

CLAS12 Møller Operations Manual - v1.3

N. Baltzell, S. Stepanyan

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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.

*Note, Møller runs must be performed with acceptable beam delivered to the **tagger dump/yoke**; consult the beamline manual for general procedures on establishing beam if necessary.*

The screenshot displays the 'Moller Run' control interface. At the top, a 'Menu' button is on the left, the title 'Moller Run' is centered, and the date/time '10/25/2018 18:33:50' is on the right. The interface is divided into several functional areas:

- Status:** A box labeled 'Status' shows 'Not Configured'.
- Status Message:** A box labeled 'Status Message' shows 'Non-Moller Configuration.'
- Run #:** A box labeled 'Run #' shows '21'.
- Configuration:** A box containing controls for 'Enter', 'Exit', and 'Reconfigure'. Below these are sliders and dropdowns for 'Quad Current' (3145, with 'Auto' checked), 'Helm Current' (3.5), 'Helm Polarity' (Positive), 'Target Choice' (Left), and 'SLM Voltage' (1400).
- Data Acquisition:** A box with 'Start Run' and 'End Run' buttons. It shows 'Polarization (%)' as '0.00000 +/- 0.00000'. The 'DAQ Status' is 'enabled' (in green). The 'Filename' is 'Data File Disabled'. It also shows 'Acq Time (s)' as 10 and 'Elapsed (s)' as 2.80.
- Monitoring:** A box showing 'Magnet Currents (A)' for 'Up Quad' (-2.0), 'Down Quad' (9.8), 'Helmholtz' (-0.00), and 'Tagger' (0.3), each with a green status indicator. It also shows 'Charge Asymmetry (%)' as '0.2723 +/- 1.5735' (with '0.2723' highlighted in a red box), 'Acc/Coinc Ratio' as '0.0000', and 'SLM' parameters: 'Voltage' (1000.0 V) and 'Current' (248.0 uA).
- Logbook Entry:** A box with a 'Submit' button and input fields for 'Entry Makers' and 'Comments' (currently 'None'). A note '(40 characters MAX)' is next to the comments field.
- Bottom Controls:** A row of controls including 'Half Wave Plate' (set to 'IN'), 'Target Motor' (set to 'Empty'), '3.380', and 'Beam Current' (0.0).

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	± 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	~ 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

Before starting the Møller procedure, confirm that Hall B orbit locks are off and our Halo and BOM FSD are masked.

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. **Request No Beam:** ask MCC to take beam away while you configure the Møller system
2. **Configure:** ensure the Configuration section is set as desired
3. **Enter:** click *Enter* in the Configuration section and wait for success status
4. **Request 4 nA:** ask MCC to resume beam delivery at 4 nA for Møller runs
5. **Start Run:** click *Start Run* in the DAQ section
6. **Monitor:** monitor the critical parameters
7. **End Run:** click *End Run* in the DAQ section
8. **Log Entry:** click *Submit* in the Logbook Entry section
9. **Request No Beam:** ask MCC to take beam away before changing the Møller configuration
10. **Reconfigure:** (Optional)
11. **Exit:** click *Exit* in the Configuration section and wait for success status

B. Procedure Details

1. **Request No Beam:** ask MCC to take beam away while you configure the Møller system
2. **Configure:** ensure the Configuration section of Fig. 1 is set as desired

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

3. **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.

4. **Request 4 nA:** ask MCC to resume beam delivery at 4 nA for Møller runs
5. **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.

6. **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.*

7. **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.

8. **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.*

9. **Request No Beam:** ask MCC to take beam away before changing the Møller configuration

10. **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).

11. **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. Quality Requirements

If quality requirements are not satisfied (accidental rate and beam charge asymmetry), first check whether our hardware settings are as expected by comparing to the parameters earlier in this document and also to recent satisfactory Møller runs in the logbook. The following subsections contain information on the quality measurements and the main parameters that can affect them. Consult with the Run Coordinator and/or beamline expert for advice on tuning these parameters, and compare their values with previous Møller runs.

A. 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 30 minutes of continuous beam. Interruptions to beam delivery, e.g. trips, will of course increase the necessary run time. Much longer than normal run duration to achieve 1.5% can be indicative of excessive accidentals or beam charge asymmetry.

B. Beam Charge Asymmetry

Beam charge asymmetry is measured by a Synchrotron Light Monitor fed to a Struck scaler latching on the helicity signals. The SLM is located a few meters upstream of, and *completely independent of*, the rest of our Møller system. 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, i.e. if the acquisition time is set at 60 seconds, beam charge asymmetry will only update once per minute.

If the beam charge asymmetry is too high, the parameters that can be considered are:

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

C. Accidentals

The accidental-coincidence ratio is measured by Møller Left/Right PMTs, downstream of the target and quadrupoles, and is independent of the helicity signals. 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 for adjustment include the same beam quality parameters in the previous section, and with the addition of our Møller configuration, e.g. Left/Right PMT voltages, malfunctioning quadrupoles, or very miscalibrated target position.

Appendices

A. Hardware 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.