Lines of hits in Hadron Calorimeter and the effect on Energy Resolution

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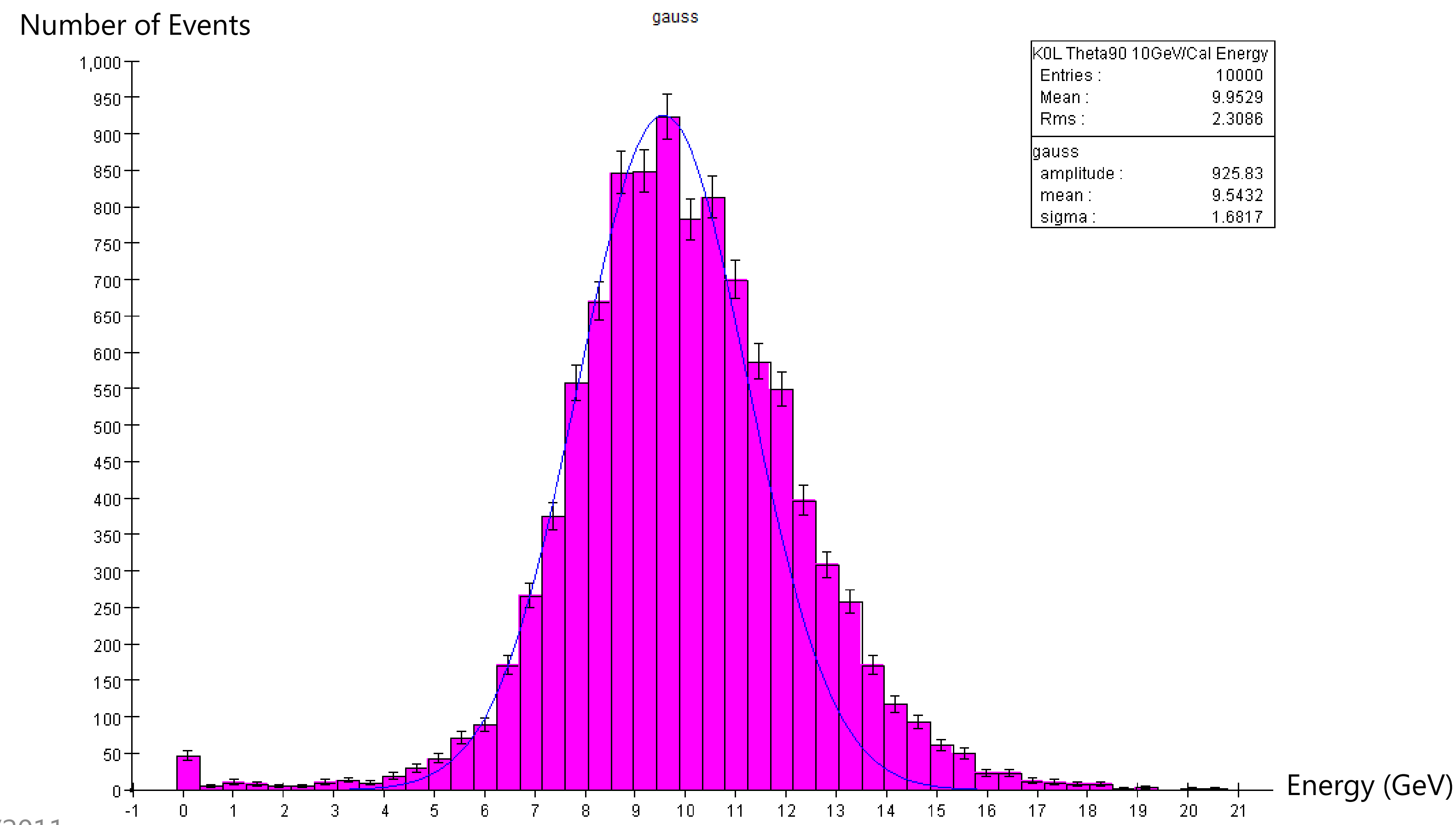
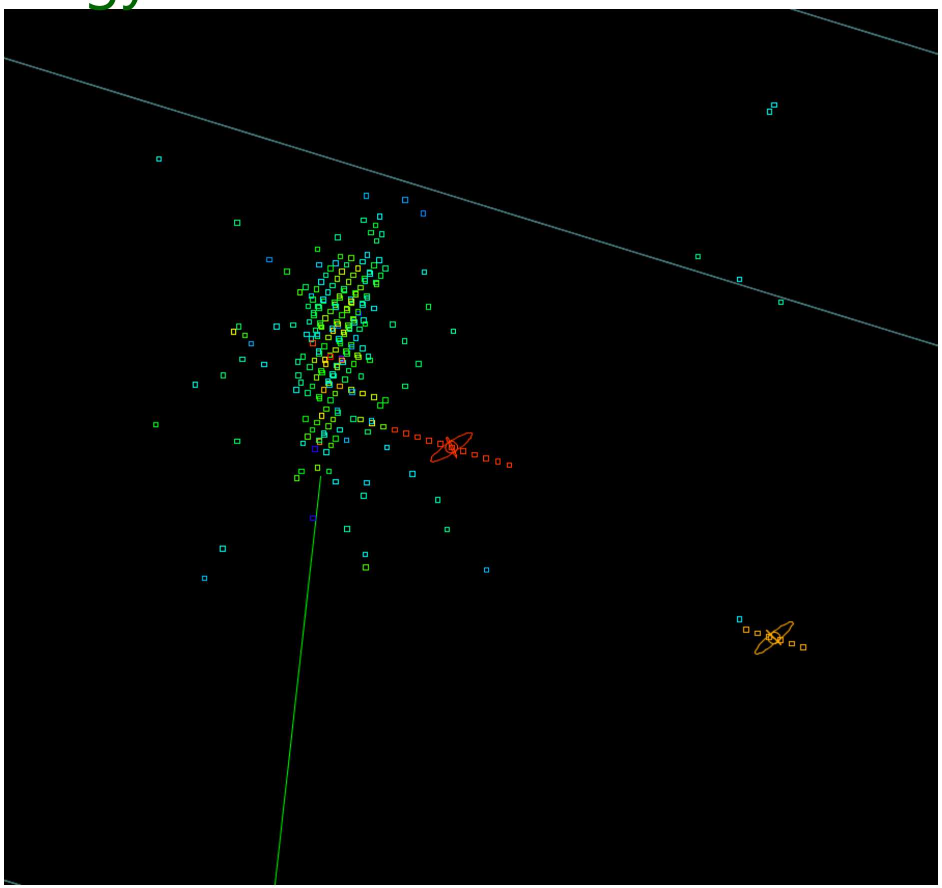
Introduction

- We have been studied the energy resolution of Hcal and found a non-symmetric shape distribution.
- All graphs in these slides are single K0L events



Hit Lines

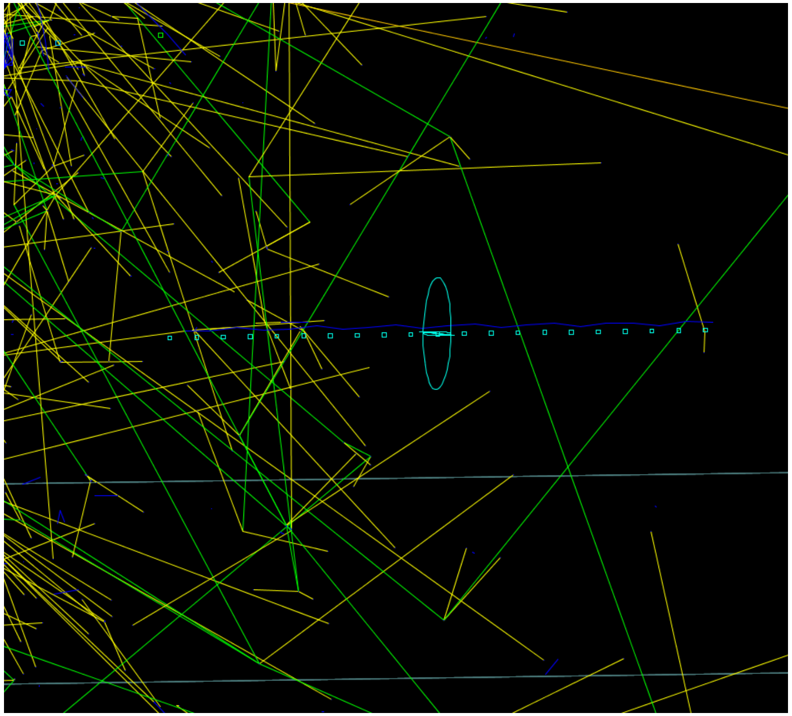
So we looked at the event display to see if we can identify the cause. One thing we noticed in events with overestimated energy are lines of hits.

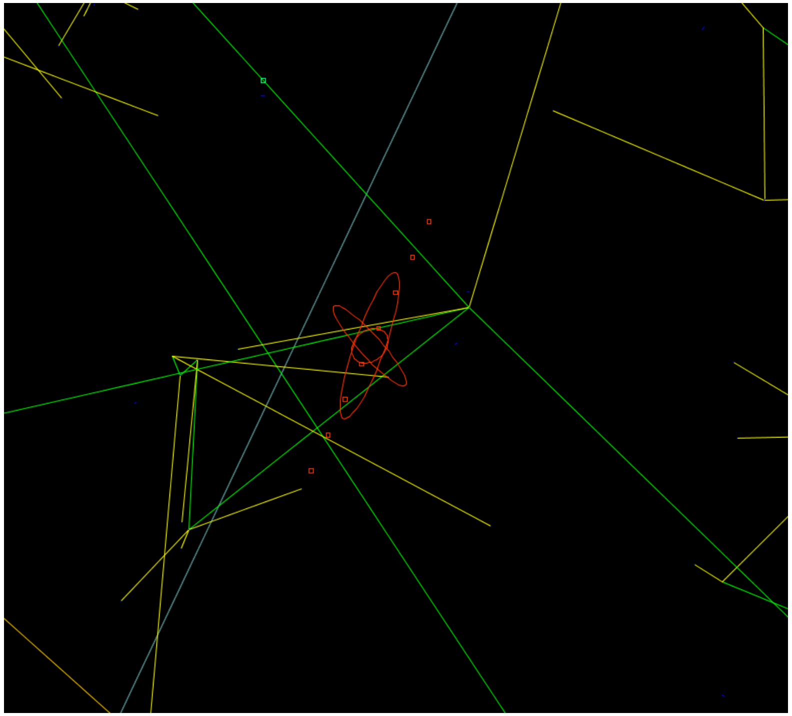


- This one is a single K0L, 50GeV, Theta90 event
- Lower energy events have this kind of structure as well
- As seen here, there are lines that seem to originate from the cluster and those that just appear out of nowhere

Detailed MC

- We suspect that these lines were caused by a particle which does not go through metal plate and simply drifts along the gas chamber.
- To verify this, Ron Cassell provided us a set of events with detailed MC interactions in calorimeter recorded
  - as opposed to normal event samples in which any MC particle created outside of tracking region will be discarded





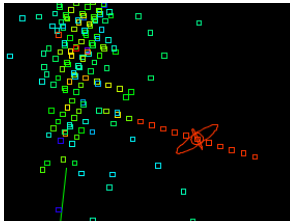
We saw both type of lines: those that we can and cannot identify the particle that causes them.

Blue: Charged Yellow: Photon Green: Neutral

Line Tagging Alg

To study this, we developed an algorithm to tag these lines.

1. Form a line for every hit in both grid directions within the same layer, then keep the longer one.
2. Get rid of duplicated/sub lines.
3. Check the criteria.
    1. The length is >= a given line length.
    2. The fraction of hits in the line that has no neighbor is >= a given isolation fraction. A hit with no neighbor in this case means it has no neighbor hit in any direction, including the immediate layer, except the hit in the lines itself.

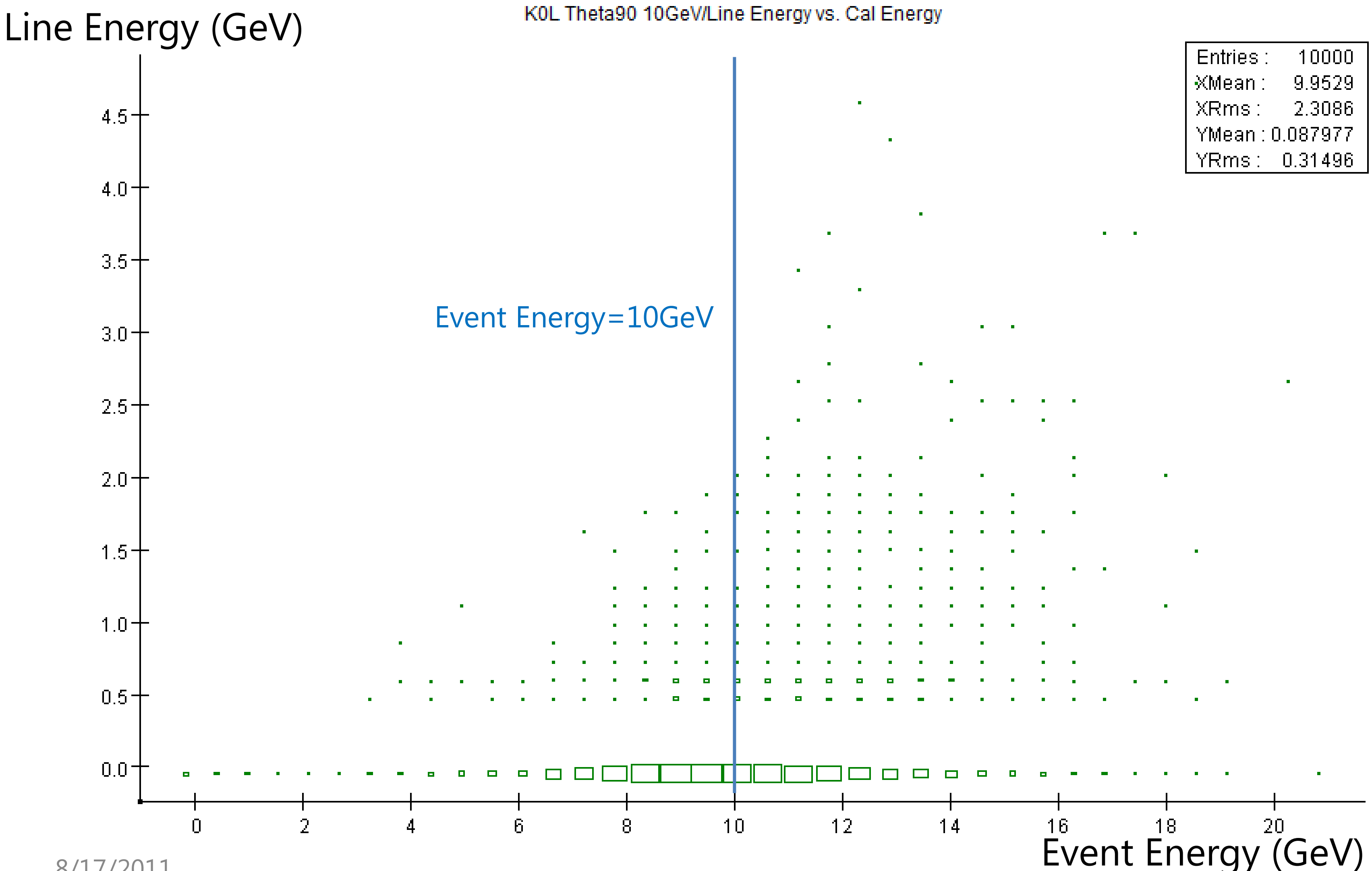


3. Lines that originated from a cluster may not be able to pass isolation check since a part of it is in the cluster. To tag them, the algorithm will break up every line that does not pass the isolation check into sublines with only isolated hits. If any of those sublines are long enough, it will be tagged.

The graphs shown after this are produced with line length>=5, isolation fraction>=0.8

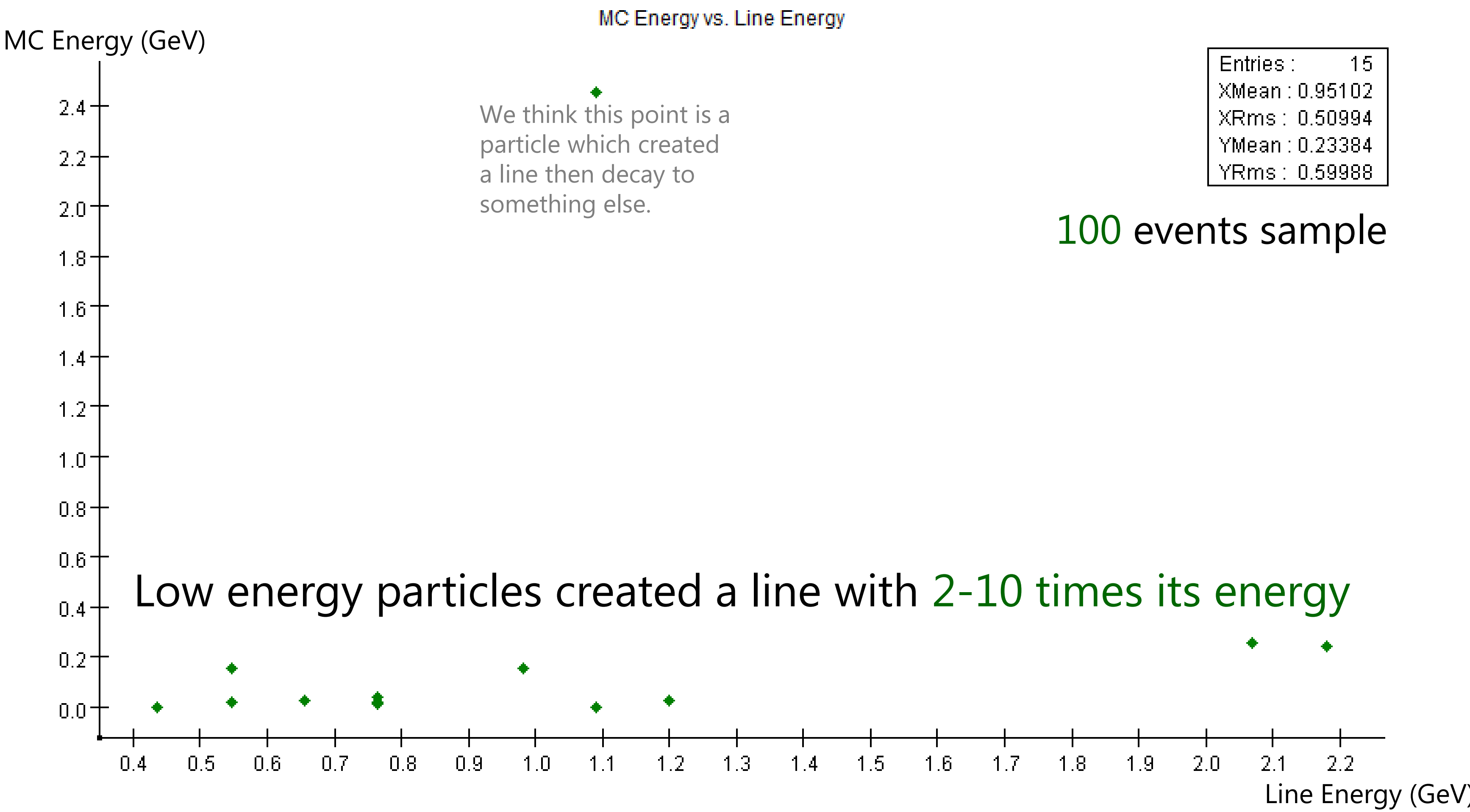
Lines Energy

Line vs. Cal Energy. K0L Theta90 10GeV.



MC Comparison

Using the samples with detailed MC particles interaction, we compare the line energy with that of MC particles that trigger them.



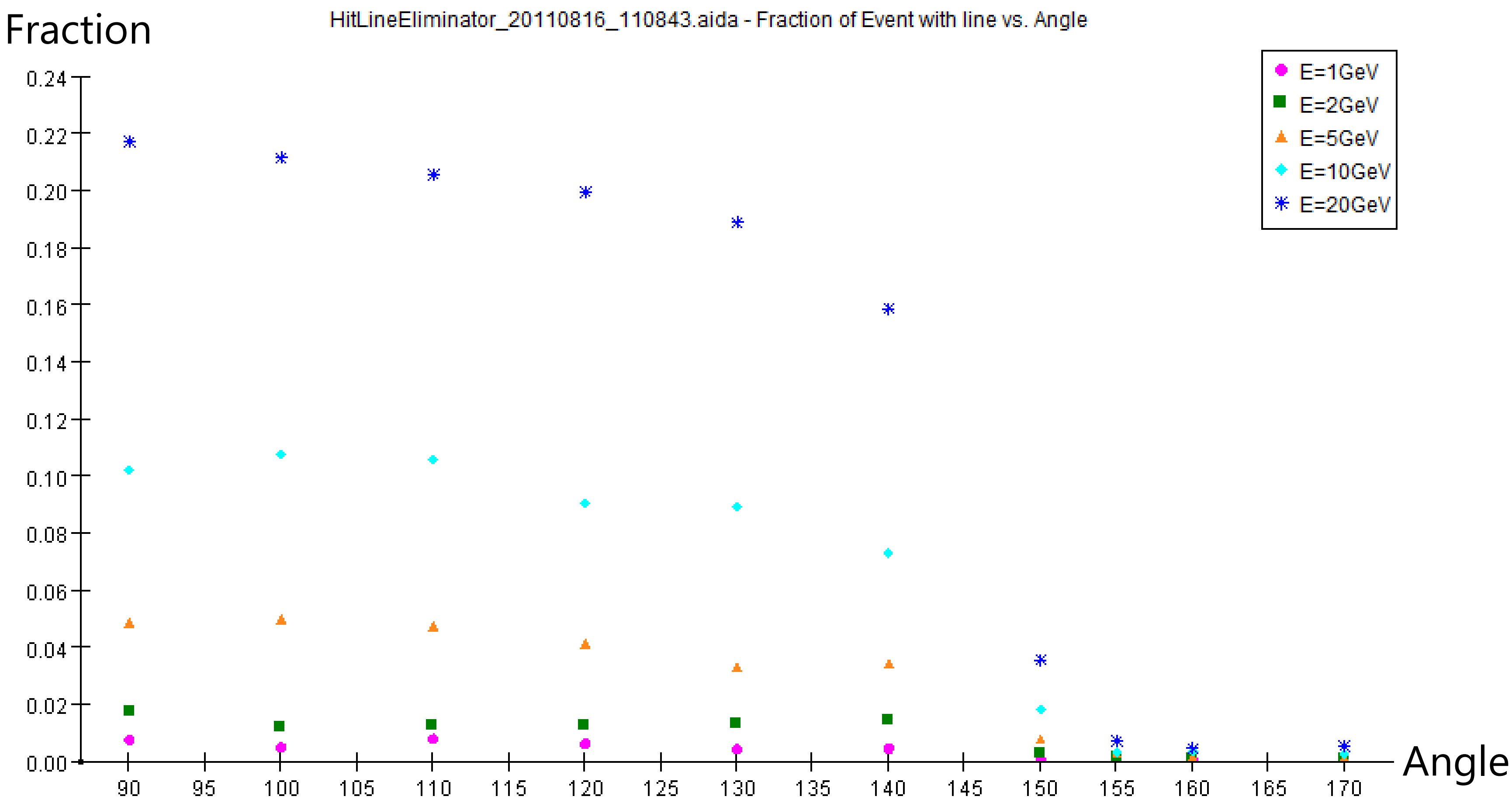
We think this point is a particle which created a line then decay to something else.

100 events sample

Low energy particles created a line with 2-10 times its energy

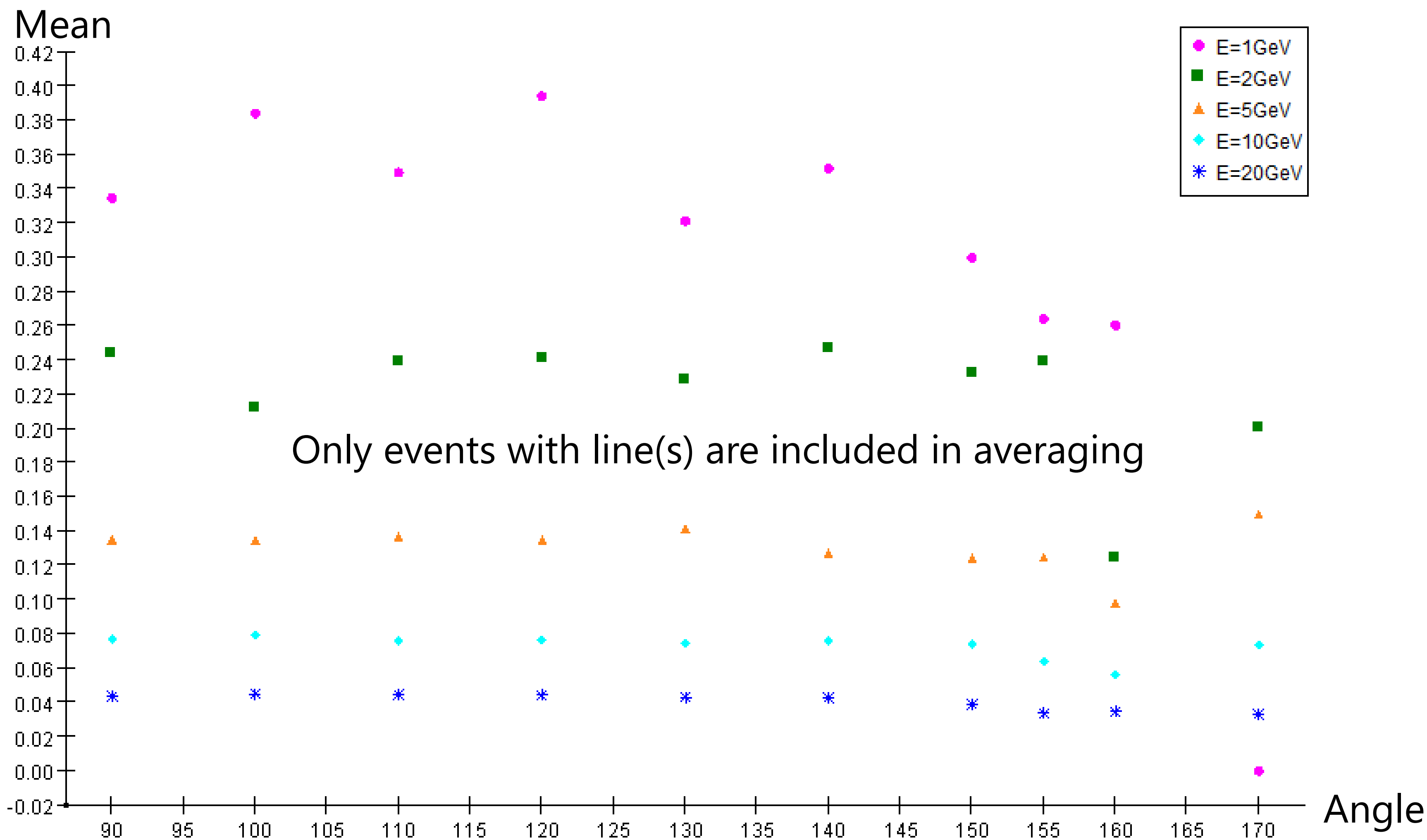
Angle Response

Fraction of events with line(s)



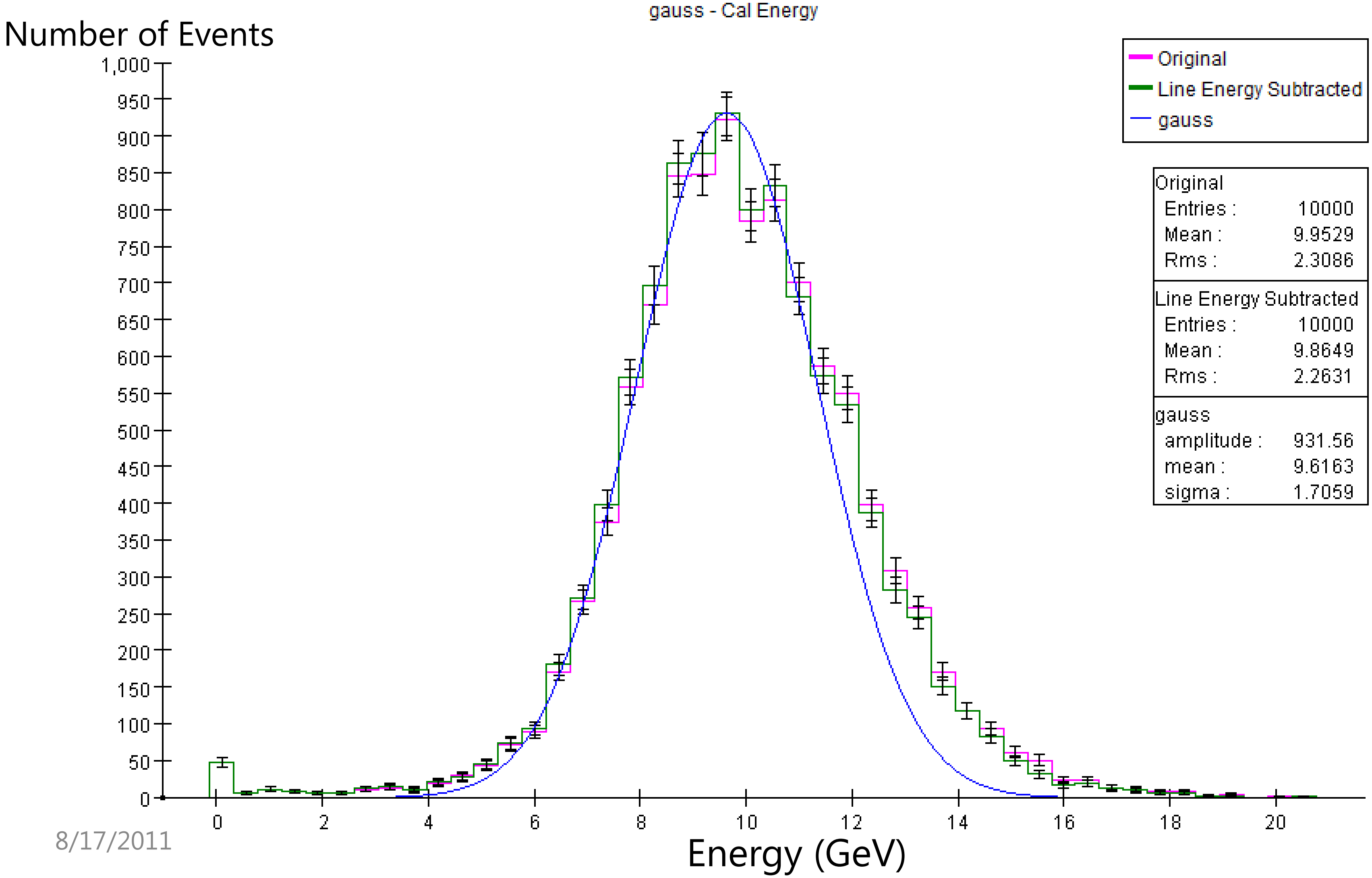
Angle Response

Average fraction of energy in lines (line energy/event energy)



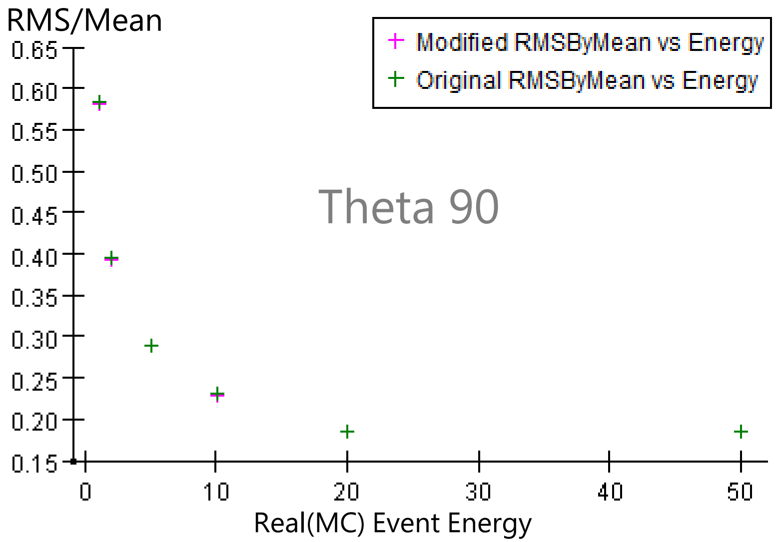
Resolution

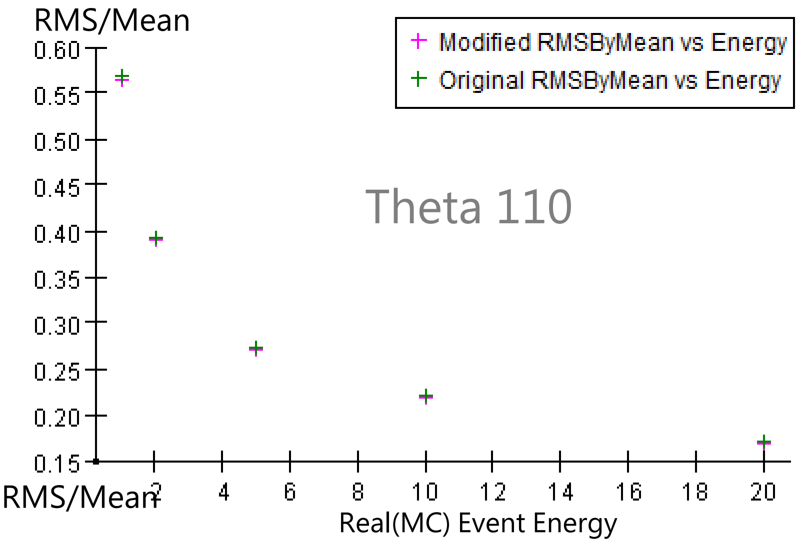
More symmetric, but very small improvement.

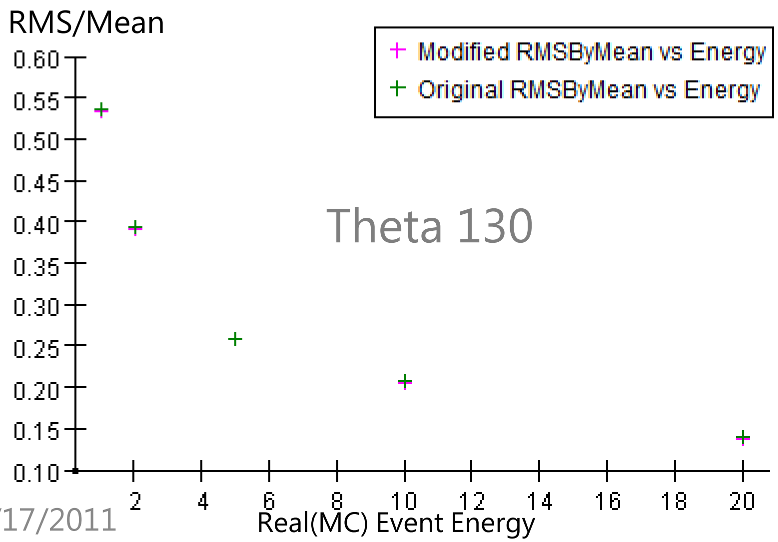


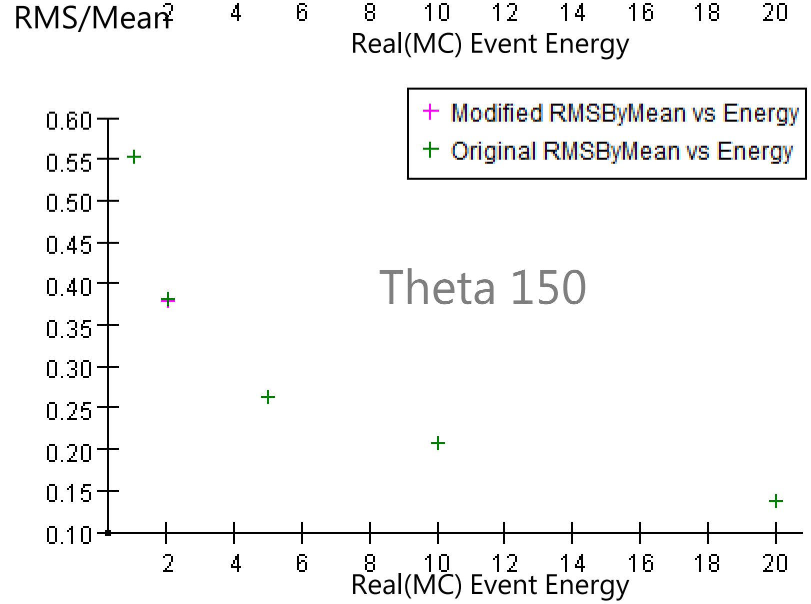
Energy Response

- Minimal improvement across the energy range.
- Almost no effect on Theta> ~150, at which we hit the Endcap









Conclusion

- We developed an algorithm to tag isolated lines of hits in Hcal.
- Comparing the line energy with MC particle energy seems to confirm that these lines overestimate the energy.
  - We only have a 100 event sample for this analysis.
- There are almost no lines when original particle angle > ~150
  - From this, and the fact that almost every longer line we found is oriented along the Z axis, we think that these particles are trapped in the magnetic field and drifts along the gas chamber
- The line energy in each event is significant. Varies from 4-40%.
- In the current implementation, the effect on energy resolution over a whole event sample set is minimal, but consistently an improvement.
- Future: Investigate the criteria parameter space to increase the efficiency of line identification.
  - The number of 3-hit-lines that passed isolation criteria is ~4x the size of 4 or 5 hit lines. That of 2-hit-lines is 40x