Study of dynamical net-charge fluctuations in Au+Au collisions in STAR at RHIC

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Introduction

The STAR experiment at Relativistic Heavy Ion Collider (RHIC) investigates the behaviour of strongly interacting matter at high density and searches for the possible formation of Quark Gluon Plasma (QGP). Event-by-event net charge fluctuation has been proposed as one of the indicators of QGP formation in heavy ion collisions. The fluctuation in net charge depends on the squares of the charges present in the system, which depends on the state from which it originates. The system passing through a QGP phase which has quarks as charge carriers, should result in a significantly different net-charge fluctuation as compared to Hadron Gas (HG).

The ratio of the charge fluctuations over entropy is expressed by the quantity D [1, 2], defined as:

$$D = 4\frac{\langle \delta Q^2 \rangle}{\langle N_{ch} \rangle}, \tag{1}$$

where δQ^2 is the variance of net-charge with $Q = N_+ - N_-$ and $N_{ch} = N_+ + N_-$. Here N_+ and N_- are the number of negative and positive particles,measured in specific transverse momentum (p_T) and pseudorapidity (η) window. It has been shown that the value of D is approximately 4 times smaller for QGP as compared to HG.

The event-by-event net-charge fluctuations have been experimentally studied [3, 4] by calculating the quantity $\nu_{+-,dyn}$ defined as :

$$\nu_{+-,dyn} = \frac{\langle N_+(N_+ - 1)\rangle}{\langle N_+\rangle^2} + \frac{\langle N_-(N_- - 1)\rangle}{\langle N_-\rangle^2} - 2\frac{\langle N_- N_+\rangle}{\langle N_+\rangle\langle N_-\rangle}, \tag{2}$$

which is a measure of the relative correlation of $++$, $--$ and $+-$ pairs. The value of $\nu_{+-,dyn}$ is determined using unit bin method i.e., $\nu_{+-,dyn}(m)$ is calculated for each multiplicity, in order to avoid its dependence on the bin width for a given centrality. These values for a given collision centrality are averaged across the selected finite multiplicity interval with the weights corresponding to relative cross section $p(m)$. The value of D has been related to $\nu_{+-,dyn}$ as :

$$\langle N_{ch}\rangle \nu_{+-,dyn} = D - 4. \tag{3}$$

Analysis Details and Results

We report the measurements of net-charge fluctuations as a function of centrality in Au+Au collisions at $\sqrt{s_{NN}}$ = 39 GeV at RHIC with STAR detector. For this analysis, we use charged particle tracks from the Time Projection Chamber (TPC) with transverse momentum in the range $0.2 < p_T < 5.0$ GeV/c for -1.0 $< \eta <$ 1.0. For the centrality selection, uncorrected charged particles multiplicity measured within $0.5 < |\eta| < 1.0$ is used in order to avoid auto-correlation (or self-correlation) between particles of interest and centrality.

Figure 1 represents $\nu_{+-,dyn}$ as a function of centrality for different η windows. In all cases, the magnitude of net charge dynamical fluctuations are observed to be negative. The value decreases while going from peripheral to central collisions involving increased number of

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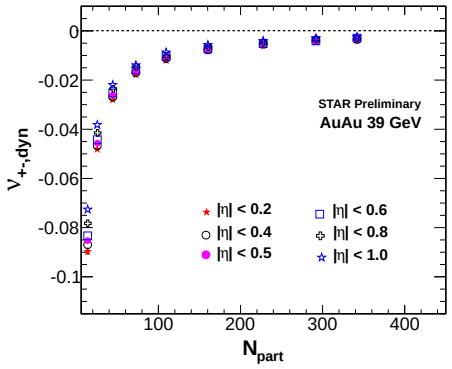

FIG. 1: Dynamical net-charge fluctuations, $\nu_{+-,dyn}$, of charged particles as a function of centrality expressed in terms of the number of participating nucleons.

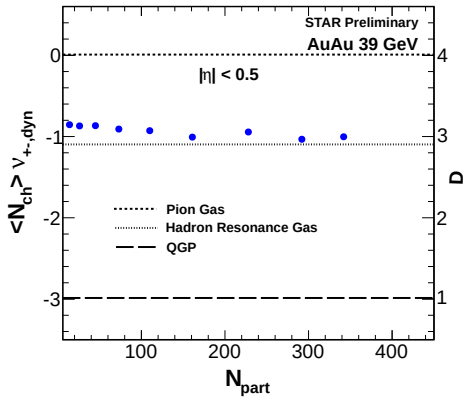

FIG. 2: $\langle N_{ch} \rangle \nu_{+,dyn}$ (left-axis) and D (right-axis) are plotted for $|\eta| < 0.5$ as a function of the number of participating nucleons.

participants. This may be due to a progressive dilution of the correlations with increased number of particle sources if the correlations are dominated by pairs of particles that originate from the same nucleon-nucleon collisions. It increases with decrease in η window for peripheral events i.e., the correlation is strongest for small rapidity intervals and increasingly diluted for larger rapidity intervals, which indicates a shorter correlation length. In Figure 2, the net-charge fluctuations, expressed in terms of $\langle N_{ch} \rangle \nu_{+,dyn}$ and D (left and right axis, respectively) as a function of the N_{part} is shown for $|\eta| < 0.5$ along with the lines indicating the predicted values of fluctuations for three cases: pion gas, HRG and QGP. It is observed that the results are near the Hadron Resonance Gas predictions. We present centrality and η dependence of the dynamical net-charge fluctuations. To understand the physical mechanism behind the measurement, we also compare $\nu_{+-,dyn}$ results to model calculation like a Heavy Ion Jet Interaction Generator(HIJING).

References

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