagger-yoke dump
- CLAS12 is OFF, especially sensitive detectors: HV on **Drift Chambers** and **SVT/MVT**

2. Setup

1. Notify MCC that you are about to do Møller run and **request to take the beam to the tagger yoke beam dump** (they will need to take the beam away and energize the tagger magnet), MCC will ask to change BTA setting to "photon"
2. Ask MCC to turn orbit locks off, and mask BOM and Halo Counters in FSD
3. Turning ON the polarimeter is done from EPICS GUIs (for now multiple control GUIs in expert mode are used).

   NOTE: BEAM SHOULD BE OFF DURING the SETUP of MøLLER POLARIMETER

   Møller setup GUIs can be launched from the **Moeller** tab on the *"clascss"* GUI.

   (a) the "Moeller Asym - All" GUI, see Fig.2 contains all the helicity gated scalers, charge asymmetry, and the beam polarization[1]. It has several controls for the measurement and monitoring:

   Buttons "Start", "Reset" and "Stop" will start and stop acquisition of data or reset acquisition (clear scaler buffers).

   The acquisition time controls update frequency of scalers, measured polarization value, and the charge asymmetry value. It is recommended to have Møller polarimeter acquisition time > 60 seconds when taking the measurements. For practical reasons, at the start when charge asymmetry will need tuning (see below) time for the scaler update can be set to ~ 10 seconds. The time can be set either by typing a value in the box or moving the slider.

   The "Attenuator Controls" are to control beam charge asymmetry. By changing voltage on intensity attenuators (IA) one can equalizes intensity across helicity states. It is recommended to use "Global Offset" that will change voltage on all four IAs at the same amount. Desire charge asymmetry is $< 0.1\%$ based on SLM.

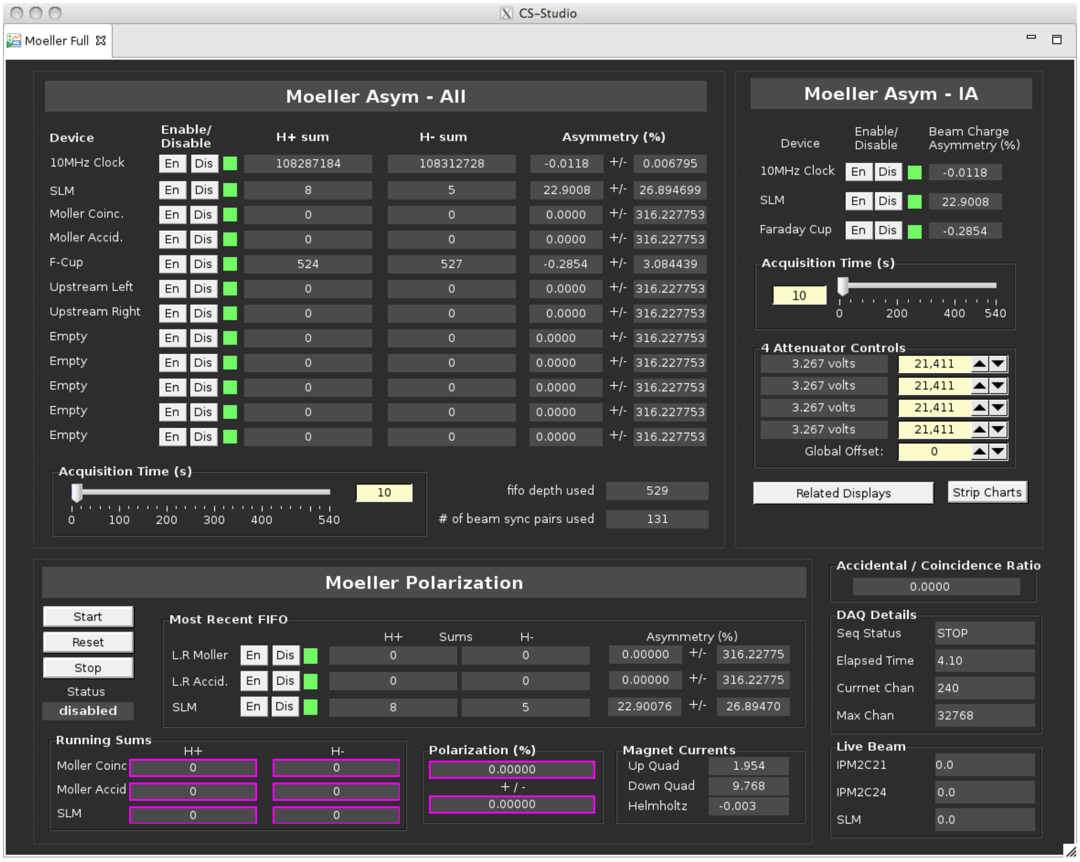

FIG. 2: The main Møller Epics expert GUI.

(b) The control for Møller quadrupole power supplies are provided in "Moeller Quadrupoles" GUI, see Fig.3. Power supplies will be turned ON and in remote before hall closing. From GUI one should first turn them on by pushing the "PS ON" buttons, then set the desire value for currents in "Current Setpoint" window. For 10.7 GeV the suggested value for the quadrupoles is 3050 A.

(c) The target is polarized to its saturation by a longitudinal (along the beam) magnetic field generated using pair of Helmholtz coils. It is expected that the target will be saturated at ~ 1.8 A current in the coils. The recommended current for Møller measurement is 3 A. A GUI for power supply of Helmholtz coils, "Moeller Helmholtz PS" see Fig.4, has two controls, button "STATE" defines state of the power supply. Typicaly it will be in "STANDBY" state when is not used. To energize coils first from the menu in "STATE" chose PS ON, then in "Current Setpoint", a white window, write the value, either 3 or -3. Beam polarization measurements with both orientations the Helmholtz field is recommended to check systematics.

(d) a target control GUI, Fig.5, allows to position desired target on the beam. Left target is the recommended target for the measurements.

4. Once the tagger magnet is energized, Møller setup is UP and ready, request the beam current

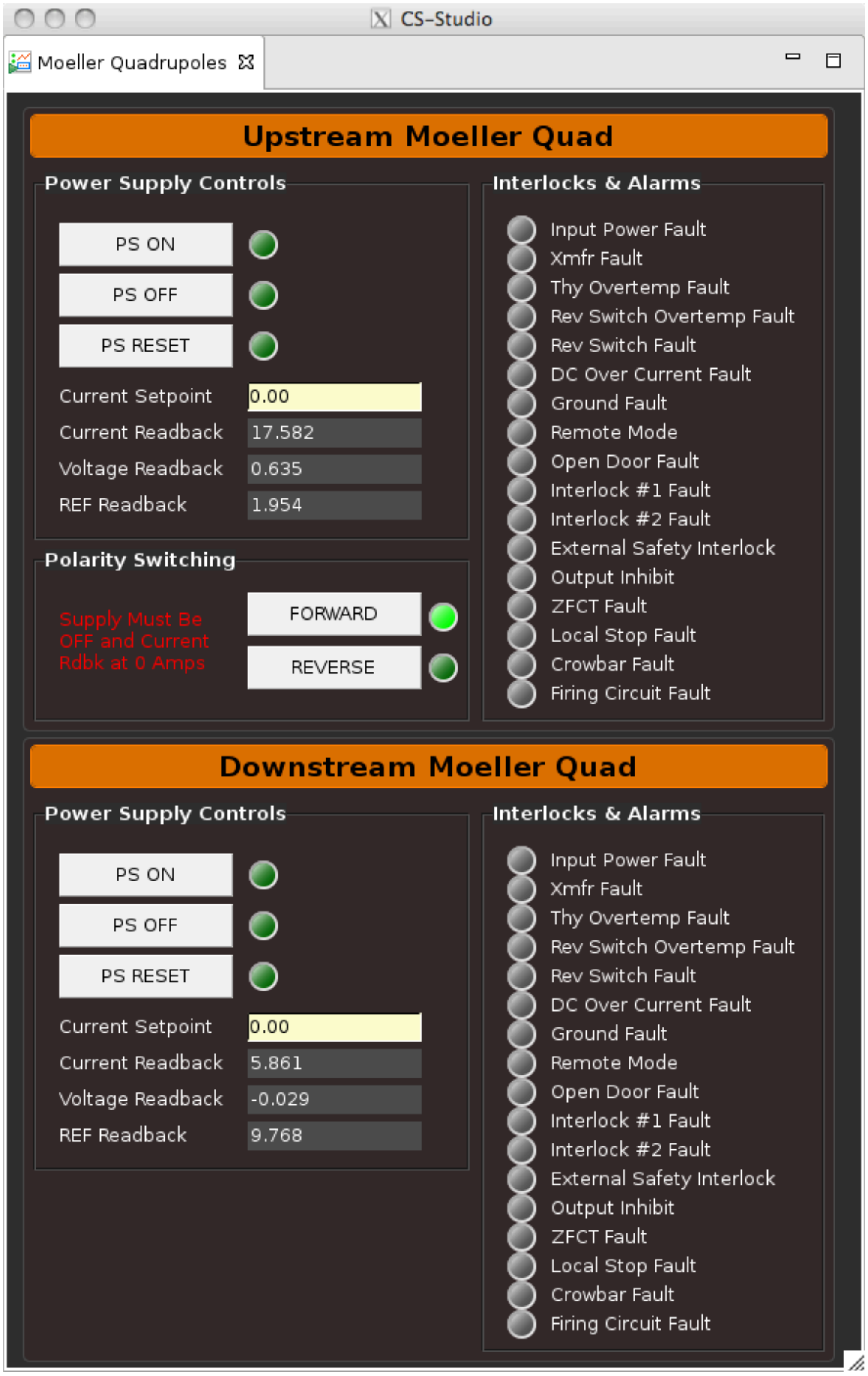

FIG. 3: Control GUI for the Møller quadrupole power supplies.

as specify for the given energy Møller measurements to be delivered[2], as measured by 2C21 nA BPM and/or SLM. Do not use 2C24A since that BPM is located downstream of the Møller setup. For $\sim$ 11 GeV beam, if beam conditions are normal, as expected, the beam current should be 4 nA.

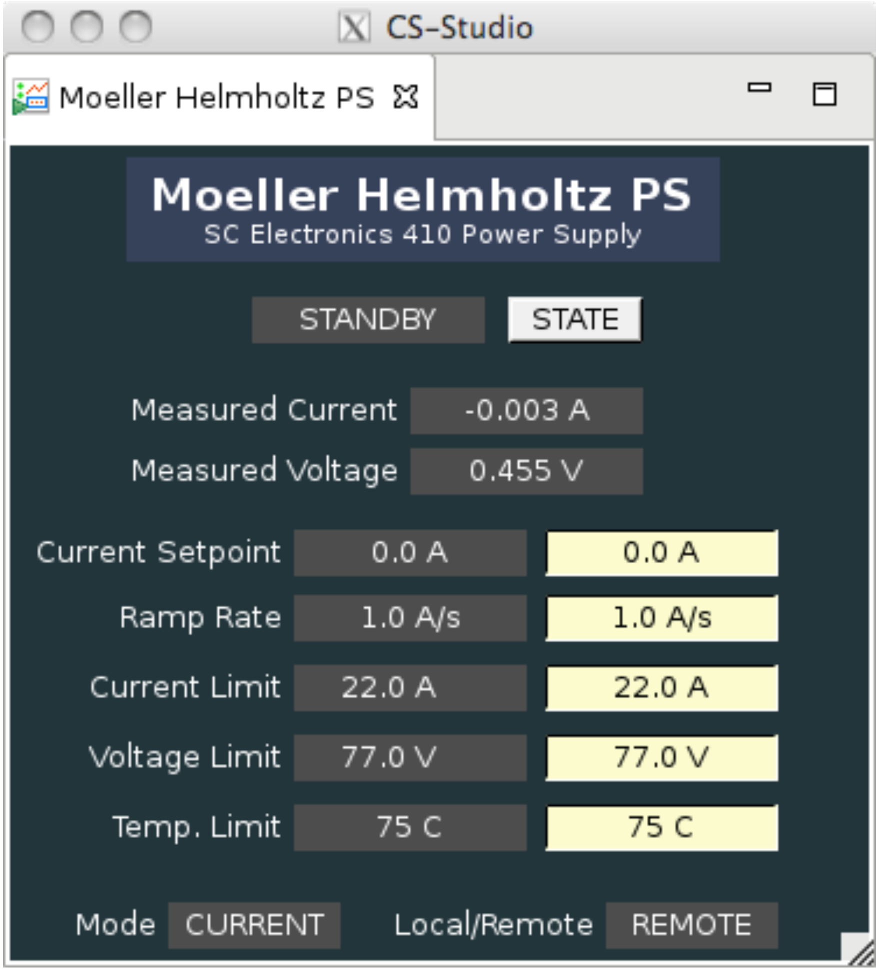

FIG. 4: Control GUI for the Møller target Helmholtz coils power supply.

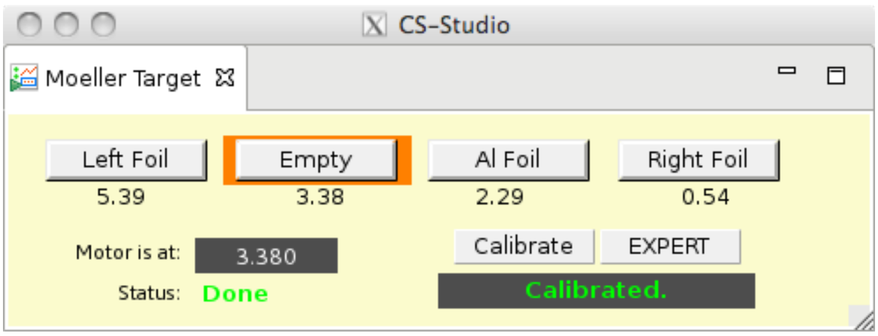

FIG. 5: Control GUI for the Møller target.

3. Data Taking

- To start a new run when DAQ is still running hit the "Reset" button on "Moeller Asym - All" GUI. If run was stoped hit the "Start" then "Reset".
- Run is complete when the error on the beam polarization on the GUI is below $\leq 1.5\%$ absolute. Typically it takes about 45 min to 60 min to get the required accuracy (beam

condition dependent).

- Make measurements with both positions of the half-wave plate, ”IN” and ”OUT” (start the first measurement with whichever position it is, then do the second measurement with the other setting).
- If needed perform measurements with both polarity of the Helmholtz coils.
- Log every measurement by sending ”Moeller Asym - All” GUI to logbook together with main scaler GUI to document beam currents, beam position, and halo counter rates.

4. Backing off Møller setup out

When done with the measurements:

- Do not forget to make a log entry including all details and the GUI!
- Request MCC to take the beam away and **de-gauss the tagger magnet if the next step is to send the beam to Faraday cup (usually it is).**
- Turn off quadrupoles by setting 0 in ”Current Setpoint”s and then when current readback is at ~ 0 A push ”PS OFF” button
- Turn off Helmholtz coils by setting 0 in the current ”Current Setpoint” and change ”STSTE” to ”STANDBY” when ”Measured Current” is ~ 0
- Retract the target by pushing ”Empty” button on the target GUI
- Once tagger magnet is degaussed, restore beam to the Faraday Cup.
- Turn ON CLAS12

B. Hardawre and Software

Description of the hardware and software involved in the CLAS12 Møller system.

1. Quadrupoles

The quadrupoles use a Dyapower power supply with communications via classc3 hosting a vx-Works EPICS IOC and DVME628 and .

2. Helmholtz

The Helmholtz coils use a SCE410 power supply, located on the first level of the space frame in the electronics racks beam-right. EPICS controls are running on a clonioc linux server in the counting house, communicating with SCE410 via a MOXA serial-ethernet converter in the same rack.

3. Synchrotron Light Monitor

The SLM is located in the upstream beam tunnel near 2c21. Controls are located on space frame, level 1. Its high voltage power supply is beam-left in CND's CAEN SY527 mainframe, while its signal is routed to a Jorger scaler in classc1, beam-right.

4. Target

The target controls are running on classc1, with an OMS motor controller, both beam-right on space frame level 1.

5. Helicity Signal

The helicity signals are routed through NIM crates and into the Struck scaler in classc6, all on space frame beam-right.

6. Struck Multi-Channel Scaler

The Struck scaler is located in classc6, beam-right. It counts SLM and Moller PMT, latched on the helicity signals.

7. Sequencing

Automated sequencing of controls is via a softioc in the counting house.

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[1] The polarization and charge asymmetry have GUIs their own, but for now this main GUI will be used.

[2] The optimal beam current is a function of beam energy. More specific information may be available on the white board in the counting house or in the run period specific documentation on the run wiki. Regardless of what currents are specified on the white board or in this document, the ratio $Left \otimes Right$ accidentals to the true coincidence rate should be kept below 5%. It may be necessary to adjust the HV on the Left and Right PMT's to achieve a low accidental rate, while maintaining a reasonable true rate.