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ELASTIC AND PROTON-DISSOCIATIVE VECTOR MESON PRODUCTION AT HIGH Q^2 OR LARGE $|t|$

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Vector meson production is studied in a hard scale regime where perturbative QCD models apply. The energy dependence of the ρ , ω and ϕ cross section is studied as a function of Q^2 and the photoproduction cross section is determined as a function of the four-momentum transfer squared at the proton vertex. In addition, polarisation measurements of ϕ mesons are presented including the measurement of the spin density matrix elements and the ratio $R = \sigma_L/\sigma_T$.

1 Introduction

Elastic and proton dissociative vector meson production, $ep \rightarrow eVX$, is studied at HERA in a wide kinematic range of the photon virtuality Q^2 , the photon-proton centre-of-mass energy W and the negative square of the four-momentum transfer t at the proton vertex.

The presence of a hard scale allows for quantitative predictions within the framework of perturbative QCD. The scale can be given by Q^2 , t or the quark mass m_q^2 . It is assumed that the photon fluctuates into a $q\bar{q}$ pair long before it interacts with the proton via a two gluon exchange. The vector meson is formed long after this interaction. The cross section is proportional to the gluon density squared of the proton and hence rises steeply with W .

2 W and Q^2 Dependence of Light Vector Meson Production

The energy dependence of elastic light vector meson production can be parameterized as W^δ . In fig. 1a the exponent δ is displayed as a function of Q^2 for different vector mesons. The increase of δ with Q^2 gives an indication for a pQCD-type hard scale behavior. Fig. 1b shows the cross section ratios of ϕ and ω mesons relative to ρ mesons. At higher values of Q^2 the ratio is consistent with the behaviour $\rho : \omega : \phi = 9 : 1 : 2$, which is expected from the flavour contents of the mesons, assuming a point-like electromagnetic coupling to the quarks.

3 t Dependence in Proton Dissociative Photoproduction

Differential cross sections $d\sigma/dt$ for ρ , ϕ and J/ψ mesons are measured² in photoproduction for $Q^2 < 0.01\text{GeV}^2$. In fig. 2a, the cross sections of ρ and ϕ

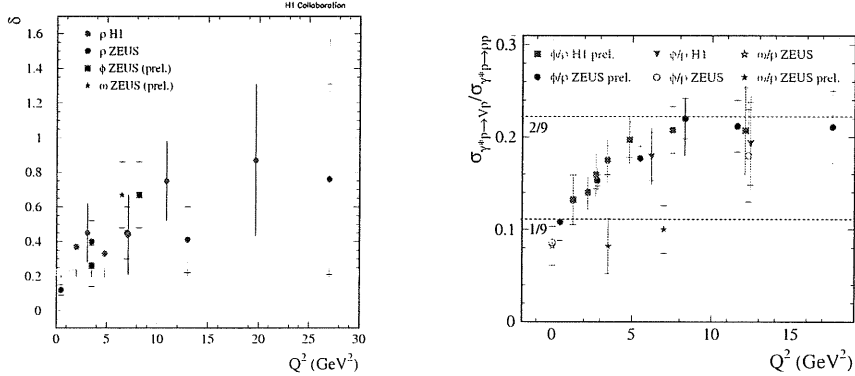


Figure 1: a) Q^2 dependence of the δ parameter for light vector meson electroproduction and b) ratios of cross sections as function of Q^2 .

mesons are compared to a model⁸ that includes both perturbative and nonperturbative contributions. The nonperturbative contribution dominates in the measured region for the ρ meson and the calculation underestimates the ϕ cross section over most of the t range covered. Fig. 2b shows good agreement between the differential J/ψ cross section and a leading order BFKL calculation⁴.

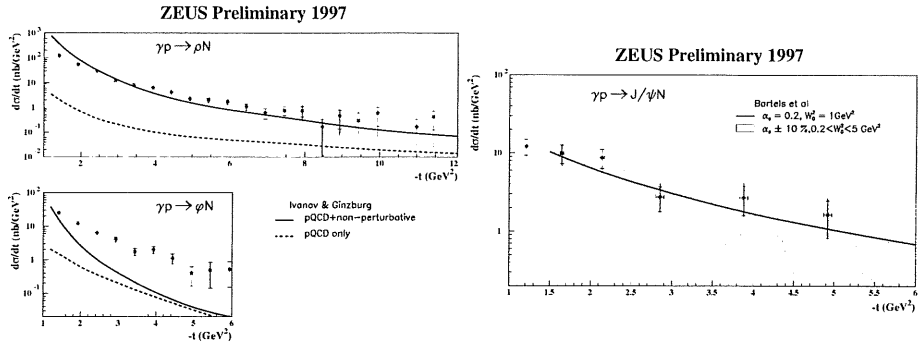


Figure 2: Differential cross section $d\sigma/dt$ for proton dissociative production of a) ρ and b) J/ψ mesons.

4 Polarisation Studies

Helicity studies have been performed for elastic ρ and ϕ electroproduction^{1,2}. The decay angular distribution $W(\cos\theta, \phi, \Phi)$ depends on 15 matrix elements r_{ij}^α and $r_{ij}^{\alpha\beta}$ which are related to the helicity amplitudes $T_{\lambda_V \lambda_\gamma}$. In the case of s-channel helicity conservation (SCHC) the helicities of the vector meson and the photon are the same ($T_{ij} = 0$ for $i \neq j$) and 10 of the 15 matrix elements are zero. Fig. 3a shows the matrix elements for ϕ mesons as a function of Q^2 .

The element r_{00}^5 is found to be significantly different from zero. The ratio of the longitudinal and the transverse cross section, $R = \sigma_L/\sigma_T$, as determined from the matrix element r_{00}^{04} is shown for different vector mesons as a function of Q^2/M^2 (fig. 3b). It increases with Q^2 and the ρ data show a flattening at high Q^2 .

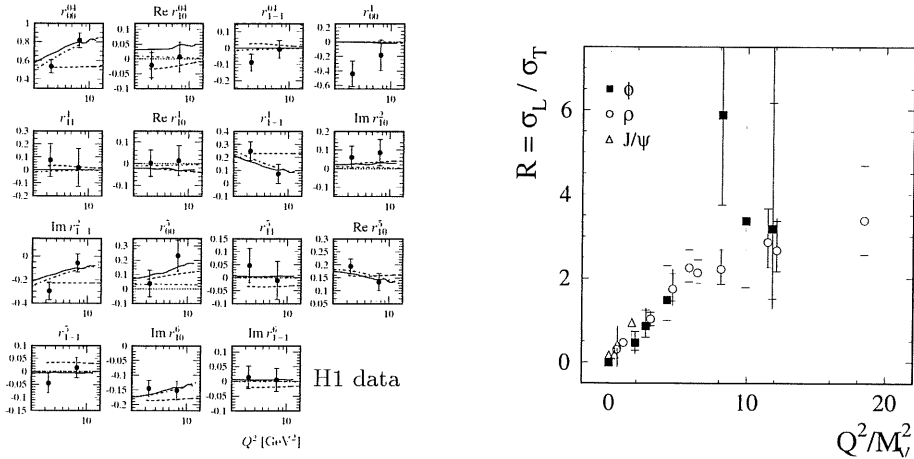


Figure 3: a) Measurements of the 15 matrix elements of the ϕ meson as a function of Q^2 . The dotted lines show the expectation for SCHC. b) $R = \sigma_L/\sigma_T$ as a function of Q^2/M^2 for different vector mesons.

5 Conclusions

Vector meson production has been studied at HERA in a wide kinematic range in Q^2 , W and t . The energy dependence for light elastic vector meson electroproduction is consistent with pQCD, unlike the high- $|t|$ behaviour of proton dissociative ρ and ϕ production. Helicity studies of elastic ϕ electroproduction show a small but significant violation of SCHC analogous to that measured for the ρ meson.

References

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