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The study of the collective formation of secondary particles by the Hurst method

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According to the theoretical predictions, a mixed phase of the quark-gluon plasma (QGP), which includes both the free quarks and gluons, and the protons with neutrons, must be formed within the range of the energies of 4 to 11 GeV per nucleon. The study of multi-particle correlations and fluctuations in secondary particle distributions is often used to search for quark-gluon plasma, since the formation of secondary particles from a fireball of nuclear matter is of a collective nature. The difficulty in identifying the formation of quark-gluon plasma is mainly because QGP is formed against an extensive background due to the usual processes of strong interaction.

The initial state, about which there is usually very little direct experimental information, leads to significant fluctuations in the distribution of secondary particles and fragments. In a central collision, the maximum number of nucleons interacts. If the collision is peripheral, then the overlap of the nuclei is incomplete, and resulting fireball is taken to different directions asymmetrically. Thus, depending on the collision geometry, fluctuations of the average value of pseudo-rapidity distribution of secondary particles should be detected.

The event-by-event analysis of nuclear collisions at high energies is the most relevant for the search for dynamic fluctuations associated with the phase transition of nuclear matter to quark-gluon plasma. It is assumed that by analyzing in detail the characteristics of each individual event, it will be possible to directly observe the effects of a phase transition in those events in which the most favorable conditions for the formation of the quark-gluon plasma are created.

In this work, we carried out a joint study of multi-particle correlations and event-by-event pseudo-rapidity fluctuations to search for non-statistical clusters of secondary particles. For this purpose, we analyzed both secondary particles emitted from the interaction region and fragments of the projectile-nucleus and target-nucleus. To study correlations, we used the Hurst method. A detailed study of event-by-event pseudo-rapidity correlations in terms of the Hurst index, multiplicity of secondary particles and target dependence has been carried out for heavy (AgBr) and light (HCNO) targets present in the nuclear emulsion (Em,NIKFI BR-2) using Au-197 projectiles at 10.6 A GeV and Pb-208 projectiles at 158 A GeV.

According to the behavior of the Hurst curve, events were divided into two types: explosive and cascade-evaporative. Events of various types differ significantly in the fragmentation of the projectile-nucleus, multiplicity of secondary particles and pseudo-rapidity distribution. Also in explosive events, events were found in which secondary particles were emitted at high angles. When analyzing the fragmentation parameters of the Au + Em and Pb + Em interaction, the relative number of explosive events is almost the same. At that, the number of events with large values of the mean pseudo-rapidity distribution <η> differs by more than 4 times. In Au + Em interactions, 64.7% of explosive events are observed. Moreover, 8.1% of interactions are events of complete destruction, in which there are no fragments of the target nucleus. Pb + Em interactions account for 59.7% of explosive-type events and 8.9% of total destruction events. In Au + Em interactions, 35.6% of the events are explosive events with large <η> values. There are only 8.4% of such events in Pb + Em.

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