Rencontres de Moriond 1997

Diffraction at HERA

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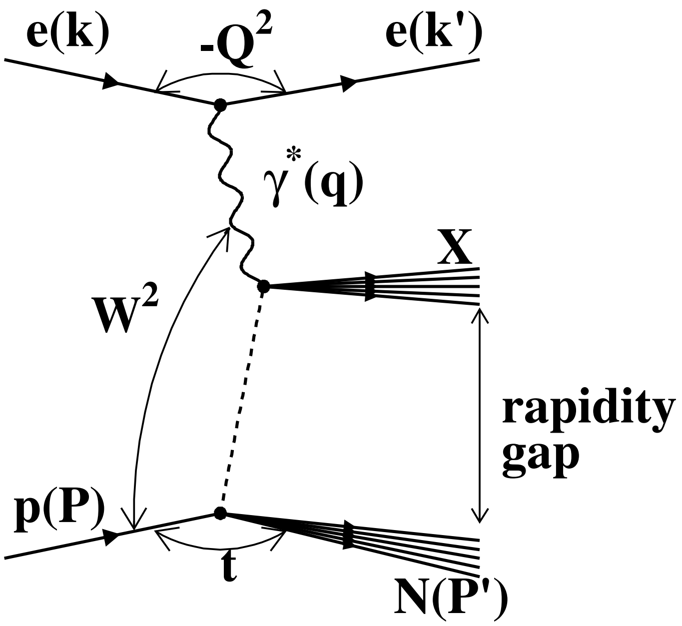
(DESY)

for the H1 and ZEUS Collaborations

Topics:

- diffractive dissociation in photoproduction
- diffractive dissociation in DIS
- diffractive di-jet-production

Diffractive Dissociation



$ep \to eXN$, $N = p$ or higher mass state

consider only pure $I\!P$-exchange as diffractive

meson-exchange: part of non-diffraction

Momentum transfer at the electron vertex:

$Q^2 = -q^2 = (k - k')^2$.

γp-CMS-energy: $W^2 = (q + P)^2$.

Momentum transfer at the proton vertex:

$t = (P - P')^2 = (q - V)^2$.

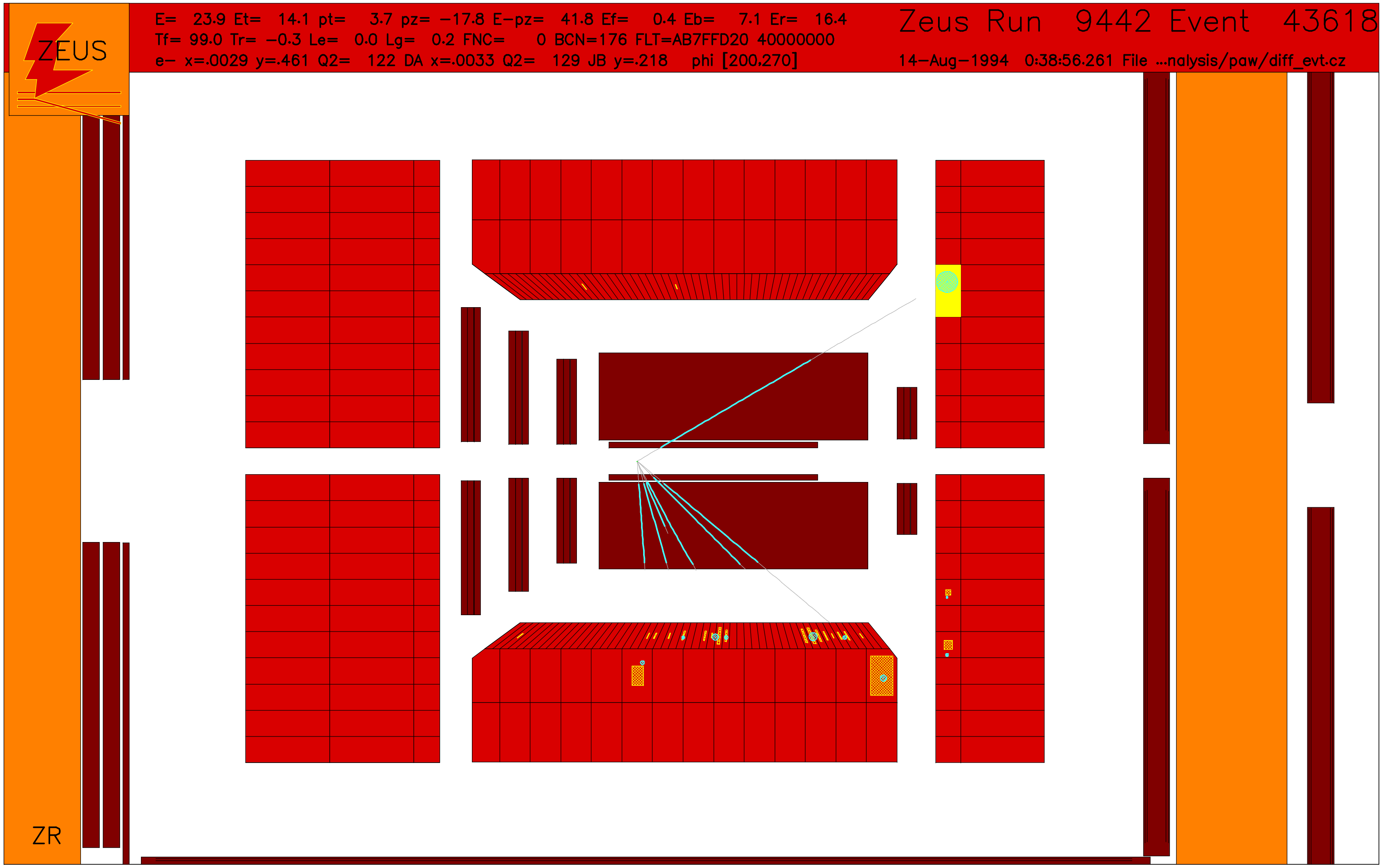
Momentum carried by the Pomeron (for $I\!P$-exch.):

$x_{I\!P} = \frac{(P-P')q}{Pq} \approx \frac{M_X^2+Q^2}{W^2+Q^2}$.

Momentum of the struck quark in $I\!P$ (for $I\!P$-exch.):

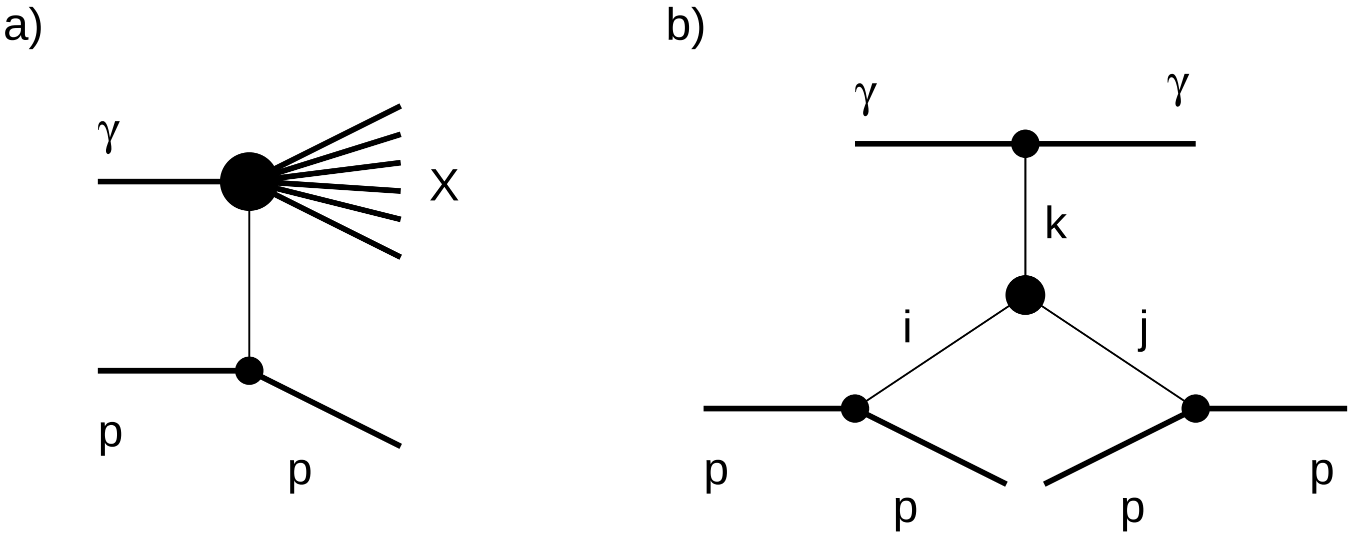
$\beta = \frac{Q^2}{2x_{I\!P}\ Pq} \approx \frac{Q^2}{M_X^2+Q^2}$.

Event-picture



Dissociation in Photoproduction

Use relation $\gamma p \to Xp$ to $\gamma pp \to \gamma pp$,



with i,j,k either $\mathbb{P}$ or $\mathbb{R}$.

Pure $\mathbb{P}\mathbb{P}\mathbb{P}$ yields (for a fixed W value):

$$\frac{\mathrm{d}\sigma_{diff}}{\mathrm{d}M_X} \sim \left(\frac{1}{M_X^2}\right)^{\alpha_{\mathbb{P}}(0)} \frac{1}{b_0 + 2\alpha'_{\mathbb{P}} \ln(W^2/M_X^2)}$$

Expect for a soft Pomeron: $\alpha_{\mathbb{P}}(0) = 1.08.$

$\alpha'_{\mathbb{P}} = 0.25\ \mathrm{GeV}^2$

b_0: "offset" in t-slope $\to$ low energy fits

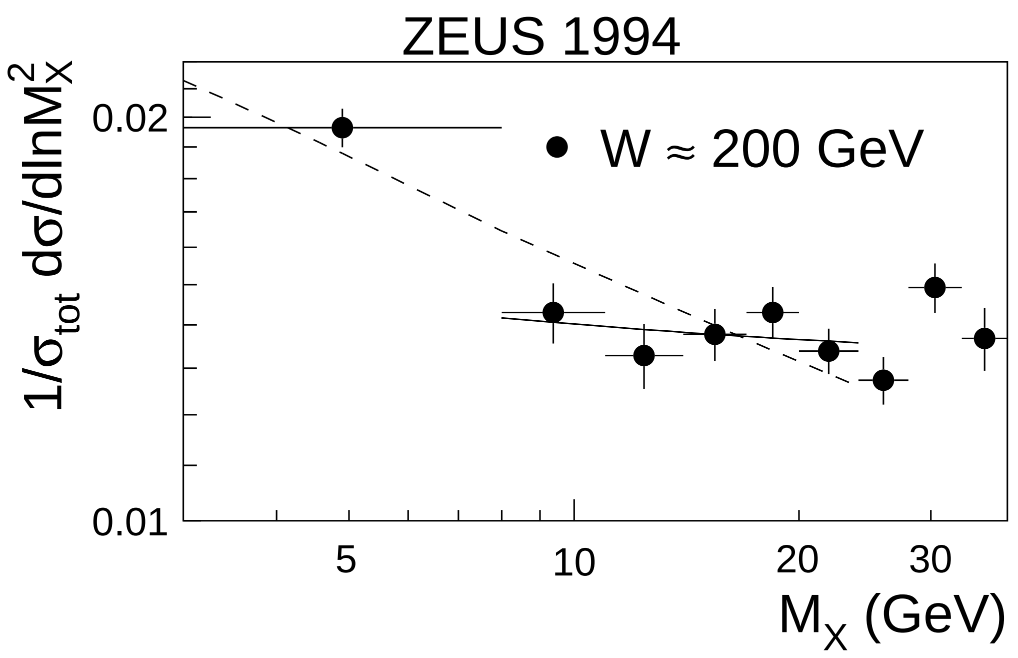
Dissociation in Photoproduction - ZEUS

Selection criteria:

- scattered electron in LUMIE detector
- rapidity gap by rejecting events with tag in the "proton remnant tagger" $(4.3 < \eta < 5.8)$
- subtract remaining non-diffractive contribution

Determine mass of system X using calorimeter information:

$$M_X^2 = 2E_\gamma\,(E + P_Z)$$



Fit with $\mathbb{P}\mathbb{P}\mathbb{P}$ exchange for $8 < M_X < 24\,\mathrm{GeV}$ yields

$$\text{ZEUS 94: } \alpha_{\mathbb{P}}(0) = 1.12 \pm 0.04 \pm 0.08$$

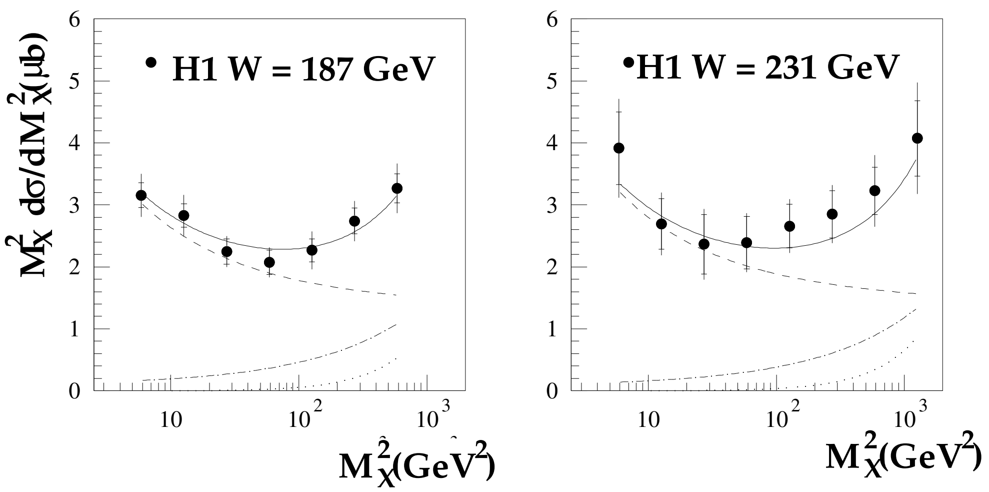
in good agreement with a soft Pomeron.

Dissociation in Photoproduction - H1

Selection criteria:

- scattered electron in eTag detector
- rapidity gap using the edge of the calorimeter, the "proton remnant tagger" and forward muon chamber ($3.2 \lesssim \eta \lesssim 7.0$)

Determine mass of system X with combined information of calorimeter and tracking.



Fit with combination of $\mathbb{P}\mathbb{P}\mathbb{P}$, $\mathbb{P}\mathbb{P}\mathbb{R}$ and non-diffractive behaviour yields

H1 94: $\alpha_{\mathbb{P}}(0) = 1.068 \pm 0.016 \pm 0.022 \pm 0.041$

in good agreement with a soft Pomeron.

Dissociation in DIS

Method 1:

Analysing the diffractive structure function

$$\frac{\mathrm{d}^3\sigma_{diff}}{\mathrm{d}Q^2\mathrm{d}\beta\mathrm{d}x_{\mathbb{P}}} = \frac{2\pi\alpha^2}{\beta Q^2}(1+(1-y)^2)\mathrm{F}_2^{\mathrm{D}(3)}(Q^2,\beta,x_{\mathbb{P}})$$

Assuming universal Pomeron exchange:

$$\mathrm{F}_2^{\mathrm{D}(3)}(Q^2,\beta,x_{\mathbb{P}}) \to \left(\frac{1}{x_{\mathbb{P}}}\right)^a \mathrm{F}_2^{\mathbb{P}}(Q^2,\beta)$$

with $a = 2\overline{\alpha_{\mathbb{P}}} - 1$ (averaged over t).

Method 2:

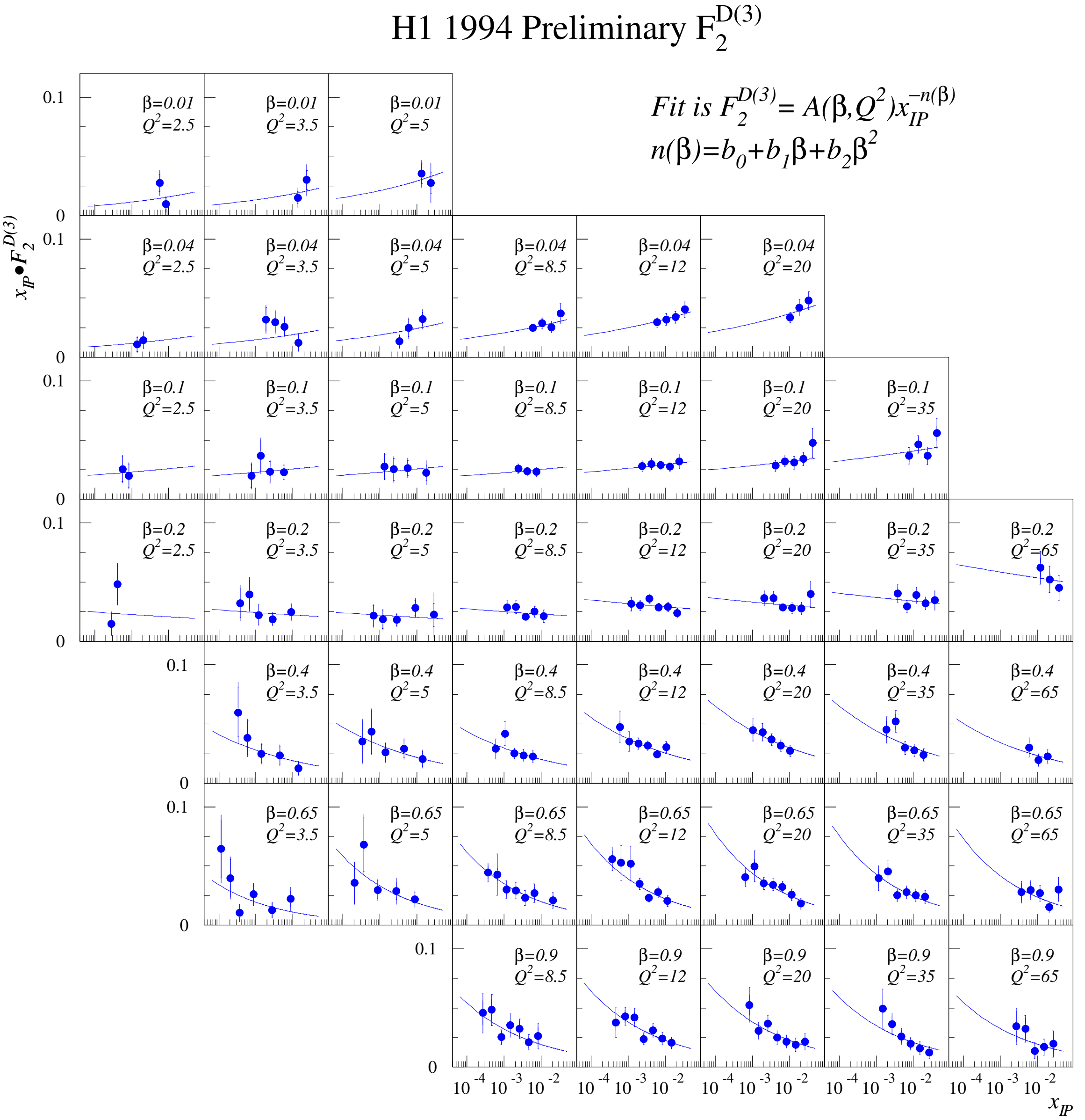
Analysing the M_X distribution

$$\frac{\mathrm{d}\sigma_{diff}}{\mathrm{d}M_X} \sim (W^2)^{(2\overline{\alpha_{\mathbb{P}}}-2)}$$

($\overline{\alpha_{\mathbb{P}}}$ again averaged over t).

Correction for the averaging over t yields $\alpha_{\mathbb{P}}(0)$ in both cases.

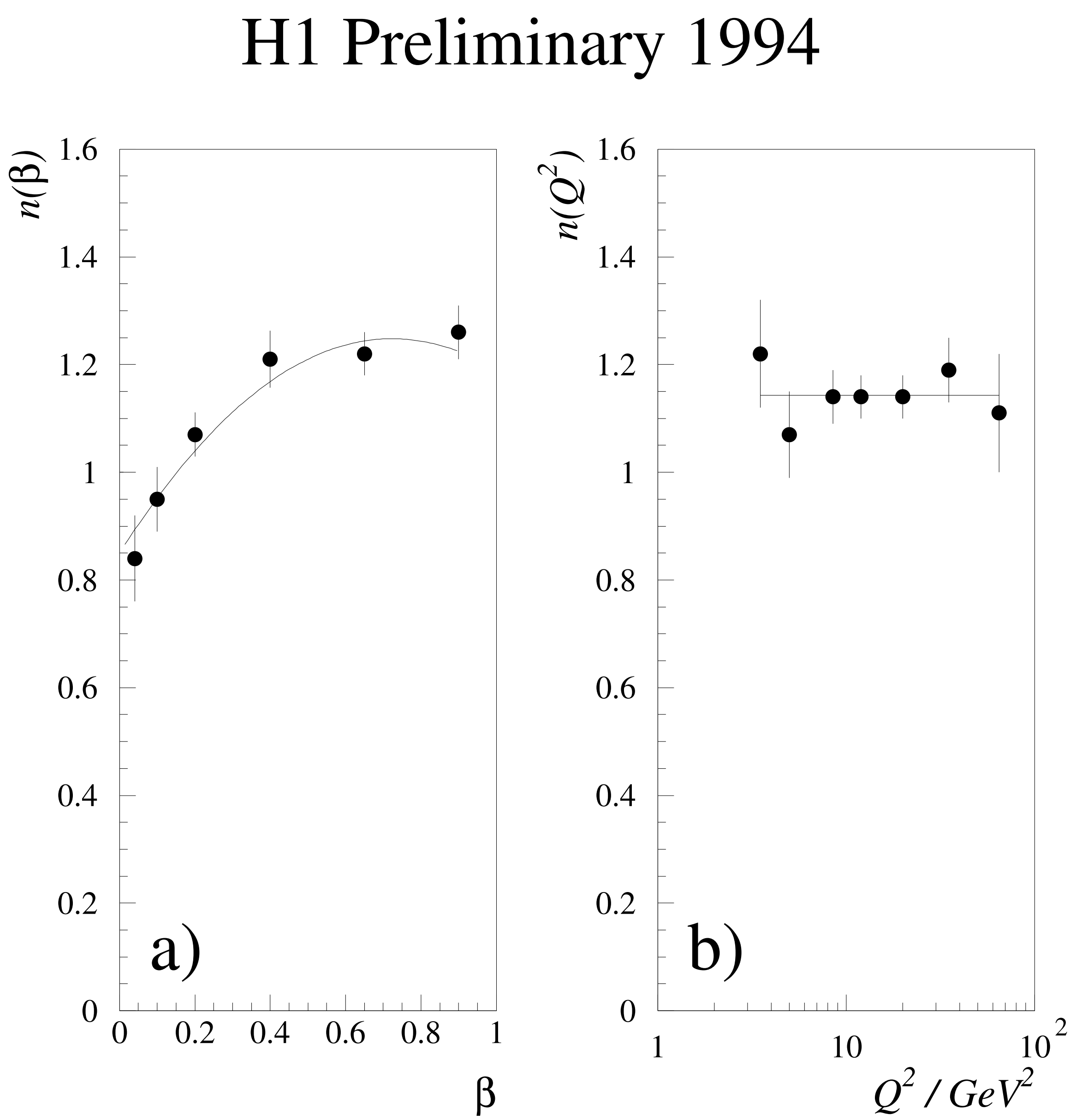
Dissociation in DIS - H1



Fit:

$$F_2^{D(3)} = \left(\frac{1}{x_{\mathbb{P}}}\right)^a F_2^{\mathbb{P}}(Q^2,\beta);\ a = a_0 + a_1\beta + a_2\beta^2$$

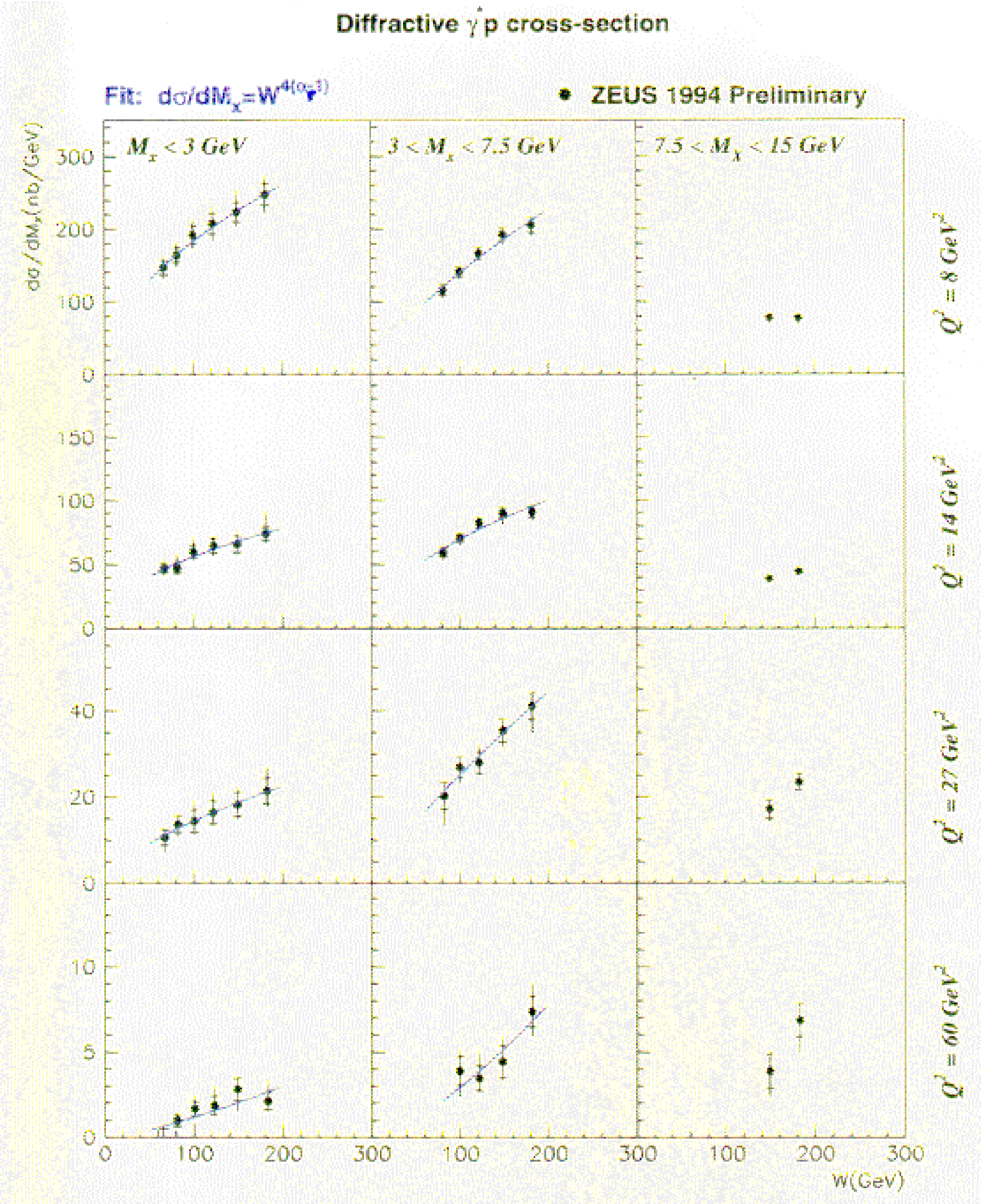
Dissociation in DIS - H1 (contd.)

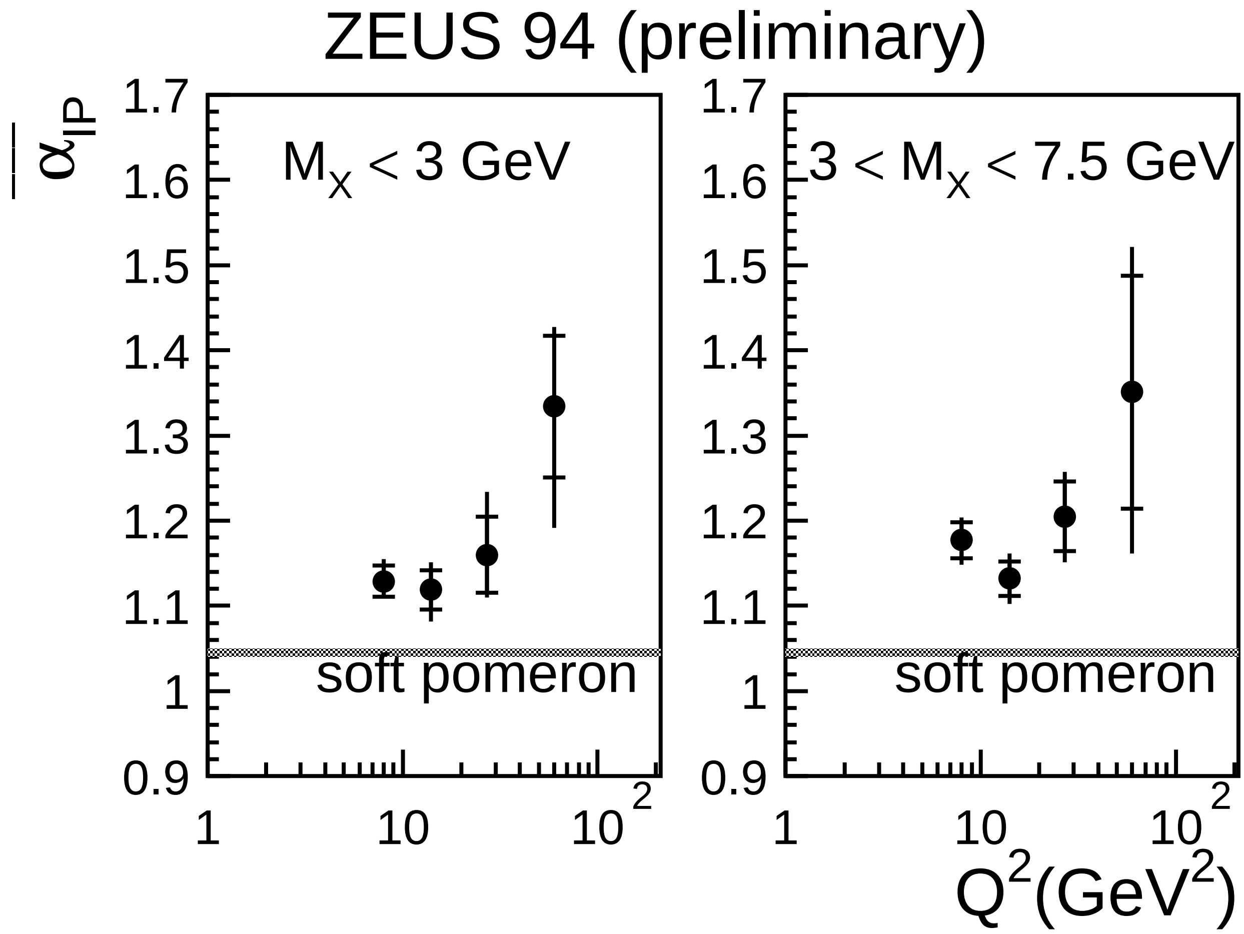


β-dependence of a, i.e. no factorization $\rightarrow$ replace $\left(\frac{1}{x_{I\!P}}\right)^a F_2^{I\!P}$ behaviour by $\left(\frac{1}{x_{I\!P}}\right)^a F_2^{I\!P} + \left(\frac{1}{x_{I\!P}}\right)^n F_2^M$ to account for non-Pomeron exchange.

Result: $\alpha_{I\!P}(0) = 1.18 \pm 0.02 \pm 0.04$.

Dissociation in DIS - ZEUS

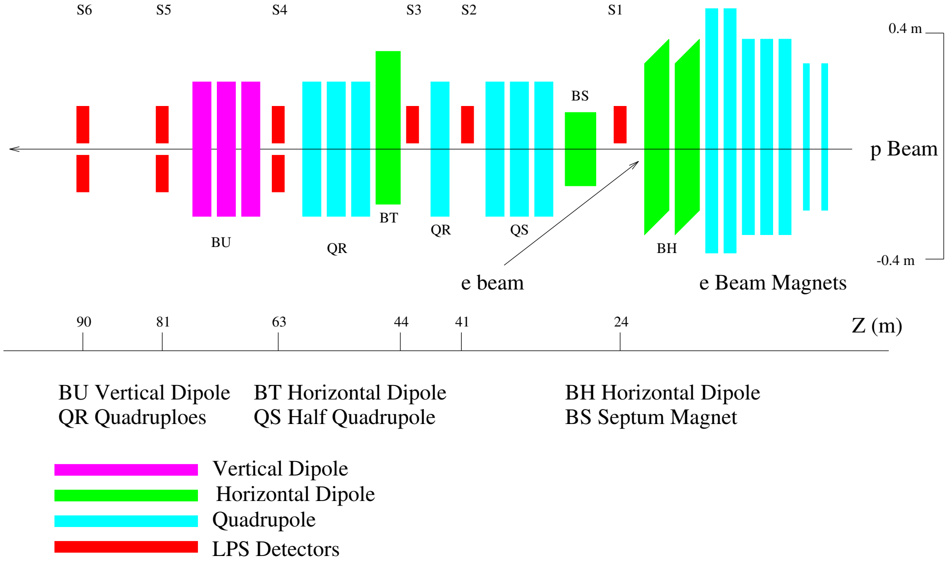




ZEUS diffractive cross sections are not compatible with the Donnachie-Landshoff Soft $\mathbb{P}$omeron

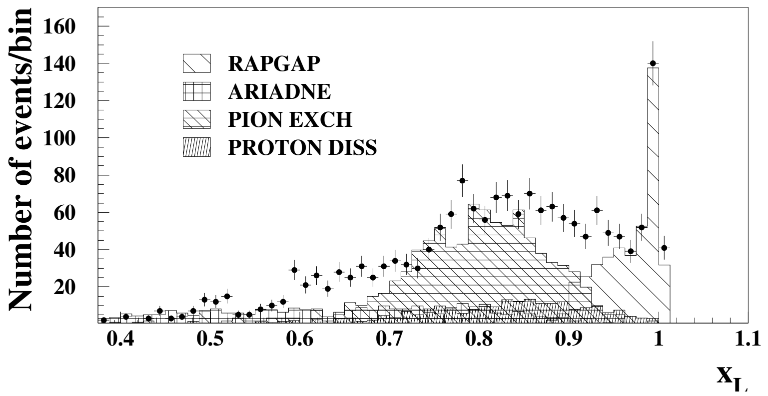
there is a tendency for $\alpha_{\mathbb{P}}$ to grow with Q^2(GeV) (more data needed)

Leading p in DIS Dissociation



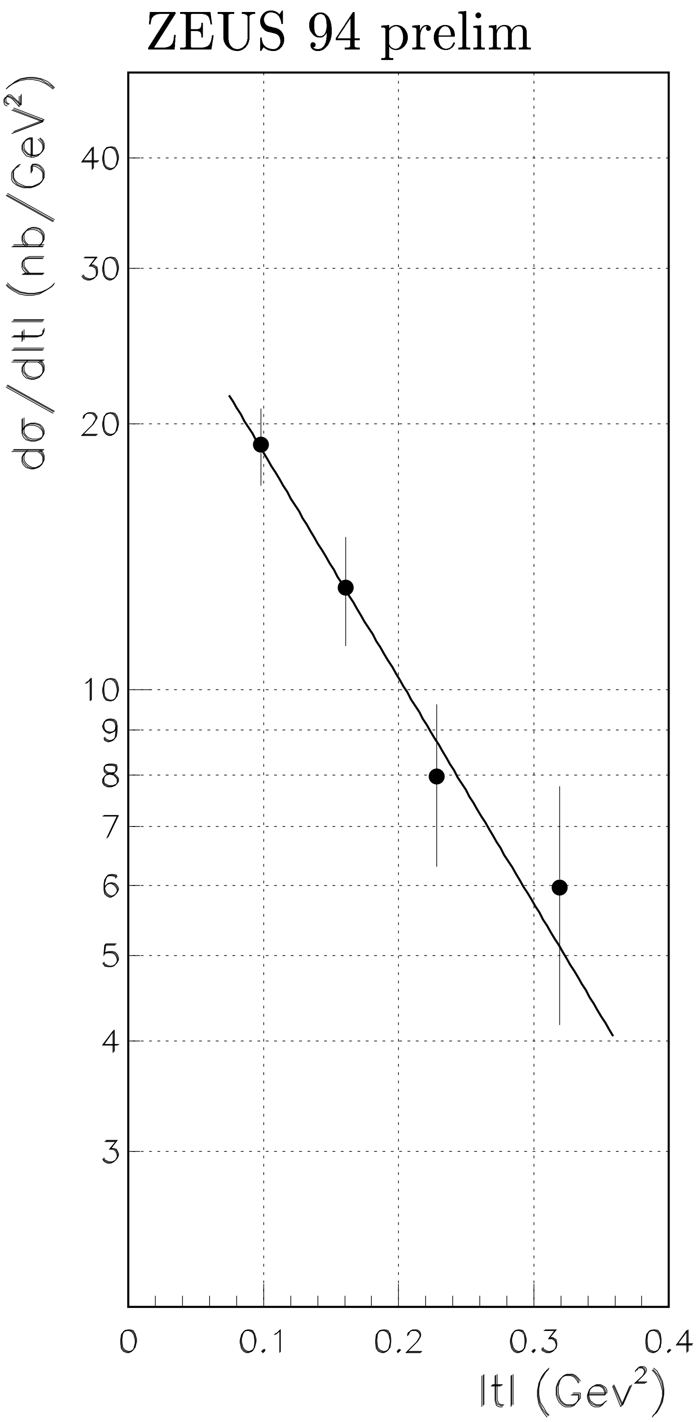
$x_L = 1 - x_{I\!P}$, fraction of the p-beam momentum

Observed x_L distribution (dots) compared to single dissociation diffractive MC and MC models for the lower x_L processes.



$\boxed{\textbf{Isolate diffractive peak } 0.97 < x_L < 1.02}$

Leading p in DIS Dissociation (contd.)



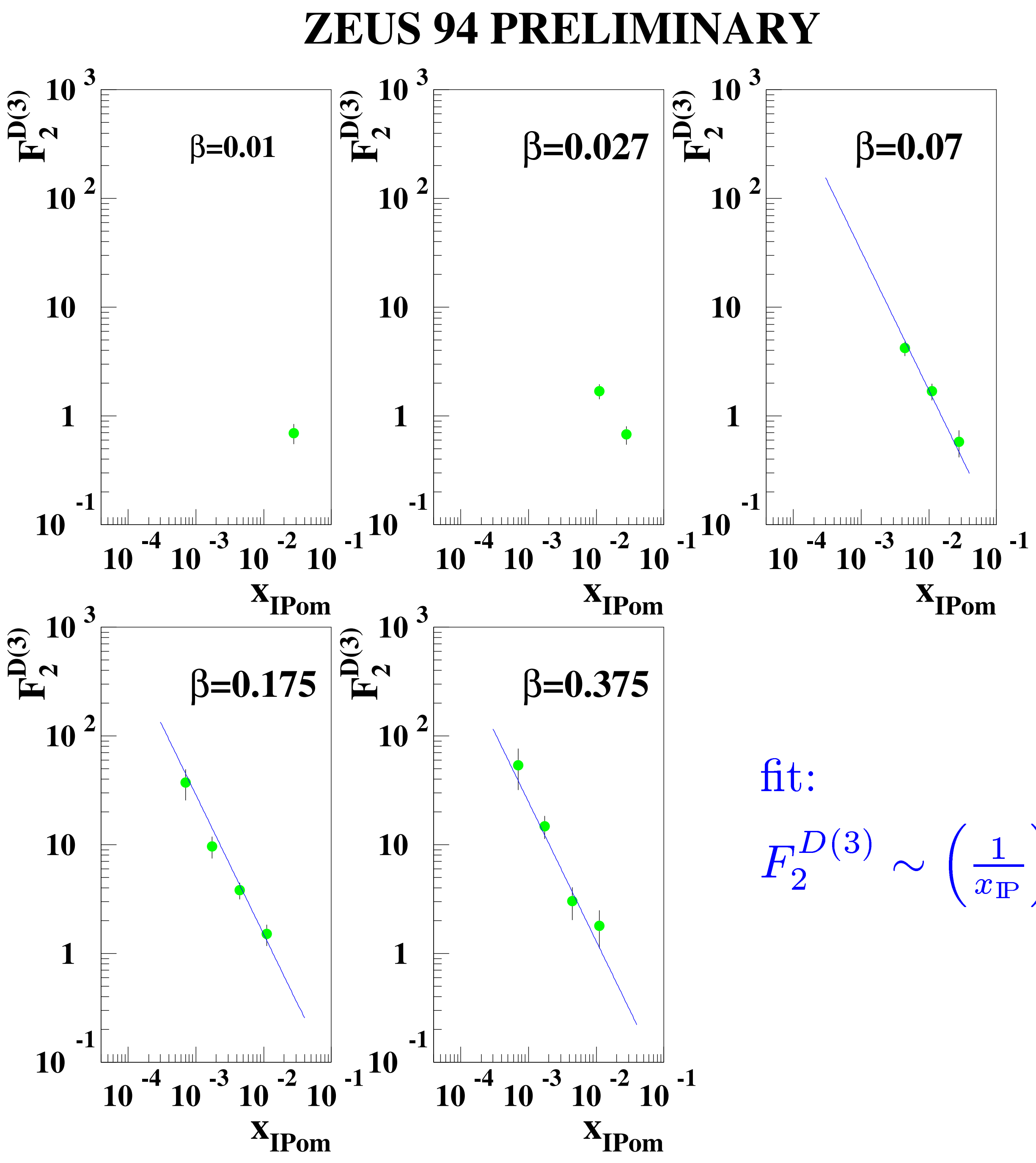
Fit to:

$d\sigma/d|t| = A \exp(-b|t|)$

$b = (5.9 \pm 1.3\ ^{+1.1}_{-0.7})\ \mathrm{GeV}^{-2}$

$0.97 < x_L < 1.02$
$0.02 < \beta < 0.4$
$70 < W < 210\ \mathrm{GeV}$
$4 < Q^2 < 30\ \mathrm{GeV}^2$
$0.07 < |t| < 0.36\ \mathrm{GeV}^2$

First measurement of t in DIS diffraction.



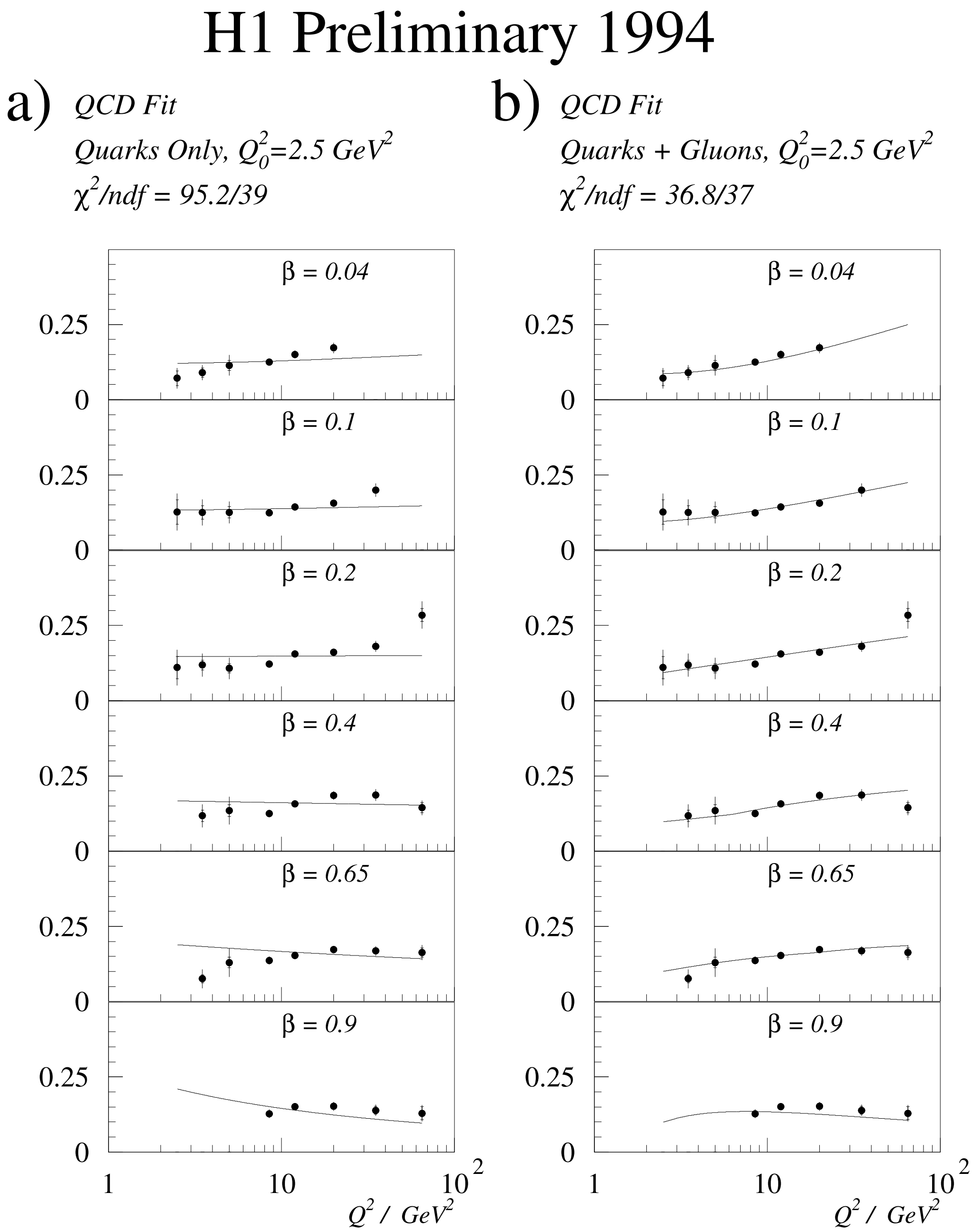
fit:

$$F_2^{D(3)} \sim \left(\frac{1}{x_{\mathbb{P}}}\right)^a$$

Fit yields $\overline{\alpha_{\mathbb{P}}} = 1.14 \pm 0.04 \pm 0.08$

QCD Fits to the Structure Function

integrate $F_2^{D(3)}(t > -1\ \text{GeV})$ over $x_{\mathbb{P}}$, $3 \cdot 10^{-4} < x_{\mathbb{P}} < 0.05$

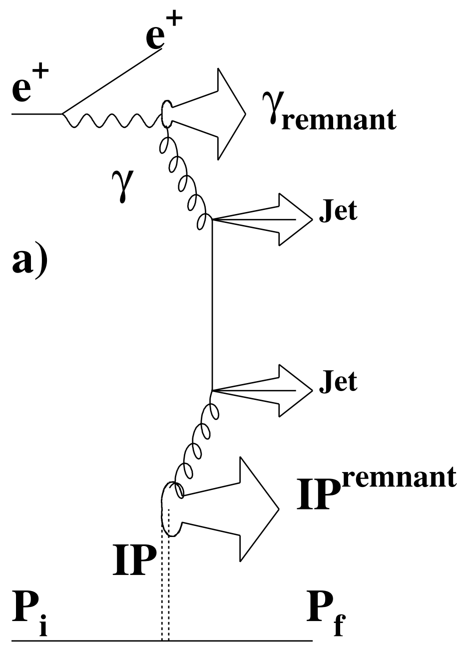


$\int F_2^{D(3)} dx_{\mathbb{P}}$ is related to partonic structure. Scaling violation $\rightarrow$ gluon content; supported by QCD fits. 80% of the momentum is carried by the gluons.

Diffractive Di-jet Production

Analysis of the reaction

$$ep \to \text{jet} + \text{jet} + eX$$



to get access to partonic structure of the Pomeron.

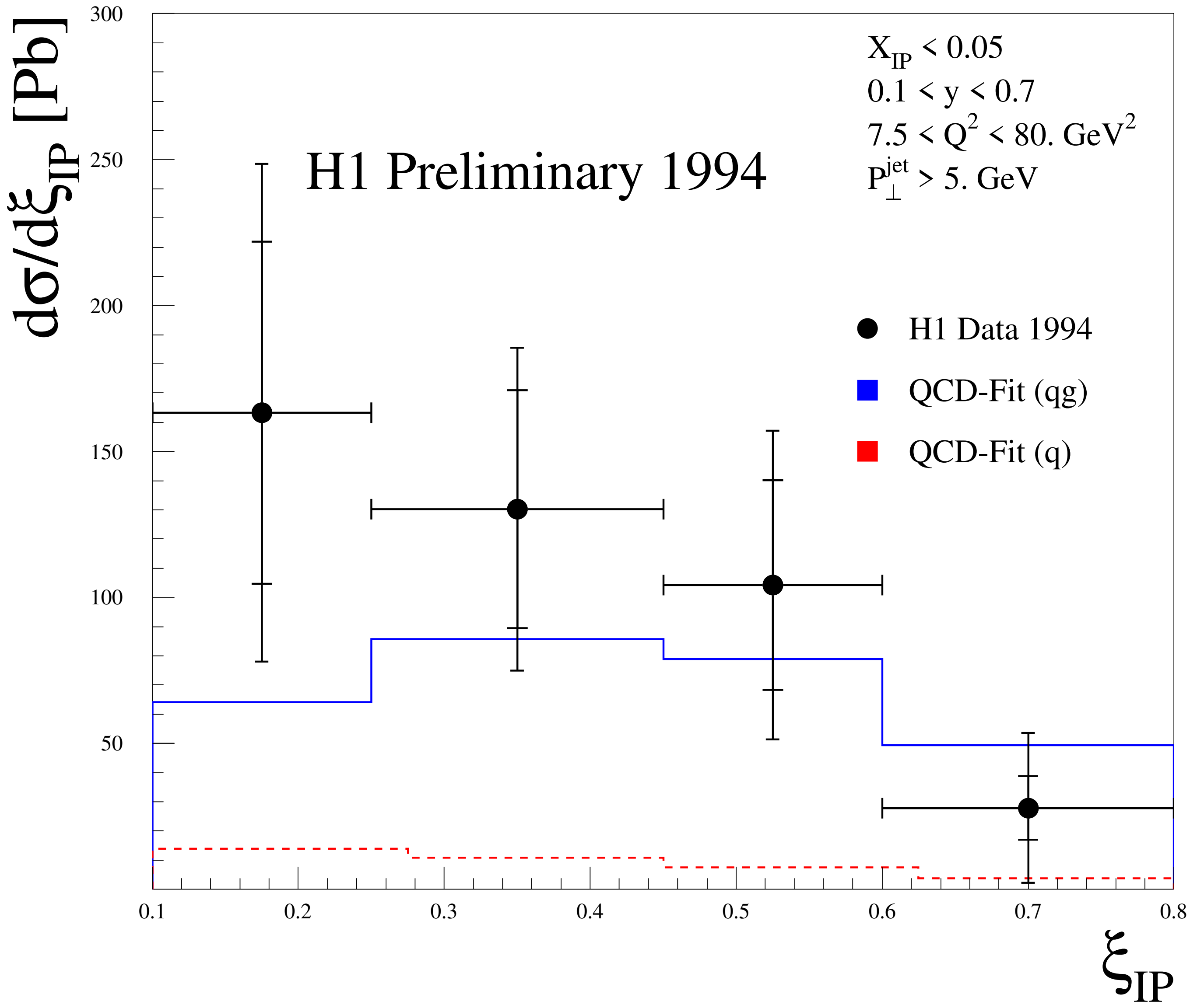
use CONE algorithm for jet identification.

Diffractive Di-jet Production in DIS

define

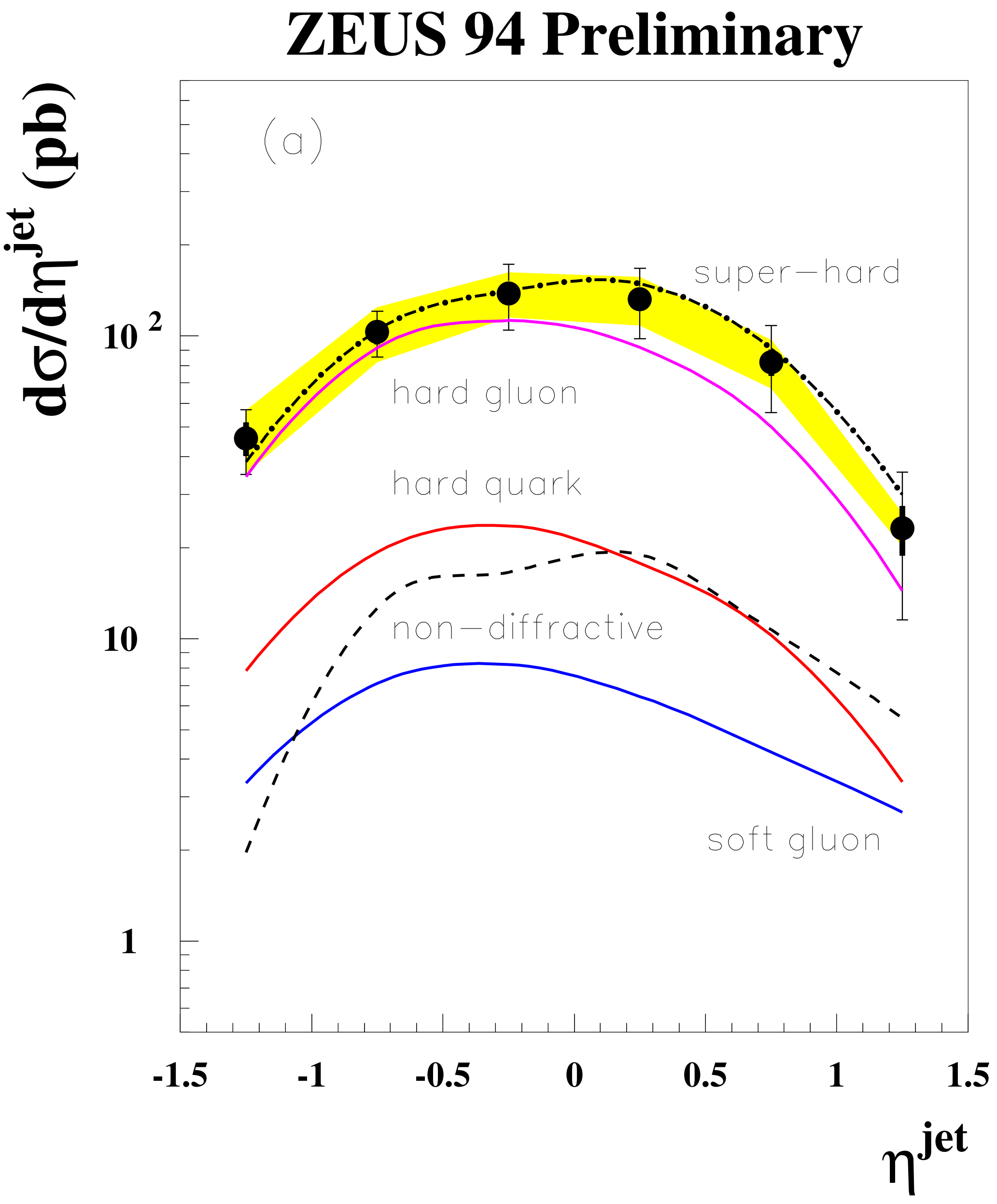
$$\xi_{\mathbb{P}} = \frac{Q^2 + M_{jj}^2}{Q^2 + M_X^2}$$

(frac. momentum of diff. exch. enetering hard scatt.)



Cross section requires hard gluon content in the Pomeron.

Diffractive Di-jet Production in Php.



Cross section requires hard gluon content in the Pomeron.

Summary

Diffraction at HERA was presented by means of diffractive dissociation and di-jet production, both in photoproduction and DIS.

- cross section behaviour:

  photoproduction: Pomeron intercept in agreement with results from hadronic cross sections

  DIS: factorization breaking seen by H1
  ZEUS finds a tendency of $\alpha_{I\!P}$ to grom with Q^2,
  $\alpha_{I\!P}$ larger than soft Pomeron expectation

- t distribution

  is exponential as expected for a diffractive process

- partonic structure:

  diffractive structure function in DIS as well as the di-jet production in photoproduction and DIS require a dominant hard gluon content