HEP97, Jerusalem 1997

Vector meson production at HERA

A. Proskuryakov
DESY/Moscow State University

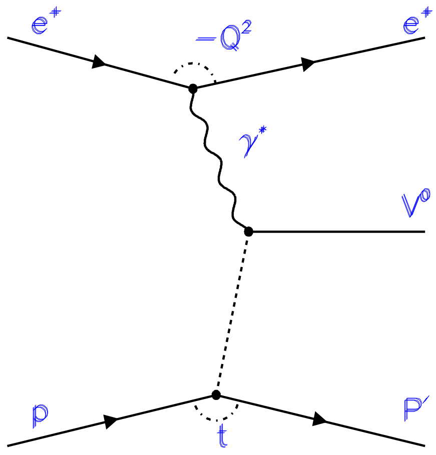
1. Introduction

2. Vector meson photoproduction

3. Vector meson production at low and high Q^2

4. Conclusions

Introduction



$$V^0 = \rho^0,\ \phi,\ \omega,\ J/\psi ...$$

W : $20 - 240$ GeV

Q^2 : $10^{-10} - 50$ GeV^2

$|t|$: $0 - 5$ GeV^2

HERA is unique tool to study vector meson production.

$\gamma p \to V^0 p$

- Soft diffractive process

  VDM and Regge theory describe low energy data

- pQCD models

  Scale: Q^2, M_V^2, t $\quad \sigma \sim [xg(x)]^2$

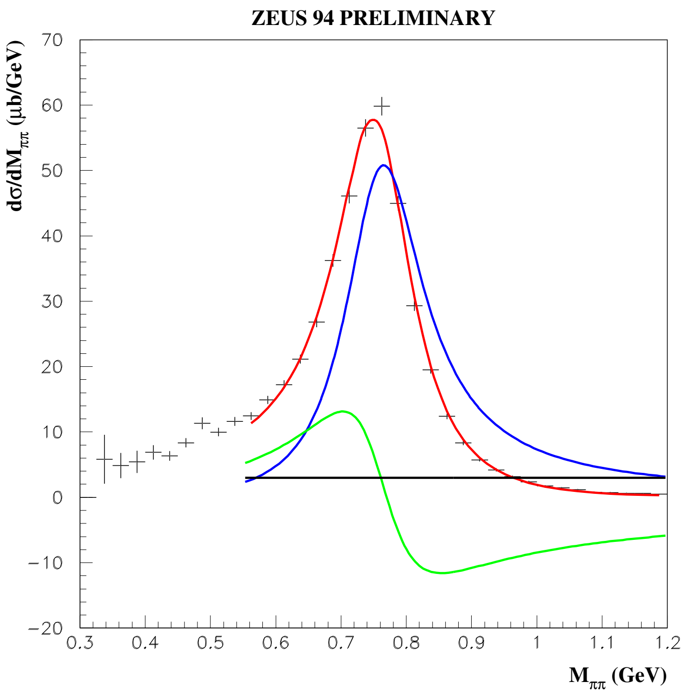
- Transition from the soft to the hard regime

Photoproduction of ρ^0 mesons

$$Q^2 \sim 10^{-5}\ \mathrm{GeV}^2$$

$$50 < W < 100\ \mathrm{GeV}$$

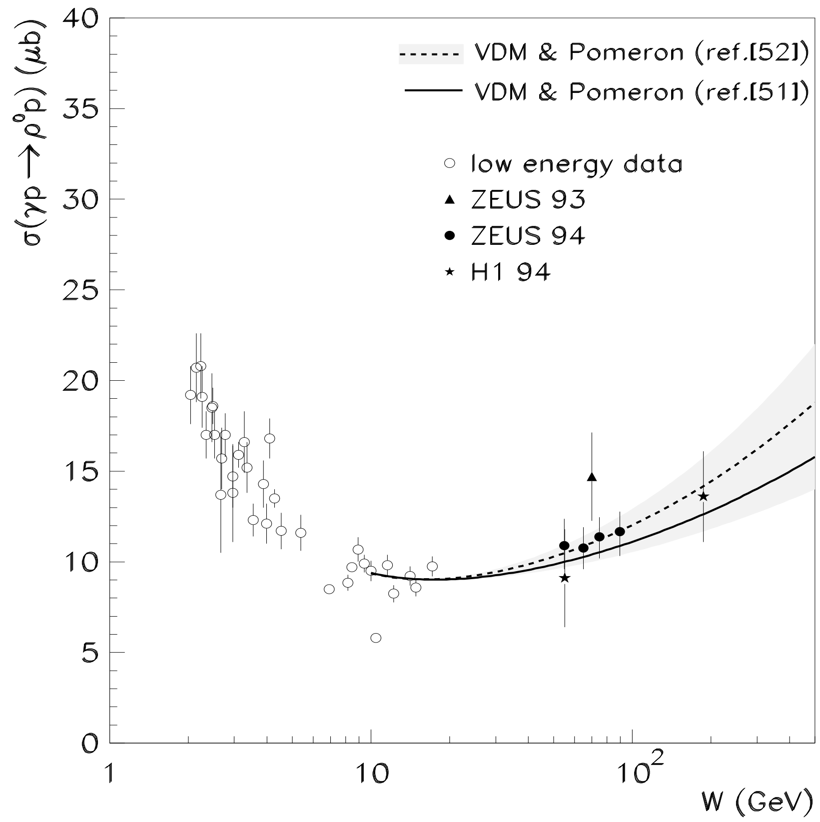
$$|t| < 0.5\ \mathrm{GeV}^2$$



Fit based on the Söding model:

$$\frac{d\sigma}{dM_{\pi\pi}} = |A \frac{\sqrt{M_{\pi\pi} M_\rho \Gamma_\rho}}{M_{\pi\pi}^2 - M_\rho^2 + i M_\rho \Gamma_\rho} + B|^2$$

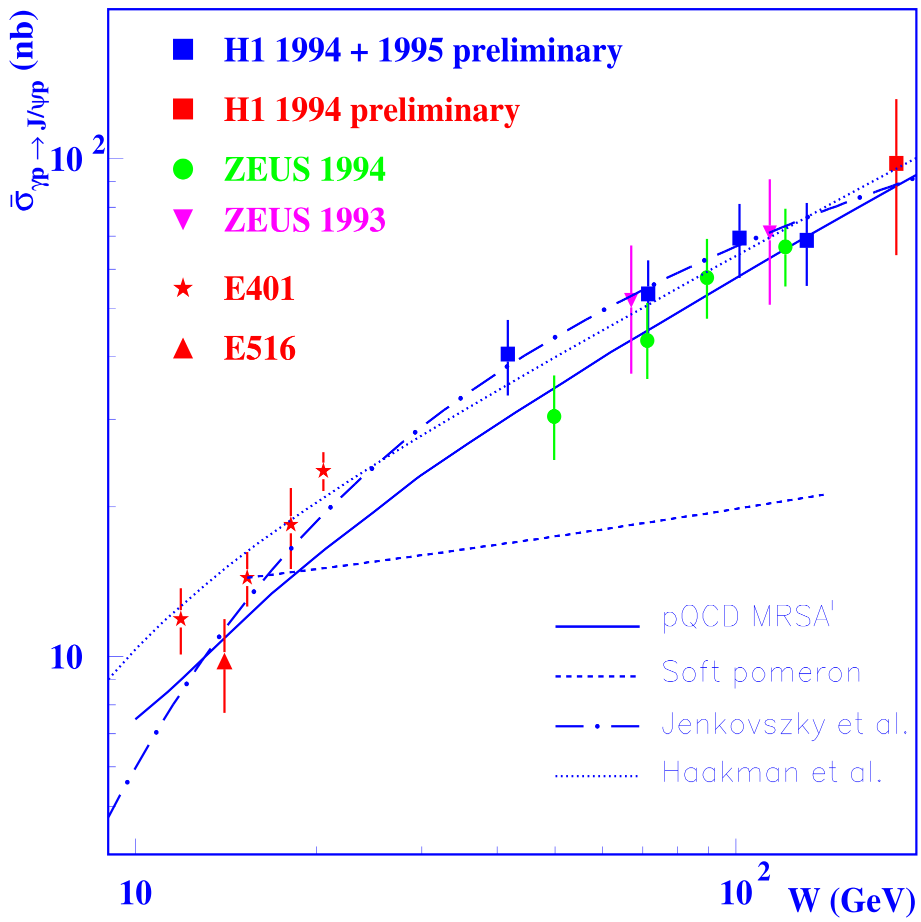
Cross section vs W



Fit to ZEUS data only: $\sigma \propto W^{\epsilon}$

$$\epsilon = 0.16 \pm 0.06^{+0.11}_{-0.14}$$

Photoproduction of J/ψ mesons

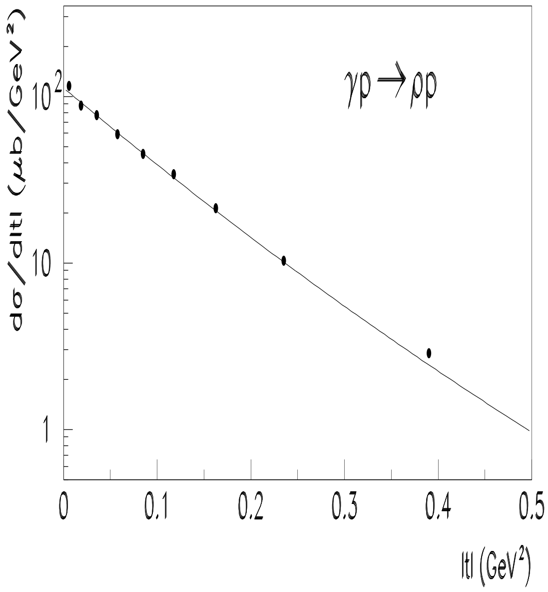


Steep energy dependence for J/ψ photoproduction

QCD models predict: $\sigma \propto (xg(x, q^2))^2$

Scale is provided by J/ψ mass

t dependence of cross section

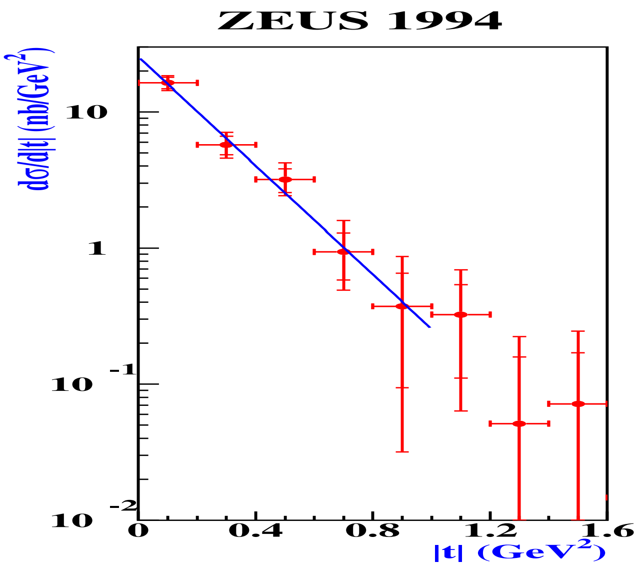


$\gamma p \longrightarrow \rho^0 p$

Fit: e^{bt+ct^2}

$b = 10.9 \pm 0.3^{+1.0}_{-0.5}$ GeV^{-2}

$c = 2.7 \pm 0.9^{+1.9}_{-1.7}$ GeV^{-4}

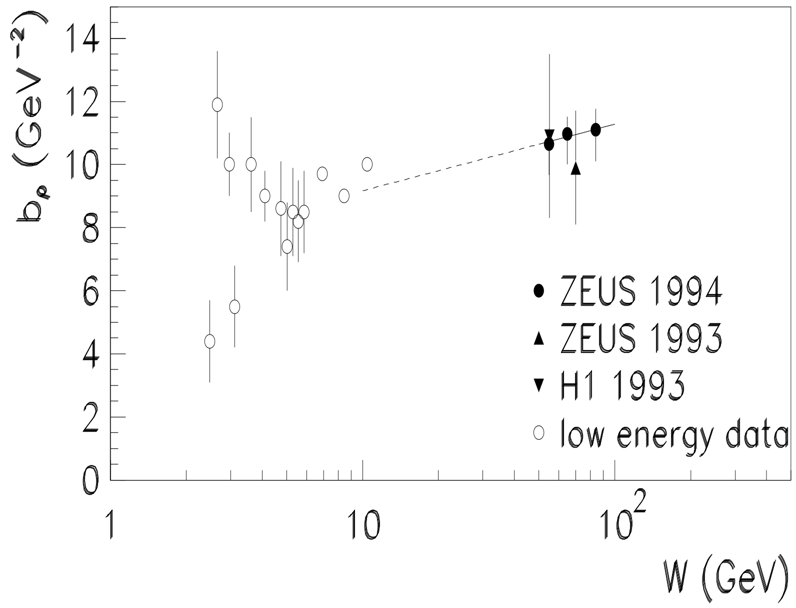


$\gamma p \longrightarrow J/\psi p$

Fit: e^{bt}

$b = 4.6 \pm 0.4^{+0.4}_{-0.6}$ GeV^{-2}

t dependence of cross section

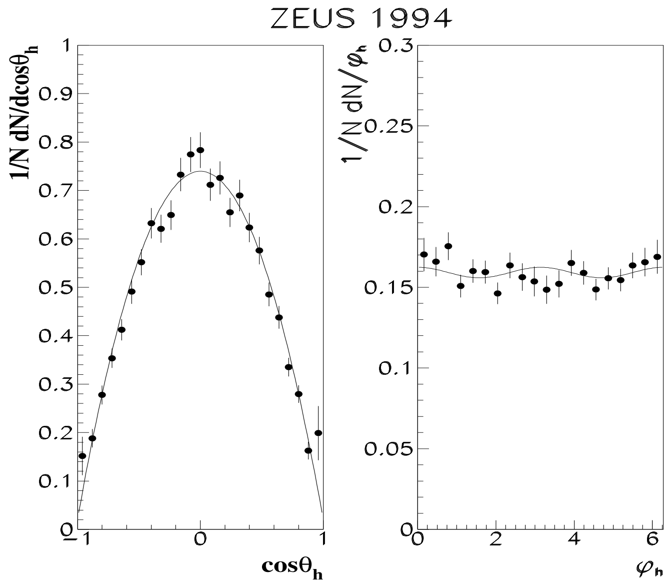


$$b = b_0 + 2\alpha' \ln W^2$$

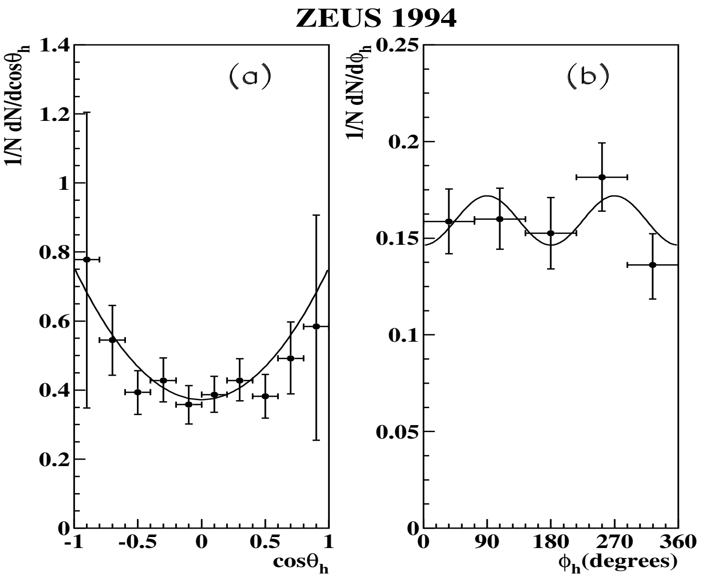
$$\alpha' = 0.23 \pm 0.15^{+0.10}_{-0.07}\ \mathrm{GeV}^{-2}\ \text{(ZEUS94 prelim.)}$$

Decay angular distributions

$\gamma p \to \rho^0 p.$ $\quad\quad$ SCHC $\Rightarrow W(\cos\theta) \propto \sin^2\theta$



$\gamma p \to J/\psi p.$ $\quad\quad$ SCHC $\Rightarrow W(\cos\theta) \propto (1 + \cos^2\theta)$

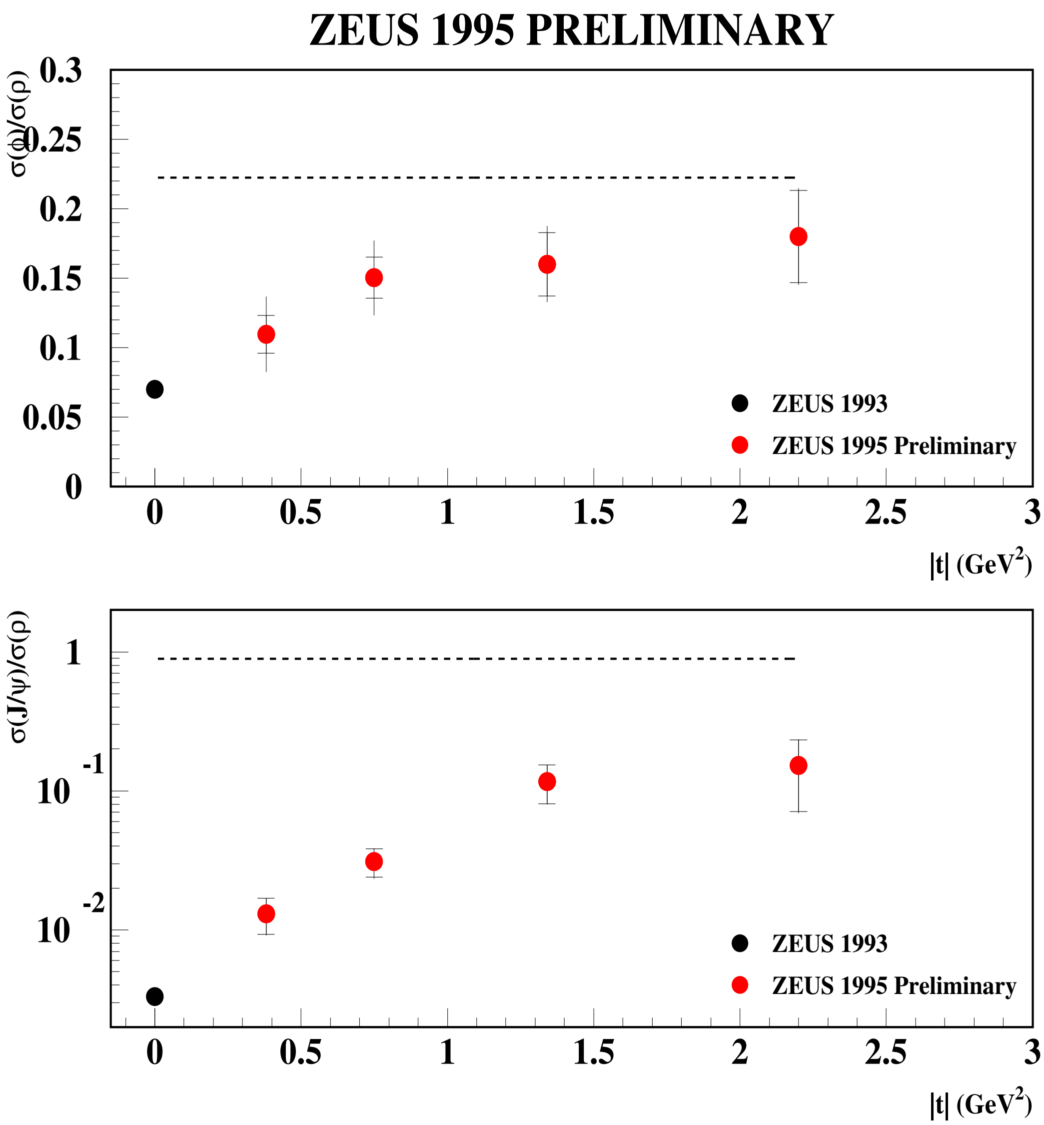


Consistent with s-channel helicity conservation

Cross section ratio at high t

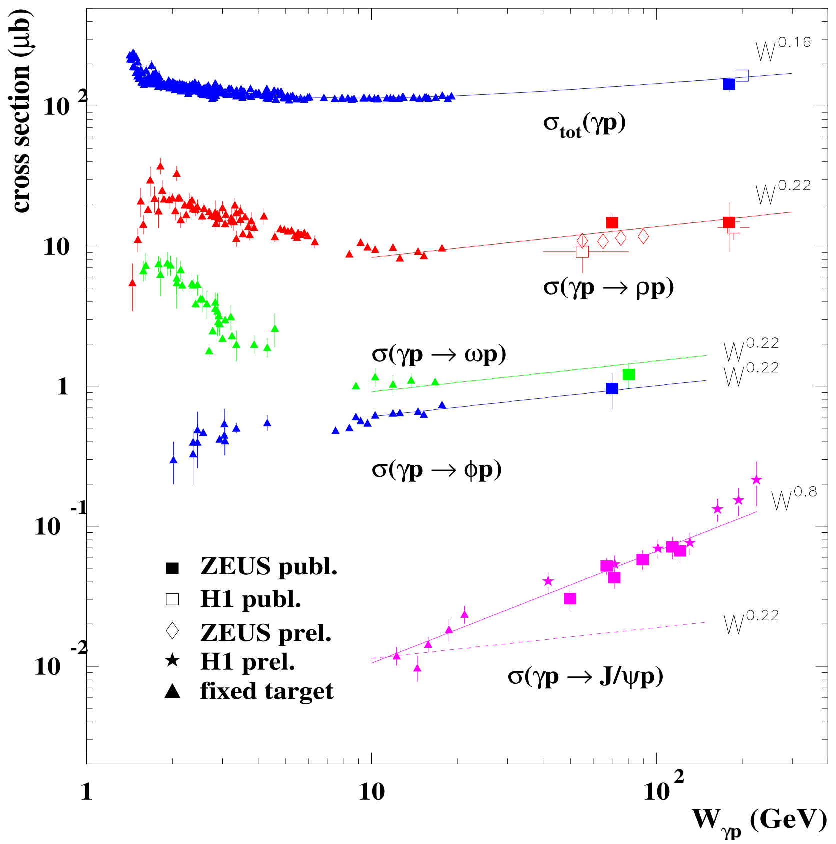
$70 < W < 120$ GeV

$Q^2 < 0.01$ GeV^2



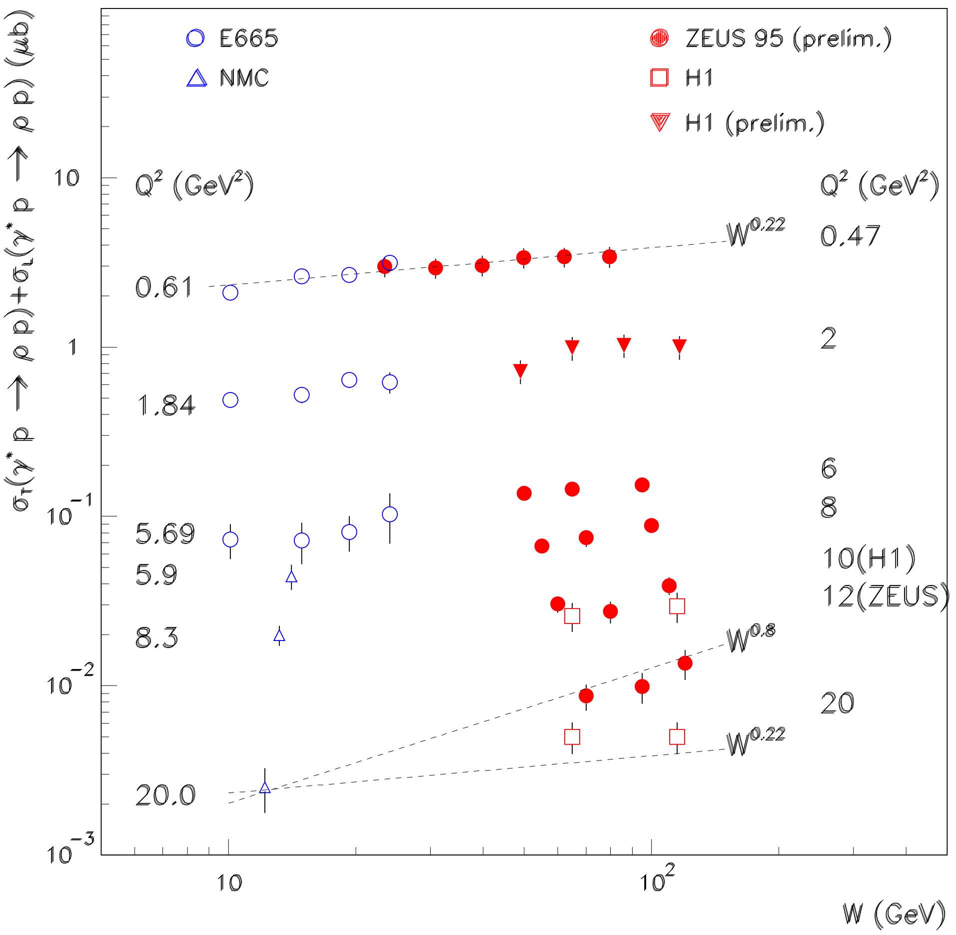
$\rho^0 : \phi : J/\psi = 9 : 2 : 8$ SU(4) restoration at high t ?

Vector meson photoproduction

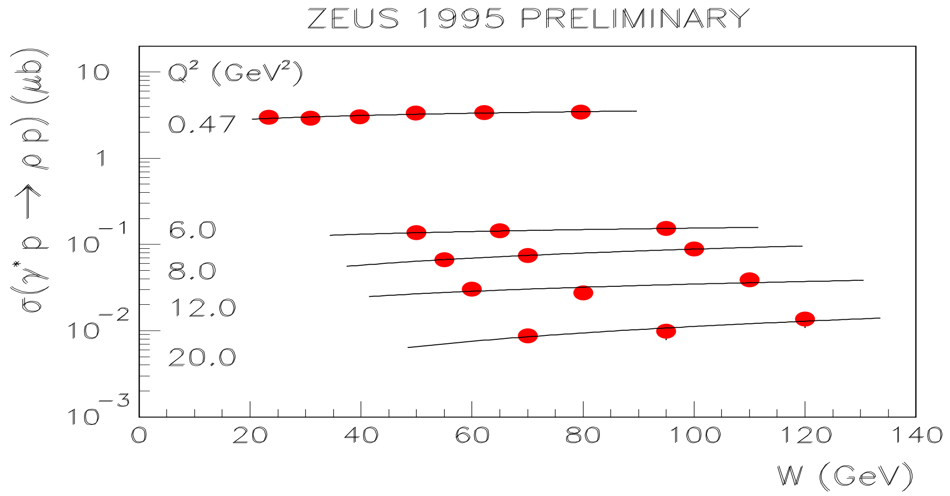


- Weak energy dependence for light vector mesons
- Steep rise for J/ψ

Cross section W dependence

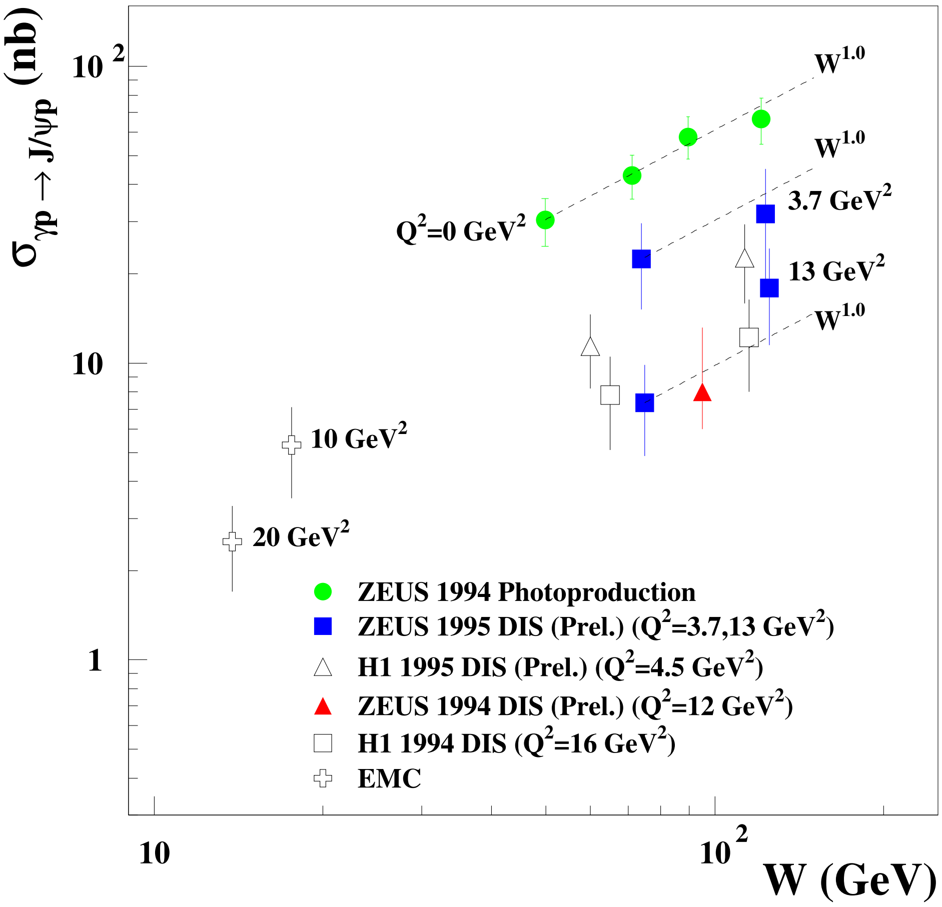


Still large normalisation uncertainty



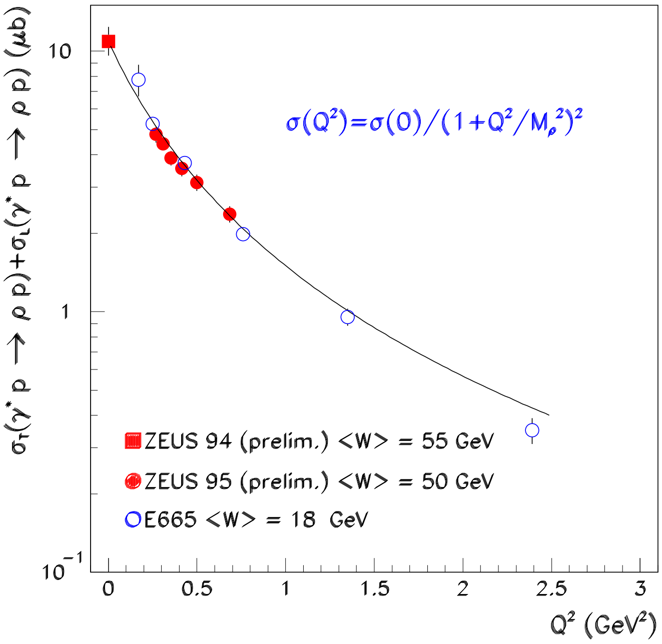
Fit: $\sigma \propto W^k$

Q^2 (GeV^2)	k
0.47	$0.18 \pm 0.05 \pm 0.13$
6.0	$0.18 \pm 0.16 \pm 0.05$
8.0	$0.47 \pm 0.16 \pm 0.09$
12.0	$0.38 \pm 0.21 \pm 0.13$
20.0	$0.77 \pm 0.19 \pm 0.19$



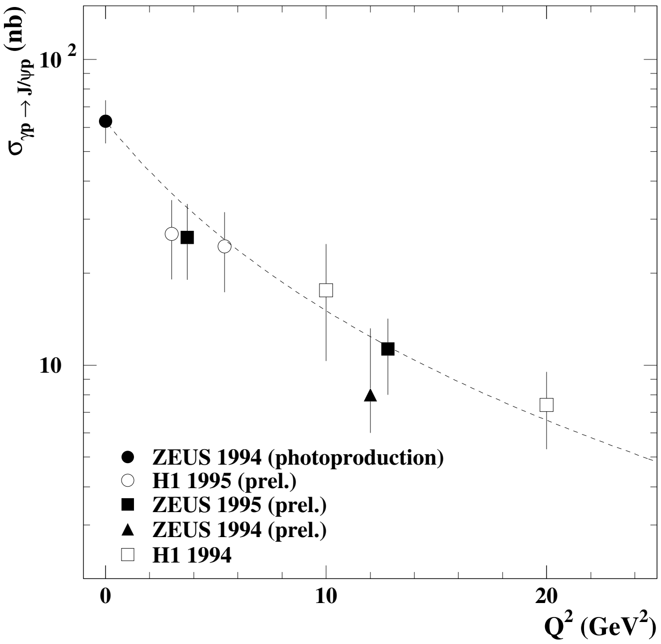
$\sigma_{\gamma p \to J/\psi p}$ (nb)
10^2
10
1
10
10^2
W (GeV)
$W^{1.0}$
$W^{1.0}$
$W^{1.0}$
Q^2=0 GeV^2
3.7 GeV^2
13 GeV^2
10 GeV^2
20 GeV^2
ZEUS 1994 Photoproduction
ZEUS 1995 DIS (Prel.) (Q^2=3.7,13 GeV^2)
H1 1995 DIS (Prel.) (Q^2=4.5 GeV^2)
ZEUS 1994 DIS (Prel.) (Q^2=12 GeV^2)
H1 1994 DIS (Q^2=16 GeV^2)
EMC

Cross section Q^2 dependence



$$\gamma^\star p \longrightarrow \rho^0 p$$

$$\sigma(Q^2) \propto \frac{1}{(Q^2+M_\rho^2)^2}$$



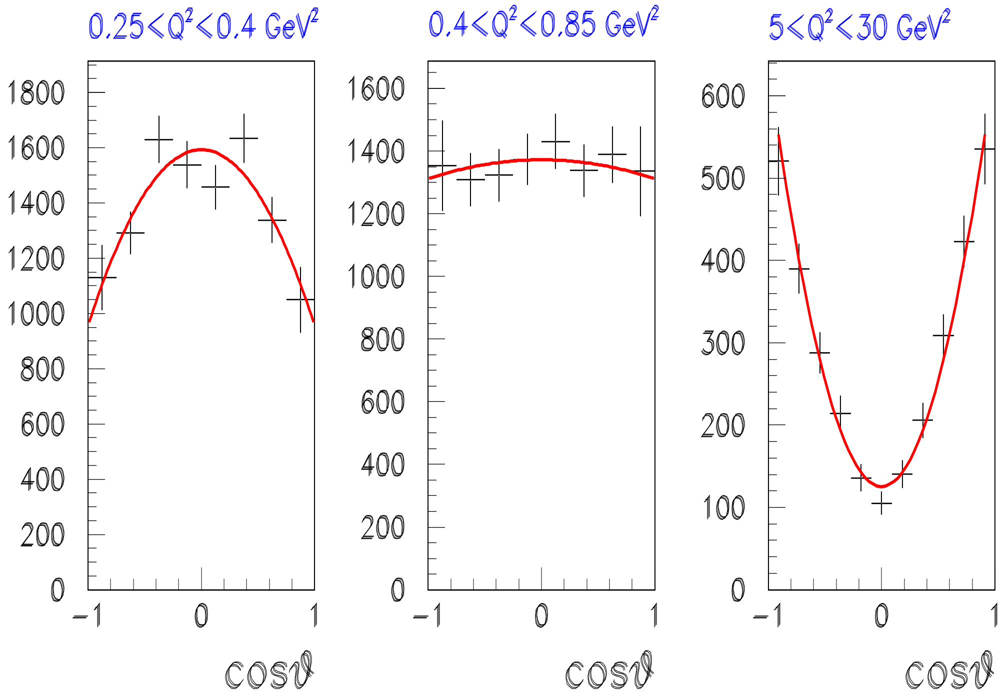
$$\gamma^\star p \longrightarrow J/\psi p$$

$$\sigma(Q^2) \propto \frac{1}{(Q^2+M_{J/\psi}^2)^2}$$

Decay angular distributions

$$W(\cos\theta) = \frac{3}{4\pi}[\frac{1}{2}(1 - r_{00}^{04}) + \frac{1}{2}(3r_{00}^{04} - 1)\ \cos^2\theta]$$

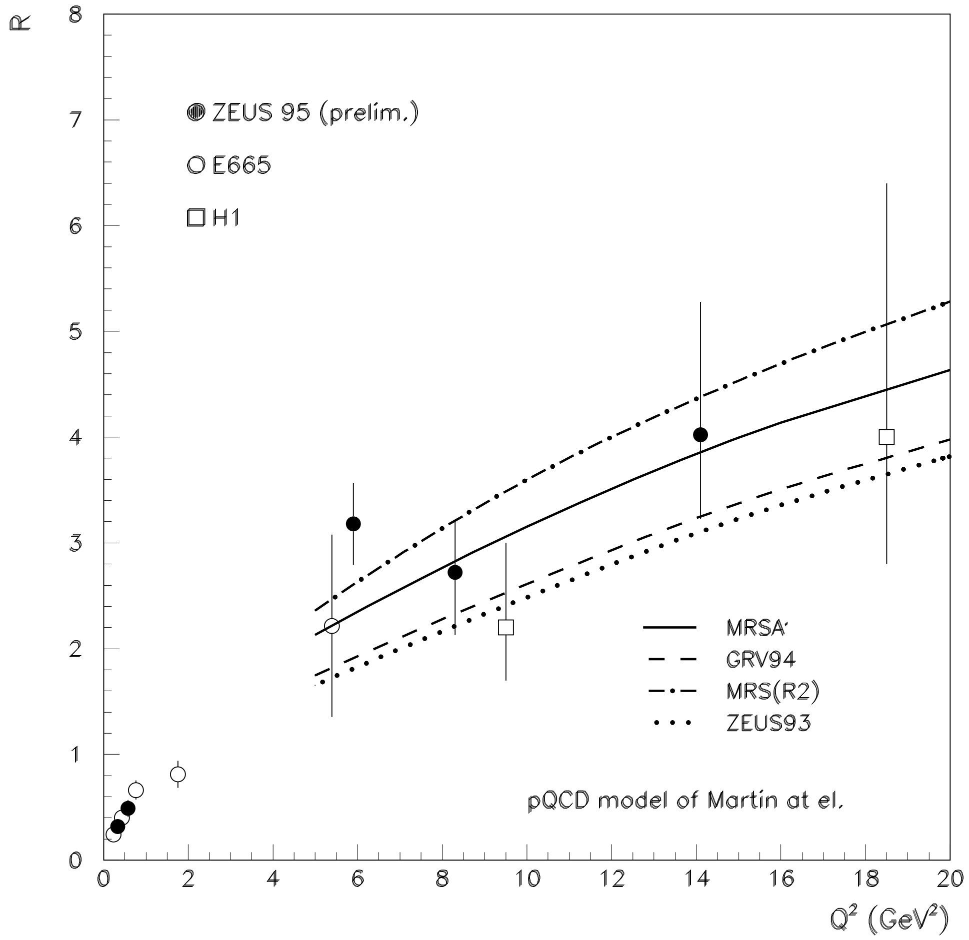
r_{00}^{04} - probability that ρ^0 meson has helicity 0



Fraction of ρ^0 mesons produced in helicity 0 state increases with Q^2

$$R = \sigma_L/\sigma_T$$

$$SCHC \Rightarrow R = \frac{1}{\epsilon}\frac{r_{00}^{04}}{1 - r_{00}^{04}}$$



Conclusions

- Elastic production of light vector mesons at low values of Q^2 and $|t|$ shows typical soft diffractive behavior.

- There is an indication that this approach fails to describe the cross section energy dependence for elastic J/ψ production. The steep rise with energy is consistent with QCD calculations.

- The Q^2 variation of the ρ^0 cross section in the low Q^2 region is well described by a $(Q^2+M_V^2)^{-n}$ function with $n \sim 2$. The similar, Q^2 dependence has been observed for elastic J/ψ production.

- The ϕ/ρ^0 cross section ratio rises with Q^2. At high Q^2 the ratio is consistent with the expectation from quark charge counting.

- The ratio of longitudinal to transverse cross sections, determined under the assumption that SCHC holds, shows a non-linear rise with Q^2.