INCLUSIVE DIFFRACTION AT HERA

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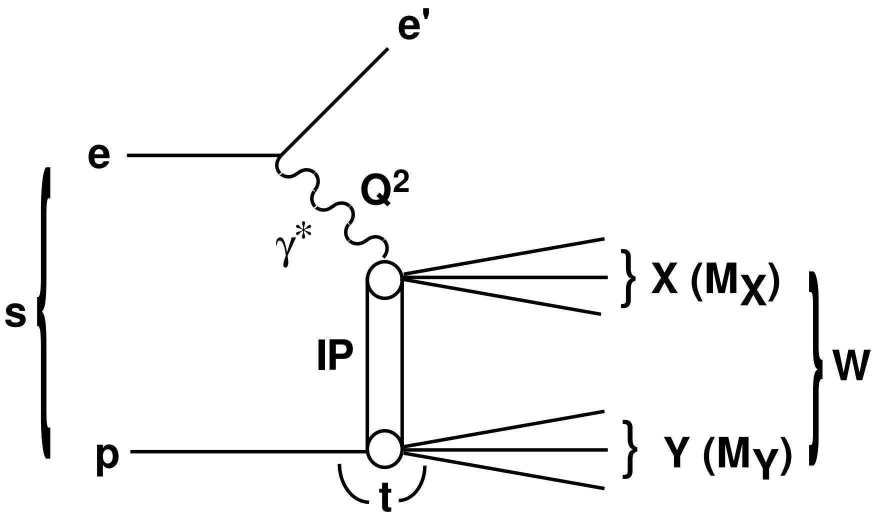
Representing the H1 and ZEUS Collaborations

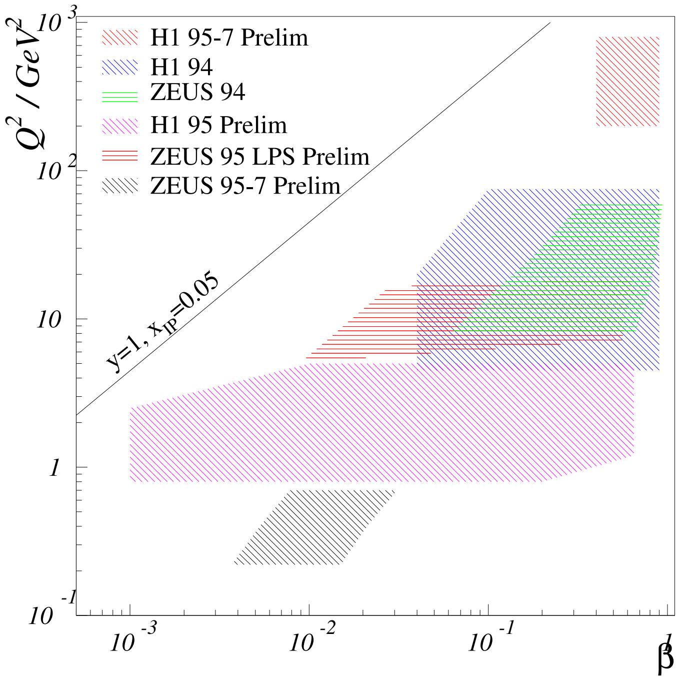
- Diffraction of γ^* at HERA
- Experimental methods of H1, ZEUS
- Diffractive Structure Function $F_2^{D(4)}$
- Diffractive Structure Function $F_2^{D(3)}$
- Q^2, β dependence of $F_2^{D(3)}$
- Energy Dependence of diffractive cross-section

KINEMATICS OF DIFFRACTION



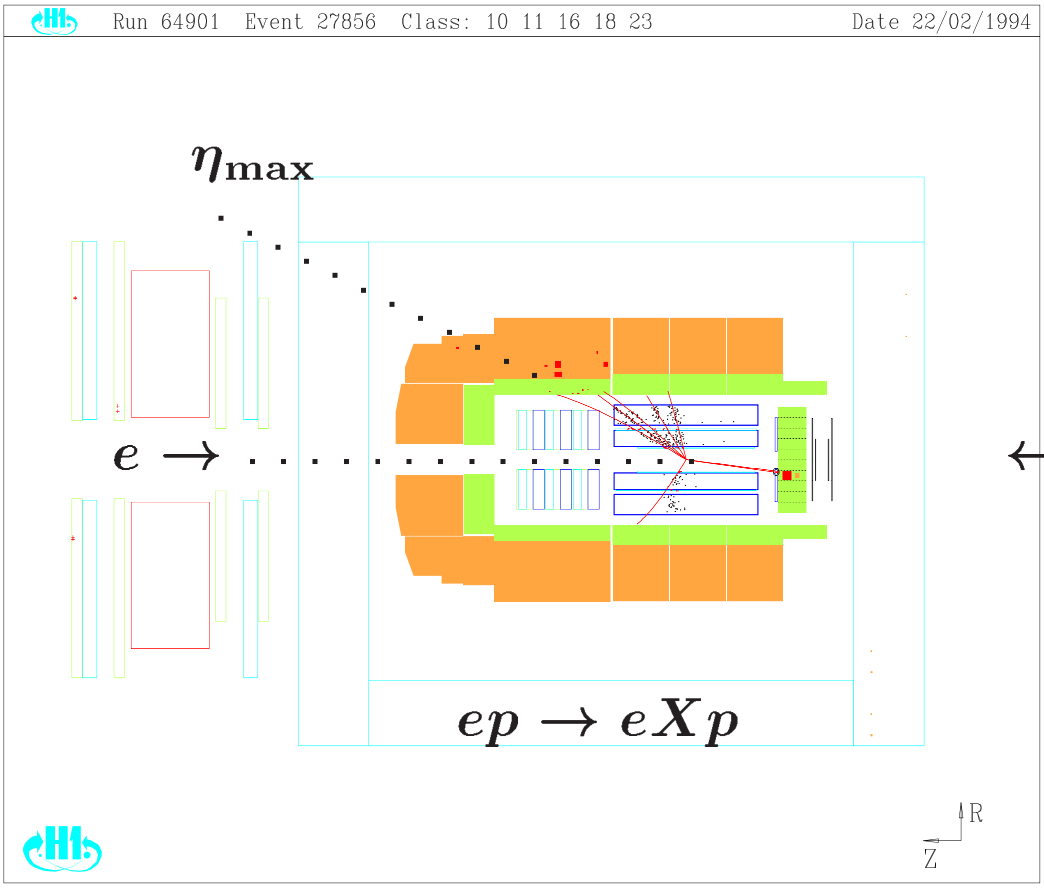
- $s = (k+p)^2$
- $W^2 = (q+p)^2$
- $Q^2 = -q^2 = -(k-k')^2$
- $t = (p-p')^2$
- $x = \frac{Q^2}{2p.q}$
- $x_{I\!P} = \frac{q\cdot(p-p')}{q\cdot p} \simeq \frac{Q^2+M_X^2}{Q^2+W^2} = x_{I\!P/\mathrm{p}}$
- $\beta = \frac{-q^2}{2q\cdot(p-p')} \simeq \frac{Q^2}{Q^2+M_X^2} = x_{q/I\!P}$
- $x_{I\!P} = \frac{x}{\beta}$

DIFFRACTION AT HERA



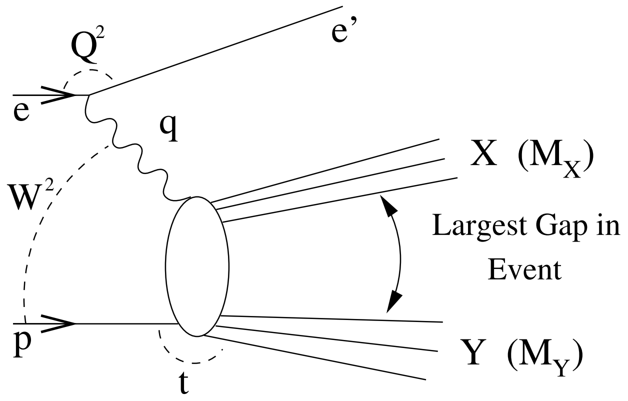
New ZEUS BPC data:

$$0.2 < Q^2 < 0.7 \text{ GeV}^2$$



EXPERIMENTAL DIFFRACTIVE SELECTION

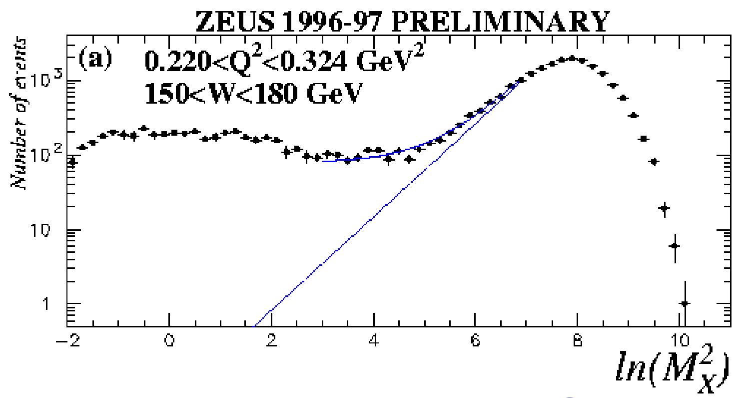
1. Largest Rapidity Gap (H1, ZEUS)



$\Delta\eta$ large

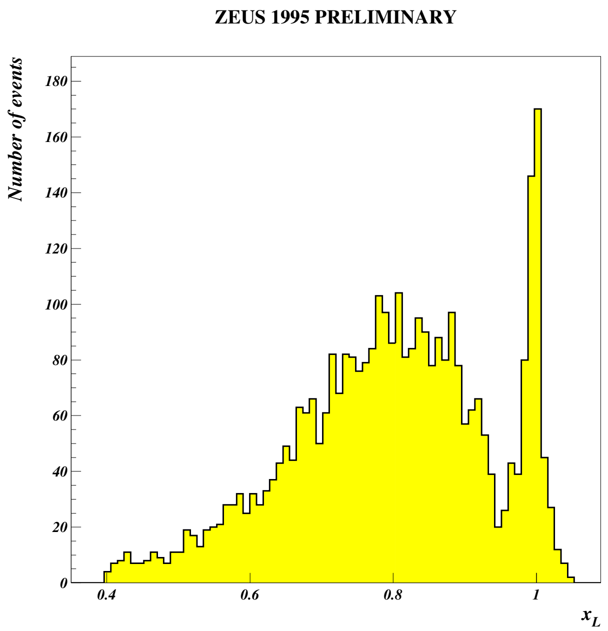
when $M_X, M_Y << W$

2. Decompose ln M_X^2 distribution (ZEUS)



Decompose into diffractive and non-diffractive

3. Detect leading protons (H1, ZEUS)



$$x_L = \frac{E_{p'}}{E_p}$$
$$= 1 - x_{I\!P}$$

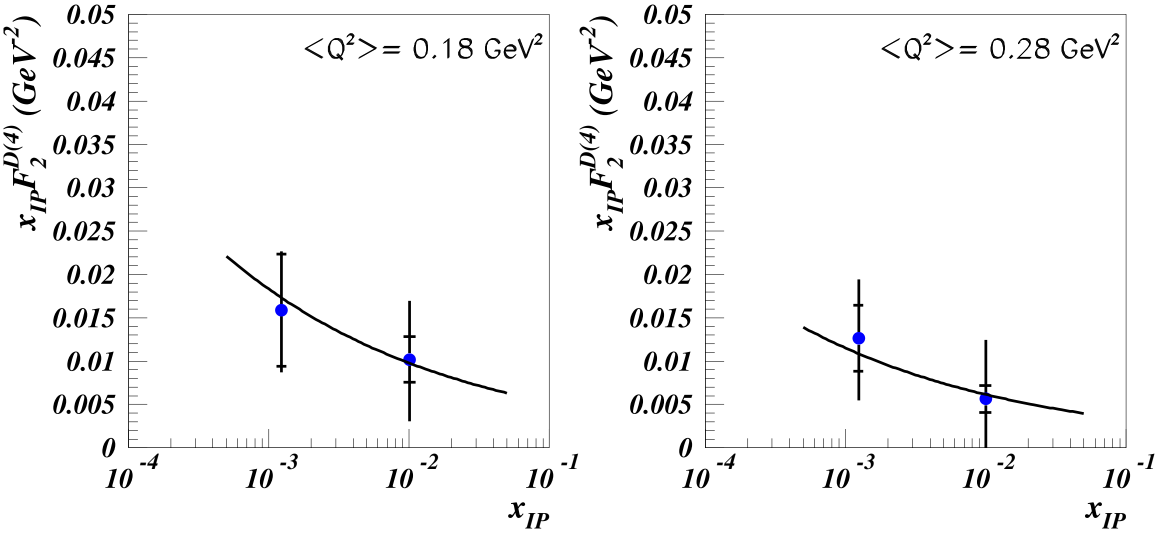
for exclusive p

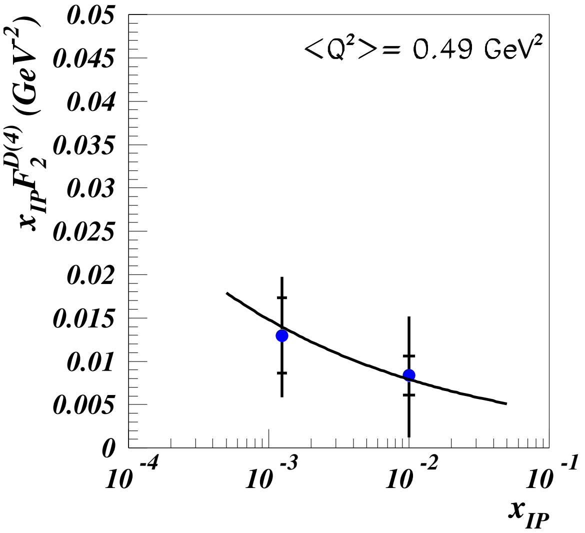
DIFFRACTIVE STRUCTURE FUNCTION, $F_2^{D(4)}$ AT LOW Q^2

$$\frac{d^4\sigma^{ep\to eXp}}{d\beta dQ^2 dx_{I\!P}\,dt} = \frac{4\pi\alpha^2}{\beta Q^4}\left(1-y+\frac{y^2}{2[1+R^{D(4)}]}\right)F_2^{D(4)}(\beta,Q^2,x_{I\!P},t)$$

All analyses assume $R^{D(4)}=0$

ZEUS 1995 PRELIMINARY





Leading p method

$0.073 < |t| < 0.4$ GeV^2

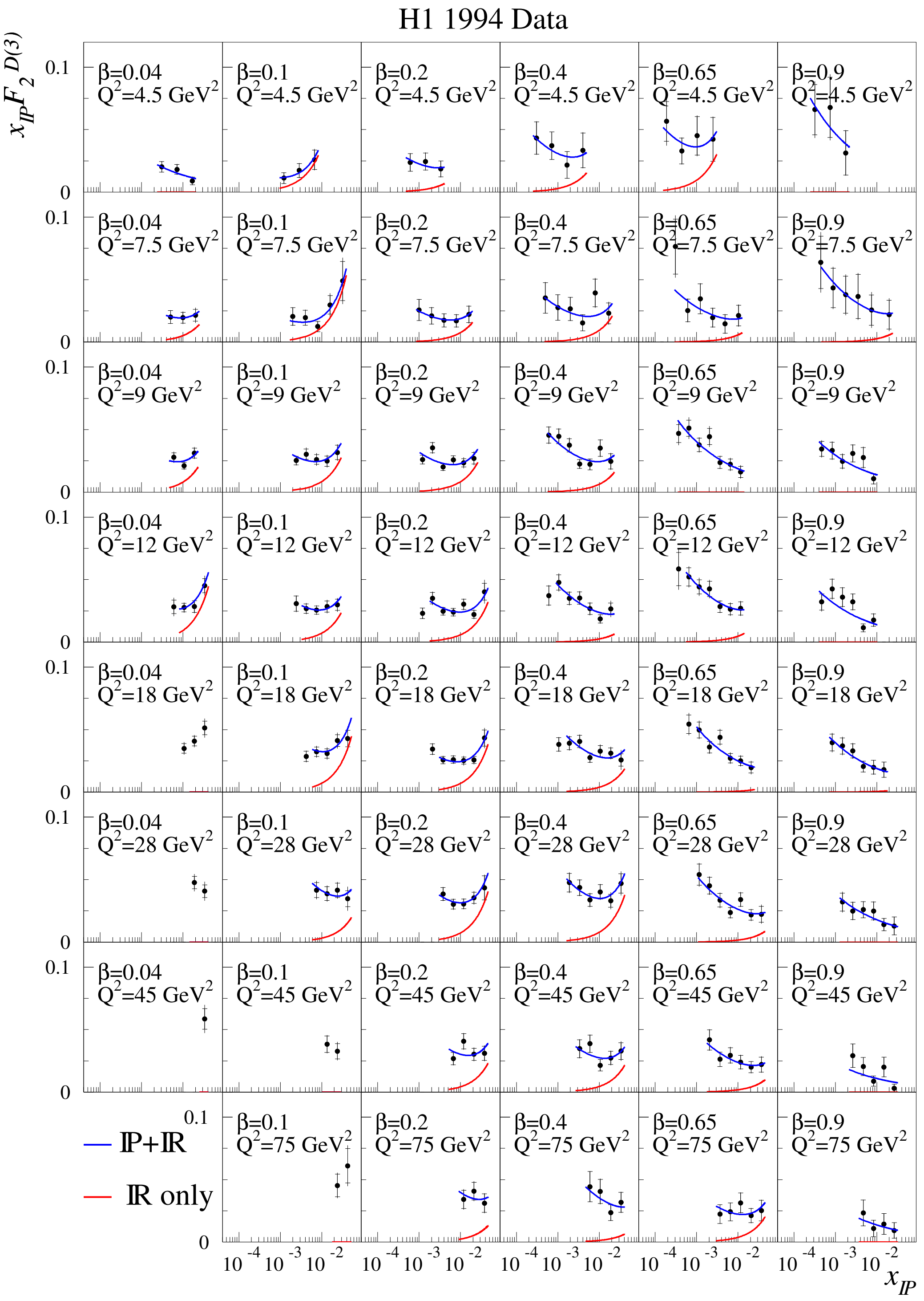
$$F_2^{D(4)}(\beta,Q^2,x_{I\!P},t) = A(\beta,Q^2,t)\left(\frac{1}{x_{I\!P}}\right)^a \qquad \alpha_{I\!P}(t) = \frac{1+a}{2}$$

$$\Rightarrow \alpha_{I\!P}(0) = 1.18 \pm 0.06\,(stat) \pm {}^{0.06}_{0.09}\,(syst)$$

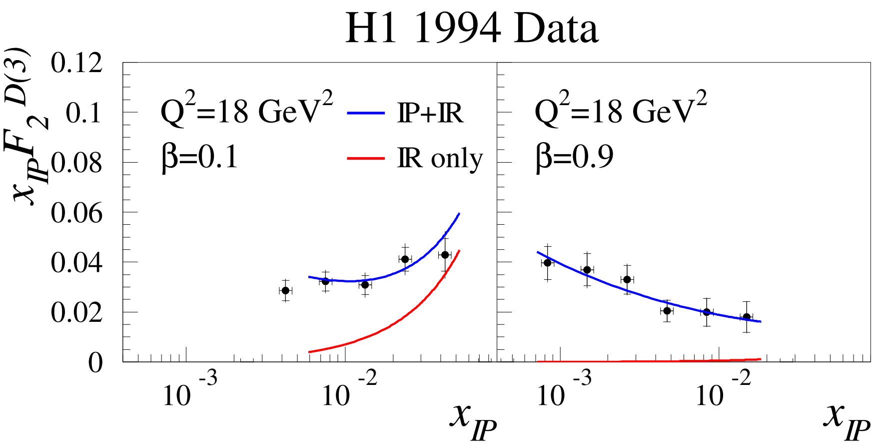
DIFFRACTIVE STRUCTURE FUNCTION, $F_2^{D(3)}$

Measure in the region $|t| < 1$ GeV^2, $M_Y < 1.6$ GeV

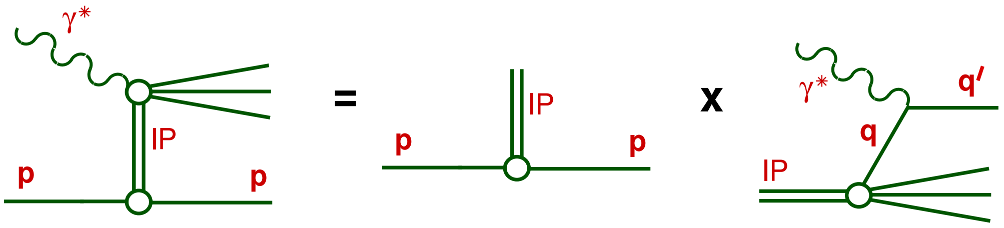
$$\frac{d^3\sigma^{ep\to eXp}}{d\beta dQ^2 dx_{I\!P}} = \frac{4\pi\alpha^2}{\beta Q^4}\left(1 - y + \frac{y^2}{2}\right) F_2^{D(3)}(\beta, Q^2, x_{I\!P})$$



DIFFRACTIVE STRUCTURE FUNCTION, $F_2^{D(3)}$



FACTORISATION:



$F_2^{D(3)}(x_{I\!P}, \beta, Q^2)$ can be represented as

$$F_2^{D(3)}(x_{I\!P}, \beta, Q^2) = f_{\mathrm{I\!P}/\mathrm{p}}(x_{I\!P})F_2^{\mathrm{I\!P}}(\beta, Q^2) + f_{\mathrm{I\!R}/\mathrm{p}}(x_{I\!P})F_2^{\mathrm{I\!R}}(\beta, Q^2)$$

$$f_{\mathrm{I\!P}/\mathrm{p}}(x_{I\!P}) = \int_{-1GeV^2}^{t_{min}(x_{I\!P})} \left(\frac{1}{x_{I\!P}}\right)^{2\alpha_{\mathrm{I\!P}}(t)-1} e^{B_{\mathrm{I\!P}}t}dt$$

$$\alpha_{\mathrm{I\!P}}(t) = \alpha_{\mathrm{I\!P}}(0) + \alpha'_{\mathrm{I\!P}}t$$

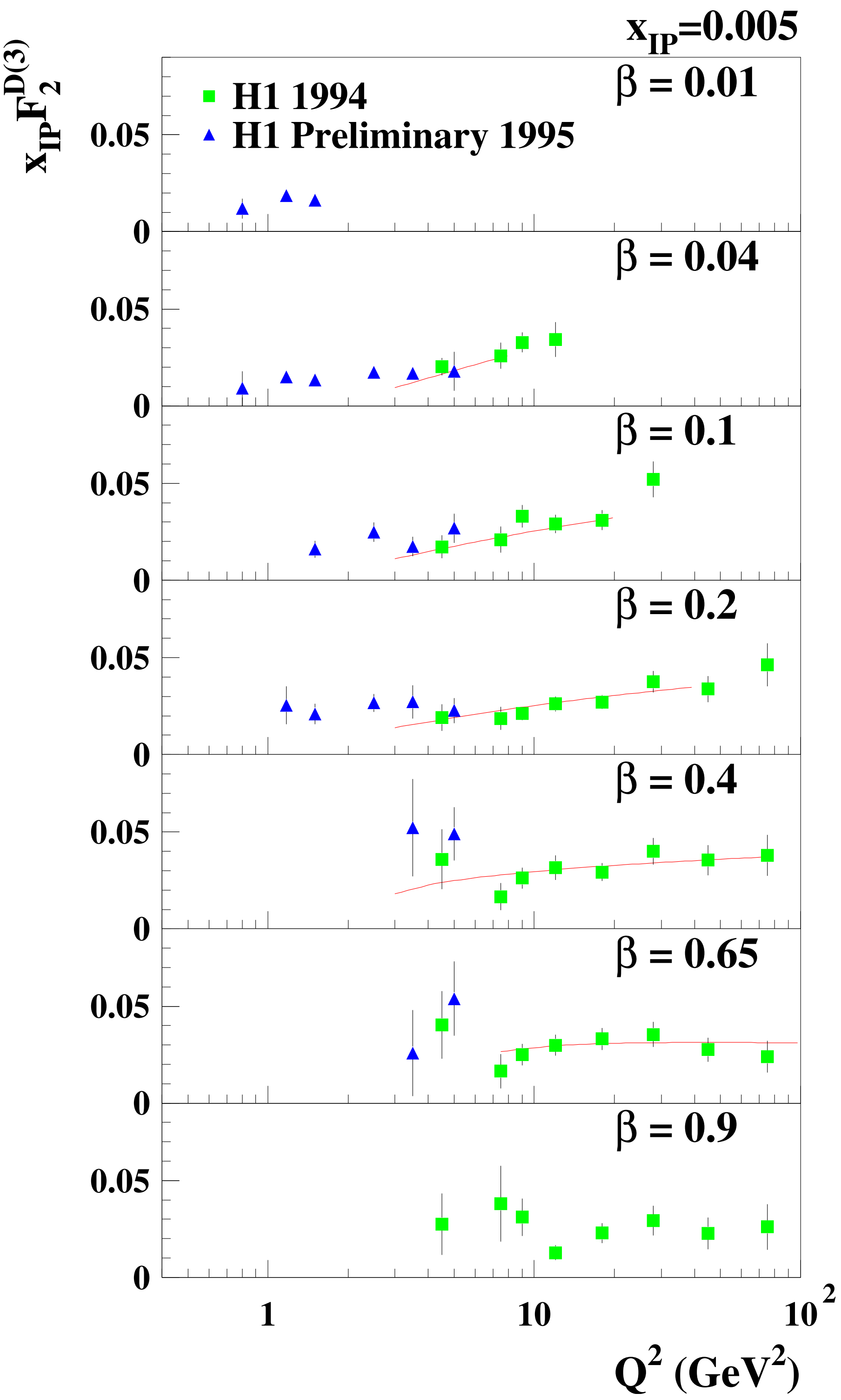
$$\alpha_{\mathrm{I\!P}}(0) = 1.203 \pm 0.020\,(stat) \pm 0.013\,(sys) \pm^{0.030}_{0.038}\,(mod)$$

(Larger than 1.085 for soft pomeron)

$$\alpha_{\mathrm{I\!R}}(0) = 0.50 \pm 0.11\,(stat) \pm 0.11\,(syst) \pm^{0.00}_{0.10}\,(mod)$$

(Consistent with f, ω, ρ, a)

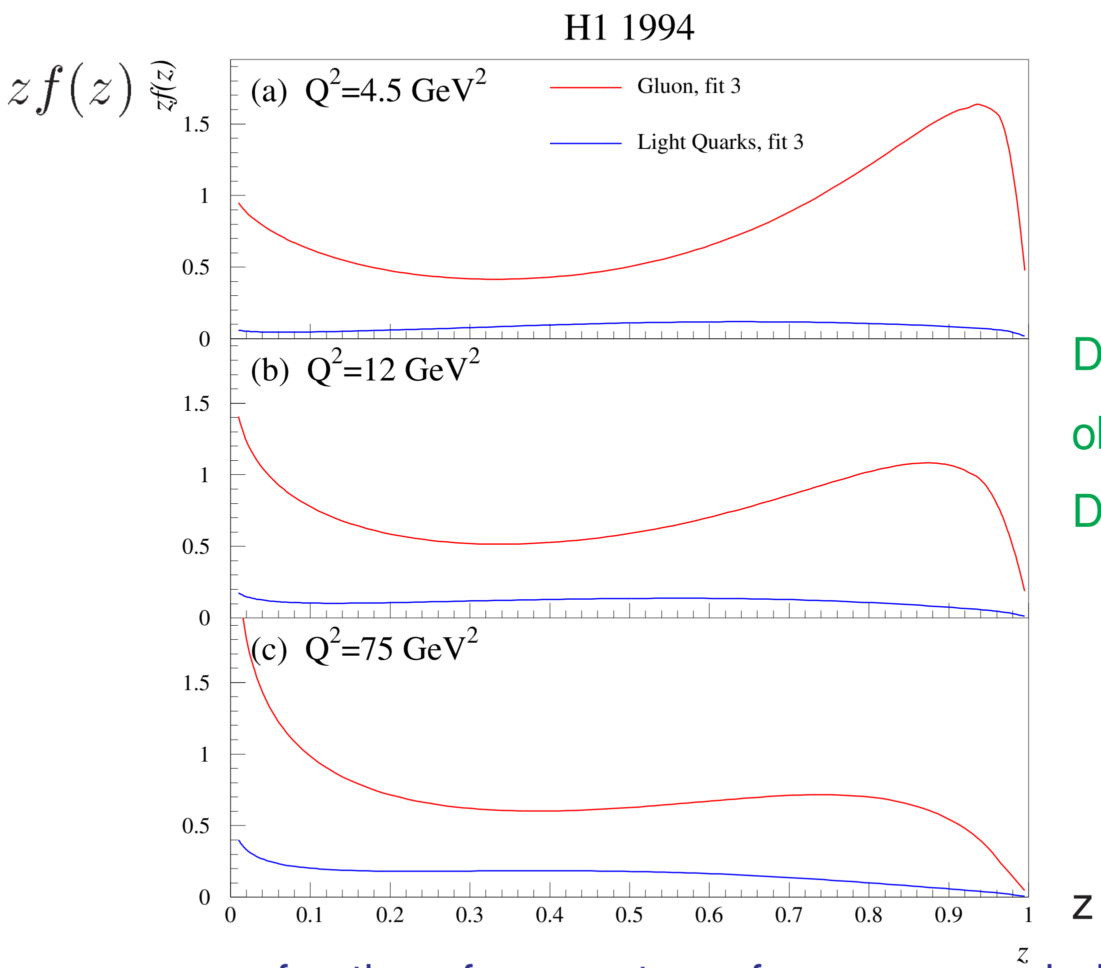
SCALING VIOLATIONS



Low fixed $x_{I\!P}$ $\Rightarrow$ subleading contribution small

Scaling violations persist to high β $\Rightarrow$ large gluon contribution

PARTON DISTRIBUTIONS



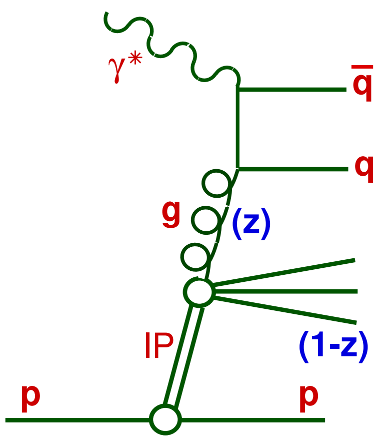
Distributions obtained from DGLAP fits

z= fraction of momentum of pomeron carried by parton.

For quarks $z = \beta$; For gluons $0 < z < \beta$

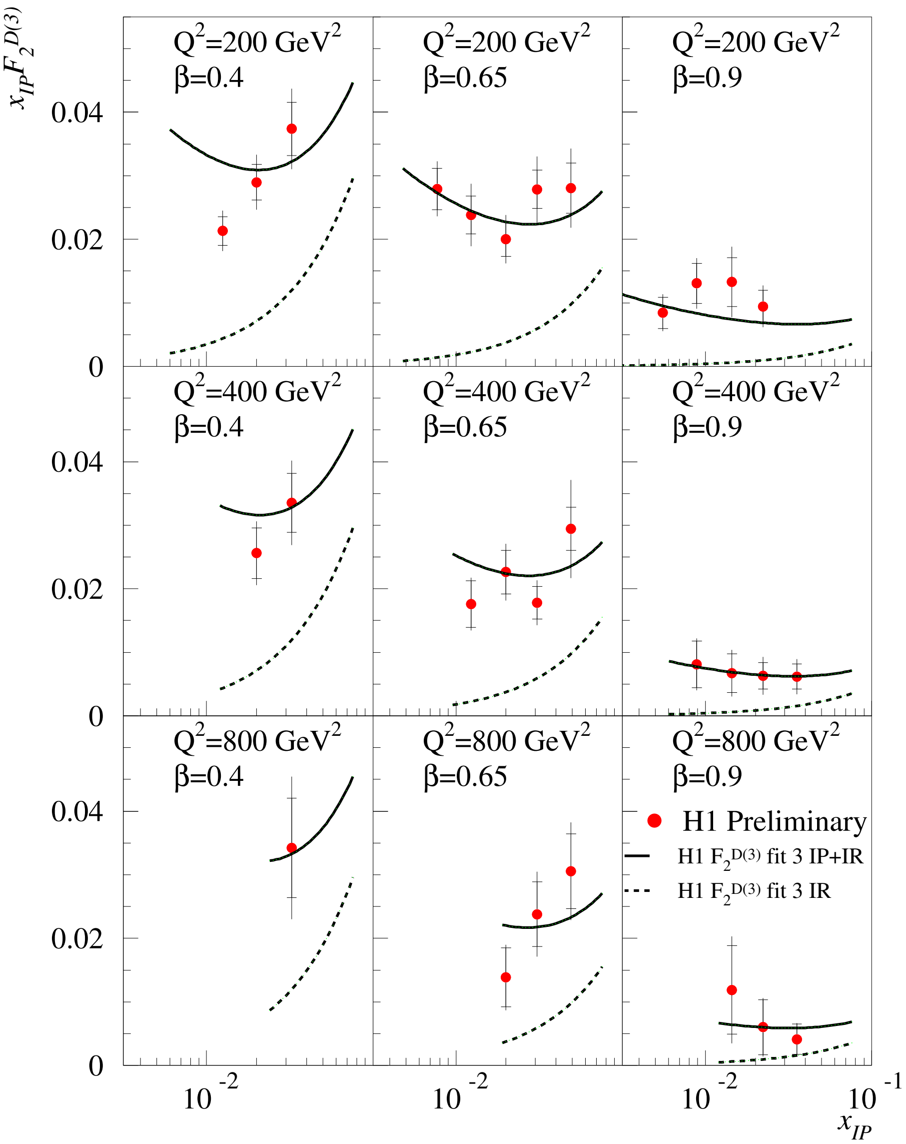
As Q^2 increases, gluons evolve from high to low z (QCD)

- large hard gluonic component $\rightsquigarrow$ BGF
- gluons present even at high z



BGF: dominant diffractive mechanism

HIGH Q^2 $F_2^{D(3)}$

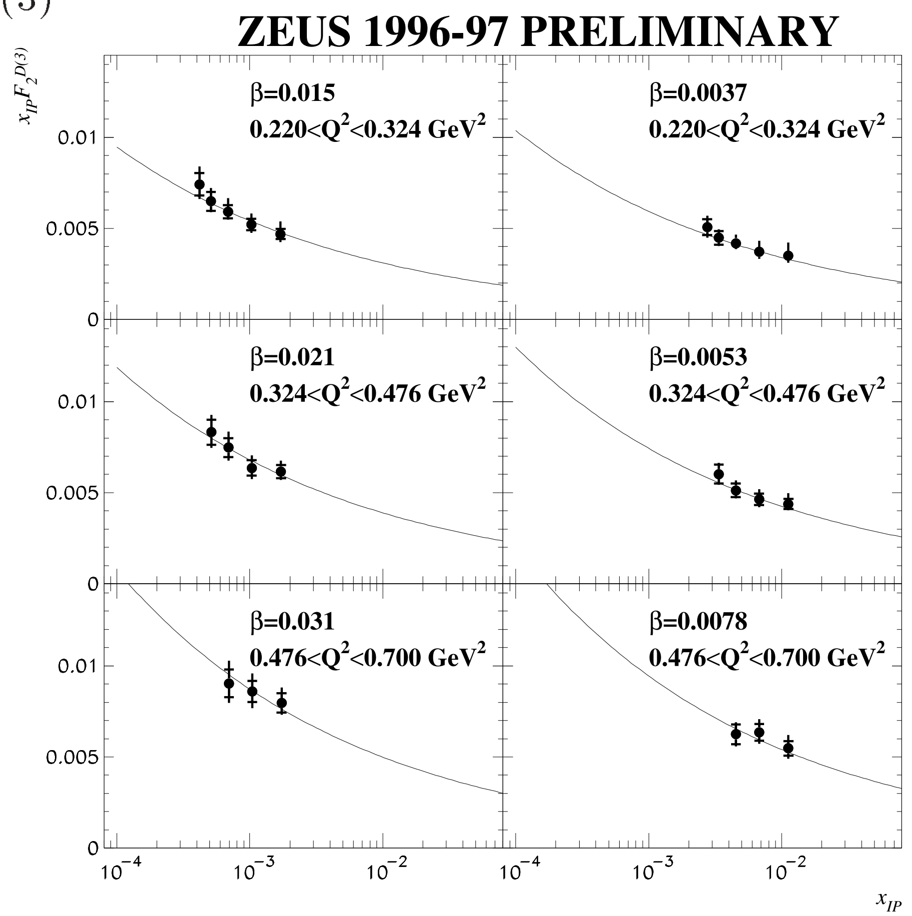


Qualitative features consistent with intermediate Q^2 data

H1 1994 parton distributions evolved to $200 < Q^2 < 800$ GeV^2 $\Rightarrow$ Parameterisation reasonable even at high β

LOW Q^2 $F_2^{D(3)}$

$x_{I\!P} F_2^{D(3)}$



$x_{I\!P}$

$M_Y \lesssim 6$ GeV

M_X decomposition method

Simple Regge fit to

$$F_2^{D(3)}(x_{I\!P}, \beta, Q^2) = A(\beta, Q^2) \cdot (1/x_{I\!P})^a$$

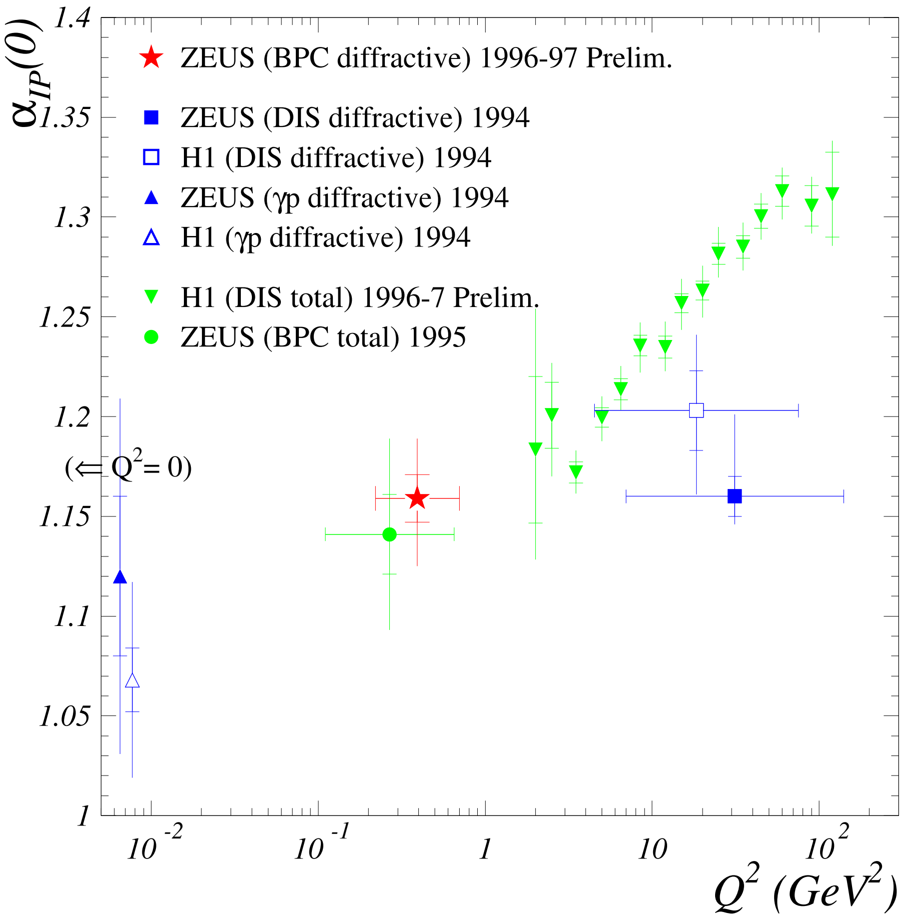
Results $\rightsquigarrow$ $\bar{\alpha}_{\mathrm{I\!P}} = 1.126 \pm 0.012$ (stat) ${}^{+0.027}_{-0.032}$ (syst)

Where $\bar{\alpha}_{\mathrm{I\!P}} = \alpha_{\mathrm{I\!P}}(0) - \alpha'_{\mathrm{I\!P}} \cdot |\bar{t}|$

Compare lnM_X^2 and leading p methods $\Rightarrow$

29 ± 15 (stat) $\%$ p-dissociation contribution to lnM_X^2 sample

EFFECTIVE POMERON INTERCEPT



Simple Regge parameterisation:

$$x_{I\!P} F_2^{D(3)} \sim A(\beta, Q^2) x^{2-2\langle\alpha_{I\!P}(t)\rangle}$$
$$F_2 \sim B(Q^2) x^{1-\alpha_{I\!P}(0)}$$

Evidence for rise of diffractive $\alpha_{I\!P}(0)$ with Q^2

Low Q^2: diffractive and inclusive $\alpha_{I\!P}(0)$ compatible

Higher Q^2: diffractive and inclusive $\alpha_{I\!P}(0)$ incompatible

'SATURATION' MODEL

Assume $\gamma^* \to q\bar{q}$ and $q\bar{q}g$ which scatter off p

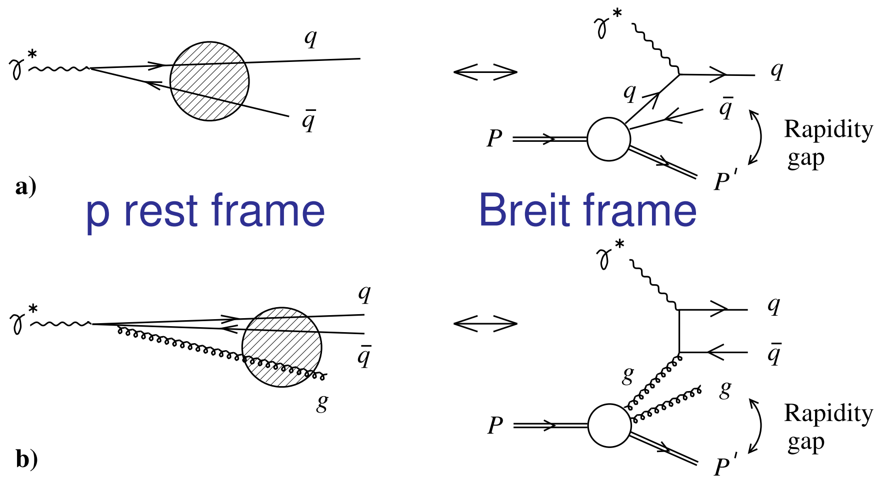
Cross section for colour dipole interaction with p saturates

at small Q^2 (large dipole sizes)

Describes transition to $Q^2 \to 0$ in inclusive cross section

For diffraction, exchange 2 gluons from p

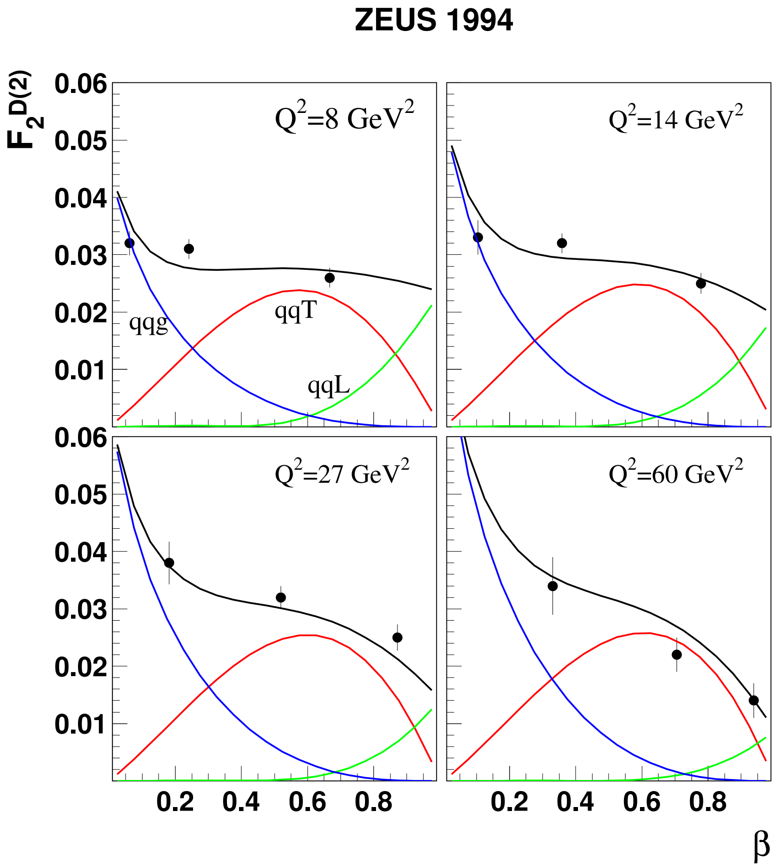
$\Rightarrow$ No more free parameters introduced



$\gamma^*_T \to q\bar{q}$

$\gamma^*_L \to q\bar{q}$

$\gamma^*_T \to q\bar{q}g$

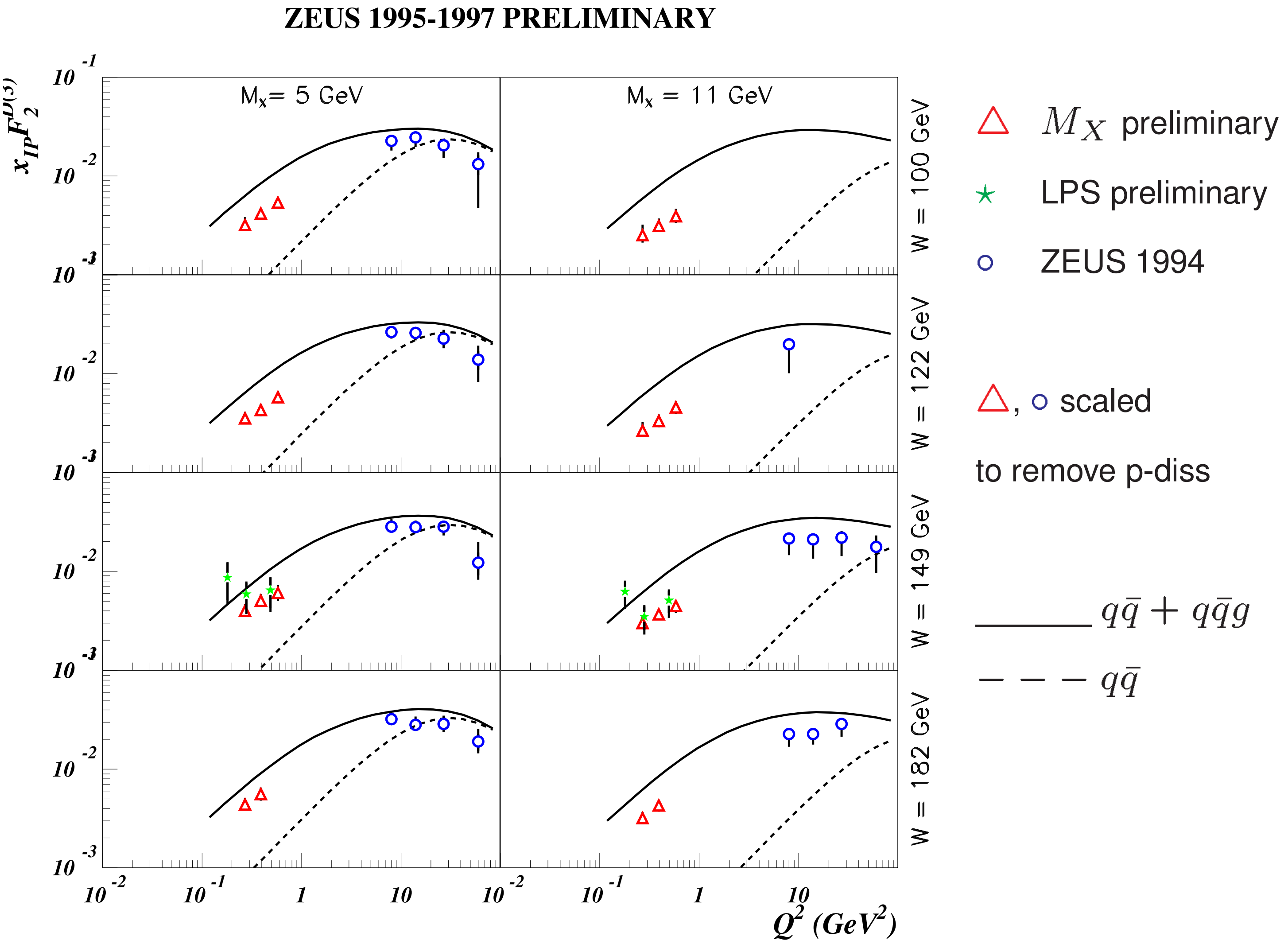


$x_{\mathbb{P}} = 0.0042$

High Q^2 data

$\Rightarrow$ good agreement

Q^2 DEPENDENCE OF $F_2^{D(3)}$



- Clear transition at low Q^2, as for F_2
- $q\bar{q}g$ term dominant at low β
- Applicability of this higher Q^2 $q\bar{q}g$ ‘saturation’ model questionable at low Q^2
- Qualitative features of transition descibed

SUMMARY

- HERA $\Rightarrow F_2^D$ over very large Q^2 range
- Results generally consistent with factorisable partonic pomeron model (Regge Theory), but evidence for Q^2 dependence of $\alpha_{\mathbb{P}}(0)$
- Effective pomeron intercept larger than for soft pomeron
- $\alpha_{\mathbb{P}}$ vs $Q^2 \Rightarrow$ diffractive and inclusive compatible at low Q^2, but different at higher Q^2
- Transition of $F_2^{D(3)}$ as $Q^2 \rightarrow 0$ qualitatively similar to inclusive F_2
- 'Saturation' model successful at reproducing general features of the data at high Q^2