Commissioning of the CLAS12 Spectrometer
Engineering Run
Version 2.6

January 11, 2018

Abstract

This document details the run plan for the commissioning of the CLAS12 spectrometer during the Jan. 2018 portion of the Engineering Run using the CEBAF electron beam at 5-pass and 1-pass energies. This commissioning run period will consist of three different phases: i) CLAS12 commissioning with FT-Off at 10.6 GeV, ii) CLAS12 commissioning with FT-On at 2.1 GeV, and iii) CLAS12 commissioning with FT-On at 10.6 GeV. The commissioning of the CLAS12 detector subsystems and spectrometer will include low luminosity operation for the initial detector turn-on, functionality checks, and optimization of the detector settings, studies of the DAQ and trigger systems, and calibration and commissioning studies at different luminosities and torus/solenoid field settings. In addition, studies will be carried out using the Hall B Møller polarimeter system to determine the injector settings that provide the maximum electron beam polarization to Hall B. Finally, zero field runs will be taken for detector alignment studies in both the CLAS12 forward and central detectors.

This document is structured as follows: In Section 1 the specific objectives of the CLAS12 Engineering Run period are detailed. In Section 2 the configuration of the Hall B beamline and detector subsystems for the run are defined. Section 3 provides a high-level overview of the different operational phases of the run period and the daily schedule and Section 4 provides details on the specific commissioning tasks to be completed in each phase, along with the associated task durations, required personnel, and offline analysis goals.

Contents

1 Introduction

In general, the objectives of the Hall B beamline and CLAS12 spectrometer commissioning procedures for the Engineering Run are to achieve reliable beam transport through thin and extended targets to the Faraday Cup, to verify the optics design of the CLAS12 torus and solenoid magnets, and to determine the alignment and operational performance of the CLAS12 detector systems using beam interactions. The plan includes detailed studies of the CLAS12 detector subsystems, along with the data acquisition and trigger systems. The dependence of the detector performance on luminosity and particle rates will be studied, monitoring background levels, channel occupancies, and currents. Initially, a loose trigger configuration will be used to accumulate data with minimal bias; more complex and selective trigger configurations will then be employed and the new data sets will be compared to minimal bias trigger data to verify the trigger operation and to determine its efficiency. The data collected during these studies will be used to perform full calibrations of the CLAS12 detector systems employing different field strengths and torus field polarity.

After completion of the commissioning, the functionality of the Hall B instrumentation, including the beamline, the CLAS12 superconducting torus and solenoid magnets, all CLAS12 detectors, the trigger and data acquisition systems, and the CLAS12 online software will have been verified. In addition, the detector resolution, acceptance, and efficiency will have been determined and the optimal configuration for future data taking identified and studied in detail.

The commissioning plan that is described in this document was developed based on the present schedule for beam delivery to Hall B in Jan. 2018 for CLAS12 commissioning. It assumes a combined efficiency for the accelerator and CLAS12 operations of 50%. The commissioning plan is focused on verifying the capability of operating the detectors with beam up to or beyond the nominal CLAS12 luminosity of 1×10^{35} cm^{-2}s^{-1} using the standard Hall B liquid-hydrogen cryotarget, on optimizing the detector configuration, on determining complete calibrations based on electron beam data, and on evaluating the detector performance. The beam time allocated for the completion of the different commissioning tasks is estimated starting from what was requested by the detector experts. A minimum time of one shift, i.e. 8 hr, is also assumed whenever major changes of the accelerator configuration (e.g. a beam energy change) are required.

2 Beam and Detector Configuration

The beamline configuration for the Engineering Run is considered the nominal Hall B beamline. Fig. 1 shows the beamline layout from the green shielding wall at the upstream end of the Hall B upstream tunnel to the tagger magnet. Fig. 2 shows the beamline downstream of the tagger magnet all the way to the Faraday cup.

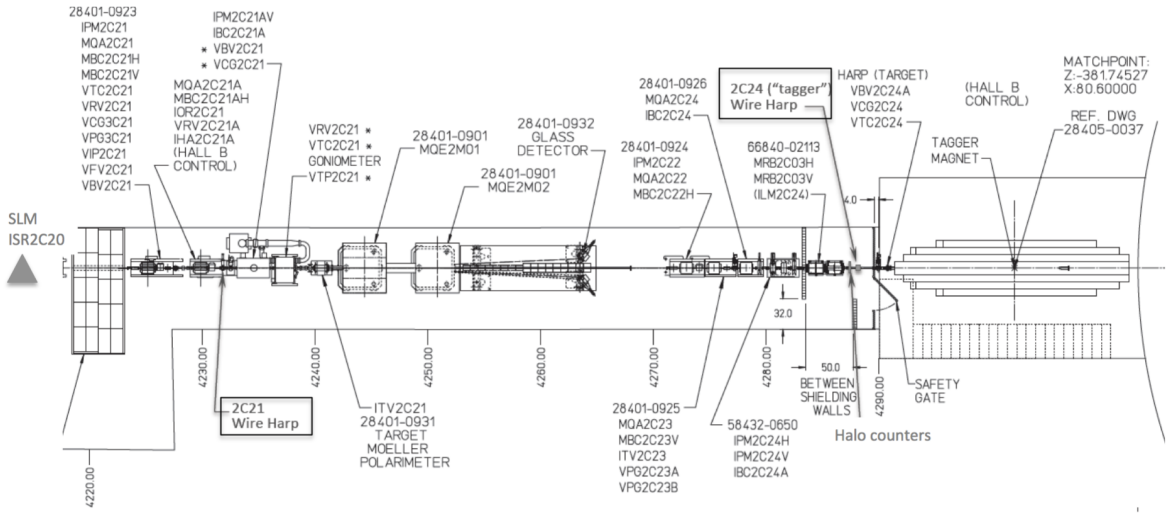

Figure 1: Schematic of the Hall B beamline from the green shielding wall to the tagger dipole.

Fig. 3 shows a schematic representation of the standard CLAS12 configuration that has been setup for the detector commissioning run. All baseline detector subsystems (ECAL, FTOF, LTCC, DC, HTCC, SVT, and CTOF) are installed, as well as all ancillary detector subsystems (CND, RICH, FT, FMT, BMT). The forward detectors are mounted relative to the superconducting torus magnet and the central detectors are mounted relative to the superconducting solenoid magnet. The standard Hall B cryotarget (5-cm-long liquid-hydrogen cell with 30 μm Al end windows) has been installed at the center of CLAS12.

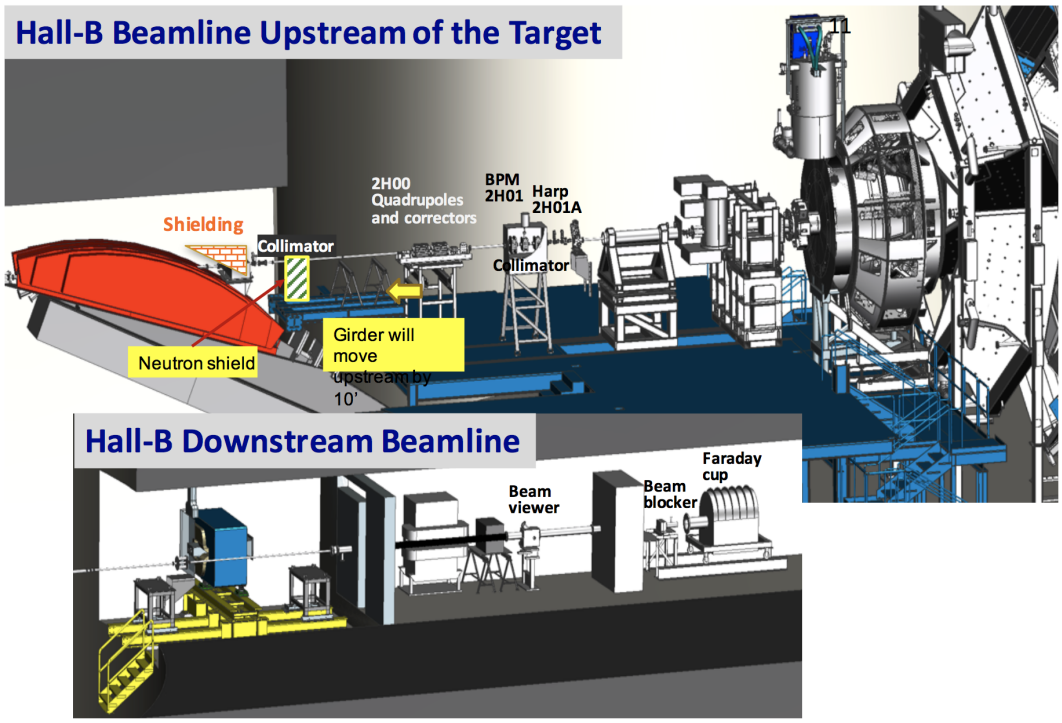

Figure 2: Schematic of the beamline configurations for nominal CLAS12 operation between the tagger dipole and the target (top) and in the downstream alcove (bottom).

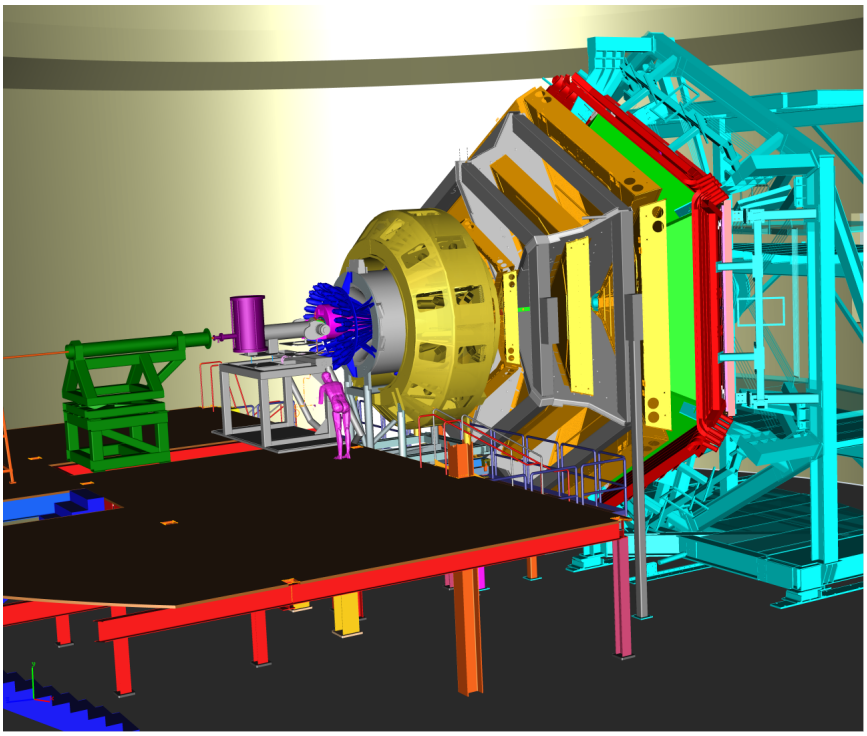

Figure 3: Schematic of the standard CLAS12 configuration including all baseline and ancillary subsystems that has been installed for the Engineering Run for detector commissioning.

3 Engineering Run Phases

The Engineering Run to commission the CLAS12 spectrometer in the period from Jan. 12-28, 2018 has been organized in three different phases:

1. Phase 1: CLAS12 commissioning with FT-Off at 10.6 GeV
2. Phase 2: CLAS12 commissioning with FT-On at 2.1 GeV
3. Phase 3: CLAS12 commissioning with FT-On at 10.6 GeV

A high-level overview of the daily schedule for the Engineering Run is given in Fig. 4. In Section 4, a detailed description and breakdown of the individual tasks within each phase are provided along with time estimates to complete the different tasks. An important associated document that is part of this Commissioning Plan is CLAS12-Note 2017-016, which provides an overview of the Monte Carlo simulation studies related to the conditions of the Engineering Run for the different beam energies and magnet currents/polarities.

For each of the different tasks that make up each of the phases, details are provided regarding the manpower required, the tools that are to be used both online and offline, and the relevant simulations with which to compare. In addition, each task is labeled as Must, Should, and Like to denote the associated priority and the associated goals for the offline analysis efforts. These priority assignments will be considered by the Run Coordinator to make adjustments to the run plan based on the actual operating efficiency of the accelerator and Hall B during the course of the commissioning run period.

Phase 1 has a duration of 5.5 days, Phase 2 has a duration of 3.5 days, and Phase 3 has a duration of 6 days. The final 2 days of the run at 10.6 GeV are reserved for contingency. Figs. 5, 6, and 7 provide a listing of the different tasks within each phase and their associated durations.

CLAS12 Engineering Run Daily Schedule

	Jan 12: Fri - Beam tuning - Moller run - Detector checks - DAQ/trigger checks 10.6 GeV	Jan 13: Sat - Readout optimization - DC studies - Trig. studies - Studies with torus negin - Calib. runs 10.6 GeV	Jan 14: Sun - Calib. runs - Field study - Studies with torus negout 10.6 GeV	Jan 15: Mon - Calib. runs - Change to FT-On 10.6 GeV	Jan 16: Tue - Change to FT-On 10.6 GeV
Jan 17: Wed - Change to FT-On - Pass change - Beam tuning 2.1 GeV	Jan 18: Thu - Detector checks - Trig. studies - Calib. runs 2.1 GeV	Jan 19: Fri - Phys. studies 2.1 GeV	Jan 20: Sat - Phys. studies 2.1 GeV	Jan 21: Sun - Pass change - Spin dance - Beam tuning 10.6 GeV	Jan 22: Mon - Detector checks - Trig. studies - Calib. runs 10.6 GeV
Jan 23: Tue - Calib. Runs - Alignment studies 10.6 GeV	Jan 24: Wed - Alignment studies - Data in RG-A conditions 10.6 GeV	Jan 25: Thu - Data in RG-A conditions 10.6 GeV	Jan 26: Fri - Data in RG-A conditions 10.6 GeV	Jan 27: Sat - Contingency 10.6 GeV	Jan 28: Sun - Contingency 10.6 GeV

Figure 4: Daily schedule for the three phases of the CLAS12 commissioning run for Jan. 2018.

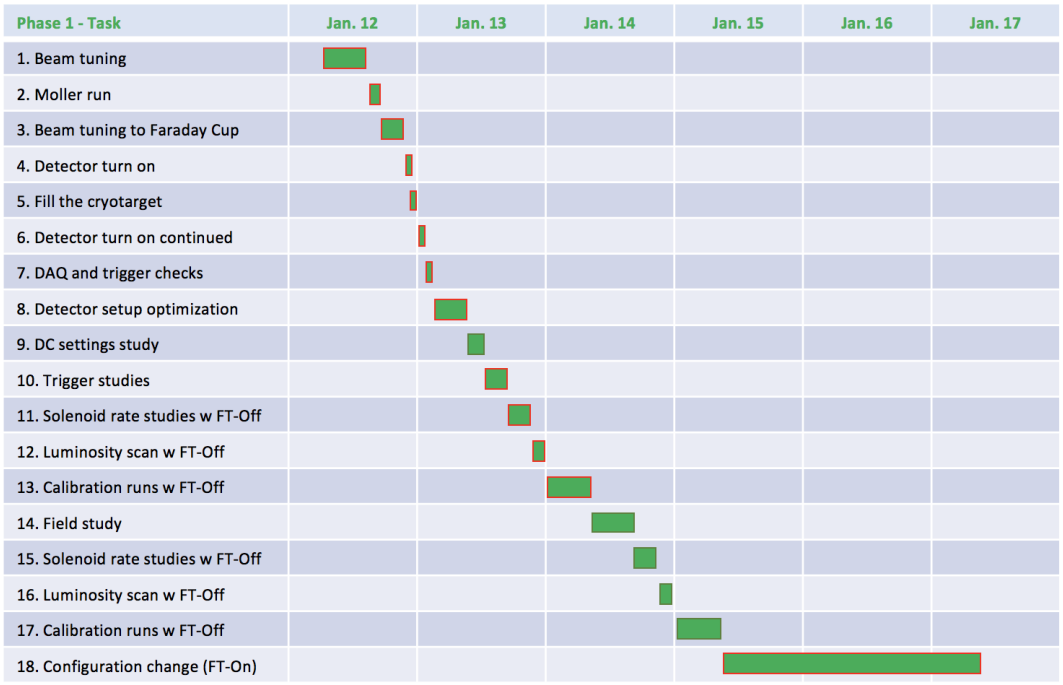

Figure 5: Plot of the tasks and their durations for Phase 1 of the commissioning run in Jan. 2018. The boxes bordered in red, green, and gold are associated with tasks priorities Must, Should, and Like, respectively.

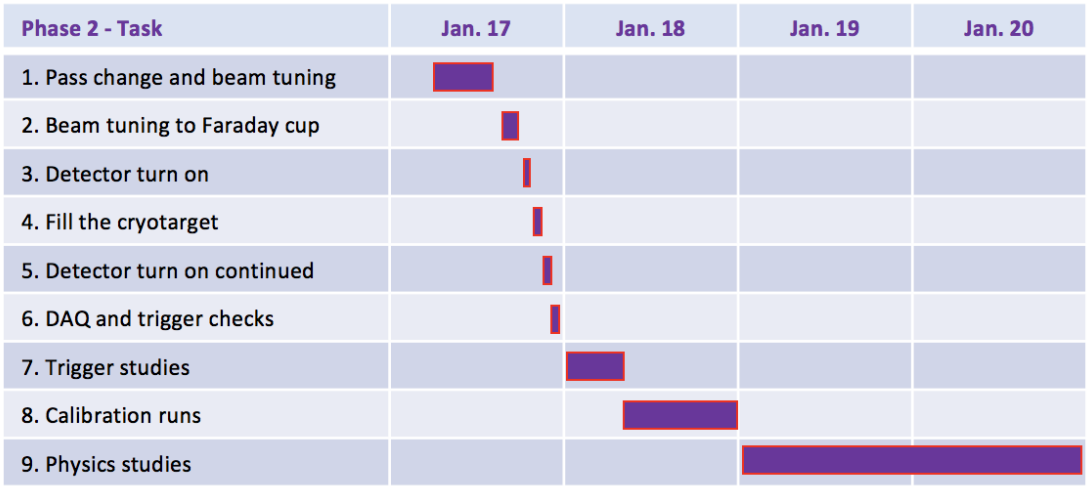

Figure 6: Plot of the tasks and their durations for Phase 2 of the commissioning run in Jan. 2018. The boxes bordered in red, green, and gold are associated with tasks priorities Must, Should, and Like, respectively.

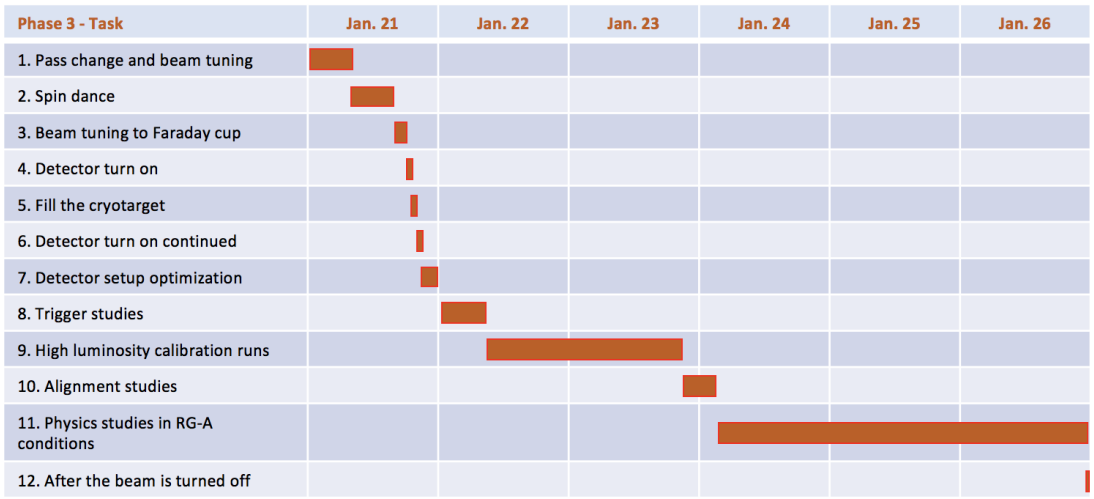

Figure 7: Plot of the tasks and their durations for Phase 3 of the commissioning run in Jan. 2018. The boxes bordered in red, green, and gold are associated with tasks priorities Must, Should, and Like, respectively.

4 CLAS12 Commissioning Run Plan

4.1 Phase 1: CLAS12 Commissioning with FT-Off at 10.6 GeV

Duration: 5.5 days
Conditions: E_b=10.6 GeV, torus field = $\pm$60%, $\pm$100%
solenoid field = 50%, 60%, 70%, 80%, 90%, 100%
No LTCC fill gas; No MM fill gas; No FT operation

The first phase of CLAS12 commissioning will begin in mid-January and will take place with 10.6 GeV (5-pass) beam. After beam tuning to the tagger magnet yoke dump and a Møller run, this phase will begin with studies with both torus field polarities to characterize the backgrounds in the CLAS12 forward and central detectors in the FT-Off configuration. This phase will also include studies to optimize the electron trigger and the DAQ readout settings for the detectors, and acquisition of calibration data for different magnet settings and different luminosities to study the performance of CLAS12. Phase 1 will concludewith a configuration change from the FT-Off configuration to the FT-On configuration.

1. Beam tuning:

   The accelerator will work to establish 5-pass beam to the Hall B tagger magnet yoke dump. See the beam tuning procedures for Hall B on the run wiki under "Procedures" at:
   https://wiki.jlab.org/clas12-run/index.php/Engineering_Run

   Note: Before beam is delivered to Hall B ensure that all CLAS12 detectors are off and the target is empty.

   - Who: Beamline expert, shift workers
   - Tools: Slow controls
   - Level: Must

   Assigned task duration: 8 hr

2. Møller run:

   When stable beam is ready for Hall B take a Møller run. See the procedures on the run wiki under "Procedures" at:
   https://wiki.jlab.org/clas12-run/index.php/Engineering_Run

- Who: Beamline expert, shift workers
- Tools: Slow controls, DAQ, Møller analysis suite
- Level: Must

Assigned task duration: 2 hr

3. Beam tuning to Faraday Cup:

   Establish beam to the Faraday cup and perform all necessary beam checks. See the beam tuning procedures for Hall B on the run wiki under "Procedures" at: https://wiki.jlab.org/clas12-run/index.php/Engineering_Run.

   This beam tuning study will include a series of horizontal and vertical beam scans across the target to find the optimal beam position on the target. The beam tuning and associated steering studies should be carried out with 5 nA of beam.

   - Who: Beamline expert, shift workers
   - Tools: Slow controls
   - Level: Must

   Assigned task duration: 4 hr

4. Detector turn on:

   With the torus at -100% field (negatives inbending) and the solenoid at 100% field (nominal polarity), turn on the forward detectors (ECAL, FTOF, LTCC, HTCC RICH); make sure scaler rates are reasonable (defined by detector experts) while running 10 nA beam. Record the rates and currents of all subsystems in the logbook.

   - Who: Detector experts, shift workers
   - Tools: Slow controls, scalers, DAQ, EPICS scaler dump tool
   - Level: Must

   Assigned task duration: 1 hr

5. Fill the cryotarget (LH_2).

   Turn the beam off before filling the cryotarget. The detectors that have been energized should be left on. When the target is full, request 10 nA beam on target.

- Who: Shift workers
- Tools: Slow controls
- Level: Must

Assigned task duration: 1 hr [End of Jan. 12]

6. Detector turn on (continued):

   If the rates of the forward detectors are reasonable at 10 nA, turn on the DCs, CTOF, and CND. If the central detector system rates and currents are reasonable (defined by the detector experts), turn on the SVT (but none of the MM trackers due to lack of gas). Note that the FT system should be left off in this FT-Off configuration. Record the rates and currents of all subsystems in the logbook, as well as the DC occupancies. The DAQ can be started and initial checkout can proceed.

   - Who: Detector experts, DAQ expert, shift workers
   - Tools: Slow controls, scalers, DAQ, online monitoring (MON12, expert suites), CED, EPICS scaler dump tool
   - Trigger: Random trigger, electron trigger
   - Level: Must

   Assigned task duration: 1 hr

7. DAQ and trigger checks:

   Once the detector subsystems have been turned on, check that the DAQ system is functioning for the basic electron trigger. Re-establish and check configuration for DAQ and trigger operation from the Dec. 2017 pass-5 operations.

   - Who: DAQ expert, trigger expert, detector experts
   - Tools: Scalers, online monitoring (MON12, expert suites), DAQMON, EVIO/HIPO tools
   - Trigger: Random trigger, electron trigger
   - Level: Must

   Assigned task duration: 1 hr

8. Detector setup optimization:

   With the DAQ system functioning at a reasonable level the detector settings and readout parameters will be optimized. For the detector subsystems, the parameters to be adjusted include pedestals, FADC and discriminator thresholds, and readout gate widths and offsets. At this time the initial checkout and settings of the RICH detector will be studied..

   This work will be performed in parallel by the detector subsystem experts. Maximum priority will be given to the ECAL, being the system used for establishing the electron trigger for data taking. Second priority will be given to the DC and FTOF subsystems, being critical for the DAQ and trigger studies. Third priority will be given to the other detector subsystems.

   During this study the nominal beam currents will be 10 nA to 50 nA. The primary tools used in this study will be the detector expert monitoring suites.

   - Who: Detector experts, DAQ expert
   - Tools: Scalers, online monitoring (MON12, expert suites), DAQMON, EVIO/HIPO tools
   - Trigger: Random trigger, electron trigger
   - Level: Must

   Assigned task duration: 6 hr

9. DC settings study:

   Take data at different thresholds and high voltage values for the DC system to optimize the settings for efficient tracking and data taking. The threshold and voltage settings will be defined by the DC subsystem experts. The beam should be at 10 nA.

   - Who: DC experts, shift workers
   - Tools: Slow controls, scalers, DAQ, online monitoring (MON12, expert suites), CED
   - Trigger: Random trigger, electron trigger, ECAL hadron trigger
   - Level: Should

   Assigned task duration: 3 hr

10. Trigger studies:

    Given the feedback from the trigger studies during the Dec. 2017 running, this step in the commissioning should optimize the settings and perform further hardware checks of each of the triggers that will be used during the first physics running period.

The trigger commissioning plan for this task is detailed on the Hall B run wiki at:
https://wiki.jlab.org/clas12-run/index.php/Engineering_Run

- Who: DAQ expert, trigger expert, offline team
- Tools: online trigger tools (**TBD**); offline - data cooking scripts, data analysis, trigger scripts (**TBD**)
- Offline goals: Test trigger operations; determine trigger efficiency and trigger purity
- Trigger: Random trigger, electron trigger, ECAL hadron trigger
- Level: Must

Assigned task duration: 4 hr

11. Solenoid rate studies with FT-Off (torus negatives inbending):

    With the torus at -100% current (negatives inbending) and a beam current of 10 nA, study the CLAS12 detector rates and currents, as well as the DC occupancies and current as a function of the solenoid field at settings of 50%, 60%, 70%, 80%, 90%, 100%. Record the rates and currents of all subsystems in the logbook, as well as the DC occupancies. Study should begin by ramping the solenoid down to 50% current and should end with the 100% current setting. The beam does not need to be turned off during solenoid magnet ramping.

    - Who: Detector experts, shift workers
    - Tools: Slow controls, scalers, DAQ, online monitoring (MON12, expert suites), CED, EPICS scaler dump tool
    - Trigger: Random trigger, electron trigger, ECAL hadron trigger
    - Level: Must

    Assigned task duration: 4 hr

12. Luminosity scan with FT-Off (torus negatives inbending):

    These studies are to be carried out the torus field at -100% (negatives inbending) and the solenoid field at 100% (nominal polarity). The scan should be performed for currents of 10 nA, 25 nA, 50 nA, 75 nA, 100 nA, and 150 nA. Stop raising the beam current if any of the detector (DC, SVT, BMT, FMT) rates or currents get close to unacceptable levels; consult with the Run Coordinator regarding the acceptable limits. For each setting, record the rates and current of all subsystems in the logbook, as well as the DC occupancies.

- Who: Detector experts, shift workers
- Tools: Slow controls, scalers, DAQ, online monitoring (MON12, expert suites), CED, EPICS scaler dump tool
- Trigger: Random trigger, electron trigger, ECAL hadron trigger
- Level: Must

Assigned task duration: 2 hr [End of Jan. 13]

13. Calibration runs with FT-Off (torus negatives inbending):

    Take calibration data in the FT-Off configuration with the torus field at -100% (negatives inbending) and the solenoid field at 100% running 50 nA of beam:

    During this study at each setting, move the beam 5 mm off axis to test vertex reconstruction, detector backgrounds, and solenoid focus. Collect 30 minutes of beam data in this condition.

    - Who: Shift workers, offline team
    - Tools: DAQ; offline - data cooking scripts, calibration suites, data analysis
    - Offline goals: Perform subsystem calibrations for each setting; Study response of CLAS12 forward and central detectors
    - Trigger: Random trigger, electron trigger, ECAL hadron trigger
    - Level: Must

    Assigned task duration: 8 hr

14. Field study:

    Take data at reduced fields in the torus and solenoid (torus -60%, solenoid 60%) to understand how the torus field affects the performance of the ECAL, FTOF, LTCC detectors and how the solenoid field affects the performance of the CND, CTOF, and HTCC detectors. In particular, these studies will confirm the effectiveness of the PMT magnetic shields for the forward and central detector systems with regard to ADC response and timing resolution. These data should be collected at a beam current of 10 nA.

    - Who: Shift workers, offline team
    - Tools: DAQ; offline - data cooking scripts, calibration suites, data analysis

- Offline goals: Study detector calibrations with specific focus on gain measurements of PMT-based detectors
- Trigger: Random trigger, electron trigger
- Level: Should

Assigned task duration: 8 hr

15. Solenoid rate studies with FT-Off (torus negatives outbending):

    With the torus at 100% current (negatives outbending) and a beam current of 10 nA, study the CLAS12 detector rates and currents, as well as the DC occupancies and current as a function of the solenoid field at settings of 50%, 60%, 70%, 80%, 90%, 100%. Record the rates and currents of all subsystems in the logbook, as well as the DC occupancies. Study should begin by ramping the solenoid down to 50% current and should end with the 100% current setting. The beam does not need to be turned off during solenoid magnet ramping.

    - Who: Detector experts, shift workers
    - Tools: Slow controls, scalers, DAQ, online monitoring (MON12, expert suites), CED, EPICS scaler dump tool
    - Trigger: Random trigger, electron trigger, ECAL hadron trigger
    - Level: Should

    Assigned task duration: 4 hr

16. Luminosity scan with FT-Off (torus negatives outbending):

    These studies are to be carried out the torus field at 100% (negatives outbending) and the solenoid field at 100% (nominal polarity). The scan should be performed for currents of 10 nA, 25 nA, 50 nA, 75 nA, 100 nA, and 150 nA. Stop raising the beam current if any of the detector (DC, SVT, BMT, FMT) rates or currents get close to unacceptable levels; consult with the Run Coordinator regarding the acceptable limits. For each setting, record the rates and current of all subsystems in the logbook, as well as the DC occupancies.

    - Who: Detector experts, shift workers
    - Tools: Slow controls, scalers, DAQ, online monitoring (MON12, expert suites), CED, EPICS scaler dump tool

- Trigger: Random trigger, electron trigger, ECAL hadron trigger
- Level: Should

Assigned task duration: 2 hr [End of Jan. 14]

17. Calibration runs with FT-Off (torus negatives outbending):

    Take calibration data in the FT-Off configuration with torus at 100% current (negatives inbending) and solenoid at 100% running 50 nA of beam:

    - Who: Shift workers, offline team
    - Tools: DAQ; offline - data cooking scripts, calibration suites, data analysis
    - Offline goals: Perform subsystem calibrations for each setting; Study response of CLAS12 forward and central detectors
    - Trigger: Random trigger, electron trigger, ECAL hadron trigger, e^+e^- trigger
    - Level: Should

    Assigned task duration: 8 hr

18. Reconfigure CLAS12 from the FT-Off to FT-On configuration:

    Remove the FT shielding and change out the Møller cone to the nominal beamline configuration.

    - Who: Hall B Engineering
    - Tools: N/A
    - Level: Must

    Assigned task duration: 48 hr

4.2 Phase 2: CLAS12 Commissioning with FT-On at 2.1 GeV

Duration: 3.5 days
Conditions: E_b=2.1 GeV, torus field $= -50\%, -100\%$
solenoid field $= 100\%$
No LTCC fill gas; No MM fill gas

The second phase of CLAS12 commissioning will take place at 2.1 GeV and will allow for data collection for detector subsystem calibration and for extraction of various cross sections to enable comparison with existing data. This is important to begin to understand how to properly normalize the measured yields in the forward and central detectors and to understand the systematics associated with such measurements before the beginning of production running with CLAS12 during the spring 2018 physics running period.

1. Pass change and beam tuning:

   Request a pass change from 5-pass to 1-pass beam. The accelerator will work to establish beam to the Hall B tagger magnet yoke dump. See the beam tuning procedures for Hall B on the run wiki under "Procedures" at:
   https://wiki.jlab.org/clas12-run/index.php/Engineering_Run

   Note: Before beam is delivered to Hall B ensure that all CLAS12 detectors are off and the target is empty.

   - Who: Beamline expert, shift workers
   - Tools: Slow controls
   - Level: Must

   Assigned task duration: 8 hr

2. Beam tuning to Faraday Cup:

   Establish beam to the Faraday cup and perform all necessary beam checks. See the beam tuning procedures for Hall B on the run wiki under "Procedures" at:
   https://wiki.jlab.org/clas12-run/index.php/Engineering_Run

   - Who: Beamline expert, shift workers
   - Tools: Slow controls
   - Level: Must

   Assigned task duration: 2 hr

3. Detector turn on:

   With the torus field at -100% (negatives inbending) and the solenoid field at 100% (nominal polarity), turn on the forward detectors (ECAL, FTOF, LTCC, HTCC, RICH); make sure scaler

rates are reasonable (defined by detector experts) while running 10 nA beam. Record the rates and currents of all subsystems in the logbook.

- Who: Detector experts, shift workers
- Tools: Slow controls, scalers, DAQ, EPICS scaler dump tool
- Level: Must

Assigned task duration: 1 hr

4. Fill the cryotarget (LH_2).

   Turn the beam off before filling the cryotarget. The detectors that have been energized should be left on. When the target is full, request 10 nA beam on target.

   - Who: Shift workers
   - Tools: Slow controls
   - Level: Must

   Assigned task duration: 1 hr

5. Detector turn on (continued):

   If the rates of the forward detectors are reasonable at 10 nA, turn on the DCs, CTOF, CND, and FT (not including FT-Trk). If the central detector system rates and currents are reasonable (defined by detector experts), turn on the SVT (but none of the MM trackers due to lack of gas). Record the rates and currents of all subsystems in the logbook, as well as the DC occupancies. The DAQ can be started and initial checkout can proceed.

   - Who: Detector experts, DAQ expert, shift workers
   - Tools: Slow controls, scalers, DAQ, online monitoring (MON12, expert suites), CED, EPICS scaler dump tool
   - Trigger: Random trigger, electron trigger, ECAL hadron trigger, FT trigger, FT+hadron trigger, e^+e^- trigger
   - Level: Must

   Assigned task duration: 1 hr

6. DAQ and trigger checks:

   Once the detector subsystems have been turned on, check that the DAQ system is functioning for the basic electron trigger. Re-establish and check configuration for DAQ and trigger operation.

   - Who: DAQ expert, trigger expert, detector experts
   - Tools: Scalers, online monitoring (MON12, expert suites), DAQMON, EVIO/HIPO tools
   - Trigger: Random trigger, electron trigger, ECAL hadron trigger, FT trigger, FT+hadron trigger, e^+e^- trigger
   - Level: Must

   Assigned task duration: 1 hr [End of Jan. 17]

7. Trigger studies:

   Optimize the triggers for the normalization studies. Study and optimize the different FT trigger definitions.

   The trigger commissioning plan for this task is detailed on the Hall B run wiki at:
   https://wiki.jlab.org/clas12-run/index.php/Engineering_Run

   - Who: DAQ expert, trigger expert, offline team
   - Tools: online trigger tools (**TBD**); offline - data cooking scripts, data analysis, trigger scripts (**TBD**)
   - Offline goals: Test trigger operations; determine trigger efficiency and trigger purity
   - Trigger: Random trigger, electron trigger, ECAL hadron trigger, FT trigger, FT+hadron trigger, e^+e^- trigger
   - Level: Must

   Assigned task duration: 8 hr

8. Calibration runs:

   After the DAQ and trigger checks have been completed, take data for the calibration of the detectors at beam currents of 10 nA and 50 nA. During this set of studies, data will be collected with a dedicated trigger for inclusive π^0 events in the FT in order to determine the energy calibration parameters. In addition, these data will be used to permit evaluation of the effect of low-energy radiative and photoproduction backgrounds from the target in the ECAL, as well to

a source of pions to cross calibrate the PCAL/EC systems. For each beam current collect 12 hr of data.

- Who: Shift workers, offline team
- Tools: DAQ; offline - data cooking scripts, calibration suites, data analysis
- Offline goals: Perform subsystem calibrations for each setting; Study response of CLAS12 forward and central detectors
- Trigger: Random trigger, electron trigger, ECAL hadron trigger, FT trigger, FT+hadron trigger, e^+e^- trigger
- Level: Must

Assigned task duration: 16 hr [End of Jan. 18]

9. Physics studies:

   After the completion of the calibration runs, optimize the DAQ setup for collection of ep elastic events. Other normalization studies will include inclusive electron scattering $ep \rightarrow e'X$ and Bethe-Heitler $ep \rightarrow e'p\gamma$ to provide a broad kinematic range to probe the response of the CLAS12 forward and central detector systems. Take data with a 50 nA beam for 24 hr at a torus field of -100% and for 24 hr at a torus field of -50%.

   - Who: Shift workers, offline team
   - Tools: DAQ; offline - data cooking scripts, calibration suites, data analysis
   - Offline goals: Perform analysis of normalized yields with aims to understand cross sections by comparing with world data
   - Trigger: Random trigger, electron trigger, ECAL hadron trigger, FT trigger, FT+hadron trigger, e^+e^- trigger
   - Level: Must [End of Jan. 20]

   Assigned task duration: 48 hr

4.3 Phase 3: CLAS12 Commissioning with FT-On at 10.6 GeV

Duration: 6 days
Conditions: E_b=10.6 GeV, torus field = 0%, -100%,
solenoid field = 0%, 100%
Fill LTCC S5 with C_4F_{10}; Flow gas to all MM

The final phase of the CLAS12 commissioning run in Jan. 2018 will take place with 10.6 GeV (5-pass) beam in the FT-On configuration. The main emphasis of this phase is to study the different triggers based on the FT system, to understand the luminosity limitations for operation of CLAS12 and to determine the operational luminosity for the RG-A spring run, and to take data in the final planned RG-A configuration. This phase will also include a limited spin dance designed to optimize the electron beam polarization in Hall B.

1. Pass change and beam tuning:

   Request a pass change from 1-pass to 5-pass. The accelerator will work to establish beam to the Hall B tagger magnet yoke dump. See the beam tuning procedures for Hall B on the run wiki under "Procedures" at:
   https://wiki.jlab.org/clas12-run/index.php/Engineering_Run

   Note: Before beam is delivered to Hall B ensure that all CLAS12 detectors are off and the target is empty.

   - Who: Beamline expert, shift workers
   - Tools: Slow controls
   - Level: Must

   Assigned task duration: 8 hr

2. Spin dance:

   Follow the game plan for the beam polarization spin dance. This will involve taking a series of Møller polarimeter runs in interaction with MCC to determine the machine settings for maximizing the electron beam polarization delivered to Hall B.

   The plans for the spin dance are detailed in the beamline commissioning plan on the Hall B run wiki at:
   https://wiki.jlab.org/clas12-run/index.php/Engineering_Run

- Who: Beamline expert, shift workers
- Tools: Slow controls, DAQ, Møller analysis suite
- Level: Must

Assigned task duration: 8 hr

3. Beam tuning to Faraday Cup:

   Establish beam to the Faraday cup and perform all necessary beam checks. See the beam tuning procedures for Hall B on the run wiki under "Procedures" at:
   https://wiki.jlab.org/clas12-run/index.php/Engineering_Run

   - Who: Beamline expert, shift workers
   - Tools: Slow controls
   - Level: Must

   Assigned task duration: 2 hr

4. Detector turn on:

   With the torus at -100% field (negatives inbending) and the solenoid at 100% field (nominal polarity), turn on the forward detectors (ECAL, FTOF, LTCC, HTCC); make sure scaler rates are reasonable (defined by detector experts) while running 10 nA beam on the empty target. Record the rates and currents of all subsystems in the logbook.

   - Who: Detector experts, shift workers
   - Tools: Slow controls, scalers, EPICS scaler dump tool
   - Level: Must

   Assigned task duration: 1 hr

5. Fill the cryotarget (LH_2).

   Turn the beam off before filling the cryotarget. The detectors that have been energized should be left on. When the target is full, request 10 nA beam on target.

   - Who: Shift workers
   - Tools: Slow controls

- Level: Must

Assigned task duration: 1 hr

6. Detector turn on (continued):

   If the rates of the forward detectors are reasonable at 10 nA, turn on the DCs, CTOF, CND, and FT (not including FT-Trk). If the central detector system rates and currents are reasonable (defined by detector experts), turn on the CVT (SVT and BMT), FMT, and FT-Trk. Record the rates and currents of all subsystems in the logbook, as well as the DC occupancies. The DAQ can be started and initial checkout can proceed.

   - Who: Detector experts, DAQ expert, shift workers
   - Tools: Slow controls, scalers, DAQ, online monitoring (MON12, expert suites), CED, EPICS scaler dump tool
   - Trigger: Random trigger, electron trigger, ECAL hadron trigger, FT trigger, FT+hadron trigger, e^+e^- trigger
   - Level: Must

   Assigned task duration: 1 hr

7. Detector setup optimization:

   Perform final detector setup optimization studies based on online and offline studies of the detector performance. Focus here should be on the FT and RICH systems.

   - Who: Detector experts, DAQ expert
   - Tools: Scalers, online monitoring (MON12, expert suites), DAQMON, EVIO/HIPO tools
   - Trigger: Random trigger, electron trigger, ECAL hadron trigger, FT trigger, FT+hadron trigger, e^+e^- trigger
   - Level: Must

   Assigned task duration: 3 hr [End of Jan. 21]

8. Trigger studies:

   Once the detector setup has been optimized and all systems are fully operational, the configuration and settings for the full set of RG-A triggers will be optimized. This includes establishing

final values for the prescale factors for the different triggers. The goal is to collect a final set of data for detailed offline studies of trigger efficiencies.

The trigger commissioning plan for this task is fully detailed on the Hall B run wiki at: https://wiki.jlab.org/clas12-run/index.php/Engineering_Run

- Who: DAQ expert, trigger expert, offline team
- Tools: online trigger tools (**TBD**); offline - data cooking scripts, data analysis, trigger scripts (**TBD**)
- Offline goals: Test trigger operations; determine trigger efficiency and trigger purity
- Trigger: Random trigger, electron trigger, ECAL hadron trigger, FT trigger, FT+hadron trigger, e^+e^- trigger
- Level: Must

Assigned task duration: 8 hr

9. High luminosity calibration runs:

   The next part of the beam commissioning plan is to take data at high luminosity to collect a sizable dataset for subsystem calibrations and systematic studies. These data will be used to establish the baseline performance of each detector subsystem at the nominal CLAS12 luminosity. During this period calibration data sets will be acquired at beam currents of i=50 nA and 75 nA. If there are no issues with subsystem rates and currents, exploratory studies at currents up to 150 nA should be completed. For each beam current collect 1-2 shifts of data.

   These studies and those from the previous step should serve to define the nominal operating luminosity of CLAS12 for 5-pass beam with negatively charged particles inbending.

   - Who: Shift workers, offline team
   - Tools: DAQ; offline - data cooking scripts, calibration suites, data analysis
   - Offline goals: Perform subsystem calibrations for each setting; Study response of CLAS12 forward and central detectors
   - Trigger: Random trigger, electron trigger, ECAL hadron trigger, FT trigger, FT+hadron trigger, e^+e^- trigger
   - Level: Must

   Assigned task duration: 36 hr

10. Alignment studies:

    Turn the beam off and ramp the torus and solenoid down to zero field. Empty the cryotarget. The 30 μm Al end windows of the target cell will be used for the thin ("point target") for the duration of the alignment studies. With a 1 nA beam, check the rates in the beamline scalers and the forward detectors. If necessary study beam stability at lower beam currents down to 200 pA. If the rates are reasonable (defined by the detector experts), turn on the CTOF and FT detectors. Record the rates and currents of all subsystems in the logbook. Take a data run for forward and central detector alignment using the tracking trigger.

    - Who: Detector experts, beamline expert, shift workers
    - Tools: Slow controls, scalers, DAQ, online monitoring (MON12, expert suites), CED, EPICS scaler dump tool; offline - data cooking scripts, data analysis, alignment codes (**TBD**)
    - Offline goals: Determine system offsets to align forward and central tracking systems
    - Trigger: Random trigger, electron trigger, FT trigger
    - Level: Must

    Assigned task duration: 6 hr

11. Physics studies in RG-A conditions:

    The next portion of the CLAS12 commissioning run will be to take data under conditions of the RG-A run group to provide data for calibrations, for understanding acceptances and rates, and to understanding background conditions. These runs will be taken with the torus field at -100% (negatives inbending) and the solenoid field at 100% (nominal polarity). The full RG-A trigger list should be configured with the nominal RG-A DAQ and detector settings. The beam current should be 75 nA to provide the nominal CLAS12 luminosity of 1×10^{35} cm^{-2}s^{-1} using the standard Hall B liquid-hydrogen cryotarget.

    - Who: Shift workers, offline team
    - Tools: DAQ; offline - data cooking scripts, calibration suites, data analysis
    - Offline goals: Study response of CLAS12 forward and central detectors
    - Trigger: Random trigger, electron trigger, ECAL hadron trigger, FT trigger, FT+hadron trigger, e^+e^- trigger
    - Level: Must

Assigned task duration: 70 hr

12. After the beam is turned off:

    Turn off all detectors and call for Hall B to be put into Restricted Access. Contact the Engineering on-call to secure the torus and solenoid magnets and to secure the cryotarget. [End of Jan. 26]