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Fluctuations and event-by-event determination of temperature and baryochemical potential at NICA energy

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One of the primary research objectives of the MPD experiment [1, 2] at the NICA collider is to scan the phase diagram of strongly interacting matter, study the phase transition between hadronic gas and quark-gluon plasma (QGP), and search for the critical point. To achieve this, various fluctuation and correlation observables are employed.

The process of nuclear collisions and the evolution of the produced QGP medium within the NICA collider energy range is highly complex, with the achieved thermodynamic equilibrium being only local. All thermodynamic characteristics of the medium exhibit inevitable event-by-event fluctuations. These fluctuations can arise both from variations in the medium volume (related to centrality selection and the choice of robust observables) and from fluctuations in other thermodynamic characteristics. Consequently, selecting events based on temperature (T) and baryon chemical potential (μ_B), and establishing the precision with which these characteristics (at the freeze-out stage) can be determined on an event-by-event basis, is of significant interest.

The Thermal-FIST package [3] was applied for the event-by-event extraction of thermodynamic characteristics and their uncertainties in heavy-ion collisions for different centrality classes. The resolution of this method for temperature and baryochemical potential was calculated across a broad range of T and μ_B. On average, the resolution was found to be at the level of 15%. The consistency of the method was also verified in terms of the adequacy of the predicted uncertainties.

The method was applied to the SMASH [4] and EPOS4 [5] Monte Carlo generators. It was demonstrated that the EPOS4 model corresponds to a statistical freeze-out scenario with fixed (T and μ_B), whereas SMASH exhibits additional temperature fluctuations. A scheme for determining fluctuations in T and μ_B in real experimental data has been developed.

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