New and Recent Measurements of F_2 and F_L at low Q^2

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H1 Collaboration

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DIS 2004, Štrbské Pleso

- Introduction
- F_2 at high x using QEDC events
- F_2 at low x
- F_L determination

Deep Inelastic Scattering

virtuality of exchanged photon:

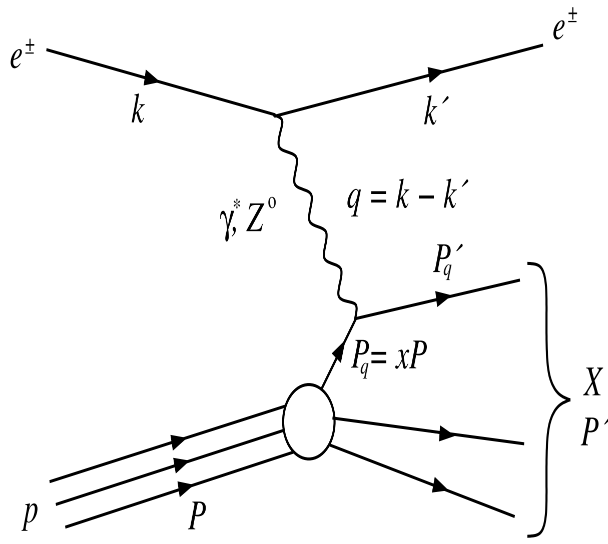
$$Q^2 = -(k - k')^2$$

proton momentum fraction:

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

inelasticity:

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



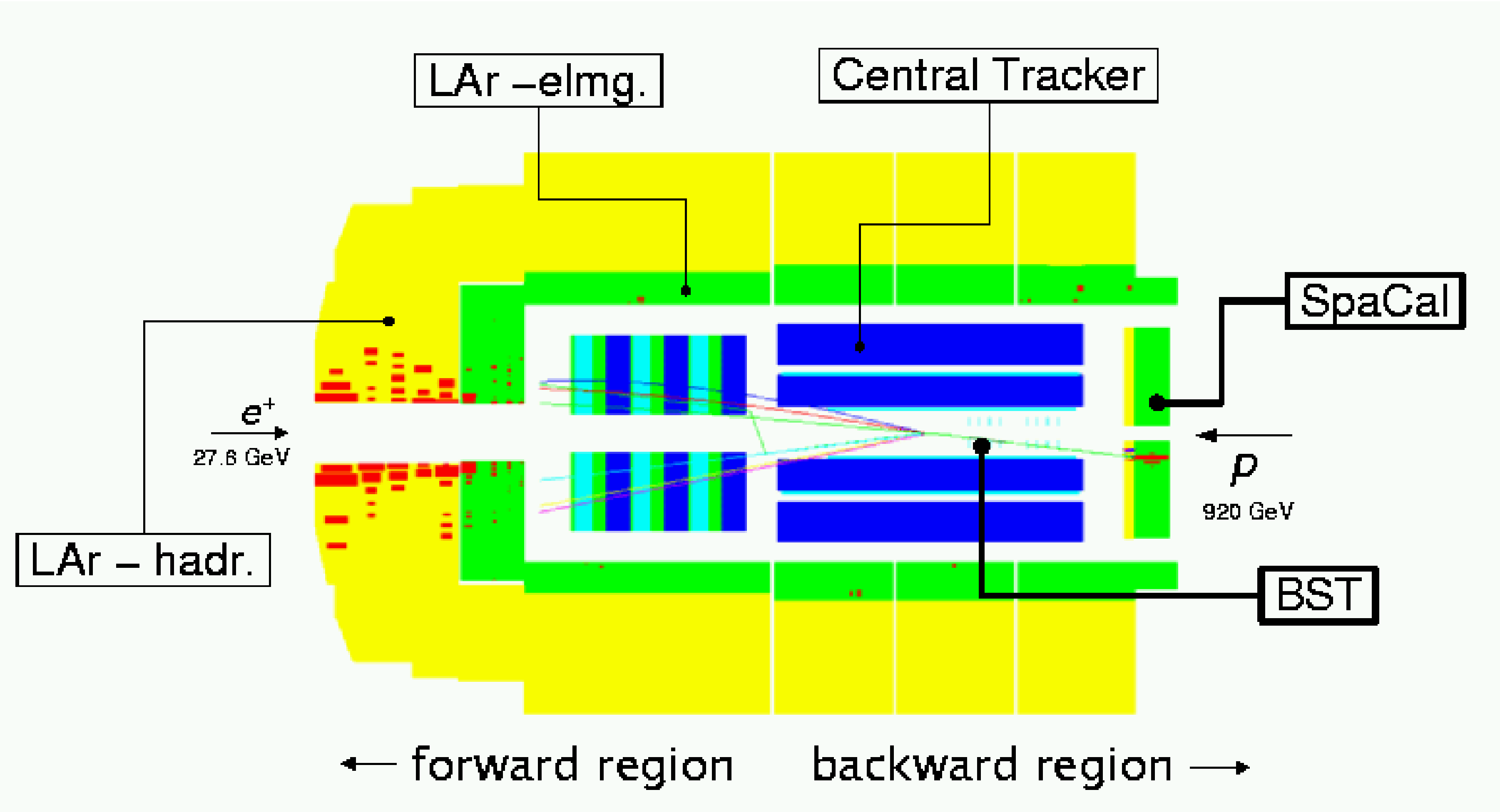
NC DIS reduced cross section (for $Q^2 << M_z^2$):

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

sizeable only at high y

dominant

DIS event in H1 detector



H1 backward detectors

SpaCal Calorimeter

- $153^o < \Theta < 177^o$
- lead - scintillating fibers
- 1192 square cells
- calibration accuracy:

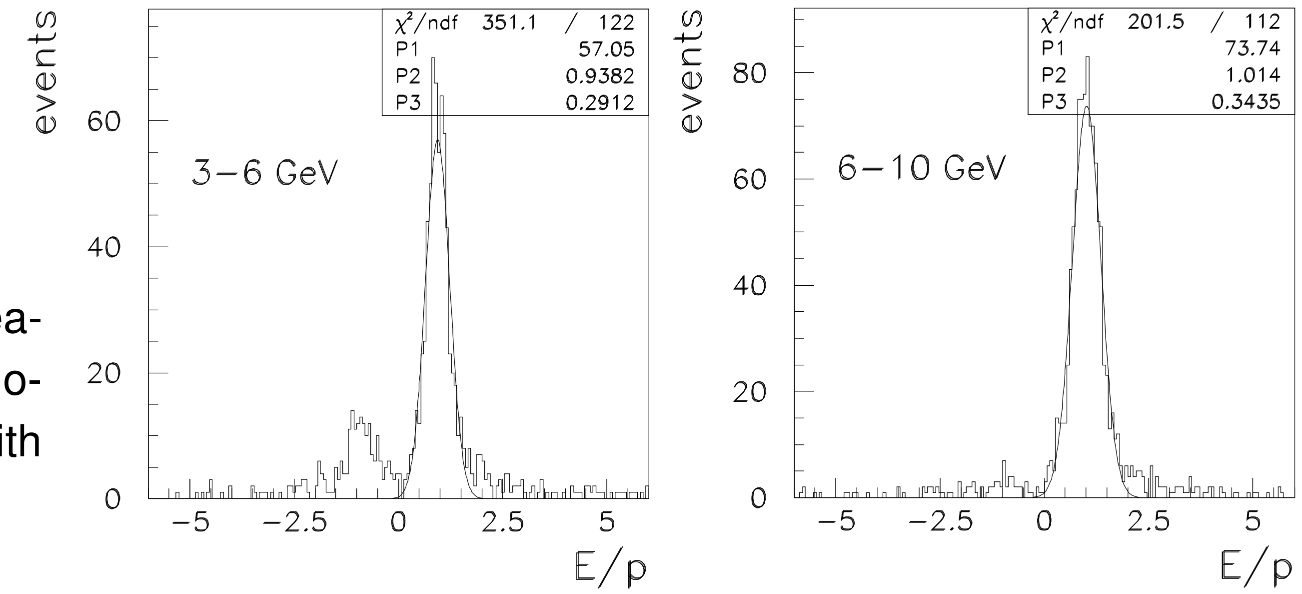
$\sim \mathbf{0.3\%}$ at 27.6 GeV (DA meth.)

$\sim \mathbf{2\%}$ at 7 GeV (SpaCal-BST match.)

Backward Silicon Tracker

- $171.5^o < \Theta < 176.5^o$
- 8 planes x 16 sectors
- track reconstruction efficiency $\sim \mathbf{95\%}$
- hit resolution $\sim \mathbf{20\mu m}$

Ratio of energy measured in SpaCal to momentum measured with BST.

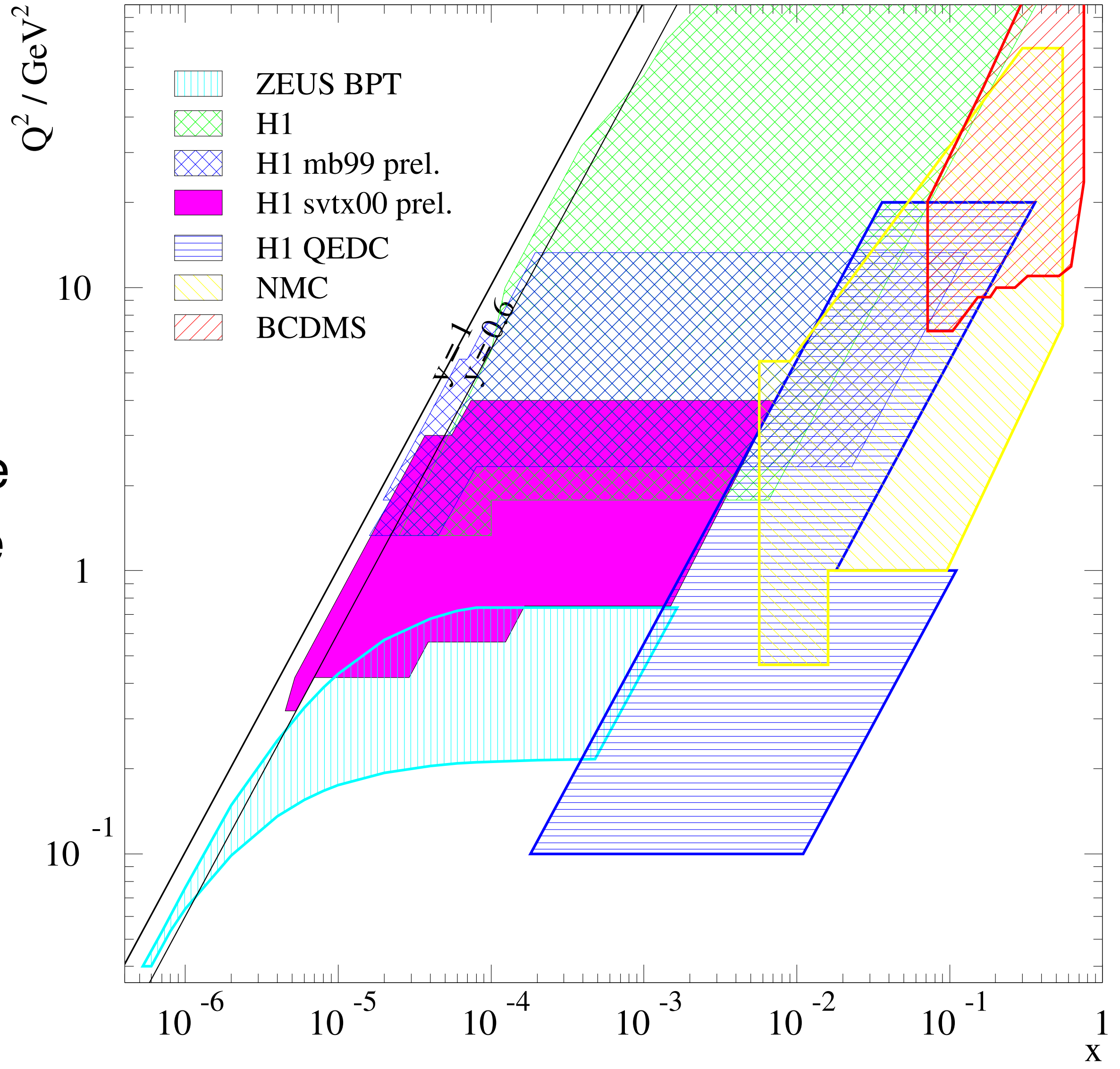


Kinematic plane coverage

- QEDC data in
  the high x region

- 2000 svtx in
  the transition region
  between perturbative
  and non-perturbative
  kinematic range
  ($\sim$ 1 GeV^2)

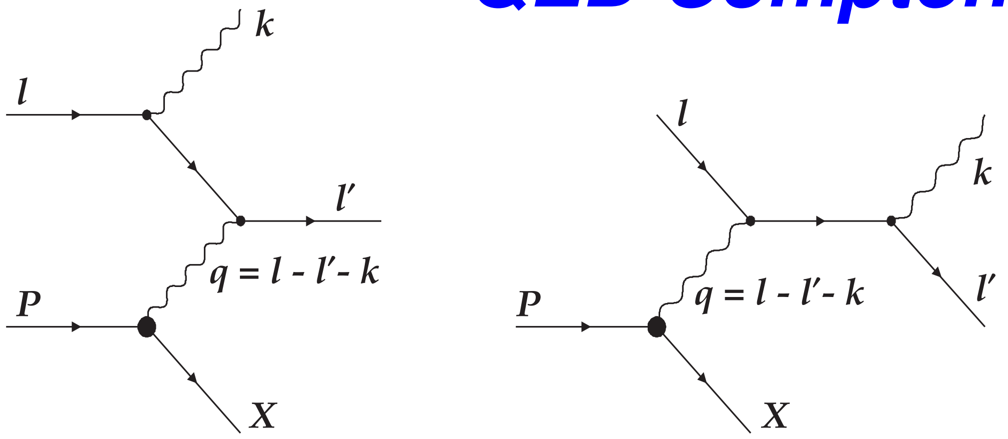
- 99 mb and 2000 svtx
  access high y region



QED Compton

$q^2 \sim 0 <=> \vec{q}||\vec{P}$

Compton scattering of a quasi real photon off an electron



$$Q^2 = -q^2 = -(l - l' - k)^2, \qquad x = \frac{Q^2}{2P\cdot(l-l'-k)}$$

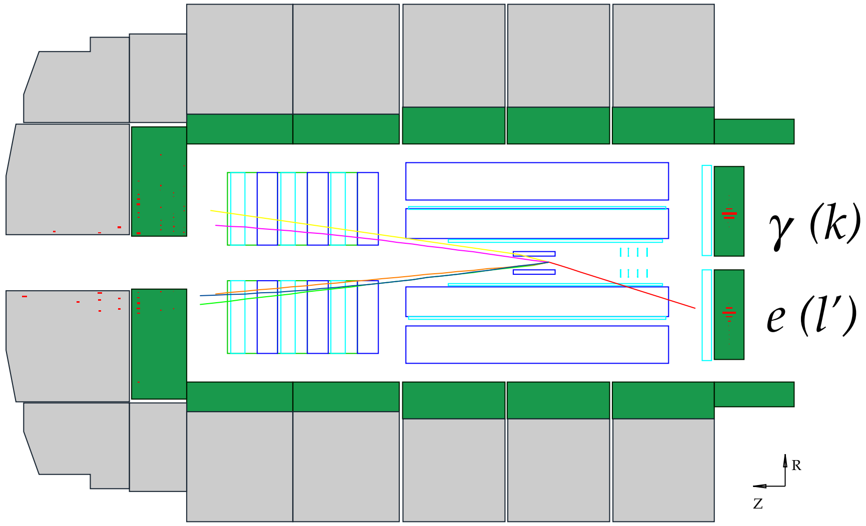
Contributions to QEDC cross section:

- elastic $W = m_p$, well known contribution (expressed by form factors)
- resonance $m_\pi + m_p < W < 2$ GeV,Δ (1236), N^* (1520) ..., well known (relatively small)
- continuum inelastic $W > 2$ GeV, p breaks, cross section expressed by F_2 and F_L, since y small $\Rightarrow F_L$ negligible.

QED Compton

Experimental signatures:

- two elm. clusters in SpaCal
- clusters back-to-back in azimuthal plane
- at least one track
- some activity in LAr cal.
- vtx in central region

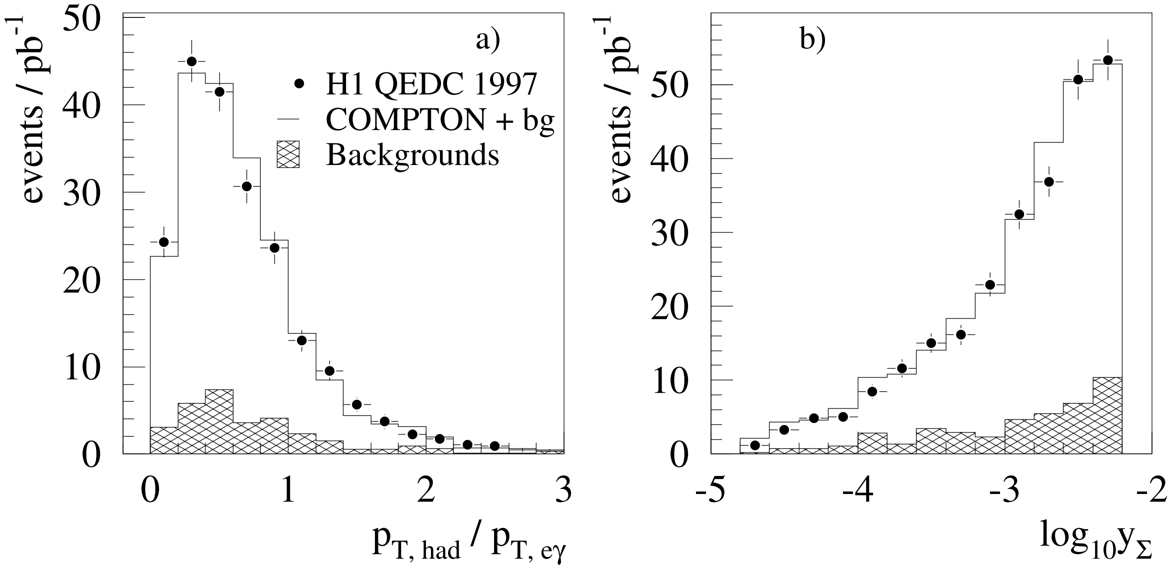


Phase space limitations: At high y DIS background (with π^o faking outgoing photon) dominates $\Rightarrow$ analysis restricted to low y region.

QEDC – MC simulation

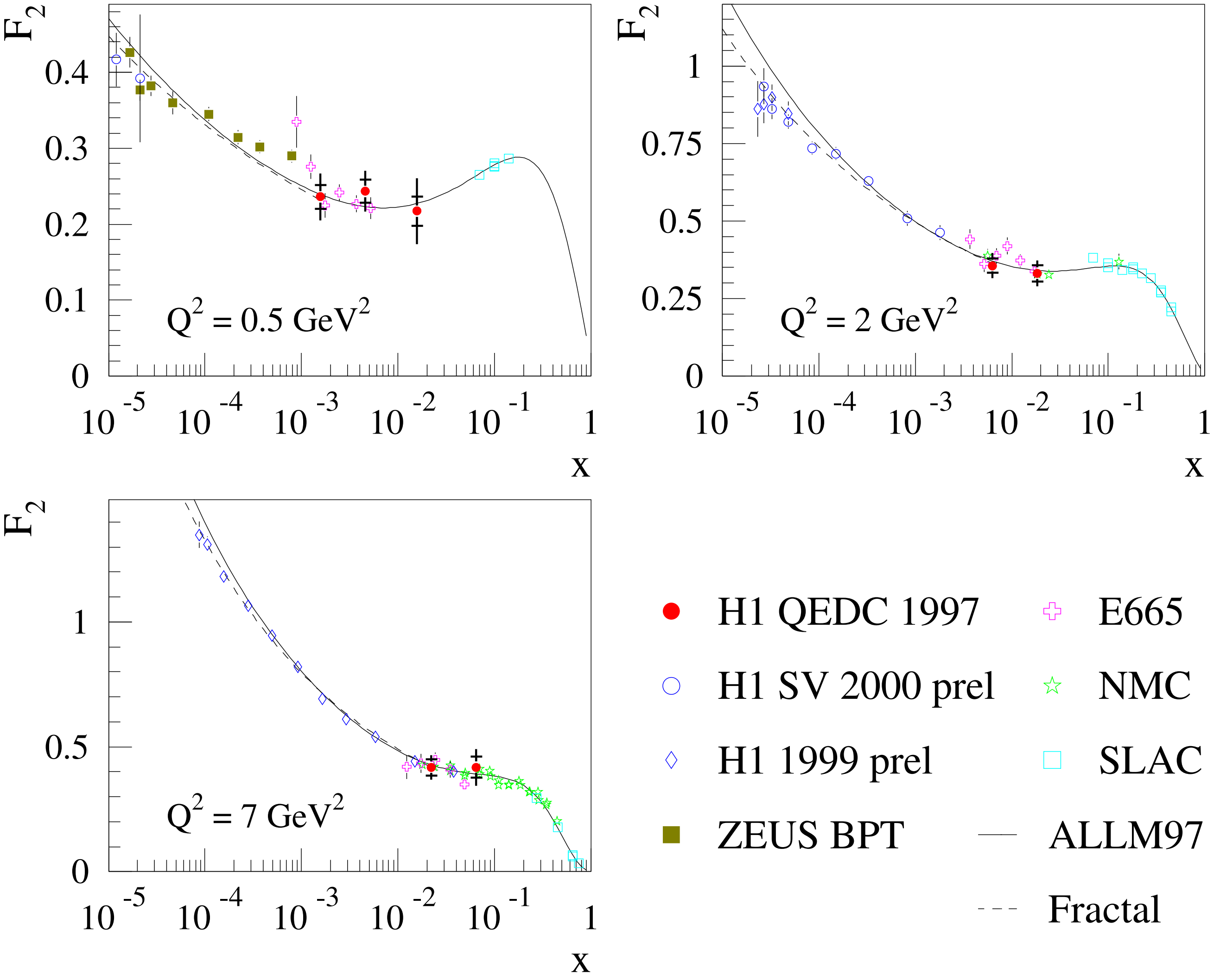
SOPHIA MC for low Q^2 or low W:

- precise description of γ hadron interactions reproducing large set of available data.
- includes: major baryon resonances, direct π production, diffractive production of light vector mesons, multiparticle production based on Dual Parton Model with Lund string fragmentation.



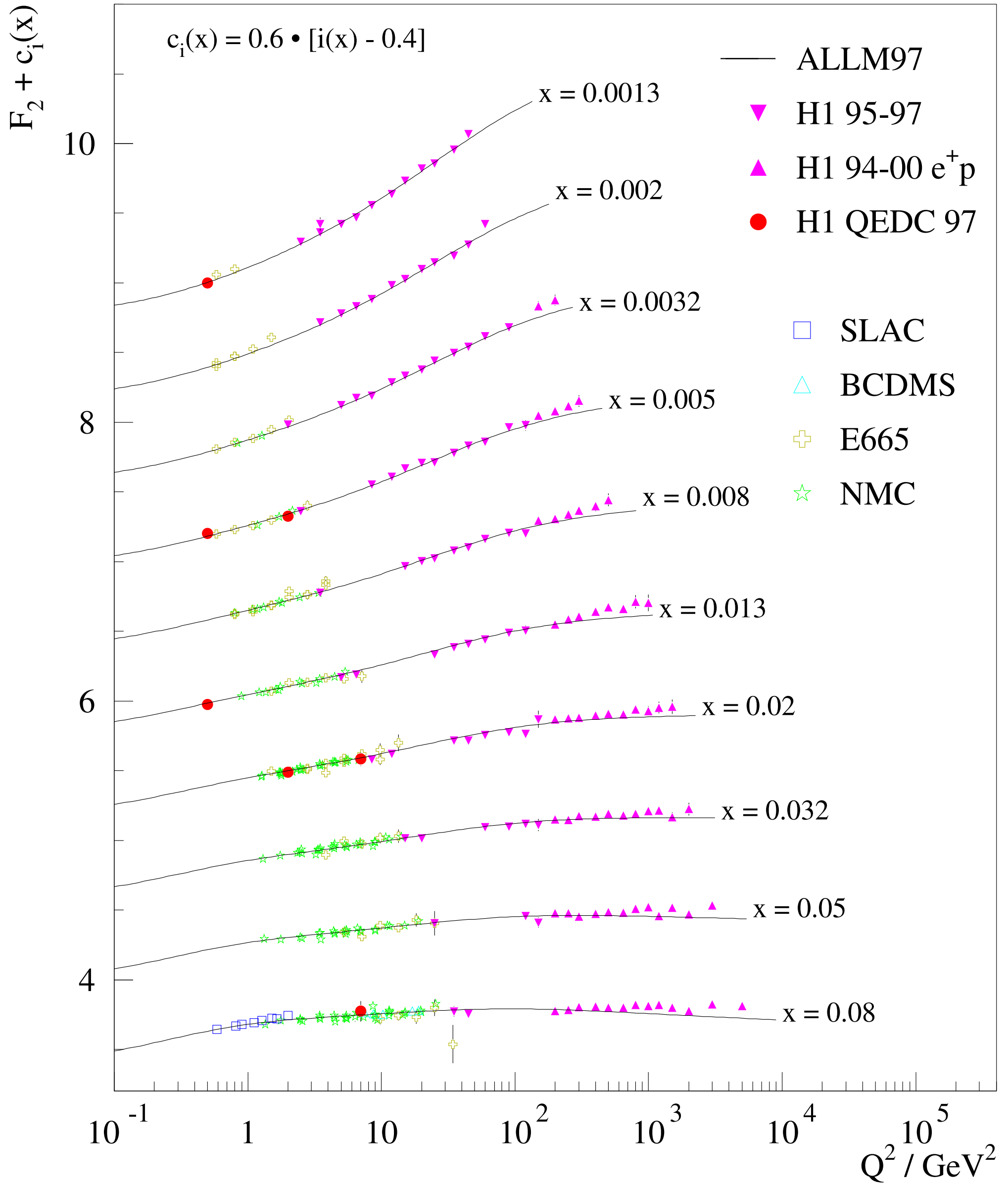
Good description of hadronic final states in forward direction by the COMPTON MC which implements SOPHIA package.

F_2 measurement with QEDC



Good agreement with fixed target data.

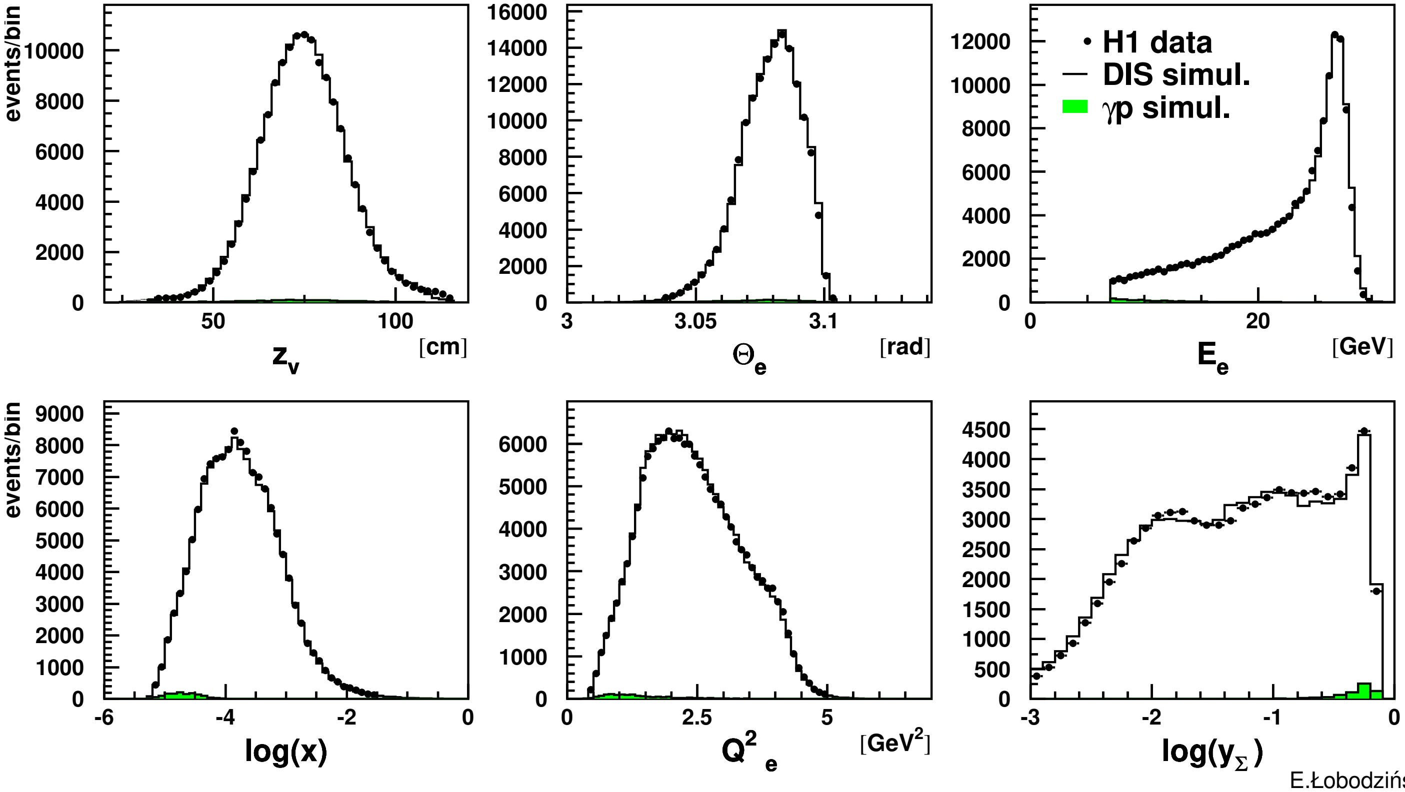
F_2 measurement with QEDC



Cross section analysis at low x

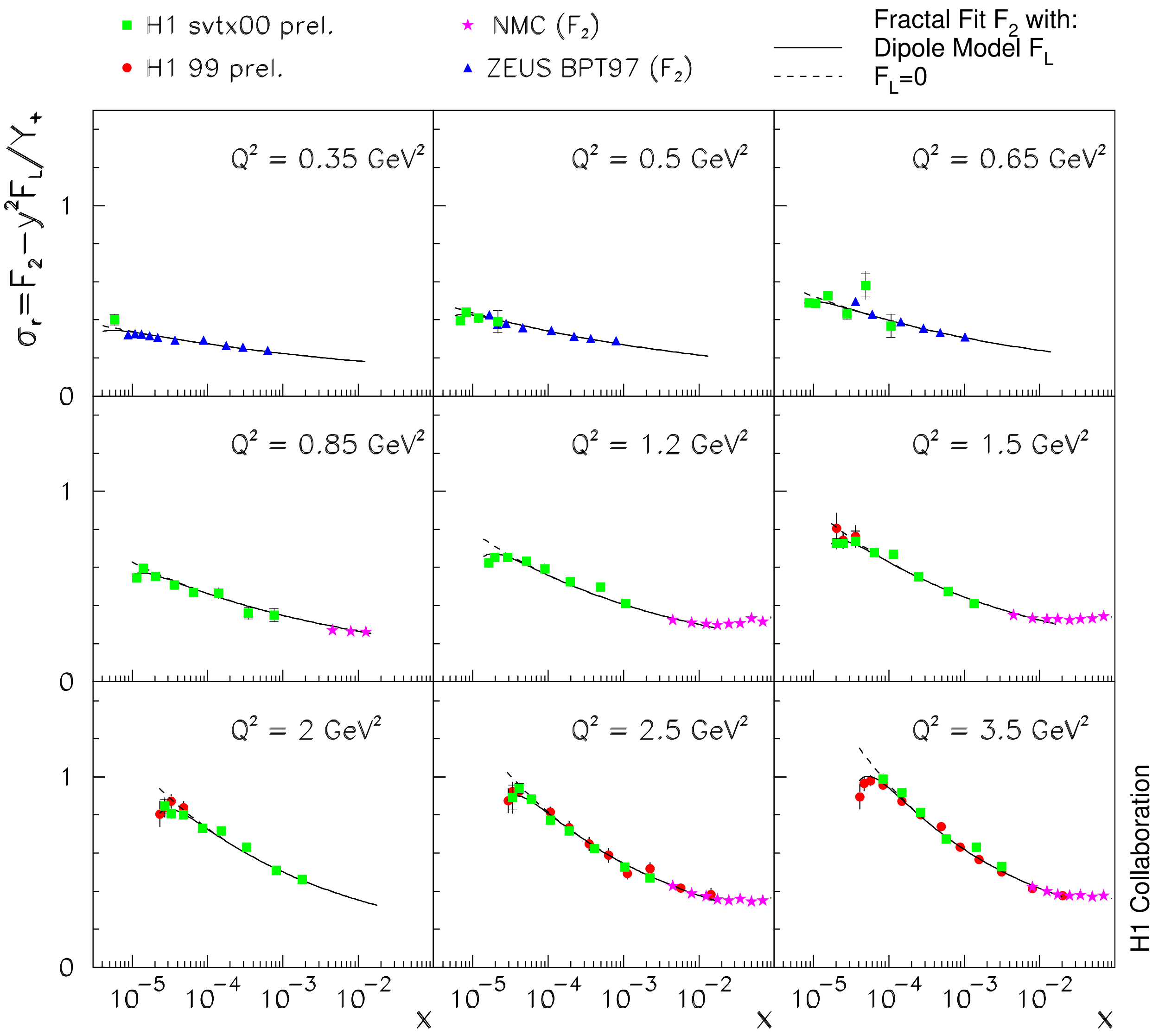
Event selection:

- inclusive SpaCal trigger ($\mathcal{L}_{99mb}$=2.7pb^{-1}, $\mathcal{L}_{00svtx}$=0.6pb^{-1})
- cluster in electromagnetic SpaCal
- BST validated track matching SpaCal cluster
- vertex in interaction region ($\sim$0cm for 99mb, $\sim$70cm for 00svtx)



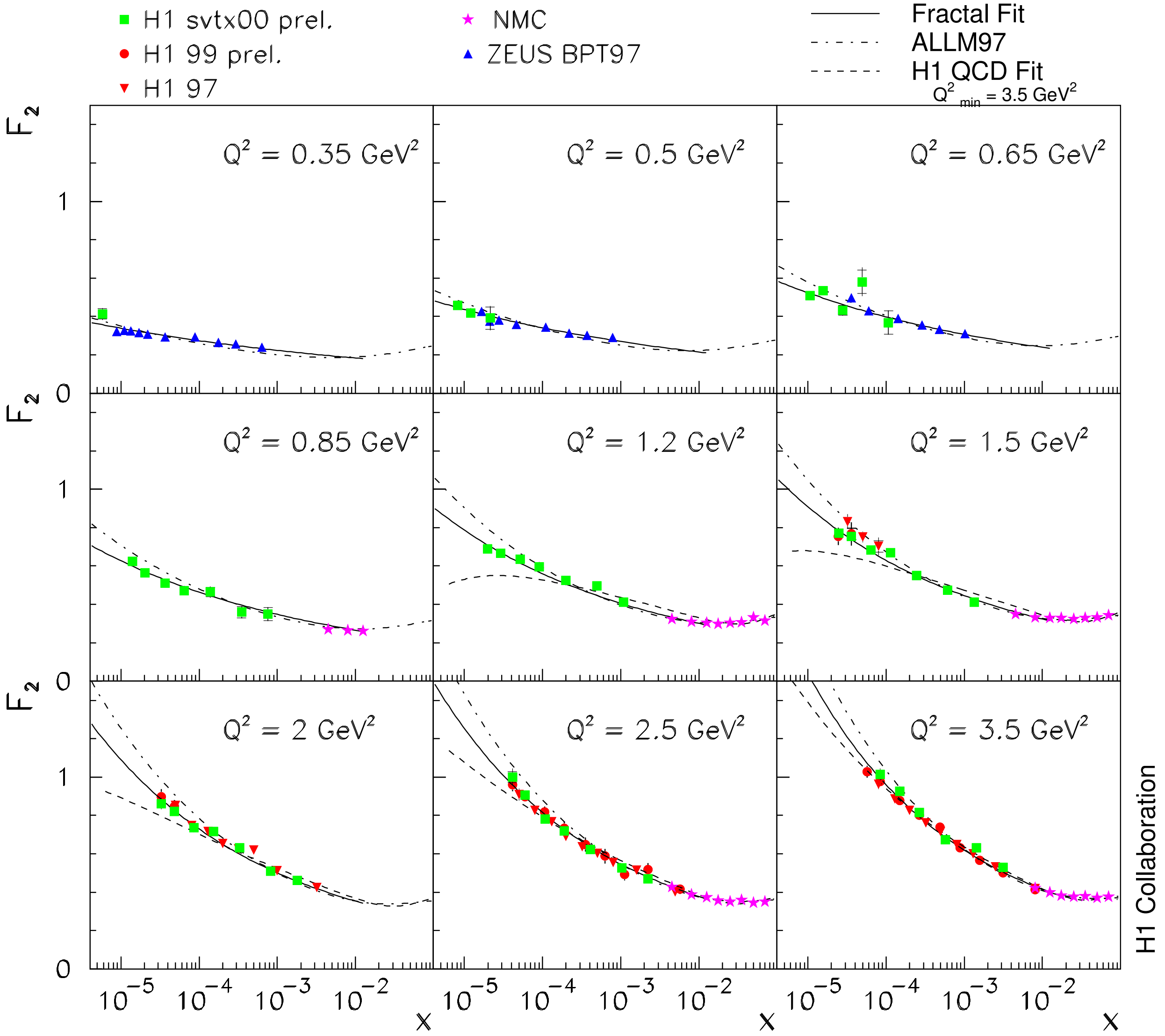
Reduced cross section σ_r

- high precision measurement (2-3% in bulk region)
- wide inelasticity range covered ($0.002 < y < 0.89$)



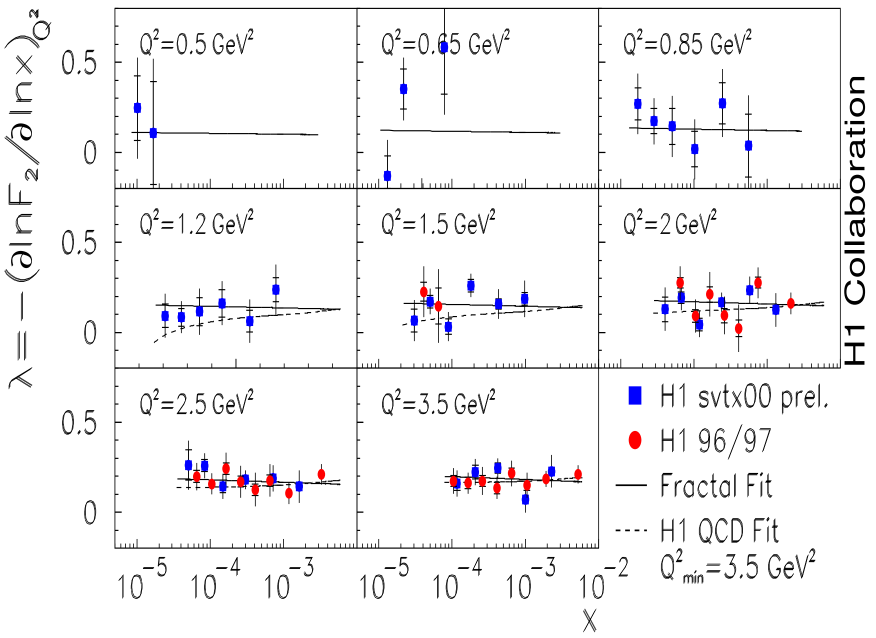
Structure function F_2

- obtained from σ_r for $y < 0.6$ using dipole model for F_L
- F_2 rise towards low x observed for all Q^2

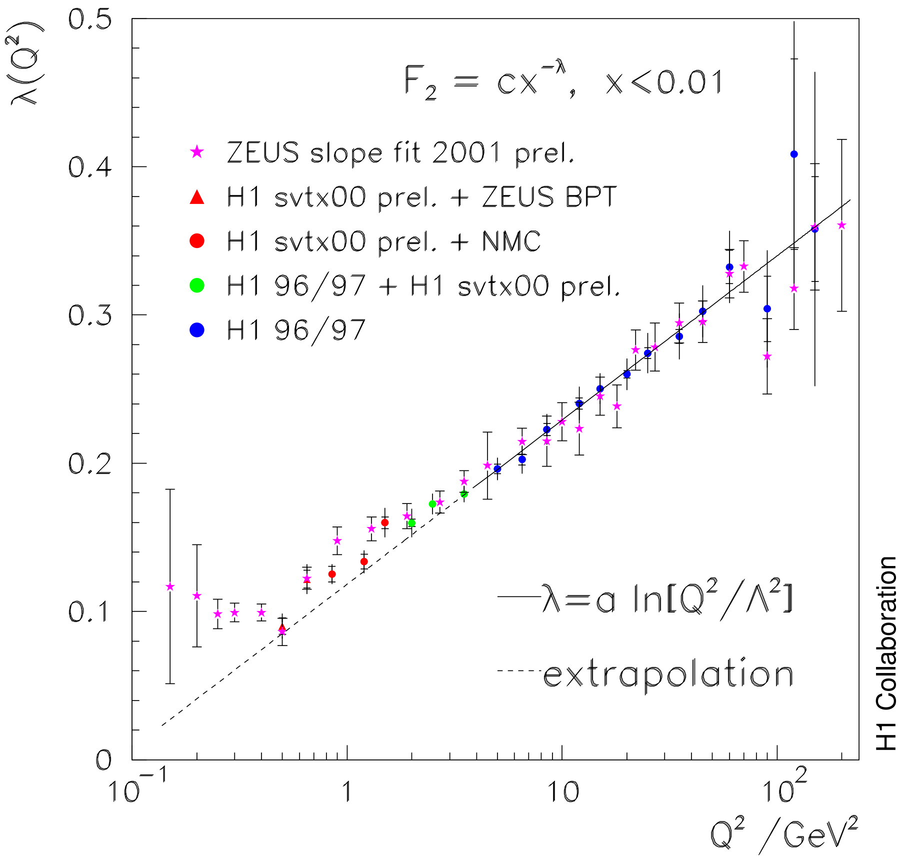


x and Q^2 dependence of F_2

$$\lambda(x, Q^2) = \left(\frac{\partial \ln F_2(x,Q^2)}{\partial \ln x} \right)_{Q^2}$$



- λ const. at fixed Q^2 for $x <$ 0.01 $\Leftrightarrow F_2(x, Q^2) = c(Q^2) \cdot x^{-\lambda(Q^2)}$

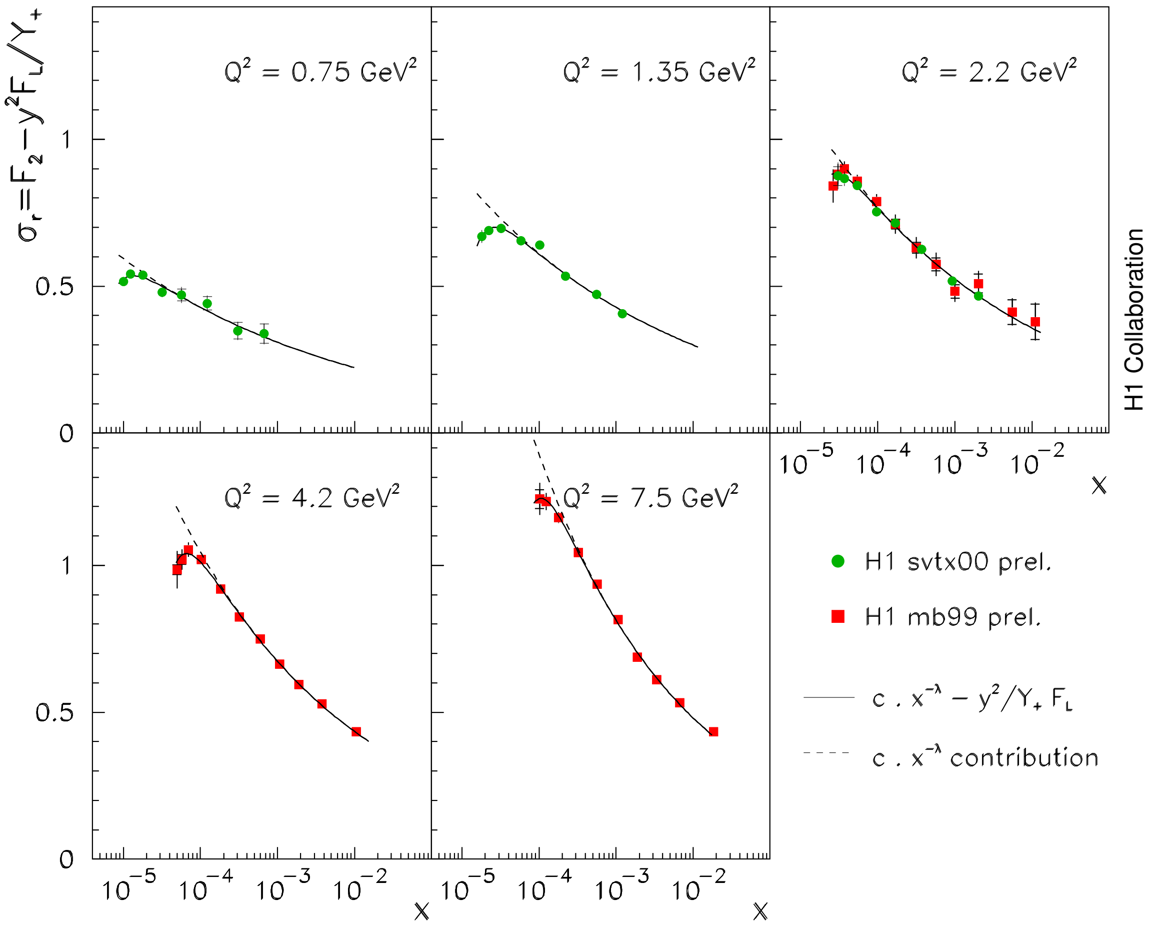


- $\lambda \sim \ln(Q^2/\Lambda^2)$ and $c(Q^2) \sim$ const. for $Q^2 >$ 3.5 GeV^2
- around Q^2= 1 GeV^2 λ deviates from log-dependence
- from soft hadronic interactions expected that $\lambda \longrightarrow 0.08$ for $Q^2 \longrightarrow 0$

F_L determination - "shape" method

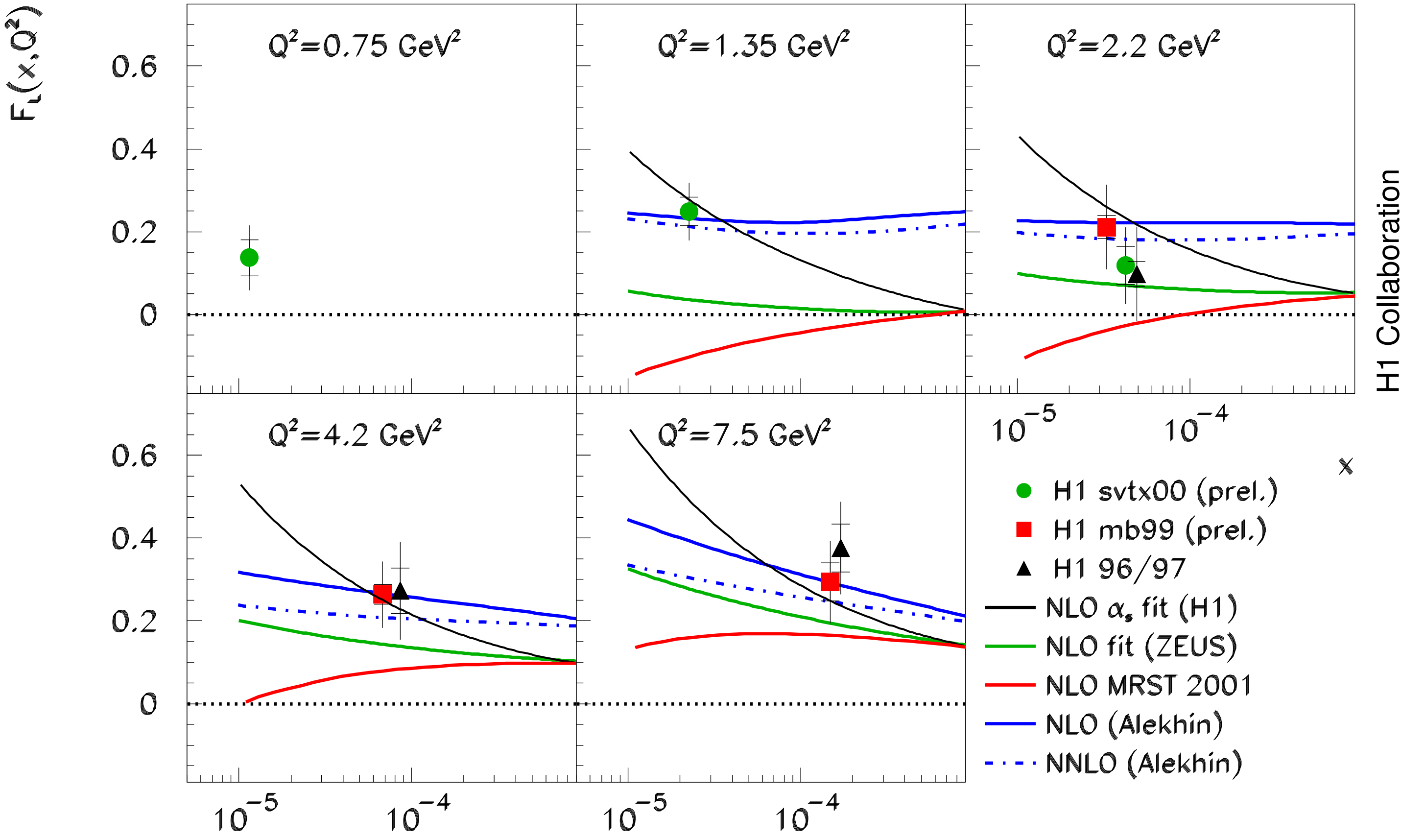
- shape of σ_r driven by kinematic factor y^2/Y_+ rather than by F_L
- constant F_L for small x range
- whole x range of measured data used to fit F_2 and F_L $\Leftrightarrow$ no extrapolation of F_2 $\Leftrightarrow$ full information used $\Rightarrow$ smaller errors
- fit in Q^2 bins:

$$\sigma = \underbrace{\mathbf{F_2}}_{\mathbf{c \cdot x^{-\lambda}}} - \mathbf{y^2/Y_+ \cdot F_L}$$



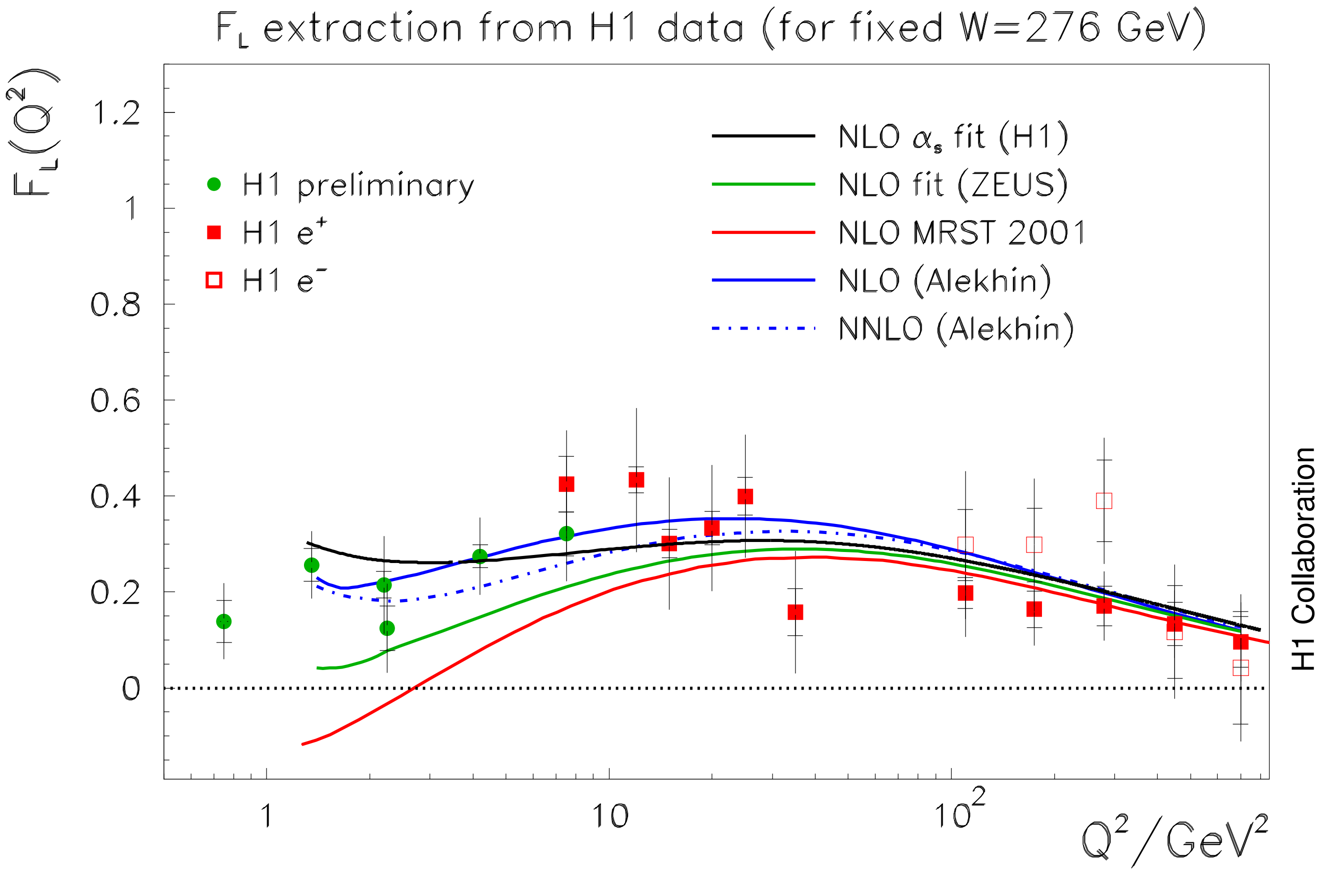
excellent description of σ_r by the "shape" fit in full kinematic region

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



- 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

Summary

- F_2 measurement for low Q^2 extended into high x region with QED Compton events – results found to be consistent with fixed target data
- F_2 measured with high precision for low $Q^2 \sim$ 0.1 - 10 GeV^2
- F_L from H1 data precise enough to constrain theoretical predictions
- to perform precise measurement of F_L runs with lowered proton beam energy necessary

Further plans

- 2000 bulk data – structure functions analysis with even higher precision.
  Aim: 1% for F_2.
- 2004 data – more precise F_L determination thanks to improved backward tracking detectors.

... but ...

- 1999 mb and 2000 svtx data – still new ideas of extension of the measurement in the kinematic space $\Rightarrow$ Alexey Petrukhin's talk