

Hydrodynamics and Jets in Dialogue

Korinna Zapp

&

Stefan Flörchinger

CERN

Quark Matter 2014

Darmstadt, 19. – 24.05.2014



Introduction

What hydro does
to jets

What jets do to
hydro

Conclusions

The plot

- ▶ want to study interplay between jets and bulk
- ▶ fully **self-consistent** description difficult
 - **combine jets & hydrodynamic evolution of bulk**
- ▶ need to iterate
 1. solve hydro without jets
 2. **compute jets in hydro background**
 3. **re-solve hydro with input from jets**
 4. re-compute jets in modified background
 - neglected due to causality
- ▶ want to **avoid** having to do it **event-by-event**
- ▶ characterise effect of jets in terms of **n-point functions**
- ▶ **caveat: separation** between jets and bulk **ill-defined**

The cast

Hydro: 1+1 viscous hydro

Floerchinger & Wiedemann, Phys. Lett. B **728** (2014) 407

- ▶ **boost-invariant** long. expansion + **transv. expansion**
- ▶ **viscosity**: $\eta/s = 0.08$
- ▶ **EOS**: parametrisation of **lattice + hadron resonance gas**

Huovinen & Petreczky, Nucl. Phys. A **837** (2010) 26

- ▶ **initial conditions**: $T_i = 485$ MeV and $\tau_i = 0.6$ fm

Shen & Heinz, Phys. Rev. C **85** (2012) 054902

Jets: JEWEL

Zapp, Krauss & Wiedemann, JHEP **1303** (2013) 080

- ▶ jet evolution in dense medium
- ▶ **common** pQCD framework for **radiation** and **scattering**
- ▶ **microscopic** description of **jet-medium interactions**
- ▶ **medium toy model**: Glauber profile + Bjorken expansion

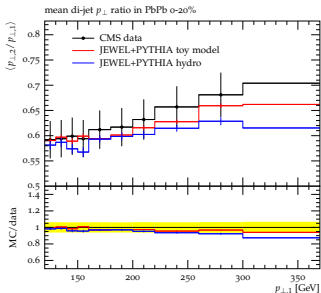
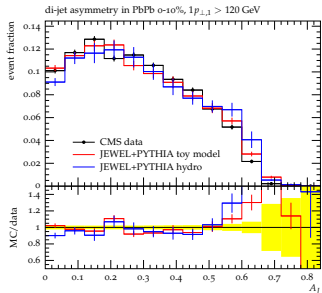
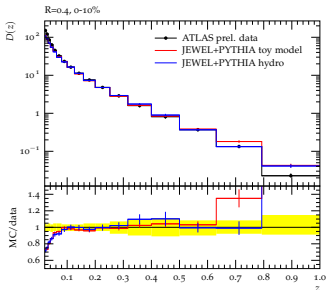
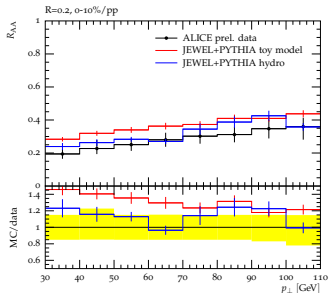
Introduction

What hydro does
to jets

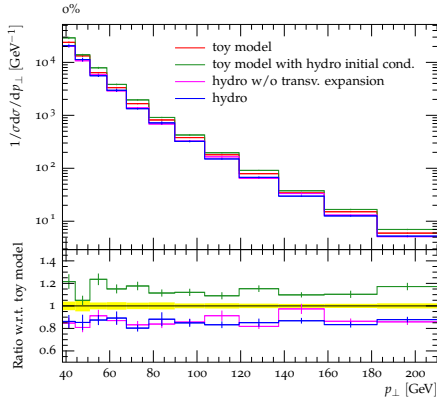
What jets do to
hydro

Conclusions

JEWEL+hydro: some results



Origin of differences



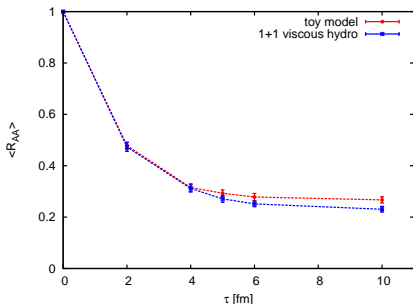
- ▶ transverse profile plays a role

T in toy model with hydro initial cond. lower than in hydro

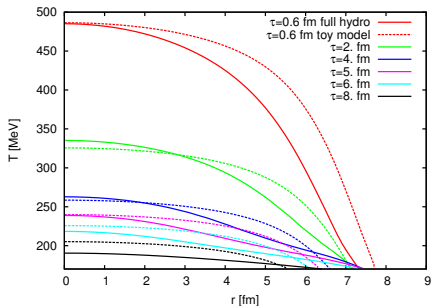
- ▶ transverse expansion enters

1. **directly** in momentum distribution: **no effect**
2. **indirectly** through temperature profile: **matters**

Origin of differences



- ▶ early times: $\langle T \rangle$ in toy model higher
- ▶ later times: $\langle T \rangle$ in hydro higher
- ▶ later times: hydro extends to larger r



Now let's change sides . . .

The source term

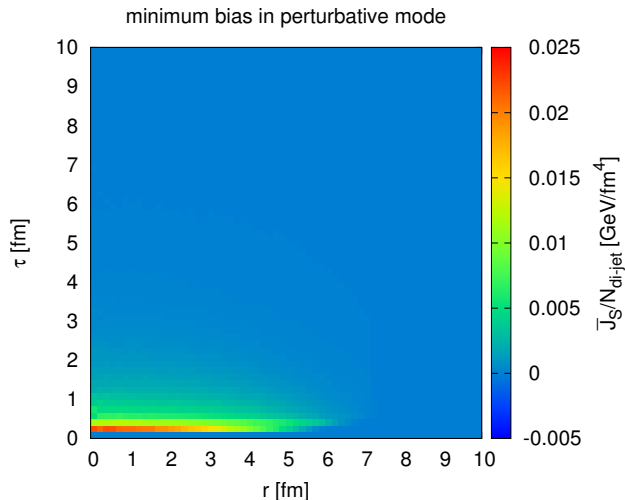
Definitions

- ▶ interface: 4-momentum transfer in scattering processes
- ▶ source term: $J^\mu(x) = \sum_i \Delta p_i^\mu \delta^{(4)}(x - x_i)$
- ▶ hydro equations: $\partial_\mu T^{\mu\nu} = J^\nu$
- ▶ projections w.r.t. fluid velocity:
 $J_S = u_\nu J^\nu \quad \& \quad J_V^\mu = \Delta^\mu{}_\nu J^\nu$
- ▶ characterise J^μ in terms of
 - ▶ event averages: $\langle J_S(x) \rangle, \langle J_V^\mu(x) \rangle$
 - ▶ correlators: $\langle J_S(x) J_S(y) \rangle, \langle J_S(x) J_V^\mu(y) \rangle, \langle J_V^\mu(x) J_V^\nu(y) \rangle$for Gaussian fluctuations this is sufficient

Setup for 'typical event'

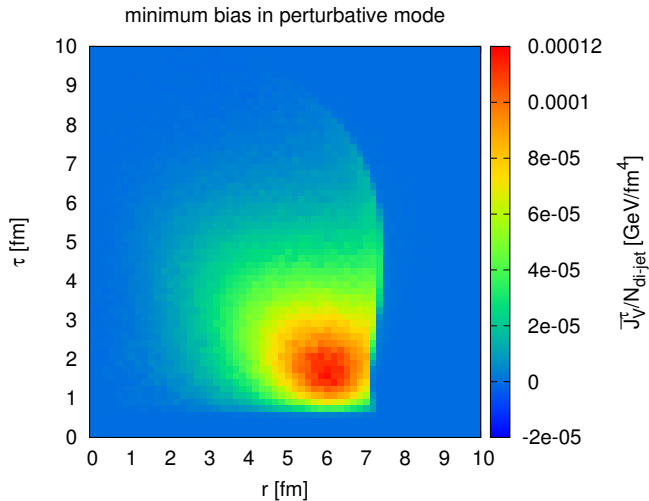
- ▶ start with $b = 0, |\eta| < 0.5$
- ▶ $p_{\perp, \text{cut}} = 3 \text{ GeV}$ generate jets where they dominate over bulk
- ▶ $\langle N_{\text{di-jet}} \rangle = T_{AA} \sigma_{\text{di-jet}} \approx 1700$

The source term: averages



$$\bar{J}_S(x) = \langle J_S(x) \rangle$$

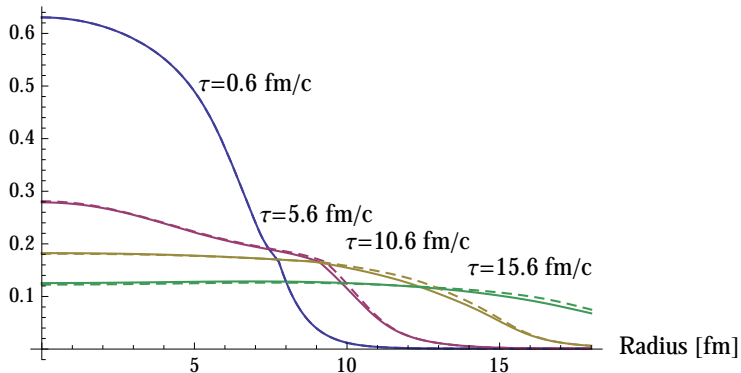
The source term: averages



$$\bar{J}_V^\tau(x) = \langle J_V^\tau(x) \rangle$$

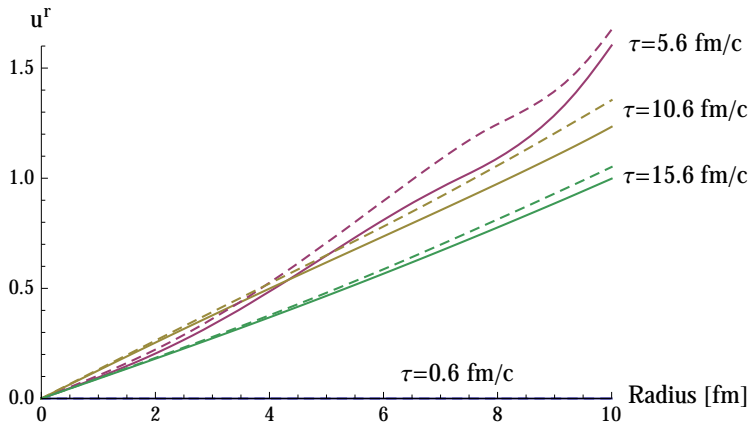
Hydro with source term

T [GeV]



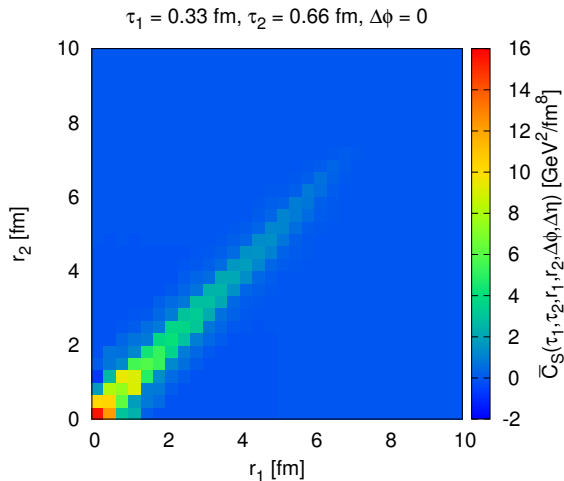
- ▶ effect of jets on temperature negligible

Hydro with source term



- ▶ small increase of transverse flow

The source term: Correlators



$$\bar{C}_S(x, y) = \langle J_S(x) J_S(y) \rangle - \bar{J}_S(x) \bar{J}_S(y)$$

- ▶ contributes to correlations (e.g. v_n)

Conclusions

Our approach

- ▶ construct **realistic source term** for hydro evol. from jets
- ▶ characterise it in terms of **averages** and **correlators**
no need to do event-by-event hydro

Influence of hydro on jets

- ▶ very **reasonable** description of data
- ▶ **small differences** between hydro and toy model
smaller than current uncertainties
- ▶ some sensitivity to **late times** in JEWEL

Influence of jets on hydro

- ▶ effect on temperature negligible
- ▶ small **increase** of **radial flow**
- ▶ potentially sizeable impact on **correlations**
work in progress – stay tuned