Baryon number transport at LHC energies with the ALICE experiment

Michal Broz for the ALICE Collaboration
Faculty of Mathematics, Physics and Informatics
Comenius University
Mlynská dolina 842 48 Bratislava, Slovakia

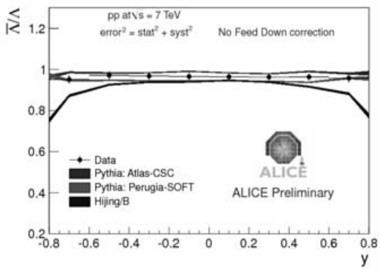
1 Introduction

The carrier of the baryon number (BN) in pp collisions is a topic that has been debated theoretically for some time [1, 2, 3, 4, 5]. Based on the Quark-Gluon String Model (QGSM) [2] the BN of a baryon is associated with its valence quarks. On the other hand, there are models describing the baryon structure with the picture of three strings starting at the valence quarks and joining together in the center, at a virtual point called "string junction" (J) [1, 3]. These two concepts result in a significantly different BN distribution with rapidity (BN transport), when the proton interacts inelastically at high energies. Experimentally, the BN transport over very large rapidity intervals is addressed by measuring the antibaryon-to-baryon production ratio at mid-rapidity, $R = N_{\overline{\mathrm{B}}}/N_{\mathrm{B}}$, or equivalently, the baryon–antibaryon asymmetry, $A = (N_{\mathrm{B}} - N_{\overline{\mathrm{B}}})/(N_{\mathrm{B}} + N_{\overline{\mathrm{B}}})$. In this article, we describe the measurement of the $\overline{\Lambda}/\Lambda$, $\overline{\Xi^{+}}/\Xi^{-}$and $\overline{\Omega^{+}}/\Omega^{-}$ratios at midrapidity in pp collisions at center-of-mass energies $\sqrt{s} = 0.9$ TeV and 7 TeV, with the ALICE experiment [6] at the LHC.

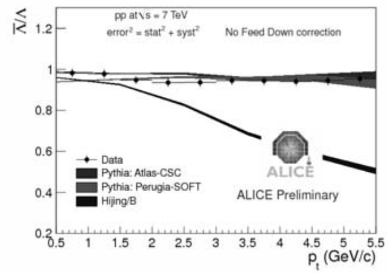
2 Data Analysis

Data recorded during the 2010 LHC pp run were used for this analysis. The trigger required a hit in one of the VZERO counters or in the SPD detector [7], in coincidence with the signals from two beam pick-up counters, one on each side of the interaction region, indicating the presence of passing bunches. The phase space for the analysis was restricted to the rapidity and momentum range of $|y| < 0.8$ and $0.5 < p_{\mathrm{t}} < 5.5$ GeV/c, for Λ and charged Ξ and $|y| < 0.8$ and $1.0 < p_{\mathrm{t}} < 5.5$ GeV/c for Ω respectively.

The Λ, charged Ξ and Ω are identified by applying selections on the characteristics of their daughter tracks, and using their weak decay topologies in the charged decay channels. The momentum as well as the particle identification (PID) relied for this analysis on the information from the TPC detector. The TPC PID helps



(a) As a function of the rapidity y



(b) Integrated over $|y| < 0.8$ as a function of the transverse momentum p_{t}

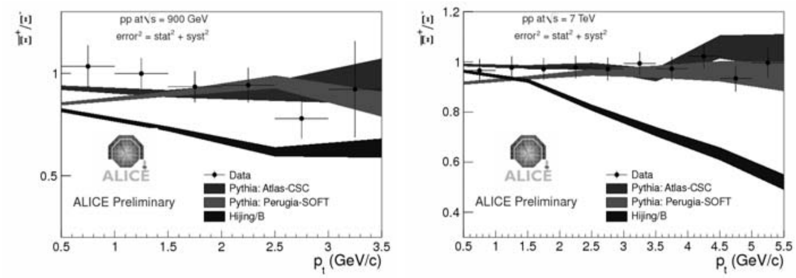
Figure 1: The $\overline{\Lambda}/\Lambda$ratio at $\sqrt{s} = 7$ TeV.

substantially to remove combinatorial background. The selections here concern all daughters. The TPC of the ALICE experiment is symmetric around mid-rapidity and has full azimuthal coverage. As a consequence, many detector effects such as the acceptance, the reconstruction and the particle identification ones are the same for particles and anti-particles and thus cancel out in the ratio. However, because of significant differences in the relevant cross-sections, antiprotons are more likely than protons to be absorbed within the detector, and a non-negligible background in the Λ sample arises from secondary interactions in the beam pipe and inner layers of the detector. The corrections applied were the following:

- corrections for absorption of (anti)proton daughter. They are extracted using a complete Monte Carlo production simulating the detector response with GEANT3[9]. This correction relies, in particular, on the proper description of the interaction cross-sections used as input by the transport models, and on the proper description of material budget.

- corrections for the proper $\mathrm{p}(\overline{\mathrm{p}})$–A inelastic cross-sections. They are extracted from comparison between GEANT3 and FLUKA [10]. Values were compared with experimental measurements [11]. While p–A cross-sections are similar in both models and in agreement with existing data, GEANT3 significantly overestimates the measured inelastic cross-sections for antiprotons in the relevant momentum range, whereas FLUKA matches the data.

- corrections for secondary particles produced in material (only Λ). The contamination of the Λ sample due to secondaries originating from interactions with the detector material was directly measured with the data and subtracted. Most of these background tracks do not point back to the interaction vertex and can



(a) $\sqrt{s} = 0.9$ TeV (b) $\sqrt{s} = 7$ TeV

Figure 2: The $\overline{\Xi^{+}}/\Xi^{-}$ratio integrated over $|y| < 0.8$ as a function of the transverse momentum p_{t}.

therefore be excluded with a cut on cosine of pointing angle (*cpa*). The contamination of secondary Λ, which remains after the *cpa* cut under the peak of primaries, is subtracted by determining its shape from Monte Carlo simulations and adjusting the amount to the data at large values of the *cpa*.

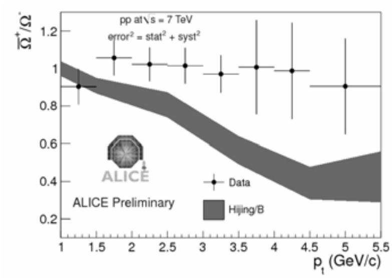


Figure 3: The $\overline{\Omega^{+}}/\Omega^{-}$ratio integrated over $|y| < 0.8$ as a function of the transverse momentum p_{t} at $\sqrt{s} = 7$ TeV.

3 Results –Summary

Within statistical errors, the measured ratio R shows no dependence on transverse momentum and rapidity for Λ (Fig. 1), on transverse momentum nor for charged Ξ

(Fig. 2), nor for Ω (Fig. 3). The data are compared with various model predictions [5, 8] in both Fig. 1 and Fig. 2. The ratios R predicted by the different models are also independent of momentum and rapidity, with the exception of HIJING/B [5], which predicts a decrease with increasing p_t. The ATLAS-CSC PYTHIA tune [8] describes the experimental values well, in case of $\overline{\Xi^+}/\Xi^-$for both energies. HIJING/B underestimates the experimental results. Perugia-SOFT tune of PYTHIA [8] which also includes enhanced baryon transfer predicts a smaller ratio.

In summary, we have measured the ratios of strange antibaryons to baryons produced in pp collisions at $\sqrt{s} = 0.9$ and $\sqrt{s} = 7$ TeV. The $\overline{\Lambda}/\Lambda$, $\overline{\Xi^+}/\Xi^-$and $\overline{\Omega^+}/\Omega^-$ratios are independent of transverse momentum and the results are consistent with standard models of baryon-number transport over very large rapidity intervals.

References

[1] G.C. Rossi and G. Veneziano, Nucl. Phys. **B123**, (1977) 507.

[2] A. Capella *et al.* Phys. Rep. **236**, 225 (1994); A.B. Kaidalov and K.A. Ter-Martirosyan, Sov. J. Nucl. Phys. **39**, 1545 (1984).

[3] B.Z. Kopeliovich, Sov. J. Nucl. Phys. **45**, 1078 (1987).

[4] D. Kharzeev, Phys. Lett. **B378**, 238 (1996).

[5] S.E. Vance and M. Gyulassy, Phys. Rev. Lett. **83**, 1735 (1999).

[6] K. Aamodt *et al.* (ALICE Collaboration), JINST **3**, S08002 (2008).

[7] K. Aamodt *et al.* (ALICE Collaboration), arXiv:1006.5432, Phys. Rev. Lett. **105**, 072002 (2010).

[8] T. Sjostrand, P. Skands, Eur. Phys. J. **C39**, 129 (2005); P. Skands, arXiv:1005.3457 [hep-ph] (2010), Perugia-0 (320) and Perugia-SOFT (322) tunes; A. Moraes (ATLAS Collaboration), ATLAS Note ATL-COM-PHYS-2009-119, 2009.

[9] R. Brun *et al.*, GEANT3 User Guide (CERN Data Handling Division DD/EE/841, 1985).

[10] http://www.fluka.org/; A. Fasso *et al.*, CERN-2005-10,INFN/TC05/11, SLAC-R-773 (2005); G. Battistoni *et al.*, AIP Conf. Proc. **896**, 31 (2007).

[11] G. Bendiscioli and D. Kharzeev, Riv. Nuovo Cimento Soc. Ital. Fis. **17**, 1 (1994).