Study of Event-by-Event correlations of charge, baryon number and strangeness in heavy-ion collisions

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Introduction

The primary goal of heavy-ion collisions at ultra- relativistic energies is to explore the signatures of a state of mater in which quarks and gluons are deconfined over a larger space than that of hadron, called Quark-Gluon-Plasma (QGP) state. In past few decades several observables have been proposed and studied to characterize the QGP state. Event-by-event fluctuations and correlation of conserved charges in limited phase space have been widely accepted as one of the most promising signals of the QGP state. Theoretical calculation shows that the event-by-event baryon-strangeness correlation coefficient C_{BS} is a tool to specify the nature of matter created in heavy-ion collision [1][2][3][4].
The correlations between baryon-strangeness, charge-strangeness, charge-baryon have been studied with a string-hadroic transport model (UrQMD) for Au+Au collisions from $\sqrt{S}_{NN}$ = 4.0 GeV to 200 GeV.

Formalism and results

The correlation between two conserved charges are defined by

$$C_{XY} = \alpha \frac{\langle XY \rangle - \langle X \rangle \langle Y \rangle}{\langle Y^2 \rangle - \langle Y \rangle^2} \qquad (1)$$

Where X, Y are the net values of the conserved charges in a given event and α is the coffecient constant [1][2].

Here the correlation coefficient between baryon-strange, charge-strange and charge-baryon have been measured with the ultra-relativistic quantum molecular dynamics model (UrQMD v3.3).
The UrQMD model simulates the non-equilibrium microscopic transport of covariant propagation of quarks and di-quarks with hadronic degrees of freedom with the full space-time evolution. This model helps to explore various resonances and their decay along with re-scattering among hadrons.

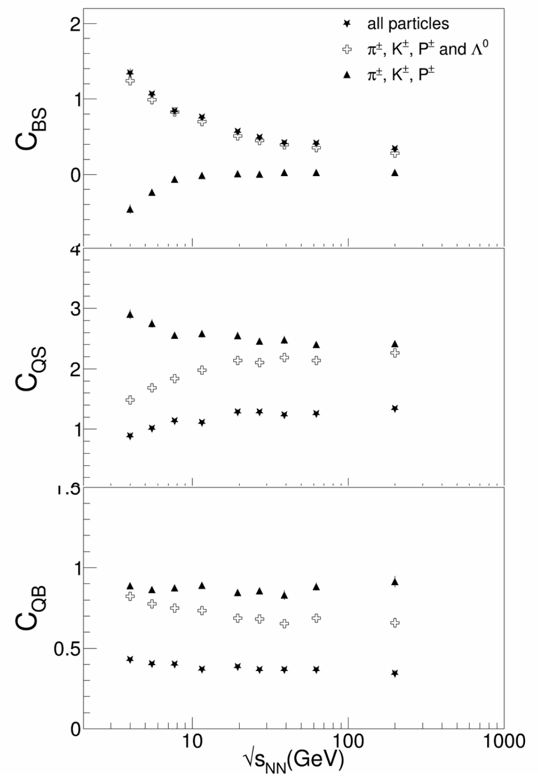

FIG. 1: Correlation coefficient C_{BS}, C_{QS} and C_{QB} for central Au+Au collisions as a function of $\sqrt{S_{NN}}$ (for all three sets). The particles are counted within $|\eta| < 0.5$. The statistical errors are within the size of the symbol.

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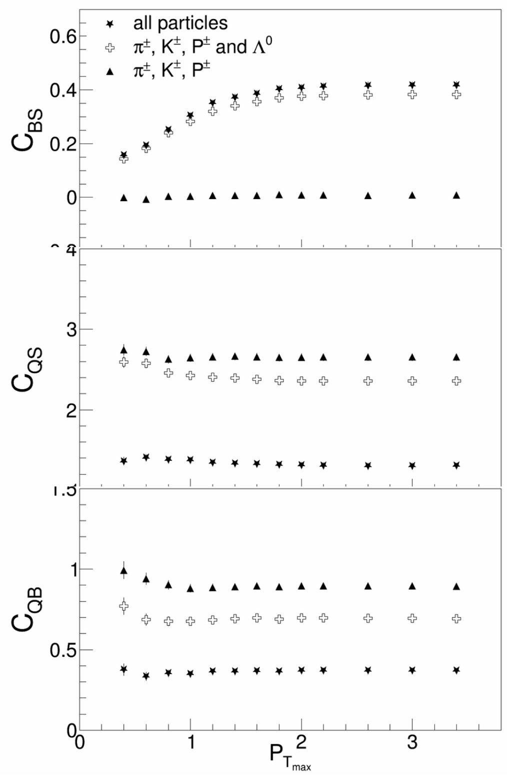

FIG. 2: Correlation coefficient C_{BS}, C_{QS} and C_{QB} for central Au+Au collision as a function of $P_{T_{max}}$ (for all three sets) for $\sqrt{S_{NN}} = 39$GeV. The particles are counted within $|\eta| < 0.5$. $P_{T_{min}} = 0.2GeV/c$.

In the present study, the UrQMD model has been used to simulate Au+Au collisions at various collision energies at time 100 fm/c after the collision. We have taken three different sets, 1^{st} one is taking all resonance particles. In 2^{nd} case we take charged pion, kaon, proton and lambda zero. and in 3^{rd} case we take only charged pion, kaon and proton. Fig. 1 shows the values of C_{BS}, C_{QS} and C_{QB} in different beam energies. As discussed in Ref. [1], C_{BS} increases while an increase of the baryon chemical potential μ_B when going to lower energies.

Here we get the similar trend with first two sets, with decreasing collision energy (i.e, increasing μ_B) C_{BS} goes down to $C_{BS} \approx 0.35$ at the highest RHIC energy available. But in case of last set we get zero C_{BS} value for higher energies and negative correlation values between baryon-strangeness for lower energies. The variation of C_{QS} for first two cases is similar as a function of beam energy but the value in first cases is nearly half than that of second case. This is mainly because we missed K^0 and $\bar{K^0}$ in 2nd case. Similarly for C_{QB}, here we missed the neutron in 2nd case.
Fig. 2 shows the variation of C_{BS}, C_{QS} and C_{QB} in different $P_{T_{max}}$ acceptance.

Summary

We have studied different correlation coefficients between different conserved charges as a function of the center-of-mass energy from $\sqrt{S_{NN}} = 4$GeV to 200 GeV and as a function of $P_{T_{max}}$ (for 39GeV) at time 100fm/c time steps using UrQMD model for Au+Au 0-5% central collisions. C_{BS} is found to decrease from the lower energies toward the higher energies for first two cases. C_{QS} increases slightly with beam energy in set I and set II but the value in set II is nearly double than that of set I. We also found that C_{QB} does not vary much with energy in all the three cases and here also the values of set II is double than that of set I. This is mainly because of neutron.

Acknowledgments

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