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Forward-Backward Multiplicity Correlations in Relativistic Heavy-Ion Collisions

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Abstract: Forward-backward multiplicitycorrelations are investigated by analyzing the experimental data on ^{6}O-AgBr collisions at 14.5A, 60A and 200A GeV/c and the findings are compared with the predictions of Monte Carlo model, HIJING. The findings indicate that the observed correlations are mainly of short-range in nature which arise due to the decay of clusters and (or) resonances produced in the central rapidity region. The result reveal that the range of F-B correlations extend to rather longer range with increasing beam energy which might be due to overall multiplicity fluctuations arising because of nuclear geometry. However, there is no evidence for the presence of long-range correlations even at the highest beam energy considered.

Keywords: Forward-backward multiplicity correlations, Relativistic heavy-ion collisions.

1. INTRODUCTION

Investigation involving correlations amongst the produced particles are regarded as an important tool to understand the particle production mechanism in hadronic and ion-ion(AA) collisions. Both short-range and long-range correlations have been observed in a wide range of incident energies[4]. These observed correlations have been interpreted via the concept of clustering [3]. Various properties of clusters, i.e, their size, width in phase space , etc may be extracted by examining the correlation amongst the nth nearest neighbour [4]. Furthermore, the interest in the study of correlations amongst the particles produced in forward(F) and backward(B) regions has grown considerably because of the idea that the formation of quark-gluon plasma in AA collisions would lead to the modification of clusters characteristics or shortening of correlation length in the pseudorapidity space[6] relative to those in hadron-hadron (hh) collisions[3,5]. Studies involving

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particle correlations are mostly based on short-range correlations. Results from Relativistic Heavy-Ion Collider(RHIC), however indicates that with increasing collision energy these correlations would extend to rather longer range.The long-range correlations, if observed in AA collisions may be taken as a signal for multiple partonic interactions in the dense matter. An attempt is, therefore, made to investigate the forward-backward correlation in AA collisions by analyzing the experimental data involving the interactions of ^{16}O ions with AgBr nuclei in emulsion at 14.5A, 60A and 200A GeV/c. The numbers of events corresponding to these three samples of events are respectively 379, 422 and 223.In order to compare the findings based on the experimental data with the Monte Carlo model, HIJING,event samples matching with the reaL data corresponding to the three energies of events are simulated and analyzed. The events are generated using the Monte Carlo code, HIJING-1.35[1].

2. FORMALISM

F-B correlation strength is estimated by examining the linear dependence of mean charged multiplicity in the B-region, $<n_b>$ on the event multiplicity in the F-region, n_f , of the form $<n_b> = a + bn_f$, where b measures the strength of the correlation.

The values of b may also be estimated using the following relation:

$$b = \frac{<n_f n_b> - <n_f><n_b>}{<n_f^2> - <n_f>^2} = \frac{D_{bf}^2}{D_{ff}^2} \qquad (1)$$

Table 1: Values of correlation coefficient, b at the three energies.

Energy (GeV)		**(Linear Fit)**	$\left(b = \frac{D_{ff}^2}{D_{ff}^2}\right)$
14.5A	Expt.	1.48±0.08	1.43±0.05
	HIJING	1.01±0.03	0.98±0.03
60A	Expt.	1.30±0.05	1.33±0.03
	HIJING	1.10±0.03	1.10±0.03
200A	Expt.	1.21±0.05	1.20±0.05
	HIJING	1.07±0.05	1.12±0.06

Where, D_{ff} and D_{bf} denote forward-forward and backward-forward dispersions respectively.

3. RESULTS AND DISCUSSIONS

The numbers of relativistic charged particles emitted in the forward and backward regions, n_f and n_b respectively are counted on event by event (ebe) basis to estimate the mean multiplicities $\langle n_f \rangle$, $\langle n_b \rangle$ and dispersions, D_{ff} and D_{bf}. It is observed that $\langle n_b \rangle$ varies linearly with n_f for the three data sets considered. The value of b are estimated using Eq. 1 and also from the linear dependence, $\langle n_b \rangle = a + bn_f$. These values are presented in Table 1.

It may be noted from the table that the values of b obtained from the linear fits and from Eq. 1 are nearly the same and indicate the presence of strong short-range correlations (SRCs) in both the real and simulated event samples. It may however, be noted from Table 1, that for the real data the correlation strength, b decreases with increasing energy. However for pp collisions in the centre of mass energy range $\sqrt{S}$ ~200-900 GeV, the values of b have been reported to increase with increasing incident energy [2]. Larger values of b at lower energies, observed in the present study may be due to the uncorrelated emission for which F-B correlations depend on the mean multiplicity and multiplicity fluctuations in the combined F-B regions.

In order to examine the presence of long-range correlations [LRCs], if any, contributions from SRCs are to be eliminated. For this purpose, FB correlations are investigated as adopted at RHIC energies [1]. According to this approach, pseudorapidity(η) windows of small but equal widths are placed in F and B regions such that they are separated by equal gaps(in η units), η_{gap} with respect to centre of symmetry (η_c).

Multiplicities, n_f and nb are then counted by changing the values of η_{gap} from 0 to 2.0 on each side of η_c and the values of b are estimated for each separation. Variations of b with η_{gap} for various data sets are displayed in Fig. 1. It is observed in the figure that for 60A and 14.5AGeV/c data (real and HIJING) the value of b first increases and then suddenly decreases to zero with increasing η_{gap}. This indicates that the correlations present are limited to η-region: $\eta \leq 1.5$ for these data and are of short-range in nature. These correlations are believed to arise due to formation of resonances or clusters in the central pseudorapidity region, the decay products of which would be emitted in both forward and backward regions. However, for 200A GeV/c, ^{16}O-Ag/Br collisions, b acquires almost a constant value ~0.7 until η_{gap}~1.25 and thereafter decreases slowly to ~0.2 with increasing η_{gap}. This observation is not sufficient to consider it as an indication for the presence of some LRC

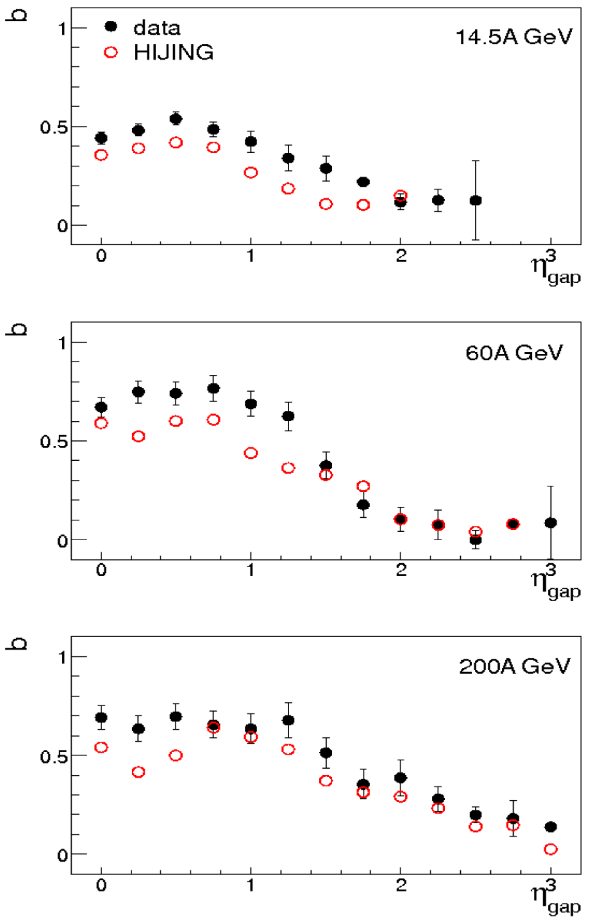

Figure 1. Variations of correlation strength b with η_{gap}, at three incident energies.

but does suggest that the range of F-B correlations characteristically extends with increasing beam energy. It has been argued that the extended range of FB correlations, if observed at higher energies, can be explained from simple statistical considerations of uncorrelated production of charged particles. The observed correlations in this region arise due to overall multiplicity fluctuations; such fluctuations in AA collisions are observed because of fluctuations in nuclear geometry. Values of b for the HIJING simulated events are found to be somewhat smaller in comparison to the corresponding b values obtained from the real data. Some agreement between the experimental and HIJING predicted values in the regions of higher η_{gap} at lower energies might be because of fluctuations arising due to limited statistics. The HIJING model, thus does not predict the presence of LRC even for the 200AGeV data. Incidentally, these findings are in accord with those observed for AA collisions at RHIC energies.

CONCLUSIONS

On the basis of the findings of this study, it may be concluded that the observed F-B correlations are mainly of short-range in nature arising due to the decay of clusters and (or) resonances produced in the central pseudorapidity region. The range of F-B correlations are observed to extend with increasing beam energy. This extended range at larger beam energy might be due to overall multiplicity fluctuations arising because of nuclear geometry. The study of F-B correlation dependence on η-bin width and (or) position reveals that the correlation strength, b, decreases with increasing beam energy. The values of correlation strengths reported at RHIC energies support this idea while HIJING results are in disagreement with the one observed for the experimental data. Finally, it may be stressed that there is no evidence for the presence of LRC in the case of HIJING data.

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