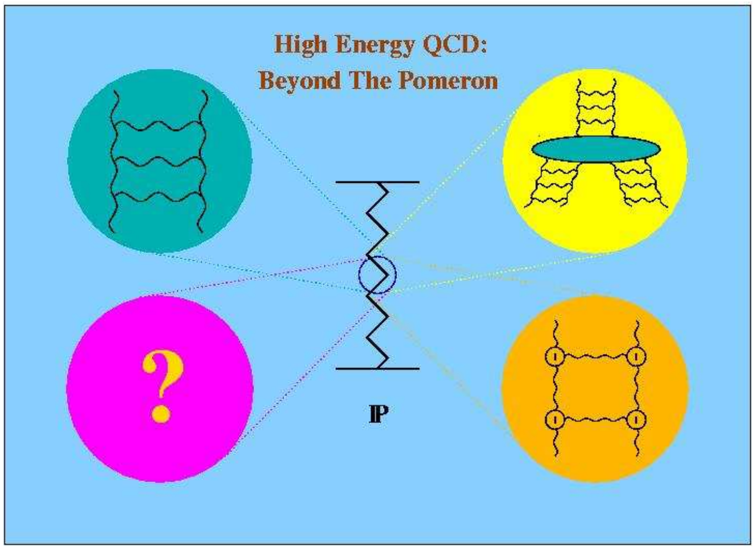
High Energy QCD Workshop BNL

23 May 2001 Upton, New York

Scaling Properties of High-Energy Diffractive Vector-Meson Production at High Momentum Transfer



- ☞ Selected Results from HERA
- ☞ Surprise in ρ^0 Photoproduction at High Momentum Transfer

J. A. Crittenden
Deutsches Elektronen-Synchrotron
DESY

General Remarks on
Exclusive VM Production at HERA

☞ **Investigation of vacuum-exchange processes**

Vacuum exchange has a
complicated, poorly understood structure

☞ **Study properties of strong interaction**

⇒ Soft interactions

* Forward, total cross sections
* Exponential t-slopes, shrinkage
* Helicity rules

⇒ Hard interactions

* Short-distance vacuum exchange
* Scale definition
* Sensitive to $|xG(\mu, x)|^2$
* Helicity rules

The hard/soft transition can be studied in

$$Q^2 \qquad M_V^2 \qquad |t|$$

☞ **Exclusivity allows study of helicity structure**

⇒ The VM helicity state is directly related to the expected scaling behavior

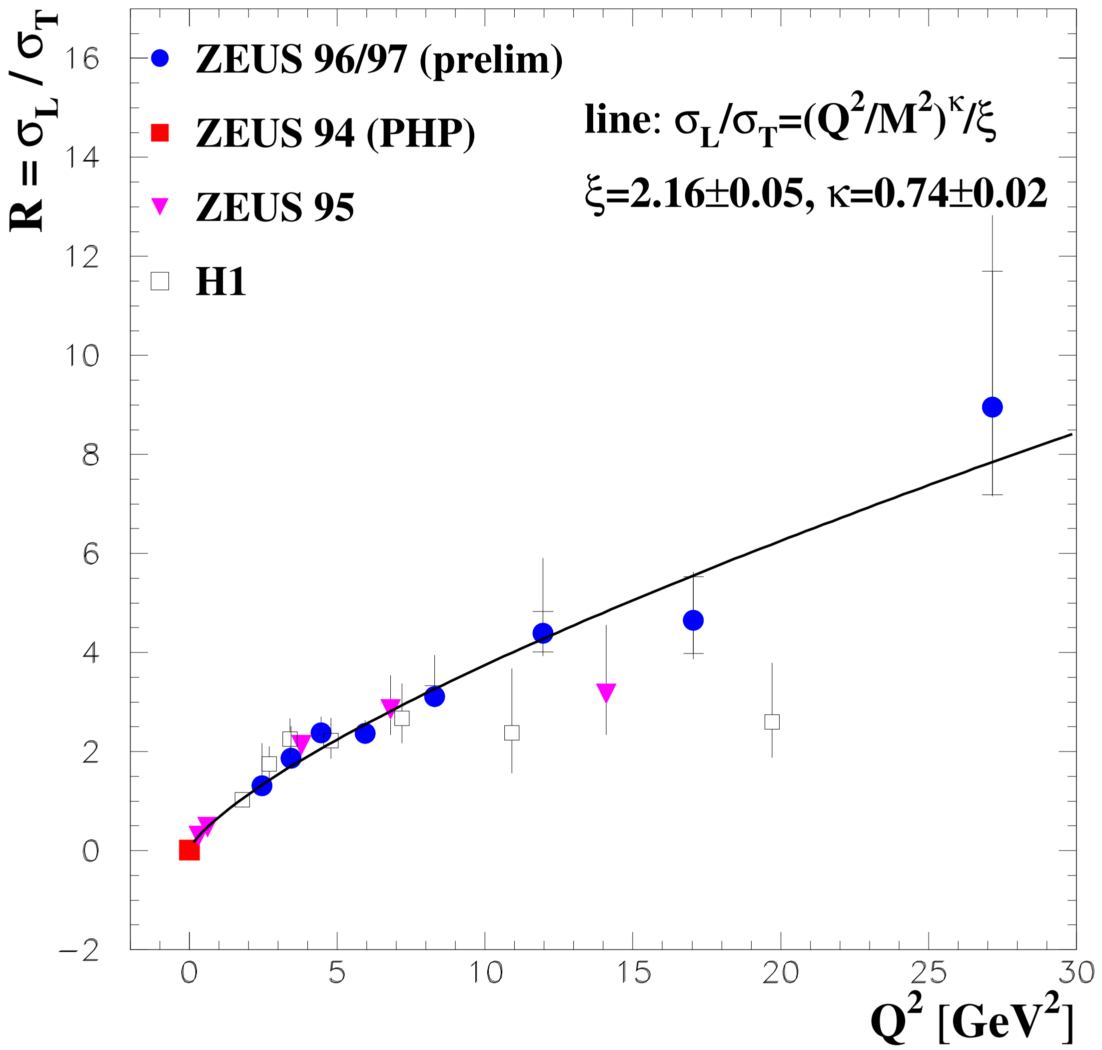
⇒ The spin-density matrix elements are directly related to meson structure

Quick Review (IV): σ_L/σ_T in Elastic ρ^0 Electroproduction

$$R = \frac{1}{\epsilon}\,\frac{r^{04}_{00} - \Delta^2}{1 - (r^{04}_{00} - \Delta^2)}$$

Δ now known to be small

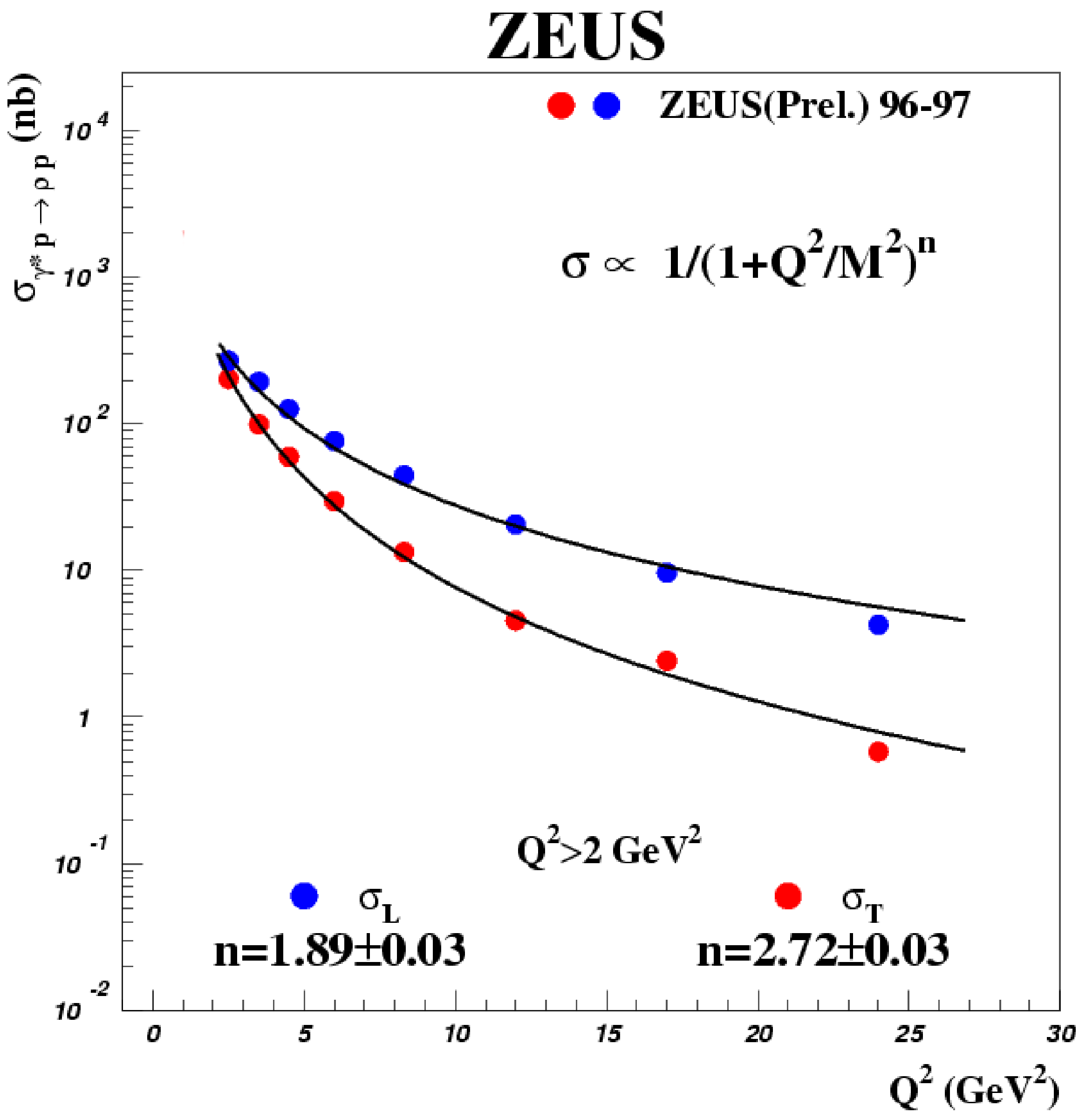
A. Kreisel/ZEUS at DIS2001



The dominance of σ_L was an early prediction of pQCD

Quick Review (VI): σ_L/σ_T in Elastic ρ^0 Electroproduction

A. Kreisel at DIS2001

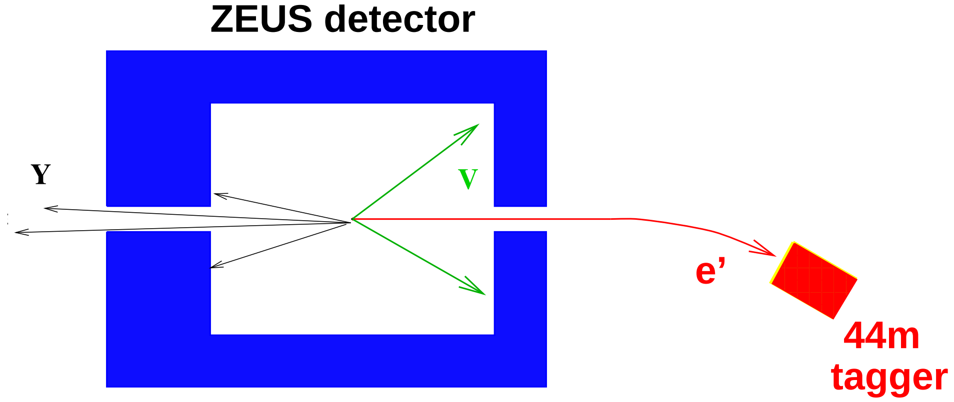


Remarkably hard scaling behavior for σ_T

(The Q^2 dependence is even weaker than Q^{-6})

Main Topic:
VM Photoproduction at High $|t|$

Photoproduction Tagging at $W \simeq$ 100 GeV



$Q^2 < 0.02$ GeV^2

$23 < E_{e'} < 25$ GeV

($\Rightarrow 80 < W < 120$ GeV)

ZEUS 1996/97 preliminary

Integrated luminosity: 24 pb^{-1}

ρ^0: $\simeq$ 18k

ϕ: $\simeq$ 2k

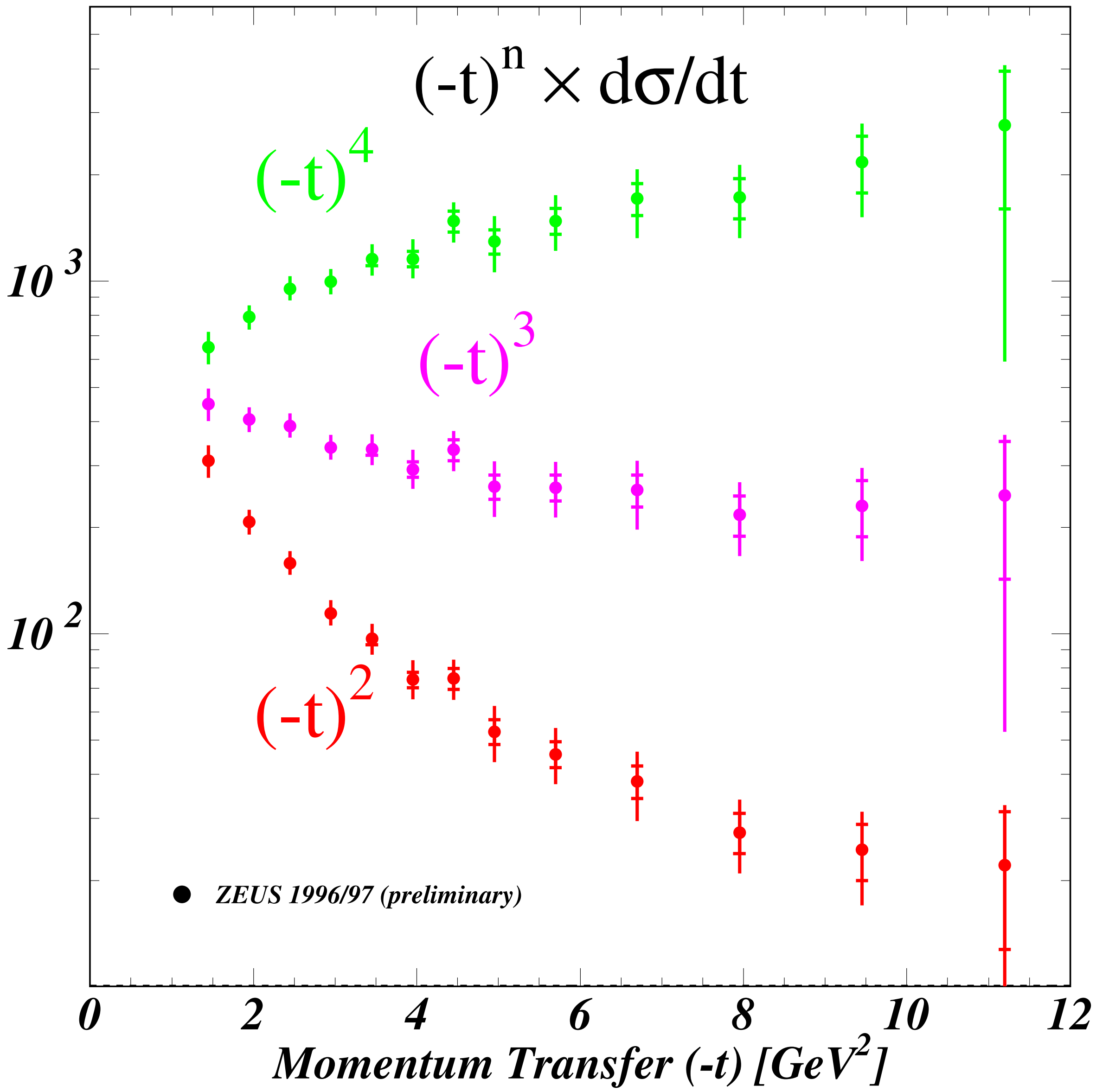
J/ψ: $\simeq$ 150

Proton-dissociative process dominates at $|t| >$ 1 GeV^2

$$\boldsymbol{x = \frac{t}{t - M_Y^2}}$$

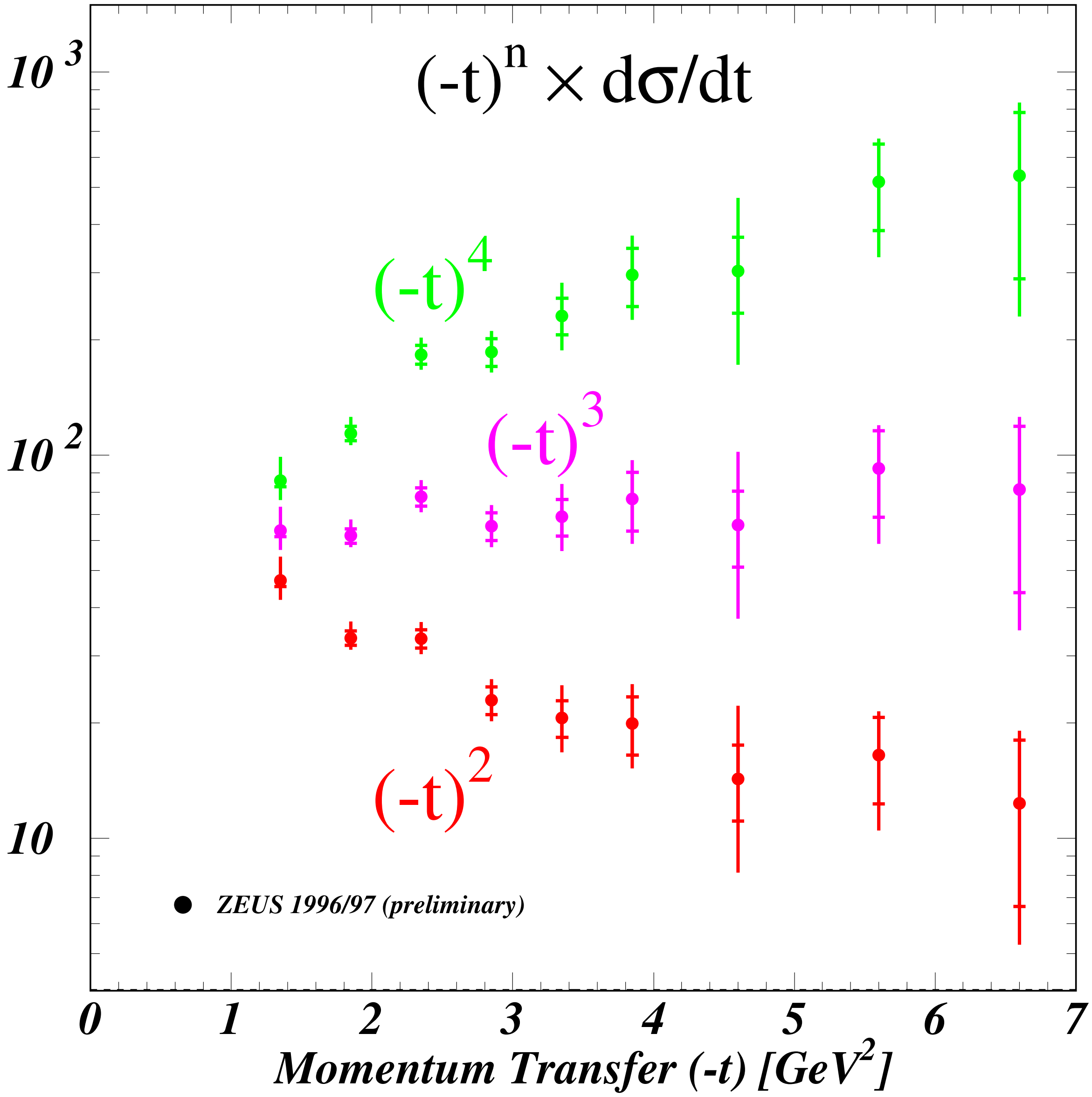
Cross sections $\frac{d\sigma}{dt}$ are integrated over $\mathbf{0.01 < x < 1}$

Diffractive ρ^0 Photoproduction (III)



Multiplying with $(-t)^n$

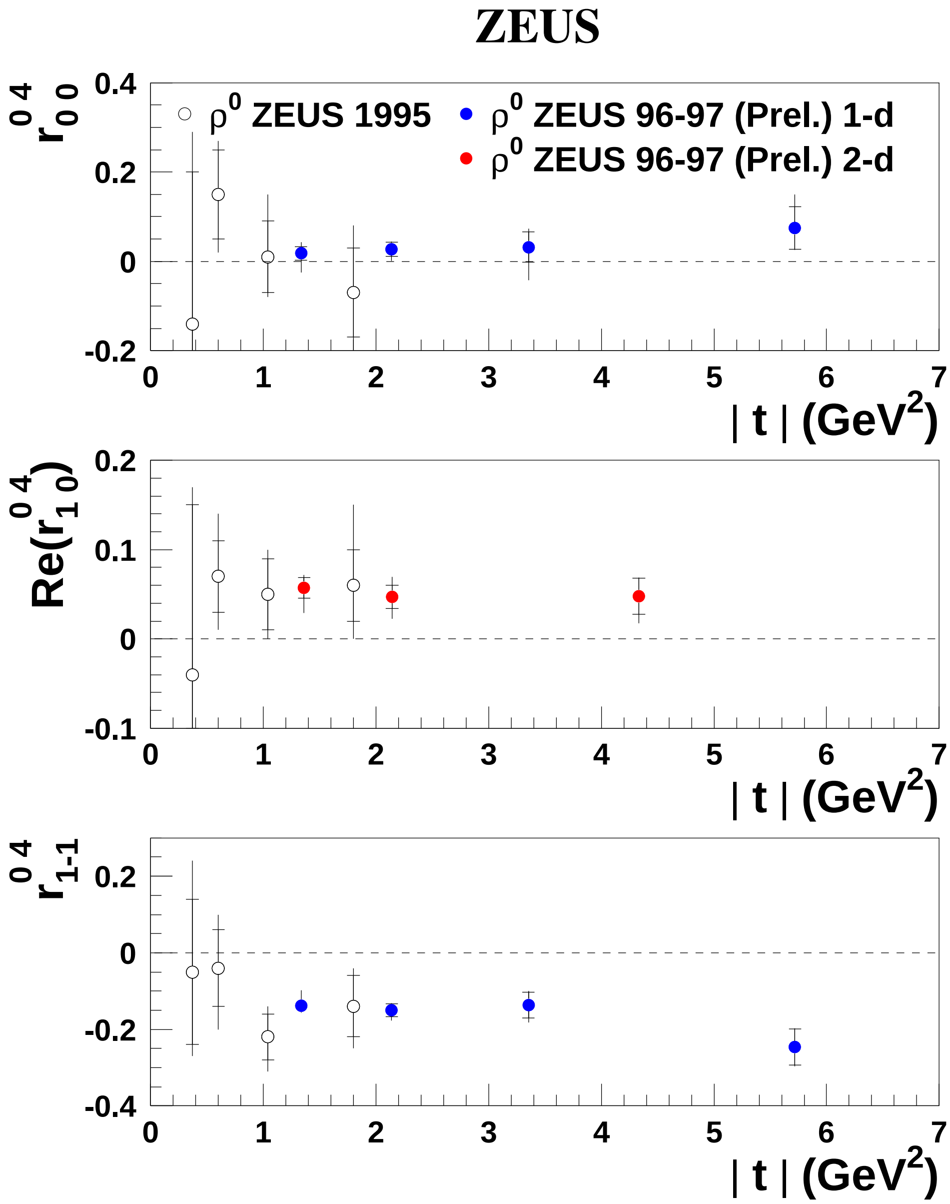
Diffractive ϕ Photoproduction (II)



Multiplying with $(-t)^n$

Decay-Angle Analysis (II)

Talk by A. Kowal at DIS2001



Transverse polarization dominates

Helicity breaking clearly measured at level of few %

(But why no dependence on t?)

Also significant double-flip contribution

See Ivanov et al, Phys. Lett. B478 (2000) 101

Some general remarks
(and some questions)

- These are the first measurements of light-vector-meson photoproduction at values of t comparable to the Q^2 values in DIS which led to the discovery of charged proton constituents in 1967.

- *BUT* this is presumably a strong interaction, rather than electromagnetic.

- We observe an extremely hard t dependence
  $\Rightarrow$ low-order process (*first* order ?)
  $\Rightarrow$ What about the meson form factor ?

- *The QCD helicity selection rules*
  appear to be violated.

- These values for t exceed the mass scales for ρ^0 and ϕ and exceed Λ^2_{QCD}
  $\Rightarrow$ Asymptotic region

  The t dependence characterizes the interaction.

Perturbative field theory

for vacuum exchange in the strong interaction (?)

What is the exchanged field?

What is the "charge"?
(Strength about 1/100 of confinement)

What is the reacting proton constituent?

Are there point-like interactions of hadronic bound states?

Attempted Synthesis

There appears to be increasing evidence for a point-like T$\to$ T vacuum-exchange transition which is difficult to reconcile with QCD

- ☞ A QCD description requires chiral-symmetry breaking, for example, quark-mass effects.
- ☞ This requirement results in a t dependence stronger than observed.
- ☞ This T$\to$T transition contributes to VM electroproduction well into the Q^2 region where pQCD successfully describes the production of longitudinal vector mesons.
- ☞ It is the dominant VM-photoproduction process at high momentum transfer.

The successful field theoretical description of this process will be a prime candidate for a theory which can be used in higher orders to describe diffractive processes at low momentum transfer, elastic and total hadronic cross sections.