Photoproduction of Vector Mesons at H1

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Results obtained for photoproduction of vector mesons in γp interactions using the H1 detector at HERA are presented. The γp cross section for elastic ρ^0 production is found to be consistent with predictions from the soft pomeron model. J/ψ production is observed to increase strongly with the center of mass energy. This increase can be described in a QCD based model suggested by Ryskin using the gluon parametrisation MRS(A'). For inelastic J/ψ production the cross section is compared to NLO QCD calculations in a colour singlet model and agreement is found.

1 Introduction

At HERA 820 GeV protons collide with 27.5 GeV positrons. The resulting center of mass energy of $\sqrt{s} \approx 300$ GeV gives the possibility of studying the production of vector mesons (VM) in new kinematical regions. Here we review the photoproduction of vector mesons ($Q^2 \approx 0$).
The diffractive (elastic and proton dissociative) production of light vector mesons can be described within the Donnachie-Landshoff model (DL) [1]. This model is based on Regge phenomenology where the VM production is mediated by pomeron exchange. The cross section as a function of the photon proton center of mass energy $W_{\gamma p}$ is predicted to increase $\propto W_{\gamma p}^{0.32}$. The differential cross section $d\sigma/dt$, with t the momentum transfer squared at the proton vertex, is expected to be $\propto e^{bt}$.
An alternative model suggested by Ryskin et al. [2] describes the interaction between proton and heavy VM by the exchange of a gluon ladder which is calculable in perturbative QCD. The cross section is predicted to be proportional to the square of the gluon density in the proton.
The main inelastic J/ψ production process is the photon gluon fusion mechanism, which can be calculated in the colour singlet model. A gluon from the proton interacts with the photon emitted by the positron. The process is sensitive to the gluon density in the proton. For this reaction NLO QCD predictions have become available recently [3].

2 Experimental Setup

A detailed description of the H1 detector has been given elsewhere [4]. Elastic ρ^0-production is analysed in its dominant decay-channel $\rho^0 \to \pi^+\pi^-$ requiring exactly two tracks in the central tracking system.
J/ψ mesons are detected via their leptonic decays by demanding two identified electrons or muons in the H1 detector.
Elastic VM production is separated from proton dissociation processes using the signals in the forward detectors close to the proton beam:

- Forward part of the Liquid Argon calorimeter
- Forward Muon System
- Proton Remnant Tagger (placed $24\,m$ from the interaction point in the proton direction)

If there is any positive signal above noise in any detector the event is classified as due to proton dissociation, otherwise it is assumed to be elastic.

3 Diffractive vector meson production

The elastic cross section for ρ^0 meson production as a function of $W_{\gamma p}$ is shown in figure 1 (left). The H1 [5] and ZEUS measurements are consistent with the slight increase expected in the DL model.
An exponential fit of the t distribution yields a value for the slope parameter for elastic ρ^0 production of $b = (10.9 \pm 2.4 \pm 1.1)\,\mathrm{GeV}^{-2}$.
The elastic cross section for J/ψ meson production as a function of $W_{\gamma p}$ is shown in figure 1 (right) [6]. The prediction in the Donnachie-Landshoff model (long dashed line) cannot describe the HERA data. A better description is given by the pQCD calculations of the Ryskin model using the gluon parametrisation MRS(A') (short dashed line). A fit of the form W^δ to the H1 data yields a value of $\delta = 0.64 \pm 0.13$.
The cross section for proton dissociative J/ψ events is shown in figure 2 (left). A fit of the form W^δ gives the result $\delta = 1.2 \pm 0.2$.
The result fitting the p_t^2 distribution for elastic J/ψ production ($t \approx -p_t^2$) is $b = (4.0 \pm 0.2 \pm 0.2)\,\mathrm{GeV}^{-2}$ (fig. 3 left) and $b = (1.6 \pm 0.3 \pm 0.1)\,\mathrm{GeV}^{-2}$ for J/ψ production with dissociation of the proton.
Diffractive production of ρ^0 and J/ψ mesons are consistent with s-channel helicity conservation.

4 Inelastic J/ψ production

The inelasticity z of the J/ψ meson is defined in the following way:

$$z = \frac{P_p \cdot P_\psi}{P_p \cdot q} \tag{1}$$

where P_p, P_ψ and (q) are the four vectors of the proton, the J/ψ meson and the photon. Elastic J/ψ events are produced at $z = 1$, whereas for inelastic production, z is below 1.

The cross section for inelastic events in a kinematical range with $z < 0.8$ and transverse momentum p_t^2 of the J/ψ meson above $1\,\mathrm{GeV}^2$ as function of $W_{\gamma p}$ is shown in fig. 2 (right) [6]. The data points are compared to NLO QCD calculations [3] using a charm mass of $m_c = 1.4\,\mathrm{GeV}$ and $\Lambda_{\overline{MS}} = 300\,\mathrm{MeV}$. Agreement in shape and absolute normalisation between data and QCD predictions is found.

An exponential fit of the form $e^{-bp_t^2}$ to the differential cross section $d\sigma/dp_t^2$ yields a value for b of: $b = (0.39 \pm 0.06 \pm 0.03)\,\mathrm{GeV}^{-2}$, which agrees within errors with the NLO QCD prediction of $b = 0.3\,\mathrm{GeV}^{-2}$.

The differential cross section $d\sigma/dz$ is well described by QCD calculations in colour singlet model (fig. 3 right). There is no evidence for the large colour octet contributions in the region $z > 0.75$, which are calculated [7] using colour octet matrix elements fitted to high energy $p\overline{p}$ data (Tevatron).

References

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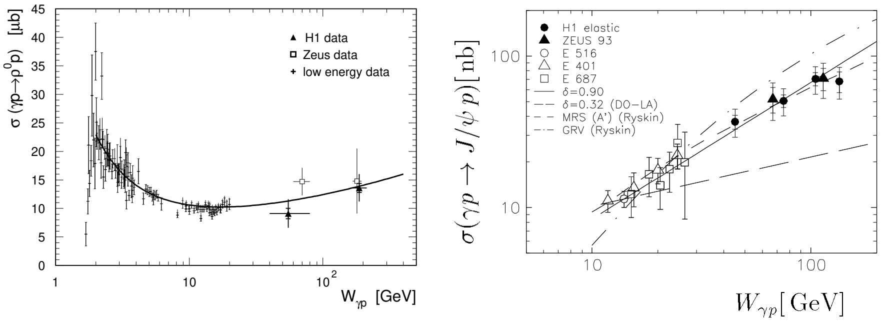

Figure 1: *Total cross section for* **elastic** *ρ^0-production (left) and for* **elastic** *J/ψ-production (right). The inner error bars of the HERA points are statistical, the outer ones contain statistical and systematic errors added in quadrature.*

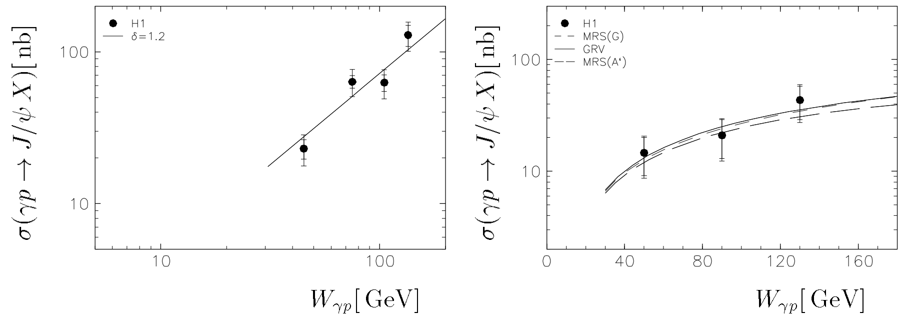

Figure 2: *Total cross section for* **proton dissociative** *J/ψ-production (left) and for* **inelastic** *J/ψ-production in the range $z < 0.8$, $p_t^2 > 1\,GeV^2$ (right).*

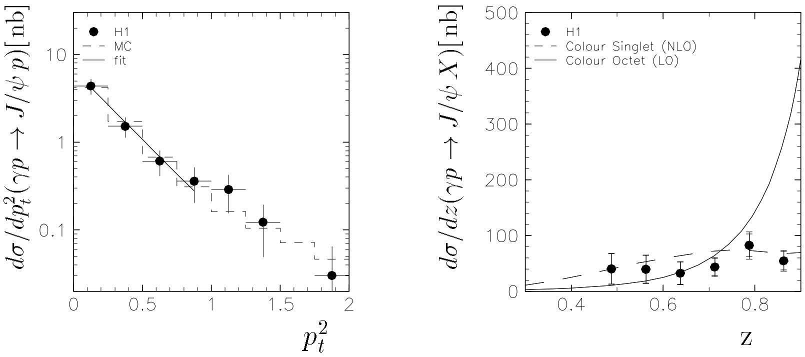

Figure 3: *Differential cross section $d\sigma/dp_t^2$ for* **elastic** *J/ψ-production (left) and $d\sigma/dz$ for* **inelastic** *J/ψ-production in the range $p_t^2 > 1\,GeV^2$ (right).*