Inclusive Diffraction

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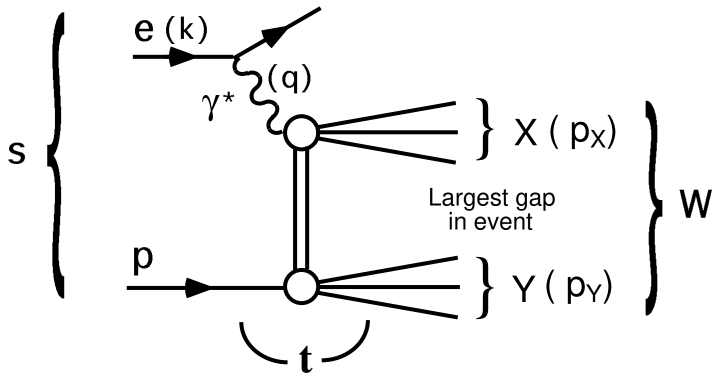
Representing the H1 Collaboration

- Diffraction at HERA
- Two new measurements from H1 at low and high Q^2
- Comparison of the new data with QCD fits to the previous medium Q^2 data
- Summary

Diffractive DIS

In Diffractive DIS, two hadronic final states separated by a rapidity gap are formed: $ep \to eXY$ + gap

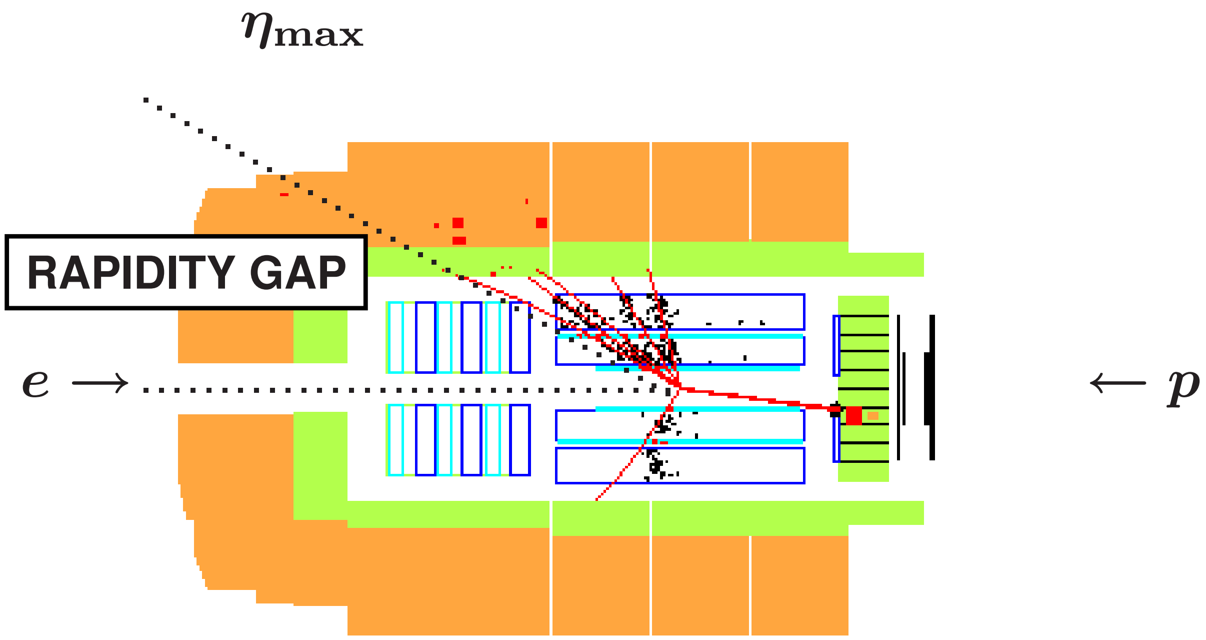


$|t| \sim m_p^2$

$M_X^2 \ll W^2$

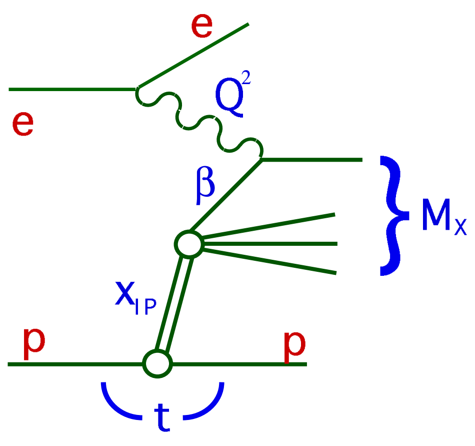
$M_Y < 1.6$ GeV

The new measurements use the rapidity gap method:



$ep \to eXp$

Diffractive Reduced Cross-Section



Diffractive kinematics:

- $x_{I\!P} = \frac{q\cdot(p-p')}{q\cdot p} \simeq \frac{Q^2+M_X^2}{Q^2+W^2}$
- $\beta = \frac{Q^2}{2q\cdot(p-p')} \simeq \frac{Q^2}{Q^2+M_X^2}$ $\qquad x = \beta x_{I\!P}$

Diffractive reduced cross-section:

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

Structure functions F_2^D and F_L^D :

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

- **Longitudinal F_L^D affects σ_r^D at high y**
- **If $F_L^D = 0$ then $F_2^D = \sigma_r^D$**
- **Integrate over t when the proton is not tagged $\longrightarrow \sigma_r^{D(3)}$**

New H1 Measurements at Low and High Q^2

New low Q^2 points →

99 data

$\mathcal{L}$ = 3.4 pb^{-1}

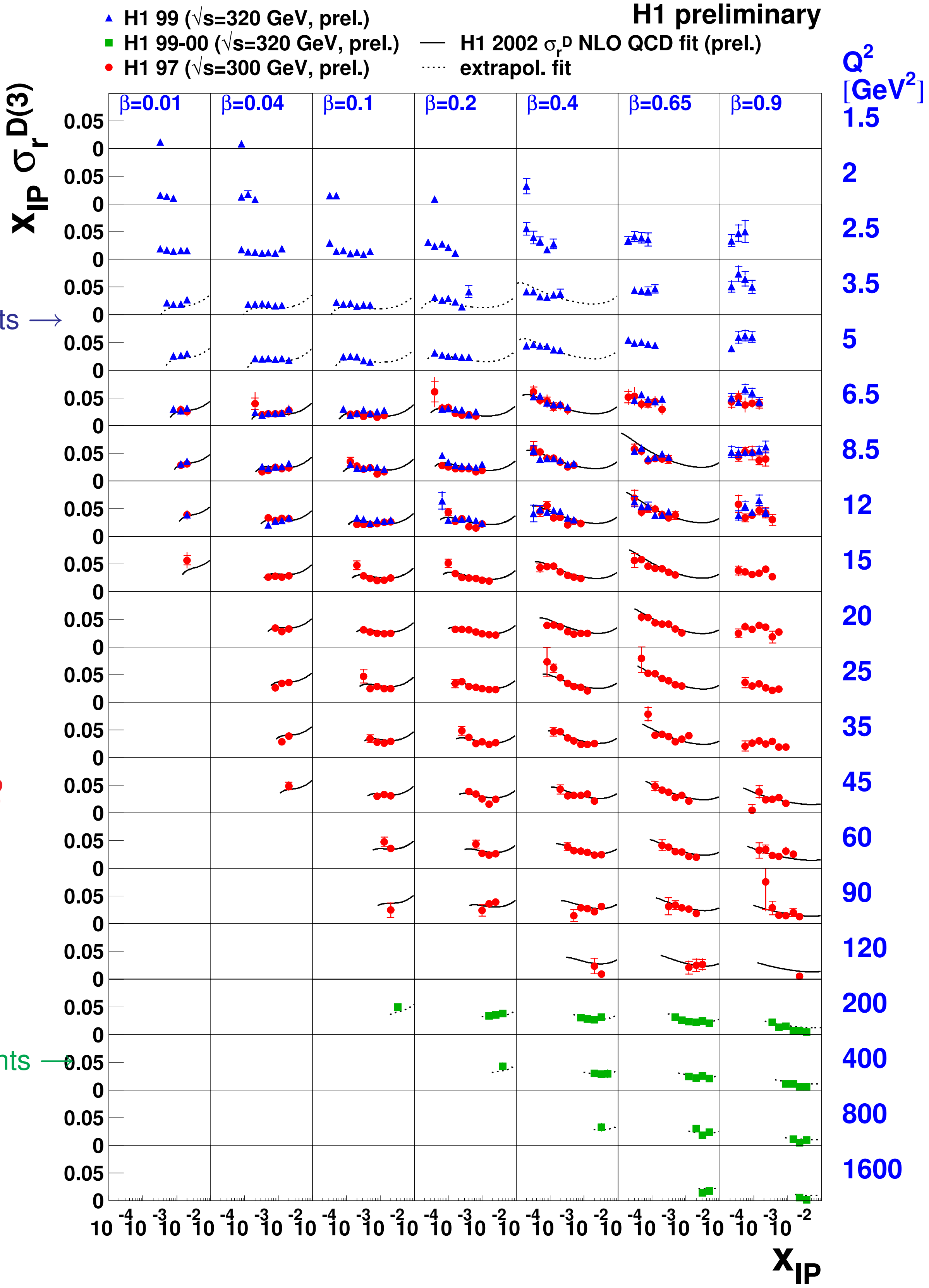
β

Q^2

New high Q^2 points →

99-00 data

$\mathcal{L}$ = 65 pb^{-1}



QCD Factorisation in Semi-Inclusive DIS

Diffractive parton densities $f_q^D(x_{I\!P}, t, x, Q^2)$ express *conditional* proton parton probability distributions with constraint of final state proton at particular $x_{I\!P}, t \ldots$

$$\sigma_r^{\mathrm{D}} \sim f_q^D(x_{I\!P}, t, x, Q^2) \otimes \hat{\sigma}_{\mathrm{pQCD}}$$

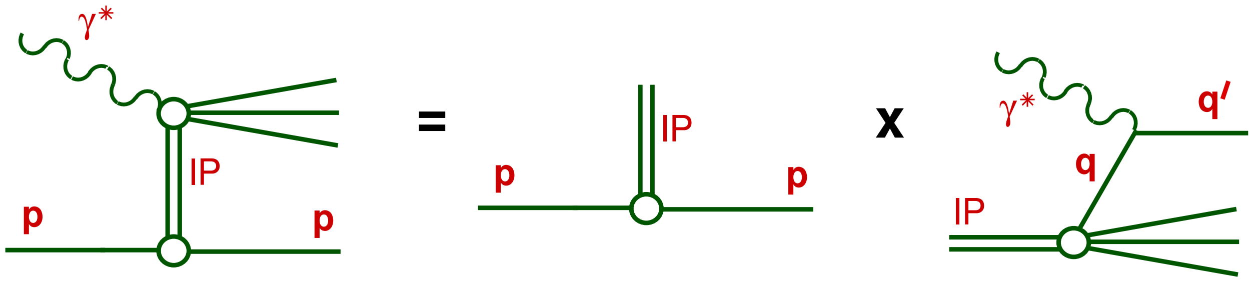
At fixed $x_{I\!P}, t$, $\;f_q^D(x_{I\!P}, t, x, Q^2)$ evolve with x, Q^2 according to same DGLAP equations as inclusive $f_q(x, Q^2)$

- Diffractive pdf's universal within diffractive DIS
- As for inclusive DIS, the QCD evolution of σ_r^D can be predicted
- This can be extended to dijet and charm productions in DIS...
- Does not work for p-p scattering!

Regge Factorisation - Resolved $\mathbb{P}$ model

Regge factorisation is an additional assumption,

there is no PROOF!



$$\sigma_r^{\mathrm{D}} \qquad \sim \quad f_{\mathbb{P}/\mathrm{p}}(x_{I\!P}, t) \qquad \times \qquad F_2^{\mathbb{P}}(\beta, Q^2)$$

$\mathbb{P}$ flux factors $f_{\mathbb{P}/\mathrm{p}}(x_{I\!P}, t)$ from Regge theory . . .

$$f_{\mathbb{P}/\mathrm{p}}(x_{I\!P}, t) = \frac{e^{Bt}}{x_{I\!P}^{2\alpha(t)-1}}$$

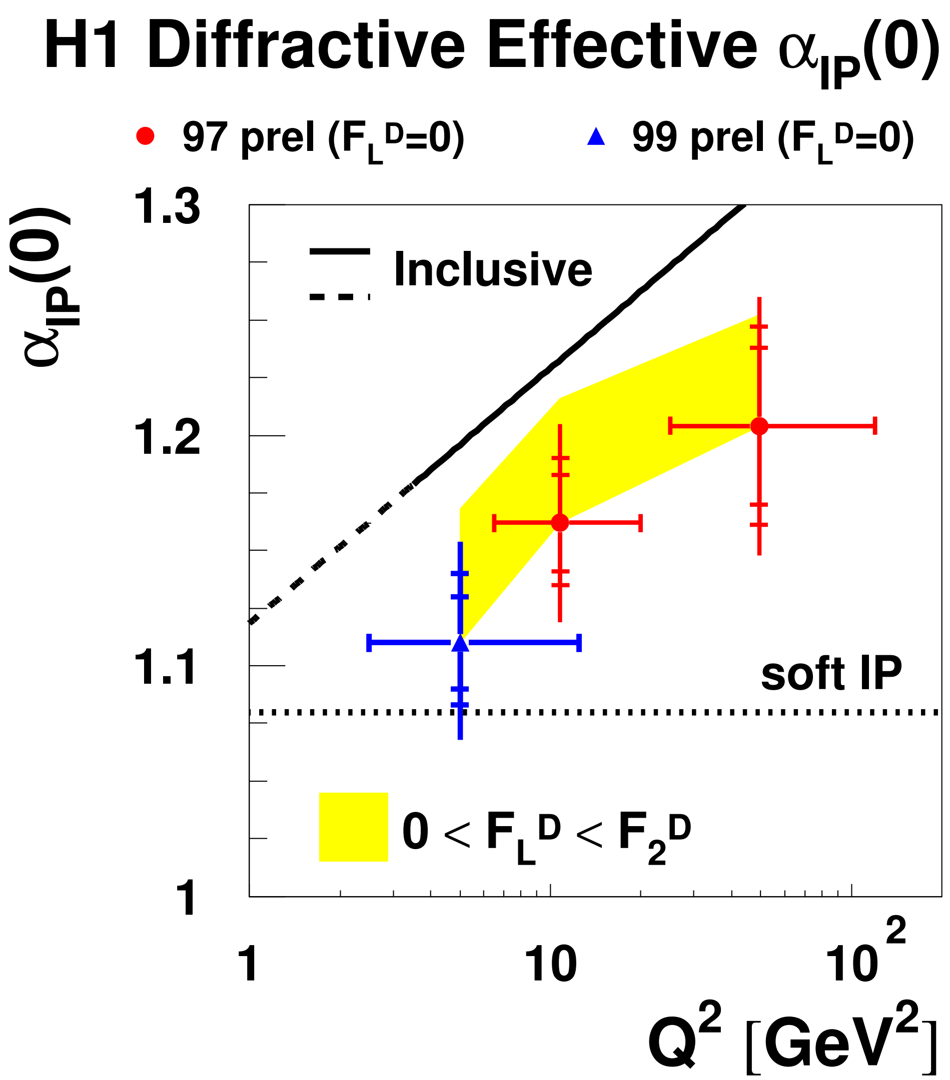
where

$$\alpha(t) = \alpha(0) + \alpha' t$$

The β and Q^2 dependence of σ_r^D does not change with $x_{I\!P}$! (important for later on)

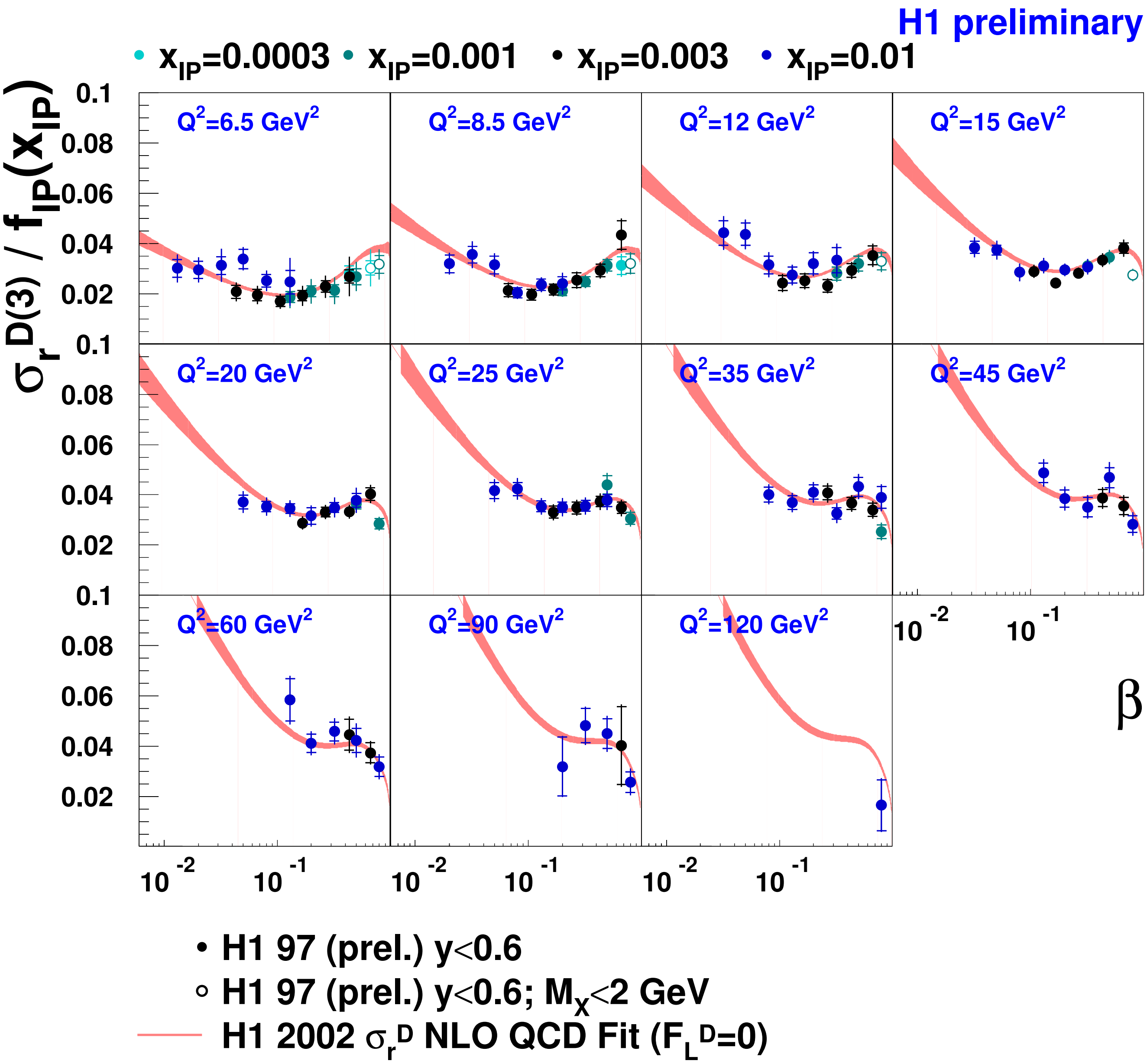
Pomeron Intercept

Regge factorisation works well in the description of the data



- The yellow represents the effect of varying the assumptions on F_L^D from $F_L^D = 0$ to $F_L^D = F_2^D$
- **But is there an indication for increase of $\alpha_{\mathbb{P}}(0)$ with Q^2? If there is, it's not significant.**

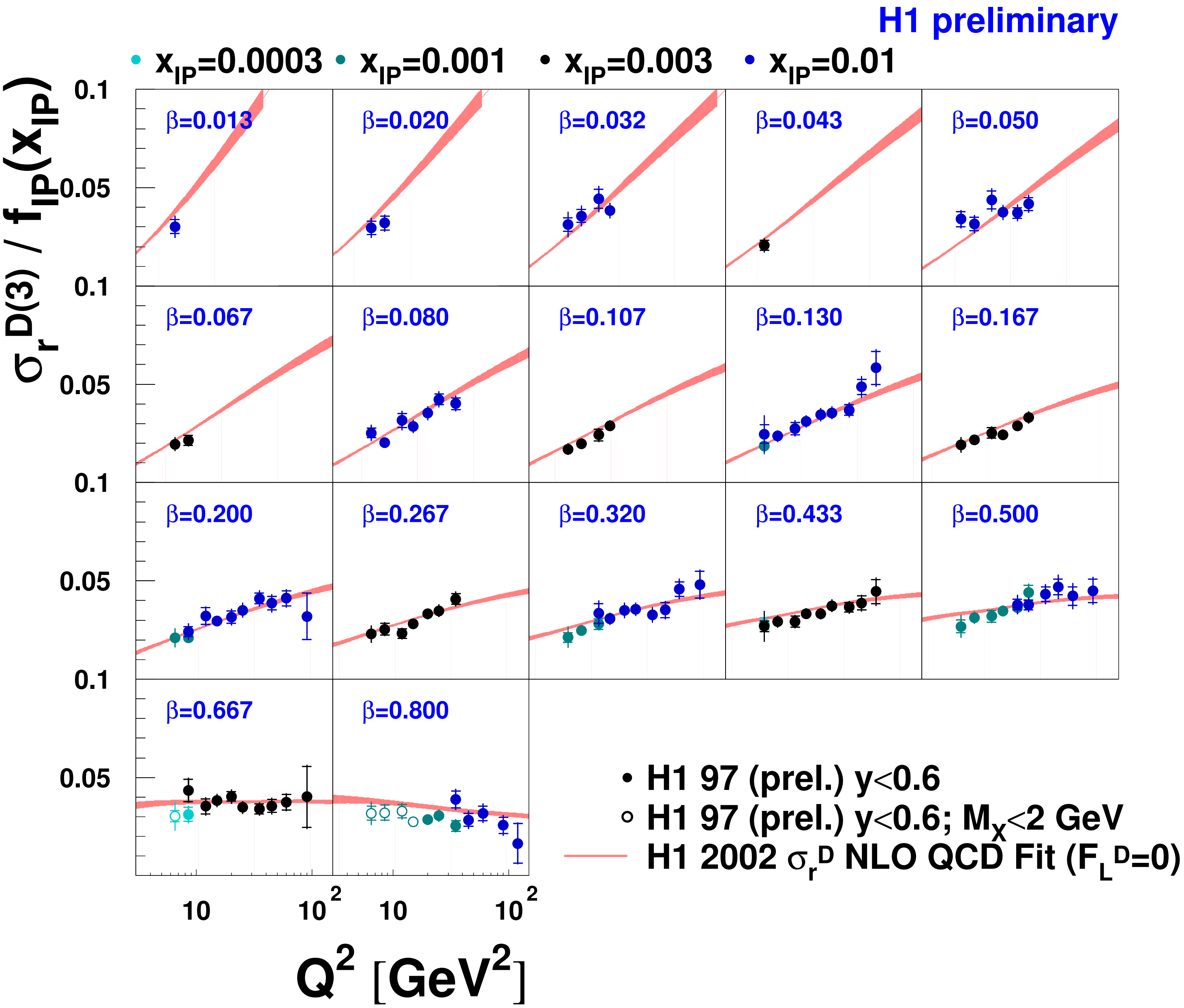
NLO Fit to the Medium Q2 Data



- $f_{\mathbb{P}}$ dependence taken out as factorisation holds for $x_{\mathbb{P}} \leq 0.01$. (Subleading exchanges become important at higher $x_{\mathbb{P}}$)
- β dependence $\sim \sum_i \beta e_i^2 (q_i^D + \bar{q}_i^D)$

β dependence + rising of σ_r^D at low Q^2 for $\beta \rightarrow 1$ well reproduced by the NLO fit

NLO Fit to the Medium Q2 Data



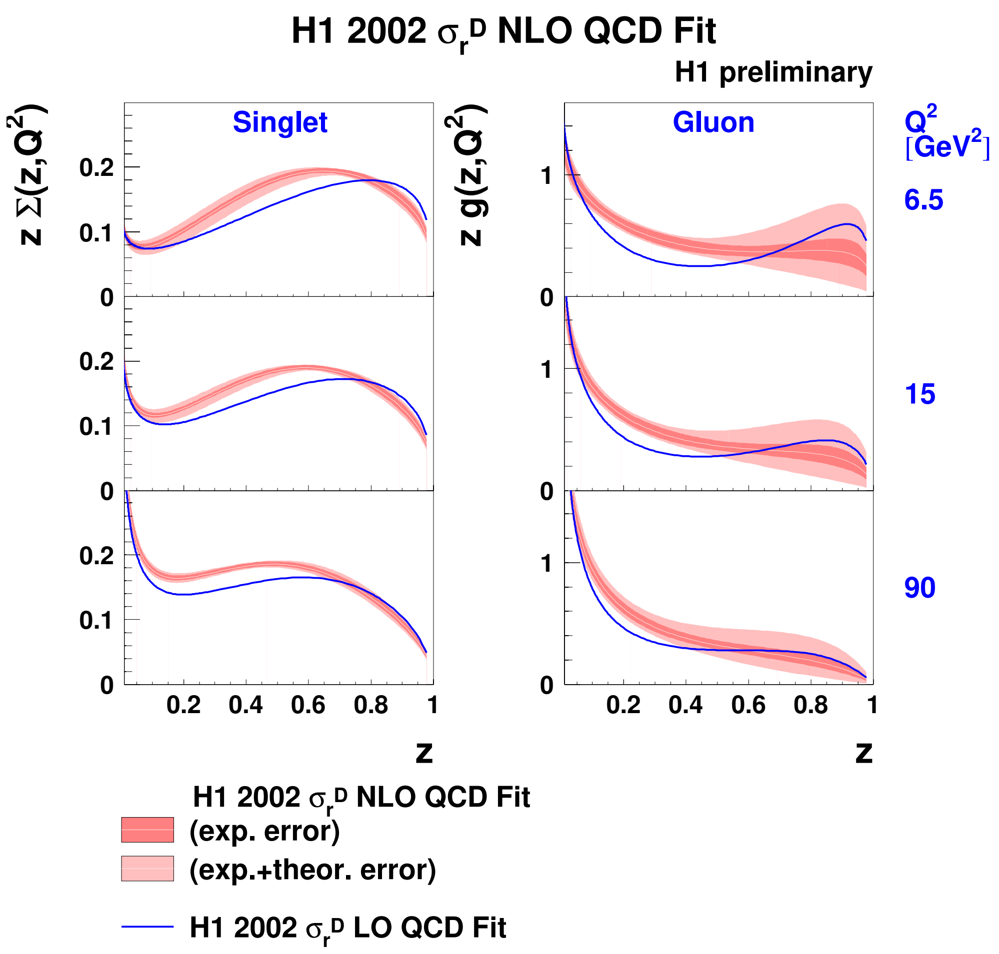
$$\frac{dF_D^2}{dlnQ^2} \sim xg^D(\beta, Q^2)$$

The strong scaling violations imply a big gluon density

Diffractive Parton Densities

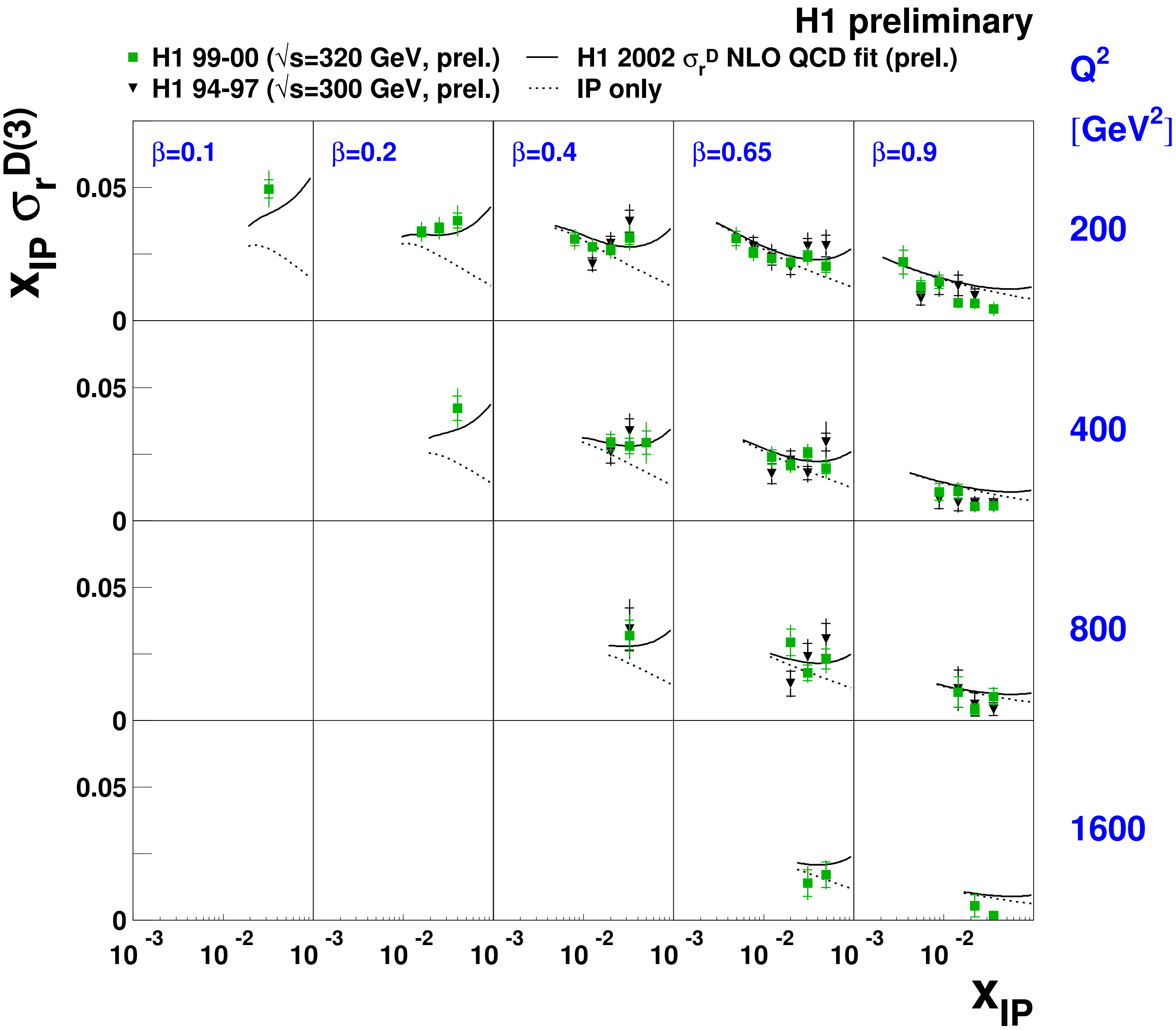
Extracted from medium Q^2 data only!

- Assume Regge factorisation for $x_{I\!P}$ dependence
- Singlet Σ and g parameterized at $Q_0^2 = 3$ GeV^2
- NLO DGLAP evolution - Fit data for $Q^2_{min} > 6.5$ GeV^2 and $M_X > 2$ GeV



- PDF extends to large fract. momenta z
- Gluon dominated - integrated fraction of exchanged momentum carried g by is $75 \pm 15\%$
- Big uncertainty at highest z

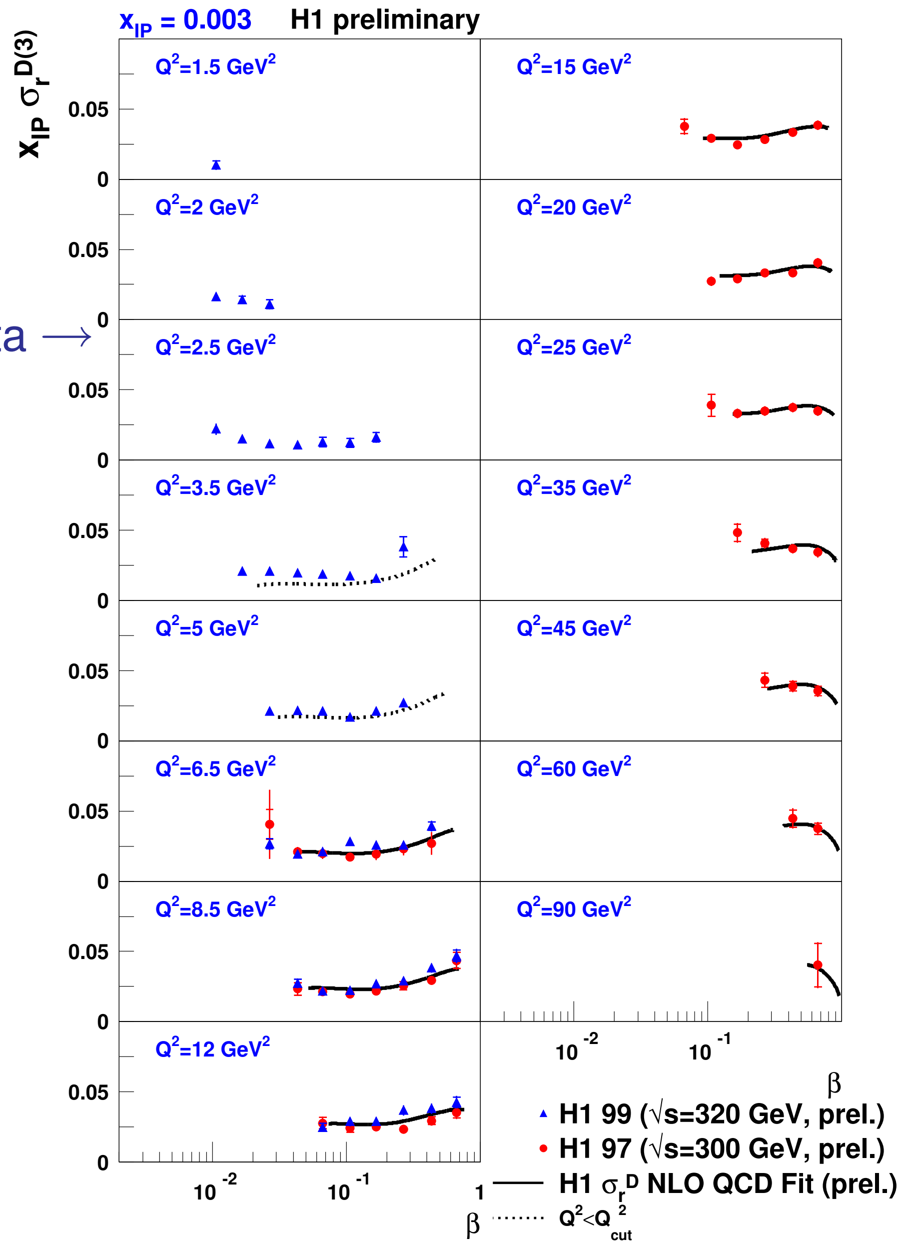
New Measurement at high Q^2



- Improved statistics and kinematic range over the previous H1 measurement and good agreement
- Good agreement is obtained with the prediction from the NLO fit to the medium Q^2 data
- Subleading trajectories contribution becomes very important at low β

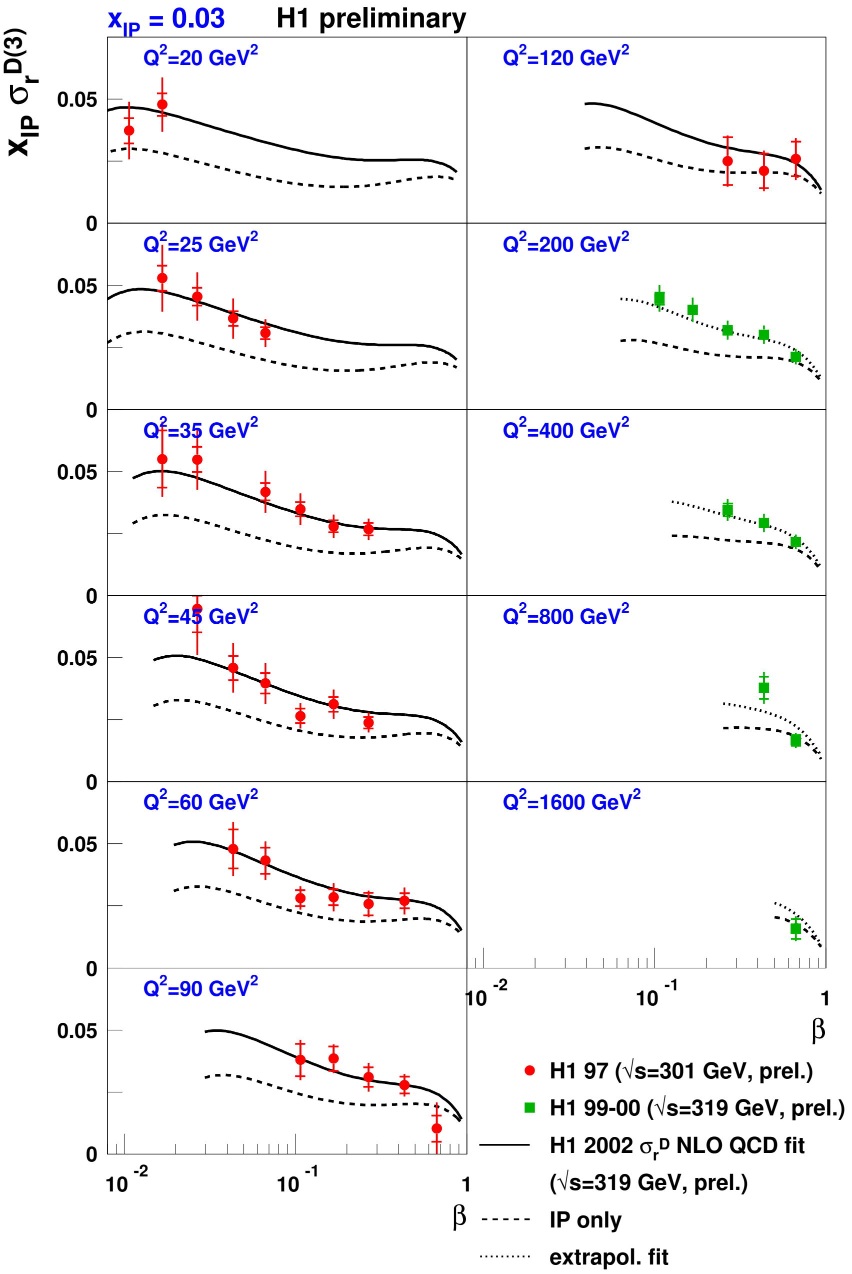
β Dependence at very Low $x_{I\!P}$

New low Q^2 data $\longrightarrow$



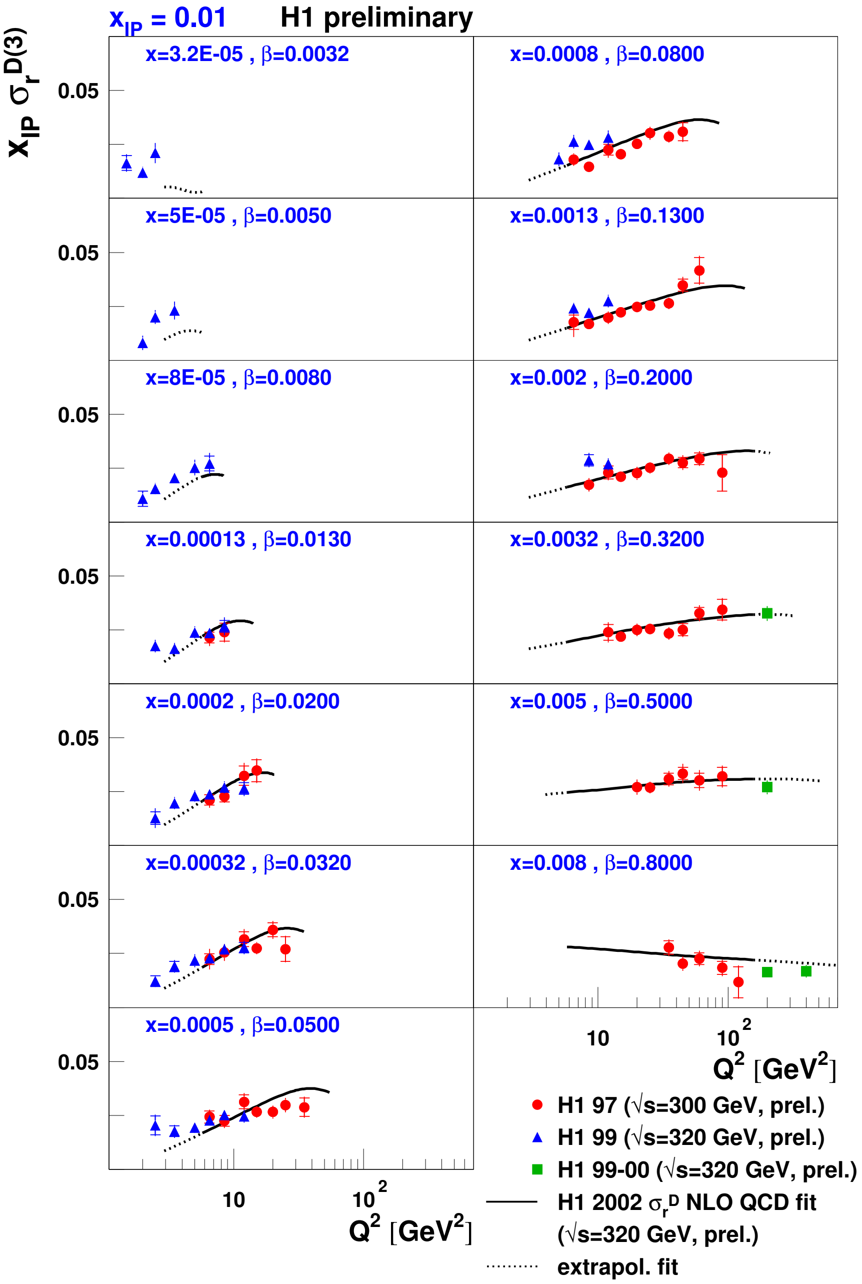
- The prediction of the QCD fits is satisfactory for $Q^2 > 5\text{GeV}^2$
- **The new low Q^2 data will give important constraints in future fits!**

β Dependence at High $x_{I\!P}$



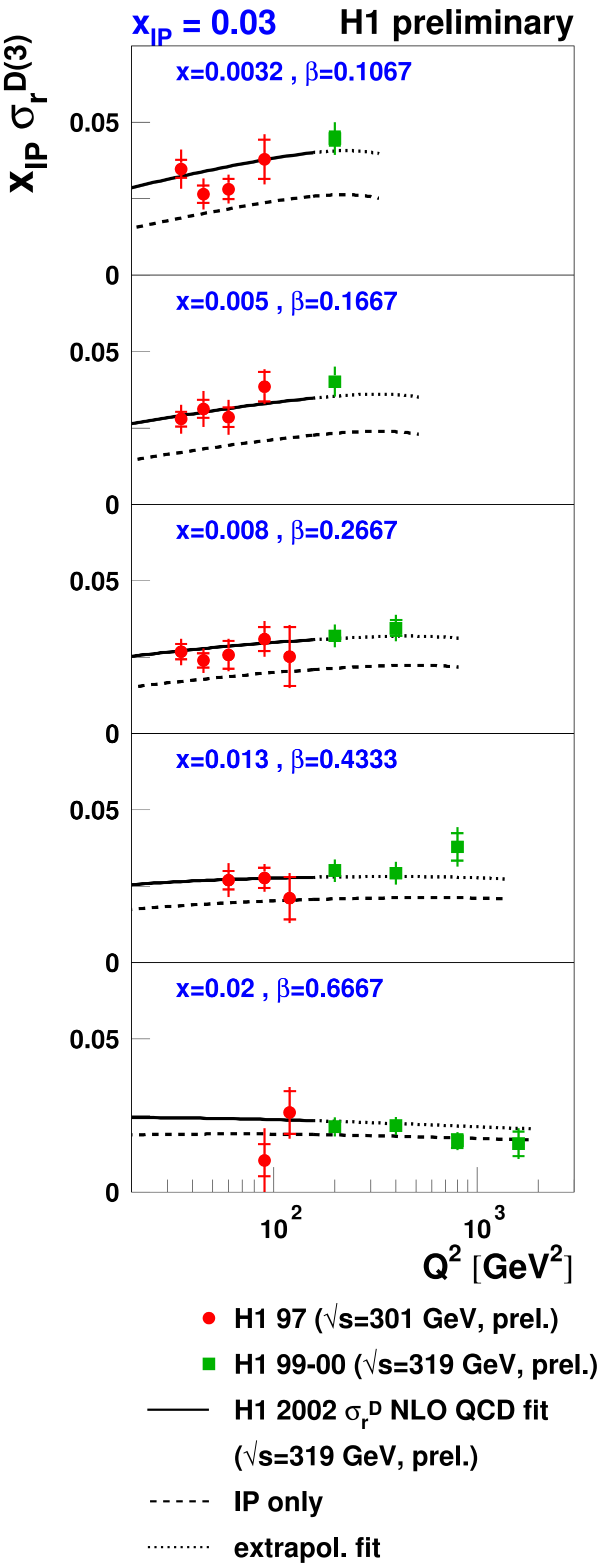
- Good agreement between the data points and the prediction from NLO fits to medium Q^2 data
- The data shows negative slope at high $x_{I\!P}$ mainly due to the contribution of meson exchanges + QCD evolution
- The high Q^2 data provide an additional constraint on the singlet and gluon distributions

Q^2 Dependence at Low $x_{I\!P}$



At low β, the positive scaling violations are due to the large gluon content

Q^2 Dependence at high $x_{I\!P}$



High Q^2 data populates the high β region where the uncertainty was big in the medium Q^2 fits!

Summary

- The phase covered by the σ_r^D new low Q^2 and high Q^2 measurements has considerably increased!

  $1.5 < Q^2 < 12$ GeV^2, $0.01 < \beta < 0.9$

  130¡$Q^2 < 1600$ GeV^2,$0.1 < \beta < 0.9$

- The new data confirm the picture of a gluon dominated exchange

- The fits to the medium Q^2 data reproduce well all data with $Q^2 > 5$ GeV^2

- The final data at **low** and **high** Q^2 will much better constrain the future fits!