Eccentricity Fluctuations in High Energy Collisions of Deformed Nuclei

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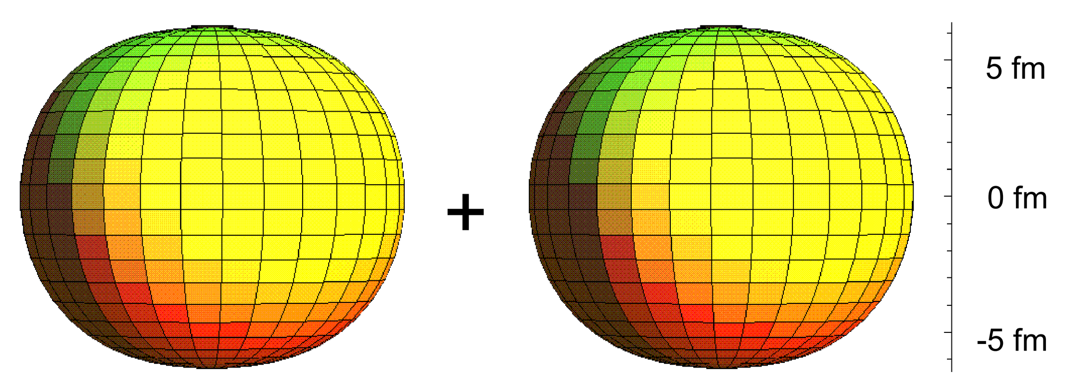
Abstract: ***The azimuthal anisotropy, especially the second harmonic Fourier coefficient v_2, is expected to be one of the most important probes in relativistic heavy ion collisions due to it's sensitivity to the equation of state (EOS). Fluctuation of v_2 is also considered as a sensitive probe in the early stage of collisions. It can be strongly influenced by the EOS as well as fluctuations of initial spatial anisotropy, eccentricity. We present our results on average eccentricity and the fluctuations of the eccentricity in heavy ion collisions at $\sqrt{s}$ = 200 GeV/n including the effect of the ground-state deformation of the colliding nuclei. A Glauber-type model simulation was used in the study. A larger fluctuation is found in more central collisions of non-spherical nuclei.***

Why collisions of deformed nuclei ?

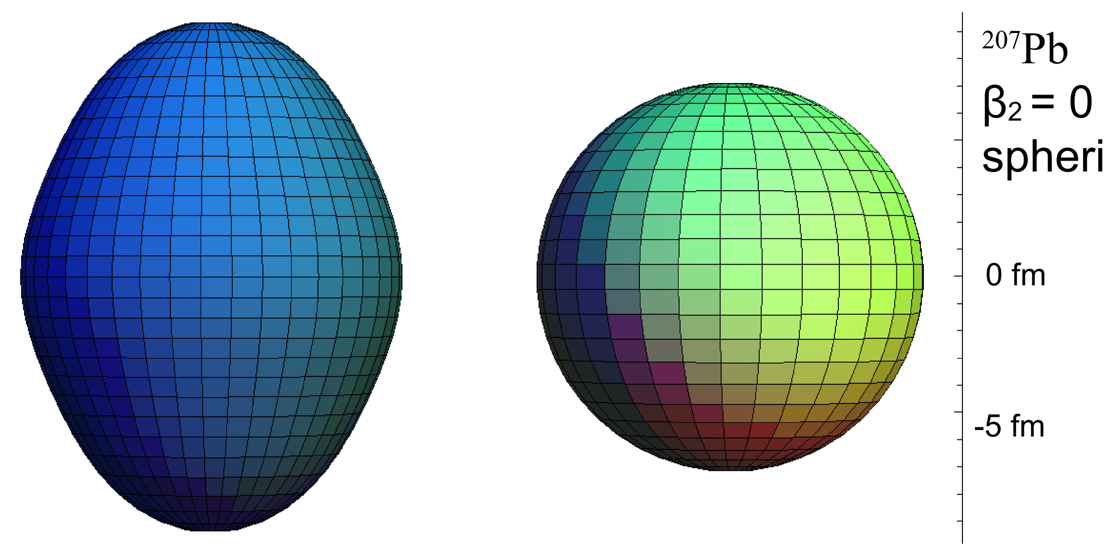
a) Most of nuclei are deformed, including ^{197}Au [1], ^{165}Ho, ^{63}Cu and ^{28}Si [2].

^{197}Au
β_2=-0.13
β_4=-0.03
oblate shape



b) Heaviest nuclei suitable for collisions are deformed, e.g. ^{238}U or ^{251}Cf.

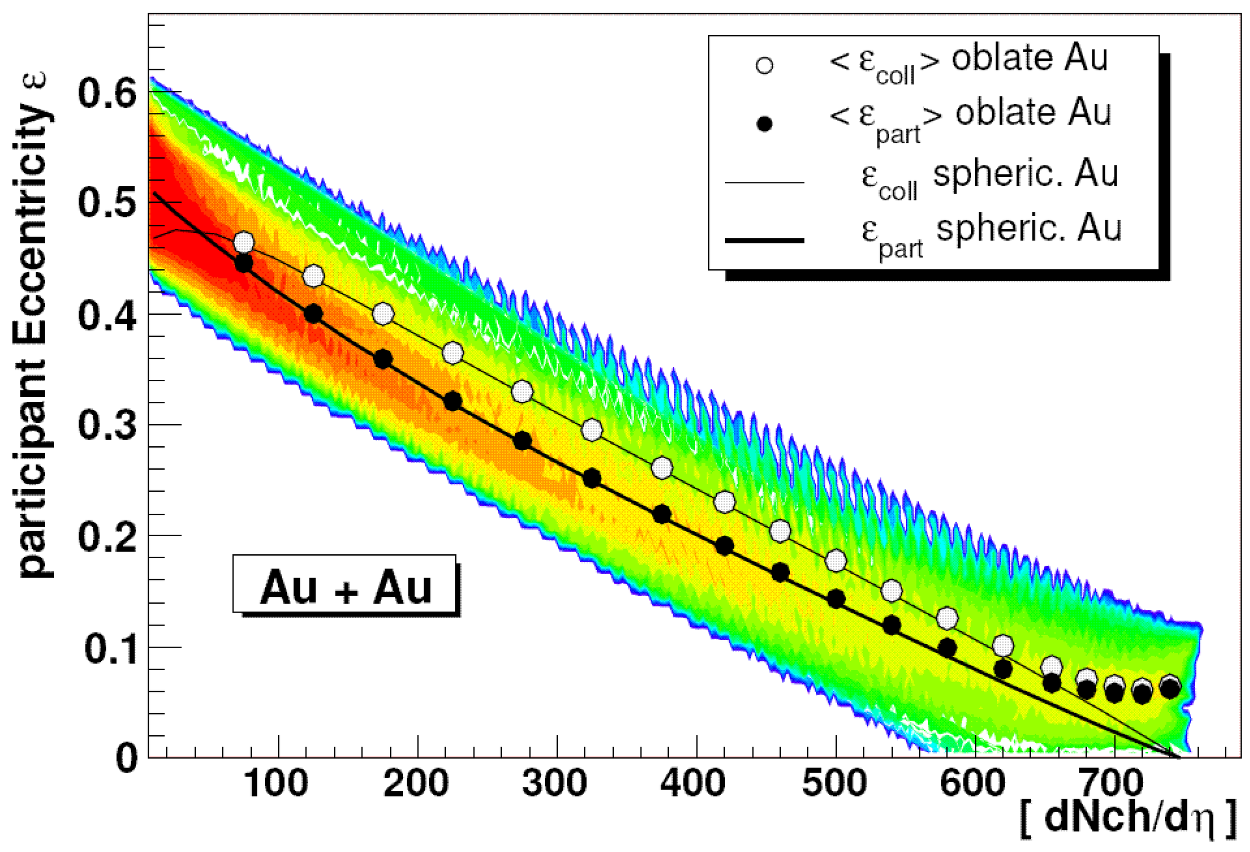
^{238}U
β_2=0.28
β_4=0.09
prolate shape



^{207}Pb
β_2 = 0
spherical

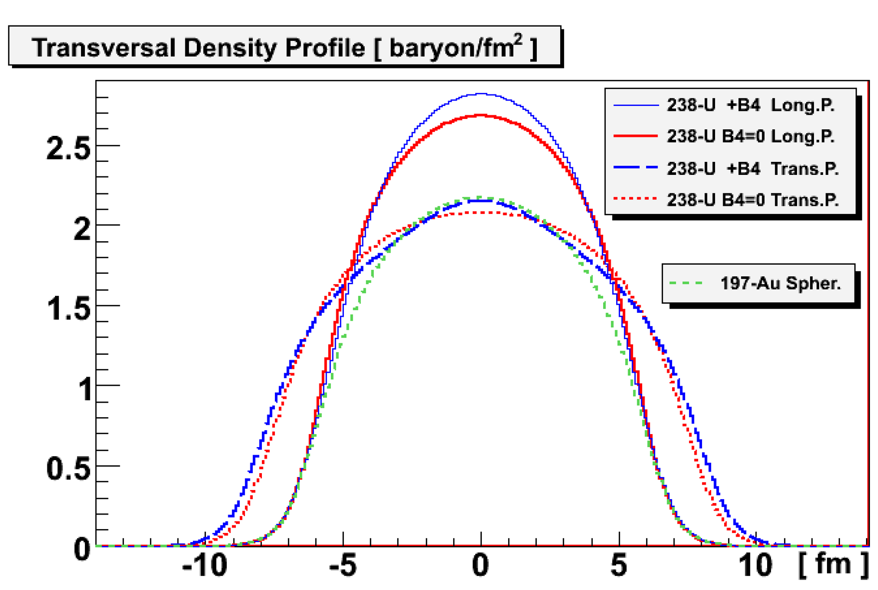
Does deformation affect Elliptic flow ?

a) Yes, initial eccentricity fluctuations increase due to deformation
→ larger v_2 fluctuations are expected.



Eccentricity values obtained from optical Glauber model simulation assuming oblate deformation β_2 = -0.13 for ^{197}Au [2]. In very central collisions, mean eccentricity (black dots) is increased due to deformation (compared to spherical Au calculations). This modifies ratio $v_2/<\varepsilon>$. In non-central collisions fluctuations of eccentricity due to finite number of interacting nucleons are much larger compared to fluctuations due to deformation (shown here).

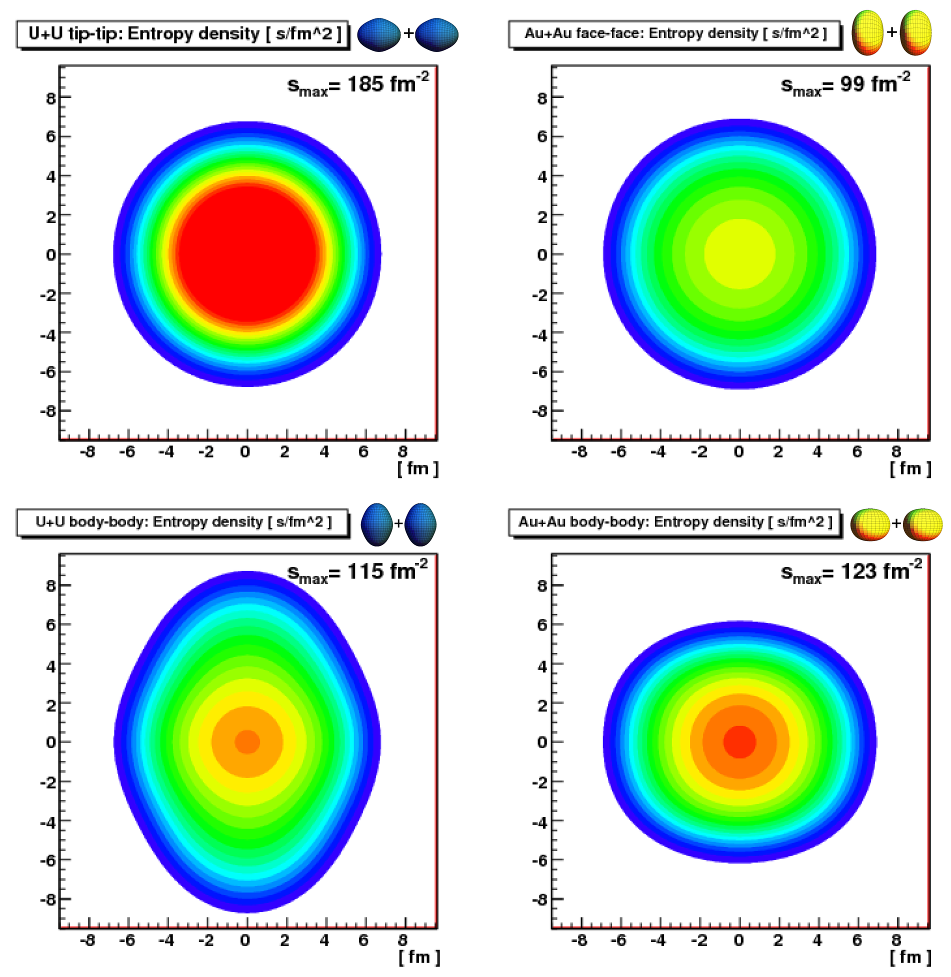
b) Also maximum baryon density and average initial eccentricity in most central collisions are affected.



Baryon density in heavy (Z>90) nuclei depends on β_2 and β_4 deformation parameters. For tip-tip U+U collisions initial tranverse density exceeds Au+Au density by factor 1.3 while in body-body U+U configuration the baryon density is comparable to Au+Au collisions. Charged particles multiplicity dNch/dη together with number of spectator nucleons are sensitive to the orientation of nuclei.

What does it mean for RHIC physics ?

There are different types of most central Au+Au events, depending on the orientation of colliding Au nuclei: body-body configuration (transverse polarization) gives the highest energy density in Au+Au collisions. In this case, average initial eccentricity <ε> is increased. Consequently the elliptic flow v_2 is larger if compared to face-face Au+Au collisions. Energy density in very central Au+Au body-body collisions is slightly higher compared to central body-body U+U collisions. Number of participants is not a good variable for the study of such collisions.



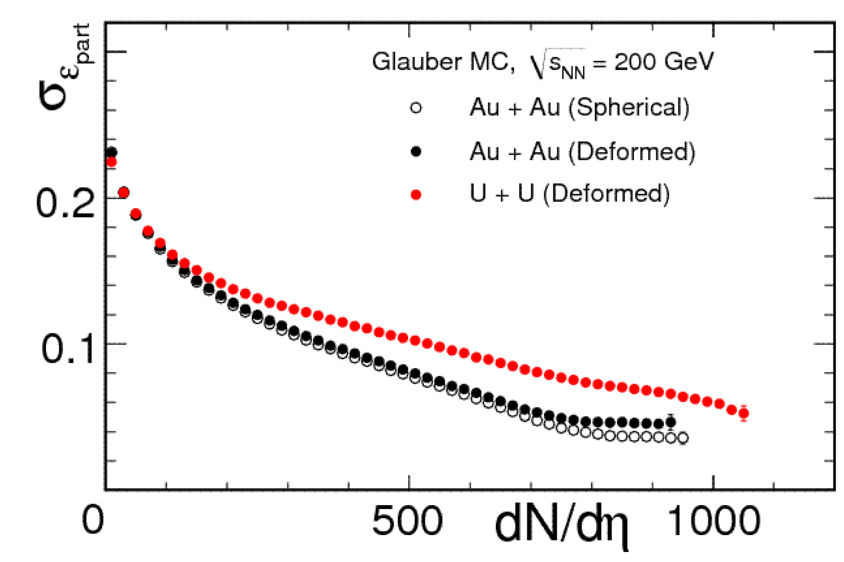
Monte-Carlo Glauber simulation:

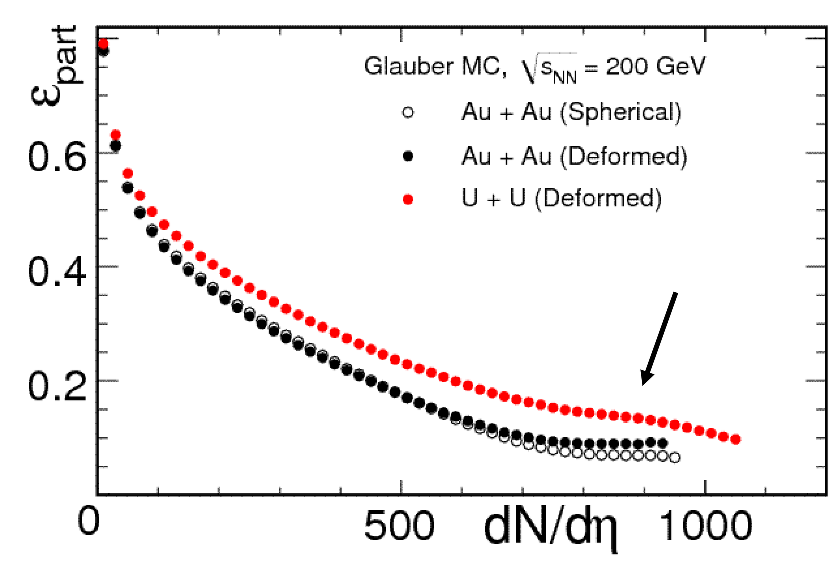
Glauber Monte-Carlo simulation can account for eccentricity fluctuations originating from the finite number of interacting nucleons. Such fluctuations are not accessible to optical Glauber models. Width σ_ε of the eccentricity fluctuations in collisions of deformed Au nuclei increases slightly for central collisions due to deformation.

In U+U collisions eccentricity fluctuations are clearly larger compared to Au+Au collisions at the same dNch/dη.

Average eccentricity <ε> in Au+Au collisions gets larger if oblate deformation of ^{197}Au is taken into account.

In U+U collisions average eccentricity exhibits a small cusp for central collisions due to effective polarization of very-high-multiplicity (VHM) collisions of prolate nuclei. This prediction can be verified experimentally at RHIC.





Summary:

- **→ increased eccentricity fluctuations (due to deformation)**
- **→ changed average Au+Au eccentricity (in central collisions)**
- **→ cusp in eccentricity for central U+U expected**

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[1] C.Nair et al. (Giant Dipole Resonance in ^{197}Au) see: arXiv:08114746.
[2] P.Moller et al. At. Data Nucl. Data Tables 59 (1995) 185.