Collins asymmetry sensitivity studies for sPHENIX

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The sPHENIX detector is a new detector built as a follow-up of the PHENIX detector at RHIC, Brookhaven National Laboratory. It is constructed around the 1.4 T BaBar solenoid and consists of silicon vertex detectors, a time-projection chamber, an electromagnetic calorimeter, as well as hadronic calorimeters inside and outside of the magnet coil. Particularly the latter will allow the unbiased detection of jets, together with high-rate capabilities of the sPHENIX data acquisition system and jet-specific triggering. sPHENIX has full azimuthal coverage in a rapidity range of $|\eta| < 1.1$. In transversely polarized proton-proton collisions jets can be used to study the transverse spin structure of the nucleon in transverse single spin asymmetries (TSSAs). When looking at the azimuthal asymmetries of final-state hadrons within the jet one becomes sensitive to the Collins fragmentation function[1] that translates the transverse quark spin of the struck quark into an azimuthal asymmetry of final state hadrons in the fragmentation. This effect has been observed first in semi-inclusive DIS (SIDIS) at HERMES[2] and particularly in electron-positron annihilation at Belle.[3] Because the Collins fragmentation requires a transversely polarized outgoing quark, this effect can be used to access the quark transversity distribution and tensor charge in the nucleon. Previous measurements obtained the up-quark transversity reasonably well, but due to the electro-magnetic interaction in SIDIS, sensitivity to down-quarks is limited. In polarized proton collisions the down-quark interaction is not suppressed by its charge. The sPHENIX experiment is expected to take polarized proton-proton collision data in 2024. To evaluate the performance, full GEANT4 simulations of sPHENIX using the PYTHIA8 generator were analyzed. Jets were reconstructed based on calorimeter clusters using the anti-kt algorithm with radius of 0.7. Charged hadrons were then selected if they fell within the same radius as the jets. The momentum fraction of the hadrons relative to the jet, its transverse momentum and azimuthal angle were then calculated. Azimuthal asymmetries (A_{UT}) were artificially created by randomly assigning spin up or down orientations to one beam and re-weighting the events based on true (*i.e.* generated) kinematic variables. The reconstructed events were then analyzed using these weights and the resulting asymmetries were compared to the asymmetries introduced on the generator level. Figure 1 shows an example of how an A_{UT}, linearly increasing in the momentum fraction would be reconstructed. Some smearing effects are visible that will be unfolded in the real data. Using these simulations the expected uncertainties of the 2024 data can be evaluated by scaling the uncertainties to the expected luminosities, as shown in Fig. 2.

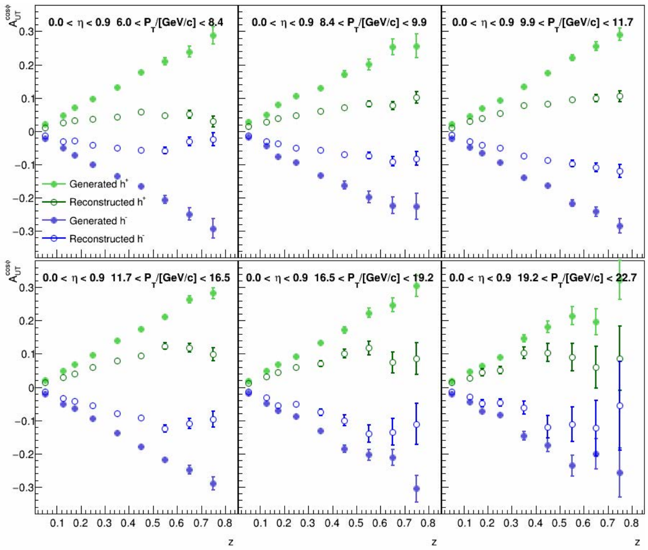

Fig. 1. Example of the generated and reconstructed asymmetries when an asymmetry linearly increasing in the momentum fraction z was introduced.

For high-momentum jets, the jet triggering will allow to accept nearly all collisions while for lower-momentum jets only a fraction will be available which is reflected in the expected uncertainties. One can see, that sPHENIX should improve on the measurements by STAR particularly at high jet momenta and be able to reduce the uncertainties on the transversity distributions significantly (represented by the theory uncertainty bands).

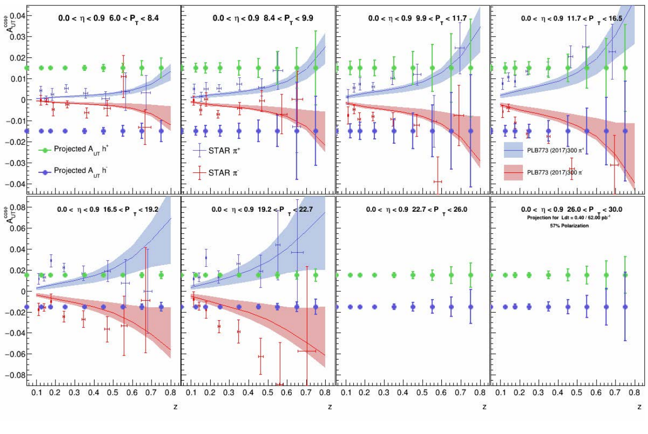

Fig. 2. Expected uncertainties for the planned 2024 polarized proton collision period.

References
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