Deuteron number fluctuations and proton-deuteron correlations in high-energy heavy-ion collisions in STAR experiment at RHIC

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The production mechanism of deuterons, which have a binding energy of 2.2 MeV, is a topic of current interest in high-energy heavy-ion collisions, where the system undergoes kinetic freeze-out at temperatures around 100 MeV. Two possible scenarios include (a) statistical thermal process and (b) coalescence of nucleons. Cumulants of deuteron number distributions and proton-deuteron correlations are sensitive to these physics scenarios. In addition, they are also sensitive to the choice of canonical versus grand canonical ensemble in statistical thermal models.

We report the first systematic measurements of collision energy and centrality dependence of cumulants (up to fourth order) of deuteron number distributions in Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7, 11.5, 14.5, 19.6, 27, 39, 54.4, 62.4, and 200 GeV. We will also discuss new measurements on proton-deuteron correlations. The measurements are performed in the STAR experiment at mid-rapidity ($|y| < 0.5$) and within transverse momentum range $0.8 < p_T(\mathrm{GeV}/c) < 4.0$, using Time Projection Chamber and Time-of-Flight detectors. The experimental results are compared to the statistical thermal model calculations with a grand canonical, canonical ensemble, and the UrQMD model that incorporates the coalescence of nucleons close by in space and momentum to form deuterons. These theoretical comparisons with the experimental measurements provide key insights into the mechanism of deuteron production in high-energy heavy-ion collisions.