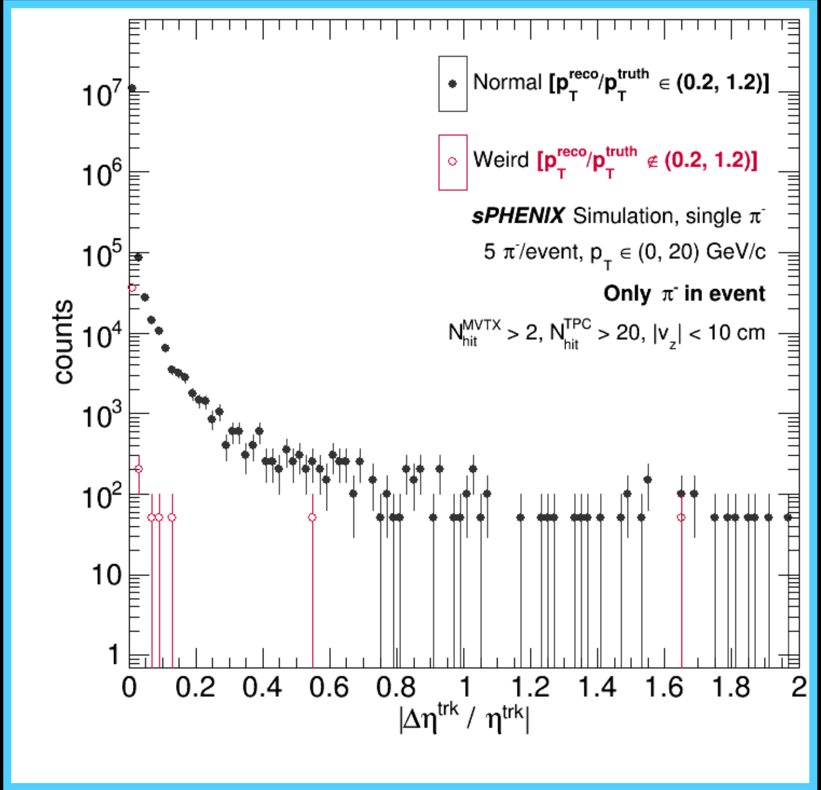
# Track Cut Study: Update

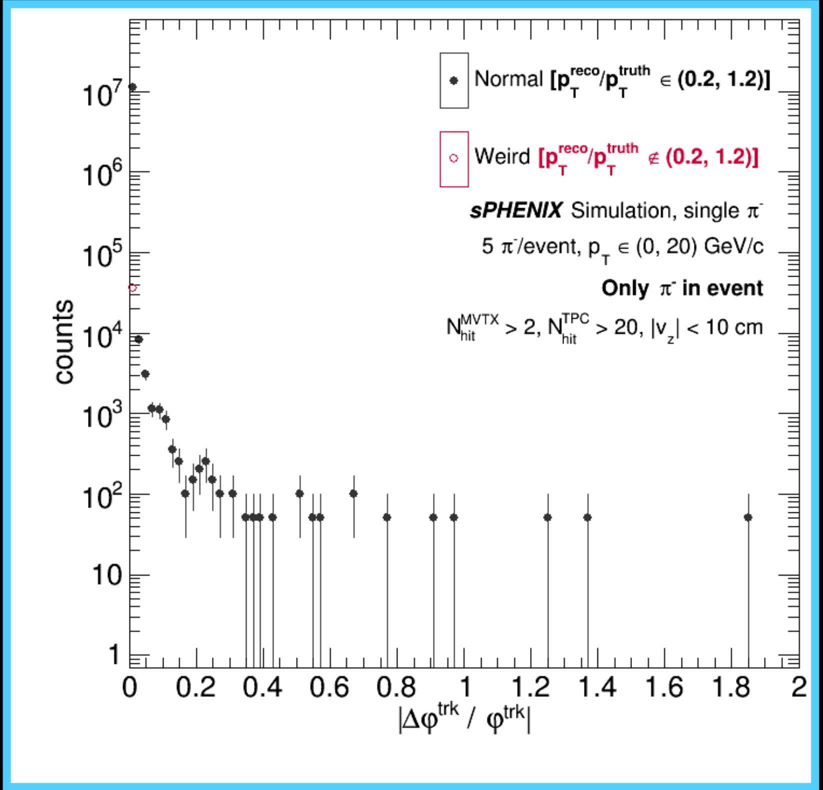
sPHENIX Tracking Meeting

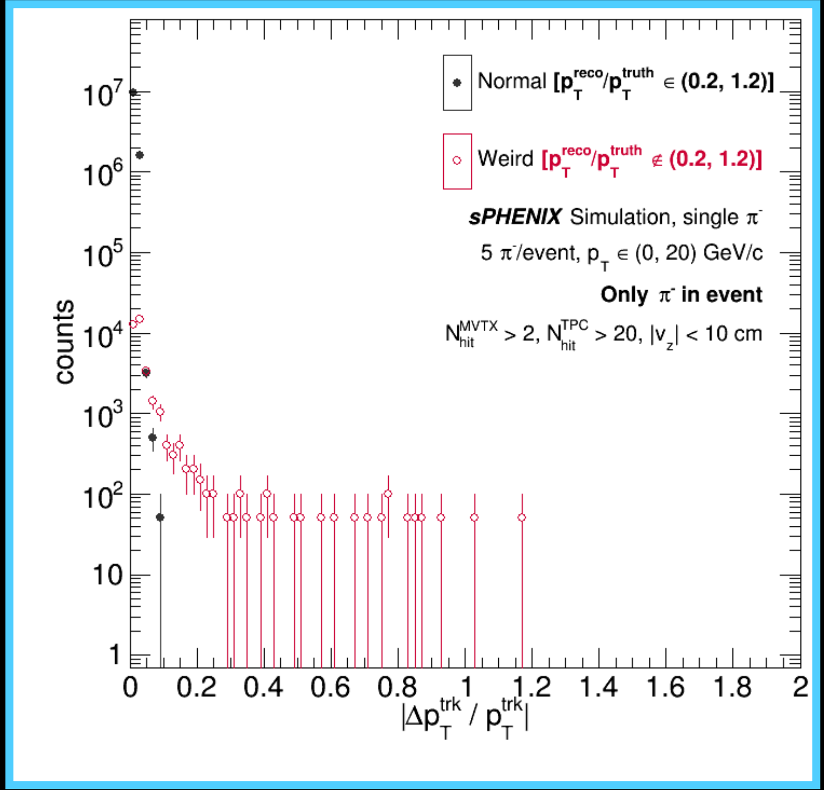
April 5th, 2023

Derek Anderson (ISU)

# Track Percent Errors | $N_\pi = 5$

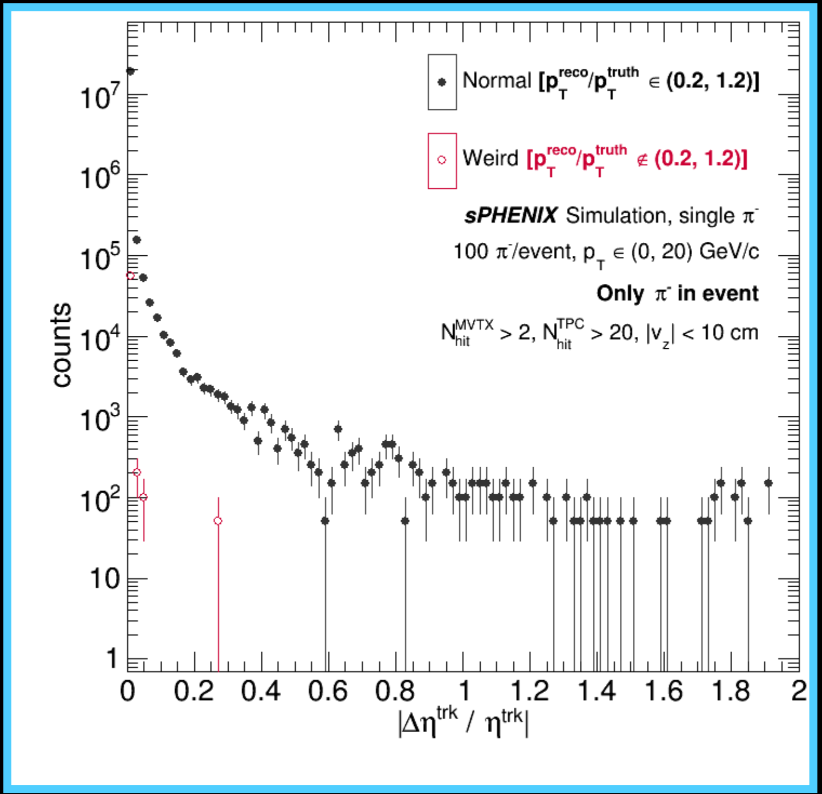


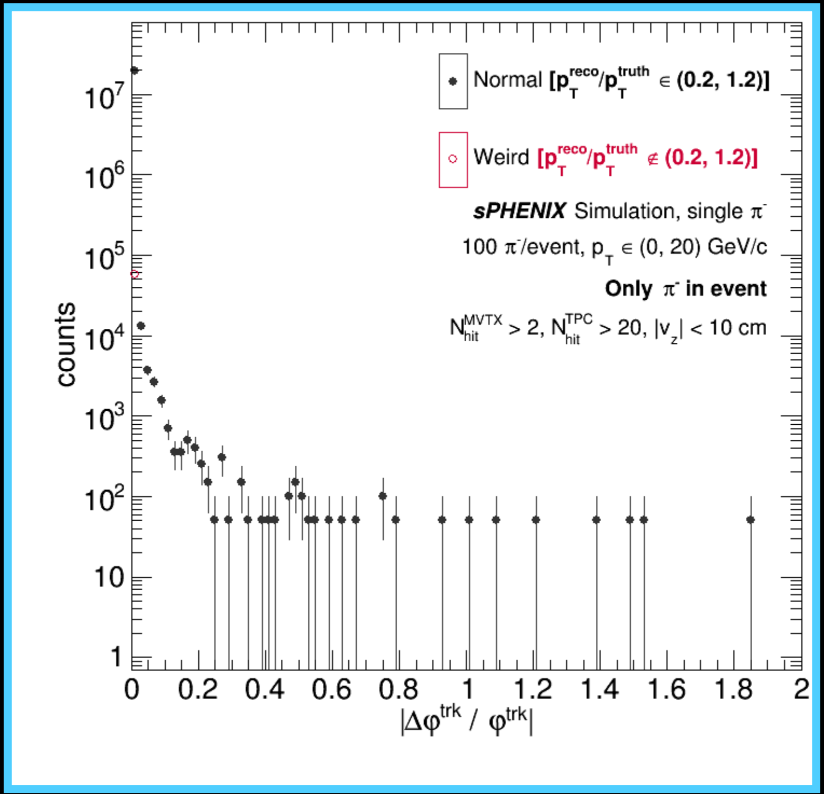



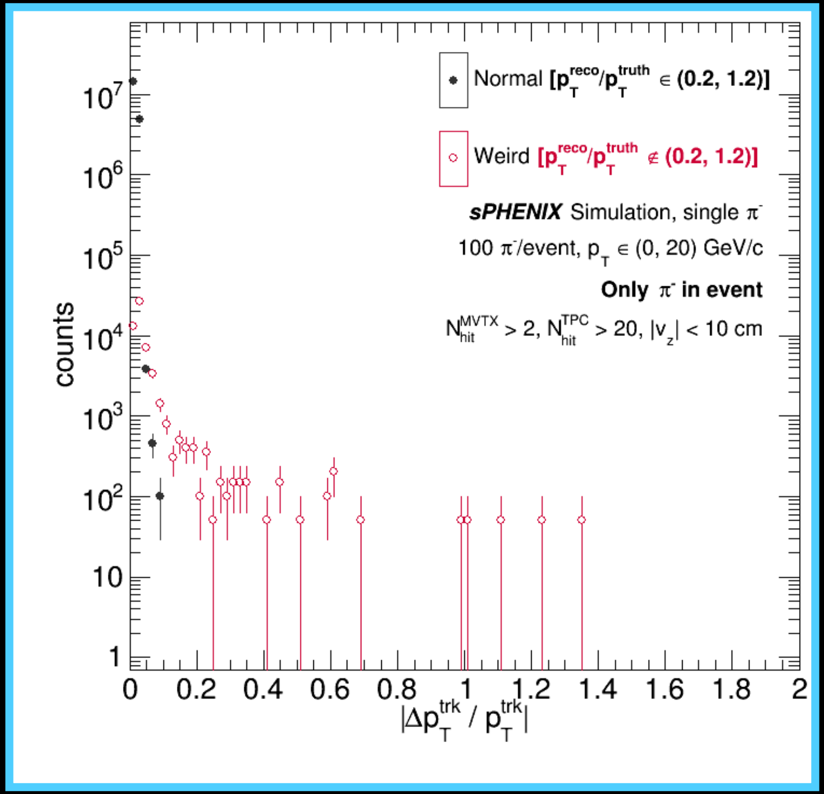




- **Shown:** %-errors on track $\eta$ **(left)**, $\varphi$ **(center)**, and $p_T$ **(right)**
  - For $N_\pi = 5$ events

# Track Percent Errors | $N_\pi = 100$

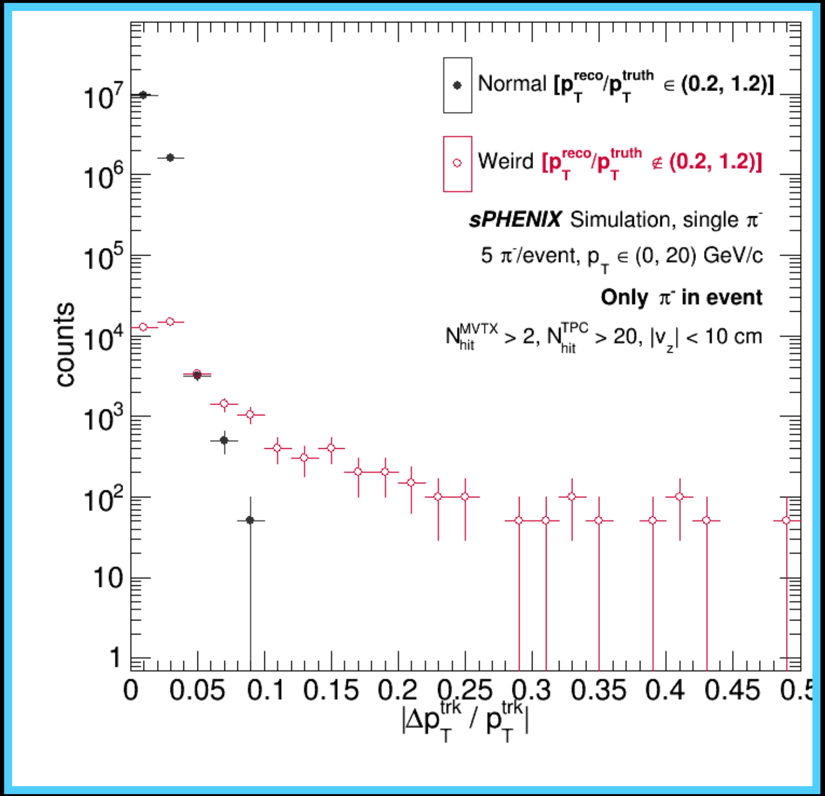


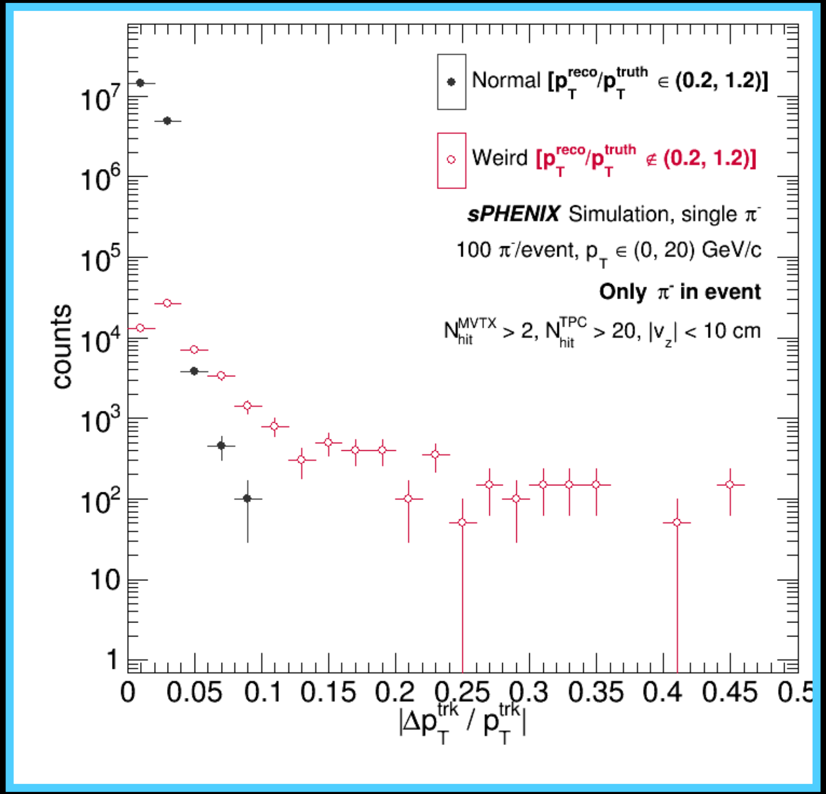




- **Shown:** %-errors on track $\eta$ **(left)**, $\varphi$ **(center)**, and $p_T$ **(right)**
  - For $N_\pi = 100$ events

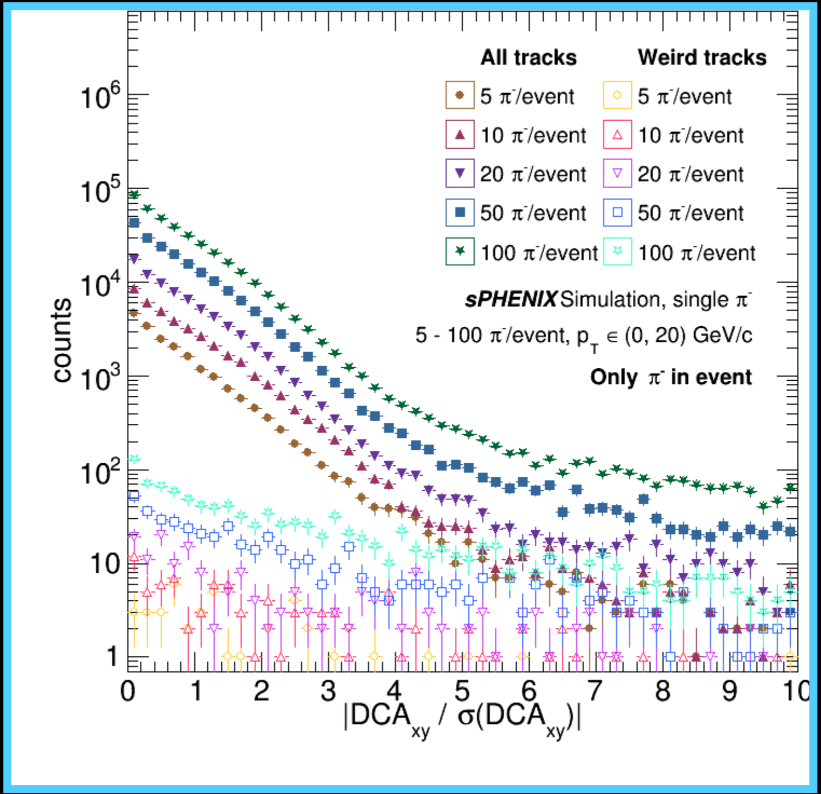
# Track Percent Errors | zoomed-in on x-axis

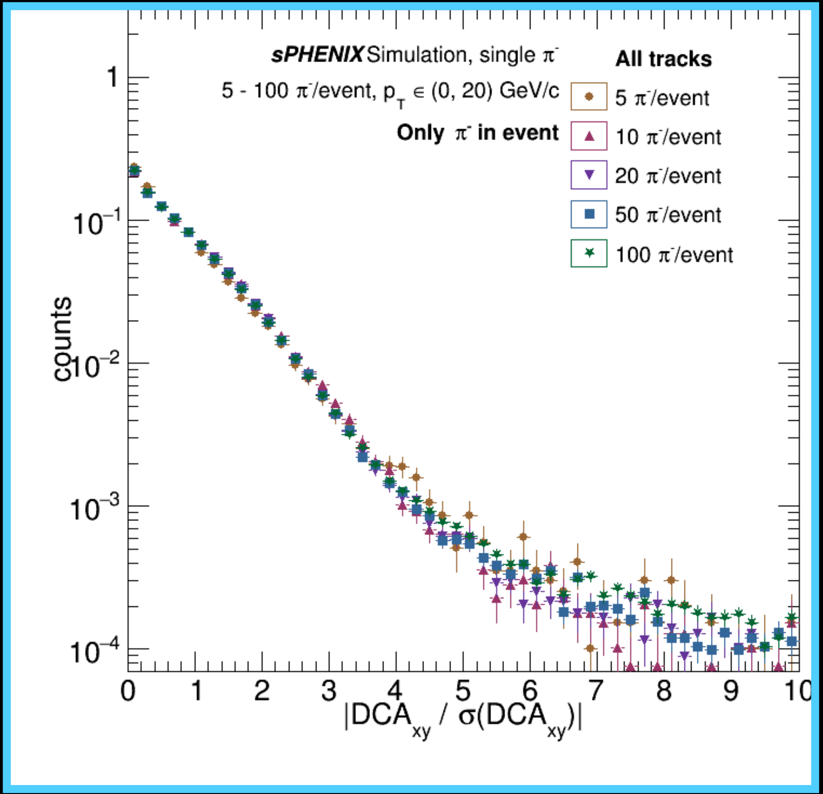


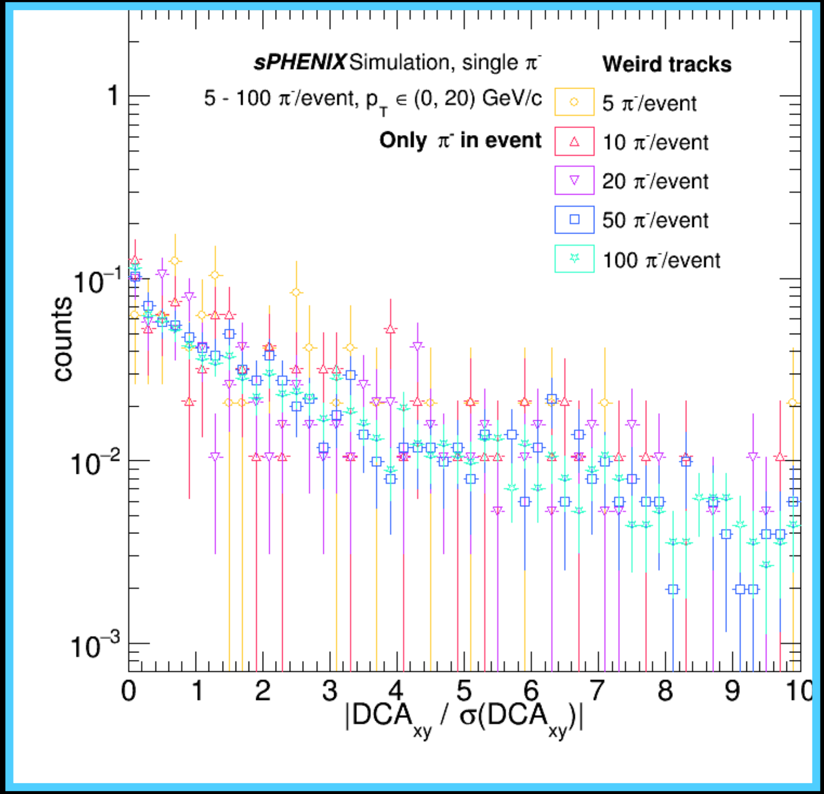




- **Shown:** %-errors on track $p_T$
  - For $N_\pi = 5$ (left) and 100 (right) events

# DCAxy/$\sigma$(DCAxy) vs. $N_\pi$

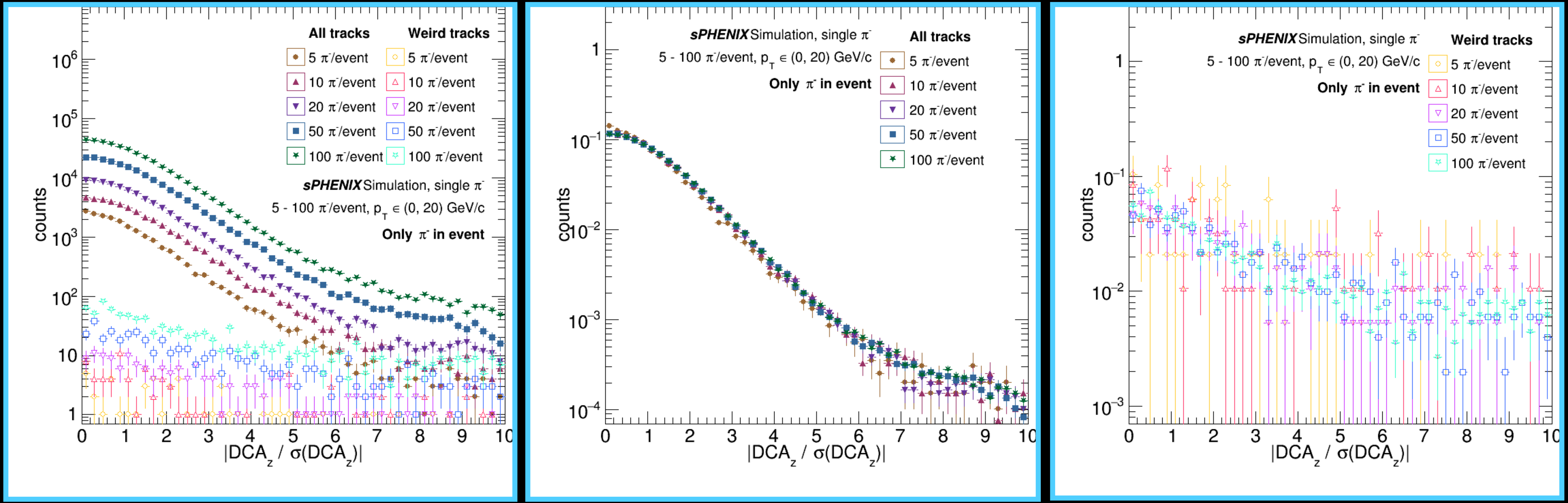


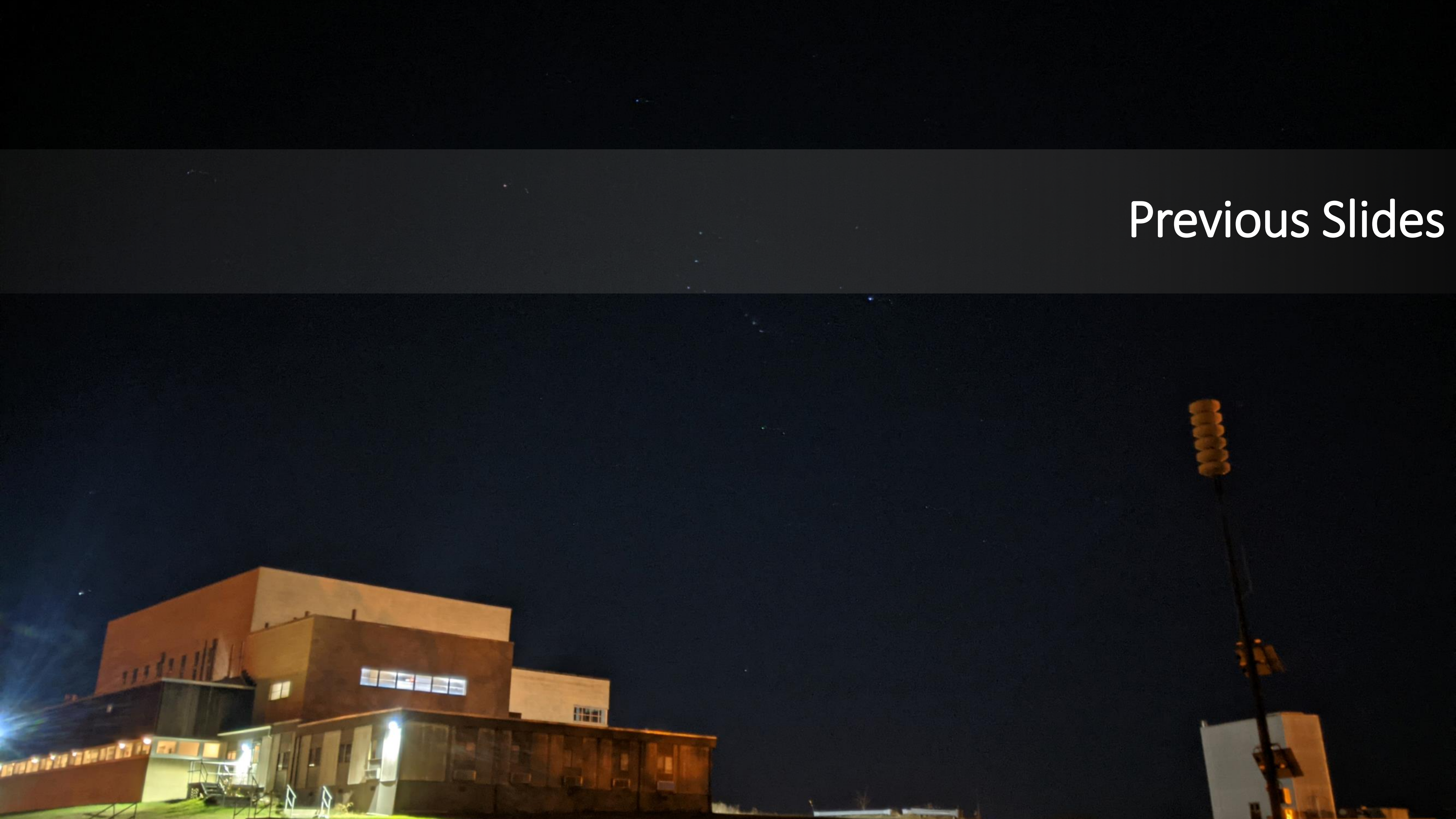

- **Shown:** DCAxy/$\sigma$(DCAxy)
  - Unnormalized **(left)** , all tracks **(normalized, center)** , and weird tracks **(normalized, right)**
  - For $N_\pi = 5$ **(orange)**, $N_\pi = 10$ **(red)**, $N_\pi = 20$ **(purple)**, $N_\pi = 50$ **(blue)**, and $N_\pi = 100$ **(green)** events

# DCAz/$\sigma$(DCAz) vs. $N_\pi$

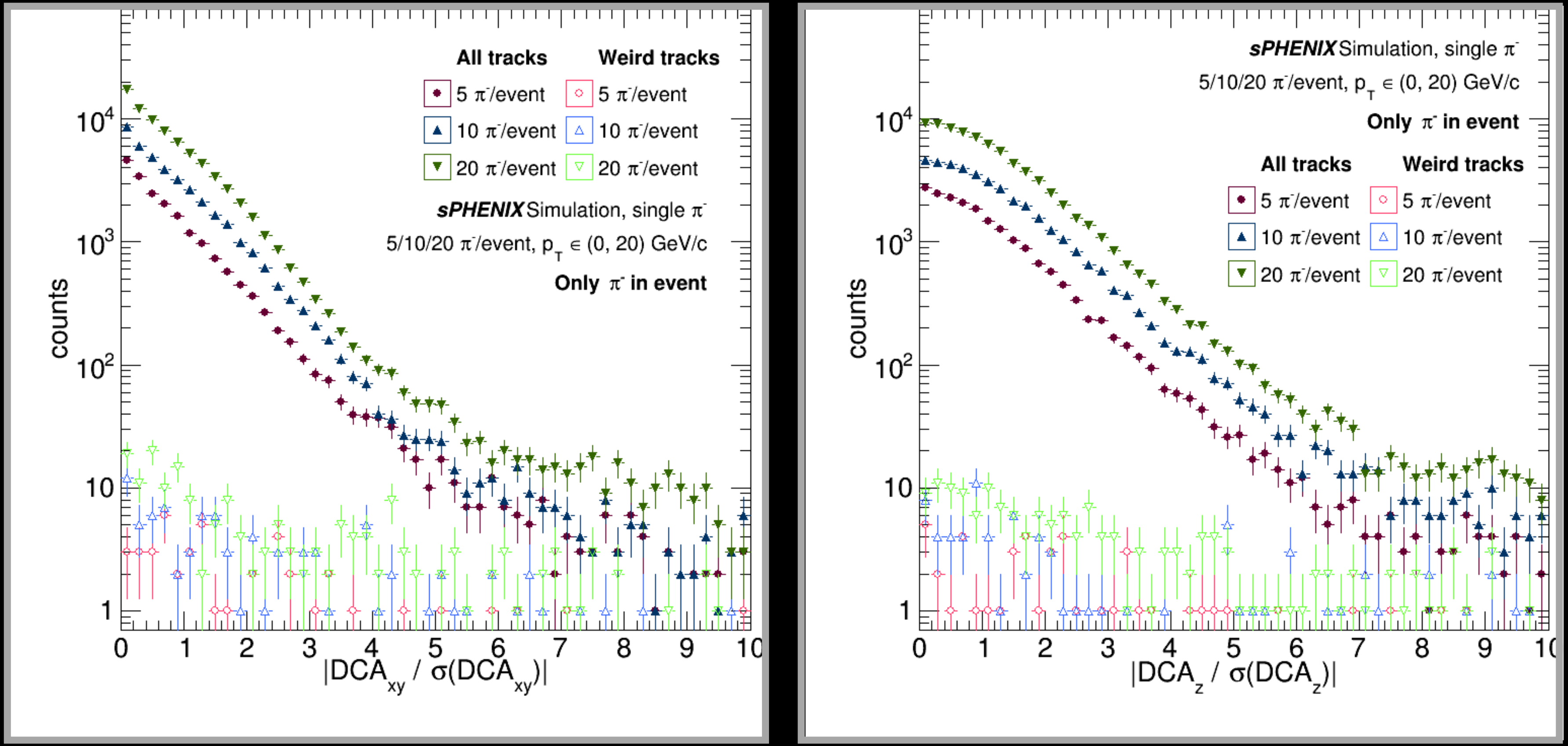



- **Shown:** DCAz/$\sigma$(DCAz)
  - Unnormalized **(left)** , all tracks **(normalized, center)** , and weird tracks **(normalized, right)**
  - For $N_\pi = 5$ **(orange)**, $N_\pi = 10$ **(red)**, $N_\pi = 20$ **(purple)**, $N_\pi = 50$ **(blue)**, and $N_\pi = 100$ **(green)** events

# Previous Slides



# How does DCA/$\sigma$(DCA) look?

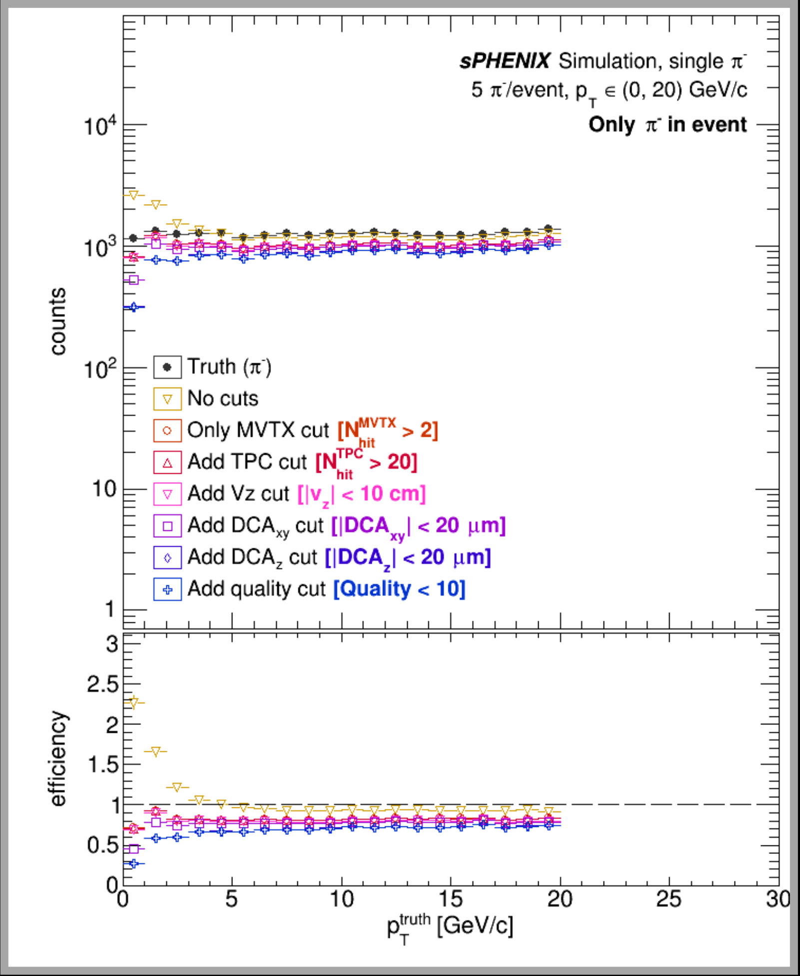


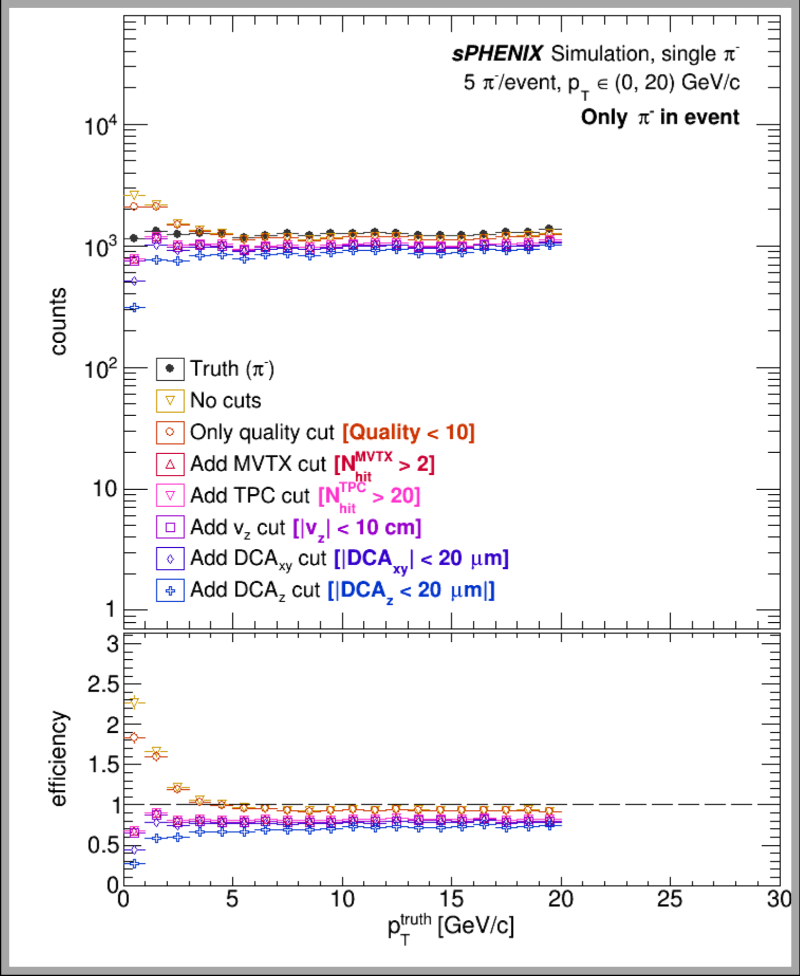

- **Shown:** DCA/$\sigma$(DCA) for DCAxy (right) and DCAz (left)
  - Shown for $N_{\pi} = 5$ **(red)**, $N_{\pi} = 10$ **(blue)**, and $N_{\pi} = 20$ **(green)** events
  - ($N_{\pi} = 50$ and $N_{\pi} = 100$ events in progress…)

# How does changing cut hierarchy affect efficiency?

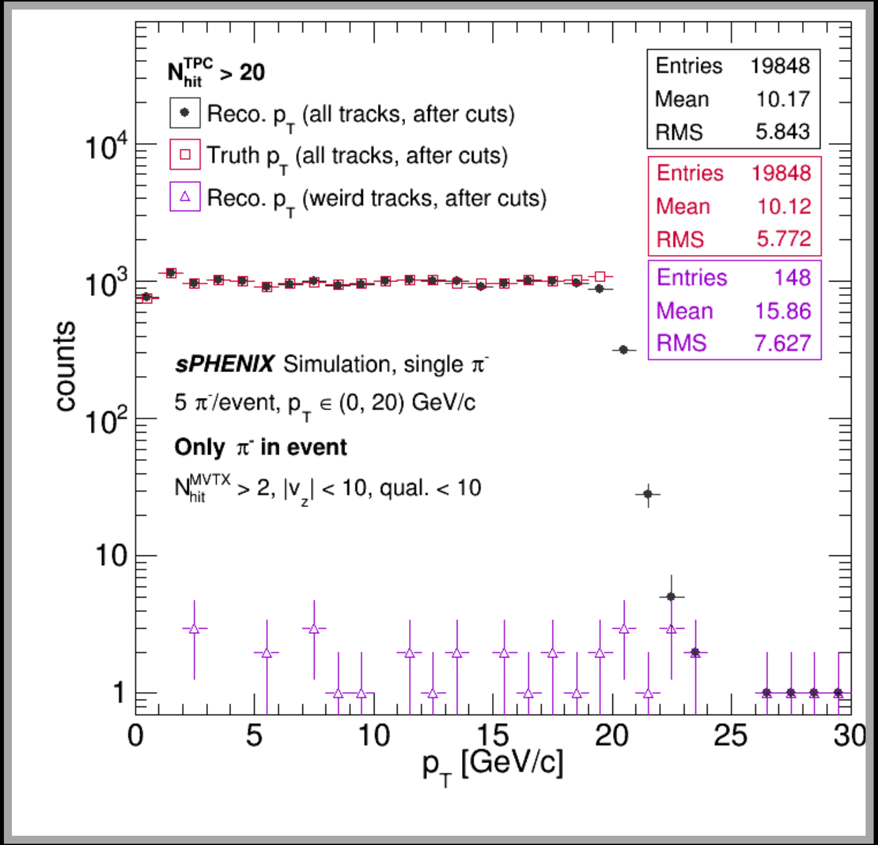
- **Shown:** How reco. efficiency evolves as cuts are added
  - **Left:** quality cut applied last
  - **Right:** quality cut applied first
  - ☞ Quality cut (< 10) on its own doesn't remove many tracks

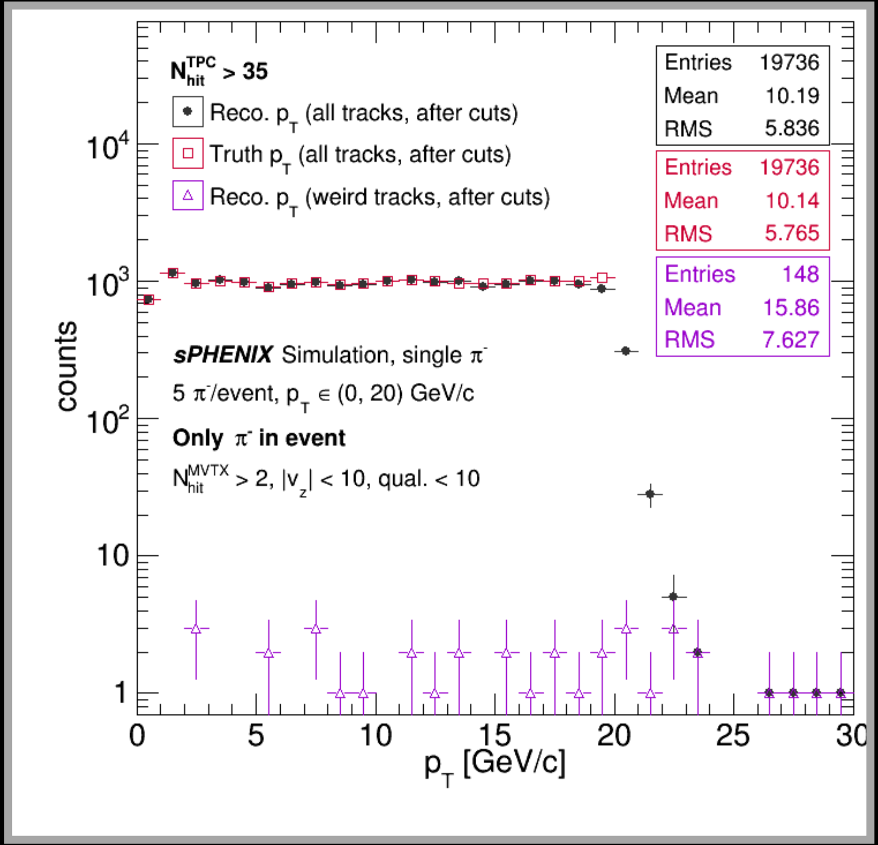
- For $\pi^-$-only events
  - Only 5 $\pi^-$/event
  - (20 $\pi^-$/events in backup)



# What happens when $N_{hit}^{TPC}$ is varied?

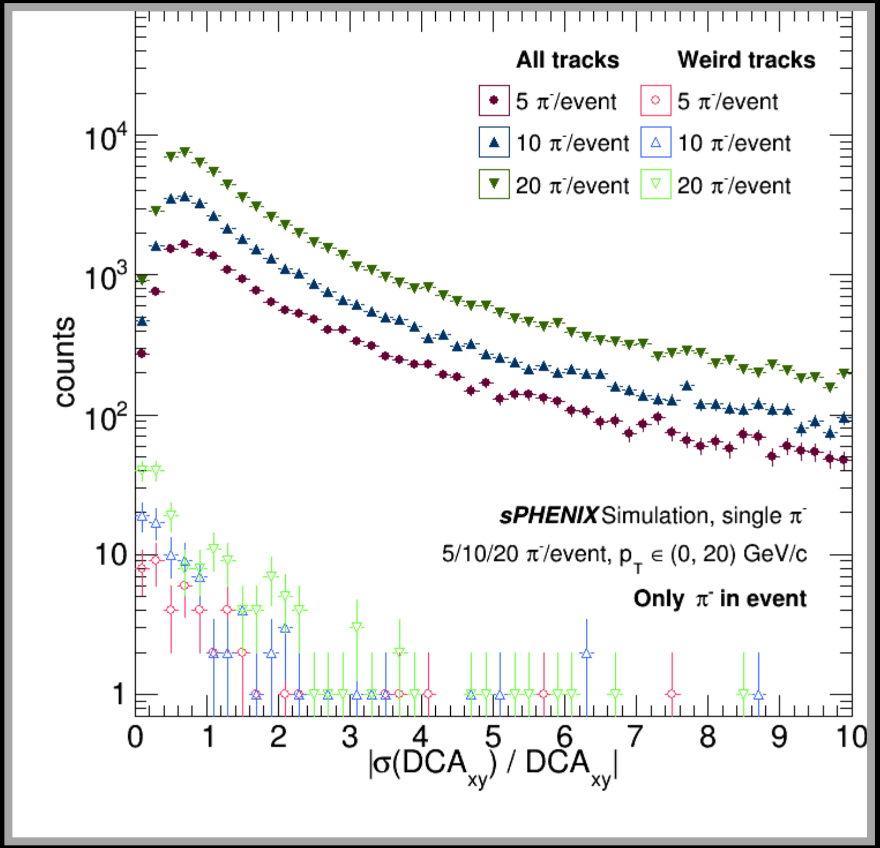


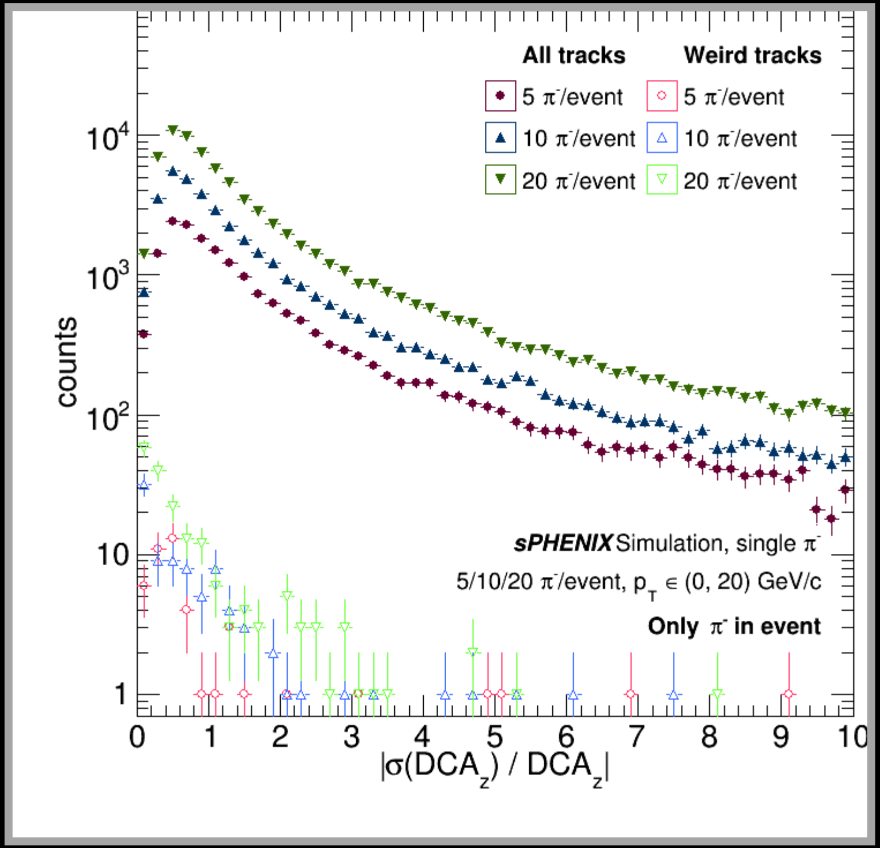




- **Shown:** Reconstructed (black and purple) $p_T$ vs. true $p_T$ (red)
  - Left: $N_{hit}^{TPC} > 20$ cut applied
  - Right: $N_{hit}^{TPC} > 35$ cut applied
- **Varying $N_{hit}^{TPC}$ cut makes little impact**

- **Note:** cuts on $N_{hit}^{MVTX}$, $v_z$, and quality also applied
- Only 5 $\pi^-$/events
  - (10, 20 $\pi^-$/events in backup)

# $\sigma$(DCA)/DCA vs. $N_\pi$

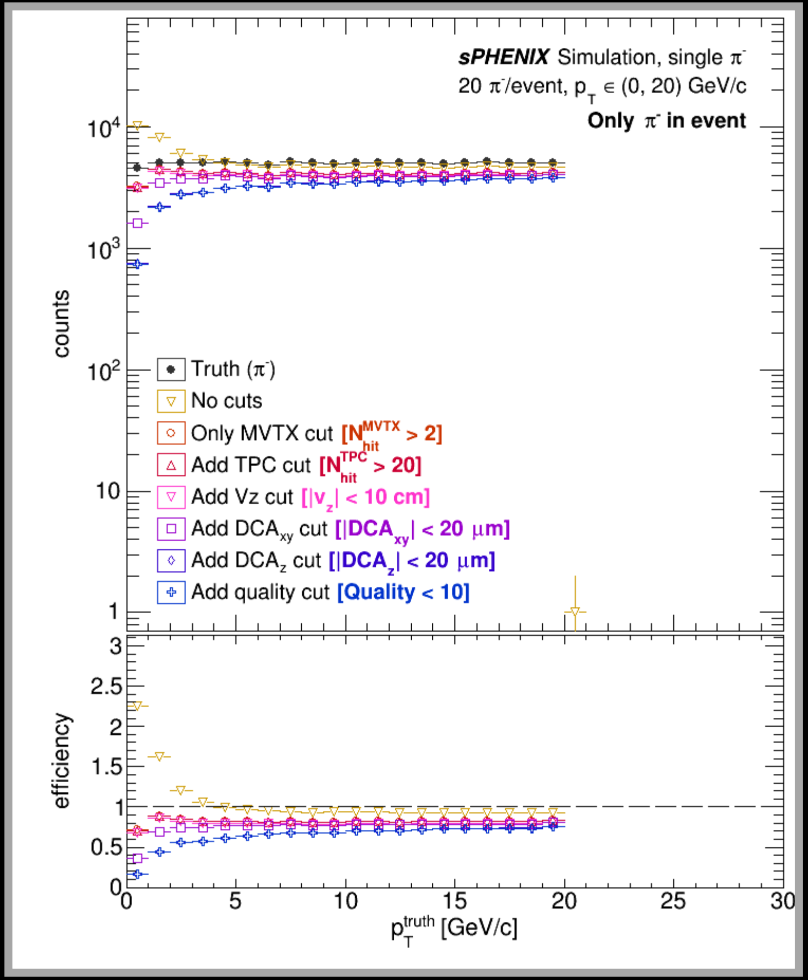


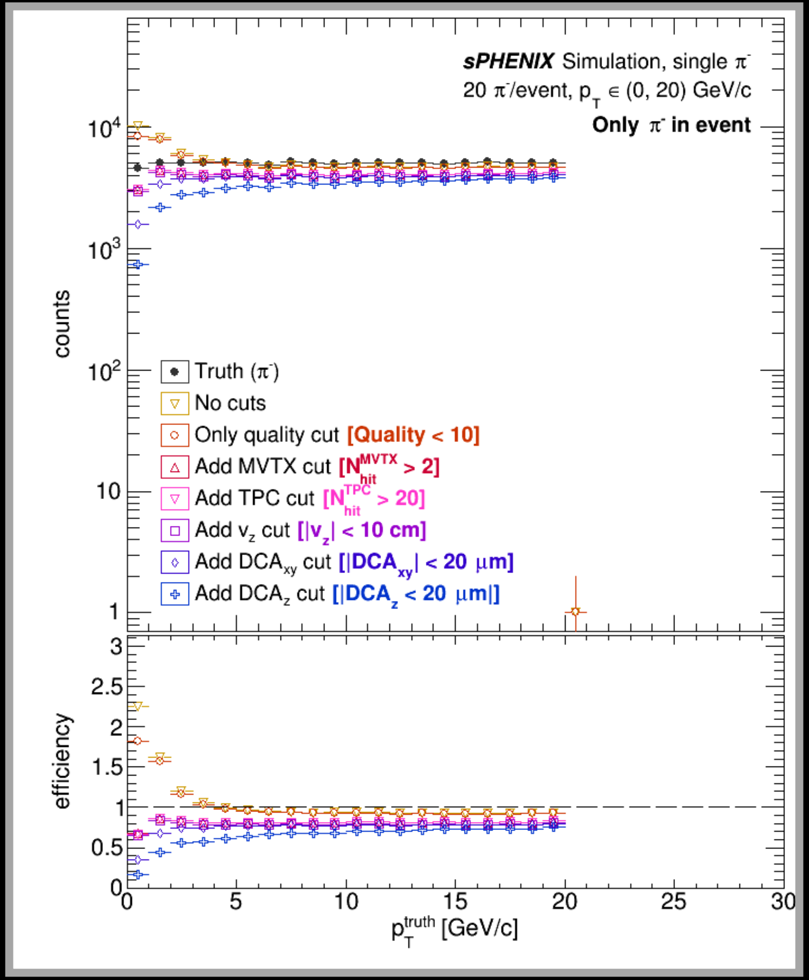




- **Shown:** $\sigma$(DCA)/DCA for DCAxy (right) and DCAz (left)
  - Shown for $N_\pi = 5$ **(red)**, $N_\pi = 10$ **(blue)**, and $N_\pi = 20$ **(green)** events

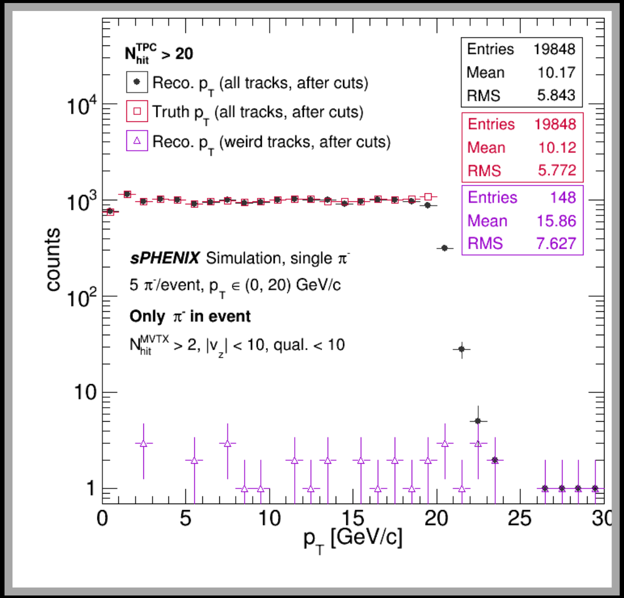
# Cuts vs. efficiency for 20 $\pi^-$/event

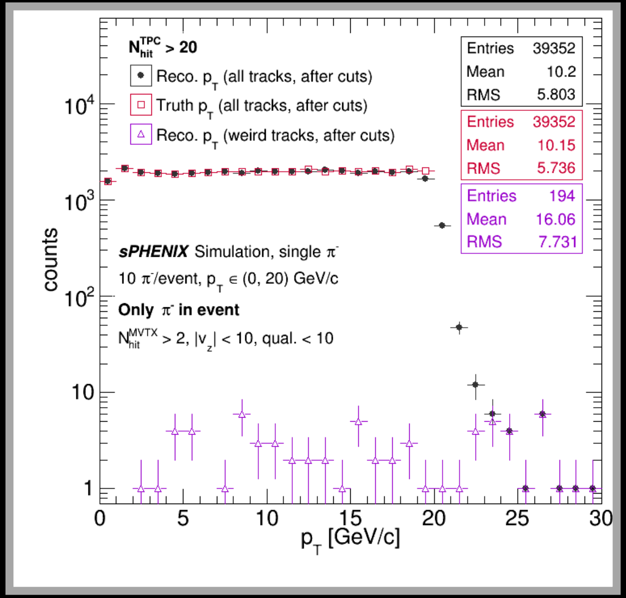
- **Shown:** How reco. efficiency evolves as cuts are added
  - **Left:** quality cut applied last
  - **Right:** quality cut applied first
  - ☞ Quality cut (< 10) on its own doesn't remove many tracks
- For $\pi^-$-only events
  - 20 $\pi^-$/event

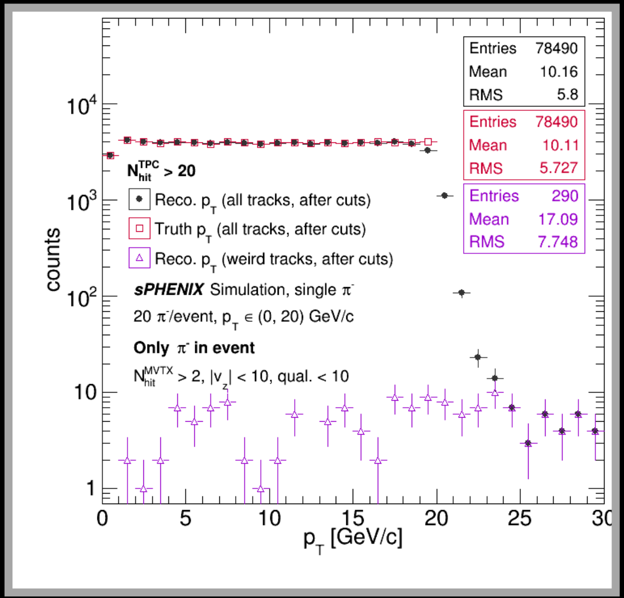


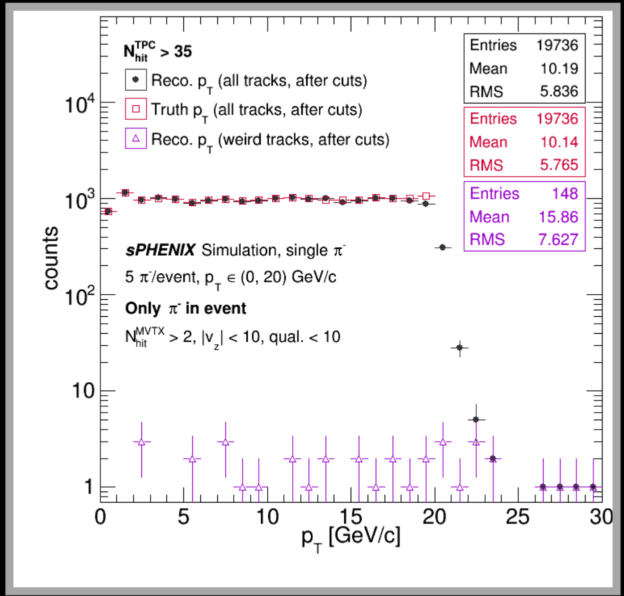



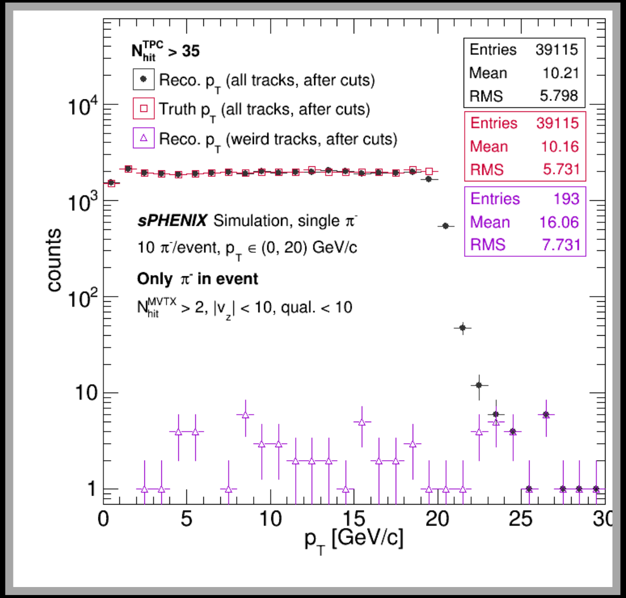
# Varying $N_\pi$ and $N_{hit}^{TPC}$

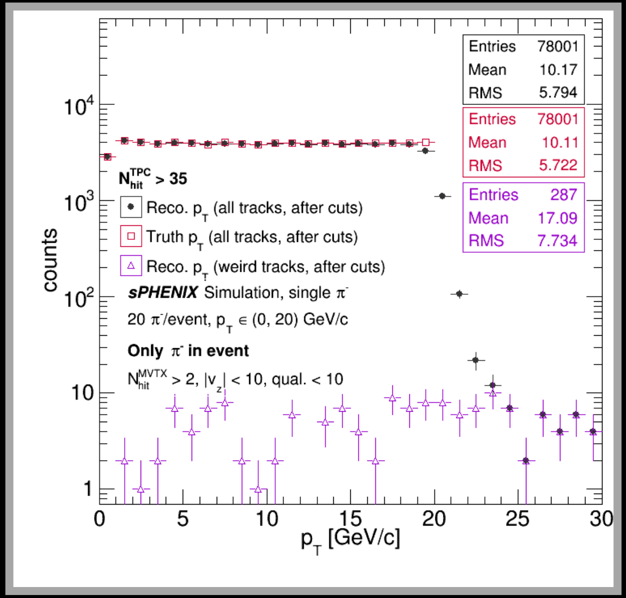


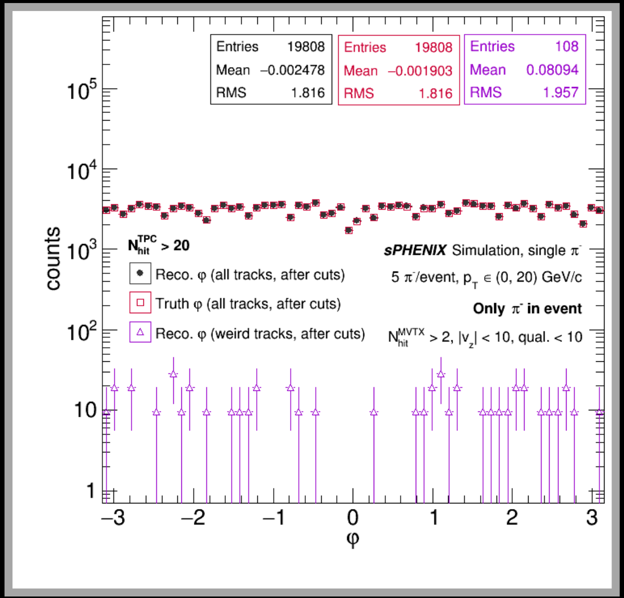



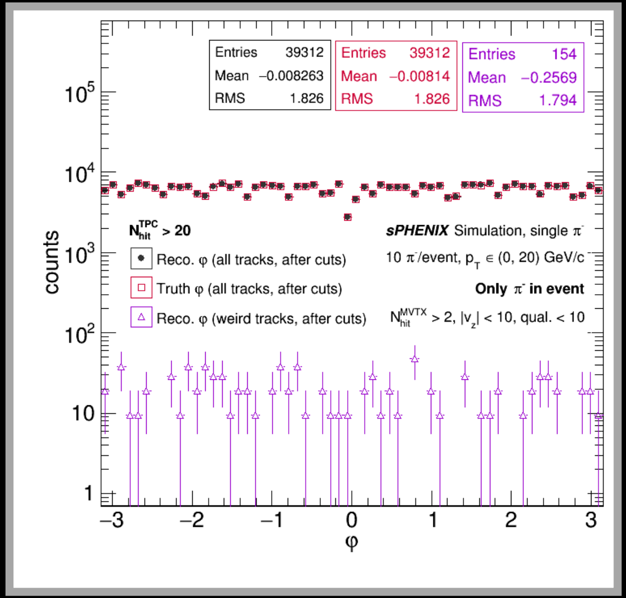



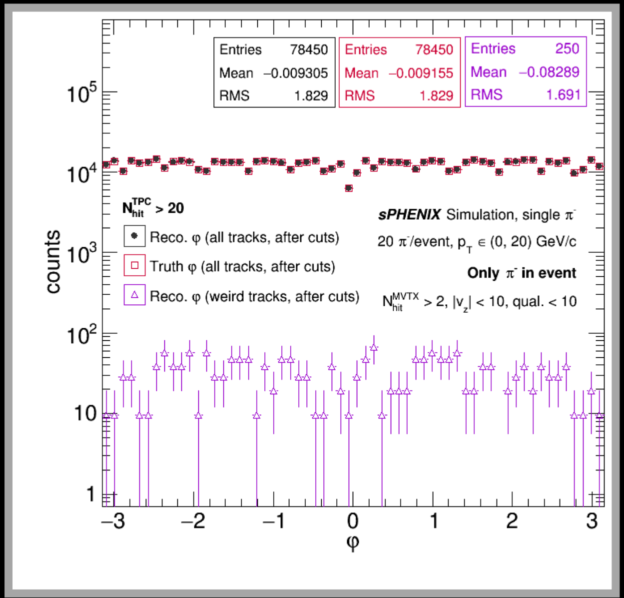



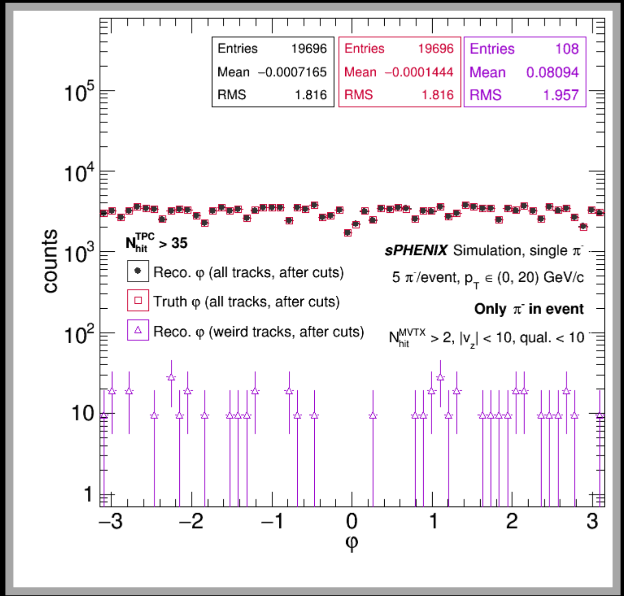



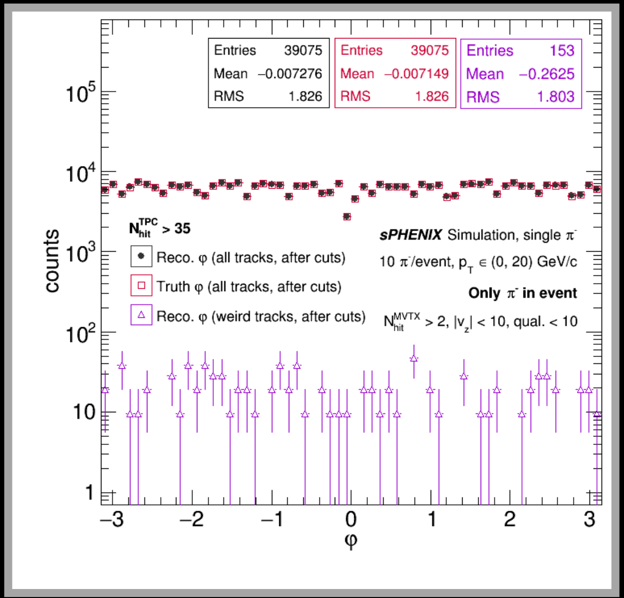
# Varying $N_{\pi}$ and $N_{hit}^{TPC}$

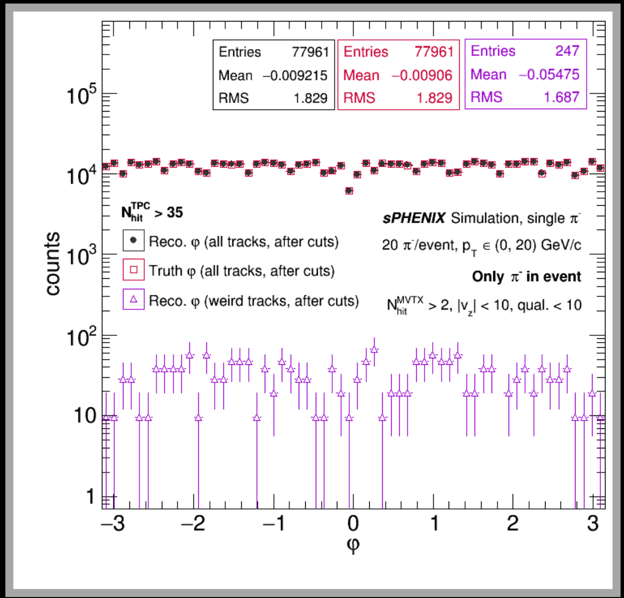


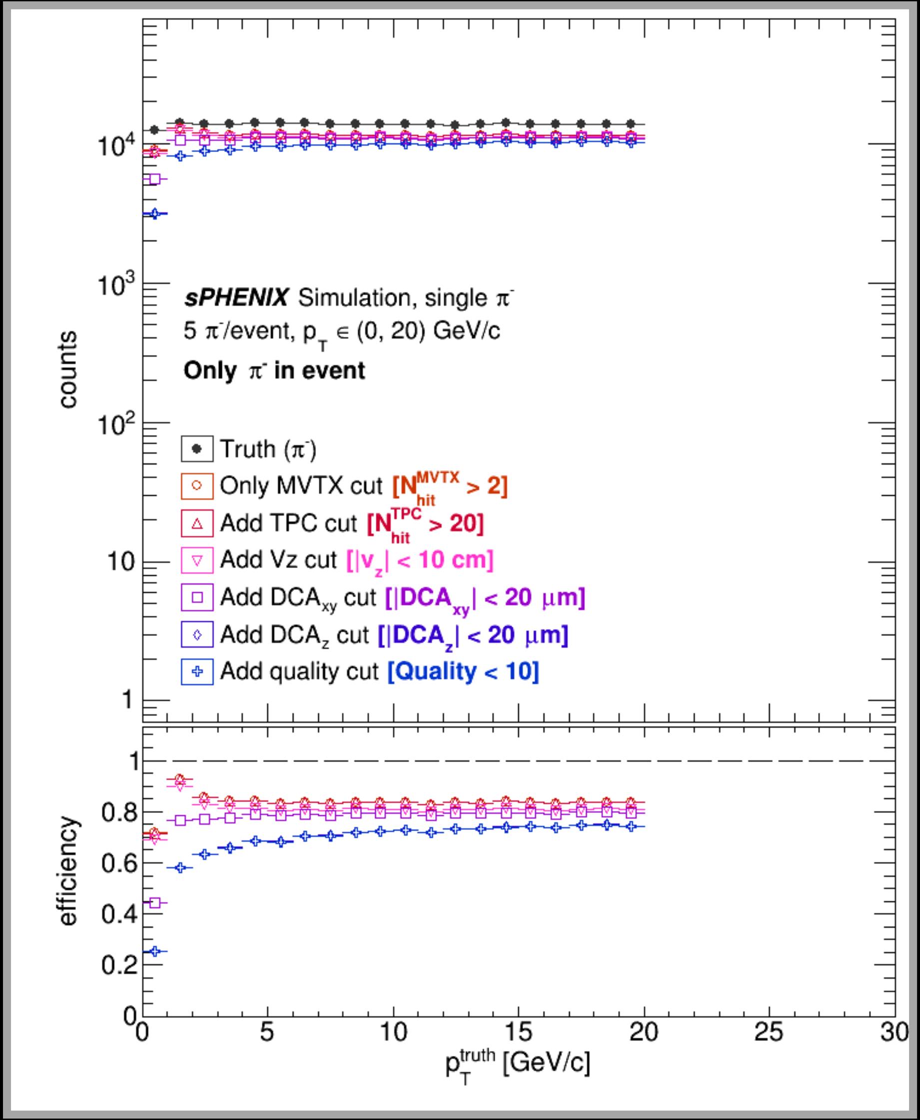



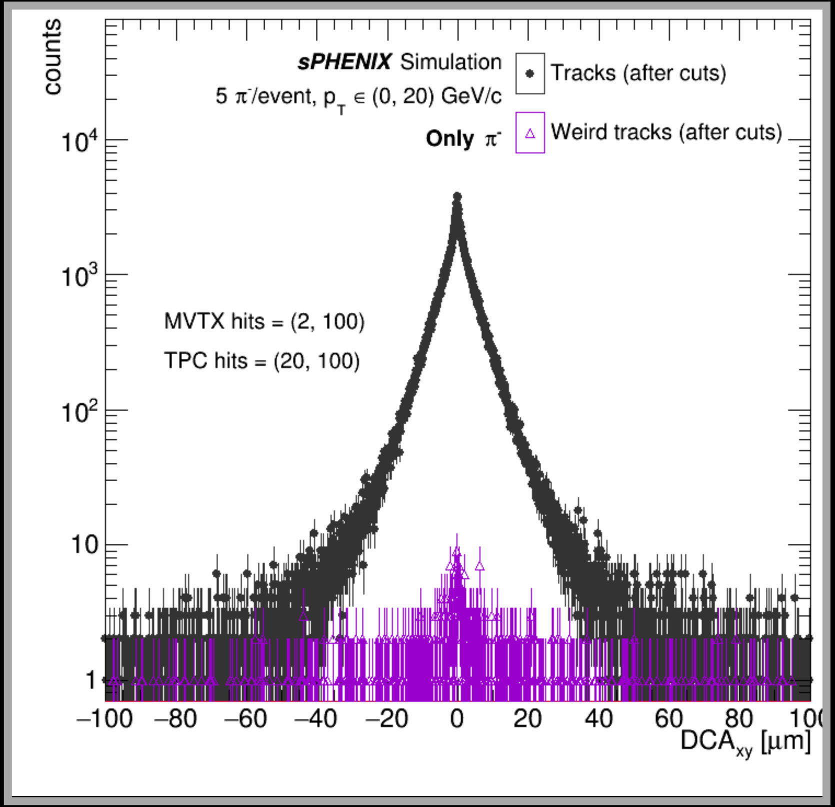
# Tracking Efficiency vs. Cuts

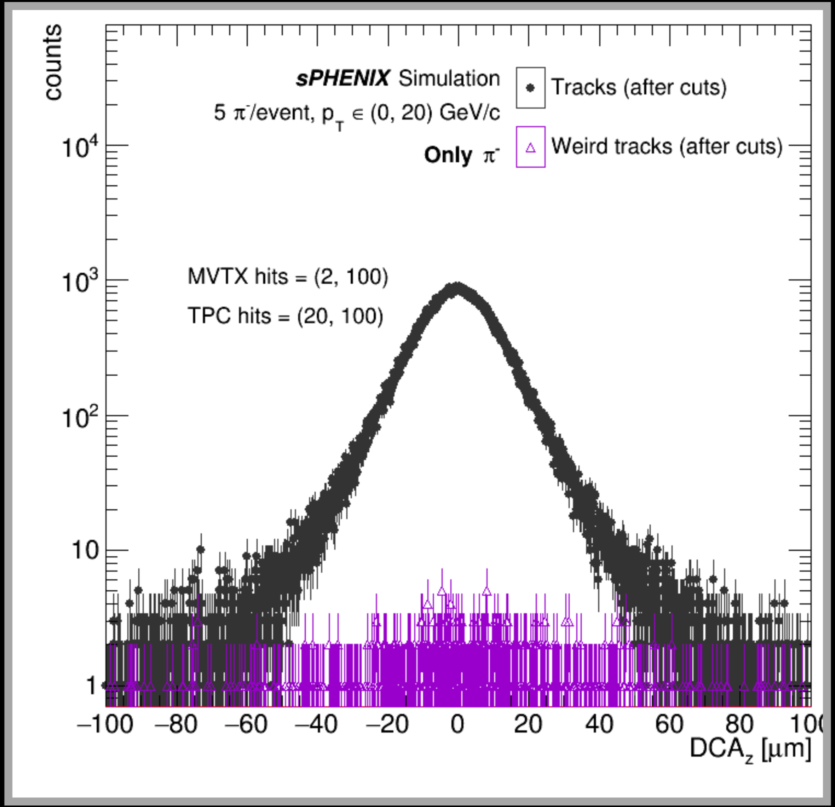
- **Shown:** How reco. efficiency evolves as cuts are added
  - Biggest effects are due to DCA…
  - **Note:** "Add quality cut" and "Add DcaZ cut" points are on top of each other

- For $\pi^-$-only events
  - Only 5 $\pi^-$/event
  - ☞ Now working on events with more $\pi^-$



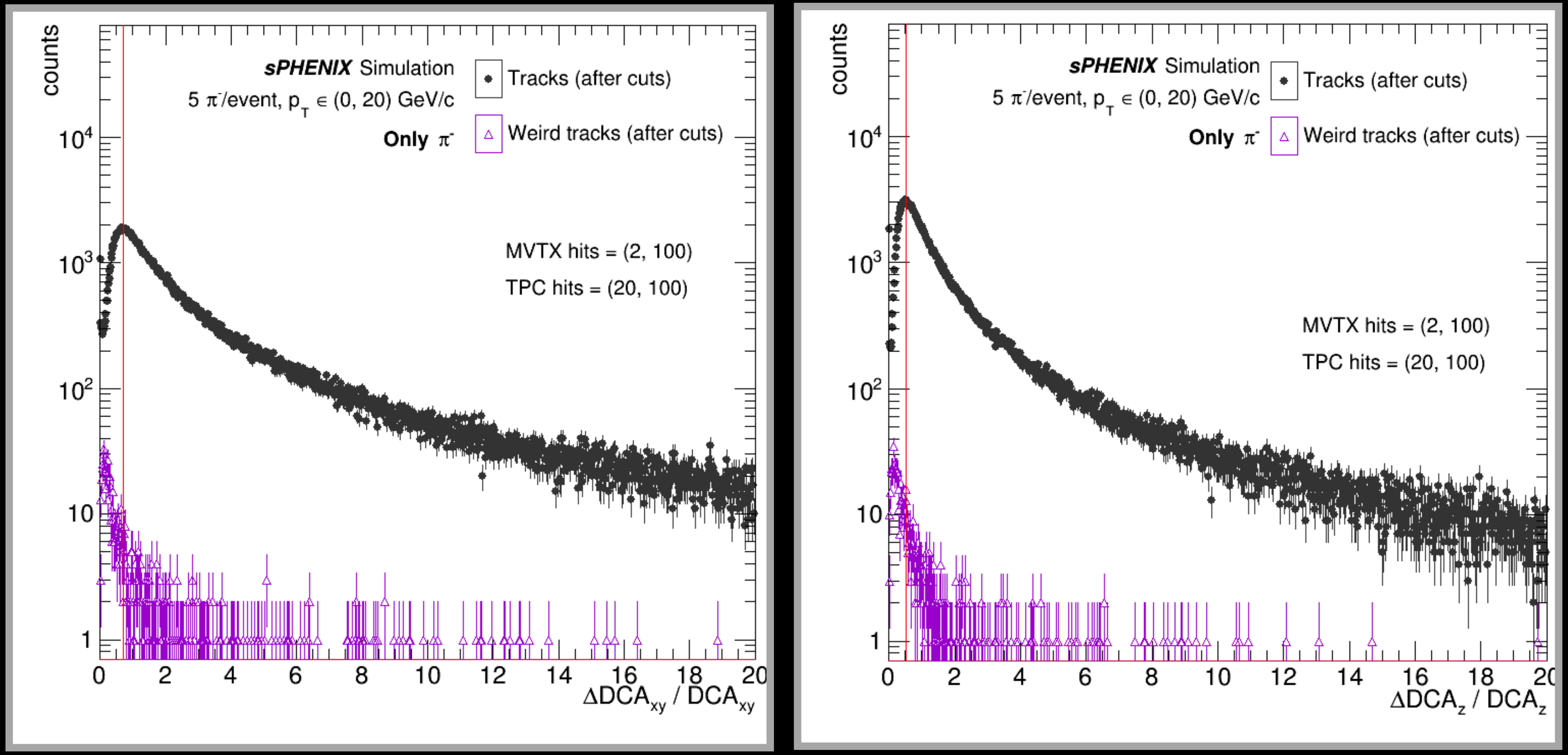
# Track DCA Distributions



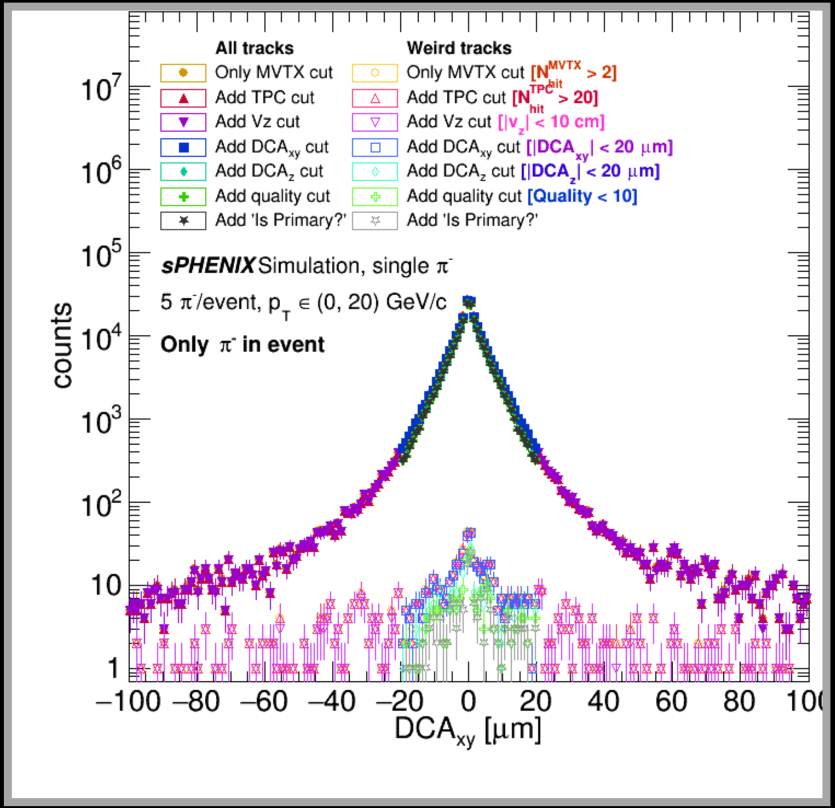

- **Left:** track DCAxy distribution
  **Right:** track DCAz distribution
  - ☞ Only for 5 $\pi^-$/event
- **Black** points are all tracks, **purple** points are weird tracks

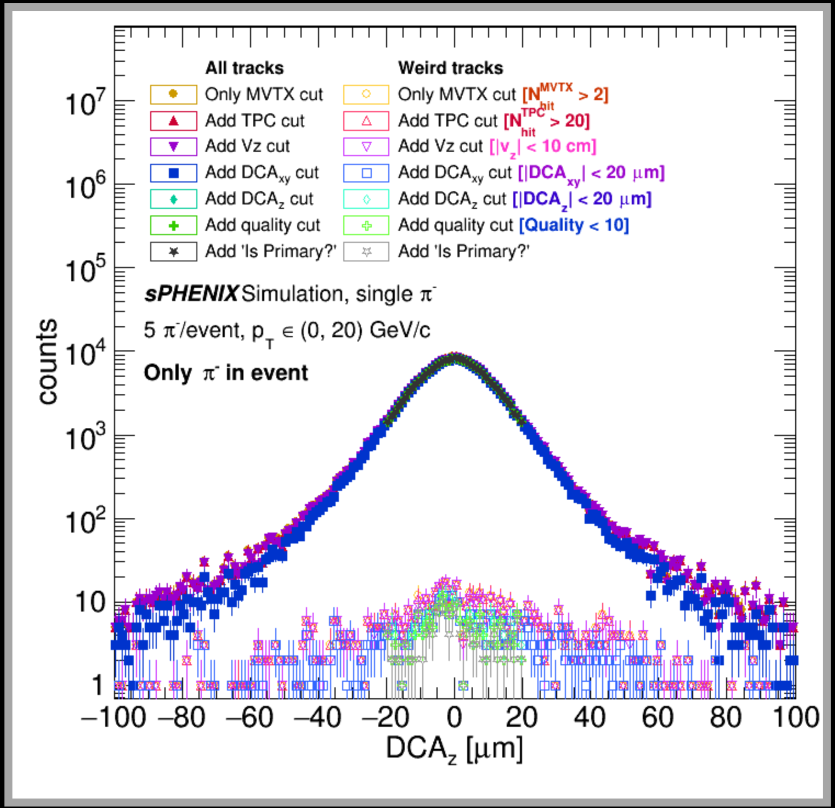
# Track $\sigma_{DCA}$/DCA Distributions




- **Left:** track DCAxy distribution
  **Right:** track DCAz distribution
  - Only for 5 $\pi^{-}$/event
- **Black** points are all tracks, **purple** points are weird tracks
- **Red** lines indicate maxima of distribution for all tracks

# Track DCA vs. Successive Cuts

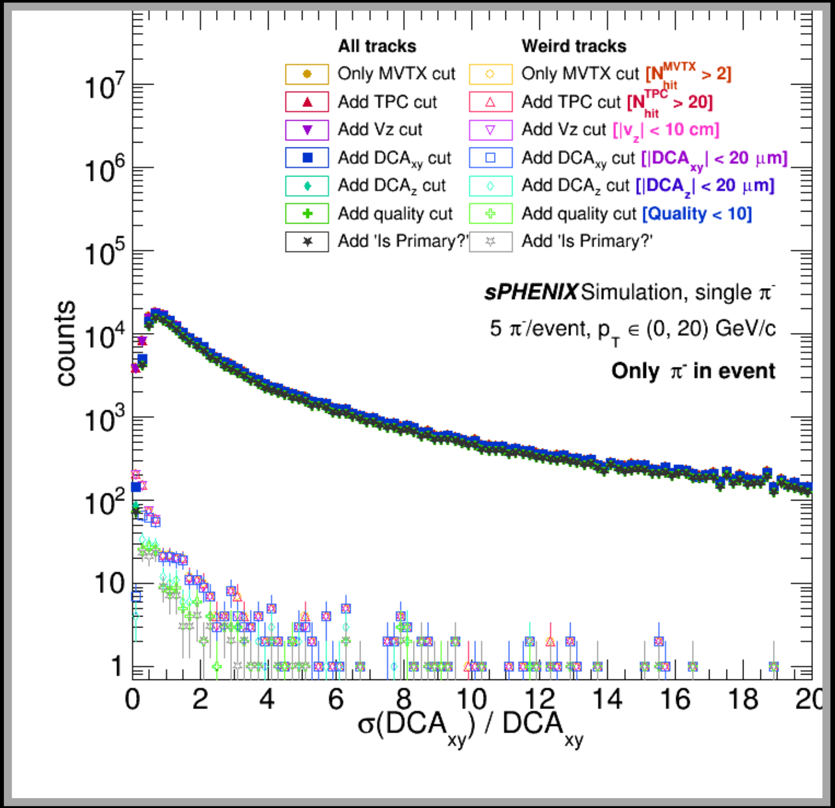


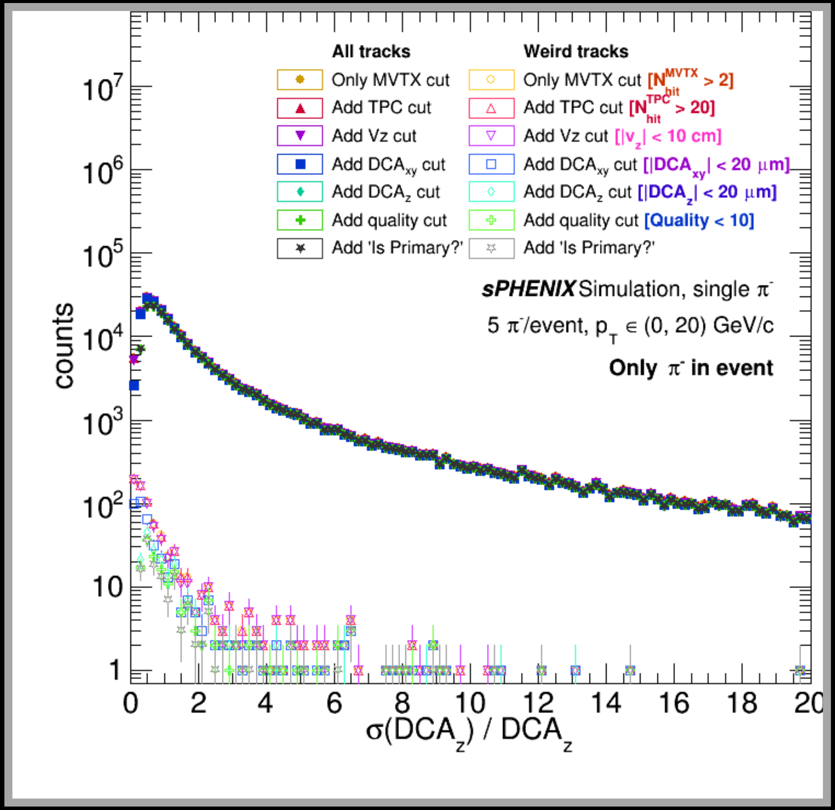




- **Left:** track DCAxy distribution
  **Right:** track DCAz distribution
  ☞ Only for 5 $\pi^-$/event
- **Closed Markers:** all tracks
  **Open Markers:** weird tracks

# Track $\sigma_{DCA}$/DCA vs. Successive Cuts

sPHENIX

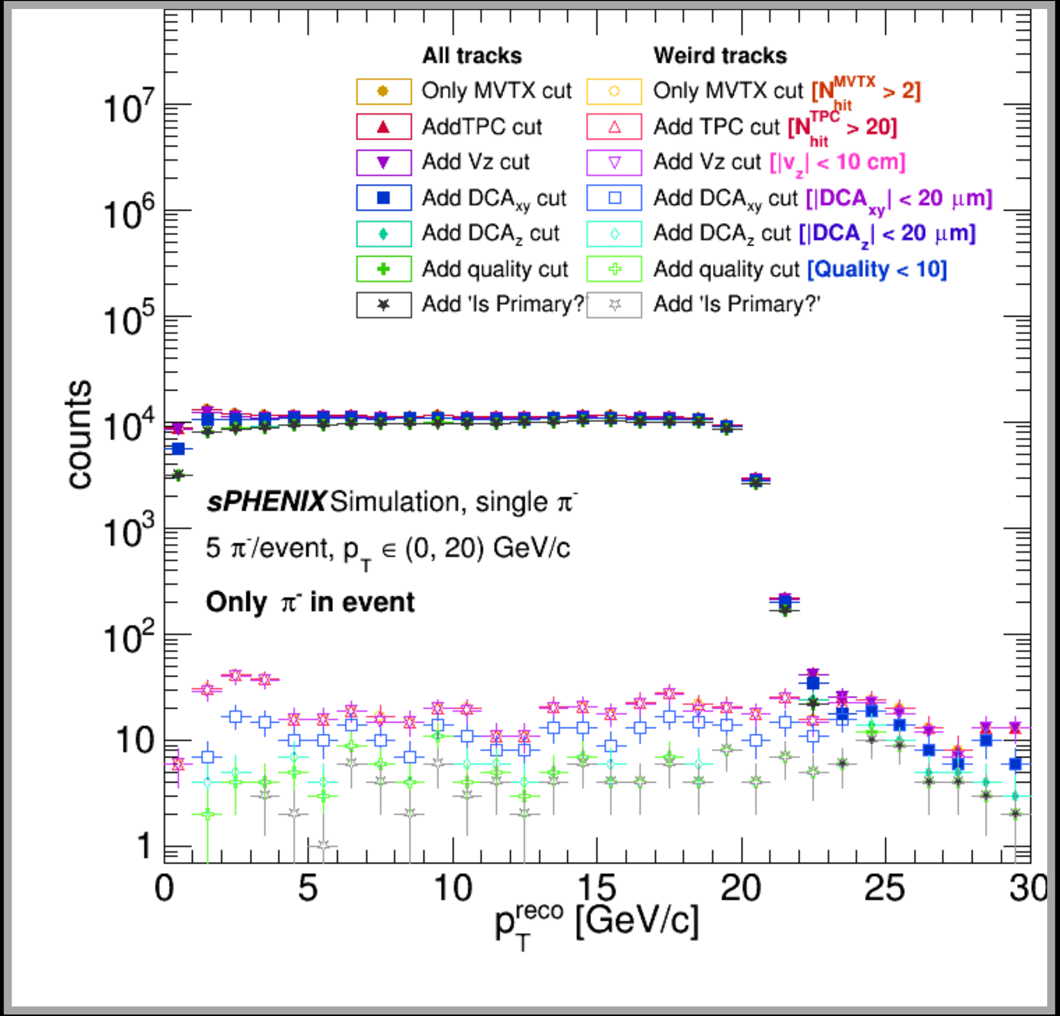


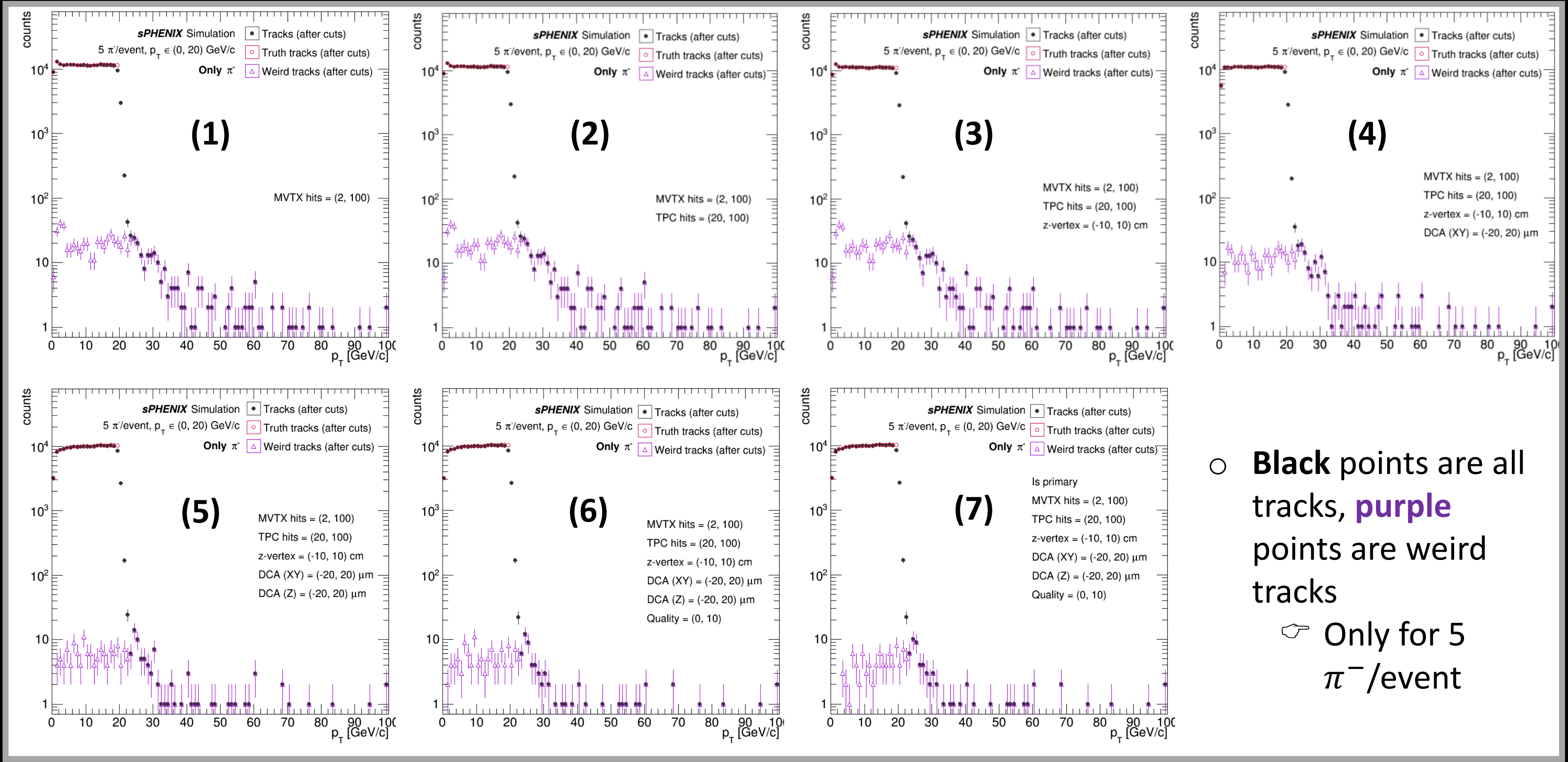

- **Left:** track DCAxy distribution
  **Right:** track DCAz distribution
  ☞ Only for 5 $\pi^-$/event
- **Closed Markers:** all tracks
  **Open Markers:** weird tracks

# Track $p_T$ vs. Successive Cuts | 1 panel

- **Left:** track DCAxy distribution
  **Right:** track DCAz distribution
  - ☞ Only for 5 $\pi^-$/event
- **Closed Markers:** all tracks
  **Open Markers:** weird tracks



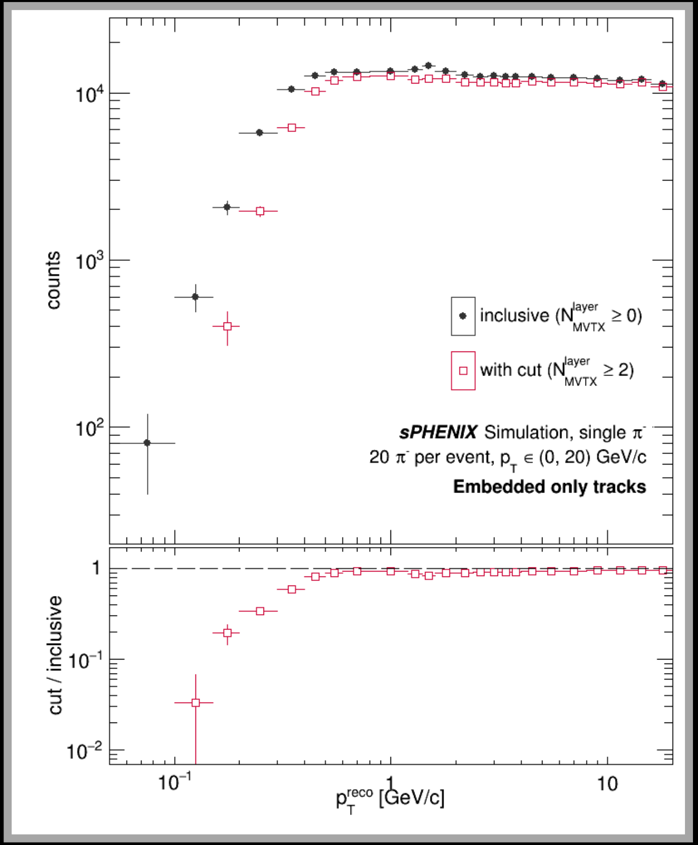
# Track $p_T$ vs. Successive Cuts | 7 panels

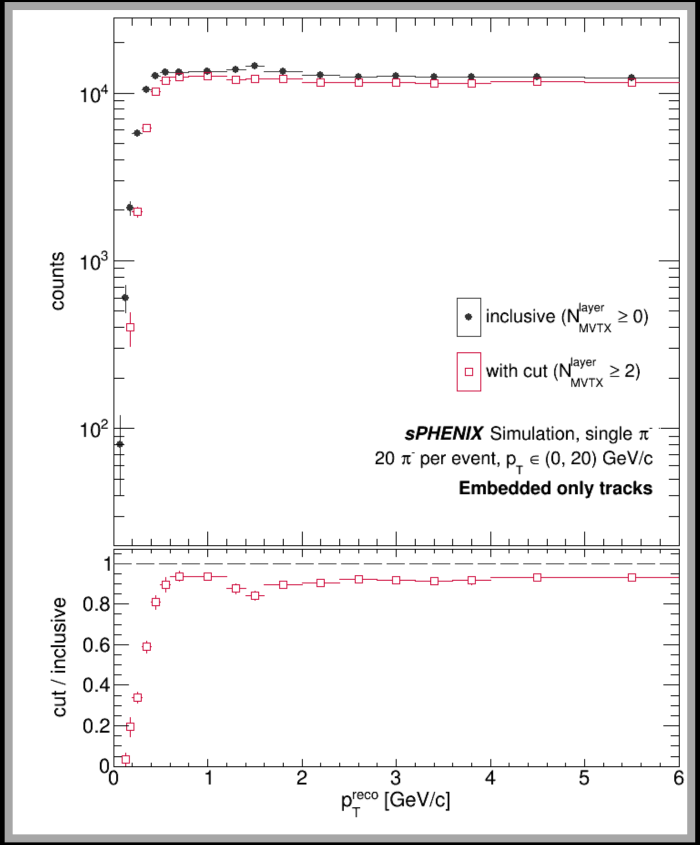



- **Black** points are all tracks, **purple** points are weird tracks
  - Only for 5 $\pi^{-}$/event

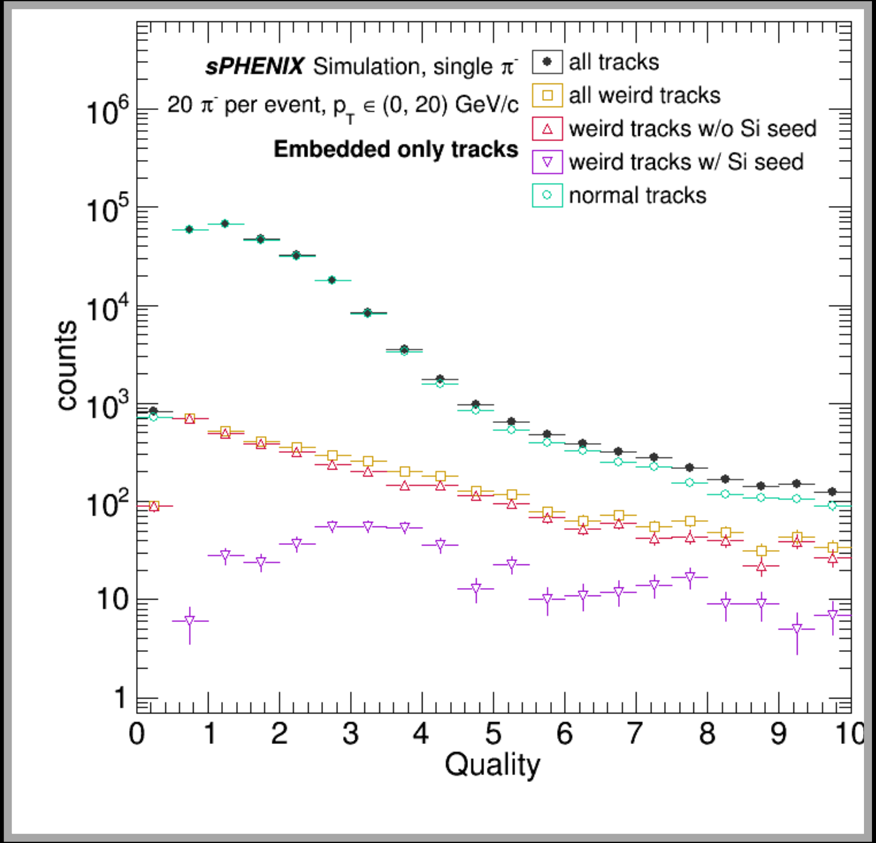
# MVTX Hits >= 2 vs. Inclusive

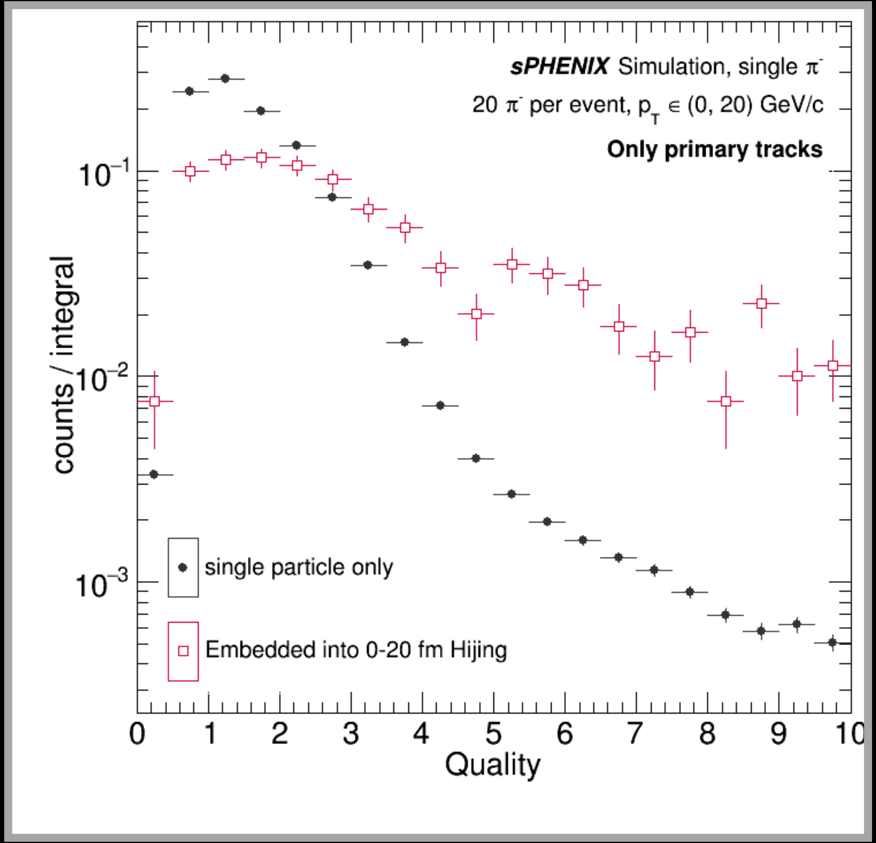
- Reconstructed track $p_T$ of primary tracks w/
  - $N_{MVTX}^{layer} \geq 2$ **(red)** vs.
  - Inclusive **(black)**
- Rebinned left figure on slide 5 to accentuate low-pT region
  - **Left:** log x-axis
  - **Right:** linear x-axis



# Track Quality in Hijing



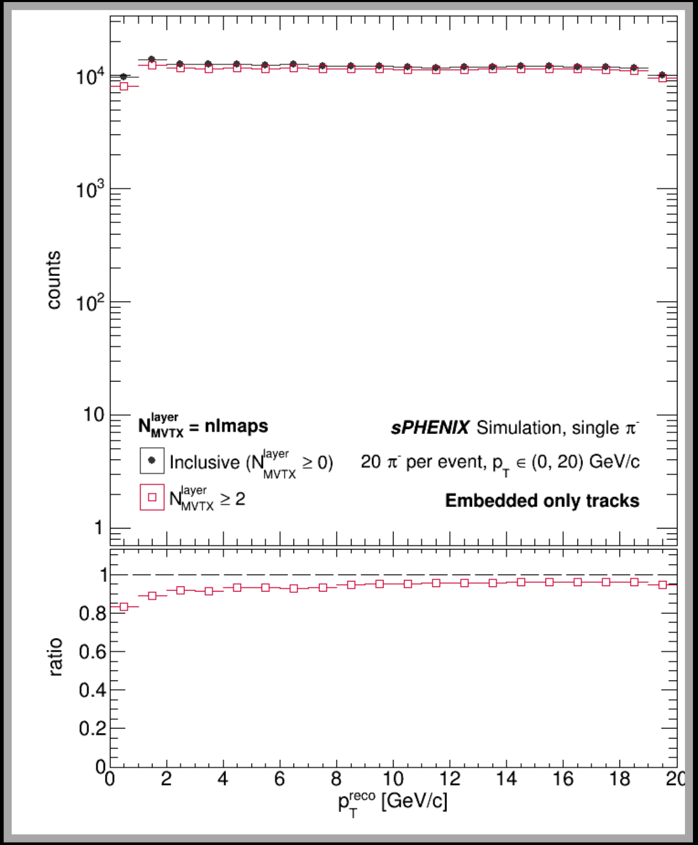



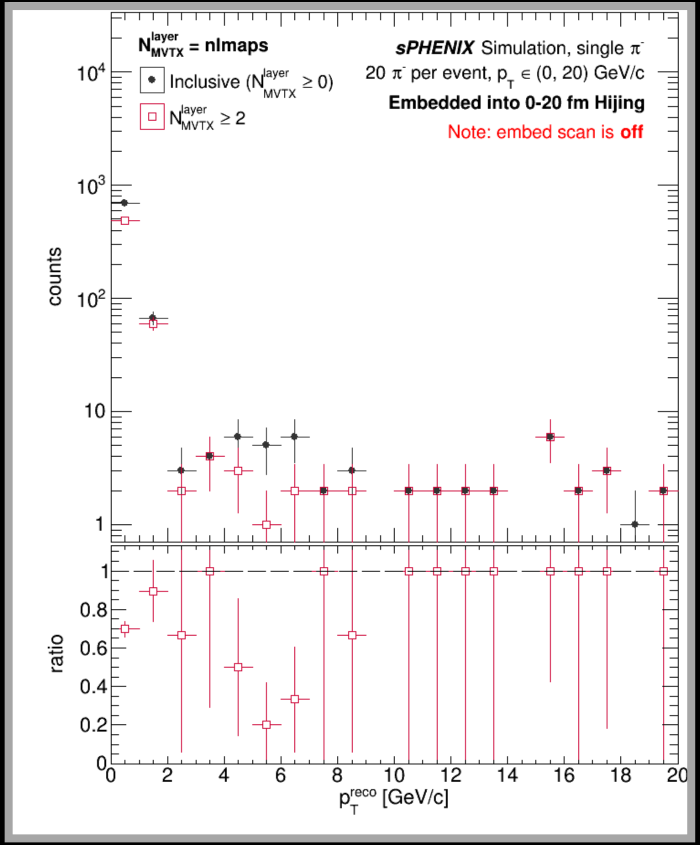

- Ratio of weird/normal (primary) tracks to all (primary) tracks as a function of quality
  - **Left:** single particle only
  - **Right:** single particle vs. embedded into Hijing
- **Reminder:**
  - Weird $\Rightarrow p_T^{reco}/p_T^{true} \notin (0.2, 1.20)$
  - Normal $\Rightarrow p_T^{reco}/p_T^{true} \in (0.2, 1.20)$

# MVTX Hits >= 2 vs. Inclusive | track pT

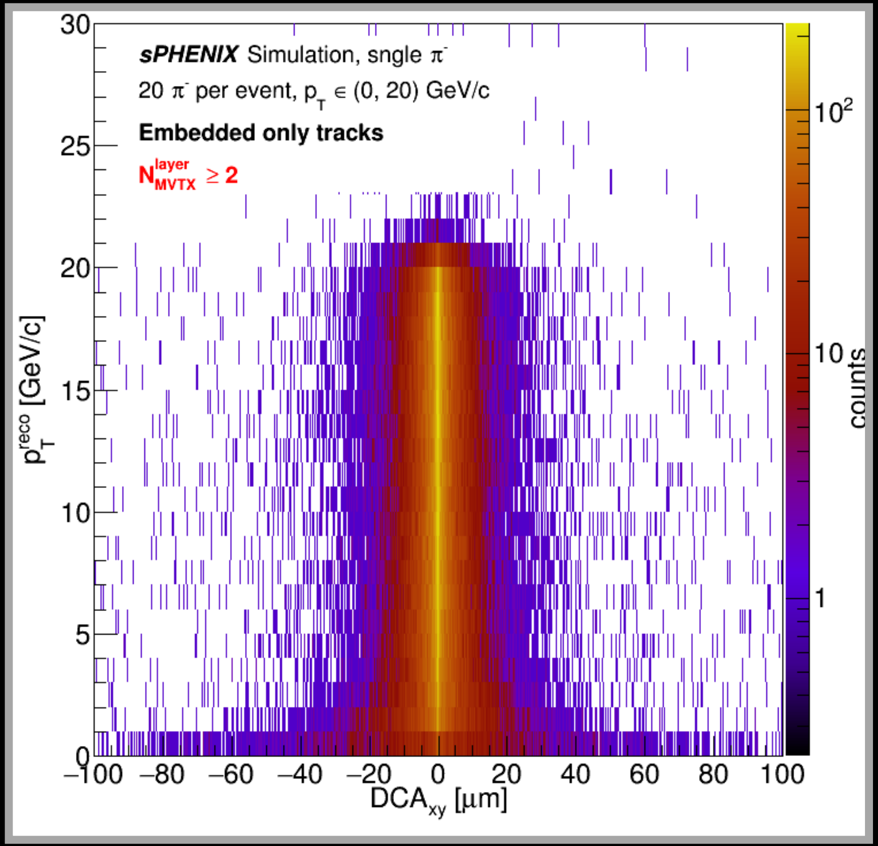
- Reconstructed track $p_T$ of primary tracks w/
  - $N_{MVTX}^{layer} \geq 2$ **(red)** vs.
  - Inclusive **(black)**

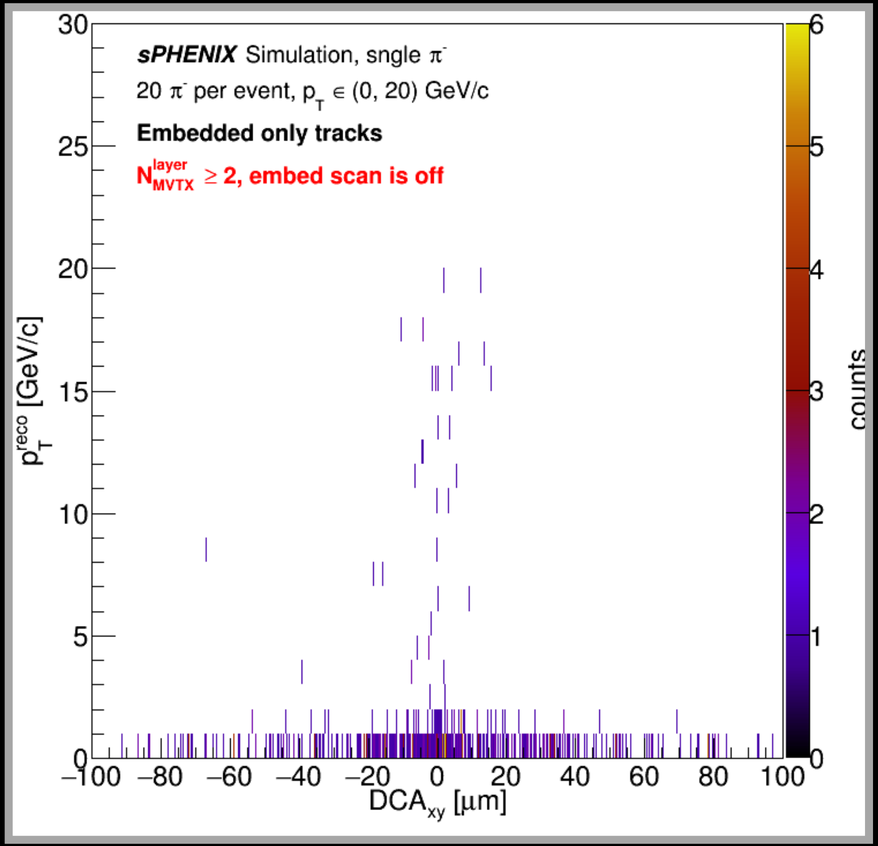
- **Left:** single particle only
  **Right:** single particles embedded into Hijing
  ⇒ Not enough stats for embedded tracks!



# MVTX Hits >= 2 | track DCAxy

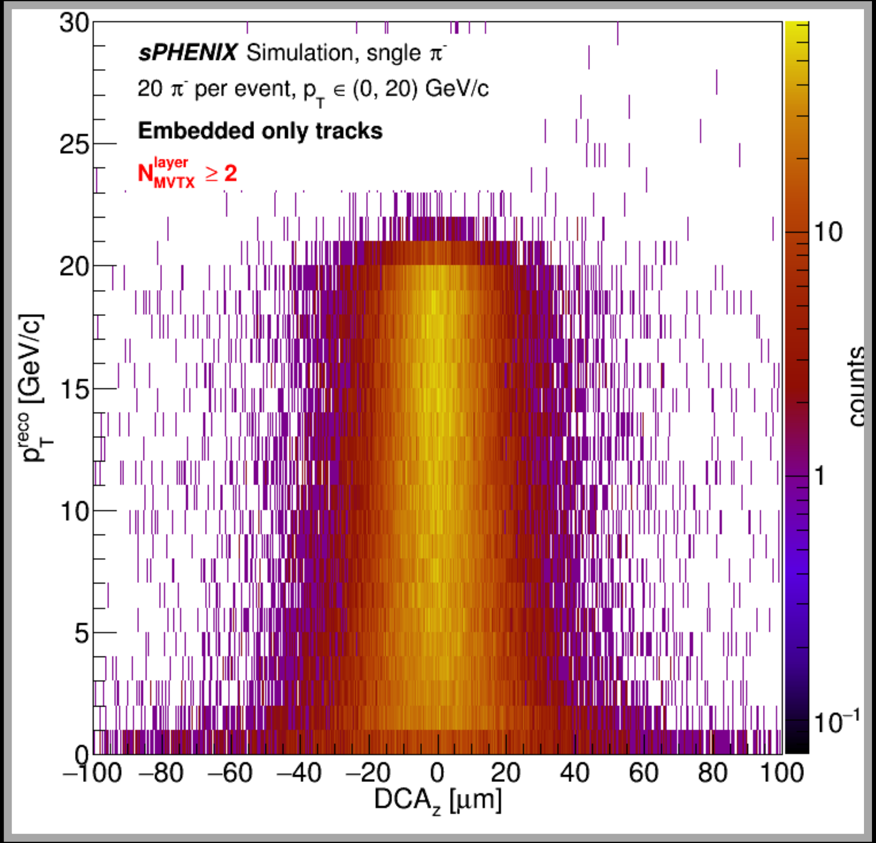


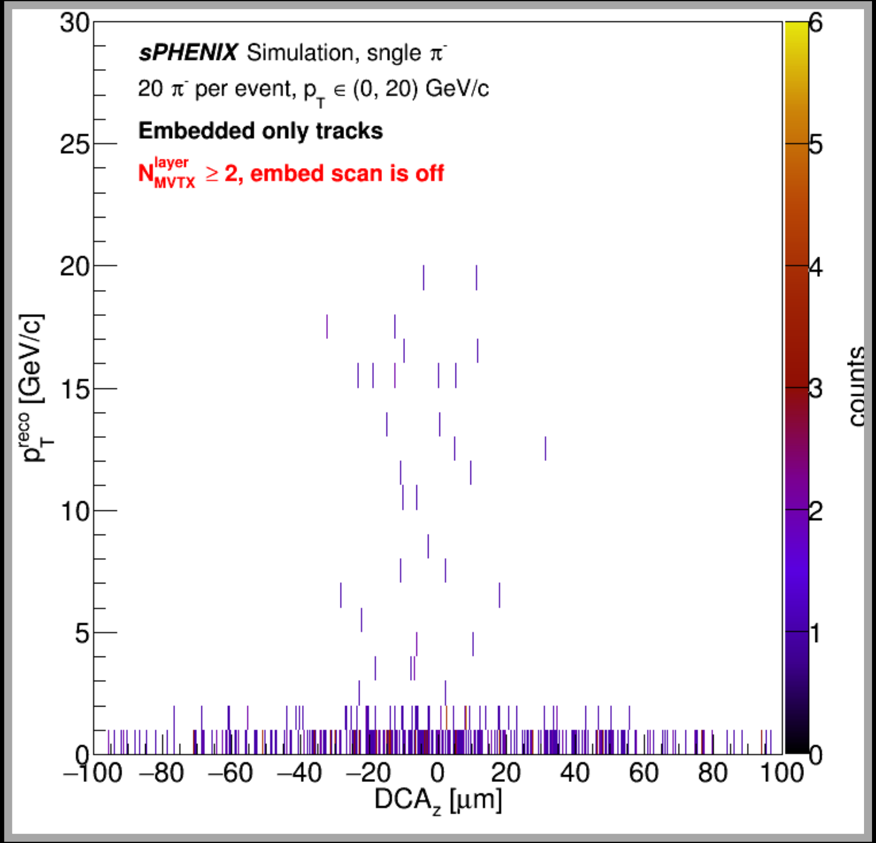




- Primary track DCAxy for primary tracks w/ $N^{layer}_{MVTX} \geq 2$

- **Left:** single particle only
  **Right:** single particles embedded into Hijing
  ⇒ Not enough stats for embedded tracks!

# MVTX Hits >= 2 | track DCAz




- Primary track DCAxy for primary tracks w/ $N^{layer}_{MVTX} \geq 2$

- **Left:** single particle only
  **Right:** single particles embedded into Hijing
  ⇒ Not enough stats for embedded tracks!

# For Next Time

**Plots to Make:**

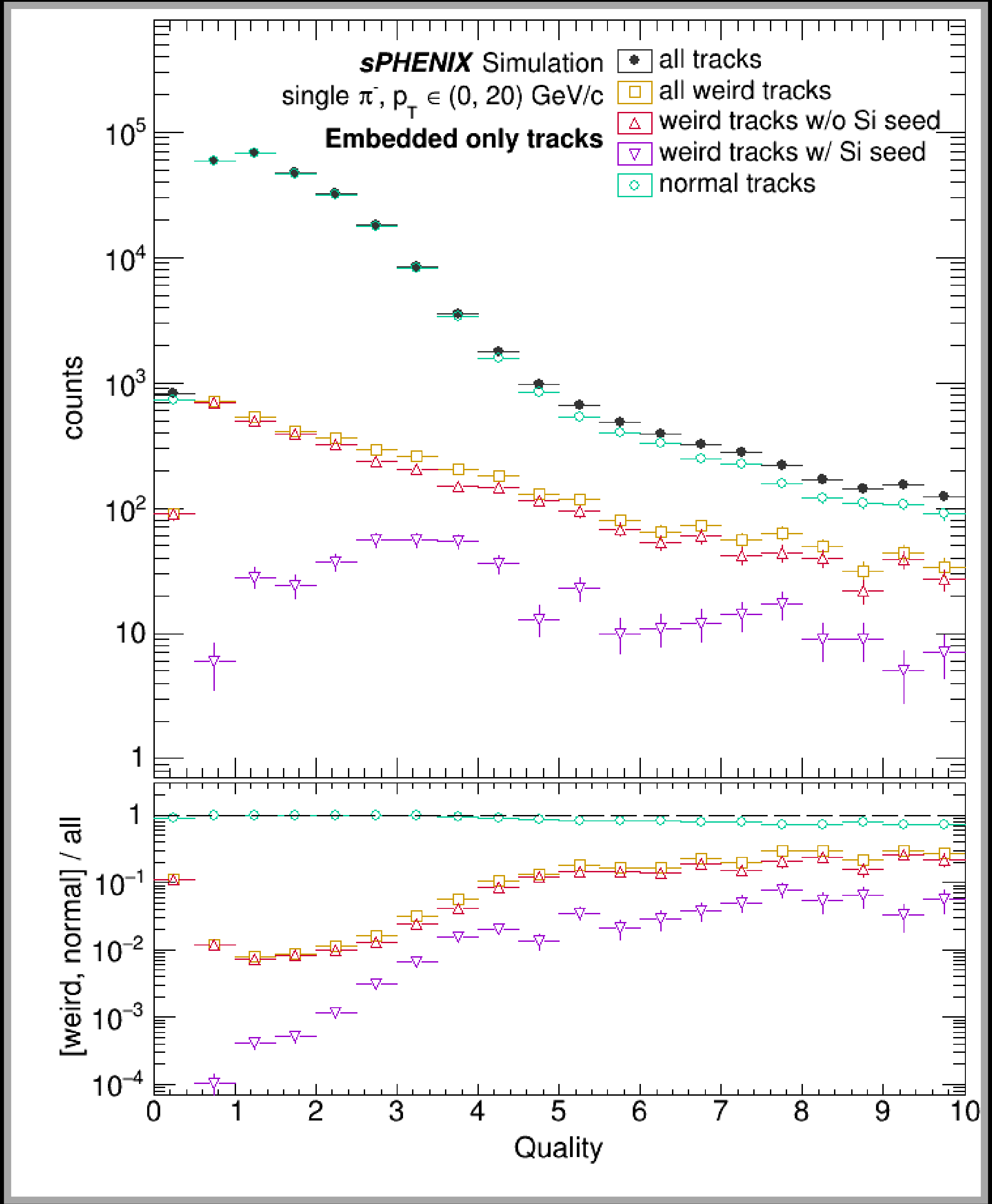
- Quality (and other track quantities) vs. $N_{TPC}^{hit}$
- Average cluster size for weird tracks vs. normal tracks
  - ☞ Do we have access to that in the evaluator?

**To Take Care Of:**

- Finish refactoring code
  - Did not set it up intelligently 😅
  - Became unmanageable as the no. of different populations to look at grew
- Generate more embedded stats

# Ratio of Weird/Normal Tracks to All

- Ratio of weird/normal (primary) tracks to all (primary) tracks as a function of quality
- **Reminder:**
  - Weird ⇒ $p_T^{reco}/p_T^{true} \notin (0.2, 1.20)$
  - Normal ⇒ $p_T^{reco}/p_T^{true} \in (0.2, 1.20)$



# Details

- **Weird Tracks:** tracks with $p_T^{trk}/p_T^{true} \notin (0.2, 1.2)$
  - Split weird track population into 2 samples:
    - W/o Silicon Seeds: **nmaps == 0**
    - W/ Silicon Seeds: **nmaps == 3**
- **Normal Tracks:** tracks with $p_T^{trk}/p_T^{true} \in (0.2, 1.2)$

- Color scheme:
  - **Black triangles =** primary tracks
  - **Magenta triangles =** truth
  - **Red X's =** weird primary tracks
  - **Blue circles =** normal primary tracks
- In 2D plots:
  - **Color maps =** all primary tracks
  - **Red X scatter plots =** weird primary tracks
  - **Blue circle scatter plots =** normal primary tracks

- Simulated sample of single $\pi^-$
  - 20 $\pi^-$ per event
  - $p_T^{true} \in (0, 20)$ GeV/c
  - Ran w/ scan_for_embed on

- Using larger sample than in previous updates:
  - No. of primary tracks: **244015**
  - No. of weird tracks: **4175**
    - No. w/o silicon seeds: **3582**
    - No. w/ silicon seeds: **578**
    - **15** weird tracks had nmaps == 4
  - No. of normal tracks: **239840**
- Cuts Applied:
  - **gprimary == 1** (select only primary tracks)
  - Cuts to select weird & normal tracks

# Some Observations

**Weird Tracks w/o Silicon Seeds**

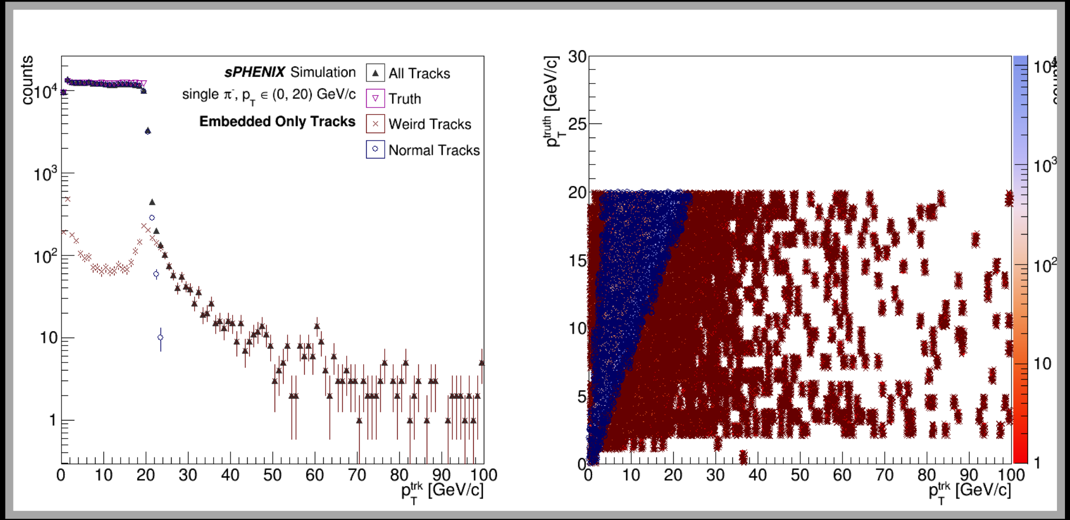
- $p_T^{trk}$ distribution is bimodal (slide 4)
- Majority seem to lie at sector boundaries in phi (slide 5)
- Majority have large DCAxy values (slides 6 and 7)
  - Show no correlation in DCAz (slides 8 and 9)
- $\chi^2$/ndf distribution is falling (slide 10)

**Weird Tracks w/ Silicon Seeds**

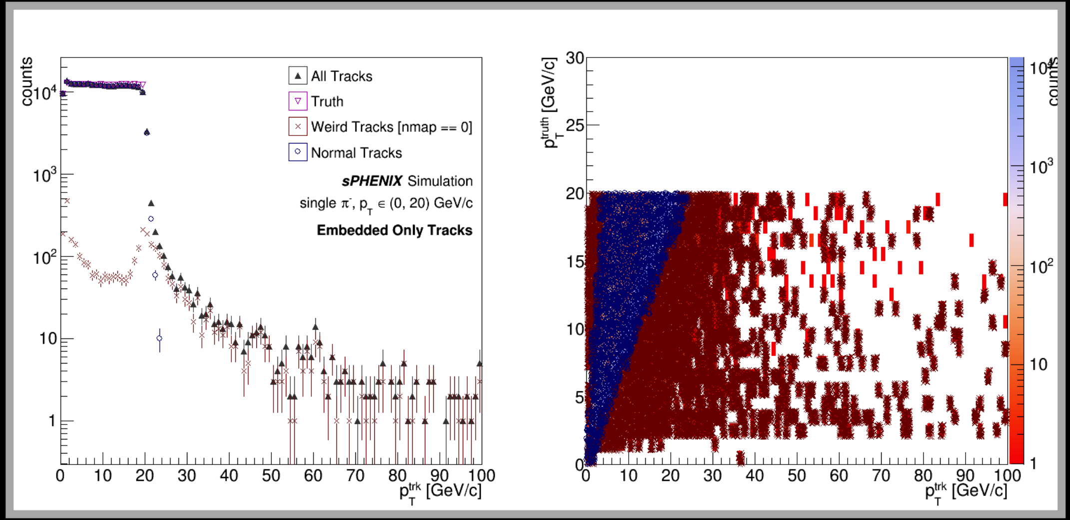
- $p_T^{trk}$ distribution is unimodal (slide 4)
- No correlation in phi (slide 5)
- $\chi^2$/ndf distribution is roughly flat (slide 10)

# Track Pt

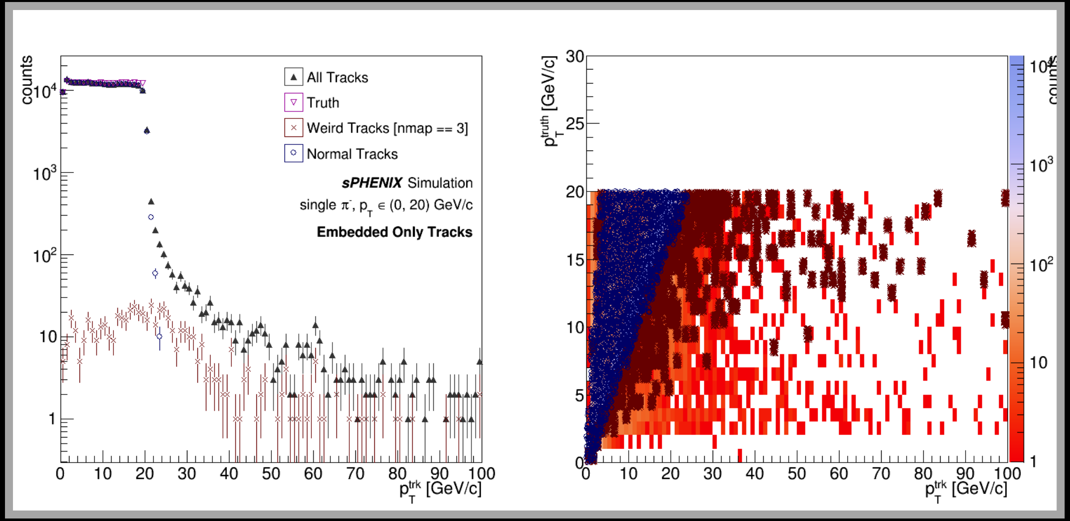
**All Weird Tracks**




**Weird Tracks w/o Silicon Seeds**




**Weird Tracks w/ Silicon Seeds**

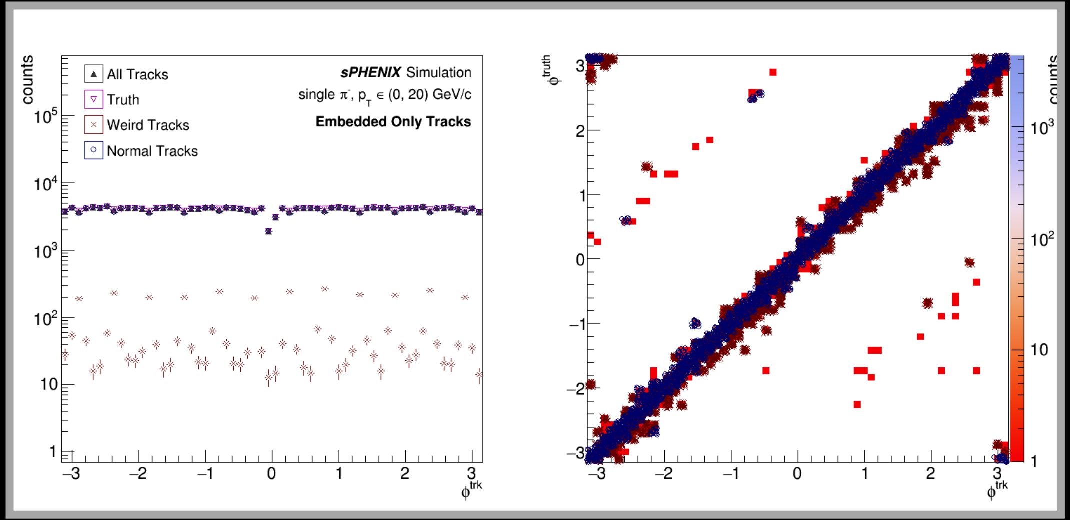



- Reconstructed and truth $p_T$
  - reco. $p_T$ (left panels)
  - reco. vs. truth $p_T$ (right panels)
  - **pt vs. gpt** leaves of ntp_track tuple

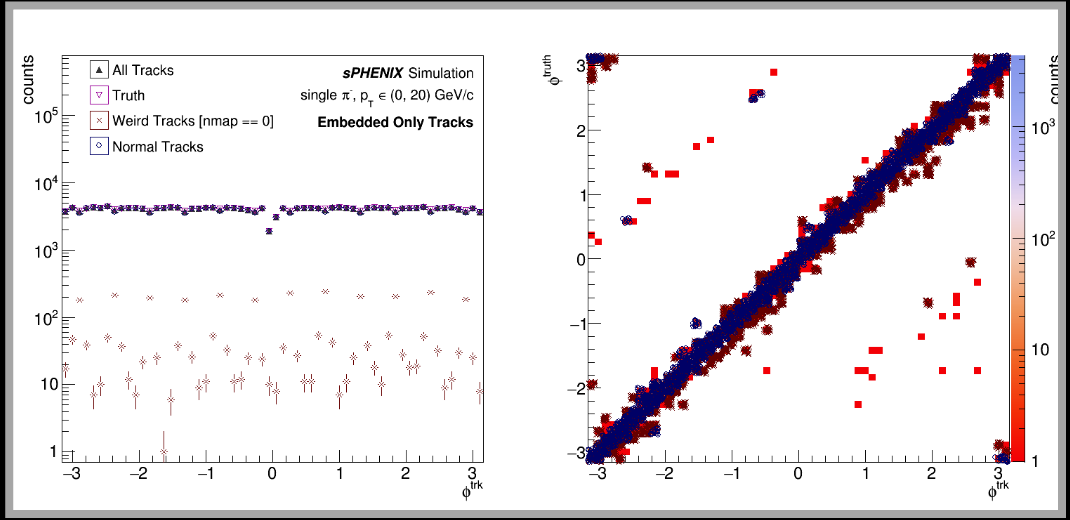
- **Note:** y-axes are **not** scaled
  - y-axis range changes between plots (apologies!)

# Track Phi

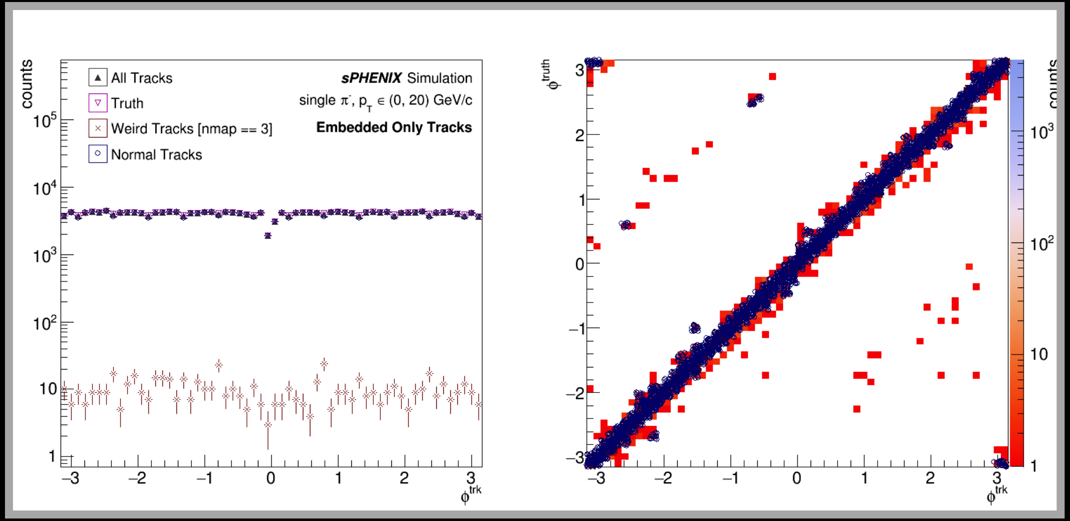
**All Weird Tracks**




**Weird Tracks w/o Silicon Seeds**



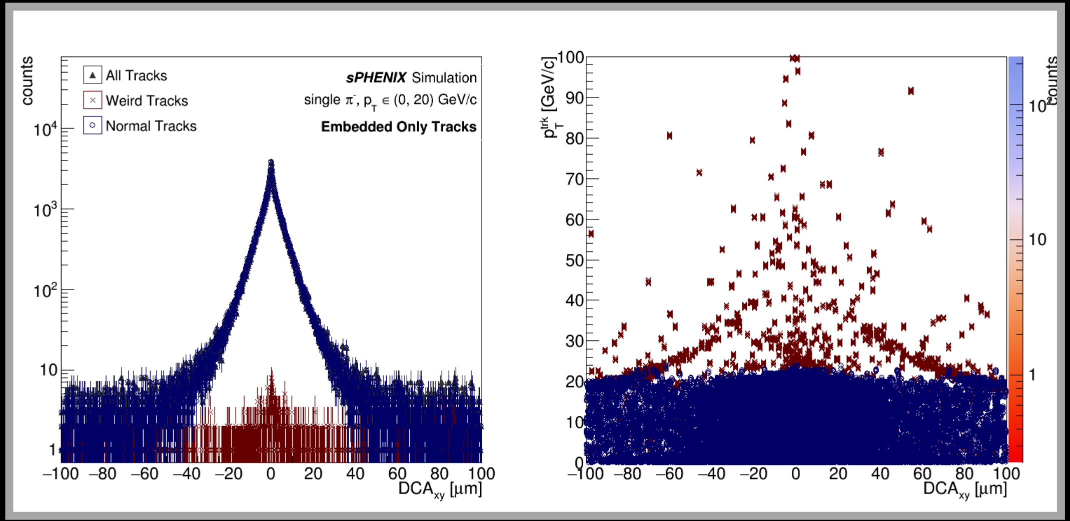

**Weird Tracks w/ Silicon Seeds**



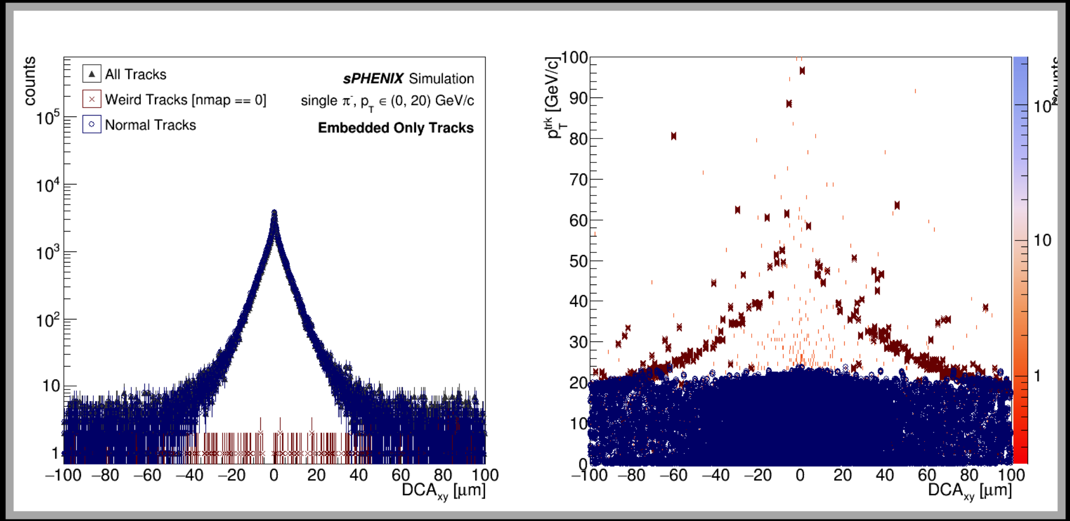

- Reconstructed and truth phi
  - reco. phi (left panels)
  - reco. vs. truth phi (right panels)
  - **phi vs. gphi** leaves of ntp_track tuple
- **Note:** y-axes are **not** scaled
  - y-axis range changes between plots (apologies!)

# Track DCAxy

**All Weird Tracks**

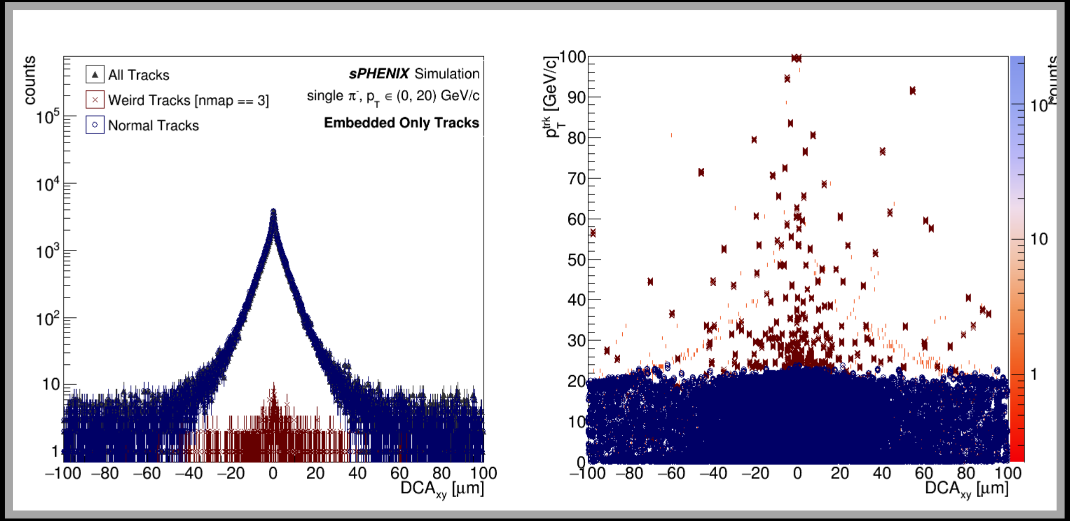



**Weird Tracks w/o Silicon Seeds**



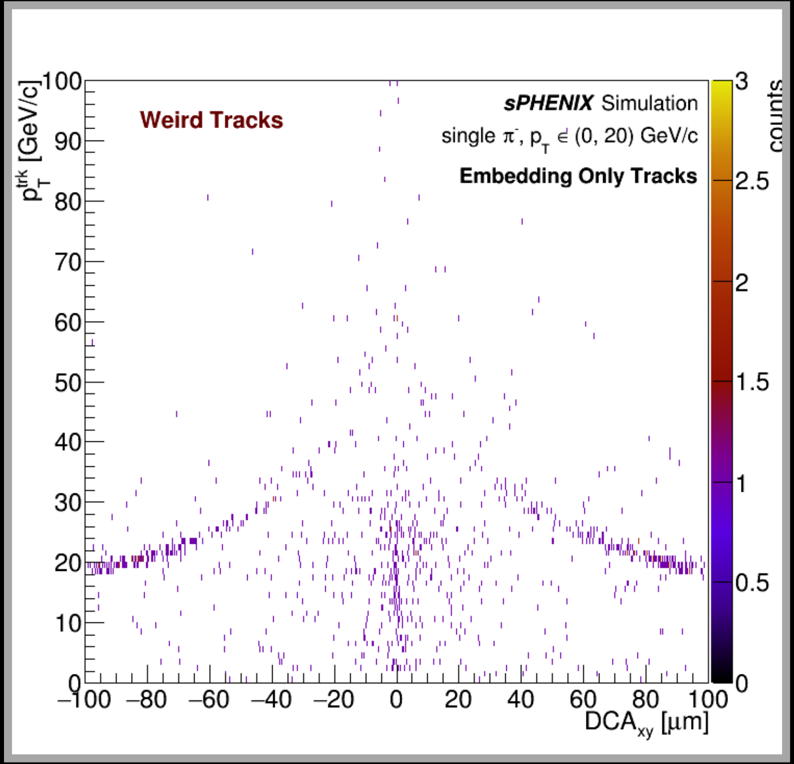

- Track DCAxy
  - Track DCAxy (left panels)
  - DCAxy vs. $p_T^{trk}$ (right panels)
  - **dca3dxy vs. pt** leaves of ntp_track tuple

**Weird Tracks w/ Silicon Seeds**

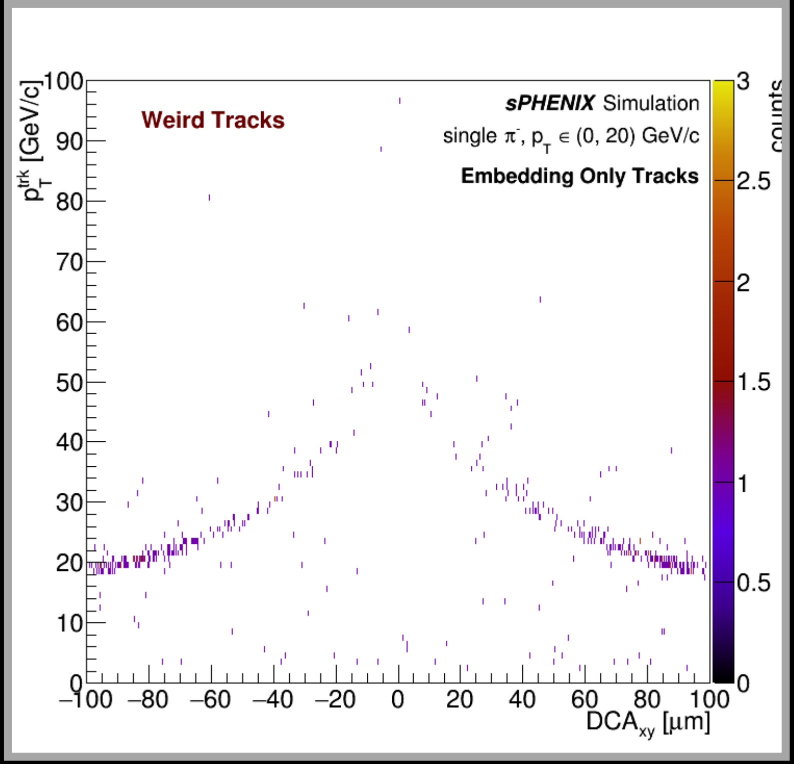



- **Note:** y-axes are **not** scaled
  - y-axis range changes between plots (apologies!)

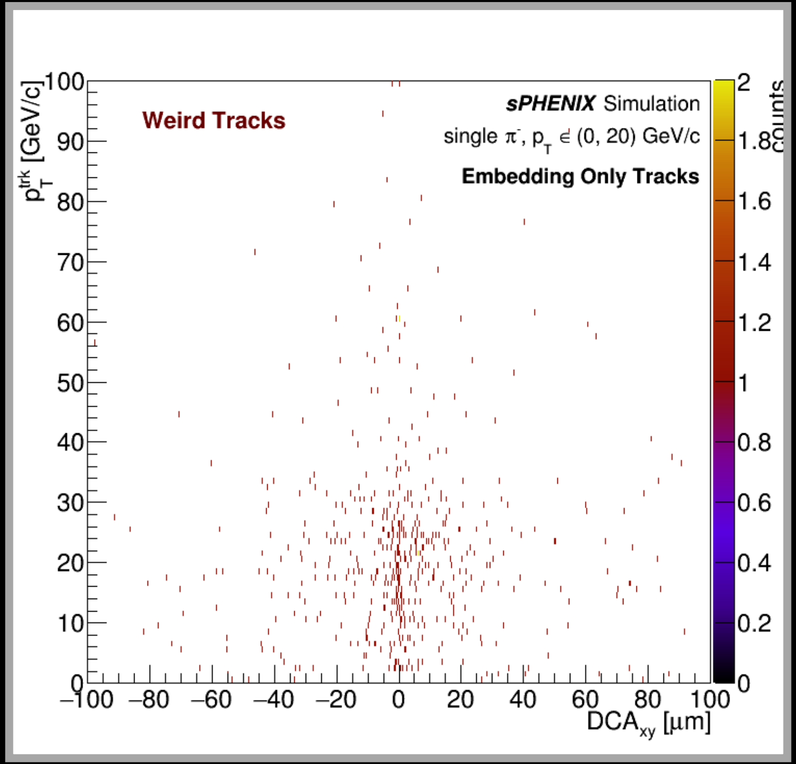
# Weird Track DCAxy




All Weird Tracks




Weird Tracks w/o Silicon Seeds

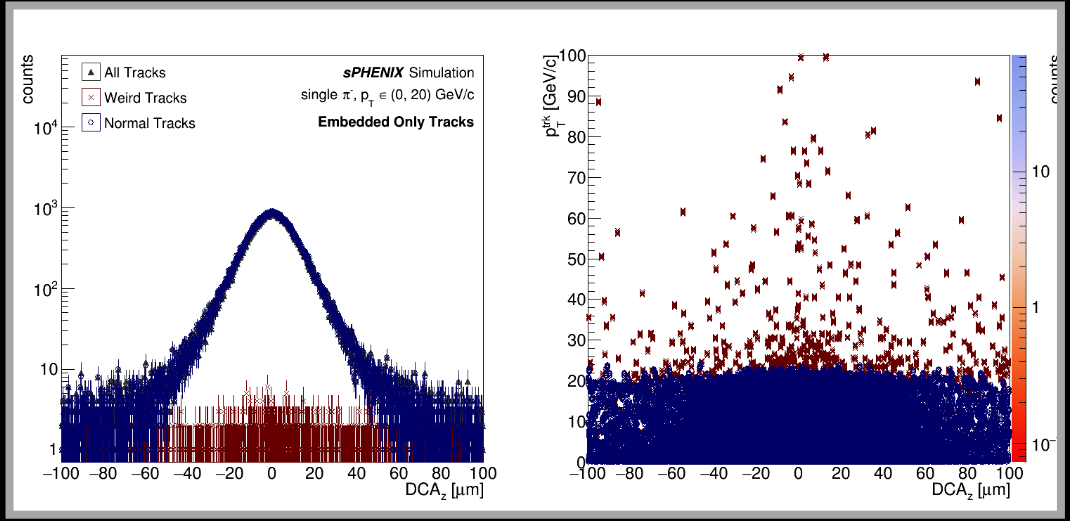



Weird Tracks w/ Silicon Seeds

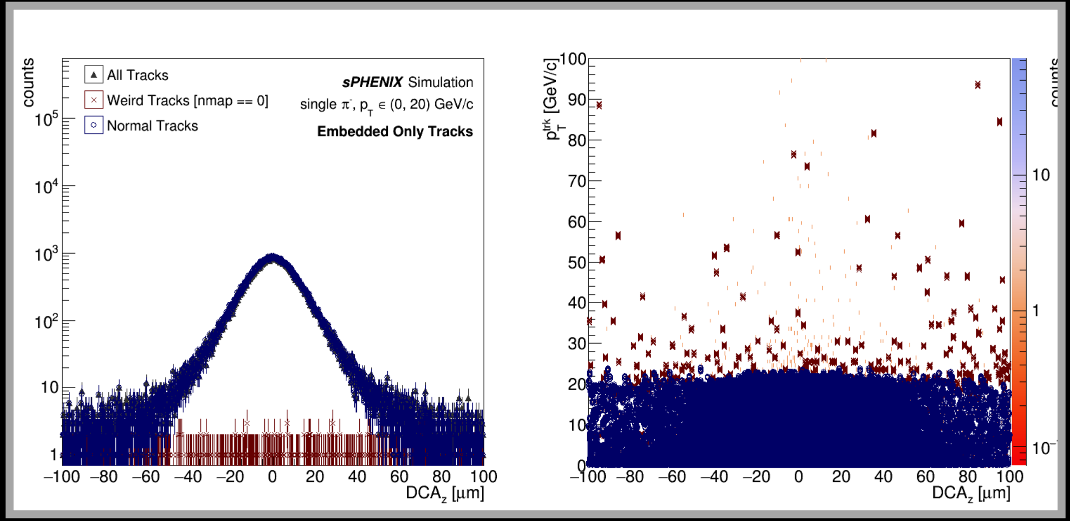
- Weird track DCAxy
  - **dca3dxy** leaf of ntp_track tuple for only weird tracks
- **Note:** z-axes are **not** scaled
  - z-axis range changes between plots (apologies!)

# Track DCAz

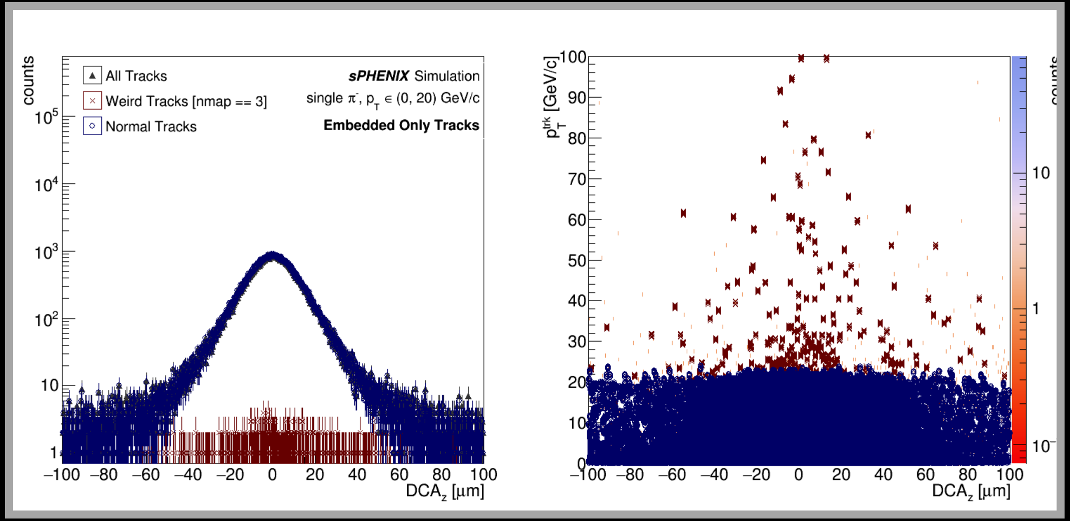
**All Weird Tracks**




**Weird Tracks w/o Silicon Seeds**



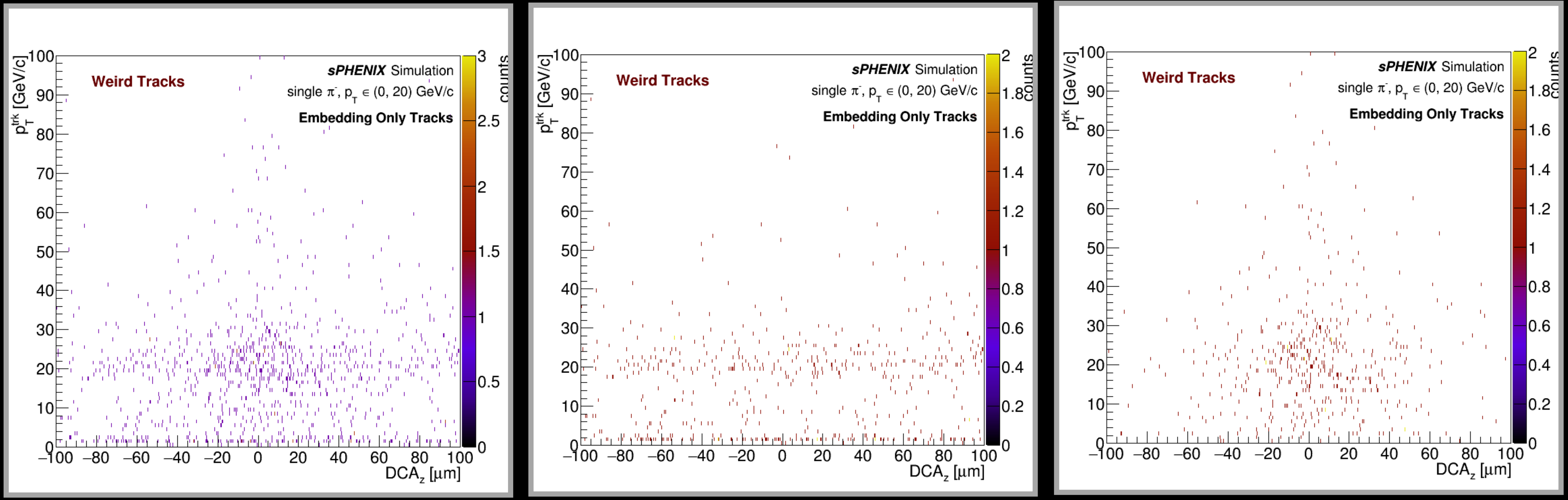

**Weird Tracks w/ Silicon Seeds**




- Track DCAz
  - Track DCAz (left panels)
  - DCAz vs. $p_T^{trk}$ (right panels)
  - **dca3dz vs. pt** leaves of ntp_track tuple

- **Note:** y-axes are **not** scaled
  - y-axis range changes between plots (apologies!)

# Weird Track DCAz

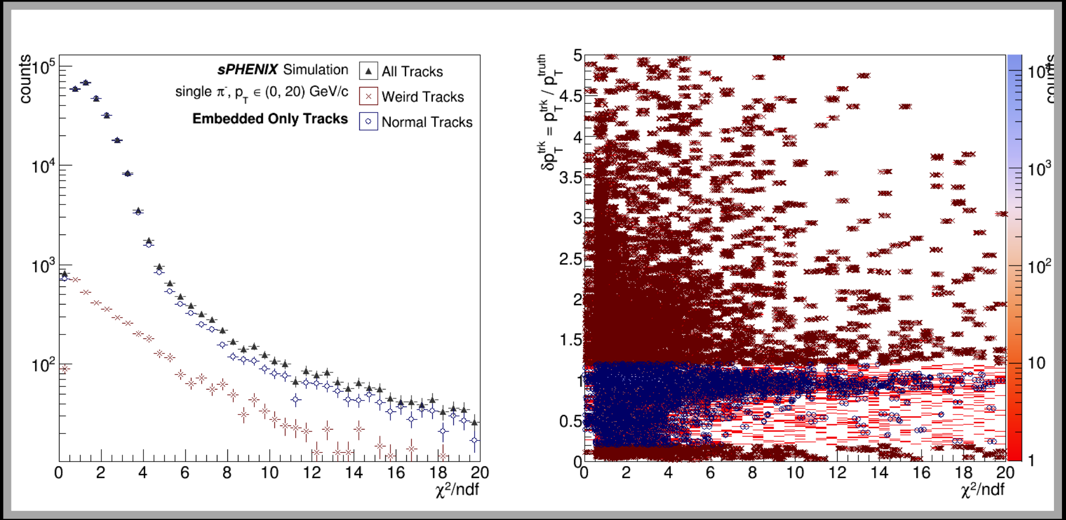



All Weird Tracks | Weird Tracks w/o Silicon Seeds | Weird Tracks w/ Silicon Seeds

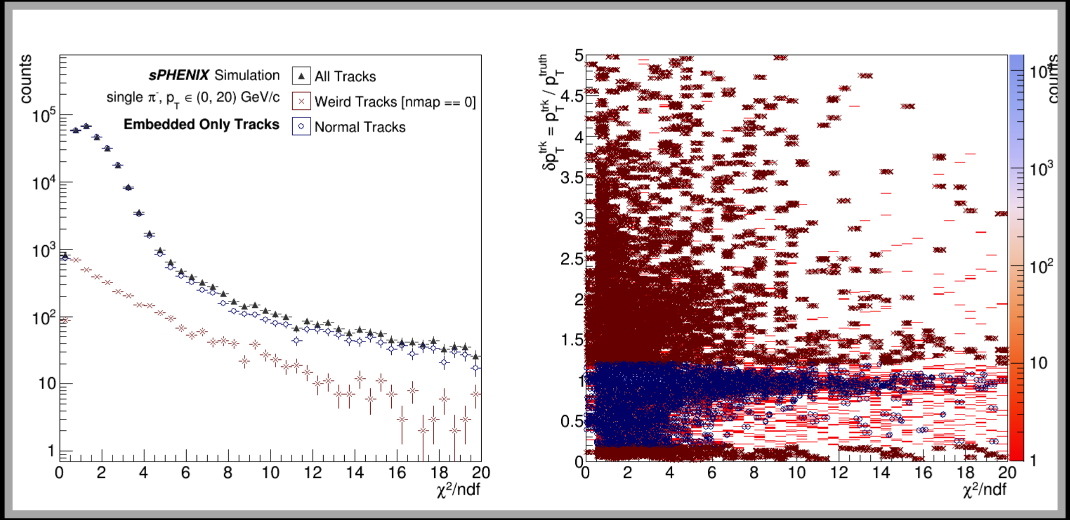
- Weird track DCAz
  - **dca3dz** leaf of ntp_track tuple for only weird tracks
- **Note:** z-axes are **not** scaled
  - z-axis range changes between plots (apologies!)

# Track Quality

**All Weird Tracks**

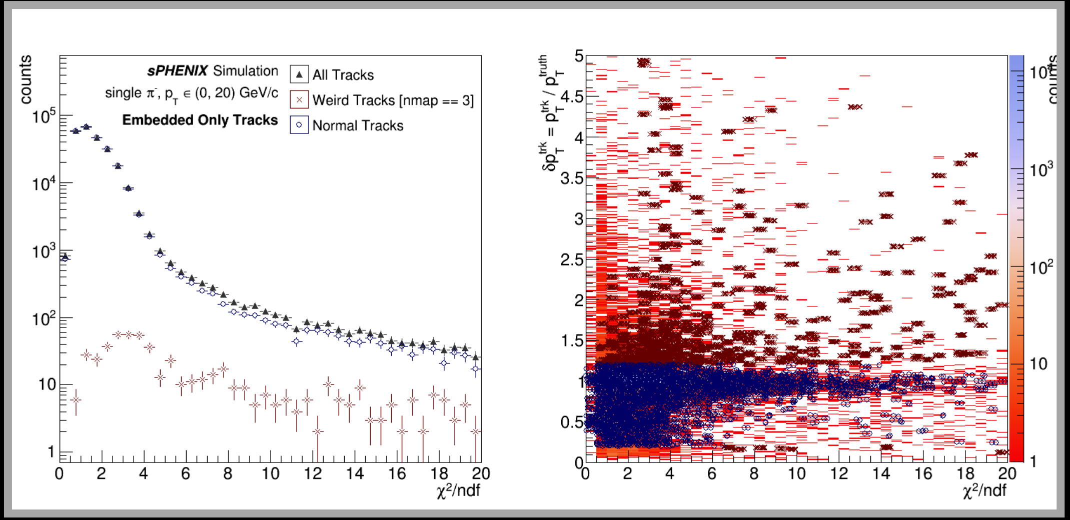



**Weird Tracks w/o Silicon Seeds**



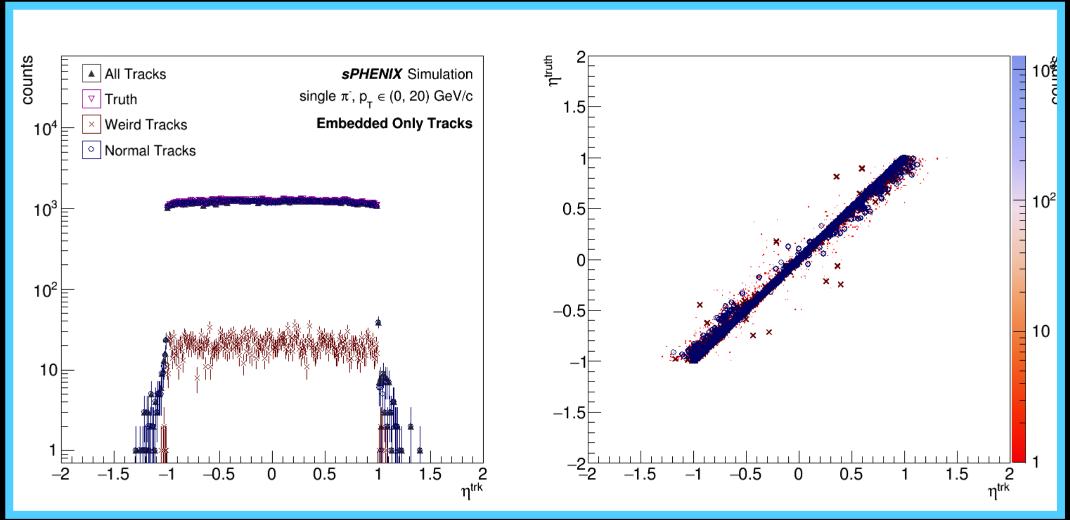

- Track $\chi^2$/ndf
  - Track $\chi^2$/ndf (left panels)
  - $\chi^2$/ndf vs. $p_T^{trk}/p_T^{true}$ (right panels)
  - **quality vs. pt/gpt** leaves of ntp_track tuple
- **Note:** y-axes are **not** scaled
  - y-axis range changes between plots (apologies!)

**Weird Tracks w/ Silicon Seeds**

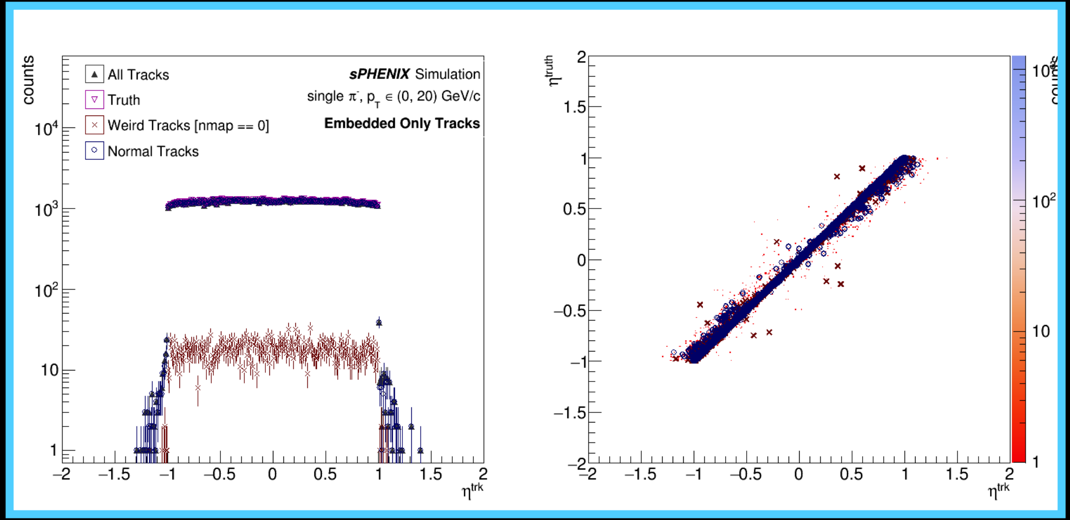


# Track Eta

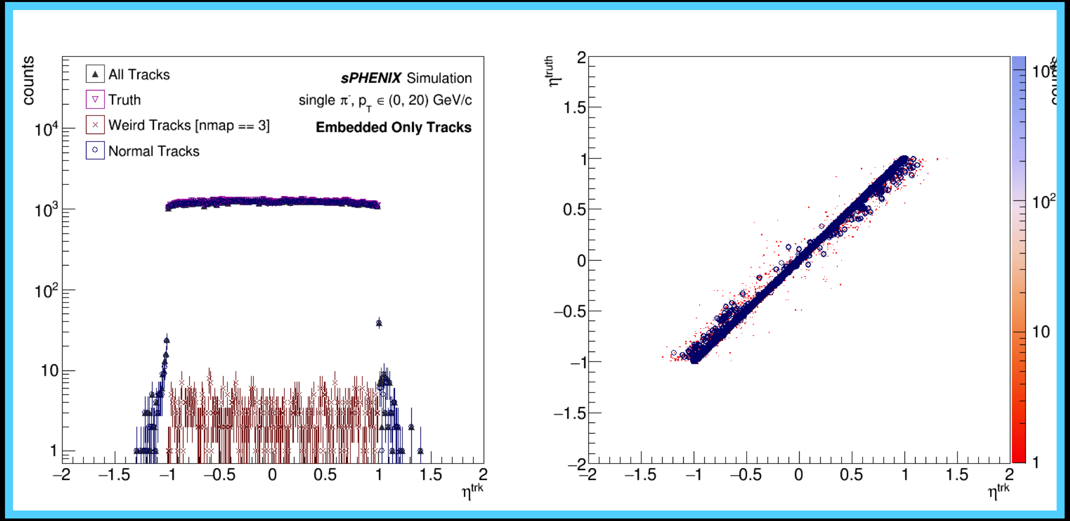
**All Weird Tracks**




**Weird Tracks w/o Silicon Seeds**



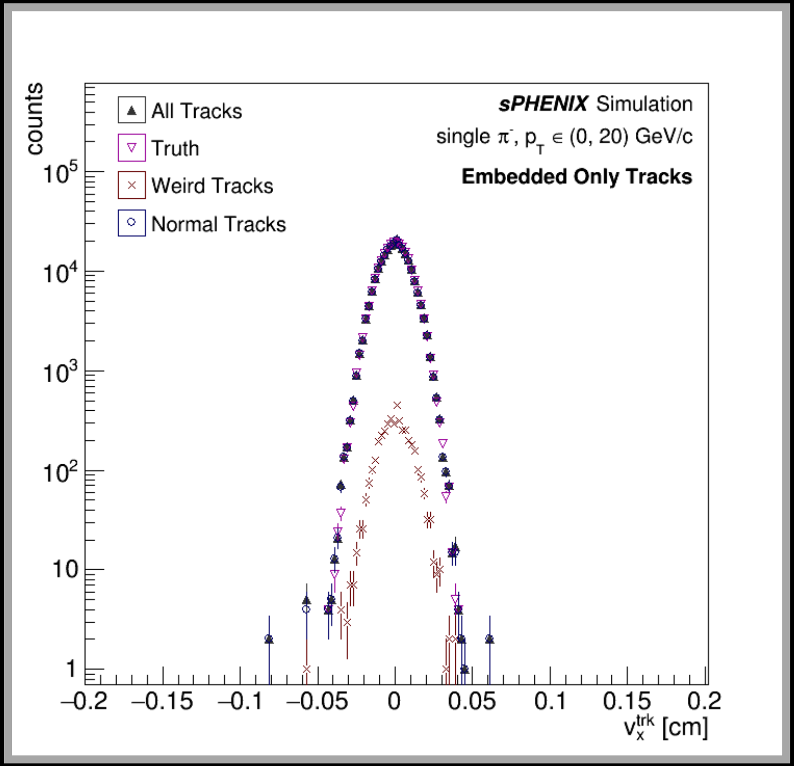

**Weird Tracks w/ Silicon Seeds**



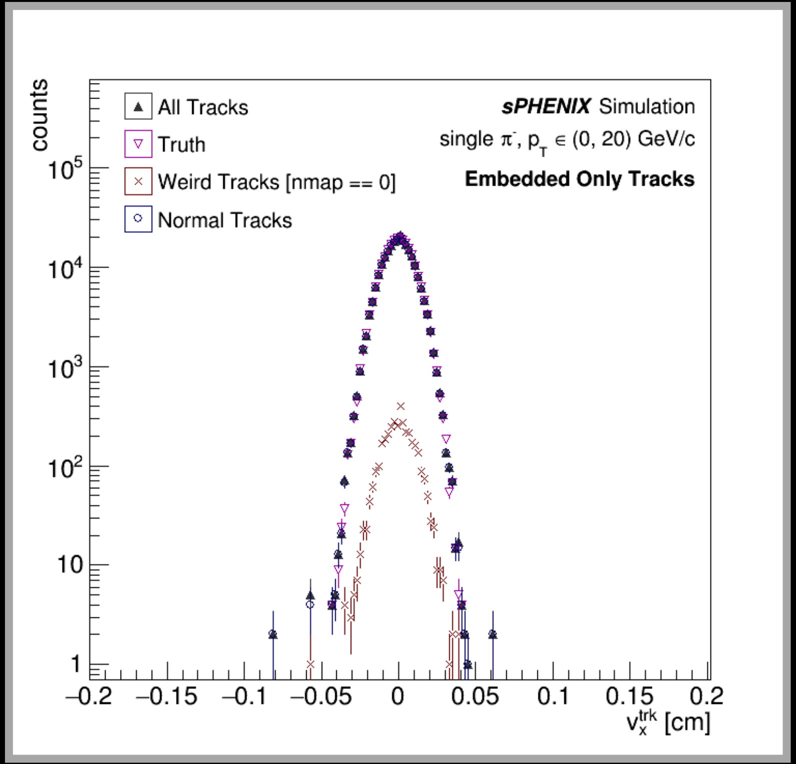

- Reconstructed and truth eta
  - reco. eta (left panels)
  - reco. vs. truth eta (right panels)
  - **eta vs. geta** leaves of ntp_track tuple

- **Note:** y-axes are **not** scaled
  - y-axis range changes between plots (apologies!)

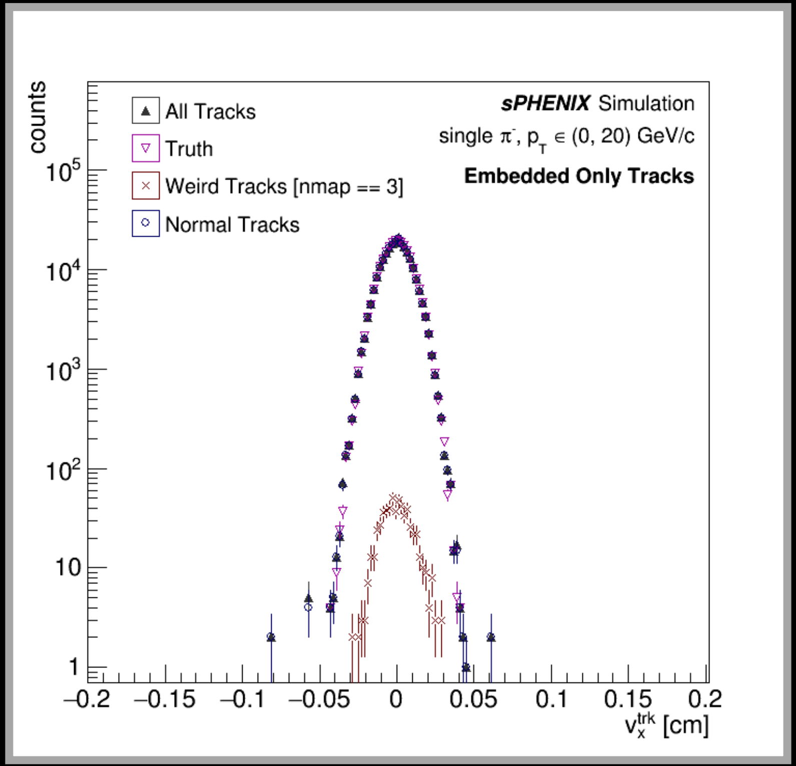
# Track X-Vertex




**All Weird Tracks**




**Weird Tracks w/o Silicon Seeds**




**Weird Tracks w/ Silicon Seeds**

- X-component of reconstructed vertex
  - **vx** leaf of ntp_track tuple
- **Note:** y-axes are **not** scaled
  - y-axis range changes between plots (apologies!)