Exclusive ρ^0 electroproduction

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Exclusive ρ^0 electroproduction at HERA has been studied with the ZEUS detector, using 120 pb^{-1} integrated luminosity, in the kinematic range of photon virtuality of $2 < Q^2 < 160$ GeV^2, and $\gamma^* p$ center-of-mass energy of $32 < W < 180$ GeV. The results include the Q^2 and W dependence of the $\gamma^* p \to \rho^0 p$ cross section and the distribution of the squared-four-momentum transfer to the proton, t. Also included is the ratio of longitudinal to transverse $\gamma^* p$ cross section as a function of Q^2, W and t. Finally, the effective Pomeron trajectory was extracted. The results are compared to various theoretical predictions, none of which are able to reproduce all the features of the data.

Exclusive electroproduction of light vector mesons is a particularly good process for studying the transition from the soft to the hard regime, the former being well described within the Regge phenomenology while the latter - by perturbative QCD. Among the most striking expectations in this transition is the change of the logarithmic derivative δ of the cross section σ with respect to the $\gamma^* p$ center-of-mass energy W, from a value of about 0.2 in the soft regime to 0.8 in the hard one, and the decrease of the exponential slope b of the differential cross section with respect to the squared-four-momentum transfer t, from a value of about 10 GeV^{-2} to an asymptotic value of about 5 GeV^{-2} when the virtuality Q^2 of the photon increases.

In this talk, the latest results of a high statistic measurement of the reaction $\gamma^* p \to \rho^0 p$ studied with the ZEUS detector are presented. A detailed presentation can be found in [1]. Here we present the main results.

The cross section $\sigma(\gamma^* p \to \rho^0 p)$ is presented in Fig. 1 as a function of W, for different values of Q^2. The cross section rises with W in all Q^2 bins. In order to quantify this rise, the logarithmic derivative δ of σ with respect to W is obtained by fitting the data to the expression $\sigma \sim W^{\delta}$ in each of the Q^2 intervals. The resulting values of δ are shown in Fig 2. Also included in this figure are values of δ from lower Q^2 measurements for the ρ^0 as well as those for ϕ, J/ψ and γ (Deeply Virtual Compton Scattering (DVCS)). In this case the results are plotted as function of $Q^2 + M^2$, where M is the mass of the vector meson. One sees a universal behaviour of the different processes, showing an increase of δ as the scale becomes larger, in agreement with the expectations mentioned above. The value at low scale is the one expected from the soft

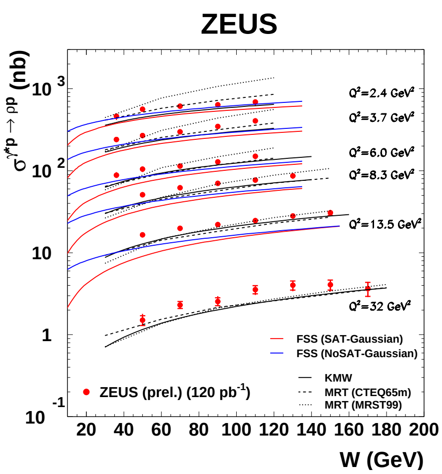

Figure 1: *W dependence of σ for different values of Q^2. The lines are the predictions of some models (see text).*

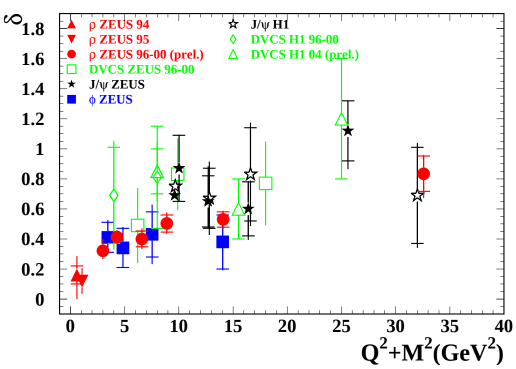

Figure 2: *δ as a function of $Q^2 + M^2$.*

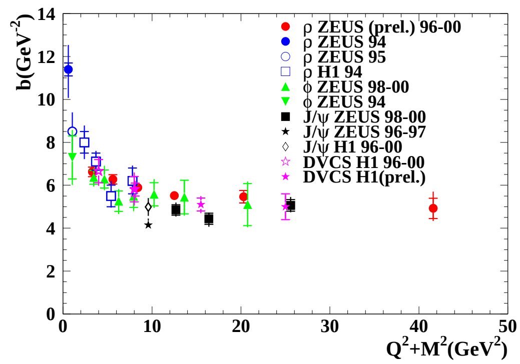

Figure 3: *b as a function of $Q^2 + M^2$.*

Pomeron intercept [2], while the one at large scale is in accordance with twice the logarithmic derivative of the gluon density with respect to W.

The differential cross section, $\mathrm{d}\sigma/\mathrm{d}t$, has been parameterised by an exponential function $e^{-b|t|}$ fitted to the data. The resulting values of b as a function of the scale $Q^2 + M^2$ are plotted in Fig. 3 together with those from other processes. As expected, b decreases to a universal value of about 5 GeV^{-2} as the scale increases. This value measures the radius of the gluon density in the proton and corresponds to a value of ~ 0.6 fm, smaller than the value of the charge density of the proton (~ 0.8 fm), indicating that the gluons are well-contained within the charge-radius of the proton.

One can study the W dependence of $\mathrm{d}\sigma/\mathrm{d}t$ for fixed t values and extract the effective Pomeron trajectory $\alpha_{IP}(t)$. This was done for two Q^2 intervals and the trajectory was fitted to a linear form to obtain the intercept $\alpha_{IP}(0)$ and the slope α'_{IP}, the values of which are tabulated in Table 1. A compilation of the effective Pomeron intercept and slope from this study together with that from other vector mesons is presented in Fig. 4. As in the other compilations, the values are plotted as a function of $Q^2 + M^2$. The value of $\alpha_{IP}(0)$ increases slightly with Q^2 while the value of α'_{IP} shows a small decrease with Q^2.

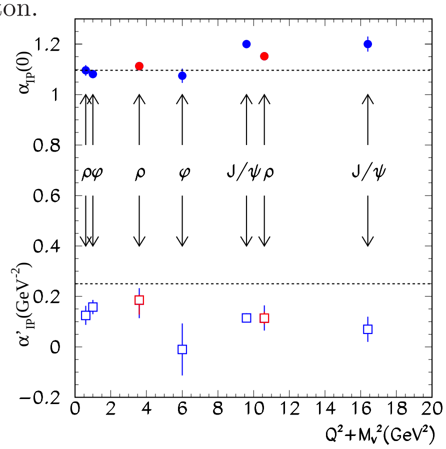

Figure 4: *A compilation of $\alpha_{IP}(0)$ and α'_{IP} for ρ, ϕ and J/ψ, as a function of $Q^2 + M^2$.*

The helicity analysis of the decay-matrix elements of the ρ^0 was used to extract the ratio R of longitudinal to transverse $\gamma^* p$ cross section, as a function of Q^2, W and t. While R is an increasing function of Q^2, as shown in Fig. 5, it is independent of W in all Q^2 intervals (Fig. 6). This unexpected behaviour indicates that the large configurations in the wave function of the transverse γ^* seem to be suppressed. This result is supported by

Q^2 (GeV^2)	$< Q^2 >$ (GeV^2)	$\alpha_{IP}(0)$	α'_{IP}(GeV^{-2}
$2-5$	3	$1.113 \pm 0.010^{+0.009}_{-0.012}$	$0.185 \pm 0.042^{+0.022}_{-0.057}$
$5-50$	10	$1.152 \pm 0.011^{+0.006}_{-0.006}$	$0.114 \pm 0.043^{+0.026}_{-0.024}$

Table 1: *The values of the Pomeron trajectory intercept $\alpha_{IP}(0)$ and slope α'_{IP}, for different Q^2 intervals.*

the independence of R on t (not shown), indicating that both polarisations of the photon fluctuate into similar size $q\bar{q}$ pairs.

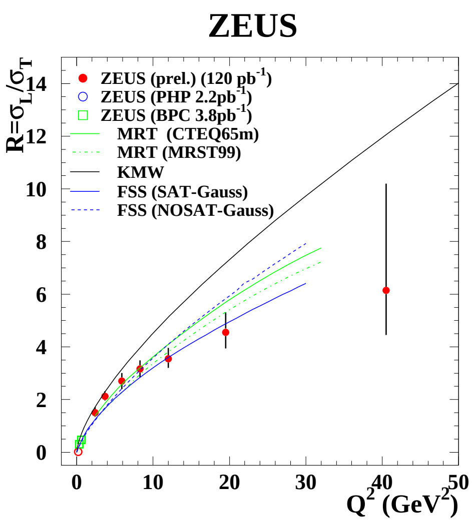

Figure 5: *R as a function of Q^2 at W=90 GeV. The lines are the prediction of models referred to in the text.*

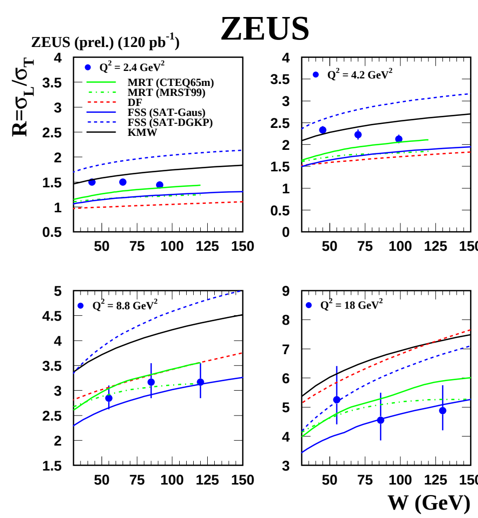

Figure 6: *The ratio R as a function of W for different Q^2 intervals. The lines are the prediction of models referred to in the text.*

The results of this study were compared to those of the H1 collaboration [3] and both measurements are in good agreement.

The results were also compared to several theoretical predictions. The predictions are a combination of perturbative and non-perturbative QCD calculations. All models use the dipole picture to describe the reaction $\gamma^* p \to \rho^0 p$. The ingredients necessary for the calculation are the virtual photon and the ρ^0 wave function and the gluon densities. Some models put their emphasis on the VM wave function [4, 5, 6, 7] while that of [8] studies the dependence on the gluon densities in the proton. Detailed comparison can be seen in [1]. Some examples are shown in Fig. 1, where the cross section values are plotted as a function of W for different Q^2 vales, in Fig. 5, where the ratio R is shown as a function of Q^2 and in Fig. 6, where R is plotted as a function of W, for different Q^2 intervals. As can be seen, none of the calculations can describe the data. The high precision of the present measurements can be most valuable to tune the different models and thus contribute to a better understanding of the ρ^0 wave function and of the gluon density in the proton.

Acknowledgments

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