ZEUS UK Collaboration Status Report

— Part 1 —

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Overview

- Introduction to HERA and ZEUS
- Detector Status
  - Central Tracking Detector
  - Microvertex Detector
  - Global Tracking Trigger
  - Transverse Polarimeter Upgrade
- Physics Results on Heavy Flavour Production
Role of UK within ZEUS

▷ Spokesman

▷ Vital UK role in data taking
  ▷ Run coordinators, Shifts, Component coordination, Background studies

▷ Joint coordinators in 3 (of 5) physics groups

▷ Monte Carlo and Tracking Coordinators

▷ Leading a wide range of analyses

ZEUS UK plays an essential role within ZEUS
HERA — World’s only $e^p$ collider

HERA Physics program:
- Understanding $p$ and $\gamma$ structure
- QCD studies
- Electroweak tests
- Searches

HERA luminosity upgrade (2000-1) — Increase in specific luminosity

Recommissioning: $L_{spec} = 1.4 \times 10^{30} cm^{-2} s^{-1} mA^{-2}$ (design $1.8 \times 10^{30}$)

- Encouraging
HERA Recommissioning

- Initially reproducability of beam orbits was poor
  - Machine now better understood
- Background conditions in experimental areas too high
  - New collimators installed in March reduced backgrounds significantly
  - Backgrounds for ZEUS still too high to operate detector effectively
- CTD essential for solving problems

ZEUS and HERA working closely together to solve this problem

CTD SL1 currents, positrons only

- positrons only
- lumi 2000 (lp=99.3mA)
- positrons only 2000
- positrons only, 12 GeV

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**$ep$ Collisions**

*Zeus Run 40747 Event 1866*

*ep collisions observed at HERA II*
Significant upgrades to the ZEUS detector

- Microvertex Detector ➔ more later!
- Global Tracking Trigger ➔ more later!
- Straw Tube Tracker ➔ Tracking in forward direction
- Luminosity Monitor ➔ 3 detectors installed
- Polarisation ➔ more later!
Central Tracking Detector (CTD)

- **Primary ZEUS UK contribution** ▶ CTD essential for ZEUS running
- Very successful throughout HERA I
- Possibly observed "Malter" effect in 2000 ▶ Fixed
  ▶ High Voltage Breakdown problems not observed since then
- dE/dx now understood for physics analysis
  ▶ dE/dx used in several results in past 2 years
- Essential for all 3 levels of the trigger at HERA I and II

- CTD used in virtually every ZEUS result published from HERA I
  ▶ Will be needed for every result from HERA II
UK MVD Responsibilities:

- Clock + Control Electronics
- Laser Alignment System
- Patch box
- Installation

MVD installed March - April 2001

MVD motivated by strong UK physics program:

Understand charm and beauty production in QCD
Micro Vertex Detector (MVD) Commissioning

- UK people heavily involved in pre-installation system test
  - Provided shift people and visualisation software

- Involved in post-installation commissioning

- MVD commissioned in ZEUS DAQ chain for July 2001 cosmic test

- Offline alignment ongoing

MVD now installed + works in situ!
Global Tracking Trigger (GTT) Algorithm

- Integrate tracking from CTD, MVD and STT at Second Level Trigger
  - Harsh environment ▶ high contribution from beam gas
- Operate within existing CTD SLT latency (Mean ~ 10 ms)
- CTD+MVD algorithm written and tested ▶ compared to current offline

▶ Track Resolutions comparable or better than current offline

Event vertex

- \( \sigma(z) \sim 355 \mu m \)
- cf 1mm current offline
- cf 8cm present CTD-SLT

Combined CTD + MVD tracks are available at the SLT
Physics Motivation for Polarisation

- Spin rotators installed around HERA experiments during shutdown
  - Polarisation possible after upgrade

AIM: 4 data sets from HERA II:

\[ e^+, e^-; P > 0, P < 0 \]

- Fully investigate structure functions and electroweak physics
  - \( \frac{\Delta P}{P} < 1\% \) required

Transverse Polarimeter upgrade - A ZEUS UK Contribution

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Transverse Polarimeter Upgrade

- Built, calibrated and installed
- Testbeam in CERN and DESY
  - Results meets specification

- Silicon detector
  - $\sigma(y) < 50 \mu m$, S/N $\sim 21$

- TPOL Calorimeter
  - $\sigma(E)/E \sim \frac{25}{\sqrt{E}} \mp 4\%$

- Installed November 2001

- Post-installation
  - Operated successfully with unpolarised beams
  - Measuring bunch-by-bunch polarisation
Already a very successful physics program from HERA I

- 113 Papers from ZEUS
- 131 pb$^{-1}$ data taken
  ▶ Many more results to come ...

- Talk about results in heavy flavour physics here
- Results on Structure Functions, Electro-Weak, Jets, Searches ...
  ▶ See next talk ...
Heavy Flavour Physics — Motivation

- Boson-Gluon-Fusion dominant contribution
  - Sensitive to gluon content of proton
- $m_c$ and $m_b$ give a hard scale to process
  - Good testing ground for QCD
- $Q^2$ and $E_T^{jet}$ can also provide a hard scale
  - Multi-scale problem

- Beauty production in $p\bar{p}$ and $e^+e^-$ above expectations
  - What about $ep$ collisions?

Heavy Flavour Physics is a major unresolved topic in QCD
Heavy Flavour Physics

Topics Covered Here:

- Charm production in Deep Inelastic Scattering
- Diffractive Charm
- Charm + Jets
  - Charm in the photon?
  - Fragmentation
- Beauty production

All results shown here led by UK people

Topics not covered here:
D* meson branching ratios
Alternative D* meson decay channels
Charm in Deep Inelastic Scattering

- Important for understanding charm in the proton
- Tag charm by $D^*$ mesons
- Vast improvement in errors from previous results
- First time $\sigma(e^-)$ measured at HERA
- $\sigma(e^+)$ and $\sigma(e^-)$ in agreement with pQCD
**Diffractive Charm**

- **Diffraction at HERA is important topic**
  - Characterised by a large rapidity gap in the final state
  - Exchange of colour singlet ➔ Often termed pomeron
  - What is the diffractive exchange?

- **Charm is sensitive to gluons**
  - Gluonic content of pomeron

- **Models with 2 gluon exchange seem to be able to describe results better**

- **Significant fraction of DIS charm production is diffractive (7%)**

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**Graph:**

- *ZEUS 95-97 prot. diss.*
- *BJLW qq*
- *ACTW fit B*
- *SATRAP-CDM*
Charm and Jets

Now high enough statistics to look at charm + dijet production

- In resolved events, photon acts as a source of partons
- Resolved charm production → sensitive to $\gamma$ structure
- Charm with dijets give access to the production dynamics
- Charm Fragmentation can be studied

Direct

High $x^{OBS}_\gamma$

Resolved

Low $x^{OBS}_\gamma$
**Charm and Jets**

- **Idea**: Probe production mechanism
- **Direct**: Approx. Symmetric
  - Boson Gluon Fusion
- **Resolved**: Strong asymmetry in photon direction

\[ e^+p \rightarrow D^{*\pm} + \text{dijets} + X \quad M_{jj} > 18 \text{ GeV} \; ; \; |\eta| < 0.7 \]

\[ x_{\gamma}^{\text{obs}} < 0.75 \]

\[ x_{\gamma}^{\text{obs}} > 0.75 \]

**Strong evidence for charm in the photon**
Is charm fragmentation universal?

Measure fragmentation:
charm → D* meson

Energy fraction, z, carried by D*

Strong sensitivity to $\epsilon$

Data similar to that from $e^+e^-$

Precision competitive with LEP - very different production process for charm
**Beauty Production**

- Electrons from semi-leptonic heavy quark decays
  - Tag using dE/dx in CTD
  - Technically difficult
  - Sensitive to b quark production
  - 15% contribution from beauty
  - HERA results on beauty above NLO pQCD predictions
  - In both Deep Inelastic Scattering and photoproduction
  - Statistical uncertainty still large

**b cross section at HERA**

![Graph showing HERA II data](image)

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<th>Theory</th>
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<td>H1 μ impact param. (prel.)</td>
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**HERA II data will be very interesting**