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INCLUSIVE ρ^0 PRODUCTION IN $\bar{p}p$ INTERACTIONS AT 22.4 GeV/c

Alma-Ata – Dubna – Helsinki – Košice – Moscow – Prague

Collaboration

1978

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Инклюзивное образование ρ^0-мезонов в $\bar{p}p$-взаимодействиях при 22,4 ГэВ/с

В работе изучается инклюзивное образование ρ^0-мезона в $\bar{p}p$-взаимодействиях при 22,4 ГэВ/с. Полное сечение и среднее число ρ^0-мезонов на событие равны 8,1 $\pm$2,0 мбн и 0,17$\pm$0,03 соответственно. Средний поперечный импульс, полученный при подгонке $p\frac{d}{T}$-распределения одной экспонентой, равен $\langle p_T \rangle$ = 0,52$\pm$0,12 ГэВ/с. Распределения по быстроте и по фейнмановской переменной x показывают, что ρ^0-мезон образуется преимущественно в центральной области.

Работа выполнена в Лаборатории высоких энергий ОИЯИ.

Препринт Объединенного института ядерных исследований. Дубна 1978

Ermilova D.I. et al. E1 – 11190

Inclusive ρ^0 Production in $\bar{p}p$ Interactions at 22.4 GeV/c

Inclusive ρ^0 production has been investigated in $\bar{p}p$ reactions at 22.4 GeV/c. The total cross section for ρ^0 production is 8.1$\pm$ 2.0 mb. The average number of ρ^0's per event is 0.17$\pm$0.03. The average transverse momentum, as obtained by extrapolation of a simple exponential to the $p\frac{d}{T}$ distribution, is 0.52$\pm$0.12 GeV. The Feynman x and center of mass rapidity distributions show ρ^0 to be "centrally" produced.

The investigation has been performed at the Laboratory of High Energy, JINR.

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E1 – 11190

INCLUSIVE ρ^0 PRODUCTION IN $\bar{p}p$ INTERACTIONS AT 22.4 GeV/c

Alma-Ata – Dubna – Helsinki – Košice – Moscow – Prague Collaboration*

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Inclusive ρ^0 production has been recently studied in a number of reactions [1-6]. In this work an analysis has been made of ρ^0 production in $\bar{p}p$ interactions at 22.4 GeV/c, with emphasis on the inclusive and semi-inclusive cross sections and on the transverse momentum distribution.

About 11400 inelastic events were used in this analysis. Experimental details have been given elsewhere [7]. For the purpose of kinematical calculations all outgoing particles were taken as pions, except those identified by ionization as protons. The contamination of unidentified protons and kaons in the ρ^0 spectra is assumed to be negligible. That the $(\bar{p}\pi^+)$ combinations, where $\bar{p}$ is taken as π^-, do not affect our ρ^0 distributions was tested from the forward-backward symmetry of the center of mass rapidity and x distributions. In these spectra we could expect an increasing influence of the antiprotons with increasing x or y^*.

The expression

$$f = \frac{(1-\beta)\phi_1}{I_1} + \frac{\beta \cdot BW \cdot \phi_2}{I_2} \qquad (1)$$

was fitted to the $(\pi^+\pi^-)$ mass distribution in a region of 0.6 GeV $< M(\pi^+\pi^-) <$ 1 GeV. Here β is a free parameter and $I_{1,2}$ are normalization integrals. The BW term in eq. (1) is the usual P-wave Breit-Wigner. The background ϕ_1 is assumed to have the same behaviour as the phase space term ϕ_2

$$\phi_1 \sim \phi_2 \sim e^{a M(\pi^+\pi^-)}, \qquad (2)$$

where a is a free parameter.

It was found that this simple form of background was quite sufficient to describe the mass spectrum ($\chi^2/ND = 7/5$). Also more complicated expressions for $\phi_{1,2}$ were tried, but they were found to be statistically not needed as χ^2/ND did not improve. We also tried different intervals for the fit and checked that the ρ° production cross section was unaffected by the choice of the region. An attempt was made to take into account the reflection of ω-production into the $(\pi^+\pi^-)$spectrum using the technique developed by Angelov et al.[6] However, our present statistics was evidently not large enough to allow this effect to be separated due to strong correlations with ϕ_1. We tried to substitute ϕ_1 by the spectra for like pion pairs but found that the probability of fitting decreased drastically. This took place also outside the region where the reflection of ω occurred.

The different inclusive ρ° spectra were obtained by fitting, for each bin, expression (1) to the corresponding $(\pi^+\pi^-)$ mass distribution. The ρ° mass was kept as a free parameter and the width was fixed at a table value of 0.150 GeV.

In the table we show the topological cross sections for ρ° production. We note that a considerable amount of ρ°'s is produced at high multiplicities. This fact is in contradiction to what has been found in non-annihilation processes[4]. Summing the topological cross sections, we get for the total cross section $\sigma(\rho^\circ) = 7.7 \pm 1.5$ mb. Fitting the total inclusive mass distribution (fig.1), we get the cross section $\sigma(\rho^\circ) = 8.1 \pm 2.0$mb. In fig.2 the inclusive ρ° cross section is shown as a function of beam momentum for pp, $\bar{p}p$ and $\pi^\pm p$ interactions [1-5]. The medium and high energy data are all consistent with

Table

ρ^0 Production Parameters

Prongs	σ(mb)	$\langle N(\rho^0)\rangle$/event	$\langle N(\rho^0)\rangle / \langle N(\pi^+)\rangle$
2	0.2 ± 0.1	0.02 ± 0.01	0.03 ± 0.02
4	1.2 ± 0.5	0.08 ± 0.04	0.04 ± 0.02
6	2.5 ± 1.2	0.26 ± 0.13	0.09 ± 0.05
8	2.6 ± 0.5	0.61 ± 0.12	0.15 ± 0.03
10	0.9 ± 0.5	0.63 ± 0.35	0.12 ± 0.07
12	0.3 ± 0.3	1.25 ± 1.25	0.21 ± 0.21
Total	7.7 ± 1.5	0.17 ± 0.03	0.09 ± 0.02

a P_{lab} logarithmic rise. According to the quark fusion model, the total ρ^0-cross section for our data is ~ 7.5 mb /8/ which is in agreement with our results. In calculating this number, the total normalization was fixed from pp and π^-p ρ^0-production data. The mass of the ρ^0 meson was found to be $M_0 = 747 \pm 11$ MeV, considerably smaller than that found in purely non-annihilation processes. However, it is a well-known experimental fact /9/ that the mass of ρ^0 in annihilation processes is essentially lower than the table value. As our study includes both processes, our ρ^0 resonance form will be probably not seen as a pure Breit-Wigner. However, our present statistics does not allow a more detailed investigation.

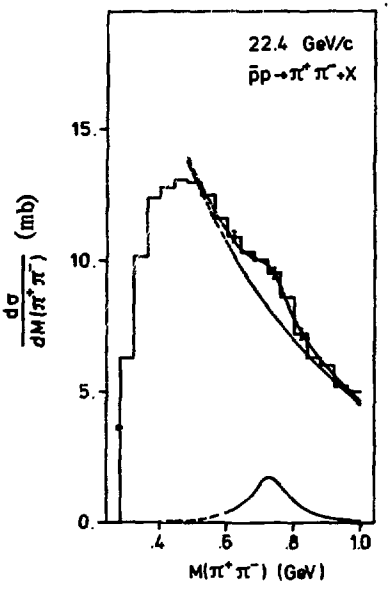

Fig. 1. $(\pi^+\pi^-)$ mass distribution. The curves show the best fit to the data (eq.(1)).

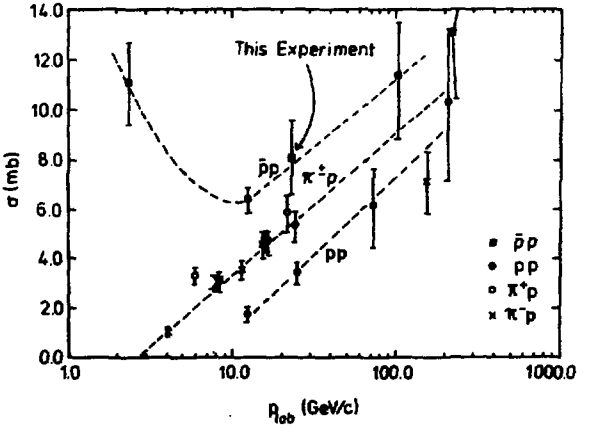

Fig. 2. $\rho^0(770)$ production cross section as a function of P_{lab} in different experiments.

In the table we also give the average number of ρ^0's per event for different topologies. This ratio increases with increasing multiplicity. The Webber annihilation model[10] predicts the ratio to be ~0.6 in annihilation processes at medium energies. This number agrees with our results for 8 and 10 prongs where annihilation is expected to be a dominant process. The ratio of ρ^0's to positive pions is given in this table as well. Also this number turns out to increase with multiplicity, but slower.

The p_T^2 distribution for ρ^0 is shown in fig.3. The slope, as obtained by fitting a simple exponential, is 2.9 ± 0.7 $(GeV/c)^{-2}$. Extrapolating this slope towards high p_T^2, we calculate the average transverse momentum, $\langle p_T \rangle = 0.52 \pm 0.12$ GeV, and the average transverse momentum squared, $\langle p_T^2 \rangle = 0.34 \pm 0.08$ GeV^2.

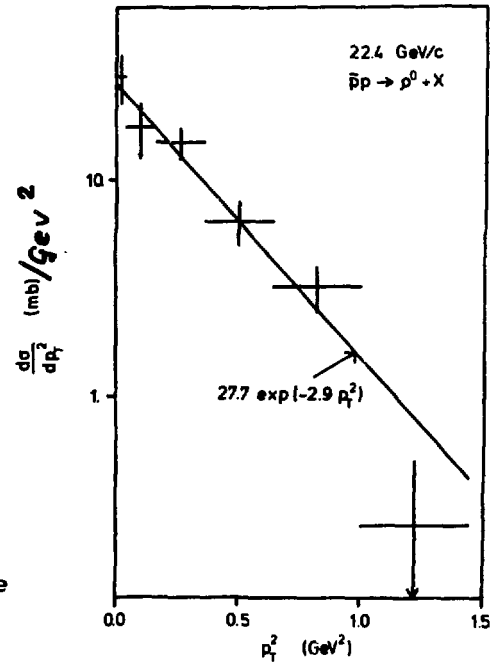

Fig.3. Transverse momentum squared distribution.

In figs.4 and 5 we show the Feynman x and center of mass rapidity distributions for ρ^0's, which suggest an essentially "central" production of ρ^0's. The average longitudinal momentum is $\langle|p_L^*|\rangle = 0.84 \pm 0.21$ GeV. A comparison with the reaction $pp \to \rho^0 + X$ at 24 GeV/c indicates that ρ^0's in our reaction are produced with higher average longitudinal momentum. The rapidity distributions for the $\bar{p}p$ reaction at 100 GeV/c and the pp reaction at 24 GeV/c are also shown in fig.5. We notice that our data points lie lower than the $\bar{p}p$ data at 100 GeV/c, but considerably higher than the pp data.

In fig.6. we show the distributions of the cosine of the polar angle and the azimuthal angle in the s- and t-channel frames for ρ^0. The deviation of the $\cos\Theta_t$-distribution (see fig.6d) from the isotropic distribution indicates a possible alignment of

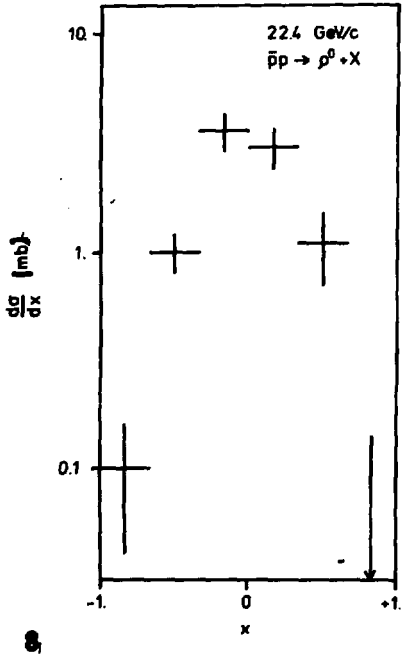

Fig.4. Feynman x distribution.

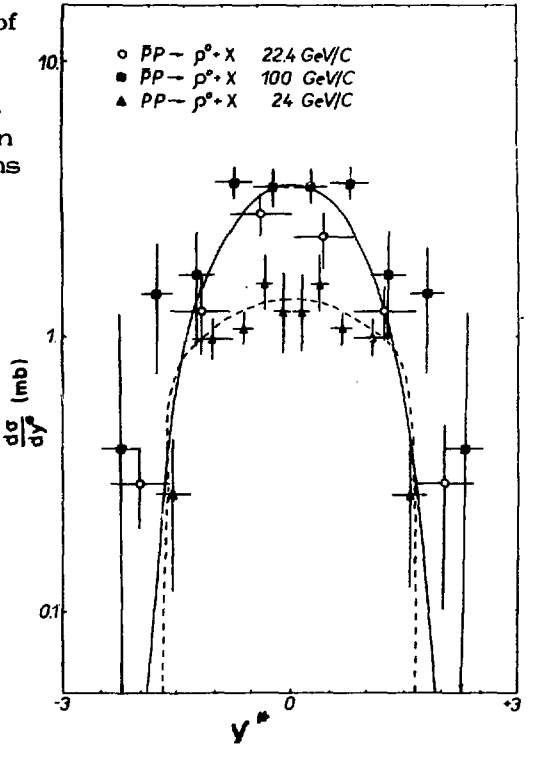

Fig. 5. Center of mass rapidity distribution. The curves are the quark fusion model predictions from /8/.

the ρ^0 spin along the z_t-axis. In fact, this distribution yields the value $\rho_{11}^{all} = 0.44 \pm 0.05$, which is by two standard deviations larger than the value 1/3 in the case of isotropy. Considering only two- and four-prong events, we get $\rho_{11}^{2,4p} = 0.26 \pm 0.13$. In the s-channel the corresponding values are $\rho_{11}^{all} = 0.33 \pm 0.05$ and $\rho_{11}^{2,4p} = 0.34 \pm 0.13$.

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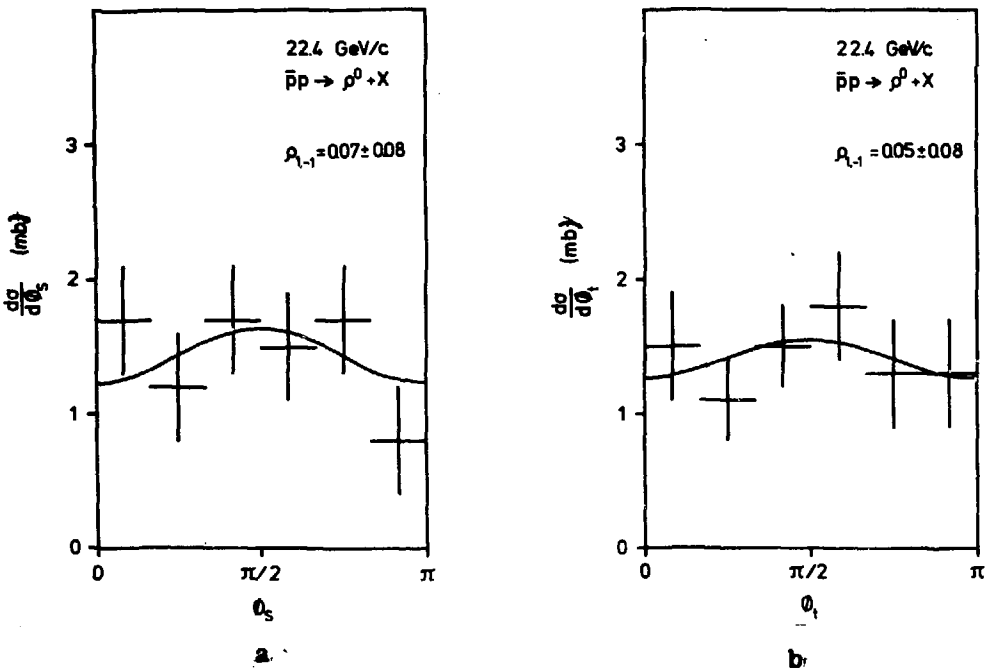
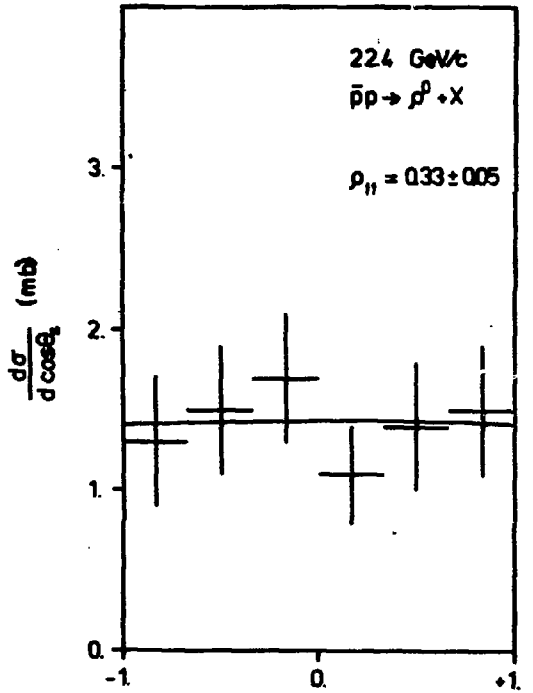
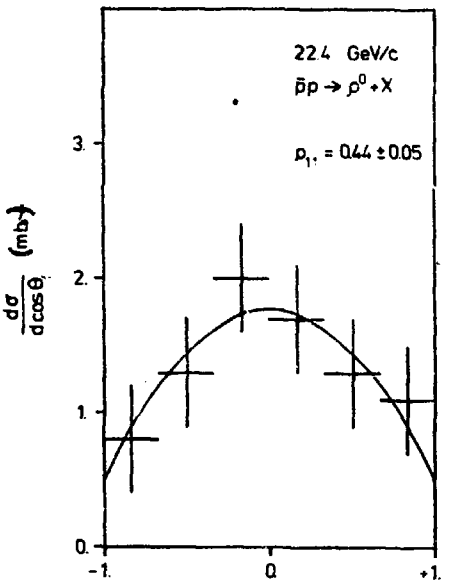
Fig.6. Distributions of the azimuthal and the cosine of the polar angle in the s- and t-channel frames.




22.4 GeV/c
$\bar{p}p \to \rho^0 + X$
$\rho_{11} = 0.33 \pm 0.05$
$\frac{d\sigma}{d\cos\theta_s}$ (mb)
3.
2.
1.
0.
-1.
0.
+1.
$\cos\theta_s$

c


22.4 GeV/c
$\bar{p}p \to \rho^0 + X$
$\rho_{1,-1} = 0.44 \pm 0.05$
$\frac{d\sigma}{d\cos\theta_t}$ (mb)
3.
2.
1.
0.
-1.
0
+1.
$\cos\theta_t$

d

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