Measurement of F_2 and F_L with H1

Doris Eckstein
DESY Zeuthen

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The DIS cross-section

$$\frac{1}{\kappa}\frac{d^2\sigma}{dxdQ^2} = \tilde{F}_2(x,Q^2) - \frac{y^2}{Y_+}\cdot\tilde{F}_L(x,Q^2) \mp \frac{Y_-}{Y_+}\cdot x\tilde{F}_3 = \sigma_r$$

$$Y_\pm = 1 \pm (1-y)^2 \qquad \kappa = \frac{2\pi\alpha^2}{xQ^4}$$

$$\tilde{F}_2 = F_2 - v\frac{\kappa_w Q^2}{Q^2+M_Z^2}\cdot F_2^{\gamma Z} + \left(v^2+a^2\right)\left(\frac{\kappa_w Q^2}{Q^2+M_Z^2}\right)^2\cdot F_2^Z$$

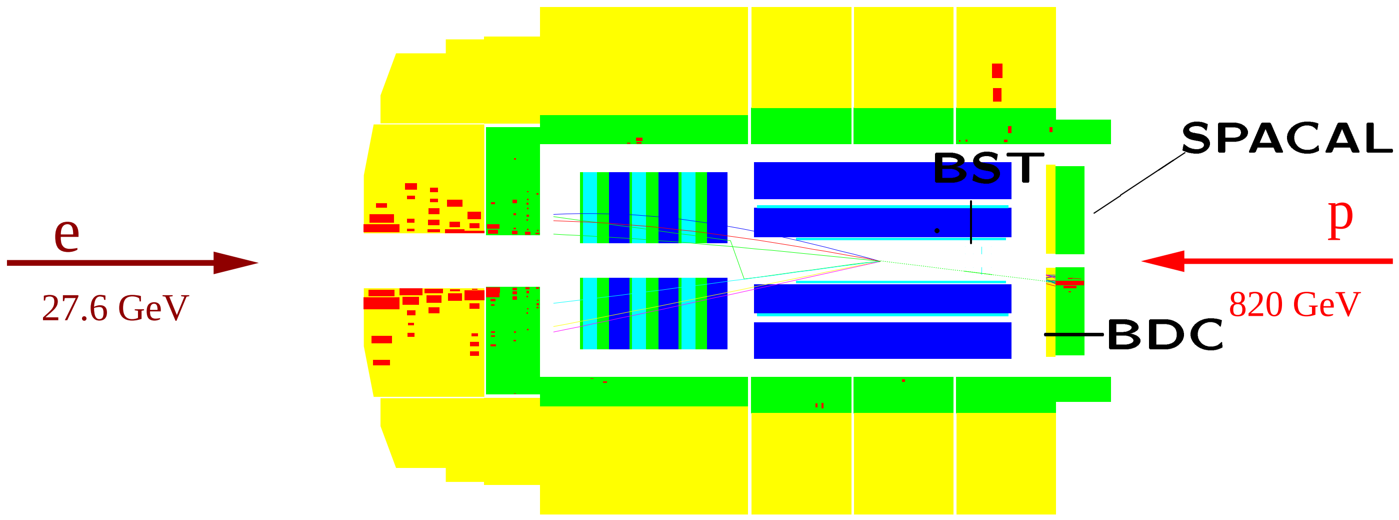
$$x\tilde{F}_3 = \quad -a\frac{\kappa_w Q^2}{Q^2+M_Z^2}\cdot xF_3^{\gamma Z} + (2va)\left(\frac{\kappa_w Q^2}{Q^2+M_Z^2}\right)^2\cdot xF_3^Z$$

$$\kappa_w = 1/(4\sin^2\theta_w\cos^2\theta_w) \qquad a = -\frac{1}{2} \qquad v = -\frac{1}{2} + 2\sin^2\theta_w$$

low $Q^2 \ll M_Z^2$	high Q^2
γ exchange	γ^2, γZ, Z^2
• $\sigma_r = F_2 - \frac{y^2}{Y_+}F_L$	• Z effect requires large Q^2
➥ $\sigma_r \simeq F_2$ at low y	• $\frac{Y_-}{Y_+}x\tilde{F}_3$
➥ $\sigma_r \Rightarrow F_2 - F_L$ for $y \to 1$	➥ Z effect requires high y

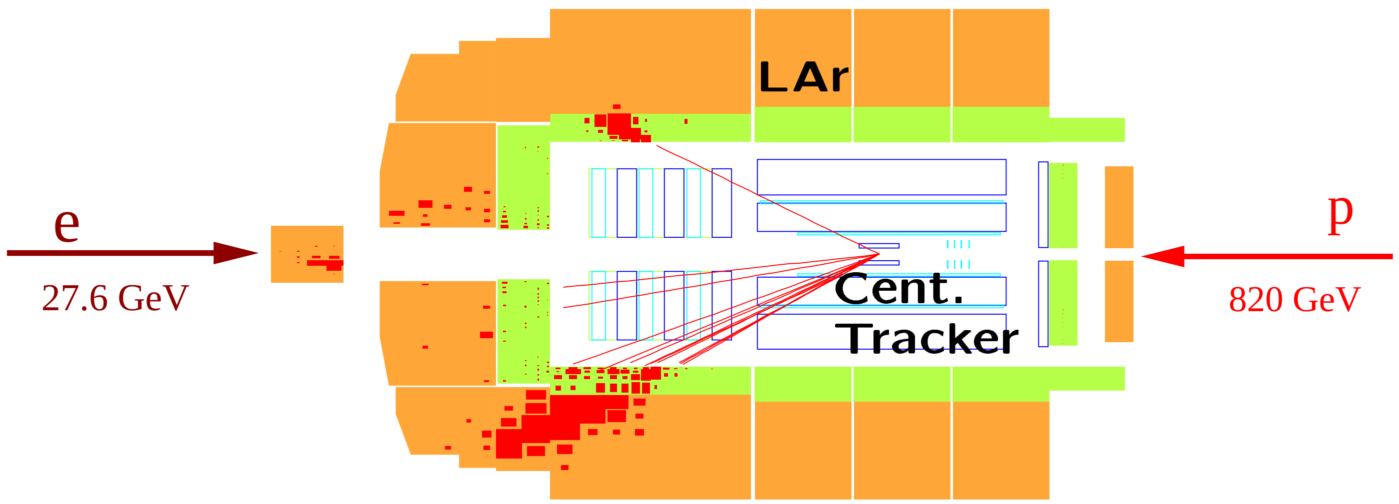
Electron in SPACAL:

$$1.5\, GeV^2 \leq Q^2 \leq 150\, GeV^2$$

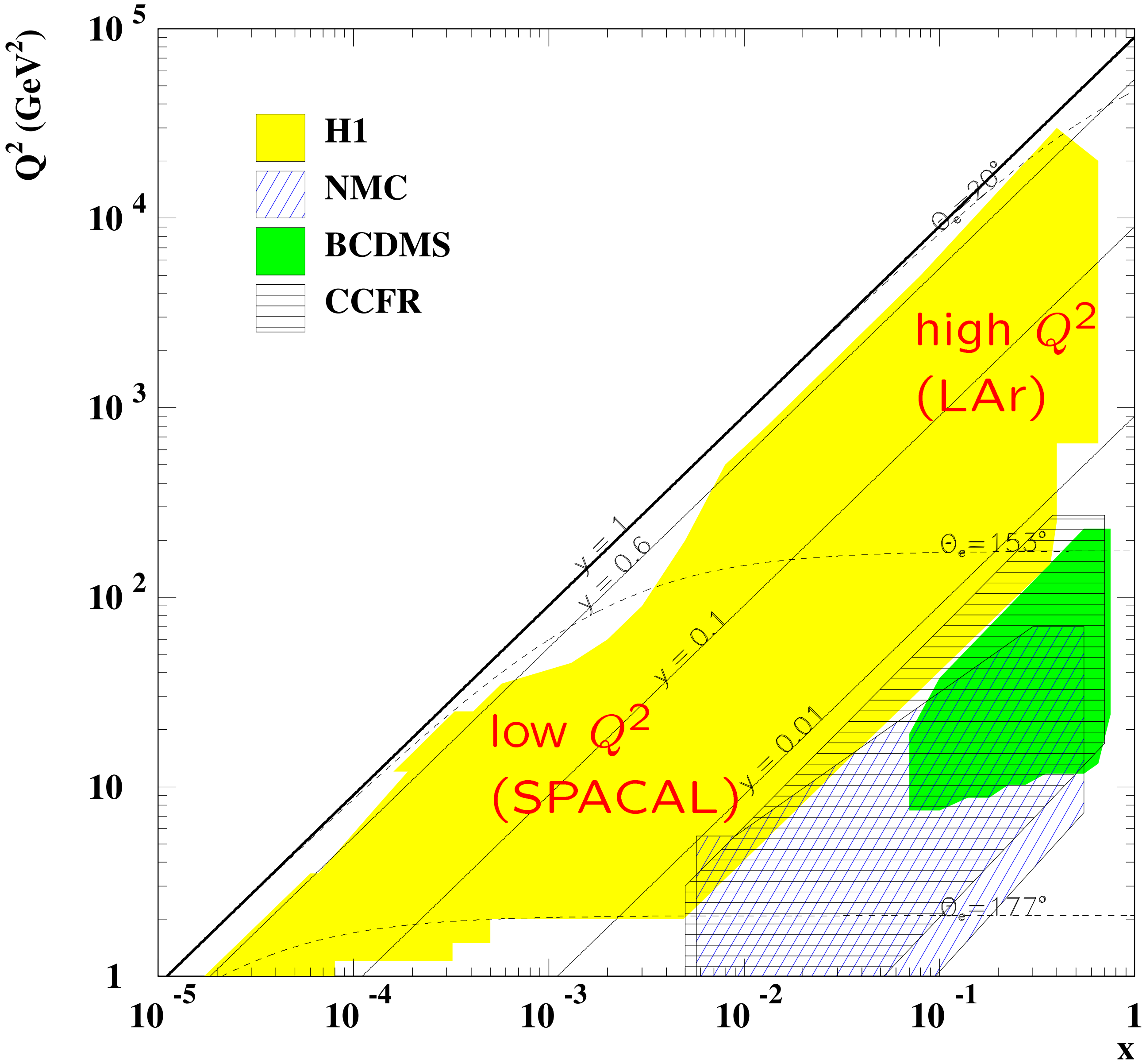


Electron in LAr:

$$150\, GeV^2 \leq Q^2 \leq 30000\, GeV^2$$



$E'_e,\ \theta_E,\ E_h,\ \theta_h\ \Rightarrow x, Q^2$ kinematics overconstrained



high y

Precision

high x

➥ F_L sensitivity

$$12\,GeV^2 \leq Q^2 \leq 150\,GeV^2 \qquad (e^+ \quad 96/97 \quad 17.9\,pb^{-1})$$
$$1.5\,GeV^2 \leq Q^2 \leq 8.5\,GeV^2 \qquad (e^+ \quad 97\text{ spec. trig.} \quad 1.8\,pb^{-1})$$
$$150\,GeV^2 \leq Q^2 \leq 30000\,GeV^2 \qquad (e^+ \quad 94-97 \quad 35.6\,pb^{-1})$$
$$200\,GeV^2 \leq Q^2 \leq 30000\,GeV^2 \qquad (e^- \quad 98/99 \quad 15.3\,pb^{-1})$$

Event selection

low Q^2

- event vertex $\pm 30\,cm$ wrt. nominal position
- electron in SPACAL
- ➥ cluster with max. energy
- ➥ compact cluster $R < 4\,cm$
- track validation
- total $E - p_z > 35\,GeV$
- fiducial and kinematic cuts

high Q^2

- event vertex $\pm 35\,cm$ wrt. nominal position
- electron in LAr
- ➥ large p_t
- ➥ compact, isolated cluster
- track validation for $\theta_e > 35^\circ$
- total $E - p_z > 35\,GeV$
- fiducial and kinematic cuts

low Q^2

- Measurement of E'_e
  - ➥ Calibration of SPACAL

    kinematic peak $E'_e = E_e$

    $E_{\text{DA}}(\theta_e, \theta_h) \leftrightarrow E_{\text{SPACAL}}$

    $\delta E'_e / E'_e = 0.3\%$ at $E'_e \geq 17\, GeV$

    $= 2\%$ at $E'_e = 2\, GeV$

- Measurement of θ_e
  - ➥ Alignment of tracking detectors BDC, BST

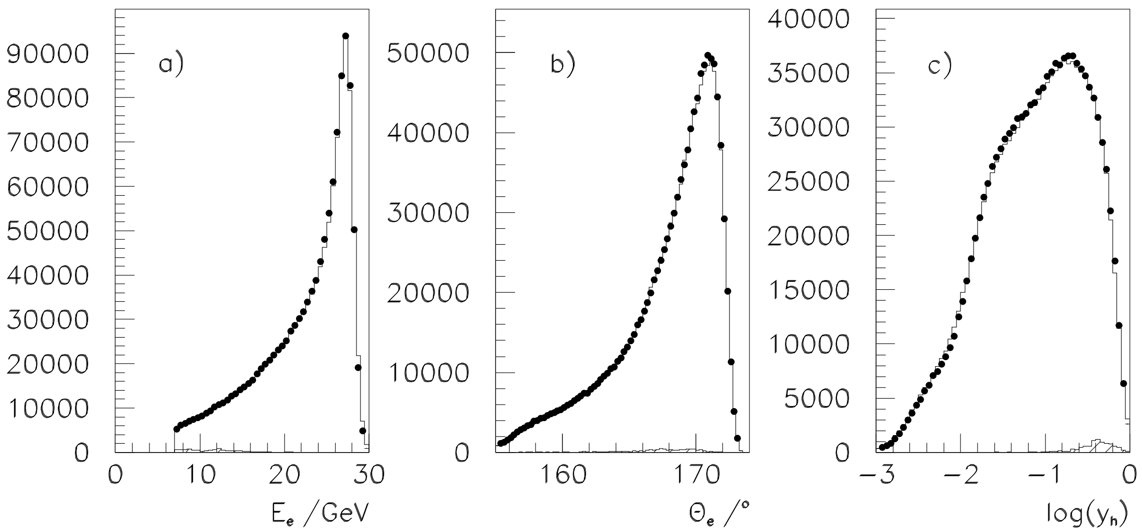
    $\delta\theta_e = 0.3\, mrad$

- Measurement of y_h
  - ➥ Calibration of LAr

    $p_t^h + p_t^e = 0$ global $\mathcal{L}$ min.

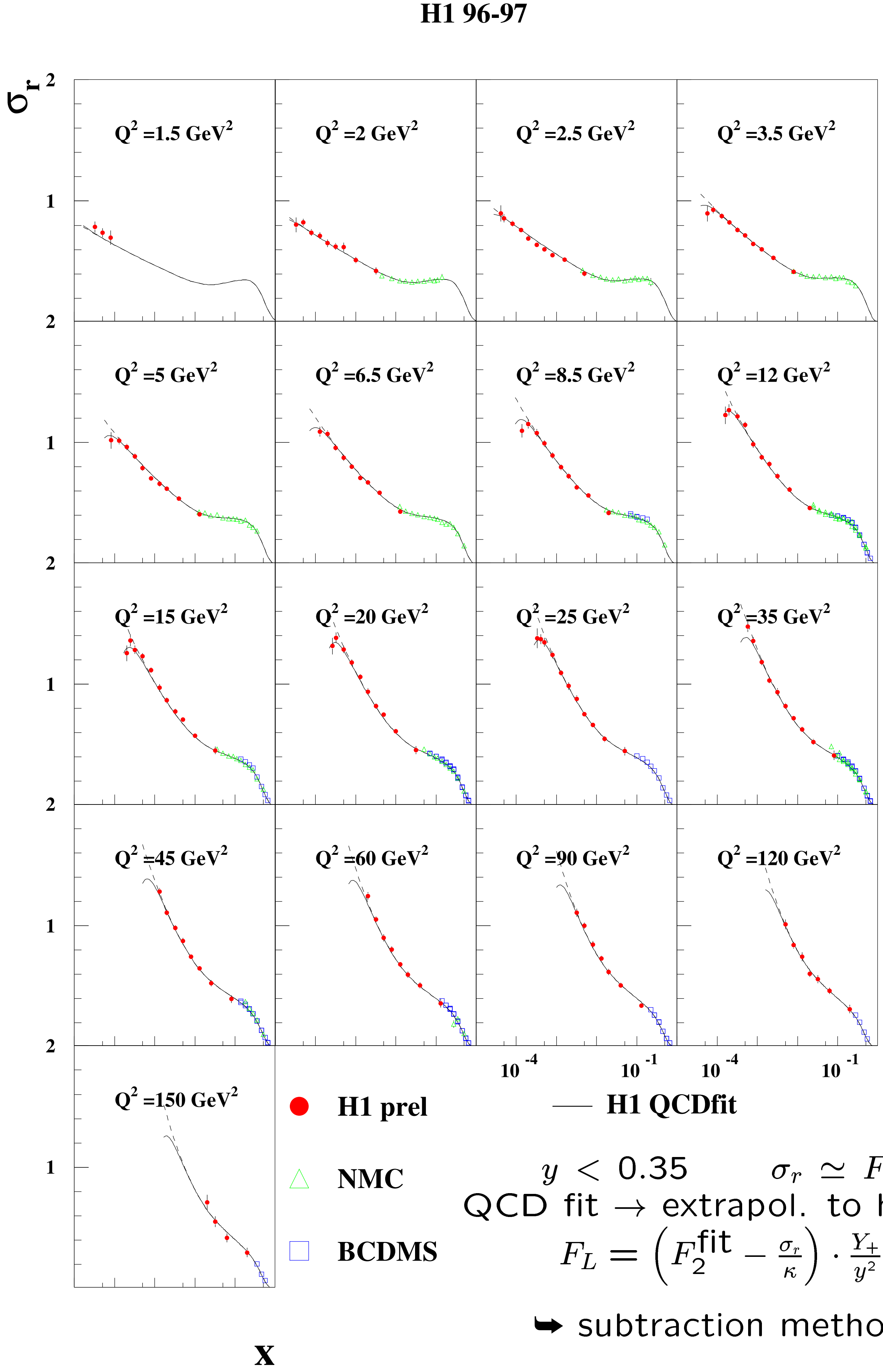
    $y > 0.003 \qquad \delta E'_h / E'_h \geq 2\%$

• Data (A+B) ■ γp simulation ⊓ DIS + γp simulation



Energy of electron candidate | Polar angle | Inelasticity

$\sim 1\%$ stat. $\sim 3\%$ syst. error $\rightarrow$ precision



$y < 0.35 \qquad \sigma_r \simeq F_2$

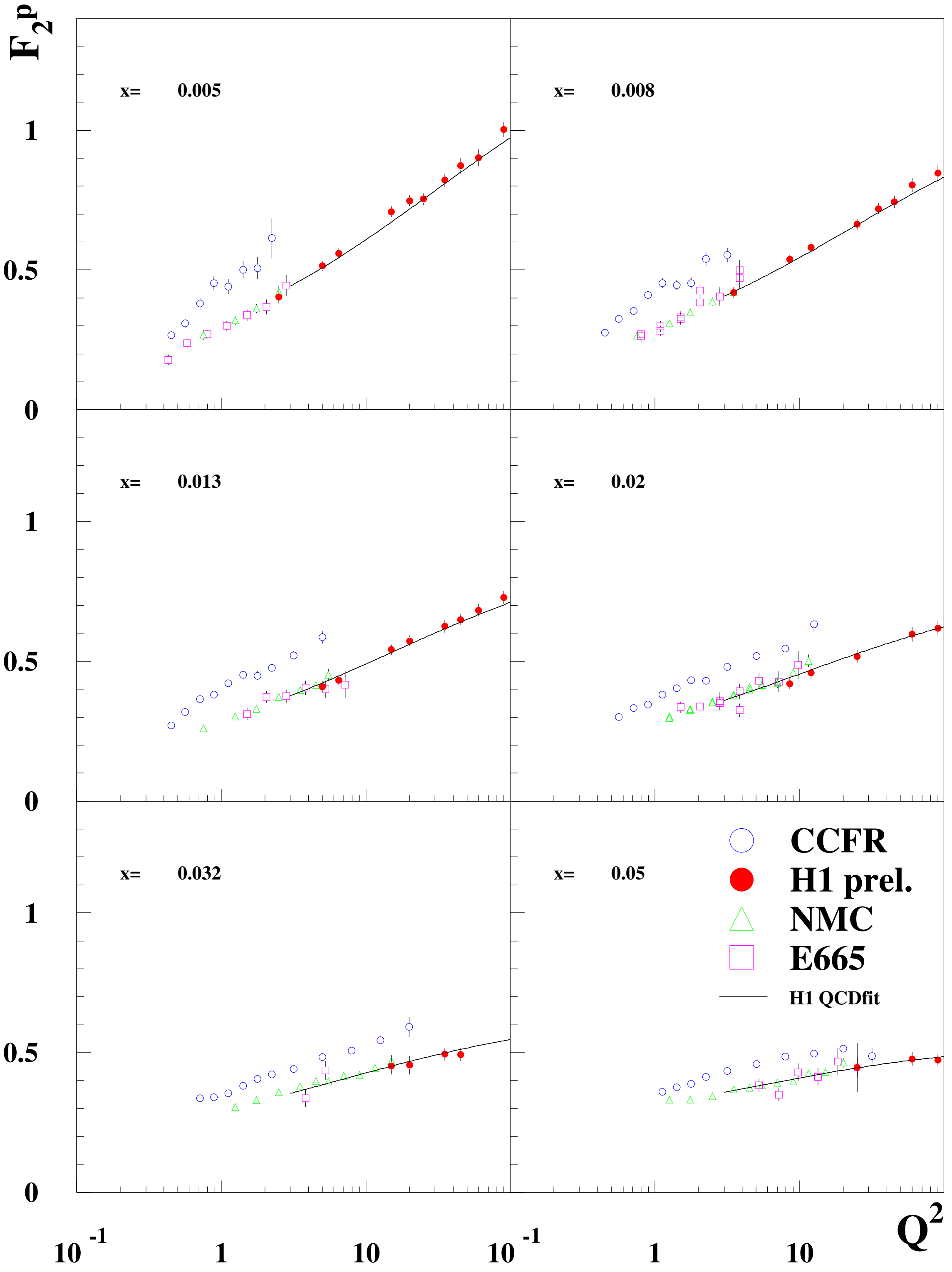
QCD fit $\rightarrow$ extrapol. to high y

$$F_L = \left(F_2^{\text{fit}} - \frac{\sigma_r}{\kappa}\right) \cdot \frac{Y_+}{y^2}$$

➥ subtraction method

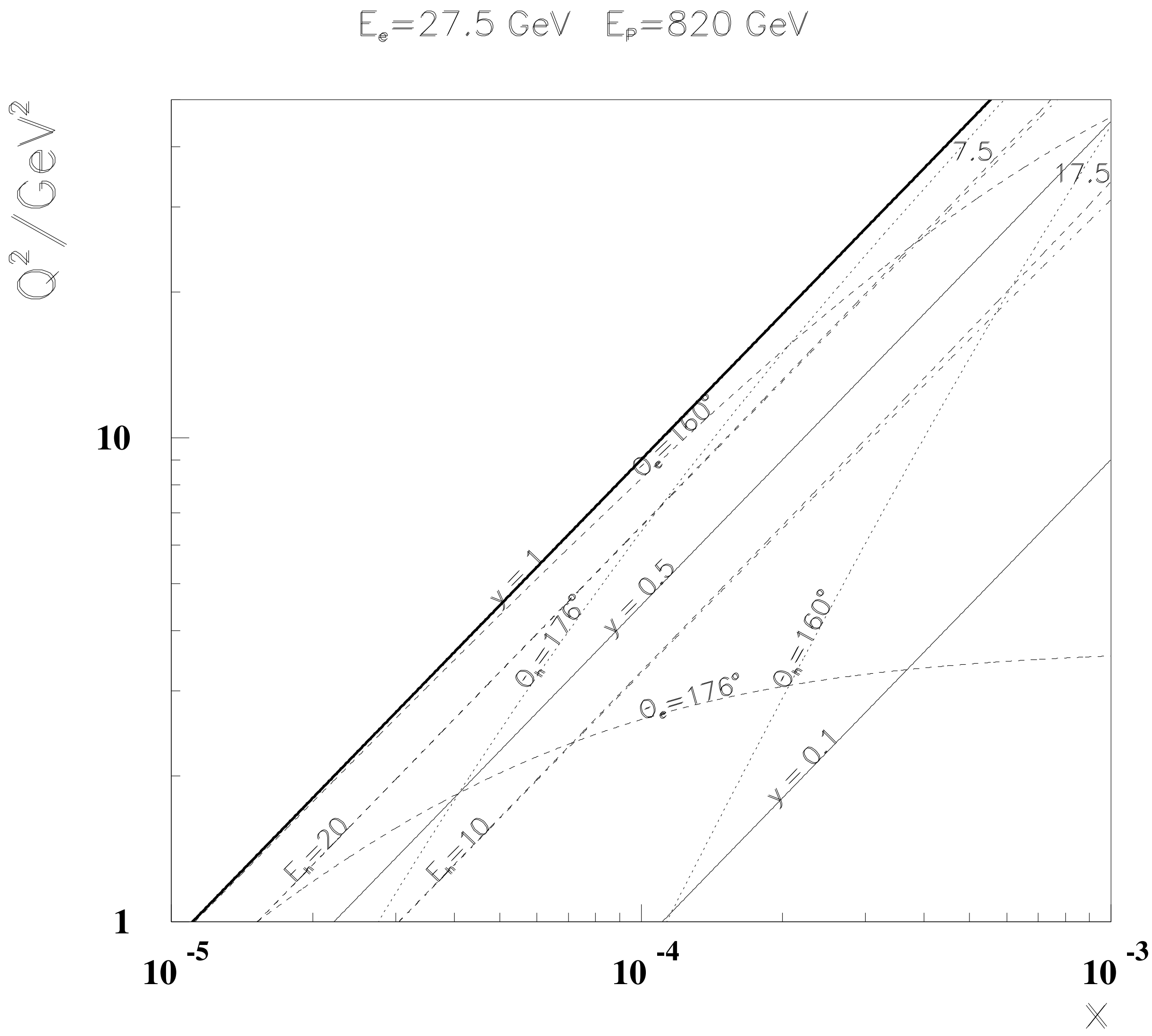
- NMC confirmed
- CCFR F_2 was too high

$\rightarrow$ reanalysis (A. Bodek in Moriond)



Measurement at high y

- new selection criteria $\rightarrow$ max. p_t
- better background rejection
  photoproduction, $\pi^0 \rightarrow \gamma\gamma$
  ➥ track validation of cluster

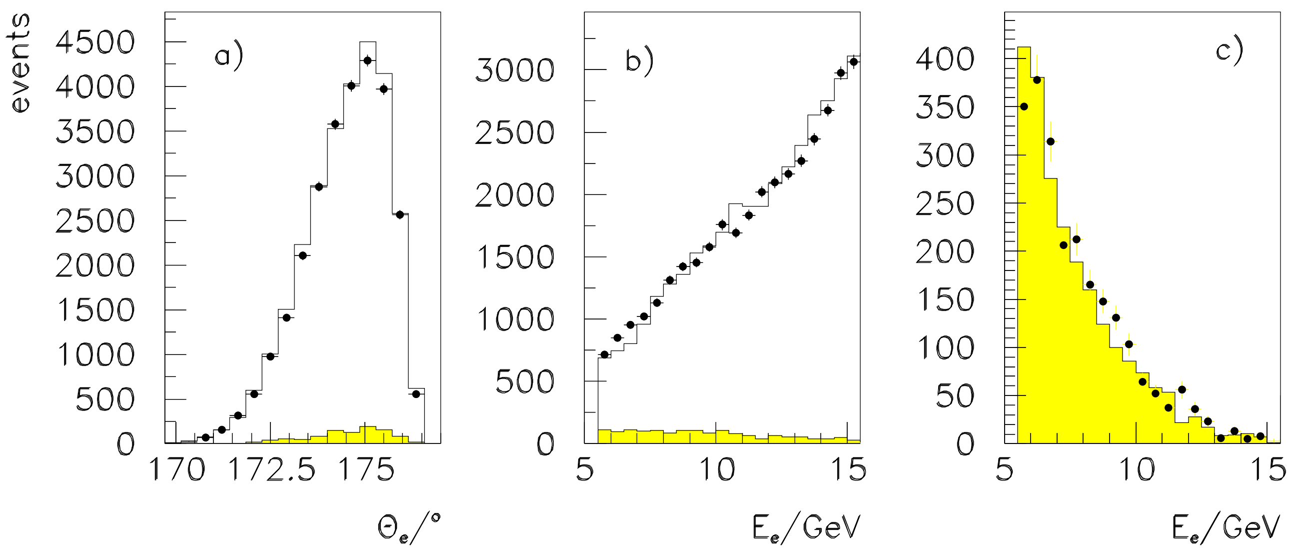


$$2\,GeV^2 \leq Q^2 \leq 5\,GeV^2$$

➥ track in Backward Silicon Tracker (BST)

check background description
➥ use events with tagged electron

• Data (B) ■ γp simulation ⊓ DIS + γp simulation



Polar angle

Energy of electron candidate

Energy of cluster for events with tagged electron

$$10\,GeV^2 \le Q^2 \le 35\,GeV^2$$

➥ track in central driftchamber (CJC)

- charge reconstruction 99.5% for $E < 15\,GeV$
  ➥ select '+' tracks
  ➥ statist. subtraction of remaining background '-' tracks
- small charge asymmetry due to $\bar{p}$ studies with Monte Carlo and e^- (1999) $vs.$ e^+ (1997)
  ➥ corrected

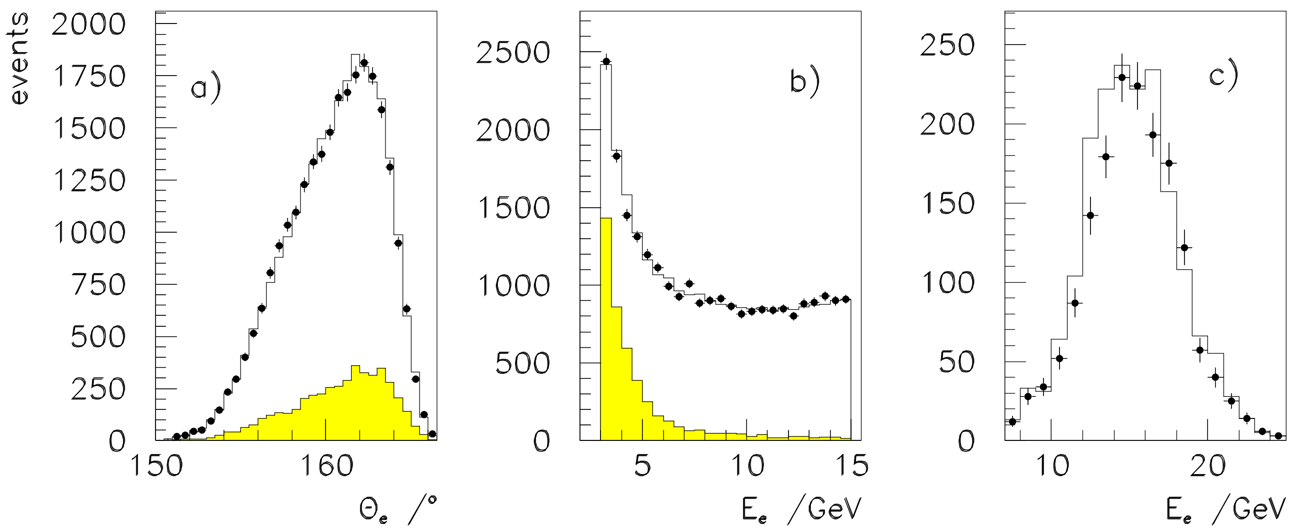
before background subtraction:

charge asymmetry:

• Data '+' (A+B)

Data '-'

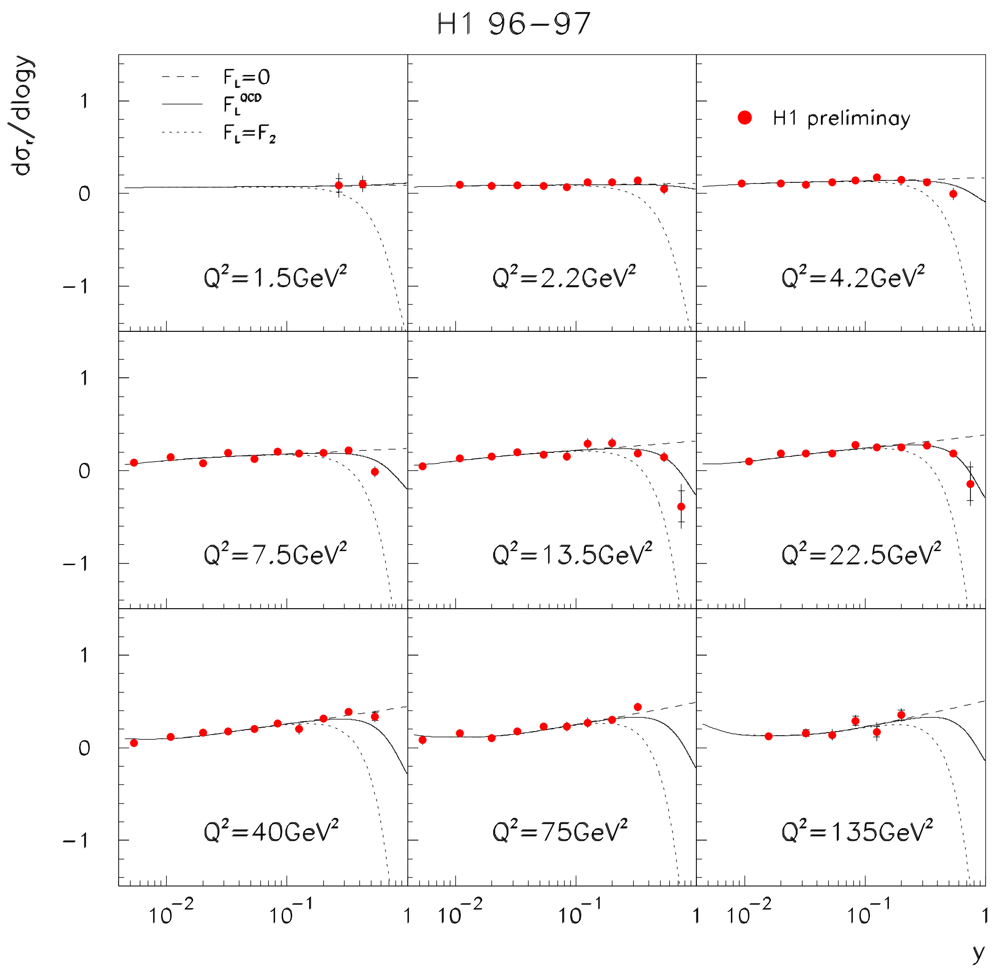
⊓ MC '+' and Data '-'



Polar angle

Energy of electron candidate

Energy of electrons in e-tagger



$$\frac{\partial\sigma_r}{\partial\log y} = \frac{\partial F_2}{\partial\log y} - F_L\cdot 2y^2\cdot\frac{2-y}{Y_+^2} - \frac{\partial F_L}{\partial\log y}\cdot\frac{y^2}{Y_+}$$

↑
from QCD fit
correct
add to sys. err.

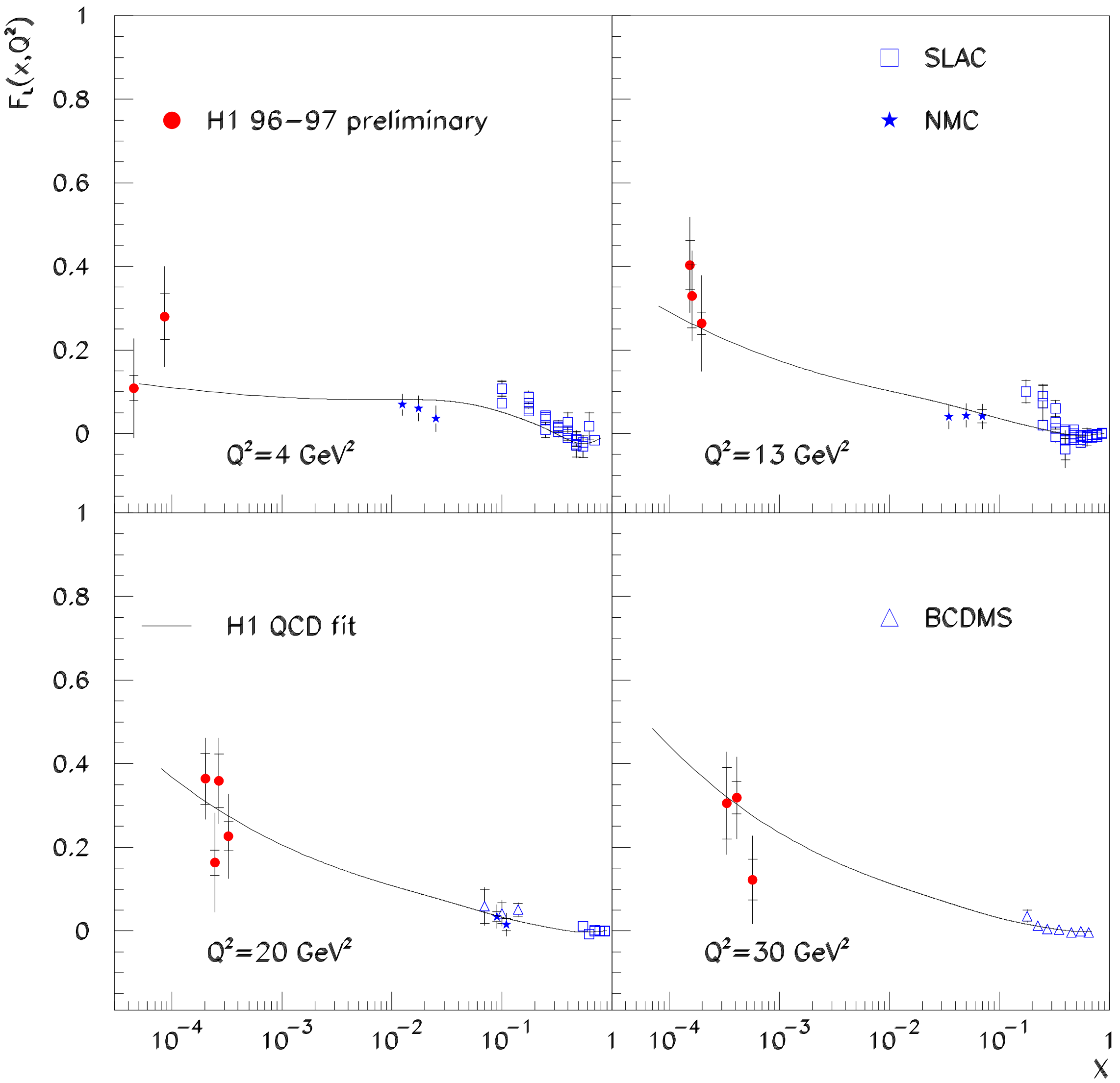
measured $\sigma_r(y_2) - \sigma_r(y_1)$ at fixed Q^2
$\Longrightarrow$ anticorrelation

$Q^2 < 20\,GeV^2$ $y < 0.2$ fit straight line

$F_2 \sim x^{-\lambda}$

$\frac{\partial F_2}{\partial\log x} = -\frac{\partial F_2}{\partial\log y} \Rightarrow \frac{\partial F_2}{\partial\log y} \sim \lambda + \lambda^2\log y + \ldots$

- derivative method: no assumptions on QCD
  ➥ low $Q^2 < 10\,GeV^2$
- subtraction method (QCD fit)
  ➥ higher $Q^2 > 10\,GeV^2$



$F_L(x, Q^2)$ comparison with fixed target measurements

➥ more data $\Longrightarrow$ more precision
still assumption needed on F_2

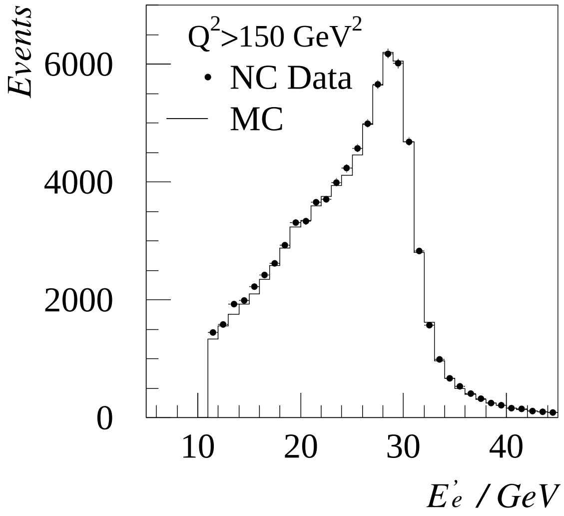
high Q^2

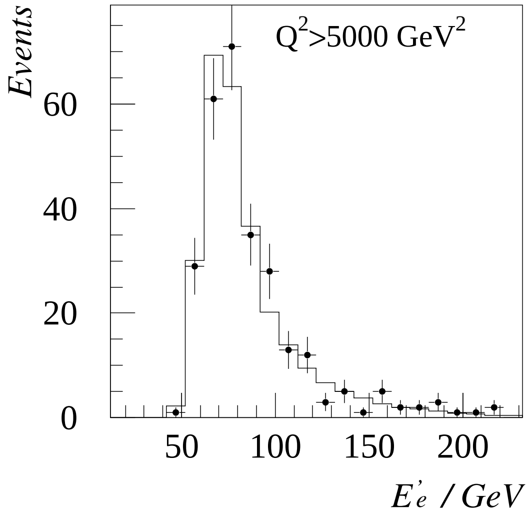
- Measurement of E'_e

  ➥ Calibration of LAr

  $E_{\mathsf{DA}}(\theta_e, \theta_h) \leftrightarrow E_{\mathsf{LAr}}$

  $\delta E'_e / E'_e = 0.7\% - 3\%$

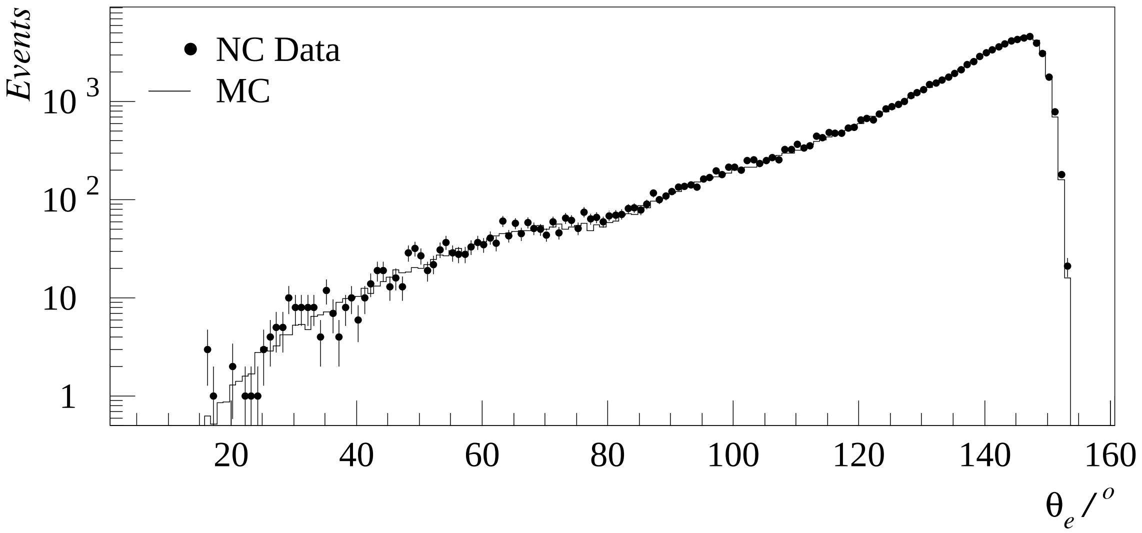




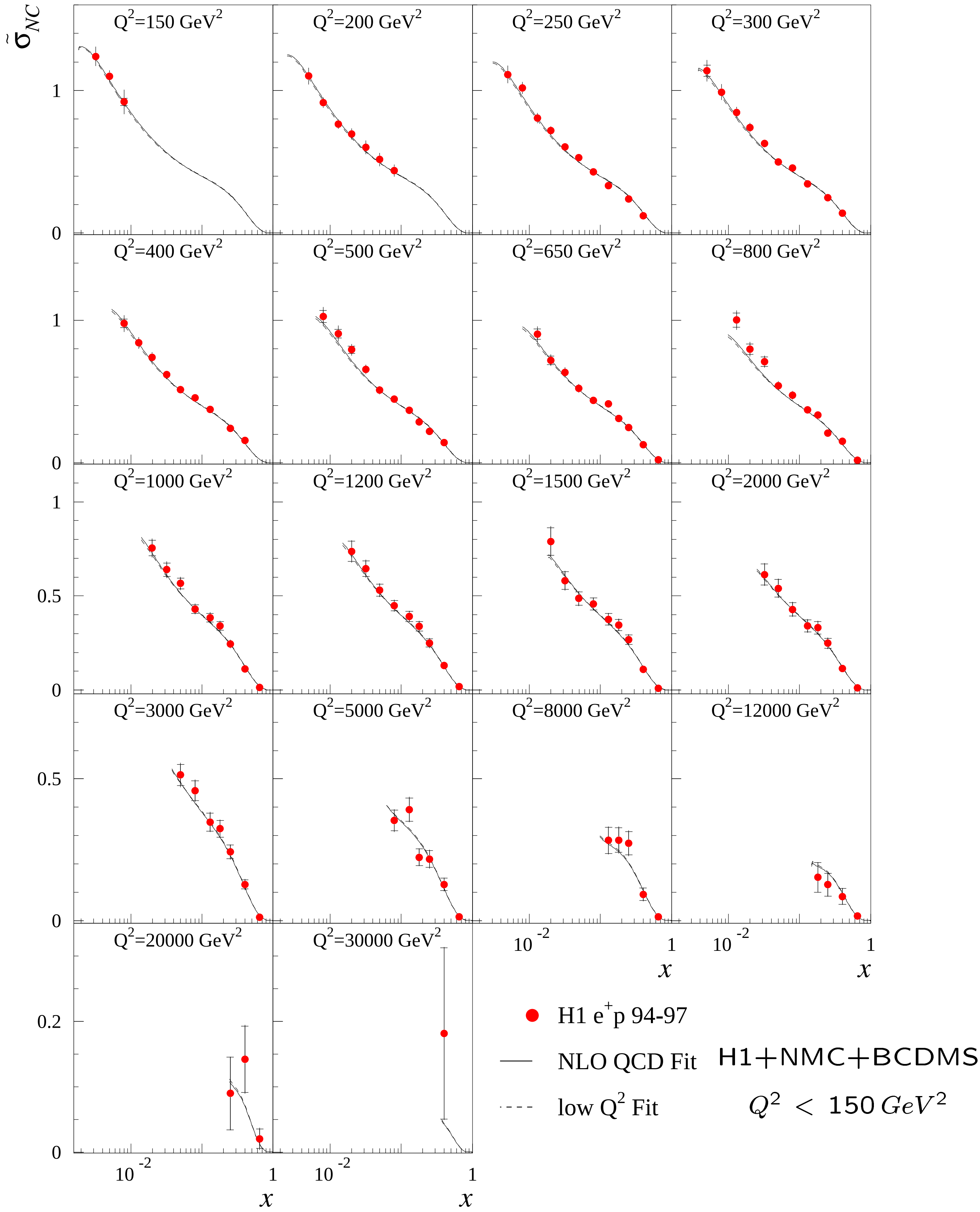
- Measurement of θ_e

  ➥ Alignment of LAr wrt. tracking chambers

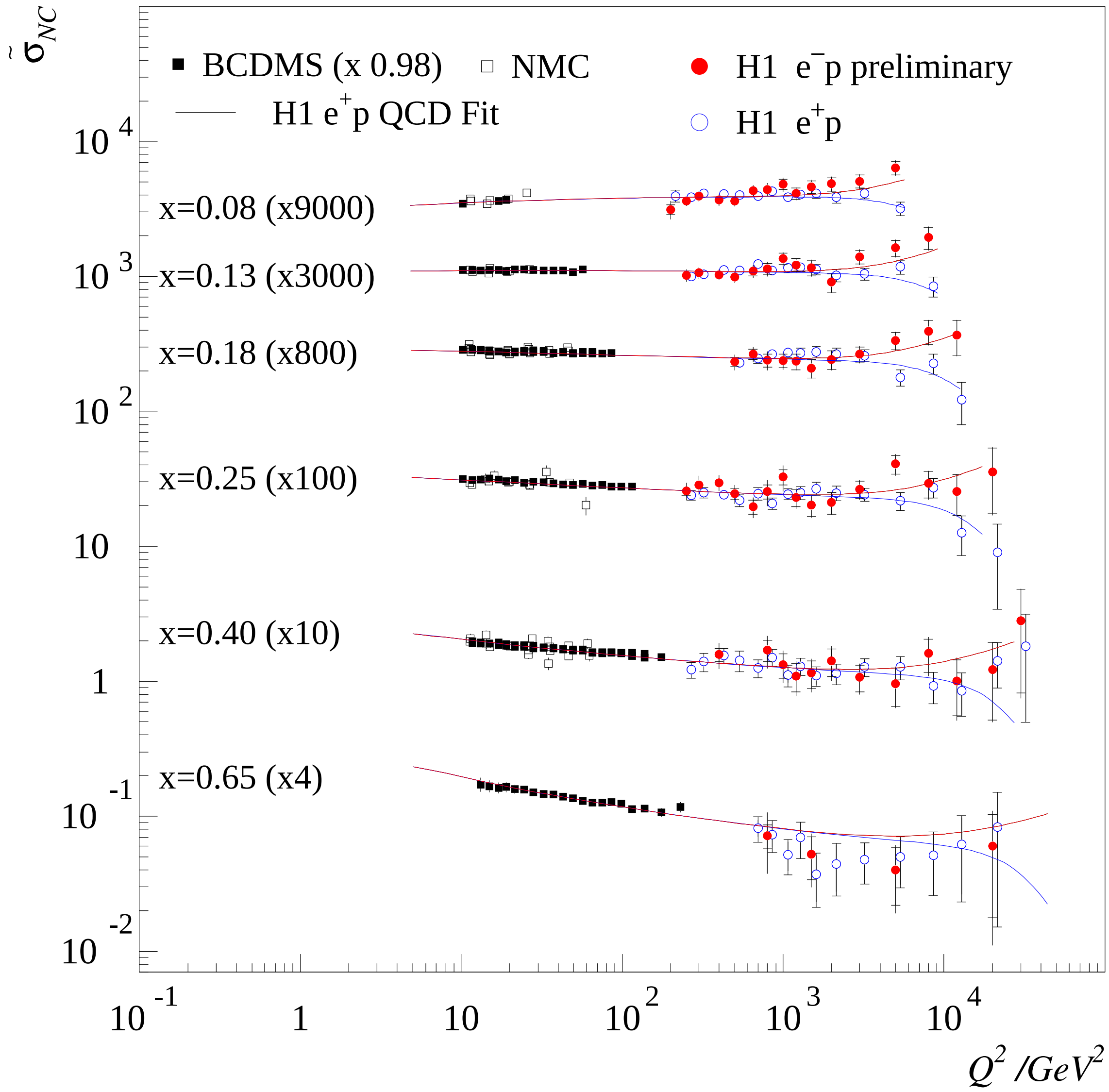
  $\delta\theta_e = 1\,mrad - 3\,mrad$



high Q^2 e^+



$\tilde{\sigma}_{NC}$
Q²=150 GeV²
Q²=200 GeV²
Q²=250 GeV²
Q²=300 GeV²
Q²=400 GeV²
Q²=500 GeV²
Q²=650 GeV²
Q²=800 GeV²
Q²=1000 GeV²
Q²=1200 GeV²
Q²=1500 GeV²
Q²=2000 GeV²
Q²=3000 GeV²
Q²=5000 GeV²
Q²=8000 GeV²
Q²=12000 GeV²
Q²=20000 GeV²
Q²=30000 GeV²
x
H1 e⁺p 94-97
NLO QCD Fit
low Q² Fit
H1+NMC+BCDMS
$Q^2 < 150\,GeV^2$

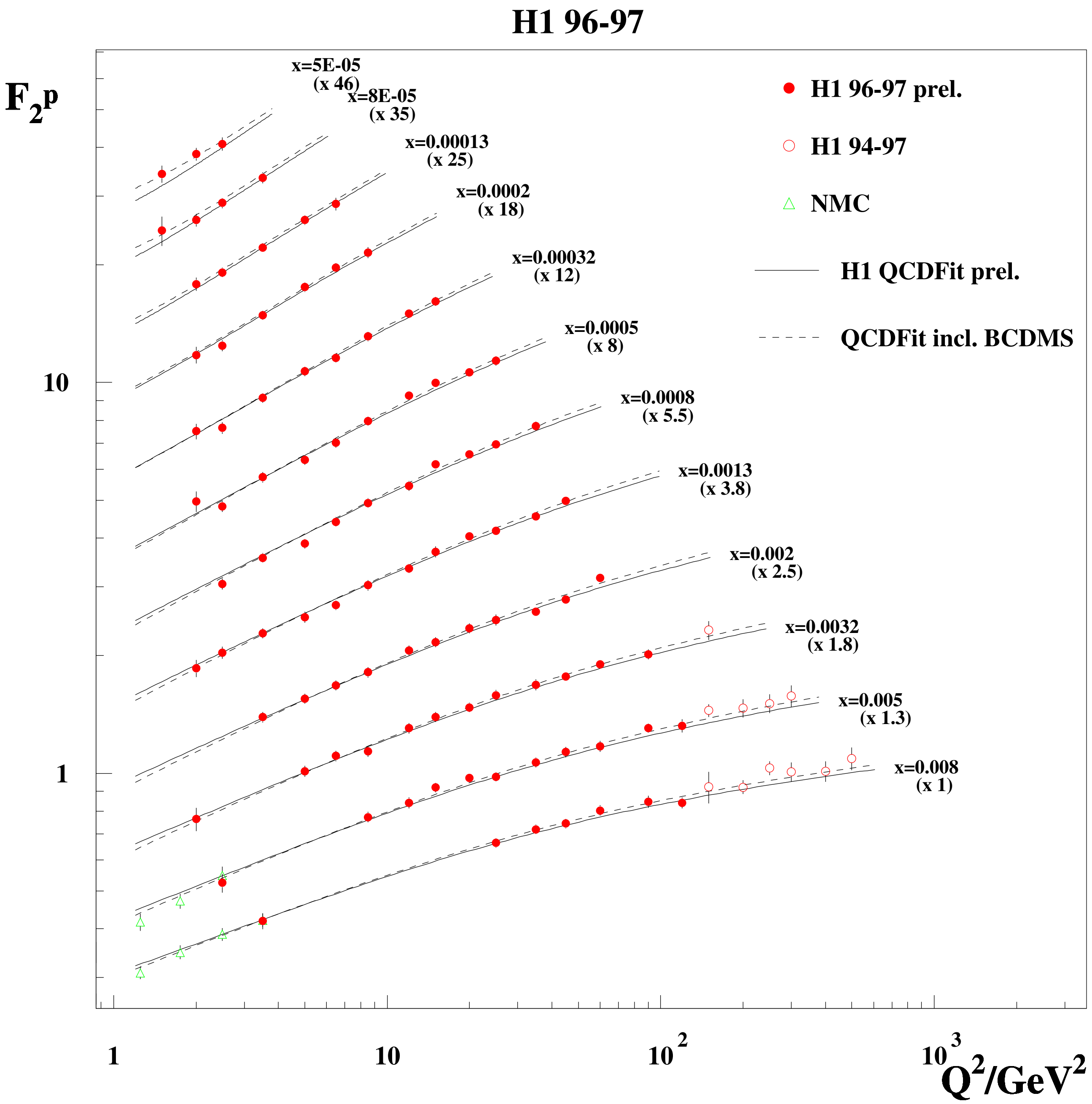


$$\sigma^{\pm} = \tilde{F}_2 - \frac{y^2}{Y_+} \cdot \tilde{F}_L \mp \frac{Y_-}{Y_+} \cdot x\tilde{F}_3$$

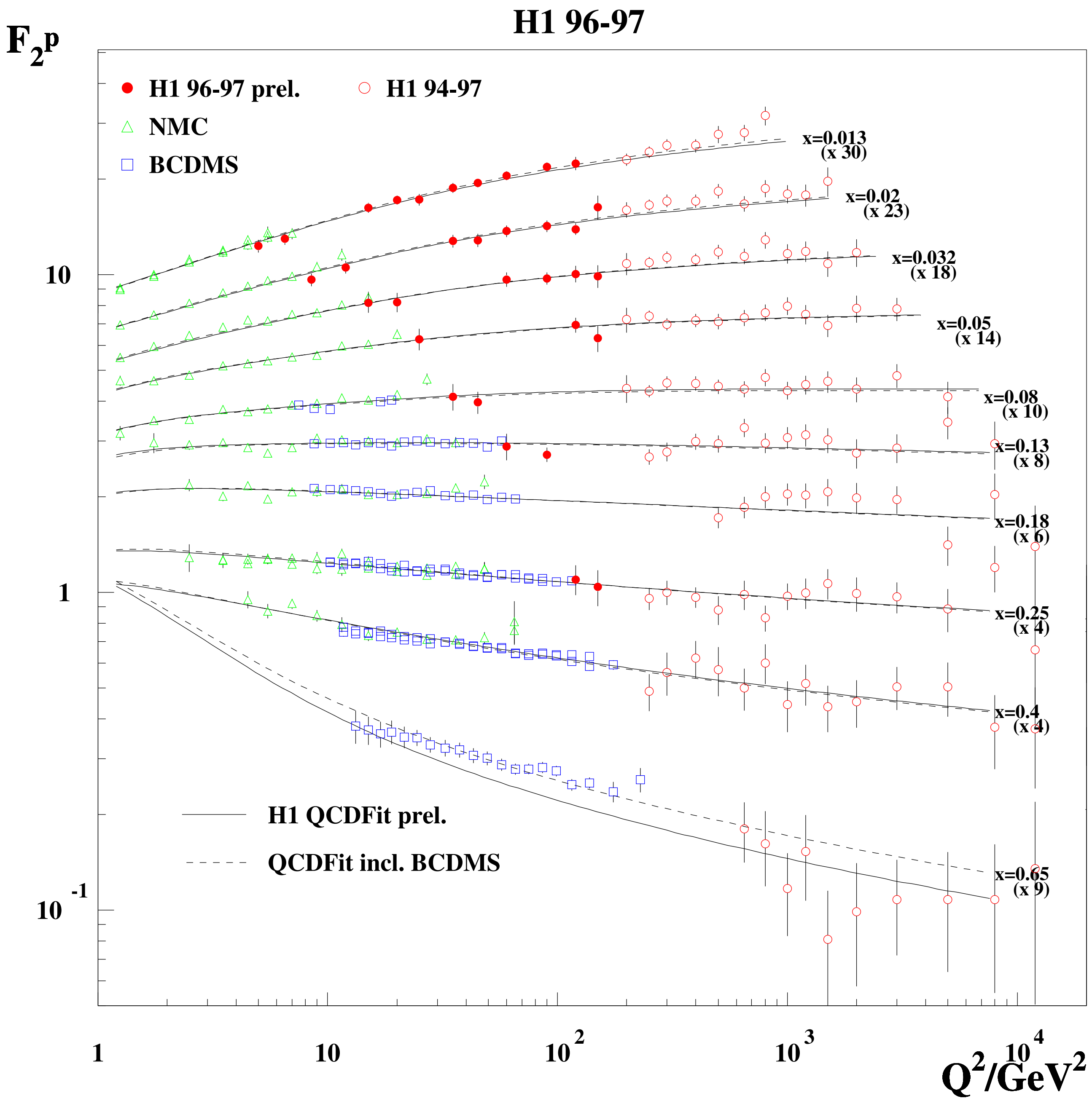
γZ interference:

$e^+ \quad \rightarrow \quad$ reduction of cross section

$e^- \quad \rightarrow \quad$ increase of cross section



- large scaling violations described by QCD fit



- overlap with fixed target

QCD fit and scaling violation analysis: see talk of T. Kurča

SUMMARY

- cross section measured in the range of
  $1.5\,GeV^2 \leq Q^2 \leq 30000\,GeV^2$
  ➥ consistent with DGLAP

- 2% $-$ 3 % syst. error in the bulk region

- high y reached
  ➥ F_L with 2 methods extracted
  for $2.2\,GeV^2 \leq Q^2 \leq 35\,GeV^2$

- measurement was extended to high x region
  ➥ NMC confirmed

- 1998-2000 measurement at $E_p = 920\,GeV$
  ➥ cross section
  ➥ F_L with more precision