Caroline Collard

Université Libre de Bruxelles
On behalf of the
H1 and ZEUS Collaborations

DIFFRACTION AT HERA

- Introduction
- Vector Meson Production
- Inclusive Measurements
- Conclustions

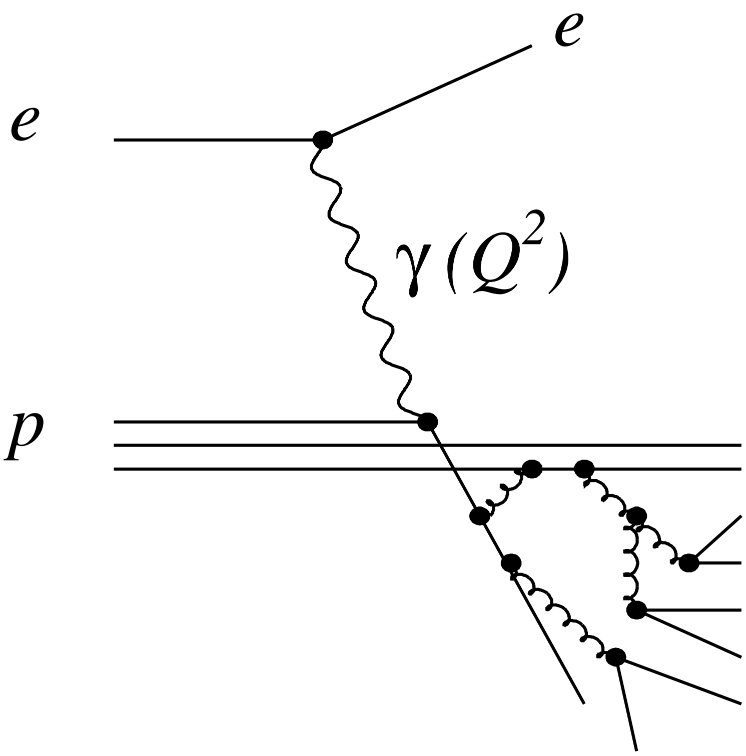
Lake Louise Winter Institute 2002
on Fundamental Interactions
February 17 - 23, 2002

at HERA :

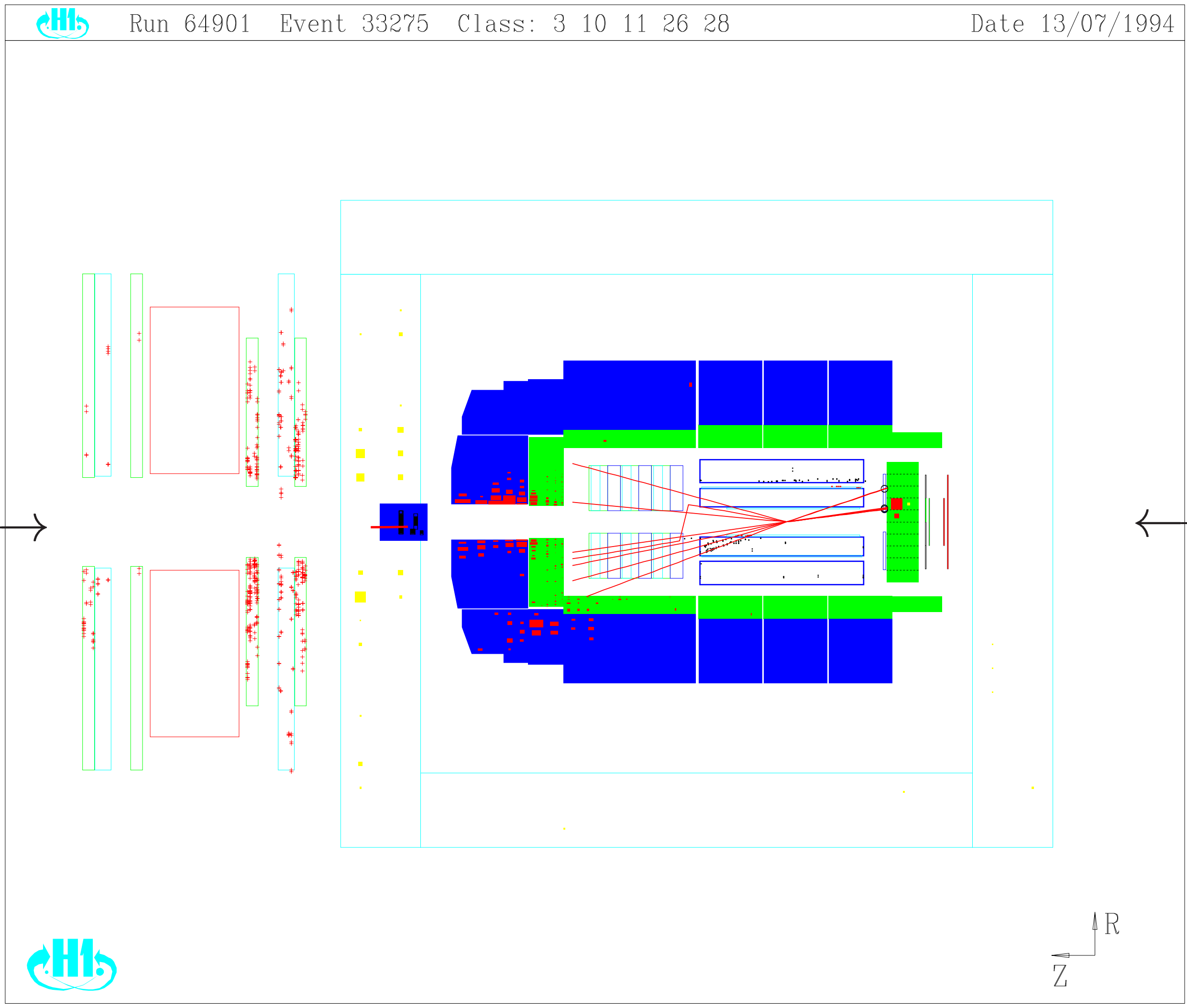
1. Deep Inelastic Scattering (DIS) event

27.5 GeV

820/
920 GeV



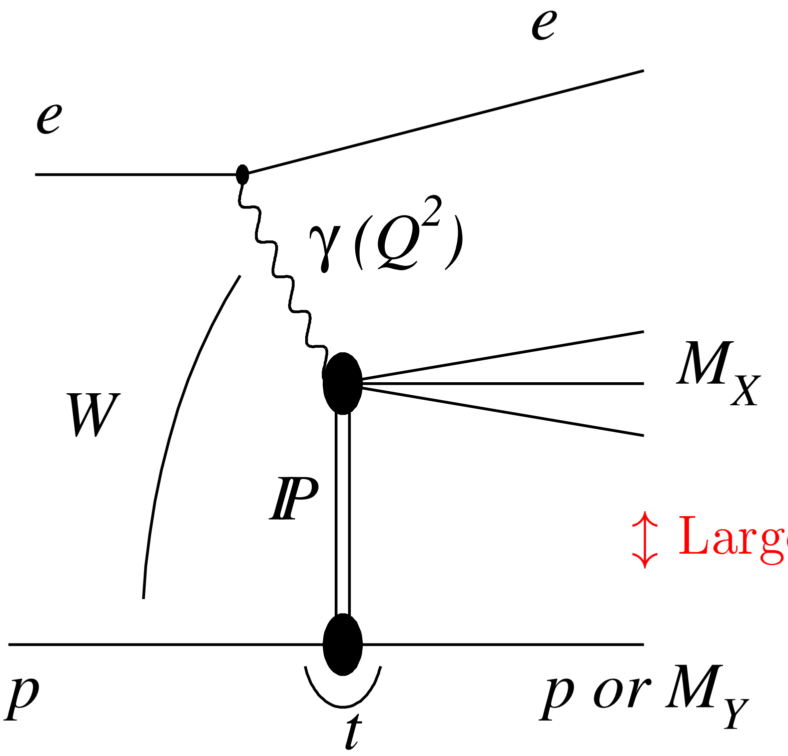
e →



← p

2. Diffractive event

10 % of the DIS events

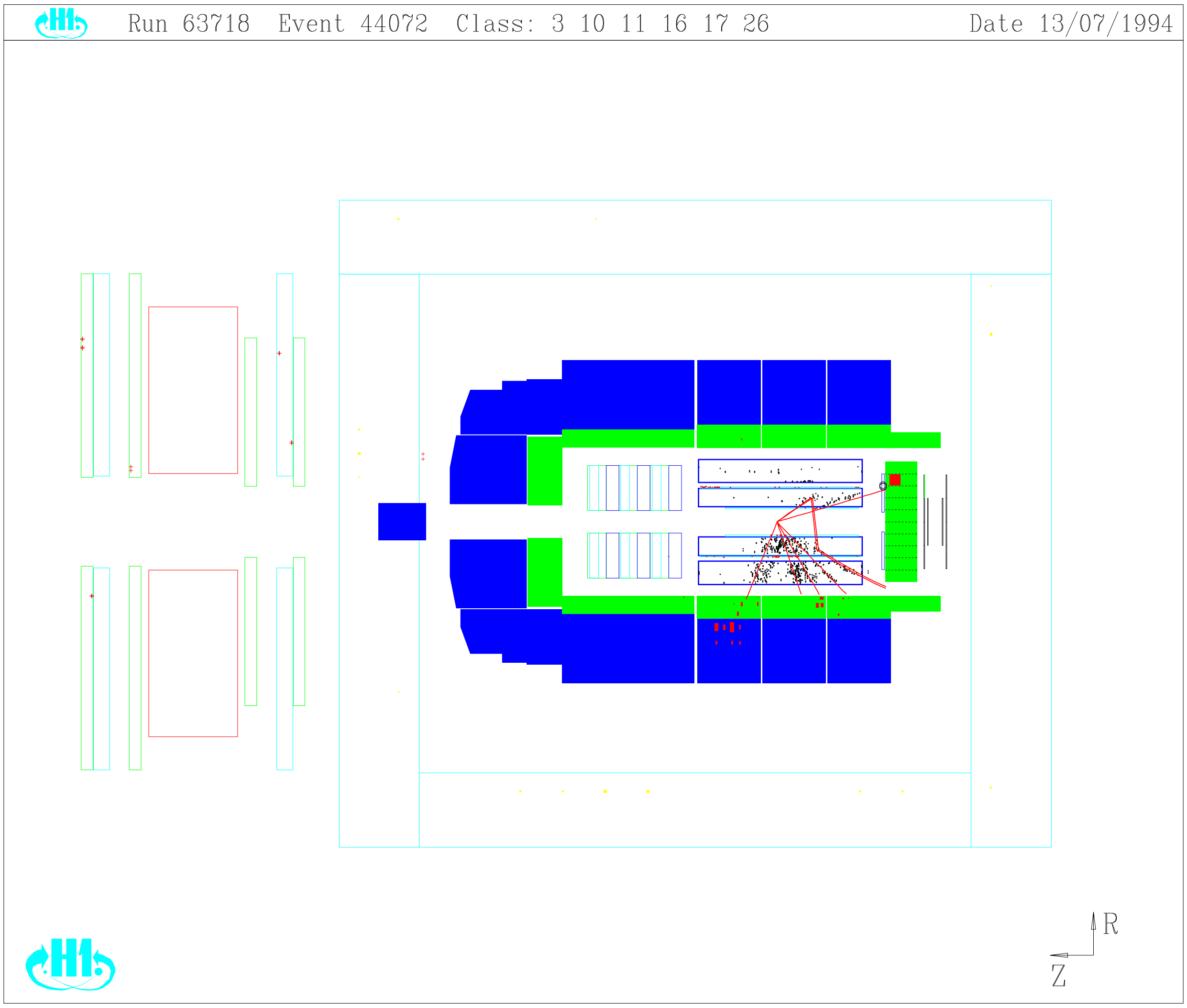


$M_X << W$

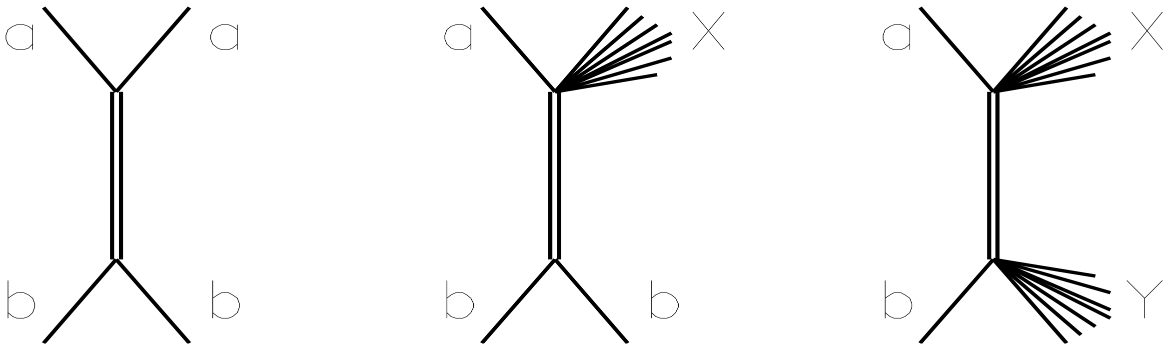
↕ Large rapidity gap

$M_Y << W$

$I\!\!P$ = colourless exchange

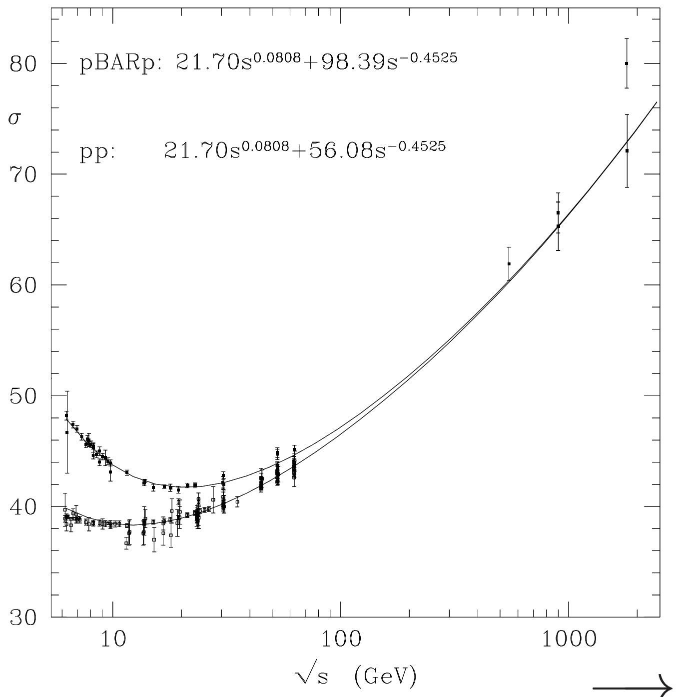


Diffraction= Generalisation of the elastic scattering



rem: Optical Theorem : $\sigma_{tot} \propto \; Im\;(Am_{el}\;(t=0))$
The elastic scattering is related to the total cross section by the Optical Theorem.

$\sigma \uparrow$

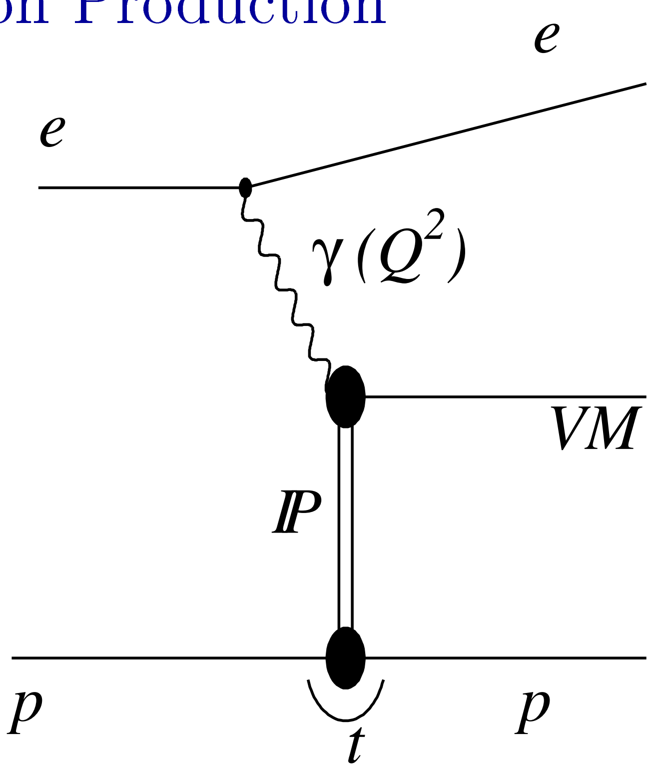


$\longrightarrow$ Energy in cms

The cross section can not increase forewer...

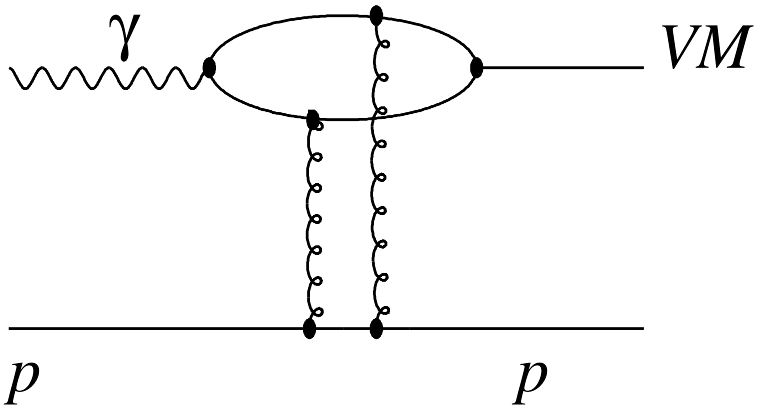
It is then important to understand the Pomeron ($I\!\!P$) in QCD and HERA is a unique place to study the structure of the Pomeron.

Vector Meson Production



$J^{PC} = 1^{--}$

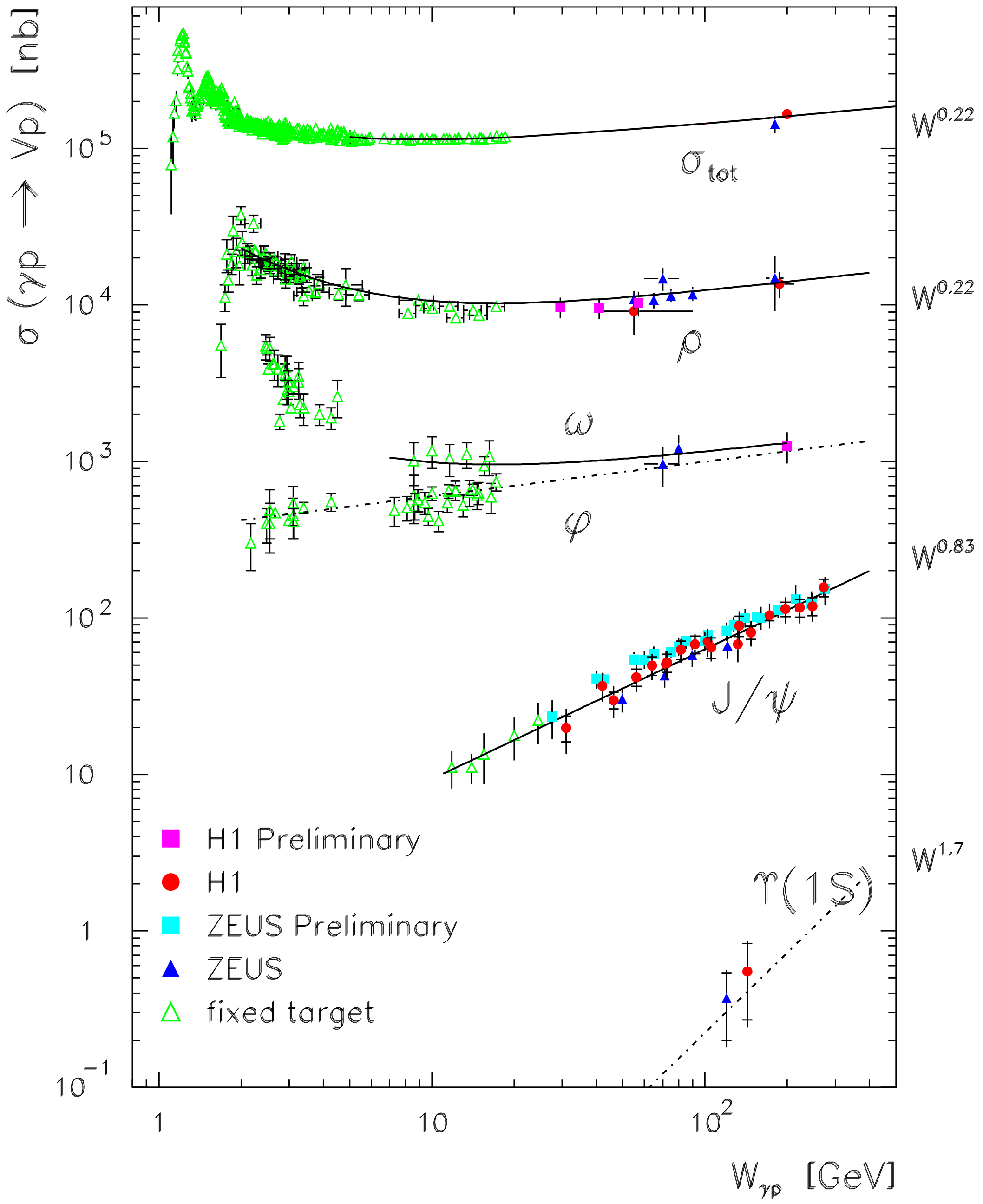
This very clean process can be calculable in pQCD in presence of a hard scale (i.e. at small distances). At the lowest order, the pomeron is modelled by a 2 gluon exchange.



$$\sigma \propto |xG(x, Q^2)|^2$$

Why 2 gluons? The pomeron is a neutral color object.

Photoproduction ($\boldsymbol{Q^2 \simeq 0}$) of $\boldsymbol{J/\Psi}$ at low $\boldsymbol{t}$



Light VM (ρ, ω, ϕ)= soft dependence of $\sigma \propto W^{0.2}$

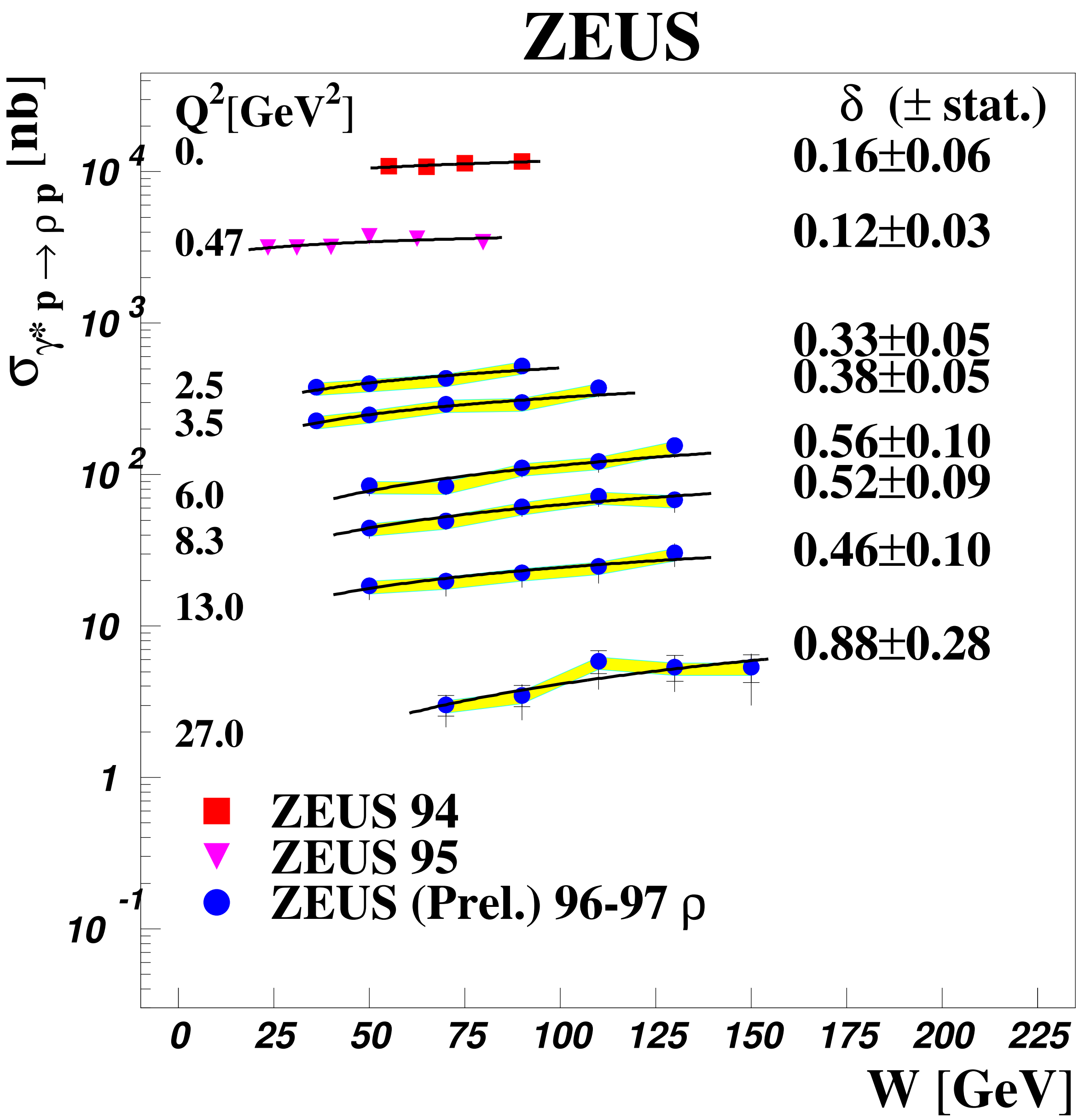
J/Ψ $\quad$ = hard dependence $\propto W^{0.8}$

predicted by pQCD

(rise of the gluons at low x, $\quad W^2 \propto \frac{1}{x}$)

$\rightarrow$ $\boldsymbol{M_q}$ plays the role of the hard scale.

Q^2 evolution of the W dependence of ρ vector meson electroproduction at low t

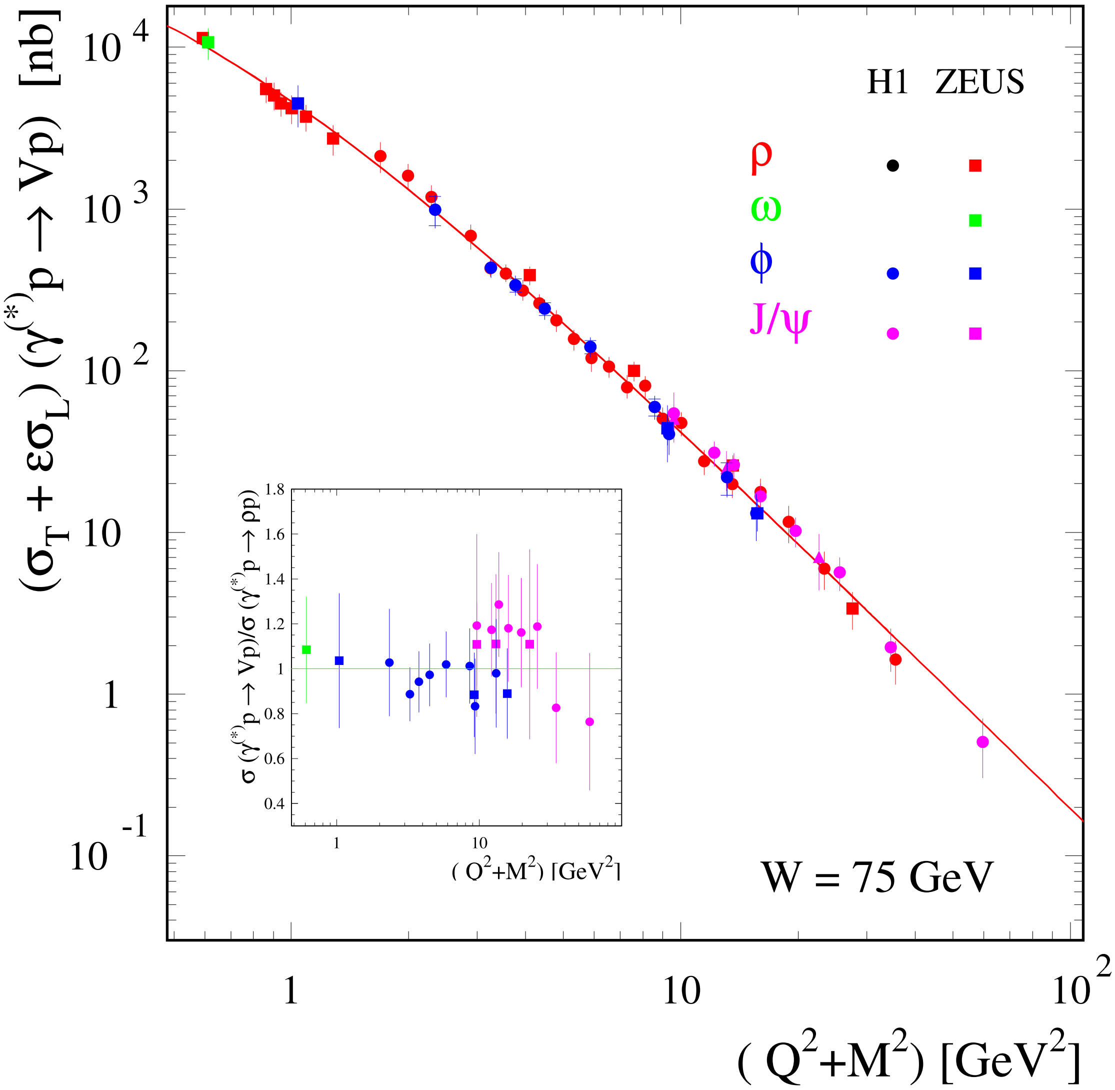


The W dependence is parametrised as W^{δ}.

→ Transition from soft to hard when Q^2 increases.

Universality ?

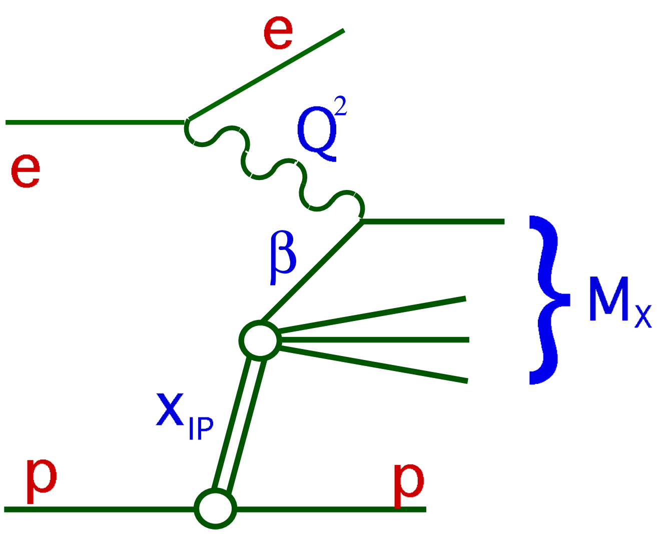
The VM cross sections are scaled by SU(4) factors
$(\sigma_\rho : \sigma_\omega : \sigma_\phi : \sigma_{J/\Psi} = 9 : 1 : 2 : 8)$



$\Rightarrow$ "universal" behaviour of the VM production.
The gluons couple the same way to the different flavours of quarks.

What is the structure of the Pomeron?

$\Rightarrow$ Study of the diffractive structure function ${F_2}^D$



$x_{I\!P}$ = fraction of p momentum carried by the $I\!P$

β = fraction of $I\!P$ momentum carried by quark coupling to γ^*

$$x = x_{I\!P} \cdot \beta$$

DIS	F_2	$\rightarrow$	p structure
Diffraction	${F_2}^D$	$\rightarrow$	$I\!P$ structure

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

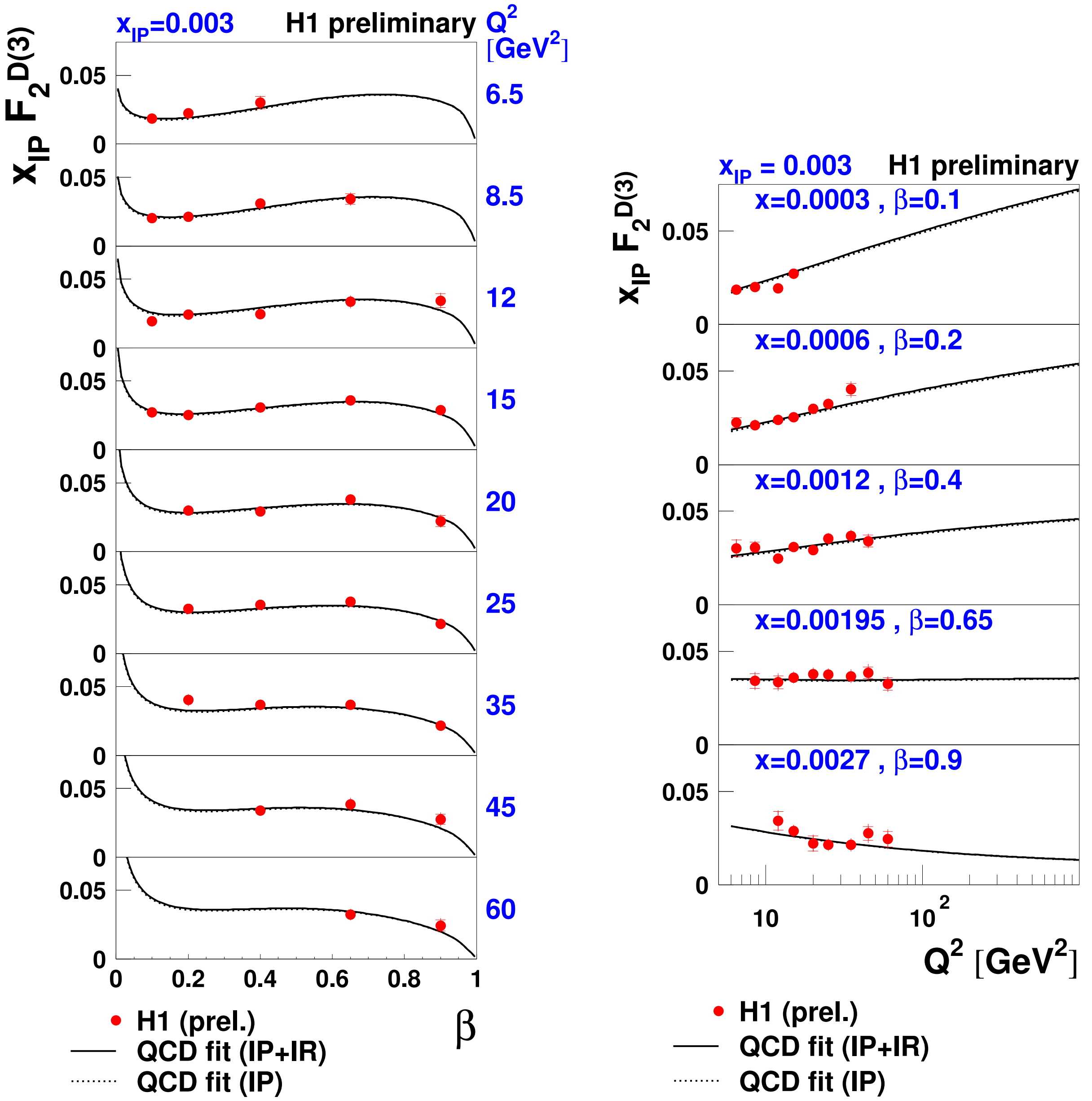
QCD Factorisation (proven by Collins):

$$\sigma(\gamma^* p \rightarrow Xp) \propto \sum_i f_{i/p}(x_{I\!P}, t, x, Q^2) \times \sigma_{\gamma^* i}(x, Q^2)$$

$f_{i/p}(x_{I\!P}, t, x, q^2)$ is the diffractive parton density

QCD Analysis

$F_2^D(\beta, Q^2)$ at fixed $x_{I\!P}$



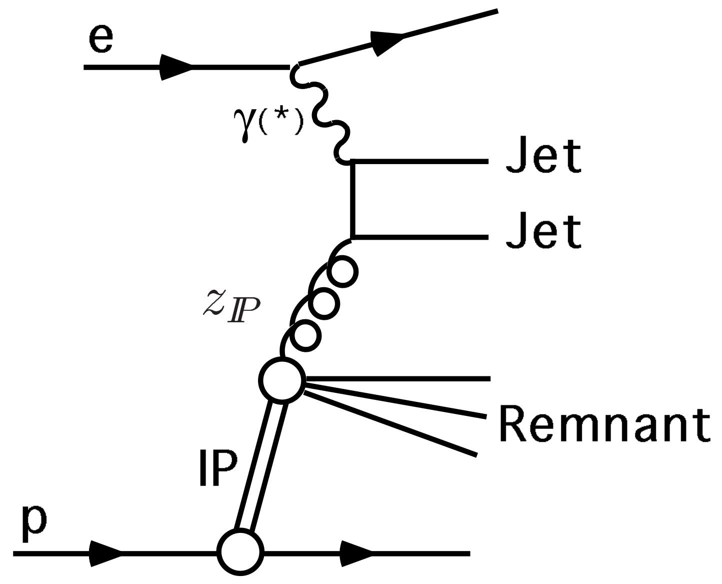
Scaling violation: At low β, F_2^D increases with Q^2 due to the gluons.

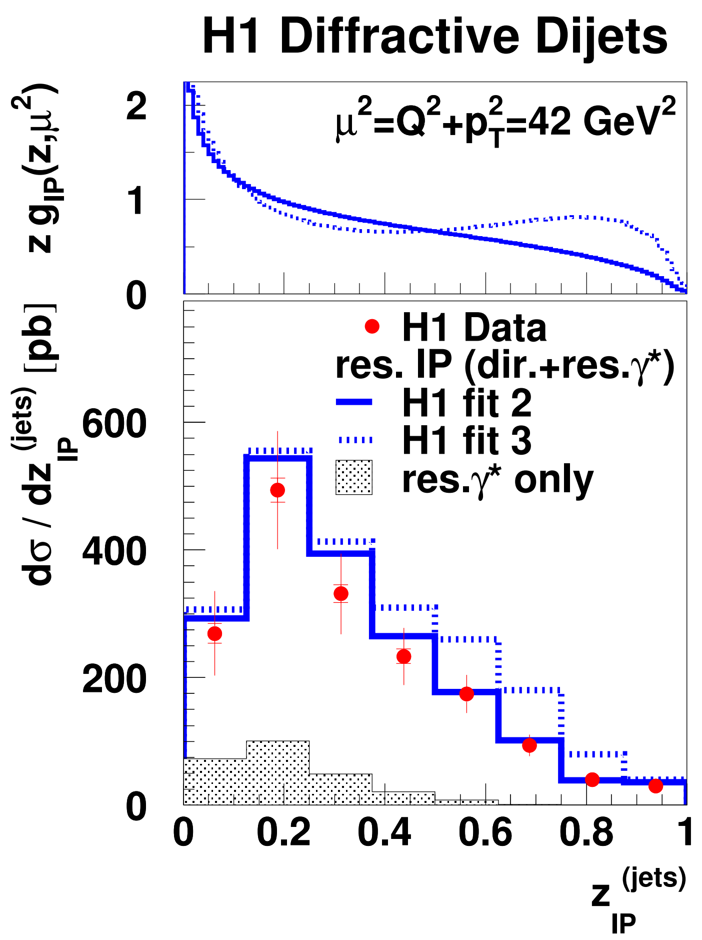
The Q^2 evolution is described by the DGLAP equations.

$\rightarrow$ extraction of the parton densities in the Pomeron.

The pomeron is composed by $\sim$ 80 - 90 % of gluons.

The parton density functions are used to predict other processes, for example the dijet production which is particularly sensitive to gluons.





Consistent with QCD factorisation

$z_{I\!P}^{jet}$ = pomeron momentum fraction carried by the q or g implied in the hard scattering

No peak at $z_{I\!P}^{jet} = 1$ is observed!
$\rightarrow$ dominance of boson-gluon fusion

Conclusions

10 % of the DIS events show a large rapidity gap.
They are diffractive events and can be explained
by the exchange of a Pomeron.

The transition from soft to hard diffraction can be
explored at HERA using different hard scales
(Q^2, M_q, p_{jet}^T,...).

This makes of HERA a unique place
to study diffraction in QCD.

The structure of the Pomeron is found
to be mostly gluonic.

Summary:

- Vector Meson production
- $F_2^{D(3)}$ and dijets