Enhancement in the rapidity width of Λ in pp and heavy-ion collisions at the LHC energies

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Introduction

Rapidity width of the produced particles is one of the important global observables of heavy-ion collisions that provides information about the final state re-scattering, longitudinal dynamics, velocity of sound, etc., and is reported to follow a mass ordering [1, 2]. Recent study [3] on rapidity widths at Alternating Gradient Synchrotron (AGS) and low Super Proton Synchrotron (SPS) energies revealed that the rapidity widths of the emitted particles also depends on the quark contents of hadrons. A clear enhancement in the width of the rapidity distributions of Λ has been observed, which was attributed to the net baryon density distribution effect. A separate mass ordering for mesons and baryons have been proposed in Ref. [3]. The rapidity distribution of Λ (uds) containing two leading quarks (but not $\bar{\Lambda}$ ($\bar{u}\bar{d}\bar{s}$)) tends to follow the net baryon density distribution. Further, net baryon density distribution depends on the transparency of the collisions and thus the evolution of the rapidity widths of various mesons and baryons from RHIC to the Large Hadron Collider (LHC) energies are expected to carry some important information about the role of the net baryon density distribution on the rapidity widths.

Further, for pp collisions at the LHC energies, the colliding protons are considered not only to be composite but also extended objects consisting of many partons [4]. In such a situation, the role of the spectator partons of the collisions on the widths of the rapidity distributions of various mesons and baryons, particularly on Λ might provide more insight into the particle production mechanism. In this report an attempt has therefore been made, to measure the widths of the rapidity distributions of the emitted particles in pp and Pb-Pb collisions with PYTHIA8 and UrQMD-3.4-generated data respectively to investigate if the dependence of the net baryon density distribution is a general characteristic of rapidity distribution in pp and heavy-ion collisions.

Results and discussions

For the present study, the events for Pb–Pb collisions were generated with Ultra-relativistic Quantum Molecular Dynamics (UrQMD) event generator, whereas pp events

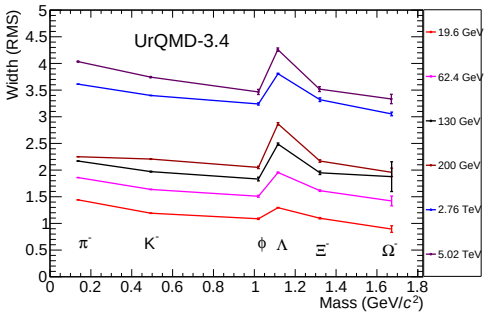

FIG. 1: Widths of the rapidity distributions of various mesons and baryons as a function of their rest masses in heavy-ion collisions at various RHIC and LHC energies (Phys. Rev. C. 96, 024903 (2017)).

were generated with PYTHIA8 Monash tuned event generator. While the UrQMD model generated (pseudo)rapidity distributions of all primary charged particles remains successful to describe the experimental results of Pb-

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Pb data at $\sqrt{s_{NN}}$ = 2.76 TeV, PYTHIA-generated data agrees well with the experimental data of pp collisions at the LHC energies, as reported in our recent works [5, 6].

From Fig. 1 it could be readily seen that the widths of the rapidity distributions of various hadrons decrease with increasing rest masses and show a sudden jump at Λ for all the studied energies. This non-trivial jump could be explained from Fig. 2, where the net baryon density distribution shows an enhancement at the extreme rapidities due to the high transparency of the Pb–Pb collisions at the LHC energies and the rapidity distribution of Λ (uds), but not $\bar{\Lambda}$ ($\bar{u}\bar{d}\bar{s}$) tends to follow the net baryon ($B-\bar{B}$) density distribution, resulting an enhancement of the rapidity width of Λ. Such observation with UrQMD-3.4-generated events gives a hint that pair production may not be the only mechanism of particle production even at the highest LHC energy.

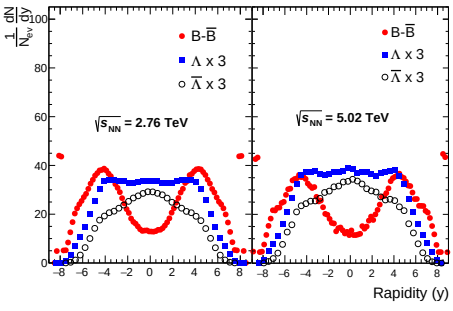

FIG. 2: Rapidity distributions of $B-\bar{B}$, Λ and $\bar{\Lambda}$ with UrQMD-3.4-generated events in Pb–Pb collisions at various LHC energies (Phys. Rev. C. 96, 024903 (2017)).

On the other hand, similar jump in the width of the rapidity distribution of Λ, as observed for heavy-ion collisions, could be seen even at the highest LHC energy for pp collisions (Fig. 3) as well. It is seen from Fig. 4 that in pp collisions at the LHC energies, the net baryon density is non-zero at the extreme rapidities, where the partons (mostly balance quarks) of the spectators of the collisions might have played an important role for baryons (Λ) production.

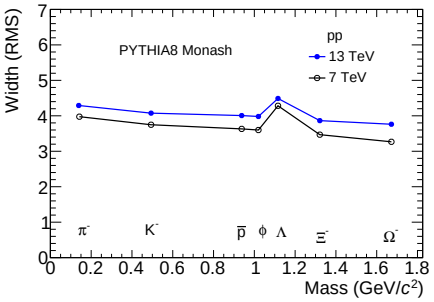

FIG. 3: Widths of the rapidity distributions of various mesons and baryons as a function of their rest masses in pp collisions with PYTHIA8-generated events at various LHC energies. This figure has been reproduced from our recent arXived paper [6].

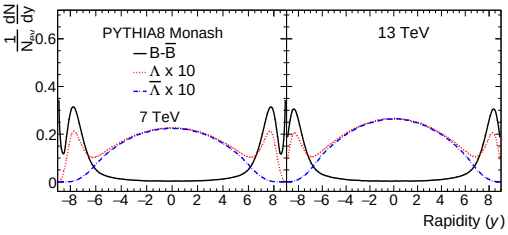

FIG. 4: Rapidity distributions of $B-\bar{B}$, Λ and $\bar{\Lambda}$ with PYTHIA8-generated events in pp collisions at various LHC energies. This figure has been reproduced from our recent arXived paper [6].

References

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