Proton Structure Functions F_2 and xF_3 at ZEUS

DIS2000 Liverpool

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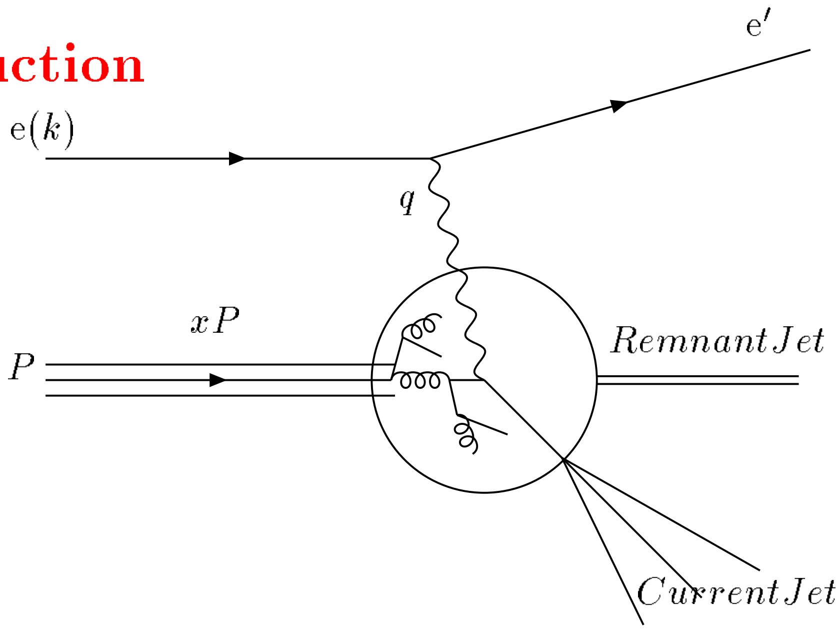
on behalf of the ZEUS collaboration

- **Introduction**
- **New F_2 Measurement**
- **First xF_3 Measurement**
- **Summary**

Introduction

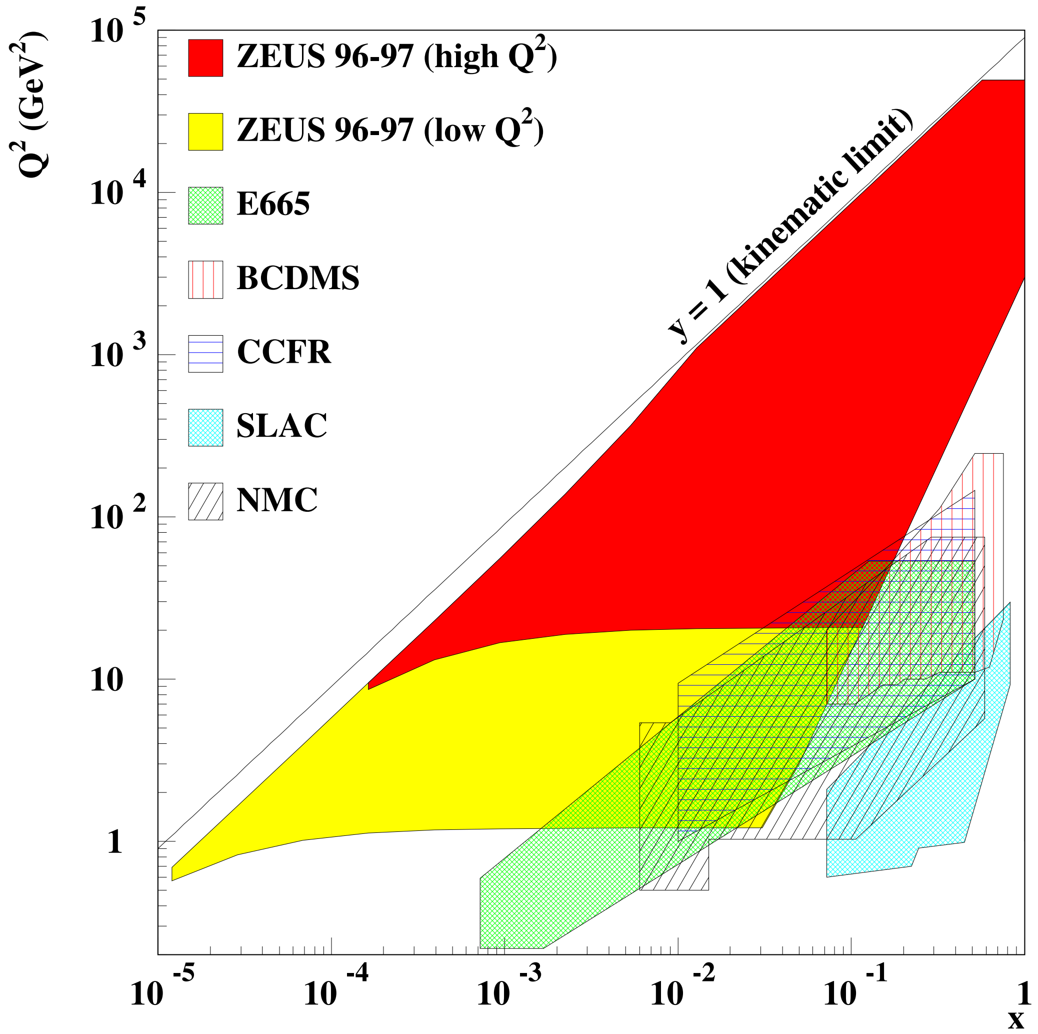


- $Q^2 = -q^2$ = squared 4-momentum transfer
- $x = \frac{-q^2}{2P\cdot q}$ = parton momentum fraction
- $y = \frac{P\cdot q}{P\cdot k}$ = fractional energy transfer
- $Q^2 = sxy$

$$\frac{\mathrm{d}^2\sigma^{NC}(e^{\pm}p)}{\mathrm{d}x\mathrm{d}Q^2} = \frac{2\pi\alpha^2}{xQ^4}\left[y^2 x\mathrm{F}_1 + (1-y)\mathrm{F}_2 \mp (y - \frac{y^2}{2})x\mathrm{F}_3\right]$$

- $\mathrm{F}_L = \mathrm{F}_2 - 2x\mathrm{F}_1$: longitudinal structure function
- $\mathrm{F}_2(x, Q^2) = \sum_f A_f[xq_f(x, Q^2) + x\bar{q}_f(x, Q^2)]$
- $x\mathrm{F}_3$ = parity violating term from Z^0 exchange

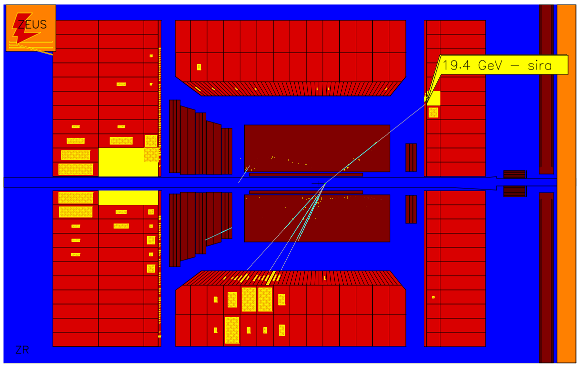
Kinematic Plane



Two data sets:

- Low Q^2:
  - 2.2 pb^{-1}
  - 1 $\mathrm{GeV}^2 < Q^2 < 25\ \mathrm{GeV}^2$
- High Q^2:
  - 30.2 pb^{-1}
  - 25 $\mathrm{GeV}^2 < Q^2$

The ZEUS detector



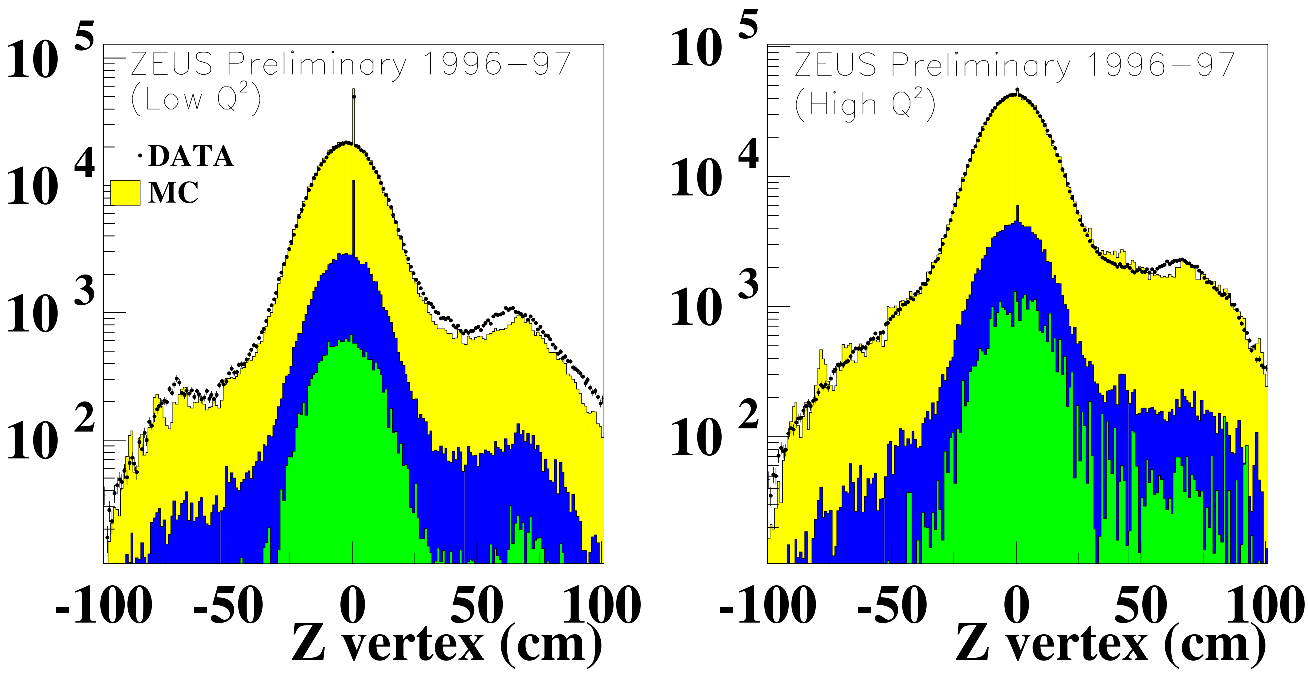
Calorimeter:

- Uranium-Scintillator
- $\sigma(E)/E = 35\%/\sqrt{E(\mathrm{GeV})}$ (hadronic)
- $\sigma(E)/E = 18\%/\sqrt{E(\mathrm{GeV})}$ (electro magnetic)

Central Tracking Detector:

- Drift Chamber
- $\sigma(p_t)/p_t = 0.0058 p_t \oplus 0.0065 \oplus 0.0014/p_t(\mathrm{GeV})$
- Vertex resolution 1 mm

Vertex:



(Side bands reflect the bunch structure of p-beam.)

Measurement of Kinematics

Measure: E'_e, E_h, θ_e, θ_h

Calculate: x, Q^2

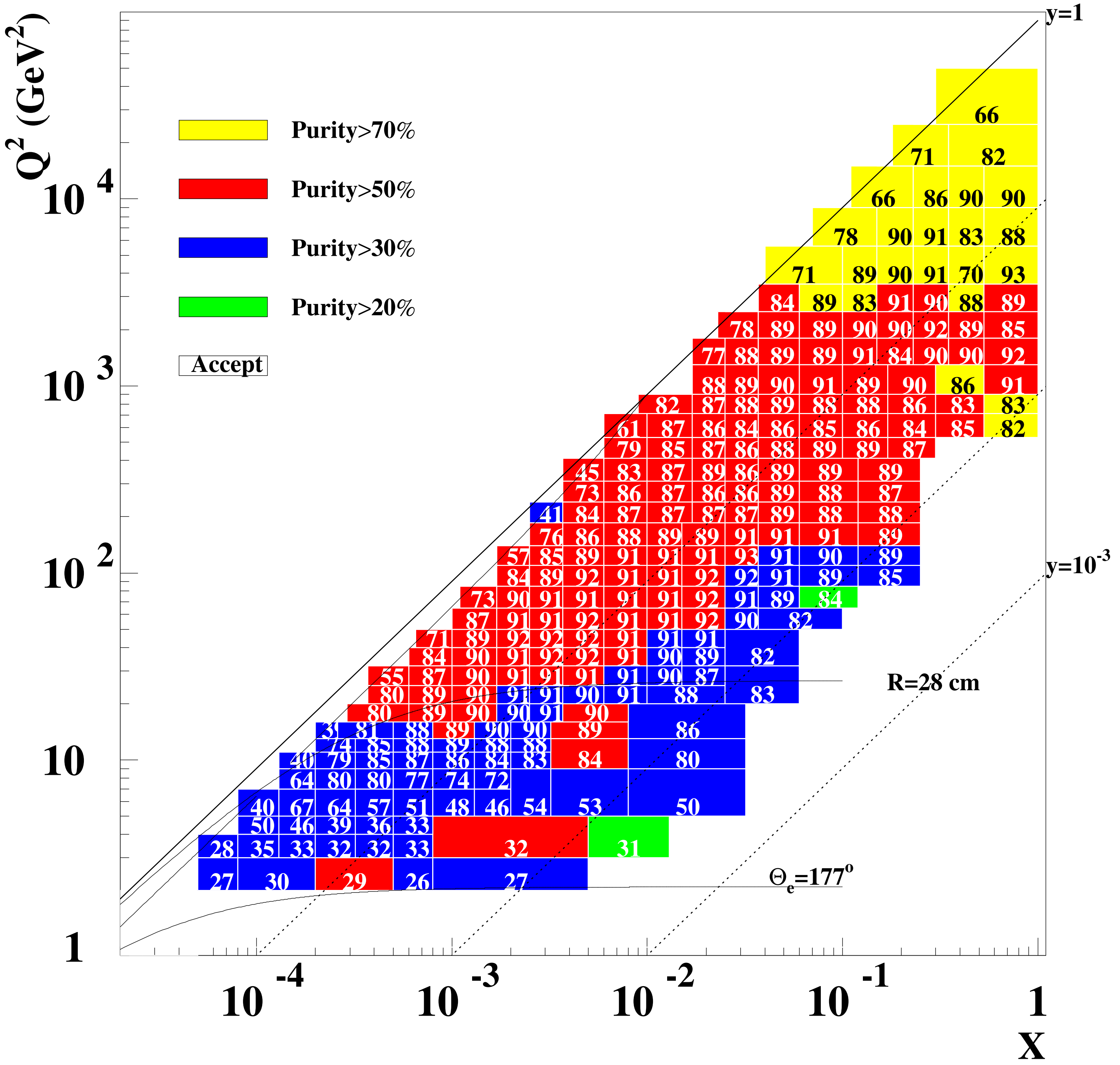
$\Longrightarrow$ PT Method:

- Based on Double Angle Method:
  - x, Q^2 from θ_e, θ_h
- Uses Pt balance as a constraint.
- Using all 4 variables.
- (See 94 publication: hep-ex/9607002)

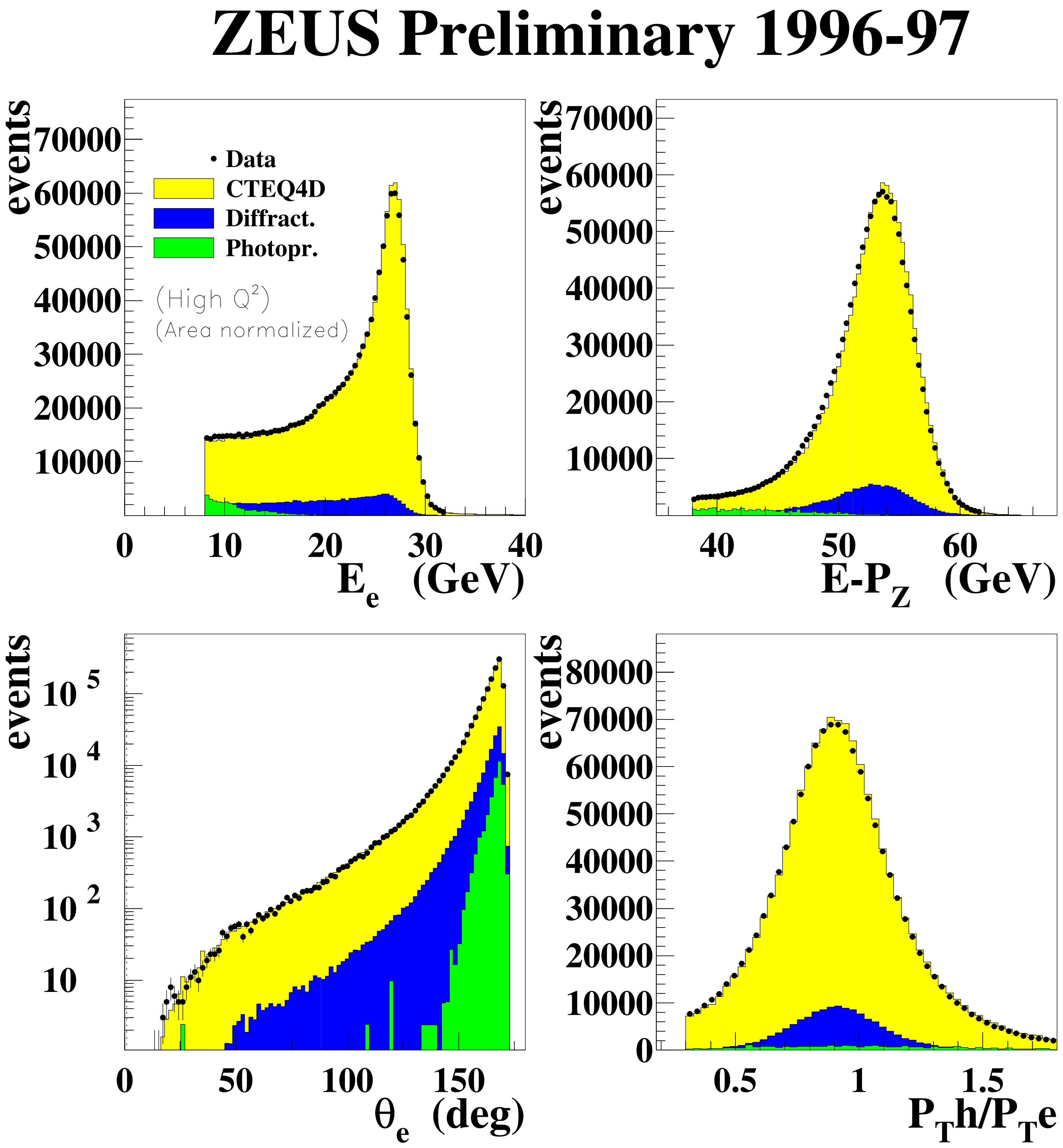
- x resolution 11% at high y, 35% at low y
- Q^2 resolution 2-5% at high y, 10-15% at low y

Binning

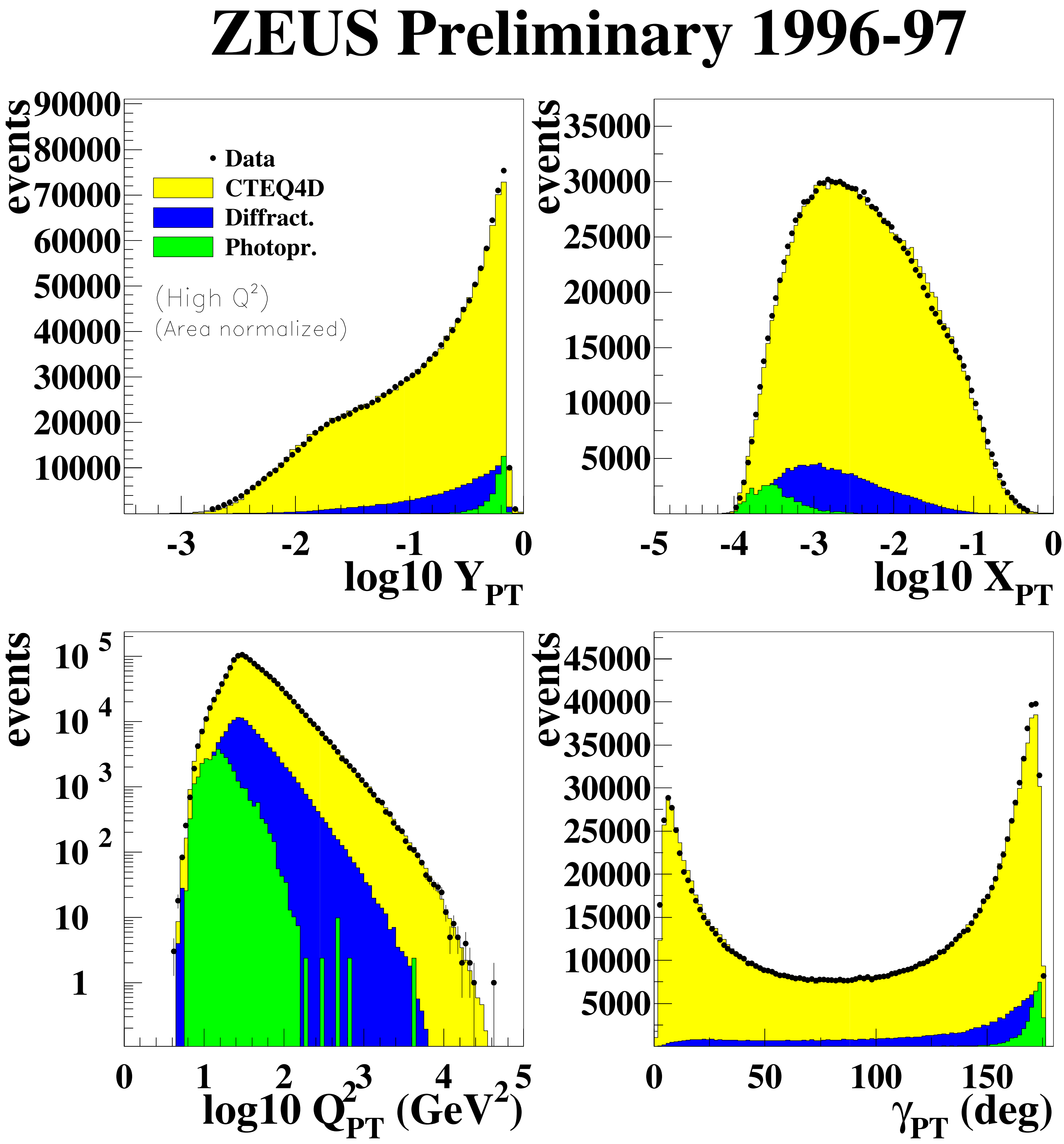
- Binning is based on resolution
- *"Good"* bin: Acc> 20% & Pur> 30%



Event Distributions (1)



Event Distributions (2)



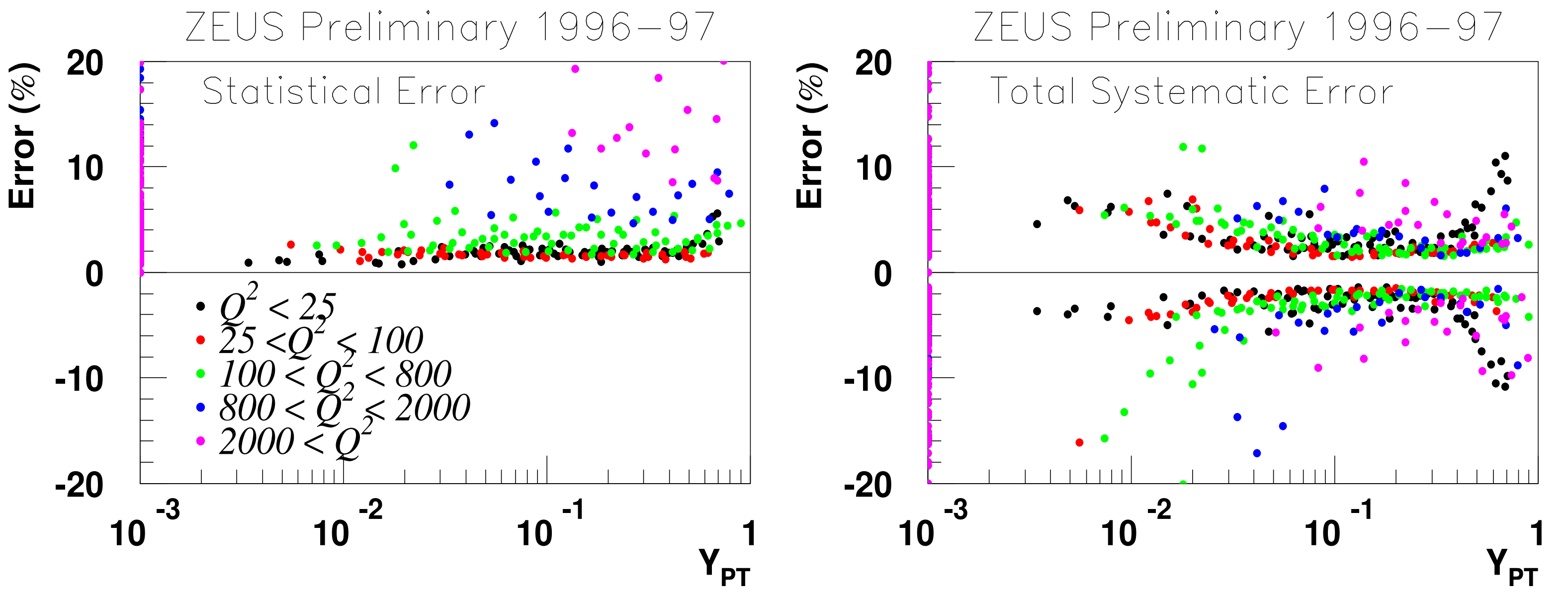
F_2 Error

Statistical

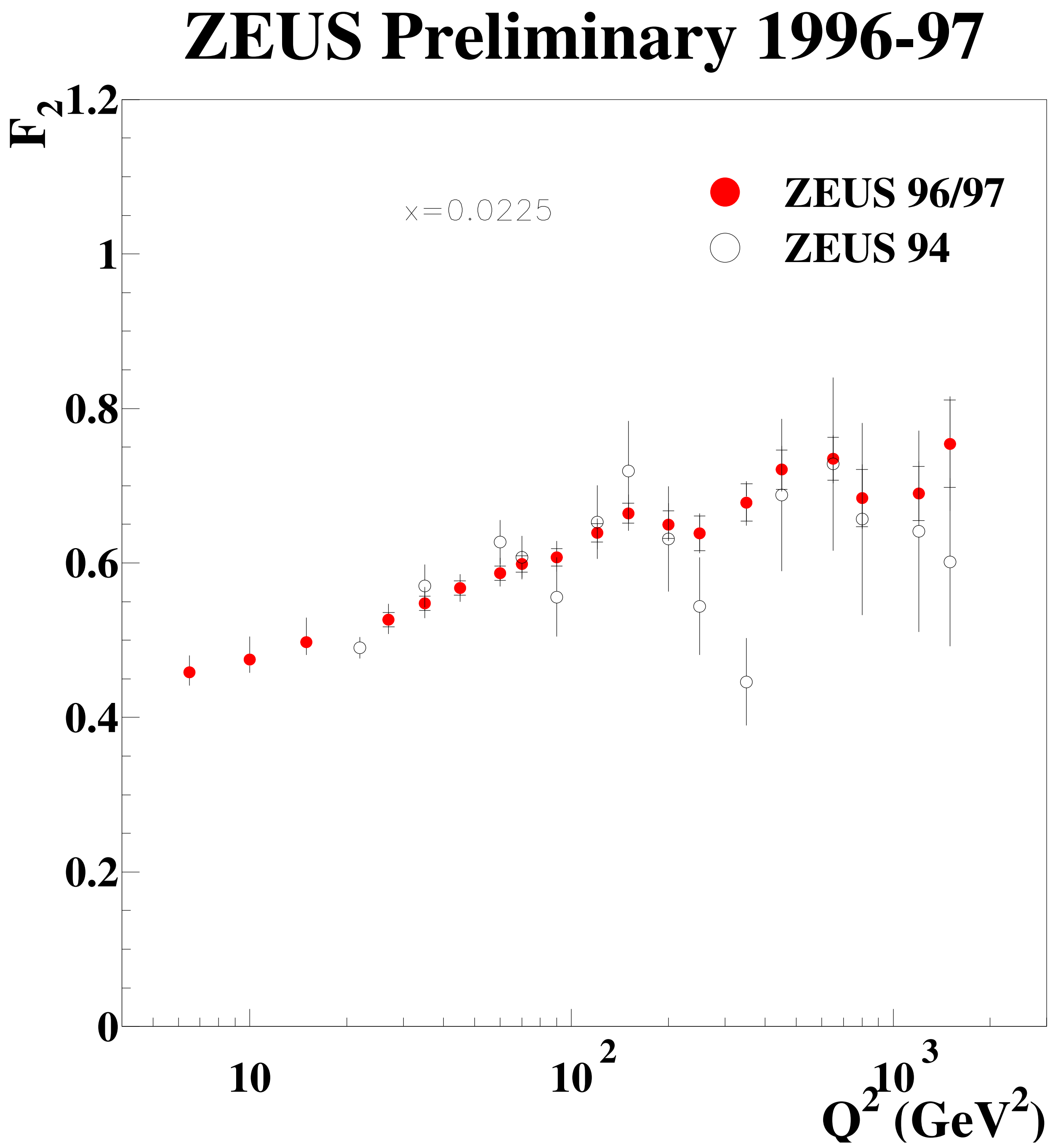
- After event selection: $0.7 \cdot 10^6$ evts at low Q^2
- After event selection: $1.3 \cdot 10^6$ evts at high Q^2
- MC sample: $7.5 \cdot 10^6$ events generated
  - 2.5 (7.5) $\times$ the data at $Q^2 = 1$ (400) GeV^2
- $\Longrightarrow$ Statistical error dominates $Q^2 > 800$ GeV^2

Systematic

- Electron energy scale $\delta E_e / E_e = 1\%$
- Hadronic energy scale $\delta E_h / E_h = 2\%$
- γp background: at high y up to 8-10%
- Hadronic final state: at low y up to 10%
- 2% normalisation error (not in the points)
- Vertex distribution affects acceptance (not in the points):
  - 1% relative normalisation error between low Q^2 and high Q^2 sample

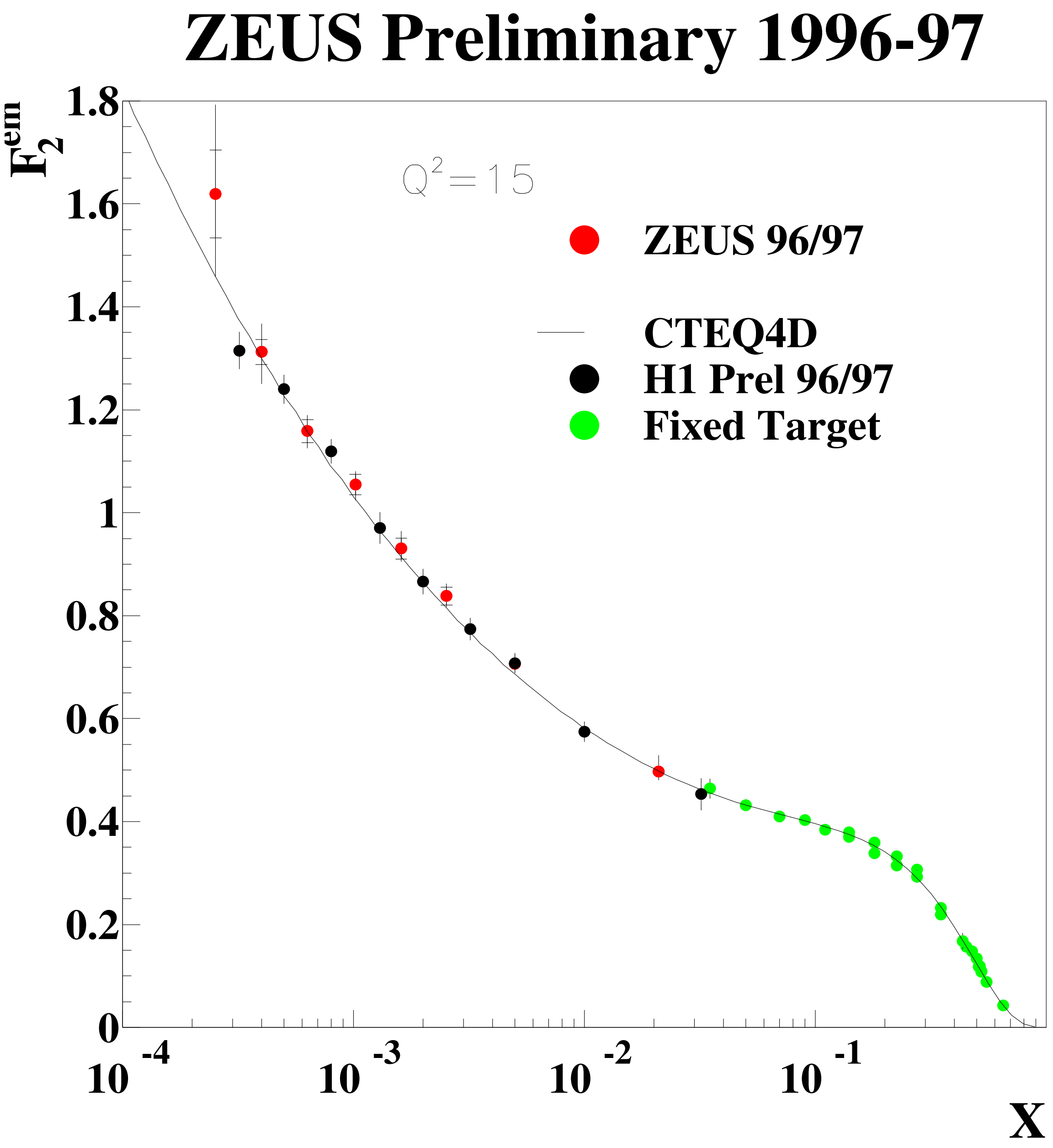


Comparison Previous Result



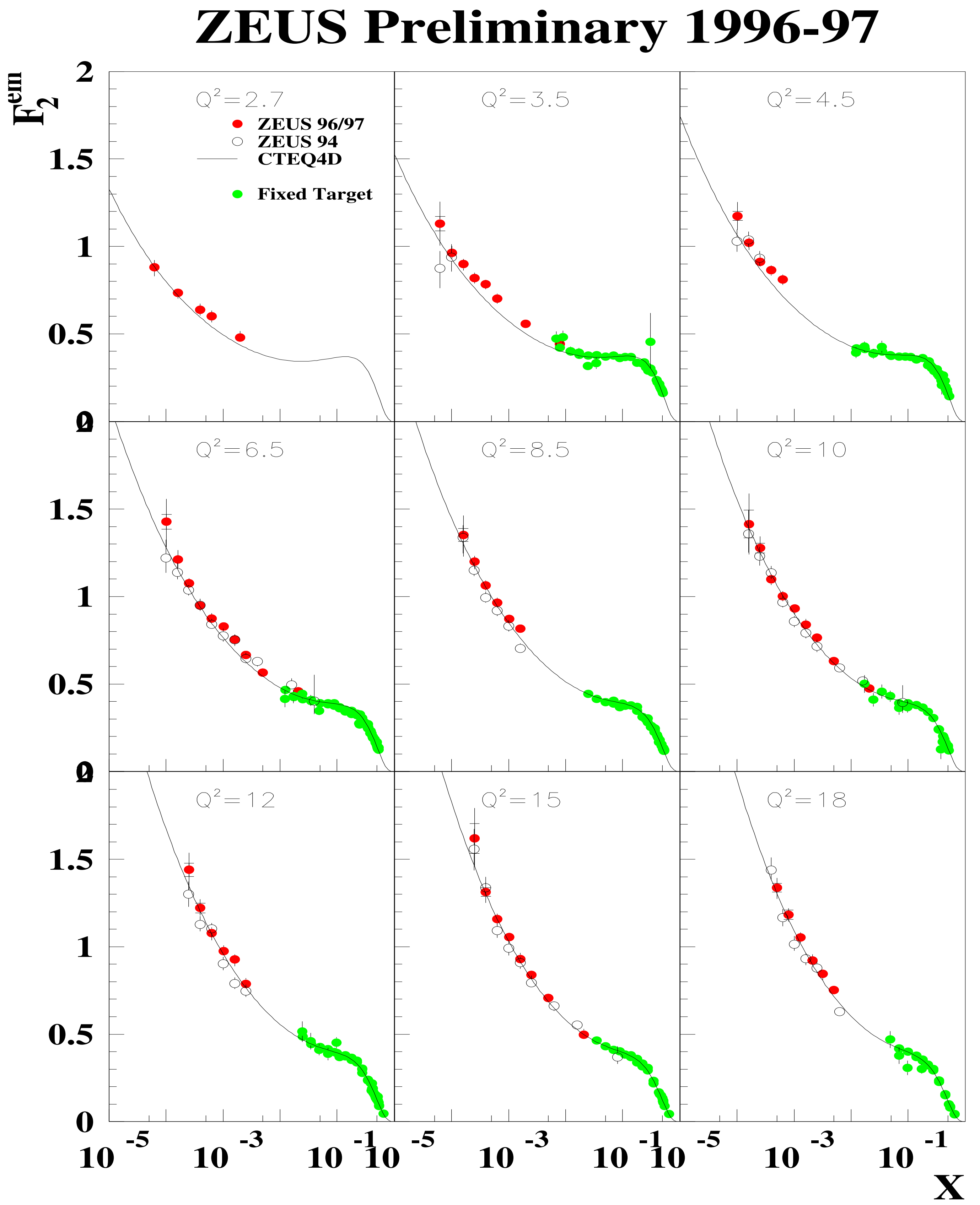
- Precision improved a lot with respect to previous analysis!

$F_2(x)$ by ZEUS and H1



- ZEUS and H1 agree well
- Fixed Target : high x: valence quark structure
- HERA : low x : strong rise of $F_2 \sim x^{-\lambda}$

New Results on F_2



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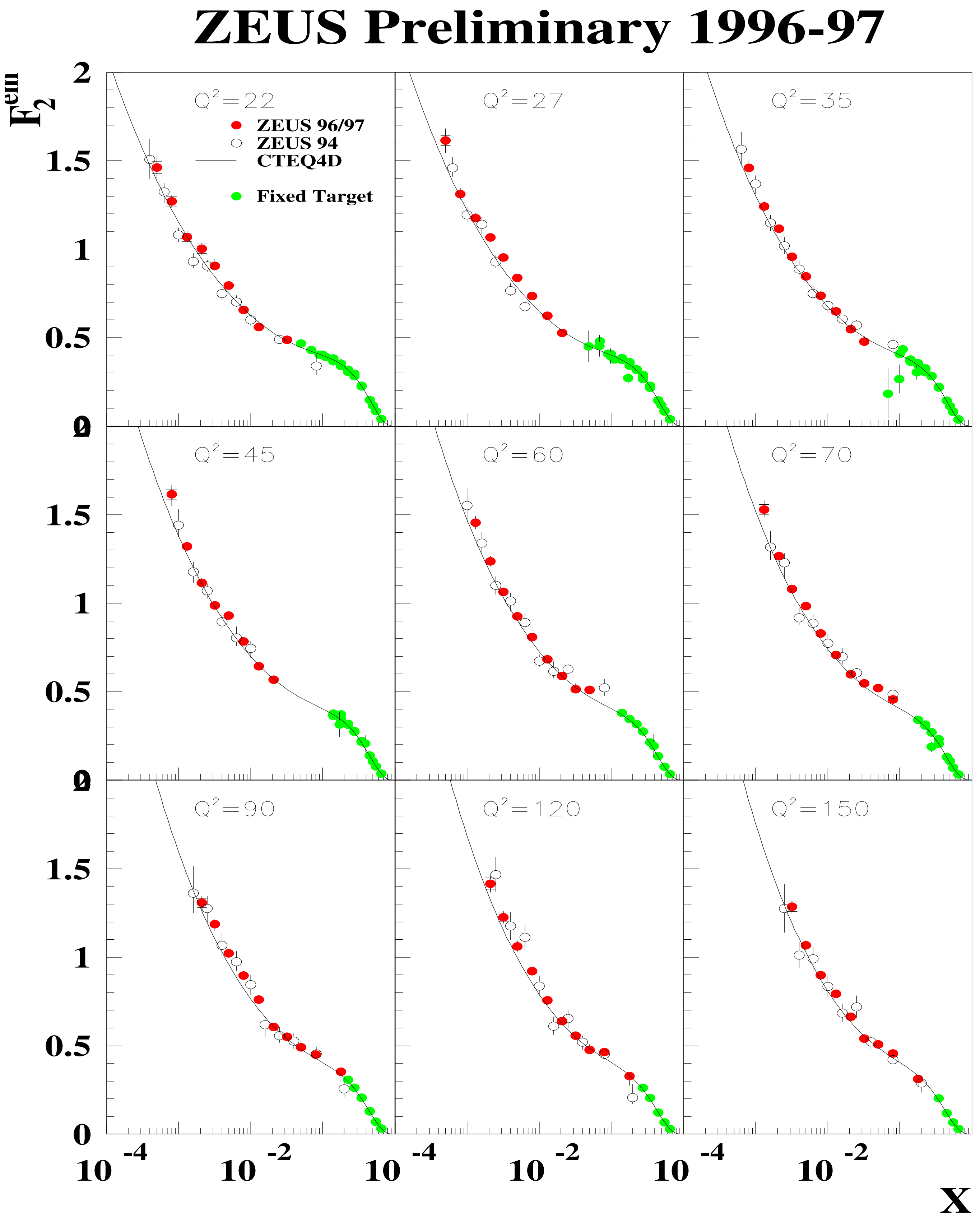

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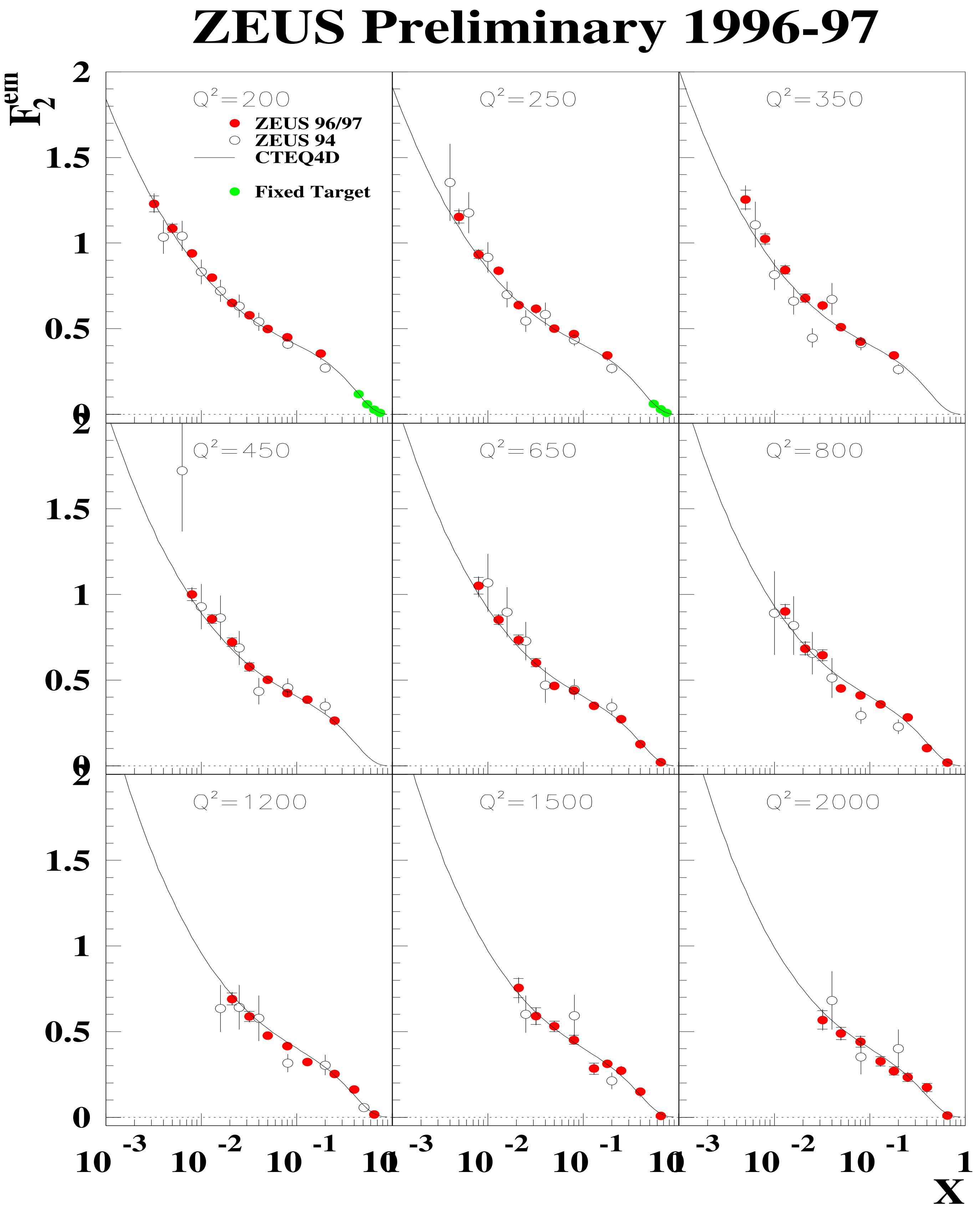

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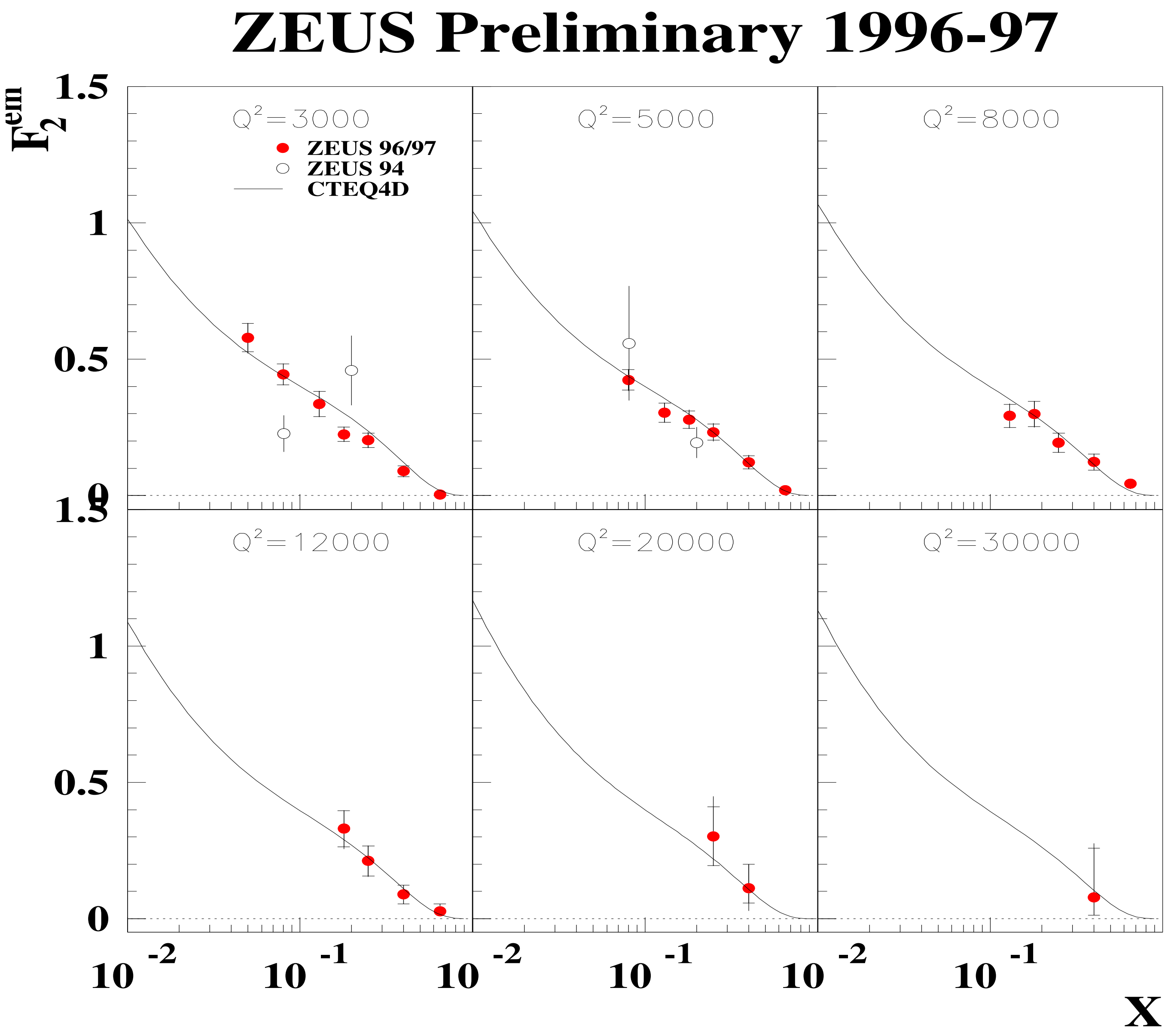
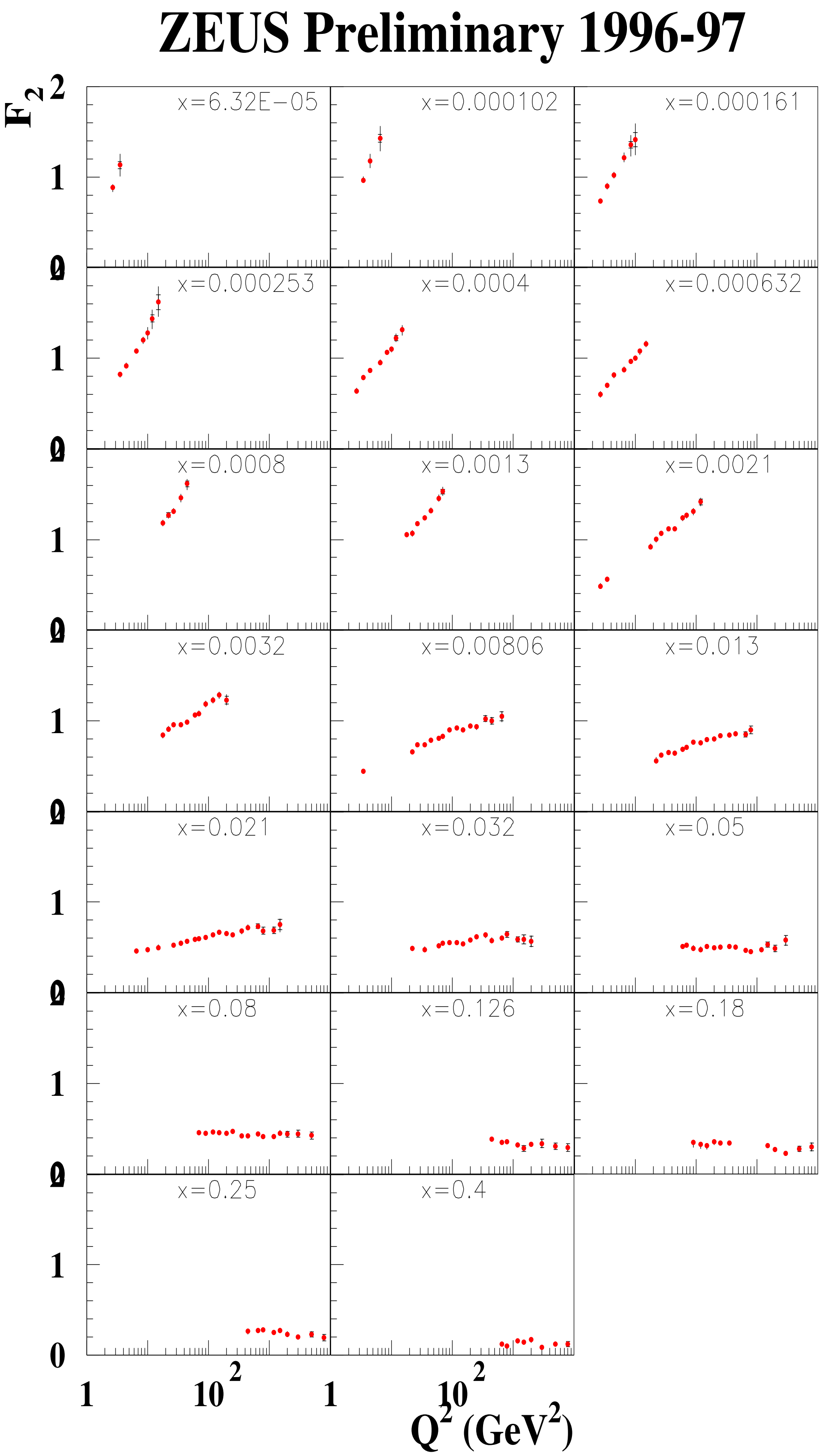
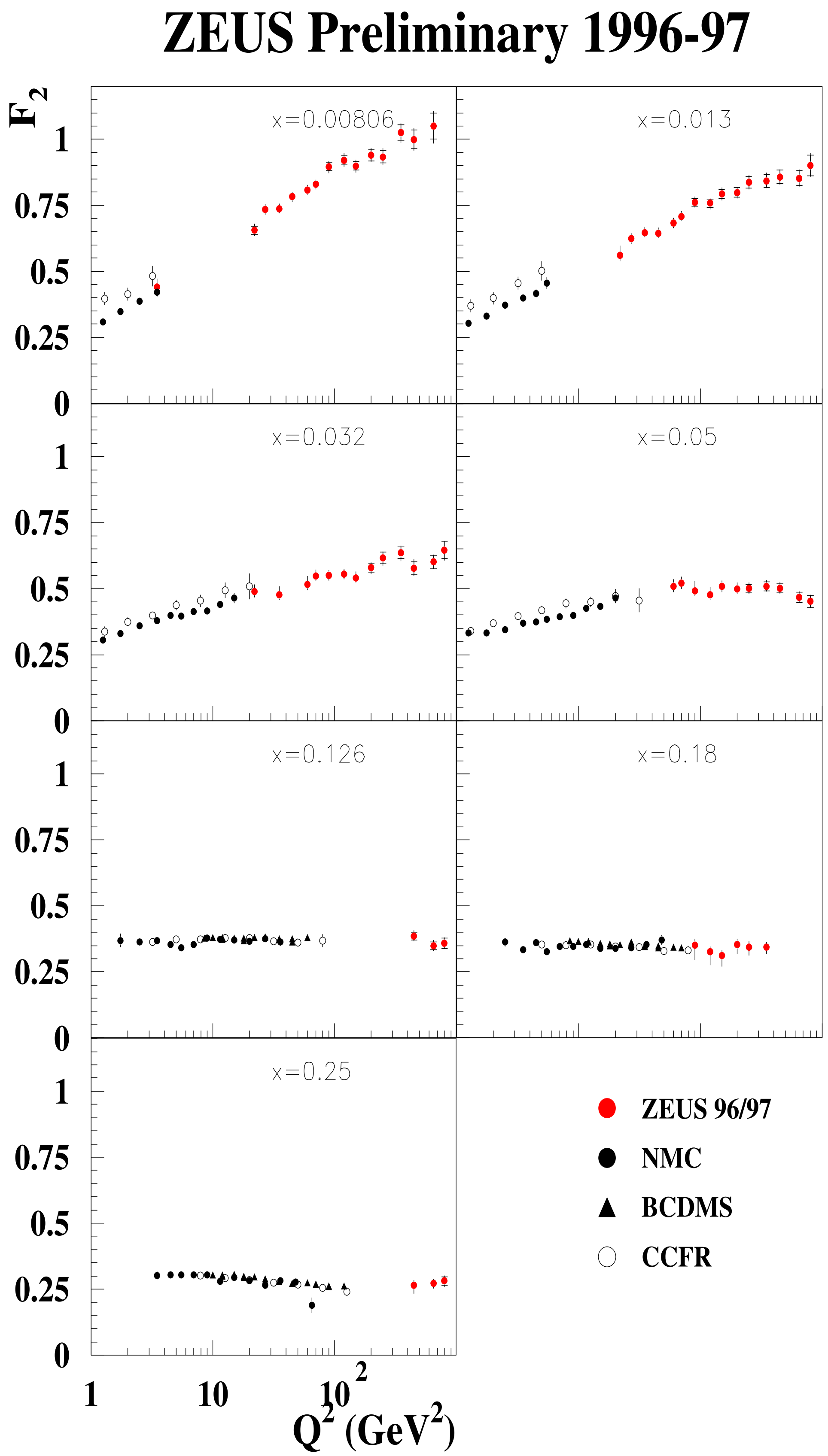


Scaling Violations



Comparison with Fixed Target



$x\mathrm{F}_3$ at HERA

(see A.Kappes talk Thursday WG3)

$$\frac{\mathrm{d}^2\sigma^{NC}(e^{\pm}p)}{\mathrm{d}x\mathrm{d}Q^2} = \frac{2\pi\alpha^2}{xQ^4}\left[y^2 x\mathrm{F}_1 + (1-y)\mathrm{F}_2 \mp (y - \frac{y^2}{2}) x\mathrm{F}_3\right]$$

Probing the valence quarks:

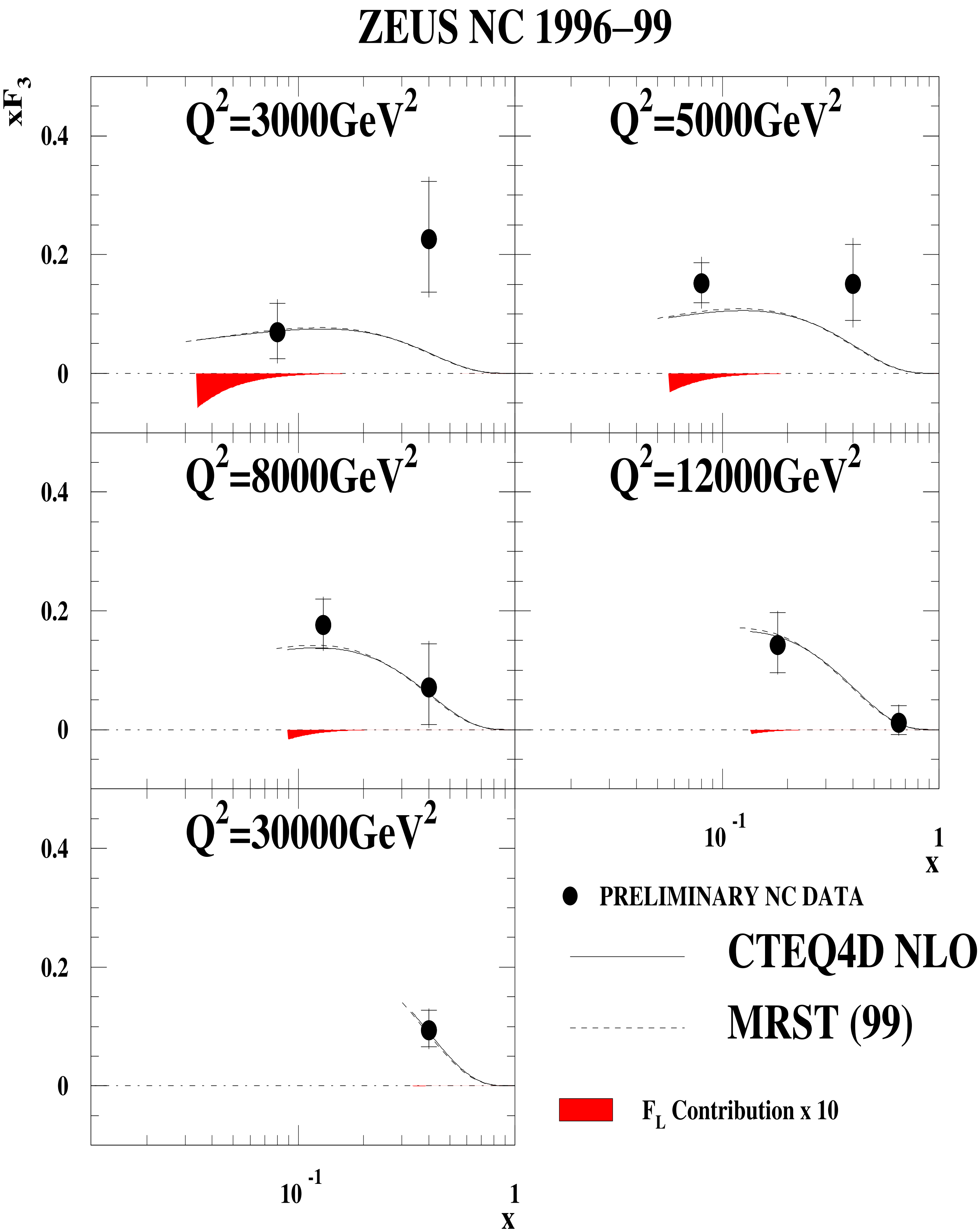
$$x\mathrm{F}_3(x,Q^2) = \sum_f B_f[xq_f(x,Q^2) - x\bar{q}_f(x,Q^2)] \quad \text{(QPM)}$$

Combine e^+p and e^-p data:

- e^+p : 96+97 : 30 pb^{-1}
- e^-p : 98+99 : 16 pb^{-1}

- First $x\mathrm{F}_3$ results at high Q^2 !
- First $x\mathrm{F}_3$ results on a proton target !
- Comparable errors to first F_2 results from HERA !

First measurement of $x\mathrm{F}_3$!



Summary

- **New results on $\mathbf{F}_2$**
  over large kinematical range:
  - $2 < Q^2 < 30000$ GeV^2
  - $6 \cdot 10^{-5} < x < 0.4$
- Systematical Error dominates $Q^2 < 800$ GeV^2
- Overlap with fixed target data

- **First $x\mathbf{F}_3$ results from HERA**
- Sensitive to valence quarks
- Lots of e^+p and e^-p luminosity to come...