Recent electroweak measurements from the H1 and ZEUS experiments

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On behalf of H1 and ZEUS

Moriond,
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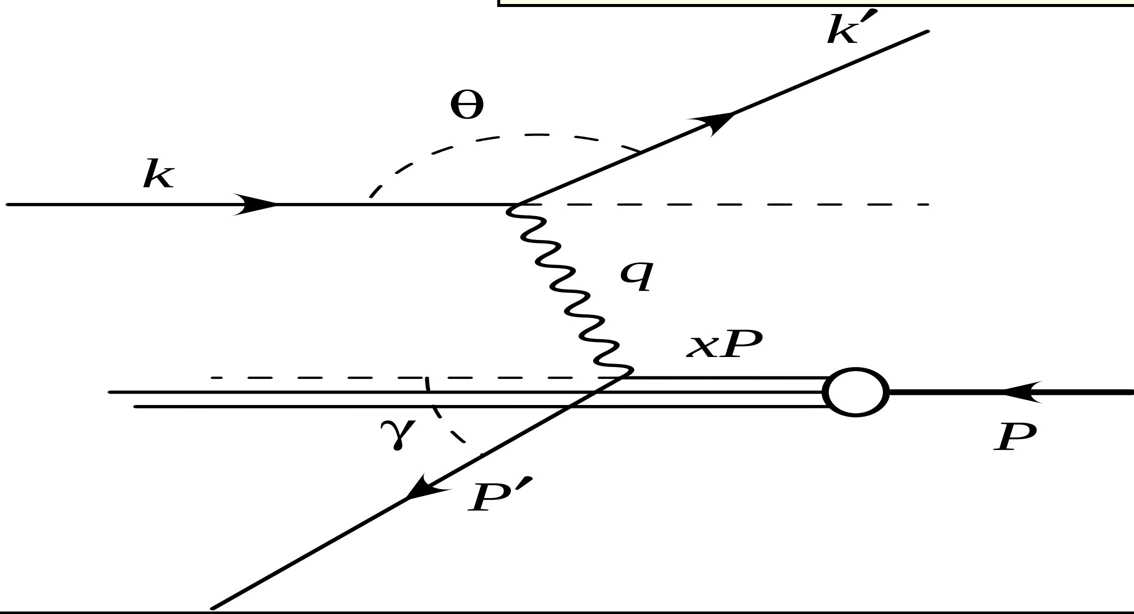
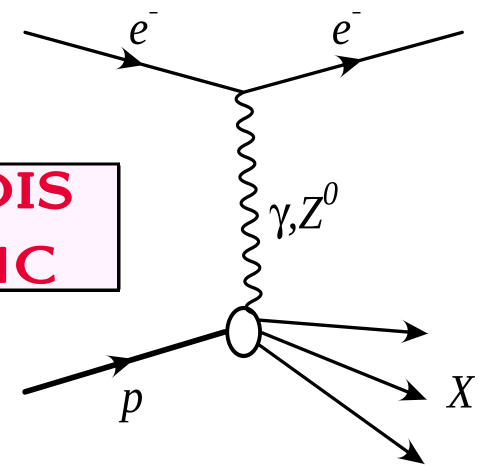
- NC & CC interactions
- Results from HERA I
- HERA II
- CC X-section & polarization
- Summary

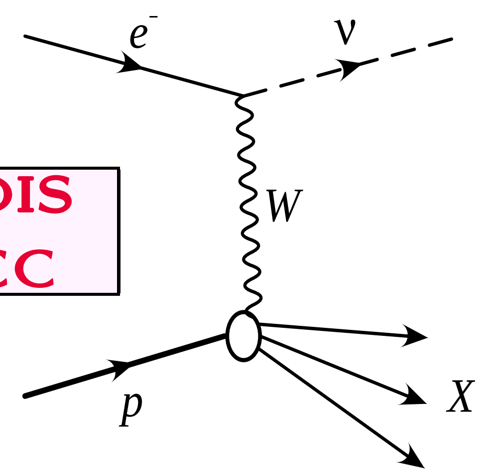
Kinematics



DIS
NC



DIS
CC

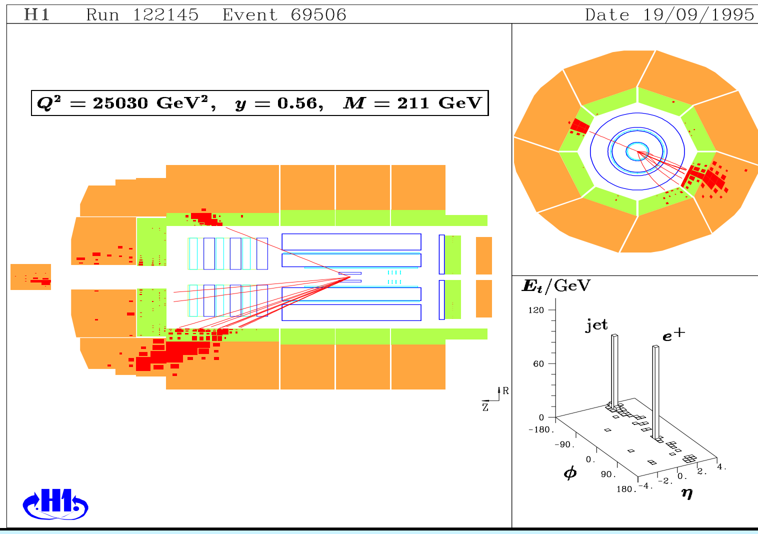


Kinematic variables

- $s \equiv (k+P)^2 \rightarrow \sqrt{s}$: C.M. energy (318 GeV)
- $Q^2 \equiv -(k-k')^2 \rightarrow$ Exch. boson virtuality
- $x \equiv \frac{Q^2}{2P\cdot q} \rightarrow$ Bjorken x
- $y \equiv \frac{q\cdot P}{k\cdot P} \rightarrow$ Inelasticity

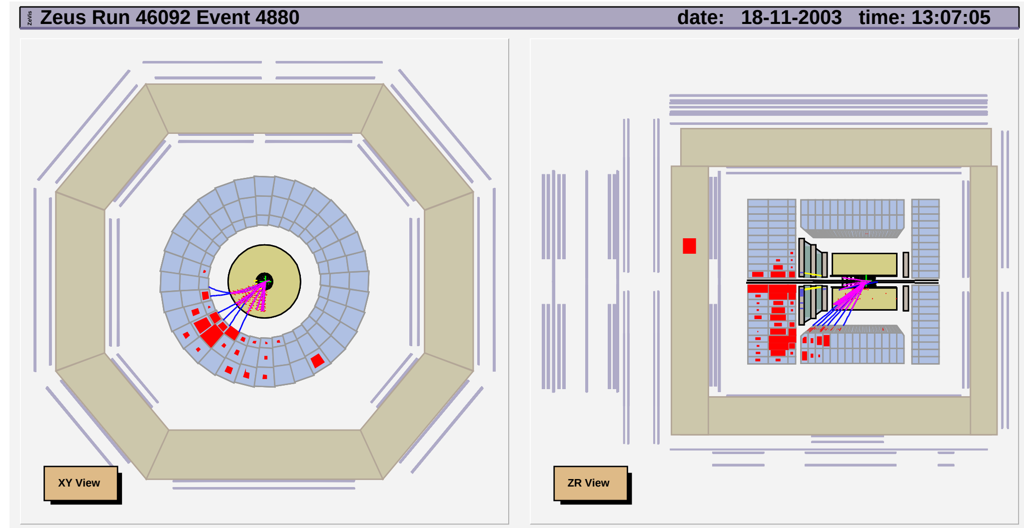
NC & CC: Examples

DIS NC event from H1



- DIS NC event $\Longrightarrow$ electron is detected in the calorimeter
- NC event $\Longrightarrow$ electron P_T balances the hadronic final state P_T

DIS CC event from ZEUS

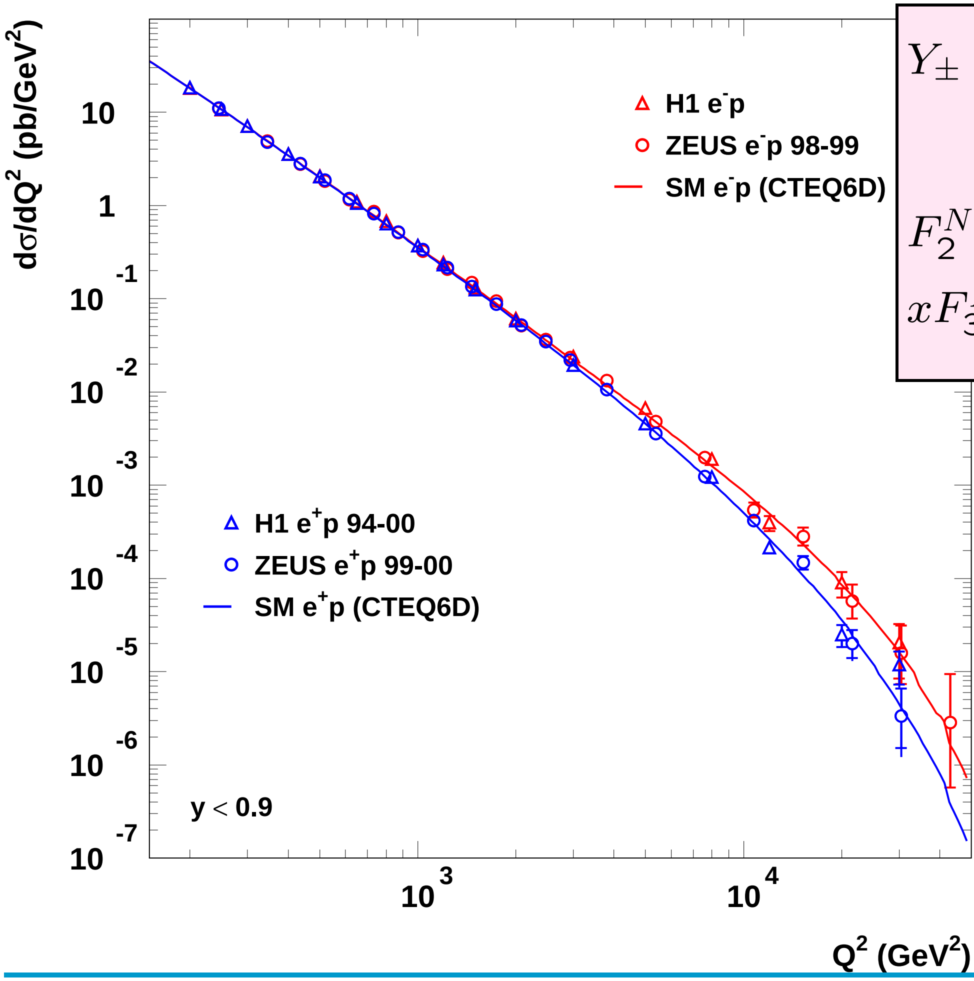


- CC event $\Longrightarrow$ ν escapes detection
- CC events $\Longrightarrow$ high missing P_T

- 99 % solid angle coverage with calorimeters

NC cross section

$$\frac{d^2\sigma^{NC}_{Born}(e^{\pm}p)}{dxdQ^2} = \frac{2\pi\alpha^2}{xQ^4}[Y_+F_2^{NC}(x,Q^2) \mp Y_- xF_3^{NC}(x,Q^2) - y^2F_L^{NC}(x,Q^2)]$$



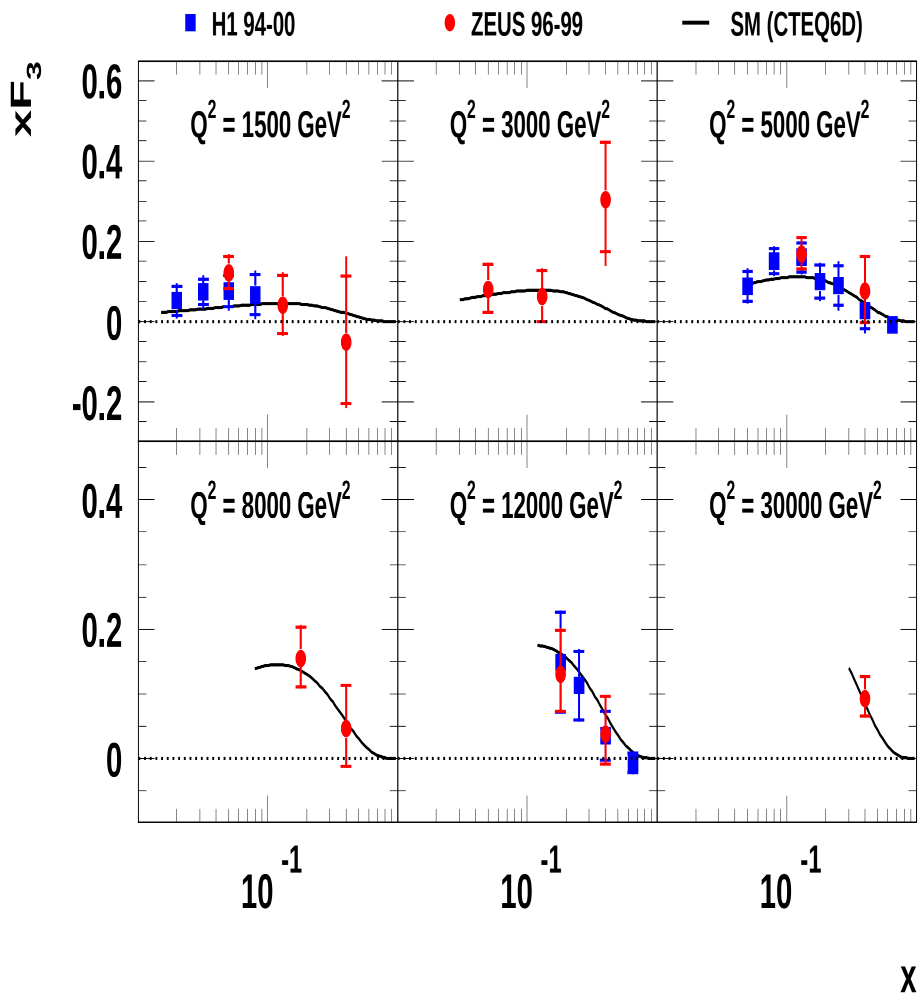
$$Y_{\pm} \equiv 1 \pm (1-y)^2$$

$$F_2^{NC}(x,Q^2) = \boldsymbol{F_2^{em}} + \frac{Q^2}{Q^2+M_Z^2}\boldsymbol{F_2^{\gamma/Z}} + \left(\frac{Q^2}{Q^2+M_Z^2}\right)^2\boldsymbol{F_2^Z}$$

$$xF_3^{NC}(x,Q^2) = \frac{Q^2}{Q^2+M_Z^2}\boldsymbol{xF_3^{\gamma/Z}} + \left(\frac{Q^2}{Q^2+M_Z^2}\right)^2\boldsymbol{xF_3^Z}$$

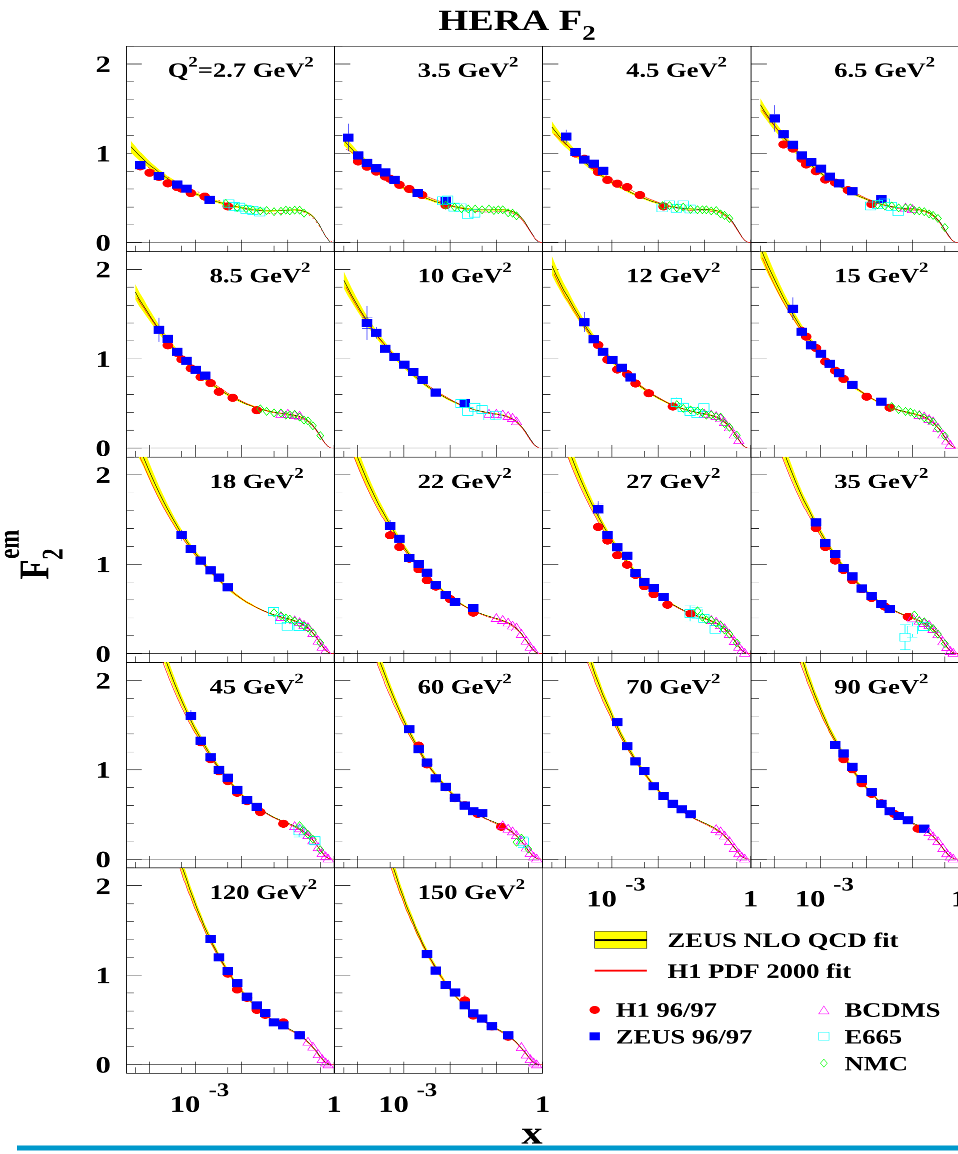
- F_2^{em} is dominant in F_2
- Interference γ/Z changes sign for e^-p, $e^+p \Longrightarrow$ direct detection of weak contribution

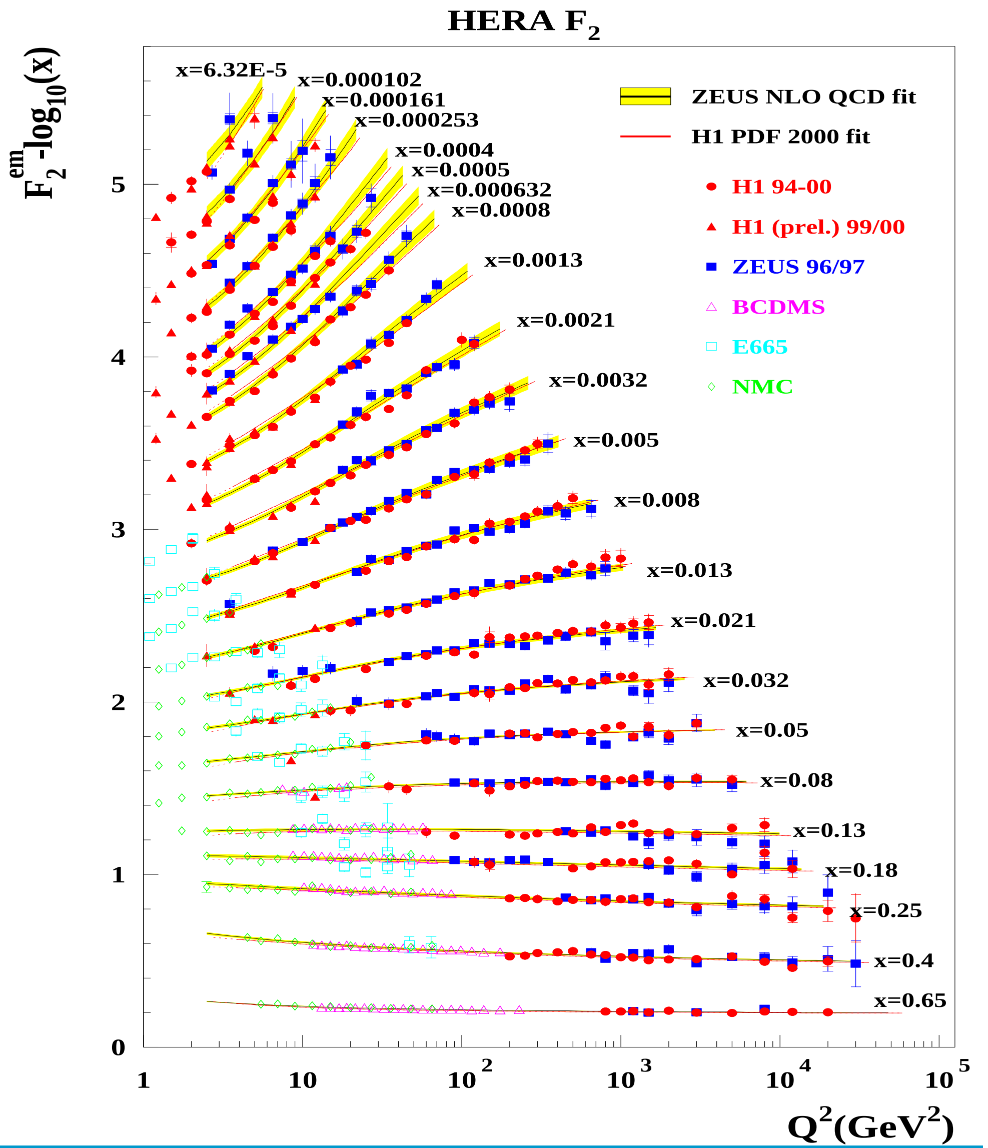
xF_3^{NC}



- High $Q^2 \Longrightarrow$ valence quarks are dominant
- xF_3 has been measured at HERA I
- Precision limited by e^-p data sample
- Clear need for higher luminosity

Structure function F_2^{em}

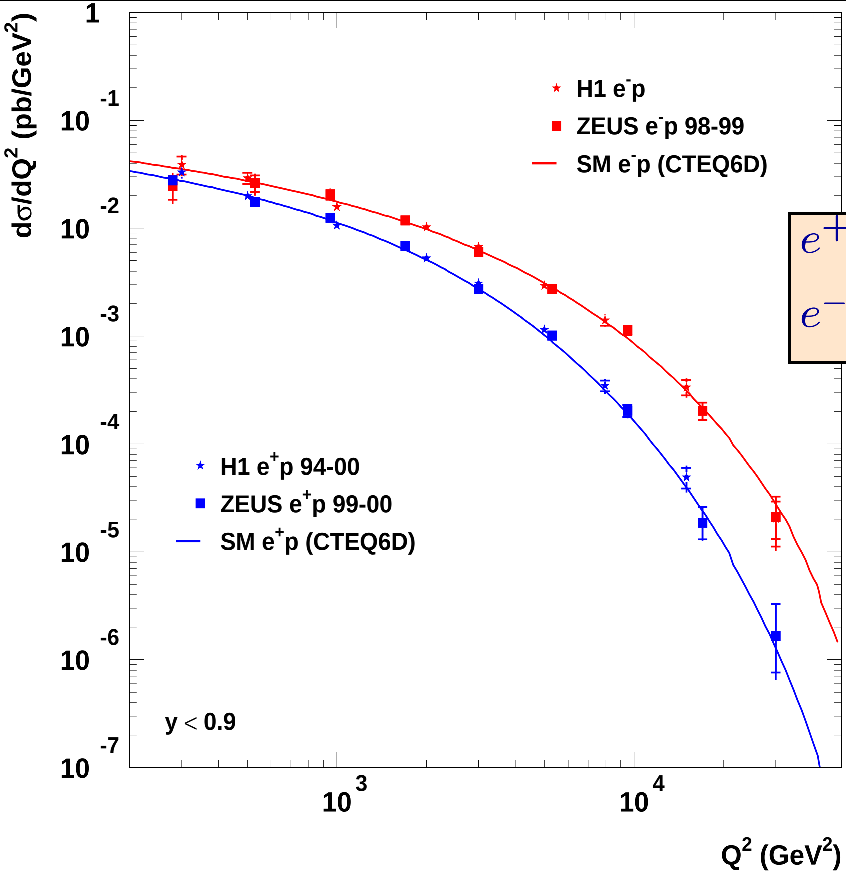




CC cross section

$$\frac{d^2\sigma^{CC}_{Born}(e^{\pm}p)}{dxdQ^2} = \frac{G_F^2}{4\pi x}\frac{M_W^4}{(Q^2+M_W^2)^2}[Y_+F_2^{CC}(x,Q^2) \mp Y_- xF_3^{CC}(x,Q^2) - y^2F_L^{CC}(x,Q^2)](1 \pm P)$$

$$e^+p: \quad F_2^{CC} = x[(d+s)+(\bar{u}+\bar{c})]$$
$$xF_3^{CC} = x[(d+s)-(\bar{u}-\bar{c})]$$
$$e^-p: \quad F_2^{CC} = x[(u+c)+(\bar{d}+\bar{s})]$$
$$xF_3^{CC} = x[(u+c)-(\bar{d}-\bar{s})]$$



$e^+p \Longrightarrow d$ **quark sensitive**

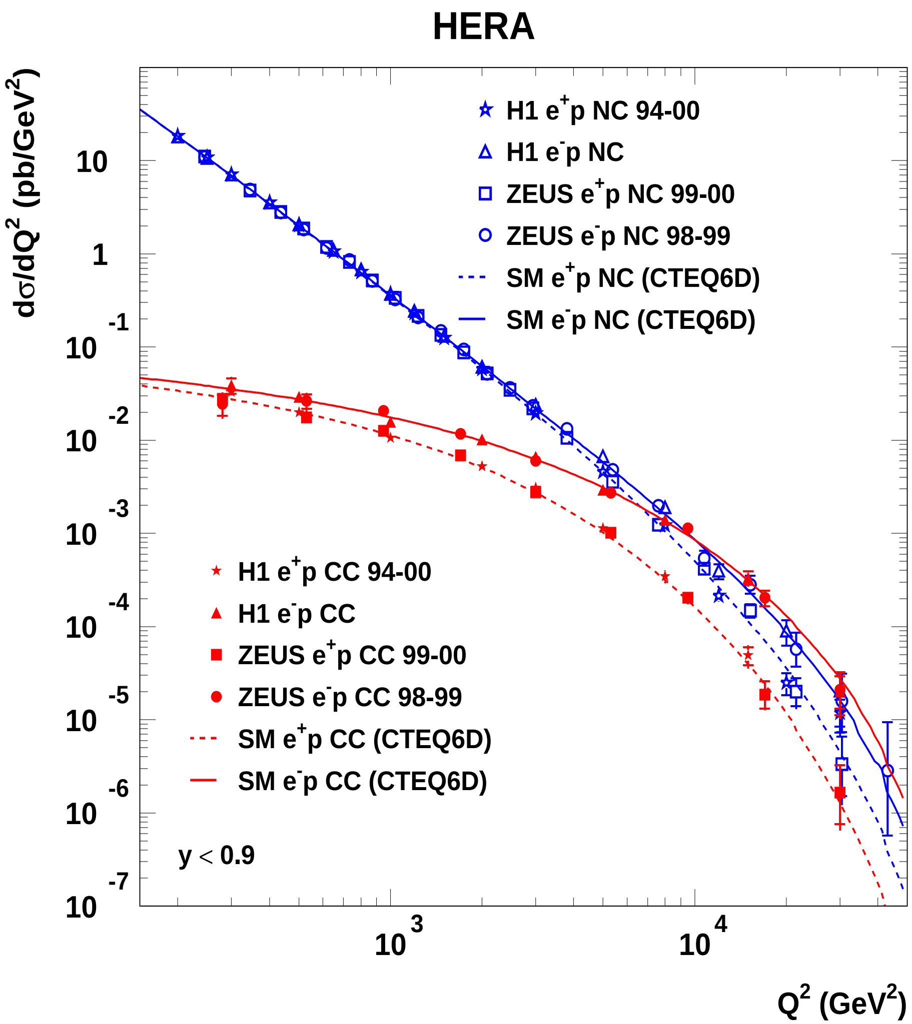
$e^-p \Longrightarrow u$ **quark sensitive**

At HERA

Low $Q^2 \Longrightarrow$ sea quarks are dominant
$\sigma^{CC}(e^-p) \approx \sigma^{CC}(e^+p)$

High $Q^2 \Longrightarrow$ valence quarks are dominant
$\sigma^{CC}(e^-p) > \sigma^{CC}(e^+p)$

EW unification

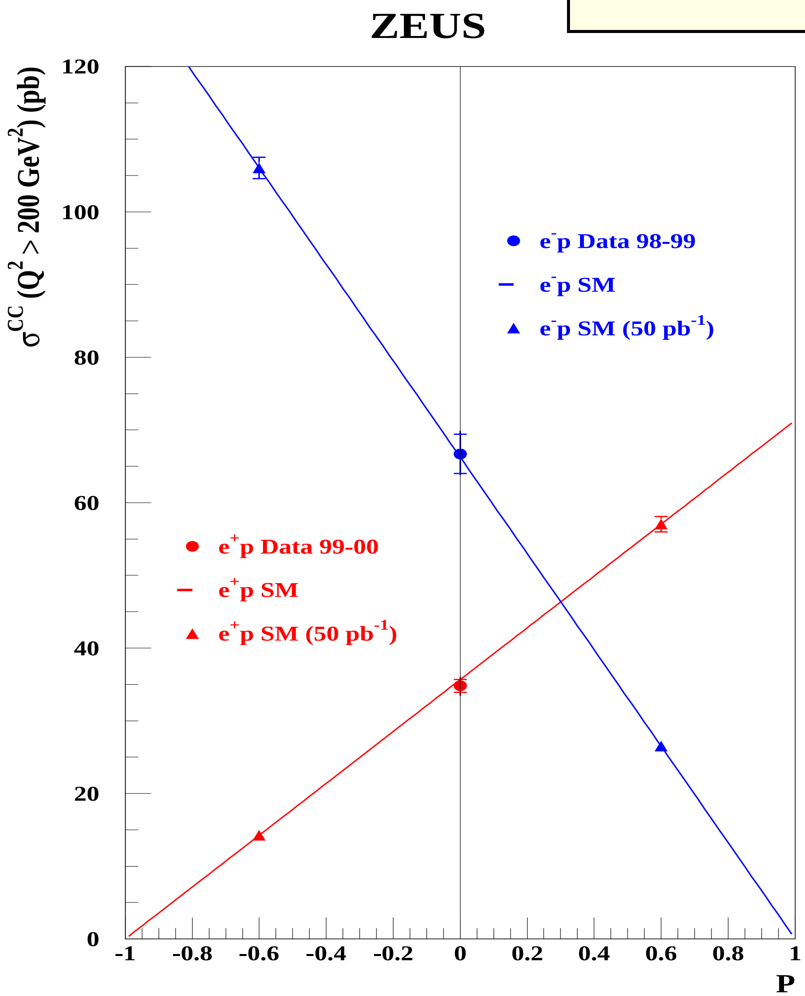


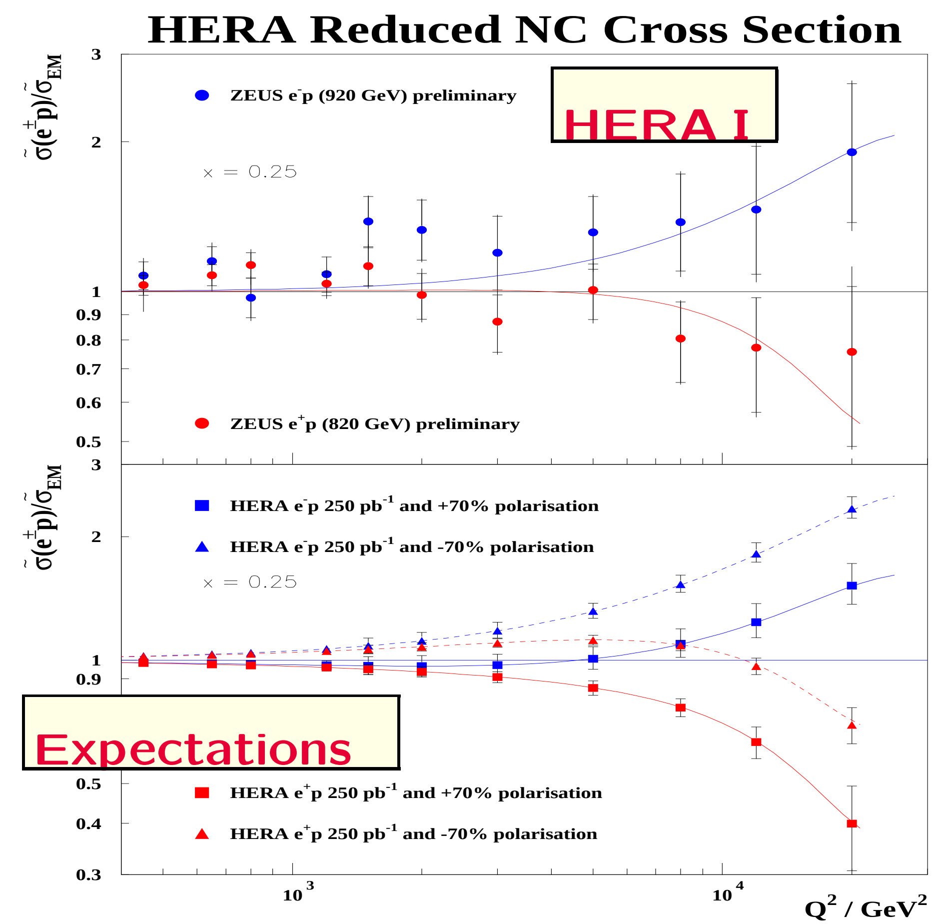
- Low $Q^2 \Longrightarrow$ NC process is dominated by QED (γ exchange only) $\Longrightarrow \frac{\sigma^{CC}}{\sigma^{NC}} \ll 1$

- At high Q^2 ($Q^2 \approx M_Z^2$), γ and Z have similar contributions to NC cross section

- At high Q^2 ($Q^2 \approx M_W^2$) $\Longrightarrow$ $\frac{\sigma^{CC}}{\sigma^{NC}} \approx 1$

HERA II

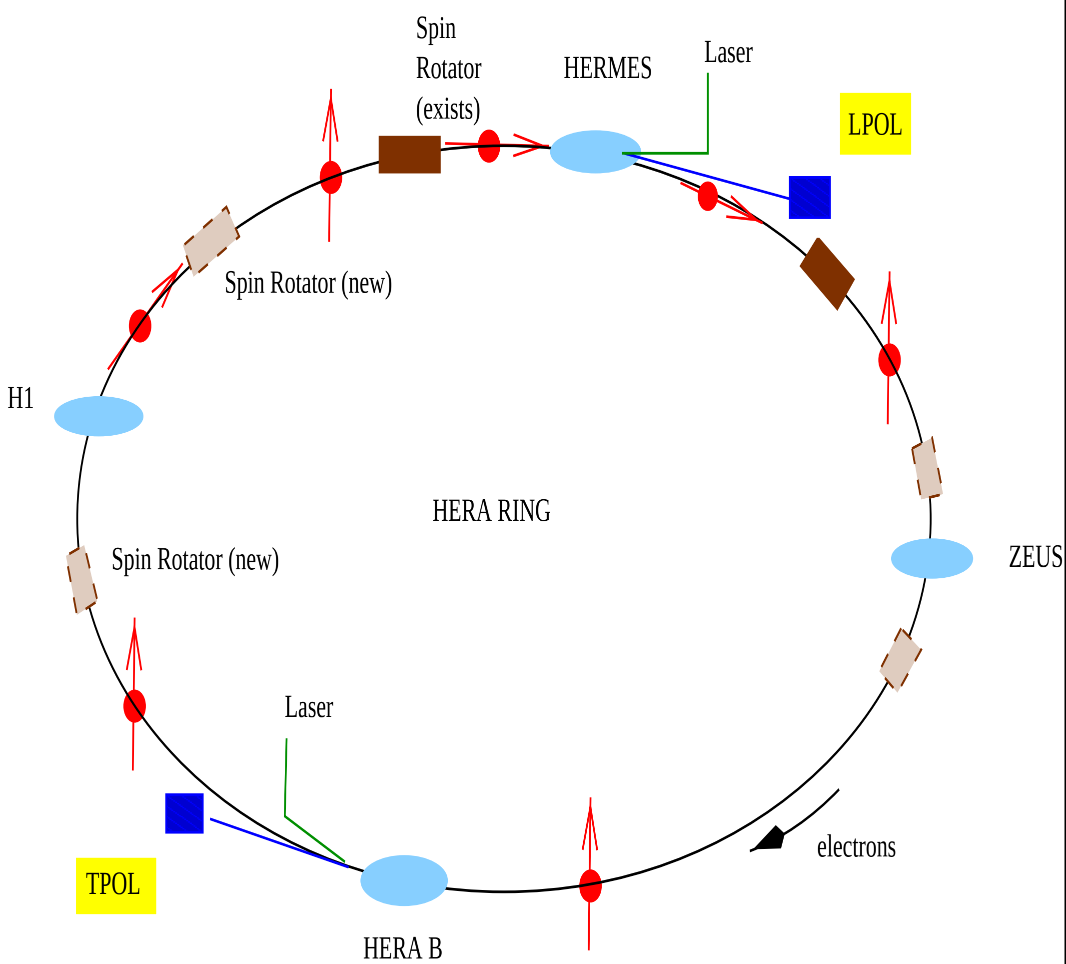




$$\sigma^{CC}(p = P) = \sigma^{CC}(p = 0)(1 \pm P)$$

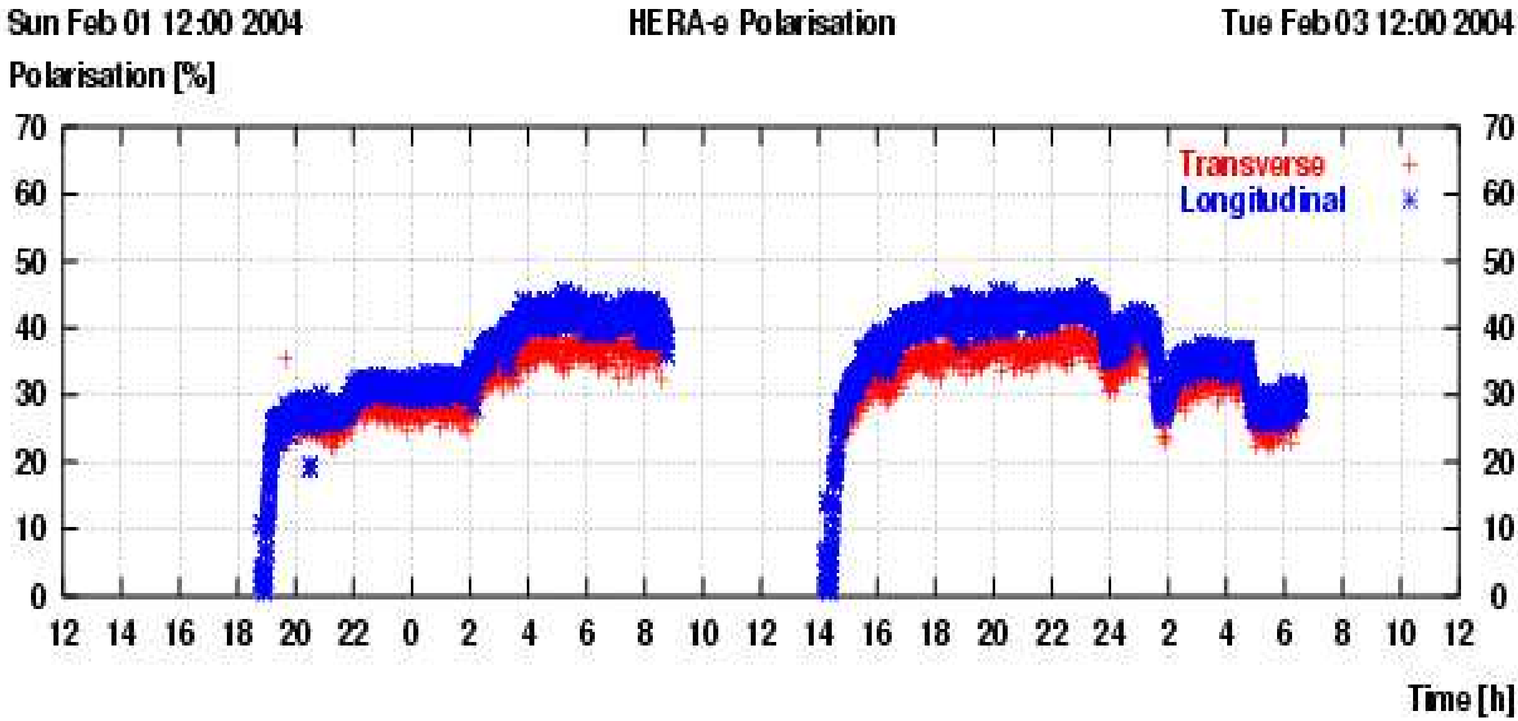
Testing the SM?

HERA upgrade

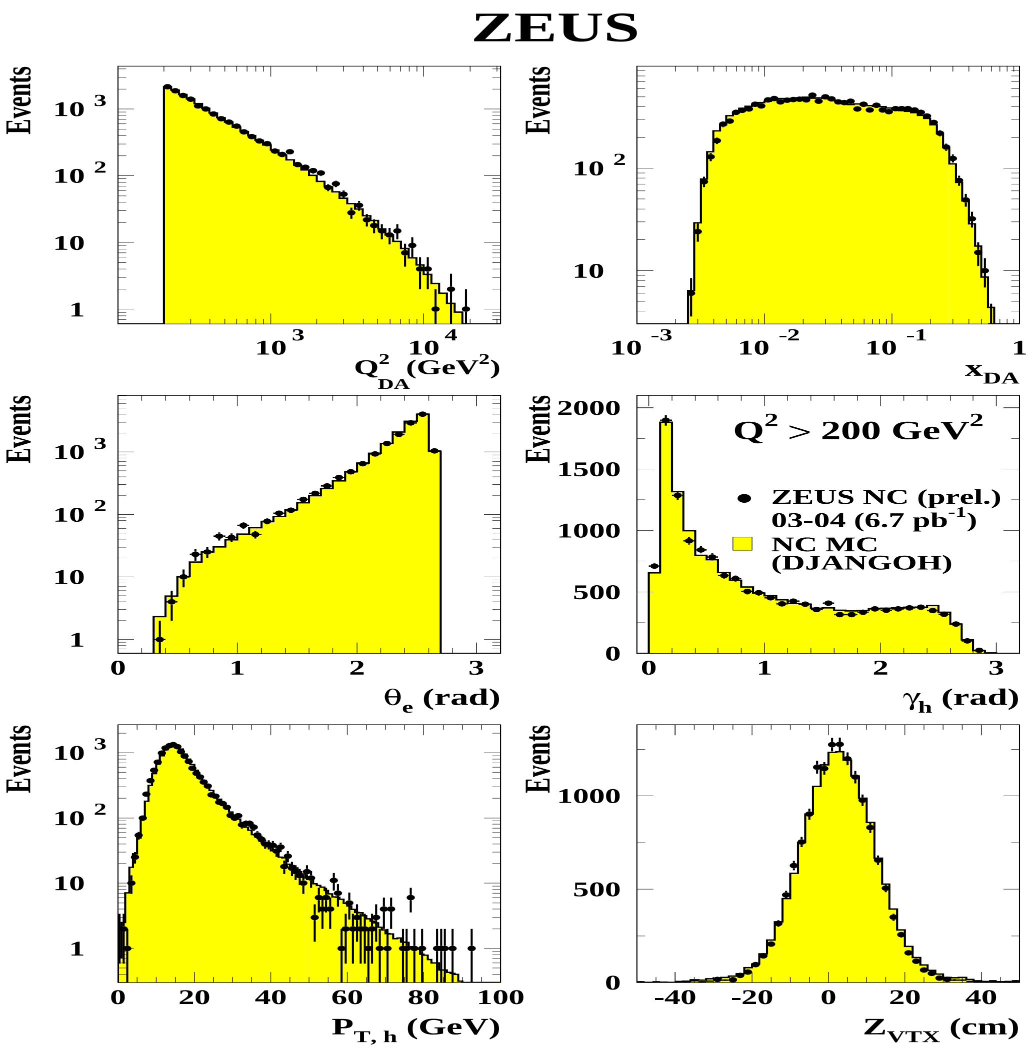


- Electrons in storage rings can become transversely polarized up to P_{Max} = 92.4 % due to synchrotron radiation. (**Sokolov-Ternov Effect**)
- Transverse polarization $\Longrightarrow$ Spin rotators $\Longrightarrow$ Longitudinal polarization.
- Two independent polarimeters (LPOL & TPOL) measure the polarization
- Spin rotators are installed close to **H1** and **ZEUS** experiments.

Polarization



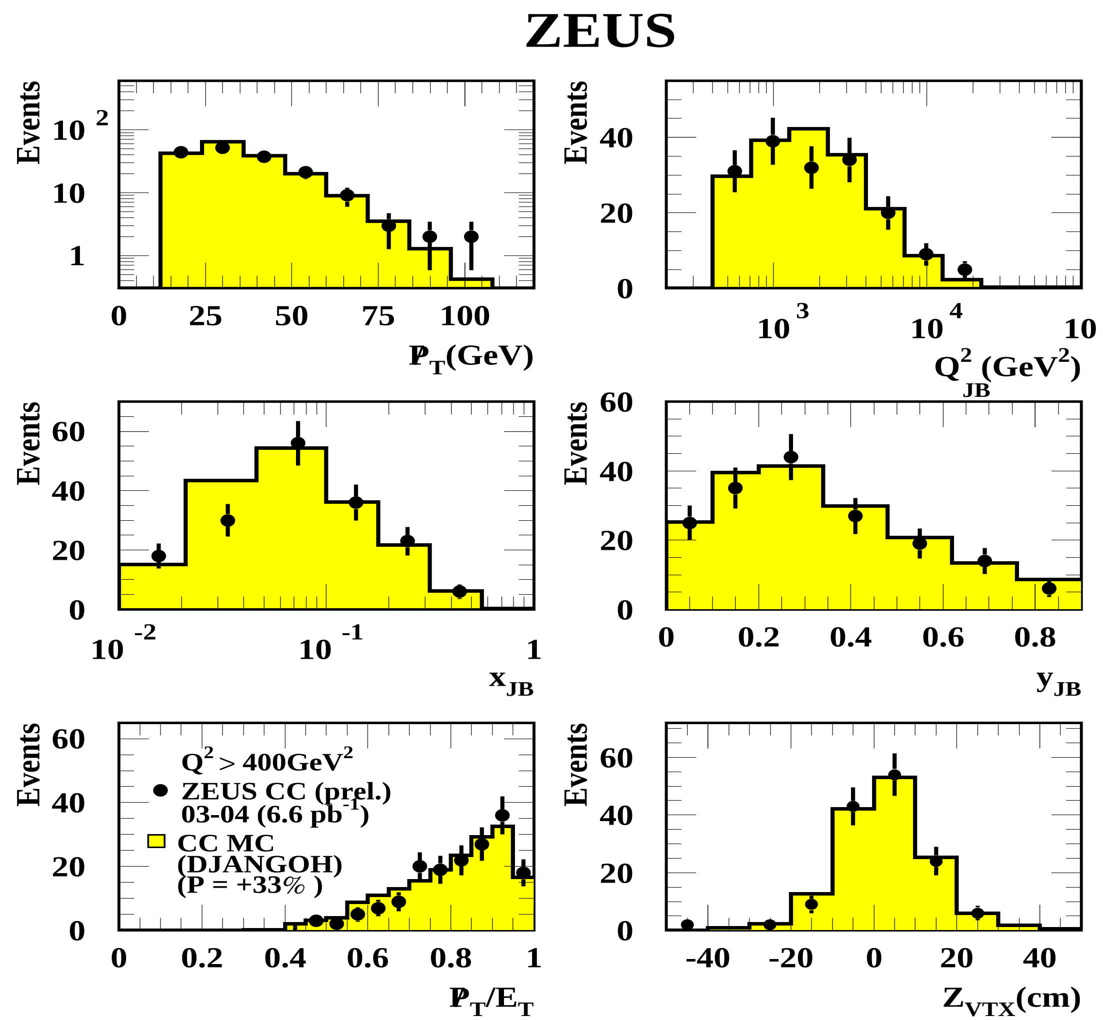
NC Events



- 15000 NC events observed with ZEUS
- Agreement between MC and data
- The hadronic final state is well simulated $\Longrightarrow$ Ready to analyze the CC events

CC Events

- 2003 & 2004 data with $Q^2 >$ 400 GeV^2, $P = 33$ % and $\mathcal{L} =$ 6.6 pb^{-1}
- The kinematic variables are reconstructed from hadronic final state only
- MC expectation gives a good description of the data



CC cross section

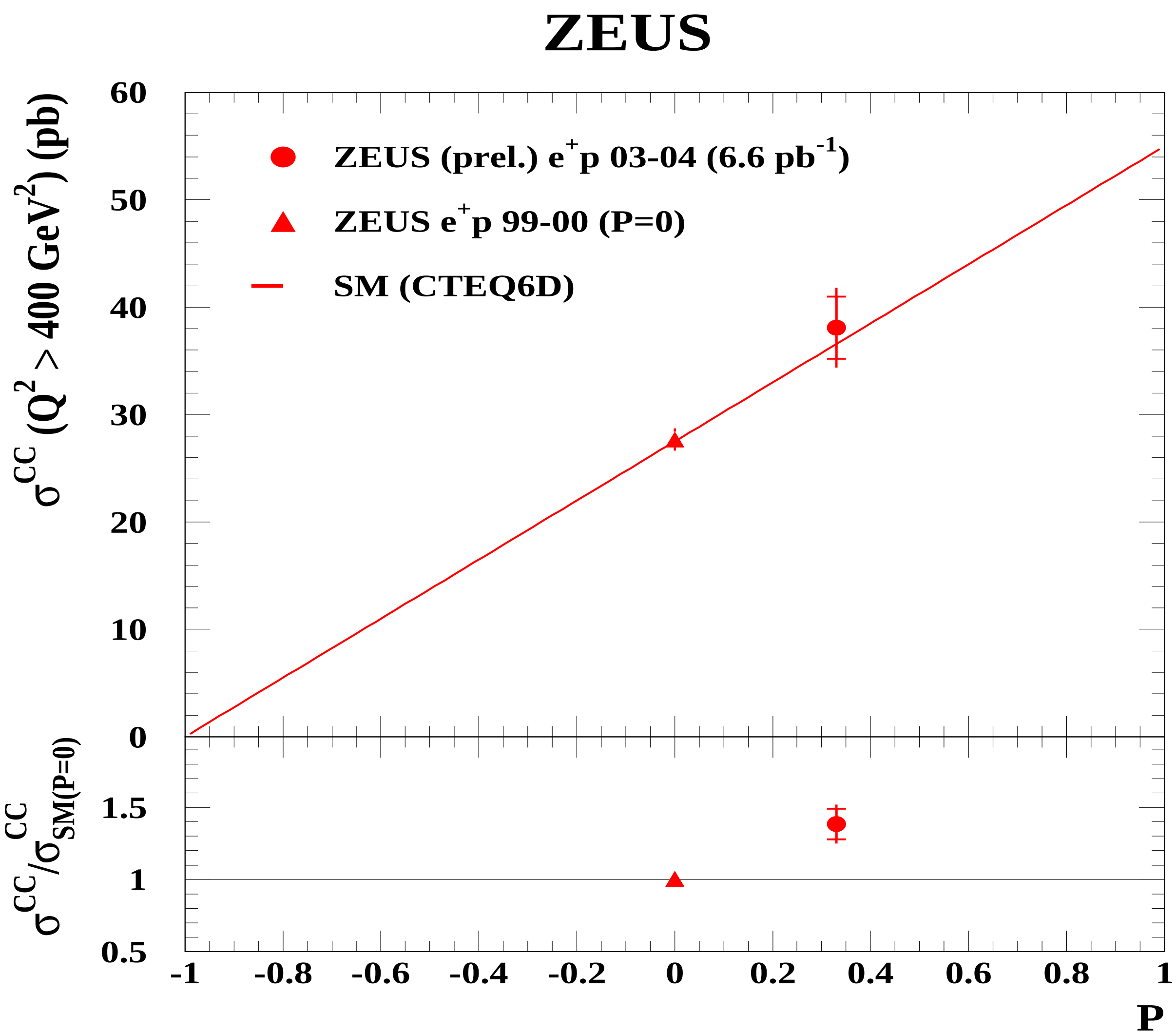
$$\sigma^{CC}_{Born}(p=P) = \frac{N^{data}}{N^{MC}} \sigma^{CC}_{theory}(p=0) \cdot (1+P)$$

- N^{data}: Number of CC events found
- N^{MC}: Number of CC events expected at $p = P$
- $\sigma^{theory}(p = 0)$ Non-polarized theoretical cross section
- P: polarization average

ZEUS result, $Q^2 > 400$ GeV^2 and $P = 33$ %

$\sigma^{CC} = 38.1 \pm 2.9(stat) \pm 0.8(syst) \pm 2.0(lumi) \pm 0.8(pol)$ pb

CC cross section vs polarization



Summary

- The structure functions have been measured with HERA I data over wide kinematic phase space.
- HERA I was upgraded to provide longitudinal polarized electrons (positrons) and to increase significantly the statistics.
- First data from HERA II are collected with **H1** and **ZEUS** detectors.
- The ZEUS CC cross section vs polarization was presented and found consistent with SM predictions.
- HERA II will deliver left/right handed positrons/electrons:

1. The CC and NC cross sections will be measured at different polarization values.
2. More statistics will be collected.