Mid–rapidity antibaryon–to–baryon ratios in pp and Pb–Pb collisions measured by the ALICE experiment

Michal Broz (for the ALICE Collaboration)[1]

Faculty of Mathematics, Physics and Informatics
Comenius University
Mlynská dolina 842 48 Bratislava, Slovakia

Abstract

Measurement of the antibaryon-baryon ratios ($\overline{\mathrm{B}}/\mathrm{B}$) at mid rapidity probes the baryon transport and the degree of baryon stopping in high-energy collisions, providing insight into the collision dynamics. In this paper, we discuss the measurement of different $\overline{\mathrm{B}}/\mathrm{B}$ ratios ($\overline{\mathrm{p}}/\mathrm{p}$, $\overline{\Lambda}/\Lambda$, $\overline{\Xi}^{+}/\Xi^{-}$) in pp collisions at $\sqrt{s}$ = 0.9, 2.76, and 7 TeV and in Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 2.76 TeV, as a function of charged particle multiplicity, rapidity and transverse momentum. Results from pp and Pb-Pb collisions are presented and compared to models.

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1. Introduction

In inelastic non-diffractive proton-proton collisions at very high energy, the incoming projectile breaks up into several hadrons that typically emerge, after the collision, at small angles close to the original beam direction. The deceleration of the incoming proton, or more precisely of the conserved baryon number (BN) associated with the beam particles, is often called ”baryon-number transport” and has been debated theoretically [1, 2].

Most of the (anti-) baryons at mid-rapidity are created in baryon-antibaryon pair production, implying equal yields. Any excess of protons over antiprotons is therefore associated with the baryon-number transfer from the incoming beam. Experimentally, the BN transport over large rapidity intervals is addressed by measuring the antibaryon-to-baryon production ratio at mid-rapidity, $\mathrm{R} = \overline{\mathrm{B}}/\mathrm{B}$,

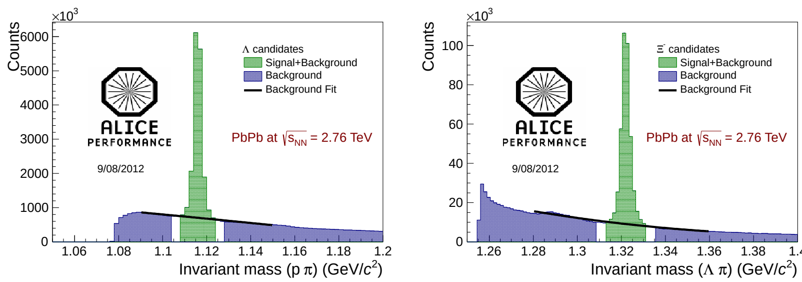
2. Data Analysis and Corrections

Data recorded during the LHC pp runs at $\sqrt{s}$ = 0.9, and 7 TeV and in Pb–Pb at $\sqrt{s_{\mathrm{NN}}}$ = 2.76 TeV in 2010 and during the pp runs at $\sqrt{s}$ = 2.76 TeV in 2011 were used for this analysis. In the case of Pb–Pb collisions events satifying a wide collision centrality selection of 0-80% were analyzed.

Protons and antiprotons were identified using their specific ionization (dE/dx) in the gas of the Time Projection Chamber (TPC)[4]. The selection was done within a 3σ band around

[1] A list of members of the ALICE Collaboration and acknowledgements can be found at the end of this issue.

the expected dE/dx value. The Λ and charged Ξ candidates were reconstructed by applying selections on the characteristics of their daughter tracks and using their weak decay topologies and no particle identification. The extraction of the Λ and Ξ yields was performed by an invariant mass distribution analysis using the corresponding mass hypotheses. All signals were clearly visible and could be easily separated from the background (see Fig. 1).



(a) Λ (b) Ξ

Figure 1: Extraction of the Λ and Ξ signals from the invariant mass distribution in Pb–Pb at $\sqrt{s_{NN}}$ = 2.76 TeV. Areas considered as signal+background (green) or pure background (blue) are shown. The lines corresponds to a polynomial fit of background areas.

Rapidity and p_{t} ranges used in this analysis are summarized on Fig. 3.

In this analysis the ratio of particles and anti-particles is measured and many detector effects cancel in the ratio.

However, because of significant differences in the relevant cross-sections, antibaryons are more likely than baryons to be absorbed within the detector, and a non-negligible background in the proton and Λ sample arises from secondary interactions in the beam pipe and inner layers of the detector.

3. Results

In Fig. 2 are shown antibaryon-to-baryon ratios in pp collisions from ALICE (in red) and other experiments [5, 6, 7, 8] as a function of Δy ($\Delta y = y_{beam} - y_{baryon}$). An approximation of the Δy dependence of the ratio can be derived in the Regge model [3]. Following this formulation the ratio R can be described by the simple form $\frac{1}{R} = 1 + C\, e^{(\alpha_J - \alpha_P)\Delta y}$ (1).

The values of the Pomeron intercept and String Junction intercepts are chosen to be α_p = 1.2 and α_J = 0.5. The parameter C is adjusted to the experimental measurements. The obtained parametrizations of the Δy dependence of the $\overline{\mathrm{p}}/\mathrm{p}$, $\overline{\Lambda}/\Lambda$, $\overline{\Xi}^{+}/\Xi^{-}$ and $\overline{\Omega}^{+}/\Omega^{-}$ ratios are shown in the Fig. 2.

The corrected antibaryon-to-baryon ratios in pp and Pb–Pb at $\sqrt{s_{NN}}$=2.76 TeV are summarized in the Fig. 3.

Multiplicity dependence was investigated using relative charged-particle pseudorapidity density $\frac{dN/d\eta}{\langle dN/d\eta \rangle}$. The charged particle multiplicity estimator for this measurement was based on the combined number of TPC and ITS tracks + number of tracklets (vectors connecting pair of clusters each one on one of the two SPD layers and pointing to the vertex) in the $|\eta| < 0.5$. No sign of charged multiplicity dependence was observed up to $\frac{dN/d\eta}{\langle dN/d\eta \rangle} \approx 6$ (see Fig. 4).

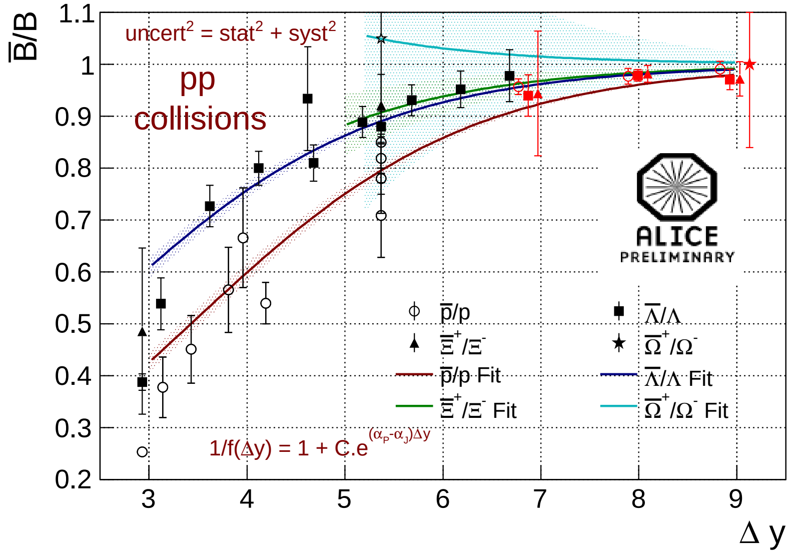


Figure 2: Central rapidity antibaryon-to-baryon ratios as a function of rapidity interval. Parametrizations with function (1) are shown. Shaded areas around the functions shows the uncertainity of the function coming from the propagation of the uncertainty of the adjusted parameter C. Red points shows the ALICE measurements.

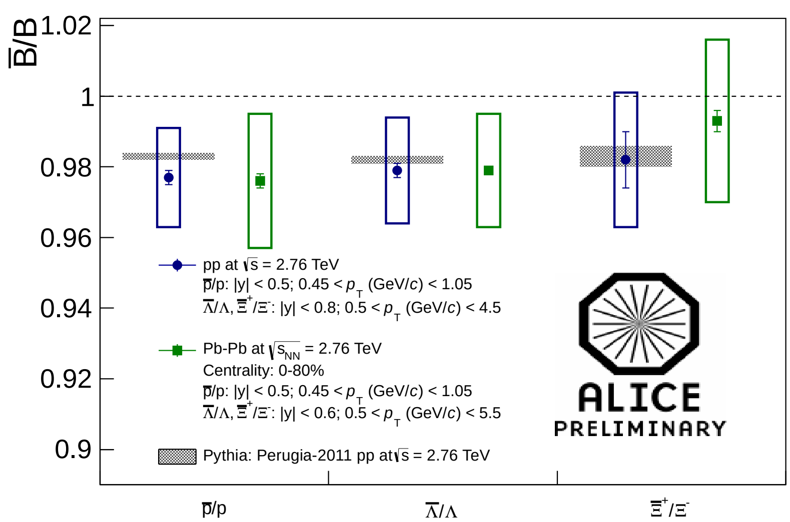
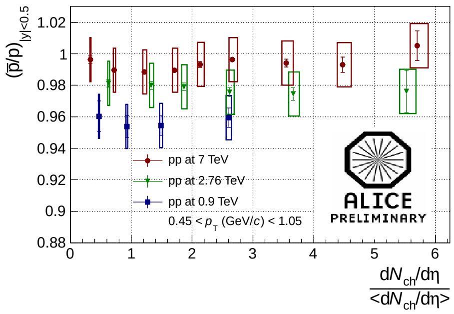
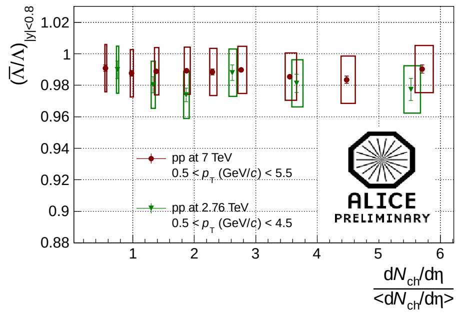


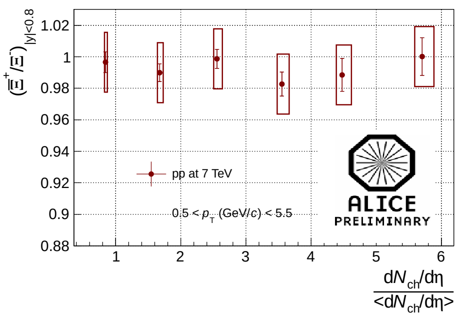
Figure 3: The mid-rapidity ratio at $\sqrt{s}$ = 2.76 TeV in pp and Pb–Pb collisions.



(a) $\bar{p}/p$



(b) $\overline{\Lambda}/\Lambda$



(c) $\overline{\Xi}^{+}/\Xi^{-}$

Figure 4: The antibaryon-to-baryon ratios in pp collisions as a function of the relative charged-particle pseudorapidity density

4. Summary

We have measured the ratios of antibaryons to baryons produced in pp collisions at $\sqrt{s}$ = 0.9, 2.76 and 7 TeV and in Pb–Pb collisions at $\sqrt{s_{\rm NN}}$ = 2.76 TeV.

Within the fiducial acceptance region, the $\bar{p}/p$, $\overline{\Lambda}/\Lambda$ and $\overline{\Xi}^{+}/\Xi^{-}$ ratios are independent of event multiplicity (in pp) rapidity and transverse momentum (not shown). The $\bar{p}/p$, $\overline{\Lambda}/\Lambda$, $\overline{\Xi}^{+}/\Xi^{-}$ ratios in Pb–Pb and pp at $\sqrt{s_{\rm NN}}$ = 2.76 TeV are compatible within the measurement uncertainties.

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