NONLINEAR EFFECTS IN NARROW JETS OF THE LEAD-PROJECTILE FRAGMENTS AT 160 A GEV

EMU01-collaboration
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The main goal of studying relativistic nuclear collisions is to obtain an evidence of the existence of long-lived Quark-Gluon Plasma; still for relativistic heavy nucleus collisions it is possible to assume the existence of a certain physical object which is a narrow jet of fragments of the projectile nucleus after its interaction with target nucleus. Within the projectile energy range 100-200 A GeV the transverse size of such physical object, which consists of a great number of projectile fragments, should be about a few fm while the longitudinal one is macroscopic.

Presumably new physical phenomena take place when projectile fragments are so closely-spaced to each other. One of them observed in the process of lead-nucleus fragmentation at 160 A GeV energy in nuclear emulsion is as follows. A narrow projectile fragment jet with a great number of secondary stars downstream the vertex has been observed in peripheral type of events, where projectile nucleus decays into fragments without any excitation of a target nucleus and without particles produced.

At CERN SPS, in the framework of the EMU01 Collaboration investigations, the part of emulsion chamber (15 layers of NIKFI BR-2) has been horizontally exposed by lead projectiles at 160 A GeV. The search for events has been carried out along the beam until its exit from the chamber and 1699 deep inelastic interactions have been found. We have selected, using the $N_h = 0$ criterion, 352 peripheral events with relativistic projectile nucleus transformed into narrow jet of relativistic fragments in the interaction point.

The same investigations have been carried out for the part of emulsion chamber (8 layers of NIKFI BR-2 emulsion) horizontally exposed at BNL by gold projectiles at 10.7 A GeV energy. The number of inelastic interactions has been found to be 499, 144 of them being peripheral events with narrow fragment jet. The event selection criterion was the same as for Pb+Em interactions.

For every analyzed event the number of interactions of lead (gold) fragments with the emulsion nuclei has been determined within 1.5 cm from the vertex of event in the corresponding fragmentation cones. The distance between the event vertex and every secondary star has been measured. The event with 7 secondary stars in the narrow jet of lead fragments is shown in the figure as an example.

The experimental results are shown in the table where the number of events with secondary stars at 1.5 cm from the vertex is shown for (Au+Em) at 10.7 A GeV and (Pb+Em) at 160 A GeV. It is seen that for gold-emulsion interactions none event with 3, 4, 5, 6 and 7 secondary stars has been observed.

In the sample of Pb+Em peripheral events there is a sub-sample of 29 events with the number of secondary interactions from 4 up to 7. The number of all charged projectile fragments has been determined after the last secondary star observed.

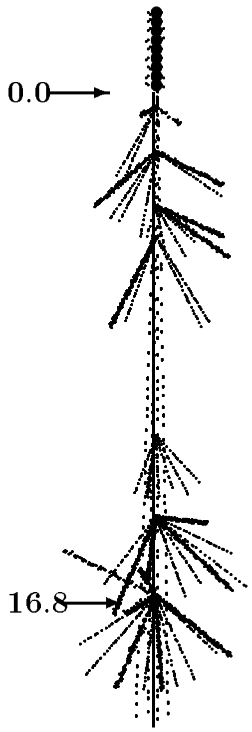

Fig. *Cascade of the seven subsequent nuclear collisions in the narrow fragment jet of the lead projectile at 160 A GeV. Only 16.8 mm separate the first collisions from the last.*

Assuming the whole number of secondary interactions in the narrow jet to be the superposition of independent interactions of k from n fragments with the emulsion nuclei, the total probability to observe such event with intervals $x_1, x_2, ...x_k$ between interactions has been estimated. The estimated probability at fragment mean free path λ=10 cm is $W = (10^{-6} - 10^{-5})$, while the experimental value is $W_{exp} = 2 \cdot 10^{-3}$. The interval correlation coefficient between neighbouring stars is equal to zero.
Therefor, the nonlinear effect, that is a great number of secondary stars near the event vertex, has been observed in the narrow jet of the 160 A GeV lead projectile fragments. This effect cannot be explained as a superposition of independent interactions of fragments with emulsion nuclei because this effect does not exist for alike Au+Em interactions at 10.7 A GeV.

Our interpretation of this effect is as follows. In the average the number of fragments and their transverse momenta are the same for both nuclei, nevertheless for high energy fragmentation of Pb (160 A GeV) the fragment density and density fluctuations in the jet are much greater than for Au at 10.7 A GeV. That is probably why the probability for few fragments in the narrow tube to interact with the same target nucleus increases.

Over the projectile energy range about few TeV per nucleon such effects should probably play a significant role. We hope our investigation should give rise to an interest towards this new physical phenomenon.

Table
Number of events with a few secondary stars within the 1.5 cm interval from the vertex in narrow jet of fragments for Au+Em at 10.7 A GeV and Pb+Em at 160 A GeV interactions.

N_{stars}	0	1	2	3	4	5	6	7	$N_{h=1}$	N_{tot}
$Au + Em$	90	42	12	0	0	0	0	0	144	499
$Pb + Em$	77	106	86	54	19	6	2	2	352	1699