Predictions for v_2

Ulrich Heinz

We predict that a careful measurement of the excitation function of the elliptic flow coefficient v_2 can reveal the existence of a phase transition in the EOS. The prediction is summarized in Fig. 14 of the attached paper. It was first published, in an incomplete version which stopped at the lower end of the RHIC energy range, in PLB 459 (1999) 667. The attached paper completes the analysis and gives all the background information on which assumptions etc. the prediction is based, and what are the detailed physical mechanisms behind the proposed phase transition signature. It will be posted next week after we have received responses from a number of colleagues who we asked for comments.

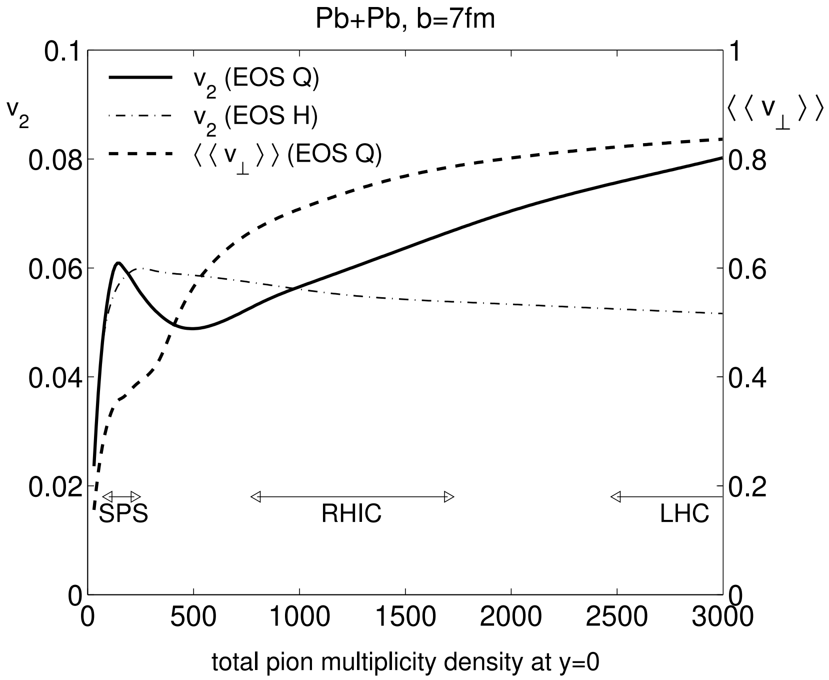
Our analysis is based on hydrodynamic studies. We argue that central U+U collisions in the side-on-side configuration are better than semiperipheral Pb+Pb collisions since they show better hydrodynamical behaviour (twice as large fireball volume). There is evidence from RQMD that fireball created in central Pb+Pb (or U+U) collisions expand hydrodynamically. We point out that that our hydrodynamic prediction on a phase transition signature in the elliptic flow can be studied in CENTRAL (b=0) U+U collisions, by triggering (as pointed out by Shuryak) on zero energy in the forward direction combined with minimal E_T.

Our prediction requires running RHIC at all possible energies and collecting a few more points at the SPS between 30 and 160 A GeV/c. In this sense it is not only a RHIC prediction. But we believe that it should still qualify for the RHIC competition.

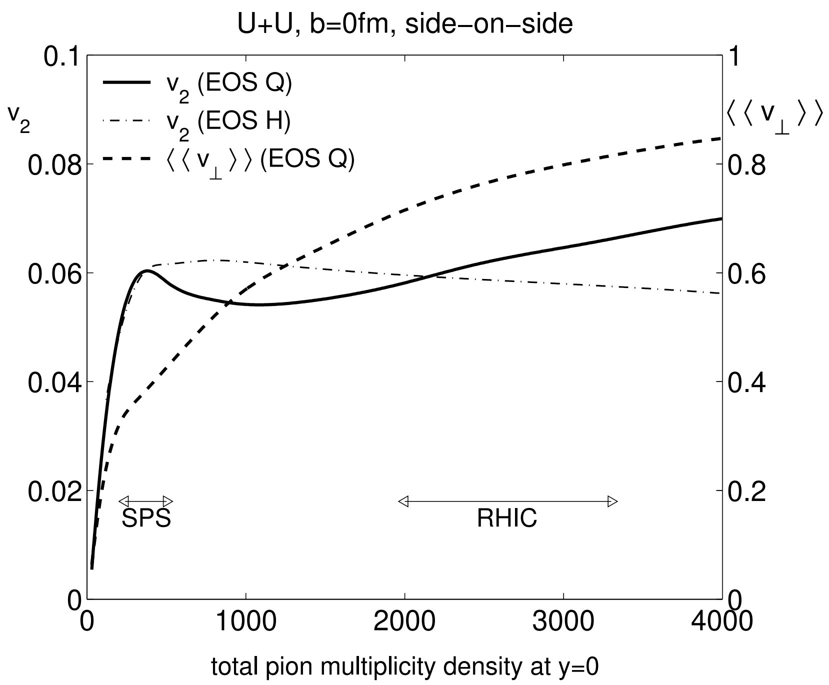
IF U+U behaves hydrodynamically, our prediction is carefully worked out in all relevant aspects. We also predict THAT central U+U collisions behave hydrodynamically, but this prediction is not supported by equally convincing theoretical studies. However, if the measured excitation function follows our Fig. 14 in the attached paper, this provides strong evidence for hydrodynamic behaviour. For non-hydrodynamic behaviour the elliptic flow response to the initial elliptic spatial deformation can only be smaller.

Our prediction addresses the phase transition proper, not only the existence of a different state of matter above a critical value. It is thus different from predictions based on average yields, momenta etc. of particles. Our prediction is really sensitive to the existence of a transition region where the energy density varies very rapidly at nearly constant pressure. It is related to Rischke's prediction of a dip in the directed flow, but has the advantage that, contrary to directed flow which is generated so early that thermalization is very doubtful, it is generated at a collision stage where hydrodynamics can probably be applied. Whereas hydrodynamic predictions of directed flow become less and less reliable as the beam energy increases, we think that the opposite is true for elliptic flow.

Please consider this email as part of our entry, together with the attached paper.



Pb+Pb, b=7fm
v2 (EOS Q)
v2 (EOS H)
⟨⟨v⊥⟩⟩ (EOS Q)
v2
⟨⟨v⊥⟩⟩
0
0.02
0.04
0.06
0.08
0.1
0.2
0.4
0.6
0.8
1
500
1000
1500
2000
2500
3000
SPS
RHIC
LHC
total pion multiplicity density at y=0



U+U, b=0fm, side−on−side
v2 (EOS Q)
v2 (EOS H)
⟨⟨v⊥⟩⟩ (EOS Q)
v2
⟨⟨v⊥⟩⟩
0.1
0.08
0.06
0.04
0.02
0
1
0.8
0.6
0.4
0.2
0
SPS
RHIC
0
1000
2000
3000
4000
total pion multiplicity density at y=0