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Evidence for collective radial flow in high-multiplicity pp collisions via long-range transverse momentum correlation at Run 3 LHC energy

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The observation of collective phenomena, a hallmark of the quark-gluon plasma (QGP) formed in heavy-ion collisions, in small systems like proton-proton (pp) collisions, remains a topic of intense debate. This study presents the first investigation of radial flow in high-multiplicity (HM) pp collisions using the novel transverse momentum correlation observable, $v_0[p_{\mathrm{T}}]$. Analogous to anisotropic flow coefficients, the $v_0[p_{\mathrm{T}}]$ probes event-by-event fluctuations of the mean transverse momentum and is sensitive to the isotropic, collective expansion of the system [1]. Our analysis is performed using PYTHIA8 (v8.315) simulated events at Run 3 LHC energy ($\sqrt{s}$ = 13.6 TeV). We measure $v_0[p_{\mathrm{T}}]$ for inclusive charged and identified particles ($p/\overline{p}$, $\pi^{\pm}$, $K^{\pm}$). To suppress non-flow correlations from jets and resonance decays, we employ a pseudorapidity gap (η_{gap}) technique and extend it to include additional azimuthal gaps. The robustness of the signal is verified using two independent centrality estimators: charged particle multiplicity at mid-rapidity and the FT0 amplitude. The results reveal two key signatures of hydrodynamic collectivity: (i) A distinct mass ordering at low-p_{T} ($p_{\mathrm{T}} \leq$ 1.5 GeV/c), where $v_0[p_{\mathrm{T}}]$ is largest for pions and smallest for protons. A characteristic baryon-meson splitting at intermediate p_{T}, with protons exhibiting a larger $v_0[p_{\mathrm{T}}]$ than mesons. Furthermore, the magnitude of $v_0[p_{\mathrm{T}}]$ shows a clear multiplicity dependence, with the largest magnitude observed for low-multiplicity (LM) (60-70\%) class, gradually following a decreasing trend for HM classes (30-40\% and 10-20\%). The persistence of these signals after applying stringent η_{gap} and azimuthal gaps strongly suggests a collective origin. These findings, extracted for the first time using the $v_0[p_{\mathrm{T}}]$ observable, provide compelling evidence that radial flow can be generated in HM pp collisions, challenging the traditional paradigm that collective effects are exclusive to larger collision systems.

References:
[1] B. Schenke, C. Shen, and D. Teaney, "Transverse momentum fluctuations and their correlation with elliptic flow in nuclear collisions,"Physical Review. C, vol. 102, no. 3, Sep. 2020, doi: https://doi.org/10.1103/physrevc.102.034905.

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