VECTOR MESON PRODUCTION AT HIGH Q^2

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Recent results for vector meson production at high Q^2 are reviewed. The total cross section for elastic electroproduction of ϱ, ϕ and J/ψ mesons for $Q^2 > 8$ GeV^2 and $<W> \approx 100$ GeV are measured at HERA with the H1 detector. The dependences of the photon-proton cross sections on Q^2, W and t are presented. The ϕ:ϱ and J/ψ:ϱ cross section ratios are determined. The elastic over dissociative ϱ cross section ratio is measured. Signals for ω and ϱ' production are presented.

We present results for electroproduction of vector mesons at large Q^2 ($Q^2 > 8$ GeV^2) and high $\gamma^{(*)}p$ centre of mass energy ($W \simeq 100$ GeV), for the reaction

$$e^{\pm}\; p \;\rightarrow\; e^{\pm}\; p\; V, \qquad V = \varrho, \omega, \phi, \varrho', J/\psi. \tag{1}$$

Results on ϱ and J/ψ mesons are published [1] (and are preliminary for the other vector mesons). Interactions where the proton diffractively dissociates are also studied for ϱ meson production (preliminary results). The analyses are based on an integrated luminosity of ≈ 3 pb^{-1} accumulated by H1 in 1994, the colliding particles being 27.5 GeV positrons or electrons and 820 GeV protons. These results are expected to shed light on the nature of the pomeron, either in a soft or a perturbative QCD approach, the latter being justified by the existence of a hard scale (high photon virtuality or high mass of the vector meson) (see ref. in [1]).

The cross section for elastic electroproduction of vector meson V is converted into the γ^*p cross section using the flux of transverse virtual photons [1]. In the following all cross sections refer to the γ^*p cross section. The kinematical variables are Q^2, W and the 4-momentum transfer squared to the proton: t. The cross section is parameterised according to a Regge approach and the optical theorem as: $d\sigma/dt \approx W^{4\varepsilon}.e^{bt}$, the Q^2 dependence being $d\sigma/dQ^2 \approx Q^{-2n}$ (or $(Q^2 + m^2_{J/\psi})^{-n}$ in case of the J/ψ production).

• W **dependence:** the W dependence of the elastic cross section for ϱ, ϕ and J/ψ meson production is shown in Fig. 1b, 1c and 1a respectively. For ϱ production, an increase faster than in photoproduction of the cross section with energy (from the NMC to H1 experiments) is observed at high Q^2. For the longitudinal cross section only, and after subtraction of the contribution of reggeon exchange, $\varepsilon = 0.18 \pm 0.05$ for Q^2=10 GeV^2, $\varepsilon = 0.14 \pm 0.06$

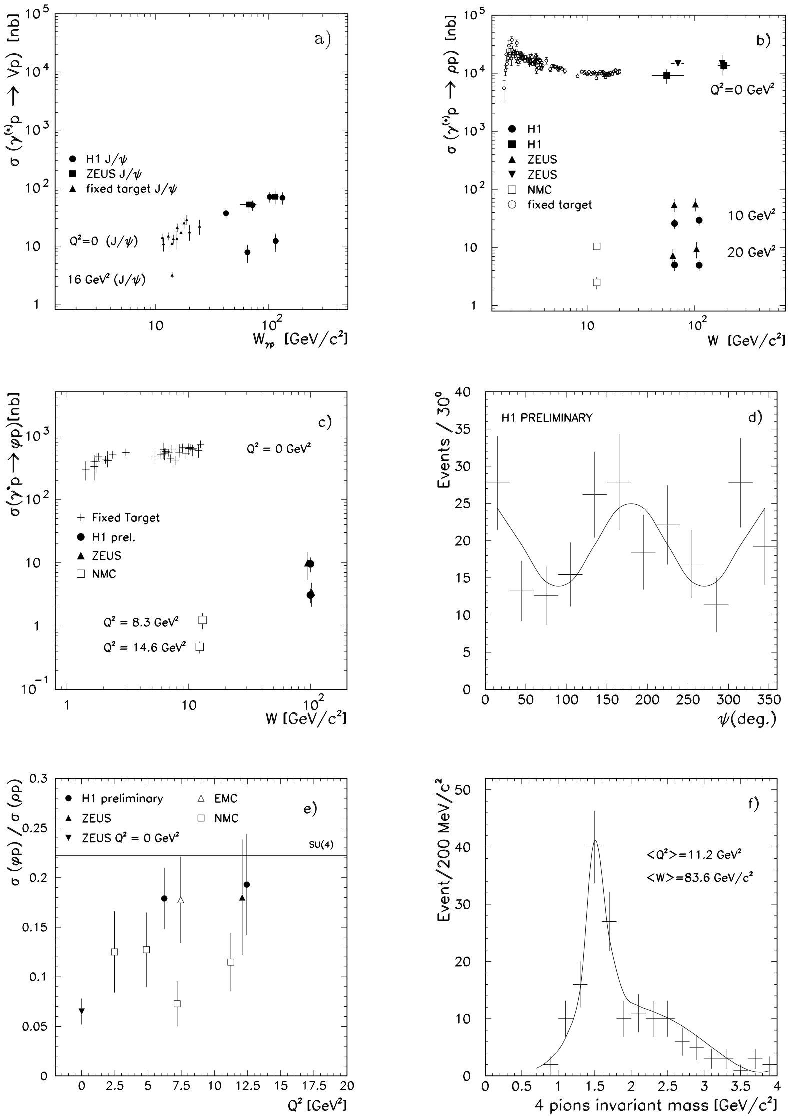

Figure 1: W dependence of the total $\gamma^{*}p$ cross section for the a) J/ψ, b) ϱ and c) ϕ meson; d) ψ angle distribution for elastic ϱ production; e) ϕ to ϱ elastic cross section ratio in function of Q^2; f) signal for ϱ' production (4π invariant mass distribution).

for Q^2=20 GeV^2. These results suggest that we are in a transition regime between soft (ε = 0.08) and hard physics processes [1]. For ϕ production, a stronger W dependence is found at high Q^2 (from NMC to H1 experiments) than in photoproduction. For J/ψ production, a steep increase of the cross section is observed with W both in photoproduction and at high Q^2, indicating that the hard regime is probably already reached at low Q^2 due to the mass of the charm quark.

• **t dependence:** the b slope parameters for the different vector mesons are listed in Tables 1 and 2. In comparison to elastic ϱ production, the slope is flatter for dissociative ϱ production (there is no proton form factor) and for J/ψ production (more compact meson wave function). Similarly to photoproduction, an indication for shrinkage of the elastic peak is observed at high Q^2, for elastic ϱ production, from the NMC to the HERA energies. Subtracting the non–resonant pion background with a similar procedure for the NMC and H1 data, the slope of the effective pomeron Regge trajectory, α', is found to be 0.28 $\pm$ 0.12 GeV^{-2} (for hadronic interactions, α' = 0.25 GeV^{-2}).

• **Q^2 dependence:** the n parameters for the different vector mesons, presented in Table 1, are in general agreement with the models [1].

• **Angular decay distributions:** the probability r^{04}_{00} for a vector meson to be longitudinally polarised can be extracted from the distribution of $\cos\theta^*$ (θ^* is the angle, in the vector meson rest frame, between the direction of the positively charged decay particule and the the $\gamma^* p$ centre of mass system (helicity frame)). The ϱ and the ϕ mesons are mostly longitudinally polarised (Table 1), as predicted by most models. Assuming s–channel helicity conservation (SCHC), the density matrix element r^1_{1-1} can be computed from r^{04}_{00}. Yet, r^1_{1-1} can also be extracted from the ψ distribution (Fig. 1d) (ψ is the angle between the V decay plane and the scattered electron plane, in the $\gamma^* p$ cms). For elastic ϱ production, the equality within errors of the two values obtained for r^1_{1-1} (0.13 $\pm$ 0.03 and 0.14 $\pm$ 0.05 respectively) supports the SCHC hypothesis.

• **Total cross-section ratios:** the ratio of the dissociative over elastic ϱ cross sections is 0.59 $\pm$ 0.12 $\pm$ 0.12. No significant Q^2 ($Q^2 \in [8-36]$ GeV^2) and W ($W \in [60-180]$ GeV) dependence is observed. This ratio was also measured for J/ψ photoproduction [2]. These measurements allow the study of the factorisation of the diffractive cross section into two factors, describing respectively the processes at the photon and at the proton vertices. Factorisation would be manifest by the independence, with respect to the nature of the produced vector meson, of the ratio of the elastic to proton dissociation cross sections, for t = 0. Taking into account the measured slopes, this ratio is 0.18 $\pm$ 0.09 for the ϱ and 0.43 $\pm$ 0.13 for the J/ψ. The ϕ:ϱ cross section ratio rises with Q^2 (Fig. 1e), and the rise is faster at high energy (HERA) than at lower energy (fixed target). The J/ψ:ϱ cross section ratio is very small in photoproduction (0.01 to 0.001), but is close to 1 at high Q^2 : 0.64 $\pm$ 0.13 (Q^2 = 10 GeV^2) and 1.3 $\pm$ 0.5 (Q^2 = 10 GeV^2) (Fig. 1a and 1b, same scale plots). This is consistent with a harder W dependence of the cross section for ϕ and for J/ψ than for ϱ mesons, and is compatible with the perturbative approach, based on the fact that the ϕ and J/ψ mesons have smaller spatial extent than the ϱ.

• **Other resonances:** signals for electroproduction of ω and ϱ' ($\varrho' \rightarrow 4\pi$) at large Q^2 are observed, the ϱ' meson decaying dominantly into a ϱ meson and a non resonant pion pair.

References

1. S. Aid et al., H1 Coll., *Nucl. Phys.* **B463** (1996) 3.
2. *Elastic and Inelastic Photoproduction of J/ψ Mesons at HERA*, preprint DESY 96-037. To be publ. in *Nucl. Phys.* **B**.

	b (GeV^{-2})	n	$<r^{04}_{00}>$
ϱ_{el}	$7.0 \pm 0.8 \pm 0.6$	$2.5 \pm 0.5 \pm 0.2$	$0.73 \pm 0.05 \pm 0.02$
ϱ_{diss}	$2.1 \pm 0.7 \pm 0.4$	$2.8 \pm 0.6 \pm 0.3$	$0.78 \pm 0.10 \pm 0.05$
ϕ	-	$2.0 \pm 0.6 \pm 0.1$	$0.77 \pm 0.11 \pm 0.02$
J/ψ	$3.8 \pm 1.2 \pm 1.8$	1.9 ± 0.3	-

Table 1: b slope (t distribution), n parameter (Q^2 distribution), and r^{04}_{00} parameter ($\cos\theta^*$ distribution), for different vector meson production. The ϱ dissociative and the ϕ results are still preliminary.

$40 < W < 140$ GeV/c^2	
$8 < Q^2 < 12$ GeV^2	$12 < Q^2 < 50$ GeV^2
$b = 7.8 \pm 1.0 \pm 0.7$ GeV^{-2}	$b = 5.7 \pm 1.3 \pm 0.7$ GeV^{-2}

$8 < Q^2 < 50$ GeV^2	
$40 < W < 80$ GeV/c^2	$80 < W < 140$ GeV/c^2
$b = 6.2 \pm 1.0 \pm 0.7$ GeV^{-2}	$b = 8.0 \pm 1.3 \pm 0.7$ GeV^{-2}

Table 2: Slopes of the t distributions for ϱ meson elastic production, for different Q^2 and W domains.