Evidence of Correlation and Clusterization in Multiparticle Production in Relativistic Heavy-Ion Collisions

A. Kamal[1]* and N. Ahmad[2]

[1] *Department of Physics, Shibli National PG College, Azamgarh-27006, INDIA*
[2] *Department of Physics, Aligarh Muslim University, Aligarh -202002, INDIA*

*email: arshadhep@gmail.com

Introduction

Study of relativistic nucleus-nucleus collisions has generated considerable interest during the recent years among high energy physicists. The space-time evolution of such collision processes undergo various substages resulting at last in the production of final state particles [1-3]. These collisions may provide an opportunity to investigate the formation and properties of quark-gluon plasma (QGP). It is envisaged that when QGP will be formed, the degrees of freedom of the new state of matter [4], quarks and gluons, will be in a de-confined state. It is interesting to emphasize that the mechanism of multiparticle production in nuclear collisions can be interpreted by carefully examining global observables, such as deposition of energy, momentum spectra and distribution of multiplicities of secondary particles.

In this paper an attempt is made to analyse some fascinating features of relativistic nuclear collisions like mean multiplicity, pseudorapidity distributions, correlated production of the secondary particles and two particle correlation among produced particles using the Snider approach in 14.5A GeV/c ^{28}Si-nucleus interactions. Experimental results are compared with those obtained for the data generated using Lund model, FRITIOF.

Results and discussion

Multiplicity is a useful parameter in the study of multiparticle production process in high energy nuclear interactions. The average multiplicities of various types of charged secondaries produced in 14.5A GeV/c ^{28}Si-nucleus interactions are listed in Table 1 for the experimental as well as FRITIOF generated data. From the table it is clear that the average multiplicity $\langle n_x \rangle$, where (x= b,g,s,h and c) exhibits strong dependence on the target mass with increasing tendency for both experimental as well as FRITIOF generated data sets on 14.5A GeV/c ^{28}Si-nucleus interactions. Here b,g,s,h and c stands for black,grey,shower,heavily ionizing tracks and compound multiplicity respectively.

Table 1 Mean multiplicities of relativistic charged particles produced in 14.5A GeV/c ^{28}Si-nuclei with various targets.

Data Type	Type of Interactions	$\langle n_b \rangle$	$\langle n_g \rangle$	$\langle n_s \rangle$	$\langle n_h \rangle$	$\langle n_c \rangle$
EXPT.	^{28}Si-CNO	2.84±0.11	1.82±0.08	16.33±0.63	4.66±0.12	18.15±0.64
	^{28}Si-Em	6.95±0.22	4.69±0.18	22.03±0.61	11.65±0.37	26.72±0.72
	^{28}Si-AgBr	10.50±0.24	7.15±0.23	26.59±0.78	17.64±0.40	33.74±1.04
FRITIOF	^{28}Si-CNO	1.52±0.03	1.81±003	19.81±044	3.73±0.04	21.62±0.46
	^{28}Si-Em	1.91±0.03	2.71±0.05	23.58±0.41	4.63±0.03	26.30±0.45
	^{28}Si-AgBr	3.72±0.10	8.24±0.50	56.68±0.90	11.95±0.18	64.93±1.40

Fig. 1 exhibit distribution of the normalized pseudorapidity of relativistic charged particles produced in 14.5A GeV/c ^{28}Si-nucleus interactions for the experimental and FRITIOF generated data respectively. It may be noted that the dashed curves in the figure are Gaussian fits which incidentally reproduce the shapes of the experimental and FRITIOF distributions reasonably we

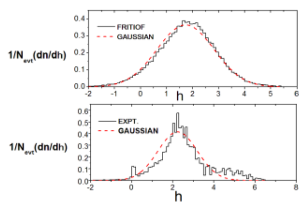

Fig. 1 η distributions for the experimental and simulated data on 14.5A GeV/c ^{28}Si-nucleus collisions.

Study of correlation between multiplicities of different types of secondary charged particles is of considerable importance for investigating the mechanism of nucleus-nucleus interactions. Therefore, an attempt is made in the present study to examine various types of multiplicity correlations amongst various types of produced particles.

Fig. 2 exhibits the variations of $<n_s>$ with n_x(x=b,g,h and c). It can be seen in Fig. 2 that n_g and n_c are strongly correlated with $<n_s>$ individually as compared to the correlations of n_b and n_h with $<n_s>$. Using the least squares fittings following relations are obtained:

$< n_s >$ = (16.04±0.93) + (0.813±0.14) n_b

$< n_s >$ = (1.45±0.17) + (0.772±0.01) n_g

$< n_s >$ = (15.57±0.85) + (1.45±0.14) n_c

$< n_s >$ = (12.36±0.76) + (0.86±0.05) n_h

Similarly, the variations of $<n_h>$ with n_x(x=b,g,h and c) can be shown.

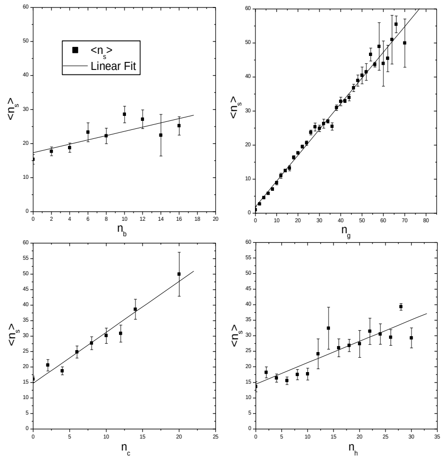

Fig. 2 Variations of $<n_s>$ with n_x(x=b,g,h and c) in 14.5A GeV/c ^{28}Si-nucleus interactions

It is widely believed that information about particle production through cluster decays may be gleaned by examining the beahviour of the distribution of the rapidity gaps between the n^{th} nearest neighbours [5].

The distribution of the rapidity gaps between adjacent rerelativistic relativistic charged particles, are calculated for 14.5A GeV/c ^{28}Si-nucleus interactions, is shown in Fig. 3. It can be seen from the figure that the occurrence of strong-short range correlation have been observed at relatively smaller values of the rapidity gaps, r. It is also evident from the figure that the rapidity gap distribution for the experimental data can be represented very well by the two channel generalization of Chew-Pignotti model [6]. The best fits of Eqn given by Chew for both experimental and FRITIOF data are respectively:

$$\frac{dn}{dr} = (4.26 \pm 0.58)\exp(-7.27 \pm 0.33)\,r + (0.11 \pm 0.01)\exp(-1.48 \pm 0.05)\,r \quad (1)$$

$$\frac{dn}{dr} = (3.35 \pm 0.89)\exp(-8.13 \pm 0.86)\,r + (0.24 \pm 0.03)\exp(-1.83 \pm 0.08)\,r \quad (2)$$

It may be mentioned that the first and the second terms in Eqns (1) and (2) represent [6] respectively the contributions of the short-range and long range correlations. It is remarkable to note that almost identical results are obtained for the FRITIOF data.

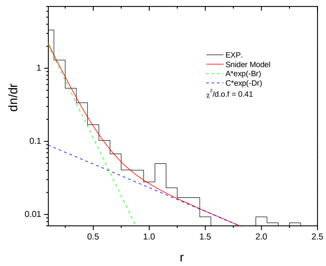

Fig. 3 Distribution of rapidity gaps between two consecutive particles for the experimental data on 14.5A GeV/c ^{28}Si-nucleus interactions.

Conclusions

From the comprehensive analysis of experimental and simulated data on 14.5 A GeV/c ^{28}Si-nucleus interactions**,** the following important conclusion can be arrived at:

(1) The mean multiplicity $<n_x>$, where (x= b,g,s,h and c) exhibits strong dependence on the target mass with increasing tendency for both experimental as well as FRITIOF generated data sets on 14.5A GeV/c ^{28}Si-nucleus interactions. The values of $<n_b>$, $<n_g>$ and $<n_s>$ obtained closer to the corresponding values are essentially reported by other workers for the case of 4.5A GeV/c ^{28}Si-nucleus interactions.

(2) The η distributions for both experimental and FRITIOF data are well fitted by Gaussian distribution. Similar distributions have also been observed by other workers.

(3) The variations of $<n_s>$ with n_x(x=b,g,h and c) are linear ones and are represented very well by linear fits to the data. It is interesting to mention that n_g and n_c are strongly correlated with $<n_s>$ individually as compared to the correlations of n_b and n_h with $<n_s>$.

(4) It is important to mention that manifestation of strong-short range correlation have been observed at relatively smaller values of the rapidity gaps, r for the experimental and FRITIOF generated data. The rapidity gap distribution for both the data sets are nicely reproduced by the two channel generalization of the Chew-Pignoti model.

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