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TO THE ESTIMATION OF ANGULAR DISTRIBUTIONS OF DOUBLE CHARGED SPECTATOR FRAGMENTS IN NUCLEUS-NUCLEUS INTERACTION AT SUPERHIGH ENERGIES

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The pseudo-rapidity distributions of double charged spectator fragments produced in the interactions of ^{12}C, ^{22}Ne, ^{24}Mn, ^{28}Si (4,5 GeV/c/nucleon), and ^{56}Fe (2,5 GeV/c/nucleon) with nuclear photoemulsion are studied experimentally. It is shown that the width of the distribution does not depend practically on the mass number of fragmenting nucleus and beam energy. The centre of the distribution is correlated with beam energy. All this allows one to estimate the angular distributions of fragments in superhigh energy nuclear collisions.

The investigation has been performed at the Laboratory of Computing Techniques and Automation, JINR.

К оценке угловых распределений двухзарядных спектаторных фрагментов в ядро-ядерных взаимодействиях при сверхвысоких энергиях

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Экспериментально исследуются псевдобыстротные распределения двухзарядных спектаторных фрагментов, рождающихся во взаимодействиях ^{12}C, ^{22}Ne, ^{24}Mn, ^{28}Si (4,5 ГэВ/с/нуклон) и ^{56}Fe (2,5 ГэВ/с/нуклон) с ядрами фотоэмульсии. Показано, что ширина распределения практически не зависит от массы фрагментирующих ядер и от энергии пучка. Положение центра распределения коррелирует с энергией пучка. Все это позволяет оценить угловые распределения фрагментов при сверхвысоких энергиях.

Работа выполнена в Лаборатории вычислительной техники и автоматизации ОИЯИ.

To study nucleus-nucleus interactions at superhigh energies, it is assumed to use different detectors of singly charged relativistic particles. The possibility of multi-charged nuclear fragment penetration through such a detector and its response are not usually considered. It is supposed that the nuclear fragments will fly at small angles to the beam direction and will

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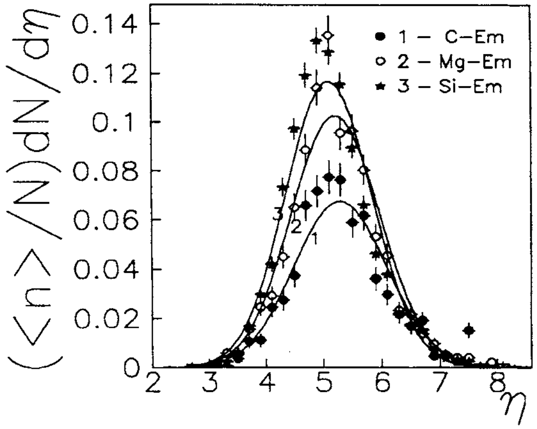

Fig. 1. Pseudo-rapidity distributions of double charged fragments in ^{12}C, ^{24}Mg, ^{28}Si + Em interactions

not enter the designed installations. Our paper is aimed to give the possibility to check up the hypothesis.

It is clear that one needs to know the distributions of nuclear fragments on kinematic variables in order to check the hypothesis. The kinematic characteristics of the fragments are studied thoroughly at low and intermediate energies. Though, these data cannot be used because there is a strong overlap of fragmentation regions of colliding nuclei at such energies.

At high energies ($E/A > 1$ GeV), there is only a restricted set of experimental data (see, e.g., [1, 2]). The needed data can be obtained from emulsion experiments. Such data were presented in Ref. 3 for gold interactions with emulsion nuclei at an energy of 10.6 GeV/nucleon. According to Ref. 3, the widths of the pseudo-rapidity distributions for double-charged, light ($3 \leq Z \leq 5$) and heavy ($Z \geq 6$) fragments are equal to 1, 1, and 3, respectively. The distribution characteristics in other interactions are unknown.

Below, we present the main characteristics of double-charged fragment pseudo-rapidity distributions in the interactions of ^{12}C, ^{24}Mg, ^{28}Si at an energy of 3.7 GeV/nucleon, ^{14}N at an energy of 2.1 GeV/nucleon, and ^{56}Fe at an energy of 1.7 GeV/nucleon with nuclear photoemulsion. The data were obtained in the experiments identical in development selection and identification of spectator fragments of projectile nuclei (see Refs. 4-8).

Figure 1 shows the pseudo-rapidity distributions of double-charged fragments in ^{12}C, ^{24}Mg, ^{28}Si + Em interactions. Here $\eta = -\ln \mathrm{tg}\,\theta/2$, where θ is the polar angle of a fragment measured from the beam direction.

As one can see, the distributions for different fragmenting systems are alike. Such quantitative characteristics of the distributions as the standard deviation ($D = \sqrt{<\eta^2> - <\eta>^2}$), mean value of pseudo-rapidity ($<\eta>$), and multiplicity of double-charged fragments are given in the Table.

According to the Table, the characteristics of the distributions depend on interaction energy, the type of projectile and target nuclei. The distributions differ from the gaussian ones (see the solid curves calculated using the data presented in the Table). Only in a rough approximation, one can assume that the width of the distributions is the same as the mean values of pseudo-rapidity at a fixed interaction energy.

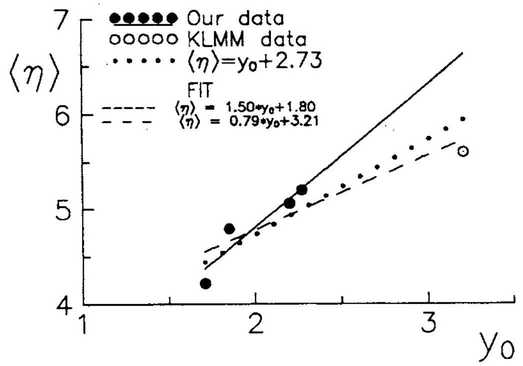

Fig. 2. Mean value of double charged fragment pseudo-rapidity distribution as a function of beam rapidity

One can understand some specific features of the distributions assuming that the rapidities of the fragments (y) are equal to the rapidity of the incident nucleus. Then at high energies one gets

$$y = \frac{1}{2} \ln \frac{E + P_z}{E - P_z} \simeq \eta - \frac{m^2}{2p_T^2},$$

where m, E, p_z, and p_T are the mass, energy, longitudinal and transversal momentum of the fragment, respectively. As far as we know, the transversal momentum distributions of fragments depend weakly on energy, so $< \eta >$ must be in straightline proportion to the rapidity of projectile nucleus. The data of Fig. 2 are not contradictory to this conclusion.

Table. Main characteristics of the pseudo-rapidity distributions

Ensemble	p_0, GeV/c/nucleon	$\langle n_\alpha \rangle$	$\langle \eta_\alpha \rangle$	$\sigma(\eta_\alpha)$
$^{12}C - Em$	4.5	$0.68 \pm .02$	$5.29 \pm .02$	$.81 \pm .02$
$^{24}Mg - Em$	4.5	$0.99 \pm .02$	$5.21 \pm .02$	$.77 \pm .01$
$^{28}Si - Em$	4.5	$1.08 \pm .02$	$5.09 \pm .01$	$.74 \pm .01$
$^{56}Fe - H$	2.5	$1.29 \pm .06$	$4.34 \pm .02$	$.64 \pm .02$
$^{56}Fe - CNO$	2.5	$1.64 \pm .07$	$4.27 \pm .02$	$.73 \pm .02$
$^{56}Fe - AgBr$	2.5	$1.75 \pm .05$	$4.15 \pm .02$	$.75 \pm .01$
$^{22}Ne - Em$	4.2	$0.82 \pm .02$	$5.06 \pm .01$	$.77 \pm .01$
$^{14}N - Em$	2.9	$0.74 \pm .03$	$4.79 \pm .03$	$.84 \pm .02$
$^{56}Fe - Em$	2.5	$1.65 \pm .04$	$4.22 \pm .01$	$.74 \pm .01$

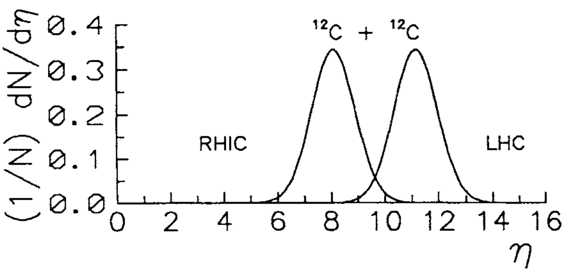

Fig. 3. Pseudo-rapidity distributions of double charged fragments in nucleus-nucleus interactions at superhigh energies

The mentioned properties of the distributions allow one to make predictions for superhigh energies. Figure 3 gives the calculated distributions of double-charged fragments in $^{12}C+^{12}C$ interactions at $\sqrt{s_{NN}} = 200$ and 5000 GeV. In principle, they can be checked up with extracted beams of superhigh energy nuclei.

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