ePIC Analysis Coordination September 27, 2024

SIDIS Working Group

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2.4.3 Multi-Dimensional Imaging of the Nucleon

2.4.3.1 Imaging in Momentum Space

Using semi-inclusive DIS, it is possible to extract information on the three-dimensional momentum structure of the nucleon by making use of transverse momentum dependent fragmentation functions. These in turn provide sensitivity to the flavor and the transverse momentum of partons in the nucleon. Already in an un-polarized nucleon the ePIC experiment can provide flavor-separated transverse-momentum dependent PDFs over a large range in x and Q^2, and for transverse momenta that reach from the low, TMD-dominated region into the perturbative region. The wide range of scales, as shown in Fig.2.1 will also solve the existing uncertainties in the TMD evolution where non-perturbative contributions require experimental input.

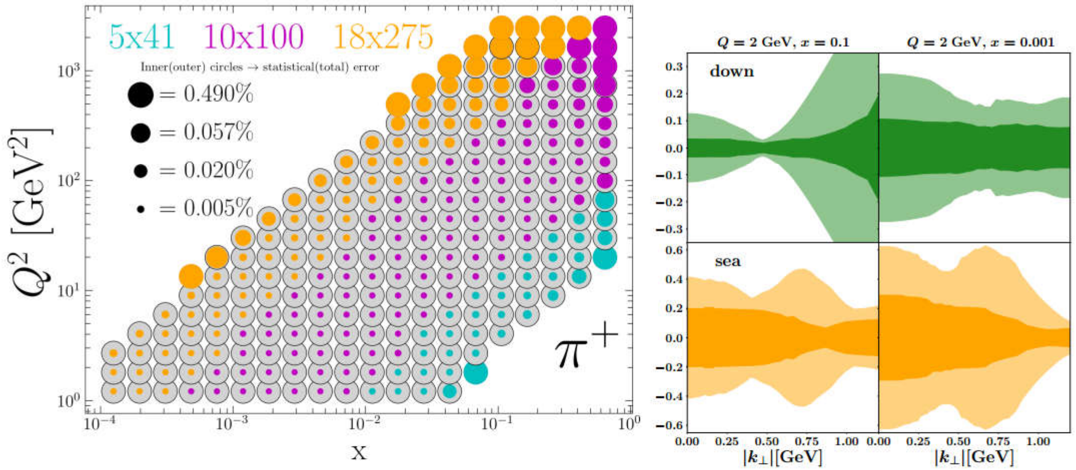

Figure 2.1: Left: Expected statistical and total uncertainty of un-polarized TMD PDFs for π^+ in the $Q^2 - x_B$ plane. The inner (colored) circle shows the statistical uncertainty, while the outer circle provides the total uncertainty for each $Q^2 - x_B$ bin. The color shows the beam energy configuration which provides the highest statistics in a specific bin. Right panel: Expected uncertainties on down (green) and sea quark (orange) TMD PDFs at $x = 0.1$ (left) and $x = 0.001$ (right) as obtained based on the MAP24 [1] global TMD fit. The lighter shaded regions show the uncertainties based on existing data while the darker shaded regions show the expected uncertainties after including ePIC data.

Writeup and figures for unpolarized TMDs are completed!

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- **Second part on A_{UT} and A_{LL} for polarised TMD PDFs**

These unpolarized TMD PDFs also serve as the unpolarized baseline for any polarized TMD observable which are obtained as single or double spin asymmetries. The most relevant are the Sivers function [] and the quark transversity [] which is obtained together with either the Collins fragmentation function [] or a di-hadron fragmentation function []. Examples of the

expected uncertainties on these asymmetries are displayed in Fig. 2.2 where one can see that over a larger range of phase space very precise uncertainties can be obtained. Those will in turn then provide flavor-separated Transversity extractions and their first moments, the tensor charges. These tensor charges are of particular interest as they can relate to interactions outside the standard model. Lattice-QCD can model the tensor charges very well and any differences with the measurements would provide a hint for BSM physics.

Figure 2.2: Expected uncertainties in three example x-Q^2 bins for the Collins asymmetries as a function of the momentum fraction z in three bins of hadron transverse momentum relative to the virtual photon direction.

➔ Text for Collins asymmtries ready ➔ Figure 2.2 will be added once completed.

➔ If ready in time, another short paragraph and a figure on A_{LL} will be added.

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TDR Plot 2: A_{UT} for polarised TMD PDFs

plot based on ECCE by: Ralf Seidl

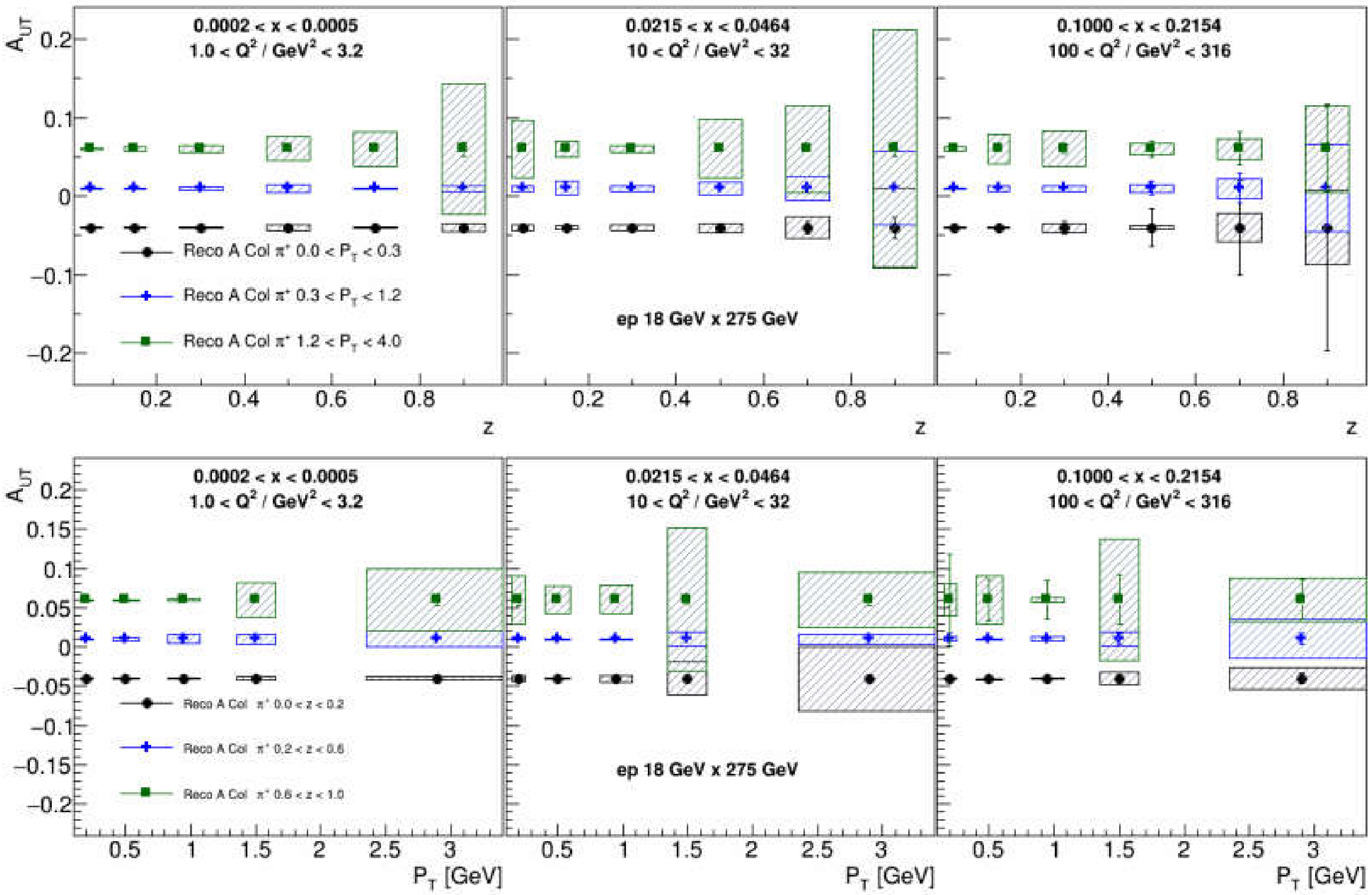

Figure 9: Projected π^+ Collins asymmetry statistical and systematic uncertainties as a function of either z (top panel) in bins of P_T or as a function of P_T in bins of z (bottom panel) for three select x and Q^2 bins. The asymmetries are shown at arbitrary values for better visibility. The statistical uncertainties are extrapolated to an accumulated luminosity of 10 fb^{-1} for the 18 GeV x 275 GeV energy option. For better visibility either 4 bins in P_T and 2 bins in z were combined or vice versa.

➔ An updated version is in progress

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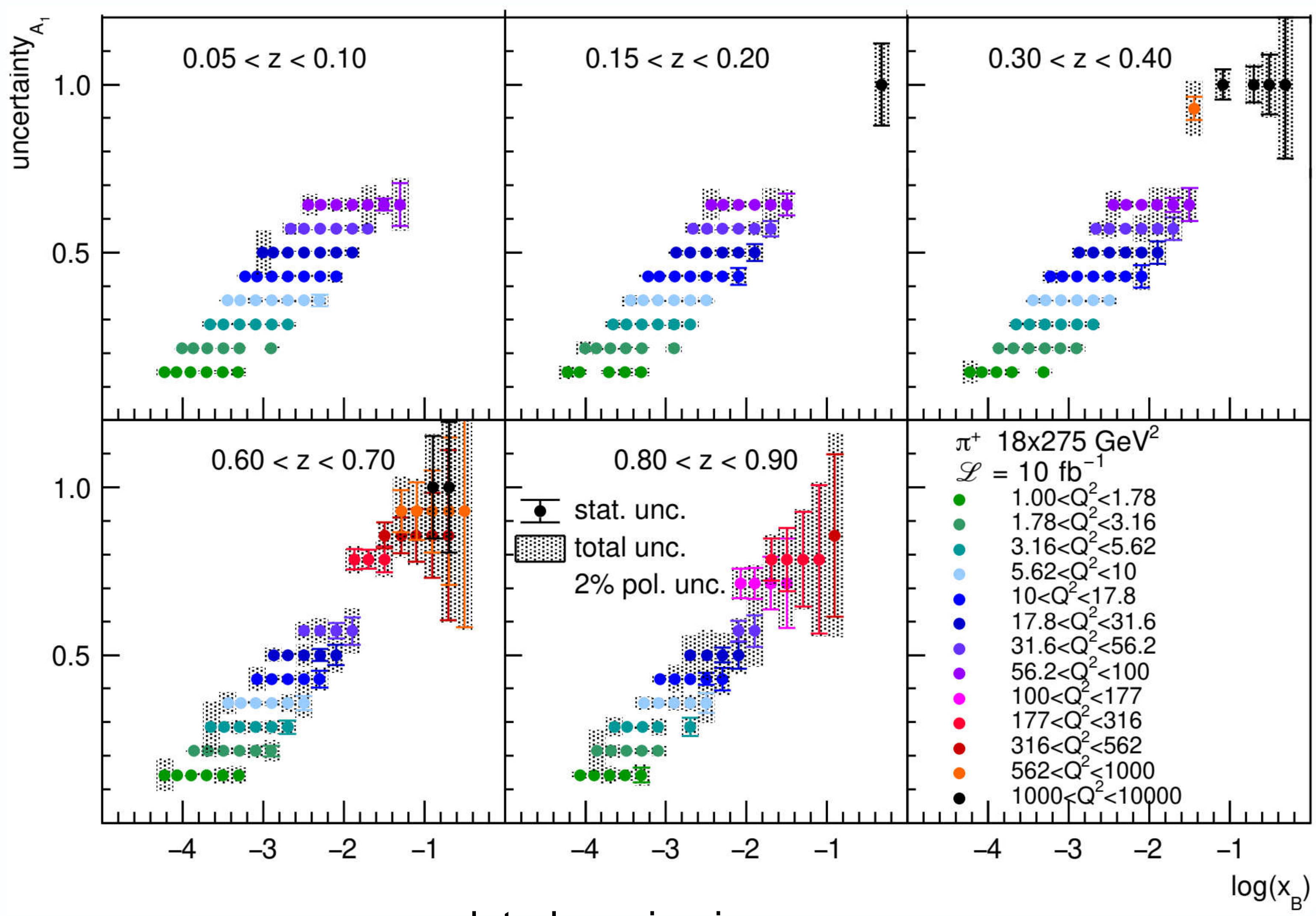
TDR plot 3: Statistical and total uncertainty of A_{LL} of π^+ for helicity PDFs

plot by: Charlotte van Hulse



updated version in progress …