1 MVD

ZEUS UK groups have been involved in the ZEUS MicroVertex Detector (MVD) project (mainly Oxford and UCL) with responsibility on the hardware side for: installation; clock and control electronics; the laser alignment system and a cable 'patchbox'. On the software side we wrote the local run control, event display and histogramming package, and are involved in the development of a second-level global track trigger We will also be involved in offline precision alignment using track data.

1.1 Clock and Control

The UCL ZEUS group provided the clock and control system for the MVD. This system consists of three main subsystems: a master controller and slave in the ADC crates; sixteen driver boards in a crate of their own; and twenty-four distribution cards in the patch boxes close to the detector, together with associated power supplies.

The master and slave system consists principally of digital logic on programmable devices. It (a) receives clock and trigger signals from the ZEUS global first level trigger (GFLT). (b) sends clock, trigger and reset signal to the HELIX driver system (c) receives busy and error signals from the ADCs and sends them to the GFLT. We also provided a ZEUS trigger simulator in the same crate as the master board, which allows standalone running. The master board also allows an external trigger to be input to the front panel, which was used durung cosmic ray data taking on the test stand.

The HELIX driver system (16 6U VME cards) fans out signals from the master and sends them as Low Voltage Differential Signals (LVDS) down approximately 20m of cable to the patch box cards. The system also interfaces with the MVD slow control to allow calibration data to be send to the detector chips at the start of a run, and provides monitoring information.

The patchbox cards consist of three cards for the control signals and three for the clock signals in each of the four patch boxes. These cards amplify the signals from the HELIX drvers and convert the control signal to single eneded CMOS signals as required by the HELIX chips. These cards formed part of what turned out to be the very challenging overall patchbox system (see below) and were designed by UCL and manufactured and installed by Oxford.

The whole system was delivered in time for cosmic ray testing in January 2001 in the test area, in which we participated, and is now fully installed and functional in the ZEUS hall.

1.2 Patchbox

The patchbox was not in the original proposal to the PPESP and did not sound too onerous ('just help with the design of a cable patch panel') when taken on. It turned out to be a major challenge and a key component on the critical path of the MVD project. Because of space limitations from existing components in ZEUS and the new magnets for the final focus, the nearest location for the main readout electronics was nearly 30m from the detector. Clearly a cable connection station was needed. Apart from very tight spatial limitations the design for what became known as the 'patch box' had to cope with:

- rearranging the cables from wafer grouped on the MVD side to function grouped (readout, clock & control, bias voltage, etc) on the readout side;

- rigorous screening of all MVD cables (high voltage, low voltage, clock and control, analogue readout) to avoid pickup in the hostile electronic environment near the beam line;

- active components to boost various the clock and control signals (see previous section).

P Shield came up with a very ingenious design of doubly insulated crates with a specially designed back-plane. To fit into the only space available around the rear beam-pipe the patch box was actually four separate boxes. The boxes were ready for the MVD 'full system test' at DESY (Dec 00 – Mar 01) and then had to be uncabled, moved to the ZEUS Hall, installed and recabled, with full testing of all MVD cables at each stage.

1.3 Alignment

The Oxford ZEUS group provided the laser alignment system [1] for the new microvertex detector. During regular operations the main purpose of the laser system will be to monitor gross movements of the MVD support structure with respect to the central tracking chamber. However the system proved its worth before and during the assembly of the MVD through 2000/01. Tests using part of the system at NIKHEF showed that the first design of the construction support frame was not rigid enough and needed strengthening. During assembly of the two halves of the MVD and their transport to DESY, periodic measurements were taken with laser system to monitor any distortions in the MVD cylindrical support tubes. Measurements were also taken before and after the delicate operation to put the two halves together at DESY prior to a full test of the MVD using cosmic rays and finally after installation of the MVD in ZEUS. VME alignment readout boards[1] are being constructed and will be installed in early 2002. At the same time the laser control system will be integrated into the MVD slow control system.

1.4 Installation

Installation was highly non-trivial because of space limitations and the delicate nature of the MVD. The procedures were worked out through extensive discussions with NIKHEF and DESY engineers and all the key stages were tested using various full-scale mock-ups. Apart from the challenge of getting the MVD into the central tube of the CTD with only mm clearance, the major problem was handling the 4m long readout and service cables attached to the MVD. These had to be fed in bundles through the CTD first. On the day everything worked perfectly and the MVD was installed by 6pm on 27/3/01. The final part of the installation was arranging the cables between the MVD and patch boxes in the very limited space around the new rear combined function magnet. This turned out to be a classic problem of fitting a round object (cables around the cylindrical magnet) into a square hole (aperture left when ZEUS rear calorimeter is closed). Although the cable routes and clearances had been checked very carefully beforehand, the first attempt failed and the calorimeter could not be closed completely. It turned out that certain drawings had not been completely accurate.The UK team had a weekend in which to try again and by using a simple wooden former and

[1] For the measurements to date, a prototype readout system with a limited number of channels has been used.

a lot of hard work managed to persuade the cables to take more rectangular profile thus allowing the calorimeter to close with a few mm spare.

1.5 Global Track Trigger

The Global Track Trigger (GTT) is a new trigger component for ZEUS. It is designed to combine the information from the existing, transputer based, readout systems for the CTD and STT with that from the new, VME based, readout system of the MVD as early as possible in the ZEUS trigger chain. Oxford and UCL are leading algorithm development and implementation. The GTT hardware consists of Gigabit eithernet communications and a farm of 12 1GHz Linux PCs for processing (this replaces the original CTD second level transputer based system and has been funded through the Yale ZEUS group). The complete GTT system for integrating the CTD and MVD information is complete and has been tested within the ZEUS DAQ system. The algorithm for combining CTD and MVD information in the barrel region is ready for testing with the first real data. The STT[2] readout will be added before data taking in 2002 and work has begun on integrating the STT and forward MVD information into the existing algorithm. The performance of the algorithm has been studied extensively, using both Monte Carlo simulated events, pass though events taken during data taking last year, and cosmic muons taken during a short run in July this year.

In order to test the GTT latency performance before the availability of real e-p interaction data, a *playback system* has been created. Monte Carlo events stored in memory are injected into the GTT trigger chain at the component VME interfaces, and sent through the GTT system exactly as for normal data. Using simulated high-E_T dijet photoproduction events containing both MVD and CTD data, at an input rate of 400 Hz, the deadtime was found to be 1.4%, consistent with the performance of the existing ZEUS DAQ and trigger systems during data taking at the end of 2000.

The resolution performance of the algorithm with simulated MVD data has been studied for track and event vertex parameter reconstruction. The event vertex resolutions for the reference Monte Carlo sample are summarised in Table 1. The resolution of the GTT using CTD-only information is significantly better than the existing CTD SLT due to the use of the stereo

[2] A new forward Straw Tube Tracker, installed as part of the upgrade.

information rather than the z-by-timing data. The improvement in the z-resolution of the primary interaction vertex will help to reduce background considerably and is also a necessary first step for more sophisticated trigger calculations, such as event track impact parameter distributions and/or secondary vertex algorithms.

	$\sigma_{z_{vtx}}$ (mm)
Current CTD-SLT	8.44×10^1
GTT (CTD Only)	1.13×10^1
Current Offline (no MVD)	1.14×10^0
GTT	4.61×10^{-1}

Table 1: Event z_{vtx} resolution for GTT, existing CTD-SLT and existing offline reconstruction.

If the system performance and backgrounds are acceptable under real data taking conditions we hope to proceed with the inclusion of GTT based triggers using information on impact parameters and secondary vertices early next year. A nice summary of the status of the MVD project as a whole is given by Fig. 1, which shows a cosmic ray event, taken during the system test and reconstructed using the GTT software.

1.6 Online Software

The MVD run control, slow control and monitoring is carried out via a package based on the CERN Root software and known as Green. This package includes histogramming and event display services (see figure) and was written by UCL. It has proved extremely flexible, and was used throughout the testing of the MVD. It is now fully integrated with the ZEUS global run control and will be used throughout data taking.

References

[1] T. Matsushita et al., Optical alignment system for the ZEUS microvertex detector, Nucl. Instr. Meth. A 466 (2001) 383–389

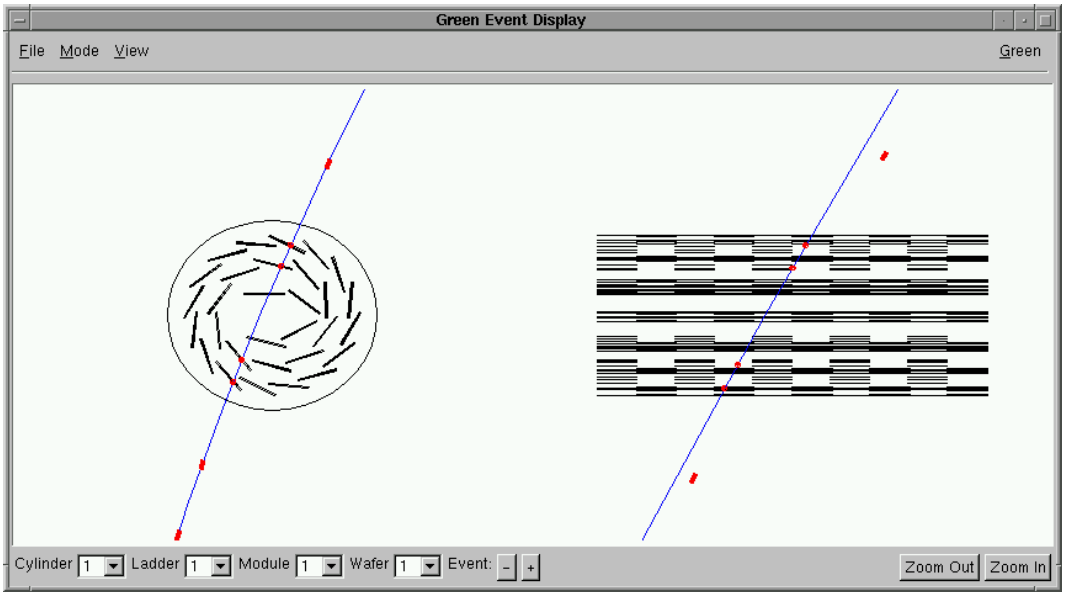

Figure 1: A cosmic ray track in the MVD, recorded during the system test, reconstructed using the GTT and display using the "Green" online event display.