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GENERAL NOTES

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Prospects for new physics in uranium-on-uranium (UU) collisions due to deformation and orientation effects have recently generated much interest in the relativistic heavy-ion community (Li, 2000; Shuryak, 2000; Das Gupta and Gale, 2000; Kolb et al. 2000). In particular, UU collisions have been proposed to extend beyond Pb+Pb collisions to better understand the J/Ψ suppression mechanism at CERN's SPS. Many other outstanding issues may also be resolved by studying deformation and orientation effects in UU collisions at relativistic energies. One of the most critical factors to all of these issues is the maximum achievable energy density in UU collisions. Because of the deformation, UU collisions at the same beam energy and impact parameter but different orientations are expected to form dense matter with different compressions and lifetimes. In particular, the large deformation of uranium nuclei lets one gain particle multiplicity, energy density, and longer reaction time by aligning the two uranium nuclei with their long axes head-on (tip-tip). We report here some results of a study on UU collisions within the relativistic transport model ART (Li and Ko, 1995).

Uranium is approximately an ellipsoid with a long and short semi-axis $R_l = R\cdot(1+2/3\delta)$ and $R_s = R\cdot(1-1/3\delta)$, where R is the equivalent spherical radius and δ, is the deformation parameter. For ^{238}U, δ=0.27 and thus a long/short axis ratio of about 1.3. Among all possible orientations between two colliding uranium nuclei, the tip-tip (with long axes head-on) and body-body (with short axes head-on and long axes parallel in the reaction plane) collisions are the most interesting ones. Shown in Fig. 1 are the evolution of central baryon densities in the UU collisions at a beam energy of 20 GeV/nucleon and an impact parameter of *0* and *6* fm, respectively. While the body-body UU collisions lead to density compressions comparable to those reached in the Au-Au and spherical UU collisions, 30% more compression is obtained in the tip-tip UU collisions at both impact parameters. The high-density phase (i.e., with $\rho/\rho_0 \geq 5$) in the tip-tip collisions lasts about 3-5 fm/c longer than the body-body collisions. The higher compression and longer passage time render the tip-tip UU collisions the most probable candidates to form the Quark-Gluon-Plasma (QGP).

The elliptic flow reflects the anisotropy in the particle transverse momentum (p_t) distribution at midrapidity, i.e.,

$$v_2 = \langle (p_x^2 - p_y^2)/p_t^2 \rangle, \qquad (1)$$

where $p_x (p_y)$ is the transverse momentum in (perpendicular to) the reaction plane, and the average is taken over all particles in all events. The v_2 results from a competition between the "squeeze-out" perpendicular to the reaction plane and the "in-plane flow". Shown in Fig. 2 is the nucleon elliptic flow as a function of impact parameter in UU collisions with different orientations at beam energy of 10

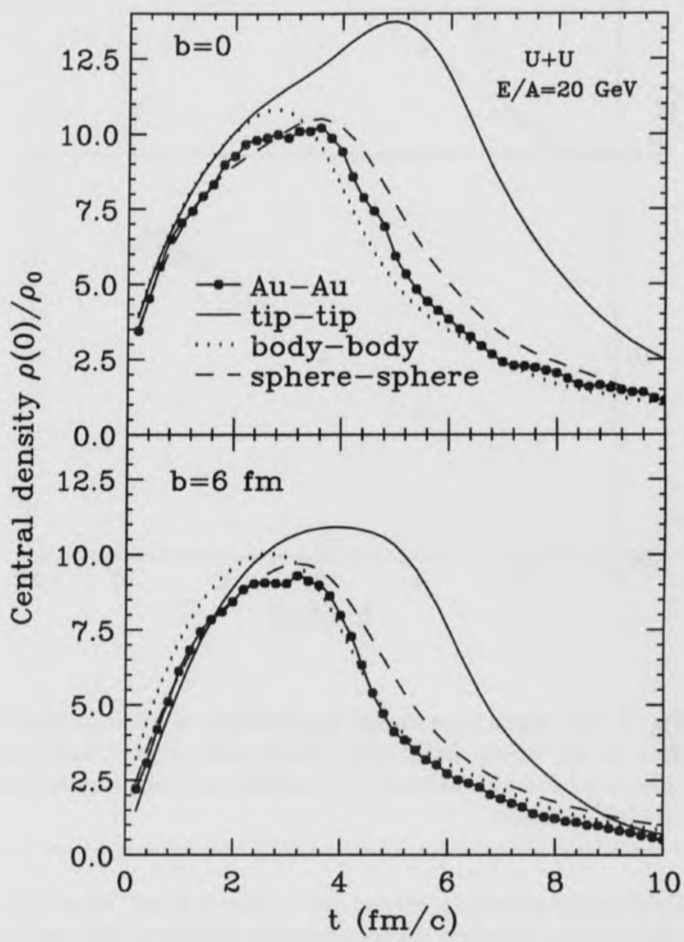

Fig. 1. The evolution of central baryon density in Au-Au (filled circles), tip-tip (solid line), body-body (dotted line) and sphere-sphere (dashed line) UU collisions at a beam energy of 20 GeV/nucleon and an impact parameter of 0 (upper panel) and 6 fm (lower panel), respectively.

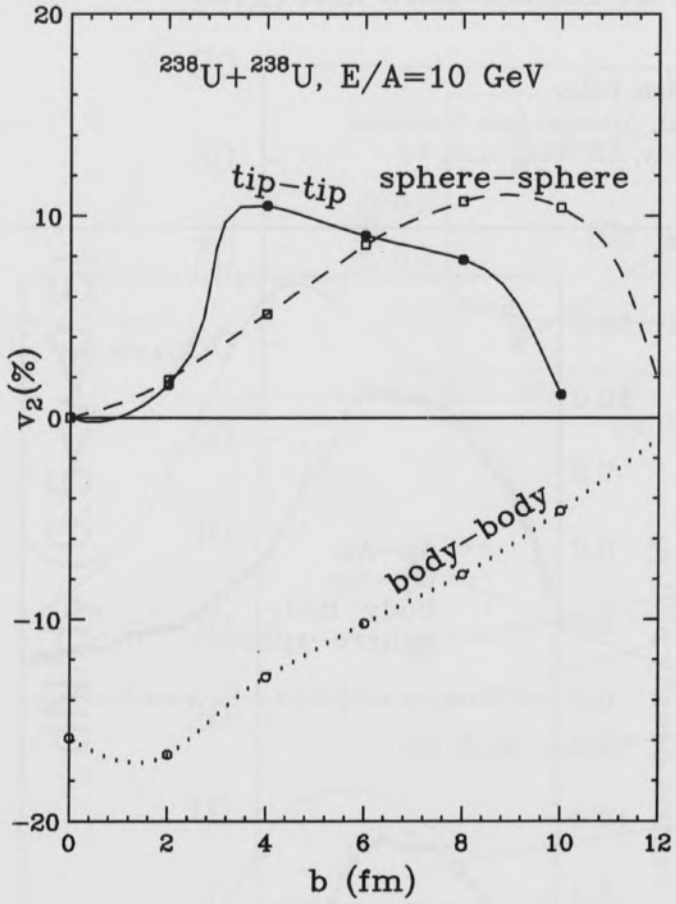

Fig. 2. The impact parameter dependence of nucleon elliptic flow in the tip-tip (solid line), body-body (dotted line) and sphere-sphere (dashed line) UU collisions at beam energy of 10 GeV/nucleon.

GeV/nucleon and an impact parameter of 6 fm. We initialized the two uranium nuclei such that their long axes are in the reaction plane in both tip-tip and body-body collisions. It is seen that both the tip-tip and sphere-sphere collisions lead to a strong "in-plane flow" (positive v_2) whereas the body-body reactions result in a large "squeeze-out" (negative v_2). Only in the body-body UU collisions, is the strength of elliptic flow the highest in the most central collisions where the shadowing effect in the reaction plane the strongest. Whereas in tip-tip and sphere-sphere UU collisions the elliptic flow vanishes in the most central collisions due to symmetry. Similar results are found for pions too.

It is also of considerable interest to study deformation and orientation effects on particle production. Shown in Fig. 3 are the multiplicities of pions and positive kaons as a function of impact parameter. The maximum impact parameter for the tip-tip and body-body UU collisions is $2R_s$ and $2R_b$ respectively. As one expects the central (with $b \leq 5$ fm) tip-tip UU collisions produce more particles due to the higher compression and the longer passage time of the reaction. While at larger impact parameters, the smaller overlap volume in the tip-tip collisions leads to less particle production than the body-body and sphere-sphere reactions. Also as one expects from the reaction geometry, the multiplicities in the body-body collisions approach those in the sphere-sphere collisions as the impact parameter reaches zero. In the most central collisions, the tip-tip UU collisions produce about 15% (40%) more pions (positive kaons) than the body-body and sphere-sphere UU collisions. These deformation and orientation effects on particle production are consistent

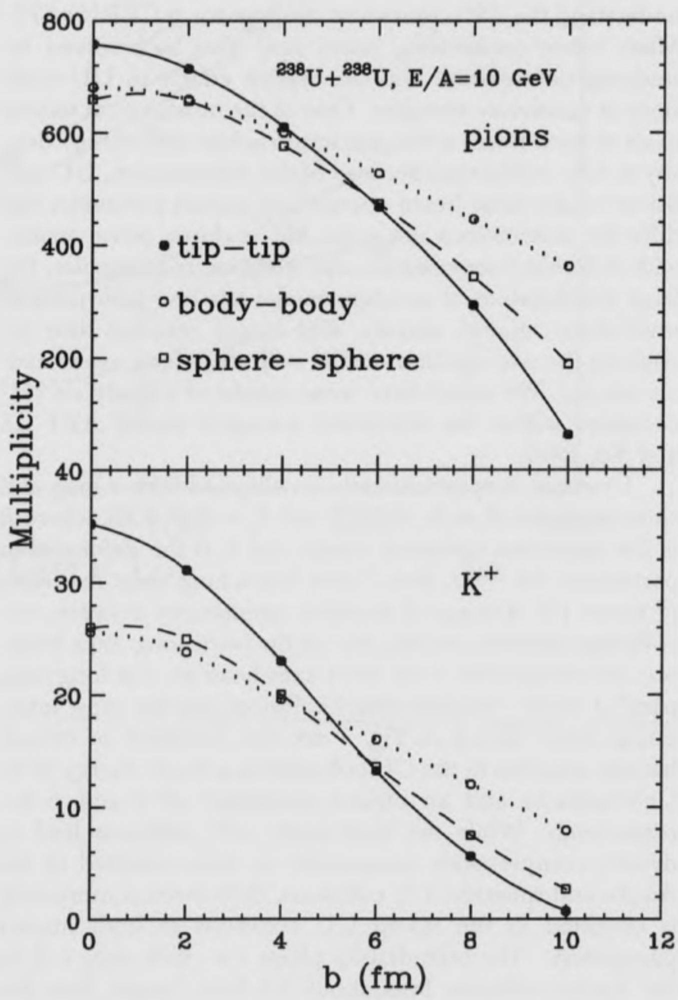

Fig. 3. The impact parameter dependence of pion (upper panel) and positive kaon (lower panel) production in the tip-tip (solid line), body-body (dotted line) and sphere-sphere (dashed line) UU collisions at a beam energy of 10 GeV/nucleon.

with those on density compression shown in Fig. 1. Compared to pions, kaons are more sensitive to the density compression since most of them are produced from second chance particle (resonance)-particle (resonance) scatterings at the energies studied here.

By using A Relativistic Transport model we have studied the deformation/orientation effects on the compression, elliptic flow, and particle production in uranium on uranium (UU) collisions at relativistic energies. The compression in the tip-tip UU collisions is about 30% higher and lasts approximately 50% longer than in the body-body or spherical UU collisions.

Moreover, we found that the nucleon elliptic flow in the body-body UU collisions has some unique features. The tip-tip UU collisions are thus more probable to create the QGP at the AGS/BNL and SPS/CERN energies. At RHIC/BNL and LHC/CERN energies, however, the "squeeze-out" of particles in the central body-body collisions is more useful for studying properties of the QGP.

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