

## Cumulant ratios of conserved quantities at FAIR energy in the UrQMD model

S. Ghosh, P. Mali, and A. Mukhopadhyay\*

Department of Physics, University of North Bengal, Siliguri, Darjeeling 734013

One of the major physics goals of the Compressed baryonic Matter (CBM) experiment to be held at the Facility for Antiproton and Ion Research (FAIR) is to investigate the characteristics of the hot and dense intermediate fireballs that are presumably created in high-energy nucleus-nucleus ( $AB$ ) collisions. As the experimental data on CBM experiment are still awaited, simulation study can help us understand the characteristics of the baryon-rich hadronic/partonic matter present in the fireball [1]. Observables like the cumulants of net-charge distribution are proportional to the correlation length and thermodynamic susceptibility of the system [2]. It is seen that the negative binomial distribution (NBD) can suitably describe the multiplicity distribution [3]. A deviation from the Poisson distribution (PD) increases with increasing acceptance [4]. We here report some preliminary results of a simulation study on the cumulant ratios of the multiplicity distributions of conserved quantities. Out of a million min. bias Au+Au events generated by the UrQMD code [5] at  $E_{\text{lab}} = 30A$  GeV, only the 0-10% most central events are taken for our analysis. Cumulants  $C_{n,N}$  of order  $n$  and multiplicity  $N$  are defined as

$$\begin{aligned} C_{1,N} &= \langle N \rangle, \quad C_{2,N} = \langle (\delta N)^2 \rangle, \\ C_{3,N} &= \langle (\delta N)^3 \rangle, \\ C_{4,N} &= \langle (\delta N)^4 \rangle - 3 \langle (\delta N)^2 \rangle^2 \end{aligned} \quad (1)$$

\*Electronic address: amphys@nbu.ac.in

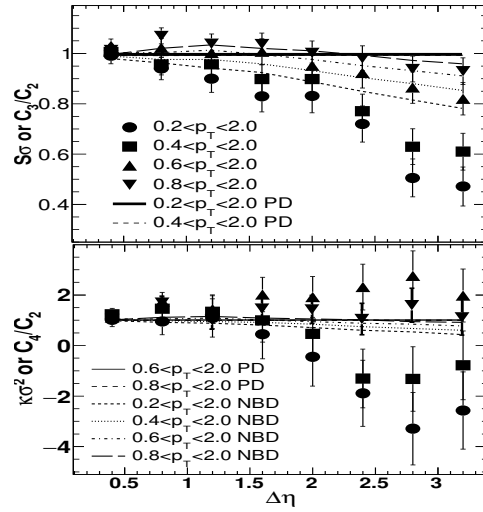


FIG. 1:  $\Delta\eta$  dependence of net-proton cumulant ratios.

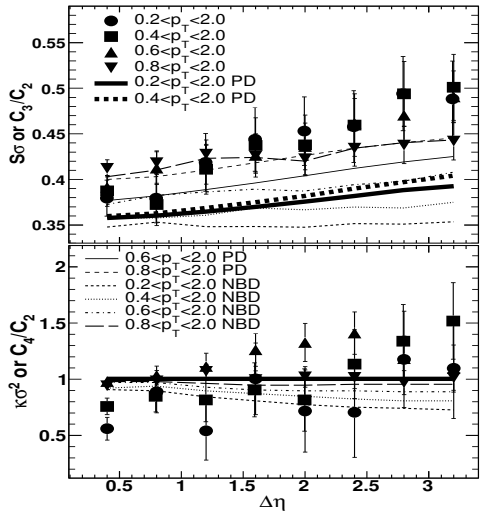
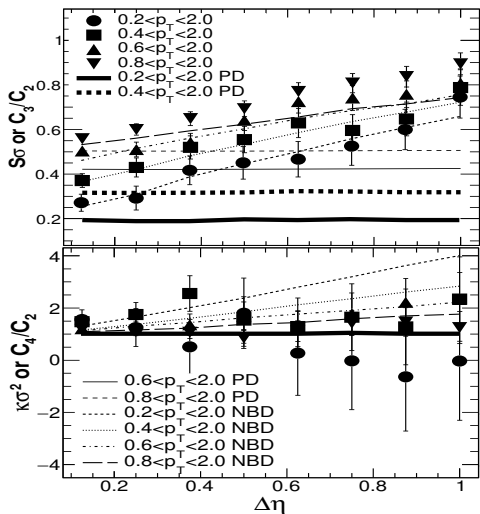
where  $\delta N = N - \langle N \rangle$  is the deviation from the mean value  $\langle N \rangle$ . Once we have these definitions, the moments of the distribution can be denoted as,

$$\begin{aligned} M &= C_{1,N}, \quad \sigma^2 = C_{2,N}, \\ S &= \frac{C_{3,N}}{(C_{2,N})^3/2}, \quad \kappa = \frac{C_{4,N}}{(C_{2,N})^2} \end{aligned} \quad (2)$$

The cumulant ratios are constructed to eliminate the trivial volume dependence

$$S\sigma = \frac{C_{3,N}}{C_{2,N}}, \quad \kappa\sigma^2 = \frac{C_{4,N}}{C_{2,N}} \quad (3)$$

In FIG.1 we plot the cumulant ratios for the net-proton distribution against  $\Delta\eta$  at different  $p_T$  range. The cumulants are modified for the auto-correlation effect [6]. The


 FIG. 2:  $\Delta\eta$  dependence of net-kaon cumulant ratios.

 FIG. 3:  $\Delta\eta$  dependence of net-charge cumulant ratios.

statistical uncertainties are calculated by using the Delta theorem. The  $\Delta\eta = |\eta - \eta_0|$  windows are chosen symmetrically about the centroid  $\eta_0$  of the overall  $\eta$ -distribution. At FAIR energy the antiproton yield is quite low as the proton production is largely influ-

enced by the effect of baryon stopping. So the observed decreasing trend in the ratio  $C_3/C_2$  at higher acceptance is almost similar to that of [4]. On most occasions this ratio remains below unity. However  $C_4/C_2$  ratios are sometimes higher than unity. NBD appears to be a better approximation than the Poisson baseline. In FIG.2 the  $S\sigma$  values show an increasing trend with increasing  $\Delta\eta$  for the net-kaon distribution. Deviations from both NBD and Poisson expectation are observed, particularly at large acceptances. In FIG.3 we plot the  $C_n$  ratios of net-charge distribution as a function of  $\Delta\eta$ . The  $C_3/C_2$  ratio gradually increases with higher acceptance. However, at high  $p_T$  values  $C_3/C_2$  shows a decreasing trend. From all the plots it is evident that at smaller  $\Delta\eta$  we see a better compatibility between the simulated result and the NBD prediction and/or Poisson baseline. In conclusion we can say that the acceptance dependence of the  $C_n$  ratios are better described by the NBD. At higher acceptance however the cumulant ratios deviate from both the NBD and Poisson expectation significantly. Possibly the effect of global conservation principle comes into the picture. A definite conclusion in this regard however requires more involved analysis of both the simulation and experimental data.

## References

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