Target Excitation Dependence Study of Multidimensional Void Scaling in ^{32}S-AgBr Interactions at 200 AGeV

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The fluctuation of local hadron density in multiparticle production processes implies the formation of spatial patterns that exhibit clusters of hadrons of varying sizes. There are clusters of hadrons separated by regions of no hadrons. The nonhadronic regions between the clusters are coined as the voids.

A lot of studies have been carried out for the second order phase transition of high energy interactions [1]. However, the study of the fluctuation of voids in hadronisation may be useful for finding the observable critical behaviors related to quark-hadron phase transition [2]. Void, as its name implies, is defined as the probability of zero particles in a certain phase space regions. In two dimensional phase space there are regions of high particle density, low particle density or no particle.

Target protons, which are also known as grey tracks in nuclear emulsion, are the low energy part of intra-nuclear cascade formed in high energy interactions. The number of grey particles gives an indirect measure of the impact parameter or the collision centrality. Centrality increases with the number of grey particles (n_g). It is to be mentioned that n_g may be considered as a measure of violence of target fragmentation [3].

Therefore it would be no doubt interesting to study the behavior of pions as a function of n_g, which has been considered as the number of collisions, more generally as a measure of target excitation [4]. In order to get better insight into the inner dynamics of the particle production in high energy nuclear collision, the target excitation dependence of fluctuation of fluctuations in pionisation has been analyzed thoroughly.

This paper intends to study the target excitation dependence of signature of quark-hadron phase transition in high energy collisions following connecting void approach [2] .

In order to find scaling behaviour of voids, binning is required. The bin number dependence provides information on critical behaviour of quark hadron phase transition.

The study is based on the events of ^{32}S-AgBr interactions at 200 AGeV. We have divided the sulphur data into two sets ($0 \leq n_g \leq 5$, $6 \leq n_g \leq 13$) depending on the number of grey particles ($\boldsymbol{n_g}$).

Void in multiparticle production have been defined and analysed following the suggestion of Hwa et al. [2].

As proposed by Hwa if V_k be the sum of the empty bins that are connected to one another by at least one side, then one can define x_k to be the fraction of bins that the k^{th} void occupies as

$$x_k = V_k / M \quad \ldots\ldots\ldots\ldots\ldots (1)$$

For every event thus have a set of void fractions that characterizes the spatial pattern. Since the pattern fluctuates from event-to-event, to perform the comparison of patterns, they first define the moments g_q for each event.

$$g_q = \frac{1}{m}\sum_{k=1}^{m} x_k^q \quad \ldots\ldots\ldots\ldots (2)$$

where the sum is over all voids in the event, and m denotes the total number of voids. The normalized G moments can be define as

$$G_q = g_q / g_1^q \ldots\ldots\ldots\ldots (3)$$

this depends not only on the order q, but also on the total number of bins M. Thus by definition $G_0 = G_1 = 1$. When q and M fixed, G_q fluctuates from event-to-event and is the quantitative measure of the void patterns, which in turn are the characteristic features of phase transition.

The M dependence of the average of G_q over all configurations is,

$$< G_q > = \frac{1}{N}\sum_{e=1}^{N} G_q^{(e)} \ldots\ldots (4)$$

where the superscript e denotes the eth event and N is the total number of events.

If $<G_q>$ versus M in log-log plot shows very good linear behavior, one can write

$$< G_q > \propto M^{\tau_q} \quad \ldots\ldots\ldots\ldots. (5)$$

This scaling behavior implies that voids of all sizes occur at PT. Since the moments at different q are highly correlated, one can expect the scaling exponent, τ_q depend on q as,

$$\tau_q = c_0 + cq \quad \ldots\ldots\ldots\ldots\ldots (6)$$

One would regard equation (6) only as a convenient parametrization of τ_q that allows focusing on c as a numerical description of the scaling behavior of the voids at PT. As suggested by Hwa the value of c ranging between 0.75 and 0.96 may be regarded as signature of quark-hadron phase transition [5].

Hwa also define $S_q = <G_q \ln G_q>$…(7) Here S_q is a measurement of the fluctuation of G_q. If S_q versus M in log-log plot shows good linear behavior, consequently, one may write

$$S_q = M^{\sigma_q} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Here also one expects the scaling exponent, σ_q depend on q as, $\sigma_q = s_0 + sq$.....(9)

Again Hwa proposed the value of s ranging between 0.7 and 0.9 may be regarded as signature of quark-hadron phase transition [5].

We divide the phase space region into a number of bins of ^{32}S-AgBr interactions and calculate the number of voids using connecting bin approach for both data sets.

For both the data sets we calculate the average G_q and then plotted $ln <G_q>$ versus *ln M* in Fig 1. The plots show a linear behavior.

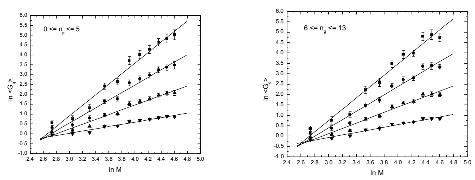

Fig 1: The variation of the $ln < G_q>$ on the *ln M*

We also calculate the S_q and then plotted $ln\ S_q$ versus *ln M* in Fig 2 for both data sets respectively. The plots again show a linear behavior.

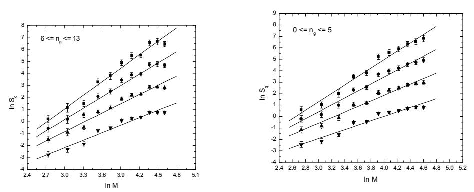

Fig 2: The variation of the $ln\ S_q$ on the *ln M*

From the linear fits of Fig 1 we calculated the value of τ_q from equation (5) and from the linear fit of Fig 2 we calculate σ_q from equation (8). Then we plot τ_q vs. q and σ_q vs. q in Fig 3. Fig 3 shows the dependence of scaling exponent τ_q and σ_q on q which also indicates a good linear behavior.

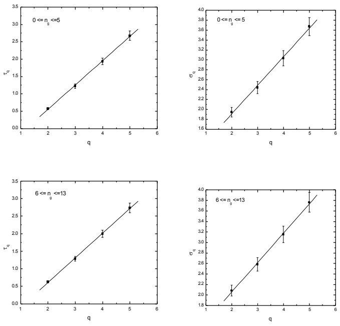

Fig 3: τ_q and σ_q versus q

From the linear fit of the graphs we have obtained the *c* & *s* values and tabulated in table 1.

Table1: Value of *c* & *s*

n_g	c	s
0 <= n_g <= 5	0.701 ± 0.014	0.578 ± 0.022
6<=n_g <= 13	0.704 ± 0.012	0.561 ± 0.018

It is observed from table 1 that the values of c and s for both the data sets are same if we consider the relevant errors. However it may be noted that the values of *c* are more near the values predicted by Hwa et al. [5] but not within the range. Again the values of *s* are less than the predicted values.

As per the prediction of Hwa and Zhang our experimental values suggest that no quark-hadron phase transition of second order have been taken place for both the data sets of ^{32}S-AgBr interactions at 200 AGeV. So we may conclude that void pattern fluctuation for our data does not show any significant dependence on target excitation.

References

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