Dynamical freeze-out in event-by-event hydrodynamics

H. Holopainen[1] and P. Huovinen[1,2]

[1]Frankfurt Institute for Advanced Studies, Frankfurt am Main, Germany

[2]Institut für Theoretische Physik, J. W. Goethe-Universität, Frankfurt am Main, Germany

ABSTRACT

We employ a dynamical freeze-out criterion, which requires the hydrodynamical expansion rate to be equal to the pion scattering rate [1], in an ideal fluid hydrodynamical calculation of spectra at RHIC (EoS $s95p$-PCE-v1, $T_{\rm chem} = 150$ MeV). We find that the p_T-spectra are very similar to those evaluated using freeze-out in constant temperature, but pion $v_2(p_T)$ is reduced by ~10%.

1.1 Freeze-out criterion

$$\frac{1}{K_n} = \frac{\tau_{\rm scat}^{-1}}{\partial_\mu u^\mu} = 1$$

1.2 Scattering rate

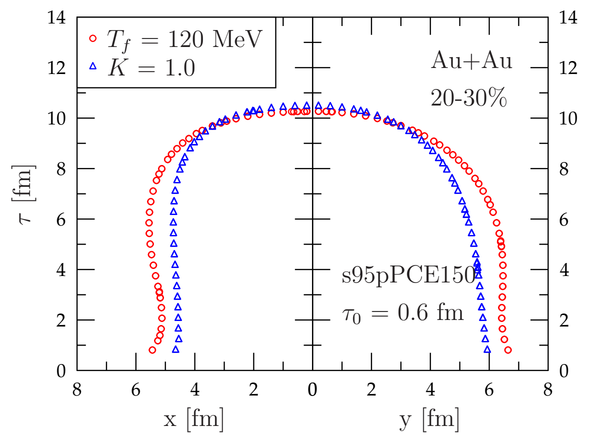
Scattering rate of pions in chemically non-equilibrated hadron gas:

$$\tau_{\rm scat}^{-1} = \frac{1}{n_\pi(T,\mu_\pi)} \sum_i \int \mathrm{d}^3p_\pi\, \mathrm{d}^3p_i\, f_\pi(T,\mu_\pi) f_i(T,\mu_\pi) \frac{\sqrt{(s-s_a)(s-s_b)}}{2E_\pi E_i} \sigma_{\pi i}(s)$$

Cross section $\sigma_{\pi i}(s)$ as in UrQMD [2]:

- $\sigma_{\pi i}(s)$ for resonance formation using Breit-Wigner
- $\sigma_{\pi m}(s) = 5$ mb for elastic pion-meson scattering

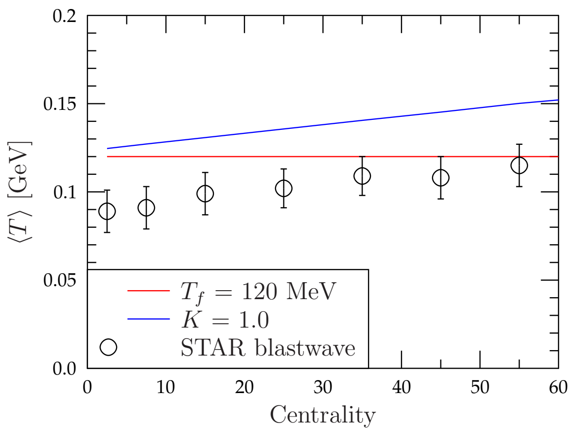
2 Changes on surface



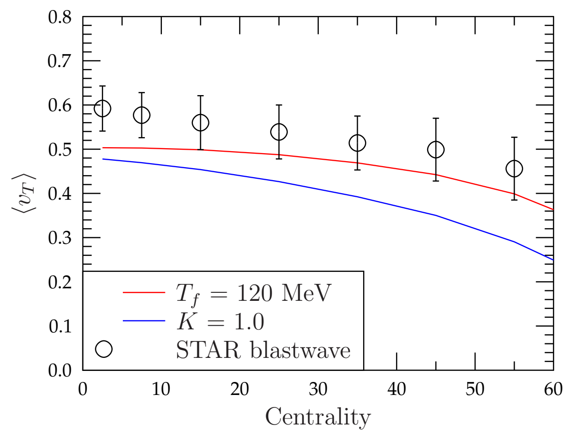
- Edges decouple earlier, *i.e.* smaller fireball

⇒ Edges are hotter

⇒ Largest transverse flow velocities cut off



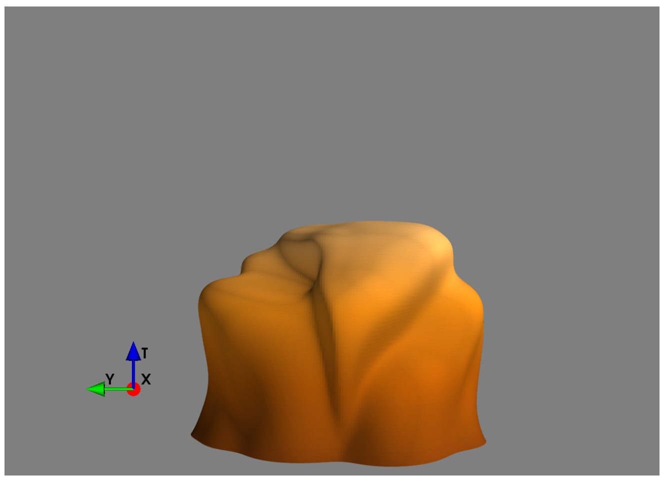
The centrality dependence of average temperature on freeze-out surface is qualitatively similar to the STAR blast wave fit to the hadron spectra.



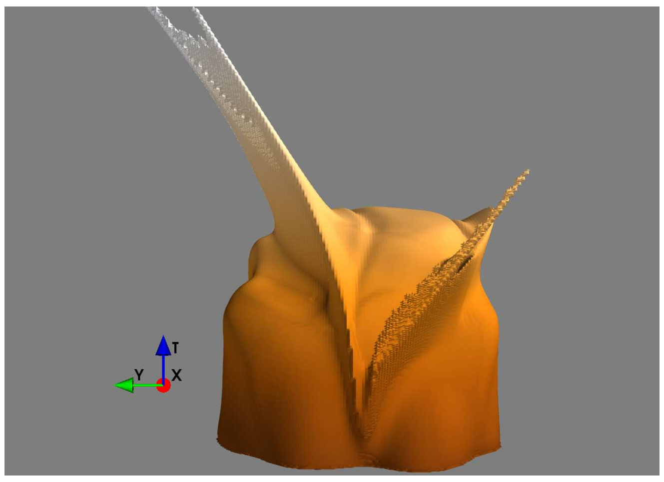
The centrality dependence of average transverse flow velocity on freeze-out surface is qualitatively similar to the STAR blast wave fit to the hadron spectra.

3 event-by-event

Initialization using MC-Glauber [3], $\sigma = 0.8$ fm:

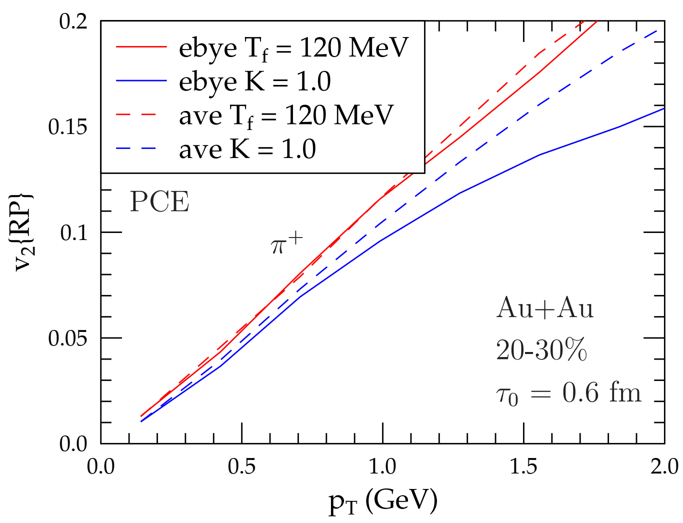


- Constant $T = 120$ MeV surface



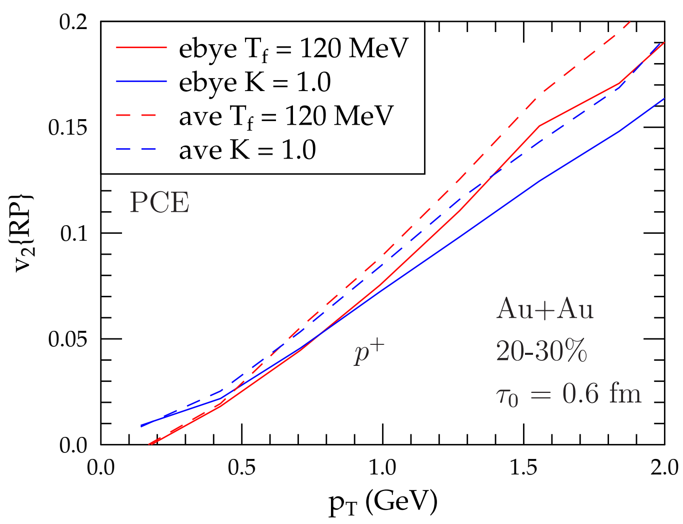
- Constant $K_n = 1$ surface

4 Effect on flow



- p_T spectra almost unchanged

⇐ Pion $v_2(p_T)$ reduced by ~10%



⇐ Proton $v_2(p_T)$ sensitive only at small and large p_T

- e-by-e vs. averaged initial state has larger effect
- In chemical equilibrium the effect on $v_2(p_T)$ disappears [4]

References

[1] J. P. Bondorf, S. I. A. Garpman and J. Zimanyi, Nucl. Phys. A **296**, 320 (1978).

[2] S. A. Bass *et al.*, Prog. Part. Nucl. Phys. **41**, 255 (1998).

[3] H. Holopainen, H. Niemi and K. J. Eskola, Phys. Rev. C **83**, 034901 (2011).

[4] H. Holopainen and P. Huovinen, arXiv:1207.7331 [nucl-th].

Acknowledgments

This work is funded by BMBF under contract no. 06FY9092 and the ExtreMe Matter Institute (EMMI).