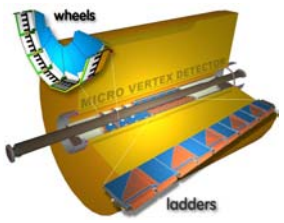
The ZEUS Experiment at HERA

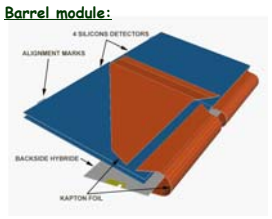
Micro-Vertex Detector

The ZEUS Micro-Vertex Detector consists of two parts:

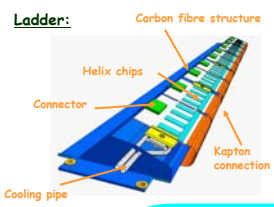
- Barrel part: three double layers of silicon-strip detectors (arranged in 4,10 and 16 ladders which in turn consist of 5 modules made out of 2 half-modules (r-z,r-φ sensors and r-φ, r-z sensors) of 512 readout channels each)
- Forward part: four double layers (= 4 wheels) of silicon-strip detectors (arranged in 14 sectors which, in turn, consist of 2 trapezoidal r-φ sensors of 480 readout channels each)

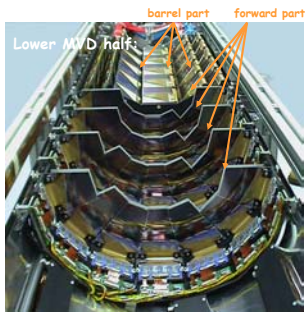


Barrel module:



Ladder:





The ZEUS Detector and HERA

The ZEUS experiment at DESY at the ep collider HERA has had its first period of data taking between 1992-2000. Over 100 pb^{-1} of data were accumulated. Some of the results from this period are shown below, labelled as **Physics Results Highlights**.

During 2000-2003, both the HERA accelerator and the ZEUS detector were upgraded:

HERA Upgrade:

The luminosity of the HERA machine will be increased by a factor of five through the use of superconducting focussing magnets close to the interaction region. The goal is to accumulate 1000 pb^{-1} of data by 2006. At the same time, spin rotators have been installed providing longitudinally polarized electron and positron beams for the ZEUS and H1 experiments. Some of the physics potential of the upgrade program is shown below, labelled as **Physics Potential of the Upgrade**.

ZEUS Upgrade:

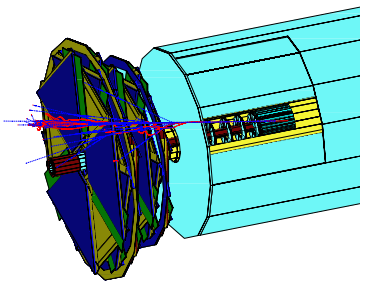
- ZEUS Micro-Vertex Detector (**MVD**) (left)
- ZEUS Straw Tube Tracker (**STT**) (right)

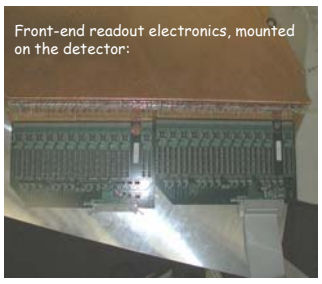
This will improve the overall tracking capabilities and increase the acceptance for high-mass and high-Q^2 physics. Furthermore, it will allow the reconstruction and tagging of heavy-flavour particles by tracks displaced from the primary vertex and by secondary vertex reconstruction.

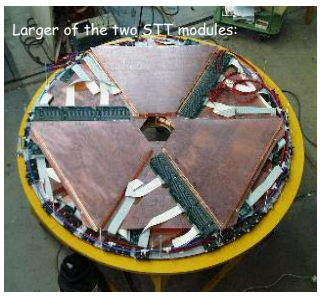
Straw Tube Tracker

The ZEUS Straw Tube Tracker is divided into two modules located in the space between the Forward Tracking Detector (FTD). It consists of straw tubes. Six sectors are arranged in a superlayer. Four superlayers constitute each module. They are rotated by four different angles with respect to each other to give as much redundancy for the reconstruction as possible.

Simulated primary electron which has started an electromagnetic shower in the endplate of the Central Tracking Detector (CTD). Also shown is the barrel and forward part of the MVD.

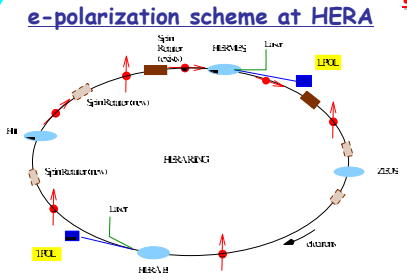




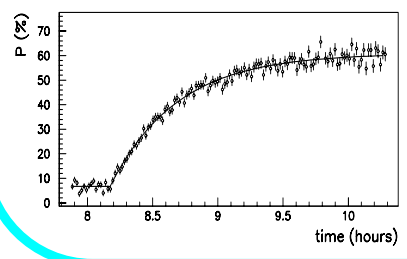


Physics Potential of the Upgrade

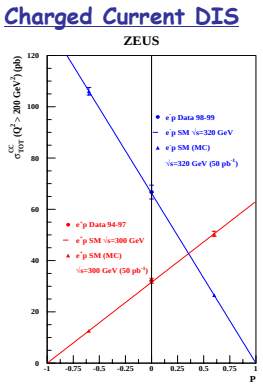
e-polarization scheme at HERA



e-polarization observed at HERA



Charged Current DIS



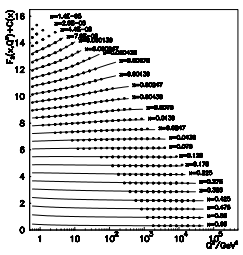
$\sigma^{CC}_{e^-p} \propto (1+P)$

P = Polarization

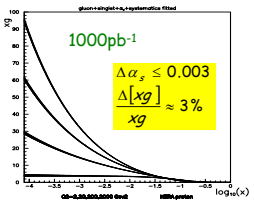
Resolution on $M_W(R)$: 80MeV

Exclusionlimit : $M_W(R) > 400$GeV

Structure Function F_2

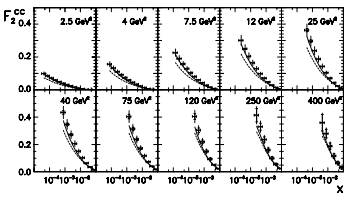


⇦ High precision F_2 over range in $(x,Q^2) \rightarrow \alpha_s$ and xg



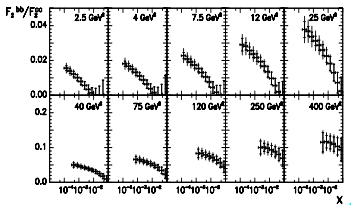
Heavy flavours in the proton

Charm: 500pb^{-1}



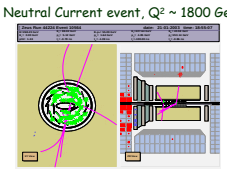
⇦ High precision $F_2^{c\bar{c}}$

Bottom: 500pb^{-1}

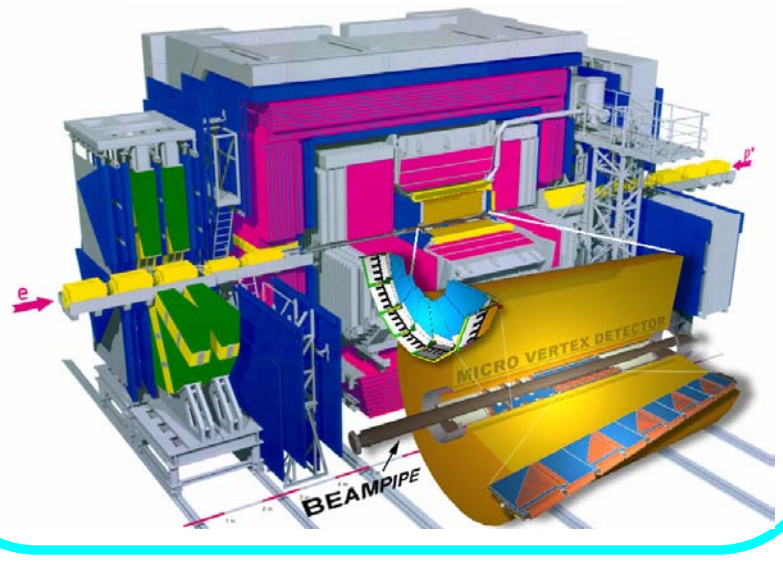


⇦ Sensitivity to bottom contribution to F_2

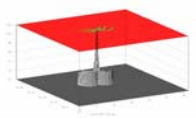
Neutral Current event, $Q^2 \sim 1800$ GeV²:



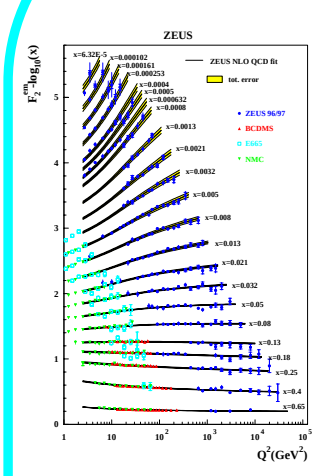
The ZEUS Detector

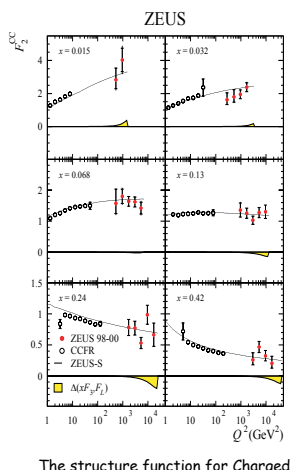


Hits from a muon track in the tanθ-φ plane. One arc-like curve represents the hits in one sector:

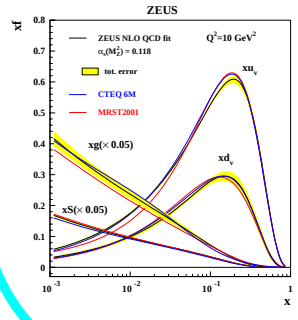


Neutral and Charged Current Deep Inelastic Scattering and Structure Functions

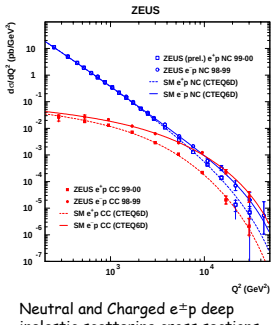




The proton structure function F_2 has been measured in Neutral Current (NC) $e^{\pm}p$ scattering and exhibits clear scaling violations (above). These scaling violations have been used to determine the strong coupling constant, α_s, and the parton densities (below)



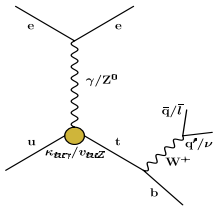
The structure function for Charged Current (CC) interactions F_2^{CC} has been measured (above), extending a fixed target measurement to higher momentum transfer



Neutral and Charged $e^{\pm}p$ deep inelastic scattering cross sections have been measured (above). At the highest momentum transfer, the NC and CC cross sections are of comparable magnitude. This is a graphical verification of electroweak unification.

Physics Results Highlights

Exotics Searches - Limits on Flavour Changing Neutral Current Interactions

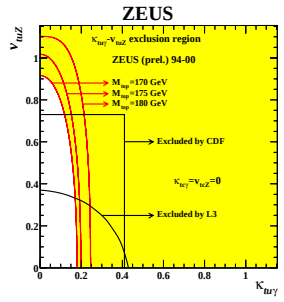


Single top can be produced at HERA through flavour changing neutral current anomalous coupling, mediated by a photon ($k_{tu\gamma}$) or a Z^0 (v_{tuZ})

No excess with respect to Standard Model predictions has been observed.

95% confidence limits have been evaluated.

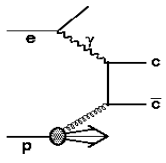
HERA experiments are most sensitive to γ exchange.

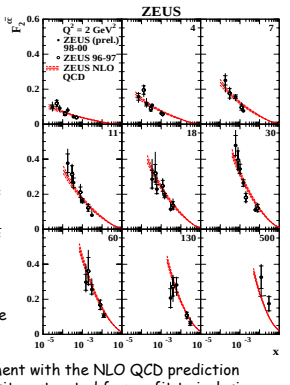


For low values of the v_{tuZ} coupling, ZEUS improves on the limits set by LEP and the Tevatron.

Heavy Flavours - Charm Production

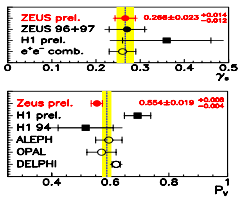
The production of charm in DIS is a direct probe of the gluon density in the proton.



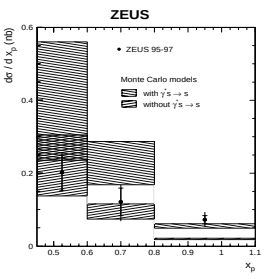


The measured structure function for charm production, $F_2^{c\bar{c}}$ (above right) is in good agreement with the NLO QCD prediction based on the gluon density extracted from a fit to inclusive ZEUS DIS data

Charm production in DIS has been measured from the rate of $D^{*\pm}$ mesons. The fragmentation functions of charm into different charmed hadrons at HERA were found to be in agreement with LEP data. The two plots (right) show the fraction of strange (P_s) and vector (P_v) mesons.



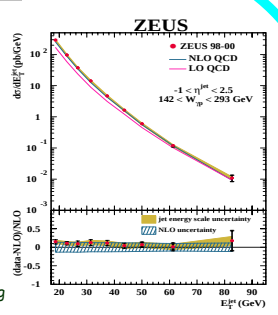
QCD and Hadronic Final State



First evidence for strange sea using leading φ(1020) mesons (above)

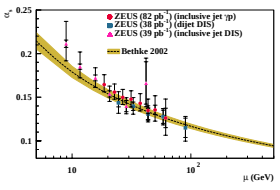
The strong coupling constant α_s is expected to run with the scale Q (below right):

- Jet cross-sections measured in neutral current DIS to extract α_s
- Data are consistent with each other and with the world average
- Errors are competitive with those of the world average
- ZEUS is producing some of the most precise QCD measurements in the world



Impressive range in jet E_T covered by the ZEUS experiment (above)
-> good agreement with NLO pQCD

$\alpha_s(Q) = \frac{4\pi}{\beta_0 \ln(Q^2/\Lambda^2)} + \ldots$

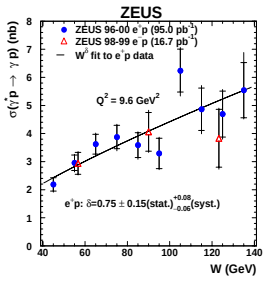


← Running within one experiment is consistent with the renormalisation group equation

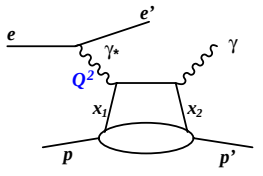
Diffraction - Deep Inelastic Virtual Compton Scattering

Perturbative QCD models:

Probing two partons with different longitudinal momenta ($x_1 \neq x_2$)



Elastic scattering: $\gamma^*p \rightarrow \gamma p$



The steep rise as a function of W^2 ($\propto 1/x$) can be explained by parton density in the proton

DVCS is a hard process

Deutsches Elektronen-Synchrotron
Hamburg, Germany

http://www-zeus.desy.de