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Shedding light on quark flavor balancing in nuclear collisions

Two-particle correlation functions of hadrons are sensitive to mechanisms of particle production and transport in elementary particle collisions. The production of quarks is determined by coupling terms of the QCD Lagrangian. These nominally conserves quark flavors in addition to energy, momentum, and electric charge: flavor currents are conserved at the level of quarks and gluons. The production of quarks with flavor f must then be balanced by the production of anti-quarks with anti-flavor f. Given flavor conversion $\mathrm{f} \rightarrow \mathrm{f}'$ is governed by \emph{weak} interaction processes, one can expect that the hadrons produced in the final state of A-A collisions is also flavor balanced. Indeed, one expects that the breaking of flavor balancing should be approximately limited to weak processes occurring on a time scale longer than the lifetime of the QGP produced in A–A collisions. That implies that one can study competing processes of particle production and their subsequent transport based flavor correlation functions. Charge and strangeness balance functions have been measured at SPS, RHIC, and LHC. In this phenomenological study, the usefulness of flavor balancing measurements based on two-particle correlation functions is explored based on simulations of proton-proton (pp) collisions at $\sqrt{s} = 13.6$ TeV with the PYTHIA 8.3 event generator. Flavor balancing is studied with a broad variety of hadron pairs, such as $\pi^+\pi^-$, $\mathrm{K}^+ - \mathrm{K}^-$, $\Lambda - \bar{p}$, $\Lambda - \bar{\Lambda}$, etc, to explore dependencies, in particular, on the number of balanced flavors in produced hadrons.

PYTHIA describes the phenomenology of particle production in nuclear collisions with 2-to-2 parton scattering, multiple partonic interactions (MPI) and Lund String Fragmentation. Additional processes involving Color Reconnection and Rope Hadronization have also been incorporated to better explain the experimental data observed in collider experiments. This work explores the effects of the MONASH tune with MPI Color Reconnection on the the normalized two-particle number cumulant R_2, computed for several hadron pairs, as a function of the multiplicity of pp collisions. It is found that the amplitudes of the R_2 hadron correlation functions increases monotonically with the number of balanced flavors in both minimum bias and multiplicity dependent analyses. Mapping Pythia particle production mechanisms to the results of this study will shed light on the actual mechanisms in place in nuclear collision.

Category

Theory

Collaboration (if applicable)

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