Low Energy Hits in nHCal

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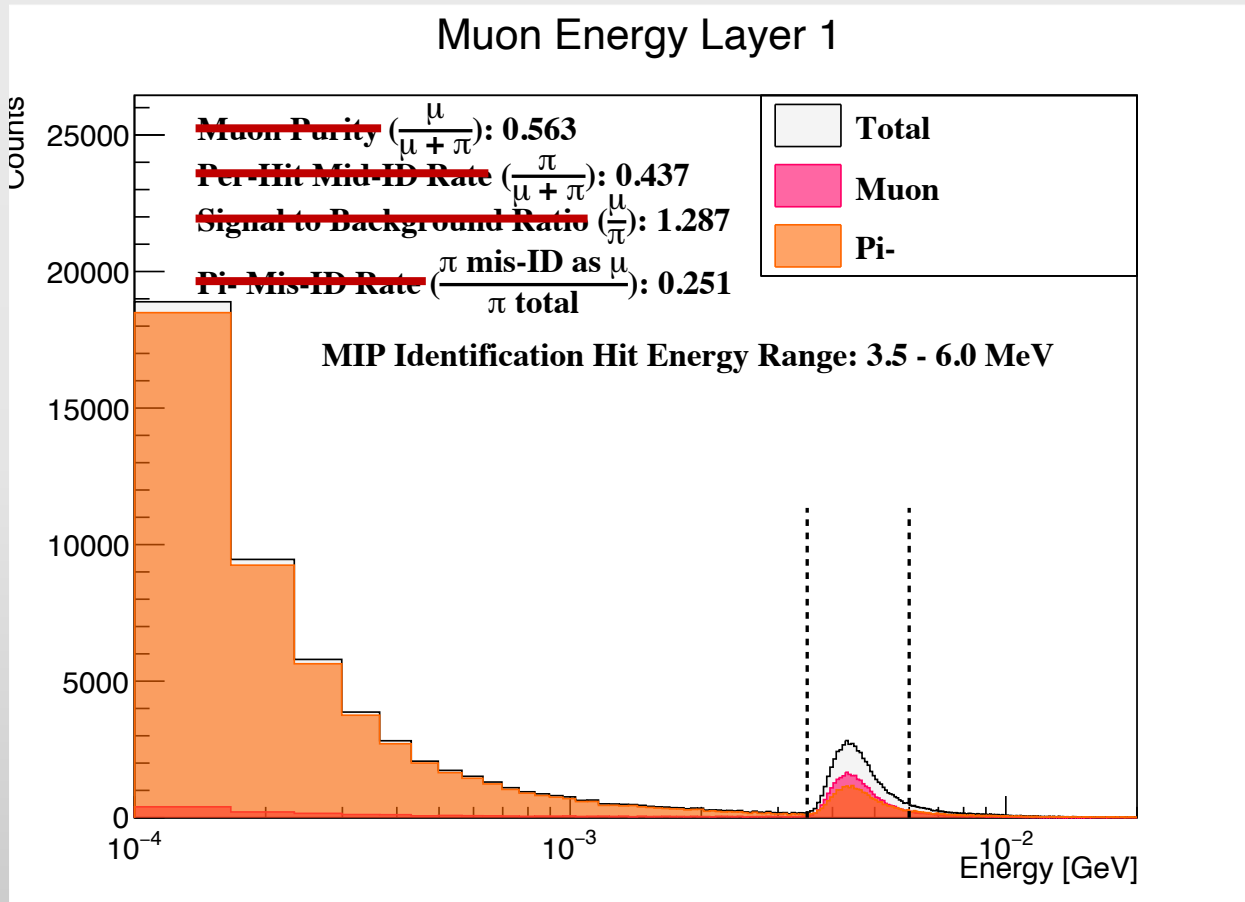
- Last week, we noted that there are hits with energy smaller than the MIP peak energy in nHCal.

- These appear with particle guns of hadrons much more than leptons.

- What is going on?

11/3/25

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What does npsim give us?

```
npsim --compactFile ../epic/install/share/epic/epic_nhcal_opt_10_layers_4p0cm_abs_2p4cm_sci.xml \
    -N 10 \
    --enableGun \
    --gun.particle=pi- \
    --gun.energy 1*GeV \
    --gun.thetaMin 145*deg \
    --gun.thetaMax 145.5*deg \
    --gun.distribution uniform \
    --part.enableDetailedHitsAndParticleInfo \
    --part.keepAllParticles=true \
    --part.minimalKineticEnergy=1*MeV \
    --outputFile 1gev_pimin_keepallparticles.root
```
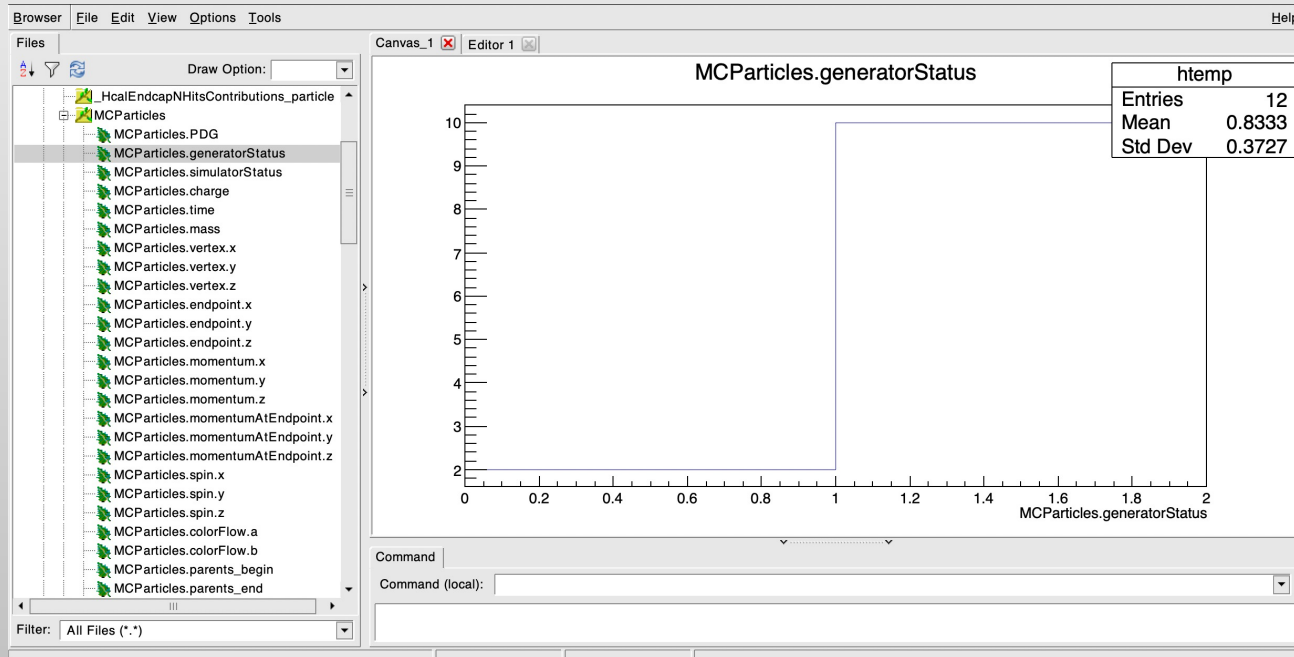
- See this npsim command with options for additional output

- Even with this, it doesn't give detailed info on secondaries.

- Npsim only writes secondary to a file in some specific scenario (about 700 secondaries/50000 gun particles)

- **BUT:** enableDetailedHitsAndParticleInfo option gives us much more detailed output

- First example: gun pi- acts like a MIP, deposits a few MeV, while protons deposit much less energy

- Other examples: small energy deposits from mostly protons, some electrons.

- Electrons/protons knocked off from atoms in scintillator?

Tell me to zoom in if I forget!

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Summary

- The low energy hits are mostly from low energy protons (dissociated from nuclei?)
- Still, shouldn't low energy charged particles deposit more energy than a MIP?
- Well: dE/dx is higher at an energy lower than the MIP energy
  - But, very low energy particles->very short range before stopping ->small total energy deposited.
  - Need to find a way (in npsim or otherwise) to check average KE or p of these protons.

Additional notes on npsim file output

- It does not (as far as I can tell) save detailed shower information.
- Instead, all hit contributions in a hit are attributed to the MCParticle (usually gun particle).
- Sometimes, a secondary is added to the MCParticle list.
  - I suspect this only happens when the parent particle is stopped and there is a particularly high energy secondary still traversing the detector
- In 50000 events, there are none where different particles (by MC index) give hits in the same layer.
- Most commonly, a handful of active tiles (=number of hits) per layer. Typically, the leading energy hit carries a large fraction of the total energy in that layer.