1P + N Decays and Shrinking Cone in TauFinder

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τ^- Workflow

Generation:

- 15,000 single τ^- MCParticle Events written to LCIO file

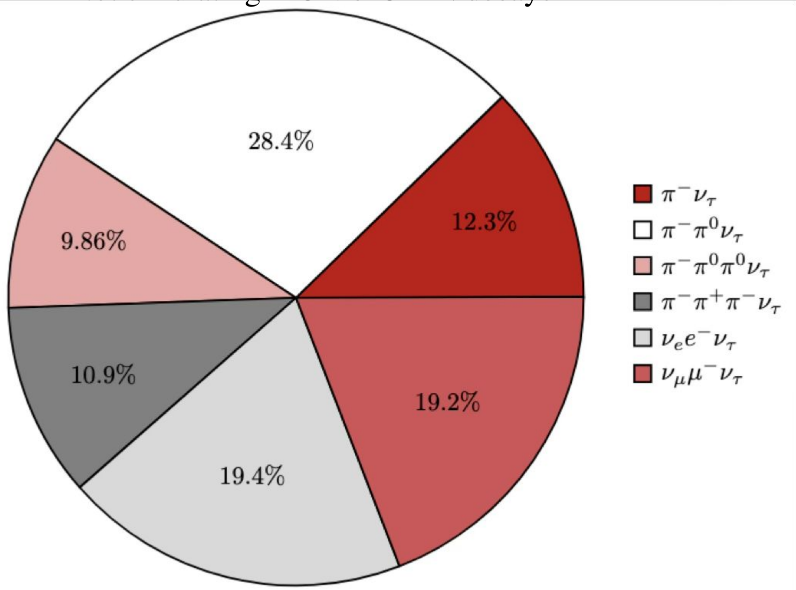
Simulation:

- Simulated τ^- MCParticle decays and interactions with MAIA detector in GEANT4

Digitisation and Reconstruction:

- Decay products are reconstructed by ACTS and PandoraPFA as particle flow objects (PFOs)
  - **Doesn't reconstruct π^0, reconstructed γ act as pseudo-π^0**
- TauFinder takes highest p_T charged track as seed, building the signal and isolation cones around it
- Any PFOs within the cone are associated to a τ^- candidate

Not simulating 1P3N or 3P1N decays



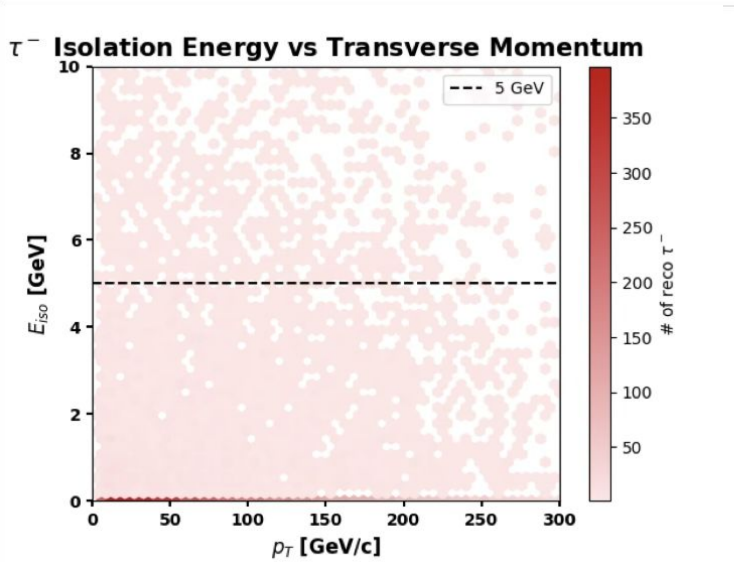
MC τ^- Parameters
$0 \leq \phi \leq 2\pi$ [rad]
$10^\circ \leq \theta \leq 170^\circ$
$20 \leq p_T \leq 320$ [GeV/c]

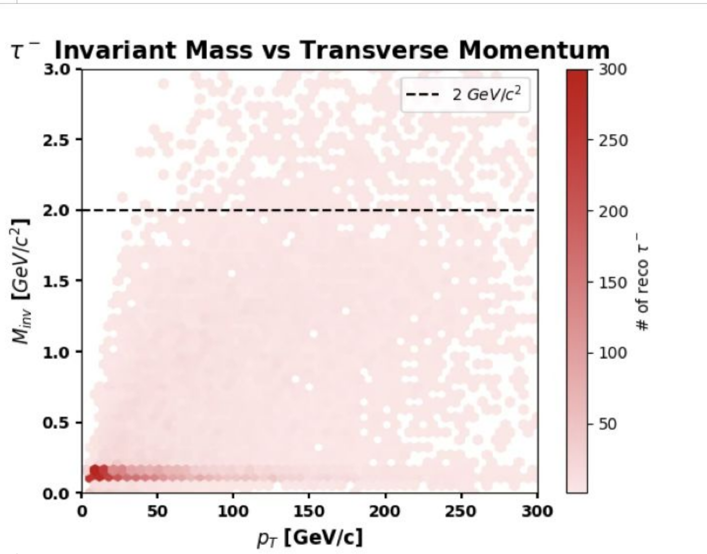
Default TauFinder Selection Cuts
τ^- $M_{inv} < 2$ GeV/c_2
0 < Charged Tracks Associated to τ^- < 4
Particles Associated to τ^- < 10
τ^- $E_{iso} < 5$ GeV

Examining Default τ^- Reconstruction

Losing large portion of reconstructed τ^- with default selection criteria:

- Maximum isolation energy (E_{iso}) criteria on the τ^- candidates cuts ~14%
- Maximum invariant mass (M_{inv}) criteria on the τ^- candidates cuts ~ 10%

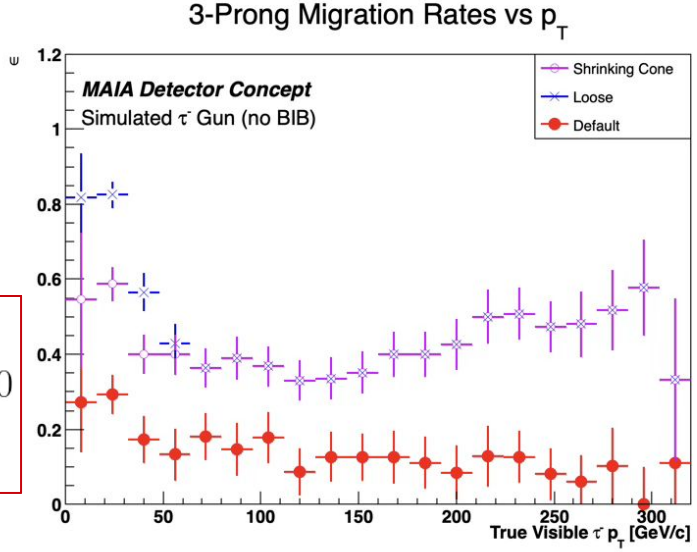




At low p_T the default cone size (0.05 rad) has high migration rate, cutting too many $\pi^\pm$

- **Suggests the need for a shrinking p_T dependent cone**

$$\text{Signal Cone Angle} = \begin{cases} 0.3 & p_T \leq 10 \\ \frac{3}{p_T} & 10 < p_T < 60 \\ 0.05 & p_T \geq 60 \end{cases}$$



τ^- Reconstruction Efficiencies

Loose cuts on E_{iso} and M_{inv}:

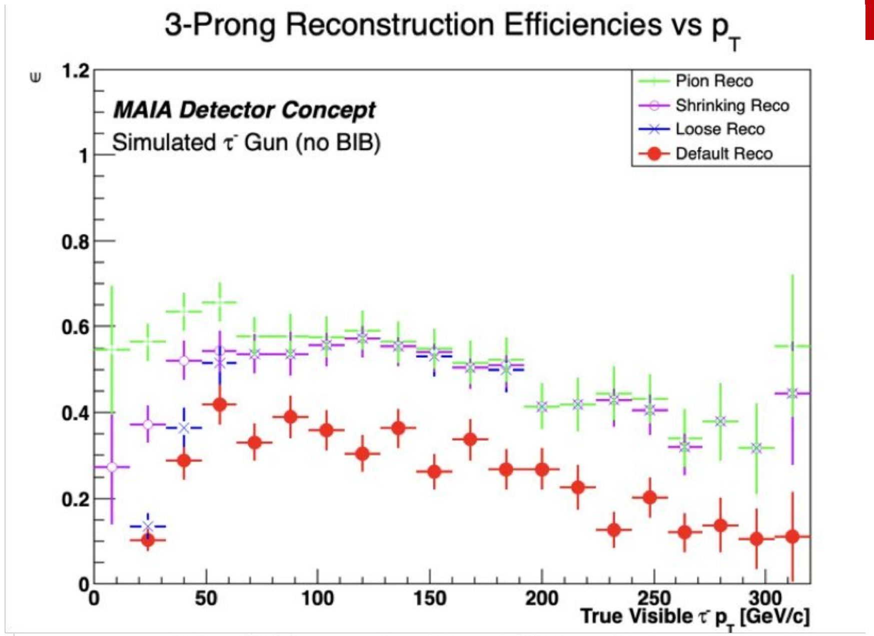
- **Boosts 1-prong + π^0s and 3-prong efficiencies by ~15%**

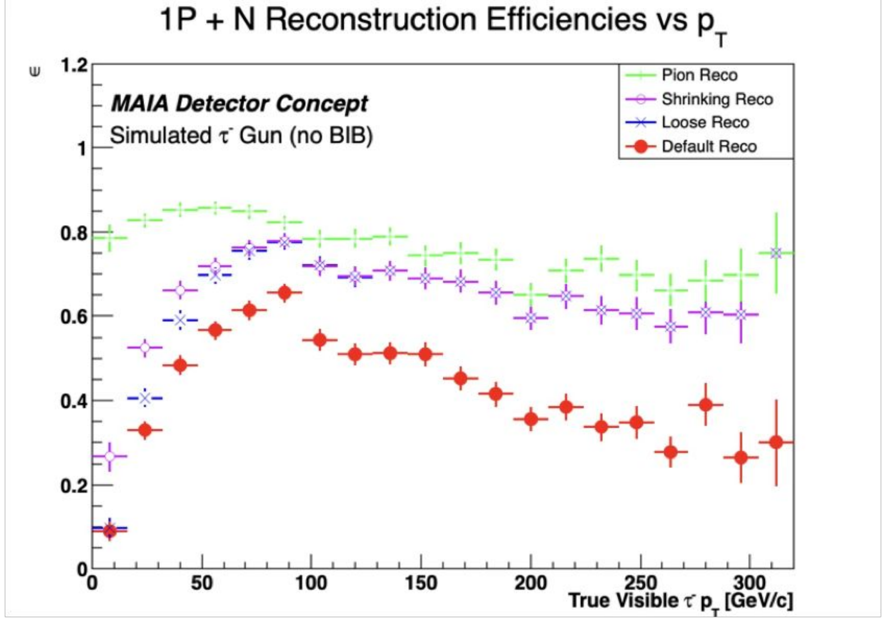
Shrinking cone:

- Added to the loose cuts
- **Boosts low p_T (< 50) 3-prong efficiencies by ~20%**
- **Creates ~1000 new τ^- candidates**
- **Reduces low p_T migration rate by ~20%**

$$\epsilon_\tau = \frac{\#\text{ of Reco 1P + Ns } \tau \text{ Matched to MC 1P + Ns } \tau}{\#\text{ of 1P + Ns MC } \tau}$$

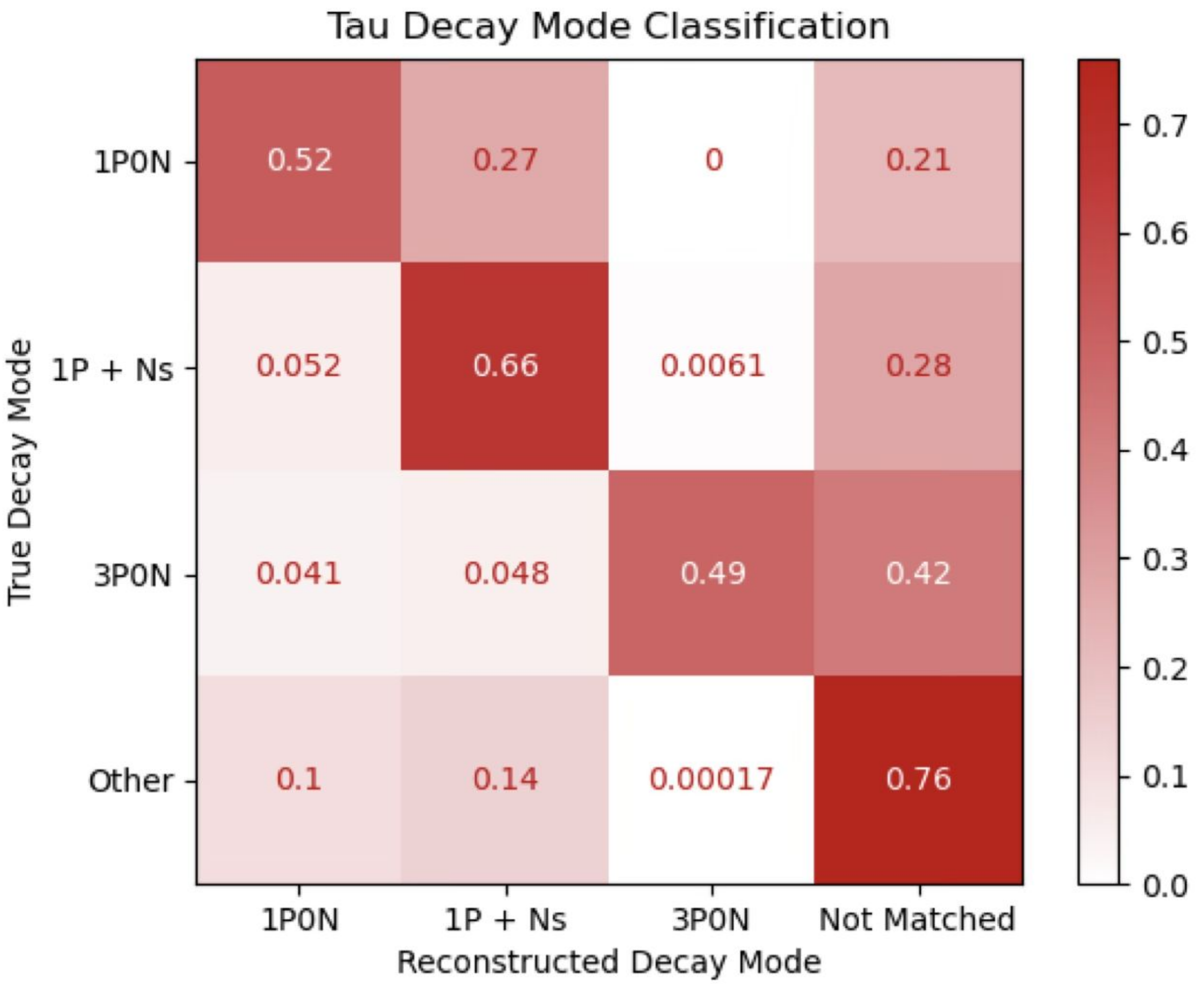
$$\epsilon_{\pi^\pm} = \frac{\#\text{ of Events With 1 Reco } \pi^\pm \text{ Matched to Unique MC } \pi^\pm}{\#\text{ of Events With 1 MC } \pi^\pm}$$





Confusion Matrix View

- **1-prongs are confused often:**
  - $\pi^{\pm}$ confusion with e^{-} or μ is a significant factor
  - Low p_T γ lead to 1-prong + π^0s confusion
- **1-prong + π^0s have the best classification rate**
- $\pi^{\pm}$ reconstruction acts as an upper limit



Conclusions and Next Steps

- **Shrinking cone boosts low $p_T\tau$ efficiency**
  - Particularly useful for the 3-prongs (original target)
  - Also benefits the 1P + N

- For now, having γ act as a pseudo-π^0 works
  - Future studies planned

- **BIB overlay has begun:**
  - Fine-tune the shrinking cone definition
  - Potentially update the pseudo-π^0 criteria
  - Adjust other TauFinder selection cuts

Thank you!

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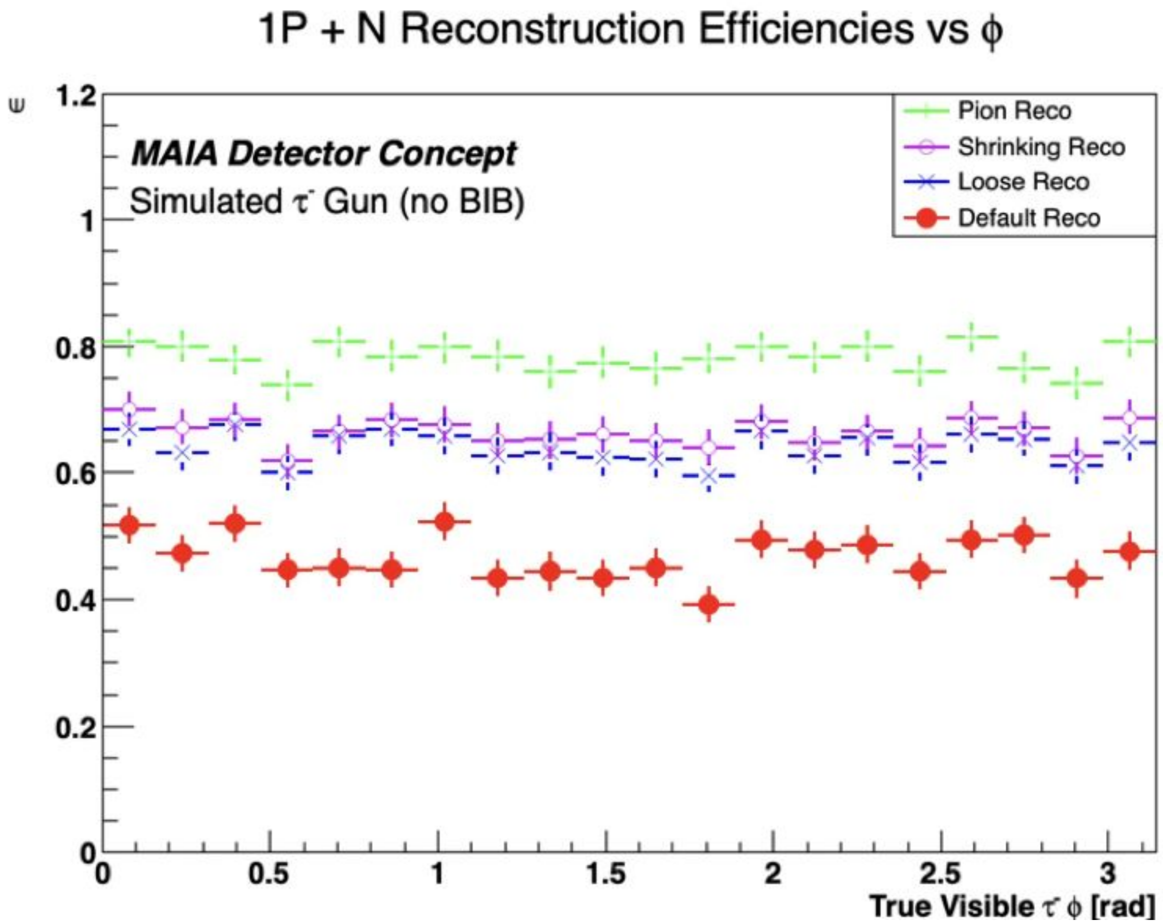
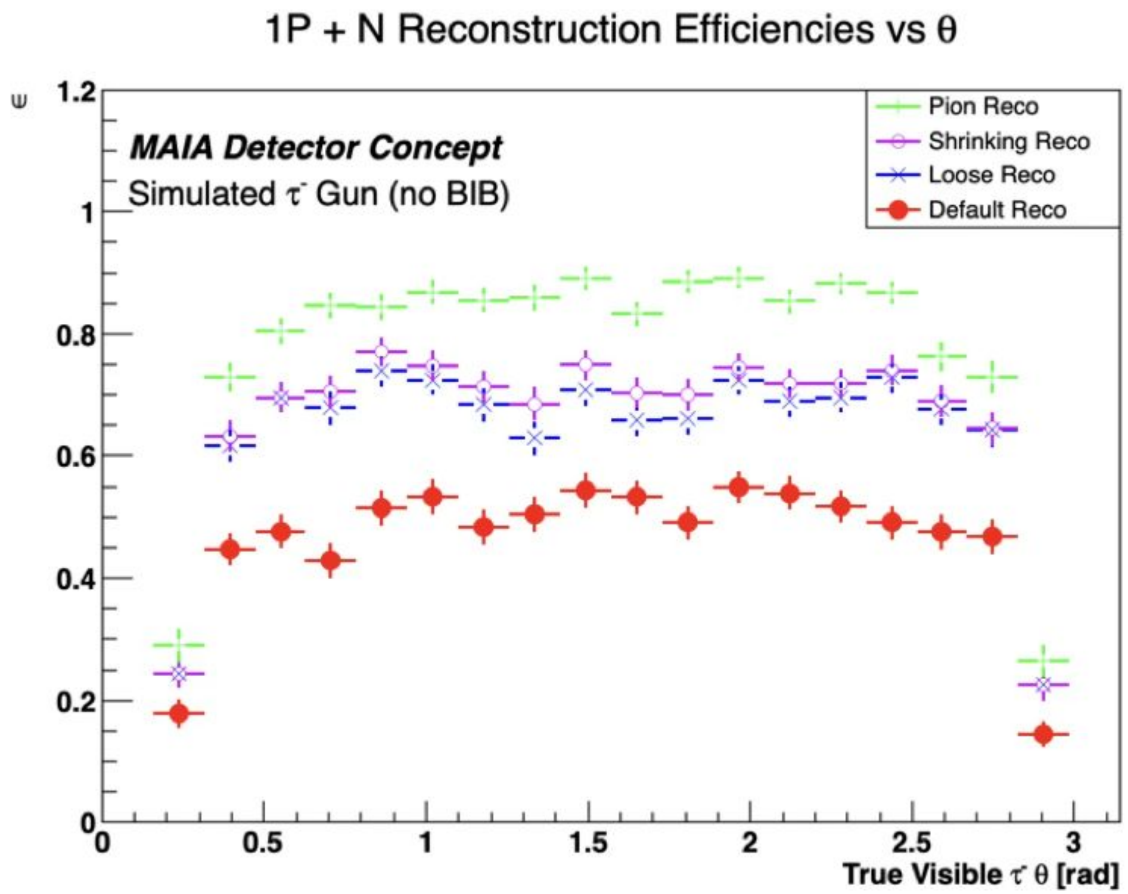
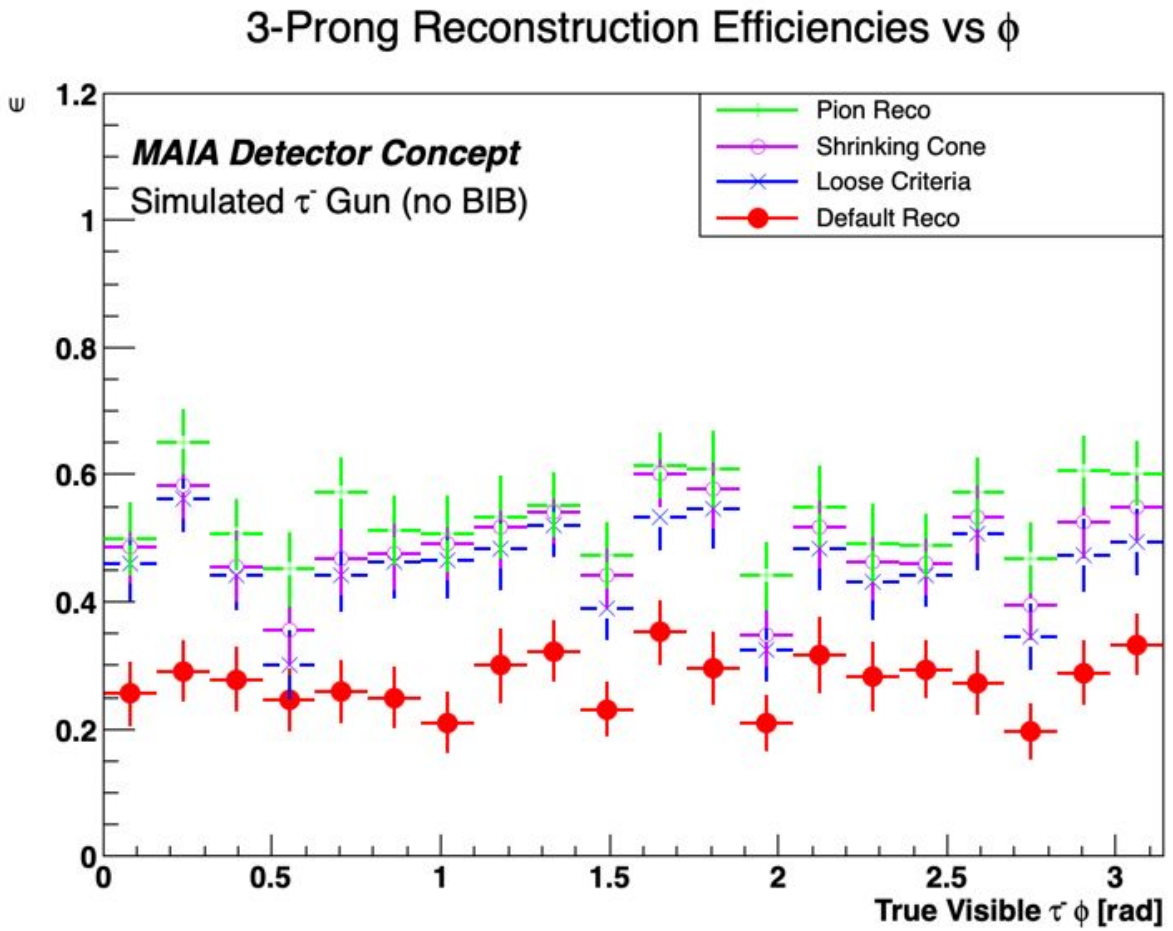
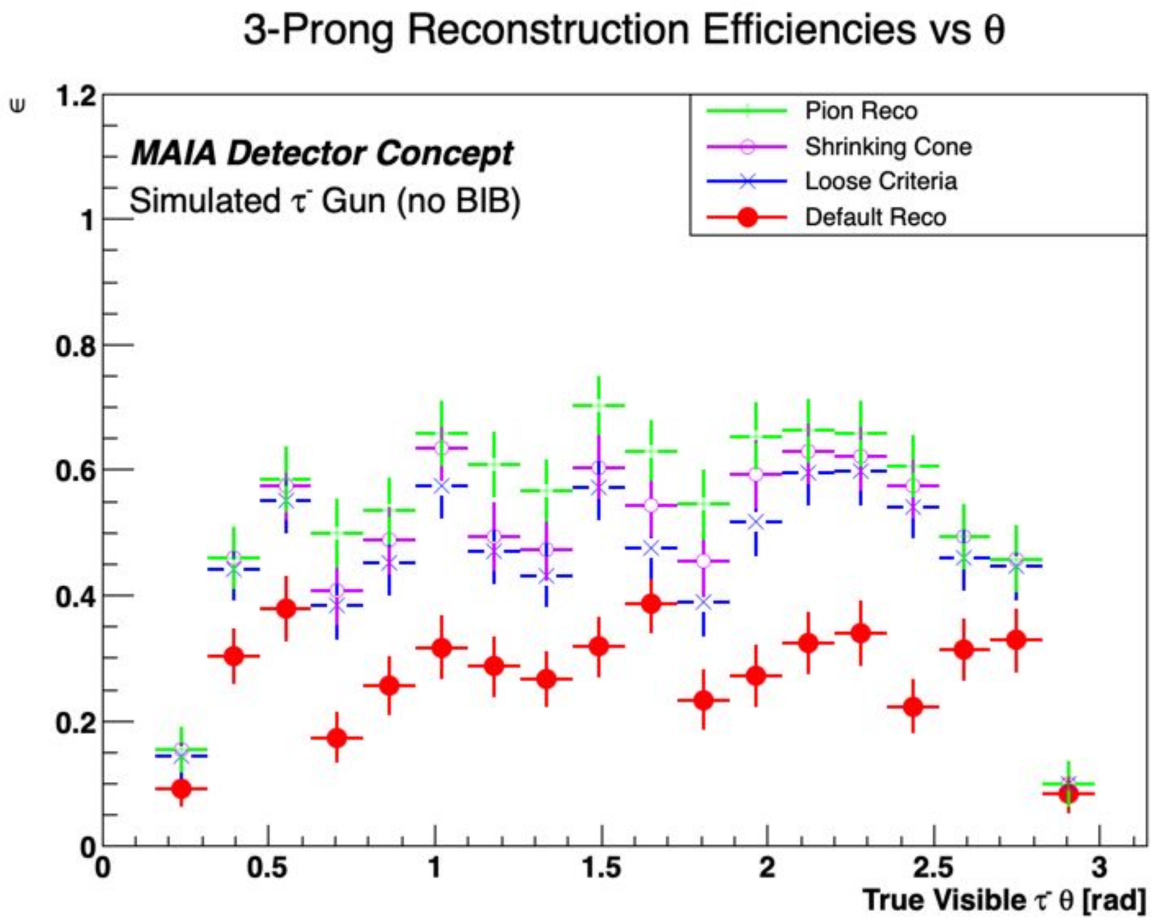
Backups: 1-Prong + N distributions



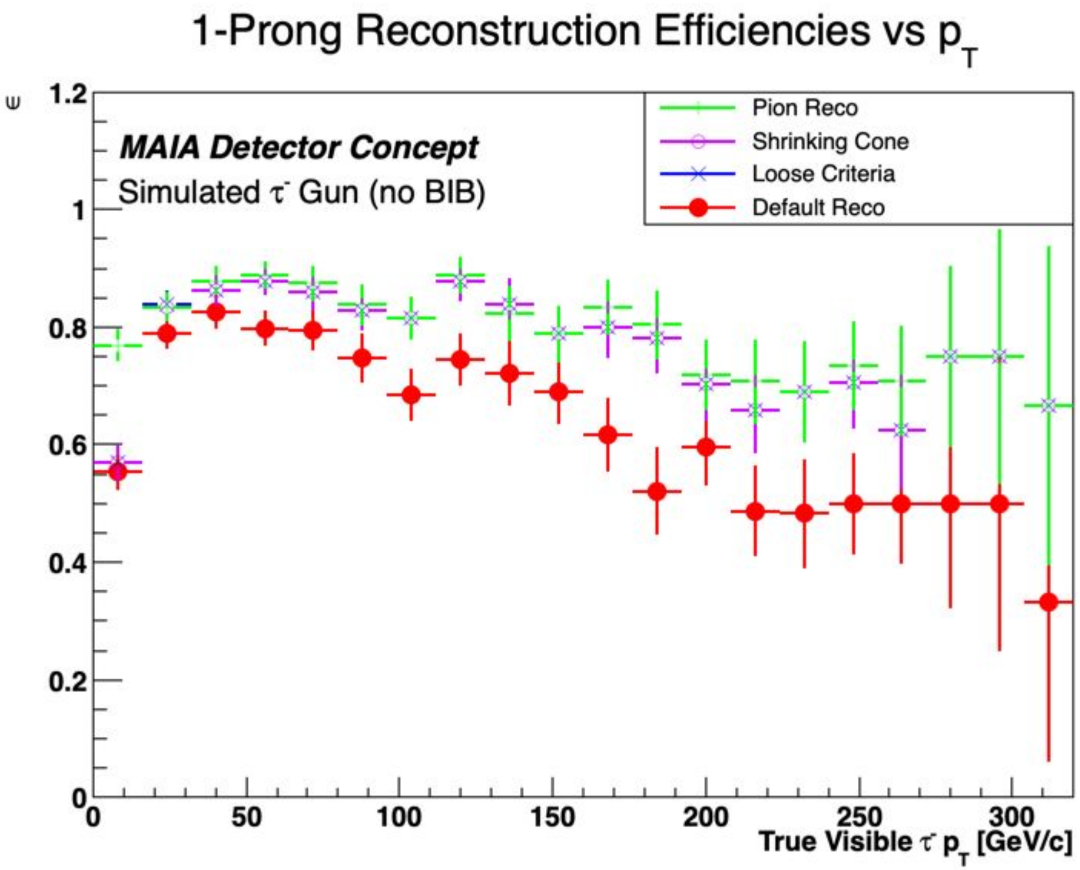


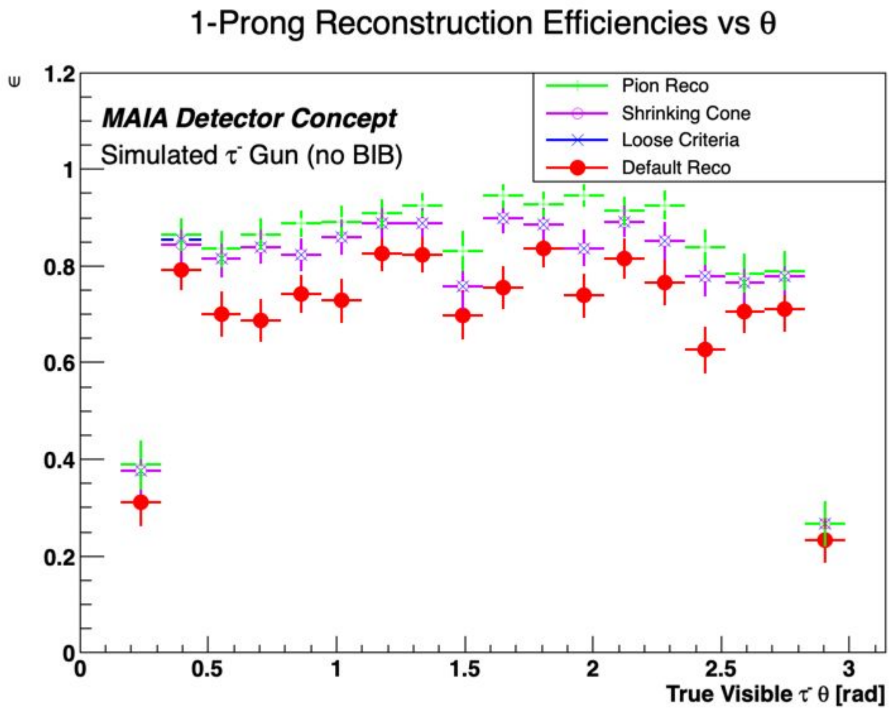
3-Prong distributions

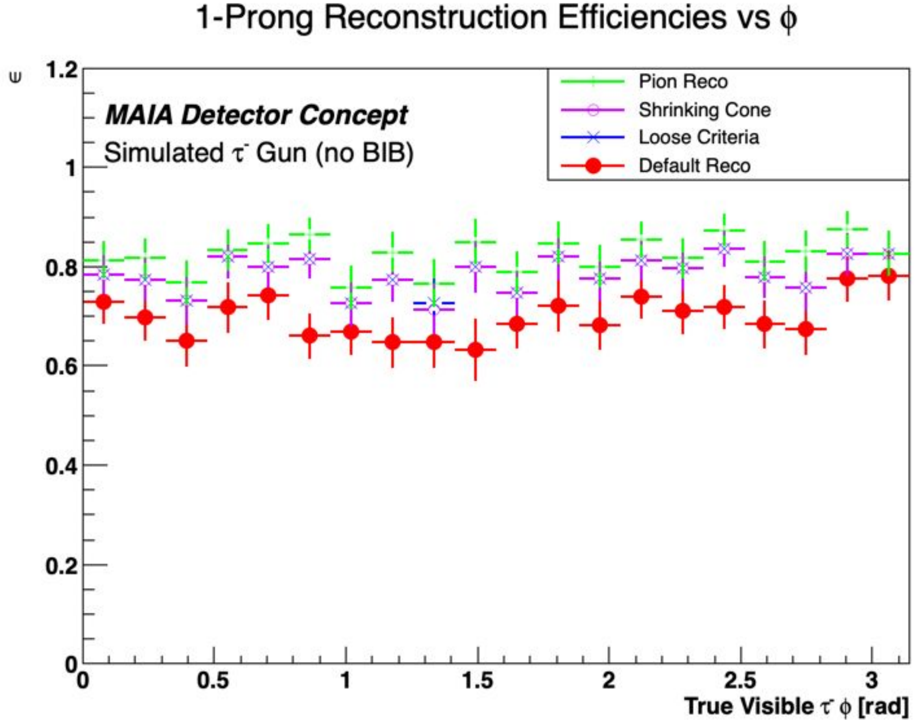




1- Prong Distributions







Example of different static cones

Plot made by Moses

Illustrates for the 3-prongs:

- Increasing the signal cone leads to a drop in efficiency at high pt ranges
- Drop in efficiency is due to failing the number of associated particles criteria