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Transverse single-spin asymmetries of weak bosons and Drell-Yan production at STAR

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The three-dimensional structure of the proton in momentum space can be described via Transverse Momentum Dependent (TMDs) parton distribution functions. One of these TMDs, known as the Sivers function $f_{1T}^{\perp}$, describes the correlation of parton transverse momentum with the transverse spin of the nucleon. In Semi-Inclusive Deep Inelastic Scattering (SIDIS) processes in e+p collisions, the quark Sivers function is associated with a final state effect from the gluon exchange between the struck quark and the target nucleon remnants. On the other hand, in p+p collisions processes, the Sivers asymmetry appears as an initial state interaction effect. As a consequence, the quark Sivers functions are of opposite sign in SIDIS and in p+p and this non-universality is a fundamental prediction from the gauge invariance of QCD. The experimental test of this sign change is one of the open questions in hadronic physics, and can provide a direct verification of color interactions of partons (quarks and gluons) inside the hadrons. Accessing the Sivers TMD function in proton+proton collisions through the measurement of transverse single spin asymmetries (TSSAs) in weak boson production is an effective path to test the fundamental QCD prediction of the non-universality of the Sivers function. Furthermore, it provides data to study the spin-flavor structure of valence and sea quarks inside the proton and to test the evolution of parton distributions. RHIC is the world's only facility that can run transversely polarized p+p collisions at a center-of-mass energy large enough to produce weak bosons. The TSSA amplitude, A_N, has been measured at STAR in p+p collisions at $\sqrt{s} = 500$ GeV, with a recorded integrated luminosity of 25 pb^{-1}. Within relatively large statistical uncertainties, the current data favor theoretical models that include change of sign for the Sivers function relative to observations in SIDIS measurements, if TMD evolution effects are small. RHIC plans to run proton+proton collisions of transversely polarized beams at $\sqrt{s} = 510$ GeV in 2017, delivering an integrated luminosity of 400 pb^{-1}. This will allow STAR to perform a precise measurement of TSSAs in both weak boson and Drell-Yan production as well as other observables sensitive to the non-universality of the Sivers function via the Twist-3 formalism, e.g. the TSSA of direct photons.