

Sensitivity of anisotropy flow coefficients and lengths of homogeneity to different equations of state

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INTRODUCTION:

In this work we perform a systematic study of the dependence on the equation of state (EoS) of the collective flow coefficients and of the Hanbury-Brown and Twiss femtoscopic parameters, by using the SPHeRIO hydrodynamic code to describe the evolution of the system formed in heavy-ion collisions, where no viscosity is considered. The calculations are carried out both in the center-of-mass frame and in the longitudinal co-moving system, for heavy ion collisions at 130 GeV and 200 GeV energies at the Relativistic Heavy Ion Collider. The resulting anisotropy flow coefficients v_2, v_3, v_4 , as well as the femtoscopic lengths of homogeneity, are compared with the data from STAR, PHOBOS and PHENIX Collaborations. It is shown that, although the three different types of EoS investigated in this work give a reasonable description of the observed data, none is clearly favored in this comparison.

HYDRODYNAMICAL MODEL:

In the hydrodynamical model it is assumed that the hot and dense medium formed in high-energy collisions is in local thermal equilibrium. This system is described dynamically by conserved quantities, such as energy-momentum tensor, baryon number, strangeness, etc.

$$\partial_\nu T^{\mu\nu} = 0$$

$$T^{\mu\nu} = (\epsilon + p)u^\mu u^\nu - pg^{\mu\nu}$$

$$\partial_\nu n_i u^\nu = 0 \quad i = 1, 2, \dots, N$$

INITIAL CONDITIONS AND DECOUPLING CRITERIA:

The initial conditions for Au+Au collisions are given by NeXus in the transverse plane at mid-rapidity and they are fluctuating event-by-event. For decoupling, the Cooper-Frye prescription is used:

$$E \frac{dN}{d^3k} = \int_\Sigma d\sigma_\mu k^\mu f(x, k),$$

where $f(x, k)$ is the thermal distribution function and Σ is a hypersurface of constant temperature.

EQUATION OF STATE:

In the past, it was common to adopt an EoS with a first-order phase transition to connect the QGP phase with the hadron gas phase in simulations. However, lattice QCD showed that the transition is a smooth crossover at zero baryon density, which may be of first order at large baryon densities, and possesses a critical end point. Here we adopt three different equations of state: a EoS assuming a 1st order phase transition with local strangeness neutrality (FOS), a lattice QCD-inspired EoS with a phenomenological critical end point (CEP) and another EoS parameterized by fitting the lattice QCD data (LQCD).

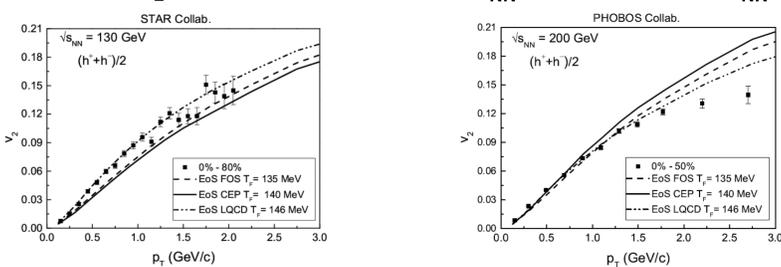
OBSERVABLES:

Collective flow coefficients:

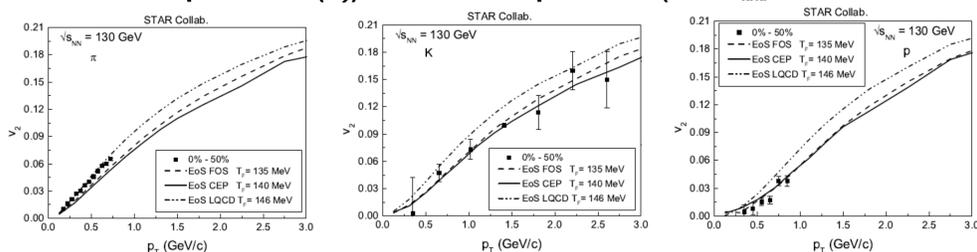
The collective flow harmonics are defined as the Fourier coefficients of the azimuthal distribution $dN/d\phi$,

$$\frac{dN}{d\phi} = \frac{N}{2\pi} \left[1 + 2 \sum_{n=1}^{\infty} \nu_n \cos n(\phi - \Psi_n) \right]$$

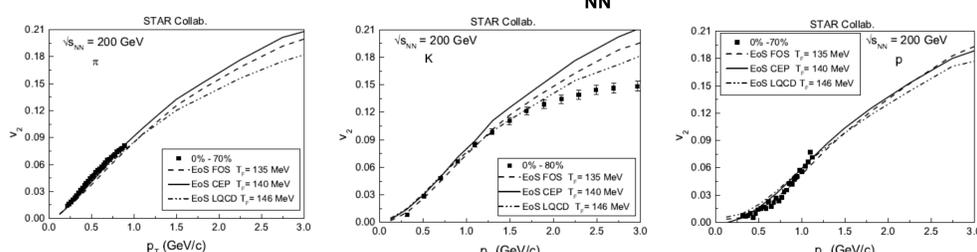
Elliptic Flow (v_2) of charged hadron – $\sqrt{s_{NN}}=130$ GeV and $\sqrt{s_{NN}}=200$ GeV



Elliptic Flow (v_2) of identified particles (at $\sqrt{s_{NN}}=130$ GeV)



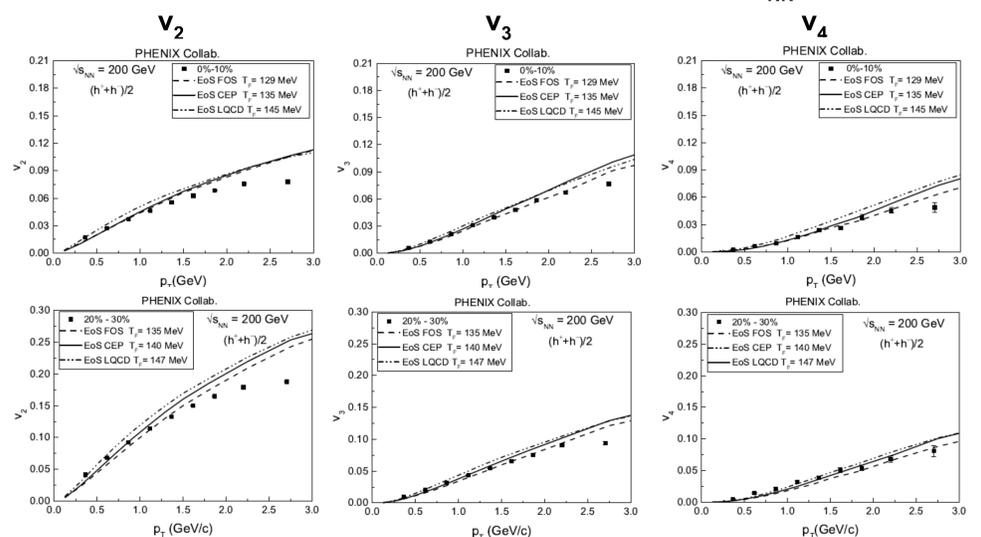
AuAu collisions at $\sqrt{s_{NN}}=200$ GeV



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Anisotropy flow coefficients – AuAu collisions at $\sqrt{s_{NN}}=200$ GeV

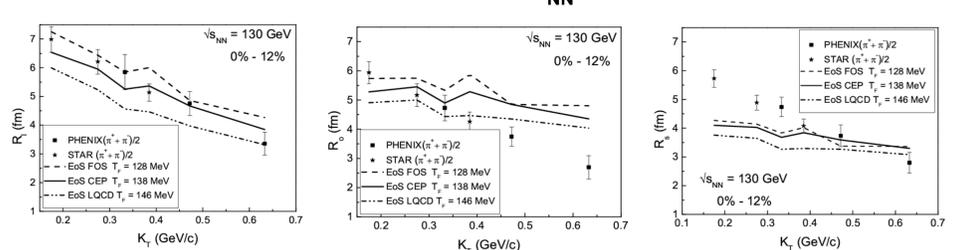


HBT-radii:

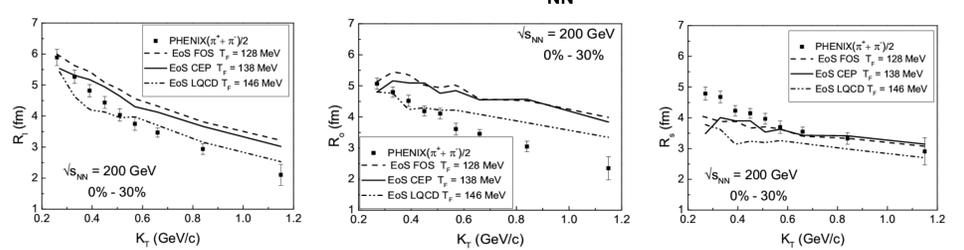
The femtoscopic correlation function of identical pions is fitted by the following parametrization to estimate the system radii R_i and strength λ

$$C(\vec{q}, \vec{K}) = 1 + \lambda \exp[-(q_o^2 R_o^2(\vec{K}) + q_s R_s^2(\vec{K}) + q_l^2 R_l^2(\vec{K}))]$$

AuAu collisions at $\sqrt{s_{NN}}=130$ GeV



AuAu collisions at $\sqrt{s_{NN}}=200$ GeV



SUMMARY AND CONCLUSIONS:

We use three different EoS to compare collective flow coefficients (v_2, v_3, v_4) and HBT femtoscopic radii results from NeXSPHeRIO with the corresponding experimental data. All EoS seem to describe the data on v_2 in the low p_T range reasonably well for both RHIC energies, with LQCD showing a better agreement. Similar behavior is observed for v_3 and v_4 at 200 GeV. As for the HBT radii, all EoS show qualitative similar trend, LQCD being closer to the R_l and R_o data points at 200 GeV, whereas FOS and CEP seem to be closer to the R_s experimental results. In general, it can be seen that these observables are not very sensitive to differences in the EoS used in the hydrodynamical evolution of the system formed in AuAu collisions at both 130 and 200 GeV, as provided by NeXSPHeRIO.

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