Results on femtoscopy from hydrodynamics in pp collisions at $\sqrt{s} = 7$ TeV

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Overview

The hydrodynamical model is an important tool for describing the collective behavior of the matter produced in relativistic heavy-ion collisions. Recently, experimental results show evidence of the same collective behavior in small systems (pp and pPb) in high multiplicity [1]. In this work, we calculated the pion femtoscopy in pp collisions at $\sqrt{s} = 7$ TeV with event-by-event hydrodynamics for both viscous and ideal cases.

Hydrodynamical Model

In the hydrodynamical description, we assume that a matter in local thermal equilibrium is formed and its evolution is governed by the conservation of energy-momentum and other conserved numbers.

- Equations of Motion

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

- Israel-Stewart

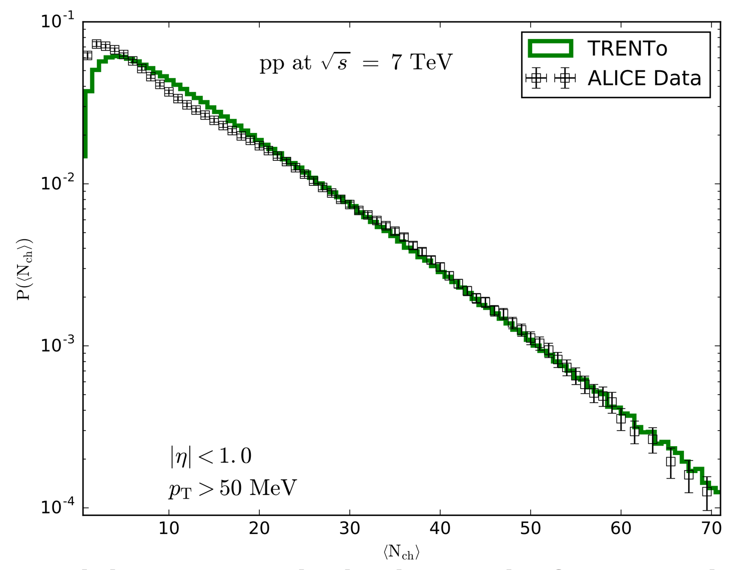
$$\Delta^{\mu\alpha}\Delta^{\nu\beta}u^\gamma \partial_{;\gamma}\pi_{\alpha\beta} = -\frac{1}{\tau_\pi}\left[\pi^{\mu\nu} - \pi^{\mu\nu}_{\text{NS}}\right] - \frac{4}{3}\pi^{\mu\nu}\partial_{;\gamma}u^\gamma$$

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

- Solved by vHLLE code [2] in 2D+1;

Ingredients

1. Initial Conditions (IC)
   Give us information about the state of the matter formed in the collisions at the instant it enters in a local thermal equilibrium.
   - Generated by TRENTo [3].
   - $p = 0.0$;
   - $k = 2.0$;
   - $w = 0.4 fm$;
   - $\tau_0 = 0.1 fm$;

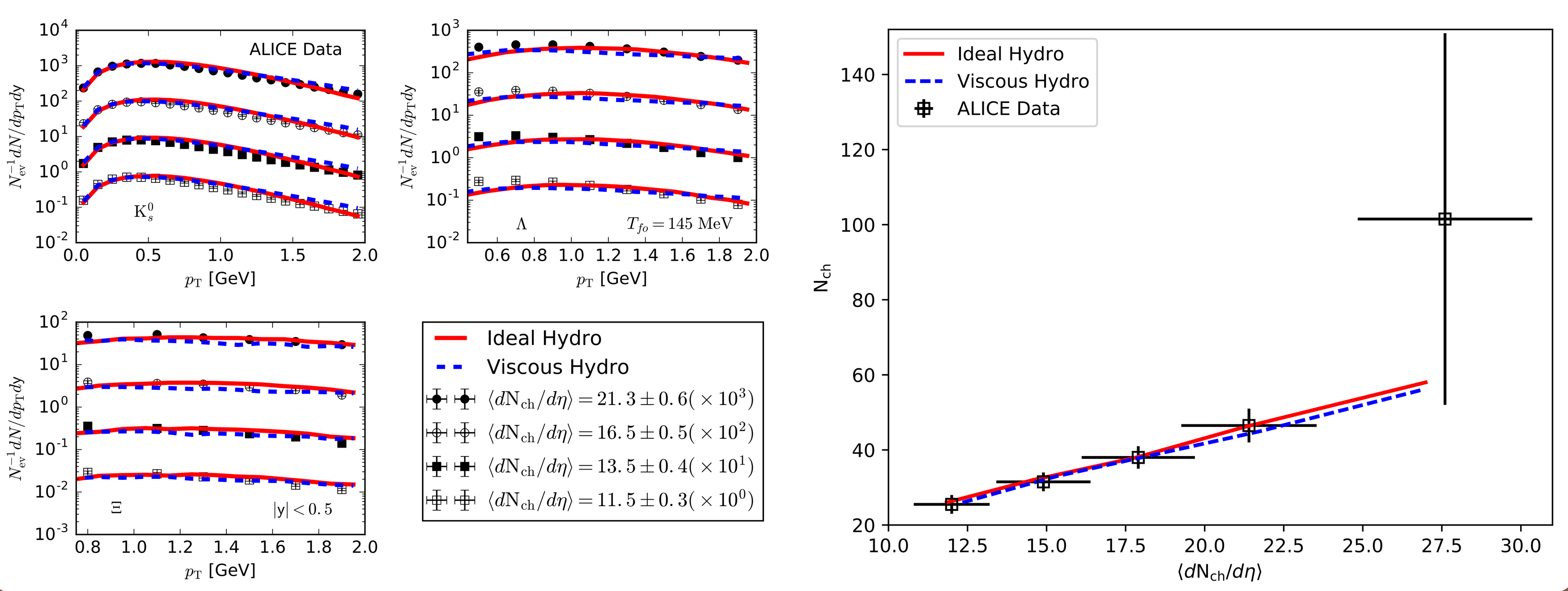


2. Equations of State (EoS)
   Relate the thermodynamic quantities and bring information about the phase transition of the matter created in the collisions;
   - HotQCD EoS with $2 + 1$ flavors [4];
   - $T_c = 154 \pm 9$ MeV;
3. Freeze-out
   The stage when the mean free-path becomes of the order of the size of the system. In that case, the hydrodynamical model is no longer valid and the particles decouple by traveling straight to the detector.

$$E\frac{d^3N}{d^3p} = \int_\Sigma d\Sigma_\mu p^\mu f(x,p)$$

   - Solved by THERMINATOR 2 [5];

Spectra and Pseudorapidity



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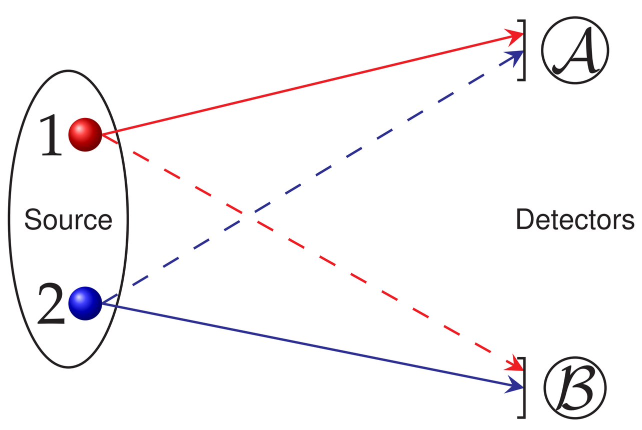
Femtoscopy

Bose-Einstein correlations or femtoscopy are a powerful probe of the space-time geometry of the particle emitting source.

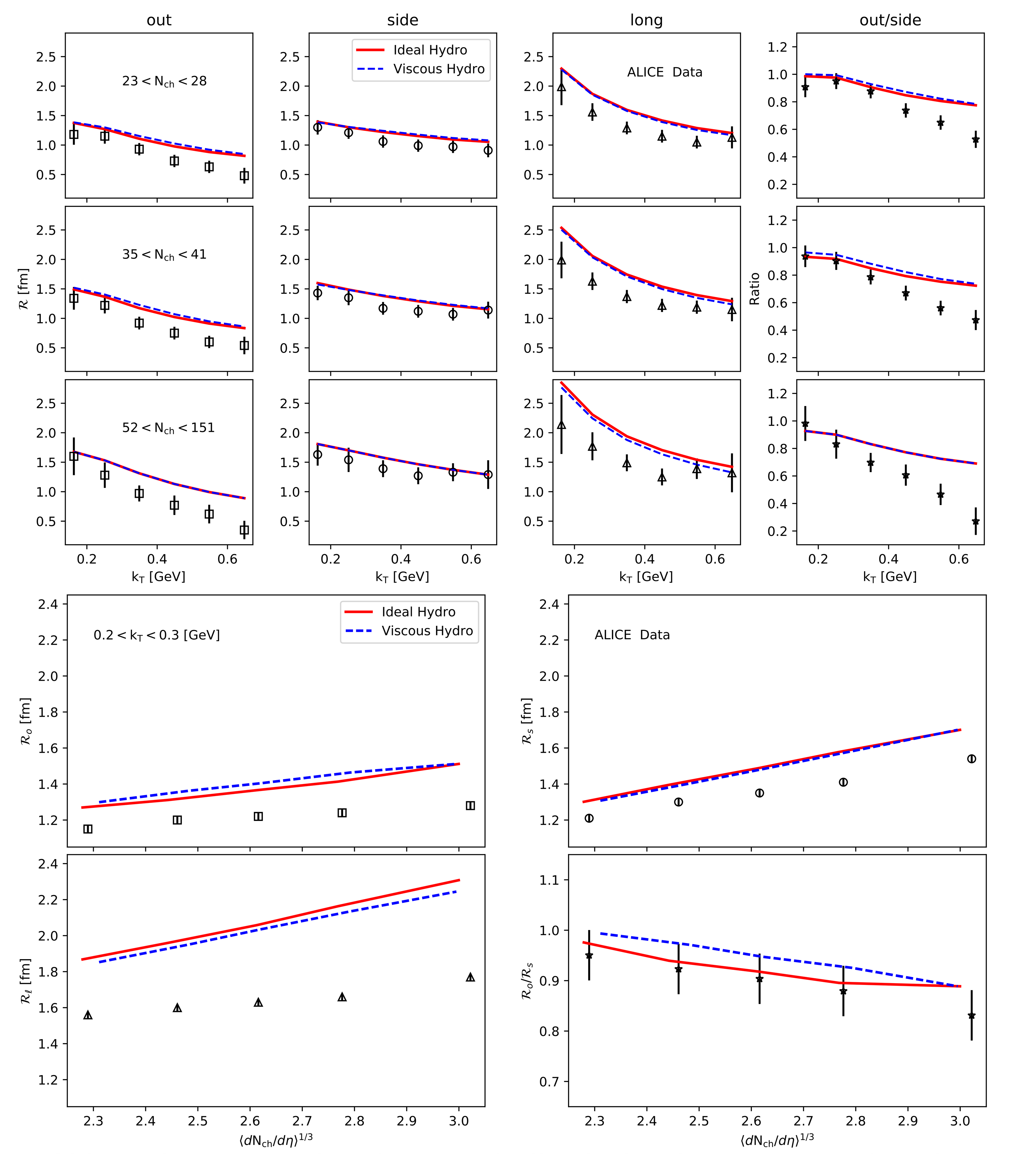


$$\mathcal{C}(p_1^\mu, p_2^\mu) = \frac{\mathcal{P}_2(p_1^\mu, p_2^\mu)}{\mathcal{P}_1(p_1^\mu)\mathcal{P}_1(p_2^\mu)}$$

- Bertsch-Pratt (3D Fit)

$$\mathcal{C} = 1 + \lambda \exp\left[-\mathcal{R}_o^2 q_o^2 - \mathcal{R}_s^2 q_s^2 - \mathcal{R}_\ell^2 q_\ell^2\right]$$

Results



Although our results show a similar behavior compared to the experimental data [6], in general, the obtained radii overestimate the data for $\mathcal{R}_o$, $\mathcal{R}_s$, and $\mathcal{R}_\ell$. We also see the small influence of viscous effects on the radii in pp collisions. We expect our results will be improved by including Coulomb interaction between the produced pions (work in progress).

References

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