# The Study of Multiparticle Production in High Energy Nucleus-Nucleus Interactions.

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## Introduction:

Reactions induced by the relativistic heavy nuclei of the cosmic rays have often been observed in nuclear emulsion. Commencement of heavy ion accelerators have opened up an entirely new era in the field of heavy ion studies at relativistic energies. The main motivation for studying high energy heavy ion reactions has been the hope of creating and studying nuclear matter at high density and high excitation energy. During the collisions, nuclei may be compressed to more than their normal density and may result in density isomers or quasi-stable states existing at other than normal density [1-7]. In the present work we have studied some characteristics of charged secondaries produced in $^{12}$C-nucleus interactions at 4.5 AGeV. The results obtained in present investigations have been compared with those obtained in hadron-nucleus collisions. Finally the findings of present work have also been compared with the predictions of various theoretical models put forward for explaining the reaction mechanism of multiparticle production in hadron-hadron, hadron-nucleus and nucleus-nucleus interactions at relativistic energies.

## Experimental details:

In the present study, emulsion stacks of many pellicles of $NIFKI-BR-2$ nuclear emulsion are used. The stacks of emulsion exposed to a beam of $^{12}\mathrm{C}-ions$ with a momentum of 4.5 GeV per nucleon at the Synchrophastron of the Joint Institute of Nuclear Research, Dubna, Russia. Each pellicle size is 18.7 cm$\times$ $9.7\ cm \times 0.06\ cm.$ These pellicles are mounted on a glass plate and is then ready for analysis. In study of hadron-nucleus interactions at 4.5 A GeV, the nuclear emulsion is in general used as both target and detector. The target consists of three groups as hydrogen, a light [L], group of CNO targets and heavy [H], group of AgBr targets. The particles emitted in the interactions are classified according to ionization produced along the track. Detailed information regarding scanning procedure, classification of charged secondaries etc. may be found in our earlier publications [11-12].

## Experimental results and discussion:

The study of multiplicity correlations amongst secondary charged particles produced in high energy hadron-nucleus collisions might provide some extremely useful information on the mechanism of multi-particle production and it allows us to discuss the dynamics of nucleus-nucleus reactions. According to the existing representation, the shower and grey particles characterize the fast stage of inelastic interactions between two nuclei, black particles correspond to the next stage of collisions, when the de-excitation process occurs through the evaporation of nucleus[5,17]. Table 1 shows percentage of disintegrating events caused by various projectiles in nuclear emulsion.

**Table 1**

| Projectile | Energy per nucleon | Percentage | | | Ref. |
|---|---|---|---|---|---|
| | | H | CNO | AgBr | |
| A | 12 | 7.47 | 28.82 | 63.71 | 4 |
| C | 4.5 | 22.20 | 31.35 | 46.45 | 3 |
| C | 4.5 | 8.00 | 35.50 | 56.50 | This work |
| Si | 4.5 | 22.23 | 24.43 | 53.34 | 14 |

It is quite interesting to note in the table that the probability of collisions with various component of emulsion depends strongly on the energy and the mass of the projectile. The average number of various secondaries along with the values obtained using other projectiles at the same projectile energy are tabulated in Table 2.

**Table:2**

| Type of interaction | $<N_b>$ | $<N_g>$ | $<N_s>$ | $<N_h>$ | $<N_b>/<N_g>$ | Ref. |
|---|---|---|---|---|---|---|
| C-AgBr | 7.20 $\pm$0.12 | 10.58$\pm$0.22 | 12.43$\pm$0.26 | 19.91$\pm$0.28 | 0.58 $\pm$0.02 | This Work |
| Mg-AgBr | 9.68 $\pm$0.18 | 12.75$\pm$0.35 | 13.09$\pm$0.25 | | 0.76 $\pm$0.03 | 13 |
| C-CNO | 1.94 $\pm$0.13 | 1.85 $\pm$0.19 | 4.94 $\pm$0.16 | 2.53 $\pm$0.15 | 0.89 $\pm$0.03 | This Work |
| Mg-CNO | 2.50 $\pm$0.13 | 1.95 $\pm$0.17 | 9.20 $\pm$0.35 | | 1.28 $\pm$0.13 | 13 |
| C-H | 0.20 $\pm$0.06 | 0.12 $\pm$0.04 | 2.93 $\pm$0.21 | 0.32 $\pm$0.07 | 1.28 $\pm$0.50 | This work |

Results can be explained in terms of the fire ball model [2]. This model reveals that the grey particles come from the participant volume and the number of participant nucleons increases as the volume of the cylinder cut in the target by the projectile increases and consequently the average number of grey particles increases. However, Gill et al [3] have reported that there are not any significant variations in $< N_g >$ amongst the nucleus-nucleus reactions. Thus, our finding is in marked disagreement with those reported by Gill et al [3]. The results reveal that for $^{12}$C-nucleus interactions the collisions with the CNO groups of nuclei are contained in the range $N_h < 7$ and beyond this range the interactions occur solely with heavy group of emulsion nuclei (AgBr). The number of heavily ionizing particles, $N_h$emitted from the target nucleus may be an important parameter for separating the events caused by the projectile in different target nuclei. It is also easy to obtain experimentally. The probability of the existence of leading particle is much higher in the forward hemisphere than in the backward hemisphere. This results indicates that the leading particle effect in 4.5 A GeV/c $^{12}$C-nucleus reactions is investigated by studying the dependence of dispersion of relativistic charged particles in forward hemisphere [7-12]. The leading particle multiplicity strongly depends on the mass of the projectile. In high energy hadron-nucleus and proton-proton collisions, there is at least a quantitative similarity in the mechanism of hadronization in the final stage of high energy hadron-nucleus as well as nucleus-nucleus reactions [14-17]. The results suggest that all the multiplicity correlations are not linear and the multiplicity correlations in heavy ions collisions may be expressed by the second order polynomial [13,15].

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