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Exclusive electroproduction of two pions at HERA

Halina Abramowicz[*†]
Tel Aviv University, Tel Aviv, Israel
E-mail: halina@post.tau.ac.il

Two pion exclusive electroproduction in the mass range $0.4 < M_{\pi\pi} < 2.5$ GeV has been studied with the ZEUS detector using 82 pb^{-1} of integrated luminosity collected during 1998-2000. The two-pion mass distribution is interpreted in terms of the pion electromagnetic form factor, $F_{\pi}(M_{\pi\pi})$, assuming that the studied mass range includes the contributions of the ρ, ρ' and ρ'' vector meson states. The masses and widths of resonances are obtained and subsequently the Q^2 dependence of the cross sections $\sigma(\rho' \to \pi\pi)/\sigma(\rho)$ and $\sigma(\rho'' \to \pi\pi)/\sigma(\rho)$ is extracted.

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[*]Speaker.
[†]for the ZEUS Collaboration

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1. Introduction

The production of light vector mesons, ρ mesons, which are $1S$ triplet $q\bar{q}$ states, has been extensively stydied at HERA [1, 2]. In this paper, a study of exclusive electroproduction of two pions, $\gamma^* + p \to 2\pi + p$, is presented in the extended two-pion mass range $0.4 < M_{\pi\pi} < 2.5$ GeV, in the kinematic range of $2 < Q^2 < 80$ GeV^2, $32 < W < 180$ GeV and $|t| < 0.6$ GeV^2. The following kinematic variables are used: Q^2 - the four-momentum squared of the virtual photon; W^2 - the squared center-of-mass energy of the photon-proton system; t - the squared four-momentum transfer at the proton vertex and $M_{\pi\pi}$ - the invariant mass of two pions. Events which were accepted for this analysis have the following topology : an electron recorded in the main uranium-scintillator calorimeter; two opposite charge tracks detected in the Central Tracking Detector (CTD) associated with the reconstructed vertex; the calorimeter energy deposits not associated with the tracks have to be smaller than 300 MeV (elasticity cut). The two charged tracks, detected in the CTD, are assumed to be pions. The above selection yielded 63517 events for this analysis.

2. Results

The two-pion invariant mass distribution was fitted as a sum of two terms,

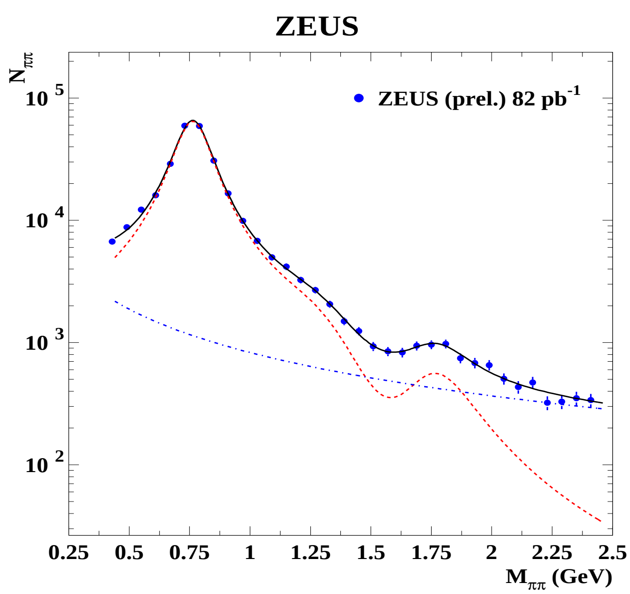

Figure 1: The two pion mass distribution, $M_{\pi\pi}$, where $N_{\pi\pi}$ is the acceptance corrected number of events. The dots are the data and the full line is the result of a fit using the KS parameterization. The dashed line is the pion form factor and the dashed-dotted line denotes the backgroung contributuon.

$$\frac{dN(M_{\pi\pi})}{dM_{\pi\pi}} = A\left(1 - \frac{M_\pi^2}{M_{\pi\pi}^2}\right)\left[|F_\pi(M_{\pi\pi})|^2 + B\left(\frac{M_o}{M_{\pi\pi}}\right)^n\right] \tag{2.1}$$

where $F_\pi(M_{\pi\pi})$ is the pion electromagnetic form factor, A is an overall normalization constant, M_π is the pion mass and $M_o = 1$ GeV. The pion form factor is written in terms of the Kuhn-Santamaria

(KS) [3] parametrization: $F_\pi(M_{\pi\pi}) = (BW_\rho(M_{\pi\pi}) + \beta BW_{\rho'}(M_{\pi\pi}) + \gamma BW_{\rho''}(M_{\pi\pi}))/(1+\beta+\gamma)$, where *BW* is the Breit-Wigner distribution and β and γ are relative amplitudes. The results of the fit are shown in Figure 1.

The ρ and ρ'' signals are clearly visible. The negative interference between all the resonances results in the ρ' signal to appear as a shoulder. The negative value of β preferred by the fit implies that the relative signs of the amplitudes of the three resonances is +, -, +, respectively. The Q^2 dependence of the relative amplitudes, β and γ, was determined by performing the fit to $M_{\pi\pi}$ in three Q^2 regions, 2-5, 5-10 and 10-80 GeV^2 . The results are shown in Figure 2(a-c). A reasonable description of the data is achieved. The absolute value of β increases with Q^2 while value of γ is consistent with no Q^2 dependence, within large uncertainties.

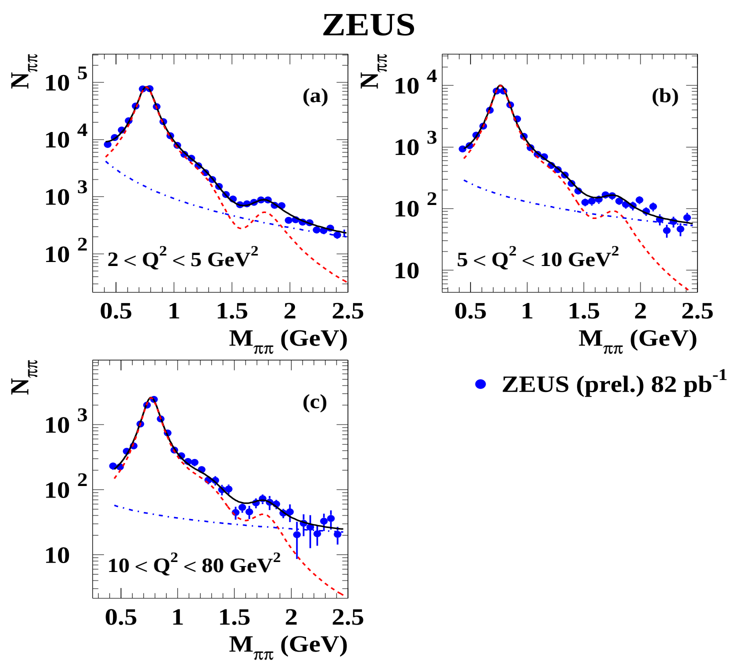

Figure 2: Same as Figure 1 for three regions of Q^2, as denoted in the figure

In this paper we study the ratio R_V defined as, $R_V = \sigma(V)\cdot Br(V \to \pi\pi)/\sigma(\rho)$ where σ is the cross section for vector meson production and $Br(V \to \pi\pi)$ is the branching ratio of the vector meson $V(\rho', \rho'')$ into $\pi\pi$. The ratio R_V may be directly determined from the results of the $M_{\pi\pi}$ mass fit, $R_{\rho'} = \beta^2 \cdot I_{\rho'}/I_\rho$ and $R_{\rho''} = \gamma^2 \cdot I_{\rho''}/I_\rho$, where I_V is the integral of the Breit- Wigner amplitude squared and the integration is carried out over the range $2M_\pi < M_{\pi\pi} < M_V + 5\Gamma_V$. Figure 3 shows the ratio R_V for $V = \rho', \rho''$, as a function of Q^2. Due to large uncertainties of $R_{\rho''}$, no conclusion on its Q^2 behaviour can be deduced. One can however clearly state that the value of $R_{\rho'}$ increases with Q^2.

3. Summary

Exclusive two pion electroproduction has been studied by ZEUS at HERA in the range $0.4 < M_{\pi\pi} <$

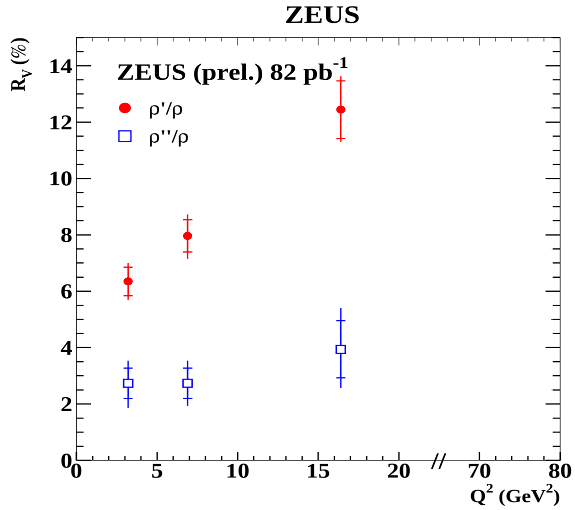

Figure 3: The ratio R_V as a function of Q^2 for $V = \rho'$ (full circles) and ρ'' (open square). The inner bars indicete the statistical uncertainty, the outer error bars represent statistical and systematic uncertainty added in quadrature

2.5 GeV, $2 < Q^2 < 80\,\text{GeV}^2$, $32 < W < 180\,\text{GeV}$ and $|t| \leq 0.6\ \text{GeV}^2$. The mass distribution is well described by the pion electromagnetic form factor which includes three resonances, $\rho, \rho'(1450)$ and $\rho''(1700)$. A Q^2 dependence of $|F_\pi(M_{\pi\pi})|^2$ is observed.
The Q^2 dependence of cross section ratios $R_{\rho'} = \sigma(\rho' \to \pi\pi)/\sigma(\rho)$ and $R_{\rho''} = \sigma(\rho'' \to \pi\pi)/\sigma(\rho)$ has been studied. An increase with Q^2 is observed for $R_{\rho'}$.

References

[1] ZEUS Coll., S. Chekanov et al., PMC Phys. **A1**, 6 (2007).

[2] H1 Coll., F.D. Aaron et al., JHEP **32**, (2010).

[3] J. H. Kuhn and A. Santamaria, Z. Phys. **C48**, 445 (1990).