Exploring electromagnetic field effects and constraining transport parameters of QGP using STAR BES II data

Constraining the initial strong electromagnetic field effects, three-dimensional structure of the initial state, and the transport properties of the Quark-Gluon Plasma (QGP) at different temperatures (T), and baryon chemical potentials (μ_B) are critical objectives of the heavy-ion program at RHIC. The dominance of Faraday+Coulomb effect during the initial stages of non-central heavy ion collisions is predicted to result in a negative Δv_1, defined by the difference in rapidity-odd directed flow (v_1) between positively and negatively charged particles. With the large dataset accumulated in the Beam Energy Scan (BES) phase II of STAR, we probe the beam energy dependence of Δv_1 for charged pions, kaons, and protons as a function of rapidity, transverse momentum (p_T), and centrality at midrapidity in Au+Au collisions at $\sqrt{s_{NN}}$ = 19.6 - 7.7 GeV. Our results support the notion of stronger Δv_1 at lower collision energies, expected due to the longer lifetime of the electromagnetic field and shorter lifetime of the fireball and a stronger effect with increasing p_T.

The flow angular decorrelations ($r_n(\eta)$) are sensitive to the 3D initial state, and new observables such as the transverse momentum correlator $G_2(\Delta\eta, \Delta\varphi)$ and flow-magnitude and flow angular correlations are sensitive to the transport parameters of the evolution. We present new measurements of the beam energy dependence of higher-order flow-angular de-correlations $r_n(\eta)(n = 2, 3)$, the transverse momentum correlator $G_2(\Delta\eta, \Delta\varphi)$, higher-order flow-angular correlation $\langle\cos(a_1 n_1 \Psi_{n1} + \cdots + a_k n_k \Psi_{nk})\rangle$ and higher-order flow-magnitude correlations $SC(n, m)\{4\}$ and $SC(n, m)\{6\}$ for various event-shape and centrality selections of Au+Au collisions in different BES energies ($\sqrt{s_{NN}}$ = 200 - 11.5 GeV) at RHIC. 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]. Through these measurements we aim to gain insights into the role of electromagnetic fields and transport parameters of the QGP by disentangling the initial and final state effects.

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