Behaviour of the rapidity width of Λ in zero net baryon density domain in pp collisions at the Large Hadron Collider energies

Nur Hussain* and Buddhadeb Bhattacharjee†
Nuclear and Radiation Physics Research Laboratory,
Department of Physics, Gauhati university, Guwahati-781014, India

Introduction

Width of the rapidity distribution of identified particles is considered to be one of the important global observables of high-energy nuclear collisions, which mainly provides information about the final state rescattering of hadrons and the particle production mechanism. It is reported in Ref. [1] that rapidity width of identified particles at Alternating Gradient Synchrotron (AGS) and low Super Proton Synchrotron (SPS) energies, follows a separate mass scaling for mesons and baryons and depends not only on the mass of the produced hadrons but also on their quark contents. The net baryon ($B - \bar{B}$) density distribution is found to influence the rapidity width to a considerable extent particularly to hadrons (like Λ, p, etc.) that have leading quarks as the constituent partons. A clear enhancement in the width of the rapidity distribution of Λ has been observed, which was attributed to the net baryon density distribution effect as a considerable fraction of Λ is produced from associate production. When the beam energy is extended to Large Hadron Collider (LHC) energies, with UrQMD-3.4-generated and available experimental results, a similar jump in rapidity width of Λ is found to exist even at the highest LHC energy, where $B - \bar{B}$ is still seen to be non-zero [2]. It is worth-mentioning that in pp collisions at 7 TeV, at the ALICE, $\Lambda/\bar{\Lambda}$ becomes unity at mid rapidity [3]. In such a situation, it is expected that $B - \bar{B}$ will become vanishingly small, if not zero, where Λ might be produced through pair production only. Since the spectator hadrons of heavy-ion collision play a significant role in particle production, particularly the Λ production, it would also be very interesting to investigate how the spectator partons of pp collision at different multiplicity classes play their role in Λ production. In this work, an attempt has been made with MC PYTHIA/UrQMD generated pp events to study the widths of the rapidity distributions of different hadrons at various LHC energies and different multiplicity classes to investigate the role of spectator partons on Λ production for the situation for which $B - \bar{B} = 0$.

Results and discussions

Events were generated with UrQMD-3.4 and PYTHIA8 Monash tuned generated data and widths of the rapidity distributions have been estimated with double Gaussian function [1]. Figure 1 shows the distributions of rapidity widths of various produced particles as a

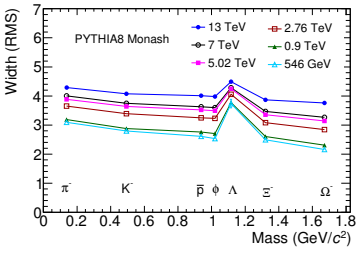

FIG. 1: Distributions of rapidity widths of various produced particles as a function of their rest masses in pp collisions at various LHC energies. These results are taken from our recent work [4].

*Electronic address: nur.hussain@cern.ch
†Electronic address: buddhadeb.bhattacharjee@cern.ch

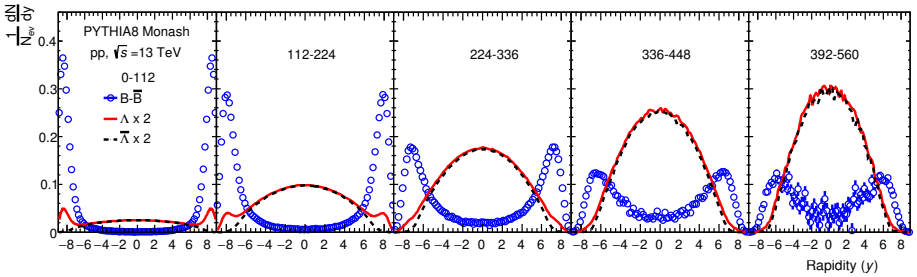

FIG. 2: Width of the rapidity distributions of $B - \bar{B}$, Λ and $\bar{\Lambda}$ in p+p collisions at $\sqrt{s} = 13$ TeV for different multiplicity classes. These results are taken from our recent work [4].

function of their rest masses in pp collisions at various LHC energies. A clear increase in the width of the rapidity distribution of Λ has been observed here again at all the studied energies. In Fig. 2, a non-zero value of $B - \bar{B}$ at extreme rapidity for low multiplicity pp events suggests the presence of more quarks than antiquarks, favouring the production of more baryons than anti-baryons in these regions. The production of Λ in such low multiplicity pp events has a substantial contribution from the partons of the spectator regions and could be the main reason of the increase of the rapidity width of Λ (Figs. 1 and 3). Further, it can be seen from Fig. 3 that rapidity widths of all studied hadrons decrease with increasing multiplicity. It is interesting to see that for the highest multiplicity class, where the beam remnant is vanishingly small, the jump in the rapidity with of Λ disappears and rapidity widths of Λ and $\bar{\Lambda}$ become almost same.

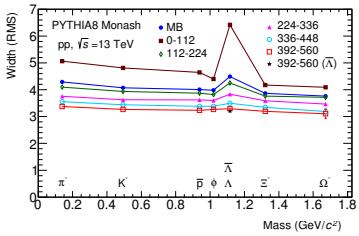

FIG. 3: Width of the rapidity distributions as a function of their rest masses for various multiplicity classes in pp collisions at $\sqrt{s} = 13$ TeV [4].

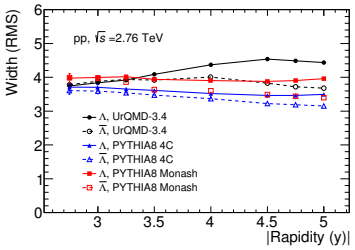

FIG. 4: Distributions of rapidity widths of Λ and $\bar{\Lambda}$ as a function of rapidity window of pp events [4].

From Fig. 4, it could be seen that for the rapidity window $|y| < 3.5$, where $B - \bar{B} = 0$, the rapidity widths of Λ and $\bar{\Lambda}$ become same. Thus at LHC energies at and around mid rapidity as well as for high multiplicity pp events over the entire rapidity region, Λ and $\bar{\Lambda}$ are mostly pair produced.

References

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