F_L measurement
(lowest x, highest y)

Petr Reimer

Institute of Physics, Prague

On behalf of the
H1 Collaboration

DIS 99

Workshop on Low x Physics

Tel Aviv, June 15-18, 1999

DIS Cross Section

- NC lepton-nucleon DIS cross section($Q^2 << M_Z^2$):

$$\frac{d^2\sigma(lN)}{dxdQ^2} = \frac{2\pi\alpha^2}{Q^4 x}[Y_+ F_2(x,Q^2) - y^2 F_L(x,Q^2)]\ (1+\delta_r)$$

with $Y_+ = 1 + (1-y)^2$

and radiative corrections δ_r

- Reduced cross section:

$$\sigma_r = \frac{d^2\sigma}{dxdQ^2}\frac{Q^4 x}{2\pi\alpha^2 Y_+} = F_2(x,Q^2) - \frac{y^2}{Y_+}F_L(x,Q^2)$$

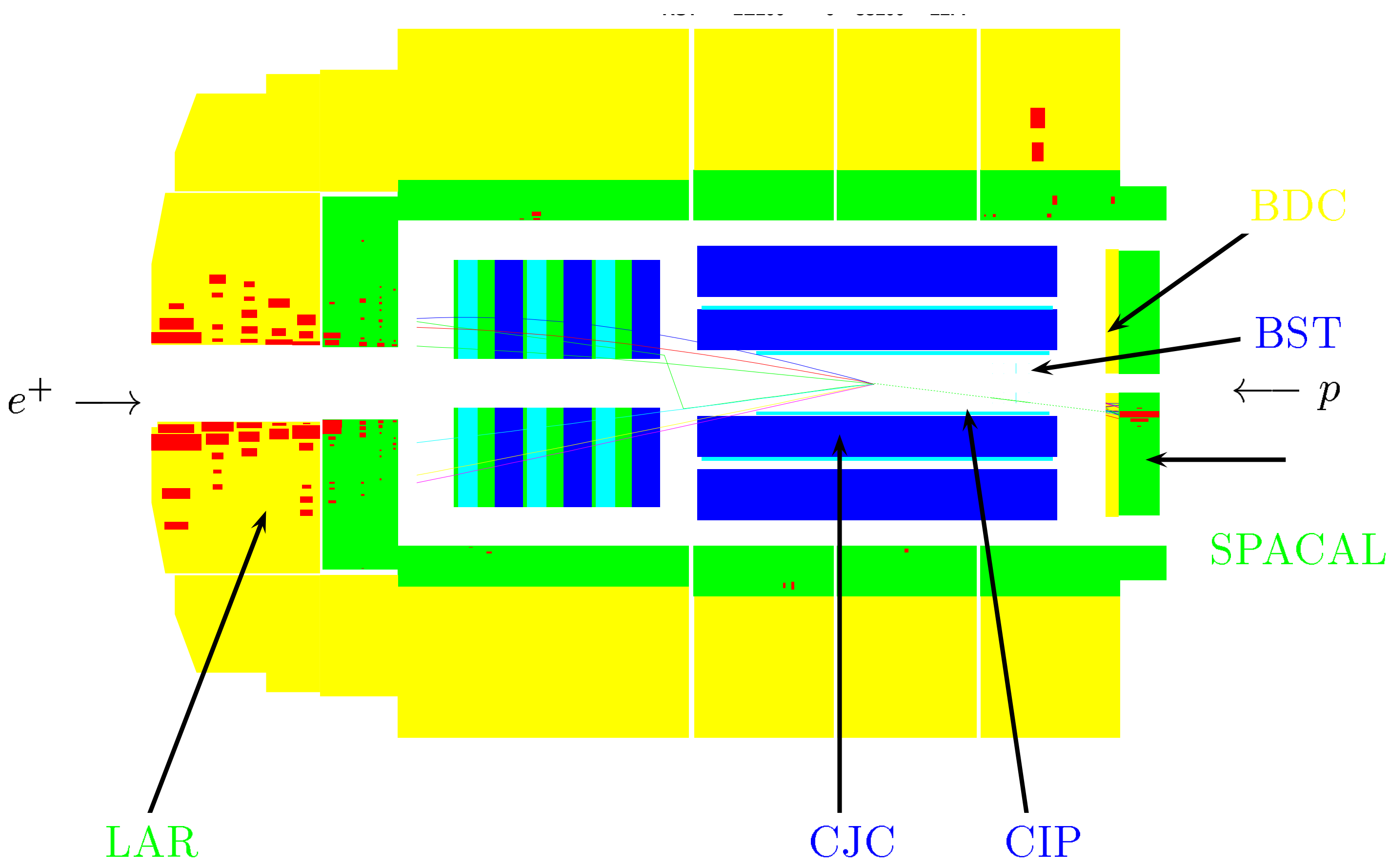
- structure functions related by $F_2 \geq F_L \geq 0$
  xsect dominated by F_2, $\sigma_r \simeq F_2$ for $y \leq 0.6$
- F_L measureable at high y

H1 DATA 97 comprises two samples:

- nominal runs , $\mathcal{L}$= 15 pb^{-1} , $10 < Q^2 < 120$ GeV^2
- dedicated run ,$\mathcal{L}$=2 pb^{-1}, $2 < Q^2 < 10$ GeV^2

$\mathcal{L}(1997) \doteq 2\star\mathcal{L}(1994+1995+1996)$

Event Selection



Kin. variables reconstructed using E'_e and θ'_e

- backward calorimeter SPACAL, backward drift chamber BDC
- backward silicon tracker BST,$172^o < \theta_e < 177^o$
- central inner prop. chamber CIP,central drift chamber CJC
- liquid argon calorimeter LAR
- vertex reconstruction: central trackers, BST

Systematic errors

Sources of systematic errors

- Precision of luminosity measurement: 1.5 %
- Angular precision $\delta\theta_e$: 0.5 mrad
  beam inclination w.r.t. z-axis, alignment of the BDC chamber and the BST Si-tracker
- elm. SPACAL calibration precision :
  low energies 3 % , high energies 0.5 %
  double angle method checked with Compton events and kinematic peak position
- Accuracy of the hadronic energy scale :
  4/5 % for LAR/ SPACAL
  p_T balance between $e^{+'}$ and hadrons
- Noise suppression in the central(forward) LAR
  isolated cells with E $<$ 400(800) MeV excluded
  $\Rightarrow$ better y resolution at $y \sim 0.01$
- Accuracy of trigger efficiencies : 0.5 % – 1 %

- Accuracy of the positron identification: 1-2 %
  Spacal cluster with max p_t or with max E
- Uncertainties of the BST efficiency 1–2 %
- Uncertainties of the vertex efficiency ~ 1 %
- Radiative corrections are small due to the cut
  $\sum_h (E_i - p_{z,i}) + (E'_e - p'_e) > 35 GeV$, h – *hadrons*

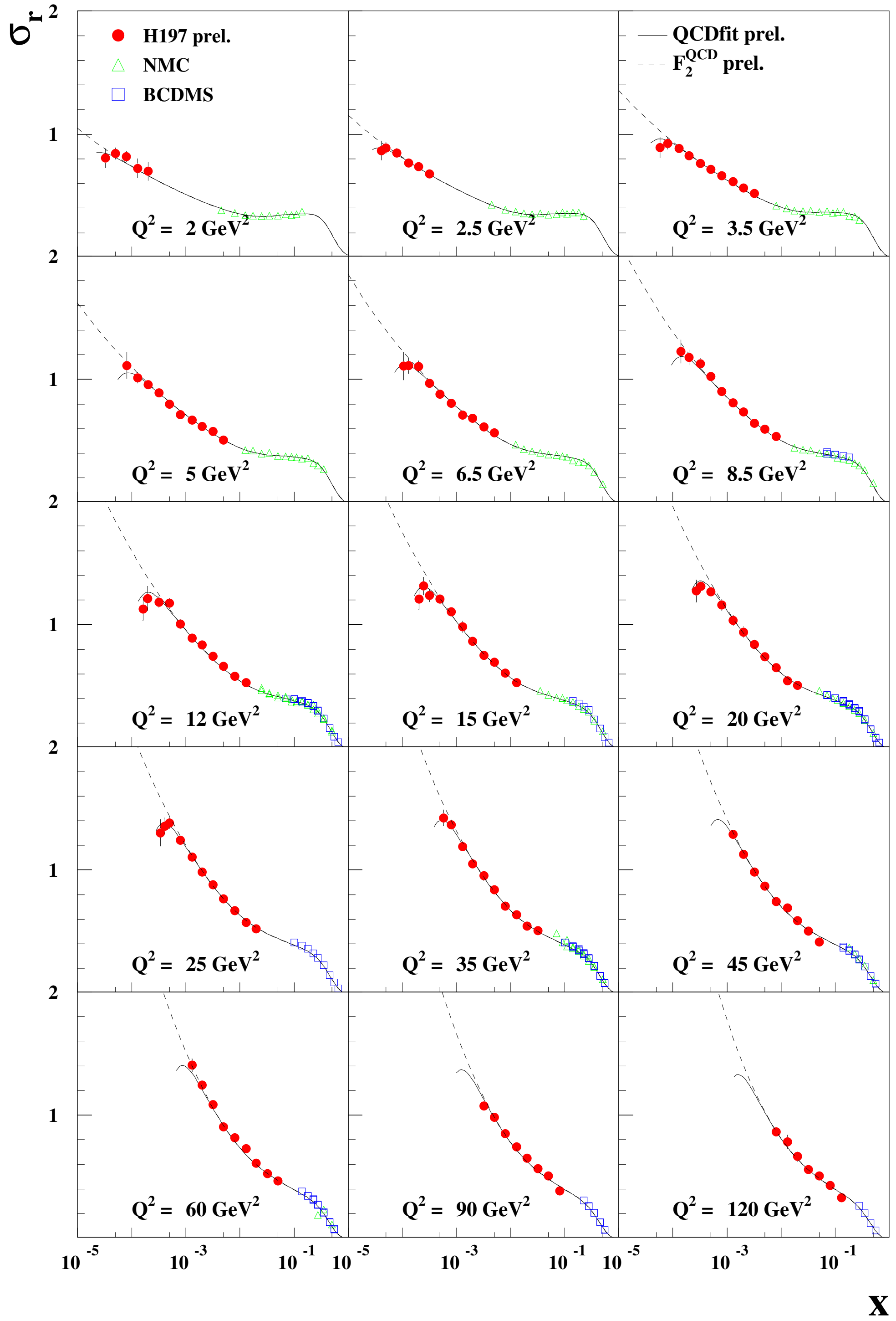
source	error [%] of σ_r
vertex efficiency	1-2
BDC efficiency	0.5
BST efficiency	1-2
trigger efficiency	0.5 - 1
positron identification	0.5-2
noise rejection in LAr	< 3 at $y < 0.02$
radiative corrections	1-2
photoproduction background	< 8 at high y
CJC-SPACAL link efficiency	2

Total systematic: mostly 3-4 %

at the edges of y-range up to 8 %

Overall statistical precision: 1 %

QCD fit to $\sigma_r(x)$



- Both F_2 and F_L included in the fit
- NLO DGLAP works down to $Q^2 \sim 2$ GeV^2
- low x: $F_2(x)$ deviates from $\sigma_r \Rightarrow$ extract F_L

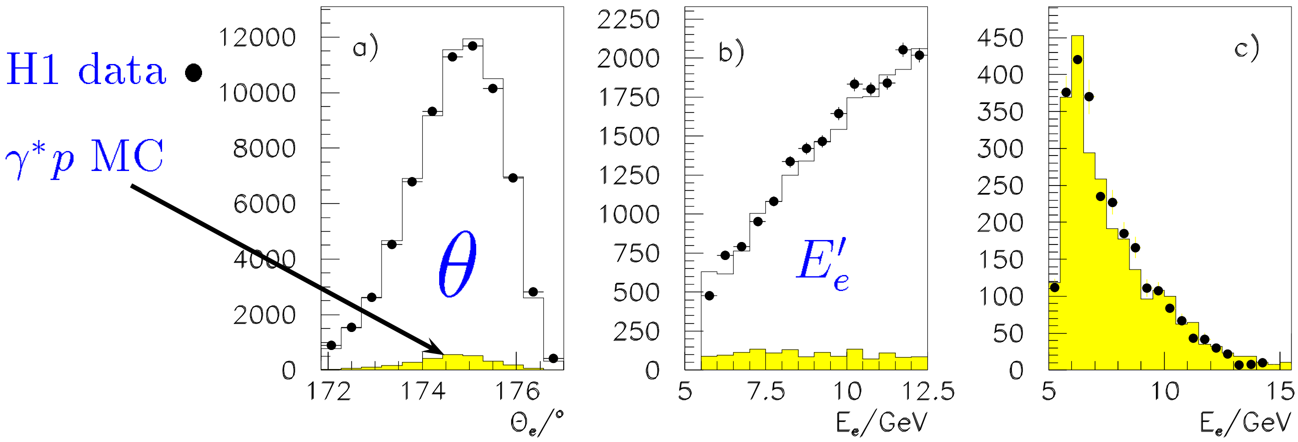
High y Analysis

$$y_e = 1 - \frac{E_e'}{E_e}\sin^2(\frac{\theta'}{2})$$

- high y - low energy of the scattered positron (E_e')
  $E_e' > 5.5$ GeV in BST accpt. region
  $E_e' > 3.0$ GeV in CJC accpt. region ($Q^2 > 12$ GeV^2)
- Main problem : $\gamma^* p$ background
  $\pi^0 \rightarrow 2\gamma$ SPACAL cluster-track link requirement
  $\pi^\pm$ rejected by cluster size cut

In BST acceptance region ($Q^2 > 2$ GeV^2):

$\gamma^* p$ backg. reduced by a factor 3 with BST validation



SPACAL energy spect.
for evt. in BST accp.
with tagged e^+

High y Analysis (cont.)

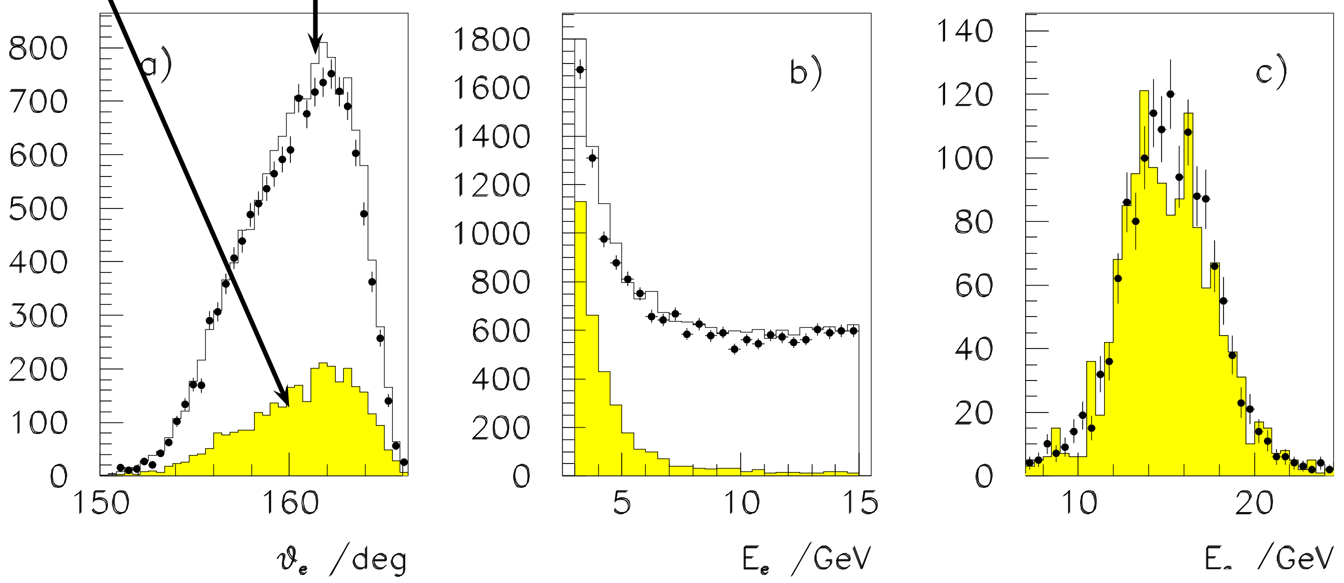
CJC acceptance region ($Q^2 > 12$ GeV^2):

- charge identification for $E_e' < 15$ GeV
- tagged bckg. charge symm. (4 %);further studies $\rightarrow$ bckg. charge symm. assumed to hold within 3 %
- select positively charged tracks
- bckg. stat. subtracted $\rightarrow$ no MC needed for $\gamma^* p$ est.

data with pos charge assignment •

data with neg charge assignment

DIS MC + data with neg charge



θ

SPACAL energy

energy in el. tagger for DIS cand. with a track of pos vs neg charge

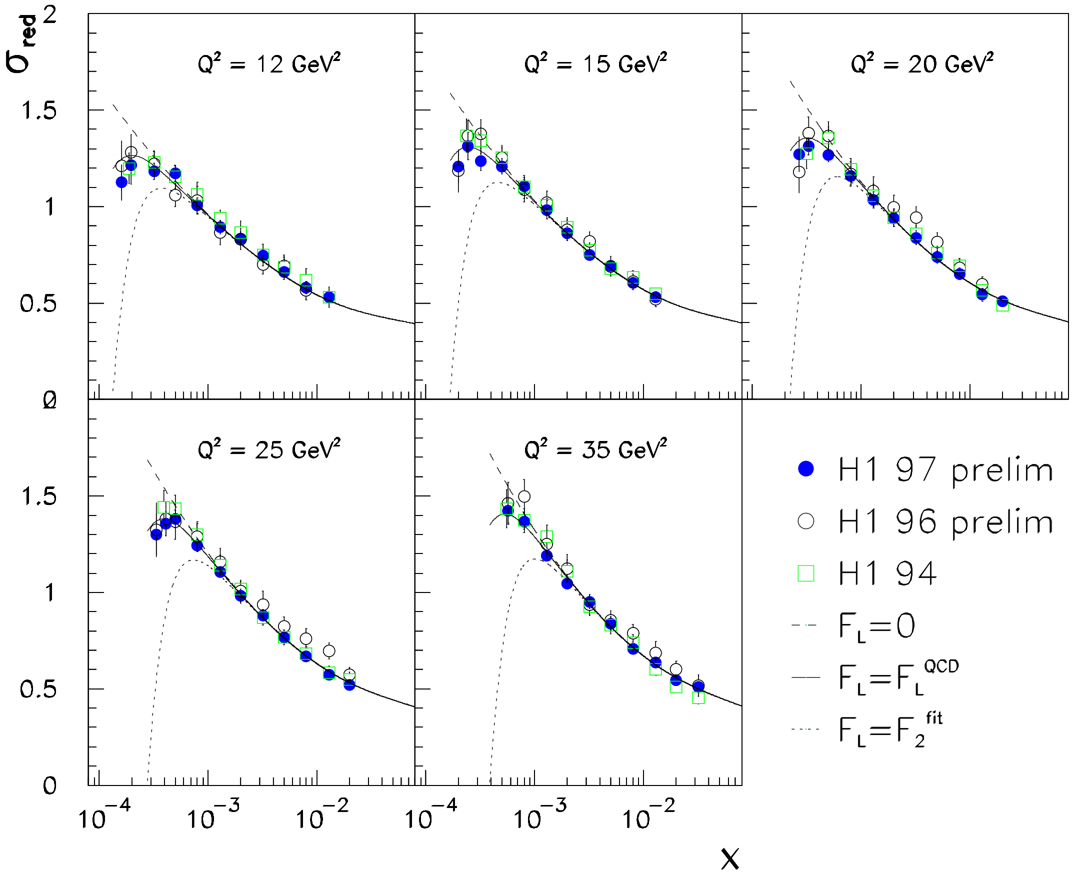
- Reduced cross section:

$$\sigma_r = \frac{1}{\kappa}\frac{d^2\sigma}{dx dQ^2} = F_2 - \frac{y^2}{Y_+}F_L$$

with $\kappa = \dfrac{2\pi\alpha^2 Y_+}{Q^4 x}$ and $Y_+ = 1 + (1-y)^2$

- **H1:**
  - QCD fit to F_2
    where F_L is negligible: $y < 0.35$
  - extrapolate to high y
  - subtract measured reduced cross section:

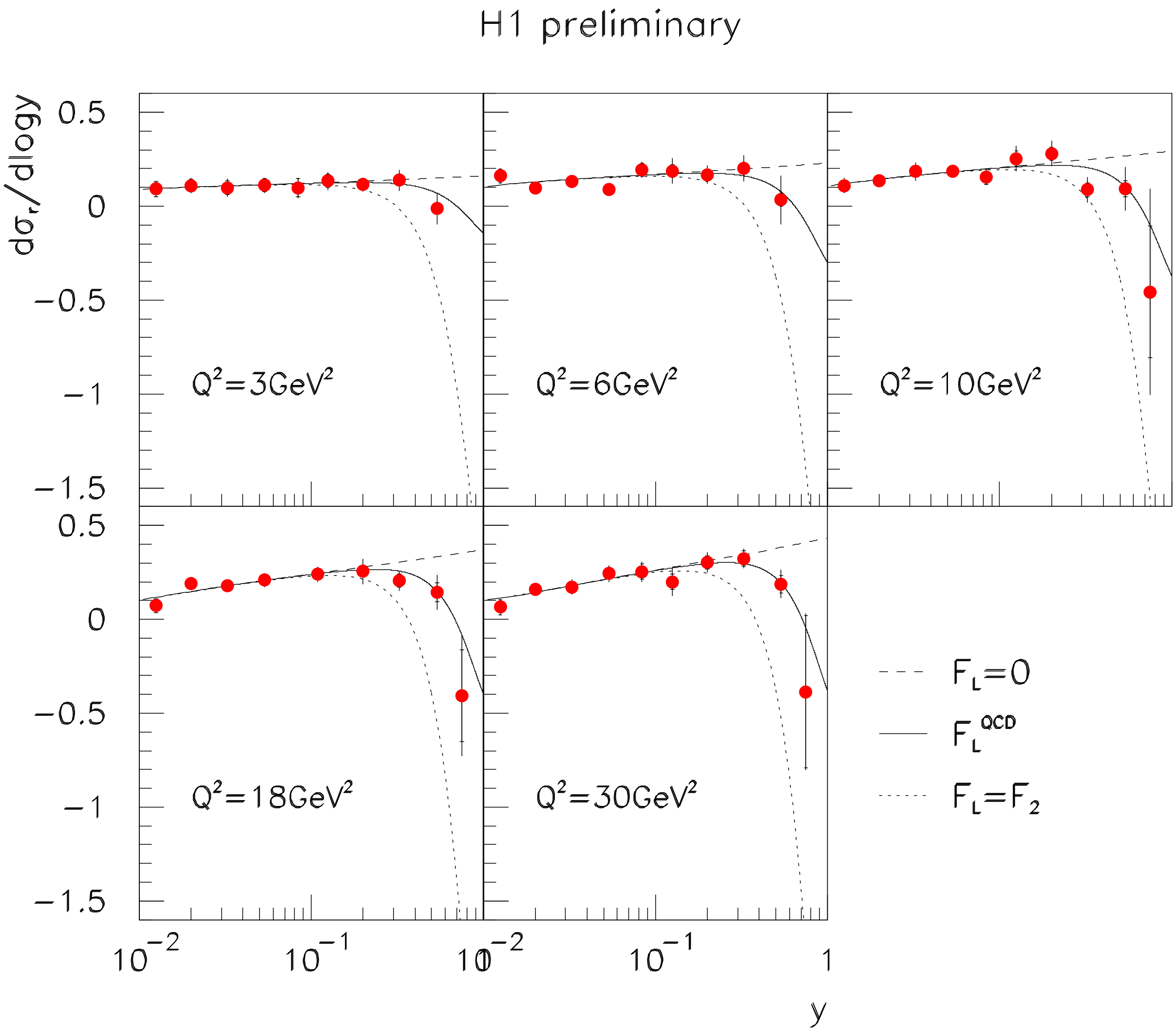
$$F_L = \frac{Y_+}{y^2}\left(F_2^{fit} - \frac{1}{\kappa}\frac{d^2\sigma^{exp}}{dx dQ^2}\right)$$



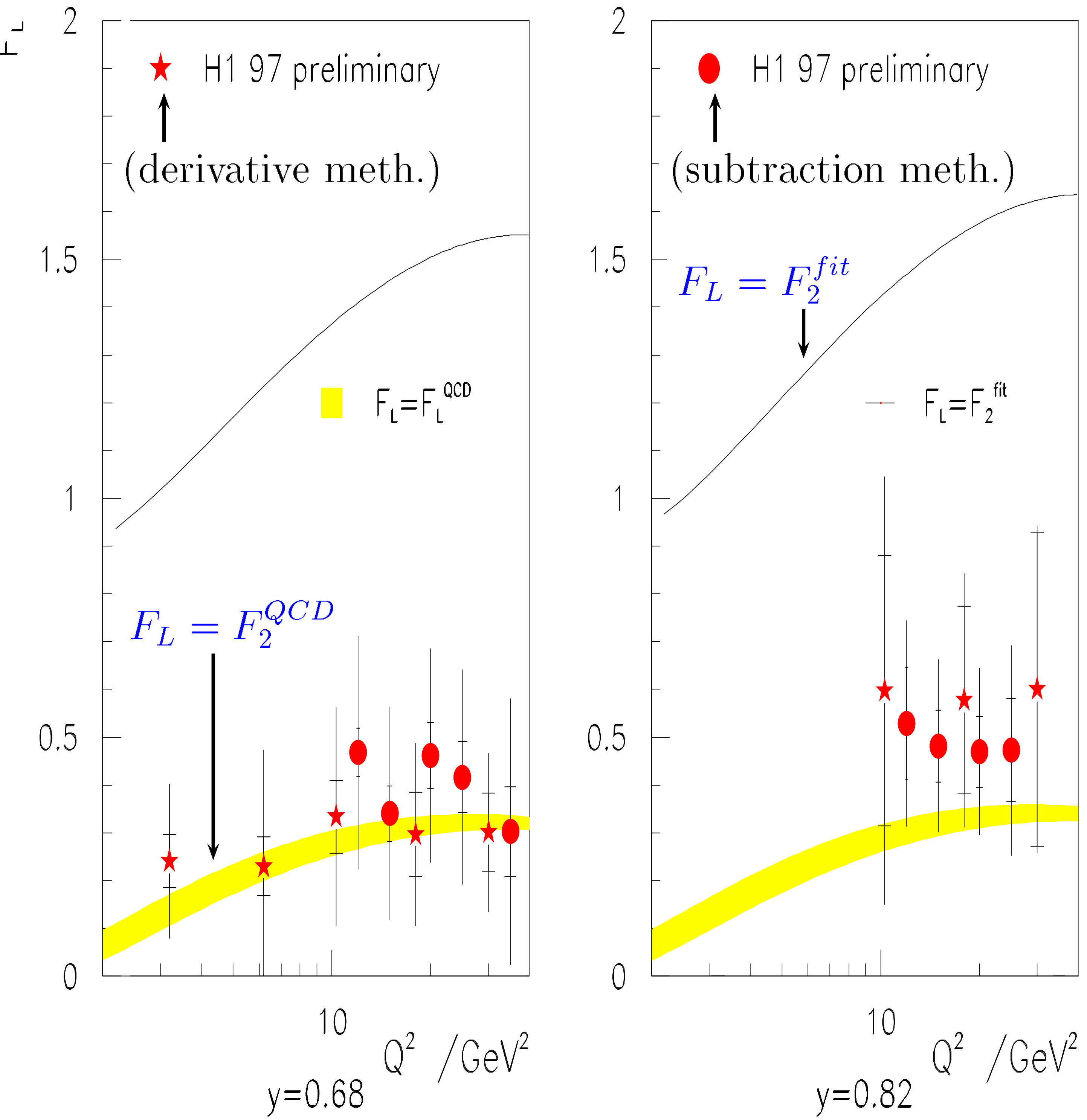
Measured σ_r used to determine $\partial\sigma_r/\partial\ln y$ at fixed Q^2:

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

- Assuming $\partial F_2/\partial\ln y = A\ln y$ + B up to large y; checked with QCD fit and put to error
- Straight line fit to $\partial\sigma_r/\partial\ln y$ in Q^2 bins at $y < 0.2$ (the extrapolation represents F_2 contrib. at high y)
- Accesses lower Q^2 and more sensitive to F_L than subtraction method + partial cancelation of syst.



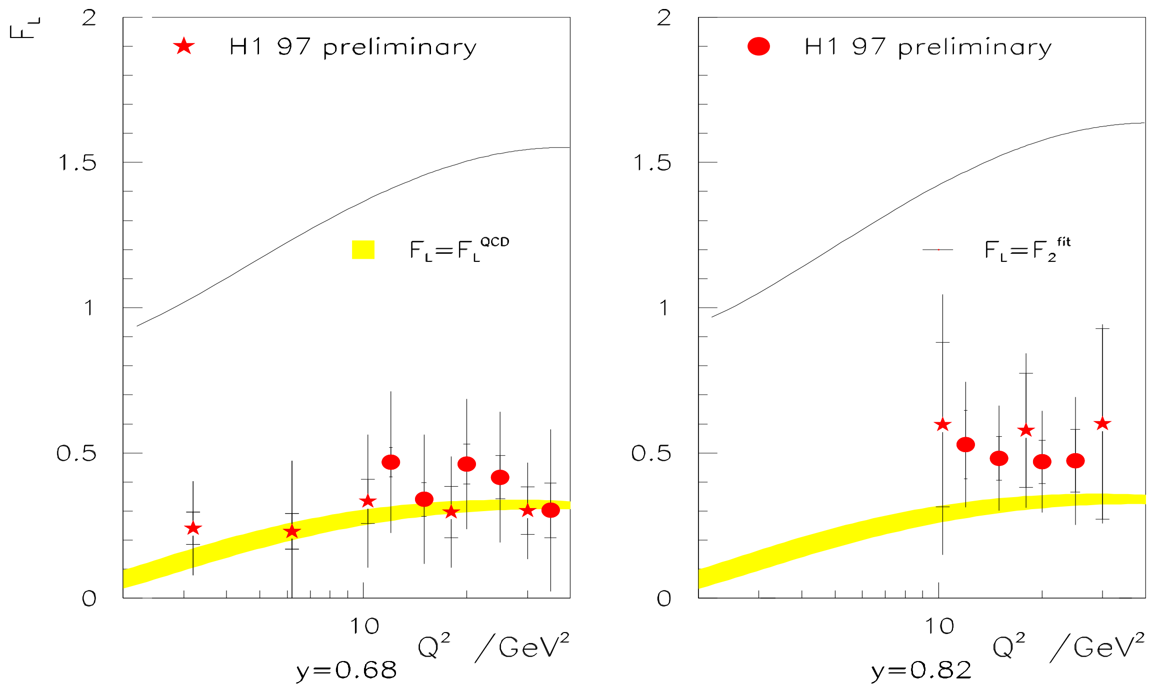
F_L



F_L
2
1.5
1
0.5
0
H1 97 preliminary
(derivative meth.)
F_L=F_L^QCD
$F_L = F_2^{QCD}$
10
Q^2 /GeV^2
y=0.68
H1 97 preliminary
(subtraction meth.)
$F_L = F_2^{fit}$
F_L=F_2^fit
y=0.82

F_L Determination

- Two methods to determine F_L:
  subtraction ($\bullet$) and derivative ($\star$) method
- Methods use different aspects of F_2 and F_L behaviour
- Systematic errors at same y correlated



- F_L determination from both methods consistent
- measured F_L consistent with QCD prediction

Summary

- σ_r **well described by NLO QCD down to** $Q^2 = 2$ **GeV**^{2}
- **Using H1 DATA97** F_L **was determined in the range** $3 \leq Q^2 \leq 35$ **GeV**^{2}
- F_L **obtained with two methods**
- **The methods agree with each other and are consistent with** F_L^{QCD}

- **Direct** F_L **measurement not assuming QCD still important: vary beam energies !**

This work was supported by GA AV ČR grant no. A1010821