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Ohio State University
Columbus, Ohio

Measurements of Diffractive Vector-Meson Photoproduction at High Momentum Transfer from the ZEUS Experiment at HERA

- ρ^0 Differential Cross Section $\frac{d\sigma}{dt}$

  $80 < E_{\gamma p}^{\mathrm{cm}} < 120$ GeV

  $-11 < t < -1.5$ GeV^2

- Scaling Properties
- ρ^0 Polarization
- Ratio of ϕ to ρ^0

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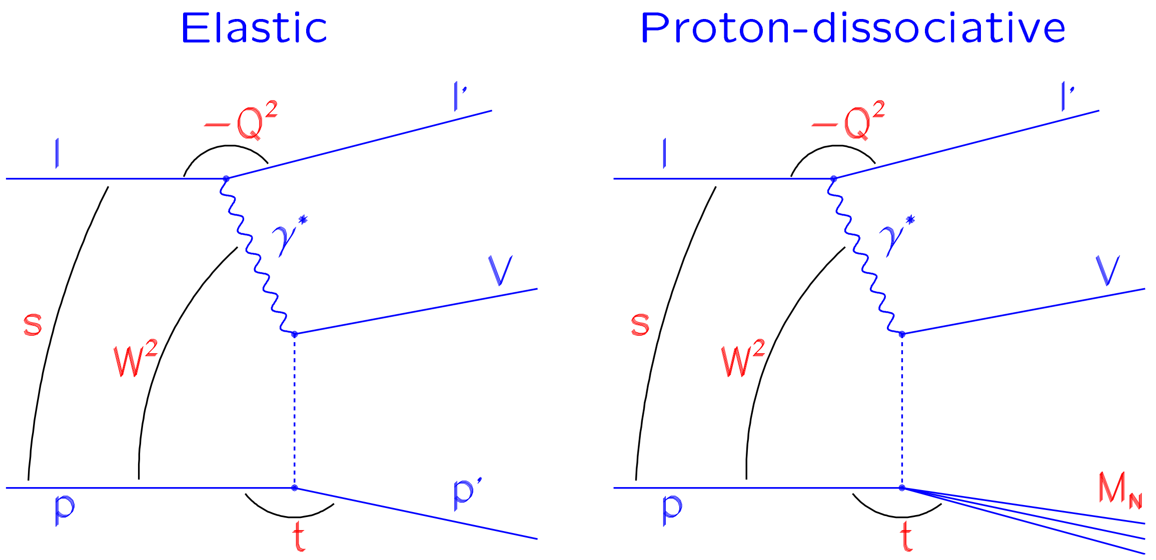
Diffractive Photoproduction of Vector Mesons



$\sqrt{s}$: Center–of–mass energy of e–p system
HERA (1996/97): 300 GeV

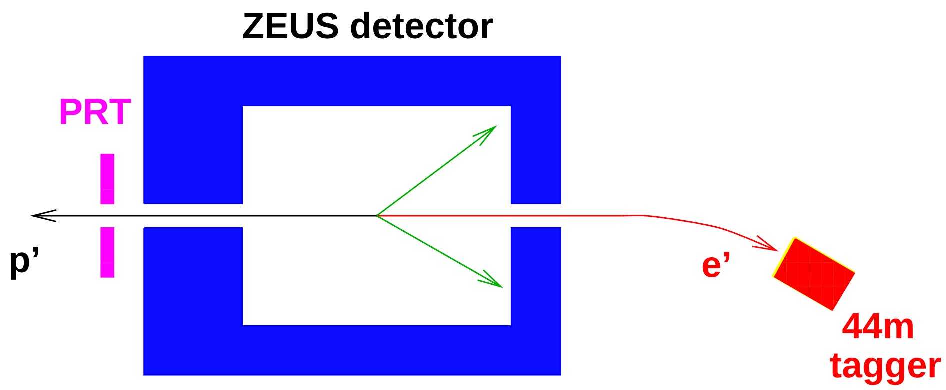
W: Center–of–mass energy of γ^*–p system
This analysis (ZEUS 1996/97 preliminary):
$80 < W < 120$ GeV

Q^2: Photon virtuality
This analysis: $Q^2 < 0.01$ GeV^2 ($\Rightarrow t \simeq -P_T^2$(V))

t: Square of the momentum transfer
This analysis: $-11 < t < -1.5$ GeV^2
Proton-dissociative process dominates

M_N: Mass of the dissociated proton system
This analysis: $M_p^2 < M_N^2 < -100 * t$

Photoproduction Tagging at $W \simeq$ 100 GeV



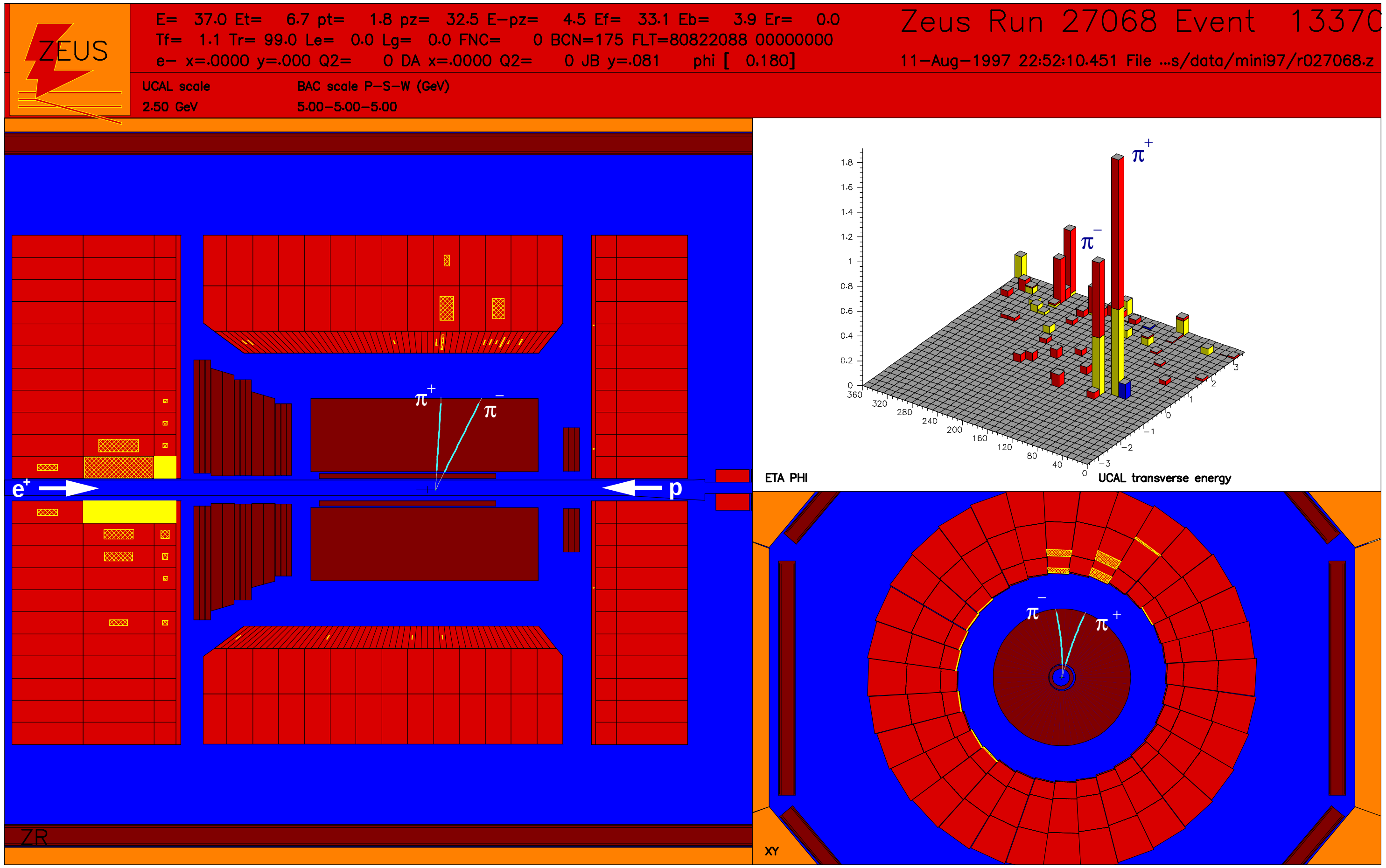
$$Q^2 < 0.01 \text{ GeV}^2$$
$$23 < E_{e'} < 25 \text{ GeV}$$
$$(\Rightarrow 80 < W < 120 \text{ GeV})$$

ZEUS 1996/97 preliminary

Integrated luminosity: 24 pb^{-1}

ρ^0: $\simeq$ 18k
ϕ: $\simeq$ 2k
J/ψ: $\simeq$ 150

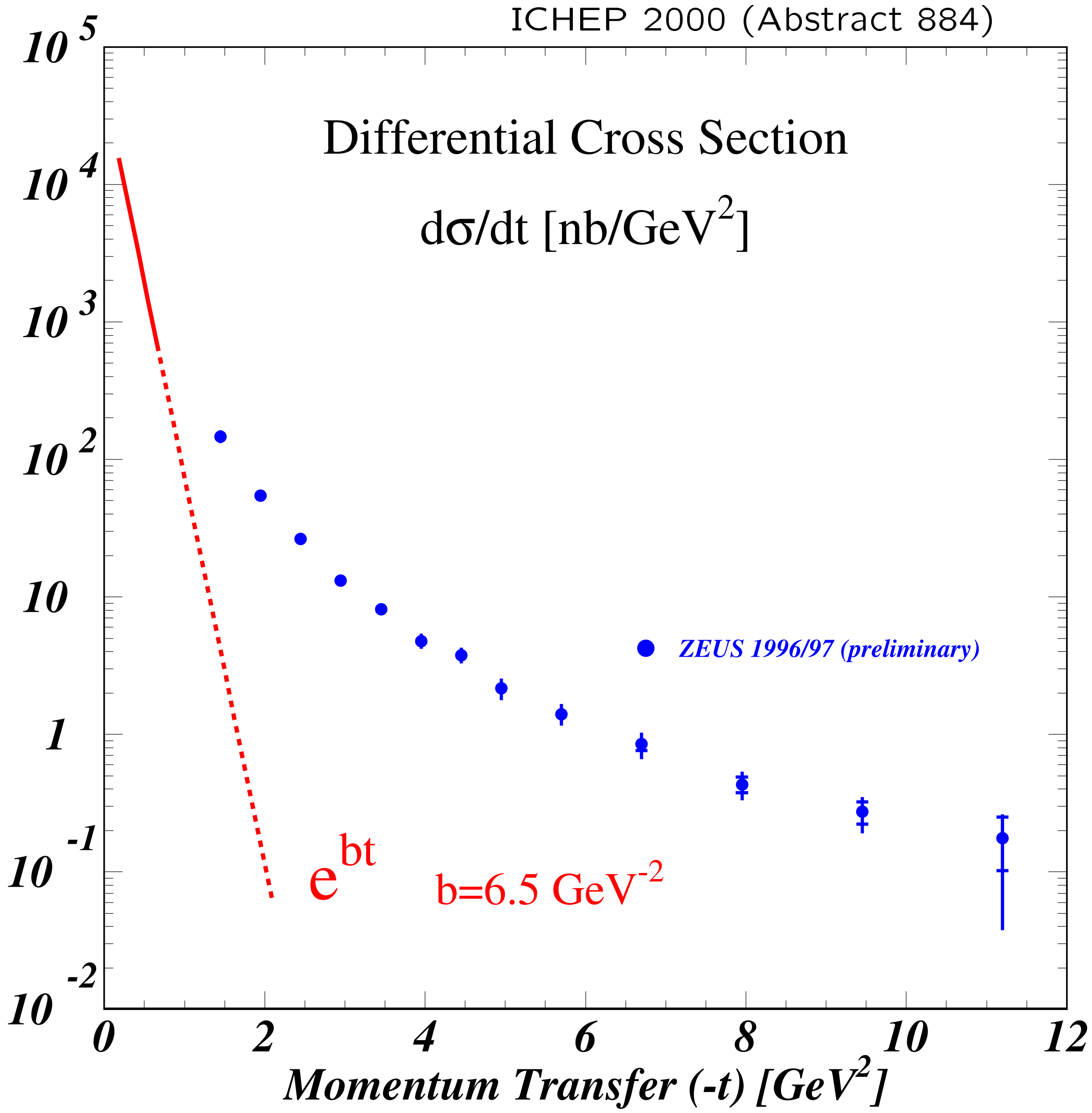
Candidate for ρ^0 Photoproduction at High $|t|$



$e^+p \to e^+N\,\rho^0 \to e^+N\,\pi^+\pi^-$ $\qquad$ $M_{\pi^+\pi^-} = 0.78$ GeV, t $= -10.0$ GeV^2, $W = 81$ GeV

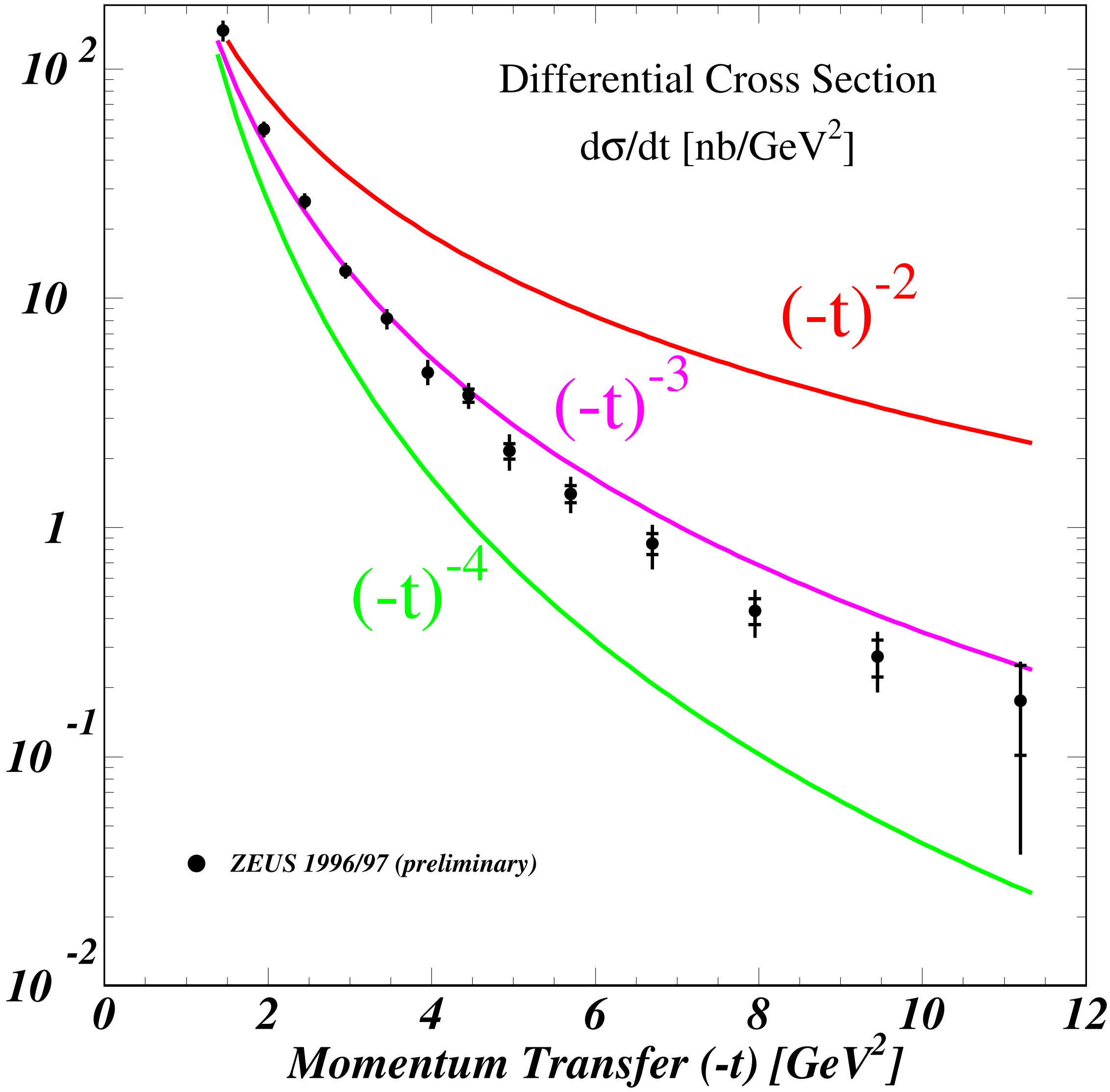
Diffractive ρ^0 Photoproduction (I)

$$\gamma + p \rightarrow \rho^0 + N$$



Asymptotic region

Diffractive ρ^0 Photoproduction (II)



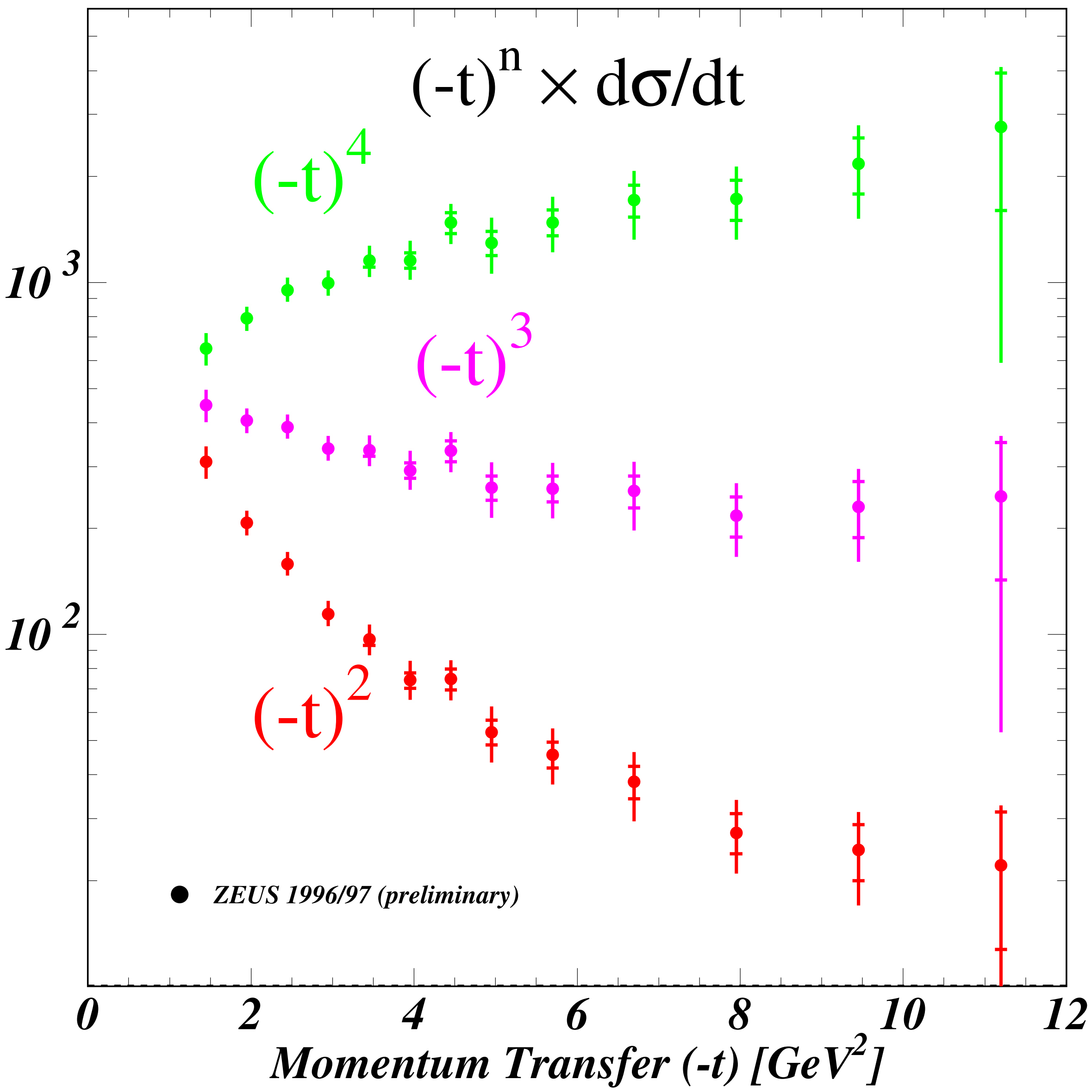
<u>Scaling Property</u>

Power dependence with

$n = 3$

matches the data fairly well

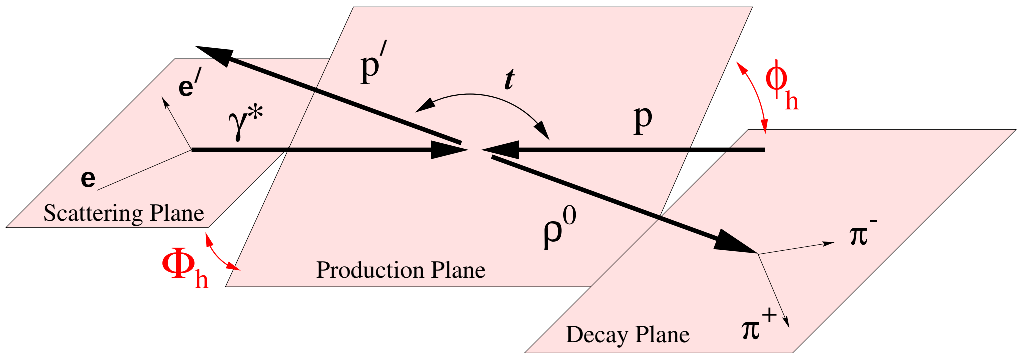
Diffractive ρ^0 Photoproduction (III)



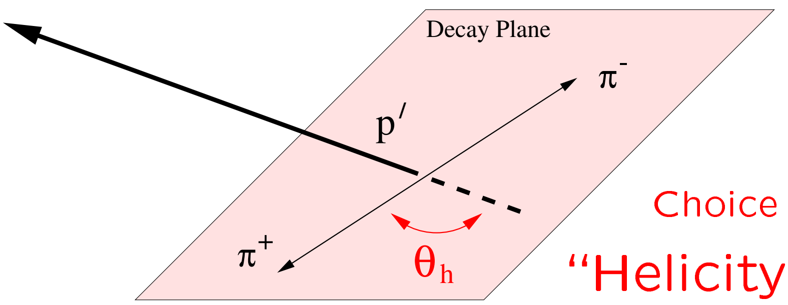
Scaling with $(-t)^n$

Decay-Angle Analysis (I)

γ^* p center-of-mass frame



ρ^0 rest frame



Choice of Z-axis:

"Helicity Frame"

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^+

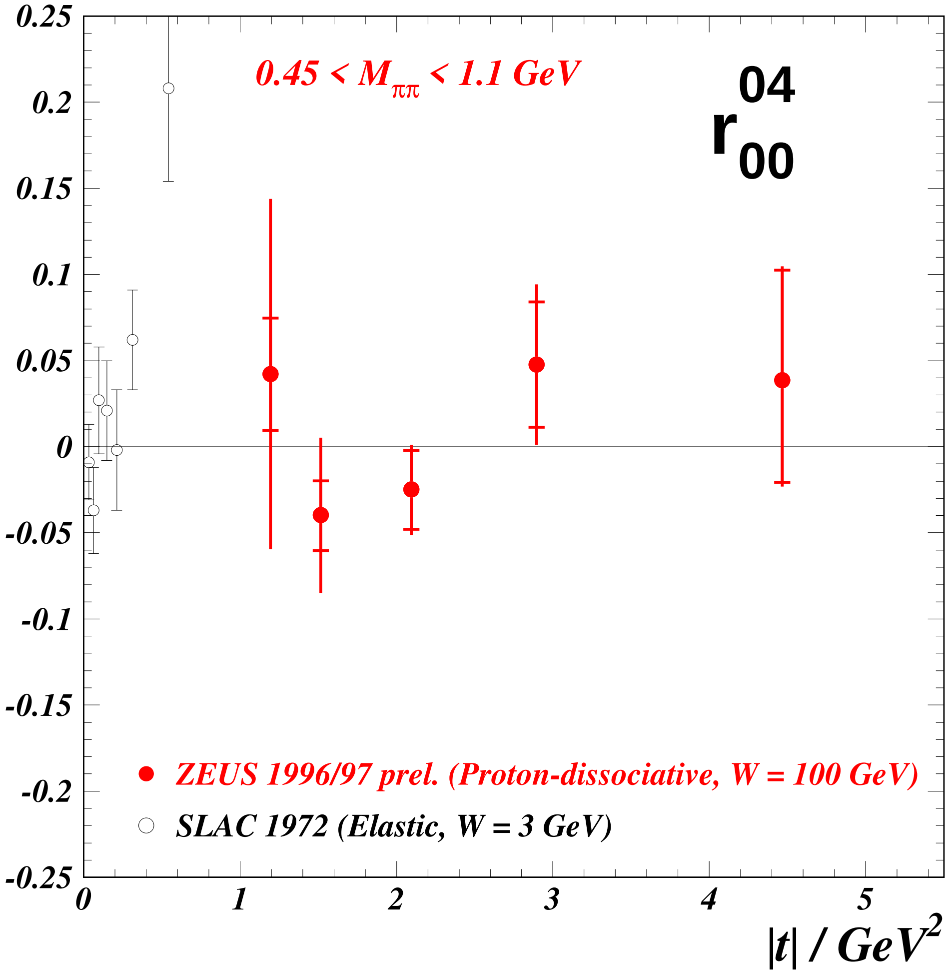
At low Q^2, Φ_h poorly measured, so integrate over it:

$$W(\cos\theta_h, \phi_h) = \frac{3}{4}\Big[\frac{1}{2}(1 - r^{04}_{00}) + \frac{1}{2}(3r^{04}_{00} - 1)\cos^2\theta_h - \sqrt{2}\mathrm{Re}(r^{04}_{10})\sin 2\theta_h \cos\phi_h - r^{04}_{1-1}\sin^2\theta_h \cos 2\phi_h \Big]$$

Decay-Angle Analysis (II)

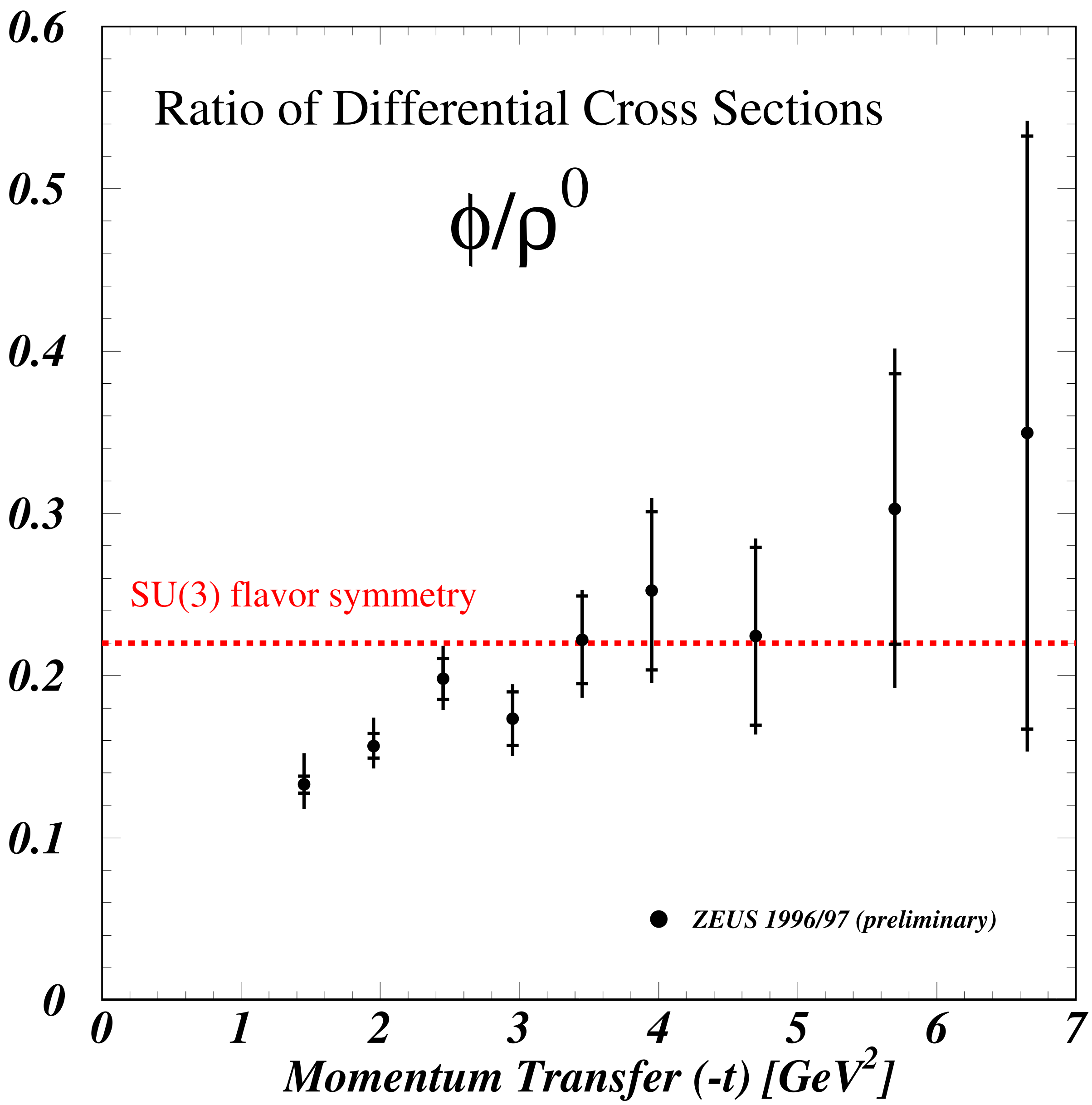
$$r_{00}^{04} \simeq \frac{T_{01}^2}{T_{01}^2 + T_{11}^2 + T_{1-1}^2}$$

r_{00}^{04} measures the degree of longitudinal polarization



Tranverse polarization dominates

Ratio of ϕ to ρ^0 Production



SU(3) flavor symmetry observed at high $|t|$

General Remarks

- These are the first measurements of vector-meson photoproduction at values of t comparable to the Q^2 values in deep inelastic scattering which led to the discovery of Bjorken scaling and charged proton constituents.

- This is presumably a strong interaction

- These values for t exceed the mass scales for ρ^0 and ϕ and Λ_{QCD} $\Rightarrow$ Asymptotic region

  The t dependence characterizes the interaction.

- We observe an extremely hard t spectrum
  $\Rightarrow$ low-order process

- Field theory for interaction without color exchange?

Conclusions

High-t vector-meson photoproduction
presents an opportunity to study
the dynamics of diffractive processes

In the asymptotic region of
momentum transfer

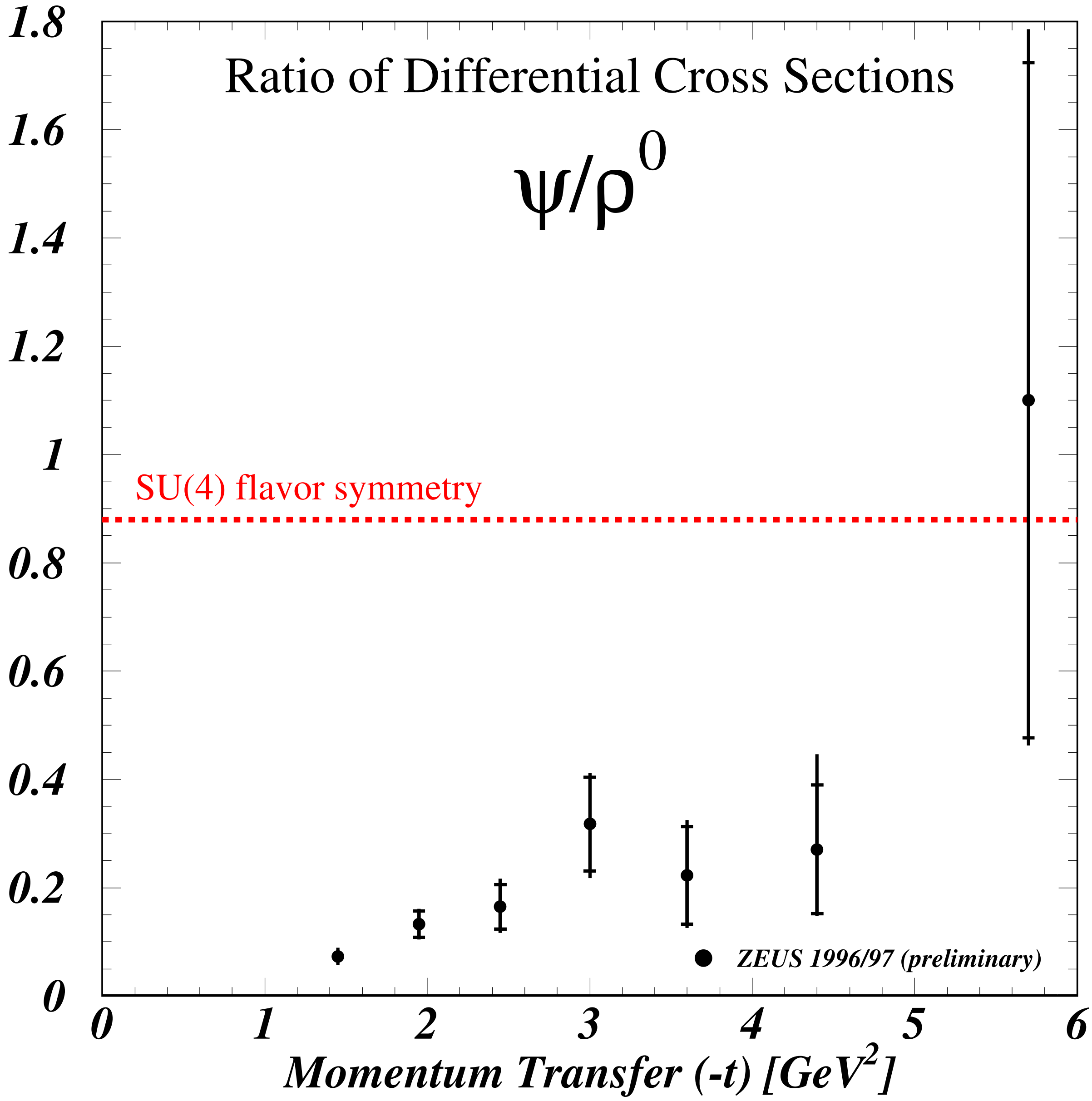
ρ^0 photoproduction exhibits a
very hard spectrum

$$\frac{d\sigma}{dt} \propto (-t)^{-n} \quad n \simeq 3$$

The final-state ρ^0 are predominantly
transversely polarized

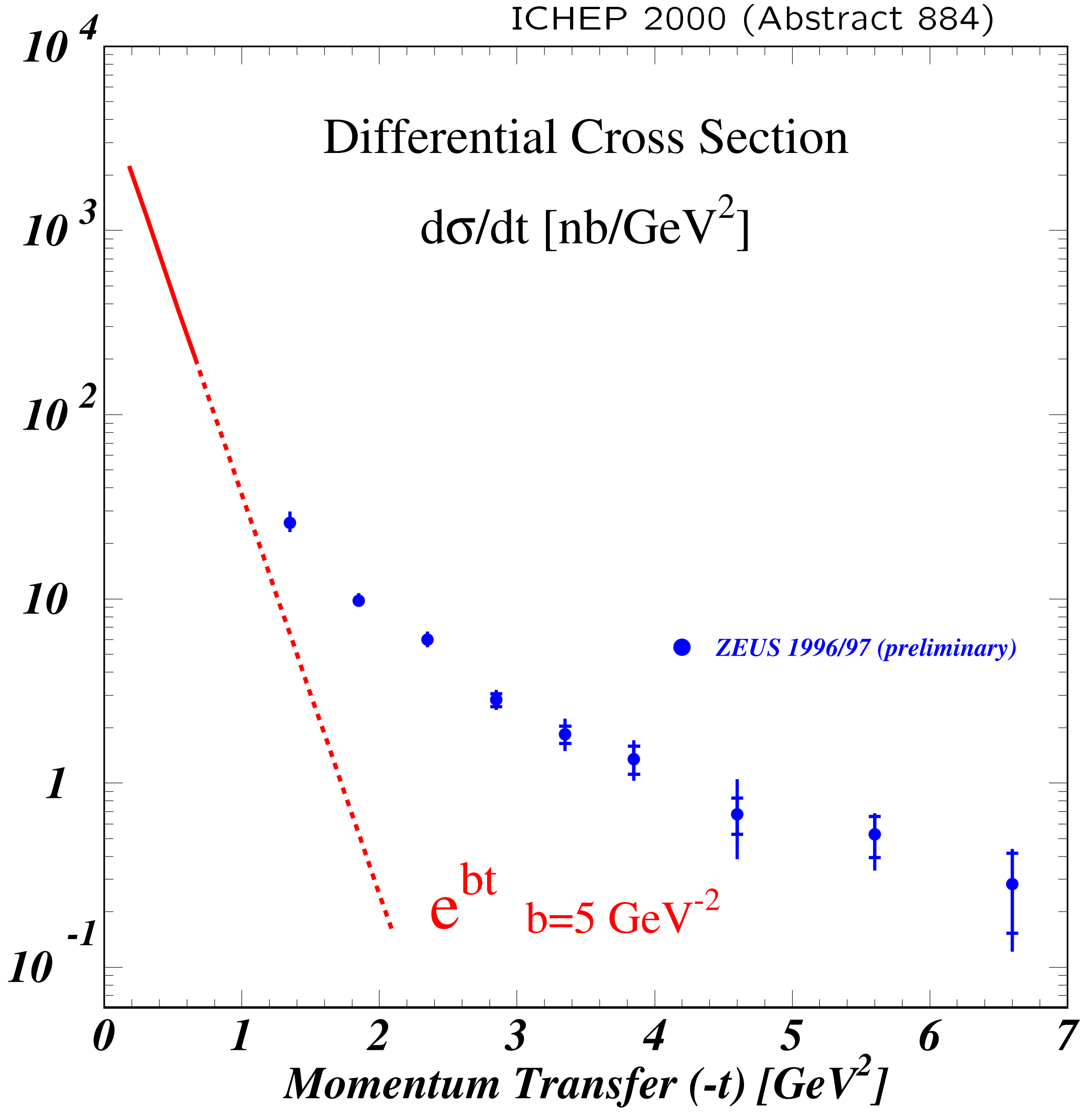
The ratio of ϕ to ρ^0 exhibits
SU(3) flavor symmetry

Ratio of J/ψ to ρ^0 Production



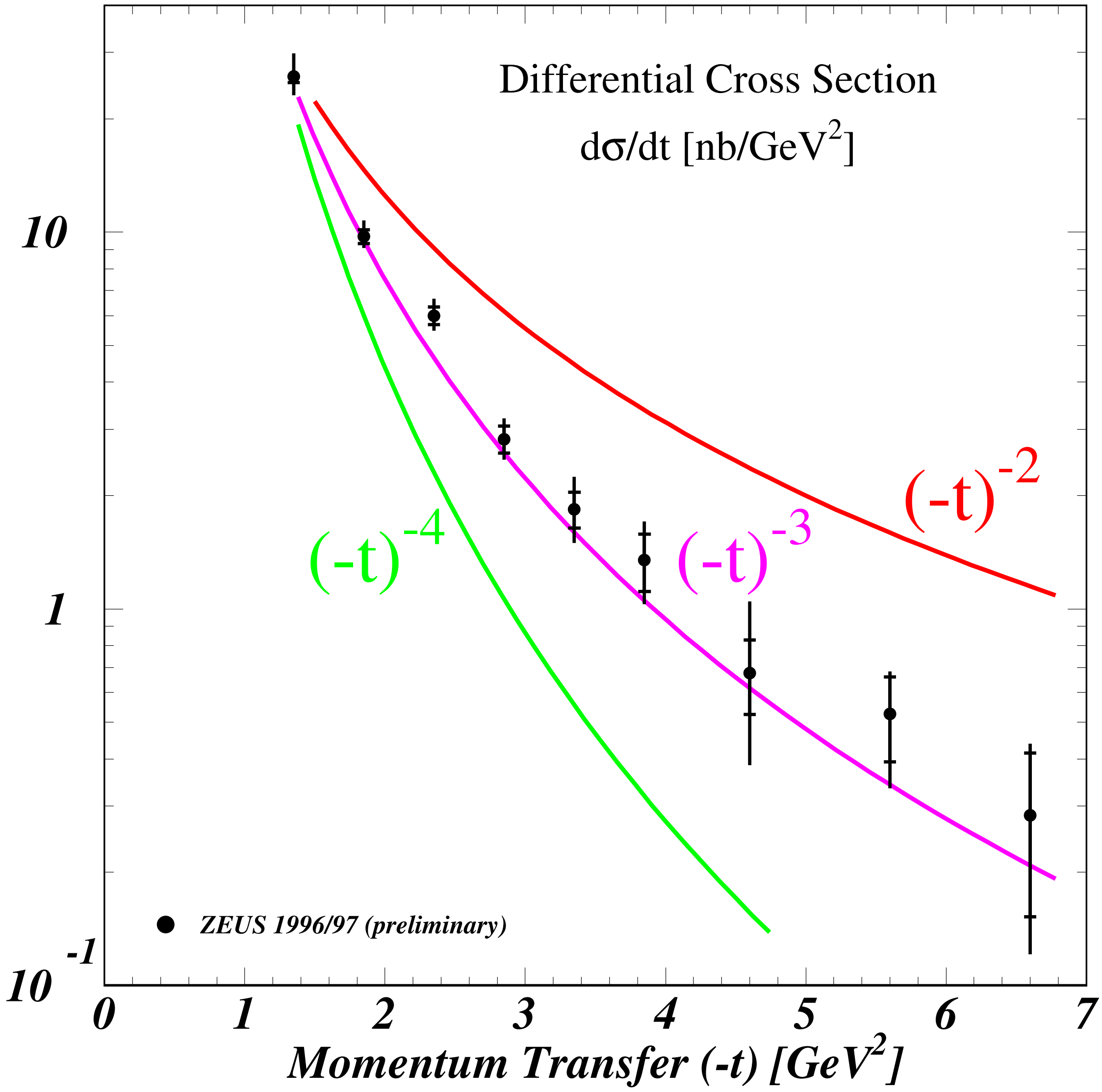
Diffractive ϕ Photoproduction (I)

$$\gamma + p \rightarrow \phi + N$$



Asymptotic region

Diffractive ϕ Photoproduction (II)



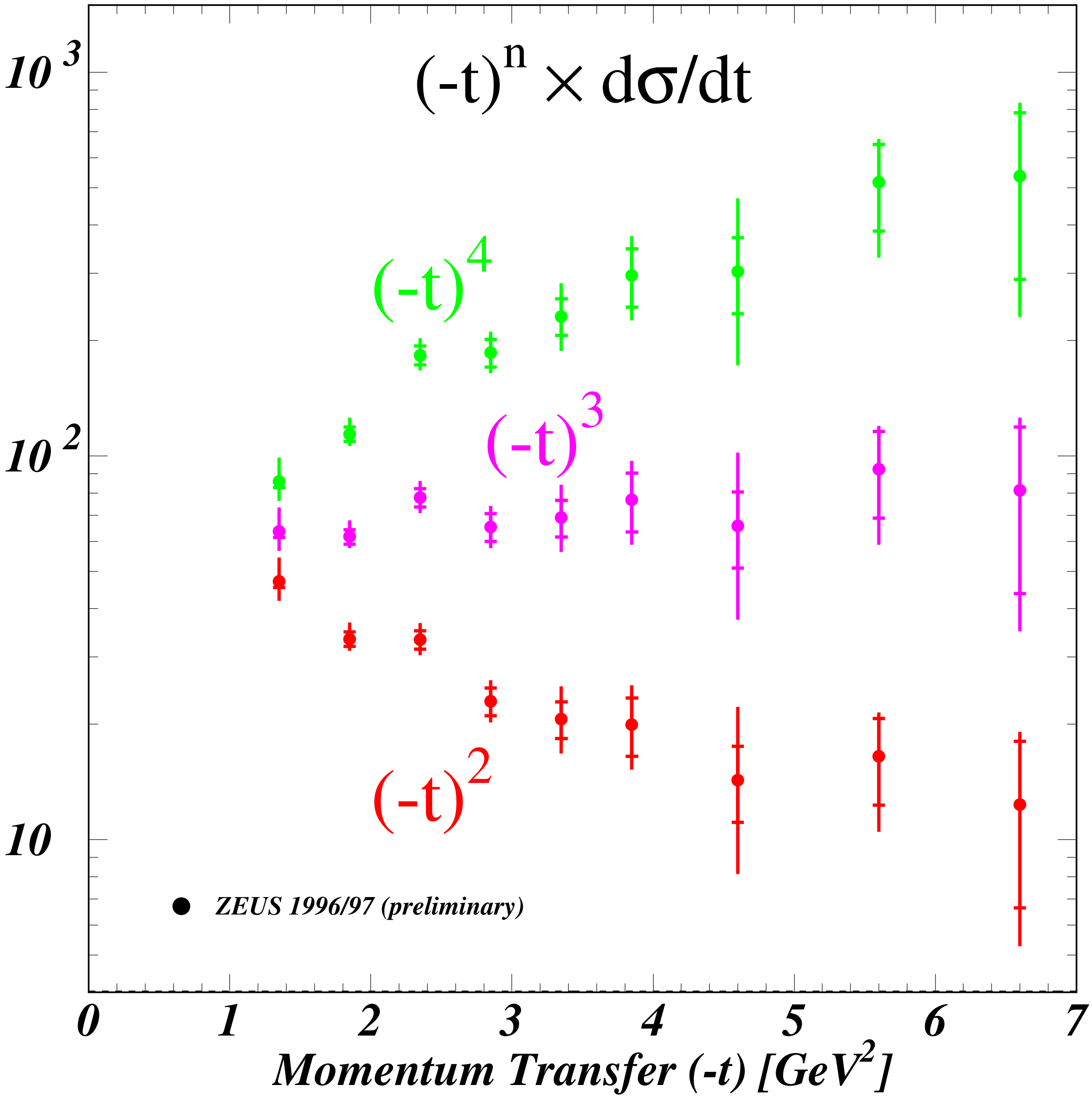
<u>Scaling Property</u>

Power dependence with

$n = 3$

matches the data well

Diffractive ϕ Photoproduction (III)

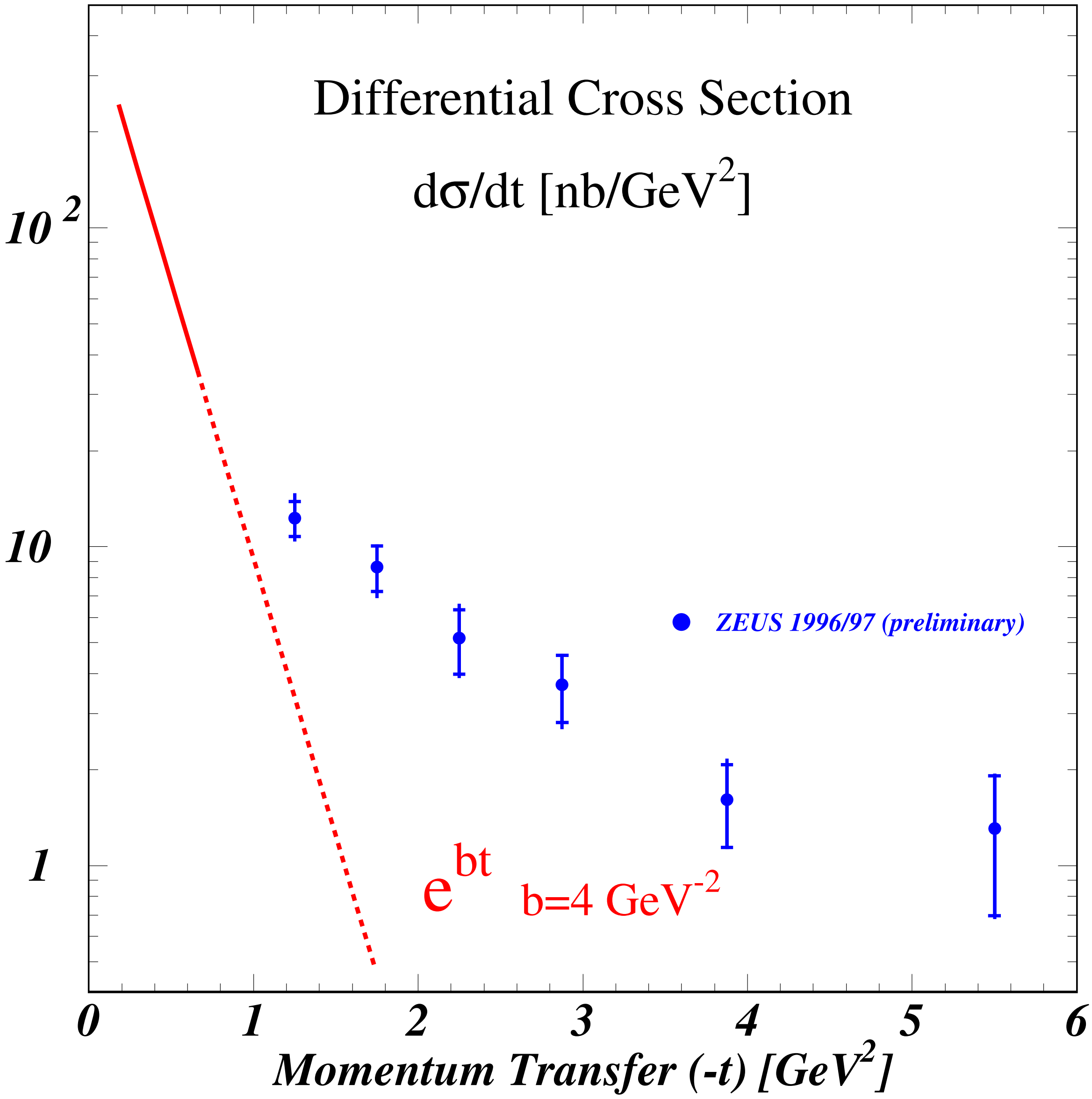


Scaling with $(-t)^n$

Diffractive J/ψ Photoproduction (I)

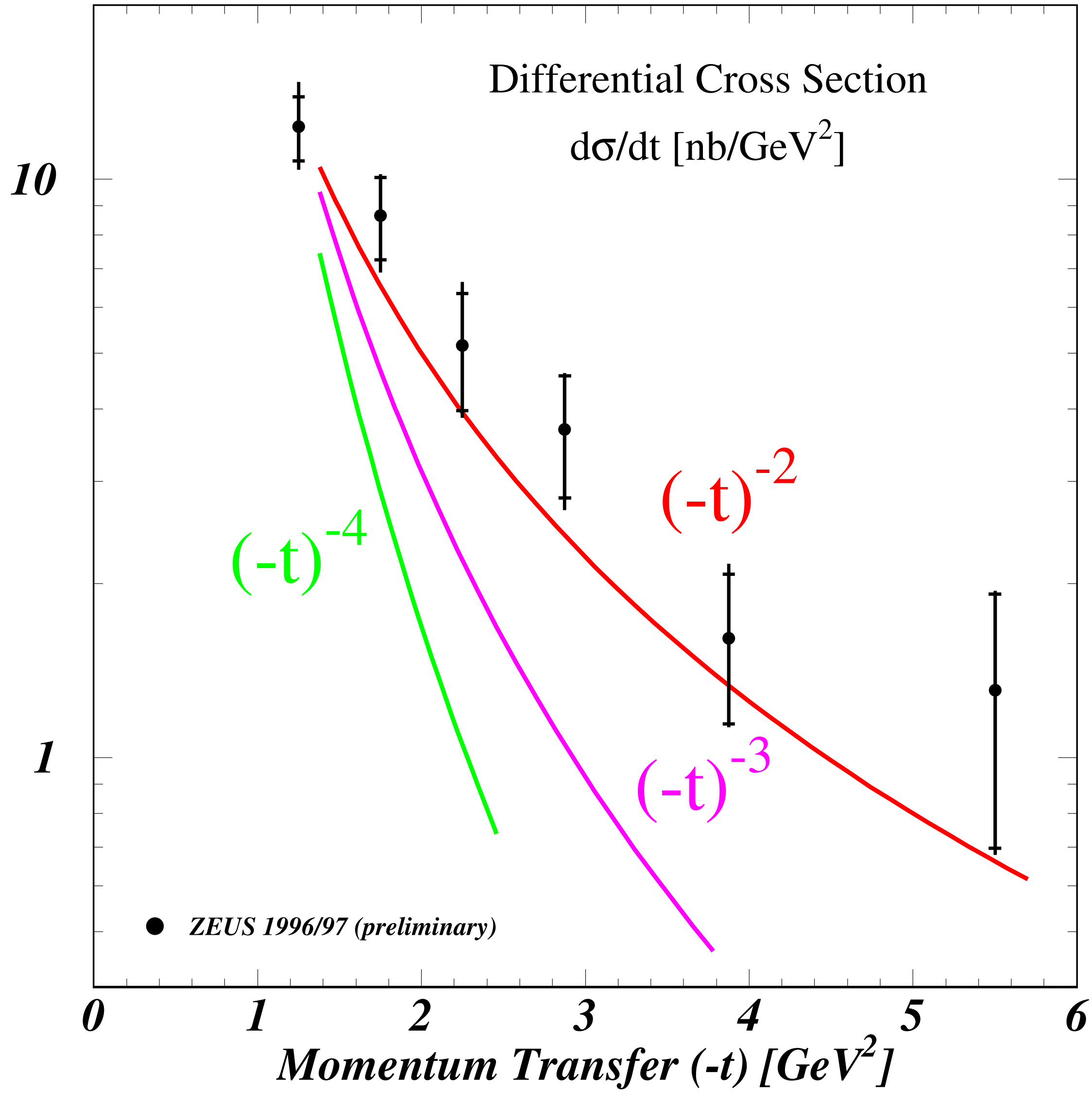
$$\gamma + p \rightarrow J/\psi + N$$

ICHEP 2000 (Abstract 884)



NOT asymptotic region

Diffractive J/ψ Photoproduction (II)



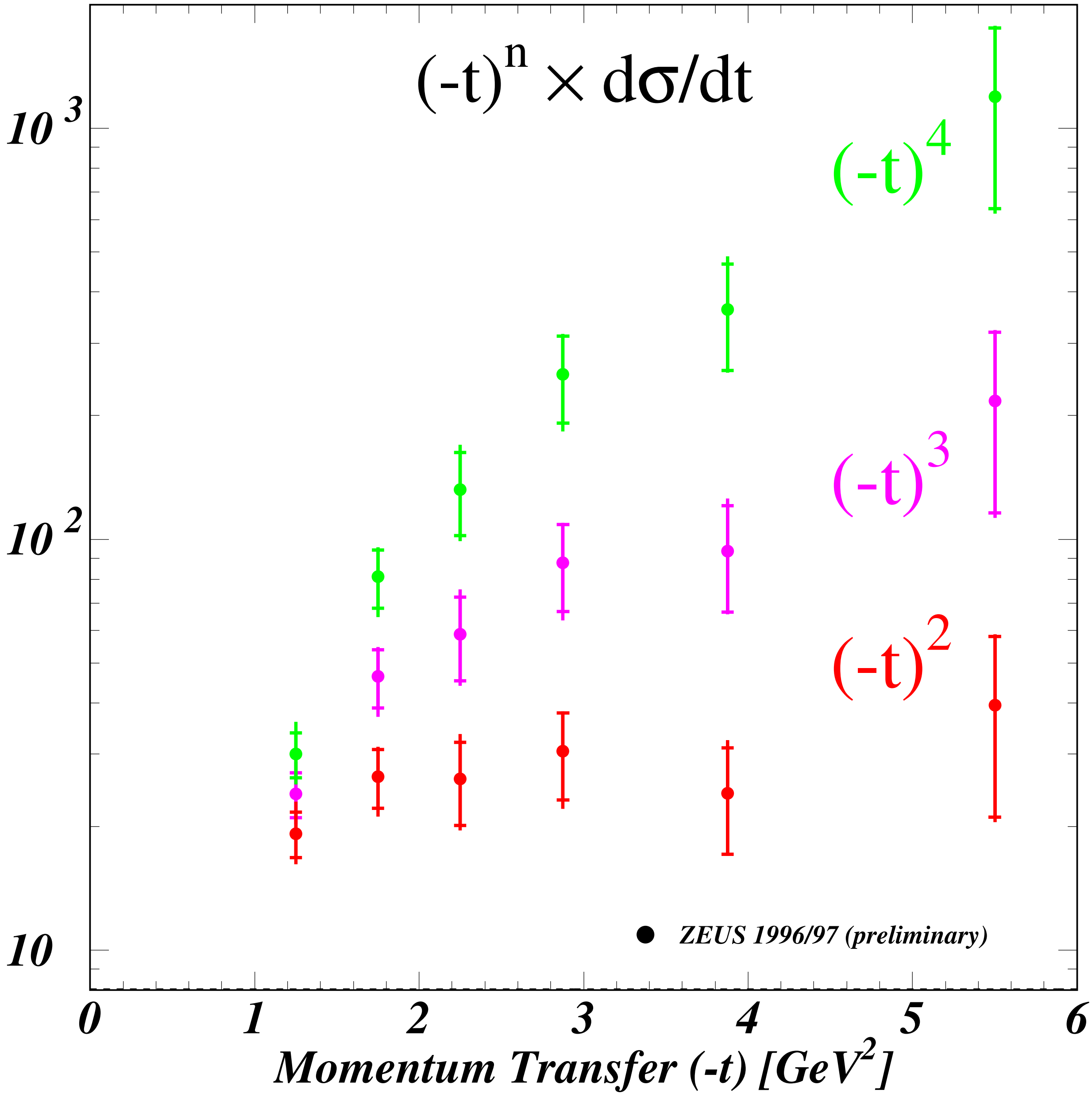
Scaling Property

Power dependence with

$n = 2$

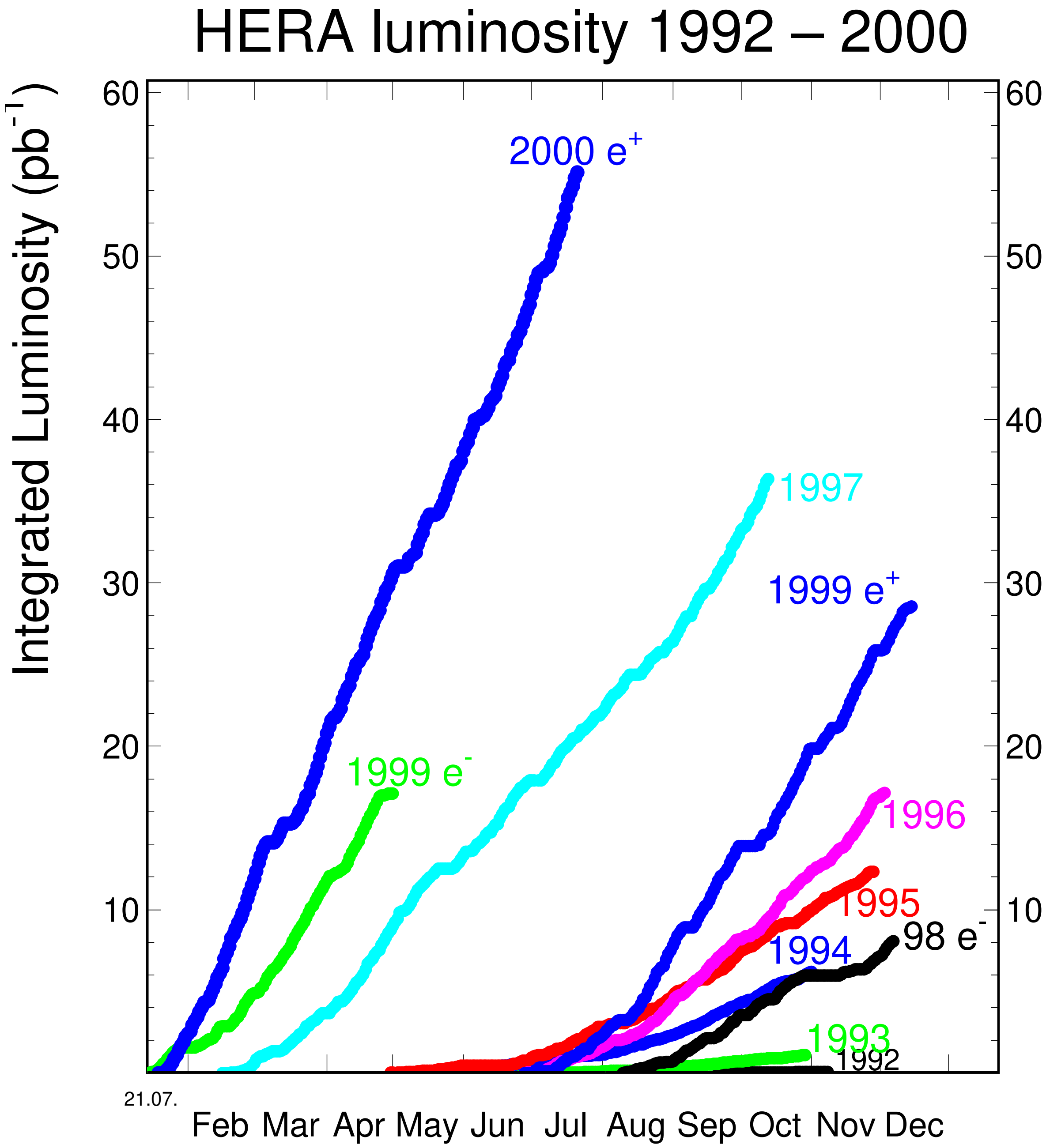
matches the data fairly well

Diffractive J/ψ Photoproduction (III)



Scaling with $(-t)^n$

ZEUS Integrated Luminosity (I)



ZEUS Integrated Luminosity (II)