Inclusive production of vector mesons in $\pi^+ p$ interactions at 250 GeV/c

EHS-NA22 Collaboration

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Abstract. We report on a study of $\rho^0$, $\rho^+$, $\omega$, $K^{*0}(892)$ and $K^{*+}(892)$ inclusive production in $\pi^+ p$ interactions at 250 GeV/c, for $\rho^+$, $K^{*0}(892)$ and $K^{*+}(892)$ for the first time in a $\pi^+ p$ experiment. The data are compared with $K^+ p$ data in the same experiment, with results of other experiments and with quark-parton models. Interesting differences are found between $\rho^+$ and $\rho^0$ production.

1 Introduction

The study of inclusive resonance production is believed to reveal more directly the primary interaction mechanism of hadron collisions than studies of stable particles.

Resonance analyses have therefore been among the main objectives of this experiment. The experiment (NA22) is performed at the CERN SPS with the European Hybrid Spectrometer (EHS) using the rapid cycling bubble chamber (RCBC) as a vertex detector. The spectrometer is exposed to a tagged, meson enriched positive beam of 250 GeV/c, the highest beam momentum so far reached for positive meson-proton collisions.

Results on inclusive vector meson production in the $K^+ p$ reactions of this experiment have been published in [1–3]. In this paper we report on inclusive vector meson production in the following $\pi^+ p$ reactions:

$\pi^+ p \rightarrow \rho^0 + X$, \hspace{1cm} (1)

$\pi^+ p \rightarrow \rho^+ + X$, \hspace{1cm} (2)

$\pi^+ p \rightarrow \omega + X$, \hspace{1cm} (3)

$\pi^+ p \rightarrow K^{*0}(892) + X$, \hspace{1cm} (4)

$\pi^+ p \rightarrow K^{*+}(892) + X$. \hspace{1cm} (5)

Inclusive production of $\rho^0$ has previously been studied in several $\pi^+ p$ [4–9] and $\pi^- p$ [9–15] experiments. Above 32 GeV/C [6], there is only one $\pi^+ p$ experiment (at 147 GeV/c) [9] with rather limited statistics. Reaction (3) has been studied at 4 GeV/c [16] only. Data on reac-
tions (2), (4) and (5) are obtained for the first time in the present experiment.*

The paper is organized as follows. In Sect. 2 we give a brief description of the experiment. Results on total and topological cross sections, their c.m. energy dependence, and a comparison with other data are described in Sect. 3. Longitudinal and transverse momentum distributions as well as ρ^0 and K*^0(892) decay distributions are presented and compared with other data and with model predictions in Sect. 4. The main conclusions are summarized in Sect. 5.

2 The Experiment

Full details on the experimental set-up of the EHS and on the minimum bias interaction trigger are given in [18]. Charged particle tracks are reconstructed over the full solid angle from measurements in the RCBC and from hits in wire- and drift-chambers of the two lever arm magnetic spectrometer. This is described in detail in [19]. Two gamma detectors are used to measure π^0's in the Feynman-x region x(π^0) ≥ 0.025. This restricts the acceptance for ρ^+ and ω to x ≥ 0.06. With cuts, identical to those used in [1], the final data sample consists of 95,405 inelastic events, corresponding to a sensitivity of 4.57 events/μb.

Total and semi-inclusive cross sections, x, ρ^3 and decay angular distributions of resonances are calculated from fits of the π^+π^−, π^+π^0, π^+π^−π^0, K−π^+ and K^+π^− invariant mass distributions with the expressions

\[ \frac{dσ}{dM} = BG(M)(1 + βBW(M)) \]  

where BW(M) is a relativistic P-wave Breit-Wigner function, and BG(M) a background function parametrized as

\[ BG(M) = α_1(M - M_{th})^2 \exp(-α_3 M - α_4 M^2). \]  

The α1 and β are fit parameters and M_{th} the threshold mass.

All experimental procedures, including experimental resolution effects, use of particle identification information, removal of reflections due to particle misidentification etc., are identical to those described in our study of vector mesons in K+p interactions [1]. More specifically, mutual reflections of ρ^0, K*^0(892) and K*^+ are taken into account via the iteration procedure described there. For illustration, we show in Fig. 1 the π^+π^−, π^+π^0, π^+π^−π^0, K−π^+ and K^+π^− invariant mass distributions in the x-intervals indicated; the superimposed curves are best fits with expression (6).

3 Total and semi-inclusive cross sections

The published data on ρ^0 and K*^0(892) inclusive cross sections and average multiplicities per inelastic collision in π^±p interactions are collected in Table 1. The energy dependence of the average K*^0(892) multiplicity (Fig. 2) shows a continuous rise with energy, well described by the form

\[ \langle n(res) \rangle = a + b \log(s/s_0), \]  

with s_0 = 1 GeV^2. The fitted values of the parameters are given in Table 2*. Figure 2 further shows the s-dependence of \langle n(K*^0(892)) \rangle for the reactions

\[ K^+ p → K*^0(892) + X, \]  

\[ K^- p → K*^+ + X. \]  

* The K*^0(892) cross section in π^±p interactions at 147 GeV/c [20] appears to be inconsistent with other results and is not used in the fit, as well as the K*^0(892) cross sections in π^±p interactions at 6 GeV/c [21], where the threshold effects still play a rôle. Including these points in the fit, we find b = 0.031 ± 0.002(χ^2/NDF = 57/8)