Inclusive Measurements and QCD fits at H1

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Workshop on low x physics
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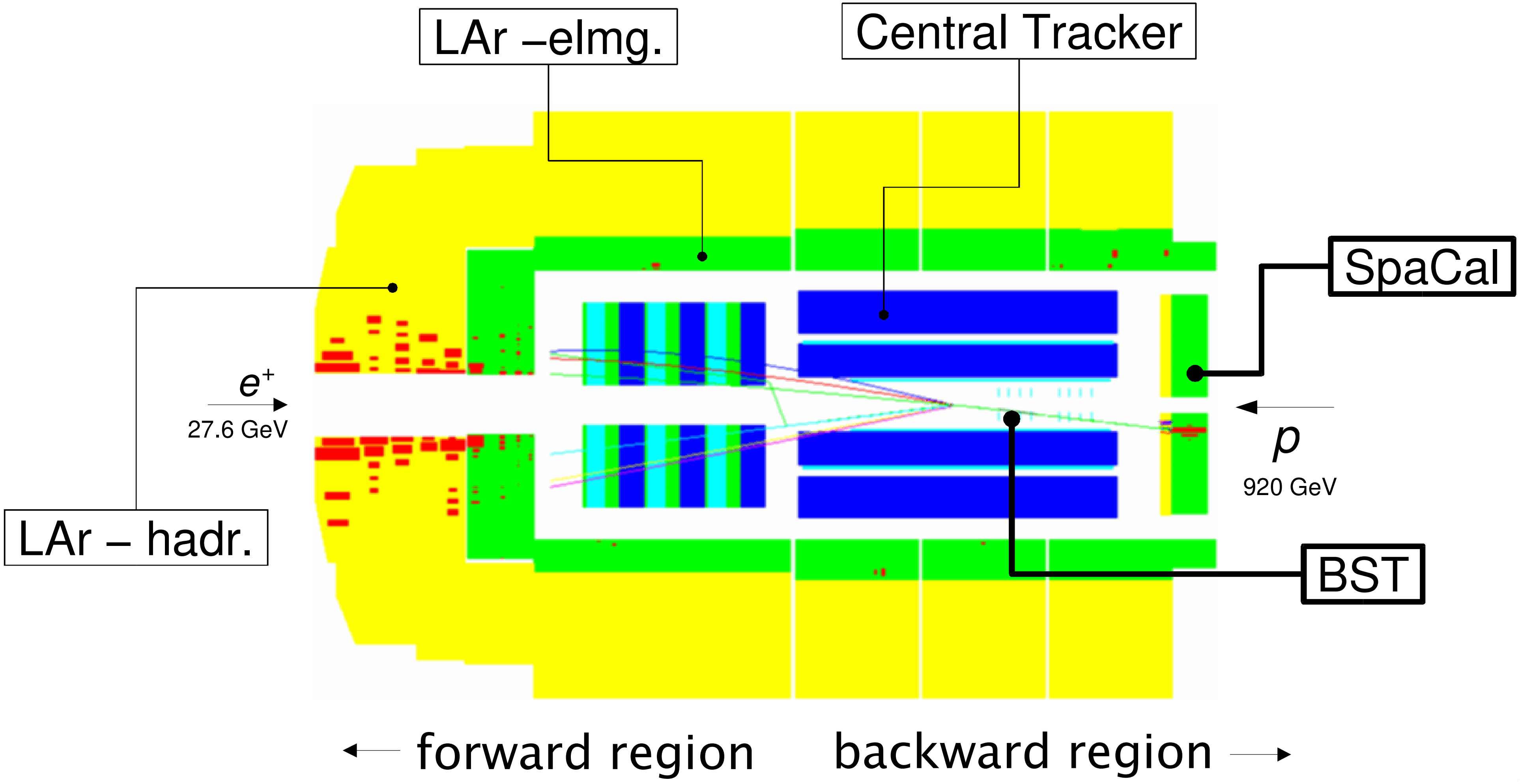
- H1 inclusive measurements
- New low Q^2 datasets
- Cross section behaviour at low x
- H1 NLO QCD fits (2000 & 2002)
- Summary & Outlook

H1 Detector at HERA in 99/00



H1 Inclusive Cross-Section Measurements

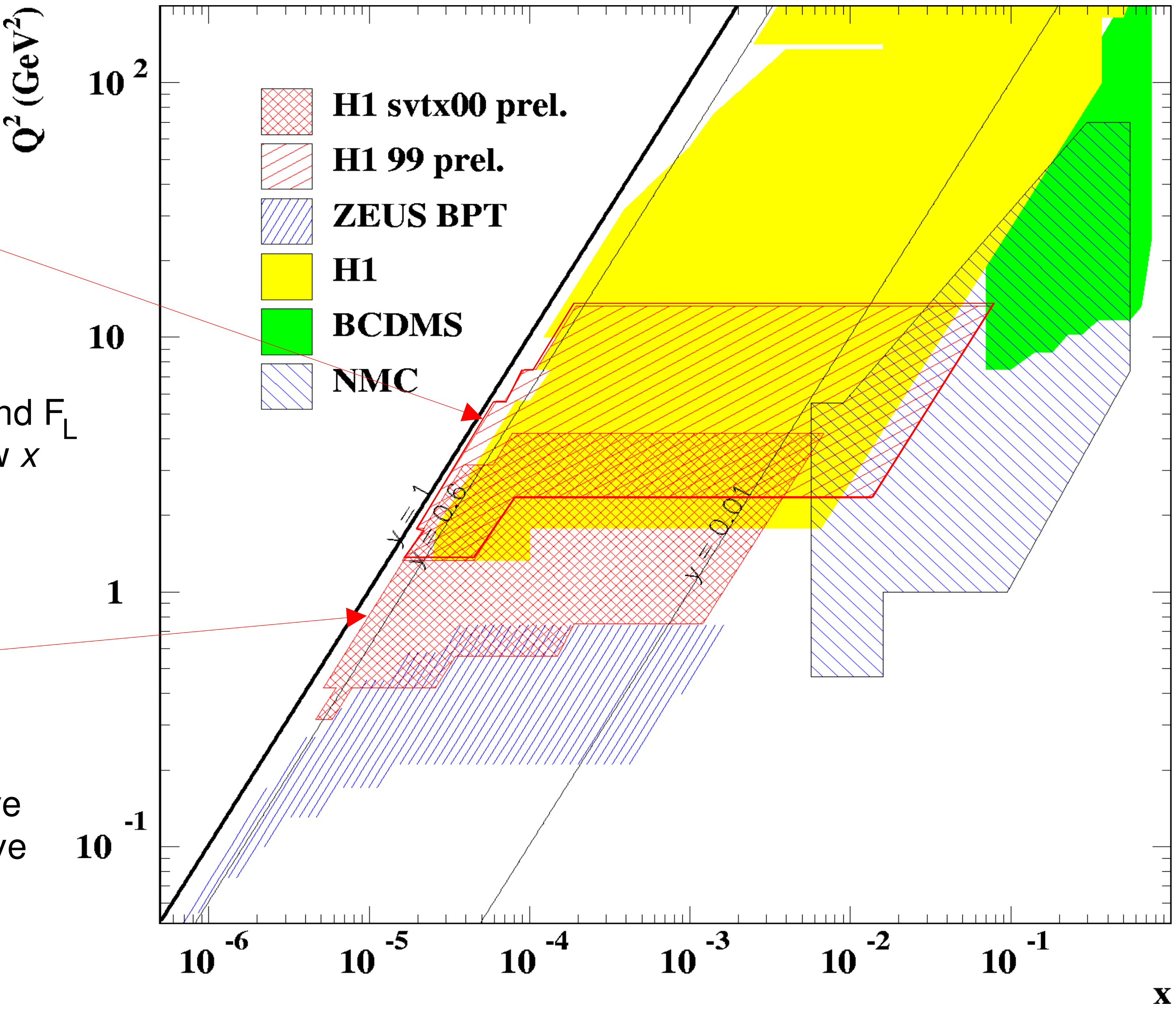
- The main published H1 data
  - 94–97 e^+p (~36 pb^{-1})
  - 98–99 e^-p (~16 pb^{-1})
  - 96–97 e^+p (~20 pb^{-1})
  - 97 low Q^2 (~2 pb^{-1})

high Q^2 NC + CC

low Q^2 precision data

- The new measurements (preliminary)
  - 94/00 e^+p (~100 pb^{-1}) – HERA1 combined
    - high Q^2
    - F_L determination
  - 99 low Q^2 (3.6 pb^{-1})
    - precision measurement of low Q^2 (1.5–12 GeV^2)
    - focused also on high y (F_L determination)
  - 2000 shifted vertex (~610 nb^{-1})
    - precision measurement of transition region $Q^2 \sim 1$ GeV^2

Kinematic plane coverage



low Q^2 1999 dedicated run

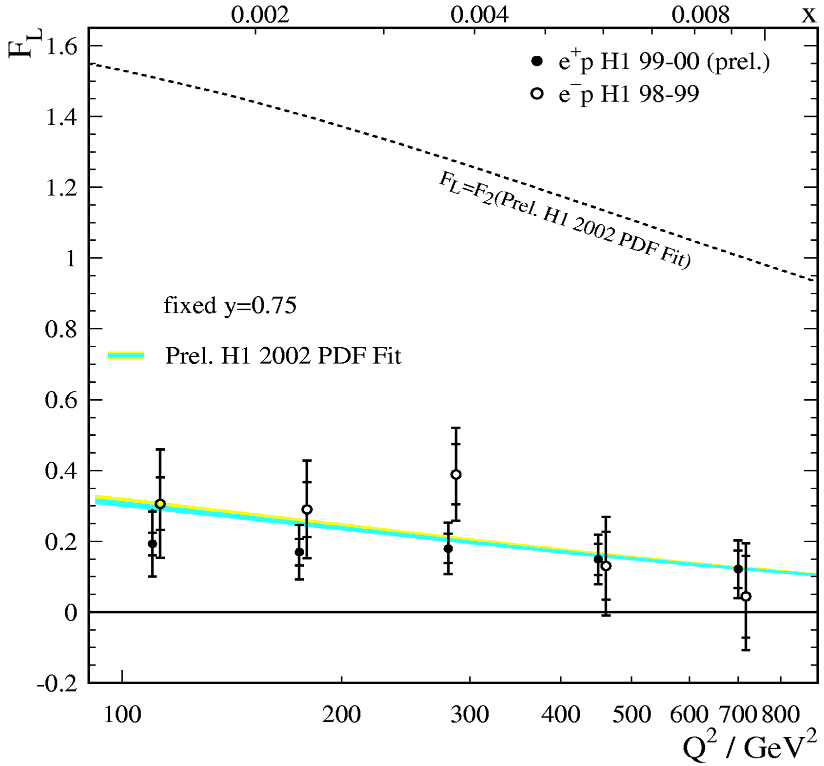
shifted vertex 2000 run

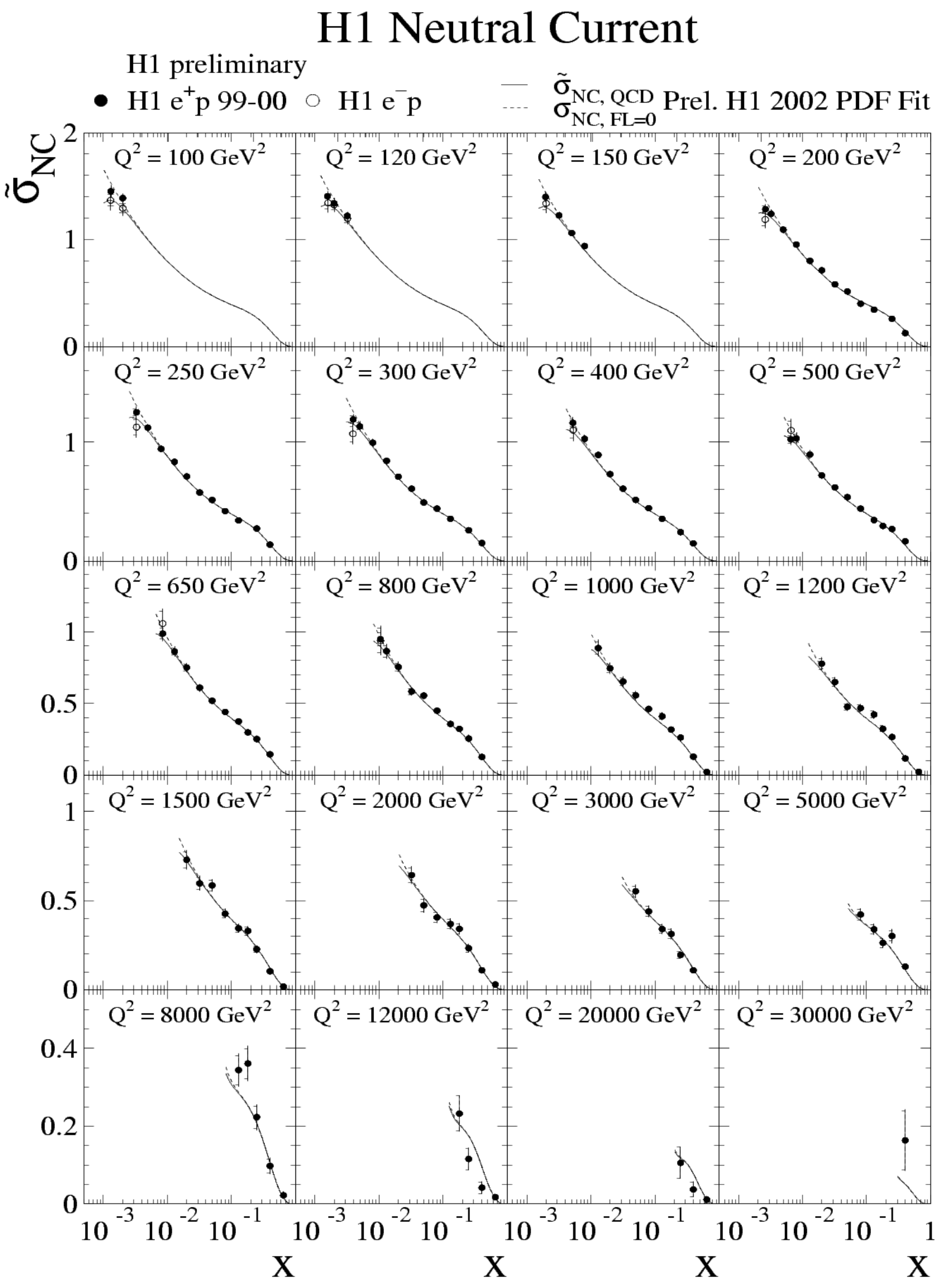
low Q^2 x−section and F_L determination at low x

Transition region between perturbative and non−perturbative kinematic range

High Q^2 H1 data

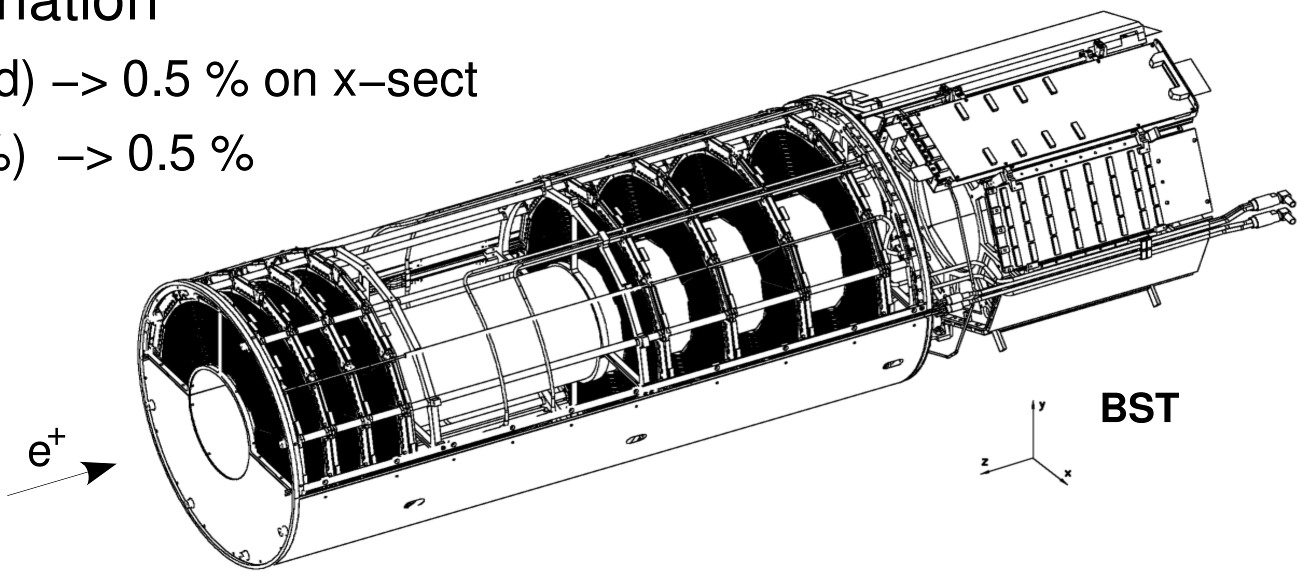
- 99/00 preliminary (65 pb^{-1})
- both NC and CC
- FL determination at high y , high Q^2





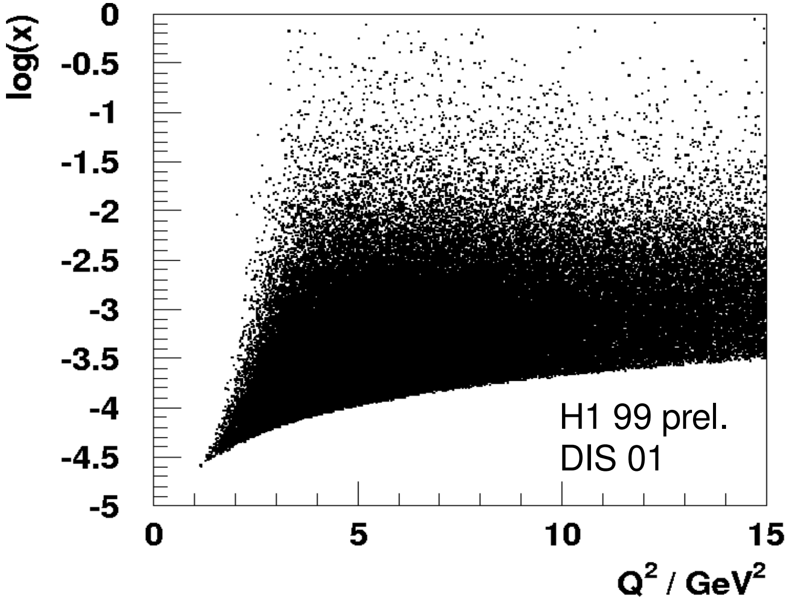
Nominal Vertex low Q^2 99 Data

- low Q^2 devoted run with minimum bias trigger
- $L = 3600\,nb^{-1}$ (~ 4x more than similar run in 1997)
- H1 has **BST** (backward **silicon tracker**) and SPACAL (lead−scintillating fibres calorimeter)
  - access to both **high y** (low x) and **low y** (large x) regions
  - F_L determination
  - ϑ_e (0.3 mrad) −> 0.5 % on x−sect
  - E'_e (0.3−2 %) −> 0.5 %

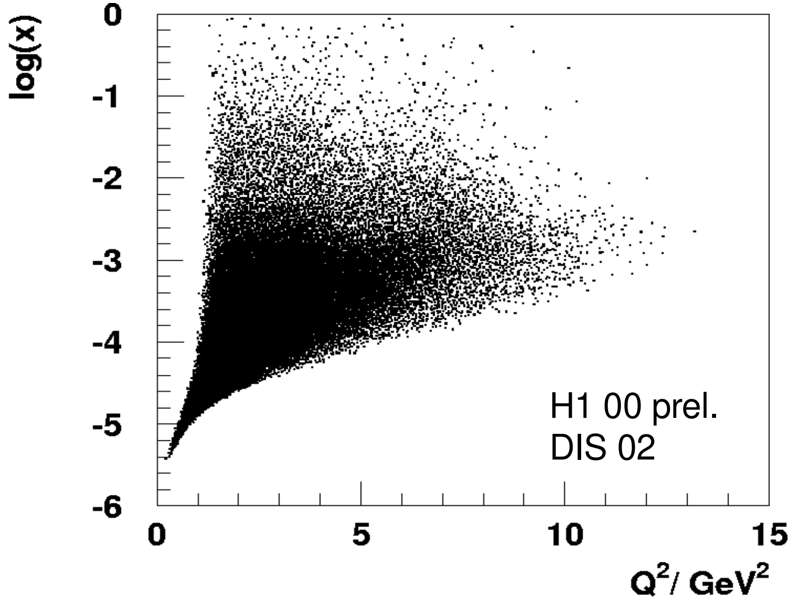


'Shifted Vertex' 2000 Data

- interaction vertex shifted by +70cm w.r.t. the nominal position $\rightarrow$ access to lower values of Q^2
- $L = 607\, nb^{-1}$ (~ 5x more than 1995 shifted vertex data)
- inclusive measurement (vertex now determined by positron in BST)
  - diffractive and elastic channels included



Nominal vertex position



Shifted vertex position

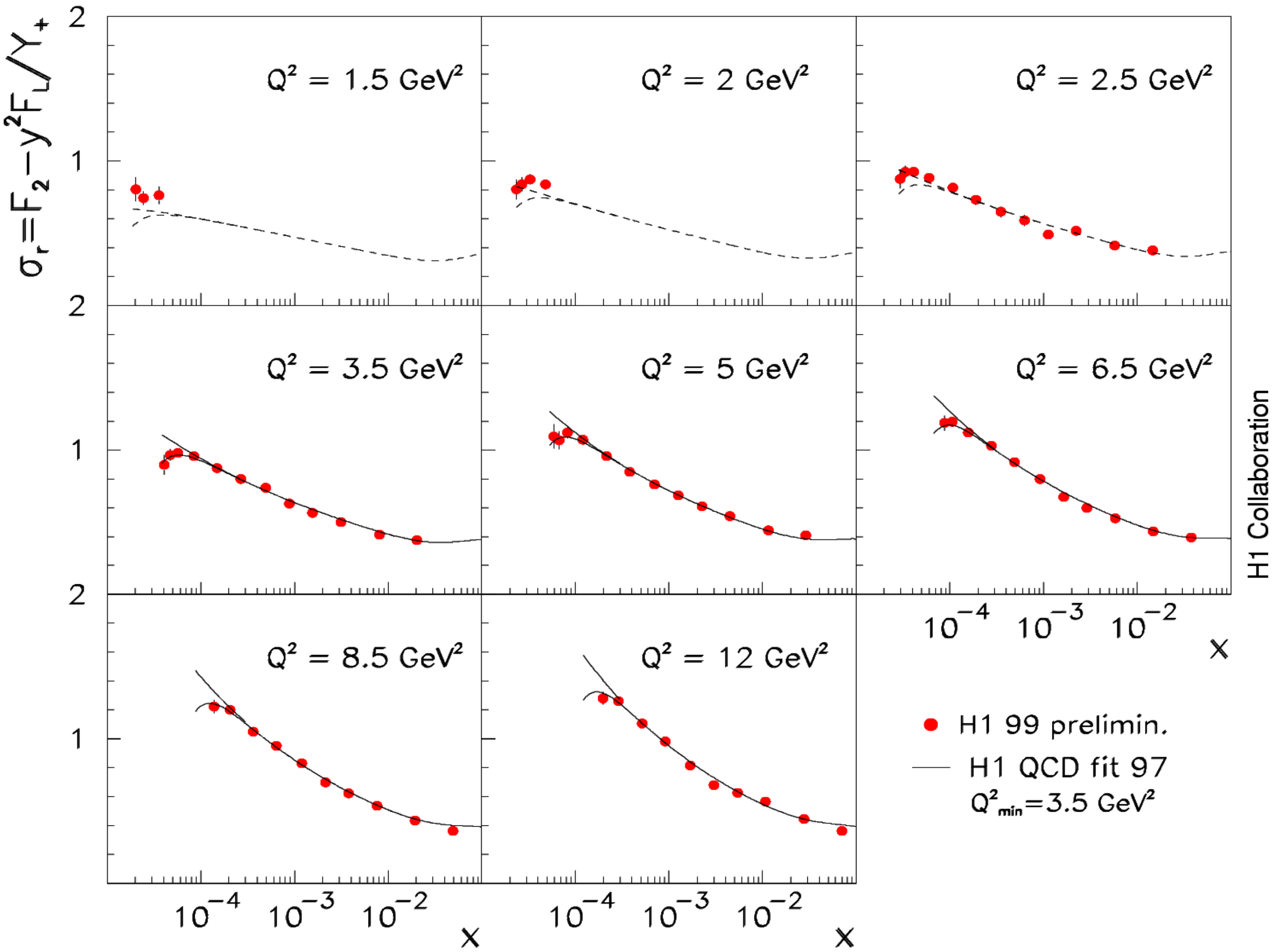
$\boxed{\sigma_r}$ 1

low y : $\sigma_r \simeq$ F_2

high y : F_L contribution is noticeable

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

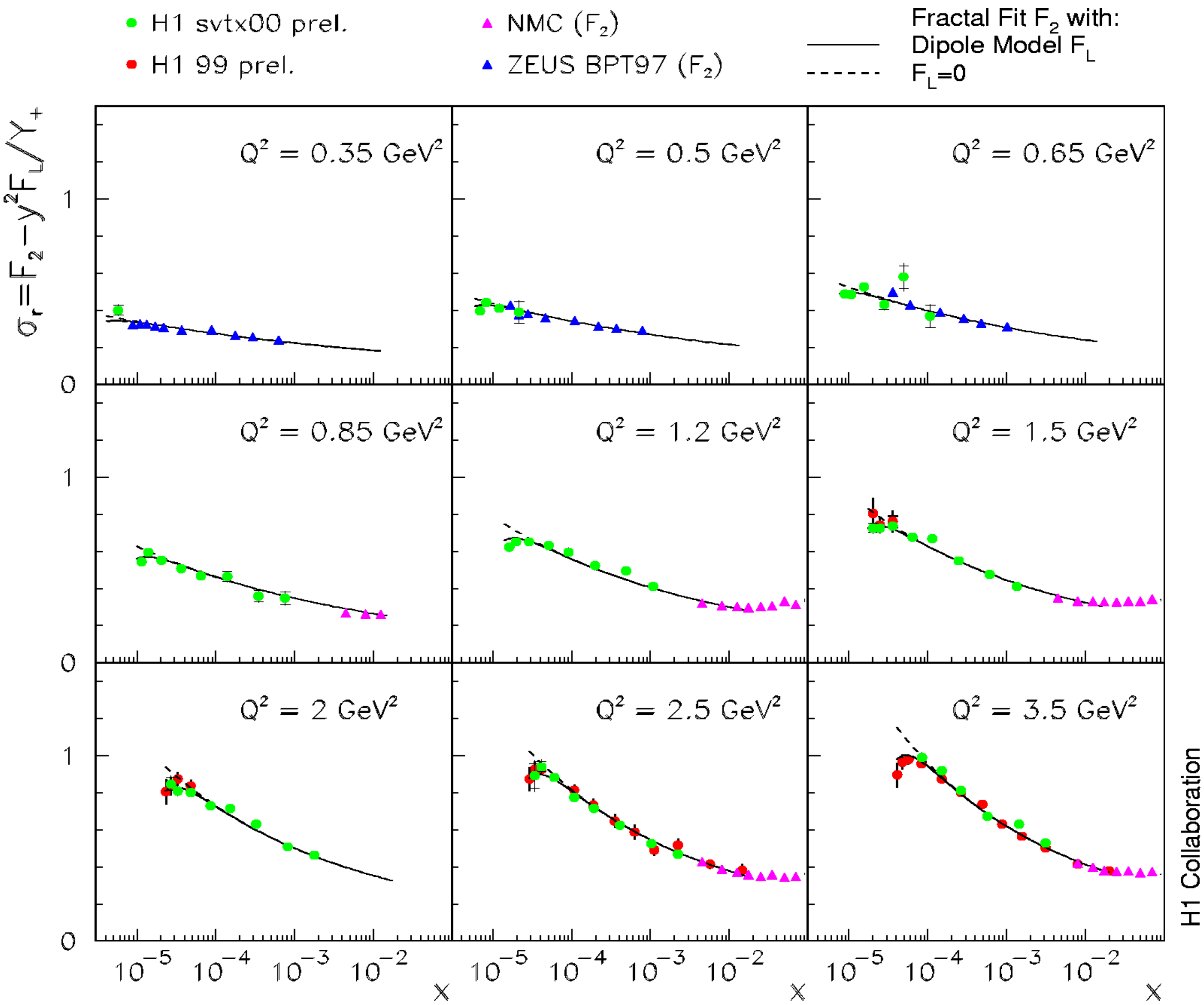
$$Y_+ = 1 + (1-y)^2$$



$\boxed{\sigma_r}_2$

compatible with the previous measurements

<u>high y</u> : F_L contribution is noticeable also at low Q^2



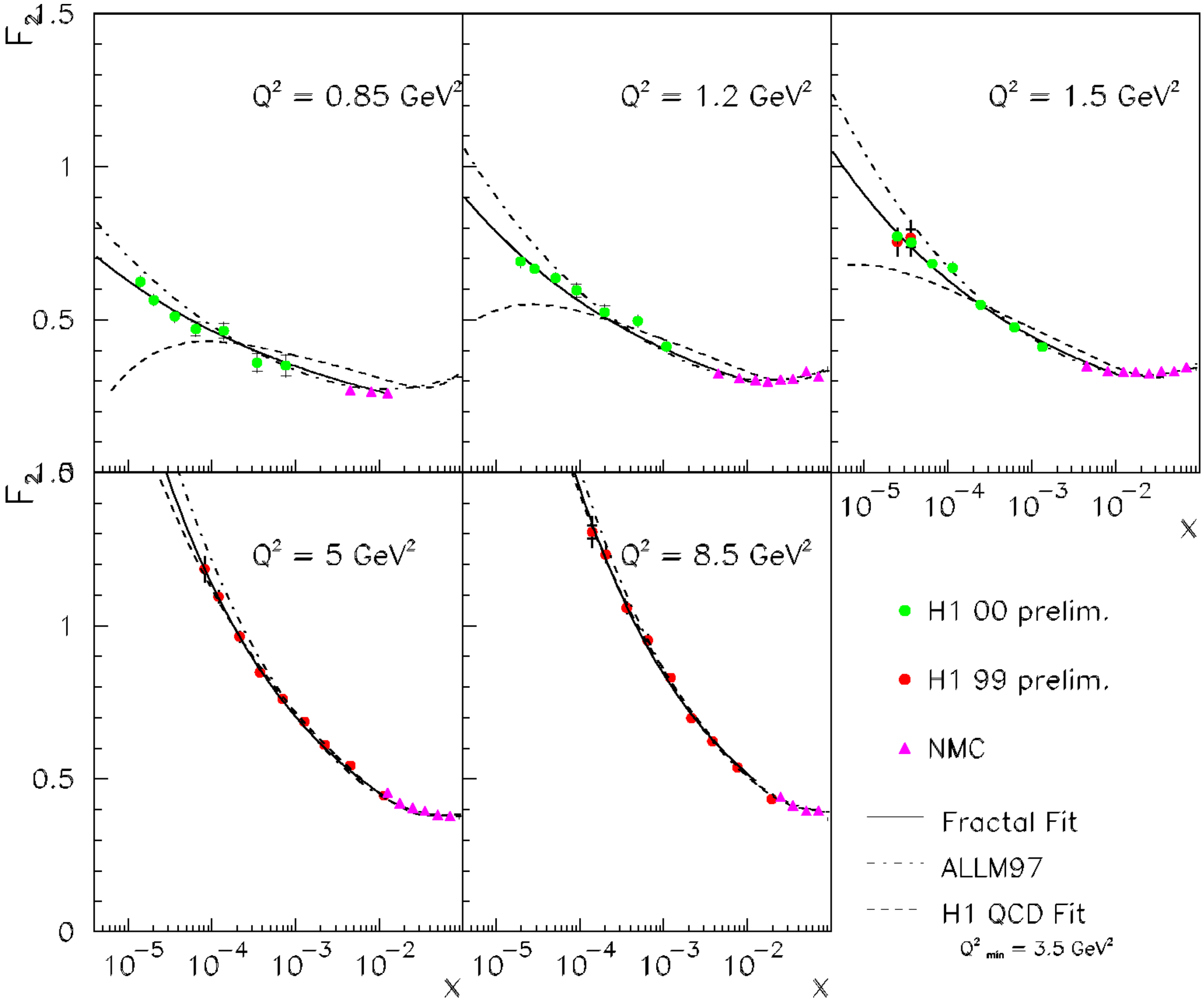
$\boxed{F_2}$

(few bins selected)
y<0.6

accurate
measurement
(3–4% typ.)

qualitative check
of various models

NLO QCD fit
breaks down at
low Q^2

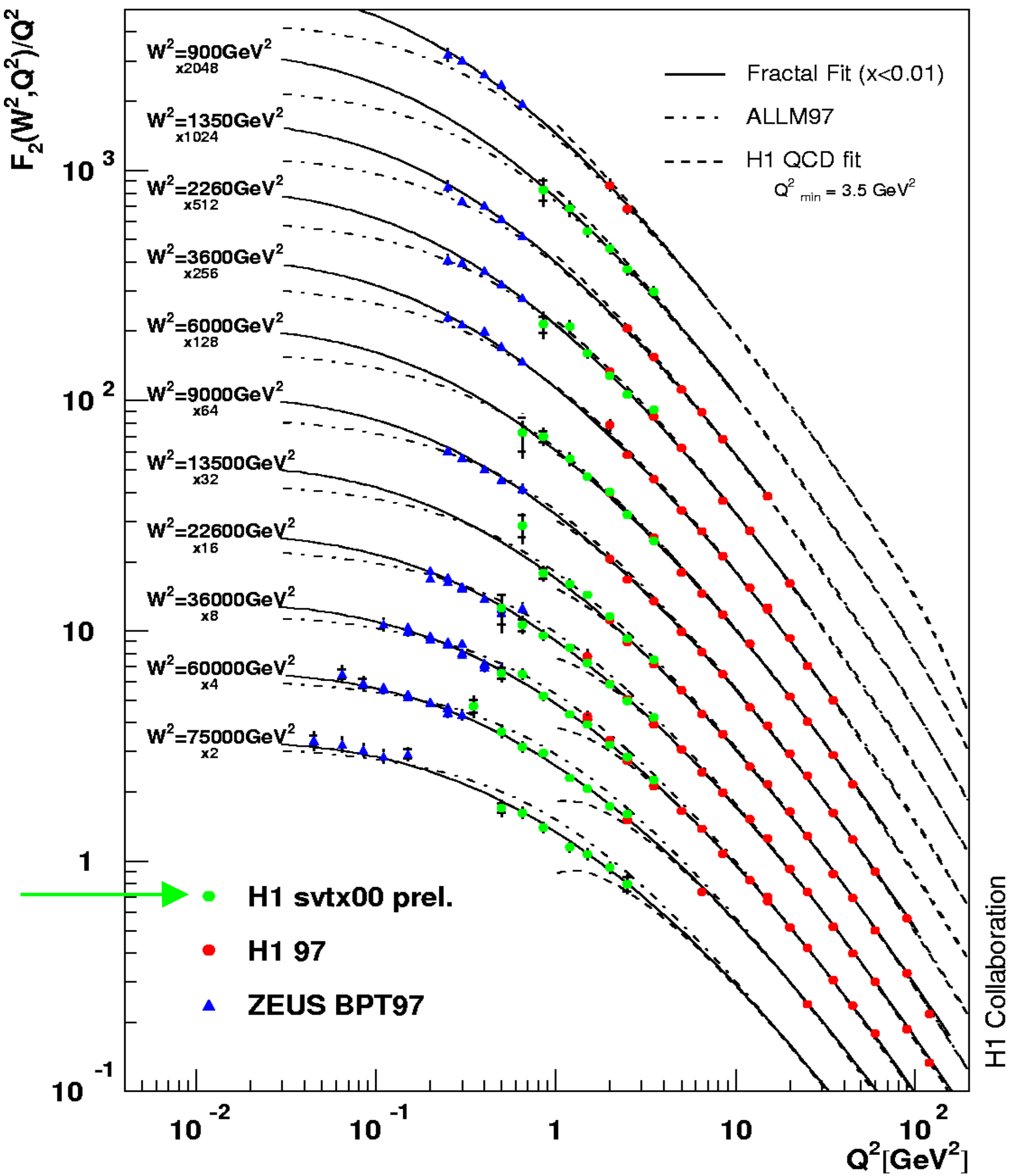


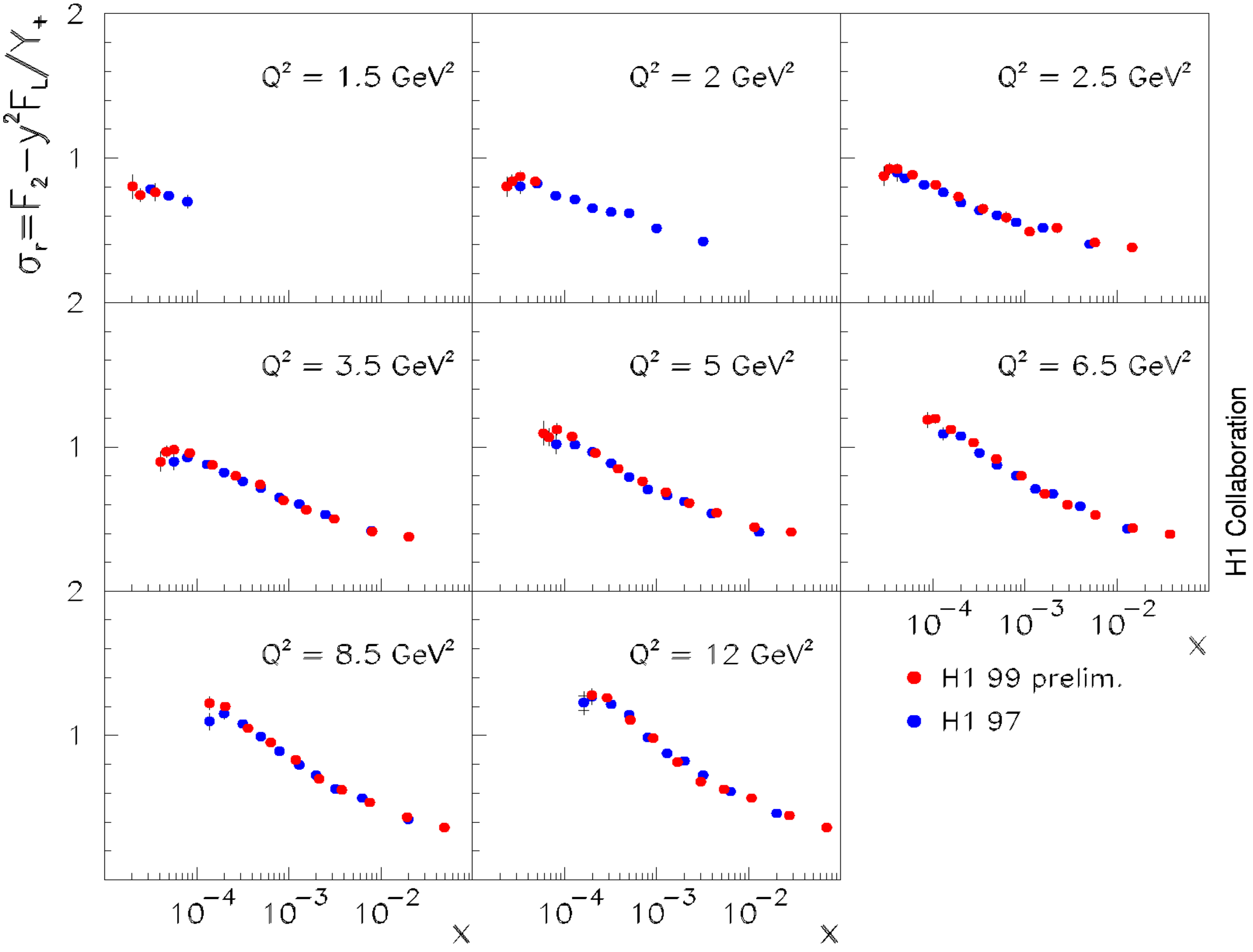
Photoproduction cross–section in the limit Q^2–> 0:

$$\sigma_{\gamma^* p} \propto F_2/Q^2$$

$$W^2 = \frac{Q^2(1-x)}{x} + M_p^2 \approx y \cdot s$$

The new H1 data cover the transition region to non–perturbative domain, $Q^2 \sim 1\,\mathrm{GeV}^2$, with accurate measurement (3–4% in bulk region).





$\sigma_r = F_2 - y^2 F_L / Y_+$
$Q^2 = 1.5$ GeV^2
$Q^2 = 2$ GeV^2
$Q^2 = 2.5$ GeV^2
$Q^2 = 3.5$ GeV^2
$Q^2 = 5$ GeV^2
$Q^2 = 6.5$ GeV^2
$Q^2 = 8.5$ GeV^2
$Q^2 = 12$ GeV^2
H1 Collaboration
H1 99 prelim.
H1 97
x

F_L determination

2 methods:

> extrapolation (at high Q^2)

> derivation (below 12GeV ^{2})

a quantity with amplified effect of FL is needed

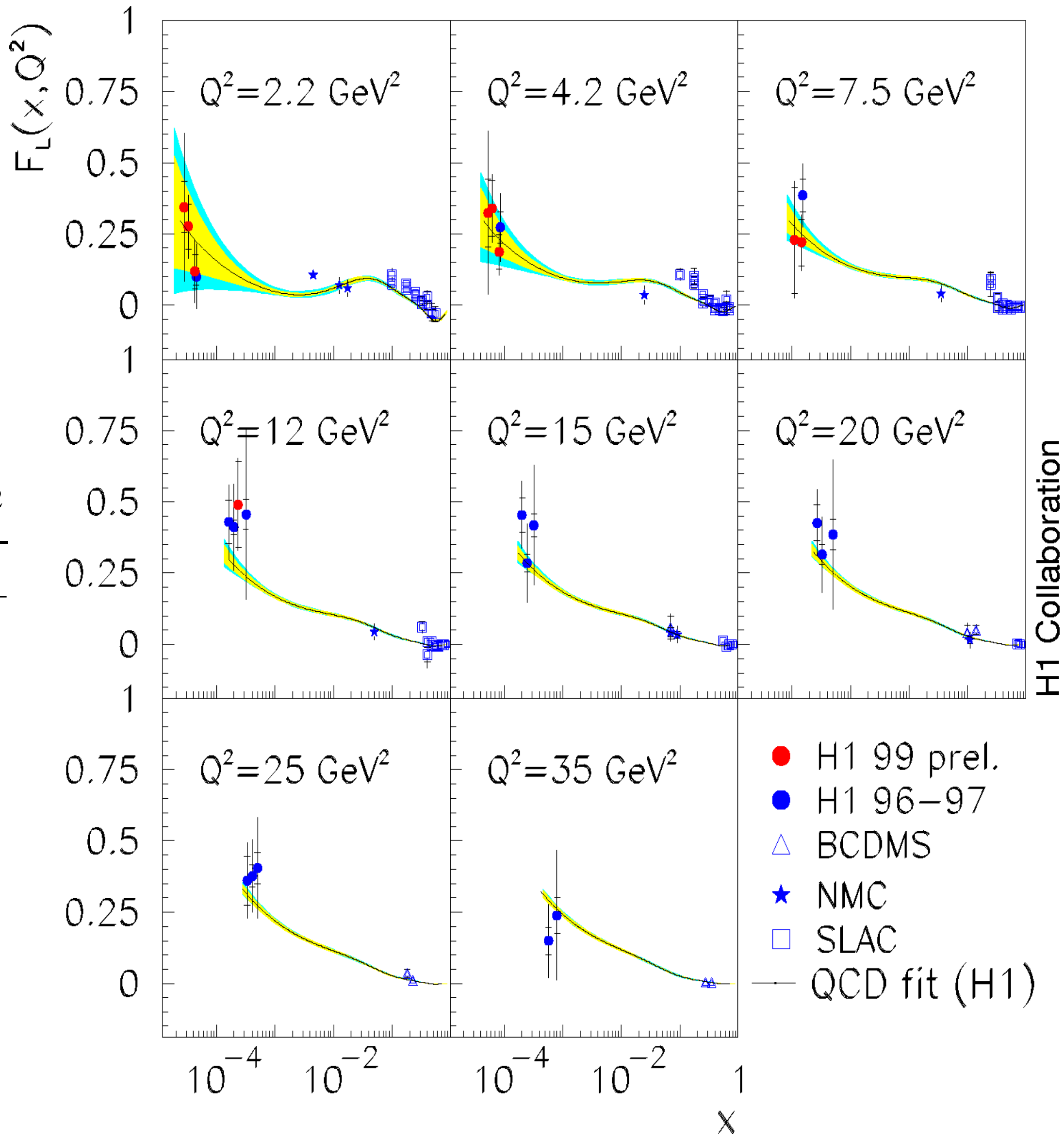
$$\left(\frac{\partial\sigma_r}{\partial\log y}\right)_{Q^2} = \left(\frac{\partial F_2}{\partial\log y}\right)_{Q^2} - F_L\cdot 2y^2\cdot\frac{2-y}{Y_+^2} - \frac{\partial F_L}{\partial\log y}\cdot\frac{y^2}{Y_+}$$

about linear at low Q2

negligible

methods agree in the region of overlap

consistent with H1 NLO QCD fit F_L



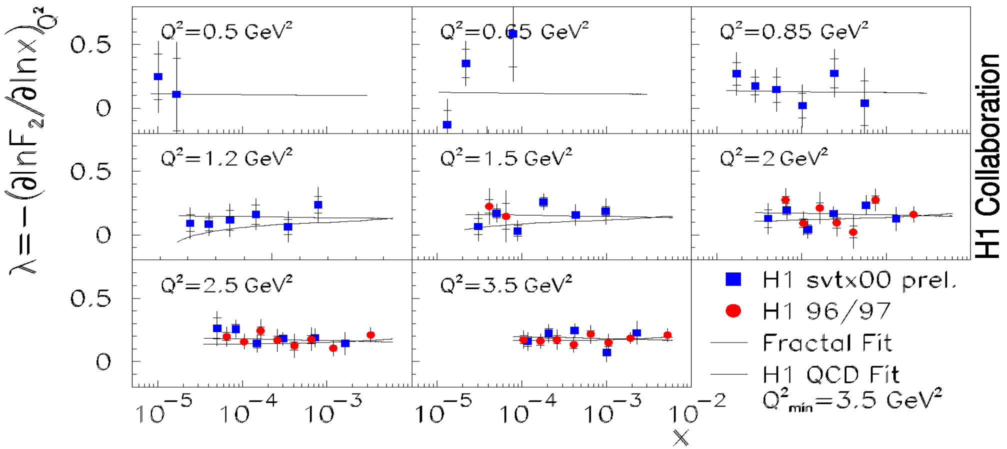
F_2 behaviour at low x

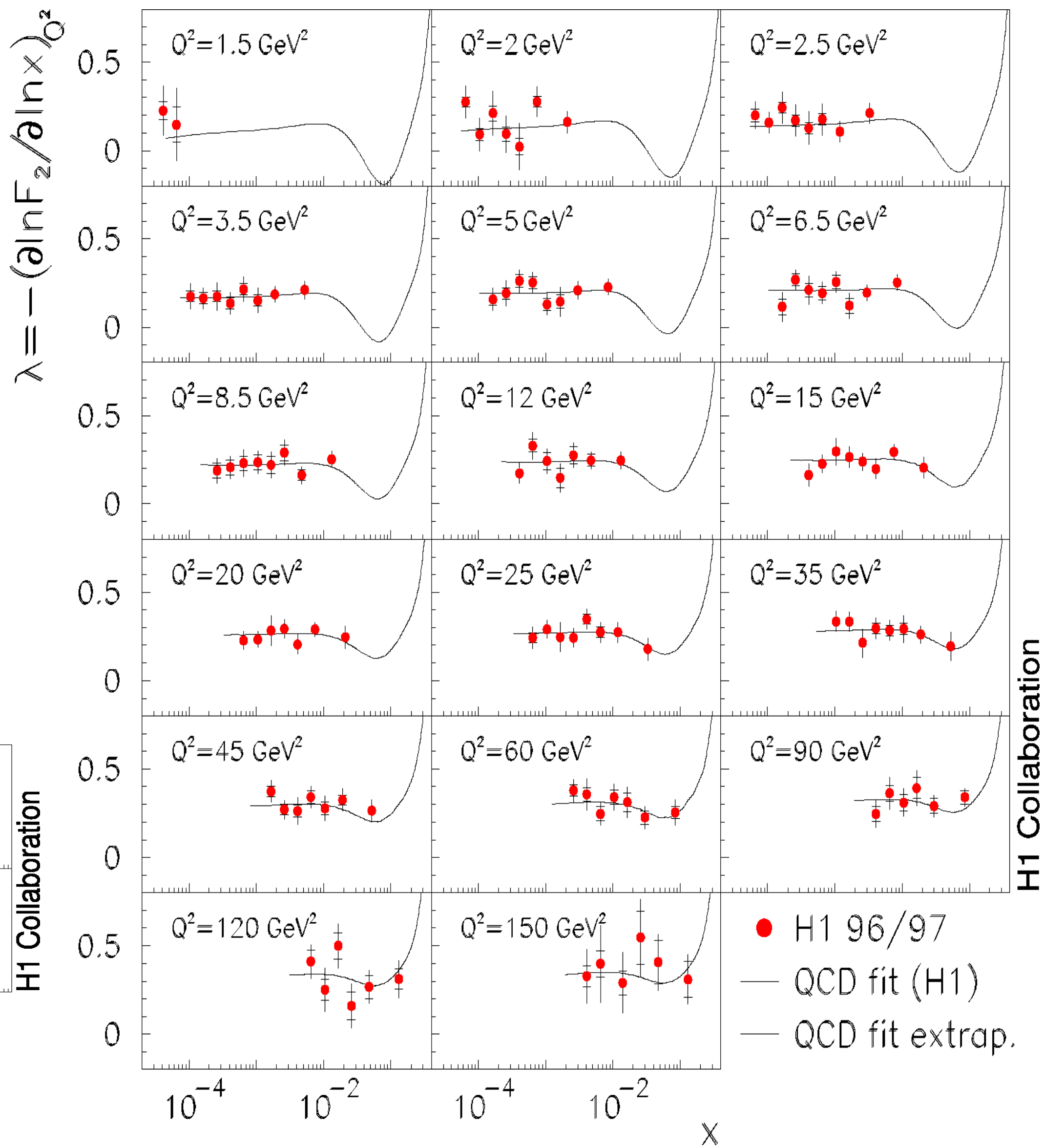
$$\lambda = -(\partial \ln F_2 / \partial \ln x)_{Q^2}$$

derivative is performed in bins of Q2 locally

within experimetal uncertainty: derivative independent of x (for x<0.01) −> no saturation

H1 svtx00 preliminary





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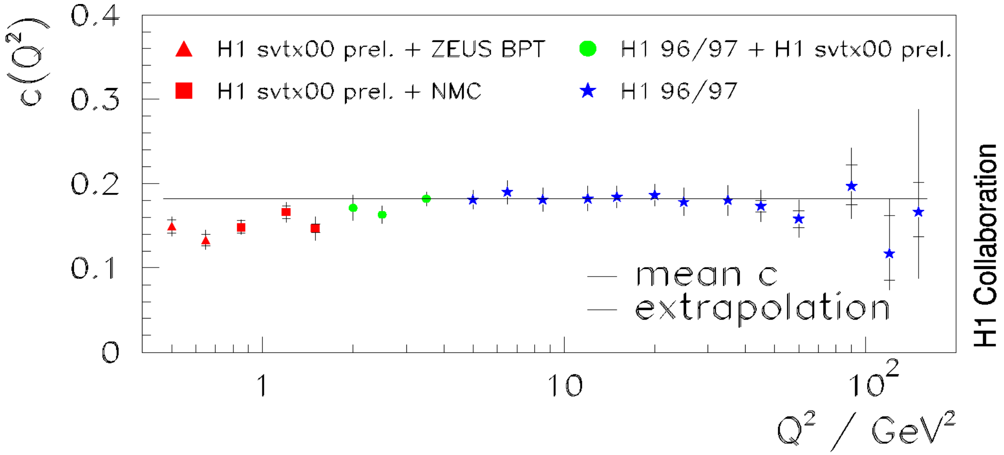
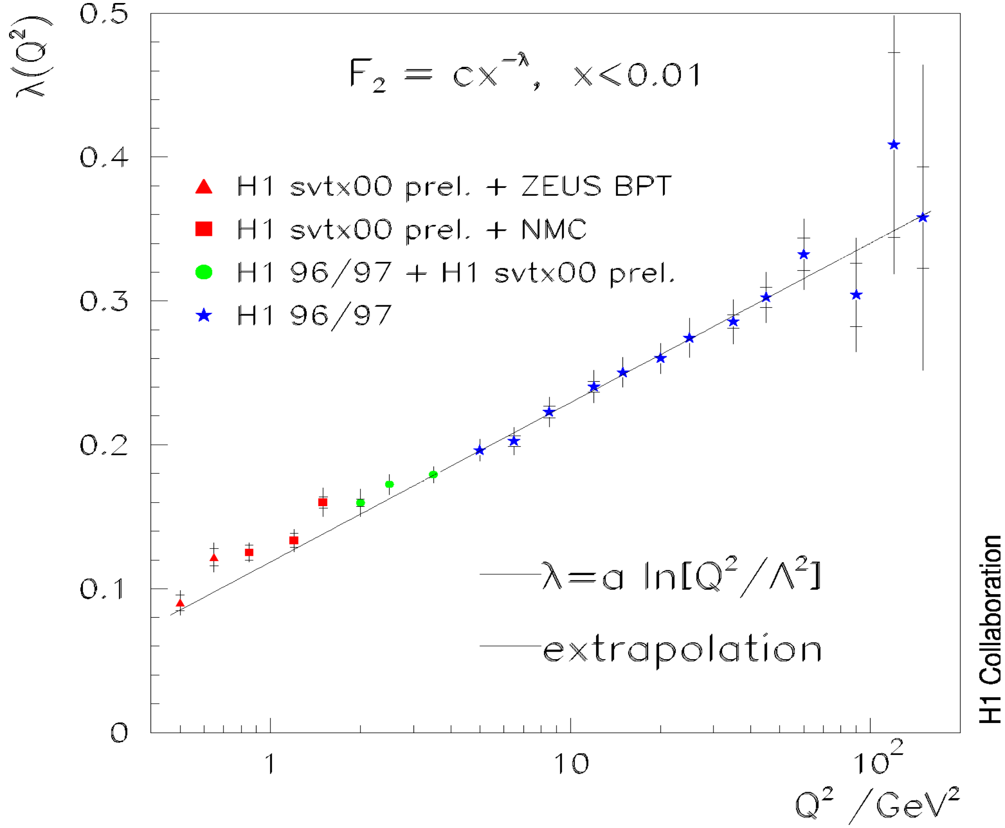
power law behaviour of F_2 at fixed Q^2:

$$F_2 \propto x^{-\lambda(Q^2)}$$

fit performed in bins of Q^2

- $x < 0.01$ –below the val. quark region
- $y < 0.6$ –F_L contribution reduced





An indication of change of $c(Q^2)$ and $\lambda(Q^2)$ at about 3 GeV^2

H1 NLO QCD Fits

- $\overline{\text{MS}}$ scheme fits (NLO)

- H1 alpha fit
  - focus on alpha & gluon

$$V=\frac{9}{4}u_v-\frac{3}{2}d_v \qquad x\,g(x)$$

$$A=u-\frac{1}{4}(u_v-2d_v)$$

in LO: $$F_2=\frac{1}{3}xV+\frac{11}{9}xA$$

- H1 PDF fit
  - focus on PDFs

$$U=u+c \quad U=u+c \quad D=d+s$$

$$D=d+s \quad x\,g(x)$$

$$u_v=U-U \quad d_v=D-D$$

$$F_2=\frac{4}{9}x(U+U)+\frac{1}{9}x(D+D)$$

- Parameterisations: $A\,x^B(1-x)^C P(x)$

where

	for				
$P(x)=1+E\,x+D\sqrt{x}$		$x\;g(x)$	$x\;D(x)$	V	A
$P(x)=1+E\,x+D\sqrt{x}+F\,x^2$		$x\;U(x)$			
$P(x)=1+E\,x$		$x\;U(x)$			
$P(x)=1$		$x\;D(x)$			

Strong coupling constant

- H1 **alpha fit**

0.1150 +−0.0017(exp) +0.0009 −0.0007(model)

if: systematic errors are not fitted: +0.0005
NMC replaces BCDMS 0.116 +−0.003 (exp) **(7.5GeV2 cut, NMC has higher twist data in)**
4 light flavours: +0.0003
BCDMS deuteron data added: 0.1158 +−0.0016 (exp) **(not much help + hadronic corrections)**

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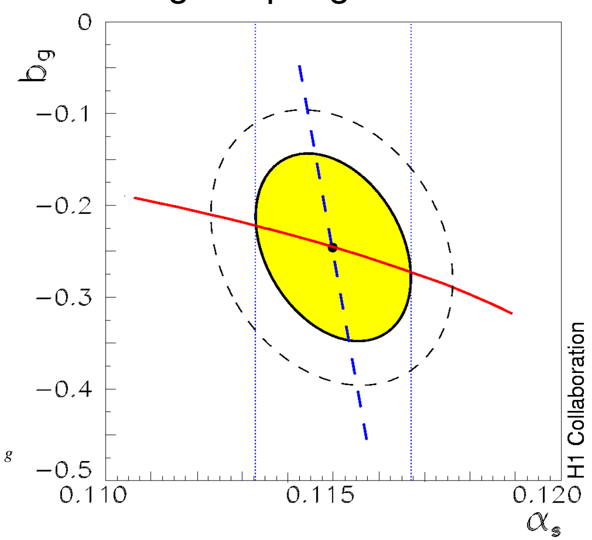
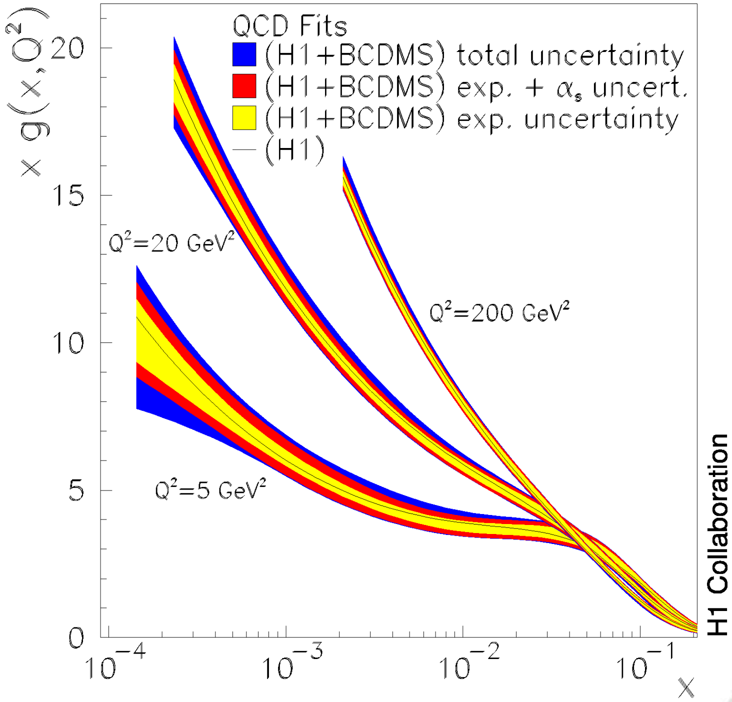
Simultaneous determination of xg(x) and strong coupling:

$$xg(x) \sim x^{b_g}$$





H1 + BCDMS:

Variations:

$Q_0^2, Q_{min}^2, \alpha_s$

heavy quark mass threshold & momentum fraction

$\chi^2/ndf = 917/(1014-13) = 0.92$

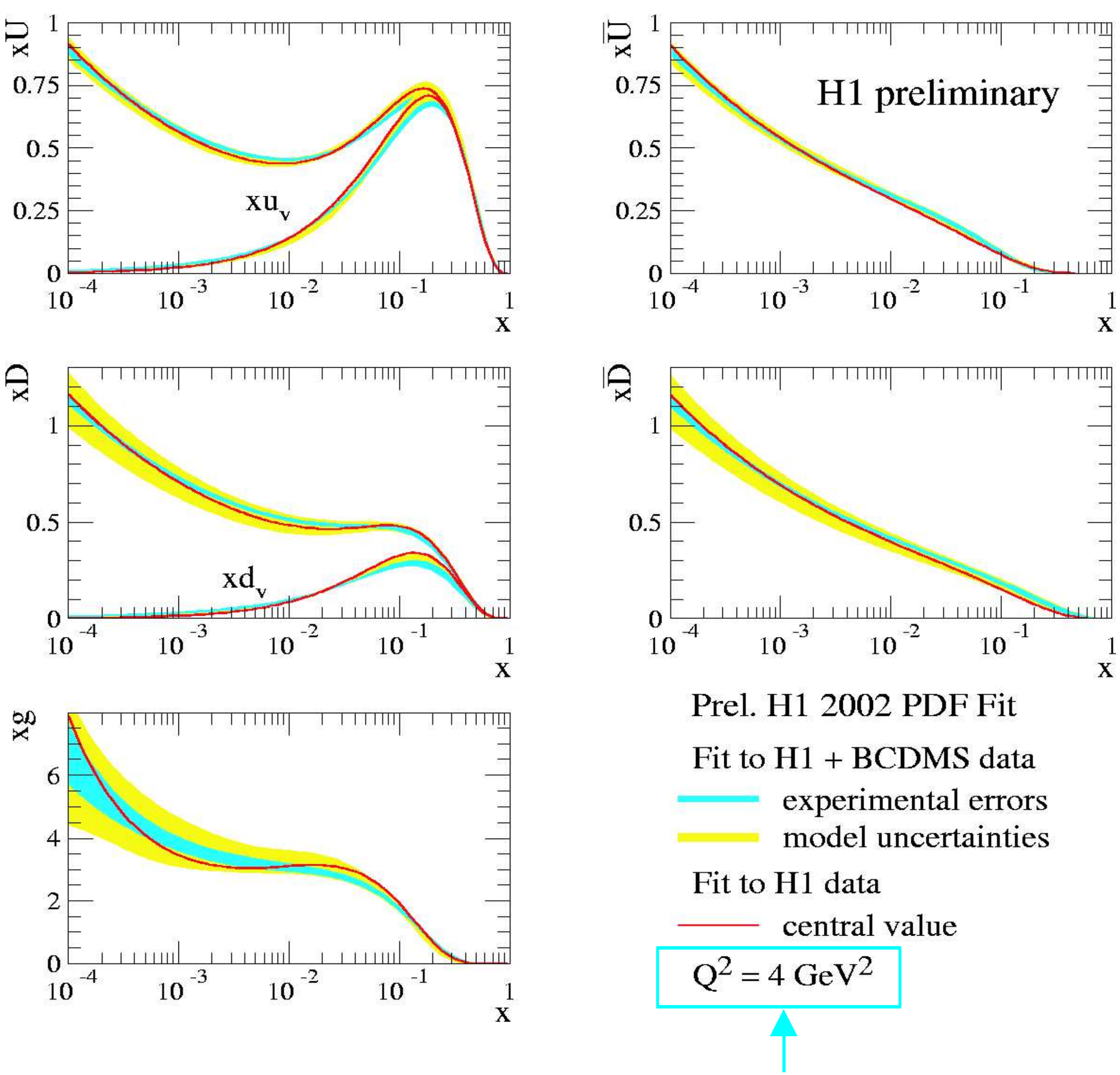
H1 only:

HERA data are able to constrain the PDFs alone

(stronger assumption on sea symmetry)

$\chi^2/ndf = 548/(621-11) = 0.90$

H1 Parton Distributions (H1 PDF fit)

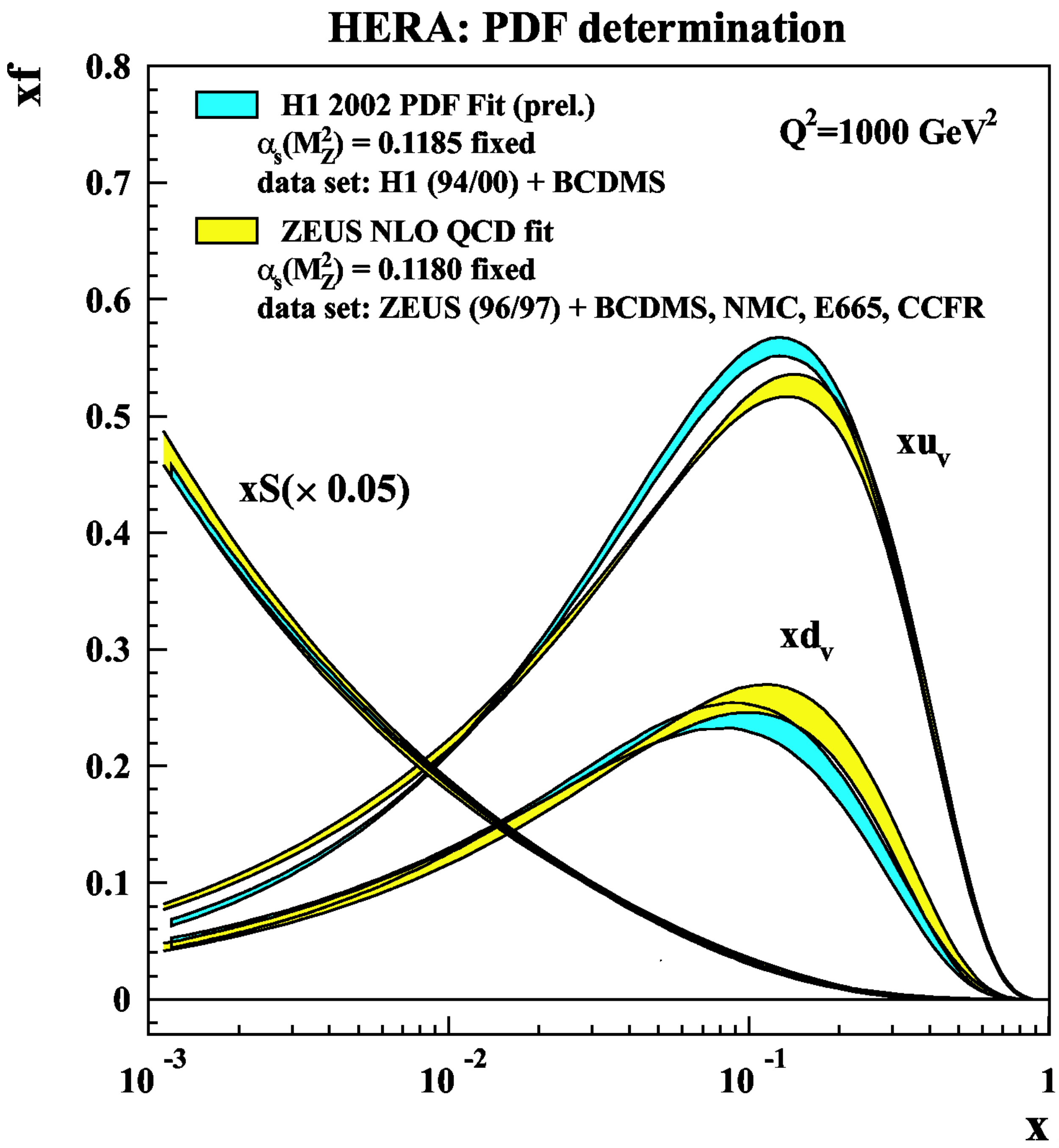


H1 vs ZEUS

comparison of PDFs

independent fits and approaches

only experimental errors!



Summary

- H1 has obtained precision data in the region of low Q^2 and for the first time in the transition region $Q^2 \sim 1\,GeV^2$
- The rise of the proton structure function F_2 towards low *x* persists at low Q^2 (no sign of saturation)
- At lowest *x* an indication of F_L is observed in the cross−section behaviour.
- H1 has accurately measured α_s from scaling violations of F_2
- Data & analysis are progressing towards determination of the parton distributions

Outlook

- **HERA 2**
  - **expected luminosity per experiment ~1fb^{-1} (2006)**
  - **longitudinally polarised leptons**
  - **F_L measurement (lowered proton beam energy)**
  - **strong coupling determination**
  - **high level of precision, confrontation with NNLO pQCD**
- **HERA 3** (proposals due in 2003)
  - **flavour decomposition at low x (eD)**
  - **very accurate measurement of transition region**
  - **discover saturation? (eA)**
  - **proton spin structure at low x, high Q^2**