# EMShower (Brief) Update

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The EMShower Algorithm

- 3D shower reconstruction algorithm in LArSoft (since ~October 2015).

- Uses 2D clusters found by the BlurredCluster algorithm (~May 2015), which is optimised for showers.

- Developments still ongoing but the algorithm shows great promise and already performs well in LArSoft.

- Developed with the DUNE 35t experiment in mind but can be optimised for any geometry.

- Will give a brief update of the status of the algorithm in this take (due to the current 35t run, development has been slow recently!).

BlurredCluster

- 2D clustering algorithm which uses a Gaussian kernel to smear the charge deposits in the detector and create a more isotropic distribution in which to perform the clustering.

 - See DUNE docDB 54 for details (can move to somewhere public too...).
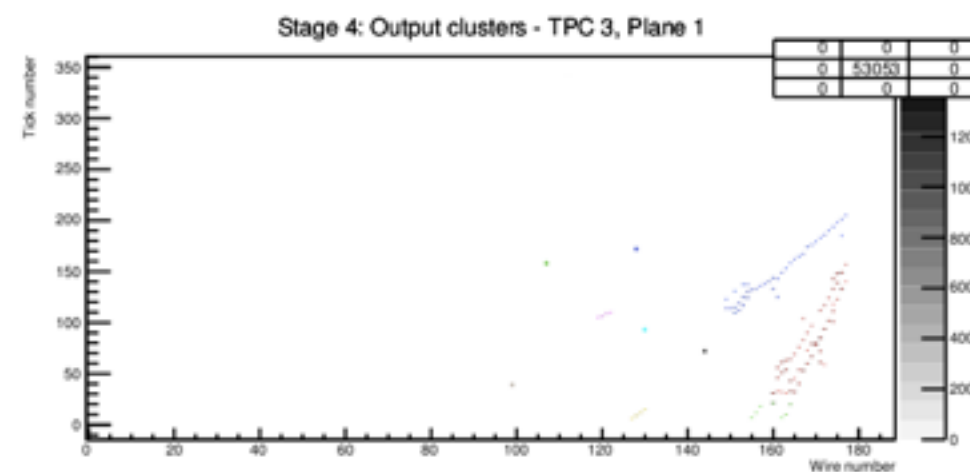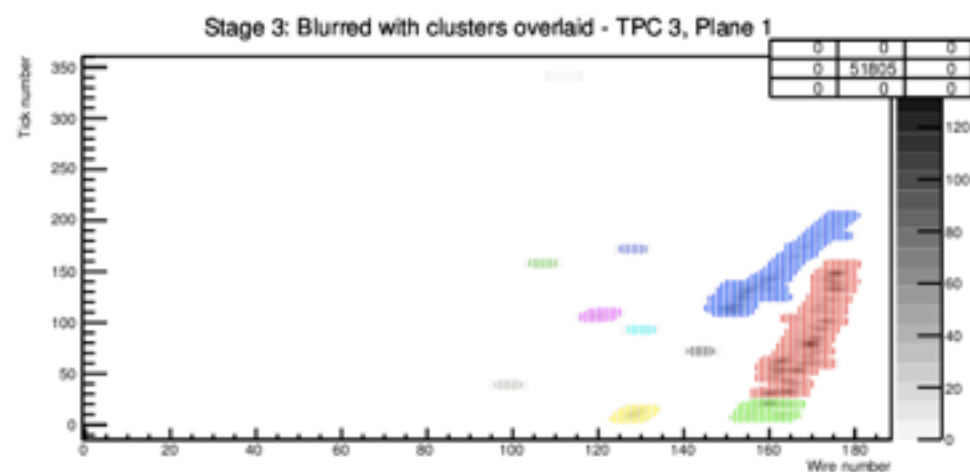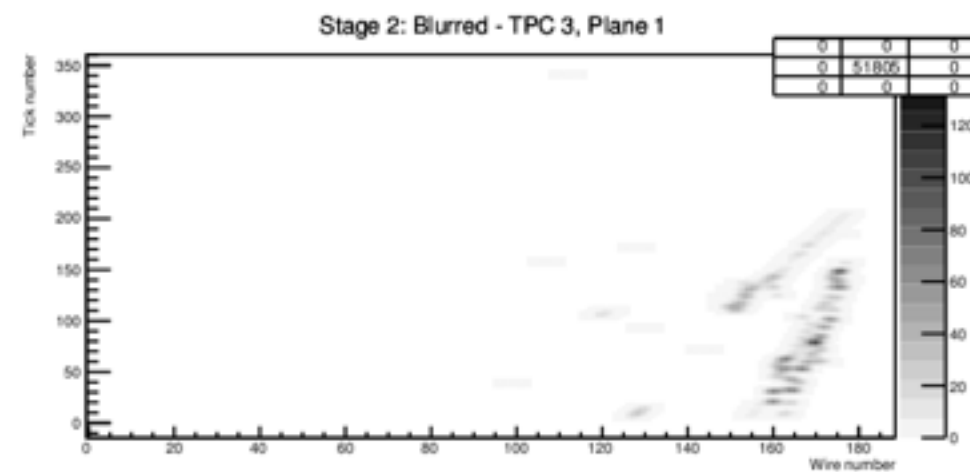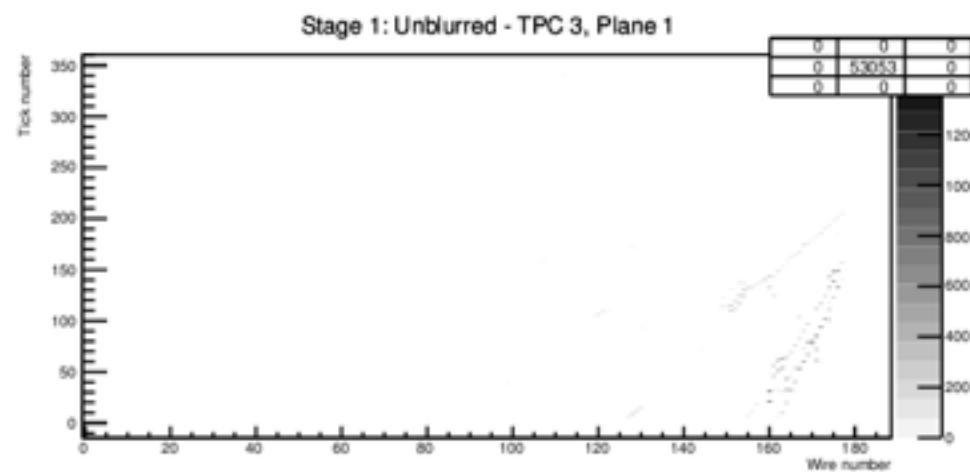
BlurredCluster

- Very little has changed recently.

- Worked on the computational efficiency of the algorithm to make it ~four times faster (averages ~0.6s per event in 35t).

- Recently started working on improving the clustering when we have hits which are spread over a range of ticks…
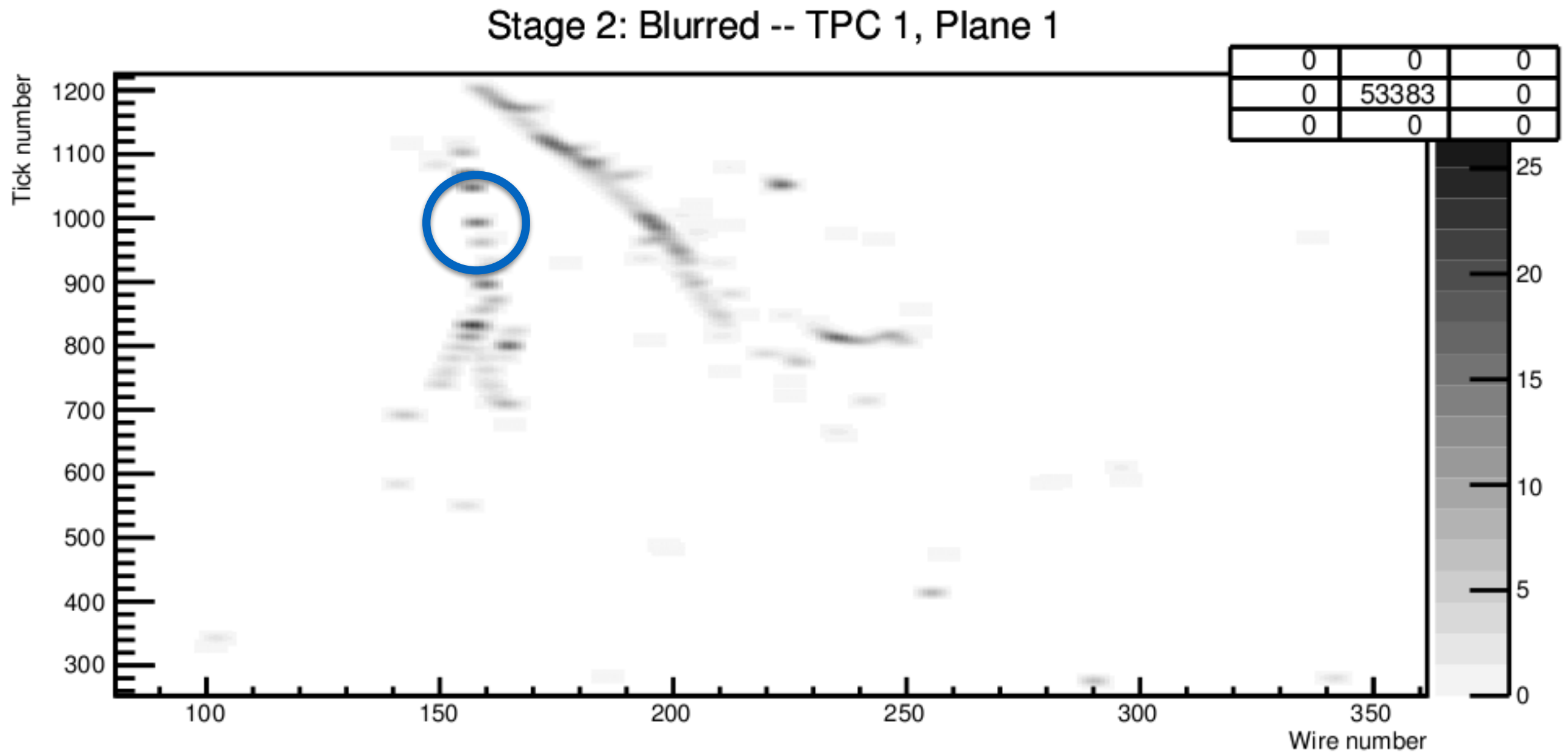
BlurredCluster Problem
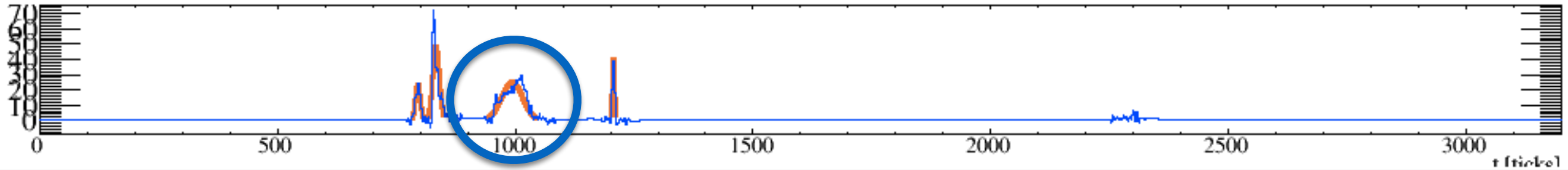
The width of the hit demonstrates how spread in time the charge is.
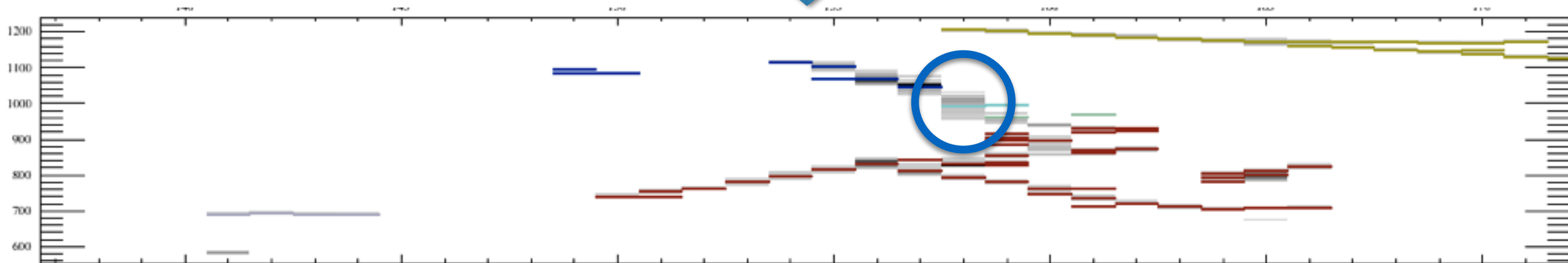
- Previously, the clustering was just modelling this as a hit at a single tick.

- This doesn't take into account all the hit information and means that clusters like the one above are broken.
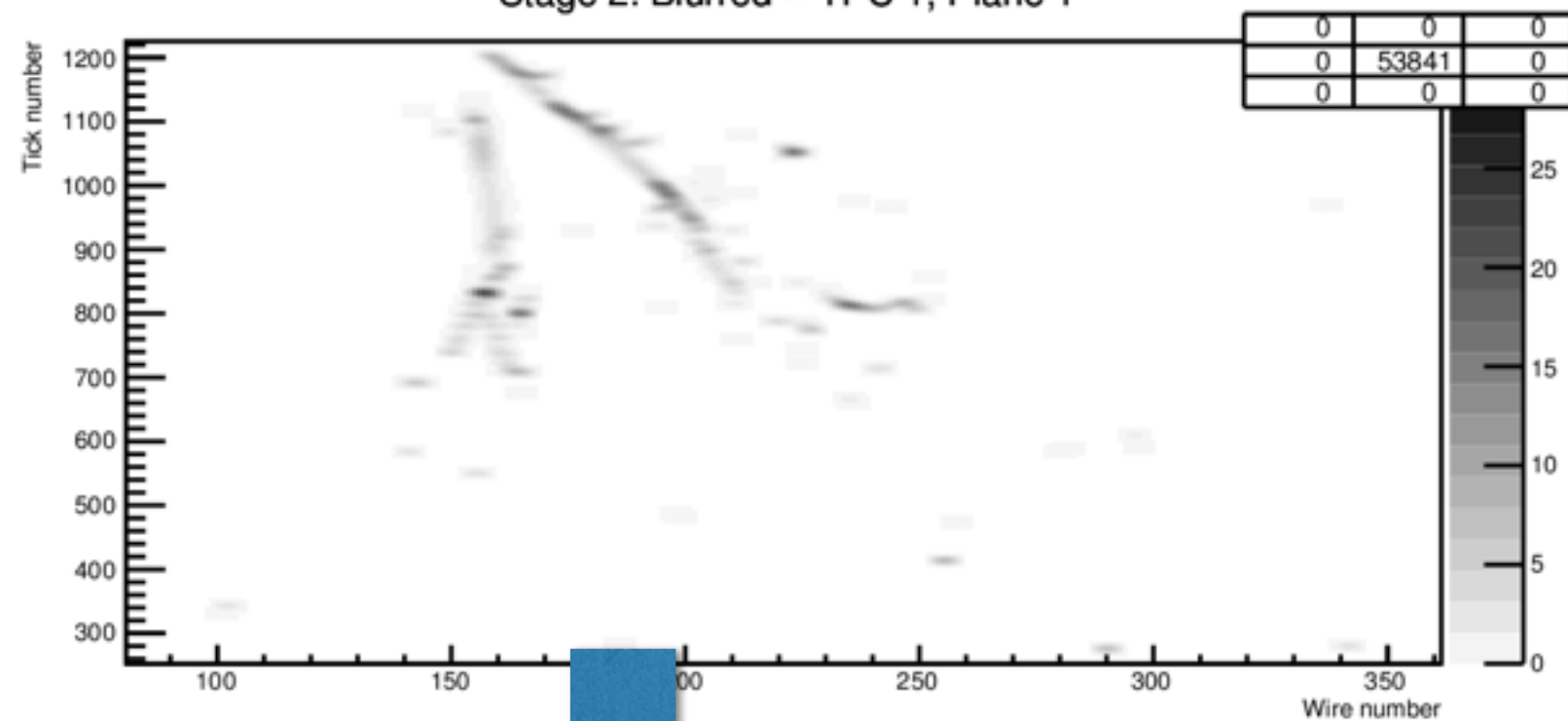
BlurredCluster: Problem

- The hit map after convolving with the Gaussian function…

Stage 2: Blurred -- TPC 1, Plane 1

BlurredCluster: Natural Solution

- It seems obvious to extend the blurring in this situation in order to use all the hit information possible.

- In this situation, it seems the blurring method is the most natural way to reconstruct these hits; they have an intrinsic 'blurring' due to the distribution of the charge.
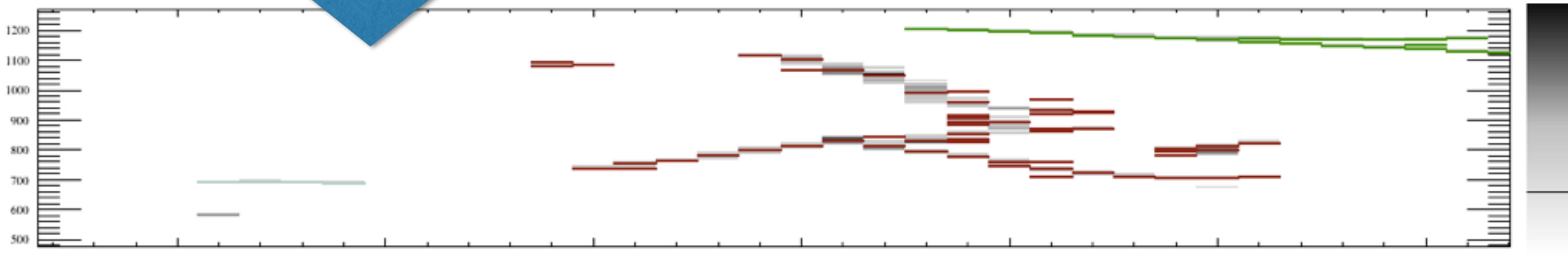
EMShower

- The shower reconstruction runs on the output of clustering and tracking on the events.

- Each cluster is associated with a track and, by using the 3D nature of tracks, means that clusters across multiple views can be matched to forms showers:
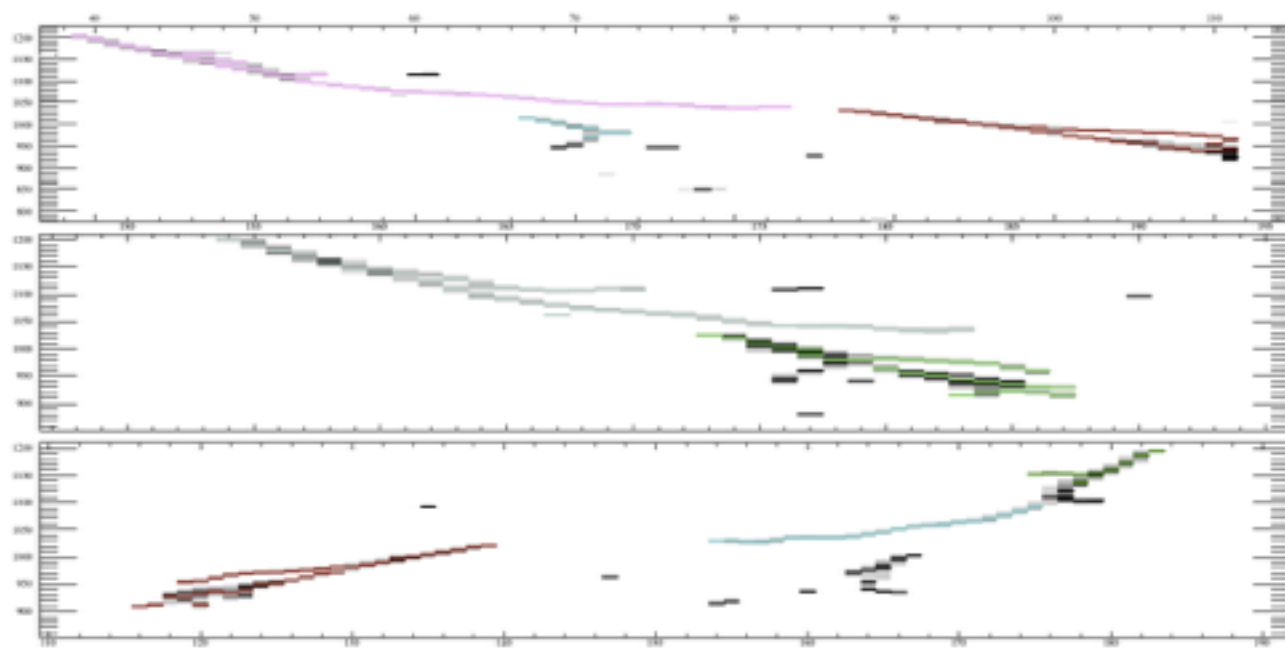
BlurredCluster   PMTrack
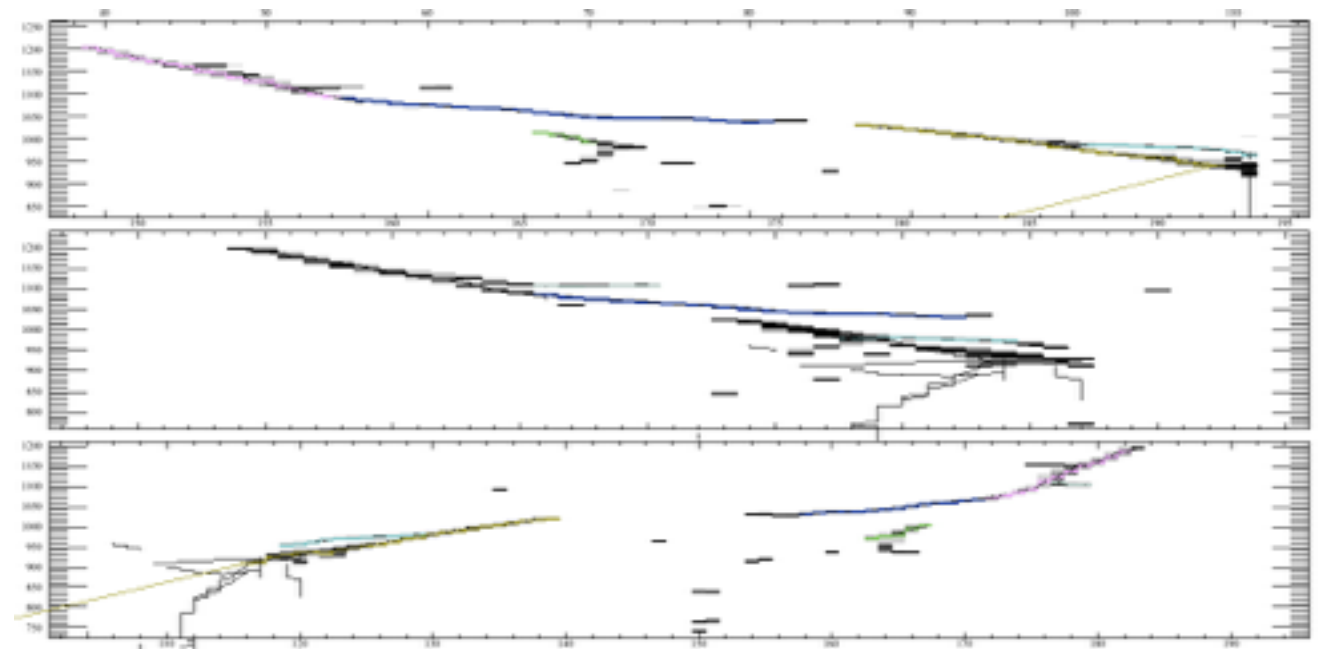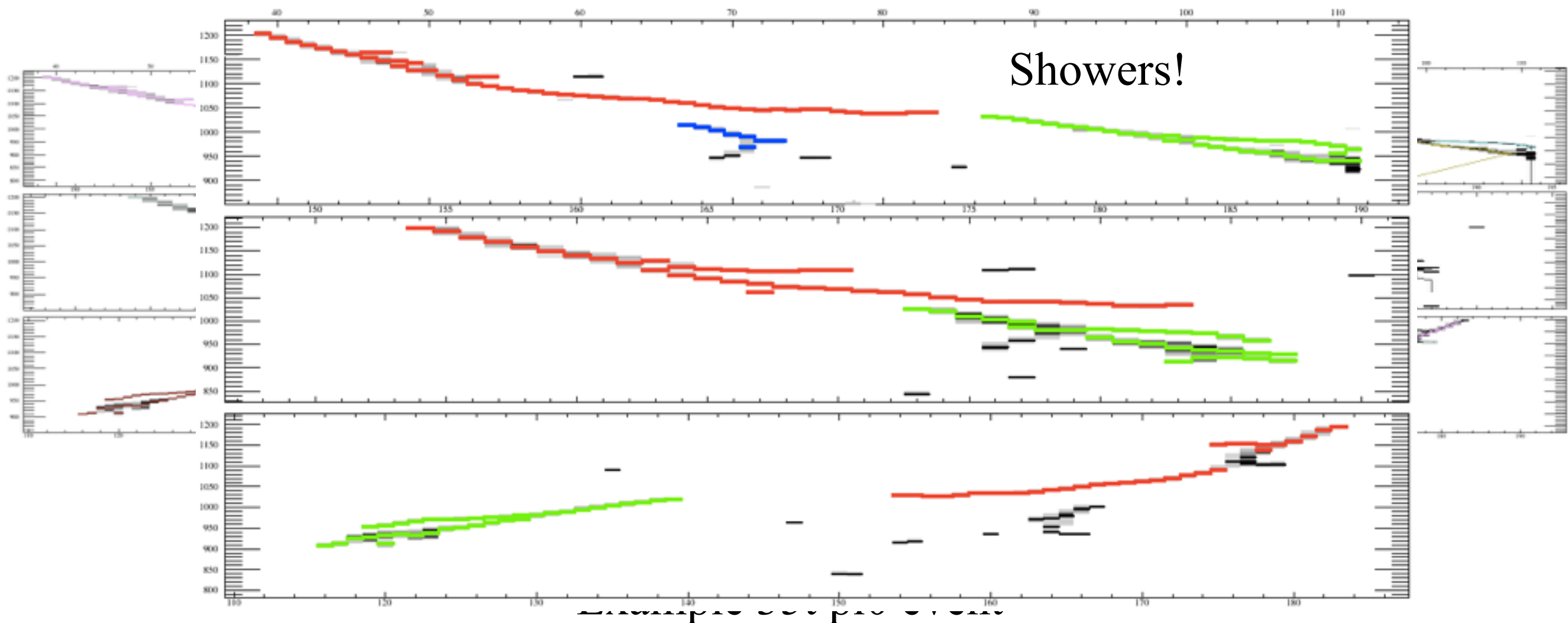
Example 35t pi0 event

EMShower

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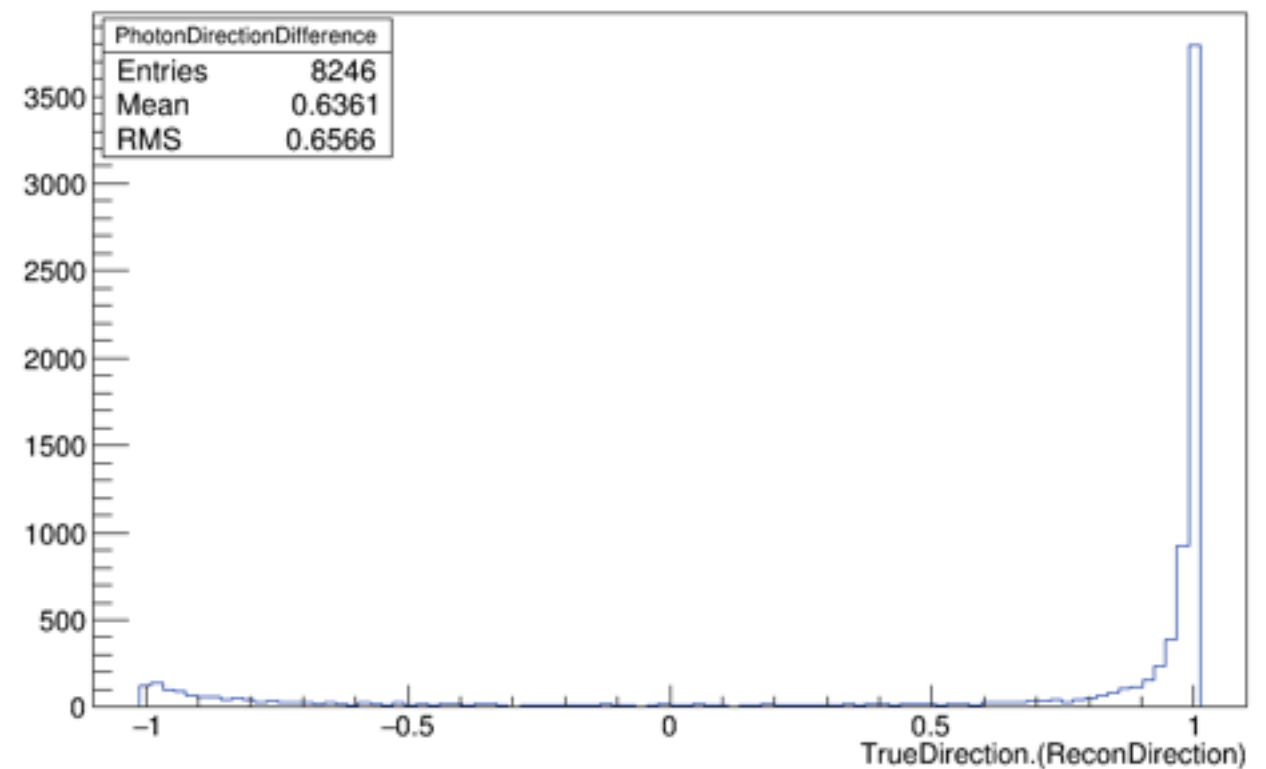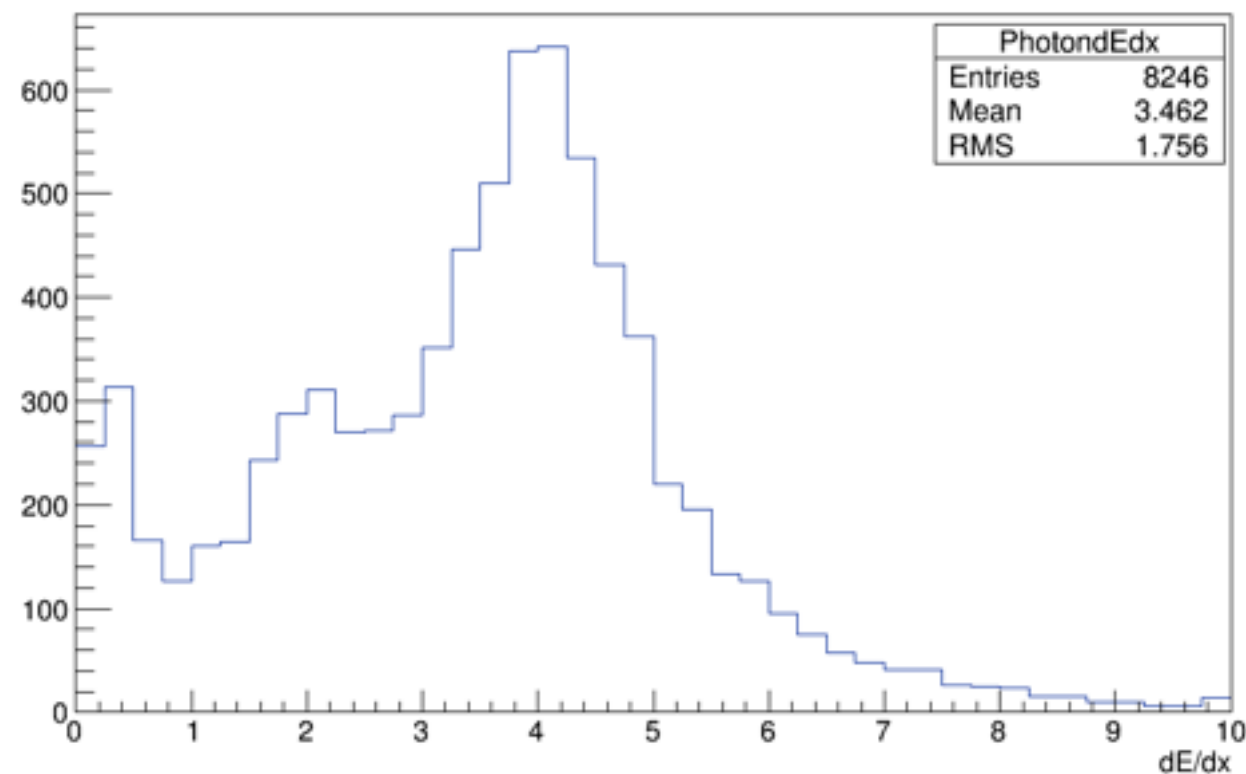

Showers!

Example 500 pi0 event

EMShower Algorithm

- After forming the shower objects, their properties are found using a series of algorithms.

  - Initially, the start and 'end' point of the shower are found;

  - The true shower start is determined;

  - The initial track-like part is reconstructed (and a recob::Track object constructed) using (at least) two of the views using PMTrack methods (ProjectionMatchingAlg::buildSegment(), R Sulej & D Stefan);

  - The shower 3D start and direction are taken from this track;

  - The total shower energy and initial dE/dx are also calculated.

- The charge <—> energy calorimetric conversion is only in place for DUNE 35t and DUNE FD; need to recalculate these for other experiments to get correct energy.
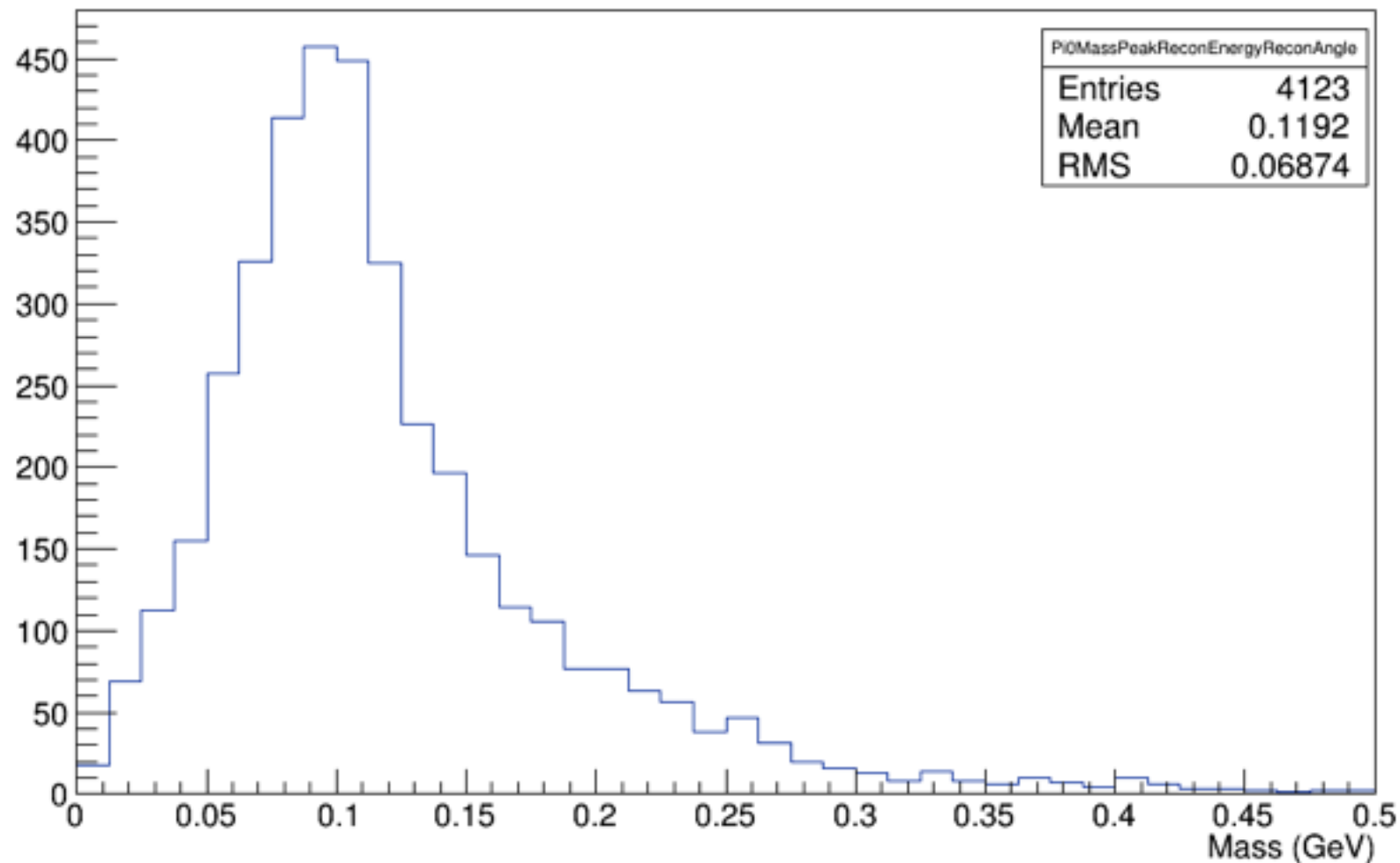
EMShower: Performance

- The last major changes to EMShower in larreco:develop were in December 2015.

  - Have plenty of changes but need a bit more time to merge...

Made in Dec '15 with 35t pi0 sample.

EMShower: Performance

- I started working on shower reconstruction with an aim to reconstruction pi0s in 35t; hence a pi0 mass peak is instructive.

- 35t (simulated, obviously!) pi0 mass peak:

Looks encouraging! And is currently ~3 months out of data

No selection performed: used truth information to select the two photons. However, *no further selection applied*. This is the full sample; filled once per pi0.

EMShower: Recent Improvements

- Been working over the last few weeks on specific improvements to the showers:

  - Improving the determination of the shower direction;

  - Better dealing with situations where the 2D reconstruction fails in one of the views.

- Made good progress (everything is on feature/wallbank_EMShowerImprovements) but still finalising the changes.

Current Reconstruction Status

- Developments are ongoing; nothing ready to merge just yet.

- Will all be ready for the next DUNE MC production (~few weeks), so will merge everything then.

- This was just a brief update to reassure everyone I'm still working on it and will continue to…

Summary

- Have very promising reconstruction for showers in LAr.

- The current reconstruction in develop looks good and there are plenty more updates to be included…

- I am continuing to work on this; will happily give more frequent updates if this is desirable.