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A COMPARISON OF MULTIPLICITIES IN PION-NUCLEUS AND PROTON-NUCLEUS INTERACTIONS AROUND 50 GeV

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A COMPARISON OF MULTIPLICITIES IN PION-NUCLEUS AND PROTON-NUCLEUS INTERACTIONS AROUND 60 GeV

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In two recent papers of our laboratory /1/, /2/ evidence was found for a specific "nuclear" multiplicity scaling at very high energies, i.e. for the fact that the mean number of relativistic prongs, $\bar{n}_s$, at a given value of N_h, the number of heavily ionizing prongs (β<o.7) can be factorized as a product of the mean charged multiplicity n_{pp} in a proton proton collision at the same energy and a function of N_h only; furthermore this function was found to be nearly linear

$$\bar{n}_s(N_h,E) = \bar{n}_{pp}(E) \times (1+bN_h) \quad (1)$$

We present here results on π^--nucleus collision in nuclear emulsions, obtained under very similar conditions with those in the proton experiments, which show that the same scaling law holds also for pion-collisions in this energy region, although an unexpected difference in the complexity of the interaction of fast pions with emulsion nuclei with respect to proton interactions is observed.

The data come from two stacks of nuclear BR-2 emulsions exposed to 45 GeV/c and 6o GeV/c π^- -beams at the IHEP-Serpukhove accelerator. The plates were area scanned under low magnification for the detection of stars with $N_h \geq 3$ only, by the same observers and under practically the same conditions as in the proton experiments. The prong multiplicities were obtained by careful counts under high magnification. The bulk of the data comes from the 6o GeV/c exposure (2924 events); to date only 579 events were collected in the 45 GeV/c stack, and are given here from comparison purposes only. The main characteristics of the observed distributions are shown in Table 1 along with data from the proton exposure at 69 GeV/c. In figure 1 and 2 we present the (n_s, N_h) correlation in the two pion-stacks.

Table 1

Beam	N_h	N_2	$\bar{n}_s$	$R \equiv \frac{\sigma}{\langle n_s \rangle}$	ζ	B/A b
45GeV/c π^-	9.66±.27	14.97*	8.92±.23	.623±.o21	-	.o43±.oo8
6oGeV/c π^-	9.73±.12		9.42±.o9	.538±.oo9	1.42±.o4	.o52±.oo4
69GeV/c p	11.96±.22	15.6**	11.o9±.17	.548±.o17	1.9o±.o5	.o6o±.oo4

* pooled data from π^- 45 GeV/c and 6o GeV/c

** pooled data from 6.2 GeV/c /4/, 21.5 GeV/c /5/, 69 GeV/c /1/ and 2oo GeV/c /6/, proton beams.

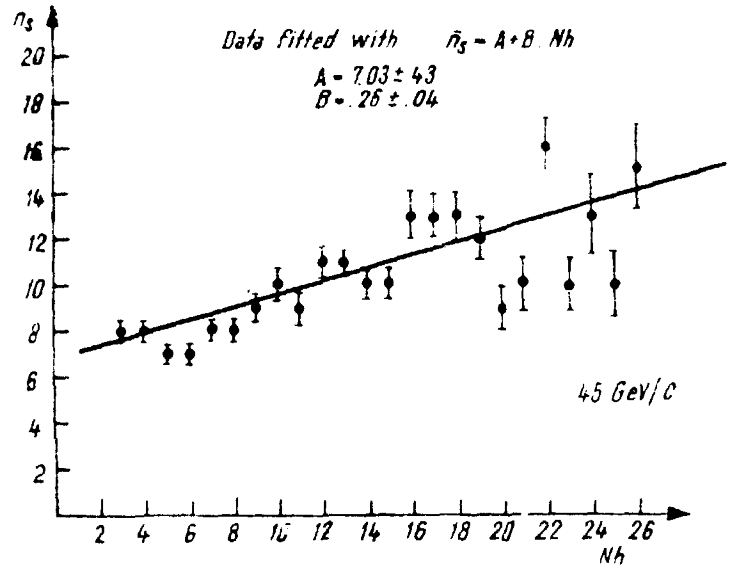
Data fitted with $\bar{n}_s = A + B\ Nh$
A = 7.03 ± 43
B = .26 ± .04
n_s
20
18
16
14
12
10
8
6
4
2
2 4 6 8 10 12 14 16 18 20 22 24 26
Nh
45 GeV/C

Fig.1.

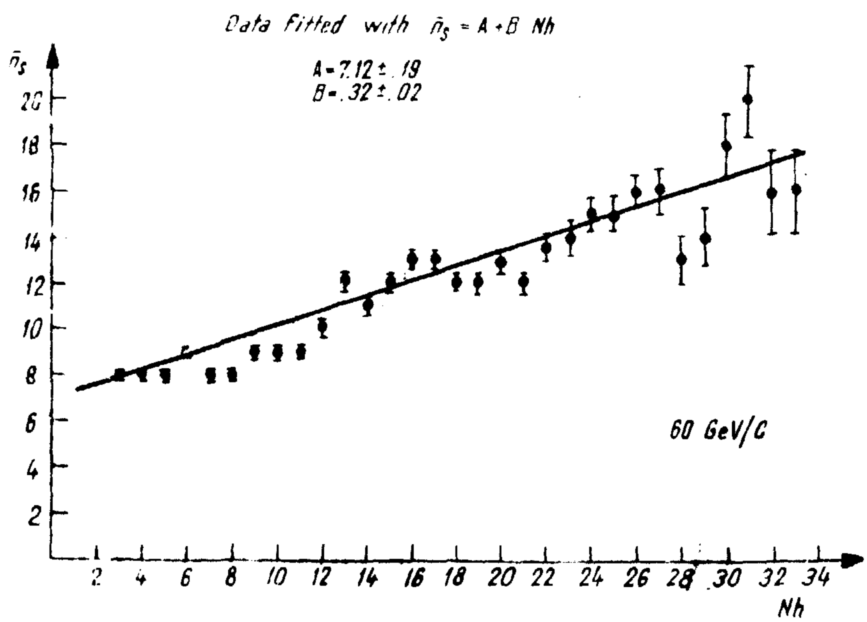
Data Fitted with $\bar{n}_s = A + B\ Nh$
A = 7.12 ± .19
B = .32 ± .02
$\bar{n}_s$
20
18
16
14
12
10
8
6
4
2
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34
Nh
60 GeV/C

Fig.2.

Several points emerge from the study of Table 1 viz.:

a) The mean number of heavily ionizing prongs in pion nucleus collisions is lower than in proton nucleus collisions. The same is observed for the multiplicity of relativistic prongs especially if we compare the ratio ζ

$$\zeta\ (N_h,\ E) \equiv \frac{\bar{n}_s(N_h,\ E)}{\bar{n}_s(\pi p,\ E)} \qquad (2)$$

b) Linear fits to the $(n_s,\ N_h)$ correlations shown in figures 1 and 2 show however that the slope b (equation 1) is not significantly different between pion and proton projectiles ; hence the scaling law (equation 1) appears to hold in pion-nucleus collisions at 6o GeV/c as well as in the high energy proton nucleus collisions. But in this case the lower value of ζ must be related to different weights of events with different N_h, in other words to the lower mean N_h value. That is so, is obvious from fig.3 in which the integral distribution of N_h is plotted against N_h^2 /3/. In this figure, circles represent the weighted mean of N_h distributions at 6.2 GeV/c, 21.5 GeV/c, 69 GeV/c and 2oo GeV/c /4,5,1,6/. The square symbols represent our results from pion-nucleus interactions pooled from 45 GeV and 6o GeV/c. As can be seen the general shape of the pion integral distribution is very similar to that of the proton distribution. Its slope parameter N_2 /3/ from the approximation beyond N_h = 8 of the integral distribution by

$$F\ (>N_h) = F_0\ e^{-\frac{N_h^2}{N_2^2}} \qquad (3)$$

is also given in Table 1.

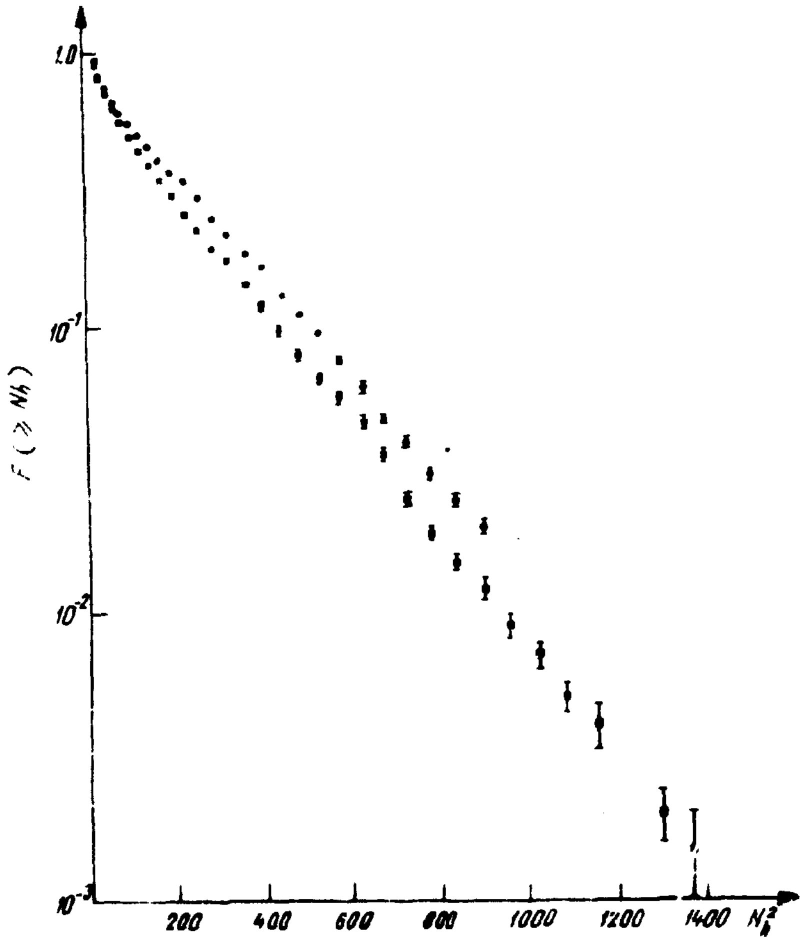

Fig.3.

As can be seen from fig.3 and from the N_2 values in figure 1, the slope corresponding to interactions with heavy nuclei is not significantly different in pion and proton interactions. However the fraction of events obeying this integral law appears to be significantly lower in pion nucleus interactions; this explains at once the low mean N_h and the lower mean ζ value. This difference must obviously be sought in the specific features of secondary interactions, inside the nucleus, of the forward products of the first proton-nucleon collision.

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