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E1 - 11190

# INCLUSIVE $\rho^{\circ}$ PRODUCTION IN $\bar{p}p$ INTERACTIONS AT 22.4 GeV/c

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

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Inclusive $\rho^\circ$ production has been recently studied in a number of reactions /1-6/ . In this work an analysis has been made of $\rho^\circ$ 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 $\rho^\circ$ spectra is assumed to be negligible. That the $(\bar{p}\pi^+)$ combinations, where $\bar{p}$ is taken as $\pi^-$, do not affect our $\rho^\circ$ 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 $\beta$ 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 $\phi_1$ is assumed to have the same behaviour as the phase space term $\phi_2$

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

where $\alpha$ 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 $\chi^2/ND$ did not improve. We also tried different intervals for the fit and checked that the $\rho^\circ$ production cross section was unaffected by the choice of the region. An attempt was made to take into account the reflection of $\omega$-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 $\phi_1$. We tried to substitute $\phi_1$ 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 $\omega$ occurred.

The different inclusive $\rho^\circ$ spectra were obtained by fitting, for each bin, expression (1) to the corresponding $(\pi^+\pi^-)$ mass distribution. The $\rho^\circ$ 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 $\rho^\circ$ production. We note that a considerable amount of $\rho^\circ$'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 $\rho^\circ$ 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

$\rho^\circ$ Production Parameters

| Prongs | $\sigma$(mb) | $\langle N(\rho^\circ)\rangle$/event | $\langle N(\rho^\circ)\rangle / \langle N(\pi^+)\rangle$ |
|---|---|---|---|
| 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 $\rho^\circ$-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 $\pi p$ $\rho^\circ$-production data. The mass of the $\rho^\circ$ 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 $\rho^\circ$ in annihilation processes is essentially lower than the table value. As our study includes both processes, our $\rho^\circ$ resonance form will be probably not seen as a pure Breit-Wigner. However, our present statistics does not allow a more detailed investigation.

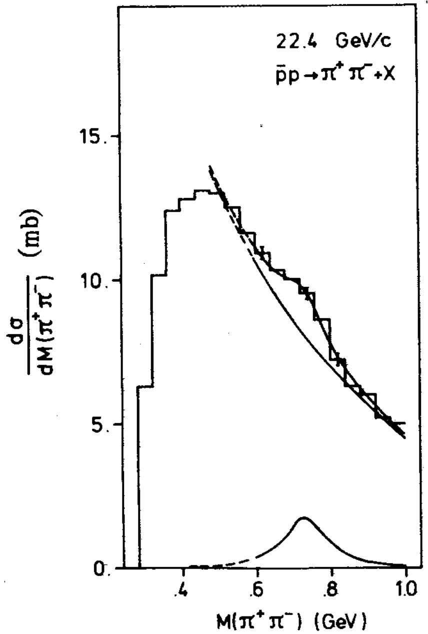



Fig. 1. $(\pi^+\pi^-)$ mass distribution. The curves show the best fit to the data (eq.(1)).

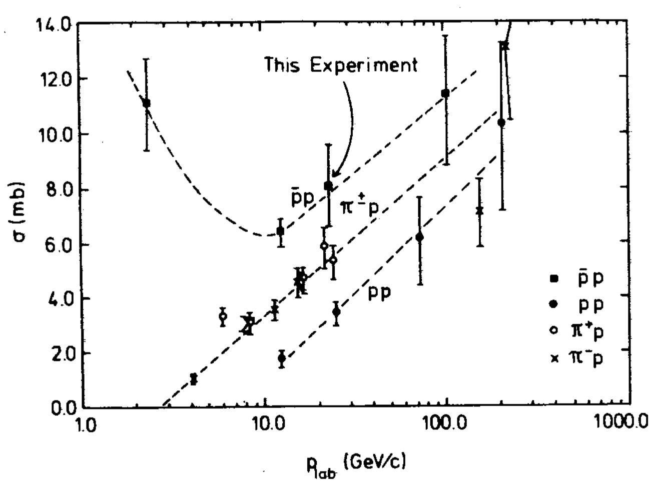



Fig. 2. $\rho^0(770)$ production cross section as a function of $P_{lab}$ in different experiments.



In the table we also give the average number of $\rho^0$'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 $\rho^0$'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 $\rho^0$ is shown in fig.3. The slope, as obtained by fitting a simple exponential, is $2.9 \pm 0.7$ $(GeV/c)^{-2}$. 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$^2$.

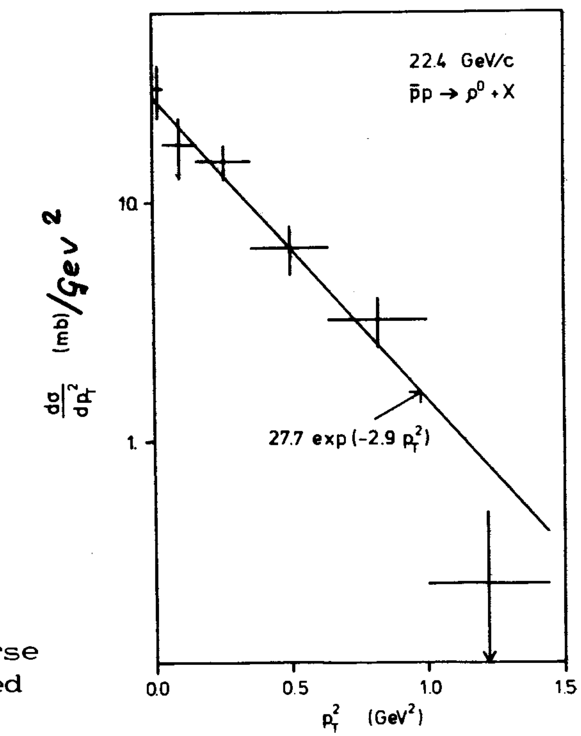



Fig.3. Transverse momentum squared distribution.

In figs.4 and 5 we show the Feynman x and center of mass rapidity distributions for $\rho^o$'s, which suggest an essentially "central" production of $\rho^o$'s. The average longitudinal momentum is $\langle|p_L^*|\rangle = 0.84 \pm 0.21$ GeV. A comparison with the reaction $pp \to \rho^o + X$ at 24 GeV/c indicates that $\rho^o$'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 $\rho^o$. The deviation of the $\cos\Theta_t$-distribution (see fig.6d) from the isotropic distribution indicates a possible alignment of

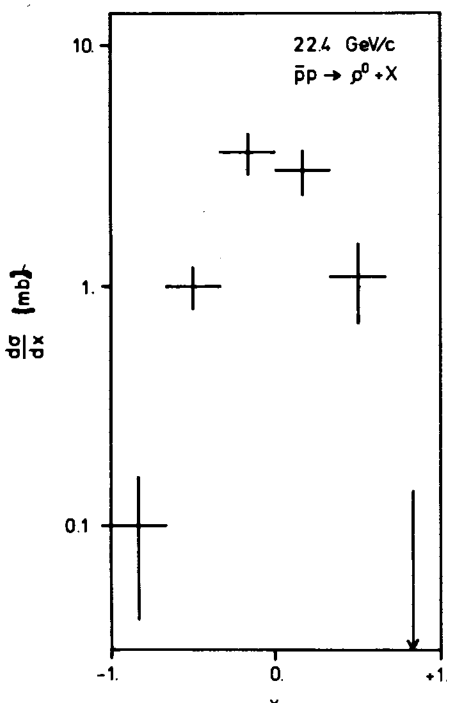
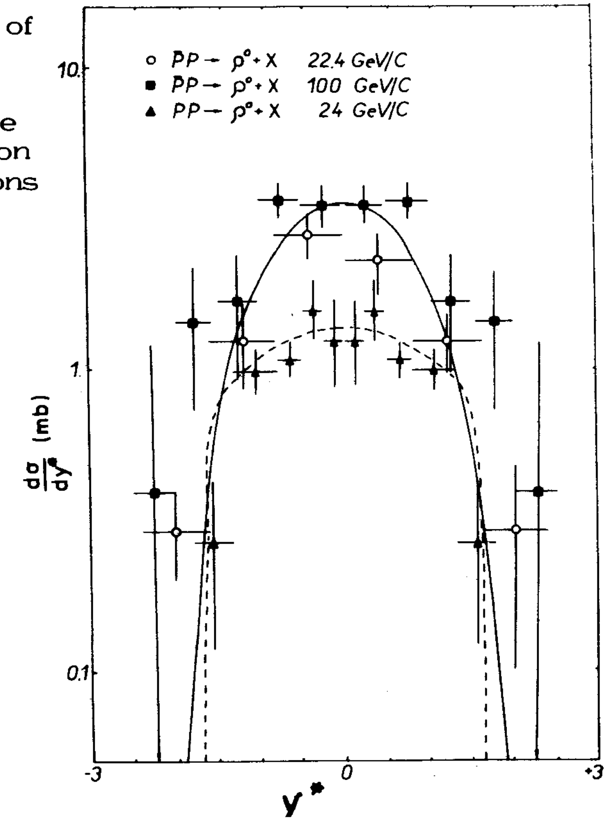



Fig.4. Feynman x distribution.



Fig.5. Center of mass rapidity distribution.

The curves are the quark fusion model predictions from /8/.




the $\rho^o$ 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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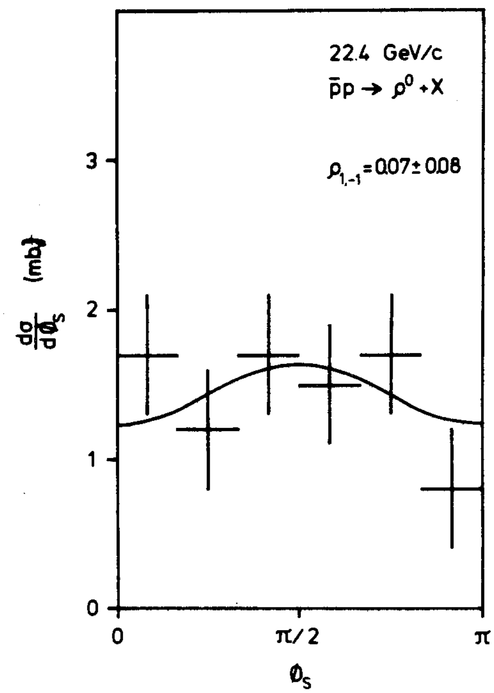
Fig. 6. Distributions of the azimuthal and the cosine of the polar angle in the s- and t-channel frames.

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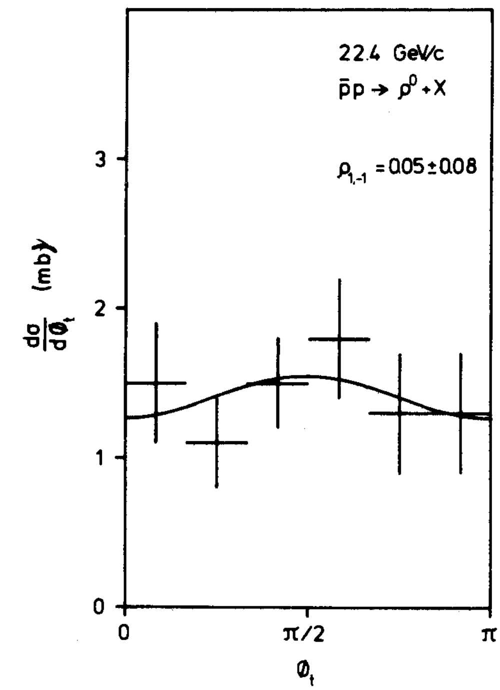


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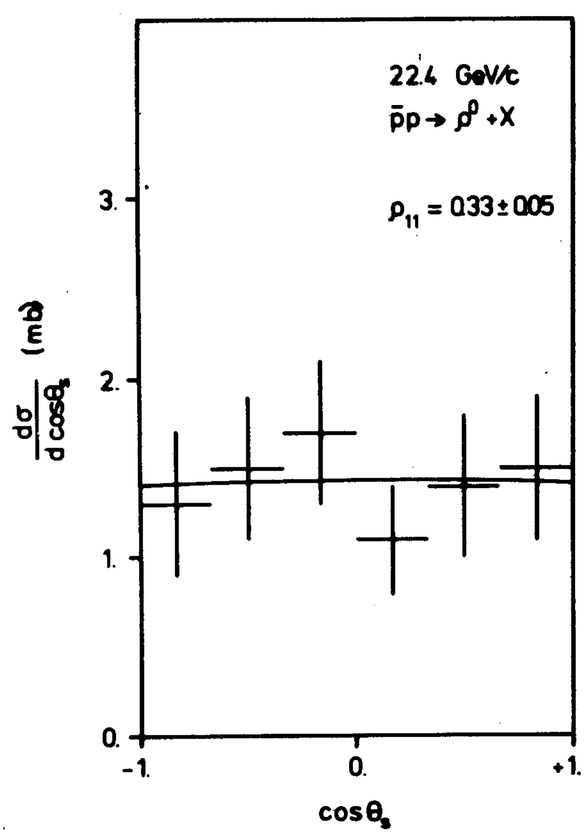


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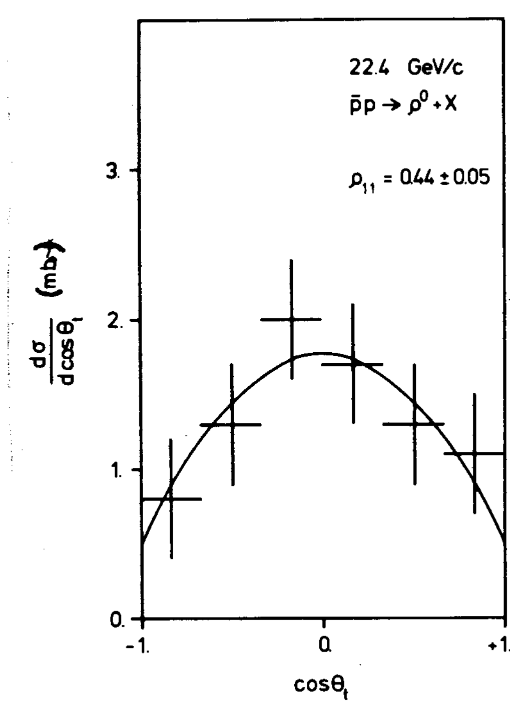


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