объединенный
институт
ядерных
исследований
дубна

E1 - 13038

J.Bartke, L.Chkhaidze, A.Gasparian,
A.Golokhvastov, S.Khorozov, E.Kuznetsova,
J.Lukstins, Zh.Musulmanbekov, N.Nurgozhin,
E.Okonov, T.Ostanevich, R.Szwed,* M.Tashimov,
G.Vardenga, M.Zhuravleva

MULTIPLICITY OF NEGATIVE PIONS PRODUCED IN CENTRAL COLLISIONS OF RELATIVISTIC NUCLEI

Submitted to ЯФ

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* Warsaw University, Warsaw, Poland.

1980

In recent years considerable attention has been given to the investigation of the collisions of relativistic nuclei with nuclear targets. This interest has been stimulated by theoretical predictions of new phenomena in nuclear matter such as high density isomers, shock waves, etc. In a search for new, high density states of nuclear matter, central nucleus-nucleus collisions seem to be the most promising[1,2]. In particular, Gyulassy and Kauffmann[2] suggest that future experiments should be focused on central collisions with the aim to obtain the pion multiplicity distribution at impact parameter $b \approx 0$. These authors show that for a wide class of models the Poisson multiplicity distribution is expected for fixed-impact-parameter collisions if there are no strong correlations between the produced pions.

This situation has led us to a study of the properties of central nucleus-nucleus collisions at the Dubna synchrophasotron. The data have been obtained using two detectors: a 2m neon-filled streamer chamber with internal Cu and Pb foil targets and a 2m propane bubble chamber with thin tantalum plates inside the chamber volume. The streamer chamber was exposed to the beams of ^{12}C and ^{16}O at 4.5 GeV/c per nucleon, while the propane bubble chamber used the ^{12}C beam at 4.2 GeV/c per nucleon. As it has already become usual, negative secondaries are chosen as representing pion production processes in the best way, the contamination with non-identified electrons and strange particles is expected to be very low here. As "central", we take collision events which exhibit the absence of charged projectile fragments in the narrow forward cone[3]. Let us remark that choosing as "central" the interactions which exhibit the absence of projectile fragmentation seems to be the proper criterion as this selection does not distort the pion multiplicity distribution which is the object of our investigation (in this respect triggering for events with the highest multiplicities would not be correct).

The definition of "projectile fragments" was somewhat different for the two detectors. In the streamer chamber the selection was made by a special "antistripping" counter which was placed downstream and included in the trigger. The counter covered a solid angle of about 6 msr. In the bubble chamber the events were selected which showed no positive tracks with an apparent momentum of above 3 GeV/c emitted forwards within a projected angle of $\pm 4^{\circ}$.

Let us note that our selection is not equivalent to the criterion $b \approx 0$ called for in ref.[2]. We have selected the events in which all protons of the incident nucleus interacted in the target, but we have no information on the number of interacting neutrons. However, one can argue that our samples are strongly enriched with central collisions.

Table

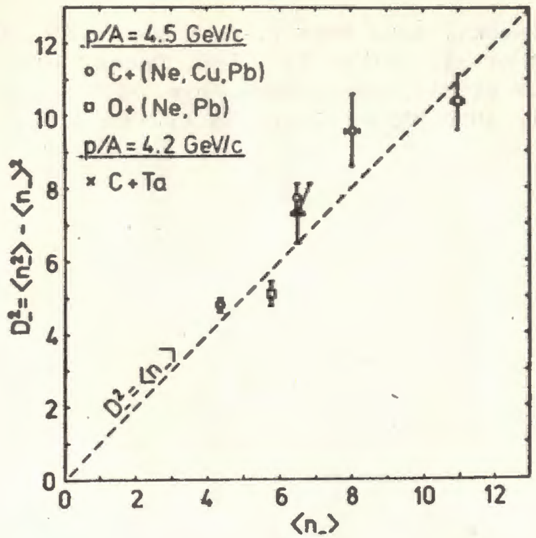
Average multiplicities and dispersions of the multiplicity distributions of negative pions in central nucleus-nucleus collisions

p_{inc}	A_i, A_t	$\langle n_- \rangle$	D_-	N
4.5 GeV/c.n	C + Ne	4.33 ± .07	2.19 ± .05	1067
	C + Cu	6.48 ± .10	2.79 ± .07	731
	C + Pb	8.02 ± .23	3.10 ± .16	180
	O + Ne	5.75 ± .10	2.25 ± .07	495
	O + Pb	10.98 ± .18	3.22 ± .12	331
4.2 GeV/c.n	C + Ta	6.49 ± .21	2.70 ± .15	161

The table gives the result: average multiplicities of negative pions, $\langle n_- \rangle$, and dispersions, $D_- = \sqrt{\langle n_-^2 \rangle - \langle n_- \rangle^2}$, for "central" collisions involving various nuclei. These data are plotted in the Figure in coordinates D_-^2 vs $\langle n_- \rangle$. One can see that our points follow rather closely the dependence $D_-^2 = \langle n_- \rangle$ characteristic for the Poisson distribution[a)]. As it has already been mentioned in ref.[4], this behaviour differs strongly from that of elementary hadron-hadron collisions for which D_- is a linear function of $\langle n_- \rangle$ (the so-called Wroblewski dependence[5]) and also from that observed for the total samples of nucleus-nucleus collisions where the multiplicity distributions are considerably wider[6].

However, one should keep in mind that the above uncertainties resulting from the selection criteria may lead to a

a) In fact, five of six multiplicity distributions analysed in this paper could be fitted with the Poisson distribution with $P(\chi^2) \geq 0.05$.



certain increase of the spread of various characteristics of the interactions studied, in particular, to an increase of the dispersion of the pion multiplicity distributions.

We would thus formulate our result as showing that the multiplicity distributions of pions resulting from central collisions between relativistic nuclei (with our selection criteria) are significantly narrower than for pp collisions and do not differ much from the Poisson distribution. This result disagrees with that of the emulsion work[7] where at much higher primary energy, however, such narrowing was not observed.

Thus, our data do not contradict the independent nucleon-nucleon collision mechanism of relativistic nuclei interaction which agrees with the conclusions of ref.[8] where the average multiplicities of secondaries in the interactions of cosmic-ray nuclei were analysed.

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Received by Publishing Department
on December 27 1979.