Master-2 internship: Analysis of data from the Time Projection Chambers of the T2K Near Detector

Le Hoang Minh

Master-2 Student
Pierre and Marie Curie University, Paris, France

lhminh167@gmail.com

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Summary of the previous report

• Last time, we raised suspicion that the change in Geant4 version might be the reason for the difference in TPC resolution of Production 7A MC and Production 6L MC.
• To confirm this suspicion, I ran the muon gun in Argon using two dierent GEANT4 versions, v4.9 and v4.10, then looked for the difference in energy loss distribution.

Raw energy loss distribution by Geant4.9.6.p04

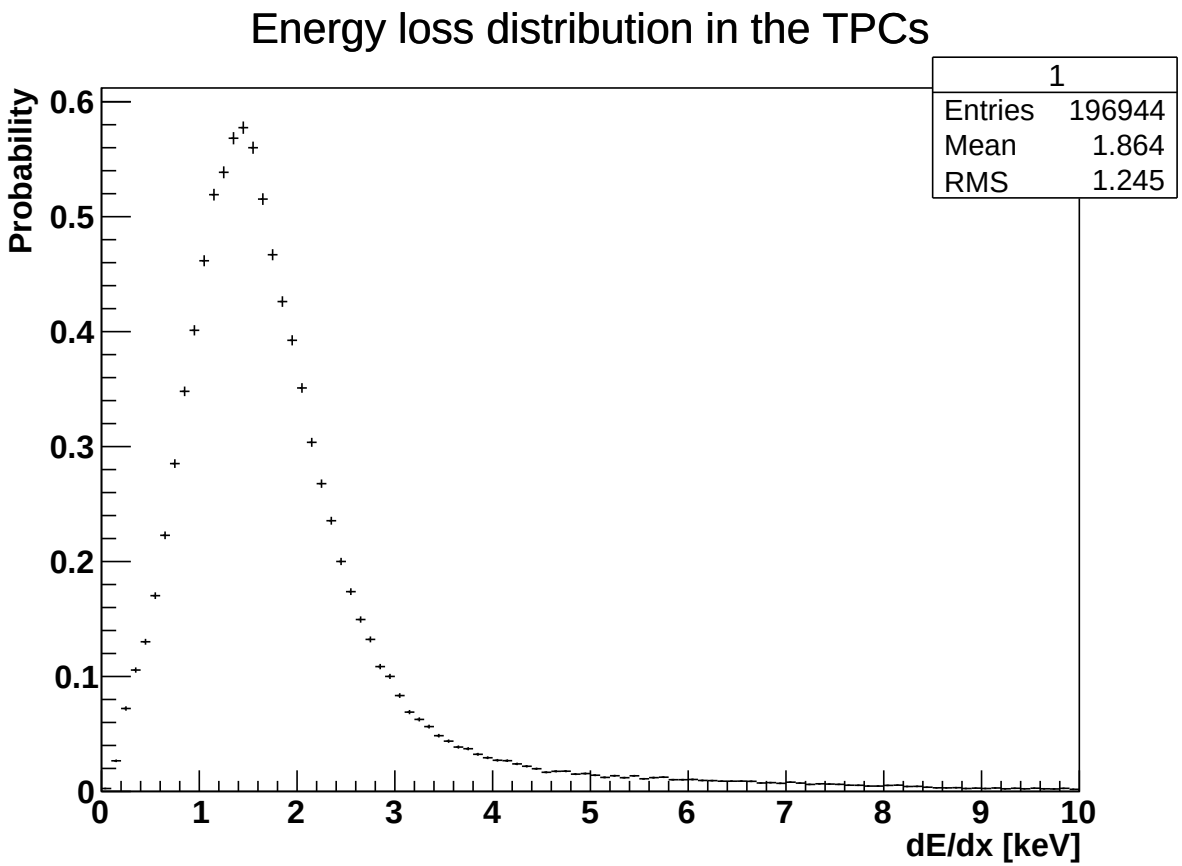


Figure: The energy loss distribution of particle-gun muons in 1 cm of argon gas produced by Geant4.9.6.p04 using emstandard_opt1 physics.

Raw energy loss distribution by Geant4.10.01.p03

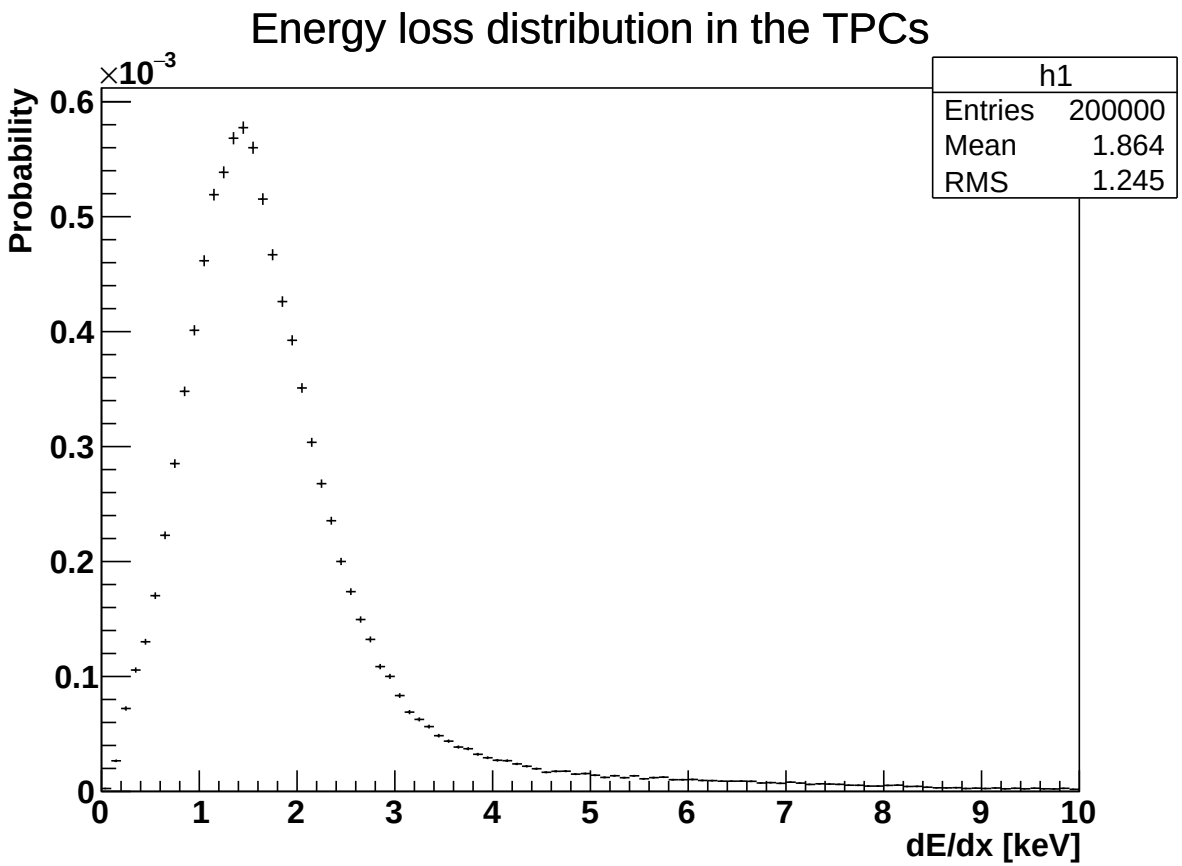


Figure: The energy loss distribution of particle-gun muons in 1 cm of argon gas produced by Geant4.10.01.p03 using emstandard_opt1 physics.

Truncated mean method

• 72 points c_i are extracted randomly from the raw energy loss distribution by the command h→GetRandom() and sorted into energy ascending order.
• Then, only, for example, 70% of the sorted list is kept, so that we can get the truncated mean C_T:

$$C_T = \frac{1}{72 * 0.7} \sum_{i}^{int(0.7*72)} c_i .$$

• This extraction is repeated 100000 times to get a nice Gaussian shape, then we fit this Gaussian to find out the resolution.

Truncated energy loss distribution

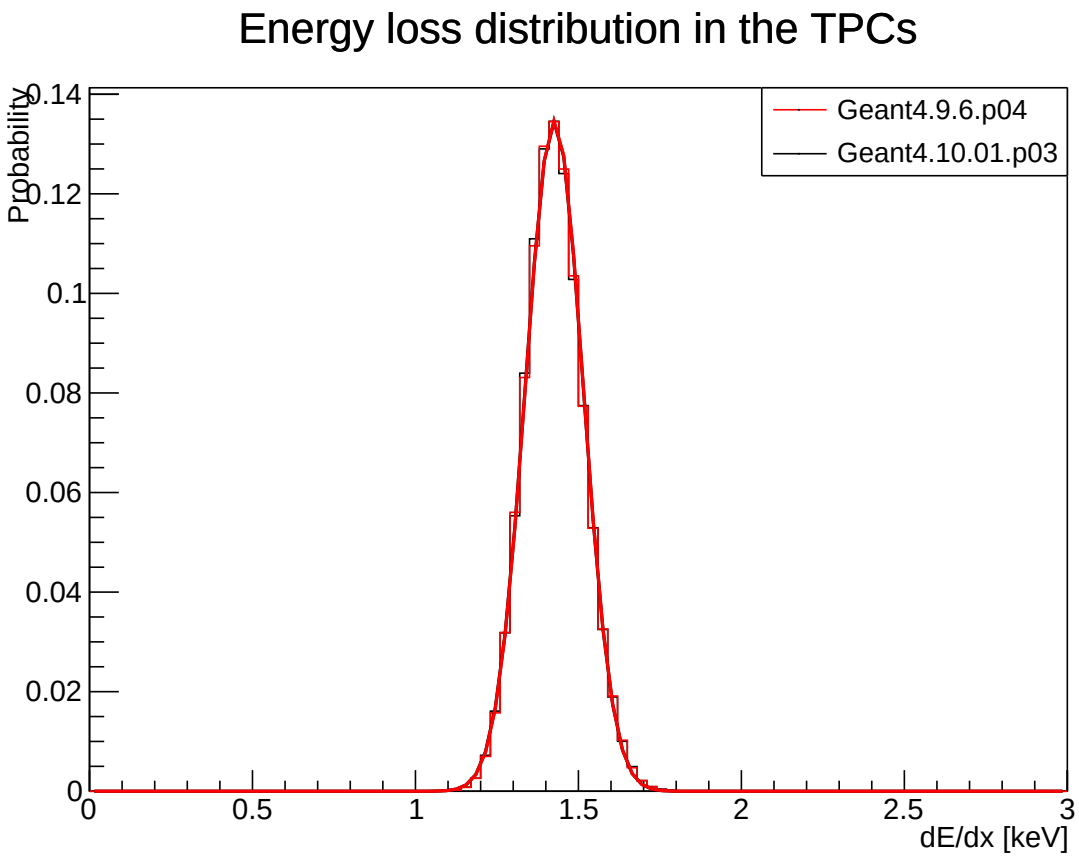


Figure: The truncated energy loss distribution of particle-gun muons in 1 cm of argon gas produced by Geant4.9.6.p04 and Geant4.10.01.p03 using a truncation factor of 80% and emstandard_opt1 physics.

A comparison of two GEANT4 versions

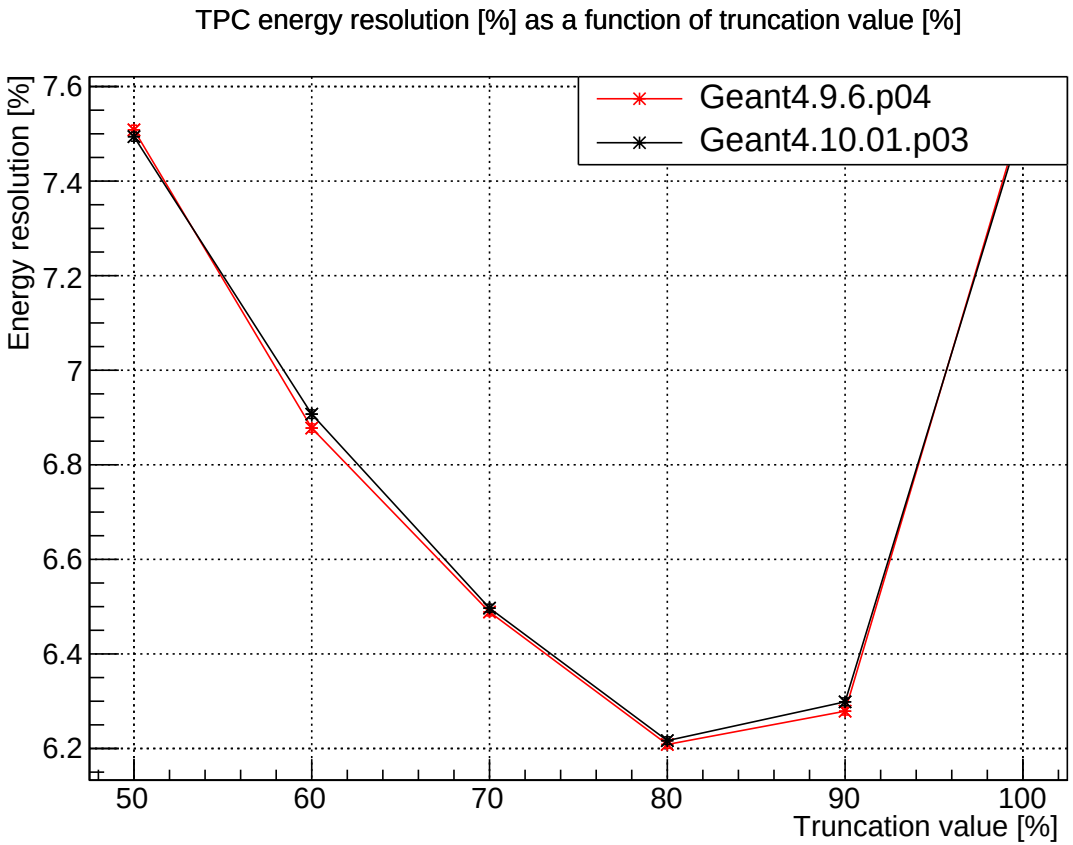
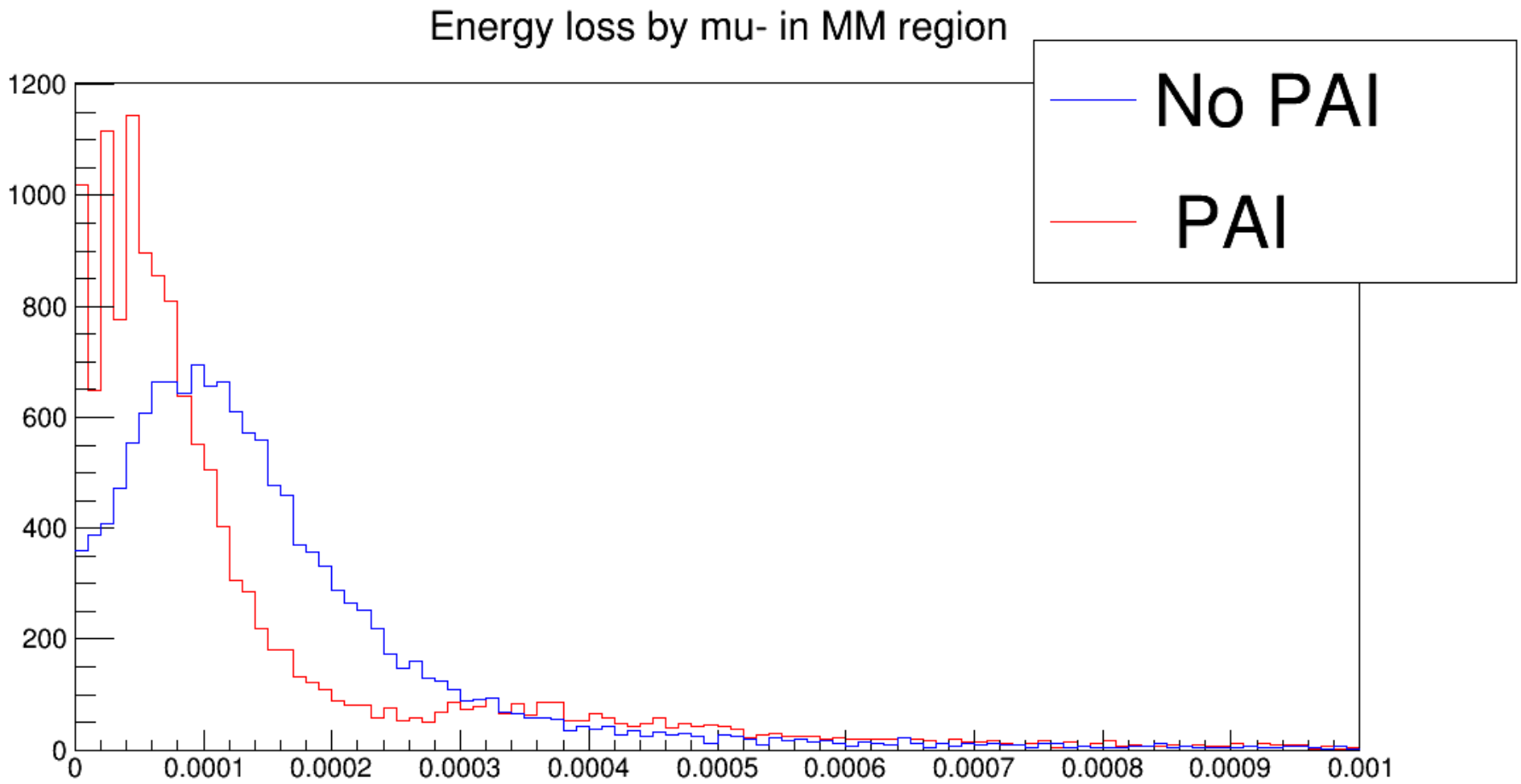
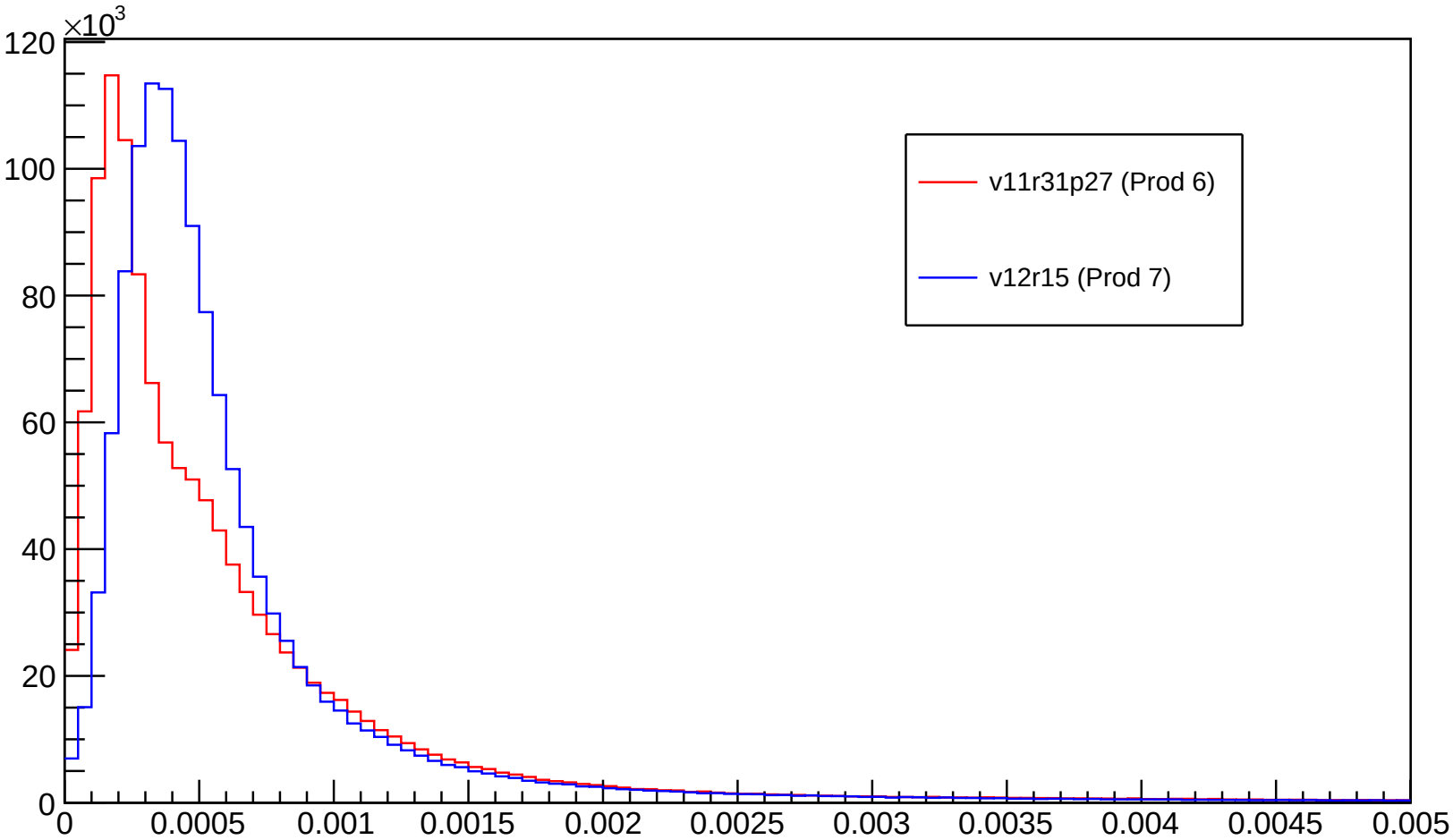


Figure: The energy resolution as a function of truncation factor of particle-gun muons in 1 cm of argon gas produced by Geant4.9.6.p04 and Geant4.10.01.p03 using emstandard_opt1 physics.

Conclusion

• Particle-gun muons produced by Geant4.9.6.p04 and Geant4.10.01.p03 have the same resolution. A colleague of my supervisor also arrived at the same result.
• Furthermore, he found out that the Photoabsorption Ionization Model (PAI) physics was enabled for the TPC "driftRegion" in Prod6 MC, but was turned off in Prod7 MC because it dramatically increased the time and memory required to run the MC.
• This changes the shape of the energy deposited by muons (and I assume all other charged particles) in the TPC. This looks similar to the effect seen in Geant segments in the TPC in the output from nd280mc.
• To confirm this relation, a ROOT file of muon gun produced by Prod7, new Geant4, new gas, and importantly, with PAI model ON, will be given to me by the next week to do the analysis.


Energy loss by mu- in MM region
No PAI
PAI
1200
1000
800
600
400
200
0
0
0.0001
0.0002
0.0003
0.0004
0.0005
0.0006
0.0007
0.0008
0.0009
0.001


Geant Hit Charges in TPC for mu-
×10^3
120
100
80
60
40
20
0
0
0.0005
0.001
0.0015
0.002
0.0025
0.003
0.0035
0.004
0.0045
0.005
v11r31p27 (Prod 6)
v12r15 (Prod 7)

Conclusion

- The optimal truncation factor, which gives the best resolution, is shifted from 70% to 80%.
- To confirm this fact, I will redo the task but with Prod6B data to see if this also happens to the data or not.

The End