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## Flow-Plane Decorrelations and Longitudinal Dynamics in Heavy-Ion Collisions

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The azimuthal correlations among local flow planes at forward, middle and backward (pseudo)-rapidities have been measured with the observable of factorization ratio derivative  $F_2$  for heavy-ion collisions at LHC and RHIC energies. The physical dynamics for the longitudinal decorrelation have not been determined. To study various longitudinal dynamics, we introduce an observable for the torque measurements ( $T_2$ ) using multiple-plane cumulants, and systematically evaluate the  $F_2$  and  $T_2$  performance through simulations of AMPT, AMPT embedded with PYTHIA jet, and non-flow phenomenological toy models. Possible longitudinal dynamics such as initial twist of participant matter and jet induced non-flow correlations would lead to distinct different rapidity dependence of  $F_2$  and  $T_2$  measurements. In particular, we show that  $T_2$  observable can significantly suppress the non-flow contributions because of the cumulant method. We argue that such decorrelation measurements with both  $F_2$  and  $T_2$  observables are important for low energy heavy-ion collisions at RHIC, where hydrodynamic fluid may not extend over sufficiently broad rapidity range.

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