On Multiplicity Correlations in Relativistic Nuclear Collisions

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Introduction

The main objective behind the study of heavy-ion collisions at relativistic energies is to understand the underlying dynamics of the multiparticle production at these energies. Needless to emphasize, for understanding the dynamics of nucleus-nucleus (AA) collisions, fluctuations in the number of participating nucleons play a vital role. Another important parameter is the time taken by the produced particles in reaching their asymptotic states. If the particles are produced instantaneusly in a collision inside the nucleus, the produced particles have a chance to re-interact with the nuclear medium. However, if the formation time is longer than the nuclear distance, the energy carried by the incident hadron will continue as a unit while passing through the target nucleus[1]. These concepts would give rise to quite different multiplicities of the produced particles. Furthermore, fluctuations in the number of participating nucleons and geometry of nuclear collisions may result in relatively larger fluctuations and random emission. For the experiments at LHC energies, involving collisions of heavier nuclei, random emission may be a dominant process. It has been suggested[2] that the random emission of particles would dominate, particularly in the central region of the rapidity space and the correlation effect, due to some sub-processes, might be suppressed. Correlations amongst particles produced in different pseudorapidity regions, are expected to unviel the secrets of muliparticle dynamics in relativistic nuclear collisions. An attempt is, therefore, made to investigate some fascinating features of the particles produced in the forward ($\theta_s \leq 90^0$) and backwrad ($\theta_s > 90^0$) hemispheres, where θ_s represents emission angle of relativistic charged particles produced in these collisions. For this purpose, data on the collisions of 4.5A and 14.5A GeV/c beams of ^{28}Si-nuclei from Synchrophasotron, Dubna and AGS, BNL with nuclear emulsion respectively are anlyzed.

The behaviour of correlated production of particles due to dynamical reasons, are also analyzed in terms of a parameter, b, which measures the strength of correlation. For this purpose, two symmetric η regions of equal width $\Delta\eta$ about $\pm\eta$ are considered. The number of charged particles in the forward and backward regions, $< N_s^f >$ and $< N_s^b >$, respectively are counted. Parameter ‘ b’, is defined as:

$$b = \frac{D^2{}_{fb}}{D^2{}_{ff}} \qquad (1)$$

where $D^2{}_{ff} =< (N_s^f)^2 > - < N_s{}^f >^2$, $D^2{}_{bb} =< (N_s^b)^2 > - < N_s{}^b >^2$ and $D^2{}_{fb} =< N_s^f N_s^b > - < N_s^f >< N_s^b >$.

Results and discussion

Multiplicity distributions of relativistic charged particles produced in the forward and backward hemispheres in 14.5A GeV/c ^{28}Si-nucleus collisions are displayed in Fig.1.

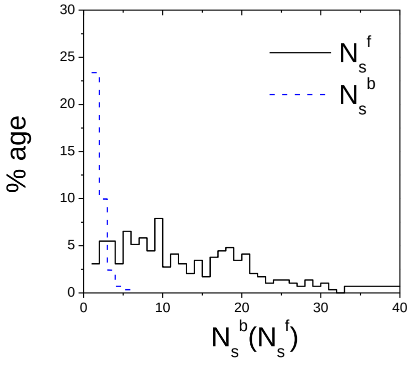

Fig. 1: N_s^b and N_s^f distributions in 14.5A GeV/c ^{28}Si-nucleus collisions.

It is interesting to note from the figure that N_s^f distribution is wider than N_s^b distribution. Further, it may be mentioned that N_s^b distribution[3] is found to be independent of the projectile mass. However, N_s^f distribution is reported[3] to become wider with increasing projectile energy.

Forward-backward muliplicity correlation strengths are estimated by examining the linear dependence of $< N_s^{b(f)} >$ on the event multiplicities in the forward (backward) region, $N_s^{b(f)}$ of the type:

$< N_s^b >$ = **(0.318± 0.0710) + (0.064±0.016)** N_s^f and

$< N_s^f >$ = **(13.373±0.966) +(3.455±0.553)** N_s^b

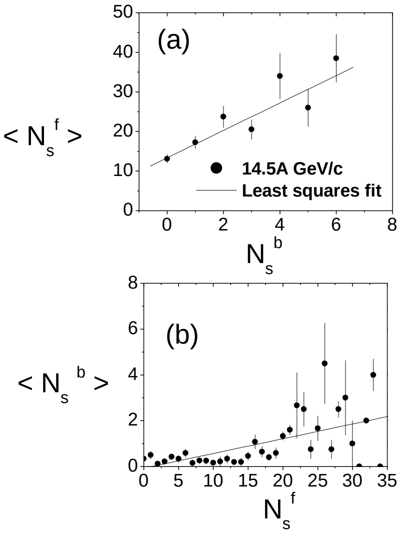

Fig. 2: Variations of $< N_s^b >$-N_s^f and $< N_s^f >$-N_s^b in 14.5A GeV/c ^{28}Si-nucleus collisions.

Fig. 2(a,b) exhibits the variations of $< N_s^f >$ with N_s^b and $< N_s^b >$ with N_s^f. Straight lines in the figures are the least squares fits to the data. It may be pointed out that $< N_s^f > - N_s^b$ correlation is stronger than the $< N_s^b > - N_s^f$ correlation and are reported to be[3] insensitive to the projectile energies.

The strength of the correlations measured by the parameter, b and plotted against width of the window, η_w, are shown in Fig. 3 for 4.5A and 14.5A GeV/c ^{28}Si-nucleus collisions. It is observed that the magnitude of the correlations is quite large for particles lying in the range $\eta_w \geq 1.0$. It may also be noted from the figure that, b increases initially with increasing bin width, η_w, and thereafter, acquires almost constant value beyond η_w ~2.0. Incidentally, our results are in fine agreement with those reported earlier[4] for ^{16}O-AgBr collisions at 60A and 200A GeV energies. Value of b slightly increases with increasing beam energy, particularly in the saturation region, i.e., in the region, $\eta_w \geq 1.5$.

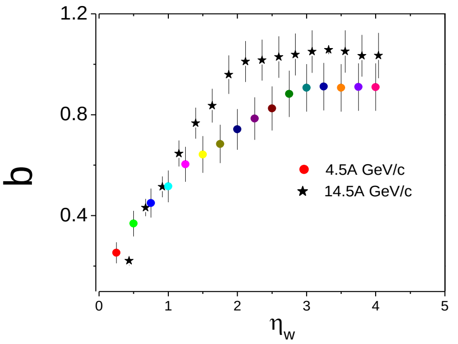

Fig. 3: Variations of parameter, b with width of wndows, η_w in ^{28}Si-nucleus collisions.

Conculsions

The study of some fascinating features of particles produced in the forward and backward hemispheres lead to the following conclusions:

1. Emission of relativistic hadrons in the backward hemisphere play key role in the production mechanism of charged particles in these collisions.
2. $< N_s^f > - N_s^b$ correlation is observed to be stronger than $< N_s^b > - N_s^f$ correlation.
3. The magnitude of the correlation is observed to be quite large in the region of $\eta_w \geq 2.0$ and slightly increases with increasing incident energy.

References

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