Hadron-In-Jet Collins Asymmetry

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Introduction

- Collins effect connects the initial state quark spin (transversity) to the final state pion distribution within the jet (Collins FF)

- Hadrons within jets are asymmetrically distributed

  - Looking at the difference between spin states will allow access to transversity distribution and Collins FF via asymmetry measurements

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Transversity =
(Collinear)

Collins FF =
(TMD)

π^+ π^-

p_{proton}

Phys. Rev. D 93, 014009 (2016)
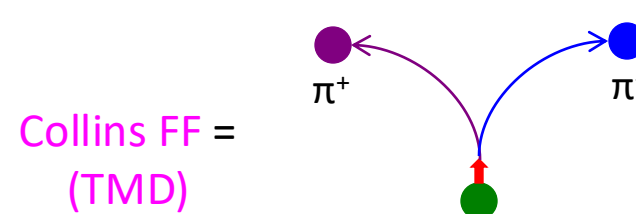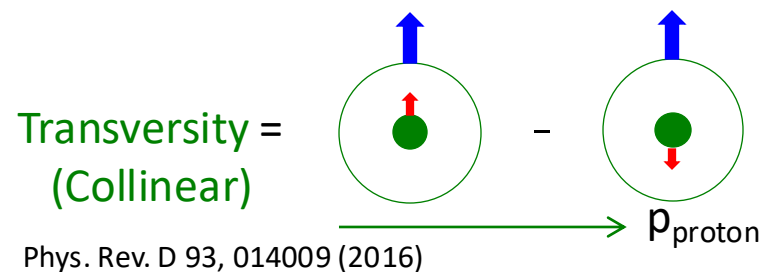
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Transversity x Collins

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Transversity x Collins

- Simulation is without polarization
  - Randomly assigned a spin state for use in calculating the angles that appear in the sinusoidal modulation
    - φ_S is related to the jet scatter direction
    - φ_H is the azimuthal angle of a hadron in the jet
    - $\varphi_C = \varphi_S - \varphi_H$ is the "Collins angle"

Introduction

- Isolate the asymmetry by exploiting the full 2π azimuthal coverage with the "cross ratio method"

$$\epsilon = P \times A_{UT}^{\sin(\phi_S - \phi_H)} = \frac{\sqrt{N_U^+ N_D^-} - \sqrt{N_U^- N_D^+}}{\sqrt{N_U^+ N_D^-} + \sqrt{N_U^- N_D^+}}$$

- N is the number of hadrons that scatter into the upper (U) and lower (D) halves of the detector resulting from protons with spin up (+) and down (-)
- Each N is binned in two dimensions: φ_C and $\{z, j_T, \text{jet } p_T\}$
  - A new binning procedure will be discussed at the end of the talk

Target Plot

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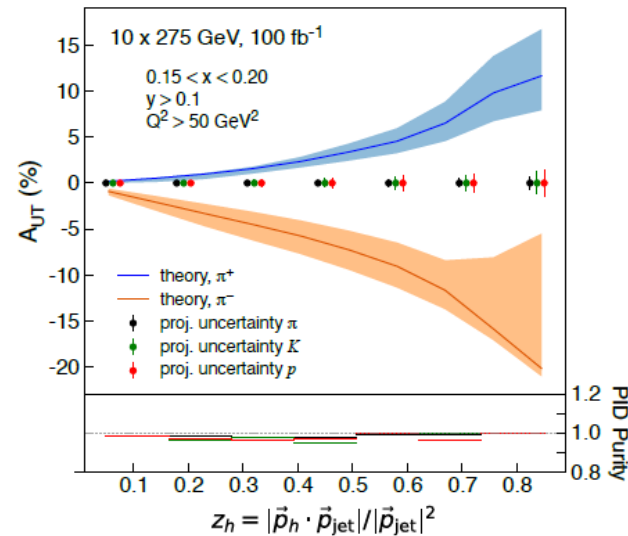

Figure 35: Projection for hadron-in-jet Collins asymmetry measurement for charged pions, kaons and protons. This is representative of the class of jet substructure measurements (FastSim).

Based on plots which appear in Phys. Rev. D **102**, 074015

Analysis At a Glance

- Sample: 18x275 GeV, campaign: 24.10.0, NCDIS
- 1M events for minimum Q^2 = 1, 10, 100 and 1000 GeV^2
- Basic cuts:
  - Jet E > 5 GeV
  - 5 < Jet p_T < 51.9 GeV/c
  - $|\eta|$ < 2.5
  - 0.05 < j_T < 4.5 GeV/c
  - 0.1 < z < 0.8
  - Jets containing the original electron are rejected
  - q_T imbalance cut (next slide)

q$_T$ Imbalance Cut

- q$_T$ is the imbalance of the transverse momentum of the reconstructed electron and the jet

$$q_T = |\vec{p}_T^{\,\mathrm{e}} + \vec{p}_T^{\,\mathrm{jet}}|$$

q$_T$ Imbalance Cut

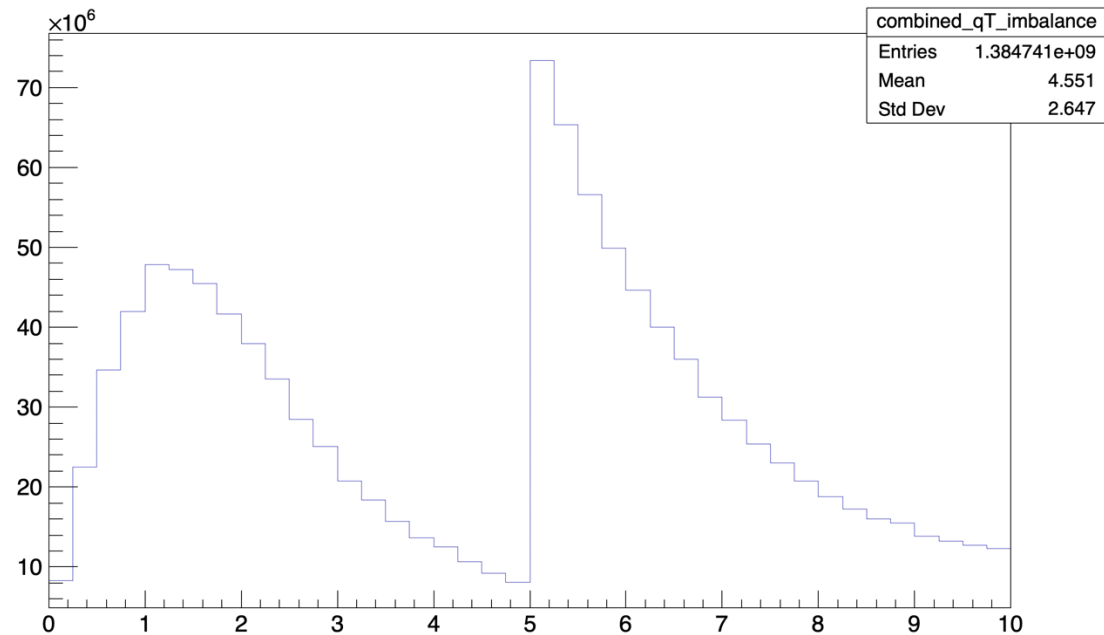- q$_T$ is the imbalance of the transverse momentum of the reconstructed electron and the jet

$$q_T = |\vec{p}_T^{\,e} + \vec{p}_T^{\,jet}|$$

- TMD framework is applicable when the imbalance is small, imposed by the cut:

$$q_T / p_T^{jet} < 0.3$$

q$_T$ Imbalance

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q$_T$ Imbalance

- Original analysis showed large bump at 5 GeV in this distribution
  - Different from the distribution shown in Phys. Rev. D **102**, 074015
- Bump at 5 GeV is now gone due to updated reco electron finder.
- Only difference between left and right is the expanded x-axis range
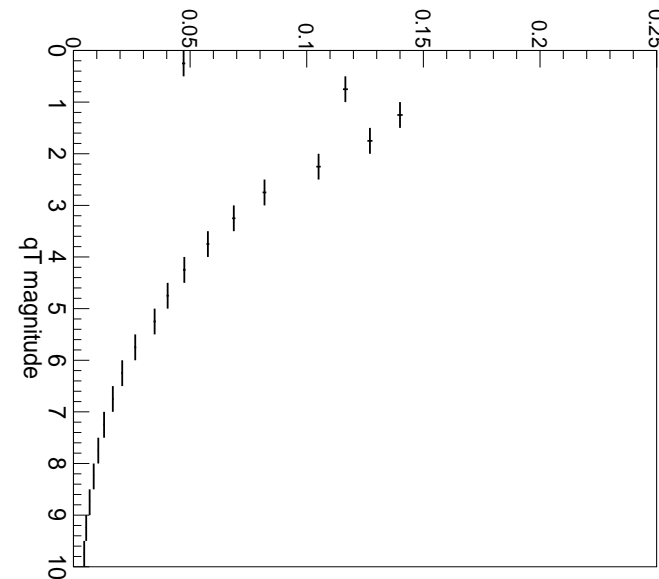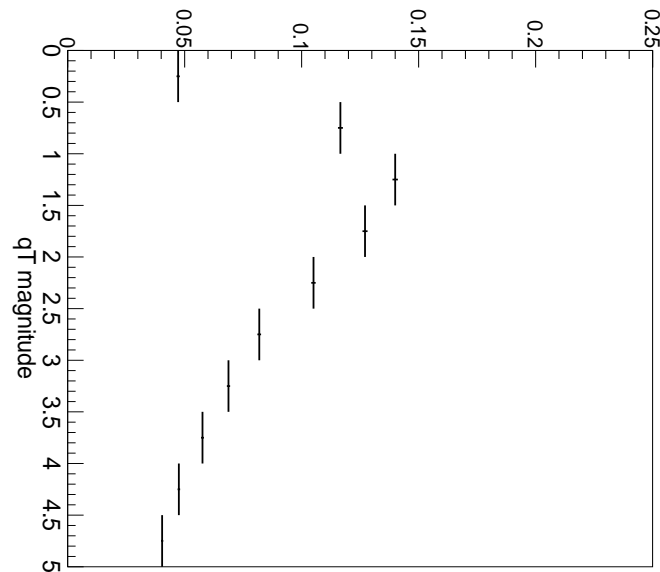
Weighting & Statistical Projection

- Analyzed 1e6 events from minimum Q^2 of 10, 100 and 1000 GeV^2

- Added the output results together according to the respective cross sections.

- Projected the statistics to 100 fb^{-1} as in the previous iteration of the plot.

- Asymmetries are generated assuming 60% polarization.

Current "Money" Plot

Black: Pions
Green: Kaons
Red: Protons

Positive charge only
100 fb^{-1}
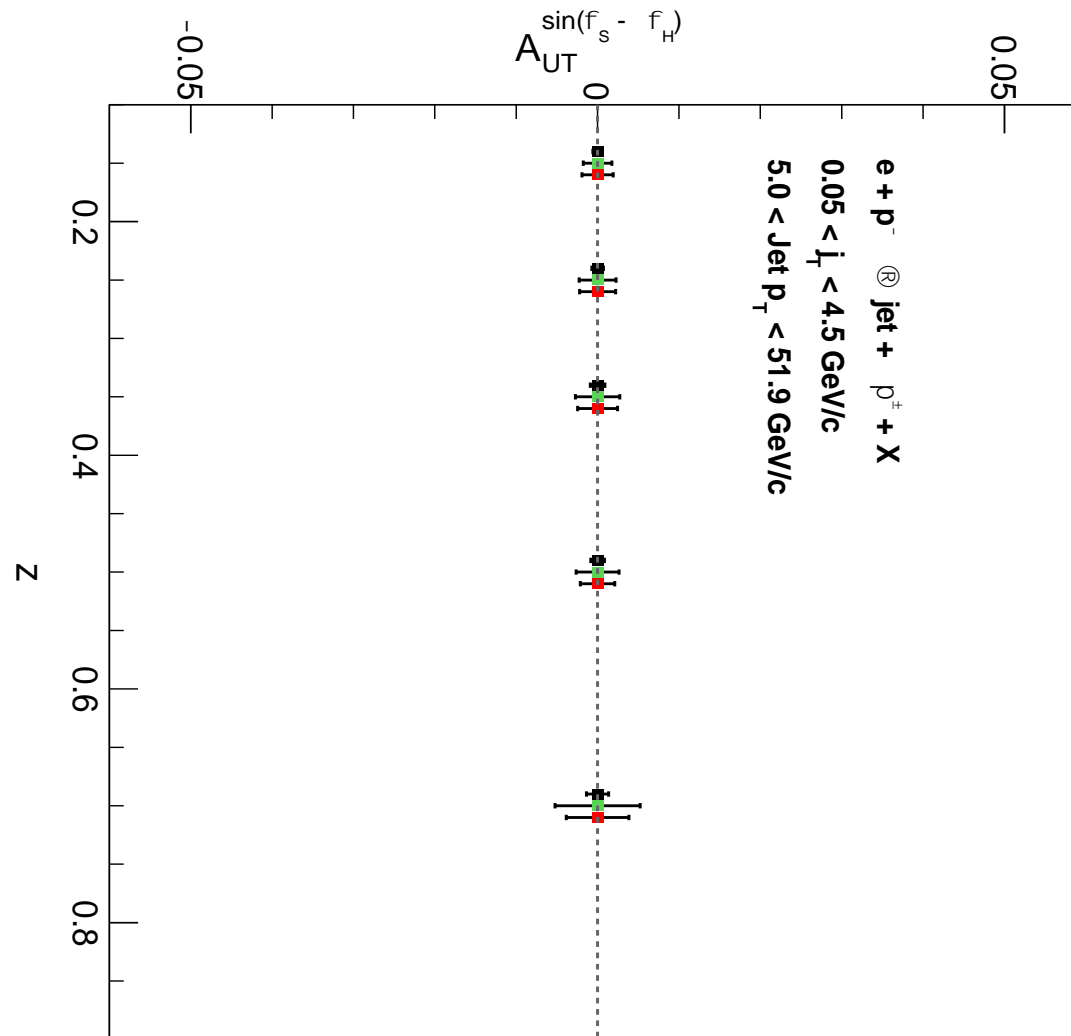
$A_{UT}^{sin(f_S - f_H)}$

$e + p^- \circledR jet + p^\pm + X$
$0.05 < j_T < 4.5$ GeV/c
$5.0 < $ Jet $p_T < 51.9$ GeV/c

z

Moving Forward: New Binning

- Currently the asymmetry projections are presented in bins of z, j_T, and jet p_T
  - p_T is proportional to Q, appearing in the PDF
  - z and j_T appear in the fragmentation function

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- This binning was the best that could be done with p+p experiments
  - DIS gives more information, so the analysis should reflect that
- The next updates to this analysis include
  - Binning the asymmetry in terms of the DIS kinematic variables x and Q^2
  - Plotting the asymmetry projection as a function of z, but in bins of x and Q^2 rather than j_T and p_T
  - To begin I will use bins similar to those from the previous target plot

Conclusion

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- Current statistical projections are in good agreement with the previous projection, but there are some issues with comparing apples to apples in the current state based on binning considerations

- This analysis is in a good state, but needs some work
  - Upcoming changes to binning will better align with the work from the SIDIS group