PRODUCTION OF LIGHT-FLAVOUR HADRONS IN THE ALICE EXPERIMENT AT THE CERN LHC*

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The ALICE experiment is dedicated to studying the hot and dense nuclear matter created in heavy-ion collisions at the Large Hadron Collider. A crucial part of the ALICE physics programme is to study small collision systems, such as proton–proton and proton–lead collisions, and compare them with the heavy-ion ones in order to disentangle effects coming from individual nucleon–nucleon interactions or from cold nuclear matter. In this contribution, the results on light-flavour hadron production from small (*pp* and *p*–Pb) to large collision systems (Pb–Pb) at various energies measured by ALICE are reported.

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1. Introduction

The Quark–Gluon Plasma (QGP) is a state of nuclear matter where the fundamental constituents (quarks and gluons) are allowed to freely move without being confined in a hadron. It is believed that the QGP state of matter was present in the early Universe within microseconds after the Big Bang. A similar matter can be now created in the heavy-ion collisions at the world accelerator facilities, especially at the Large Hadron Collider (LHC).

2. Heavy-ion collisions at the LHC

The QGP created in heavy-ion collisions at the LHC does not last long, it turns into hadrons after a very short time (10^{-22}–10^{-21} s). We can divide the experimental variables for investigating QGP into two main groups. First probing of QGP is *locally* using hard probes produced before QGP in hard collisions such as fast partons, heavy quarks, di-leptons or direct photons.

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The second way for probing is *globally* via bulk properties such as hadron chemistry (quark composition and its evolution) or isotropic and anisotropic flow (collective phenomena). Many bulk properties can be investigated by the production of the light-flavour hadrons (*i.e.* containing *up*, *down* or *strange* quark).

3. Light-flavoured hadrons in ALICE detector

The light-flavour hadrons can be divided into three groups regarding their detection in the main tracking systems in the ALICE detector [1]. The charged stable hadrons (π, K, p) are identified via energy loss and velocity measurement. The long-lived (*i.e.* weakly decaying) strange hadrons $(K^0_{\rm S}, \mathit{\Lambda}, \mathit{\Xi}, \mathit{\Omega})$ are identified via decay topology with one ($K^0_{\rm S}$ and $\mathit{\Lambda}$) or two secondary vertices ($\mathit{\Xi}$ and $\mathit{\Omega}$). The yield is extracted by analysing invariant mass distributions of the decay products. The short-lived (strongly decaying) strange hadrons ($K^{*0}(892)$, $\phi(1020)$) are identified via analysis of the invariant mass distribution of the daughter particles (primary tracks) and the yield is extracted from signal analysis in the invariant mass distribution as well.

4. Results

The corrected transverse momentum spectra ($p_{\rm T}$-spectra) for the charged hadrons in Pb–Pb and *pp* collisions at $\sqrt{s_{NN}} = 5.02$ TeV are shown in Fig. 1. The maximum of the $p_{\rm T}$-spectra is shifted towards higher momenta when

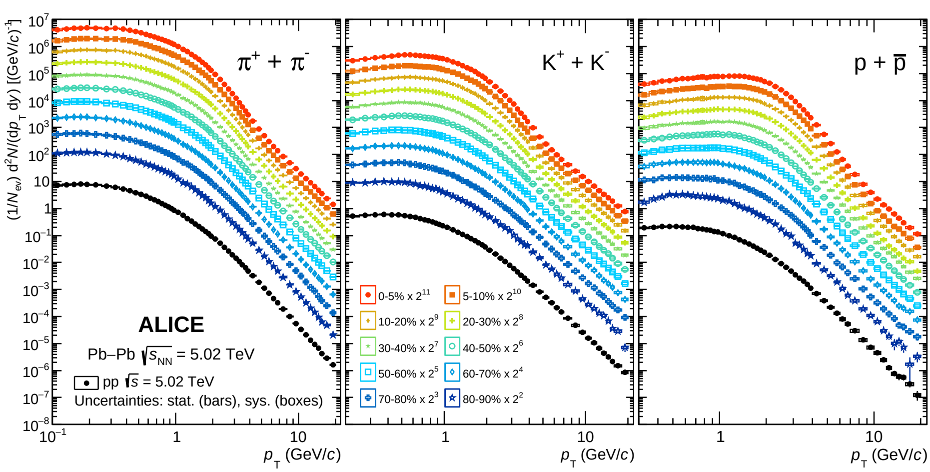

Fig. 1. Transverse momentum spectra of pions (left), kaons (middle), and protons+(anti-)protons (right) measured in *pp* and Pb–Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV for different centrality classes. More details in [2].

going from peripheral collisions (80–90%) to central collisions (0–5%) due to a strong radial flow. This effect is also mass-dependent — heavier particles have more shift in the maximum than lighter ones.

The production of strange quarks in QGP should be energetically favoured and faster than production in hadron gas [3]. The experimental variable known as the strangeness enhancement based on a comparison of strange hadron production in the nucleus–nucleus collision with respect to the nucleon–nucleon (or nucleon–nucleus) collision has confirmed this at various collisional energies [4]. At the LHC, the strangeness enhancement is present also in small systems such as *pp* or *p*–Pb as it is depicted in Fig. 2 [5]. It rises with the multiplicity (a proxy for the volume of the system after collision) and this rise is ordered by the hadron strangeness S ($S_p = 0$, $S_\Lambda = -1$, $S_\Xi = -2$, $S_\Omega = -3$).

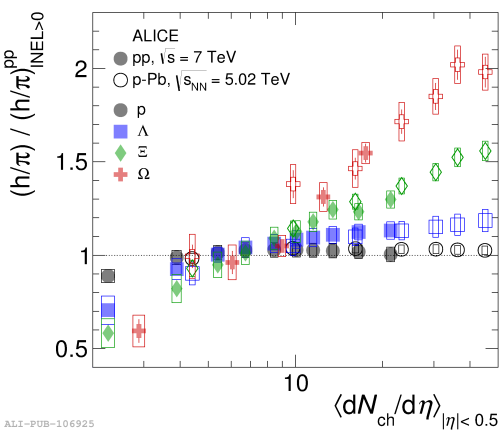

Fig. 2. Particle yield ratios to pions of strange and multi-strange baryons and protons normalised to the values measured in the inclusive *pp* sample, both in *pp* and in *p*–Pb collisions as a function of average charged-particle density. More details in [5], presented plot adjusted for CERN Courier: https://cerncourier.com/a/proton-proton-collisions-become-stranger/

Resonances can probe late hadronic stages of the heavy-ion collision evolution due to their lifetimes comparable with the hadron phase lifetime. After chemical freeze-out (vanishing of inelastic interactions), the yields of resonances can change due to two processes: regeneration (increases yield) and decay products rescattering (decreases yield). Measurements show (Fig. 3) that the production ratio K^{*0}/K (ratio to the resonance ground state) decreases with system size which means that the rescattering is more prominent than regeneration for K^*. On the other hand, the ϕ/K ratio is not affected due to the much longer ϕ lifetime.

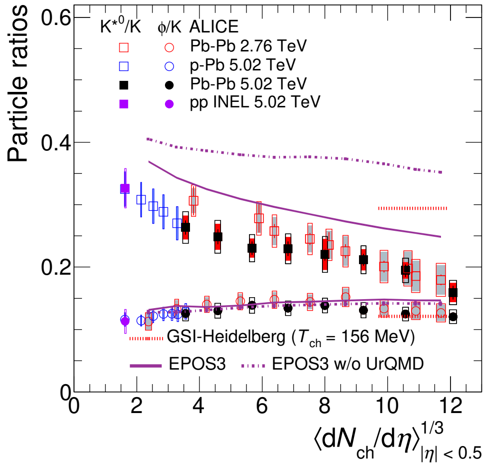

Fig. 3. p_{T}-integrated particle yield ratios K^{*0}/K and ϕ/K as a function of average charged-particle density $\langle \mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta\rangle^{1/3}$ measured at midrapidity in pp, p–Pb, and Pb–Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV. More details in [6].

5. Summary

The bulk properties (in Pb–Pb) studied via light-flavour particles in ALICE exhibit that the maxima of p_{T}-spectra are shifted going from peripheral to central collisions (due to radial flow), the effect of the strangeness enhancement is also seen in high multiplicity pp and p–Pb collisions, and the resonance yields decrease with the system size due to rescattering of decay products during the hadron phase of the heavy-ion collision.

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