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Beam energy dependence of specific heat in Ultra-relativistic Heavy-Ion Collisions

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Experiments at RHIC and LHC are on the quest to unearth the nature of the QCD phase transition and to get a glimpse of how matter behaves at such extreme conditions. Phase transitions are governed by a set of thermodynamic parameters, like, temperature (T), pressure, entropy and energy density (E), and can be further characterized by their response functions, like, specific heat,compressibility, and susceptibility. In thermodynamics, the heat capacity (C) is defined in terms of the ratio of the event-by-event fluctuations of the energy of a part of a finite system in thermal equilibrium to the energy $(\Delta E^2) = T^2 C(T)$. This can be applied for a locally thermalized system produced during the evolution of heavy-ion collisions. But for a system at freeze-out, specific heat can expressed in terms of the event-by-event fluctuations in temperature of the system where volume is fixed: $\frac{1}{C} = \frac{(\langle T^2 \rangle - \langle T \rangle^2)}{\langle T \rangle^2}$. We define the specific heat as the heat capacity per pion multiplicity within the experimentally available phase space in rapidity and azimuth. For a system in equilibrium, the mean values of temperature and energy density are related by an equation of state. However, the fluctuations in energy and temperature have quite different behavior.
Energy being an extensive quantity, its fluctuations have a component arising from the volume fluctuations, and not directly suited for obtaining the heat capacity. Here, we obtain the specific heat for heavy-ion collisions at SPS, RHIC beam energy scan energies and for LHC energy. Experimental results from NA49, STAR, PHENIX, PHOBOS and ALICE are combined to obtain the specific heat as a function of beam energy. The results are compared to results from AMPT event generator, HRG model and lattice calculations. We also present local hot spot search at LHC energy for better understanding the collision dynamics.

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