NC and CC Cross Sections at High Q^2 from ZEUS at HERA

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- Introduction
- Neutral Current
  Results: $\frac{d\sigma}{dQ^2}$, $\frac{d\sigma}{dx}$, $\frac{d\sigma}{dy}$
- Charged Current
  Results: $\frac{d\sigma}{dQ^2}$, $\frac{d\sigma}{dx}$, $\frac{d\sigma}{dy}$, $\frac{d^2\sigma}{dx\,dQ^2}$, M_W
- Summary

Introduction

Born level NC DIS cross section $(e^+p \to e^+X)$:

$$\frac{d^2\sigma^{NC(e^+)}}{dxdQ^2} = \frac{2\pi\alpha^2}{xQ^4}\left[Y_+ F_2^{NC}(x,Q^2) - Y_- \, xF_3^{NC}(x,Q^2)\right]$$

$$(Y_\pm = 1 \pm (1-y)^2)$$

PDFs, couplings, $\frac{Q^2}{Q^2+M_Z^2}$ (wk.part) $\Rightarrow F_2^{NC}$, F_3^{NC}

Born level CC DIS cross section $(e^+p \to \bar{\nu}_e X)$:

$$\frac{d^2\sigma^{CC(e^+)}}{dxdQ^2} = \frac{G_F^2}{4\pi x}\left(\frac{M_W^2}{M_W^2+Q^2}\right)^2 \cdot$$

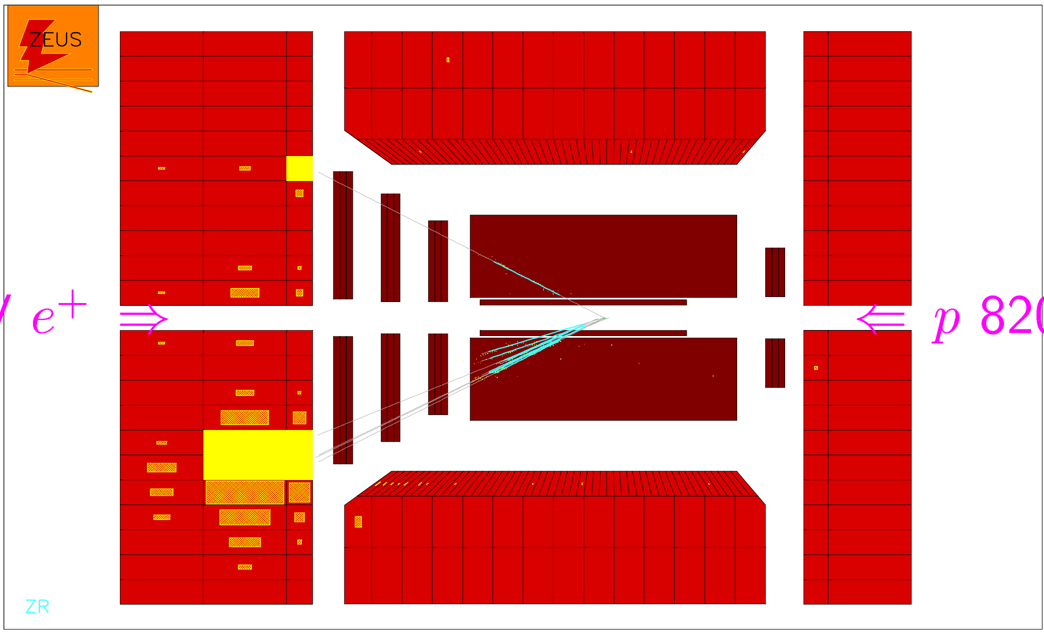
$$\left[Y_+ F_2^{CC}(x,Q^2) - Y_- \, xF_3^{CC}(x,Q^2)\right]$$

- parton distribution at high photon,boson virtuality Q^2
- weak sector: weak couplings;
  NC: Z^o exchange $\to M_Z$;
  CC: pure W exchange $\to M_W$
- new physics? $\to$ talks in PA10

Neutral Current

1994 to 1997 data $\rightarrow 46.6\,\mathrm{pb}^{-1}$

27.5GeV $e^+ \Rightarrow$



$\Leftarrow p$ 820GeV

Selection Criteria for $e^+p \rightarrow e^+X$ (excerpt):

- positron found with $E_e > 10\,\mathrm{GeV}$, track, isolated
- vertex position: $-50 < z < 100\,\mathrm{cm}$
- energy-momentum conserved: $\sum E - p_z > 38\,\mathrm{GeV}$
- background removal: $y_e < 0.95$, $P_T < 4\sqrt{E_T}$
- kin. range: $Q^2 > 400\,\mathrm{GeV}^2$

cross section corrected for this

Reconstruction – Double Angle Method

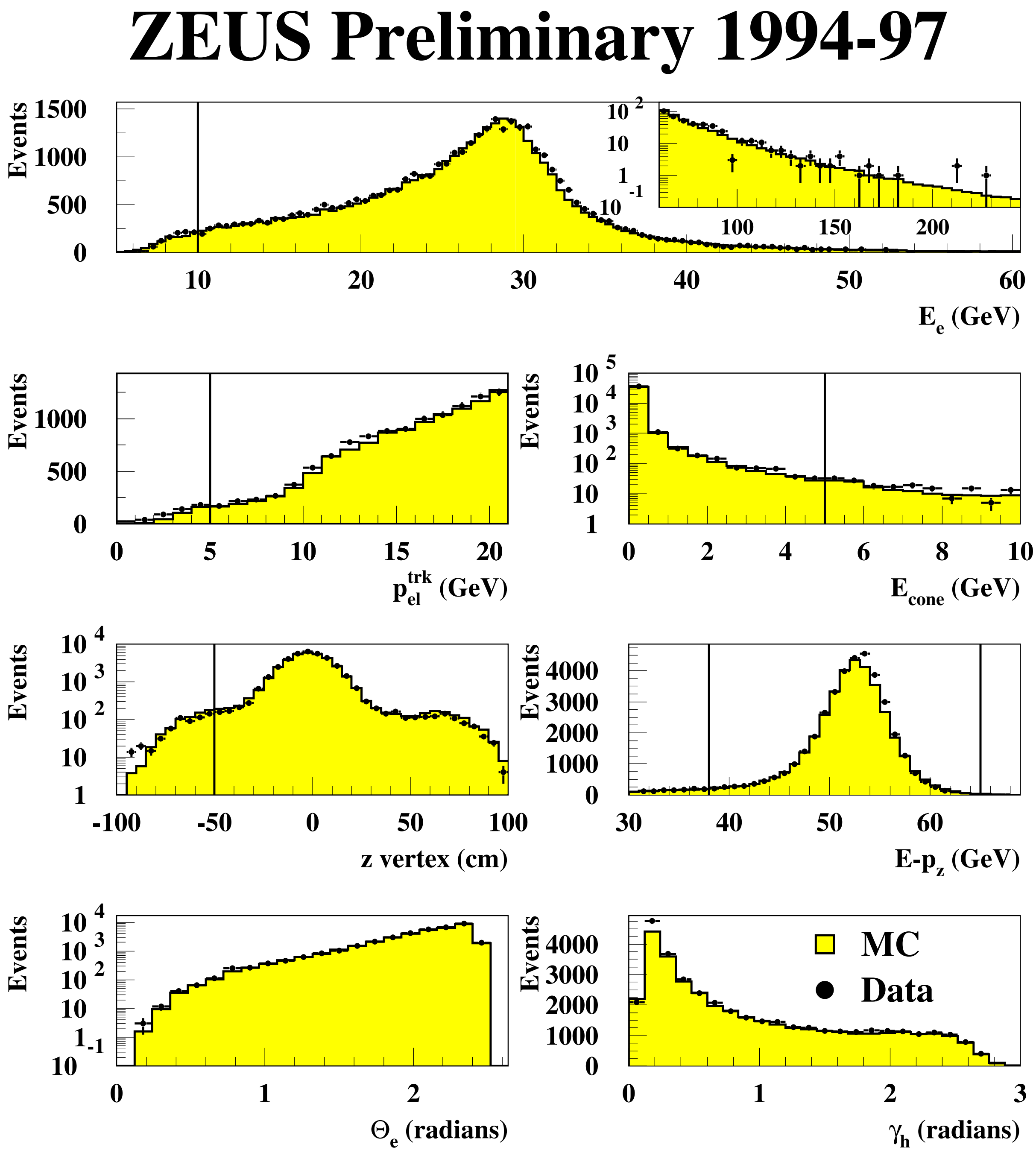
positron angle θ_e (tracking) $+$
hadron angle γ_h (calorimeter) $\Rightarrow Q^2$, x, y

NC – Data-MC Comparison

Simulation

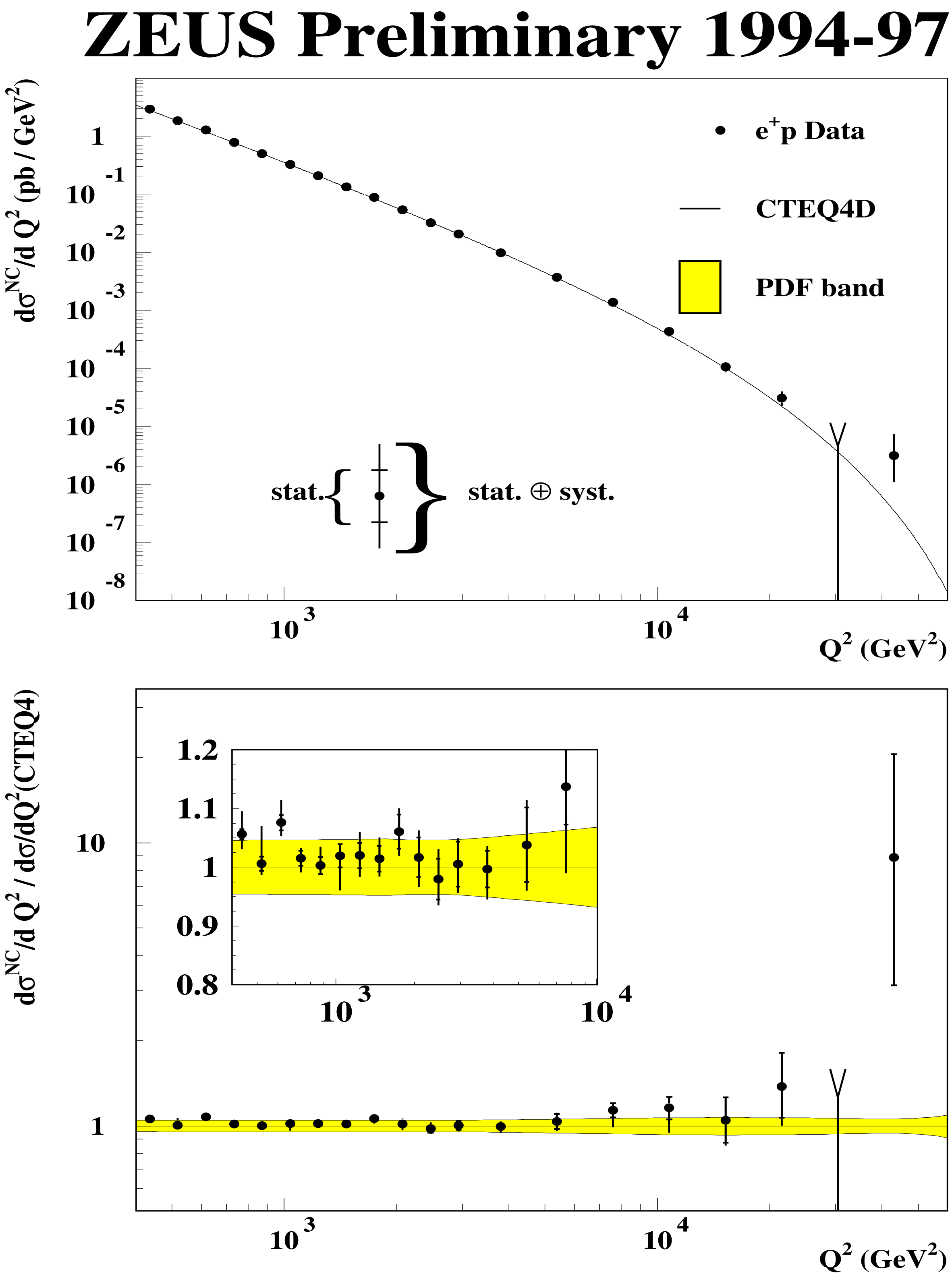
HERACLES with ARIADNE or MEPS for NC DIS

PYTHIA, HERWIG for photoprod. background ($< 3\%$)



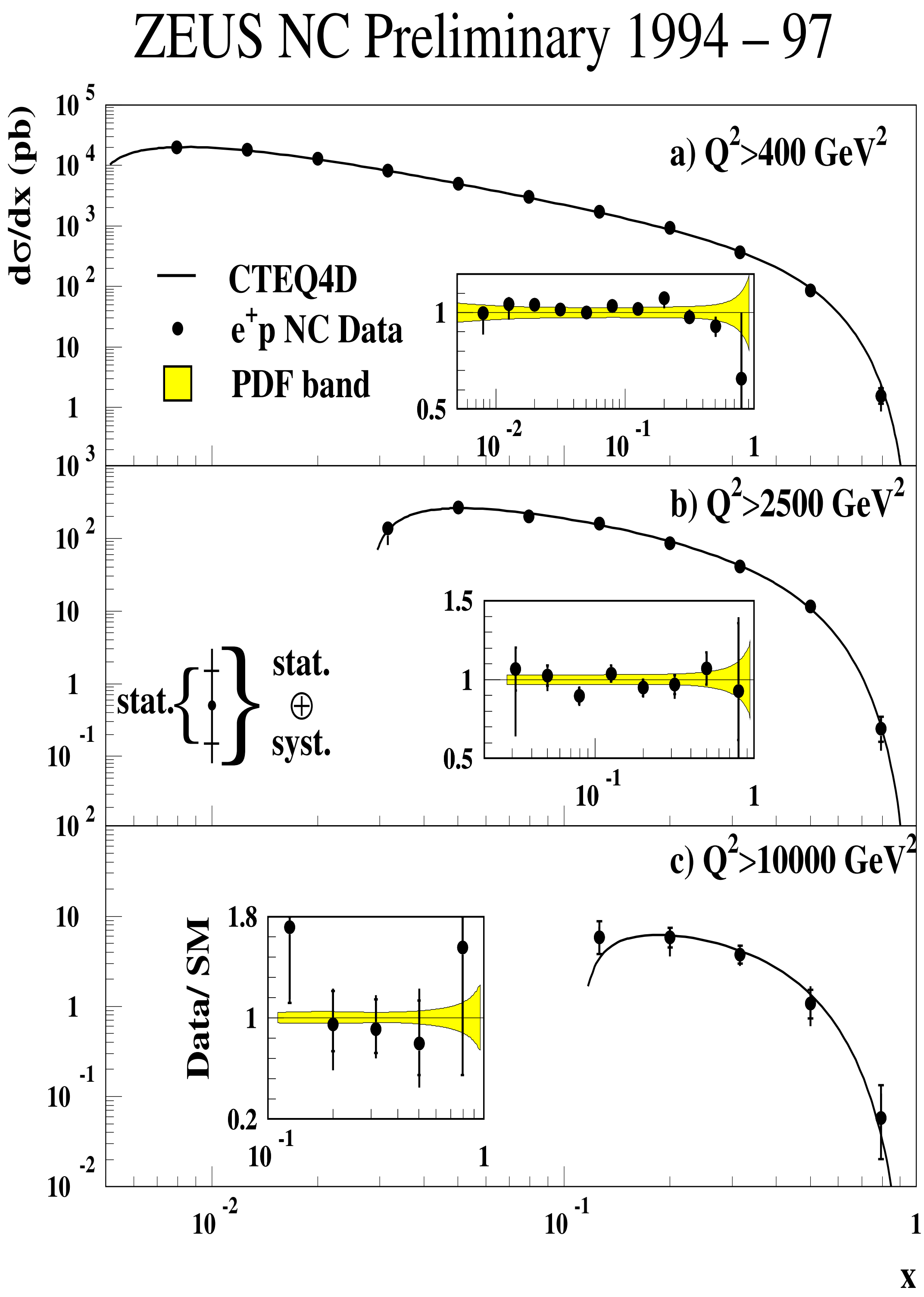
NC MC describes data!

NC – Cross Section in Q^2



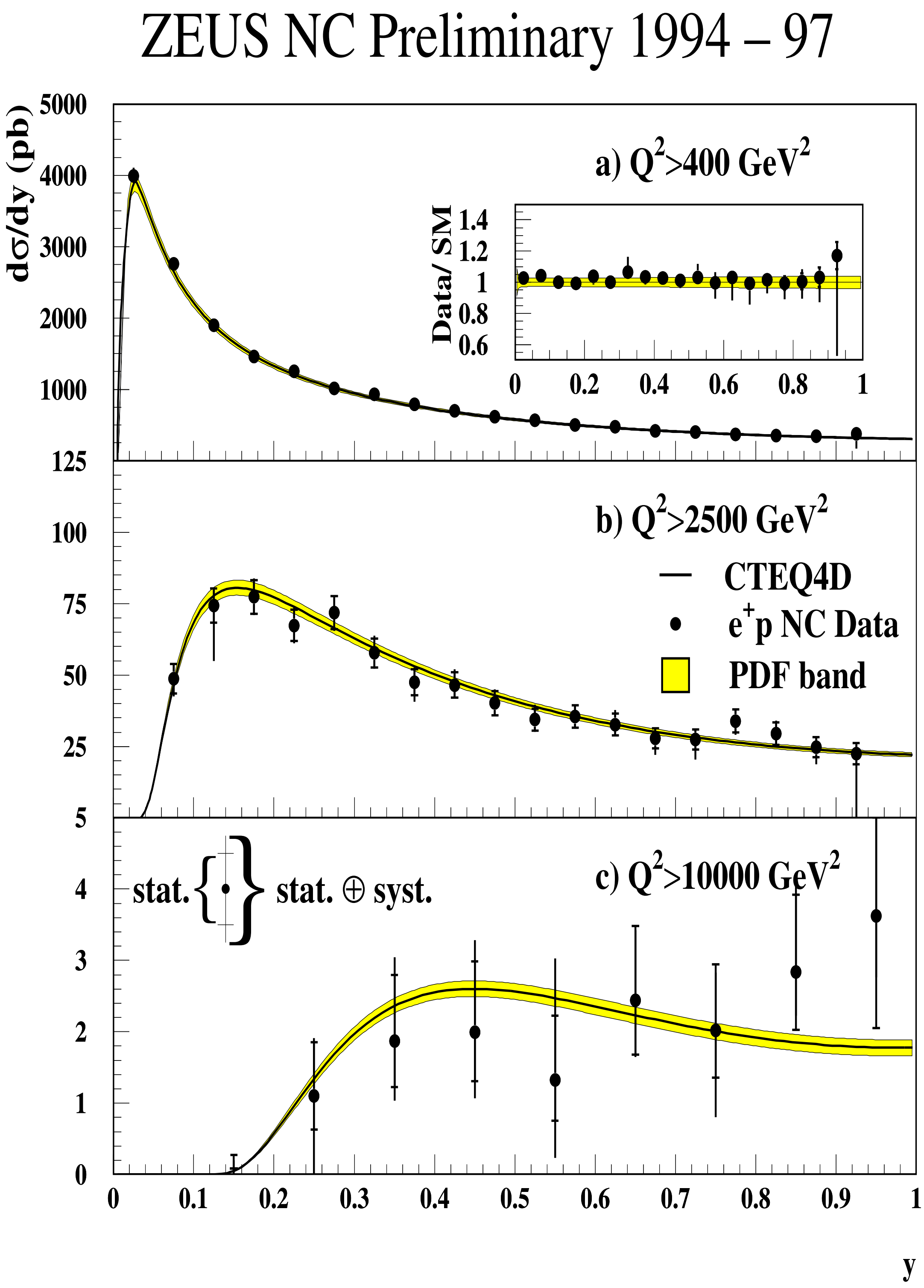
dependence on photon,boson virtuality – hard scale

NC – Cross Section in x



dependence on scaling var. → parton distribution

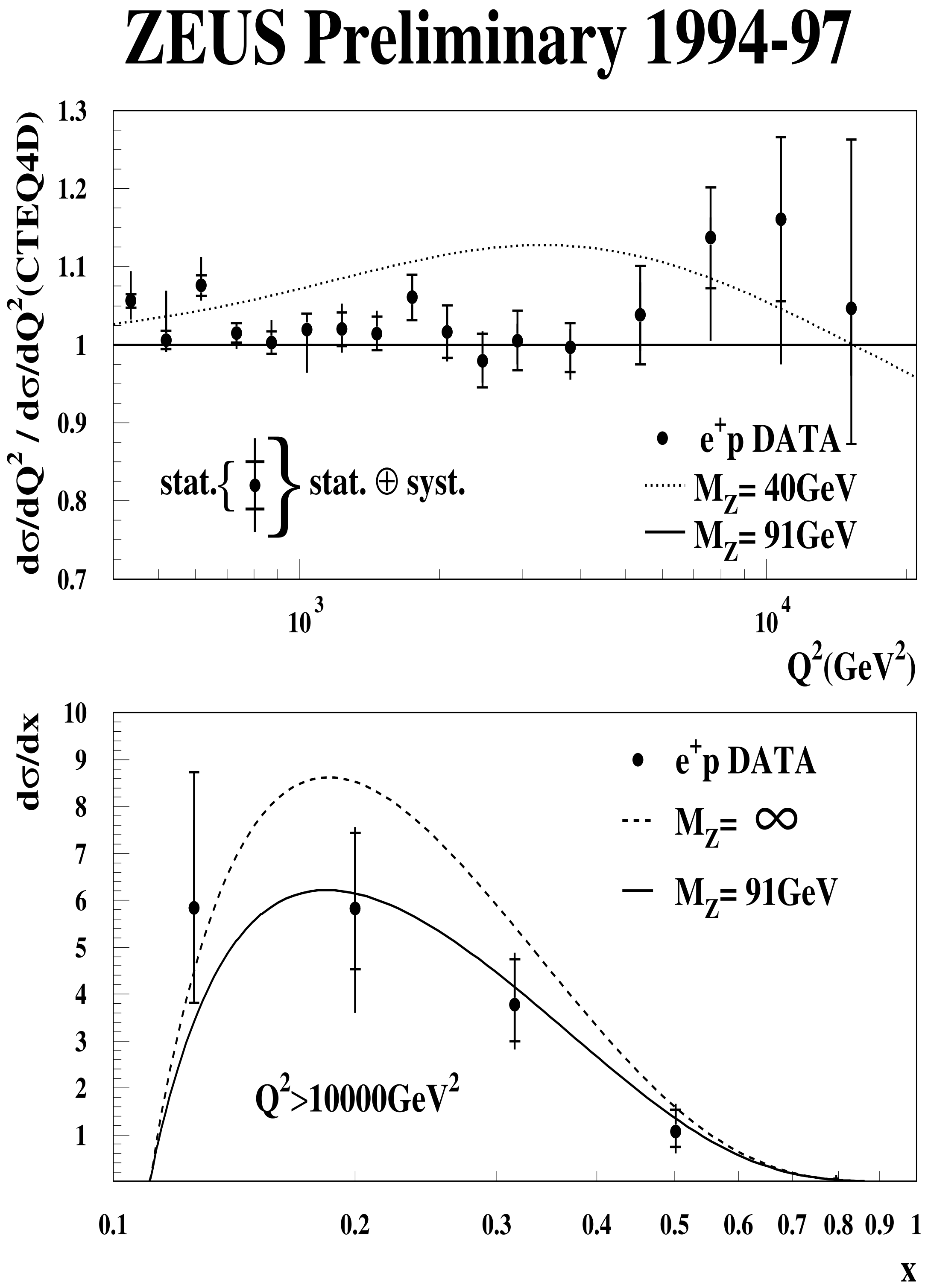
NC – Cross Section in y



dependence on rel. energy transfer → ess. kinematic

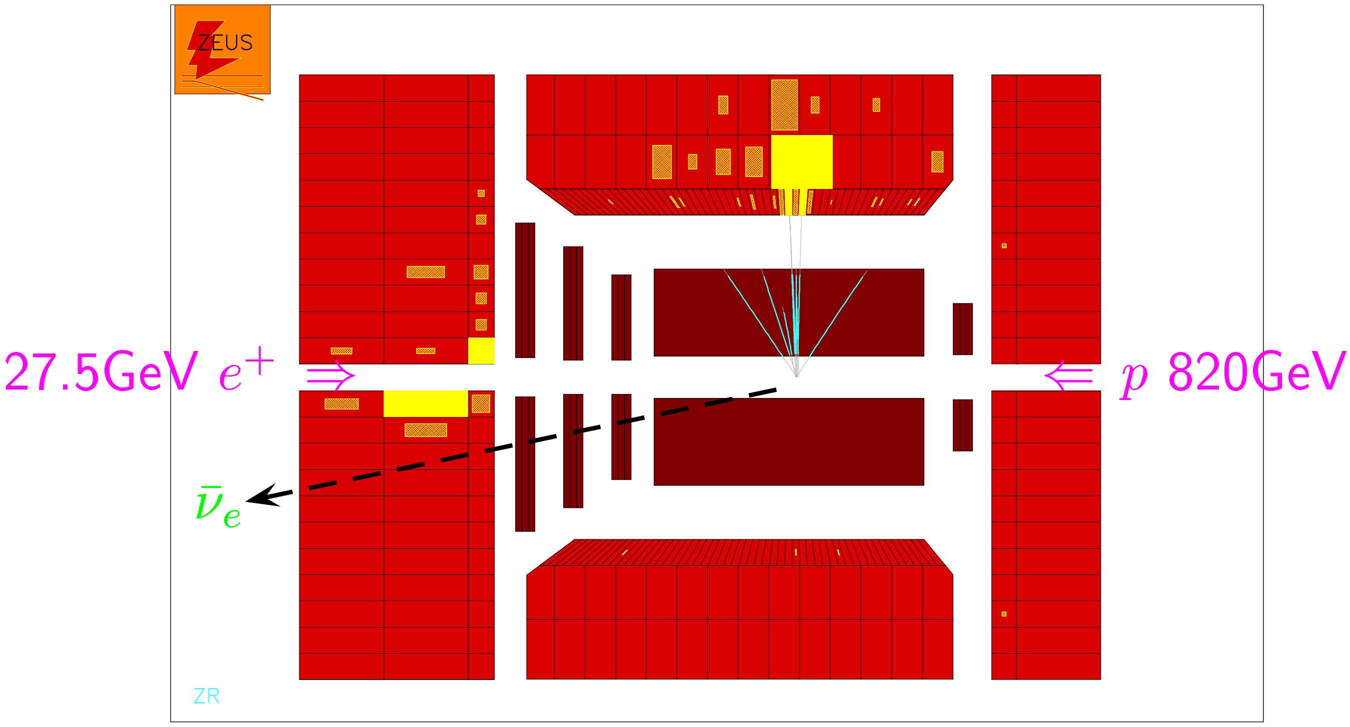
NC – Sensitivity to M_Z

sensitivity to propagator ratio $\frac{Q^2}{Q^2+M_Z^2}$ in F_2, xF_3



Charged Current

1994 to 1997 data $\rightarrow$ $46.6\,\mathrm{pb}^{-1}$



Selection Criteria for $e^+p \rightarrow \bar{\nu}_e X$ (excerpt):

- $\nu \rightarrow$ missing energy: $\not{P}_T > 10\,\mathrm{GeV}$
- vertex position: $-50 < z < 50\,\mathrm{cm}$
- background removal: $\not{P}_T/E_T > 0.4(0.5)$, DIS NC rejection, timing, muon finding
- kin. range: $Q^2 > 400\,\mathrm{GeV}^2$ and $y < 0.9$

  cross section corrected for this

Reconstruction – Jacquet-Blondel Method

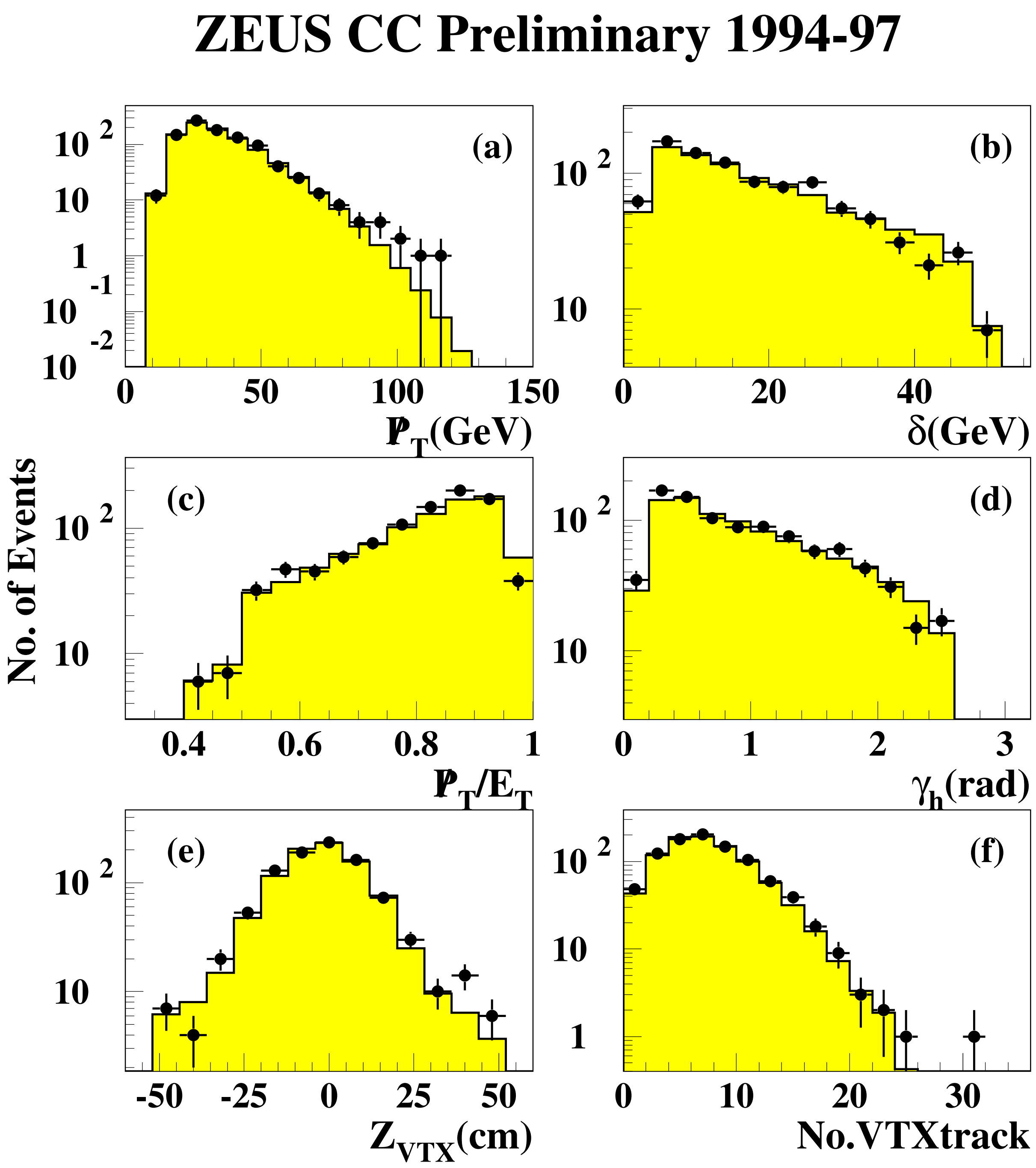
$E - P_Z$ and P_T from hadronic final state (calorimeter, corrected) $\Rightarrow$ Q^2, x, y

CC – Data-MC Comparison

Simulation

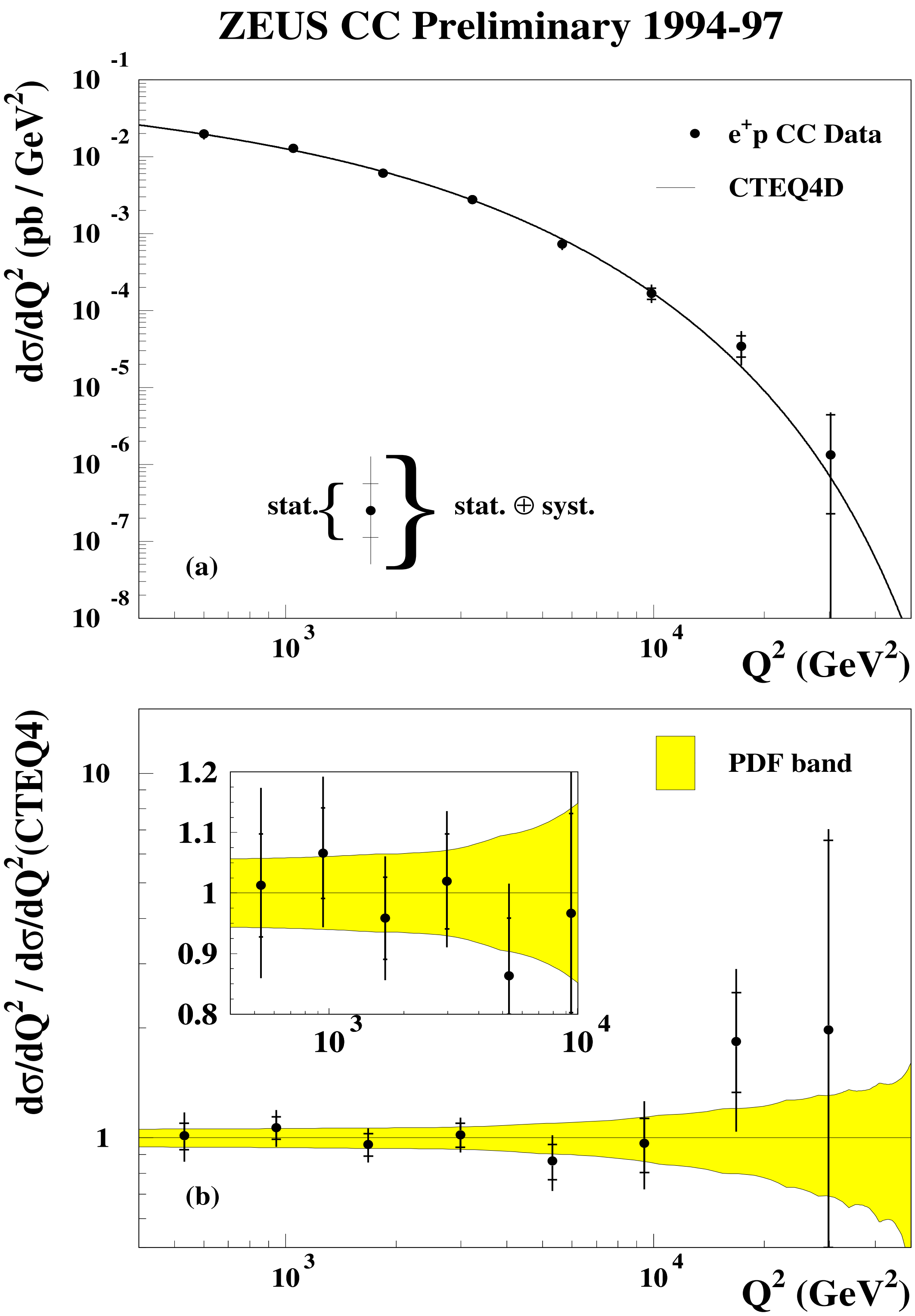
HERACLES for CC DIS and NC background

HERWIG,EPVEC,LPAIR other background ($< 2.5\%$)



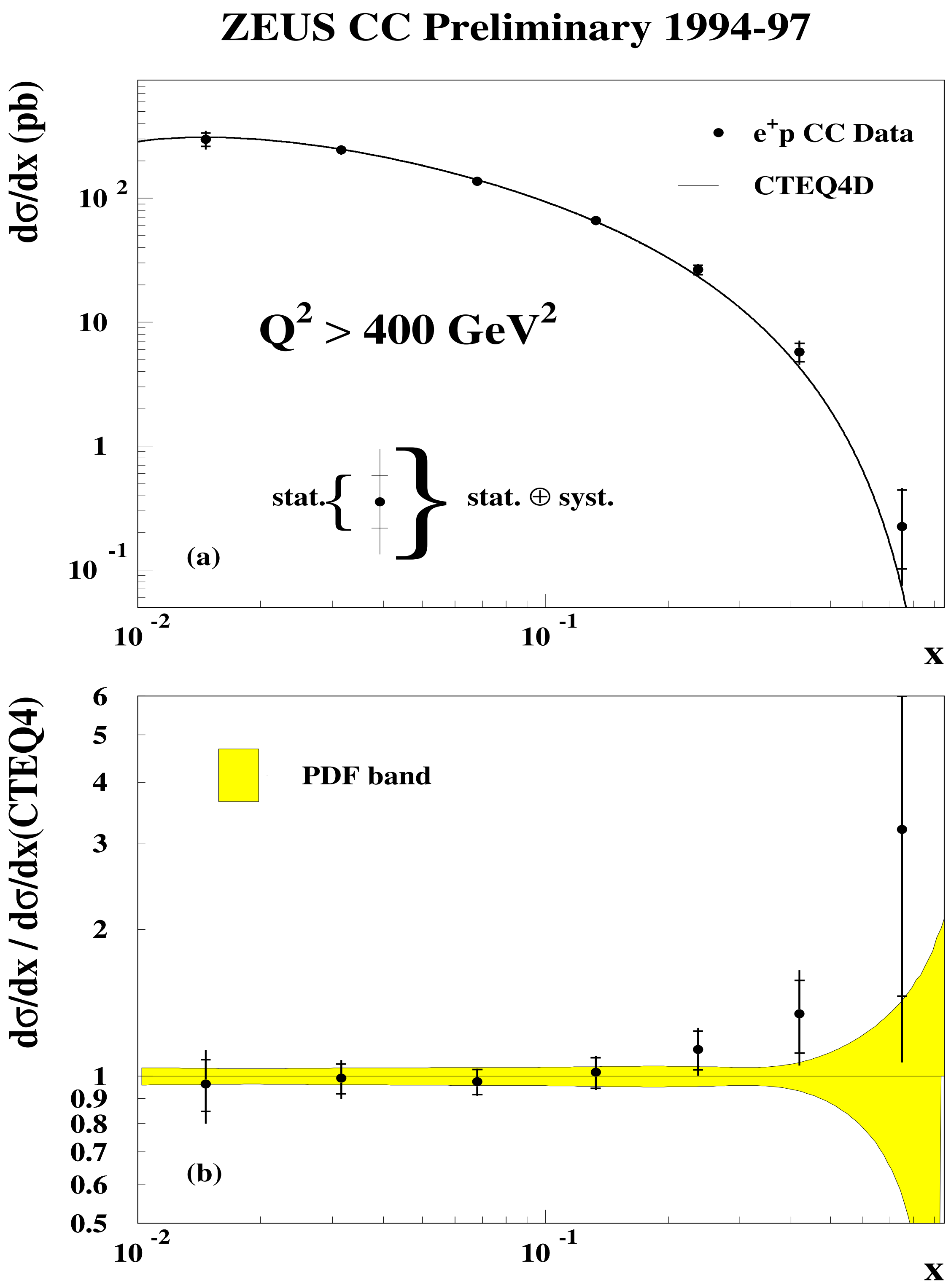
CC MC describes data!

CC – Cross Section in Q^2



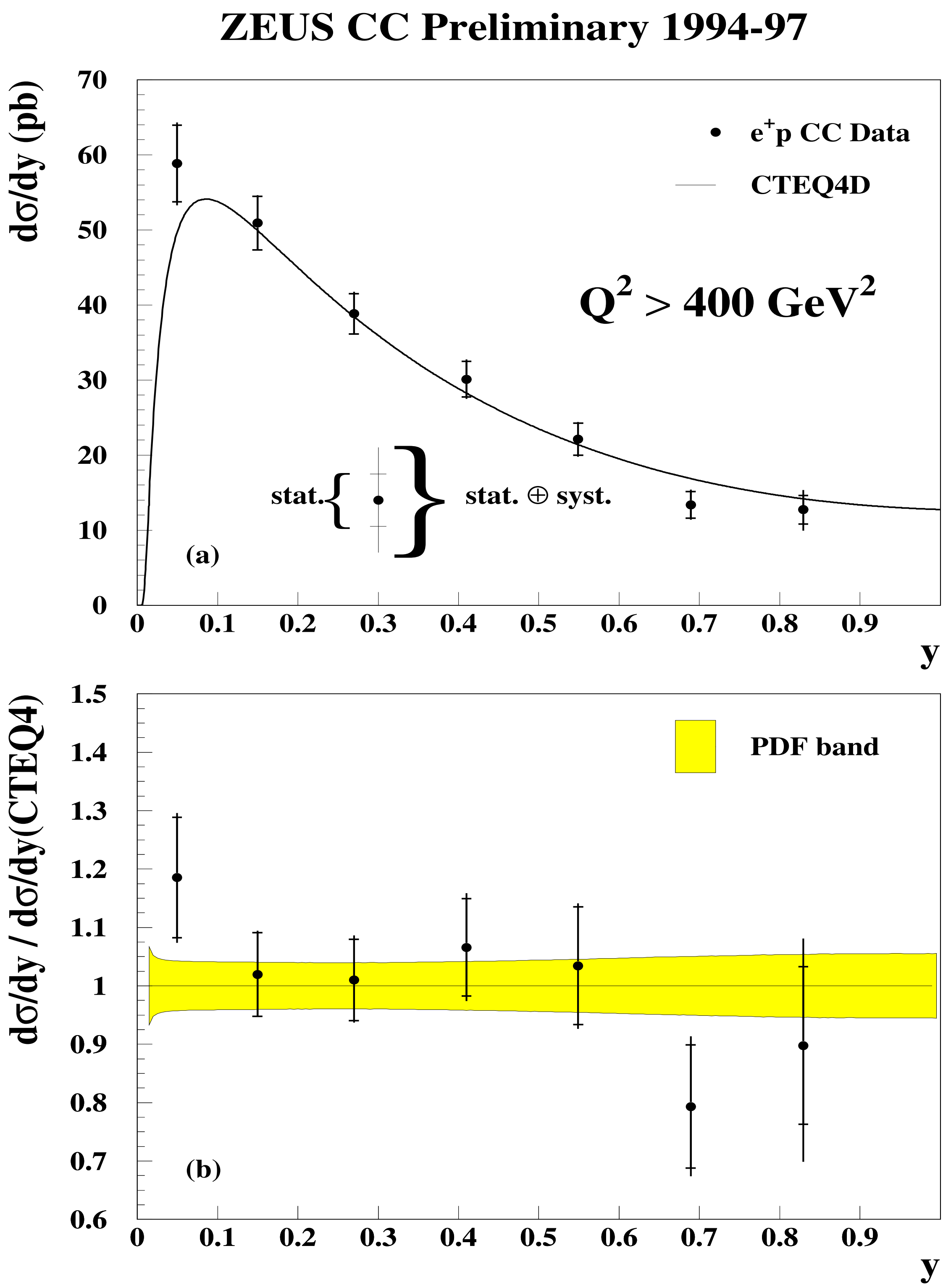
dependence on photon,boson virtuality – hard scale

CC – Cross Section in x



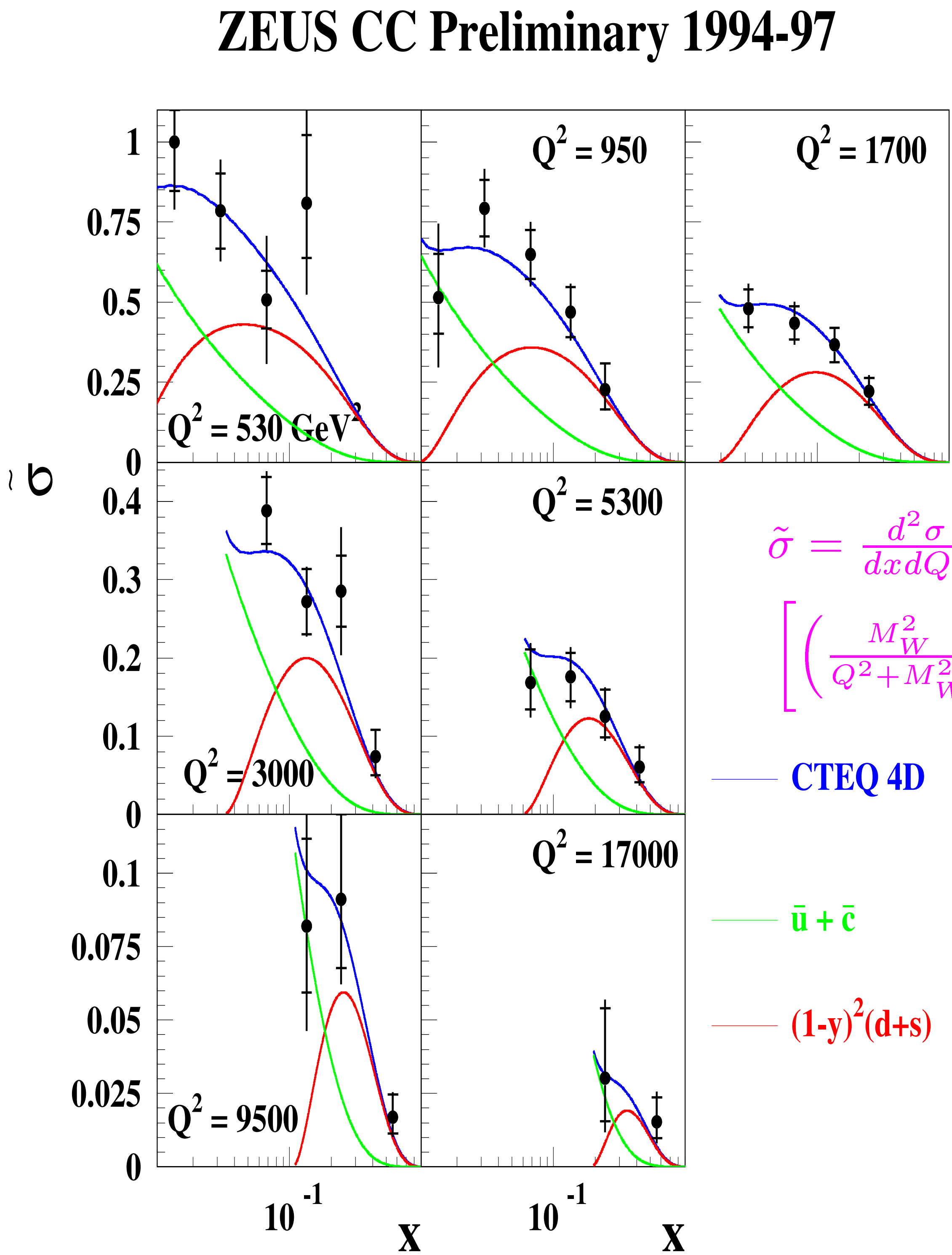
dependence on scaling var. → parton distribution

CC – Cross Section in y



dependence on rel. energy transfer → ess. kinematic

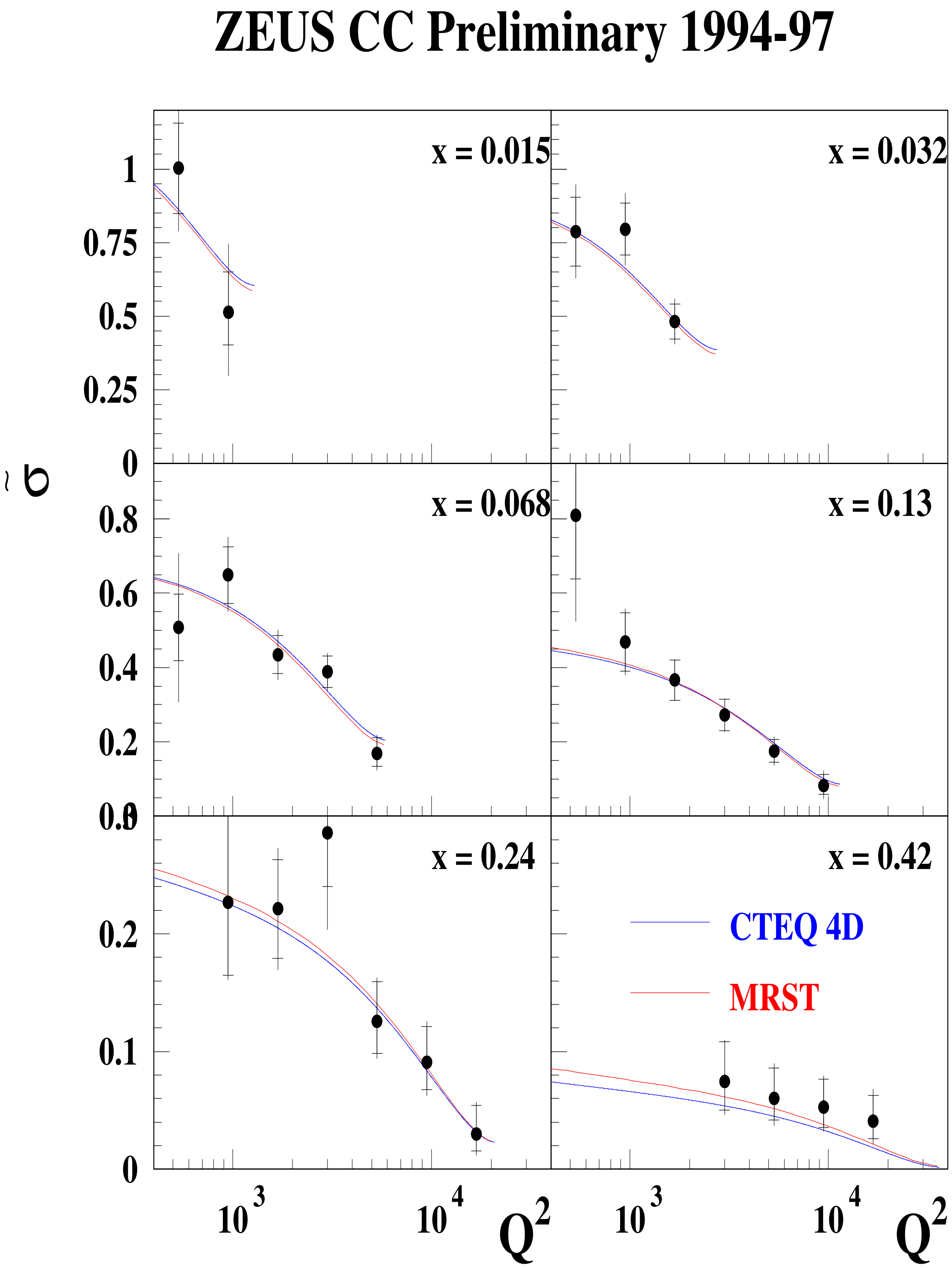
CC – Reduced Cross Section



$$\tilde{\sigma} = \frac{d^2\sigma}{dx\,dQ^2}\,\frac{2\pi x}{G_F^2}\cdot\left[\left(\frac{M_W^2}{Q^2+M_W^2}\right)^2\right]^{-1}$$

sensitivity to parton distribution functions

CC – Reduced Cross Section (contd.)

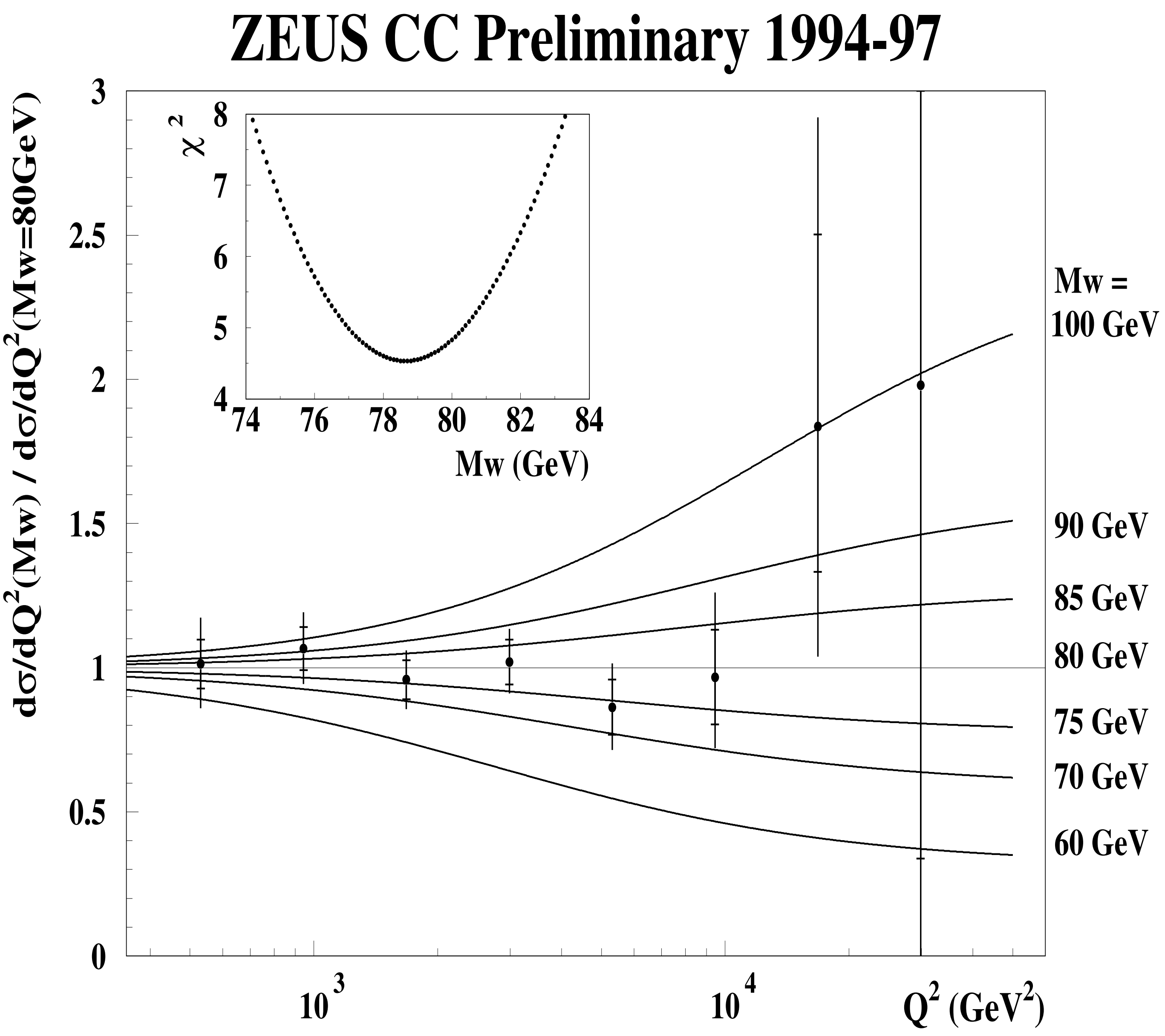


CC – Deriving M_W

sensitivity to W mass via $\frac{M_W^2}{Q^2+M_W^2}$ (keeping G_F fixed)

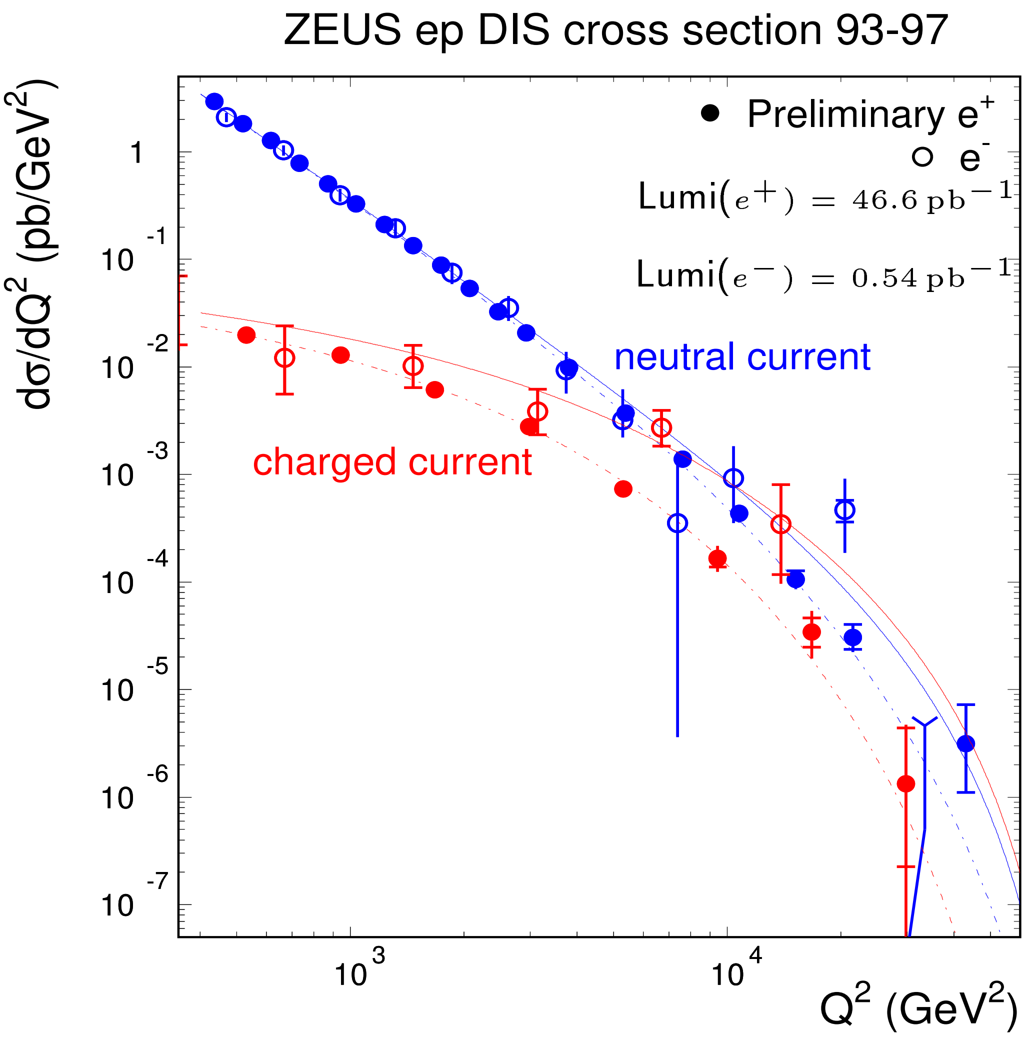
fitting $\frac{d\sigma}{dQ^2}$ yields: $M_W = 78.6^{+2.5}_{-2.4}(\text{stat.})^{+3.3}_{-3.0}(\text{syst.})\,\text{GeV}$.

PDG value: $M_W = 80.41 \pm 0.10\,\text{GeV}$



Summary and Outlook

NC and CC cross sections in good agreement
with prediction from standard model
over a range of several orders of magnitude



electroweak physics at HERA within reach

expecting more exciting physics
from electron running starting this year