1P0N and 3P0N Tau Reconstruction

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MAIA Detector Tau Studies

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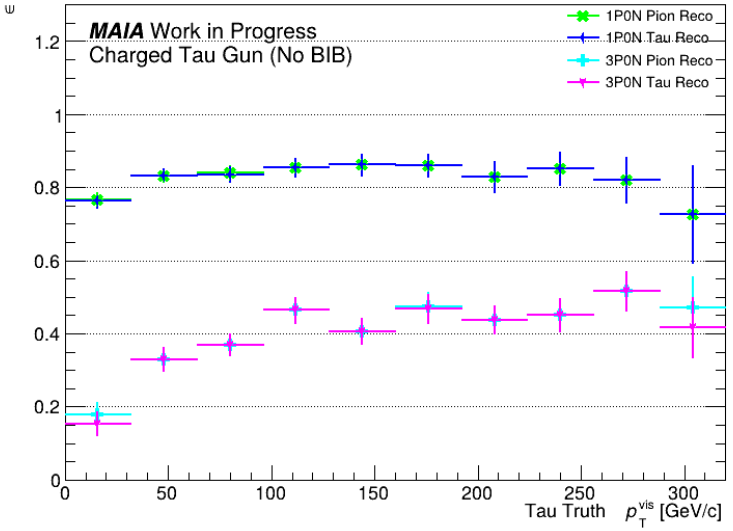
Overview

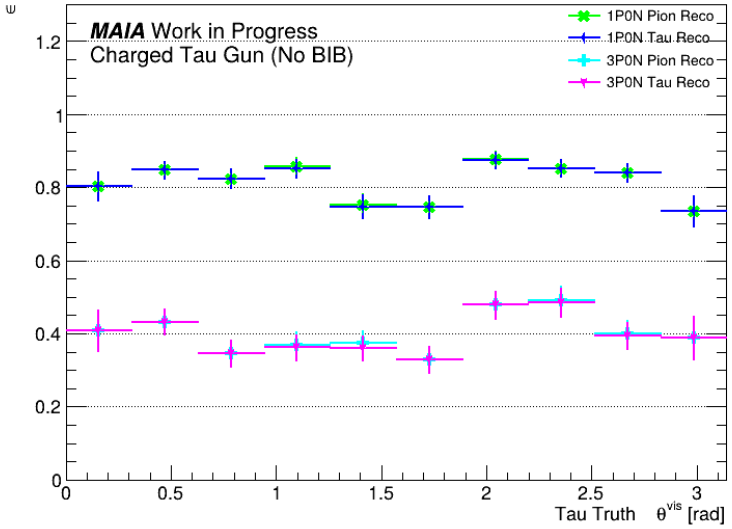
- Latest geometry and software
- Updated efficiencies
- Misidentification
- Truth matching failure
- Hadronic interactions
- Conclusions and next steps

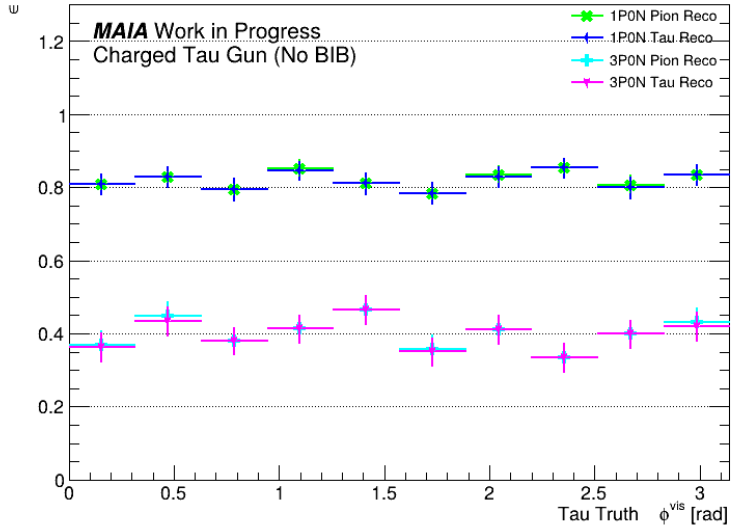
Geometry and Software Updates

- Removed overlaps in vertex detector, inner tracker, nozzle, and calorimeters: https://github.com/madbaron/detector-simulation/commits/KITP_10TeV/
- Added MAIA material map and TGeo file: https://github.com/MuonColliderSoft/ACTSTracking/tree/main/data
- Updates to ACTSTracking (though not sure exactly what) in latest software container version
- Using reconstruction workflow provided by Federico Meloni: https://github.com/madbaron/SteeringMacros

Updated 1P0N and 3P0N Reco Efficiencies





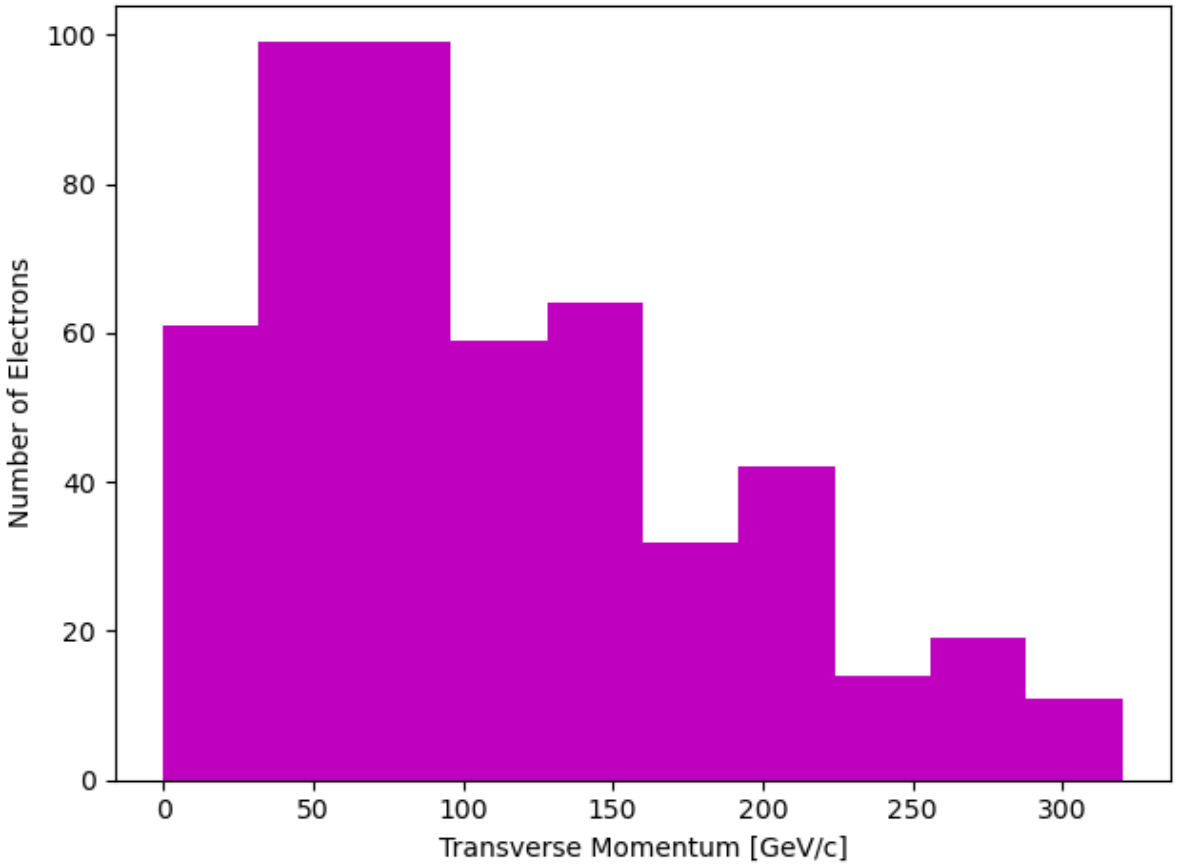


Decay Mode	$\pi^{\pm}$ Reco Efficiency	$\tau^{\pm}$ Reco Efficiency
1P0N	82.05%	81.89%
3P0N	40.14%	39.7%

- 1P0N efficiencies are unaffected by geometry and software updates
- 3P0N efficiencies decrease by ~15%
  - Worst in low p_T bins
- Efficiencies now appear to be flat in polar angle θ

Misidentification at Low p_T

- Charged pions appear to be misidentified as electrons more frequently for low visible p_T 3P0N events
- Need to check how Pandora is identifying electrons/charged pions to understand why



Truth Matching Failure

- While browsing failed 3P0N events, noticed that duplicates were incorrectly labeled, implying truth matching failure using LCRelations
- This wasn't noticed in old software
- Most likely a large contributor to decrease in 3P0N efficiencies
- Need to come up with more robust truth matching algorithm

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Event number: 8012
Number of unique reco pis: 2, Number of duplicate reco pis: 1

True Pion Pt: 10.96, True Pion Energy: 12.94, Reconstructed: Yes

True Pion Pt: 1.20, True Pion Energy: 1.45, Reconstructed: Yes

True Pion Pt: 12.48, True Pion Energy: 14.85, Reconstructed: No
Pion Reco Pt: 11.04044432242474, Pion Reco Energy: 13.033788681030273
Pion Reco Pt: 1.2082964577756352, Pion Reco Energy: 1.4666472673416138
Duplicate Pion Reco Pt: 12.542239934751462, Duplicate Pion Reco Energy: 14.926431655883789
```

```
Event number: 5845
Number of unique reco pis: 1, Number of duplicate reco pis: 2

True Pion Pt: 7.58, True Pion Energy: 7.92, Reconstructed: Yes

True Pion Pt: 2.12, True Pion Energy: 2.29, Reconstructed: No

True Pion Pt: 5.95, True Pion Energy: 6.28, Reconstructed: No
Pion Reco Pt: 7.572759354123493, Pion Reco Energy: 7.91811466217041
Duplicate Pion Reco Pt: 5.950905683248212, Duplicate Pion Reco Energy: 6.274542808532715
Duplicate Pion Reco Pt: 2.1108008861628953, Duplicate Pion Reco Energy: 2.287201404571533
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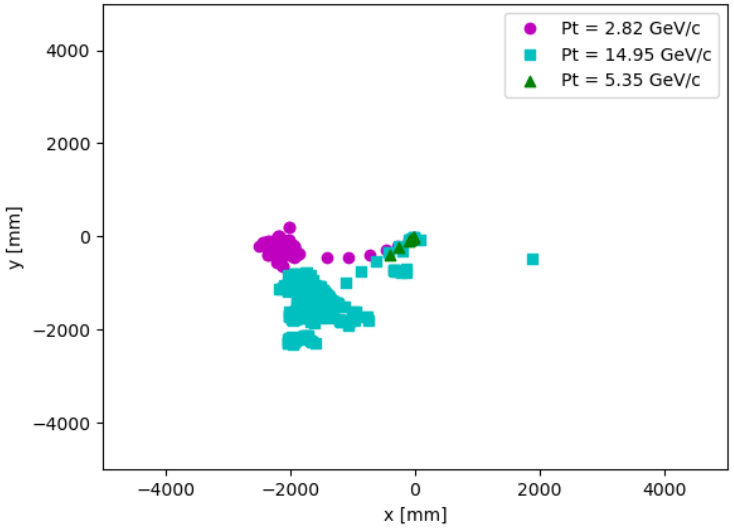
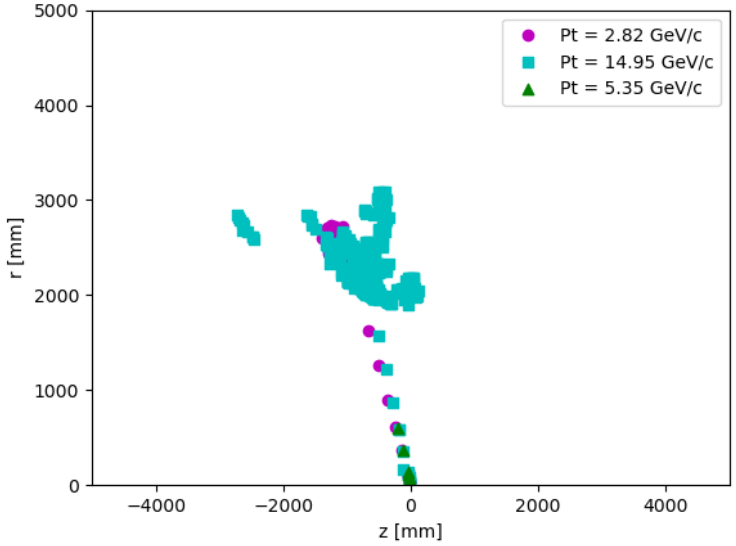
Hadronic Interactions



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Event number: 8587
Number of unique reco pis: 2, Number of duplicate reco pis: 0

True Pion Pt: 2.82, True Pion Energy: 3.08, Reconstructed: Yes

True Pion Pt: 14.95, True Pion Energy: 15.78, Reconstructed: Yes

True Pion Pt: 5.35, True Pion Energy: 5.68, Reconstructed: No
True Pion Endpoint-Daughter PDG: 211, True Pion Endpoint-Daughter Vertex Radius: 607.55
True Pion Endpoint-Daughter PDG: 211, True Pion Endpoint-Daughter Vertex Radius: 607.55
True Pion Endpoint-Daughter PDG: 111, True Pion Endpoint-Daughter Vertex Radius: 607.55
True Pion Endpoint-Daughter PDG: 111, True Pion Endpoint-Daughter Vertex Radius: 607.55
True Pion Endpoint-Daughter PDG: 211, True Pion Endpoint-Daughter Vertex Radius: 607.55
True Pion Endpoint-Daughter PDG: 211, True Pion Endpoint-Daughter Vertex Radius: 607.55
True Pion Endpoint-Daughter PDG: 2112, True Pion Endpoint-Daughter Vertex Radius: 607.55
True Pion Endpoint-Daughter PDG: 1000010030, True Pion Endpoint-Daughter Vertex Radius: 607.55
True Pion Endpoint-Daughter PDG: 2112, True Pion Endpoint-Daughter Vertex Radius: 607.55
True Pion Endpoint-Daughter PDG: 2212, True Pion Endpoint-Daughter Vertex Radius: 607.55
True Pion Endpoint-Daughter PDG: 2112, True Pion Endpoint-Daughter Vertex Radius: 607.55
True Pion Endpoint-Daughter PDG: 1000010020, True Pion Endpoint-Daughter Vertex Radius: 607.55
True Pion Endpoint-Daughter PDG: 2212, True Pion Endpoint-Daughter Vertex Radius: 607.55
True Pion Endpoint-Daughter PDG: 1000010020, True Pion Endpoint-Daughter Vertex Radius: 607.55
Pion Reco Pt: 2.8164696575477977, Pion Reco Energy: 3.069620132446289
Pion Reco Pt: 14.975836456671624, Pion Reco Energy: 15.800155639648438
MisID Type: 11, MisID Pt: 5.352642301428696, MisID Energy: 5.68993616104126
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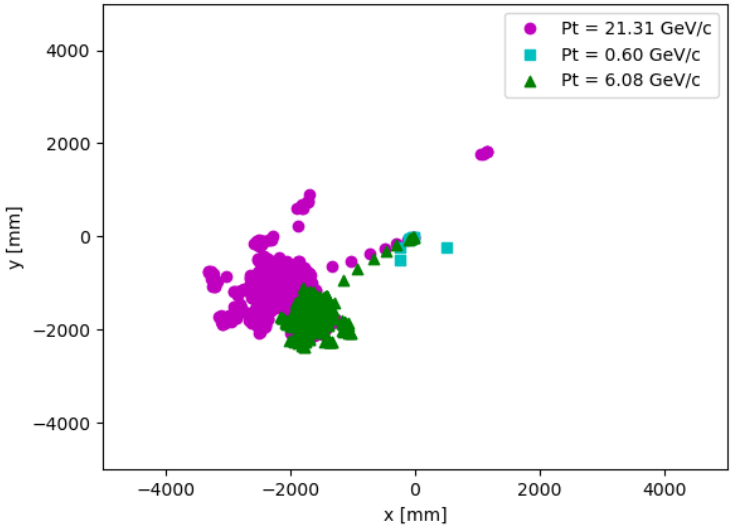
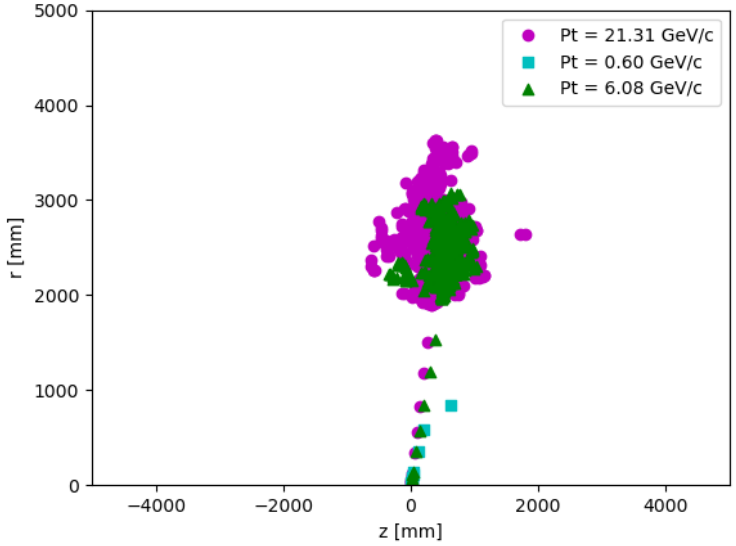
Hadronic Interactions



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Event number: 1672
Number of unique reco pis: 2, Number of duplicate reco pis: 1

True Pion Pt: 21.31, True Pion Energy: 21.62, Reconstructed: Yes

True Pion Pt: 0.60, True Pion Energy: 0.65, Reconstructed: No
True Pion Endpoint-Daughter PDG: 2112, True Pion Endpoint-Daughter Vertex Radius: 822.30
True Pion Endpoint-Daughter PDG: 2112, True Pion Endpoint-Daughter Vertex Radius: 822.30
True Pion Endpoint-Daughter PDG: 2112, True Pion Endpoint-Daughter Vertex Radius: 822.30
True Pion Endpoint-Daughter PDG: 2112, True Pion Endpoint-Daughter Vertex Radius: 822.30
True Pion Endpoint-Daughter PDG: 2112, True Pion Endpoint-Daughter Vertex Radius: 822.30
True Pion Endpoint-Daughter PDG: 2112, True Pion Endpoint-Daughter Vertex Radius: 822.30

True Pion Pt: 6.08, True Pion Energy: 6.28, Reconstructed: Yes
Pion Reco Pt: 21.287760519717132, Pion Reco Energy: 21.604448318481445
Pion Reco Pt: 0.6000185067696799, Pion Reco Energy: 0.6470839381217957
Duplicate Pion Reco Pt: 6.083416346284378, Duplicate Pion Reco Energy: 6.277514934539795
```

Conclusions and Next Steps

- 1P0N efficiencies are unaffected by geometry and software updates
- 3P0N efficiencies decreased by ~15%
  - Most likely due to truth matching failures
  - Low p_T bins suffering the most due to higher frequency of charged pions misidentified as electrons
- Observed low-ish frequency of hadronic interactions between charged pions and detector material
- Should have overlayed BIB samples by end of week

1P0N and 3P0N Reco Regional Efficiencies