ZEUS results on inclusive diffraction

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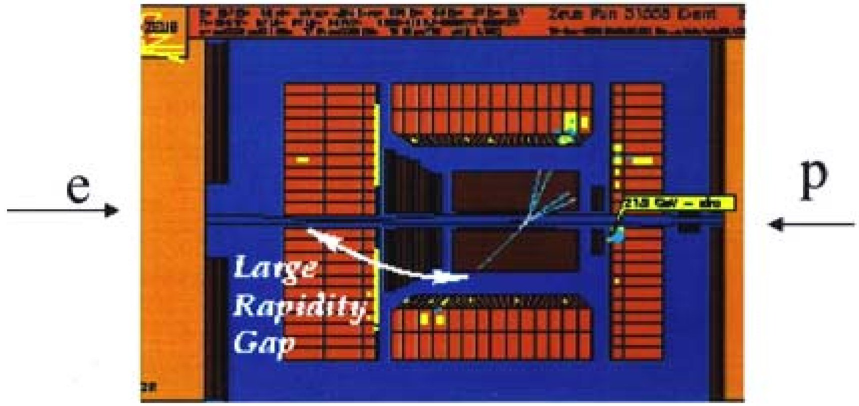
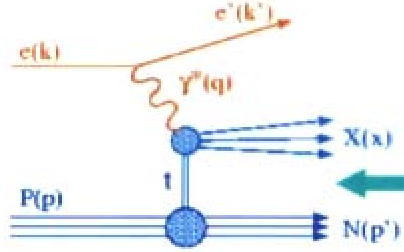
XXXIII International Symposium on
Multiparticle Dynamics
Krakow, Poland
September 5-11, 2003

on behalf of ZEUS

- **Diffractive cross section**
  Q^2 and W dependences
- **Diffractive structure function**
  Q^2 and β dependences

Inclusive diffraction $\gamma^* p \to Xp$

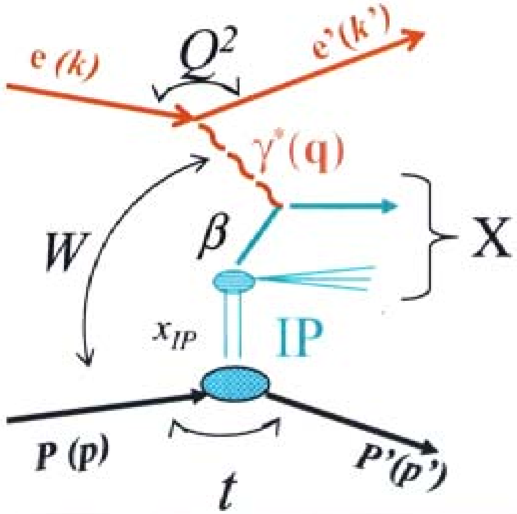




Exchange of color singlet producing a

GAP

in the particle flow



- $\gamma^* p$ cross section

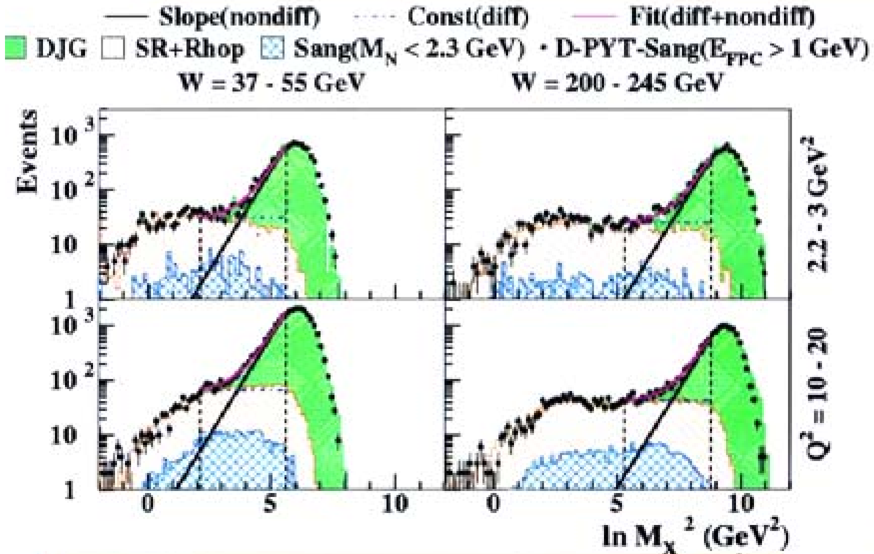
$$\frac{d\sigma^D_{\gamma^* p}}{dM_X} = \frac{\pi Q^2 W}{\alpha(1+(1-y)^2)} \cdot \frac{d^3\sigma_{ep\to e'Xp'}}{dQ^2 dM_X dW}$$

- 3-fold differential diffr. structure function

(assumes $F_L^{D(4)} = 0$)

$$F_2^{D(3)}(\beta, Q^2, x_{IP}, t) = \frac{\beta Q^4}{4\pi\alpha^2(1-y+y^2/2)} \cdot \frac{d\sigma_{ep\to e'Xp'}}{d\beta dQ^2 dx_{IP}}$$

Selection of events $\gamma^* p \rightarrow Xp$ with M_x method



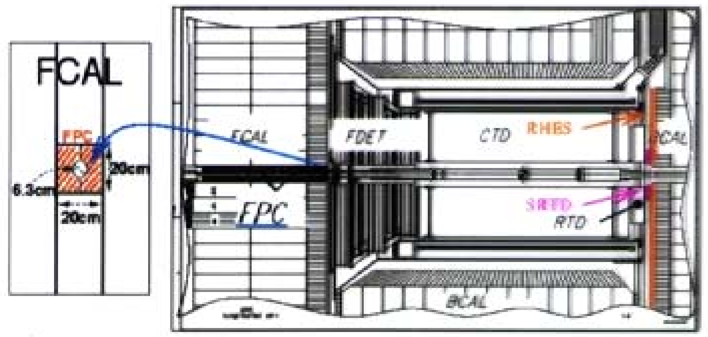
Properties of M_x distribution:

- flat vs ln M_x^2 for diffractive events
- exponentially falling for decreasing M_x for non-diffractive events

Diffr. Non-diffr.

$$\frac{dN}{d\ln M_X^2} = D + c \cdot exp(b \cdot \ln M_X^2)$$

- D, c, b from a fit to data
- contamination from reaction $ep \rightarrow eXN$



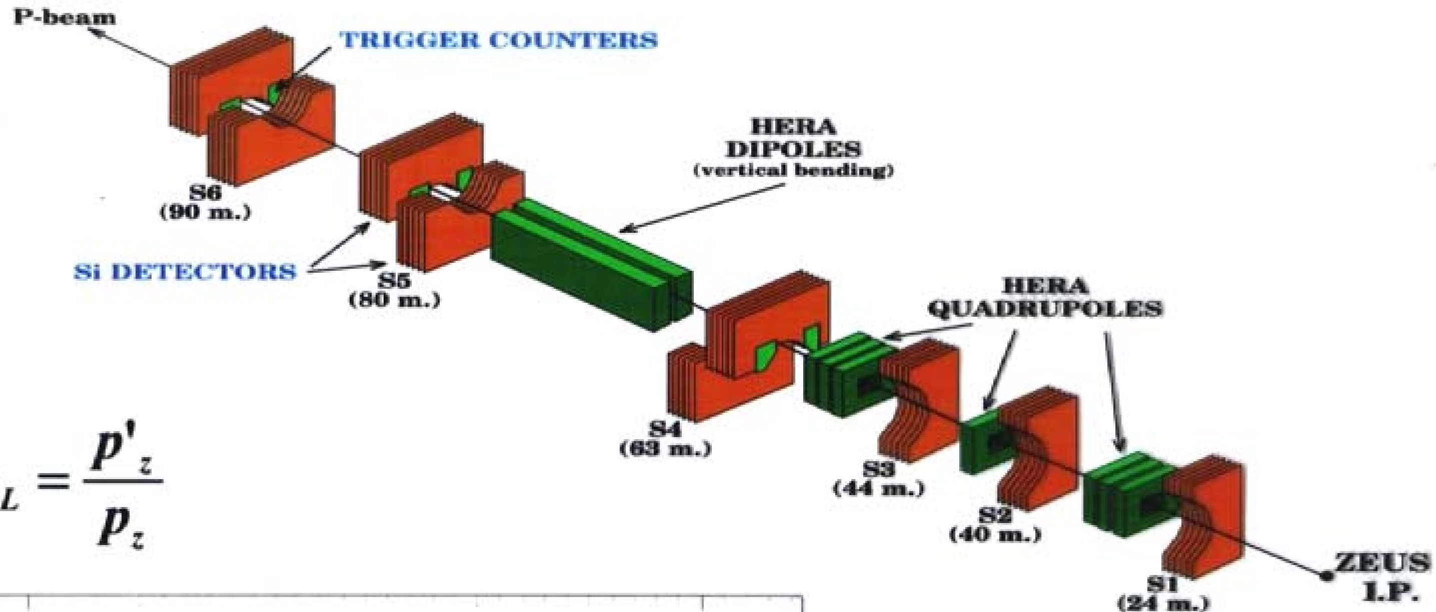
Forward Plug Calorimeter (FPC):

CAL acceptance extended by 1 unit in pseudorapidity from η=4 to η=5

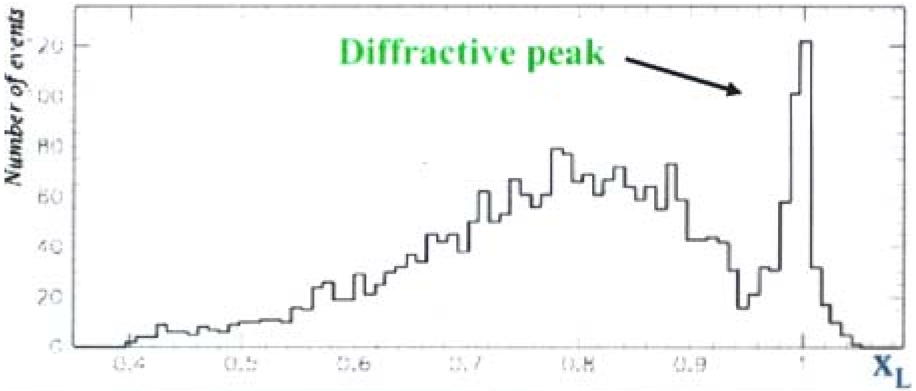
$\rightarrow$ higher M_x and lower W

$\rightarrow$ if $M_N > 2.3$ deposits $E_{FPC} > 1$ GeV recognized and rejected!

Selection of events $\gamma^* p \rightarrow Xp$ with LPS method

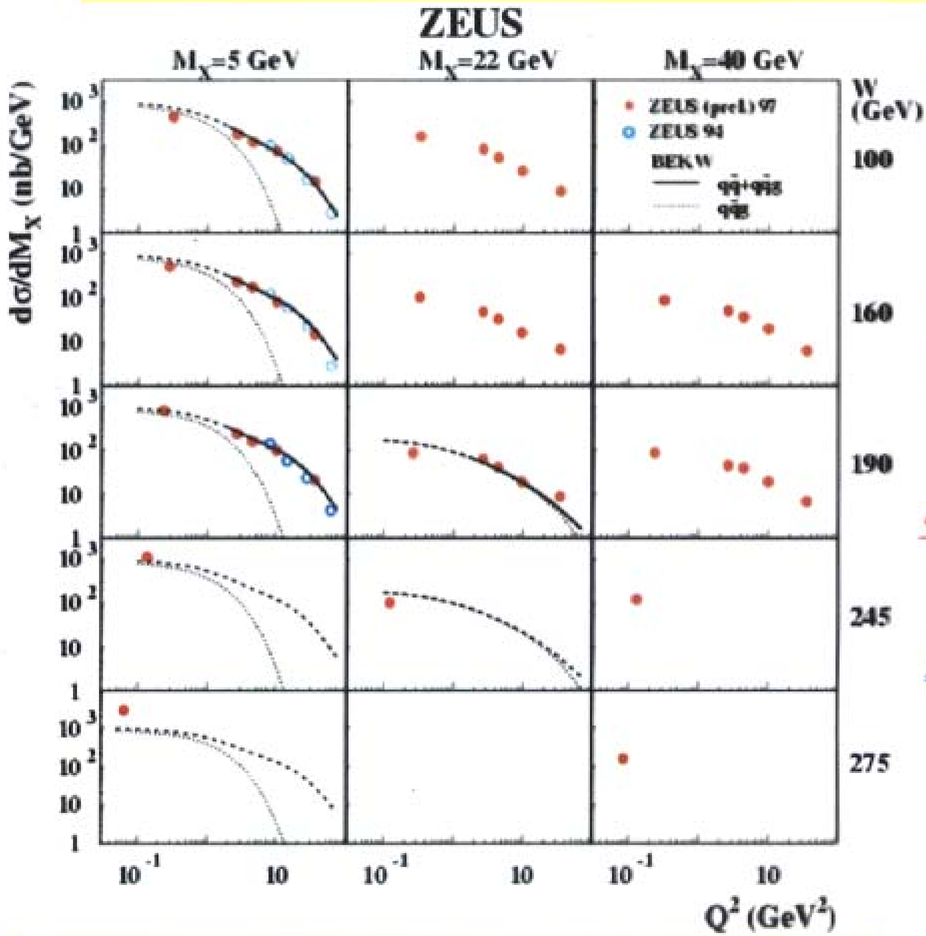


$$x_L = \frac{p'_z}{p_z}$$



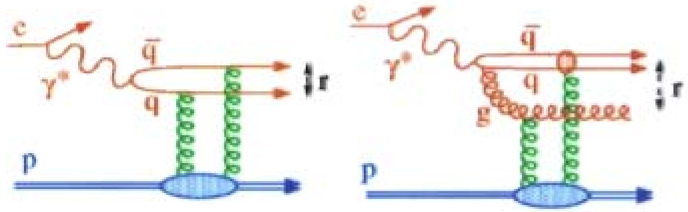
- Measurement of t distribution
- Free of p-diss background
- Low acceptance → low statistics

Cross section Q^2 dependence (LPS method)



Extension to lower Q^2, higher W, higher M_x

- **Transition to a constant cross section as $Q^2 \to 0$**
  (similar to total cross section $\sigma^{\gamma^* p}$)
- **Main features of the data described by BEKW parameterization**
  (Bartels, Ellis, Kowalski and Wüsthoff)

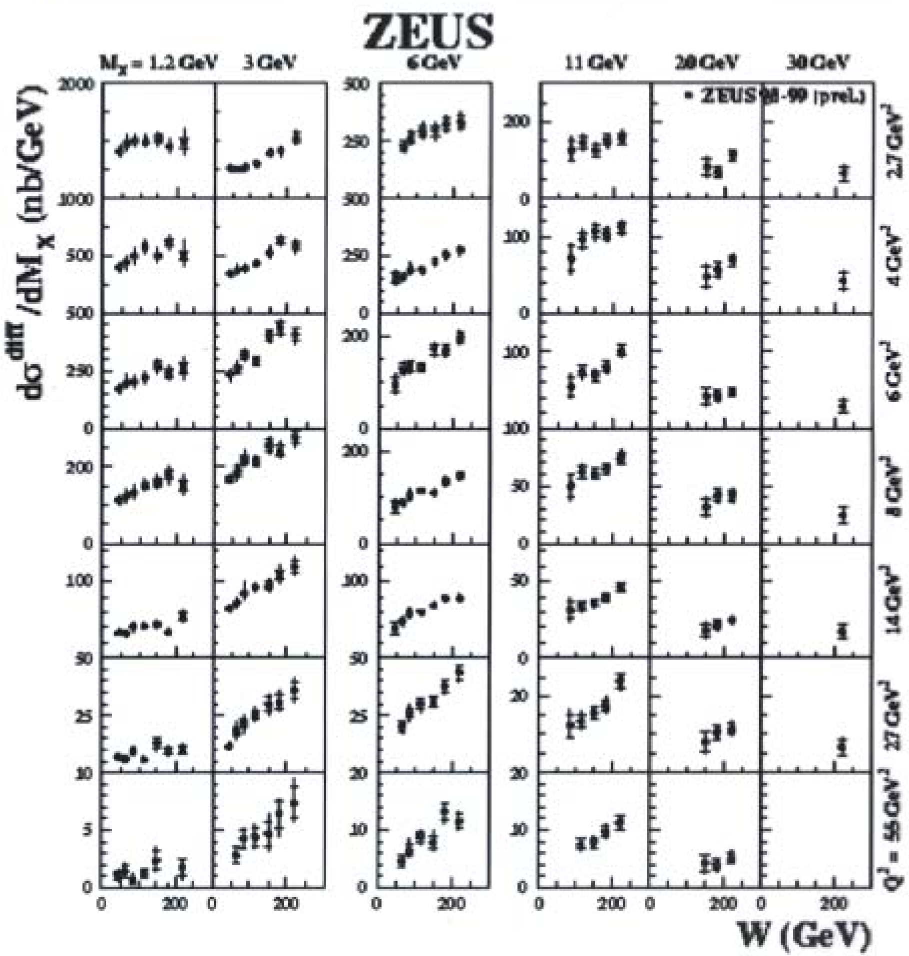


$$F_T^{q\bar{q}} \sim \left(\frac{x_0}{x_{IP}}\right)^{n_T(Q^2)} \beta(1-\beta)$$

$$F_T^{q\bar{q}g} \sim \left(\frac{x_0}{x_{IP}}\right)^{n_g(Q^2)} ln\left(1+\frac{Q^2}{Q_0^2}\right)(1-\beta)^{\gamma}$$

- **qqg fluctuations dominant at low Q^2**

Cross section W dependence (M_x method)



$\gamma^* p \rightarrow XN$ cross section

$$\frac{d\sigma^{diff}_{\gamma^* p \rightarrow XN}(M_X, W, Q^2)}{dM_X} =$$

$$= \frac{\pi Q^2 W}{\alpha(1+(1-y)^2)} \cdot \frac{d^3\sigma^{diff}_{ep}}{dQ^2\, dW\, dM_X}$$

p-dissociation events with M_N<2.3 GeV included

- M_X< 2 GeV: weak W dependence
- M_X> 2 GeV: $d\sigma/dM_X$ rises with W

α_{IP} from diffractive and total $\gamma^* p$ scattering

diffractive cross section:

$$\frac{d\sigma^{diff}}{dM_X^2} \sim (W^2)^{2(\overline{\alpha_{IP}^{diff}(t)}-1)}$$

$\alpha_{IP}^{diff}(0)$ form fit to data

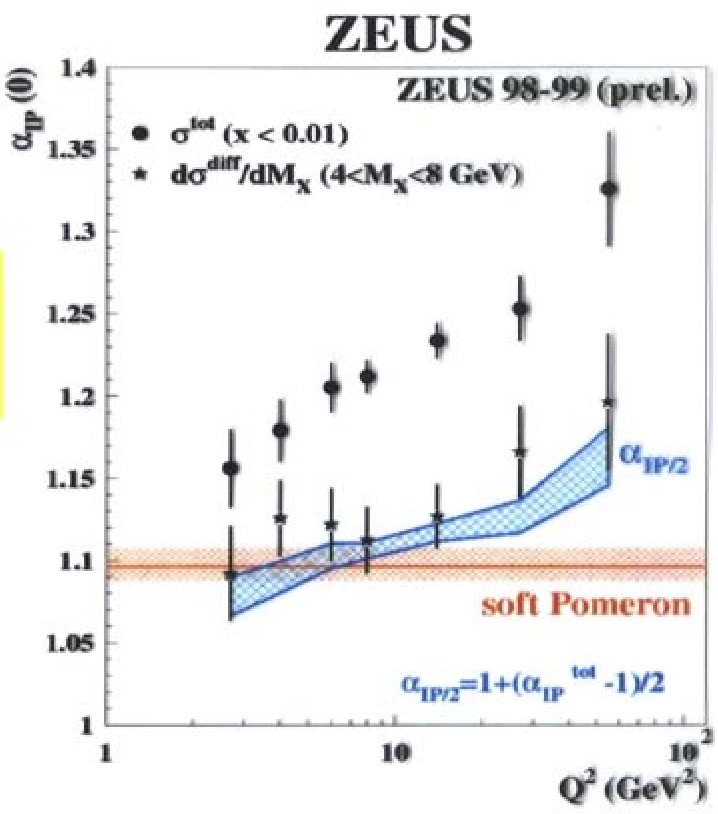
- value of α_{IP}^{diff} higher than soft Pomeron
- indication of a rise of α_{IP}^{diff} with Q^2

total cross section:

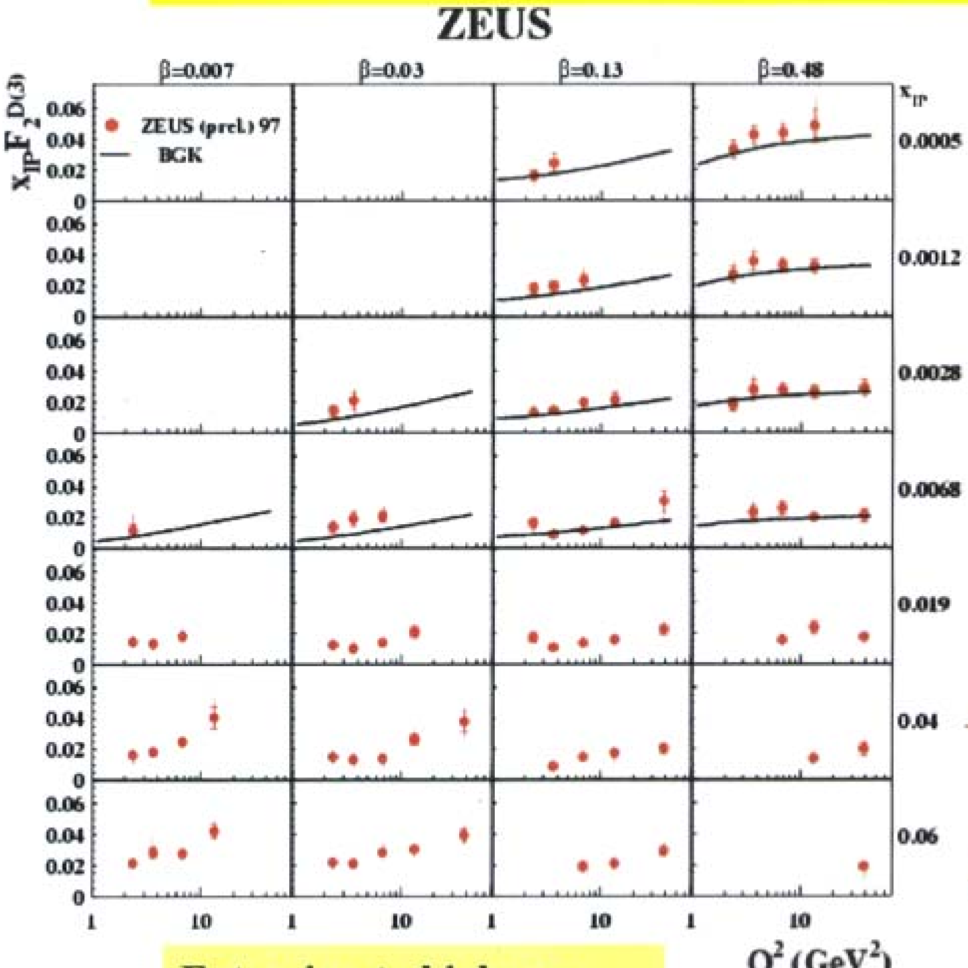
$$\sigma_{tot}^{\gamma^* p} = \frac{4\pi\alpha}{Q^2} F_2(x, Q^2) \sim$$

$$\sim \frac{1}{W^2} Im T_{\gamma^* p \to \gamma^* p}(W^2, t=0) \sim (W^2)^{\alpha_{IP}^{tot}(0)-1}$$

Data ($4<M_X<8$ GeV) consistent with the same W-dependence for the diffractive and the total cross section: $\alpha_{IP}^{diff} \sim 1 + (\alpha_{IP}^{tot} - 1)/2$

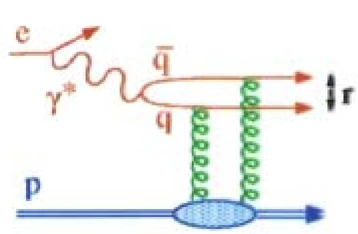


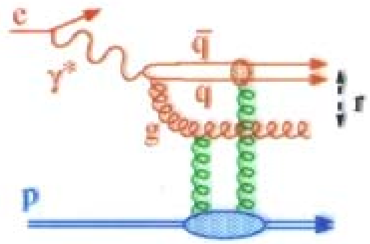
$F_2^{D(3)}$ Q^2 dependence (LPS method)



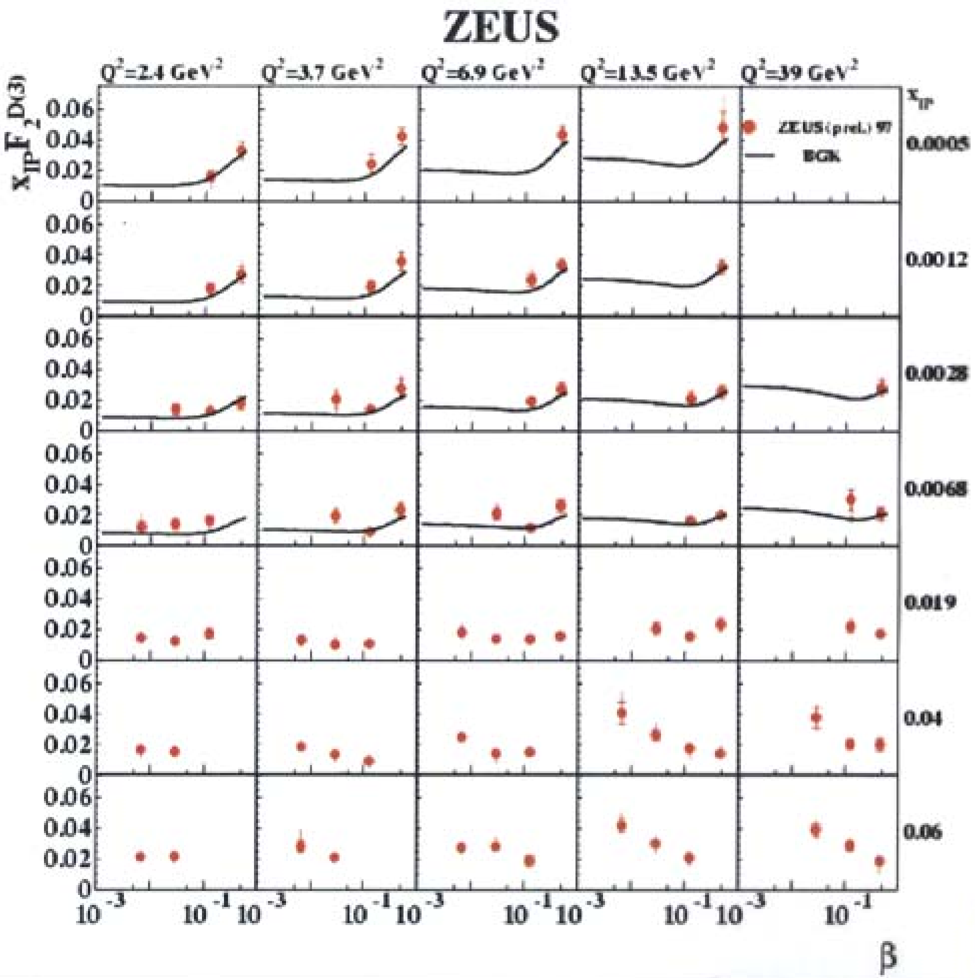
Extension to higher x_{IP}

- **Positive scaling violation at all values of x_{IP}**
- $F_2^{D(3)} \propto Q^2$ **at low Q^2**
- **Data well described by BGK saturation model**





$F_2^{D(3)}$ β dependence (LPS method)

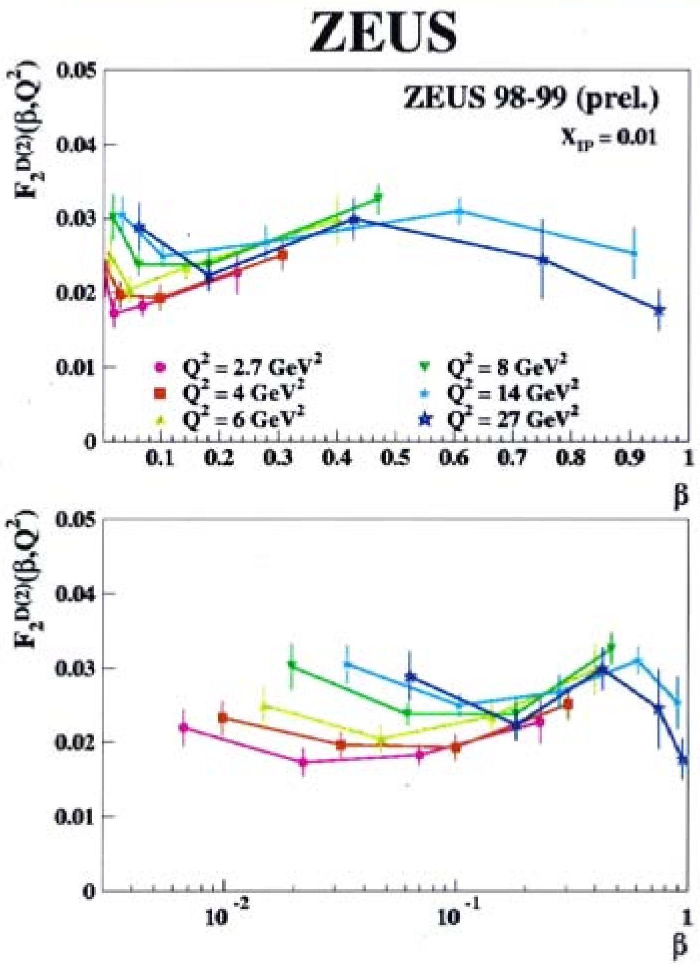


- Different β dependences in diffractive and non-dffractive regions

- Data well described by BGK saturation model

Extension to higher x_{IP}

$F_2^{D(3)}$ at fixed x_{IP} (M_X method)



$$F_2^{D(2)}(\beta, Q^2) = x_{IP} F_2^{D(3)}(x_{IP}, \beta, Q^2)|_{x_{IP}=x_0}$$

- Maximum near β=0.5 consistent with a β(1- β) behaviour suggesting main contribution from a quark antiquark state

- For high β $F_2^{D(2)}$ decrease with rising Q^2

- As $\beta \rightarrow 0$ $F_2^{D(2)}$ rises. The rise becomes more strong as Q^2 increases.

⇨ **Evidence for pQCD evolution**

Summary and outlook

- Recent data from ZEUS with improved precision and extended kinematic range

  - Q^2 dependence of the diffractive cross section softens for $Q^2 \to 0$

  - W dependence of diffractive and total cross section similar at high Q^2

  - data described by dipole models (BEKW, saturation)

- New data in the high x_{IP} region:

  - scaling violations of $F_2^{D(3)}$ at all x_{IP}

  - different β dependences of $F_2^{D(3)}$ at low x_{IP} and high x_{IP}

- Indication for α_{IP} to rise with Q^2 in diffraction

- $F_2^{D(2)}$ pQCD like evolution with β and Q^2