



Contribution ID: 6

Type: not specified

Higher moments of net kaon multiplicity distributions at RHIC energies for the search of QCD Critical Point

The Relativistic Heavy-Ion Collider (RHIC), at BNL, has started its beam energy scan (BES) program by colliding heavy-ions extending the reach in baryonic chemical potential upto 400 MeV. One of the main goals of this beam energy scan program is to locate the critical point which is postulated to lie at the end of the phase transition boundary between partonic and hadronic matter. Finite temperature lattice QCD calculations at baryon chemical potential $\mu_B = 0$ suggest a crossover above a critical temperature $T_c \sim 170 - 190$ MeV from a system with hadronic degrees of freedom to a system where the relevant degrees of freedom are quarks and gluons. Several QCD based calculations find the quark-hadron phase transition to be first order at large μ_B . The point in the QCD phase plane (T vs μ_B) where the first order phase transition ends is the QCD critical point (CP). In a static, infinite medium, the correlation length (ξ) diverges at the CP. ξ is related to various moments of the distributions of conserved quantities such as net baryons, net charge, and net strangeness [1]. Typically variances ($\sigma^2 = (\Delta N)^2$; $\Delta N = N - M$; where M is the mean) of these distributions are related to ξ as $\sigma^2 \propto \xi^2$ [2]. Finite size and time effects in heavy-ion collisions put constraints on the values of ξ . A theoretical calculation suggests $\xi \approx 2 - 3$ fm for heavy-ion collisions [2, 3]. It was recently shown that higher moments of distributions of conserved quantities, measuring deviations from a Gaussian, have a sensitivity to CP fluctuations that is better than that of σ^2 , due to a stronger dependence on ξ [2, 3, 4]. The numerators in skewness ($S = (\Delta N)^3 / \sigma^3$) go as $\xi^{4.5}$ and kurtosis ($k = [(\Delta N)^4 / \sigma^4] - 3$) go as ξ^7 [5]. Presence of a Critical Point might result in divergences of the correlation lengths.

Here we report the measurements of the various moments (standard deviation (σ), skewness (S) and kurtosis (k)) and their products ($k\sigma^2$, $S\sigma$) of the net kaon multiplicity measured by the STAR detector at mid-rapidity for Au+Au collisions at $\sqrt{s_{NN}} = 7.7$ to 200 GeV center of mass energies. The energy and centrality dependence of higher moments of net-kaons and their products (such as $S\sigma$ and $k\sigma^2$) will be presented in all BES energies. Theoretical calculations, containing the non-CP physics from the HIJING, AMPT, UrQMD models will be compared to the data.

References

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