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Probing the speed of sound in QGP with multi-particle $[p_T]$ cumulants in ALICE

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The speed of sound squared, c_s^2 , one of the properties of the quark-gluon plasma (QGP) connected to the QCD equation of state, can be extracted from ultra-central heavy-ion collisions, where the medium mostly maintains a fixed size and fluctuations in the initial state and thermal fluctuations dominate. We present the first ALICE measurements of the event-by-event mean transverse momentum, $\langle [p_T] \rangle$, in particular its average and higher-order fluctuations as a function of multiplicity using particle spectra and multi-particle $\langle [p_T] \rangle$ cumulant techniques, in ultra-central Pb-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV. The pronounced rise in $\langle [p_T] \rangle$ and the sudden transition in higher-order fluctuations at high multiplicities are used to extract the speed of sound in QGP, c_s^2 , and to probe the thermalisation of the QGP, respectively. Our approach yields valuable insights into the thermalized nature of the deconfined state resulting from heavy-ion collisions, contributing to a deeper understanding of the QCD equation of state.

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