Photon 97

13 May 1997

Egmond aan Zee

The Netherlands

Recent Results from Investigations of Diffractive Vector Meson Production with the ZEUS Detector at HERA

J. A. Crittenden

Physikalisches Institut
Universität Bonn

Outline

Kinematic Variables

Electroproduction of ρ^0 Mesons
at Intermediate and High Q^2

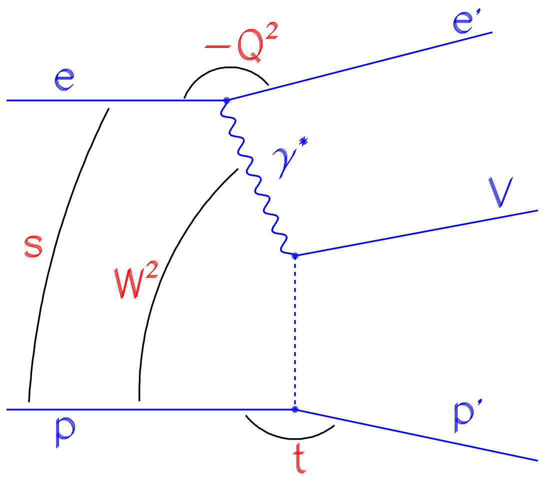
Photoproduction of ρ^0, ϕ, and J/ψ Mesons at High $|t|$

Elastic Production of J/ψ Mesons at Low and High Q^2

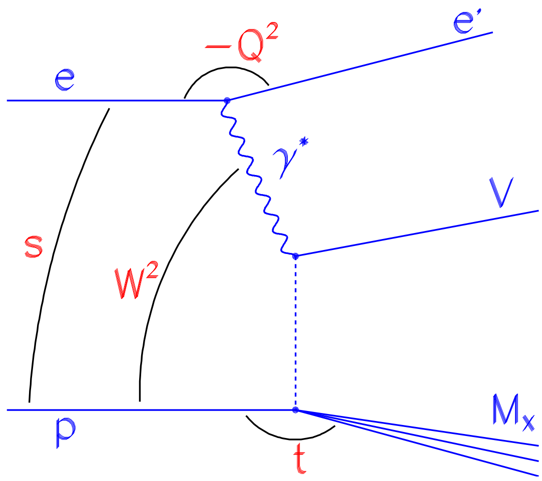
Summary and Conclusions

Diffractive Electroproduction of Vector Mesons

Elastic



Proton Dissociative



$\sqrt{s}$: Center–of–mass energy of e–p system (300 GeV)

W: Center–of–mass energy of γ^*–p system (20 – 130 GeV)

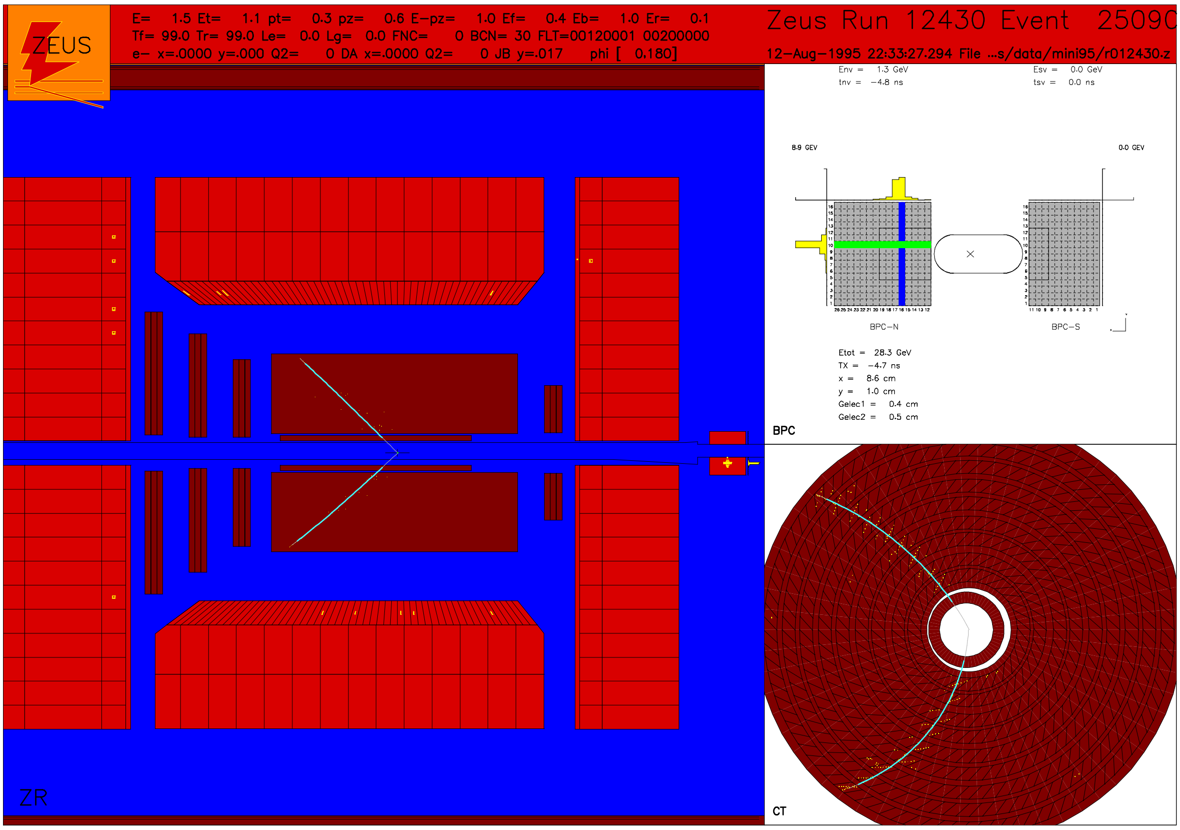
Q^2: Photon Virtuality (10^{-10} – 20 GeV^2)

t: Square of Momentum Transfer at the Proton Vertex ($0 < |t| < 4$ GeV^2)

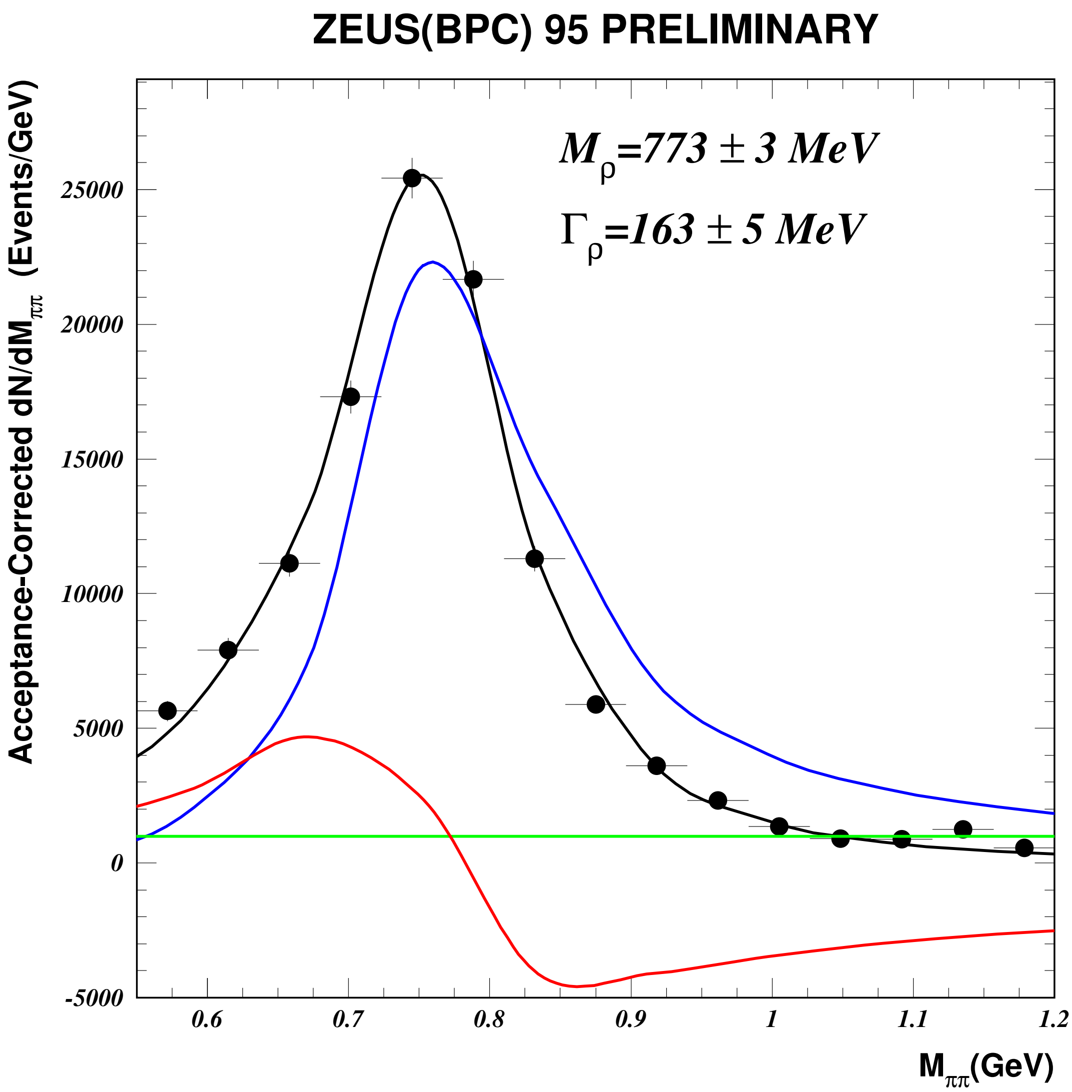
Can the hard scale necessary for perturbative QCD calculations be set by <u>either</u> Q^2, M_V^2, <u>or</u> $|t|$??

What experimental signatures for the region of pQCD validity ?

Diffractive Production of ρ^0 Mesons

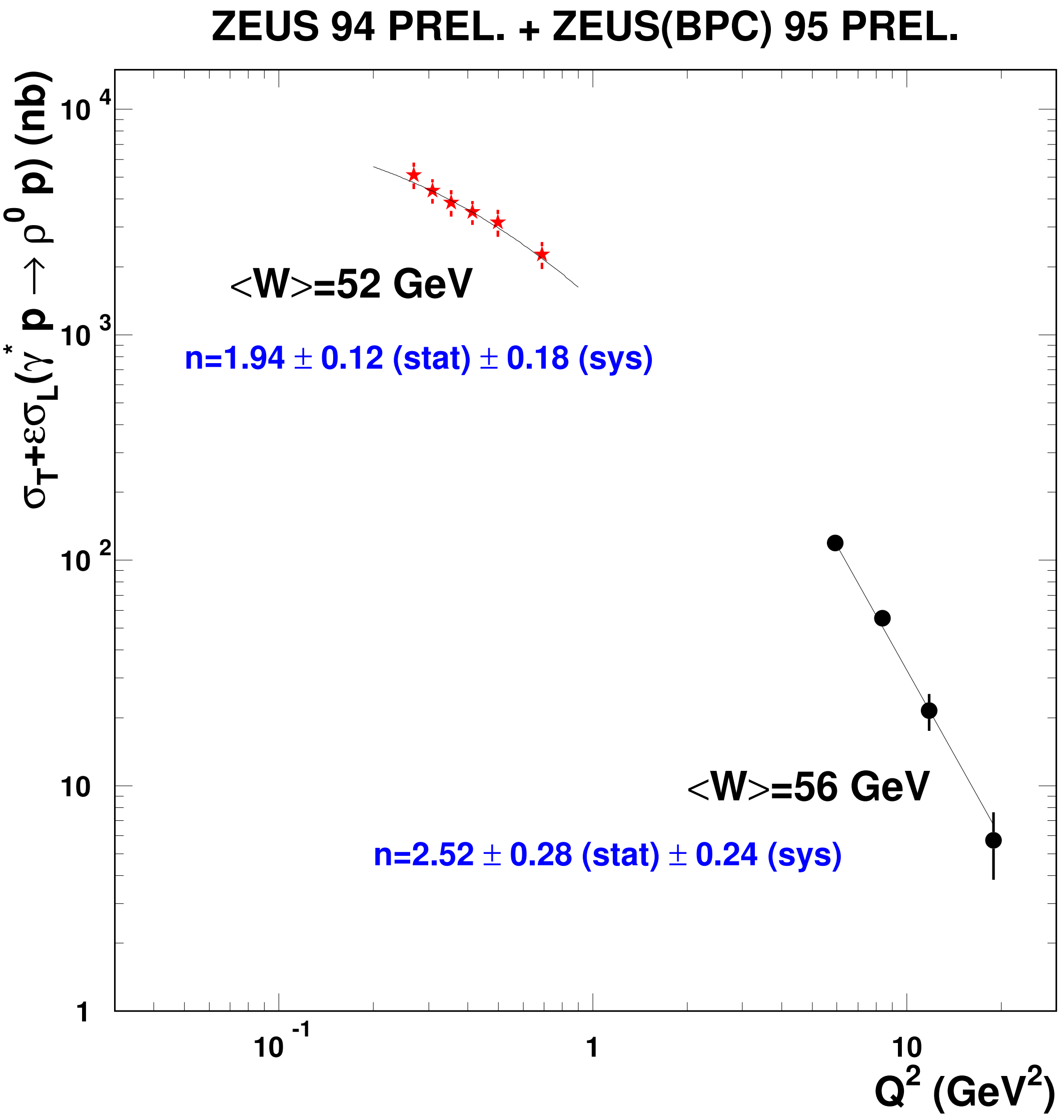


e$^+$ in BPC	e$^+$ in UCAL
1995: 3.8 pb^{-1}	1994: 2.6 pb^{-1}
$0.25 < Q^2 < 0.85$ GeV^2	$5 < Q^2 < 30$ GeV^2
$20 < W_{\gamma^* p} < 90$ GeV	$42 < W_{\gamma^* p} < 134$ GeV
$\simeq$ 6000 events	$\simeq$ 750 events



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

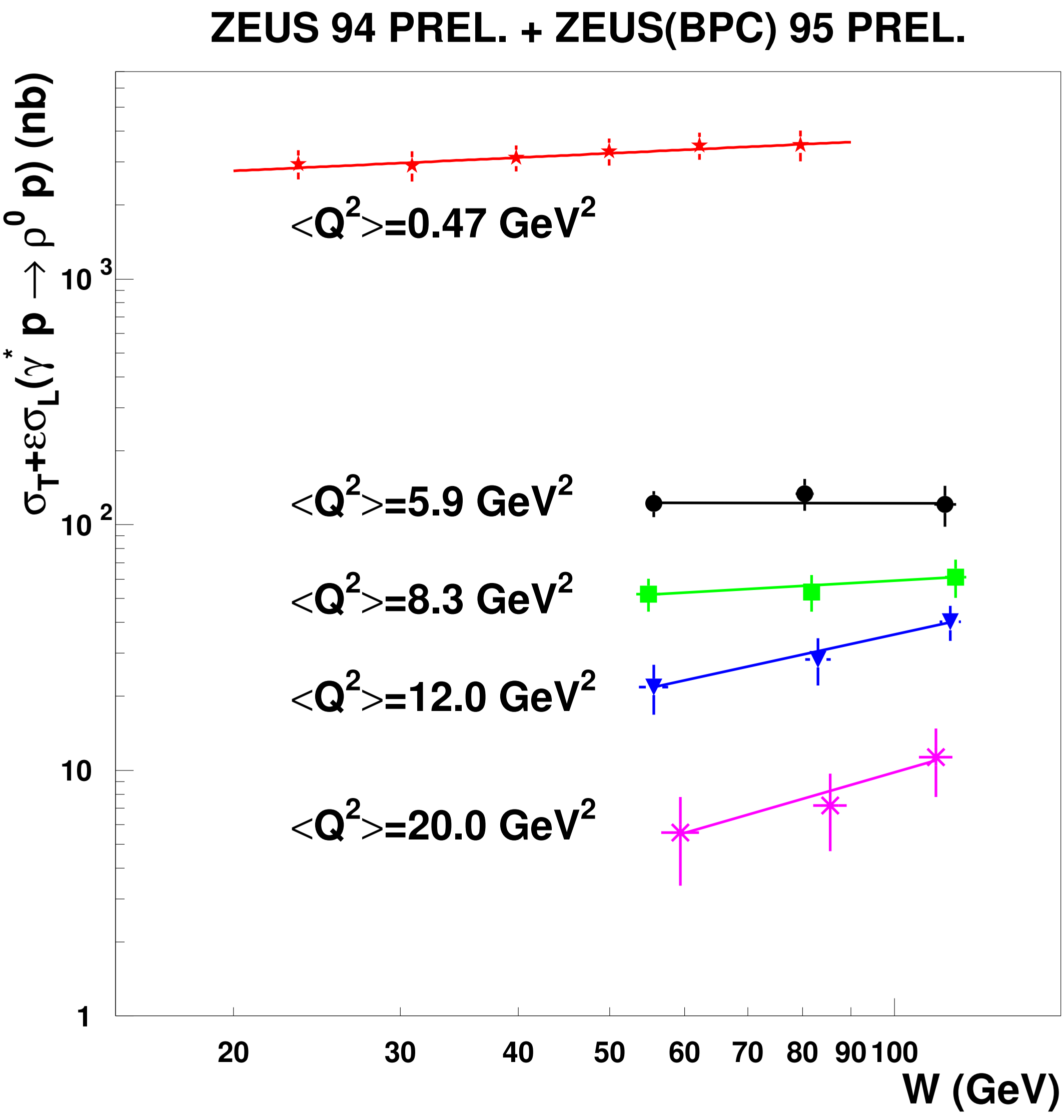
$\sigma_T + \epsilon\,\sigma_L(\gamma^* p \to \rho^0 p)$



Fit to the shape $(Q^2 + M_\rho^2)^{-n}$

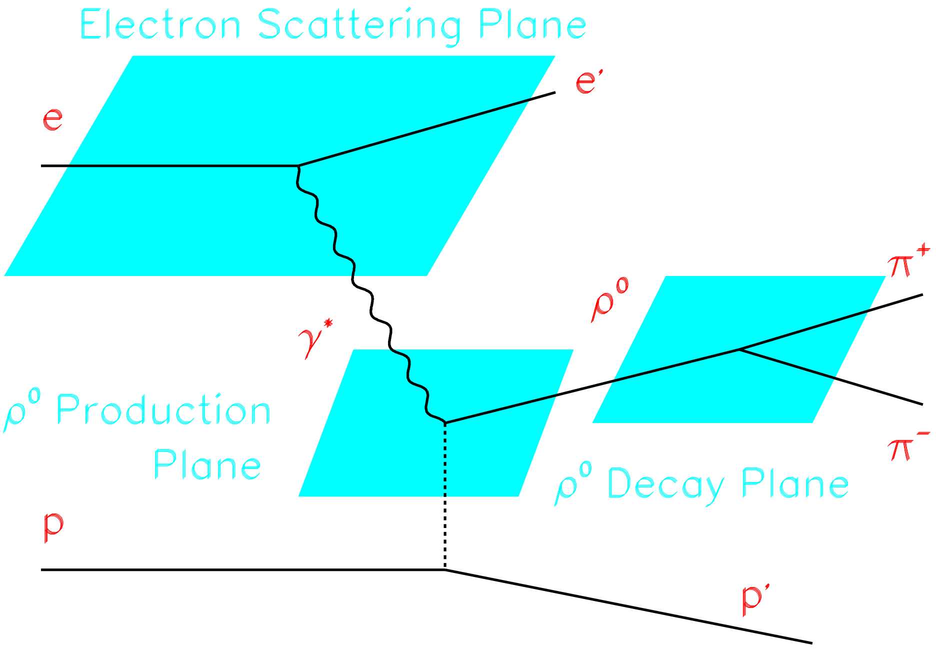
but notice the mixture of σ_L and σ_T ($\epsilon \simeq 1$) ...

$$\sigma_T + \epsilon\, \sigma_L(\gamma^* p \to \rho^0 p)$$



Does the energy dependence steepen with Q^2 ??

Helicity Analyses



Φ_h Angle between the electron scattering plane and the ρ^0 production plane

θ_h Polar angle of π^+ in the ρ^0 rest frame

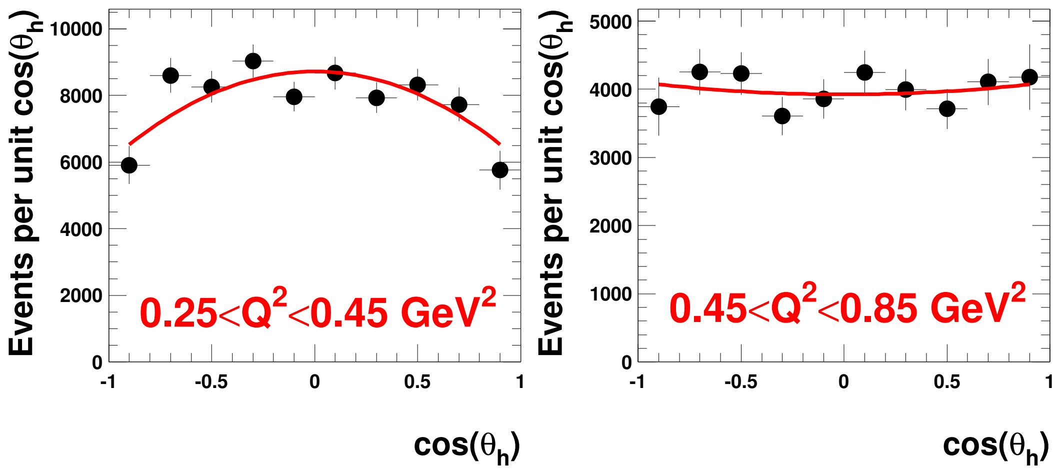
ϕ_h Azimuthal angle of π^+

If helicity is conserved in the γ/ρ^0 transition, then the decay angular distributions depend only on the difference $\psi_h = \phi_h - \Phi_h$.

r^{04}_{00}: Probability that ρ^0 is produced with helicity 0

$$\frac{dN}{d\cos\theta_h} \propto 1 - r^{04}_{00} + (3r^{04}_{00} - 1)\cos^2\theta_h$$

ZEUS 94 PREL. + ZEUS(BPC) 95 PREL.

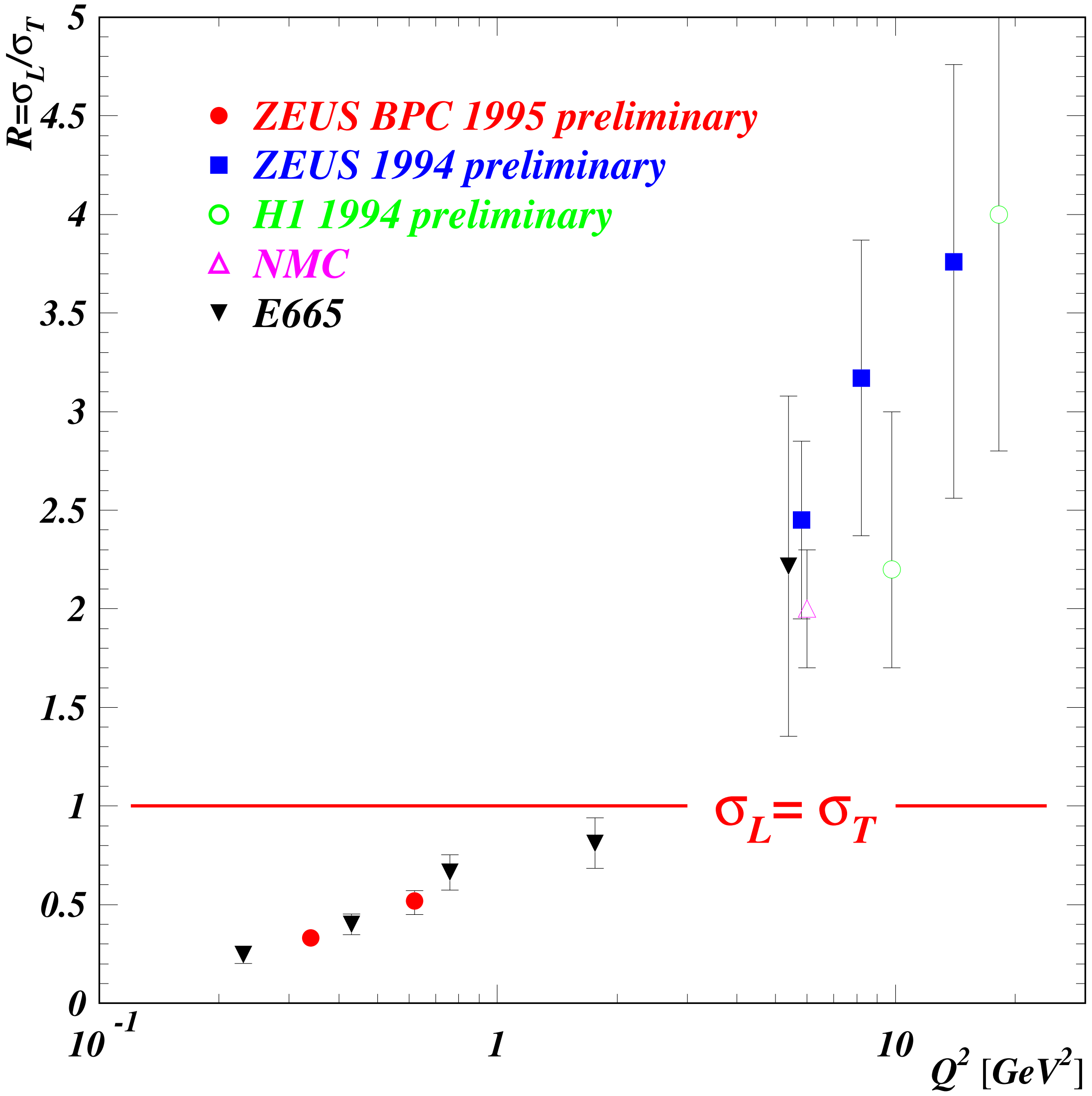


Q^2 (GeV^2)	r^{04}_{00}
0.34	0.24 ±0.02(stat)
0.62	0.34 ±0.03(stat)
5.8	$0.71^{+0.03}_{-0.04}$(stat)$^{+0.01}_{-0.01}$(sys)
8.2	$0.76^{+0.04}_{-0.04}$(stat)$^{+0.00}_{-0.02}$(sys)
14	$0.79^{+0.04}_{-0.05}$(stat)$^{+0.02}_{-0.01}$(sys)

$$\boxed{R = \frac{\sigma_L}{\sigma_T} \text{ vs } Q^2}$$

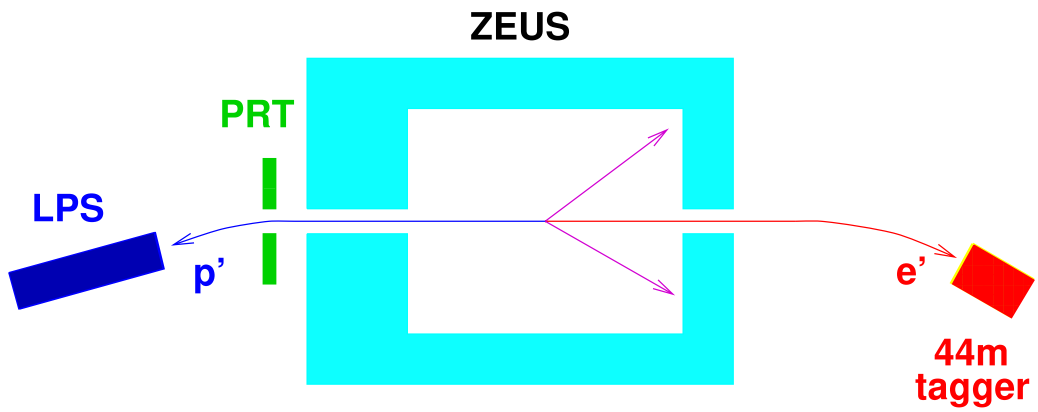
Assuming s–channel helicity conservation:

$$R = \frac{1}{\epsilon} \frac{r^{04}_{00}}{1 - r^{04}_{00}}$$



44m Tagger

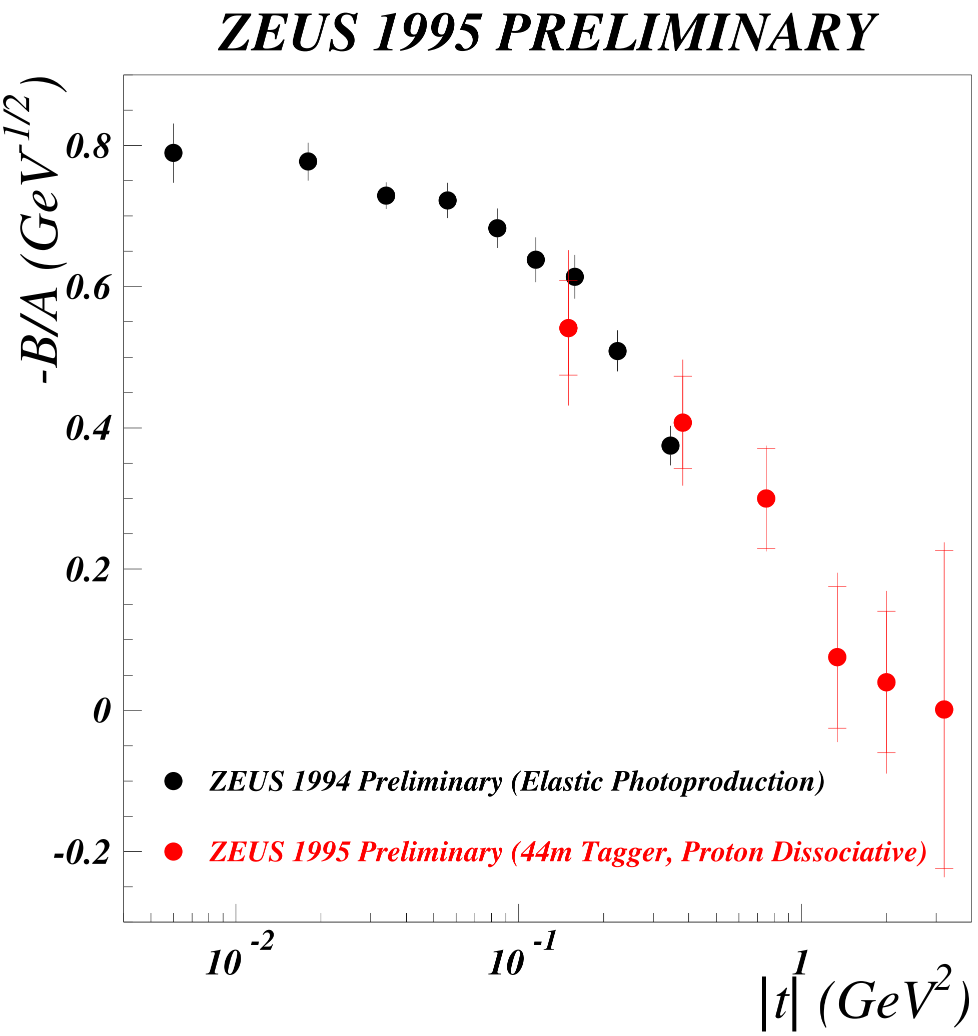
$$|t| \simeq Q^2 + p_T^2(\rho^0)$$



e^+ in 44m Tagger	Untagged Sample
1995: 2.1 pb^{-1}	1994: 2.2 pb^{-1}
$10^{-5} < Q^2 < .01$ GeV^2	$10^{-10} < Q^2 < 4$ GeV^2
$85 < W_{\gamma^* p} < 105$ GeV	$50 < W_{\gamma^* p} < 100$ GeV
$\|t\| < 4$ GeV^2	$\|t\| < 0.5$ GeV^2
$\simeq 3k$ events	$\simeq 80k$ events
(primarily proton dissociative)	(primarily elastic)

ρ^0 Mass Spectrum Skewing vs. $|t|$

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

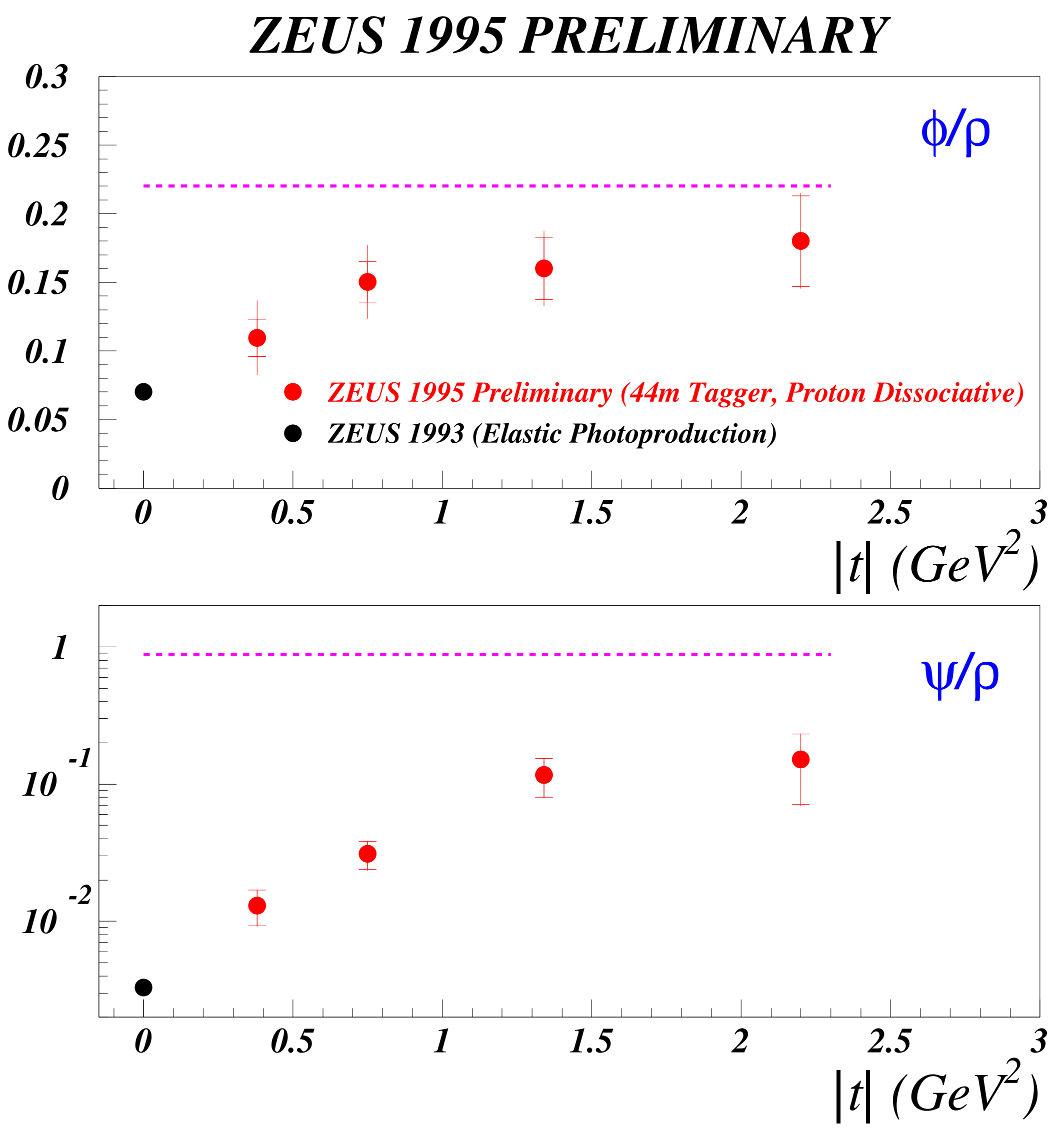


Vector Meson Production Ratios

If direct e–m coupling to quarks without form factors

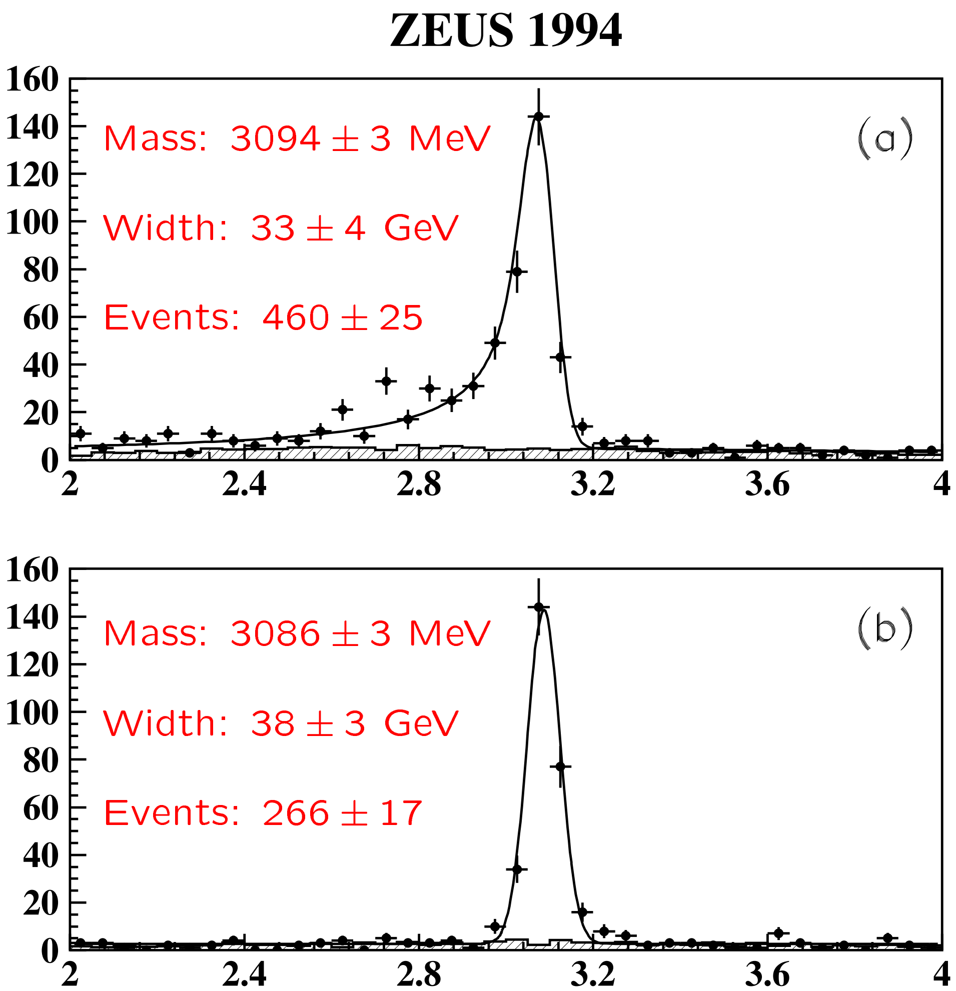
$$\rho^0 \;:\; \omega \;:\; \phi \;:\; J/\psi$$

$$9 \;:\; 1 \;:\; 2 \;:\; 8$$

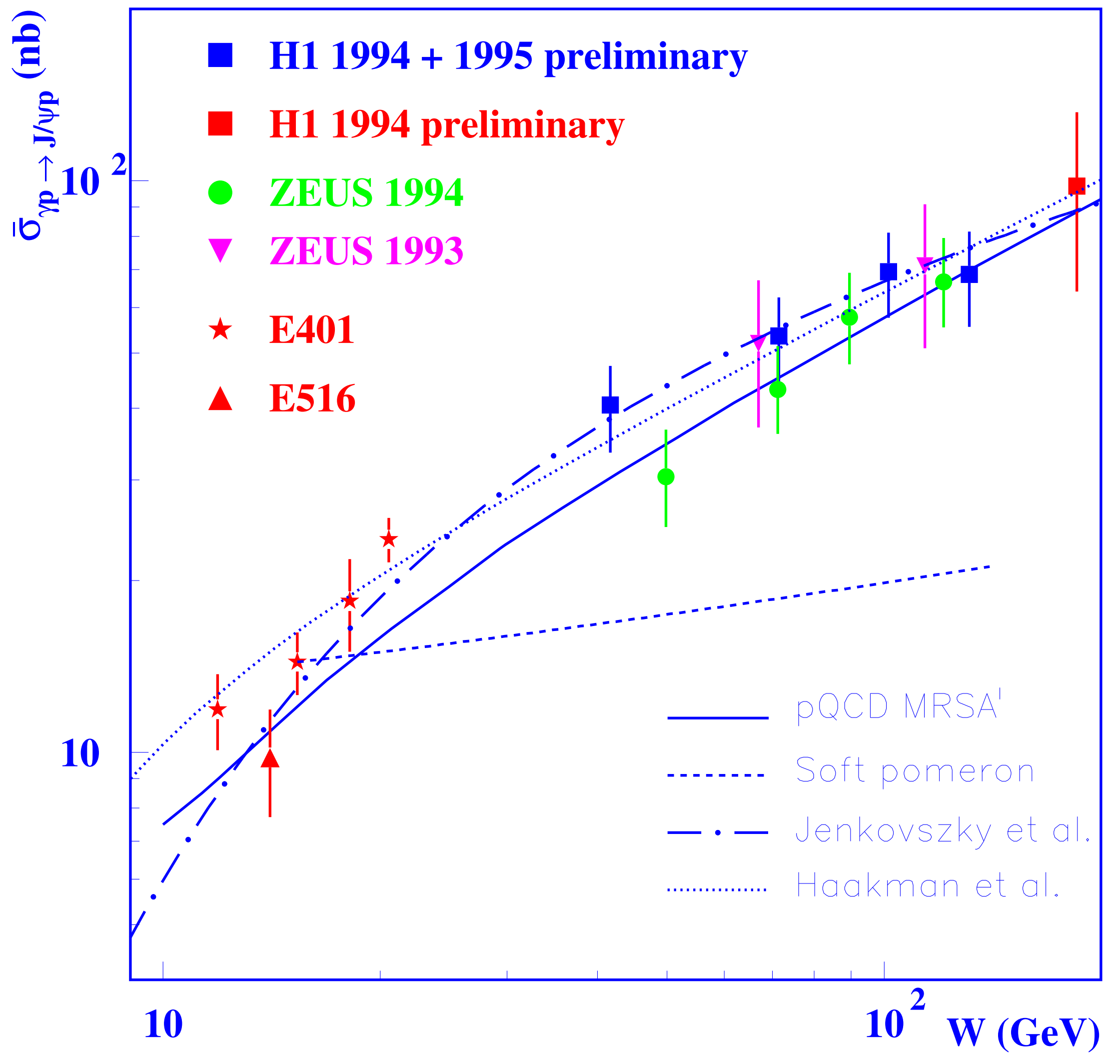


Photoproduction of J/ψ Mesons

$(\langle Q^2 \rangle \lesssim 0.1$ GeV$^2)$ hep–ex/9704013



Photoproduction of J/ψ Mesons

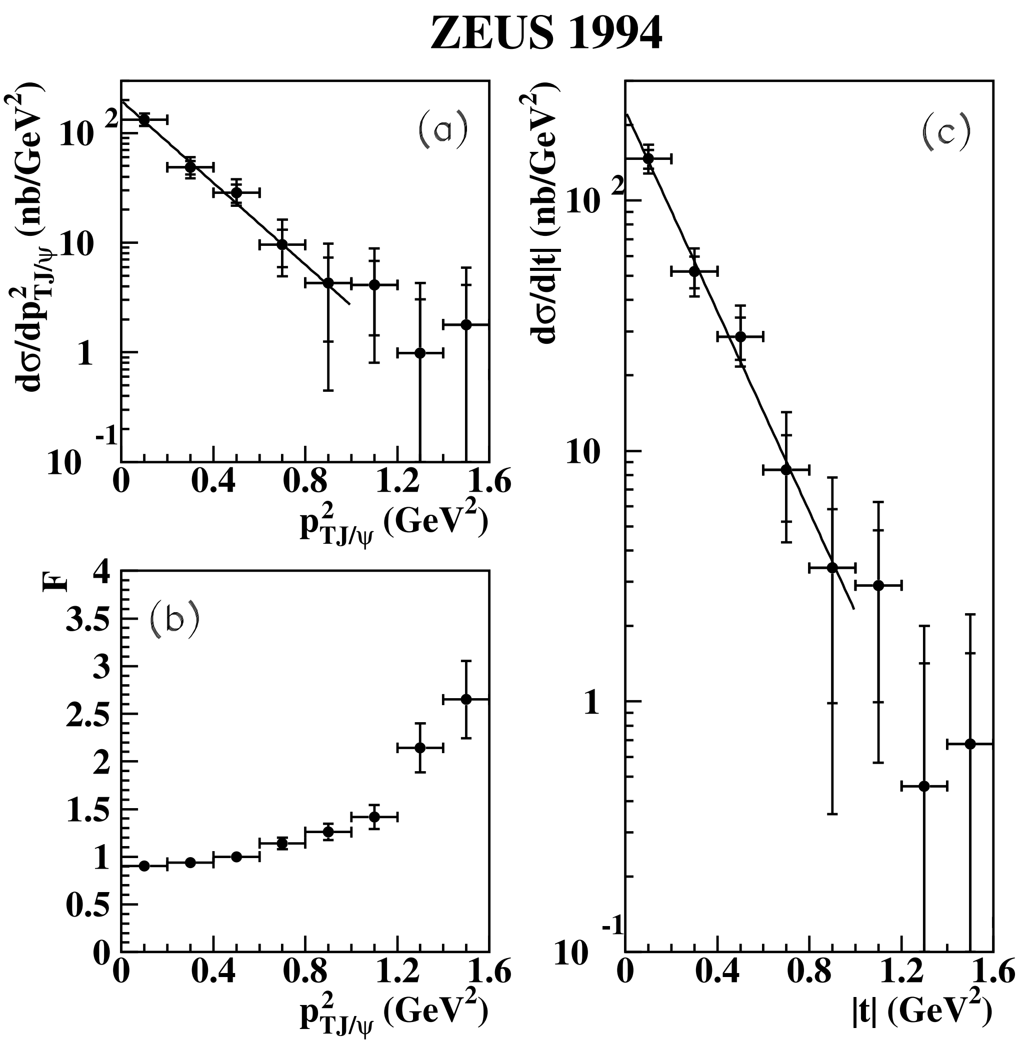


Steep energy dependence for J/ψ at low Q^2

$\rightarrow$ Mass provides the hard scale

Photoproduction of J/ψ Mesons

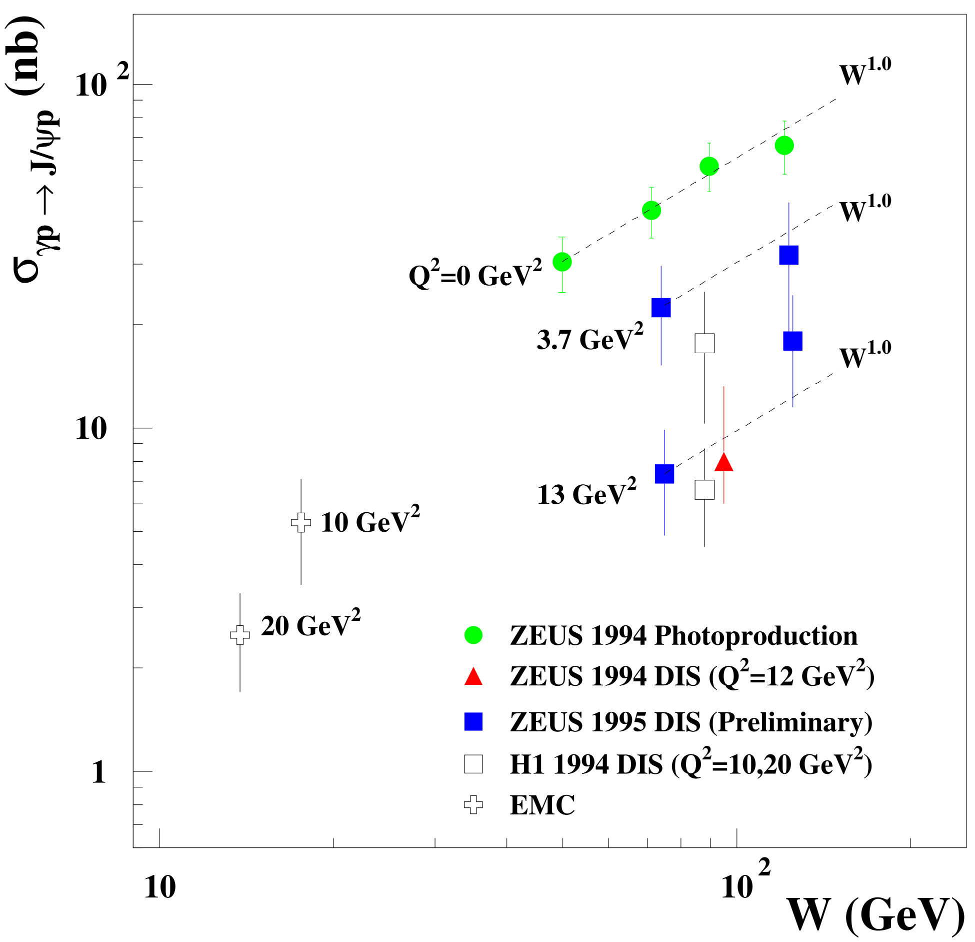
The Exponential Slope in $|t|$



$$b_{J/\psi} = 4.6 \pm 0.4\,(stat)^{+0.4}_{-0.6}\,(sys)\ \mathrm{GeV}^{-2}$$

(Reminder : $b_{\rho^0} = 9.8 \pm 0.8\,(stat) \pm 1.1\,(sys)\ \mathrm{GeV}^{-2}$)

J/ψ Mesons in DIS



Summary

- Results for ρ^0 at Intermediate Q^2
  - ρ^0 mass spectrum skewing measured
  - Q^2 dependence consistent with $(Q^2 + M_V^2)^{-\mathrm{n}}$

    But need to separate σ_L and σ_T
  - Helicity analyses show consistency with SCHC
  - The Q^2–dependence of σ_L/σ_T has been measured

    σ_L dominates for $Q^2 \gtrsim 2$ GeV
    Consistency with low–energy E665 results in μp

- Results for ρ^0, ϕ, and J/ψ Mesons at High $|t|$
  - Nonresonant background decreases with $|t|$
  - Ratios of ϕ and J/ψ production to ρ^0 increase with $|t|$

- Results for J/ψ Mesons at Low and High Q^2
  - Energy dependence as seen with ZEUS data alone *inconsistent* with simple soft diffractive production mechanism
  - Exponential slope of t–dependence shows the J/ψ to be smaller than the ρ^0

Conclusions

These results show preliminary evidence for the hard scale to be given by either Q^2, M_V^2, or $|t|$

The ZEUS experiment is sensitive to the transition region in ***EACH*** of these variables

These studies are statistics–limited