

The QCD Phase Transition in Nuclear Collisions

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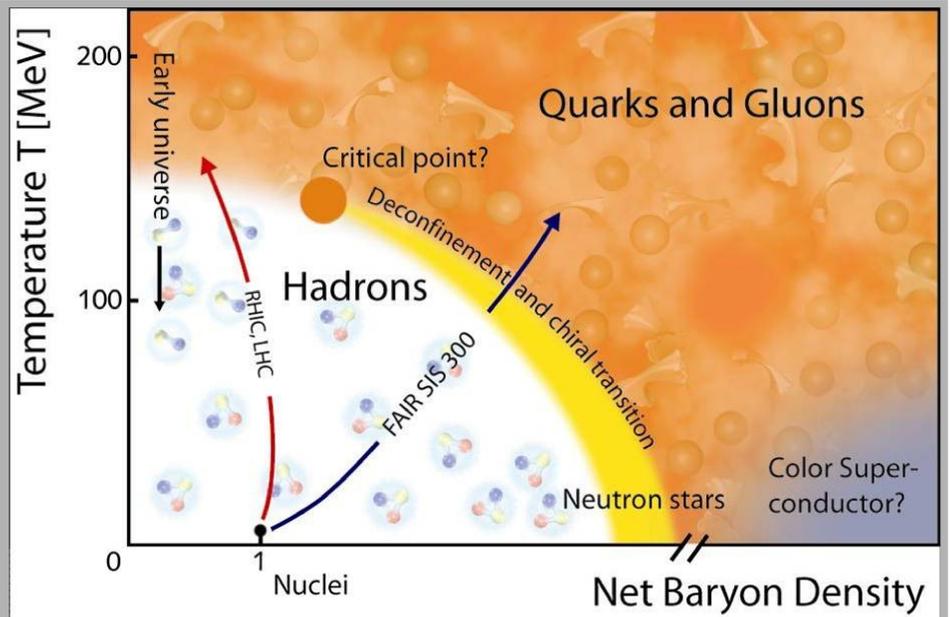
Motivation

- Study the effects of a first order phase transition in nuclear collisions
- Find observables sensitive to the unstable phase associated with this phase transition

Method

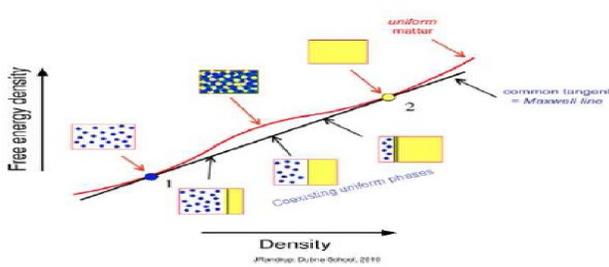
We introduce an equation of state with a mechanically unstable phase in a fluid dynamical model. This model is augmented with a finite-range term to describe the effects of a surface tension and long range interactions:

$$p(\mathbf{r}) = p_0(\varepsilon(\mathbf{r}), \rho(\mathbf{r})) - a^2 \frac{\varepsilon_s}{\rho_s^2} \rho(\mathbf{r}) \nabla^2 \rho(\mathbf{r})$$



The Equation of State

In order to obtain a suitable equation of state we perform a suitable spline between two idealized systems, a gas of pions and interacting nucleons and a bag of gluons and quarks.



Quantitative Measures

We define moments of the spacial net baryon density distribution to quantify the magnitude of clustering

$$\langle \rho^N \rangle \equiv \frac{1}{A} \int \rho(\mathbf{r})^N \rho(\mathbf{r}) d^3 r$$

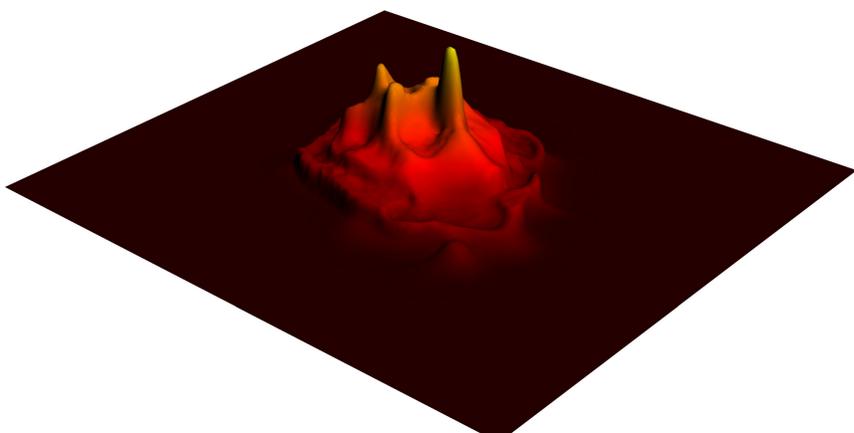
Effects if the instabilities

We then start the ideal 3+1D fluid dynamical simulation from an initialization obtained with the UrQMD transport model.

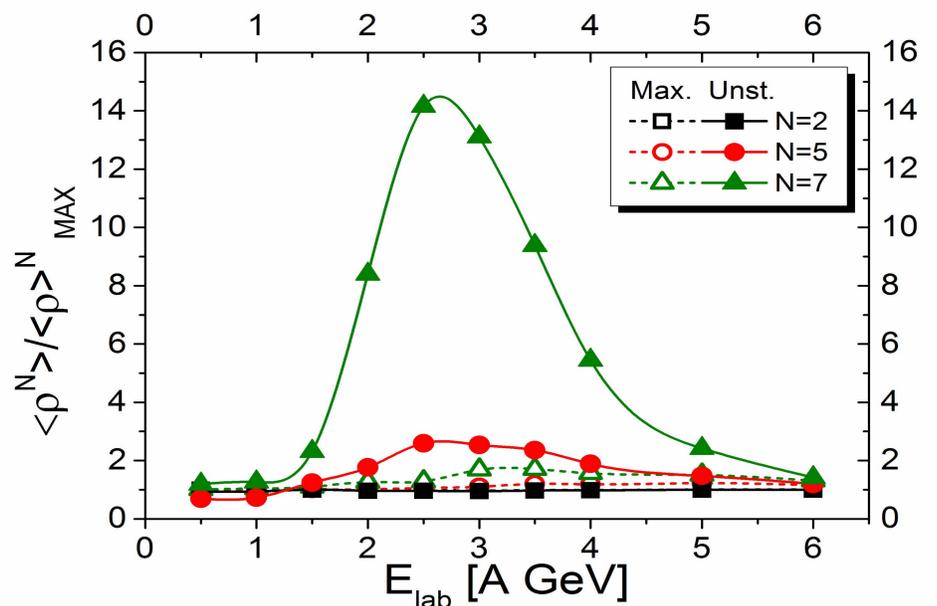
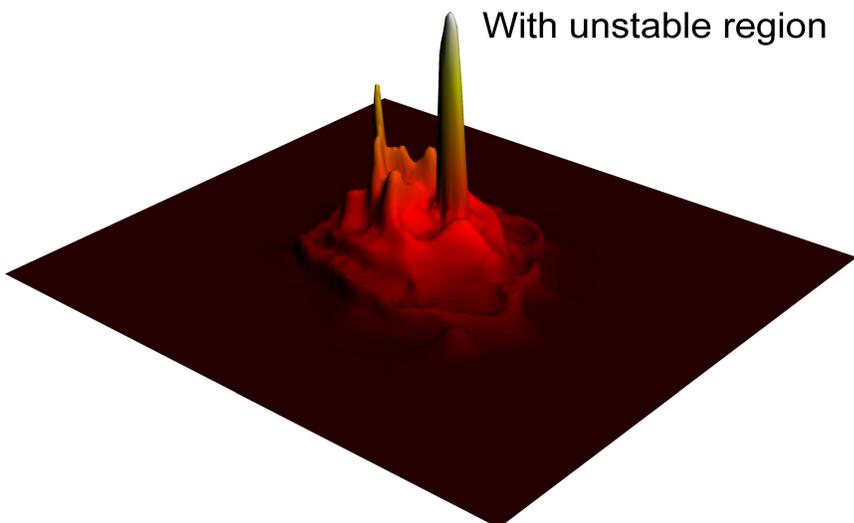
Which are shown for different beam energies:

An enhancement of local density fluctuations is observed in the case of an unstable phase!

Baryon Density distributions for collisions of lead nuclei at a fixed target beam energy of 3 A GeV
Without unstable region



With unstable region



Summary

We have obtained a transport model suitable for simulating nuclear collisions in the presence of a first order phase transition.

We have found that the associated instabilities may cause significant amplification of initial density irregularities

Related Publications

- J. Steinheimer and J. Randrup, Phys. Rev. Lett. 109, 212301 (2012)
- J. Steinheimer and J. Randrup, Phys. Rev. C 87, 054903 (2013)
- J. Steinheimer, J. Randrup and V. Koch, accepted by Phys. Rev. C