HERA Diffractive Structure Function data and Parton Distributions

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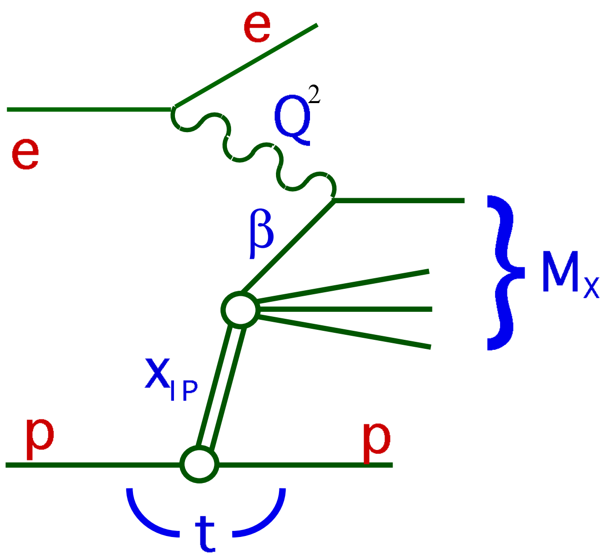
HERA-LHC Workshop Final Meeting

DESY, March 2005

- Comparison of H1 and ZEUS diffractive DIS data
- NLO QCD fit to ZEUS-Mx data

Diffractive Cross section and Structure Functions



$x_{\mathbb{P}} = \xi = \frac{Q^2+M_X^2}{Q^2+W^2} = x_{\mathbb{P}/p}$
(momentum fraction of colour singlet exchange)

$\beta = \frac{Q^2}{Q^2+M_X^2} = x_{q/\mathbb{P}}$
(fraction of exchange momentum of q coupling to γ^*, $x = x_{\mathbb{P}}\beta$)

$t = (p - p')^2$
(4-momentum transfer squared)

Diffractive reduced cross section σ_r^D:

$$\frac{d^4\sigma}{dx_{\mathbb{P}}\ dt\ d\beta\ dQ^2} = \frac{4\pi\alpha^2}{\beta Q^4}\left(1 - y + \frac{y^2}{2}\right)\sigma_r^{D(4)}(x_{\mathbb{P}}, t, \beta, Q^2)$$

Structure functions F_2^D and F_L^D:

$$\sigma_r^{D(4)} = F_2^{D(4)} - \frac{y^2}{2(1-y+y^2/2)}F_L^{D(4)}$$

Integrated over t: $F_2^{D(3)} = \int dt\ F_2^{D(4)}$

– Longitudinal F_L^D: affects σ_r^D at high y

– If $F_L^D = 0$: $\sigma_r^D = F_2^D$

[γ inelasticity $y = Q^2/sx$]

Recent Diffractive DIS Data

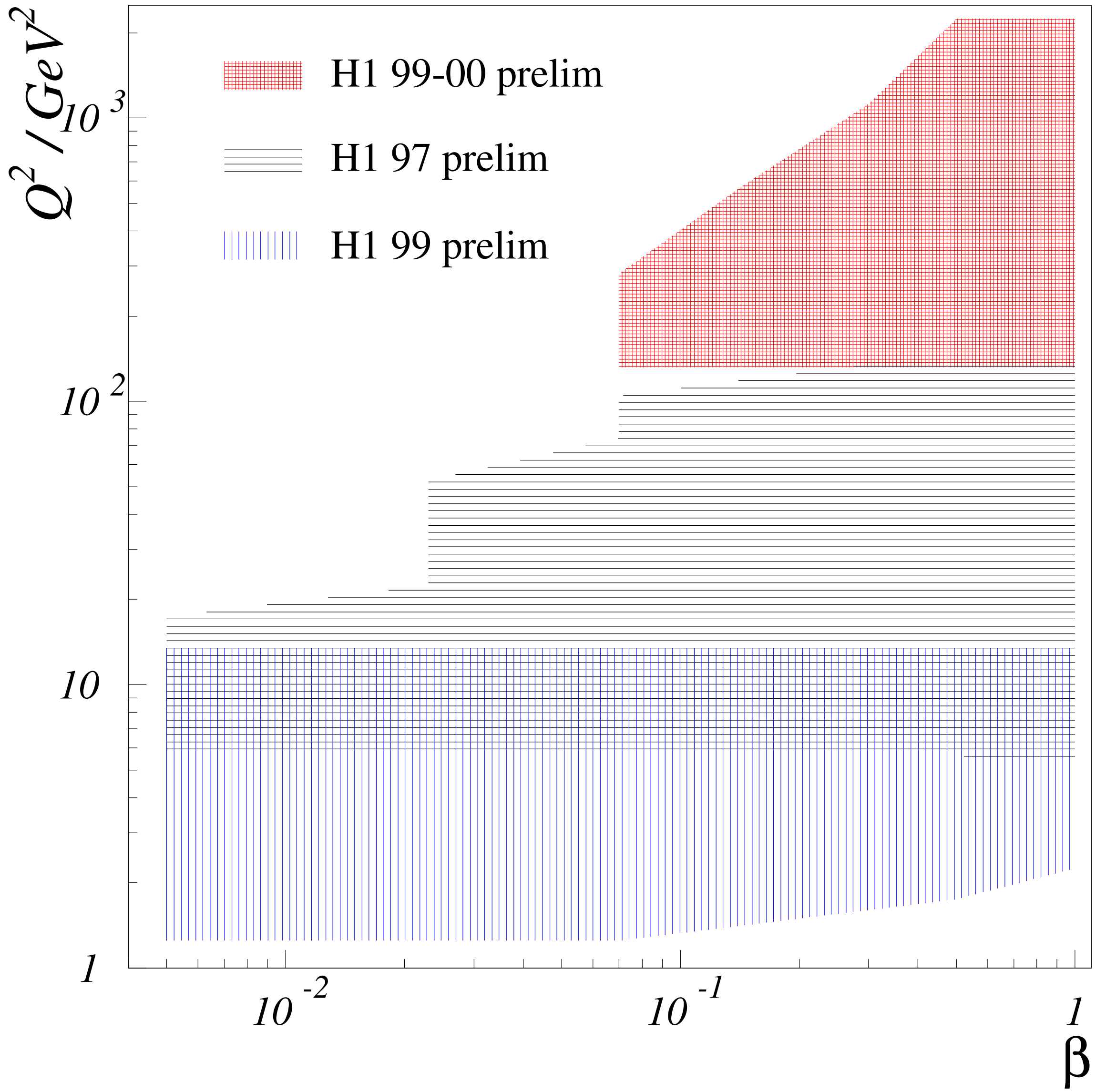
ZEUS Data:

- "Study of Deep Inelastic Inclusive and Diffractive Scattering with the ZEUS Forward Plug Calorimeter" (Mx method)
  DESY-05-011, accepted by Nucl. Phys. B $2.4 < Q^2 < 39$ GeV^2 (98-99)
- "Dissociation of virtual photons in events with a leading proton at HERA" (Leading Proton)
  Eur. Phys. J C38 (2004) 43 $2.7 < Q^2 < 55$ GeV^2 (97)

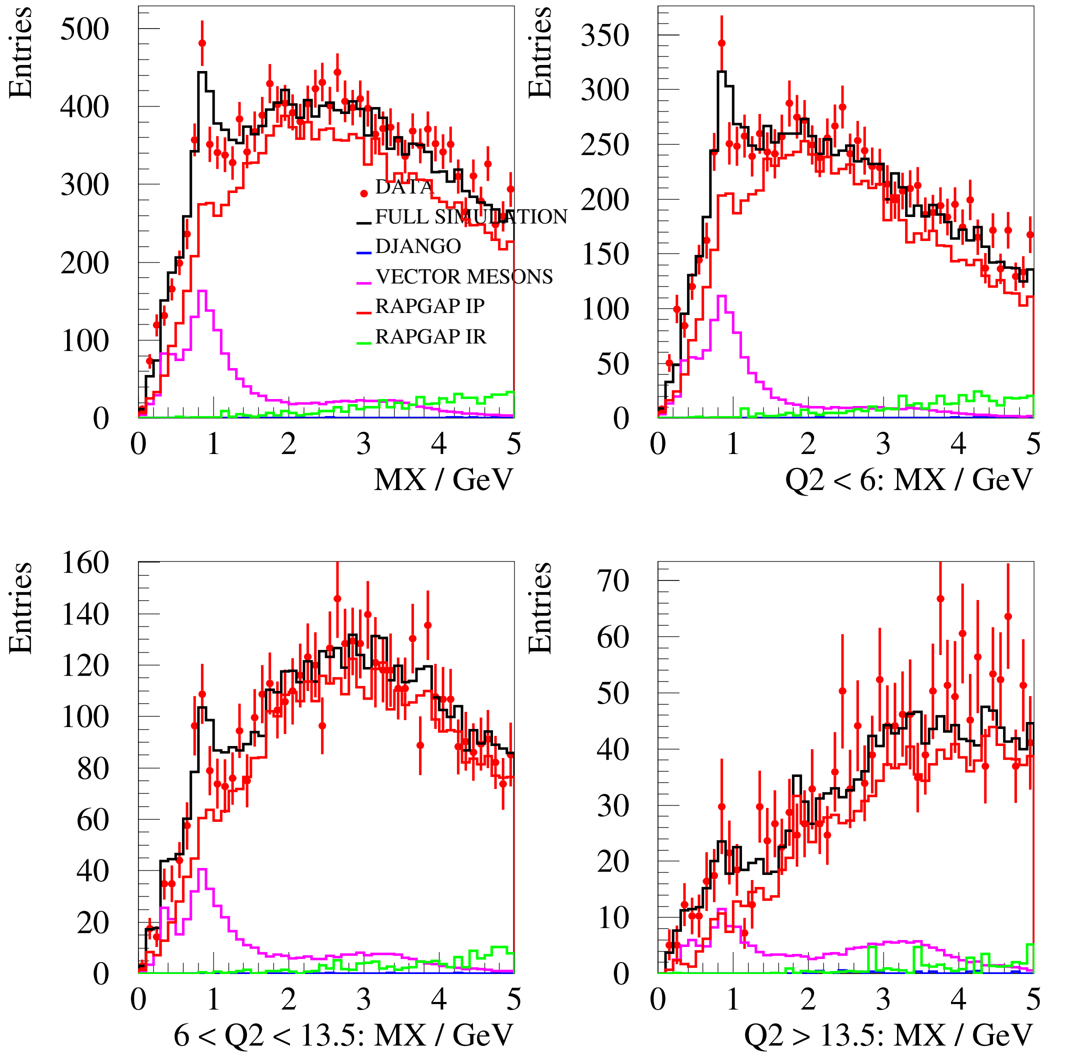
H1 Data:

- "Measurement of semi-inclusive diffractive deep-inelastic scattering with a leading proton at HERA" (Leading Proton)
  Paper 6-984 subm. to ICHEP 2002, H1prelim-01-112 $2.6 < Q^2 < 20$ GeV^2 (99-00)
- "Measurement of the Diffractive DIS Cross Section at low Q^2 " (LRG method)
  Paper 981 subm. to ICHEP 2002, H1prelim-02-112 $1.5 < Q^2 < 12$ GeV^2 (99)
- "Measurement and NLO DGLAP QCD Interpretation of Diffractive Deep-Inelastic Scattering at HERA" (LRG method)
  Paper 980 subm. to ICHEP 2002, H1prelim-02-012 $6.5 < Q^2 < 120$ GeV^2 (97)
- " Measurement of the Inclusive Diffractive Cross Section $\sigma_r^D(3)$ at high Q^2" (LRG method)
  Paper 5-090 subm. to EPS 2003, H1prelim-03-011 $200 < Q^2 < 1600$ GeV^2 (99-00)

H1 Diffractive DIS Data: Kinematic plane



H1 Data: control plots at low Q^2



M_X dependence in different Q^2 intervals ...

Data well under control, also at low Q^2

Comparisons H1 vs ZEUS Data: Prerequisites

(1) Datasets correspond to different requirements on outgoing proton system (p or Y):

- H1 rapidity gap: $M_Y < 1.6$ GeV; ZEUS Mx: $M_Y < 2.3$ GeV
- H1/ZEUS Leading proton data: $M_Y = m_p$
- All data correspond to $|t| < 1.0$ GeV^2

$\Rightarrow$ For the purpose of direct comparisons,
leading proton and ZEUS-Mx data have been scaled to $M_Y < 1.6$ GeV

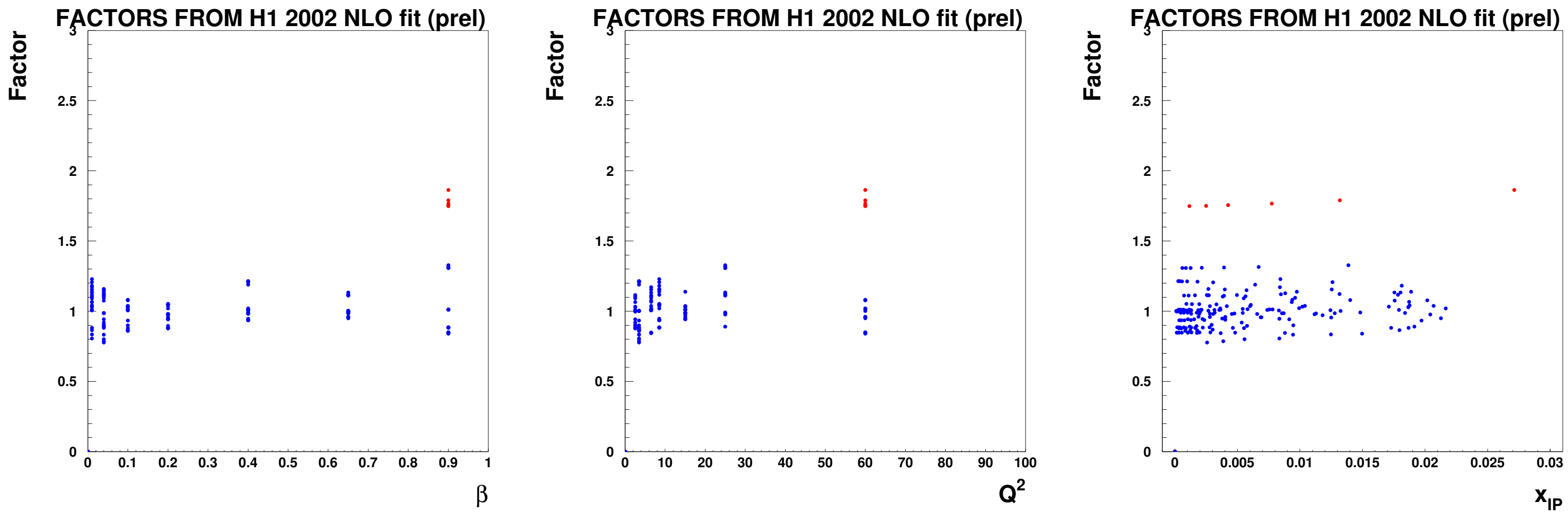
Scaling factors:
ZEUS LPS and H1 FPS: 1.1
ZEUS Mx: $1.1 * 0.7 = 0.77$

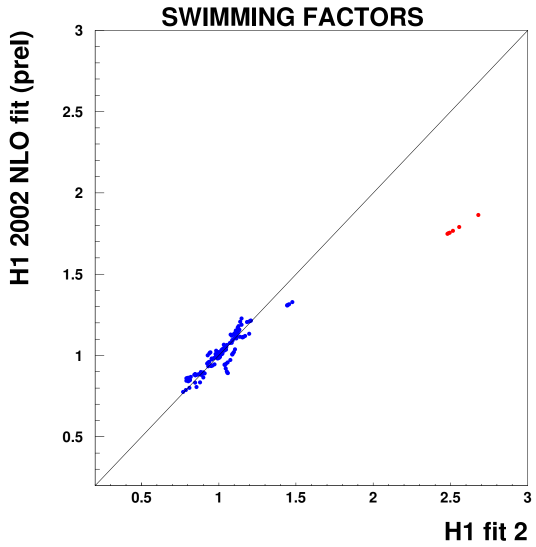
(2) Data points are measured at different values of Q^2, β, $x_{I\!P}$:

$\Rightarrow$ H1-FPS and ZEUS data have been transported to the central values of the H1 LRG measurements

- Both the H1 2002 fit and the old 'fit 2' have been used
- Points are only shown if the correction applied is
  (a) less than 25% different between the two fits
  (b) less than 50% in total

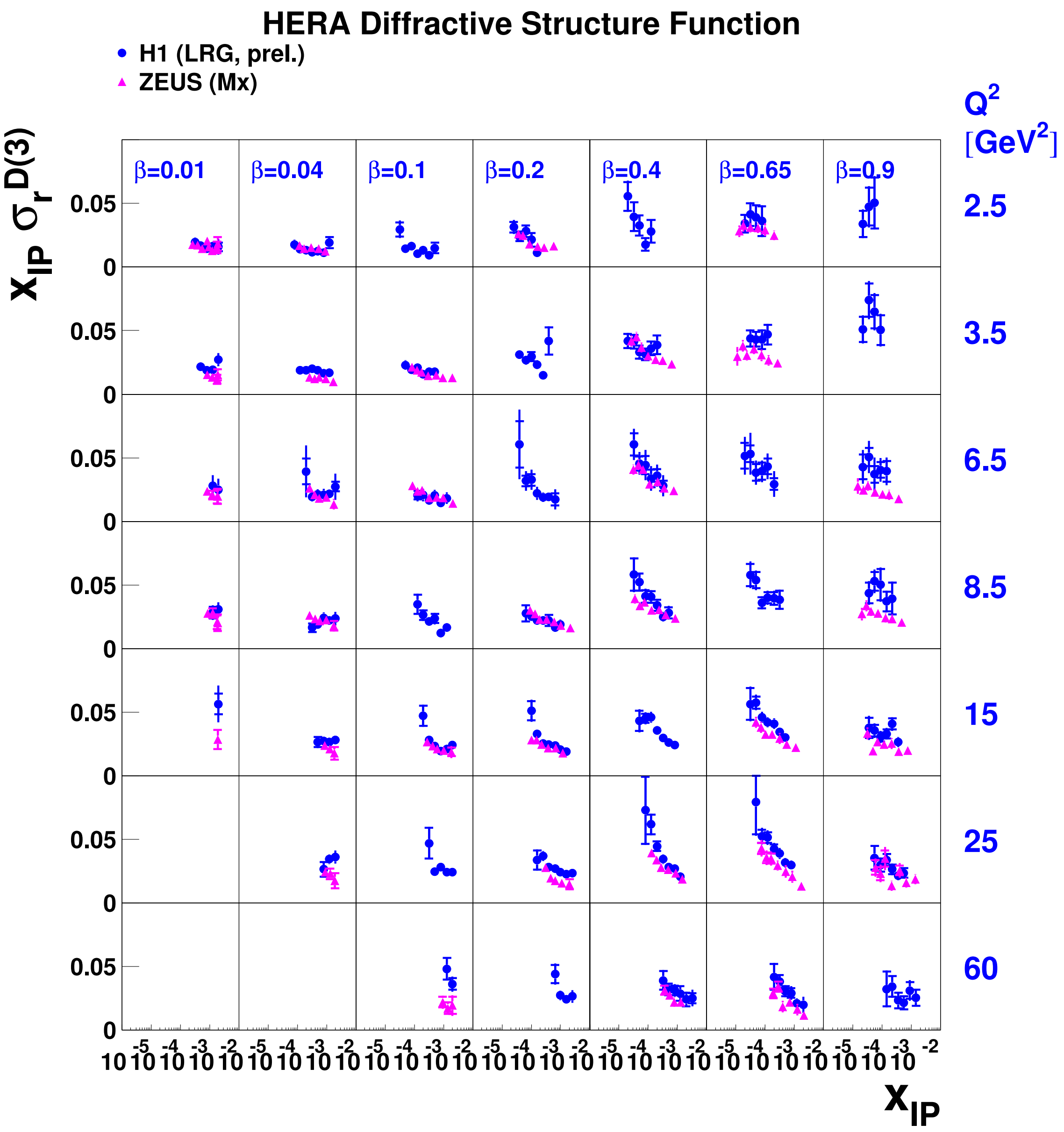
Corrections applied to ZEUS Mx data



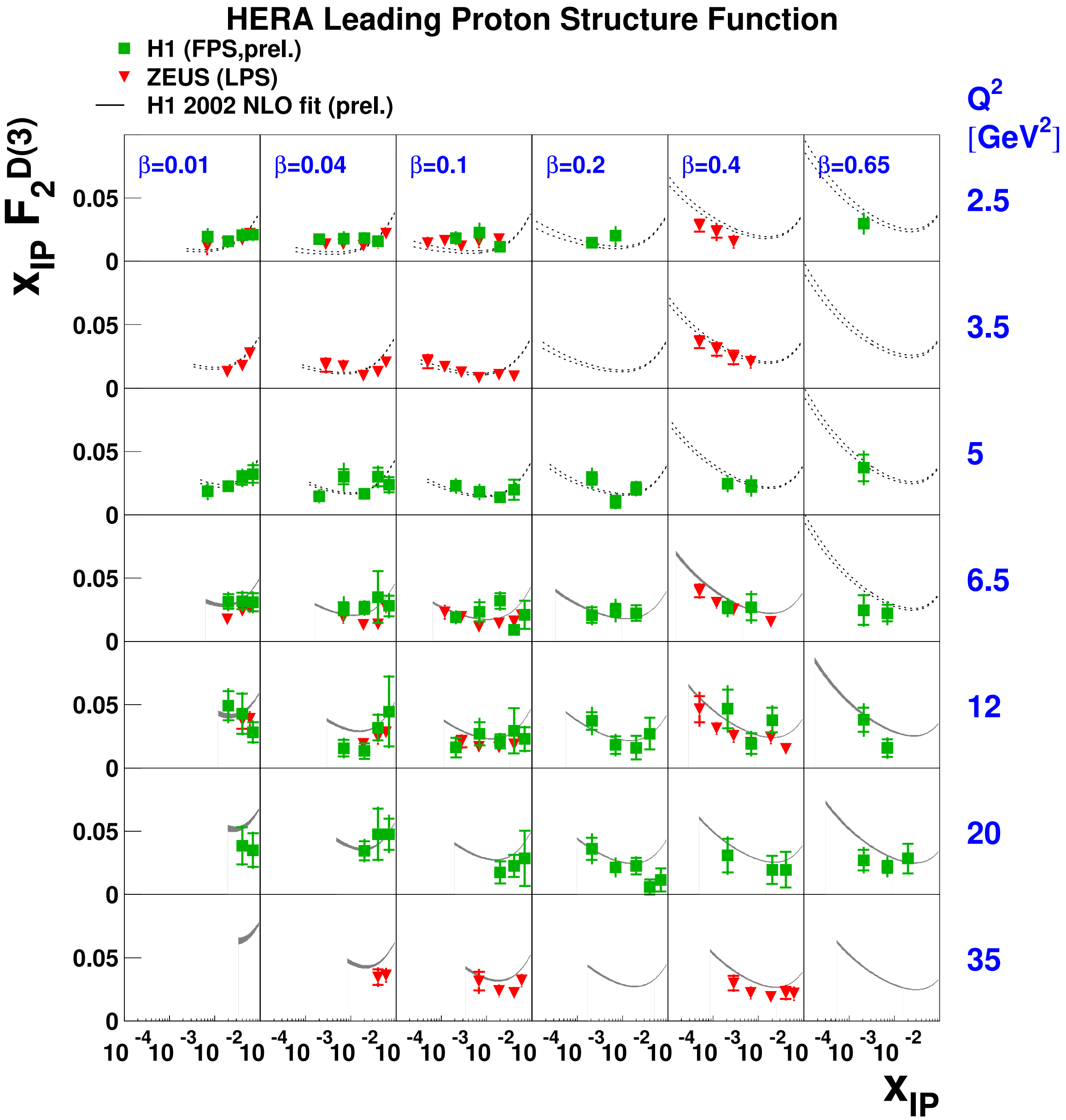


Points in red have been excluded!

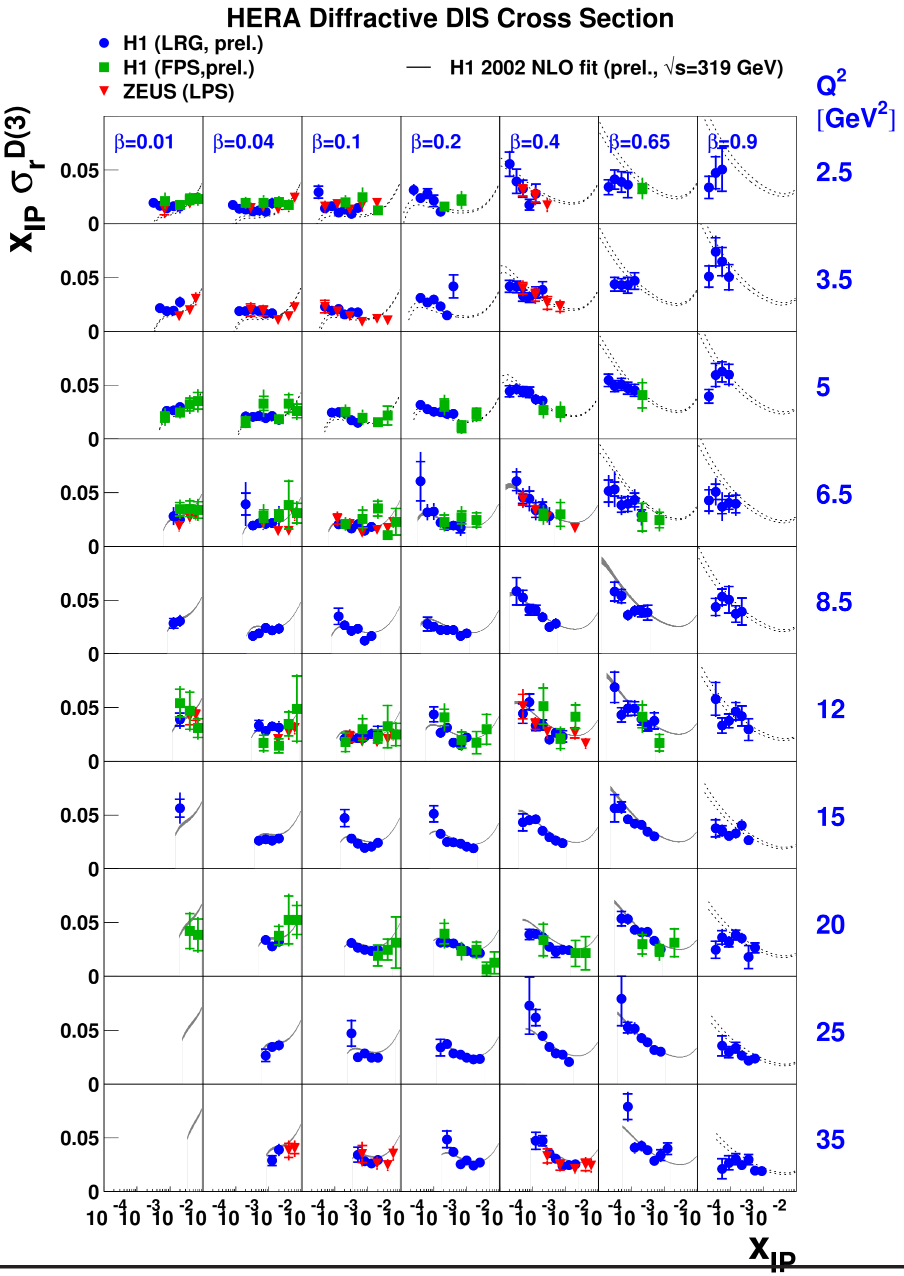
Comparison of ZEUS Mx with H1 LRG Data

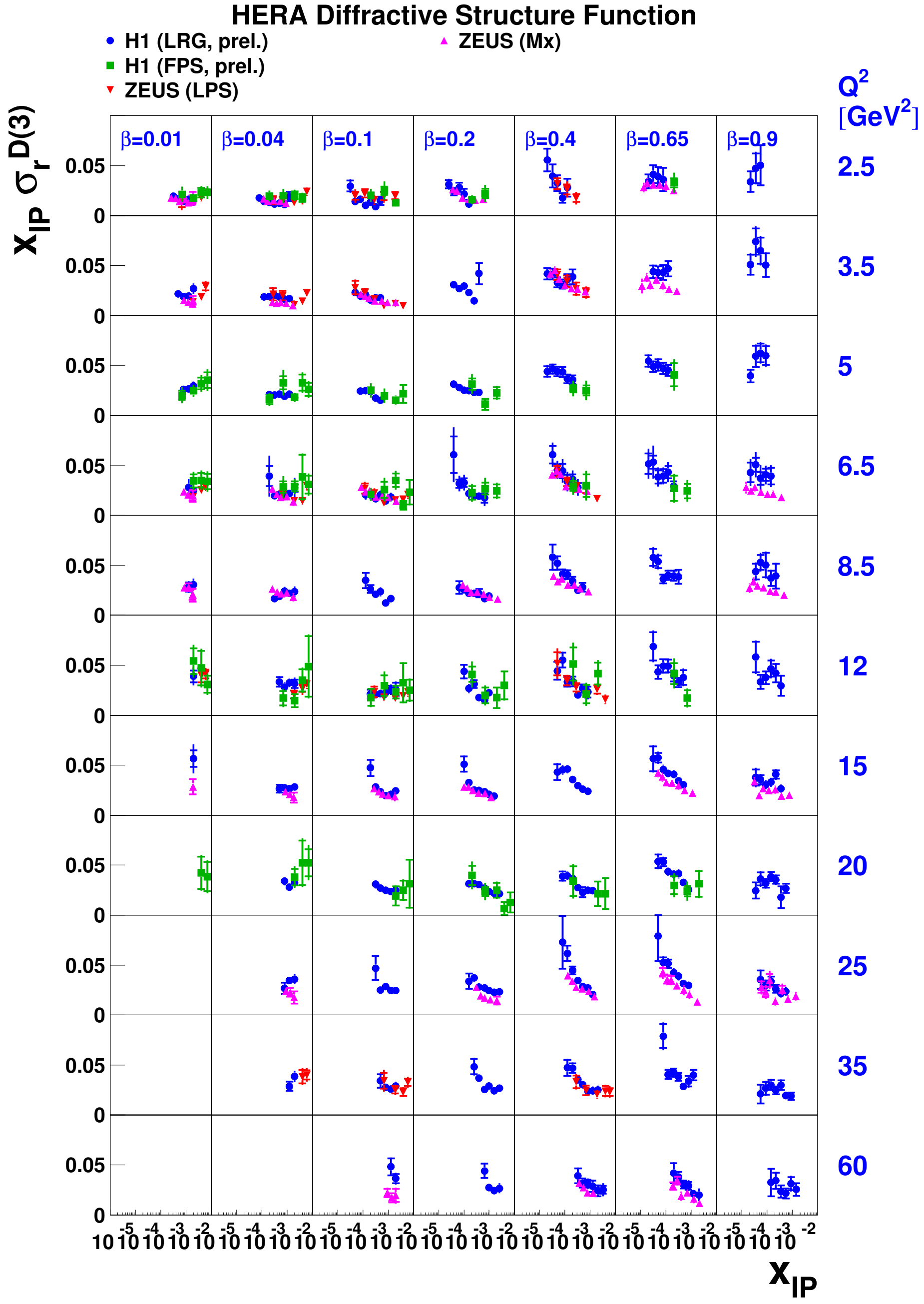


Comparison of Leading Proton Data (here for $M_Y = m_p$)



Comparison of Leading Proton with H1 LRG data (now for $M_Y < 1.6$)

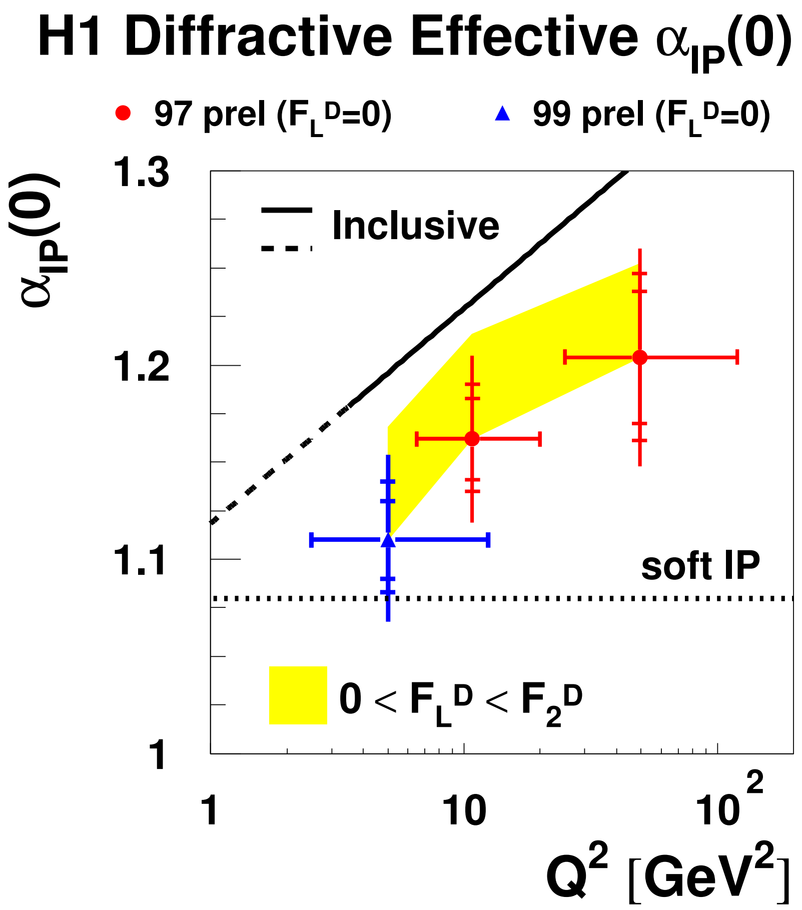


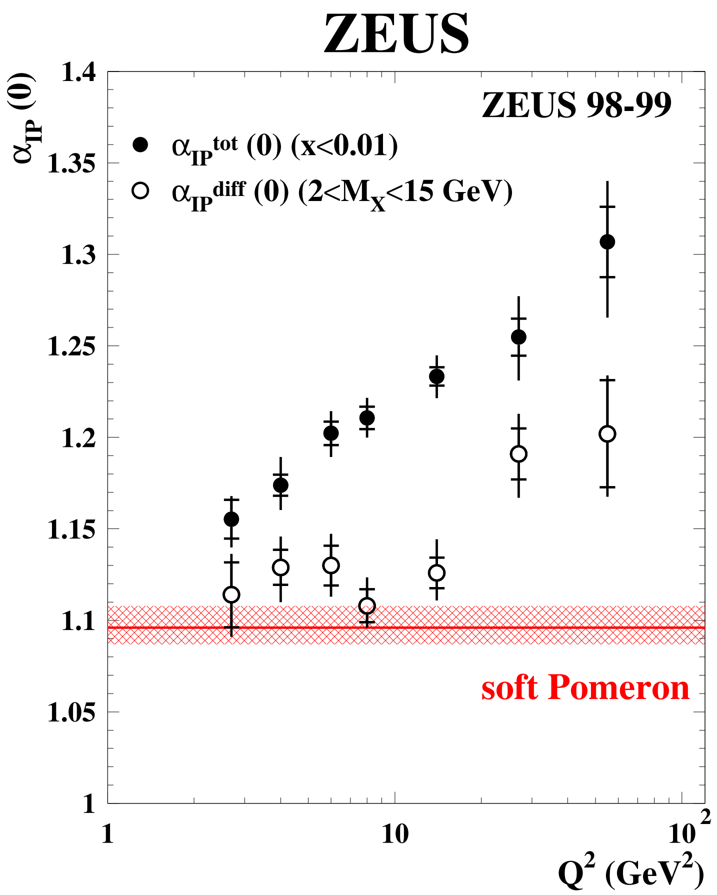


Comparison of all data
($M_Y < 1.6$)

(only Q^2 bins with at least two datasets shown)

H1 and ZEUS Pomeron Intercepts





Reminder of H1 2002 NLO DGLAP QCD Fit

QCD Fit Technique:

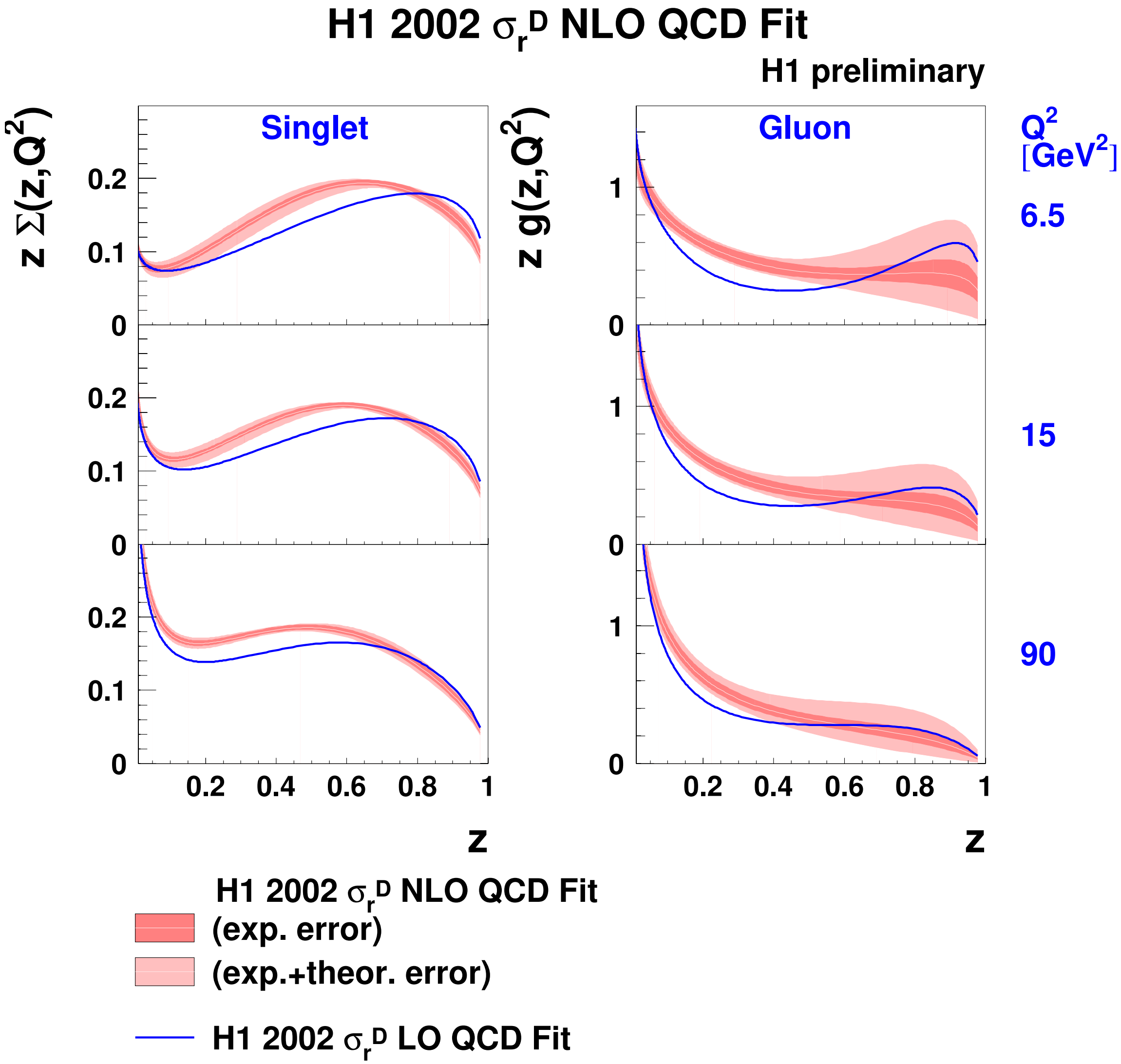
- factorize $f(x_{I\!P})f(z,Q^2)$
- Singlet Σ and gluon g parameterized at $Q_0^2 = 3\ \mathrm{GeV}^2$
- NLO DGLAP evolution
- Fit data for $Q^2 > 6.5\ \mathrm{GeV}^2$, $M_X > 2\ \mathrm{GeV}$

PDF's of diffractive exchange:

- Extending to large fractional momenta z
- Gluon dominated
- Σ well constrained

$$\chi^2/ndf = 308/306$$
$$\alpha_{I\!P}(0) = 1.173\ (\mathrm{Reggefit})$$

NB: $\lambda_{QCD} = 200 \pm 30\ \mathrm{MeV}$ variation included in outer error band



NLO QCD fit to ZEUS Mx data

Strategy:

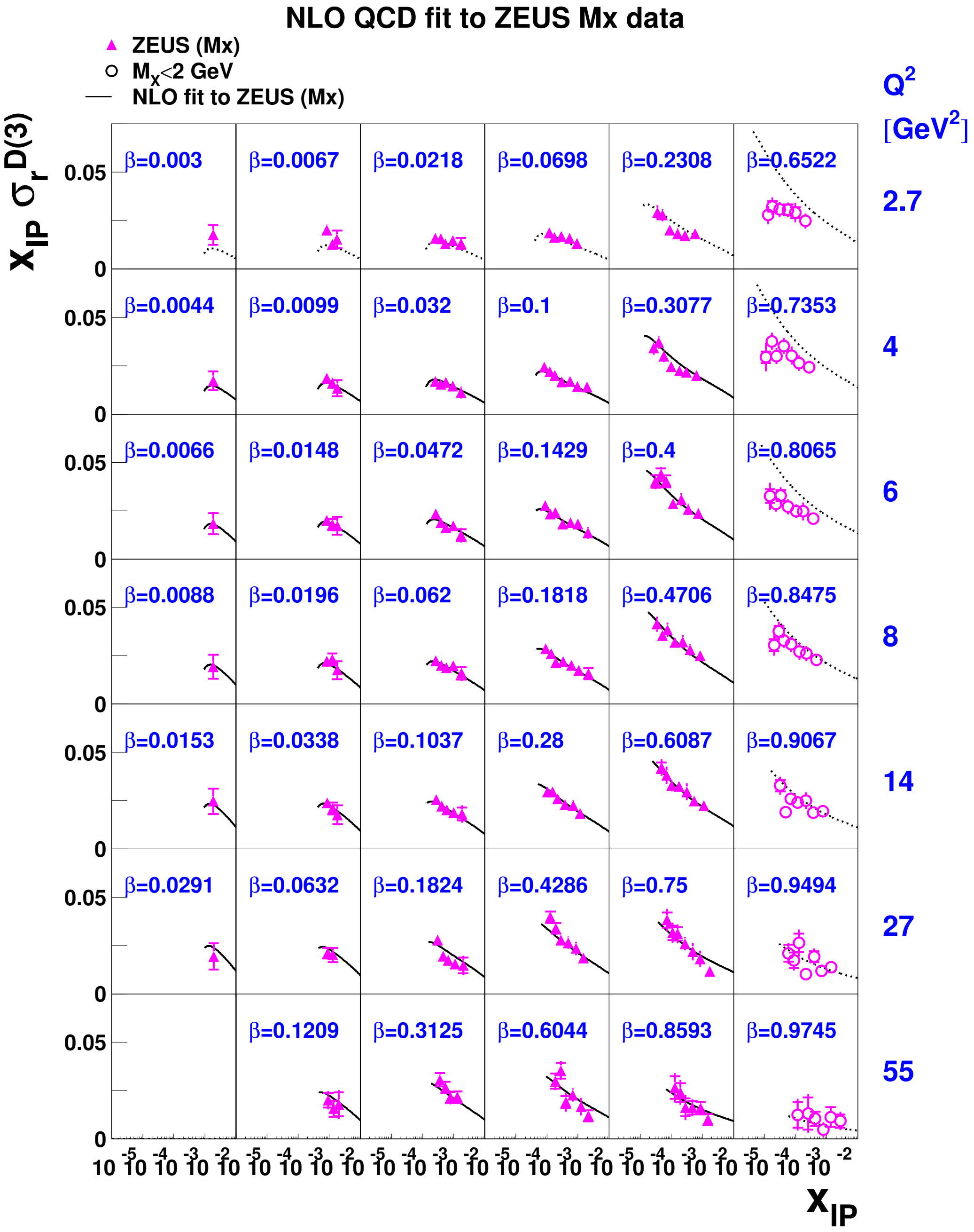
- Make QCD fit in a very similar way as for H1 fit 2002, so that pdf's can be directly compared
- Use ZEUS Mx data in original binning, scaled to $M_Y < 1.6$ GeV

The 'NLO fit to ZEUS data':

- Fit Mx data for $Q^2 > 4$ GeV^2 (H1: 6.5)
- The total (stat.+syst. added) error of the data is considered
- No meson component (includung one does not improve the fit)
- Pomeron intercept fitted at the same time as pdf's
- everything else the same as for H1 2002 fit

$$\chi^2/ndf = 90/131$$
$$\alpha_{I\!P}(0) = 1.132 \pm 0.006(\text{exp.})$$

A very good fit is obtained with a common Intercept!

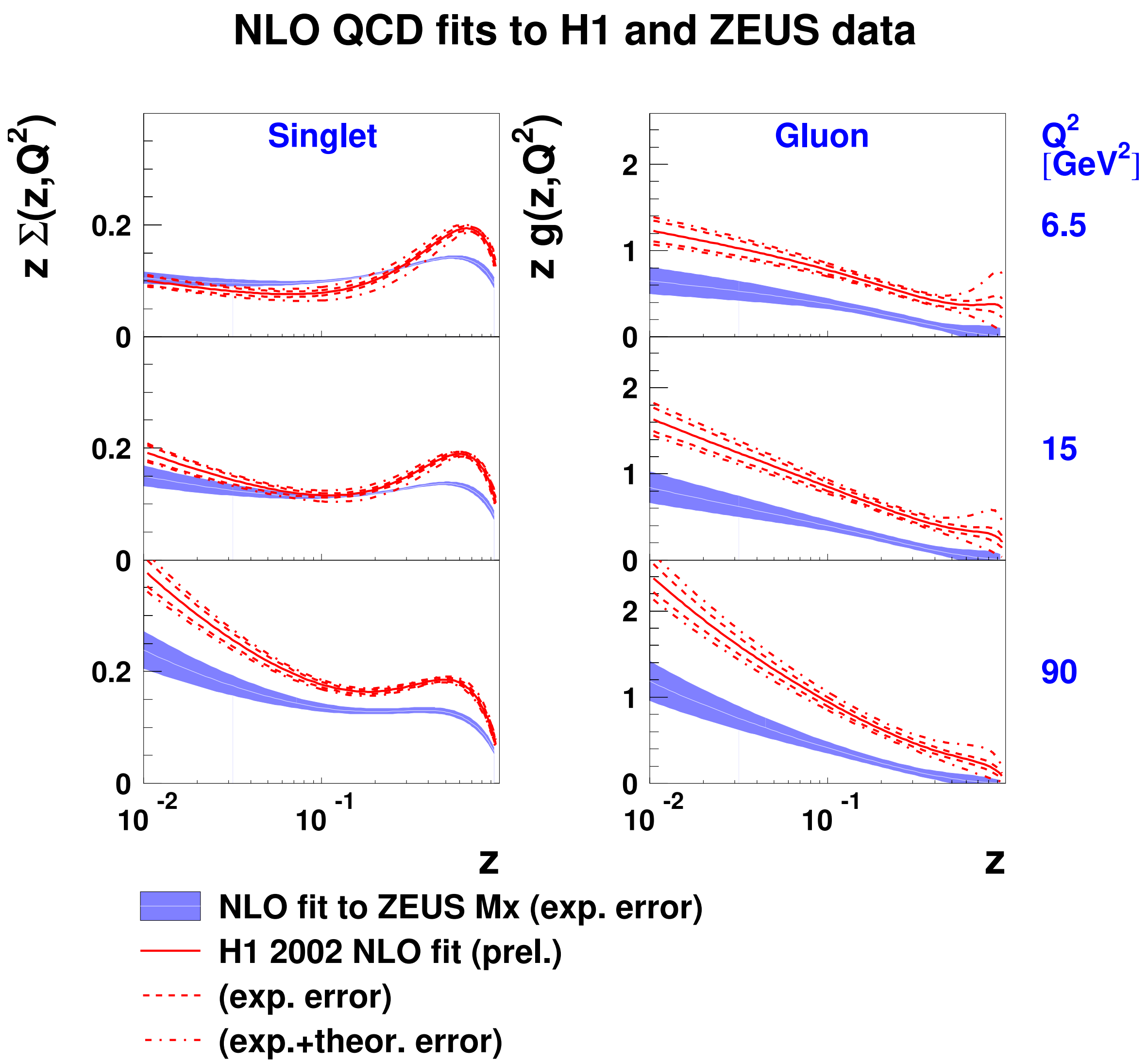


NLO QCD fit to ZEUS Mx data

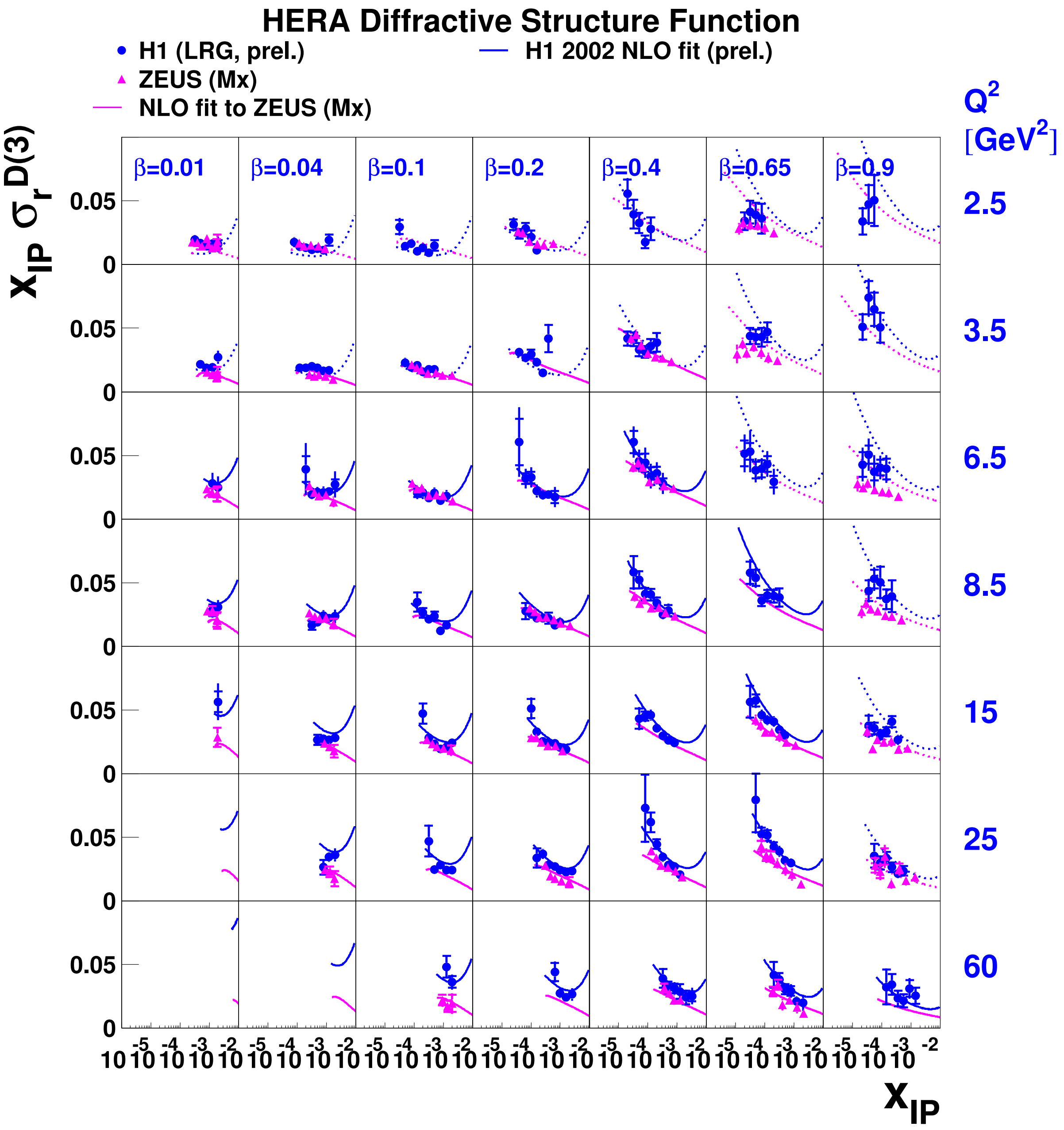
Data for $M_X < 2$ GeV not fitted (as for H1 fit)

Fit describes data well

NLO fit to ZEUS Mx data



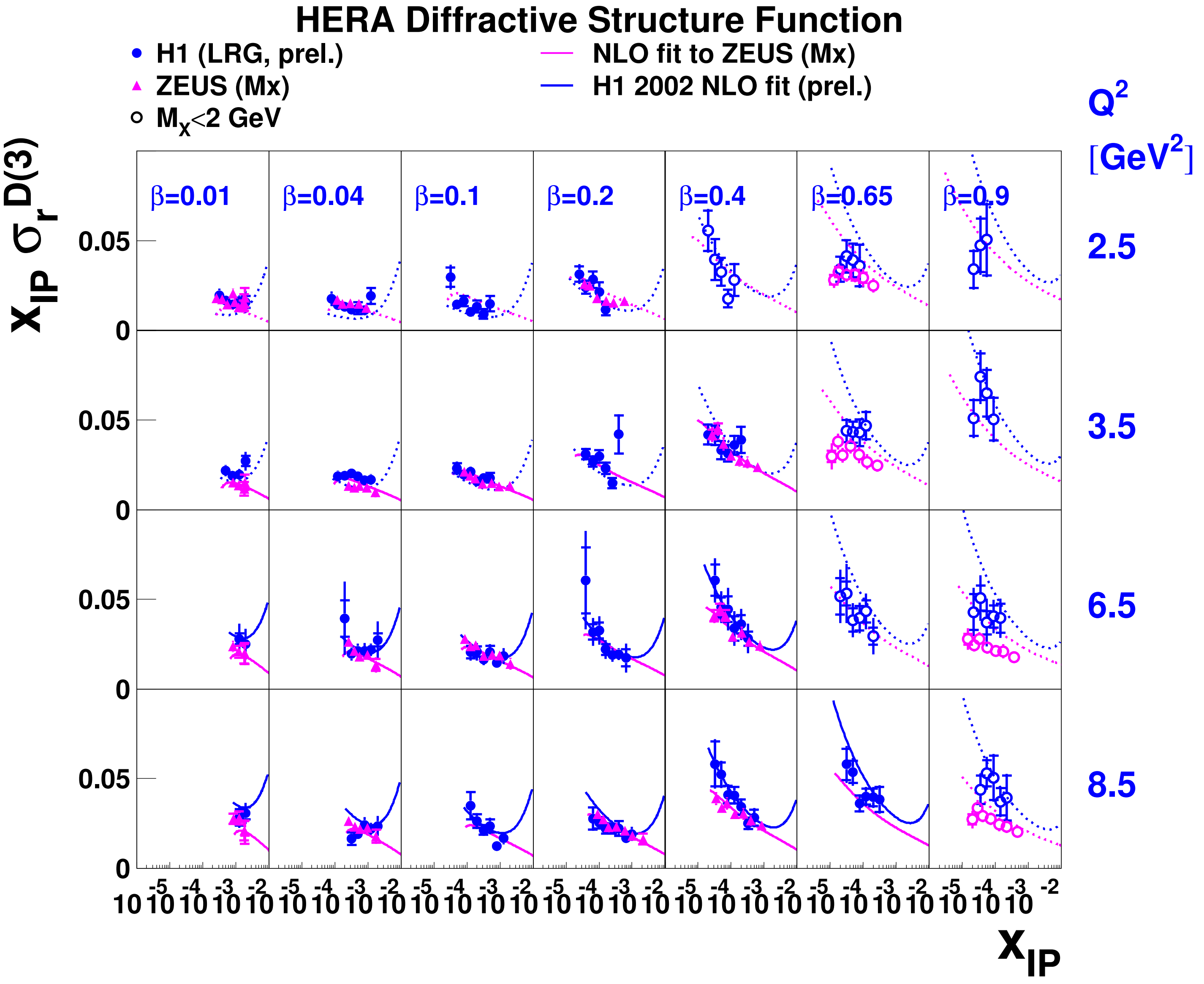
- Singlet similar at low Q^2, evolving differenly to higher Q^2 due to coupling to gluon
- Gluon factor $\sim$ 2 smaller than H1 gluon



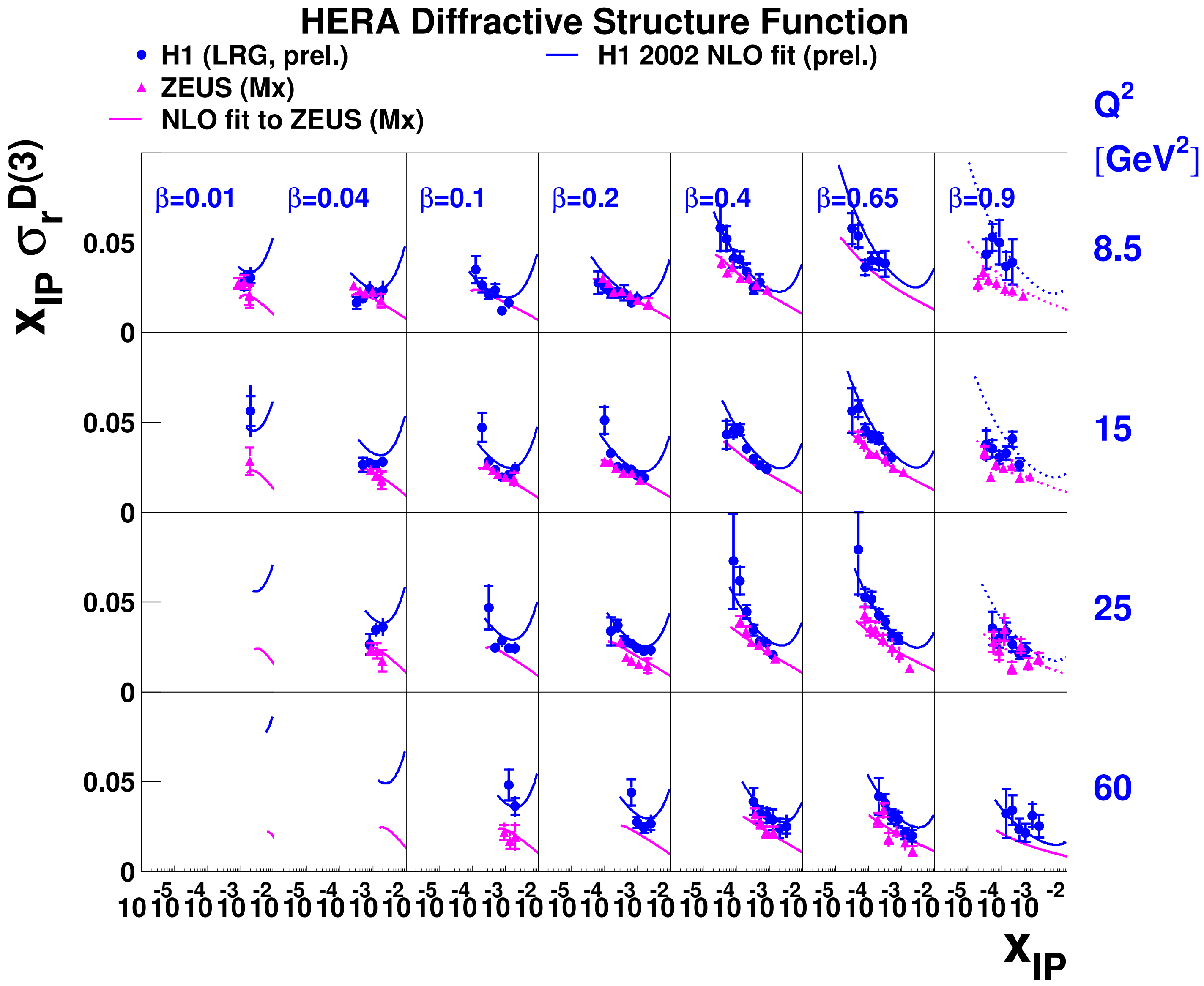
H1 and ZEUS data and fits

- Differences in data in high β region not included in fits
- Smaller positive scaling violations in ZEUS data, leading to smaller gluon

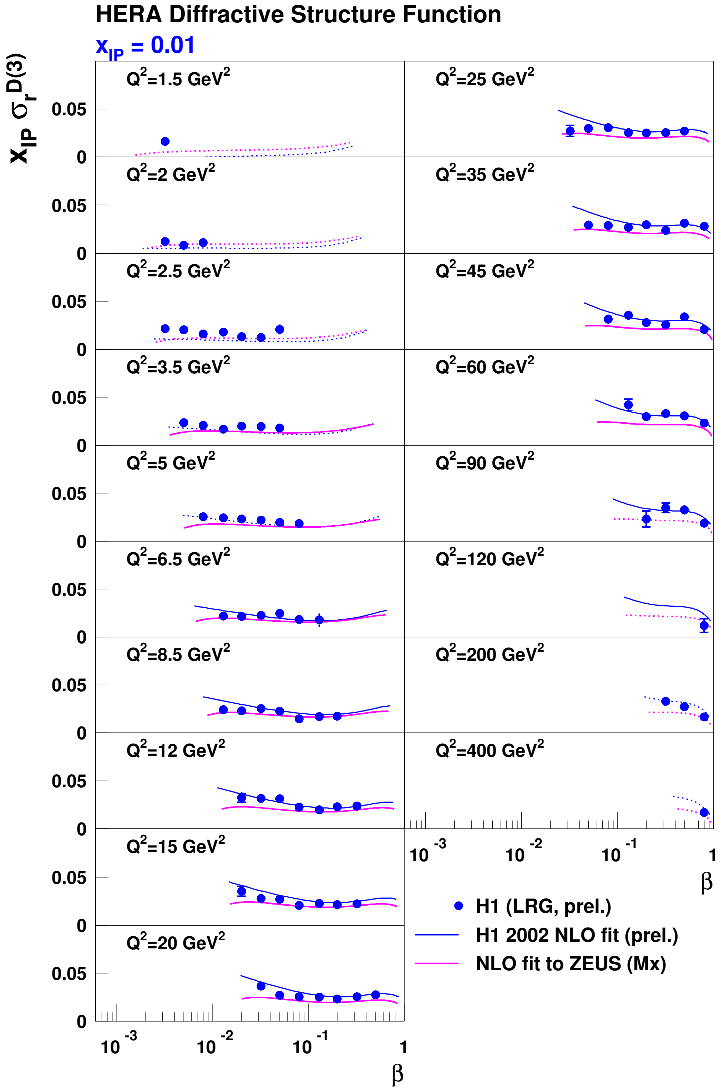
H1 and ZEUS data and fits: looking closer

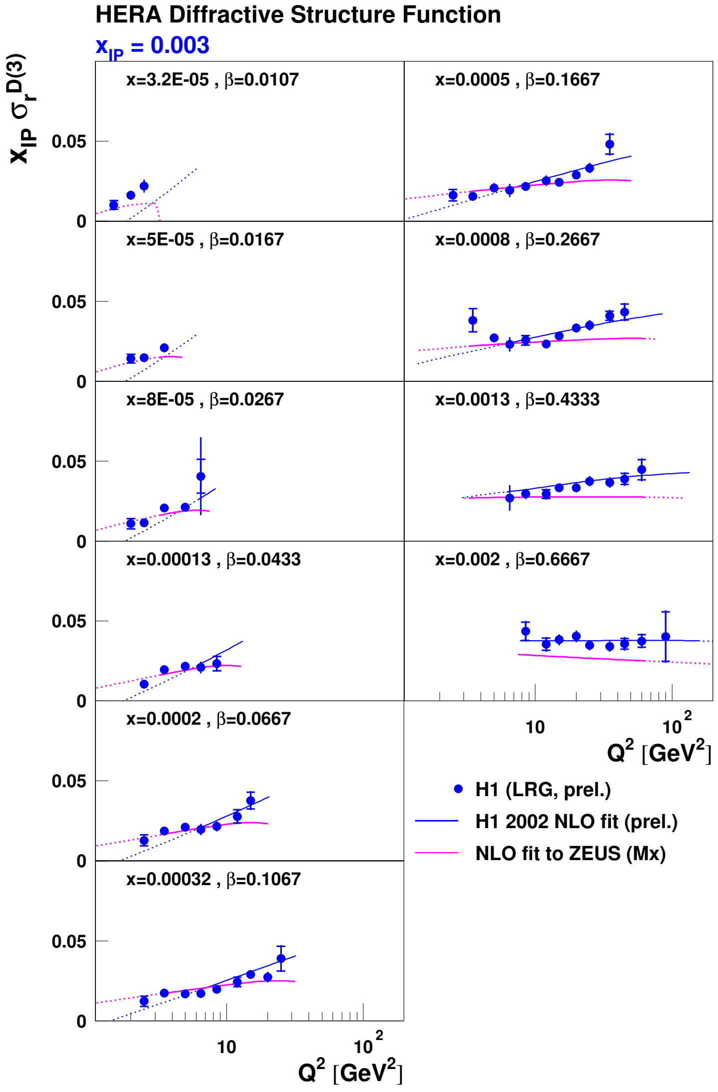


H1 and ZEUS data and fits: looking closer



H1 data vs ZEUS fit: Q^2, β dependences





Conclusions

Comparisons between recent diffractive DIS data

- Reasonable agreement between all F_2^D data sets
- From detailed comparison between H1-LRG and ZEUS-MX, differences observed at:
  (a) low M_X (high β)
  (b) Q^2 dependences

NLO QCD fit to ZEUS-Mx data:

- Good fit, $\alpha_{I\!P}(0) \sim 1.13$
- Significant difference between diffractive gluon densities from H1 and ZEUS