Event by Event Particle Yield Ratio Fluctuations in Heavy-Ion Collisions at FAIR energies.

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To search for the first order phase transformation from hadronic to partonic degrees of freedom or the critical point is a challenging task in the relativistic heavy ion physics. Lattice QCD calculations show that in the co-existence region of hadronic and partonic degrees of freedom and in the vicinity of critical endpoint event-by-event(ebe) fluctuations in the strangeness to entropy ratio increases significantly[1]. Therefore, investigations involving the energy and system size dependence of observables sensitive to this ratio may provide information about the location of critical endpoint. The energy dependence of inclusive k^+ and π^+ yields, studied in NA49 experiment, exhibit a peak at energies $\sim$ 30-40A GeV[1]. The dynamical fluctuations of π/k ratio has been reported by STAR[2] to decrease with increasing beam energy. Some of their findings are reproduced by URQMD model predictions. This encourages to carry out a systematic study of particle yield ratios and their dependence of system size with changing mean multiplicity in lower energy region but with better experimental resolution, which is one of the goals of future CBM experiment. An attempt is, therefore, made to study the various features particle yield ratios by carrying out Monte Carlo simulations in the framework of URQMD model at energies corresponding to FAIR, i.e. $E_{lab} = 10, 20, 30$ and 40A GeV. The number of events in data sample is $5.0 * 10^6$ and the pseudorapidity(η) and p_T cuts used are $|\eta| < 1.0$ and $0.2 \le p_T \le 1.5$ GeV/c.

ebe relative particle yield are studied in terms of the fluctuation measure, $\nu_{dyn}[A, B]$, defined as[3]:

$$\nu_{dyn} = \frac{< N_+(N_+ - 1) >}{< N_+ >^2} + \frac{< N_-(N_- - 1) >}{< N_- >^2} - 2\frac{< N_+ N_- >}{< N_+ >< N_- >}$$

where N_A and N_B denotes the multiplicities of particles A and B in each event in the considered η and p_T ranges. Since the third term of above equation contains the correlation term, the negative values of ν_{dyn} would indicate the degree of correlation between two particle types. $\nu_{dyn} = 0$ for the production of A and B particles in a statistically indepen-

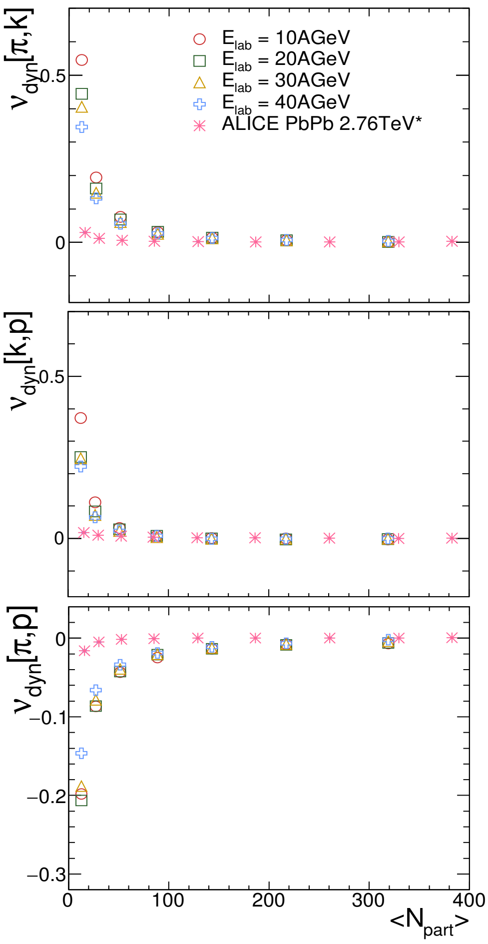

FIG. 1: Variations of ν_{dyn} for π-k, k-p and π-p pairs with number of participating nucleons.

dent way or for Poissonian multiplicity distributions[3].

Centrality dependence of ν_{dyn} for π-k, π-p and k-p are looked into by plotting ν_{dyn} against the number of participating nucleons, N_{part} in FIG.1. It may be observed in the figure that for π-k and k-p, ν_{dyn} acquire positive values for all centrality classes. It is also noted that the trends of variations of ν_{dyn} for π-k and k-p are almost similar and appears to be independent of centrality from the most central to mid-central collisions and thereafter the values of this parameter systematically increases with increasing centrality. There is no significant energy dependence exhibited by the data for all centrality classes. STAR-HSD simulations predicts almost energy independent values of $\nu_{dyn}[k,p]$ in the range, $\sqrt{s_{NN}} = 6.3$-200 GeV for 0-5% centrality. STAR data, however, show that $\nu_{dyn}[k,p]$ is negative and the magnitude increases towards zero with beam energy[4] whereas for π-k fluctuations. $\nu_{dyn}[\pi,k]$ values have been reported to be energy independent.

The values of ν_{dyn} for various hadron pairs obtained from 2.76 TeV Pb-Pb data from the ALICE experiment[3] are also displayed in the figure. It is interesting to note that the values of ν_{dyn} for π-k and k-p from the ALICE data are close to those obtained in the present study for the semi-central and central collisions, while for peripheral collisions values from the ALICE data are quite small.

The values of $\nu_{dyn}[\pi,p]$ are, however tend to be small but positive for semi-central and central collisions, and then change sign and exhibit a systematic decrease from semi-central to peripheral collisions. Similar dependence of this fluctuation measure on collision centrality has been observed with the real data at LHC energy[3]. These findings are in close agreement with those predicted by HSD and URQMD models at RHIC energies and can be attributed to the particular realization of the string and resonance dynamics used in these models as the quarks and gluon degrees of freedom are not included in these models.
Due to intrinsic multiplicity dependence of ν_{dyn}, the values of this parameter are scaled by the charged particle densities at mid-rapidity, $dN_{ch}/d\eta$. Values of $dN_{ch}/d\eta$ are estimated by applying the same η and p_T cuts. Almost energy and system size independent values of the quantity, $\nu_{dyn} \times dN_{ch}/d\eta$ for the three pairs of hadrons are observed. Similar findings have been reported by ALICE collaboration for 2.76 TeV Pb-Pb data. The obsreved trend is expected if a superposition of independent source is assumed, e.g. in wounded nucleon model.

References

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