Pre-hydrodynamic evolution and its signatures in final-state observables

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Introduction

Hybrid models coupling hydrodynamical simulations of the quark-gluon plasma (QGP) to a hadronic cascade model have been successful in describing important aspects of the hot and dense strongly interacting matter formed in relativistic heavy-ion collisions.

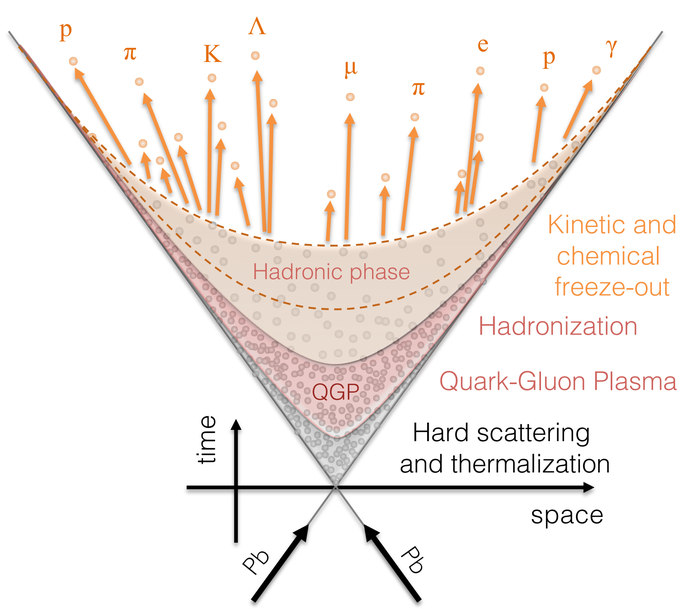

Figure 1: Stages of a HIC mapped to numerical chain

It is not yet clear, however, how the out-of-equilibrium matter formed immediately after the initial hard scattering evolves into a fluid close to equilibrium.

We utilise a hybrid model in order to probe three different pre-equilibrium dynamics scenarios in simulations of Pb-Pb collisions, and study global observables.

The Simulation Chain

The simulation chain we have employed is composed of:

- Initial condition generation: TRENTo [2]
- Pre-equilibrium dynamics: Kompost [3]
- Hydrodynamical evolution: MUSIC [4]
- Hadron gas evolution: UrQMD [5]

The Setup

We have simulated collisions of Pb-Pb nuclei with $\sqrt{(s_{NN})}$=2.76 TeV and considered three different hydrodynamisation scenarios:

- no pre-equilibrium dynamical evolution;
- a 1fm/c free streaming period starting at τ = 0.2fm/c;
- a 1fm/c Effective Kinetic Theory (EKT) period simulated with the Kompost model starting at τ = 0.2fm/c;

Multiplicity vs centrality

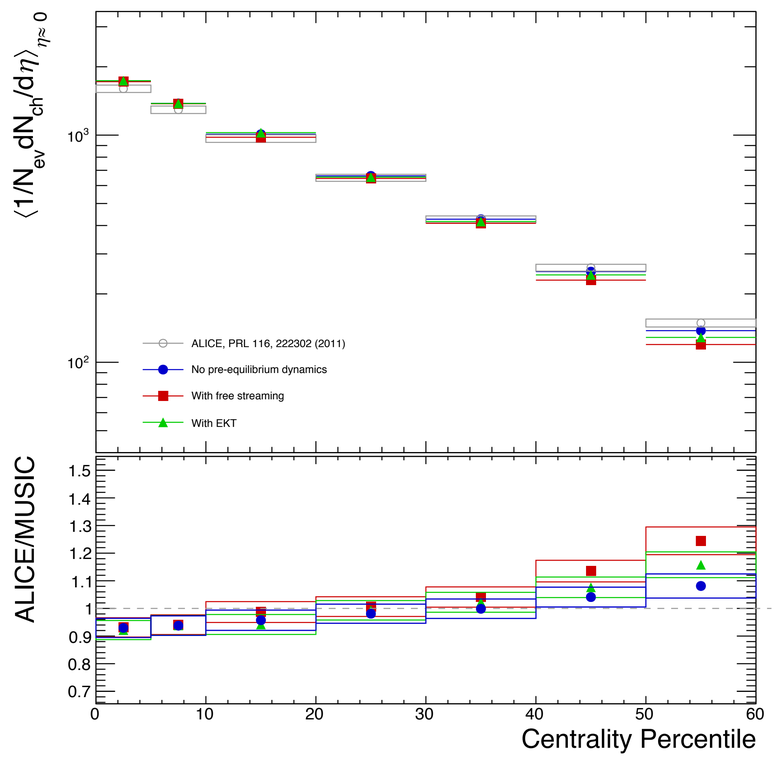

Figure 2: Charged-particle multiplicities as a function of centrality in the different pre-equilibrium scenarios.

Flow Observables

A principal component analysis (PCA) of the two-particle correlation matrix characterises flow fluctuations: the leading component proxies the differential flow, and subleading modes characterise flow correlations between two different transverse momenta [7,8].

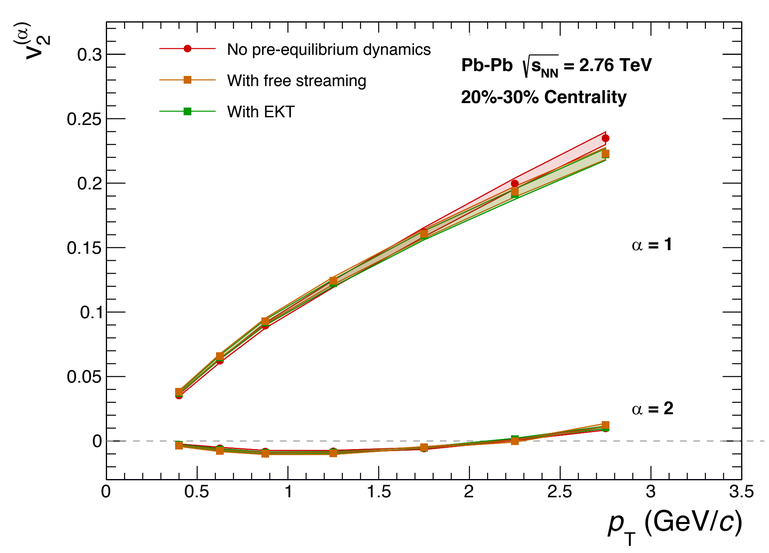

Figure 3: ExTrEM PCA analysis of v_2 in various pre-equilibrium scenarios

We note this observable to be insensitive to pre-equilibrium dynamics. This is not the case for the integrated flow coefficient $v_2\{2\}$.

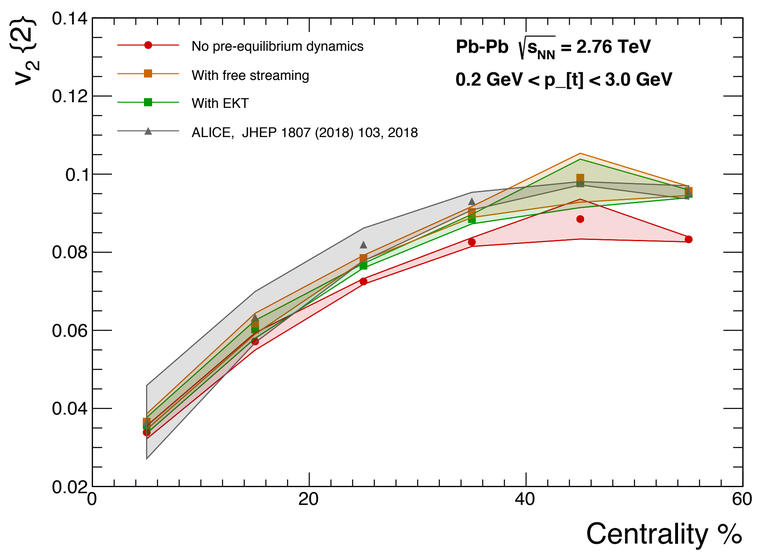

Figure 4: Integrated $v_2\{2\}$ in various pre-equilibrium scenarios.

This is explained by an increase in the transverse momentum spectra across all centralities, when pre-equilibrium dynamics is introduced.

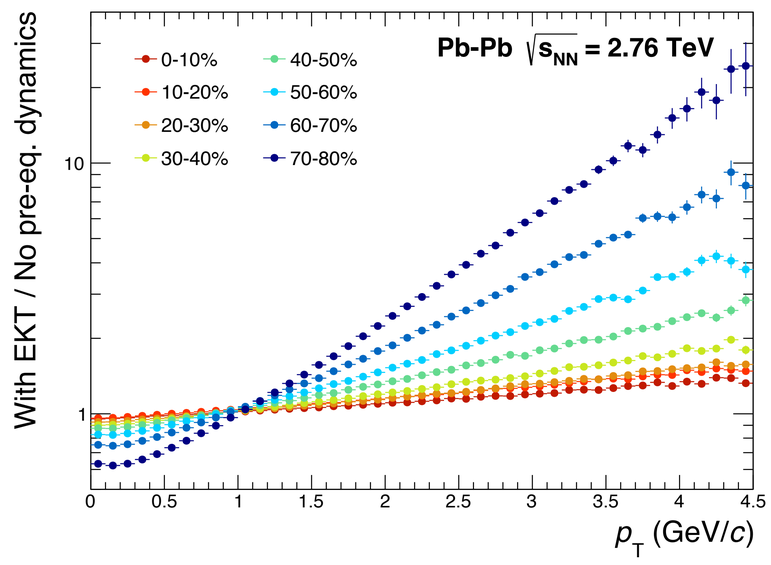

Figure 5: p_T spectra ratio for two pre-equilibrium scenarios

Such an effect can also be seen in the average particle momentum on the transverse plane.

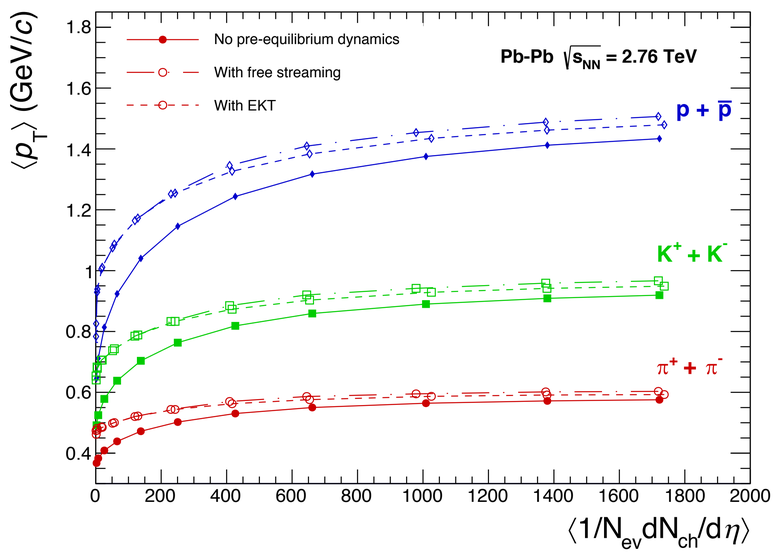

Figure 6: Average p_T in various pre-equilibrium scenarios

Conclusions and Outlook

- The effect of the addition of pre-equilibrium dynamics is mainly restricted to p_T spectra.
- The anisotropic PCA modes (i.e., n≠0 modes) are insensitive to it, allowing for isolating fluctuation sources from the remaining collision stages.
- This study is being extended to systems with smaller sizes.

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