F_L determination by H1

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H1 Collaboration

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HERA-LHC Workshop, DESY Hamburg

- Introduction
- F_L determination at medium and high Q^2
- F_L determination at low Q^2

Deep Inelastic Scattering

virtuality of exchanged photon:

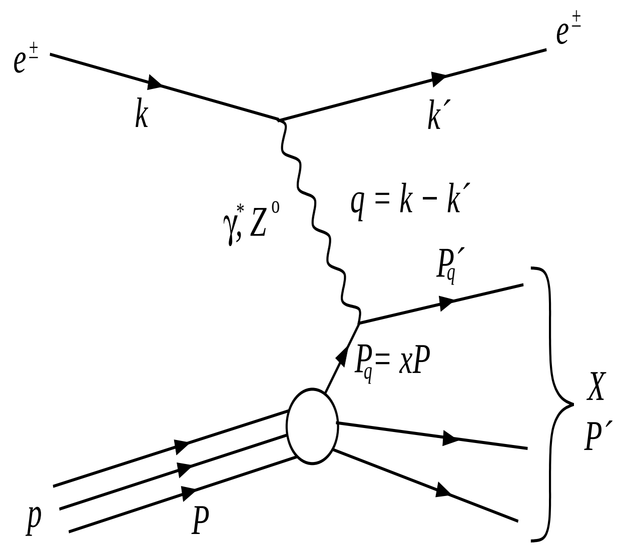
$$Q^2 = -(k - k')^2$$

proton momentum fraction:

$$x = Q^2/2P(k - k')$$

inelasticity:

$$y = P(k - k')/Pk$$



NC DIS reduced cross section (for $Q^2 << M_Z^2$):

$$\sigma_r = F_2(x, Q^2) - \frac{y^2}{Y_+} \cdot F_L(x, Q^2), \qquad Y_+ = 1 + (1 - y)^2$$

sizeable only at high y

dominant

Longitudinal structure function F_L

- In Quark Parton Model
  photon interacts with spin 1/2 particle having only longitudinal momentum $\Rightarrow \mathbf{F_L(x) = 0}$ (Callan-Gross relation)
- In QCD
  quarks interact via gluons;
  quark struck by virtual photon has transverse momentum $\sim \mathbf{Q} \Rightarrow \mathbf{F_L(x, Q^2) > 0}$

$\mathbf{F_L}$ due to its origin is directly connected with gluon distributions in the proton $\Rightarrow$ sensitive test of perturbative QCD

Kinematic plane

H1 data

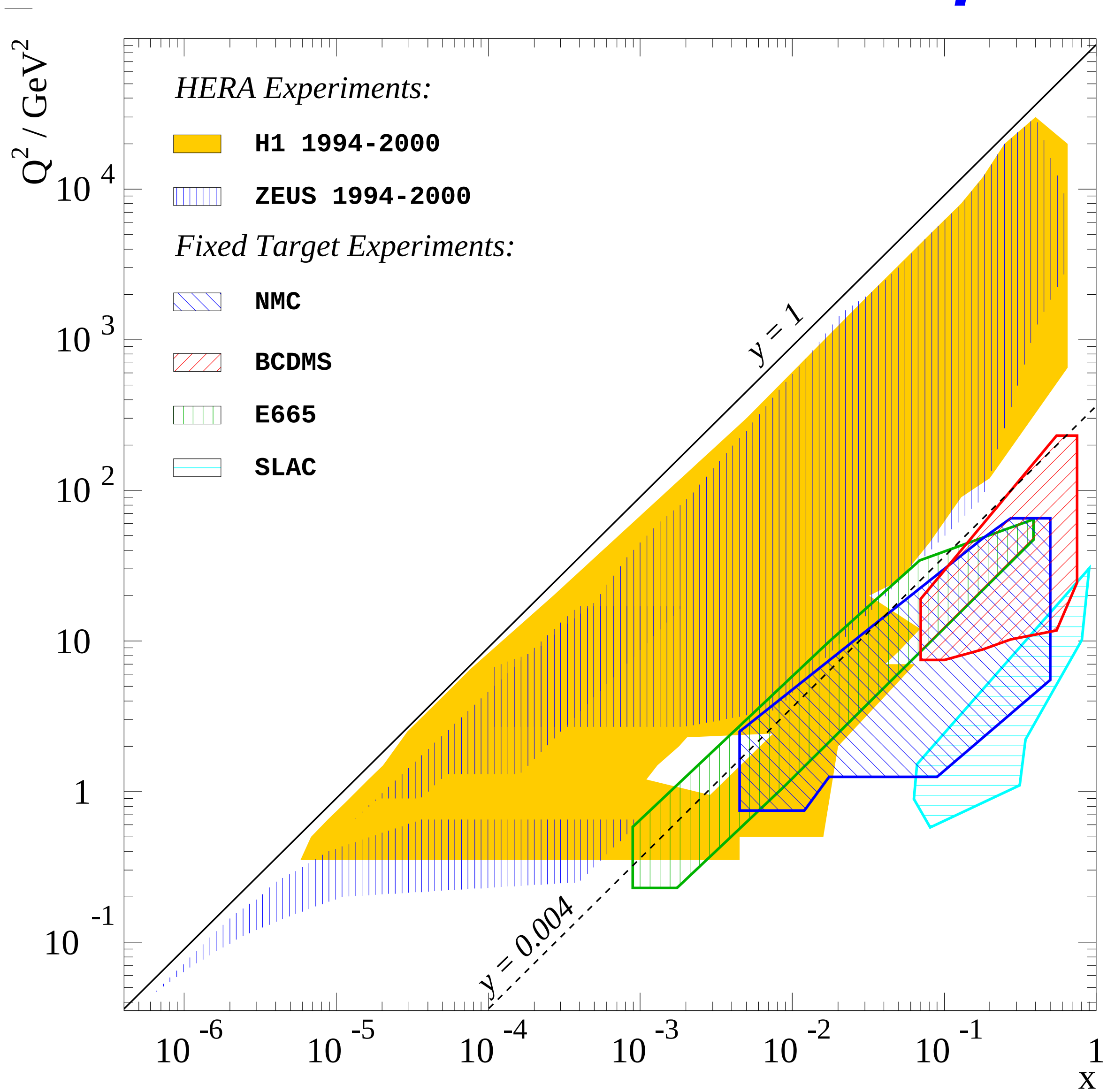
accesses high y region

i.e. region where F_L

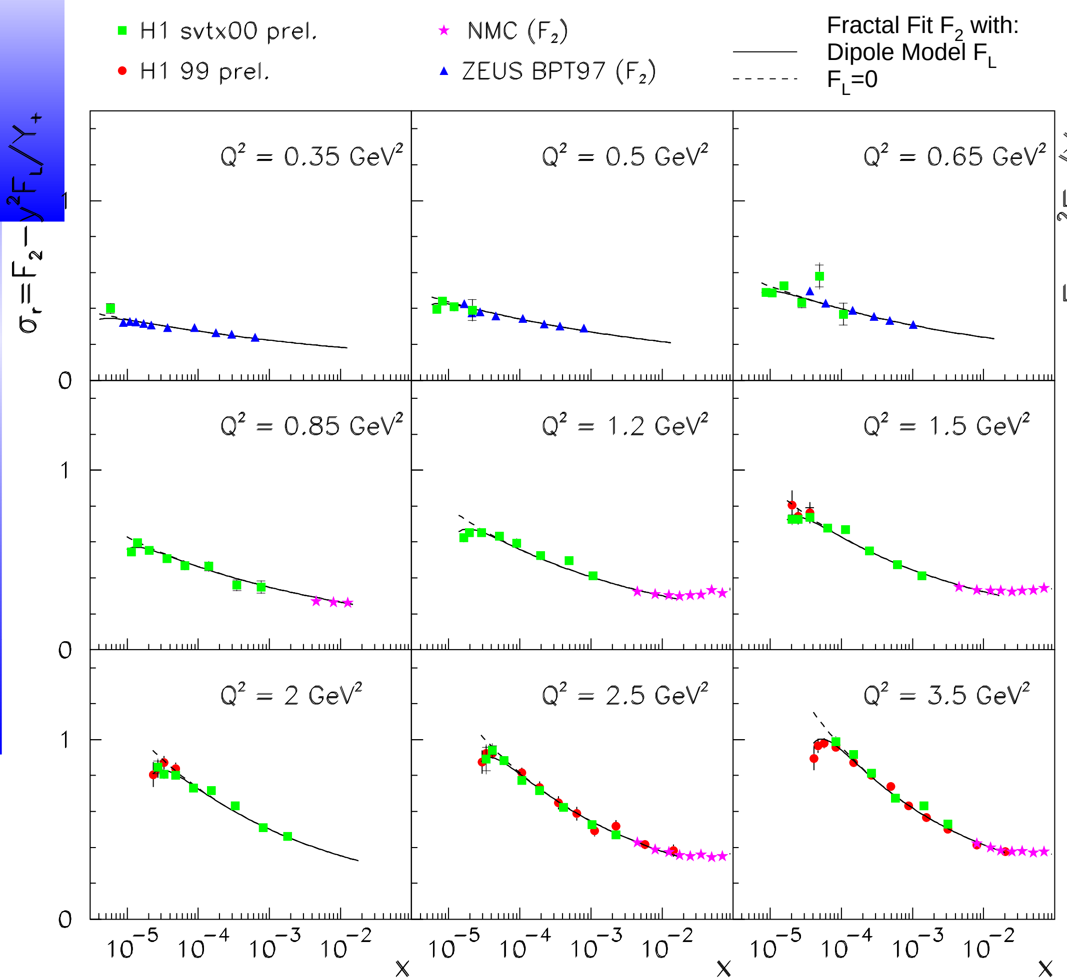
contribution to

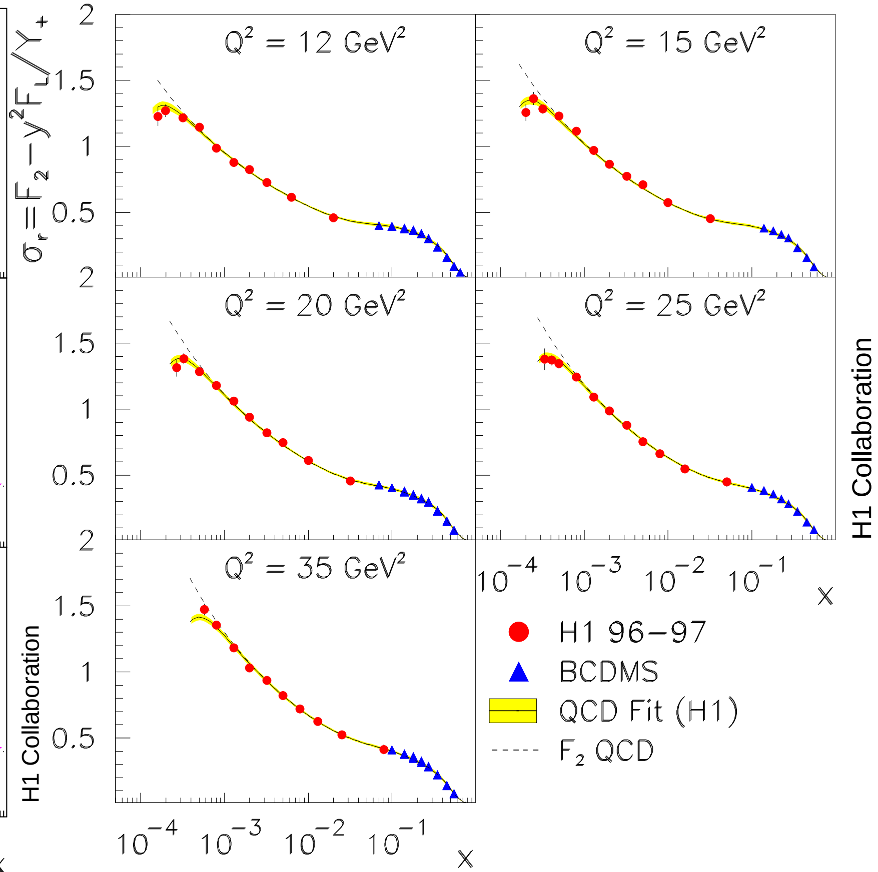
the cross section

is significant



Reduced cross section σ_r





At high y bending of the cross section is observed,
it is attributed to F_L

F_L at medium and high Q^2

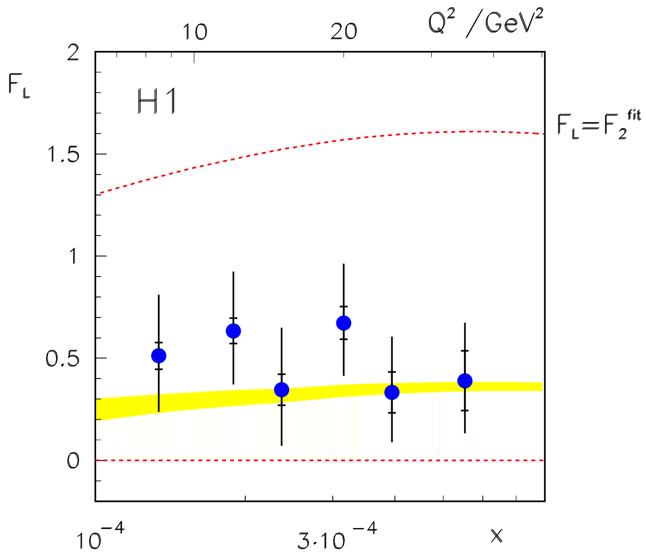
The extrapolation method (H1 Coll. Phys. Lett. B 393 (1997) 452 [hep-ex/9611017]):

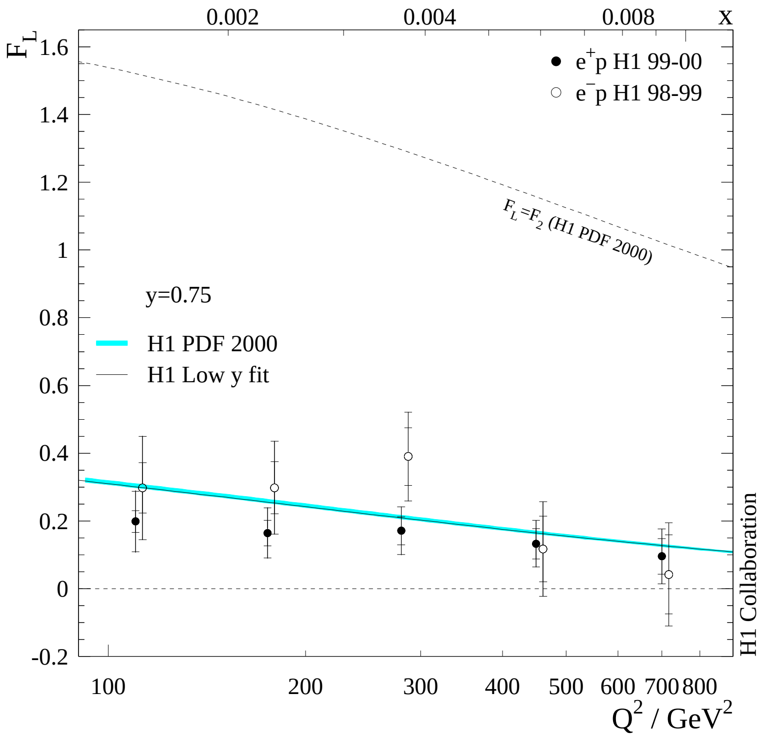
- NLO QCD fit using DGLAP was performed to H1 data (for y<0.35) and BCDMS data (to constrain high x).
- fitted parton distributions were evolved into the new region (high y) with NLO DGLAP evolution equation and used to calculate F_2.
- $F_L = F_2 - Y_+/y^2 \cdot \sigma_r$

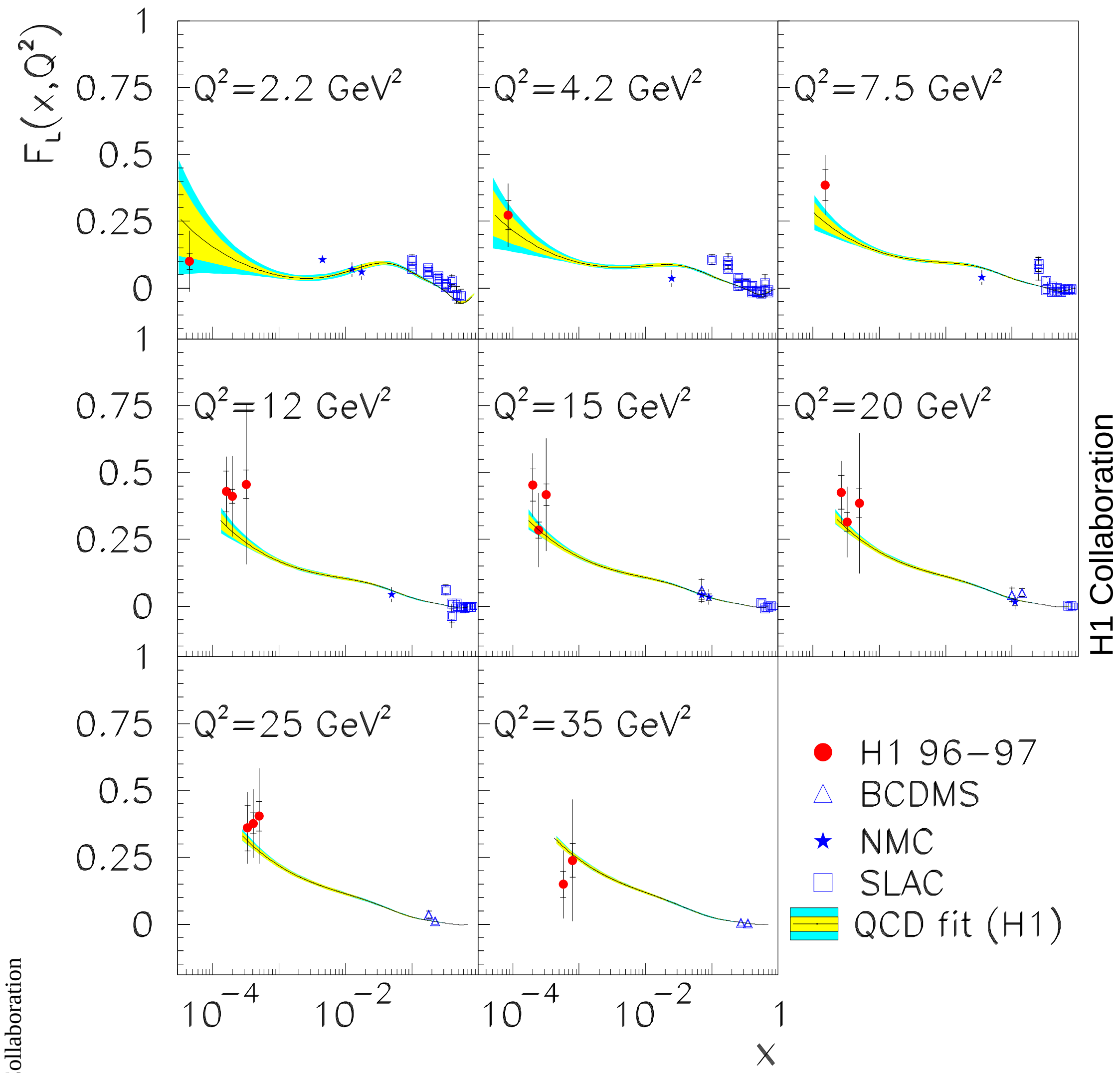
Errors:

- stat. errors due directly to the cross sect. measurement at high y
- systematic uncertainties arise from:
  - measurement errors at high y
  - model uncertainties related to the extrapolation of F_2 from the low to the high y region
- correlations in syst. between low and high y taken into account

F_L results – medium and high Q^2



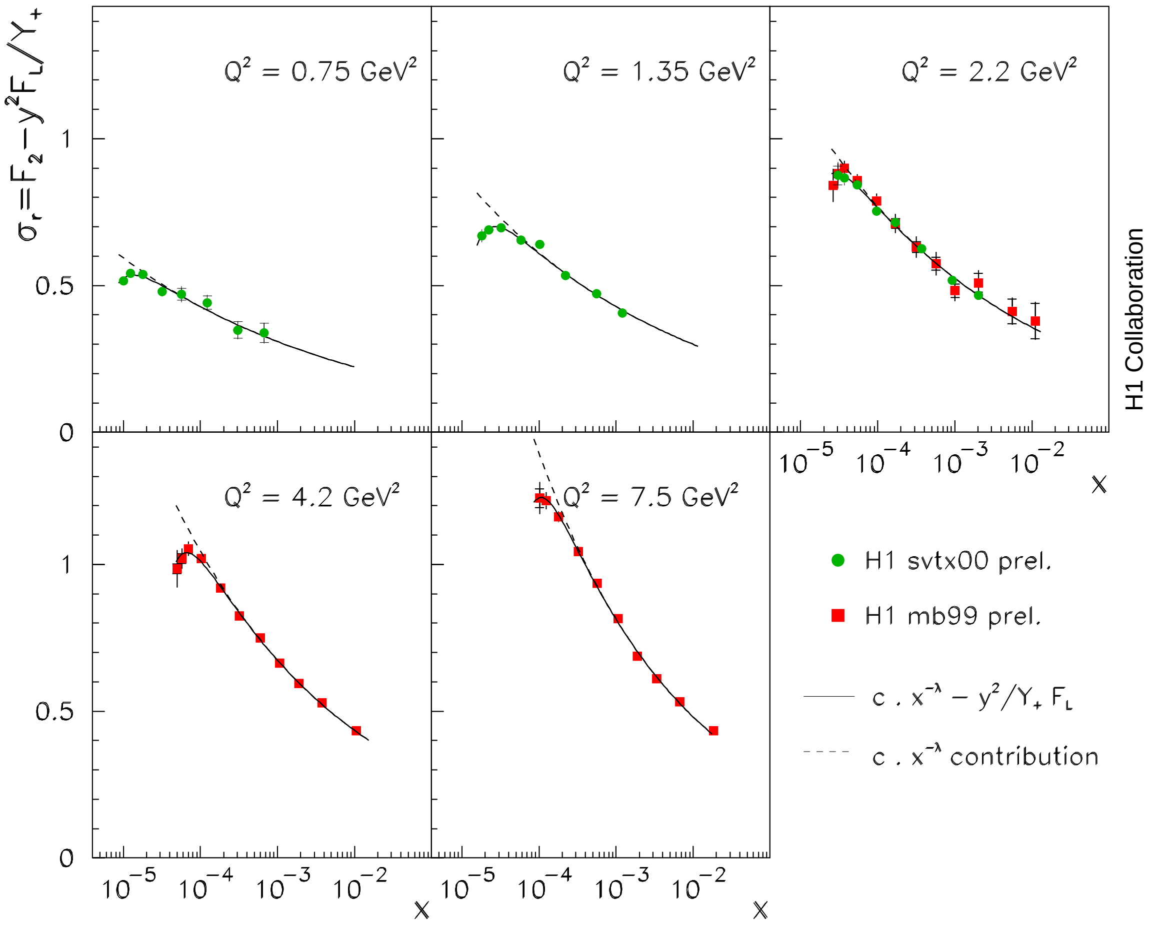




F_L at low Q^2 - “shape” method

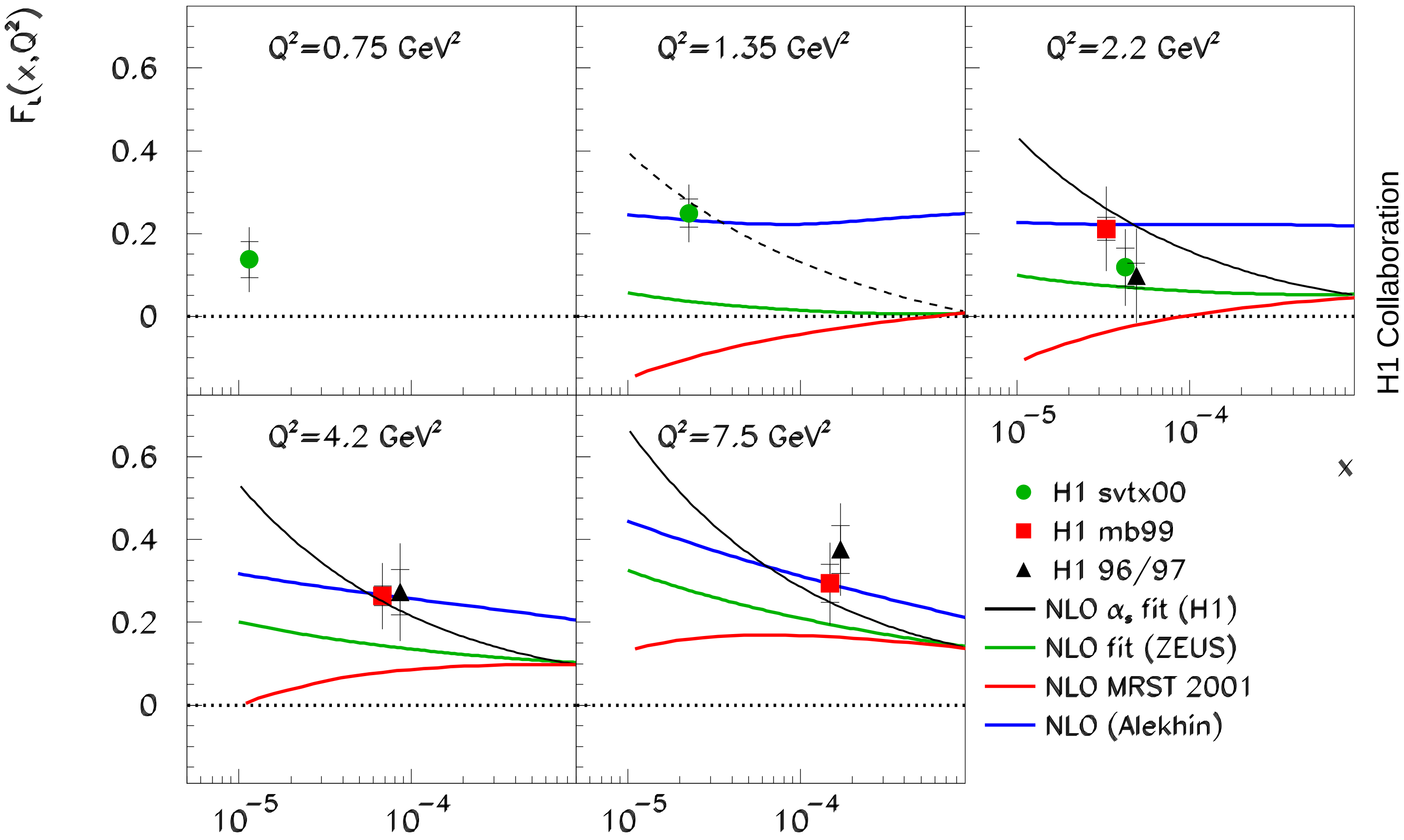
- shape of σ_r driven by kinematic factor y^2/Y_+ rather than by F_L
- constant F_L for small x range
- whole x range of measured data used to fit F_2 and F_L $\Leftrightarrow$ no extrapolation of F_2 $\Leftrightarrow$ full information used $\Rightarrow$ smaller errors
- fit in $\mathbf{Q^2}$ bins: $\boldsymbol{\sigma = F_2 - y^2/Y_+ \cdot F_L}$

$$\mathbf{F_2} \uparrow \mathbf{c \cdot x^{-\lambda}}$$



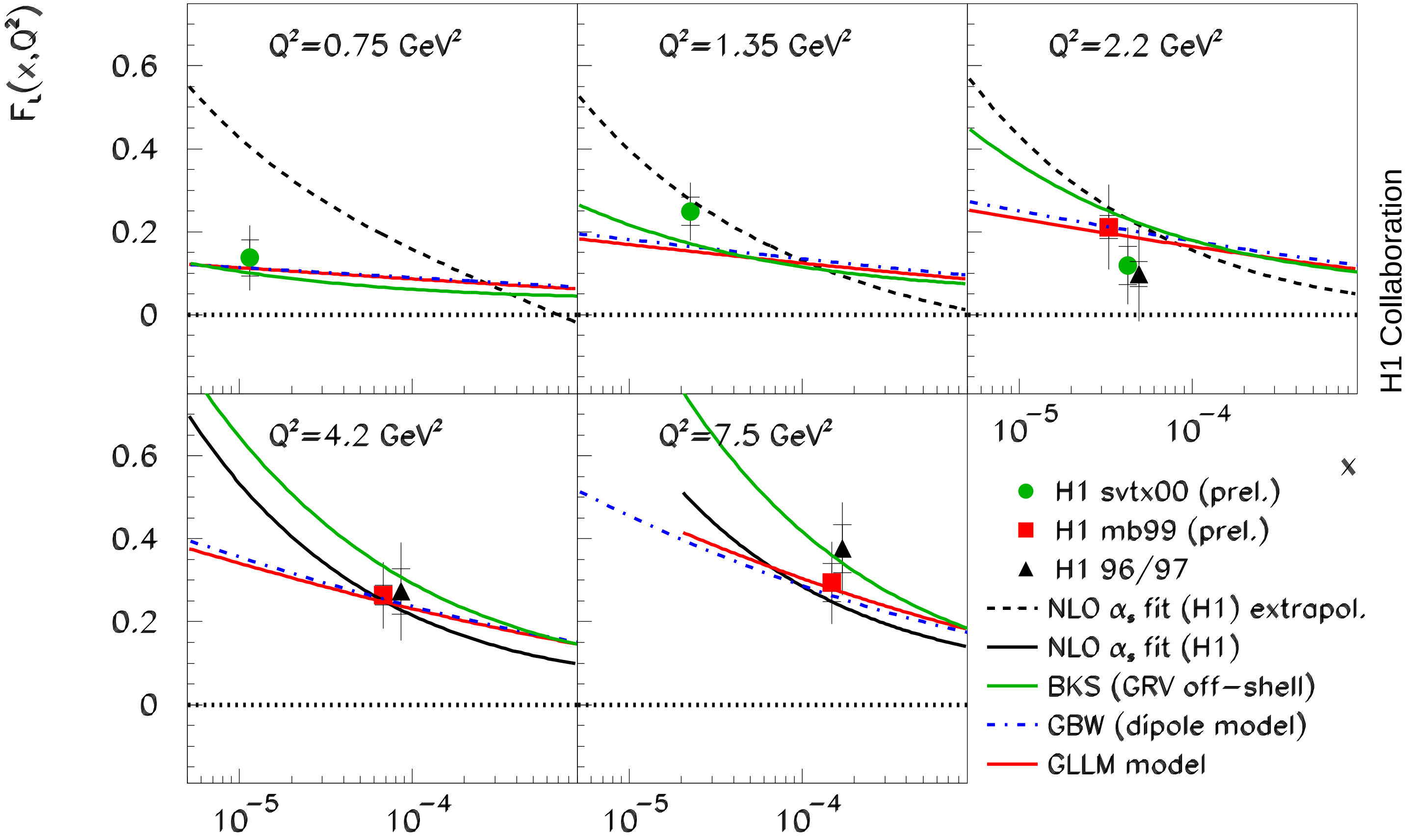
excellent description of σ_r by the “shape” fit in full kinematic region

F_L results



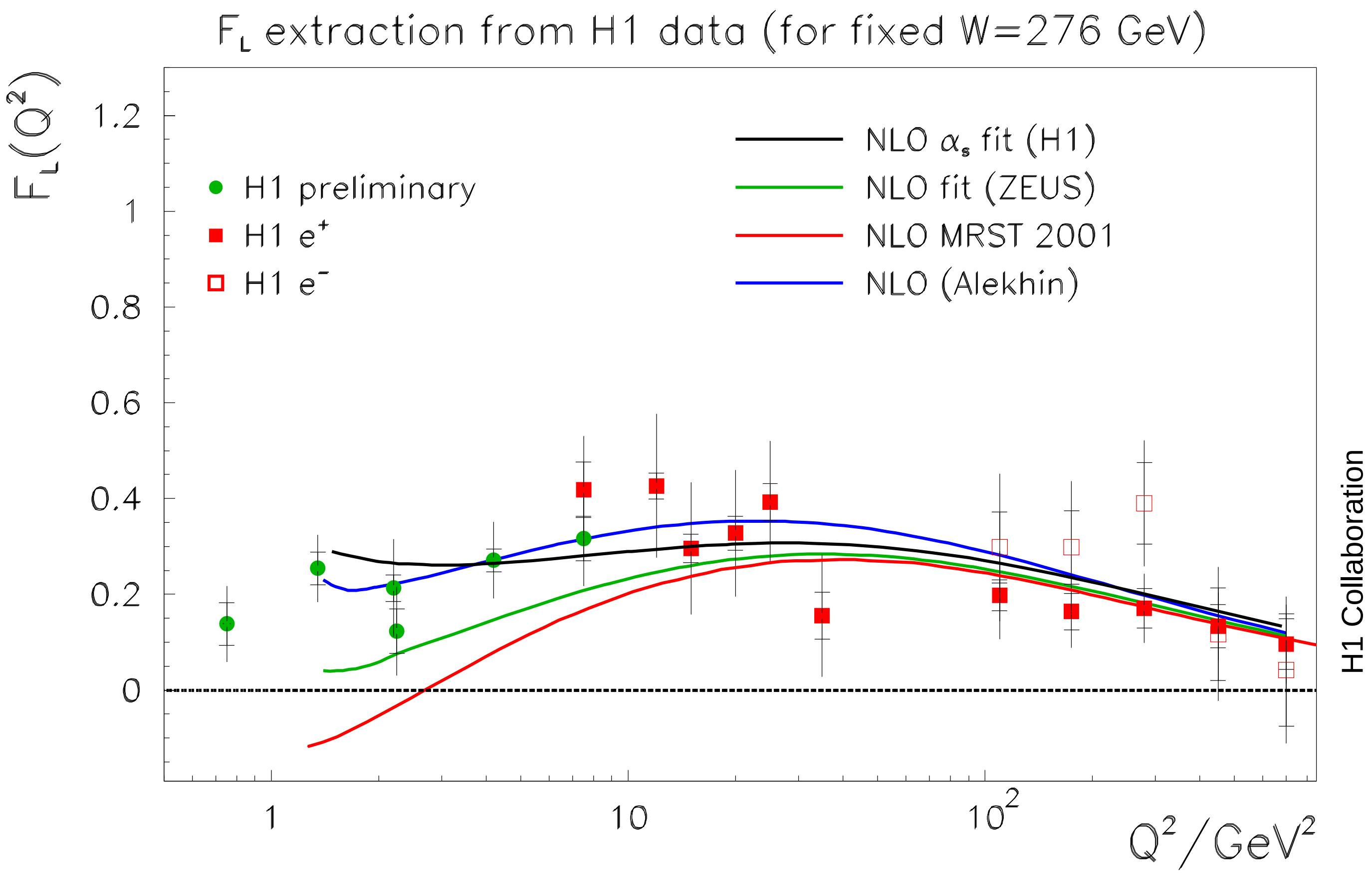
- extracted $F_L > 0$ in all Q^2 bins
- extracted F_L is able to constrain theoretical predictions
- measurement of x dependence of F_L is desirable – can be achieved by running with dedicated low E_p beam

F_L results



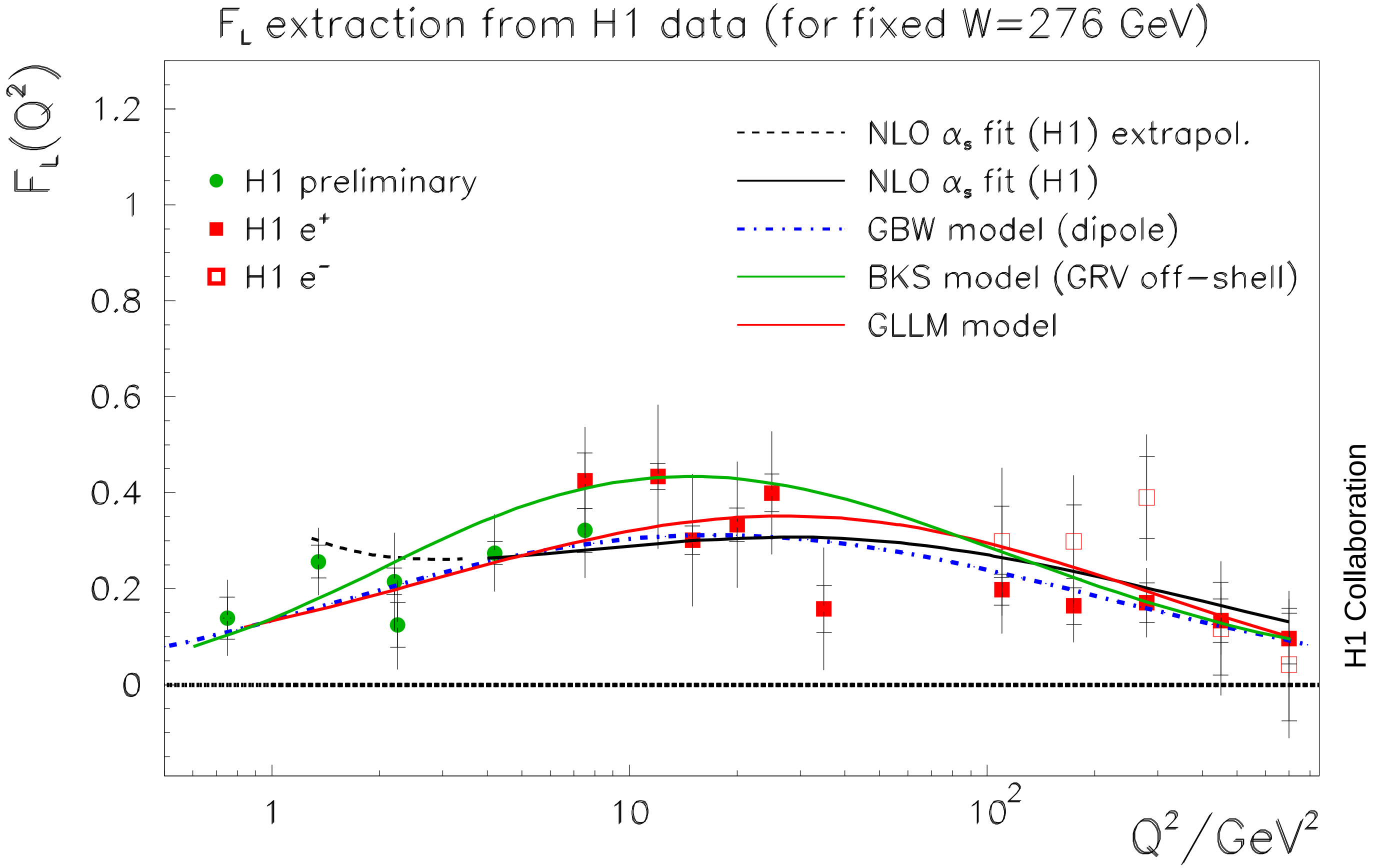
- BKS (GRV off-shell) – B. Badełek, J. Kwieciński, A. Staśto *Z. Phys.* C74, 297 (1997)
- GBW (dipole model) – K. Golec-Biernat, M. Wüsthoff *Phys. Rev.* D59, 014017 (1999)
- (GLLM model) – E. Gotsman, E. Levin, M. Lublinsky, U. Maor *Eur. Phys. J.* C27, 411 (2003)

F_L results



- H1 NLO QCD fit consistent with the data in the DIS region
- Alekhin NLO (and NNLO) in agreement with data
- MRST 2001 NLO QCD fit too low at low Q^2
- ZEUS NLO QCD fit also tends to be low at low Q^2

F_L results



- predictions of all models shown here are in a good agreement with the data

Summary

- F_L extracted in H1 experiment in the wide range of Q^2
- precision of extracted F_L high enough to constrain theoretical predictions
- to perform precise measurement of F_L runs with lowered proton beam energy necessary