XXIV QUARK MATTER DARMSTADT 2014

Contribution ID: **350** Type: **Contributed Talk**

What the collective flow excitation function can tell about the quark-gluon plasma

Wednesday 21 May 2014 10:00 (20 minutes)

The midrapidity slope $\mathrm{d}v_1/\mathrm{d}y$ of the directed flow v_1 has been predicted to be sensitive to the possible first-order phase transition between the hadron gas and the quark-gluon plasma. The recent STAR data from the RHIC beam energy scan (BES) show that the net-proton $\mathrm{d}v_1/\mathrm{d}y$ changes sign twice within the collision energy range 7.7 - 39 GeV. To further investigate this phenomenon, we study the collision energy dependence of v_1 utilizing a Boltzmann + hydrodynamics hybrid model. Such a hybrid approach provides a natural framework for the transition from high collision energies, where the hydrodynamical description is essential, to smaller energies, where the hadron transport dominates. Calculation with dynamically evolved initial and final state shows no qualitative difference between an equation of state with cross-over and one with first-order phase transition [1], in contrast to the earlier pure fluid predictions.

We have also investigated the energy evolution of the elliptic flow v_2 and triangular flow v_3 [2]. The v_2 analysis shows that pre-equilibrium transport dynamics are partially compensating for the diminished elliptic flow production in the hydrodynamical phase at lower energies, resulting to relatively weak collision energy dependence which is in qualitative agreement with STAR BES results. The medium described by transport is, however, too viscous to build up triangular flow, making v_3 the clearer signal for the formation of (near-)ideal fluid in relativistic heavy ion collisions.

References:
[1] J. Steinheimer, J. Auvinen, H. Petersen, M. Bleicher and H. Stocker, work in progress;
[2] J. Auvinen and H. Petersen, Phys. Rev. C88, 064908 (2013).

On behalf of collaboration:

None

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Session Classification: Correlations and fluctuations

Track Classification: Collective Dynamics