

Exclusive ϕ Meson Production at HERA

The ZEUS Collaboration

The scattering process electron+proton \rightarrow electron+proton+ ϕ meson, followed by the decay $\phi \rightarrow K^+K^-$, is simple and experimentally clean, and yet contains a wealth of information concerning the strong force. The electron and proton stay intact in the scattering process, and the ϕ meson is produced from the vacuum. Exactly how this comes about is not known, but we imagine the following steps: the electron radiates a virtual photon some time before the interaction; the photon fluctuates into a virtual quark-antiquark pair; this pair scatters from the gluon cloud in the proton, acquiring the needed energy and momentum to become real; the quark-antiquark pair forms a ϕ meson. The ϕ meson later decays, and the decay products, in this case a K^+ meson and a K^- meson, are then observed in the detector, together with the scattered electron. The scattered proton generally remains in the beampipe and is unobserved. The radiation of a virtual photon by the electron is understood using the quantum theory of electromagnetism, QED, as is the formation of the quark-antiquark pair. What is not well known is the scattering of the quark-antiquark pair from the proton, or the ϕ wavefunction. Studying the scattering process $eP \rightarrow eP\phi$ therefore yields information on these aspects of the strong interactions.

The main results of the paper are the measurement of the dependence of the scattering cross section on the energy of the photon-proton system, W , on the four-momentum transfer squared to the electron, Q^2 , on the four-momentum transfer squared to the proton, t , and on the angular distributions of the ϕ decay products. These results are compared to those obtained from scattering processes involving other vector mesons, and general trends in the data are observed. These indicate the existence of scaling variables for the quark-antiquark-proton scattering process. An example is given in the figure below, where the slope of the W -dependence of the cross section is plotted as a function of $Q^2 + M_V^2$, where M_V is the vector meson mass.

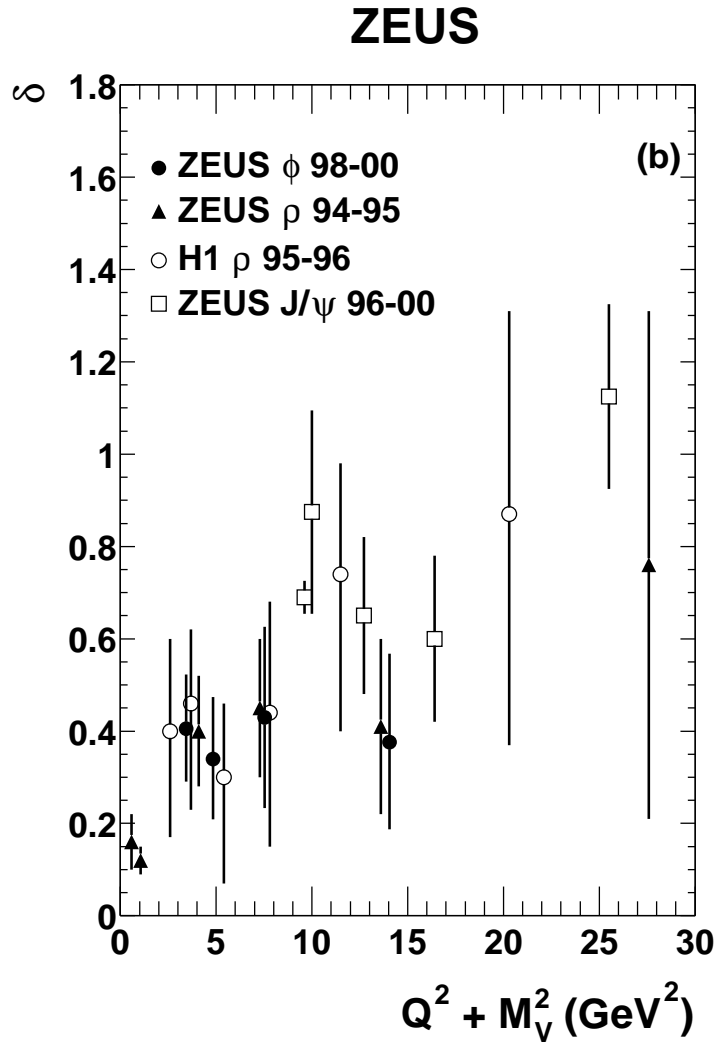


Figure 1: The slope of the W dependence for the scattering process $eP \rightarrow ePV$, extracted from fits of the cross section to the form $\frac{d\sigma}{dW} \propto W^\delta$ for different vector mesons, V , and different values of Q^2 .