1 Central Tracking Detector Status and Infrastructure

The Central Tracking Detector (CTD) is a large-volume, cylindrical drift chamber covering the central region ($15^\circ < \theta < 175^\circ$). It provides charged-particle tracking, momentum measurement and identification through dE/dx. It also participates in all three levels of the ZEUS trigger.

The CTD's 4608 sense wires are arranged in nine superlayers, superlayer one being the innermost. The wires in odd-numbered superlayers run parallel to the chamber axis, whilst those in even-numbered layers have a small stereo angle ($\approx 5^\circ$). Taken together they provide sufficient information to reconstruct tracks in three dimensions. All sense wires in the chamber are equipped with Flash Analogue-to-Digital Conversion (FADC) electronics and, in addition, all wires in superlayer one and the odd-numbered wires in superlayers three and five have z-by-timing electronics for the first-level trigger.

During the shutdown for the HERA upgrade the CTD was flushed with argon:CO_2. Despite not being operated for ten months, it successfully participated in cosmic tests for the ZEUS microvertex detector in July 2001.

1.1 Triggering

ZEUS operates a three-level trigger, of which the first is a hardware-based system whose principal aim is to reduce backgrounds that do not come from the interaction point. CTD information is essential for this and the detector uses dedicated, pipelined processor cards which provide tracking information to the global first-level trigger.

The ZEUS second-level trigger uses more precise software algorithms to clean the event sample further and classify certain types of physics events. Detail tracking information is provided by the CTD second-level trigger which makes use of the data from all five axial superlayers and the z-by-timing information from layers 1, 3 and 5. A precise measurement of the event vertex at the second level is a powerful technique for rejection of background. Before the shutdown for the HERA upgrade, modifications were made to the CTD Transputer network in order to allow data from the FADC electronics to be sent to the Global Tracking Trigger (GTT). This system will combine CTD data with the precise information from the new microvertex detector to provide a very accurate event vertex measurement. The link to the GTT computer systems has now been successfully tested.

The third-level trigger (TLT) runs on a farm of Unix workstations and PCs using an appropriate version of the off-line reconstruction code. The CTD TLT code is an optimised version of the full off-line reconstruction. Its performance is only slightly below that of the off-line version and aids monitoring of the system by providing early warning of any changes in critical CTD parameters.

1.2 Infrastructure and Monitoring

In general the CTD support infrastructure has performed very well. The CTD water cooling circuit is now fully operational again. A blocked pipe to the forward end plate was cleared by "sucking" the blockage out of the system. The water flow rates through both arms of the cooling system are now well above the minimum required to cool the CTD and show no signs of further fall off. Fine filters are also now installed between the main ZEUS cooling circuit and the input to the CTD water cooling system which it is hoped will prevent further problems.

The gas system operated reliably throughout the long HERA upgrade shutdown. After the cosmic tests for the microvertex detector some fluctuations in the gas composition were noticed. The problem was traced to a faulty mass flow controller, which has now been replaced with a new unit. The flow meters on the gas system have also been replaced as part of its ongoing maintainance.

New uninterruptable power supplies (UPS) have also been installed in the CTD high-voltage (HV) system. These new UPSs will provide increased protection from power failures and be more reliable than the previous units.

Since water was added to the gas mixture to overcome the Malter effect, as described in last year's report, the chamber has shown no further sign of HV instability. The addition of water caused some shift in the operating parameters of the CTD, including the reduction of the Lorentz angle to 41° from the nominal value of 45°. After some investigation it proved possible to restore this partially by reducing the CO_2 composition of the gas by 2% and increasing the ethane by 2% whilst keeping the argon constant, coupled with a small increase in the HV. The chamber is now operating efficiently once more and will continue to run with water in the gas mixture for the lifetime of ZEUS.

Over the course of the shutdown the ZEUS data-acquisition environment has been upgraded to operate with the larger data-rates expected in the post-upgrade environment. In particular, the ZEUS event-builder (EVB), a system that assembles the complete data for an event from all the sub-components of the detector, has been replaced with a new system. The CTD was one of the first components to move to the new EVB and is operating successfully with it.

ZEUS has implemented a system for automatic online data monitoring. For the CTD, this is done by checking a small number of critical histograms which are also made available to the shift crew. The automatic histogram checking was initially incorporated into the CTD online program, but will be moved to a dedicated machine in future for ease of maintenance and development. More detailed monitoring is performed off-line using samples of the data which are automatically analysed and then checked by a small team of experts. This system has proved to be effective over a number of years in the early diagnosis of problems. It also provides calibration constants for the CTD and quality control of the CTD data used for physics analysis.

The continued operation and reliability of the CTD is of utmost importance to ZEUS. The chamber is now ready for data-taking in the new HERA environment and will remain at the heart of ZEUS physics for the lifetime of the experiment.