Search for the QCD critical point by the higher moments of the net-charge and net-proton multiplicity distribution in STAR Experiment at RHIC

Nihar Ranjan Sahoo (for the STAR Collaboration)*
Variable Energy Cyclotron Center, Kolkata, INDIA

Introduction

The Beam Energy Scan program has been undertaken at the Relativistic Heavy Ion Collider (RHIC), at BNL, to search for the QCD critical point (CP). This program covers the wide range of colliding energies corresponding to the baryon chemical potential ranging from 20 MeV to 410 MeV [1] in the QCD phase diagram . Figure 1 is our current understanding of the QCD phase diagram. Close to $\mu_B = 0$, according to Lattice QCD calculations, a cross over from hadronic state to a state where the relevant degree of freedom is partonic. The characteristic signature for the CP is the divergence of the thermodynamic susceptibilities of conserved quantities like net-charge, net-baryon, net-strangeness [2] and the correlation length(ξ)[3]. These quantities are related to the higher moments (standard deviation, skewness and kurtosis) of the event-by-event distribution of the above conserved quantities. The variance, skewness and kurtosis are related to ξ^2, $\xi^{4.5}$ and ξ^7[3] respectively. The presence of the CP is expected to lead to non-monotonic behavior of the above higher moments and their products as a function of the beam energy [3].

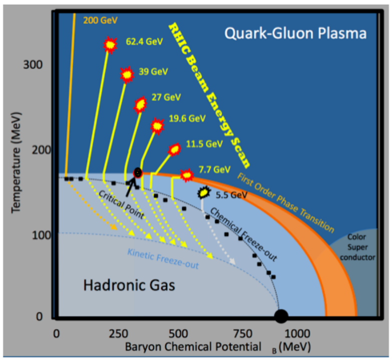

FIG. 1: Schematic representation of the QCD Phase Diagram. The location of the critical point, the separation between the 1st-order transition and chemical freeze-out, and the focusing of the event trajectories towards the critical point are chosen to illustrate plausible possibilities.

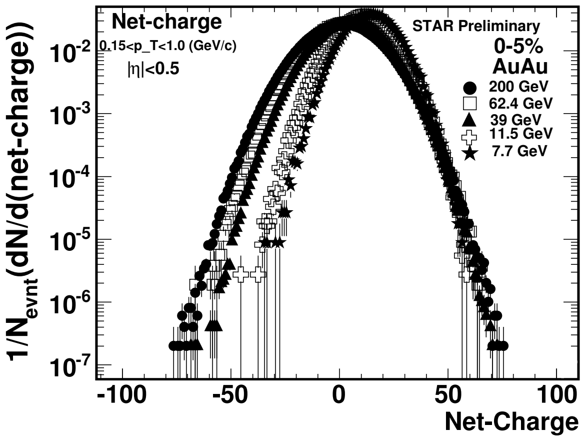

FIG. 2: The event normalized net-charge multiplicity distribution for 0-5% central events of Au+Au collisions at colliding energies 200 GeV (filled circle), 62.4 GeV (rectangle), 39 GeV (filled triangle), 11.5 GeV (cross) and 7.7 GeV (filled star).

Analysis Details and Results

The STAR experiment provides the excellent particle identification and large acceptance for the event-by-event fluctuation analysis. The Time Projection Chamber (TPC)

*Electronic address: `nrsahoo@veccal.ernet.in`

is the main tracking device. For the better particle identification efficiency, Time of Flight (TOF) detector is used. The TPC detector is used to identify the charged particles within full azimuthal angle and ± 1.8 unit of pseudo-rapidity (η). For the centrality selection, uncorrected charged particles multiplicity measured within $0.5 < |\eta| < 1.0$ from the TPC is utilized to avoid auto-correlation effect in the net-charge higher moments calculation. To get the average number of participant ($< N_{part} >$) for each centrality, Glauber model calculation is done.

We report on the STAR results of the higher moments of net-charge, net-proton distribution and the products of their higher moments for Au+Au collisions at $\sqrt{(s_{NN})}$ ranging from 7.7 to 200 GeV. The charged particles in low transverse momentum $0.15 < pT < 1.0$(GeV/c) and $|\eta| < 0.5$ region are measured. Figure 2 shows the net-charge multiplicity distribution for the Au+Au collisions at various colliding energies. The protons and anti-protons are measured in rapidity ($|y| < 0.5$) and low transverse momentum ($0.4 < pT < 0.8$ GeV/c). The energy dependence of the 0-5% central events of the $S\sigma$ and $\kappa\sigma^2$of the net-charge multiplicity distribution are compared with the Hadron Resonance Gas (HRG) model[4], and that of the net-proton results are compared with the HRG and Lattice gauge theory calculation[5].

References

[1] J. Cleymans et al., Phys. Rev. C 73, 034905 (2006).

[2] M. Cheng et al., phys. Rev. D 79, 074505 (2009).

[3] M.A. Stephanov, Phys. Rev. Lett. 102, 032301 (2009).

[4] F. Karsch and K. Redlich, Physics Letters B 695 (2011).

[5] R. Gavai and S. Gupta, Phys. Lett. B (2011).