Evidence of Forward–Backward Multiplicity Correlations In Ring Like And Jet Like Events

Mitali Mondal, Soma Biswas Ghosh, Saheli Chowdhury, Dipak.Ghosh and Argha.Deb*

Nuclear and particle Physics Research Centre, Department Of Physics, Jadavpur University, Kolkata-700032, India.

e.mail: argha_deb@yahoo.com

The study of fluctuations and correlations in forward and backward rapidity have become the area of interest in relativistic heavy-ion collisions as it can be used as a useful tools for revealing the mechanism of particle production [1-2]. Correlations studies are important for understanding about the late stages of interactions. Correlations of the produced particles in different rapidity regions may also provide an understanding of the elementary interactions which lead to hadronization. In recent years many works has been performed to investigate the forward-backward multiplicity correlations in high energy nuclear interactions [3].

If we analyze the azimuthal distribution of pions in case of ultrarelativistic heavy ion collisions, it reveals two different classes of substructures, which are referred to as ring-like and jet-like structures [4]. Ring-like structures are occurrences where many pions are produced in narrow regions along the pseudorapidity (η) axis, which are at the same time diluted over whole azimuth (φ) like the spokes of a wheel. On the other hand, jet-like structure consists of cases where particles are focused in both dimensions.

In this paper, we have presented a detailed investigation of two particle rapidity correlations in terms of the dynamical fluctuation observable σ_c^2 in the forward-backward pseudorapidity windows for both ring-like and jet-like events of ^{16}O-AgBr interactions at 60 AGeV. Here we have considered only the produced pions in ring-like and jet-like events. The data used in the present investigation have been arisen from sets of Illford G5 nuclear emulsion stacks exposed to a ^{16}O beam with incident energy of 60 AGeV at the CERN SPS [5] .The ring like and jet like events can be separated using a method adopted by Adamovich et.al [4].

In order to examine the forward backward correlations we have first determined the pseudorapidity distribution of the experimental data of both ring-like and jet-like events. For both the events, the central rapidity (η_c) has same value, i.e. η_c=3. The total pseudorapidity range is divided into two zones with respect to the η_c value. The zone, where the pseudorapidity values are greater than η_c, is referred as the forward zone. On the other hand, the zone where the pseudorapidity values are less than η_c, has been designated as the backward zone. We have again constructed two symmetric pseudorapidity regions in forward and backward zones, where the difference between the minimum value of the pseudorapidity for constructed forward region and maximum value of the pseudorapidity for constructed backward region is noted as η_{gap}. Forward–backward correlations have been investigated [6-7] by calculating the multiplicities of the produced charged particles on an event-by-event basis in the forward and backward windows. For each event, the multiplicity of charged particles falling in the forward pseudorapidity window is compared with that of the backward pseudorapidity window. Let N_f be the multiplicity of the produced charged particles in the forward η window and N_b be the multiplicity of the produced charged particles in the backward η window. In terms of N_f and N_b, a multiplicity asymmetry variable C can be defined as [7]

$$C = \frac{(N_f - N_b)}{\sqrt{(N_f + N_b)}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

The asymmetry variable C is chosen to have particular sensitivity to various types of long-range and short-range correlations [2]. The variance of the charged particle multiplicity in the forward hemisphere has been given as $D_{ff} = <N_f^2> - <N_f>^2$ and similarly for the backward hemisphere, the variance is given by $D_{bb} = <N_b^2> - <N_b>^2$. We have also introduced the covariance of charged particles in both hemispheres by $D_{fb} = <N_f N_b> - <N_f><N_b>$. In terms of D_{ff}, D_{bb} and D_{fb}, the variance of C can be defined as given in [8].

$$\sigma_c^2 = \frac{D_{ff} + D_{bb} - 2D_{fb}}{<N_f + N_b>} \qquad (2)$$

The quantities within angular brackets are event-averaged values. Furthermore, if the multiplicity fluctuations are only of statistical nature, then according to the binomial partitioning of $N_f + N_b$, the value of the σ_c^2 will be ≈ 1. Thus, any deviation in the value of σ_c^2 from unity would be an indication of the presence of dynamical fluctuations [6-8].

We have varied the pseudorapidity separation η_{gap} symmetrically around η_c and have calculated the values of the observable of dynamical fluctuation σ_c^2 according to equation (2) for both ring-like and jet-like events. The values of σ_c^2 for each η_{gap} are listed in table 1. From the table, it is clear that the values of σ_c^2 are significantly greater than 1 for all the values of η_{gap} for both ring-like and jet-like events. This result exposes the forward-backward multiplicity correlations in the pseudorapidity space in ring-like and jet-like events produced in ^{16}O-AgBr interactions at 60AGeV. It is also evident from table 1 that with increasing separation between the forward and backward zone, the values of σ_c^2 increase for both ring-like and jet-like events.

Events	η_{gap}	$\sigma^2{}_c$ (experimental data)	$\sigma^2{}_c$ (Random data)
Ring like $\eta_{centre} = 3$	0	18.254	1.228
	0.2	18.963	1.208
	0.3	19.221	1.155
	0.4	19.902	1.123
	0.5	20.80	1.194
	0.6	21.136	1.231
Jet like $\eta_{centre} = 3$	0	14.174	0.935
	0.2	14.886	0.910
	0.3	15.186	0.969
	0.4	15.289	0.965
	0.5	15.674	0.902
	0.6	16.14	0.887

Table 1: The values of σ_c^2 for ring- like and jet-like events for experimental and random data of produced pions in ^{16}O-AgBr interactions at 60 AGeV

We have repeated the analysis of forward–backward multiplicity correlations with the random data sample for both ring-like and jet-like events and have calculated the values of σ_c^2 for different η_{gap}. The values of σ_c^2 for different η_{gap} for random data sample are also been listed in table1. From the table it is seen that the values of σ_c^2 for the entire random data samples are close to 1. This observation establishes the fact that the observed correlations among the produced pions for both the ring-like and jet-like events are not merely due to statistical origin. Therefore, the correlations can be interpreted as a consequence of dynamical fluctuation present in the multi particle production mechanism of ring-like and jet-like events. From table 1 it can be noted that the values of σ_c^2 remains almost constant with the increase of η_{gap} for both ring-like and jet-like events for random data sample. However, it is interesting to observe that the values of σ_c^2 monotonically increases with the increase of η_{gap} for both ring-like and jet-like events. It implies that the dynamical fluctuation increases with the increase of η_{gap}.

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