June 16, 1997

Addendum to Proposal PPESP/97/10; A Silicon Microvertex Detector for ZEUS

ZEUS UK Collaboration

1 Introduction

A request for resources to participate in the construction and installation of a silicon microvertex detector (MVD) for the ZEUS experiment at HERA was presented at the last PPESP meeting (27/5/97). The proposal was well received and the committee wished to have several issues clarified. This document addresses the issues raised by the committee.

2 Physics Goals

The inclusion of a MVD in the ZEUS experiment will greatly enhance the efficiency with which charm can be identified. One of the principal motivations for the inclusion of the MVD is that it will allow a precise determination of F_2^{charm} to be made; this is illustrated in Fig. 1 and Fig. 2. Fig. 1 shows the precision with which F_2^{charm} may be extracted using a luminosity of 500 pb^{-1} and the existing ZEUS detector. The error bars do not allow discrimination between the different theoretical models presented. The situation is transformed with the proposed MVD. After 500 pb^{-1}, using the lifetime tag described in our proposal (method 3 [1]) we obtain the results shown in Fig. 2. Note that the precision of the measurement is now sufficient to distinguish between the theoretical models.

3 Clock and Control

In this section we provide details of the clock and control electronics for the MVD. A baseline design was unavailable until now because of the recent decision by ZEUS to change from the ATLAS binary electronics solution to the HELIX analogue readout chip.

The MVD readout will be synchronous across the detector. To achieve this, the clock and control system provides interfaces between the ZEUS global first level trigger (GFLT), the run control system, the analogue to digital converter (ADC) crates and the HELIX readout chips. A schematic diagram of the functionality of the clock and control system is given in Fig. 3.

The main functions of the clock and control are:

1. Receive the clock from the GFLT during a run and distribute appropriate clocks to the ADC and HELIX.
2. Receive trigger Accept, Abort signals and trigger information for the event from the GFLT during a run and send them to the ADC.
3. Send trigger input and trigger test pulse commands to the HELIX chips on instruction from the GFLT.
4. Receive configuration data and instructions from the run control system before a run and pass these to the HELIX chips via a three line serial interface.
5. Receive confirmation of valid data from the HELIX chips and send these to the ADC.

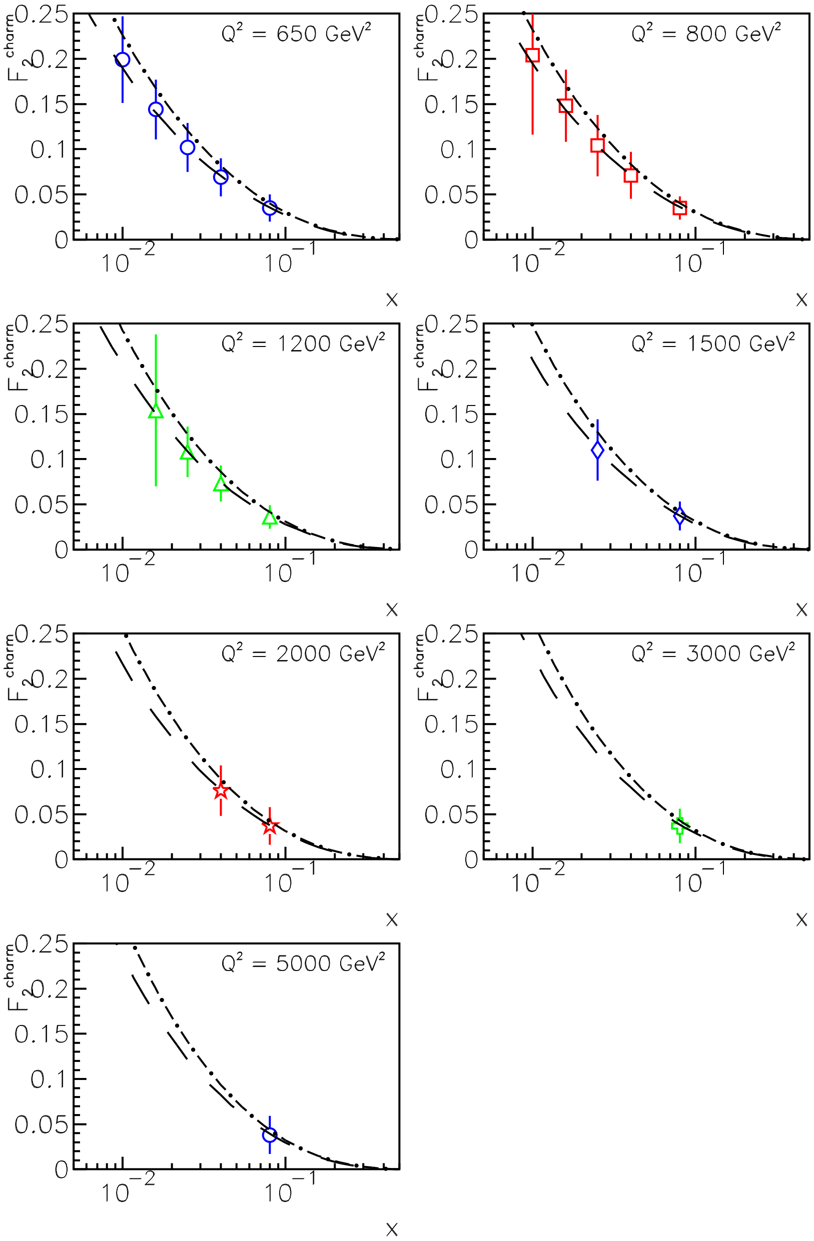

Figure 1: $F_2^{\rm charm}$ measured using D^* tagging in the existing ZEUS tracking system after an integrated luminosity of 500 pb^{-1}. The GRV proton parton distribution is used for the points, and the solid curve shows CTEQ4M, the dashed shows MRSA$'$.

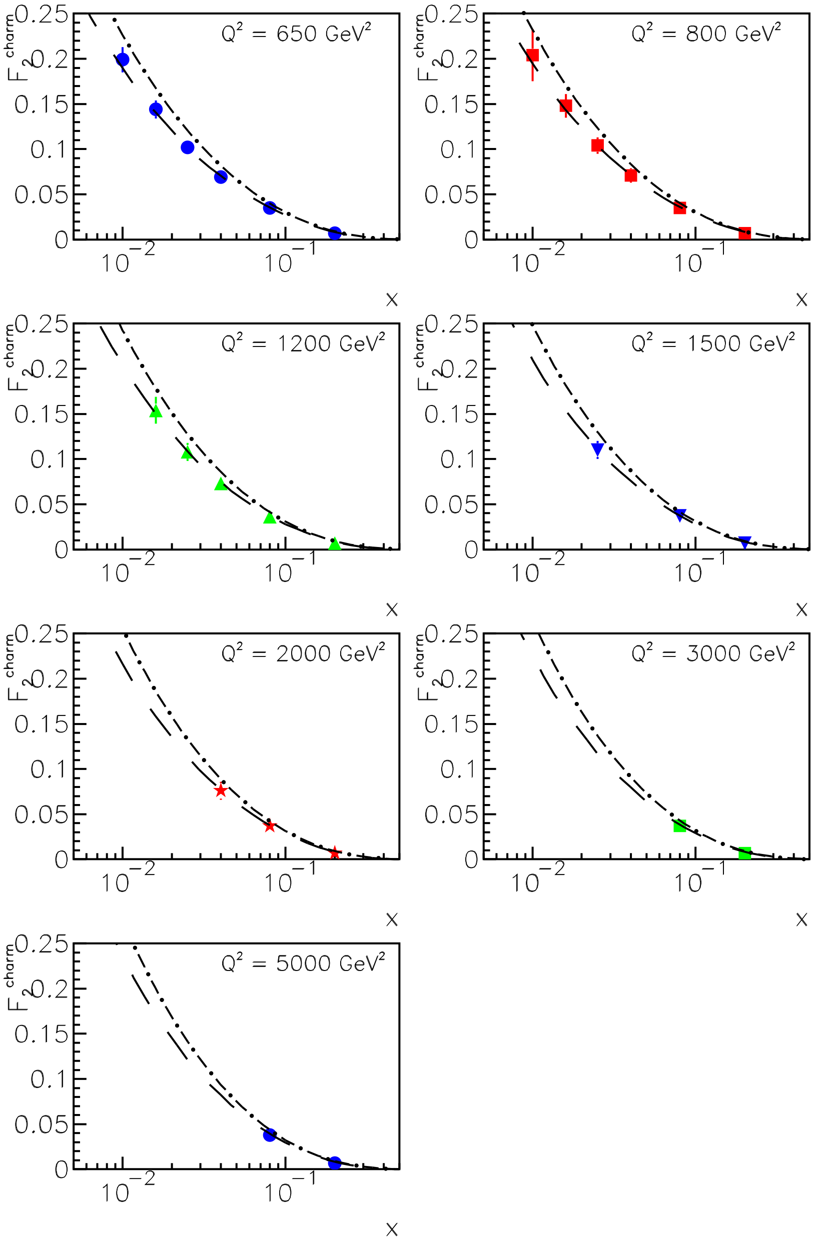

Figure 2: $F_2^{\rm charm}$ measured using displaced track tagging in the upgraded ZEUS tracking system after an integrated luminosity of 500 pb^{-1}. The proton parton distribution sets are as in Fig. 1.

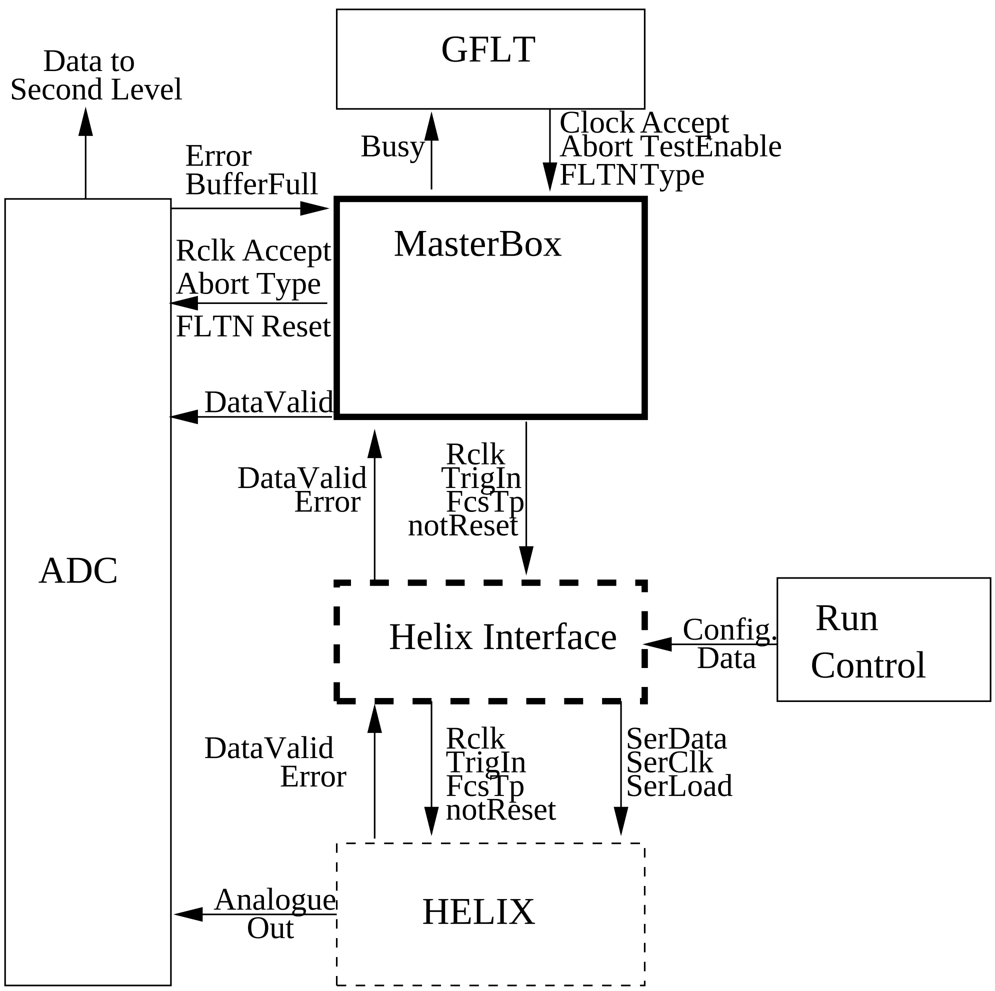

Figure 3: Overview of ZEUS MVD Clock and Control. Full boxes are in the rucksack (free standing electronics hall about 20m from the detector), dashed boxes in the cryotower area, close to the detector. Boxes in bold are considered part of the clock and control system. Key: Clock = 96ns HERA clock, Rclk = 48ns readout clock, FLTN = FLT number, Type = trigger type, TrigIn = trigger input, FcsTp = test pulse command. The names reflect those used in the Helix128S-2 User Manual [2].

6. Receive synchronisation error signals from the HELIX chips and perform error recovery.
7. Receive Buffer Full signals from the ADC and translate them into a Busy signal for the GFLT.

Physically, the clock and control system will be divided into two parts (indicated in Fig. 3). The 'Masterbox' will sit in the rucksack, along with the GFLT, the ADC crates and the run control system. It will communicate with a 'HELIX interface' which will be positioned closer to the detector, in space which is available in the ZEUS cryotower. Communication between the two will be via six optical links. The HELIX interface will fan out to the HELIX chips on the MVD via copper cables.

3.1 Masterbox

The Masterbox will consist of a single 9U board carrying out the overall control tasks and carrying the optical links, communicating via copper cables with one 'slave' 9U board sitting in each ADC crate. Communication between the ADC boards and the slaves will be via the backplanes of these crates.

3.2 HELIX Interface

The HELIX interface will consist of a VME crate containing 16 6U 'front end driver' boards, each performing the necessary functions and fanning out to 16 readout cells. A readout cell consists of 8 HELIX chips, and there are 256

Item	Estimated Cost
Masterbox	*£5,000*
Prototype/Spare Master	*£5,000*
Slaves (3 + spare)	*£8,000*
Optical links	*£600*
HELIX interface	
Front end drivers (16 + spares)	*£20,000*
Patch panel board (1 + spare)	*£2,000*
VME crate	*£4,000*
Processor	*£4,000*
Cabling and connectors	*£4,000*
Total	*£52,600*

Table 1: Cost estimates for clock and control of ZEUS silicon microvertex detector.

readout cells in total. There are 144 (9 signals $\times$ 16 cells) twisted pair cables on each board connecting to the readout cells on the detector.

There will be a further 'patch panel' board receiving the six optical links and distributing them to the 16 front end drivers.

Finally, the crate will contain a processor board which will monitor for synchronisation errors during the run, and before runs will receive configuration data from the run control system and download it to the HELIX chips via the front end drivers.

3.3 Definition of Proposed Responsibilities

We propose to take responsibility for development and construction of all the electronics, software and cabling associated with the clock and control system, as detailed in table 1. This represents a good match to expertise already existing in the ZEUS-UK collaboration.

3.4 Estimated Costs

Estimates of costs have been made based upon previous experience with ZEUS electronics and other projects. Combined with the resources required for prototyping and testing which are detailed in table 1 we therefore estimate the total cost of the project at £ 52,600.

In addition we will make use of an existing GFLT test box produced for development and testing of the CTD readout, and a VME test crate at UCL.

3.5 Estimated Staff Requirements

For the clock and control project the total staff effort requirements over the next three years for design, prototyping and software are estimated as two staff years for the Masterbox and two staff years for the Helix Interface. Most of this effort is available from collaborating Universities (Bristol,Glasgow,UCL). A contribution of approximately half a staff year from RAL Technology Dept. on board design for the Helix interface would be extremely helpful. The current close collaboration with the members of the ZEUS collaboration responsible for the ADC, data acquisition and HELIX parts of the readout will necessarily continue.

4 Alignment

Because of the expertise of the UK physicists and technicians the intellectual input and drive needed for the survey and alignment project comes from the UK. Our tasks are:

- Translate physics requirements into mechanical tolerances.
- Design survey and alignment procedures, develop tools and perform necessary measurements required by these procedures at each step of the detector construction, assembly, installation and data taking.
- Modify for the ZEUS requirements an optical system based on transparent silicon diodes, developed at the MPI and being installed at the HERA-B experiment. The necessary modifications are:

Financial Year	Installation	Alignment	Clock and Control	Total
97/98	£0	£20,000	£2,000	£22,000
98/99	£38,000	£27,000	£20,000	£85,000
99/00	£2,000	£3,000	£31,000	£36,000

Table 2: Spend profile for ZEUS UK silicon microvertex detector projects.

1. Smaller size transparent diodes are needed.
2. Readout chips need to be mounted away (probably a few metres) from the transparent silicon diodes (due to lack of space they cannot be bonded as at the MPI and HERA-B.)
3. Very demanding ZEUS specific mechanics needs to be developed, as there is much less space available at ZEUS than at HERA-B.
4. Tests of the detector modules and ladders under temperature gradient or mechanical stress using the speckle interferometer set up by the Oxford Atlas group.

5 Spend Profile and Milestones

The milestones for the project are summarised in Fig. 4. The anticipated spend profile for the original proposed expenditure is given in table 2. Adjustments to fit this within the total envelope of the available resources are underway.

5.1 MVD Installation

Design and evaluation of the installation scheme is already underway. Design of the necessary equipment will continue until summer 1998, after which manufacture will begin, for completion in time for installation of the MVD inside ZEUS at the end of 1999.

5.2 Alignment

Speckle interferometer measurements for detector alignment will commence in September 1997. Design of the complete alignment system should be completed by March 1998, allowing all parts which are to be installed on the MVD to be delivered by August 1998. In July 1999 the assembled and surveyed MVD goes from NIKHEF to DESY, where further tests and surveys will take place in time for installation and alignment in ZEUS at the end of 1999.

5.3 Clock and Control

The proximity of the HELIX interface to the detector means that during HERA running, access to it will only be possible on a monthly basis. In addition there is an intention to take cosmic ray data with the full MVD before installation. Thus a fully working system should be available early in 1999, before installation. Thus design work should begin in October this year, and prototyping be completed by mid 1998, for production by summer 1999.

References

[1] A Silicon Microvertex Detector for ZEUS, DESY PRC, 1997.

[2] Helix128S-2 User Manual,

`http://www.ihep.uni-heidelberg.de/Asic/project_Hera-B_engl.html`

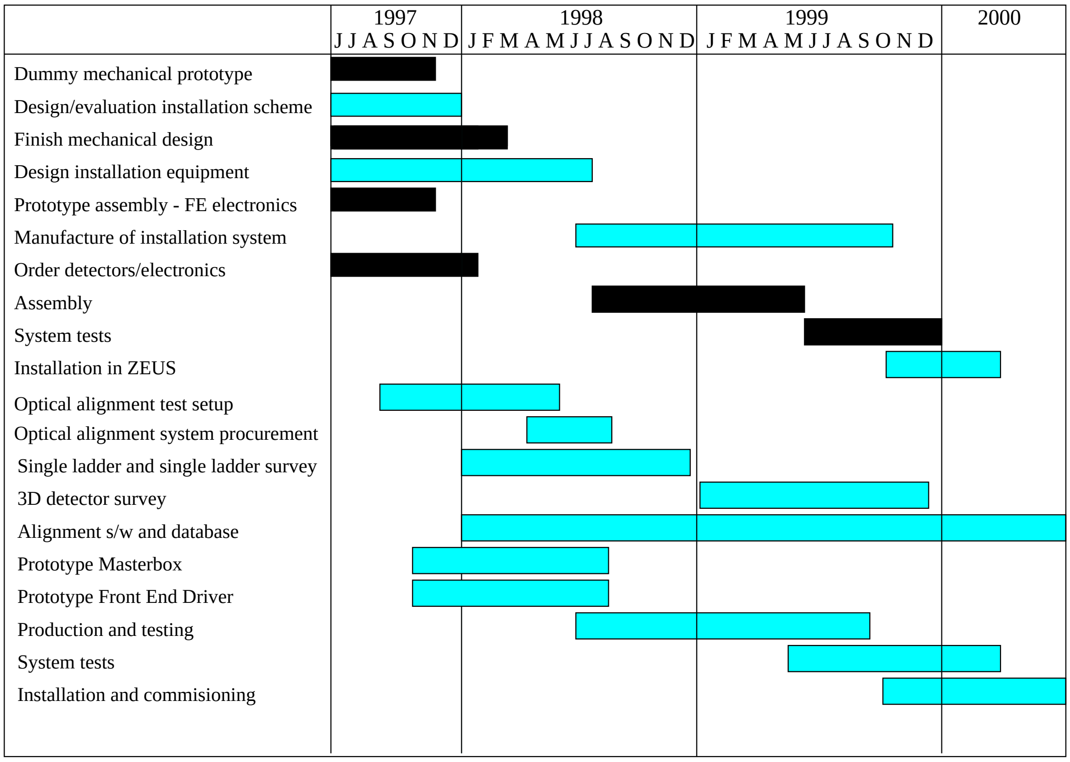

Figure 4: Schedule and milestones for the ZEUS MVD. UK responsibilities are shown in the lighter shading.