Diffractive meson pair photoproduction in Söding model

(N. Starkov and N. Z.)

1. Introduction
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3. Numerical results
4. Absorbtive effects
5. Conclusions

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ZEUS Note 96-111

(1.) Introduction

H1 and ZEUS exp. results for
diffractive ρ^0-photoproduction

H1 Collab. NP B463 (96) 3

ZEUS Collab. Z. Phys. C69 (96) 39

- confirmed the general properties of soft diffractive hadron processes
- showed necessity of futher both exp and theor. studies at high

$$Q^2,\ t,\ M_{\pi\pi},\ q_t,\ \ldots$$

$\Rightarrow$ the transition from soft to hard diffractive γp-interactions

$\Rightarrow$ the nature of vacuum colorless exchange

$\mathbb{P}$

Process of DD of an incoming particl (a photon on our case) into low mass states contains three different contributions : Sov. J. Part. and Nucl. 9(78)266 N.Z., V. Tsare

1) production of hadron states ($\rho, \varphi, \ldots$ -resonances in our cases), which then decay into final states hadrons: $\pi^+\pi^-$, K^+K^-, D^+D^-, ...

2) Drell-Hiida-Deck (DHD) nonresonant background term (resonance like one) for final state production

S. Drell, K. Hiida PRL 7(61)199
R. Deck: PRL 13(64) 169

3) final state interactions terms

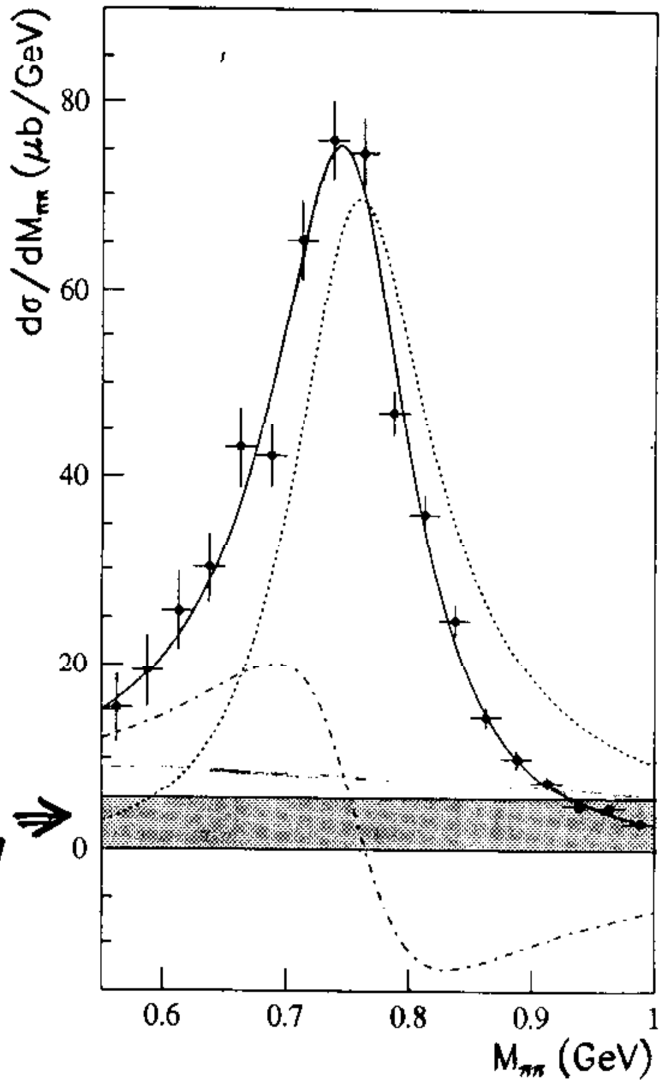
M. Ross L. Stodolsky PR 149(66)11

DHD mechanism for nonres. background in ρ^0-photoprod. has been used by P. Söding PL 19(66)702

⇓

main consequence - the shift of ρ-mass spectrum in $d\sigma/dM_{\pi\pi}$ because of interferen between $\gamma p \to \pi^+\pi^- p$ and $\gamma p \to \rho^0 p \to \pi^+\pi^- p$ production amplitudes was confirmed H1 and ZE

ZEUS Collab. Z. Phys. C69 (1996) 39



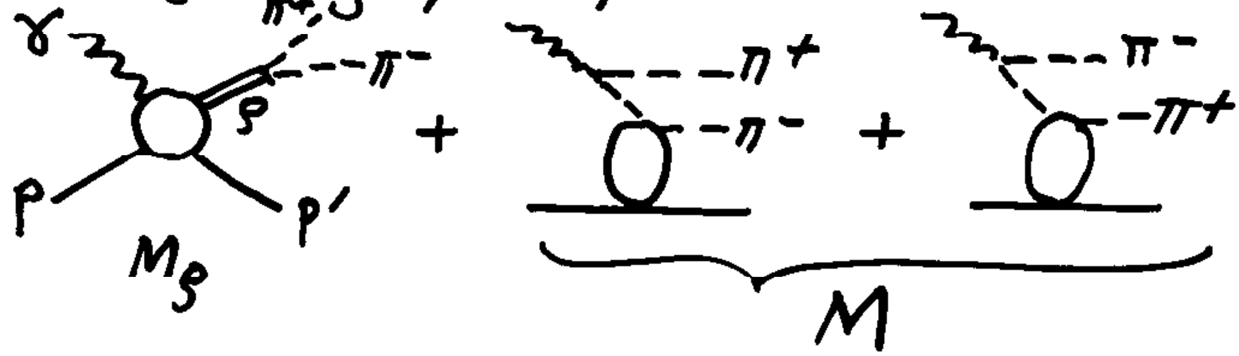
We wanted to describe the background ⇒

Figure 6: The acceptance corrected differential cross section $d\sigma/dM_{\pi\pi}$ for $60 < W < 80$ GeV and $|t| < 0.5$ GeV^2. The points represent the ZEUS data and the curves indicate the results of the fit to the data using expressions (7-10). The dotted line shows the contribution of the Breit Wigner term, the dash-dotted line that of the interference term and the dashed line that of the non-resonant background; the shaded band indicates the size of the statistical uncertainty on the non-resonant background term. The solid curve is the sum of these three terms. The horizontal bars indicate the size of the bins.

$\gamma p \to \pi^+\pi^- p$, $K^+K^- p$, $D^+D^- p$, ... are the most interesting of itself

J. Pumplin PR D2 (1970) 18.

② Söding model for ρ^0-photoproduction



$$M \sim \frac{\epsilon_\mu q_{(+)\mu}}{Q\cdot q_{(+)}} T_{\pi N}(Q-q_{(+)}) - \frac{\epsilon q_{(-)}}{Q q_{(-)}} T(Q-q_{(-)}),$$

$$\Downarrow$$

$$\frac{d\sigma^T}{dt} = \frac{\alpha}{2\pi^2} e^{Bt} \frac{\sigma_{tot}^2}{16\pi} \int \frac{z(z-1)\,dz\, d^2 q_{t(-)}}{m^2_{(+)t}\, m^2_{(-)t}} \cdot A F^2(q^2_{t(-)}) \qquad (1)$$

where $q_{t(-)}$ – two component tr. momentum in Sudakov decomposition of 4-momentum of π^--meson: $q_{(-)} = zQ + \beta_{(-)} p + q_{t(-)}$

with $z = \frac{q_{(-)} p}{Qp}$, $\beta_- = \frac{m^2_{(-)t}}{z 2Qp}$, $m^2_{(-)t} = \mu^2 + \vec{q}^{\,2}_{t(-)}$

Q and p – 4 momenta of γ and p (with $m_p = 0$)

$t \simeq -(\vec{p}\,'_t)^2$, $q_{t(+)} = -\vec{p}\,'_t - \vec{q}_{t(-)}$

$$A = \left[\frac{1-z}{z} \frac{m^2_{(-)t}}{m^2_{(+)t}} q^2_{t(+)} + \frac{z}{1-z} \frac{m^2_{(+)t}}{m^2_{(-)t}} q^2_{t(-)} - 2\vec{q}_{t(+)} \vec{q}_{t(-)}\right] \qquad (2)$$

„Form factors" F of two meson states.

1) describe off mass shell meson exchange
2) suppress high $\vec{q}^{\,2}_{t(-)}$ or $M_{\pi\pi}=(q_{(+)}+q_{(-)})^2$ distributions

These f.f. are unknown (in original Söding model ones are absent). For instance they can be taken in pole forms:

$$\boxed{F_\pi(q^2_{t(-)})=\frac{m_\rho^2}{m_\rho^2+\vec{q}^{\,2}_{t(-)}}} \qquad (3)$$

For 2π-, $2K$- and $2D$-photoproduction we can take

m_ρ, m_φ, m_8 — father „version 1"

or

$m_{\pi(1300)}$, m_φ, $m_{J/\psi}$ — „version 2" (Ryskin, Shabelski, hep-ph/9701407)

$\sigma_{tot}(Mp)$

DL parametrization gives for $W=100$ GeV

$\sigma_{tot}(\pi p)=29.2$ mb, $\sigma_{tot}(Kp)=25.1$ mb (Donnachie Landshoff, PL B296 (92) 2…)

$$\sigma_{tot}(Dp)\ ? = 3\,\text{mb} \div \sigma_{tot}(\pi p)/2$$

Slope parameter B

$$B_{\pi p}=B_{Kp}=10\ \text{GeV}^{-2},\quad B_{Dp}=6\ \text{GeV}^{-2}\ ?$$

$\Rightarrow \gamma p \to D^+D^-p$ strongly depends from

$\sigma(Dp)$, B and F: m … m …

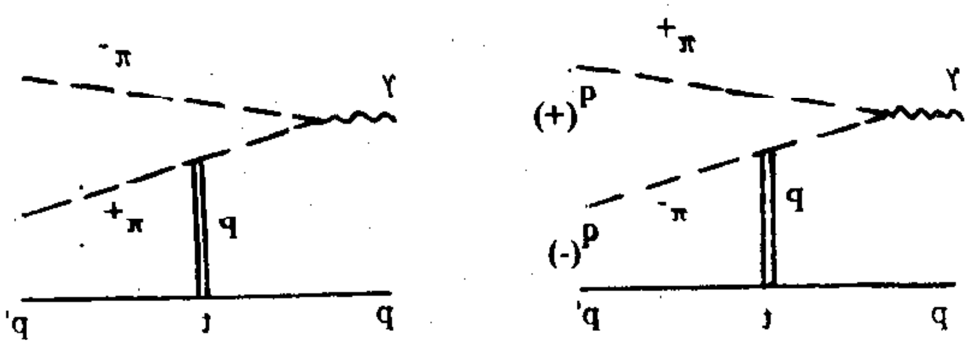


Figure 1.

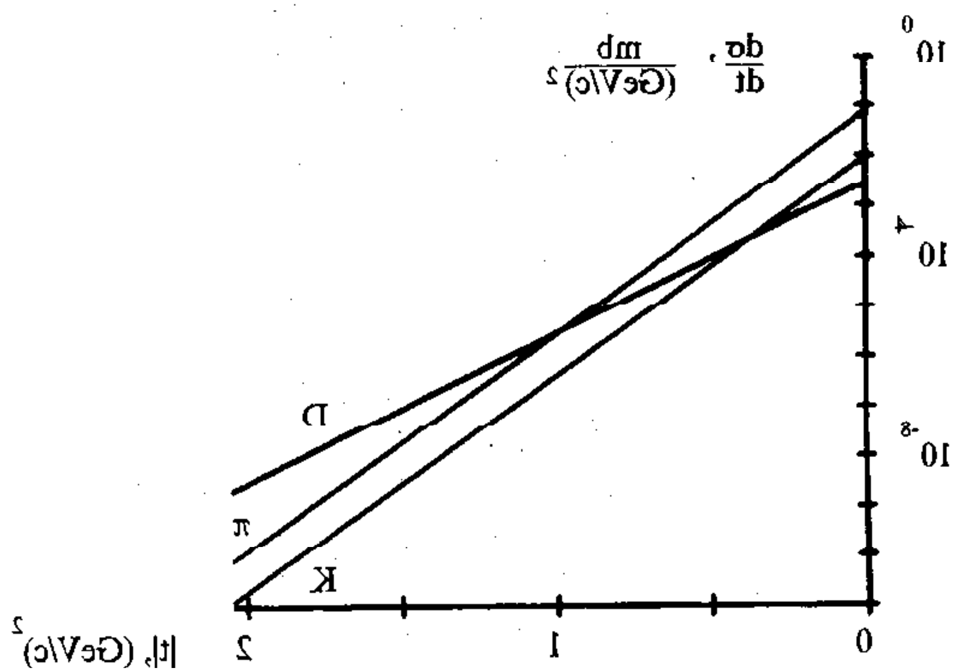


Figure 2.

From (1) by integrating $d\sigma/dt\, d^2 q_{t(-)}$

$\sigma_{tot}(2M)$, μb

	"version 1"		"version 2"	
2π $\sigma_{tot}(\pi p) = 29.2\,mb$	m_ρ in F	4.6	10	$m_{\pi(1300)}$
$2K$ $\sigma_{tot}(Kp) = 25.1$	m_φ	1.4	1.4	m_φ
$2D$ $\sigma_{tot}(Dp) = \sigma(\pi p)/2$	m_B	~ 1	0.5	$m_{J/\psi}$

$\Rightarrow$ version 2 gives the lager cross sections

The distributions $d\sigma^T/dM$ over the mass $M = (q_{(+)} + q_{(-)})$ of meson pairs can be obtained by the transition from z to M in eq. (1), using at $t=0$:

$$z(1-z)M^2 = \mu^2 + \vec{q}^{\,2}_{t(-)} ,$$
$$\frac{dz}{dM} = 2M\, m_t^2 / [M^4 (1 - 4m_t^2/M^2] \qquad (4)$$

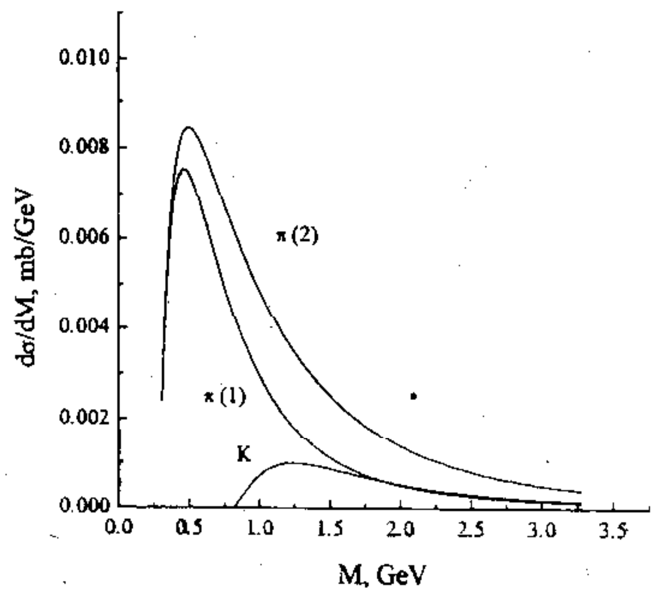


Figure 5.

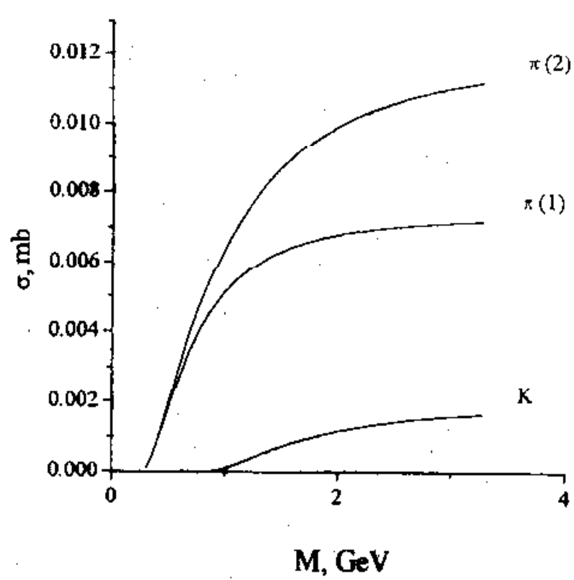


Figure 6.

(4.) Some remarks on absorbtive corrections

Meson pair photopr. c.s. contains the final state interaction contribution also

The effects of rescattering in f.s. for 2π-photoproduction ~ 20-40% J. Pumplin PR D2(70)1859

Two kinds of the abs. corrections was not included in (1):

1) the elastic rescattering of mesons on each other

2) one of both mesons on the target (p)

1) – essential for resonance production of 2π can be take into account the special prescripti (multiply the b. term in a given partial wave by $e^{i\delta}\cos\delta$) M. Ross, L. Stodolsky PR 149(66)1172

– don't affect on the slope parameter J. Pumplin PR D2

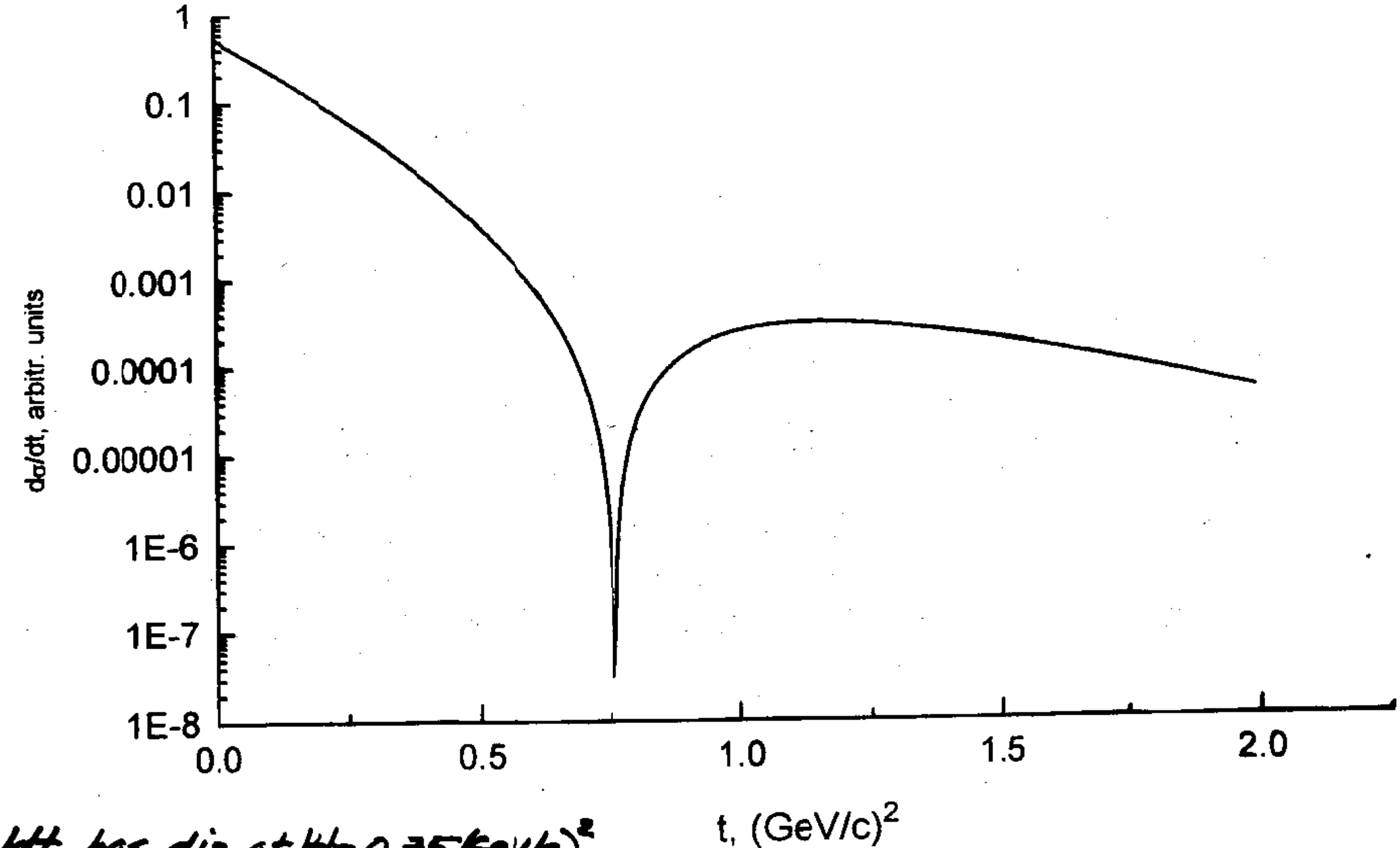
2) give strong effect for $d\sigma/dt$, when in the eikonal approximation $d\sigma/dt \sim \exp Bt$ is replaced by

$$\frac{d\sigma}{dt} \sim \left[\exp(Bt/2) - \frac{\sigma}{16\pi B} e^{Bt/4}\right]^2 \qquad (5)$$

Inelastic diffractive intermediate state leads to the replacement $\sigma \to \lambda\sigma$, where $\lambda \cong 1 + \sigma_d/\sigma_{el}$

[illegible]

$\sigma = 28\,mb$, $B = 7\,(GeV/c)^{-2}$, $\lambda = 1.3$



1) $d\sigma/dt$ has dip at $|t| = 0.75\,(GeV/c)^2$

2) $d\sigma/dt$ changes of the slope parameter at $|t| > 0.8\,(GeV/c)^2$

Figure 7.

(5.) Conclusions

1. We estimated the non-resonant meson pair photoproduction c.s at HERA energies
2. Results essentially depend on the behaviour of f.f. and the absorption in the final state

and remarks

1. Söding mechanism contribution is visible at low $Q^2 \neq 0$ (Ryskin, Shabelski.
2. Diffractive non-resonant 2K-photoproduction contribution is important for correct extraction of K^--meson photoproduction at HERA.
   As was poited by Pumplin the process $\gamma p \to K^+ K^- p$ is interesting because it could be studied at low K^+K^- masses without interference from φ-resonance production
3. D^+-meson photoproduction mechanism should give contribution to the μ-production at high q_t (background for muon pairs from J/ψ)
4. (1) can be used for extraction of the elastic $\pi^\pm p$, $K^\pm p$ and $D^\pm p$ cross sections M. Arneodo, Ryskin, Shabelski
   or
   for extraction of f.f. if $\sigma_{\pi p}$. σ_{Kp} are known