Energy and centrality dependence of dynamical charge fluctuation at FAIR energies

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The Compressed Baryonic Matter (CBM) experiment at the Facility for Anti-proton and Ion Research (FAIR) is being designed to investigate the behavior of dense baryonic matter at moderate/low temperature [1]. Pending the real experiment, it would be an worthwhile exercise to use simulation techniques and examine how the signatures proposed to identify and characterize baryon free QCD matter, are expected to behave in a baryon rich environment. One of the striking indicators of the formation of extended QCD matter could be the suppression of fluctuation of conserved quantities on an event-by-event basis, such as the net charge [2]. The fluctuations are expressed in terms of the dynamical charge fluctuation parameter ($\nu_{\pm}^{dyn}$), which is found to be free from any Poisson type statistical component, within a reasonable limit of acceptance is independent of the detection efficiency, and is defined as [3],

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

where, N_+ and N_- are, respectively, the multiplicities of positively and negatively charged particles, and $<>$ represents an average over event ensemble. $\nu_{\pm}^{dyn}$ explicitly depends on the collision centrality expressed either in terms of the no. of participating nucleons (N_{part}), or by the particle number density ($dN_{ch}/d\eta$). Assuming an independent particle production mechanism and considering zero re-scattering effect, the dynamical fluctuation term is expected to scale inversely

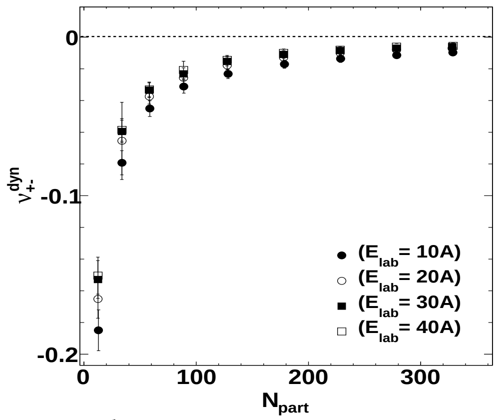

FIG. 1: $\nu_{\pm}^{dyn}$ as a function of participating nucleons within $|\eta| < 0.5$

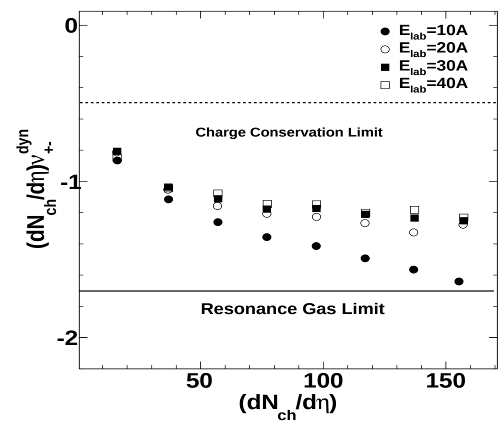

FIG. 2: $(dN_{ch}/d\eta)\nu_{\pm}^{dyn}$ vs. $dN_{ch}/d\eta$

with the centrality of collisions. One can thus infer that the modulus of the quantity $(dN_{ch}/d\eta)\,\nu_{\pm}^{dyn}$ should remain independent of collision centrality. But the STAR experiment reported a violation of such scaling behavior [4]. In this letter, we report the incident energy and centrality dependence of $\nu_{\pm}^{dyn}$ in Au+Au collisions at E_{Lab}=10A, 20A,

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30A and 40A GeV, using min. bias events 10^6 for each, generated by the UrQMD model [5], and examine certain issues that are already investigated at RHIC/LHC. The no. of participating nucleons N_{part} and binary collisions (N_{coll}) are obtained from MC Glauber model. In Fig.1 we present the variation of $\nu_{\pm}^{dyn}$ with N_{part}. $\nu_{\pm}^{dyn}$ is found to be < 0, indicating the dominance of the correlation term of Eq.(2). For all the energies $\nu_{\pm}^{dyn}$ decreases with increasing centrality. This monotonic reduction in fluctuation results from a progressive dilution in two particle correlations arising out of an increase in the no. of sub-collisions involved. Except for very peripheral collisions, $\nu_{\pm}^{dyn}$ almost overlaps with each other at all the four energies considered. The absolute value of $\nu_{\pm}^{dyn}$ is highest at 10A GeV and gradually decreases at higher energies. In Fig.2 we examine the variation of $\nu_{\pm}^{dyn}$ scaled by $(dN_{ch}/d\eta)$ with $(dN_{ch}/d\eta)$. No scaling is however observed. The magnitude of $(dN_{ch}/d\eta)\,\nu_{\pm}^{dyn}$ remains within the charge conservation and hadron resonance gas limits. Except for $E_{Lab} = 10$A GeV data, the magnitude of $|(dN_{ch}/d\eta)\,\nu_{\pm}^{dyn}|$ is smallest for peripheral collisions and increases gradually up to 48 % in central collisions. The 10A GeV data show an increase of almost 85% as we move from peripheral to central region and gradually moves towards the resonance gas limit. In Fig.3 we scale $\nu_{\pm}^{dyn}$ by N_{part} and plot it as a function of N_{part}, which remains almost unchanged for 30A & 40A GeV. On the contrary the 10A and 20AGeV data show monotonic decreasing trend with increasing N_{part}. In Fig.4 we sacle $\nu_{\pm}^{dyn}$ by N_{coll} and plot it against N_{part}. The absolute value of $N_{coll}\,\nu_{\pm}^{dyn}$ is highest and almost same at most peripheral collisions. With increasing centrality the quantity decreases with a saturation effect at highest N_{part}. This tendency though quite similar to the RHIC results, the absolute value of $N_{coll}\,\nu_{\pm}^{dyn}$ is much larger in magnitude than that reported by the STAR collaboration [4]. In conclusion, we can say that except for $E_{lab} = 10$A GeV the observed nature of the centrality dependence of $\nu_{\pm}^{dyn}$ as simulated by UrQMD at FAIR energies, are almost consistent with the RHIC results.

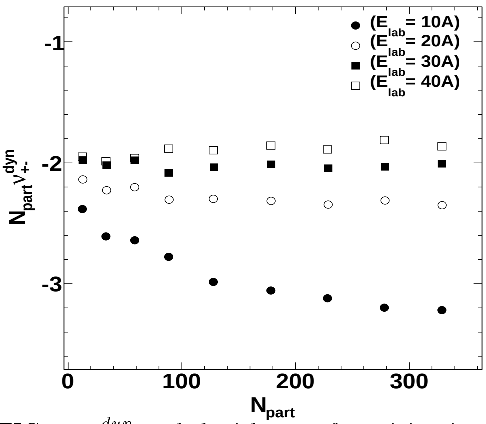

FIG. 3: $\nu_{\pm}^{dyn}$ scaled with no. of participating nucleons N_{part} vs. centrality

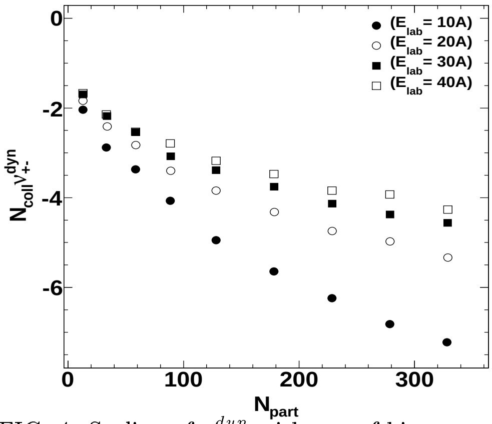

FIG. 4: Scaling of $\nu_{\pm}^{dyn}$ with no. of binary nucleons N_{coll} vs. centrality

References

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