Study track pointing resolution with DIS events

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07/16/2025

Requirement

Yellow report

Table 8.5: Requested vertex position resolution.

Pseudorapidity Range	Resolution
$-3.5 < \eta < -3.0$	N/A
$-3.0 < \eta < -2.5$	$\sigma_{xy} \sim 30/p_T \oplus 40\ \mu$m
$-2.5 < \eta < -1.0$	$\sigma_{xy} \sim 30/p_T \oplus 20\ \mu$m
$-1.0 < \eta < 1.0$	$\sigma_{xy} \sim 20/p_T \oplus 5\ \mu$m
$1.0 < \eta < 2.5$	$\sigma_{xy} \sim 30/p_T \oplus 20\ \mu$m
$2.5 < \eta < 3.0$	$\sigma_{xy} \sim 30/p_T \oplus 40\ \mu$m
$3.0 < \eta < 3.5$	$\sigma_{xy} \sim 30/p_T \oplus 60\ \mu$m

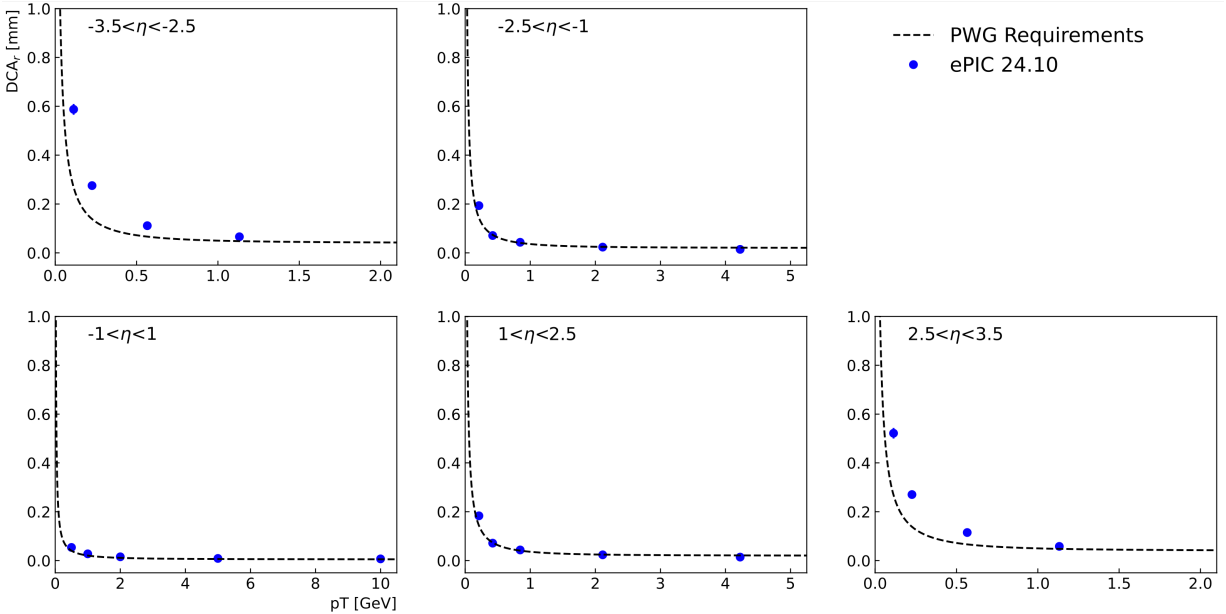
preTDR

η **range**	dp/p [%]	$\mathbf{DCA}_r$ [μm]
$(-3.5, -2.5)$	$0.10 \times p \oplus 2.0$	$30/p_T \oplus 40$
$(-2.5, -1.0)$	$0.05 \times p \oplus 1.0$	$30/p_T \oplus 20$
$(-1.0, 1.0)$	$0.05 \times p \oplus 0.5$	$20/p_T \oplus 5$
$(1.0, 2.5)$	$0.05 \times p \oplus 1.0$	$30/p_T \oplus 20$
$(2.5, 3.5)$	$0.10 \times p \oplus 2.0$	$30/p_T \oplus 40$

- No explicit requirement for σ_z

preTDR

- Single pions at the nominal collision vertex of (0,0,0)



Analysis setup

- Simulation sample
  - NC DIS events
  - ep @ 10x100
  - $Q^2 > 1$ $(GeV/c)^2$
  - Simulation campaign: 25.04.1

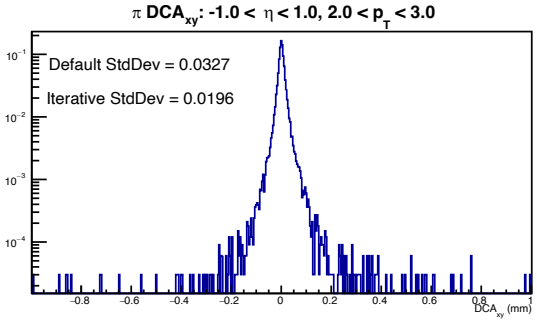
- Track selection
  - Primary tracks
  - Truth PID

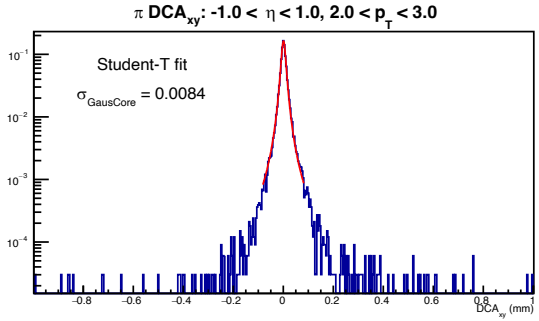
Quantify DCA resolution

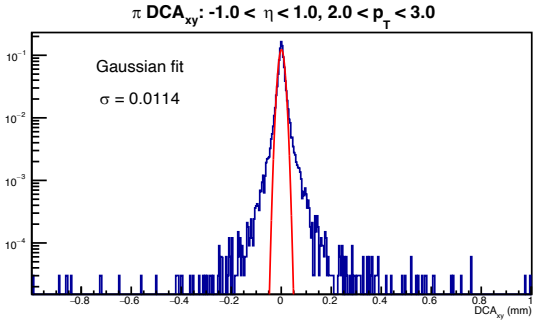
- DCA calculation
  - Based on helix swimming to **MC** primary vertex
  - DCA_{xy}: DCA **in *x*-*y* plane** between primary track and primary vertex
  - DCA_z: *z* component of **3D** DCA

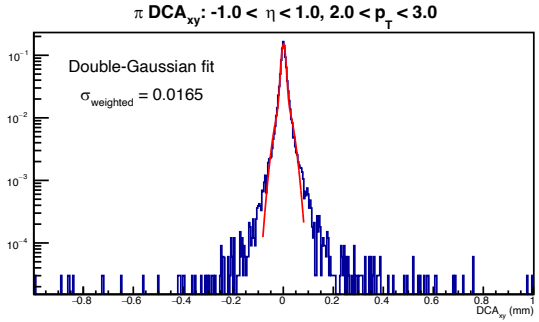
- Quantify DCA
  - Fitting
  - Iterative standard deviation
    - Get standard deviation within [-5*StdDev, 5*StdDev]
    - Repeat 10 times and the resulting standard deviation stabilizes
    - Minimize effect of outliers

Example 1



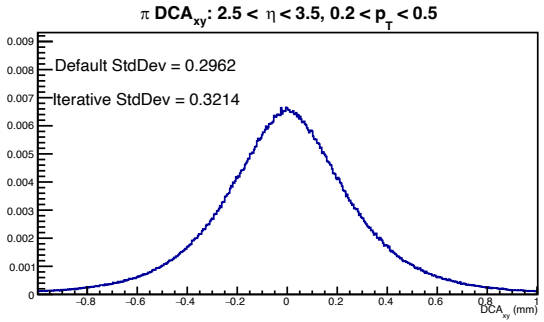


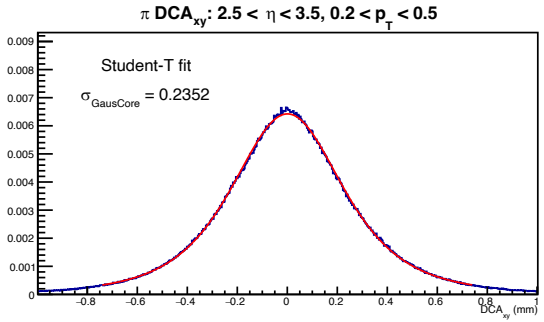


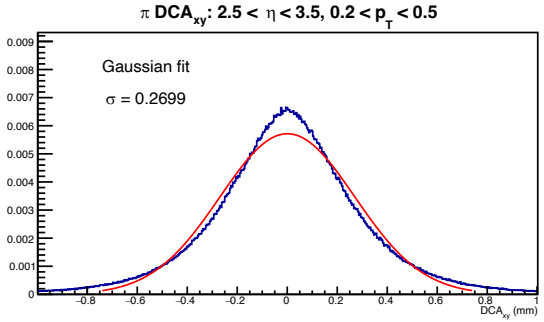


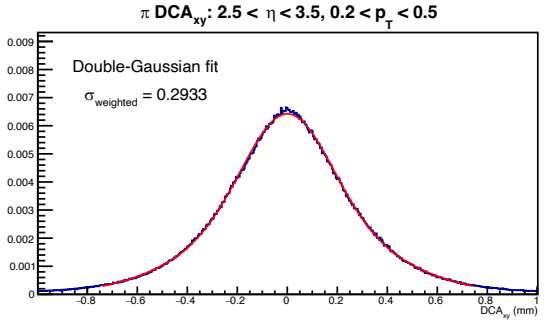
- Iterative StdDev is smaller than default StdDev due to exclusion of outliers
- Student-T and single Gaussian fits yield smaller resolution

Example 2

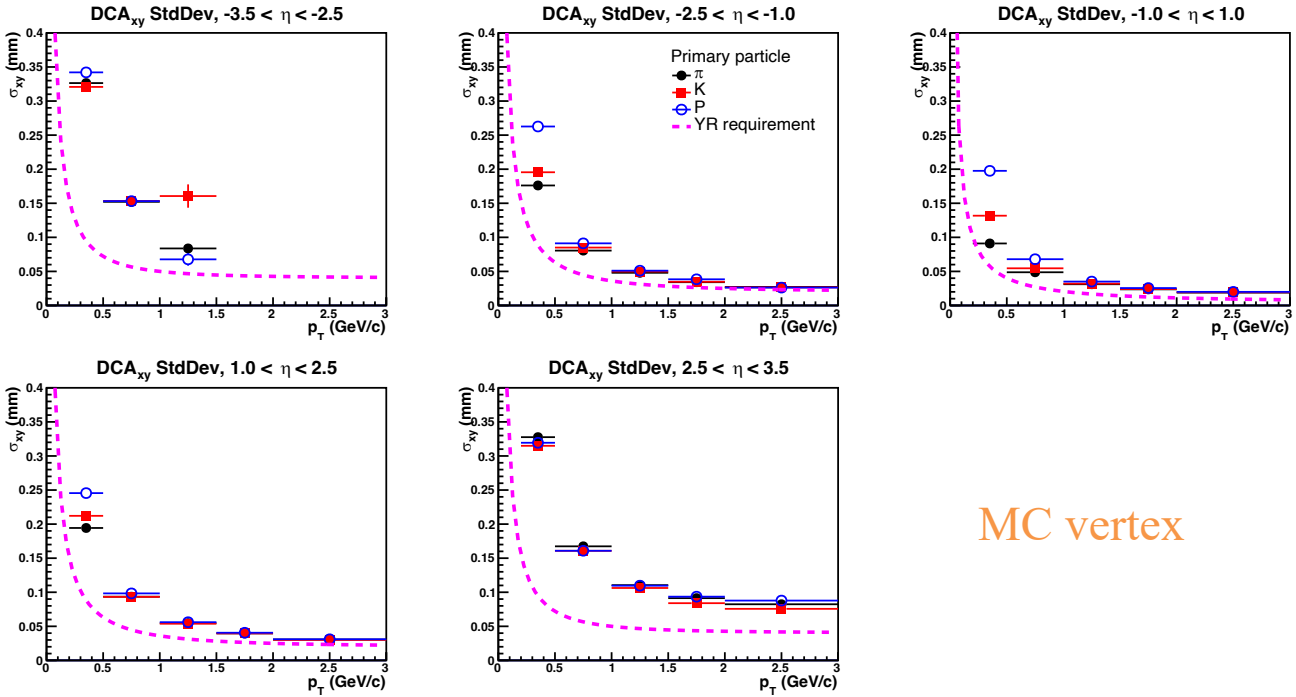

π DCA_xy: 2.5 < η < 3.5, 0.2 < p_T < 0.5
Default StdDev = 0.2962
Iterative StdDev = 0.3214
DCA_xy (mm)


π DCA_xy: 2.5 < η < 3.5, 0.2 < p_T < 0.5
Student-T fit
σ_GausCore = 0.2352
DCA_xy (mm)


π DCA_xy: 2.5 < η < 3.5, 0.2 < p_T < 0.5
Gaussian fit
σ = 0.2699
DCA_xy (mm)


π DCA_xy: 2.5 < η < 3.5, 0.2 < p_T < 0.5
Double-Gaussian fit
σ_weighted = 0.2933
DCA_xy (mm)

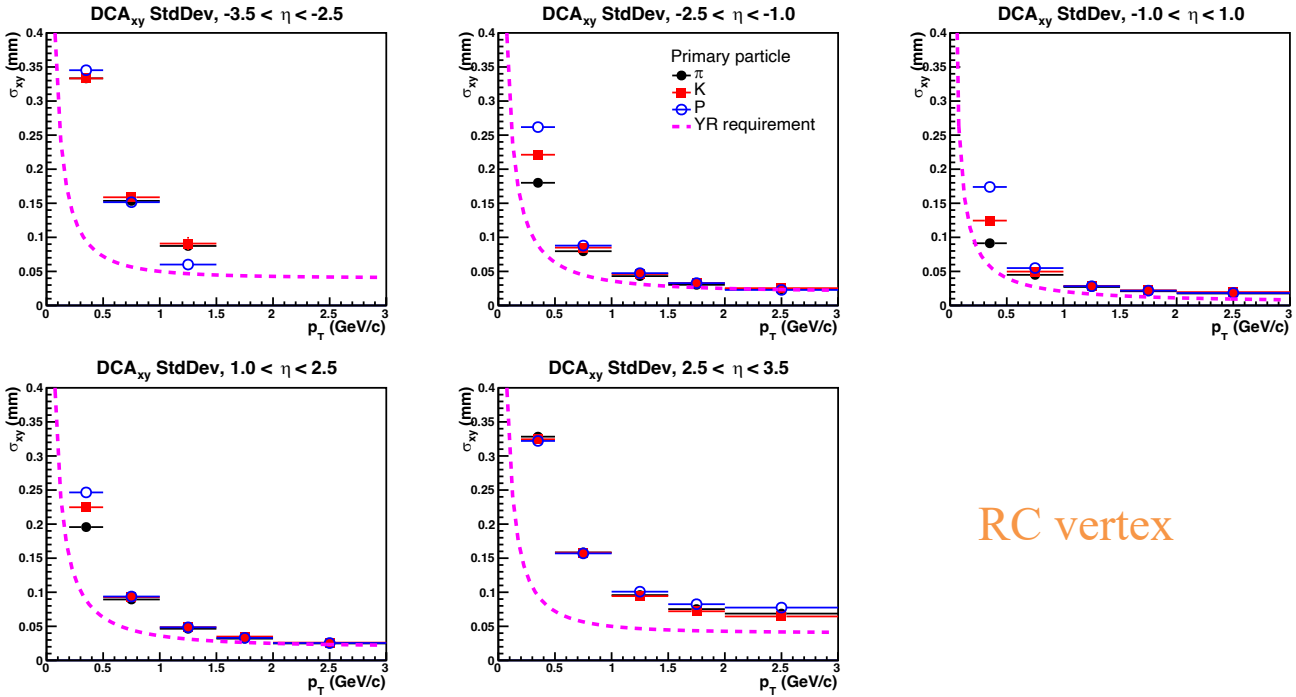
DCA_{xy} resolution: iterative StdDev



MC vertex

- Worse than requirement at low p_T and large rapidity

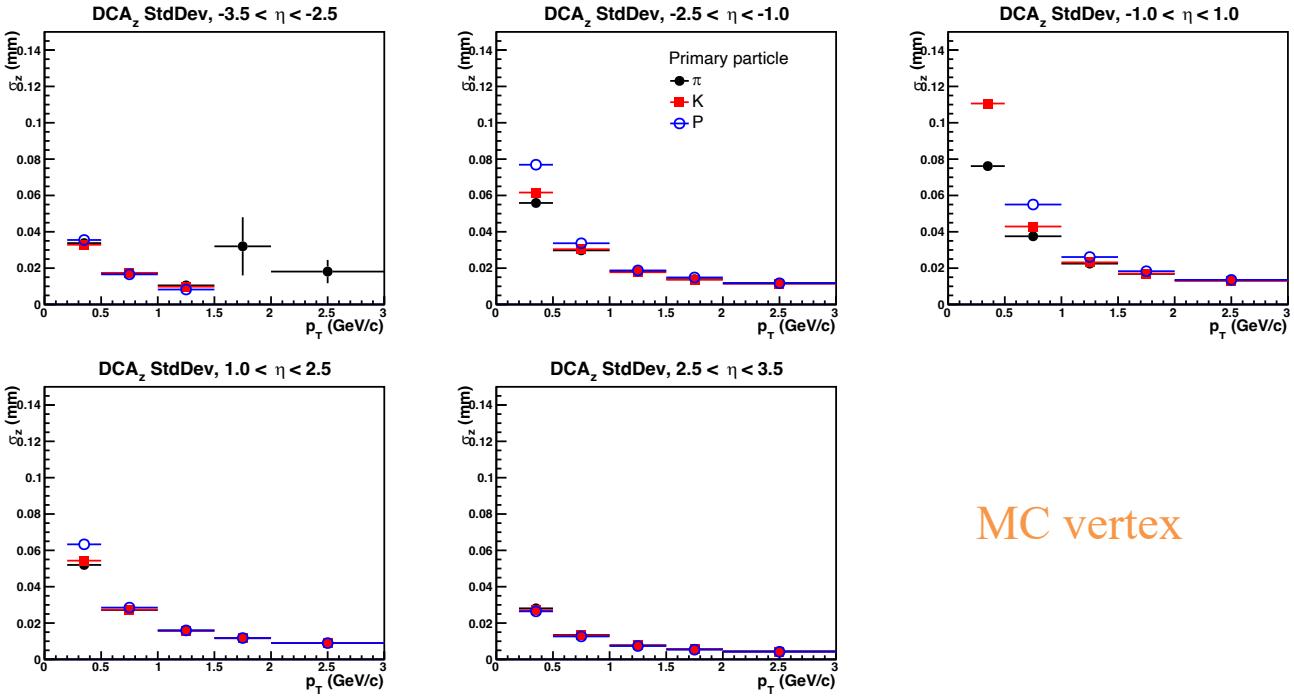
DCA_{xy} resolution: iterative StdDev



RC vertex

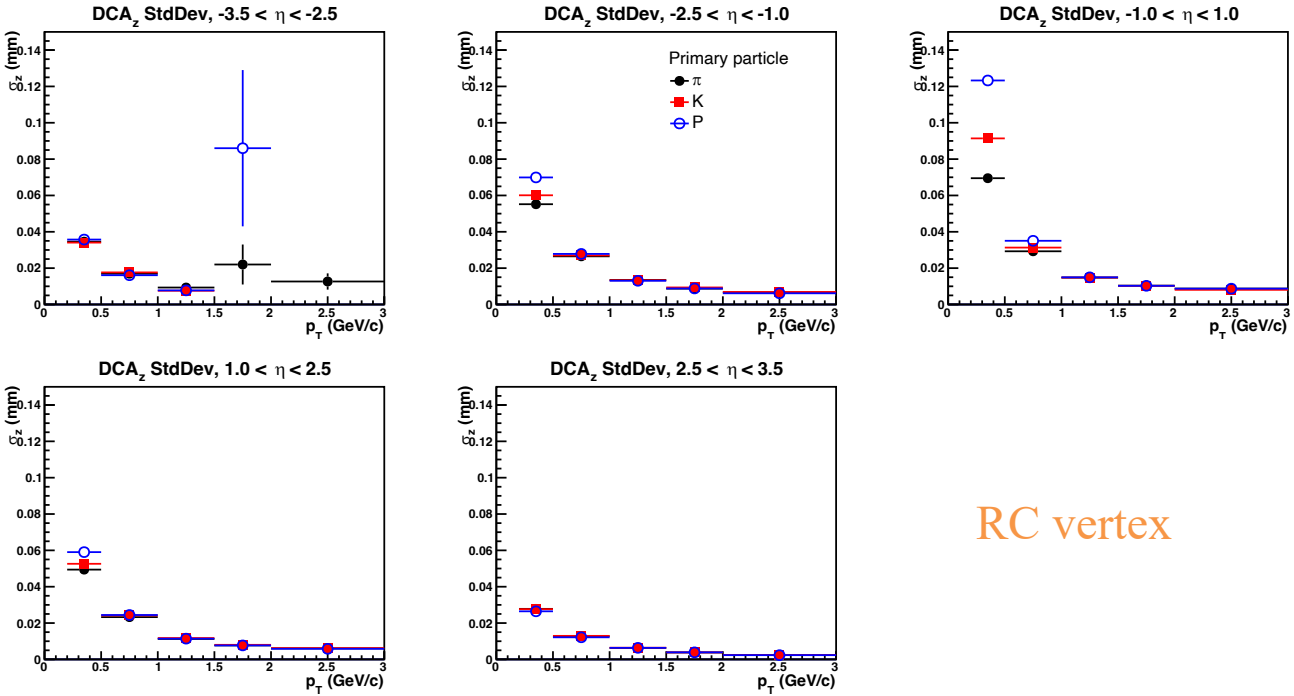
- Slightly "better" resolution compared to using true vertex

DCA_z resolution: iterative StdDev



MC vertex

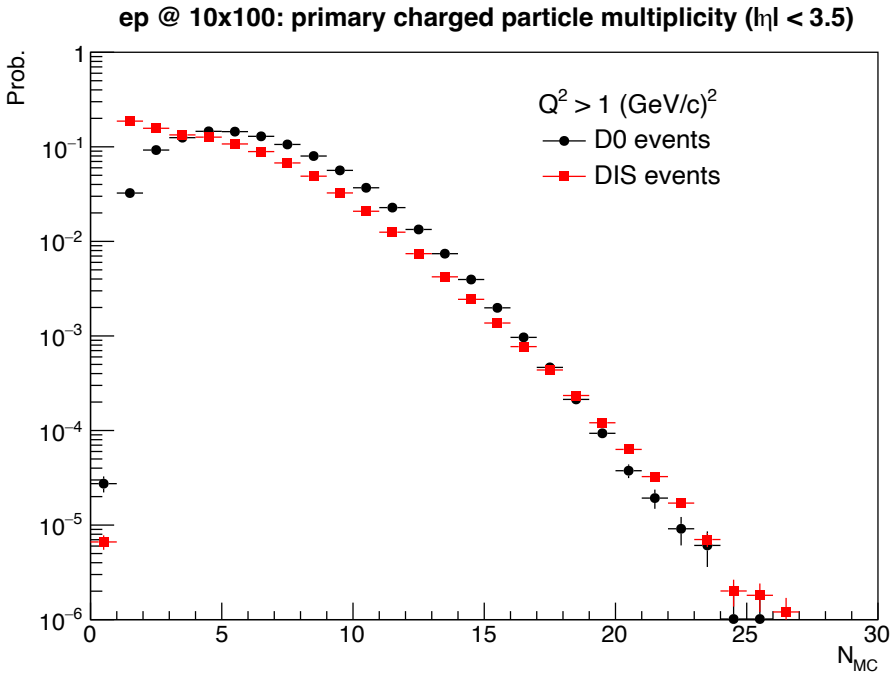
DCA_z resolution: iterative StdDev



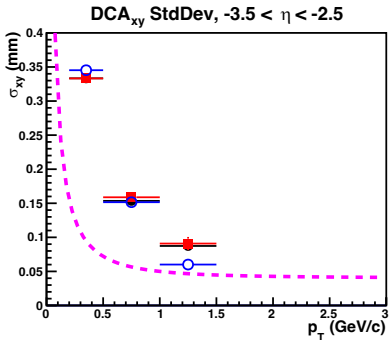
RC vertex

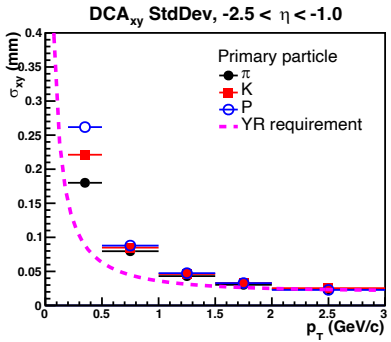
- Slightly "better" resolution compared to using true vertex

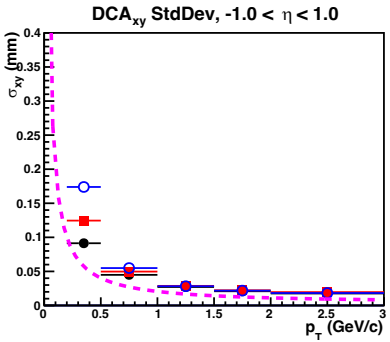
Compare multiplicity distribution

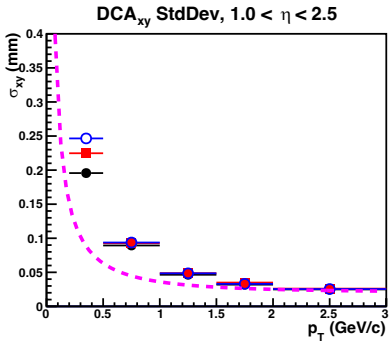


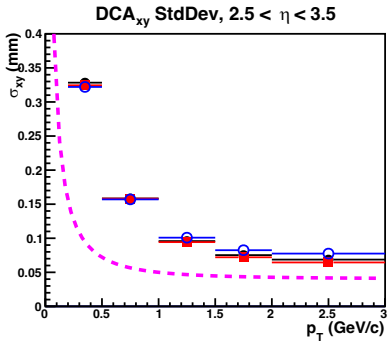
DCA_{xy} resolution: iterative StdDev







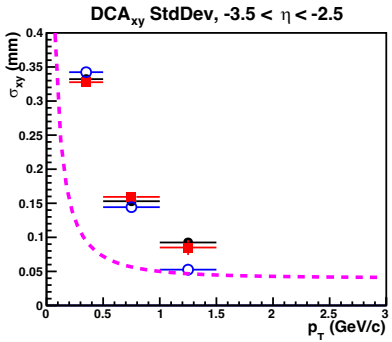


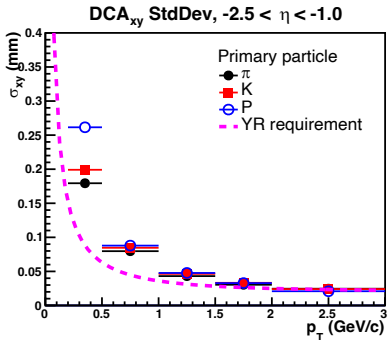


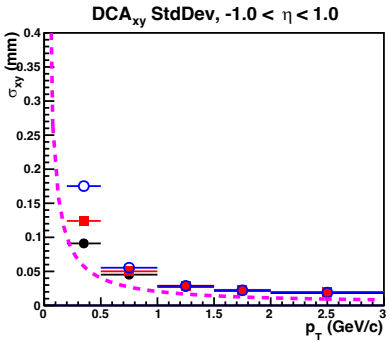
$N_{MC} >= 0$

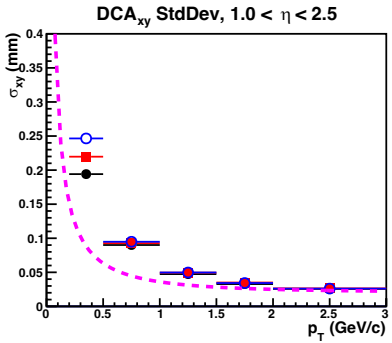
RC vertex

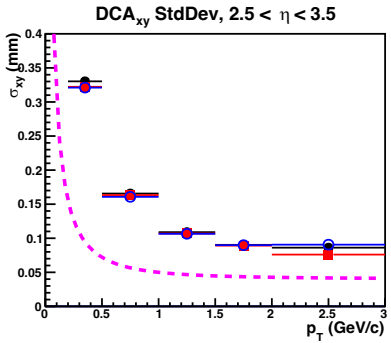
DCA_{xy} resolution: iterative StdDev







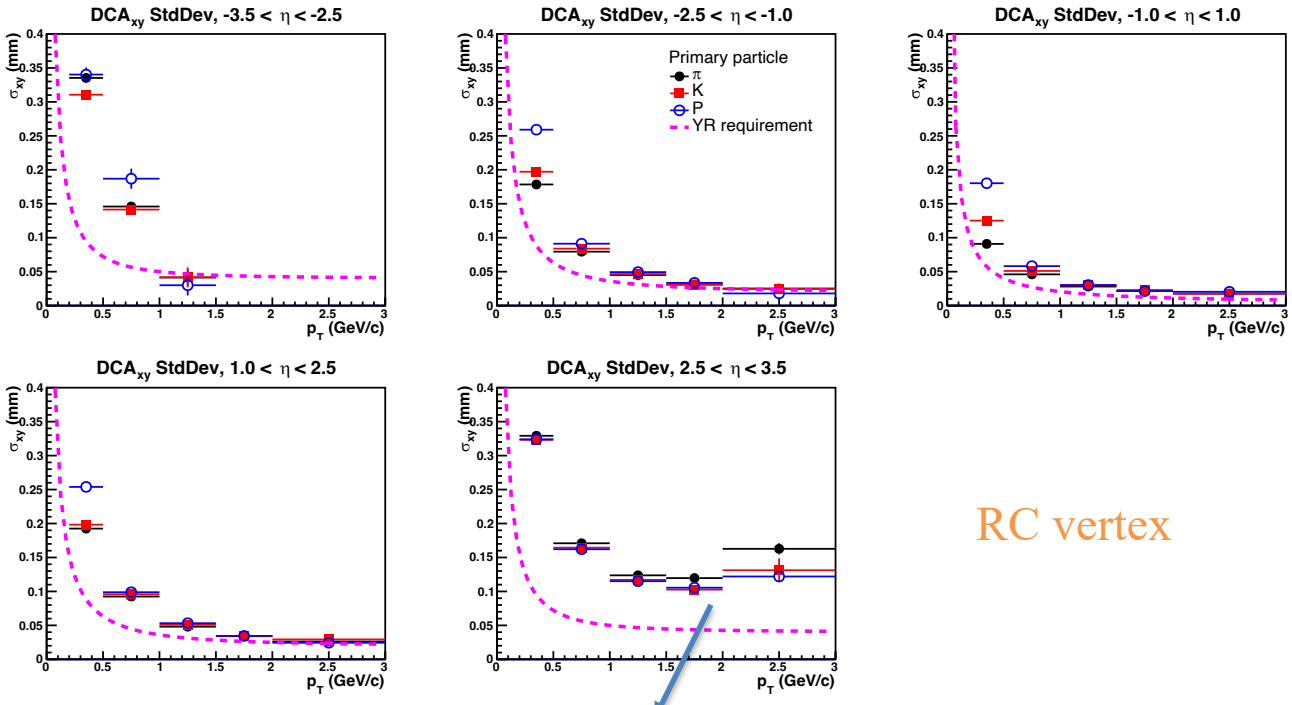




$N_{MC} >= 5$

RC vertex

DCA_{xy} resolution: iterative StdDev



N_{MC} >= 10

RC vertex

- Running out of statistics

Primary vs. secondary tracks

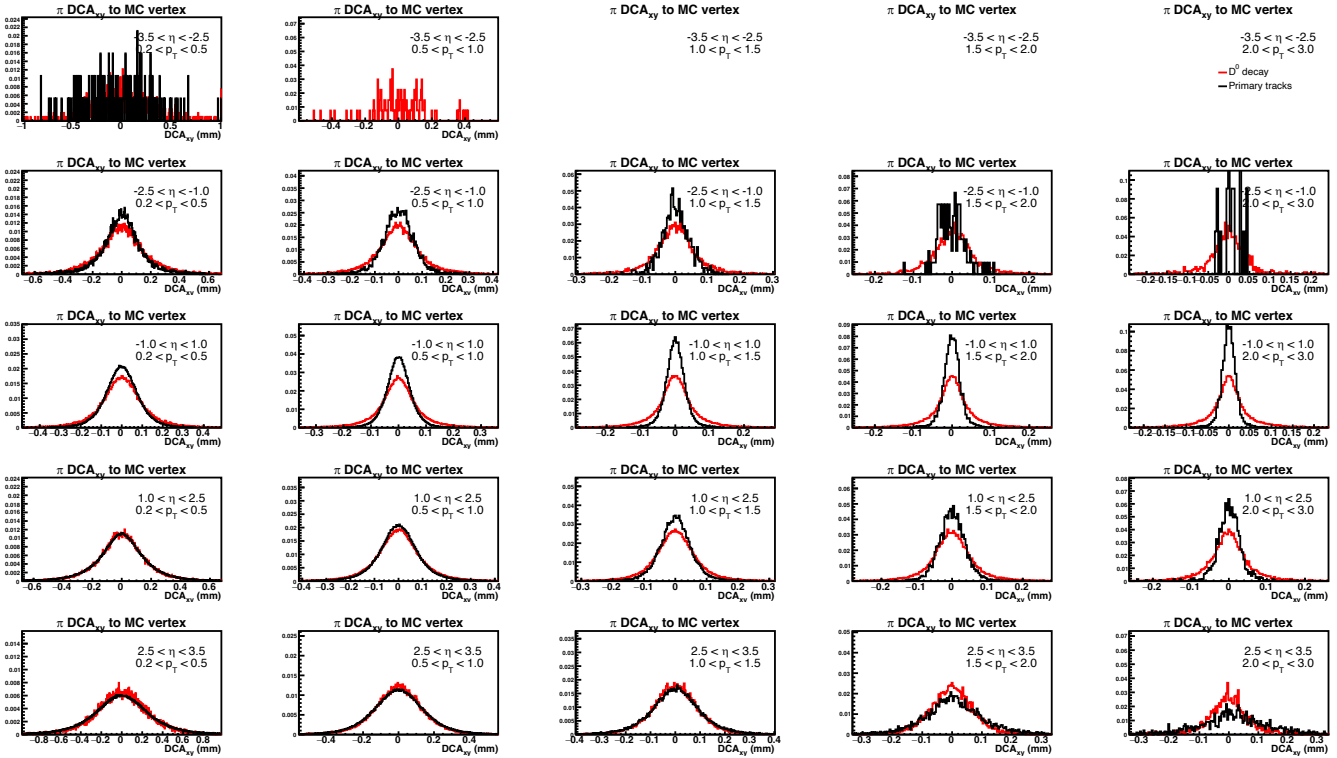
Analysis setup

- Simulation sample
  - D0 events
  - ep @ 10x100
  - $Q^2 > 1$ $(GeV/c)^2$
  - Simulation campaign: 25.04.1

- Track selection
  - Primary vs. secondary tracks
  - Truth PID

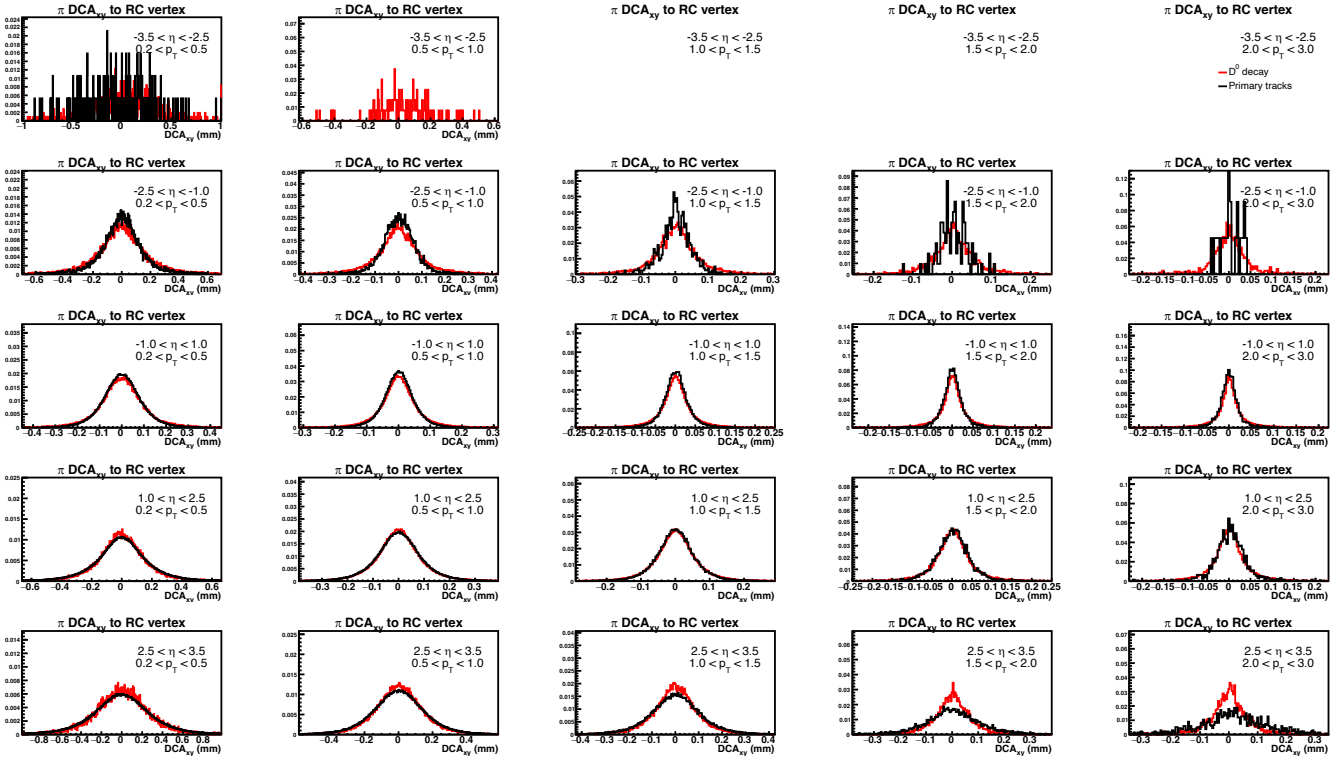
π DCA_{xy}

MC vertex



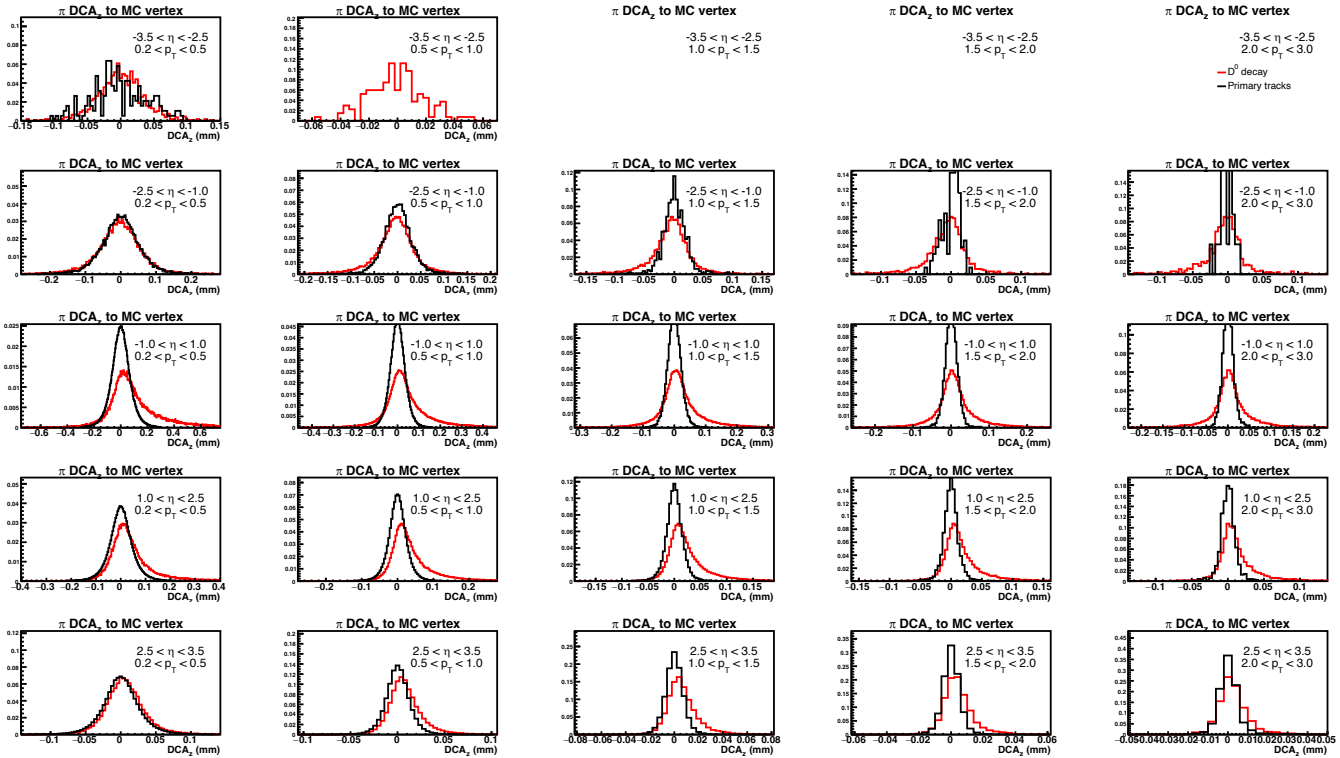
π DCA_{xy}

RC vertex



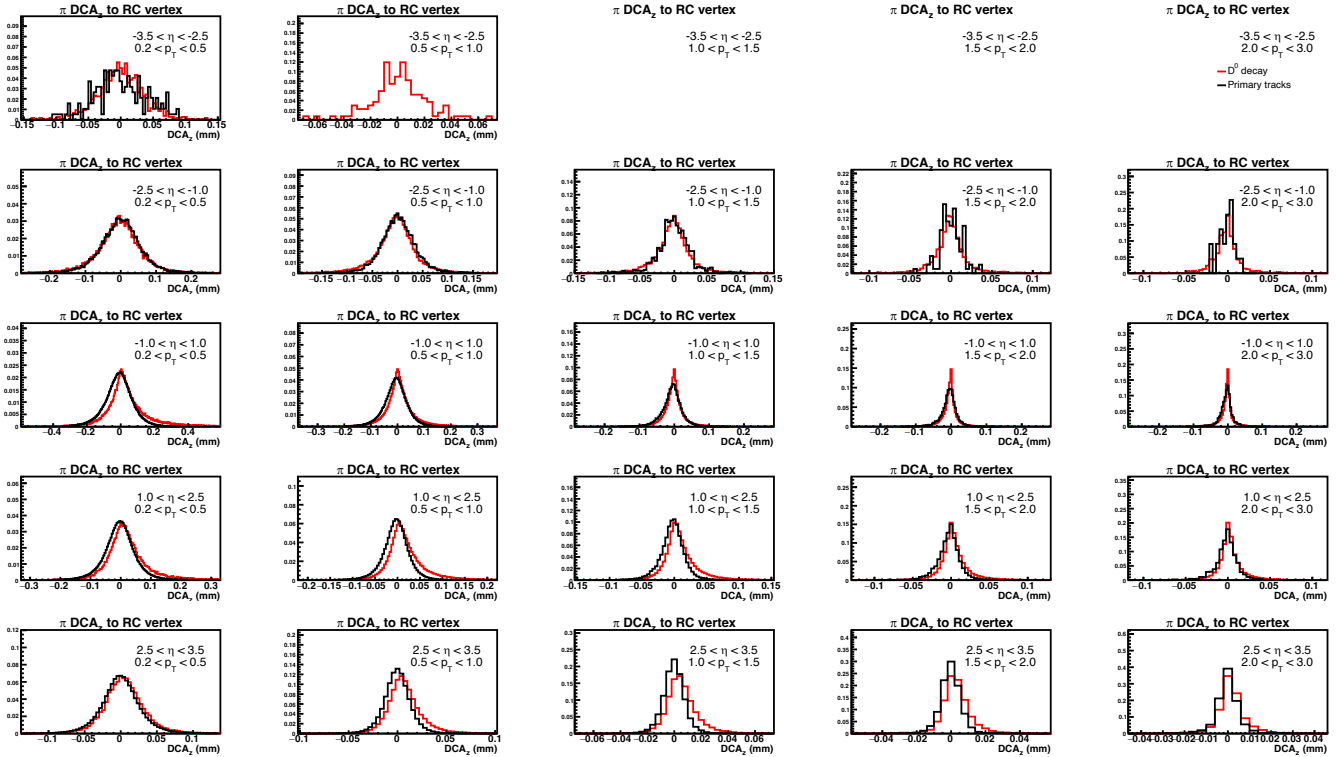
π DCA_z

MC vertex



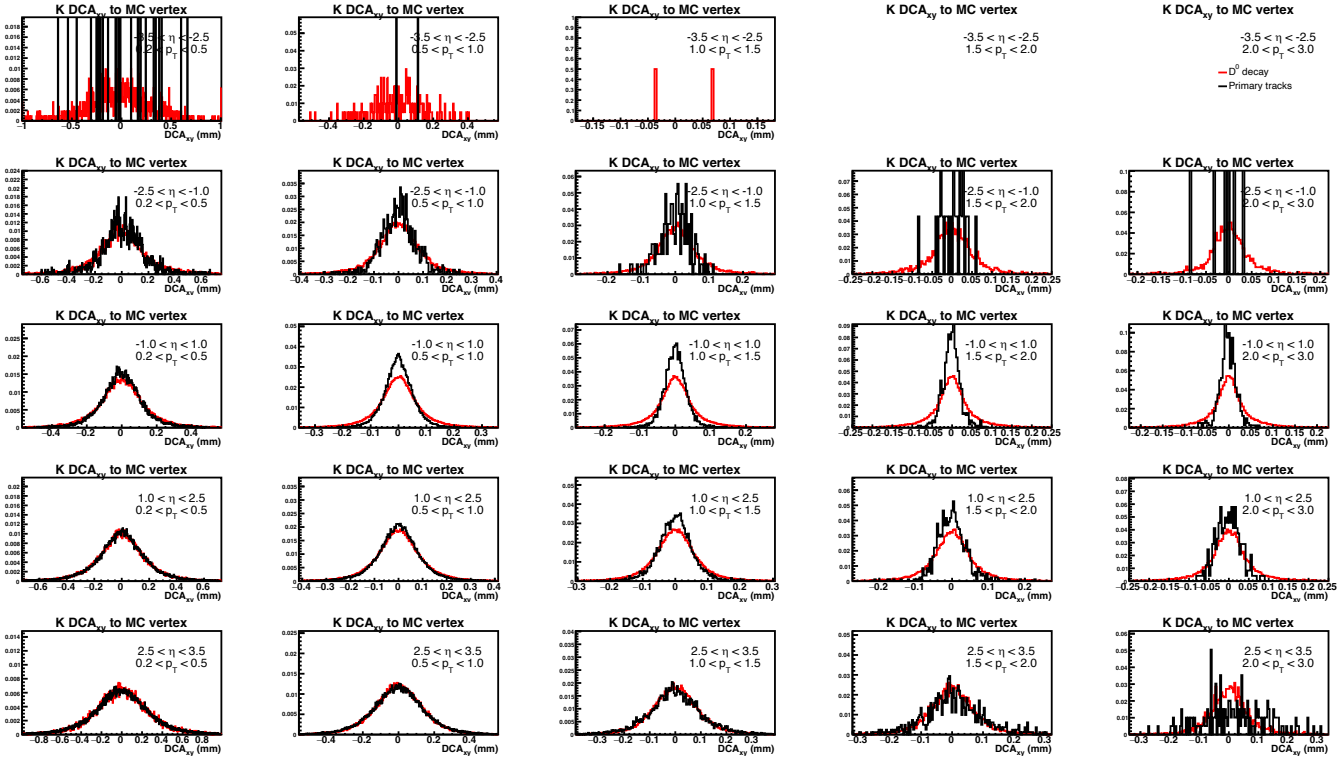
π DCA_z

RC vertex



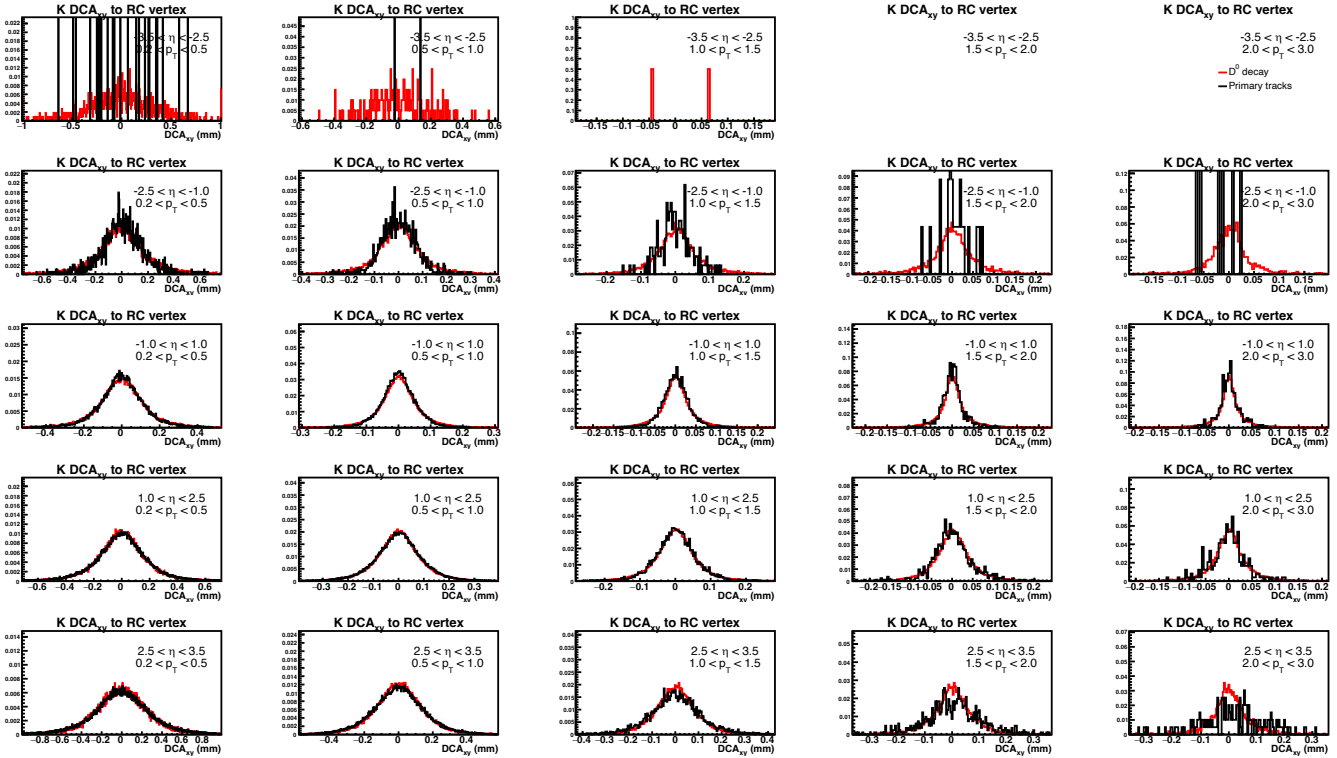
Kaon DCA_{xy}

MC vertex



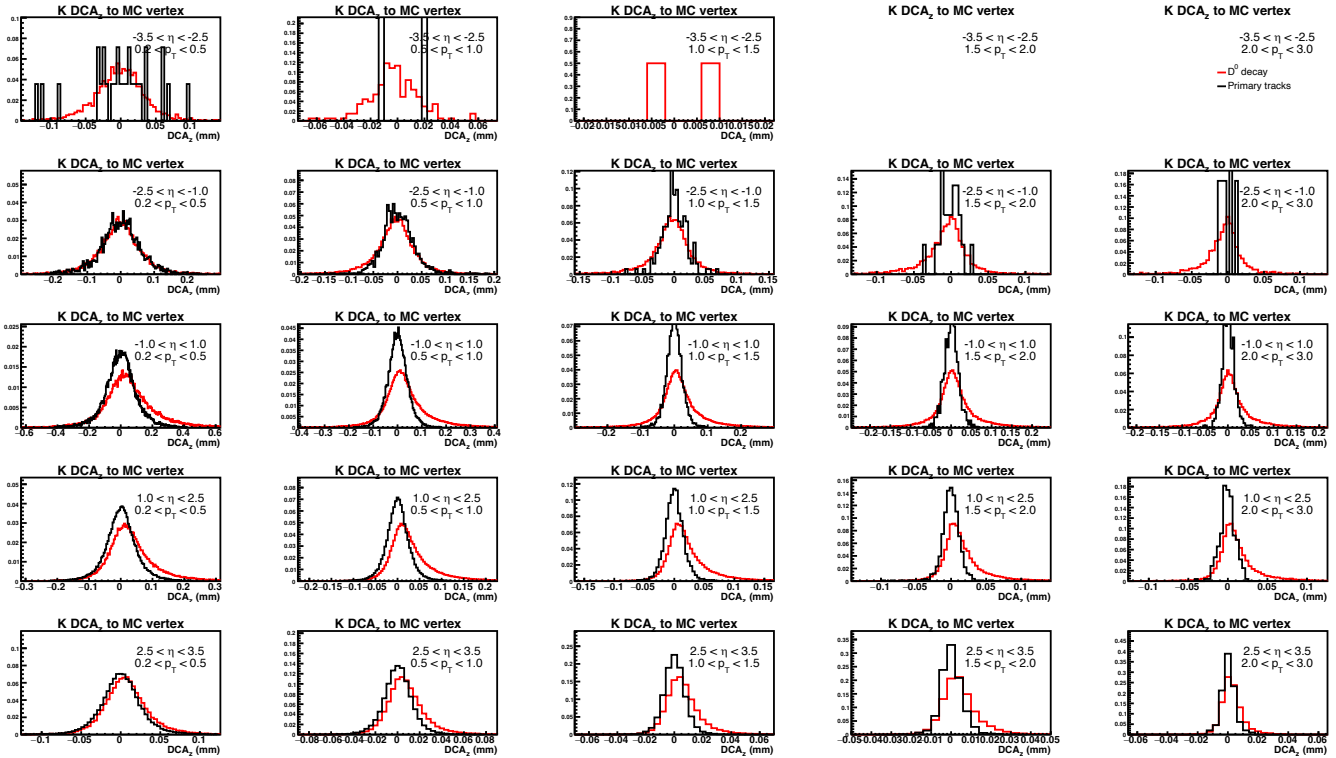
Kaon DCA_{xy}

RC vertex



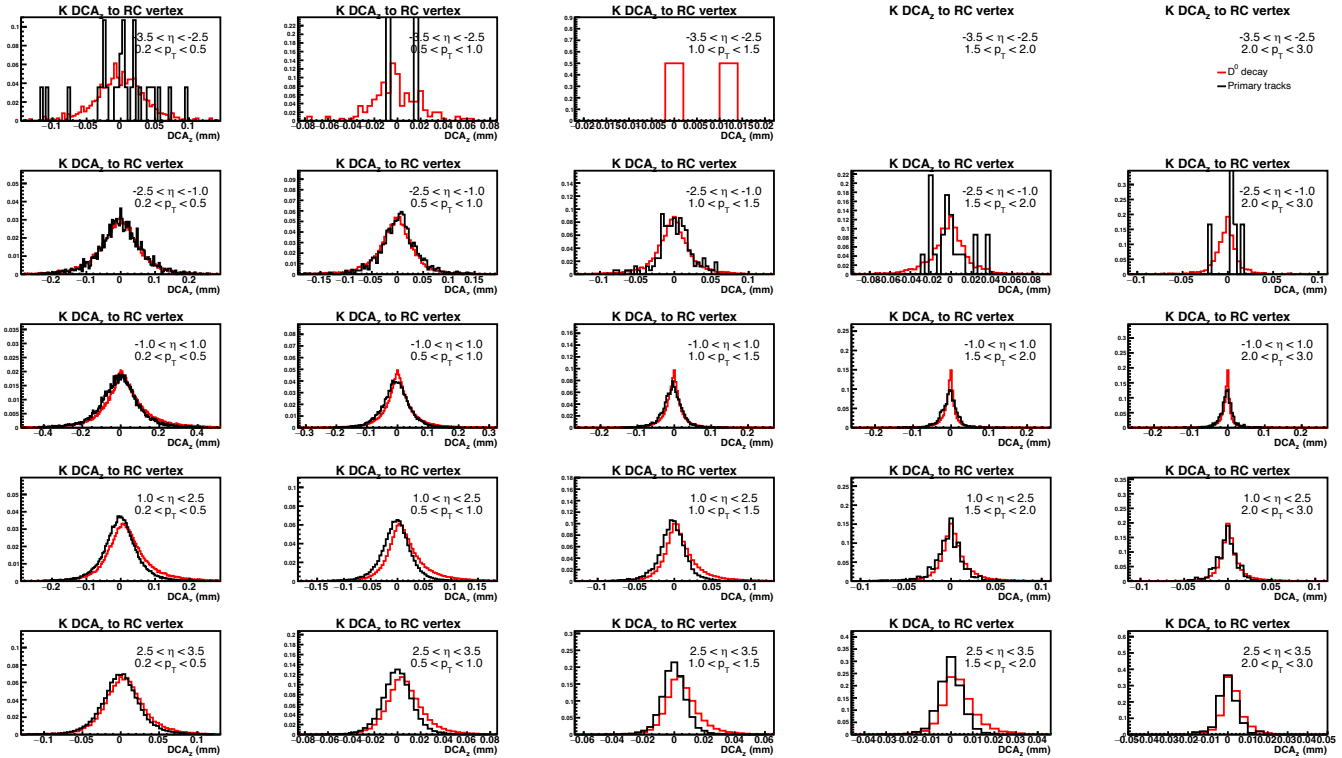
Kaon DCA_z

MC vertex

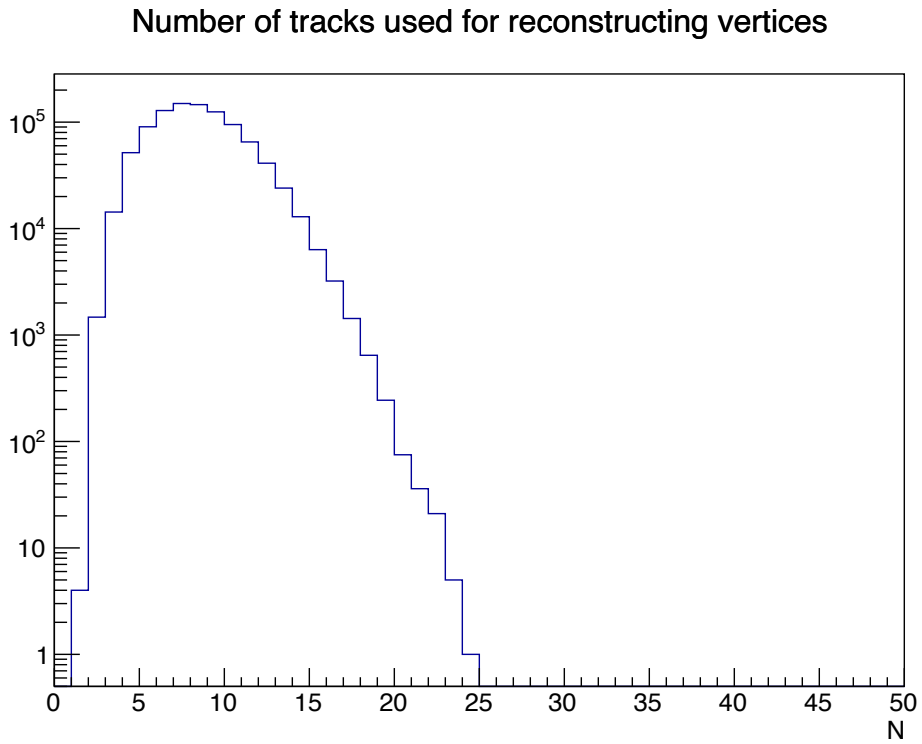


π DCA_z

RC vertex

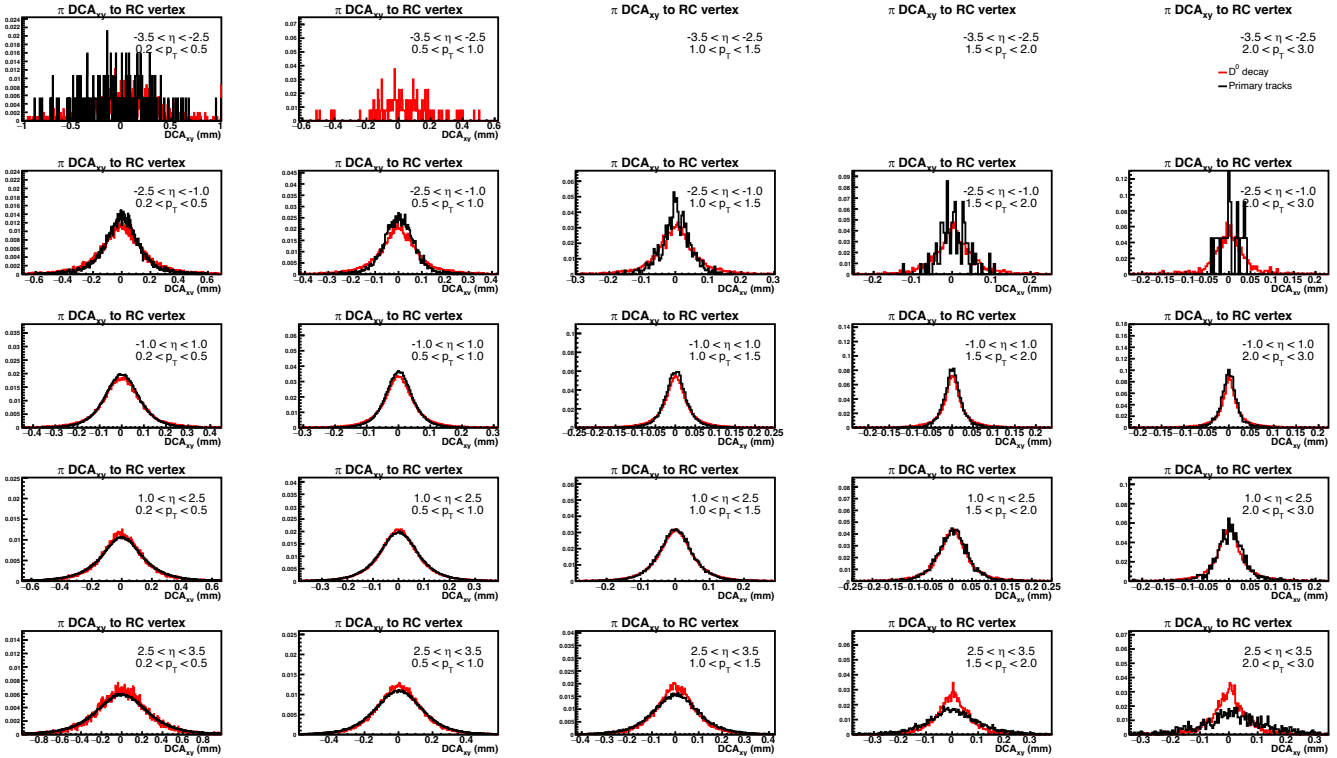


Tracks used for finding vertices



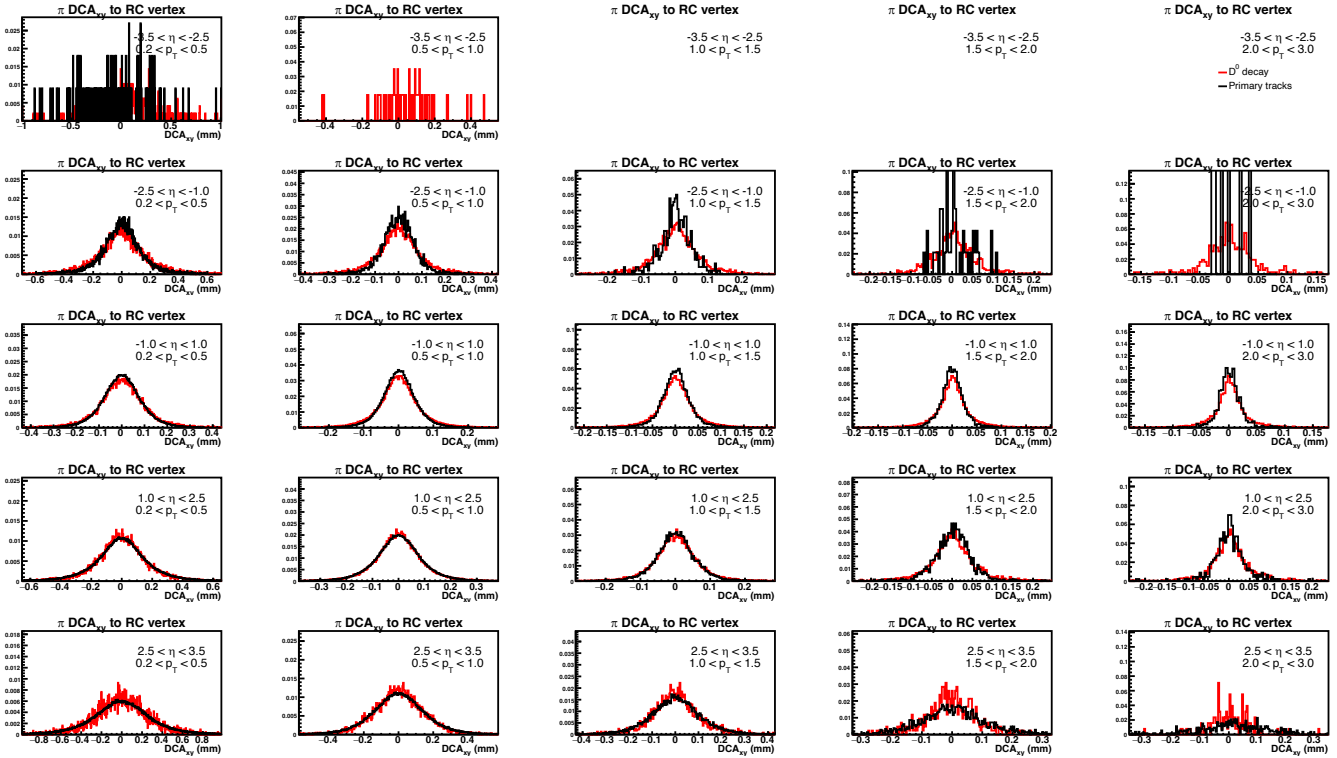
π DCA_{xy}

RC vertex
$N_{trk} > 0$



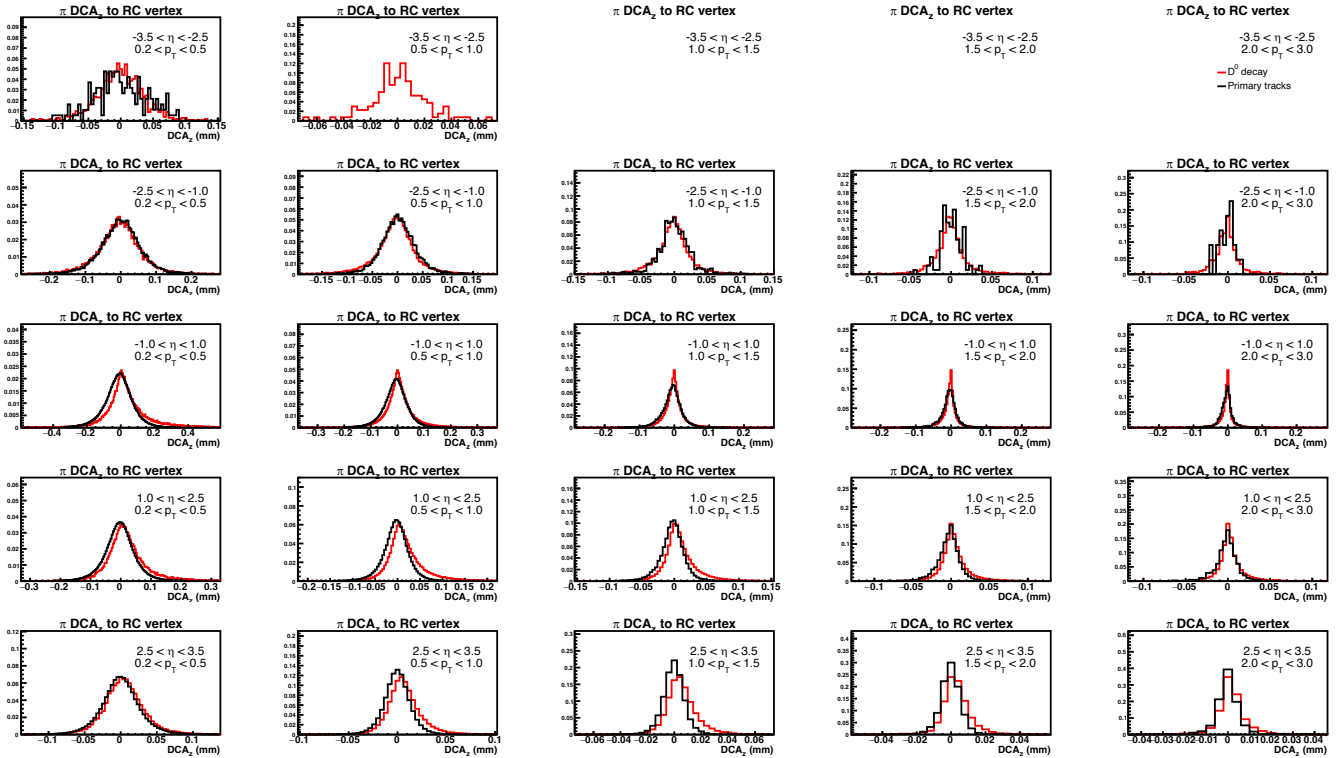
π DCA_{xy}

RC vertex
$N_{trk} \geq 10$



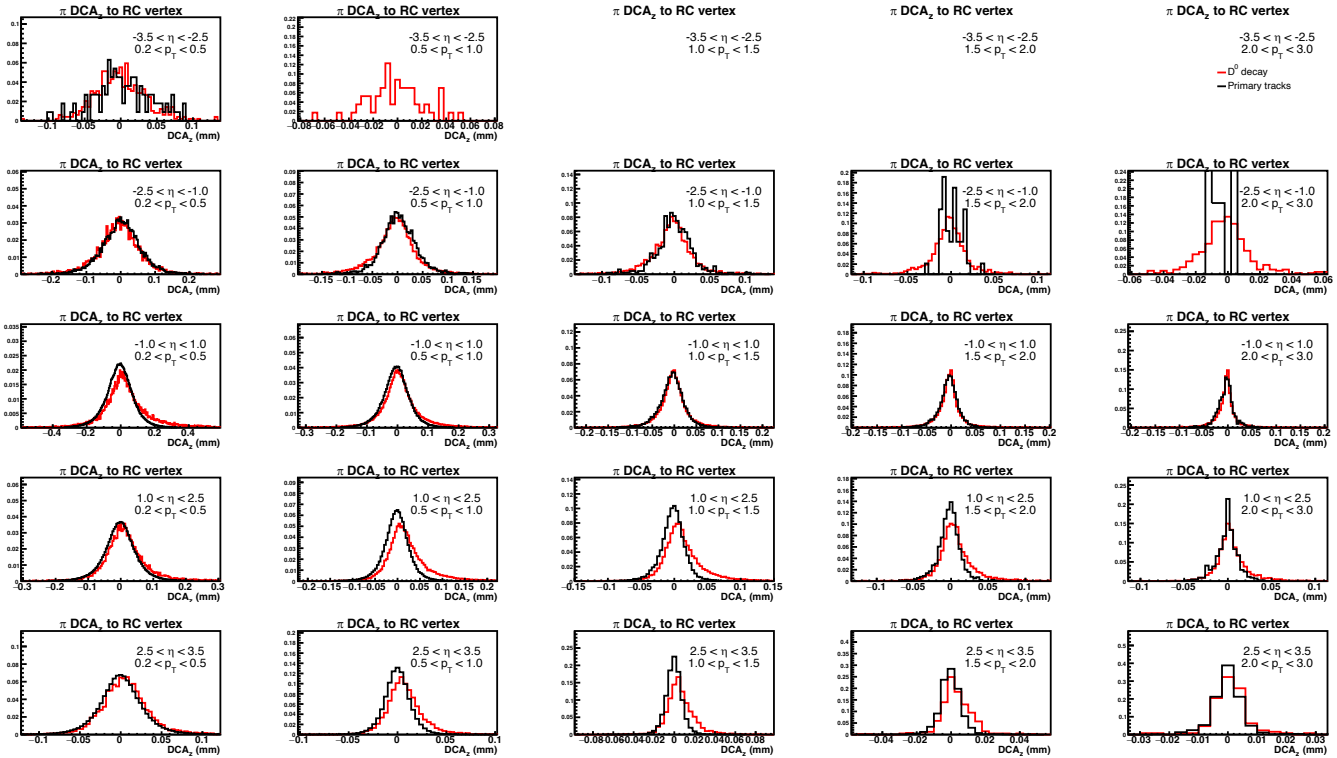
π DCA_z

RC vertex
$N_{trk} > 0$



π DCA_z

RC vertex
$N_{trk} \geq 10$



Summary

- Iterative StdDev provides a stable approach for quantifying resolution compared to fitting routines
  - Outliers are removed
- Derived track pointing resolution in *x*-*y* plane from DIS events does not fully meet requirements, especially at low p_T and high rapidity
  - Worse than single pion simulation

- Differences in single track DCA distribution between primary vs. secondary tracks are mostly washed out when using reconstructed vertices