STAR heavy ion program for 2021+ and prospect for constraining the initial state

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The extended pseudorapidity range of STAR's BES-II and forward upgrades (fSTAR) along with high statistics data from anticipated heavy ions runs in the years 2021 and beyond provide unique prospects on constraining the initial stages of heavy ion collisions. STAR's BES-II upgrade sub-systems comprised of the inner Time Projection Chamber (iTPC, $1<|\eta|<1.5$) and Event Plane Detector (EPD, $2.1<|\eta|<5.1$) that are commissioned and fully operational since the beginning of 2019. These detectors will be used to explore the origin of small system collectivity via O+O collisions in 2021. The measurements of long-range di-hadron correlations and jet-quenching in O+O will have the capability to constrain the relative contribution of initial state vs. final state effects and the role of sub-nucleonic scale fluctuations. In addition, with the completion of the fSTAR upgrade by September 2021, STAR will have charged particle tracking systems (FTS) and electromagnetic/hadronic calorimetry (FCS) in the forward pseudorapidity region of $2.5 < \eta < 4$. During the 2023-2025 Au+Au running period, these upgrades will help STAR to perform several unique correlation measurements including: 1) the longitudinal decorrelation of event planes and flow harmonics over a wide range of pseudorapidity in Au+Au (200 GeV) collisions that can map the longitudinal structure of the initial stages of colliding nuclei and constrain the rapidity dependence of the parton densities in colliding ions, 2) the precision measurements of photonuclear vector meson production in ultra-peripheral Au+Au collisions that provide promising ways to probe the gluon distribution inside nuclei. These measurements will not only address key questions about the A+A initial state but have the potential to provide essential constraints on the initial stages of e+A collisions at the EIC.