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General Balance Functions of $\pi^{\pm}$, $K^{\pm}$ and $p/\bar{p}$ in Pb–Pb Collisions at the LHC

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In relativistic heavy-ion collisions, correlations of particles with opposite quantum numbers provide insight into general charge creation mechanisms, the time scales of quark production, collective motion of the Quark Gluon Plasma (QGP), and re-scattering in the hadronic phase. The longitudinal and azimuthal widths of general charge balance functions for charged pion ($\pi^{\pm}$), kaon ($K^{\pm}$) and (anti-)proton ($p/\bar{p}$) are used to examine the two-wave quark production scenario recently proposed to explain quark-antiquark productions within the QGP, which predicts a large increase in up and down quark pairs relative to strange quark pairs around the time of hadronization. In addition, the magnitudes of balance functions for different species pairs provide quantitative differential information on pair production channels, which probes the fragmentation mechanism of strings into different quark flavors.

The first measurement of balance functions of the full species matrix of $\pi^{\pm}$, $K^{\pm}$ and $p/\bar{p}$ in Pb–Pb collisions at $\sqrt{s_{\rm NN}} = 2.76$ TeV at the LHC is presented, which provides critical information about the QGP hadronization chemistry in two dimensions of relative rapidity (Δy) and relative azimuthal angle ($\Delta\varphi$). The balance function results provide key constraints on particle productions in theoretical models. The first balancing charge yield results show the balancing pair production probabilities, which indicate the QGP hadronization chemistry may have little centrality dependence. The widths of balance function projections onto Δy and $\Delta\varphi$ of different species pairs show different trends as a function of collision centrality, which are qualitatively consistent with the two-wave quark production scenario and the radial flow effect.

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