Dynamical charge fluctuation at FAIR energy

Somnath Ghosh and Amitabha Mukhopadhyay
Department of Physics, University of North Bengal, Siliguri 734 013, India

The Compressed Baryonic Matter (CBM) experiment [1] to be held at the Facility for antiproton and ion research (FAIR) is being designed to investigate the baryonic matter under extreme thermodynamic conditions. The hot and dense matter produced in this experiment will be rich in baryon number. It would be worthwhile to examine how the signatures proposed for identifying and characterizing a baryon free QGP like state behave in a baryon rich environment. Event-by-event fluctuation of net electrical charge and/or baryon number is one such indicator of the formation of the QGP, used and tested in RHIC and LHC heavy-ion experiments. One starts by defining the net charge $Q = (N_+ - N_-)$ and the total charge $N_{ch} = (N_+ + N_-)$ where the quantities N_+ and N_- are respectively, the multiplicities of positively and negatively charged particles. For a QGP like state comprising of fractional charges, the net charge fluctuation will be significantly less compared to an ordinary hadronic gas state. To characterize the net charge fluctuation the D-parameter is introduced as [2]

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

where $\langle \delta Q^2 \rangle$ denotes the variance in net charge. This is a measure of charge fluctuation per unit entropy. However, the measured value of this parameter indirectly depends on the detection efficiency of the detector and is contaminated by the statistical noise. To overcome these limitations the dynamic charge fluctuation

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

devoid of any Poisson type statistical component is introduced. In this letter we report some preliminary results on dynamic net-charge fluctuation in Au+Au collision at an incident energy of $E_{lab} = 30$A GeV using the UrQMD model [3]. A statistics of 0.2 million min. bias events is used.

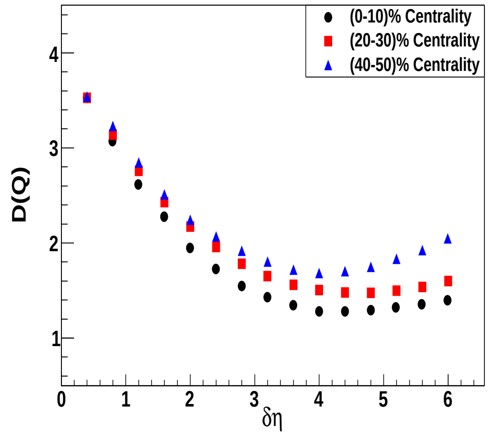

FIG. 1: Variation of D(Q) with size of the η window for different centralities

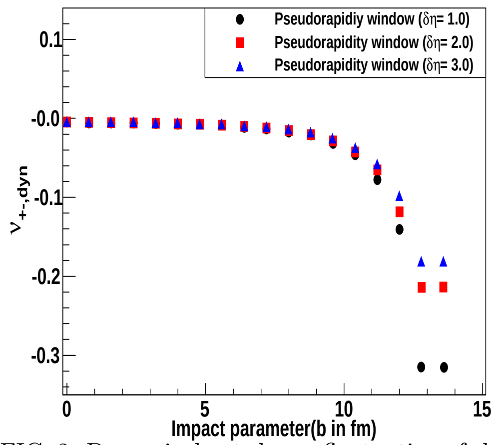

FIG. 2: Dynamical net charge fluctuation of charged particles in Au+Au collisions at $E_{lab} = 30$A GeV.

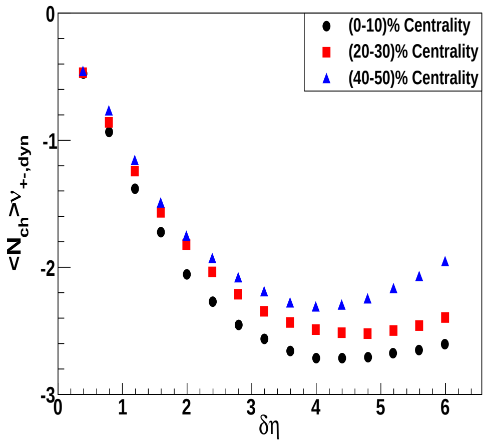

FIG. 3: Plot for $< N_{ch} > \nu_{+-,dyn}$ as a function of $\delta\eta$ at three different centralities

In Fig.1 we plot the D parameter as a function of pseudorapidity (η) window size at three different centralities namely $(0-10\%)$, $(20-30\%)$ and $(40-50\%)$. A strong initial decrease in $D(Q)$ with increasing $\delta\eta$ followed by a somewhat saturation tendency is observed. This kind of measured fluctuations however may get diluted during the evolution of the system from hadronization to kinetic freeze-out because of the diffusion of charged hadrons in rapidity space. Therefore, in Fig.2 we plot the variation of $\nu_{+-,dyn}$ against impact parameter of the colliding nuclei. We have chosen three different (η) windows about the peak value of the distribution namely $\delta\eta = 1.0$, 2.0 and 3.0. The values of $\nu_{+-,dyn}$ are found to be negative indicating a dominance of the correlation between opposite charge pairs. As one moves to the most peripheral events a sharp fall in the $\nu_{+-,dyn}$ value is observed, which is quite similar to the observation of one previous such analysis [4]. In Fig.3 we plot $< N_{ch} > \nu_{+-,dyn}$ against $\delta\eta$ again at three different centralities, the nature of which is more or less similar to that of the $D(Q)$ parameter, and the values are more or less consistent with the relation $D(Q) =< N_{ch} > \nu_{+-,dyn} + 4$ [5]. In Fig.4 we have plotted the ratio of the $< N_{ch} > \nu_{+-,dyn}$ at $\delta\eta$ normalized by its value at $\delta\eta = 0.2$ for the most central $(0-10\%)$ events. The ratio increases monotonically with increasing size of the η window and beyond $\eta = 4.0$ it saturates. This behavior may be due to more re-scattering and resonace decay effects. The results of our analysis at a typical CBM energy as generated by the UrQMD model seems to be consistent with other such heavy-ion induced experiments. No signal of a QGP like state can be inferred from the analysis. However, a more detailed analysis incorporating the correction due to global charge conservation, involving larger statistics, other models and using different colliding systems are necessary.

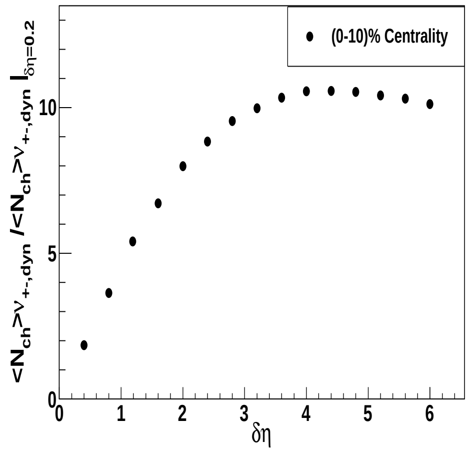

FIG. 4: Plot for $< N_{ch} > \nu_{+-,dyn}$ normalized by its value at $\delta\eta = 0.2$ for most central $(0-10\%)$ events

References

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