# 1P0N and 3P0N Tau Reconstruction in MAIA

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MAIA Detector Tau Studies

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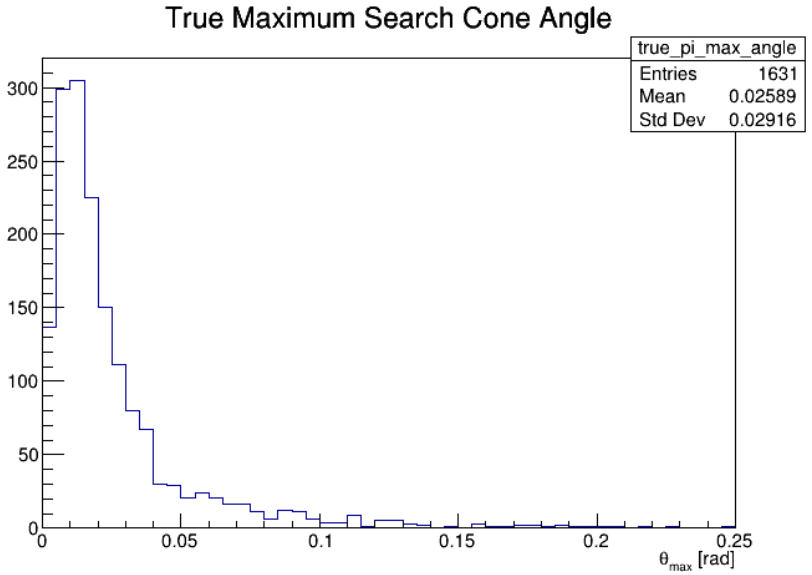
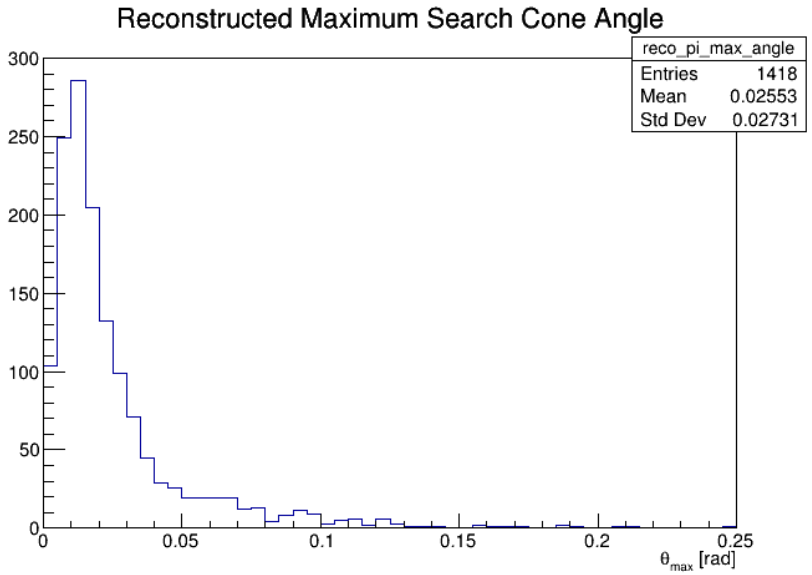
# Overview

- Optimizing 1P0N and 3P0N TauFinder reconstruction without BIB
- Limitations of PandoraPFA reconstruction
- Conclusions and next steps

# Scan for Search Cone Opening Angle

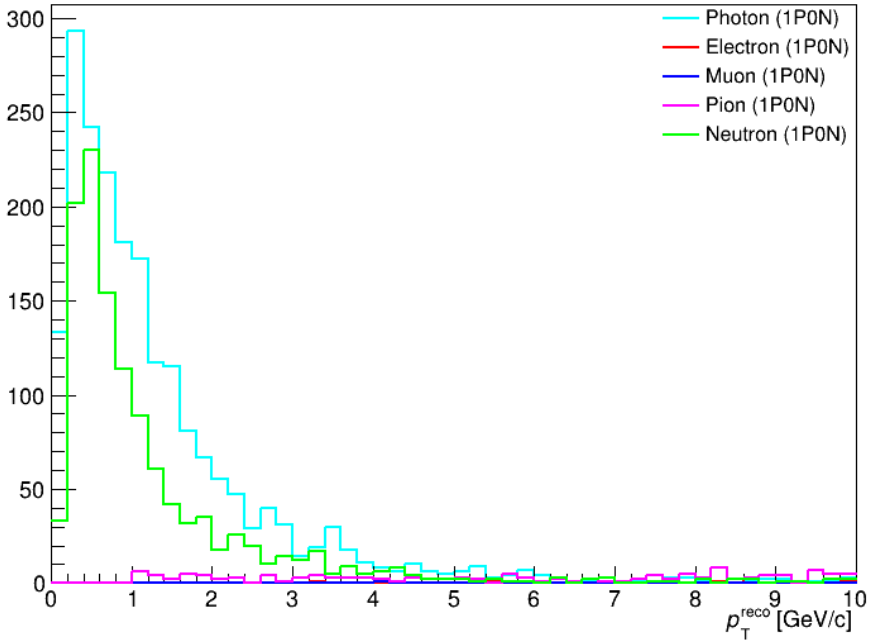
$$\theta_{max} = \cos^{-1} \frac{\overrightarrow{p_{seed}} \cdot \overrightarrow{p_n}}{|\overrightarrow{p_{seed}}||\overrightarrow{p_n}|}$$

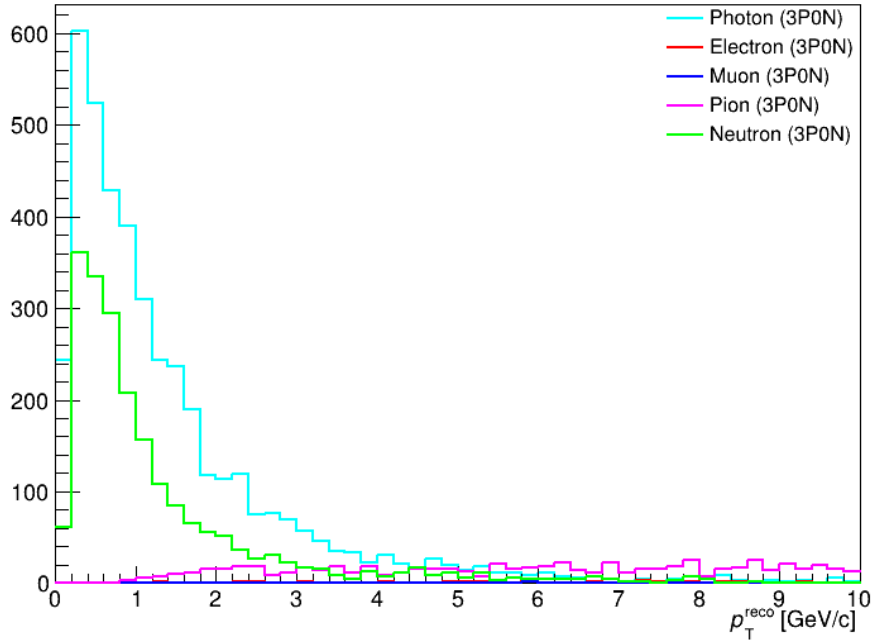



- $\theta_{max}$ calculated between charged particle seed and each $\pi^{\pm}$ in all true 3P0N events
  - Seed given by charged particle with highest $p_T$ as done in TauFinder
- True and reconstructed distributions show that search cone opening angle at 0.25 rad will accept all reconstructed $\pi^{\pm}$s
  - However, this will associate too many PFOs with reconstructed $\tau$ candidates
  - Decided to set search cone opening angle to 0.15 rad instead

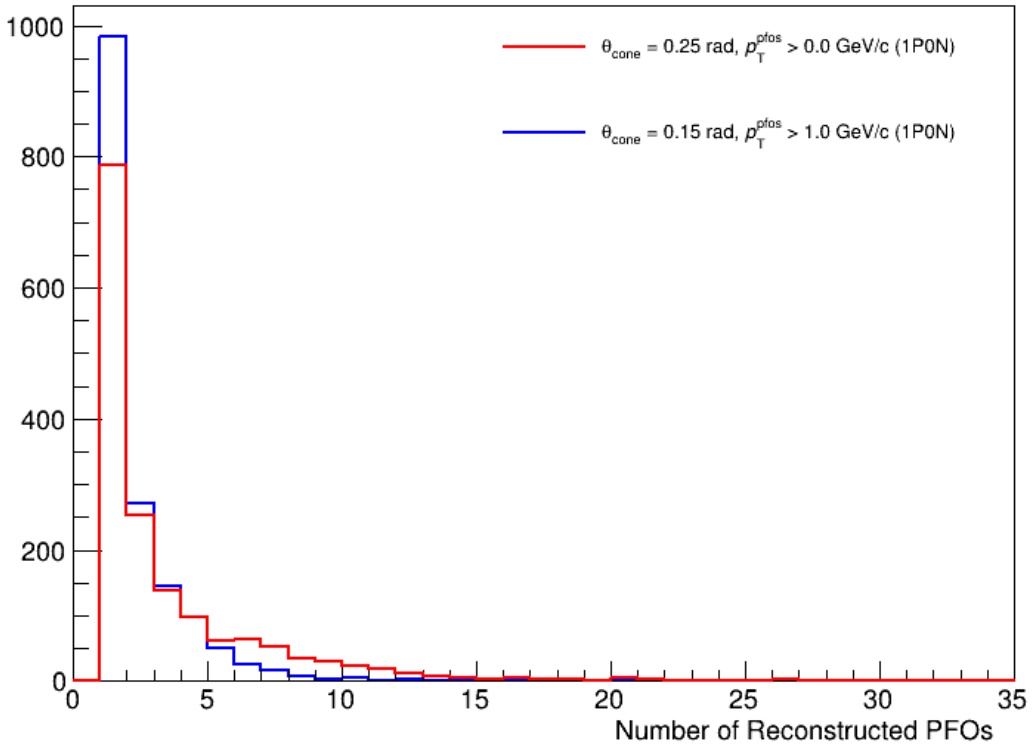
# Removing Non-$\pi^{\pm}$ PFOs

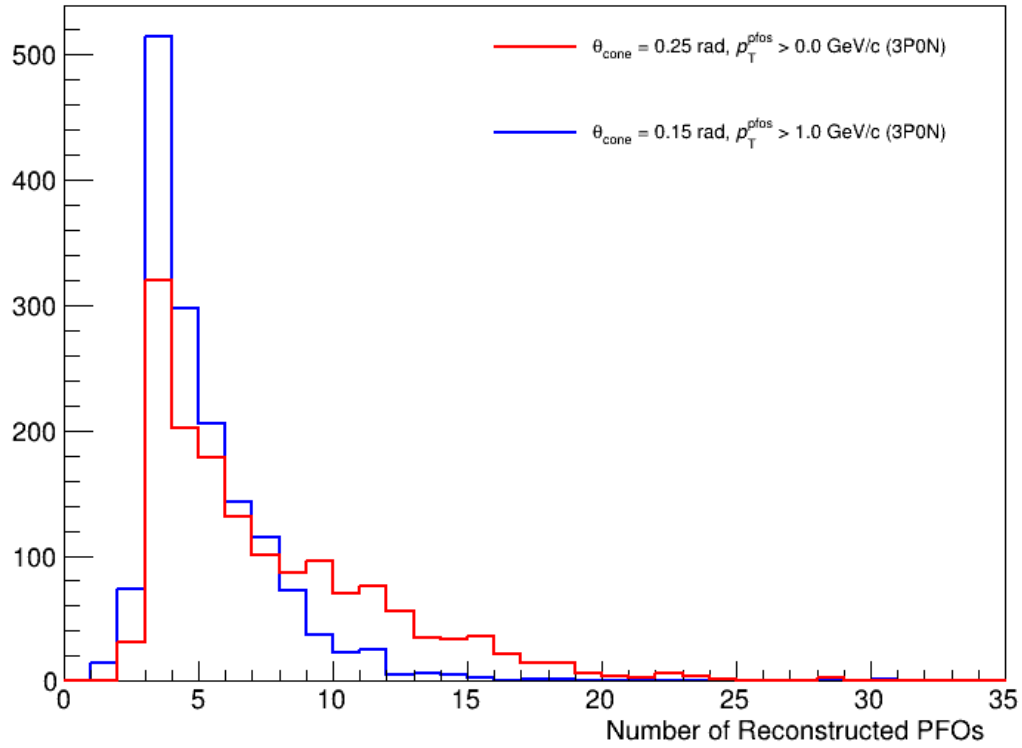



- Reconstructed $p_T$ of PFOs associated with reconstructed $\tau$ candidates with a search cone opening angle of 0.25 rad for true 1P0N and 3P0N events
- Photons and neutrons dominate distribution at low $p_T$
  - $p_T$ cut of 1 GeV/c removes large number of photons and neutrons associated with reconstructed $\tau$ candidate and keeps almost all reconstructed $\pi^{\pm}$s

# Decreased Number of PFOs

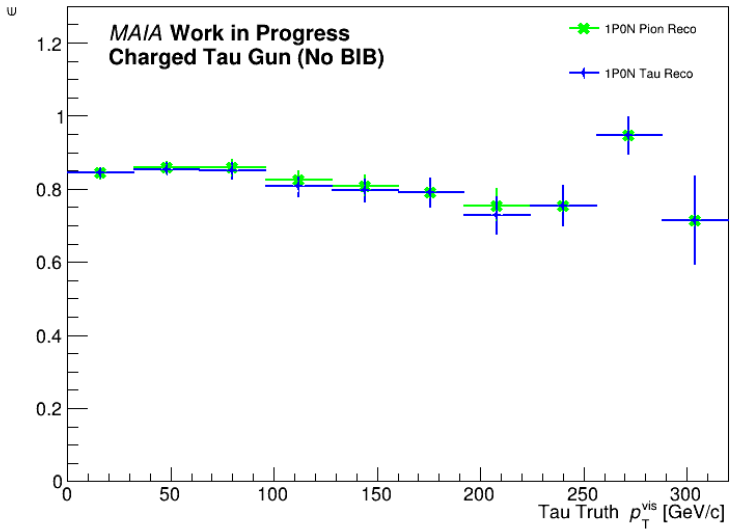


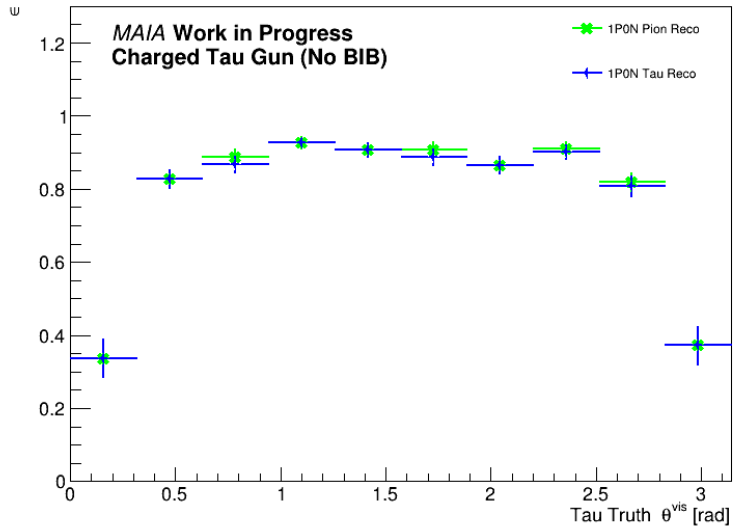



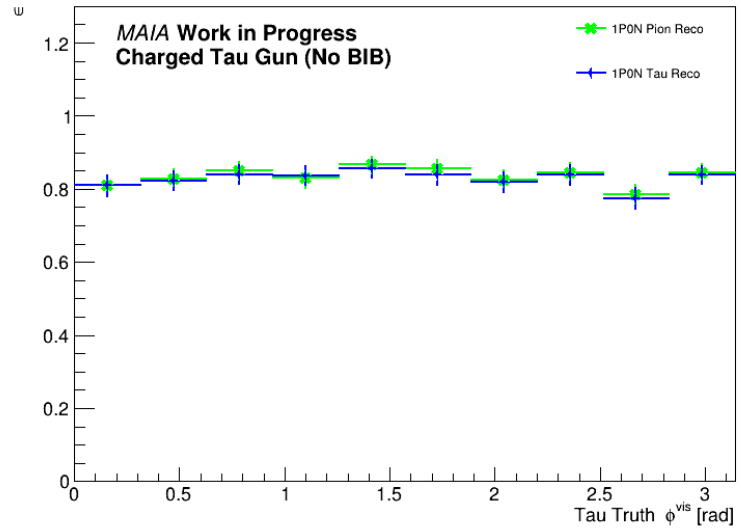

- TauFinder rejects reconstructed $\tau$ candidates with more than 10 associated PFOs
- Number of PFOs associated with reconstructed $\tau$ candidates decreases for 1P0N and 3P0N with "new" $\tau$ reconstruction
  - More $\tau$ candidates with less than 10 PFOs
  - Less $\tau$ candidates with more than 10 PFOs

# Updated 1P0N Efficiencies

$$\epsilon_\tau = \frac{\#\ of\ 1P0N\ Reco\ \tau\ Matched\ with\ 1P0N\ MC\ \tau}{Total\ \#\ of\ 1P0N\ MC\ \tau} \qquad \epsilon_{\pi^\pm} = \frac{\#\ of\ Single\ Reco\ \pi^\pm\ Matched\ with\ Single\ MC\ \pi^\pm}{Total\ \#\ of\ Single\ MC\ \pi^\pm}$$



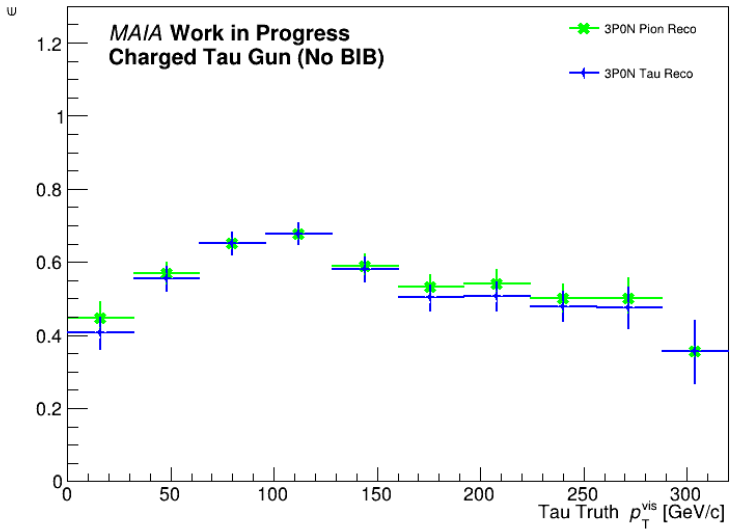



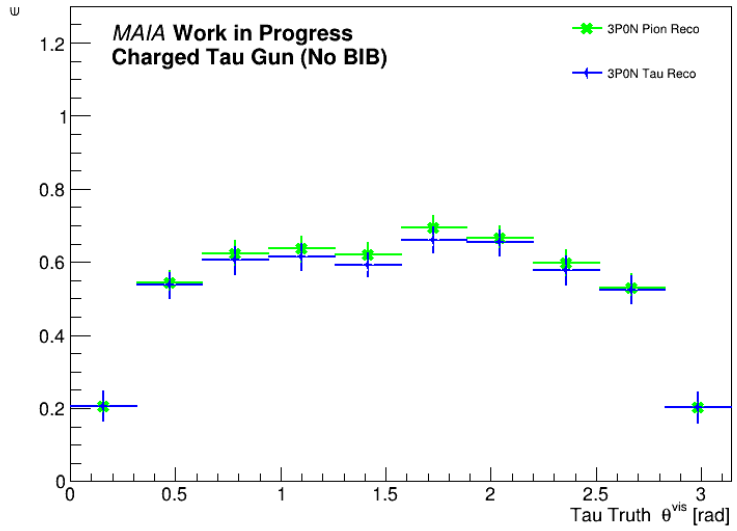



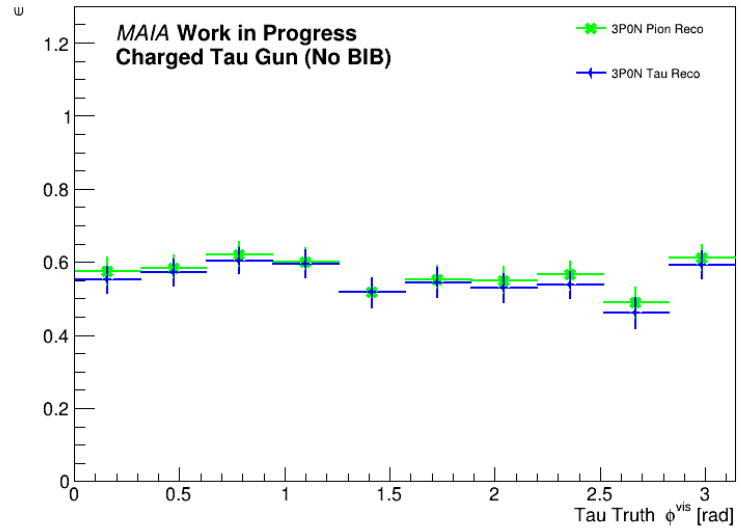

- 1P0N tau reconstruction efficiency matches single charged pion reconstruction efficiency
  - Average of ~85%
- Improvement in efficiencies requires improvement in charged pion reconstruction

# Updated 3P0N Efficiencies

$$\epsilon_\tau = \frac{\#\ of\ 3P0N\ Reco\ \tau\ Matched\ with\ 3P0N\ MC\ \tau}{Total\ \#\ of\ 3P0N\ MC\ \tau} \qquad \epsilon_{\pi^\pm} = \frac{\#\ of\ Triple\ Reco\ \pi^\pm\ Matched\ with\ Triple\ MC\ \pi^\pm}{Total\ \#\ of\ Triple\ MC\ \pi^\pm}$$

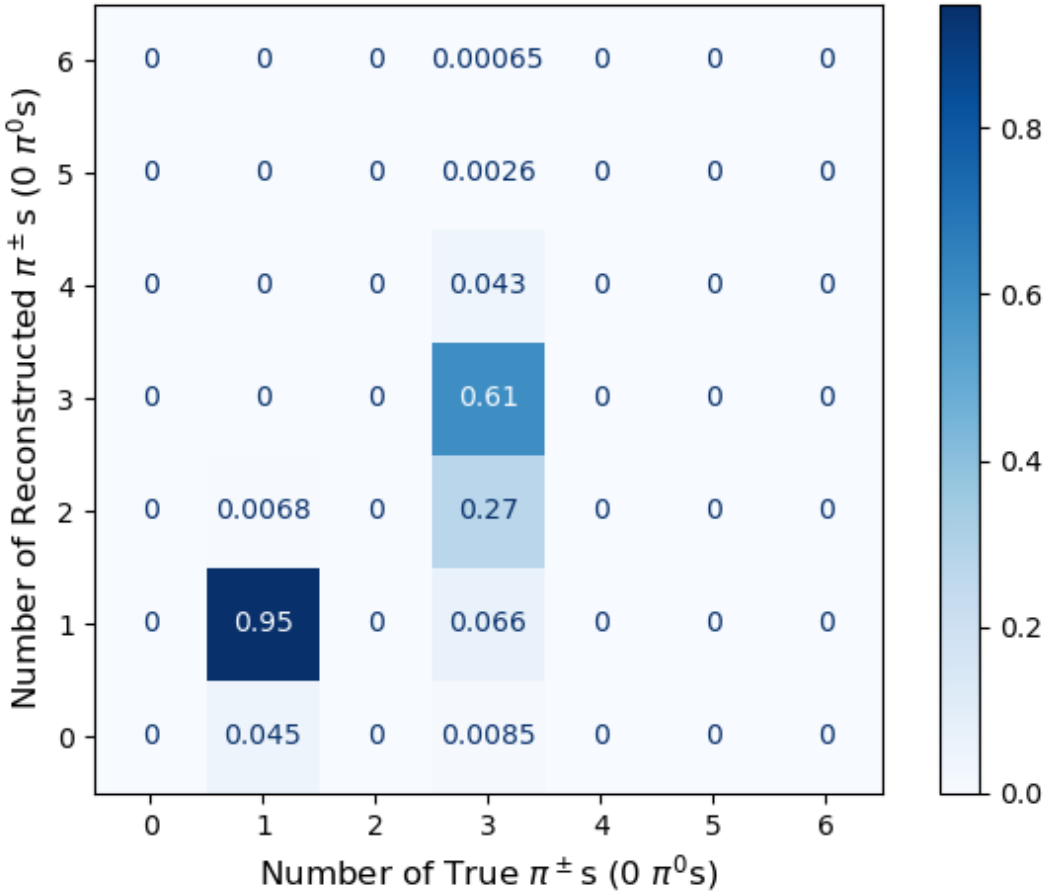



- 3P0N tau reconstruction efficiency nearly matches triple charged pion reconstruction efficiency
  - Average of ~55%
  - Inefficiencies are due to too many PFOs and too small of a search cone
- Improvement in efficiencies requires improvement in charged pion reconstruction

# $\pi^{\pm}$ Reconstruction with PandoraPFA




- $\tau$ reconstruction limited by reconstruction of $\pi^{\pm}$s with PandoraPFA
  - Number of reconstructed $\pi^{\pm}$s < number of true $\pi^{\pm}$s implies misidentification
  - Number of reconstructed $\pi^{\pm}$ > number of true $\pi^{\pm}$s implies track duplication
- Mostly a concern for 3P0N events
  - Efficiency would improve by ~27% if reconstructing 2/3 $\pi^{\pm}$s is included in efficiency definition
- $\pi^{\pm}$s are misidentified as either electrons, muons, or neutrons

# Conclusions and Next Steps

- 1P0N and 3P0N TauFinder reconstruction efficiency can be optimized with search cone angle at 0.15 rad and $p_T$ cut at 1 GeV/c
  - Need to do further studies of isolation energy and invariant mass
- Tau reconstruction limited by charged pion reconstruction
  - Inefficiencies come from misidentification and track duplication
  - Can redefine 3P0N efficiency to improve by ~27%
- Starting BIB simulation/overlay this week

# Removing Non-$\pi^{\pm}$ PFOs