New results on light vector meson production in elastic and diffractive ep collisions at HERA

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Abstract
We present measurements of cross sections as function of kinematic variables W, Q^2 and t for elastic and diffractive production of ρ, ω and Φ mesons at HERA (300 GeV c.m.s. energy). Cross section ratios are compared with predictions of flavour independent production. Results of the helicity analysis are also presented.

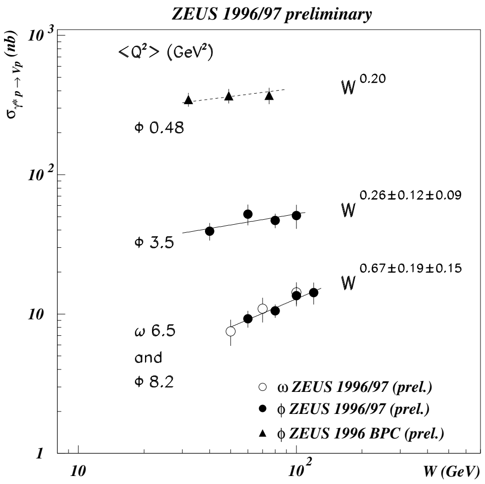

Figure 1. W dependence of cross sections.

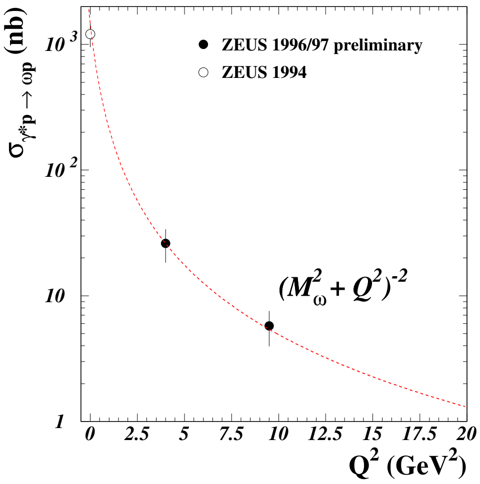

Figure 2. Q^2 dependence of cross sections.

The aim of studying the vector meson (V) production at HERA, $ep \to Vp$ or VX (X – a hadronic state) is to learn about soft and hard phenomena and the transition between them. The slopes in the W dependence of cross sections for ω and Φ increase with Q^2 as shown in Fig. 1 (≈ 0.8 is expected in the hard regime). The Q^2 dependence of the cross section for ω production is compatible with the $1/(M_\omega^2 + Q^2)^2$ dependence (Fig. 2).

In diffractive processes the differential cross section $d\sigma/dt$ (t is the four momentum squared transferred between the V and the proton vertices) may be parametrised by an exponential $exp(-b|t|)$ (for $|t| < 1\,GeV^2$) and the parameter b is related to the transverse sizes of the V and the proton vertices: $4b \approx R_V^2 + R_p^2$. The resolution in the V vertex increases with Q^2 and thus R_V^2 decreases, b reaching a value of $5 \div 6$ GeV^{-2}, corresponding to the proton size (≈ 1 fm), as shown in Fig. 3 [1]. In the proton dissociative process the measured magnitude of b falls below the proton size (Fig. 4).

In Fig. 5 the ratio of proton dissociative and elastic cross sections for ρ production is shown. If factorisation holds this ratio should be Q^2

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independent which is the case for $Q^2 \geq 4$ GeV^2.

Photoproduction cross sections of ρ and Φ measured in a wide range of t are presented in Fig. 6; no agreement with the theoretical prediction [2] is seen for Φ.

Evidence for Q^2 and t providing a hard scale is shown, in terms of cross section ratios, in Figs. 7 and 8. At high values of the respective variables the ratios are consistent with the assumption of flavour independence (dotted lines).

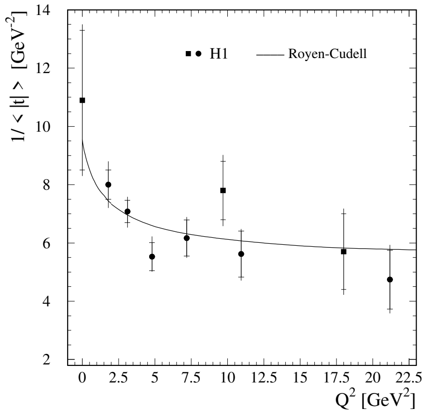

Figure 3. Q^2 dependence of the slope parameter ($b \approx 1/\langle t \rangle$) for elastic ρ production with theoretical prediction [3] .

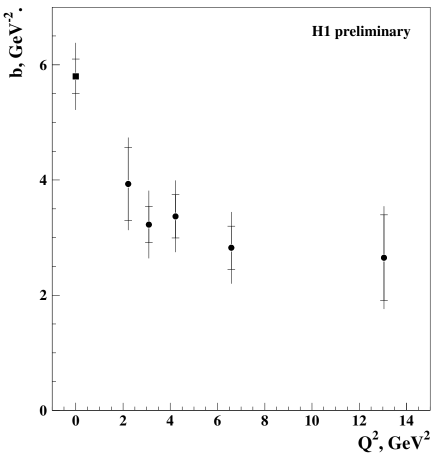

Figure 4. Q^2 dependence of the slope parameter b for proton dissociative ρ production.

The density matrix elements (15 parameters) were fitted to the angular distributions for the

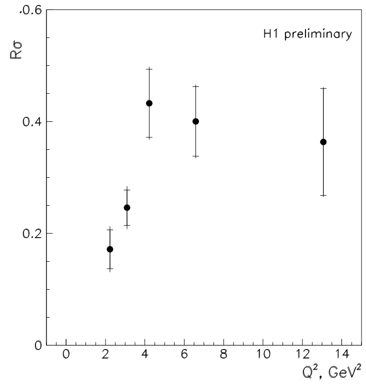

Figure 5. $R_\sigma = \sigma_{pdiss.}/\sigma_{elastic}$ as a function of Q^2 for ρ production.

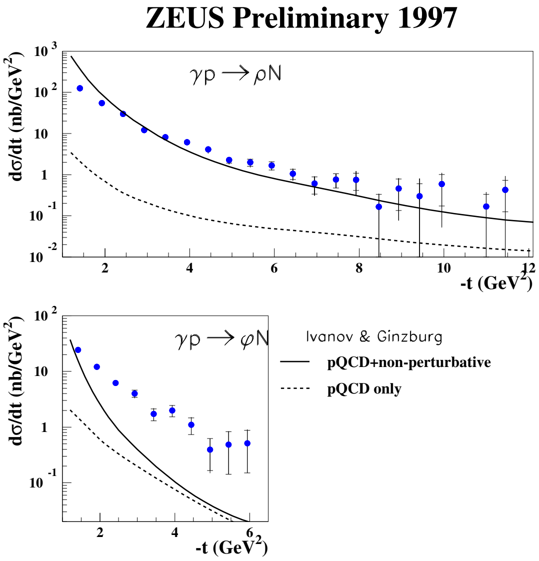

Figure 6. t dependence of cross sections in photoproduction and a theoretical prediction [2].

elastic ρ production in deep inelastic scattering (Fig. 9) [5]. The observed deviations from the s-channel helicity conservation are successfully described in QCD [6]. Detailed studies of the ρ photoproduction showed that the values of certain fitted parameters depend on whether determined for the invariant mass $M_{\pi\pi}$ lower or higher than the nominal resonance mass, as shown in Fig. 10 for r_{00}^{04} (in progress).

In conclusion, we observe several new features of the light V production process. In particular

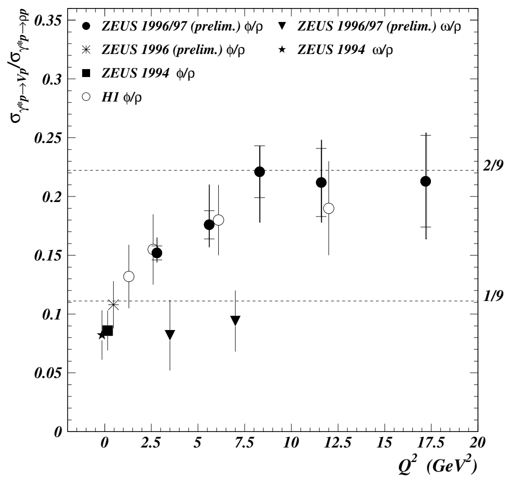

Figure 7. Q^2 dependence of elastic V production cross section ratios.

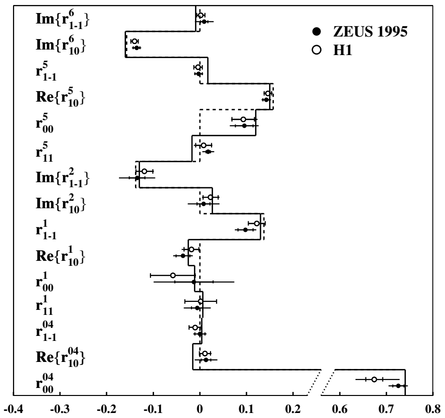

Figure 9. Results of the 15 parameter fit and comparison with theoretical prediction [6].

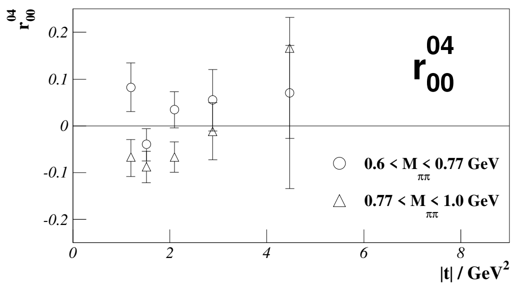

Figure 10. t dependence of the parameter r^{04}_{00} in two $M_{\pi\pi}$ ranges for ρ photoproduction (ZEUS preliminary).

the measured slope of the W dependence of cross sections for the elastic ω and Φ production at higher values of Q^2 is consistent or close to that expected in the hard regime. The measurements of the t dependence of cross sections extend up to 12 GeV^2 (ρ). The ratios of cross sections for the measured processes are consistent with being flavour independent at larger values of Q^2 or t. A small violation of the s-channel helicity conservation is observed in deep inelastic scattering which, in terms of the density matrix elements, is correctly described in QCD.

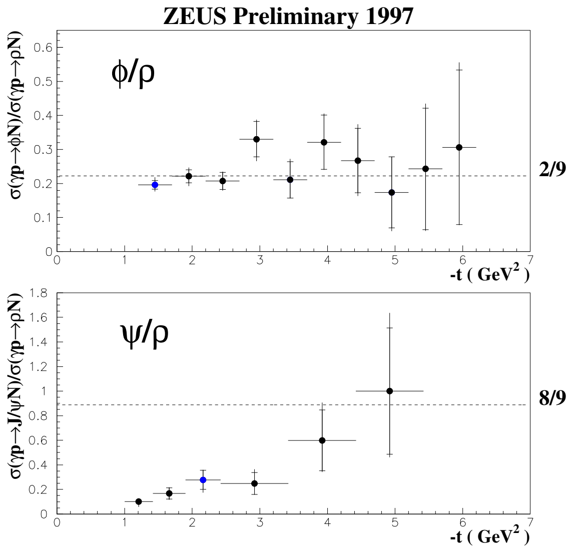

Figure 8. t dependence of cross section ratios in photoproduction.

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