Investigation of two-particle inclusive correlations in inelastic pion-nuclear interactions at 50 GeV/c

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The correlations between different charge combinations of pion pairs from inelastic collisions of negative pions with nuclei are investigated at 50 GeV energy. It is shown that the two-particle inclusive correlations in pion-nucleus collisions depend on the charges of the pions and are different from those in the elementary pion-nucleus interaction act.

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We report here the results of an investigation of two-particle correlation phenomena along the longitudinal collision axis (in the scale of longitudinal rapidities y) and in the transverse plane (azimuthal correlations) in inclusive interactions of negative pions with nuclei ($\pi^- A$) at 50 GeV/c. The experimental data were obtained with emulsion stacks placed in a strong pulse magnetic field (180 kOe) and bombarded by the accelerator of the Institute of High Energy Physics (Serpukhov).

The material analyzed in the present paper amounts to 536 $\pi^- A$-interaction events (without elastic collisions, coherent-production reactions, and events satisfying the necessary selection criteria for the interaction with nucleons ($\pi^- N$). We measured the momenta and charges of approximately 3000 particles. A detailed description of the experimental procedure, of the selection of the number of interactions, and of the measurement technique was given in [1], while data on the single-particle distribution in part of the considered material were published in [1,2].

We used for the analysis of the rapidity correlations the standard technique of two-particle correlation functions

$$C_2(y_1, y_2) = \frac{1}{\sigma_{in}} \frac{d^2\sigma}{dy_1 dy_2} - \frac{1}{\sigma_{in}^2} \frac{d\sigma}{dy_1} \frac{d\sigma}{dy_2}, \tag{1}$$

$$R_2(y_1, y_2) = \sigma_{in} \frac{d^2\sigma}{dy_1 dy_2} \Big/ \left(\frac{d\sigma}{dy_1} \frac{d\sigma}{dy_2}\right) - 1 \tag{2}$$

as applied to inclusive reactions with nuclei:

$$\pi^- A \to \pi^+ \pi^+ + \ldots , \tag{3}$$

$$\pi^- A \to \pi^- \pi^- + \ldots , \tag{4}$$

$$\pi^- A \to \pi^+ \pi^- + \ldots , \tag{5}$$

$$\pi^- A \to \pi^{ch} \pi^{ch} + \ldots , \tag{6}$$

taking as the argument the longitudinal rapidity in the "pion + intranuclear nucleon" collision system

$$Y = \tfrac{1}{2} \ln \frac{E + p_{\parallel}}{E - p_{\parallel}} - \operatorname{arch} \gamma_c \tag{7}$$

(E and p are in the laboratory frame, and γ_c is the Lorentz factor of this system in the laboratory frame).

Figure 1 shows the values of the function $C_2(0,y)$ for different combinations of pion pairs in $\pi^- A$ and $\pi^- N$ collisions. Figure 2 shows the values of $R_2(0,y)$ for the reactions (3)—(6) in comparison with the data for the same reactions with protons at $p = 40$ GeV/c from [3]. Figure 3 shows the value of $R_2(y_1, y_2 = y_1)$ (along the diagonal of the correlation matrix) for reactions (3)—(6). It shows also the analogous values of R_2 for $\pi^- N$ collisions at 40 GeV. [3] The Table lists the values of the asymmetry coefficients

$$A = \left(\int_{\pi/2}^{\pi} \frac{d\sigma}{d\epsilon} d\epsilon - \int_{0}^{\pi/2} \frac{d\sigma}{d\epsilon} d\epsilon \right) \Big/ \int_{0}^{\pi} \frac{d\sigma}{d\epsilon} d\epsilon \tag{8}$$

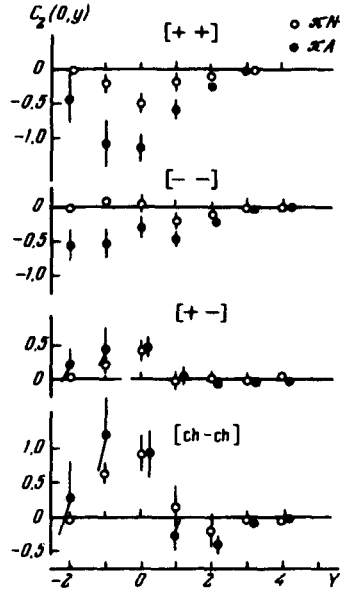

FIG. 1. The function $C_2(0,y)$ for different pion pairs in $\pi^- N$ and $\pi^- A$ events at 50 GeV.

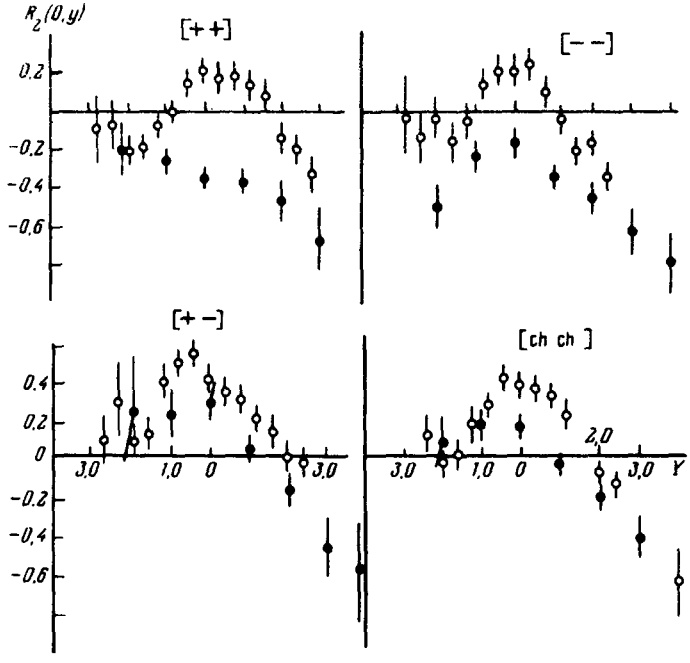

FIG. 2. The function $R_2(0,y)$ for different pion pairs in π^-A events at 50 GeV/c and for π^-p at 40 GeV/c. [3]

of the distributions over the paired azimuthal angle

$$\epsilon = \arccos\left(p_{\perp 1}p_{\perp 2}/\left(p_{\perp 1}p_{\perp 2}\right)\right) \tag{9}$$

between the transverse-momentum vectors of the different pairs of pions for π^-N and π^-A collisions (the values of A for the π^-N events agree within the limits of errors with the analogous values for the event at 40 GeV/c).

Let us formulate the main conclusions resulting from the analysis of the data in the Table and in the figures. As seen from the table, the azimuthal correlations in collisions with nuclei are apparently somewhat weaker that in π^-N interactions more material is necessary (for more reliable conclusions).

TABLE I. Values of the coefficients A for $\pi\pi$ pairs from π^-N and π^-A collisions.

	π^-N	π^-A
$\pi^+\pi^-$	0.07 ± 0.02	0.04 ± 0.01
$\pi^+\pi^+$	0.02 ± 0.04	− 0.01 ± 0.03
$\pi^-\pi^-$	0.09 ± 0.04	0.04 ± 0.03
ch ch	0.07 ± 0.01	0.02 ± 0.01

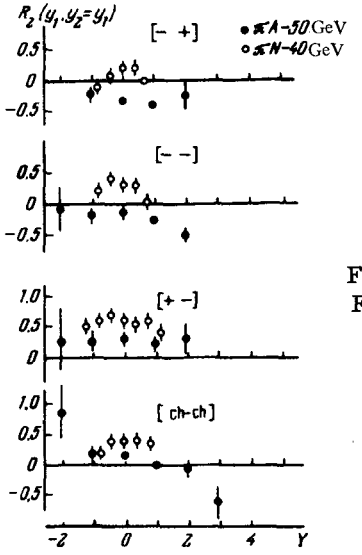

FIG. 3. The function $R_2(y_1, y_2=y_1)$ for the events of Fig. 2.

The correlations between the different charge combinations of the pions in pion-nucleus interactions are different. In the $\pi^+\pi^-$ system there are positive correlations of short-range character. The $\pi^-\pi^-$ and $\pi^+\pi^+$ correlations, being negative, differ in form in the fragmentation region of the target nucleus (we note that in this region there is an admixture of relativistic photons among the positively-charged particles).

The correlation functions are not symmetrical about $y=0$. This may be the simple consequence of the asymmetry of the single-particle rapidity distributions in π^-N and π^-A collisions. The sensitivity of the asymmetry of the correlation functions to the form of the single-particle distributions and to the form of the distributions in multiplicity can be of interest for the study of pion-nucleus interactions.

The behavior of the inclusive two-particle correlation functions for different combinations $\pi^+\pi^+$, $\pi^-\pi^-$, $\pi^+\pi^-$, in π^-A collisions differ from the analogous in pion-nucleon interactions. The difference between the correlation functions is particularly large for the $\pi^+\pi^+$ and $\pi^-\pi^-$ systems. We emphasize that these differences are closely related with the increase of the multiplicity in π^-A interactions.

The observed difference of the inclusive two-particle correlation functions in the π^-A interactions from those in the elementary act of pion-nucleon interaction can be of significant value for the verification of different models of hadron interactions with nucleons in nuclei.

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