The University Of Sheffield.

TRACS Migration to PandoraModularShowerCreation

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Shower Characterisation

- Pattern recognition (Pandora) reconstructs PFParticles which are classified as track-like or shower-like
- Next stage is to characterise the shower (create a recob::Shower)
  - Start Position
  - Direction
  - dEdx (At the start of the shower)
  - Energy
  - Best Plane
  - Length
  - Opening Angle
- Existing Algorithms:
  - EMShower: General purpose which can take PFParticle or cluster input
  - PandoraShower: Takes PFParticle input but topology only (No Calorimetry)

Introduction to TRACS

- Tool Based Reconstruction Algorithm for Characterising Showers
- Pushed to larreco last year (Coordination Meeting August 13th 2019)
- Developed by Dom Barker, myself, Dom Brailsford in SBND
- Built a modular framework to fully create a recob::Shower from a PFParticle input (Pandora)
- Runs over a set of art::Tools
  - Each tool should calculate one thing (e.g. start position)
  - Can change which methods are used in fcl
  - Created a suite of tools with many different approaches
  - Use ShowerElementHolder to pass information between tools
- Currently used as the main shower reconstruction in SBND and ICARUS (Contributions from Tom Ham and Bruce Howard)
- Has been used in DUNE FD (D. Brailsford)

TRACS: Technical Details: Module

- LArSoft producer module that you actually run
- Initialised the art:Tools based on parameter list
- Manages the ShowerElementHolder for passing information between the module and tools
- Runs through the tools for each PFParticle
- Retrieves the shower parameters from ShowerElementHolder
- Creates the recob::Shower and adds assns (e.g. Shower $<->$ Hits)

TRACS: Technical Details: ShowerElementHolder

- ShowerElementHolder is map to a templated base class with set, get and check functions
- Can store any object you want, not just things in the recob::Shower
- e.g. One tool calculates and stores subset of hits for calculating dEdx in another tool
- Can store Element&Error for things that require errors in recob::Shower (e.g. Shower Energy)

TRACS: Technical Details: Tools

- Tools are derived from a base class IShowerTool
- Has access to Alg with commonly used functions
- Each tool should aim to do one thing (e.g. Start Position, Direction, dEdx, Energy...)
- Can create assns from within tools
- e.g. Create an assn from the Shower to recob::PCAxis in the ShowerPCADirection tool
- Someone who has an idea for shower reco should create a new tool and not deal with the module or ShowerElementHolder (Skeleton and Example tools to help people get started)

LArPandoraModularShowerCreation

- Circular dependency prevented the PandoraSlidingFit Tool
- Moved from larreco to larpandora to overcome this issue
- Should increase usage across experiments
- Will live alongside LArPandoraShowerCreation
- Experiments will have to opt-in
- Can reproduce LArPandoraShowerCreation from LArPandoraModularShowerCreation (To within fraction of mm)
- Produce some ‘extra’ showers where LArPandoraShowerCreation failed
- Experiments will need to configure to use their CalorimetryAlgs

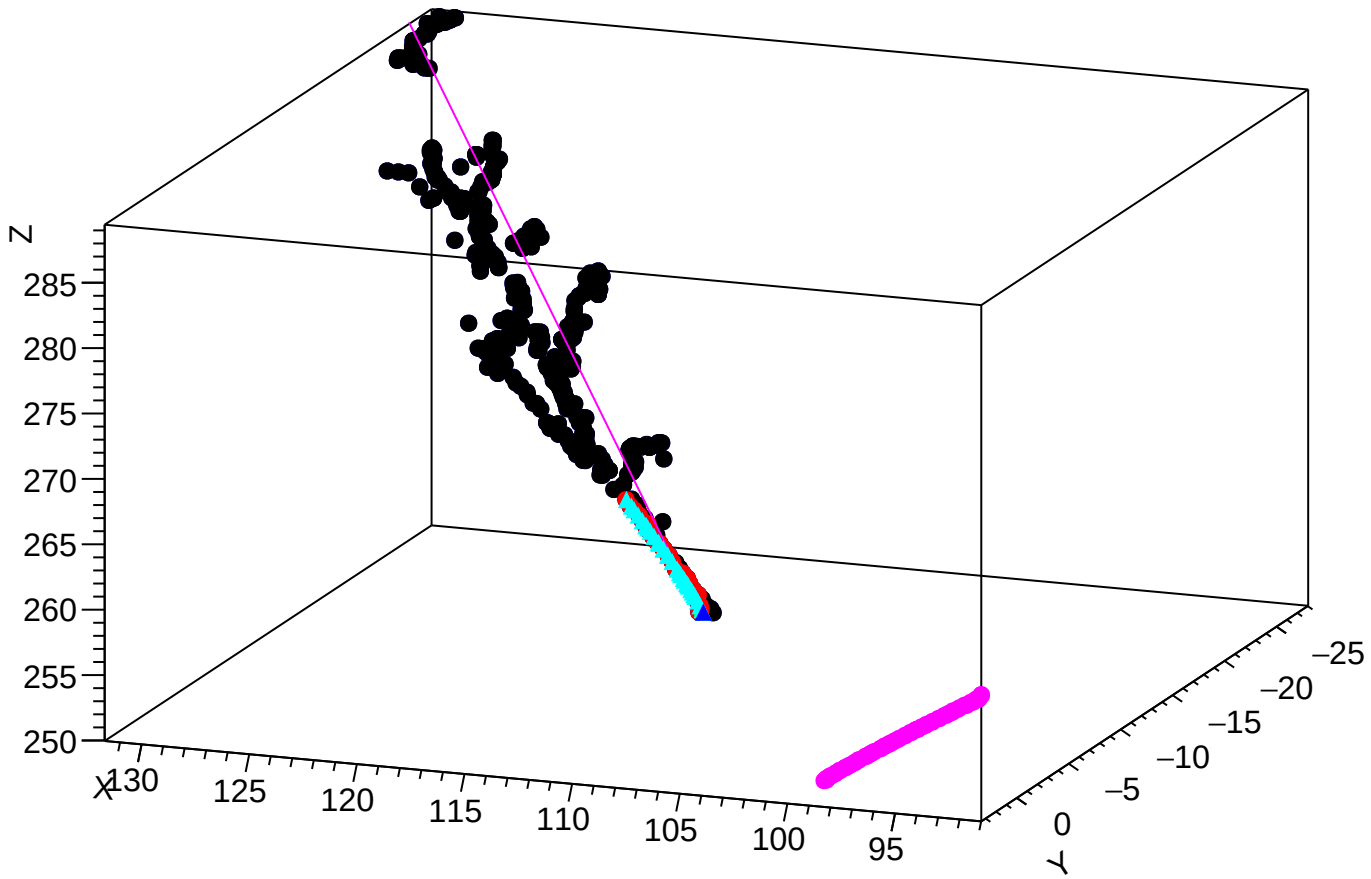
Improvements From TRACS

- Can now push PandoraSlidingFit and related tools
- Functions to store FindManyP objects in ShowerElementHolder (Yields significant speed up)
- Simplified configuration: Make tools inherit fcl parameters from the module
- Renamed some tools (See backup slide)
- Numerous small bug fixes
- Documentation improvements

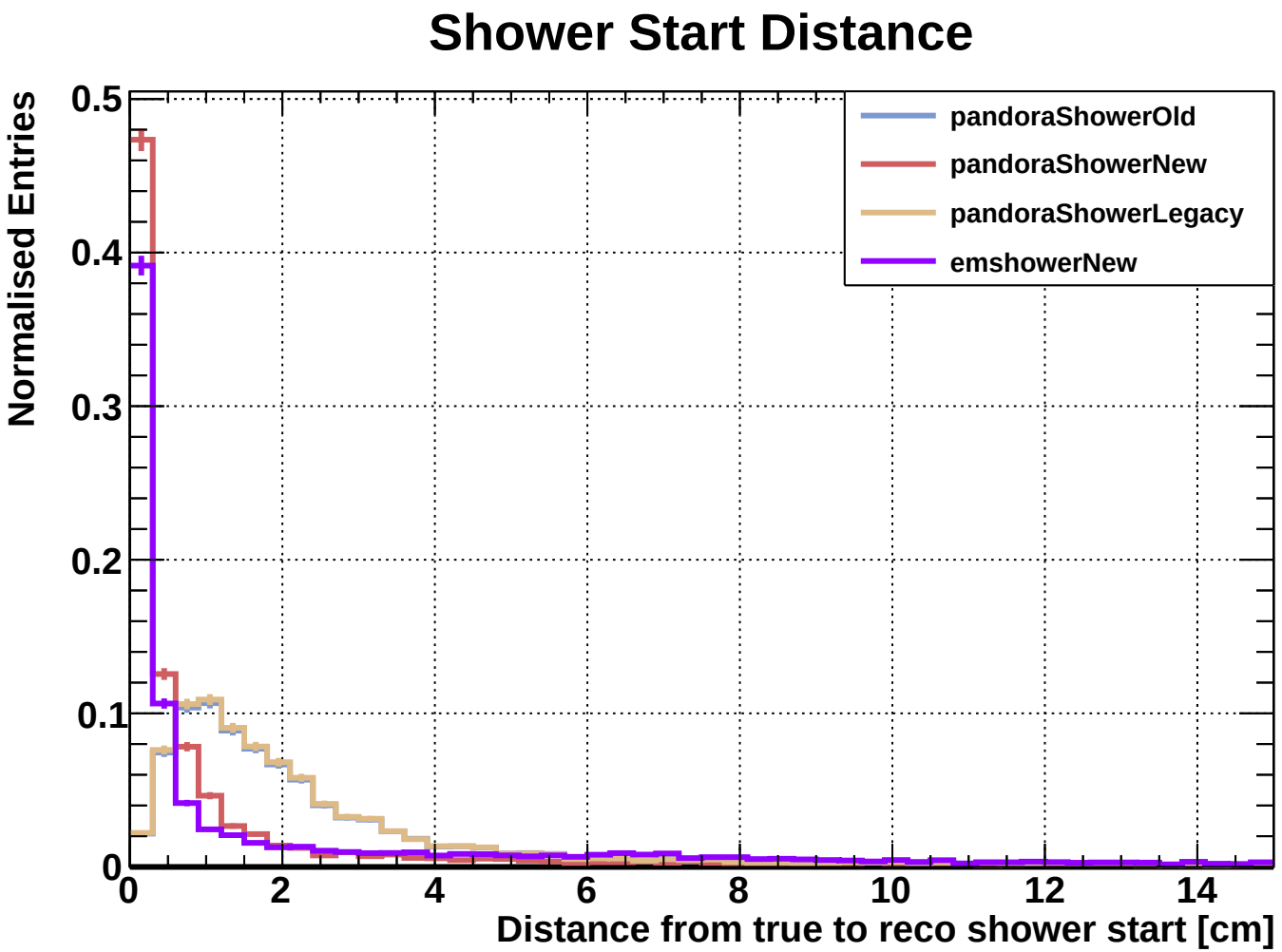
Experiment Changes

- TRACS being removed is a breaking change for experiments that use it as part of the standard reco chain
  - SBND and ICARUS have branches available for this
- DUNE FD will opt in when D. Brailsford is back off holiday
- Most tools should run out of the box
- Need to configure calorimetric tools to use experiment specific Calorimetry Algs

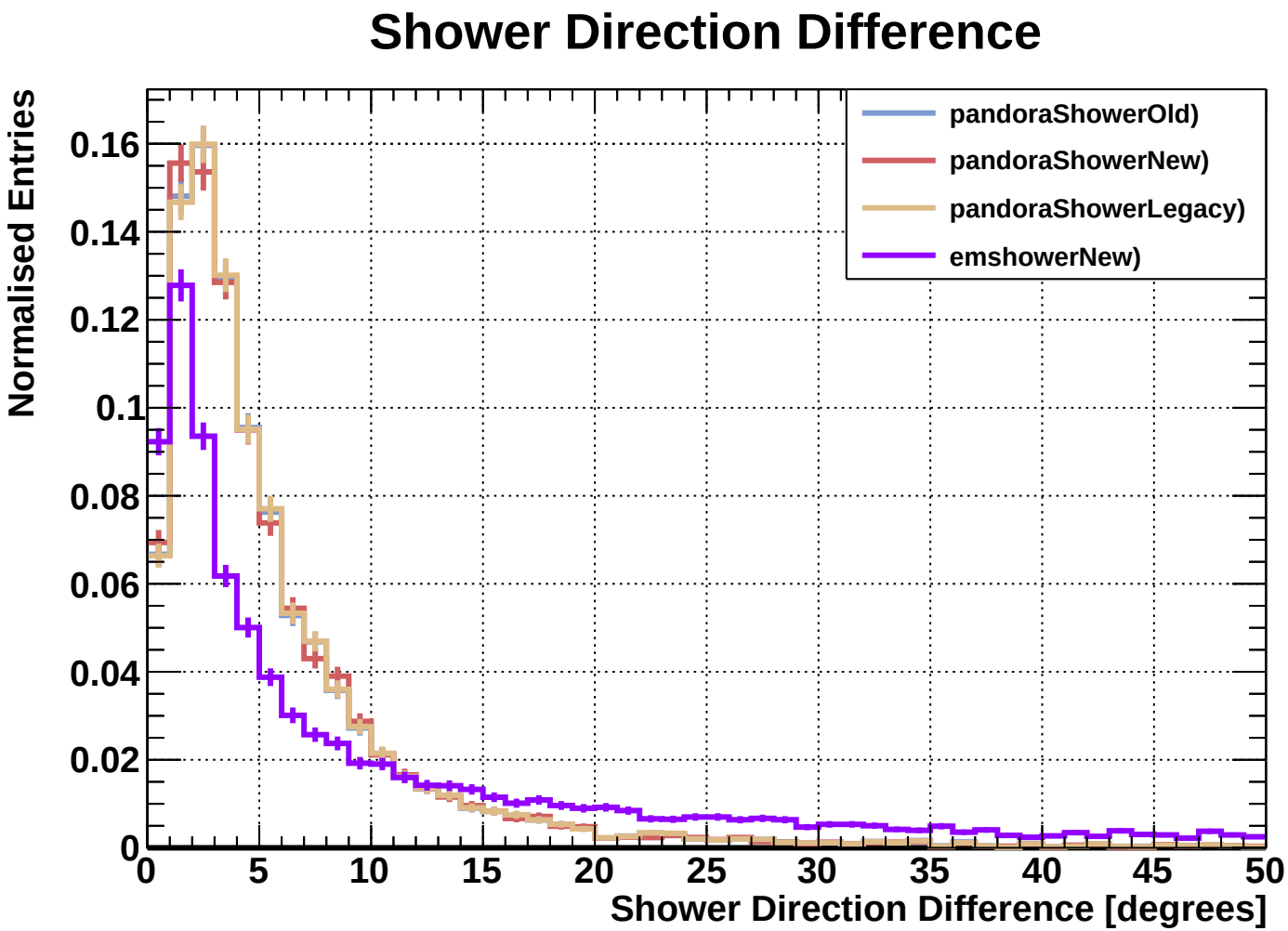
Example Event Display



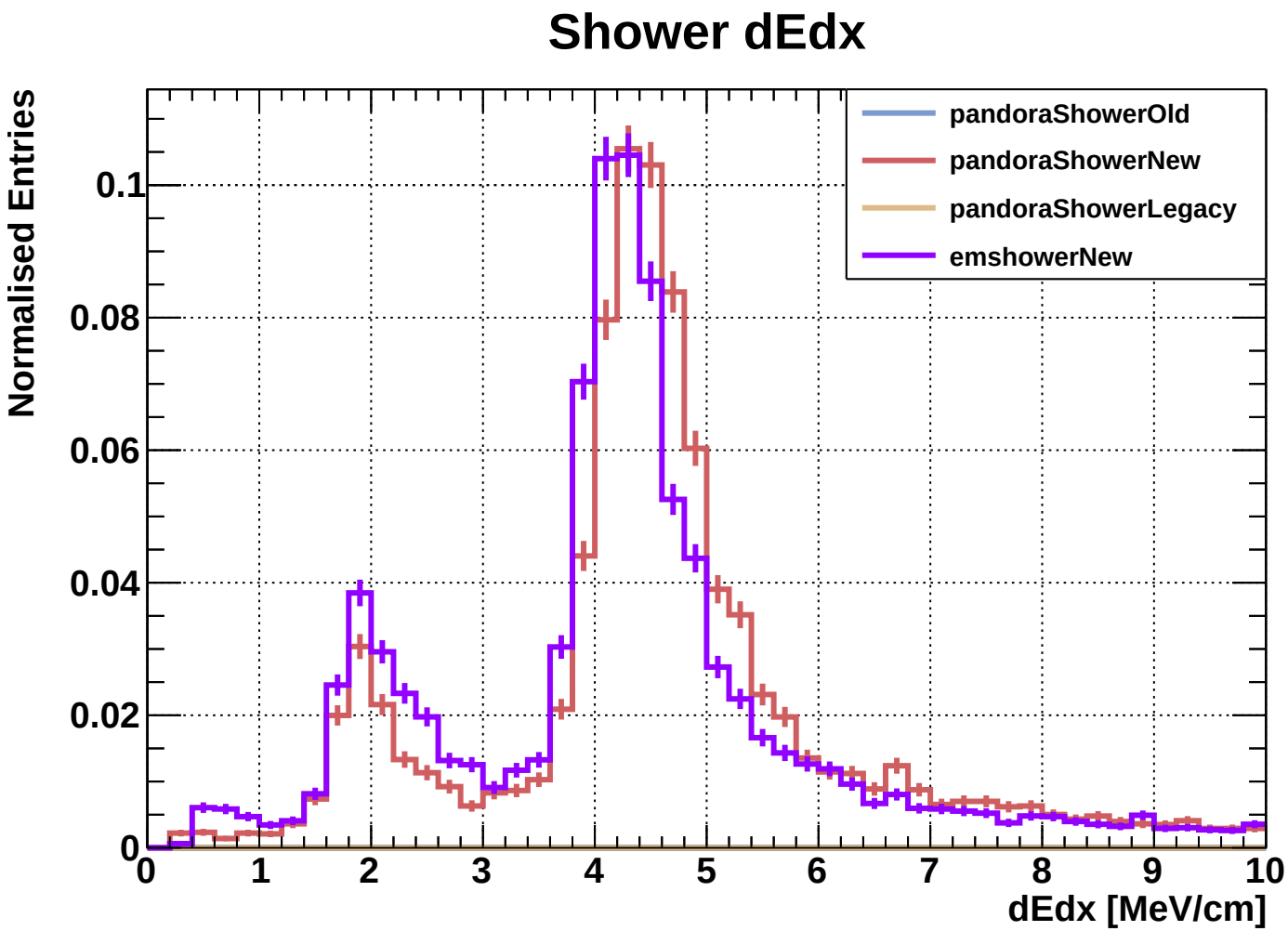
Performance: Shower Start Position



Performance: Shower Direction

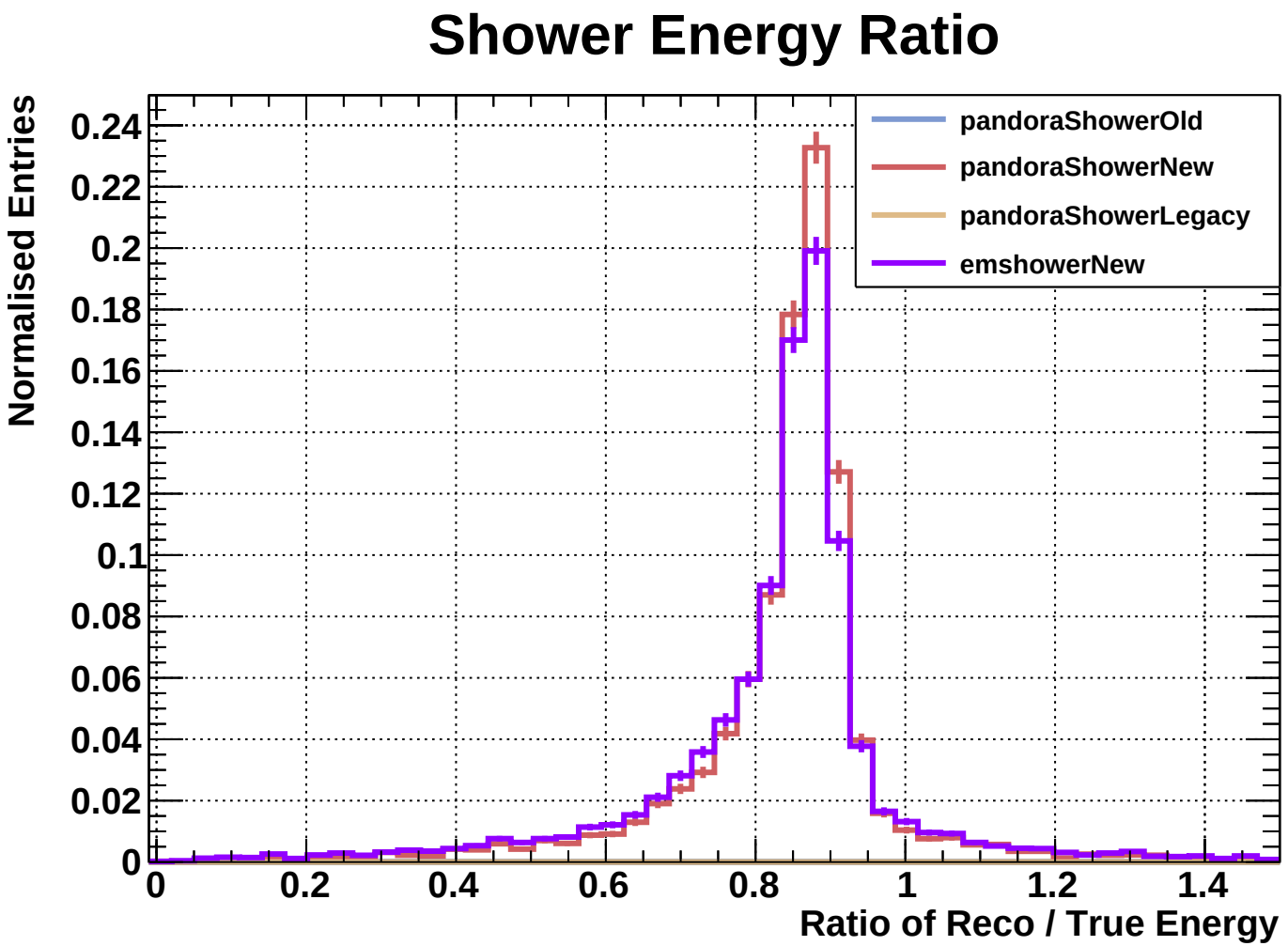


Performance: Shower dEdx

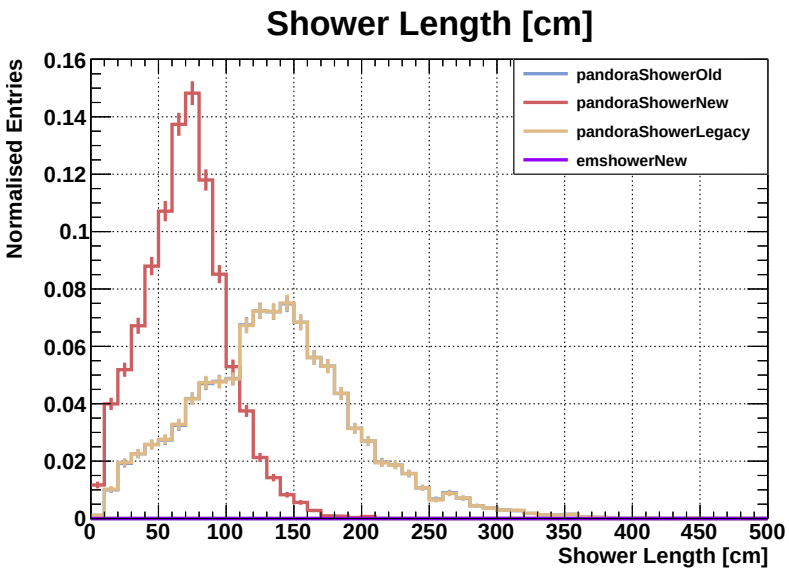


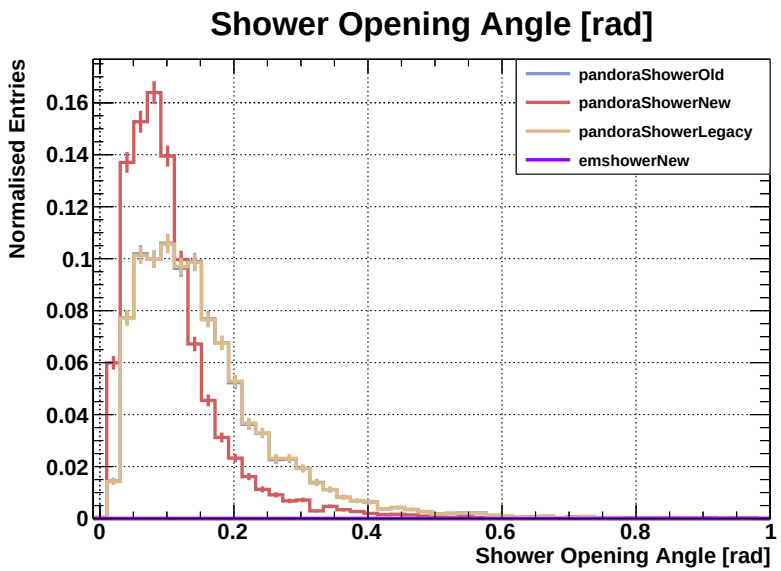
Performance: Shower Energy

$$\textbf{Shower Energy Ratio} = \frac{\textbf{Shower Reco. Energy}}{\textbf{Shower True Energy}}$$



Performance: Shower Length and Opening Angle





Outstanding Issues

- Need to update to LArSoft v09
  - Much of the work was done by Kyle on TRACS but I neglected copying this over
- Discuss applying clang-format to larpandora (Same as done is larpandoracontent)

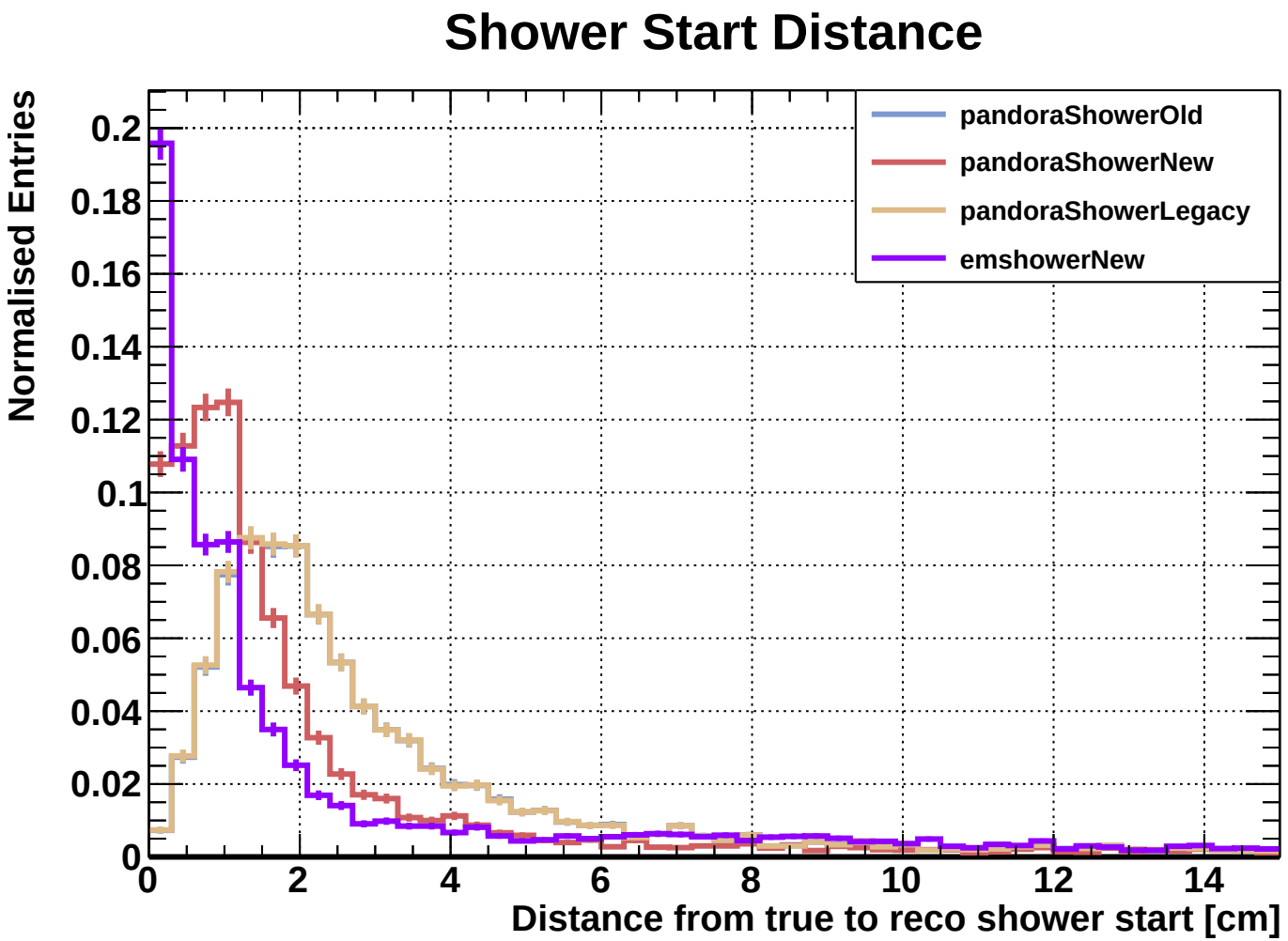
Conclusions

- TRACS has been migrated to LArPandoraModularShowerCreation
- Tested in SBND, ICARUS and DUNE
- Fully create a recob::Shower
- Wide range of tools available: Many options
- Few outstanding issues before ready to merge

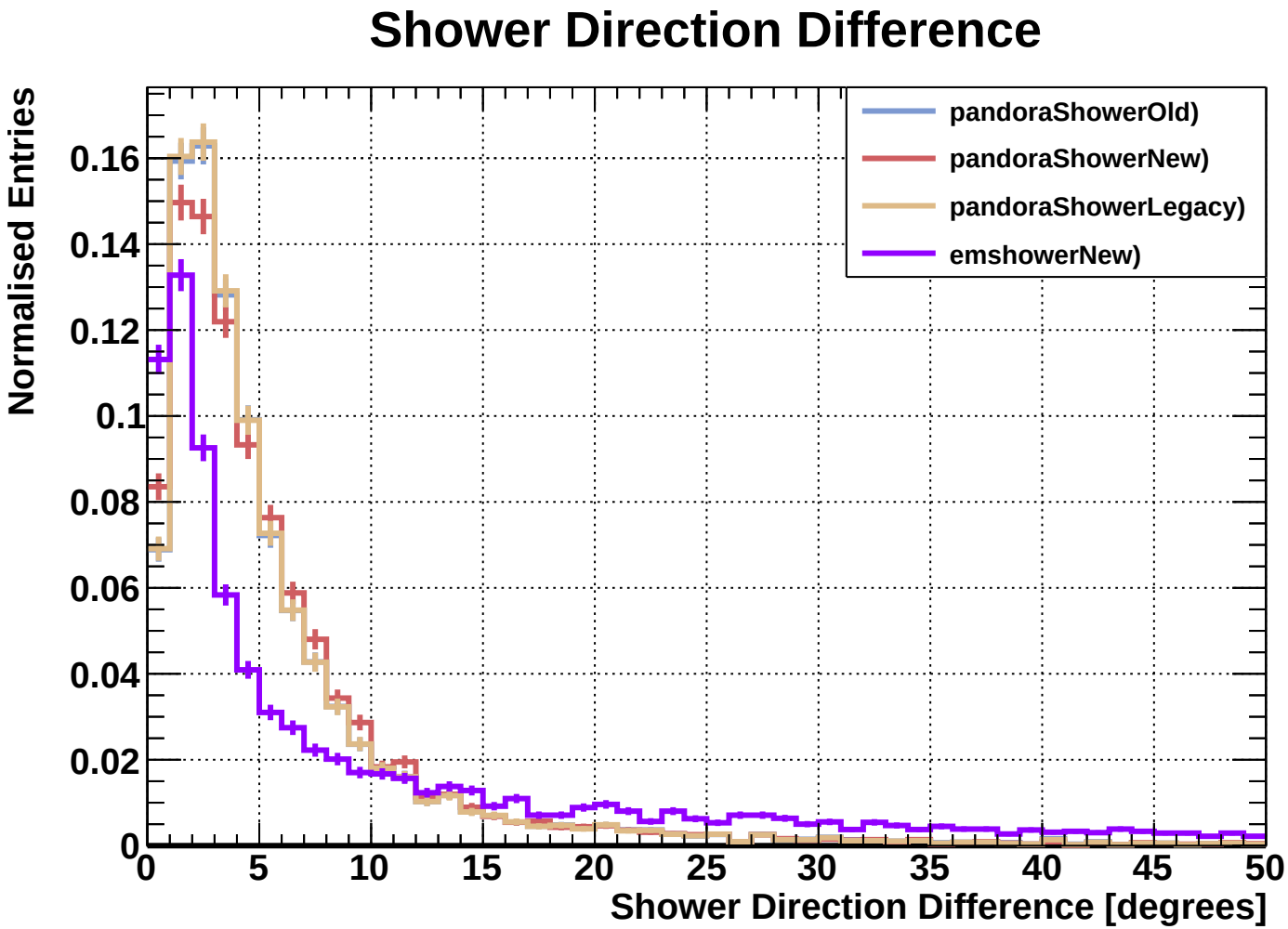
Tool Name Changes

- Shower3DTrackHitFinder → Shower 3DCylinderTrackHitFinder
- ShowerGenericTool → ShowerSkeletonTool
- ShowerResidualTrackHitFinder → ShowerIncrementalTrackHitFinder
- ShowerStandardCalodEdx → ShowerUnidirectionaldEdx
- ShowerSlidindStandardCalodEdx → ShowerTrajPointdEdx
- ShowerSmartTrackTrajectoryPointDirection → ShowerTrackColinearTrajPointDirection

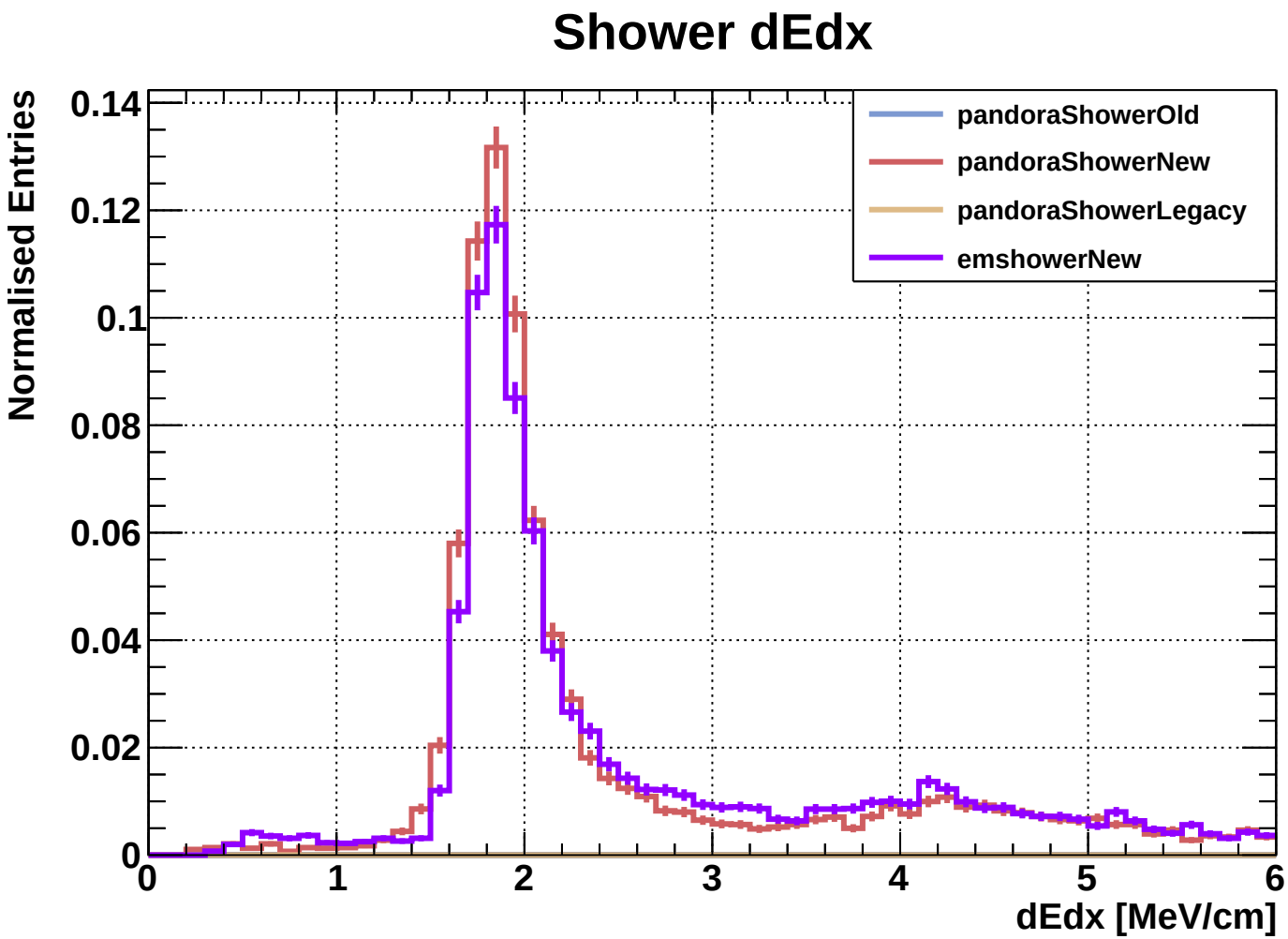
Performance: Shower Start Position



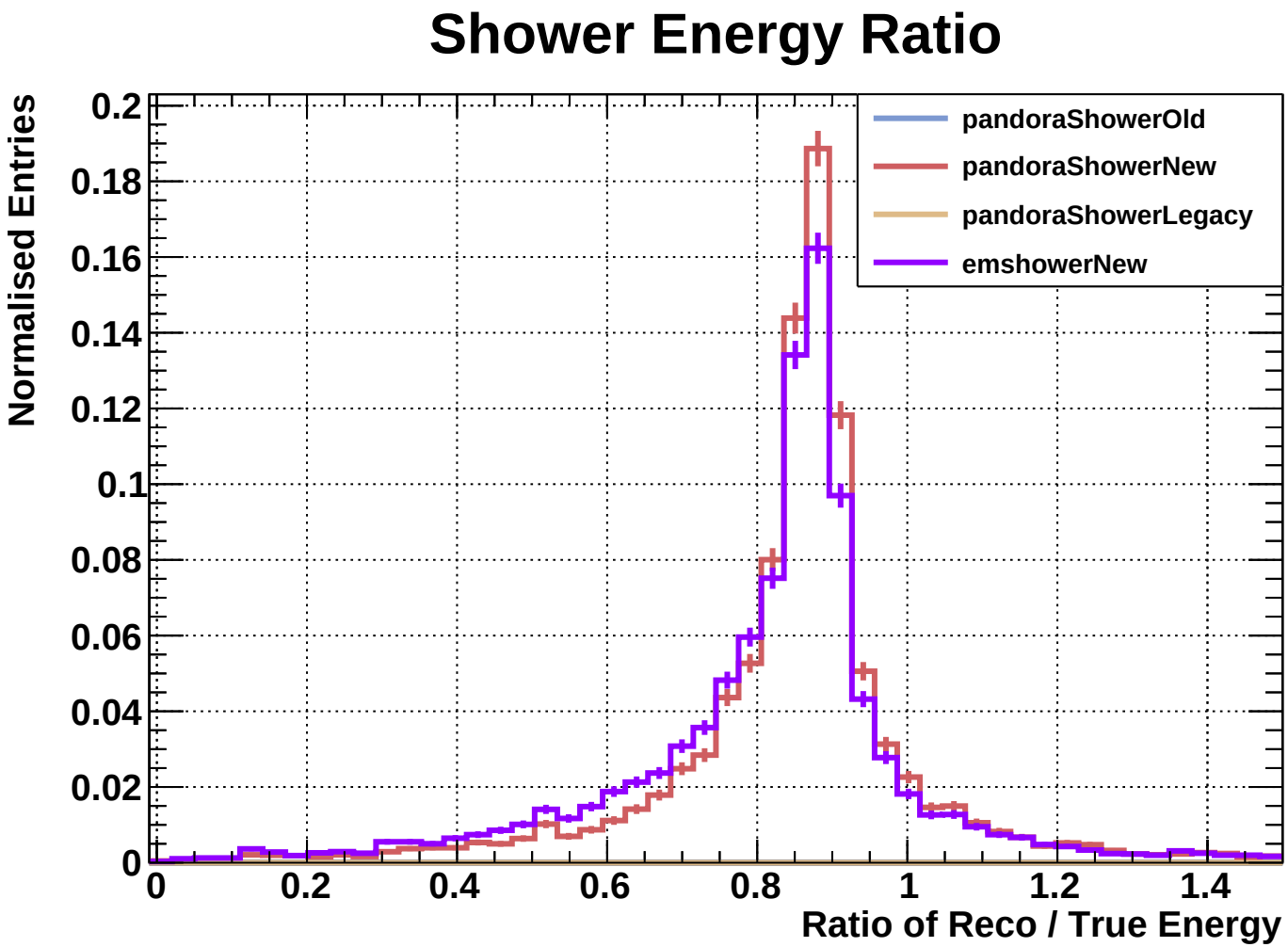
Performance: Shower Direction



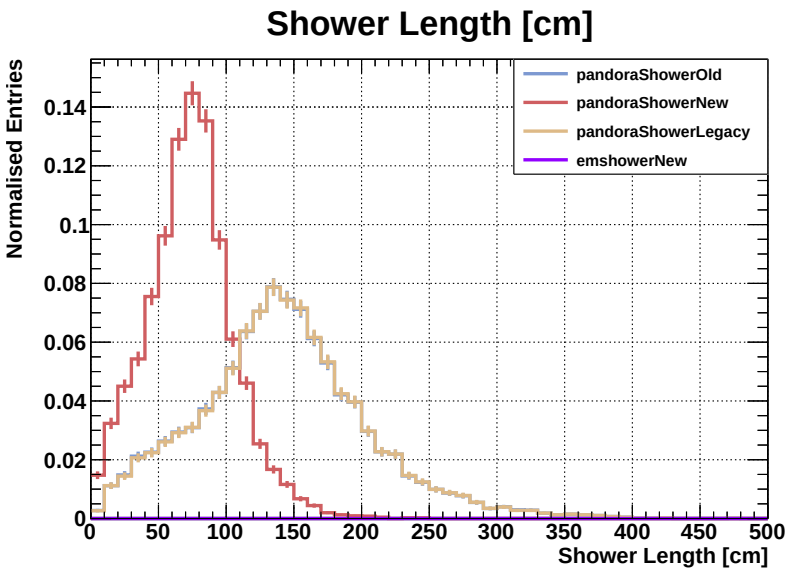
Performance: Shower dEdx

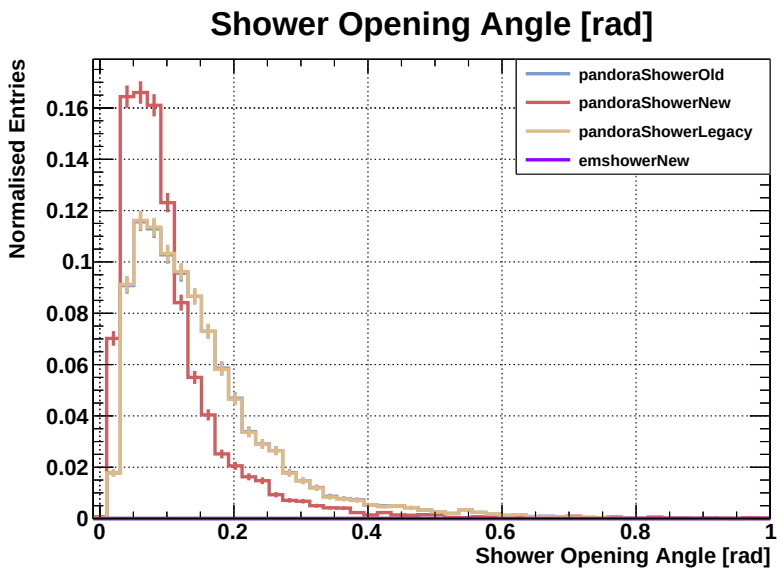


Performance: Shower Energy

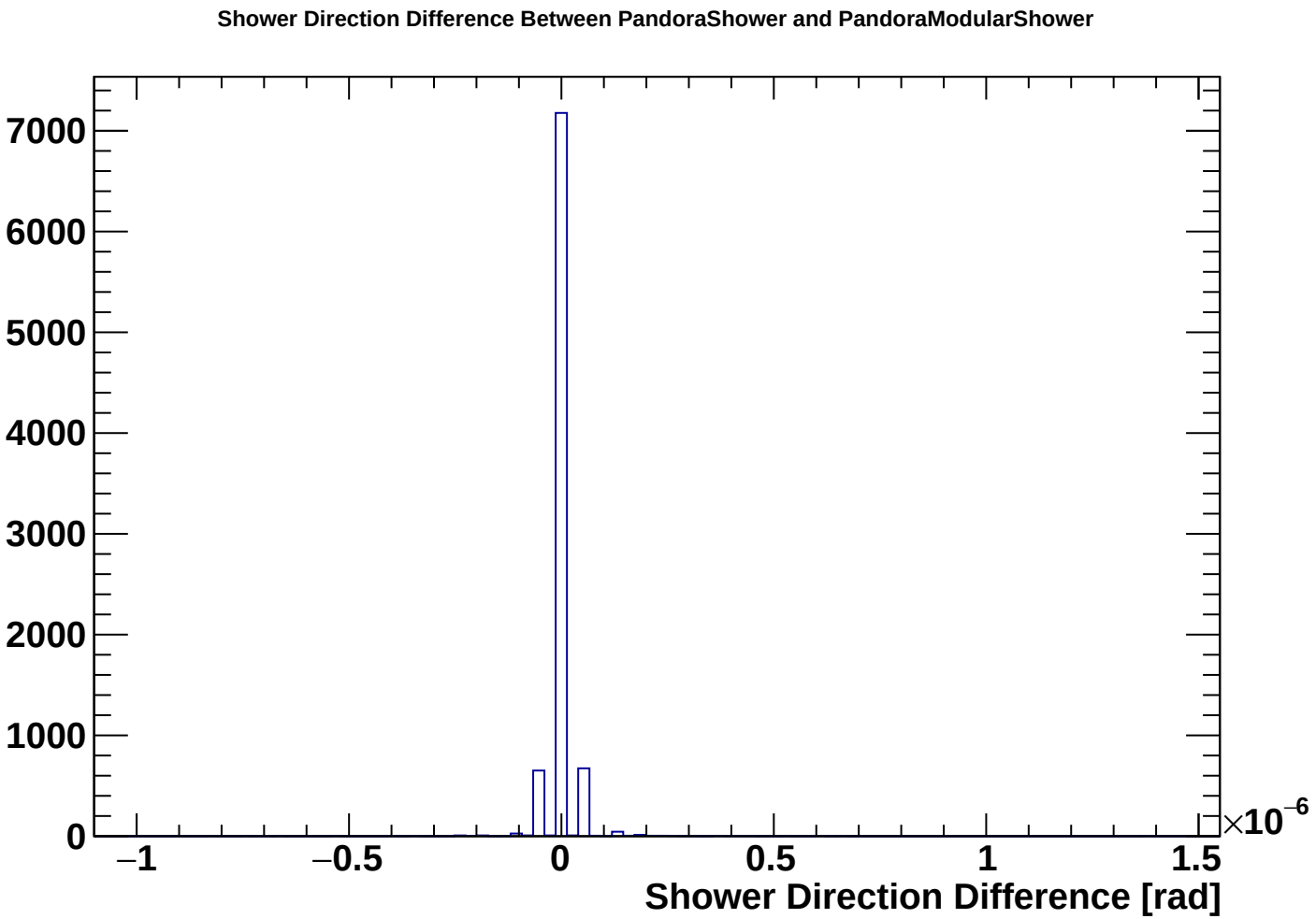


Performance: Shower Length and Opening Angle

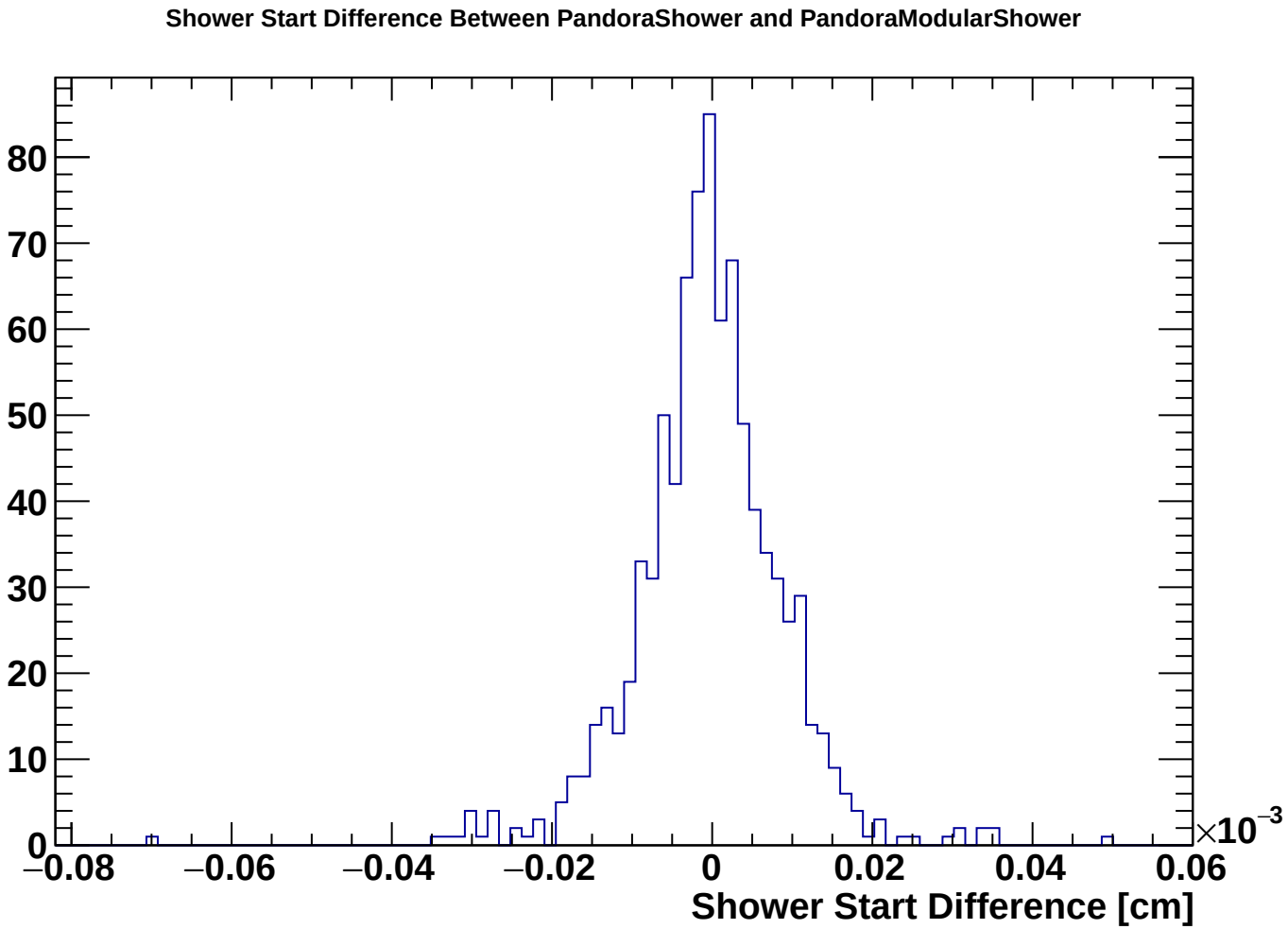




PandoraShower Comparison: Direction



PandoraShower Comparison: Start Distance



Run Time Comparison

TimeTracker printout (sec)	Min	Avg	Max	Median	RMS	nEvts
Full event	0.0512771	0.266388	1.38615	0.223308	0.185578	100
source:RootInput(read)	0.000432191	0.00143411	0.0310399	0.000659451	0.00326663	100
reco:pandoraShowerOld:LArPandoraShowerCreation	0.00323318	0.0263379	0.420784	0.0170087	0.0430009	100
reco:pandoraShowerNew:LArPandoraModularShowerCreation	0.00444911	0.0318908	0.112019	0.0247244	0.022719	100
reco:pandoraShowerLegacy:LArPandoraModularShowerCreation	0.00165497	0.0107134	0.0343293	0.00881204	0.00745511	100
reco:emshowerNew:EMShower	0.00585534	0.0355579	0.170443	0.0288772	0.0250588	100