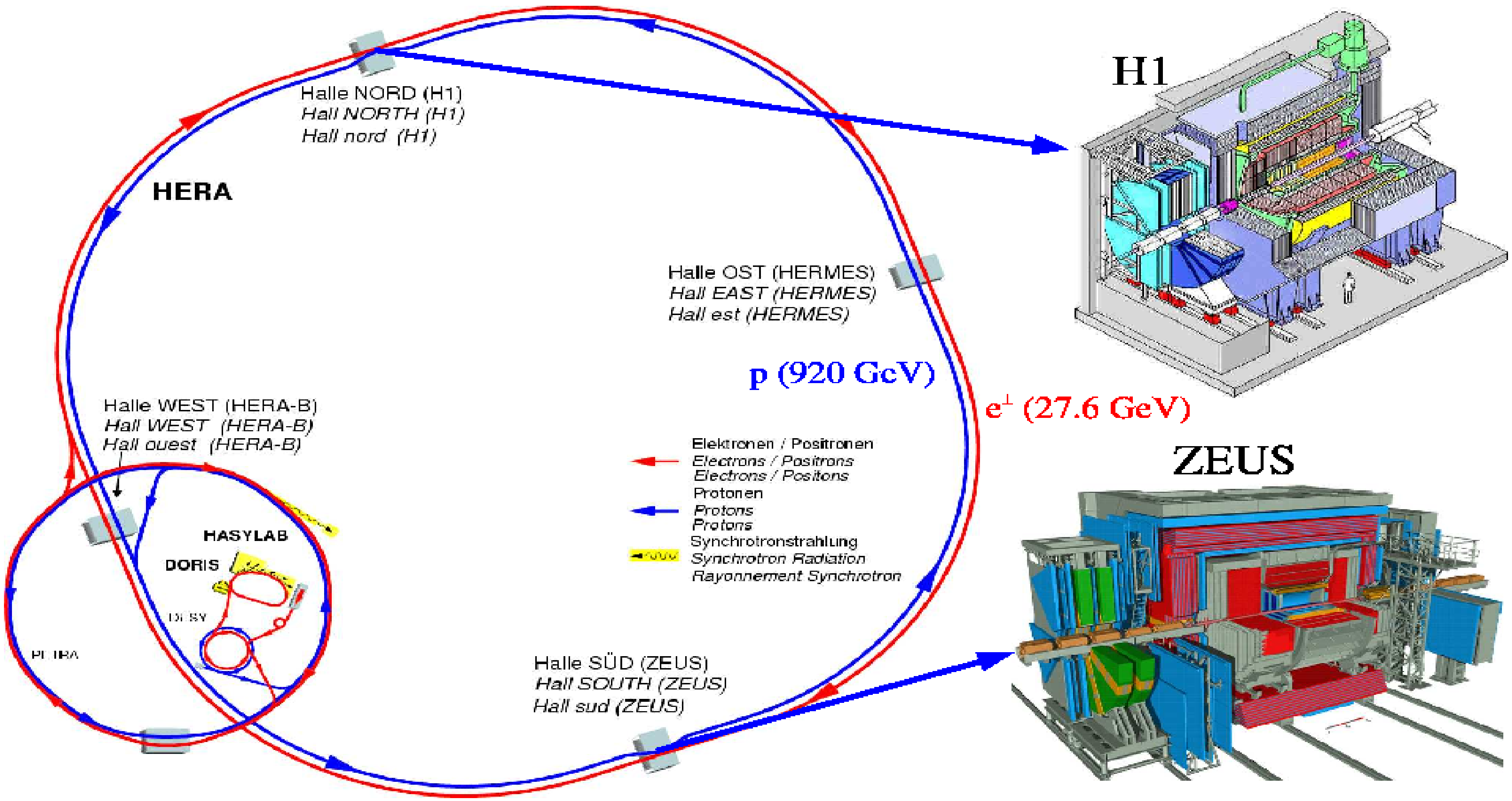
The Diffractive Structure Functions from Large Rapidity Gap Data at H1

Paul Laycock
Wednesday 21st April 2010
DIS XVIII, Firenze

- HERA datasets
- Diffractive DIS
- FLD
- F2D

HERA, collider experiments and data



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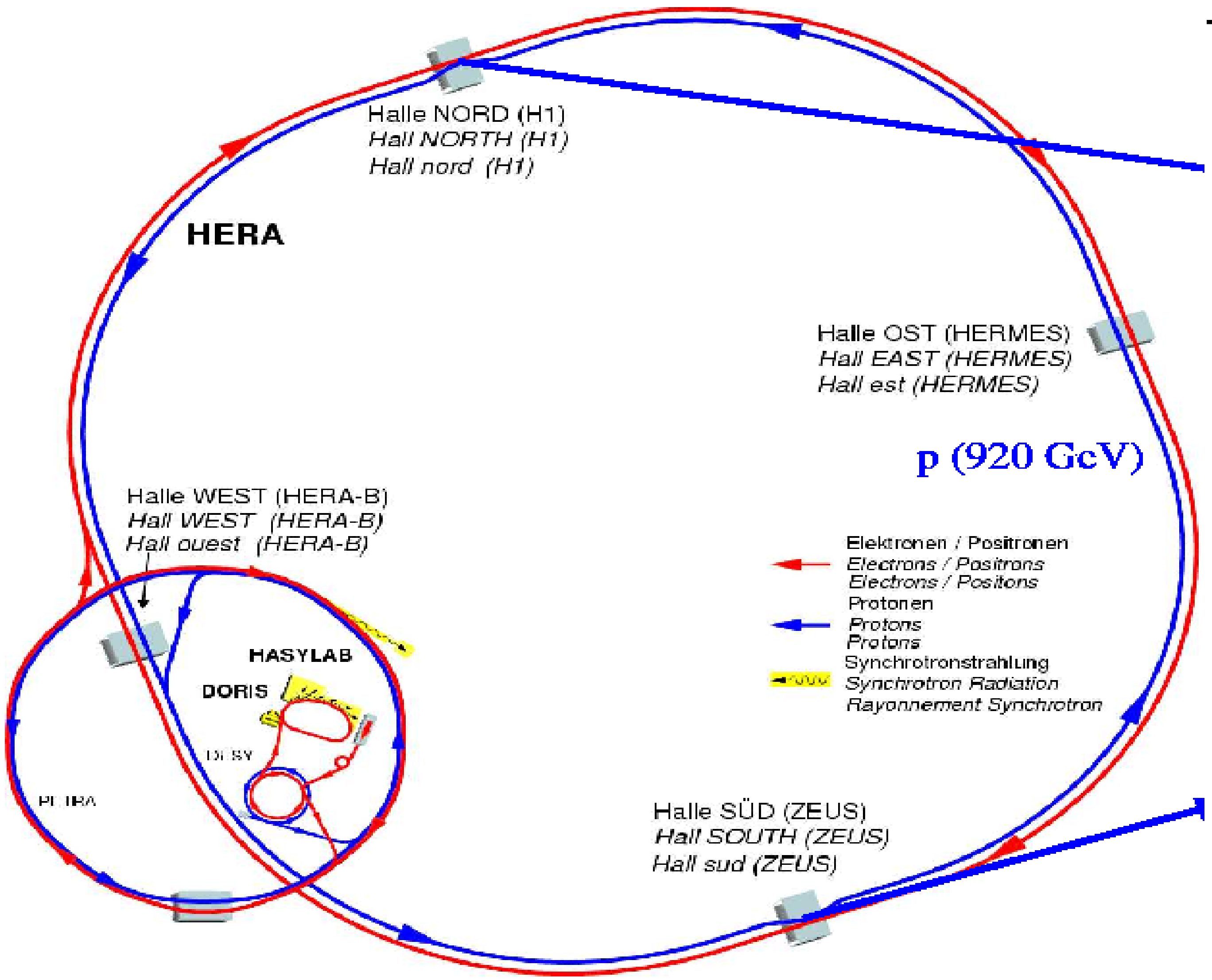
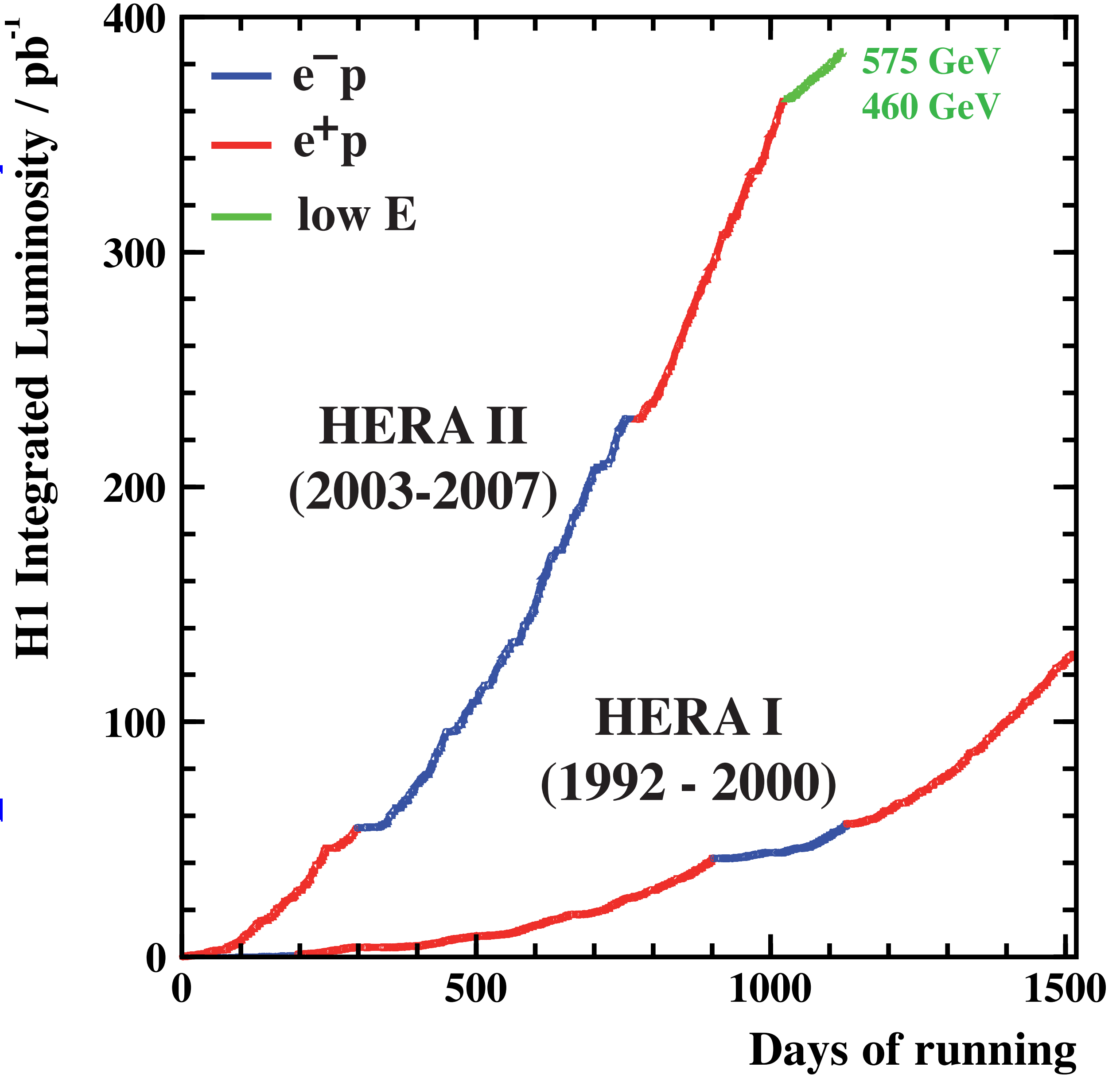
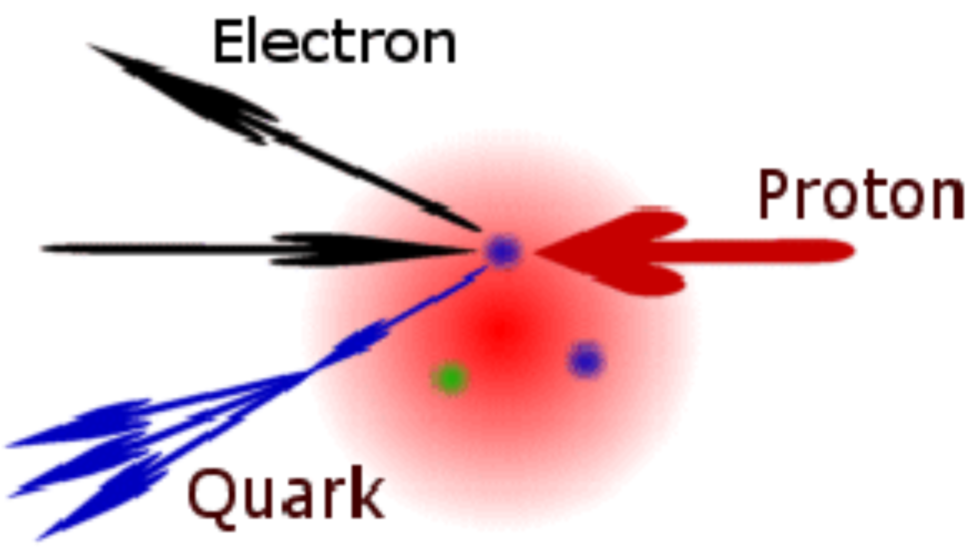
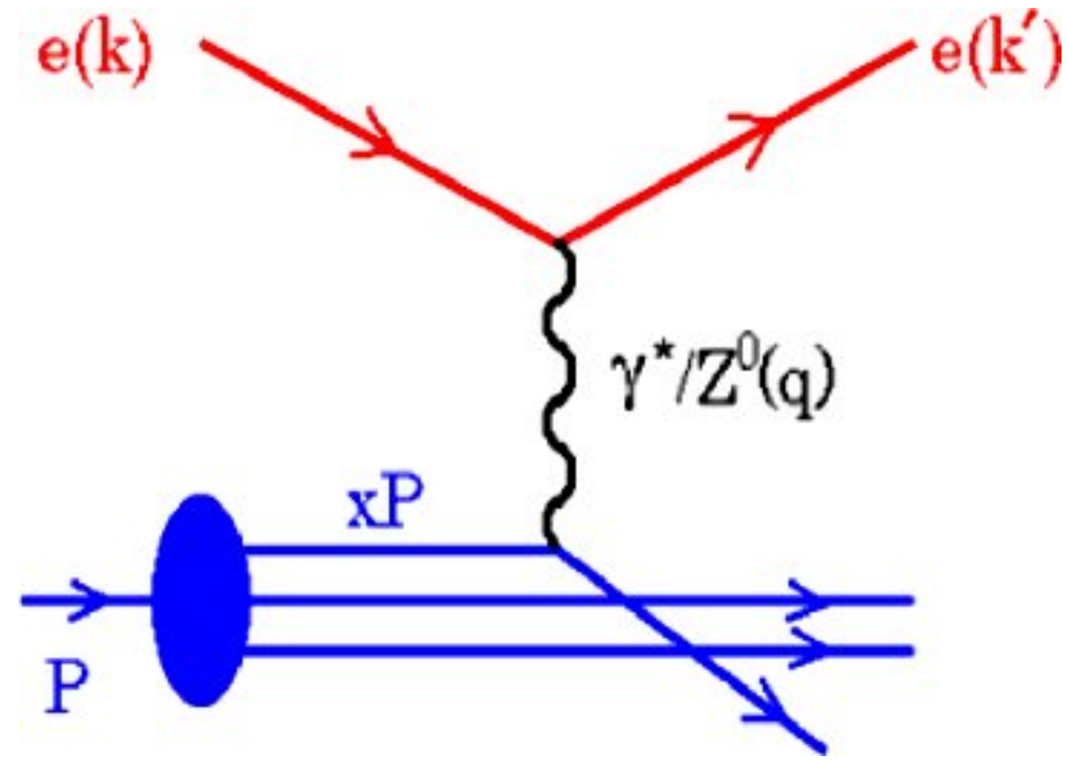




- The unique HERA machine collided 27.5 GeV electrons or positrons with protons of 460, 575, 820 and 920 GeV providing 0.5 fb^{-1} to H1 and Zeus
- The final precision analyses of this data are being delivered

Deep inelastic Scattering



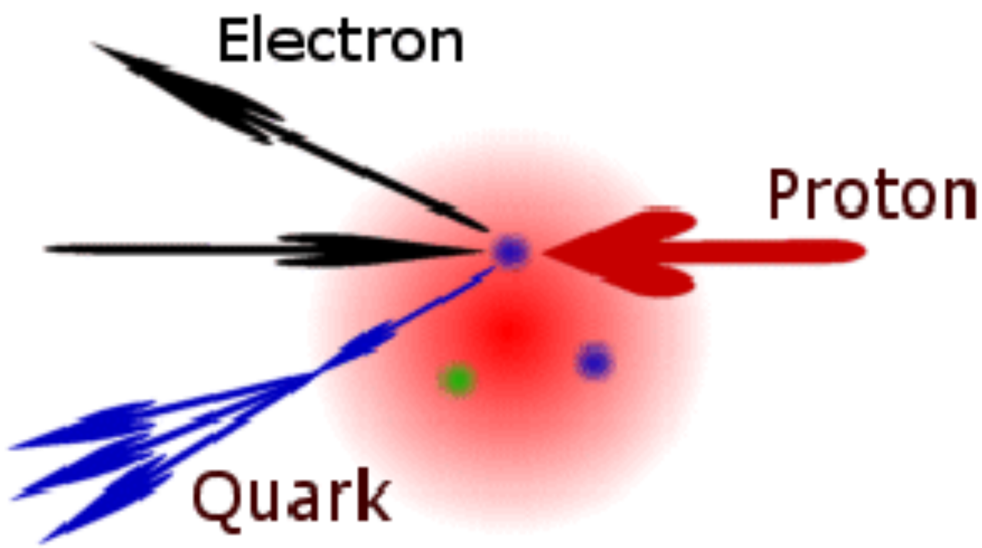


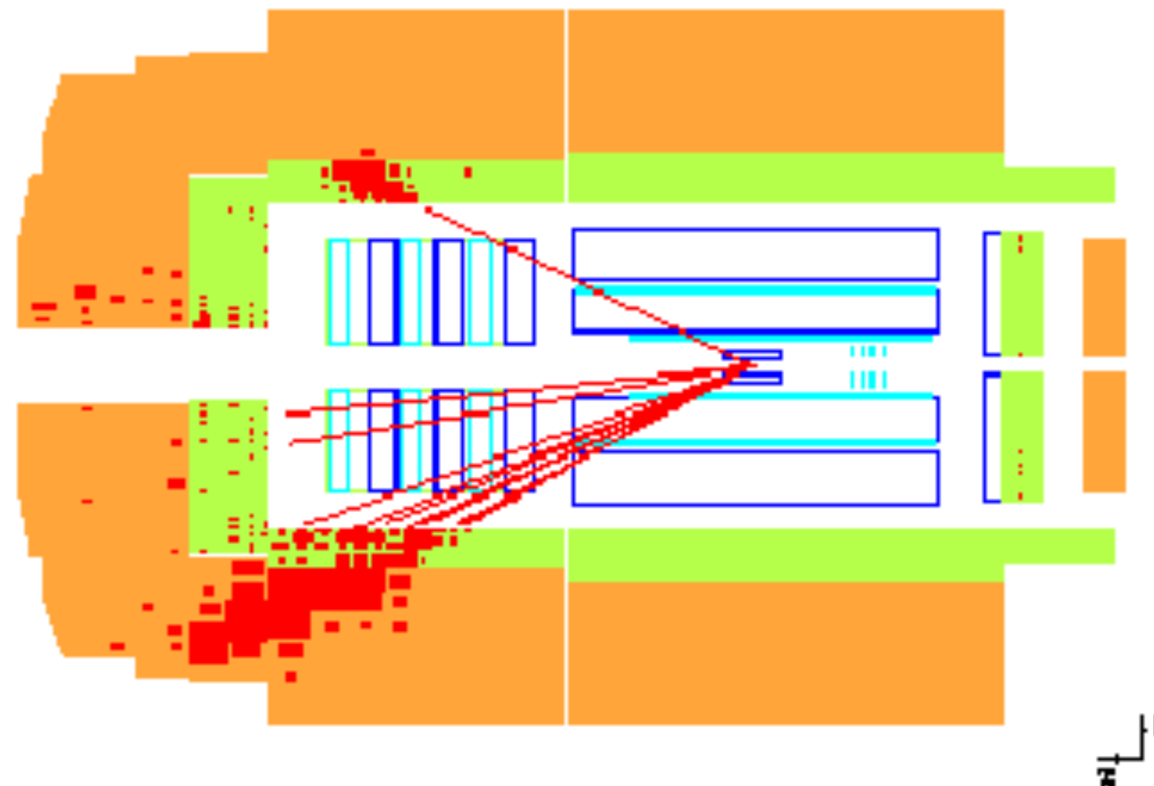
$$Q^2 = -q^2 = -(k-k')^2$$ *Virtuality / resolving power of the photon*

$$x = \frac{Q^2}{2p\cdot q}$$ *Momentum fraction of the struck quark*

$$y = \frac{p\cdot q}{p\cdot k}$$ *Inelasticity of the event*

Deep inelastic Scattering



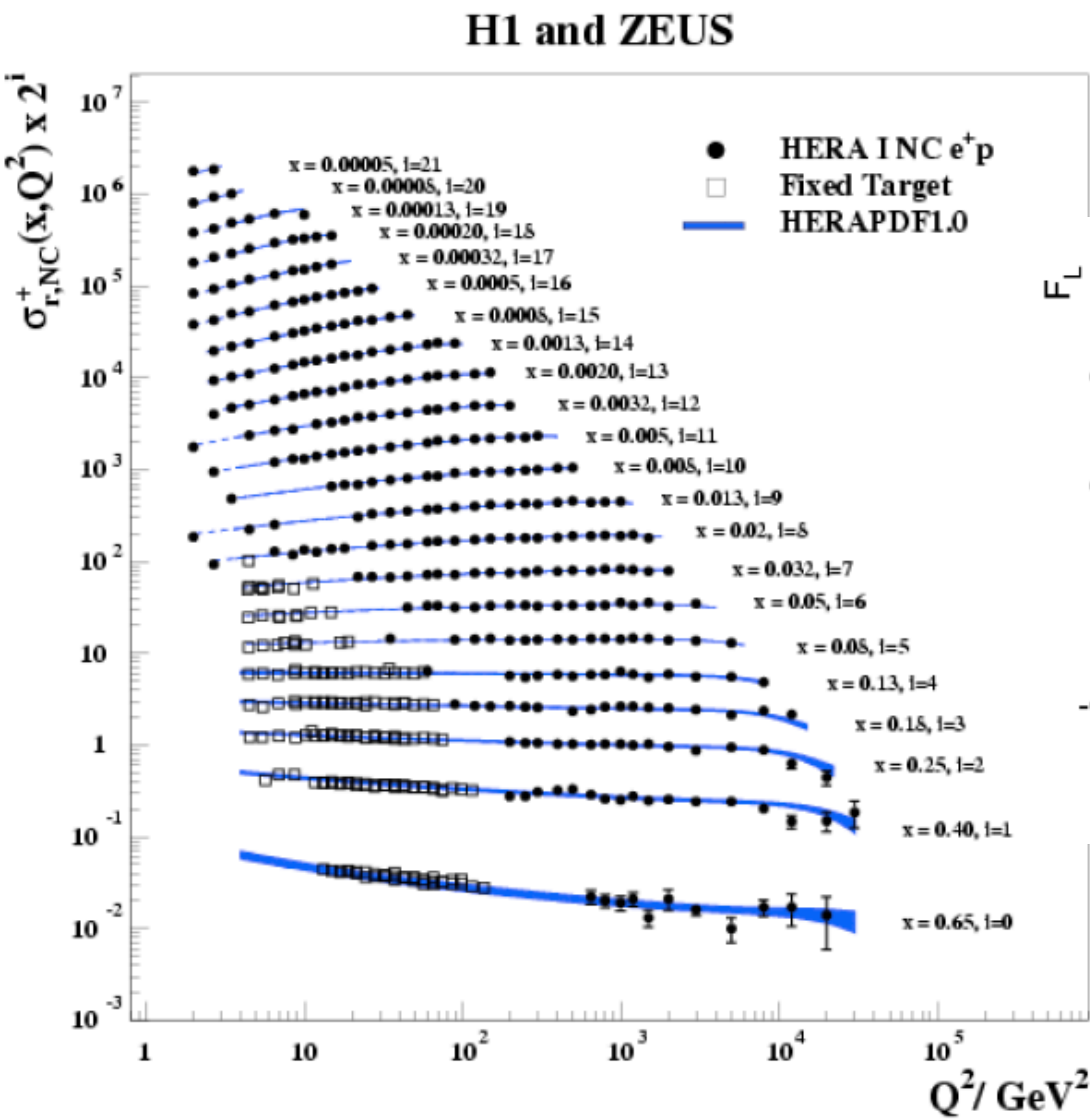


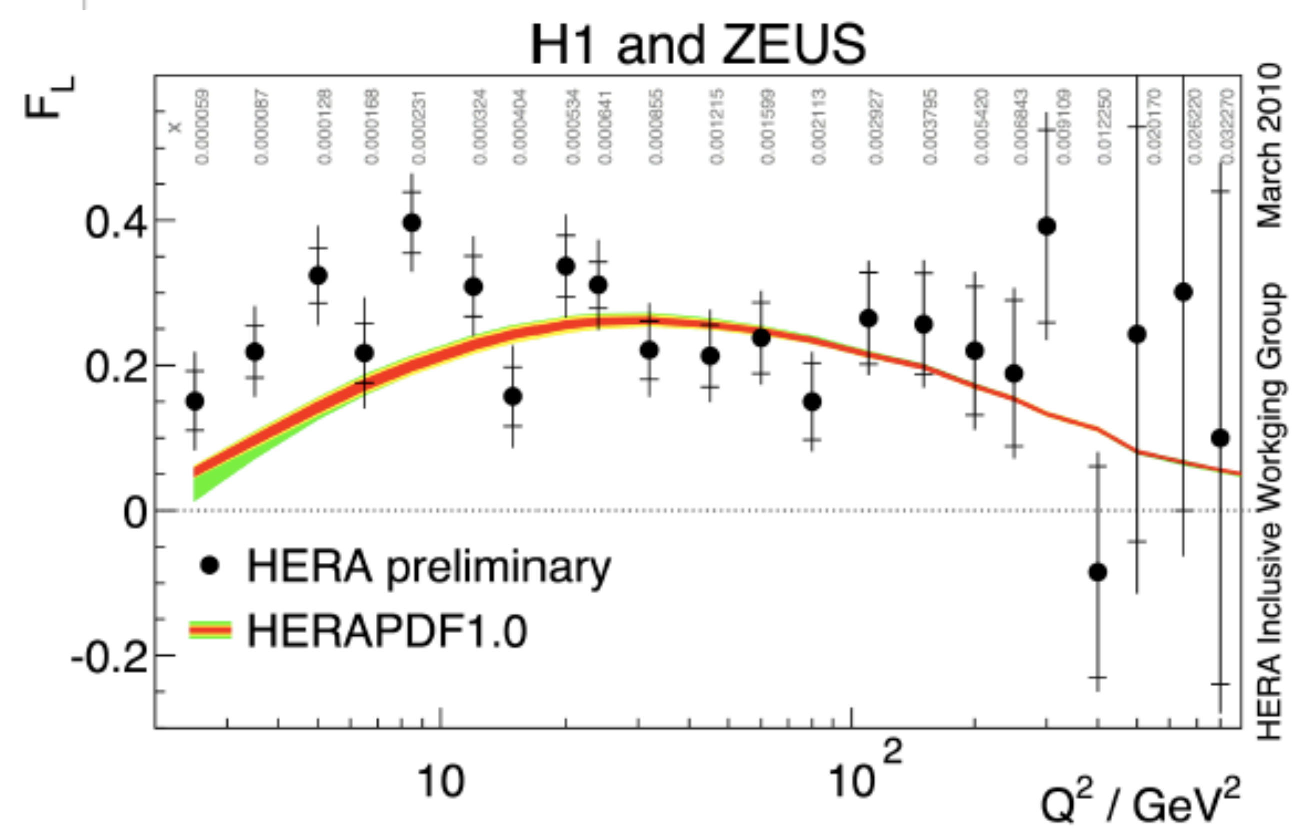
Measure: $$\frac{d^2\sigma^{ep}_{NC}}{dx dQ^2} = \frac{2\pi\alpha^2 Y_+}{xQ^4}\left(F_2(x,Q^2) - \frac{y^2}{Y_+}F_L(x,Q^2)\right)$$

Extract:

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

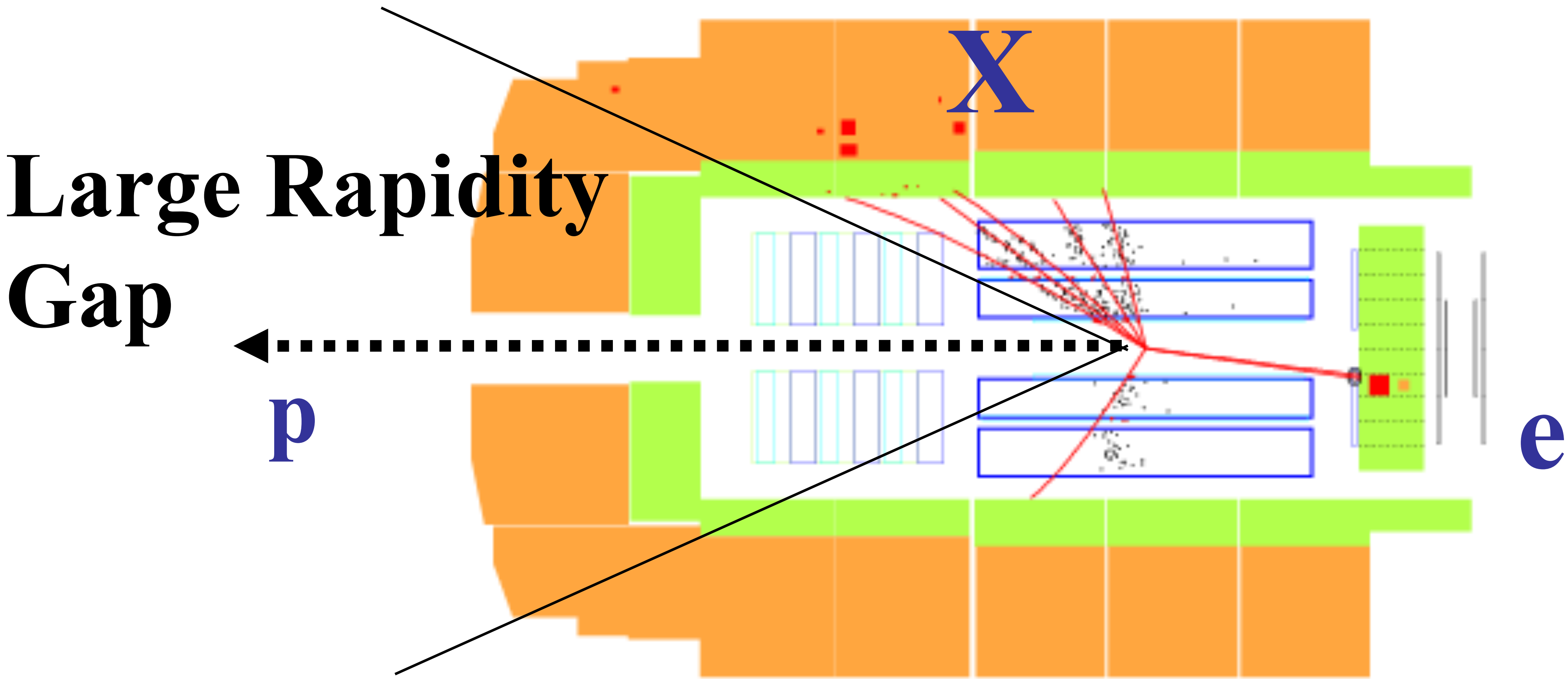
Inclusive F2 and FL





- Target is to repeat this for diffraction

Diffractive Deep Inelastic Scattering



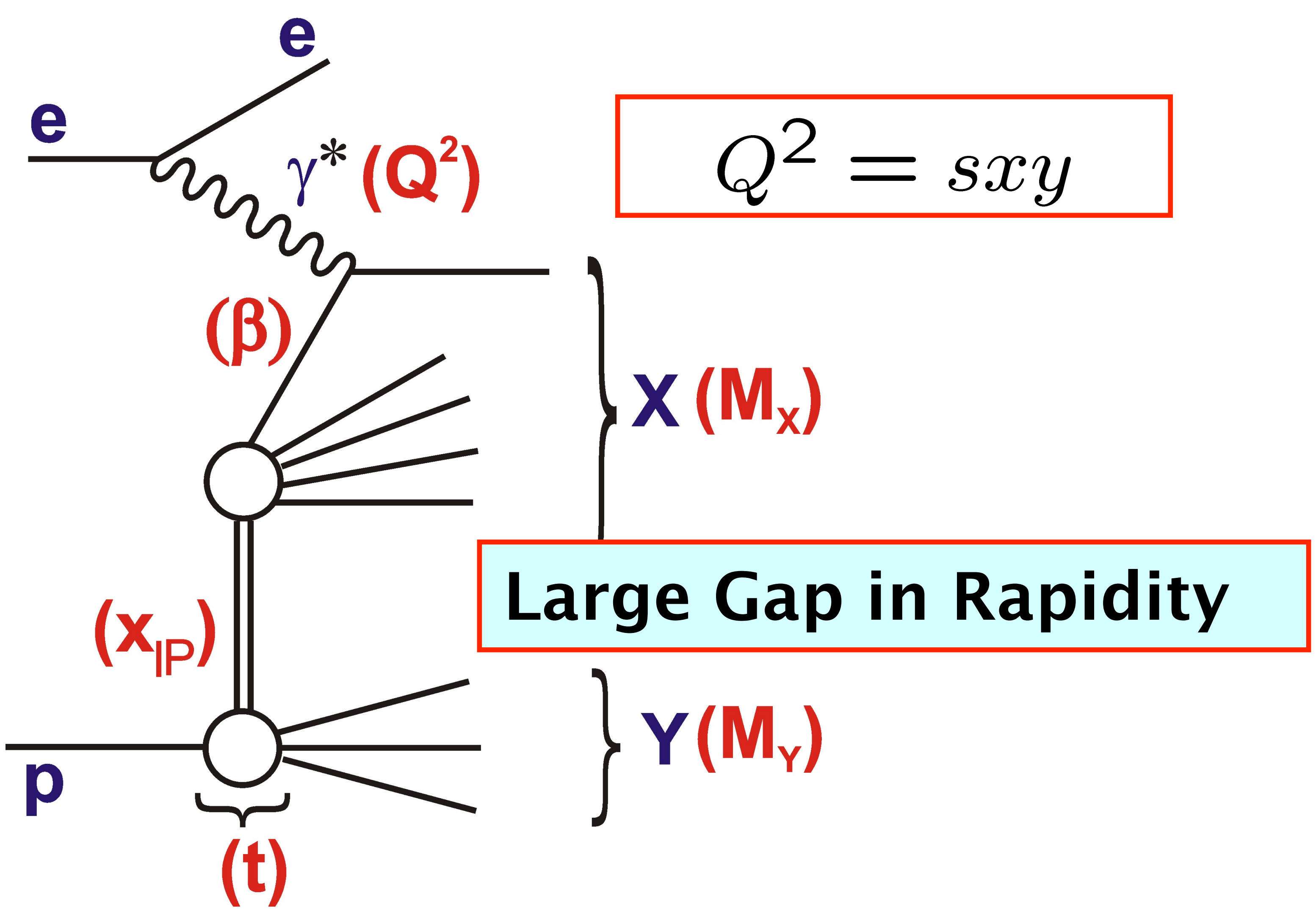
- Quasi-elastic scattering involving a colour singlet exchange
- Select events based on the Large Rapidity Gap topology
- The experimental mandate is simple - measure the kinematic dependences of the cross section for the process

Diffractive Structure Functions

$$x = x_{I\!P}\beta$$

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

$$x_{I\!P} = \frac{Q^2+M_X^2}{Q^2+W^2}$$



$$Q^2 = sxy$$

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

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

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

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

Diffractive Structure Functions

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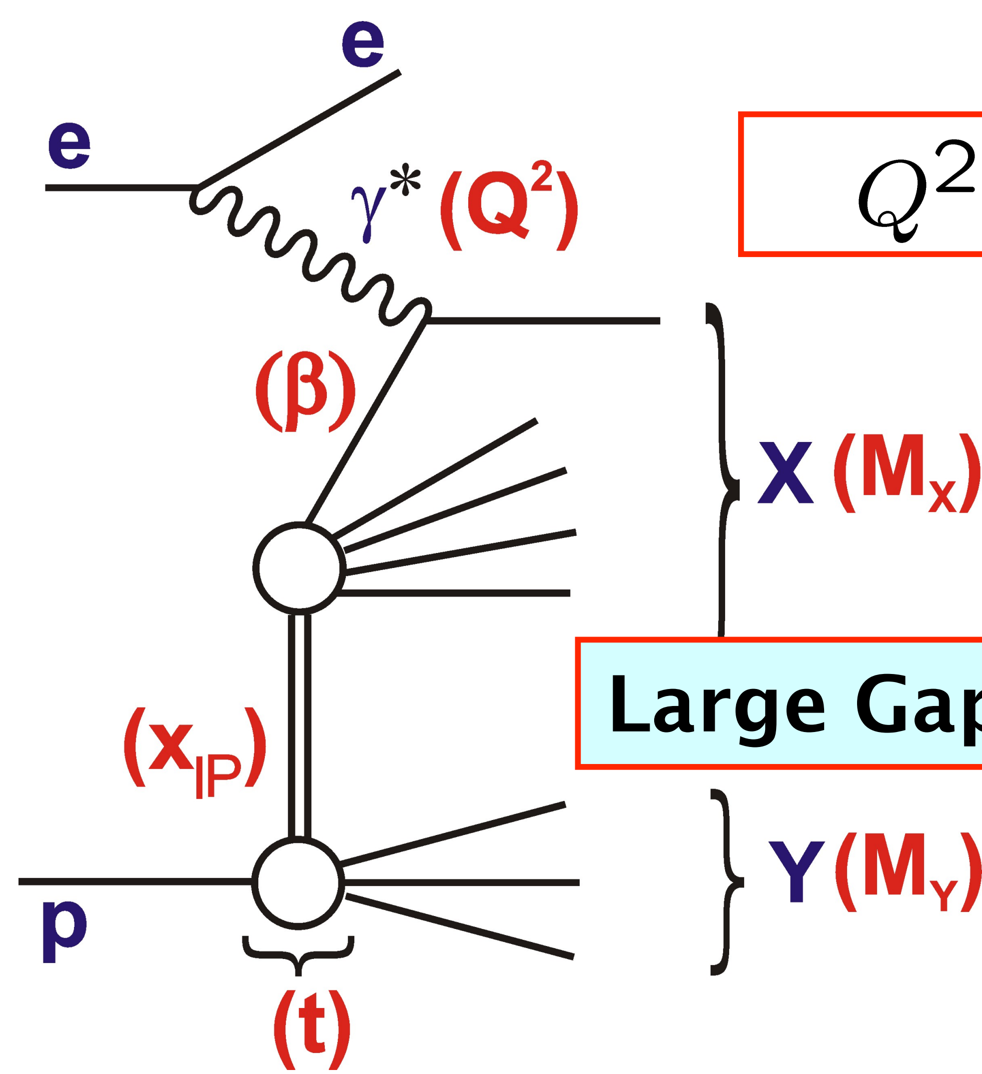

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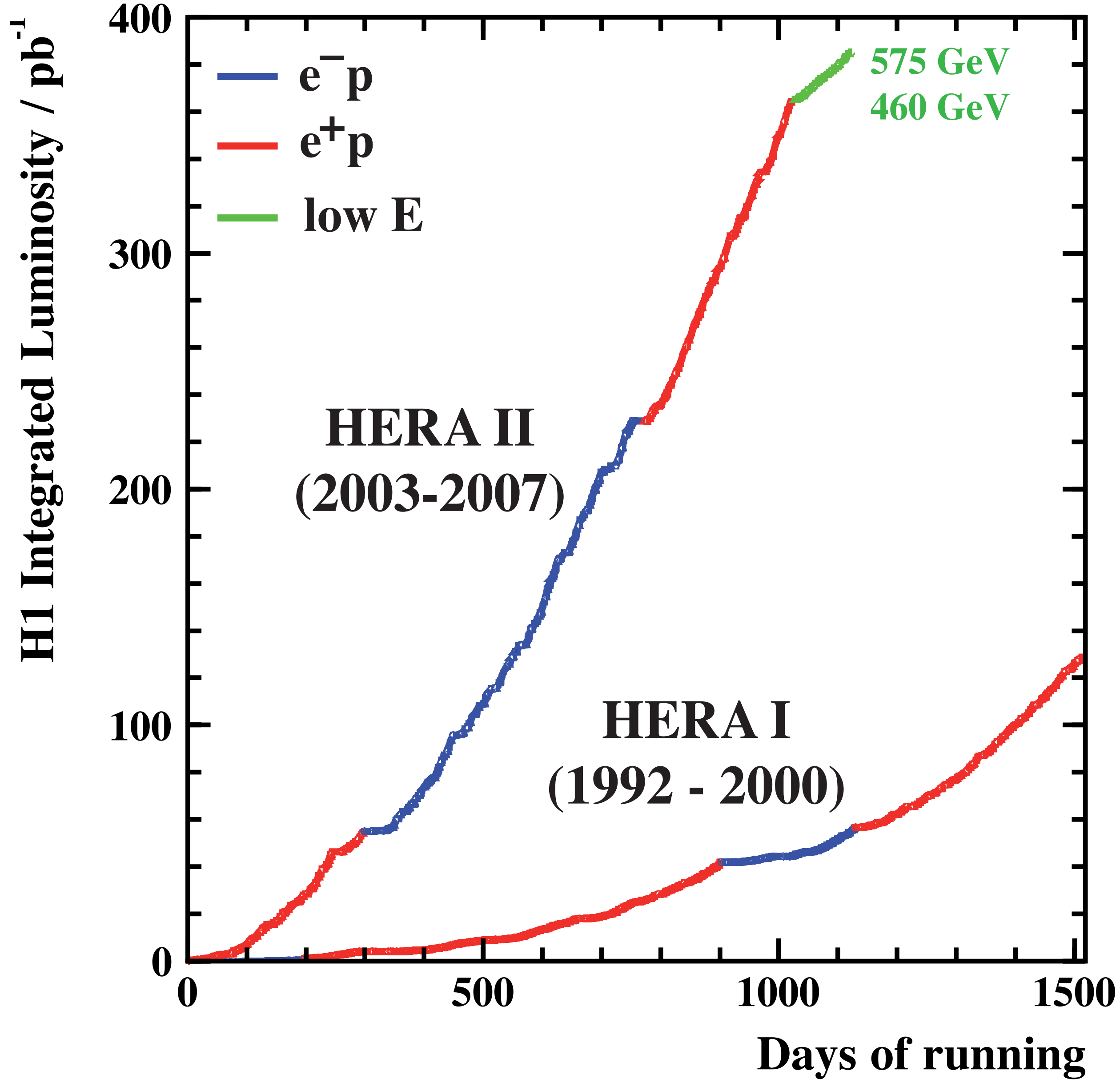
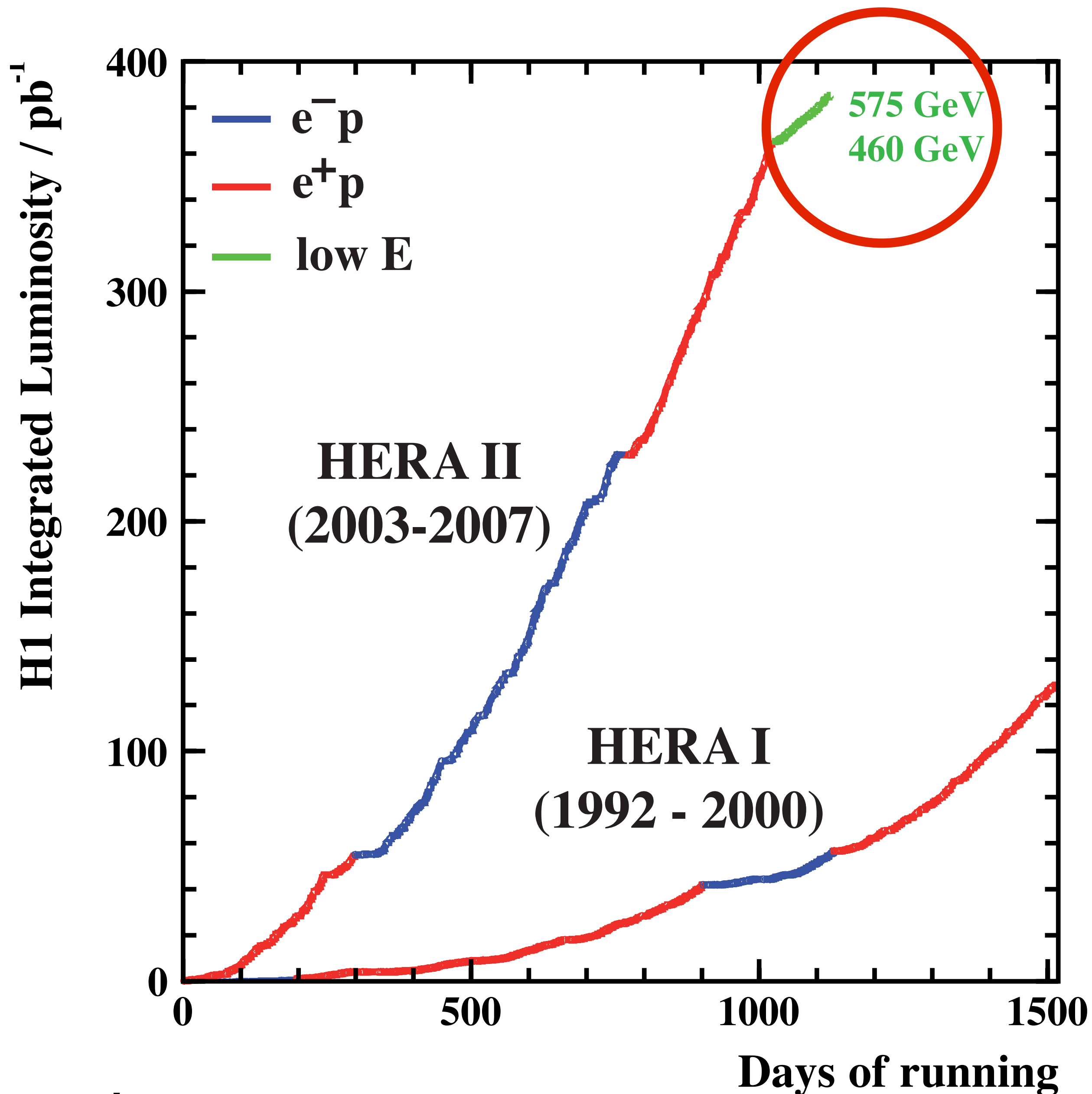
H1 data



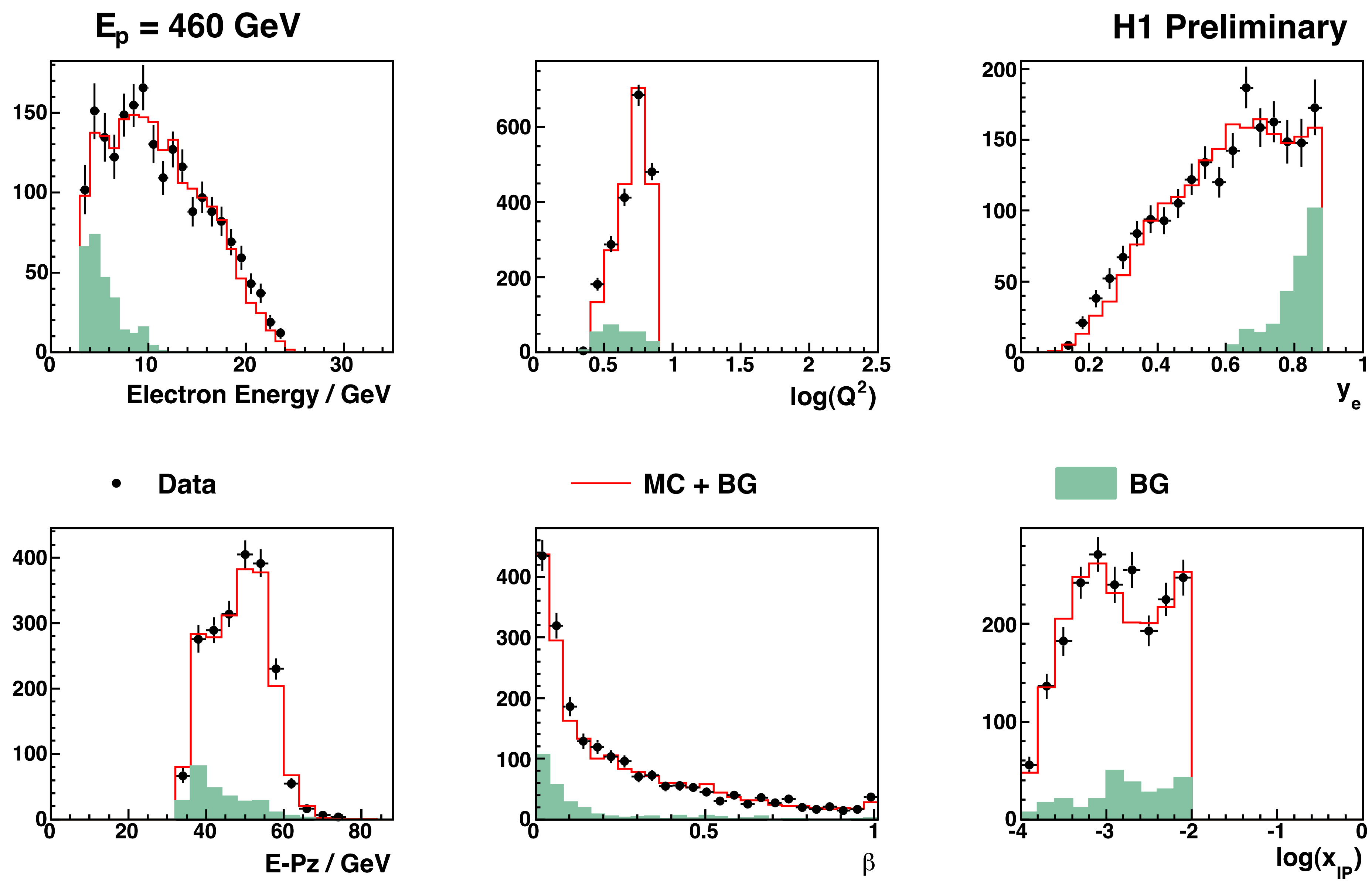
H1 Integrated Luminosity / pb^{-1}
Days of running
0
500
1000
1500
100
200
300
400
e^{-}p
e^{+}p
low E
575 GeV
460 GeV
HERA II
(2003-2007)
HERA I
(1992 - 2000)

H1 data



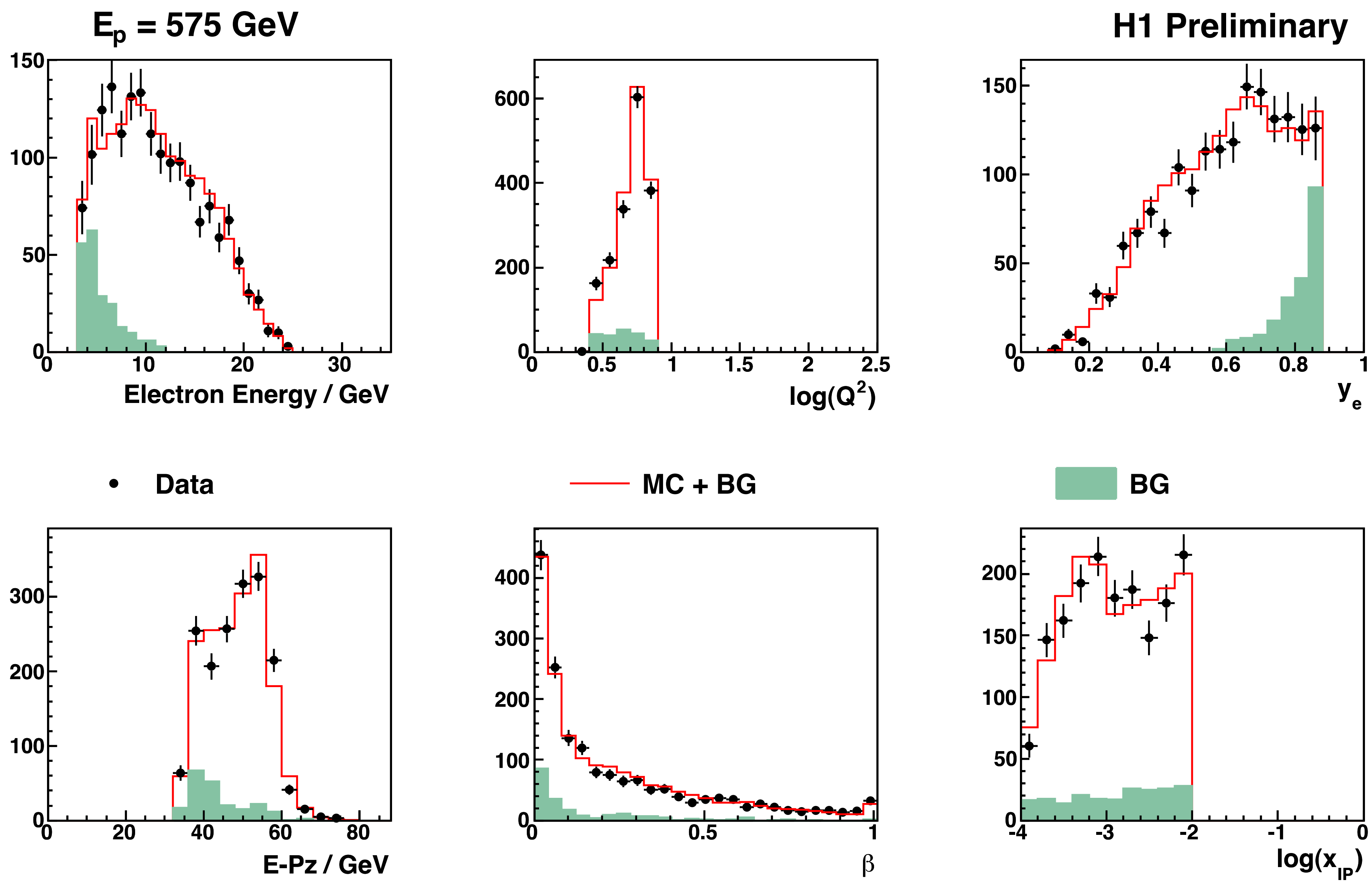
- Start with the ending...
- The low (E_P=460 GeV) and medium (E_P=575 GeV) energy runs
- Measure cross sections at fixed x, Q^2 and different y --- F_L^D

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 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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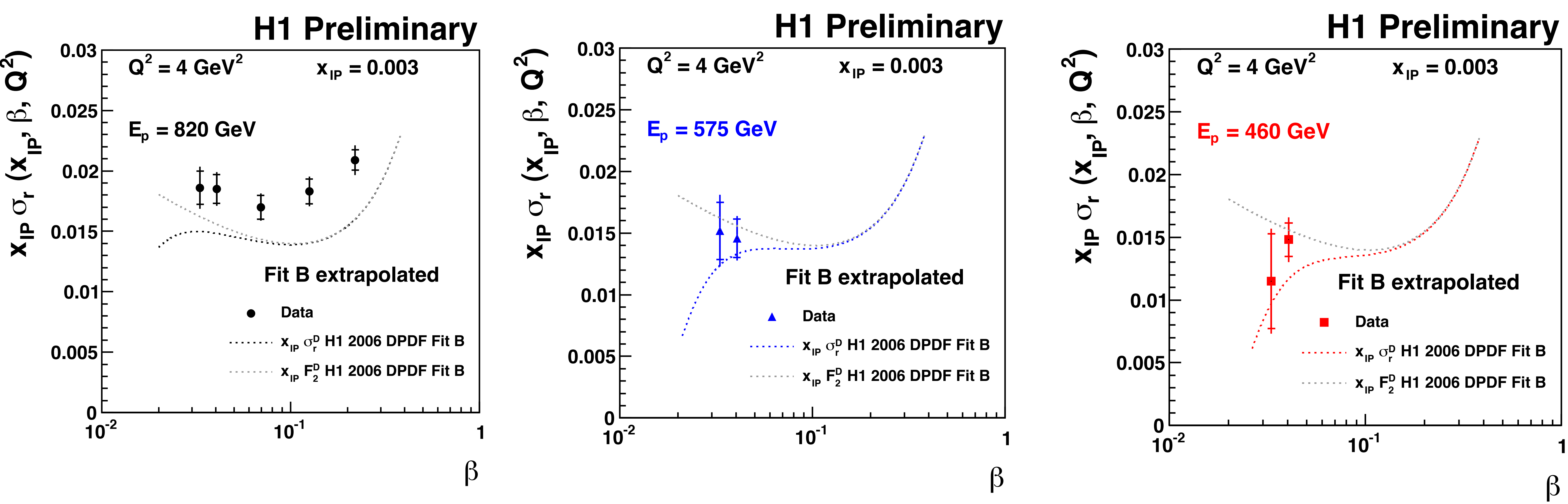
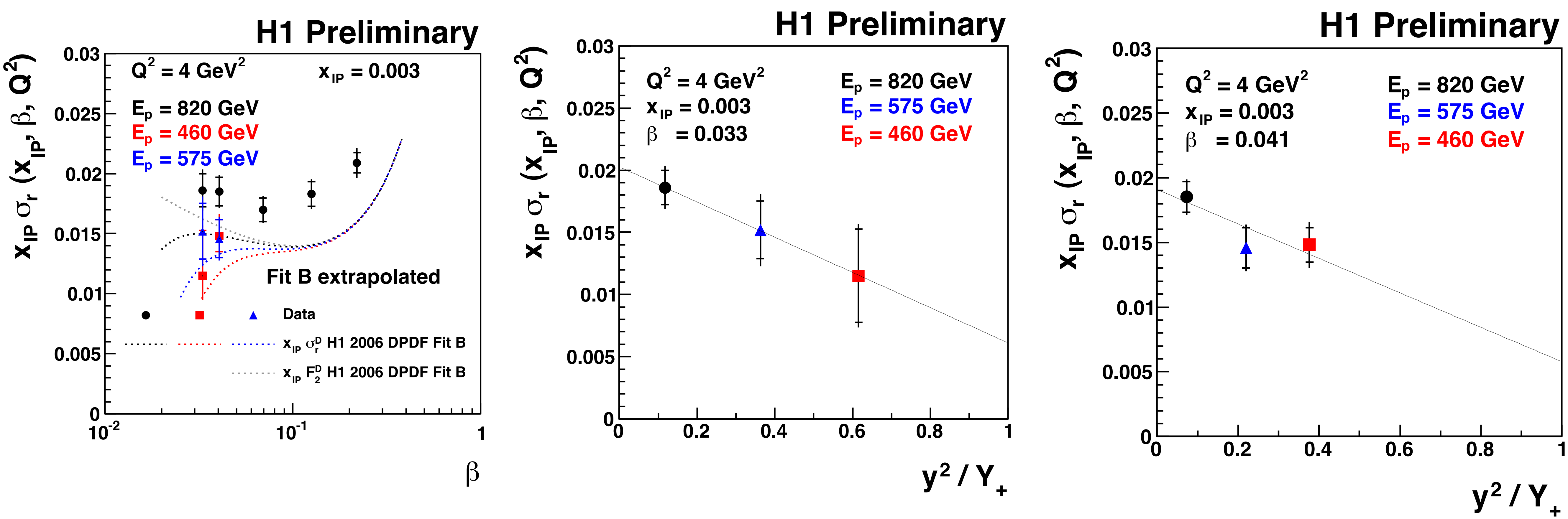
Diffractive cross sections at low Q^2 and high y



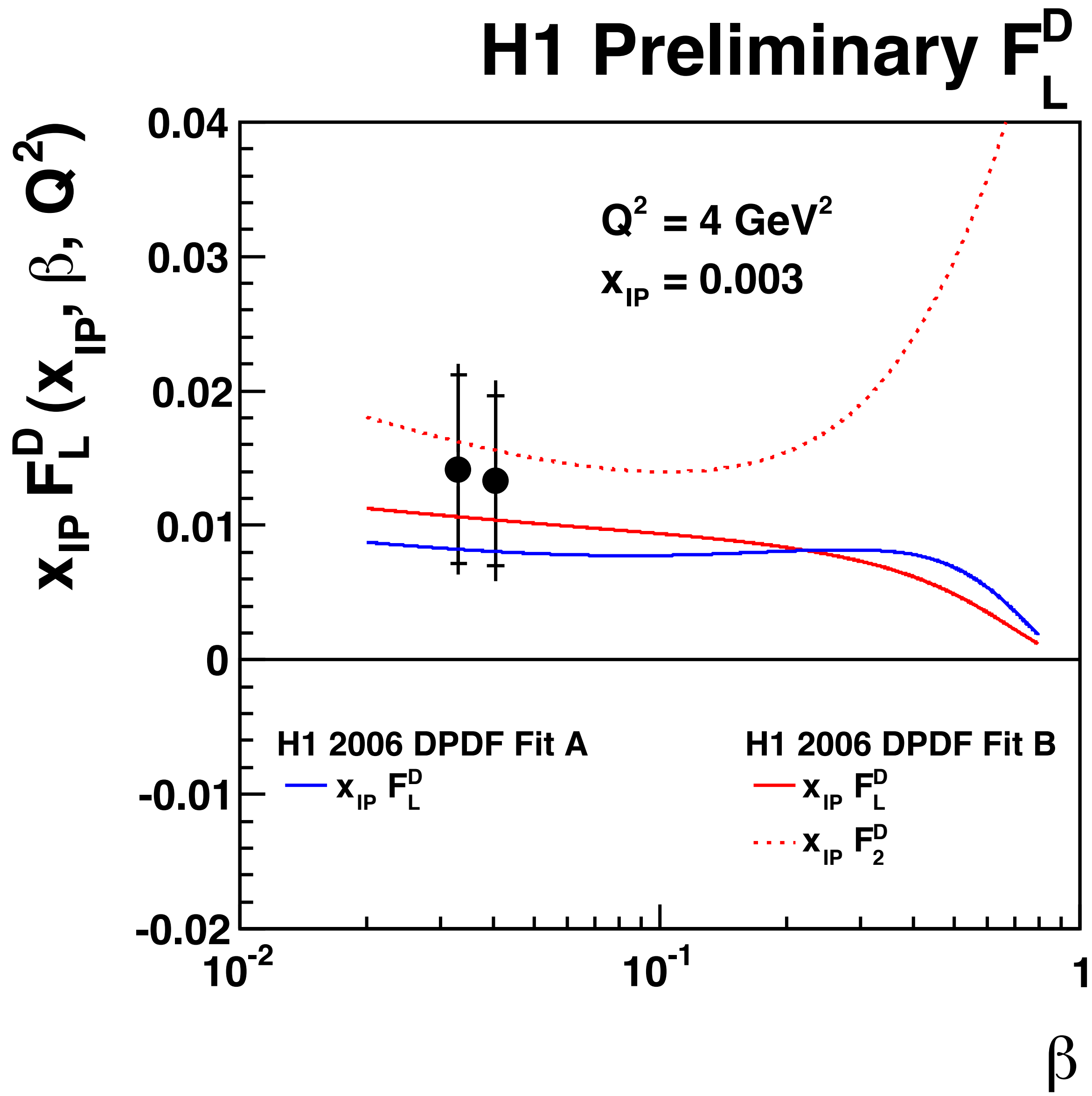
- Left are ***published*** data with E_p = 820 GeV, the extrapolation of Fit B is shown and undershoots the data at low Q^2 (only data with Q^2 >= 8.5 GeV^2 were included)
- New low Q^2 (=4 GeV^2) diffractive cross sections at E_p = 575 GeV (centre, blue) and E_p = 460 GeV (right, red) compared to extrapolated Fit B

F_L^D extraction



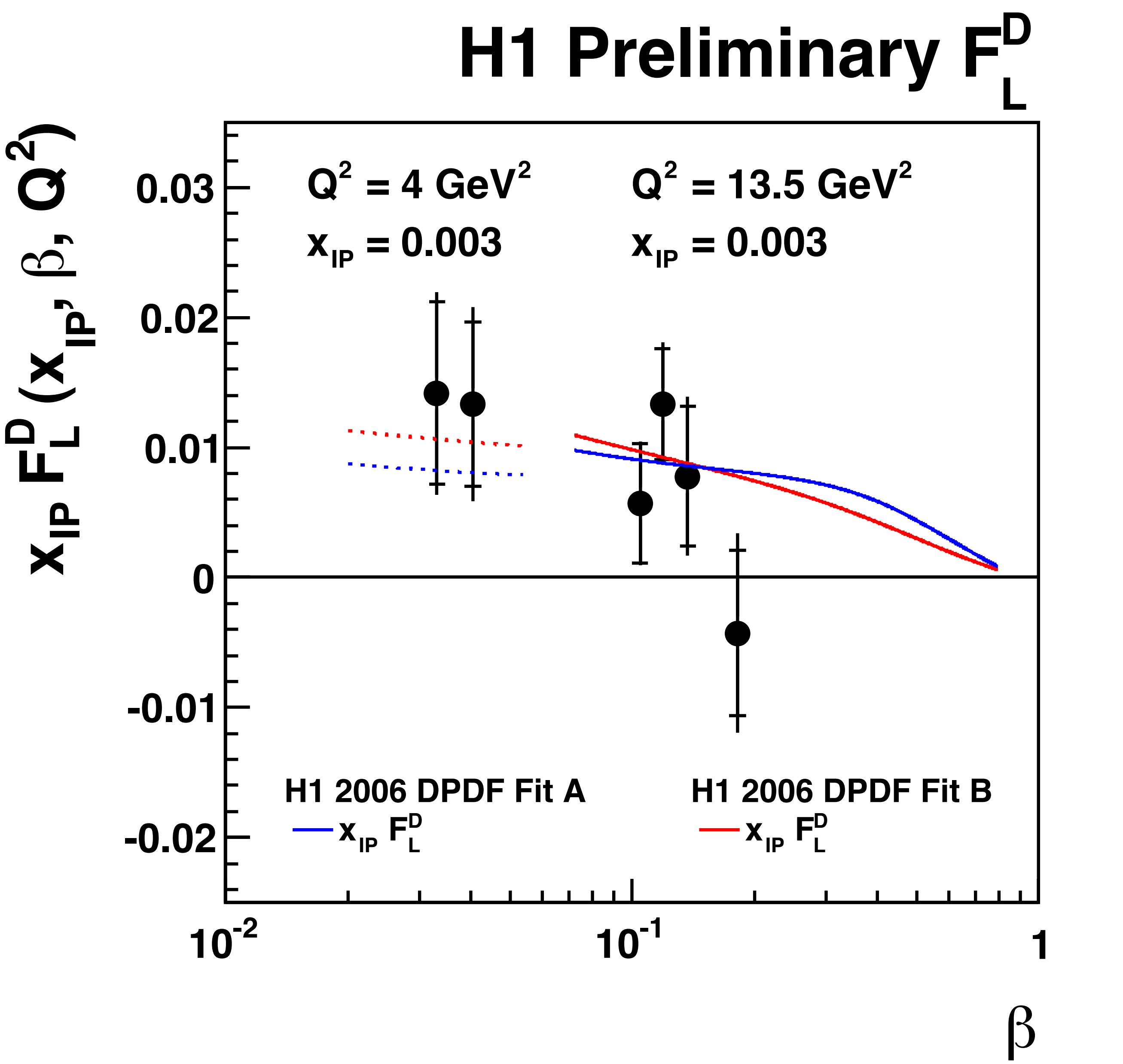
- The linear fits to the two highest y bins are shown, allowing two new measurements at low Q^2 to be made

The diffractive longitudinal structure function



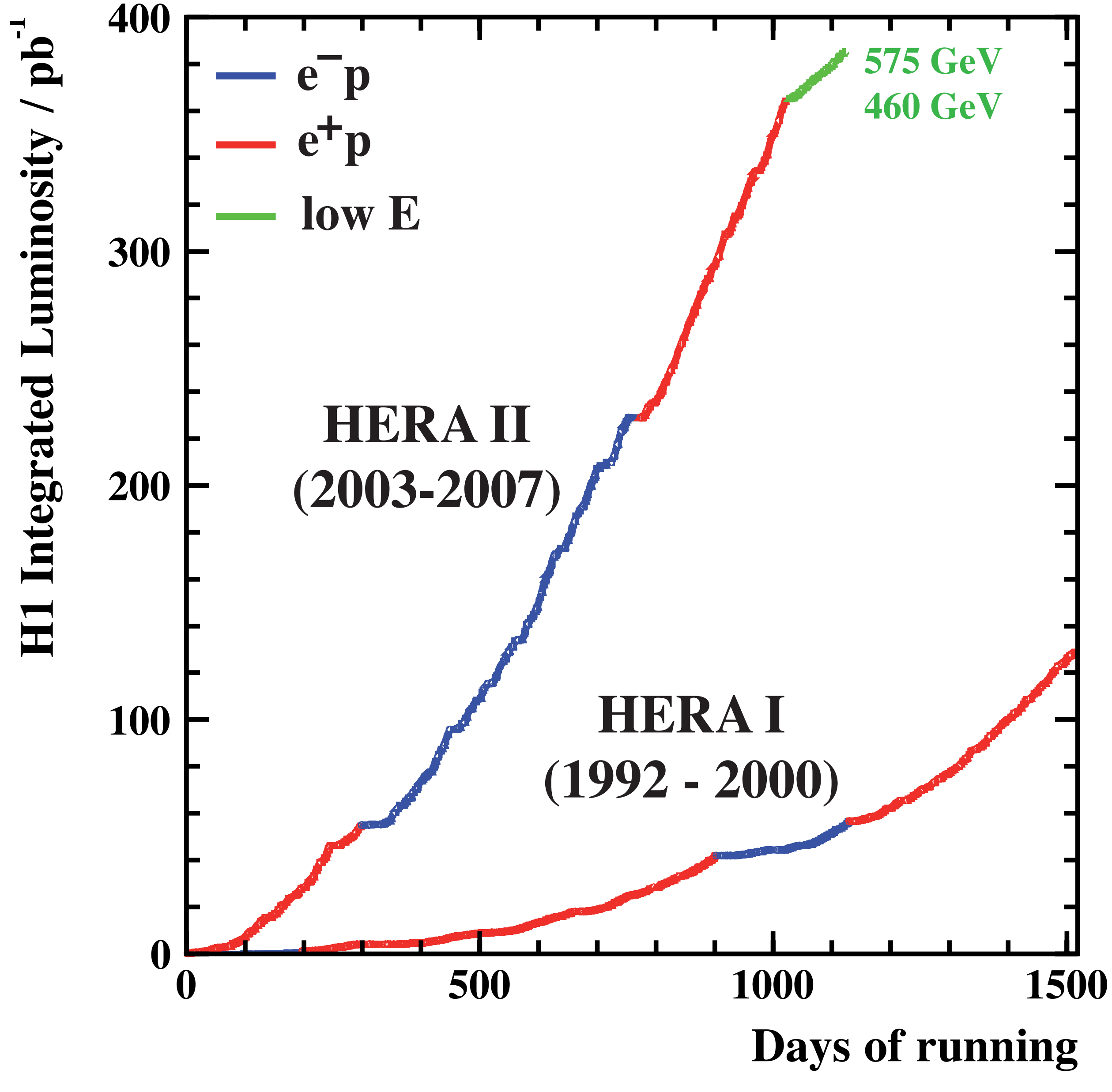
- At low Q^2, the extrapolation of the NLO QCD fit predicts that F_L^D is approximately half the size of F_2^D
- The measurements are consistent with the extrapolated fit

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 extrapolated fit

H1 data



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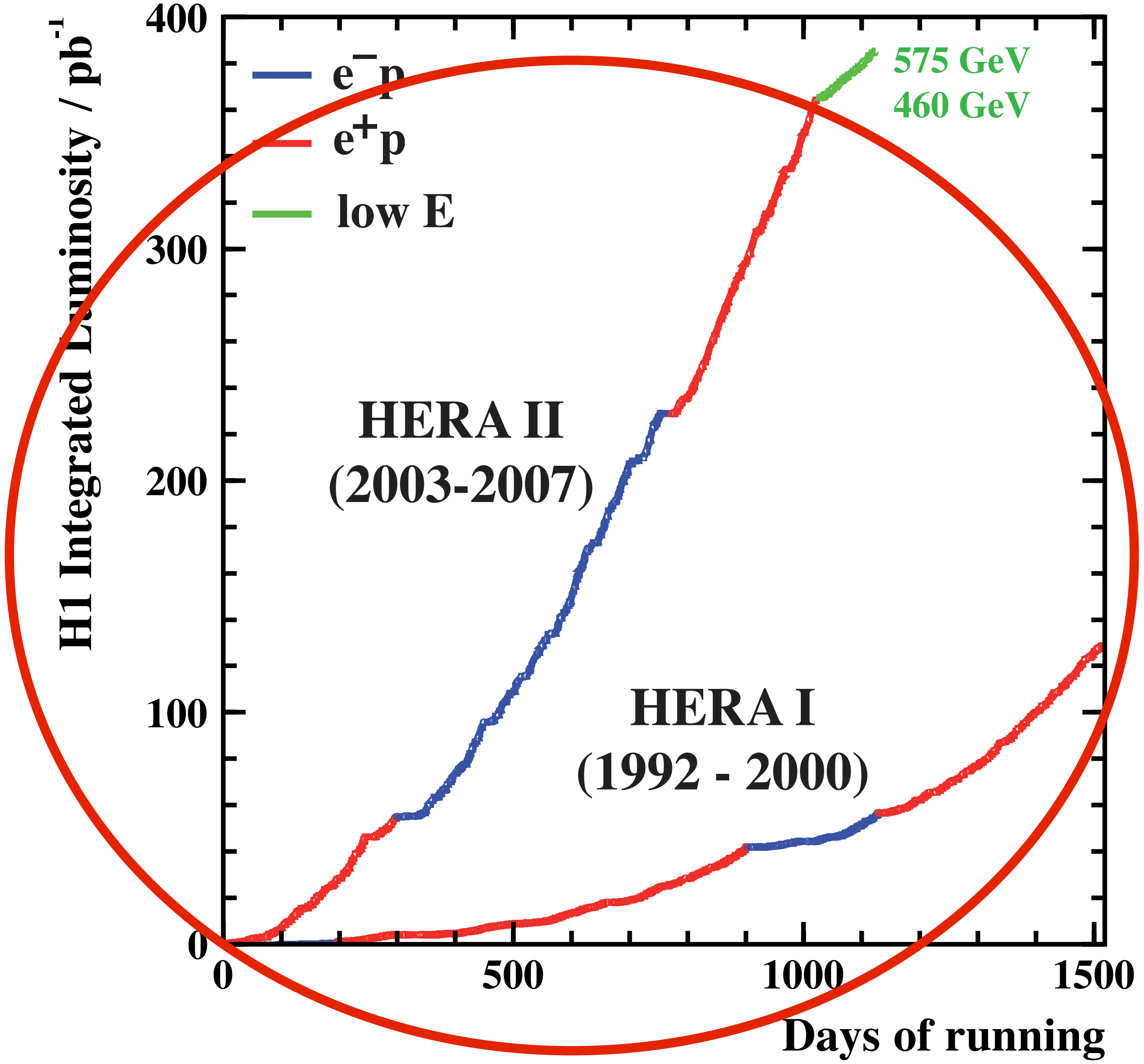
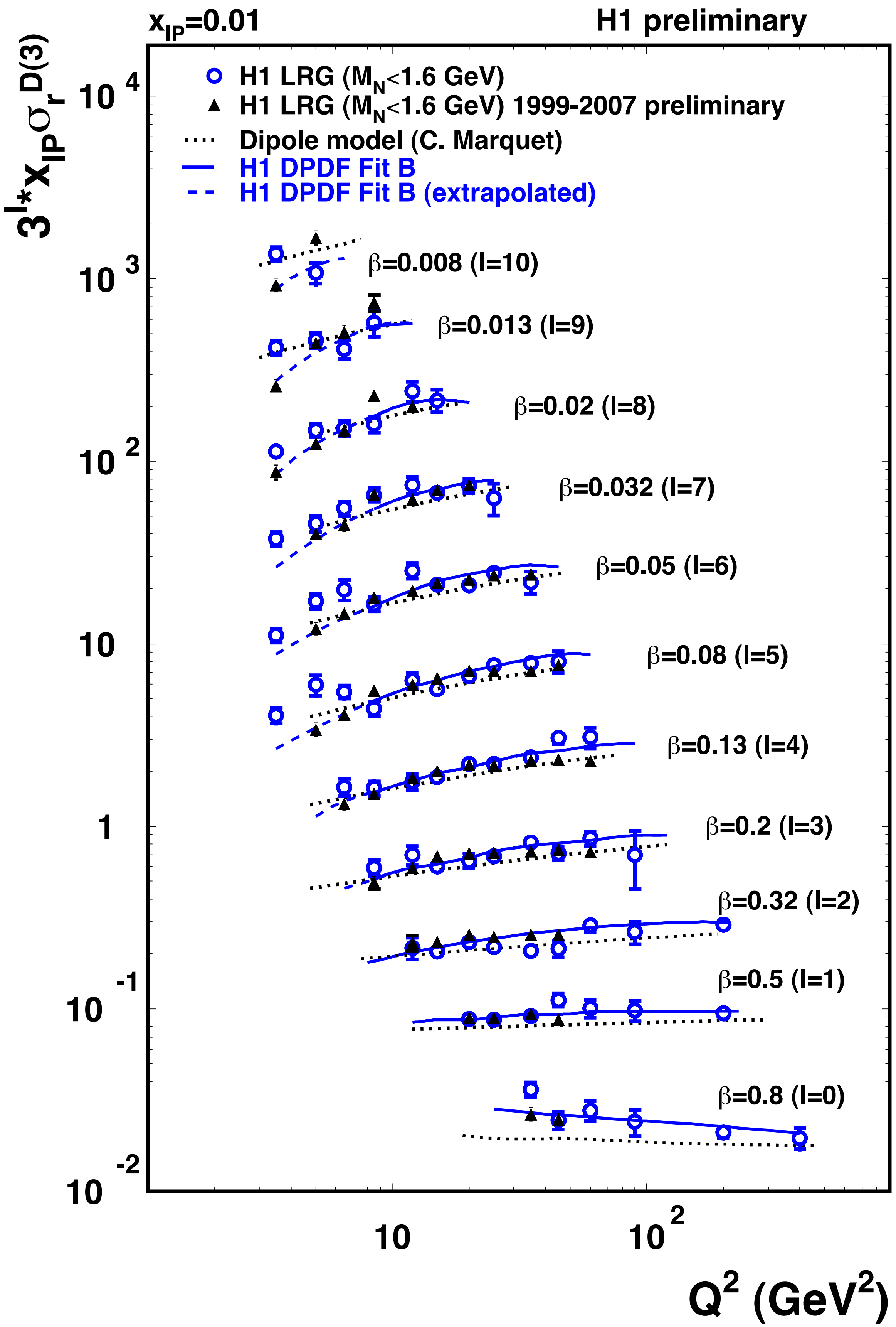
H1 data



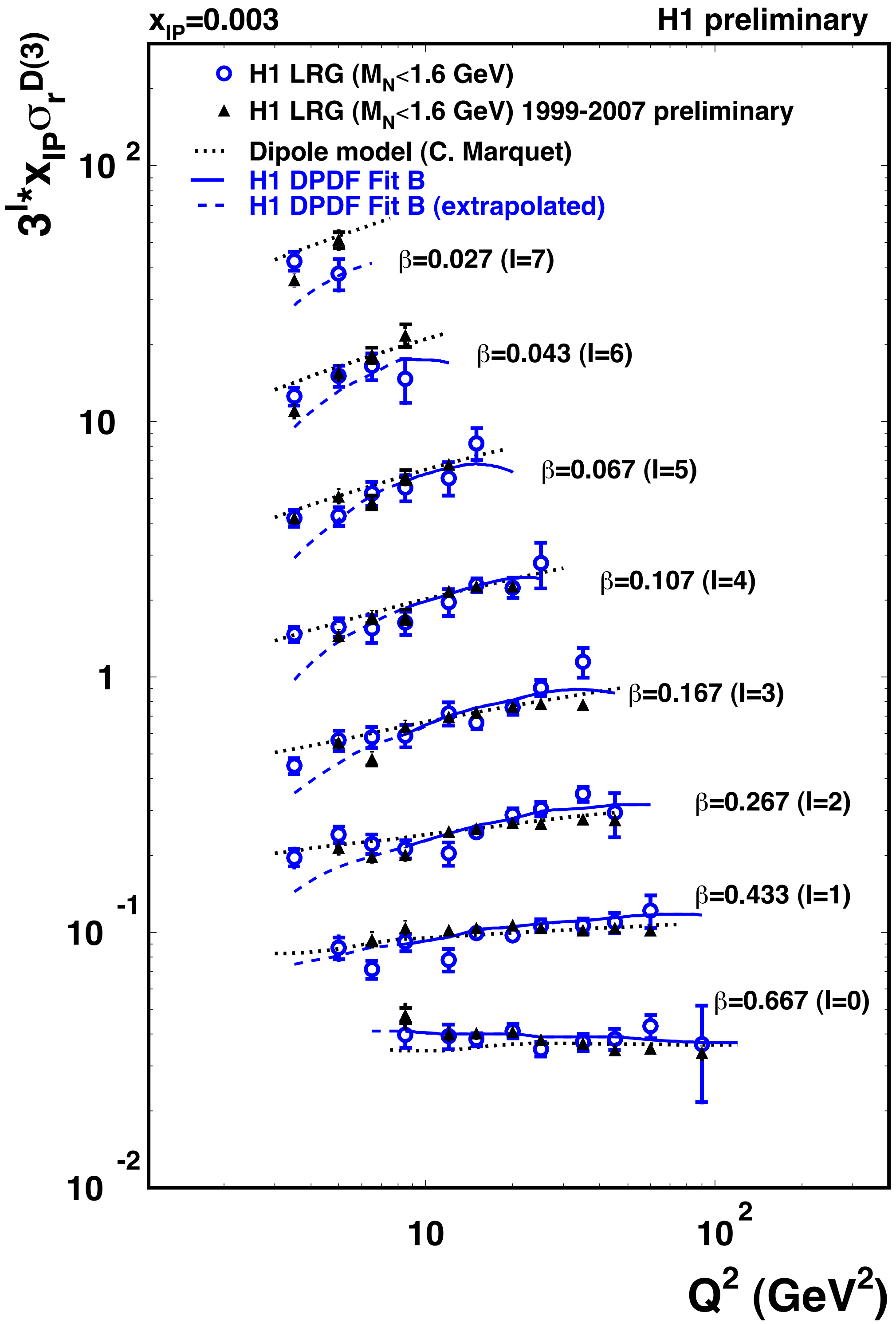
- The full HERA data sample, including both HERA I and HERA II datasets, has been analysed in order to measure σ_r^D to the best precision possible
- Question, can we also produce those classic scaling violation plots?

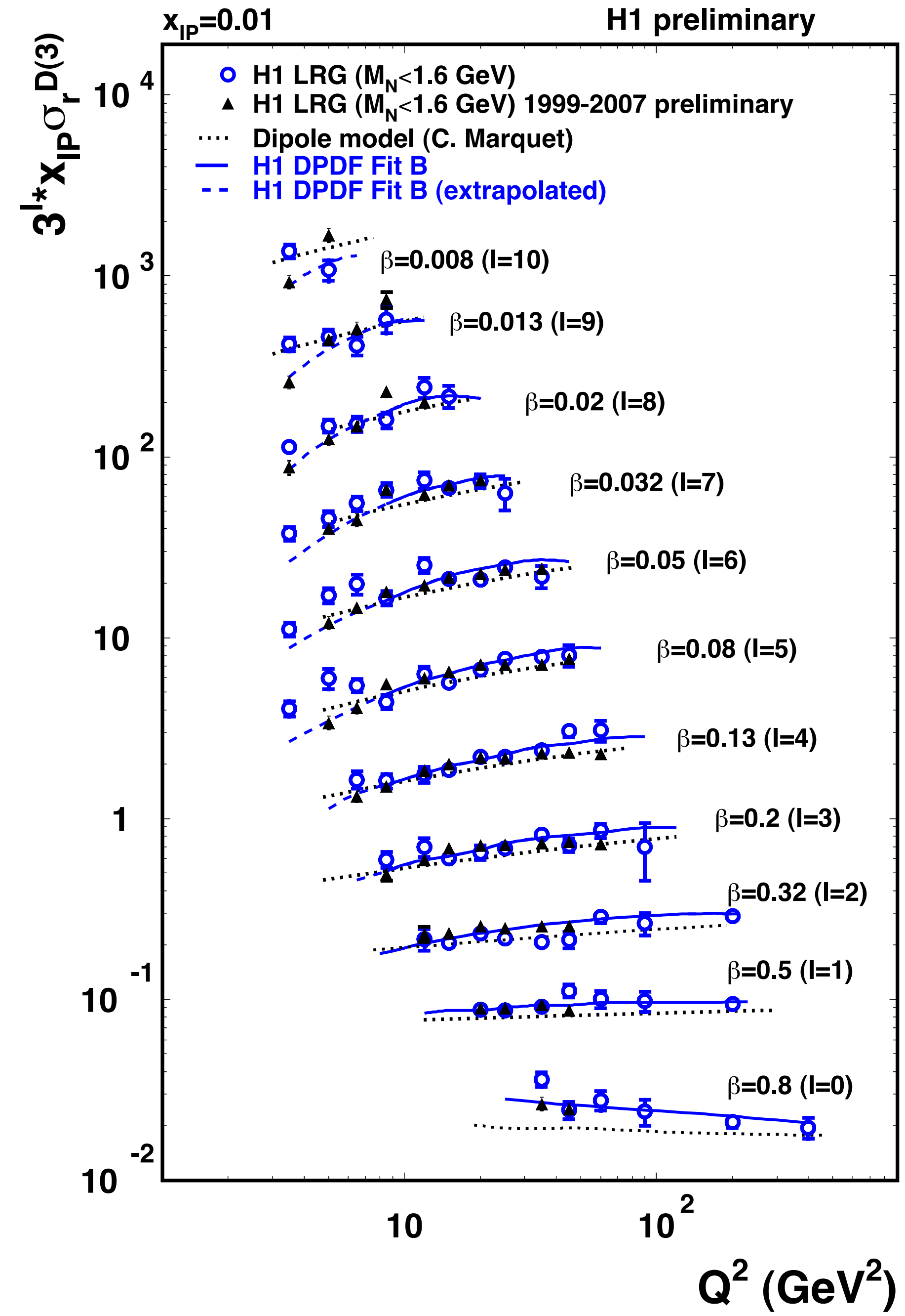
σ_r^D at fixed x_{IP}



- The published data (blue) compared to the latest analysis of H1 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

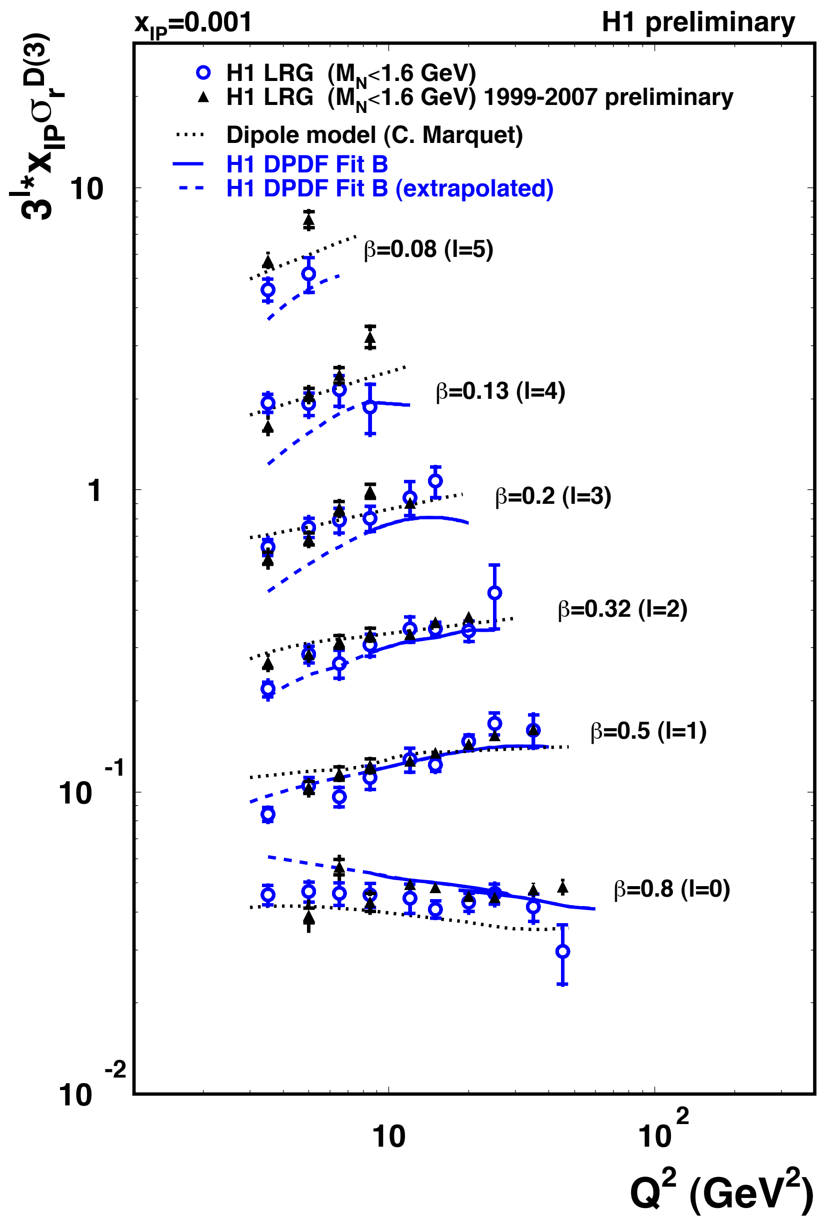
σ_r^D at fixed x_{IP}

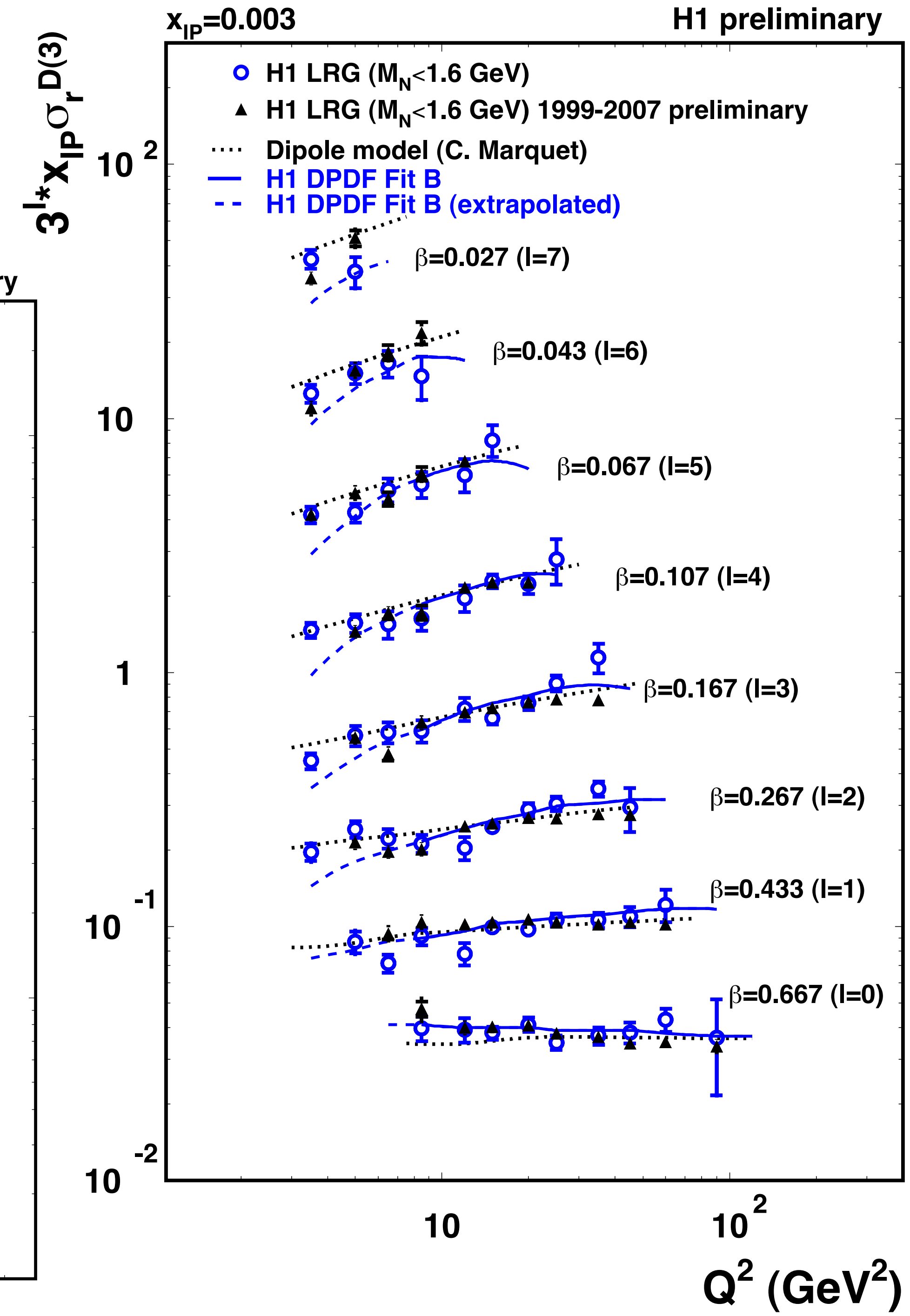


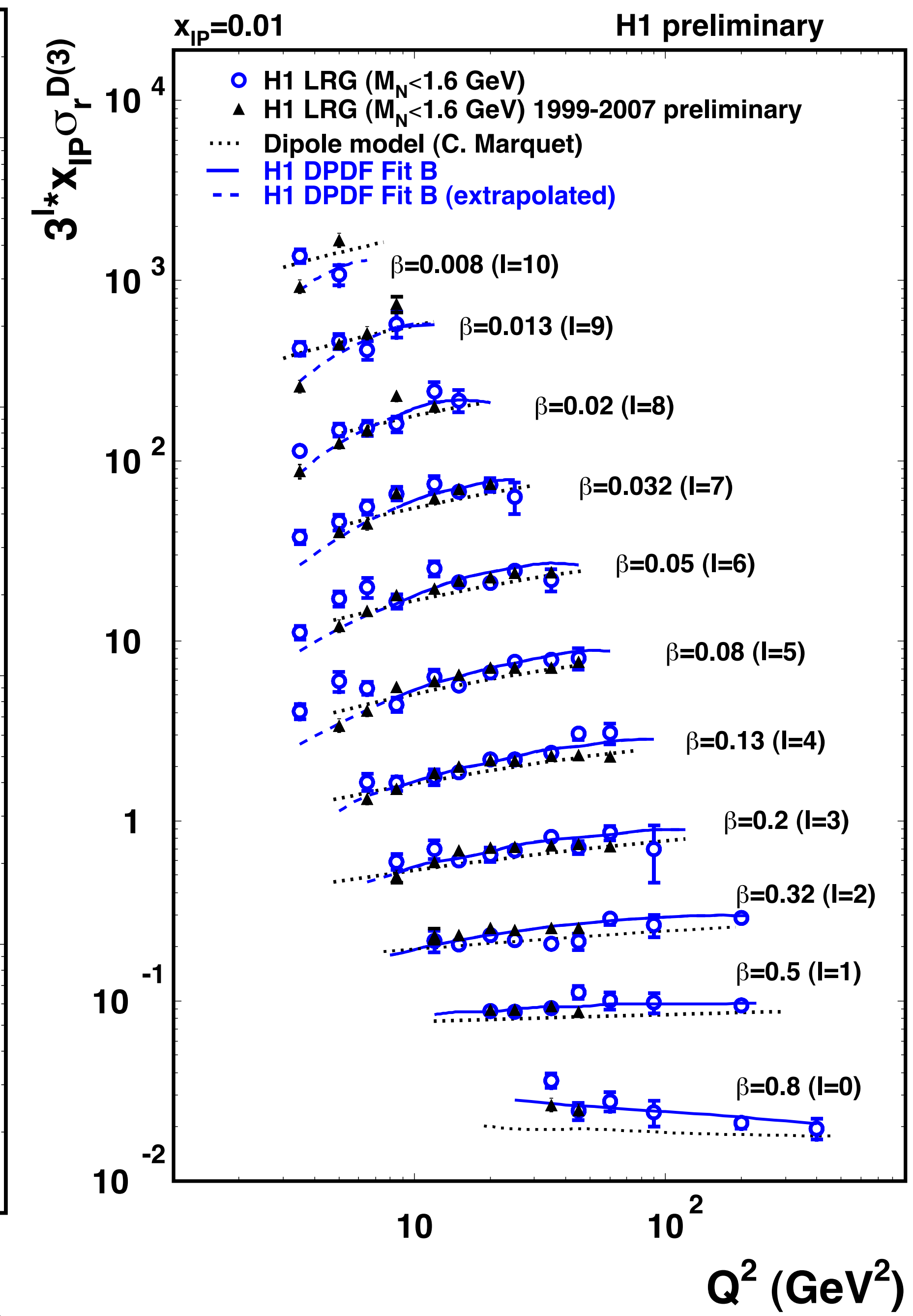


Similarly good precision in the next lowest x_{IP} bin

σ_r^D at fixed x_{IP}

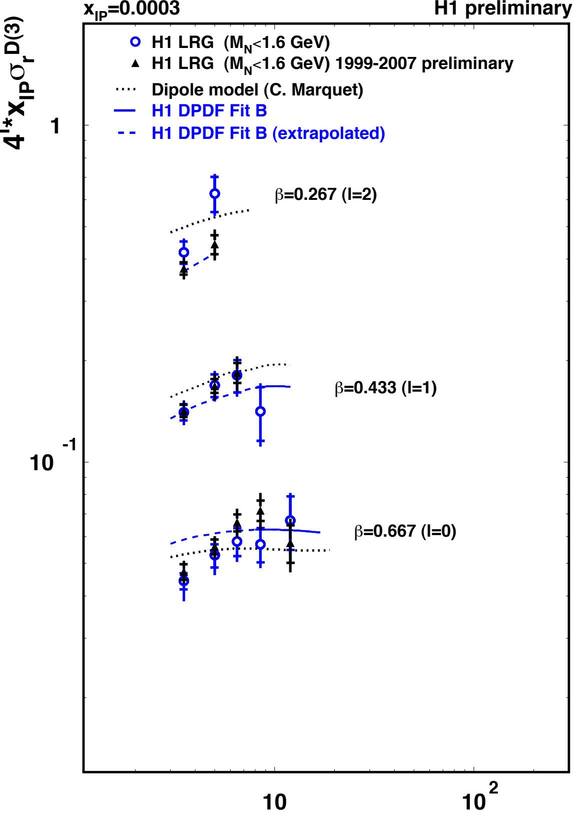


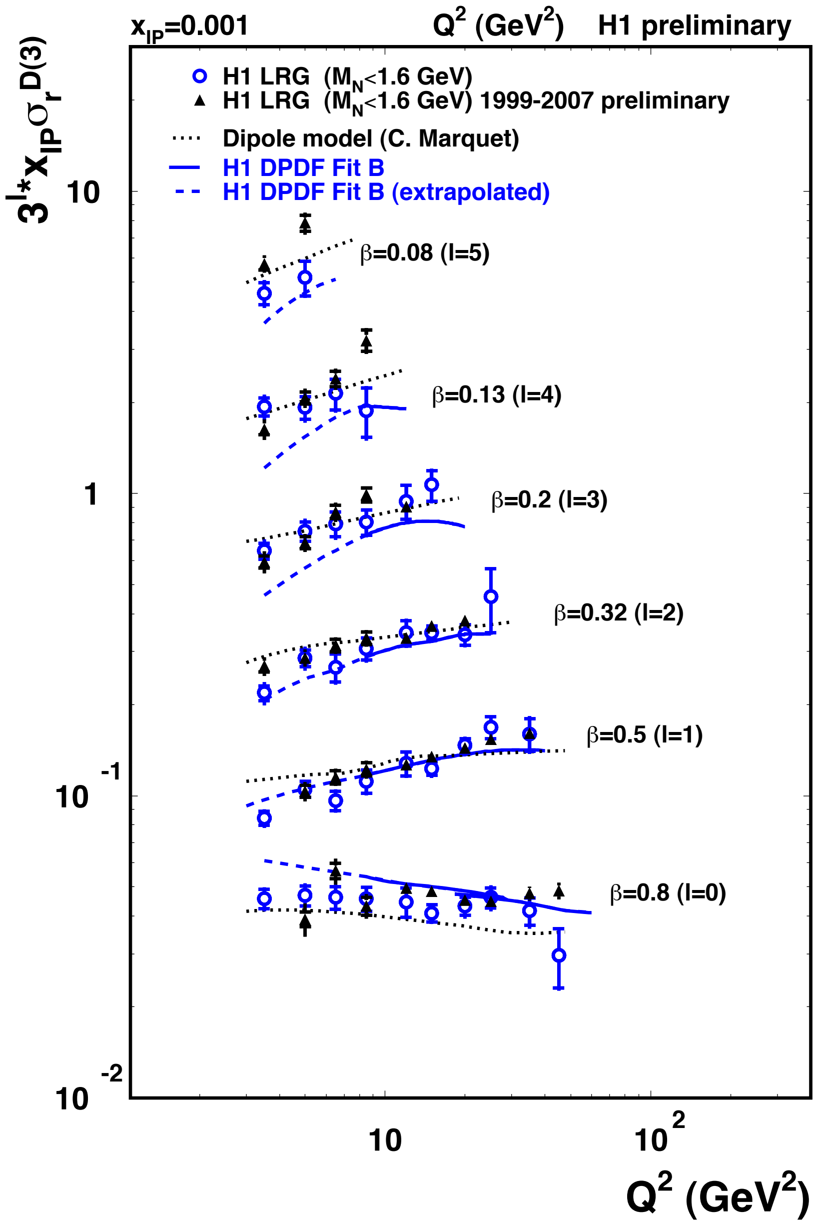


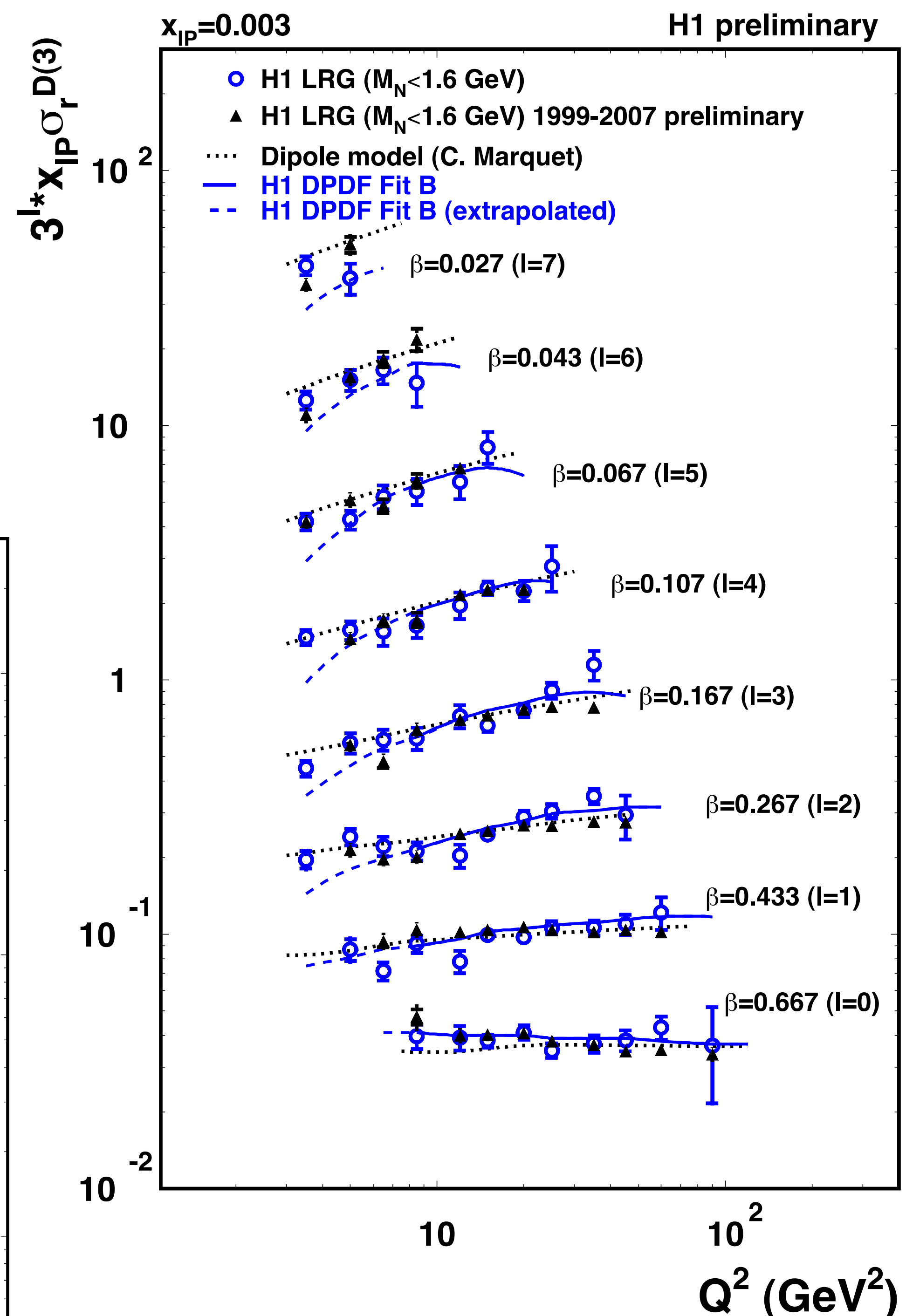


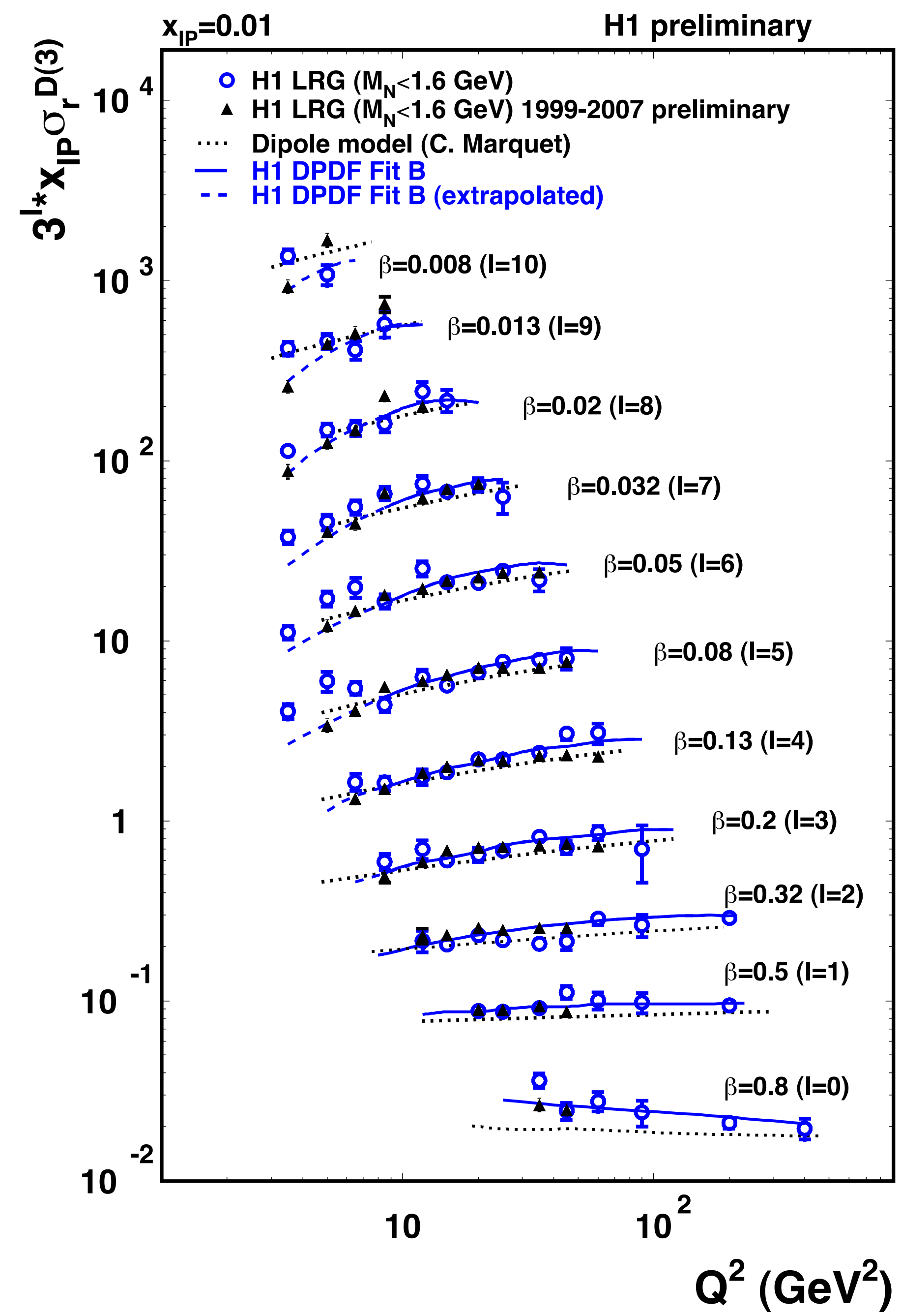
... and lower x_{IP}...

σ_r^D at fixed x_{IP}



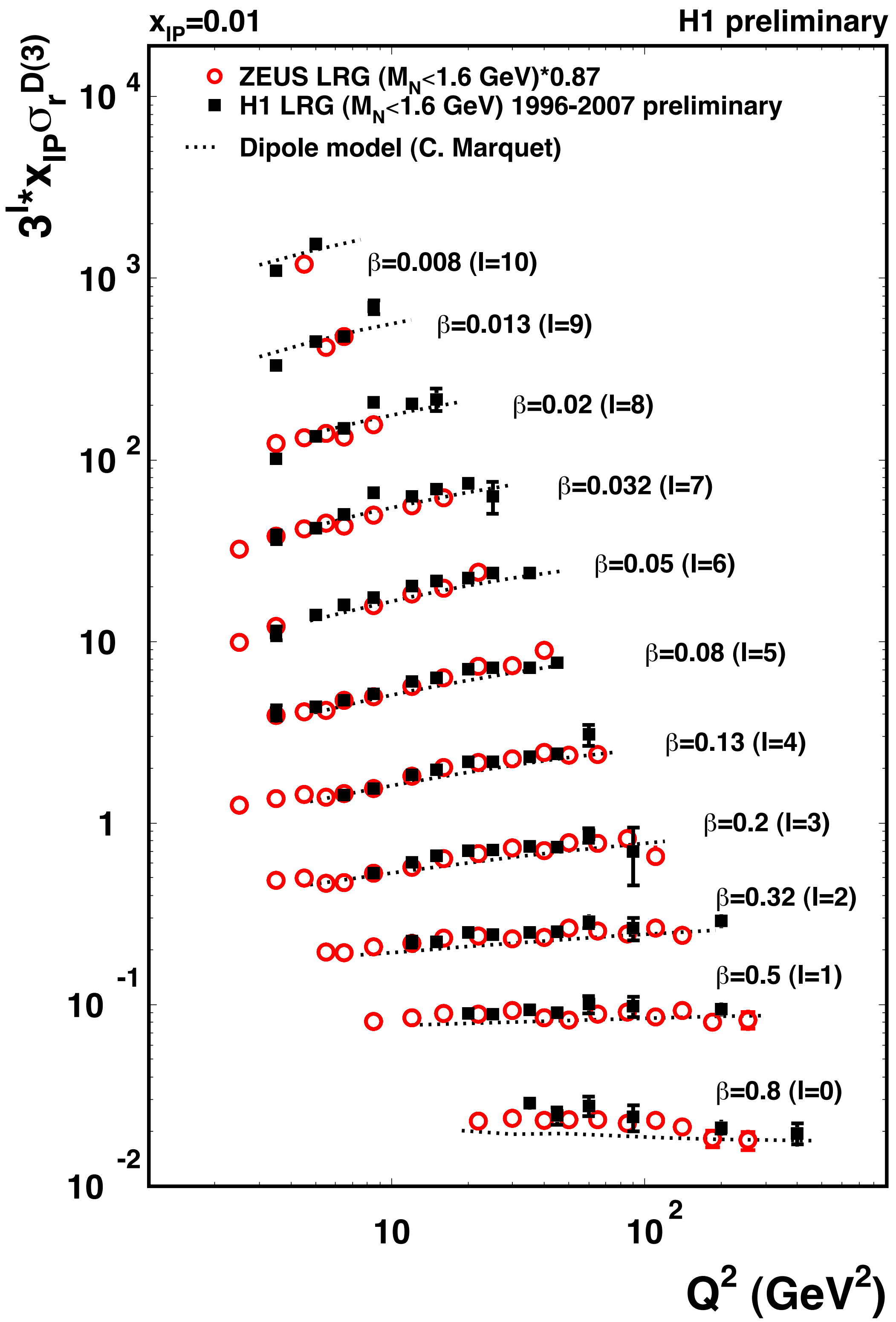






Beautifully consistent data..... combine!

σ_r^D at fixed x_{IP} H1 and Zeus



- The new H1 LRG data has been combined with the published data to create

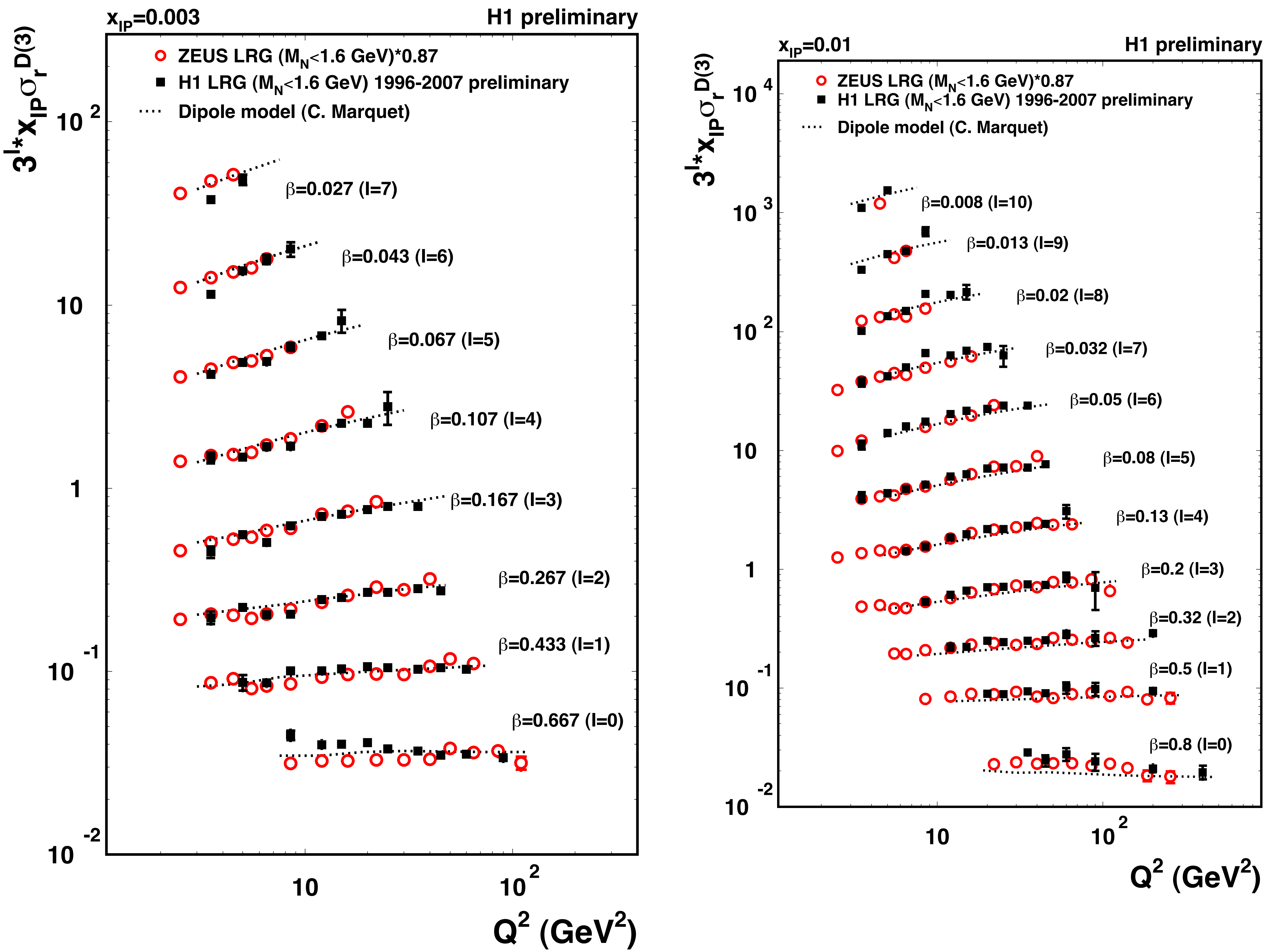
  one combined H1 LRG dataset

- Compare H1 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...

- ...H1 and Zeus LRG data are in good agreement

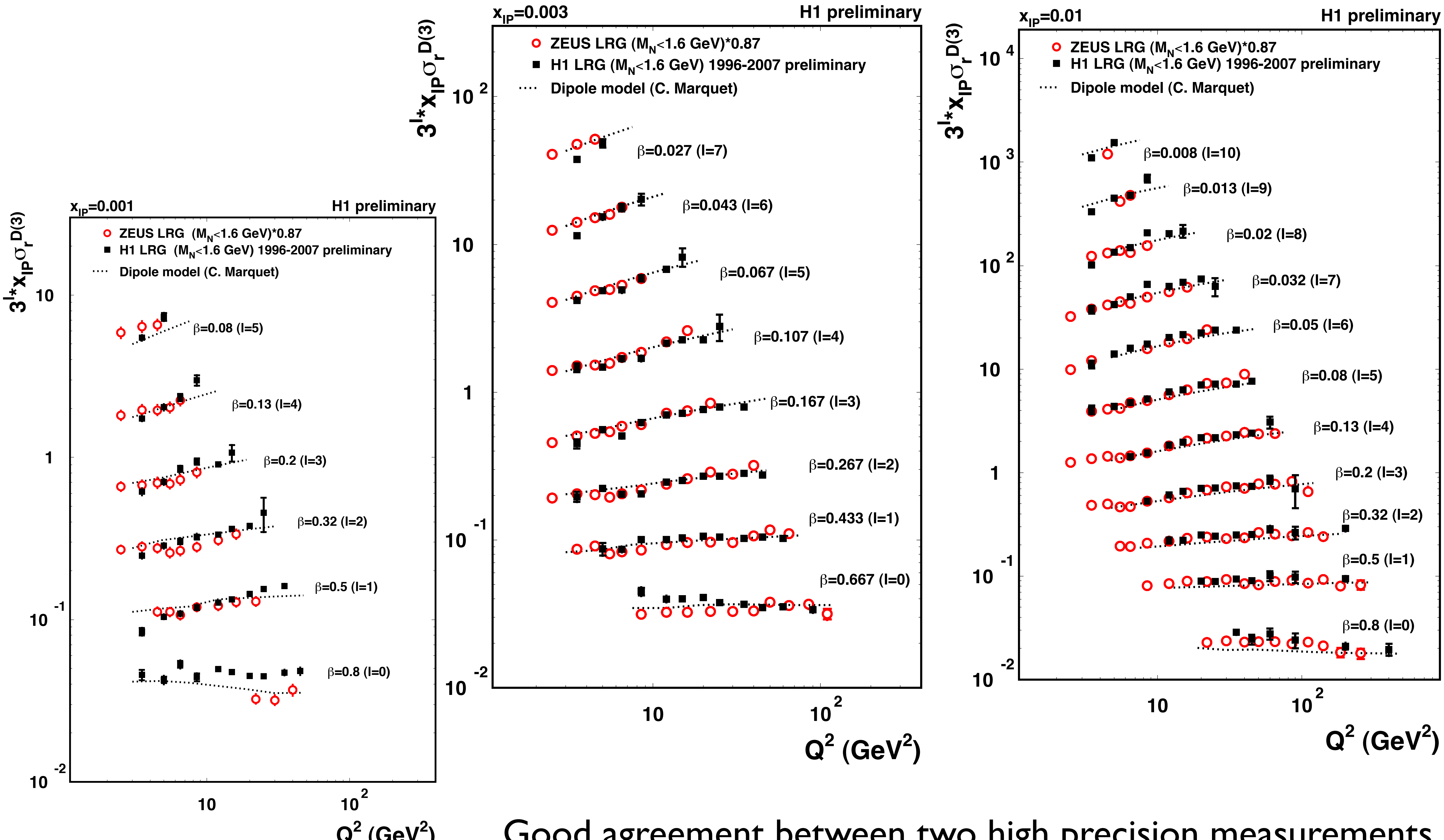
σ_r^D at fixed x_{IP} H1 and Zeus



Good agreement between two high precision measurements

Differences to understand at high beta

σ_r^D at fixed x_{IP} H1 and Zeus



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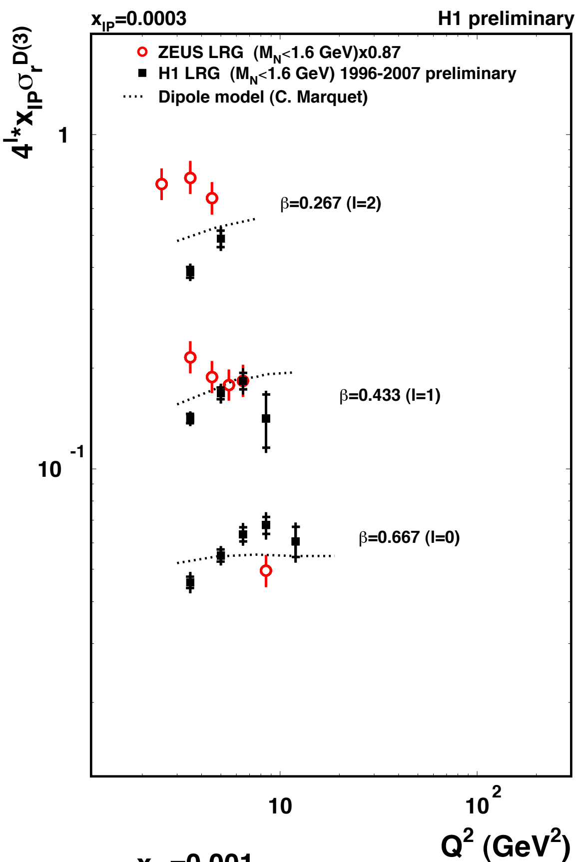
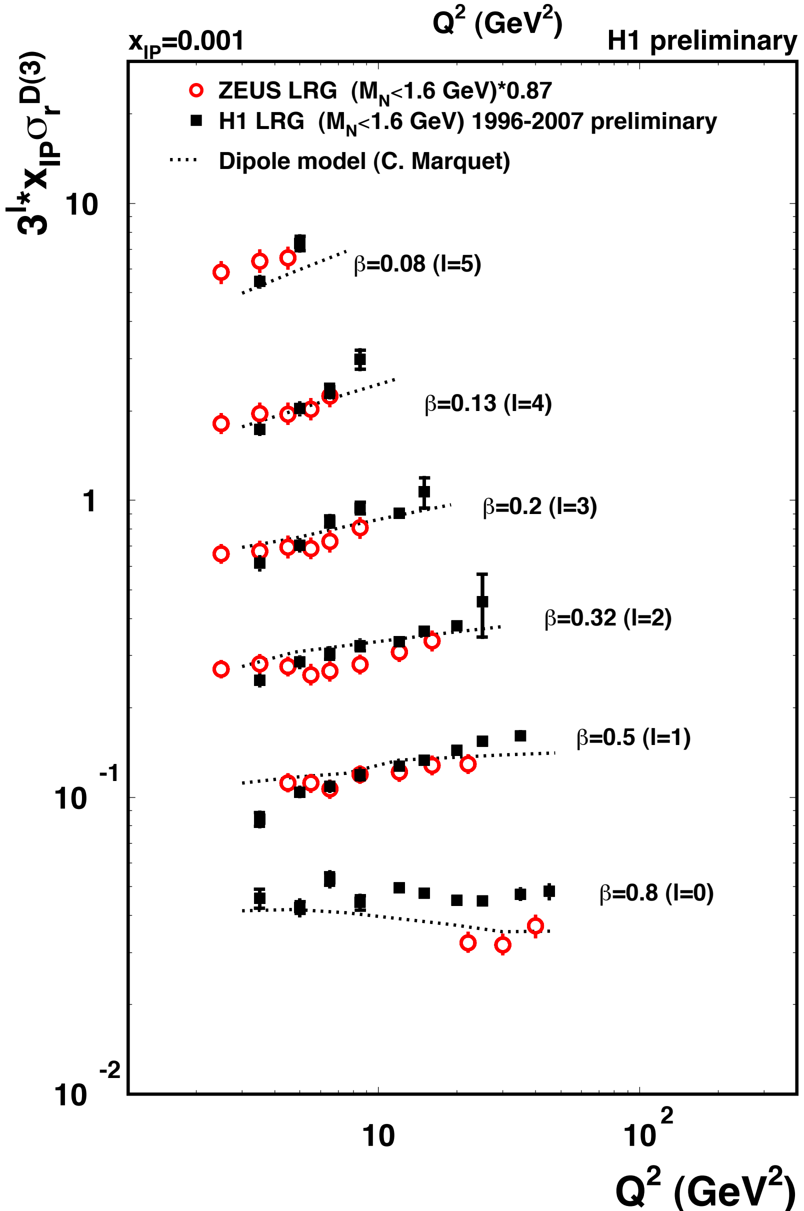
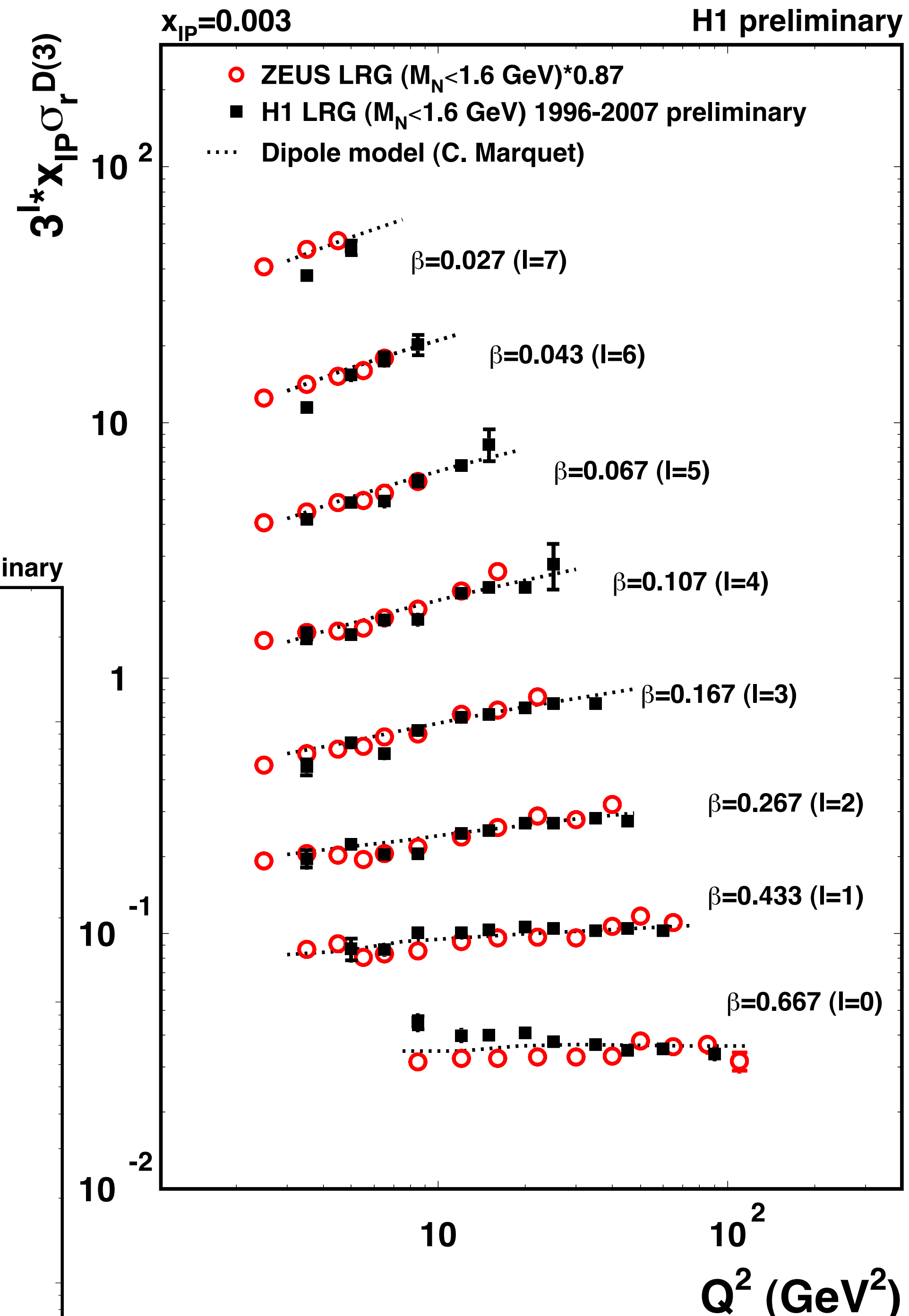
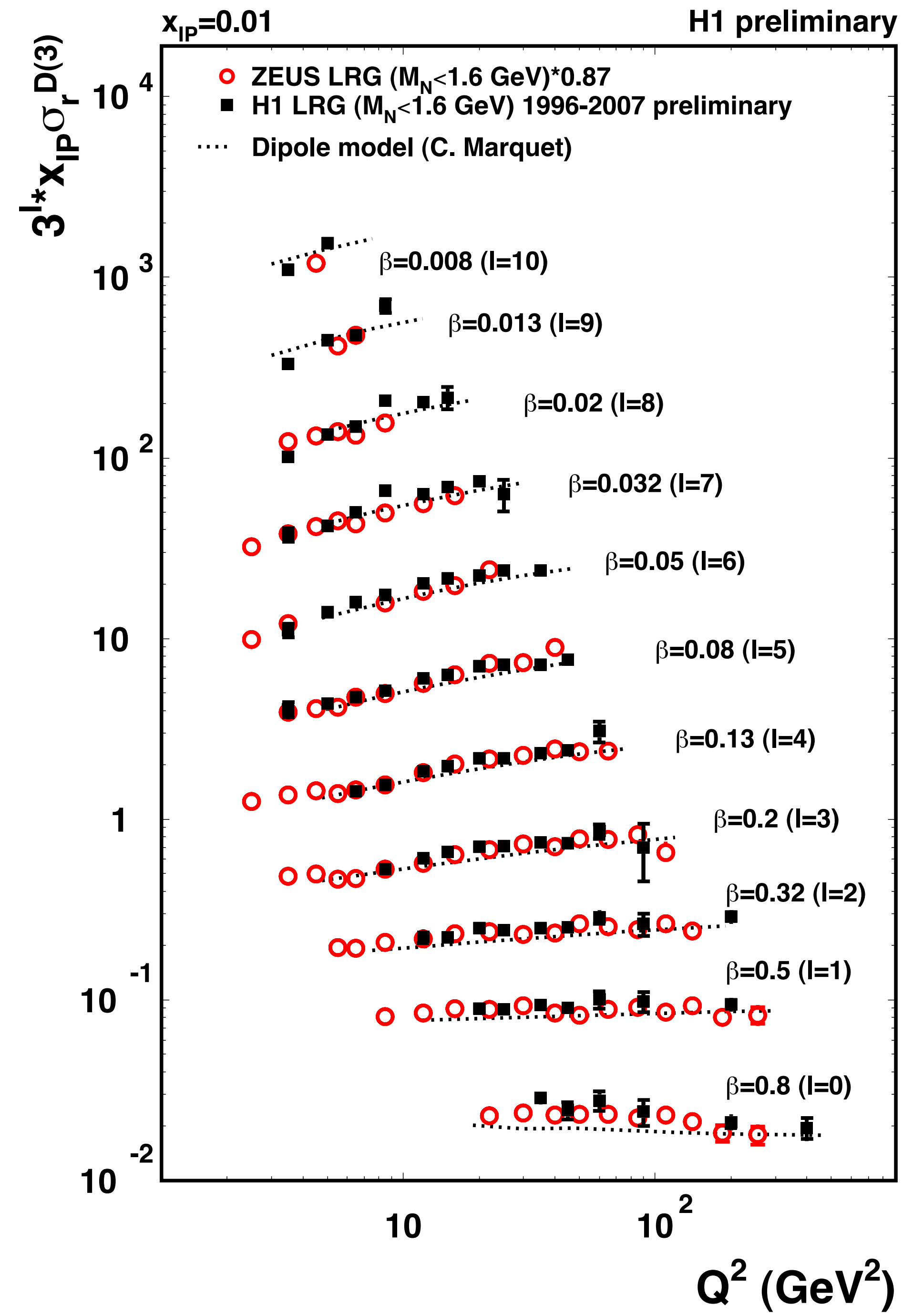


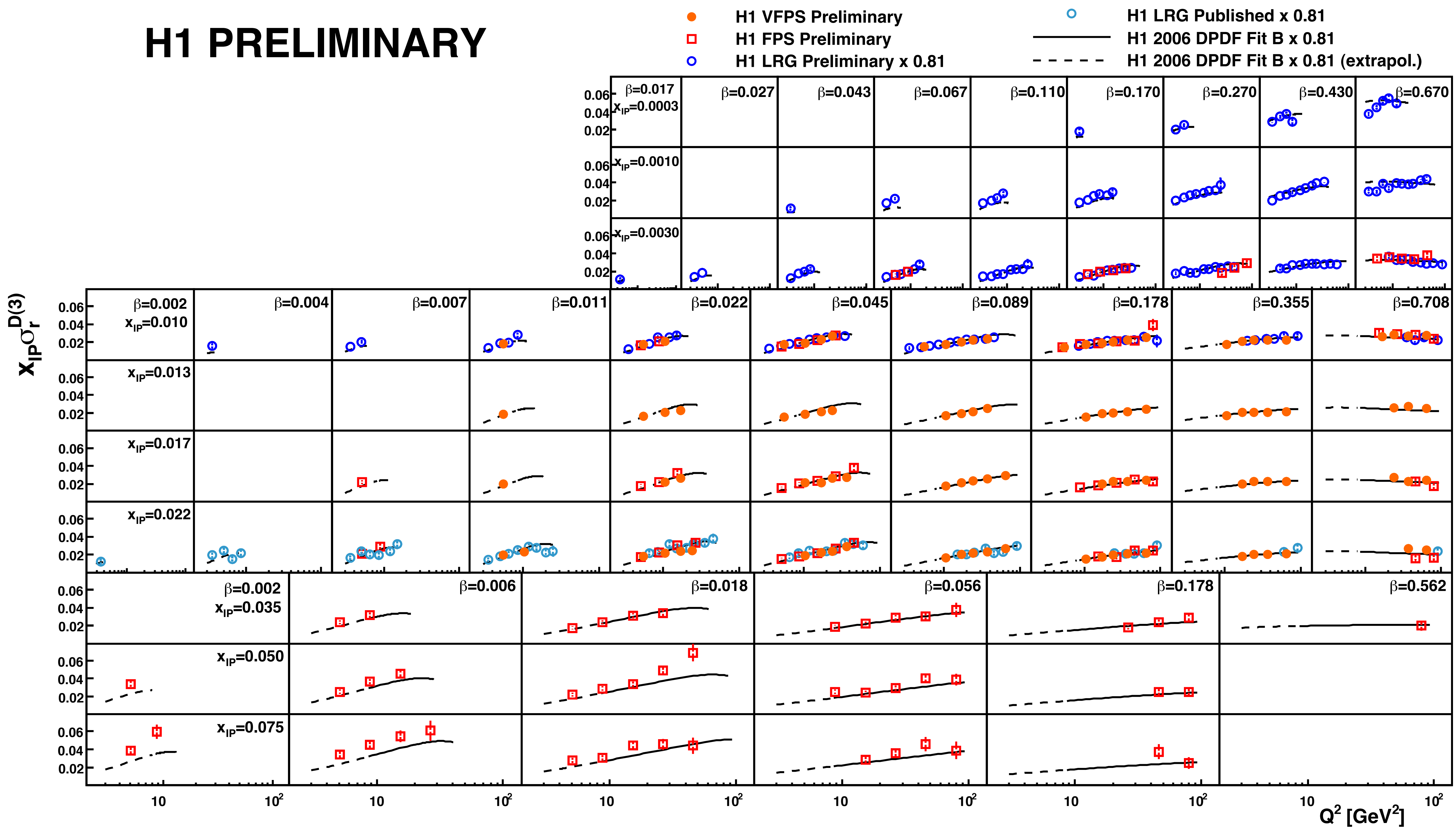






Good agreement between two high precision measurements

Towards a complete H1 diffractive dataset



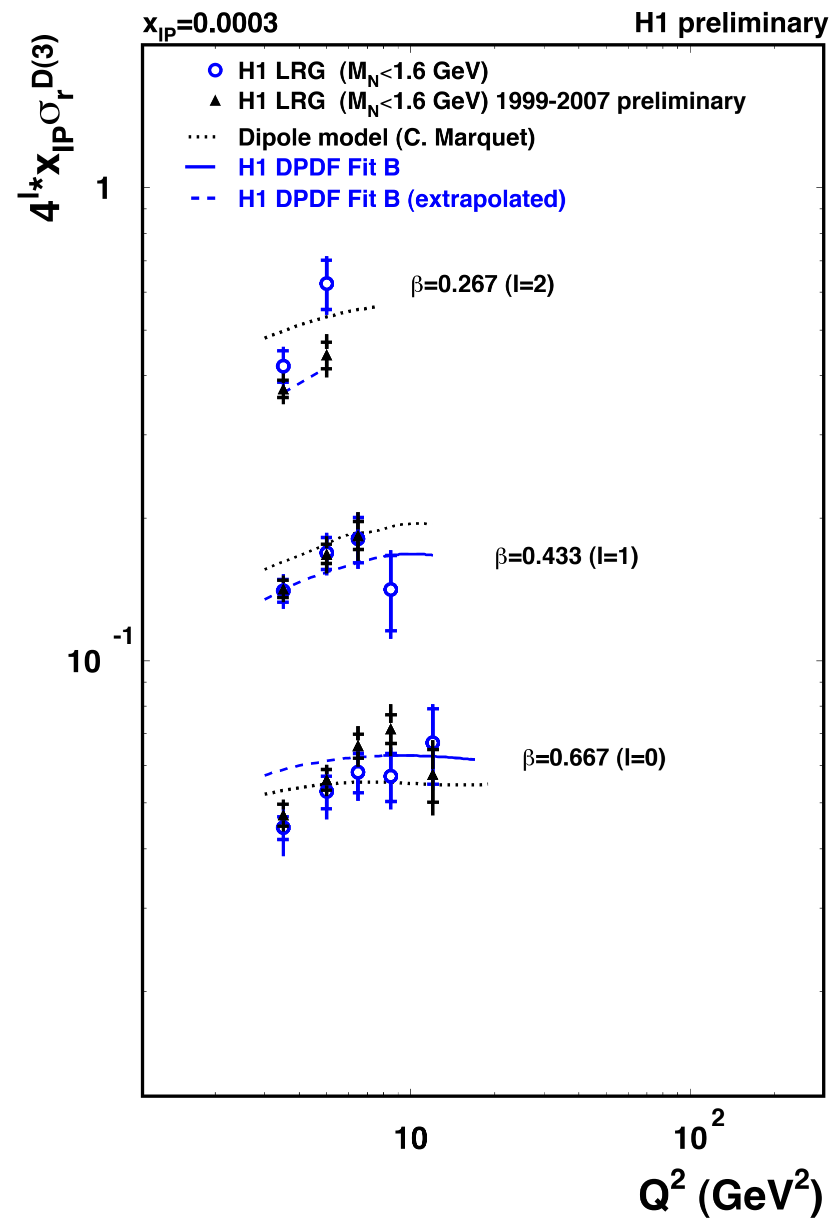
- Still fantastic prospects to come from using all LRG, FPS and VFPS data!

Summary

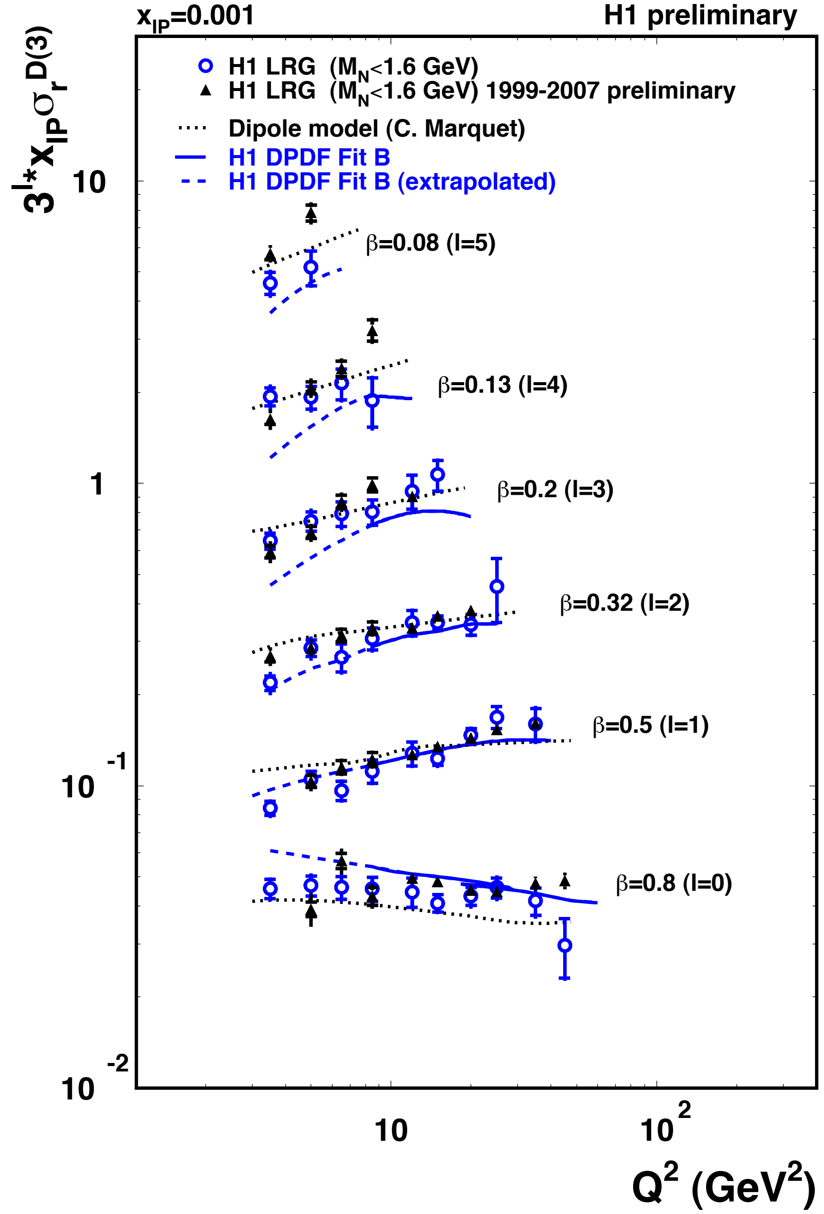
- The diffractive longitudinal structure function measurement at H1 has been extended to low Q^2
- The results are in good agreement with the NLO QCD picture of diffraction

- 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***
- Looking forward to further combinations

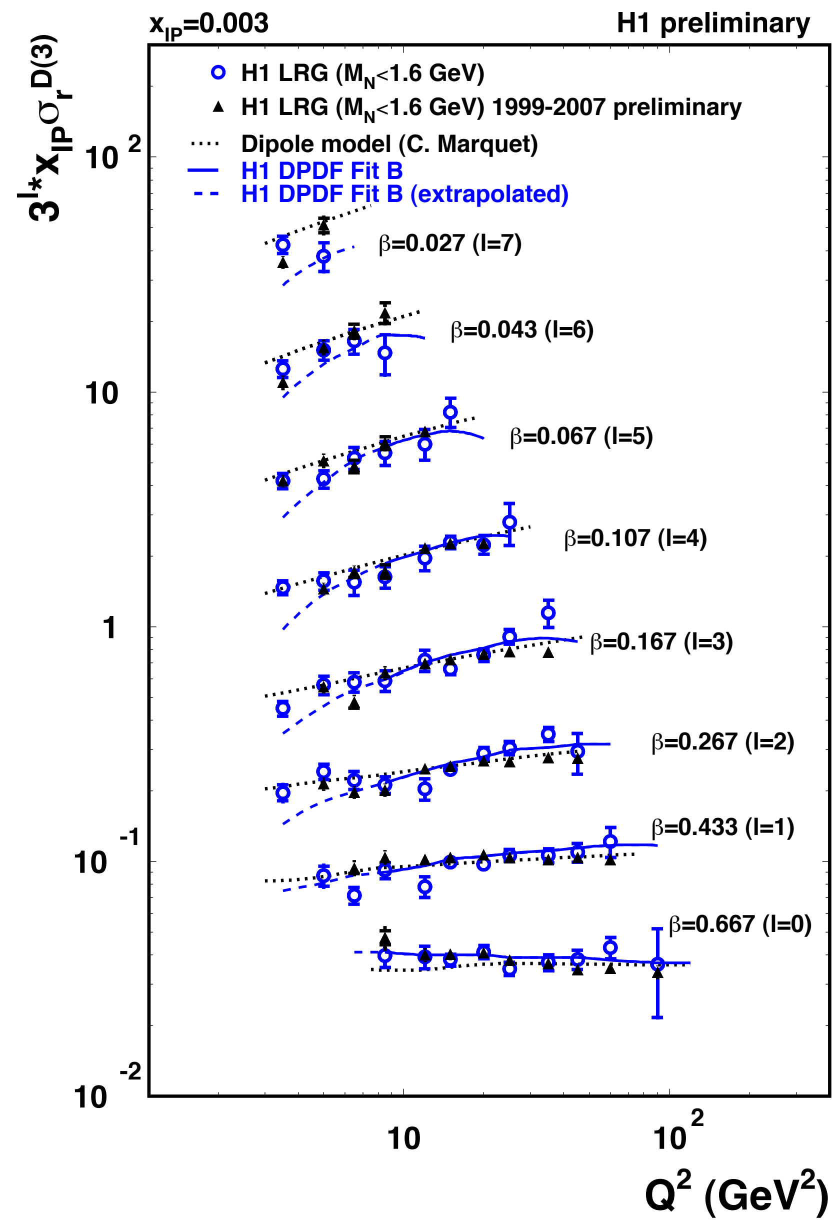
- Backup slides



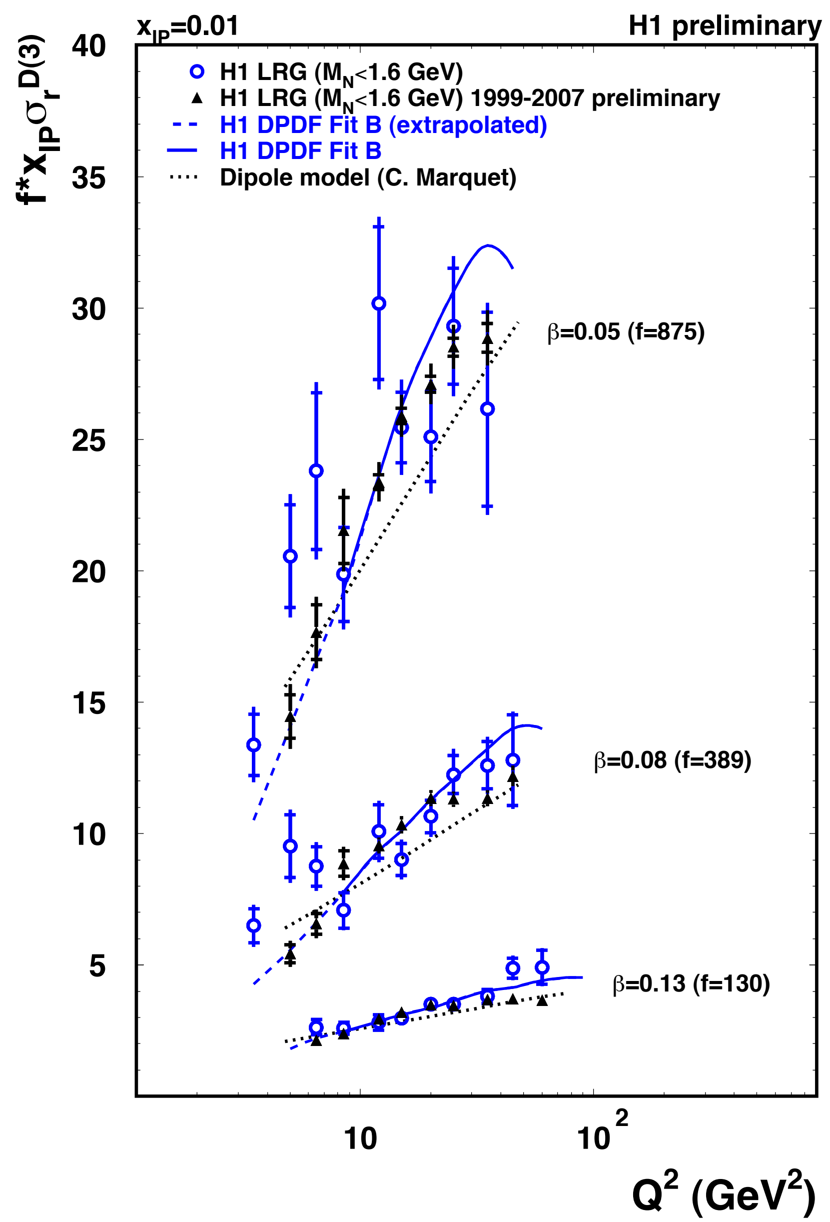
x_IP=0.0003
H1 preliminary
H1 LRG (M_N<1.6 GeV)
H1 LRG (M_N<1.6 GeV) 1999-2007 preliminary
Dipole model (C. Marquet)
H1 DPDF Fit B
H1 DPDF Fit B (extrapolated)
β=0.267 (I=2)
β=0.433 (I=1)
β=0.667 (I=0)
4^I*x_IP σ_r^D(3)
1
10^-1
10
10^2
Q^2 (GeV^2)



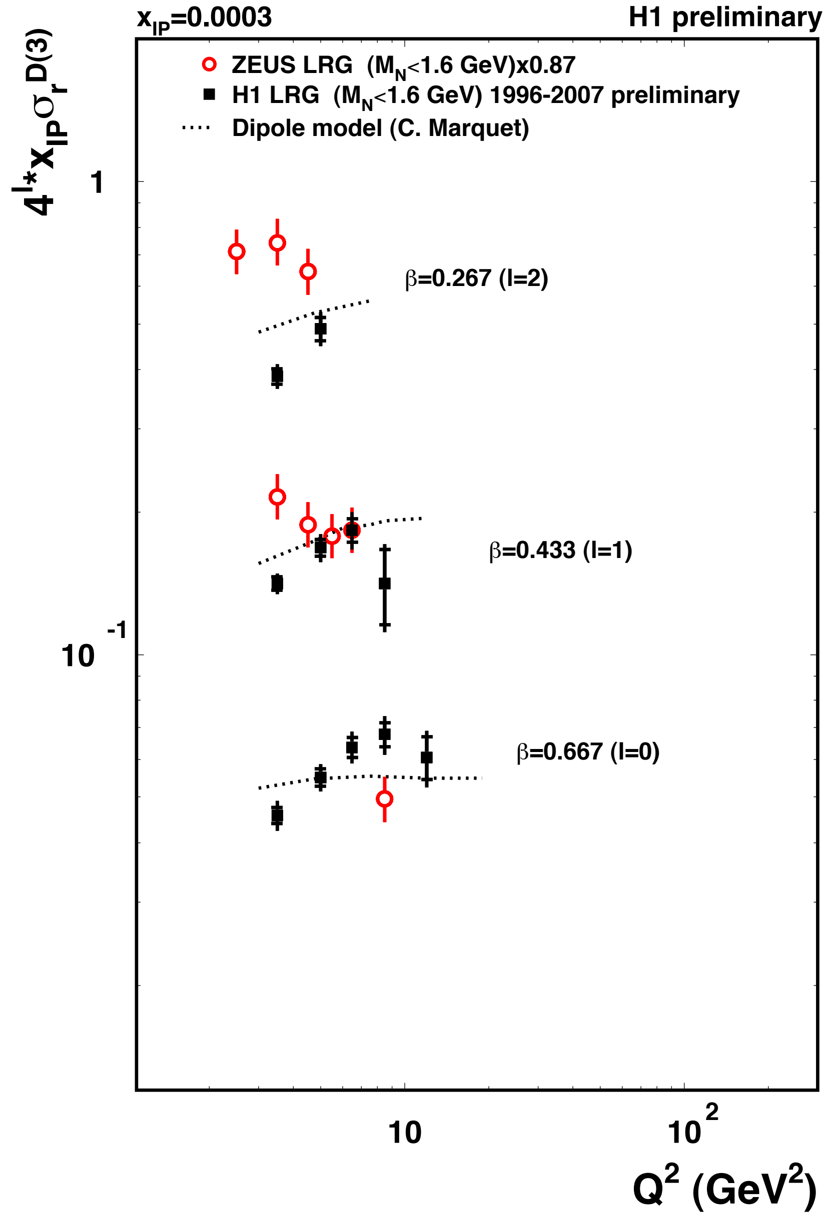
x_{IP}=0.001
H1 preliminary
$3^{l}*x_{IP}\sigma_r^{D(3)}$
H1 LRG (M_N<1.6 GeV)
H1 LRG (M_N<1.6 GeV) 1999-2007 preliminary
Dipole model (C. Marquet)
H1 DPDF Fit B
H1 DPDF Fit B (extrapolated)
β=0.08 (l=5)
β=0.13 (l=4)
β=0.2 (l=3)
β=0.32 (l=2)
β=0.5 (l=1)
β=0.8 (l=0)
10
1
10^{-1}
10^{-2}
10
10^2
Q^2 (GeV^2)



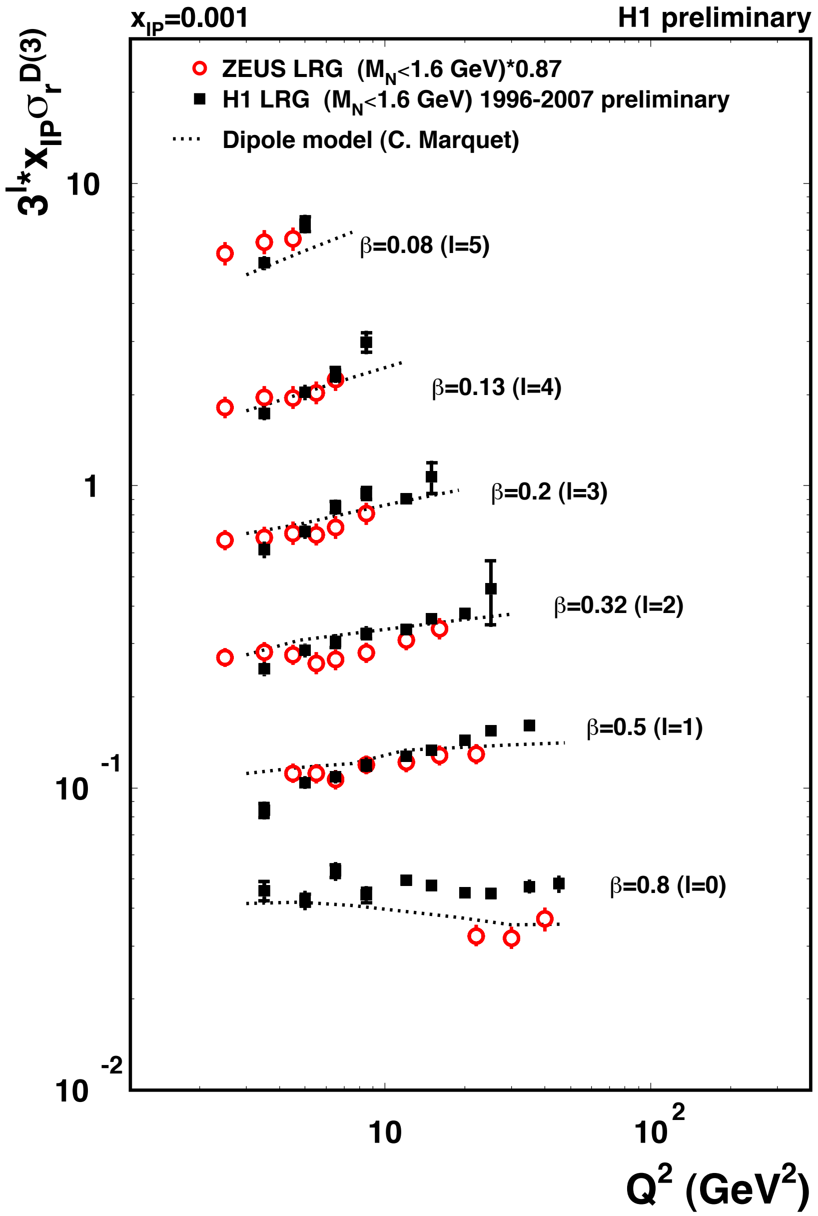
x_IP=0.003
H1 preliminary
H1 LRG (M_N<1.6 GeV)
H1 LRG (M_N<1.6 GeV) 1999-2007 preliminary
Dipole model (C. Marquet)
H1 DPDF Fit B
H1 DPDF Fit B (extrapolated)
β=0.027 (I=7)
β=0.043 (I=6)
β=0.067 (I=5)
β=0.107 (I=4)
β=0.167 (I=3)
β=0.267 (I=2)
β=0.433 (I=1)
β=0.667 (I=0)
3^I*x_IP σ_r^D(3)
Q^2 (GeV^2)
10^2
10
1
10^-1
10^-2



x_{IP}=0.01
H1 preliminary
$f^{*}x_{IP}\sigma_r^{D(3)}$
H1 LRG (M_N<1.6 GeV)
H1 LRG (M_N<1.6 GeV) 1999-2007 preliminary
H1 DPDF Fit B (extrapolated)
H1 DPDF Fit B
Dipole model (C. Marquet)
β=0.05 (f=875)
β=0.08 (f=389)
β=0.13 (f=130)
40
35
30
25
20
15
10
5
10
10^2
Q^2 (GeV^2)



- What's the point



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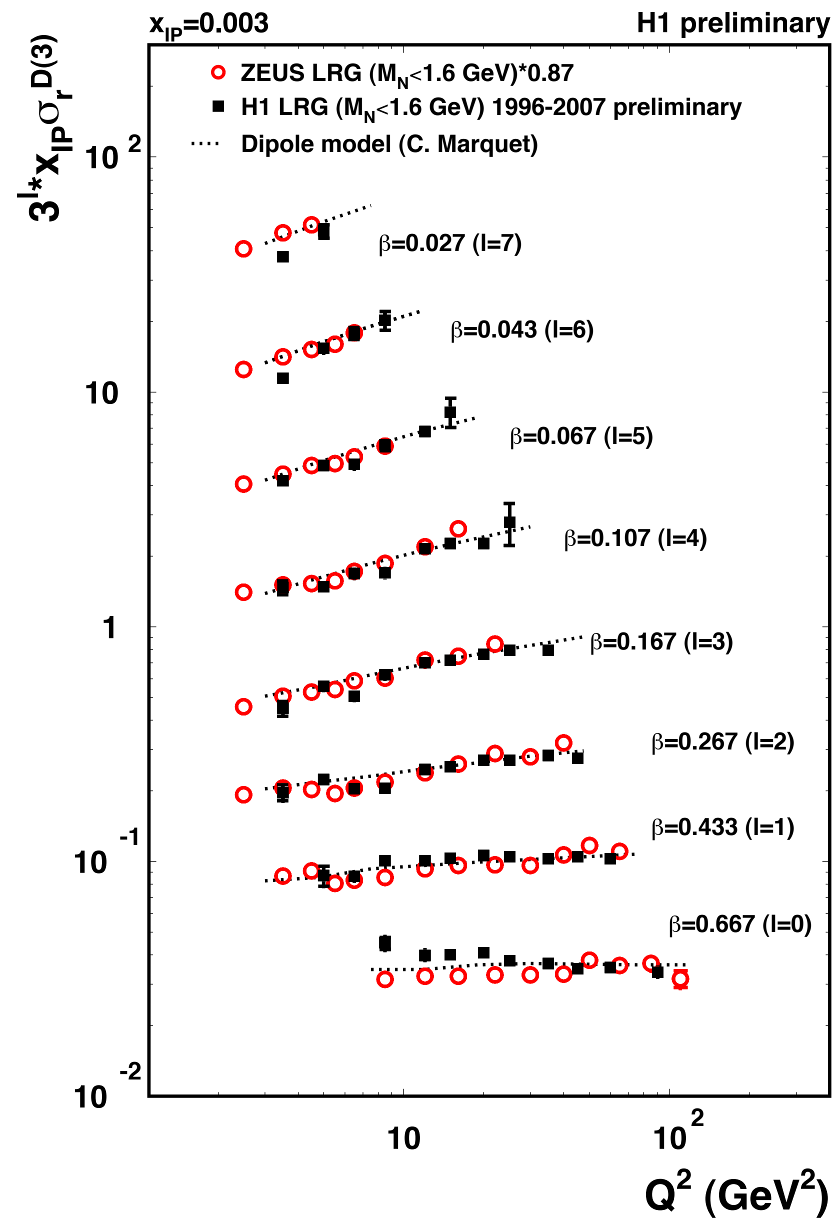

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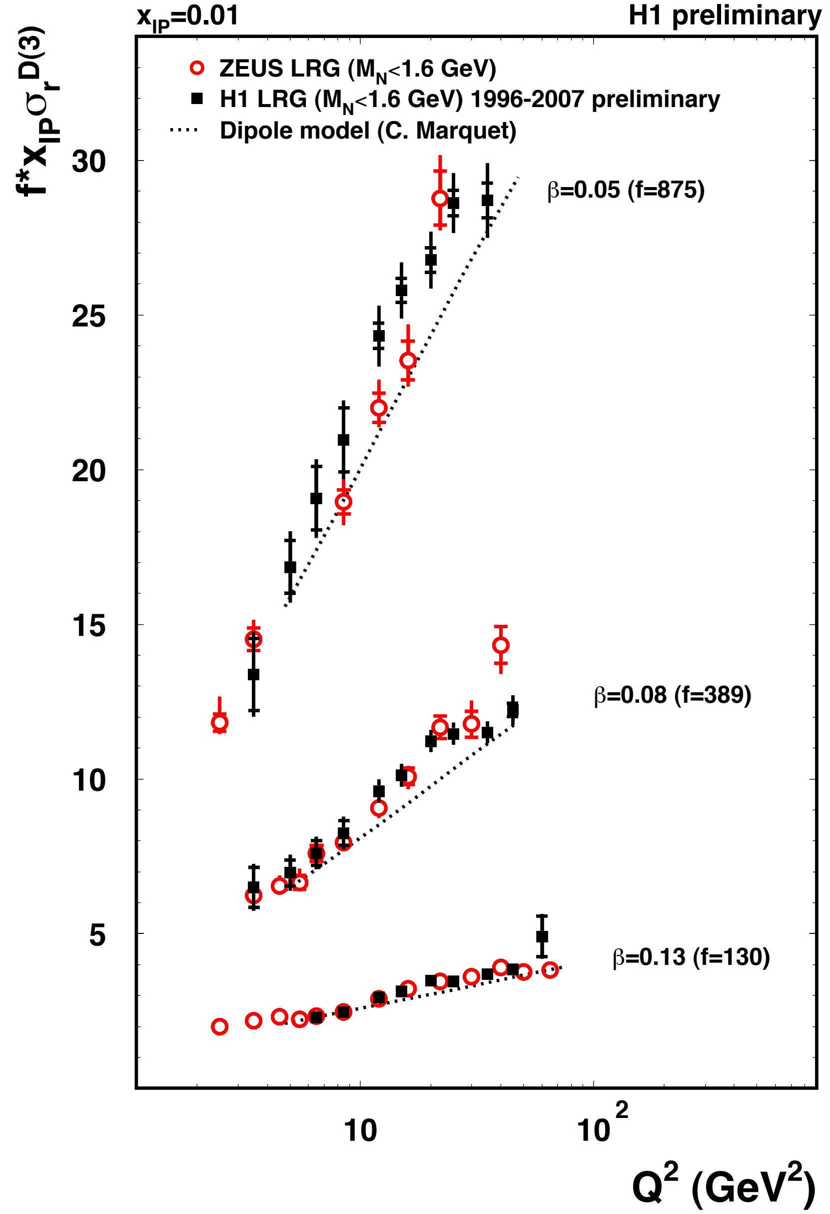

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