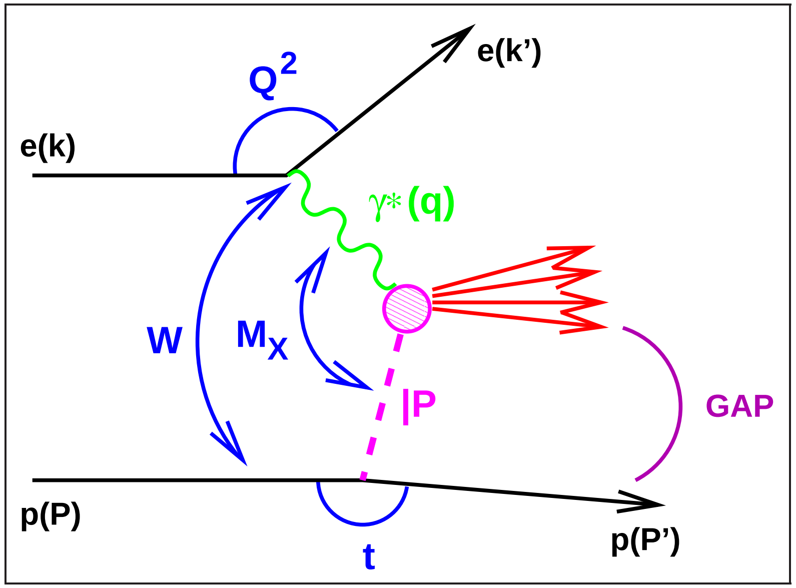
Measurement of the Diffractive Cross Section in eP Interactions at Low Q^2

Antonio Pellegrino
Argonne National Laboratory

- analyses and data samples
- energy dependence of the diffractive cross section at low Q^2
- Q^2 dependence of the diffractive cross section from low Q^2 to the DIS regime
- comparison between the energy and Q^2 dependence of the diffractive and the total cross section (ratio plots)

Diffractive Kinematics and Cross Sections



$$M_X^2 = (q + P - P')^2$$
$$Q^2 = -q^2$$
$$W^2 = (q + p)^2$$
$$t = (P - P')^2$$

$$\frac{d^4\sigma_{ep}^{\text{diff}}}{d\ln Q^2 d\ln W\, dM_X\, dt} = \frac{\alpha}{\pi}\left[1 + (1-y)^2\right]\frac{d\sigma_{\gamma^* p}^{\text{diff}}}{dM_X dt}$$

In analogy with the quark-parton picture of DIS:

$\mathbb{P}$-momentum fraction carried by struck parton

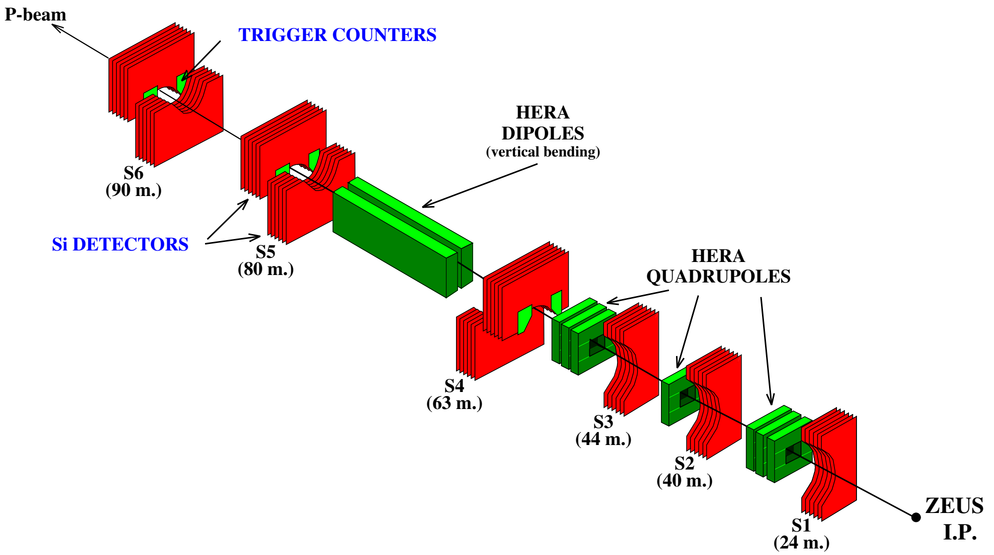
$$\beta \equiv \frac{Q^2}{2\,(P-P')\,q} = \frac{Q^2}{Q^2 + M_X^2 - t}$$

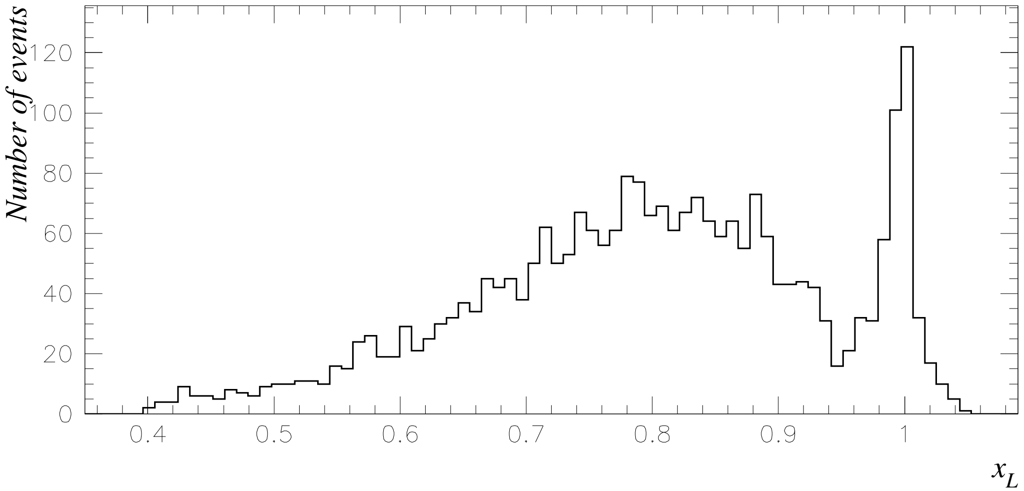
P-momentum fraction carried by $\mathbb{P}$

$$x_{\mathbb{P}} \equiv \frac{x_{BJ}}{\beta} = \frac{(P-P')\,q}{p\,q}$$

$$\frac{d^4\sigma_{ep}^{\text{diff}}}{d\beta dQ^2 dx_{\mathbb{P}} dt} = \frac{2\pi\alpha^2}{\beta Q^4}\left\{1 + (1-y)^2 - y^2\frac{R^{D(4)}}{1+R^{D(4)}}\right\} F_2^{D(4)}(\beta, Q^2, x_{\mathbb{P}}, t)$$

Analysis with the ZEUS Leading Proton Spectrometer





$0.14 < Q^2 < 50$ GeV^2

$80 < W < 250$ GeV

$3.0 < M_X < 33$ GeV

$0.073 < t < 0.4$ GeV^2

$\sim 3.3\ pb^{-1}$ taken with the ZEUS LPS in 1995

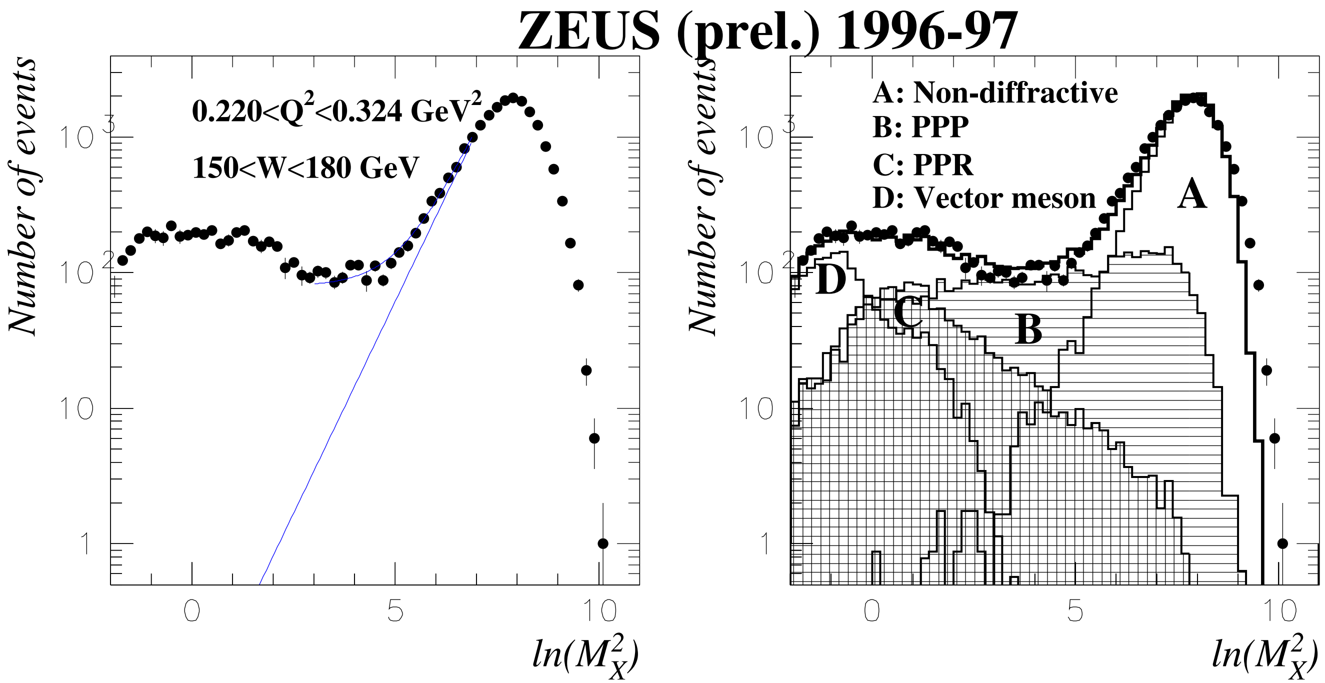
Measure:

$$x_L \equiv \frac{p^{LPS}}{E_p}$$

$$t = -\frac{(p_T^{LPS})^2}{x_L}$$

- low geometrical acceptance $\Rightarrow$ statistical limitations
- clean selection of diffractive events obtained by requiring $0.97 < x_L < 1.02$

Analysis with the $\ln M_X^2$ Method



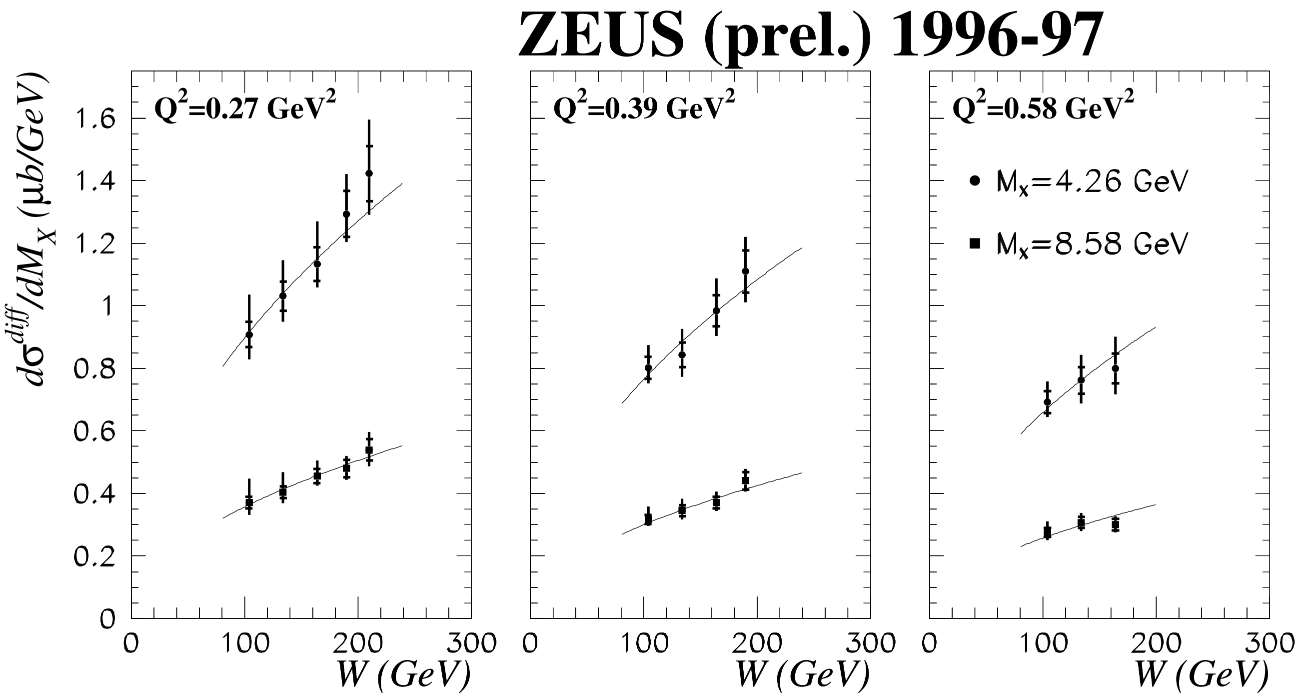
$0.22 < Q^2 < 0.7$ GeV^2
$90 < W < 220$ GeV
$3.0 < M_X < 12$ GeV

$\sim 6.2\ pb^{-1}$ taken with the ZEUS Beam Pipe Calorimeter (BPC) in 1996-1997

select diffractive events statistically:
excess of events over the **exponential fall-off** of the $\ln M_X^2$ distribution of non-diffractive events

- higher statistics than obtained from LPS measurements
- contamination from proton-dissociation $eP \to eXN$
  (system N escapes undetected through the beam-pipe)
  - estimated from comparison with LPS: $29 \pm 15\%$ (stat. only)

W Dependence of Inclusive Diffraction at Low Q^2



Fit to data a constant power of W

$$\frac{d\sigma^{\text{diff}}}{dM_X} = A_i \cdot W^{a^{\text{diff}}}$$

in terms of an effective Pomeron intercept $\bar{\alpha}_{\mathbb{P}}$

$$\bar{\alpha}_{\mathbb{P}} = \frac{a}{4} + 1$$

the fit gives a good description of the BPC data

$\bar{\alpha}_{\mathbb{P}} = 1.126 \pm 0.012(\text{stat.})^{+0.031}_{-0.029}(\text{syst.}).$ (ZEUS prel.)

related to the Pomeron intercept $\alpha_{IP}(0)$ by $\bar{\alpha}_{IP} = \alpha_{IP}(0) - \alpha'_{IP} \cdot |\bar{t}|$
(assume $\alpha'_{IP} = 0.25\ \text{GeV}^{-2}$ and $|\bar{t}| = 0.13\,\text{GeV}^2$)

What are the curves in the plots?

ZEUS VMDREGGE

displayed only at low Q^2 to guide the eye

form of the type

$$\frac{1}{Q^2 + 0.51} \cdot W^{a^{\text{diff}}}$$

GBW

Saturation Model

by K. Golec-Biernat and M. Wüsthoff

(see talk by K. Golec-Biernat)

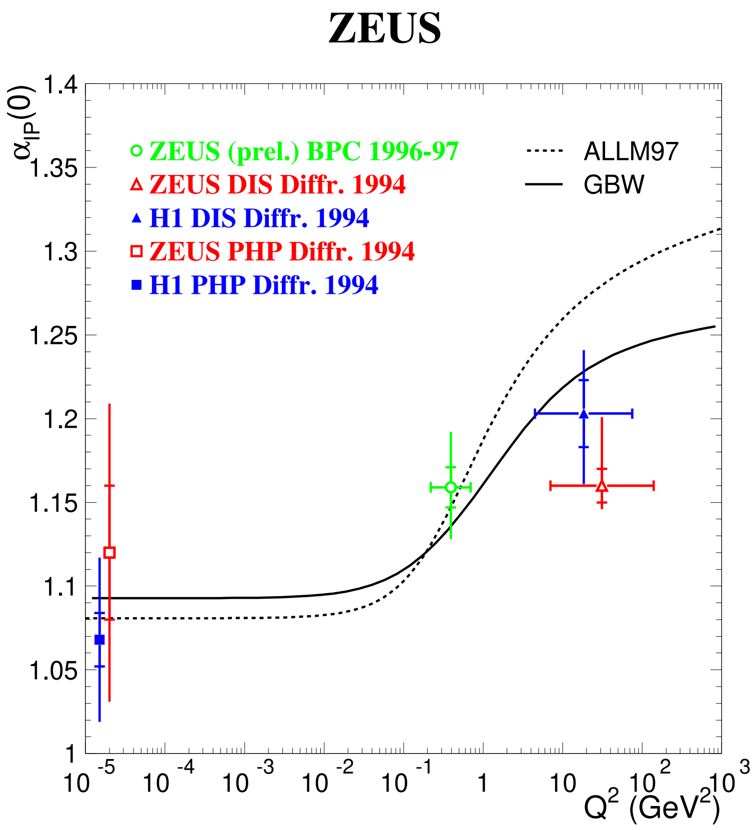
based on the dipole picture of small-x interactions

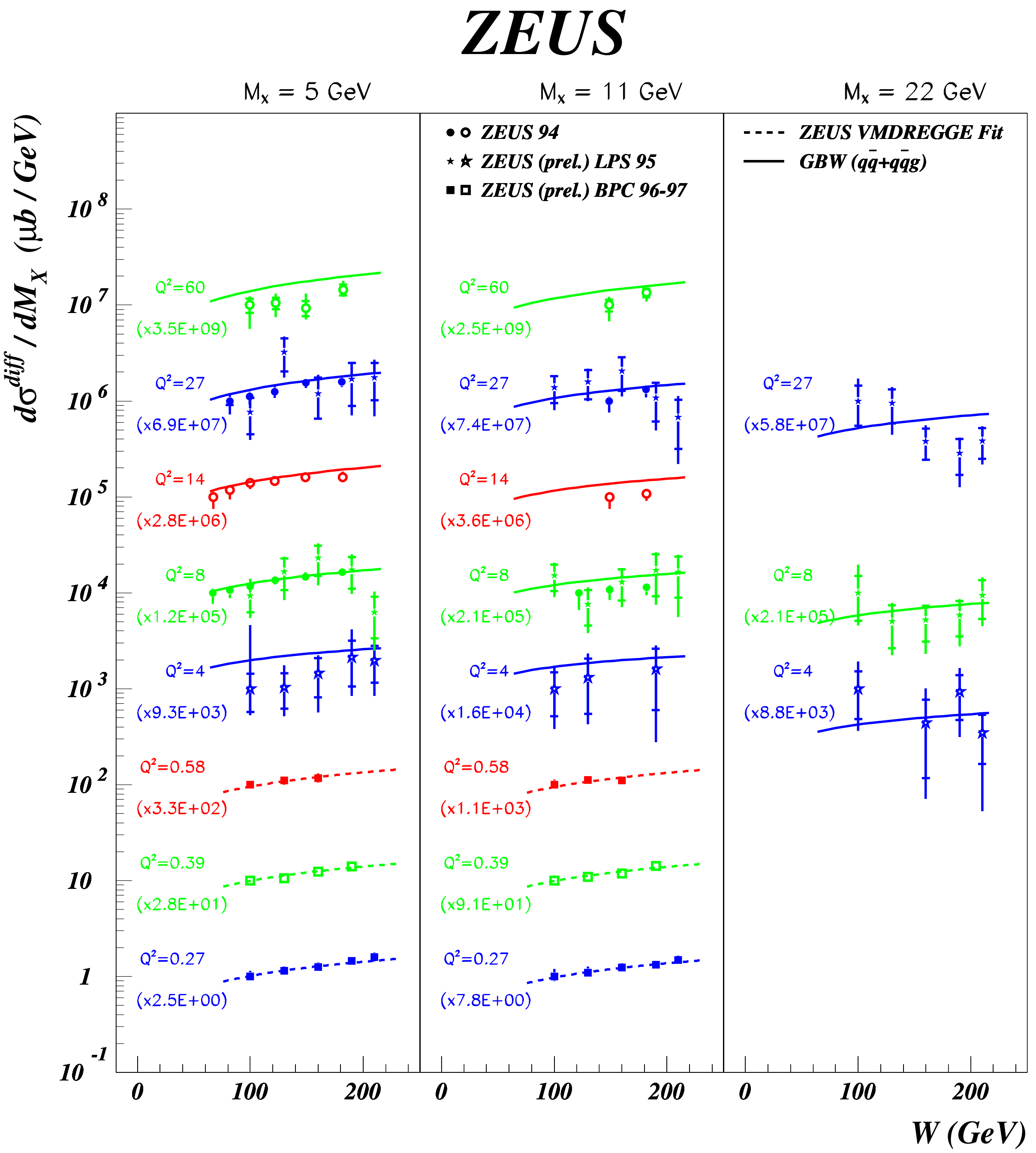
provides a **good description** of the transition from low Q^2 to the perturbative regime in **inclusive DIS**

predicts $\left.\frac{d\sigma^{\text{diff}}}{dM_X dt}\right|_{t=0}$

including the contributions from elastic $\boldsymbol{q\bar{q}}$ **scattering** and from the **emission of an extra gluon** in the final state

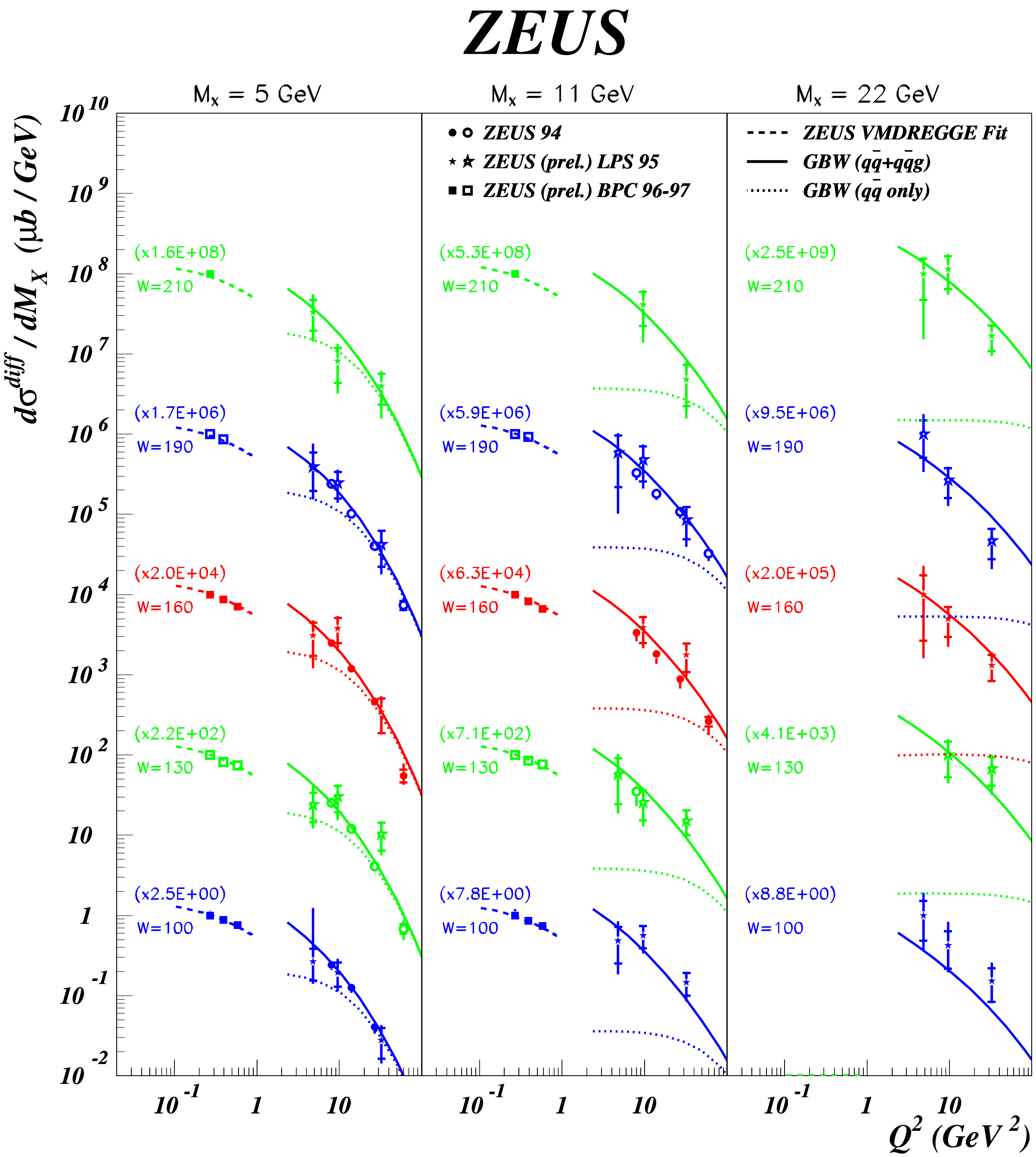
Overview of the W Dependence of Inclusive Diffraction





No statistically significant change from the low Q^2 to the DIS regime

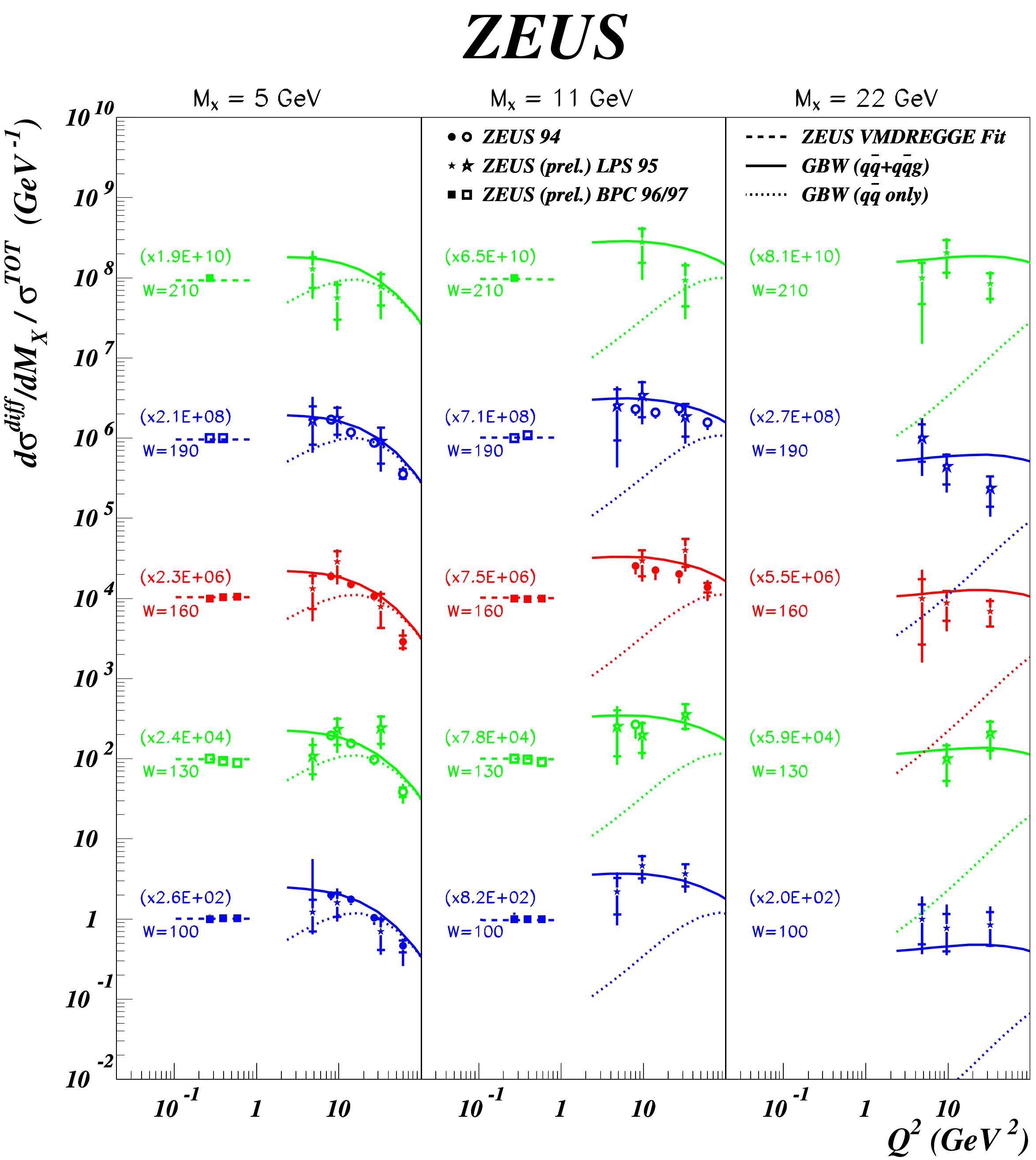
Q^2 Dependence of Inclusive Diffraction



going from the DIS regime to low Q^2, we observe a **change in the Q^2 dependence** of the diffractive cross section

- the cross section falls approximately by a factor 10 from low Q^2 to DIS
- at low Q^2, the Q^2 dependence softens considerably with respect to DIS
- this is qualitatively analogous to what observed for the total cross section $\sigma_{tot}^{\gamma^* p}$

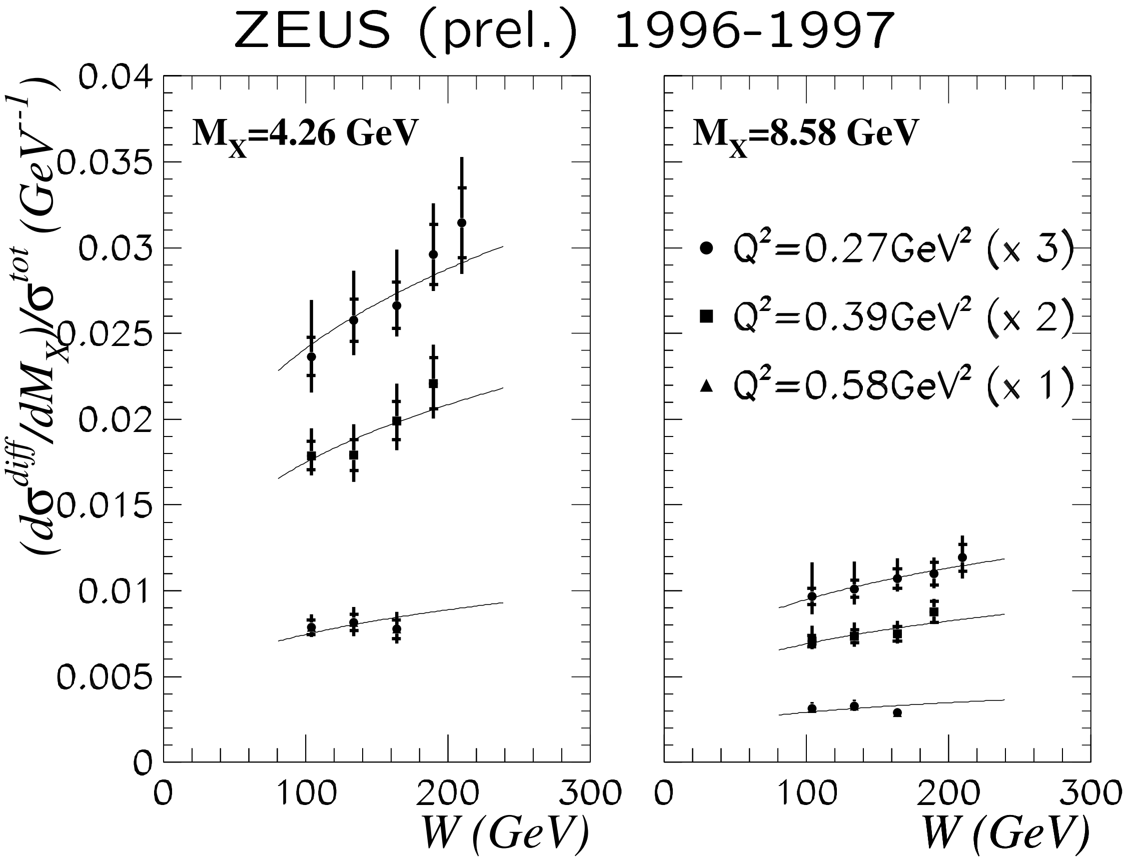
Q^2 Dependence of Inclusive Diffraction vs that of $\sigma_{tot}^{\gamma^* p}$



how far can we push the analogy with $\sigma_{tot}^{\gamma^* p}$?

- at low Q^2, the Q^2 dependence of the diffractive cross section is quite similar to that of $\sigma_{tot}^{\gamma^* p}$ (ratio approximately flat)
- in DIS, the diffractive cross section decreases with Q^2 more rapidly than $\sigma_{tot}^{\gamma^* p}$
- the ratio between the two appears to increase from low Q^2 to DIS

W Dependence of Inclusive Diffraction vs that of $\sigma_{tot}^{\gamma^* p}$



Fit to data a constant power of W

$$\frac{d\sigma^{\text{diff}}/M_X}{\sigma_{tot}^{\gamma^* p}} = N_i \cdot W^{\rho}$$

the fit gives a good description of the BPC data and yields

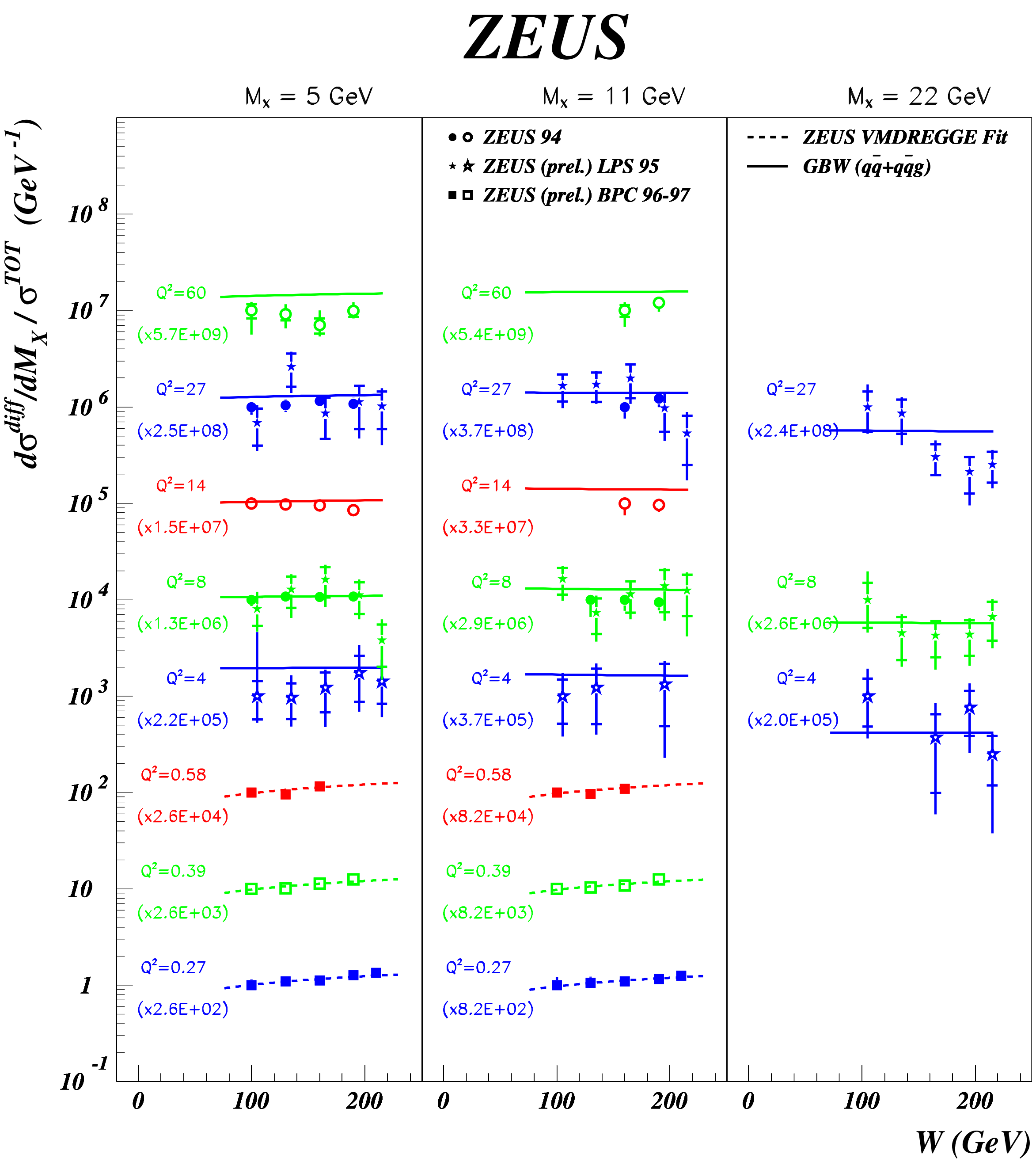
$$\rho = 0.24 \pm 0.07(\text{stat.})$$

consistent with the naive expectation $\rho = a^{diff}/2$

The result obtained in DIS (ZEUS 94) was

$$\rho = 0.00 \pm 0.03(\text{stat.})$$

W Dependence of Inclusive Diffraction vs that of $\sigma_{tot}^{\gamma^* p}$



- **in DIS** the W dependence of the diffractive cross section is weaker than that of $\sigma_{tot}^{\gamma^* p}$ ($\rho \sim 0$)

- **at low** Q^2 the W dependence of the diffractive cross section is stronger than that of $\sigma_{tot}^{\gamma^* p}$ ($\rho \sim a^{diff}/2$)