INCLUSIVE DIFFRACTION AT LOW Q^2

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on behalf of the ZEUS Collaboration

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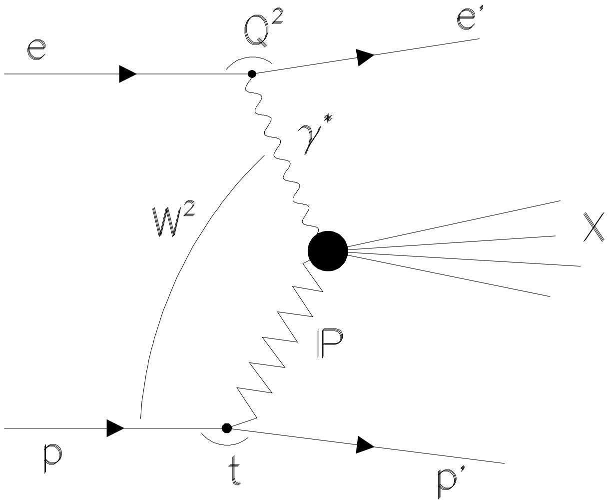
Diffraction at HERA



$$Q^2 = -q^2$$
$$W^2 = (q+p)^2$$
$$t = (p - p_Y)^2$$

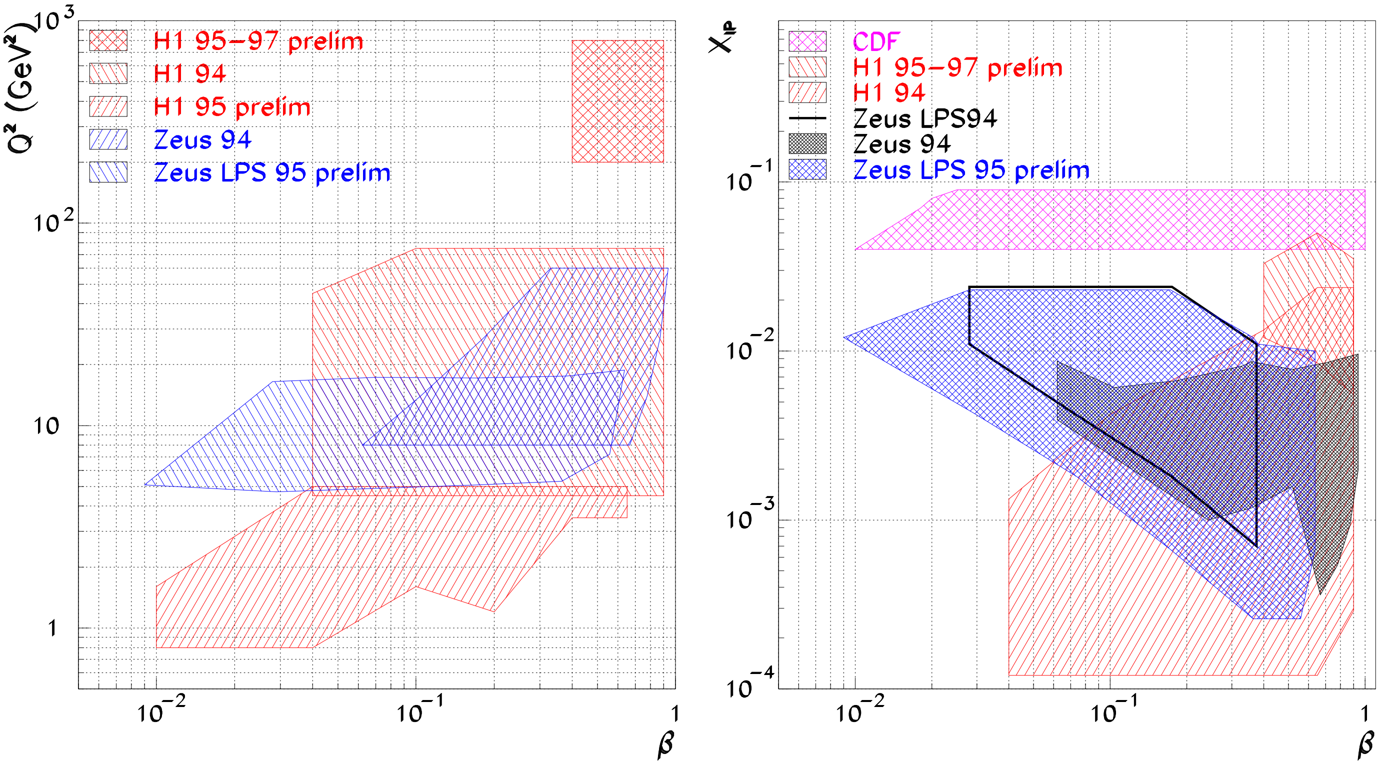
Fraction of $I\!P$ momentum carried by the struck quark:

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

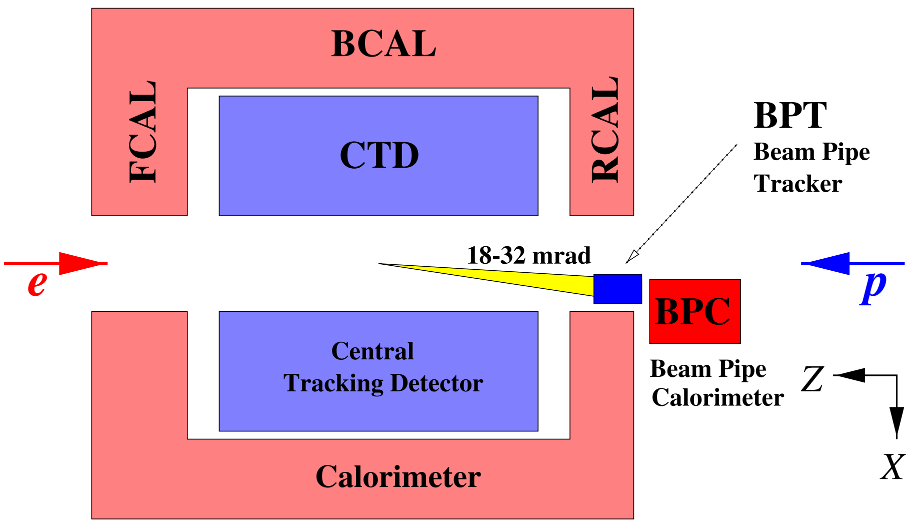
Fraction of proton momentum carried by the $I\!P$:

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

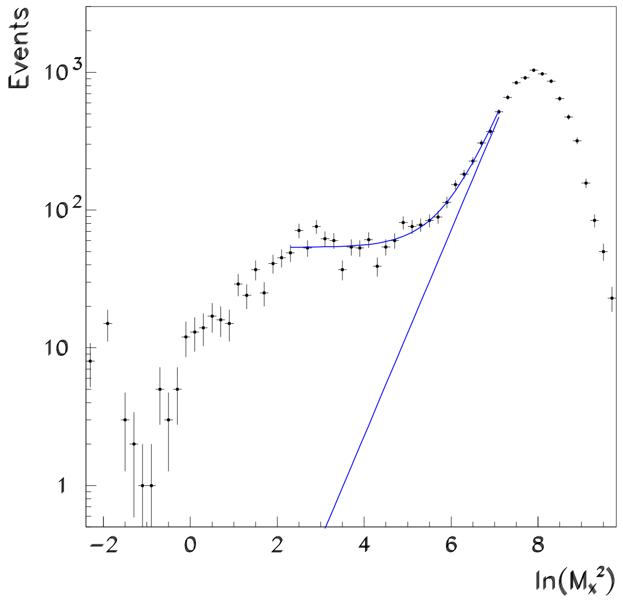
Phase space



Beam Pipe Calorimeter (BPC)



Selection of diffractive events



Method I:

We look at the $\ln M_X^2$ distribution and select diffraction as the excess of events over the exponential $\ln M_X^2$ fall-off of the non-diffractive events

96-97 data $\sim 6.2\ pb^{-1}$

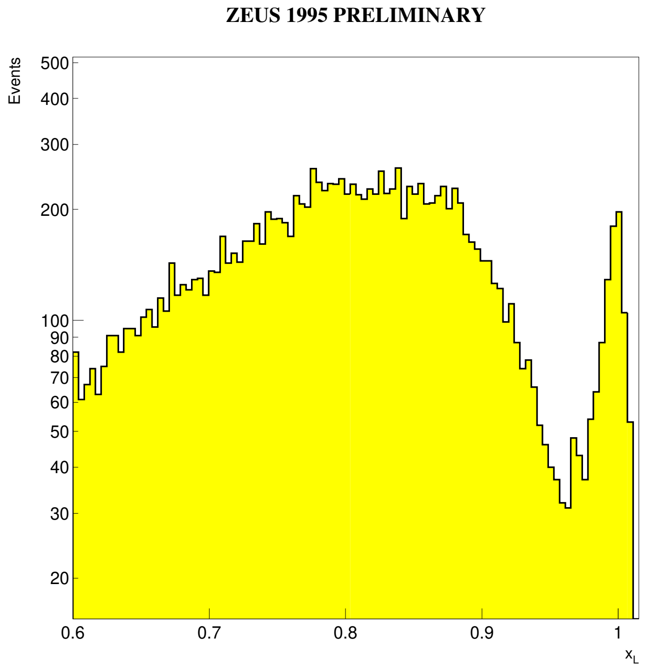
$$0.22 < Q^2 < 0.7\ \mathrm{GeV}^2$$
$$90 < W < 220\ \mathrm{GeV}$$
$$3.0 < M_X < 12\ \mathrm{GeV}$$

Selection of diffractive events

Method II:

Require the detection of a high energy proton in the Leading Proton Spectrometer (LPS)

(95 data $\sim 1\ pb^{-1}$)

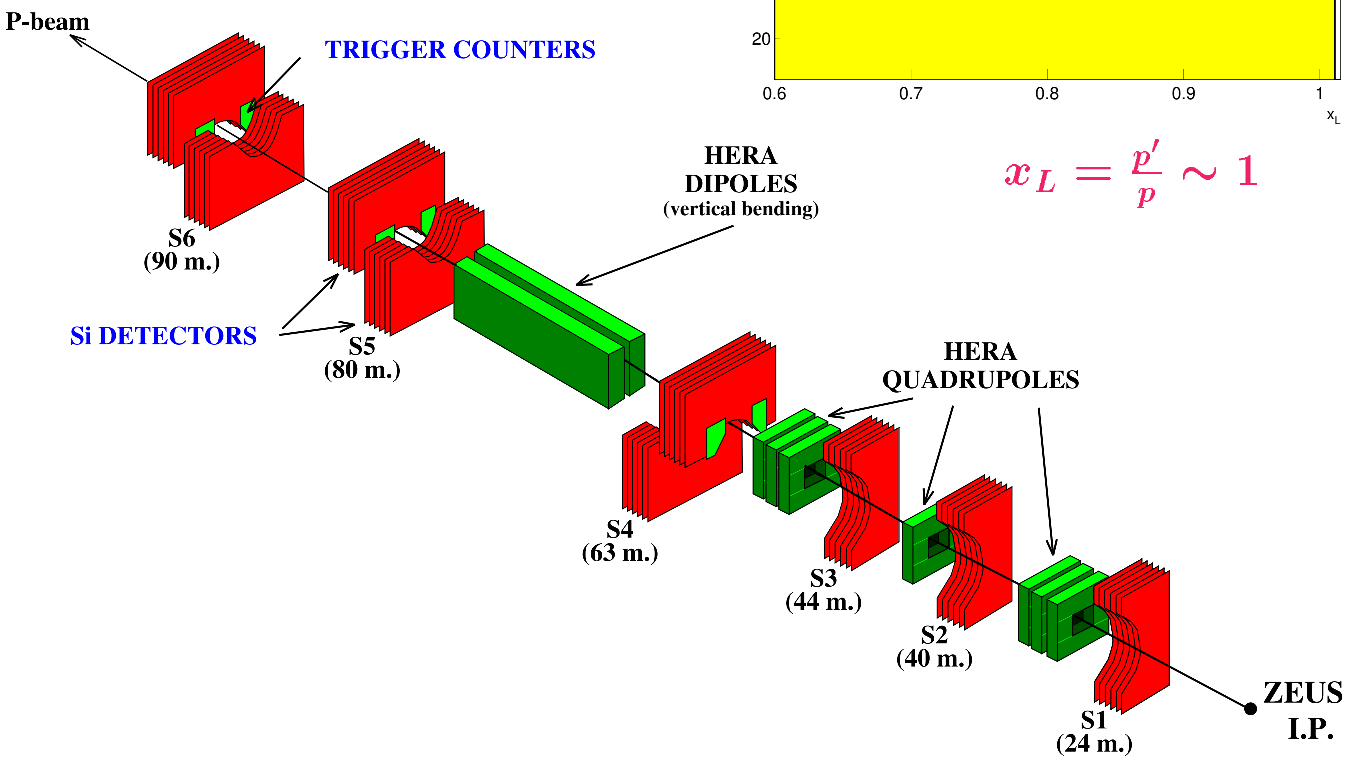


$0.14 < Q^2 < 0.7\ \mathrm{GeV}^2$

$0.073 < |t| < 0.4\ \mathrm{GeV}^2$

$3.0 < M_X < 32\ \mathrm{GeV}$

$$x_L = \frac{p'}{p} \sim 1$$



$\Rightarrow$ Allows to measure t

$\Rightarrow$ Allows M_X up to 35 GeV

$\Rightarrow$ No contamination from proton diffractive dissociation

What am I going to show to you?

- **Energy behaviour of the diffractive cross section (Method I and II):**

$$\frac{d\sigma^D_{\gamma^* p \to Xp}}{dM_X}(M_X, Q^2, W) = \frac{\pi Q^2 W}{\alpha(1+(1-y)^2)} \frac{d^3\sigma^D_{ep}}{dM_X dQ^2 dW}$$

$$\frac{d\sigma^D}{dM_X} \sim (W^2)^{2\bar{\alpha}_{I\!P}-2} \longrightarrow \alpha_{I\!P}(0)$$

- **Diffractive Structure Function:**

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

$$x_{I\!P}\, F_2^{D(4)}(\beta, Q^2, x_{I\!P}, t) \propto 1/x_{I\!P}^{(2\alpha_{I\!P}-1)} \rightarrow \alpha_{I\!P}(0)$$

,

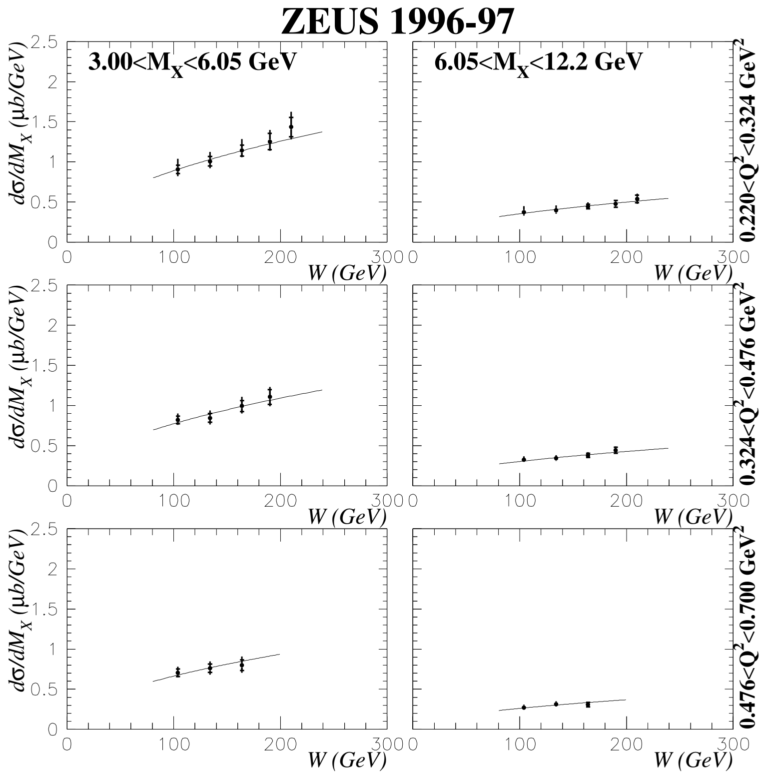
- **First look at the Q^2 dependence of the data at low Q^2**

$$x_{I\!P} F_2^{D(3)} = \frac{Q^2}{4\pi\alpha^2} \frac{Q^2 + M_X^2}{2M_X} \frac{d\sigma^D_{\gamma^* p \to Xp}}{dM_X}(M_X, Q^2, W)$$

- **Can the data be understood in terms of quarks and gluons?**

Energy behaviour of the diffr. cross section

$$\frac{d\sigma_{\gamma^* p \to XY}}{dM_X}\,(M_X, Q^2, W)$$



Using method I:

$0.22 < Q^2 < 0.70\ \mathrm{GeV}^2$

$90 < W < 220\ \mathrm{GeV}$

$3 < M_X < 12\ \mathrm{GeV}$

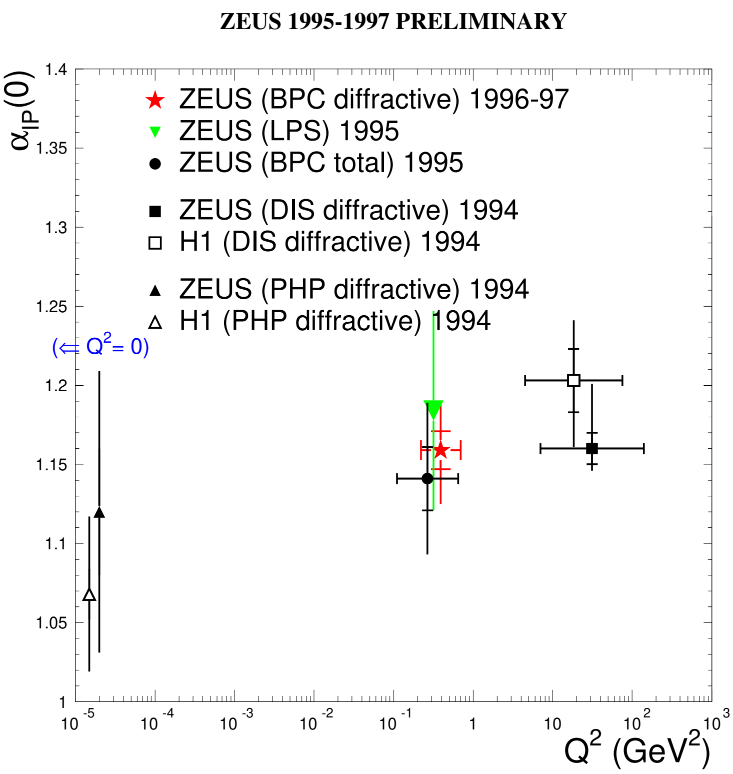
$$\frac{d\sigma^D}{dM_X} \sim (W^2)^{2\bar{\alpha}_{I\!P}-2}$$

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

$\alpha'_{I\!P} = 0.25\ \mathrm{GeV}^{-2}$

$|\bar{t}| = 1/7.5\ \mathrm{GeV}^2$

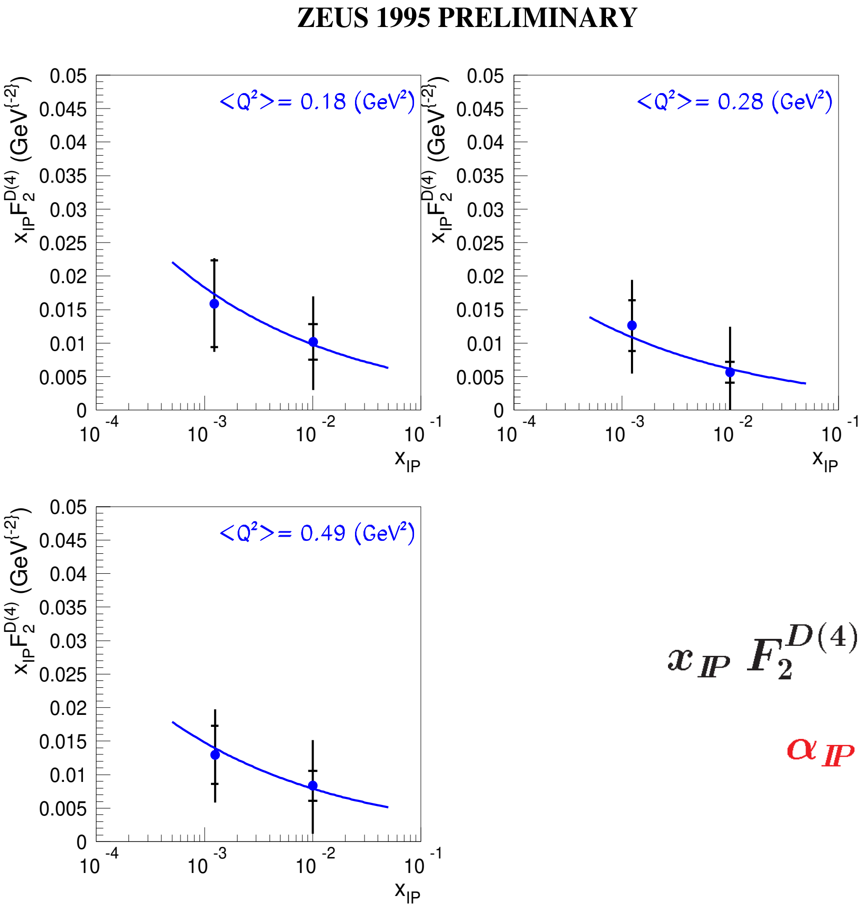
$$\alpha_{I\!P}(0) = 1.159 \pm 0.012^{+0.027}_{-0.032}$$



Data consistent with PHP and with higher Q^2 results

Measurement of $F_2^{D(4)}$

Using the LPS, select events with $x_L > 0.97$



$0.14 < Q^2 < 0.70$ GeV^2

$0.0.073 < |t| < 0.4$ GeV^2

$3 < M_X < 32$ GeV

$90 < W < 220$ GeV

From the fit:

$$x_{I\!P}\, F_2^{D(4)}(\beta, Q^2, x_{I\!P}, t) = 1/x_{I\!P}^{(2\alpha_{I\!P}-1)}$$

$$\alpha_{I\!P}(0) = 1.184 \pm 0.063^{+0.06}_{-0.09}$$

N.B.:

Method I: Includes contamination of p-dissociation (...but large statistics).

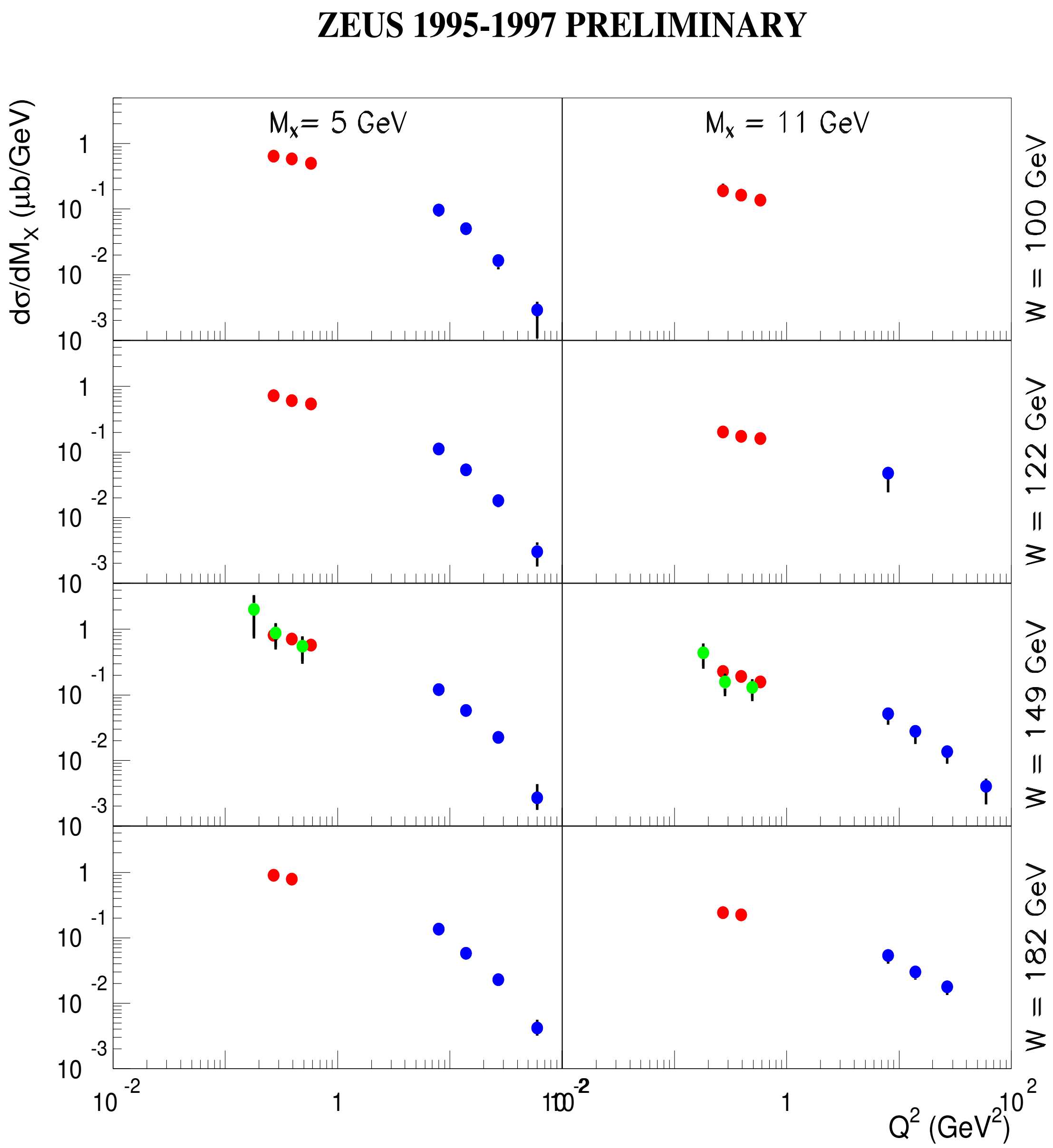
Method II: no p-dissociation.

The ratio of the cross section from the two methods gives the amount of p-dissociation in Method I. In the kinematic range of the present data:

$$\frac{\sigma^{Diff-MethodI}}{\sigma^{Diff-MethodII}} = 1.4 \pm 0.3$$

Measurement of $\frac{d\sigma^D}{dM_X}$ vs Q^2

$$\frac{d\sigma}{dM_X} = 4\pi^2\alpha\frac{2M_X}{Q^2+M_X^2}\cdot\frac{1}{Q^2}\cdot x_{I\!P}F_2^{D(3)}$$



ZEUS DIS 94

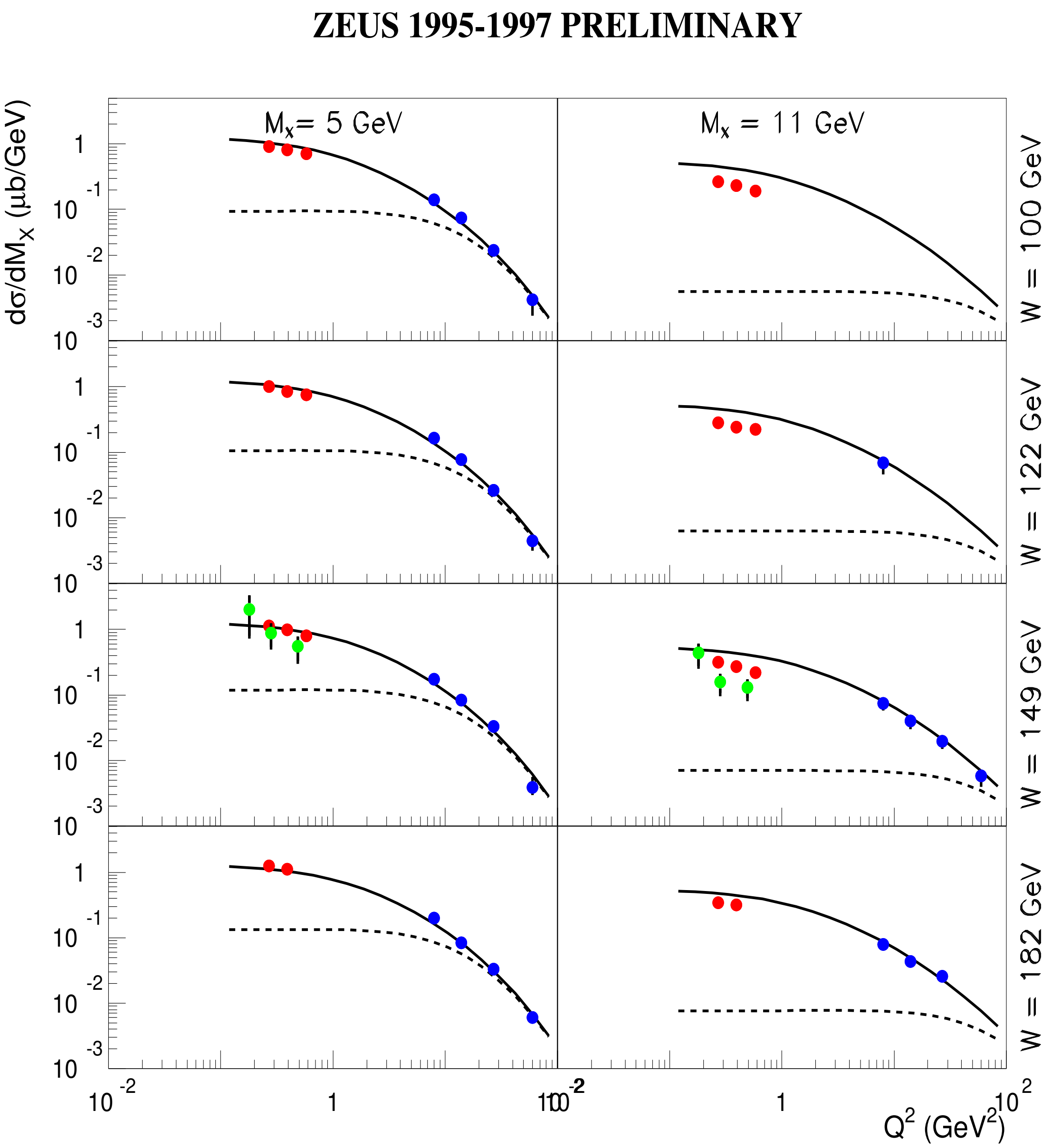
ZEUS BPC 96-97 PRELIMINARY (Method I)

ZEUS BPC+LPS 95 PRELIMINARY (Method II)

Q^2 dependence of $\frac{d\sigma^D}{dM_X}$ softens significantly at low Q^2

$$\rightarrow x_{I\!P}F_2^{D(3)} \propto Q^2$$

Measurement of $\frac{d\sigma}{dM_X}$ vs Q^2



ZEUS DIS 94

ZEUS LPS 95 PRELIMINARY (Method II)

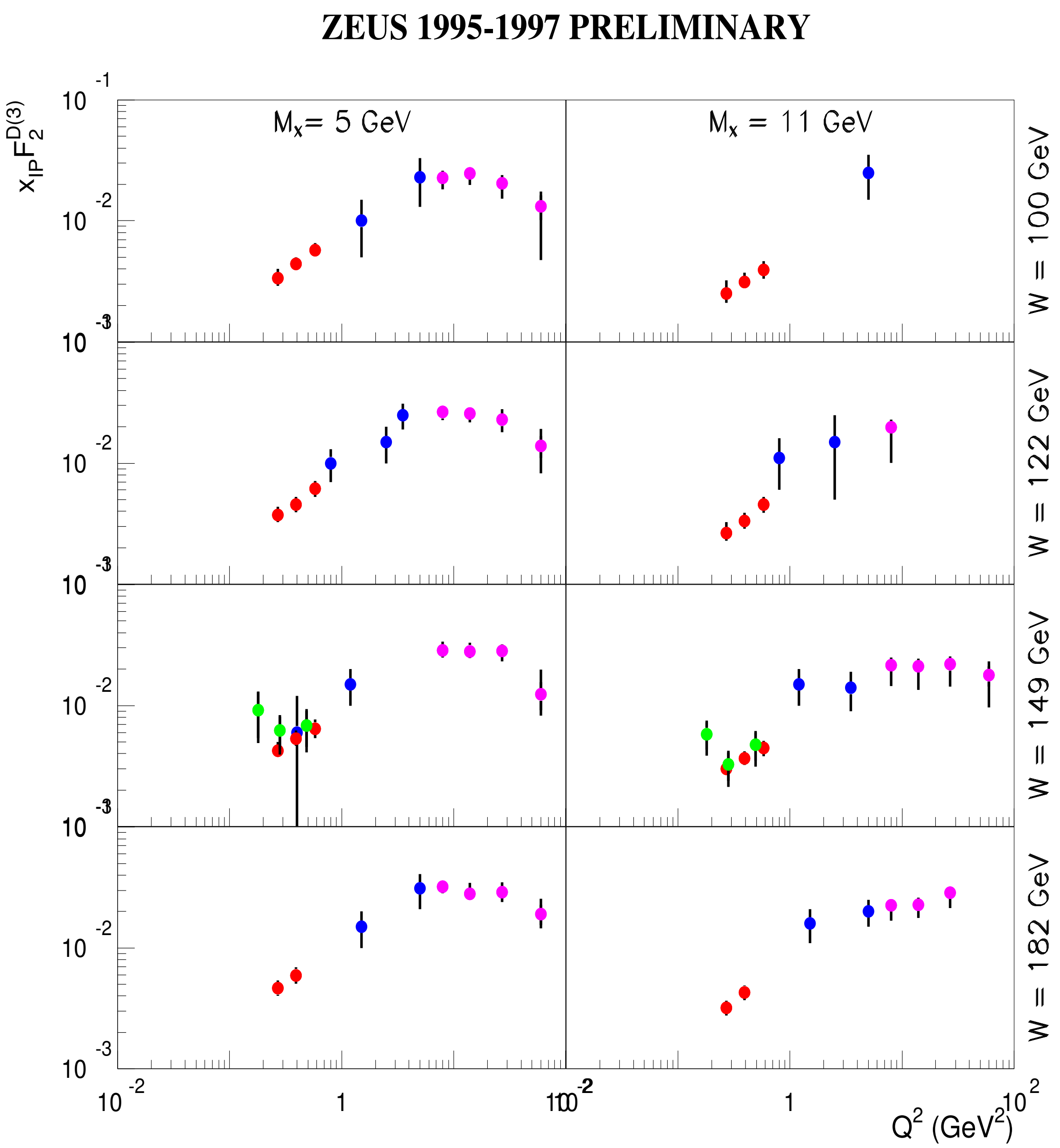
ZEUS BPC 96-97 PRELIMINARY (Method I)

Curves by K. Golec-Biernat (private comunication)

Important contribution of $q\bar{q}g$ at low Q^2?

Measurement of $x_{IP}F_2^{D(3)}$ vs Q^2

$$x_{IP}F_2^{D(3)} = \frac{Q^2+M_X^2}{8\pi^2\alpha M_X} \cdot Q^2 \cdot \frac{d\sigma^D}{dM_X}$$



ZEUS BPC 96-97 PRELIMINARY (Method I)

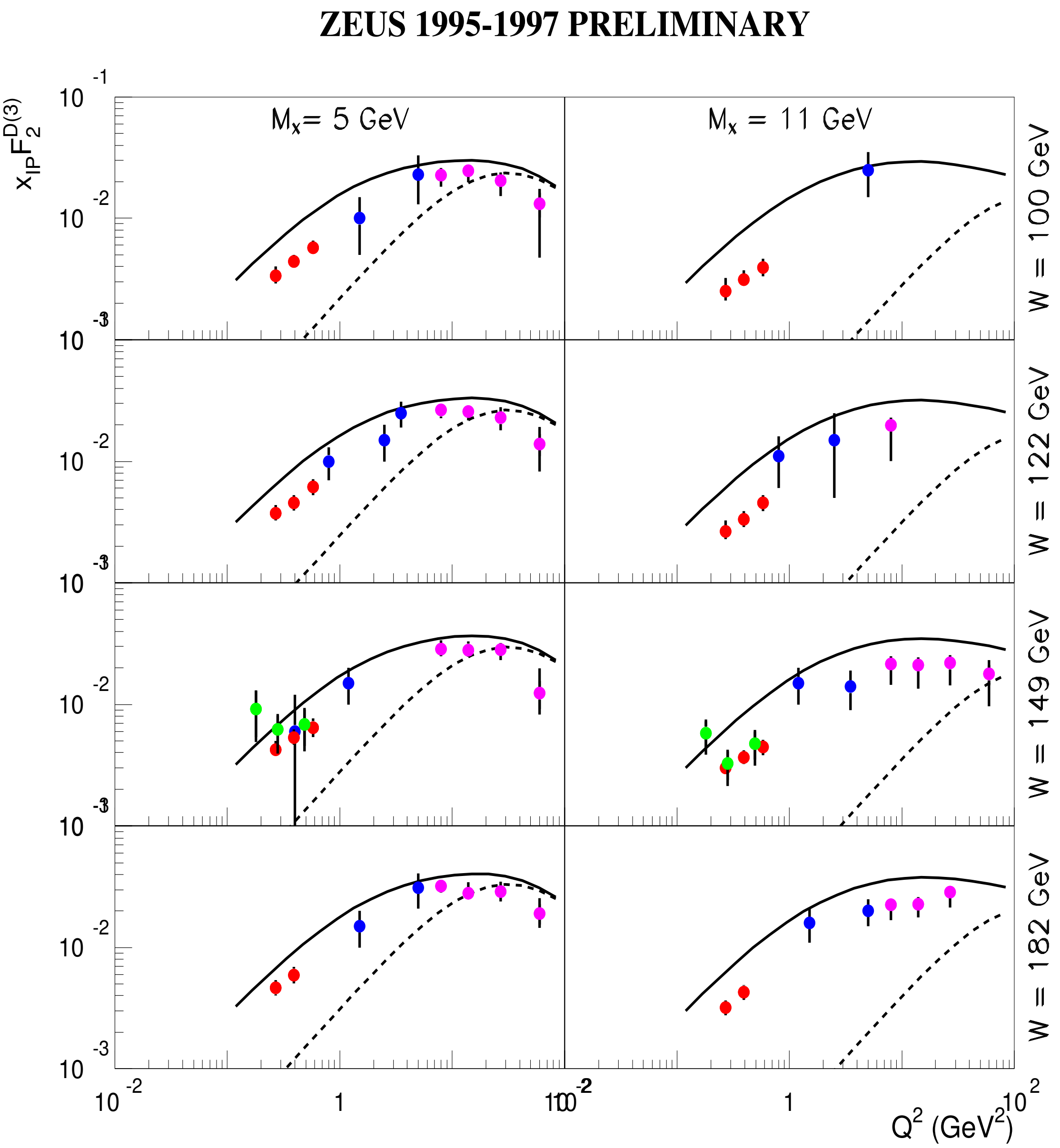
ZEUS LPS 95 PRELIMINARY (Method II)

ZEUS DIS 94

H1 shifted vertex 95 PRELIMINARY

Low Q^2 data show a strong dependence of $x_{IP}F_2^{D(3)}$ on Q^2

Measurement of $x_{I\!P} F_2^{D(3)}$ vs Q^2



ZEUS BPC 96-97 PRELIMINARY (Method I)

ZEUS LPS 95 PRELIMINARY (Method II)

H1 shifted vertex 95 PRELIMINARY

ZEUS DIS 94

Curves by K. Golec-Biernat (private comunication)

Important contribution of $q\bar{q}g$ at low Q^2?

Summary

- **Photon diffractive dissociation measured at very low Q^2, $Q^2 < 0.7$ GeV^2.**
- **Diffractive signal extracted with two methods:**
  1. **ln M_X^2 method;**
  2. **measuring a high energy proton in the Leading Proton Spectrometer.**
- **From $d\sigma/dM_X$ vs W determined**

$$\alpha_{I\!P}(0) = 1.159 \pm 0.012^{+0.027}_{-0.032}.$$

- **From $x_{I\!P} F_2^{D(4)}$ vs $x_{I\!P}$ determined**

$$\alpha_{I\!P}(0) = 1.184 \pm 0.063^{+0.06}_{-0.09}$$

- **First evidence of a softening of the Q^2-dependence of diffractive $\frac{d\sigma}{dM_X}$ at low Q^2, i.e. a stronger Q^2-dependence of $x_{I\!P} F_2^{D(3)}$ (in analogy with inclusive cross-section behaviour).**
- **From a first comparison with the saturation model, it would seem that the model reproduces the general features of the data and that the data are consistent with a significant $q\bar{q}g$ contribution.**