The model
Cascade-hydro-cascade approach:
- Initial state: UrQMD cascade [1]
- Hadronic cascade: UrQMD

Initial conditions for hydrodynamics evolution from UrQMD
Switch from UrQMD to fluid at Bjorken proper time $\tau = \sqrt{T^2 - z^2} = \tau_0$, where $\tau_0 = \frac{z}{\sqrt{T^2-\sqrt{2}m_{\pi}^2}}$. Switching surface is the red curve.

Fluid shear stress tensor are:
\[ \gamma^{\mu\nu} = \text{averaged or event-by-event} \left\{ \gamma^{\mu\nu}_I \right\} \text{ of fluid} \]

Initial shear stress tensor $\gamma^{\mu\nu} = 0$.

Option 1) Averaged initial state
Initial particle distribution is taken as an average over $10^4$ UrQMD simulations of initial state. No smoothing involved.

Option 2) Fluctuating initial state
Fluctuating, but smooth initial state \[ E \propto \exp\left(-\frac{(x+y-z)^2}{R^2} - \sqrt{2}x \right), \] where $R = 1.4$ fm

Fluctuating IC with $R = 1.4$ fm yields 23% larger average $dS/dy|_{y=0}$ than the averaged IC.

Equation of state
The equation of state from Chiral model [3] is used, which agrees qualitatively with lattice QCD results for zero baryon density. However the EOS is also constructed for large (baryon) densities.

Hydrodynamic phase
Numerical 3+1D relativistic viscous hydro solution in Israel-Stewart formalism and Milne coordinates is used. The evolutionary equations for shear stress tensor are:
\[ \gamma^{\mu\nu} = \gamma^{\mu\nu}_I \]
- Bulk viscosity $\zeta = 0$, charge diffusion $= 0$
- Shear relaxation time ansatz used: $\tau_\gamma = 3\eta/(2T)$

Fluid–particle transition
\[ T^{\mu\nu}_I, N^{\mu\nu}_I \text{of hadron-resonance gas} = \left\{ T^{\mu\nu}_I, N^{\mu\nu}_I \right\} \text{of fluid} \]
- Cooper-Frye prescription for hadron sampling

\[ p_\mu = \sum f_{\mu}(x) \left( 1 + \frac{1}{2} \frac{\gamma^{\mu\nu}}{T^{\mu\nu}} \right) p^\nu \]

- Cornelius subroutine [4] to compute $\Delta n_I$ on transition hypersurface.
- UrQMD cascade is employed after partitional surface.

References

Acknowledgements: The authors acknowledge the financial support by the ExtreMe Matter Institute EMMI, German LOEWE initiative, Helmholtz International Center for FAIR, BMBF (contract no. 06FY8002) and Helmholtz Young Investigator Group (grant no. VH-NF-822). Computational resources have been provided by the Center for Scientific Computing (CSC) at the Goethe-University of Frankfurt.