JUSTIN MOHS

QUARK MATTER HIGHLIGHT: TALK BY J.-F. PAQUET

IN COLLECTIVE DYNAMICS 3

Multi-system Bayesian constraints on the transport coefficients of QCD

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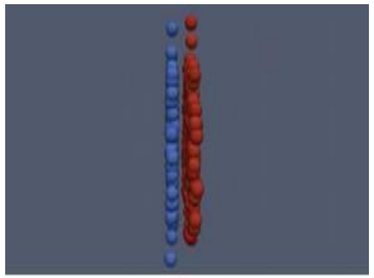
for the JETSCAPE Collaboration

November 5, 2019

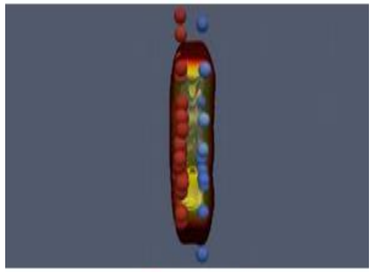
Modelling the soft sector



$\tau = "0^+"$: Nuclei collide

- Trento ansatz used to parametrize the energy deposition

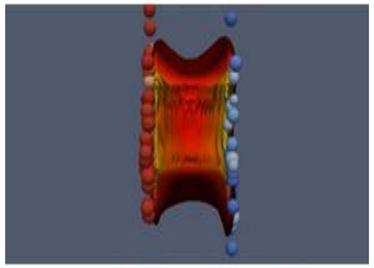
Ref.: Moreland, Bernhard, Bass (2015) PRC92,011901



$\tau \sim 0.1$ fm: "Pre-equilibrium phase"

- Free-streaming

Ref.: Everett (2018), https://github.com/derekeverett/freestream-milne



$\tau \sim 1$ fm: Beginning of "hydrodynamic phase"

- 2+1D relativistic viscous hydrodynamics [MUSIC]
- Equation of state: hadron resonance gas + lattice QCD [HotQCD Collaboration (2014) PRD90,094503]
- Shear and bulk viscosity

MUSIC ref.: Schenke, Jeon, Gale (2010) PRC82,014903; (2011) PRL106,042301; Paquet, Shen, Denicol, Luzum, Schenke, Jeon, Gale (2016) PRC93,044906

Hadron resonance gas + lattice combination: https://github.com/j-f-paquet/eos_maker

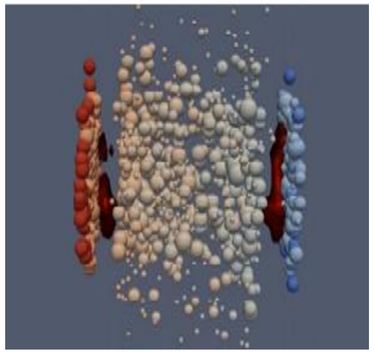


Figure ref.: J. Bernhard, H. Petersen, MADAI Collaboration

$\tau \sim 10$ fm: End of "hydrodynamic phase"

- Fluid converted to hadrons [iS3D]
- Hadronic interactions with SMASH hadronic transport

iS3D ref.: McNelis, Everett, Golden & Heinz, in preparation; https://github.com/derekeverett/iS3D

SMASH ref.: Weil, Steinberg, Staudenmaier, Pang, Oliinychenko, Mohs, Kretz, Kehrenberg, Goldschmidt, Bäuchle, Auvinen, Attems, Petersen (2016) PRC94, 054905
https://smash-transport.github.io/

Modelling the soft sector

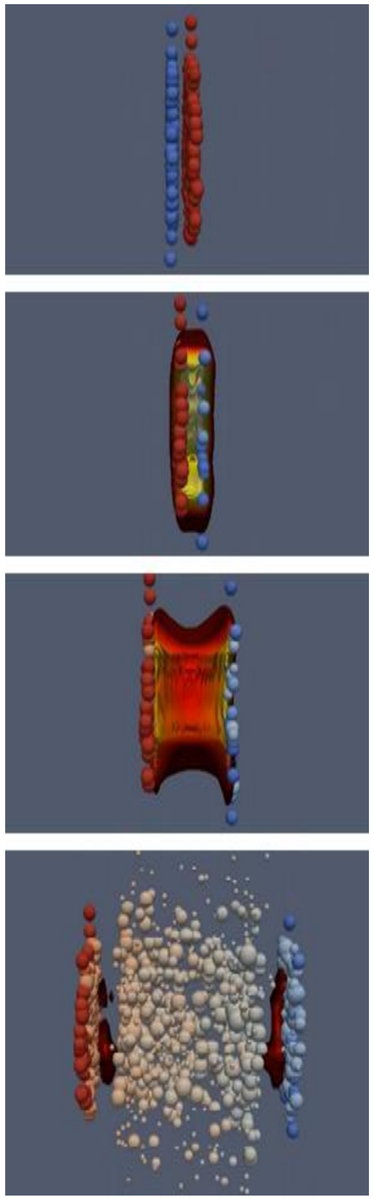


Figure ref.: J. Bernhard, H. Petersen, MADAI Collaboration

$\tau = "0^+"$: Nuclei collide

- Trento ansatz used to parametrize the energy deposition
- 5 parameters: (i-iii) nucleon width, fluctuation & minimum distance, (iv) transparency parameter, (v) normalization

$\tau \sim 0.1$ fm: "Pre-equilibrium phase"

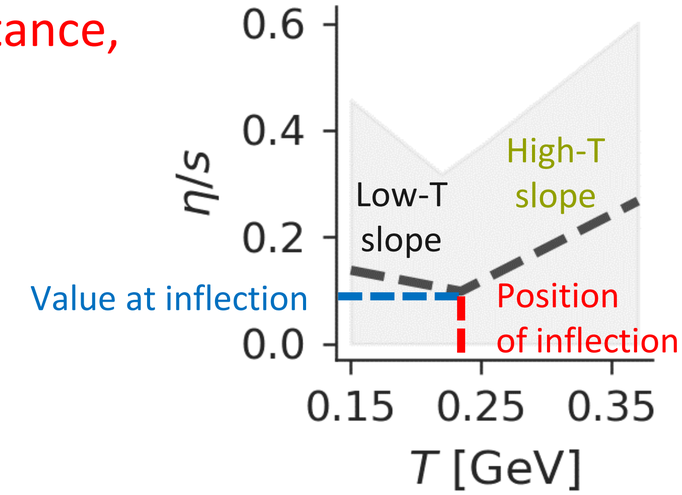
- Free-streaming
- Free-streaming time is a parameter

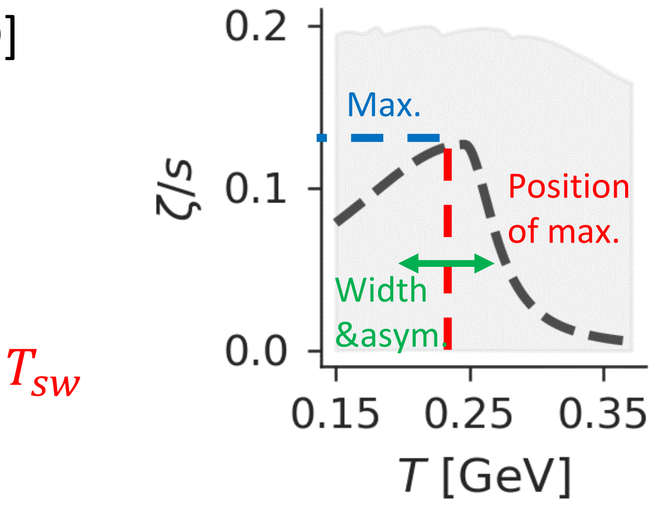
$\tau \sim 1$ fm: Beginning of "hydrodynamic phase"

- 2+1D relativistic viscous hydrodynamics [MUSIC]
- Equation of state: hadron resonance gas + lattice QCD [HotQCD]
- Shear and bulk viscosity: $\frac{\eta}{s}(T)$ and $\frac{\zeta}{s}(T)$ parametrized

$\tau \sim 10$ fm: End of "hydrodynamic phase"

- Fluid converted to hadrons [iS3D]: Cooper-Frye at temperature T_{sw}
- Viscous corrections in Cooper-Frye: 4 different models
- Hadronic interactions with SMASH hadronic transport



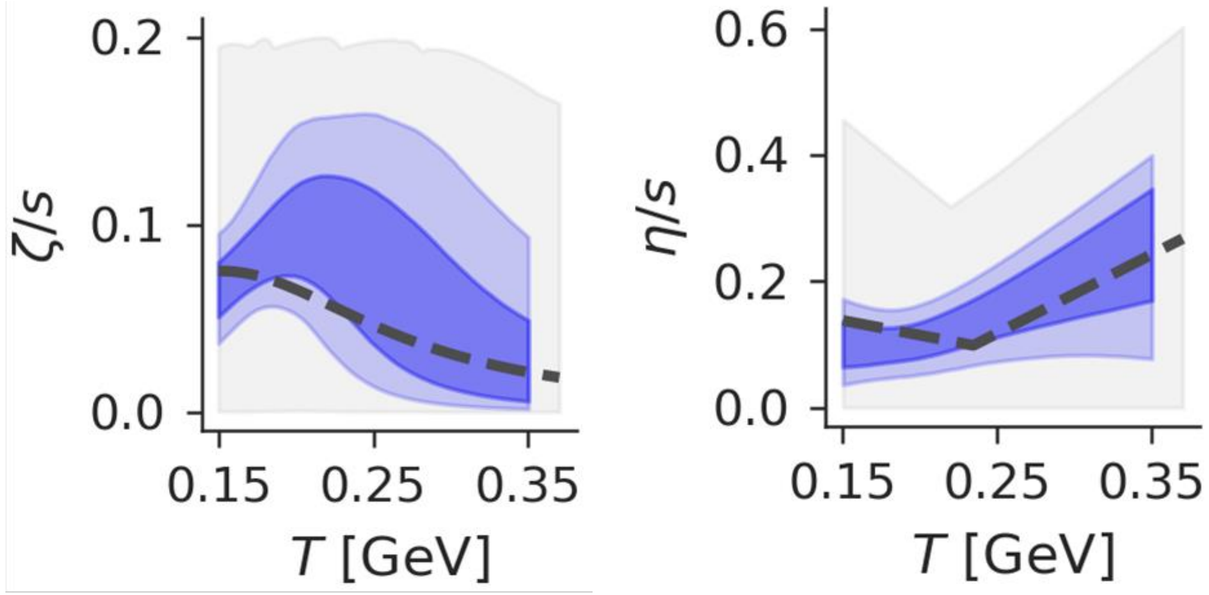


Validating the analysis: closure tests

- **Bayesian analysis can & should be validated** before comparisons with experimental data

Closure test

I. **Choose** a set of model parameters
II. Calculate hadronic observables: identified hadron dN/dy & $\langle p_T \rangle$, $v_{2/3/4}\{2\}$
III. Perform Bayesian analysis on calculated hadronic observables with **known parameters** and compare

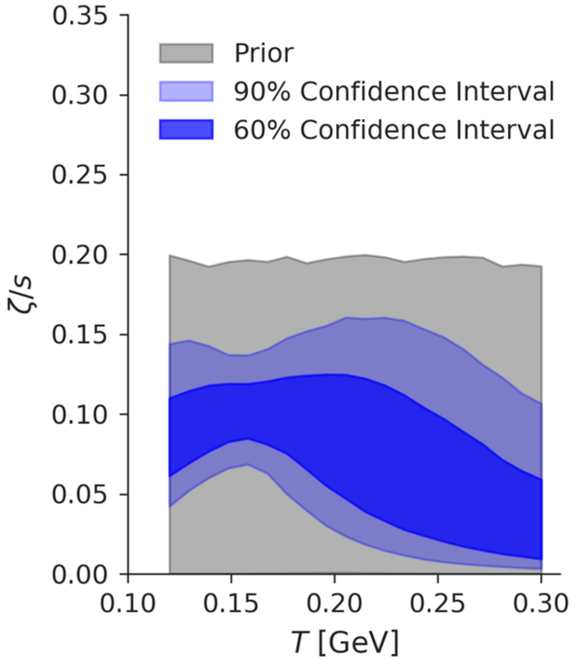


Grey region: all possible values of viscosity known to the emulator

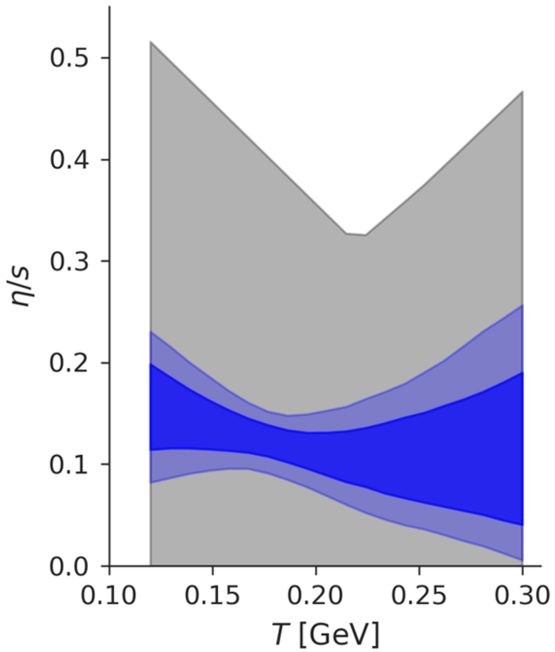
Dark & light blue: 60% & 90% confidence intervals of the Bayesian analysis

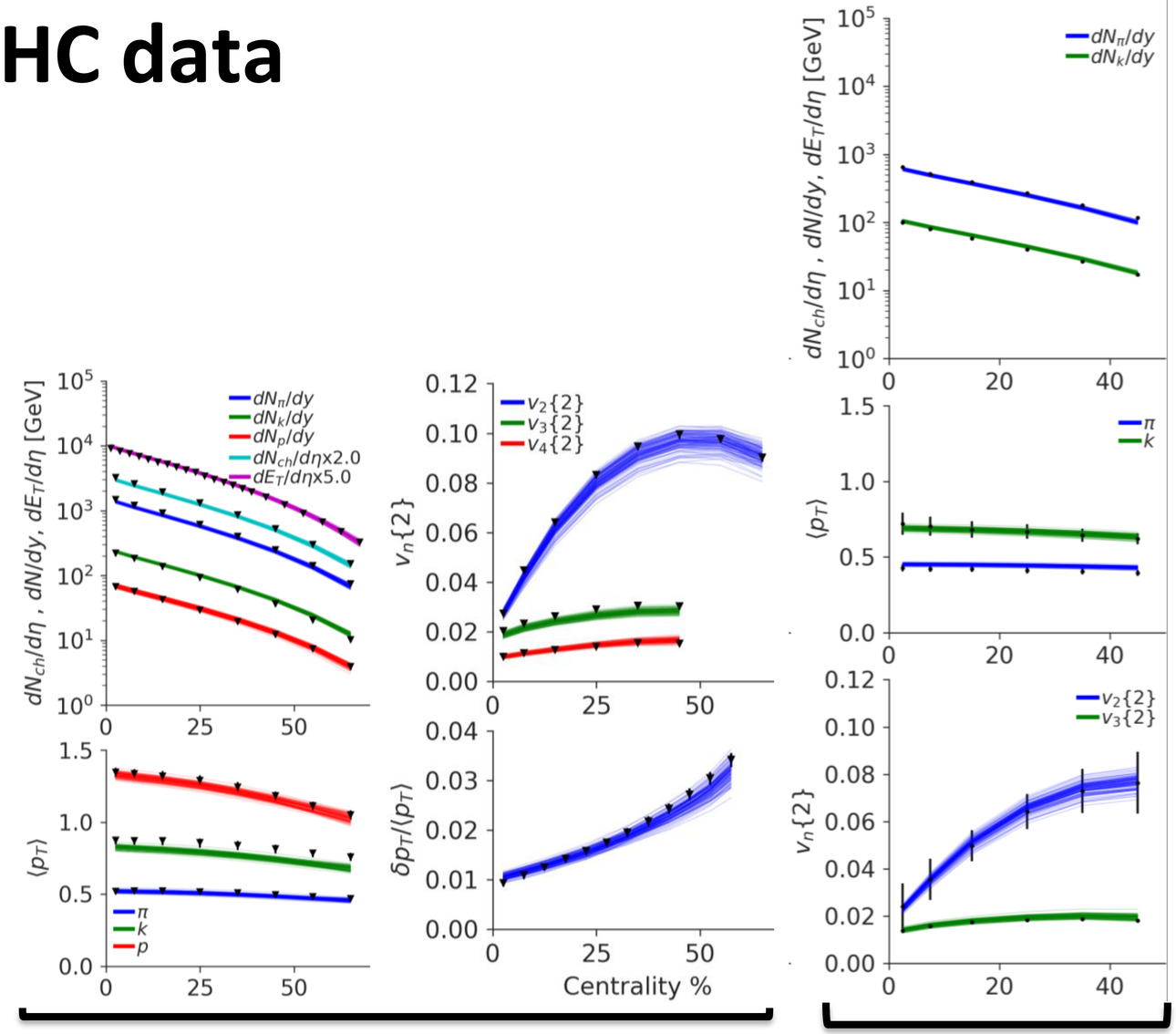
Combined analysis: RHIC & LHC data

Bulk viscosity



Shear viscosity



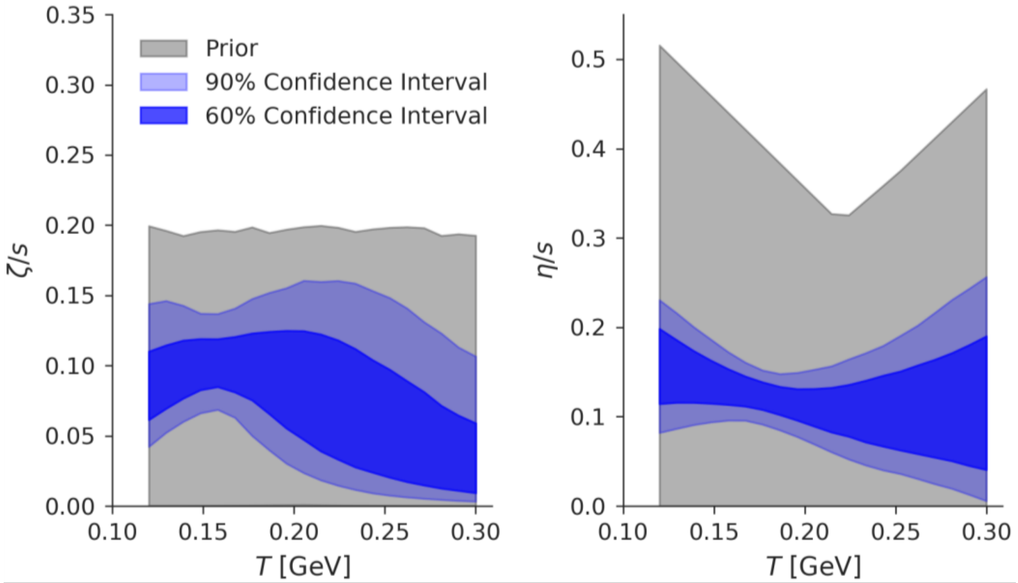


PbPb $\sqrt{s_{NN}}$=2760 GeV
[All measurements from ALICE]

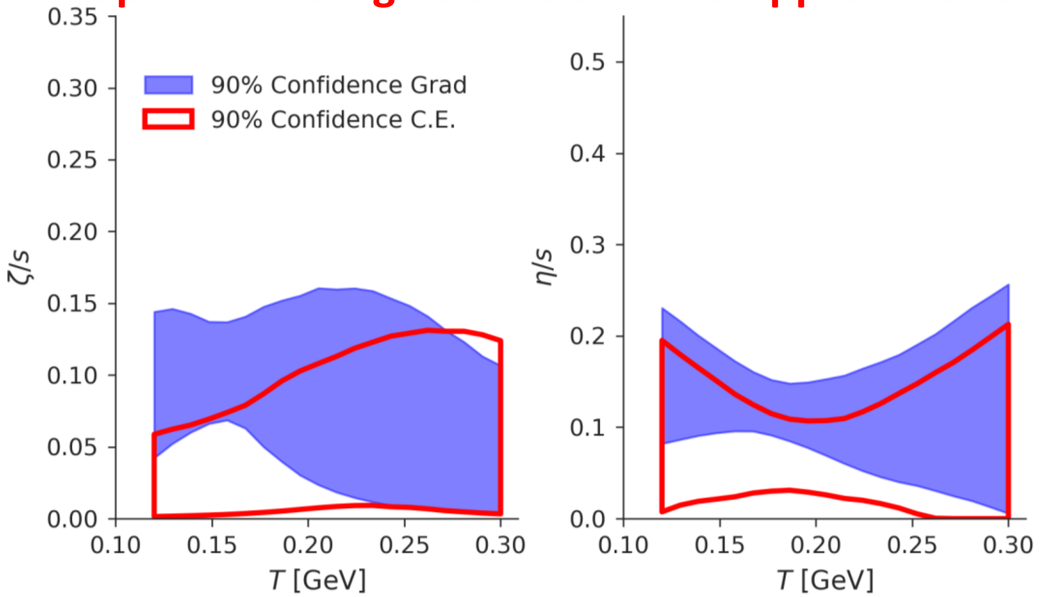
AuAu
$\sqrt{s_{NN}}$=200 GeV
[All measurements from STAR]

Viscous corrections to momentum distribution

14 Moments (Grad)

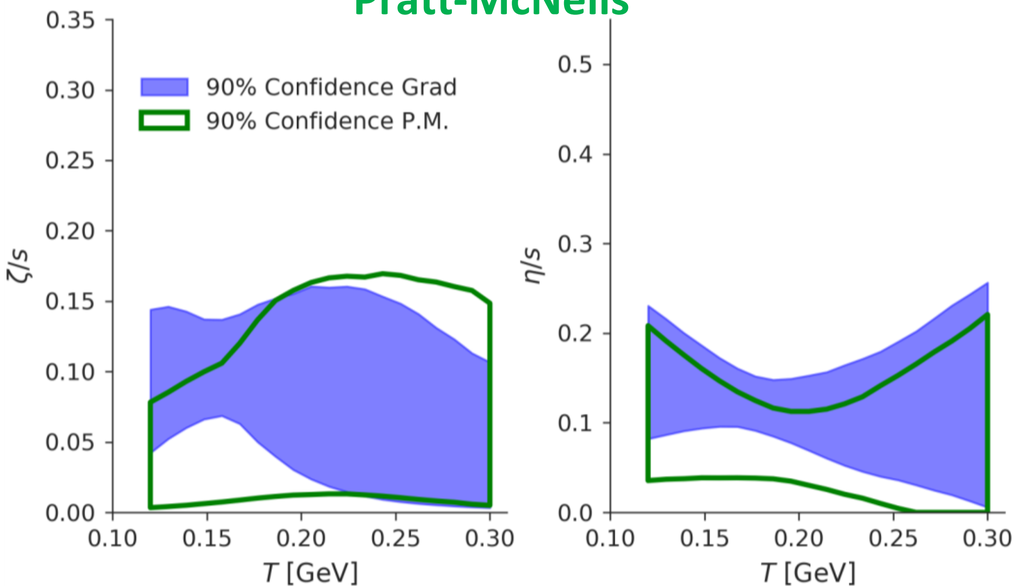


Chapman–Enskog Relaxation Time Approximation



Pb-Pb
$\sqrt{s_{NN}}$=2760 GeV
&
Au-Au
$\sqrt{s_{NN}}$=200 GeV

Pratt-McNelis



Pratt-Bernhard