EXCLUSIVE VECTOR MESON PRODUCTION AT LOW T WITH THE ZEUS DETECTOR AT HERA

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Exclusive production of vector mesons has been studied in ep collisions with the ZEUS detector at HERA. Preliminary results are presented for ρ^0 production, using $96-97$ data with an integrated luminosity of 38 pb^{-1}, and for J/ψ production, using $96-99$ data with an integrated luminosity of 75 pb^{-1}. The W and Q^2 dependence of the $\gamma^* p \to \rho^0 p$ cross section and of the ratio of the production cross sections, $R = \sigma_L/\sigma_T$, for longitudinally (σ_L) and transversely (σ_T) polarized virtual photons have been measured for center-of-mass energies $32<W<160$ GeV and for photon virtualities $2<Q^2<80$ GeV^2. The J/ψ cross section has been measured for center-of-mass energies $50<W<150$ GeV and for photon virtualities $2<Q^2<40$ GeV^2 and compared with theoretical predictions. The properties of the exchanged Regge trajectory in ρ^0 production have been investigated.

1 Event selection

The selected events are characterized by the presence of two oppositely-charged tracks, and a positron detected in the ZEUS [1] calorimeter.

For ρ^0 production, the two tracks are assumed to be pions, requiring $m_{\pi\pi}$ to be in the range $0.6 < m_{\pi\pi} < 1.2\,\text{GeV}$. About 21000 events were selected in the kinematic range $2 < Q^2 < 80\,\text{GeV}^2$, $32 < W < 160\,\text{GeV}$ and $|t| < 0.6\,\text{GeV}^2$. The acceptance corrections and resolution effects were evaluated using the dedicated Monte Carlo generator ZEUSVM [2] interfaced to HERACLES [3]. The Monte Carlo was also used to correct for the tails of the ρ^0 relativistic Breit-Wigner mass distribution, and to integrate the measured cross section up to $|t| = \infty$; an exponentially falling t distribution was assumed, with a slope of $b = 7\,\text{GeV}^{-2}$.

The selected sample is contaminated with proton-dissociation events. In order to correct for this contribution, all measured cross sections have been scaled down by $24^{+9}_{-5}\,\%$, as determined in a previous analysis [4].

In the J/ψ case, both the electron and muon decay channels were used, selecting events in the mass range $2.6 < m_{ee} < 3.4\,\text{GeV}$ and $2.8 < m_{\mu\mu} < 3.4\,\text{GeV}$. The contribution from non-resonant QED processes producing e^+e^-, $\mu^+\mu^-$ pairs was evaluated using the GRAPE-Dilepton [5] Monte Carlo program.

The level of proton dissociation contamination was estimated to be $21 \pm 9\,\%$ for the data taken during 1996-7. For the data taken during 1998-9, the contamination was reduced to $13 \pm 5\,\%$ thanks to the presence of the Forward Plug Calorimeter (FPC) [6].

2 Results

The W dependence of $\sigma(\gamma^* p \to \rho^0 p)$ is shown in Fig. 1 for various Q^2 values. The W dependence of the cross section is assumed to be of the form W^δ (solid line), and the value of δ is extracted from the fit. As predicted in pQCD, a marked increase of δ with Q^2 is observed.

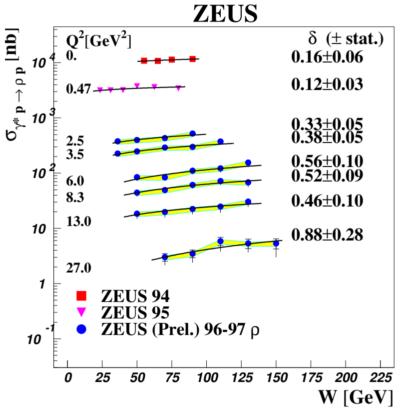

Figure 1. W dependence of the cross section $\sigma(\gamma^* p \to \rho^0 p)$ for various Q^2 values as denoted in the figure. The data for $Q^2 < 1\,\mathrm{GeV}^2$, obtained in previous ZEUS measurements, are shown for comparison. The lines represent the results of fitting $\sigma \sim W^\delta$ at each Q^2 value and the results of the fit are shown in the figure.

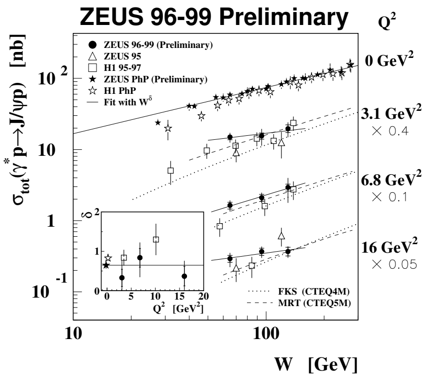

Figure 2. W dependence of the cross section $\sigma(\gamma^* p \to J/\psi p)$ compared with theoretical predictions for $Q^2 = 3.1, 6.8$ and $16\,\mathrm{GeV}^2$. The solid lines indicate the results of fits to the function W^δ. The measurements from photoproduction are also shown for comparison.

The W dependence of the J/ψ production cross section is shown in Fig. 2. The cross section values were compared with theoretical predictions of Frankfurt et al. (FKS) [7] using CTEQ4M [8], and of Martin et al. (MRT) [9] using CTEQ5M [10]. Theory and data are consistent within the uncertainty of the measurement.

2.1 The ratio of longitudinal to transverse cross sections, $R = \sigma_L/\sigma_T$

In the dipole picture [11], the transverse size of the dipole is expected to be smaller for longitudinally polarized virtual photons, γ^*_L, than for the transversely polarized ones, γ^*_T. pQCD effects are therefore expected to set in at lower Q^2 values for γ^*_L induced reactions.

The measurement of R was already described elsewhere [12]. The present data indicate a continuous rise of R with Q^2 (Fig. 3). The Q^2 dependence of r^{04}_{00} is well described by a functional form $R = \frac{1}{\xi}(Q^2/m^2_\rho)^\kappa$. The results are plotted as a function of W, for different Q^2 values, in Fig. 4. No W dependence of R is observed for fixed Q^2. The tendency for the value of R to rise with Q^2 is visible in the whole W range.

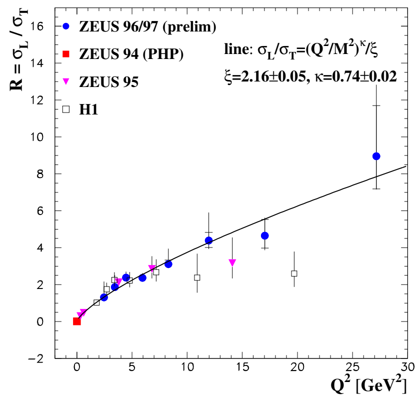

Figure 3. The value of R as a function of Q^2. The present measurements are compared to previous measurements as denoted in the figure.

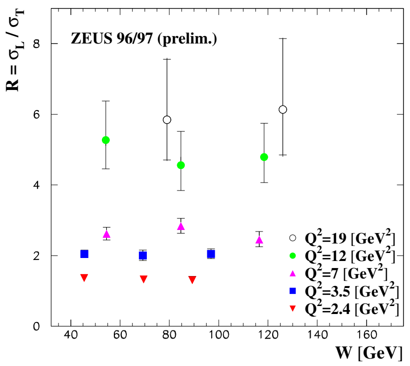

Figure 4. The value of R is presented as a function of W, for different Q^2 values.

2.2 Measurement of the Pomeron trajectory, $\alpha_{I\!P}(t)$, from DIS ρ^0

The luminosity accumulated in 1996-97 allowed the first measurement of the Pomeron ($I\!P$) trajectory, $\alpha_{I\!P}(t)$, in exclusive production of ρ^0 for $Q^2 > 2\,\mathrm{GeV}^2$.

The energy dependence of elastic and diffractive hadron-hadron scattering is well described, in the framework of Regge phenomenology, by $\frac{d\sigma}{dt} \propto W^{4(\alpha(t)-1)}$, where the $I\!P$ trajectory, $\alpha_{I\!P}(t) = \alpha_0 + \alpha' t$, is found to be the same for all hadrons. When considering $\gamma^* p$ scattering an obvious analogy between diffractive vector meson (VM) production and hadron-hadron scattering arises. It is therefore interesting to check whether Regge phenomenology holds and if the same $I\!P$ trajectory is found for different VMs in different Q^2 ranges.

The $I\!P$ trajectory, $\alpha_{I\!P}(t)$, was measured by fitting the W dependence of the $\gamma^* p$ cross section in bins of t, $\frac{d\sigma}{dt}|_{t_0}(W) \sim W^{\delta}$, where $\delta = 4(\alpha_{I\!P}(t) - 1)$. This was done for four t bins in two Q^2 ranges, $2 < Q^2 < 6$ and $6 < Q^2 < 40\,\mathrm{GeV}^2$ (Fig. 5). Since the two Q^2 ranges display the same behavior within errors, all eight point were fitted together to a single trajectory, leading to the following result: $\alpha_0 = 1.14 \pm 0.01(stat.)^{+0.03}_{-0.03}(syst.)$, $\alpha' = 0.04 \pm 0.07(stat.)^{+0.13}_{-0.04}(syst.)\,\mathrm{GeV}^{-2}$.

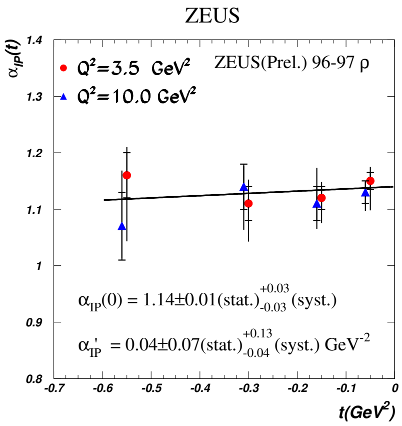

Figure 5. $\alpha_{I\!P}(t)$, as measured for DIS ρ^0, for two Q^2 bins, $2 < Q^2 < 6$ and $6 < Q^2 < 40$ GeV^2. The result of a linear fit to all 8 points is given in the figure.

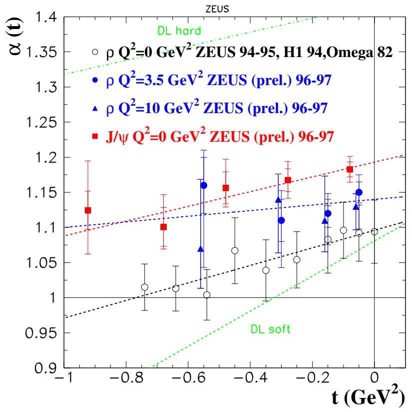

Figure 6. The value of $\alpha_{I\!P}(t)$ as a function of t as measured for DIS ρ^0, compared with previous results for photoproduction ρ^0 and photoproduction J/ψ.

This trajectory was compared to the results obtained in photoproduction of ρ^0 and of J/ψ (Fig. 6). One can clearly see that the soft $I\!P$ trajectory cannot describe the existing data and that, in fact, all of the VM data cannot be described by a single trajectory.

Acknowledgments

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