Chapter 4

Upgrade Strategy and CLAS^{++} Detector Components

4.1 CLAS Upgrade Strategy

The main goal of the CLAS upgrade is to maintain its capability to obtain high statistics data for exclusive electron scattering reactions at beam energies of 12 GeV. At the higher energies, and in the regions of interest for the physics program at large hadronic invariant masses, particle multiplicities increase and make it more difficult to isolate exclusive processes from an increasing level of multihadron background. In addition, the missing mass resolution decreases which will render the separation of exclusive processes from multihadron background less effective. Lastly, exclusive processes are of interest at high photon virtualities Q^2, where the electroproduction cross section is expected to fall-off with the power of $1/Q^6$. In order to achieve acceptable count rates for these reactions experiments have to be carried out higher luminosities than at 6 GeV. To accomodate these requirements in the CLAS upgrade two major improvements are required:

- the missing mass technique needs to be complemented by a more complete detection of the hadronic final state
- the luminosity that CLAS can operate at needs to be increased by about one order of magnitude to $L = 10^{35}\ cm^{-2}\ s^{-1}$

The coverage for hadronic final states will be increased by complementing the present CLAS detection system by a new central detector that allows detection of charged particles and neutral particles over the full acceptance. Moving this central detector upstream converts the present CLAS detection system into a detector for forward going particles.
Knowing the directions of all particles gives the following analysis options:

- use of kinematical fitting procedures to determine the final state
- veto events with incomplete determination of the final state (this lowers the detection efficiency but avoids contaminating lower multiplicity final states)

The key to operating CLAS at increased luminosity is to keep the occupancy of the drift chambers low. A crucial ingredient is the magnetic shield that protects the tracking system from Møller electrons. The mini-torus can no longer be used since its mechanical structure blocks part of the solid angle. The preferred solution is a short superconducting solenoidal magnet which also serves as a magnet for the momentum analysis of large angle tracks.

The upgrade plan is based on retaining major components of CLAS, the torus magnet, scintillation counters, gas Cerenkov counters, electromagnetic calorimeters, and part of the electronics, while replacing the tracking chambers, adding a new central detector, a pre-shower detector, and a second gas Cerenkov counter. A single-sector exploded view of the upgraded CLAS^{++} detectors is shown in Fig. 4.1. Conceptual designs of the components of the upgrade plan are discussed in more detail in the following sections.

4.2 CLAS Torus Magnet

The original CLAS Toroidal Magnet was designed and fabricated by Oxford Inc. The CLAS^{++} upgrade is based on using the original CLAS Torus with some modifications. At this time the extent of the modifications is not clear, but the concept is to reuse as much of the Torus as possible. At minimum this includes:

- all six coils
- the service module
- the cryogenic supply from the End Station Refrigerator and all associated piping
- the power supplies and bus bars
- vacuum pumping system
- backup AC electrical generator system which provides power upon a loss of site power to keep the computer hardware and vacuum system operational and allows for controlled rundown of the magnet.

The minimum modification required will be to replace all 72 out-of-plane (OOP) supports. These supports keep the coil centered in the vacuum case and support both magnet and gravitational loads. Experience gained from the original CLAS operation

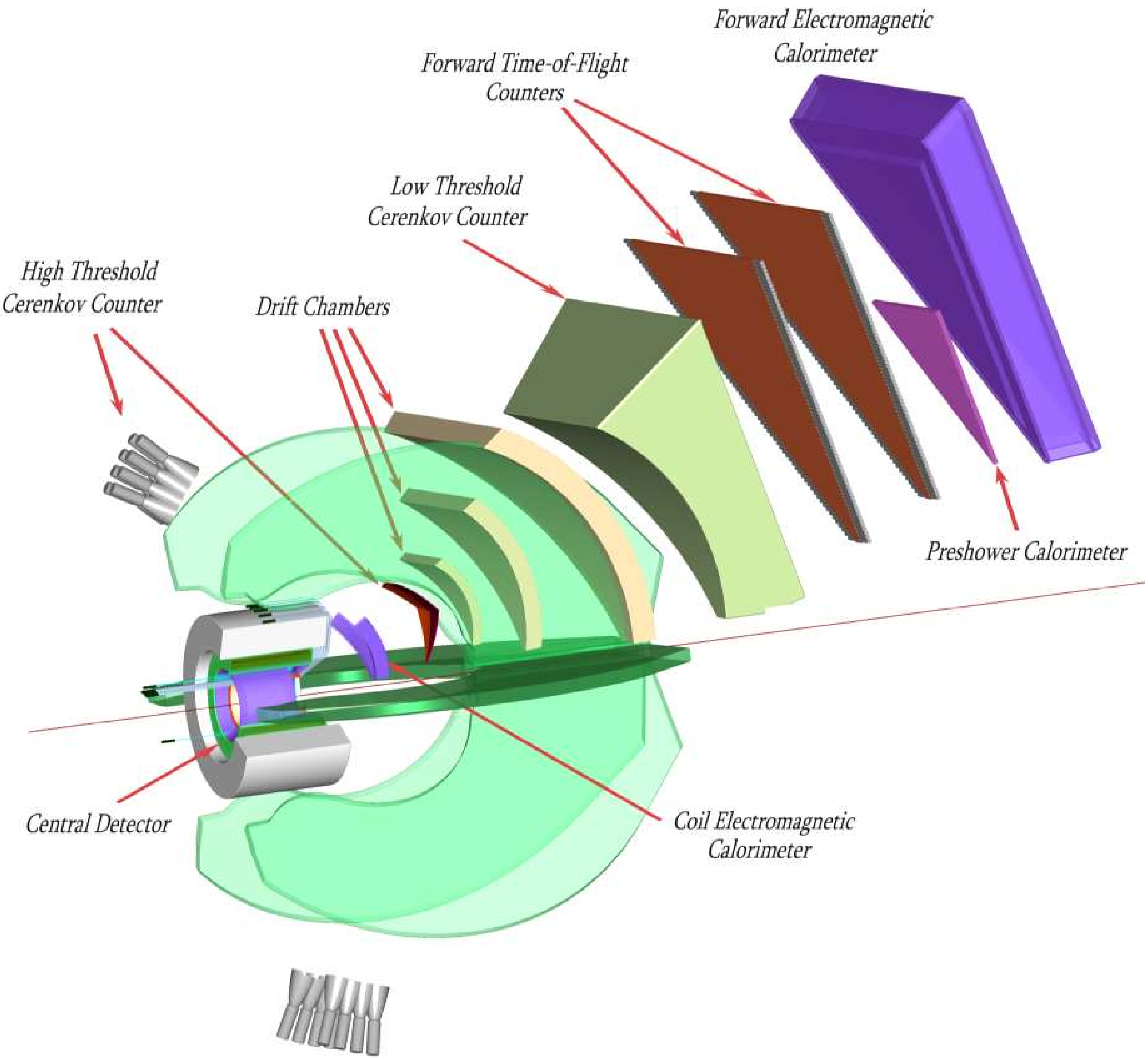

Figure 4.1: Exploded view of the CLAS^{++} detector system for a single Torus magnet sector showing, beginning at the target, the Central Detector system, the inner electromagnetic calorimeter, the high threshold Cerenkov counter, the region 1, 2 , 3 drift chambers, the low threshold Cerenkov detector, the double layer forward time-of-flight counters, the preshower calorimeter, and the forward electromagnetic calorimeter. The light collection system outside of the Torus coils collects the light from the high threshold inner Cerenkov counter.

has shown this to be a requirement for operating a high field solenoid inside the torus at full field. The CLAS Torus will also be modified to allow for the addition of the Central Detector, Solenoid Magnet, and iron flux return. This will require that the backward (upstream) end of the coils are moved out, and the following items will need replacement:

- backward support ring
- forward fixings
- a new cold ring may be needed. The cold ring provides cryogenic distribution to all 6 coils; it also contains quench protection circuitry and temperature stabilization

Issues that require further study:

- impact of iron of the Central Detector affecting Torus field lines
- impact of iron of the CD on Torus OOP and IP support
- hysteresis of iron affecting magnetic field
- quenching and ramping of magnets. Sequencing and interlocking
- swaying of the Torus either beam left or right due to attraction to the iron

After all modifications have been completed, the position and geometry will be surveyed, and the magnetic field will be mapped in the region where particle tracking will be done, i.e. up to about 40° in polar angle, and for all six sectors.

To optimize the installation schedule a cold ring will be procured in advance of the end of 6 GeV CEBAF operations. When the upgrade starts, CLAS will be disassembled, and each of the 6 coils will be removed from the superstructure. The original cold ring will be removed. The top coil will be hung from its support rods, and the coils will be reinstalled in a similar fashion to the original system.

Support for the 20,000kg of iron will be from the floor of the Hall whereas the Torus will remain hung from the superstructure.

4.3 Central Detector

4.3.1 Introduction

The CLAS^{++} detector consists of a forward detector system (FD) which is sensitive to charged and neutral particles emitted at lab angles between 5 and 40 degrees and a central detector (CD) which covers the angular range from 40 to 135 degrees.