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Energy Dependence of the Cross-Section for the Exclusive Photo-Production of J/ψ Mesons at HERA

H1 Collaboration

Abstract

The energy dependence of the cross-section for the reaction $\gamma p \rightarrow J/\psi p$ has been studied over an extended range in the H1 detector at HERA. Results are presented spanning the kinematic region $30 < W < 285$ GeV where W is the energy of the collision in the photon-proton centre-of-mass system.

Abstract: 572
Parallel sessions: 7,5
Plenary sessions: 9,7

1 Introduction

Previous analyses of the exclusive photo-production of J/ψ mesons, the reaction $\gamma p \to J/\psi p$, using the H1 detector [1] are complemented by new measurements at higher γp interaction energies. These measurements are made possible by utilising detector components able to identify the decay products of the J/ψ mesons travelling in the backward direction (positron beam direction). The dependence of the cross-section on the photon-proton centre-of-mass energy, W, is thus determined over the extended range $30 < W < 285$ GeV and is presented here.

2 Data and Event Selection

The data used for the new measurements were collected during 1997 using the H1 detector [2] at the HERA collider, which was operated with positrons at an energy of 27.5 GeV and protons at 820 GeV, and correspond to an integrated luminosity of 12 pb^{-1}. The new measurements span the range in photon-proton centre-of-mass energy, $135 < W < 285$ GeV and are described here. Details of the earlier results are described in [1].

The decay $J/\psi \to e^+e^-$ is used. Two separate event selections have been carried out, which cover two different ranges of W. The selection covering the W range between 135 GeV and 210 GeV requires one electron to be observed as a track in the central tracking detector with polar angle $80° < \theta < 155°$ which is identified as an electron in the liquid argon calorimeter. The second decay electron is observed as an electromagnetic cluster with $E > 3.5$ GeV in the backward electromagnetic calorimeter (Spacal [3]). Combinations of signals from the Spacal, central tracking detector and proportional chambers are used to trigger the events. For the range $210 < W < 285$ GeV both electrons are observed as electromagnetic clusters with $E > 4.2$ GeV (one cluster with $E > 6.3$ GeV) in the Spacal. The signal from the two electrons also provides the trigger for the events. For a precise measurement of the polar angle θ of the electrons the backward silicon tracker (BST [4]) is utilised. In addition this device is used to separate clusters originating from photons and clusters originating from electrons which cause a track in the BST. Thus background from the QED Compton process can be reduced.

Apart from the decay products of the J/ψ meson, it is required that no further charged tracks are found in the detector. Additionally detectors close to the forward beam-line are used to reject events in which the proton dissociates. By insisting that the scattered positron is not observed in the H1 detector a sample of events is isolated with photon virtuality, Q^2, less than about 1 GeV^2. Positron-proton cross-sections measured in this kinematic range are converted to (real) photo-production cross-sections by convolution with a photon flux function.

3 Results

The invariant mass distributions obtained from the above selection are shown in figure 1. The new data are divided into six W bins. In figure 2 the resulting photo-production cross-sections are shown, together with those from the previous H1 analysis in the kinematic range $30 < W < 150$ GeV [1], and those published by the ZEUS collaboration [5] and fixed target experiments [6, 7, 8].

For the analysis of the kinematic region $135 < W < 285$ GeV described here, the largest systematic uncertainties in the cross-section measurements arise in the QED non-resonant background subtraction (12% for $135 < W < 210$ GeV, 15% for $210 < W < 285$ GeV), and in the subtraction of the proton dissociation background (10%). The total systematic uncertainties amount to 17% in the region $135 < W < 210$ GeV and 20% in the region $210 < W < 285$ GeV.

A fit to the energy dependence of the cross-section measured by H1 and ZEUS of the form W^δ yields $\delta = 0.80 \pm 0.10$ and is shown in figure 2. This is significantly steeper than predicted by soft pomeron exchange, where $\delta \approx 0.22$, but qualitatively in agreement with a perturbative QCD calculation [9] in which the rise reflects the increasing gluon density in the proton as the momentum fraction x_g decreases.

4 Conclusion

The cross-section for the process $\gamma p \to J/\psi p$ has been measured over a range $40 \leq W \leq 285$ GeV in centre-of-mass energy W which extends to essentially the kinematic limit at HERA. When compared with the measurements, an asymptotic dependence of the form W^δ gives an excellent description with $\delta = 0.80 \pm 0.10$. This is substantially steeper than is observed in soft hadronic processes, for which a phenomenological interpretation in terms of the exchange of a pomeron with intercept $\alpha_{I\!P}(0) \approx 1.1$ can describe the data.

References

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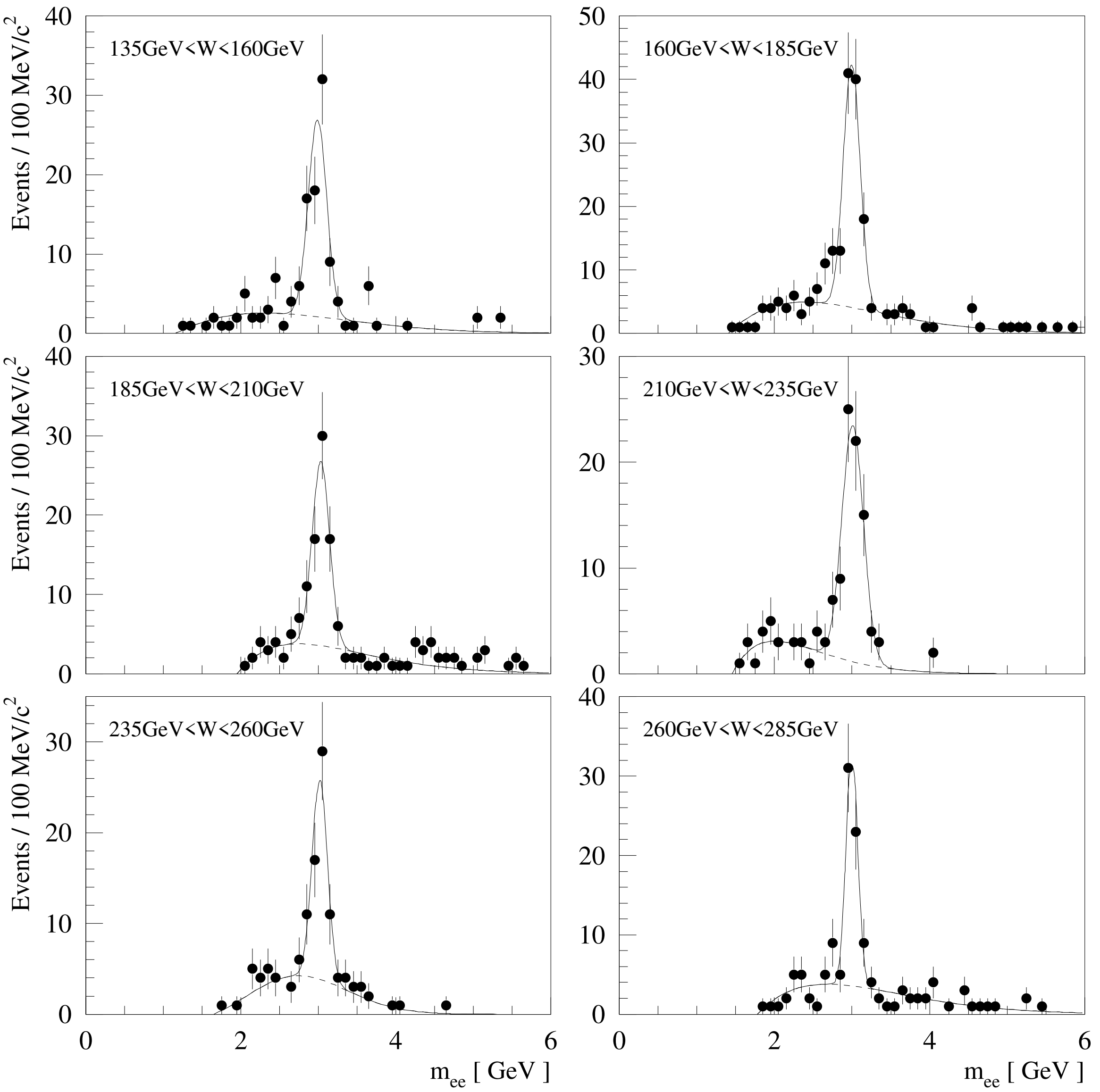

Figure 1: Invariant mass distributions in six W bins from the analysis described in this note. Gaussian fits to the J/ψ peaks are shown on top of a polynomial background.

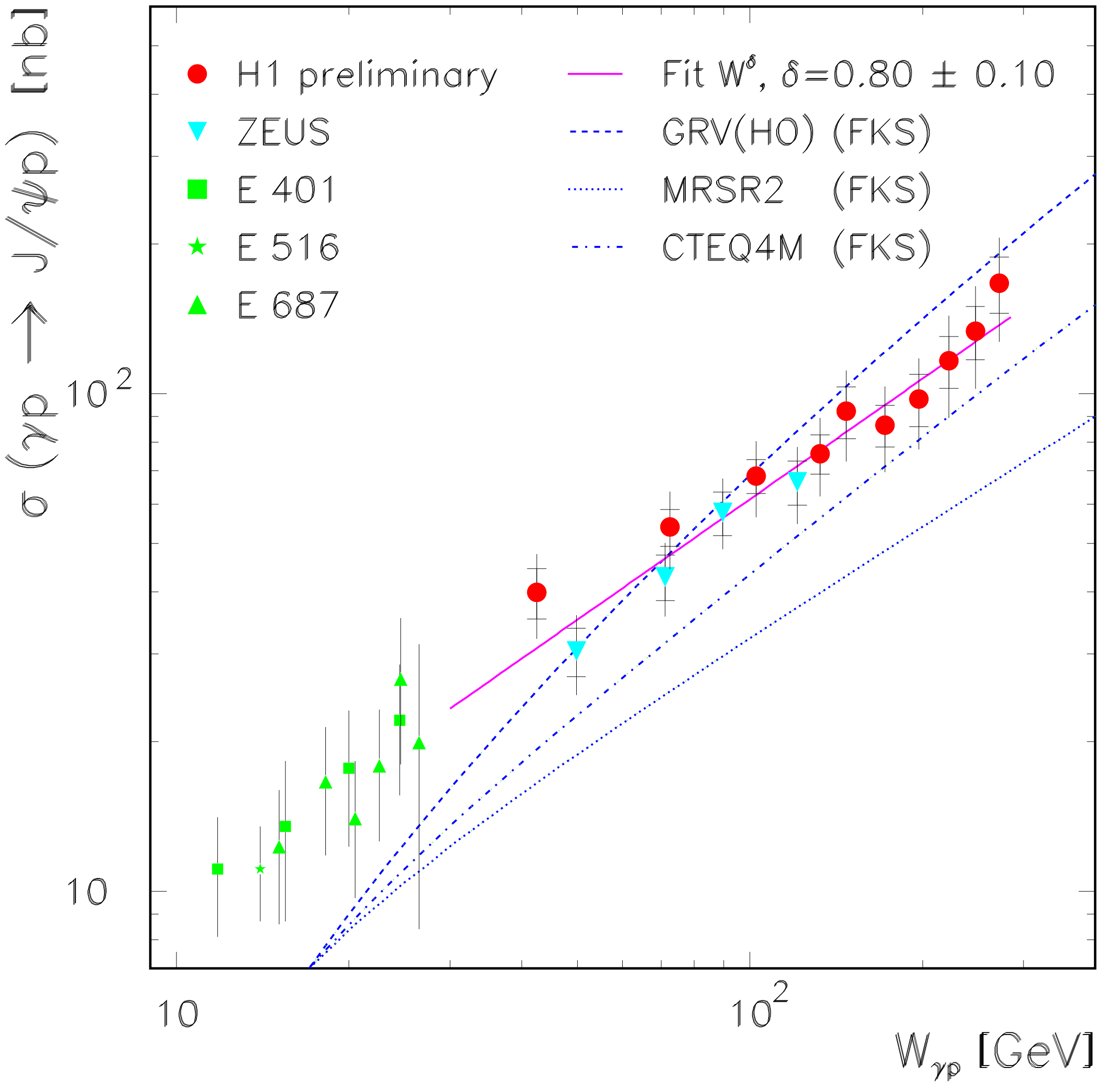

Figure 2: The cross-section for the photo-production reaction $\gamma p \to J/\psi p$ as a function of the photon-proton centre-of-mass energy as measured by H1, ZEUS [5] and fixed target experiments [6, 7, 8]. The inner error bars show the statistical errors. Systematic uncertainties are added in quadrature to form the total error bars. A fit of the form W^δ to the HERA data is indicated, along with predictions of QCD calculations by Frankfurt, Koepf and Strikman [9] for three parametrisations of the gluon density in the proton.