Some comments about jet quenching in small collision systems

Ulrich Heinz

THE OHIO STATE UNIVERSITY

In collaboration with J. Scott Moreland (Duke)

Exploring the Perfect Liquid

Munich Institute for Astro- and Particle Physics,
Garching, 6. – 8. September 2018

BEST COLLABORATION

JETSCAPE

Why has jet quenching not been observed in pp and pPb collisions

even though flow signatures suggest the formation of a QGP medium?

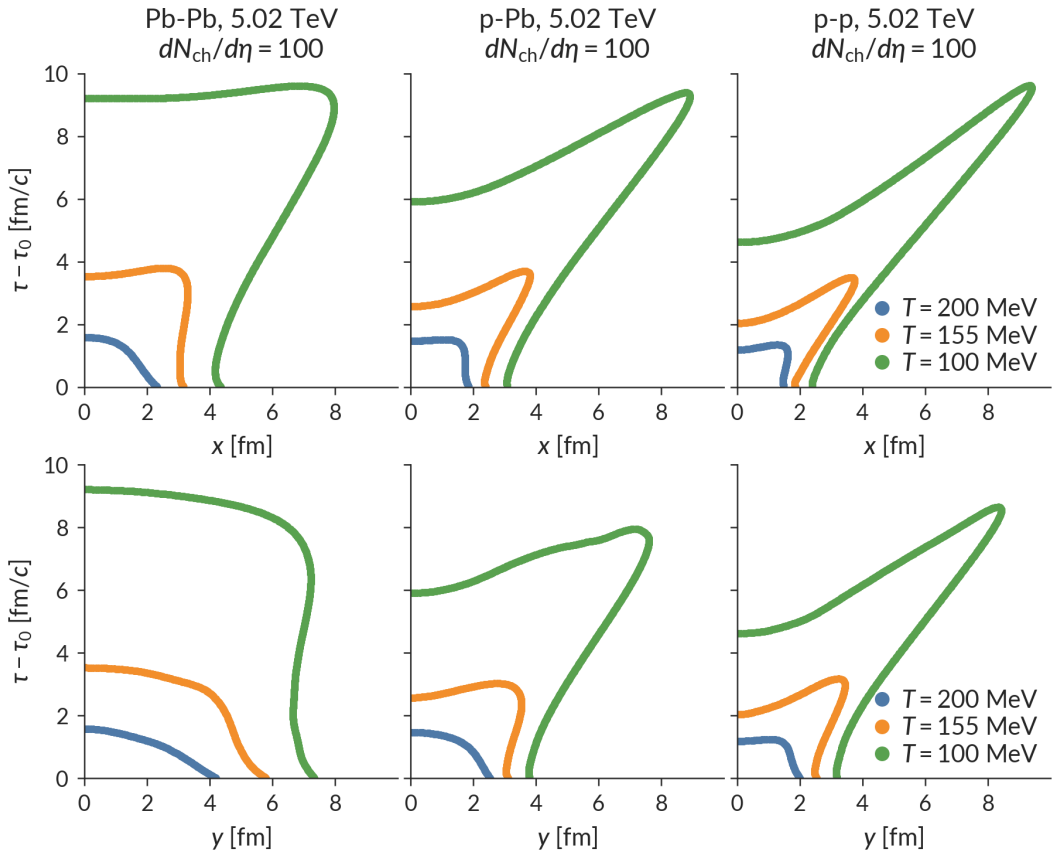
Hydrodynamic evolution of isotherms in small systems:

Three collision systems with the same multiplicity $dN_{\rm ch}/d\eta = 100$

calibrated iEBE-VISHNU with averaged TRENTO ICs with nucleon substructure

short direction:

long direction:



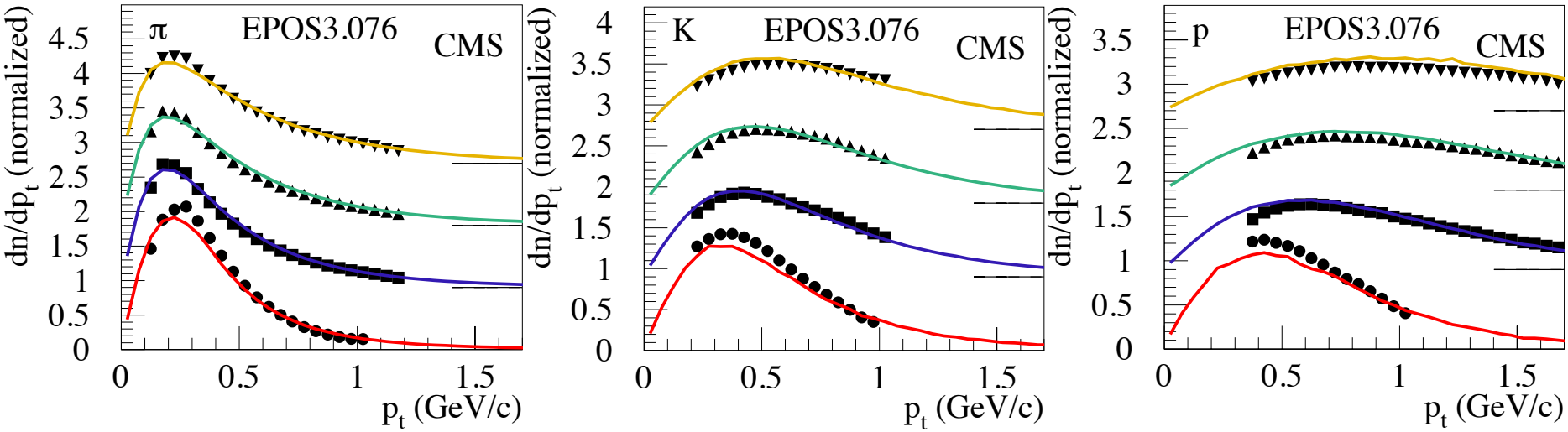
Collision systems with similar $dN_{\rm ch}/d\eta$ have similar freeze-out volumes!

$\Longrightarrow$ **Stronger radial flow in initially smaller systems!**

Radial flow in pp collisions at the LHC

Werner, Guiot, Karpenko, Pierog (EPOS3), PRC 89 (2014) 064903;

Data: CMS Collaboration (8, 84, 160, 235 charged tracks)



Elliptic flow (double ridge) discovered in high-multiplicity pp by CMS at 7 TeV (and confirmed by ATLAS at 13 TeV) also reproduced by EPOS.

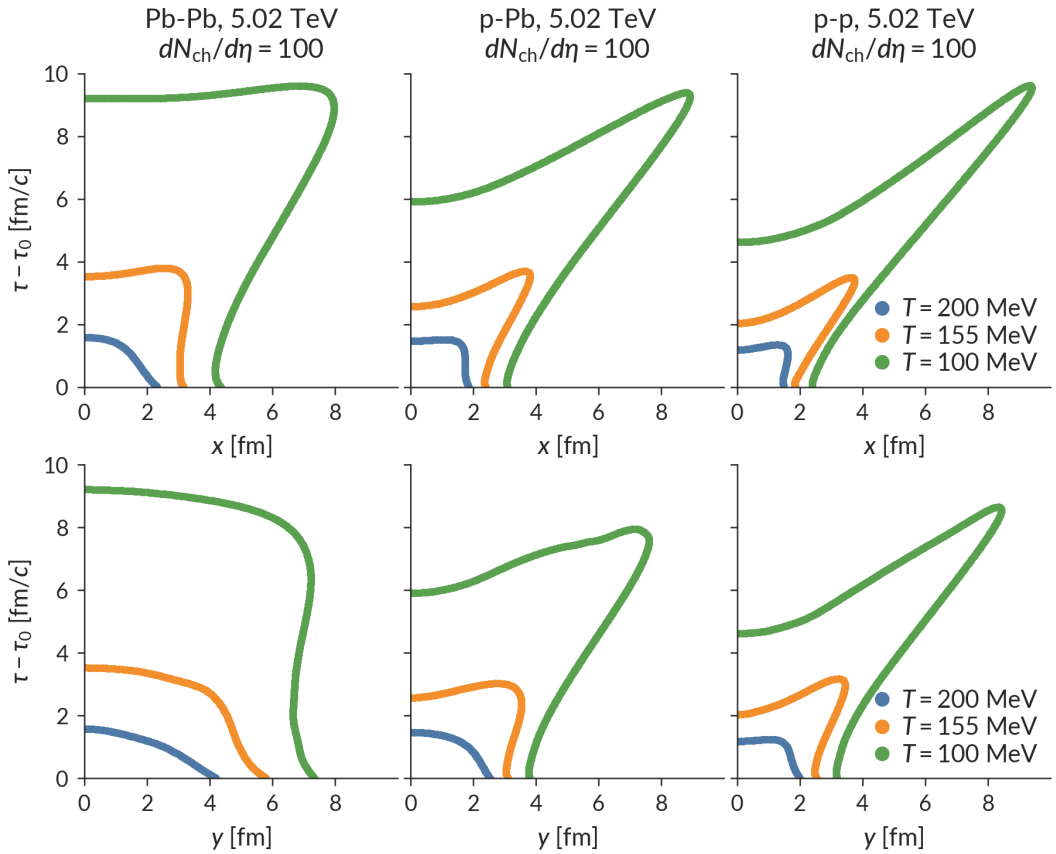
Hydrodynamic evolution of isotherms in small systems:

Three collision systems with the same multiplicity $dN_{\rm ch}/d\eta = 100$

calibrated iEBE-VISHNU with averaged TRENTO ICs with nucleon substructure

short direction:

long direction:



Collision systems with similar $dN_{\rm ch}/d\eta$ have similar freeze-out volumes

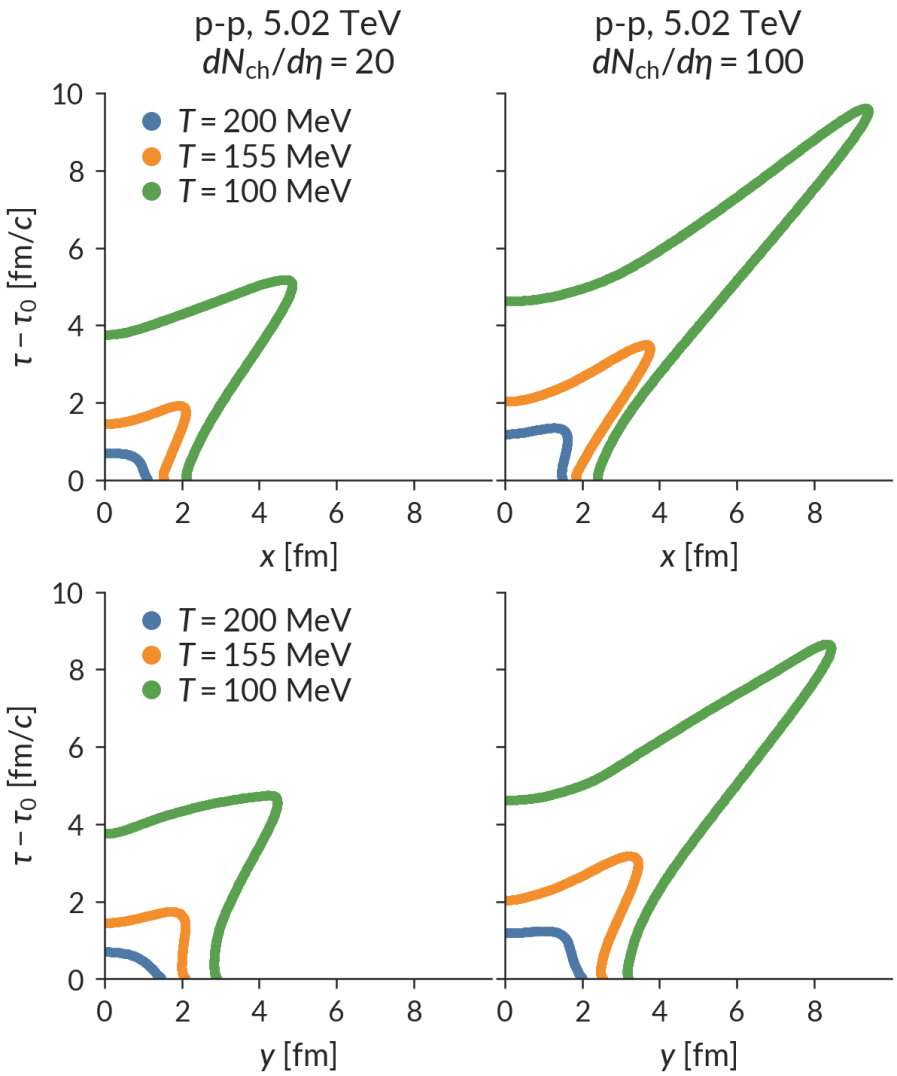
but different space-time volumes for the color-opaque medium!

Hydrodynamic evolution of isotherms in small systems:

p-p collisions at smaller and higher multiplicity, $dN_{\rm ch}/d\eta = 20$ and 100:

short direction:

long direction:



On average, much smaller QGP space-time volume in min. bias than in high-multiplicity p-p collisions!

How can there be high-p_T elliptic flow (v_2)
without
significant suppression of high-p_T hadrons (R_{AA})
in pp and pPb collisions?

Anisotropic flow at high p_T: jet quenching or simple rescattering?

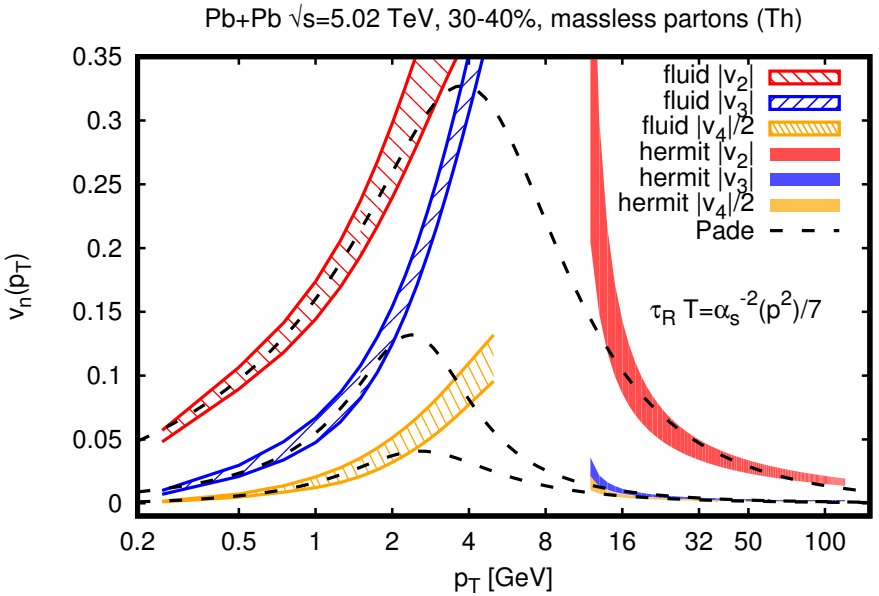
- Flow-like signatures are also obtained from kinetic theory in the limit of *large Knudsen numbers* ("single scattering limit")

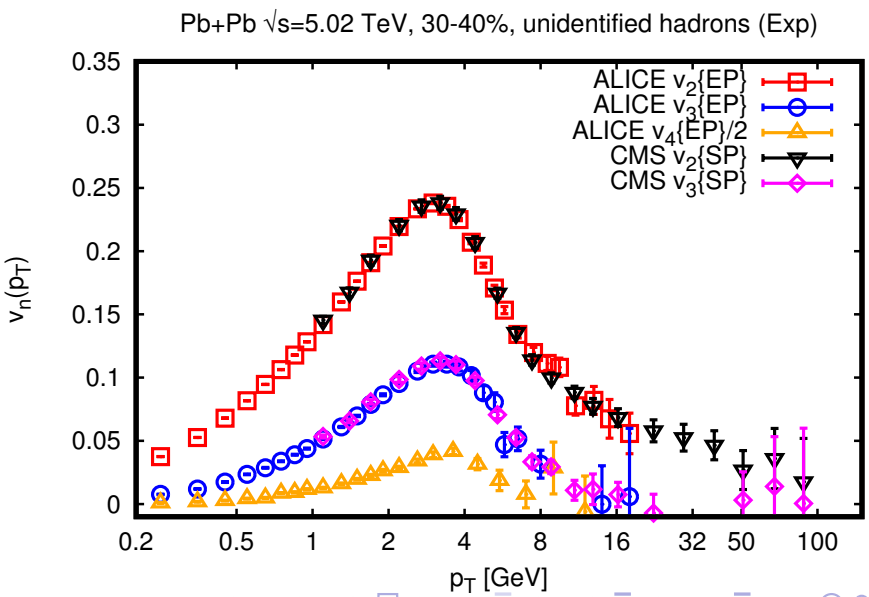
  Heiselberg & Levy '99, Kolb et al. '01, Alver et al. '10, Borghini & Gombeaud '11, Romatschke '18, Kurkela & Wiedemann '18, Borghini et al. '18, ...

Anisotropic flow at high p_T: jet quenching or simple rescattering?

- Flow-like signatures are also obtained from kinetic theory in the limit of *large Knudsen numbers* ("single scattering limit")

  Heiselberg & Levy '99, Kolb et al. '01, Alver et al. '10, Borghini & Gombeaud '11, Romatschke '18, Kurkela & Wiedemann '18, Borghini et al. '18, ...
- This may actually explain the anisotropic flow measured at high p_T: (Romatschke '18)





Conclusions

- Different space-time geometries in pp, pPb, and PbPb collisions may turn out to be an essential element in our understanding of (the lack of) jet quenching signals in these different collision systems.

- Detailed studies of jet shower evolution in a realistic dynamically expanding medium are urgently needed.