Impact studies for transverse spin measurements at the EIC†

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The ECCE proposal was one of three proposals for the project detector of the Electron Ion Collider to be built at Brookhaven national laboratory. It has since been chosen and forms the baseline of the ePIC collaboration that has been formed recently. One of the goals of the EIC is the extraction of the three-dimensional transverse spin and momentum structure of the nucleon. These can generally be accessed via semi-inclusive deeply inelastic scattering (SIDIS) events where in addition to the scattered lepton also a final-state hadron is detected and its transverse momentum and azimuthal asymmetries are extracted. Within the ECCE proposal several full detector simulations were performed using GEANT4 and PYTHIA6 as generators. While transverse momentum dependence is reasonably described in the generator, transverse spin effects are not included. Those were artificially included based on global fits of existing data by reweighting each event according to these parameterizations. In doing so azimuthal single spin asymmetries such as the so-called Sivers and Collins asymmetries could be generated and reconstructed after the full simulations.

An example is shown in Fig. 1 for the Collins asymmetry of charged pions in two kinematic example bins as a function of the hadron fractional momentum z. In the higher x bin, where x describes the momentum fraction the struck parton carries, a sizeable asymmetry is visible for both charges. The reconstructed asymmetries are able to reproduce these results rather well, suggesting little smearing of all kinematic variables involved. Extrapolating these simulations to the expected accumulated luminosities of 10 fb^{-1} and assigning discrepancies between generated and reconstructed asymmetries as maximal systematic uncertainties, the expected precision of the EIC measurements can be evaluated, as shown in Fig. 2. These expected uncertainties can then be fed into the aforementioned global fits to extract the impact of the EIC measurements on the transverse polarization of quarks in the nucleon, its integrals the tensor charges, and the Sivers function, as previously performed in Ref. 1). It was found that the ECCE detector proposal fullfills the requirements of the Yellow Report[2] well and the impact on the transverse spin and momentum structure of the nucleon is immense. As example the impact on the uncertainties of the tensor charged for up and down quarks is shown in Fig. 3 in comparison to the current precision and the Lattice QCD predictions. Eventually, discrepancies between Lattice and measurements could hint at physics beyond the standard model once the phenomenological description is sufficiently improved.

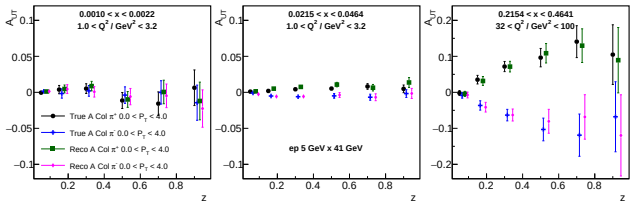

Fig. 1. Example of the positive (generated: black, reconstructed: green) and negative (generated: blue, reconstructed: purple) pion Collins asymmetries as a function of momentum fraction z, in three example bins of DIS variables x and Q^2 in 5 GeV × 41 GeV e-p collisions. For simplicity, transverse momentum was integrated over.

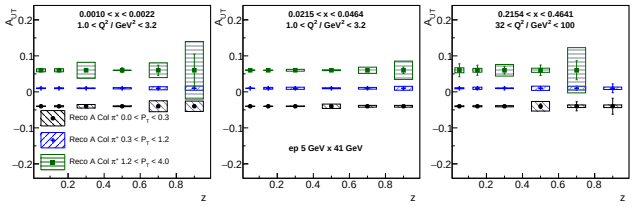

Fig. 2. Expected uncertainties for positive pion Collins asymmetries in three transverse momentum bins as a function of momentum fraction z, in three example bins of DIS variables x and Q^2 in 5 GeV × 41 GeV e-p collisions.

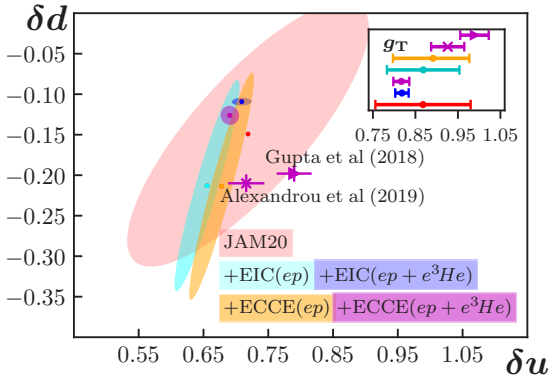

Fig. 3. Expected impact on the tensor charges under inclusion of the expected ECCE uncertainties. The small differences between Yellow Report and ECCE impact values arise from the different pseudo-data sets resulting is slightly different central values.

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References

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2) R. Abdul Khalek *et al.*, arXiv:2103.05419.