New constraints on 3D initial state and transport parameters of QGP using the Beam Energy Scan phase II data of STAR

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Constraining the three-dimensional structure of the initial state and transport properties of the Quark-Gluon Plasma (QGP) at different temperatures (T) and baryon chemical potentials (μ_B) is a critical objective of heavy-ion programs at RHIC and the LHC. This work presents comprehensive measurements on both topics for various event-shape and centrality selections of Au+Au collisions at RHIC BES-I (e.g. 11.5, 19.5, and 39 GeV), BES-II (14.6, 27, and 54.4 GeV), and 200 GeV. We present new measurements of the beam energy dependence of higher-order flow-angular de-correlations ($r_n(\eta_a, \eta_b)$) that are sensitive to the three-dimensional initial state. We also study new observables which are selectively sensitive to the viscous attenuation in the final state, such as the transverse momentum correlator $G_2(\Delta\eta, \Delta\varphi)$. We observe a non-monotonic behavior in the longitudinal width of $G_2(\Delta\eta, \Delta\varphi)$ with the collision energy, which is expected to be proportional to η/s according to the ansatz proposed by S. Gavin et. al. [1]. In addition, we further explore the higher-order flow-angular correlation $\langle\cos(a_1 n_1 \Psi_{n1} + \cdots + a_k n_k \Psi_{nk})\rangle$ and the higher-order flow-magnitude correlations $SC(n,m)\{4\}$ and $SC(n,m)\{6\}$ using the 2- through 6-particle correlation method. The higher-order flow-angular (magnitude) correlations are predicted to be sensitive to both initial and final state effects. We compare our findings with similar studies conducted at the LHC and with viscous hydrodynamic calculations. Our analyses aim to disentangle the initial and final-state effects and extract the QGP transport properties.

[1] S. Gavin and M. Abdel-Aziz, Phys. Rev. Lett. 97, 162302 (2006)