A NEW MEASUREMENT OF EXCLUSIVE ρ° PHOTOPRODUCTION AT HERA

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Exclusive ρ° photoproduction has been measured with high statistics by the H1 Collaboration. The kinematical range is $20 < W < 90$ GeV, $|t| < 3$ GeV^2 and $Q^2 < 4$ GeV^2. Cross sections are measured differentially in W and t and allow the extraction of the Pomeron trajectory, for the first time using ρ° photoproduction data of one single experiment. The preliminary result, $\alpha_{\mathbb{P}}(t) = 1.093 \pm 0.003(stat.)^{+0.008}_{-0.007}(syst.) + (0.116 \pm 0.027(stat.)^{+0.036}_{-0.046}(syst.))\ \mathrm{GeV}^{-2} \cdot t$, deviates significantly from the canonical expectation.

1. Introduction

Exclusive photoproduction of ρ° has been extensively studied in the last 40 years, first in fixed target experiments[1], and more recently in the ep collider experiments H1[2] and ZEUS[3,4,5,6] at HERA, where the γp CMS energy W reaches values of up to 300 GeV. At large W values, Regge phenomenology describes the diffractive scattering as being mediated by the dominating exchange of the Pomeron trajectory, $\alpha_{\mathbb{P}}(t) = \alpha_{\mathbb{P},0} + \alpha'_{\mathbb{P}} \cdot t$. The values $\alpha_{\mathbb{P},0} = 1.08 - 1.10$ and $\alpha'_{\mathbb{P}} = 0.25$ GeV^{-2} were determined from global fits to hadron-hadron scattering data[7,8,9]. A first determination of the Pomeron trajectory with data from exclusive ρ° photoproduction was made by the ZEUS collaboration[6], using their own data at $W = 94, 73$ and 71 GeV, as well as the H1 data at $W = 55$ GeV and the OMEGA[10] data at $W = 8$ and 10 GeV. The result indicated a deviation of $\alpha'_{\mathbb{P}}$ from the "canonical" value. However, the inherent uncertainty in the combination of cross sections from different experiments prohibited firm conclusions.

In the present analysis, data from a single experiment are for the first time used to extract the Pomeron trajectory for exclusive ρ° photoproduction. For details of the analysis, see ref.11.

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2. Experimental procedure

The determination of $\alpha_{\mathbb{P}}(t)$ from exclusive ρ° photoproduction in a single experiment requires large statistics over a wide range of W and t, since the W dependence has to be determined in bins of t: $\frac{\mathrm{d}\sigma_{\gamma p}(W)}{\mathrm{d}t} \propto \left(\frac{W}{W_0}\right)^{4(\alpha_{\mathbb{P}}(t)-1)}$.

After the detector upgrade for the HERA-2 running period, H1 has taken the new Fast Track Trigger (FTT)[12] into operation. Combining charged track segments in the central drift chambers (CJC), the FTT allows the triggering on final states with given total track charge and multiplicity, and with a charged track p_t threshold as low as 100 MeV. In the first few months of stable operation of the FTT in summer 2005, more than 271000 2-prong events with total charge 0 were collected in data corresponding to an integrated luminosity of 570 nb^{-1}. More than 241000 of these events lie in the $\pi^+\pi^-$ mass interval $0.6 - 1.1$ GeV. The background, mainly from production of other vector mesons (ϕ, ω and ρ'), is $< 2\%$.

Since the triggering and event selection does not involve the detection of the scattered electron, the modulus of the squared momentum transfer at the electron vertex, Q^2, is limited to $Q^2 < 4$ GeV^2 with $< Q^2 >= 0.01$ GeV^2. The W and t ranges are $20 < W < 90$ GeV and $|t| < 3$ GeV^2. Since in the reaction $ep \to e\rho Y$, where Y is either the proton or a proton dissociation system, the outgoing proton system is not measured, the variable t is calculated from the total transverse momentum $p_{t,\pi\pi}$ of the $\pi^+\pi^-$ system, $t = -p_{t,\pi\pi}^2$. Similarly, $W = \sqrt{2E_p(E_{\pi\pi} - p_{z,\pi\pi})}$, with E_p being the nominal proton beam energy and $E_{\pi\pi}$ and $p_{z,\pi\pi}$ the energy and longitudinal momentum component of the $\pi\pi$ system.

Extensive Monte Carlo studies were made, using the generator program DIFFVM[13]. Signal events, i.e. events entering the cross section, are defined with the condition $(M_Y^2 + Q^2)/(W^2 + Q^2) < 0.01$, where M_Y is the mass of the system Y. The MC events were reweighted in the variables W, t and $m_{\pi\pi}$, to obtain a good description of the experimental distributions.

The events are distributed in twelve bins of $|t|$ and five to ten bins of W, altogether eighty bins, since the W range varies with $|t|$. In each W, t bin, the average correction factor is ~ 0.25, including acceptance, triggering and reconstruction efficiencies. The ρ° dipion mass spectrum was given by a Breit-Wigner function, skewed to the model of Ross-Stodolsky[14] [a]. In each W, t bin the number of ρ° events was obtained by first fitting to the data, and then integrating the Breit-Wigner function from $m_{\pi\pi}$ threshold to

[a] An analysis using the Söding interference model[15] gives completely equivalent results.

$m_{\rho^\circ,0} + 5\Gamma_{\rho^\circ,0}$, where $m_{\rho^\circ,0}$ and $\Gamma_{\rho^\circ,0}$ are the PDG[16] values. The averages of the 80 fit values for m_{ρ° and Γ_{ρ° are very close to the PDG values.

The cross sections thus obtained include both the elastic and the proton dissociative parts of the process. In order to separate these two components of the cross section, use is made of two subdetector systems in the "forward" direction of H1, namely the FTS (Forward Tagging System) and FMD (Forward Muon Detector). The dissociated proton system Y produces hits in these detectors, however, also elastic protons at larger values of $|t|$ may generate forward hits through secondaries. The efficiencies of the elastic and dissociative processes for forward hit generation were studied in detail with the MC simulation, and the fractions of forward "tagged" (i.e. with hits in the forward subdetectors) events in the MC simulation and in the data were compared to obtain the number of elastic events in each W, t bin.

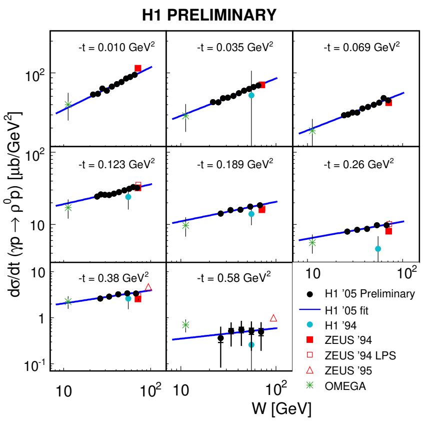

Figure 1. γp cross sections for elastic ρ° production as a function of W, in bins of t. The preliminary H1 data are compared to previous results from the H1, ZEUS and OMEGA experiments. The curves show fits to the current H1 data alone, as discussed in the text.

3. Results

Figure 1 shows the resulting elastic ρ° photoproduction cross section, as a function of W in eight bins of t. In each t bin the H1 data have been fitted to the function $\frac{\mathrm{d}\sigma^{\gamma\mathrm{p}}(W)}{\mathrm{d}t} = \frac{\mathrm{d}\sigma^{\gamma\mathrm{p}}(W_0)}{\mathrm{d}t}\left(\frac{W}{W_0}\right)^{4(\alpha-1)}$, with $W_0 = 37$ GeV. Data and fits are compared to the previous measurements from ZEUS and H1, and to the lower W data from the OMEGA experiment. There is good agreement between the measurements, in particular the OMEGA data agree well with the extrapolation of the fits to the H1 data.

The fitted values of α are shown as a function of t in Fig.2. The fit of the Pomeron trajectory $\alpha_{\mathbb{P}}(t) = \alpha_{\mathbb{P},0} + \alpha'_{\mathbb{P}} \cdot t$ to the α values is also shown, as is the global Pomeron trajectory of Donnachie and Landshoff.

The resulting preliminary values of the fit parameters are $\alpha_{\mathbb{P},0} = 1.093 \pm 0.003(stat.)^{+0.008}_{-0.007}(syst.)$ and $\alpha'_{\mathbb{P}} = 0.116 \pm 0.027(stat.)^{+0.036}_{-0.046}(syst.)$. While the intercept agrees well with the expected value range, the slope $\alpha'_{\mathbb{P}}$ differs significantly from the canonical value 0.25 GeV^{-2}. This indicates that a model, in which the exchange of one global, linear Pomeron trajectory explains all diffractive scattering at high energies, is too simple.

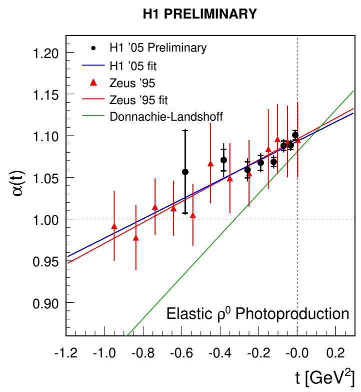

Figure 2. The measured values of the parameter α for elastic ρ° photoproduction, together with a fit of the Pomeron trajectory of the form $\alpha_{\mathbb{P}}(t) = \alpha_{\mathbb{P},0} + \alpha'_{\mathbb{P}} \cdot t$. The previous result, obtained using data from the ZEUS, H1 and OMEGA experiments, is also shown, as is the parametrisation from Donnachie and Landshoff.

The present result agrees well with a previous result which was obtained using ZEUS, H1 and OMEGA data at $W = 94, 73, 71, 55, 10$ and 8 GeV. This previous result is also shown in Fig.2.

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