

Vector Mesons in Photoproduction

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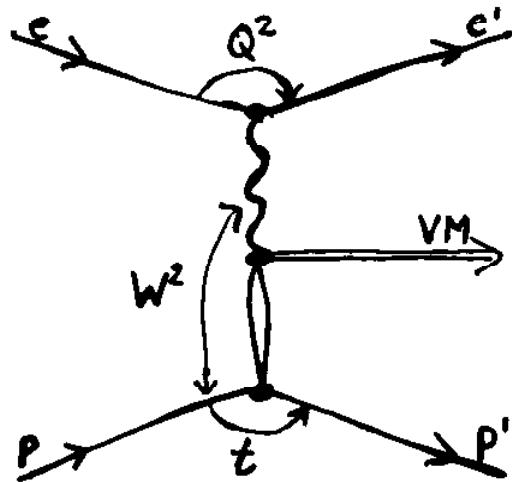
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ZEUS Collaboration

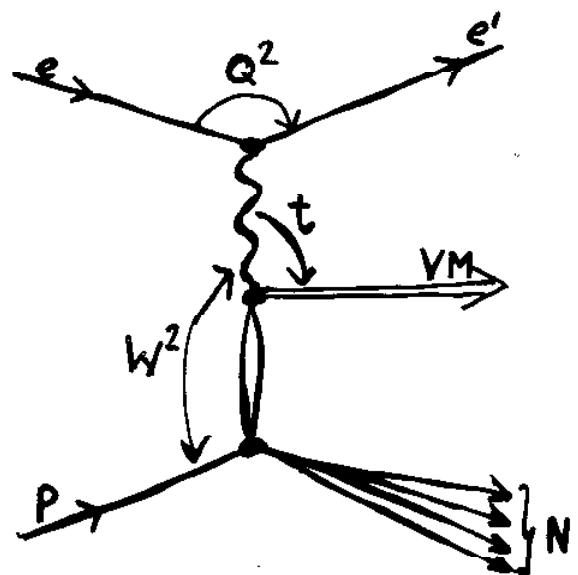
- Results on ρ^0 meson photoproduction
 - $\gamma p \rightarrow \rho^0 p$
 - $\gamma p \rightarrow \rho^0 N$
- Ratio of $\sigma(\phi)/\sigma(\rho^0)$, $\sigma(J/\psi)/\sigma(\rho^0)$ vs. $|t|$

Photoproduction of Vector Mesons

elastic

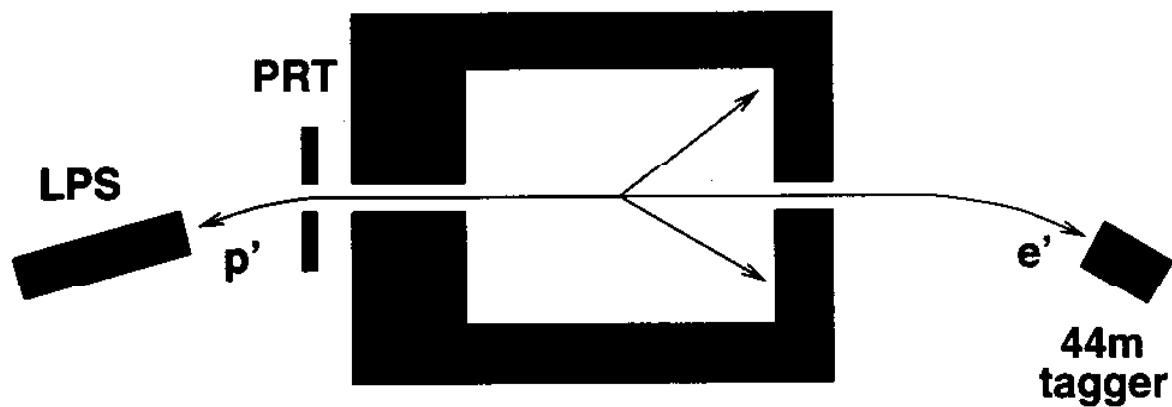


proton dissociative



kinematics (W, t) determined from 4-momentum of vector meson measured in central detector

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ZEUS DATA

1994

untagged photoproduction

$$\downarrow \\ Q^2 < 4 \text{ GeV}^2$$

$$50 < W < 100 \text{ GeV}$$

$$M_N < 10 \text{ GeV}$$

$$|t| < 0.5 \text{ GeV}^2$$

1995

tagged photoproduction

$$\downarrow \\ Q^2 < 10^{-2} \text{ GeV}^2$$

$$85 < W < 105 \text{ GeV}$$

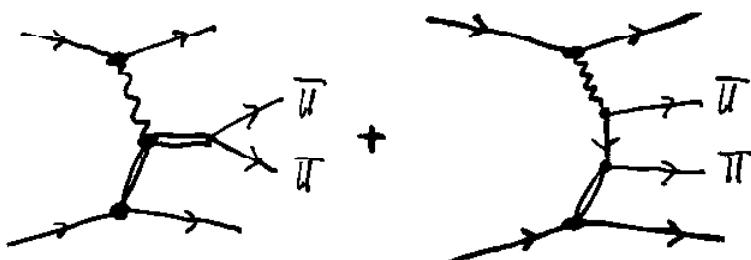
$$M_N < 10 \text{ GeV}$$

$$|t| < 4 \text{ GeV}^2$$

ρ^0 Resonance Shape

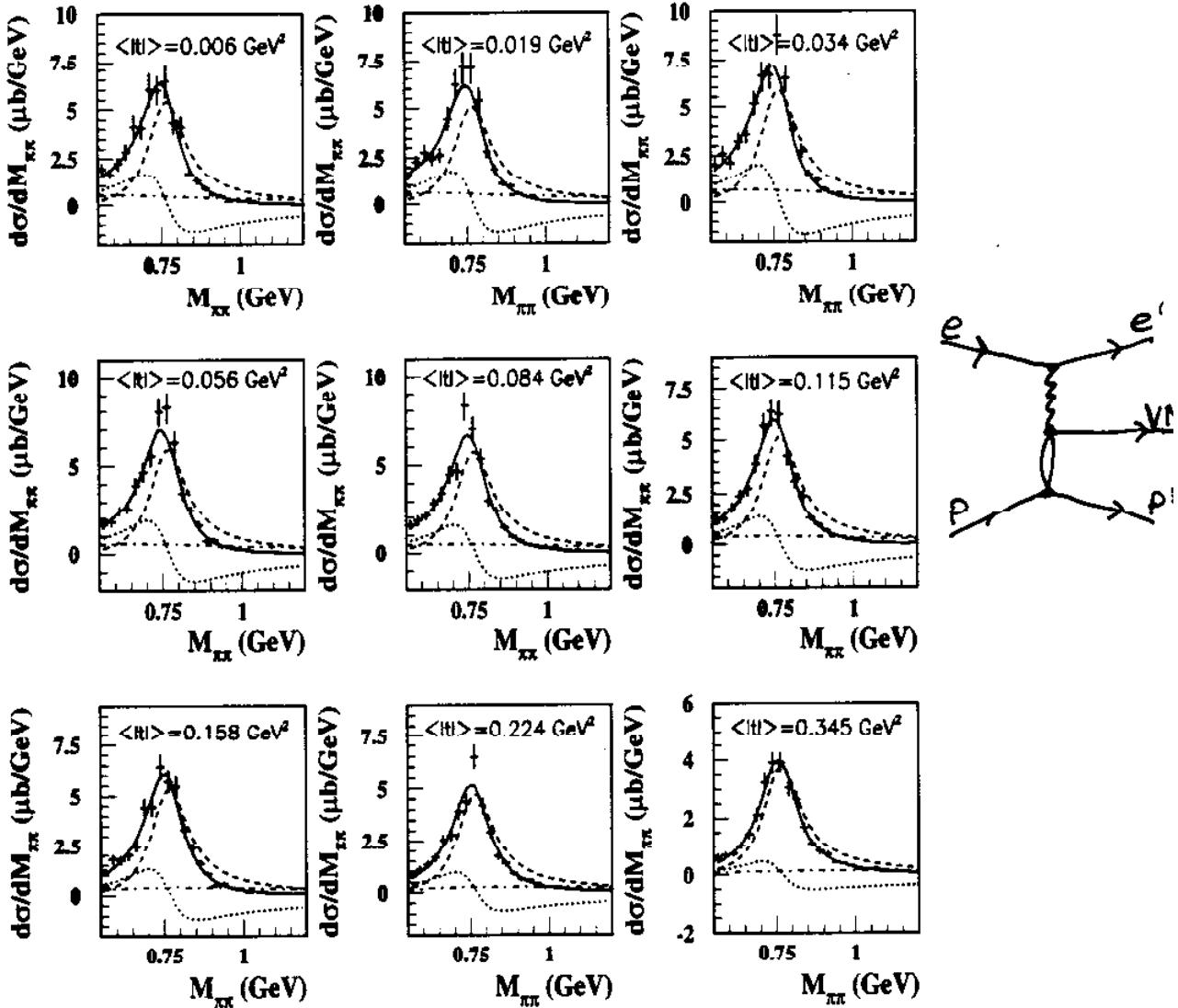
$M_{\pi\pi}$ spectra are skewed as observed at lower energies.

Interference of:

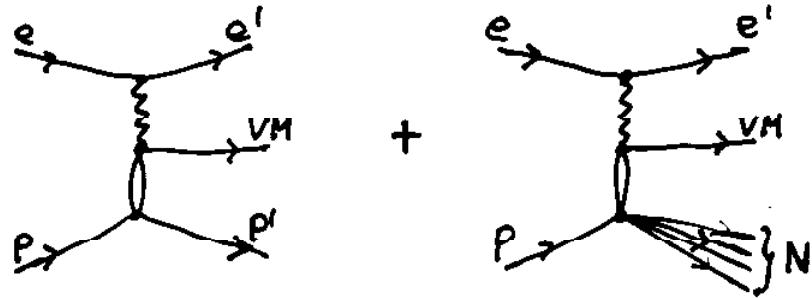


fit to data with $\frac{d\sigma}{dM_{\pi\pi}} = \left| A \frac{\sqrt{M_{\pi\pi} M_\rho \Gamma_\rho}}{M_{\pi\pi}^2 - M_\rho^2 + i M_\rho \Gamma_\rho} + B \right|^2$

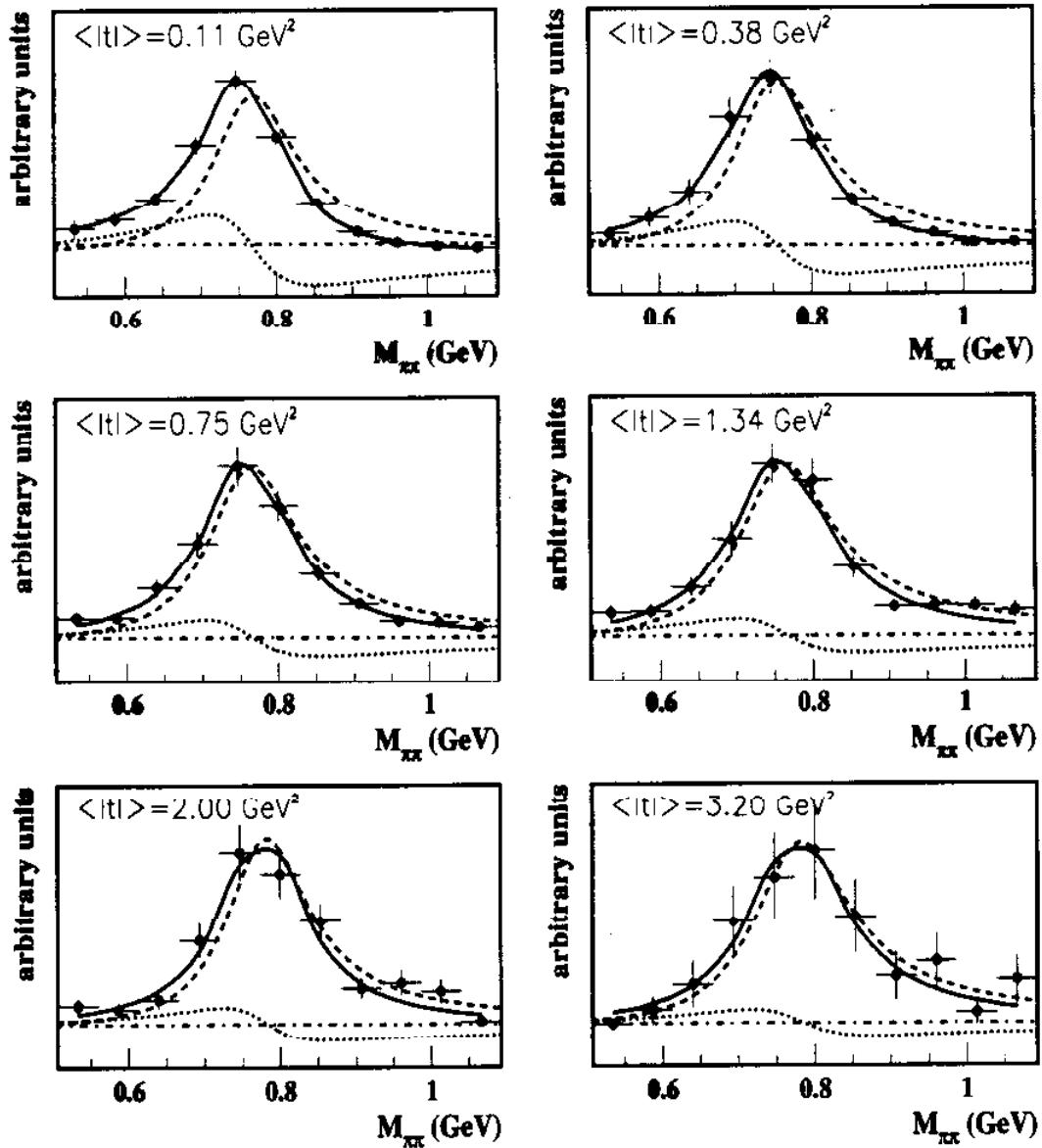
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ρ^0 Resonance Shape



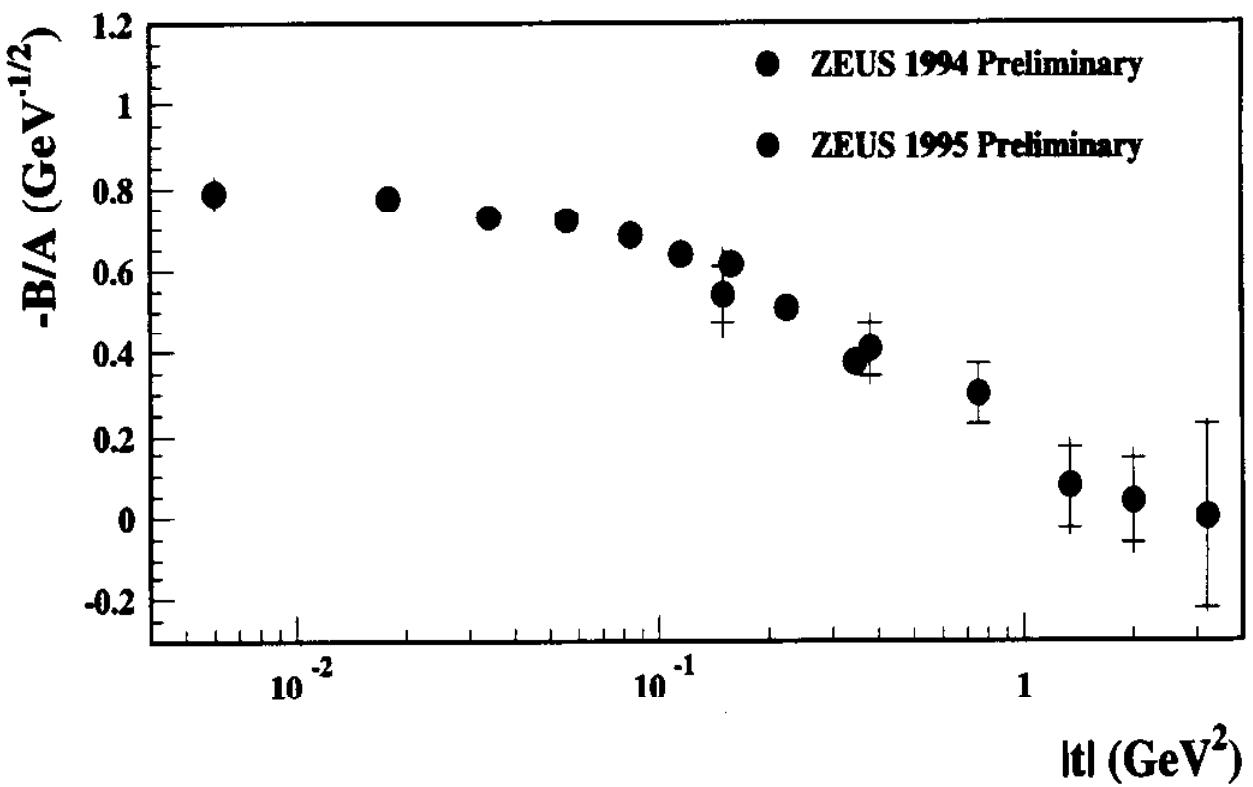
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ρ^0 Resonance Shape

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

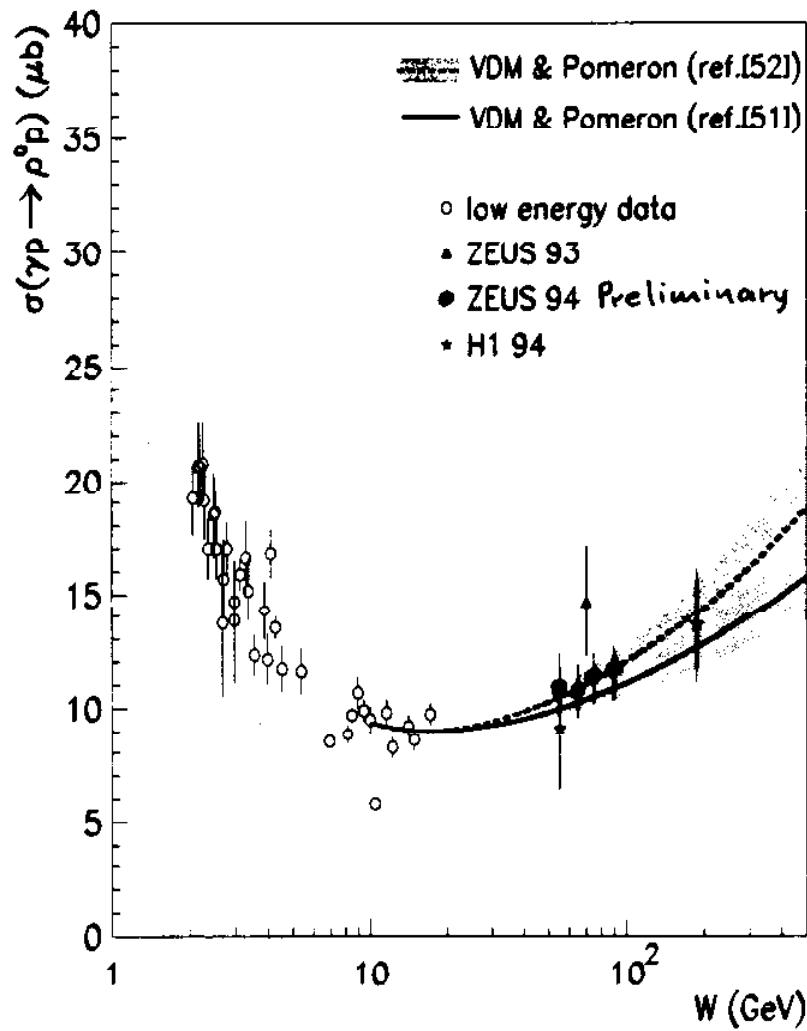
The quantity $-B/A$ is a measure of the ratio of the non-resonant to resonant contribution.



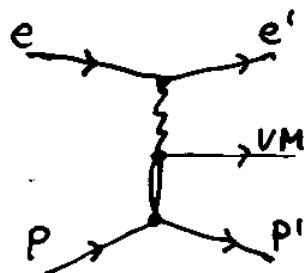
Amount of skewing decreases with increasing $|t|$

Elastic photoproduction of ρ^0 meson

Energy dependence of cross section



α_s from	Donnachie
α_s from	Landshoff
	Cudell et al.



A fit to the present data with $\sigma \sim W^a$ gives

$$a = 0.16 \pm 0.06 \text{ (stat.)} \quad {}^{+0.11}_{-0.14} \text{ (syst.)}$$

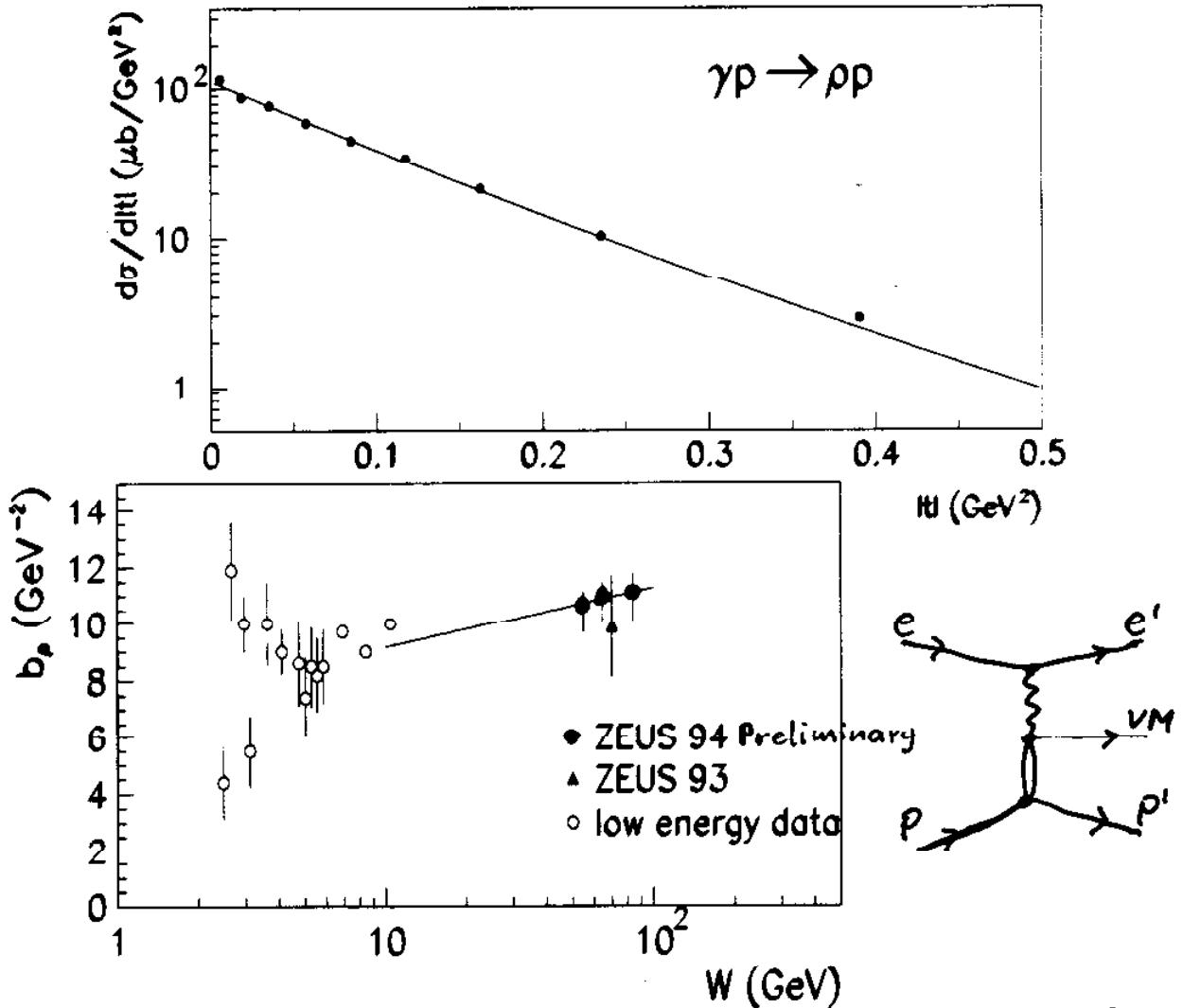
consistent with the value expected for a soft pomeron ($a \simeq 0.22$)

Elastic photoproduction of ρ^0 meson

fit to data with $\frac{d\sigma}{dt} = Ae^{-b_\rho|t|+c_\rho t^2}$

$$b_\rho = 10.9 \pm 0.3 \text{ (stat.)} \quad {}^{+1.0}_{-0.5} \text{ (syst.) GeV}^{-2}$$

$$c_\rho = 2.7 \pm 0.9 \text{ (stat.)} \quad {}^{+1.9}_{-1.7} \text{ (syst.) GeV}^{-4}$$



A fit of the form $b_\rho(W) = b(W_0) + 2\alpha'_{pom} \ln W^2$
 $\alpha'_{pom} = 0.23 \pm 0.15 \text{ (stat.)} \quad {}^{+0.10}_{-0.07} \text{ (syst.) GeV}^{-2}$

consistent with $\alpha'_{pom} = 0.25 \text{ GeV}^{-2}$ as obtained from fits to data on soft hadronic processes.

ρ^0 Helicity Analysis

In helicity frame:

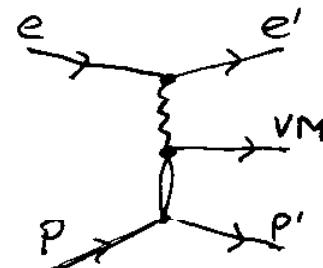
$$W(\cos \theta_h, \varphi_h) = \frac{3}{4\pi} \left[\frac{1}{2} (1 - r_{00}^{04}) + \frac{1}{2} (3r_{00}^{04} - 1) \cos^2 \theta_h \right] \\ - \sqrt{2} \operatorname{Re}[r_{10}^{04}] \sin 2\theta_h \cos \varphi_h \\ - r_{1-1}^{04} \sin^2 \theta_h \cos 2\varphi_h$$

r_{00}^{04} - is probability that the ρ^0 be produced with longitudinal polarization (in helicity 0 state)

r_{1-1}^{04} - is related to the interference between the helicity non-flip and double flip amplitudes

$\operatorname{Re}[r_{10}^{04}]$ - is related to the interference between the helicity non-flip and single flip amplitudes

If s-channel helicity conservation (SCHC) holds, r_{1-1}^{04} and $\operatorname{Re}[r_{10}^{04}]$ should be zero.



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$$r_{00}^{04} = 0.01 \pm 0.01 \text{ (stat.)} \pm 0.02 \text{ (syst.)}$$

$$r_{1-1}^{04} = -0.01 \pm 0.01 \text{ (stat.)} \pm 0.01 \text{ (syst.)}$$

$$\operatorname{Re}[r_{10}^{04}] = 0.01 \pm 0.01 \text{ (stat.)} \pm 0.01 \text{ (syst.)}$$

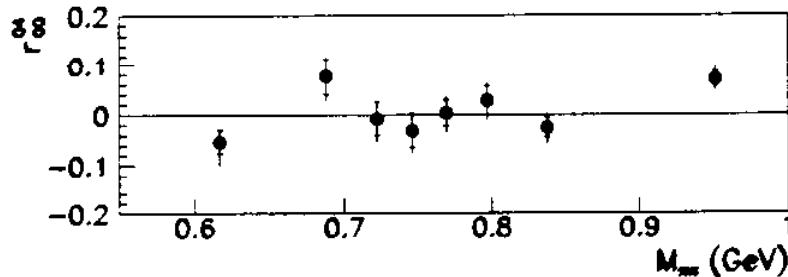
In the kinematic range $50 < W < 100 \text{ GeV}$, $|t| < 0.5 \text{ GeV}^2$:

* ρ^0 mesons are produced predominantly with helicity ± 1
 * ρ^0 mesons are produced predominantly with helicity 0 in SCHC

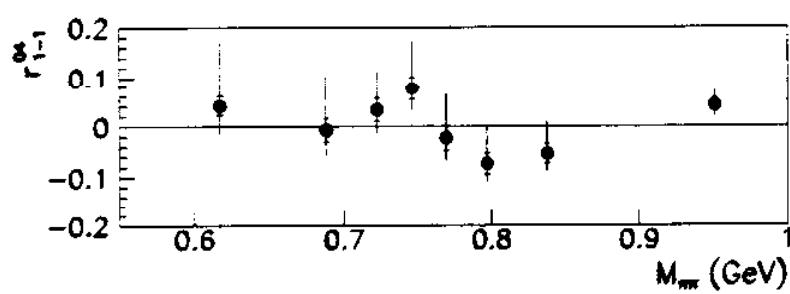
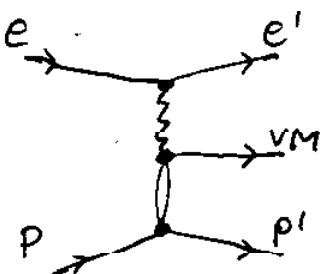
ρ^0 Helicity Analysis

Mass dependence of r_{00}^{04} , r_{1-1}^{04} and $\Re e[r_{10}^{04}]$

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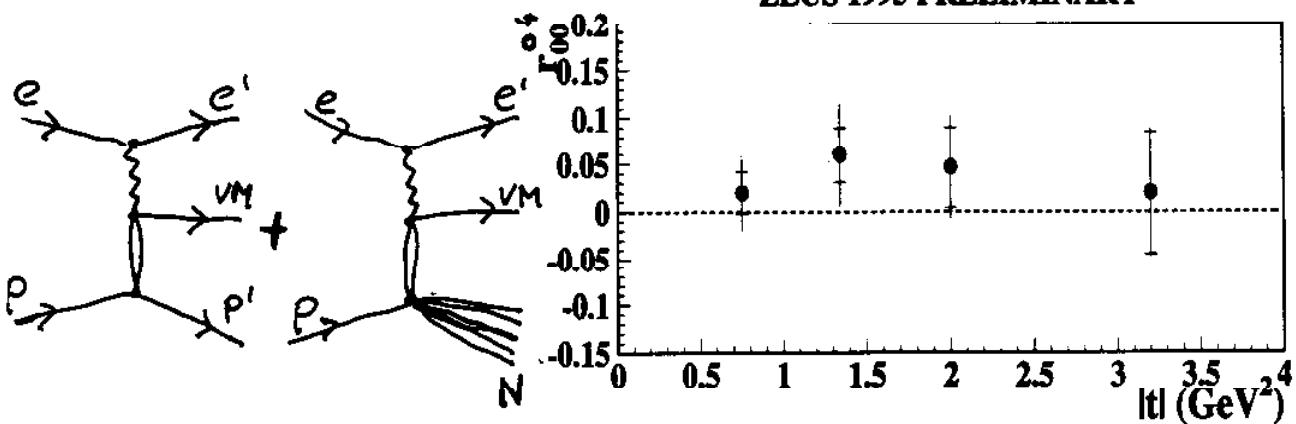


$|t| < 0.5 \text{ GeV}^2$



$|t|$ dependence of r_{00}^{04}

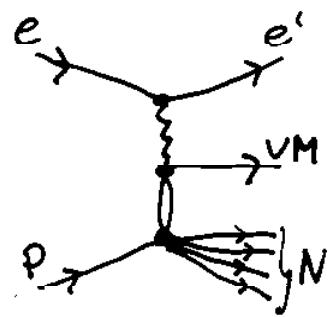
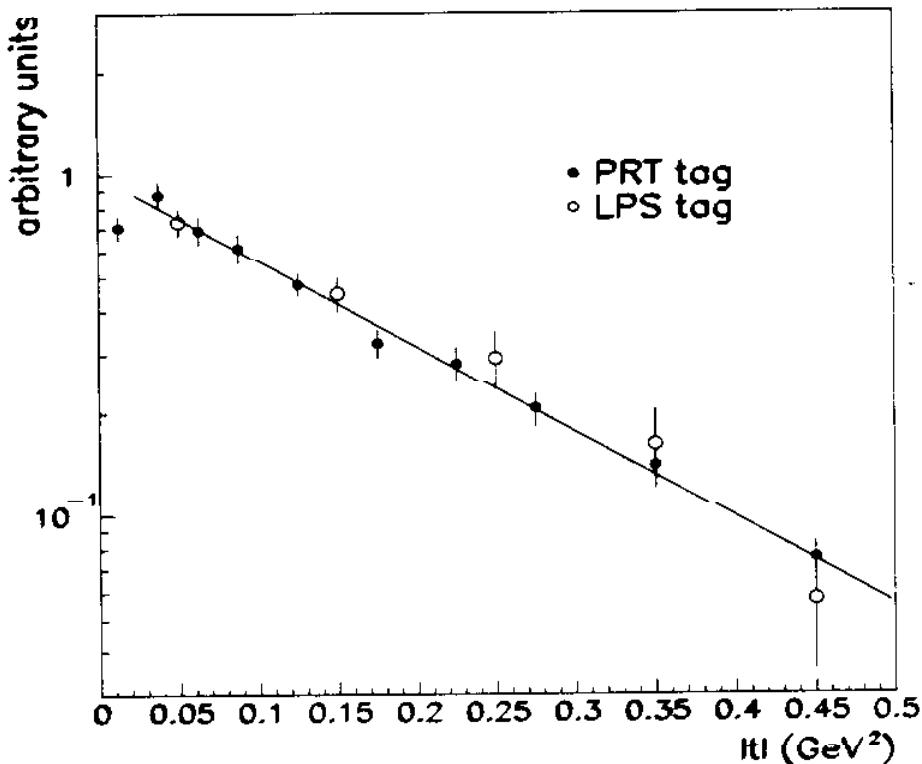
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predominantly ρ^0 produced with helicity ± 1

proton dissociative ρ^0 photoproduction

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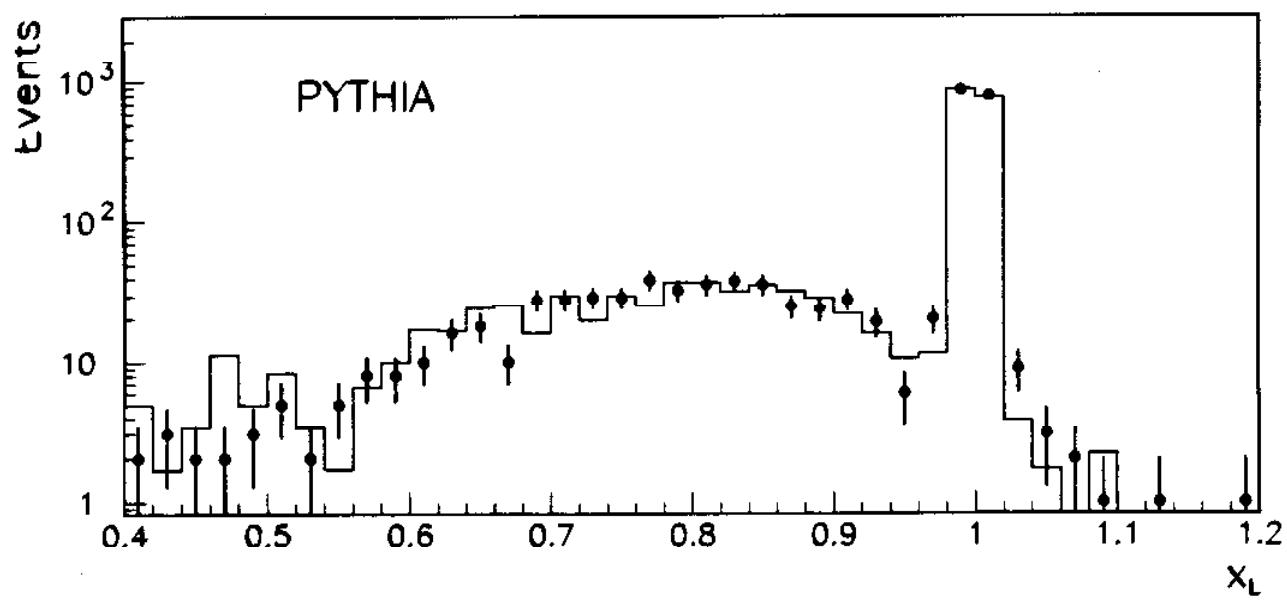
fit to data with $\frac{d\sigma}{d|t|} = A e^{-b|t|}$

PRT tag; $b = 5.8 \pm 0.3$ (stat.) ± 0.5 (syst.) GeV^{-2}
 LPS tag; $b = 5.7 \pm 0.6$ (stat.) ± 0.9 (syst.) GeV^{-2}

Ratio of the elastic to the proton-dissociative photoproduction cross sections

$$\frac{\sigma(\gamma p \rightarrow \rho^0 p)}{\sigma(\gamma p \rightarrow \pi^0 N)} = 2.0 \pm 0.2 \text{ (stat.)} \pm 0.7 \text{ (syst.)}$$

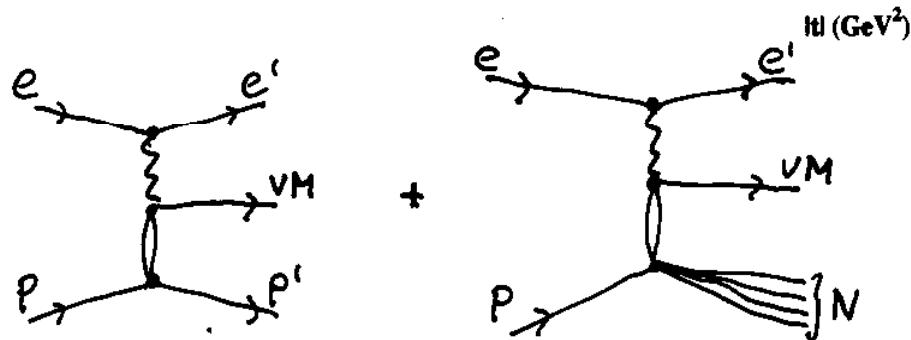
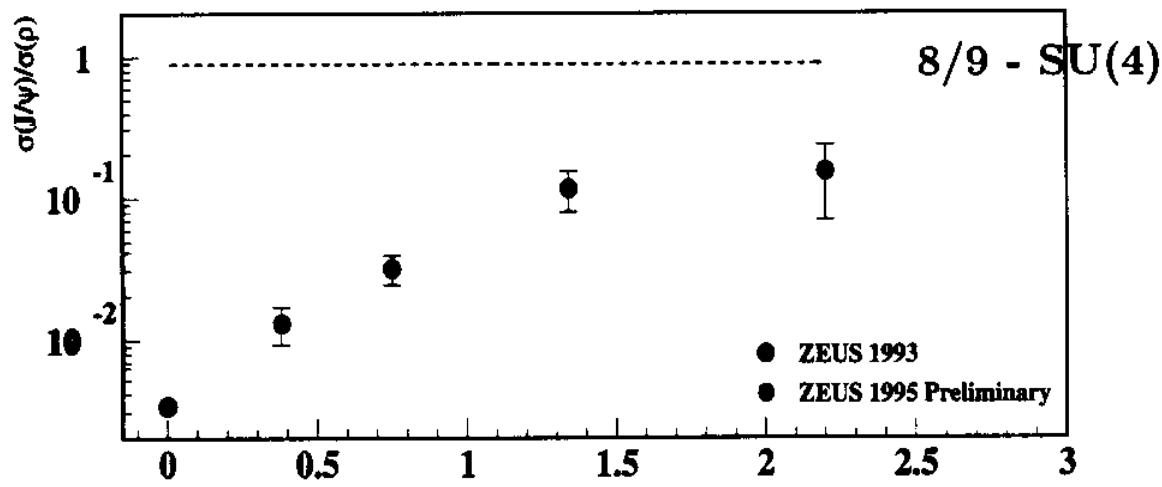
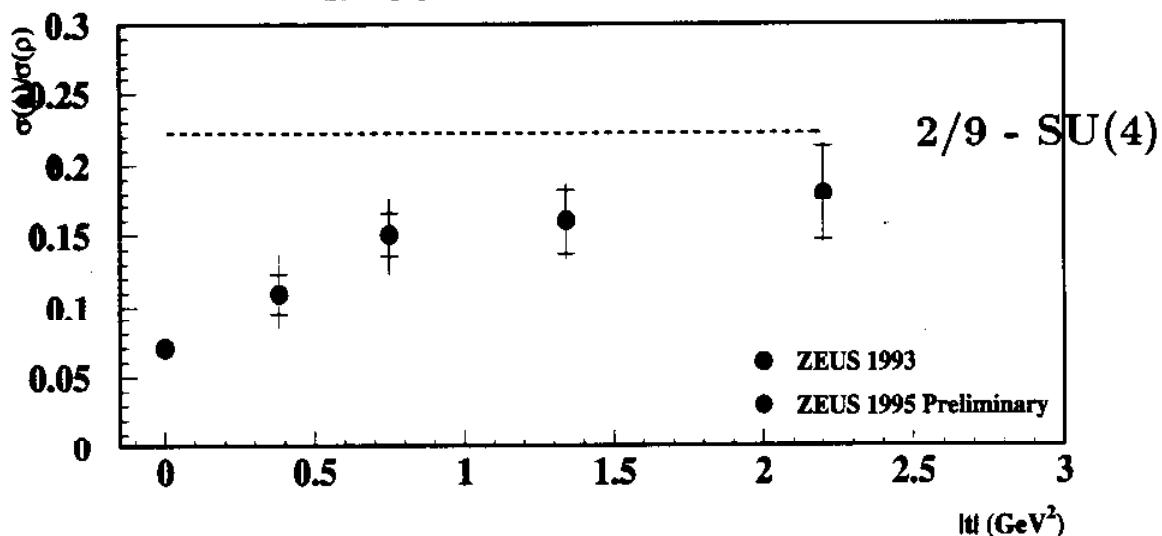
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VM photoproduction at large $|t|$

Ratio of the cross sections $\sigma(\phi)/\sigma(\rho^0)$ and $\sigma(J/\psi)/\sigma(\rho^0)$ as a function of $|t|$.

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Conclusion

- Photoproduction of ρ^0 meson at low $|t|$
 - slow increase of σ and b with W , consistent with soft pomeron expectation
 - predominantly produced with helicity ± 1
 - SCHC holds
 - $\sigma_{\gamma p \rightarrow \rho^0 p} / \sigma_{\gamma p \rightarrow \rho^0 N} \simeq 2$
 - $b_{\gamma p \rightarrow \rho^0 p} / b_{\gamma p \rightarrow \rho^0 N} \simeq 2$
- Photoproduction of VM mesons at large $|t|$
 - ρ^0 meson predominantly produced with helicity ± 1
 - ratio of the cross sections $\sigma(\phi)/\sigma(\rho^0)$ and $\sigma(J/\psi)/\sigma(\rho^0)$ increase with $|t|$.
Approach the QPM expectation ?