PROCEEDINGS OF SCIENCE

Inclusive Production of ρ^0, K^{*0} and ϕ Mesons at HERA

Grażyna Nowak*
for the H1 Collaboration,
Henryk Niewodniczański Institute of Nuclear Physics PAN
ul. Radzikowskiego 152, 31-342 Kraków, Poland
E-mail: grazyna.nowak@ifj.edu.pl

The production of $\rho(770)^0$, $K^*(892)^0$ and $\phi(1020)$ mesons is studied in non-diffractive photoproduction processes at HERA using events measured with the H1 detector. The corresponding average γp centre-of-mass energy is 210 GeV. The mesons are reconstructed in the rapidity range $|\, y_{lab} \,| < 1$ and transverse momentum range $0.5 < p_T < 7$ GeV. The differential cross sections are measured as a function of transverse momentum and rapidity. The data are compared to the predictions of hadroproduction models.

European Physical Society Europhysics Conference on High Energy Physics
July 16 - 22, 2009
Kraków, Poland

*Speaker.

PoS(EPS-HEP 2009)063

1. Introduction

The production of hadrons in high energy particle collisions allows to study the hadronisation in different processes and to test the predictions of phenomenological models. The presented studies [1] of light neutral meson production at ep collisions at HERA are compared to measurements at e^+e^- collisions at LEP [2], to pp and Au-Au collisons at RHIC [3] and to the theoretical predictions obtained from hadroproduction models.

2. Phenomenology and Monte Carlo Simulation

The invariant differential cross section of the produced hadrons can be parametrised with a power law distribution, $\frac{1}{\pi}\frac{d^2\sigma^{\gamma p}}{dp_T^2 dy_{lab}} = \frac{A}{(E_{T_0}+E_T^{kin})^n}$, where $E_T^{kin} = \sqrt{m_0^2 + p_T^2} - m_0$ is the transverse kinetic energy, m_0 is the nominal resonance mass, A is a normalisation factor independent of p_T and E_{T_0} a free parameter. The exponential behaviour of the power law function at low E_T^{kin} values follows from a thermodynamic model of hadroproduction [4]. At high E_T^{kin}, the power law originates from perturbative QCD.

Photoproduction processes are simulated using the PYTHIA [5] and PHOJET [6] programs with the implementation of the LUND colour string fragmentation model [7] for hadronisation.

3. Event and Hadron Selection

The data used in this analysis were taken in the 2000 year, in which HERA collided 920 GeV protons with 27.6 GeV positrons at an ep centre-of-mass energy of 319 GeV. The data sample corresponds to an integrated luminosity of 38.5 pb^{-1}.

Photoproduction events are selected by requiring a scattered positron to be measured in the positron tagger. Due to the positron tagger acceptance the photon virtuality Q^2 is smaller than 0.01 GeV^2. Events are accepted if the reconstructed γp centre-of-mass energy lies within the interval $174 < W < 256$ GeV. This corresponds to an average $\langle W \rangle$ of 210 GeV. Additional selection criteria suppress background from elastic and diffractive processes.

The mesons are identified by the kinematic reconstruction of their decays: $\rho(770)^0 \to \pi^+\pi^-$, $K^*(892)^0 \to K^+\pi^-$ or $\overline{K}^*(892)^0 \to K^-\pi^+$ and $\phi(1020) \to K^+K^-$. The transverse momentum and the rapidity of the mesons are required to satisfy $p_T > 0.5$ GeV and $|y_{lab}| < 1$.

To extract the ρ^0, K^{*0} and ϕ signals the distributions of the respective invariant masses (m) of their decay products are fitted using a function defined as $F(m) = S(m) + R(m) + B(m)$, where $S(m)$ corresponds to the contribution from the relevant signal, $R(m)$ represents the sum of reflections and $B(m)$ is a part corresponding to contributions from combinatorical background. The function $S(m)$ is a convolution of the relativistic Breit-Wigner function and the detector resolution. For the ρ^0 meson distortions in the ρ^0 line shape due to Bose-Einstein correlations (BEC) are observed. Similar behaviour is seen at LEP [8] and RHIC [3]. The effects of BEC are included in simulations which then are in agreement with the data in the region of the ρ^0 resonance. The result of fitting the function F to the data is shown in Fig. 1. Clear signals of all three resonances are observed.

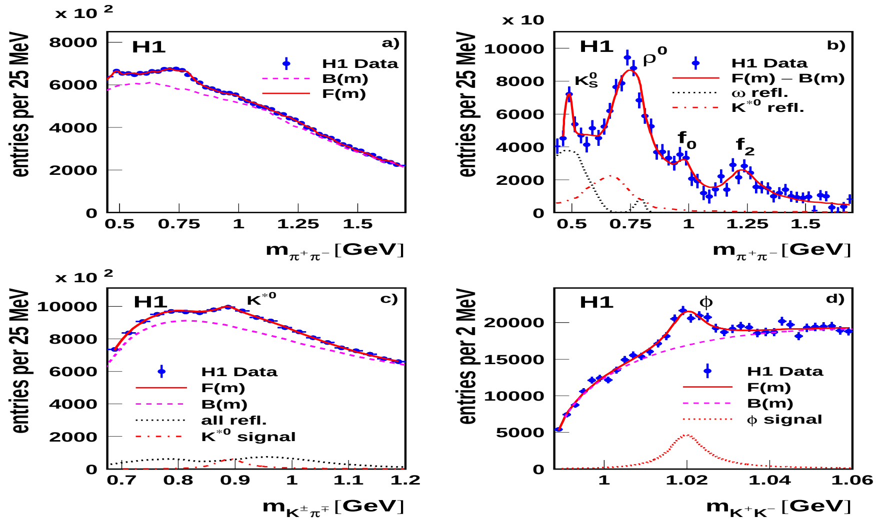

Figure 1: The invariant mass spectra for $\pi^+\pi^-$ in a) and b), for $K^\pm\pi^\mp$ in c) and for K^+K^- in d). The full curves show the result of the fit; the dashed curves correspond to the contribution of the combinatorical background $B(m)$. In b), the data and the fit $F(m)$ are shown after subtraction of the combinatorical background $B(m)$; the dotted and dash-dotted curves show the contributions from reflections. In c), the dotted curve corresponds to the contribution from the reflections and the dash-dotted curve corresponds to the contribution of the K^{*0} signal. In d), the dotted curve corresponds to the contribution of the ϕ signal.

4. Results

The measured differential cross sections for the photoproduction of $\rho^0(770), K^{*0}(892)$ and $\phi(1020)$ mesons are presented in Fig. 2. The transverse momentum spectra, as shown in Fig. 2a, are described by the power law distribution with the value of the power n fixed to be 6.7, as derived from measurements of charged particle spectra by the H1 collaboration [9]. The resonance production rates are constant as a function of rapidity, within errors (Fig. 2b). The PYTHIA and PHOJET models do not describe the shape of the measured p_T spectra (Fig. 2c). Moreover, the Monte Carlo p_T spectra are not described by the power law distribution.

The average transverse energy of the produced mesons derived from the power law parametrisation, $\langle E_T \rangle = \langle E_T^{kin} \rangle + m_0$, is of the same value of about 0.3 GeV for all the resonances. The values of average transverse momentum $\langle p_T \rangle = \sqrt{\langle E_T^2 \rangle - m_0^2}$, presented in Tab. 1, are similar in γp and pp collisions at about the same centre-of-mass energy $\sqrt{s} \approx$200 GeV and are lower than in Au-Au collisions with similar nucleon-nucleon collision energies $\sqrt{s_{NN}} \approx 200$ GeV [3].

All inclusive photoproduction cross sections measured by the H1 collaboration [10] can be described by the power law distribution with the same value of n, as shown in Fig. 3.

The cross-section ratios $R(K^{*0}/\rho^0)$, $R(\phi/\rho^0)$ and $R(\phi/K^{*0})$ are measured in the rapidity interval $\mid y_{lab} \mid <1$ and integrated over the full p_T range. The following values are obtained:

$$R(K^{*0}/\rho^0) = 0.221 \pm 0.036;$$
$$R(\phi/\rho^0) = 0.078 \pm 0.013;$$

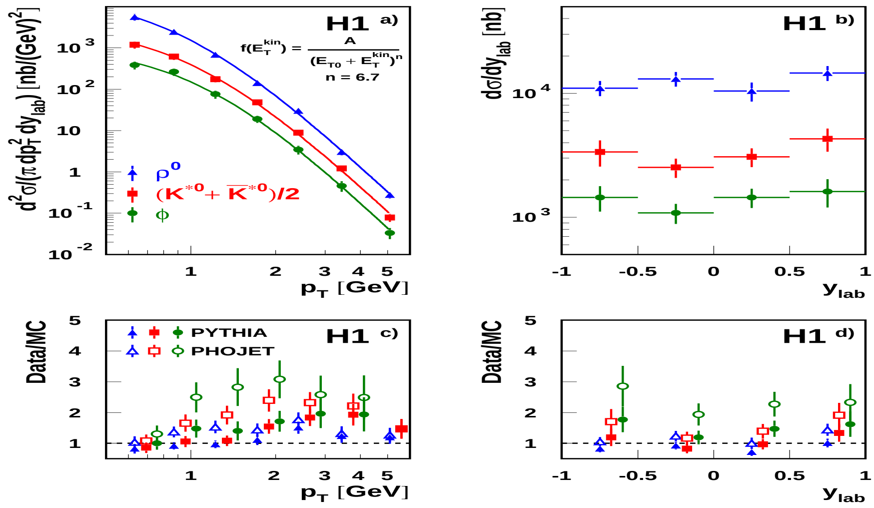

Figure 2: The inclusive differential non-diffractive cross sections for ρ^0, K^{*0} and ϕ mesons measured in *a*) as a function of transverse momentum for $|\, y_{lab}\, |<1$ and in *b*) as a function of rapidity for p_T >0.5 GeV. The curves on the figure *a*) correspond to the power law with n =6.7. The ratios of data to Monte Carlo predictions "Data/MC" are shown for the PYTHIA (full points) and PHOJET (empty points) simulations as a function of transverse momentum for $|\, y_{lab}\, |<1$ in *c*) and as a function of rapidity for p_T >0.5 GeV in *d*). Statistical and systematic errors are added in quadrature.

		ρ^0	K^{*0}	ϕ
γp	$\langle p_T \rangle$ [GeV]	0.726 ± 0.027	0.810 ± 0.030	0.860 ± 0.035
pp	$\langle p_T \rangle_{pp}$ [GeV]	0.616 ± 0.062	0.81 ± 0.14	0.82 ± 0.03
Au-Au	$\langle p_T \rangle_{Au-Au}$ [GeV]	0.83 ± 0.10	1.08 ± 0.14	0.97 ± 0.02

Table 1: The average transverse momentum for ρ^0, K^{*0} and ϕ mesons in γp, pp and Au-Au interactions at nucleon-nucleon centre-of mass-energy of 200 GeV. The errors correspond to the quadratically summed statistical and systematic erros.

$$R(\phi/K^{*0}) \;=\; 0.354 \pm 0.060.$$

The errors are given by the statistical and systematic errors added in quadrature.

The $R(\phi/K^{*0})$ value is similar to the result obtained in pp interactions but is smaller than the value measured in Au-Au collisions at $\sqrt{s_{NN}} \approx$200 GeV [3].

5. Conclusions

First measurements of the inclusive non-diffractive photoproduction of $\rho^0(770), K^{*0}(892)$ and $\phi(1020)$ mesons at HERA are presented. Differential cross sections for the production of these resonances are measured as function of the kinematic variables, p_T and y_{lab}. The resonance production rates are constant as a function of rapidity and can be parametrised by a power law distribution when plotted as a function of transverse momentum. The resonances are produced with about the

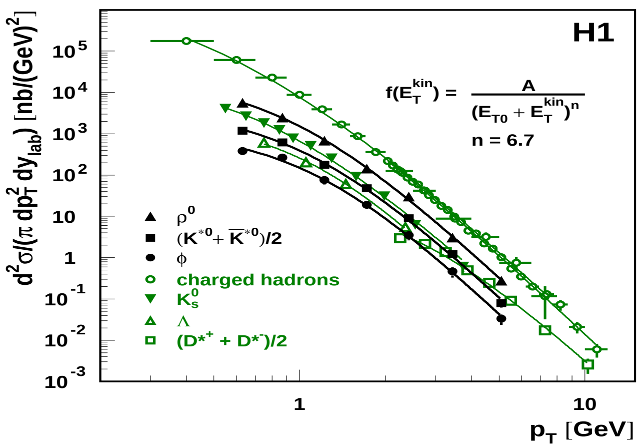

Figure 3: The inclusive invariant differential cross sections as a function of transverse momentum. The curves show the results of fits to the power law. Statistical and systematic errors are added in quadrature.

same value of the average transverse kinetic energy which supports a thermodynamic picture of hadronic interactions.

The distortions of the ρ^0 line shape are described by Monte Carlo simulations with Bose-Einstein correlations. Similar behaviour of the ρ^0 resonance shape is observed in e^+e^- collisions at LEP and pp and heavy-ion collisions at RHIC.

The ratio $R(\phi/K^{*0})$ measured in photoproduction is in agreement with the pp results but is smaller then the value obtained in Au-Au collisions at RHIC.

References

[1] F. D. Aaron *et al.* [H1 Collaboration], Phys. Lett. B **673** (2009) 119 [arXiv:0901.0477 [hep-ex]].

[2] A. Boehrer, Phys. Rept. **291** (1997) 107 and the references therein.

[3] J. Adams *et al.* [STAR Collaboration], Phys. Rev. Lett. **92** (2004) 092301; Phys. Rev. C **71** (2005) 064902; Phys. Lett. B **612** (2005) 181.

[4] R. Hagedorn, Nuovo Cim. Suppl. **3** (1965) 147.

[5] T. Sjöstrand, L. Lönnblad and S. Mrenna, “PYTHIA 6.2 Manual”, arXiv:hep-ph/0108264.

[6] R. Engel, Z. Phys. C **66**, 203 (1995);
R. Engel and J. Ranft, Phys. Rev. D **54**, 4244 (1996), "PHOJET Monte Carlo v.10".

[7] T. Sjöstrand, Comput. Phys. Commun. **82** (1994) 74.

[8] P. D. Acton *et al.* [OPAL Collaboration], Z. Phys. C **56** (1992) 521;
D. Buskulic *et al.* [ALEPH Collaboration], Z. Phys. C **69** (1996) 379.

[9] I. Abt *et al.* [H1 Collaboration], Phys. Lett. B **328** (1994) 176;
C. Adloff *et al.* [H1 Collaboration], Eur. Phys. J. C **10** (1999) 363.

[10] C. Adloff *et al.* [H1 Collaboration], Z. Phys. C **76** (1997) 213;
A. Aktas *et al.* [H1 Collaboration], Eur. Phys. J. C **50** (2007) 251.