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Probing the QGP to Hadron-Gas Phase Transition with Charge, Strange, and Baryon Balance Functions

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Charge balance functions (BFs) were introduced at the beginning of the RHIC era as a tool to investigate the evolution of particle production in heavy-ion collisions and identify the presence of delayed hadronization as an indicator of the formation of long lived isentropic expanding quark gluon plasma in high-energy nucleus-nucleus (A–A) collisions. It later emerged that BFs are rather sensitive to the radial expansion dynamics of the matter formed in these collisions and can, in principle, be used to probe hadron production mechanisms such as the formation of clusters. Later still, it was found that the azimuthal dependence of hadrons BFs, particularly heavier hadrons, is sensitive to the diffusivity of light quarks. In this work, we show how the conservation of quantum numbers can be properly accounted for and how cross-species BF can be exploited to determine the relative strengths of distinct species pairs from heavy hadron decay feeddowns, long range correlations arising at the onset of collisions, and contributions from baryon stopping. We addtionally examine the possibility of probing the degree of equilibration achieved in A–A collisions (at both RHIC and LHC energies) as well as the evaluation of QGP susceptibilities by means of measurements of charge, strange, and baryon BFs. We show that baryon BFs, in particular, may enable a detailed assessment of baryon stopping. This work is based on Monte Carlo simulations performed in a variety of models and provides a road map for future studies at the LHC based on detector upgrades such ALICE 3.

Category

Experiment

Collaboration (if applicable)

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