Describing High Energy Collisions With Hydrodynamics

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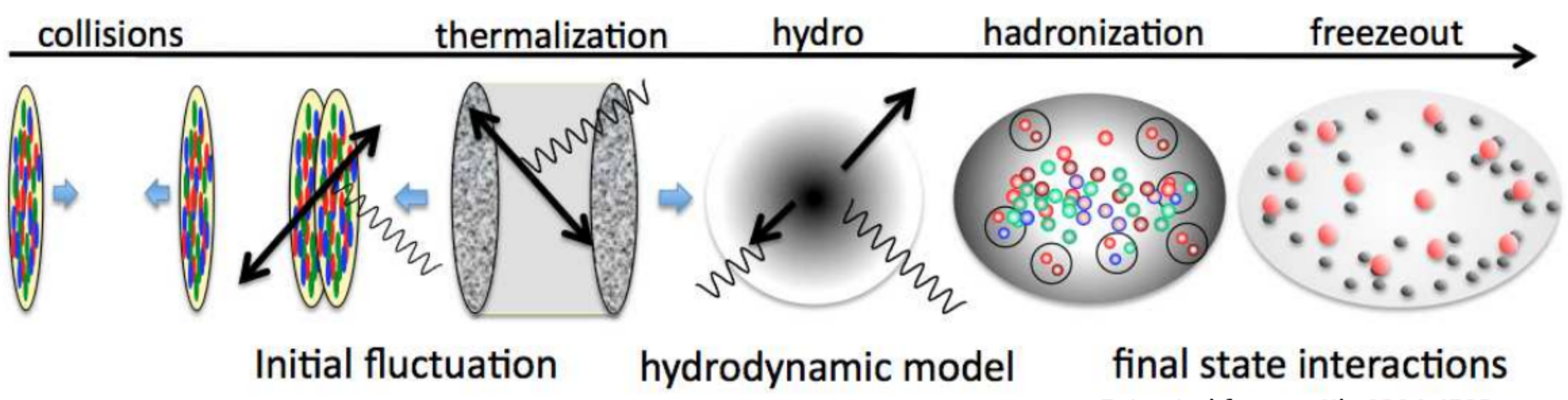
Overview

Relativistic heavy ion collisions allow the study of the behavior of matter under extreme pressure and temperature conditions. Under these conditions it is possible to observe a transition from ordinary matter to a quark-gluon plasma (QGP). One possible tool for studying the system formed in these collisions is the hydrodynamic model. The application of this model is based on the assumption that the system reaches a state of local thermodynamic equilibrium and in the fact that the matter formed in these collisions shows a collective behavior. Recently, experimental results have shown evidence of a similar collective behavior in small colliding systems (pp and pPb at LHC and pAu, dAu and ^{3}HeAu at RHIC).

Hydrodynamic Model



Extracted from: arXiv:1204.4795

Hydrodynamic Equations

$$\partial_{;\mu}T^{\mu\nu} = 0 \quad \text{where} \quad T^{\mu\nu} = \epsilon u^{\mu}u^{\nu} - (P+\Pi)\Delta^{\mu\nu} + \pi^{\mu\nu}$$

- Israel-Stewart - vHLLE [1] (2D+1 - boost invariance)

$$\Delta^{\mu\alpha}\Delta^{\nu\beta}u^{\gamma}\partial_{;\gamma}\pi^{\alpha\beta} = -\frac{1}{\tau_\pi}\left[\pi^{\mu\nu} - \pi^{\mu\nu}_{\text{NS}}\right] - \frac{4}{3}\pi^{\mu\nu}\partial_{;\gamma}u^{\gamma}$$

$$u^{\gamma}\partial_{;\gamma}\Pi = -\frac{1}{\tau_\Pi}\left[\Pi - \Pi_{\text{NS}}\right] - \frac{4}{3}\Pi\partial_{;\gamma}u^{\gamma}$$

where

$$\pi^{\mu\nu}_{\text{NS}} = \eta\left(\Delta^{\mu\lambda}\partial_{;\lambda}u^{\nu} + \Delta^{\nu\lambda}\partial_{;\lambda}u^{\mu}\right) - \frac{2}{3}\eta\Delta^{\mu\nu}\partial_{;\lambda}u^{\lambda},$$

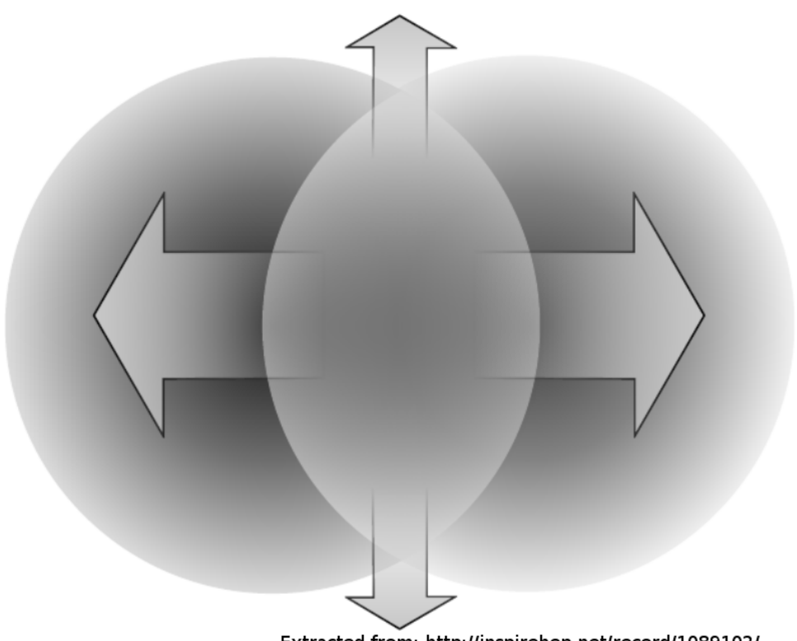
$\Pi_{\text{NS}} = \zeta\partial_{;\lambda}u^{\lambda}$ and $\Delta^{\mu\nu} = g^{\mu\nu} - u^{\mu}u^{\nu}$.

Ingredients

- Initial Conditions (IC) - T_RENTo [2]
- Equation of State (EoS)- Inspired in lattice QCD results [3, 4]
- Freeze-out - THERMINATOR2 [5]

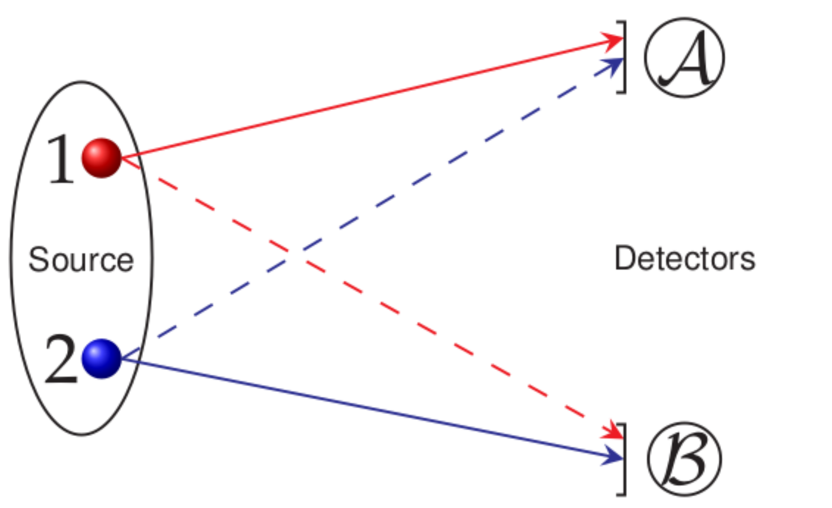
Observables

Elliptic Flow



Extracted from: http://inspirehep.net/record/1089102/

HBT

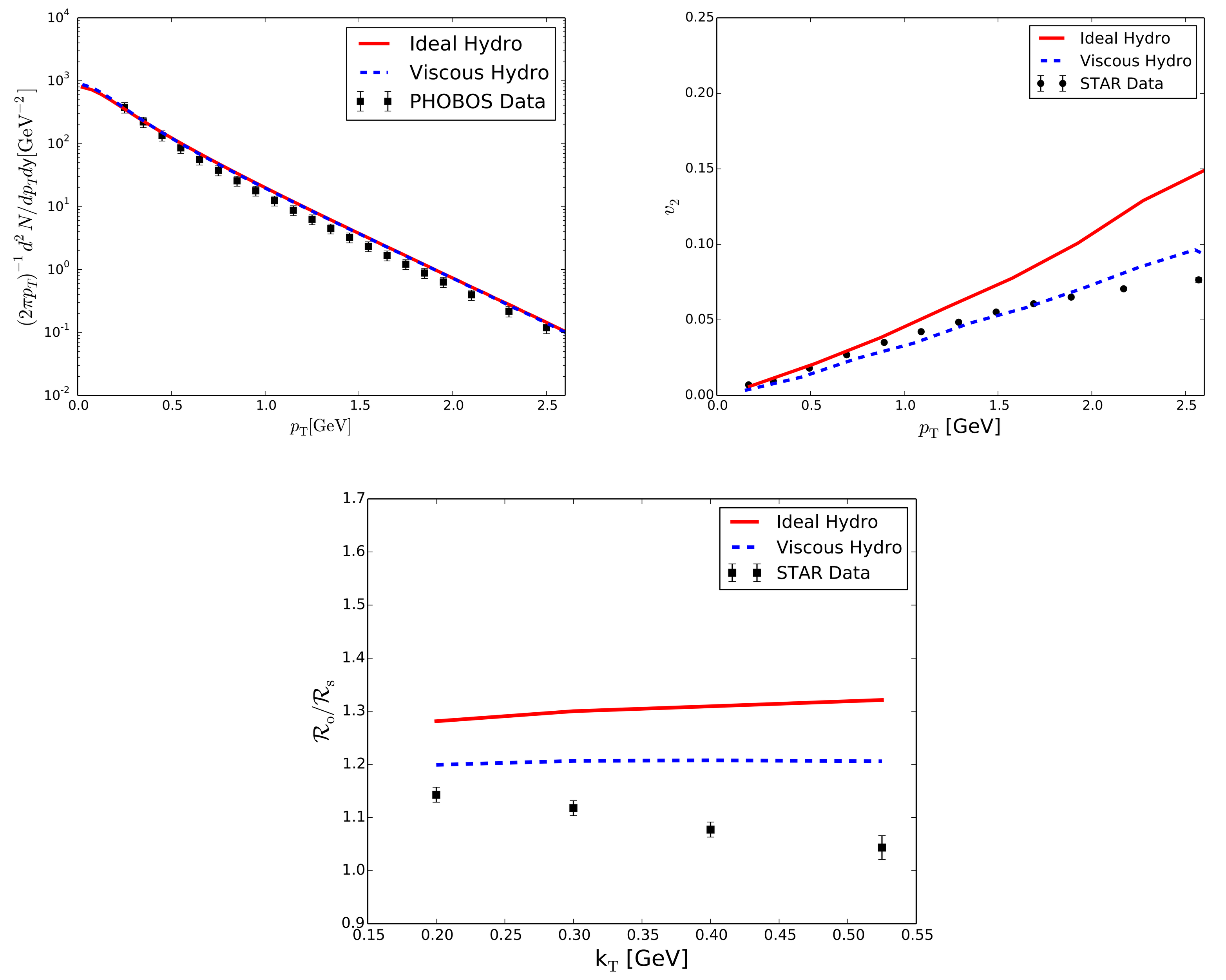


$$v_2 = \langle\cos(2(\phi - \psi_2))\rangle \qquad \mathcal{C} = \frac{\mathcal{P}_2(p_1^\mu, p_2^\mu)}{\mathcal{P}_1(p_1^\mu)\mathcal{P}_1(p_2^\mu)} \to 1 + \lambda e^{\left[-\sum_i \mathcal{R}_i^2 q_i^2\right]}$$

Results

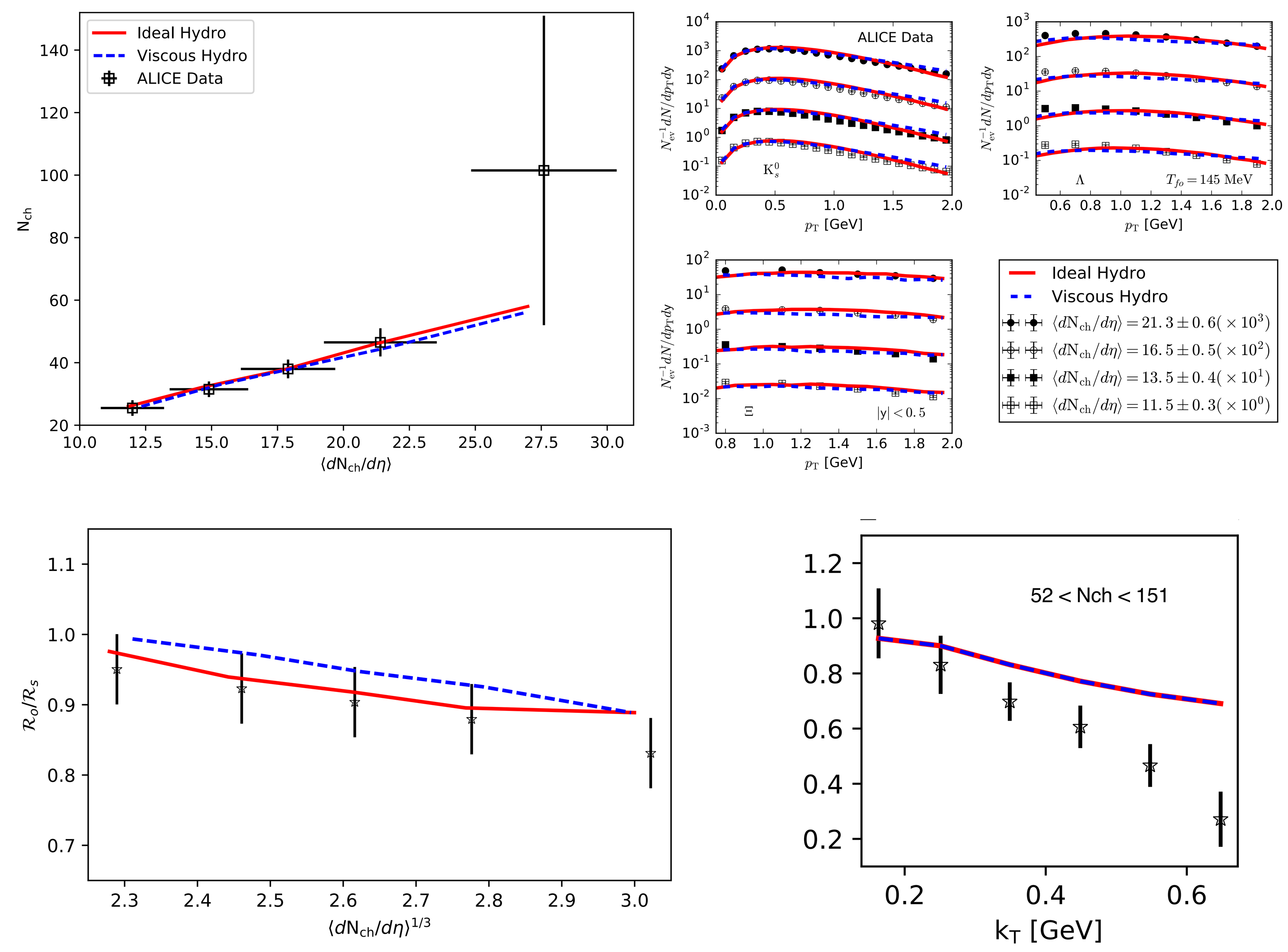
Heavy-Ion Studies (EoS [3] and Smooth IC)

- RHIC - AuAu@0-5% 200 GeV (Data from PHOBOS [6] and STAR [7])



Investigating Small Systems (EoS [4] and event-by-event IC)

- LHC - pp 7 TeV (Data from ALICE [8])



We concluded that the hydrodynamic model is a good tool to discribe the data for both heavy ion collisions and small colliding systems.

Acknowledgements

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References

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