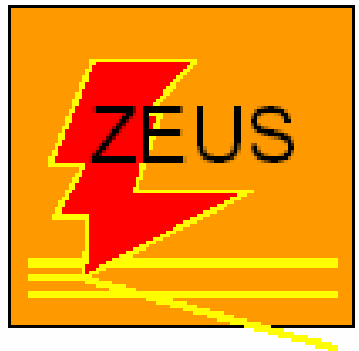
Polarised Cross Sections in DIS at HERA

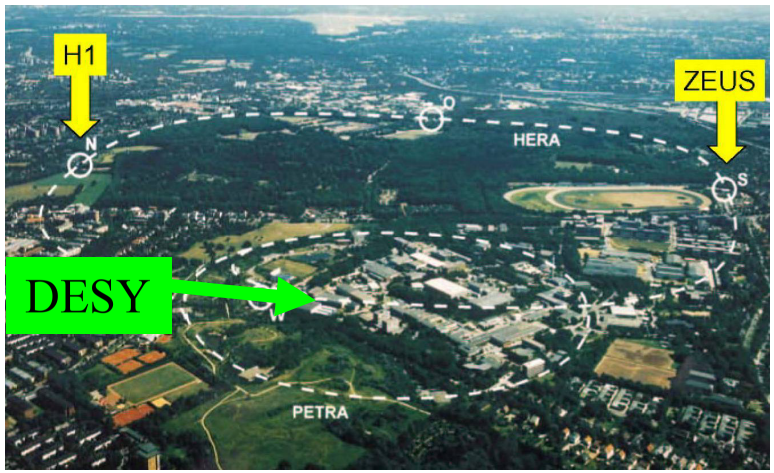


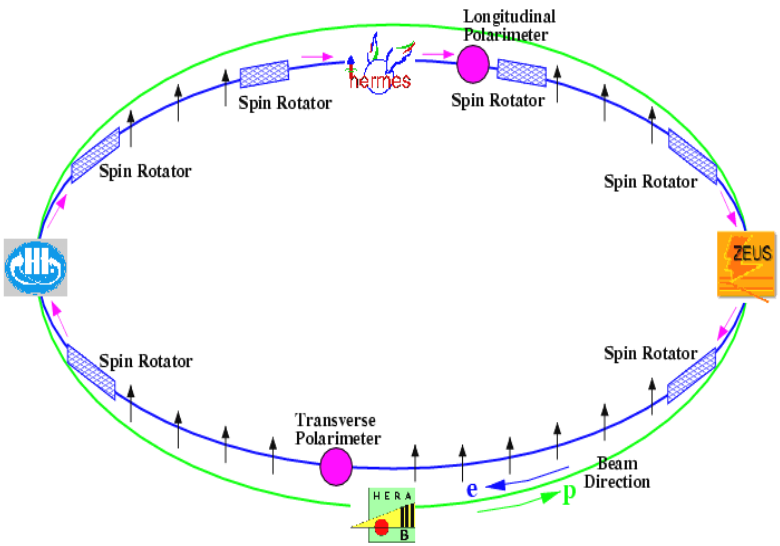
Hiroshi Kaji (Tokyo Metropolitan University)
on behalf of
the H1 and ZEUS Collaborations

Contents

- HERA Collider and Polarisation
- Deep Inelastic Scattering (DIS)
- Total Cross Sections
- Differential Cross Sections
- Summary

HERA Collider





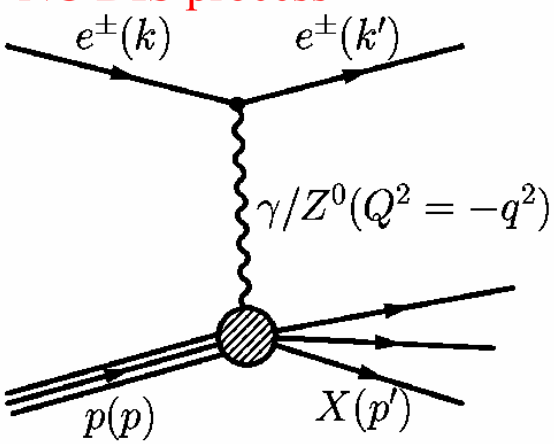
- HERA is an ep collider
  - protons, 920 GeV
  - electrons (positrons), 27.5 GeV
  - CM energy : $\sqrt{s} = 318$ GeV
- two sites for collider experiment
  - H1, North site
  - ZEUS, South site
- since Autumn 2003 (HERA–II), longitudinally polarised lepton beam became available for collider experiments
- Polarisation P

$$\mathcal{P} = \frac{N_R - N_L}{N_R + N_L}$$ (N_R, N_L : no. of right- and left-handed electrons in the beam)

  - Polarity is changeable (positive <=> negative)

Deep Inelastic Scattering

NC DIS process

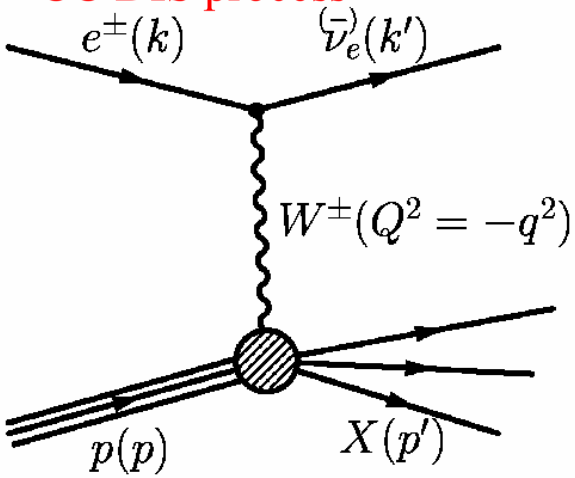


- Deep Inelastic scattering (DIS) can be classified into two processes
  - Neutral Current process (NC) exchanging neutral particle (γ or Z boson)
  - Charged Current process (CC) exchanging charged particle (W boson)

Weak boson exchange also can be measured at HERA

- In general, kinematics of DIS can be described by using a pair of following variables

CC DIS process



$Q^2 = -q^2 = -(k-k')^2$: virtuality of exchanged boson

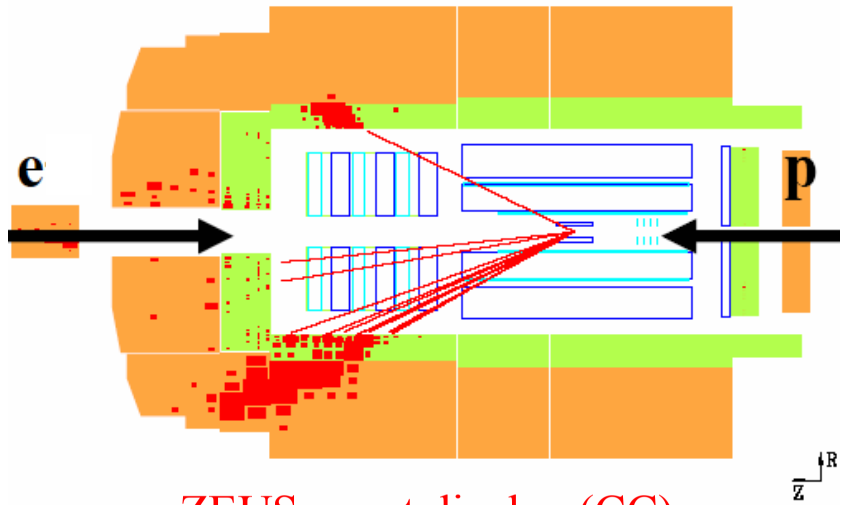
$x = \dfrac{Q^2}{2p\cdot q}$: fraction of proton momentum carried by struck quark

$y = \dfrac{p\cdot q}{p\cdot k}$: fractional energy transferred from incoming lepton at proton rest frame

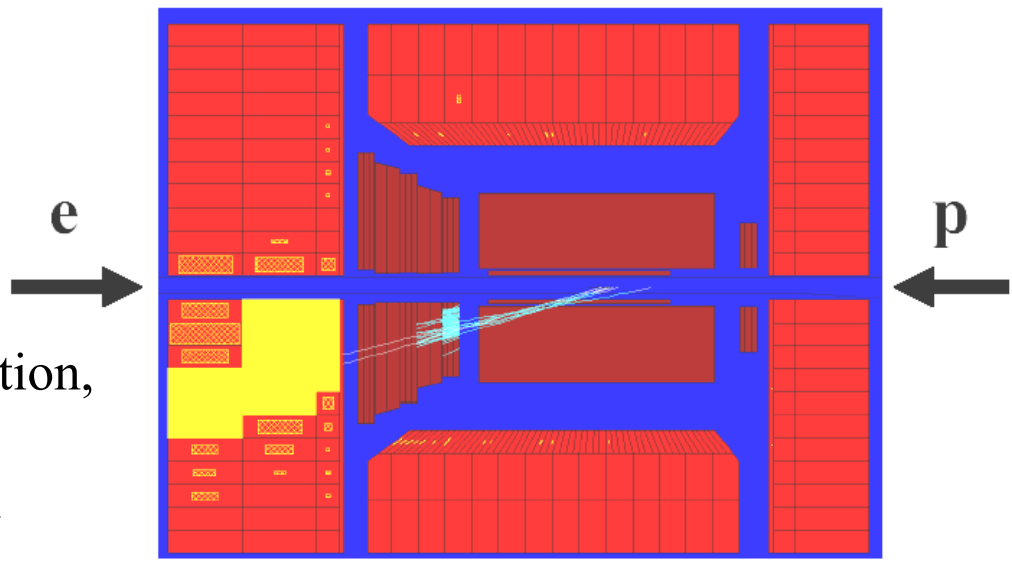
Event Characteristics

- Neutral Current process (NC)
  - gives a clear experimental signature of high E_T electron
  - Precise kinematic reconstruction using both electron and hadron information
  - Large statistics
  - Good tool for understanding detector performance and response
  - In particular, checks on hadronic system in NC are vital for CC analysis

H1 event display (NC)



ZEUS event display (CC)



- Charged Current process (CC)
  - Final state neutrino escapes detection,
    - results in large missing P_T
- Kinematics reconstructed solely from hadron information

Polarisation Dependence

Charged Current Cross Section

-- Linear dependence on polarisation, because of 'pure' weak interaction

$$\frac{d^2\sigma^{CC}(e^{\pm}p)}{dxdQ^2} = (1 \pm P)\frac{{G_F}^2}{2\pi x}\left(\frac{{M_W}^2}{{M_W}^2+Q^2}\right)^2\left[Y_+ {F_2}^{CC} \mp Y_- x{F_3}^{CC} - y^2 {F_L}^{CC}\right]$$

-- Direct sensitivity to the right-handed charged current

Neutral Current Cross Section

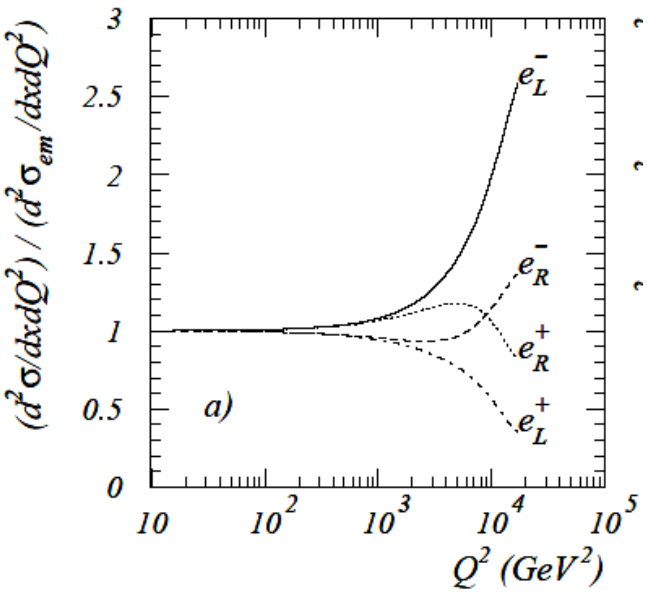
-- Polarisation dependence appears through the interference between γ and Z boson exchanges

$$\frac{d^2\sigma^{NC}(e^{\pm}p)}{dxdQ^2} = \frac{2\pi\alpha}{xQ^2}\left[H_0^{\pm} + P \cdot H_P^{\pm}\right]$$

H_0 : unpolarised structure function

H_P : polarised structure function

-- Polarisation effect can be visible only at high Q^2 region



Data Set

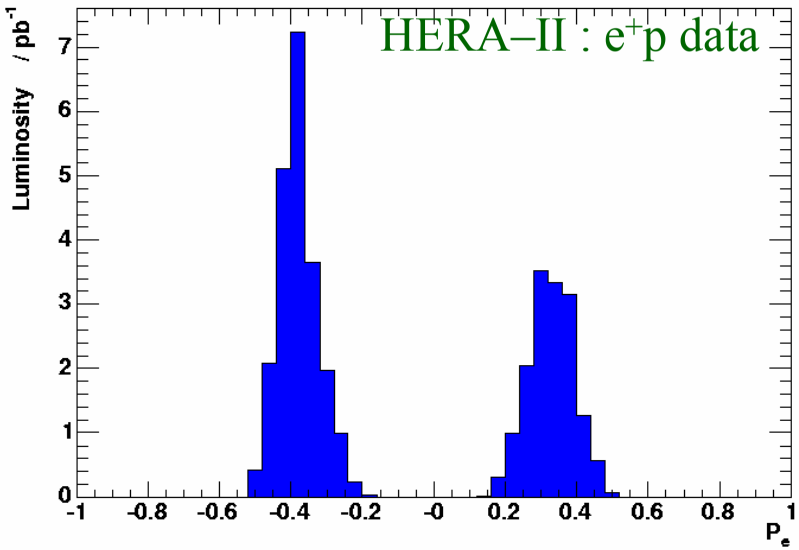
H1 data set

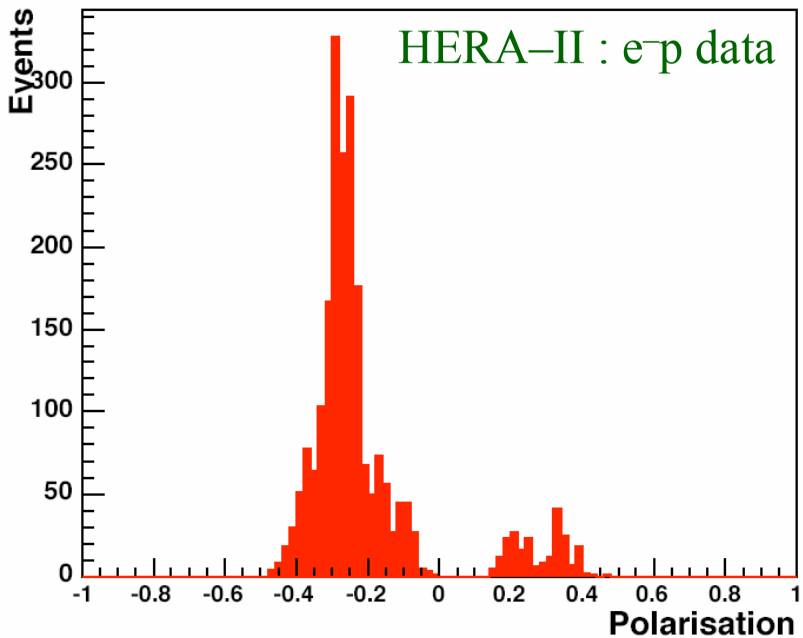
	P < 0	P > 0
e^+p data	$L = 21.7\ pb^{-1}$ $P = -40.2\ \%$	$L = 15.3\ pb^{-1}$ $P = 33.0\ \%$
e^-p data	$L = 17.8\ pb^{-1}$ $P = -25.4\ \%$	

ZEUS data set

	P < 0	P > 0
e^+p data	$L = 16.4\ pb^{-1}$ $P = -40.2\ \%$	$L = 14.1\ pb^{-1}$ $P = 31.8\ \%$
e^-p data	$L = 35.3\ pb^{-1}$ $P = -25.9\ \%$	$L = 6.5\ pb^{-1}$ $P = 29.2\ \%$

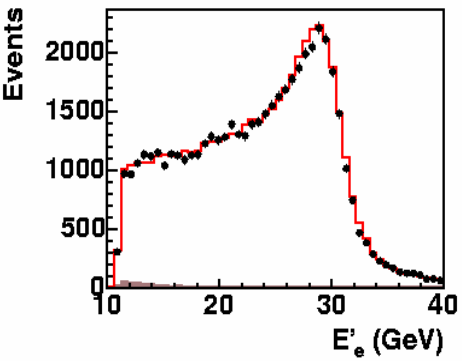
Electron data taken since winter 2004

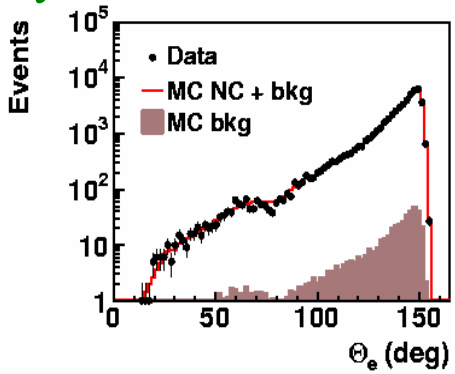


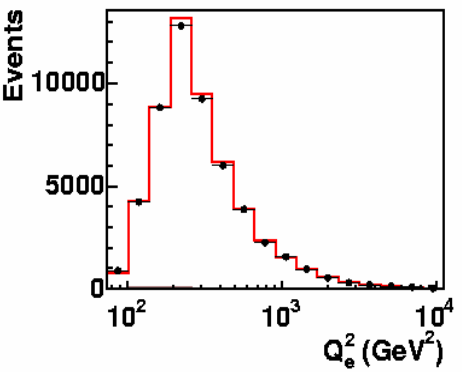


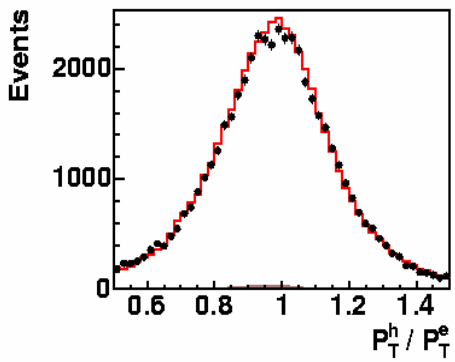
Event Distribution (H1)

NC e^-p (negative)
$Q^2>200GeV^2$ and $0.03<y<0.85$

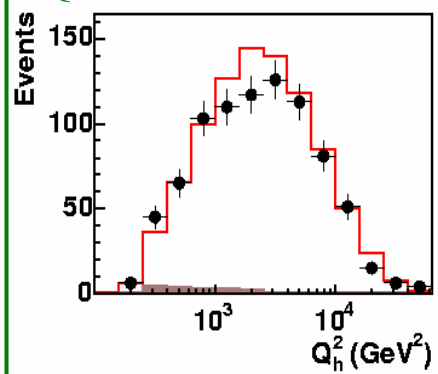


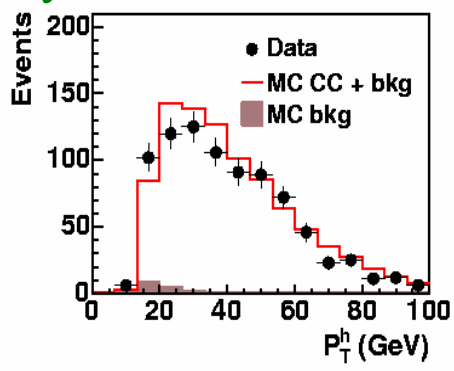


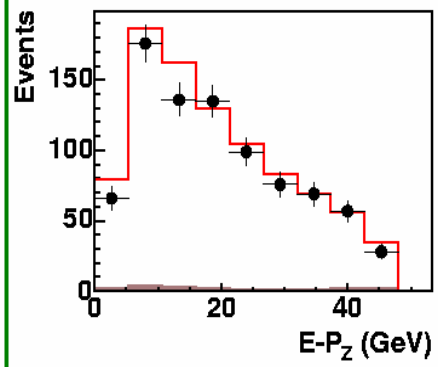


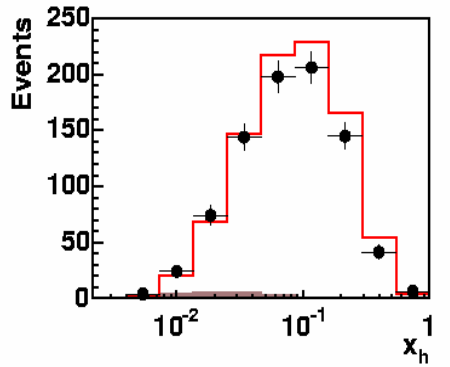


CC e^-p (negative)
$Q^2>200GeV^2$ and $0.03<y<0.85$



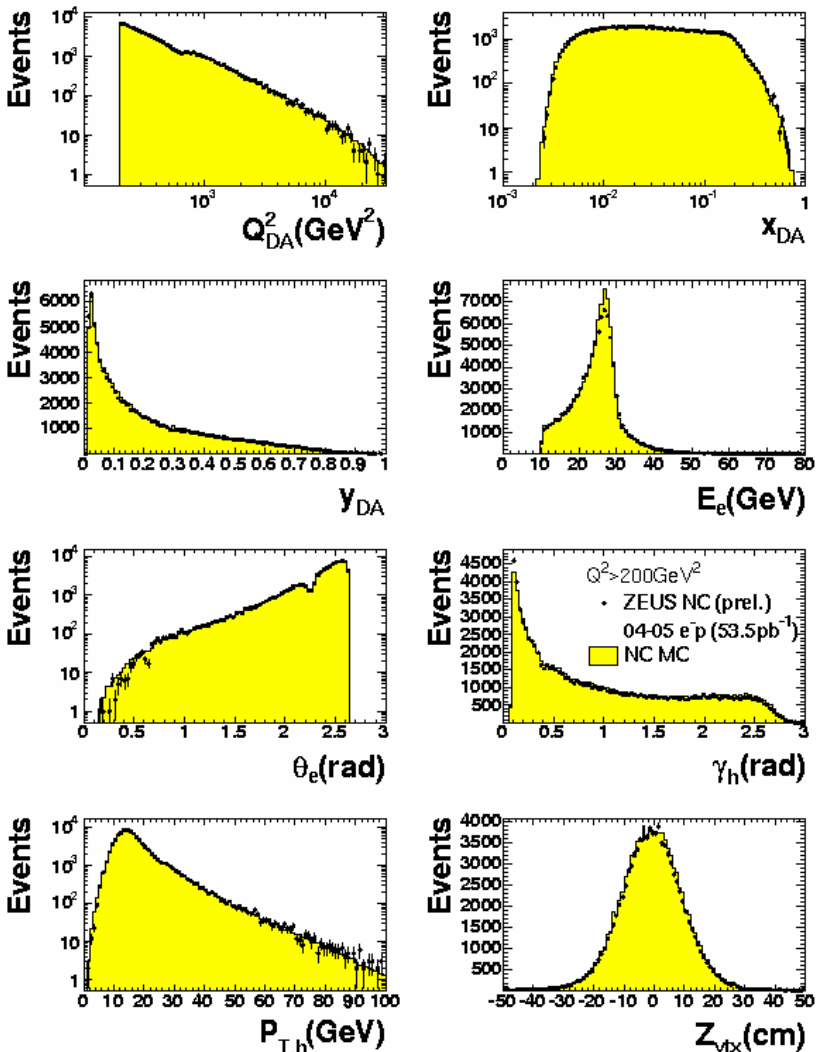




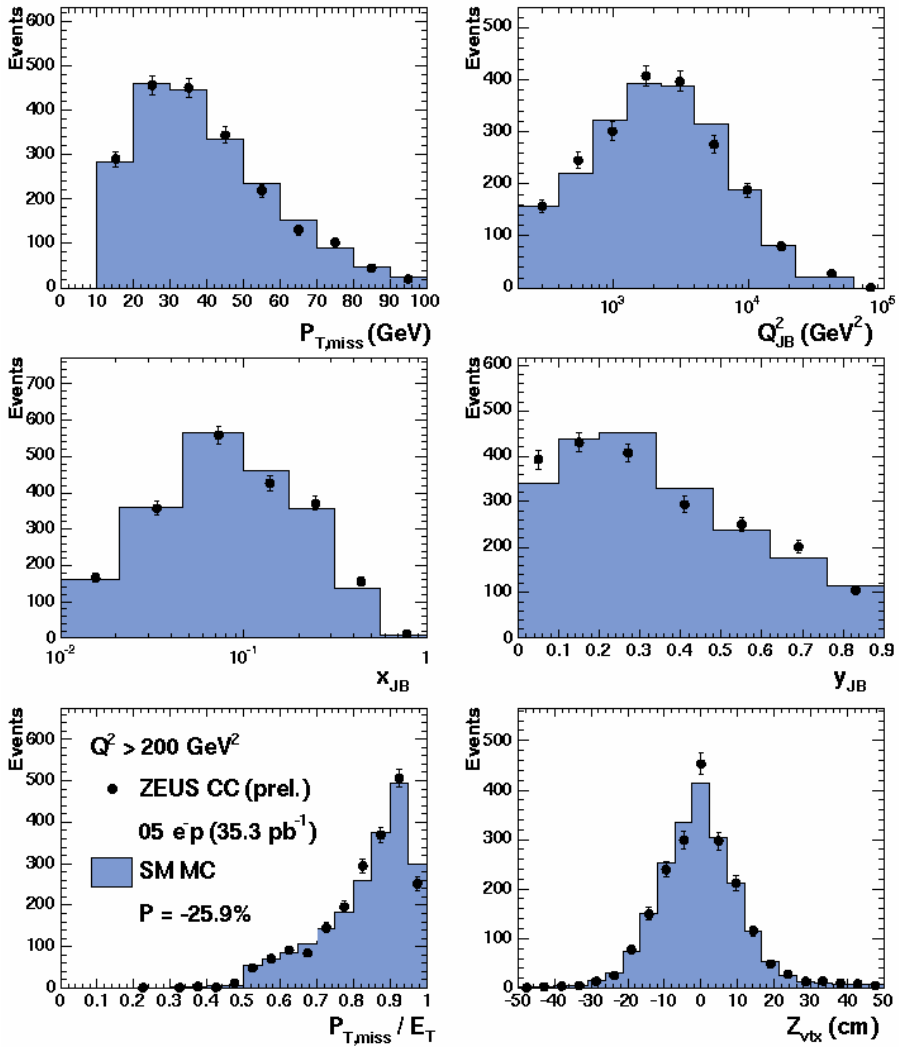


- Hadronic system in NC well understood
- Comparison between data and MC is fine

Event Distribution (ZEUS)



NC e^-p $Q^2>200GeV^2$



CC e^-p (negative) $Q^2>200GeV^2$ and $y<0.9$

Data are well understood in both H1 and ZEUS analysis

CC Total Cross Section (H1)

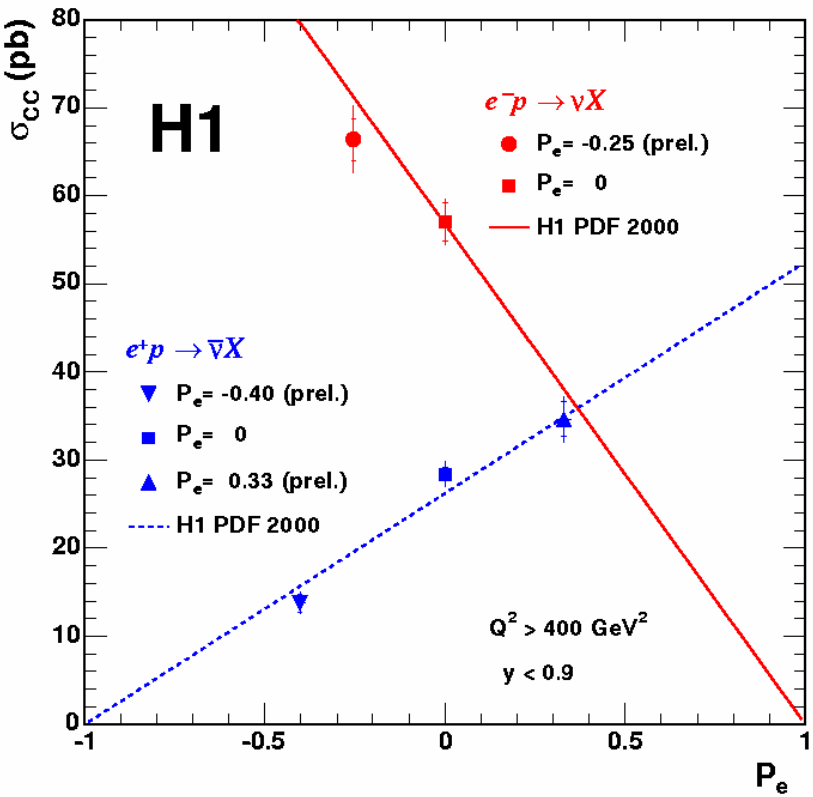
- HERA–II e^+p result ($Q^2>400\text{GeV}^2$ and $y<0.9$)

$$\sigma_{CC}(P_e=+0.33) = 34.67\,\text{pb} \pm 1.94\,\text{pb}\ (\text{stat}) \pm 1.66\,\text{pb}\ (\text{sys})$$
$$\sigma_{CC}(P_e=-0.40) = 13.80\,\text{pb} \pm 1.04\,\text{pb}\ (\text{stat}) \pm 0.94\,\text{pb}\ (\text{sys})$$

- new HERA–II e^-p result ($Q^2>400\text{GeV}^2$ and $y<0.9$)

$$\sigma_{CC}(P_e=-0.25) = 66.42\,\text{pb} \pm 2.39\,\text{pb}\ (\text{stat}) \pm 2.99\,\text{pb}\ (\text{sys})$$

- Total cross section vs. Polarisation
  → Direct observation of chiral structure of weak interaction
  - A clear linear dependence is observed both e^- and e^+
  - Data are in agreement with the SM prediction



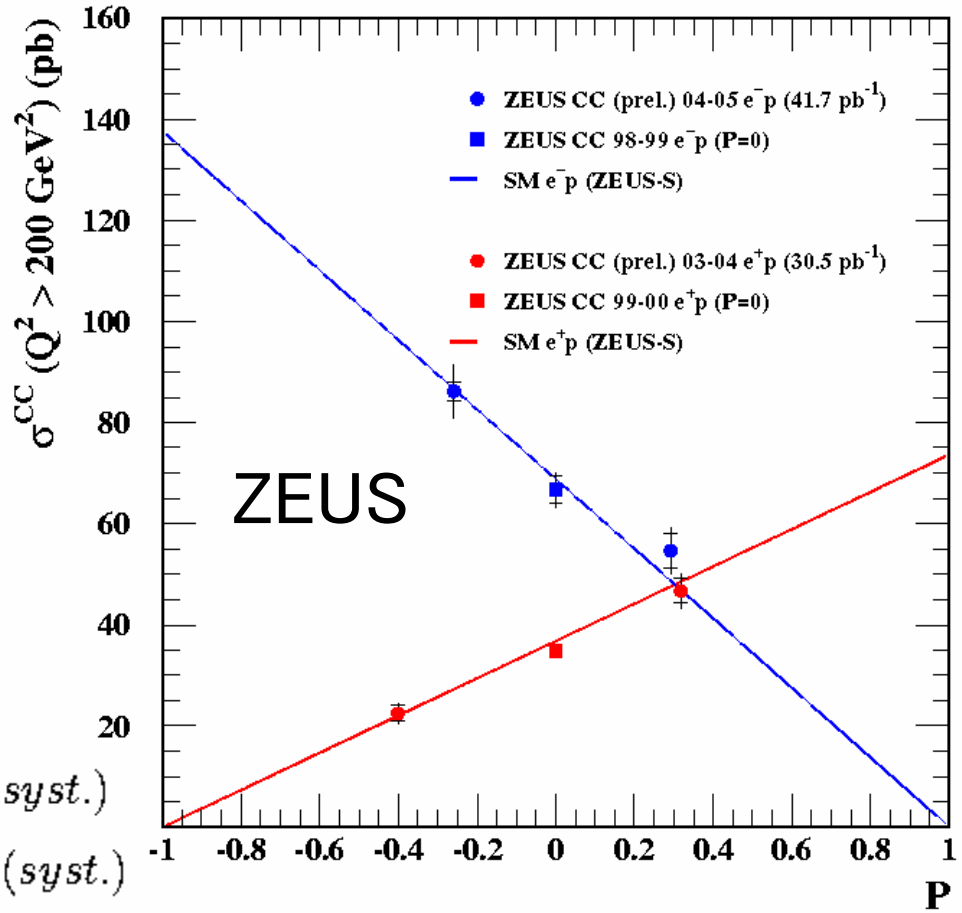
CC Total Cross Section (ZEUS)

Total Cross Section vs. Polarisation

-- The measurement with four kinds of polarised beam have been done

-- Linear dependence seen in both e^+p data and e^-p data

-- Data is consistent with SM prediction



HERA–II e^+p result ($Q^2>200\text{GeV}^2$)

$$\sigma^{CC}(P = 0.318 \pm 0.009) = 46.7 \pm 2.4(stat.) \pm 1.0(syst.)$$

$$\sigma^{CC}(P = -0.402 \pm 0.011) = 22.5 \pm 1.6(stat.) \pm 0.5(syst.)$$

new HERA–II e^-p result ($Q^2>200\text{GeV}^2$)

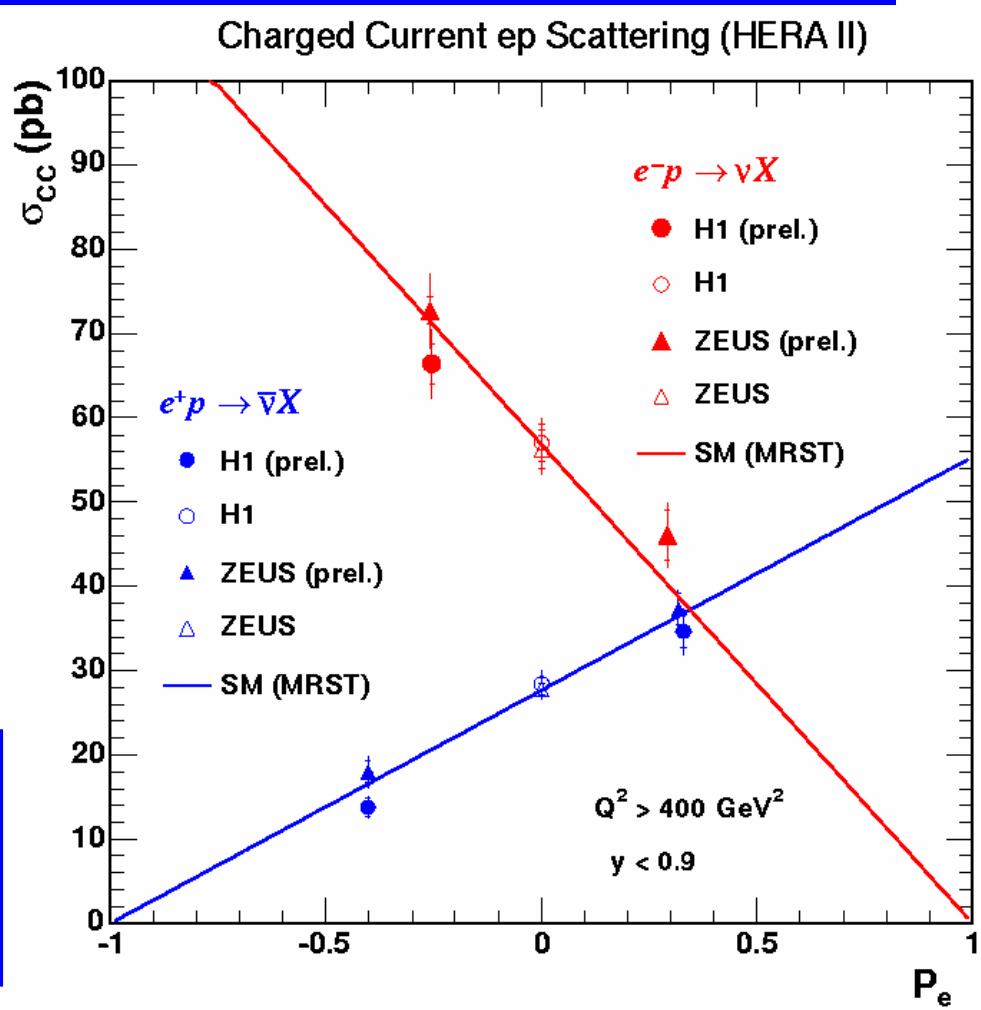
$$\sigma^{CC}(\mathcal{P} = 0.292 \pm 0.005) = 54.6 \pm 3.5(\text{stat.})^{+1.4}_{-1.1}(\text{syst.})\ \text{pb}$$

$$\sigma^{CC}(\mathcal{P} = -0.259 \pm 0.005) = 86.2 \pm 1.9(\text{stat.})^{+2.6}_{-2.2}(\text{syst.})\ \text{pb}$$

(5% of luminosity error, not included)

H1 and ZEUS Combined

-- kinematic region
$Q^2>400GeV^2$ and $y<0.9$

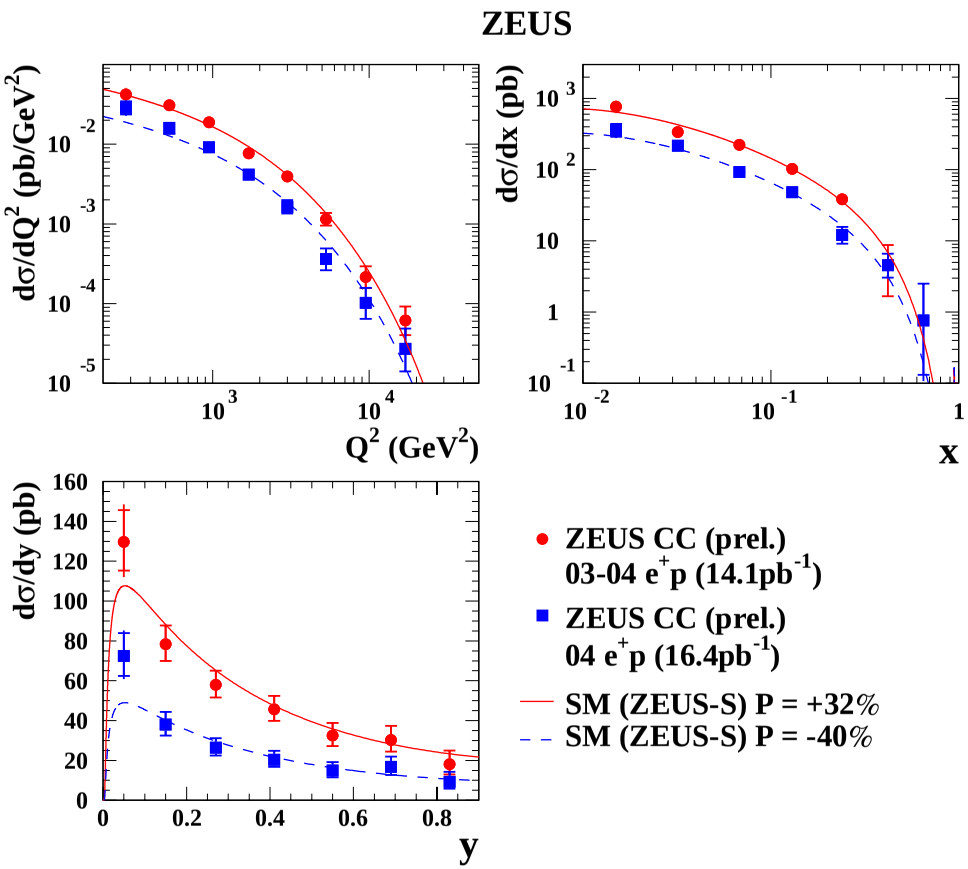


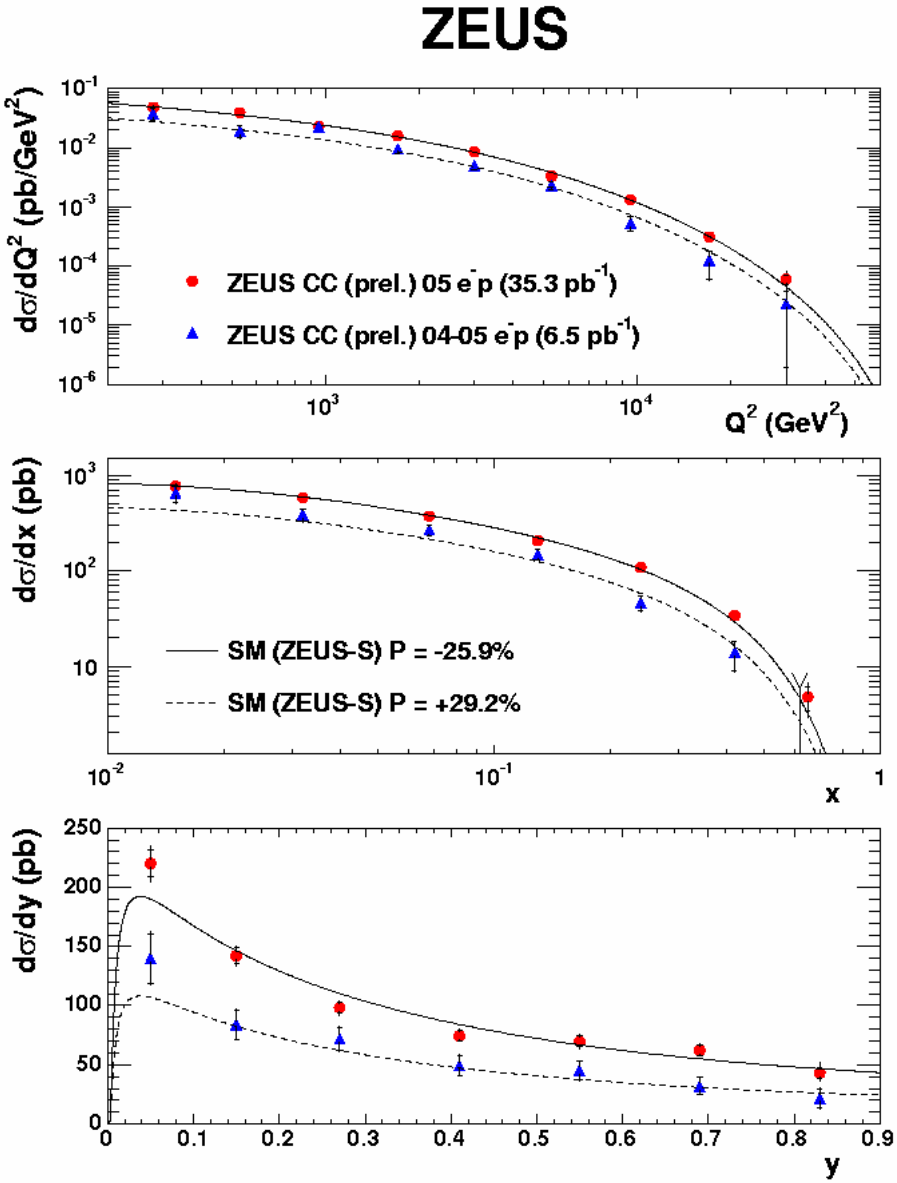
Right Handed CC Cross Section was extrapolated by linear fit to H1+ZEUS e^+p data

$$\sigma_{e^+p\to\bar{\nu}X}(P_{e^+}=-1)=0.2\pm1.8(sta)\pm1.6(sys)pb$$

consistent with 0 (Standard Model)

CC Differential Cross Sections (ZEUS)

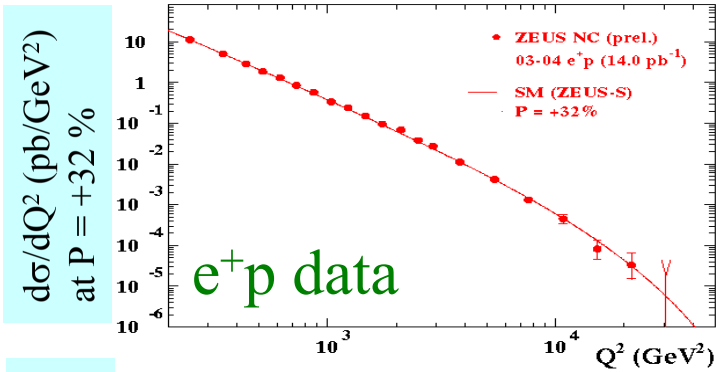


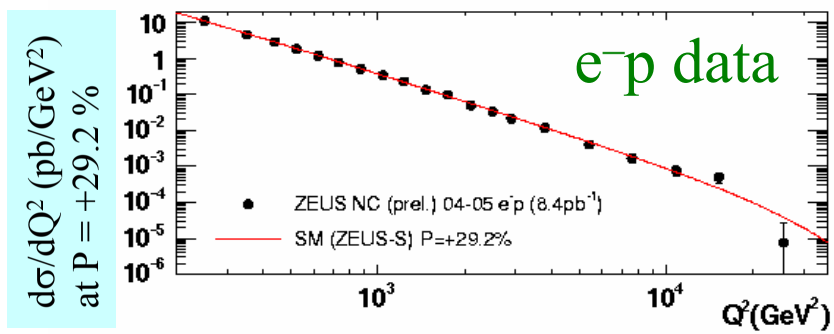


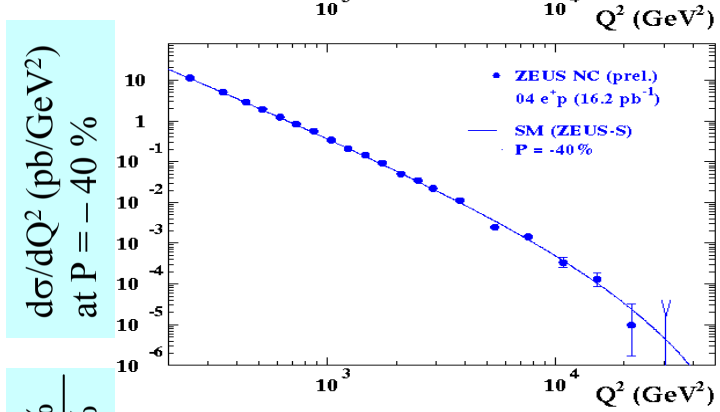
polarisation dependence seen not only total cross section

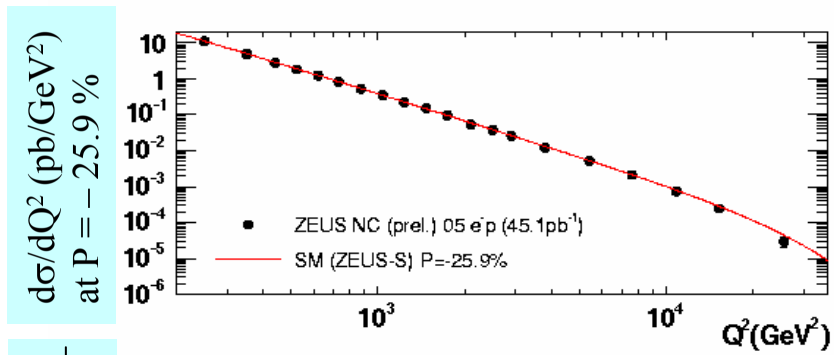
but differential cross section in all kinematic regions

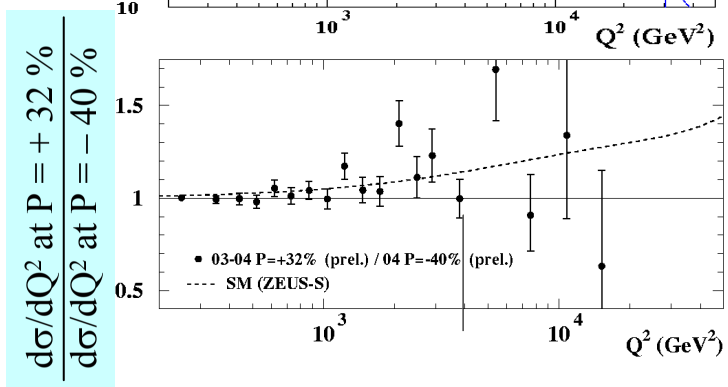
NC Differential Cross Section (ZEUS)

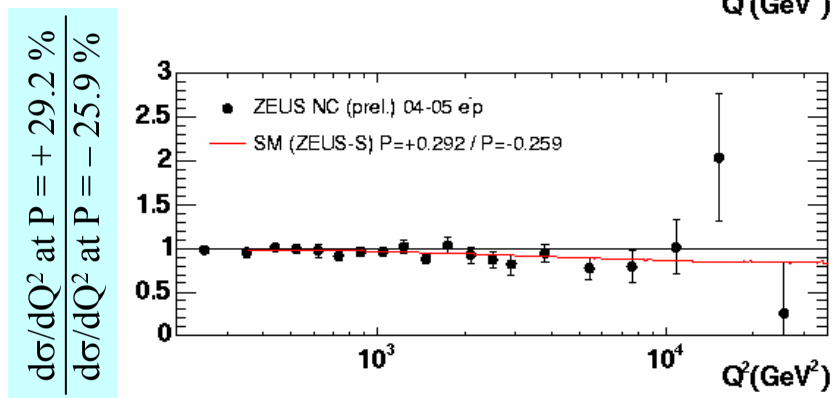












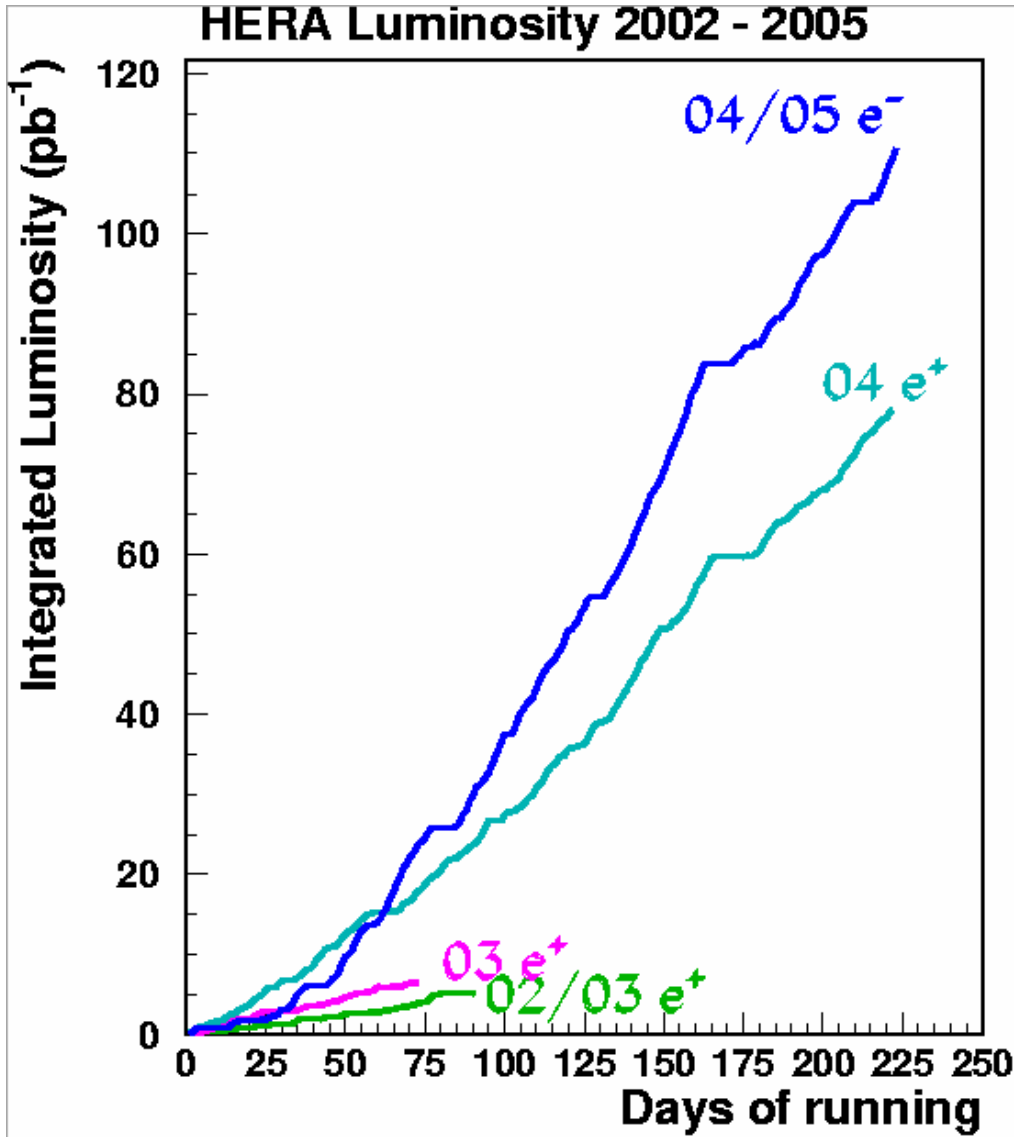
- $d\sigma/dQ^2$ for NC : Polarisation dependence is not observed conclusively with the current limited statistics

Summary

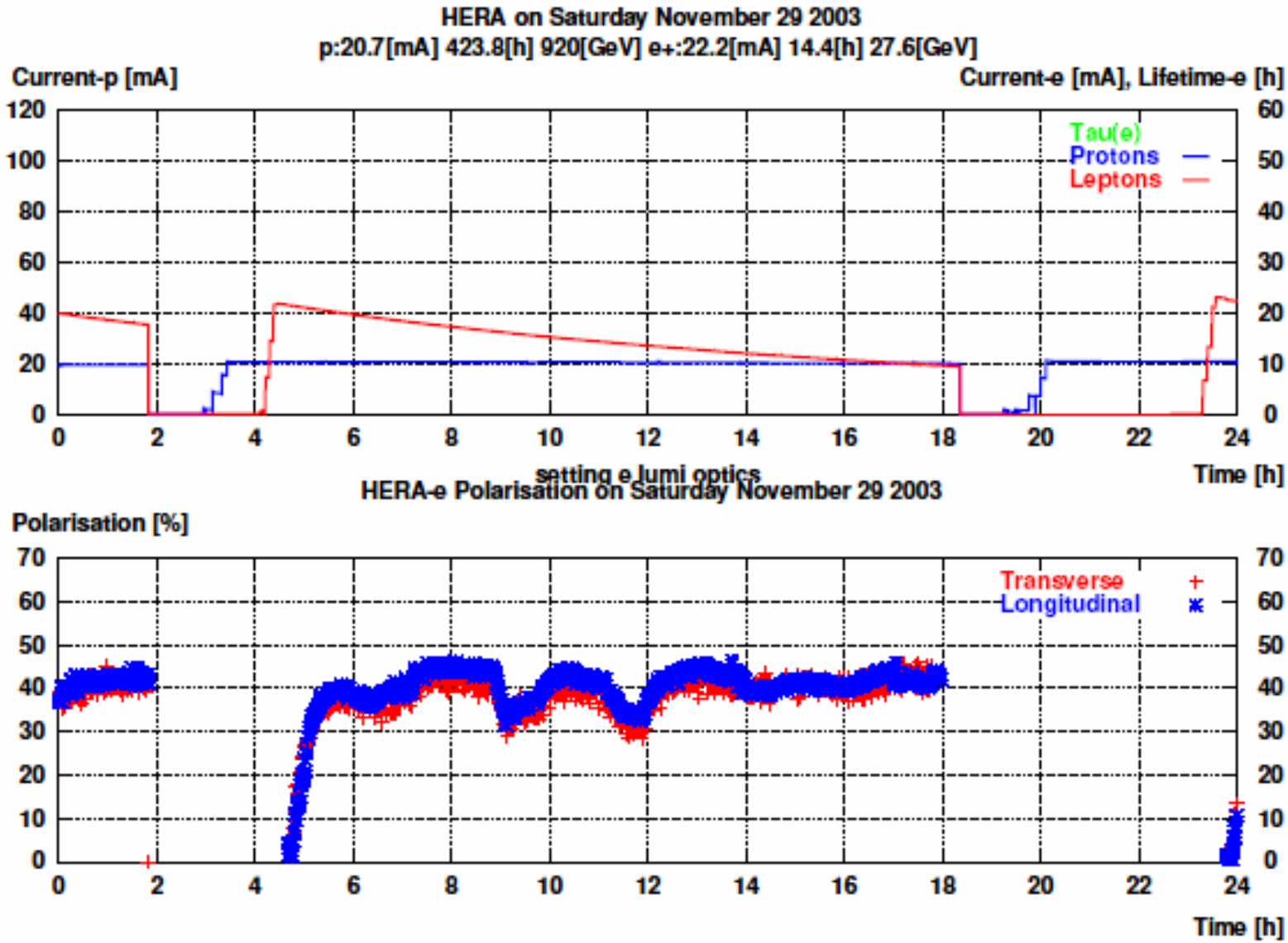
- H1 and ZEUS measured polarised cross sections in DIS
  - polarised e^+p data
  - polarised e^-p data latest results
- CC total cross section
  - shows linear dependence on polarisation of initial lepton
- RH CC cross section
  - extrapolated by using both H1 and ZEUS e^+p results
  - consistent with 0
- CC differential cross section
  - also shows polarisation dependence in all kinematic regions
- NC differential cross sections
  - $d\sigma/dQ^2$ are measured
- We will take 700 pb^{-1} of polarised data with P ~ +/– 40 % by mid 2007

Back-Up Slide

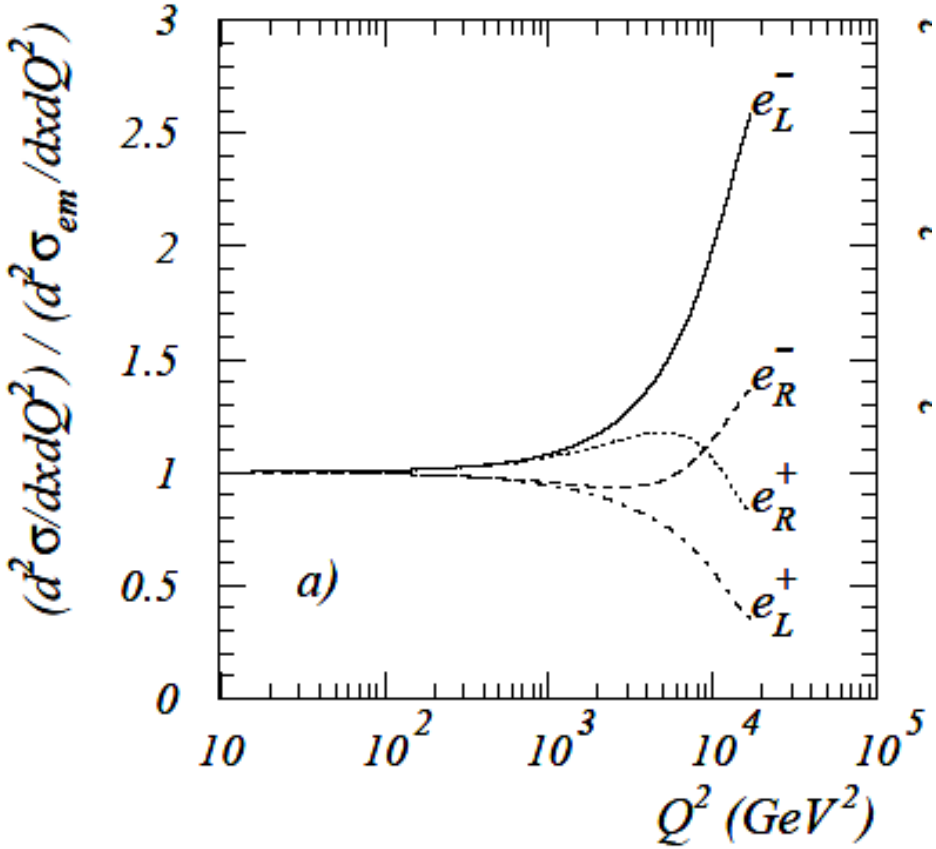
HERA luminosity

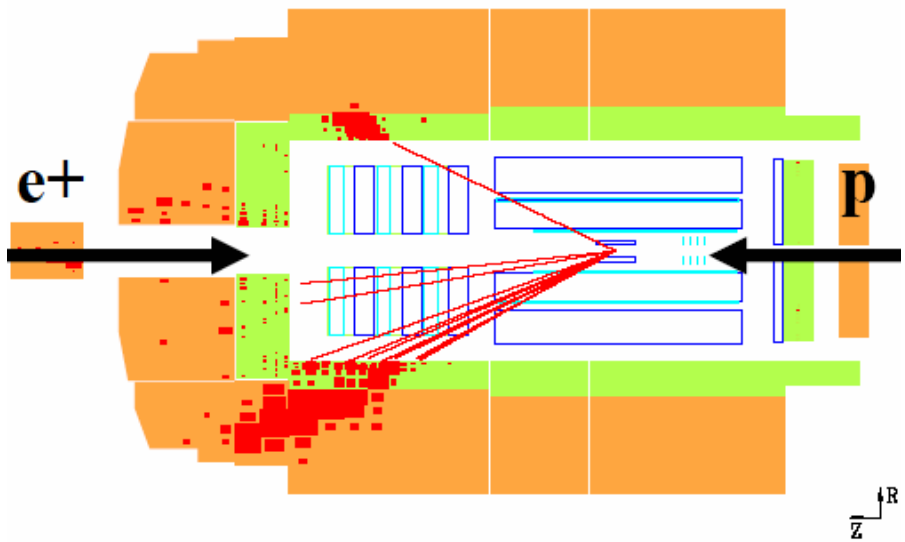


polarisation

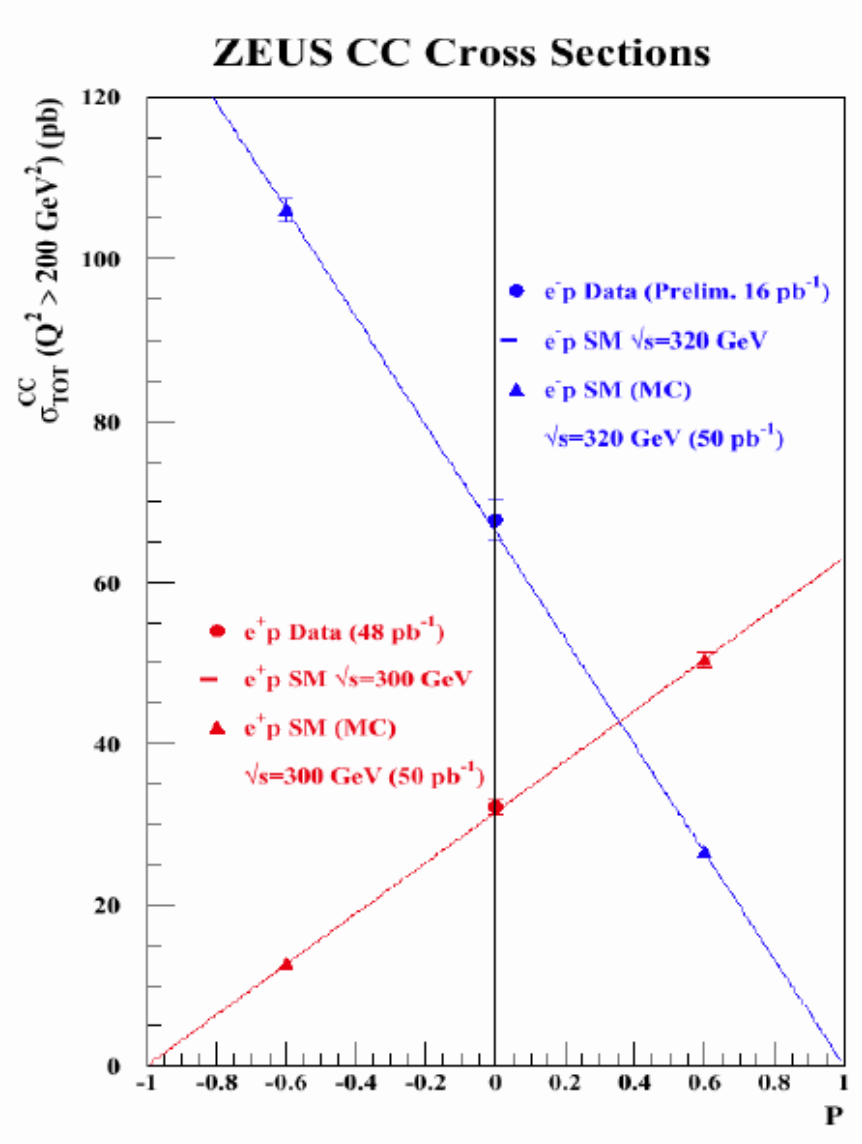


Neutral Current process





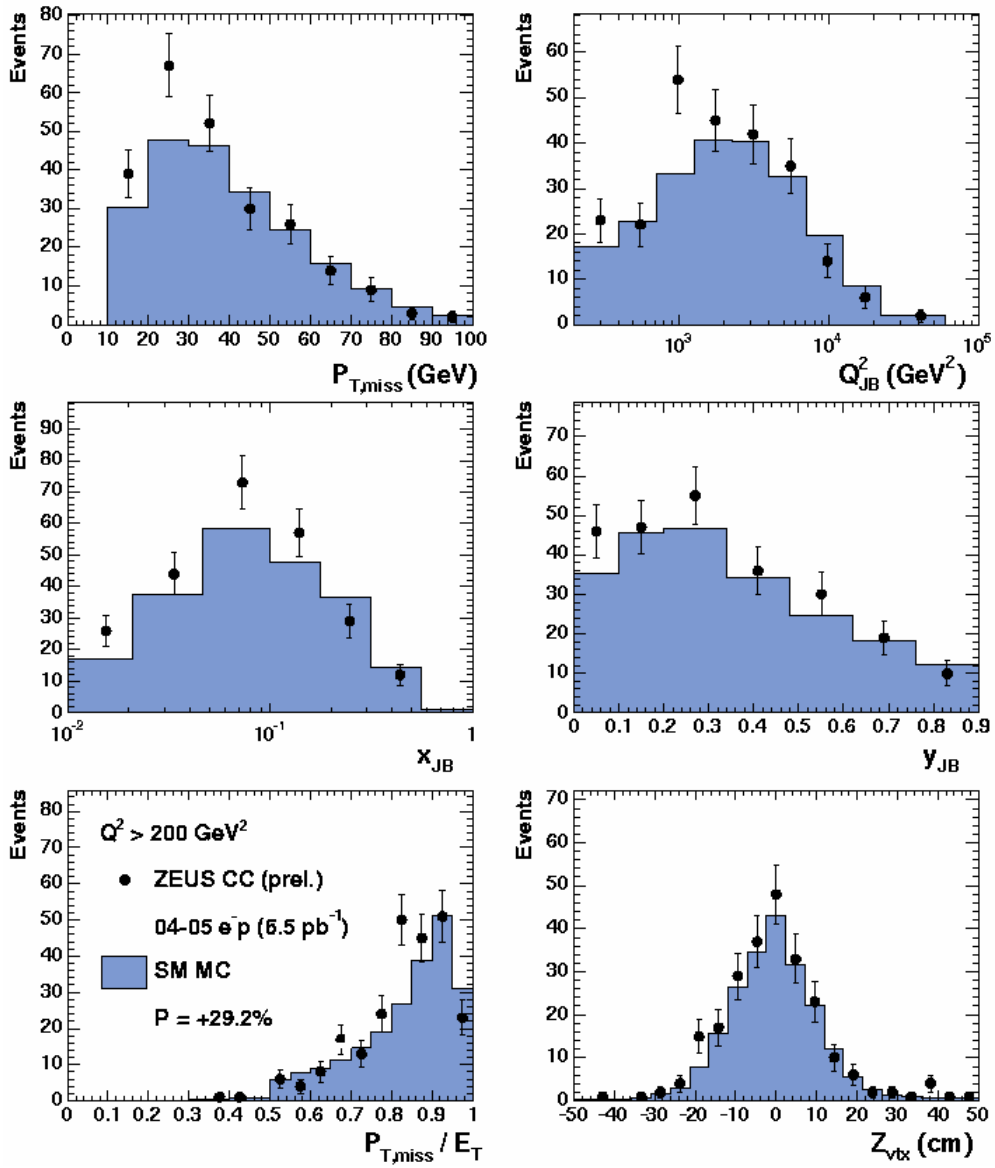
Charged Current process



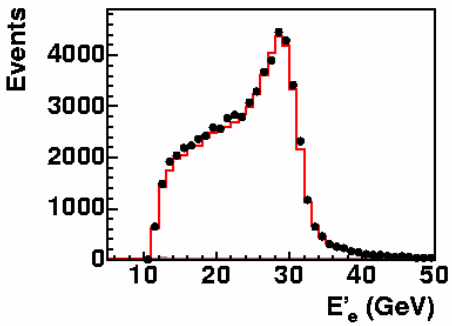
$$\sigma_{CC}^{e^{\pm}(pol)p} = (1 \pm P)\sigma_{CC}^{e^{\pm}(unpol)p}$$

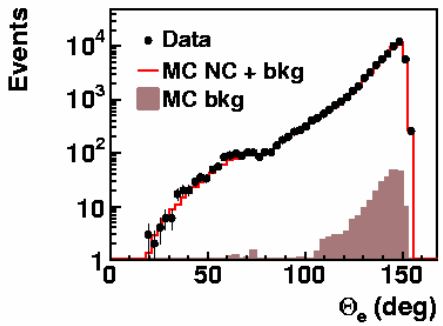
control plot (ZEUS)

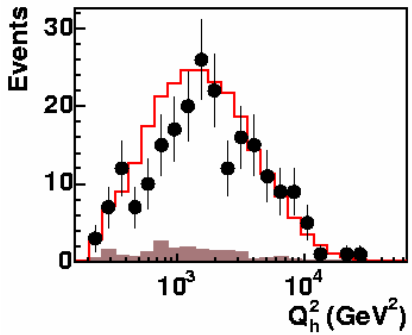
RH (CC) e^-p

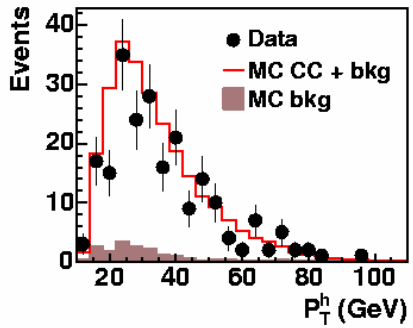


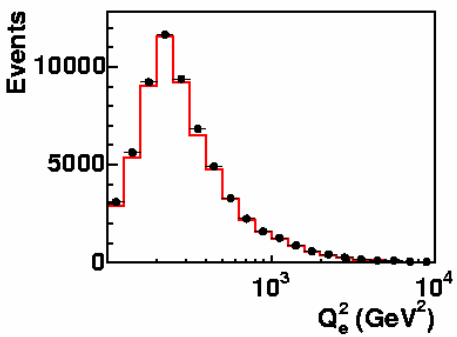
Event Distribution (H1)

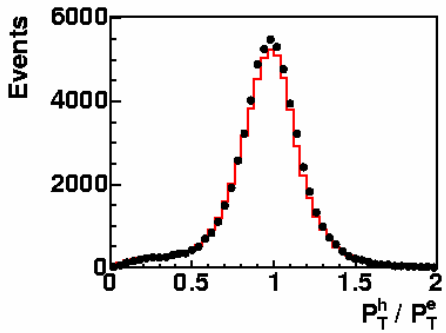


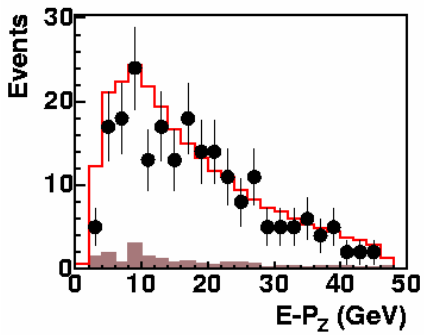


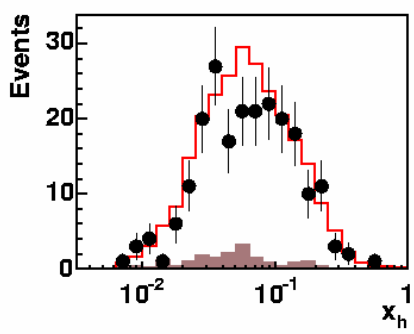








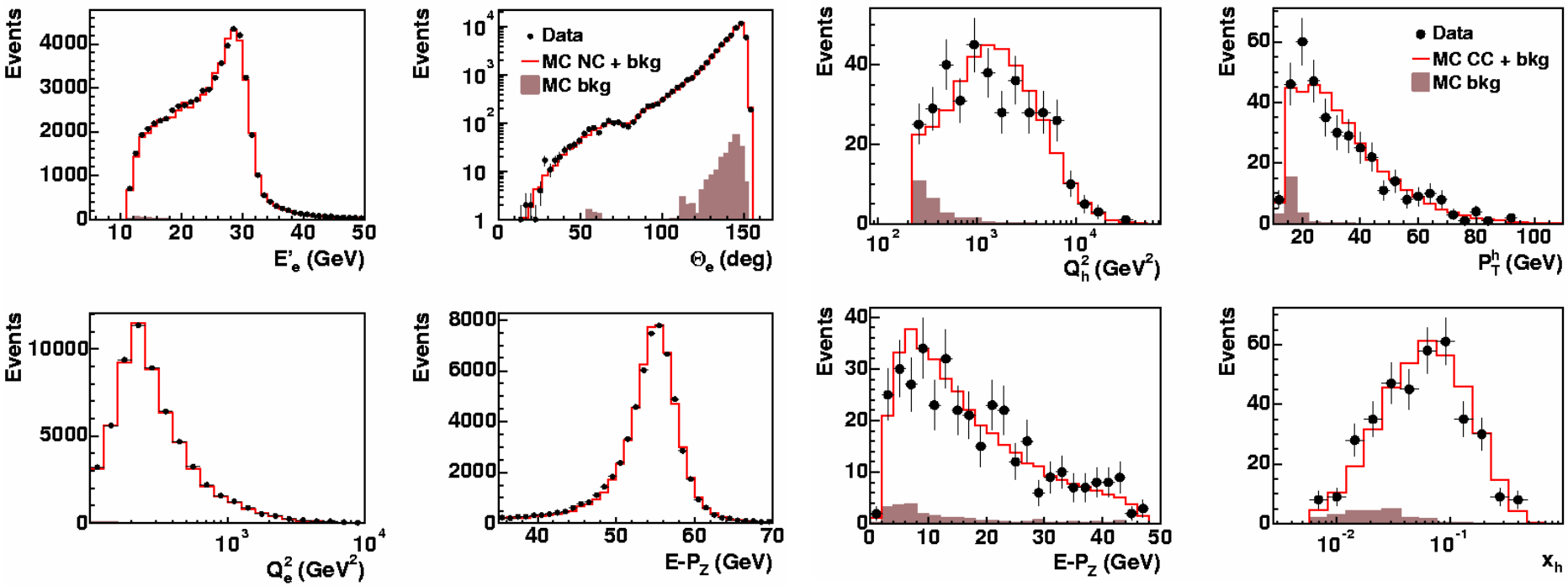




LH (NC) e^+p

LH (CC) e^+p

Event Distribution (H1)



RH (NC) e^+p

RH (CC) e^+p

Total Cross Section (ZEUS)