Measurement of long-range two-particle correlations in pp collisions at $\sqrt{s} = 200$ GeV with RHIC-sPHENIX

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Long-range two-particle correlations have become a pivotal observable for investigating the collective behavior in high-energy heavy-ion collisions. Correlations manifested as azimuthal anisotropies that span a broad pseudorapidity range–commonly referred to as the "ridge,"—were initially discovered in heavy-ion collisions.[1)] They are interpreted as signatures of hydrodynamic flow in a strongly interacting medium, such as the quark-gluon plasma (QGP).[2)] Surprisingly, similar ridge-like structures have also been measured in smaller collision systems, such as proton-proton (pp) and proton-nucleus (pA) collisions.[3)] Hydrodynamic and transport models, which successfully describe observables in heavy-ion collisions, have also been applied to these small systems.[4)] However, the origin of the ridge in small systems remains a topic of ongoing debate, with possible explanations ranging from initial-state effects to final-state interactions or a combination of both. One prevailing hypothesis suggests that both initial-state momentum anisotropies and final-state interactions play critical roles in generating collective-like signals in small collision systems.[5)] Probing a wide range of kinematic regions is essential for disentangling the various contributions to the ridge. Such studies enable us to differentiate genuine collective effects from background contributions and to access the impact of initial-state fluctuations on the evolution of the system.

This analysis utilizes pp collisions at $\sqrt{s} = 200$ GeV, recorded by sPHENIX at the Relativistic Heavy Ion Collider (RHIC) in 2024. sPHENIX, the successor to PHENIX, features a large geometric acceptance, high-precision tracking, and fast data acquisition enabled by a streaming readout system. The Monolithic Active Pixel Sensor Vertex Detector (MVTX), the Intermediate Silicon Tracker (INTT), and the Time Projection Chamber (TPC) provide high-resolution tracking and vertex reconstruction in the central pseudorapidity region ($|\eta| < 1.1$), with full azimuthal coverage ($0 \leq \phi \leq 2\pi$). The Event Plane Detector (sEPD) extends this coverage to the forward and backward rapidity regions ($2.0 < |\eta| < 4.9$), also with full azimuthal acceptance. This extensive pseudorapidity and azimuthal coverage enables the measurement of long-range two-particle correlations across a wide rapidity gap, allowing for effective separation of collective flow effects from short-range, non-flow contributions. Additionally, the streaming readout system facilitates efficient collection of high-multiplicity events. The combination of central tracking and forward rapidity detection allows for detailed investigations into longitudinal decorrelations and initial-state fluctuations, providing crucial constraints for theoretical models of the early-stage dynamics.

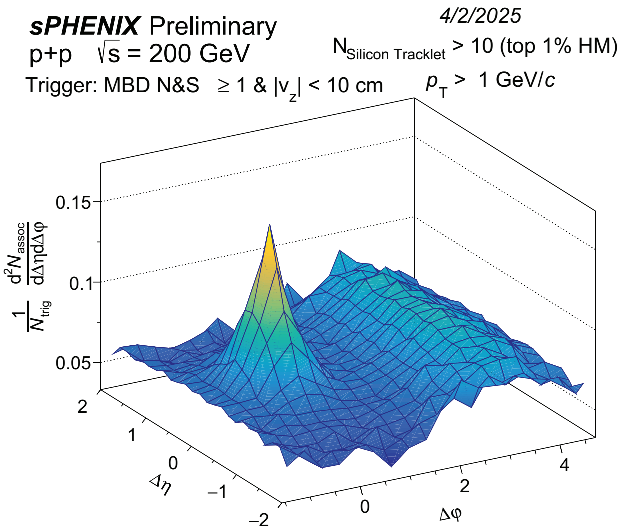

Fig. 1. Two-particle correlations observed in the top 1% highest-multiplicity events, reconstructed using silicon-only tracks and based on at most 1% of the total dataset.

Two-particle correlation measurements are performed using charged particle tracks reconstructed by the tracking detectors. Optimization of the tracking algorithm is currently in progress. Preliminary results, shown in Fig. 1, depict two-particle correlations for the top 1% highest-multiplicity events, based on silicon-only tracks and utilizing no more than 1% of the full dataset. Future analyses will employ the complete dataset to perform systematic studies of two-particle correlations as functions of charged-particle multiplicity, pseudorapidity gap, and transverse momentum.

References

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