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# Longitudinal multiplicity fluctuations and flow decorrelations in Pb+Pb collisions with the ATLAS detector

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Longitudinal dynamics has recently become a topic of great interest in the study of ultra-relativistic heavy ion collisions. Both the multiplicity and the azimuthal anisotropic particle distribution measured in narrow $\eta$ intervals can fluctuate from the backward to forward pseudorapidtity region event-by-event. The multiplicity fluctuation is measured in $pp$, $p$+Pb and Pb+Pb collisions. A genuine long-range correlation (LRC) is found, similar across three systems. Both PYTHIA 8 and EPOS-LHC models significantly underpredict the magnitude of LRC in $pp$ collisions. A comprehensive study of decorrelations of flow harmonics $v_n$ is done for Pb+Pb collisions at 2.76 and 5.02 TeV. The decorrelation of $v_n$ between $\eta_1$ and $\eta_2$ is found to follow a linear dependence on the pseudorapidity separation $|\eta_1 - \eta_2|$ for $v_{2-5}$, and shows a small but a measurable variation with the collision energy. Furthermore, the higher order moments of flow decorrelations are measured. The first measurement of non-linear mode-mixing effects between lower and higher order flow harmonics as a function of pseudorapidity is also presented. These results will help to constrain initial conditions along longitudinal direction and also help to understand the longitudinal evolution of the fireball. In addition, differential measurement of v_n is presented in broad ranges of $p_T$ (0.5-40 GeV), pseudorapidity ($|\eta|$<2.5) and the collision centrality. The first measurement of $v_6$ and $v_7$, as well as flow harmonics in ultra-central collisions are discussed. A procedure of removing correlations arising from back-to-back jets is implemented in the two-particle correlation method to evaluate $v_n$ free of a jet-bias. The scaling relations between the $v_n$ harmonics are also discussed.

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