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Recent Results from Decay-Angle Analyses of ρ^0 Photoproduction at High Momentum Transfer from ZEUS

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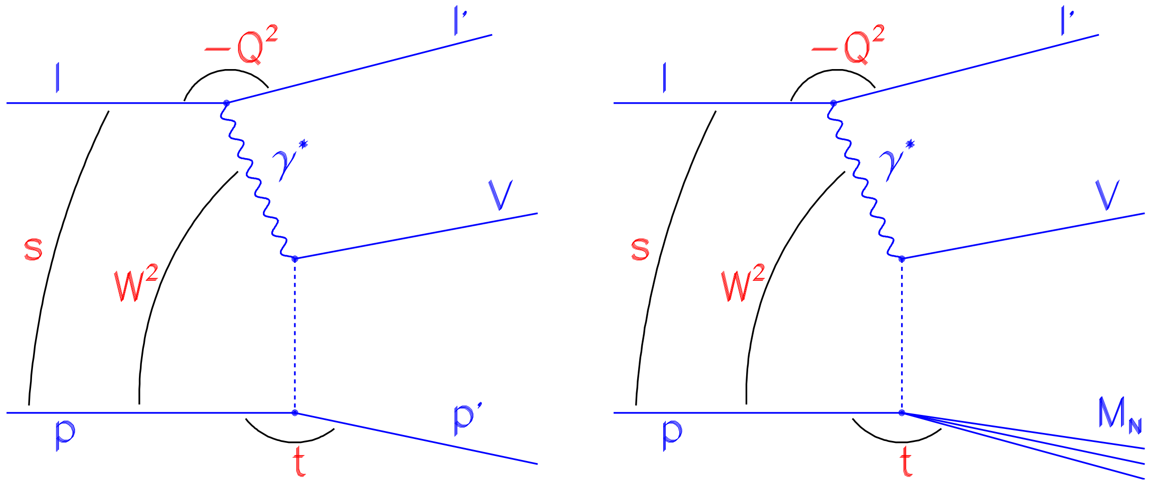
Diffractive Photoproduction of Vector Mesons

Elastic   Proton-dissociative



$\sqrt{s}$: 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):

$80 < W < 110$ GeV

Q^2: Photon Virtuality

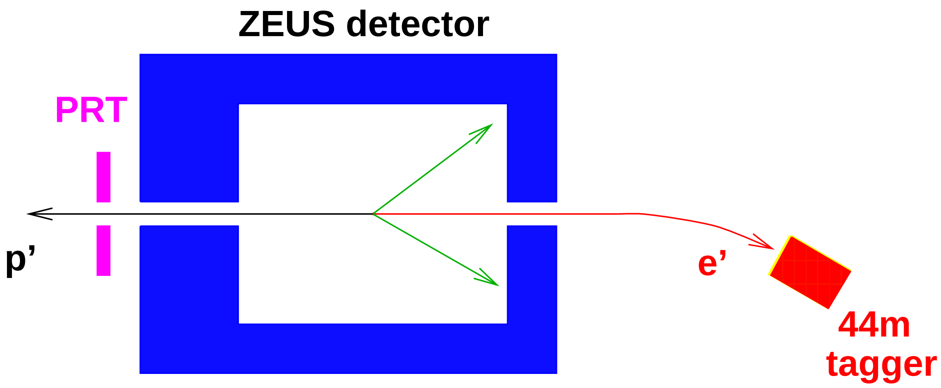
This analysis: $Q^2 < 0.01$ GeV^2 ($\Rightarrow t \simeq -P_T^2(\mathrm{V})$)

t: Square of Momentum Transfer at the Proton Vertex

This analysis: $1 < |t| < 9$ GeV^2 (bin limits)

Proton-dissociative process dominates

Photoproduction Tagging at $W \simeq$ 100 GeV



$$Q^2 < 0.01 \text{ GeV}^2$$
$$22 < E_{e'} < 25 \text{ GeV } (\Rightarrow W)$$

Proton Remnant Tagger used to separate elastic/dissociative

ZEUS 1995 preliminary

Int. luminosity: $\simeq 2$ pb^{-1}

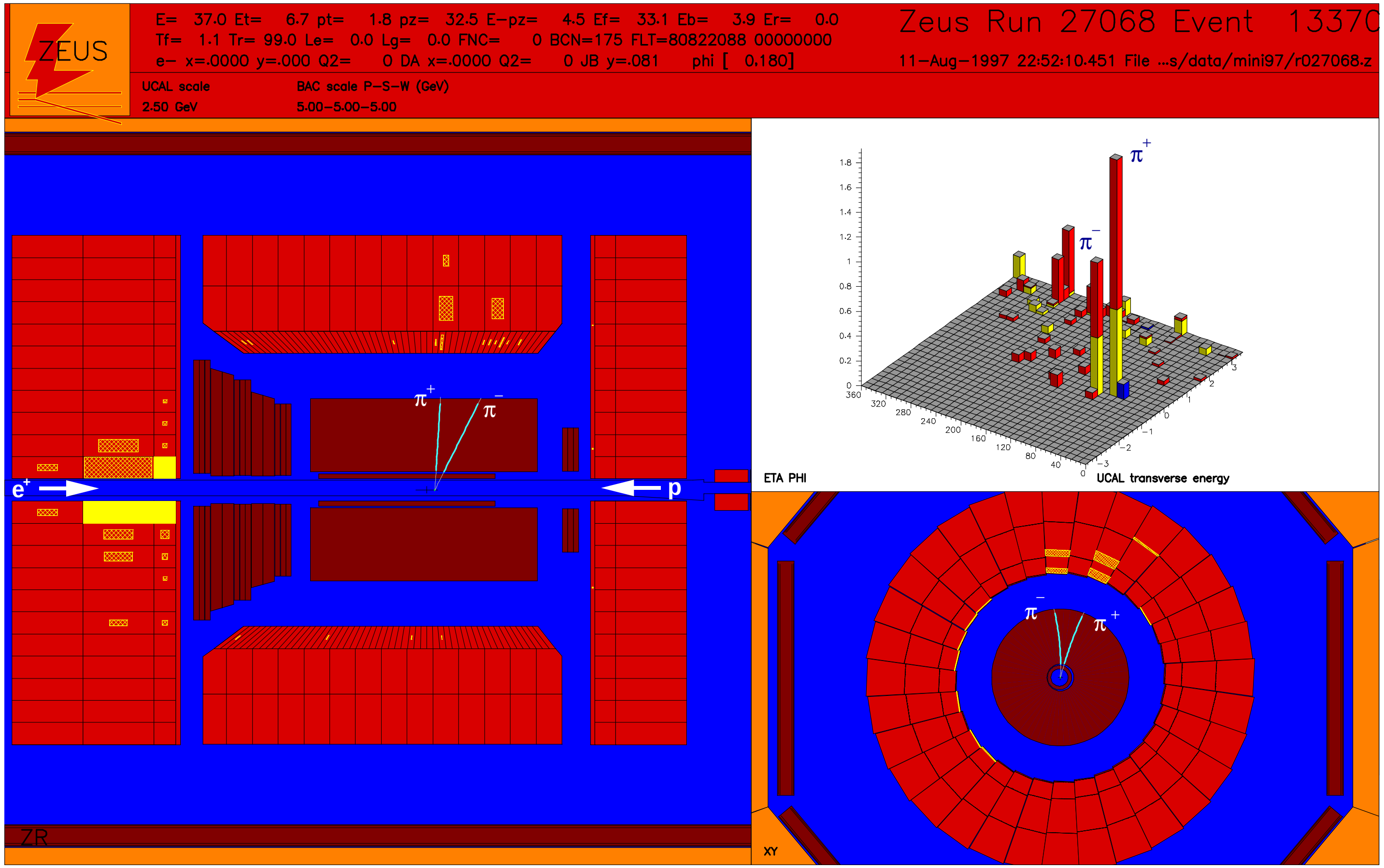
Elastic kinematic limit $\longrightarrow$ $2 \cdot 10^{-8} < |t| < 3$ GeV^2

ZEUS 1996/97 preliminary

Int. luminosity: $\simeq 25$ pb^{-1}

$1 < |t| < 9$ GeV^2 (bin limits)

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



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

Physics Motivation

Can the momentum transfer $|t|$ serve as a perturbative scale?

Early QCD:

Gross+Wilczek, Low, Nussinov, Humpert+Wright, ...

More recently:

I.F. Ginzburg and D.Yu. Ivanov, Phys. Rev. **D54** (1996) 5523

S.J. Brodsky, M. Diehl, P. Hoyer, and S. Peigné, hep-ph/9812277

Semi-exclusive Processes: New Probes of Hadron Structure

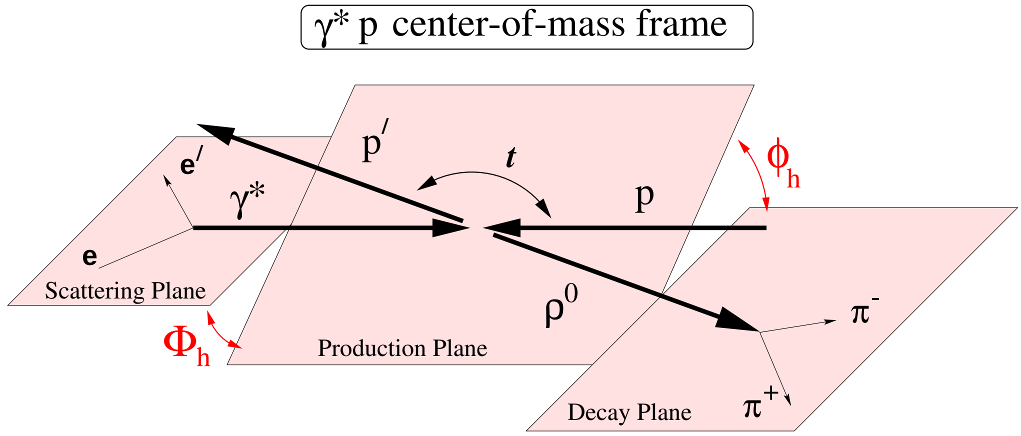
$\Longrightarrow$ Predict longitudinal polarization of ρ^0 at high $|t|$

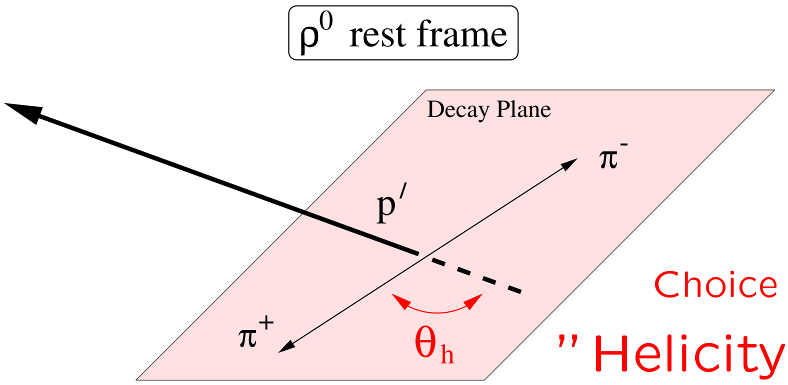
The final-state angular distributions are sensitive to products of the helicity amplitudes: $\mathsf{T}_{\lambda_{\pi\pi}\lambda_\gamma}$

In photoproduction, the contribution from longitudinal photons is small:

$$R \equiv \frac{\sigma_L}{\sigma_T} = \frac{T_{00}^2 + 2\,T_{10}^2}{T_{01}^2 + T_{11}^2 + T_{1-1}^2} \ll 1$$

Decay Angles





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^+

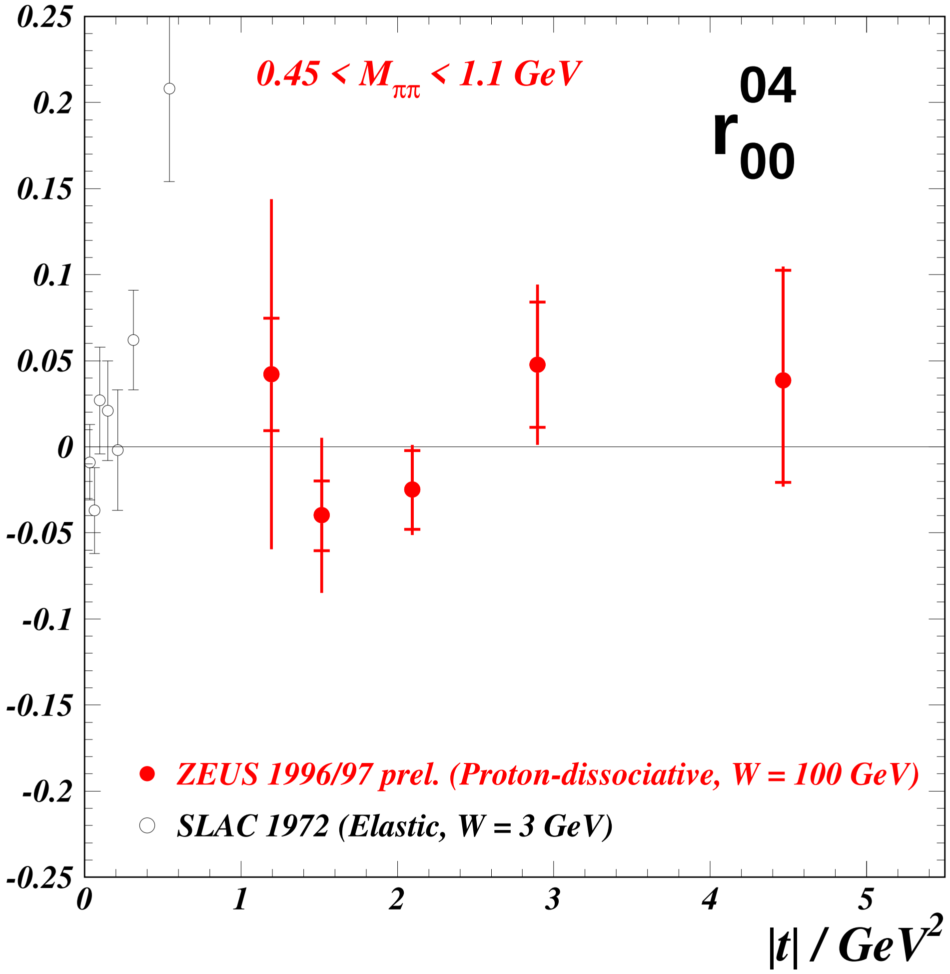
At low Q^2, Φ_h poorly measured, so integrate over it:

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

Helicity Analysis (I)

$$r^{04}_{00} \simeq \frac{T^2_{01}}{T^2_{01}+T^2_{11}+T^2_{1-1}}$$

r^{04}_{00} measures the degree of longitudinal polarization

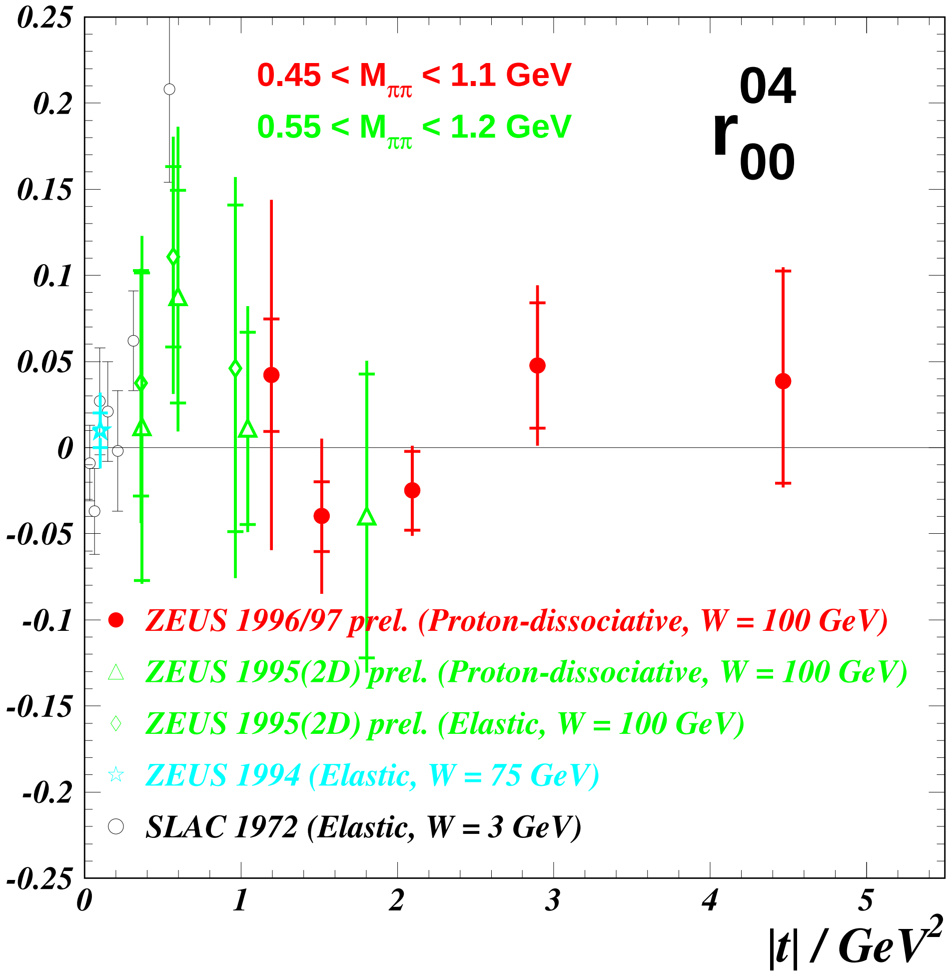


Long. pol. does *NOT* dominate at high $|t|$

Helicity Analysis (II)

$$r^{04}_{00} \simeq \frac{T^2_{01}}{T^2_{01}+T^2_{11}+T^2_{1-1}}$$

r^{04}_{00} measures the degree of longitudinal polarization

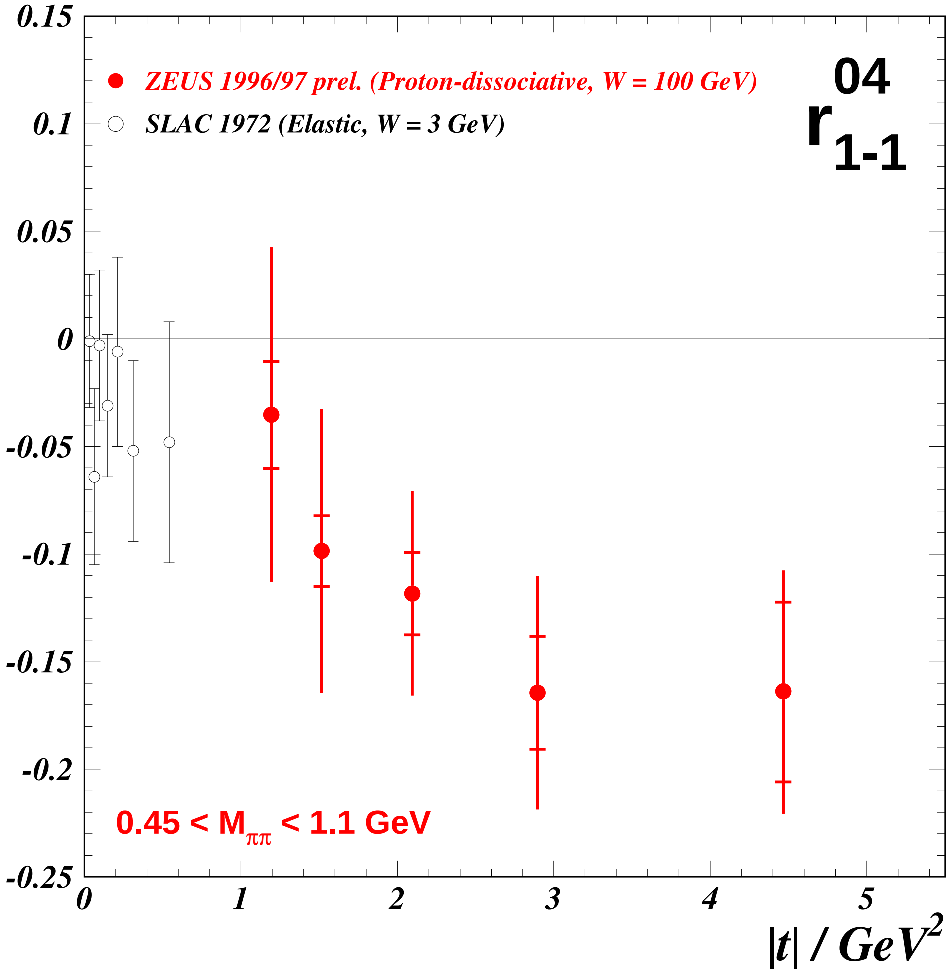


No difference elastic/dissociative observed

Helicity Analysis (III)

$$r^{04}_{1-1} \simeq \frac{Re(T_{11}T^*_{1-1})}{T^2_{01}+T^2_{11}+T^2_{1-1}}$$

r^{04}_{1-1} *sensitive to helicity flip of trans. photon*

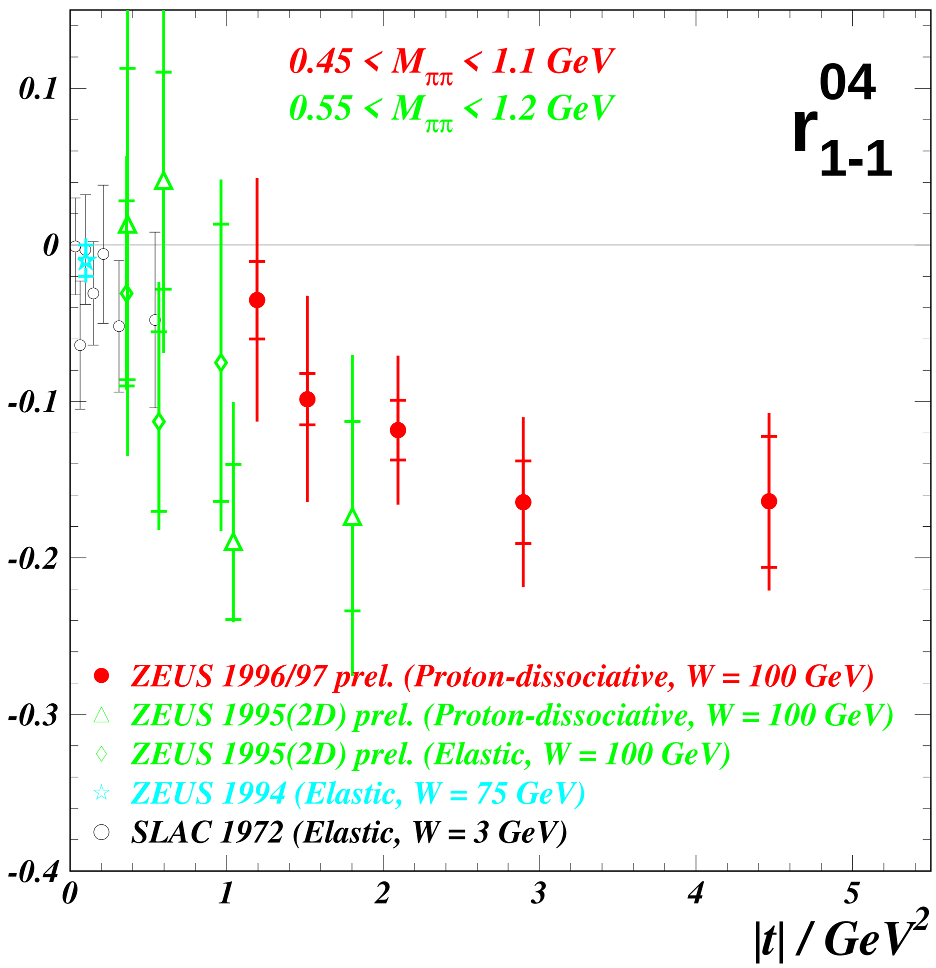


Clear double-flip contribution (But is it the ρ^0?)

Helicity Analysis (IV)

$$r^{04}_{1-1} \simeq \frac{Re(T_{11}T^*_{1-1})}{T^2_{01}+T^2_{11}+T^2_{1-1}}$$

r^{04}_{1-1} sensitive to helicity flip of trans. photon

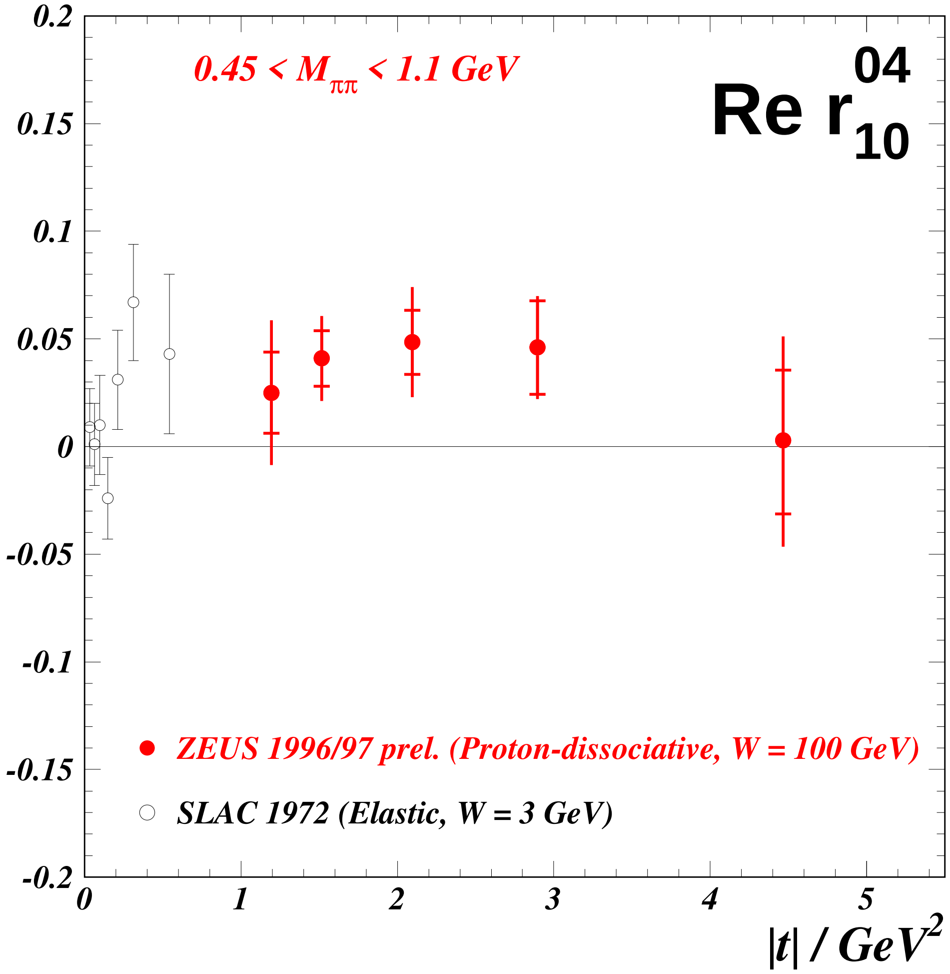


$\boxed{\text{Double-flip observed only at high } |t|}$

Helicity Analysis (V)

$$Re(r^{04}_{10}) \simeq \frac{1}{2}\left[\frac{Re(T_{11}T^*_{01})+Re(T_{1-1}T^*_{0-1})}{T^2_{01}+T^2_{11}+T^2_{1-1}}\right]$$

$Re(r^{04}_{10})$ *sensitive to single flip via interference*

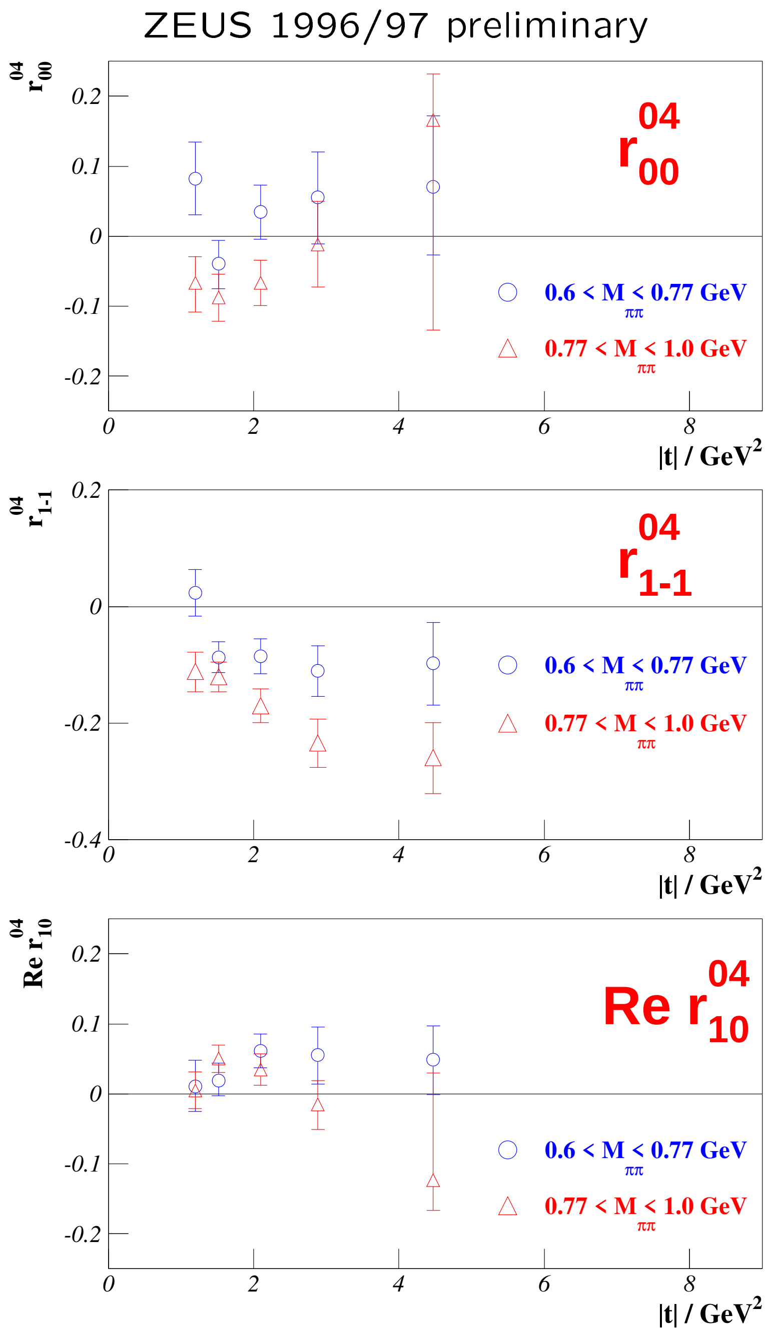


Indication of single-flip contribution (Is it the ρ^0?)

Helicity Analysis (VI)

Dipion-mass Dependence in r_{ij}^{04}

Are production and decay independent??

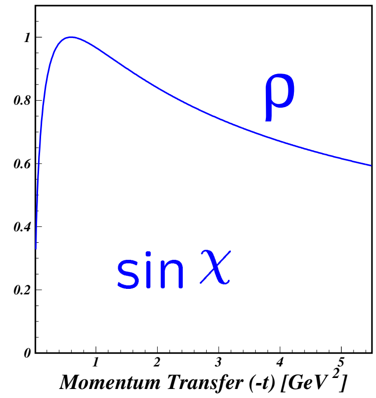


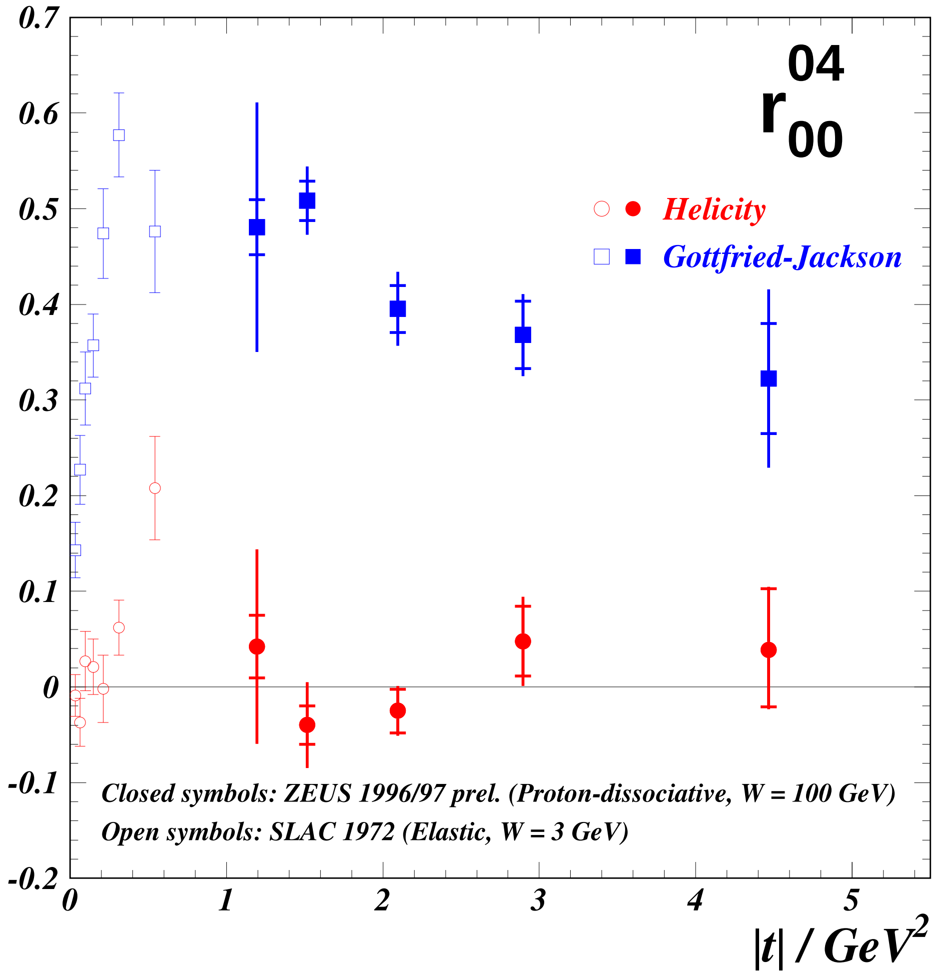
Single-flip contribution depends on mass region !

Choice of Spin Axis (I)

The angle χ between the Z-axes of the
Gottfried-Jackson and Helicity systems

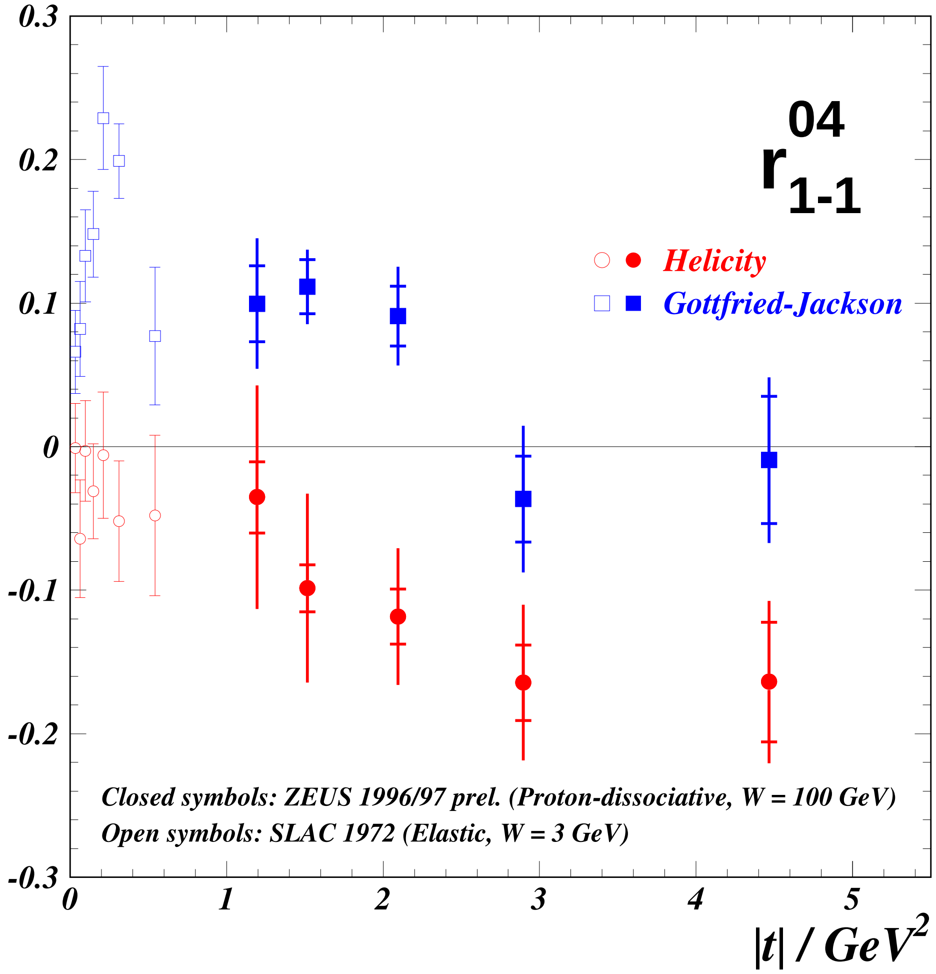
$$\cos\chi = \left(\frac{m_\rho^2 + t}{m_\rho^2 - t}\right)$$





Extension of SLAC data to $|t| \gg m_\rho^2$

Choice of Spin Axis (II)



Frame distinction decreases at high $|t|$

Summary

New results obtained for ρ^0
photoproduction
at
$W \simeq 100$ GeV
and
$1 \lesssim |t| \lesssim 6$ GeV^2

☞ **Dominant longitudinal polarization excluded**

☞ **Matrix element r^{04}_{1-1} differs from zero**

Help from theory needed
to distinguish ρ^0 from continuum