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SOME ASPECTS OF SEMI-INCLUSIVE REACTIONS IN FOUR-PRONG π^-p INTERACTIONS AT 5 GEV/C

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Некоторые аспекты полуинклюзивных реакций в четырехлучевых взаимодействиях при 5 ГэВ/с

В работе изучены некоторые феноменологические аспекты полуинклюзивных реакций при 5 ГэВ/с

$$\pi^- p \to \pi^\pm + 3 \text{ зар. частицы} + X^\circ$$
$$\to \rho^\circ + 2 \text{ зар. частицы} + X^\circ$$
$$\to \Delta^{++} + 2 \text{ зар. частицы} + X^\circ$$
$$\to p + 3 \text{ зар. частицы} + X^\circ.$$

Изучено распределение быстрот, поведение инвариантной функции F_s, двухчастичные корреляции по быстроте.

Сообщение Объединенного института ядерных исследований
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Lebedev R.M., Glagolev V.V., Cotorobai F., Besliu C. et al. **E1 - 7923**

Some Aspects of Semi-inclusive Reactions in Four-Prong $\pi^- p$ Interactions at 5 GeV/c

In this paper we present some phenomenological aspects of the following semi-inclusive reactions at 5 GeV/c:

$$\pi^- p \to \pi^\pm + 3 \text{ charged particles} + X^\circ$$
$$\to \rho^\circ + 2 \text{ charged particles} + X^\circ$$
$$\to \Delta^{++} + 2 \text{ charged particles} + X^\circ$$
$$\to p + 3 \text{ charged particles} + X^\circ$$

The rapidity distribution, the behaviour of the function F_s and two-particle rapidity correlations have been studied.

Communications of the Joint Institute for Nuclear Research.
Dubna, 1974

Last years inclusive and semi-inclusive reactions were intensively studied. Quite a number of papers concerning inclusive reactions have been published to date whereas the information on semi-inclusive reactions in the literature is insufficient /1,2/. In this paper we present some phenomenological aspects of the following semi-inclusive reactions

$$\pi^- p \to \begin{cases} \pi^\pm + X^\circ + 3 \text{ charged particles} \\ \rho^\circ + X^\circ + 2 \text{ -''- -''-} \\ \Delta^{++} + X^\circ + 2 \text{ -''- -''-} \\ p + X^\circ + 3 \text{ -''- -''-} \end{cases}$$

(X° are any neutral particles).

It is interesting to study, in addition to general distributions, some dynamic characteristics of this type reactions.

Here we present the results obtained in an analysis of about 15 thousand four-prong events without strange particles. The semi-inclusive distributions for particles and resonances are presented in the first part of this paper. In the second part we present some data on two-particle rapidity correlations. Table 1 shows the used variables and their distributions.

1. Semi-Inclusive Distributions

The rapidity distributions for positively and negatively charged pions and for protons are shown in fig. 1. These distributions are similar for pions. The maxima of distributions for negatively charged pions and protons are shifted in opposite directions with respect to that for positively charged pions.

Figure 2 presents the invariant function $F_s(x, p_\perp^2, s)$ for the same particles integrated over all the values of the transverse momentum squared. For negatively charged pions one can observe a marked asymmetry in the region $|x| \approx 0.7 \div 1$. A large asymmetry is observed for protons as well. This effect is probably due to the presence of the pion and proton that have the properties of leading particles among secondary particles.

It is convenient to observe the diffraction effect if the invariant function F_s is analysed in different intervals of the transverse momentum squared. One can see from figs. 3 and 4 that for negatively charged pions and protons the leading effect becomes maximum for the least values of the transverse momentum squared ($p_\perp^2 = 0 \div 0.06$ GeV^2/c^2) and disappears at $p_\perp^2 \geq 0.39$ GeV/c^2. For posi. ely charged pions (fig. 5) the dependence of the function F_s on the transverse momentum squared is not observed. Such a behaviour can be explained by the production of negatively charged pions and protons in the diffraction process /1/. A similar result has been obtained in the inclusive reactions $\pi^- p \to \pi^- +$ anything at 16 GeV/c /3/ and 21 GeV/ /4/.

Figure 6 and 7 show the semi-inclusive distributions we plot for the ρ° and Δ^{++} resonances. One can note that the distributions for negatively charged pions and ρ°-mesons as well as for protons and Δ^{++} are correspondingly similar.

A study of the behaviour of semi-inclusive distributions for the missing mass is an additional source of information. Figures 8 and 9 present the reduced rapidity and function F_s for the missing mass X°. The rapidity distributions for protons (fig. 1) do not differ significantly from those for X° (fig. 8) whereas a sharp asymmetry is observed in the distribution of the invariant function F_s for protons (fig. 2), and F_s for X° (fig. 9) is practically symmetric. In addition, the function F_s for the missing mass X° does not depend markedly on cuts in the transverse momentum squared. This property is probably due to the nondiffractive production of X°. Investigating the influence of the missing mass on the distributions for single particles, we have plotted them for the following three intervals of the missing mass: ($0 \div 0.5$; $0.5 \div 1.1$; $1 \div 1.5$) -GeV (figs. 10-15). The distribution for the invariant function of the proton shows that the diffractive character of the interaction disappears with increasing the missing mass.

2. Two-Particle Rapidity Correlations

A study of two-particle rapidity distributions and the behaviour of the correlation function $C(y_i, y_j)$ as a function of rapidities gives new data on the interaction dynamics. One of the important problems is to obtain information on the cluster production in the processes of particle generation. Figures 16 and 17 present two-particle rapidity distributions for different pairs of particles. These curves are similar to the Gaussian distribution. Similar results have been obtained at higher energies in $\pi^- p$ interactions at 18 and 40 GeV/c. One can see from fig. 17 that $\frac{\partial^2 \sigma}{\partial y_i \partial y_j}$ is more narrow for $\pi^+ p$ pairs with the effective masses inside the Δ^{++} resonance region than for the same $\pi^+ p$ pairs without effective mass cut. This is an evidence of the production of $\pi^+ p$ clusters which agrees with a strong production of the Δ^{++} resonance observed in the effective mass spectrum of $\pi^+ p$ pairs /5/. One can arrive at a similar conclusion studying the correlation function $C(y_1, y_2)$

$$C(y_1, y_2) = \frac{1}{\sigma} \frac{\partial^2 \sigma}{\partial y_1 \partial y_2} - \frac{1}{\sigma^2} \frac{\partial \sigma}{\partial y_1} \frac{\partial \sigma}{\partial y_2}.$$

This function takes a completely different form depending on the fact whether it is calculated for all $\pi^+\pi^-$ and $\pi^+ p$ pairs or only for the pairs with the effective masses corresponding to the ρ° and Δ^{++} resonances (figs. 18, 19).

The behaviour of the correlation function for the events generated by the Monte-Carlo method makes it possible to consider the effect observed in the experiment to be mainly related to the ρ° and Δ^{++} production. It is possible that such a behaviour of the correlation function enables somebody to detect the presence of resonances under unfavourable background conditions in effective mass distributions.

The authors are grateful to their colleagues from the Institute of High Energy Physics in Berlin for their help in this work and also to Prof. K.Lanius for useful discussions.

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Table 1

y_i	RAPIDITY	$y_i = \frac{1}{2} \mathrm{Log}(P_L^i + E_i^*)/(P_L^i - E_i^*)$ P_L^i LONGITUDINAL MOMENTUM, E_i^* ENERGY } C.M.S
ζ	REDUCED RAPIDITY	$\zeta_i = (y_i^* - y_B^*)/(y_A^* - y_B^*)$ y_B^* RAPIDITY FOR TAPGET y_A^* BEAM
F_s	INVARIANT FUNCTION OF x	$F_s = \frac{2E^*}{\pi\sqrt{s}} \partial^2\sigma/\partial p_\perp^2 \partial x$ $x = 2 P_L/\sqrt{s}$ s - SQUARED TOTAL ENERGY $p_\perp$ - TRANSVERS MOMENTUM
$C(y_i,y_j)$	CORRELATION FUNCTION	$C(y_i,y_j) = \frac{1}{\sigma_t} \frac{\partial^2\sigma}{\partial y_i \partial y_j} - \frac{1}{\sigma_t^2}\left(\frac{\partial\sigma}{\partial y_i}\right)\left(\frac{\partial\sigma}{\partial y_j}\right)$ σ_t - TOTAL S.I. CROSS-SECTION

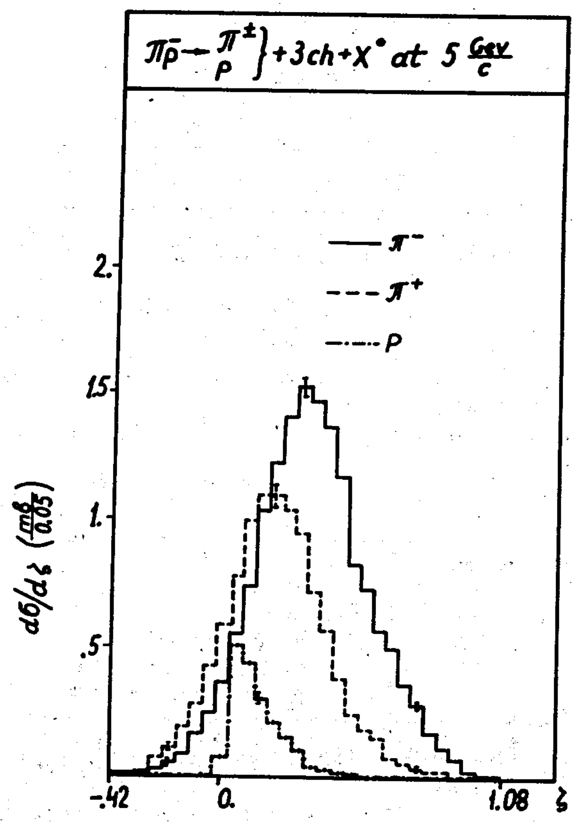

Fig. 1. Rapidity distributions for π^+, π^- and p .

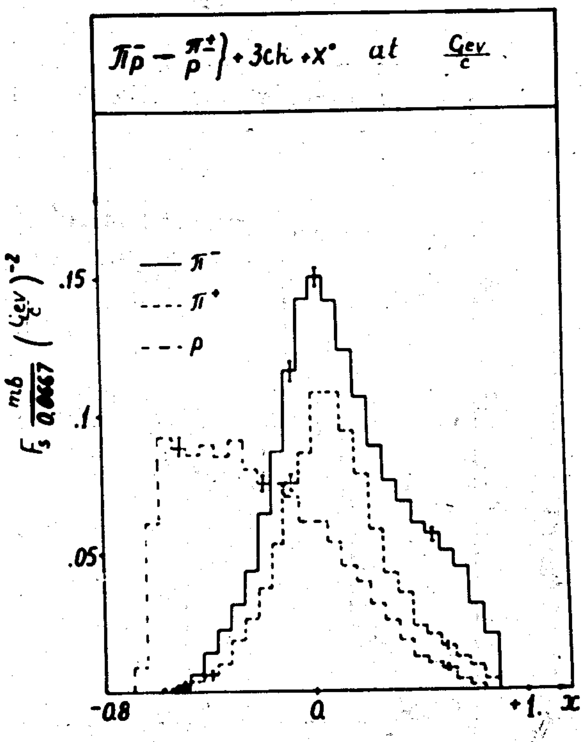

Fig. 2. Distributions of the invariant function F_s versus x for all values of the transverse momentum squared for π^+, π^- and p .

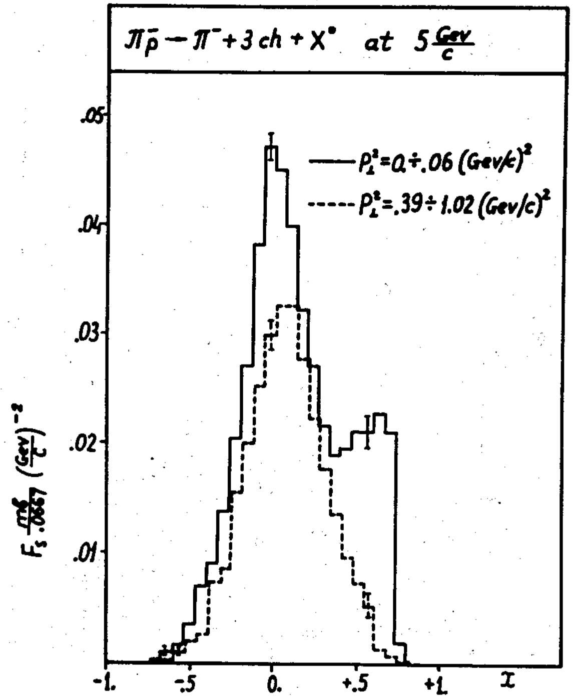

Fig. 3. Distributions of the invariant function F_s versus x for π^- -mesons in two intervals of the transverse momentum squared.

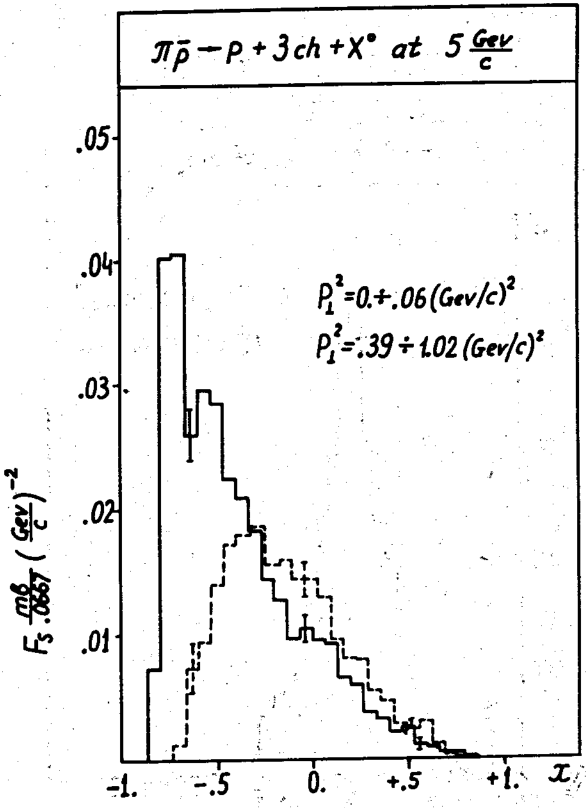

Fig. 4. Distributions of the invariant function F_s versus x for protons in two intervals of the transverse momentum squared.

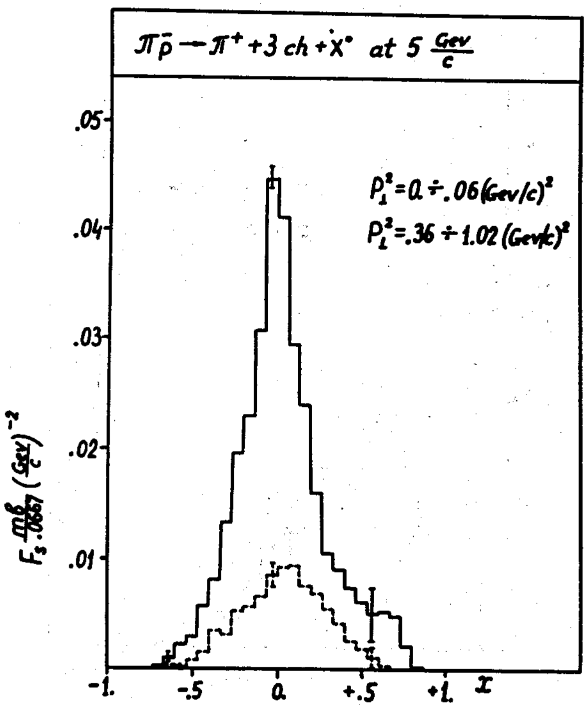

Fig. 5. Distributions of the invariant function F_s versus x for π^+-mesons in two intervals of the transverse momentum squared.

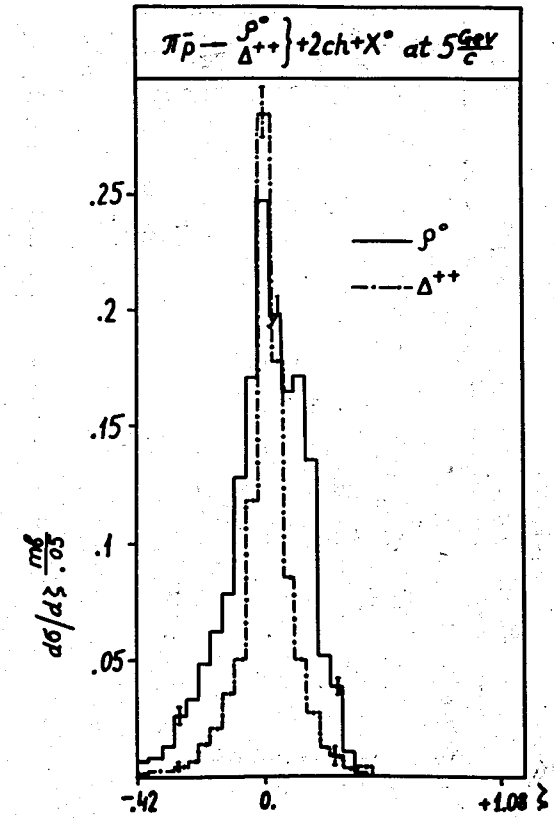

Fig. 6 a). Rapidity distributions for ρ° and Δ^{++}.

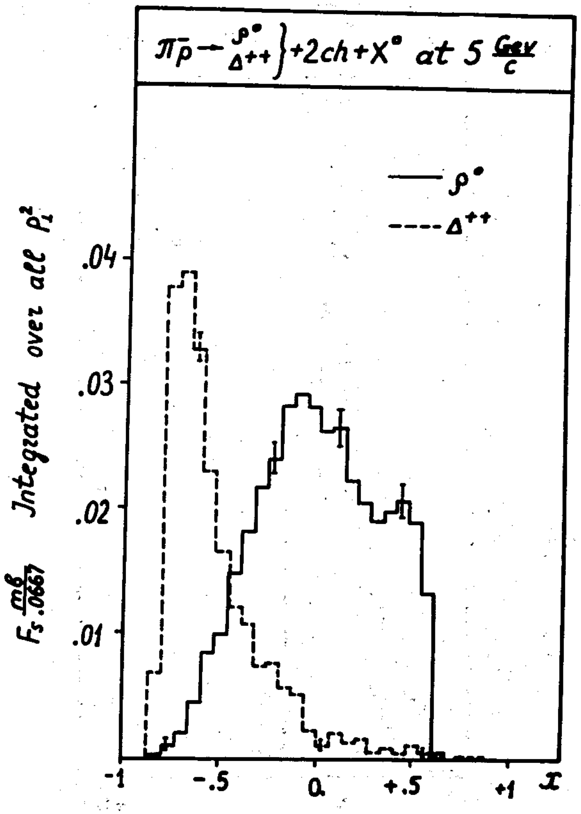

Fig. 6b). Distribution of the invariant function F_s versus x for ρ° and Δ^{++} .

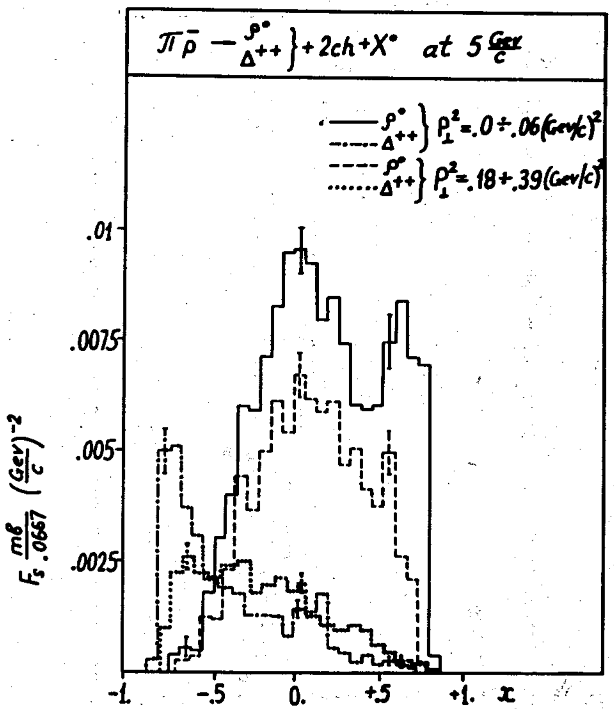

Fig. 7. Distributions of the invariant function F_s versus x for ρ° and Δ^{++} in two intervals of the transverse momentum squared.

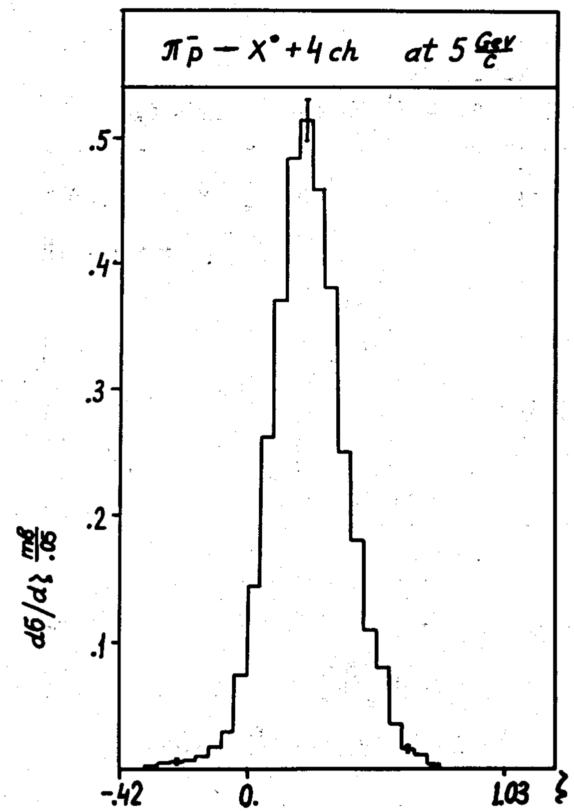

Fig. 8. Rapidity distribution for the missing mass X° .

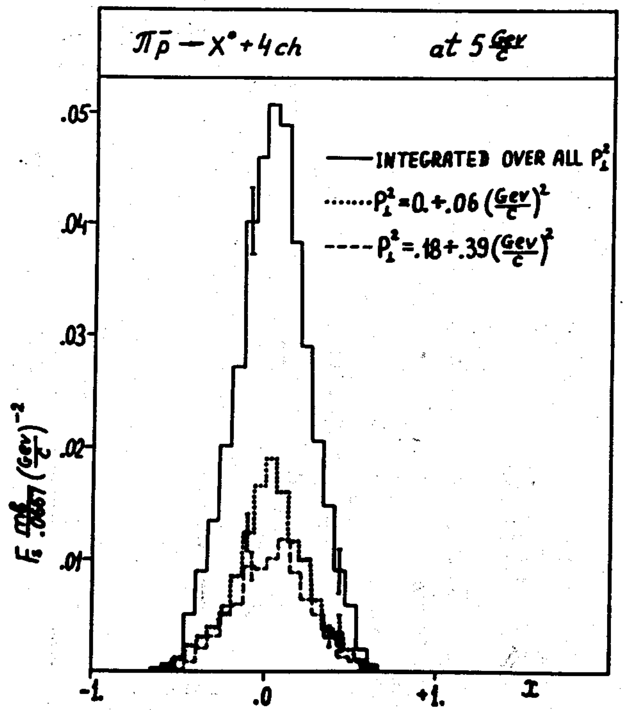

Fig. 9. Distributions of the invariant function F_s versus x for the missing mass in different intervals of the transverse momentum squared.

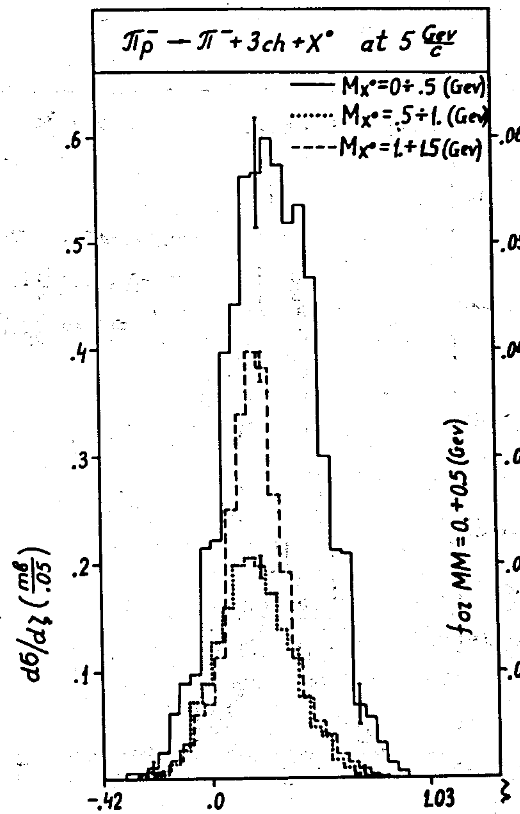

Fig. 10. Rapidity distribution for various intervals of the missing mass for π^-.

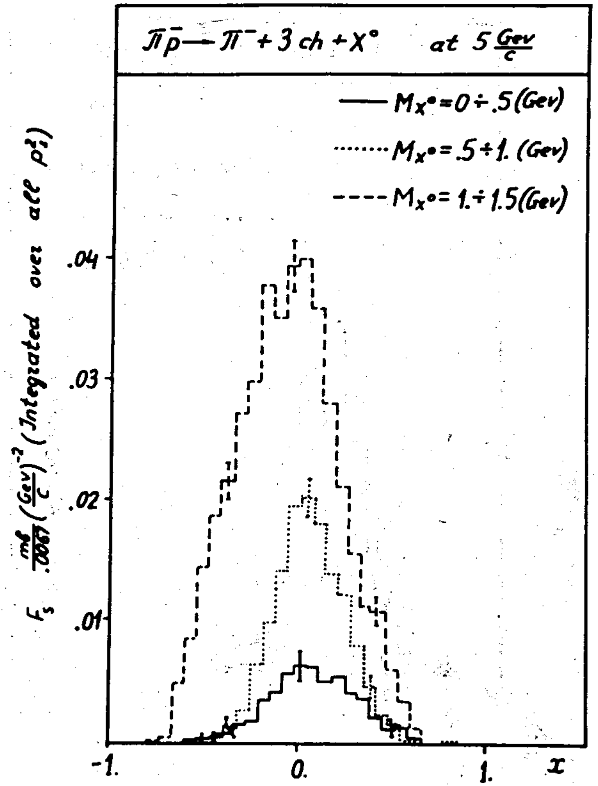

Fig. 11. Distributions of the invariant function F_s versus x for π^- -mesons in different intervals of the missing mass.

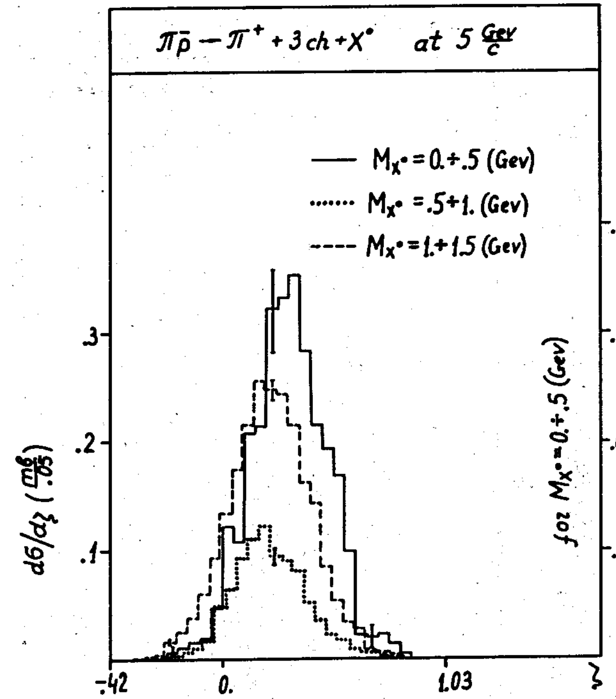

Fig. 12. Rapidity distribution for π^+-mesons in various intervals of the missing mass.

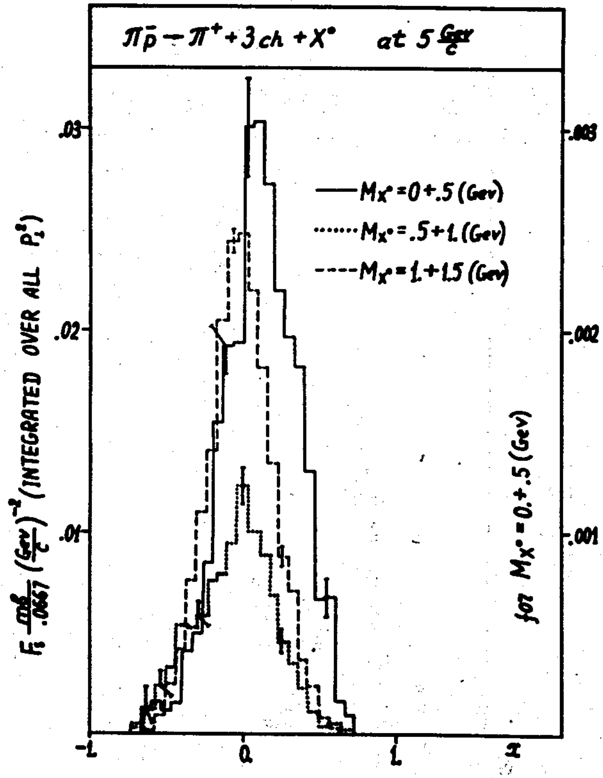

Fig. 13. Distributions of the invariant function F_s versus x for π^+ in different intervals of the missing mass.

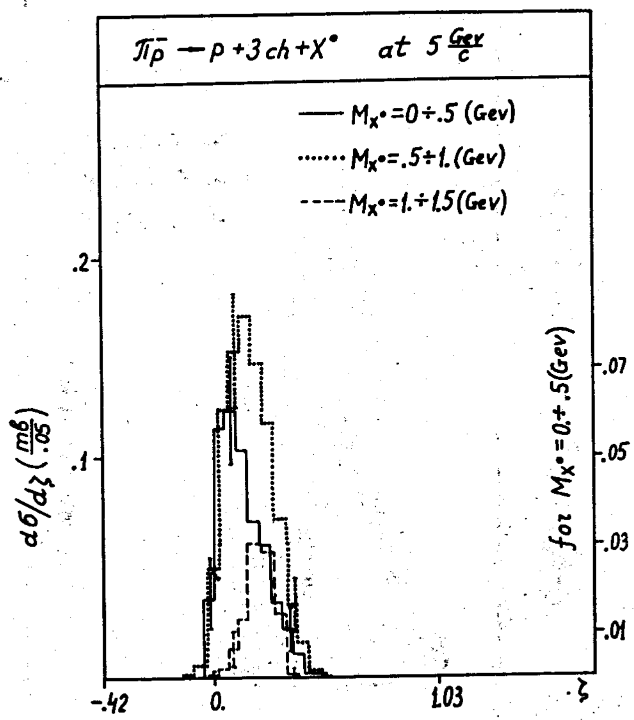

Fig. 14. Rapidity distributions for protons in different intervals of the missing mass.

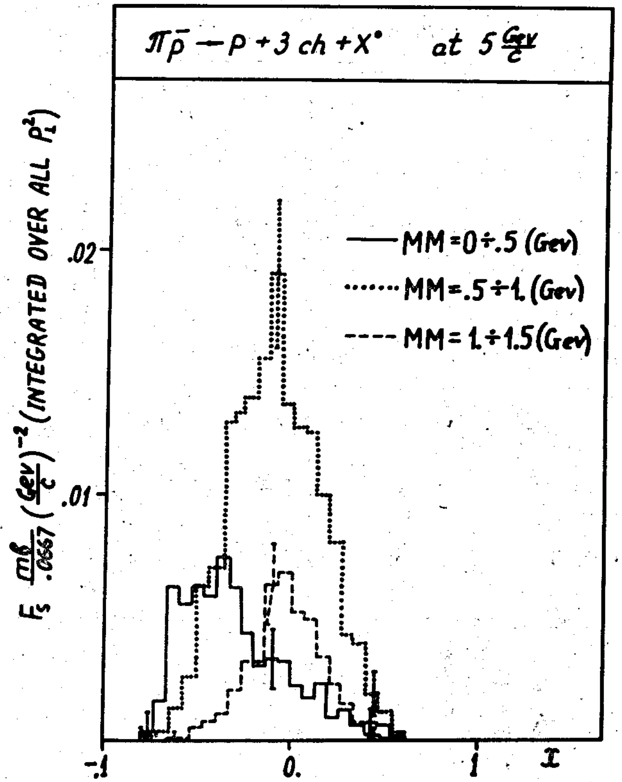

Fig. 15. Distributions of the invariant function F_s versus x for protons in different intervals of the missing mass.

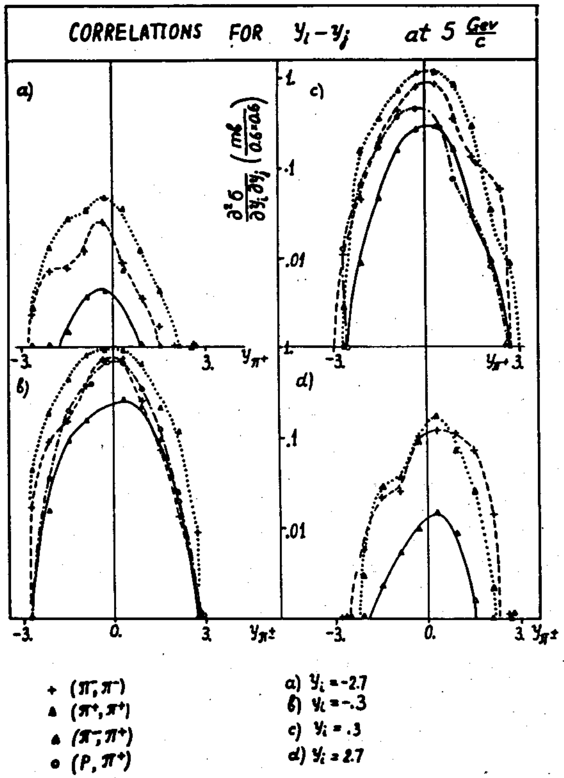

Fig. 16. Two-particle rapidity distributions at 5 GeV/c.

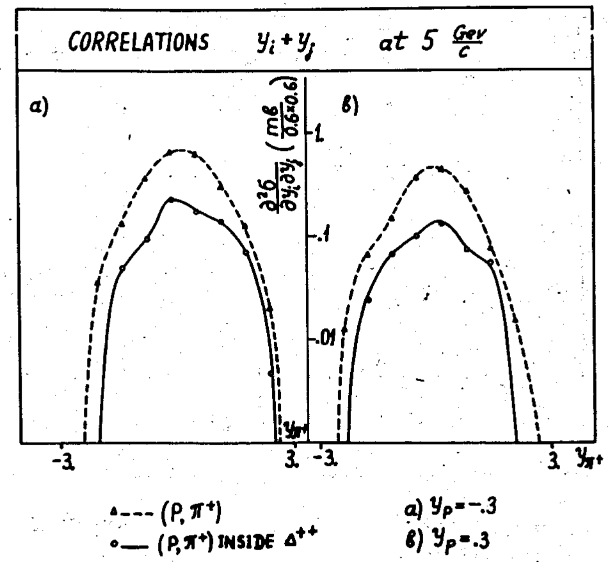

Fig. 17. Two-particle rapidity distributions at 5 GeV/c.

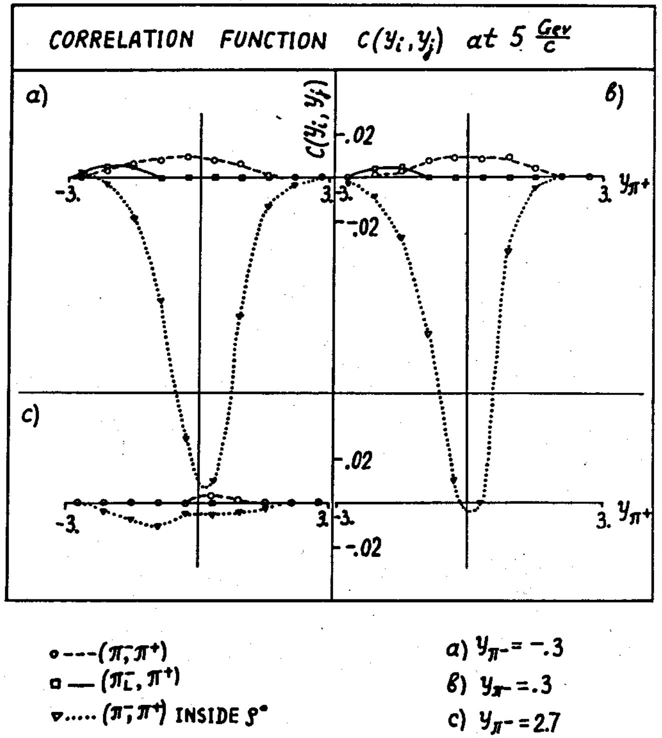

Fig. 18. Correlation function $C(y_{\pi^-}, y_{\pi^+})$ at 5 GeV/c. For y_{π^-} the mean values of intervals are indicated (0.6 in width).

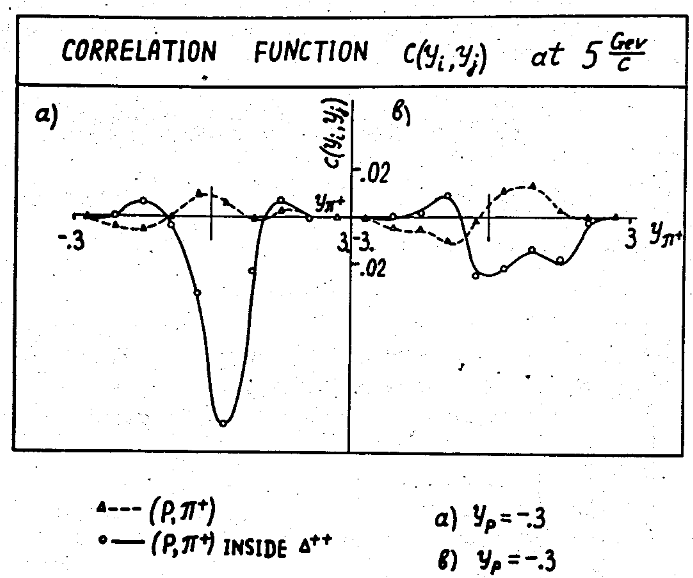

Fig. 19. Correlation function $C(y_p, y_{\pi^+})$ at 5 GeV/c. For y_p the mean values of intervals are indicated (0.6 in width).