Inelastic J/ψ Production at H1

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Preliminary results on inelastic electro- and photo-production of J/ψ mesons in *ep*-scattering are presented [1]. The analysis is based on the 2004-2007 data taken with the H1 detector at HERA. Single and double differential cross sections are measured.

1 Introduction

Inelastic production of J/ψ mesons at HERA is dominated by boson gluon fusion (*BGF*), $\gamma^{(*)}g \rightarrow c\overline{c}$. Different models were developed to reconcile the quantum numbers of the J/ψ meson with those of the BGF process. In the Colour Singlet Model (*CSM*) [2, 3] this is achieved by radiating off a hard gluon. In the ansatz based on non-relativistic QCD (*NRQCD*) the formation of bound $c\overline{c}$ pairs factorizes into the hard subprocess of the creation of the$c\overline{c}$ pair which may have quantum numbers different from those of the J/ψ meson, and the non-perturbative long distance matrix element (*LDME*) describing the transition to the J/ψ meson [4]. Previous measurements in photo-production at HERA [5, 6] showed good agreement with the CSM NLO calculations [3].

Recent preliminary results on single and double differential cross sections of inelastic J/ψ photo- and electro-production presented in this paper are used to gain further insight into the underlying production mechanism. The data are compared to predictions from two different Monte Carlo models in which the leading order CSM matrix element is implemented. The CASCADE program [7] is based on k_T-factorization and parton evolution according to the CCFM equations [8]. It is matched with the $\mathcal{O}(\alpha_s)$ matrix element [9] taking into account the virtuality and the transverse momentum of the incoming gluon. The EPJPSI program [10] uses the DGLAP evolution scheme [11] assuming collinear factorization of the parton density distributions and the hard matrix elements.

2 Results

The data presented were collected with the H1 detector at HERA in the years 2004 to 2007 when HERA was operated with 27.5 GeV electrons[a] and 920 GeV protons colliding at a centre-of-mass energy of $\sqrt{s} = 318$ GeV.

Two different kinematic *ep* scattering regimes are explored in this analysis depending on the virtuality Q^2 of the photon: a) photo-production (γp) when scattering occurs on a quasi-real photon target and b) electro-production (*DIS*) in which a highly virtual photon is involved in the scattering process. The phase space selections for both samples are summarized together with the respective luminosities in Table 1. Here, $W_{\gamma p}$ is the hadronic centre-of-mass energy and $P^*_{T,J/\psi}$ and $z_{J/\psi} = p_\psi \cdot p / q \cdot p$ denote the transverse momentum of the J/ψ mesons

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[a]The term “electron” will be used for both electron and positrons.

		DIS	γp
Q^2	[GeV^2]	3.6 - 100	0
$W_{\gamma p}$	[GeV]	50 - 225	60 - 240
$P^*_{T,J/\psi}$	[GeV]	> 1	> 1
$z_{J/\psi}$		0.3 - 0.9	0.3 - 0.9
$\mathcal{L}$	[pb^{-1}]	258	166

Table 1: Selection cuts and luminosities for the DIS and γp samples.

with respect to the photon direction and the elasticity of the J/ψ mesons, respectively.

The J/ψ meson is identified via its leptonic decay modes $J/\psi \to \mu^+\mu^-$ (γp and DIS) and $J/\psi \to e^+e^-$ (DIS only).

Figure 1 shows the measured inelastic J/ψ cross section as a function of variables of the event kinematics Q^2 and $W_{\gamma p}$ for the DIS and the γp samples. In case of DIS the ep cross section is shown while for the γp measurement the γp cross section is given which includes the photon flux factors using the Weizsäcker-Williams approximation.

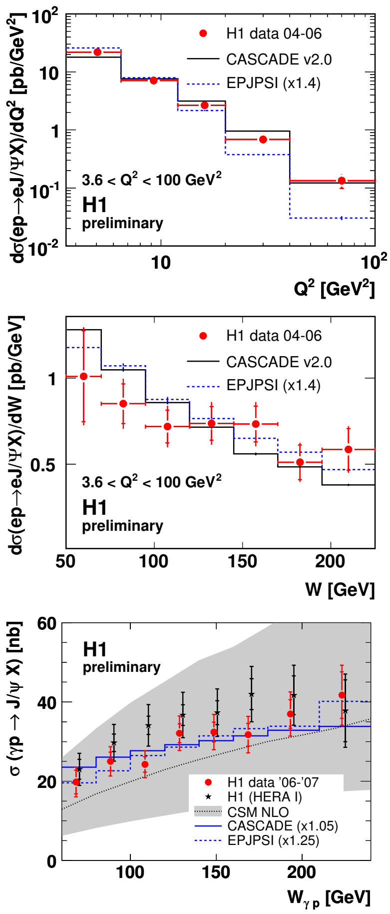

Figure 1: Inelastic J/ψ cross sections as a function of Q^2 and $W_{\gamma p}$ for DIS and γp.

The cross sections are not corrected for contributions from decays of B-mesons, χ_c or $\psi(2S)$ mesons. The fraction of events arising from B mesons and diffractive $\psi(2S)$ production with the subsequent decay into $J/\psi X$ is estimated to be 2.5% and 1.5%, respectively, for the total sample.

In Fig. 1 the predictions from the Monte Carlo programs CASCADE and EPJPSI are also included. The expectations from CASCADE agree well with the data in shape and in absolute value, both, in the DIS and in the γp regime. The EPJPSI model underestimates the cross section systematically. Furthermore, in DIS it predicts a much steeper fall of the cross section with rising Q^2.

The γp data is also compared to the results of the HERA-I analysis [5]. Good agreement is observed within the errors. In addition the figure includes the predictions from the NLO CS model [3] for the γp data as a shaded band. It agrees with the data albeit having large uncertainties mainly due to our ignorance of the charm quark mass m_c and the current precision of the strong coupling constant α_s.

Figure 2 shows the inelastic J/ψ cross section as a function of $P^{*2}_{T,J/\psi}$ and $z_{J/\psi}$ for the DIS and the γp samples. As mentioned above the background contributions from diffractive production of $\psi(2S)$ mesons and from beauty production are not subtracted from the data. These contributions are not uniform with respect to $z_{J/\psi}$. Diffractive $\psi(2S)$ production mainly contributes at large $z_{J/\psi}$ where it amounts to about 5%. J/ψ mesons from beauty have small elasticities. This background rises to about 10% in the lowest $z_{J/\psi}$ bin.

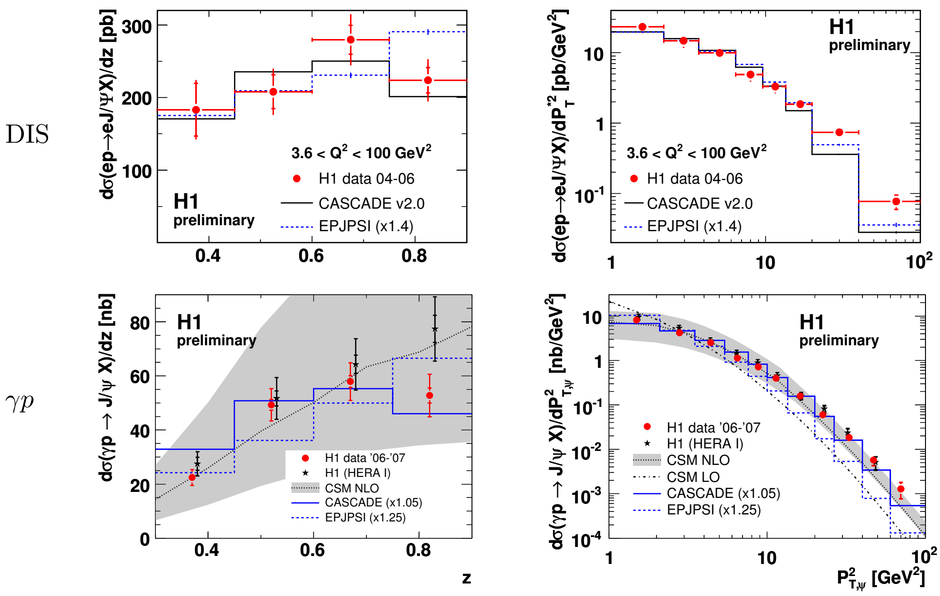

Figure 2: Inelastic J/ψ cross section as a function of $z_{J/\psi}$ and $P^{*2}_{T,J/\psi}$ for DIS and γp.

The measurements are also compared with the predictions from CASCADE and EPJPSI. Disregarding the normalization needed for EPJPSI the shapes of the measured differential cross sections are equally well described by both programs in the DIS regime. EPJPSI fails to reproduce the shape of the $P^{*2}_{T,J/\psi}$ cross section in γp while CASCADE is in agreement with the data everywhere. The NLO CSM (shaded band) agrees also well with the γp data in these quantities within its quite large uncertainty.

So far only single differential cross sections as a function of the ep kinematics and the properties of the J/ψ have been presented. To test the color singlet model further double differential cross sections have been investigated. In Fig. 3 the inelastic J/ψ cross section is shown in comparison with the predictions from CASCADE as a function of $P^{*2}_{T,J/\psi}$ in bins of $z_{J/\psi}$. Good agreement is also observed between data and the model when looking more differen-

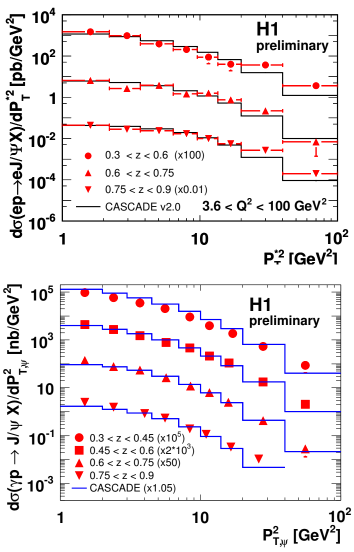

Figure 3: Inelastic J/ψ cross section in bins of $z_{J/\psi}$ as a function of $P^{*2}_{T,J/\psi}$ for DIS and γp.

tially in two dimensions both in DIS and in γp. Only at low elasticities in γp does CASCADE tend to overshoot the data.

3 Conclusions

Preliminary results from the H1 collaboration on the inelastic J/ψ cross section in DIS and γp based on the HERA-II data have been presented. Single and double differential cross sections have been compared with predictions from Monte Carlo models in which the color singlet matrix elements are implemented. The CASCADE model in particular has been found to be in good agreement with the measurements. The NLO calculations using the Color Singlet Model available in photoproduction also agree with the data within uncertainties. These results show no necessity for considering other processes than those implemented in the color singlet model to describe inelastic J/ψ production in ep scattering at HERA.

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