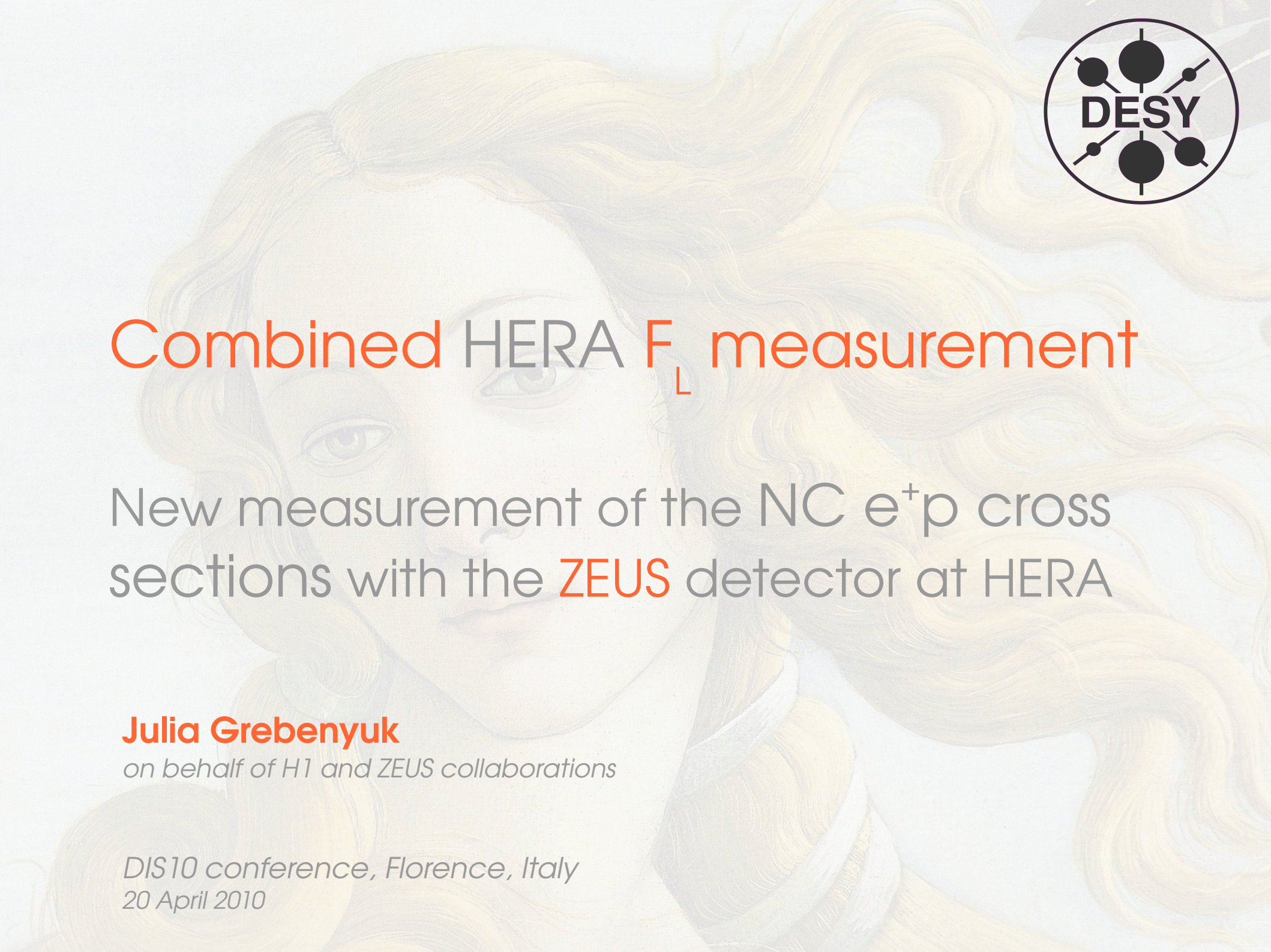


Combined HERA F_L measurement

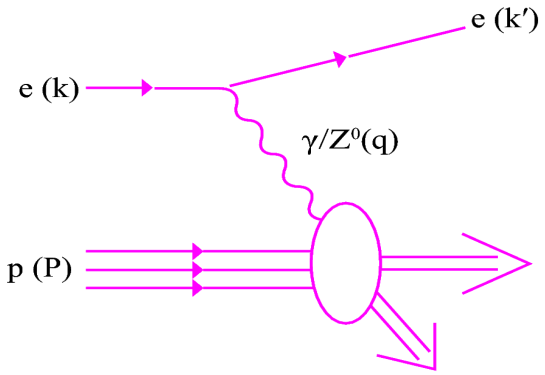
New measurement of the NC e^+p cross sections with the ZEUS detector at HERA

Julia Grebenyuk
on behalf of H1 and ZEUS collaborations

DIS10 conference, Florence, Italy
20 April 2010

DIS and structure functions

Deep Inelastic Scattering (DIS) is a key tool for studying structure of the proton



NC DIS cross section at low Q^2 in reduced form can be written via structure functions:

$$\sigma_r(x,Q^2,y)=\frac{d^2\sigma^{ep}_{NC}}{dx\,dQ^2}/\left(\frac{2\pi\alpha^2 Y_+}{xQ^4}\right)=F_2(x,Q^2)-\frac{y^2}{Y_+}F_L(x,Q^2)$$

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

Q^2 – virtuality of exchanged photon
x – Bjorken scaling variable
y – inelasticity
s – center-of-mass energy, $s=4E_eE_p$

$Q^2 = xys$

→ **F_2** - dominant term, contains quark and gluon contributions

→ **F_L** - reflects the gluon contribution, non-negligible at high y

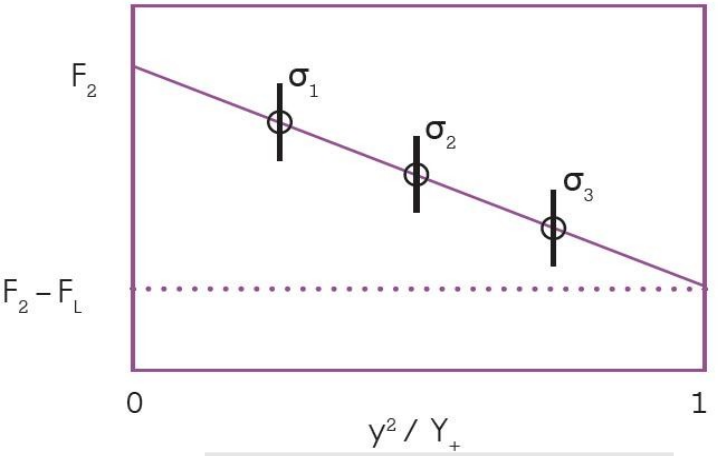
→ F_L is directly sensitive to gluon densities

→ F_L is a pure QCD effect

F_L measurement

Direct F_L measurement requires reduced cross sections at **same x and Q^2 but different y:**

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



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

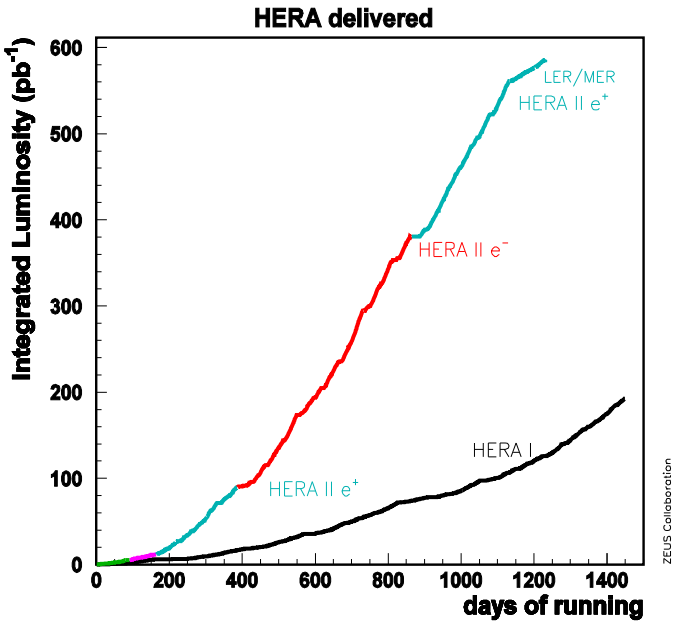
At given x and Q^2:
→ F_L is the negative slope

Q^2 = xys: different y → different s(CME)
→ different beam energies

Larger difference in y → better sensitivity to F_L

Direct F_L measurement only possible if HERA operates with different proton beam energies

- Most luminosity taken with E_e=27.5 GeV, E_p=920 GeV
- In the last year of running data taking with lowered beam energies: E_p=460 and 575 GeV



Analysis strategy

Inclusive DIS measurement

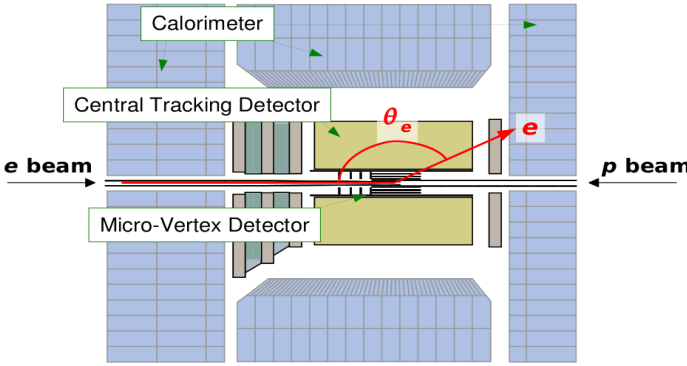
Information from the scattered electron (energy E_e and scattering angle Θ_e) is used to reconstruct the kinematics:

$$y = 1 - \frac{E_e}{2E_{e_{beam}}}(1-\cos\theta_e), \quad Q^2 = 2E_e E_{e_{beam}}(1-\cos\theta_e)$$

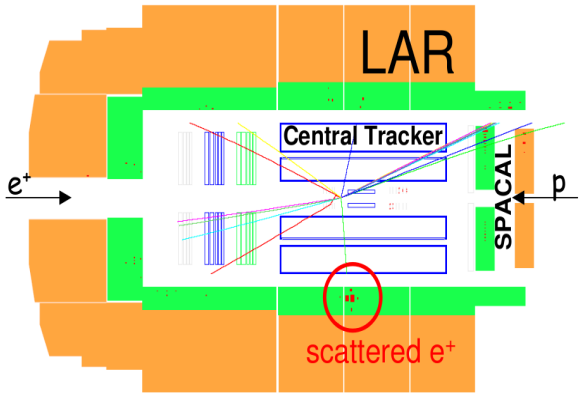
Low-y
→ high energy well separated scattered electron
→ almost no background

High-y
→ low energy scattered electron
→ lot of hadronic activity around scattered electron
→ large background

ZEUS



H1



Experimentally challenging: low scattered electron energy (low y) and low scattering angles (low Q^2)

Main background: photoproduction events

Data combination

NC cross sections used for combination:

H1	ZEUS
$2.5 < Q^2 < 800$ GeV^2	$24 < Q^2 < 110$ GeV^2
Eur. Phys. J. C63, 625 (2009)	Phys. Lett. B682, 8 (2009)
Eur. Phys. J. C64, 561 (2009)	
H1prelim: 09-044, 08-042	

In the H1/ZEUS kinematic overlap region: *comparable precision; combining data will improve precision*

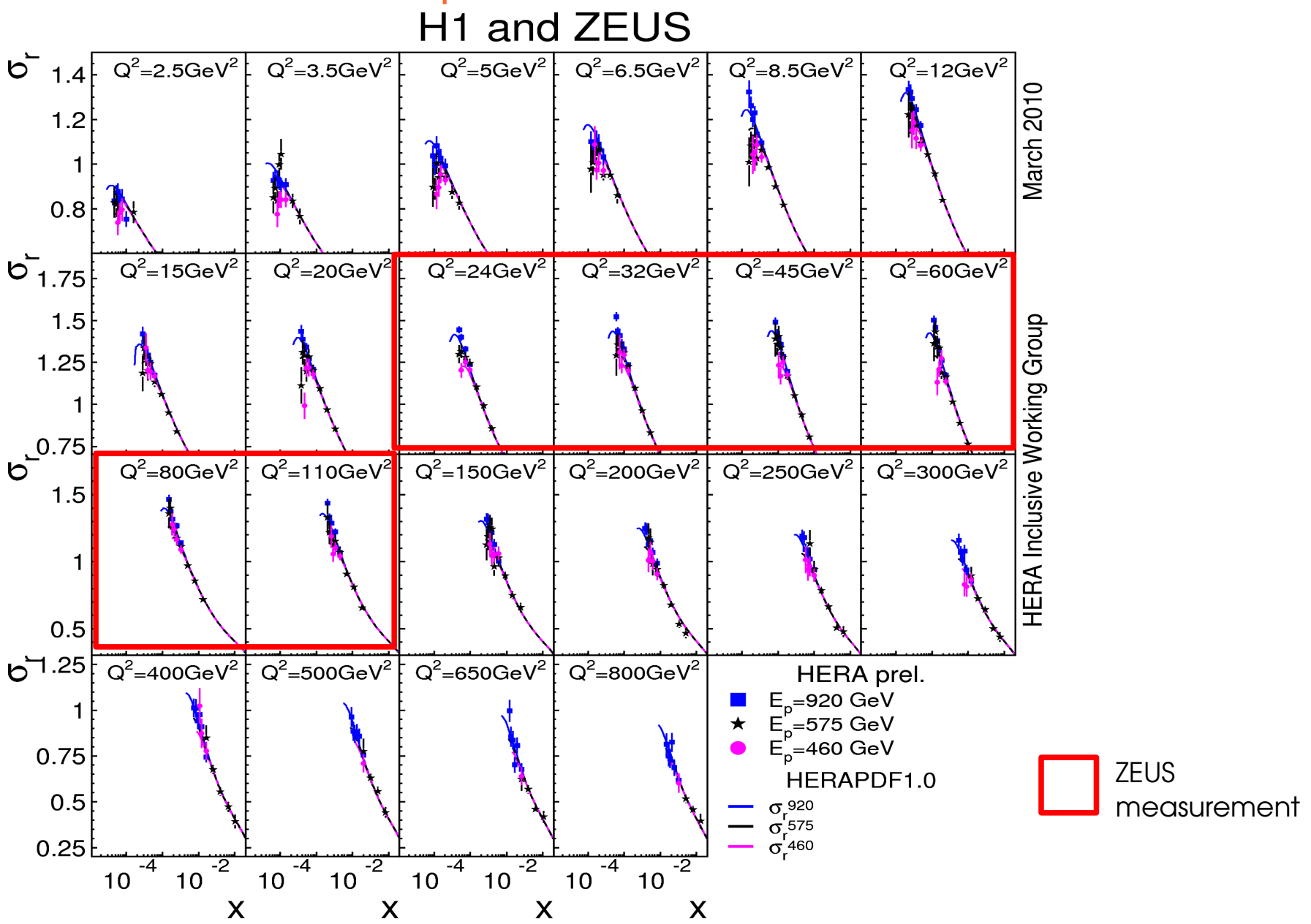
Method of combination:

- same as for previous HERA data combinations *(see talk by S. Habib)*

Procedure:

- Move cross sections to common grid
- Average cross sections (minimum χ^2)
- extract F_L from combined cross sections

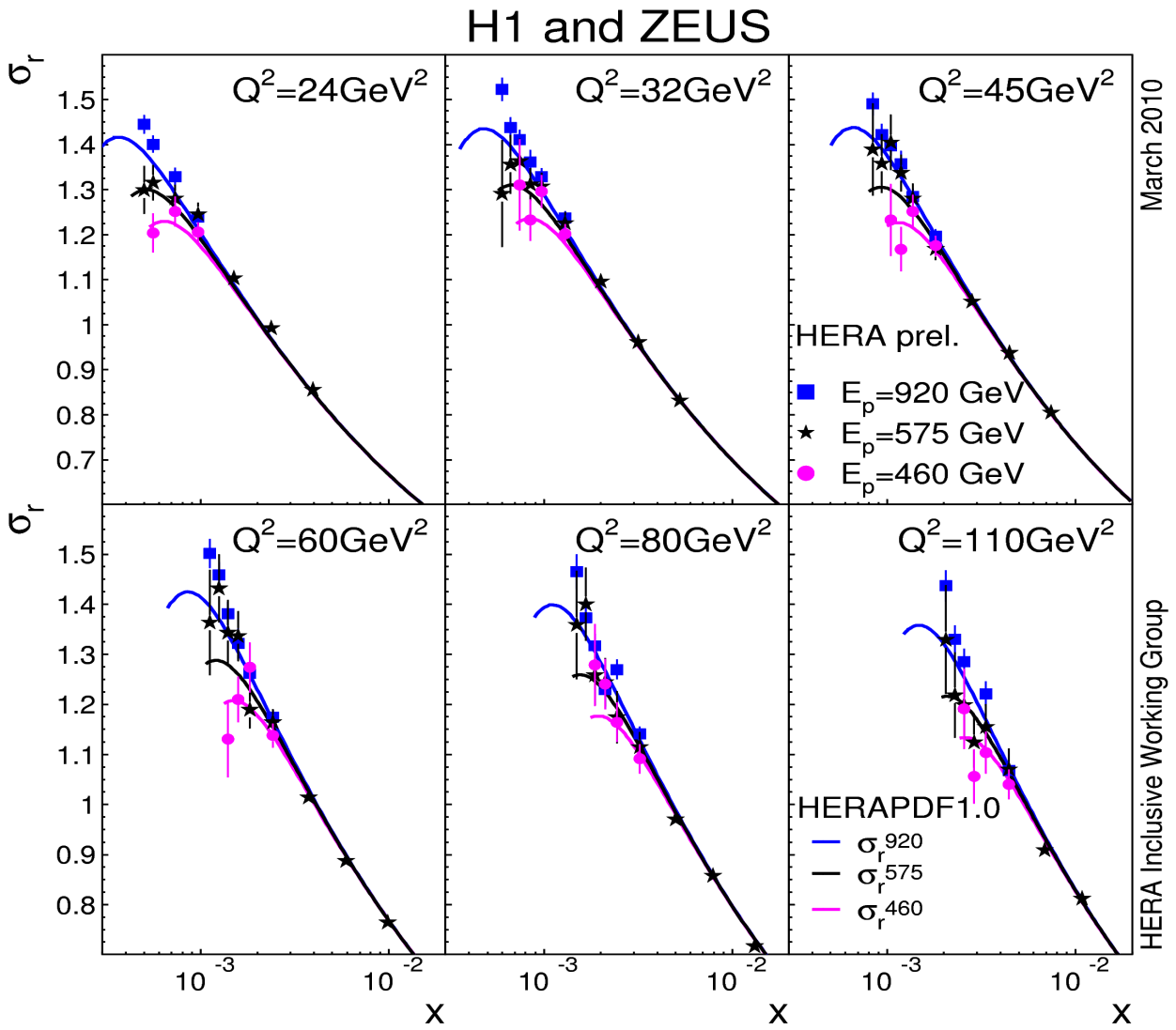
Combined HERA NC e+p cross sections



Combined cross sections are an input for further QCD analysis *(see talk by V. Radescu)*

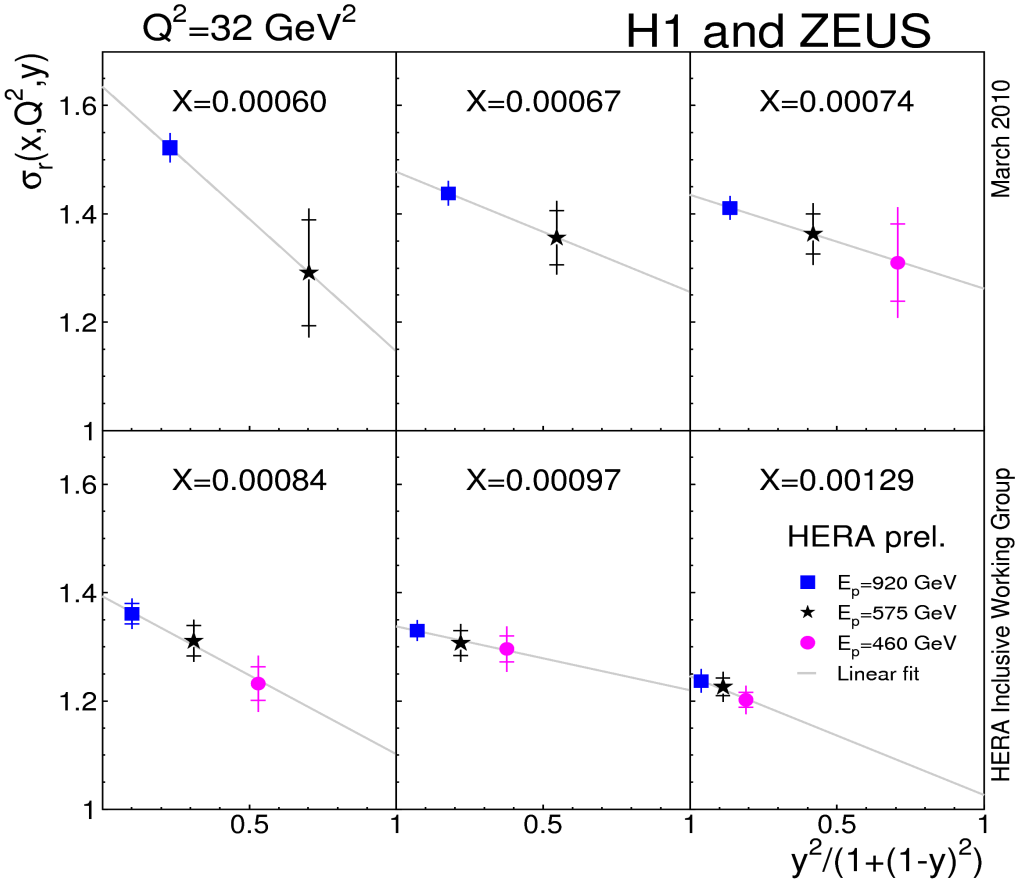
Combined HERA NC e+p cross sections

H1/ZEUS kinematic overlap region: $24 < Q^2 < 110\ \mathrm{GeV}^2$



F_L extraction

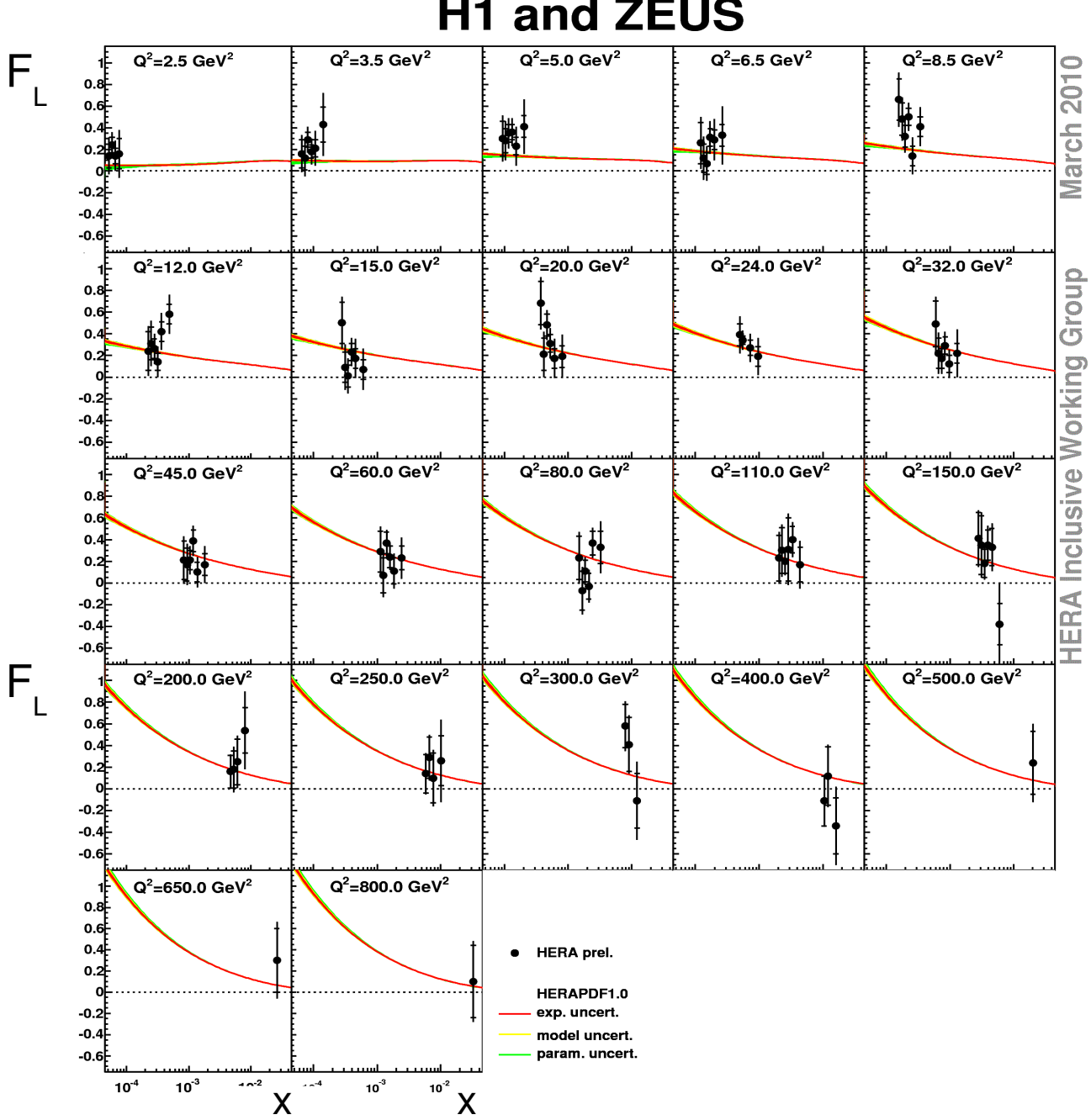
After the cross sections are combined, F_L can be extracted:



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

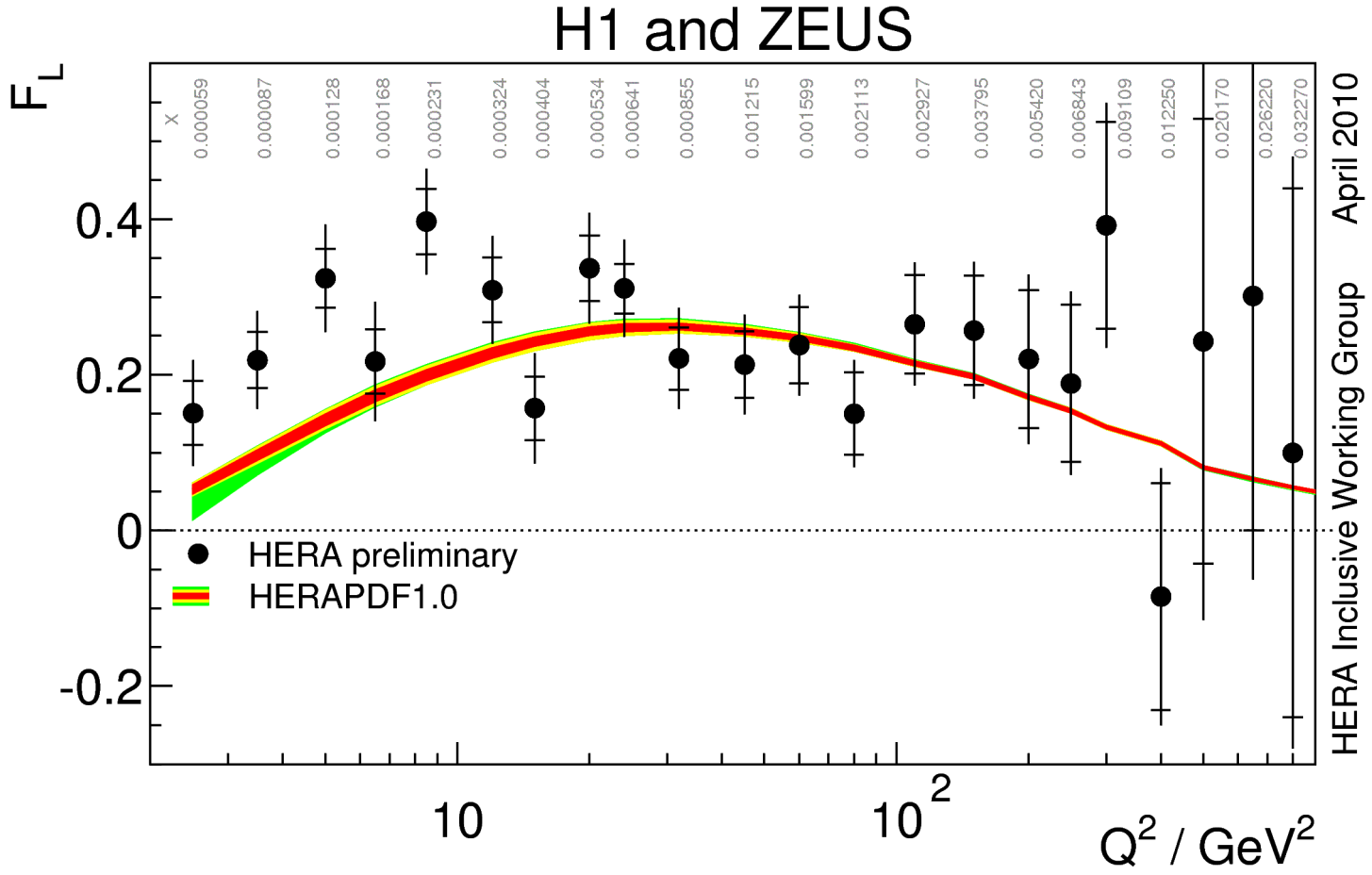
At given x and Q^2:
$\rightarrow$ F_L is the negative slope

HERA F_L in bins of Q^2 as a function of x



Averaged F_L, $2.5 < Q^2 < 800$ GeV^2

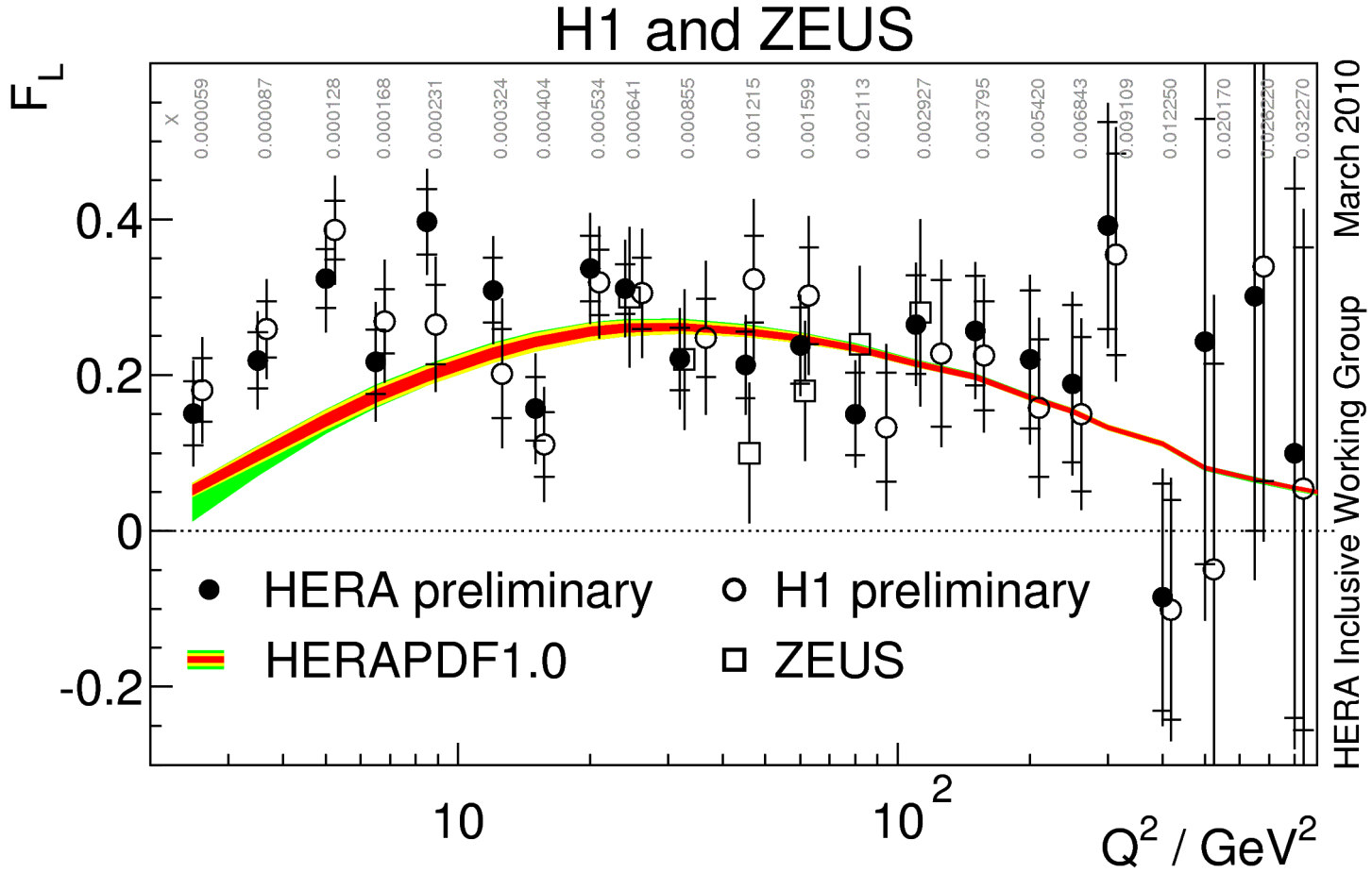
F_L, averaged over x, is obtained for each Q^2 bin:



Good agreement between data and predictions for $Q^2>10$ GeV^2 .
Data excess HERAPDF1.0 predictions at low-Q^2 region *(see talk by V. Radescu)*

HERA F_L , compared to H1 and ZEUS measurements

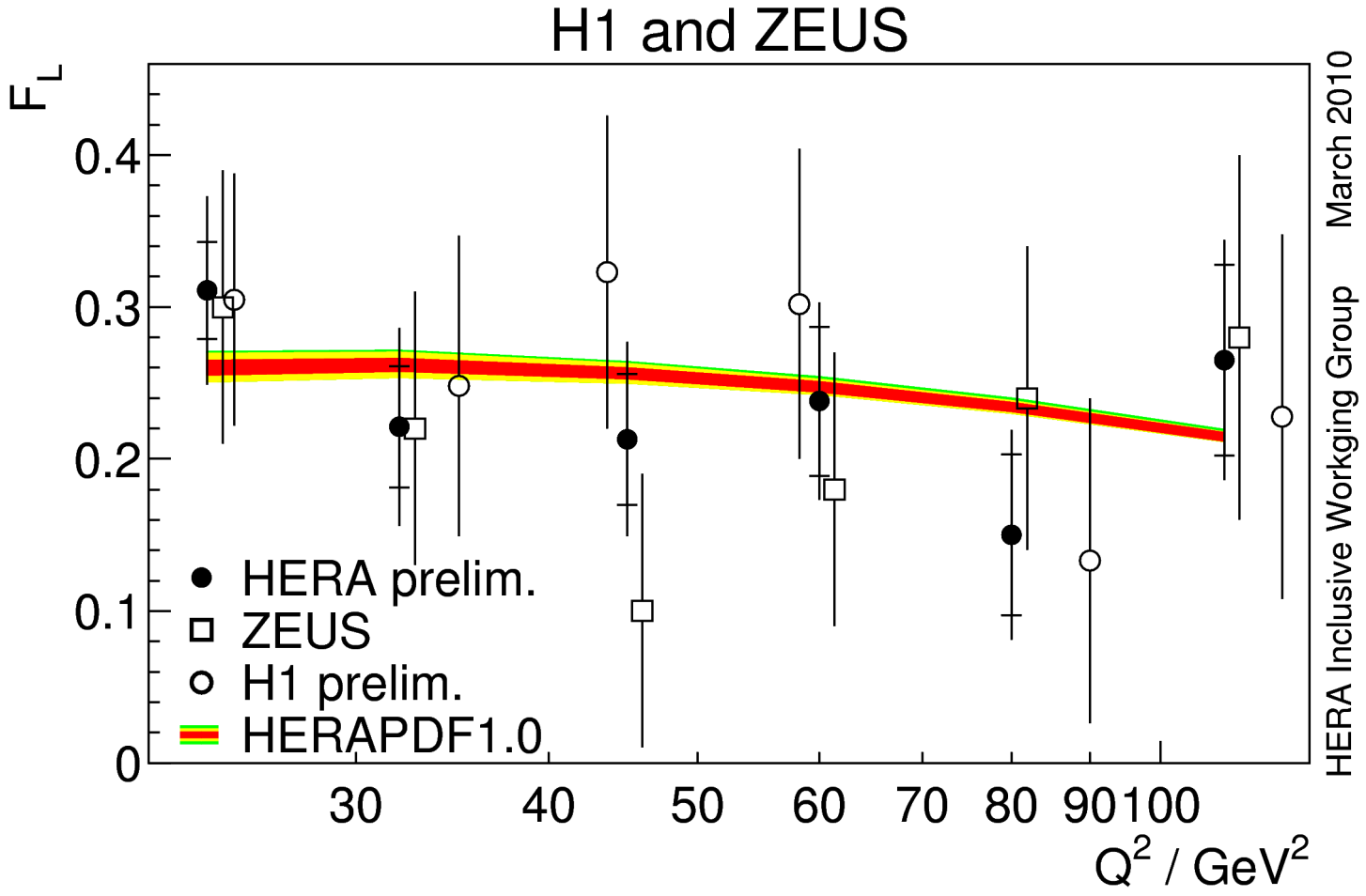
F_L, averaged over x, compared to H1 and ZEUS measurements:



Improved precision in the H1/ZEUS overlap region

HERA F_L , compared to H1 and ZEUS measurements

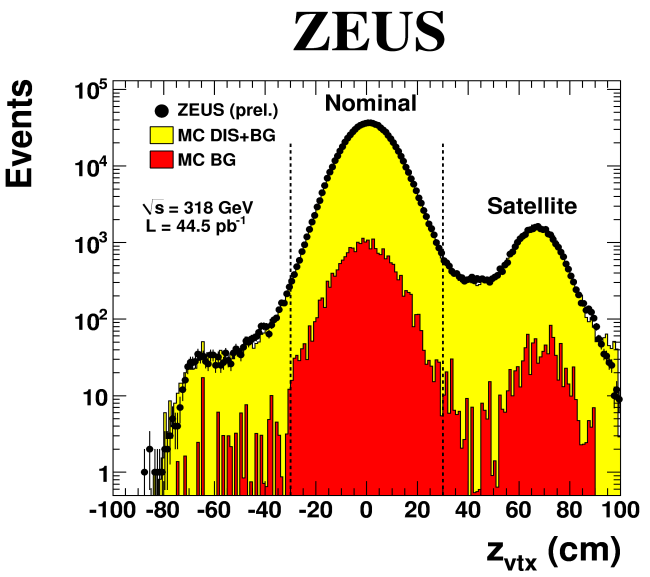
F_L in H1/ZEUS overlap region ($24 < Q^2 < 110$ GeV^2), compared to individual measurements:

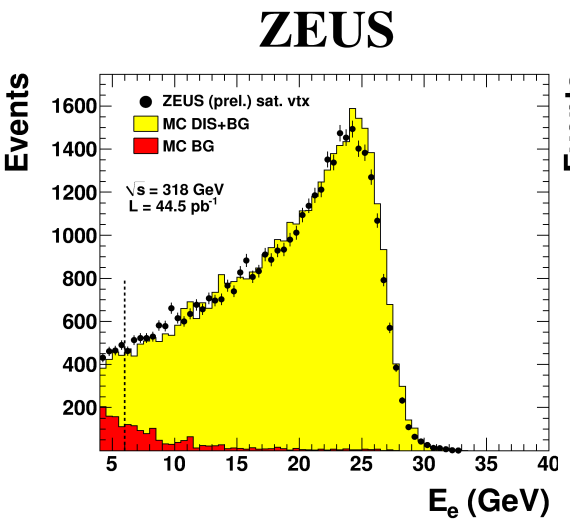


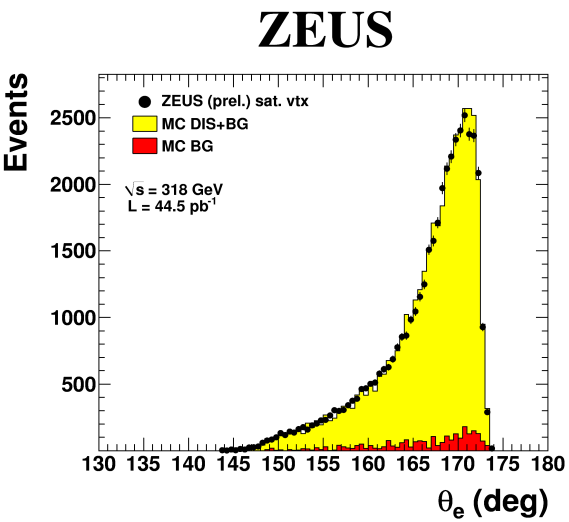
Extended to low-Q^2 region ZEUS measurement will be very useful

New measurement of NC cross sections at ZEUS

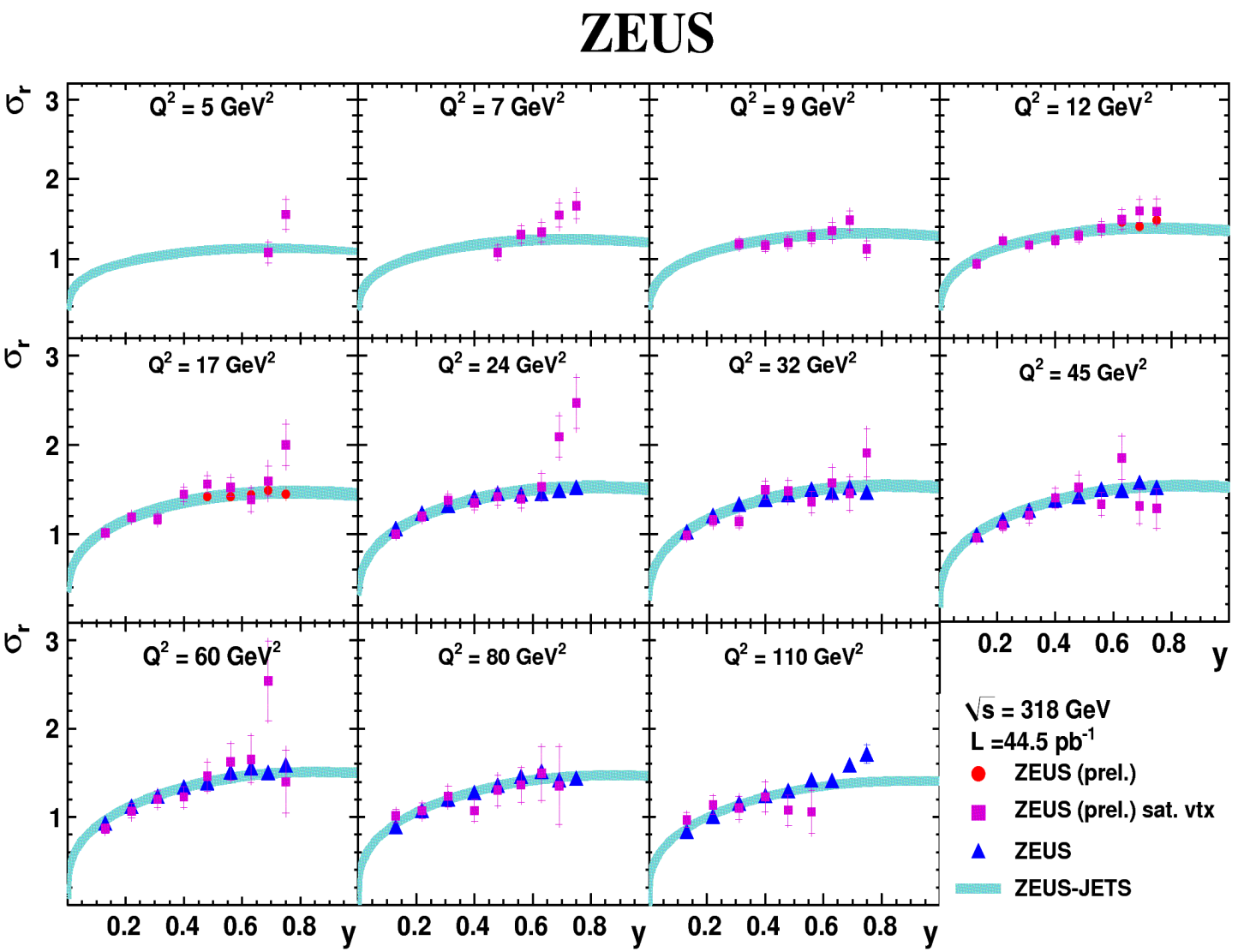
- NC e+p cross sections, published by ZEUS last year for $24 < Q^2 < 110$ GeV^2
  - Lower limit in Q^2 due to tracking system acceptance
  - Ee > 6 GeV
- Nominal analysis extension:
  - $Q^2 > 12$ GeV^2
- Beam structure: presence of satellite vertex events:
  - can be used to access lower electron scattering angles $\rightarrow$ lower Q^2







Measured reduced cross sections: E_p=920 GeV

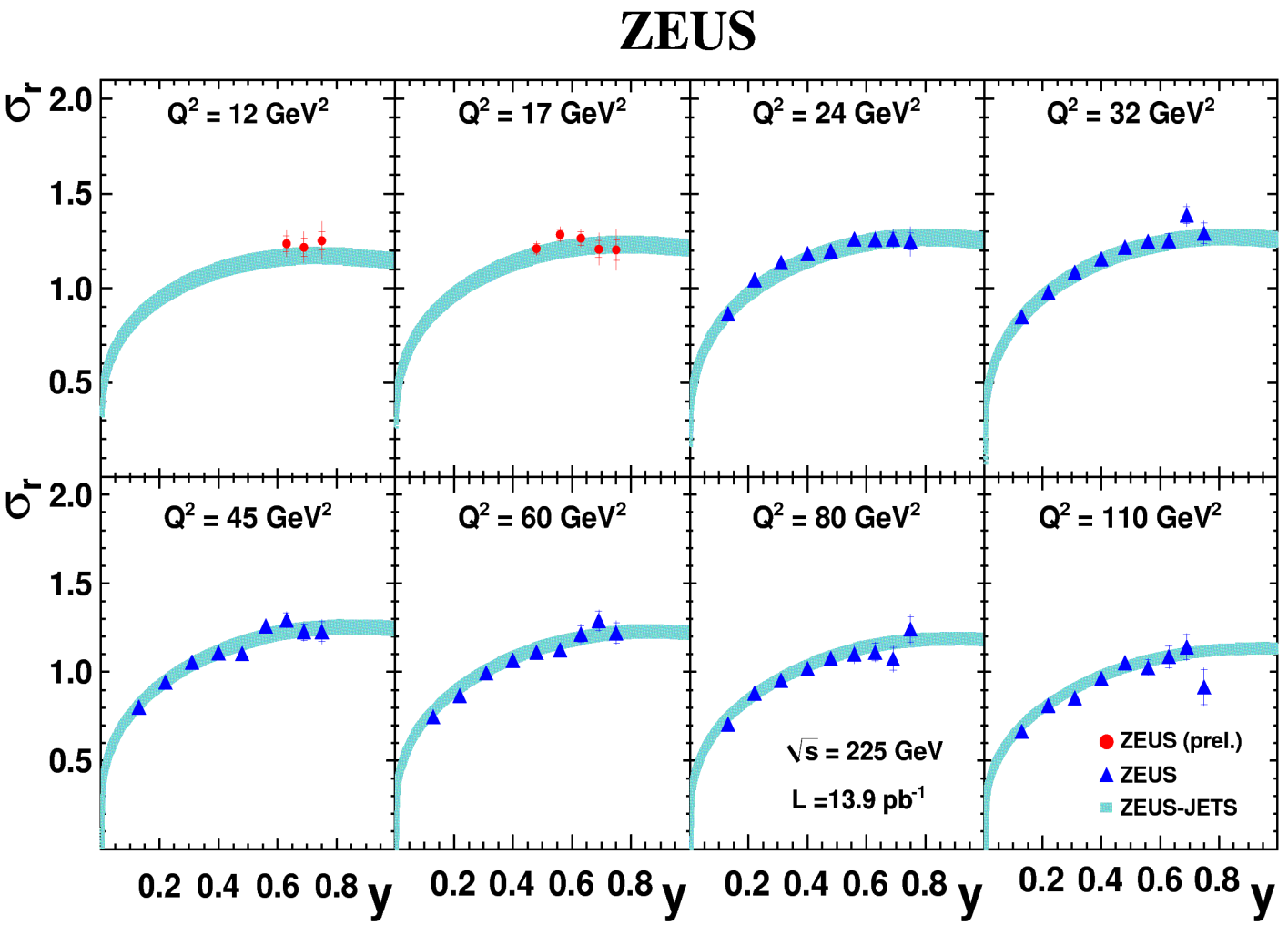


$5\ \text{GeV}^2 < Q^2 < 110\ \text{GeV}^2$

$5 \cdot 10^{-4} < x < 7 \cdot 10^{-3}$

- Shifted vertex and nominal vertex cross section measurement extended to lower Q^2
- New data agree well with previous measurements and predictions

Measured reduced cross sections: E_p=460 GeV

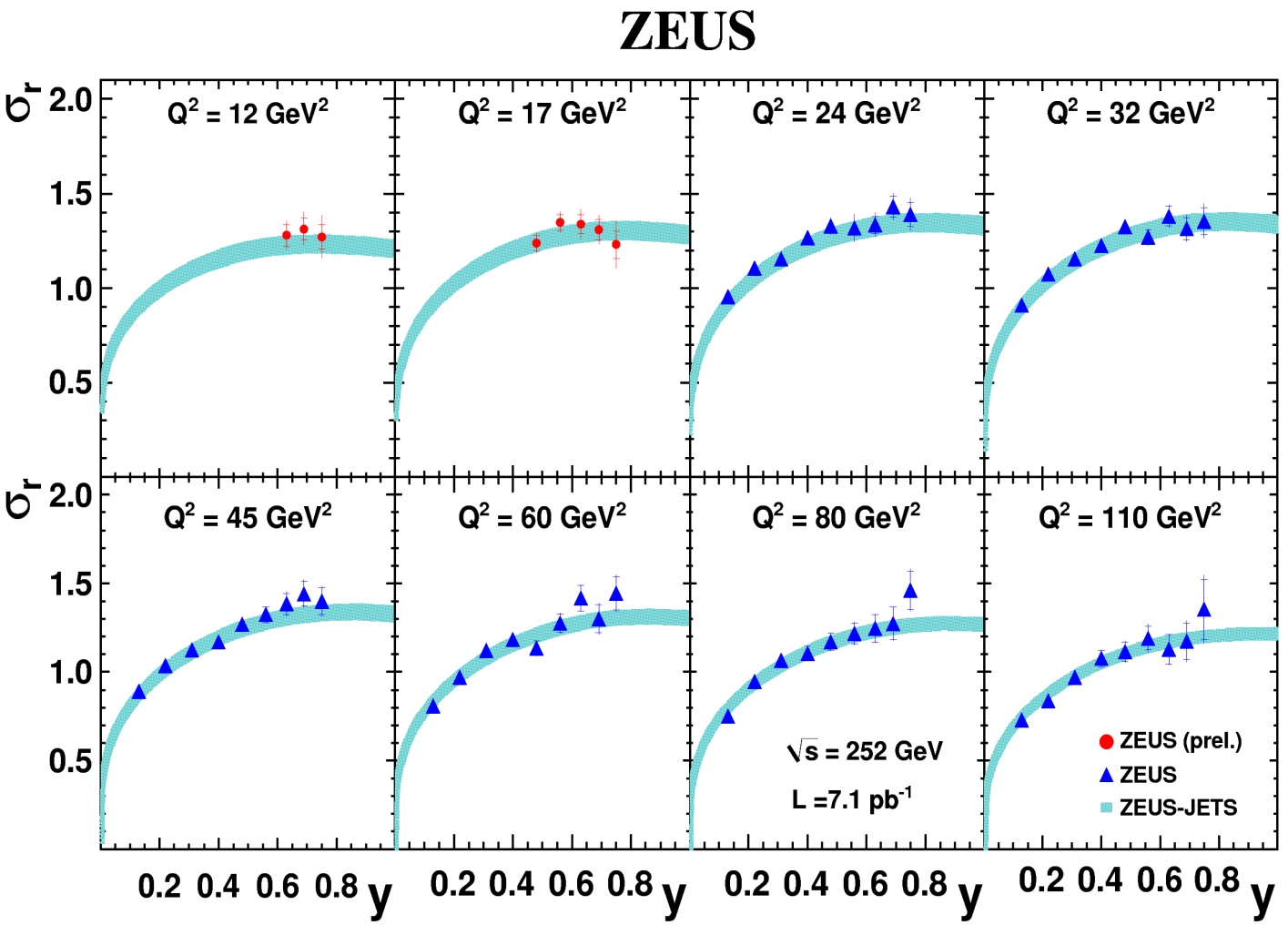


$12\ \text{GeV}^2 < Q^2 < 110\ \text{GeV}^2$

$5 \cdot 10^{-4} < x < 7 \cdot 10^{-3}$

- Nominal vertex cross section measurement extended to lower Q^2
- New data agree well with predictions

Measured reduced cross sections: E_p=575 GeV



$12\ \text{GeV}^2 < Q^2 < 110\ \text{GeV}^2$

$5 \cdot 10^{-4} < x < 7 \cdot 10^{-3}$

- Nominal vertex cross section measurement extended to lower Q^2
- New data agree well with predictions

Summary

- NC e+p **cross sections, measured by H1 and ZEUS, are combined** in the region of $2.5 < Q^2 < 800\ \mathrm{GeV}^2$
  - Improved precision and check of consistencny
  - Data ready for further QCD analysis
- Joint **HERA longitudinal proton structure function F_L is extracted**

- NC e+p cross sections measurement with the **ZEUS** detector is **extended to lower Q^2**
  - Satellite vertex events are used to access lower Q^2 region ($5 < Q^2 < 110\ \mathrm{GeV}^2$)
  - Nominal analysis extended to $Q^2 > 12\ \mathrm{GeV}^2$
  - New ZEUS measurement is ready for further combination and QCD analysis

Backup

Data combination procedure

- Cross sections are measured in bins of Q^2 as a function of x
- First H1 and ZEUS ata points are moved to common (Q^2,x) grid (using HERAPDF1.0 to define swimming corrections)
- After swimming, points are averaged
  - χ^2 minimisation method used
  - For single data set χ^2 is defined as:

$$\chi^2(m,b)=\sum_i \left(\frac{\left(m^i-\sum \Gamma^i_j(m_i)\,b_j-\mu^i\right)^2}{\sigma_i(m^i,b_j)}\right)+\sum_j b_j^2$$

- Error correlations taken into account

m_i – prediction for the measurement
μ_i – measured value
Γ_i – correlated systematics
σ_i – stat. and uncorr syst. uncertainties
b_i – shifts of the correlated syst.