

New Measurements of F_2^D and F_L^D with HI at HERA

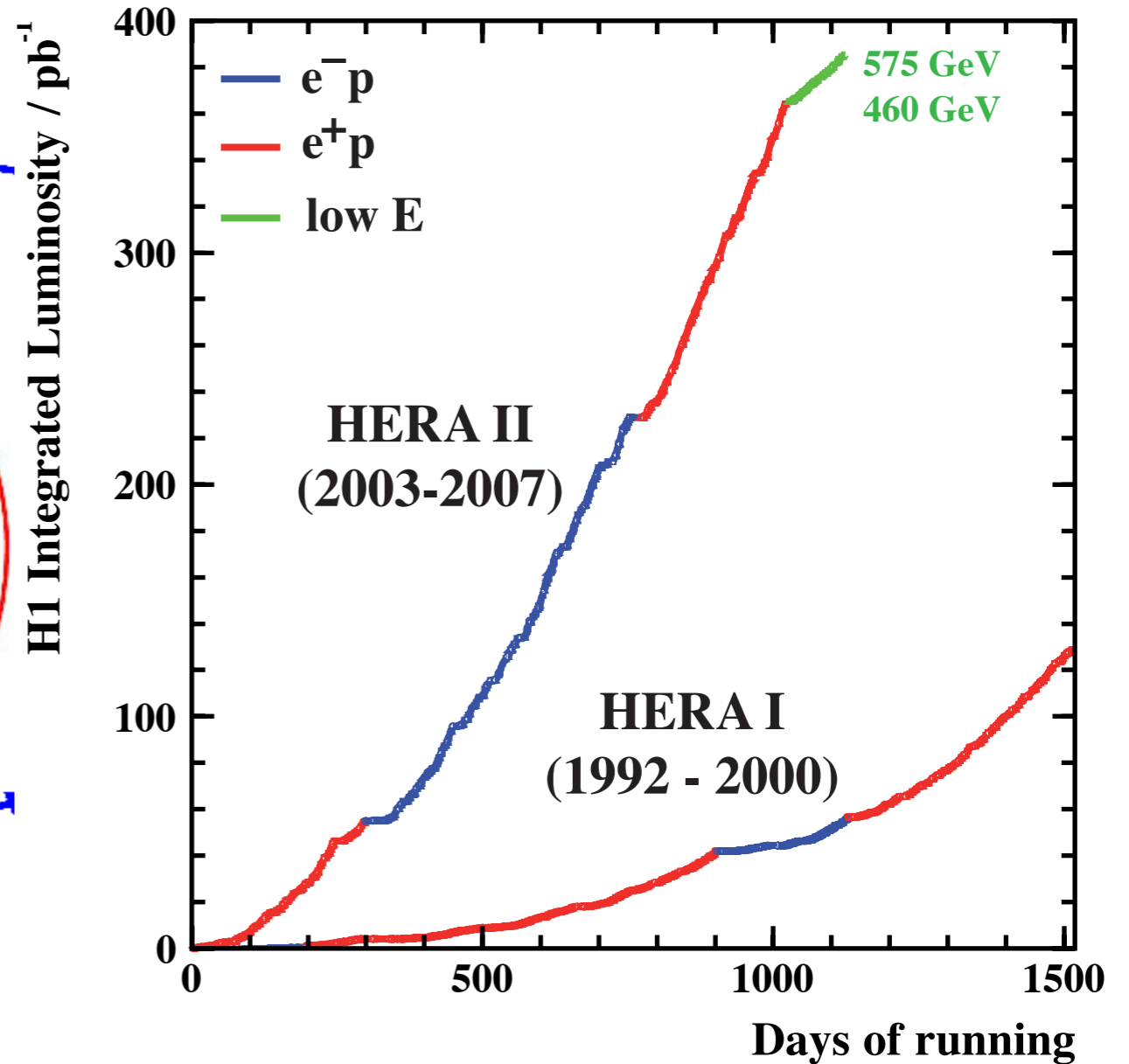
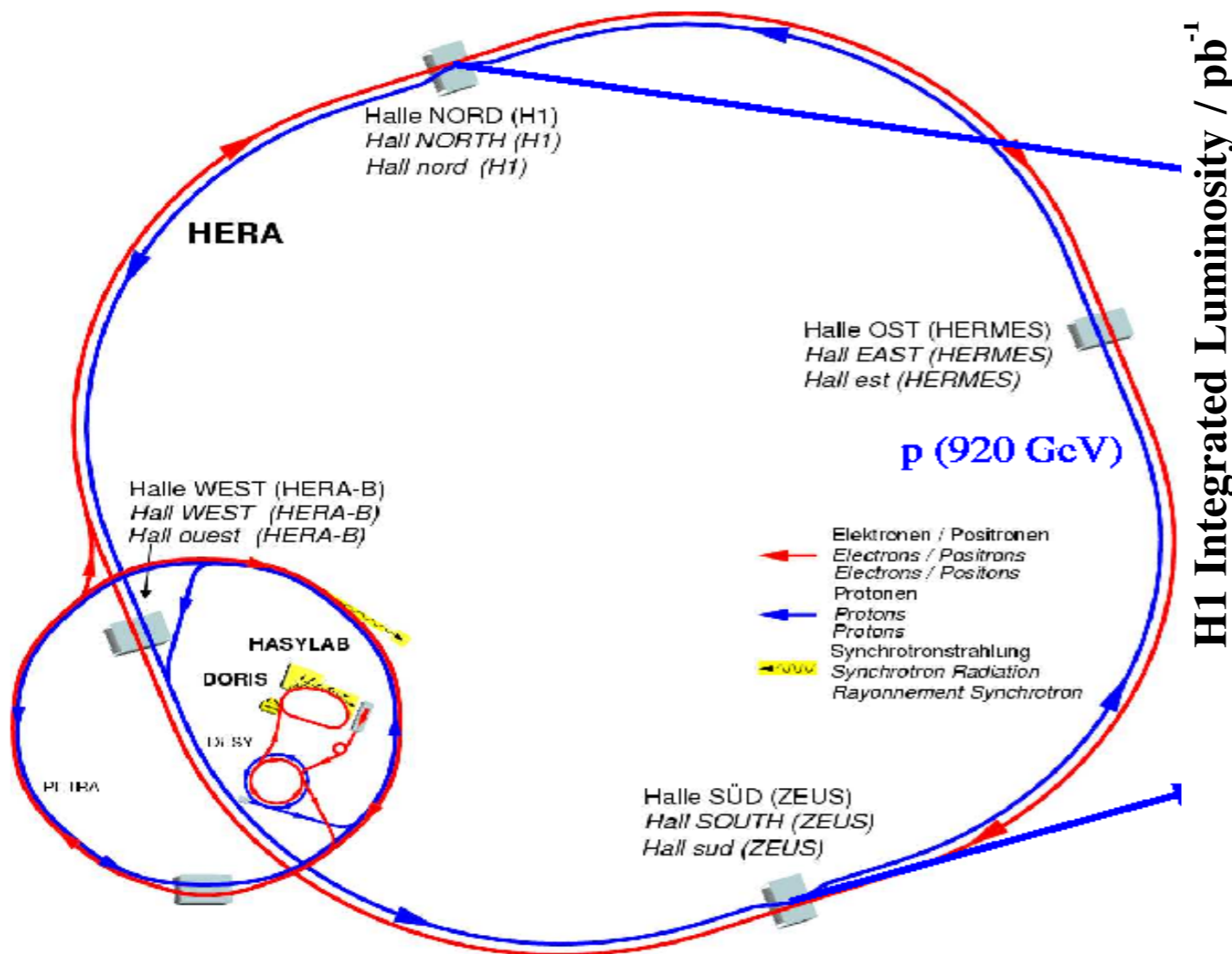


Paul Laycock
Thursday 24th June 2010
Low x 2010, Kavala, Greece

- HERA datasets
- Diffractive DIS
- F_L^D and F_2^D

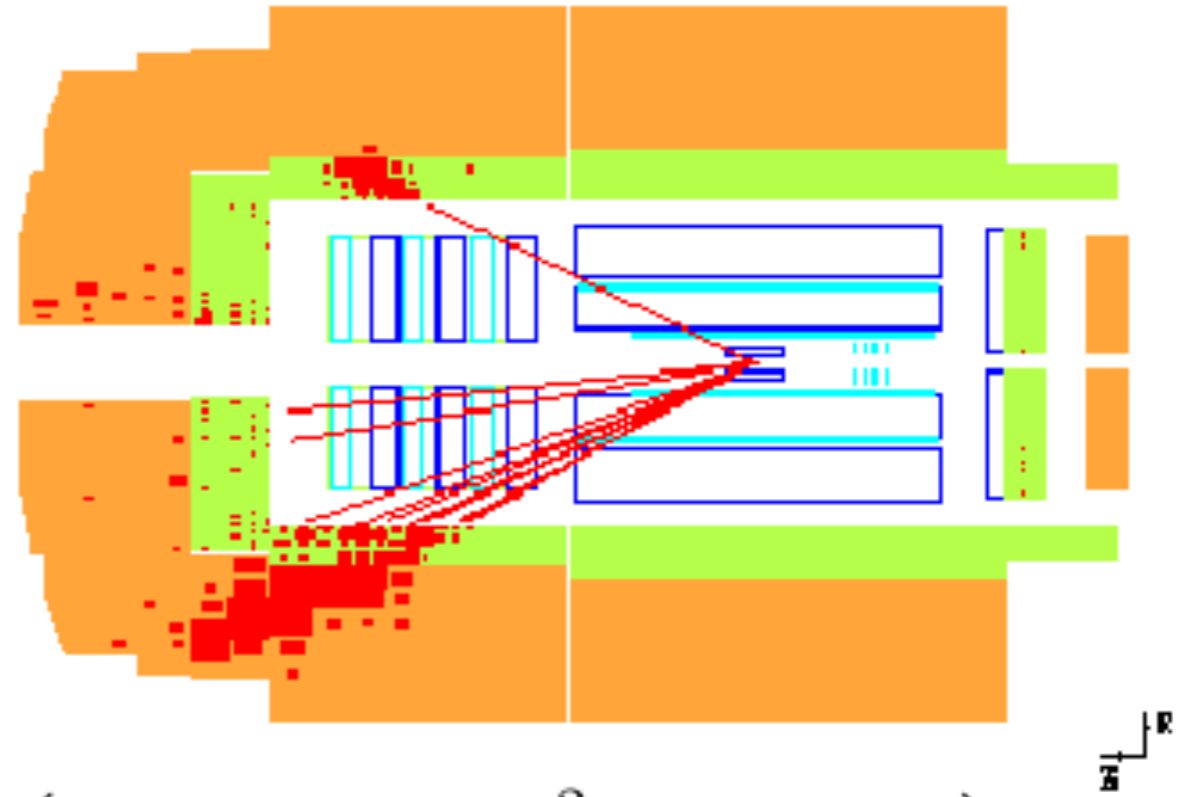
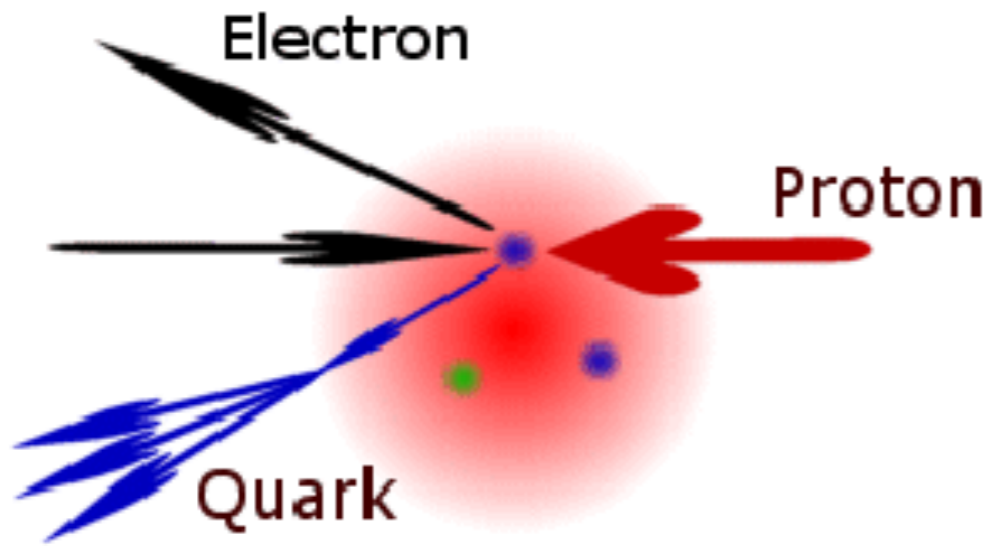


HERA, collider experiments and data



- The unique HERA machine collided 27.5 GeV electrons or positrons with protons of 460, 575, 820 and 920 GeV providing 0.5 fb⁻¹ to H1
- The final precision analyses of this data are being delivered

Deep-inelastic Scattering



Measure:

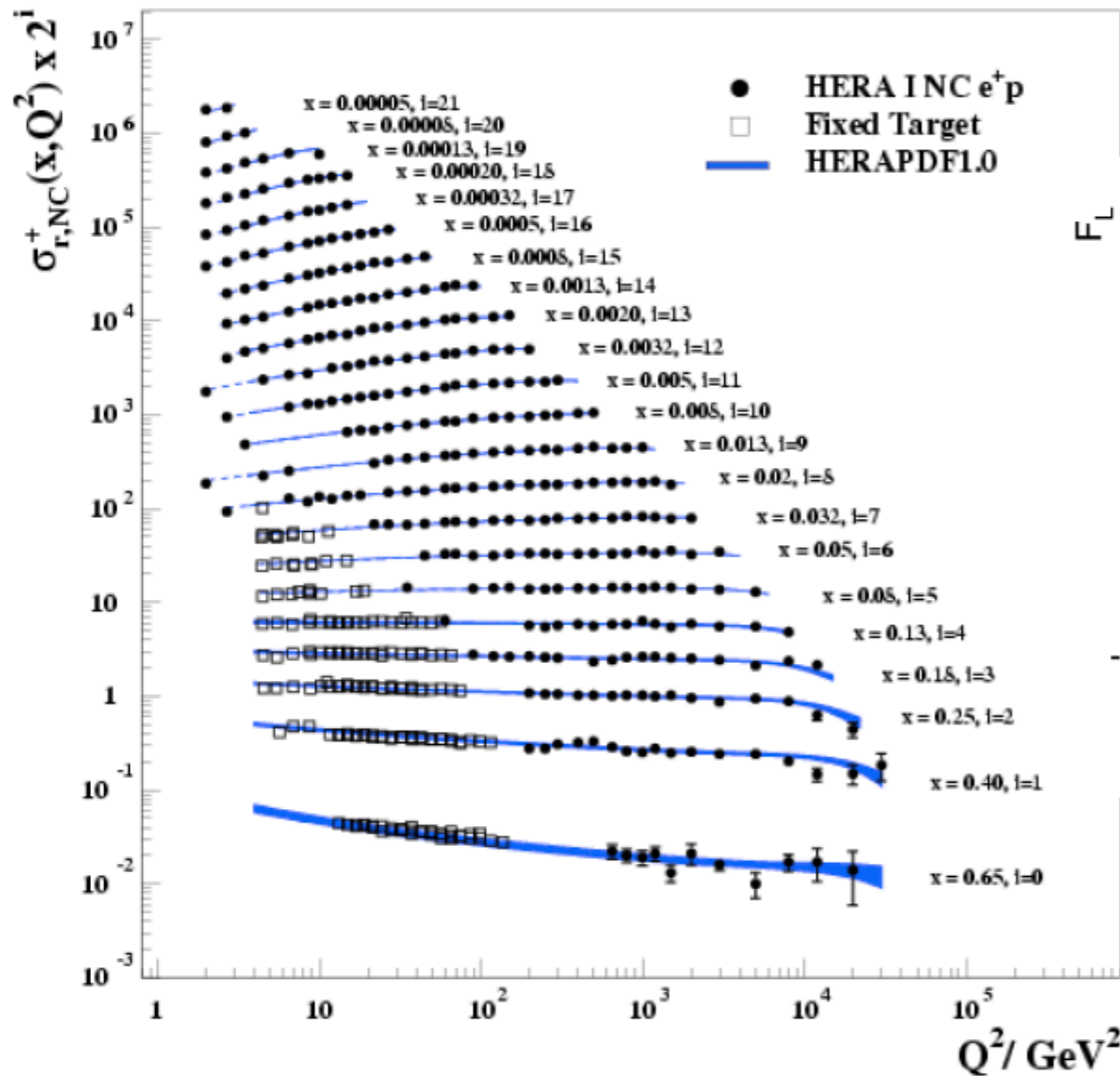
$$\frac{d^2\sigma_{NC}^{ep}}{dx dQ^2} = \frac{2\pi\alpha^2 Y_+}{xQ^4} \left(F_2(x, Q^2) - \frac{y^2}{Y_+} F_L(x, Q^2) \right)$$

Extract:

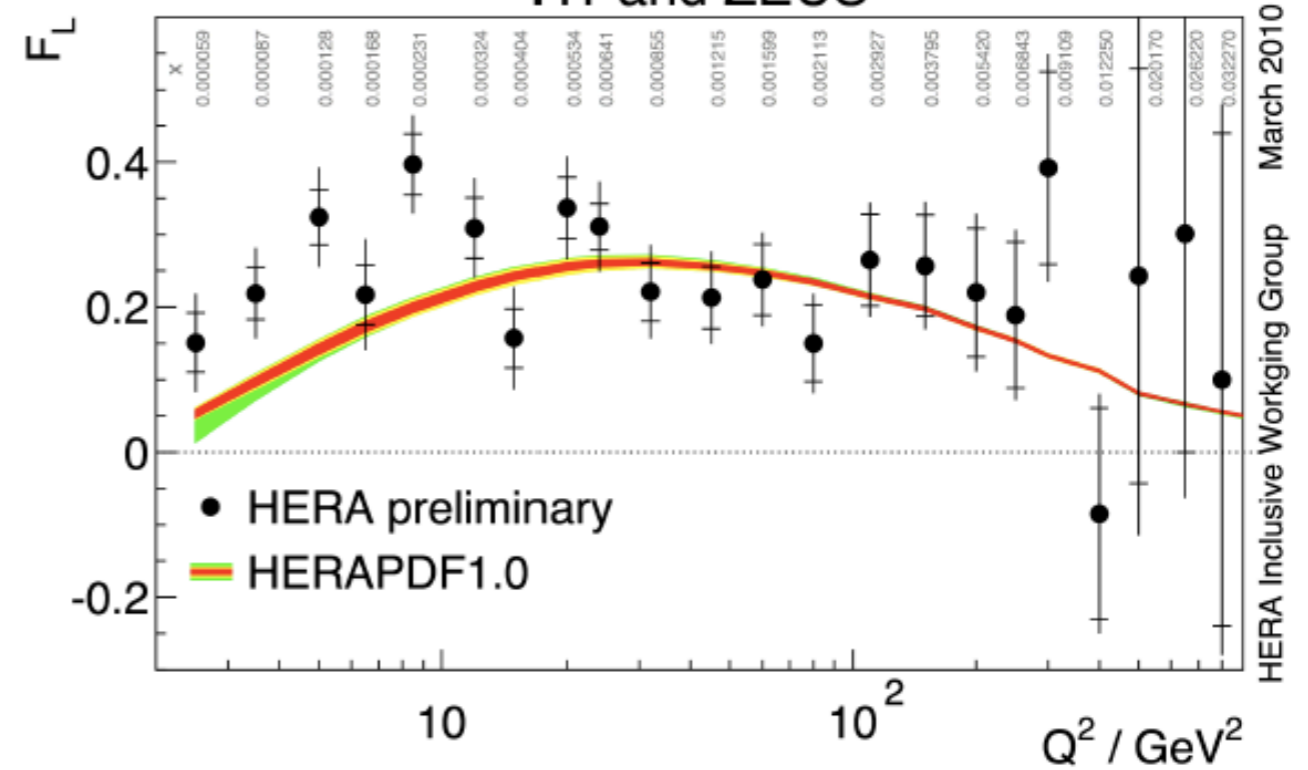
- F_2 directly related to (PDFs) quark content: $F_2 \sim x \sum e^2 (q + \bar{q})$
- $dF_2/d\ln Q^2$ (scaling violations) sensitive to gluon content
- F_L only non-zero in higher order QCD – independent access to gluon density and QCD dynamics

Inclusive F_2 and F_L

H1 and ZEUS



H1 and ZEUS



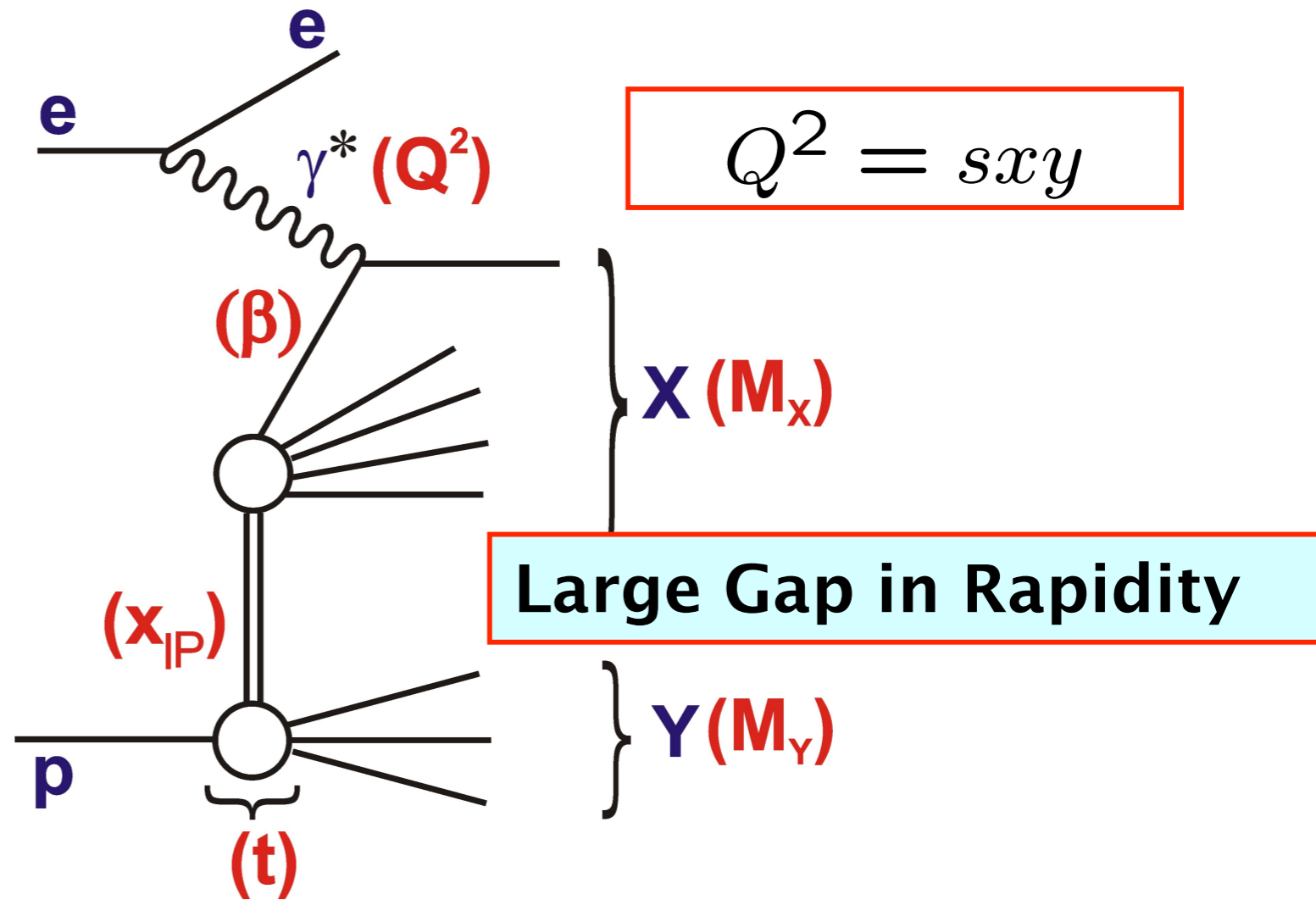
- Experimental confirmation of the DGLAP picture of inclusive DIS
- Target is to repeat this for diffraction

Diffractive Structure Functions

$$x = x_{IP} \beta$$

$$\beta = \frac{Q^2}{Q^2 + M_X^2}$$

$$x_{IP} = \frac{Q^2 + M_X^2}{Q^2 + W^2}$$



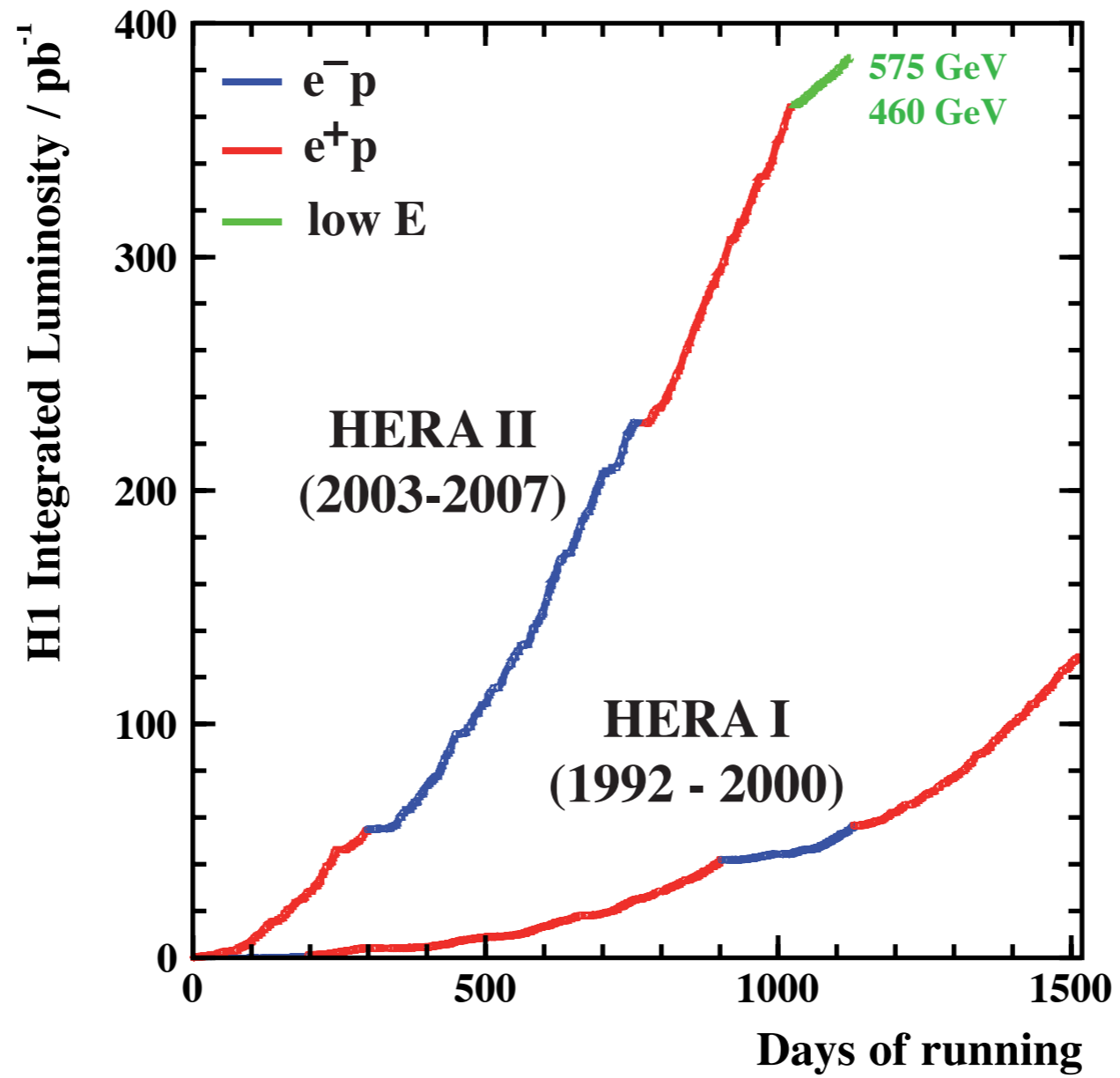
$$Y_+ = 1 + (1 - y)^2$$

Cross section:
$$\frac{d^4 \sigma^{ep \rightarrow eXp}}{dx dQ^2 dx_{IP} dt} = \frac{4\pi\alpha^2}{xQ^4} Y_+ \sigma_r^{D(4)}(x, Q^2, x_{IP}, t)$$

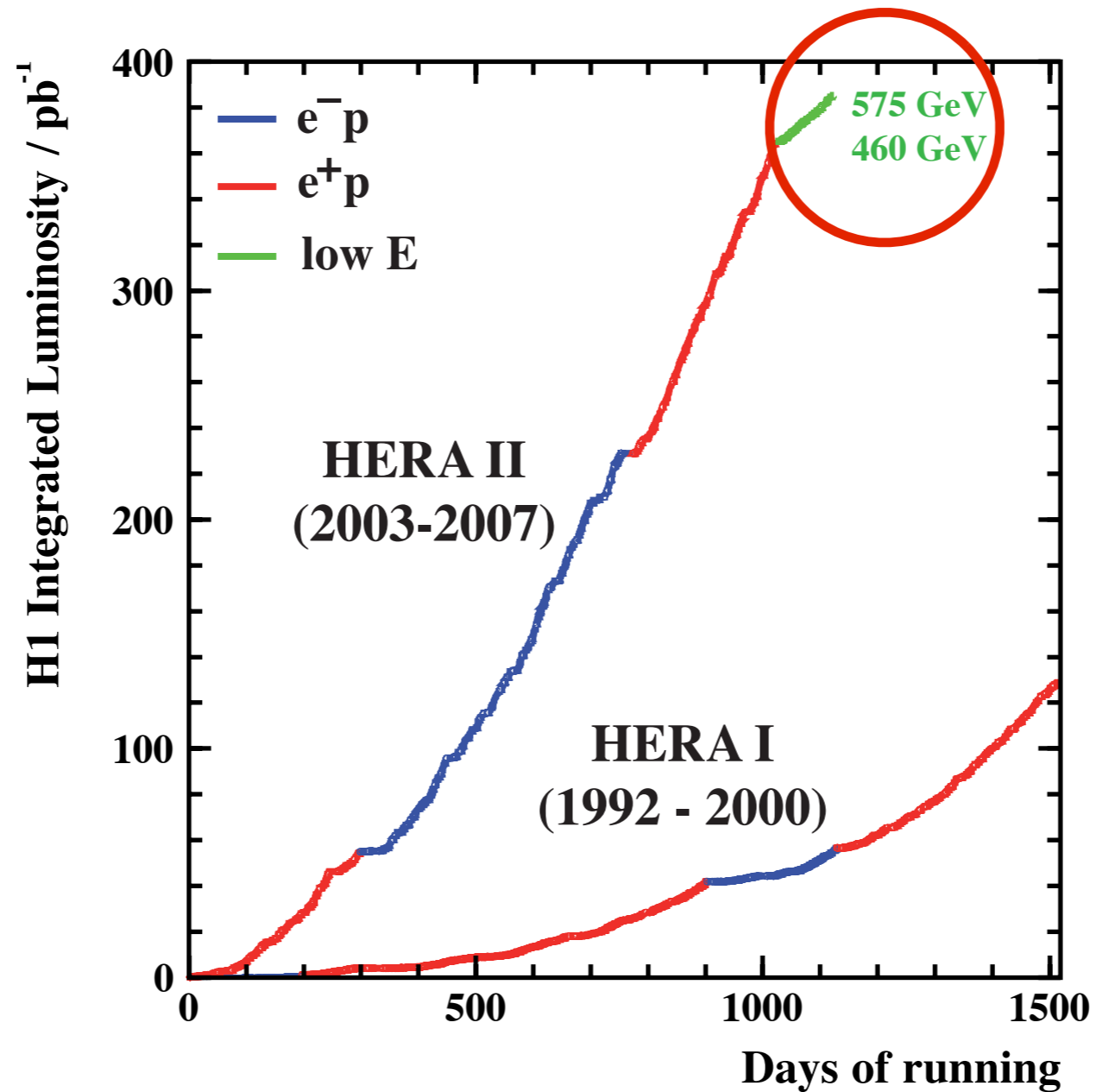
$$\sigma_r^{D(4)} = F_2^{D(4)} - \frac{y^2}{Y_+} F_L^{D(4)}$$

$$\sigma_r^{D(3)} = \int_{-1}^{t_{min}} \sigma_r^{D(4)} dt$$

HI data



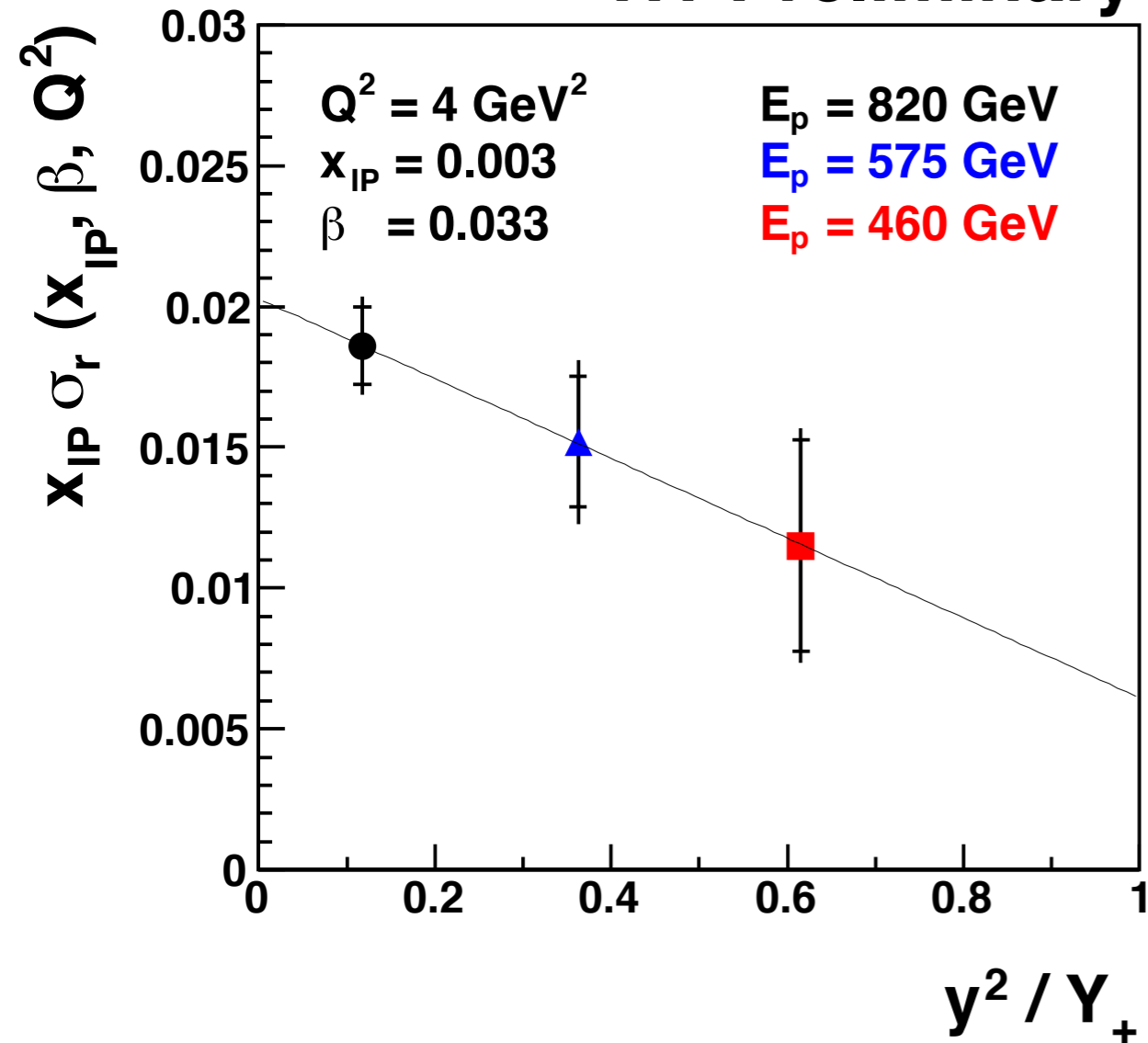
H1 data



- Analyse the low ($E_p=460$ GeV) and medium ($E_p=575$ GeV) energy runs
- Measure cross sections at fixed x_{IP} , β , Q^2 and different $y \rightarrow F_L^D$

F_L^D Extraction

H1 Preliminary



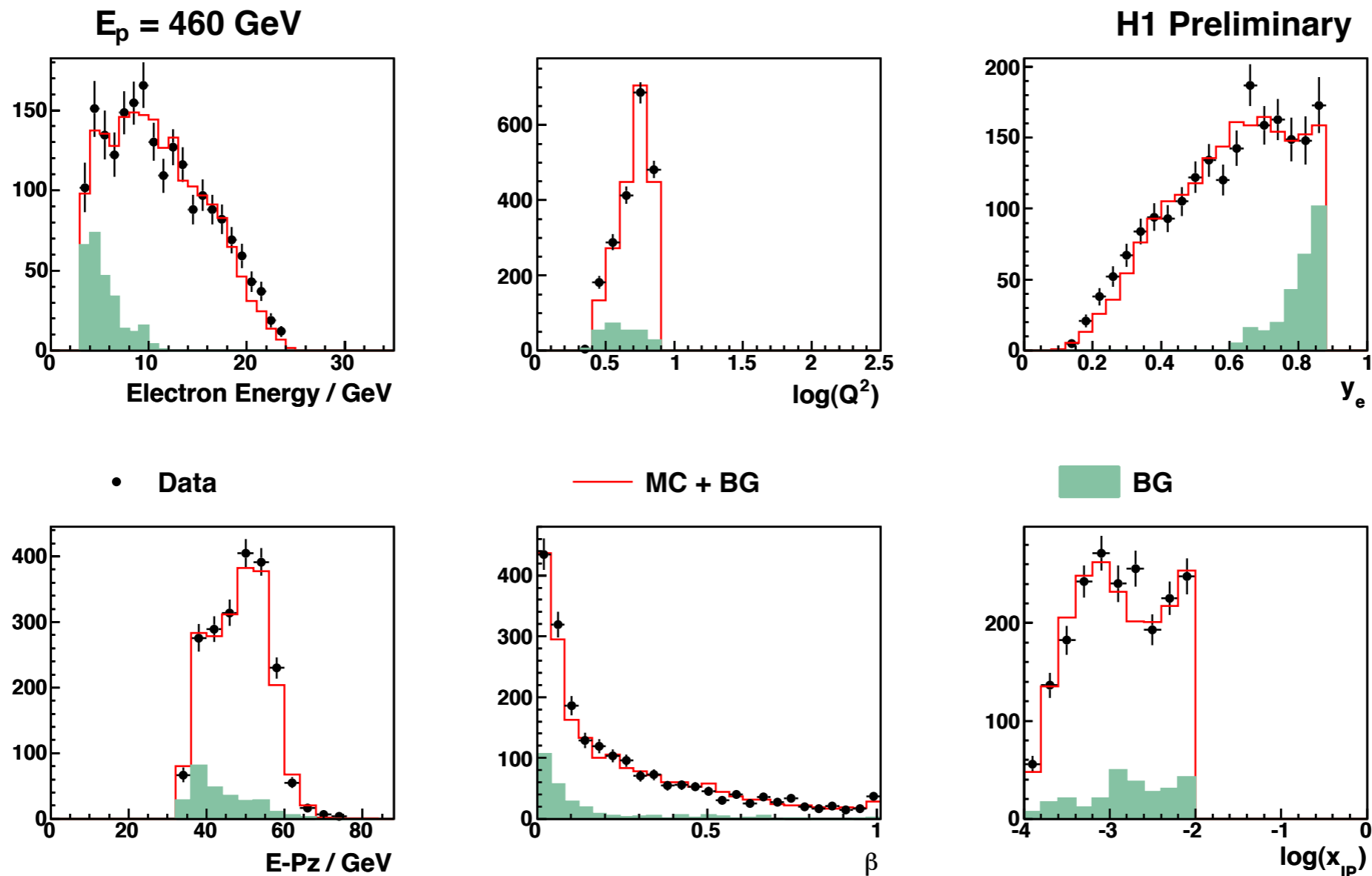
- Measure reduced cross sections at three different beam energies at fixed x_{IP} , β and Q^2

$$\sigma_r^{D(4)} = F_2^{D(4)} - \frac{y^2}{Y_+} F_L^{D(4)}$$

- Plot as a function of y^2 / Y_+ (Rosenbluth plot)
- Extract F_L^D as the slope

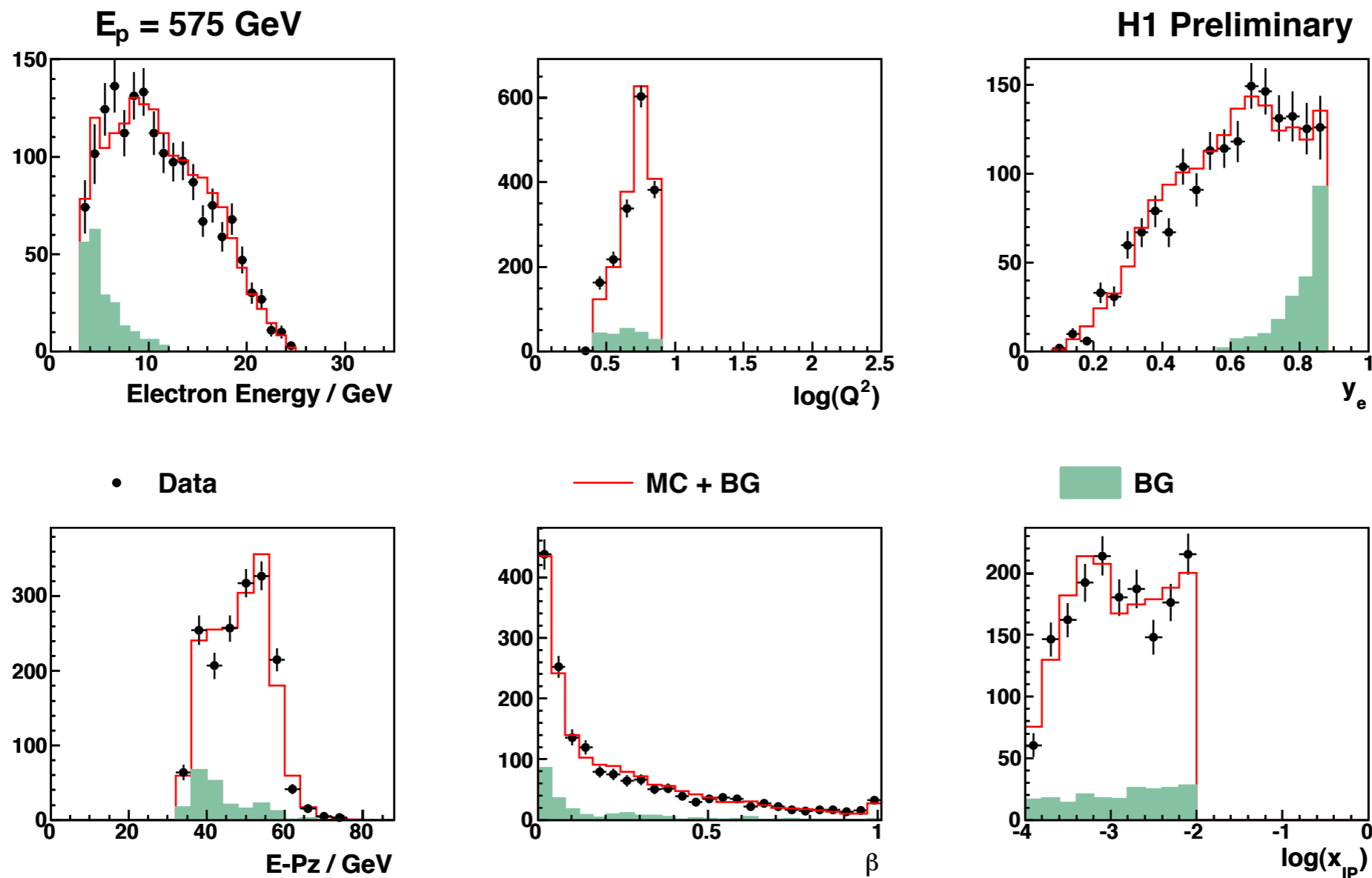
- Analysis at medium $Q^2 > 7 \text{ GeV}^2$ shown last year
- Extend the measurement down to $Q^2 > 2.5 \text{ GeV}^2$

The low (460 GeV) energy data



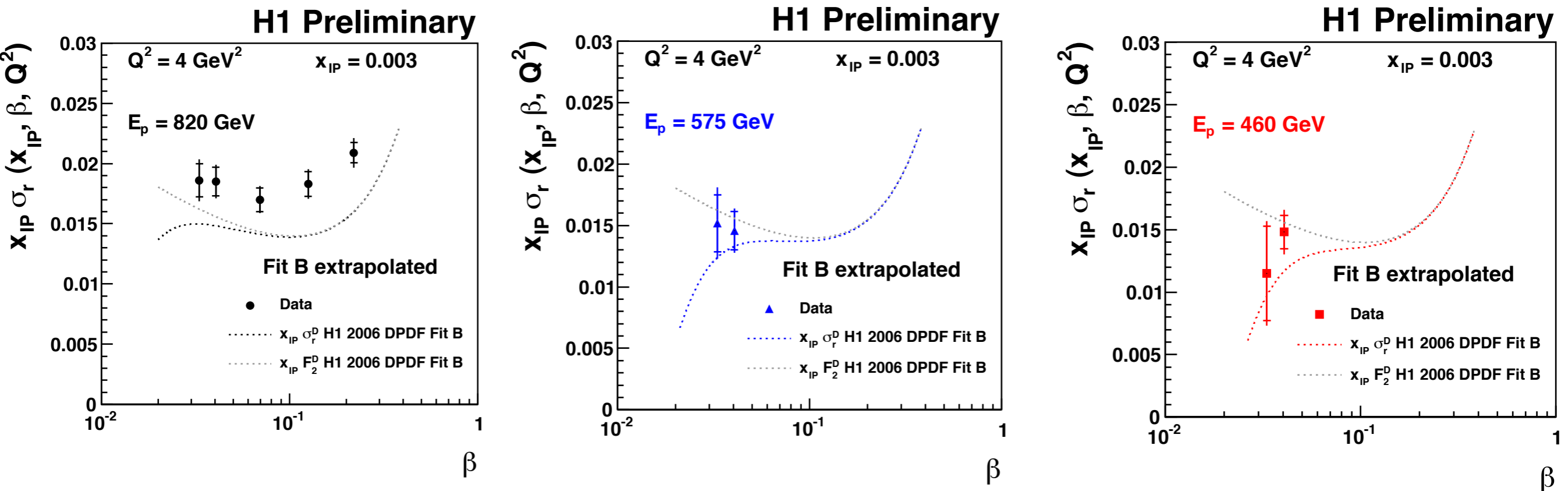
- Analyse data down to Q^2 of 2.5 GeV^2 and electron energy of 3.4 GeV
- Extremely challenging measurement!
- Good control of the data, using data (wrong-charge events) to understand the significant photoproduction background in the region of interest at high y

The medium (575 GeV) energy data



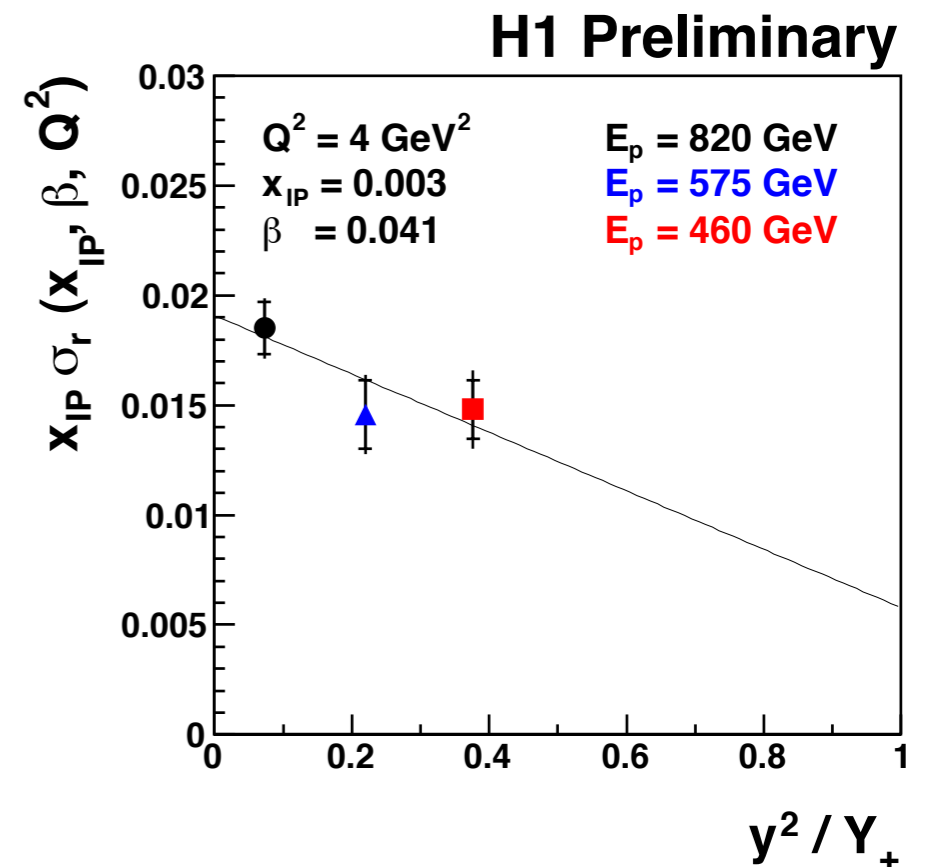
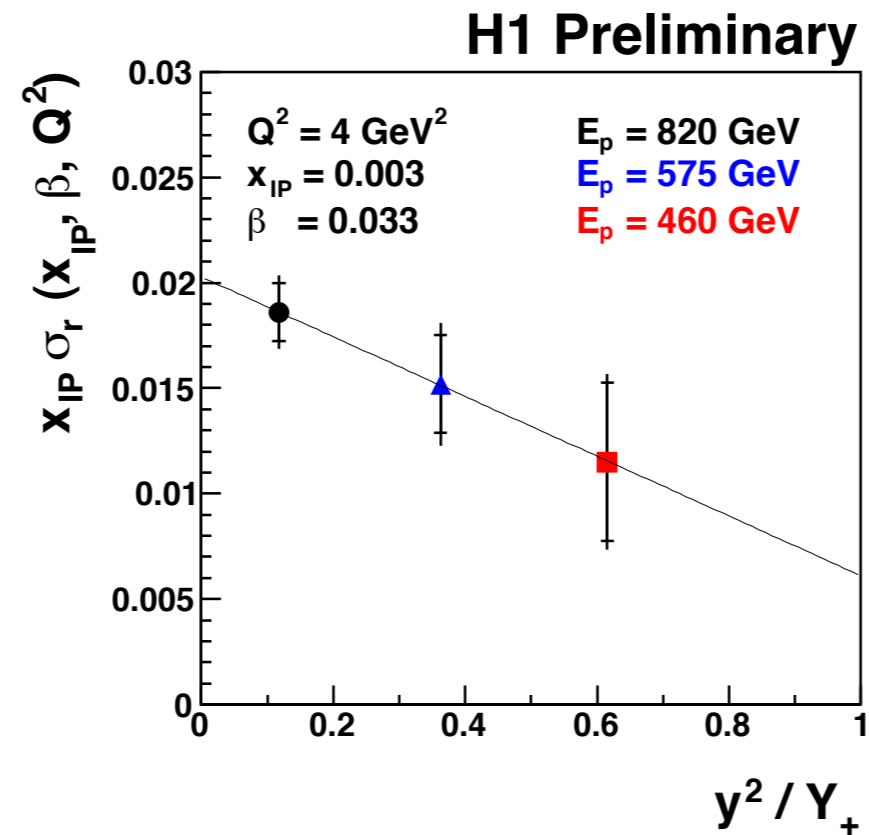
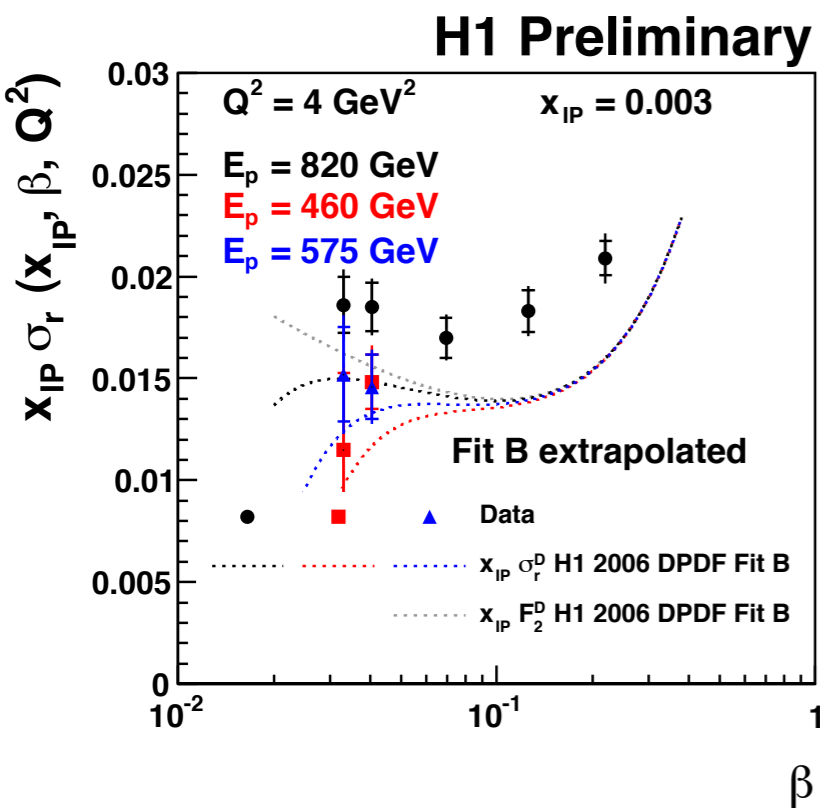
- Analyse data down to Q^2 of 2.5 GeV^2 and electron energy of 3.4 GeV
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Diffractive cross sections at low Q^2 and high y



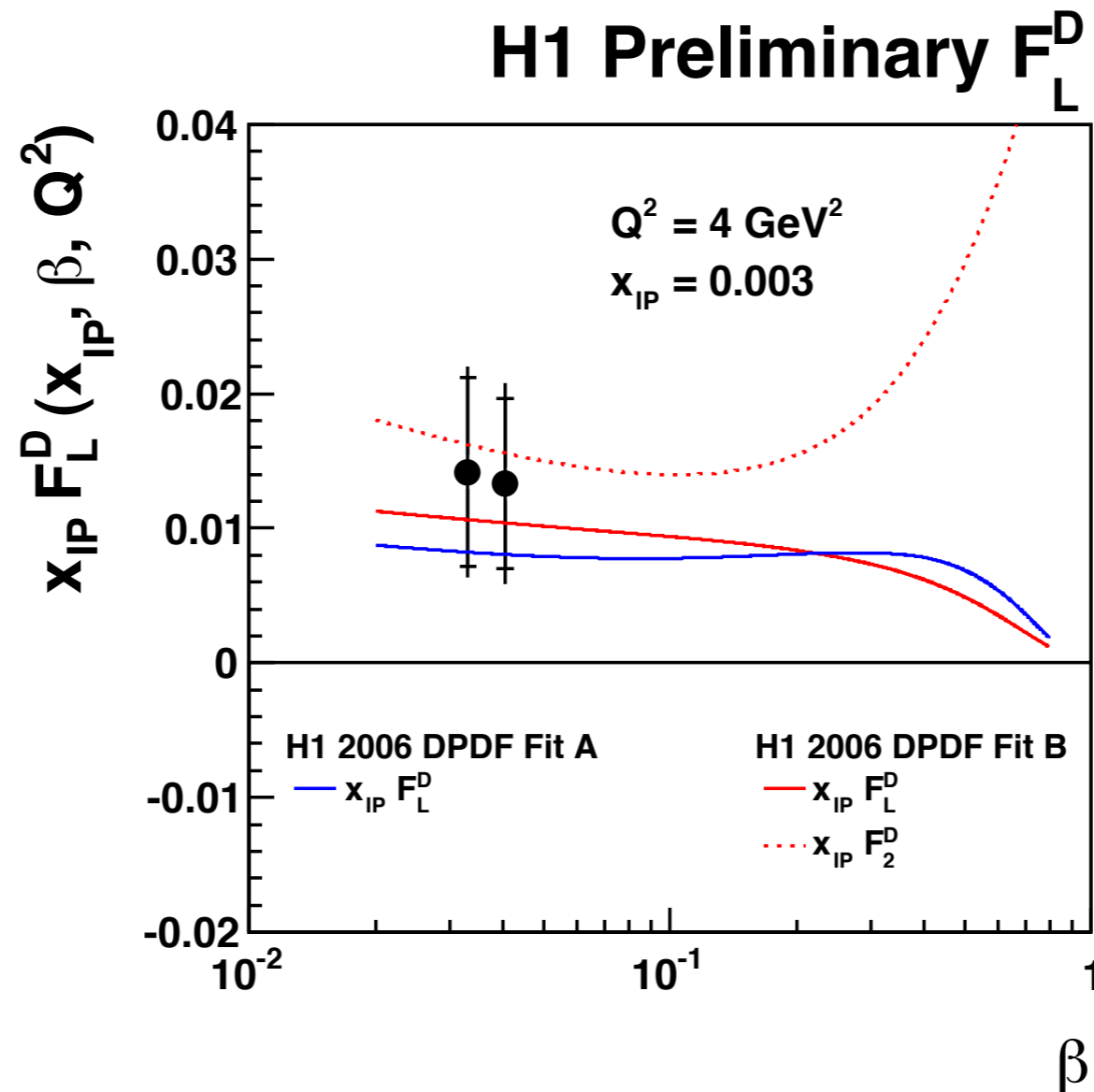
- Left are **published** data (hep-ex/0606004) with $E_p = 820 \text{ GeV}$
- The extrapolation of Fit B for F_2^D (upper curve) and σ_r^D is shown - it undershoots the data at low Q^2 (only data with $Q^2 \geq 8.5 \text{ GeV}^2$ were included)
- New low Q^2 ($=4 \text{ GeV}^2$) diffractive cross sections at $E_p = 575 \text{ GeV}$ (centre, blue) and $E_p = 460 \text{ GeV}$ (right, red) compared to extrapolated Fit B

F_L^D extraction



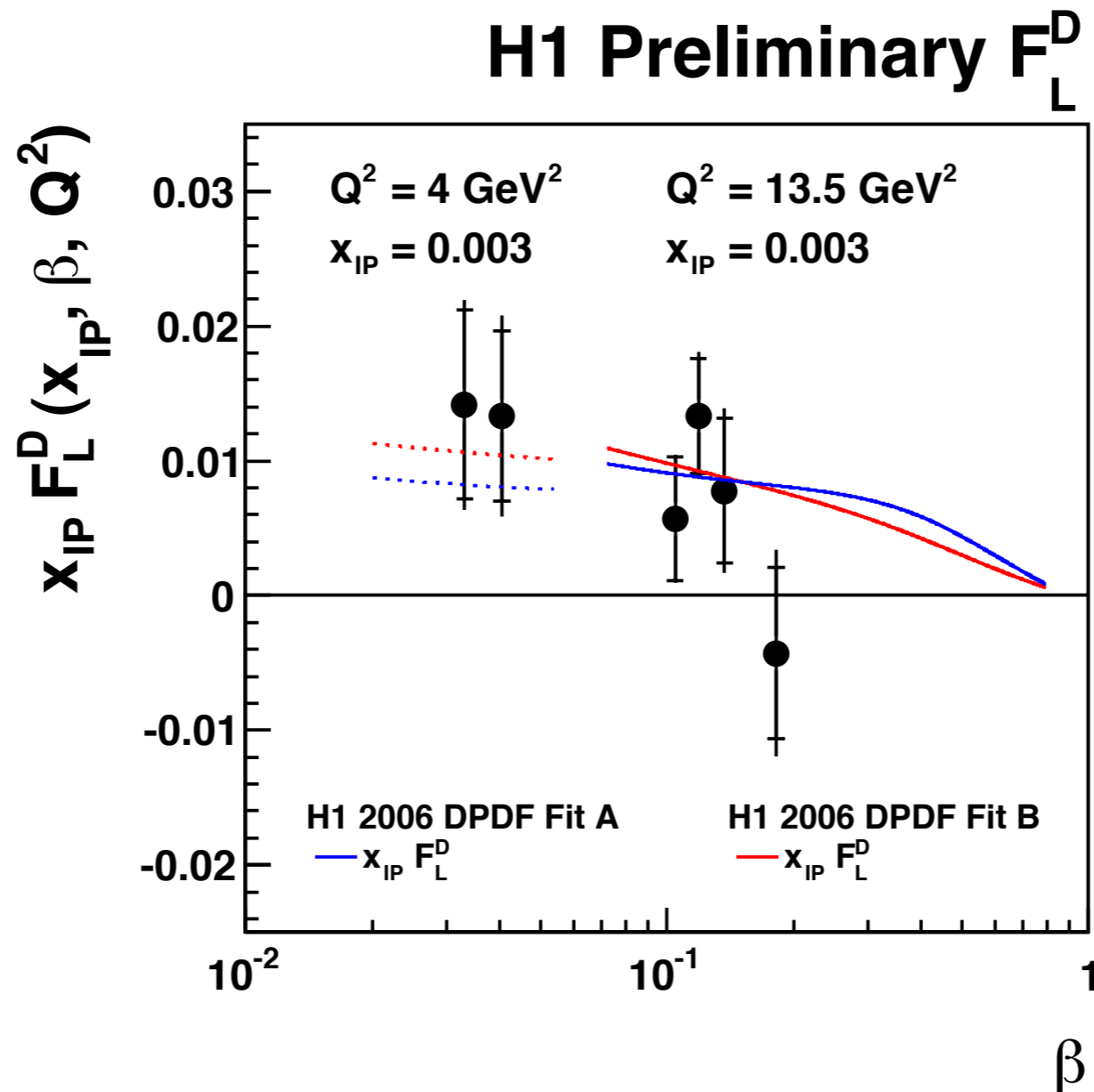
- The linear fits to the Rosenbluth plots for the two highest y bins are shown, allowing two new measurements at low Q^2 to be made

The diffractive longitudinal structure function



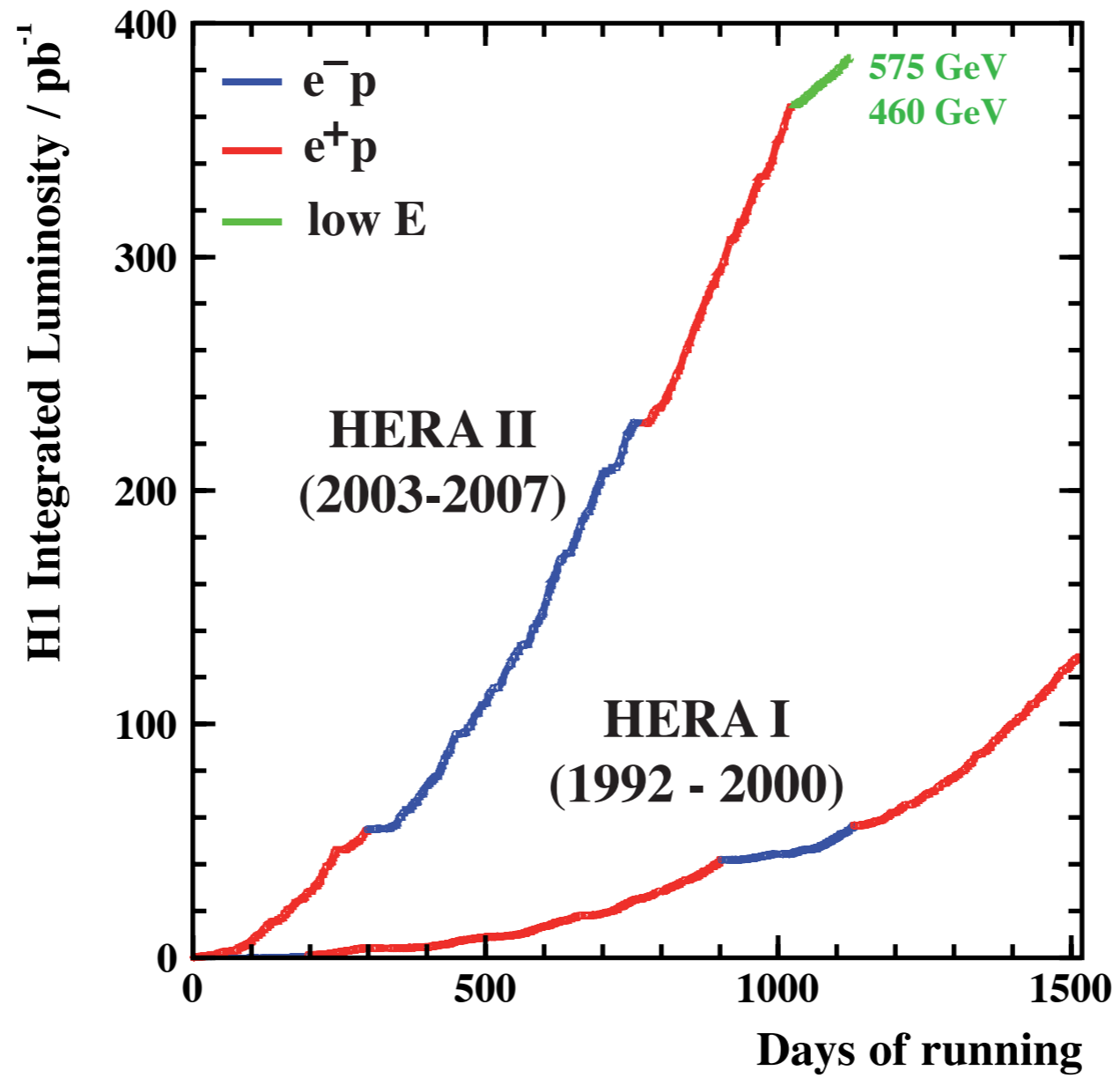
- At low Q^2 , the extrapolation of the NLO QCD fit predicts that F_L^D is approximately half the size of F_2^D
- The measurements are consistent with the extrapolation of Fit B

The diffractive longitudinal structure function

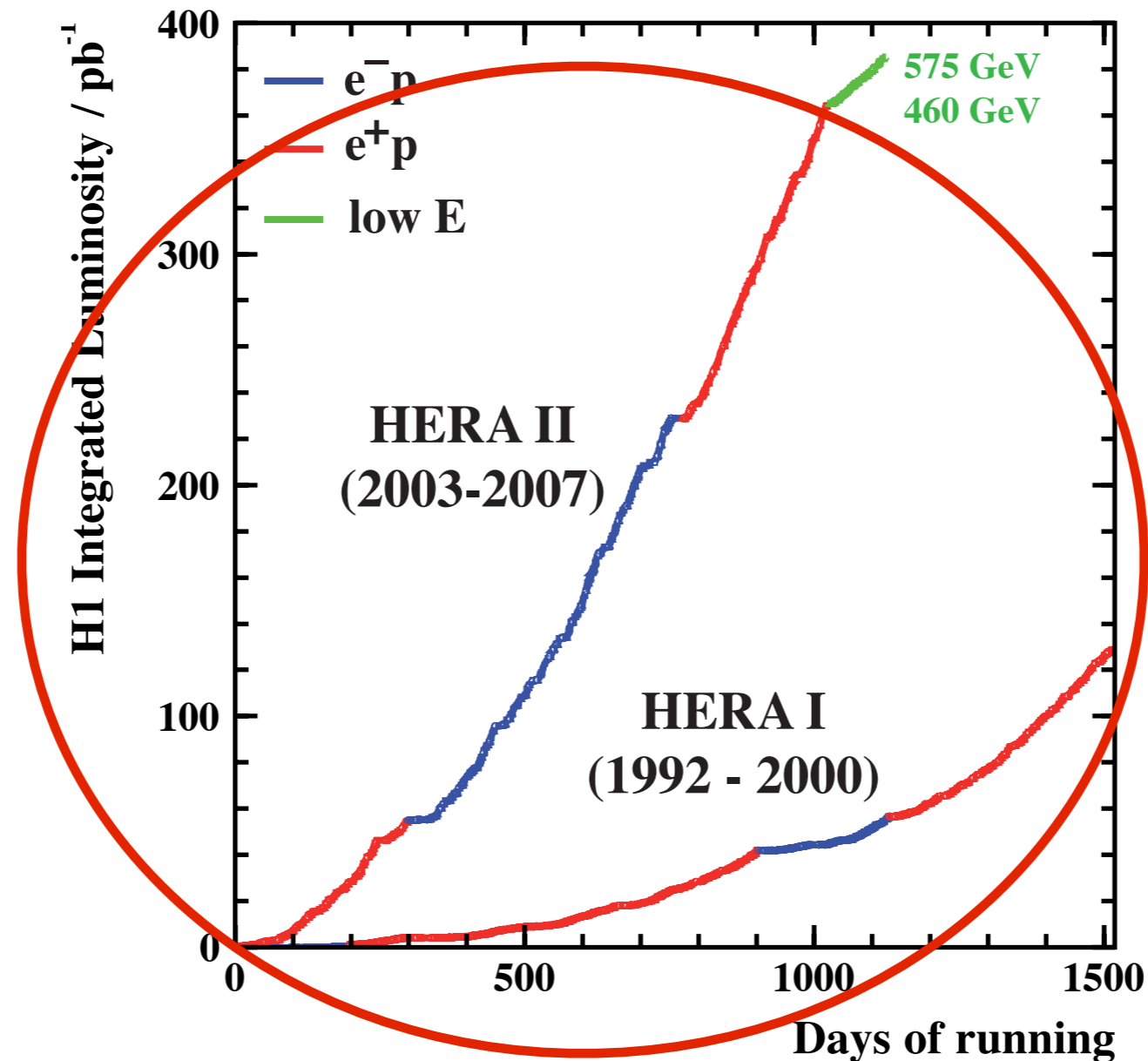


- The new measurements at low Q^2 , shown together with the previous measurement of F_L^D at medium Q^2
- The measurements are consistent with the extrapolation of Fit B

HI data

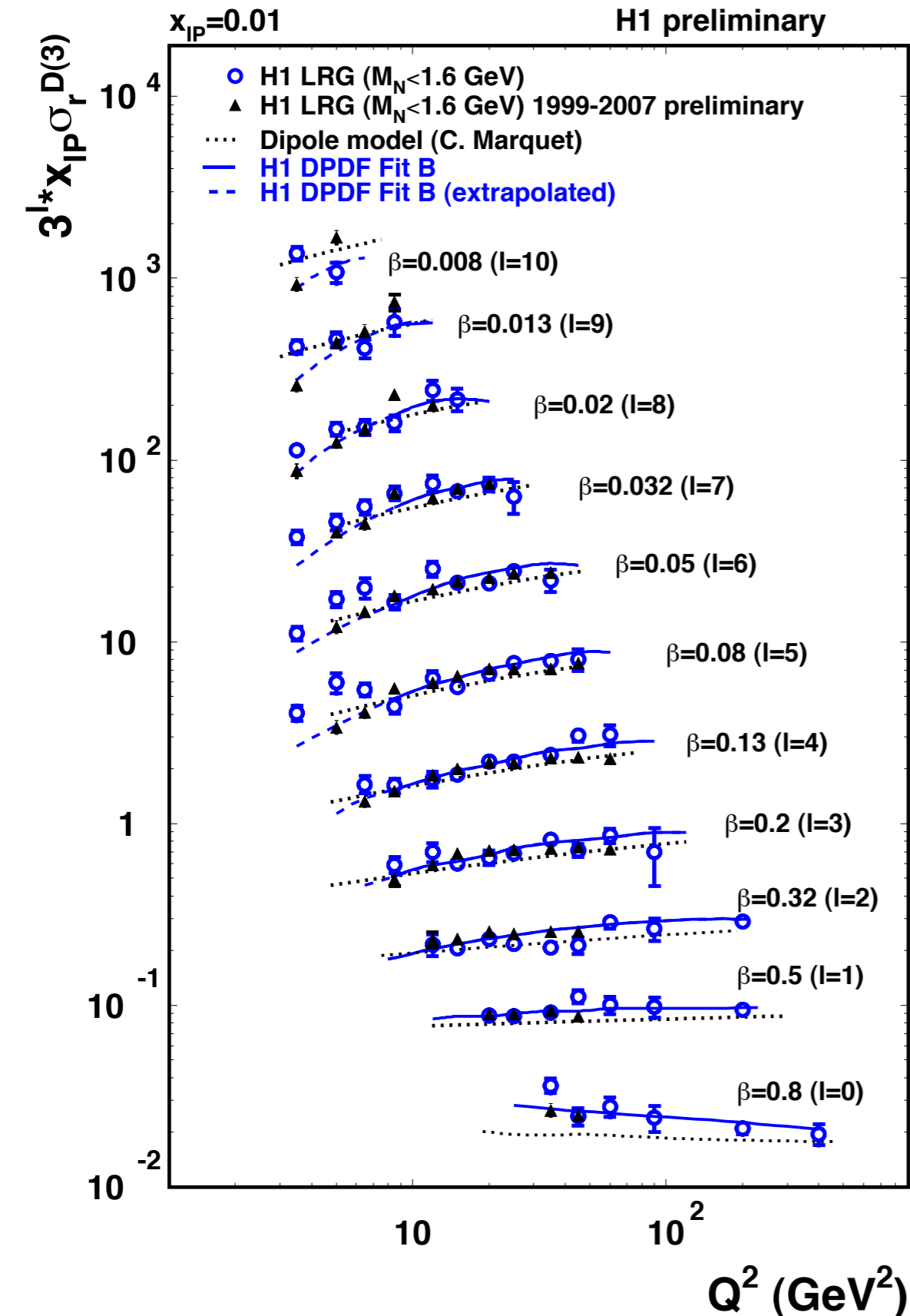


HI data



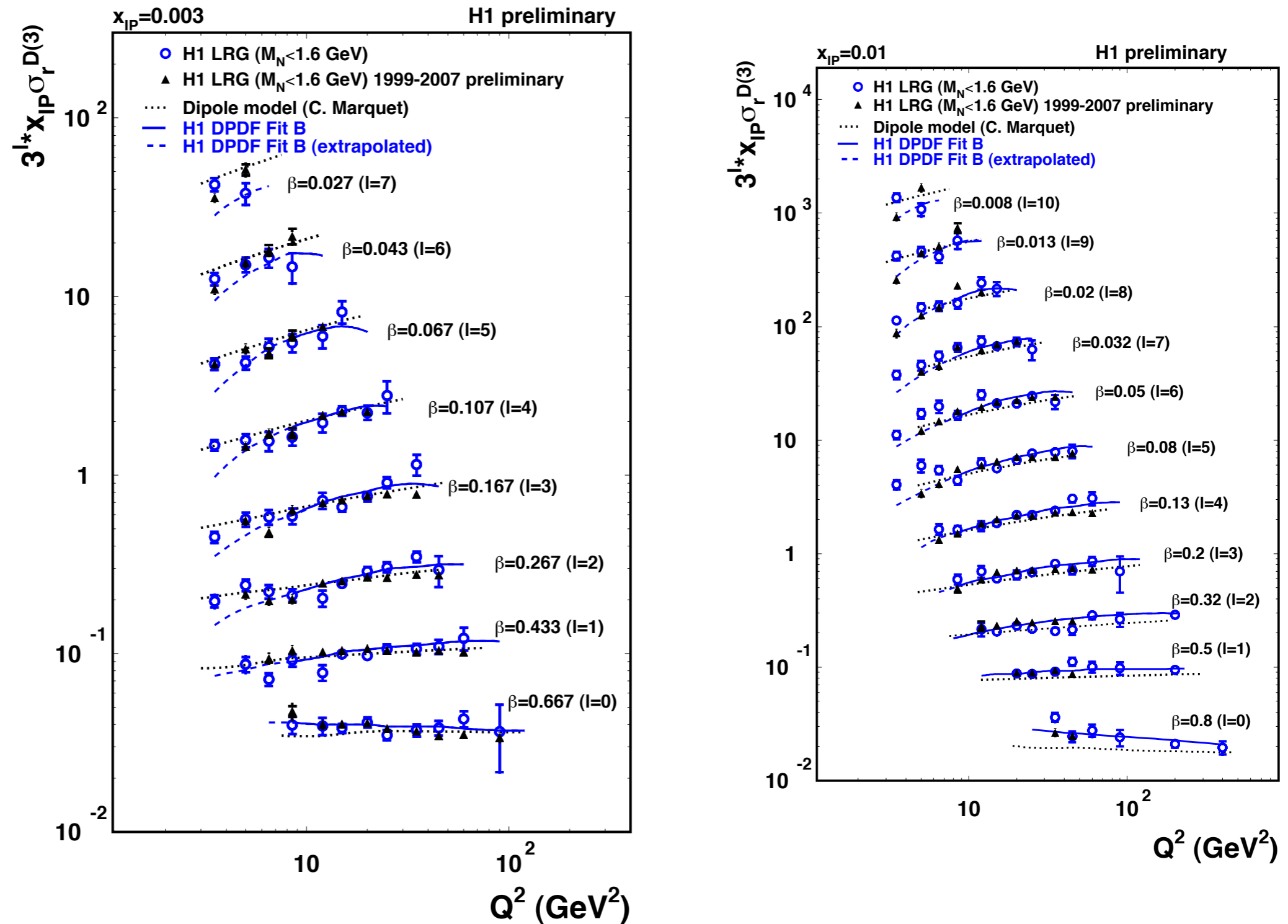
- The full HERA data sample, including both HERA I and HERA II datasets, has been analysed in order to measure σ_r^D to the best precision possible
- Question, can we also produce those classic scaling violation plots?

New H I LRG data - σ_r^D at fixed x_{IP}



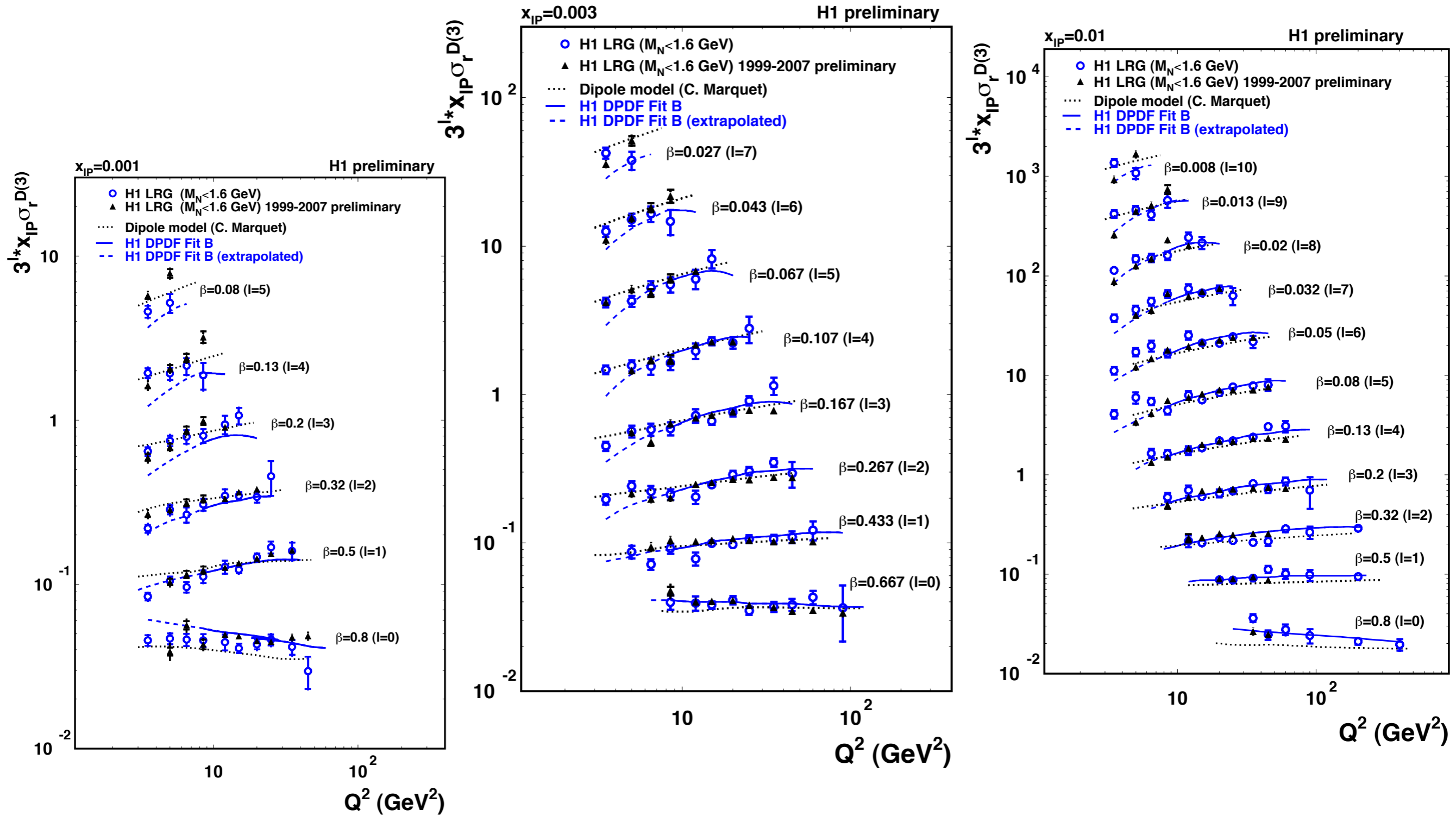
- The published data (**blue**) compared to the latest analysis of H I LRG data (**black**)
- The larger dataset allow a more precise extraction of the reduced cross section compared to the published data
- Very precise measurements of the classic scaling violations for diffraction

New HILRG data - σ_r^D at fixed x_{IP}



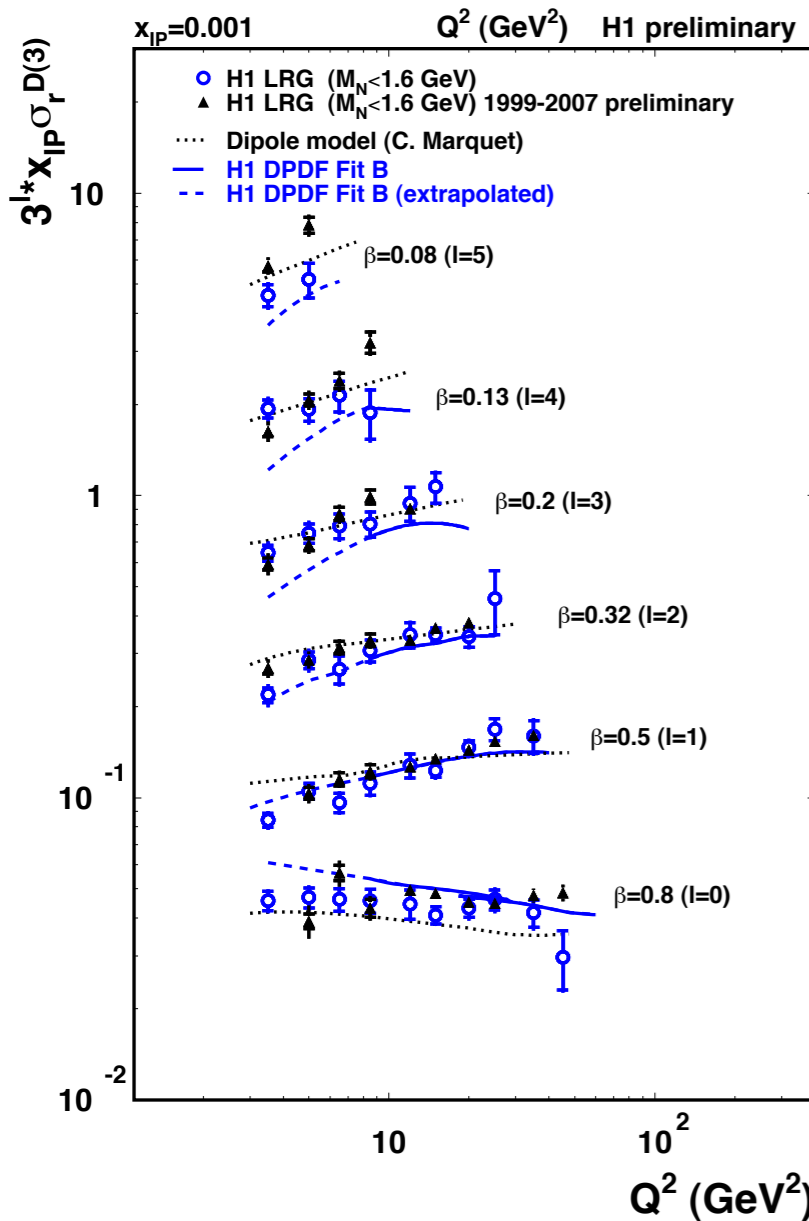
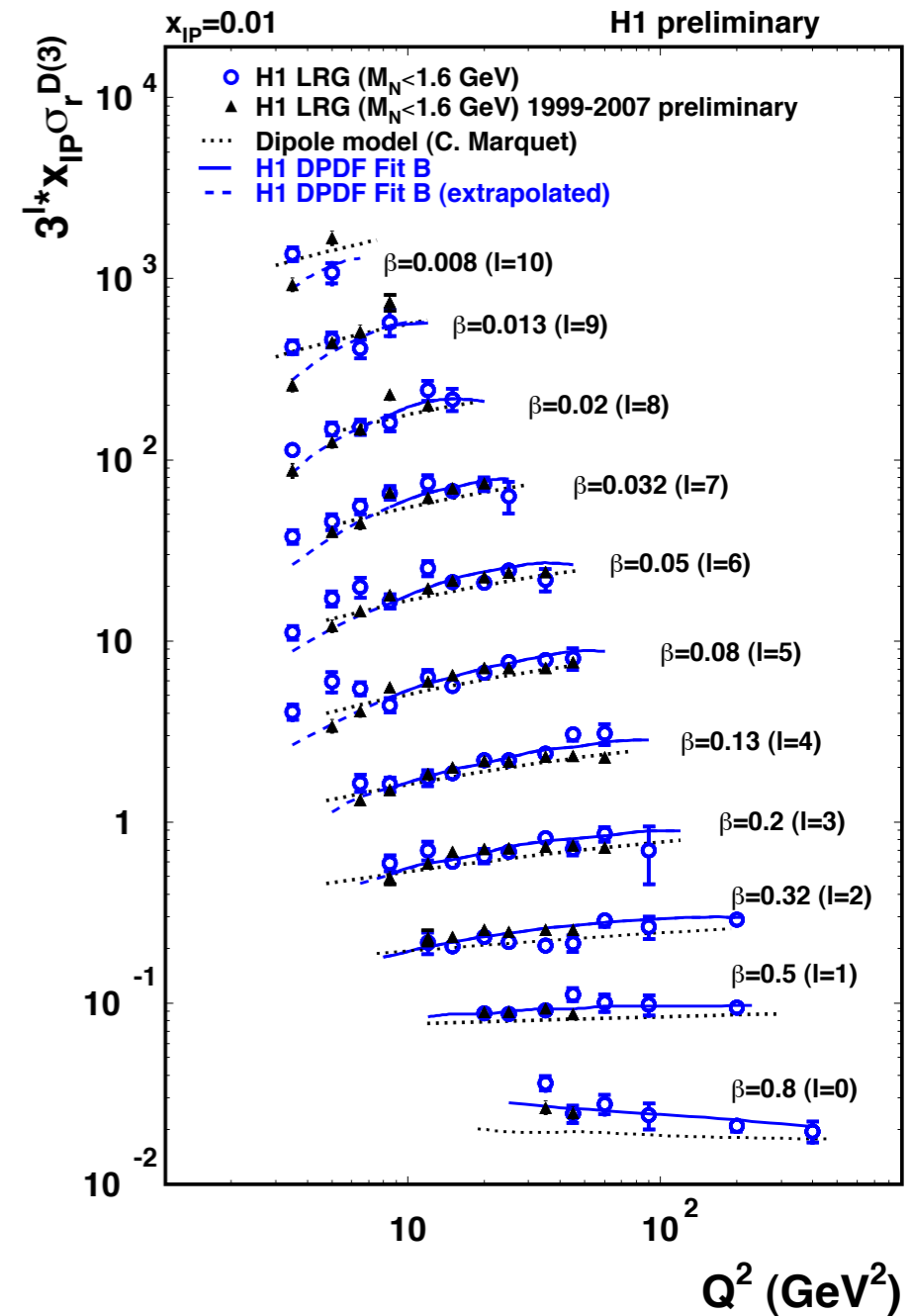
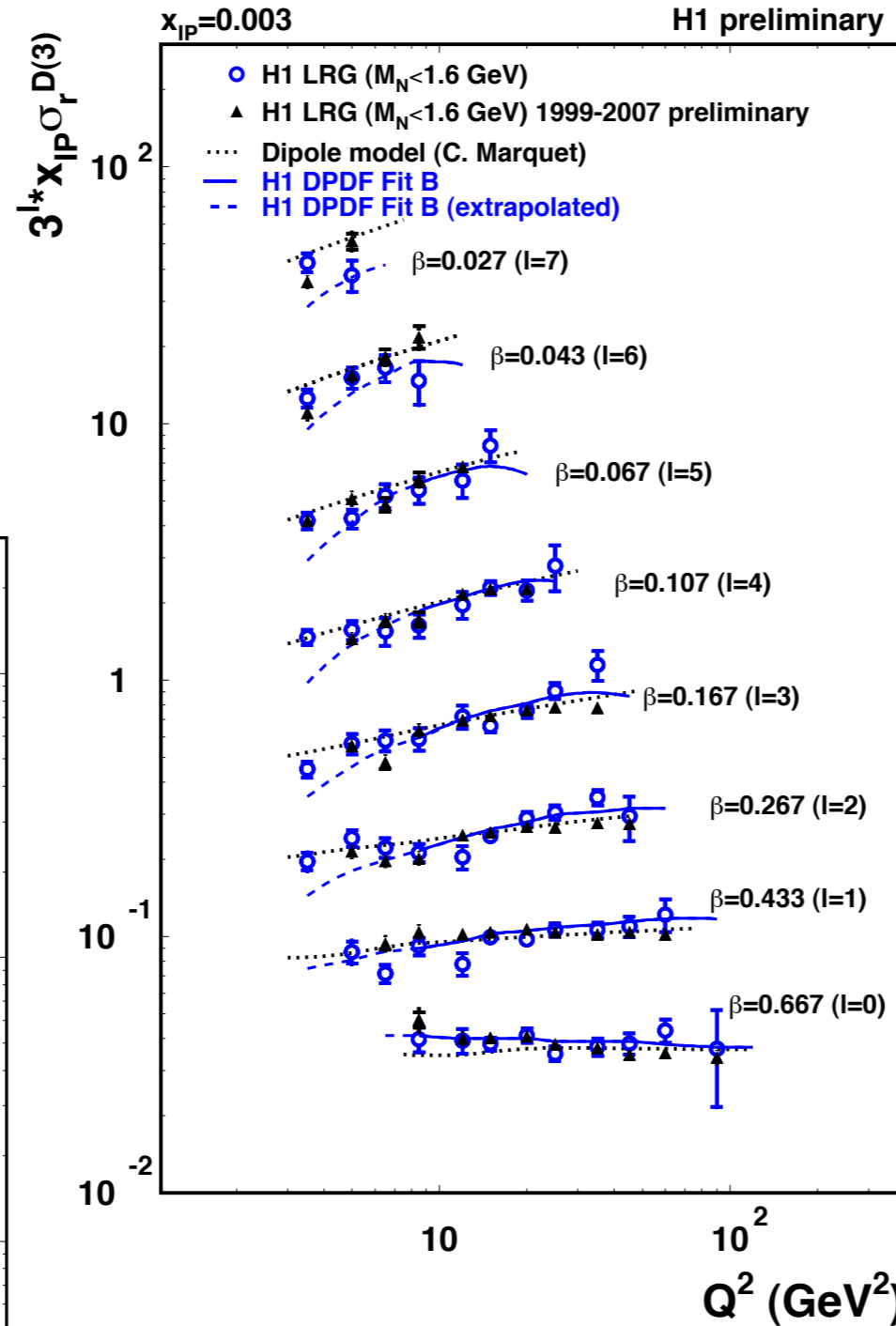
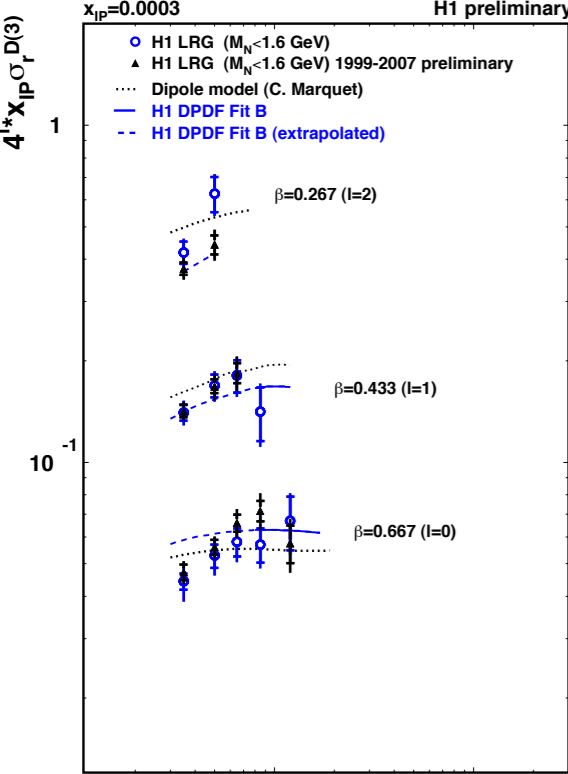
Similarly good precision in the next lowest x_{IP} bin

New H I LRG data - σ_r^D at fixed x_{IP}



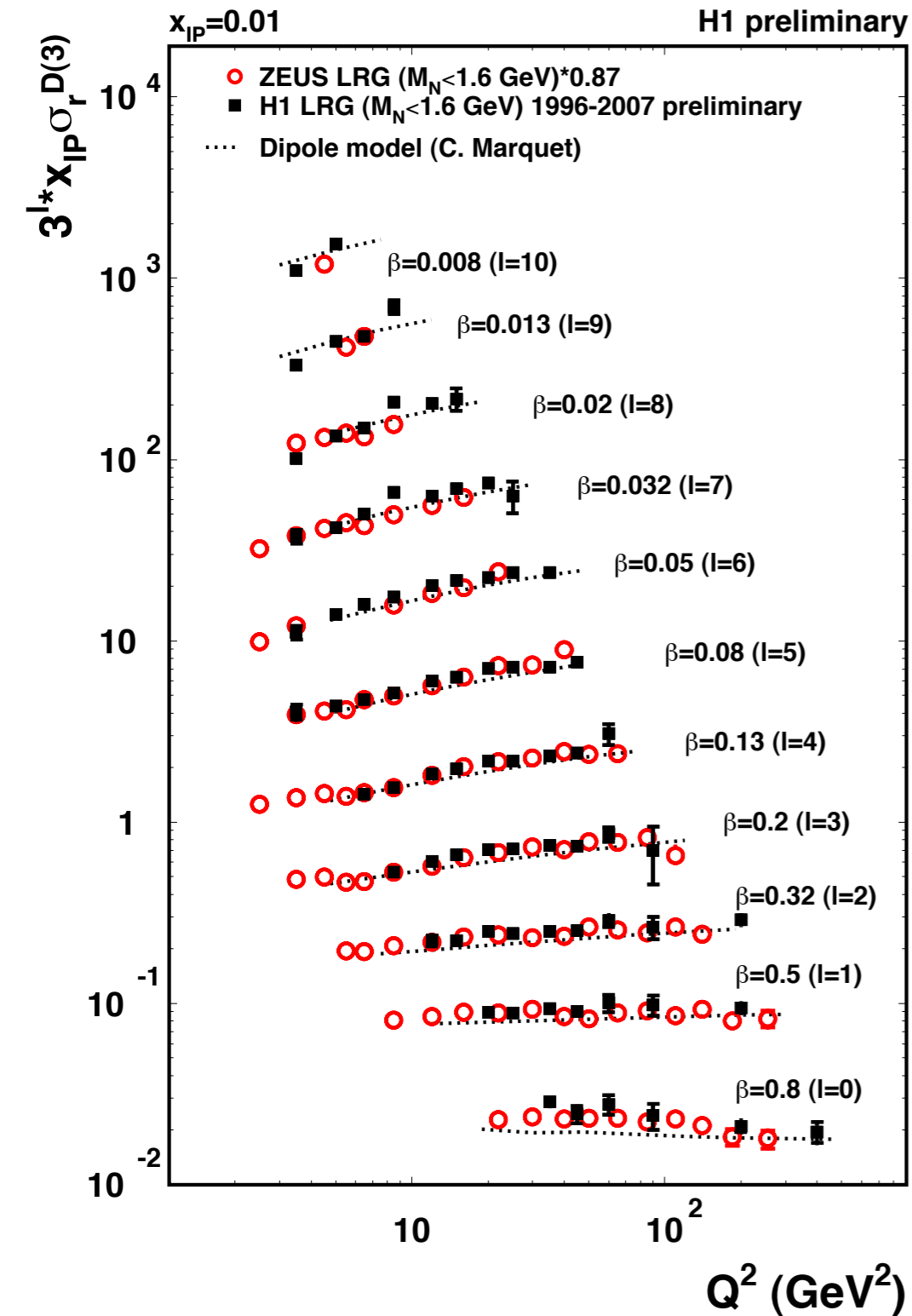
... and lower x_{IP} ...

New H1LRG data - σ_r^D at fixed x_{IP}



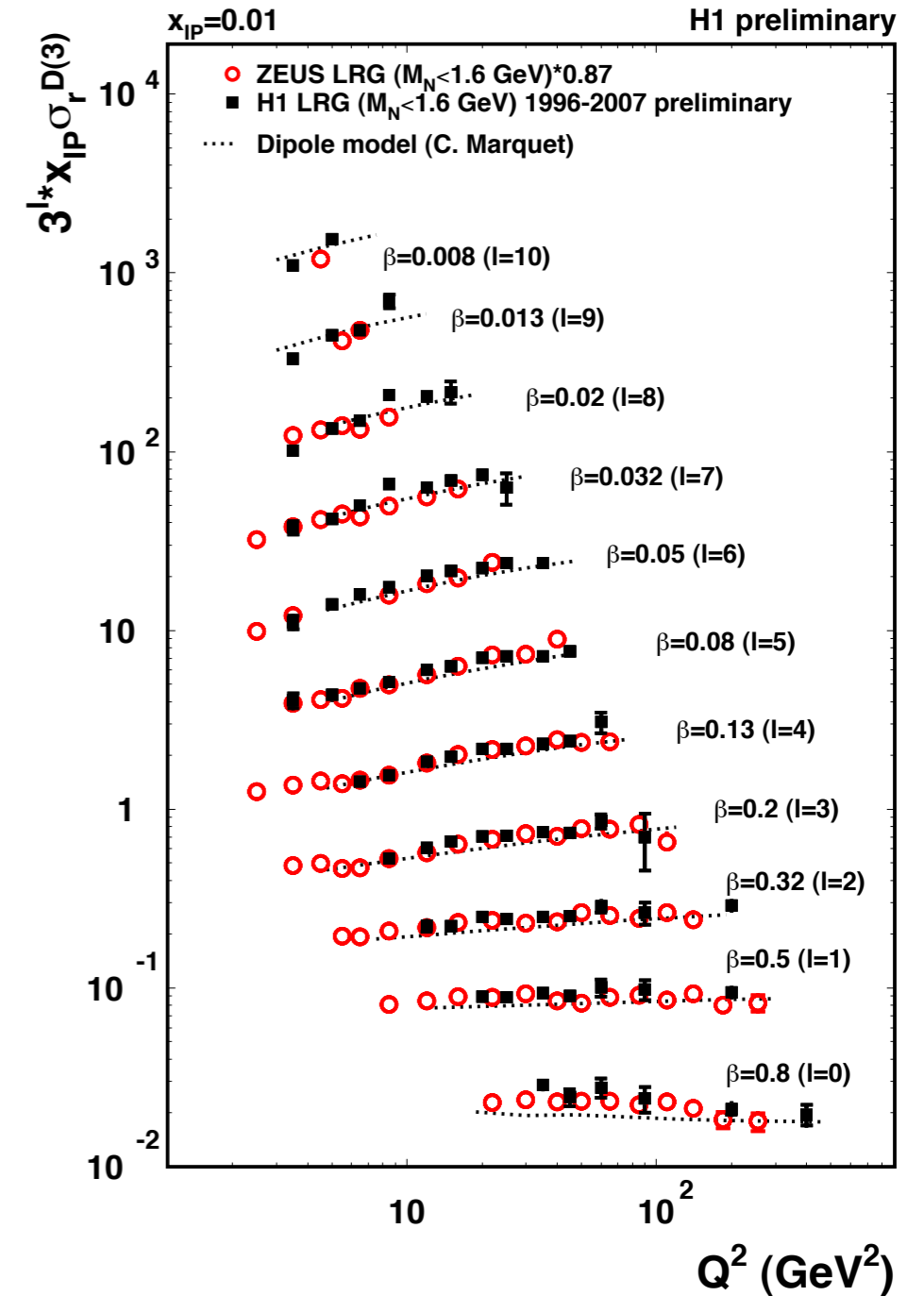
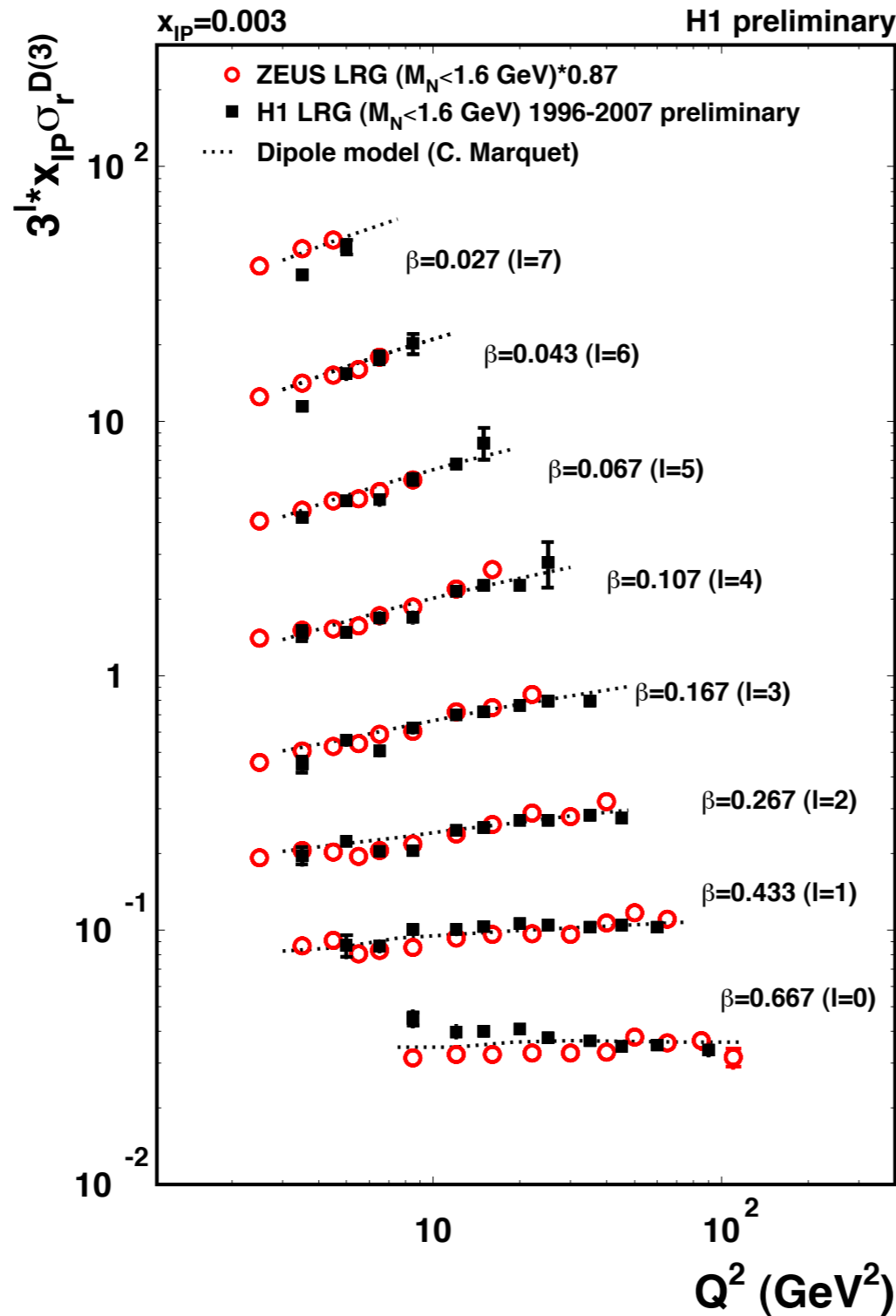
Beautifully consistent data → combine using weighted average

σ_r^D at fixed x_{IP} H I and Zeus



- The new H I LRG data has been combined with the published data to create **one combined H I LRG dataset**
- Compare H I LRG data (**black**) to the published Zeus data (**red**) which is scaled by the “known” factor of 0.87
- Apart from the normalisation discrepancy, which is (just) consistent within large normalisation uncertainties...
- ...H I and Zeus LRG data are in good agreement

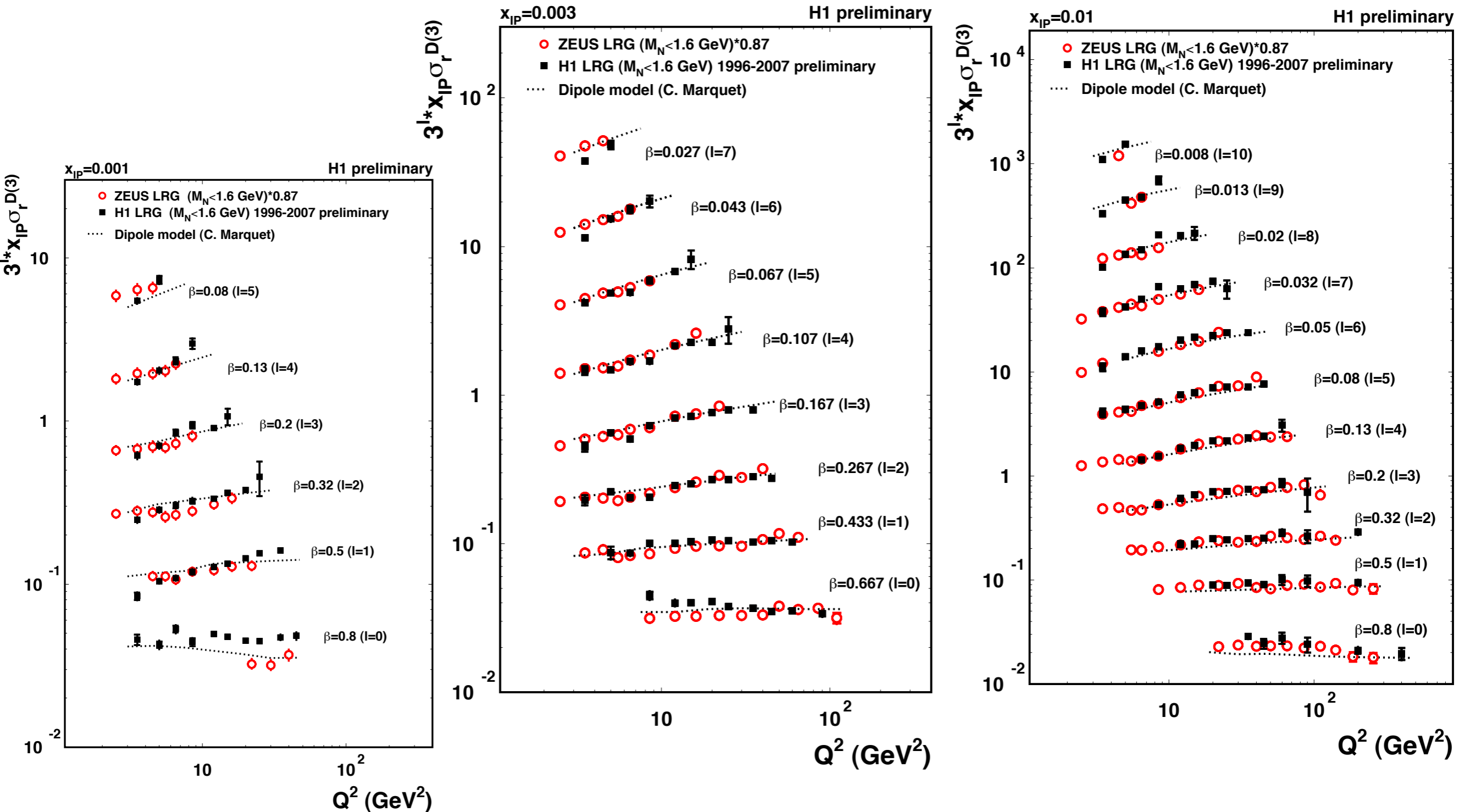
σ_r^D at fixed x_{IP} H1 and Zeus



Good agreement between two high precision measurements

Differences to understand at high beta

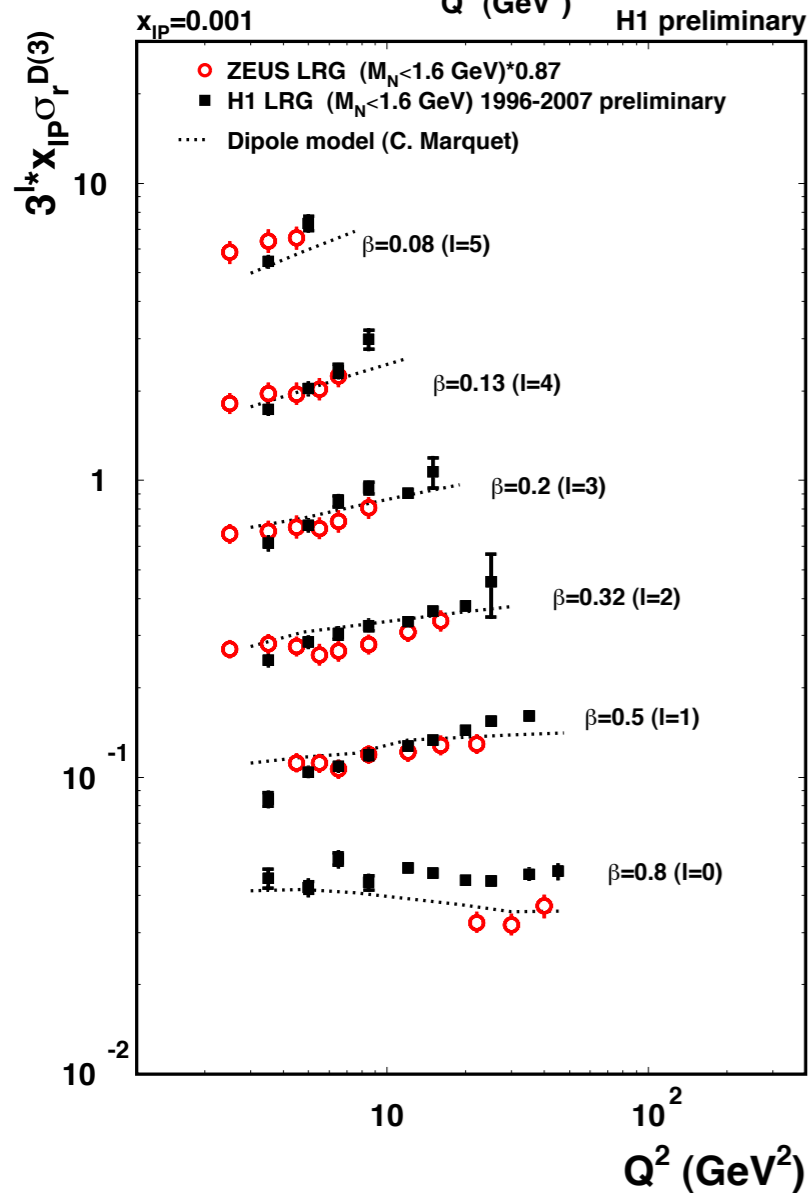
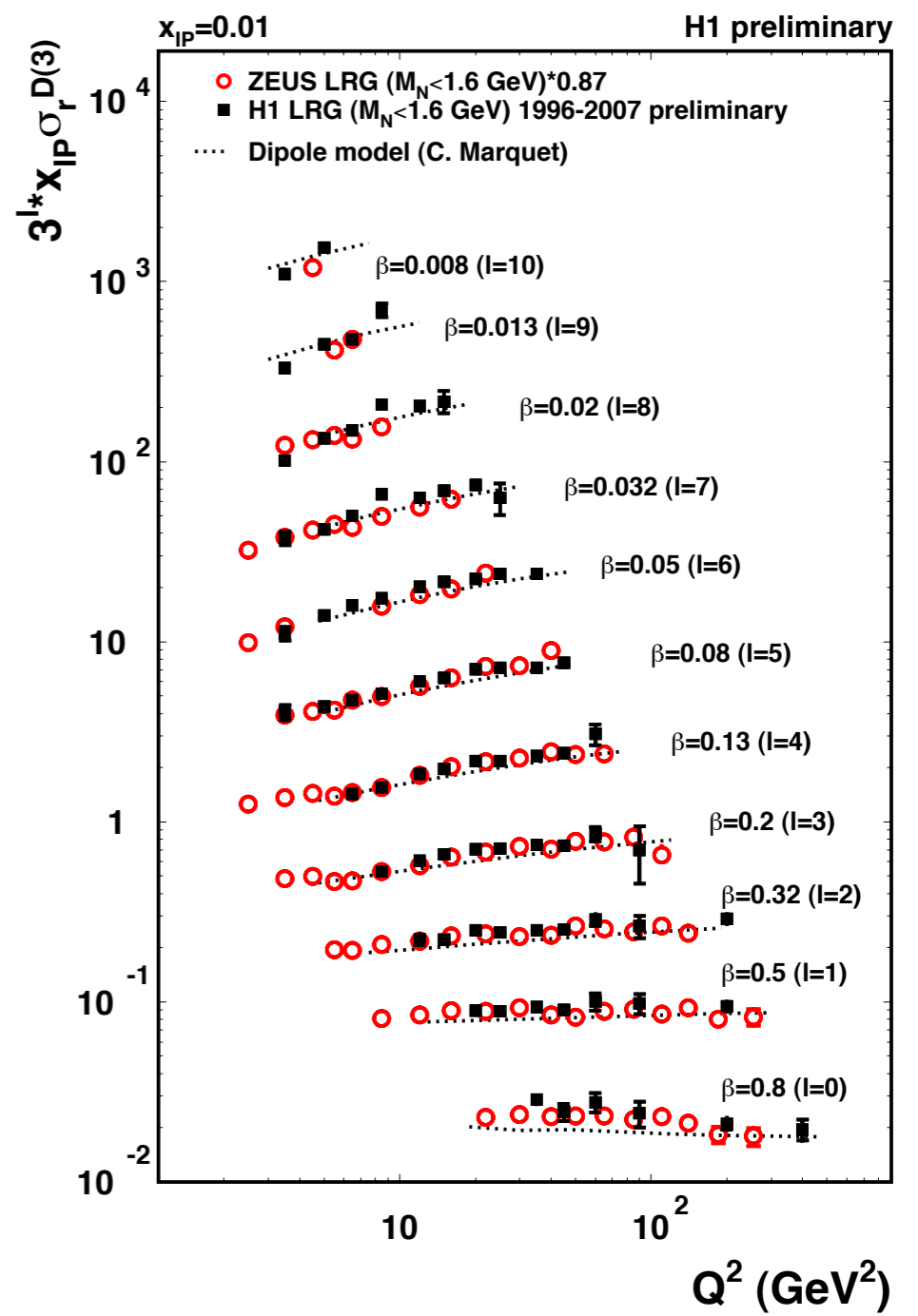
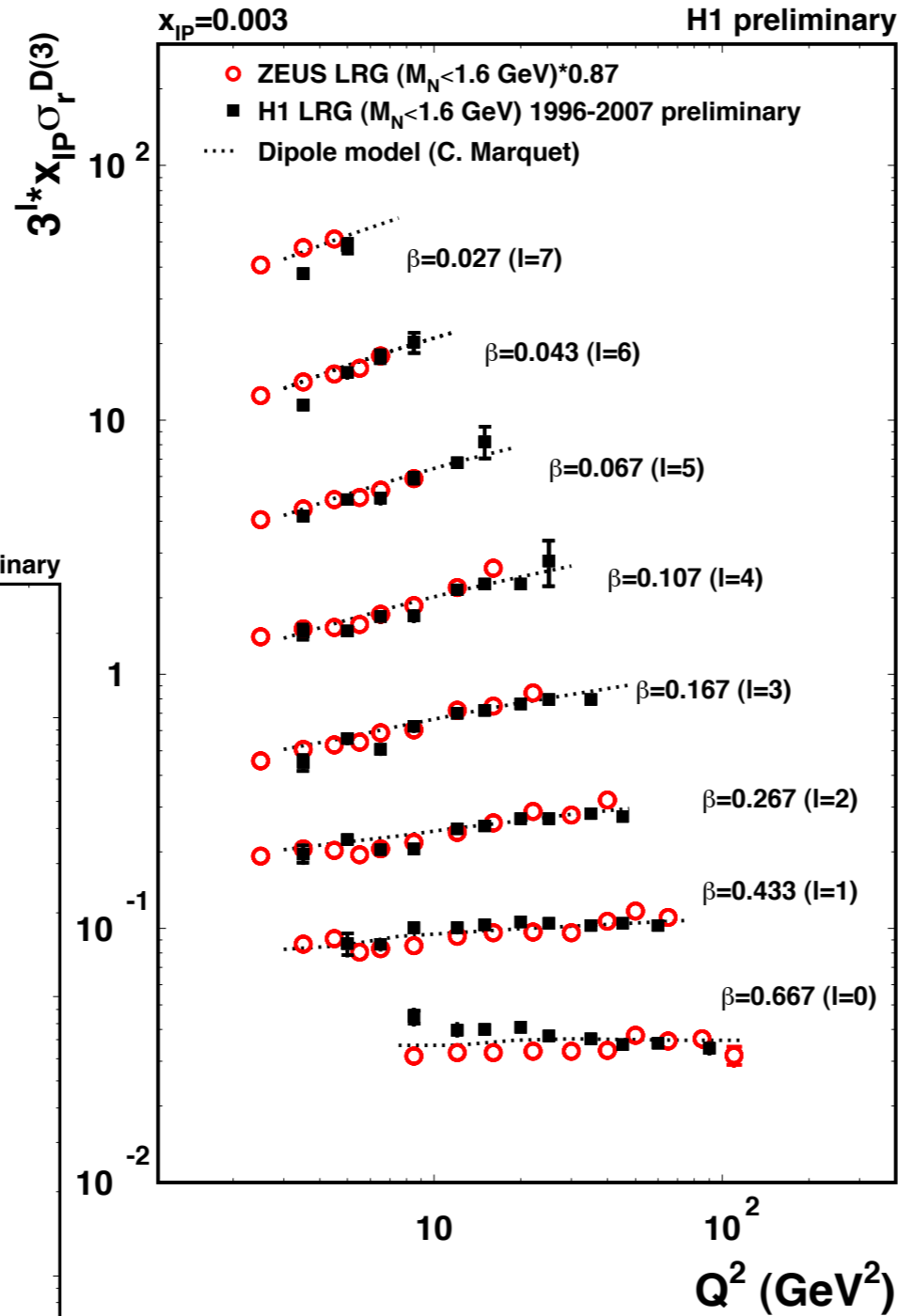
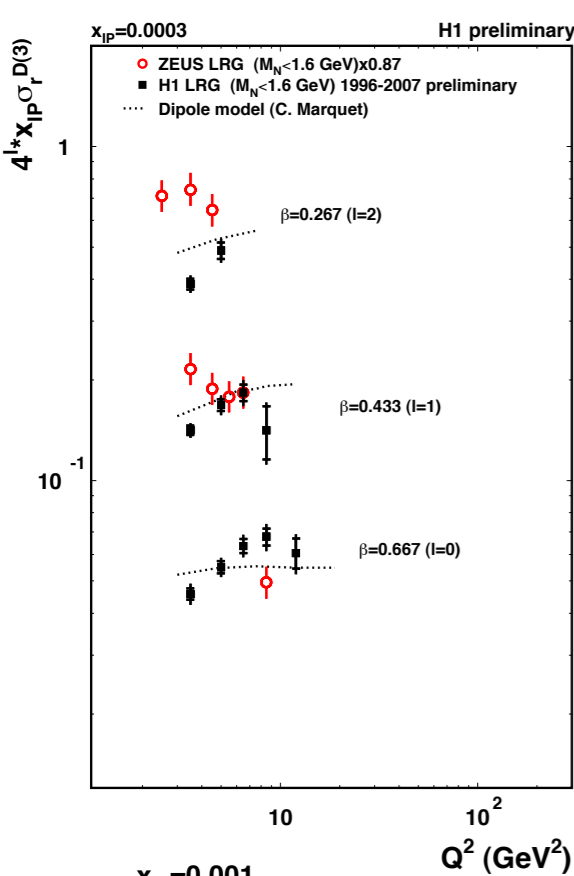
σ_r^D at fixed x_{IP} H1 and Zeus



Good agreement between two high precision measurements

Differences to understand at high beta

σ_r^D at fixed x_{IP} H1 and Zeus



Good agreement between two high precision measurements

Summary

- New measurements of the inclusive diffractive DIS cross section at low Q^2 ($Q^2 > 2.5 \text{ GeV}^2$) and high y , using the low ($E_p = 460 \text{ GeV}$) and medium ($E_p = 575 \text{ GeV}$) energy runs from HERA have been presented
- The diffractive longitudinal structure function measurement at H1 has been extended to low Q^2
- The new results are in good agreement with the NLO QCD picture of diffraction, where F_L^D is approximately half the size of F_2^D
- **The new results together with the result at medium Q^2 provide a more compelling confirmation of the NLO QCD picture of diffraction**
- Inclusive diffractive DIS studied in H1 using Hera I and Hera II data
- Good agreement with the published data
- ***One precise combined H1 LRG dataset***

- Backup slides