DENSE STRANGE QUARK MATTER

January 12, 2007

Low energy RHIC run goals:

0) critical point and related covered by others.

1) search for new forms of dense and strange quark matter:

strangeletts;

2) equilibrium lattice confronts dynamical experiment:

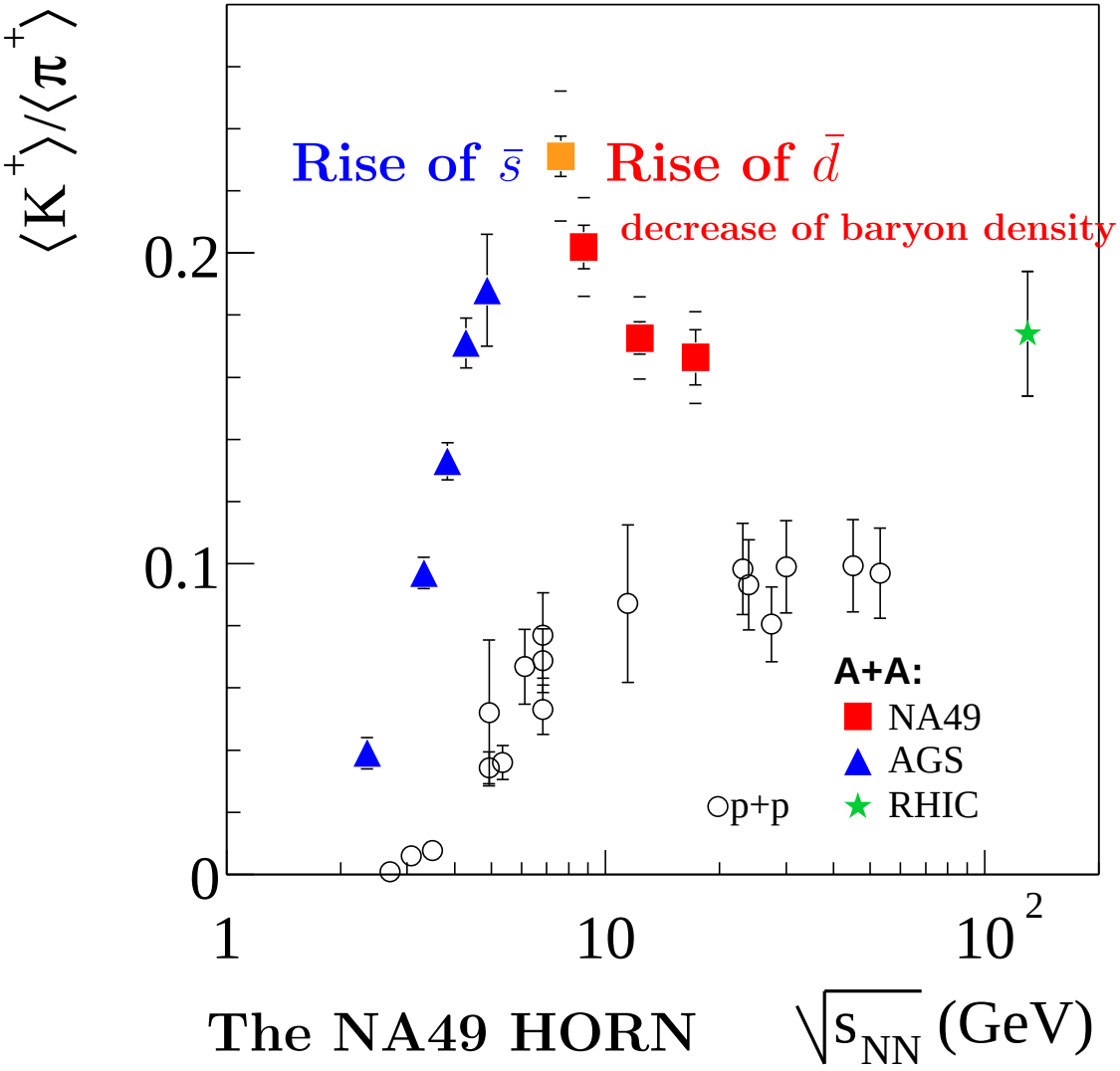
matter-antimatter symmetry in hadronization

symmetry of matter/antimatter $m_\perp$ spectra;

3) Finetuning of phase boundary

2+γ_s-flavors

Competition between speed of strangeness production and baryon density (i.e. transparency).



This is incompatible with the smooth particle freeze-out $T(\mu_B)$.

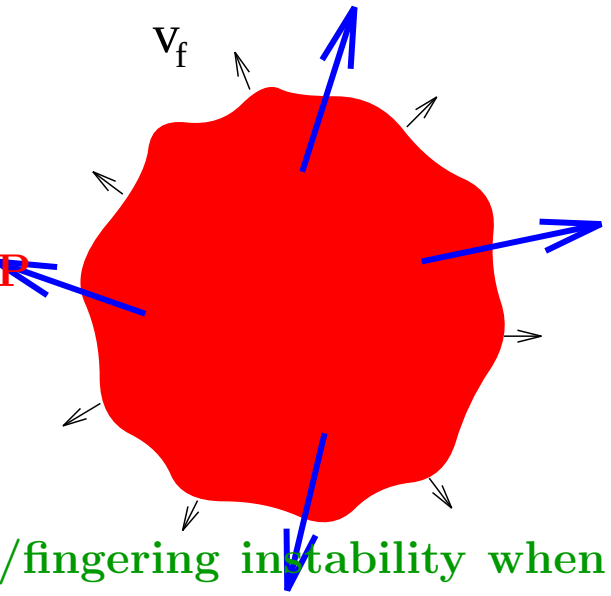
MATTER-ANTIMATTER SYMMETRY

Recombination hadronization implies symmetry of $m_\perp$ spectra of (strange) baryons and antibaryons also in baryon rich environment.

THIS IMPLIES: A common matter-antimatter particle formation mechanism, AND negligible antibaryon re-annihilation/re-equilibration/rescattering.

Such a nearly free-streaming particle emission by a quark source into vacuum also required by other observables: e.g. reconstructed yield of hadron resonances and HBT particle correlation analysis

Practically no hadronic 'phase'
No 'mixed phase'
Direct emission of free-streaming
hadrons from exploding filamentary QGP



Possible reaction mechanism: filamentary/fingering instability when in expansion the pressure reverses.

QUESTION: where is EXPERIMENTAL T, μ_b phase boundary

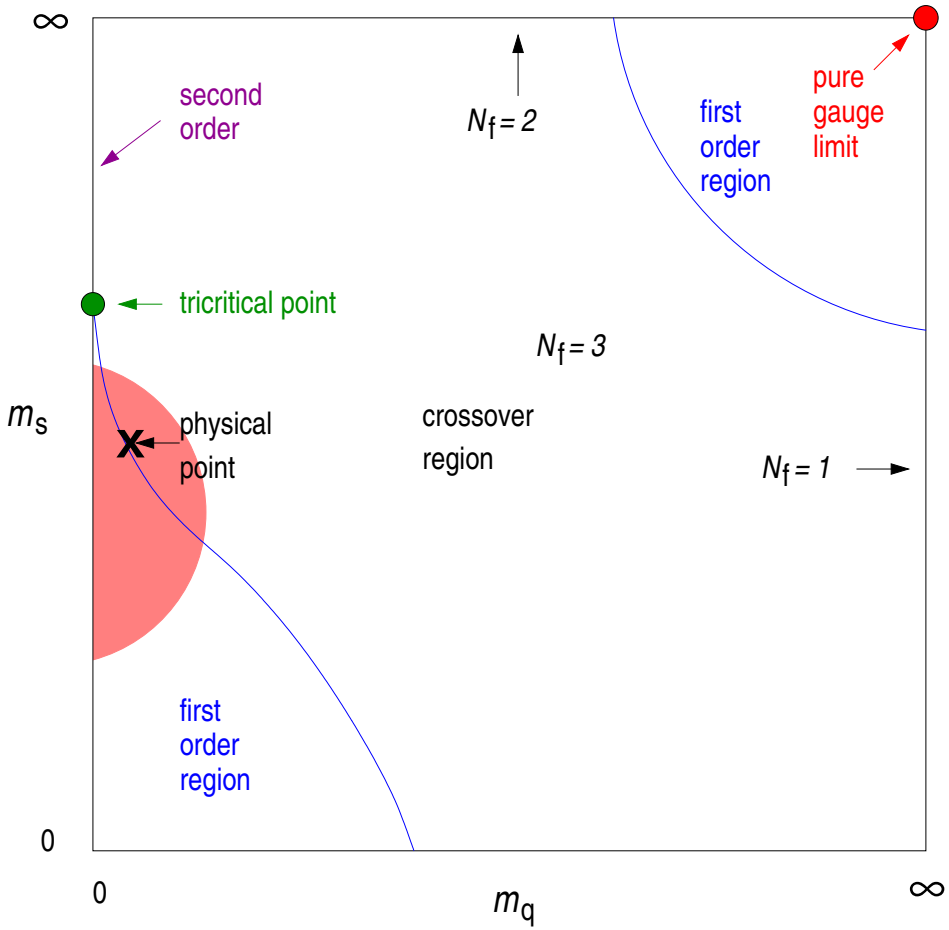
System very fine-tuned. Is there a Phase transition, what if? Latent heat? Will lattice yield answers, are heavy ion experiments ABLE to provide the answer? Another fine-tuning: the "true" vacuum state has about 100 orders of magnitude lower energy density than the deconfined phase.

- **Lattice explores equilibrium conditions, temperature of phase transition depends on available degrees of freedom.**

  For 2+1 flavors: $T = 162 \pm 3 \pm 10$
  For 2 flavors $T \to 170$ MeV, the nature of phase transition/transformati
  changes when number of flavors rises from 2 to 2+1 to 3

- **Nuclear collision explore non-equilibrium, there are two distinct dynamical effects**
  - Matter expansion, flow effect:
    colored partons like a wind, displace the boundary
  - Active degrees of freedom are $2 + \gamma_s$

Fermi degrees of freedom and phase transition in QCD, $\mu_b = 0$



adapted from: THE THREE FLAVOR CHIRAL PHASE TRANSITION WITH AN IMPROVED QUARK AND GLUON ACTION IN LATTICE QCD. By A. Peikert, F. Karsch, E. Laermann, B. Sturm, (LATTICE 98), Boulder, CO, 13-18 Jul 1998. in Nucl.Phys.Proc.Suppl.73:468-470,1999.

Note that we need some additional quark degrees of freedom to push the system over to phase transition. Conventional wisdom: baryon density: