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Multi-strange baryon production at mid-rapidity in Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV with ALICE

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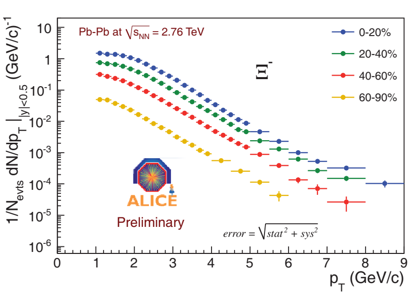
Summary. — The ALICE Collaboration at the CERN Large Hadron Collider has measured the production of multi-strange baryons in Pb-Pb collisions at 2.76 TeV. Preliminary results on mid-rapidity transverse momentum spectra of the charged Ξ and Ω baryons, in different centrality classes, are presented.

PACS 25.75.-q – Relativistic heavy-ion collisions.

The study of strange and multi-strange particle production in relativistic heavy-ion interactions is an important tool to investigate the properties of the strongly interacting system created in the collision, as there is no net strangeness content in the colliding nuclei. In particular, baryons with more than one unit of strangeness are very useful probes of the early partonic stages of the collision due to their small hadronic cross-section. The enhancement of strangeness production in relativistic heavy-ion collisions relative to proton-induced reactions was one of the predicted signatures of the Quark-Gluon Plasma formation [1]. It was first observed at SPS, confirmed afterwards by data at RHIC [2], and the original assumptions, on which the explanation of strangeness enhancement was based, have gone through further theoretical developments [3]. The ALICE data can provide additional test for these theories.

The ALICE experiment was specifically designed to study heavy-ion physics at the LHC, namely the properties of strongly interacting matter at high-energy density. The first LHC heavy-ion run took place at the end of 2010, using Pb ions, accelerated so that the centre-of-mass energy of the collision is $\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV; and the ALICE detector collected almost 30×10^6 nuclear interaction minimum bias triggers. The analysis described in this proceedings is mainly based on the sub-detectors mentioned in the following. The tracking and vertexing are performed with the full tracking system: the Inner Tracking System (ITS, six layers of silicon detectors) and the Time Projection Chamber (TPC), which is also used for particle identification via specific ionization. The Silicon Pixel Detector (SPD, the two innermost layers of the ITS) and the VZERO detector (scintillation hodoscopes placed on either side of the interaction point) were used for triggering. The VZERO was crucial for the centrality determination as well.



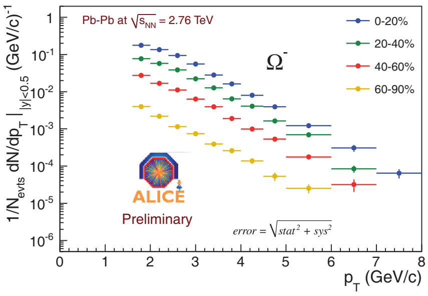


Fig. 1. – Transverse-momentum spectra of the Ξ^- and the Ω^- in four centrality classes.

Multi-strange baryons are measured through the reconstruction of the topology of the following weak decays: $\Xi^- \to \Lambda + \pi^-$, $\Omega^- \to \Lambda + K^-$ (with $\Lambda \to \pi^- + p$) plus the charge conjugates for the anti-particle decays. The resulting branching ratios are 63.9% and 43.3% for the Ξ and the Ω, respectively. The Ξ and the Ω candidates are found by combining reconstructed charged tracks: cuts on geometry and kinematics, *e.g.* related to the impact parameter of the tracks and the invariant masses, are applied to select first the Λ candidate and then to match it with all the remaining secondary tracks (bachelor candidates). In order to reduce the combinatorial background while keeping reasonable the signal loss, the selection cuts are tightened and optimized at the analysis level. In addition, cuts on particle identification via specific ionization in the TPC for the three daughter tracks are used.

The raw counts in p_T bins are obtained extracting the signal from the invariant mass distributions; here a symmetric region around the peak ($\pm 3\sigma$) is defined fitting the distribution with the sum of a gaussian and a polynomial. In each p_T bin, the background is sampled on both sides of the peak in two regions 6σ wide and 6σ away from the peak and fitted with a polynomial of second degree, and the signal in the peak region is obtained subtracting the integral of the fit function of the background from the peak population. About 3×10^6 HIJING events were generated and used to compute the acceptance-efficiency correction. In order to extract particle yields integrated over the full p_T range, the corrected spectra (fig. 1) are fitted using the blast-wave parametrization [4]. Yields are then calculated integrating the corrected spectra in the measured p_T range and extrapolating with the fit function outside.

The enhancements have been calculated as the ratio between the yields in Pb-Pb collisions and those in pp interactions at the same energy, both normalized to the number of participants. The pp reference values were obtained interpolating ALICE data at two energies ($\sqrt{s_{NN}} = 0.9$ and $7\,\text{TeV}$ [5,6]) for the Ξ and STAR data at 200 GeV and ALICE data at 7 TeV for the Ω. For both particles, the excitation function of PYTHIA yields (Perugia 2011 tune 88 S350 [7]) is assumed: despite a constant underestimation of the yields, its energy dependence in $s^{0.13}$ (which is slightly higher than $s^{0.11}$, the one for charged-particle pseudorapidity density [8]) was found to be satisfactory. In fig. 2 the enhancements as a function of the mean number of participants are shown (full symbols): they increase with centrality and with the strangeness content of the particle as already observed at lower energies. Comparing the ALICE measurements with those at SPS and RHIC (hollow symbols), the enhancements are found to decrease as the centre-of-mass energy increases, continuing the same trend established at lower energies and first observed at SPS [2].

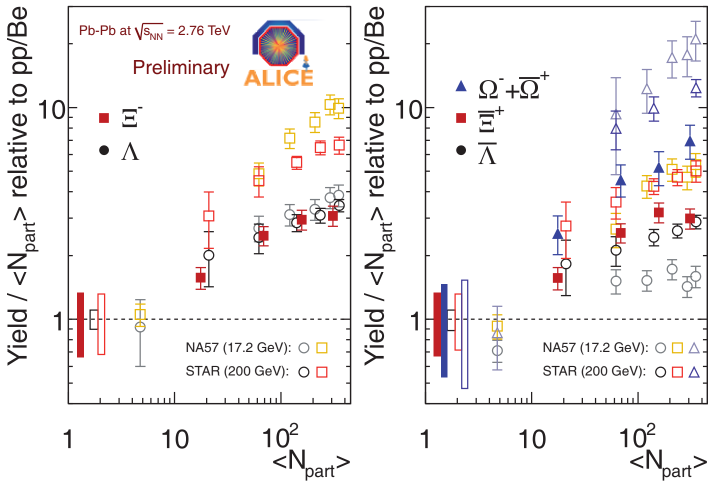


Fig. 2. – Enhancements in $|y| < 0.5$ as a function of the mean number of participants N_{part} measured by ALICE and compared to SPS and RHIC data. The bars on the dotted line indicate the systematic uncertainties on the pp reference.

Conclusions

ALICE has measured multi-strange baryon spectra in Pb-Pb interactions at $\sqrt{s_{\mathrm{NN}}} = 2.76\,\mathrm{TeV}$, up to p_{T} of 9 and $8\,\mathrm{GeV}/c$ for the most central collisions, for Ξ and Ω, respectively. The enhancements follow the hierarchy based on the strangeness content of the particle and are found to increase with collision centrality. The comparison with lower energy data shows a decrease of the strangeness enhancement as the energy increases, following the same trend observed at SPS and between SPS and RHIC, in qualitative agreement with the removal of canonical suppression.

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