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Future opportunities of small system scan at RHIC

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The observation of multi-particle azimuthal correlations in high-energy small-system collisions has led to intense debate on its physical origin between two competing theoretical scenarios: one based on initial-state intrinsic momentum anisotropy (ISM), the other based on final-state collective response to the collision geometry (FSM). To complement the previous scan of asymmetric collision systems (p+Au, d+Au and He+Au), we propose a scan of small symmetric collision systems at RHIC, such as C+C, O+O, Al+Al and Ar+Ar at $\sqrt{s_{\mathrm{NN}}} = 0.2$ TeV, to further disentangle contributions from these two scenarios. These symmetric small systems have the advantage of providing access to geometries driven by the average shape of the nuclear overlap, compared to fluctuation-dominant geometries in asymmetric systems. A transport model is employed to investigate the expected geometry response in the FSM scenario. Different trends of elliptic flow with increasing charge particle multiplicity are observed between symmetric and asymmetric systems, while triangular flow appears to show a similar behavior.

The enhanced pseudo-rapidity coverage of STAR with iTPC, EPD, and forward upgrade, together with sPHENIX's capabilities of state-of-art hard-probe measurments, make RHIC the ideal place for the proposed scan. Furthermore, a comparison of O+O collisions at $\sqrt{s_{\mathrm{NN}}} = 0.2$ TeV and at $\sqrt{s_{\mathrm{NN}}} = 2.76 - 7$ TeV, as proposed at the LHC, provides a unique opportunity to disentangle the collision geometry effects at nucleon level from those arising from subnucleon fluctuations. Such a proposal of O+O collisions at RHIC in year 2020-2021 has been included in STAR Beam Use Request[1]. Uncertainty projections of key measurements will be presented.

[1] STAR Collaboration Beam Use Request for Run-20 and Run-21, https://drupal.star.bnl.gov/STAR/starnotes/public/sn0721

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