

# Collision Energy Evolution of Elliptic and Triangular Flow in a Hybrid Model\*

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We have studied the collision energy dependence of elliptic flow  $v_2$  and triangular flow  $v_3$  in Au+Au collisions within the energy range  $\sqrt{s_{NN}} = 5 - 200$  GeV, utilizing a transport + hydrodynamics hybrid model [1,2]. The transport part is described by the Ultrarelativistic Quantum Molecular Dynamics (UrQMD), combined with an intermediate (3+1)-dimensional ideal hydrodynamical evolution phase using a chiral model equation of state. This approach provides a consistent framework for investigating both high-energy heavy ion collisions with negligible net-baryon density and a large hydrodynamically evolving medium, and the collisions at smaller energies with finite net-baryon density, where the hydrodynamics phase is very short-lived or does not exist at all.

The hybrid model reproduces the qualitative behavior of the experimentally measured elliptic flow (see Fig. 1(a)). While  $v_2$  produced by hydrodynamics is considerably diminished at lower collision energies, this decrease is partially compensated by the transport dynamics, as shown in Fig. 1(b). The pre-hydrodynamics transport phase is of particular importance for understanding the collision energy evolution, while the hadronic rescatterings after the hydrodynamical phase contribute more systematically  $\sim 10\%$  to the total flow at all energies. However, the viscous matter described by transport dynamics is unable to produce triangular flow, which consequently shows a significantly larger relative decrease in midcentral collisions with decreasing  $\sqrt{s_{NN}}$  (Fig. 1(c)). Our conclusion is that the triangular flow provides the clearer signal for the formation of low-viscous fluid in heavy ion collisions.

## References

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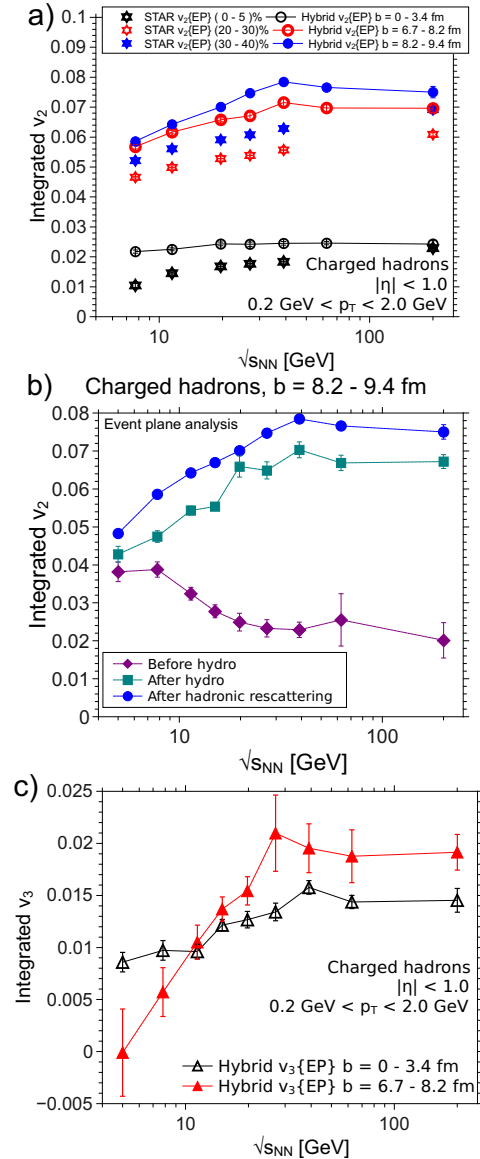


Figure 1: a): Integrated elliptic flow  $v_2\{\text{EP}\}$  for charged hadrons with  $0.2 < p_T < 2.0$  at midrapidity  $|\eta| < 1.0$  in Au+Au collisions, for collision energies  $\sqrt{s_{NN}} = 7.7 - 200$  GeV and three different impact parameter ranges, compared with the STAR data [3, 4]. b): Magnitude of  $v_2\{\text{EP}\}$  in midcentral collisions ( $b = 8.2 - 9.4 \text{ fm}$ ) at the beginning of hydrodynamical evolution (diamonds), immediately after the end of hydrodynamics phase (squares) and after the full simulation (circles). c): Integrated  $v_3\{\text{EP}\}$  in central collisions ( $b = 0 - 3.4 \text{ fm}$ , open triangles) and midcentral collisions ( $b = 6.7 - 8.2 \text{ fm}$ , solid triangles).