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EXCLUSIVE ELECTROPRODUCTION OF J/ψ AT HERA

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The exclusive electroproduction of J/ψ meson, $ep \to ep\ J/\psi$, has been studied with the ZEUS detector at HERA for virtualities of the exchanged photon in the ranges $0.15 < Q^2 < 0.8\,\mathrm{GeV}^2$ and $2 < Q^2 < 100\,\mathrm{GeV}^2$. The photon-proton centre-of-mass energy was in the range $30 < W < 220\,\mathrm{GeV}$ and the squared four-momentum transfer at the proton vertex $|t| < 1\,\mathrm{GeV}^2$. The results are in agreement with perturbative QCD calculations and exhibit a strong sensitivity to the gluon distribution in the proton.

1 Introduction

The exclusive electroproduction of J/ψ, $ep \to e\ J/\psi\ p$, is a clean process that can be measured precisely in a large phase space.

The interest of this measurement resides in his sensitivity to the gluon density in the proton. The presence of an hard scale justifies the application of QCD factorisation methods. The cross section can be estimated from a hard interaction part calculable in pQCD, the $c\bar{c}$ wave function of the meson and the generalised parton distributions (GPDs) which contain information about the correlations of the partons inside the proton and their momentum distribution. At the leading-order approximation in $\ln(1/x)$ and vanishing t, the generalised gluon distribution can be approximated by the usual gluon distribution. The cross section is expected to rise steeply with W, a reflection of the steep rise of the gluon density as x decreases.

Here, the results of the new ZEUS measurement [1] are reported.

2 Analysis

The data cover the kinematic range $30 < W < 220\,\mathrm{GeV}$ and $|t| < 1\,\mathrm{GeV}^2$ for two ranges of photon virtuality, $2 < Q^2 < 100\,\mathrm{GeV}^2$ and $0.15 < Q^2 < 0.8\,\mathrm{GeV}^2$, corresponding to integrated luminosities of $83\,\mathrm{pb}^{-1}$ and $69\,\mathrm{pb}^{-1}$, respectively. This analysis extend both the W and Q^2 ranges of the previous ZEUS and H1 results [2,3]. The signature of exclusive J/ψ electroproduction consists of the scattered electron and two oppositely charged leptons from the J/ψ decay, e^+e^- or $\mu^+\mu^-$. The scattered proton is deflected through a small angle and escapes undetected down the beampipe. The energy and position of the scattered electron were measured in the calorimeter (high Q^2 sample) and beam pipe calorimeter (low Q^2 sample). The J/ψ mesons were reconstructed from the decay leptons, electrons and muons, both measured in the central tracking detector. In the case of the electron decay channel, one of the two electrons, outside the acceptance of the tracking system, was measured in the calorimeter. Non-exclusive events and events with dissociation of the proton were suppressed by requiring no further cluster in the calorimeter and in the forward plug calorimeter with energy above the noise level.

3 Results

The $\gamma^* p$ cross section, measured as a function of W and Q^2, is shown in Fig. 1. It is compared to predictions by Martin, Ryskin and Teubner (MRT), performed at the leading order $\alpha_s \ln(Q^2)$, using three different gluon distributions: MRST02 [6], CTEQ6M [7] and ZEUS-S [8]. The predictions were normalised to the ZEUS photoproduction measurement [4] at $W = 90\,\text{GeV}$. While CTEQ6M describes the W and Q^2 dependence of the data, MRST02 has the wrong shape in W, particularly at low Q^2. ZEUS-S describes the W dependence but falls too quickly with increasing Q^2.

The data exhibit a strong sensitivity to the gluon distribution in the proton. However, full NLO calculations are needed in order to use these data in global fits to constrain the gluon density. Recently, NLO calculations have been completed for the exclusive photoproduction of heavy vector mesons [9].

The differential cross section, $d\sigma^{\gamma^* p \to J/\psi p}/dt$, measured as a function of t in the range $|t| < 1\,\text{GeV}^2$, is shown in Fig. 2a-d for different Q^2 intervals. A function of the form $d\sigma/dt = d\sigma/dt|_{t=0} \cdot e^{-b|t|}$ was fitted to the data; the slope parameter b from the fit is shown in Fig. 2e as a function of Q^2 and is compared to the ZEUS photoproduction [4] and H1 electroproduction [3] values. The t distribution, measured for $|t| < 1\,\text{GeV}^2$, is well described by an exponential dependence over the range $2 < Q^2 < 100\,\text{GeV}^2$. The slope parameter, b, is consistent with being constant in this range. The mean value is $b = 4.72 \pm 0.15(\text{stat.}) \pm 0.12(\text{syst.})\,\text{GeV}^{-2}$, consistent with that observed in J/ψ photoproduction.

References

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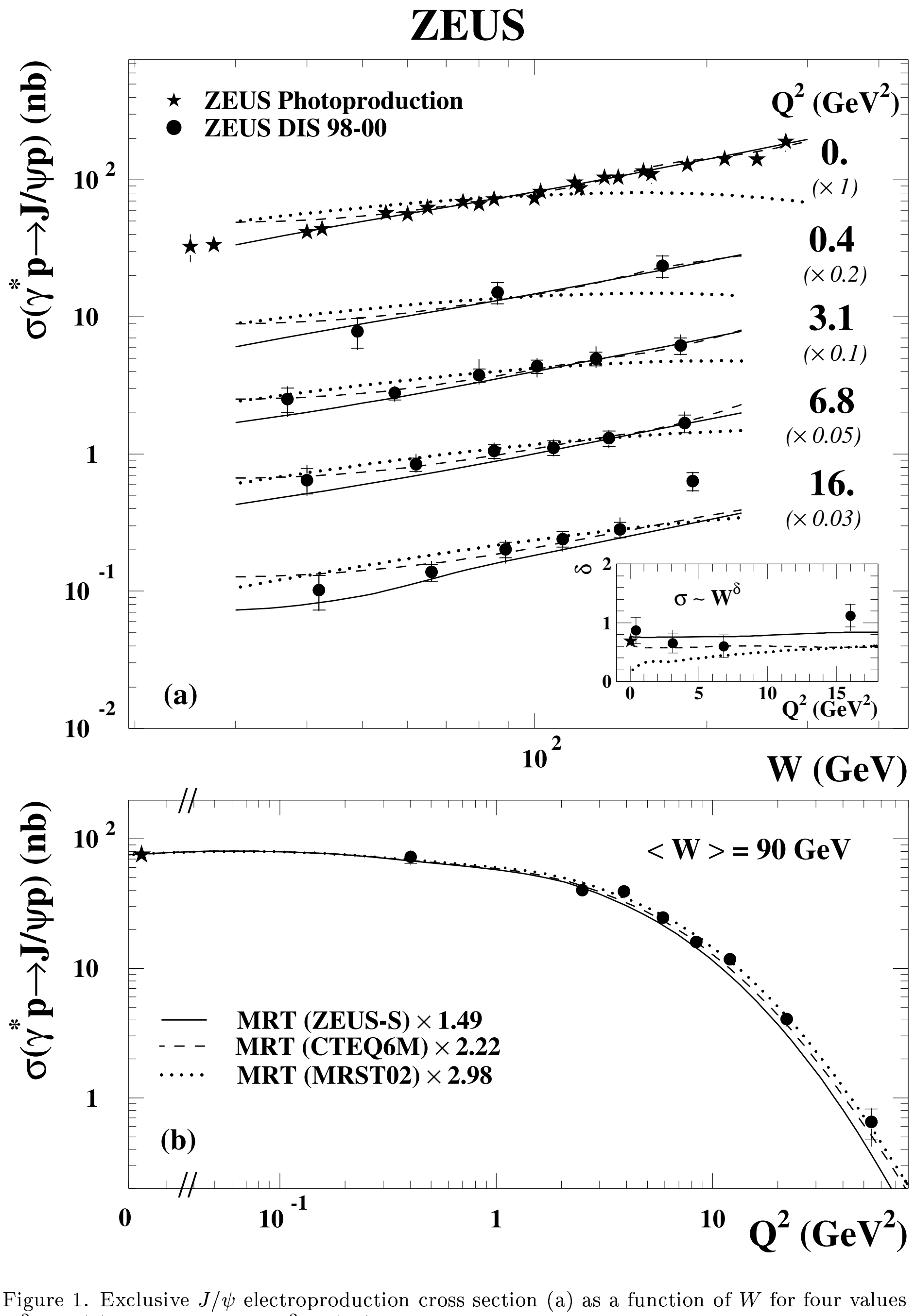

Figure 1. Exclusive J/ψ electroproduction cross section (a) as a function of W for four values of Q^2 and (b) as a function of Q^2 at $\langle W \rangle = 90\,\mathrm{GeV}$. ZEUS photoproduction results are also shown. The data are compared to the MRT predictions (see text) obtained with different parametrisations of the gluon density and normalised to the ZEUS photoproduction point at $\langle W \rangle = 90\,\mathrm{GeV}$. The insert shows the parameter δ as a function of Q^2. The inner error bars represent the statistical uncertainties, the outer bars are the statistical and systematic uncertainties added in quadrature. An overall normalisation uncertainty of $^{+5\%}_{-8\%}$ was not included.

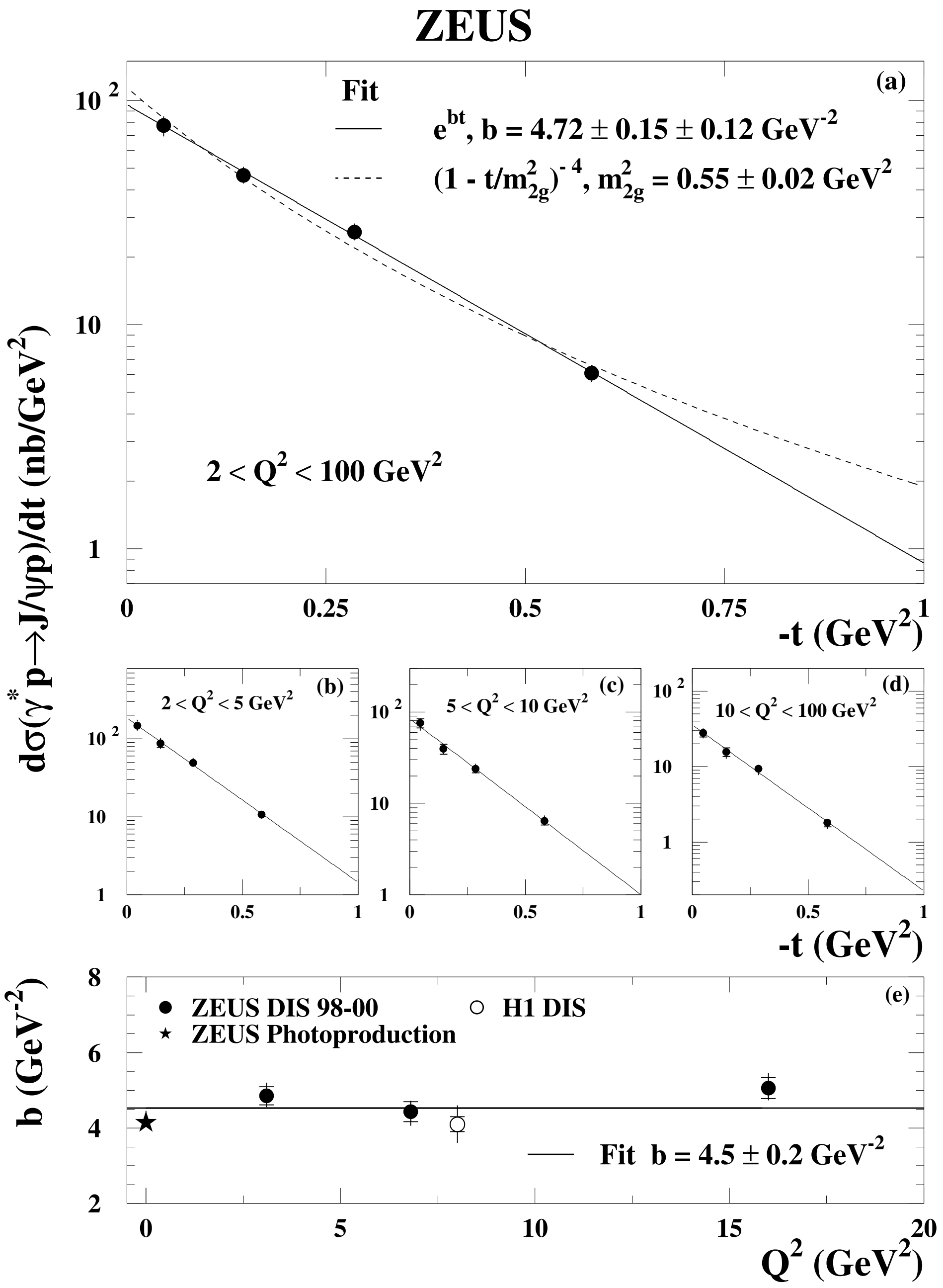

Figure 2. Differential cross-sections $d\sigma/dt$ (a) over the entire Q^2 range and (b)-(d) for three bins of Q^2, for $30 < W < 220\,\mathrm{GeV}$ and $|t| < 1\,\mathrm{GeV}^2$. The full lines are the results of a fit to the form $d\sigma/dt = d\sigma/dt|_{t=0} \cdot e^{-b|t|}$ and the dashed line is the result of a fit using an elastic form factor assuming two-gluon exchange: $d\sigma/dt \propto (1 - t/m^2_{2g})^{-4}$. (e) The slope b, as a function of Q^2, compared to the ZEUS photoproduction and H1 results. The mean value of b is indicated by the horizontal line. The inner error bars represent the statistical uncertainty, the outer bars the statistical and systematic uncertainties added in quadrature.