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MANY PION DYNAMICAL CORRELATION IN Mg–AgBr INTERACTION AT 4.5 AGeV/c

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This paper presents new data on many particle dynamical correlation among the shower particles produced in ^{24}Mg-AgBr interaction. This study has been done using the cumulative rapidity gap distribution technique. The experimental data have been compared with the Monte Carlo simulated values to look for true dynamical correlation in each case. The correlation effect has been observed in this data.

1. Introduction

During the last few years, considerable studies using well known two particle correlation function were made in hadron-hadron [1], hadron-nucleus [2] and in $\alpha\alpha$, αp, pp interaction at the CERN ISR [3]. Only the two particles spectra has been observed in these studies. The limitation of this method is that only two particles are examined simultaneously and the information about the rest of the particles in the event is disregarded. Correlations where more than two particles are considered can be studied, but the problem becomes more complex as the number of particles increases. The investigations of correlation between produced particles have also been done by studying the distribution of rapidity gaps between particles when the rapidity gaps are differentiated according to the number of particles inside the gap. In this method, not only the two particles forming the gap enter the analysis, but the information about the rest of the events is also considered.

In this paper an extensive analysis has been made of the correlation among particles produced in heavy ion interaction (^{24}Mg–AgBr) at Dubna energy (ie. at 4.5 A GeV/c). We have used the normalized semi-inclusive (ie. for fixed total multiplicity) rapidity gap correlation function which has advantages over the normalized two particle correlation function. This new method has already been published in proton-emulsion [4] and light-ion interaction [5].

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2. Methodology

In general the normalized two particle rapidity gap correlation function can be described as,

$$R(y_1, y_2) = \frac{\rho^{(2)}(y_1, y_2)}{\rho^{(1)}(y_1)\,\rho^{(2)}(y_2)} - 1 \qquad (1)$$

where $\rho^{(1)}(y) = \sigma_{in}^{-1}\frac{d\sigma}{dy}$ and $\rho^{(2)}(y_1, y_2) = \sigma_{in}^{-1}\frac{d^2\sigma}{dy_1\,dy_2}$ are the particle densities. In ratio, the numerator represents the experimental distribution of rapidity gaps and the denominator represents the corresponding distribution if no correlations were present.

In order to eliminate trivial correlation effect, we can now define the normalized semi-inclusive (ie. for fixed total multiplicity) rapidity gap correlation function which depends only on the rapidity difference $| y_1 - y_2 |$. Thus the semi-inclusive ratio is,

$$R_n(\Delta y) = \frac{\int_y \rho_n^{(2)}(y, y+\Delta y)\,dy}{\int_y \rho_n^{(1)}(y)\,\rho_n^{(1)}(y+\Delta y)\,dy} - 1 \qquad (2)$$

The above equation represents the distribution of rapidity gap Δy between the produced particles, where all such gaps contribute, regardless of the number of additional particles that are found inside the gap. There is, however, a basic difference in cases where two particles have a rapidity difference of Δy and where no other particles are found between them compared to the cases where one or more particles were distributed in this rapidity interval. For fixed multiplicity n, ${}_nG_k$ can be defined as the gap-length between two particles having exactly $(k-1)$ particles distributed in the interval between them. Now the ratio between the experimental distribution of rapidity gap ie. ${}_nf_k(G)$ and the corresponding distribution calculated from one dimensional density distribution ie. ${}_n\tilde{f}_k(G)$ can be found in exact accordance with equation (1). Thus,

$${}_nR_k(G) = \frac{{}_nf_k(G)}{{}_n\tilde{f}_k(G)} - 1 \qquad (3)$$

defines the normalised semi-inclusive rapidity gap correlation function of order k.

To avoid large statistical error, the rapidity gap distribution function and the corresponding function with no correlation can be redefined respectively, taking the summation of the contribution from different multiplicities. Hence,

$$F_k(G) = \frac{\sum_{n>k} \pi(n)(n-k)\,{}_nf_k(G)}{\sum_{n>k} \pi(n)(n-k)}$$

and

$$\tilde{F}_k(G) = \frac{\sum_{n>k} \pi(n)(n-k)\,{}_n\tilde{f}_k(G)}{\sum_{n>k} \pi(n)(n-k)}$$

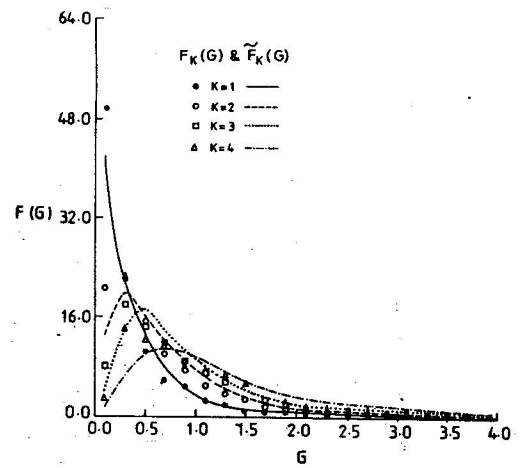

Fig.1

Fig. 1 Plot of many particle rapidity gap distribution function, $F_k(G)$ with G for different orders (k). The curves represent Monte Carlo values.

where $\pi(n)$ is the experimentally determined multiplicity distribution. Thus the inclusive ratio is

$$R_k(G) = \frac{F_k(G)}{\tilde{F}_k(G)} - 1 \qquad (4)$$

3. Results and discussions

For this analysis we have used our own data of ^{24}Mg-emulsion interaction at 4.5 GeV/c per nucleon [6]. The production angles of the charge particle have been measured in this experiment and pseudo-rapidity ($\eta = -\ln\tan\theta/2$) has been used as an approximation of rapidity. To search for the correlation among produced particles, we have compared the experimental data with the data from calculations performed by the Monte Carlo method. In Fig. 1 the gap distribution $F_k(G)$ and $\tilde{F}_k(G)$ as measured in this data are shown for orders $k = 1, 2, 3$ & 4. Here the curve represents the values of the rapidity gap distribution function $\tilde{F}_k(G)$ due to Monte Carlo calculation. We have observed a significant change of shape with the increasing order, specially near $G = 0$. Since for higher order, the probability of finding the other particles between the two particles forming the gap must decrease as the length of the gap decreases, the value of the function drops to zero with the increasing order near $G = 0$. The drop at the other end is nothing but the reflection of the choosen rapidity interval. When we compare the function $F_k(G)$ & $\tilde{F}_k(G)$, we find small but significant deviations indicating correlations for all orders (k).

In Fig. 2 (a,b,c,d) we have plotted the ratio $R_k(G)$ for the same order as in Fig. 1. The data reveals the following interesting features:

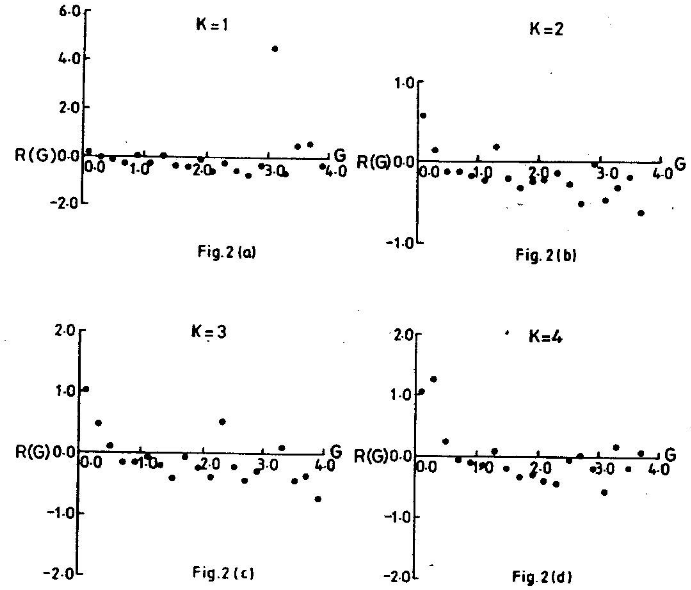

Fig. 2 Many particle correlation function $R_k(G)$ is plotted against G for order $k = 1$ (a), $k = 2$ (b), $k = 3$ (c), $k = 4$ (d).

1) Signal of dynamical correlations for all k which ensures the existence of correlations not only between the neighbouring particles produced in the vicinity.
2) Correlations exist in small as well as large gaps.
3) For $K = 1$, 2 & 4, strong signal for correlation is observed either in small or in large gaps whereas in case of $k = 3$, signal appears in both small and large gaps.

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