ZEUS UK Collaboration
Status Report

David Bailey
University of Bristol

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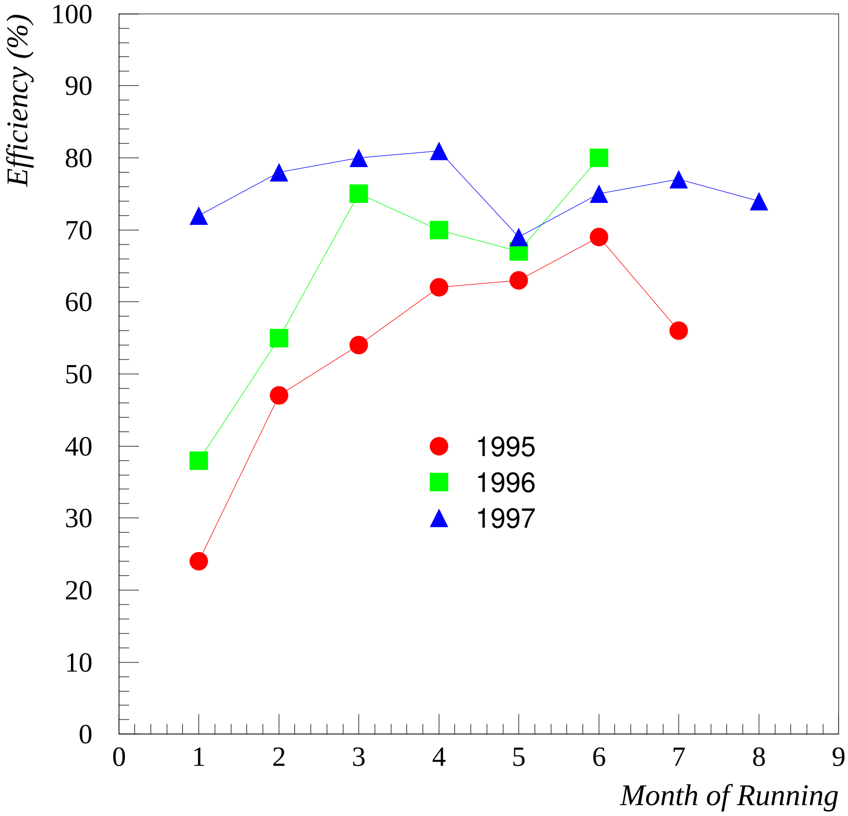
Overview

- Zeus Detector Status
  - » Performance during running
  - » Detector upgrades
  - » HERA upgrade
  - » Microvertex Detector
- CTD Performance
  - » Resolution
  - » *dE/dx*
  - » Triggering
  - » CTD 2005
- Physics Results (Part 1)
  - » Charm with everything

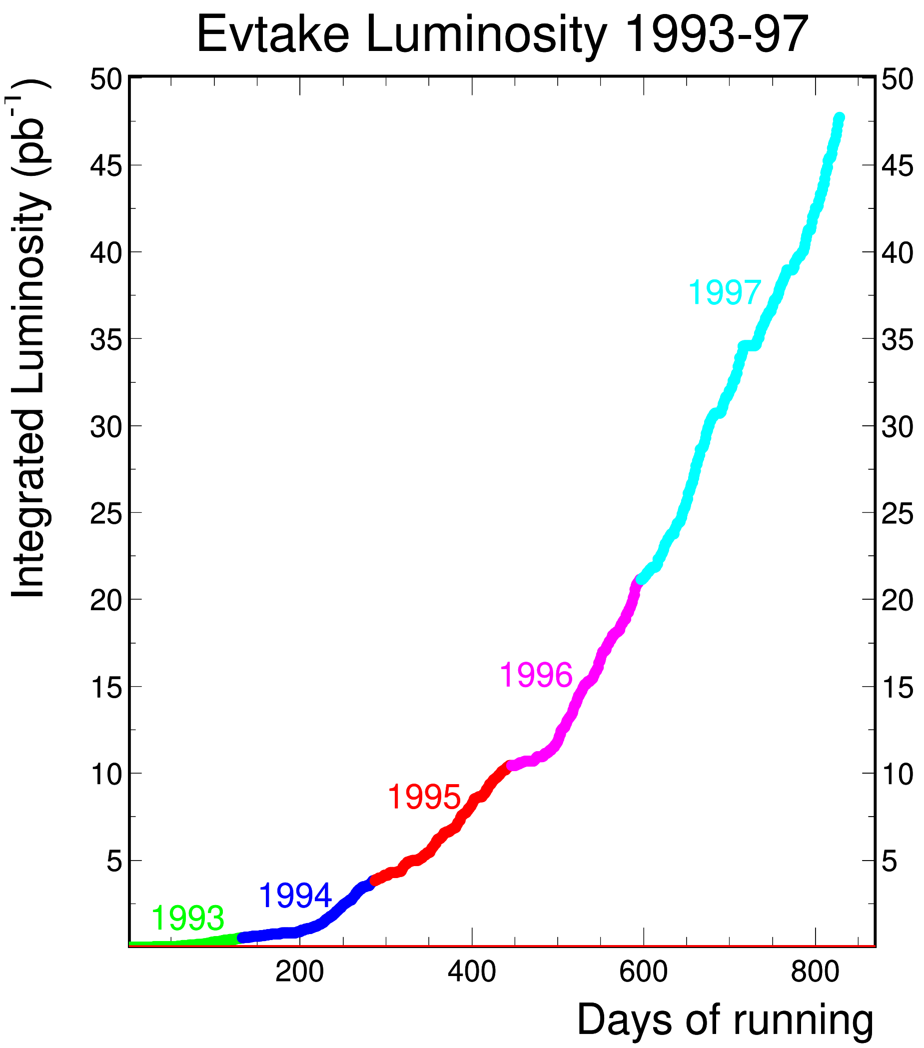
Zeus Status



» 1997 data-taking efficiency close to 80% throughout

» Benefited from short shutdown

Zeus Luminosity

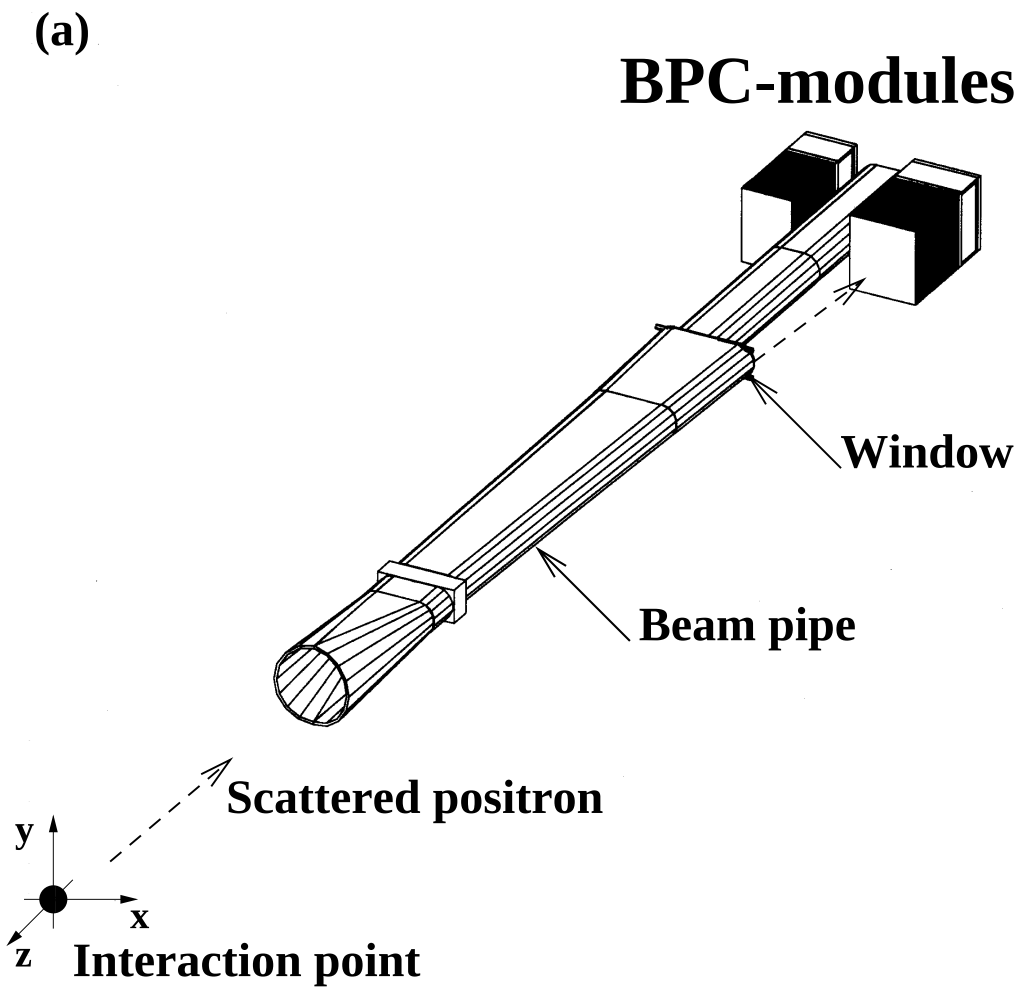


- » 28pb^{-1} (out of 36) on tape in 1997
- » More than doubled existing dataset

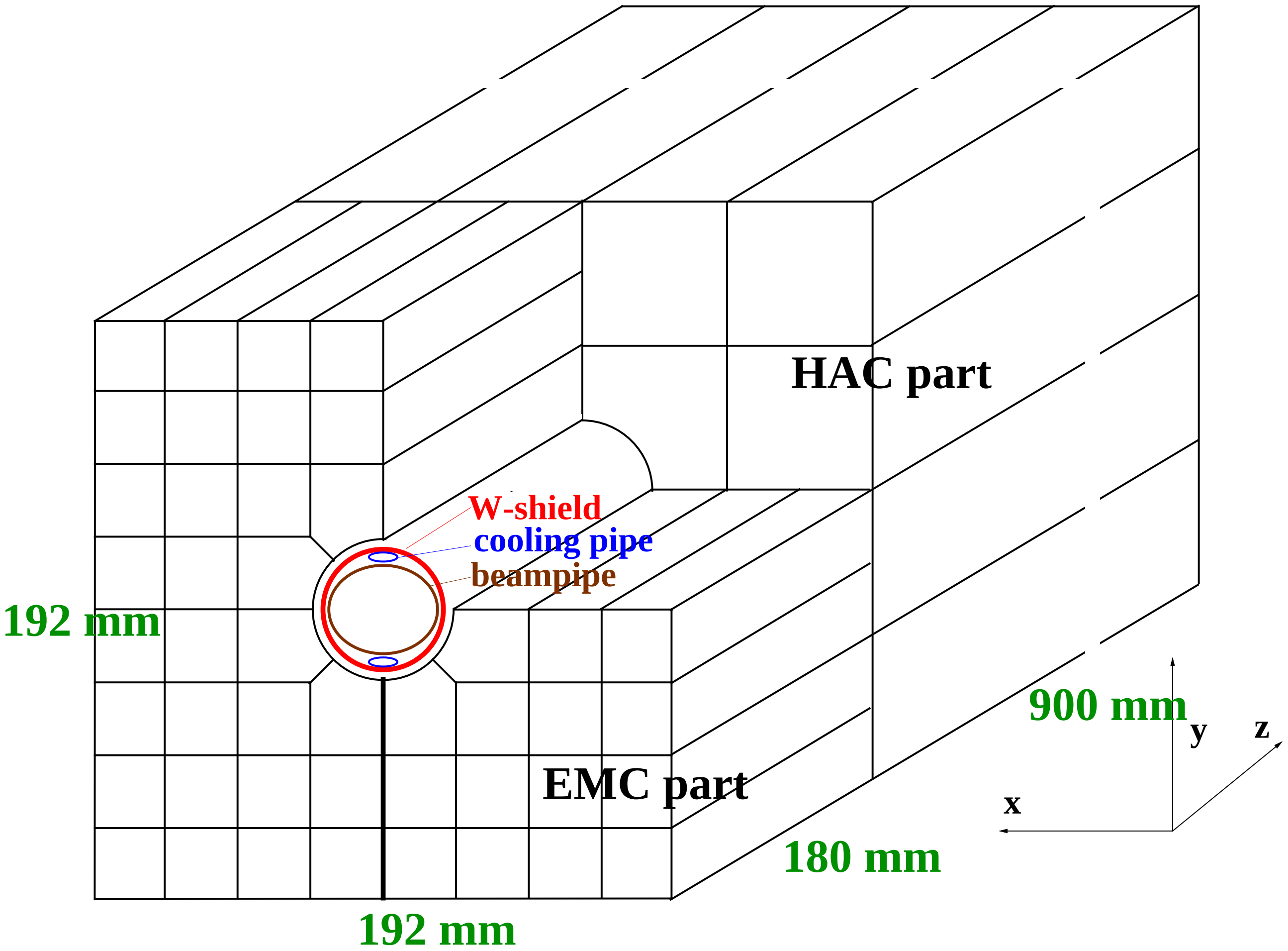
Zeus Upgrades

- HES installation completed
  - » FHES operational for 1998
- Silicon Telescope installed in front of BPC
  - » Precision low Q^2 cross sections
  - » Background suppression
- Barrel Presampler installed
  - » Test modules commissioned in 1997
  - » Full presampler ready for 1998
- Forward Plug Calorimeter
  - » Installed and ready for 1998
  - » Enhanced acceptance for diffractive physics

BPC Schematic



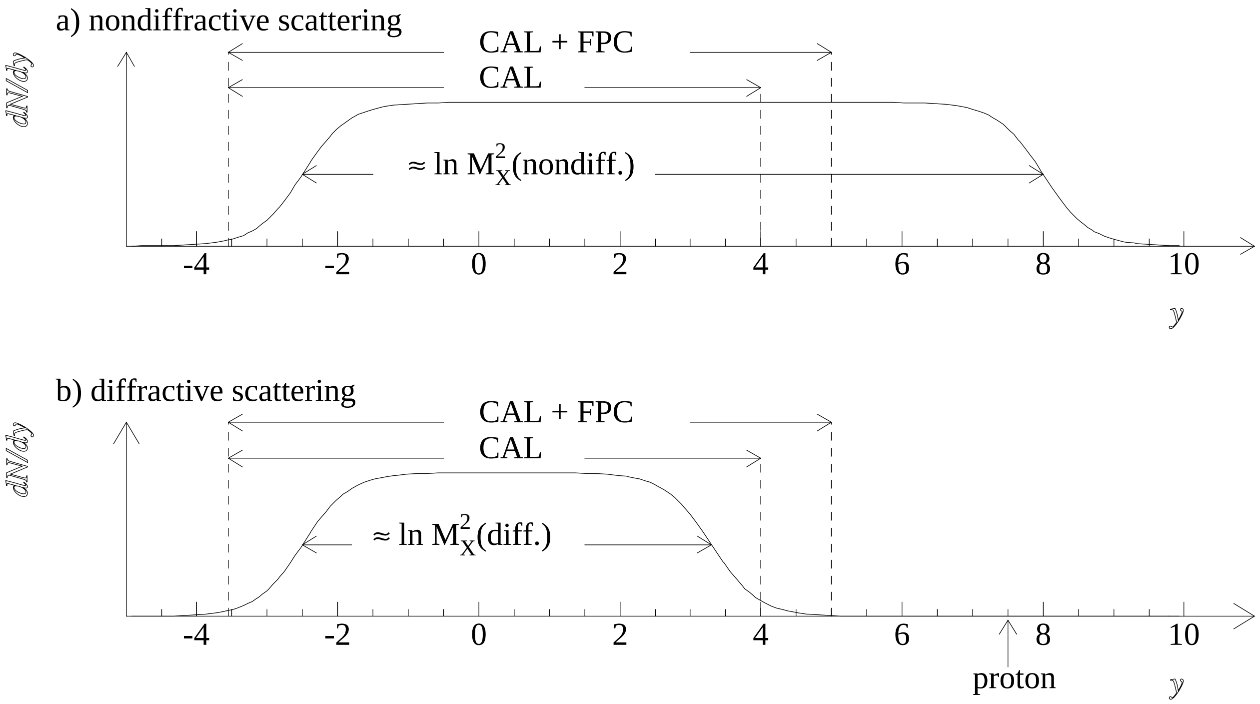
Forward Plug Calorimeter

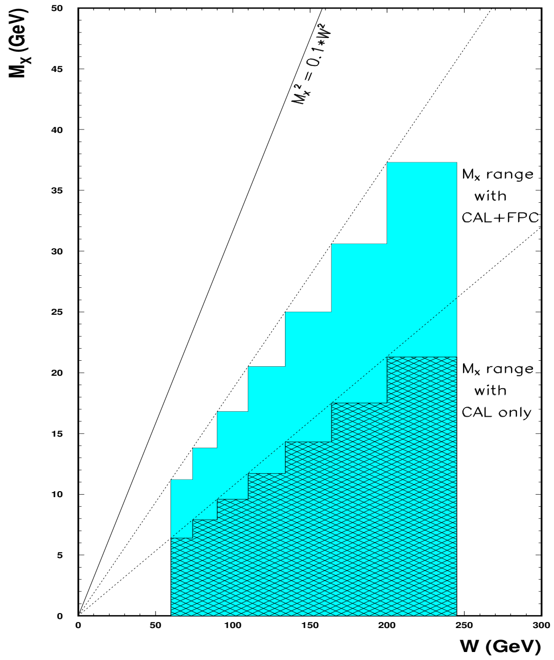


- Improved acceptance for:
  - » Diffractive physics
  - » Forward jets (BFKL)

Forward Plug Calorimeter

- Extended ranges in M_x and pseudorapidity





The Future...

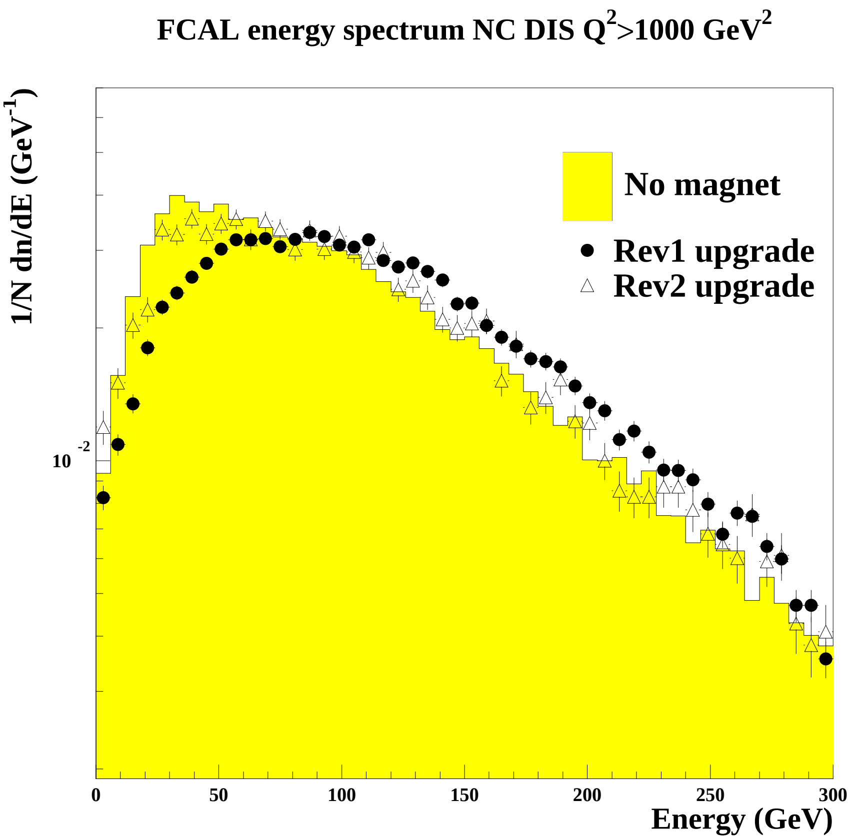
- HERA Upgrade
  - » 36.4pb^{-1} delivered in 1997 exceeded all expectations but is close to maximum achievable annual luminosity
  - » Still to make high statistics, high-Q^2 measurements
  - » To explore electroweak physics we need ~1fb^{-1} on tape by 2005
    - – To realise these goals requires a major upgrade to the experimental interaction region
  - » New possibilities to use polarised lepton beams
- UK Physicists are heavily involved in the upgrade program, assessing the impact of modifications to the machine on ZEUS as a whole

Upgrade Parameters

	1997	Upgrade
Inst. Lumi	1.4×10^{31} $cm^{-2}s^{-1}$	7.4×10^{31} $cm^{-2}s^{-1}$
I_p	77mA	140mA
I_e	36mA	58mA
E_p	820GeV	820GeV
E_e	27.5GeV	27.5GeV
Electron β_x	2.0m	0.63m
β_y	0.7m	0.26m
Proton β_x	7.0m	2.45m
β_y	0.7m	0.18m

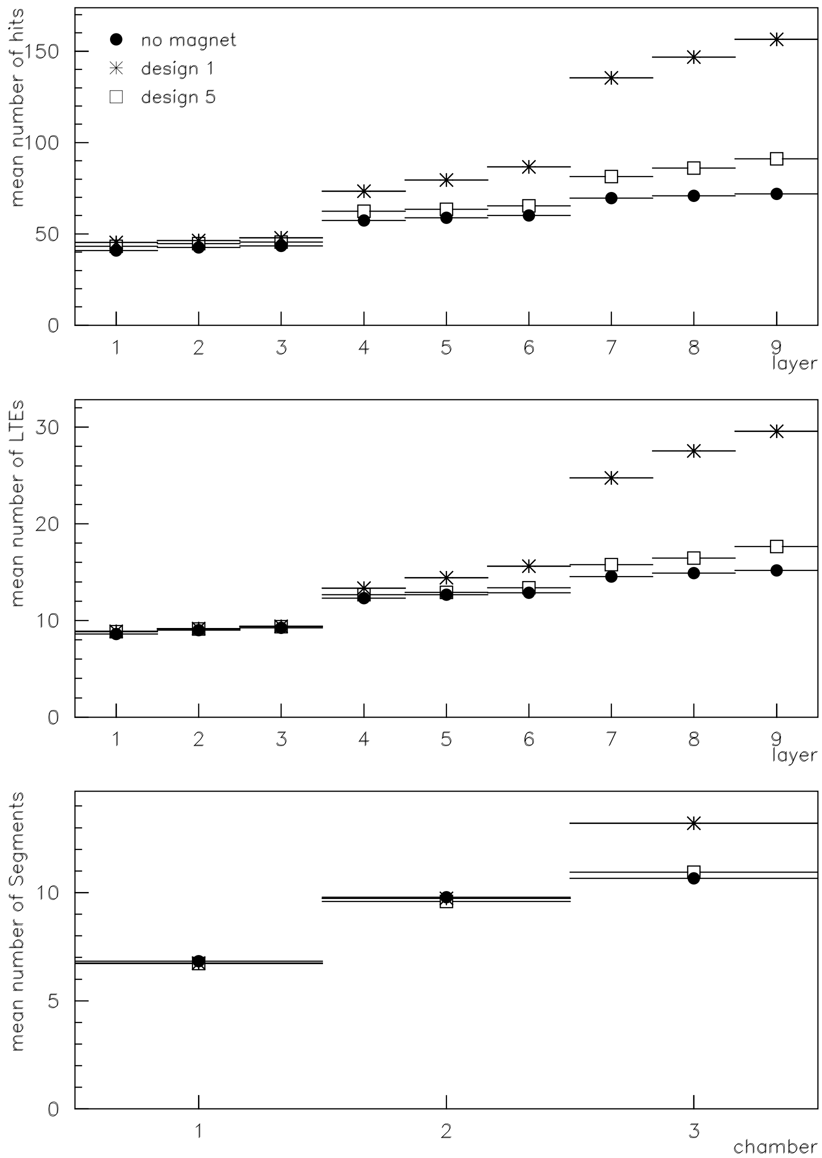
Upgrade Impact on ZEUS

- Effect on FCAL Energies



Upgrade Impact on ZEUS

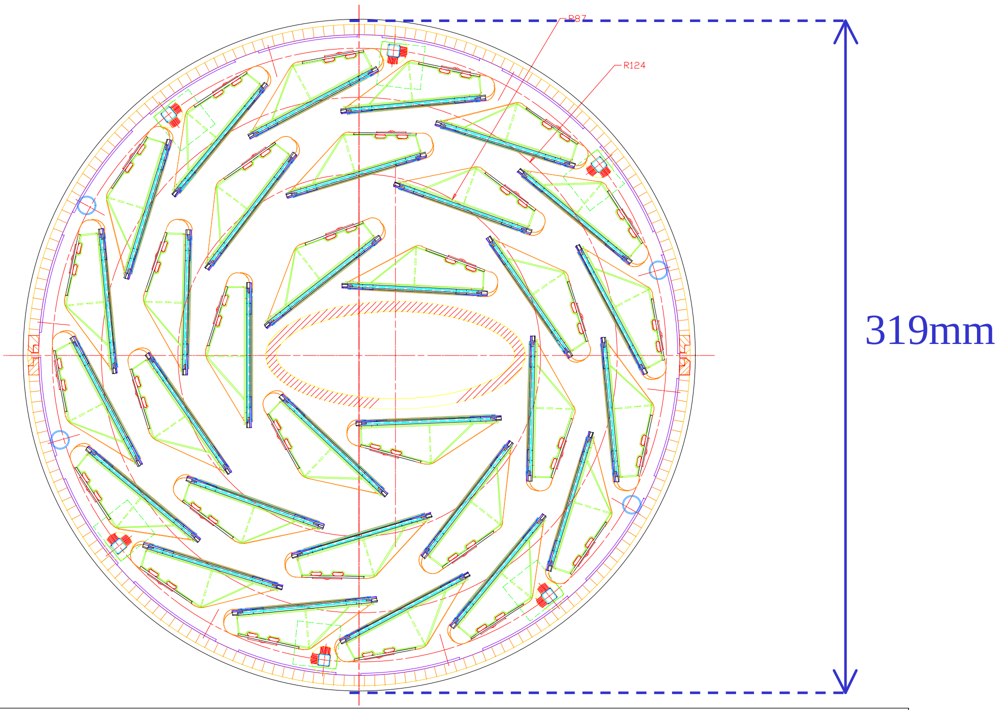
- Effect on FDET Multiplicity

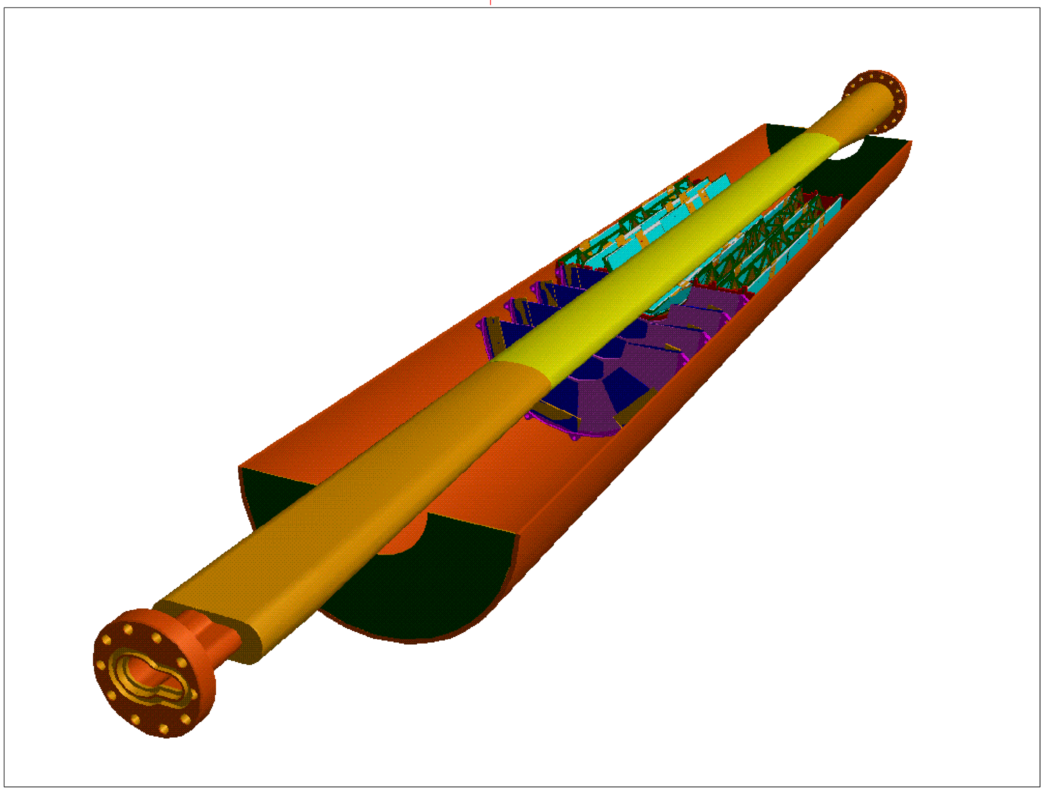


ZEUS Microvertex Detector

- Already presented and approved
  - » Currently in the final design stages
- Installation scheduled for 1999/2000 shutdown
- Will bring significant benefits:
  - » Secondary vertex detection
    - – Order of magnitude increase in charm detection efficiencies
      - Precise measurement of F_2^{charm}
      - Tagging charm in jets
    - – Enhanced capability for exotic physics searches
  - » Improved primary vertex and tracking measurement

MVD Layout





Charm Tagging with Microvertex Detector

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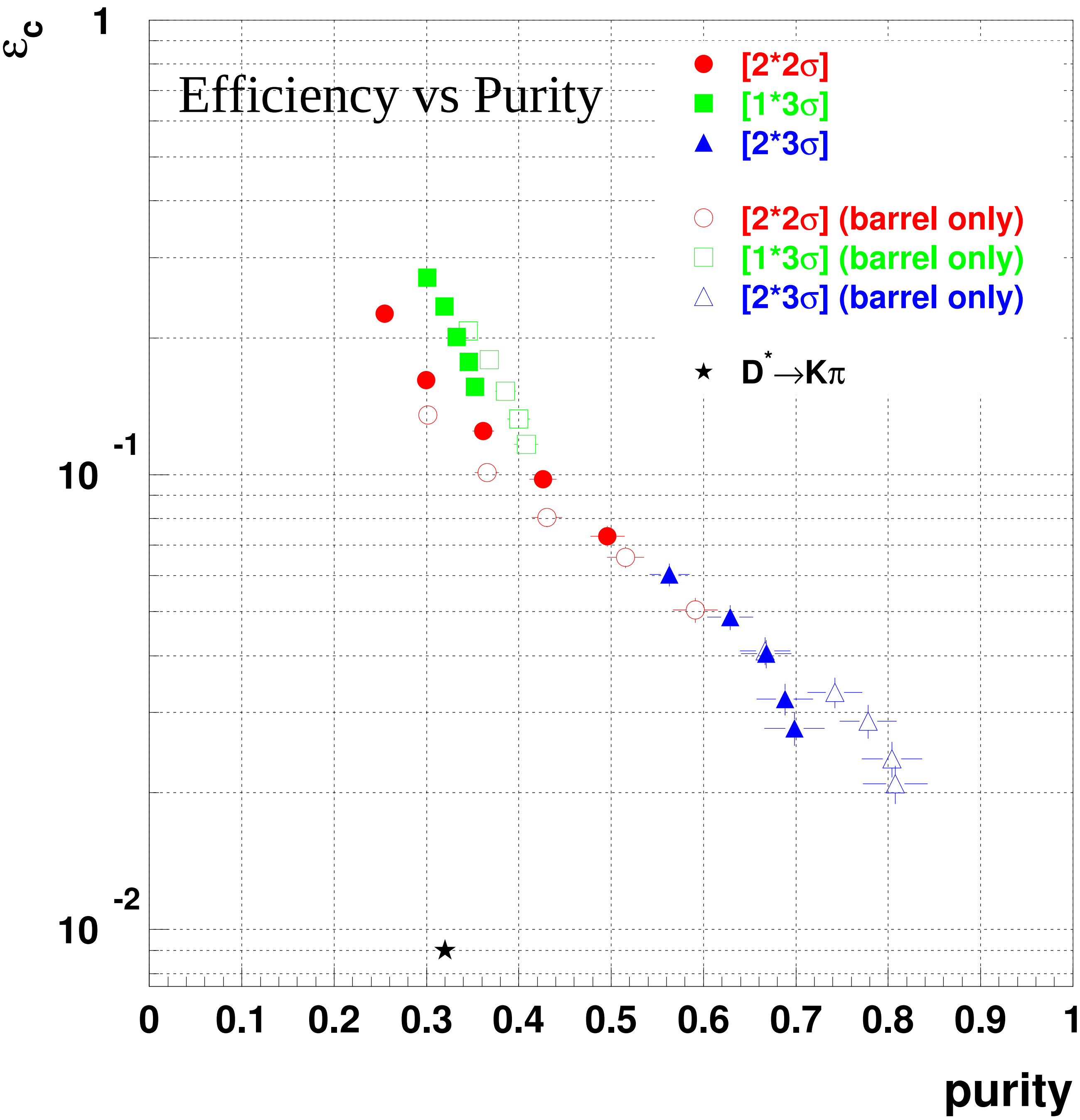
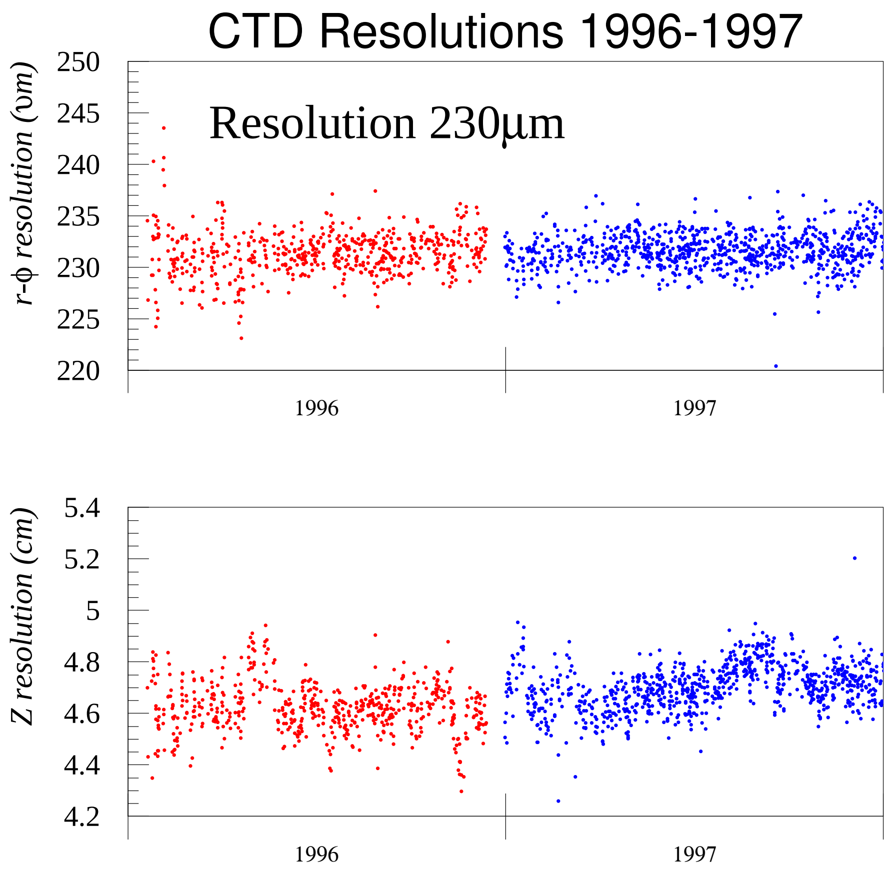


ZEUS-UK MVD Progress

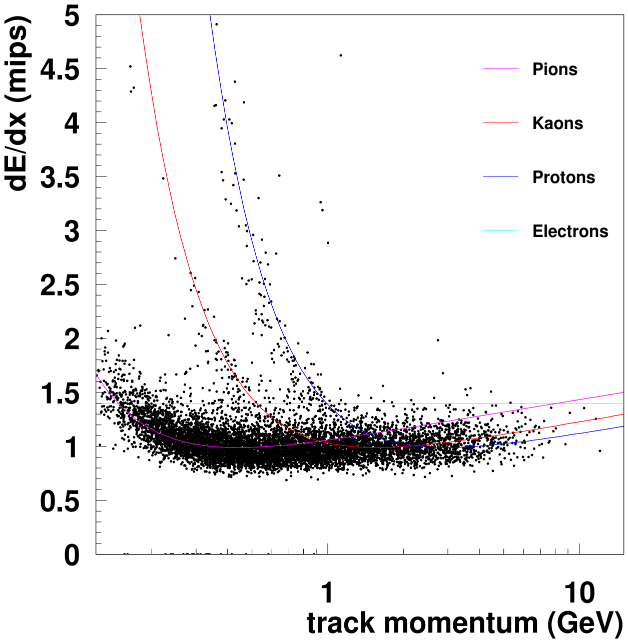
- Installation of MVD in ZEUS
  - » Installation scheme specified
  - » Design drawings for installation and mounting on the CTD are complete
    - – Required close contact between UK, beampipe and MVD construction groups
  - » Next steps to produce detailed engineering drawings and manufacture installation equipment
- Alignment of MVD
  - » Test setup of opto-electronic alignment system working
    - – Position resolution <1μm achieved for single sensor in lab
  - » Database for alignment parameters under discussion
- Clock and control electronics
  - » Functionality completely specified
    - – Prototype ready by August 1998 for electronics integration tests

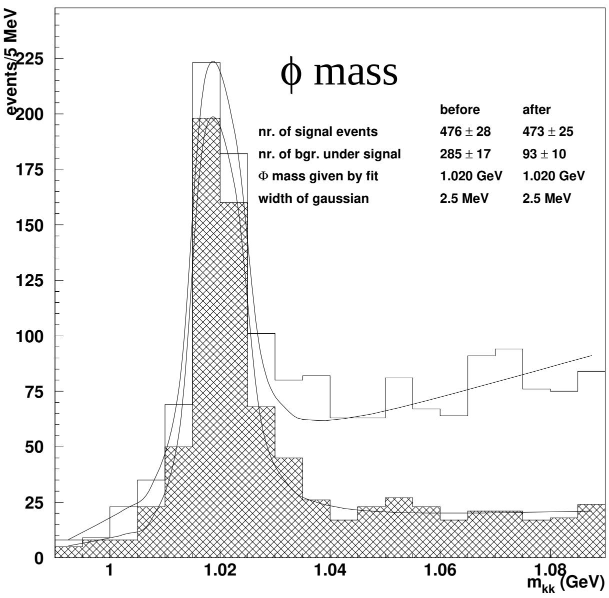
CTD Status



- Running smoothly
  - » Resolutions stable
  - » Significant effort required from DQM to maintain optimal performance
- ZEUS physics depends on the CTD

dE/dx



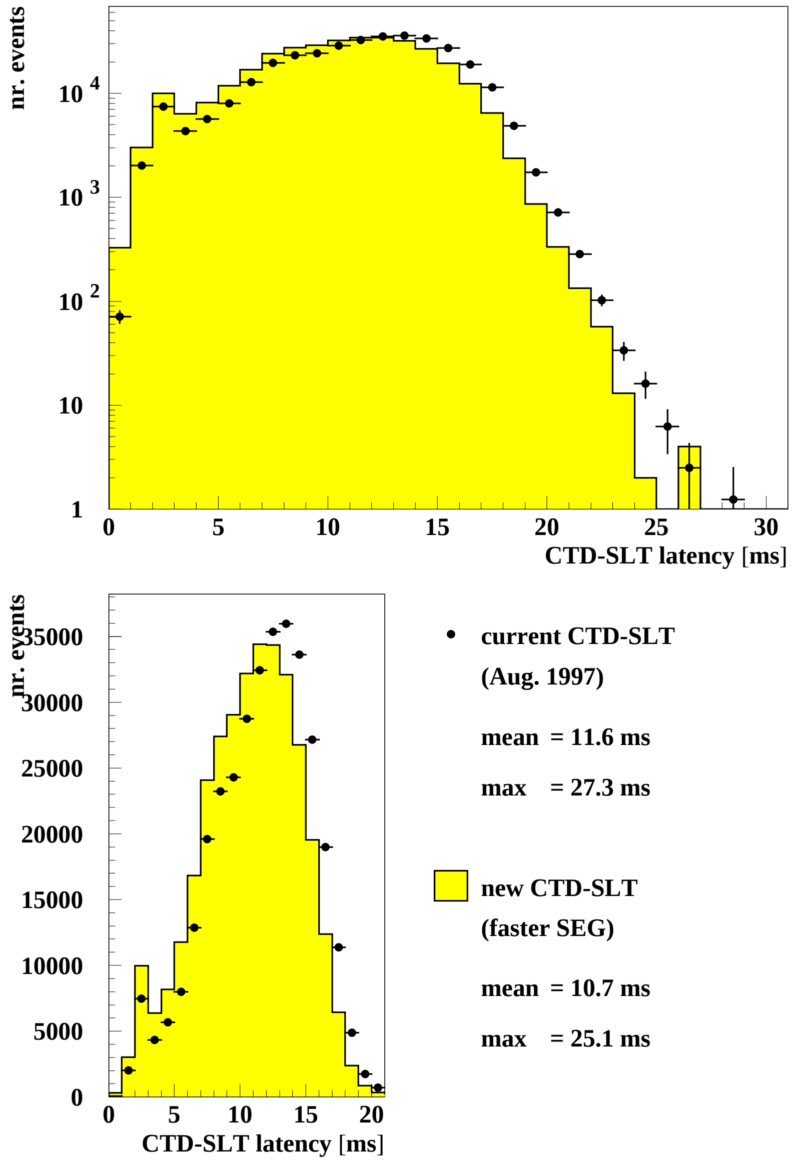


- *dE/dx* used in many analyses
  - » Improved signal:background for exclusive final state measurements (see above)
- HV set by pressure for optimal pulseheight distribution
- Clear particle separation
- Resolution 10%

CTD Trigger

- ZEUS trigger selects events from *e-p* interactions
  - » Powerful background rejection
    - – Rate reduction from ~10KHz to ~5Hz of physics events
  - » Three-level design
  - » CTD information is used at all levels of the trigger
- CTD first-level trigger was completed for 1996 running and is vital for efficient Zeus data-taking
- CTD second-level trigger processing speed improved to minimise deadtime
- CTD data now available for use in MVD/Global second-level trigger scheme

CTD SLT Latency



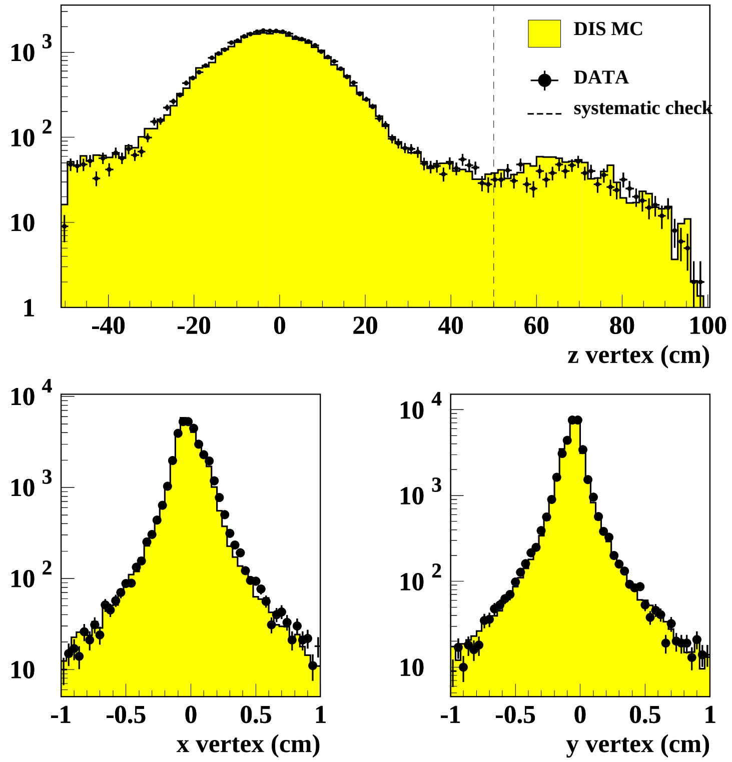
- Latency reduced by ~1ms after code improvements

CTD 2005

- The CTD has operated reliably for 6 years with no degradation in performance
- Rich physics program until 2005
  - » The CTD must operate efficiently and reliably until then
- We are addressing the issues involved:
  - » Thorough review of all CTD subcomponents
    - – Software
    - – Electronics
    - – Spares availability
  - » Continuing access to expert knowledge in the UK
    - – Experience of UK engineers crucial on occasion

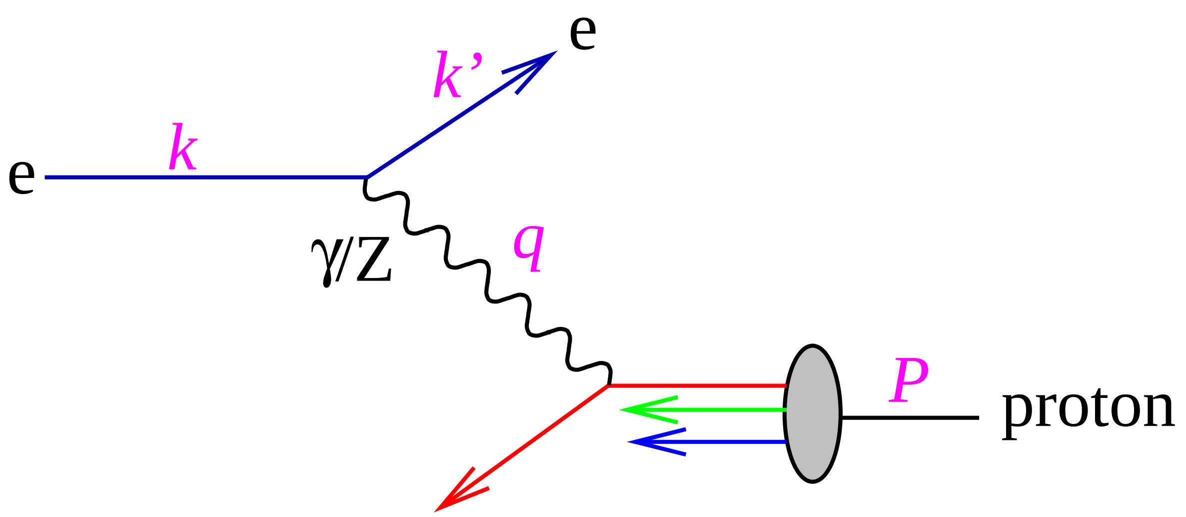
The CTD in Physics

- ZEUS analyses depend on the CTD
  - » Vertex
    - – Accurate reconstruction of kinematic variables



  - » Tracks
    - – Exclusive final states
    - – Particle identification
      - •High-Q^2 electrons
      - •μ identification
  - » Good Monte Carlo description

Kinematic Variables



$$Q^2 = -(k - k')^2$$

$$x = \frac{Q^2}{2P \cdot q}$$

$$y = \frac{P \cdot q}{P \cdot k}$$

- Variables reconstructed from energy and angle of positron and hadronic system

Charm Production

- Search for charm by reconstructing D^* in final states using tracking
- Most popular decay used is

$$D^* \to D^0 \pi$$
$$D^0 \to K\pi$$

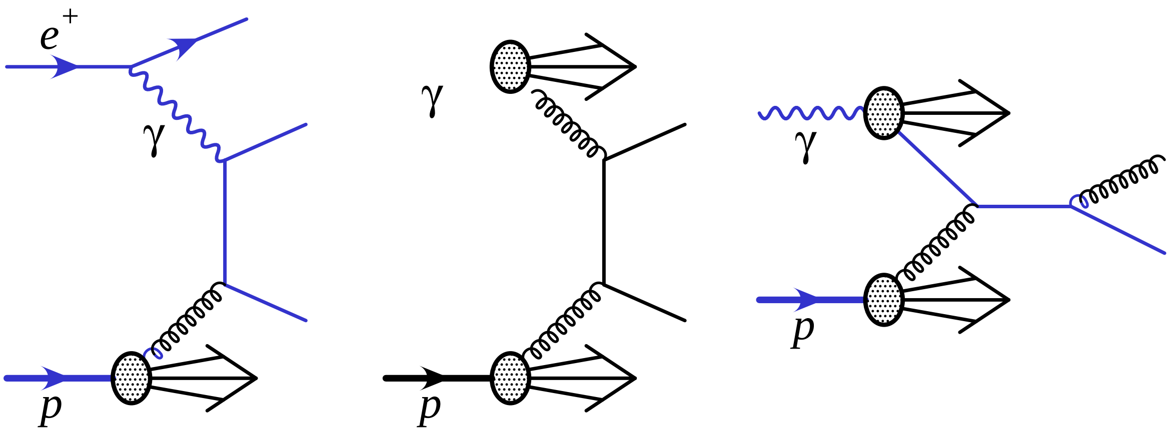
Also look for

$$D^* \to D^0 \pi$$
$$D^0 \to K\pi\pi\pi$$

And semi-leptonic decays

- Start at the low-Q^2 end of the market...

Charm in the Photon



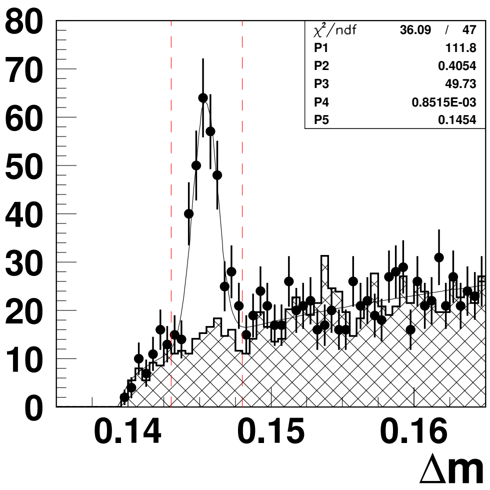
- To leading order, two types of process contribute to charm cross-section - "Direct" and "Resolved"
  - » Question of how to treat charm in the photon
- Particular interest in "Resolved" charm as charm content of photon is poorly understood

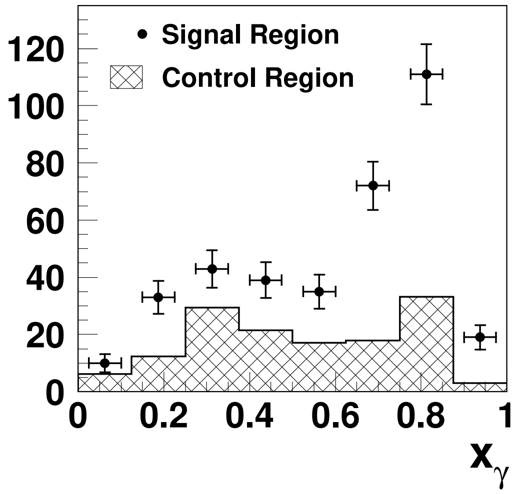
Charm in the Photon

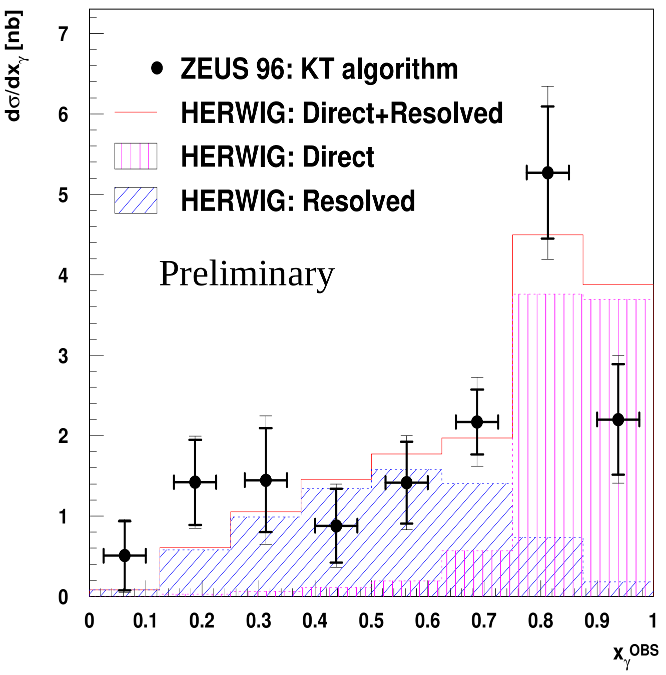
$$x_\gamma^{OBS} = \frac{\sum_{jets} E_T^{jet} e^{-\eta^{jet}}}{2yE_e}$$

- Use dijet sample to measure x_γ
- x_γ is a measure of the fraction of the photon's momentum participating in the hard process
  - » "Direct" processes have x_γ close to 1
- Cross section $d\sigma/dx_\gamma$ gives clues to the nature of the underlying process
- Look for D^*s associated with these jets

Charm in the Photon



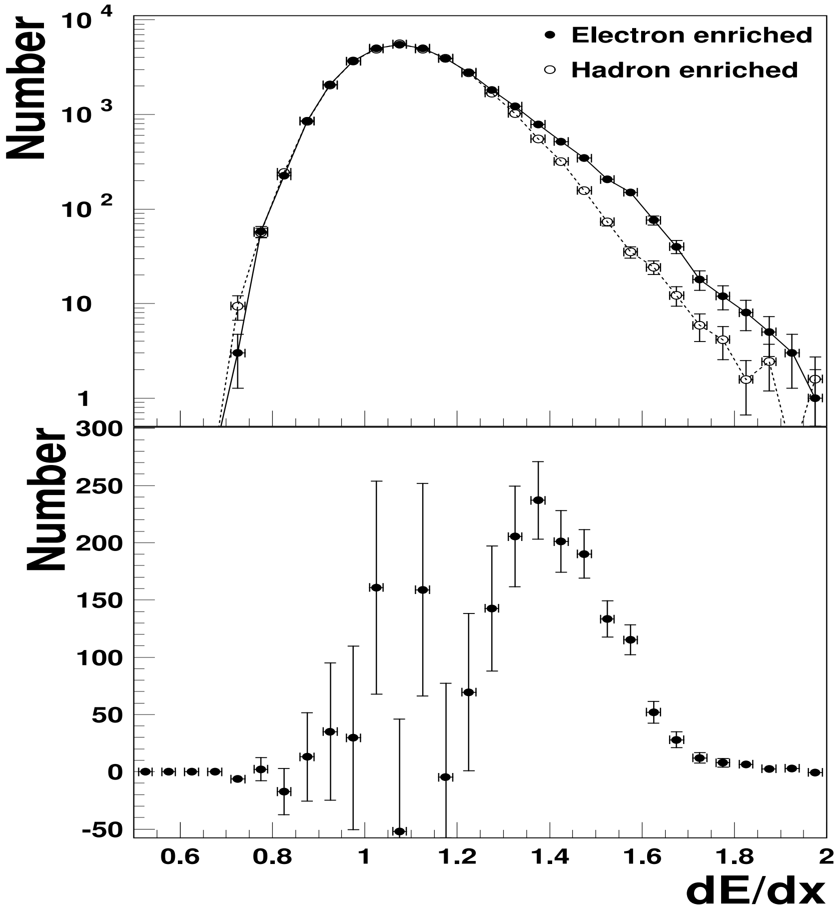




- Clear evidence for a significant “resolved” component to charm production
- The work on charm in jets is just beginning in earnest

Semi-Leptonic Charm

- Analysis still in early stages
- Uses *dE/dx* to identify electrons from semi-leptonic decays of charm
- Statistically independent sample of charm
- First obvious analysis for microvertex detector



Charm in the Proton

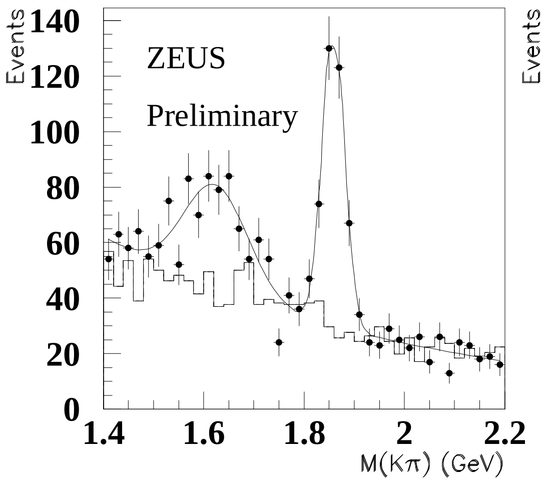
- Moving up in Q^2…
- For virtual γ exchange

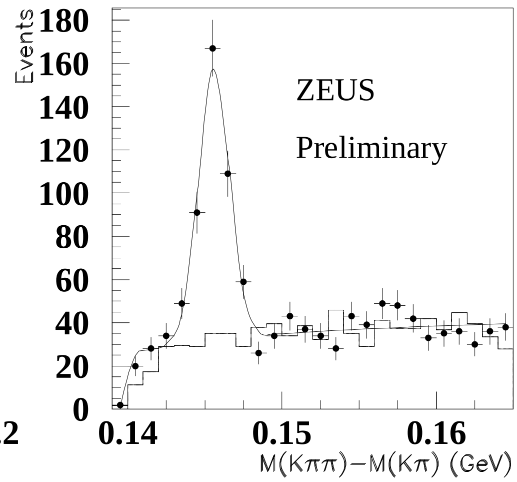
$$\frac{d^2\sigma}{dxdQ^2} = \frac{2\pi\alpha^2}{xQ^4}\left[2(1-y)+\frac{y^2}{1+R}\right]F_2(x,Q^2)[1+\delta_r(x,Q^2)]$$

$R = \dfrac{F_L}{F_2 - F_L}$, F_L is longitudinal structure function

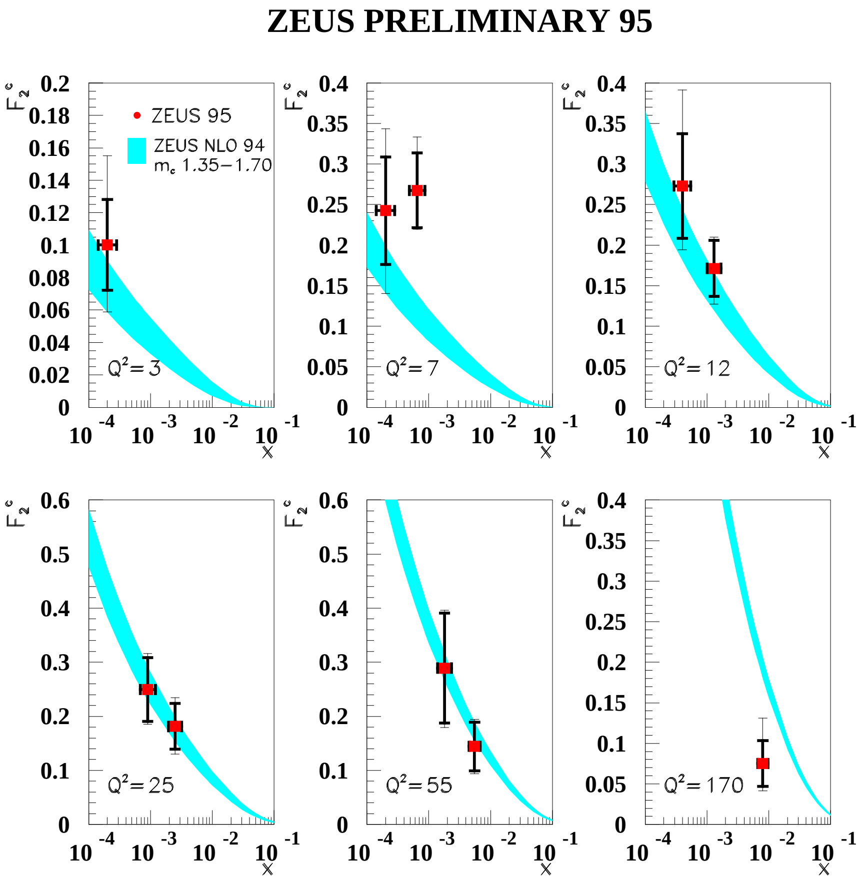
δ_r correction for radiative effects

- Reconstruct D* in final state
  - » Measure charm content of F_2 directly



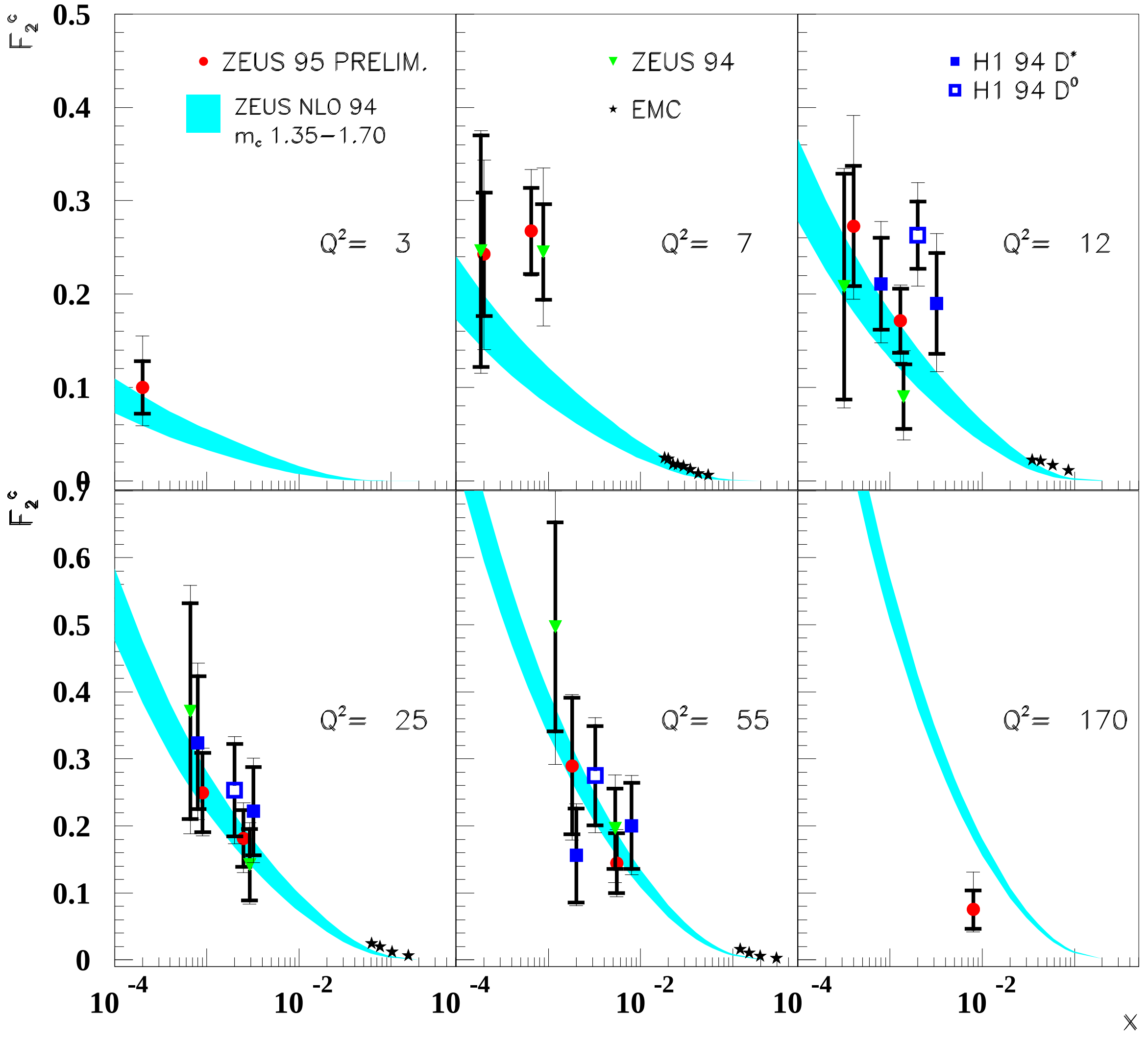


Charm in the Proton



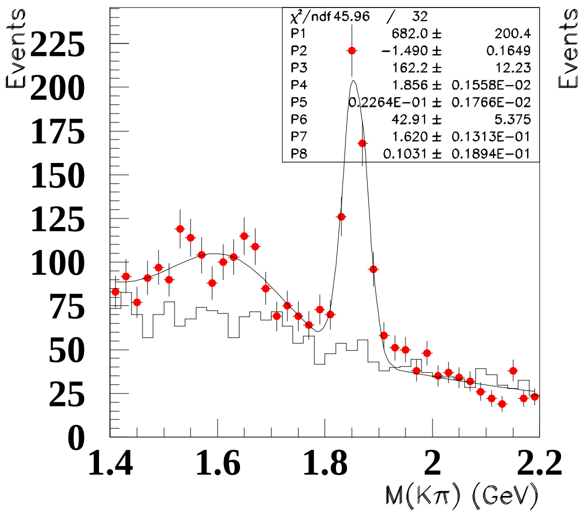
- Direct handle on gluon density (BGF mechanism dominant)
- Sensitivity to low-*x* QCD compared to inclusive F_2 measurement
- Understand Q^2 evolution of massive quark parton density

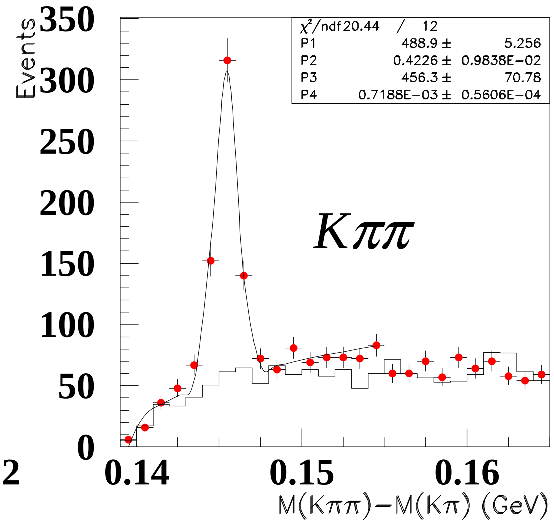
Charm in the Proton



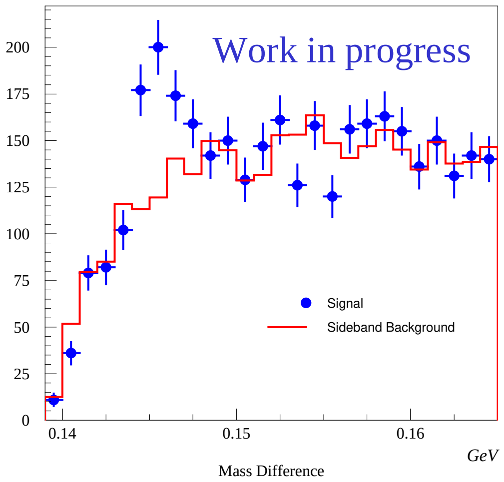
Charm in the Proton

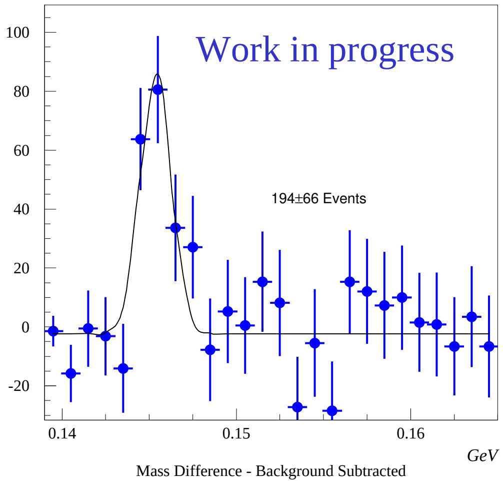
- More data now available from 1996/1997 running





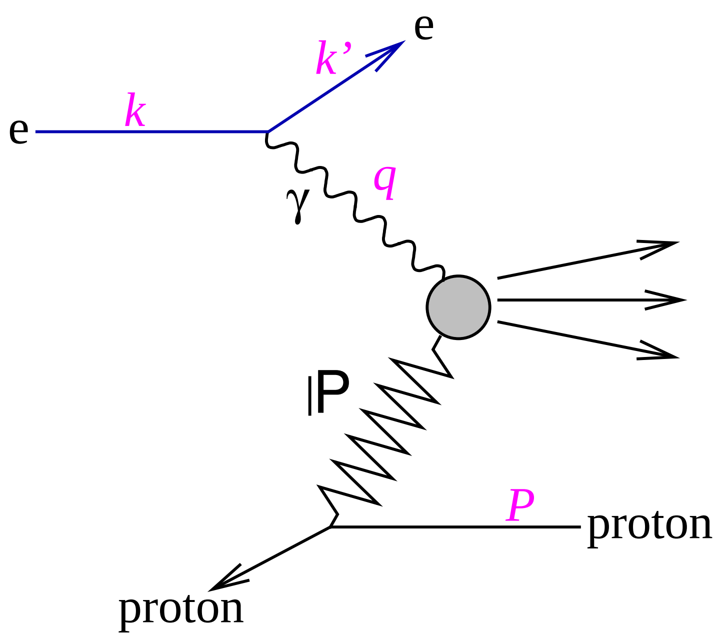
- New channels to be investigated: *Kππππ* decay mode of D*



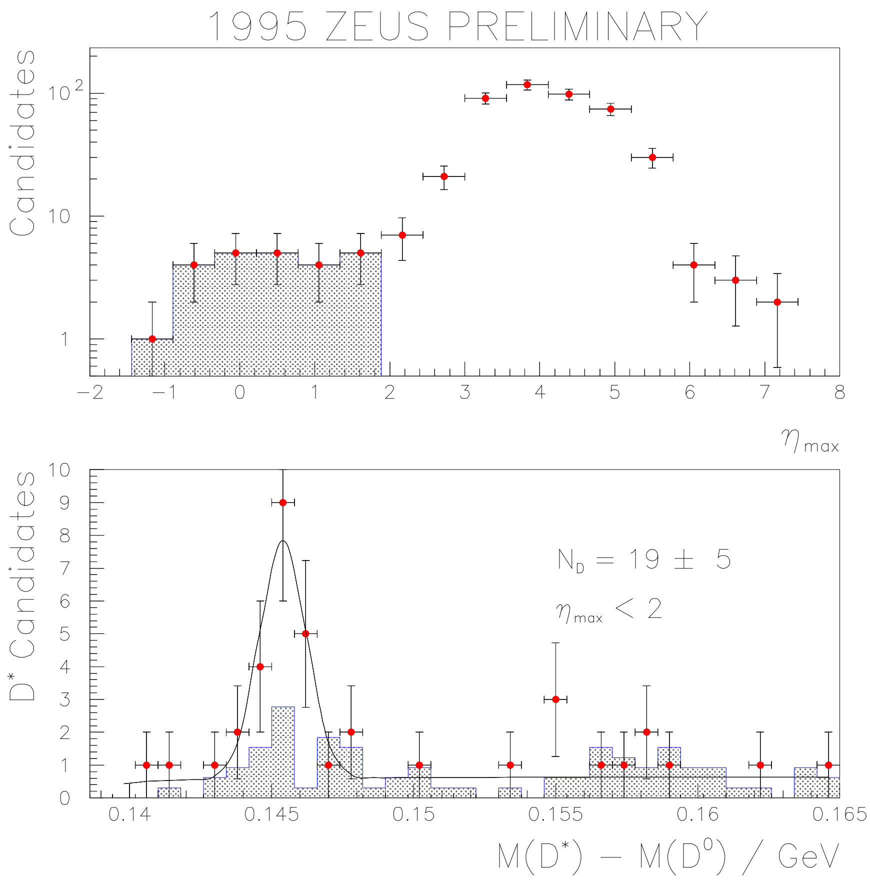


Charm in the Pomeron?

- Diffractive events characterised by no energy in calorimeter around forward beam direction
- Process now understood as probing the structure of a colourless exchange object - the Pomeron



Charm in the Pomeron?



- Select events by position of most forward calorimeter object (η_{max})

Charm in the Pomeron?

- One of the key processes to differentiate models of diffraction and give insight on the nature (or existence) of the pomeron
- Now moving on to look at combined 1996/1997 data
  - » Higher statistics
  - » Differential distributions

To Conclude

- We are looking forward to electron running 1998/1999
- After the upgrade HERA will provide high-luminosity running with polarised electrons and positrons
  - » New physics?
  - » Polarised measurements
- Microvertex detector upgrade
  - » High charm tagging efficiencies
  - » Zeus and UK effort on schedule

- **And there's more to come...**