TrajCluster IX

Improvements, MC Matching, Performance

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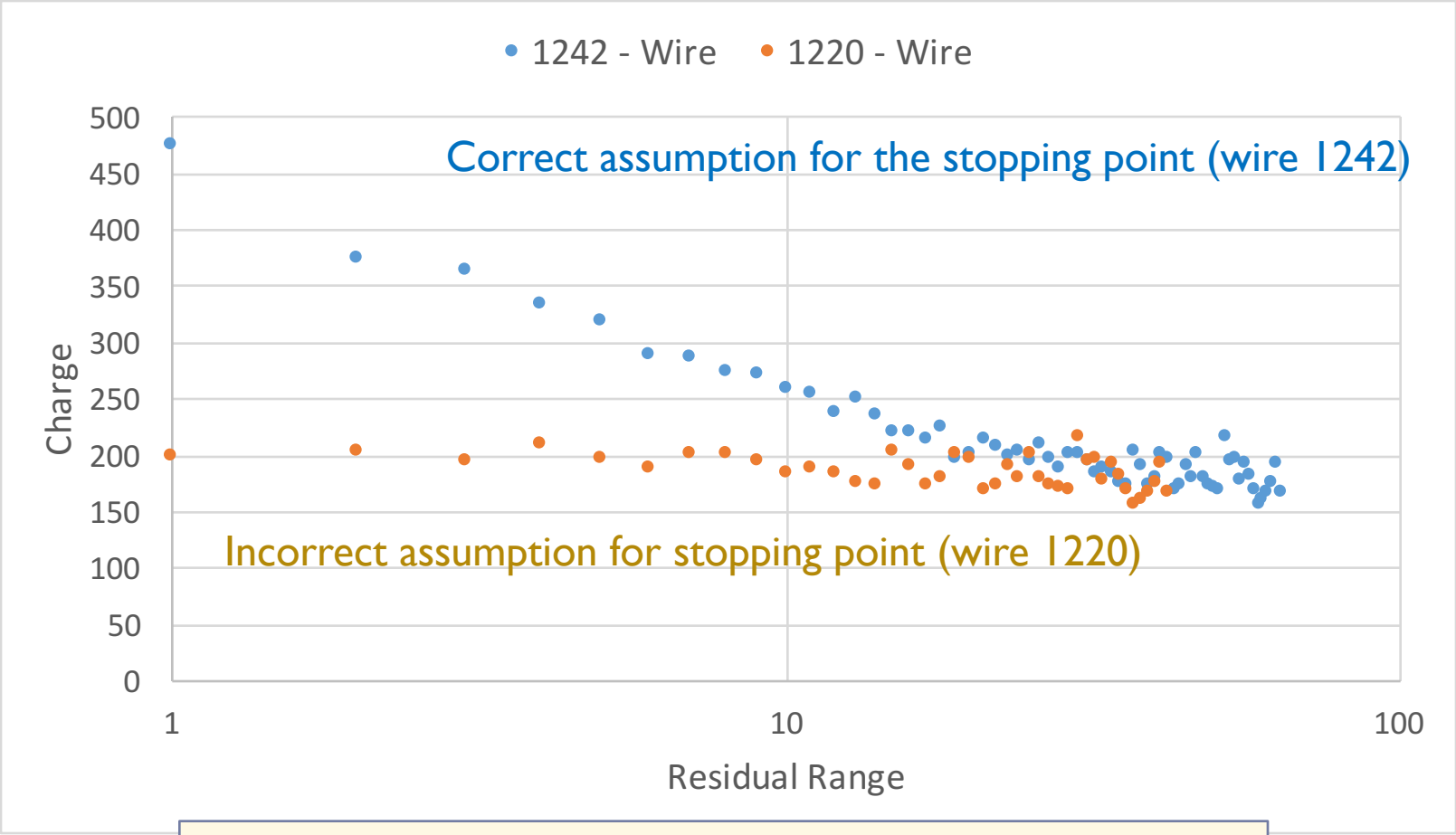
Outline

- Stopping tracks - *preliminary*
- Improved kink checking
- MC truth performance metric + tools
  - Provides a quick turn-around guide for code development and fcl parameter optimization
  - Not proposed to be a standard metric
- Performance on BNB nu events
- Status

Chg vs Residual Range (RR)



<u>Don't expect a power law dependence near the Bragg peak</u>
No recombination correction made at this point.
Use linear fit of Chg vs log(RR).
Expect 10% ionization fluctuations

ChkStop - New

- Goal is to get the stopping point right for decaying particles, e.g. Kaons
- Consider each end of the trajectory (TJ)
  - Find the point near the end which has the max charge (PtWithMaxChg) and assume it is the stopping point
  - Fit Chg vs log(RR) between these points
  - Set new TJ variable StopsAtEnd if slope pull and fit χ^2 meets cuts
- User fcl parameters

```
TrajClusterAlg.ChkStopCuts: [1.3, 5, 2.5] # [Min chg ratio, Chg slope pull cut, Chg fit Chi cut]
```

- New bitset used to prevent merging stopping TJs with the daughter

```
std::bitset<2> StopsAtEnd {0};    // Set true if it looks like the trajectory stops at end[0] or end[1]
```

Improved Kink Checking

While stepping…

- Old
  - Fit the last 3 points added to the end of the TJ
  - Calculate angle difference btw last 3-point fit and previous points
  - Stop tracking if the angle exceeds fcl parameter fKinkAngCut
- New - to better track low momentum trajectories

```
TrajClusterAlg.KinkCuts: [ 0.35, 1.5, 3 ] # kink angle, MCS kink significance, nPts fit
```

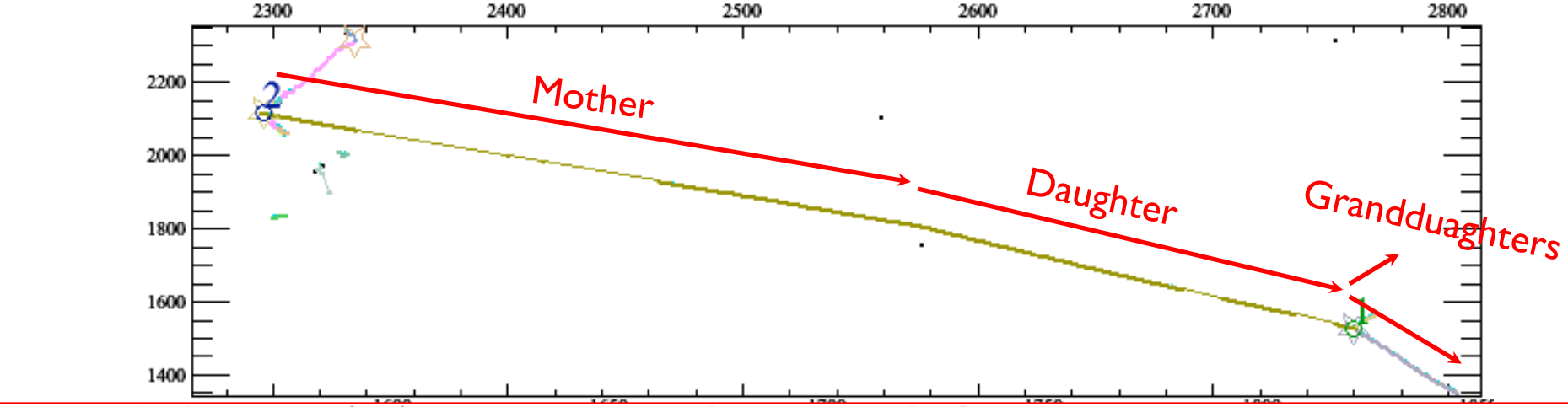
  - Fit the last nPtsFit points added to the end of the TJ
  - Calculate θ_{MCS} at each step and construct the kink cut

```
// MCSThetaRMS is the scattering angle for the entire length of the trajectory. Convert
// this to the scattering angle for one WSE unit
float thetaRMS = MCSThetaRMS(tjs, tj, tj.EndPt[0], tj.EndPt[1]) / sqrt(TrajPointSeparation(tj.Pts[tj.EndPt[0]], tj.Pts[lastPt]));
float kinkAngCut = fKinkCuts[0] + fKinkCuts[1] * thetaRMS;
```

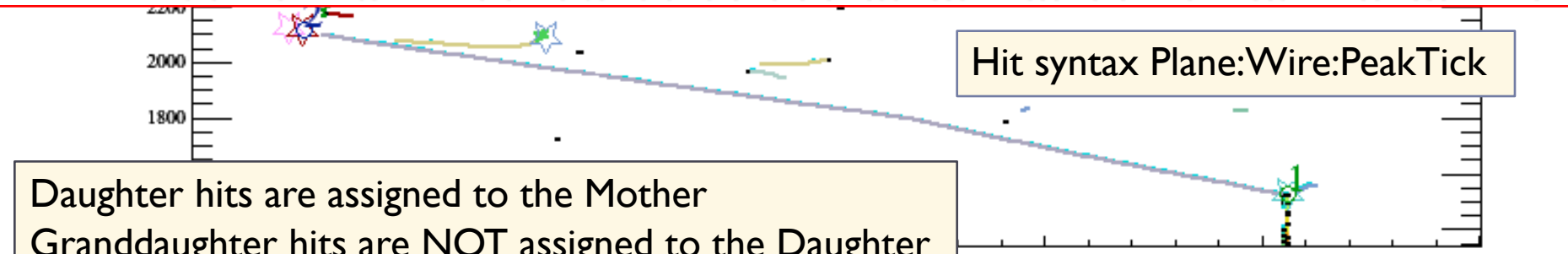
```
std::bitset<2> KinkAtEnd {0};    // Set true if there is a kink at end[0] or end[1]
```

MatchTruth

- Loop through sim::ParticleList
  - Select kBeamNeutrino, kSingleParticle or kCosmicRay
  - Ignore neutronInelastic and hadElastic processes
- Create a list of mother - daughter pairs
  - Ignore hIoni and eIoni processes – δ-rays
  - Create a mother – daughter pair if
    - There is only one <u>charged</u> daughter and
    - The daughter PDG code == mother PDG code
- Match all hits to truth particles
  - Require energyFrac > 0.5
- Define EP == Efficiency * Purity as a performance metric
  - Efficiency = nTruRecHits / nTruHits
  - Purity = nTruRecHits / nMatchedHitsInTj

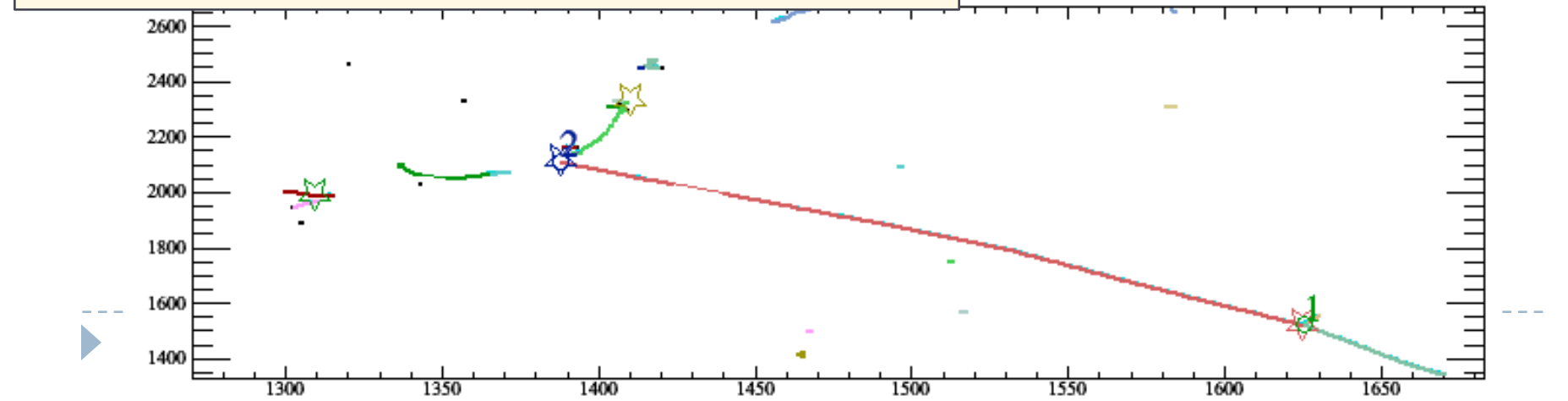


part	PDG	TrkID	MomID	KE(MeV)	Process	Trajectory_extent_in_plane
0	2212	2	0	678	primary	0:1388:2109-0:1528:1804 1:1584:2100-1:1717:1807 2:2295:2117-2:2574:1810
1	2212	52	2	437	ProtonInelastic	0:1529:1801-0:1624:1525 1:1718:1803-1:1805:1527 2:2575:1809-2:2759:1530
26	2212	318	52	160	ProtonInelastic	0:1627:1515-0:1670:1346 1:1805:1358-1:1806:1502 2:2761:1524-2:2804:1354
27	2212	319	52	65	ProtonInelastic	0:1626:1526-0:1630:1558 1:1806:1526-1:1812:1563 2:2760:1530-2:2770:1567



Hit syntax Plane:Wire:PeakTick

Daughter hits are assigned to the Mother
Granddaughter hits are NOT assigned to the Daughter



MatchTruth – Tools

- Print EP averages weighted by T (KE) event-by-event
  - Use to optimize fcl settings

```
Event 166818 Electron 0.54 15061 Muon 0.83 562 Pion 0.73 231 Kaon 0.78 3 Proton 0.74 1098 combined 0.75
Event 166819 Electron 0.54 15061 Muon 0.83 562 Pion 0.73 231 Kaon 0.78 3 Proton 0.74 1098 combined 0.75
Event 166820 Electron 0.54 15067 Muon 0.83 565 Pion 0.73 231 Kaon 0.78 3 Proton 0.74 1101 combined 0.75
```

- User-defined output of poorly matched trajectories
  - Use for code development

```
TrajClusterAlg.MatchTruth: [1, 0, 0.5, 10] # [1(nu), 2(cosmics), PrintLevel, Max EP, Min nTruHits]
```

  - Example: print BadEP when Max EP < 0.5 & Min nTruHits > 9

```
pdgIndex 4 BadEP 0.466667 nMatchedHitsInPartList 14 from true hit 0:1569:4751_1 to 0:1582:4770_1 events processed 39
```

Poorly reconstructed proton (pdgIndex = 4) in plane 0. There are 14 matched hits on the "true trajectory". The end hits of the true trajectory are displayed.
Syntax: Plane:Wire:PeakTick_TrajectoryID.

Performance

- Using 820 prodgenie BNB nu events
- MatchTruth histograms
  - Neutrino 3D vertex position truth – reco
  - "dWire" by particle type
    - Difference between the starting (true-reco) and stopping wire (true-reco) - both ends plotted in the same histogram
    - This is a better metric than EP for stopping tracks
      - You really care about the last 10 – 20 points for calorimetric PID
  - EP vs T (MeV)

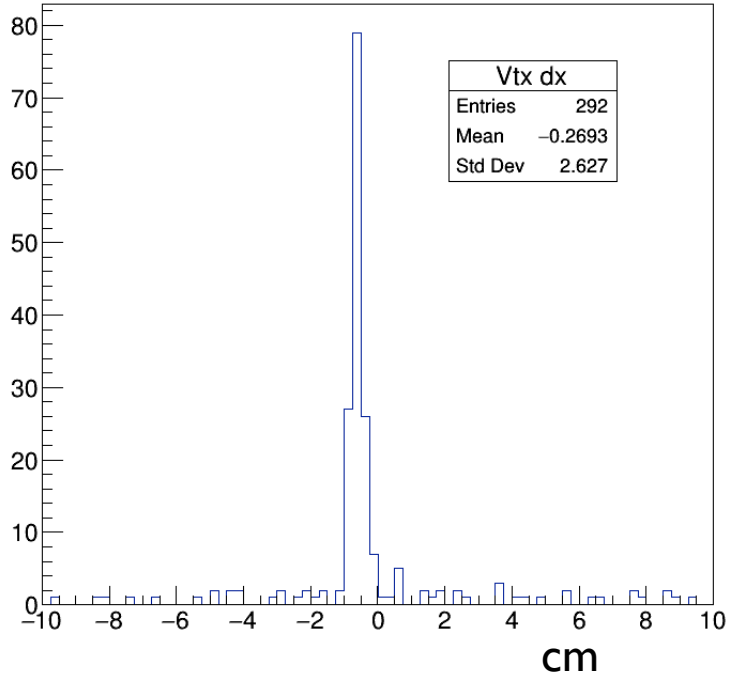
True – Reco for ALL 3D vertices

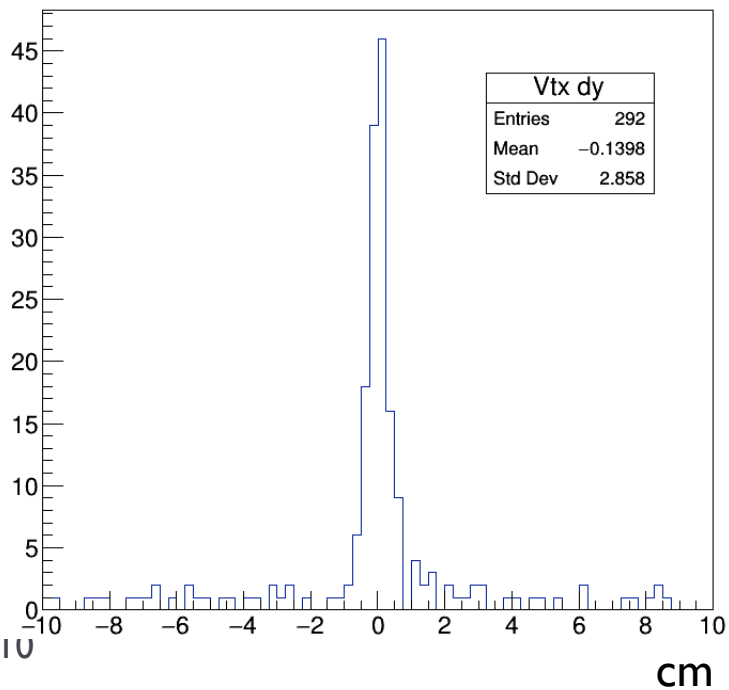
<u>Notes</u>

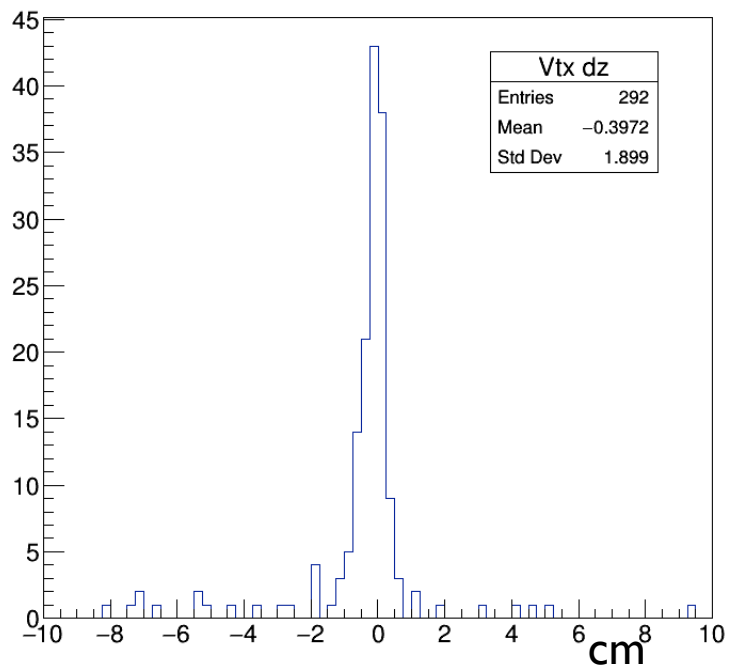
Need 2+ trajectories to make a vertex

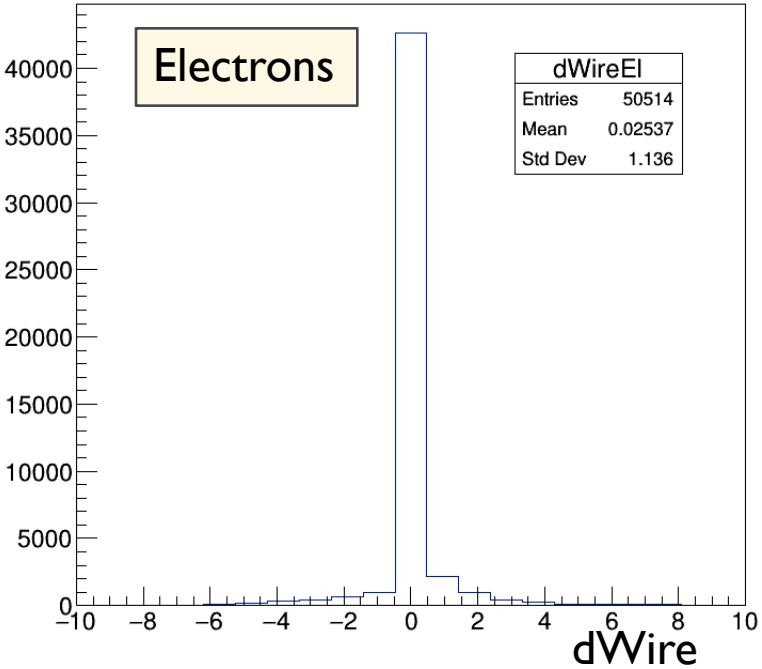
Includes mother-daughter vertices

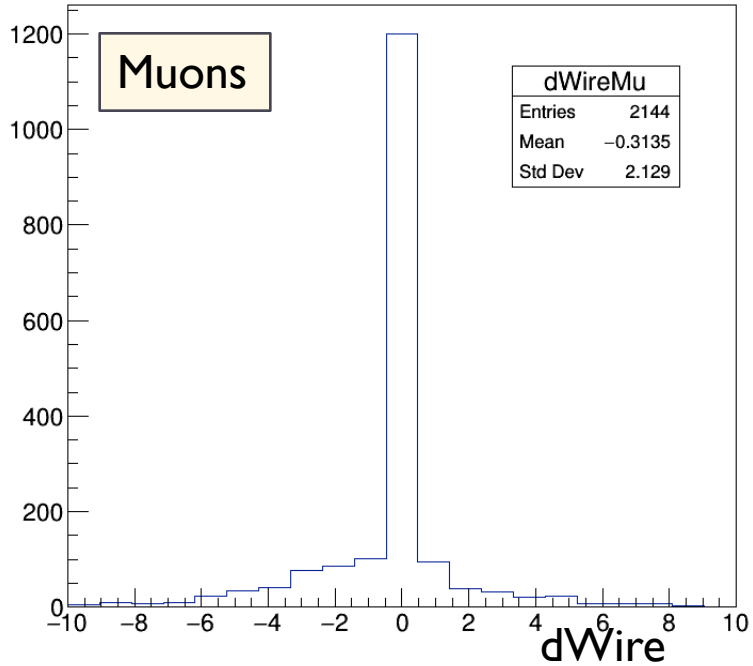
No neutrino vertex ID

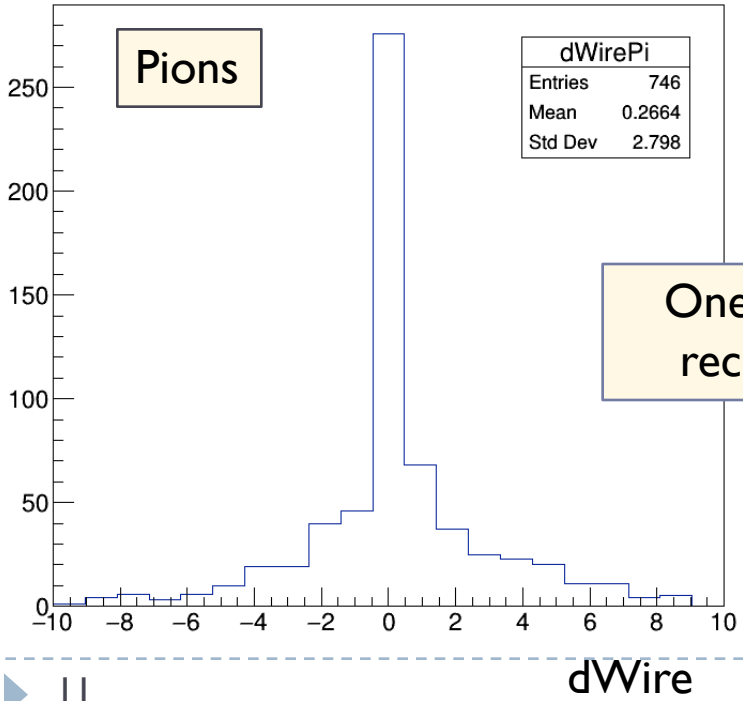


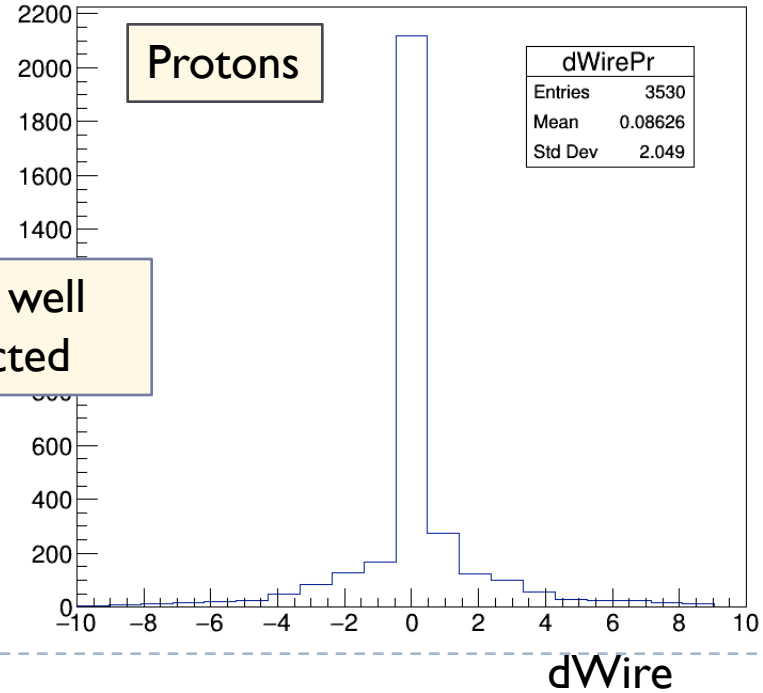




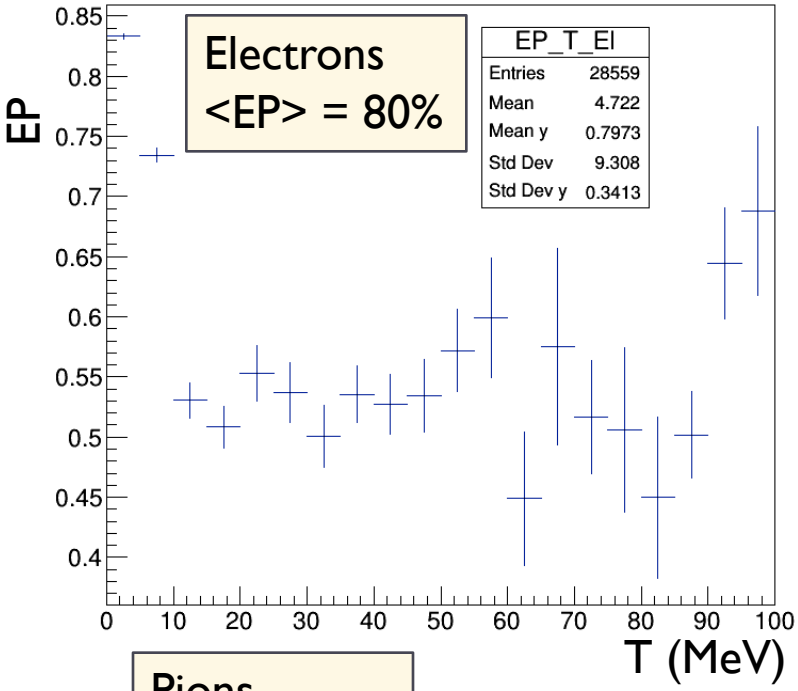


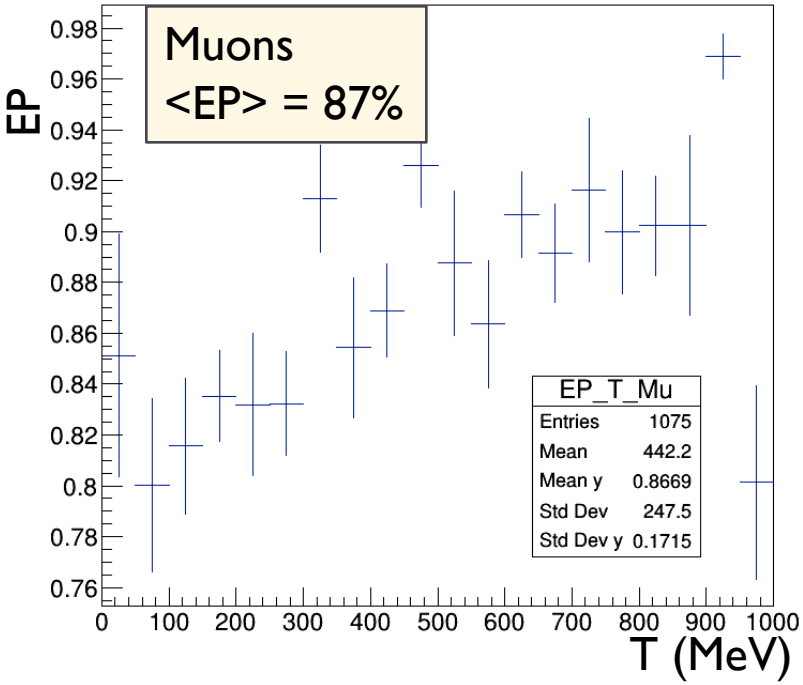


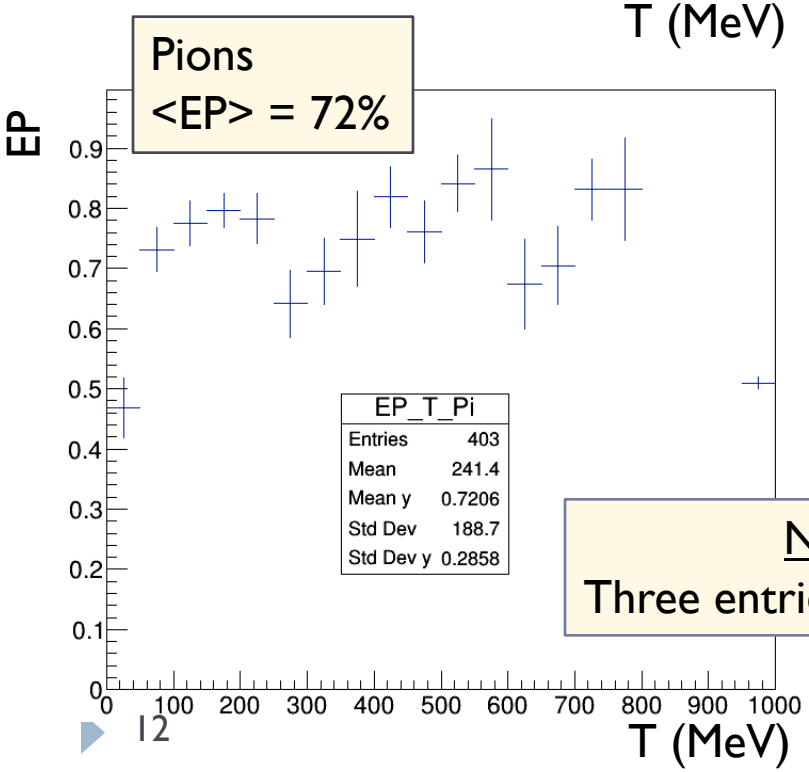


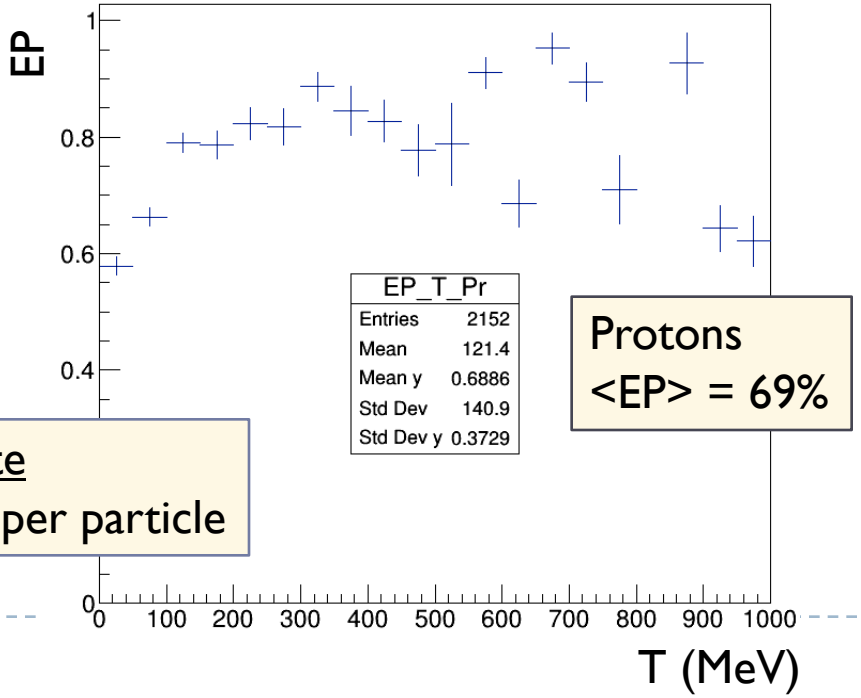


One end is well reconstructed









Note

Three entries per particle

Status

- Code lives on feature/bb_TJWork
  - Breaking changes addressed for ArgoNeuT, uB and DUNE
- Can push to develop