



EM Shower Task Force Report

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EM Shower Task Force

- Francesca Stocker had looked into CNN score (track-like vs shower-like)
- James Pillow is looking into shower characterization
- Ben Jargowsky had looked into CNN score for electrons and is going to work on CVN energy reconstruction
- Milo Vermeulen is working on pi-zero reconstruction, focusing in gamma selection/reconstruction at the moment
- Mike Mooney et al, working on pi-zero reconstruction using ML

ProtoDUNE EM Task Force meeting

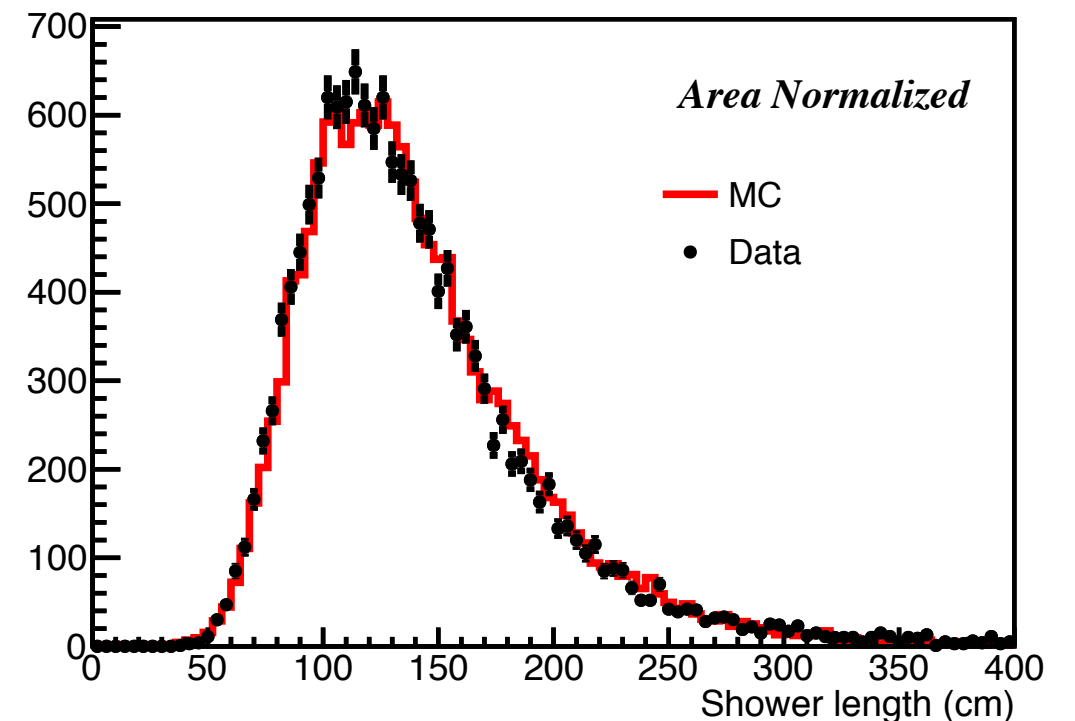
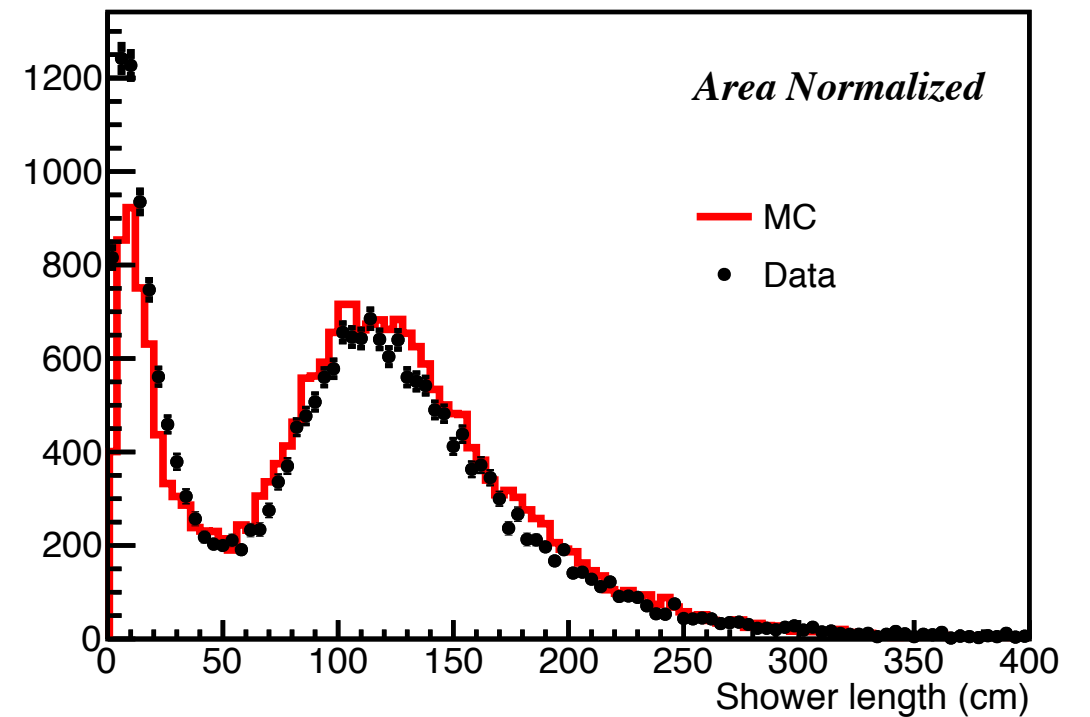
Time: Nov 14, 2019 09:00 AM Central Time (US and Canada)

Join Zoom Meeting

<https://fnal.zoom.us/j/7388416627>

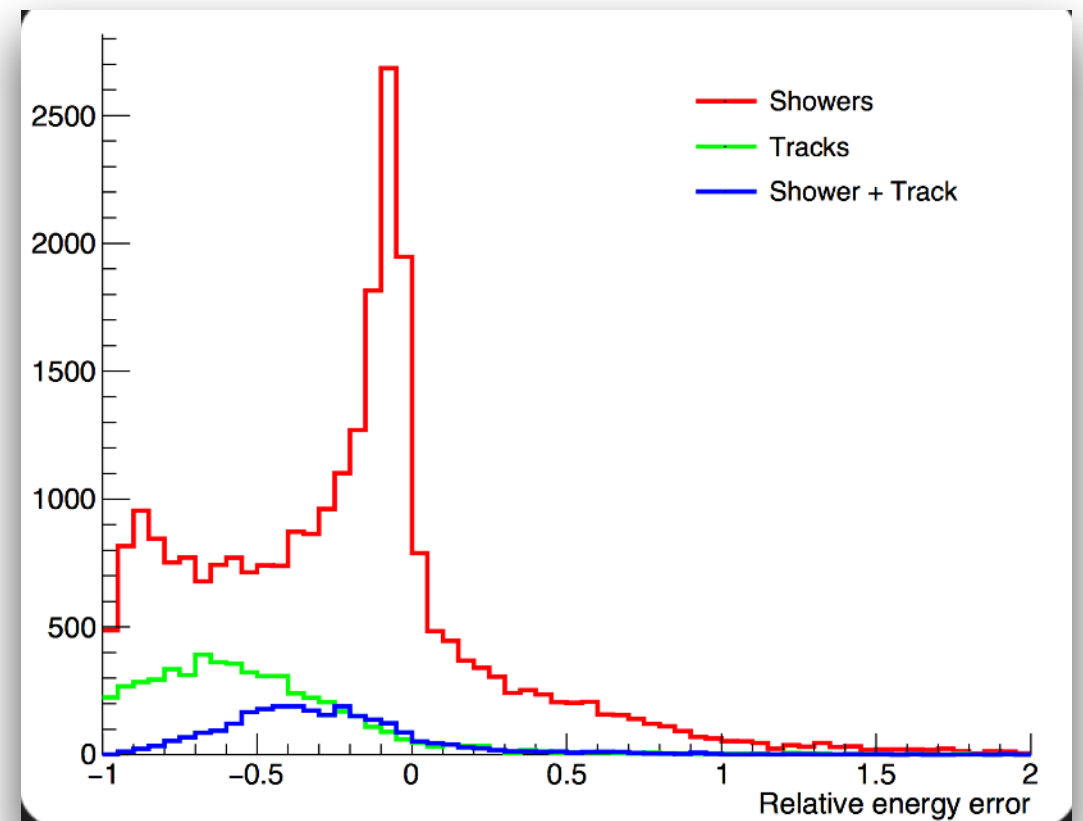
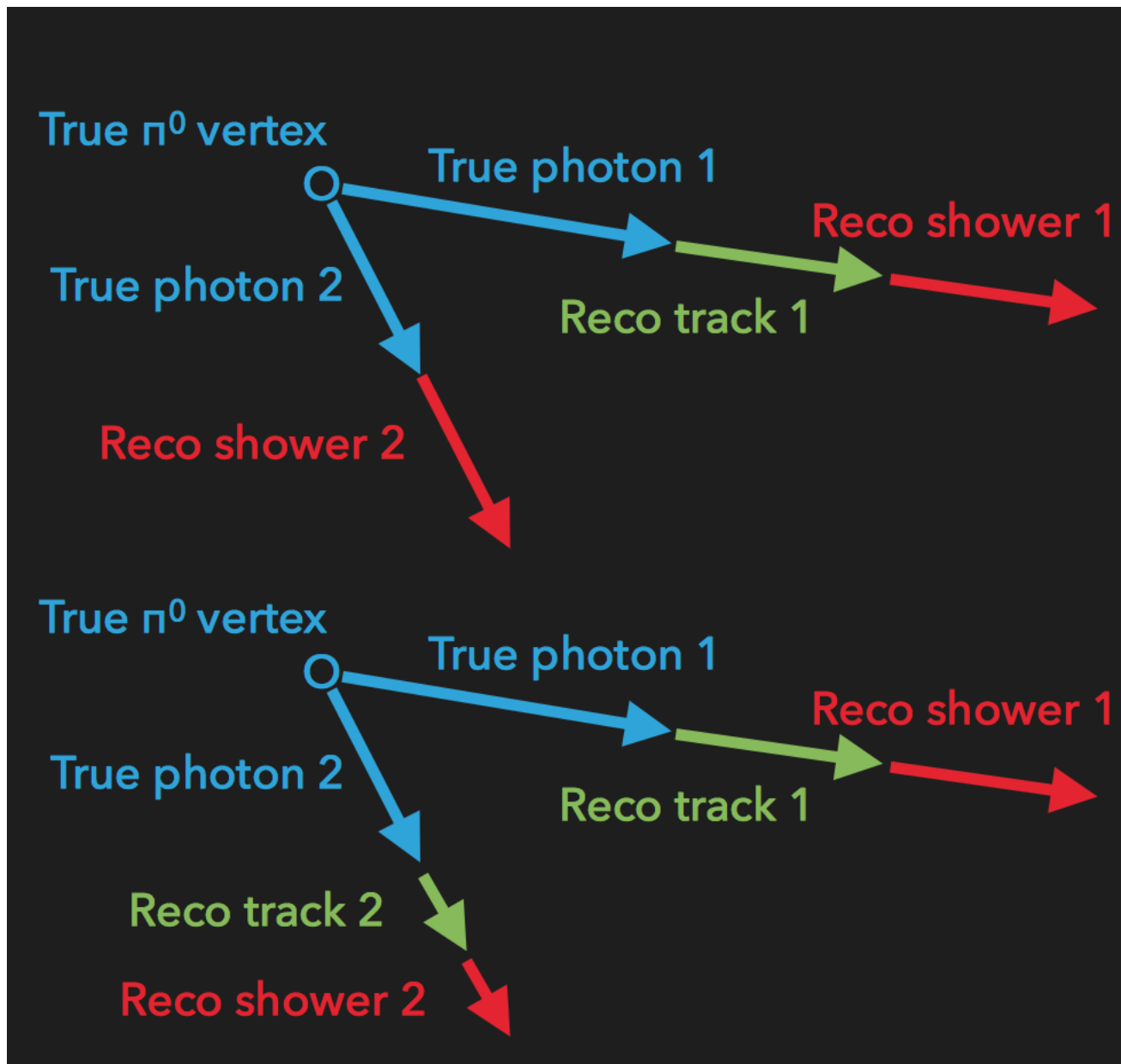
Electron Analysis

- For electron analysis we look at complete showers to estimated dE/dx at the beginning and shower energy
- Most of the time Pandora does a great job reconstructing showers, however sometimes Pandora breaks showers into different showers
- Can we recover some of those incomplete showers?



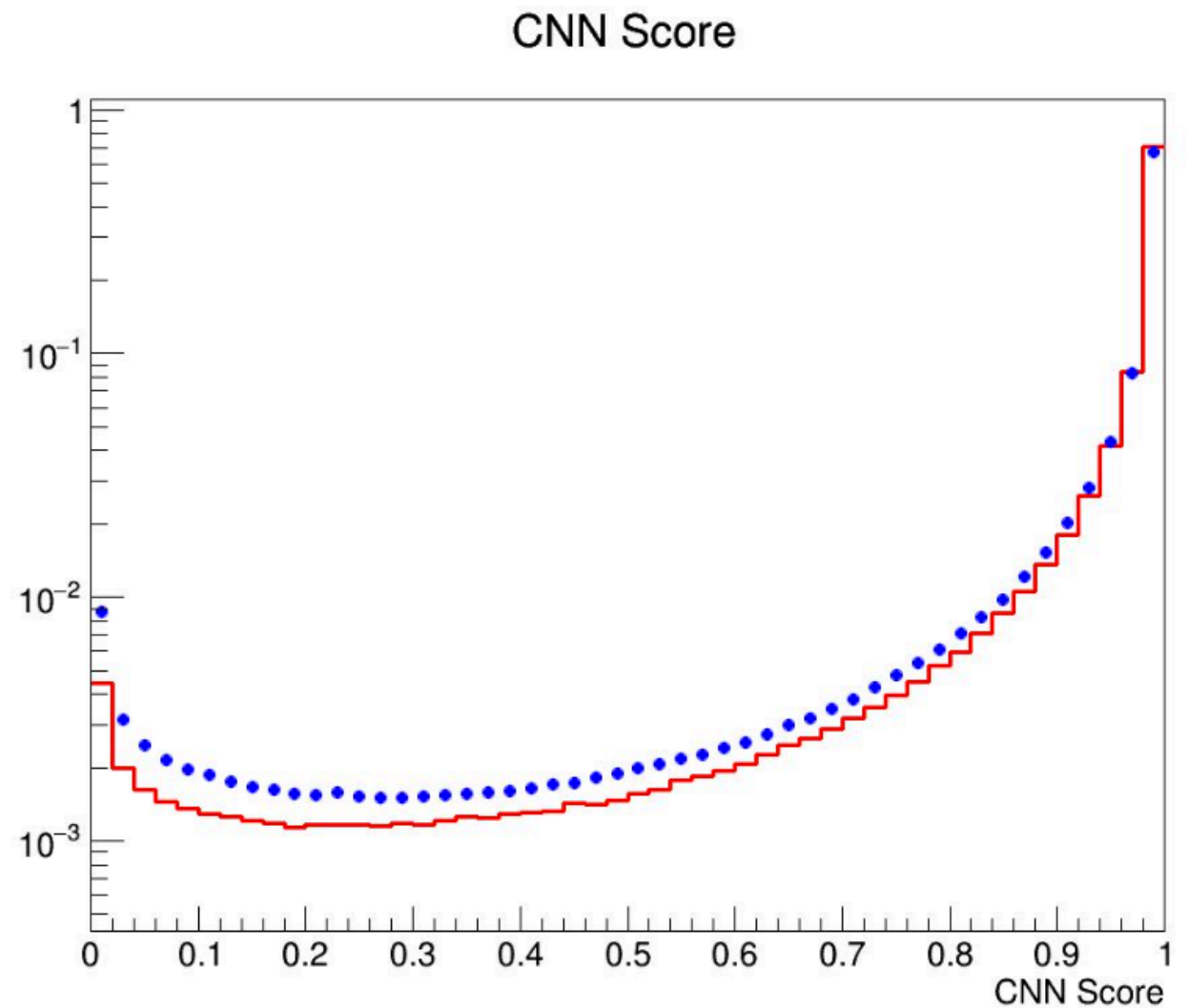
Pi-zero Analysis

- Gammas from pi-zero sometimes are reconstructed into different objects
- Can we reconstruct gammas as a one single reco object?



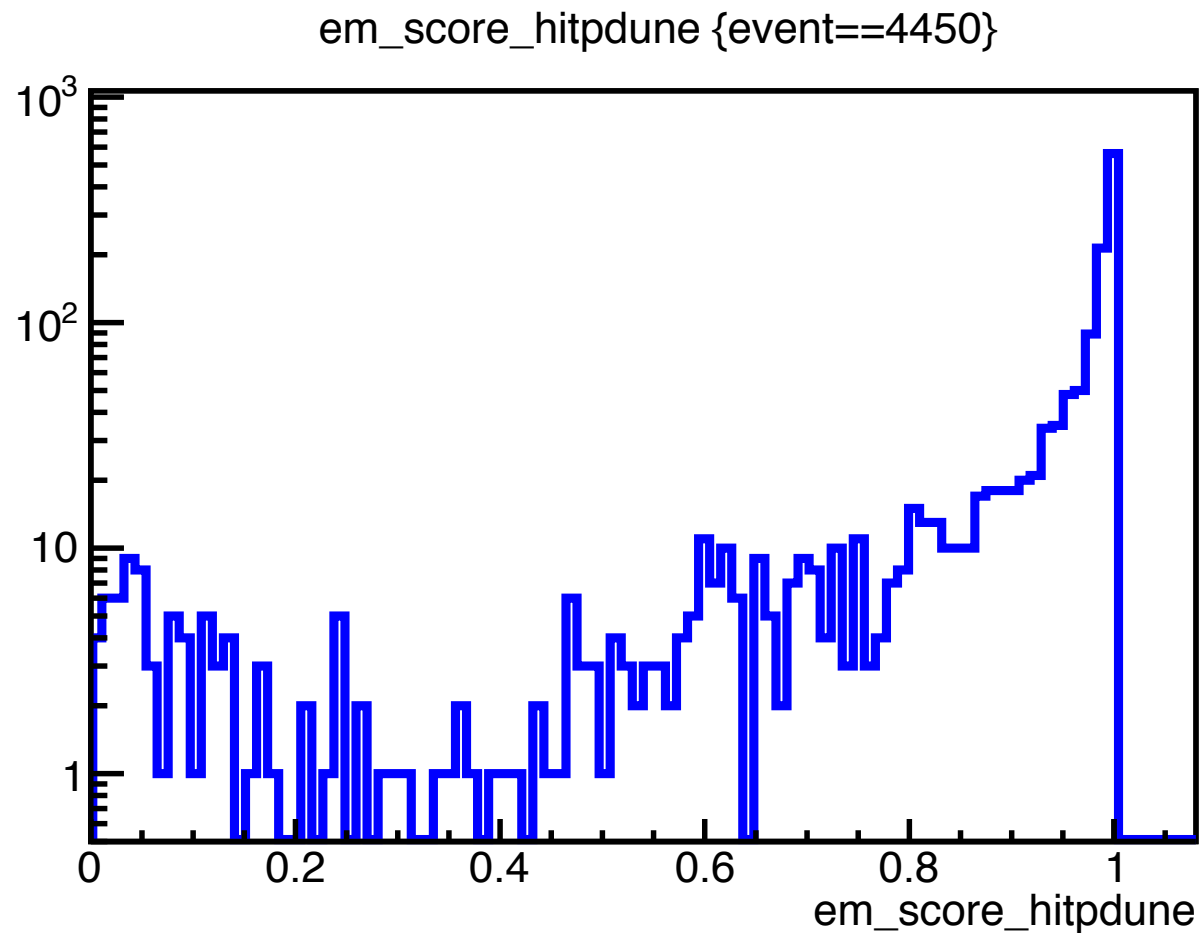
Pandora Shower

- Francesca look at the CNN score for her pion analysis and found interesting results (see talk)
- Model was trained to identified: EM-like hit, Track-like hit, Michel-like hit, other
- Look at the CNN score for data (run 5809) and MCC12 using complete showers
- As expected most of the hits within the shower are EM-like

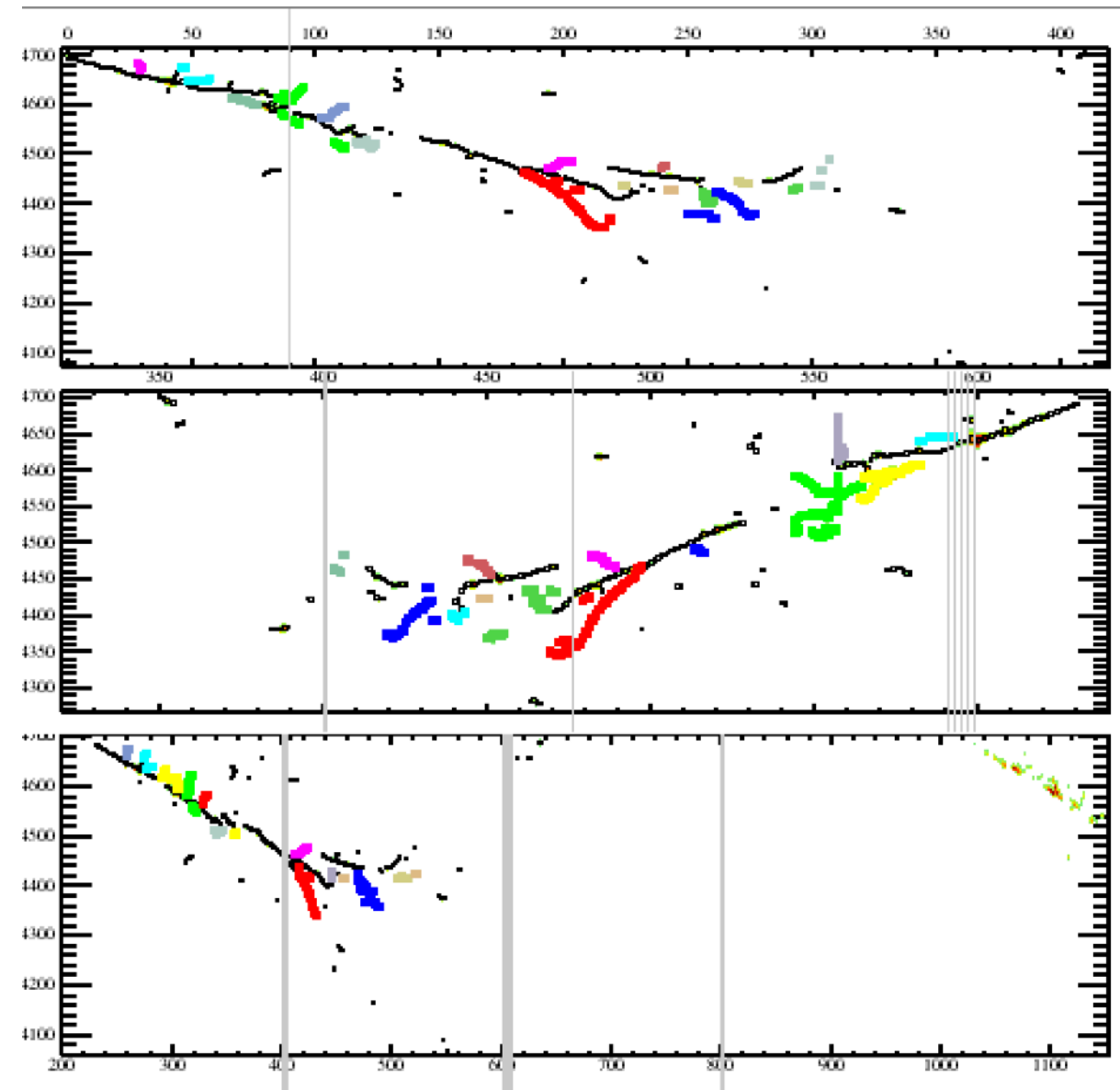


Pandora Shower

- How does the CNN score looks for events where the shower is broken e.g. multiple showers
- Using single electron sample a la MCC12



- Can we help Pandora?



Pandora Shower reco2.0

The plan

- Motivated by Jake Calcutt analysis to re-run pandora ([see talk](#))
- Use CNN score to feed Pandora and try to re-run shower reconstruction Create a new collection of recob::Hit using high EM-like CNN score >0.35
- Pass new collection of recob::Hit to Pandora to give it another try

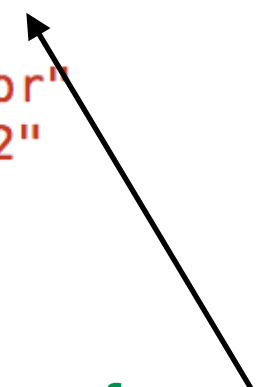
```
72 reco: [  
73     pandora2, pandora2Shower  
74 ]
```

re-run pandora w/ new input



```
106 #Pandora configurations  
107 physics.producers.pandora2.HitFinderModuleLabel: "emreco"  
108 physics.producers.pandora2Writer.HitFinderModuleLabel: "emreco"  
109 physics.producers.pandora2Writer.GeneratorModuleLabel: "generator"  
110 physics.producers.pandora2Shower.PFParticleLabel: "pandora2"  
111 physics.producers.pandora2Shower.UseAllParticle: true
```

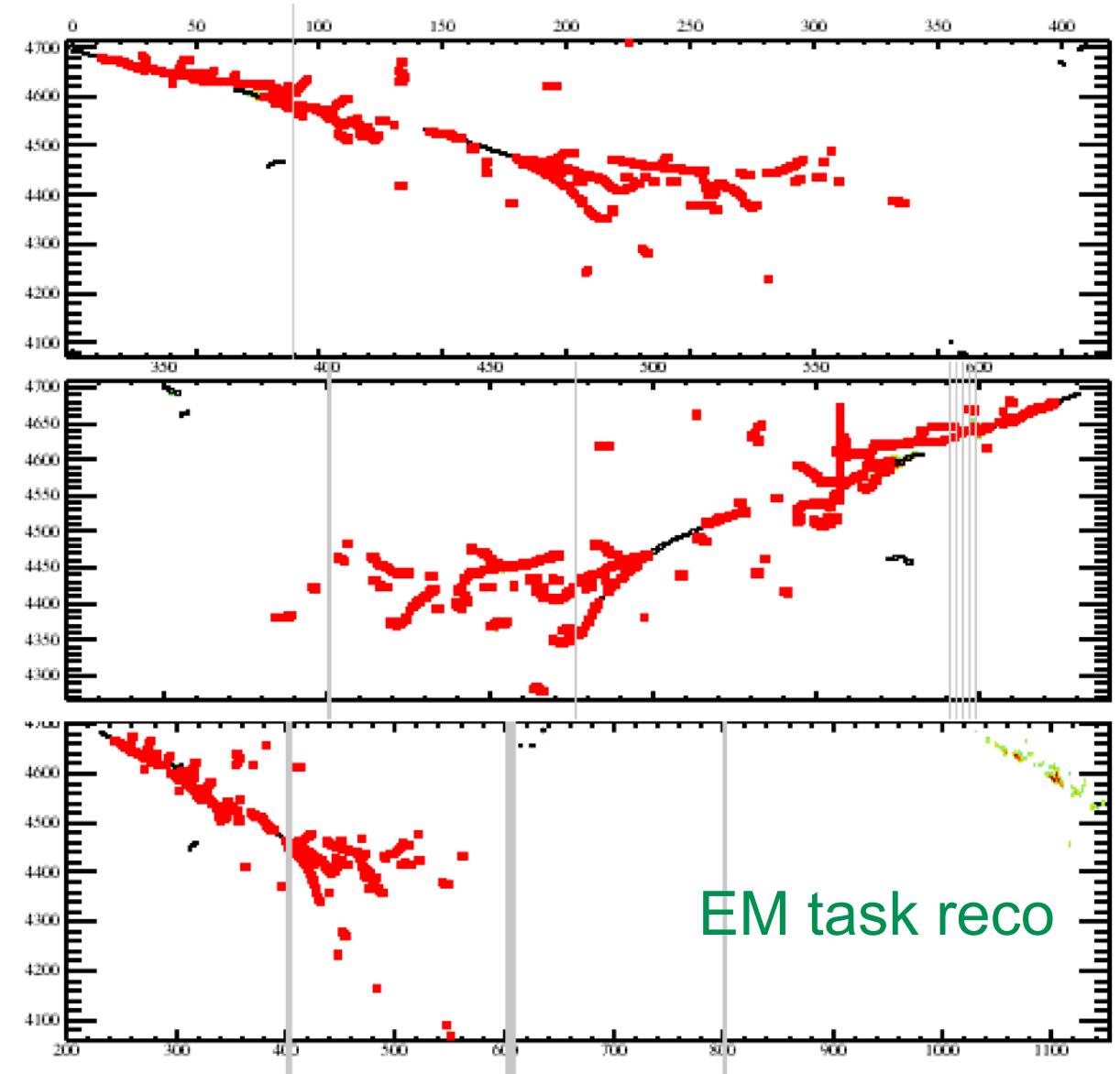
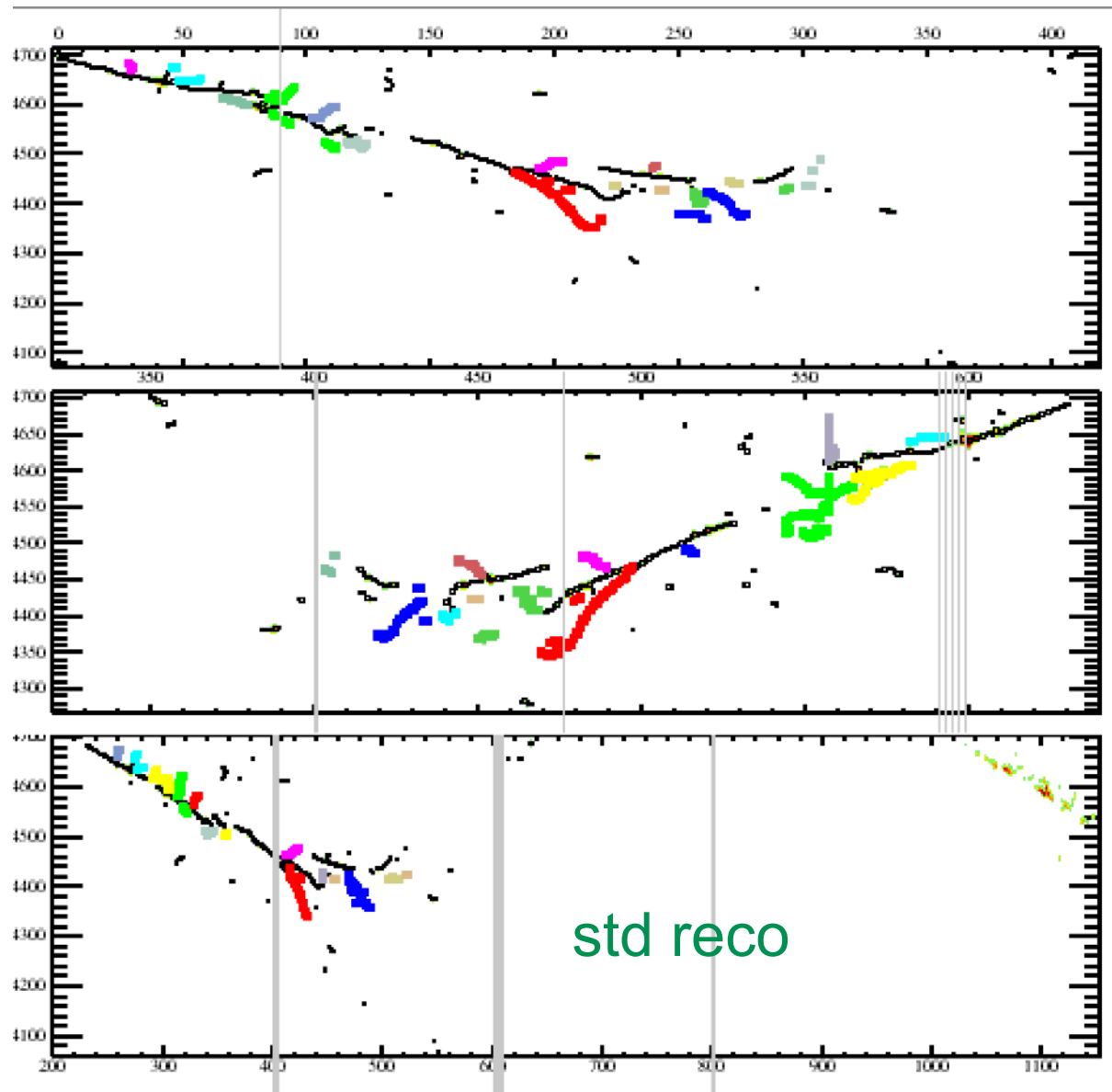
"emreco"
"emreco"
"generator"
"pandora2"



New collection of recob::Hit

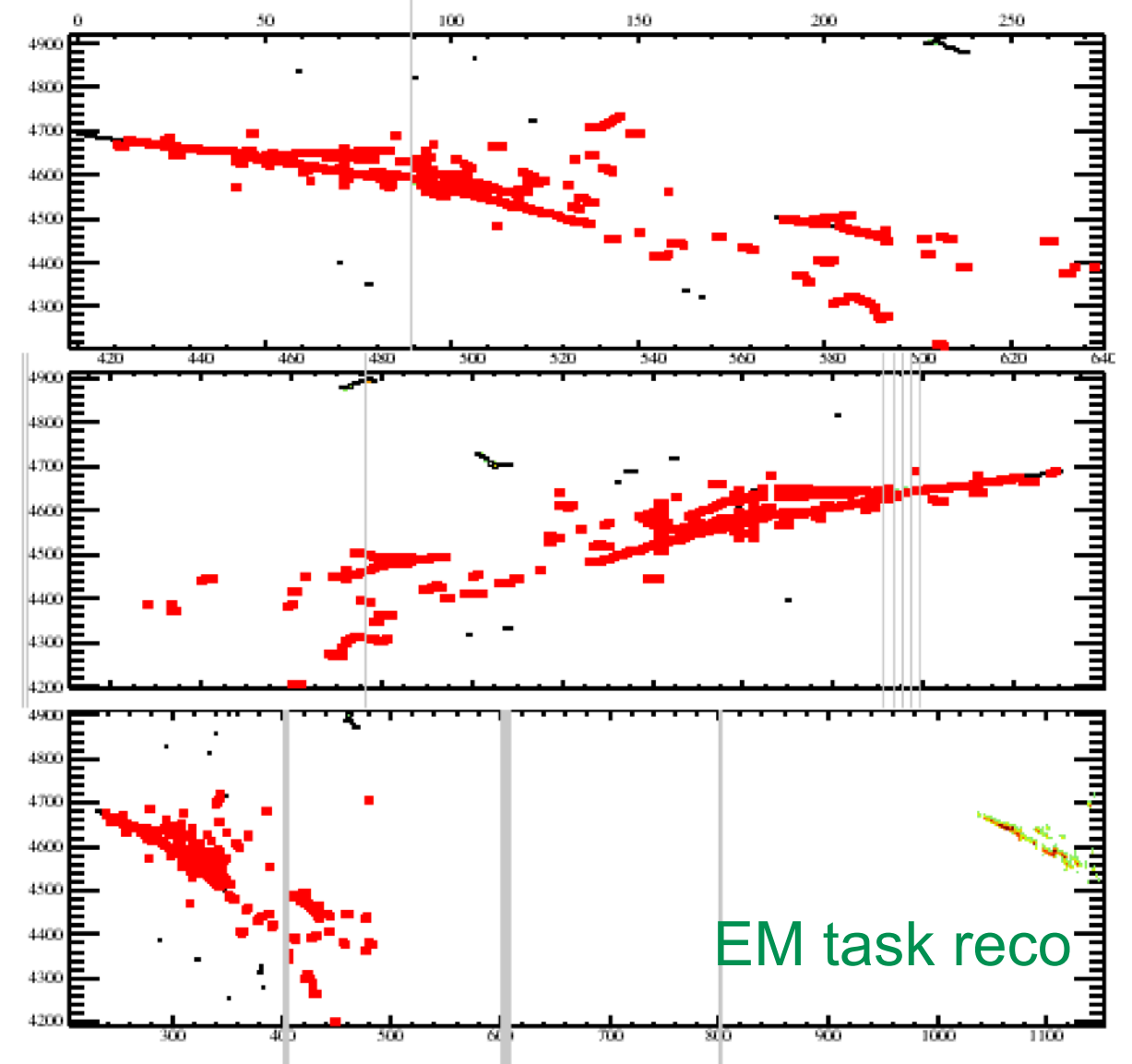
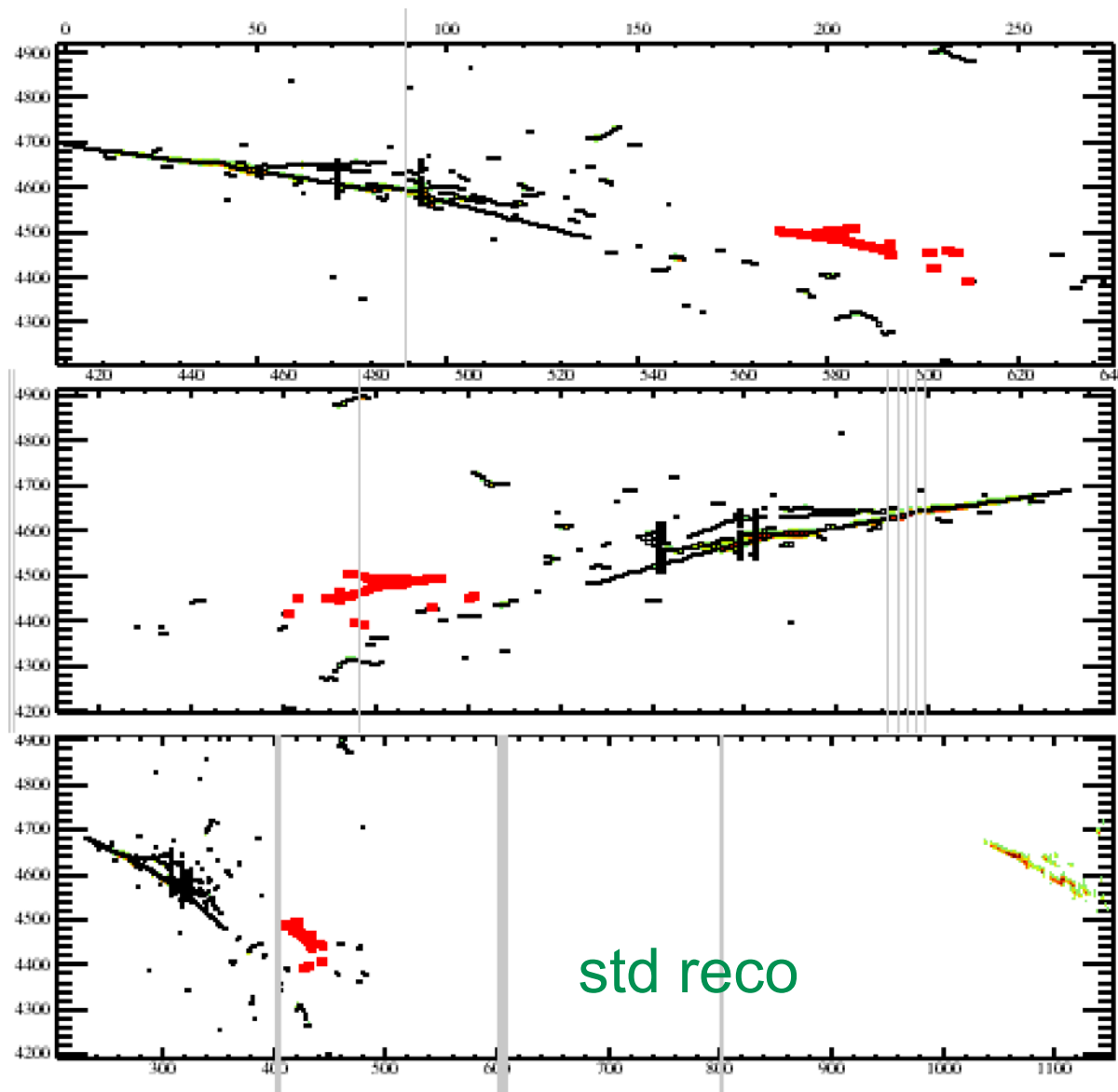
Pandora Shower reco2.0

- For most of the case Pandora does a great job!
- Just look at cases when things went south



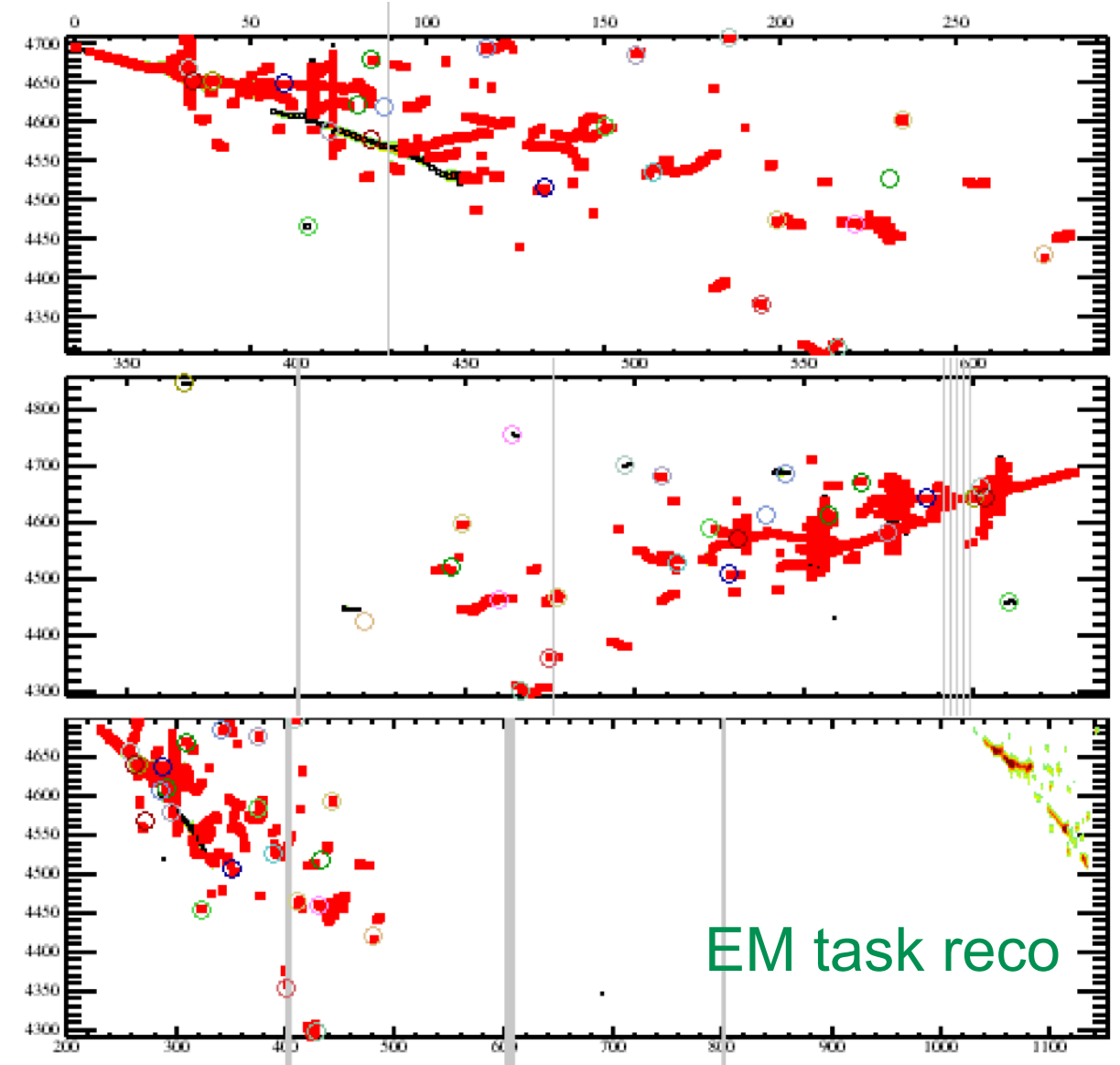
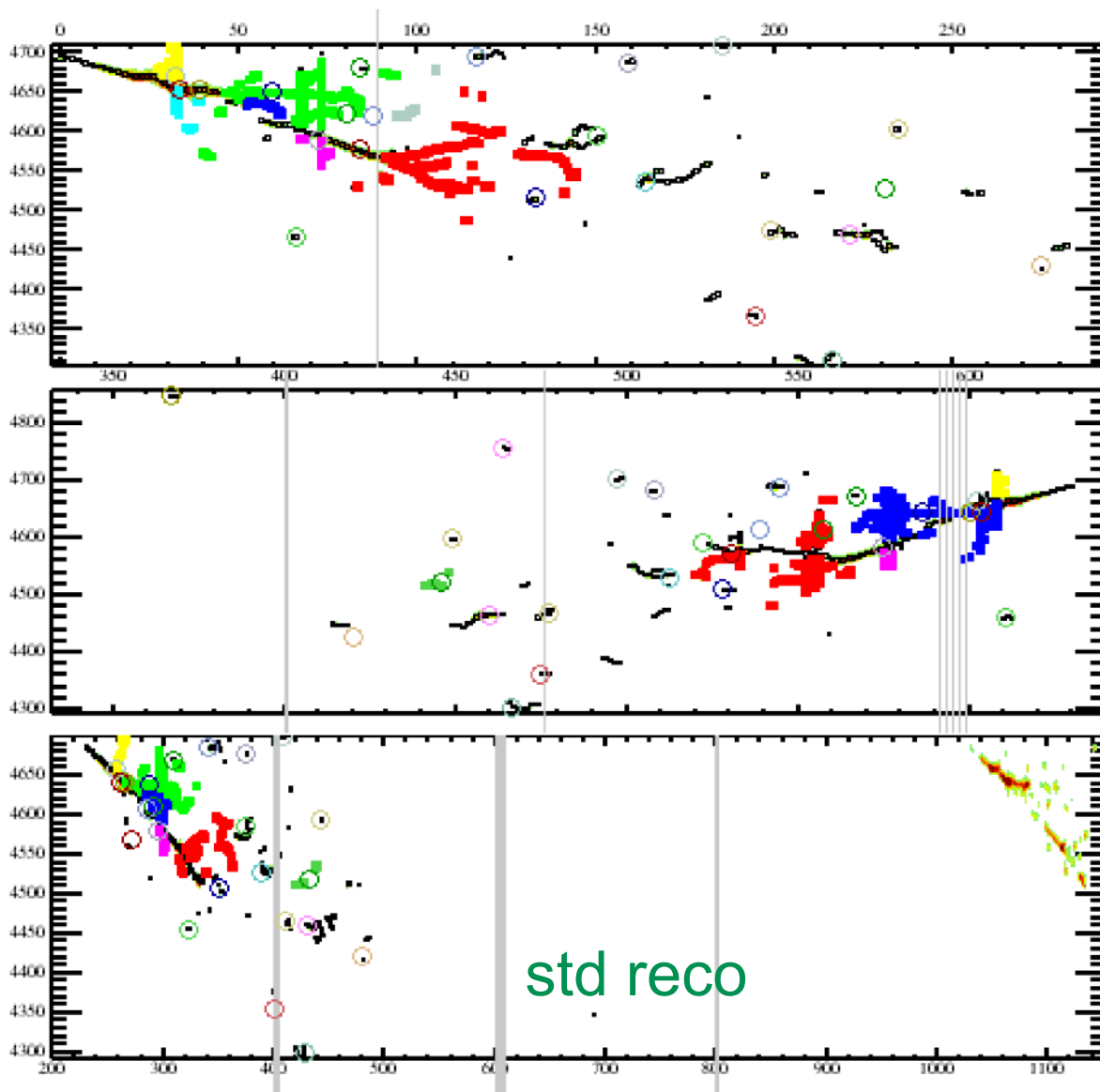
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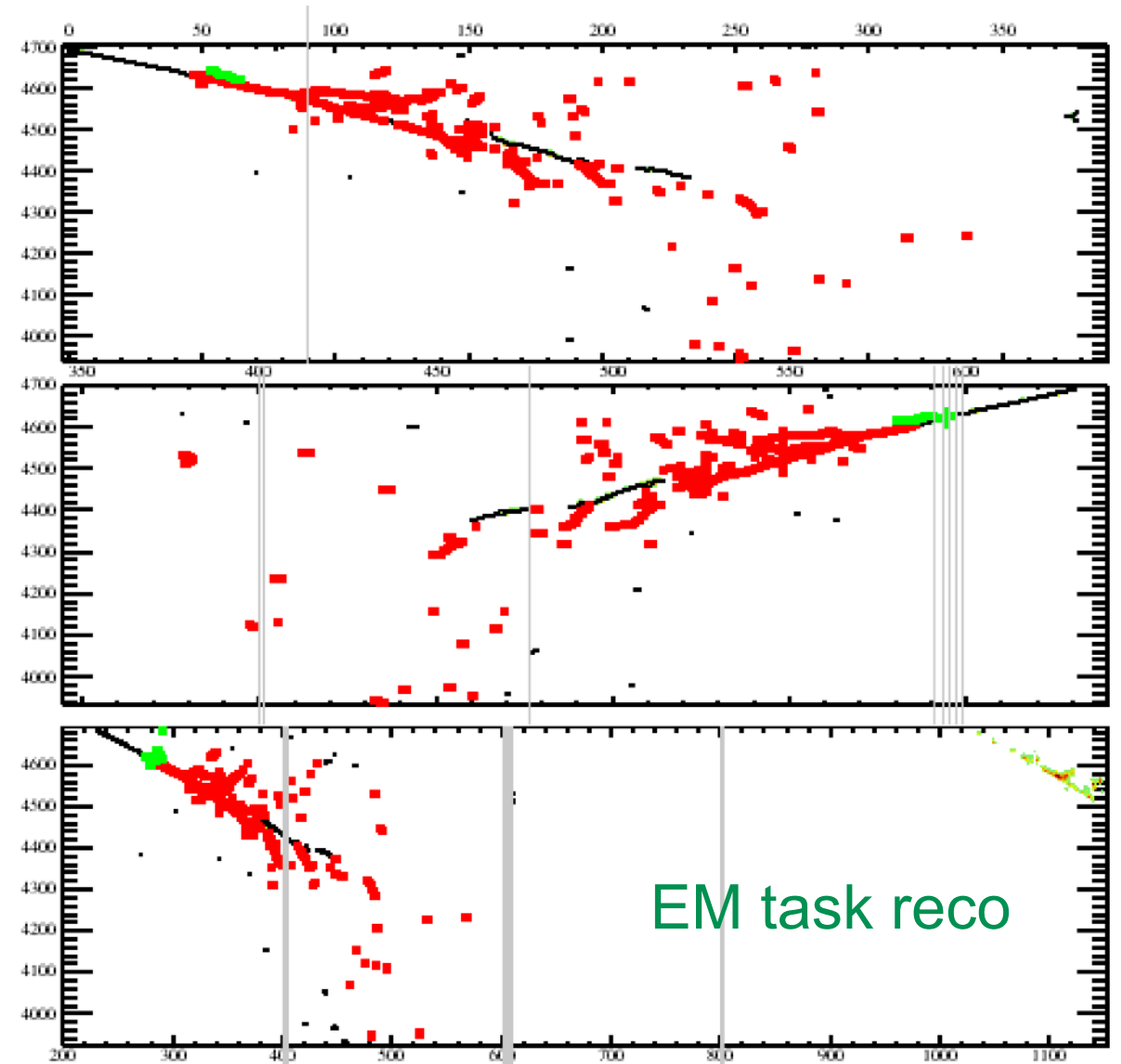
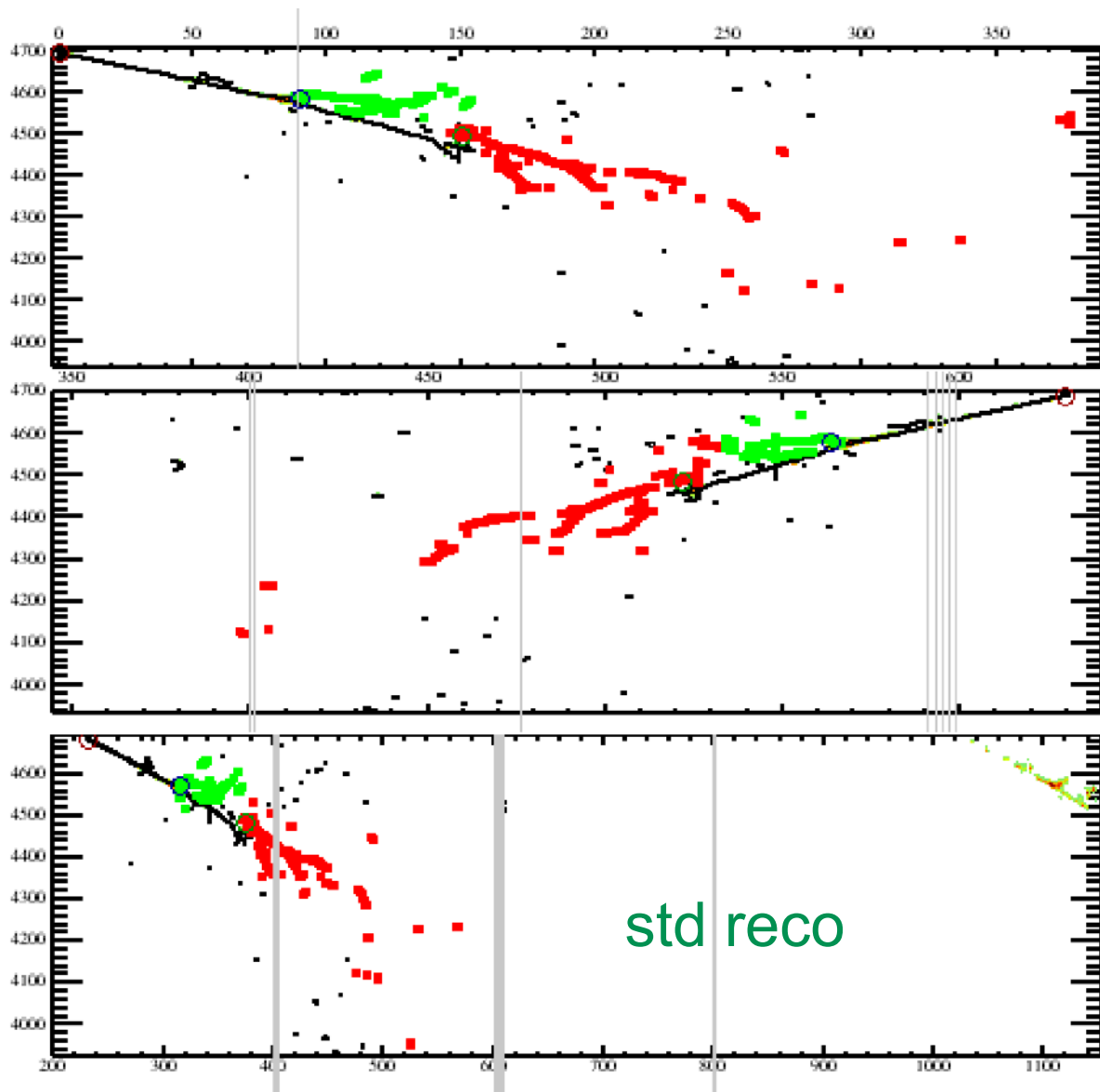
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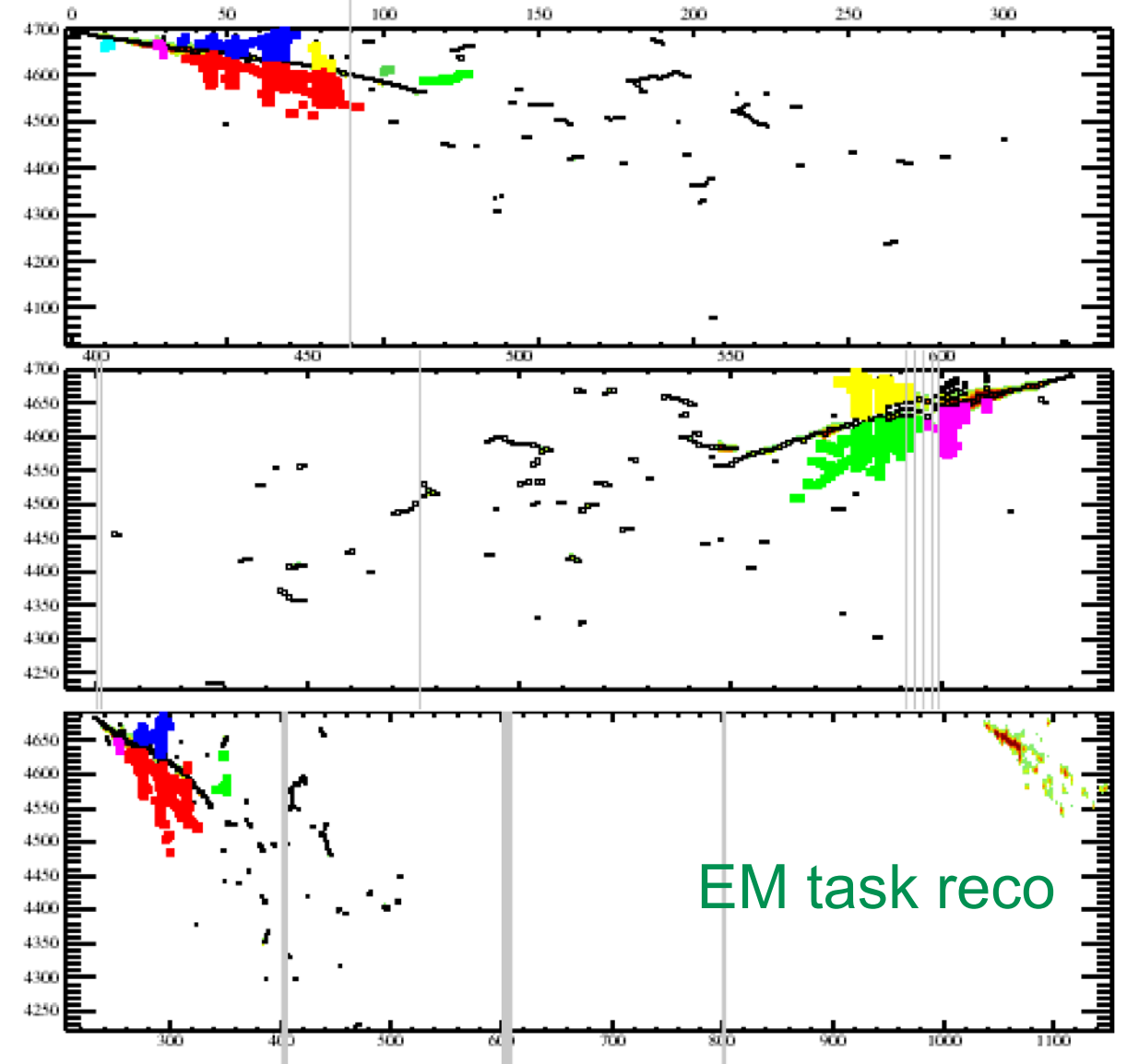
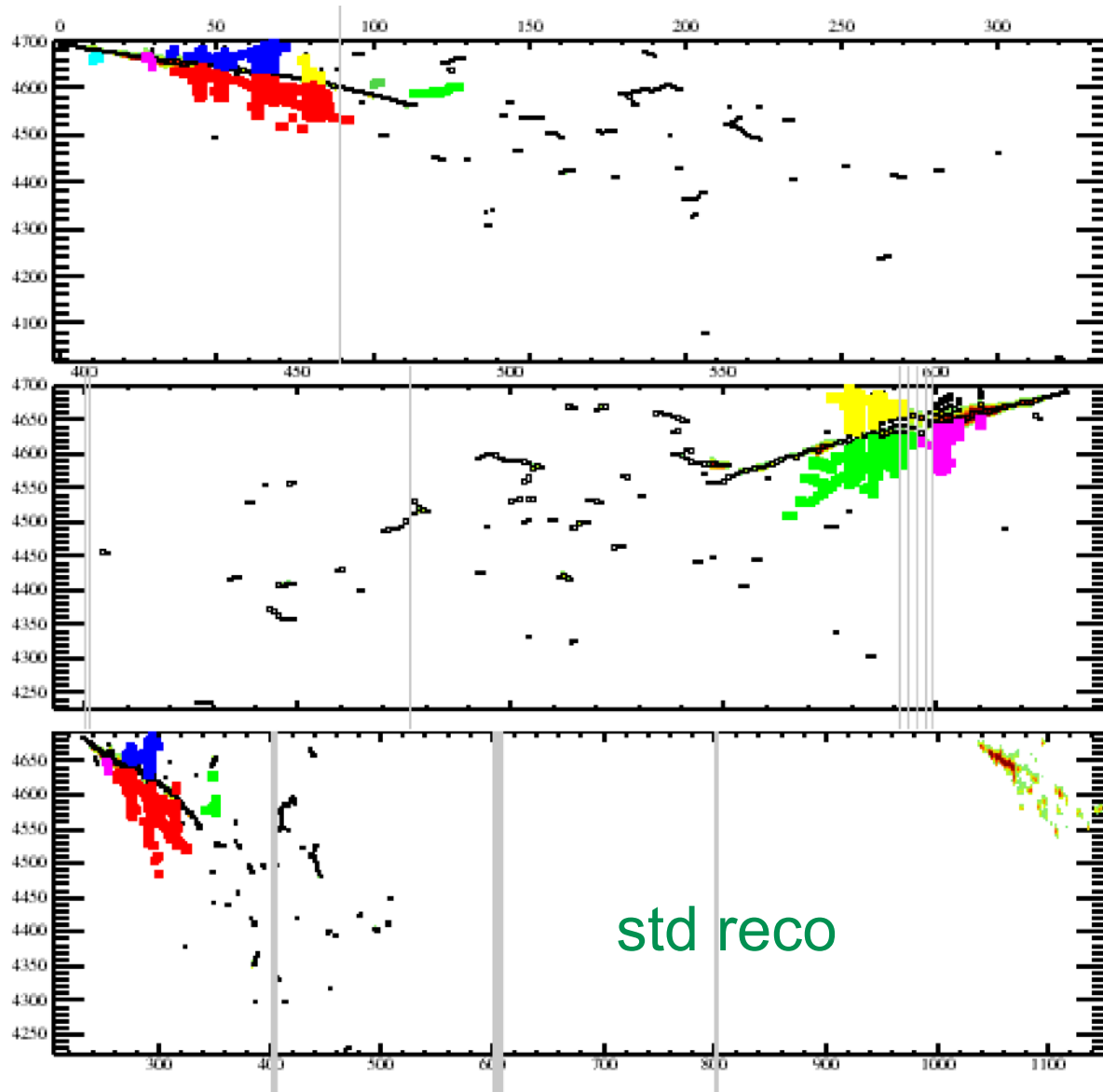
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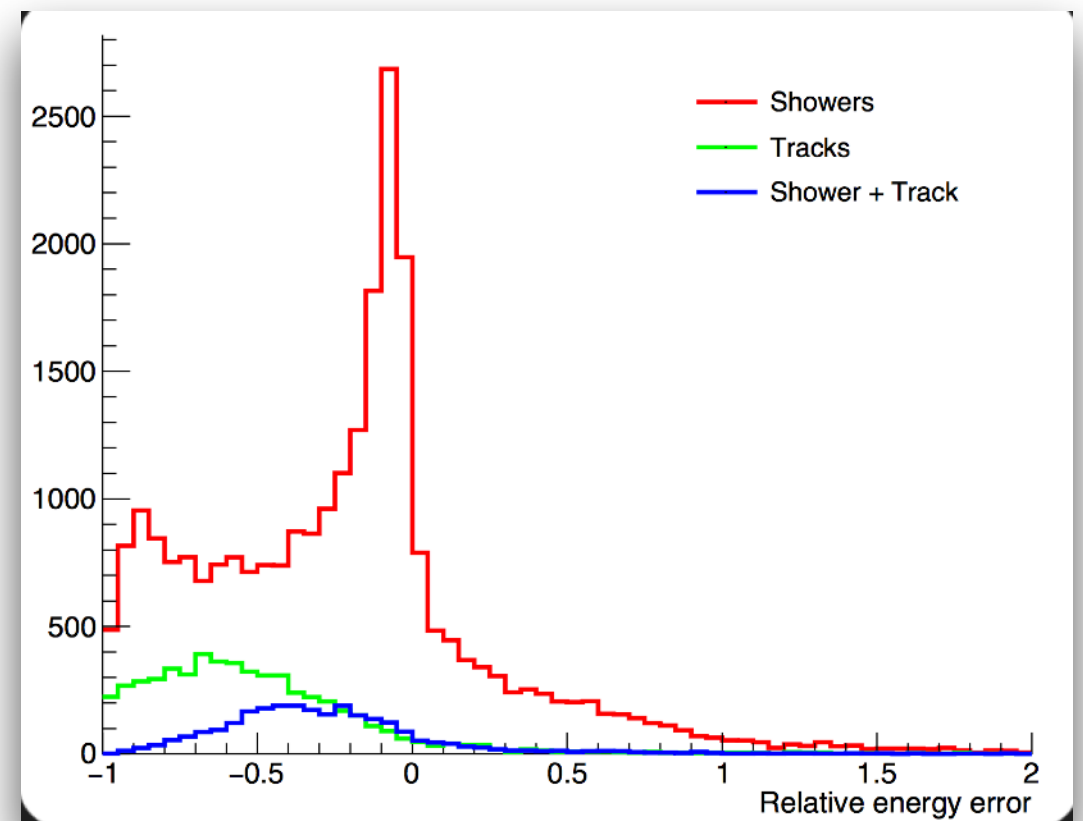
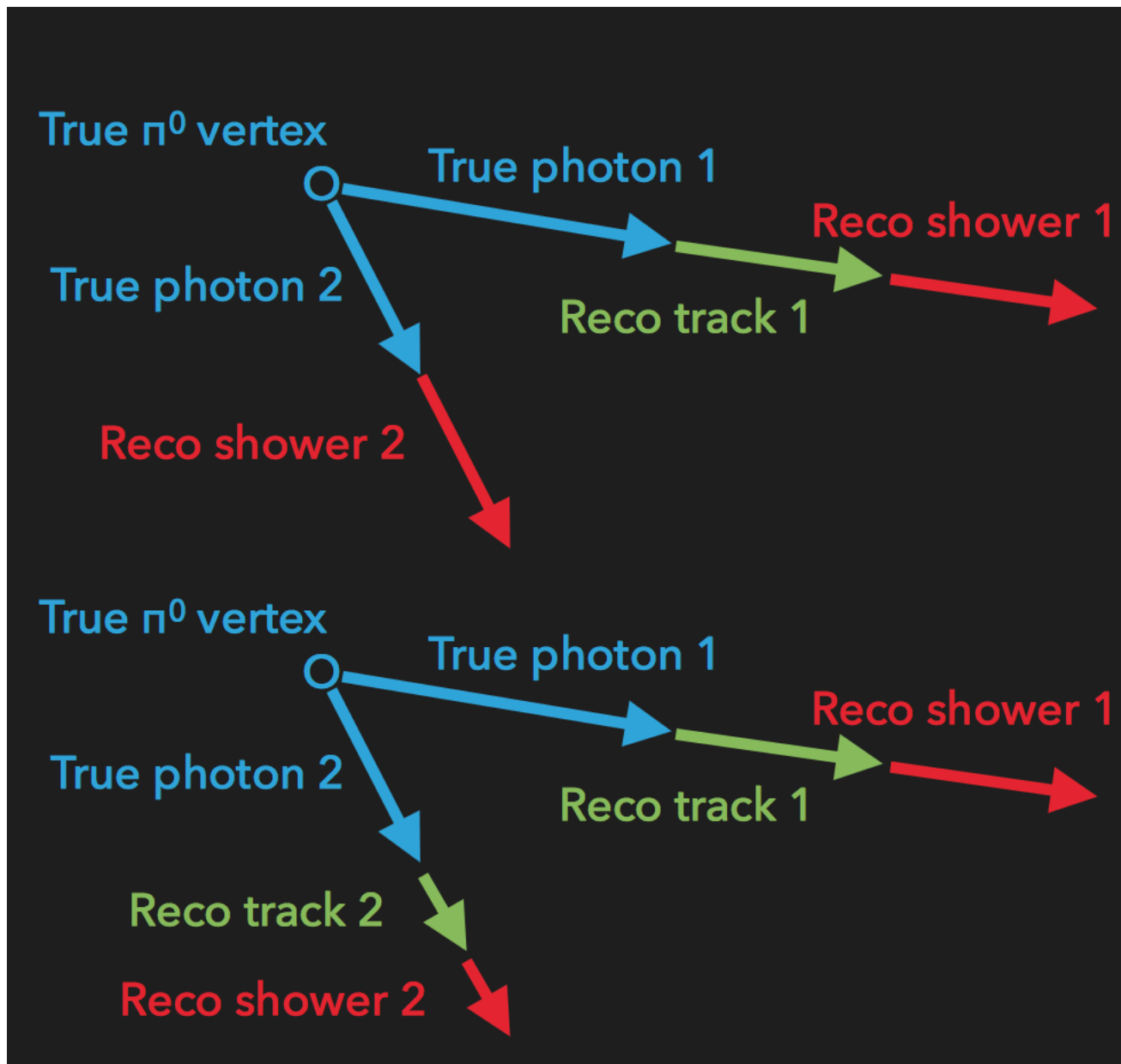


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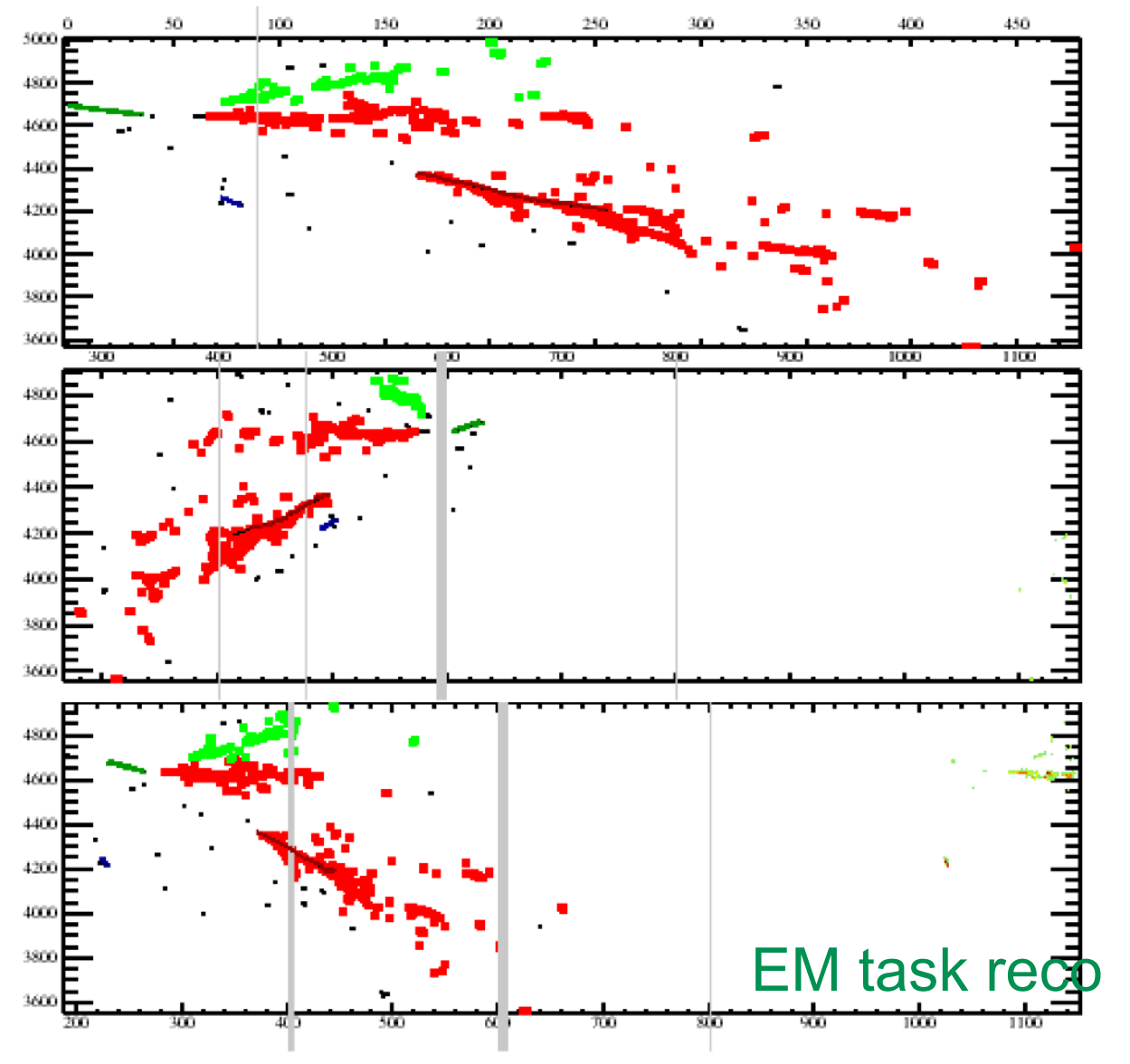
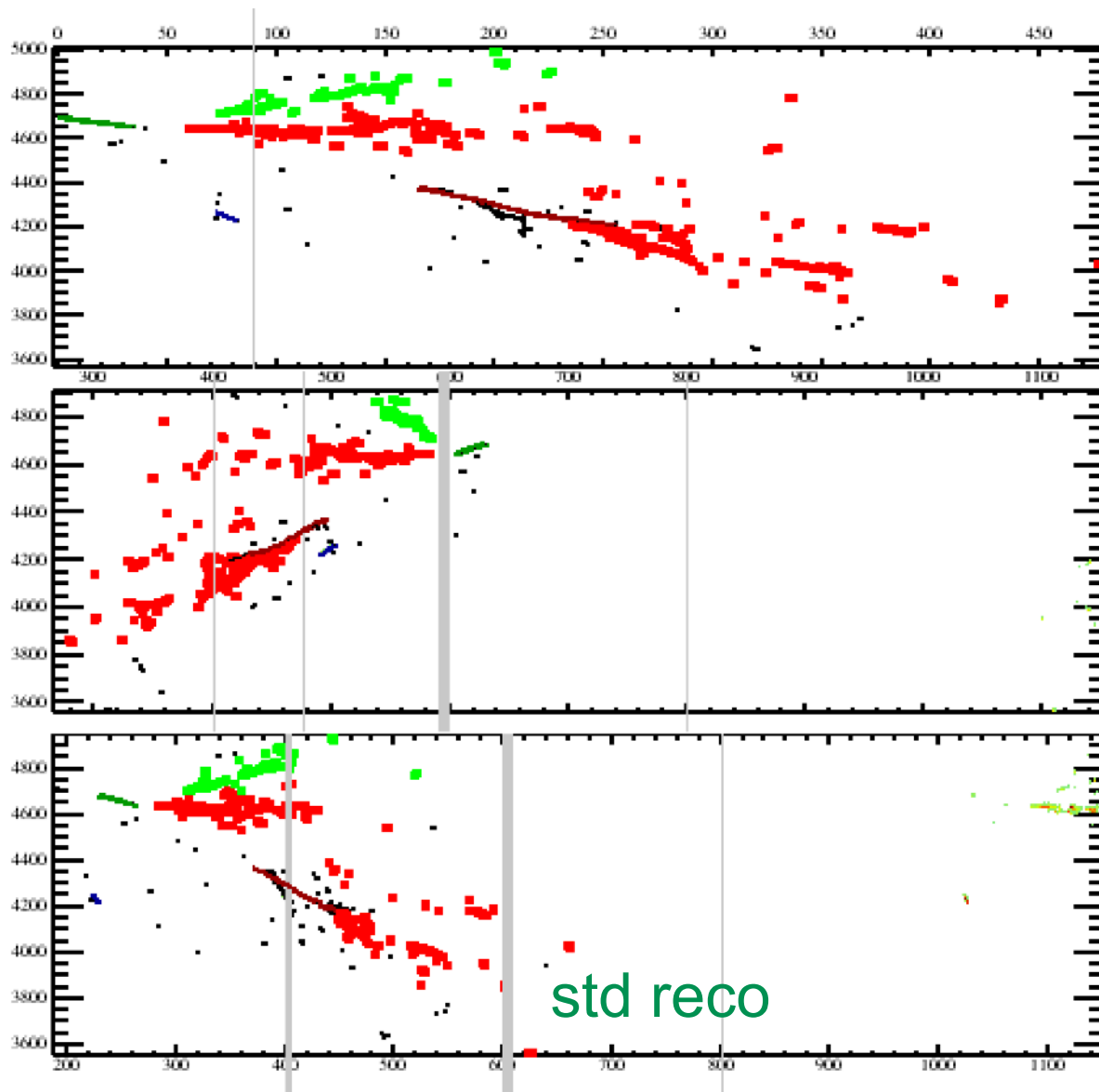


Pi-zero Analysis



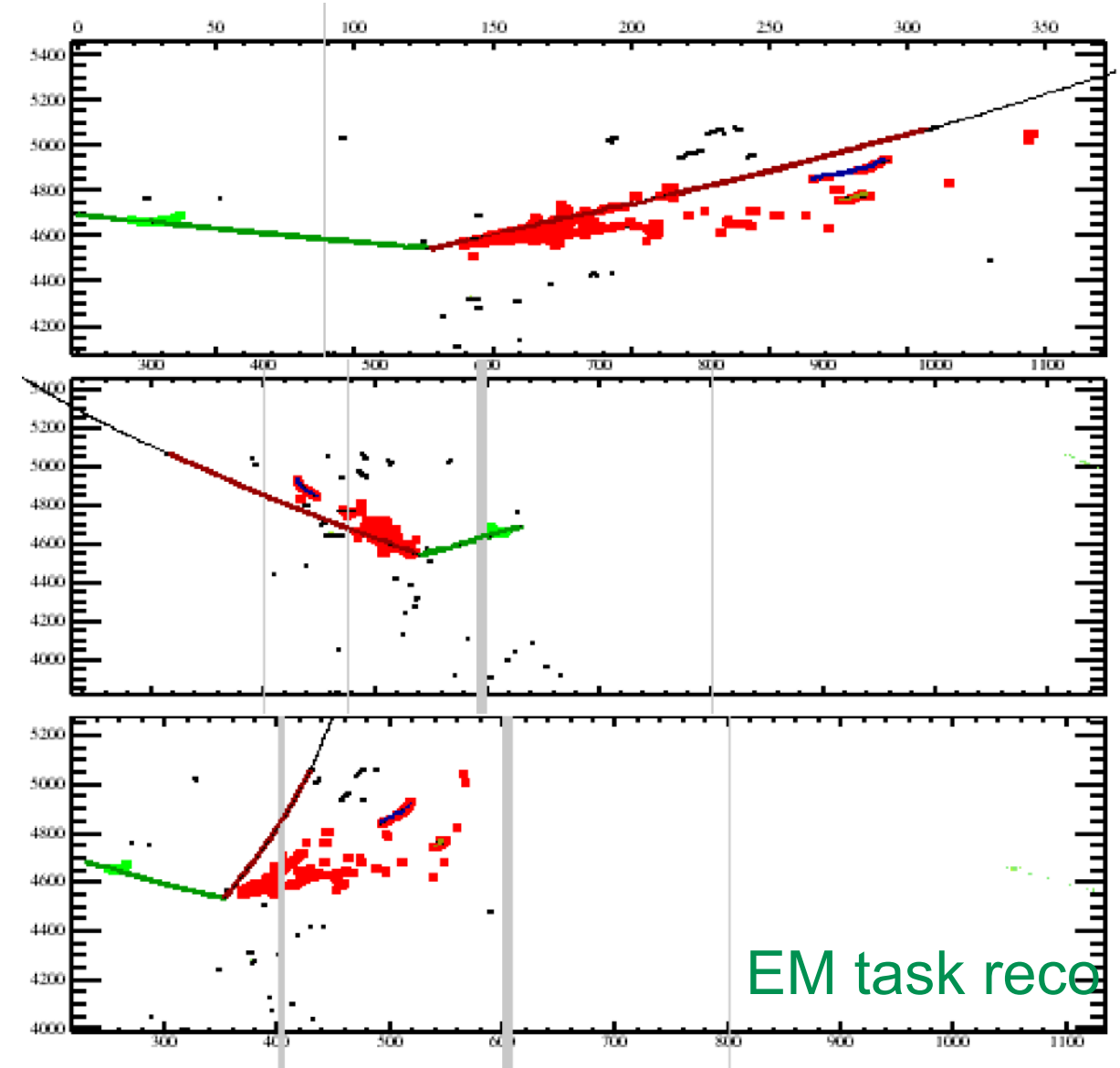
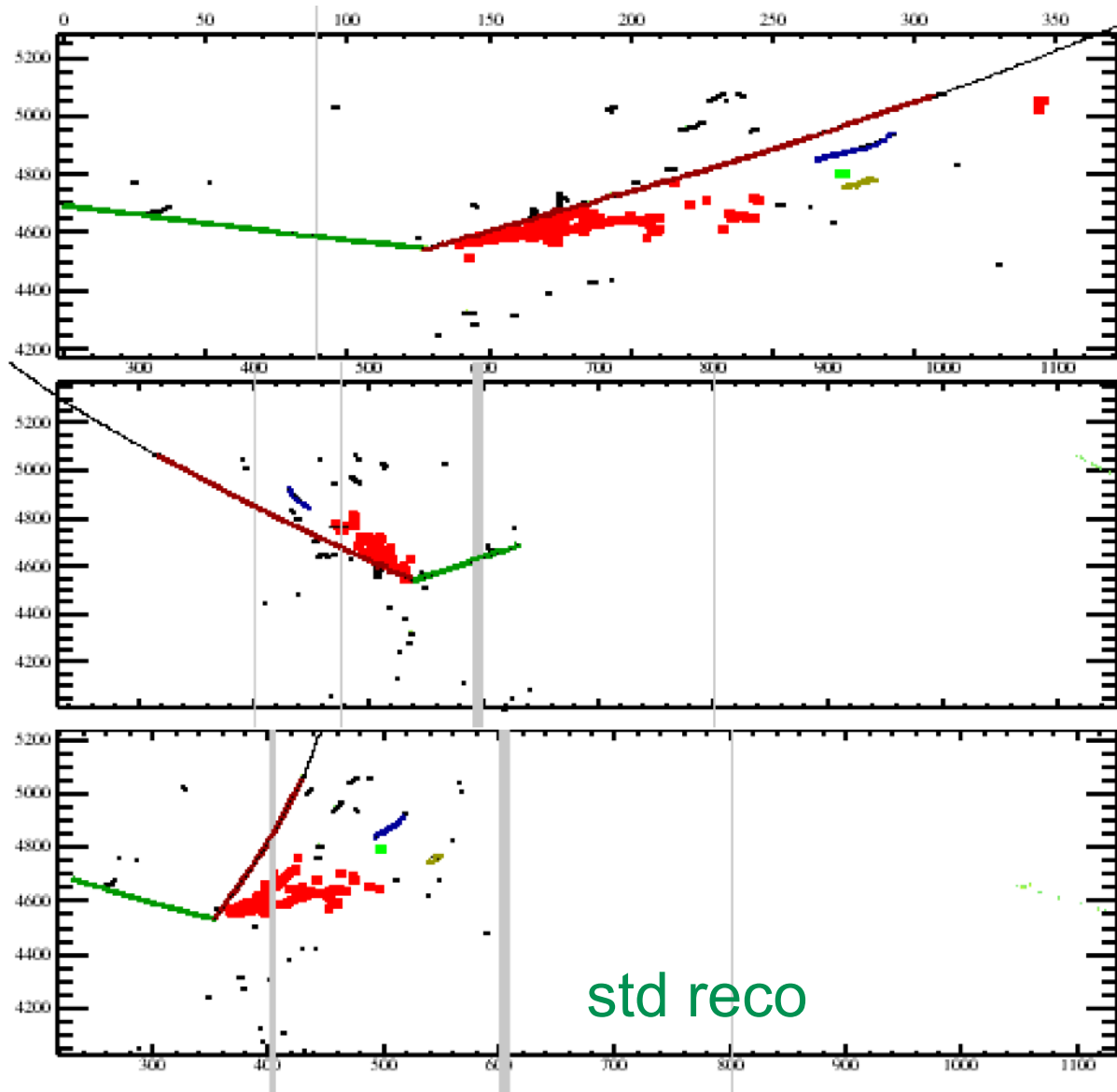
Pandora Shower reco2.0

- Example of track + shower; reco vs reco2



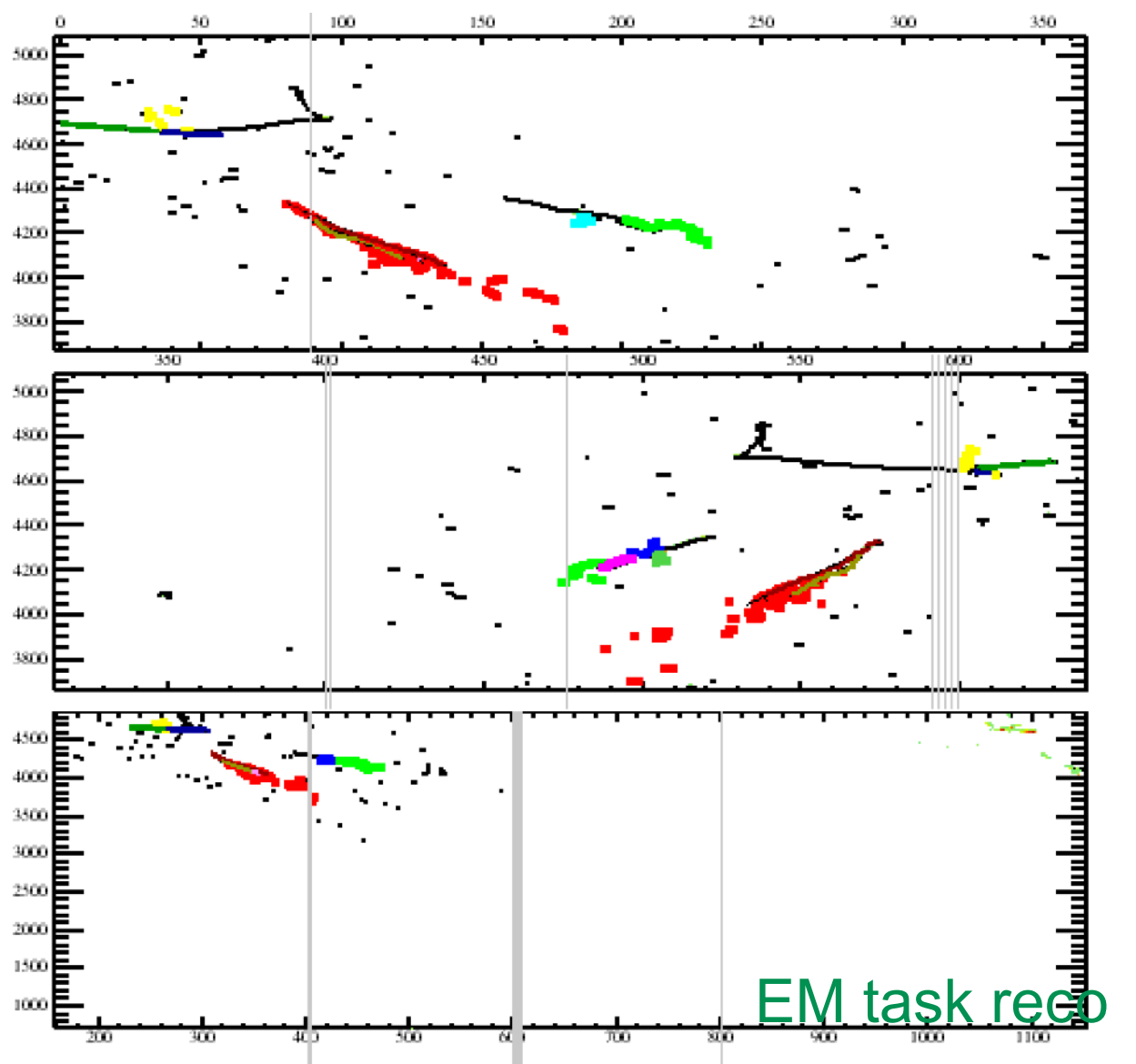
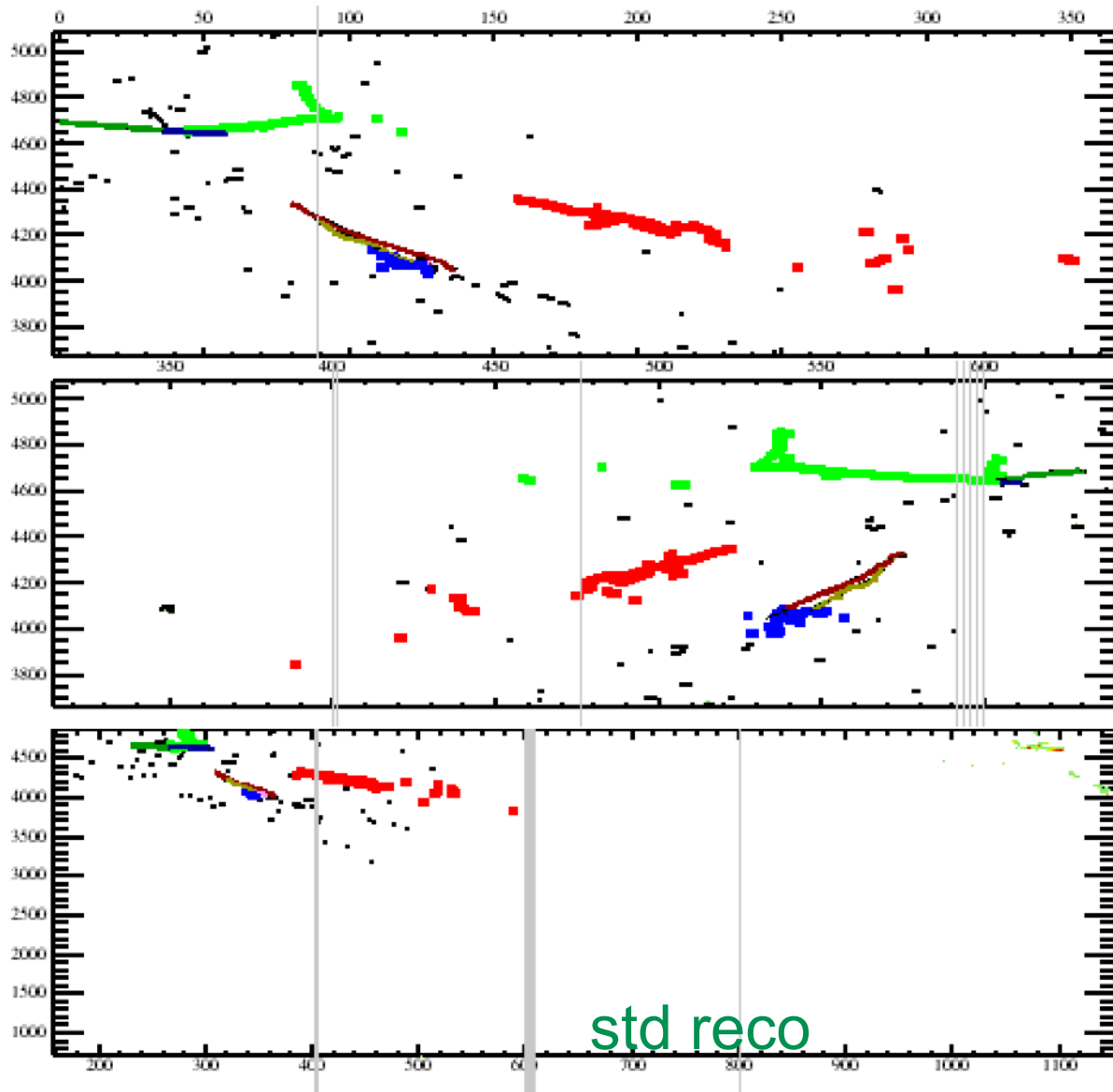
Pandora Shower reco2.0

- Example of track + shower; reco vs reco2



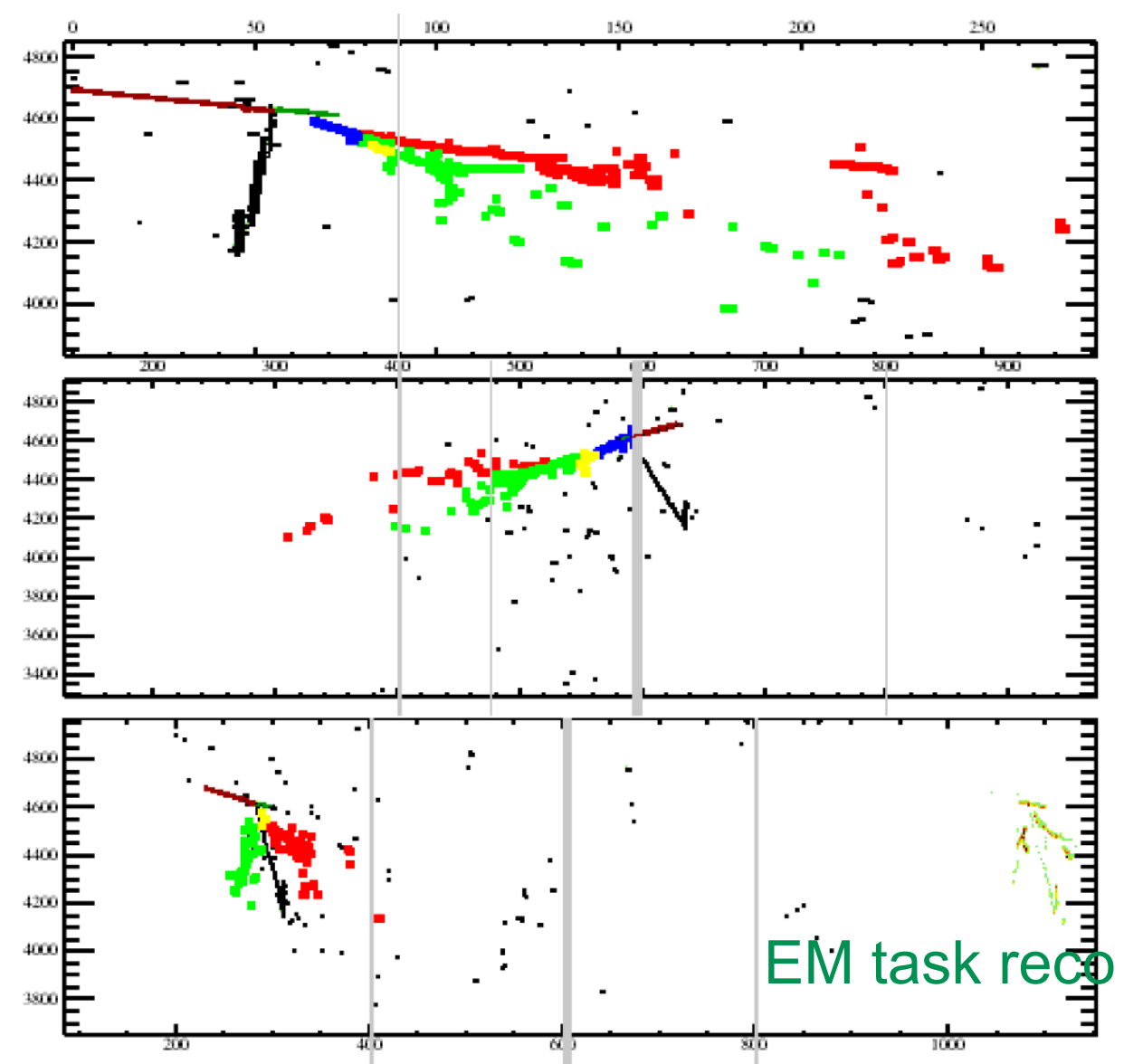
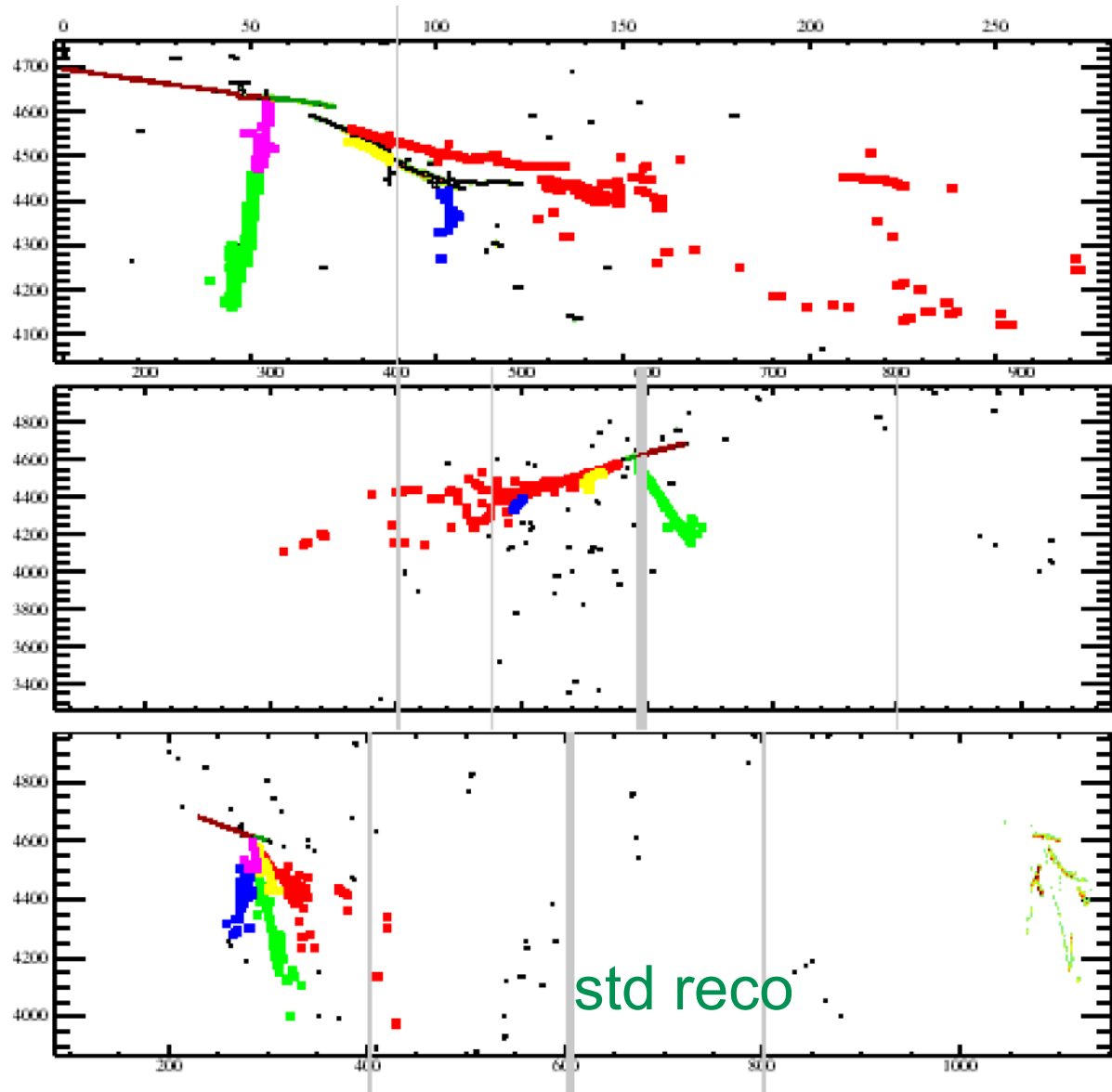
Pandora Shower reco2.0

- Example of track + shower; reco vs reco2



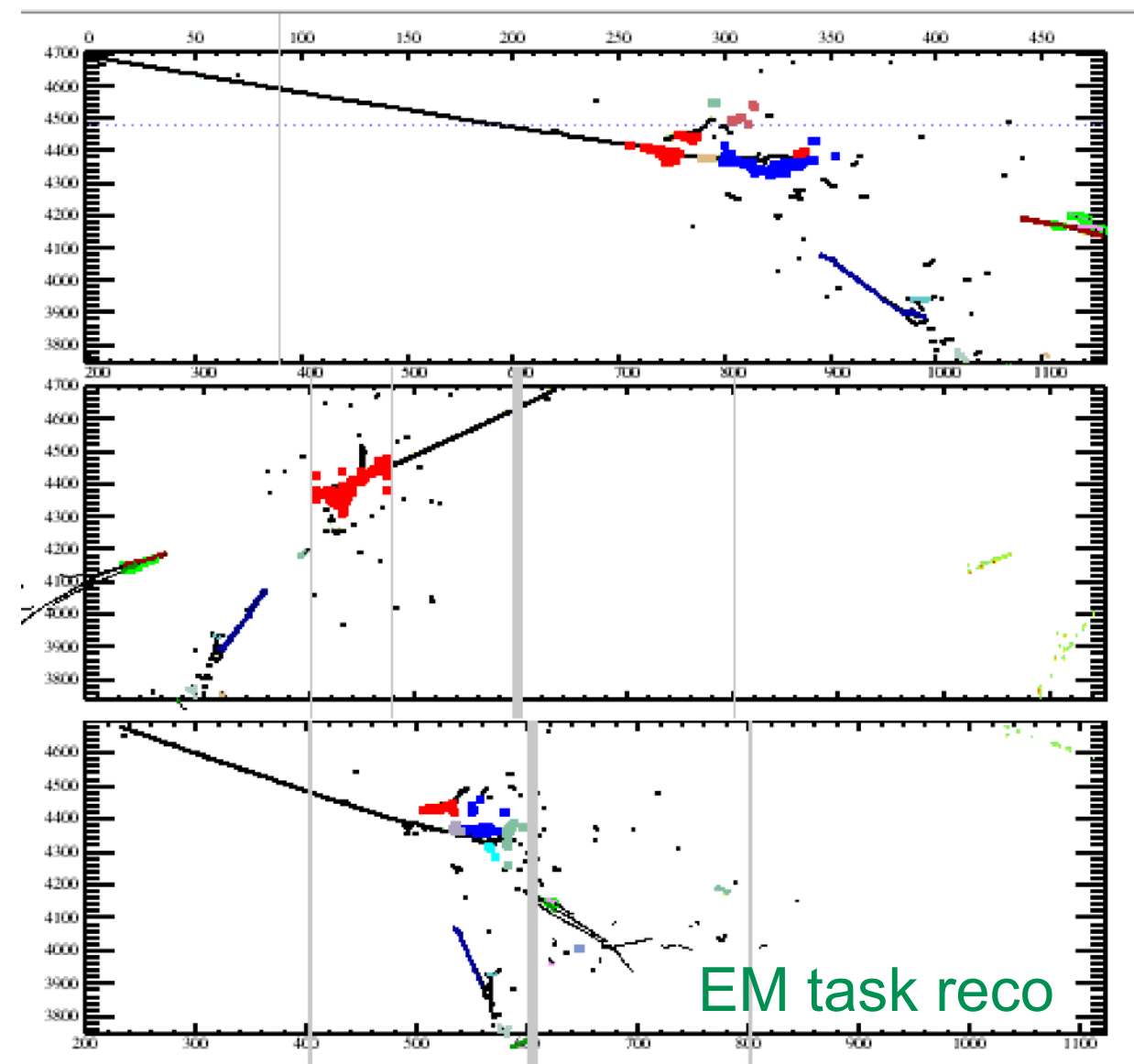
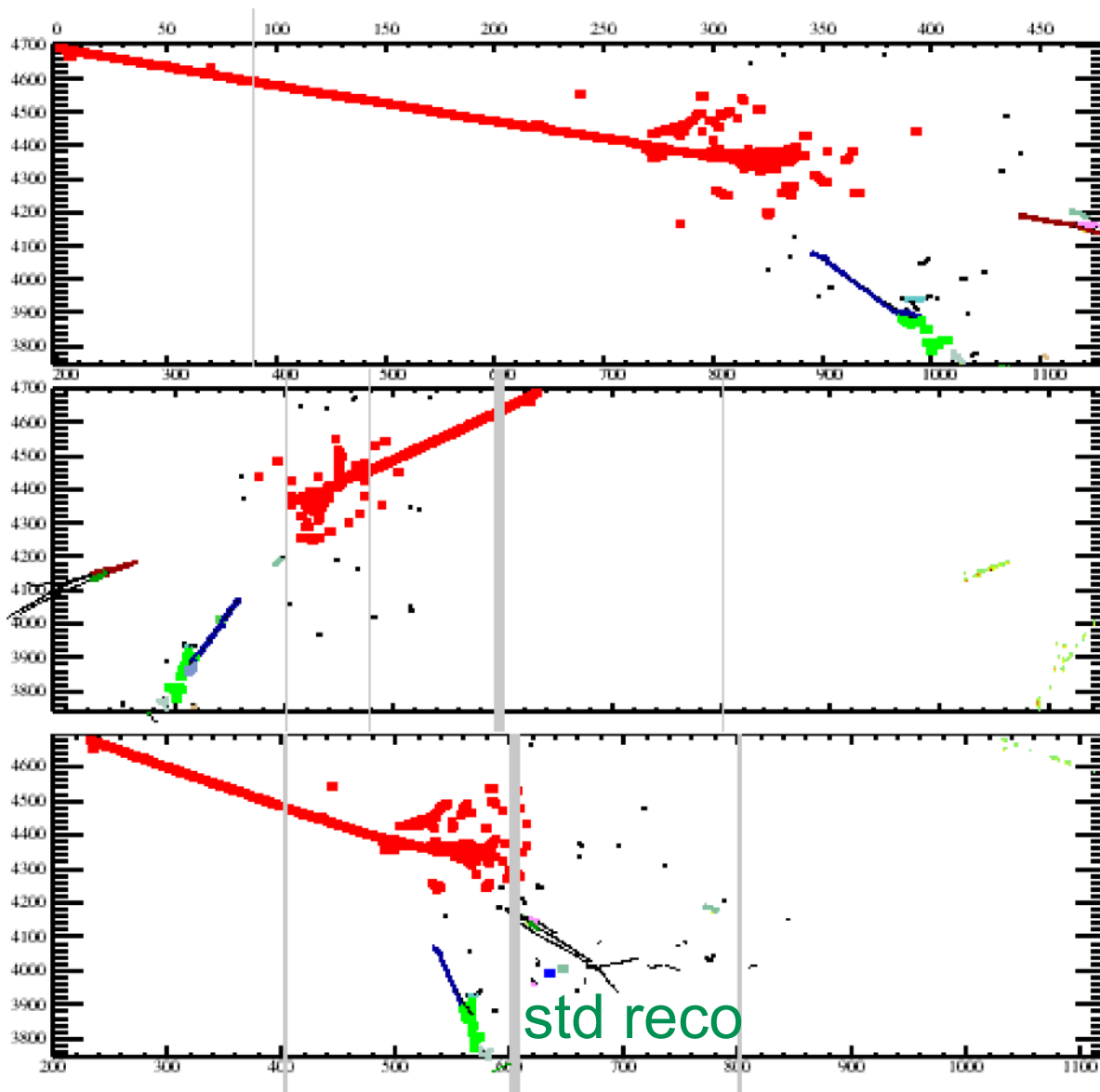
Pandora Shower reco2.0

- Example of broken showers; reco vs reco2



Pandora Shower reco2.0

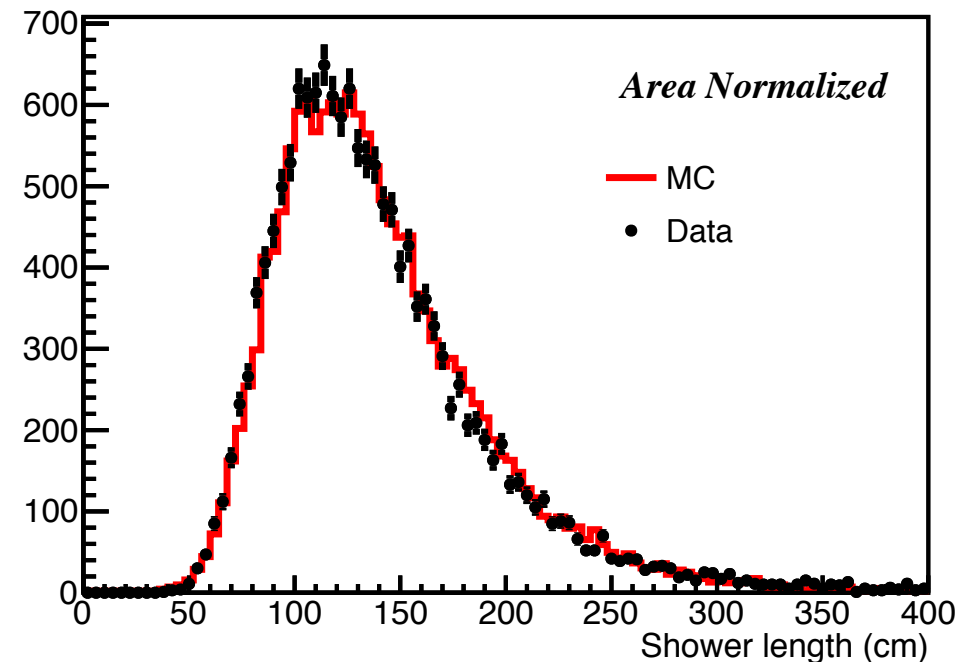
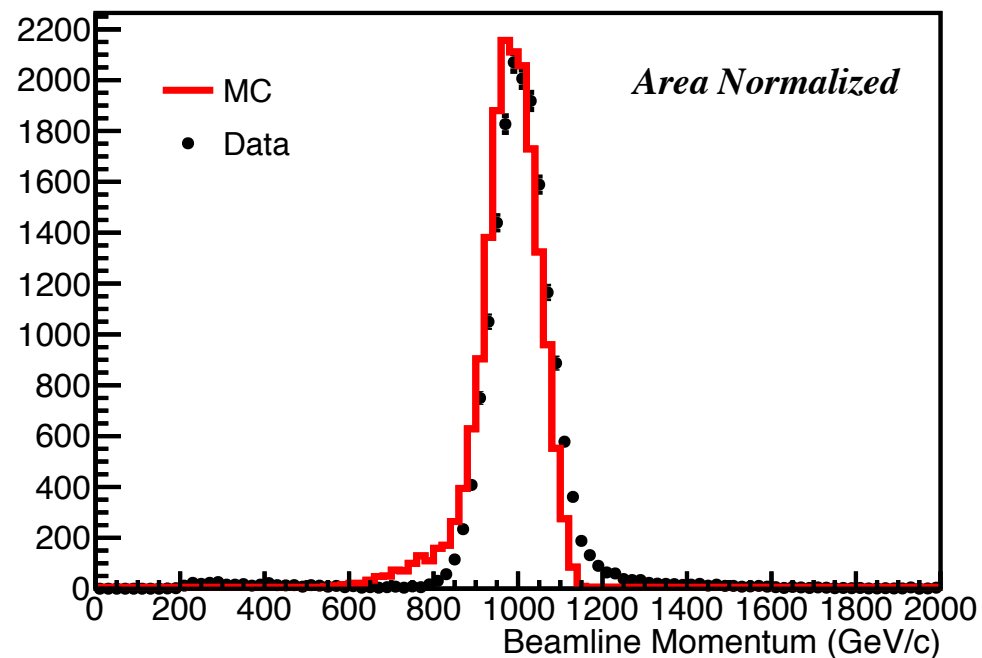
- reco vs reco2



Energy Resolution

Electron Energy

- Sample Production 2 & MCC12
- Selection
 - Beamline momentum reconstruction
 - Electron candidate (Cherenkov ID)
 - PFP beam particle must be a shower
 - Complete shower (number of hits)



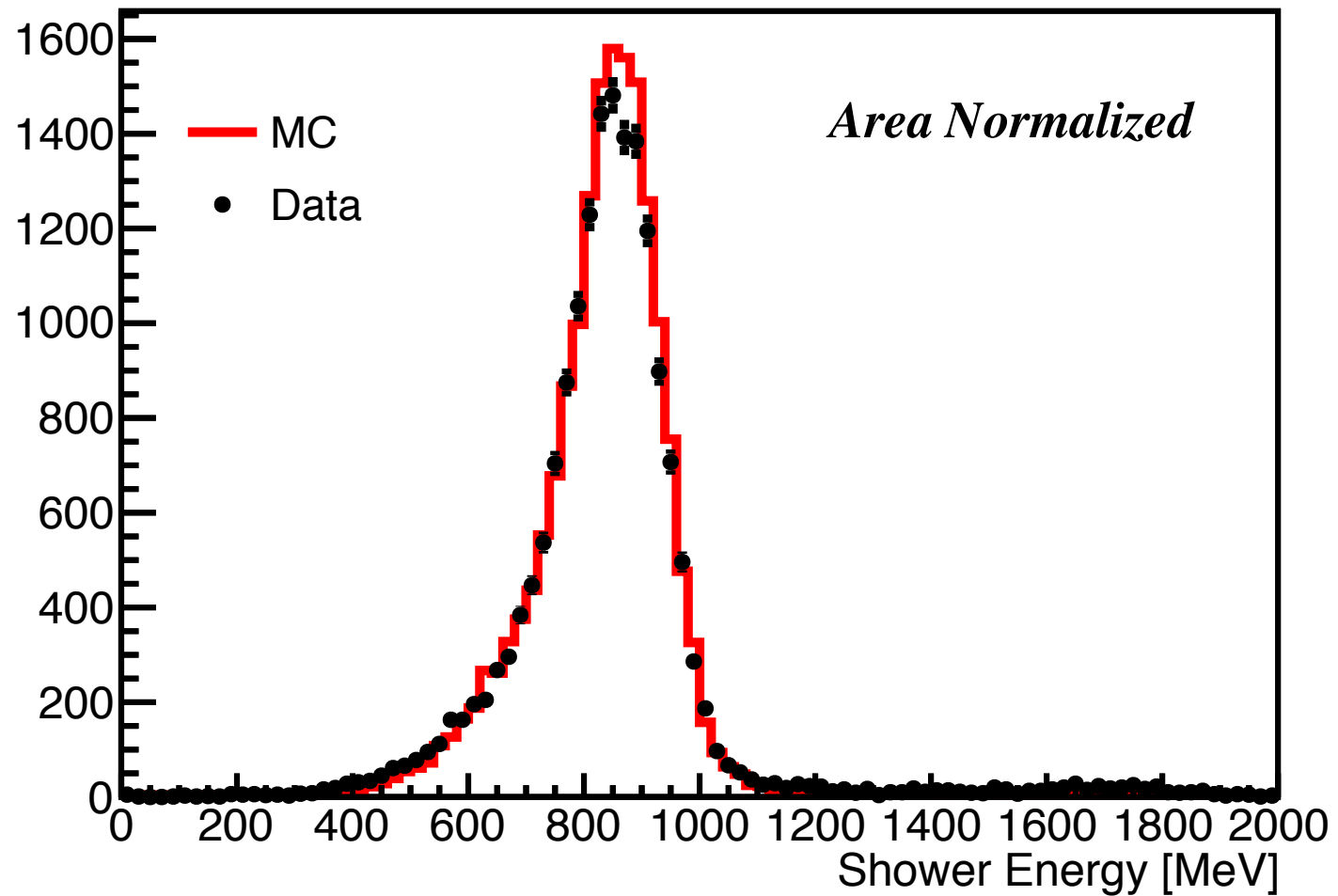
Energy Reconstruction

$$E_{calo} = \sum_{i=1}^{i=N \text{ hits}} \frac{\epsilon_i(X, Y Z) dQ_i W_{ion}}{\text{calorimetry factor} \cdot \text{Recombination factor}}$$

- ϵ_i = correction factor X(life time) and YZ(wire response, etc.) run 5809
- dQ_i = hit charge
- W_{ion} = 23.6e-6, from Argoneut
- calorimetry factor = 5.58e-3 run 5809
- Recombination factor = 0.63, from FERMILAB-PUB-15-458-ND

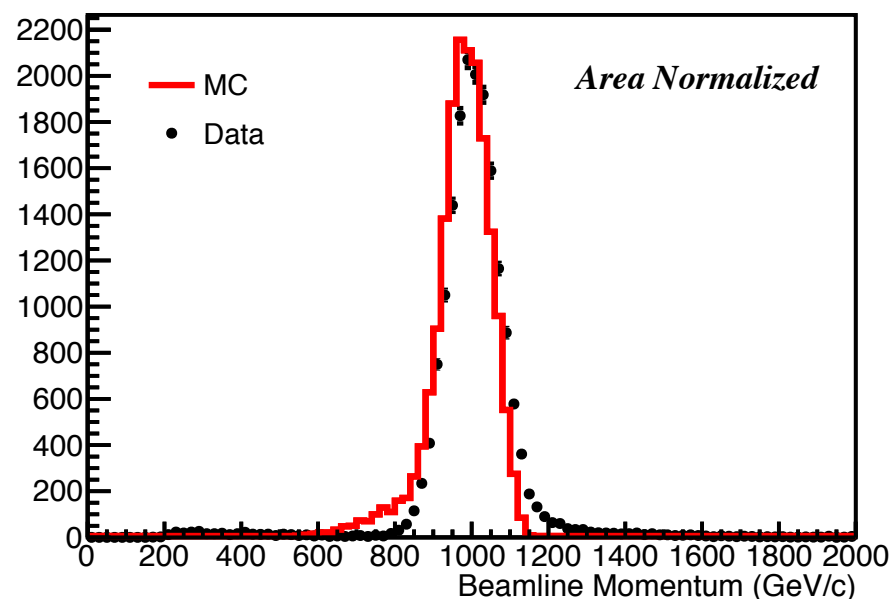
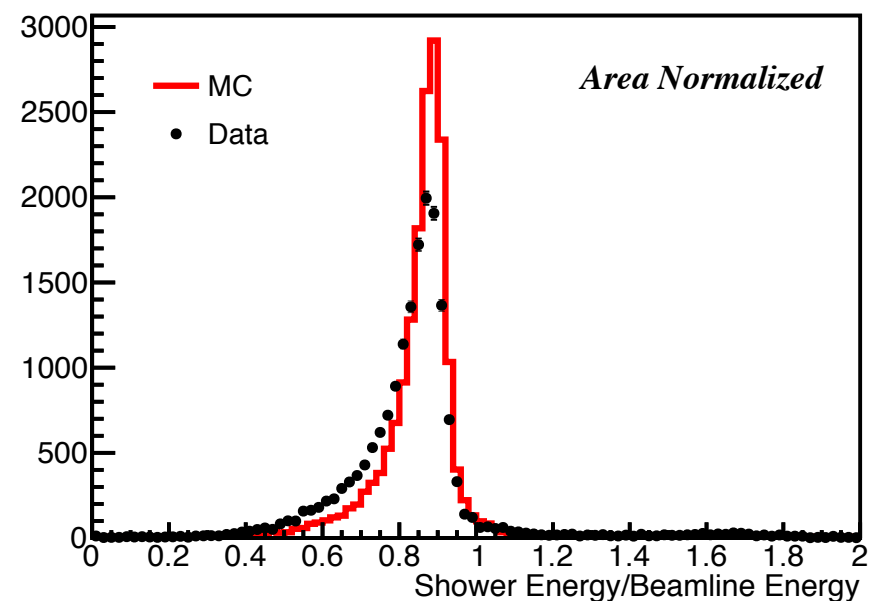
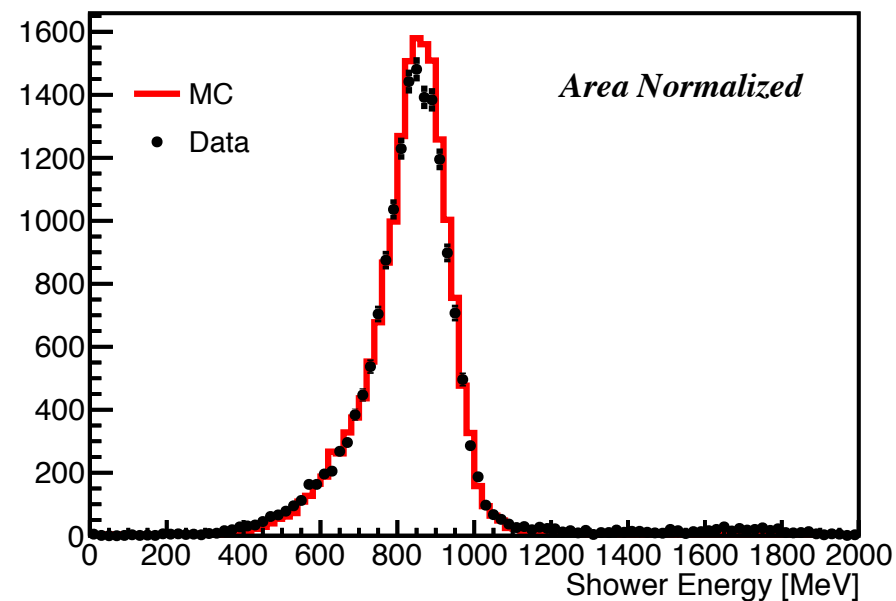
Energy Reconstruction

- Run 5809 (1 GeV/c positrons)



Energy Reconstruction

- Run 5809 (1 GeV/c positrons)



- Need to account for energy loss upstream
- Check completeness using true deposited energy
- Can we estimate the energy resolution using shower energy/beamline energy?

Energy Reconstruction

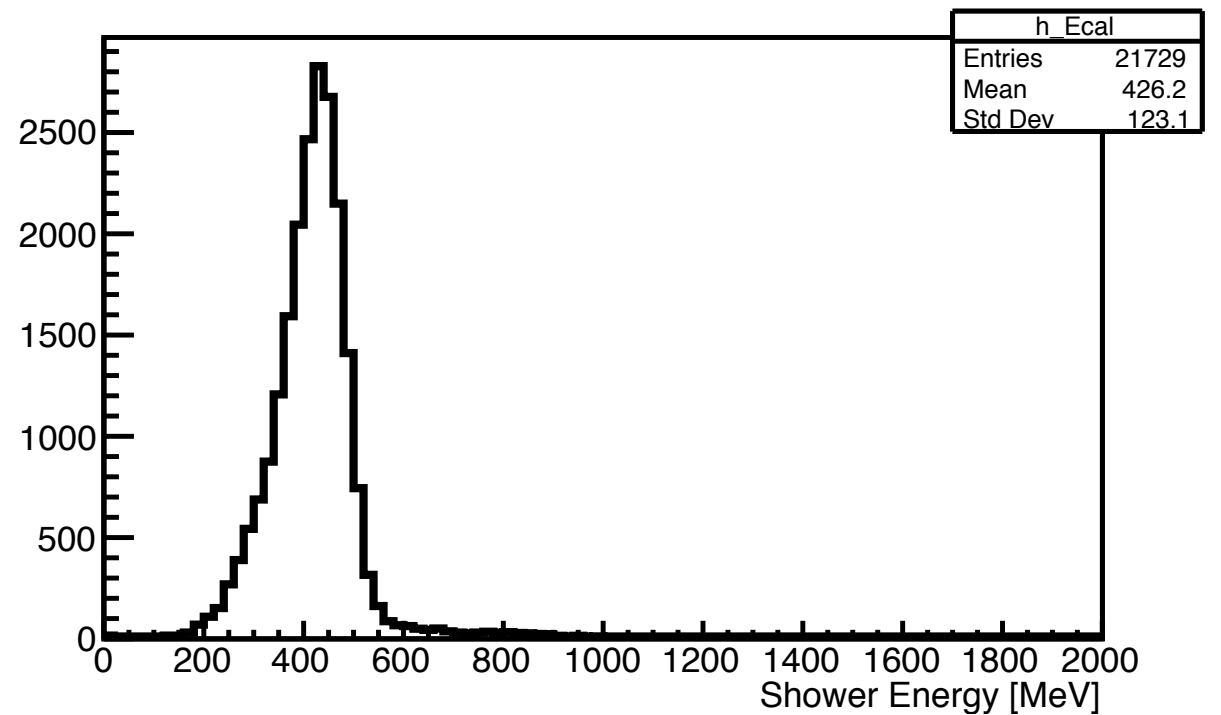
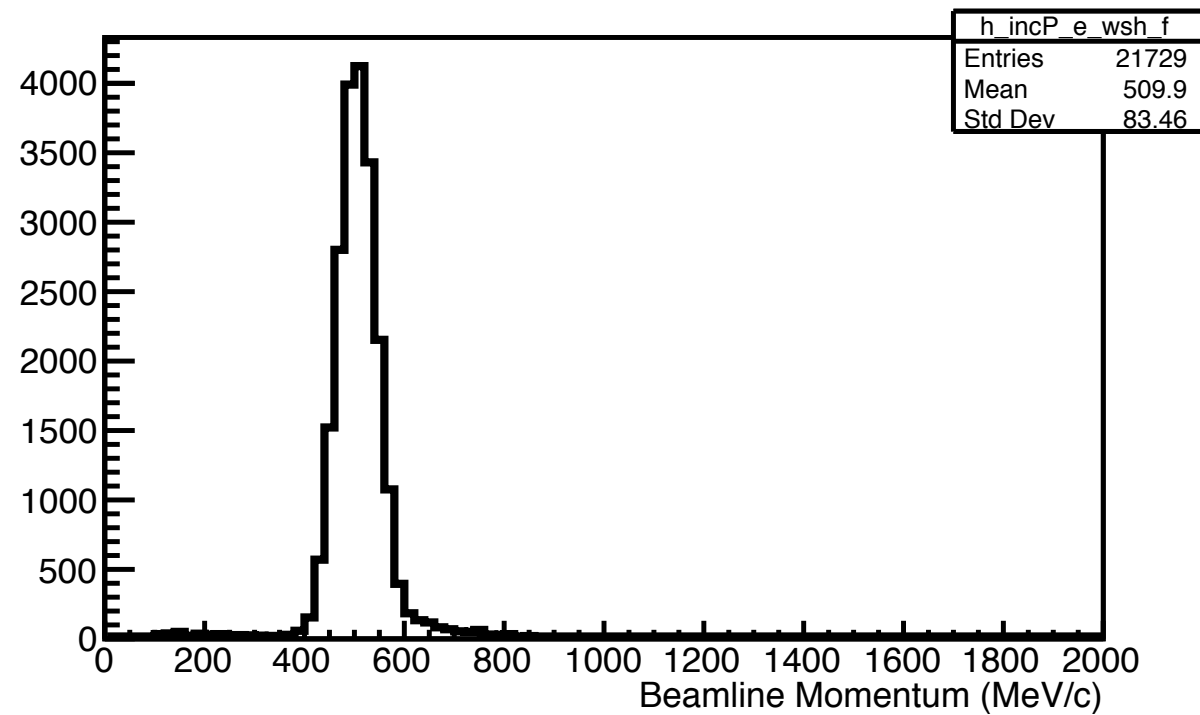
- Follow same procedure for 0.5 GeV/c, 1 GeV/c, 2 GeV/c, 3 GeV/c and 6 GeV/c
- Runs 5826, 5809, 5824, 5777, 5770
- Selection
 - Beamline momentum reconstruction
 - Electron candidate (Cherenkov ID)
 - PFP beam particle must be a shower
 - Complete shower (number of hits)
 - Energy reconstruction *using same calorimetry factors based on run 5809*

$$E_{calo} = \sum_{i=1}^{i=N \text{ hits}} \frac{\epsilon_i(X, Y, Z) dQ_i W_{ion}}{\text{calorimetry factor} \cdot \text{Recombination factor}}$$

Energy Reconstruction

Preliminary results

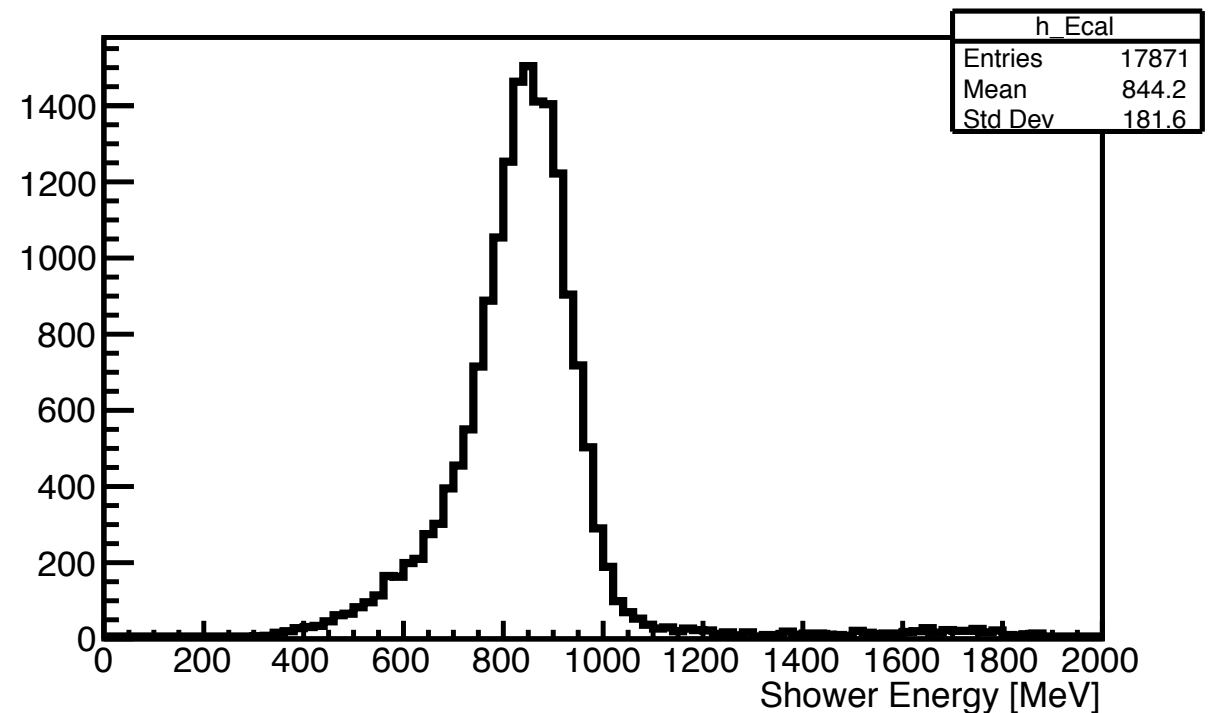
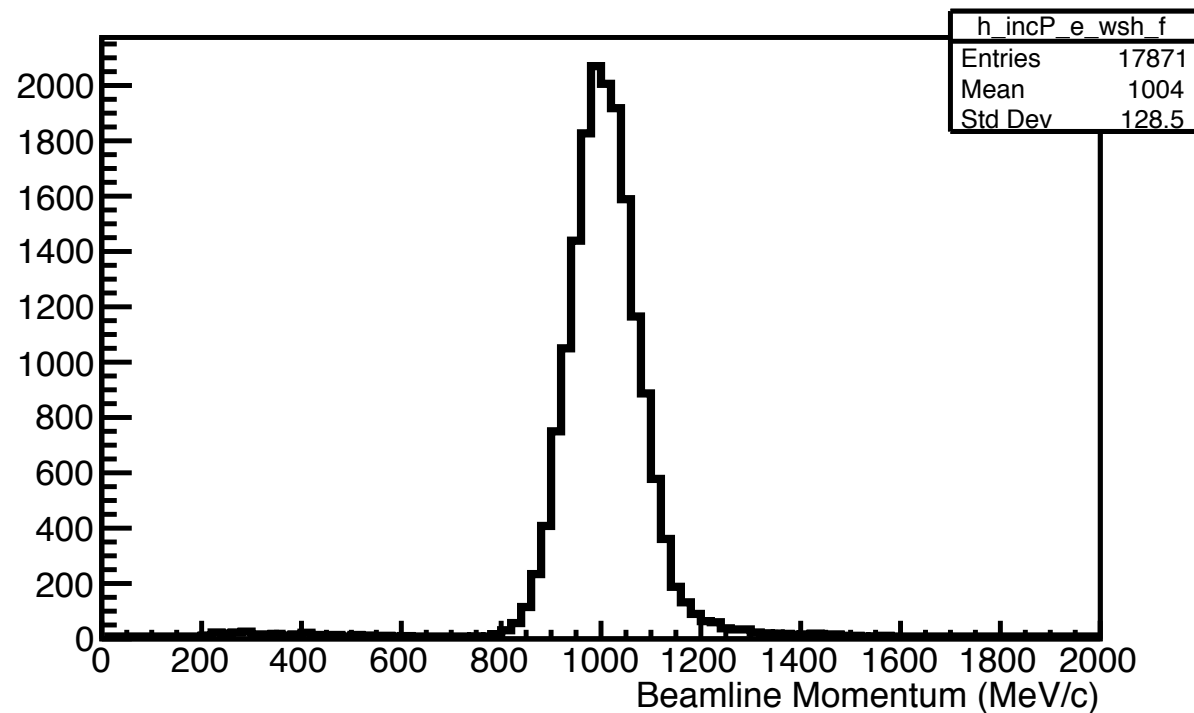
- Run 5826 (0.5 GeV/c)



Energy Reconstruction

Preliminary results

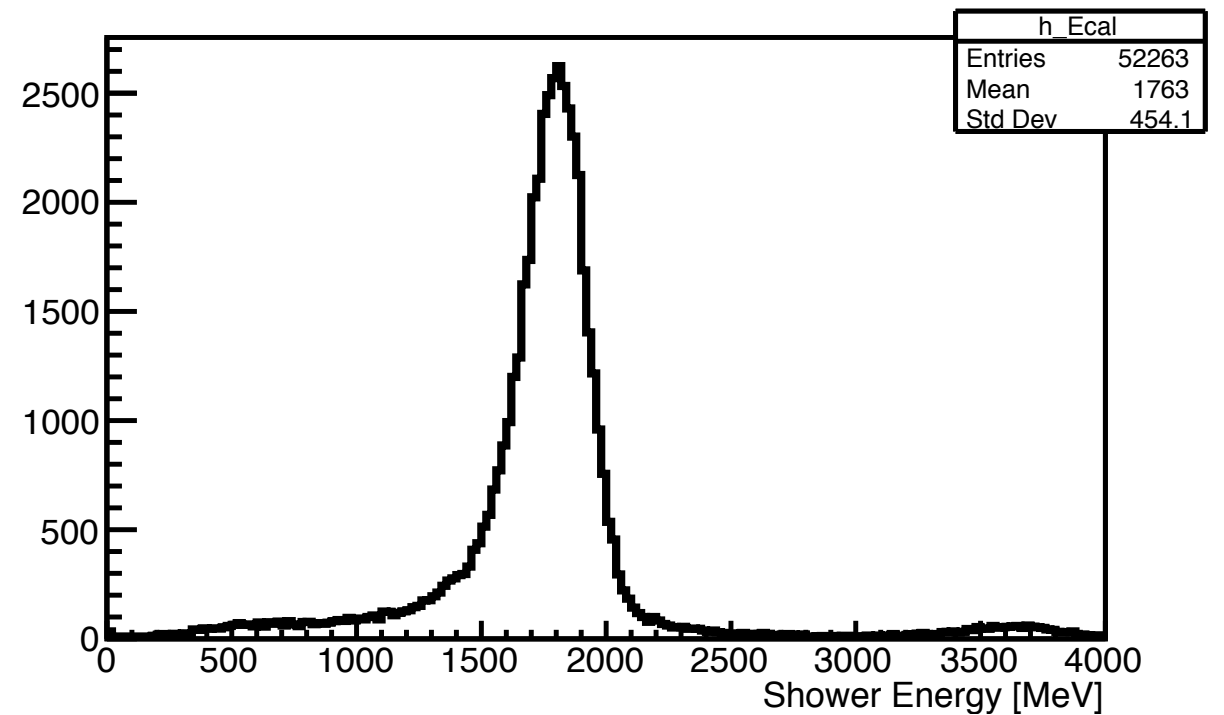
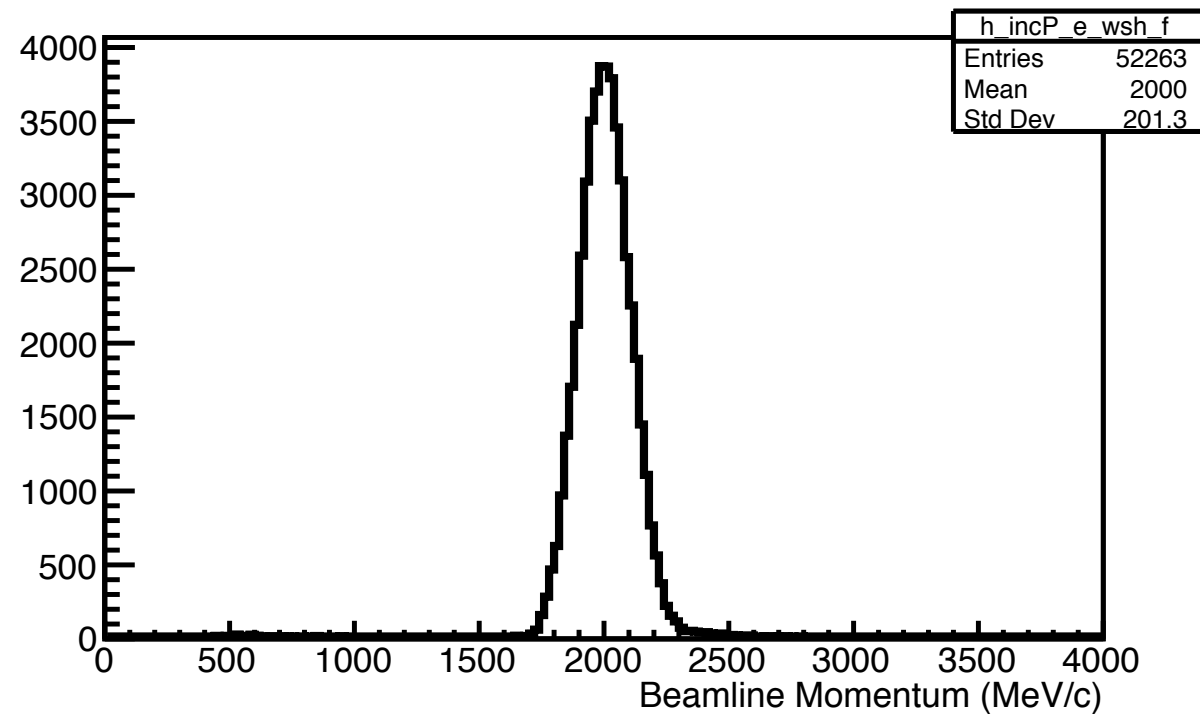
- Run 5809 (1.0 GeV/c)



Energy Reconstruction

Preliminary results

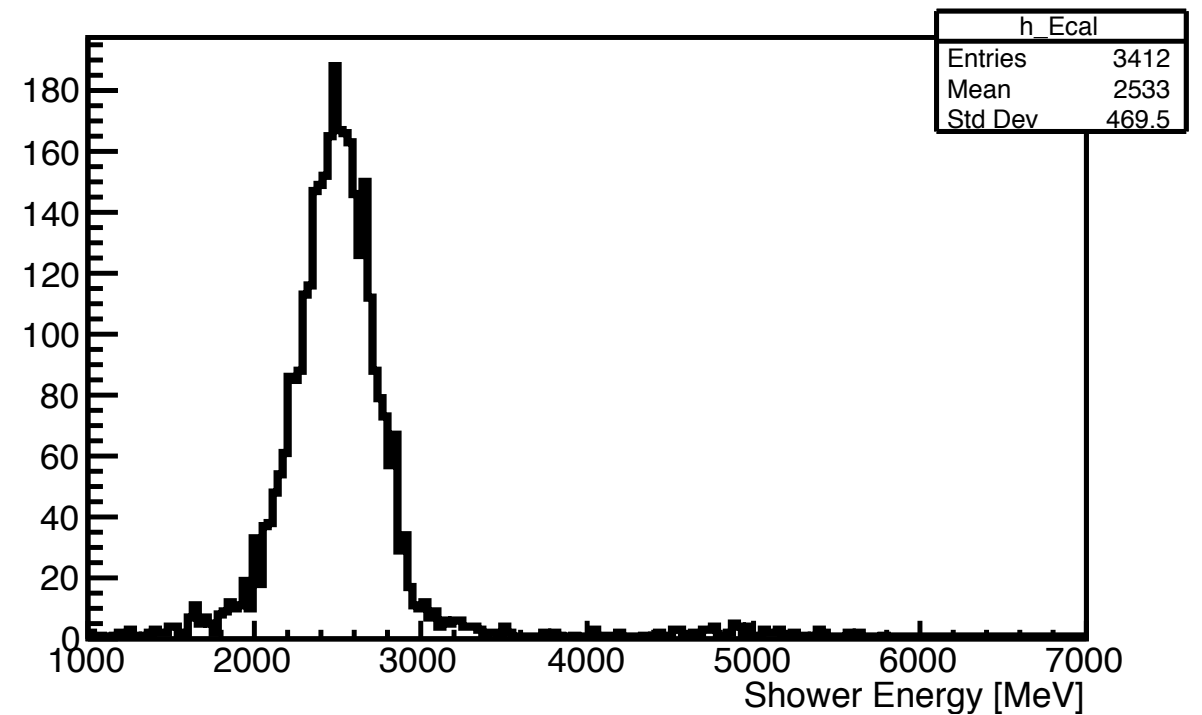
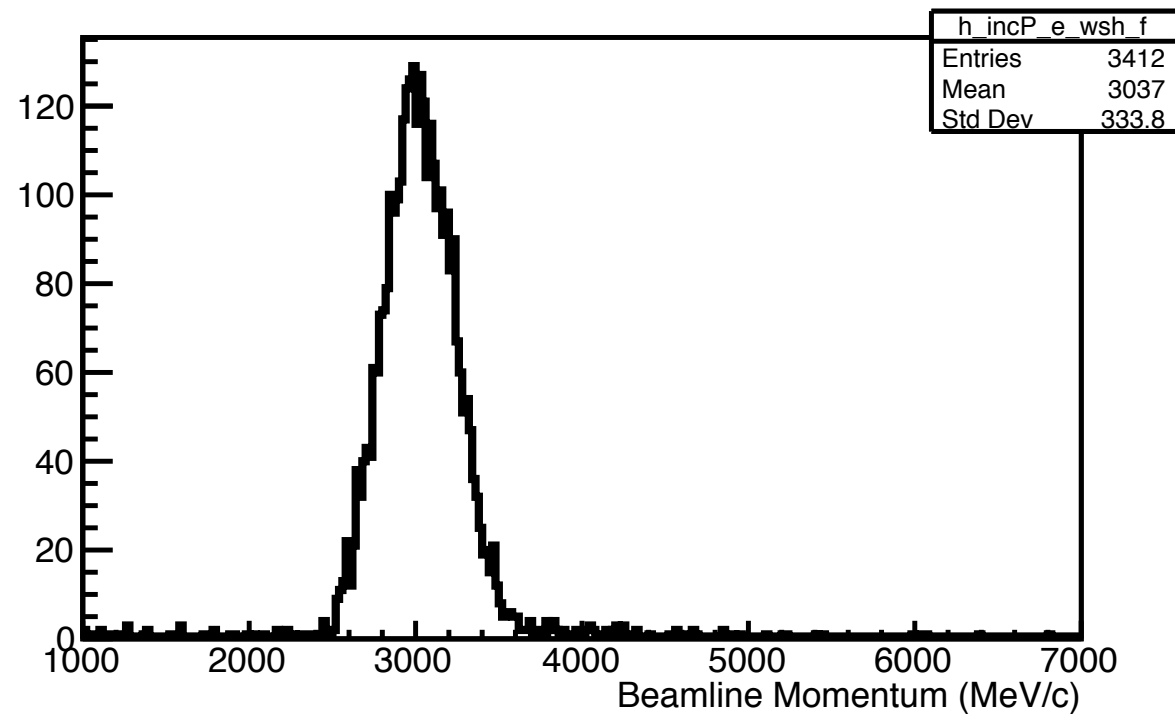
- Run 5824 (2.0 GeV/c)



Energy Reconstruction

Preliminary results

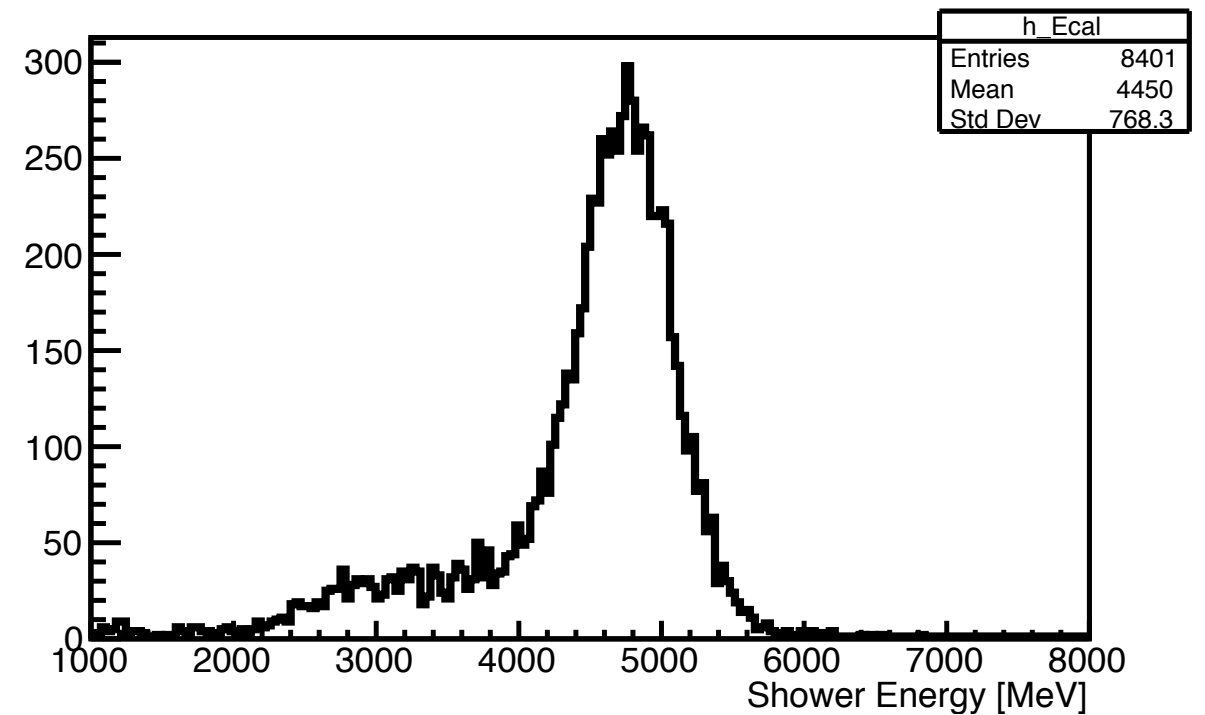
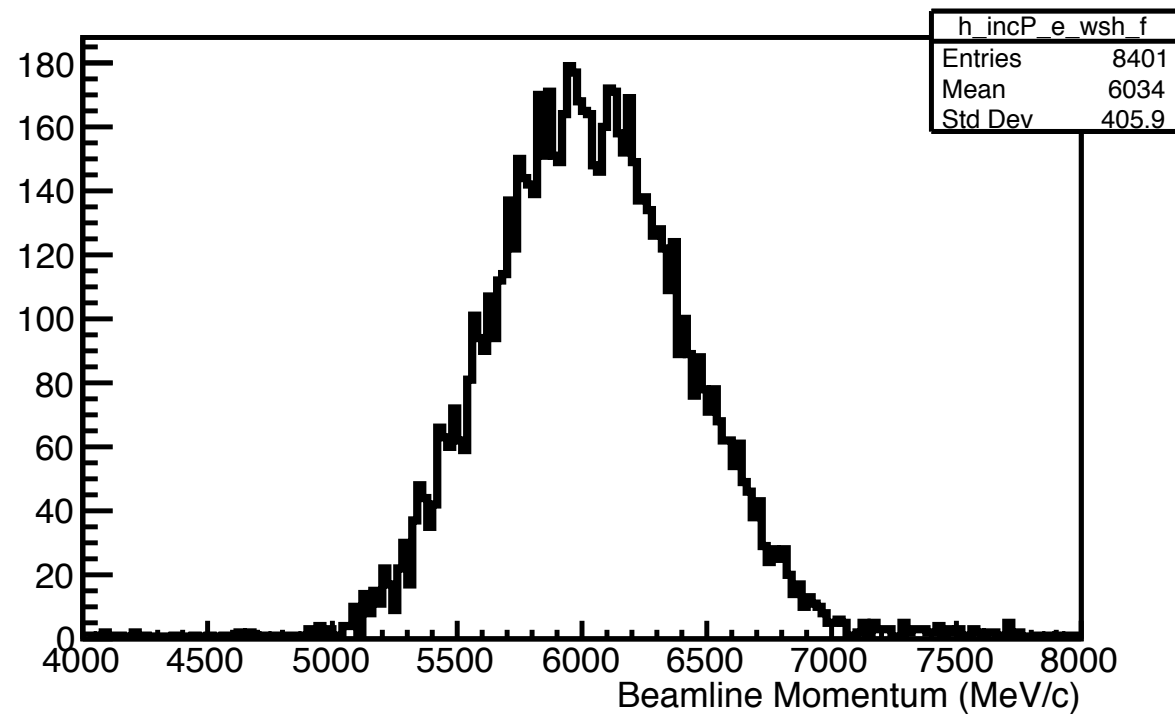
- Run 5777 (3.0 GeV/c)



Energy Reconstruction

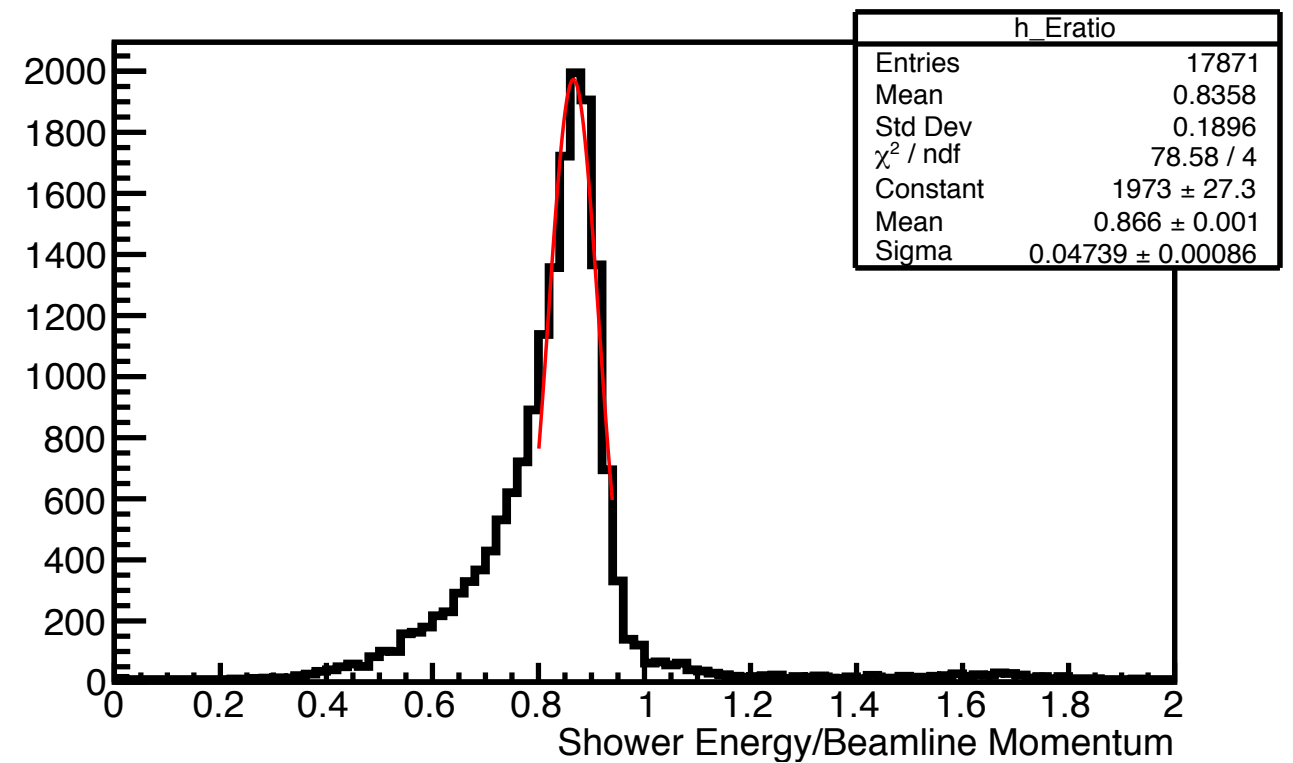
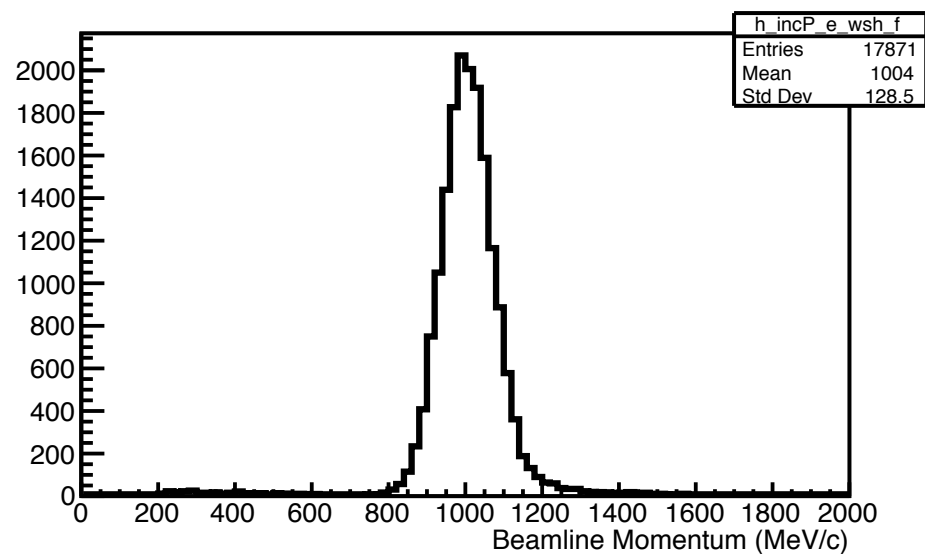
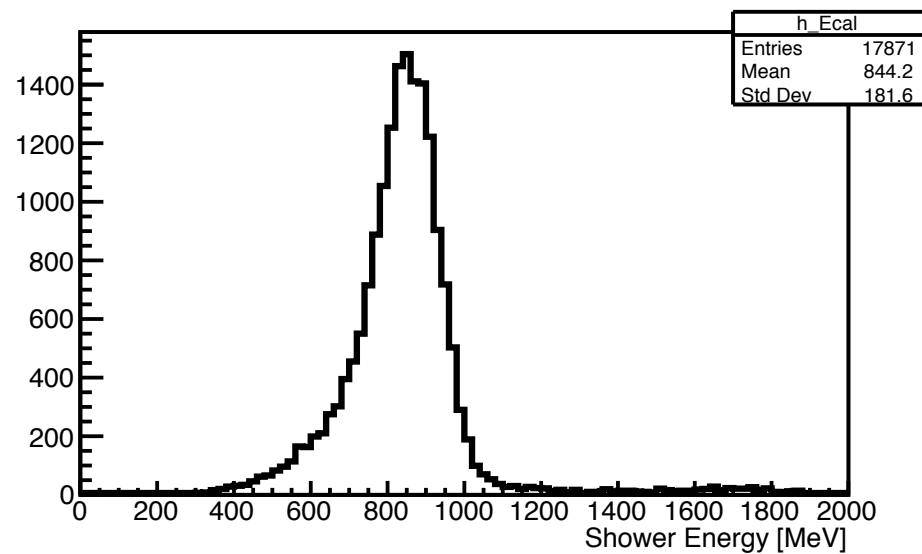
Preliminary results

- Run 5770 (6.0 GeV/c)



Energy Reconstruction

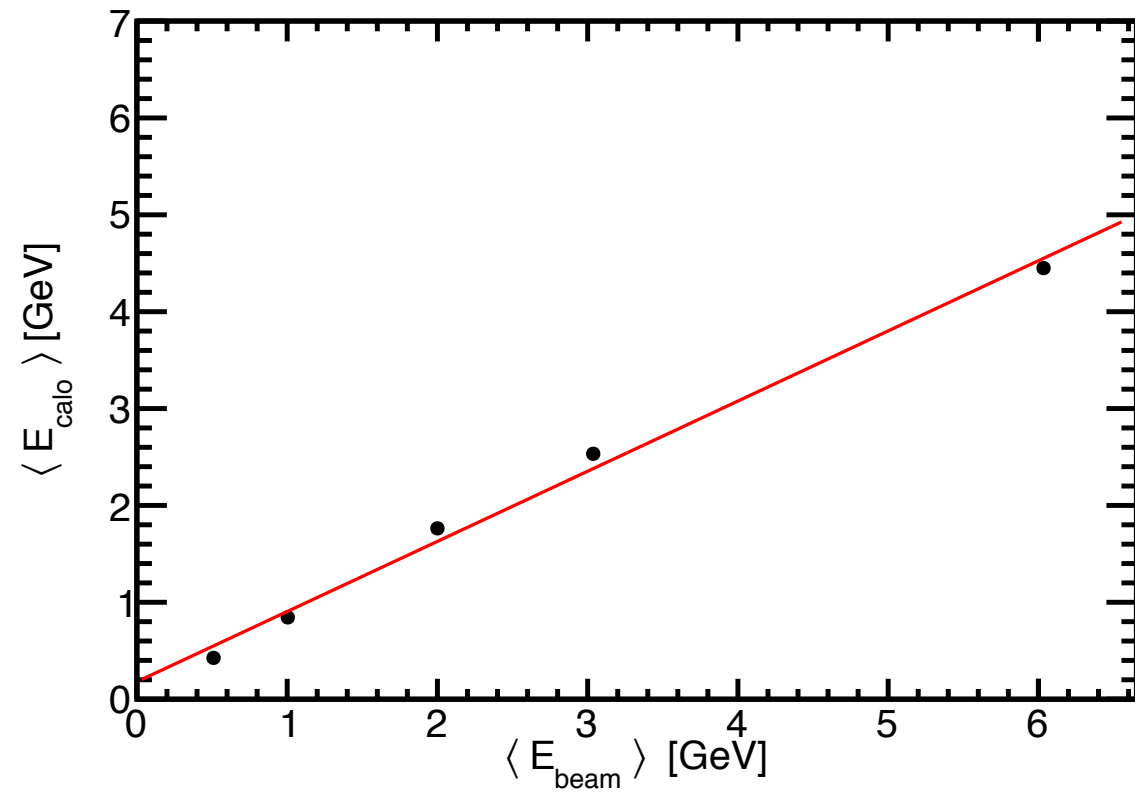
- How do we calculate the energy resolution?



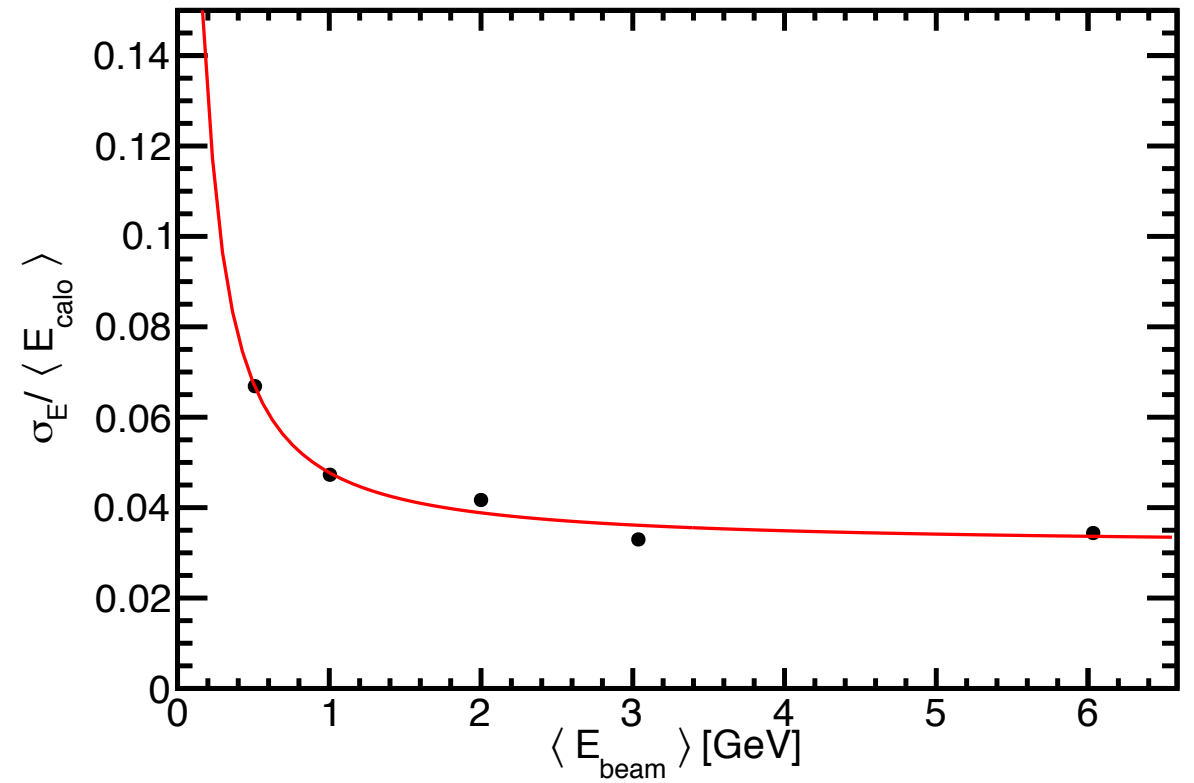
- Use sigma of the ratio

Energy Resolution

Preliminary results



$$\frac{\sigma_E}{E} = p_0 \oplus \frac{p_1}{\sqrt{E}} \oplus \frac{p_2}{E}$$



Summary

- Lot of progress in the EM task force
- Preliminary results on first physics deliverable (energy resolution) looks promising
- Things to do
 - Check true energy deposited vs shower energy (completeness)
 - Take into account upstream energy loss
 - Calibration for every single run and others factors (recombination factor)
- Suggestions are welcome

The End