Low-x Workshop DESY/Zeuthen

5 June 1998 Berlin

Recent Results on Vector Meson Production from ZEUS

- Electroproduction of ρ and ϕ Mesons
- Heavy Quarkonia
- High $|t|$ and $\alpha'_{I\!P}$

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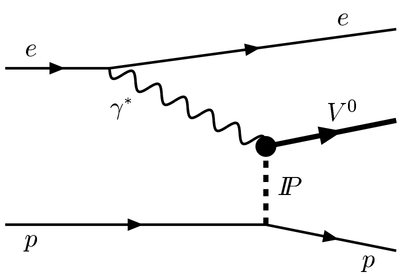
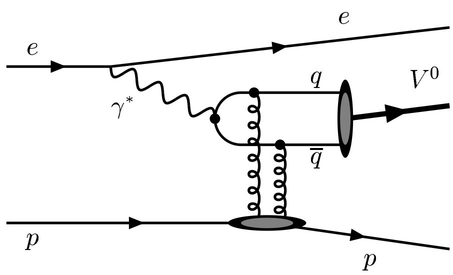
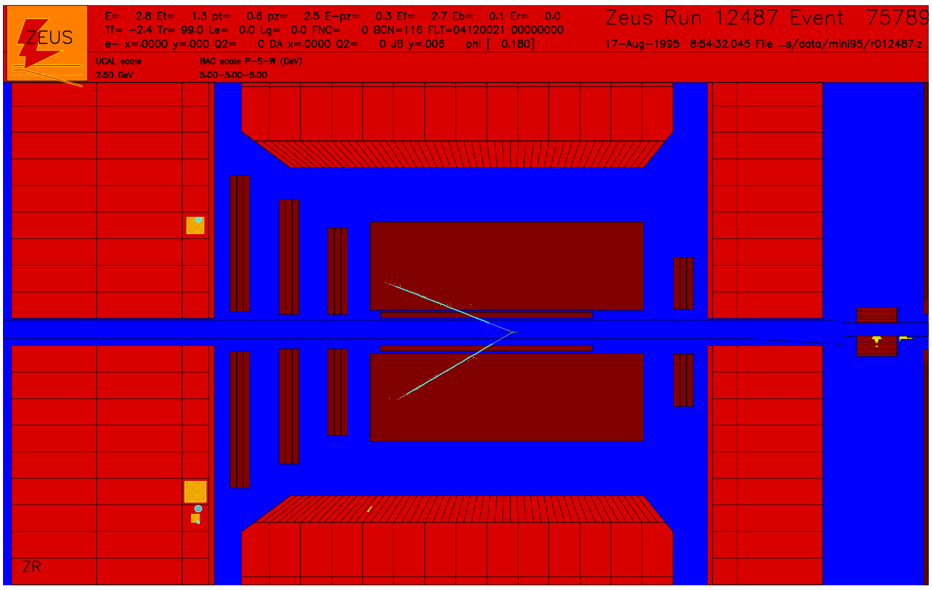
Elastic Vector-Meson Production



$$\frac{\mathrm{d}\sigma}{\mathrm{d}|t|} \propto e^{b_0 t}\, W^{4(\alpha_{I\!P}(t)-1)}$$



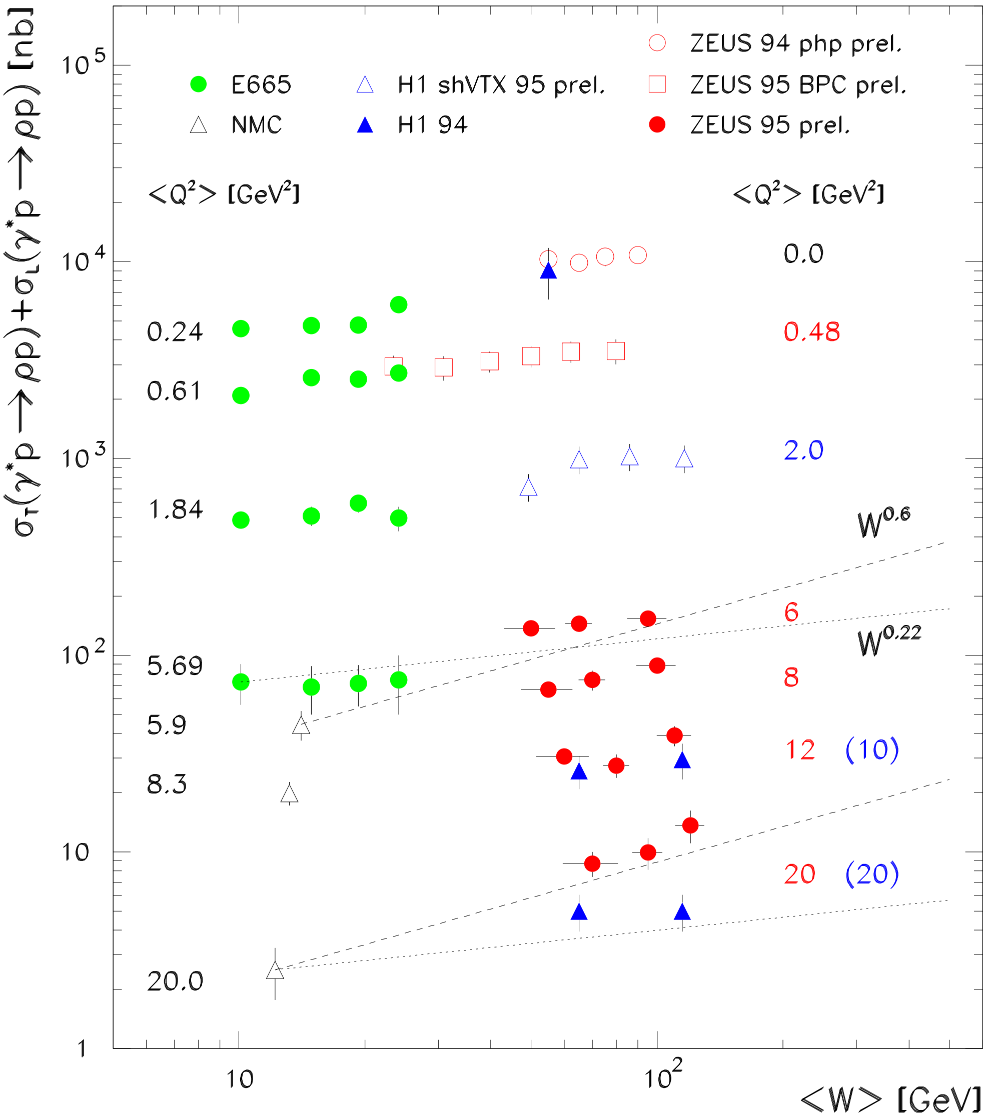
$$\left.\frac{\mathrm{d}\sigma_{\mathrm{L}}}{\mathrm{d}|t|}\right|_{t=0} \propto \frac{\alpha_s^2(\bar{Q}^2)}{\alpha \bar{Q}^6} \left| \left[1 + \frac{\mathrm{i}\pi}{2} \frac{\mathrm{d}}{\mathrm{d}(\ln x)}\right] xG(x,\bar{Q}^2) \right|^2$$



Example of exclusive vector-meson production

with final-state positron in beam-pipe calorimeter

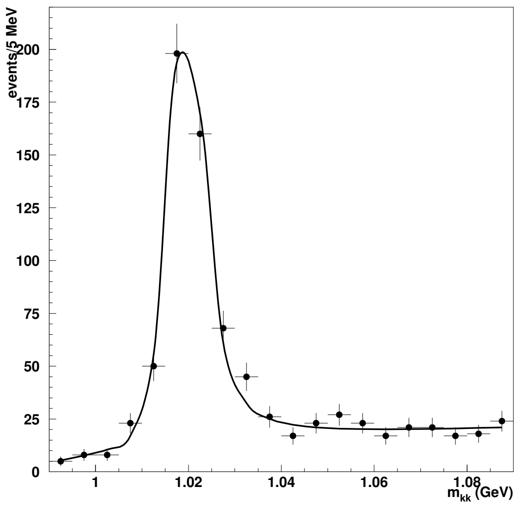
Elastic ρ^0 Cross Sections

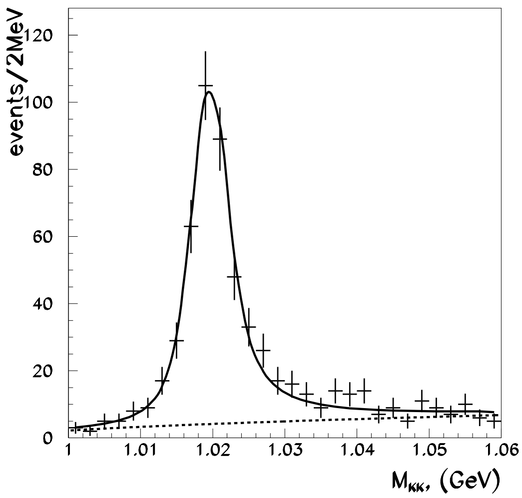


$\Rightarrow$ Experimental discrepancies require further study

Electroproduction of ϕ Mesons

1996 Preliminary



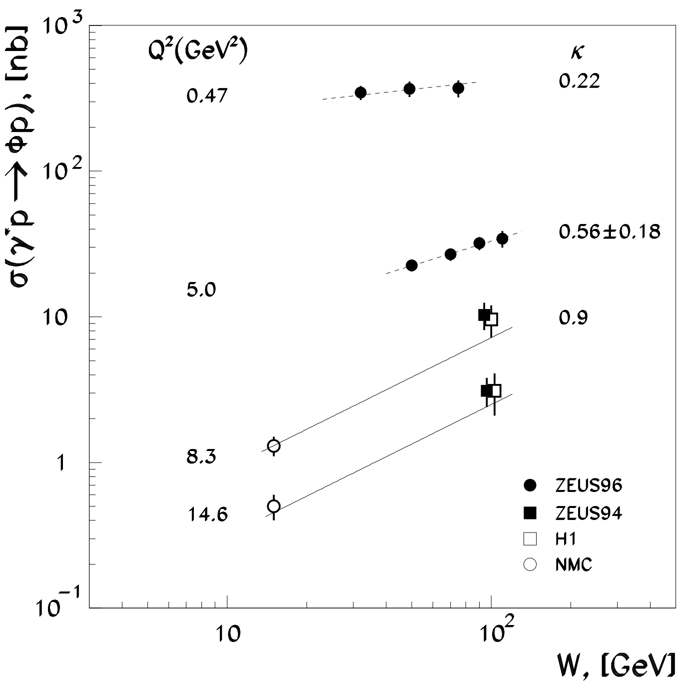


BPC: $0.25 < Q^2 < 0.85\,\mathrm{GeV}^2$

$20 < W < 90$ GeV

DIS: $3 < Q^2 < 20\,\mathrm{GeV}^2$

$40 < W < 140$ GeV

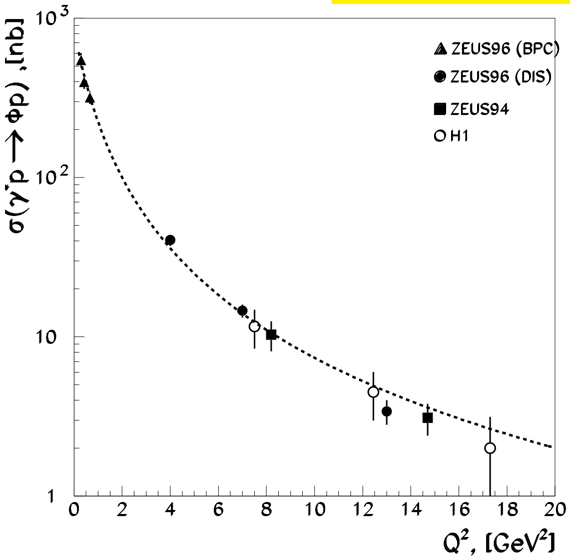


$\sigma \propto W^{\kappa}$

Steep energy dependence for ϕ at high Q^2 !

Electroproduction of ϕ Mesons

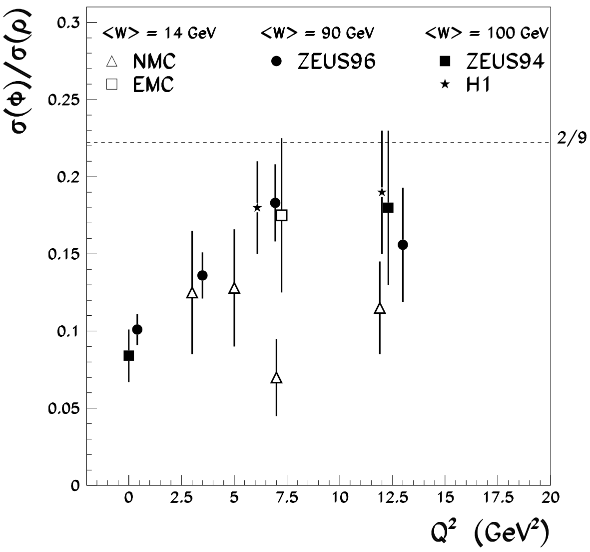
Q^2 dependence



$$\sigma(Q^2) = \sigma(0)\left[1 + \frac{Q^2}{M^2}\right]^{-n}$$

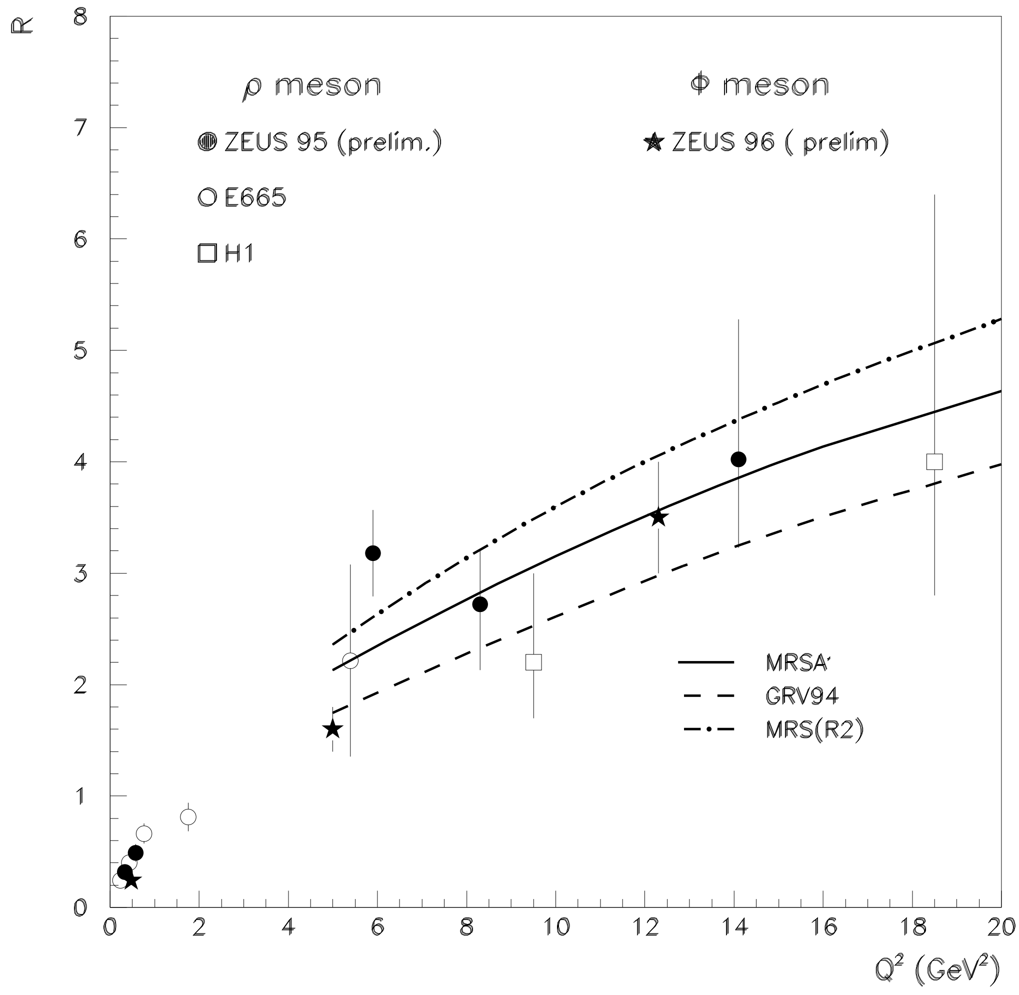
$$n = 2.03 \pm 0.05$$

Ratio of ϕ to ρ^0



$\dfrac{\phi}{\rho}$ increases with Q^2

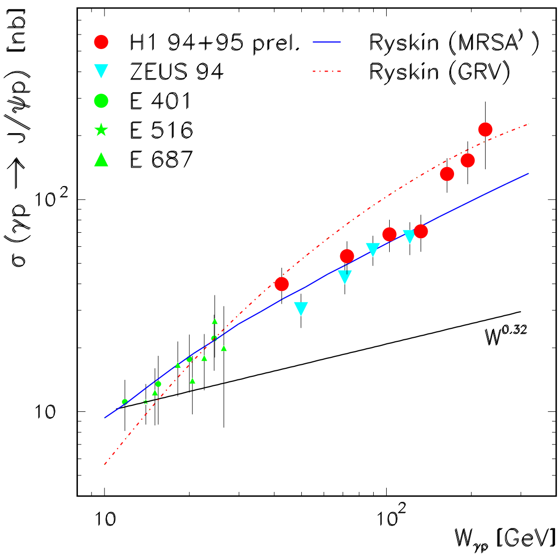
$$R = \frac{\sigma_L}{\sigma_T} \text{ vs } Q^2$$



$\Rightarrow$ R increases with Q^2 for ϕ as well as for ρ^0

Elastic J/ψ Production

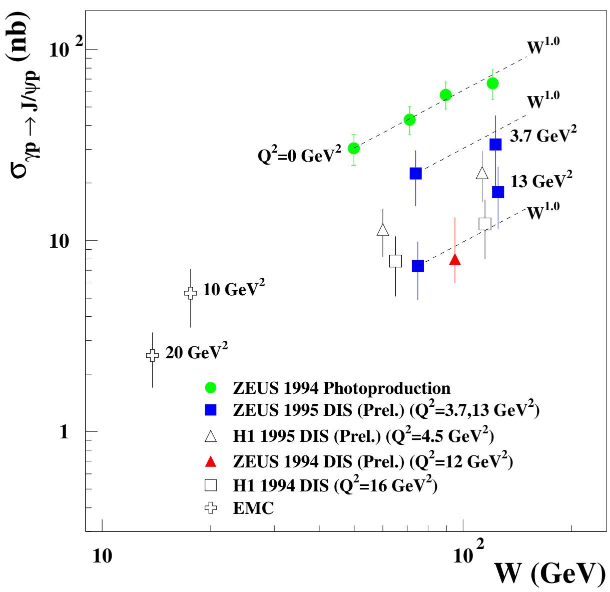
Photoproduction



$\sigma_{J/\psi}$ rises more steeply than σ_ρ, σ_ϕ

Rough agreement with pQCD calculations

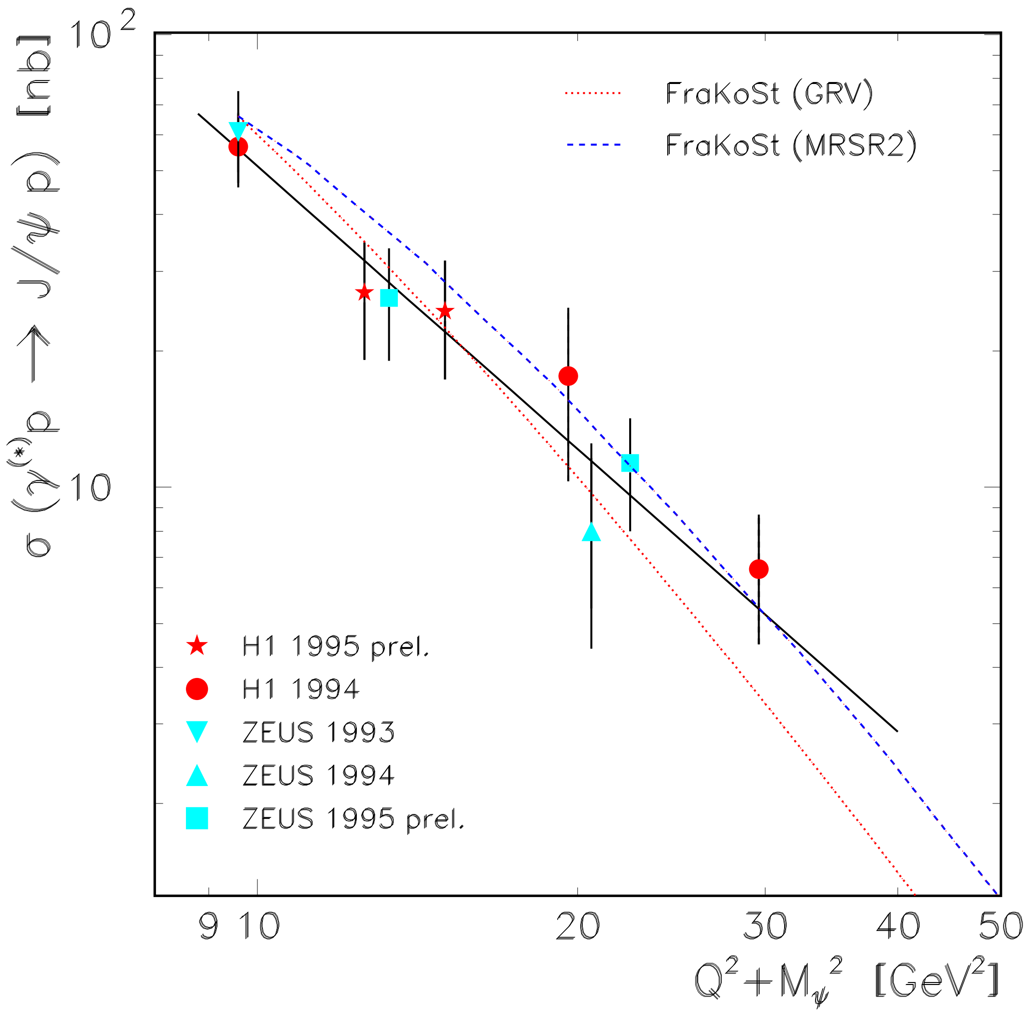
Electroproduction



Slope comparable to photoproduction

Electroproduction of J/ψ Mesons

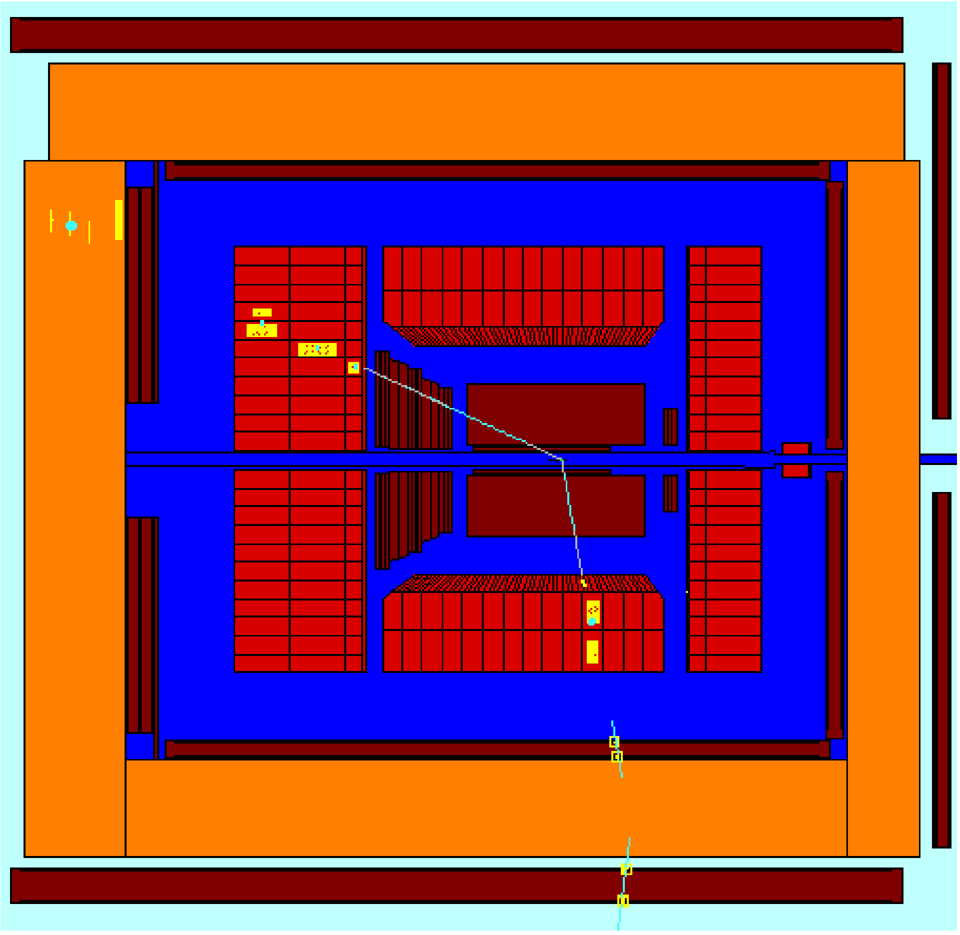
Q^2 dependence



Frankfurt et al., Phys. Rev. **D57** (1998) 512

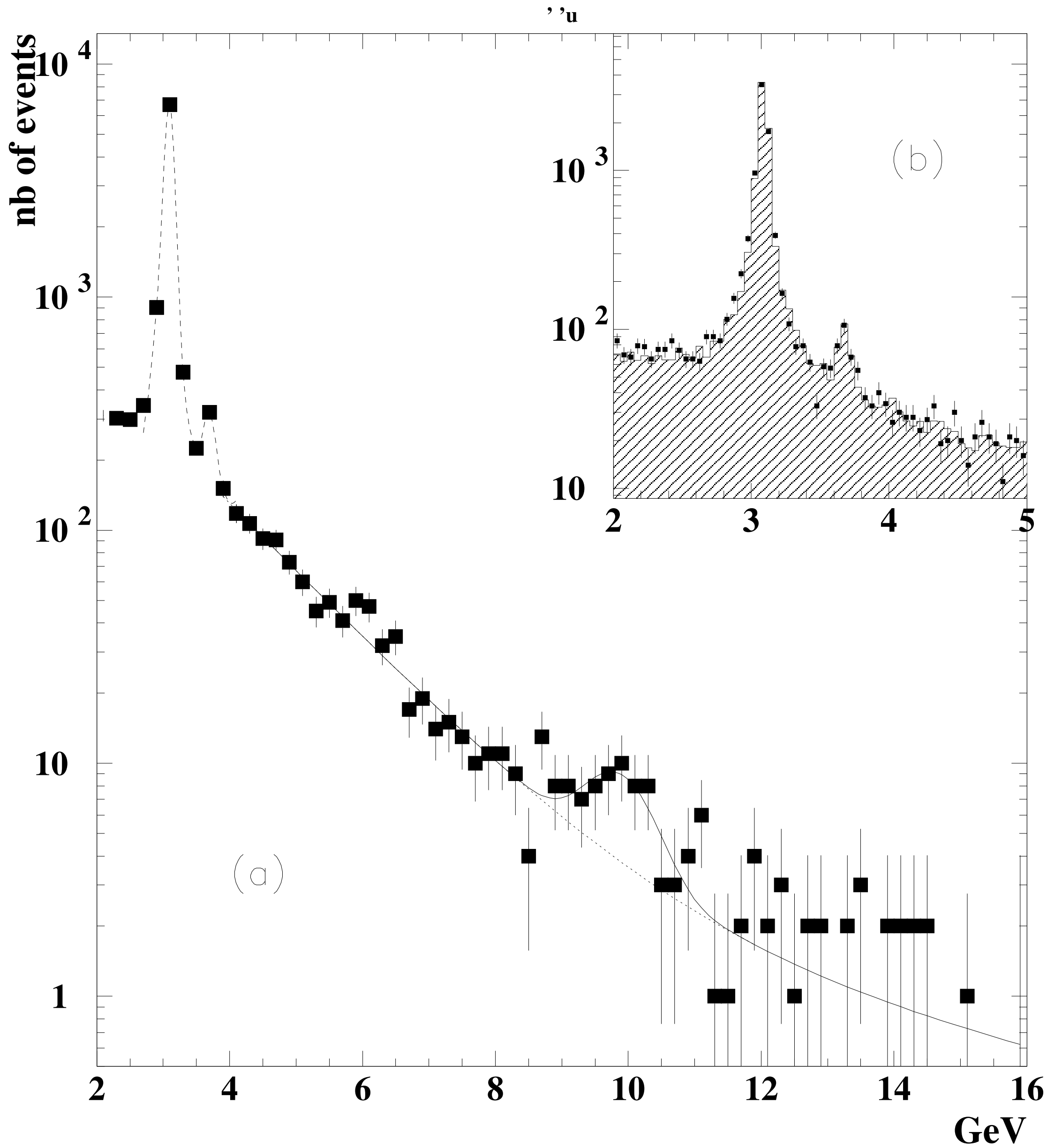
$$\sigma(Q^2) = \sigma(0)\left[1 + \frac{Q^2}{M^2}\right]^{-n} \qquad n = 2.1 \pm 0.1^{+0.4}_{-0.3}$$

1995-97 Elastic $\mu^+\mu^-$ Sample

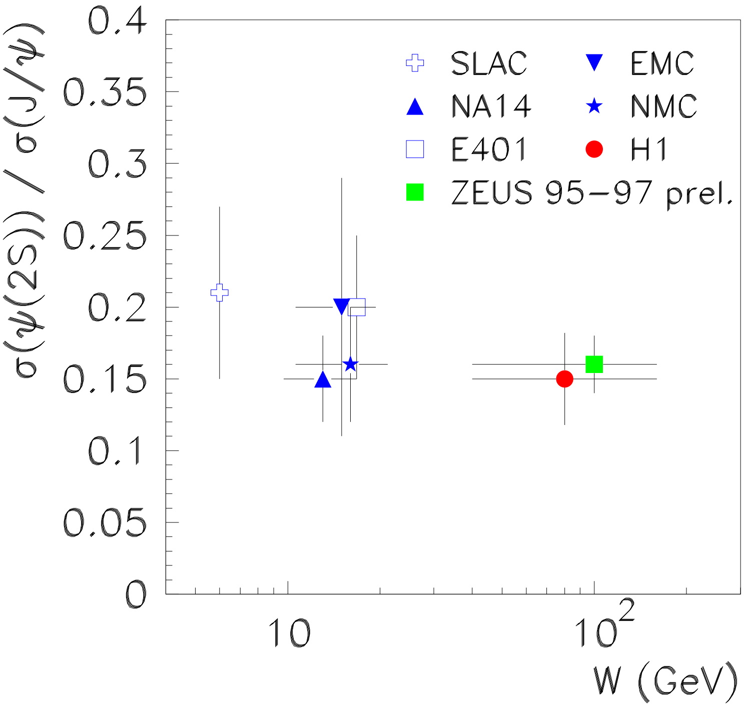


Example of elastic $\mu^+\mu^-$ photoproduction

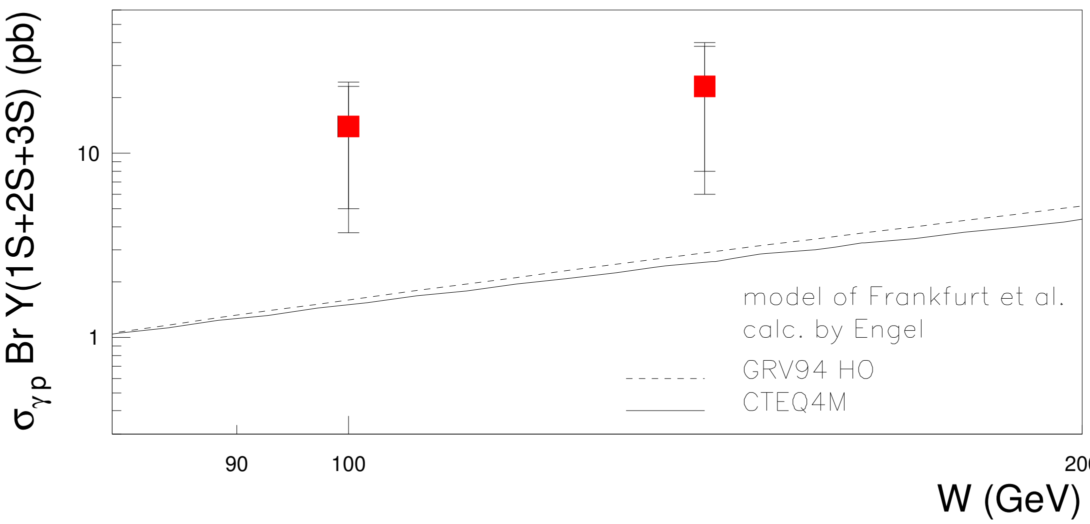
Elastic $\mu^+\mu^-$ Mass Spectrum



Ratio of $\psi(2S)$ to J/ψ

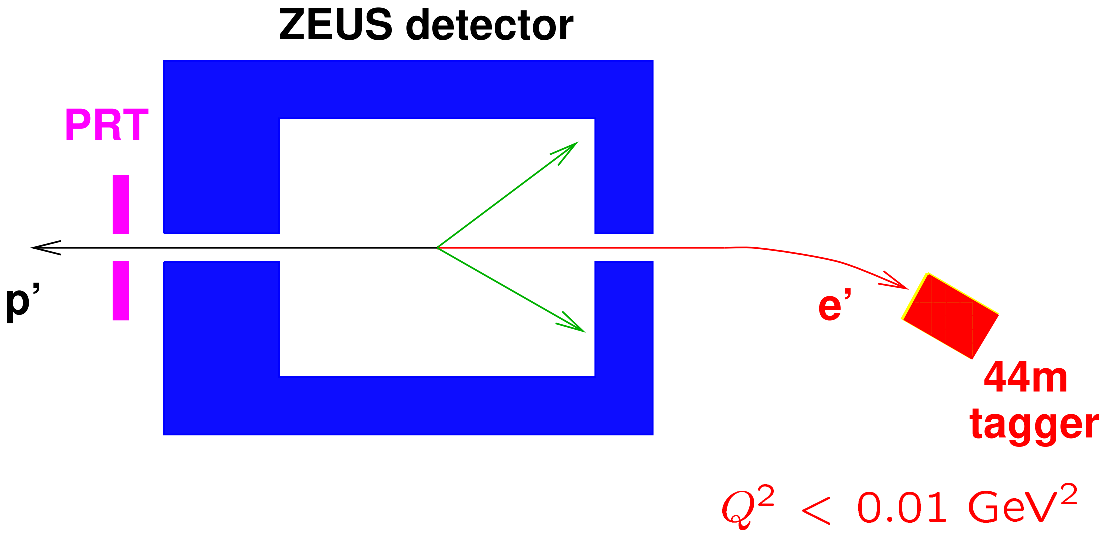


Elastic Υ cross section



Vector Meson Photoproduction at High $|t|$

$$|t + p_T^2(\text{VM})| < Q^2$$



1995

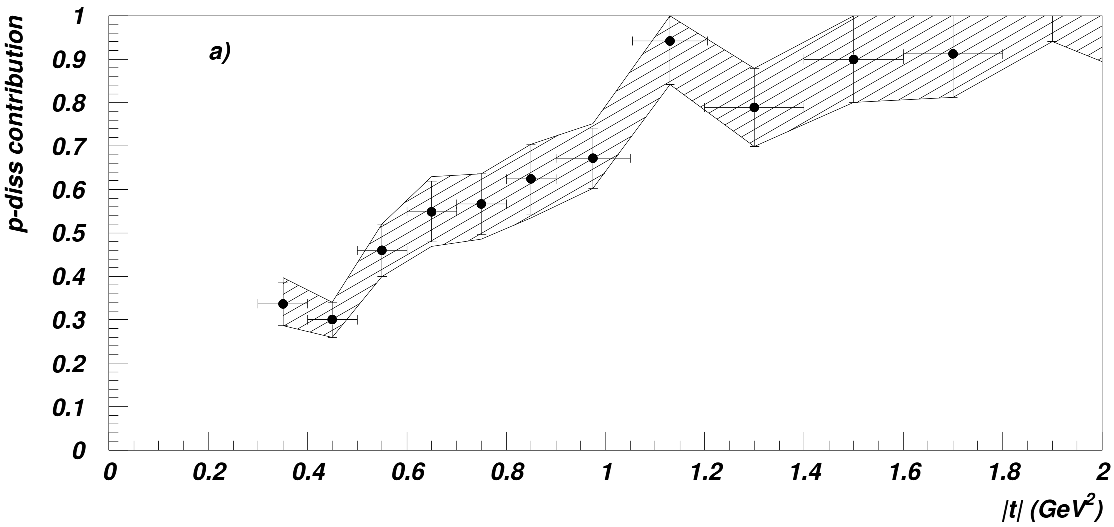
2 pb^{-1}

ρ^0: 23k
ϕ: 373
J/ψ: 120

Proton-Dissociative Contribution

Obtained by comparing relative PRT rates

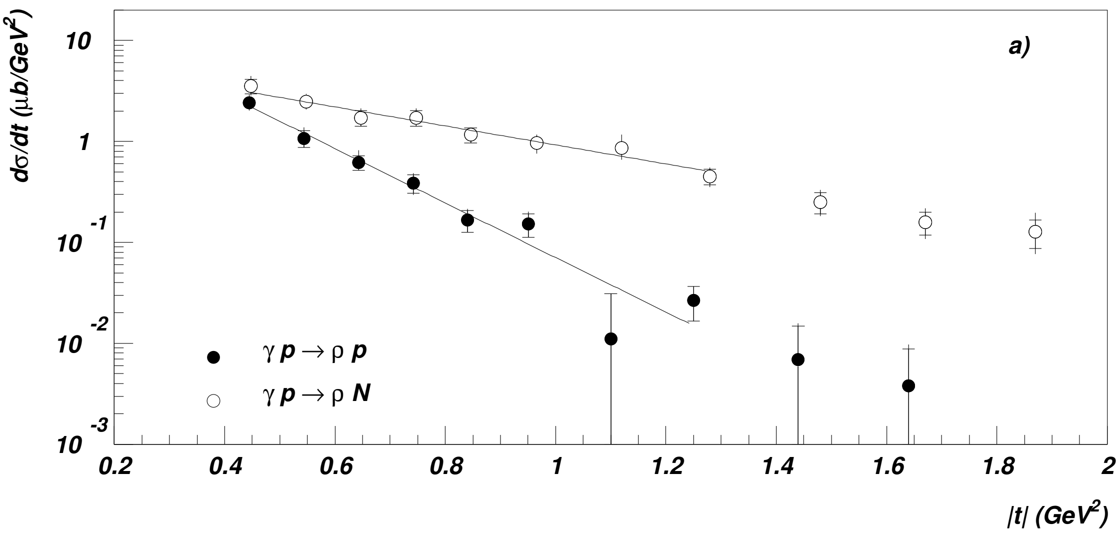
in data and proton-dissociative MC

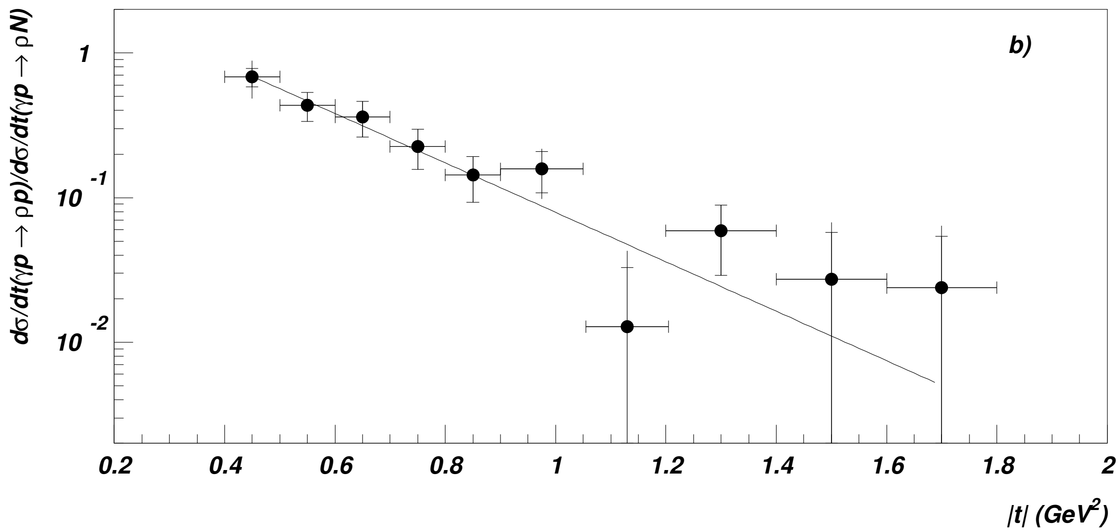


Diffractive ρ^0 photoproduction

Proton dissociation dominates for $|t| > 0.5\,\mathrm{GeV}^2$

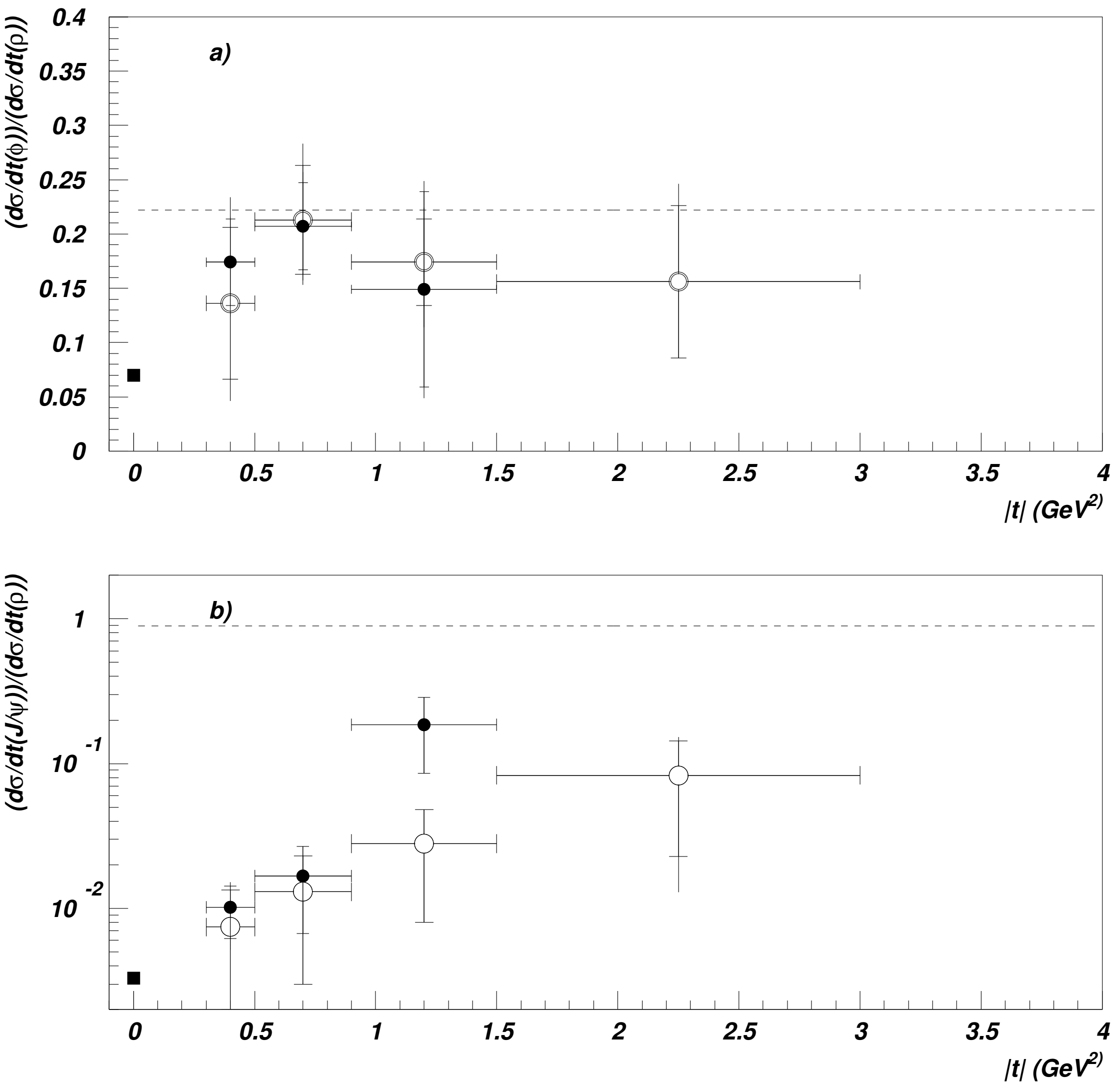
Exponential t-Slopes





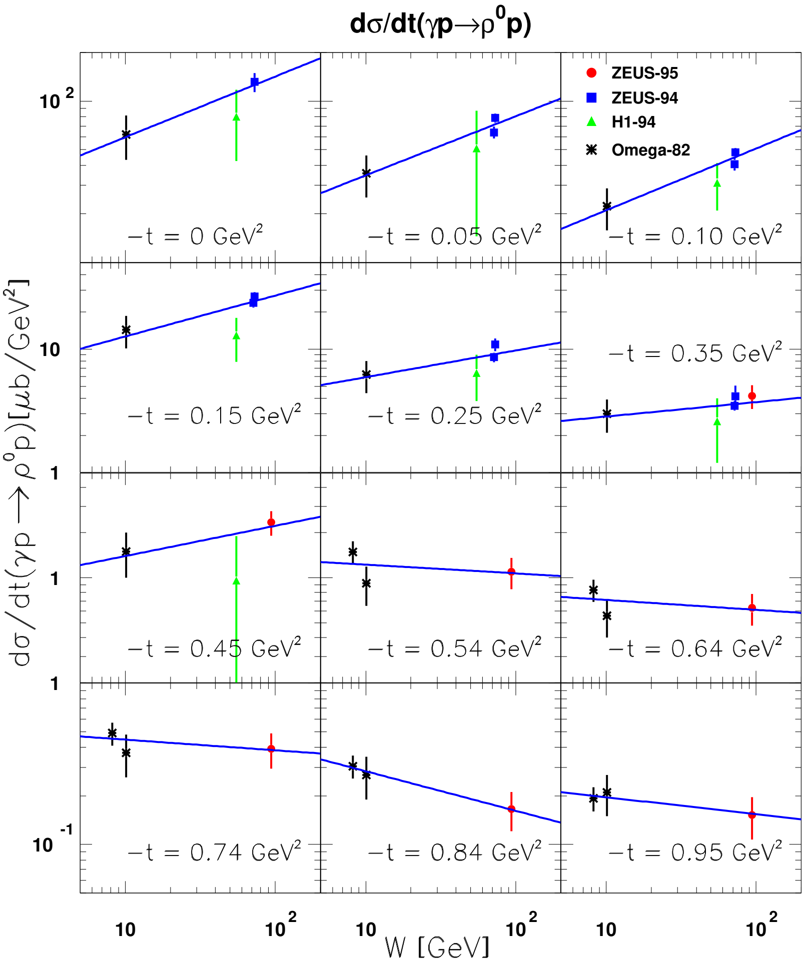
	b_{el}	b_{pdiss}	b_{ratio}	
ρ^0:	6.2 ± 1.0	2.2 ± 0.4	3.9 ± 0.7	GeV^{-2}
ϕ:	5.6 ± 1.0	2.9 ± 0.5	2.7 ± 2.0	GeV^{-2}
J/ψ:	3.1 ± 1.3	1.6 ± 0.5	1.5 ± 1.2	GeV^{-2}

Vector-Meson Production Ratios



Closed circles: Elastic
Open circles: Proton-dissociative

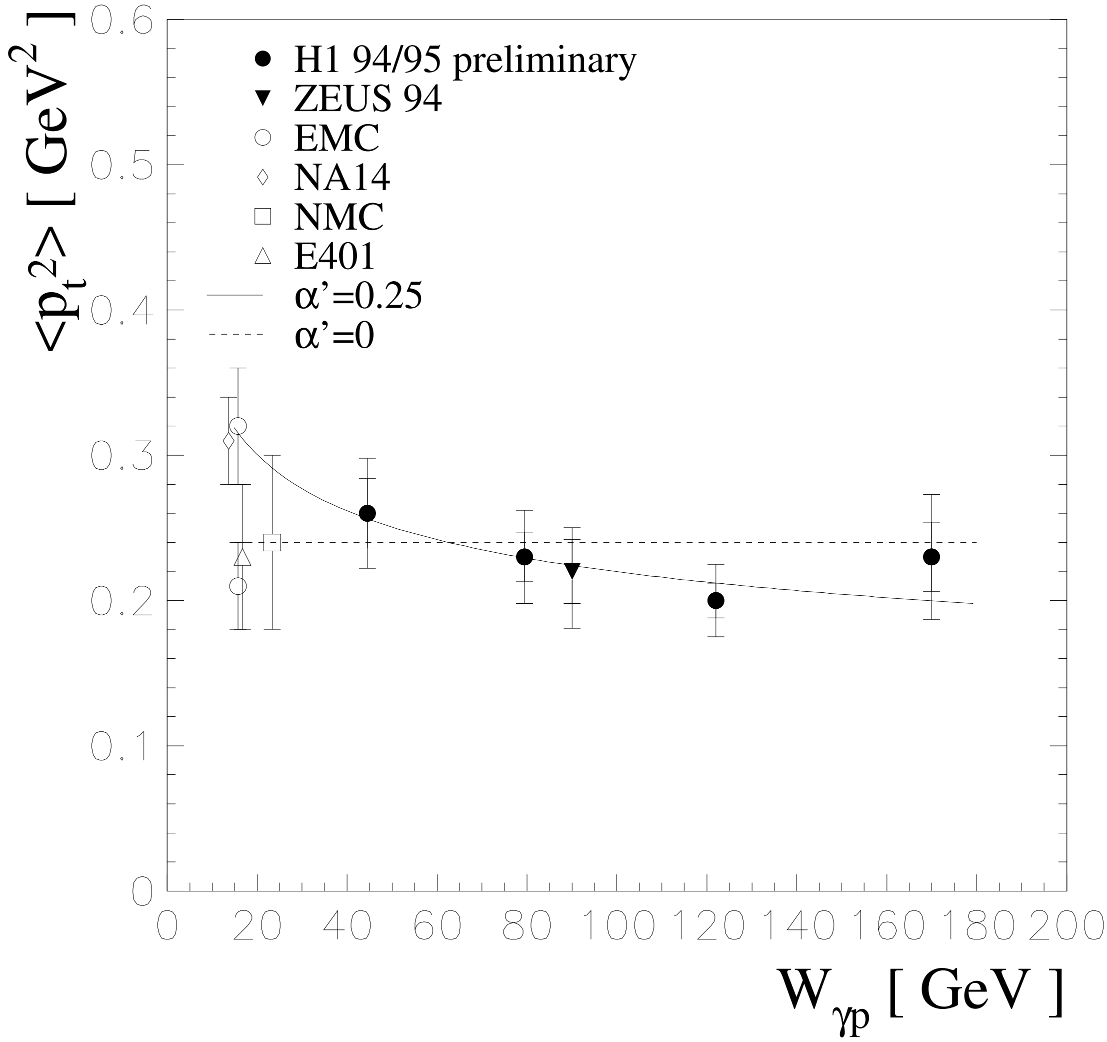
Determining $\alpha_{I\!P}(t)$ Using $\frac{d\sigma}{dt}(W)$



$$\sigma \propto W^{4(\alpha_{I\!P}(t)-1)}, \;\; \alpha_{I\!P}(t) = \alpha_{I\!P}(0) + \alpha'_{I\!P} \cdot t$$

$\Longrightarrow$ Sensitive to transition between rising and falling energy dependence

Determining $\alpha'_{I\!P}$ Using $< p_T^2 >$



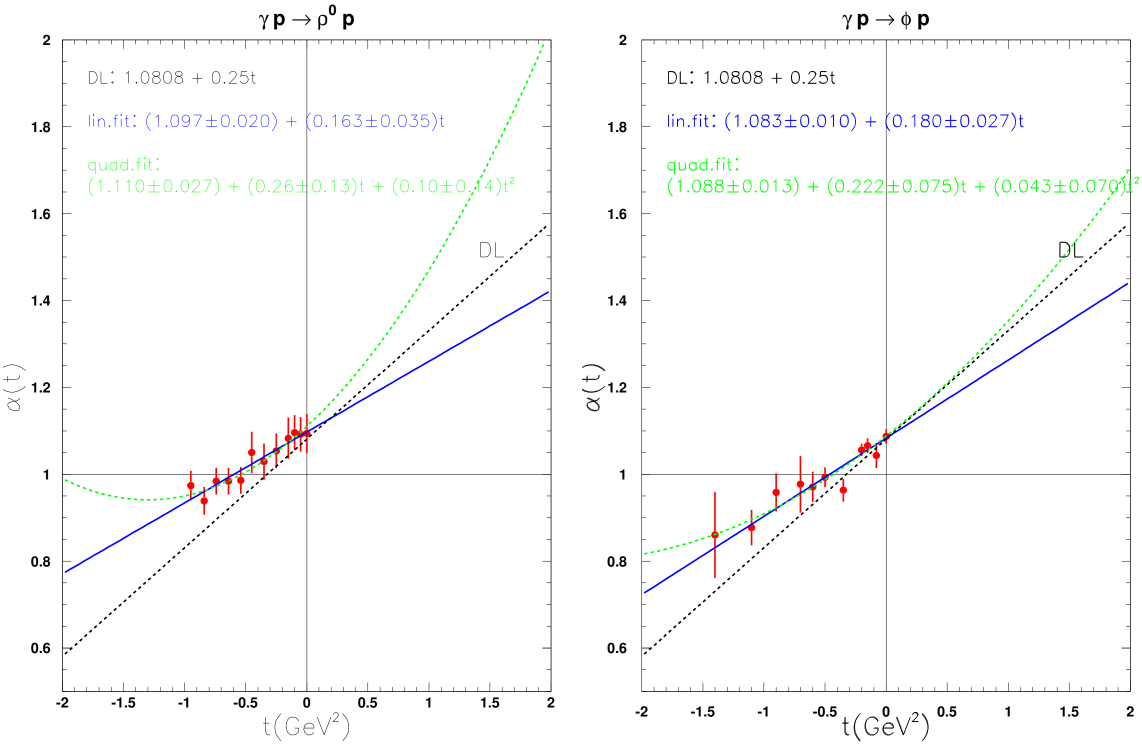
$$\sigma \propto e^{b_0 t} \, W^{4(\alpha_{I\!P}(t)-1)}$$

$< P_T^2 >$ sensitive to b_0

Sensitivity to $\alpha'_{I\!P}$ greatest at low energy

$\Rightarrow$ Inconclusive on shrinkage

Measuring $\alpha_{I\!P}(t)$ with ρ^0 and ϕ

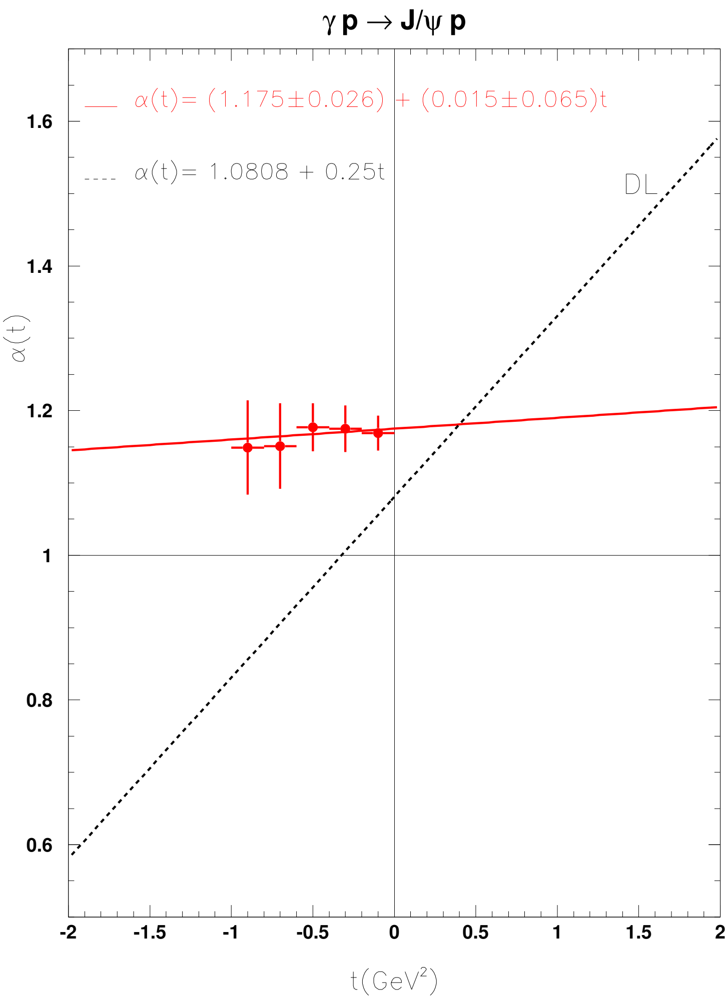


	$\alpha_{I\!P}(0)$	$\alpha'_{I\!P}$
ρ^0:	1.097 ± 0.020	0.163 ± 0.035 GeV^{-2}
ϕ:	1.083 ± 0.010	0.180 ± 0.027 GeV^{-2}

$\Longrightarrow$ Shrinkage similar to hadronic cross sections

Measuring $\alpha_{I\!P}(t)$ with J/ψ Mesons

A. Levy, hep-ex/97-12-519



	$\alpha_{I\!P}(0)$	$\alpha'_{I\!P}$
J/ψ:	1.175 ± 0.026	0.015 ± 0.065 GeV^{-2}

$\Rightarrow$ **Shrinkage absent for J/ψ !**

Summary

ZEUS has new results on:

- ☞ Elastic ρ^0 and ϕ electroproduction
  - $\Rightarrow$ W dependence
  - $\Rightarrow$ Q^2 dependence
  - $\Rightarrow$ $R = \frac{\sigma_L}{\sigma_T}$ versus Q^2
- ☞ Elastic J/ψ electroproduction
  - $\Rightarrow$ W dependence
  - $\Rightarrow$ Q^2 dependence
- ☞ Elastic $\psi(2S)$ photoproduction
- ☞ Elastic Υ photoproduction
- ☞ Proton-dissoc. ρ^0, ϕ, J/ψ photoprod.
- ☞ Production ratios at high $|t|$
- ☞ $\alpha_{I\!P}(t)$ for ρ^0, ϕ, and J/ψ

Major effort underway !!