Multiplicity dependence of the average transverse momentum in pp, p–Pb, and Pb-Pb collisions at the LHC*

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One of the key ways of investigating particle production in high-energy hadron collisions is to measure the relationship between the number, or multiplicity, of particles produced and their momentum transverse to the direction of the colliding beams. The results cast light on processes ranging from the interactions of individual partons (quarks and gluons) to the collective motion of hot, dense matter containing hundreds of partons. We have investigated, using data collected with ALICE in proton-proton (pp), proton-lead (p–Pb) and lead-lead collisions (Pb–Pb) at the LHC, the first moment, $\langle p_\mathrm{T} \rangle$, of the charged-particle transverse momentum spectrum and its correlation with the charged-particle multiplicity N_ch [1].

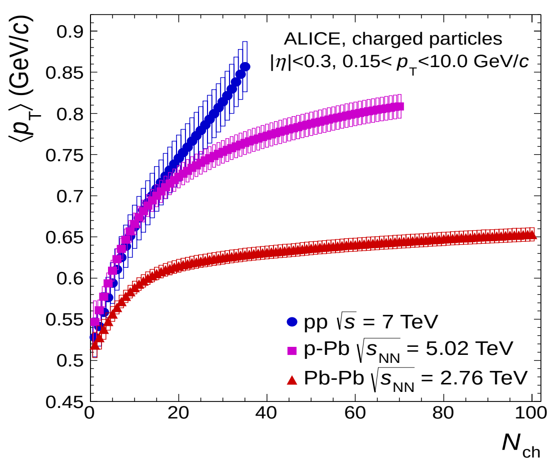

Figure 1: Average transverse momentum $\langle p_\mathrm{T} \rangle$ versus charged-particle multiplicity N_ch in pp, p–Pb, and Pb–Pb collisions for $|\eta| < 0.3$. The boxes represent the systematic uncertainties on $\langle p_\mathrm{T} \rangle$. The statistical errors are negligible.

Figure 1 shows the average transverse momentum $\langle p_\mathrm{T} \rangle$ of charged particles versus the charged-particle multiplicity N_ch measured in pp collisions at $\sqrt{s}$ = 7 TeV, in p–Pb collisions at $\sqrt{s_\mathrm{NN}}$ = 5.02 TeV, and in Pb–Pb collisions at $\sqrt{s_\mathrm{NN}}$ = 2.76 TeV. We note that the same N_ch value corresponds to a very different collision regime in the three systems. The p–Pb data exhibit features of both pp and Pb–Pb collisions, at low and high multiplicities, respectively. The saturation trend of $\langle p_\mathrm{T} \rangle$ versus N_ch is less pronounced in p–Pb than in Pb–Pb collisions and leads to a much higher value of $\langle p_\mathrm{T} \rangle$ at high multiplicities than in Pb–Pb.

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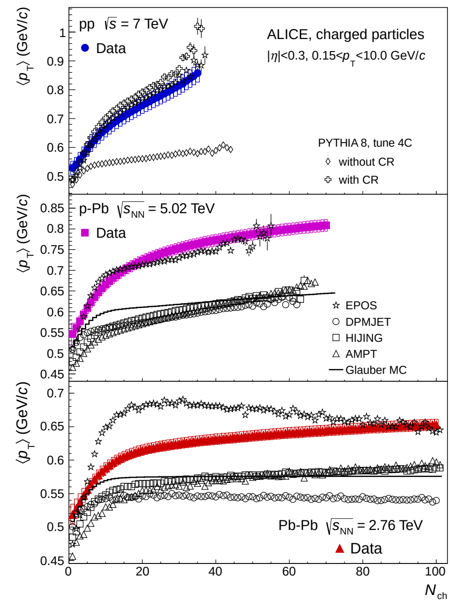

Figure 2: Average transverse momentum $\langle p_\mathrm{T} \rangle$ as a function of charged-particle multiplicity N_ch measured in pp (upper panel), p–Pb (middle panel), and Pb–Pb (lower panel) collisions in comparison to model calculations.

Figure 2 shows a comparison of the data to model predictions (see references in [1]). The strong correlation of $\langle p_\mathrm{T} \rangle$ with N_ch is reproduced in the PYTHIA event generator with the mechanism of color reconnections between hadronizing strings. This can be interpreted as a collective final-state effect, in which strings from independent parton interactions do not independently produce hadrons, but fuse prior to hadronization. This leads to fewer, but more energetic, hadrons. The EPOS model, which implements collective behavior in pp collisions, also describes the pp data. Remarkably, also p–Pb collisions are well described, while for Pb–Pb collisions there is a significant discrepancy between model and data. A Glauber Monte Carlo model for p–Pb and Pb-Pb collisions, with inputs from pp data, fails to describe the data. These data are an essential input to improve our understanding of particle production as well as the role of initial and final state effects in these systems.

References

[1] ALICE Collaboration, B. B. Abelev *et al.*, Phys. Lett. **B727**, 371 (2013).

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