Hadron-In-Jet Collins for TDR

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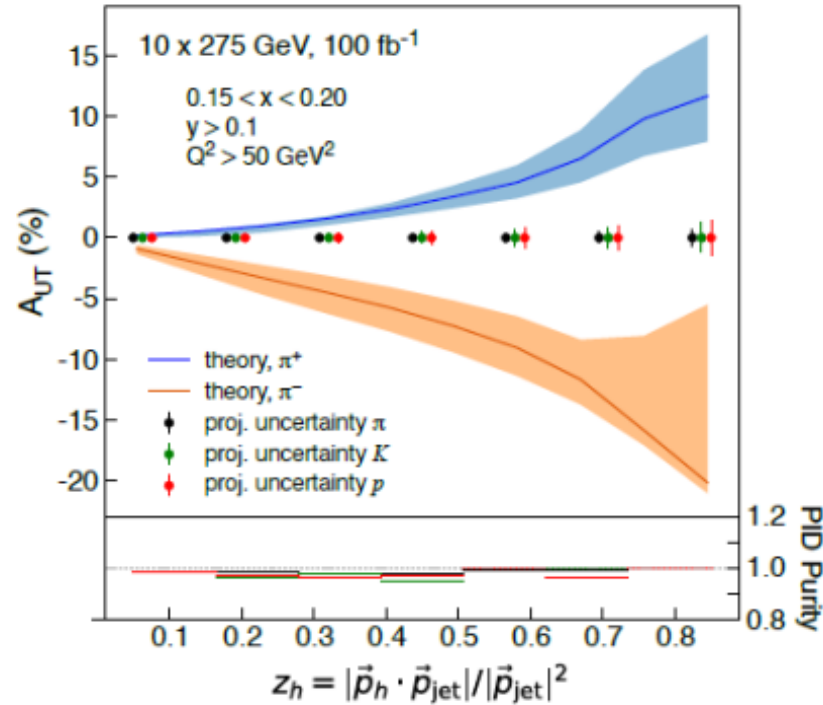ePIC Jet & HF Working Group Meeting

May 29, 2024

Target Plot:

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).

Introduction

- Collins effect connects initial proton spin to final state azimuthal distribution of hadrons in a jet (pions, kaons, protons)

- 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
    - $\phi_C = \phi_S - \phi_H$ is the "Collins angle"

$$d\sigma \approx F_{UU} \left\{ 1 + A_{UT}^{\sin(\phi_S - \phi_H)} \sin(\phi_S - \phi_H) \right\}$$

Introduction Cont.

- 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 $\{z, j_T, \text{jet } p_T\}$

Analysis Basics

- Sample: 18x275 GeV, campaign: 23.12.0, NCDIS

- 1M events for minimum Q^2 = 100 GeV^2 and Q^2 = 1000 GeV^2

- Basic cuts:
  - Jet E > 5 GeV
  - 5 < Jet p_T < 51.9 GeV/c (binning may need to be adjusted for final plot, started with previous STAR binning)
  - $|\eta|$ < 2.5
  - 0.05 < j_T < 4.5 GeV/c
  - 0.1 < z < 0.8
  - Jets containing the original electron are rejected
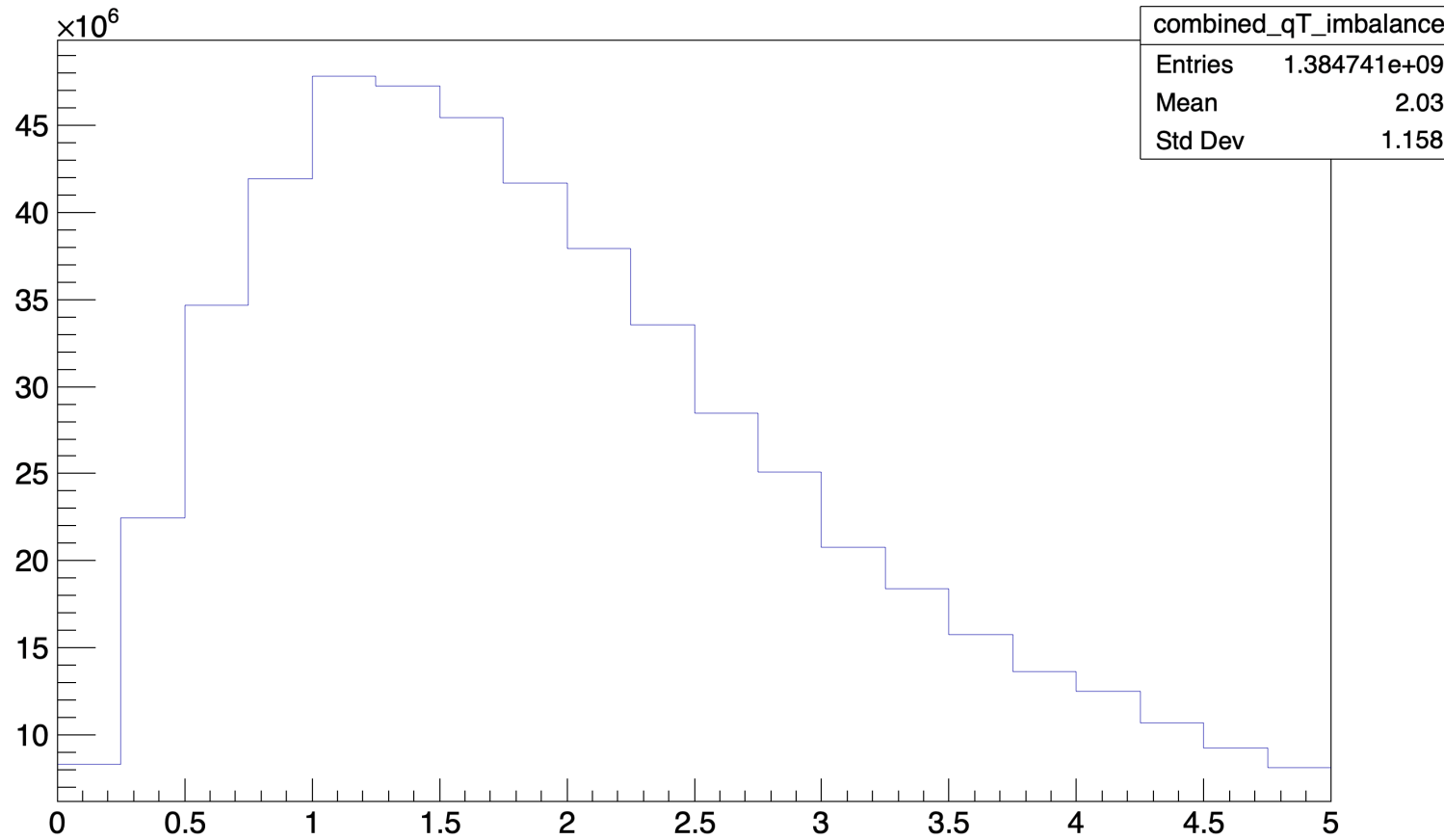
q$_T$ Imbalance Cut

- As suggested by Miguel, a q$_T$ imbalance cut was added, where
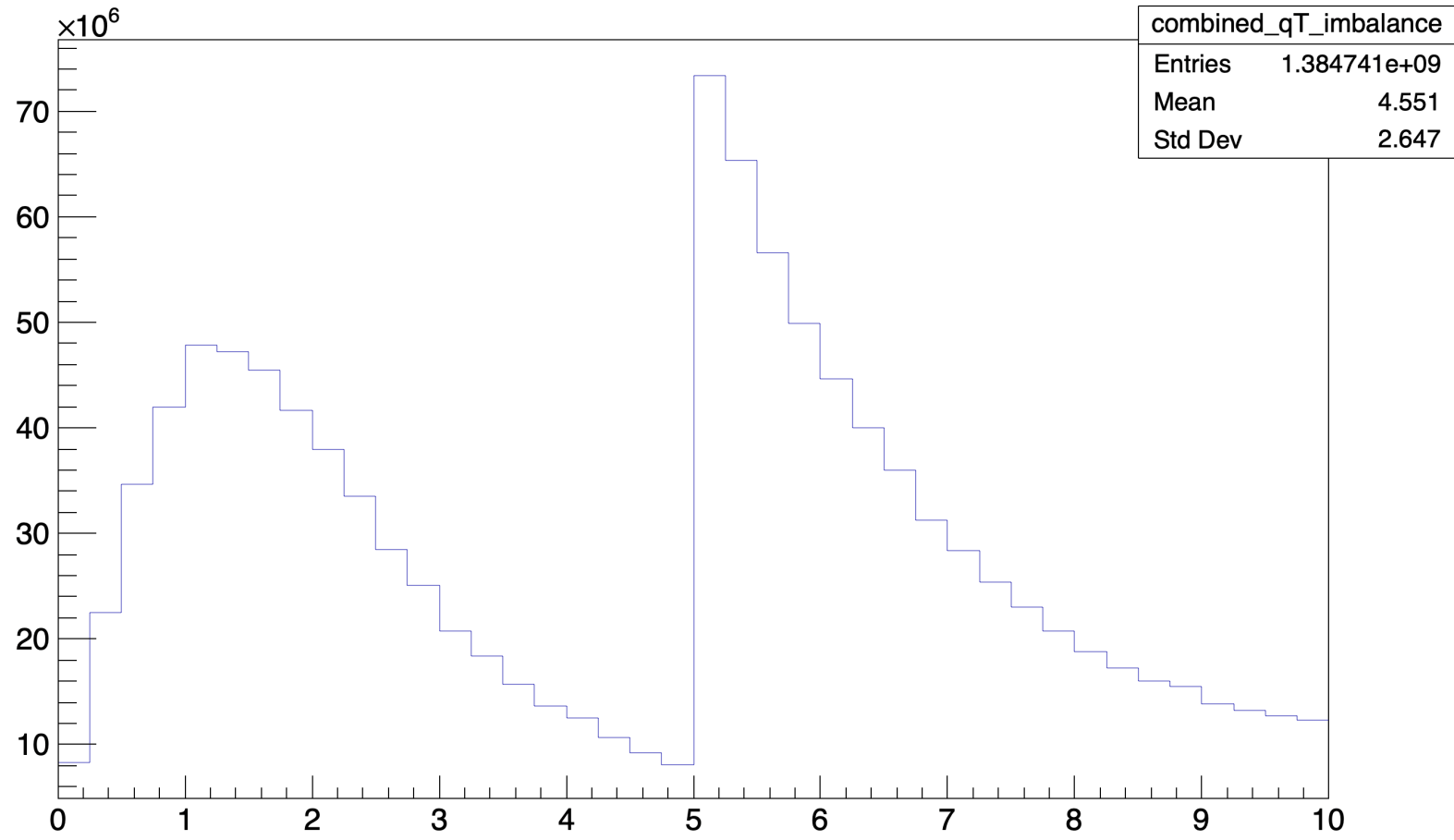
$$q_T = |\vec{p}_T^{\,e} + \vec{p}_T^{\,\text{jet}}|$$

- The cut is:

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

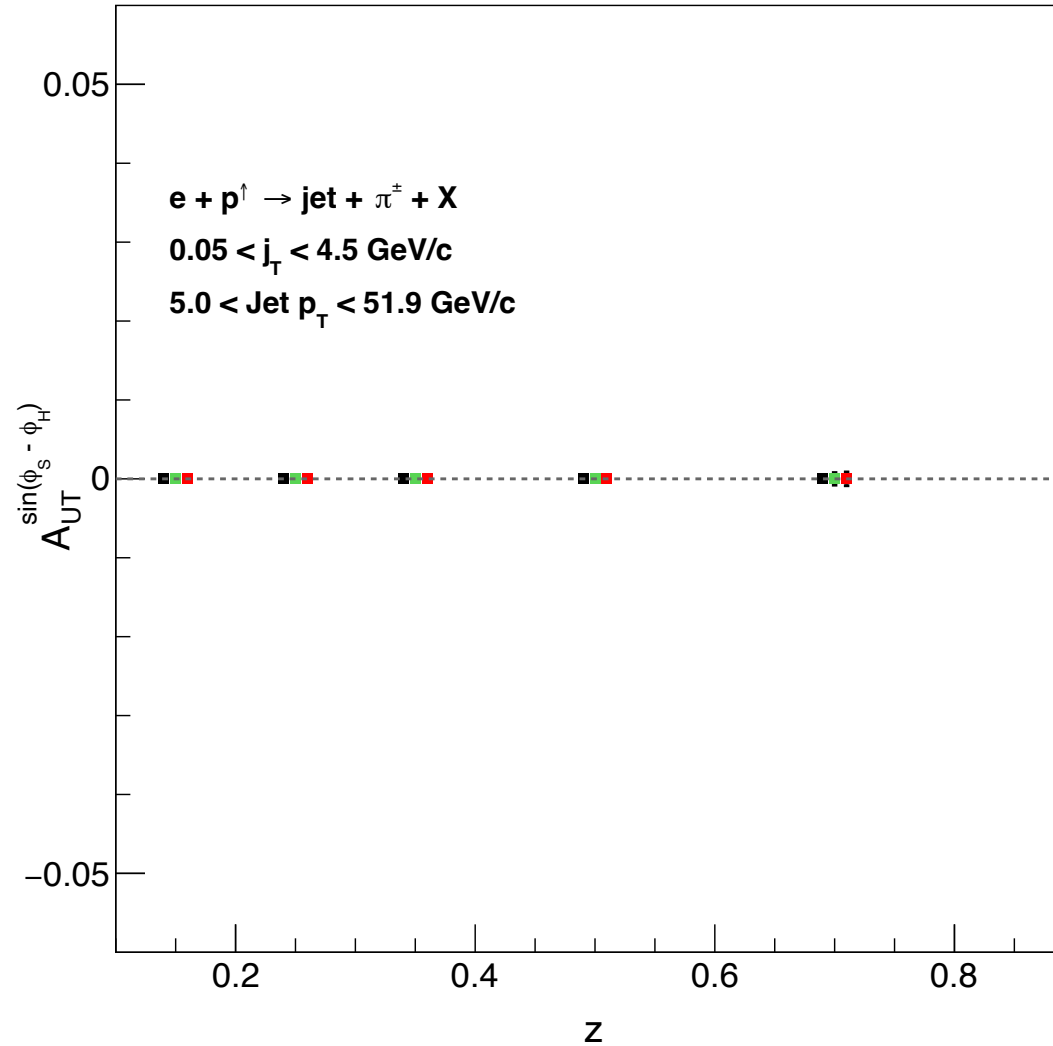# q$_T$ Imbalance

q$_T$ Imbalance Cut

Weighting & Statistical Projection

- Analyed 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.

Current Plots (May 29, 2024)
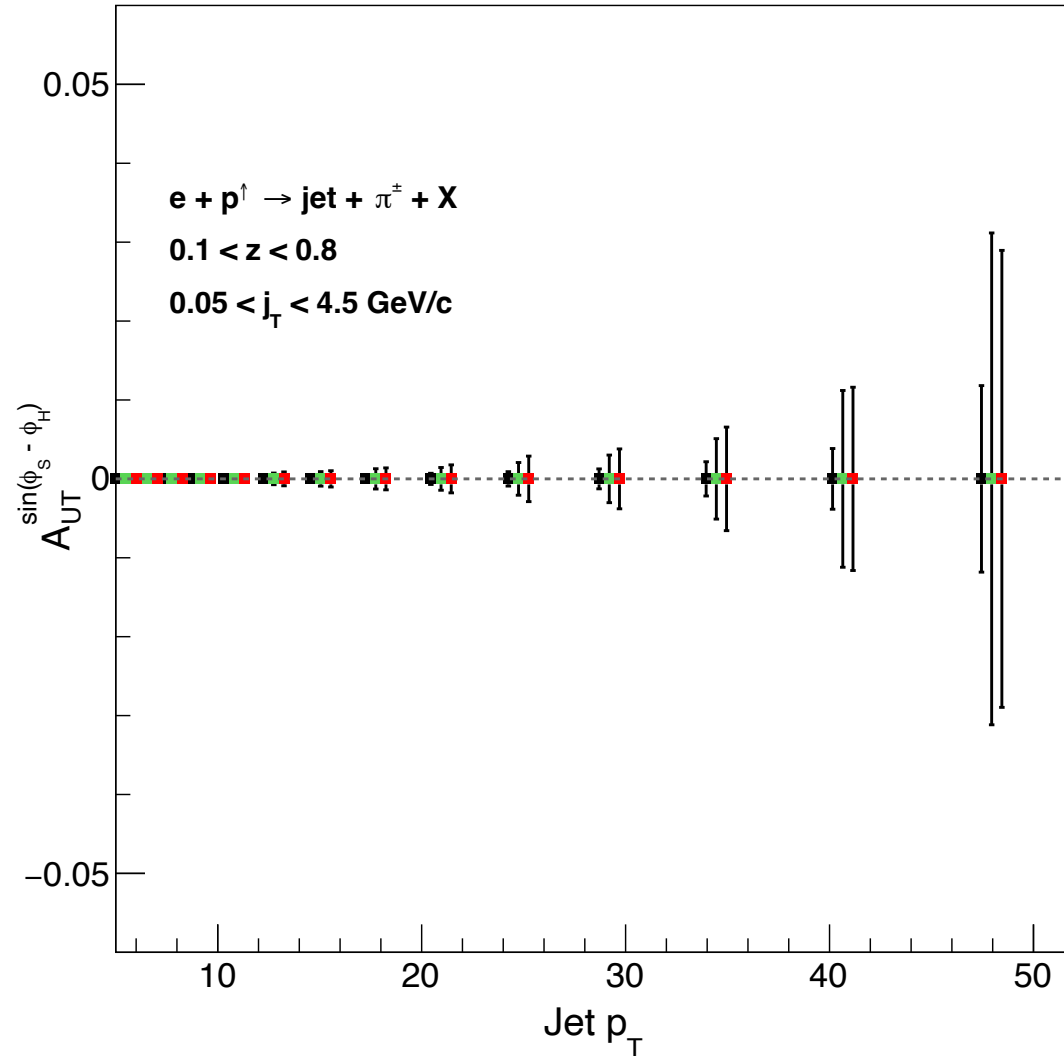
Black: Pions
Green: Kaons
Red: Protons

Positive charge only
100 fb^{-1}

$e + p^{\uparrow} \rightarrow jet + \pi^{\pm} + X$

$0.05 < j_T < 4.5$ GeV/c

$5.0 < Jet\ p_T < 51.9$ GeV/c

Axis labels: $A_{UT}^{\sin(\phi_S - \phi_H)}$ vs z

Current Plots (May 29, 2024)

Black: Pions
Green: Kaons
Red: Protons

Positive charge only
100 fb^{-1}

$e + p^{\uparrow} \rightarrow jet + \pi^{\pm} + X$

$0.1 < z < 0.8$

$0.05 < j_T < 4.5$ GeV/c

y-axis: $A_{UT}^{\sin(\phi_S - \phi_H)}$

x-axis: Jet p_T

Current Plots (May 29, 2024)

Black: Pions
Green: Kaons
Red: Protons

Positive charge only
100 fb^{-1}

$e + p^{\uparrow} \rightarrow$ jet $+ \pi^{\pm} + X$

$0.1 < z < 0.8$

$5.0 <$ Jet $p_T < 51.9$ GeV/c

To Do

1. Update binning on the z plot to match previous plot?
2. Add theory curves
3. Pretty up the plot
4. Anything else?