The CLAS12 Detector

To meet the requirements of an exciting science program to study hadron structure with unprecedented accuracy, the equipment at JLab will undergo major upgrades. In particular it will include the CEBAF Large Acceptance Spectrometer for 12 GeV (***CLAS12***). The main new features of CLAS12 include operation with a luminosity of 10^{35} $cm^{-2}sec^{-1}$, an order of magnitude increase over previous CLAS operation, which will allow precise measurements of many exclusive reactions. CLAS12 also features improved particle identification capabilities at forward angles. The detector system consists of two major parts with different functions, the Forward Detector (***FD***) and the Central Detector (***CD***). These are described below.

The Forward Detector

A 3D view of the ***FD*** is shown in the figure. Improved electron-pion separation at higher momentum is achieved with threshold gas Cherenkov counters for the detection of charged pions with momenta above 5 GeV/c. The new high threshold Cherenkov counter (***HTCC)*** is positioned in front of the Torus magnet, and is designed to present a minimal amount of material to charged particles traversing the HTCC. This will minimize multiple scattering and its impact on the momentum resolution. To achieve this goal, low mass composite materials were chosen as the basis for the mirror system, which presents less than 150 mg/cm of material.

At the heart of the FD is the new superconducting ***Torus*** magnet. As for the Torus magnet in CLAS, the new magnet consists of six superconducting coils arranged symmetrically in azimuth, but unlike CLAS, covers only the range of 5^o to 40^o in polar angle. Charged particle tracking is accomplished with a set of 3 regions of drift chambers (***DC***) located upstream, in between, and downstream of the Torus coils. Tracking is accomplished in each region with 12 layers of hexagonal drift cells arranged at stereo angles of $\pm 6^o$. This arrangement provides good angular resolution both in polar and azimuthal angles. The drift chamber system provides 36 measurements for a charged track and has sufficient redundancy for pattern recognition and track reconstruction.

The Torus magnet and the drift chambers are followed by the low-threshold Cherenkov counters (***LTCC***). This detector provides charged pion identification for momenta p>3.0 GeV/c. The LTCC detectors have been used in CLAS but are being refurbished to provide improved response to charged pions. Following the LTCC are three arrays of plastic scintillators for precise Time-of-Flight measurements (***FTOF***) for charged particle identification. The new first layer consists 60x60mm thick bars of plastic scintillators. They provide superb timing information of δT=30-80psec depending on the length of the scintillator bar, the best resolution of any existing detectors system based on plastic scintillators. The other two layers are being refurbished from CLAS. For an equal pion, kaon, and proton yield this will enable a pion/kaon separation of 4σ for momenta up to 3 GeV/c, and a K/p separation up to 4.5 GeV/c from time-of-flight measurements alone. For parts of the experimental program the identification of pions and kaons is needed for momenta up to 8 GeV/c. This can be achieved by replacing individual LTCC detectors with Ring Imaging Cherenkov (***RICH***) detectors. Plans have been developed to build one or more RICH detectors for CLAS12.

Large parts of the physics program require the identification of single high-energy photons and the separation from $\pi^0 \rightarrow \gamma\gamma$ up to 9 GeV/c. The granularity of the existing electromagnetic calorimeter (***EC***) will be improved by adding a pre-shower calorimeter (***PCAL***) of ~5 radiation length in front of EC. This configuration provides a factor of 2.5 better spatial resolution and the separation of two photons for momentum up to 10 GeV/c. In the very forward direction for angles below 5°, a Forward Tagger (***FT***) system will detect small angle scattered electrons using a lead-tungstate inner calorimeter (***IC***) consisting of 400 crystals and a set of scintillators strips and tracking chambers. The crystals will also provide high energy γ and π^0 identification for momenta up to 10 GeV/c.

The Central Detector

A 3D view of the Central Detector (***CD***) is shown in the figure. The CD is based on a compact superconducting Solenoid magnet with a maximum central magnetic field of 5 Tesla. The ***Solenoid*** magnet provides momentum analysis for charged tracks at polar angles from 35° to 135°. It also protects the tracking detectors from intense background electrons, and acts as a polarizing field for polarized solid-state targets. All three functions require a high magnetic field along the beam axis. The overall size of the Solenoid is restricted to 200 cm in diameter, which allows a maximum warm bore for the placement of detectors of only 80 cm in diameter. To obtain sufficient momentum resolution in the limited space available requires high field and excellent position resolution of the tracking detectors. The central field in the target region must also be very uniform at $\delta B/B < 10^{-4}$ to allow the operation of a dynamically polarized target. To achieve a sustained high polarization for polarized ammonia targets (NH_3 and ND_3) requires a strong magnetic field. Magnetic fields at 5 Tesla have been most recently used for such targets with polarization of up to 90% for the free hydrogen in NH_3. Furthermore, the Solenoid field guides the copiously produced Møller electrons away from the sensitive detectors to locations, where they can be passively absorbed in tungsten absorbers.

Charged particle tracking in the CD is provided by a vertex tracker (***SVT***), which uses silicon strip technology. The SVT is made from 8 stereo layers of silicon sensors and provides tracking for polar angle from 35° to 135°. At larger radii, 3 double layers of micromesh (***MM***) gas detectors provide additional tracking that improves momentum and polar angle resolution significantly.

Particle identification is achieved with the central time-of-flight scintillator array (***CTOF***) consisting of 48 bars of fast plastic scintillator equipped with 96 photomultipliers that provide 2-sided light readout and a timing resolution of $\delta T < 60$ psec. Specially shaped light guides bring the scintillator light to an area of reduced magnetic field where a combination of passive and active magnetic shielding is employed that allows operation of photomultiplier tubes. The short flight path from the target to the CTOF array allows for particle identification in a momentum range of up to 1.2 GeV/c and 0.65 GeV/c for π/p and π/K separation, respectively.

For some experiments, the detection of fast neutrons in the central angle range is needed. To accomplish this, the central neutron detector (***CND***), a barrel consisting of 3 layers of 48 scintillator bars, will be used that provides neutron detection with efficiencies of 10-15%. Two neighboring bars are connected through a half circular light guide on the downstream end with photomultipliers attached at the other ends.

Other components are part of the Hall B ***beamline***, e.g. cryogenic liquid targets and polarized targets, the Moller polarimeter, a Faraday cup and beam current and position monitors. For real photon experiments a ***photon energy tagging*** spectrometer is retained from CLAS operation.