CROSS SECTIONS OF VECTOR MESON PRODUCTION AT INTERMEDIATE VIRTUAL PHOTON ENERGIES OF HERMES*

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(Received July 13, 2000)

Cross section measurements of exclusive ρ^0 and ϕ production on a ^{1}H target in the range of $0.7 < Q^2 < 5.0$ GeV^2 as well as extrapolated photoproduction cross section are presented in comparison with world data. The W-dependence of the ϕ-leptoproduction cross section is shown to be in agreement with a gluon exchange mechanism. A clear W-dependence of the cross section ratio of ϕ to ρ^0 leptoproduction is observed over a wide kinematical range of W at $2.5 < Q^2 < 4$ GeV^2. Fits of the Q^2-dependences of the total, longitudinal, and transverse cross sections of ϕ and ρ^0 mesons are compared with ones from HERA collider experiments.

PACS numbers: 13.60.Le

1. Introduction

The ρ^0 and ϕ mesons detected at the HERMES spectrometer [1] are identified by their decay products in the following channels: $\rho^0 \to \pi^+\pi^-(100\%)$ and $\phi \to K^+K^-(49\%)$. The ρ^0 mesons are identified by requiring $0.6 < M_{\pi\pi} < 1$ GeV, with $M_{\pi\pi}$ being the invariant mass of the two detected hadrons assuming that both are pions [2]. The $\phi \to K^+K^-$ background is removed by the requirement of $M_{KK} > 1.04$ GeV. The ϕ mesons are selected with the cut $0.99 < M_{\pi\pi} < 1.05$ GeV. Correlations between the momenta of the two kaons due the restrictive phase space of $\phi \to K^+ K^-$ decays are used with the requirement that $\mid p_1 - p_2 \mid \leq 0.3 \times (p_1 + p_2)$. The absence of a signal in the Cherenkov detector is required to identify the kaon tracks.

* Presented at the Meson 2000, Sixth International Workshop on Production, Properties and Interaction of Mesons, Cracow, Poland, May 19–23, 2000.

The non-exclusive background is removed mainly by the requirement of missing energy $-0.4 < \Delta E < 0.4$ GeV. The remaining background (around 8%) is subtracted from the ^{1}H data using a Monte Carlo calculation of pions(kaons) from deep-inelastic scattering [2]. The data are corrected for the finite acceptance of the spectrometer.

2. Cross sections

Exclusive ϕ meson production cross sections on a ^{1}H target have been measured for W values between 4.0 and 6.0 GeV, and Q^2 values between 0.7 and 5.0 GeV^2. In Fig. 1 the virtual photoproduction cross section is plotted versus W, and compared to existing measurements [3–5] in a wide range of W. A fit of the W-dependence of $\sigma(\gamma^* p \to \phi p)$ is made using the functional form W^δ with δ as free parameter. The value of δ is found to be Q^2-dependent, going from 0.22 ± 0.02 at $Q^2 = 0$ to 0.53 ± 0.09 at $Q^2 = 2.5$ GeV^2. The result of ϕ meson production fits are in agreement with the Q^2-dependence of $W^{\delta(Q^2)}$ extracted from ρ^0 electroproduction data of H1 and ZEUS [6]. As the W-dependence for ϕ production is the same over a wide range (from 4 to 120 GeV), it is tentatively concluded that the same gluon exchange mechanism plays an important role throughout this W-domain.

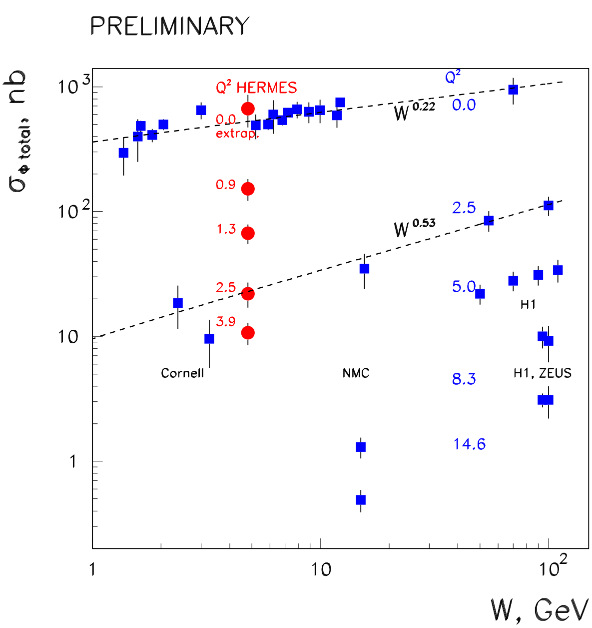

Fig. 1. The cross section for $\gamma^* p \to \phi p$ as a function of W for photoproduction and DIS.

The Q^2-dependence of the cross section ratio for ϕ to ρ^0 production is displayed in Fig. 2 together with other experiments [3–5]. The ratio of cross sections shows a clear Q^2-dependence for $2 < Q^2 < 5$ GeV^2. However, in the gluon exchange mechanism one would expect a similar Q^2 dependence for ρ^0 and ϕ production, which is indeed observed for the high Q^2 data (which also corresponds to higher values of W). The deviation at low Q^2 is possibly caused by contribution of a two-quark exchange mechanism to the ρ^0 production cross section, see Ref. [2], which is also supported by the OFPD calculations [7] of the longitudinal cross section.

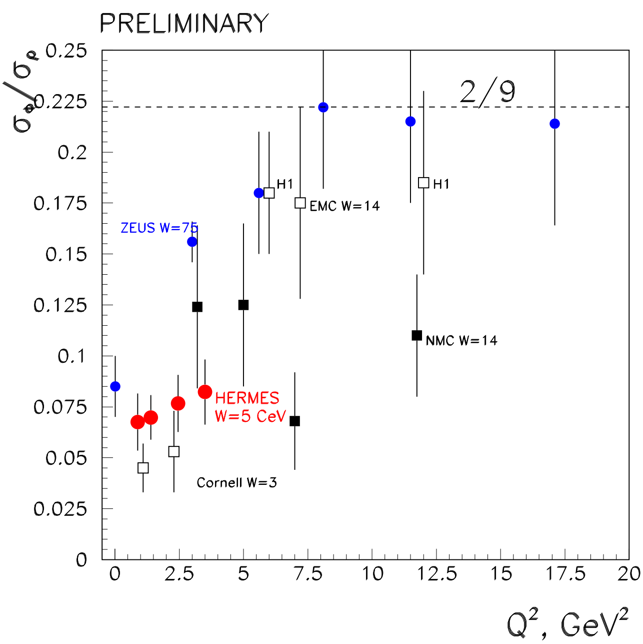

Fig. 2. Production rate of ϕ meson relative to ρ^0 as a function of Q^2

3. Fit of Q^2 dependence

The obtained ratios of the longitudinal to transverse ϕ and ρ^0 production cross sections from the measurements of the spin density matrix elements can be used to determine the Q^2-dependence of the longitudinal and transverse cross sections separately. The Q^2-fits have been done to the same form $\sigma \propto 1/(1+Q^2/M_V^2)^m$ for the total, longitudinal, and transverse components of ϕ and ρ^0 cross sections (see Table I). The observed differences in power of Q^2 between the longitudinal and transverse components required by the fits are in qualitative agreement with the pQCD predictions of Ref. [10].

TABLE I

The parameter m of the fit $\sigma \propto 1/(1+Q^2/M_V^2)^m$ to ϕ and ρ^0 cross sections from HERMES ^{1}H data. Statistical and systematic uncertainties are included in the fitting procedure.

σ	m at HERMES	m at H1, ZEUS
$\sigma_{\mathrm{total}\phi}$	2.70 ± 0.28	2.03 ± 0.05 [8]
$\sigma_{\mathrm{L}\phi}$	2.067 ± 0.275	
$\sigma_{\mathrm{T}\phi}$	3.018 ± 0.344	2.8 ± 0.1 [9]
$\sigma_{\mathrm{total}\rho^0}$	2.49 ± 0.18	2.37 ± 0.10 [9]
$\sigma_{\mathrm{L}\rho^0}$	1.89 ± 0.18	
$\sigma_{\mathrm{T}\rho^0}$	2.72 ± 0.23	2.47 ± 0.03 [9]

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