Commissioning the CLAS12 Experimental Equipment
Version 2.2

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Chapter 1

Introduction

The purpose of this document is to describe the procedures that will be followed to commission the CLAS12 detector and each ot its components. The goal of these procedures is to (1) ensure the quality standards defined by the Technical Design Report (TDR) of the detector, (2) optimize the sequence of operations during construction, installation and operation in terms of time, manpower and computing resources, (3) ensure the proper functioning of each detector subsystem before and after installation in Hall B, (4) obtain initial calibration data for each subsystem necessary for the reconstruction of physics events, (5) determine the performance of each subsystem, and (6) optimize the overall detector configuration according to the requirements of the physics runs.

The achieve these goals, the CLAS12 commissioning plan will be divided in three phases, i.e.:

- quality assurance and system checkout,
- commissioning without beam,
- commissioning with beam.

The first phase, *quality assurance and system checkout*, will consist of all procedures that will be applied, before and during the subsystem assembly, to check that all detector components are compliant with their specifications and to ensure the proper functioning of the subsystems before and after installation in Hall B. In particular, the quality assurance procedures will include tests on specific subsystem components (e.g. PMTs, cables, electronics boards, etc.) to measure their characteristics and to check them against the specified requirements, to verify that active components are responding correctly, and to identify and replace faulty elements. During this phase, the component parameters that will be measured will be saved in a common database

for future reference and utilization. The system checkout procedures will be performed upon completion of the subsystem assembly and will include alignment and verification of the subsystem positioning, full tests of items such as high- and low-voltage supplies and controls if applicable, front-end electronics, readout electronics, data acquisition and trigger system.

The second phase of CLAS12 commissioning will focus on the verification of the subsystem performance, after completion of the checkout procedures and before the beginning of the in-beam operation. The purpose of the associated procedures will be to optimize the subsystem configuration, determine the initial calibration that will be later used in the reconstruction algorithms and verify that the subsystem performance is consistent with the design goals. This will be achieved via data taking in special configurations, exploiting dedicated equipment depending on the subsystem type (e.g. laser or pulser runs), as well as using radioactive sources or cosmic rays. Data will be collected in different configurations of the CLAS12 magnets, data acquisition and trigger to obtain the maximum information as requested by the subsystem groups.

The final phase of the commissioning will be performed upon beam delivery in Hall B. After completion of the beamline commissioning, which will be performed in strict collaboration with the Accelerator Group, the commissioning of each of the CLAS12 subsystems will be performed using the optimal configuration(s) of beam energy, beam intensity, CLAS12 magnet settings, CLAS12 DAQ and Trigger, as requested by the subsystem groups and determined based on detailed simulation of the spectrometer. Data will be collected at different beam energies and intensity to verify the response of the CLAS12 subsystems to specific reactions and to measure noise levels and rates. The accumulated data will be used to determine the final detector calibration that will be used by the CLAS12 reconstruction software. Finally, the performance of each individual subsystem (energy and time resolution, acceptance and efficiency), as well as the full CLAS12 detector, will be determined from the analysis of the accumulated data.

This document is structured as follows. In Chapter 2, 3 and 4, a summary of the procedures that will be completed during each of the commissioning phases is presented. This information is detailed for each of the CLAS12 subsystems, listed in Chapter 5 as well as for the whole CLAS12 spectrometer. Run conditions for the initial data taking are presented and the reaction channels that will be analyzed to determine the full detector calibration and estimate its performance are discussed. The specific commissioning plans for each of the CLAS12 subsystems are contained in the Appendix.

Chapter 2

Quality Assurance and System Checkout

2.1 Objectives

In general, the objectives of the CLAS12 quality assurance and detector checkout before beam is delivered to Hall B are:

1. to eliminate dysfunctional or weak components in the detector that are instrumental for the overall operation of the individual detector systems and can be spotted without using the electron beam;

2. to determine via direct measurements the relevant parameters determining the performance of each of the detector components and to store them for future reference and utilization;

3. to ensure that the individual detector systems are operational according to specifications upon completion of its installation in Hall B.

This will include the following aspects of the detector systems.

2.2 Quality Assurance Phase

During the construction of the individual detector systems, each of their components will be subject to a thorough quality assurance process to identify and eliminate faulty or weak elements and to ensure the selected ones are compliant with specifications.

2.2.1 Silicon Vertex Tracker

Detailed quality assurance procedures for the SVT, covering all the phases of the detector construction, have been defined in collaboration with experts at FNAL. These tests include both mechanical and electrical measurements, involving both the single components and the assembled modules, to be performed before and during the construction at FNAL and after the delivery at JLab.

The first test consists in the accurate survey of the detector modules via optical measurements to be performed at FNAL before mounting the sensors. The module dimensions and flatness, the position of mounting pins and the sensor locations will be determined and checked against the chosen tolerances. The second test will be performed at FNAL in a dedicated test station after the sensors will be mounted on the boards. This will consist in the measurement of the gain, the noise and the power consumption of each channel. Identified defects will be possibly fixed and faulty modules will be returned to the production line for repair. The same electrical measurements will be repeated on each channel upon delivery of the module at JLab, to ensure no problems developed during the transport and handling.

In a second phase, each module will be mounted on the barrel support and tested again with cosmic rays. A dedicated DAQ setup will be used to record the response of the detector, using a plastic scintillator read-out by a PMT for triggering. The data will be analyzed to check the response of each channel and sensor. As more modules will be installed on the support, the cosmic ray data will allow for the verification of their relative alignment and for the evaluation of their efficiency and resolution.

Upon completion of the module installation of the support, a full survey of the barrel tracker will be performed and additional cosmic ray data will be collected to determine the ultimate efficiency and spatial resolution.

2.2.2 MicroMegas Tracker

The quality assurance procedures for the MicroMegas tracker includes three different types of tests, specifically verification of dimensions, measurement of gain and energy resolution, measurement of efficiency and spatial resolution. These tests will be performed on each of the detector units composing the barrel and forward MicroMegas Tracker.

Dimensions of both the flat and curved detectors will be determined using optical measurements and the resulting values will be checked against the design tolerances. Particular care will be

devoted to the measurement of the distance between the mesh and the strip which affects the gain of the detector. Gain and energy resolution will be measured with a ^{55}Fe source. Typical gain homogeneity that is expected is of the order of about 30%. Finally the efficiency and spatial resolution of each detector will be determined with cosmic rays. A dedicated DAQ setup will be used to record data from the detectors using a plastic scintillator for triggering.

After completing the construction and test of all the detector units, these will be assembled to form the barrel and forward detectors. The assembled systems will be surveyed to verify the relative alignment of the detector units. The response to cosmic rays of the barrel and forward detectors will then be measured to determine the overall efficiency and resolution. For this test, the forward detector will be placed horizontally. The data acquisition system will be triggered by a plastic scintillator. The survey and the cosmic ray test will be performed first at Saclay and repeated at JLab after the delivery of the detectors.

2.2.3 Central Time of Flight

According to the detector specification, the CTOF design resolution should be 60 ps. Given the detector layout, this is a very stringent requirement that can be reached only with a thorough selection and optimization of all the key components of the detector. For this reason, the scintillation bars, light guides, photomultipliers and magnetic shields will be inspected and checked individually upon delivery.

First the relevant dimensions of the scintillation bars and light guides will be checked for compliance with the specifications. The scintillation bars and light guides will then be checked with a light source and a radiometer and compared to reference measurements. Checks of the PMTs will be performed using an oscilloscope with associated signal and HV cables and an HV power supply. Each of these procedures will be applied for each component before the final counter assembly.

The assembled counters will then be tested with radioactive sources and cosmic rays to measure their time resolution. The cosmic ray measurement will be performed using three counters simultaneously, selecting events in which a cosmic muon has crossed the three scintillation bars and determining the average time-of-flight resolution of the three bars. For these tests, front-end electronics and a DAQ system will be setup using the electronic boards selected for the final detector readout. The readout system will be expanded as more counters become available to perform a full checkout of the detector when the assembly will be completed.

2.2.4 Central Neutron Detector

The construction of the CND will be performed at IPN-Orsay. Upon delivery in the IPN laboratories, all detector components will be checked. Scintillators will be inspected for inclusions and impurities; PMTs will be tested with a light source to measure their gain as a function of the applied voltage; scintillators will be coupled to light guides and PMTs, and checked for light leaks looking at the signal from cosmic rates on an oscilloscope. The functioning of voltage dividers, splitters and discriminators will also be tested.

After completing this phase, the assembly of the detector modules consisting of three scintillation bar pairs, with their associated light guides and PMTs, will be performed. Each detector module will then be tested with cosmic rays, to verify the assembly procedure and determine its performance. The 24 CND modules will then be shipped to JLab and, upon delivery at the laboratory, will be tested again with cosmic rays to ensure no damage was caused during the transportation. Tests with cosmic rays will utilize the front-end electronics and HV supplies selected for the detector operation. In this phase, the HV supplied to the PMTs will be set to equalize the detected charge for minimum ionizing particles.

2.2.5 Drift Chambers

During construction, a series of tests will be performed to evaluate the quality of the different construction tasks and to verify that the planned standards are achieved. These include measurements of the wire tension to evaluate the sagging effect and to determine the actual position of the wires, wire continuity tests to verify the quality of the electrical connection and to detect crossed wires, and high voltage tests. When the assembly of a chamber is complete, the size of gas leaks will be determined and finally signals due to cosmic rays will be measured to ensure the chamber is operational and ready for installation.

2.2.6 Low Threshold Čerenkov Counter

The LTCC system will be built from the refurbishing of the existing CLAS Čerenkov Counter. Quality assurance tests will focus on the verification of the main components of the existing system and on the control of the disassembly and reassembly procedures.

The six sectors of the CLAS Čerenkov Counter will be removed from Hall B and moved to a test area where the mirror sagging induced by gravity will be measured accurately using optical

tools. The measured values will be used, together with calculations based on finite element analysis and GEANT4 simulations, to determine the optimal position of each mirror in the new detector. The sectors will then be disassembled and individual components will be tested. Bad PMTs and voltage dividers will be replaced. The detector frames will be modified to match the new geometry and the sectors will then be reassembled in the new configuration. Mirrors will be mounted and oriented in the new positions using a laser system to verify their final alignment. Gas windows will be attached on the upstream and downstream sides of the frames and the sectors will be filled with gas and leak-checked to verify the window sealing.

2.2.7 Forward Time of Flight

The first part of the FTOF commissioning will be focused on the refurbishing of the CLAS-TOF counters that will be used in panel 1A and 2 of the new detector. The bench testing that will be performed at Jefferson Lab will include checks of individual counters with radioactive sources and cosmic rays to verify functionality, identify light leaks, bad PMTs or broken light guides. In addition, the timing resolution for sets of three counters will be measured using cosmic rays and selecting events with cosmic muons crossing the three bars to determine the average time resolution.

In parallel, detailed quality assurance tests will be performed on all components (scintillation bars, PMTs and voltage dividers) that will be used to assembly the counters for FTOF panel 1B. Each of the counters will be assembled and then checked to identify possible light leaks or malfunctioning. Final tests to determine the time resolution will be performed using a stack of the six identical counters from the six sectors and detecting the cosmic muons crossing the counters. This method will allow for determination of the time resolution of the individual counters.

The cosmic ray measurements will be used to determine the HV settings for the PMTs that give identical signals for minimum ionizing particles and to determine the initial calibration constants for the counters. Upon completion of these tasks, both the refurbished counters and the newly built ones will be ready for installation in the Hall B.

2.2.8 Electromagnetic and Pre-Shower Calorimeters

The first phase of the electromagnetic calorimeter commissioning consists of detailed quality assurance tests on the components of the new Pre-Shower Calorimeter (PCAL). These include checks of the functionality of each PMT, after the installation and cabling of all the PMTs and the sealing

of the box for the module. The HV supplied to the PMTs will be adjusted to place the single photoelectron peak at a specific ADC channel and the signals will be scrutinized to identify light leaks, excessively noisy tubes and cross talk. Light leaks will be repaired and noisy or low-gain PMTs will be replaced. In a second phase, the response of a PCAL sector module to cosmic rays will be measured to verify the functionality of the system and to determine initial calibrations. Readout will be first performed with standard QDC boards connected via delay cables; later the QDCs will be replaced with flash-ADCs and the adapted reconstruction algorithms will be tested via comparison with the first results. Upon completion of this test procedure for one sector module, this will be ready for installation in Hall B.

In parallel to the PCAL quality assurance and testing, the refurbishing of the existing EC will begin after the end of the CLAS operation in May 2012. After removal of the cables and the related support structure, tests of each PMT will be performed to identify malfunctioning tubes or voltage dividers, find broken housings and repair light leaks. Analysis of the existing CLAS data will be performed in advance to provide initial indications of the faulty items. After completing the detector refurbishing, cosmic ray tests of the EC will commence and continue until the installation of the PCAL system will begin.

2.2.9 Forward Tagger

The quality assurance procedure for the Forward Tagger system will include tests of each of the key components of the calorimeter, scintillation hodoscope and tracker.

In the case of the calorimeter, the $PbWO_4$ crystals will be tested at the ACCOS facility at CERN measuring mechanical properties as dimensions and surface roughness, optical properties as the longitudinal and transverse transmission, scintillation properties as light yield and decay time, and radiation resistance. The measured parameters will be checked against specifications and crystals that will not meet the expectations will be returned to the vendor for replacement. The light sensors, i.e. Avalanche Photo-Diodes, will be tested with a light source upon delivery at INFN to measure the gain dependence on the applied voltage and temperature, the dark current and the signal amplitude for a fixed light pulse. The preamplifiers will be tested sending a reference pulse to the input and measuring gain, noise and output signal shape. In addition, both the cooling system, used to stabilize the crystals and APDs at the chosen operating temperature, and the LED system, used to monitor the stability of the crystal optical properties and APD response over time, will be tested extensively before proceeding with the system assembly.

Similar tests are foreseen for the individual components of the scintillation hodoscopes. The plastic scintillator tiles will be first visually inspected to identify possible defects both before and after machining the grooves to host the wavelength-shifting fibers. The fibers will then be glued in the grooves and the light-collection efficiency will be estimated by coupling the fibers to a reference light sensor and observing the signal from a ^{90}Sr source. The preamplifier boards will be first tested feeding a reference pulse to each individual channel and measuring gain, noise and output signal shape. In a second step, SIPMs will be connected to the preamplifier board and the single photo-electron pulse will be measured to verify that the signal amplitude and time length are consistent with the specifications. Finally the WLS fiber will be connected to the SIPMs and the signal from both a ^{90}Sr source and cosmic rays will be measured for each scintillation tile.

The main components of the MicroMegas tracker will be tested following the same procedures developed for the central tracker and outlined in Section 2.2.2.

2.3 System Checkout

After completion of the installation of the individual detector systems in Hall B, each will be checked to verify the proper functioning of all its subsystems (high and low voltage, cabling, gas system, laser/led systems, cabling, front-end and readout electronics), the positioning of the detector and its relative alignment to the other CLAS12 components.

2.3.1 Checkout of cable routing

A checkout of the cable routing schemes of the signal readout will be initially performed for the individual detectors without high voltage or low voltage applied to the system. For the drift chamber system, this will be carried out with digital signals injected channel-by-channel into the front-end electronics. Similarly, cable routing of the electromagnetic calorimeters (PCAL, EC), the forward and central time-of-flight (FTOF, CTOF) arrays, the Čerenkov counters (LTCC, HTCC), the central trackers (SVT, MM) and forward tagger (FT) will be checked. This procedure will weed out swapped signal cables and faulty signal connections.

2.3.2 High Voltage System checkout

The high voltage (HV) system of the drift chambers will be tested by reading out electronic noise in the drift chambers when the high voltage has been applied. This will be done in a "self-triggering" mode, where the discriminator thresholds of the front-end electronics are set to sufficiently low values to allow electronics noise to pass the threshold. This procedure allows checking that all channels are properly supplied with the voltage required to operate the preamplifier and amplifier-discriminator boards (ADBs). Similarly, the HV distribution to the photomultiplier tube (PMT) based detectors (PCAL, EC, HTCC, LTCC, FTOF, CTOF) will be checked by turning the HV supplied to individual channels ON and OFF and observing the appearance and disappearance of noise and cosmic ray signals induced in the scintillators coupled to the PMTs. A similar procedure will be used for the other detector systems. HV will be supplied to each SVT and MM module and the corresponding signals, noise levels and leakage currents will be measured. HV for each group of APDs and SIPMs used in the readout of the FT calorimeter and hodoscope will be turn on/off and the appearance/disappearance of the associated signals will be verified.

2.3.3 Low Voltage System checkout

The functionality of the low voltage (LV) distribution to the front-end electronics will be tested by turning the supplies to clusters of channels ON and OFF and observing the appearance and disappearance of related channels in the occupancy plots. This will be accomplished by using the CLAS12 data acquisition system run in a free-running mode. This check will involve the DC, SVT, MM and FT systems. The current driven by each system will be measured to check the corresponding power consumption.

2.3.4 Solenoid and Torus magnet checkout

The Solenoid magnet checkout in Hall B will occur after the initial quality assurance tests and field mapping outside of the Hall. It will consist of ramping the field to a moderate level to ensure integrity of the magnet after transport to the Hall, and the functionality of the cryogenics interfaces and controls and of the power supply. The Torus magnet will be assembled in Hall B by the vendor from pre-fabricated components. After assembly, the magnet will be interfaced with the cryogenic system in the Hall, cooled down, and ramped up. A magnet quench will be initiated to verify the quench detection and protection system. This will be part of the vendor's responsibility. Once the

magnet is accepted and in its final location, magnetic field tests will be carried out to determine deviations from the ideal symmetry and the force loads in the system.

2.3.5 Silicon Vertex Tracker and MicroMegas Tracker checkout

The integration of the SVT and MM trackers will be completed in a clean room at JLab before installation in Hall B. The system will then be surveyed to verify the relative position and alignment of the two tracking systems. Cosmic ray measurements will be used to determine the overall performances and identify the presence of coherent noise and cross talks.

Upon completion of the installation in Hall B, the tracker will be again surveyed and then aligned to the CLAS12 solenoid. The SVT and MM gas systems will be checked out and finally the trackers safety interlock systems will be thoroughly tested before beginning routine operations. The checkout of the trackers will then be completed analyzing their response to cosmic rays. For this measurement, triggers will be provided by a plastic scintillator or, if already available, by the CTOF or CND detectors. Data will be recorded first without magnetic field in order to have straight tracks and then with the Solenoid magnet ramped up to 1/2 and full field to test the accuracy of track reconstruction in the barrel part. For this purpose the track will be reconstructed in the SVT/MM layers in one hemisphere, and checked against the track parameters reconstructed in the layers of the opposite hemisphere. Agreement within multiple scattering effects is expected.

2.3.6 CTOF cosmic ray checkout

After complete assembly and integration of the CTOF counters into the Solenoid magnet, a survey of the counters will be performed to verify their alignment and to determine their positions. The measured values will be saved in the CLAS12 database to be utilized by the CLAS12 simulation, calibration and reconstruction software. The detector will be then checked out with cosmic rays. For this purpose, a single small scintillation start counter will be placed in the center of the CTOF barrel for triggering. A signal in the start counter and a hit in one of the CTOF scintillators, which indicates passage of a cosmic ray muon, will be used to calibrate the CTOF scintillators on the opposite side of the CTOF barrel. The Solenoid will then be powered up in steps of 1/10 of maximum current, and the response of the CTOF PMTs and the resulting time-of-flight resolution will be measured.

2.3.7 CND cosmic ray checkout

After completion of the test of the CND modules as described in Sec. 2.2.4, the modules will be installed in the Solenoid magnet and surveyed to check their alignment and to determine their positions. The measured values will be saved in the CLAS12 database to be utilized by the CLAS12 simulation, calibration and reconstruction software. Signal and HV cables wil be positioned and connected to the corresponding electronic units. The detector will be then checked out with cosmic rays: data will be accumulated triggering on a minimum of three CND modules and events corresponding to muons crossing the detector radially will be selected to verify the proper functioning of the whole system and to determine the timing resolution. The quality of the PMT signals and the overall timing resolution will also be studied as a function of the Solenoid field, following the same procedure outlined for the CTOF in the previous section.

2.3.8 DC checkout

After installation and cabling of the Drift Chambers in the Hall, continuity of the cables will be checked and the time delay for signal cables will be measured. The gas system will then be made operational by measuring flows, pressures and possible contaminants to identify and repair leaks. The high and low voltage distribution systems will be tested as described above and finally the presence of signals will be checked both using oscilloscopes and reading out TDCs using a random or cosmic trigger.

A crucial part of the DC checkout will be survey of the chamber location with respect to an internal torus coordinate system. This will be performed using reference marks on the torus to define the coordinate system and then measuring the DC locations by a combination of reference fiducials and proximity sensors. The outcomes of this procedure will be the three coordinates and three angles defining the position of each of the 18 chambers.

2.3.9 LTCC checkout

Upon completion of the installation of the LTCC in Hall B, the gas control system will be tested and each sector will be leak-checked. Cabling and connections will be verified as outlined in Sec. 2.3.1. The HV control and monitoring system will be tested as explained in Sec. 2.3.2. The PMTs and front-end electronics will be checked by recording the single photo-electron signals in self-triggering mode. The response of the tubes to the light will be checked by injecting light pulses

in each sector box using LEDs. The procedure will be repeated as a function of the Torus field to test the effectiveness of the PMT magnetic shields. Finally, the HV setting of the individual channels will be adjusted with an iterative procedure to produce equal size SPE signals.

2.3.10 FTOF checkout

After completing the installation of the FTOF counters in the Hall, cabling and connections will be verified as outlined in Sec. 2.3.1. The HV control and monitoring system will be tested as explained in Sec. 2.3.2. Finally the whole FTOF system will be tested in self-triggering mode using cosmic rays and recording signal with the CLAS12 DAQ. Functionality of the front-end electronics (fADCs, discriminators, TDCs and scalers) will be tested, and noise levels and spectra of each PMT will be checked as a function of the Torus field.

2.3.11 EC and PCAL checkout

Cosmic ray data accumulated with the EC system in self-triggering mode will be used for the checkout of this detector system as well as the complete test of the front-end and trigger electronics used for the readout of the EC and PCAL. Noise levels on the fADCs will be studied by connecting only signal cables and disconnecting HV cables or powering off the HV supplies. Light leak checks will be repeated using the fADCs. The EC cosmic ray data will also be used to optimize the HV settings of the EC PMTs and perform full calibration of the system.

After installation of the six PCAL modules on the forward carriage, similar tests will be extended to this system. Initially the HV values determined during the QA tests of the system will be loaded and cosmic ray data will be accumulated using the new front-end electronics and trigger systems. The data will be analyzed to extract optimal HV settings for the PMTs corresponding to the best signal-to-noise ratio for the minimum ionizing particle peak while maintaining good linearity for the electromagnetic shower events. Calibration constants, such as the absolute light yield and attenuation length, will be determined and stored in the CLAS12 database for future utilization. Functionality and efficiency of the fADC based readout and trigger system will also be studied.

2.3.12 FT checkout

Upon completion of the installation in Hall B, the detector will be surveyed to first verify the relative position and alignment of the calorimeter, hodoscope and tracker and then to check the

alignment with respect to the ideal beam line. Possible misalignement or sagging of the FT will be compensated acting on the adjustable support connecting the detector to the torus ring. The procedure will be repeated after the installation of the moller shield.

Signal, HV and slow control cables, gas pipes and cooling lines will be installed and checked out as follows. Cabling and connections will be verified as outlined in Sec. 2.3.1. The HV control and monitoring system will be tested as explained in Sec. 2.3.2.

The gas and cooling systems of the calorimeter will be tested to ensure no sizable leaks are present and that a stable and uniform temperature can be maintained. The LED system will then be used to send light pulses of adjustable amplitude to the individual channels. The output signals will be recorded with the CLAS12 DAQ, providing a check of the functionality of the entire system. The data will then be analyzed to study the linearity and time stability of the calorimeter, to measure noise levels and cross talks, and finally to study the time response of the system and determine initial timing calibrations.

The checkout of the hodoscope will be performed measuring the single photo-electron signal from each SIPMs with the CLAS12 DAQ. This will provide a check of the functionality of the light sensors, preamplifiers and front-end electronics (fADCs, discriminators and TDCs).

The checkout of the tracker will be performed following the same procedure outlined for the central tracker as described in Sec. 2.3.5.

Finally the whole FT system will be tested in self-triggering mode using cosmic rays and recording signal with the CLAS12 DAQ.

2.3.13 Slow Controls checkout

The slow controls procedures to adjust the critical parameters of the equipment will be checked out once the full system has been installed in the experimental hall. It will include checkout of all systems controlled by EPICS such as HV, LV, discriminator control system, detector scaler monitors, beam monitors, magnet controls and monitors, helicity scalers and the beam polarization measurement system (Möller). Part of the slow controls checkout will be performed in conjunction with the individual detector checkout.

Chapter 3

Commissioning without Beam

3.1 Objectives

After completion of the systems checkout, the overall functioning of the CLAS12 components after installation will have been established. The following phase of the CLAS12 commissioning will be focused on optimizing the subsystem configuration, determining the initial calibrations that will be later used in the reconstruction algorithms and verifying that the subsystem performances are consistent with the design goals. These objectives will be achieved by means of special runs, including pedestals and pulser runs to calibrate the front-end electronics, laser or LED runs for selected subsystems and cosmic ray measurements.

The associated procedures are detailed in this chapter.

3.1.1 Pedestal and Pulser Calibration Runs

Calibration of the front-end electronics and, in particular, of the flash ADCs and TDCs used to read out most the CLAS12 detector systems, will be performed taking pedestal runs and pulser runs. For the former, the CLAS12 DAQ will be triggered by a random pulse and the flash ADC samples will be recorded to determine the signal baselines. For the latter, pulses from a generator will be fed to all TDC channels or to a chosen subset and will be used to trigger the DAQ after going through a variable delay. The values of TDC hits will be analyzed as a function of the delay to measure offsets and slopes for each TDC channel.

3.1.2 SVT calibration

The first step for the calibration of the SVT will be accomplished by means of special calibration runs designed to determine gain and noise of each channel. This will be achieved by injecting a small charge in each channel in absence of real signals. Gain values will be determined from the amplitude of the recorded signal. Noise and threshold dispersion values will be evaluated by studying the channel occupancy as a function of the applied threshold. The resulting values will be used to choose the values to be used by the zero-suppression algorithms.

The second step in the SVT calibration will be based on cosmic-ray data. These will provide both the mean to determine the tracking efficiency and resolution and to synchronize the detector with the Level-1 trigger of CLAS12. This will be achieved using a dedicated trigger provided by the Central Time-Of-Flight (CTOF) detector, based on a coincidence between opposite scintillation bars. Tracks will be reconstructed in the SVT layers of one hemisphere, and checked against the track parameters reconstructed in the SVT layers of the opposite hemisphere. Agreement within multiple scattering effects is expected. This procedure will be first applied in the absence of magnetic field to have straight tracks and then with the Solenoid magnet ramped up to 1/2 and full field to test the accuracy of track reconstruction.

3.1.3 MM calibration

Full calibration of the MicroMegas tracker will be achieved by performing special runs and measuring the detector response to cosmic rays.

Pedestals of the dedicated front-end electronics will be determined by triggering the DAQ with an internal clock and recording the measured signals. The procedure will be repeated with the SVT detector on and off to study potential interferences. The resulting pedestal values will be then used by the zero-suppression algorithm. The functionality of the front-end electronics will be verified by running special diagnostic runs, in which pre-calibrated internal charges will be injected in each channel to check gain and noise.

Tracking efficiency and resolution for the barrel part will be determined with cosmic-ray data. The CLAS12 DAQ will be trigger by requiring the coincidence of opposite scintillation bars in the CTOF or CND detectors. Tracks will be reconstructed in one hemisphere of the MM tracker and checked against the track parameters reconstructed in the opposite hemisphere. Agreement within multiple scattering effects is expected. This procedure will be first applied in the absence of

magnetic field to have straight tracks and then with the Solenoid magnet ramped up to 1/2 and full fields to test the accuracy of track reconstruction. Similarly, tracking efficiency for the forward part will be determined by using a trigger based on the CLAS12 forward detectors (EC-PCAL and FTOF) and selecting tracks pointing to the target.

3.1.4 CTOF cosmic ray calibration

Initial calibration of the CTOF system will be obtained using cosmic rays and following the procedure outlined in Sec. 2.3.6. The HV supplied to the PMTs will be adjusted to equalize the detected charge for minimum ionizing particles. This accumulated data will then allow for determination of all the detector calibration parameters, such as attenuation lengths, effective light velocities, time offsets, and for the determination of the time resolutions od the individual scintillation bars. The calibration paramaters will be stored in the CLAS12 database to be utilized by the CLAS12 simulation and reconstruction software.

3.1.5 CND cosmic ray calibration

Initial calibration of the CND system will be obtained using cosmic rays and following the procedure outlined in Sec. 2.3.7. The HV supplied to the PMTs will be adjusted to equalize the detected charge for minimum ionizing particles. This accumulated data will then allow for determination of all the detector calibration parameters, such as attenuation length, effective light velocity, time offsets, and for determination of the time resolutions and detection efficiencies of the individual scintillation bars. The calibration paramaters will be stored in the CLAS12 database to be utilized by the CLAS12 simulation and reconstruction software.

3.1.6 DC cosmic ray calibration

After completing the system checkout procedure for the system, data from cosmic rays will be accumulated. The trigger will be provided by the FTOF system and other CLAS12 detectors to select muon tracks that cross the chambers and are oriented toward the target region. The data will then be analyzed to check for dead areas, noisy channels, possible cable swaps and to determine initial calibrations. The efficiency of single DC layers (1 out of 36) or of a single superlayer (1 out of 6) will be mapped by excluding the layer (or superlayer) to be tested from the fit, and measuring

the hit probability in that same region by projecting the reconstructed track into that particular region.

3.1.7 Single photon calibration for HTCC/LTCC

The standard procedure for calibrating the low threshold Čerenkov counter (LTCC) response has been to use the single photo-electron "noise" signal and to adjust the PMT HV to equalize the output signal. This technique uses a self-triggering procedure that allows calibrating all 216 channels simultaneously using an iterative and semi-automatic procedure: the single photo-electron signals are measured and their average charge is determined for each PMT; the values obtained for different PMTs are compared and the corresponding HV values are adjusted to compensate possible differences.

For the HTCC, a similar procedure will be used. To check the sensitivity of the HTCC PMTs to the fringe field of the solenoid magnet, the calibration will be repeated with the magnetic field ramped up in steps of 1/10 of the maximum field. The (possibly shifted) single photo-electron peak will be recorded, and then the HV will be adjusted to restore the no-field peak position.

3.1.8 FTOF cosmic ray calibration

Initial calibration of the FTOF system will be determined using cosmic rays. Initially, the HV values supplied to the PMTs will be set to the values determined during the bench tests. These values will be adjusted based on the analysis of cosmic ray data with an iterative procedure. Data will be accumulated using triggers based on the FTOF and EC systems; the EC will be used to select tracks coming from the target region, to reproduce the real working condition. The analysis of the cosmic ray data will allow for a full calibration of the system, extracting calibration constants that will be stored in the CLAS12 database for future utilization by the CLAS12 simulation and reconstruction code.

3.1.9 EC and PCAL cosmic ray calibration

Cosmic muon runs will be used as a diagnostic tool to evaluate and calibrate both the PCAL and EC. For this purpose, cosmic muon data will be accumulated with standalone (PCAL+EC) and coincidence (PCAL·EC) triggers to study the efficiency of a trigger based on the energy sum or clustering algorithms. These data will also be used to determine the relative spatial alignment

of the EC and PCAL systems, their relative timing, their associated attenuation lengths, for gain matching of the two detectors and for measuring their relative efficiency.

Cosmic ray data will also be accumulated using information from other detector systems as the FTOF and DC. This external information will be used to determine the relative spatial alignment, the relative timing and the efficiency of the EC/PCAL detectors.

3.1.10 FT calibration

The first phase of the FT calorimeter calibration will be accomplished by performing special runs with the dedicated LED system. Light pulses of adjustable intensity will be injected in individual crystals or group of crystals and the dependence of the output signal charges as a function of the pulse intensity will be studied to verify the functioning, the linearity, the gain stability and the noise level of the individual channels. The analysis of the relative time delays of different channels will also allow for the determination of the time offsets constants.

The second phase of the FT calibration will be based on cosmic-ray data. Trigger based on the FT system alone (FT-Cal, FT-Hodo and FT-Trk) or in coincidence with CLAS12 will be used. Data with a trigger based on the FT-Cal alone will be dominated by particles crossing the crystals in the transverse direction, providing the necessary information to match the channel gain and to determine the charge-to-energy conversion factor. Data with a trigger based on a coincidence of the FT-Cal and FT-Hodo will select particles crossing the whole FT system, testing the coincidence between hodoscope, calorimeter and tracker elements and determining the relative time offsets. In addition, analysis of these data will provide information to match the gain of the hodoscope tiles and to determine the charge-to-energy conversion factors. Further selection of the recorded events choosing particles crossing only one FT-Cal crystal and one FT-Hodo tile will also allow for the study of the tracker efficiency. Finally the synchronization of the FT system with the CLAS12 detectors will be achieved by analyzing data recorded with a trigger based on the CLAS12 forward detectors.

3.1.11 Cosmic calibration of the Central and Forward Detector

After completing the initial calibration of the individual detector systems, special triggers will be setup to select cosmic rays crossing the central or forward parts of CLAS12 and study their overal efficiencies and resolutions.

For the central detector, the trigger will be based on the coincidence of the opposite scintillation bars of the CTOF or CND barrels, selecting particles crossing the whole system. Track parameters reconstructed from the SVT and MM will be compared to verify the relative alignment and to determine the efficiencies and resolutions of the two trackers. The reconstructed track paramaters will then be combined to obtain the best estimate of the particle trajectories and their projected crossing points on the CTOF and CND detectors will be estimated. These will be used to study the spatial alignement of the whole central detector and to correlate the time information from the CTOF and CND systems determining their relative time offset,

For the forward detector, a trigger will be setup that uses the stereo readout of the inner and outer parts of the EC to select cosmic rays pointing toward specific regions of the PCAL and FTOF. The analysis of such events will allow for a detailed mapping of the responses of these detectors across their entire active areas and for the determination of the relative time offsets. Extension of this procedure to involve the DC, will also allow for the study of their tracking efficiency.

Chapter 4

Commissioning with Beam

4.1 Objectives

In general, the objectives of the Hall B and CLAS12 commissioning procedure are to achieve reliable beam transport through thin and extended targets to the beam dump, 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. Operation of the CLAS12 detector system in the presence of magnetic fields, and in conjunction with the trigger and data acquisition system and other ancillary systems will be studied as well. The dependence of the detector performance on luminosity and particle rates will be studied, monitoring noise levels and channel occupancies. The data collected during these procedures will be used to perform full calibrations of the CLAS12 detector systems.

After completion of the commissioning, the functionality of the Hall B instrumentation, including the beam line, the CLAS12 superconducting Torus and Solenoid magnets, all CLAS12 detectors, the trigger and data acquisition systems, as well as 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.

4.2 Beam Line Operation

The beam line instrumentation will be the first system to be commissioned upon beam delivery in Hall B. This system includes:

1. Beam diagnostic devices:
   (a) beam position monitors (BPM)
   (b) halo counters
   (c) Faraday Cup
   (d) synchrotron light monitor
   (e) harps
2. Raster magnet
3. Collimators, radiators
4. Photon tagger
5. Cryogenic target
6. Möller polarimeter

Since most of these components are already installed and have already been used in Hall B, no special tests will be necessary and the commissioning of the system will follow the standard procedures used for run preparations during the 6 GeV era. The only exceptions are the (1) the raster magnet power supplies, (2) the BPM readout system, and (2) the Möller polarimeter.

The upgrade of the raster magnet power supplies, necessary for the higher beam energy of the new experiment, was performed in the last phases of CLAS running and commissioning of the equipment was completed.

The readout system of the BPMs will be upgraded with the installation of new lock-in amplifiers that will allow for a faster response. This task, including the commissioning of the new equipment, is under the responsibility of the Accelerator Division.

The upgrade of the Möller polarimeter will include the replacement of the target and the optimization of the polarimeter geometry for the new operating energy. The commissioning of the system will require the accurate measurement of the target polarization, the checkout of the quadrupole magnets and power supply, and the checkout of the Möller detectors and readout. These tests will be performed before beam delivery in Hall B. Finally, when beam will be available, Möller runs with known beam polarization will be performed to compare the measured polarization

with the expected one. The measurements will be done at different beam energies, from the lowest to the highest value, and using several Wein-filter settings to determine maximum polarization.

Except for these three systems, no changes in beam diagnostic devices are foreseen at this time. The cryo-target hardware will remain unchanged and will not require special commissioning procedures other then standard procedures to verify its functioning and prepare it for the experiment.

Upon delivery of electron beam, standard beam tuning procedures will be followed in collaboration with the Accelerator crew. These will include:

- Verify that FSD (fast shutdown) from the beam line devices is operational.
- Calibrate the upstream beam monitors as BPMs and SLM. Verify that halo counters and BOM are operational.
- Optimize the beam transport through the hall and CLAS12 to the Faraday cup (FC) and/or the beam dump at various beam currents. Determine the temperature rise of the FC for beam currents of 5, 10, 15, 20, 30, and 50 nA, and 6.6, 8.8, and 11 GeV beam energies.
- Verify the accuracy, stability, and reproducibility of the beam monitors.
- Verify beam parameters such as spot size and angle dispersion using the beam position monitors.
- Verify that helicity information from the accelerator is available and we can control beam charge asymmetry.
- Establish background levels from the beam dump and/or Faraday cup for optimized beam parameters. Develop optimal shielding conditions of the tunnel at various running conditions.
- Calibrate the current integrator (Faraday cup) at various beam energies and beam currents.

4.3 Commissioning of the CLAS12 Systems

After completing the beam-line instrumentation commissioning, testing of the CLAS12 detectors will begin, following the specific plans developed for each system. This will require use of beam at different energies and intensities, as well as different targets, magnet configurations, and triggers, depending on the specific needs. To minimize time and improve the efficiency of the process, tests

with compatible run conditions will be performed in parallel, recording data from all the detectors involved. These tests will also provide the opportunity to perform a thorough test of the DAQ, and of the trigger and the slow-control systems.

4.3.1 CTOF and CND Commissioning

The in-beam test of the central detector systems will begin with the CTOF and CND detectors. Given the similar structure of the two systems, the commissioning plan is envisioned to include similar types of measurements that will be performed simultaneously using an electron beam energy of a few GeV and a thin target. The DAQ will be triggered by the OR of the signals from the scintillation counters of the two detectors. Data will be collected at different beam intensities and solenoid magnet settings (50%, 75%, 100%) to study rates and occupancies. The HV settings of the PMTs will be adjusted to match the signals of minimum-ionizing particles. Full calibrations will then be performed, selecting minimum-ionizing particles and analyzing the corresponding signals to extract both energy and time calibration parameters.

4.3.2 SVT and MM Commissioning

The same beam and target configuration will be used to commissioning the central trackers. A thin target such as CH_2 or carbon will be used in order to have a well-defined z vertex. The DAQ will be triggered by the CTOF and CND detectors or by the forward detectors (EC-PCAL, FTOF) to have particles in different angular ranges. Initially, data will be collected without magnetic field (both Solenoid and Torus magnets will be OFF) and at very low beam currents ($<$0.1 nA) to avoid the intense Möller background. The collected data will be analyzed performing full tracking reconstruction to verify the detector alignment. Then the solenoid magnet will be ramped up and data at higher beam intensity will be collected, studying rates, noise and occupancy levels as a function of the solenoid field and beam intensities. These data will be used to calibrate the two detector systems and to tune the tracking algorithm.

4.3.3 EC-PCAL Commissioning

Operation at high luminosity will make unprecedented demands on the forward detectors. The PCAL and EC will have to perform as one detector when forming an electron trigger, which implies their energy and timing calibrations must be consistent and well-established prior to running. Since

this will be the first detector system to be installed in Hall B, data taking with cosmic rays will continue for several months allowing for a very accurate calibration of the system. However, final calibrations and performance studies will be possible only with the electron beam. In-beam tests will include:

1. Luminosity studies in which PMT currents and gains will be measured, trigger rates in the PCAL and EC will be studied, the fADC baseline will be examined looking for shifts and multiple hits, the TDC timing will be checked for multiple hits, and the TDC and fADC hit information will be correlated;

2. Zero-field runs to the check relative alignment of the EC-PCAL to the rest of CLAS12;

3. Studies of trigger efficiency as a function of the beam intensity to establish the baseline performance (low current) and estimate efficiency losses (high current);

4. Low luminosity data taking with incident scattered electrons of 6-10 GeV and pions of 1-3 GeV to provide data for energy cross-calibration of the PCAL/EC combination;

5. Data taking at various beam energies: 6, 7, 8, 9, 10 GeV to evaluate the effects associated with low-energy radiative and photo-production backgrounds from the target;

6. Tests of cluster-finding algorithms and verification of the geometrical matching between the CLAS12 detectors and the EC-PCAL system.

4.3.4 FTOF Commissioning

The commissioning of the FTOF system will begin by taking data at low luminosity to perform the checkout of the system in a realistic but clean environment. The luminosity will then be increased to study rates and occupancies as a function of the beam current. The procedure will be repeated for different settings of the tous magnetic field (25%, 50%, 75%, 100%) to verify the proper functioning of the PMTs. The data, collected in self-triggering mode, will then be analyzed to extract all the relevant calibration parameters and to evaluate the final time resolution of the individual counters.

4.3.5 HTCC and LTCC Commissioning

The commissioning of the Čerenkov detectors will begin by taking data at low luminosity to perform the checkout of the systems in a realistic but clean environment. The stability of the fADC baseline will be verified by performing pedestal runs and the single photo-electron signal will be measured. If necessary, the HV settings of the PMTs will be adjusted to match the size of the SPE signals. The beam current will then be increased to study rates and occupancies as a function of the luminosity. The procedure will be repeated for different settings of the tous magnetic field (25%, 50%, 75%, 100%) to verify the proper functioning of the PMTs. The detector response to high energy electrons will then be measured to evaluate their efficiency. The DAQ will be trigger by the EC-PCAL system, whose signal will be analyzed to ensure the presence of an electron in the acceptance of the forward detectors by looking for large energy deposition and to correlate with the hits in the Čerenkov detectors.

4.3.6 DC Commissioning

The DC commissioning will be performed by having the electron beam incident on a solid and thin target, such as CH_2 or carbon, in order to have a point-like source of charged tracks emerging from the nominal CLAS12 center. The DAQ will be triggered by the HTCC to select events with the scattered electron in the acceptance of the forward detectors and to evaluate the event start time. FTOF time information will also be used for the track reconstruction. The first data will be collected by operating CLAS12 without magnetic fields (both Solenoid and Torus magnets will be OFF) and at very low beam currents ($<$0.1 nA) to avoid the intense Möller background. These data will be used to verify the relative alignment of the three detector regions and the absolute alignment with respect to the rest of the CLAS12 equipment and, in particular, with respect to the forward MM tracker. Then the solenoid and torus magnets will be ramped up and the detector response as a function of magnetic field will be studied. Finally, the beam current will be increased and rates and occupancies will be studied as a function of the luminosity. Full tracking will be performed and the tracking efficiency at high luminosity will be compared to that measured at low luminosity to study possible losses and to optimize the track reconstruction procedure.

4.3.7 FT Commissioning

The response of the FT detector to few GeV electrons scattered from a thin target will be used for the system commissioning. Initially data will be collected at very low beam currents ($<$0.1 nA) with the both the solenoid and torus magnets off to verify the relative alignment of the system components, i.e. the calorimeter, the hodoscope, and the tracker, by detecting particles emitted from the nominal CLAS12 center and travelling along a straight path. The solenoid magnet will then be ramped up and rates, occupancies, and noise in the individual channels will be measured as a function of the solenoid field and beam current. The DAQ will be triggered by requiring a single high energy cluster in the FT calorimeter and electrons will be selected by requiring a hit in a matching hodoscope tile. These data will be used to perform timing calibrations and initial energy calibrations for both the hodoscope and calorimeter, while the tracker will be calibrated following the same procedure outlined in Sec. 4.3.2. Then the response to high energy π^0's decaying to two photons will be measured to check the hodoscope veto efficiency and to perform full energy calibration of the calorimeter by reconstructing the π^0 mass.

4.4 CLAS12 Calibration and Performance Tests

When the commissioning of the individual detector systems has been completed, performance tests of the whole central and forward detectors will begin. These will be aimed toward determining the optimal detector configuration and ultimate performance.

4.4.1 Forward Detector Performance Studies

The overall performance of the CLAS12 Forward Detector will be studied by looking at the response to particles generated from the interaction of the electron beam with a liquid-hydrogen target. Data will be collected at different beam energies, beam currents, and magnetic field settings to explore the behavior of the detectors as a function of the running conditions. The DAQ will be triggered by a coincidence of the EC-PCAL and HTCC to select events with the scattered electron in the acceptance of the Forward Detector. Full event reconstruction will be performed and fine-tuning of the detector calibrations will be achieved by correlating the information of the different detector systems.

Electrons will be identified by matching high energy clusters in the EC-PCAL with negative

tracks in the DC and MM and hits in the HTCC and FTOF. The FTOF time resolution will be measured using the RF beam structure for accurate information on the event start time. The HTCC efficiency as a function of the electron momentum and angle will be mapped and compared to the expectations. Other charged tracks reconstructed in the DC and MM will be matched to hits in the FTOF and LTCC and the corresponding information will be used to perform particle identification.

The collected data will be analyzed to extract physics observables such as cross sections and mass spectra. First of all, the cross section for inclusive electron scattering will be evaluated as a function of the electron energy and polar angle. The resulting value will be compared to world data to check the electron detection efficiency and determine the detector fiducial regions. Momentum and angular resolution will be determined studying elastic scattering events ($ep \rightarrow e'p'$) and other exclusive reactions such as two pion production ($ep \rightarrow e'p\pi^+\pi^-$). In both cases, all the final state particles will be detected and momentum conservation will be used to study the accuracy of the tracking as a function of the kinematics and estimate possible distortion in the reconstructed variables induced by misalignments of the detectors and magnets. For the same exclusive reactions, events where all the final particles but one are constructed will be used to study the detector inefficiencies. The particle identification capabilities of the Forward Detector will be tested by studying reactions with strange content, such as $ep \rightarrow e'K^+\Lambda$, where the hyperon will be reconstructed by measuring its decay to proton and π^-. Finally, neutron and photon detection efficiency and reconstruction algorithms will be tested by studying reactions such as $ep \rightarrow e'\pi^+n$ or $ep \rightarrow e'\pi^0p$.

Elastic scattering events will also be used to perform the final calibration of the FT. The electron beam energy will be chosen in order for the scattered electron to match the energy and angular range of interest for the system. The DAQ will be trigger by the FT, requiring the coincidence of a cluster of appropriate energy in the calorimeter and a matching hit in the hodoscope. These data will be analyzed to determine the final acceptance, efficiency, and resolution of the detector.

4.4.2 Central Detector Performance Studies

The overall performance of the CLAS12 Central Detector will be verified by reconstructing hadrons generated at large angles from the interaction of the electron beam with the liquid-hydrogen target. Like in the case of the Forward Detector, data will be collected at different beam energies, beam currents, and solenoid magnet settings, to map the response of the detector over the full

kinematic range of interest as a function of the chosen configuration. The DAQ will be triggered by the Forward Detector to select events with an electron going in the forward direction and the response of the central systems to recoiling hadrons will be measured. Full event reconstruction will be performed and fine-tuning of the detector calibrations will be achieved by correlating the information of the different detector systems.

The information on the scattered electron from the Forward Detector will be used to fix the event start time. Charged hadrons recoiling in the acceptance of the Central Detector will be reconstructed by matching their tracks in the SVT and MM detectors with hits in the CTOF and CND. The CTOF and CND time resolution will be measured using the RF beam structure for accurate information on the event start time. The residual hits in the CTOF and CND will be considered as neutrals and the time-of-flight information will be used to discriminate neutrons from photons.

The acceptance, efficiency, and resolution of the Central Detector will be evaluated by studying exclusive reactions such as elastic scattering, single pion or two pion production. In all cases the electron will be reconstructed in the Forward Detector. Events in which all final state particles are detected will be used to determine the momentum and energy resolution of the central trackers by imposing momentum conservation. Events in which one of the final state particles, emitted in the angular range of the central detector, was missed will be used to estimate inefficiencies. The particle identification capabilities of the CTOF and CND will be determined by studying reactions such as $ep \rightarrow e'K^+\Lambda$, $ep \rightarrow e'\pi^+n$, and $ep \rightarrow e'\pi^0p$. For these studies the beam energy will be chosen carefully to increase the probability of the hadron of interested being emitted in the acceptance of the Central Detector.

Chapter 5

CLAS12 Subsystems

The list of the CLAS12 subsystems that will be checked out and commissioned according to the present plan is given in the following table.

System	**Subsystem**	**Contact Persons**	
		Hardware	*Software*
Beamline Instrumentation	Beamline	F. X. Girod, E. Pasyuk (JLAB)	
	Möller Polarimeter	B. Raue (FIU)	
Magnets	Solenoid Magnet	L.Quettier (JLAB)	
	Toroidal Magnet	L. Quettier (JLAB)	
Central Detector	SVT	Y. Gotra (JLAB)	V. Ziegler
	MM	F. Sabatie (CEA	S. Procureur (CEA)
	CTOF	V. Baturin (JLAB) W. Kim (KNU)	V. Baturin (JLAB)
	CND	S. Niccolai (IPN)	S. Niccolai (IPN)
	HTCC	Y. Sharabian (JLAB)	M. Ungaro (UCONN)

Forward Detector	DC	M. Mestayer (JLAB)	M. Mestayer (JLAB)
	FTOF	D. Carman (JLAB)	D. Carman (JLAB)
	LTCC	M. Ungaron (JLab) J. Price (CSUDH)	M. Ungaro (UCONN) A. Vlassov (ITEP)
	EC & PCAL	K. Hicks (Ohio) C. Smith (UVA) S. Stepanyan (JLAB)	W. Brooks (UTFSMA) M. Wood (Canisius)
	RICH	P. Rossi (INFN)	M. Contalbrigo (INFN)
	FT	M. Battaglieri (INFN) R. De Vita (INFN) F. Sabatie (CEA) D. Watts (Edinburgh)	D. Weygand (JLAB) S. Procureur (CEA)
Online	FEE, DAQ & Trigger	S. Boiarinov (JLAB), C. Cuevas (JLab), W. Gu (JLab) V. Kubarovsky (JLAB) B. Raydo (JLab)	
	Slow Controls	K. Livingston (Glasgow) N. Gevorgyan (Yerevan)	
	Monitoring	D. Weygand (JLAB)	
Offline	Architecture	D. Weygand (JLAB)	
	Database	J. Goetz (UCLA)	
	Reconstruction	D. Weygand (JLAB) V. Ziegler (JLab)	

Appendix A

CLAS12 Subsystem Commissioning Information

In this Chapter we report the detailed commissioning plans for the CLAS12 subsystems. For each of them, specific information on the planned tests and procedures are detailed for the three phases of the commissioning process, i.e.:

- quality assurance and system checkout,
- commissioning without beam,
- commissioning with beam.

The information on *Quality Assurance* will consist of the list of procedure that will be followed during the construction of the subsystem and its installation in Hall B to ensure of the proper function of all its parts and entually replace faulty components, ensure the proper functioning of the whole subsystem, verify alignment and positioning, etc. Upon completion of the installtion in Hall B, the subsystem will be checked performing specific tests listed in the Subsection on *System Checkout*. For detectors, the planned tests are divided according to (1) checkout of the front-end electronics, (2) checkout of the high-voltage system and distribution, (3) checkout of the low-voltage system, (4) checkout of DAQ and trigger operation.

The procedure planned during the second phase of the commissioning, *commissioning without beam*, are divided in two categories:

Appendix B

Beamline Instrumentation

B.1 Contact person

The contact person for this subsystem is:

Name	*Affiliation*	*email*	*Area of Responsability*
F.-X. Girod	Jefferson Lab	fxgirod@jlab.org	Hardware
E. Pasyuk	Jefferson Lab	pasyuk@jlab.org	Hardware

B.2 General remarks

The standard Hall-B beam line instrumentation includes:

1. Beam diagnostic devices:
   (a) beam position monitors (BPM; nA cavities)
   (b) halo counters (PMTs with Lucite or scintillators)
   (c) Beam Offset Monitors (scintillating fibers)
   (d) synchrotron light monitor
   (e) harps
2. Møller polarimeter
3. raster magnet
4. collimators, radiators
5. photon tagger
6. cryogenic target
7. Downstream tungsten beam cones
8. Faraday Cup

The upgrade of the general beam line instrumentation is not in the scope of the CLAS 12 project. Everything will remain essentially as it is now with a few exceptions.

1. Upgrade of the raster magnet power supplies. This is already done including commissioning.
2. Upgrade of the Møller polarimeter. This component has its own commissioning plan and it is not included here.
3. Upgrade of the BPM readout to make it faster. This would require installation of new locking amplifiers. This work is to be done by Accelerator division including commissioning.
4. Upgrade of the Faraday cup

At this time no changes in beam diagnostic devices are foreseen. Epics software would require some work and improvements. This is part of the slow control software in general.
Cryo-target hardware remains unchanged therefore will not require recommissioning other than standard procedures to get it cold and ready for an experiment. Does not need any special commissioning with beam.
Beam line instrumentation must be commissioned before everything else that needs beam. The commissioning procedure is not different from standard preparation for the experiment as we have it now. Pre-beam commissioning includes power up all hardware, HV, electronics. Make sure all motors can be controlled. Required resources: 1 person 1 day. Commissioning with beam is standard beam tune up procedure done together with Accelerator crew. Calibrate BPMs, SLM, Faraday cup. Verify that halo counters and BOM are operations. Verify that FSD from the beam line devices is operational. Verify that helicity information from the accelerator is available and we can control beam charge asymmetry . Resources needed: CLAS shifts + MCC crew, 1 day.

Møller polarimeter: see separate commissioning plan.

Tagger. No upgrades are planned at the moment. If there will be experiments requiring tagger it will be commissioned then. Pre-beam preparation and check up 1 person 1 day. Commissioning with beam 1 day.

Downstream tungsten cone absorber : the succesful operation of CLAS12 at the design luminosity requires shielding of the low energy backgrounds. The occupancies in particular of the Drift chambers must be kept low enough to ensure efficiency of the tracking. Each configuration change will require the actual detector occupancies to be checked against simulations.

B.3 System Checkout

Checkout of the beam line diagnostic instrumentation	
Description	*Check that all devices are powered up and readout electronics is ready*
Manpower and time needed	*1 person, 1 day*
Software for analysis of results	*CLAS EPICS software*
Computing resources	*CLAS on-line computers*
Dependencies from other systems	
Information to be saved in the database	*Time lines and histories of all sow control variables are archived*

B.4 Commissioning with beam

Beam Run #1 : Low current calibration of SLM vs Faraday cup	
Description and goals	*Check the beam current readings of SLM and Faraday cup simultaneously at low current (<10 nA)*
DAQ Configuration and Trigger	*EPICS readout*
Dependencies from other systems	*None*
Manpower and time needed	*1 person, 1/2 day*
Software for analysis of results	*N.A.*
Computing resources	*N.A.*
Information to be saved in the database	
Repetition frequency	*Checked at the beginning of run periods; repeated as needed*

Beam Run #2 : High current calibration of the Faraday cup	
Description and goals	*Check the simulation of the Faraday cup configuration with absorber (up to 200 nA)*
DAQ Configuration and Trigger	*EPICS readout*
Dependencies from other systems	*SLM*
Manpower and time needed	*1 person, 1/2 day*
Software for analysis of results	*N.A.*
Computing resources	*N.A.*
Information to be saved in the database	*Absorber attenuation*
Repetition frequency	*Should be stable*

Beam Run #3 : CLAS occupancies with Downstream tungsten cone shielding	
Description and goals	*Check the simulation of CLAS occupancies (in particular DC) with high current (up to 200 nA)*
DAQ Configuration and Trigger	*Random trigger; standard trigger*
Dependencies from other systems	*All detectors*
Manpower and time needed	*1 person, 1/2 day*
Software for analysis of results	*EPICS and standard online monitoring*
Computing resources	*N.A.*
Information to be saved in the database	*N.A.*
Repetition frequency	*Each configuration change*

Appendix C

Möller Polarimeter

C.1 Contact person

The contact person for this subsystem is:

Name	*Affiliation*	*email*	*Area of Responsability*
B. Raue	Florida International University	baraue@fiu.edu	Hardware

C.2 Quality Assurance and System Checkout

C.2.1 Quality Assurance

Test #1	
Description	*Measure polarization of the existing permendur target foils. Requires ramping up and down Helmholtz power supplies and reading induced currents in pickup coils. Mechanical systems already exist. Need slow-controls software and interface. No beam time necessary*
Special equipment	*Measure polarization of the existing permendur target foils. Requires ramping up and down Helmholtz power supplies and reading induced currents in pickup coils. Mechanical systems already exist. Need slow-controls software and interface. No beam time necessary*
DAQ Configuration and Trigger	*N/A*
Manpower and time needed	*Test only takes 1 day once slow-controls software is written*
Software for analysis of results	*Slow controls and readout software. This is standalone software*
Computing resources	*Negligible*
Information to be saved in the database	*One number: Möller target polarization*

C.2.2 System Checkout

Checkout of Magnets	
Description	*Möller quadrupoles and power supplies*
Manpower and time needed	*Power supply technician, 1 man day*
Software for analysis of results	*Standard power supply control software*
Computing resources	*N/A*

Dependencies from other systems	*LCW must be in place.*
Information to be saved in the database	*N/A*

Checkout of Detectors	
Description	*Möller detectors and readout*
Manpower and time needed	*DAQ expert, 1 man day*
Software for analysis of results	*Present Möller detector readout software adapted to CLAS12 standards*
Computing resources	*CLAS12 DAQ*
Dependencies from other systems	*N/A*
Information to be saved in the database	*N/A*

C.3 Commissioning without beam

None required.

C.4 Commissioning with beam

Beam Run #1	
Description and goals	*Möller runs with known beam polarization. Minimally need to do measurements at or near the lowest beam energy and highest beam energy but preferably at several beam energies. Will measure beam polarization and compare to expectation. Use several Wein-filter settings to determine maximum polarization*
DAQ Configuration and Trigger	*DAQ set to Möller running mode (similar to present system)*
Dependencies from other systems	*Reasonable to expect this to be done as an overall commissioning of 12 GeV polarized beam operation. That is, done in conjunction with other experimental halls*
Manpower and time needed	*DAQ expert, 1 man day. Möller expert, 2-3 man days*
Software for analysis of results	*Present Möller software is sufficient*
Computing resources	*Consistent with present Möller running. Very minimal*
Information to be saved in the database	*N/A*
Repetition frequency	*One time should be sufficient*

Appendix D

Silicon Vertex Tracker (SVT)

D.1 Contact person

The contact persons for this subsystem are:

Name	*Affiliation*	*email*	*Area of Responsability*
Y. Gotra	Jefferson Lab	gotra@jlab.org	Hardware
V. Ziegler	Jefferson Lab	ziegler@jlab.org	Software

D.2 Quality Assurance and System Checkout

For each individual module:

- Test 1: Mechanical survey
- Test 2: Module performance test at Fermilab: sensor leakage current, LV current, register test, gain calibration, and noise measurements
- Test 3: Module reception test at JLAB: sensor leakage current, LV current, register test, gain calibration, and noise measurements

For a set of modules in a dedicated cosmic ray test stand:

- Test 4: Tracking and hit efficiencies, alignment, and spatial resolution measurements with cosmic rays

After integration of the barrel on the SVT mechanical structure:

- Test 5: Survey of module positions on the barrel and the barrel itself
- Test 6: Cosmic run with full barrel in nominal configuration (with full electronics chain)

After integration of SVT with Micromegas (MM), full checkout of the Tracker:

- Test 7: Alignment and Survey of SVT versus MM
- Test 8: Cosmic run with both tracking systems, cross-talk, noise measurements, alignment, tracking efficiencies, occupancies, resolutions, temperature measurements

After integration of full Central Detector:

- Test 9: Cosmic runs with all systems on (magnet on/off)

D.2.1 Quality Assurance

Test #1	
Description	*Mechanical survey*
Special equipment	*Optical CMM (at Fermilab)*
DAQ Configuration and Trigger	*no DAQ*
Manpower and time needed	*For each module: 30 min (part of module assembling procedure)*
Software for analysis of results	*MySQL and scripts*
Computing resources	*None*
Information to be saved in the database	*Module dimensions, flatness, position of mounting pins, sensor locations*

Test #2	
Description	*Module performance test (at Fermilab)*
Special equipment	*SVT DAQ (VME based), LV and HV PS (MPOD)*
DAQ Configuration and Trigger	*Local DAQ, configuration files*
Manpower and time needed	*Per module: 1 man.days* *Total: 94*1 = 94 man.days*
Software for analysis of results	*ROOT software*
Computing resources	*Moderate*
Information to be saved in the database	*Gain, noise, currents, channel faults*

Test #3	
Description	*Module reception test (at JLAB)*
Special equipment	*SVT DAQ (VME based), LV and HV PS (MPOD)*

DAQ Configuration and Trigger	*Local DAQ, configuration files*
Manpower and time needed	*Per module: 2 hours* *Total: 94*2/8 = 24 man.days*
Software for analysis of results	*ROOT software*
Computing resources	*Moderate*
Information to be saved in the database	*Gain, noise, currents, channel faults*

Test #4	
Description	*Efficiencies, alignment, spatial resolution measurements on a dedicated cosmic test stand with cosmic rays*
Special equipment	*Cosmic test bench (Scintillator paddles + PM)*
DAQ Configuration and Trigger	*VME based SVT DAQ, Scintillator trigger*
Manpower and time needed	*Installation + check-out: 5 man.day* *Data taking: 10 days* *Data analysis: 10 days* *Total (man.days): 10 + 5 + 10 = 25 man.days* *Total (days): 20 days*
Software for analysis of results	*ROOT analysis software*
Computing resources	*Moderate, analysis farm at JLAB*
Information to be saved in the database	*Gain, noise calibrations, alignment constants, efficiency, spatial resolutions*

Test #5	
Description	*Survey of the SVT barrel (clean room JLab)*
Special equipment	*Survey equipment*

DAQ Configuration and Trigger	*None*
Manpower and time needed	*10 man days*
Software for analysis of results	*Survey software*
Computing resources	*None*
Information to be saved in the database	*Barrel geometry, module positions*

Test #6	
Description	*Cosmic run with full barrel*
Special equipment	*Cosmic test bench (Scintillator paddles + PMT)*
DAQ Configuration and Trigger	*VME based SVT DAQ, Scintillator trigger*
Manpower and time needed	*Installation + checkout: 5 man.day* *Data taking and analysis: 35 days* *Total (man.days): 15*6 + 5 + 20*2=135 man.days* *Total(days): 45 days*
Software for analysis of results	*ROOT analysis software*
Computing resources	*Medium, analysis farm at JLAB*
Information to be saved in the database	*Gain, noise calibrations, alignment constants, efficiency, spatial resolutions*

Test #7	
Description	*Alignment and Survey of SVT versus MM*
Special equipment	*Survey equipment*
DAQ Configuration and Trigger	*None*
Manpower and time needed	*2 man.days alignment + 2 man.days survey*
Software for analysis of results	*Survey software*

Computing resources	*None*
Information to be saved in the database	*Geometry parameters*

Test #8	
Description	*Cosmic rays with both tracking systems*
Special equipment	*Scintillator paddles, temperature probes*
DAQ Configuration and Trigger	*MSVT Standalone DAQ, Scintillator trigger*
Manpower and time needed	*Installation + checkout: 5 man.days* *Data taking: 15 days*
Software for analysis of results	*ROOT analysis software, CLAS12 Tracking software*
Computing resources	*Medium, JLAB Computer Farm*
Information to be saved in the database	*Alignment constants, calibrations, slow controls, run DB*

Test #9	
Description	*Cosmic rays with all systems on (Magnet on/off)*
Special equipment	*Scintillator paddles (to be defined)*
DAQ Configuration and Trigger	*MSVT Standalone DAQ, Scintillator trigger*
Manpower and time needed	*Data taking: 15 days*
Software for analysis of results	*ROOT Dream analysis software, CLAS12 Tracking software (SOCRAT)*
Computing resources	*Medium, JLAB Computer Farm*
Information to be saved in the database	*Alignments, calibrations, slow controls, run info*

D.2.2 System Checkout

Checkout of FrontEnd Electronics	
Description	*Calibrations, channel mapping, noise occupancies, trigger rate stress test, stability over time, immunity to condition change, etc.*
Manpower and time needed	*10 man.days*
Software for analysis of results	*CLAS12 DAQ, CLAS12 slow control*
Computing resources	*Computer farm, moderate amount of disk space for data*
Dependencies from other systems	*Gas, LV and HV system, DCS*
Information to be saved in the database	*Channel maps, calibration constants, slow control data*

Checkout of HighVoltage system and distribution	
Description	*Plug the detector to HV supply, check ENC, leakage current monitoring*
Manpower and time needed	*3 man.days*
Software for analysis of results	*CLAS12 slow control system*
Computing resources	*None*
Dependencies from other systems	*Gas system must be checkedout prior to HV system*
Information to be saved in the database	*Updated HV distribution map*

Checkout of LowVoltage system for electronics	
Description	*Low voltage and electronics on, check cable mapping, verification of voltages and currents on all components*
Manpower and time needed	*2 man.day*

Software for analysis of results	*CLAS12 slow control system*
Computing resources	*None*
Dependencies from other systems	*None*
Information to be saved in the database	*PS Channel mapping*

Checkout of DAQ and trigger	
Description	*Test of different DAQ and trigger configurations*
Manpower and time needed	*5 man.day*
Software for analysis of results	*CLAS12 slow control system, CLAS12 DAQ*
Computing resources	*Computer farm, moderate amount of disk space for data*
Dependencies from other systems	*May need other systems for some DAQ configurations (CTOF, MM)*
Information to be saved in the database	*None*

Checkout of gas system	
Description	*Leak test of gas line (nitrogen), plug detector to gas system, leak test, humidity monitoring*
Manpower and time needed	*2 man.days*
Software for analysis of results	*CLAS12 slow control system*
Computing resources	*None*
Dependencies from other systems	*DCS, interlocking on dew point*
Information to be saved in the database	*Leak rates, gas flows and pressures, humidity and temperature data*

Checkout of safety system	
Description	*Checkout and test interlocks between LV/HV/cooling/gas/magnet quench*
Manpower and time needed	*10 man.days*
Software for analysis of results	*CLAS12 DCS system*
Computing resources	*None*
Dependencies from other systems	*All systems interlocked*
Information to be saved in the database	*None*

D.3 Commissioning without beam

D.3.1 Special calibration procedures

Special Run	
Description	*Calibration run*
Goal	*Measure gain, noise*
DAQ Configuration and Trigger	*Internal trigger, SVT DAQ configuration for calibration run*
Manpower and time needed	*1 man.days*
Software for analysis of results	*ROOT analysis software needs to be developed*
Computing resources	*Moderate*
Dependencies from other systems	*DAQ*
Information to be saved in the database	*Calibration constants*

D.3.2 Calibration with Cosmic Rays

Run #1	
Description and goals	*Cosmic run with solenoid magnetic field off*
DAQ Configuration and Trigger	*DAQ cosmic, external (scintillator paddle) trigger*
Dependencies from other systems	*Several different runs can be taken with different regions on/off for noise studies*
Manpower and time needed	*Depends on required statistics, can take days for alignment calibration*
Software for analysis of results	*Track reconstruction software, to be developed by software team*

Computing resources	*Computer farm, moderate amount of disk space*
Information to be saved in the database	*Potential update of efficiency maps*
Repetition frequency	*Once or Twice per run period, or when beam is off for a long time*

Run #2	
Description and goals	*Cosmic run with solenoid magnetic field on (50% nominal)*
DAQ Configuration and Trigger	*DAQ cosmic, external (scintillator paddle) trigger*
Dependencies from other systems	*Several different runs can be taken with different regions on/off for noise studies*
Manpower and time needed	*Depends on required statistics, can take days for alignment calibration*
Software for analysis of results	*Track reconstruction software, to be developed by software team*
Computing resources	*Computer farm, moderate amount of disk space*
Information to be saved in the database	*Potential update of efficiency maps*
Repetition frequency	*Once or Twice per run period, or when beam is off for a long time*

Run #3	
Description and goals	*Cosmic run with solenoid magnetic field on (100% nominal)*
DAQ Configuration and Trigger	*DAQ cosmic, external (scintillator paddle) trigger*
Dependencies from other systems	*Several different runs can be taken with different regions on/off for noise studies*
Manpower and time needed	*Depends on required statistics, can take days for alignment calibration*

Software for analysis of results	*Track reconstruction software, to be developed by software team*
Computing resources	*Computer farm, moderate amount of disk space*
Information to be saved in the database	*Potential update of efficiency maps*
Repetition frequency	*Once or Twice per run period, or when beam is off for a long time*

D.4 Commissioning with beam

Beam Run #1	
Description and goals	*Geometry and tracking tuning. Typically a normal electron run, but potentially with thin target(s) such as CH_2 or carbon in order to have well defined zvertex.*
DAQ Configuration and Trigger	*Typical CLAS12 main trigger*
Dependencies from other systems	*All systems should be on*
Manpower and time needed	*Long runs (24 hours) may be needed to have enough statistics*
Software for analysis of results	*CLAS12 calibration, alignment, and tracking analysis software to be developed*
Computing resources	*Computer farm, significant amount of CPU time and disk space (to be defined) for raw data processing*
Information to be saved in the database	*Updated geometry, updated efficiency maps, alignment constants*
Repetition frequency	*Useful after large configuration changes*

Beam Run #2	
Description and goals	*Geometry and tracking tuning with B=0 field. Typically a normal electron run, but potentially with thin target(s) such as CH_2 or carbon in order to have well defined zvertex.*
DAQ Configuration and Trigger	*Typical CLAS12 main trigger*
Dependencies from other systems	*All systems should be on*
Manpower and time needed	*Long runs (24 hours) may be needed to have enough statistics*

Software for analysis of results	*CLAS12 calibration, alignment, and tracking analysis software to be developed*
Computing resources	*Computer farm, significant amount of CPU time and disk space (to be defined) for raw data processing*
Information to be saved in the database	*Updated geometry, updated efficiency maps, alignment constants*
Repetition frequency	*Useful after large configuration changes*

Appendix E

MICROMEGAS Trackers

E.1 Contact person

The contact persons for this subsystem are:

Name	*Affiliation*	*email*	*Area of Responsability*
F. Sabatie	CEA - Saclay	franck.sabatie@cea.fr	Hardware
S. Procureur	CEA - Saclay	sebastien.procureur@cea.fr	Software

E.2 Quality Assurance and System Checkout

E.2.1 Quality Assurance

For each individual detector (18+ spare detectors for Barrel and 6+spare for Forward) the following tests will be performed:

Test 1: ferification of dimensions (flat and curved for Barrel);

Test 2: gain and energy resolution measurements over the whole detector area;

Test 3: efficiency and spatial resolution measurements with cosmic run.

After integration of the whole barrel and forward on the final mechanical structure

Test 4: survey of Barrel and Forward detectors;

Test 5: cosmic run with full Barrel detector in nominal configuration (with full electronics chain);

Test 6: cosmic run with full Forward detector in horizontal configuration (with full electronics chain).

After integration of Micromegas with SVT, full check-out of MSVT

Test 7: alignment and Survey of MM versus SVT;

Test 8: cosmic rays with both tracking systems, cross-talk, noise measurements, temperature measurements.

After integration of full Central Detector

Test 9: cosmic rays with all systems on (Magnet on/off).

Test #1	
Description	*Verification of dimensions (flat and curved for Barrel)*
Special equipment	*Mitutoyo optical measurements (at Saclay)*
DAQ Configuration and Trigger	*No DAQ*
Manpower and time needed	*Per Barrel detector : 3 man.days for flat and curved* *Per Forward detector : 2 man.days* *Total : 24*3 + 8*2 = 88 man.days*
Software for analysis of results	*Mathlab*

Computing resources	*None*
Information to be saved in the database	*Strip dimensions (width, length) and orientations (wrt to a reference on the PCB), dead areas if any, drift spacing (at several locations), curvature*

Test #2	
Description	*Gain and energy resolution measurements over the whole detector area*
Special equipment	*55Fe source, Ortec Pre-amplifier + amplifier, MCA, semi-automatic X-Y table*
DAQ Configuration and Trigger	*MCA DAQ, DREAM Test DAQ, Mesh Trigger, Labview*
Manpower and time needed	*Per detector: 2 man.days (1 man.day installation, 1 man.day measurement)* *Total : (24+8)*2 = 64 man.days*
Software for analysis of results	*ROOT software*
Computing resources	*Not significant*
Information to be saved in the database	*Gain and energy resolution*

Test #3	
Description	*Efficiency and spatial resolution measurements with cosmic run*
Special equipment	*Cosmic test bench (Scintillator paddles + PM, reference XY detectors)*
DAQ Configuration and Trigger	*DREAM Test DAQ, Scintillator trigger*
Manpower and time needed	*Installation + check-out (per detector) : 1 man.day* *Data taking : 5 days (can do up to 6 detectors at once)*

	Total (man.days) : 24+8 = 32 man.days *Total (days) : 30 days*
Software for analysis of results	*ROOT Dream analysis software*
Computing resources	*Analysis farm at Saclay*
Information to be saved in the database	*Efficiency maps, spatial resolutions*

Test #4	
Description	*Survey of Barrel and Forward detectors (preliminary checks at Saclay, then full survey in clean room JLab)*
Special equipment	*Survey equipment*
DAQ Configuration and Trigger	*None*
Manpower and time needed	*2 man.days*
Software for analysis of results	*Survey software*
Computing resources	*None*
Information to be saved in the database	*Geometry*

Test #5	
Description	*Cosmic run with full Barrel detector in nominal configuration (with full electronics chain and final mechanical structure) at Saclay in cosmic bench, then at JLab after re-assembly*
Special equipment	*Cosmic test bench (Scintillator paddles + PM, reference XY detectors) at Saclay, only Scintillator paddles at JLab*
DAQ Configuration and Trigger	*DREAM Test DAQ, Scintillator trigger*
Manpower and time needed	*Installation + check-out: 2 man.days* *Data taking : 5 days*

Software for analysis of results	*ROOT Dream analysis software, CLAS12 Tracking software (SOCRAT)*
Computing resources	*Computer Farm (Saclay or JLab)*
Information to be saved in the database	*Efficiency maps, spatial resolutions*

Test #6	
Description	*Cosmic run with full Forward detector in horizontal configuration (with full electronics chain) at Saclay in cosmic bench, then at JLab after re-assembly*
Special equipment	*Cosmic test bench (Scintillator paddles + PM, reference XY detectors) at Saclay, only Scintillator paddles at JLab*
DAQ Configuration and Trigger	*DREAM Test DAQ, Scintillator trigger*
Manpower and time needed	*Installation + check-out: 2 man.days* *Data taking : 5 days*
Software for analysis of results	*ROOT Dream analysis software, CLAS12 Tracking software (SOCRAT)*
Computing resources	*Computer Farm (Saclay or JLab)*
Information to be saved in the database	*Efficiency maps, spatial resolutions*

Test #7	
Description	*Alignment and Survey of MM versus SVT*
Special equipment	*Survey equipment*
DAQ Configuration and Trigger	*None*
Manpower and time needed	*2 man.days alignment + 2 man.days survey*
Software for analysis of results	*Survey software*

Computing resources	*None*
Information to be saved in the database	*Geometry*

Test #8	
Description	*Cosmic rays with both tracking systems, cross-talk, noise measurements, temperature measurements*
Special equipment	*Scintillator paddles, temperature probes*
DAQ Configuration and Trigger	*MSVT Stand-alone DAQ, Scintillator trigger*
Manpower and time needed	*Installation + check-out: 2 man.days* *Data taking : 5 days*
Software for analysis of results	*ROOT Dream analysis software, CLAS12 Tracking software (SOCRAT)*
Computing resources	*Computer Farm*
Information to be saved in the database	*None*

Test #9	
Description	*Cosmic rays with all systems on (Magnet on/off)*
Special equipment	*Scintillator paddles (to be defined)*
DAQ Configuration and Trigger	*MSVT Stand-alone DAQ, Scintillator trigger*
Manpower and time needed	*Data taking : 5 days*
Software for analysis of results	*ROOT Dream analysis software, CLAS12 Tracking software (SOCRAT)*
Computing resources	*Computer Farm*
Information to be saved in the database	*None*

E.2.2 System Checkout

Checkout of Front-End Electronics (DREAM)	
Description	*Channel mapping, trigger rate stress test, stability over time, immunity to condition change, etc.*
Manpower and time needed	*2 people during 3 days*
Software for analysis of results	*CLAS12 DAQ, CLAS12 slow control*
Computing resources	*Computer farm, reasonable amount of disk space for runs and analysis*
Dependencies from other systems	*Gas, LV and HV system must be checked out beforehand*
Information to be saved in the database	*Updated channel maps, tuned FEE parameters*

Checkout of High-Voltage system and distribution	
Description	*Plug detector to HV supply, turn on one channel at a time, check detector, leak current monitoring*
Manpower and time needed	*2 people during 3 days + 2 days gas equilibrium*
Software for analysis of results	*CLAS12 slow control system*
Computing resources	*None*
Dependencies from other systems	*Gas system must be checked-out prior to HV system*
Information to be saved in the database	*Updated HV distribution map*

Checkout of Low-Voltage system for electronics	
Description	*Low voltage and electronics on, verification of voltages and currents on all components*

Manpower and time needed	*0.5 man.day*
Software for analysis of results	*CLAS12 slow control system*
Computing resources	*None*
Dependencies from other systems	*None*
Information to be saved in the database	*None*

Checkout of DAQ and trigger	
Description	*Test of different DAQ and trigger configurations*
Manpower and time needed	*1 man.day*
Software for analysis of results	*CLAS12 slow control system, CLAS12 DAQ*
Computing resources	*Computer farm, reasonable amount of disk space for runs and analysis*
Dependencies from other systems	*May need other systems for some DAQ configurations*
Information to be saved in the database	*None*

Checkout of gas system	
Description	*Leak test of gas line, plug detector to gas system, flush with Argon, leak test, flammable gas detector test, gas distribution box calibration, flush with nominal gas (Ar+iC4H10), dry air system*
Manpower and time needed	*2 people during 4 days + 4 days gas equilibrium*
Software for analysis of results	*CLAS12 slow control system*
Computing resources	*None*
Dependencies from other systems	*None*

Information to be saved in the database	*Leak rates, gas flows and pressures*

Checkout of safety system	
Description	*Check-out and test interlocks between LV/HV/cooling/gas/magnet quench*
Manpower and time needed	*2 man.days*
Software for analysis of results	*CLAS12 safety system*
Computing resources	*None*
Dependencies from other systems	*All systems interlocked*
Information to be saved in the database	*None*

E.3 Commissioning without beam

E.3.1 Special calibration procedures

Special Run #1	
Description	*Pedestal run*
Goal	*Pedestals*
DAQ Configuration and Trigger	*Internal or clock trigger, DAQ pedestal configuration*
Manpower and time needed	*1 person, 30 min for data taking, then 10min for data processing, pedestal updates on FEE*
Software for analysis of results	*Pedestal analysis and re-configuration of DREAM for 0-subtraction. Software needs to be developed*
Computing resources	*Nothing significant*
Dependencies from other systems	*Potentially need SVT ON/OFF to compare pedestal width*
Information to be saved in the database	*Pedestals*

Special Run #2	
Description	*DREAM diagnostics run*
Goal	*Test FEE with pre-calibrated internal charges for diagnostics*
DAQ Configuration and Trigger	*Internal, DAQ special configuration (to be defined)*
Manpower and time needed	*1 person, 30 min for data taking, then 30min for data processing*
Software for analysis of results	*DREAM analysis software*
Computing resources	*Nothing significant*
Dependencies from other systems	*None*

Information to be saved in the database	*None*

E.3.2 Calibration with Cosmic Rays

Run #1	
Description and goals	*Cosmic run with solenoid magnetic field off*
DAQ Configuration and Trigger	*DAQ cosmic, external (scintillator paddle) trigger, potentially Neutron Counter can be used as trigger for cosmics?*
Dependencies from other systems	*Several different runs can be taken with different detectors on/off for noise studies*
Manpower and time needed	*For one run, configuration about 30min, the run itself may last for 12 to 24 hours to get significant statistics*
Software for analysis of results	*Micromegas analysis software + tracking, to be developed by Saclay team, about 6 month work for 2 people*
Computing resources	*Computer farm, reasonable amount of disk space*
Information to be saved in the database	*Potential update of efficiency maps*
Repetition frequency	*Once or Twice per run period, or when beam is off for a long time*

Run #2	
Description and goals	*Cosmic run with solenoid magnetic field on (50% nominal)*
DAQ Configuration and Trigger	*DAQ cosmic, external (scintillator paddle) trigger, potentially Neutron Counter can be used as trigger for cosmics?*
Dependencies from other systems	*Several different runs can be taken with different detectors on/off for noise studies*
Manpower and time needed	*For one run, configuration about 30min, the run itself may last for 12 to 24 hours to get significant statistics*

Software for analysis of results	*Micromegas analysis software + tracking, to be developed by Saclay team, about 6 month work for 2 people*
Computing resources	*Computer farm, reasonable amount of disk space*
Information to be saved in the database	*Potential update of efficiency maps*
Repetition frequency	*Once or Twice per run period, or when beam is off for a long time*

Run #3	
Description and goals	*Cosmic run with solenoid magnetic field on (100% nominal)*
DAQ Configuration and Trigger	*DAQ cosmic, external (scintillator paddle) trigger, potentially Neutron Counter can be used as trigger for cosmics?*
Dependencies from other systems	*Several different runs can be taken with different detectors on/off for noise studies*
Manpower and time needed	*For one run, configuration about 30min, the run itself may last for 12 to 24 hours to get significant statistics*
Software for analysis of results	*Micromegas analysis software + tracking, to be developed by Saclay team, about 6 month work for 2 people*
Computing resources	*Computer farm, reasonable amount of disk space*
Information to be saved in the database	*Potential update of efficiency maps*
Repetition frequency	*Once or Twice per run period, or when beam is off for a long time*

E.4 Commissioning with beam

Beam Run #1	
Description and goals	*Geometry and tracking tuning. Typically a normal electron run, but potentially with thin target(s) such as CH2 or carbon in order to have well defined z-vertex.*
DAQ Configuration and Trigger	*Typical CLAS12 main trigger*
Dependencies from other systems	*All systems should be on*
Manpower and time needed	*Long runs (2-3 hours) may be needed to have enough statistics for detectors in the backward region*
Software for analysis of results	*CLAS12 analysis software (including tracking), to be developed by CLAS12 collaboration and partly Saclay. Micromegas geometry post-analysis software to be developed by Saclay*
Computing resources	*Computer farm, significant amount of CPU time and disk space (to be defined) for raw data processing*
Information to be saved in the database	*Updated geometry, updated efficiency maps,*
Repetition frequency	*Useful after large configuration changes*

Beam Run #2	
Description and goals	*Geometry and tracking tuning with B=0 field. Typically a normal electron run, but potentially with thin target(s) such as CH2 or carbon in order to have well defined z-vertex.*
DAQ Configuration and Trigger	*Typical CLAS12 main trigger*
Dependencies from other systems	*All systems should be on*

Manpower and time needed	*Long runs (2-3 hours) may be needed to have enough statistics for detectors in the backward region*
Software for analysis of results	*CLAS12 analysis software (including tracking), to be developed by CLAS12 collaboration and partly Saclay. Micromegas geometry post-analysis software to be developed by Saclay*
Computing resources	*Computer farm, significant amount of CPU time and disk space (to be defined) for raw data processing*
Information to be saved in the database	*Updated geometry, updated efficiency maps*
Repetition frequency	*Useful after large configuration changes*

Beam Run #3	
Description and goals	*Gain definition runs. A run or several runs during which HV will be adjusted to accommodate the spark rate for a specific configuration*
DAQ Configuration and Trigger	*Typical CLAS12 main trigger*
Dependencies from other systems	*All systems should be on*
Manpower and time needed	*Long runs (2-3 hours) may be needed to have enough statistics for detectors in the backward region*
Software for analysis of results	*CLAS12 analysis software (including tracking), slow control for HV change*
Computing resources	*Computer farm, significant amount of CPU time and disk space (to be defined) for raw data processing*
Information to be saved in the database	*Updated gains*
Repetition frequency	*Useful after any configuration changes or long beam-off periods to double-check spark rates are stable*

Appendix F

Central Time of Flight (CTOF)

F.1 Contact person

The contact persons for this subsystem are:

Name	*Affiliation*	*email*	*Area of Responsability*
V. Baturin	Jefferson Lab	baturin@jlab.org	Hardware
W. Kim	Kyungpook University	wooyoung@jlab.org	Hardware
V. Baturin	Jefferson Lab	baturin@jlab.org	Software

F.2 Quality Assurance and System Checkout

F.2.1 Quality Assurance

Test #1 Component Checkout	
Description	*The individual parts that make up the CTOF counters, including the PMTs, the scintillation bars, the light guides, and the magnetic shields will be inspected and checked individually*
Special equipment	*Checks of the PMTs will be performed using an oscilloscope with associated signal and HV cables and a LeCroy HV power supply. Checks of the scintillation bars and the light guides will be performed with a light source and a radiometer and compared to reference measurements. All of this work will be done on each component before counter assembly. The relevant critical dimensions of the scintillation bars and light guides will also be checked for compliance*
DAQ Configuration and Trigger	*No DAQ system is necessary for these checks*
Manpower and time needed	*This work is scheduled to take about 3 to 4 months to complete as repairs will be made as problems are identified. Two technicians will be required for this work*
Software for analysis of results	*No software or analysis of results is necessary for these checks*
Computing resources	*No computing resources are necessary for these checks*
Information to be saved in the database	*No information will be stored in the database from these checks*

Test #2 PMT Basic Functionality Checkout	
Description	*Check the signals from each CTOF PMT at nominal voltage to verify basic functionality of each unit and to check for any light*

	leaks in the scintillation bar wrapping or installation of the light-tight boots
Special equipment	*Checks will be performed using an oscilloscope with associated signal and HV cables and a LeCroy HV power supply*
DAQ Configuration and Trigger	*No DAQ system is necessary for these checks*
Manpower and time needed	*This work is scheduled to take about 3 to 4 months to complete as repairs will be made as problems are identified. Two technicians will be required for this work*
Software for analysis of results	*No software or analysis of results is necessary for these checks*
Computing resources	*No computing resources are necessary for these checks*
Information to be saved in the database	*No information will be stored in the database from these checks*

Test #3 Measure Counter Timing Resolutions	
Description	*Measure the timing resolution of each counter with cosmic rays and radioactive sources. This includes determining the PMT HV settings and calibration constants*
Special equipment	*These tests will require a stand-alone DAQ system with readout of ADCs, TDCs, and scalers. The electronics setup will include discriminators and standard trigger logic. A LeCroy HV power supply and a set of small reference timing counters are required. Much of this infrastructure is already in place in the CTOF work area*
DAQ Configuration and Trigger	*The DAQ will be a single VME crate CODA readout configuration. The trigger will be formed from an overlap of signals from the CTOF counter*
Manpower and time needed	*This work will require two technicians for a period of about 4 to 6 months depending on the level of problems/issues found during the tests*

Software for analysis of results	*The analysis software and interfaces will all need to be written to carry out these tasks both from the online and offline side. The offline analysis code will be based on existing algorithms and code from CLAS6*
Computing resources	*The stand-alone DAQ system will be setup on a local PC with all data and analysis carried out on that machine. Disk space of 50 Gb will be sufficient*
Information to be saved in the database	*The initial HV settings and calibration constants will be recorded in the database*

F.2.2 System Checkout

Checkout of CTOF After Installation	
Description	*Verify cabling and connections* *Checkout of HV control and monitoring* *Cosmic runs to verify ADC, TDC, scaler functionality* *Cosmic runs to check out each PMT and counter* *Runs with torus magnet off, half field, full field*
Manpower and time needed	*Estimate that this will involve several man-weeks worth of effort*
Software for analysis of results	*The required software for these tests will be based on online software prepared by the DAQ and CODA groups with input from the CTOF group*
Computing resources	*The tests will require the CLAS12 DAQ system with some limited amount of data storage on the silo of 50 Gb*
Dependencies from other systems	*The DAQ system and trigger will need to be in full working order and the torus needs to be energized to complete the measurements and checkout*
Information to be saved in the database	*No data from these tests will need to be included in the database*

F.3 Commissioning without beam

F.3.1 Special calibration procedures

Special Run	
Description	*Required special runs include standard ADC pedestal run and TDC pulser calibration run*
Goal	*Measure the ADC pedestals for accurate energy loss measurements and TDC linearity measurements*
DAQ Configuration and Trigger	*A standard DAQ pedestal and TDC pulser run*
Manpower and time needed	*Runs will be analyzed online. Manpower is minimal provided the DAQ is fully functional at this time*
Software for analysis of results	*Standard online scripts will be employed*
Computing resources	*No requirement beyond DAQ system*
Dependencies from other systems	*None*
Information to be saved in the database	*ADC pedestals and TDC calibration constants*

F.3.2 Calibration with Cosmic Rays

Cosmic Run	
Description and goals	*This data is required to calibrate the PMT HV settings and after analysis will be used to determine the counter calibration constants for measurements of the counter time resolutions*
DAQ Configuration and Trigger	*Standard DAQ configuration for TOF cosmic ray running using CTOF self-triggering*

Dependencies from other systems	*No dependences besides DAQ/trigger operability*
Manpower and time needed	*Will need roughly 4 man-weeks of student help to calibrate the system and determine the counter resolutions*
Software for analysis of results	*The software for the calibrations and timing resolution determination should already be in full operation by this point in time*
Computing resources	*The collected data will be moved to the JLab silo and require 50 Gb. Data will be cooked using farm and analyzed from CLAS12 accounts. Relatively modest requirements*
Information to be saved in the database	*The HV settings and calibration constants will be stored in the database*
Repetition frequency	*The HV calibrations will be done once a month or so initially*

F.4 Commissioning with beam

Beam Run	
Description and goals	*After initial system checkout in a realistic noise and RF environment, a series of rate studies will be performed, data at several torus magnetic field settings will be acquired (1/2 field, full field), and a timing calibration run will be acquired*
DAQ Configuration and Trigger	*Standard DAQ configuration for TOF cosmic ray running using CTOF self-triggering*
Dependencies from other systems	*No dependences besides DAQ/trigger operability*
Manpower and time needed	*Will need roughly 4 man-weeks of student help to calibrate the system and determine the counter resolutions*
Software for analysis of results	*The software for the calibrations and timing resolution determination should already be in full operation by this point in time*
Computing resources	*The collected data will be moved to the JLab silo and require 50 Gb. Data will be cooked using farm and analyzed from CLAS12 accounts. Relatively modest requirements*
Information to be saved in the database	*The HV settings and calibration constants will be stored in the database*
Repetition frequency	*The timing calibrations will be a regular part of offline data cooking procedures*

Appendix G

CND Instrumentation

G.1 Contact person

The contact persons for this subsystem are:

Name	*Affiliation*	*email*	*Area of Responsability*
S. Niccolai	IPN Orsay	silvia@jlab.org	Hardware
S. Niccolai	IPN Orsay	silvia@jlab.org	Software

G.2 Quality Assurance and System Checkout

G.2.1 Quality Assurance

Test #1 Component Checkout	
Description	*All of the components of the CND (scintillators, light guides, PMTs and magnetic shields) will be checked individually in Orsay by the technicians and engineers of the Detectors Group of IPN and the IPN scientists involved in CLAS12*
Special equipment	*The functioning of the PMTs will be checked by looking at their output signals on an oscilloscope; HV cables and power supply will be used for this task. The performance of the scintillation bars and the light guides will be verified with a light source*
DAQ Configuration and Trigger	*No DAQ needed*
Manpower and time needed	*2 months of work with 2 technicians*
Software for analysis of results	*No software or analysis needed*
Computing resources	*No computing resources will be needed*
Information to be saved in the database	*No information will be stored in the database for these checks*

Test #2 Test of PMTs	
Description	*Verify all electrical connections and make sure that each of the 144 PMTs work; check for light leaks.*
Special equipment	*HV power supplies, oscilloscope*
DAQ Configuration and Trigger	*No DAQ needed*
Manpower and time needed	*2 months of work with 2 technicians*
Software for analysis of results	*No software needed*

Computing resources	*None needed*
Information to be saved in the database	*No information will be stored in the database for these checks*

Test #3 Study Counter Performance	
Description	*Determine the HV settings for each of the PMTs using cosmic rays for initial gain matching. Then study energy sums and timing resolutions.*
Special equipment	*These tests will require a stand-alone DAQ system with readout of ADCs, TDCs, and scalers. The electronics setup will include discriminators and standard trigger logic. A HV power supply will be required.*
DAQ Configuration and Trigger	*These tests will be setup at ORSAY and carried out by the CND group.*
Manpower and time needed	*2 months of work with 2 technicians*
Software for analysis of results	*The analysis software and interfaces will all need to be written to carry out these tasks from both the online and offline side.*
Computing resources	*A stand-alone DAQ system will need to be setup. Local data storage of 50 Gb will be sufficient.*
Information to be saved in the database	*The initial HV settings and calibration constants will be recorded in the database.*

G.2.2 System Checkout

Checkout of Front-End Electronics	
Description	*Verify the functioning of all voltage dividers, discriminators, and TDC and ADC channels for each counter. Check quality of PMT signals in the magnetic field of the solenoid. Cosmic rays will be used for these tests*

Manpower and time needed	*2 months of work with 2 people.*
Software for analysis of results	*The software for these tests will be written by the CND group with the help of the DAQ and CODA groups at JLab.*
Computing resources	*The detector will be connected to readout electronics in Hall B. The Hall B DAQ system will be used for these tests. Disk space of 50 Gb will be sufficient.*
Dependencies from other systems	*CLAS12 DAQ and solenoid field on*
Information to be saved in the database	*The PMT HV values will be verified and stored in the database.*

G.3 Commissioning without beam

G.3.1 Special calibration procedures

Special Run #1	
Description	*Required special runs include standard ADC pedestal run and TDC pulser calibration run*
Goal	*Measure the ADC pedestals for accurate energy loss measurements and TDC linearity measurements*
DAQ Configuration and Trigger	*A standard DAQ pedestal and TDC pulser run.*
Manpower and time needed	*Runs will be analyzed online. Manpower is minimal provided DAQ is fully functional at this time*
Software for analysis of results	*Standard online scripts will be employed*
Computing resources	*No requirement beyond DAQ system.*
Dependencies from other systems	*None*
Information to be saved in the database	*ADC pedestals and TDC calibration constants*

G.3.2 Calibration with Cosmic Rays

Run #1: CND Cosmic Ray Calibrations	
Description and goals	*This data is required to calibrate the PMT HV settings and after analysis will be used to determine the counter calibration constants for measurements of the counter time resolutions*
DAQ Configuration and Trigger	*Standard DAQ configuration for CND cosmic ray running using CND self-triggering*

Dependencies from other systems	*No dependences besides DAQ/trigger operability.*
Manpower and time needed	*Will needed roughly 3 to 4 man-weeks of effort to calibrate the system and determine the counter resolutions*
Software for analysis of results	*The software for the calibrations and timing resolution determination (the CND reconstruction package) is currently under development by the CND group and will be ready for use for these calibrations*
Computing resources	*The collected data will be moved to the JLab silo and require 50 Gb. Data will be cooked using farm and analyzed from CLAS12 accounts. Relatively modest requirements*
Information to be saved in the database	*The HV settings and calibration constants will be stored in the database*
Repetition frequency	*The HV calibrations will be done once a month or so initially.*

G.4 Commissioning with beam

Beam Run #1: CND Detector Calibrations	
Description and goals	*After initial system checkout in a realistic noise and RF environment, a series of rate studies will be performed, data at several solenoid fields will be acquired, and the system will take standard calibration data (timing and energy loss).*
DAQ Configuration and Trigger	*A CND-only trigger, requiring a signal above a predefined threshold from one paddle*
Dependencies from other systems	*These studies will require that the CLAS12 solenoid be on*
Manpower and time needed	*Will need roughly 4 man-weeks to calibrate the system and determine its operating parameters*
Software for analysis of results	*The CND reconstruction and calibration package will be required*
Computing resources	*The collected data will be moved to the JLab silo and required 50 Gb. Data will be cooked using farm and analyzed from CLAS12 accounts. Relatively modest requirements*
Information to be saved in the database	*The parameters for energy loss, attenuation length, and effective velocity will be stored in the database*
Repetition frequency	*In general, production data will be used for this purpose, thus this is not expected to be a standard calibration*

Beam Run #2 - CND Neutron Detection Efficiency Measurement	
Description and goals	*Production data taken on a proton target and the full CLAS12 setup. The epe+(n) reaction channel will be selected. The CND detection efficiency will be obtained, for each kinematic bin covered by the CND, as the ratio of events for which a neutron was identified in the CND over the total number of e+(n) events*

DAQ Configuration and Trigger	*CLAS12 electron-run trigger (CC+EC), ordinary DAQ configuration for production runs*
Dependencies from other systems	*All of the CLAS12 detector, including the CND should be calibrated*
Manpower and time needed	*Once calibrated and reconstructed data are available, this work can be performed by a student in 2-3 weeks*
Software for analysis of results	*The standard CLAS12+CND reconstruction and calibration package*
Computing resources	*As we will use production runs of a proton-target experiment, no additional storage space is needed*
Information to be saved in the database	*The neutron detector efficiencies will be stored in the database*
Repetition frequency	*Likely this calibration will be performed for each data set requiring neutron detection*

Appendix H

Drift Chambers

H.1 Contact person

The contact persons for this subsystem are:

Name	*Affiliation*	*email*	*Area of Responsability*
M. Mestayer	Jefferson Lab	mestayer@jlab.org	Hardware
M. Mestayer	Jefferson Lab	mestayer@jlab.org	Software

H.2 Quality Assurance and System Checkout

H.2.1 Quality Assurance

Test #1- Wire Tension Testing	
Description	*We vibrate the wire using the Lorentz force of an external magnetic field on a current in the wire to determine its resonant frequency. The goal is to determine its tension and thus, its gravitational sag. We reject and re-string wires which are out of tolerance*
Special equipment	*Magnet, frequency-adjustable current source, oscilloscope*
DAQ Configuration and Trigger	*n.a.*
Manpower and time needed	*Large, done by the stringers*
Software for analysis of results	*We need a data-base to keep a record of the tensions and software to correct the wire position for the gravitational sag*
Computing resources	*Data-base for stringing, someone to write the algorithm which corrects the track position as a function of its azimuthal position (along the wire)*
Information to be saved in the database	*Parameters to be used in calculating the wire sag as a function of wire number and sector; limits on acceptable tension values as a function of wire number, possibly individual tension measurements*

Test #2 Wire Continuity Tests	
Description	*Measure electrical connectivity from one end of wire to other to insure a good electrical connection; measure cross-continuity with neighbor wires to detect crossed wires.*
Special equipment	*DVM, wire harness*
DAQ Configuration and Trigger	*n.a.*
Manpower and time needed	*Part of stringing effort*

Software for analysis of results	*n.a.*
Computing resources	*n.a.*
Information to be saved in the database	*n.a.*

Test #3 Gas Tightness Test	
Description	*Determine size of gas leaks, if detectible*
Special equipment	*Gas bottles, flowmeter*
DAQ Configuration and Trigger	*n.a.*
Manpower and time needed	*Part of stringing*
Software for analysis of results	*n.a.*
Computing resources	*n.a.*
Information to be saved in the database	*n.a.*

Test #4 High Voltage Conditioning	
Description	*Connect wires to high voltage supply; bring to operating voltage; observe and record current over time; allow time for current to decrease. In special cases, remove the wire*
Special equipment	*High voltage supply, DVM*
DAQ Configuration and Trigger	*n.a.*
Manpower and time needed	*Part of stringing*
Software for analysis of results	*n.a.*
Computing resources	*n.a.*
Information to be saved in the database	*List of removed (dead) wires, if any*

Test #5 Observation of Signals	
Description	*Observe signals due to cosmic rays, cathode emission to ensure that the chamber is operational*
Special equipment	*On-chamber H.V. and signal boards; external post-amplifier, oscilloscope*
DAQ Configuration and Trigger	*n.a.*
Manpower and time needed	*Part of stringing*
Software for analysis of results	*n.a.*
Computing resources	*n.a.*
Information to be saved in the database	*Possible additions to dead wire list*

Test #6 Cable (HV, LV, Signal) Placement and Integrity	
Description	*After the cables are laid, check continuity across the length. In the case of signal cables measure the time delay by pulsing the 17th pair on each signal cable and measuring the delay time for the signal to return on the other 16 channels*
Special equipment	*A test-stand with pulser, post-amp and TDC*
DAQ Configuration and Trigger	*Runs with LabView*
Manpower and time needed	*Test-stand built by electronics group; measurements will take a few minutes per cable; 1512 cables*
Software for analysis of results	*LabView*
Computing resources	*n.a.*
Information to be saved in the database	*Cable delays put into time delay tables*

Test #7 Survey of Chamber Positioning	
Description	*Measure the chamber location with respect to an internal torus coordinate system*
Special equipment	*Place marks on torus, establish torus-based coordinate system, measure each chambers (18) group of marks; place a proximity sensing device on each chamber, establish the location of each chamber relative to the torus marks by measuring the signals from the proximity sensors*
DAQ Configuration and Trigger	*Proximity sensor will have its own data-acquisition*
Manpower and time needed	*Design system: 8 fte-wks; place fiducial marks on torus: 6 weeks; 3 fte, Locate chamber with respect to marks: 6 weeks; 3 fte*
Software for analysis of results	*Survey groups software, software in proximity sensor*
Computing resources	*n.a.*
Information to be saved in the database	*Installed position (x,y,z, 3 angles) for each of 18 chambers*

Test #8 Torus Magnetic Field Mapping	
Description	*Map the torus magnetic field and fit to a model which allows the calculation of the field in the tracking region with a precision of 1 part per thousand*
Special equipment	*Flip-coils, Hall probes, voltage integrators, survey group*
DAQ Configuration and Trigger	*Specialized data-acquisition*
Manpower and time needed	*Design: 1 fte-yr, data-taking: 8 weeks, 4 people*
Software for analysis of results	*Data-recording software (bx, by, bz at x, y, z); fitting software to produce a magnetic field model which matches the data*
Computing resources	*Modest*

Information to be saved in the database	*Tables of bx, by, bz at x, y, z*

H.2.2 System Checkout

Checkout of Drift Chamber Gas System	
Description	*Establish operation, measure flows and pressures, measure contaminants on inflow from gas shed and outflow back to shed to look for leaks*
Manpower and time needed	*0.5 fte-yrs*
Software for analysis of results	*n.a.*
Computing resources	*Modest, specialized*
Dependencies from other systems	*Gas system in place, chambers installed*
Information to be saved in the database	*n.a.*

Checkout of Drift Chamber HV and LV Systems	
Description	*Check all operation features of supplies and distribution systems. Measure the voltage and current of all channels.*
Manpower and time needed	*1 fte-yr*
Software for analysis of results	*n.a.*
Computing resources	*n.a.*
Dependencies from other systems	*Ideally, chambers installed*
Information to be saved in the database	*Only possible dead channels*

Checkout of Drift Chamber Amplifier-Discriminator Boards and TDC system	
Description	*Bench-test boards, crates.* *Check signal on oscilloscope.* *Read out tdcs using a random or cosmic ray trigger*
Manpower and time needed	*0.5 fte-yr*
Software for analysis of results	*Wire → adb -¿ tdc map; channel → time constant; software resides in crate*
Computing resources	*On-line DAQ needed*
Dependencies from other systems	*Trigger, on-line DAQ*
Information to be saved in the database	*Possible list of dead wires*

H.3 Commissioning without beam

H.3.1 Special calibration procedures

Special Run for Noise Studies	
Description	*Signal observation of wires on oscilloscope, looking for hot or dead channels. Occupancy plot looking for dead areas. Histogram to estimate coherent noise*
Goal	*Eliminate noise sources. Set discriminator values*
DAQ Configuration and Trigger	*For occupancy plot and noise histogram, we need on-line daq and TDC readout software*
Manpower and time needed	*0.25 fte-yrs*
Software for analysis of results	*Histogramming software: occupancy and time plots*
Computing resources	*On-line DAQ*
Dependencies from other systems	*Gas, HV, LV, ADB and TDCs working*
Information to be saved in the database	*Trigger time delay; possible additions to dead wire list*

H.3.2 Calibration with Cosmic Rays

Run: Drift Chamber Cosmic Ray Tests	
Description and goals	*Measure functionality of all systems: chamber to tdc; look for dead areas, possibly look for cable swaps*
DAQ Configuration and Trigger	*Cosmic ray trigger from large-angle FTOF and/or CTOF, or random trigger*
Dependencies from other systems	*Need trigger, on-line daq, FTOF and/or CTOF*
Manpower and time needed	*0.25 fte-yrs*

Software for analysis of results	*Histogramming package: occupancy plots*
Computing resources	*On-line system*
Information to be saved in the database	*Possible list of dead wires*
Repetition frequency	*Anytime we disconnect cables*

H.4 Commissioning with beam

Beam Run: Drift Chamber Tracking	
Description and goals	*Electron beam on solid target*
DAQ Configuration and Trigger	*One-electron trigger (additional track requirement would be helpful); standard DAQ*
Dependencies from other systems	*Need HTCC for trigger and calculating event start-time, FTOF for track timing*
Manpower and time needed	*0.25 fte-yrs*
Software for analysis of results	*Event-reconstruction software; much software work needed*
Computing resources	*Modest*
Information to be saved in the database	*Calibration (event-dependent time delays, time-to-distance parameters, possible additions to dead wire list*
Repetition frequency	*Not necessary, can be re-done with real data*

Appendix I

Forward Time of Flight (FTOF)

I.1 Contact person

The contact persons for this subsystem are:

Name	*Affiliation*	*email*	*Area of Responsability*
D. Carman	Jefferson Lab	carman@jlab.org	Hardware
D. Carman	Jefferson Lab	carman@jlab.org	Software

I.2 Quality Assurance and System Checkout

I.2.1 Quality Assurance

Test #1 PMT Basic Functionality Checkout	
Description	*Check the signals from each FTOF PMT/divider at nominal voltage to verify basic functionality of each unit and to check for any light leaks*
Special equipment	*Checks will be performed using an oscilloscope with associated signal and HV cables and a LeCroy HV power supply*
DAQ Configuration and Trigger	*No DAQ system is necessary for these checks*
Manpower and time needed	*This work is scheduled to take about 6 months to complete as repairs will be made as problems are identified. Two technicians will be required for this work*
Software for analysis of results	*No software or analysis of results is necessary for these checks*
Computing resources	*No computing resources are necessary for these checks*
Information to be saved in the database	*No information will be stored in the database from these checks*

Test #2 Measure Counter Timing Resolutions	
Description	*Measure the timing resolution of each counter with cosmic rays. This includes determining the PMT HV settings and calibration constants*
Special equipment	*These tests will require a stand-alone DAQ system with readout of ADCs, TDCs, and scalers. The electronics setup will include discriminators and standard trigger logic. A LeCroy HV power supply and a set of small reference timing counters are required*
DAQ Configuration and Trigger	*The DAQ will be a single VME crate CODA readout configuration. The trigger will be formed from an overlap of signals from the FTOF*

	counter and the reference timing counters
Manpower and time needed	*This work is scheduled to take about 6 months to complete as repairs will be made as problems are identified. It will require two technicians plus assistance to setup the DAQ system and electronics*
Software for analysis of results	*The analysis software and interfaces will all need to be written to carry out these tasks both from the online and offline side. The offline analysis code will be based on existing algorithms and code from CLAS6*
Computing resources	*The stand-alone DAQ system will be setup on a local PC with all data and analysis carried out on that machine. Disk space of 50 Gb will be sufficient*
Information to be saved in the database	*The initial HV settings and calibration constants will be recorded in the database*

I.2.2 System Checkout

Checkout of FTOF After Installation	
Description	*- Verify cabling and connections* *- Checkout of HV control and monitoring* *- Cosmic runs to verify ADC, TDC, scaler functionality* *- Cosmic runs to check out each PMT and counter* *- Runs with torus magnet off, half field, full field*
Manpower and time needed	*Estimate that this will involve several man-weeks worth of effort*
Software for analysis of results	*The required software for these tests will be based on online software prepared by the DAQ and CODA groups with input from the FTOF group.*
Computing resources	*The tests will require the CLAS12 DAQ system with some limited amount of data storage on the silo of 50 Gb.*
Dependencies from other systems	*The DAQ system and trigger will need to be in full working order and the torus needs to be energized to complete the measurements*

	and checkout
Information to be saved in the database	*No data from these tests will need to be included in the database*

I.3 Commissioning without beam

I.3.1 Special calibration procedures

Special Run # 1	
Description	*Required special runs include standard ADC pedestal run and TDC pulser calibration run*
Goal	*Measure the ADC pedestals for accurate energy loss measurements and TDC linearity measurements*
DAQ Configuration and Trigger	*A standard DAQ pedestal and TDC pulser run*
Manpower and time needed	*Runs will be analyzed online. Manpower is minimal provided the DAQ is fully functional at this time*
Software for analysis of results	*Standard online scripts will be employed*
Computing resources	*No requirement beyond DAQ system*
Dependencies from other systems	*None*
Information to be saved in the database	*ADC pedestals and TDC calibration constants*

I.3.2 Calibration with Cosmic Rays

Run #1: FTOF Cosmic Ray Calibrations	
Description and goals	*This data is required to calibrate the PMT HV settings and after analysis will be used to determine the counter calibration constants for measurements of the counter time resolutions*
DAQ Configuration and Trigger	*Standard DAQ configuration for TOF cosmic ray running using FTOF self-triggering*

Dependencies from other systems	*No dependences besides DAQ/trigger operability.*
Manpower and time needed	*Will need roughly 4 man-weeks of student help to calibrate the system and determine the counter resolutions*
Software for analysis of results	*The software for the calibrations and timing resolution determination should already be in full operation by this point in time*
Computing resources	*The collected data will be moved to the JLab silo and require 50 Gb. Data will be cooked using farm and analyzed from CLAS12 accounts. Relatively modest requirements*
Information to be saved in the database	*The HV settings and calibration constants will be stored in the database*
Repetition frequency	*The HV calibrations will be done once a month or so initially*

I.4 Commissioning with beam

Beam Run #1	
Description and goals	*After initial system checkout in a realistic noise and RF environment, a series of rate studies will be performed, data at several torus magnetic field settings will be acquired (1/2 field, full field), and a timing calibration run will be acquired*
DAQ Configuration and Trigger	*Standard DAQ configuration for TOF cosmic ray running using FTOF self-triggering*
Dependencies from other systems	*No dependences besides DAQ/trigger operability*
Manpower and time needed	*Will need roughly 4 man-weeks of student help to calibrate the system and determine the counter resolutions*
Software for analysis of results	*The software for the calibrations and timing resolution determination should already be in full operation by this point in time*
Computing resources	*The collected data will be moved to the JLab silo and require 50 Gb. Data will be cooked using farm and analyzed from CLAS12 accounts. Relatively modest requirements*
Information to be saved in the database	*The HV settings and calibration constants will be stored in the database*
Repetition frequency	*The timing calibrations will be a regular part of offline data cooking procedures*

Appendix J

Low Threshold Cerenkov Counter (LTCC)

J.1 Contact person

The contact persons for this subsystem are:

Name	*Affiliation*	*email*	*Area of Responsability*
M. Ungaro	Jefferson Lab	ungaro@jlab.org	Construction/Coordination/Softw
Y. Sharabian	Jefferson Lab	youris@jlab.org	Construction
P. Stoler	Rensselaer Polytechnic Institute	stolep@rpi.edu	Coordination
J. Price	California State University, Dominguez Hills	jprice@csudh.edu	Software/Calibration

J.2 Quality Assurance and System Checkout

J.2.1 Quality Assurance

Test #1- Sector removal	
Description	*Remove the LTCC sector from the CLAS6 foward carriage for modification*
Special equipment	*CC installation/removal tooling; overhead crane, truck for transportation*
DAQ Configuration and Trigger	*None*
Manpower and time needed	*0.5 expert-weeks, 1 worker-weeks per sector (1 expert, 3 workers)*
Software for analysis of results	*None*
Computing resources	*None*
Information to be saved in the database	*None*

Test #2 - Mirror sagging	
Description	*Test Mirror Sagging due to different sectors positioning*
Special equipment	*Removal tooling; overhead crane, semi-clean room (approximately class 10,000)*
DAQ Configuration and Trigger	*None*
Manpower and time needed	*2 expert-weeks, 0.6 worker-weeks per sector (1 expert, 3 workers)*
Software for analysis of results	*None*
Computing resources	*None*
Information to be saved in the database	*Sagging parameters*

Test #3 - Sector disassembly	
Description	*Remove all CC hardware from sidewalls; deliver sidewalls to machine shop for modification.*
Special equipment	*None*
DAQ Configuration and Trigger	*None*
Manpower and time needed	*2 expert-weeks; 4 worker-weeks (1 expert, 2 workers)*
Software for analysis of results	*None*
Computing resources	*None*
Information to be saved in the database	*None*

Test #4 - Gas System Refurbish	
Description	*Install differential pressure transducer (DPT). Detector Box Internal Piping and fitting Replacement*
Special equipment	*None*
DAQ Configuration and Trigger	*None*
Manpower and time needed	*4 expert-weeks; 4 worker-weeks (2 expert, 2 workers)*
Software for analysis of results	*None*
Computing resources	*None*
Information to be saved in the database	*None*

Test #5 - Sector reassembly	
Description	*Reattach the CC hardware to the sidewalls after modification by the machine shop*
Special equipment	*None*

DAQ Configuration and Trigger	*None*
Manpower and time needed	*2 expert-weeks, 4 worker-weeks (1 expert, 2 workers)*
Software for analysis of results	*None*
Computing resources	*None*
Information to be saved in the database	*None*

Test #6 - Mirrors Alignment	
Description	*Align the mirrors to have the proper roll, yaw, and pitch to maximize the efficiency for electrons and pions with both positive and negative charge*
Special equipment	*Special support frame to hold LTCC vertical; laser lines with remote aiming device; mylar strips marked every centimeter, attached to LTCC sector; semi-clean room (approximately class 10,000)*
DAQ Configuration and Trigger	*None*
Manpower and time needed	*12 expert-weeks, 5 worker-weeks (2 expert, 2 workers)*
Software for analysis of results	*Excel (or similar) spreadsheet to compare actual position of laser spot with expected position*
Computing resources	*Laptop/Desktop containing alignment spreadsheet*
Information to be saved in the database	*Alignement parameters*

Test #7 - Window attachment	
Description	*Attach the gas windows to the upstream and downstream sides of the LTCC sector*

Special equipment	*None*
DAQ Configuration and Trigger	*None*
Manpower and time needed	*3 expert-weeks, 3 worker weeks (1 expert, 2 workers)*
Software for analysis of results	*None*
Computing resources	*None*
Information to be saved in the database	*None*

Test #8 - Sector reinstallation	
Description	*Install the completed LTCC sector in the forward carriage*
Special equipment	*CC installation/removal tooling; overhead crane*
DAQ Configuration and Trigger	*None*
Manpower and time needed	*1 expert-weeks, 1 worker weeks (1 expert, 3 workers)*
Software for analysis of results	*None*
Computing resources	*None*
Information to be saved in the database	*None*

J.2.2 System Checkout

Checkout of Front-EndElectronics	
Description	*Check FADC signal from all tubes using SPE*
Manpower and time needed	*5 expert-weeks (2 experts)*
Software for analysis of results	*EVIO4 reader, ROOT*
Computing resources	*1 Laptop, 1 Desktop*
Dependencies from other systems	*CODA in CLAS12 production configuration*
Information to be saved in the database	*None*

Checkout of Gas System	
Description	*Gas flow and leak checks*
Manpower and time needed	*2 expert-weeks 2 worker-weeks (2 expert 2 workers)*
Software for analysis of results	*None*
Computing resources	*None*
Special equipment	*Pressure gauges, Leak-Testing tools*
Information to be saved in the database	*None*

Checkout of High-Voltage System	
Description	*Match HV to produce same SPE peaks*
Manpower and time needed	*2 expert-week (1 expert)*
Software for analysis of results	*EVIO4 reader, ROOT*
Computing resources	*Laptop/Desktop*

Dependencies from other systems	*None*
Information to be saved in the database	*PMT HV values*

Checkout of DAQ/Trigger	
Description	*Verify Signal in all channels: identify cable swaps, verify PMTs and HV distribution, FADC trigger*
Manpower and time needed	*3 expert weeks (1 expert)*
Software for analysis of results	*EVIO4 Reader, ROOT*
Computing resources	*laptop/desktop*
Dependencies from other systems	*DAQ. May use light pulse inside the box*
Information to be saved in the database	*None*

J.3 Commissioning without beam

J.3.1 Special calibration procedures

Special Run #1 - Pedestal Measurement	
Description	*Determine Pedestal (if necessary)*
Goal	*Measure Mean and Sigma of Pedestal*
DAQ Configuration and Trigger	*Random Trigger*
Manpower and time needed	*0.1 expert weeks (2 expert)*
Software for analysis of results	*EVIO4 reader, ROOT*
Computing resources	*laptop/desktop*
Dependencies from other systems	*DAQ*
Information to be saved in the database	*Mean, Sigma of Pedestal*

Special Run #2 - Single Photoelectron Measurement	
Description	*Determine the SPE*
Goal	*Measure and fit the SPE distribution*
DAQ Configuration and Trigger	*CLAS12 production trigger / Threshold lowered*
Manpower and time needed	*2 expert weeks (1 expert)*
Software for analysis of results	*EVIO4 reader, ROOT*
Computing resources	*Laptop/Desktop*
Dependencies from other systems	*DAQ, Torus Magnet*
Information to be saved in the database	*Mean, Sigma of SPE*

Special Run #3 - HV Matching Feedback System	
Description	*Online live automatic HV matching*
Goal	*Automatic System that provides live HV matching*
DAQ Configuration and Trigger	*CLAS12 production trigger*
Manpower and time needed	*5 expert weeks (1 expert)*
Software for analysis of results	*EVIO4 reader, ROOT*
Computing resources	*Laptop/Desktop*
Dependencies from other systems	*DAQ, Slow Control*
Information to be saved in the database	*Mean, Sigma of SPE, HV*

Special Run #4 - SPE Online Calibration	
Description	*Software to automatically determine and monitor SPE*
Goal	*Measure and fit the online SPE distribution*
DAQ Configuration and Trigger	*CLAS12 production trigger*
Manpower and time needed	*5 expert weeks (1 expert)*
Software for analysis of results	*DAQ, ET Simulator, EVIO4 reader, ROOT*
Computing resources	*Laptop/Desktop*
Dependencies from other systems	*May use light pulse inside Box*
Information to be saved in the database	*Mean, Sigma of SPE*

J.3.2 Calibration with Cosmic Rays

None

J.4 Commissioning with beam

Special Analysis #1 - Pedestal Measurement	
Description and goals	*Determine Pedestal (if necessary), measuring mean and sigma*
DAQ Configuration and Trigger	*Random Trigger*
Dependencies from other systems	*DAQ*
Manpower and time needed	*0.1 expert weeks (2 expert)*
Software for analysis of results	*EVIO4 reader, ROOT*
Computing resources	*laptop/desktop*
Information to be saved in the database	*Mean, Sigma of Pedestal*
Repetition frequency	*??*

Special Analysis #2 - Single Photoelectron Measurement	
Description and goals	*Provide Online Calibration and Monitoring*
DAQ Configuration and Trigger	*CLAS12 production trigger*
Dependencies from other systems	*Torus*
Manpower and time needed	*1 expert-week*
Software for analysis of results	*EVIO4, ROOT*
Computing resources	*Laptop/Desktop*
Information to be saved in the database	*SPE Parameters, HV*
Repetition frequency	*??*

Special Analysis #3 - LTCC Efficiency	
Description and goals	*LTCC Efficiency as a function of particles p, theta, phi*
DAQ Configuration and Trigger	*CLAS12 production trigger*
Dependencies from other systems	*Torus, DC, FTOF, HTCC, reconstruction*
Manpower and time needed	*1 expert-week*
Software for analysis of results	*EVIO4, ROOT*
Computing resources	*Laptop/Desktop*
Information to be saved in the database	
Repetition frequency	*??*

Special Analysis #4 - LTCC Timing	
Description and goals	*Calibrate LTCC timing*
DAQ Configuration and Trigger	*CLAS12 production trigger*
Dependencies from other systems	*Torus, DC, FTOF, HTCC, reconstruction*
Manpower and time needed	*1 expert-week*
Software for analysis of results	*EVIO4, ROOT*
Computing resources	*Laptop/Desktop*
Information to be saved in the database	*T0 and T1*
Repetition frequency	*??*

Appendix K

High Threshold Cherenkov Counter

K.1 Contact person

The contact person(s) for this subsystem is(are):

Youri Sharabian	*Jefferson Lab*	*youris@jlab.org*	*Primary contact*
Andrew Puckett	*Jefferson Lab*	*puckett@jlab.org*	

K.2 Quality Assurance and System Checkout

K.2.1 Quality Assurance

Test 1: Reflectivity checks of mirrors and Winston Cones	
Description	*Check test mirrors and production mirrors coated by outside vendor to assure reflectivity specification is met.*
Special equipment	*Deuterium UV lamp, monochromator, reference mirror, PMT, black box, optical bench, miscellaneous optical components*
DAQ Configuration and Trigger	*Simple CODA setup with single PMT+ADC/TDC (use existing PMT test stand in EEL 108A, self-trigger).*
Manpower and time needed	*Approximately 1-2 man-weeks for setup, then check parts continuously as they are received over the course of 6 months. Approximately 1-3 man-hours per part after test setup is built.*
Software for analysis of results	*Use existing vendor-supplied control software for spectrophotometry equipment, CODA for PMT DAQ. Simple analysis software already exists or will be developed by us (determine PMT count rate, could be as simple as recording a scaler value), 2 man-days (maximum) for analysis software development.*
Computing resources	*Data will be stored on a PC in EEL 108A. Estimated disk space requirements less than 100 GB. Compute time requirements negligible.*
Information to be saved in the database	*Measured reflectivities of mirrors and Winston Cones, possibly as a function of wavelength.*

Test 2: Alignment checks of final assembled mirror	
Description	*Check and adjust/optimize final alignment of assembled mirror with respect to final PMT locations.*
Special equipment	*Final assembled HTCC mirror and containment vessel without PMTs installed, laser, gimbal mount and support structure for positioning and orientation of laser at the nominal target position.*
DAQ Configuration and Trigger	*none*
Manpower and time needed	*1-2 man-months (not including HTCC assembly).*
Software for analysis of results	*none*
Computing resources	*none*
Information to be saved in the database	*mirror alignment parameters, any deviations from ideal geometry.*

K.3 Commissioning without beam

K.3.1 Special calibration procedures

Test 3: PMT quality assurance	
Description	*PMT quality assurance tests, including measurements of dark current (< 100 nA), gain, and timing resolution.*
Special equipment	*PMT, LED light source (single and multiple photons), black box. Use existing test stand in EEL 180A*
DAQ Configuration and Trigger	*Simple CODA system as part of test stand in EEL 108A and/or TED high-bay.*
Manpower and time needed	~ 3 *man-weeks to test all 58 PMTs using existing setup. PMT tests are nearly completed.*
Software for analysis of results	*Existing PAW software and macros existing on the DAQ computer in EEL 108A will be used.*
Computing resources	*Existing DAQ computer in EEL building will be used.*
Information to be saved in the database	*HV settings required to align the single-photoelectron peaks of the PMTs, dark current results, ADC spectra, calibration constants, etc.*

K.4 Commissioning with beam

Test 4: Containment vessel QA	
Description	*Check final assembled containment vessel with mirrors and PMTs installed for gas and light-tightness.*
Special equipment	
DAQ Configuration and Trigger	*none*
Manpower and time needed	
Software for analysis of results	*none*
Computing resources	*none*
Information to be saved in the database	*none*

Test 5: Magnetic Shield QA	
Description	*Test effectiveness of three-layer passive magnetic shielding. Measure the suppression factor for longitudinal applied fields (worst case for field at PMT entry window). Require* $B/B_0 \lesssim 1\%$ *for longitudinal applied field.*
Special equipment	*Helmholtz coil setup in EEL 108A or ANL, Gaussmeter, existing tooling for positioning of magnetic shield and Hall probe.*
DAQ Configuration and Trigger	*Human DAQ reads gaussmeter with eyes and records field measurement in notebook or spreadsheet.*
Manpower and time needed	*Approximately 2 man-hours per shield set, total of ∼50 sets.*
Software for analysis of results	*Use existing ROOT macro developed by A. Puckett to plot the data (prepared as a text file.)*
Computing resources	*Negligible computing resources.*
Information to be saved in the database	*Record longitudinal suppresion factor measured in the linear region (*$B_0 \lesssim 50$ *G.).*

Test 6: Compensation Coil QA	
Description	*Test electrical connections, grounding, wiring, insulation, resistance, etc. for final wound compensation coils. Test effectiveness of compensation coil in killing residual longitudinal field component (with Gaussmeter and/or PMT gain measurements).*
Special equipment	*Helmholtz coils and PMT test stand in EEL 180A*
DAQ Configuration and Trigger	*PMT test DAQ – CODA*
Manpower and time needed	*Approximately 1-2 man-weeks after winding and wiring of compensation coils is already completed.*
Software for analysis of results	*PMT test paw macros (existing).*
Computing resources	*Small compute time and disk space requirements on EEL 108A PC.*
Information to be saved in the database	*Optimal current in compensation coil as a function of applied magnetic field.*

Special Run #1: Gain monitoring/matching with LED light-source system	
Description	*Monitor stability of PMT response in final assembled detector with LED light source that provides constant, uniform intensity of light.*
Goal	*Match PMT gains and monitor stability.*
DAQ Configuration and Trigger	*CODA DAQ in CLAS12 with HTCC self-trigger and/or LED source-based trigger.*
Manpower and time needed	*Once assembled, HTCC LED light-source monitoring and calibration runs will be taken opportunistically during experiment down times. Gain matching procedure will consist of several iterations of short (few mins.) runs, data analysis and calibration of the HV for each PMT to match the gains and align the single-photoelectron peaks for all PMTs to a constant pulse-height.*
Software for analysis of results	*Calibration software to be developed by HTCC group using simulated data well before installation of HTCC in Hall B. Estimated time required for development is approximately 0.5 man-weeks.*
Computing resources	*CLAS12 online farm in counting house; disk and compute time requirements small. Unpack raw data, fill histograms with ADC spectra, fit ADC spectra to calibrate.*
Dependencies from other systems	*none.*
Information to be saved in the database	*High-voltage settings, trigger thresholds, etc.*

Special Run #2: Determination of the compensation coil current in CLAS12 magnetic field	
Description	*With the HTCC in its final location in Hall B and the solenoid and torus fields ON, use the light-monitoring system to determine the optimal current in the compensation coils by scanning the current through the compensation coil about its nominal value, and observing the PMT gain variation as a function of compensation coil current.*
Goal	*Optimal compensation coil settings in the real magnetic field of CLAS12.*
DAQ Configuration and Trigger	*Standard CODA, HTCC self-trigger with light-monitoring system.*
Manpower and time needed	*Approximately 0.5 expert-days to take a series of LED runs and analyze the data.*
Software for analysis of results	*Gain matching software developed by HTCC group.*
Computing resources	*Small computing resources needed.*
Dependencies from other systems	*CLAS12 solenoid and torus magnets on.*
Information to be saved in the database	*Compensation coil current settings.*

Beam Run #1: Calibration and gain matching with beam	
Description and goals	*Determine the photoelectron yield for good electron tracks from the target, e.g. standard LH_2 target, perform fine adjustments of HV to align signals in each channel, determine the optimal threshold for each segment in θ, determine ADC-to-ph.e. conversion constants, determine HTCC efficiency for electrons vs. p, θ, ϕ, etc.*
DAQ Configuration and Trigger	*Standard CLAS12 trigger, but with low threshold on HTCC*
Dependencies from other systems	*Depends on forward tracking, TOF and ECAL+PCAL. TOF and tracking should be already calibrated. EC+PCAL need not already be calibrated but it is better if they are.*
Manpower and time needed	*Requires approximately 1-2 expert-days to perform analysis and make fine adjustments of HV.*
Software for analysis of results	*Software will be ready by beam turn-on, tested on simulated data. Requires cooking of other detectors, DC and FTOF at a minimum. 2 expert-weeks for development of HTCC calibration part, will be developed by A. Puckett.*
Computing resources	*Because there are only 48 channels, HTCC calibration requires only small compute resources relative to other subsystem calibrations, but this particular test requires cooking and calibration of the other detectors.*
Information to be saved in the database	*HV settings, ADC-to-n.ph.e. conversion constants, per-channel fine timing offsets and walk corrections, etc.*
Repetition frequency	*This type of calibration should be performed at the beginning of each run and after any major configuration change, in order to insure the most efficient trigger conditions. It can be performed using production data and will be repeated on an as-needed basis. It is expected to be relatively stable and should not be required more than 1-2 times per production run; at the beginning of the run and again as part of the offline analysis if needed.*

Appendix L

Electromagnetic Calorimeter (EC) and Preshower Calorimeter (PCAL)

L.1 Contact person

The contact persons for this subsystem are:

Name	*Affiliation*	*email*	*Area of Responsability*
K. Hicks	OHIO University	hicks@ohio.edu	Hardware
C. Smith		lcsmith@jlab.org	Hardware
S. Stepanyan	Jefferson Lab	stepanya@jlab.org	Hardware
W. Brooks	Universidad Técnica Federico Santa María	william.brooks@usm.cl	Software
M. Wood	Canisius College	wood5@canisius.edu	Software

L.2 Synopsis

PCAL is a new detector requiring a full checkout and calibration of all PMTs. This will be performed initially in the EEL Building using cosmics, followed by in-situ verification of cosmic calibration and function after Hall B installation, and in-beam calibration and integration with EC. Current plans are to adopt existing EC calibration software for this purpose.

EC is the only CLAS6 detector component retained for CLAS12. Existing calibration software will be modified to integrate into the CLAS12 DAQ software. Re-verification of existing EC calibration software will be necessary after the planned forward carriage uncabling, EC refurbishment and recabling and upgrade of EC to new FADC frontend and trigger electronics.

Because PCAL and EC both share EM shower energy deposited from electrons and photons, calibration procedures will be necessary to verify the detectors work together as a unit to produce accurate energy, time and position information need to construct clusters for the CLAS12 trigger. Accurately combining energy information from PCAL and EC will be especially challenging given the larger photoproduction background environment seen by PCAL. Verification and optimization of background suppression algorithms will be an important part of the commissioning activity.

L.3 Quality Assurance and System Checkout

L.3.1 Quality Assurance

PCAL: Light leak check (EEL Room 125)	
Description	*PMT housings and mounting fixtures should be light-tight. This requires checking each PMT, after all PMTs are installed and PCAL box is sealed, with initial HV set high enough to see single photoelectron peak on an analog scope. This work can be done prior to or during full cable installation for cosmic tests.* 1. *Adjust HV to place single photoelectron peak at 5 mV on scope.* 2. *Check for PMT light leaks and repair at source of leak.* 3. *Check for excessively noisy PMTs (not light leaks) . PMTs with excessively low gain or not visible single photoelectron peak should be set aside.* 4. *Check crosstalk between adjacent PMTs while triggering on cosmic muons.*
Special equipment	*Analog oscilloscope, preferably Tektronix 2465B.* *Portable HV supply.* *Opaque sealing tape or putty*
DAQ Configuration and Trigger	*n.a.*
Manpower and time needed	*Based on EC experience 1 week. PCAL design may make this shorter. Work can be done in parallel if multiple scopes and HV channels are available.*
Software for analysis of results	*n.a.*

Computing resources	*n.a.*
Information to be saved in the database	*Noisy PMTs should be noted. Record HV determined in 1) for each PMT*

EC: Repair and refurbishment of PMTs and housing (Forward Carriage)	
Description	*After uncabling and removal of cable support structures on the forward carriage, EC optical fiber aluminum housing and PMT mounting structures will be accessible in some areas for the first time in 15 years. This opportunity should be used to reinforce or replace failing tape seals and repair known or potential light-leaks, replace broken or weak PMT housings and replace dead PMT/HV dividers. An ample supply of spare HV dividers and PMTs should be made available to replace weak and aged components.* 1. *Inspect all taped light seals along aluminum housing of optical fibers* 2. *Repair loose fitting or failed tape joints* 3. *Identify and repair light leaks around PMT housings* 4. *Replace cracked or wobbly PMT housings* 5. *Replace dead PMT/HV dividers*
Special equipment	*Analog oscilloscope, preferably Tektronix 2467B* *Portable HV supply* *Opaque sealing tape or putty* *Ladder* *50 XP2262 or equivalent PMTs* *50 refurbished HV dividers* *10 spare PMT housings*

	Optical grease
DAQ Configuration and Trigger	*Pedestal runs taken prior to decabling can be used to identify noisy PMTs or light leaks.*
Manpower and time needed	*1 month. Work can be done in parallel if multiple oscilloscopes and HV channels are available.*
Software for analysis of results	*n.a.*
Computing resources	*n.a.*
Information to be saved in the database	*Record location and type of replaced PMT/HV divider*

L.3.2 System Checkout

PCAL System Checkout	
Description	*The plan is to evaluate each PCAL module immediately after construction in the EEL Room 125 using CLAS12 front-end electronics, CAEN HV controls and a working CODA/CLAS12 DAQ system. The PCAL module will be fully cabled with HV cables to two CAEN mainframes, signal cables to the splitter panels, and patch cables to the front-end FADC250 modules and VME discriminators. Initial HV values determined from the quality checks in 1.1 will be loaded into the CAEN HV mainframes. Crate Trigger Processor (CTP) will be programmed to construct a total energy sum, and a simulated sector trigger will be sent to the Trigger Supervisor (TS) which will distribute a L1ACCEPT to the TI in the FADC crate. Data taken during EEL Room cosmic runs will be used to evaluate the performance of PCAL as soon as possible after construction, and to pre-calibrate the PCAL prior to installation in Hall B, which should save time during commissioning.* *Obtain cosmic muon triggers to evaluate function of PCAL and DAQ components:*

	1. Determine optimum FADC capture window for muon trigger *2. Determine optimum FADC bit-depth and sampling frequency for MIP calibration.* *3. Demonstrate operation of CTP energy sum and/or single pixel trigger.* *4. Demonstrate FADC readout and trigger uniformity and efficiency.* *5. Evaluate pedestal noise of FADC and pedestal subtraction methods (event-by-event, lookup table, etc.)* *6. Determine range of PMT HV to provide best S/N for cosmic muon minimum ionizing peak while maintaining good linearity for EM shower events.* *7. Obtain cosmic muon data for evaluating scintillator attenuation lengths.* *8. Obtain cosmic muon data to permit gain matching of PMTs.* *9. Determine absolute light yield of scintillator/PMT (photoelectrons/MeV).* *10. Exercise and debug slow controls, calibration, gain monitoring, event display and PCAL reconstruction software.*
Special equipment	*Cable trays with overhead extension* *Two equipment racks* *192 HV cables* *192 signal cables* *192 patch cables from splitter to VXS/ FADC250 and VME/discrim.* *3 64 ch. PCAL splitter panels* *2 CAEN HV mainframes* *2 20 slot VXS crates (1 frontend, 1 trigger)* *1 VME crate (Discriminators may be required for proper cable termination at splitter)*

	12 16 ch. VME discriminators *12 16 ch. FADC250* *Trigger boards (TI,CTP,SD,SSP,GTP,TS)*
DAQ Configuration and Trigger	*Total energy sum and/or pixel trigger desirable*
Manpower and time needed	*1-2 months for first module. 1 month/module thereafter*
Software for analysis of results	*Legacy EC derived calibration code, PCAL reconstruction code. Further code developed as we proceed with tests*
Computing resources	*Flatscreen monitor, functioning DAQ workstation and environment, EPICS or equivalent control of CAEN HV mainframe, 1 TB disk space*
Dependencies from other systems	*DAQ, Trigger, Slow Controls and Monitoring*
Information to be saved in the database	*1. Initial HV settings for PCAL modules.* *2. Initial attenuation lengths for scintillator stacks.*

EC System Checkout	
Description	*Following decabling and refurbishment the EC will be recabled into the CLAS12 configuration consisting of CAEN HV mainframes and VXS and VME based front-end electronics. Signal continuity and correct cable placement will need to be verified. If possible this opportunity should be used to evaluate ground loop noise by connecting only signal cables first to a single sector. Baseline FADC input noise levels will then be determined using free running pulser trigger. This would be repeated with HV cables connected, but HV off. HV values will be restored to their CLAS6 values and light leaks checks will be repeated using FADC noise data.*
Manpower and time needed	
Software for analysis of results	

Manpower and time needed	
Software for analysis of results	
Computing resources	
Dependencies from other systems	
Information to be saved in the database	

L.4 Commissioning without beam

L.4.1 Special calibration procedures

PCAL and EC Special Runs	
Description	*Special calibration procedures for PCAL: After PCAL installation on the forward carriage and cable installation it would be advisable to repeat the sequence of procedures developed during the EEL tests as well as the System Checkout procedures outlined for EC discussed in 1.4. Pulser runs for TDC calibration should be performed. HV values for PMTs obtained during the EEL runs should be loaded into the CAEN mainframes.* *Special calibration procedures for EC: Pulser runs for TDC calibration should be performed.* *In summary, the special runs for this system will include:* *1) FADC pedestal run (if applicable)* *2) FADC calibration run (if possible)* *3) TDC calibration run*
Goal	*1) Determine pedestals to be subtracted later or on-the-fly from FADC data.* *2) Determine linearity and gain of each FADC channel (if possible)* *3) Determine linearity and gain of each TDC channel*
DAQ Configuration and Trigger	*1) EC_CALIB with pulser trigger* *2) New configuration* *3) EC_CALIB with calibration module*
Manpower and time needed	*1) 1-2 minutes per run* *2) TBA* *3) 5 minutes per run*

Software for analysis of results	*1) PEDMAN or equivalent* *2) TBA* *3) EC_TIME*
Computing resources	*CLAS12 DAQ*
Dependencies from other systems	
Information to be saved in the database	*1) Pedestal values for each FADC channel* *2) FADC gain values* *3) TDC gains and offsets*

L.4.2 Calibration with Cosmic Rays

Cosmic Run	
Description and goals	*Cosmic muon runs will be used as a diagnostic tool to evaluate and calibrate both the PCAL and EC and to debug the DAQ frontend readout electronics and trigger. To this purpose, we will:* *1) Accumulate cosmic muon data with standalone (PCAL+EC) and coincidence (PCAL·EC) triggers.* *Goals:* *a) Test CTP energy sum and peak and cluster finding algorithms.* *b) Determine relative alignment of EC/PCAL in x,y,z.* *c) Determine EC/PCAL scintillator attenuation lengths.* *d) Gain match EC/PCAL PMTs to within 5e) Determine relative timing of EC/PCAL using pixel triggers to localize hits.* *f) Determine relative efficiency of PCAL and EC.* *2) Accumulate cosmic muon data with PCAL·EC·FTOF and*

	PCAL·EC+FTOF trigger. *Goals:* *a) Determine relative alignment of FTOF and PCAL/EC.* *b) Determine relative timing of EC/PCAL and FTOF.c) Use PCAL/EC as hodoscope to determine absolute efficiency of FTOF along length of FTOF bars.* *d) Use PCAL/EC as hodoscope to cross-calibrate FTOF hit position based on FTOF(left)-FTOF(right) measurement.* *3) Accumulate cosmic muon data with PCAL/EC trigger combined with drift chamber tracking data (segment finder, road finder).* *Goals:* *a) Evaluate geometric matching of cluster and tracks.* *b) Evaluate geometric matching efficiency under low background conditions.* *c) Obtain geometric alignment data.*
DAQ Configuration and Trigger	*TBA*
Dependencies from other systems	*TBA*
Manpower and time needed	*1 month*
Software for analysis of results	*TBA*
Computing resources	*TBA*
Information to be saved in the database	*TBA*
Repetition frequency	*TBA*

L.5 Commissioning with beam

Commissioning Run #	
Description and goals	*Operation at high luminosity will make unprecedented demands on the forward detectors. PCAL and EC will have to perform as one detector when forming an e- trigger, which means their energy and timing calibrations must be consistent and well-established prior to running. For optimal performance in background rejection and trigger uniformity it may be necessary to store energy calibration constants in the frontend FADCs rather than rely only on hardware PMT gain matching as in CLAS6. Likewise, to take advantage of the 5 layers of hodoscope tracking provided by EC, PCAL and FTOF for rejection of single hit or multi-hit backgrounds, the quality of online timing calibration must exceed previous operations. Rapid calibration schemes must be developed and tested during the commissioning phase.* *1) Luminosity studies (measure PMT currents, PMT gain and trigger rates in PCAL and EC vs luminosity, examine FADC for baseline shifts and multiple hits, TDC timing for multiple hits, correlate TDC and FADC hit information).* *2) Zero-field runs to check relative alignment of PCAL/EC and rest of CLAS12.* *3) Low current trigger efficiency studies to establish baseline efficiencies.* *4) High current trigger efficiency studies to measure efficiency losses.* *5) Obtain low luminosity data with e- hits from 6-10 GeV to and pions from 1-3 GeV to provide data for energy cross-calibration of PCAL/EC combination.* *6) Obtain data at various beam energies: 6,7,8,9,10 GeV to permit*

	evaluation of effect of low-energy radiative and photoproduction backgrounds from target in PCAL. *7) Evaluate cluster finding and geometrical matching between detectors and PCAL/EC*
DAQ Configuration and Trigger	*TBA*
Dependencies from other systems	*TBA*
Manpower and time needed	*2 months*
Software for analysis of results	*TBA*
Computing resources	*TBA*
Information to be saved in the database	*TBA*
Repetition frequency	*TBA*

Appendix M

Forward Tagger

M.1 Contact person

The contact persons for this subsystem are:

Name	*Affiliation*	*email*	*Area of Responsability*
M. Battaglieri	INFN -Genova	battaglieri@ge.infn.it	Hardware
R. De Vita	INFN -Genova	devita@ge.infn.it	Calorimeter Hardware
D. Watts	Edinburgh University	dwatts1@ph.ed.ac.uk	Hodoscope Hardware
F. Sabatie	CEA - Saclay	franck.sabatie@cea.fr	Tracker Hardware
D. Weygand	Jefferson Lab	weygand@jlab.org	Software
S. Procureur	CEA - Saclay	sebastien.procureur@cea.fr	Tracking Software

M.2 Quality Assurance and System Checkout

M.2.1 Quality Assurance

Test #1: FT-Cal PbWO-II crystals	
Description	*Measure the physical/optical properties (size, light yield, decay time, light transmission, radiation hardness,)*
Special equipment	*The tests will be performed at the ACCOS facility at CERN*
DAQ Configuration and Trigger	*The facility has all the necessary electronics/daq/trigger*
Manpower and time needed	*The ACCOS facility tests 20 crystals at time, 100/day therefore we expect to operate the machine for 1 week, 2 people*
Software for analysis of results	*ACCOS produces automatically the results*
Computing resources	*No need of computer resources*
Information to be saved in the database	*Some information will be saved in the DB: size, LY, light transmission, radiation hardness, decay time*

Test #2: FT-Cal light sensors	
Description	*Measure the properties of the light sensors at fixed temperature T (visual inspection, gain (G) vs. voltage (V), linearity, dark current, dead areas)*
Special equipment	*The tests will be performed in Genova using laser and LED sources*
DAQ Configuration and Trigger	*The DAQ will be custom, optimize to the necessary tests*
Manpower and time needed	*3months, 1 person*
Software for analysis of results	*Custom system*
Computing resources	*No need of computer resources*
Information to be saved in the database	*dG/dV, dG/dT, QE, dark current*

Test #3: FT-Cal front-end electronics	
Description	*Measure the properties of preamplifiers for APD/SiPM readout: gain, output signal shape for reference pulse, noise and motherboard*
Special equipment	*The tests will be performed in Genova/Orsay using local test bench*
DAQ Configuration and Trigger	*NA*
Manpower and time needed	*1month, 1 person*
Software for analysis of results	*NA*
Computing resources	*NA*
Information to be saved in the database	*Gain, rise time, fall time, noise (RMS)*

Test #4: FT-Cal cooling system	
Description	*Test of cooling system including pipe and vessel tightness, T uniformity, cooling power*
Special equipment	*The tests will be performed in Genova using local test bench*
DAQ Configuration and Trigger	*NA*
Manpower and time needed	*2 weeks, 1 person*
Software for analysis of results	*NA*
Computing resources	*NA*
Information to be saved in the database	*Temperatures should be store during data tacking*

Test #5: FT-Cal RO electronics	
Description	*Test of the whole RO chain from the preamp to the stored data: proper functioning of each board and each channel: ADC conversion factor, charge linearity, TDC conversion factor and linearity, Discriminator minimum threshold*

Special equipment	*The tests will be performed at JLab/Genova using the local electronic test benches*
DAQ Configuration and Trigger	*?*
Manpower and time needed	*?*
Software for analysis of results	*NA*
Computing resources	*NA*
Information to be saved in the database	*ADC conversion function, TDC conversion function, Discriminator minimum threshold*

Test #6: FT-Cal Slow controls	
Description	*Test of the functionality of crates and boards and power/signals distribution*
Special equipment	*The tests will be performed in Genova using the local electronic test benches*
DAQ Configuration and Trigger	*NA*
Manpower and time needed	*1 week 1person*
Software for analysis of results	*HV and LV monitoring system*
Computing resources	*NA*
Information to be saved in the database	*LV, dead channels*

Test #7: FT-Cal monitoring	
Description	*Test of the functionality of the system, individual LED calibration, light output*
Special equipment	*The tests will be performed in Genova using the local electronic test benches*

DAQ Configuration and Trigger	*NA*
Manpower and time needed	*1 week 1person*
Software for analysis of results	*Dedicated software to control the system and analyze the results that will be integrated in standard CLAS12 DAQ*
Computing resources	*NA*
Information to be saved in the database	*Individual LED light output*

Test #8: FT-Cal cables	
Description	*Test of the functionality of all connection cables*
Special equipment	*The tests will be performed in Genova using the local electronic test benches*
DAQ Configuration and Trigger	*NA*
Manpower and time needed	*1 week 1person*
Software for analysis of results	*NA*
Computing resources	*NA*
Information to be saved in the database	*NA*

Test #9: FT-Cal checkout 1	
Description	*Test of the full assembled calorimeter: -Vacuum tightness* *-Cooling and T stability* *-HV check for individual channels, LV check, cabling check* *-Light transmission and signal output for individual channel using the light monitoring system (presence of signal, linearity tests)* *-Cross-talk between crystals*

Special equipment	*The tests will be performed first in Genova and then repeated before installation in CLAS12*
DAQ Configuration and Trigger	*DAQ bench test Genova / DAQ bench test JLab*
Manpower and time needed	*1 week 1person (x2) + space for JLab tests*
Software for analysis of results	*Local CODA installation*
Computing resources	*INFN-GE CODA setup for tests in Genova and JLab*
Information to be saved in the database	*NA*

Test #10: FT-Cal checkout 2 Cosmic rays	
Description	*Measure the FT-Cal response to cosmic ray for (individually) -gain matching* *-absolute light output* *-relative timing*
Special equipment	*The tests will be performed first in Genova and then repeated before installation in CLAS12*
DAQ Configuration and Trigger	*DAQ bench test Genova / DAQ bench test JLab*
Manpower and time needed	*1 week 1person (x2) + space for JLab tests*
Software for analysis of results	*Local CODA installation + dedicated monitoring tools*
Computing resources	*INFN-GE CODA setup for tests in Genova and JLab*
Information to be saved in the database	*NA*

Test #11: FT-Hodo-Prototyping	
Description	*Geant4 simulation of detector elements:* *Geant 4 simulation of various designs of detector elements Each element comprising plastic scintillator tiles with wavelength shifting*

	fibres embedded in surface of scintillator tile. Simulate the various detector element designs comprising different tile sizes/shapes and coiled/linear wavelength shifting fibre. Simulations will include modeling of propagation and capture of scintillation photons. Compare predicted yield of scintillation photons for various configurations and different techniques to embed the fibre. Couple to simulation of forward tagger with realistic beam parameters to assess the contribution from splashback. *Construct prototype detector elements to be used in hodoscope:* *Construct 2-3 prototype detector elements. Initial tests will use standard PMT (Hamamatsu h36140-10) coupled to wavelength shifting fibre.* *Characterise test modules:* *Assess efficiency of modules for detecting MIPs at various regions on surface of tile, establish timing resolution. Exploiting cosmic and beta source tests. Compare with Geant4 simulation predictions.* *Test with SiPMTs:* *Detector modules will likely be coupled to SiPMT in final design for operation in magnetic field of CLAS12. Default design is use same amp and SiPMT as used in current hodoscope. Tests of alternative amp modules and light sensors will be carried out as part of the tests in Genoa.*
Special equipment	*DAQ system with ADC and TDC readout available in detector labs at Edinburgh. Hamamatsu tubes and additional plastic scintillator modules available for coincidence measurements with sources/cosmics.* *Wavelength shifting fibres and scintillator tiles available at Edinburgh. Diamond tipped cutting tool equipment available for manufacturing prototypes.*

DAQ Configuration and Trigger	*Use Edinburgh DAQ system. Double coincidence between 2 plastic scintillator strips with prototype detector sandwiched between.*
Manpower and time needed	*Personpower and time needed for prototype development and design:* *- Geant simulations: 1 month, 1 person* *- Manufacture of prototypes: 1 week, 1 person* *- Bench tests of prototypes: 1 month, 1 person* *- Light sensor (SiPMT) and readout tests in Genoa: 1 month, 1 person* *Personpower and time for construction of final array:* *- Construction and testing of detector modules: 1 month, 2 person* *- Mounting onto support board: month, 1 person* *- Connecting WLS fibres to light sensors and readout: month, 1 person* *- Testing complete array with cosmics/sources: month, 1 person*
Software for analysis of results	*Geant4 framework exists. Implementation for tests carried out by Edinburgh RA and student. Results analyzed in ROOT.*
Computing resources	*No need for computing resources*
Information to be saved in the database	*NA*

Test #12: FT-Micromegas	
Description	*A detailed description of MM commissioning is reported in the MM commissioning plan. FT-MM will adopt the same procedures reported there.*
Special equipment	
DAQ Configuration and Trigger	
Manpower and time needed	

Software for analysis of results	
Computing resources	
Information to be saved in the database	

M.2.2 System Checkout

Checkout of FT-Cal with LED	
Description	*Installation of the FT-Cal in CLAS12* *Test of the full assembled calorimeter:* *- Vacuum tightness* *- Cooling and T stability* *- HV check for individual channels, LV check, cabling check* *Light transmission and signal output for individual channel using the light monitoring system (presence of signal, linearity tests)*
Manpower and time needed	*1 week INFN and Hall-B technicians for installation* *1 week checkout INFN researchers* *1 week DAQ JLab expert to integrate the FT-Cal in the CLAS12 RO and trigger systems*
Software for analysis of results	*NA*
Computing resources	*NA*
Dependencies from other systems	*CLAS12 DAQ and Trigger*
Information to be saved in the database	*Translation tables*

Checkout of FT-Hodo with cosmics	
Description	*Installation of hodoscope in CLAS12.* *- Mounting of device onto supports*

	Installation of hodoscope in CLAS12. *- Mounting of device onto supports* *- Cable routing of input voltage and signal readout cables* *- Connection of readout to ADC/TDC modules* *Signal test of all hodoscope detector elements in-situ using cosmics. Software analysis for comparison of relative timing and MIP efficiency of individual hodoscope elements*
Manpower and time needed	*2-3 days HallB technician and Edinburgh researchers* *1 week checkout Edinburgh researchers* *1/2 week JLab DAQ expert to integrate ADC and TDC output from FT hodo into recorded data stream*
Software for analysis of results	*NA*
Computing resources	*NA*
Dependencies from other systems	*CLAS12 trigger and DAQ. Will require development of FT-Hodo stand alone cosmic trigger*
Information to be saved in the database	*NA*

Checkout of FT-Micromegas	
Description	*A detailed description of MM checkout is reported in the MM commissioning plan. FT-MM will adopt the same procedures reported there.*
Manpower and time needed	
Software for analysis of results	
Computing resources	
Dependencies from other systems	
Information to be saved in the database	

M.3 Commissioning without beam

M.3.1 Special calibration procedures

Special Run #1 FT-Cal LED monitoring	
Description	*Measurement of the response of each channel to LED pulses*
Goal	*LED run to check (individually):* *- Channel functionality* *- linearity;* *- gain stability* *- timing* *- noise and resolution*
DAQ Configuration and Trigger	*CLAS12 DAQ and trigger with a special FT-CAL-LED configuration*
Manpower and time needed	*2 day 1 person*
Software for analysis of results	*Monitoring histograms to be implemented in standard CLAS12 special run monitoring*
Computing resources	*ND*
Dependencies from other systems	*Stand-alone tests*
Information to be saved in the database	*TBD*

M.3.2 Calibration with Cosmic Rays

FT Cosmic Ray calibration	
Description and goals	*Measure the FT-Cal response to cosmic ray for (individually)* *- gain matching*

	- absolute light output - time synchronization with respect to CLAS12 (trigger) - absolute time Measure the FT-Hodo response to cosmic rays - gain matching - absolute light output - test coincidence timing between hodoscope elements - test coincidence timing between hodoscope elements & forward tagger - time synchronization with respect to CLAS12 Measure the FT-Micromegas response to cosmic rays (see detailed MM commissioning plan)
DAQ Configuration and Trigger	*Dedicated FT-Cal-COSMIC trigger and DAQ configuration. Dedicated FT-HODO COSMIC Trigger*
Dependencies from other systems	*FTOF, DC, CLAS12-trigger*
Manpower and time needed	*Few days for data tacking and 2 weeks of analysis*
Software for analysis of results	*Reconstruction software with matching between FT-Cal and other CLAS12 subsystems (F-TOF, DC and trigger)*
Computing resources	*Minimal requirement of central systems*
Information to be saved in the database	*TBD*
Repetition frequency	*Any available time, 1 per week at least*

M.4 Commissioning with beam

Beam Run #1: FT electron calibration	
Description and goals	*Use the elastic electron scattering to measure the FT response (FT components alignment and absolute efficiency, FT-Cal energy and position resolution, FT-MM position resolution, FT-Hodo response to MIPs) to scattered electrons in the energy range 0.5-5 GeV tagging the proton.* *Different current sets :Minimum possible current (I=100pA) to 10E34, E=1,2,3,4,5,6 GeV LH2 standard 5cm target, thin target for alignment.* *Magnets configuration: TBD after running detailed MC simulations*
DAQ Configuration and Trigger	*Standard CLAS12 DAQ configuration + FT trigger*
Dependencies from other systems	*All CLAS12 on, and in particular the CD to tag the proton*
Manpower and time needed	*1 week (?)*
Software for analysis of results	*CLAS12 reconstruction software*
Computing resources	*?*
Information to be saved in the database	*TBD*
Repetition frequency	*Once at the beginning of CLAS12 operations. Dedicated calibration procedures make using of the standard data will be developed*

Beam Run #2: FT π_0 calibration	
Description and goals	*Use the reaction p(e,e pi0) to measure the FT response (FT-Hodo veto efficiency, FT-Cal resolution via Mpi0 reconstruction, background in FT-M) to pi0 induced em shower, detecting the scattered*

	electron and the proton Current scan (from minimum to nominal luminosity) E=6, 9GeV. *LH2 standard 5cm target.* *Magnets configuration: TBD after running detailed MC simulations*
DAQ Configuration and Trigger	*Standard CLAS12 DAQ configuration + FT trigger*
Dependencies from other systems	*All CLAS12 (CD+FD)*
Manpower and time needed	*1 week (?)*
Software for analysis of results	*CLAS12 reconstruction software*
Computing resources	*?*
Information to be saved in the database	*TBD*
Repetition frequency	*Once at the beginning of CLAS12 operations. Dedicated calibration procedures make using of the standard data will be developed*

Appendix N

CLAS12 Front-End Electronics, DAQ and Trigger

N.1 Contact persons

The contact persons for this subsystem are:

Name	*Affiliation*	*email*	*Area of Responsability*
S. Boyarinov	Jefferson Lab	boiarino@jlab.org	DAQ Software/CODA
V. Kubarovsky	Jefferson Lab	vpk@jlab.org	Trigger
C. Cuevas	Jefferson Lab	cuevas@jlab.org	Front-End Hardware, Trigger Hardware, System Testing
B. Raydo	Jefferson Lab	braydo@jlab.org	Front-End Hardware, Trigger Hardware/Firmware, System Testing
W. Gu	Jefferson Lab	jgu@jlab.org	DAQ Hardware, Trigger Interface Hardware/Firmware, System Testing

N.2 Quality Assurance and System Checkout

N.2.1 Quality Assurance

TESTING during installation	
Description	*DAQ Hardware Testing Scope: Verify proper installation of new electronic hardware to include:* • *VXS crates Network verification* • *VME64x crates Network verification* • *Trigger system fiber optics Post installation attenuation testing* • *Trigger system fiber optic de-skewing adjustments* • *Global Clock distribution and verification* • *Global Synchronization verification tests* • *Front-end boards*
Special equipment	*All equipment needed for verification testing will be provided by the Fast Electronics or DAQ groups. Test equipment for the verification of the parallel fiber optic cable used specifically for the trigger signal distribution will be provided by the selected installation contractor.*
DAQ Configuration and Trigger	*Existing DAQ CODA software will be used to configure hardware front end modules and trigger modules. Configuration of the modules will use the PLAYBACK method to pre-load the front end modules with data that can deterministically verify all hardware in the trigger system path.*

Manpower and time needed	*Not counting the installation manpower for installing the DAQ crates, and fiber optic cabling (contractors for wiring), we have estimated that it will require at least 1 FTE of time. The 1 FTE could be several people per month, but 1 FTE should be adequate to commission all DAQ/Trigger crates required for CLAS12*
Software for analysis of results	*Fortunately, analysis software has been developed for the testing of a full front-end crate. This software includes plotting routines for the verification of the hardware performance during acceptance testing. Manpower will be needed to scale this software to manage a full DAQ/Trigger system for a system the size of CLAS12. This needs to be considered, and no estimate for manpower is given. In addition TDC calibration software and pedestal analysis software will be needed.*
Computing resources	*Existing clon cluster will be sufficient*
Information to be saved in the database	*In addition to saving the location of each front end and trigger modules (inventory database including information on repair actions), it will be required to save configuration files for the global trigger equations and other essential files for global trigger configuration.*

N.2.2 System Checkout

Checkout of DAQ and Trigger System	
Description	*The checks that will be performed on the trigger system upon completion of the installation are:* 1. *Checkout of Front-End electronics:* (a) *Verify clock and synchronization signals (Signal Distribution and Trigger Interface boards)* 2. *Checkout of the Crate Trigger Processors* 3. *Checkout of the Global Trigger Crate:* (a) *Sub-System Processor (SSP)* (b) *Global Trigger Processor (GTP)* 4. *Checkout of Trigger Distribution Crate:* (a) *Trigger Supervisor (TS)* (b) *Trigger Distribution boards (TD)* *The verification steps outlined above will be completed by using the PLAYBACK mode that has been developed for the Flash ADC and trigger system modules. The PLAYBACK mode allows for complete test verification of all front-end modules including the Trigger system chain. Test data will be loaded to each Flash ADC channel and the PLAYBACK mode will propagate this data through the VXS crates, Trigger modules, Fiber Optic cables/patch panels and Global Trigger modules to completely verify all connections and functionality of the Trigger system hardware.* *TDCs, Discriminators, TI and HV testing will be mostly completed during installation of the related detector system*

	TDCs, Discriminators, TI and HV testing will be mostly completed during installation of the related detector system
Manpower and time needed	*2 people during 6 month, help from Fast Electronics and CODA groups*
Software for analysis of results	*Control and Monitoring Software for FADCs and Trigger Boards, generic trigger-control software to be developed Trigger System Firmware for CTPs, SSPs and GTPs to be developed New version of CODA Trigger simulation software*
Computing resources	*Existing clon cluster Jlab farms*
Dependencies from other systems	*No other system is required to verify the front-end and trigger system. The PLAYBACK mode will allow for an independent test without detector signals.*
Information to be saved in the database	*Trigger-related configuration information including particular trigger settings (for calibration runs at least)*

N.3 Commissioning without beam

N.3.1 Special calibration procedures

Special Runs	
Description	*Special calibration runs upon detector readiness*
Goal	*Check DAQ and Trigger functionality on real detectors, get calibration constants*
DAQ Configuration and Trigger	*On detector groups requests*
Manpower and time needed	*2 people, 3 month*
Software for analysis of results	*To be provided by detector groups*
Computing resources	*Existing clon cluster*
Dependencies from other systems	*All detectors*
Information to be saved in the database	*Calibration constants*

N.3.2 Calibration with Cosmic Rays

Runs	
Description and goals	*Cosmic calibration runs, conduct detectors check and obtain cosmic calibration constants, collect data for online monitoring and offline reconstruction debugging purposes*
DAQ Configuration and Trigger	*On detector groups request*
Dependencies from other systems	*All detectors readiness*

Manpower and time needed	*2 people, 3 month*
Software for analysis of results	*Online data processing software: data quality check, calibration etc*
Computing resources	*Existing clon cluster*
Information to be saved in the database	*Cosmic calibration constants*
Repetition frequency	*Will be defined by detector groups*

N.4 Commissioning with beam

Beam Run #	
Description and goals	*DAQ and Trigger performance and reliability test*
DAQ Configuration and Trigger	*Production run configuration(s)*
Dependencies from other systems	*Whole CLAS12 must be completely ready*
Manpower and time needed	*2 people, 1 month, Fast Electronics and CODA groups help*
Software for analysis of results	*Complete online monitoring and analysis software, level 3 if applicable*
Computing resources	*Upgraded clon cluster (new disk storage, some new networking, new workstations, faster link to SILO etc)*
Information to be saved in the database	*Runtime information must check that nothing is missing*
Repetition frequency	*Just regular calibration runs on detector groups requested schedule*

Appendix O

Slow Controls

O.1 Contact person

The contact person for this subsystem is:

Name	*Affiliation*	*email*	*Area of Responsability*
N. Gevorgyan	Jefferson Lab	nerses@jlab.org	Hardware

O.2 Quality Assurance and System Checkout

O.2.1 Quality Assurance

Test #1 High/Low Voltage systems	
Description	*Check the software for controlling, monitoring, backing up and restoration of HV/LV set values, bookkeeping of long-term channel behavior. Requires an input from detector systems on the types of HV equipment type*
Special equipment	*HV/LV mainframes loaded with respective boards*
DAQ Configuration and Trigger	*DAQ will not be used*
Manpower and time needed	*4 man*week*
Software for analysis of results	*EPICS is going to be a base software upon which our add-on applications and configurations would be implemented.* *Another component is database software most likely MySQL server for storage of long term settings and monitored parameters*
Computing resources	*A server is needed for software IOC and shared DB server*
Information to be saved in the database	*Latest demanded Voltages. Possibly, drawn currents for monitoring*

Test #2 Controlling discriminators	
Description	*Check the discriminator controlling-monitoring software. Requires an input from detector systems on the equipment to prepare appropriate software*
Special equipment	*Discriminators*
DAQ Configuration and Trigger	*DAQ will not be used*
Manpower and time needed	*4 man*week*

Software for analysis of results	*EPICS is going to be a base software. Drivers if not available should be developed to control discriminators.* *Another component is database software most likely MySQL server for long term storage of settings and monitored parameters*
Computing resources	*A server for software IOC and shared DB server*
Information to be saved in the database	*Discriminator thresholds*

Test #3 Monitoring Scalers	
Description	*Check raw scalers from detectors, beam halo counters, Faraday Cup, SLM, BOM, etc.. Requires an input from detector systems on the equipment to prepare appropriate software*
Special equipment	*Scalers*
DAQ Configuration and Trigger	*DAQ will not be used*
Manpower and time needed	*4 man*week*
Software for analysis of results	*EPICS is going to be a base software. Drivers if not available should be developed to control scalers.* *Another component is database software most likely MySQL server for long term storage of monitored parameters*
Computing resources	*A VME create for IOC and shared DB server.*
Information to be saved in the database	*Scaler counts from various detectors systems*

Test #4 Miscellaneous sensors (Temperature, Pressure, Flow, Magnetic Field)	
Description	*Check connected sensors. Requires an input from detector systems and engineering on the equipment to prepare appropriate software*
Special equipment	*Scalers, ADC*
DAQ Conf. and Trigger	*DAQ will not be used*

Manpower and time needed	*6 man*week*
Software for analysis of results	*EPICS is going to be a base software. Drivers if not available should be developed to control sensors.* *Another component is database software most likely MySQL server for long term storage of monitored parameters*
Computing resources	*A VME create for IOC and shared DB server*
Information to be saved in the database	*Measured parameters from various detectors systems*

Test #5 Magnets	
Description	*Check the connected power supply control-monitoring channels. Requires an input from engineering on the equipment to prepare appropriate software*
Special equipment	*PLC, ADC*
DAQ Configuration and Trigger	*DAQ will not be used*
Manpower and time needed	*2 man*week*
Software for analysis of results	*EPICS is going to be a base software. Drivers if not available should be developed to control sensors.* *Another component is database software most likely MySQLserver for long term storage of monitored parameters.*
Computing resources	*A server for software IOC and shared DB server.*
Information to be saved in the database	*Measured current, Voltage parameters from magnets*

Test #6 60Hz	
Description	*Check the 60Hz system for monitoring 60Hz variations in the beam intensity associated with frequency of power line*

Special equipment	*Scalers*
DAQ Configuration and Trigger	*DAQ will not be used*
Manpower and time needed	*4 man*weeks*
Software for analysis of results	*60Hz analyzing software based on EPICS.* *Another component is database software most likely MySQL server for long term storage of monitored parameters*
Computing resources	*A server for IOC and shared DB server*
Information to be saved in the database	*Measured 60Hz component parameters*

Test #7 Helicity counts	
Description	*Check configuration of helicity triggered counts from various detectors (Faraday Cup). Possible R&D of new scalers*
Special equipment	*Scalers, ADC*
DAQ Configuration and Trigger	*DAQ will not be used*
Manpower and time needed	*4 man*week*
Software for analysis of results	*EPICS is going to be a base software.* *Another component is database software most likely MySQL server for long term storage of monitored parameters*
Computing resources	*A server for IOC and shared DB server*
Information to be saved in the database	*Measured helicity aware scaler counts*

Test #8 Moller polarimeter	
Description	*Check the scalers for Moller electron polarization measurment*
Special equipment	*Scalers*

DAQ Configuration and Trigger	*DAQ will not be used*
Manpower and time needed	*4 man*week*
Software for analysis of results	*Moller polarization measurement software based on EPICS. Another component is database software most likely MySQL server and web logbook application for logging measured data*
Computing resources	*A VME create for IOC and shared DB server*
Information to be saved in the database	*Measured current, Voltage parameters from magnets*

O.2.2 System Checkout

Checkout of High/Low Voltage systems	
Description	*Test of HV systems with load. Make sure all channels are on, are drawing reasonable currents and Voltages are kept stable without fluctuations. The mainframes have enough power supplies for particular detector systems and working flawlessly. Communication from EPICS to mainframes is working and stable*
Manpower and time needed	*4 man*week*
Software for analysis of results	*None*
Computing resources	*A server is needed for software IOC and shared DB server*
Dependencies from other systems	*Close cooperation is needed with detector systems experts. Networking infrastructure should be fully functional*
Information to be saved in the database	*The High or Low-Voltage set values. Other supplemental values like currents drawn*

Checkout of Discriminator control-monitoring	
Description	*The discriminators should be checked if they are controlled and/or monitored correctly by EPICS.*

	Changing the discriminator thresholds via hardware interface and checking changes in the EPICS. And changing thresholds in the EPICS and checking changes in the hardware
Manpower and time needed	*1 man*week*
Software for analysis of results	*None*
Computing resources	*A server for software IOC and shared DB server*
Dependencies from other systems	*Other system detector systems those will use discriminators*
Information to be saved in the database	*Thresholds*

Checkout of Monitoring Scalers	
Description	*Check input signals coming to scalers for noisiness and for compatibility with scalers.Check with increased Voltage or lowered thresholds in order to get accidental counts*
Manpower and time needed	*4 man*week*
Software for analysis of results	*None*
Computing resources	*A VME create(s) for scalers*
Dependencies from other systems	*Mostly beamline but also other detector systems for sector sums (EC,TOF) should provide signals for scalers*
Information to be saved in the database	*Map of signals should be documented*

Checkout of Miscellaneous Sensors (Temperature, Pressure, Flow, Magnetic Field)	
Description	*Check input signals coming to scalers for noisiness and for compatibility with scalers. Compare the values in the hardware with those in EPICS*
Manpower and time needed	*4 man*week*
Software for analysis of results	*None*

Computing resources	*A VME create(s) for scalers*
Dependencies from other systems	*Beamline, Target, Hall-B engineering groups should provide signals for scalers*
Information to be saved in the database	*Map of signals should be documented*

Checkout of Magnets	
Description	*Check input signals coming from magnets power supplies. Compare the values in the hardware with those in EPICS*
Manpower and time needed	*2 man*week*
Software for analysis of results	*None*
Computing resources	*A VME create(s) for scalers*
Dependencies from other systems	*Hall-B engineering should provide the signals*
Information to be saved in the database	*Map of signals should be documented*

Checkout of 60Hz	
Description	*Check signals coming to the scalers for noisiness and compatibility. Check the presence of 60Hz (e.g. pulse generated) or higher harmonics in various signals*
Manpower and time needed	*4 man*week*
Software for analysis of results	*60Hz analyzing software based on EPICS*
Computing resources	*A VME create(s) for scalers*
Dependencies from other systems	*Some beamline components should be operational*
Information to be saved in the database	*None*

Checkout of Helicity Counts	
Description	*Check possible new scalers. Check signals coming to the scalers for noisiness and compatibility. Check the helicity counts from various detectors. Use a generator instead of helicity signal*
Manpower and time needed	*2 man*week*
Software for analysis of results	*None*
Computing resources	*A VME create(s) for scalers*
Dependencies from other systems	*Beamline, Accelerator should provide appropriate signals*
Information to be saved in the database	*None*

None

Checkout of Moller polarimeter	
Description	*Check signals coming to the scalers for noisiness and compatibility*
Manpower and time needed	*2 man*week*
Software for analysis of results	*None*
Computing resources	*A VME create(s) for scalers*
Dependencies from other systems	*Beamline should provide appropriate signals*
Information to be saved in the database	*None*

O.3 Commissioning without beam

O.3.1 Special calibration procedures

Special Run #1 Helicity counts	
Description	*Using generator as a helicity signal check if the DAQ records the helicicty gated counts from various detectors*
Goal	*Make sure that fake generator triggered helicity signal is correctly feed into trigger supervisor and marks events with helicity positive, negative or unknown states*
DAQ Configuration and Trigger	*Standard DAQ configuration. The trigger is from generator*
Manpower and time needed	*1 man*week*
Software for analysis of results	*Standard DAQ recording and analyzing software, to record and then analyze helicity signal correctness*
Computing resources	*The clon cluster should be enough*
Dependencies from other systems	*DAQ and Beamline should be ready*
Information to be saved in the database	*None*

O.4 Commissioning with beam

Beam Run #1 Helicity counts	
Description and goals	*Using the helicity signal from accelerator check if the DAQ records the helicicty gated counts from various detectors*
DAQ Configuration and Trigger	*Standard DAQ and trigger configuration*
Dependencies from other systems	*DAQ, Beamline should be ready for this test*
Manpower and time needed	*1 man*week*
Software for analysis of results	*Standard DAQ recording and analyzing software, to record and then analyze helicity signal correctness*
Computing resources	*Clon cluster should be enough*
Information to be saved in the database	*None*
Repetition frequency	*Once*

Beam Run #2 Moller polarimeter	
Description and goals	*Using the Moller setup take a beam polarization measurement*
DAQ Configuration and Trigger	*Moller DAQ configuration*
Dependencies from other systems	*Beamline should be ready for this test*
Manpower and time needed	*1 man*week*
Software for analysis of results	*Moller polarization measurement software*
Computing resources	*A VME create for Moller DAQ*
Information to be saved in the database	*Upstream and Downstream Quad magnet currents* *Moller PMTs high Voltages* *Helmholtz magnet current*

	Moller Target Position *Tagger magnet current* *Beam positions and currents at different BPMs, SLM and Faradey Cup* *Slit size, 1/2 waveplate, Horizontal and Vertical Wien Angle* *Phi_FG* *Settle time* *Flip Frequency* *Delay Mode* *Pattern* *Mode* *Laser Power* *Attenuator* *True and Accidental Rates*
Repetition frequency	*Every time the beam energy/pass was changed*