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## Differential measurements of $\phi$ -meson global spin alignment and off-diagonal spin density matrix elements in Au+Au collisions at STAR

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A significant global spin alignment ( $\rho_{00}$ ) signal for  $\phi$ -mesons was observed by the STAR collaboration in Au+Au collisions using the data from the first phase of the Beam Energy Scan at RHIC (BES-I) [1]. Conventional physical mechanisms which contribute to  $\rho_{00}$  fail to explain the observed signal; however, it may be attributable to the presence of a  $\phi$ -meson strong force field [2] or to non-zero  $\rho_{00}$  in the helicity frame induced by the relative motion of  $s\bar{s}$  pairs to the thermal background in heavy-ion collisions [3]. Recently, a quark recombination model with quark-antiquark spin correlations was developed and is able to simultaneously explain lambda polarization ( $P_\Lambda$ ) and  $\phi$ -meson  $\rho_{00}$  measurements, in addition to predicting non-zero off-diagonal spin density matrix elements [4]. Therefore, measurements of off-diagonal matrix elements of  $\phi$ -mesons may provide a probe of  $s\bar{s}$  spin correlations. Off-diagonal spin density matrix elements could also be important when measuring Chiral Magnetic Effect (CME) observables involving vector meson decay products, as these elements represent a possible physics background [5]. Previous  $\rho_{00}$  measurements in [1] use a 1D angular distribution in  $\theta^*$  (polar angle of a daughter kaon in the  $\phi$ -meson's rest frame with respect to the orthogonal of the harmonic plane), which cannot account for possible contributions to  $\rho_{00}$  from off-diagonal spin density matrix elements. In this talk, we address this by measuring  $\phi$ -meson  $\rho_{00}$  and off-diagonal spin density matrix elements using both angular dimensions  $\theta^*$  and  $\beta$  of a daughter kaon in the  $\phi$ -meson's rest frame, where  $\beta$  is the azimuthal angle within the reaction plane, measured relative to the beam axis. We will present differential measurements of  $\phi$ -meson global  $\rho_{00}$  and off-diagonal spin density matrix elements with respect to rapidity and transverse momentum, using data from the second phase of RHIC BES (BES-II) in Au+Au collisions at  $\sqrt{s_{NN}} = 19.6$  GeV collected by STAR.

- [1] STAR Collaboration., Nature **614**, 244–248 (2023)
- [2] X.L. Sheng et al., Physical Review C **108**, 054902 (2023).
- [3] X.L. Sheng et al., Physical Review D **110**, 056047 (2024).
- [4] J.P. Lv et al., Physical Review D **109**, 114003 (2024).
- [5] Z. Wang et al., Physical Review C **111**, 014910 (2025)

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