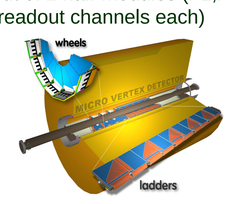
The ZEUS Experiment at HERA

MVD

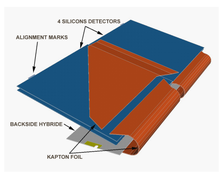
The ZEUS Micro-Vertex Detector consists of two parts:

⇨ 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)

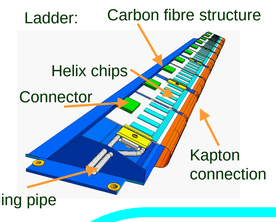


⇨ Forward part: four double layers (= 4 wheels) of silicon-strip detectors (arranged in 14 sectors which in turn consist of 2 trapezodial r-φ sensors of 480 readout channels each)

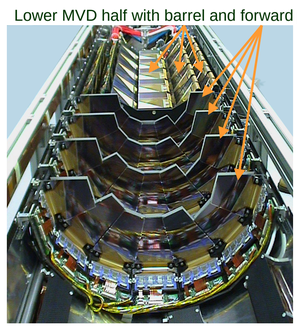
Barrel module:



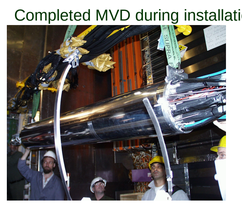
Ladder:



Lower MVD half with barrel and forward part:

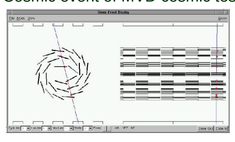


Completed MVD during installation:



After successful installation (forward side):

Cosmic event of MVD cosmic test:



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 is shown below labeled as **Physics Results Highlights**.

In 2000-2001, both the HERA accelerator and the ZEUS detector have gone through significant upgrade programs:

⇨ ZEUS Micro-Vertex Detector (**MVD**) (left)

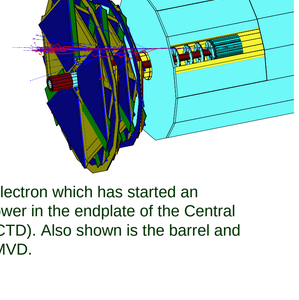
⇨ ZEUS Straw Tube Tracker (**STT**) (right)

This will improve the overall tracking capabilities and increase the acceptance for high-mass and high-Q2 physics. Furthermore, it will allow the reconstruction and tagging of heavy-flavor particles by tracks displaced from the primary vertex and by secondary vertex reconstruction.

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 2005-2006. 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 labeled as **Physics Potential of the Upgrade**.

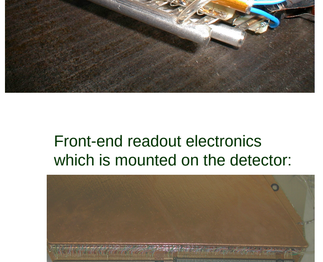
STT

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.

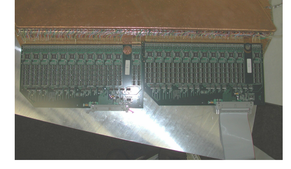


Simulated primary electron which has started an electromagnetic shower in the endplate of the Central Tracking Detector (CTD). Also shown is the barrel and forward part of the MVD.

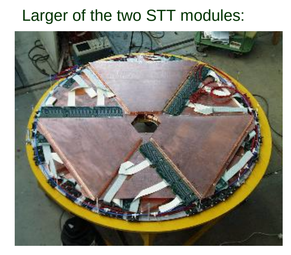
Edge of an STT sector with the gas distribution system. Straws are made of double layer of Kapton foil. A 50μm Cu/Be wire is strung down the middle of each straw.



Front-end readout electronics which is mounted on the detector:

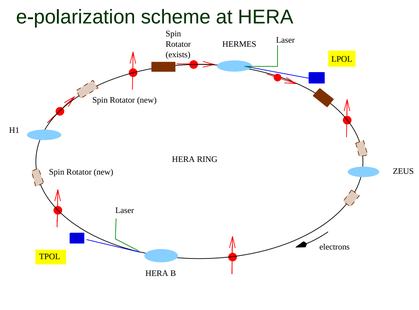


Larger of the two STT modules:

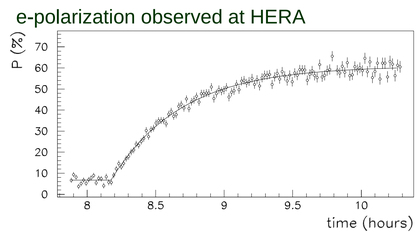


Physics Potential of the Upgrade

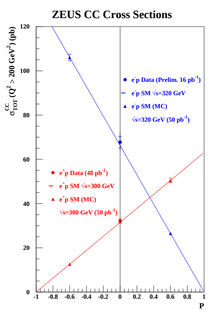
e-polarization scheme at HERA



e-polarization observed at HERA



Charged current



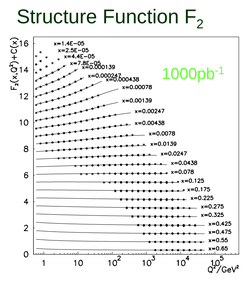
$\sigma^{CC}_{e^-p} \propto (1 \pm P)$

P = Polarization

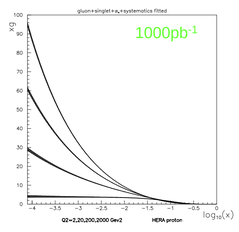
Resolution on M_W : 80MeV

Exclusion limit : $M_W(R) > 400\text{GeV}$

Structure Function F_2



⇨ High precision F_2 over large x,Q^2 range → α_s and xg

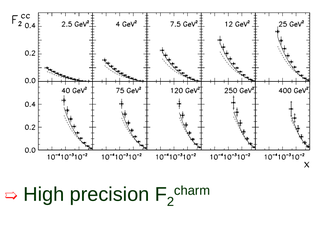


$\frac{\Delta\alpha_s}{\alpha_s} \le 0.003$

$\frac{\Delta[xg]}{xg} \approx 3\%$

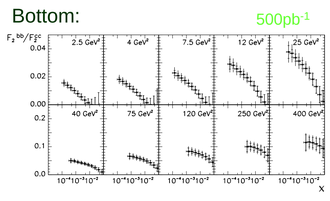
Heavy flavours in the proton

Charm:

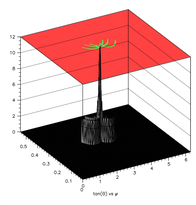


⇨ High precision F_2^{charm}

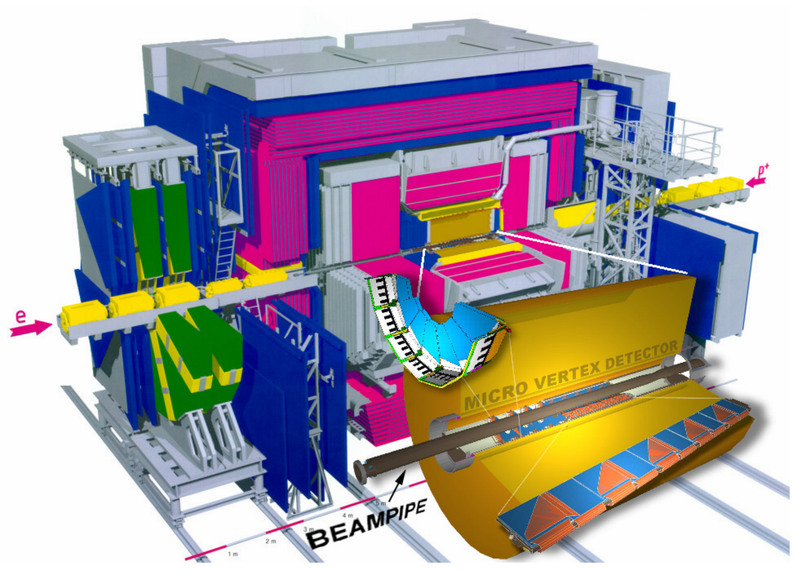
Bottom:



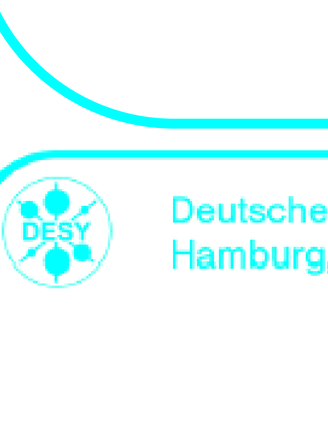
⇨ Sensitivity to bottom contribution to F_2



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

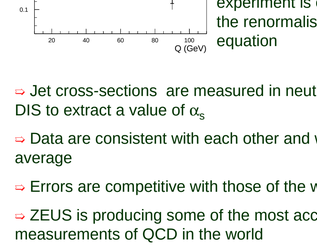


Inclusive Neutral Current and Charged Current deep-inelastic $e^{\pm}p$ scattering



Neutral and Charged Current $e^{\pm}p$ deep-inelastic scattering cross-sections have been measured. At the highest momentum transfer (lower right) the NC and CC cross-sections are of similar magnitude - a graphic verification of the electroweak unification. The proton structure function F_2 has been measured in NC $e^{\pm}p$ scattering (left) and exhibits clear scaling violations. These scaling violations have been used to determine the strong coupling constant (α_s) and the gluon density (upper right).

Measurement of Open Beauty Photoproduction



The production and semi-leptonic decay of beauty quarks has been studied using an integrated luminosity of 38.6 pb^{-1}

The cross-section for b quarks in the region of transverse momentum $p_T > p_T^{min}$ = 5 GeV is compared to NLO QCD predictions as a function of p_T^{min}

Measurement of J/ψ Helicity Distribution

The Helicity parameter α has been measured for J/ψ inelastic photoproduction as a function of the J/ψ transverse momentum.

The results are compared with predictions of semi-hard calculations using KMS and GRV unintegrated gluon distributions.

Physics Results Highlights

Vector-meson production at ZEUS

⇨ ρ in photoproduction: slow rise in W

similar to hadron-hadron total cross-sections: soft process

⇨ With hard scale (Q^2,M_V^2): steep rise in W

reflecting large gluon density at low-x ($W^2 \sim 1/x$): consistent with pQCD (hard process)

Search for Large Extra Dimensions and Quark Radius

⇨ LED-models: exchange of Kaluza-Klein graviton excitations in high-energy collisions

⇨ At HERA: deviations from NC DIS at highest Q^2

ZEUS Large Extra Dimensions and Quark Radius

Data/SM from e^+p:

Data/SM from e^-p:

Also fitted with classical quark form factor:

$F(Q^2)=(1-R^2Q^2/6)^2$

Preliminary 95% CL limits from combined 1994-2000 $e^{\pm}p$ data

Result from 130 pb^{-1}:

$M_S^+ > 0.81$ TeV
$M_S^- > 0.82$ TeV
$R_q < 0.73 \cdot 10^{-16}$ cm

QCD and hadronic final state

The strong coupling constant α_s is expected to run with the scale Q:

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

Running within one experiment is consistent with the renormalisation group equation

⇨ Jet cross-sections are measured in neutral current DIS to extract a value of 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 accurate measurements of QCD in the world

Deutsches Elektronen-Synchrotron
Hamburg, Germany

http://www-zeus.desy.de