Collective flow in small systems from an integrated dynamical model

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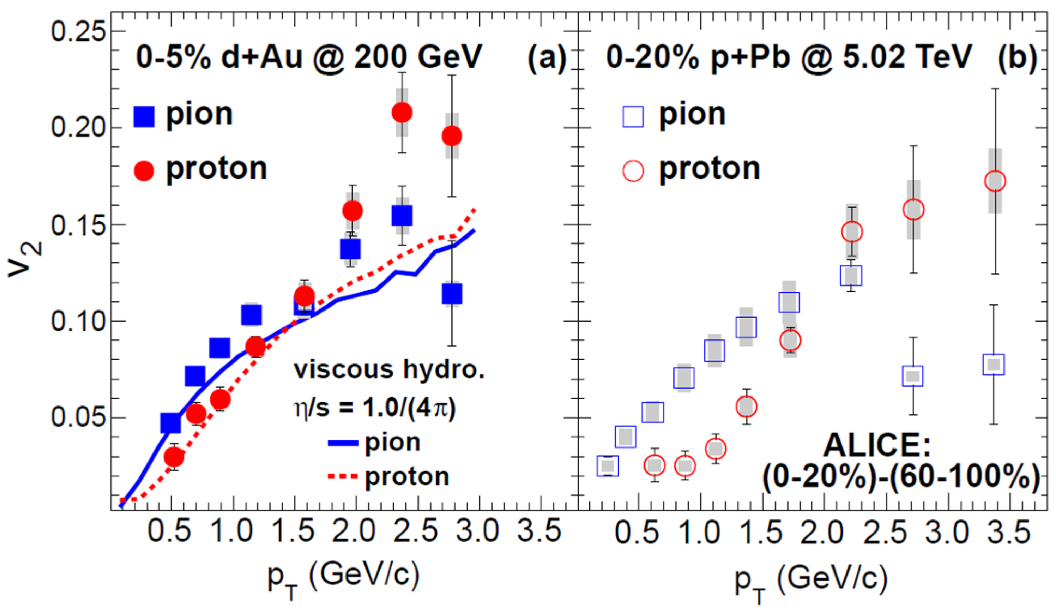
1. Introduction

Collective-flow-like behaviors in small systems



Observation of mass ordering for identified hadrons

Consistent with hydrodynamic flow

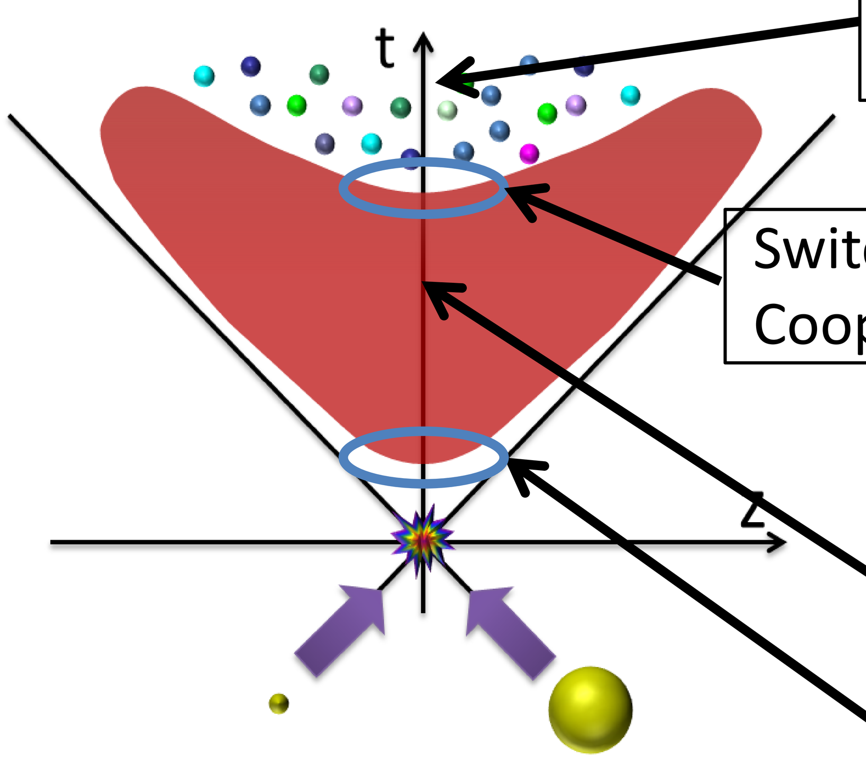
A. Adare *et al.*, Phys. Rev. Lett. 114,192301(2015).

Purpose of the current study

Analysis of flow observables in small systems by employing an integrated dynamical model with QGP fluid formation

2. Integrated dynamical model

T. Hirano *et al.*, Prog. Part. Nucl. Phys. 70, 108 (2013).



Hadronic rescatterings
Hadron cascade simulations (JAM)

Switch from fluid to cascade
Cooper-Frye formula ($T_{sw} = 155$ MeV)

Hydrodynamic QGP evolution
Fully (3+1) dimensional ideal hydrodynamic simulations

Experimental condition
RHIC: d+Au, $\sqrt{s_{NN}} = 200$ GeV

Initial condition

Initialization model

Brodsky-Gunion-Kuhn type initial nuclear effects [1]
MC-Glauber model
Event Generator PYTHIA [2]

- Transverse profile fluctuation
- Asymmetric longitudinal profile

+

New!

- Multiplicity fluctuation
- Longitudinal fluctuation and correlation

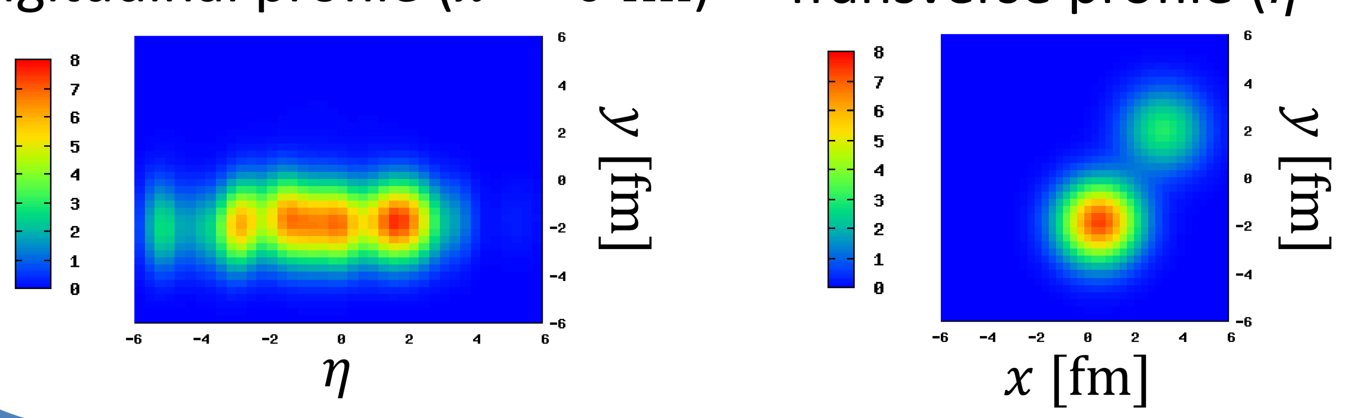
Example of initial condition of the parton density in d+Au collision

Smearing parameter: $\delta_x = 0.3$ fm, $\delta_y = 0.3$ fm, $\delta_\eta = 0.3$

Cell size: $dx = 0.3$ fm, $dy = 0.3$ fm, $d\eta = 0.3$

Initial time: $\tau_0 = 0.6$ fm

Longitudinal profile ($x = 0$ fm) Transverse profile ($\eta = 0$)

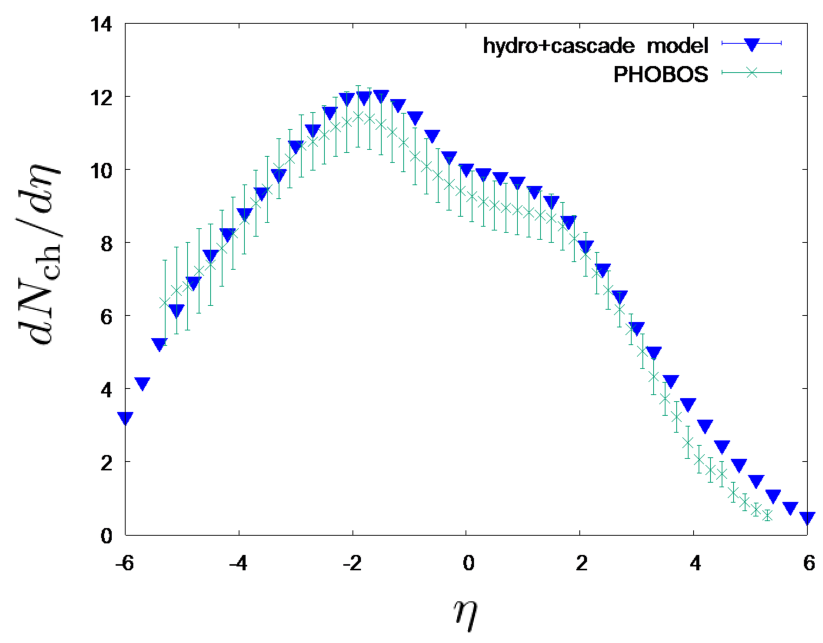


[1] S.J. Brodsky, J.F. Gunion and J.H. Kuhn, Phys. Rev. Lett. 39, 1120(1977).
[2] T. Sjöstrand *et al.*, Comput. Phys. Commun. 191, 159 (2015).

3. Results

Charged particle pseudo-rapidity density distribution

Experimental configuration: MinBias events

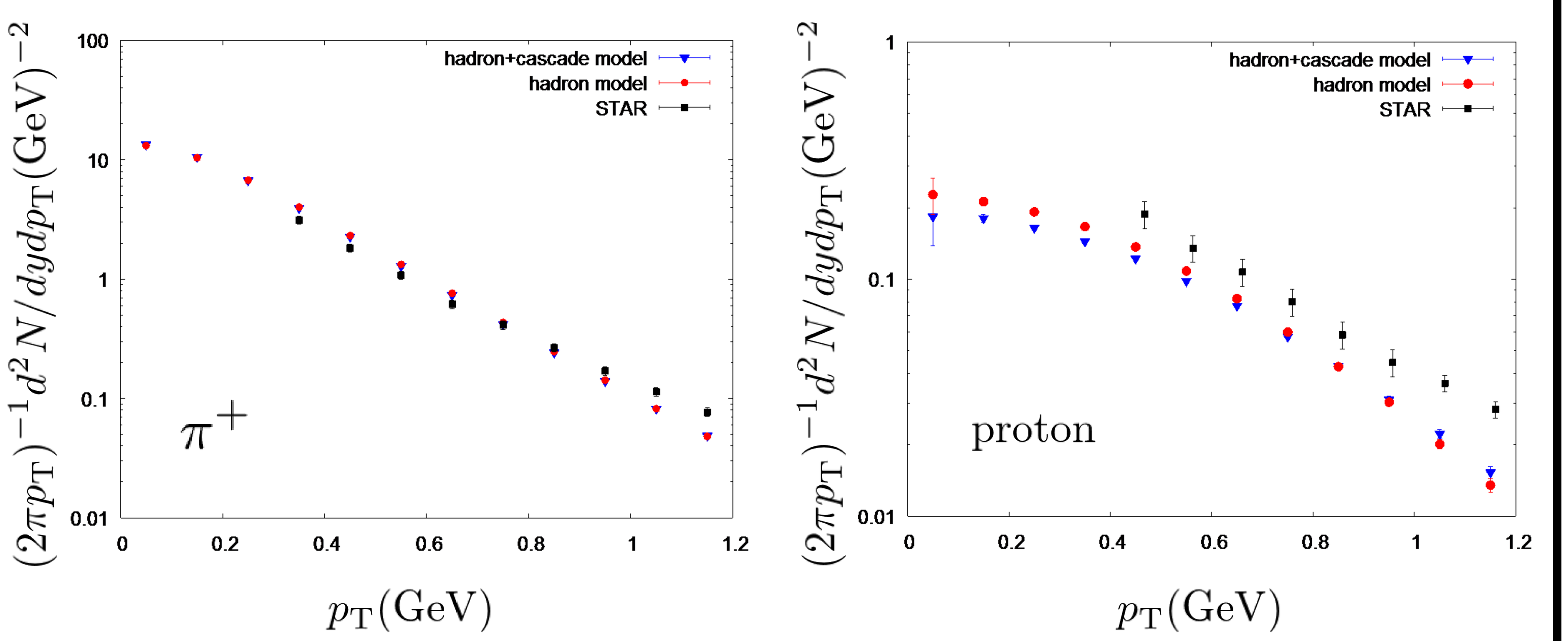


Reproduction of PHOBOS data
B. B. Back *et al.*, Phys. Rev. Lett. 93 082301 (2004).

Good description of asymmetric $dN_{ch}/d\eta$ by BGK initialization

Identified hadron transverse momentum spectra

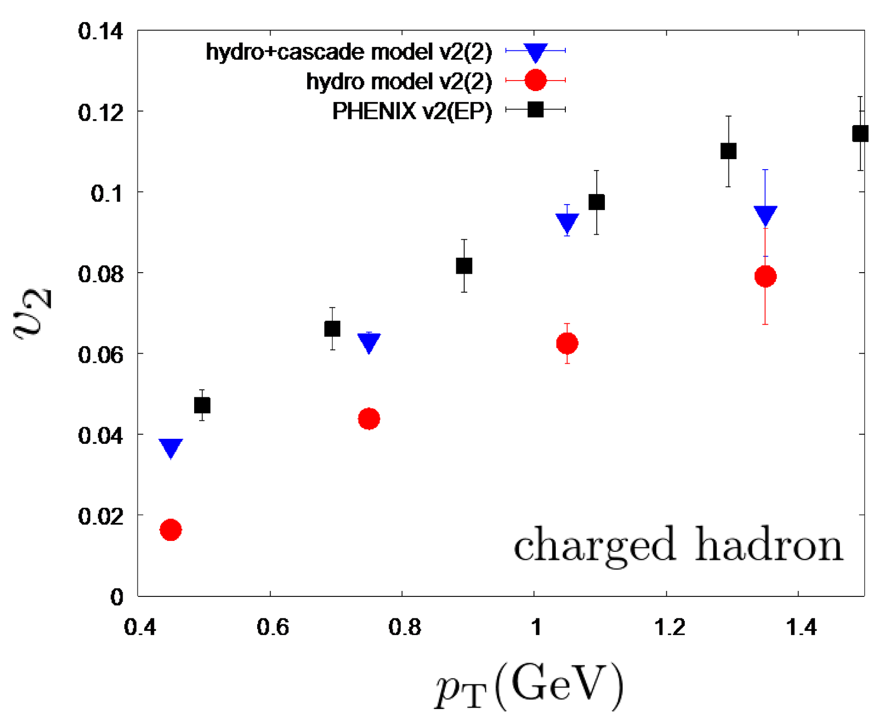
Experimental configuration: MinBias events, -0.5 <*y*< 0.0



Description of STAR data for pions in low p_T
John Adams *et al.*, Phys.Lett.B616:8-16,(2005)

p_T slope of protons is more sensitive to hadron rescatterings than that of pions

Elliptic flow parameter



Experimental configuration
Centrality 0-5%, $|\eta| < 0.35$

Reproduction of PHENIX v_2 data

Both QGP fluid-dynamic expansion and hadronic rescatterings contribute to final v_2

4. Summary

- Development of a novel hydrodynamic initialization model
- Analysis of observables in d+Au collisions by employing the model
  - Charged particle pseudo-rapidity density distribution
  - Identified hadron transverse momentum spectra
  - Elliptic flow parameter

The observed large v_2 is attributed to both QGP expansion and hadronic rescatterings.

The hadronic afterburner also plays an important role in the whole dynamical evolution in small systems.

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