Conference Paper

Initial state fluctuations and complete destruction of the projectile nucleus in interactions of asymmetric nuclei at high energies

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Abstract

A study of characteristics of the events of complete destruction of the projectile nucleus in the interactions between asymmetric nuclei for different initial states of the collision, is performed. In the interactions of the sulfur nuclei with heavy emulsion nuclei at energy 200 AGeV, anomalous high number of events the complete destruction of the projectile nuclei, is observed. The high probability of such events depends on the energy of interaction (it is not detected in the interactions of the sulfur nuclei with emulsion nuclei at energy of 3.7 AGeV), on the degree of asymmetry of the interacting nuclei (it is not detected in interactions of the sulfur nuclei with light emulsion nuclei) and on initial state of interaction (it is not detected in peripheral collisions). These events are characterized by high multiplicity of secondary particles and narrow angular distribution at large angles (they form narrow peak in the region of small values of average pseudorapidity).

Keywords: QGP, complete destruction of projectile nucleus, initial state fluctuations.

1. Introduction

Quark-gluon plasma (QGP) is a special state of nuclear matter, in which quarks become quasi-free. The search and investigation of QGP manifestations led to a purposeful concentration of both theoretical and experimental studies in nucleus-nucleus interactions [1-2].

First of all, the interaction with extreme characteristics is investigated: large multiplicities, large transverse momenta of secondary particles, high particle density per unit interval of pseudorapidity distribution, etc. For the research and for analysis of

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non-statistical fluctuations in distributions of secondary particles different approaches and methods are used [3-9].

In this paper the analysis of events of the complete destruction of the projectile nucleus, are presented. Such events are considered as events in which the most favorable conditions for the formation of the QGP have been created. It is assumed that events of the complete destruction are central interactions, in which the maximum energy of the projectile nucleus is transferred into the interaction area [10].

2. Dependence of probability of complete destruction of projectile nucleus on interaction energy

For analysis we used experimental data on inelastic interactions of sulfur nuclei with emulsion nuclei ^{32}S+Em at energies of 3.7 and 200 AGeV [11-12].

To estimate the number of interacting protons of the projectile nucleus, we used auxiliary value $n_{g'}$=Q-ΣZ_f, where Q are charge of the projectile nucleus and ΣZ_f is the sum of the charges of all fragments of the projectile nucleus.

Fig. 1 shows the distribution by the number of interacting protons of the projectile nucleus $n_{g'}$. As it can be seen from Fig. 1(left), a trough-like distribution with an increased number of events in the area of both small and large values of $n_{g'}$, is observed. In the area of small values of $n_{g'}$ the increase of the probability of events is explained by the increase of peripheral interactions. The peak at large $n_{g'}$ requires special consideration.

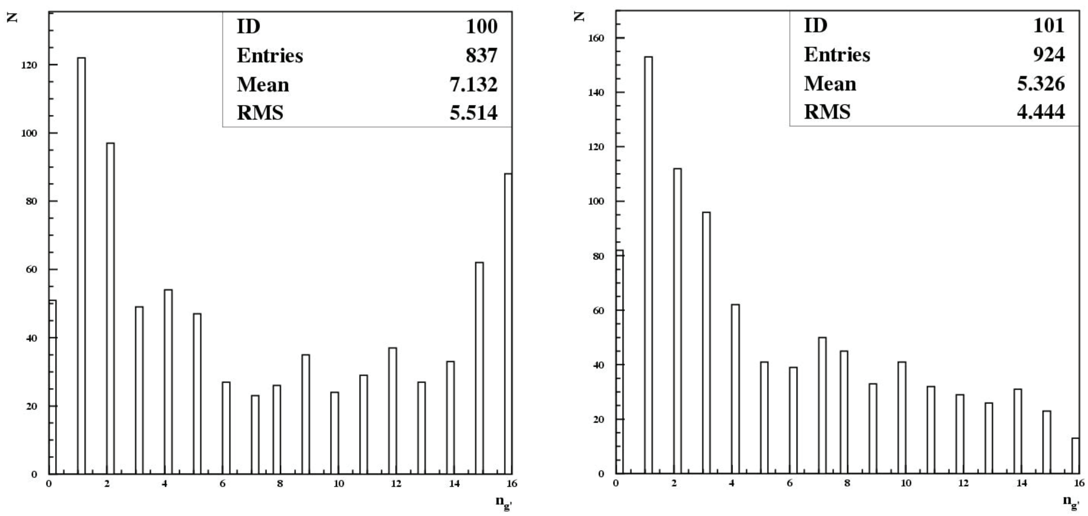

Figure 1: The distribution by the number of interacting protons of the projectile nucleus $n_{g'}$ for interactions of sulfur nuclei ^{32}S with emulsion nuclei at 3.7 AGeV (right) and at 200 AGeV (left).

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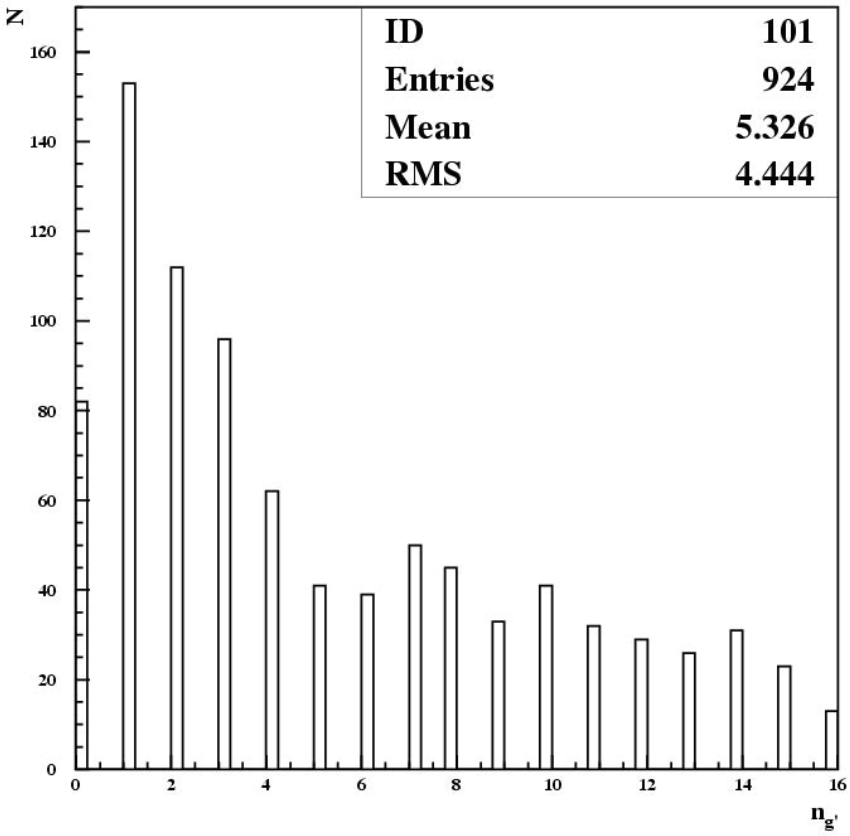

Figure 2: The distribution of number of interacting proton of the projectile nucleus $n_{g'}$ for ^{32}S+Em interactions at 3.7 and 200 AGeV with different number of fragments of the target nucleus N_h.

The events with $n_{g'}$=16 correspond to complete destruction of the projectile nucleus. In the events with $n_{g'}$=15 one single-charge fragment is detected. The probability of such events (with $n_{g'}$=16 or $n_{g'}$=15) is ~ 18% from presented ones in Fig. 1(left).

At the first stage, we analyzed the dependence of the probability of the events of complete destruction on the energy of the projectile nucleus. Fig. 1(right) shows the distribution by the number of interacting protons of the projectile nucleus for interactions of ^{32}S+Em 3.7 AGeV.

As it can be seen from Fig. 1(right), anomalous number of events of complete destruction of the projectile nucleus is not detected. Thus, the probability of such events depends critically on the energy of the primary nucleus.

3. The interaction of nuclei of different degrees of asymmetry

Nuclear photoemulsion is convenient detector for estimation of the influence of asymmetric parameters (relative dimensions) of the interacting system on the probability of occurrence of events of complete destruction of the projectile nucleus. It includes

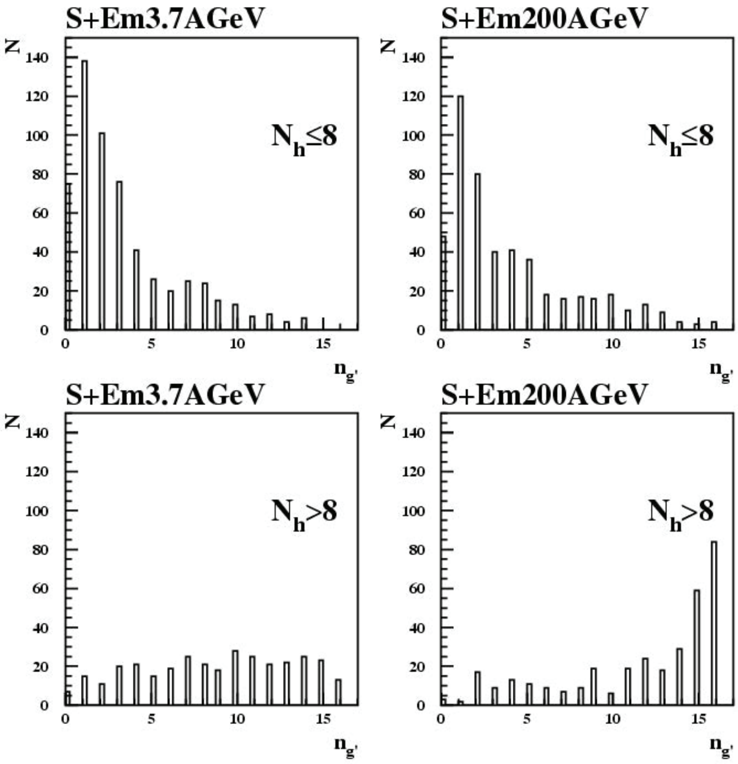

Figure 3: The dependence of the number of fragments of the target nucleus N_h on the multiplicity of n_s particles for the interactions of ^{32}S+Em 200 AGeV.

light, medium and heavy nuclei. This allows us to analyze various types of nuclear interactions obtained under exactly the same experimental conditions.

In analyzed experiments a standard nuclear emulsion of the BR-2 type was used. It includes hydrogen (39.2%), nuclei of the *CNO* group (35.3%) and the *AgBr* nucleus (25.5%). To separate the interaction with light (CNO) and heavy (AgBr) nuclei we considered events with number of target-nucleus fragments $N_h \leq 8$ and with $N_h > 8$. The criterion N_h=8 corresponds to the charge of the largest of the light nuclei of the photoemulsion - the oxygen nucleus.

The distribution by the number of interacting proton of the projectile nucleus $n_{g'}$ for ^{32}S+Em interactions with different number of fragments of the target nucleus N_h, are shown in Fig. 2. For comparison, the interactions of ^{32}S+Em at 200 AGeV and at 3.7 AGeV, are presented.

As it can be seen from Fig. 2, in the events with $N_h \leq 8$, the distributions of $n_{g'}$ are similar regardless of the energy. A significant difference is found in the events of interaction of sulfur with heavy nuclei of the photoemulsion. At lower energies, an almost flat-like distribution is observed. And at 200 AGeV, the significant peak in the region of large values of $n_{g'}$, is observed.

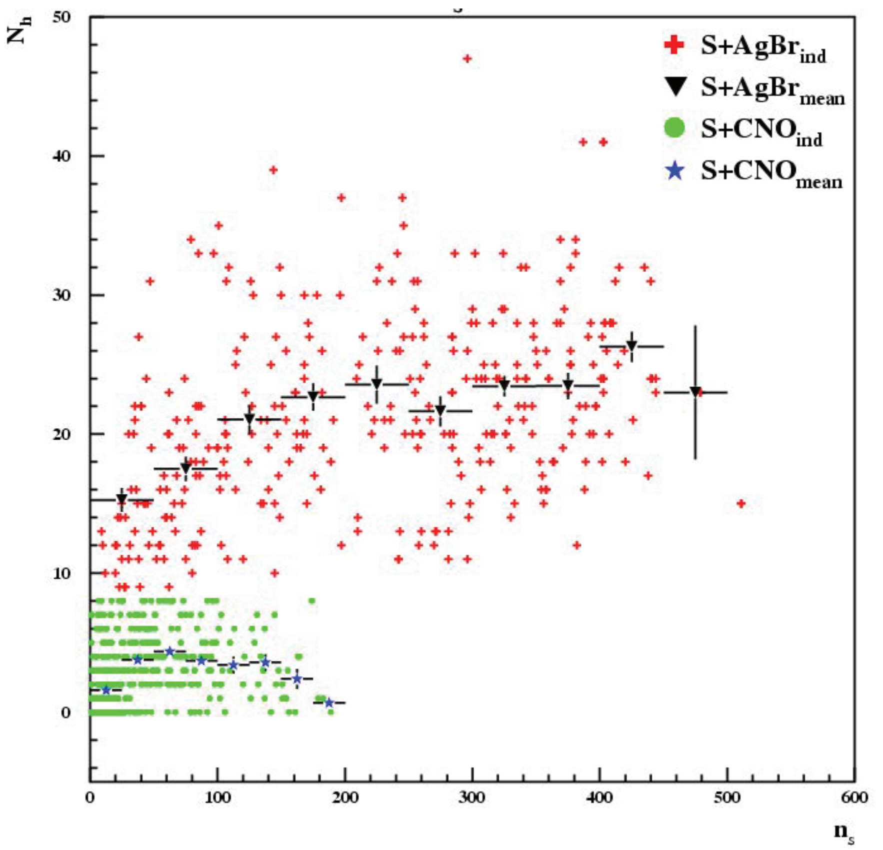

Figure 4: The multiplicity distribution of secondary particles n_s, the number of the target nucleus fragments N_h, and the mean pseudorapidity distributions $< \eta >$ of secondary particles for the ^{32}S+*Em* 200 A GeV interactions with a different number of interacting protons of the projectile nucleus $n_{g'}$.

4. Initial state of collision

One of the most optimal approaches for separating peripheral and central events is analysis of the dependence of the number of fragments of the target nucleus on the multiplicity of secondary particles. This correlation is shown in Fig. 3. As it can be seen from Fig. 3 in ^{32}S+AgBr interactions the average dependence shows the steady growth before n$_s$=200. Then it goes on the plateaus. Similar growth is discovered and for ^{32}S + CNO dependence, but before n$_s$=75. These criteria allow us to separate peripheral and central collision.

To understand the distinctive features of the events of complete destruction we performed a comparative analysis of the distributions of secondary particles in events with $n_{g'} \leq 14$ and $n_{g'} \geq 15$. The results of the comparison for the multiplicity of the secondary particles n$_s$, the number of the fragments of the target nucleus N_h and the mean pseudorapidity distributions of secondary particles are shown in Fig. 4.

As it can be seen from Fig. 4, all the graphs presented are critically different from each other. The multiplicity distribution of the secondary particles for the events $n_{g'} \leq$

14 is concentrated in the region of small values with the mean value of n_s = 66.83. The multiplicity of events with $n_{g'} \geq 15$ is 5 times higher. The number of fragments of the target nucleus in most events with $n_{g'} \geq 15$ is bigger than eight. Thus, basically such events appear in the interactions of sulfur with heavy nuclei of the emulsion, which is confirmed by the results presented in Fig. 2.

The mean pseudorapidity distribution of secondary particles in events with $n_{g'} \geq 15$ is characterized by a narrow peak in the region of small values $< \eta >$. The dispersion of the distribution in this case is 2.5 times less than for events with $n_{g'} \leq 14$.

5. Conclusion

In interactions of sulfur nuclei at 200 AGeV with heavy nuclei of photoemulsion, an anomalously high probability of events of the complete destruction of the projectile nucleus, is found. In ∼ 18% of events, the projectile nucleus is destructed completely, or one single-charge fragment is remained.

The high probability of such events depends on the energy of interaction (it is not detected in the interactions of the sulfur nuclei with emulsion nuclei at energy of 3.7 AGeV), on the degree of asymmetry of the interacting nuclei (it is not detected in interactions of the sulfur nuclei with light emulsion nuclei) and on initial state of interaction (it is not detected in peripheral collisions). The events of the complete destruction of the projectile nucleus are characterized by high multiplicity of secondary particles and narrow angular distribution at large angles (they form narrow peak in the region of small values of average pseudorapidity).

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