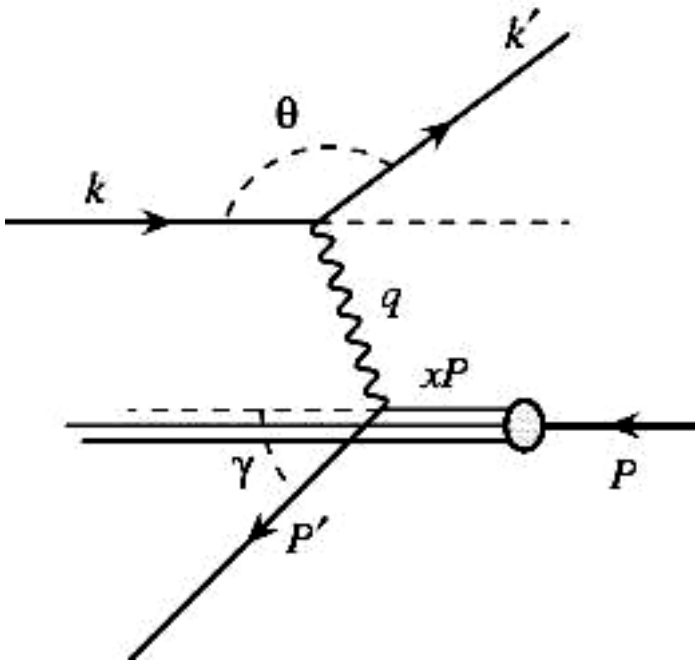
Imperial College London

ZEUS

High Q^2 DIS cross sections at HERA with longitudinally polarised positron beams

Alex Tapper

Deep inelastic scattering at HERA



Neutral current: exchange of γ or Z^0

Charged current: exchange of $W^{\pm}$

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

$$x = \frac{Q^2}{2p \cdot q} \qquad y = \frac{p \cdot q}{p \cdot k}$$

$$s = (p + k)^2 \qquad Q^2 = x \cdot y \cdot s$$

- Q^2 is the probing power
- x is the Bjorken scaling variable
- y is the inelasticity

Neutral current DIS cross section

NC Reduced cross section: $\tilde{\sigma}_{NC}(x,Q^2)$

$$\frac{d^2\sigma^{NC}(e^{\pm}p)}{dxdQ^2} = \frac{2\pi\alpha^2}{xQ^4} Y_+ \left[F_2 - \frac{y^2}{Y_+} F_L \mp \frac{Y_-}{Y_+} xF_3 \right] \qquad Y_{\pm} = 1 \pm (1-y)^2$$

Dominant contribution

Sizeable only at high y

Contribution only important at high Q^2

$$F_2 = F_2^{em} + \frac{Q^2}{Q^2+M_Z^2} F_2^{\gamma Z} + \left[\frac{Q^2}{Q^2+M_Z^2}\right]^2 F_2^Z \propto \sum_{q=u\ldots b} (q+\bar{q})$$

$$xF_3 = \frac{Q^2}{Q^2+M_Z^2} xF_3^{\gamma Z} + \left[\frac{Q^2}{Q^2+M_Z^2}\right]^2 xF_3^Z \propto \sum_{q=u\ldots b} (q-\bar{q})$$

Charged current DIS cross section

CC e^+p cross section:

$$\frac{d^2\sigma^{CC}(e^+p)}{dxdQ^2} = \frac{G_F^2}{4\pi x}\left(\frac{M_W^2}{M_W^2+Q^2}\right)^2\left[\bar{u}+\bar{c}+(1-y)^2(d+s)\right]$$

CC e^-p cross section:

$$\frac{d^2\sigma^{CC}(e^-p)}{dxdQ^2} = \frac{G_F^2}{4\pi x}\left(\frac{M_W^2}{M_W^2+Q^2}\right)^2\left[u+c+(1-y)^2(\bar{d}+\bar{s})\right]$$

Electron/positron-proton collisions probe different quark content of proton

Big difference in cross section magnitude

Cross sections suppressed due to large mass of W boson compared to NC DIS

Polarised DIS cross sections

NC cross section modified by P:

$$\frac{d^2\sigma(e^{\pm}p)}{dxdQ^2} = \frac{2\pi\alpha^2}{xQ^4}\left[H_0^{\pm} + PH_P^{\pm}\right] \qquad P = \frac{N_R - N_L}{N_R + N_L}$$

Unpolarised contribution

Polarised contribution - only includes Z and γZ terms

Polarised contribution only significant at high Q^2 - subtle effect at HERA

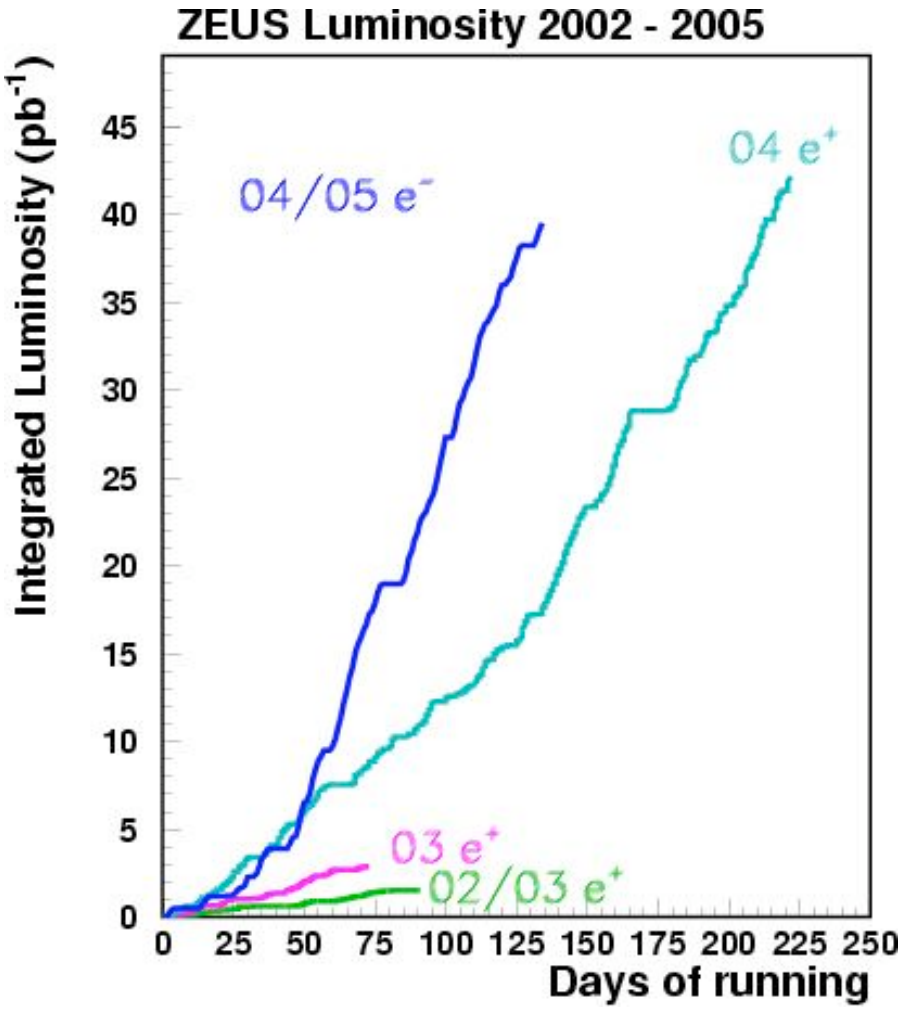
CC cross section modified by P:

$$\sigma_{CC}^{e^{\pm}p}(P) = (1 \pm P) \cdot \sigma_{CC}^{e^{\pm}p}(0)$$

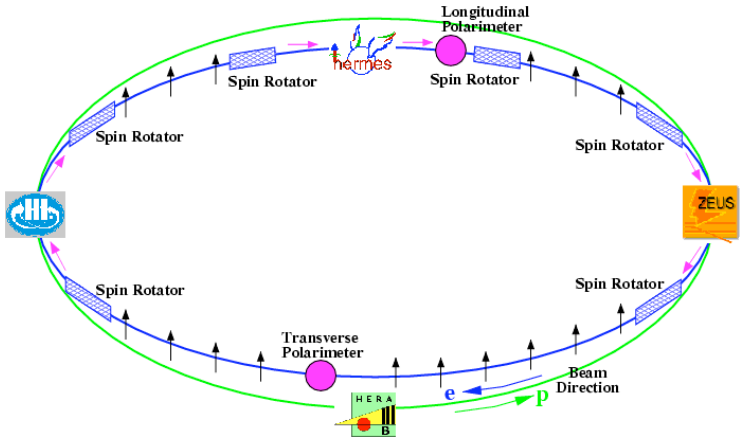
Polarisation scales P=0 cross section linearly - clear and large effect at HERA

HERA II operation - luminosity

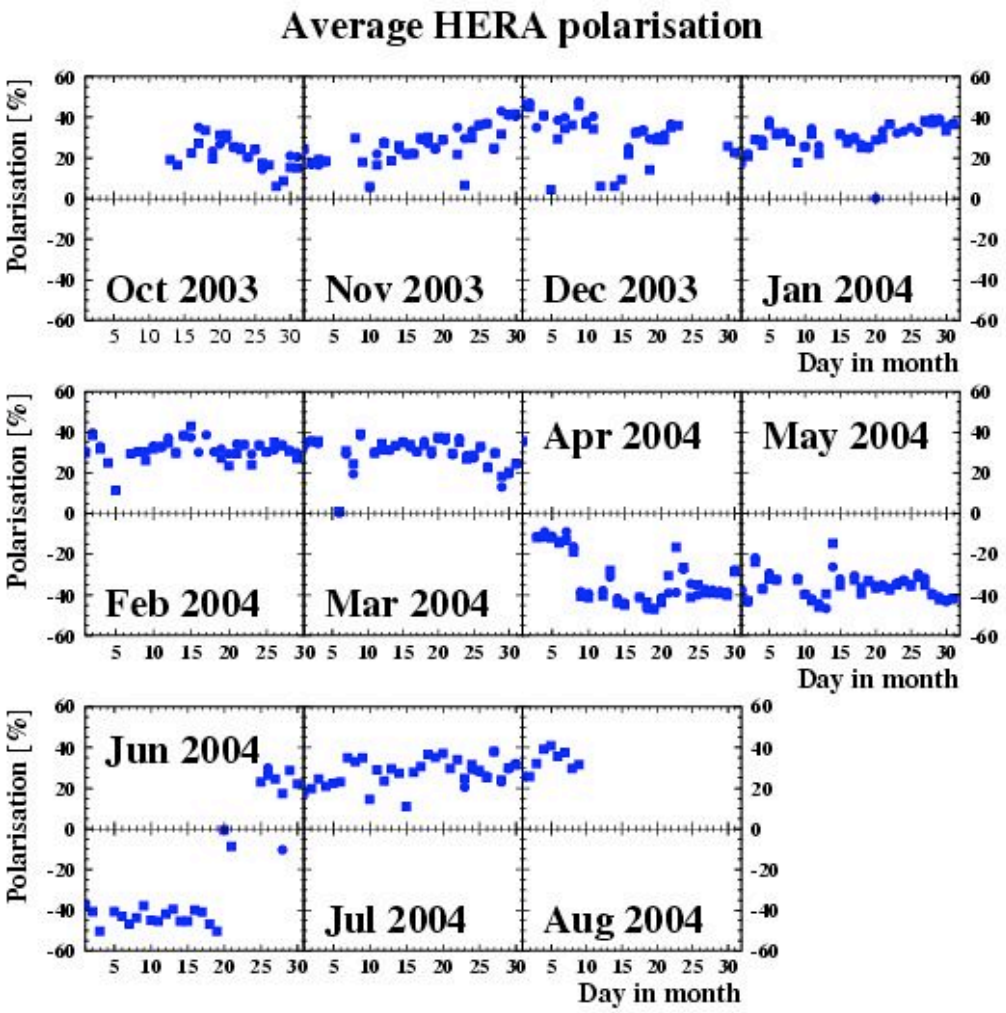
- Positrons/electrons of energy 27.6 GeV
- Protons of energy 920 GeV
- Centre-of-mass energy ~320 GeV
- ZEUS physics luminosity over 40 pb^{-1} of both e^+p and e^-p collisions
- This analysis based on 30.5 pb^{-1} e^+p data collected in 2003 and 2004



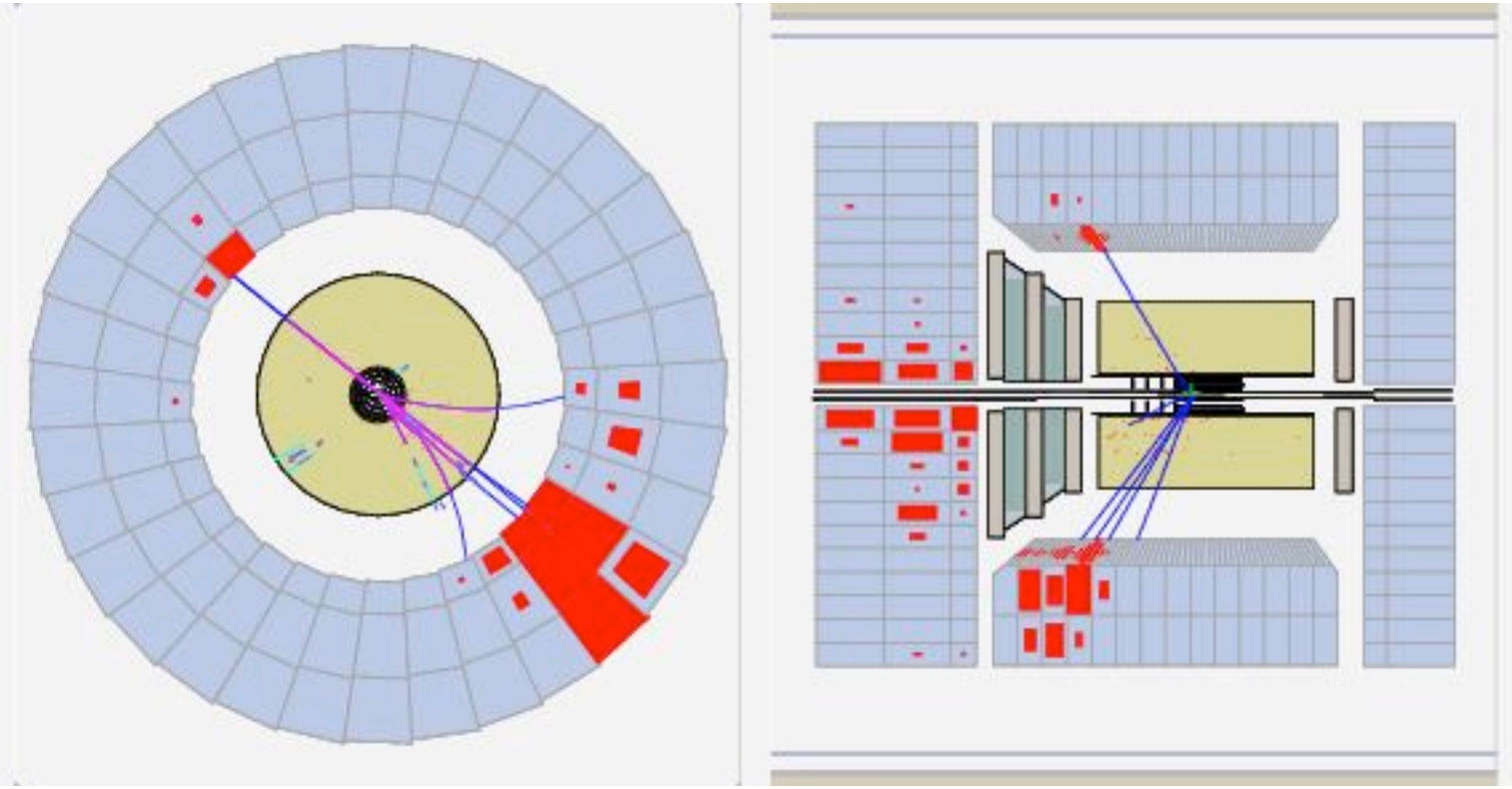
HERA II operation - polarisation



- Transverse polarisation of leptons builds up naturally
- Measured by two independent Compton polarimeters
- Spin rotators convert to longitudinal polarisation
- Luminosity weighted average polarisations of
  -40% and +32%

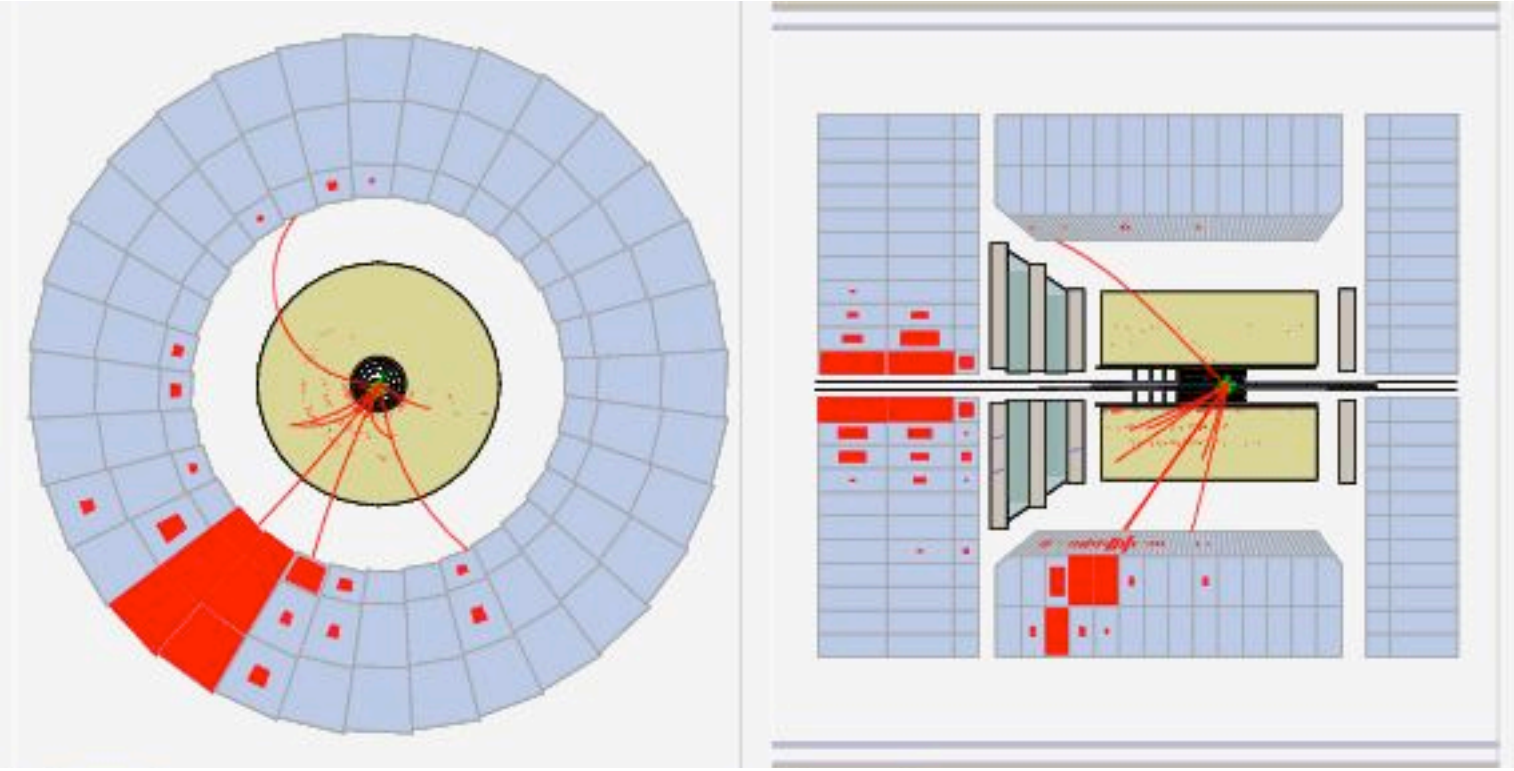


NC events in the ZEUS detector



Isolated high P_T positron with hadronic jet balanced in ϕ

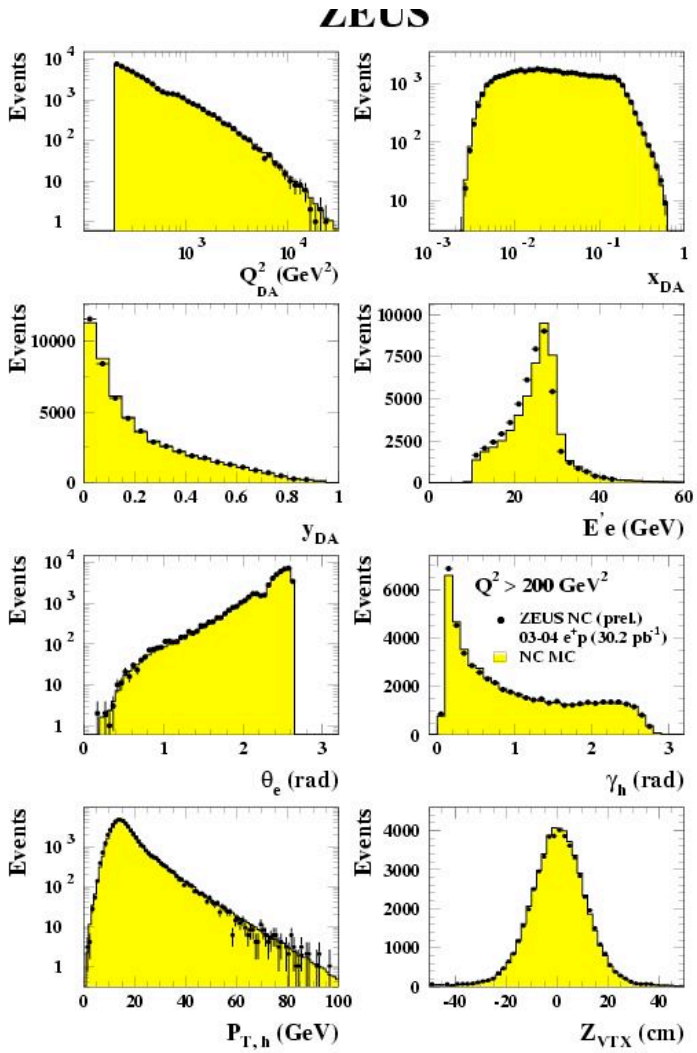
CC events in the ZEUS detector



Missing transverse momentum from the undetected neutrino

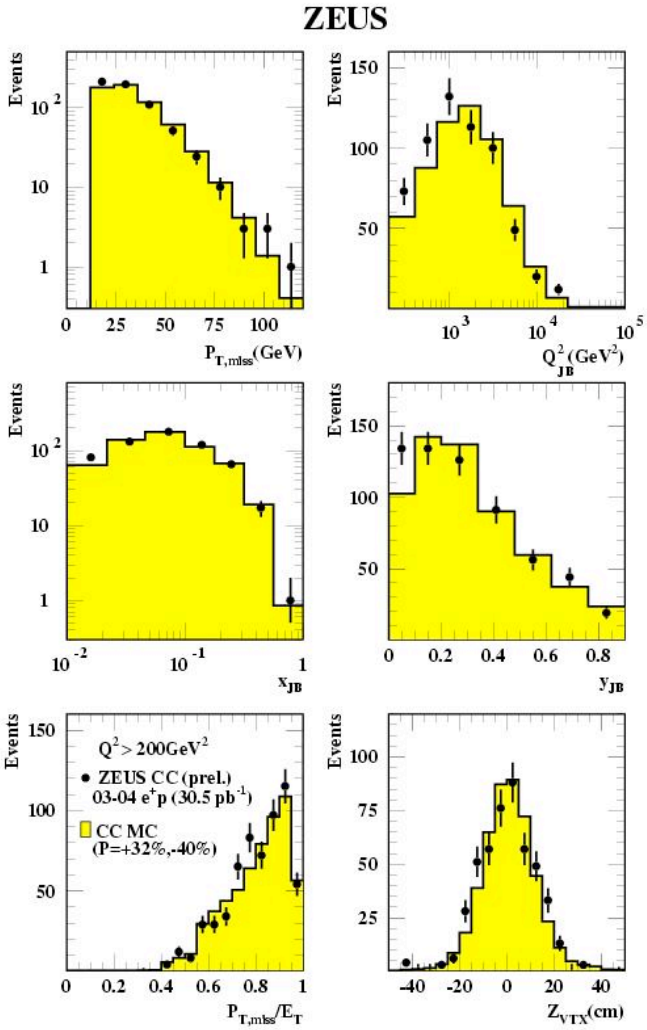
Neutral current sample

- Q^2, x and y from double angle reconstruction
- Scattered electron energy and angle
- Z position of ep interaction vertex
- Angle and transverse momentum of hadronic final state
- Hadronic system measurement crucial to charged current measurement
- Checked with high precision NC sample



Charged current sample

- Missing transverse momentum
- Q^2, x and y from hadronic final state
- Z position of ep interaction vertex
- Data well described by Monte Carlo
- Use to unfold cross sections



Charged current cross sections

$Q^2 > 200\ GeV^2$

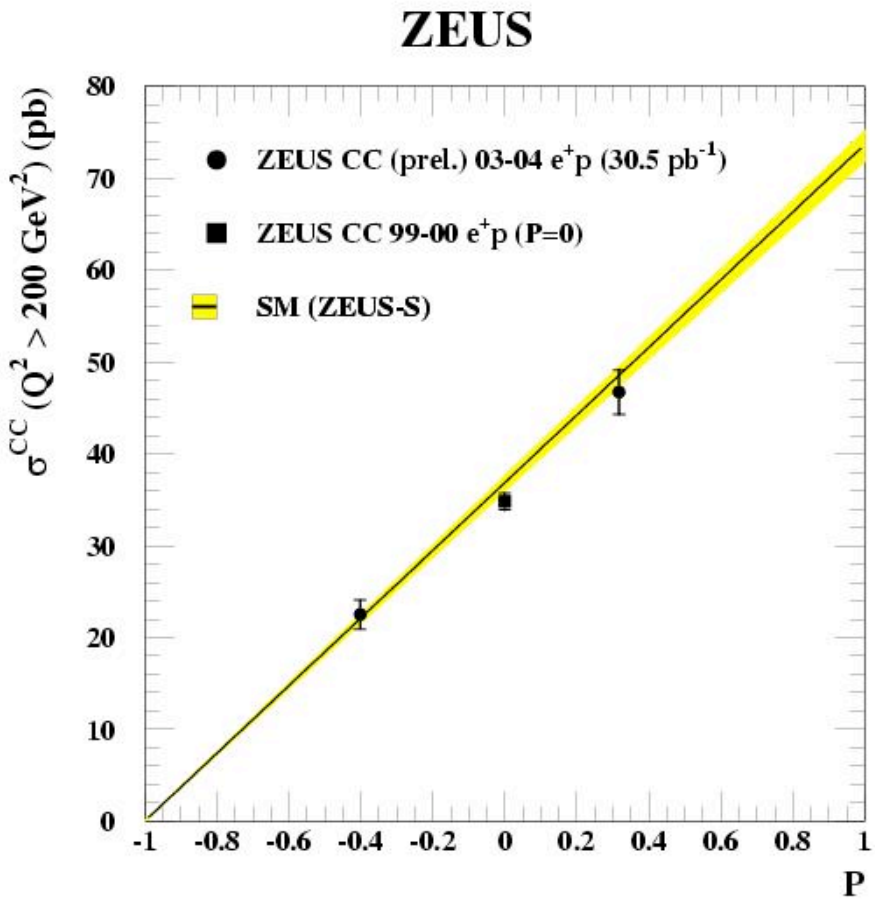
P = +31.8 ± 0.9%
L = 14.1 pb^{-1}

σ = 46.7 ± 2.4 (stat.) ± 1.0 (syst.)
± 2.3 (lumi) pb

P = -40.2 ± 1.1%
L = 16.4 pb^{-1}

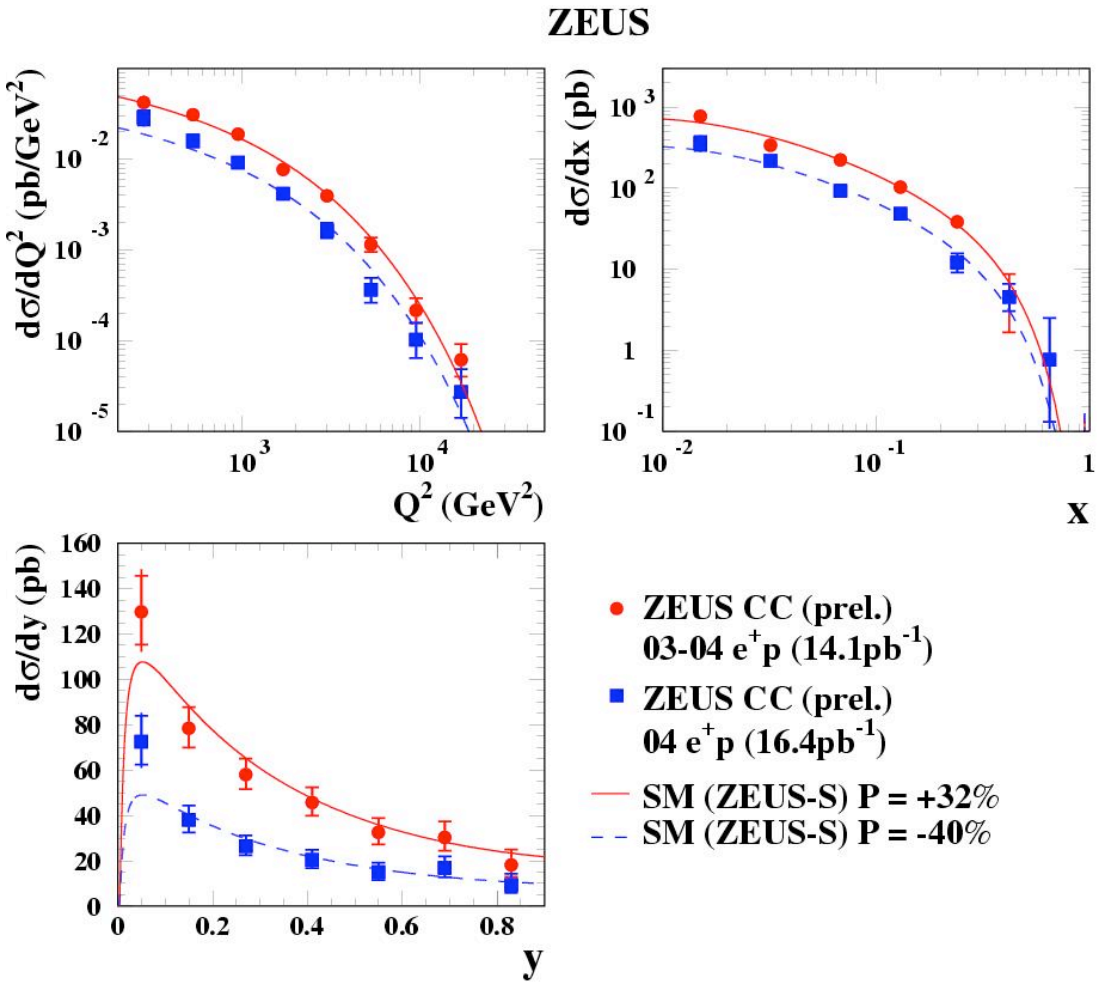
σ = 22.5 ± 1.6 (stat.) ± 0.5 (syst.)
± 1.1 (lumi) pb

No hint of right-handed charged current $\sigma(P=-1)=0$



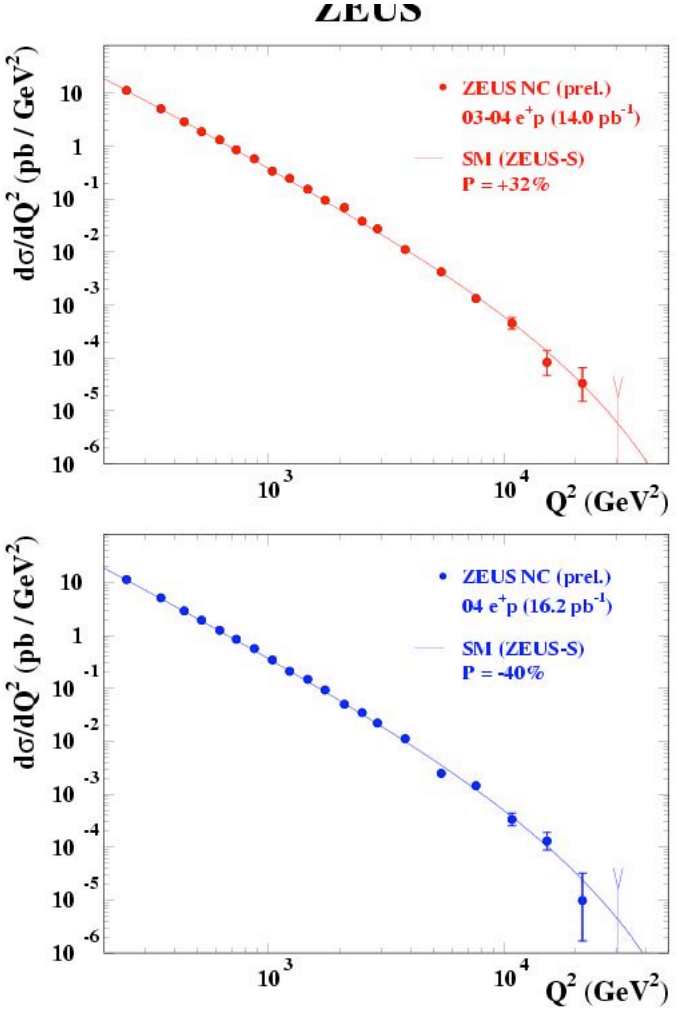
Charged current cross sections

- Single differential cross sections
  - $d\sigma/dQ^2$
  - $d\sigma/dx$
  - $d\sigma/dy$
- Well described by Standard Model
- Overall normalisation scaled by (1+P) factor



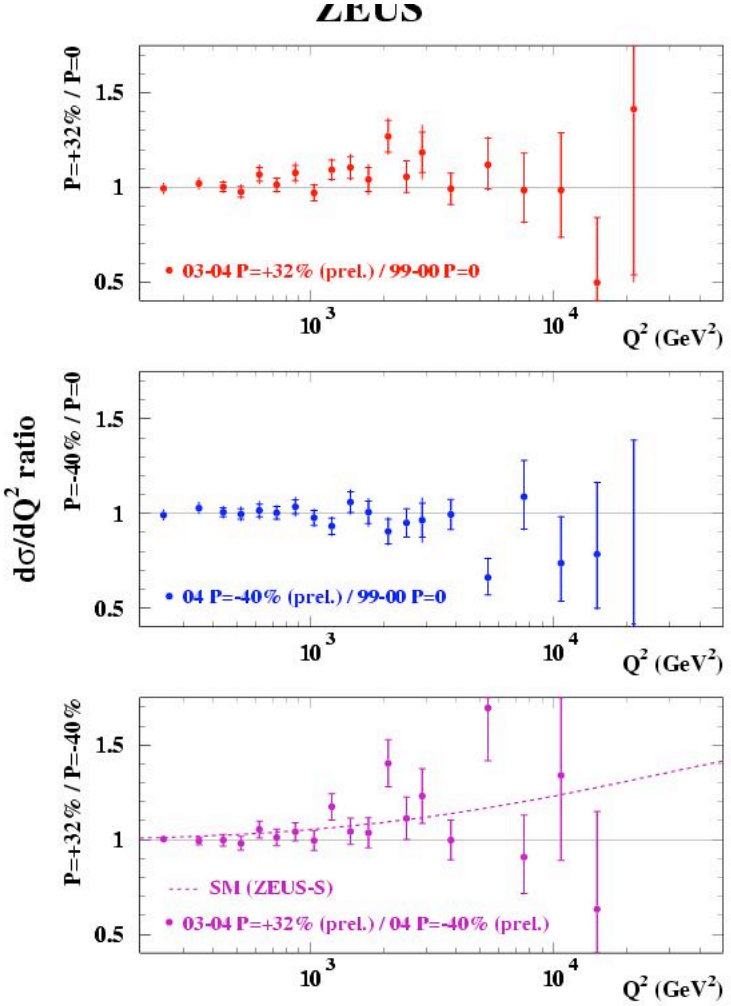
Neutral current cross sections

- $d\sigma/dQ^2$ cross sections for polarised e^+p samples
- Well described by Standard Model predictions



Neutral current cross sections

- Ratio of polarised cross sections
- Unpolarised cross sections from Phys. Rev. D 70 (2004) 052001
- Precision statistically limited
- Not yet conclusive observation of effect of longitudinal polarisation on cross sections
- Consistent with Standard Model prediction



Summary and future prospects

- Preliminary measurements of charged and neutral current cross sections with longitudinally polarised positron beams
- Measurements in good agreement with the Standard Model
- Expect first e^-p results later in the summer
- Precision measurements with full HERA II data set O(1 fb^{-1})