Topological reconstruction of D^0

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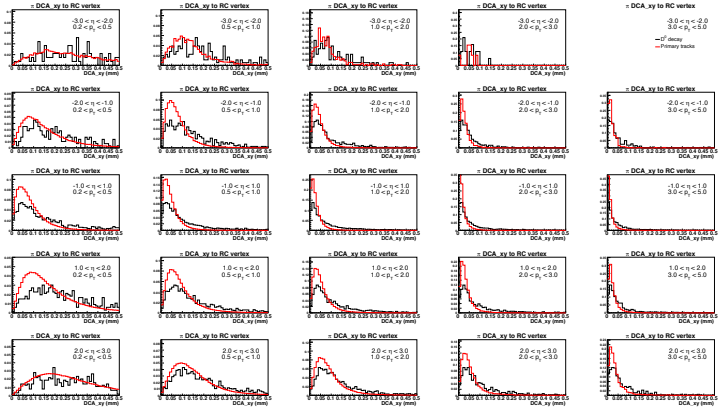
Reminder

- Presented single track DCA based on ACTS functionality last time
- Two-track DCA calculation was (is?) not available with ACTS



DCA_{xy} for pion: primary vs. secondary

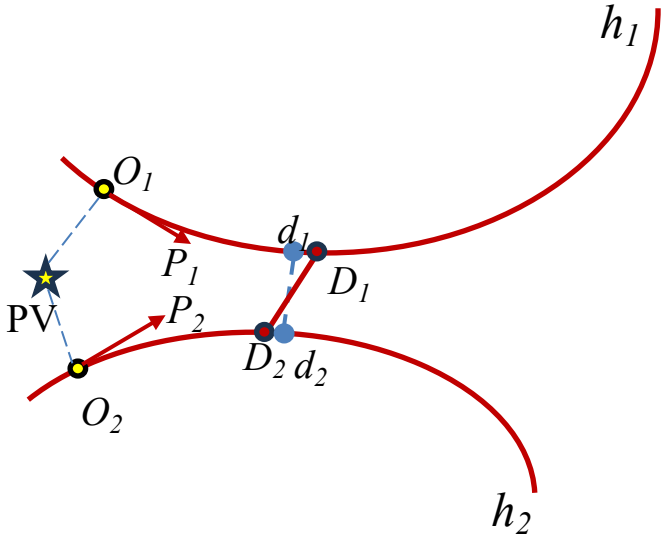
- This presentation: single-track and two-track DCA based on Helix method

Analysis setup

- PYTHIA 8.306 ep@18x275, NC, $Q^2_{min} = 100$
- With beam effects
- D^0-enriched sample: each event contains at least one D^0 or anti-D^0
- Select events with D^0 or anti-D^0 that decays into π + K
  - Branching ratio: (3.947±0.030)%

- EIC geometry: *epic-24.09.0*
- EICrecon: **default realistic seeding**

Helix method for DCA calculation



Courtesy: X. Dong

Track helix construction: (3D momentum, 3D position, B, q)

Pros:

1) Simple, fast, flexible with good precision
2) Many functions available and widely tested

Cons:

1) No error estimation / KF propagation
2) Do not account for detector material
3) Constant magnetic field (can be improved)

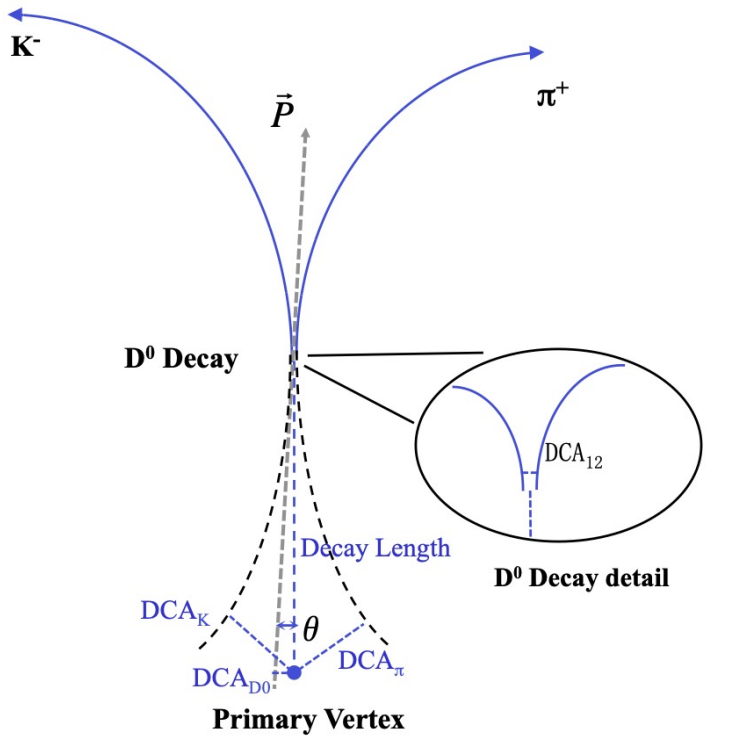
Two-helix DCA calculation:

Step 1: DCA positions in bending plane - analytical (d_1,d_2)

Step 2: Scan the vicinity around (d_1,d_2) iteratively to find the minimum distance (D_1-D_2)

- Decreasing step size in each iteration (coarse ~10 cm to fine ~ 1 mm in default)

Topological reconstruction



- Topological variables
  - DCA_{π}, DCA_{K}, DCA_{12}
  - DCA_{D0}, decay length, cos(θ)
- Calculated based on helix swimming in a constant magnetic field
  - Adopted from STAR code
  - B = -1.7 T

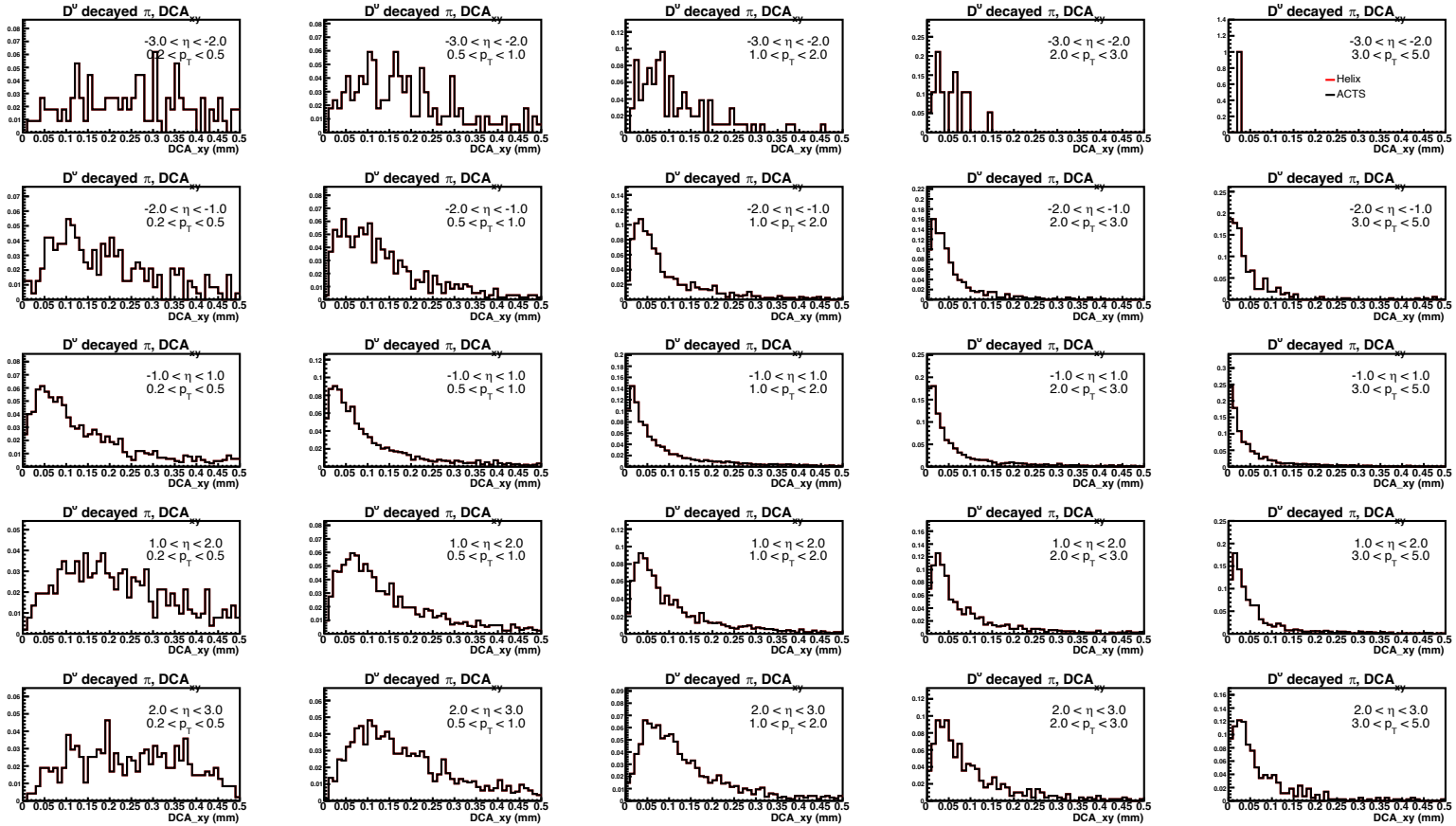
STAR, Phys. Rev. C 99, 034908 (2019)

Compare secondary track DCA: ACTS vs. helix

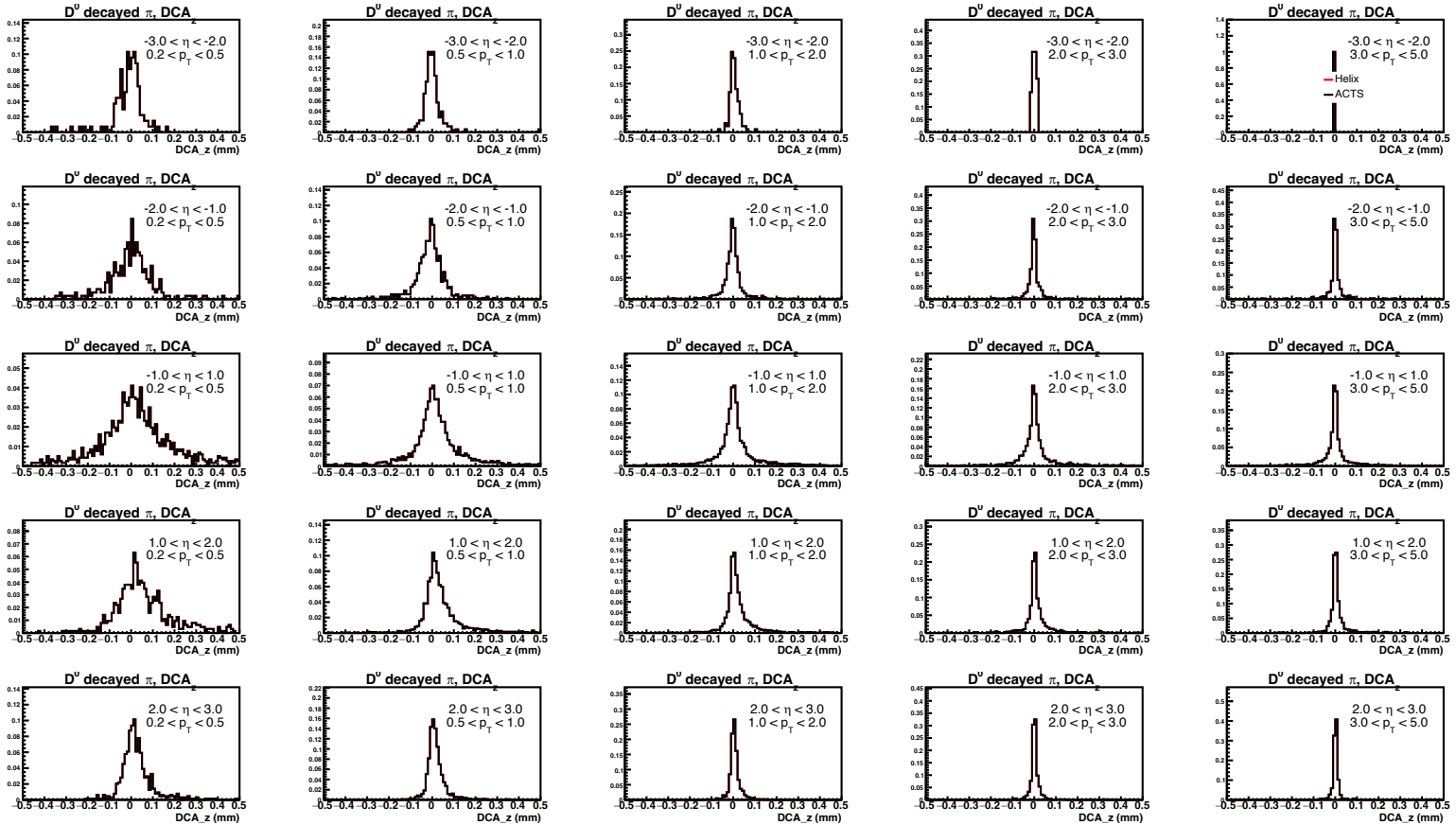
DCA_{xy} for secondary pion: ACTS vs. helix

p_T

η

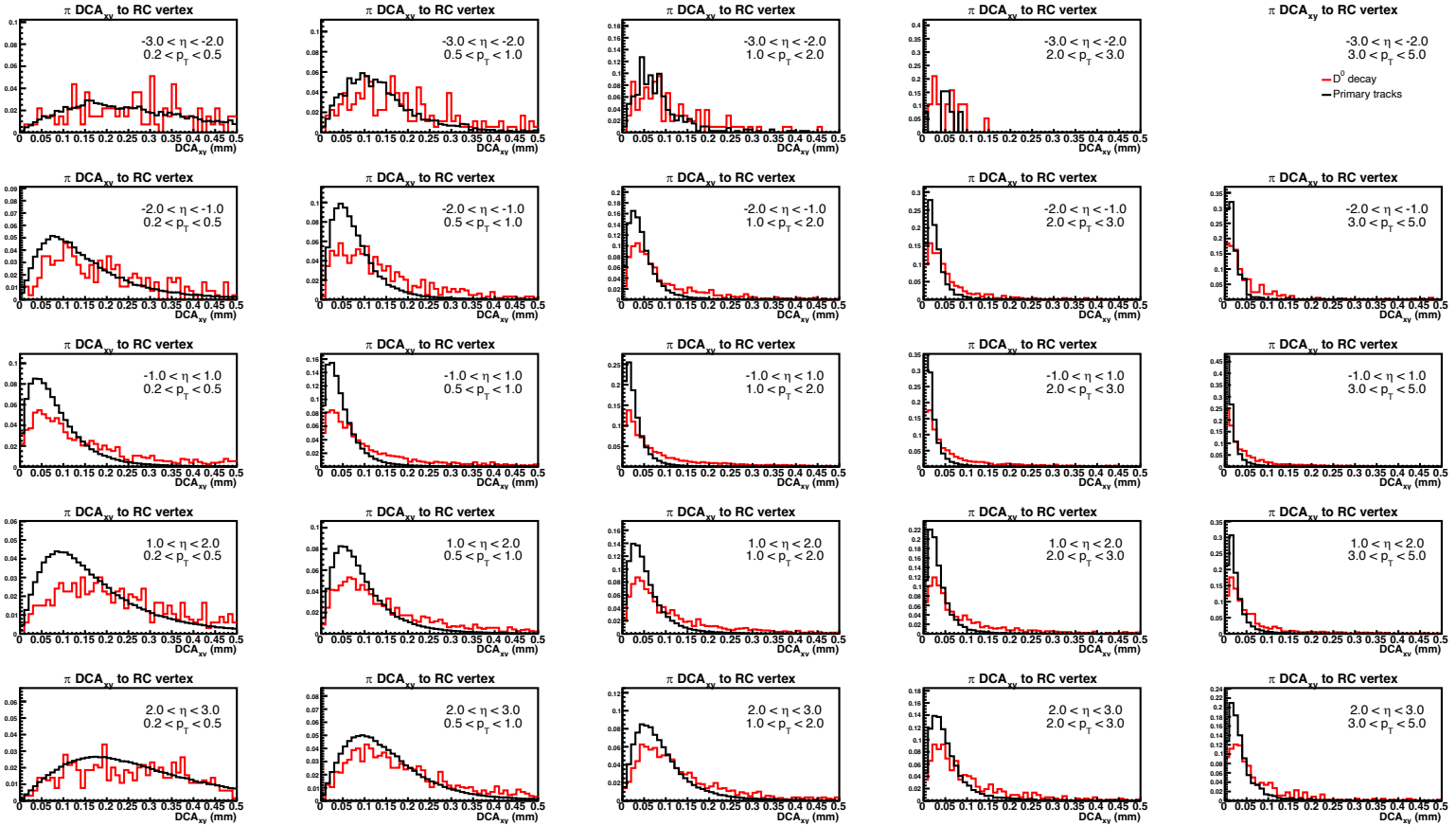


DCA_z for secondary pion: ACTS vs. helix

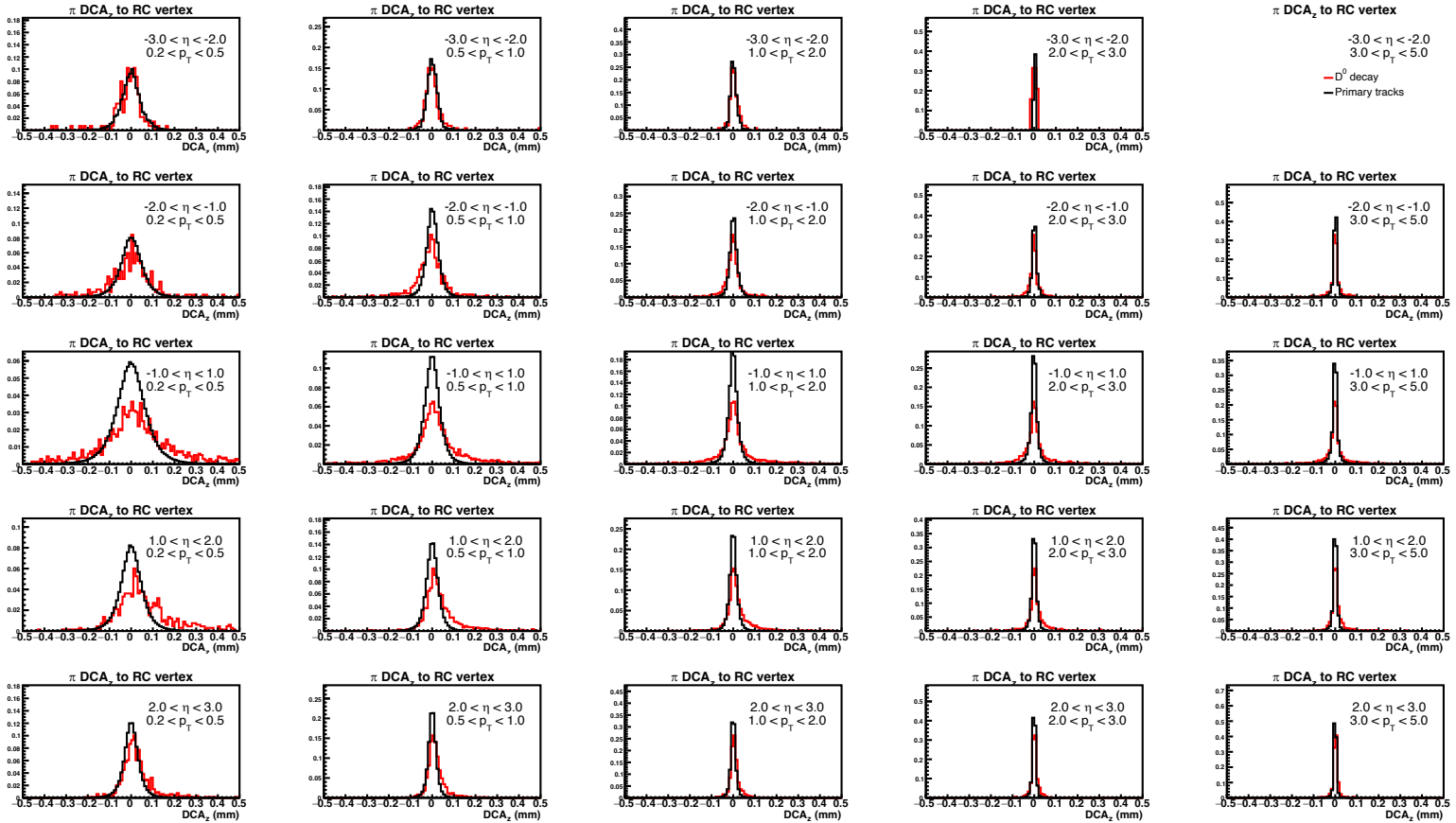


Compare topological variables

DCA_{xy} for pion: primary vs. secondary



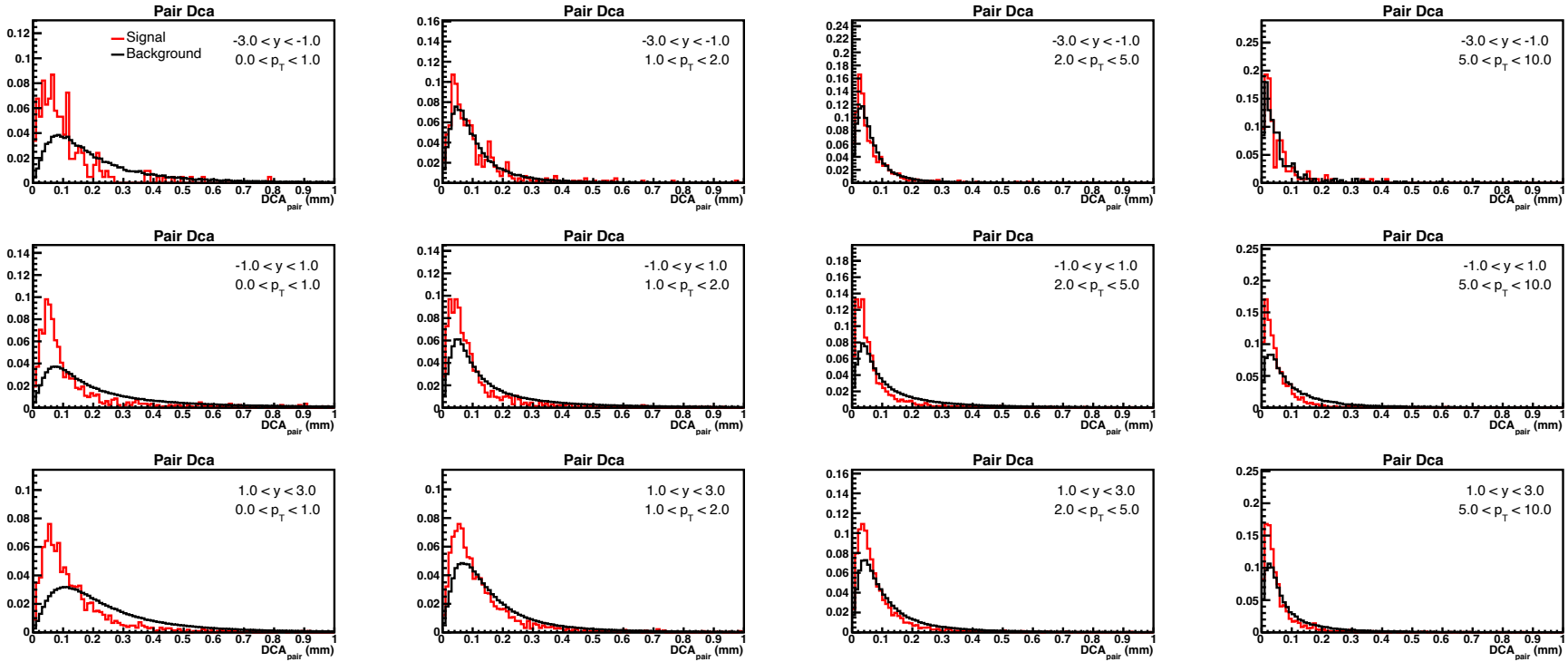
DCA_z for pion: primary vs. secondary



DCA_{D0} : signal vs. background

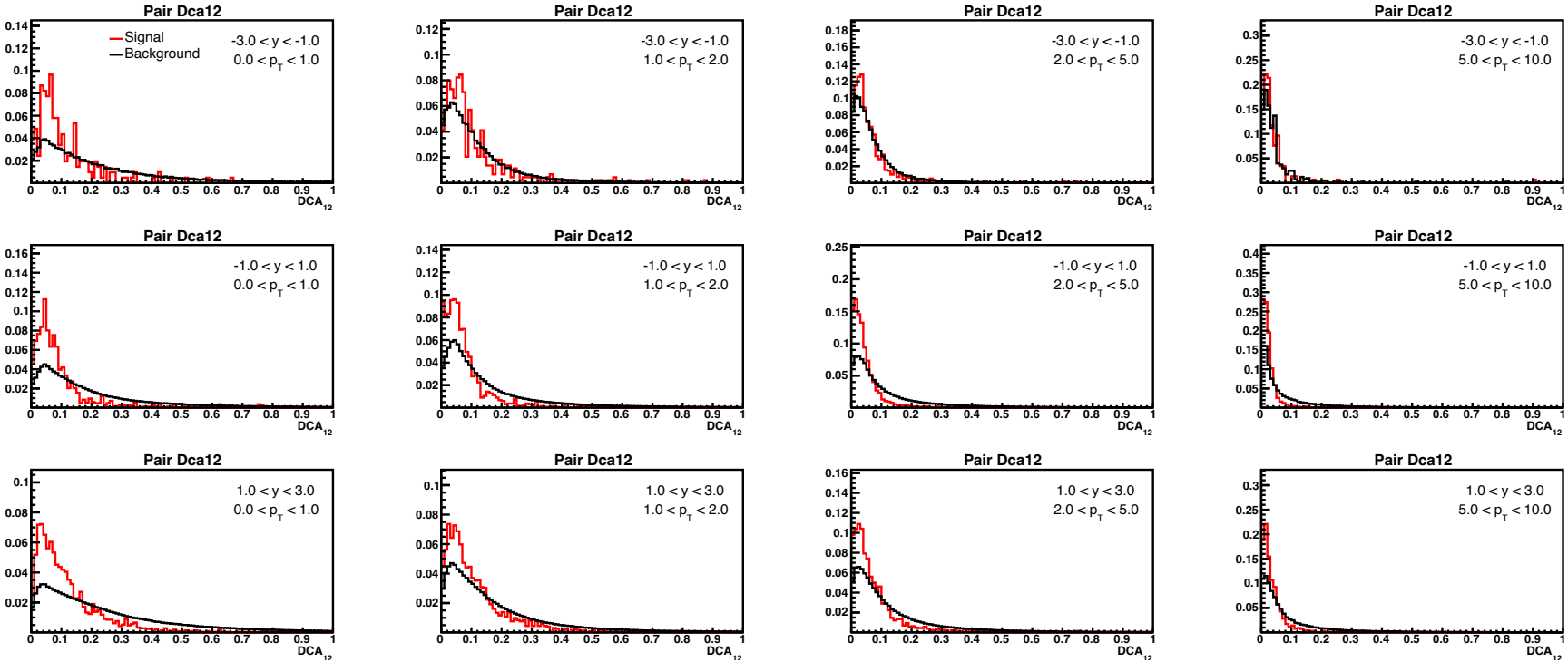
p_T

y



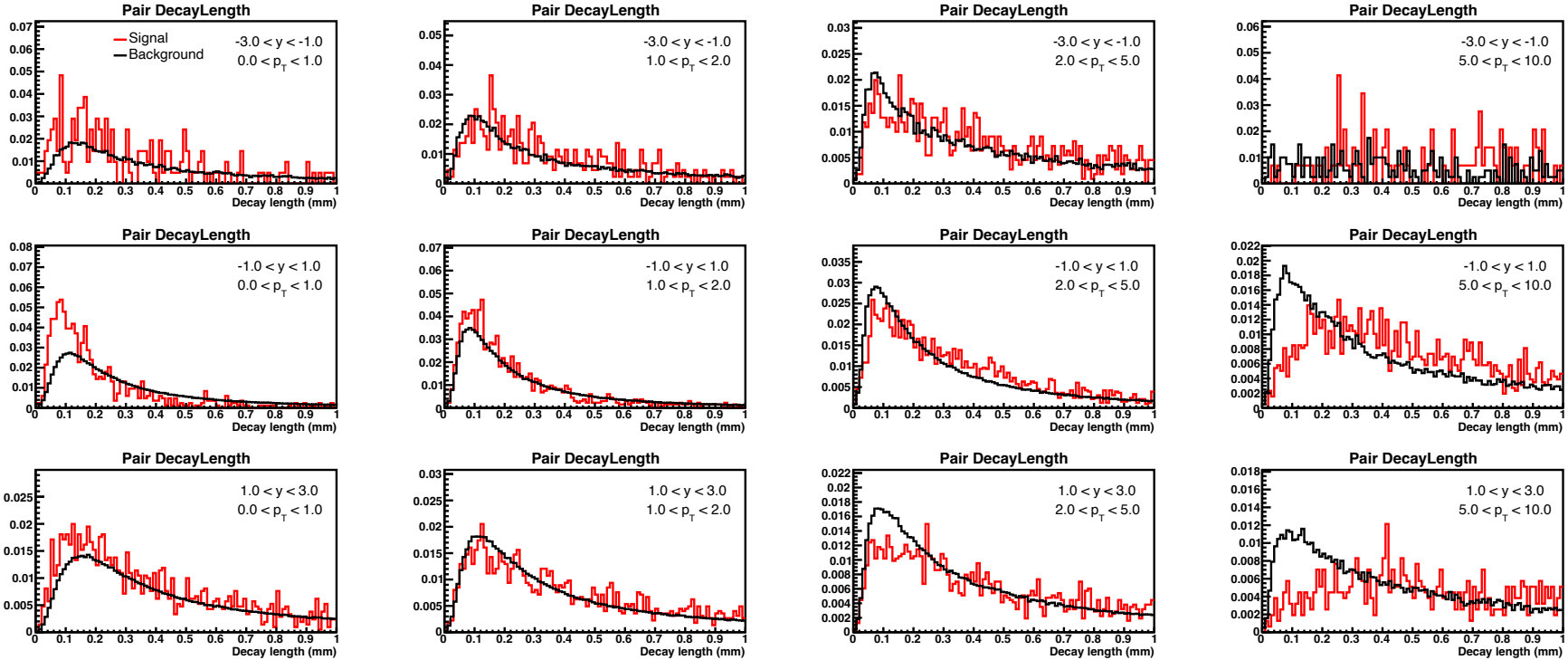
- DCA_{π}, $DCA_K > 20$ μm

DCA_{12}: signal vs. background



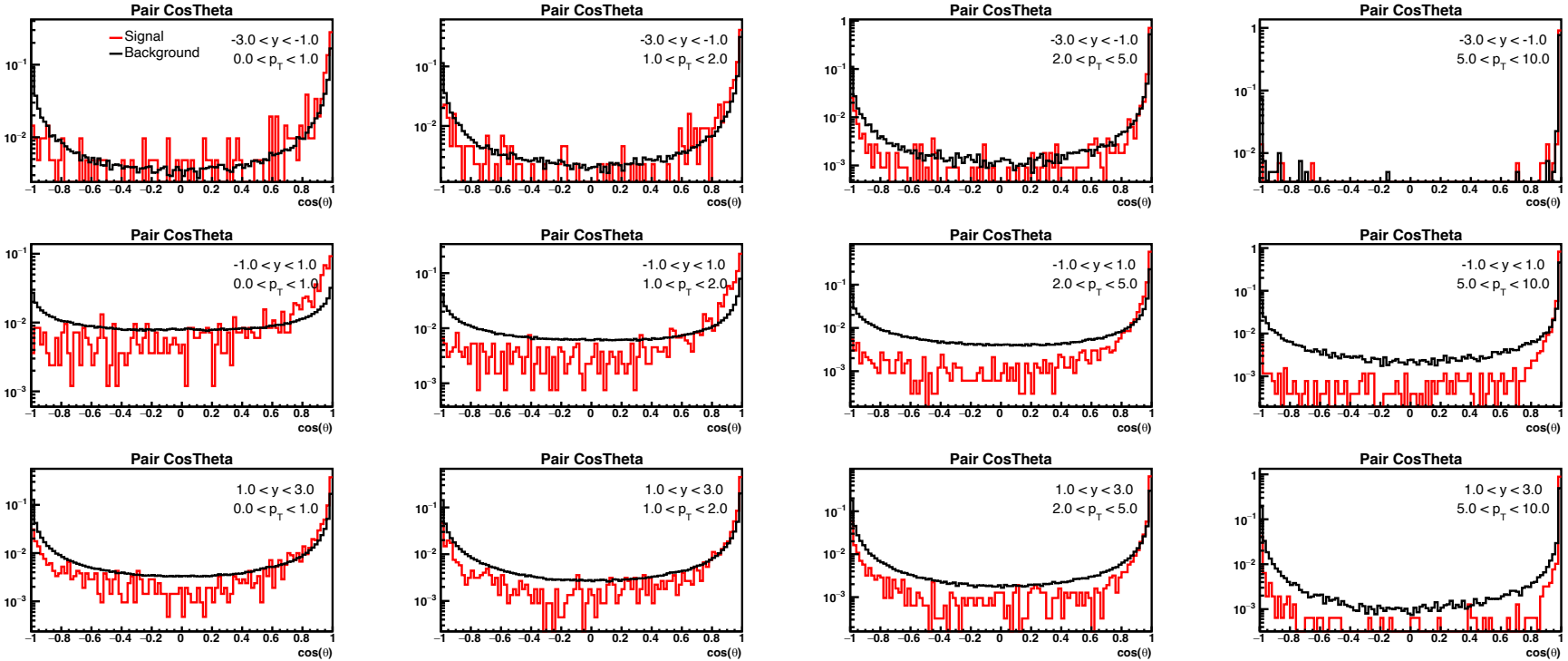
- DCA_{π}, $DCA_{K} > 20$ μm

Decay length: signal vs. background



- DCA_π, $DCA_K > 20$ μm

cosθ: signal vs. background



- DCA_π, $DCA_K > 20$ μm

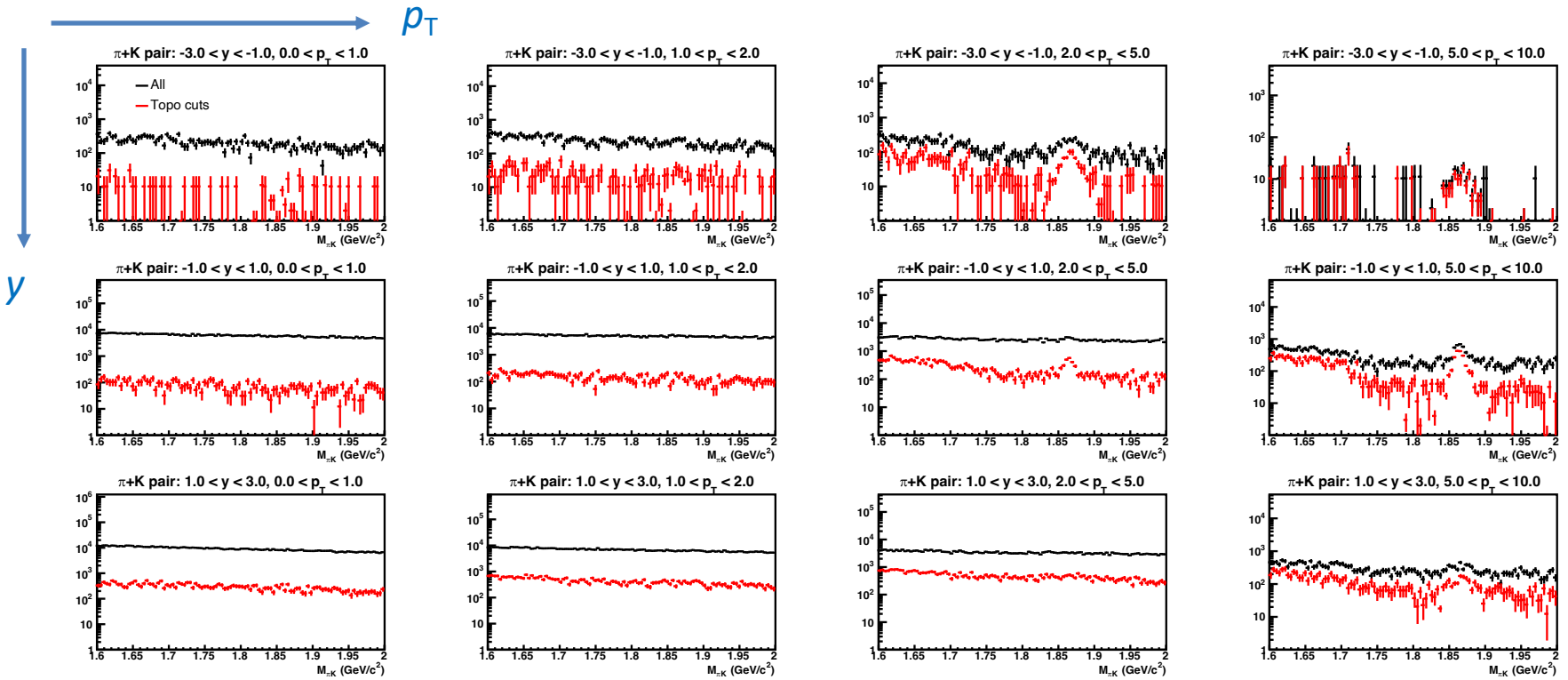
D^0 reconstruction

- Truth PID

- Topological cuts
  - $DCA_\pi > 20$ μm, $DCA_K > 20$ μm
  - $DCA_{12} < 70$ μm
  - $DCA_{D0} < 100$ μm
  - Decay length > 50 μm
  - $\cos\theta > 0.95$

- Take events with D^0 that do not decay to the π+K channel as background, and scale them (x10.4) to approximate true background in DIS events
  - DIS : D^0 events = 9:1
  - Potentially over-estimating the background

Invariant mass distribution



Info

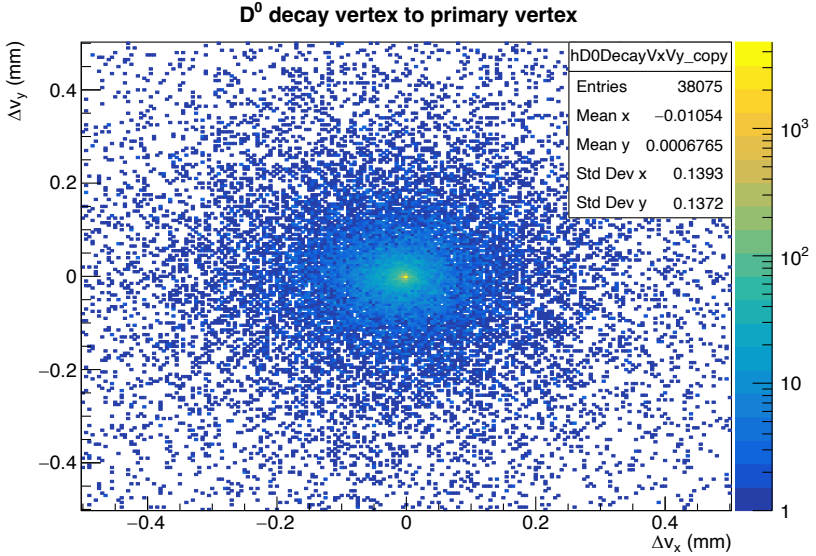
- Code: https://github.com/marrbnl/ePIC/tree/main/HF_reco/helix
- D0 sample: /gpfs/mnt/gpfs02/eic/rongrong/D0/Geo202409_Real_default

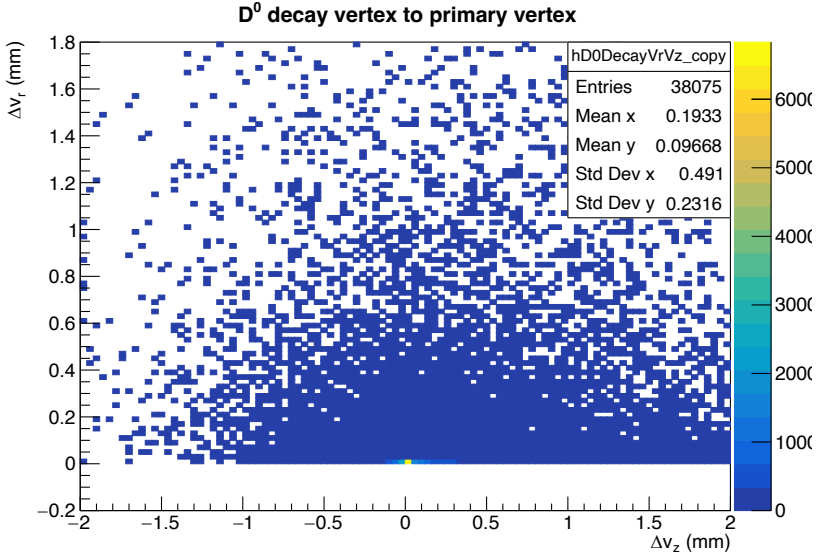
What's next?

- Use machine learning to optimize cuts on topological variables to improve signal-to-background ratio in different D^0 (p_T, y) bins
- Need a large D^0 sample for training

Backup

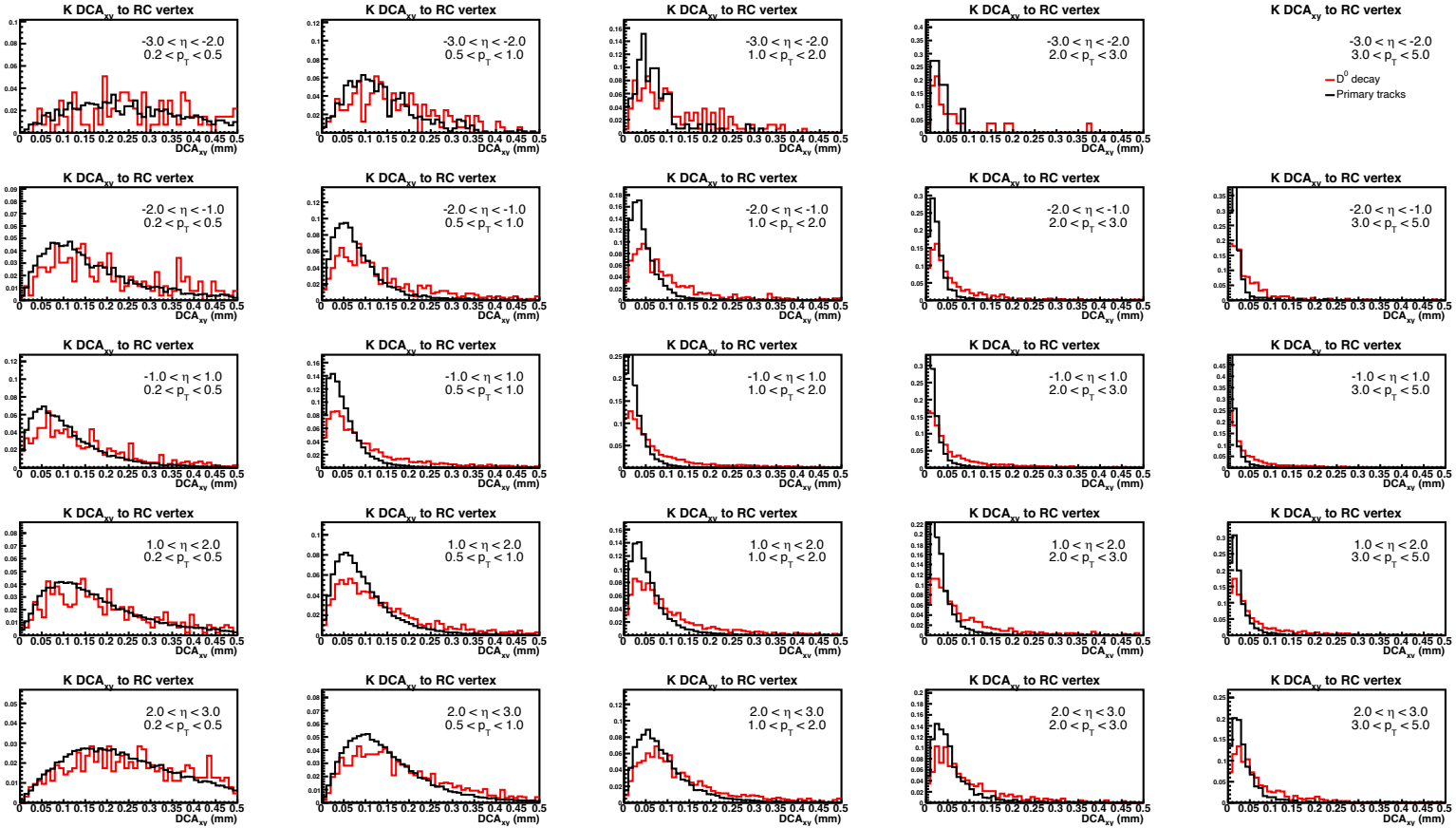
D^0 decay vertex w.r.t. primary vertex



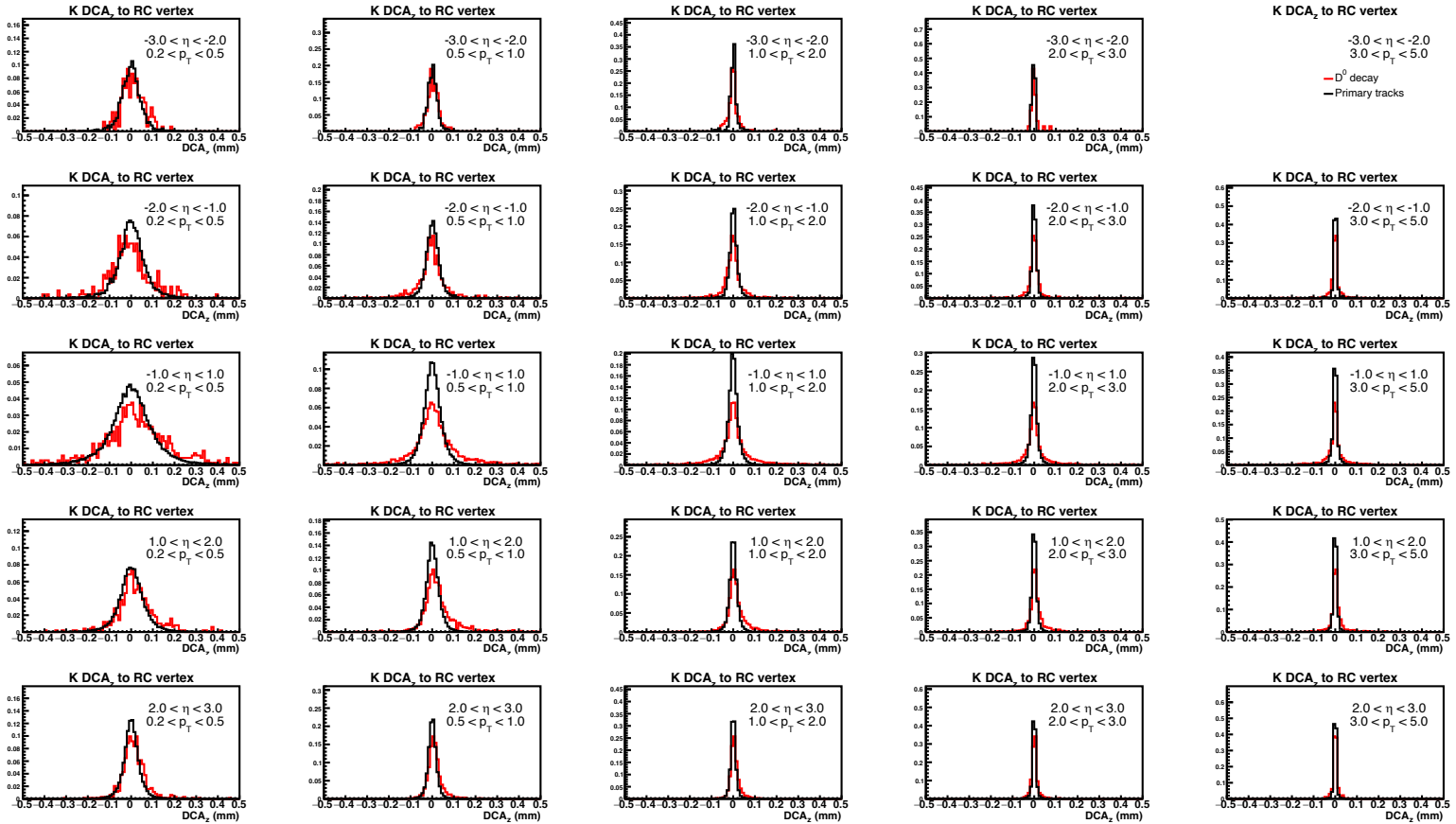


- MC information

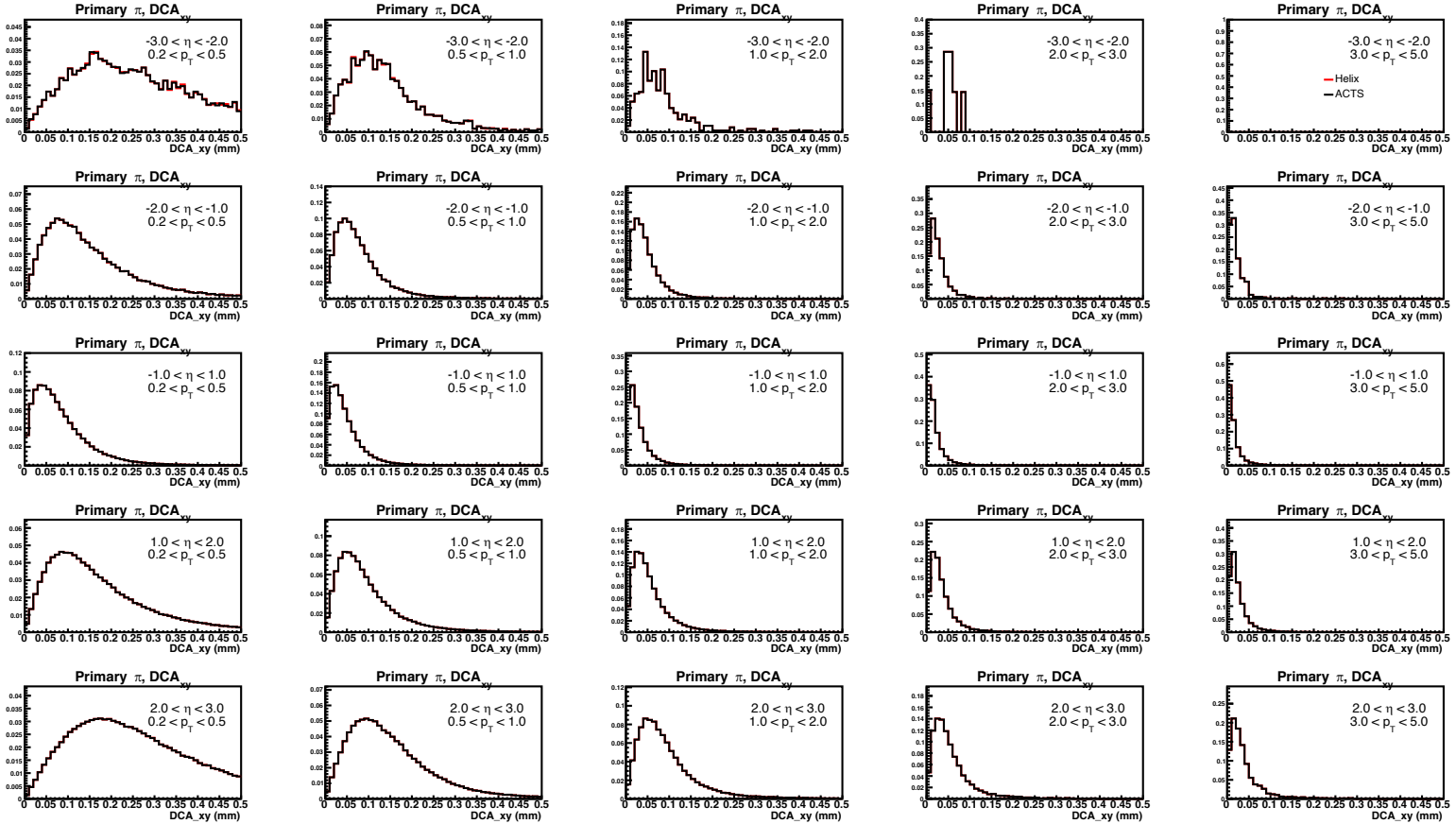
DCA_{xy} for Kaon: primary vs. secondary



DCA_z for Kaon: primary vs. secondary



DCA_{xy} for primary pion: ACTS vs. helix



DCA_z for primary pion: ACTS vs. helix