HERA Diffractive Structure Function data and Parton Distributions

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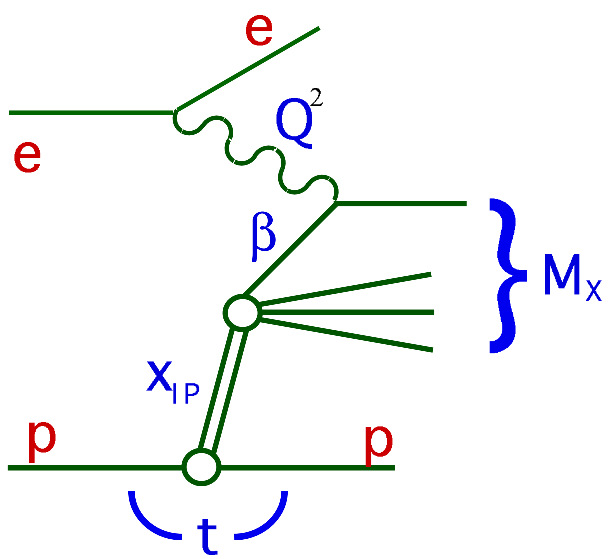
DIS 2005

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

Diffractive Cross section and Structure Functions



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

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

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

Diffractive reduced cross section σ_r^D:

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

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

[γ inelasticity $y = Q^2/sx$]

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

Recent Diffractive DIS Data

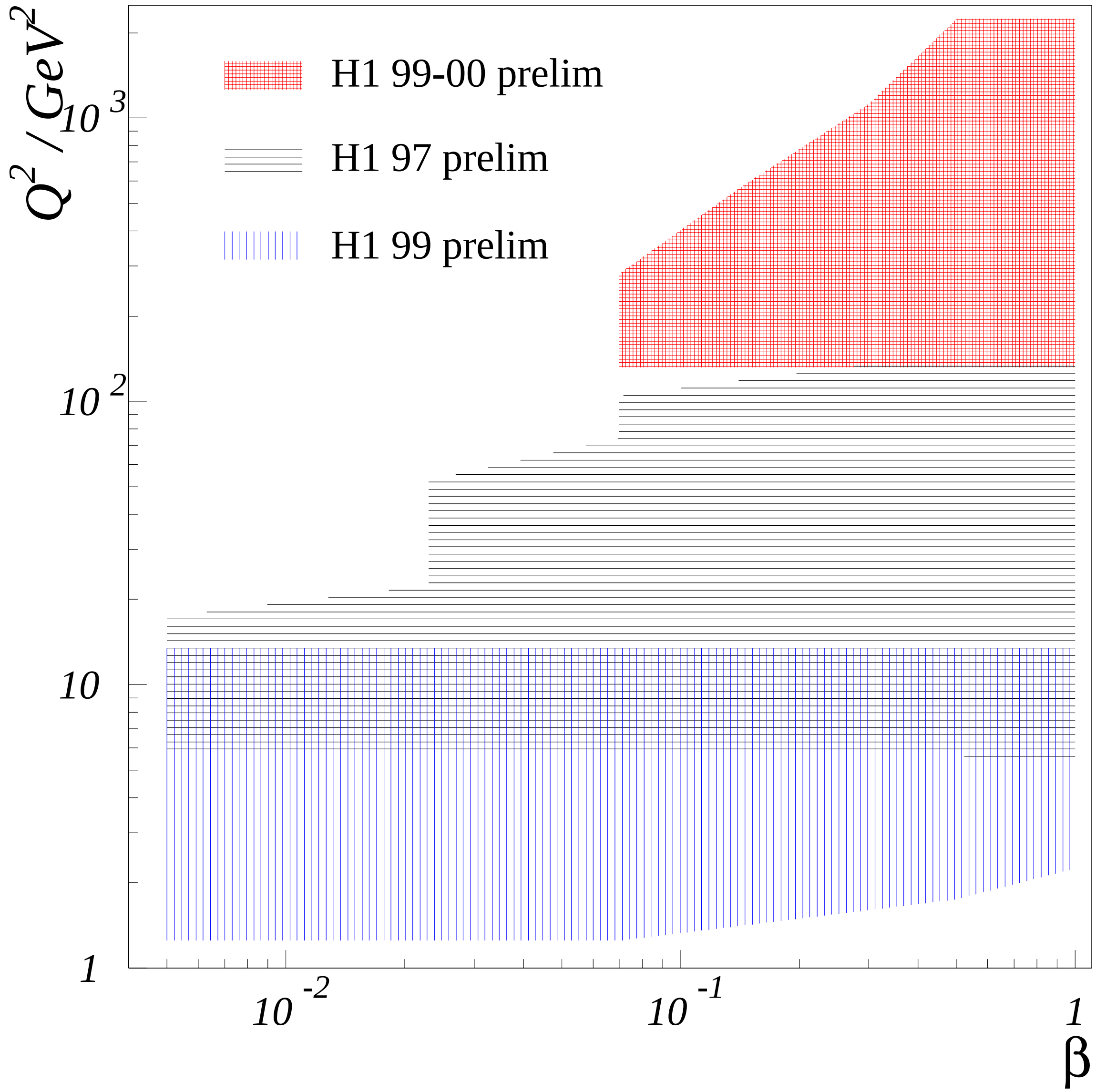
ZEUS Data:

- "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



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 except ZEUS Mx correspond to $|t| < 1.0 \text{ GeV}^2$

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

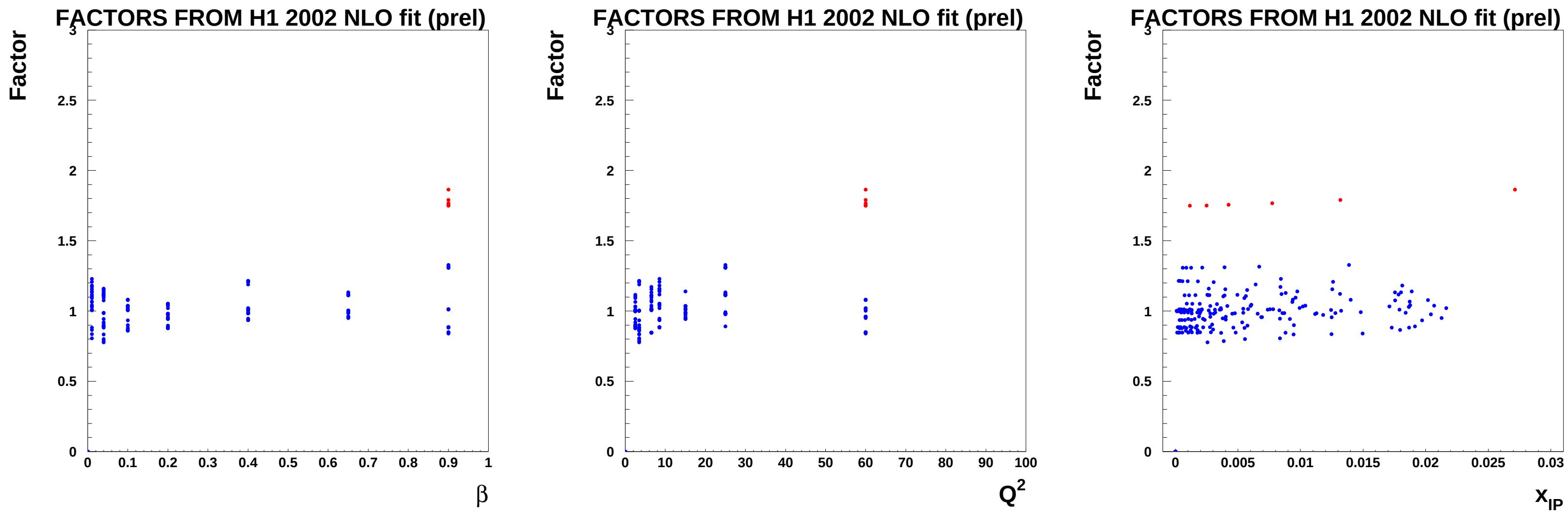
Factor 1.1 taken from H1 1994 publication to correct from $M_Y = m_p \rightarrow M_Y < 1.6$ GeV

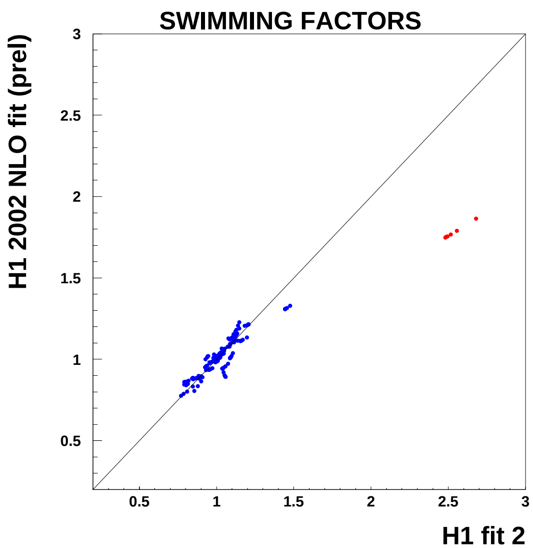
Factor 0.7 taken from ZEUS publication to correct from $M_Y < 2.3$ GeV $\rightarrow M_Y = m_p$

Scaling factors:
ZEUS LPS and H1 FPS: 1.1 $(M_Y = m_p \longrightarrow M_Y < 1.6 \text{ GeV})$
ZEUS Mx: $0.7 * 1.1 = 0.77$ $(M_Y < 2.3 \text{ GeV} \longrightarrow M_Y = m_p \longrightarrow M_Y < 1.6 \text{ GeV})$

Factor 0.77 implies a lot of cross-section between $M_Y < 2.3$ GeV and $M_Y < 1.6$ GeV which intuitively seems strange, suggests significant uncertainty on relative normalisation of data sets

Corrections applied to ZEUS Mx data





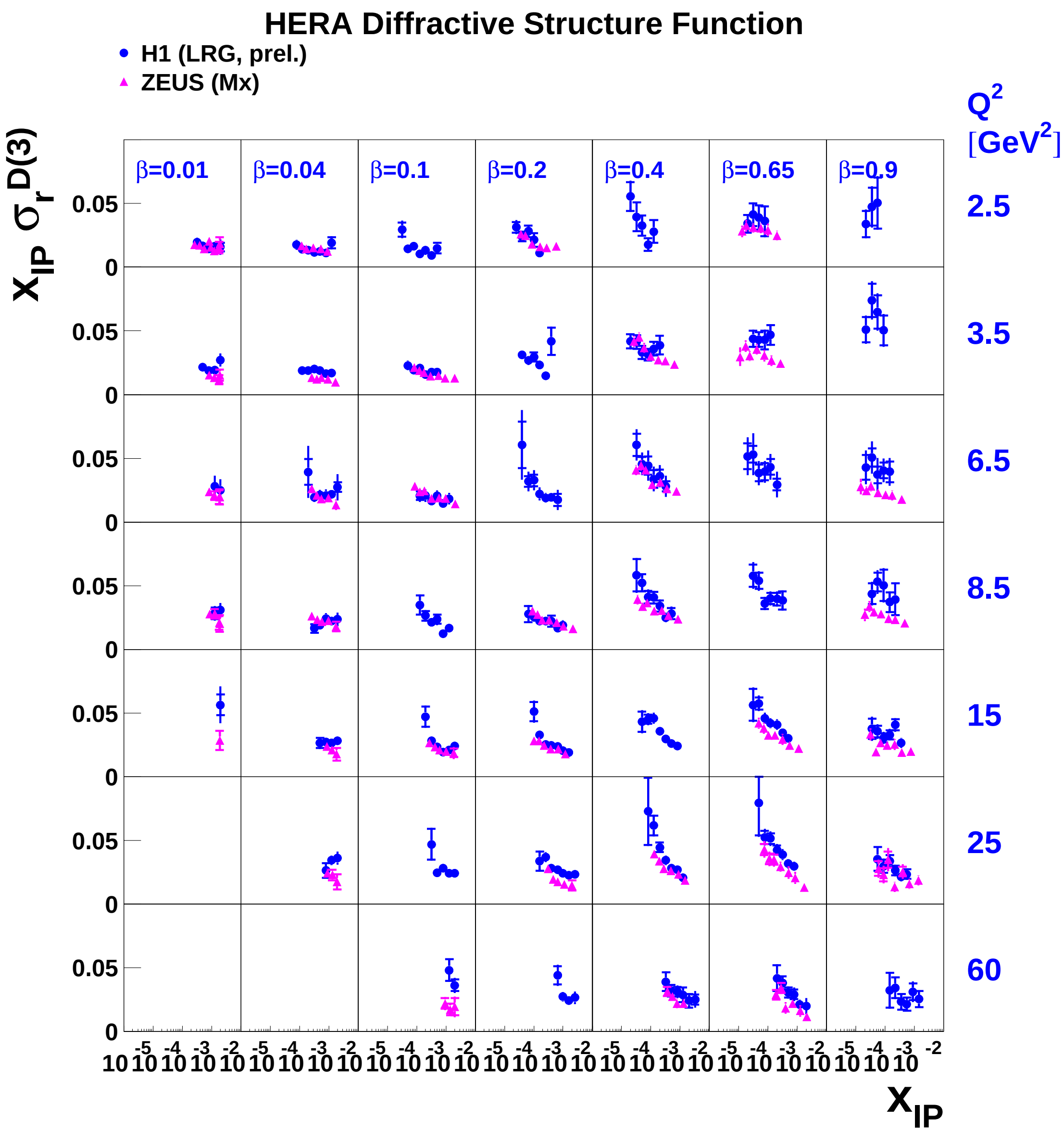
(2) Data points are measured at different values of Q^2, β, $x_{I\!P}$

$\Rightarrow$ 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

Points in red have been excluded!

Comparison of ZEUS Mx with H1 LRG Data



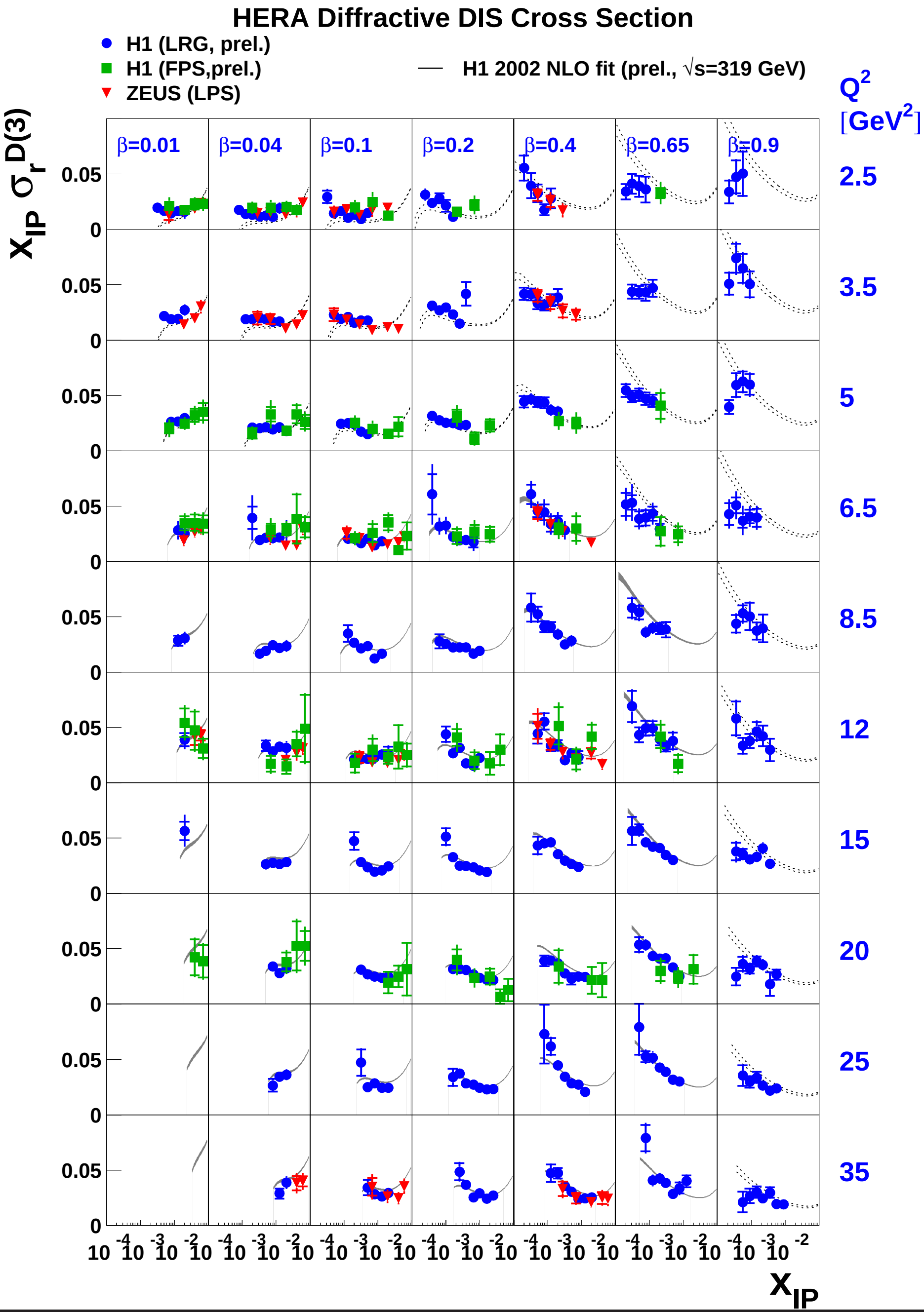
There is reasonable agreement between the two datasets

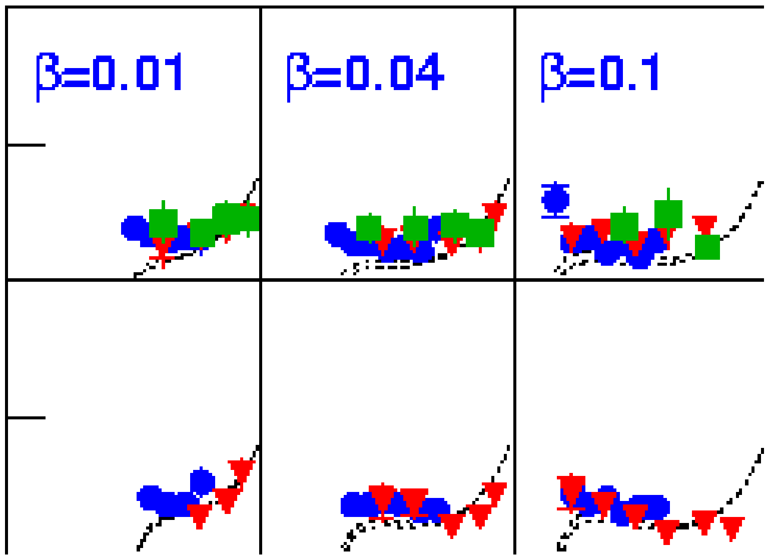
On closer inspection differences can be seen:

- at low M_X (high β)
- in the Q^2 dependences

These differences will be seen in the fits

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

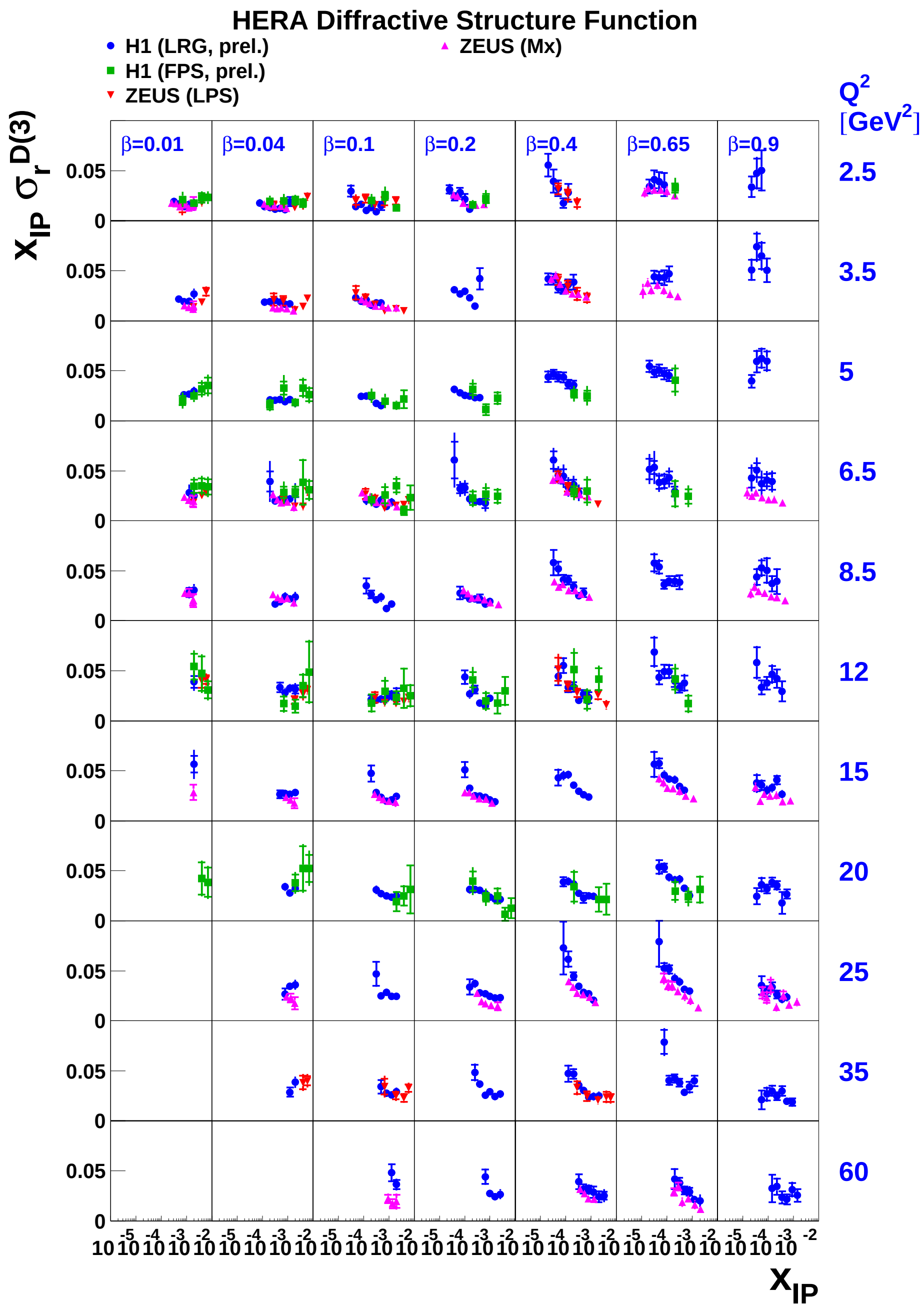




Good agreement between the Large Rapidity Gap and both leading proton measurements

Blown up is one of the lowest Q^2 bins

Also see good agreement at high Q^2



Comparison of all data ($M_Y < 1.6$)

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

Reminder of H1 2002 NLO DGLAP QCD Fit

QCD Fit Technique:

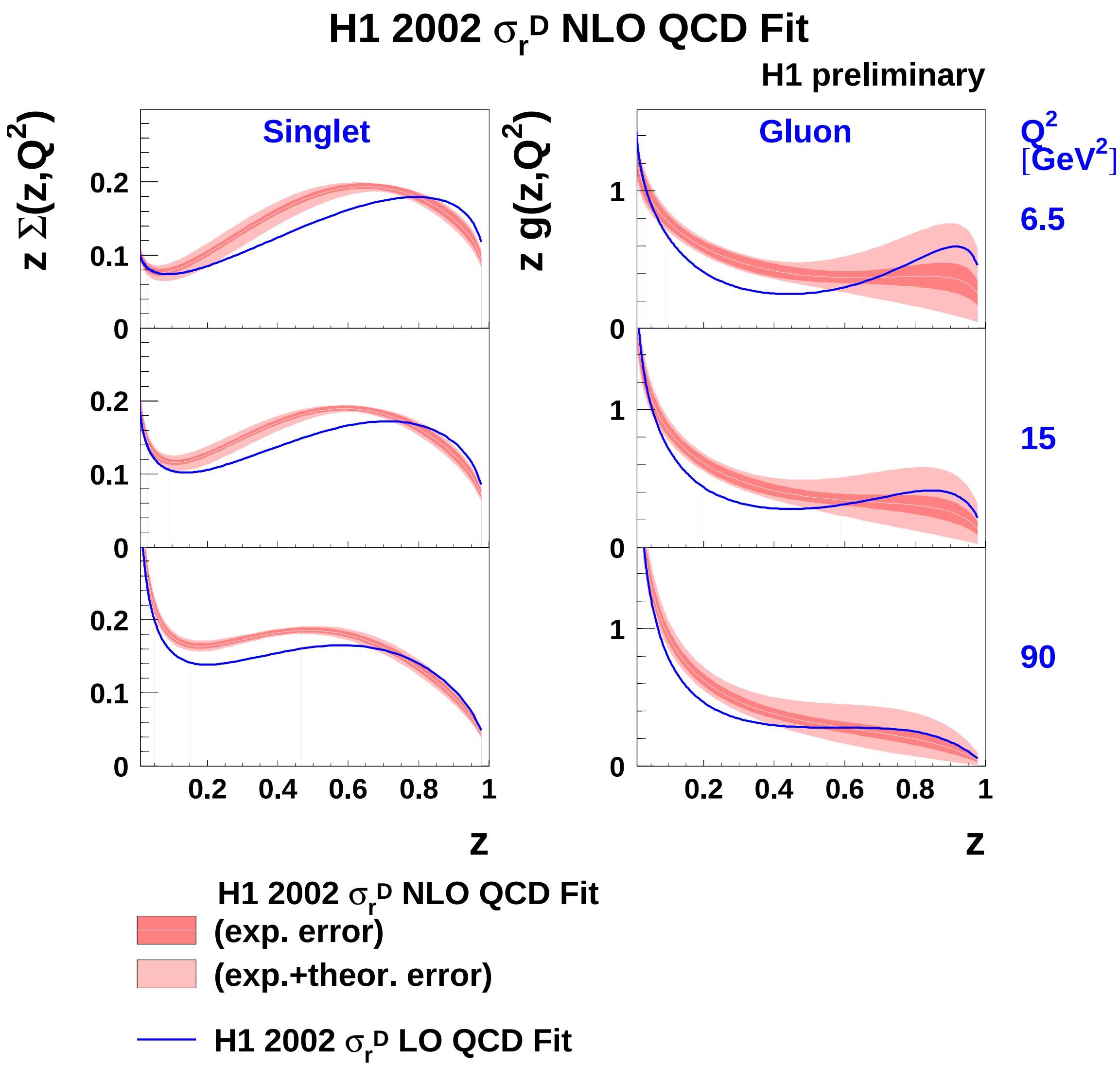
- factorize $f(x_{I\!P})f(z,Q^2)$
- Singlet Σ and gluon g parameterized at $Q_0^2 = 3\ \mathrm{GeV}^2$
- NLO DGLAP evolution
- Fit data for $Q^2 > 6.5\ \mathrm{GeV}^2$, $M_X > 2\ \mathrm{GeV}$

PDF's of diffractive exchange:

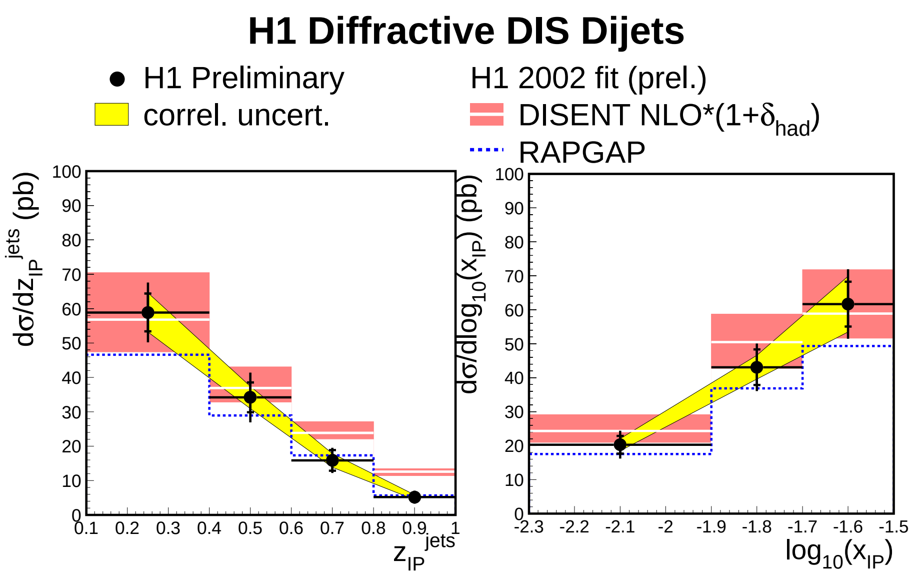
- Extending to large fractional momenta z
- Gluon dominated
- Σ well constrained

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

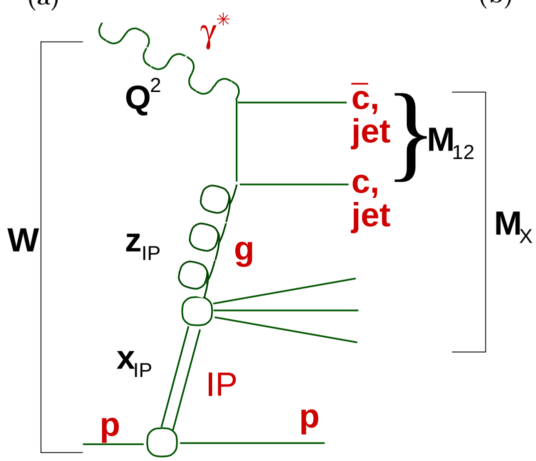
NB: $\Lambda_{QCD} = 200 \pm 30$ MeV variation included in outer error band

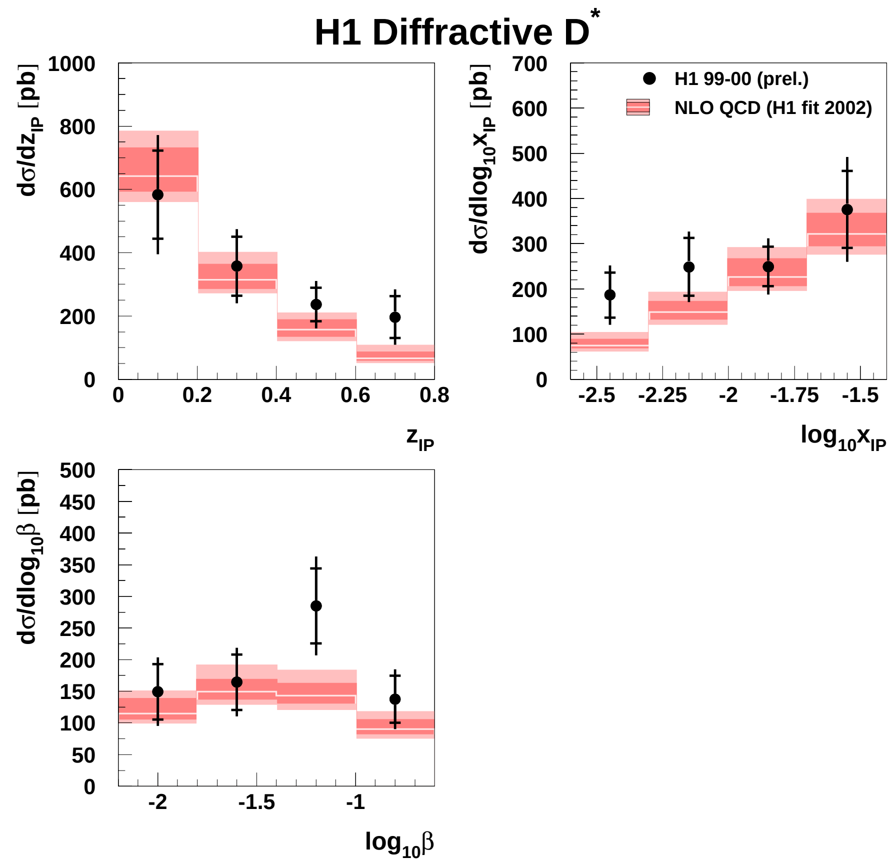


Comparison of H1 2002 NLO DGLAP QCD fit with exclusive dijet and charm production



(a) (b)





Good agreement between the extracted pdfs and diffractive dijet and charm production

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 $M_Y < 1.6\ \mathrm{GeV}$

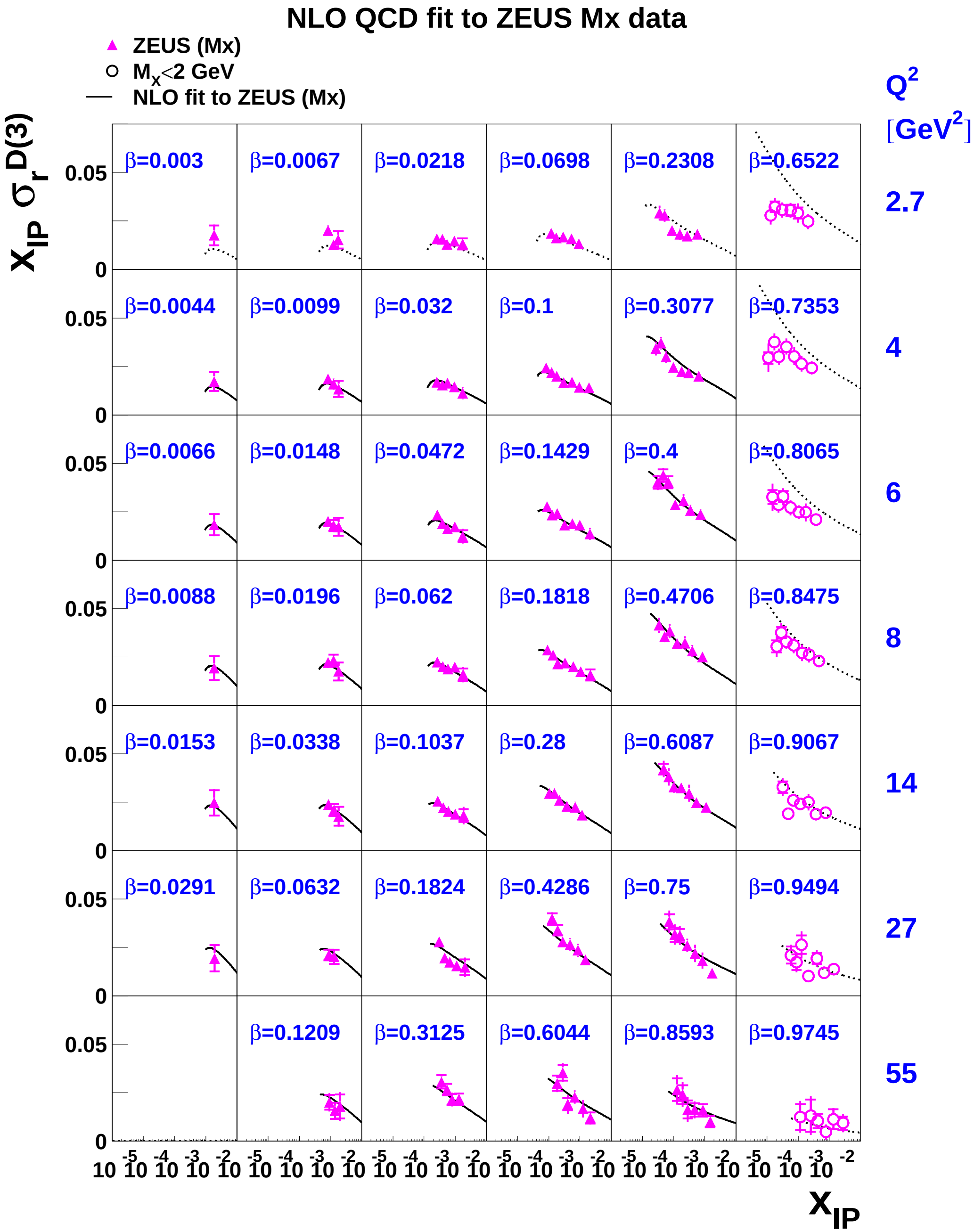
The 'NLO fit to ZEUS data':

- Fit Mx data for $Q^2 > 4\ \mathrm{GeV}^2$ (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

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

A very good fit is obtained with a common Intercept!

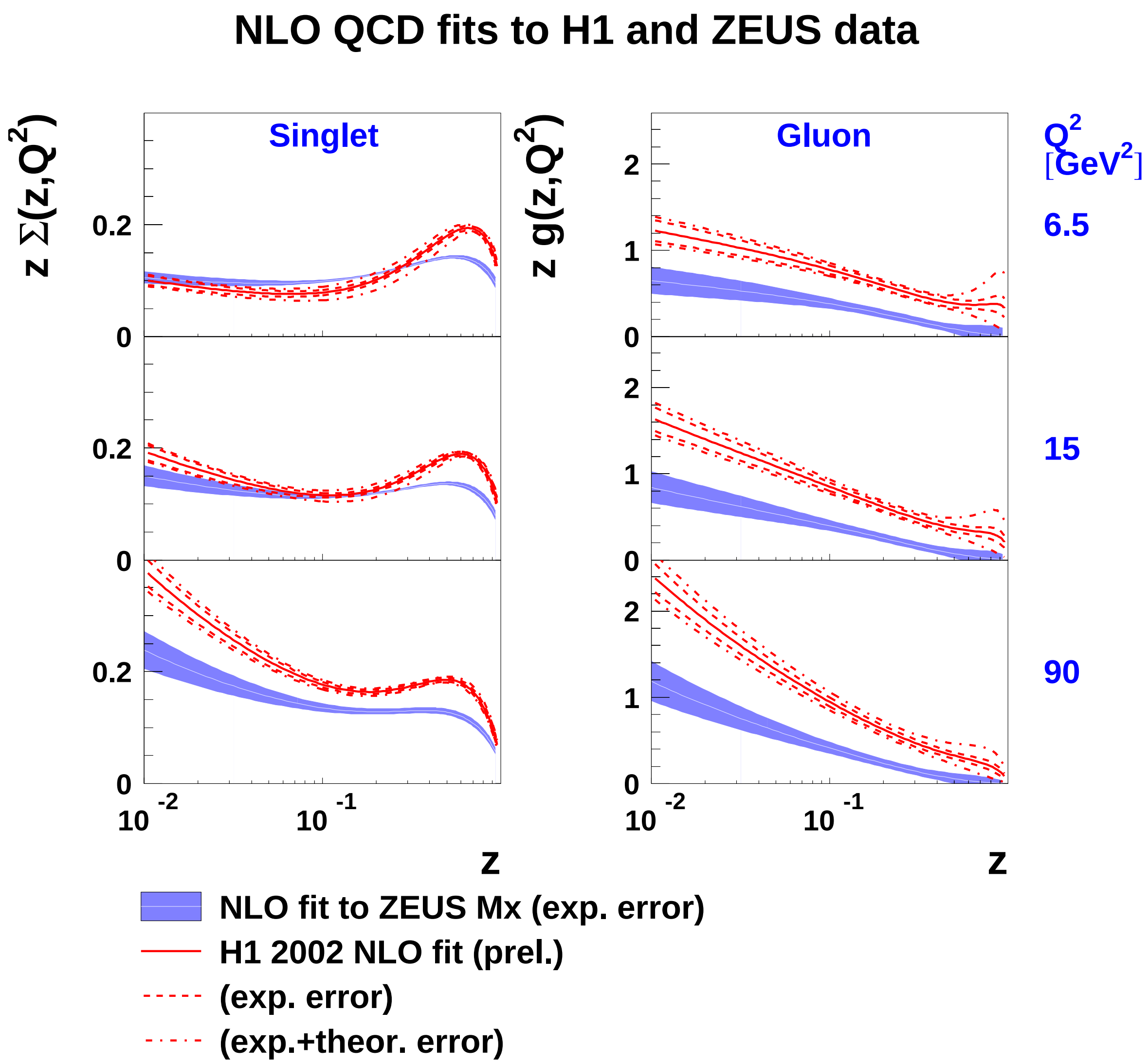
NLO QCD fit to ZEUS Mx data



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

Fit describes data well

NLO fit to ZEUS Mx data



Observations:

- Singlet similar at low Q^2, evolving differenly to higher Q^2
- Gluon factor ~ 2 smaller than H1 gluon

Reminder that data comparisons revealed differences

- at low M_X (high β)
  Most of those points are not included in the fit
- in the Q^2 dependences
  Different Q^2 evolution means different gluon

$\longrightarrow$ Observed differences in the data explain the differences in the extracted pdfs

Conclusions

Comparisons between recent diffractive DIS data

- Reasonable agreement between all F_2^D data sets and good agreement between H1-LRG data and both H1 and ZEUS leading proton data

- From detailed comparison between H1-LRG and ZEUS-MX, differences observed at:
  - low M_X (high β)
    $\longrightarrow$ Not influencing the fit as $M_X < 2$ excluded from the fit
  - Q^2 dependences
    $\longrightarrow$ Different Q^2 evolution means different gluon

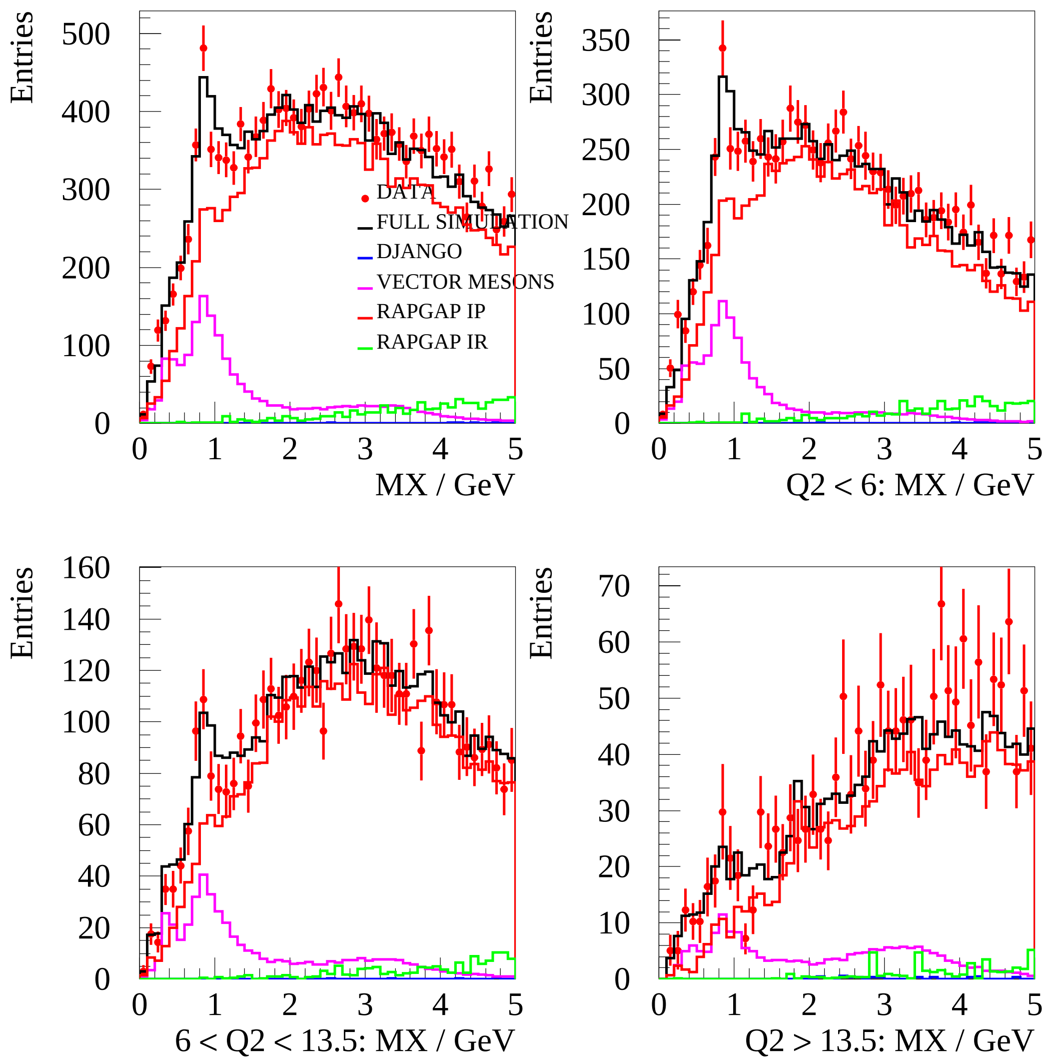
NLO QCD fit to ZEUS-Mx data:

- Good fit, $\alpha_{I\!P}(0) \sim 1.13$

- Significant difference between diffractive gluon densities from H1 and ZEUS

Backup

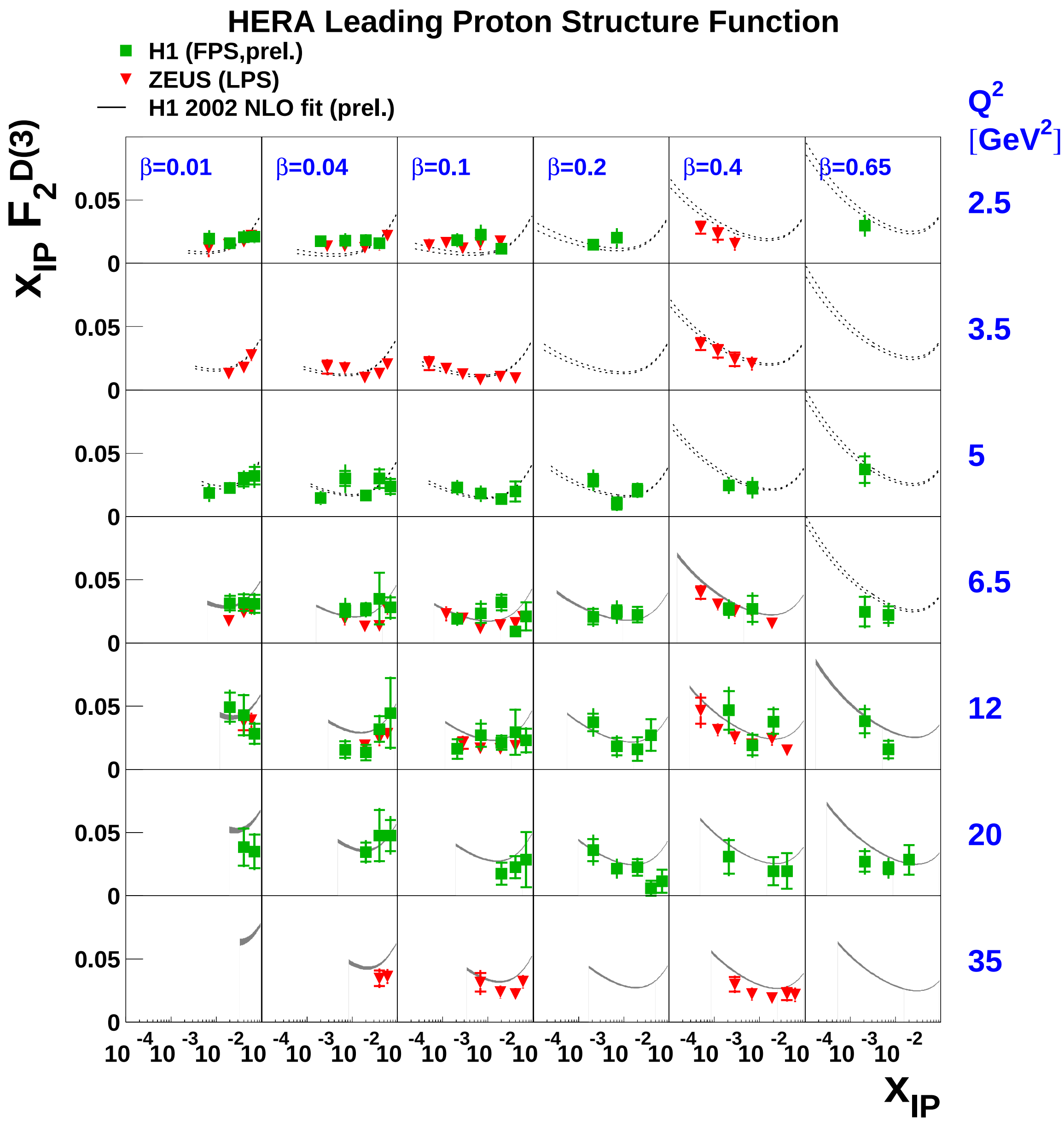
H1 Data: control plots at low Q^2



M_X dependence in different Q^2 intervals ...

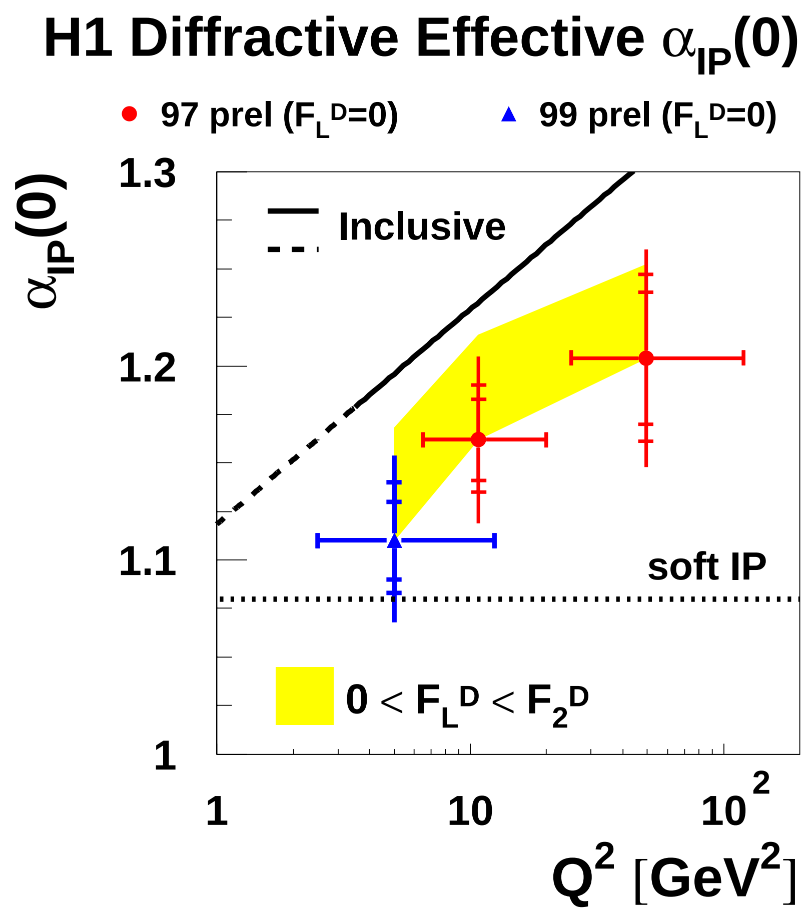
Data well under control, also at low Q^2

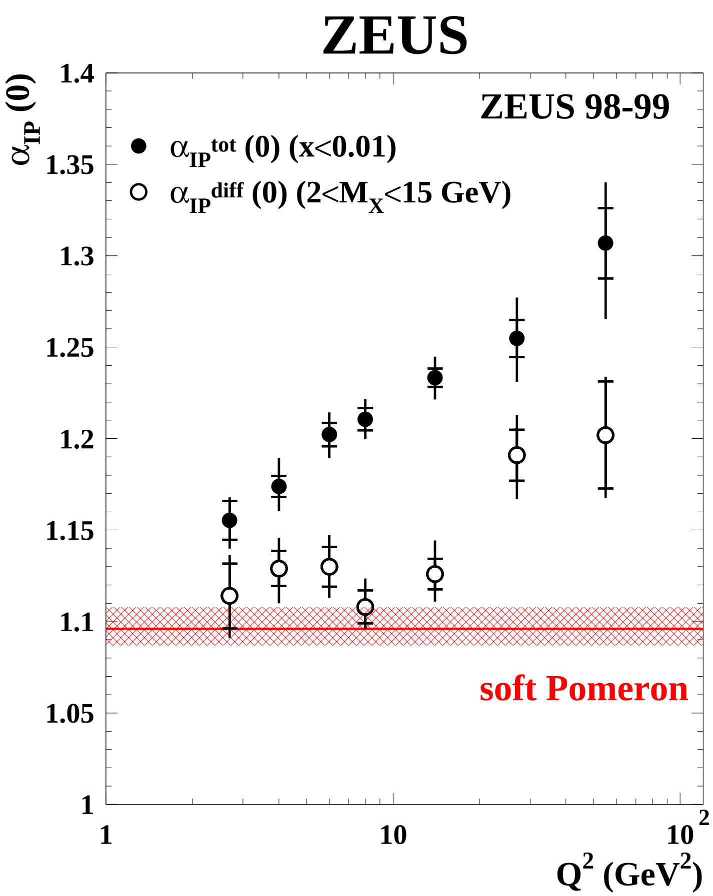
Comparison of Leading Proton Data (here for $M_Y = m_p$)



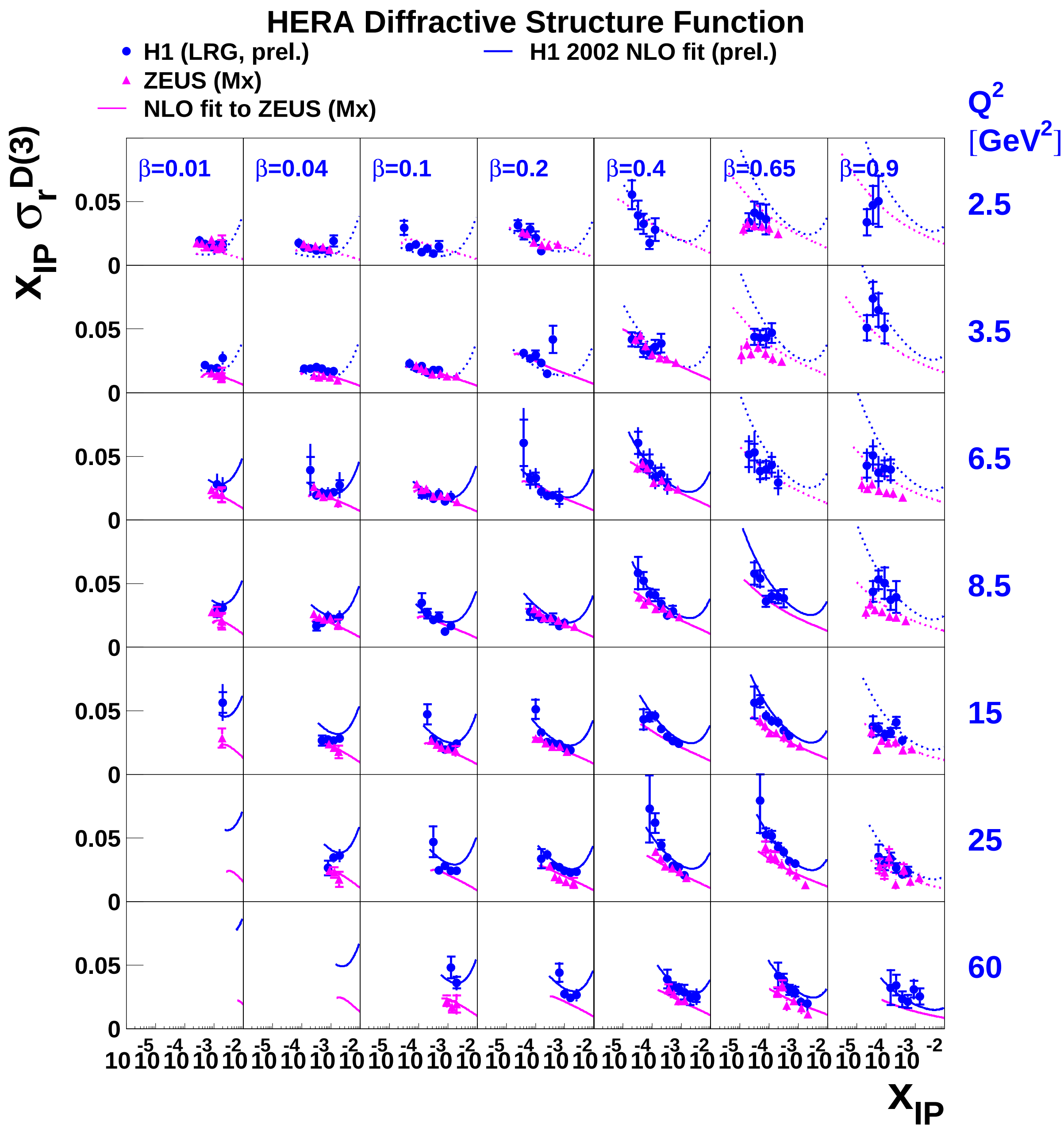
Good agreement between the two leading proton analyses

H1 and ZEUS Pomeron Intercepts



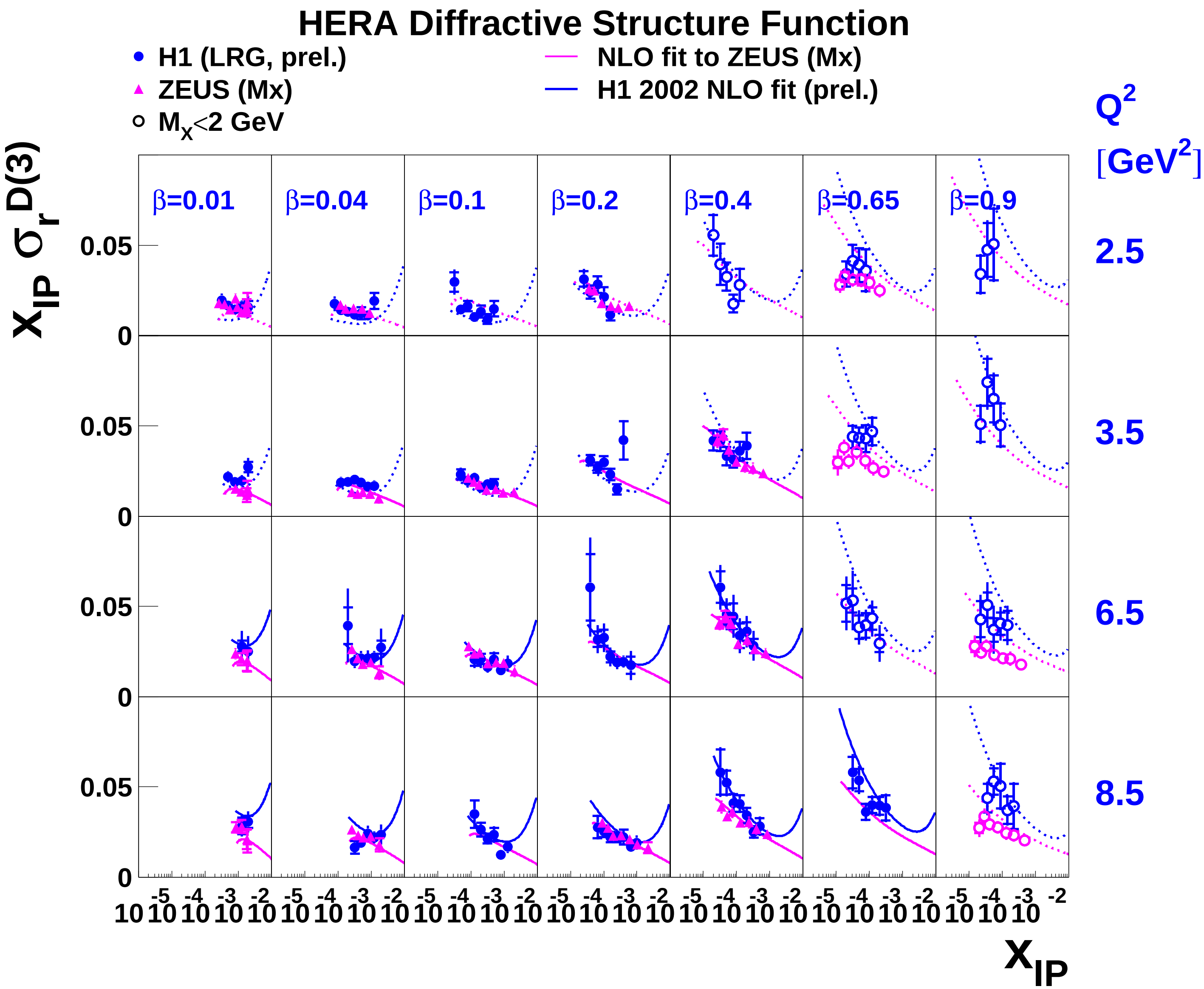


H1 and ZEUS data and fits



- 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