Exclusive Electroproduction of Light Vector Mesons from ZEUS

A.A. Savin[a]
On behalf of the ZEUS Collaboration

[a]DESY, Germany and Moscow State University, Russia,
Notkestr.85, 22603 Hamburg, Germany

Exclusive production of ρ^0, ϕ and ω mesons at high Q^2 is presented. Cross sections and their ratios as functions of the photon virtuality Q^2 are measured. The W behavior of the cross sections is analyzed. The helicity angles analysis of the ρ^0 data indicate SCHC breaking both at high and at low Q^2.

1. INTRODUCTION

The elastic process $ep \rightarrow V^0 ep$, where V^0=(ρ,ω,ϕ), has been studied in the kinematic range $3 < Q^2 < 30\ GeV^2$, $40 < W < 120\ GeV$, $|t| < 0.6(1.)\ GeV^2$. The data sample corresponds to a luminosity of 37 pb^{-1} accumulated during the 1996-97 running period. The 1995 data sample of 6 pb^{-1} has been used in some part of the ρ^0 analysis presented here. In the considered kinematic range, two classes of theoretical models have been proposed to describe the data:
- Vector Dominance Model [1] in conjunction with Regge theory (Donnachie and Landshoff's parameterization [2]). In this approach the W behavior of cross section is $\sigma_{\gamma^* p \rightarrow V^0 p} \propto W^{0.22}$;
- pQCD models [3,4], where the pomeron is described as a 2-gluon exchange. In this framework the cross section is proportional to the gluon distribution squared, which gives $\sigma_{\gamma^* p \rightarrow V^0 p} \propto W^{0.8}$ (see e.g. [3]) .
At high enough Q^2 one expects the pQCD calculations to be valid. Also in this region one expects ratios of the cross sections $\rho : \omega : \phi =$ 9:1:2 as predicted by SU(3).
The measurement of the vector meson decay particles angular distributions is very important because they are related to the spin-density matrix elements of the vector meson. For the ρ and ϕ case we have measured the full set of such spin-density matrix elements which completely determine the decay angular distributions. From these elements we also calculated $R = \sigma_L/\sigma_T$ - the ratio of longitudinal to transverse photon cross section.

2. THE MASS SPECTRUM

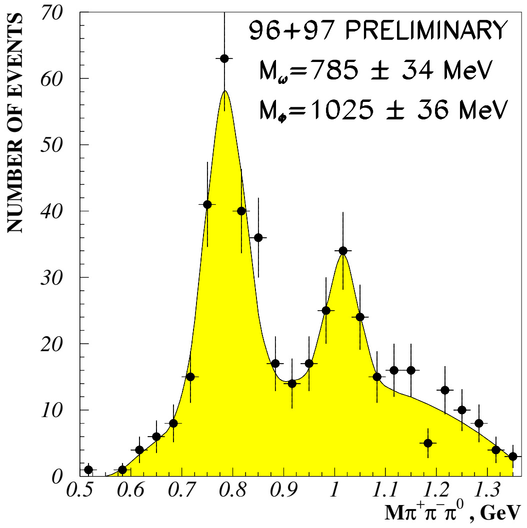

Figure 1. The invariant mass spectrum of $\pi^+\pi^-\pi^0$ system. Solid line is the result of fit described in the text.

The $\pi^+\pi^-$ invariant mass distribution in the ρ^0 region as well the K^+K^- for the ϕ case were discussed elsewhere [6,7]. The $\pi^+\pi^-\pi^0$ spectrum from the ω decay was shown at HERA only for photoproduction case [8]. The first attempt to measure the $\pi^+\pi^-\pi^0$ final state at high Q^2 is shown in Fig.1. The data are fitted with 2 Gaussians for the mass peaks and polynomial for the background description. One sees two mass peaks at 785 MeV and at 1025 MeV with a width of about 35 MeV. The peak values are in good agreement with PDG masses for the ω and the ϕ, 782 and 1020 MeV, respectively. There are about 150 ω candidates in the peak. The existence of the $\phi \to \pi^+\pi^-\pi^0$ signal proves the consistency of the method; only the $\phi \to K^+K^-$ mode is used later for cross sections calculations.

3. DEPENDENCE ON W AND Q^2

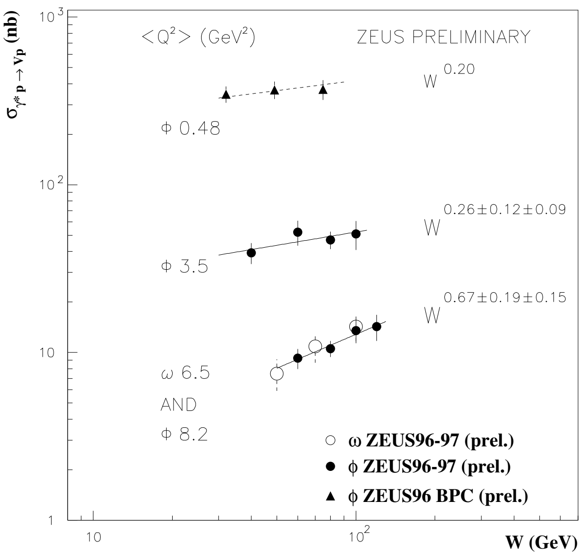

Figure 2. Cross sections $\sigma_{\gamma^* p \to V^0 p}$, where $V^0 = (\omega, \phi)$, versus W for different Q^2 bins as measured by ZEUS in 1996-97. The solid lines with numbers on the right side are the results of the fit to the ϕ data. The dashed line shows a function $\sigma \propto W^{0.2}$ on top of the data points. The ω data are not fitted.

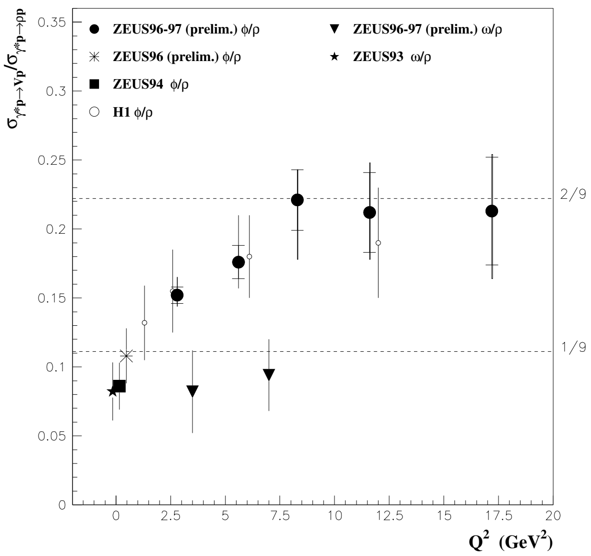

Figure 3. Ratios $\sigma_{\gamma^* p \to V^0 p}/\sigma_{\gamma^* p \to \rho p}$, where $V^0 = (\omega, \phi)$, versus Q^2. The dashed lines show the values predicted by SU(3).

Fig.2 shows the cross sections $\sigma_{\gamma^* p \to V^0 p}$, where $V^0 = (\omega, \phi)$, versus W for different Q^2 bins. For ρ see [6]. The data exhibit a much steeper behaviour then predicted by soft pomeron exchange and at high Q^2 approach the prediction of pQCD models.

The Q^2 dependence of the cross sections can be described well by $\sigma_{\gamma^* p \to V^0 p} \propto 1/(M_{V^0}^2 + Q^2)^n$, where $n \simeq 2$ for all vector mesons. It contradicts to the simplest VDM calculation [1] and quit agrees with the pQCD models expectations.

The cross sections ratios $\sigma_{\gamma^* p \to \omega p}/\sigma_{\gamma^* p \to \rho p}$ and $\sigma_{\gamma^* p \to \phi p}/\sigma_{\gamma^* p \to \omega p}$ are shown in Fig.3. It is the first time such a complete picture for all light vector mesons in a very wide Q^2 range has been obtained within one experiment. The ϕ/ρ ratio rises with Q^2 and at Q^2 more than 6-7 GeV^2 is in good agreement with the SU(3) predictions. The ω/ρ ratio has a much flatter behavior and at high Q^2 also supports the SU(3) expectations.

4. DECAY ANGULAR DISTRIBUTIONS

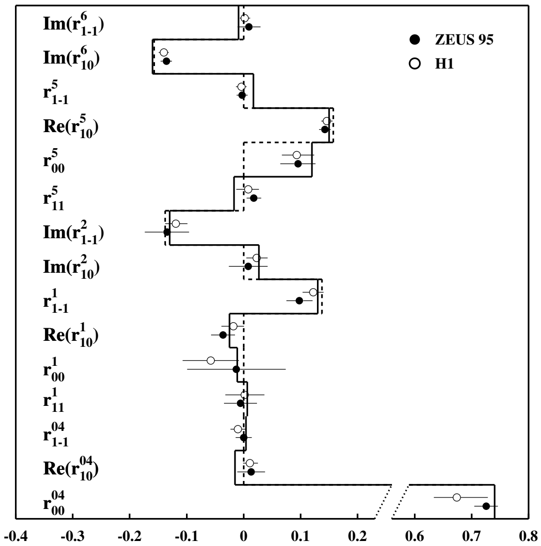

Figure 4. The 15 linear combinations of spin-density matrix elements obtained from the ρ^0 data analysis compared with the predictions of the model calculations of [9] (continuous histogram) and of SCHC (dashed histogram). The ZEUS data cover the kinematic range $3 < Q^2 < 30\ GeV^2$, $40 < W < 120\ GeV$, $|t| < 0.6\ GeV^2$. The H1 data cover the range $1 < Q^2 < 60\ GeV^2$.

Fig.4 shows the results for the 15 combinations of spin-density matrix elements from the ρ^0 analysis. The ZEUS and the H1 data agree very well. There is a clear indication that SCHC is violated: the r^5_{00} matrix element is not equal 0, as expected by SCHC, i.e. the longitudinally polarized ρ^0 can be produced also from transverse photons. The results of the pQCD model calculation [9] describe the data. Deviations from SCHC were also observed by ZEUS at $0.25 < Q^2 < 0.85\ GeV^2$. The issue of R calculated without assuming SCHC differs from those based on SCHC by only 3% at most .

5. CONCLUSIONS

The first time the exclusive electroproduction of ω mesons has been measured at high Q^2 at HERA. The cross sections dependences on W and Q^2 are consistent with those found for ρ and ϕ. The ratio $\rho : \omega : \phi$ is found to be in a good agreement with SU(3) predictions at $Q^2 > 6 - 7\ GeV^2$.The SCHC violation is observed both at high and at low Q^2, but it should effect the $R = \sigma_L/\sigma_T$ calculations by only 3% at most.

REFERENCES

1. H. Fraas, D. Schildknecht, Nucl. Phys. **B14** (1969) 543.
2. A. Donnachie and P.V. Landshoff, Phys. Lett. **B348** (1995) 213.
3. M.G. Ryskin, Z. Phys. **C57** (1993) 89.
4. M.G. Ryskin et al., Z. Phys. **C76** (1997) 231.
5. K. Schilling and G. Wolf, Nucl. Phys. **B61** (1973) 381.
6. ZEUS Coll., J. Breitweg et al., Europ. Phys. Journal **C6** (1999) 603.
7. ZEUS Coll., J. Breitweg et al., paper N793, submitted to the IHEP98, Vancouver, Canada, July 1998
8. ZEUS Coll., M. Derrik et al., Z. Phys **C73** (1996) 73.
9. D.Yu. Ivanov and R. Kirschner, Phys. Rev. **D58** (1998) 114026.
10. D. Schildknecht, G.A. Schuler, B. Surrow, CERN-TH-98-294 (1998), hep-ph/9810370.
11. A.D. Martin, M.G. Ryskin, T. Teubner, Phys. Rev. **D55** (1997) 4329.