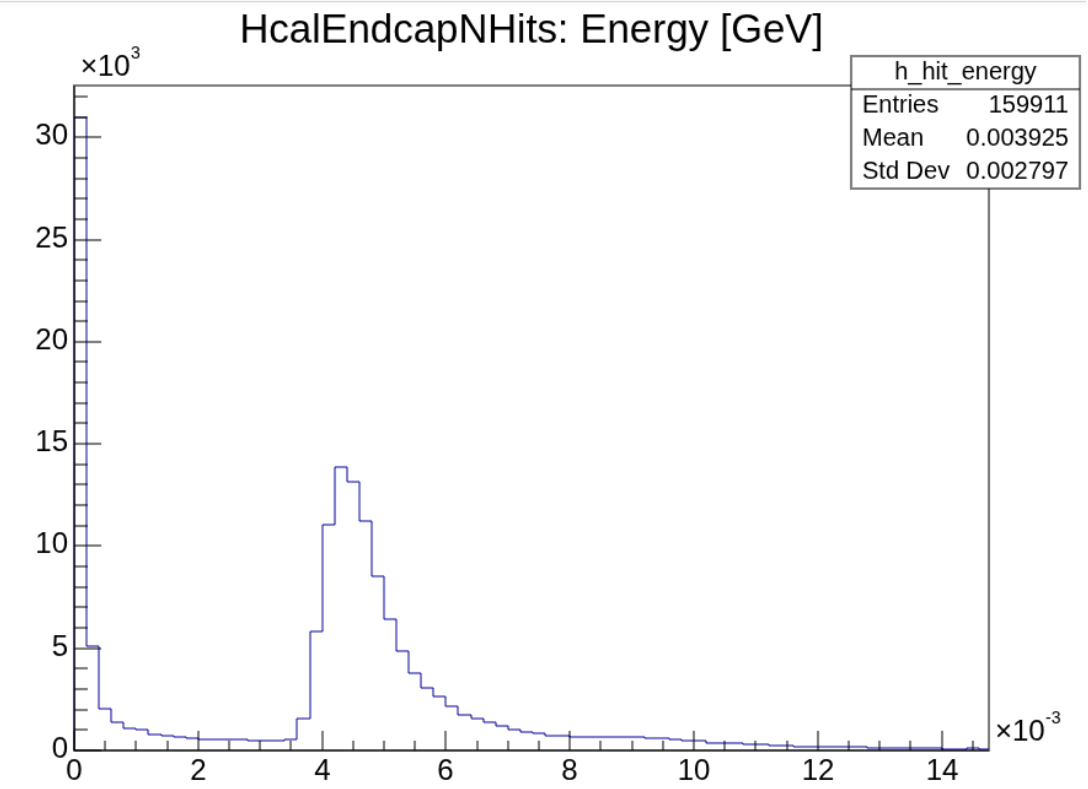
NHcal Background Analysis

Riley Reedy

Setup

- July campaign: FULL NC DIS 10x275 $Q^2 > 1$
- **Dataset**: epic:/FULL/26.07.1/epic_craterlake/Bkg_Exact1S_2us/GoldCt/10um/DIS/NC/10x275/minQ2=1
- **File**: pythia8NCDIS_10x275_minQ2=1_beamEffects_xAngle=-0.025_hiDiv_1.*******.edm4hep.root
- 1485 events (# 2us frames created)

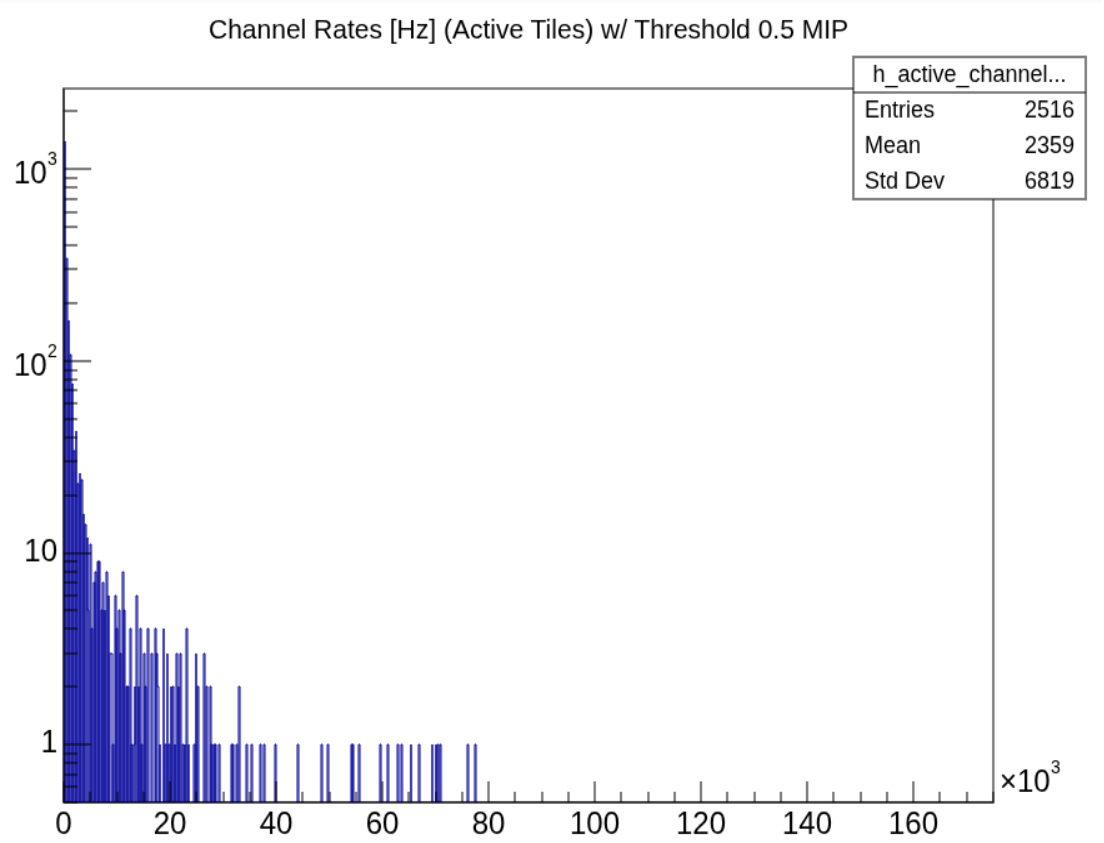
MIP Threshold



- npsim muon gun
- Craterlake Geometry
- 10 GeV energy (momentum)
- 10K events
- Truth level hit energy plotted

- 1 MIP = 4 Mev

Channel Rates at 0.5 MIP = (2 MeV)

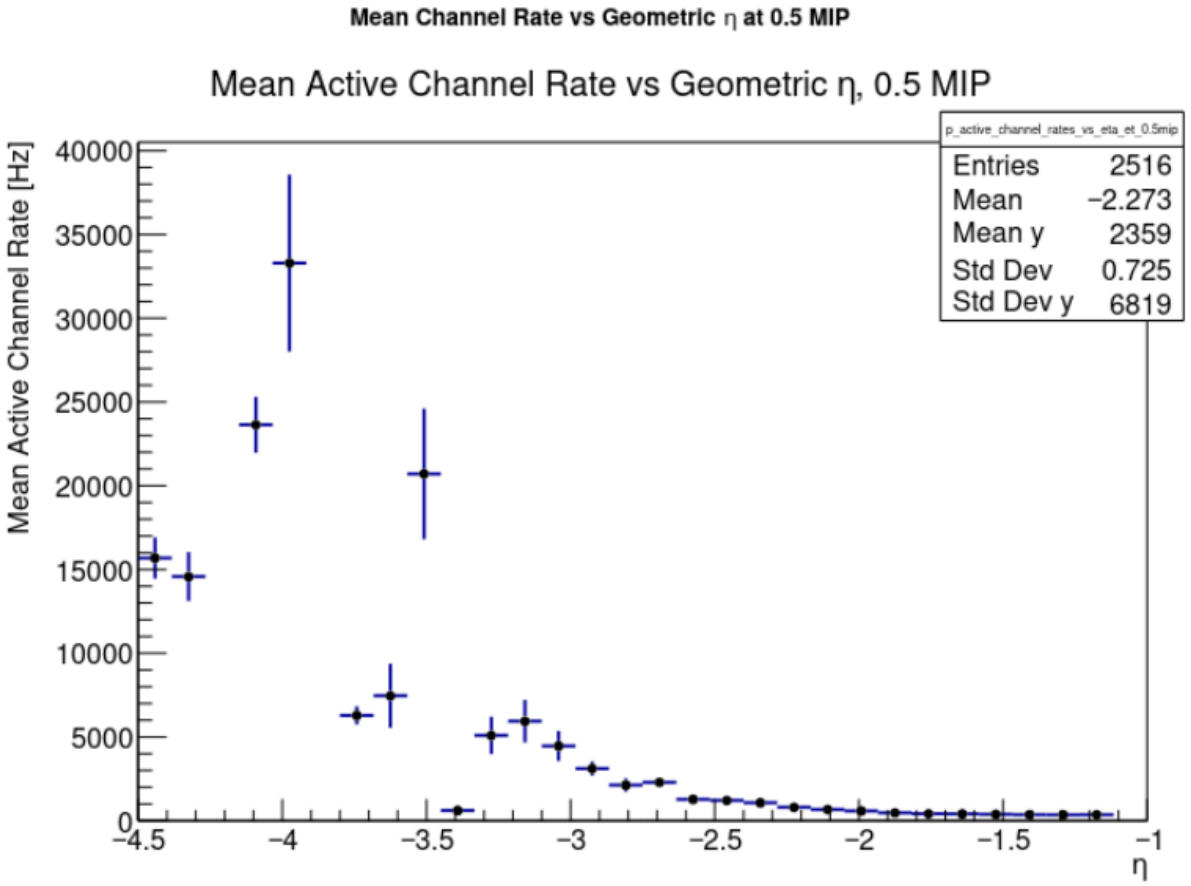


- 2516 Active Channels (rate > 0)
- 99th percentile = 33 kHz
- 95th percentile = 12 kHz
- Mean 2.4 kHz

- Compare to LFHCal :
- 99th = 3.1 kHz, 95th = 1.08 kHz

Rate vs Eta

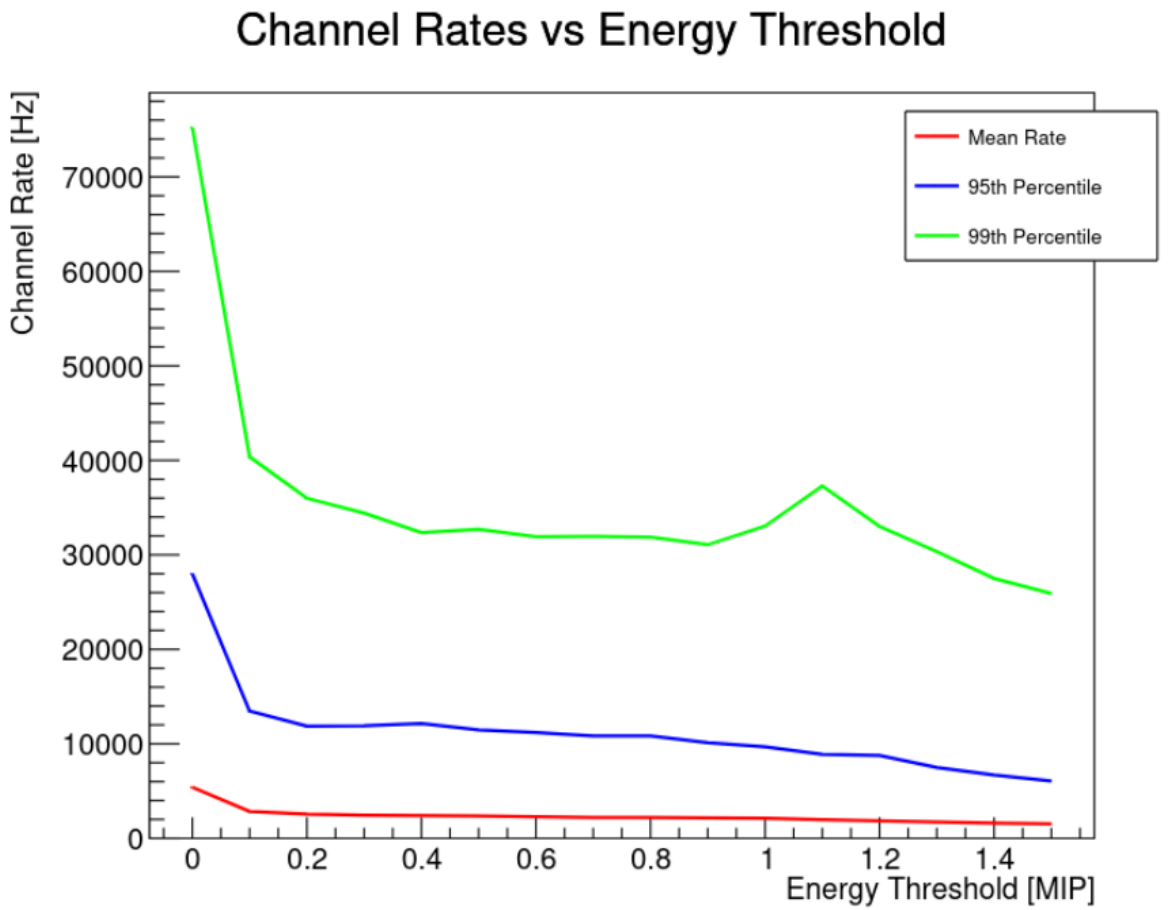
- Rates peak at more negative eta (closer to the beamline)
- This matches the lfhcal's behavior
- ~ -3.4 uncharacteristically low for every MIP cutoff plot



Rates vs MIP threshold

- More statistics on next round
- Current resolution

  $\Delta R = 1/(1485 * 2us) = 336$ Hz



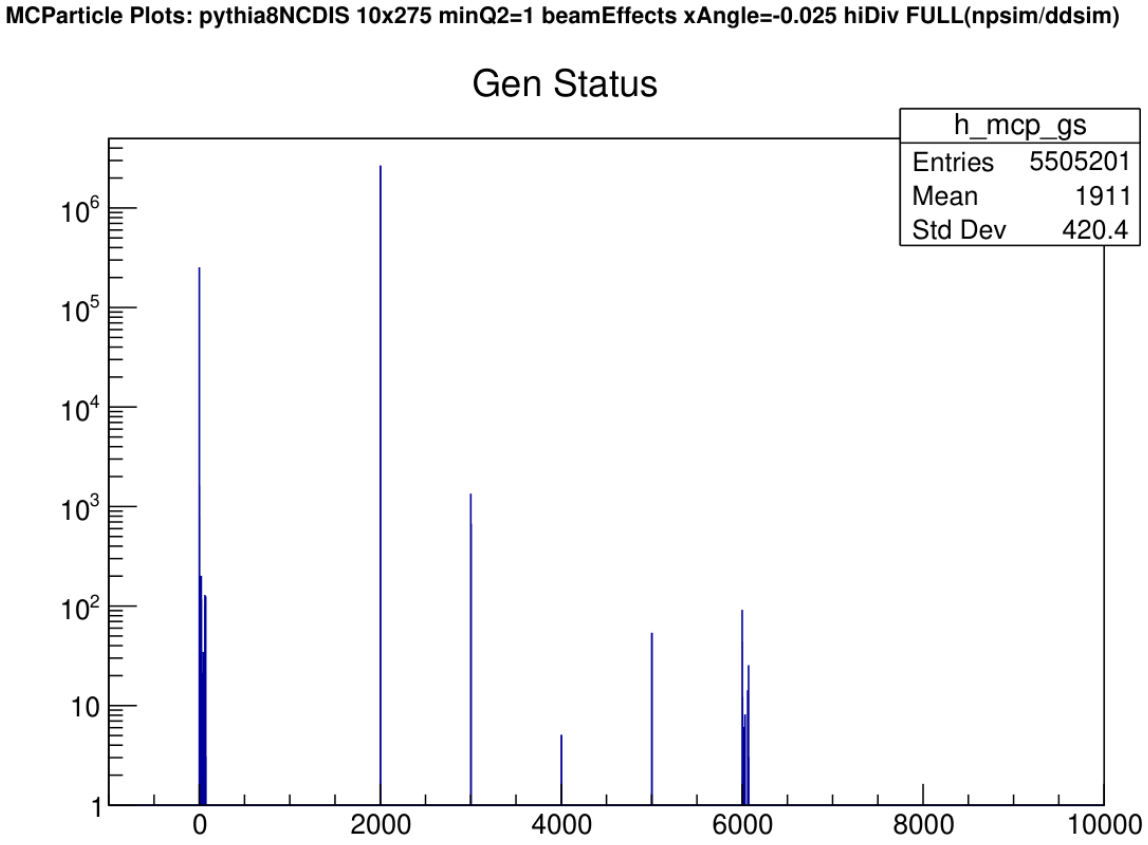
Thoughts

- Finding issue with eta=–3.4
- Summing the layers to mimic true nhcal channels
- Comparing the eta dependence of nhcal to that of the lfhcal

Backup Slides

Mixed Signal (DIS) with background

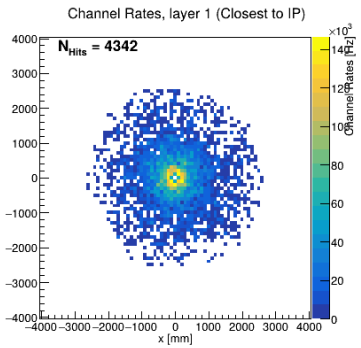
Symbol	Process	Sampling Frequency (kHz)	Status Code Shift
●	signal	500	0
●	synrad	14000	2000
●	ebrems	316.94	3000
●	etouschek	1.3	4000
●	ecoulomb	0.72	5000
●	p.b.gas	22.5	6000

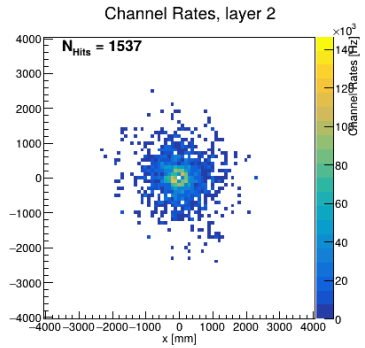


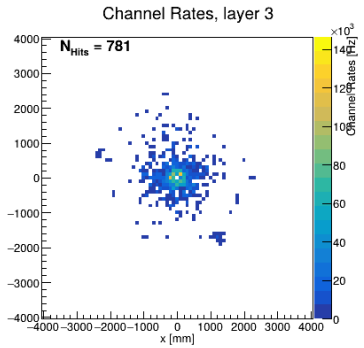
Truth/Sim Level Analysis

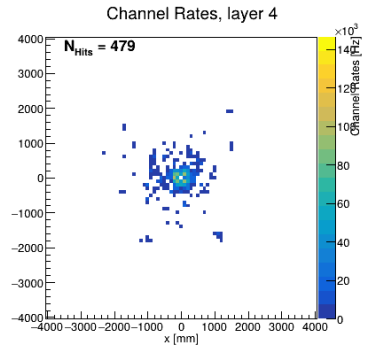
- Events plotted are simulation level calorimeter hits from mcparticle deposits
- A hit is the sum of all hit contributions for the 2us frame
- One MIP = 1 MeV
- Threshold set to .1MIP

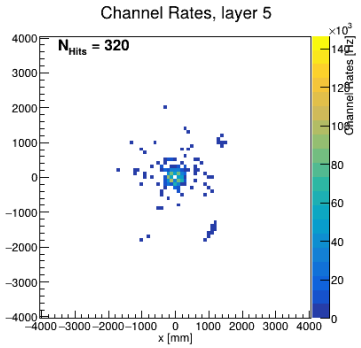
Channel Rates (no threshold)

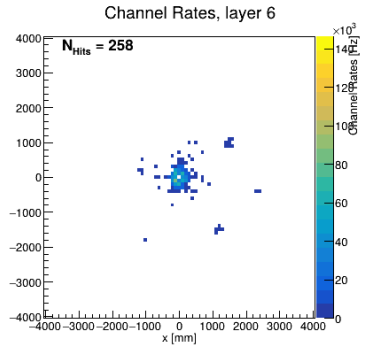


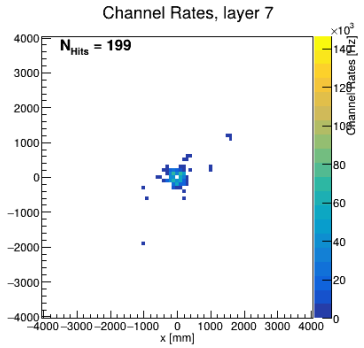


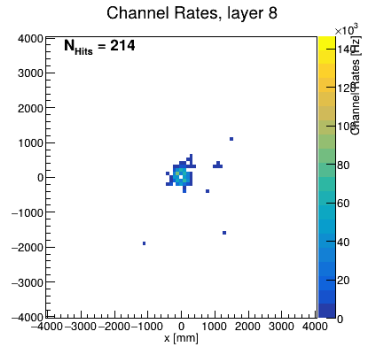


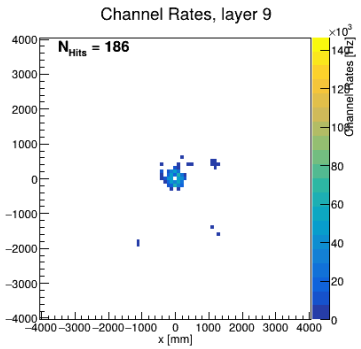


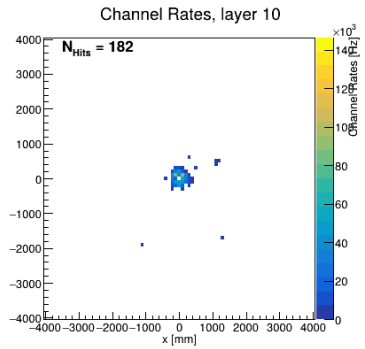


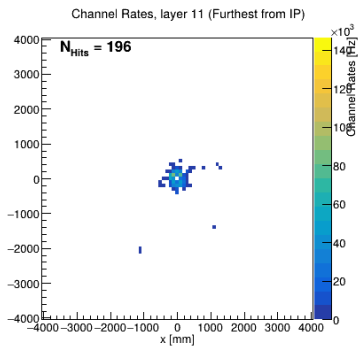






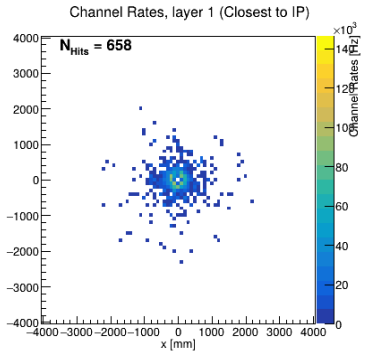


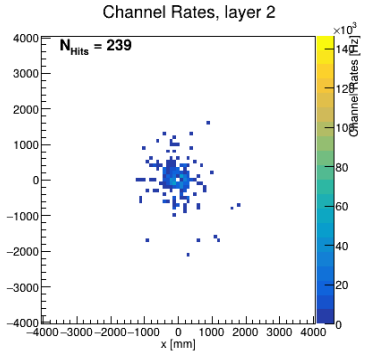


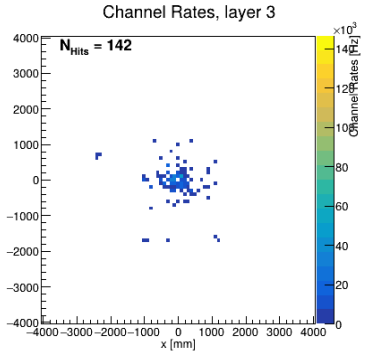


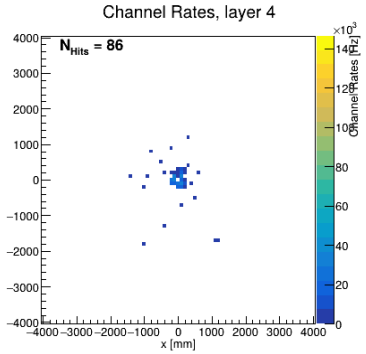
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Particle Gun Type:
Gun Energy:
Angle Range: (150-175 Acptnc)
Angle Range: (0-360 Acptnc)
Num Events:
Recon Stage [Sim, Reco, TrckMtch, CTM]
Recon Stage -> Sim Level
Bins Filled as: Hit Counts
Hit Energy Cut: N/A
Normlztn/Scaling: 1/#frames/2us

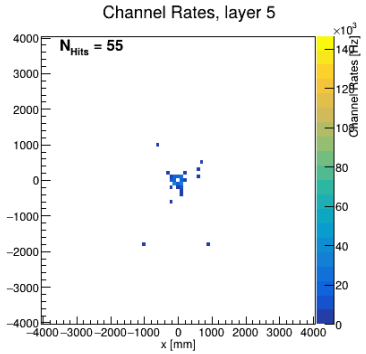
Channel Rates

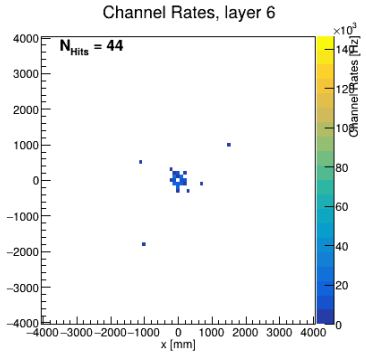


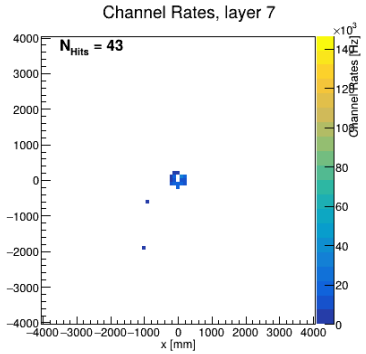


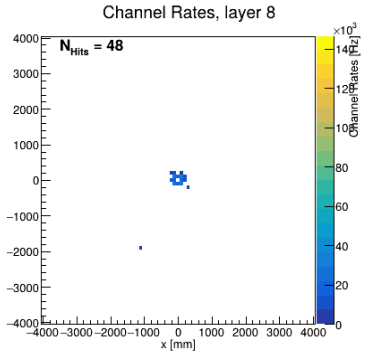


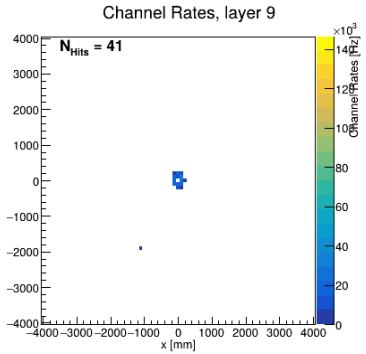


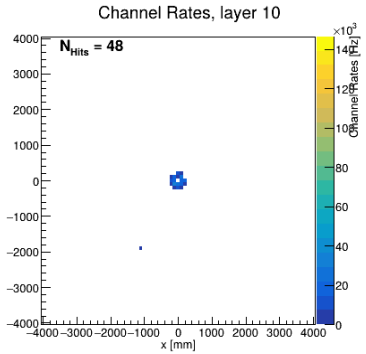


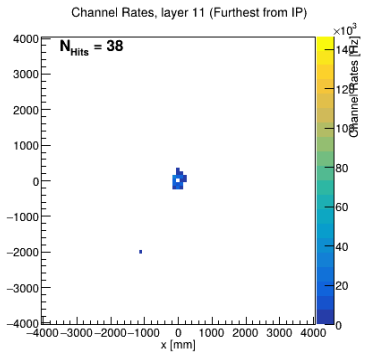






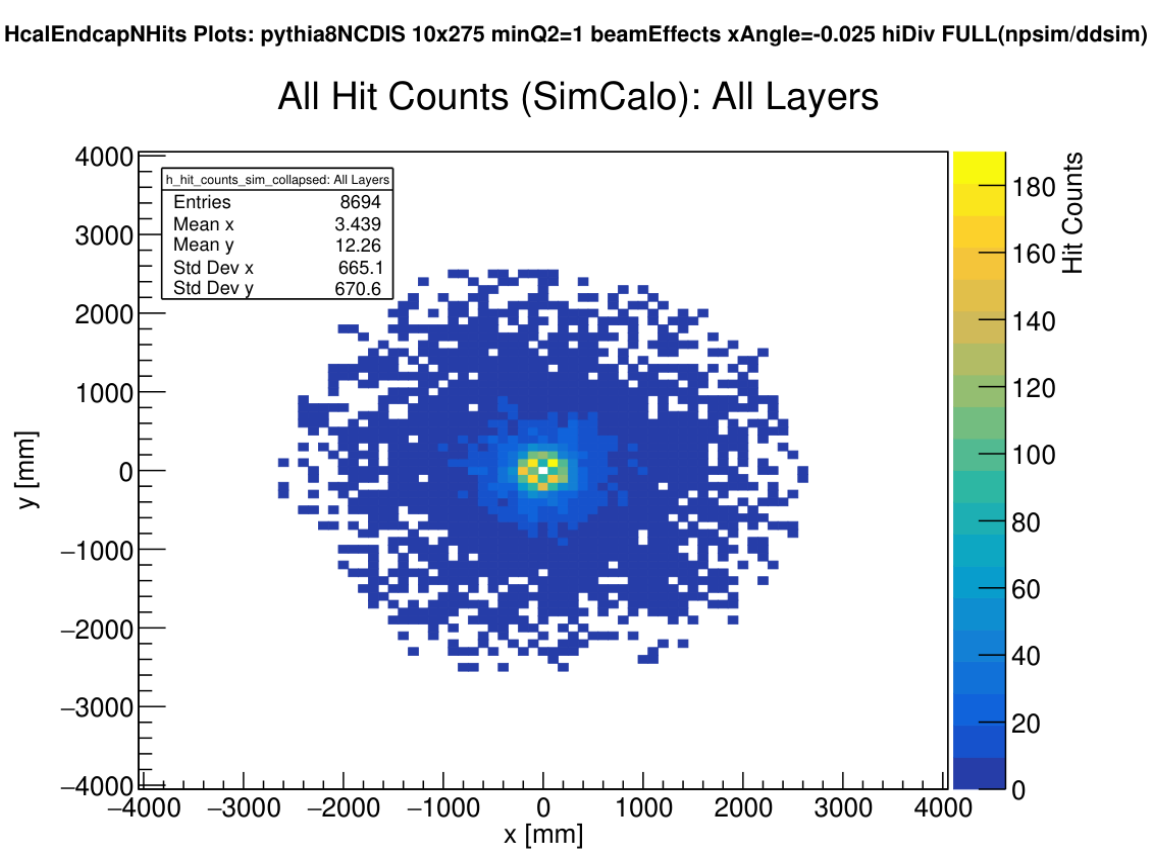


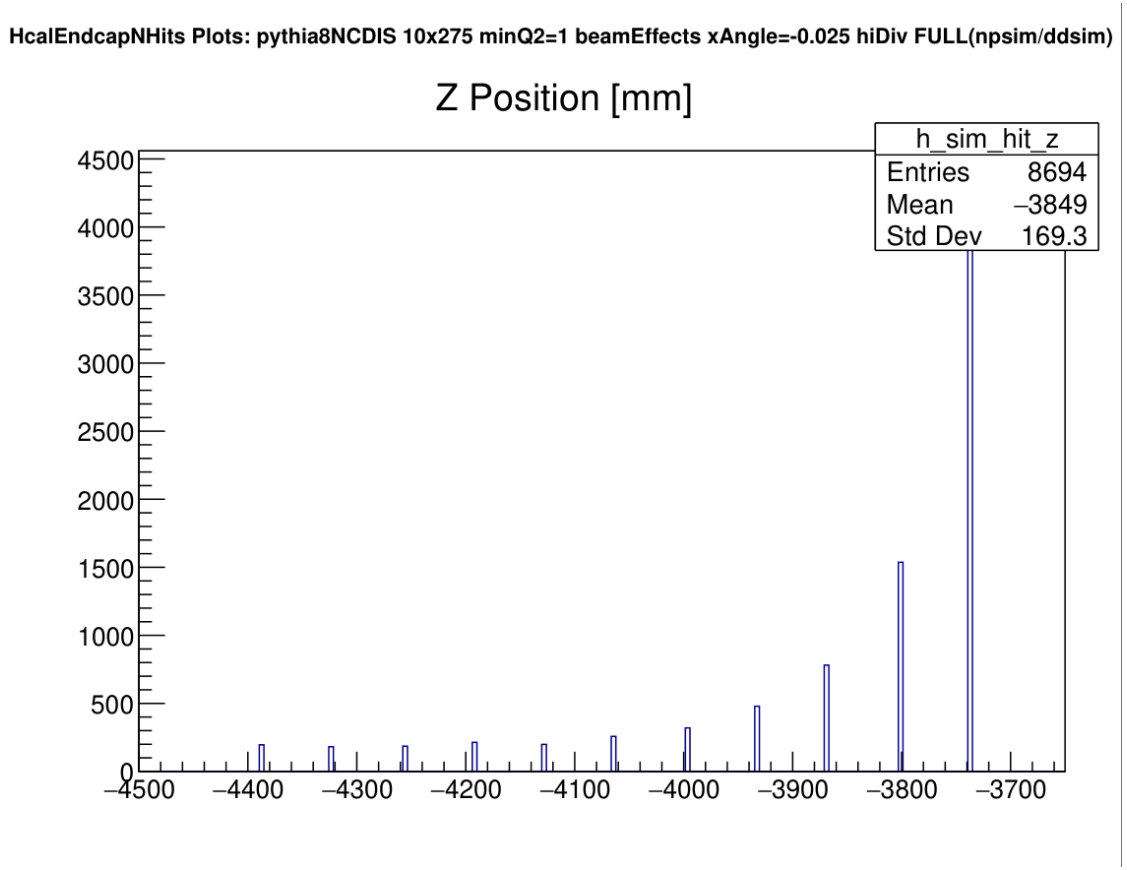




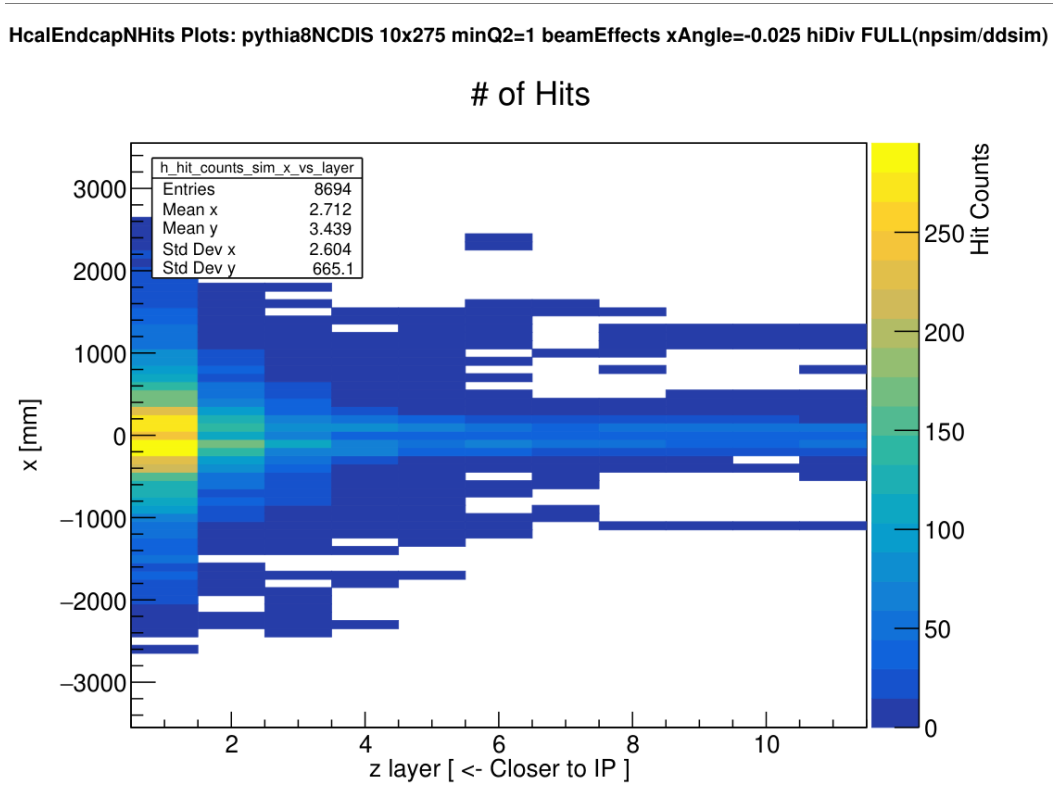
Geometry:
Particle Gun Type:
Gun Energy:
Angle Range: (150-175 Acptnc)
Angle Range: (0-360 Acptnc)
Num Events:
Recon Stage [Sim, Reco, TrckMtch, CTM]
Recon Stage -> Sim Level
Bins Filled as: Hit Counts
Hit Energy Cut: N/A
Normlztn/Scaling: 1/#frames/2us

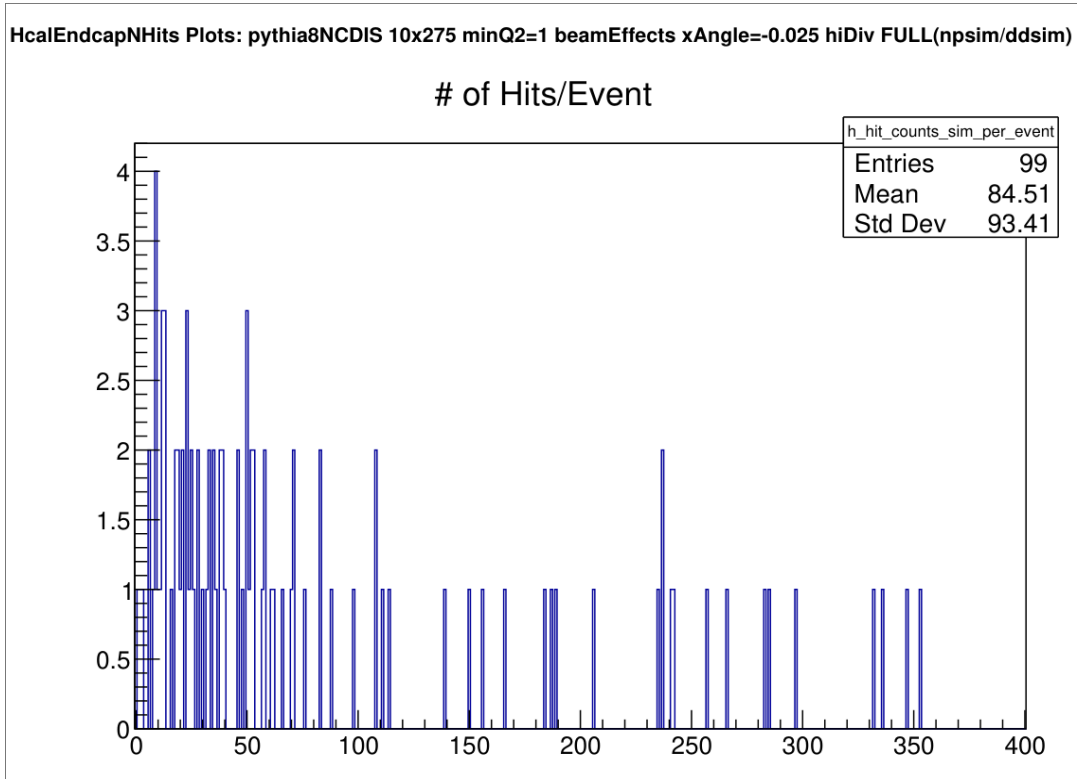
Hits Position Profile



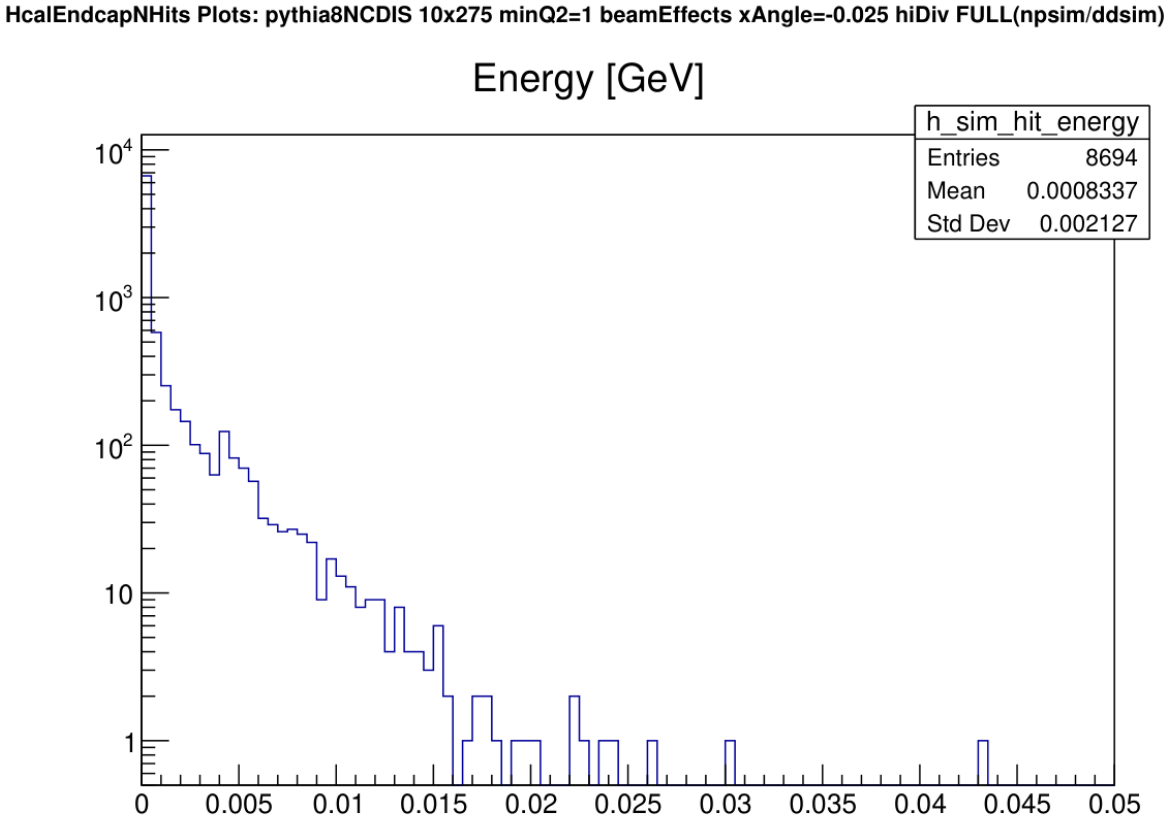


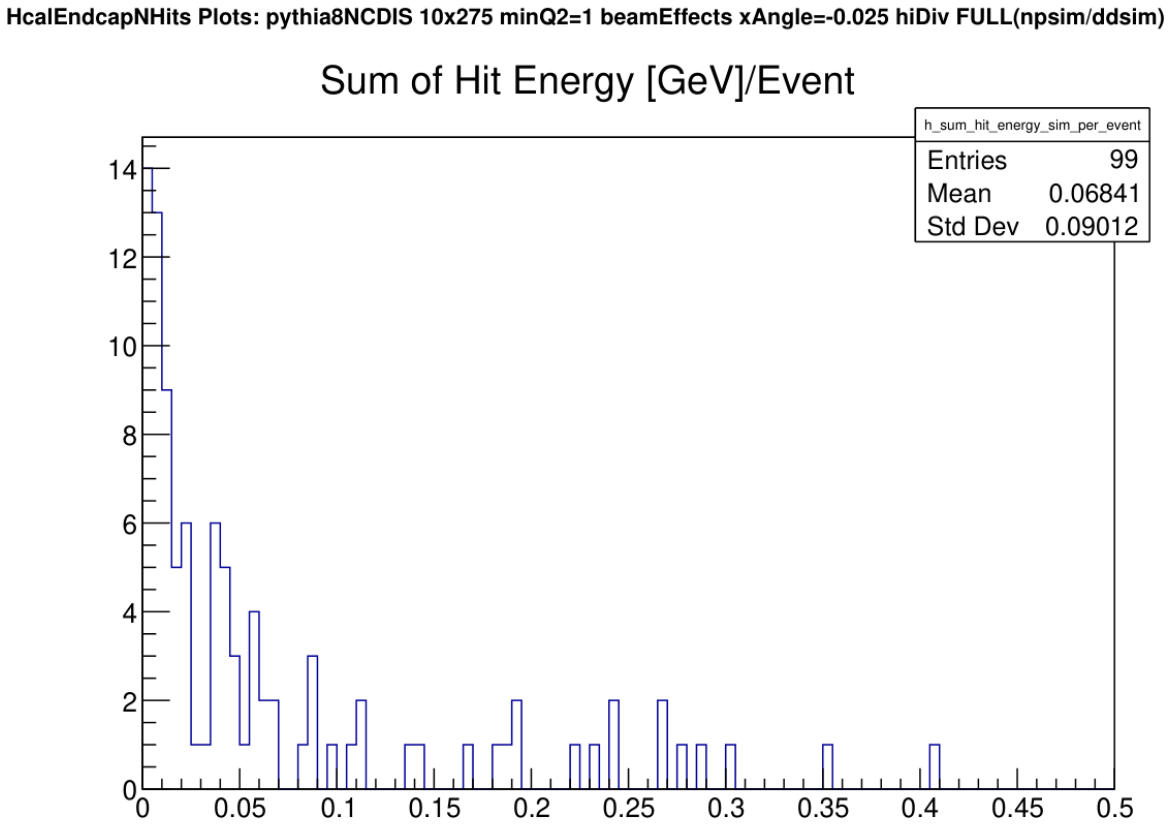
Hits Counts Profile



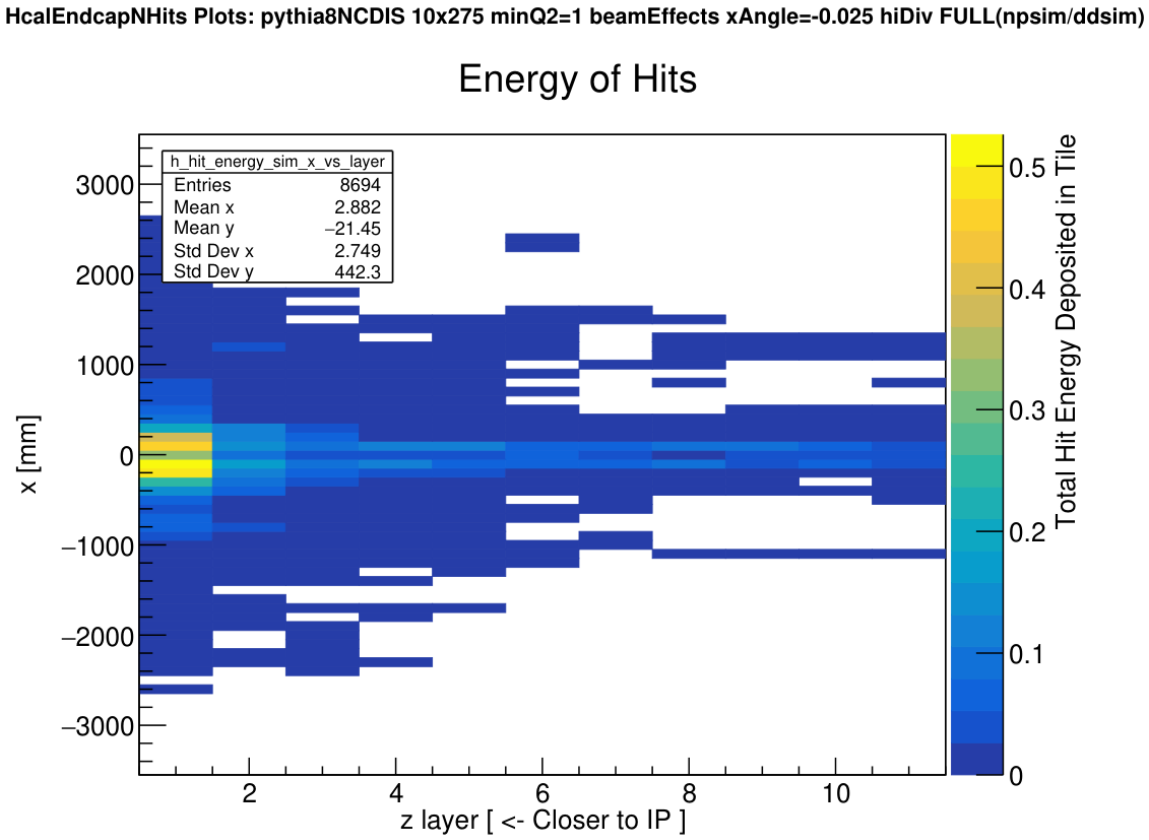


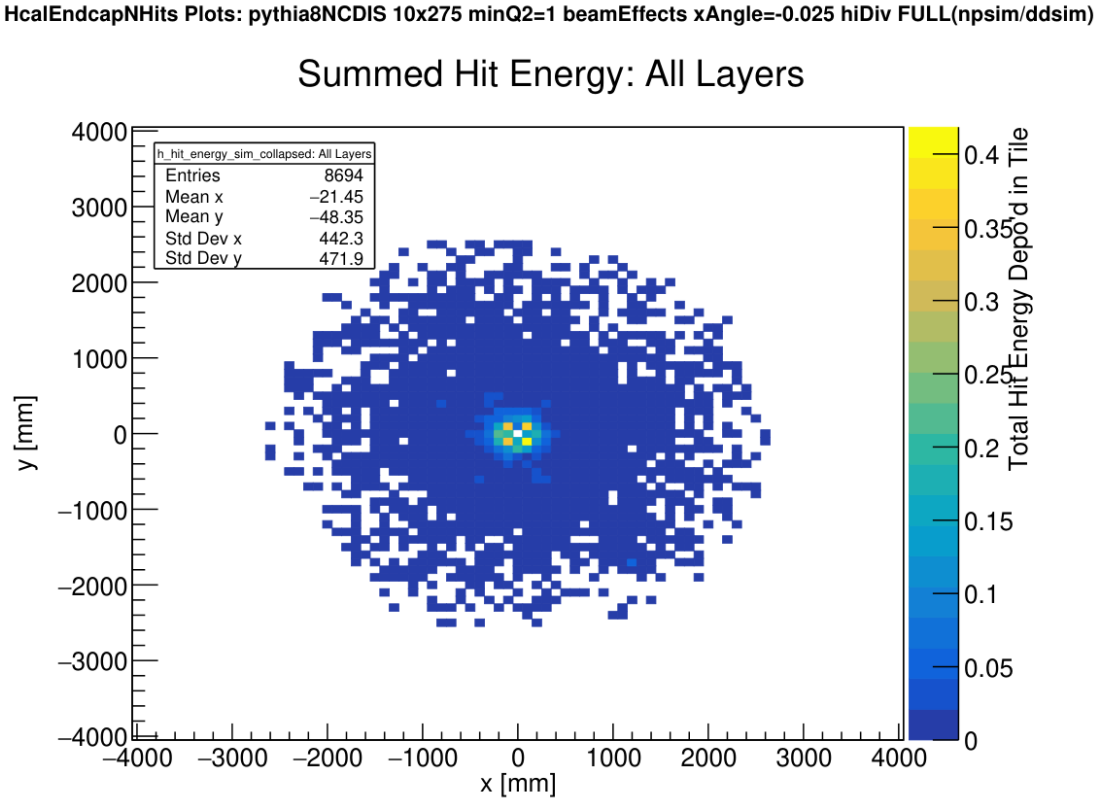
Energy Profile



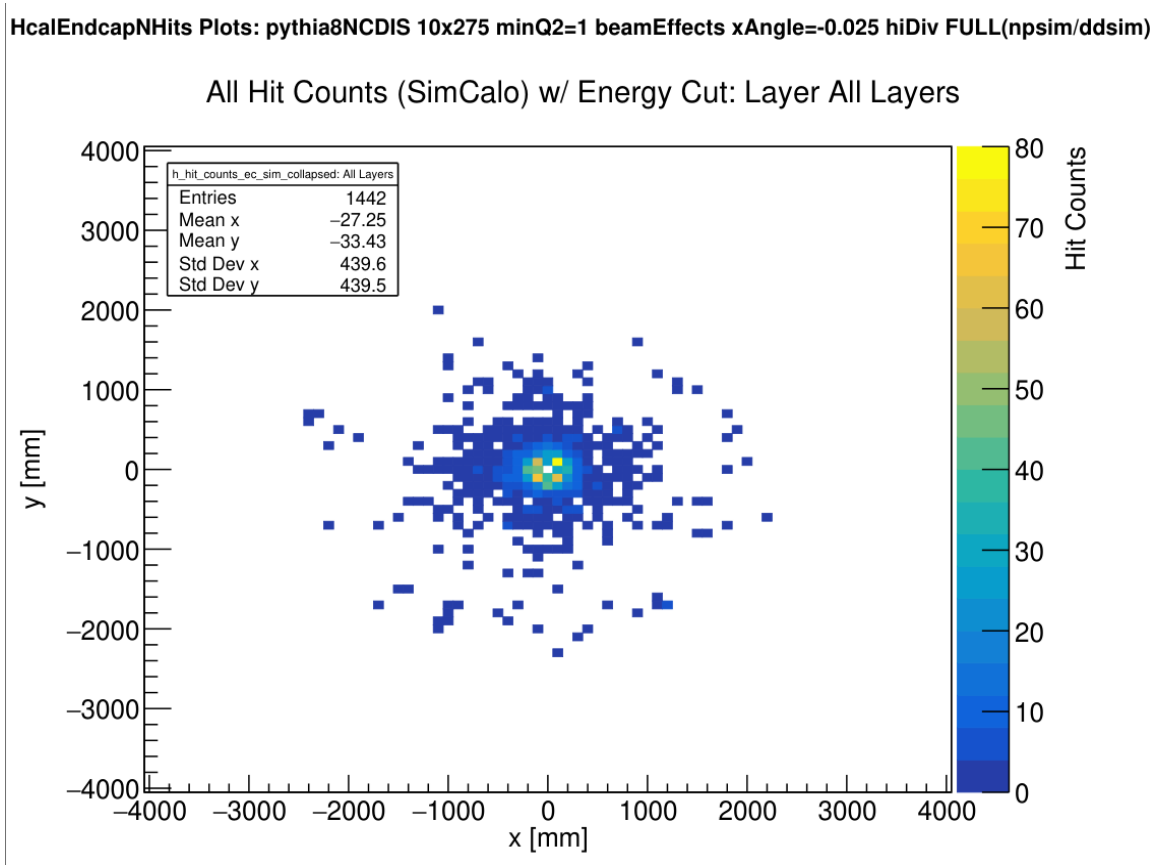


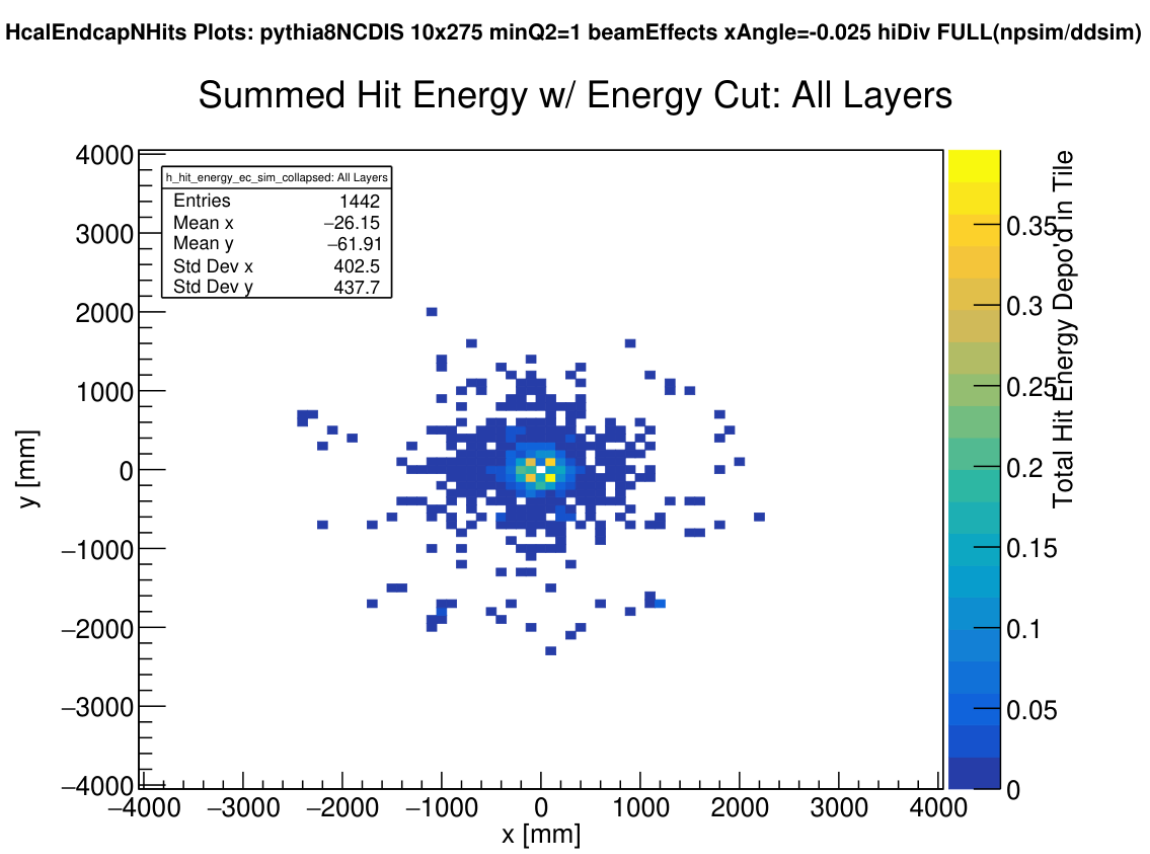
Energy Positional Profile





Hit Counts & Energy (Energy Cut .1MeV)





Outline

- Simulation chain
- Background files
- Rate and Occupancy

MCParticles

- Completely truth level, they do the bookkeeping for the behavior of every particle that lived for an event
- Details it carries include:
  - Its initial and final conditions
  - Particle type (pdg), mass, charge, etc..

- For the background analysis, this means everything that lived in a 2uS time frame

Simulation Steps

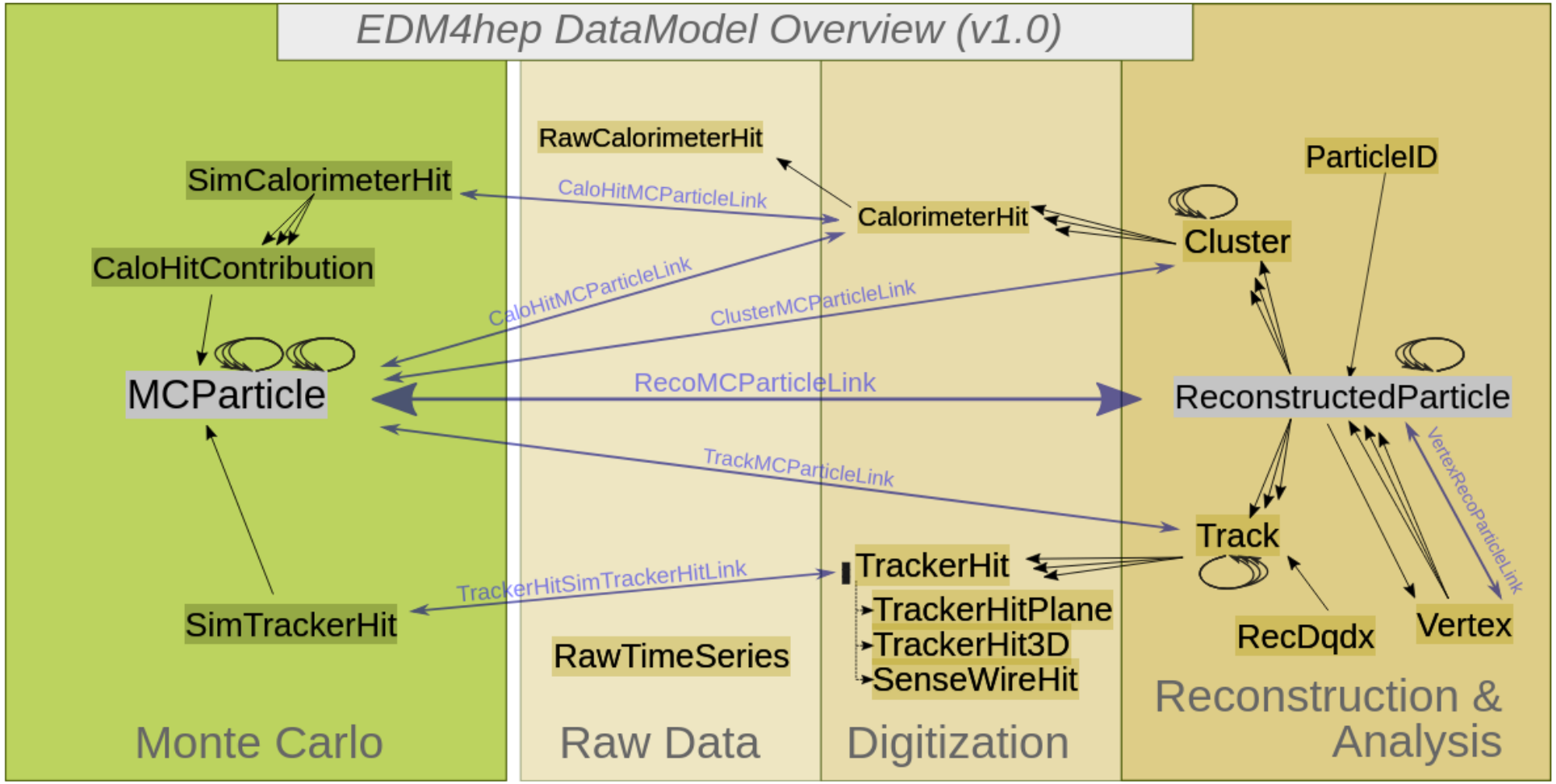
- **MCParticle** are advanced through the simulation in steps
- At every step, the simulation evaluates this new state, the check determines
  - Did the particle deposit energy here? (important!)
    - This is the basis for Hits
  - Did the particle decay here? (create more mcparticles)
  - Did a force change the motion of this particle? etc
- Was energy deposited in our detector? -> **CaloHitContribution**

Hits!

- **CaloHitContributions** are all the tiny bits of energy left in the detector. Each includes:
  - energy deposited, particle PDG, timestamp
  - step position, step length (from geant)

- **SimCalorimeterHits** are made up of hit contributions
  - For the nhcal, a hit will only be happening inside a scintillating tile
  - A hit is made up of the sum of every contribution to that tile in an event
  - The hits position is tied to the cellID of the hit,

EICrecon's "Digitization"



The Background Files (DIS mixed signal)

- Each event is 2us long
- Guaranteed to have at least 1 signal (DIS) process per event
- The rate that the backgrounds are sent are dependent on their sampling frequency

Symbol	Process	Description	Sampling Frequency (kHz)	Status Code Shift
	signal	DIS NC 18x275 $Q^2>1$ (Deep inelastic scattering neutral current)	500	0
	synrad	Synchrotron Radiation	14000	2000
	ebrems	Electron bremsstrahlung radiation	316.94	3000
	etouschek	Electron Touschek scattering (intrabeam scattering)	1.3	4000
	ecoulomb	Electron Coulomb scattering processes	0.72	5000
	p.b.gas	Proton beam gas interactions	22.5	6000

Occupancy & Rate

- Rate of a tile: Occupancy / 2us
- **Tile Occupancy** = # hits on that tile / # frames in the run
- Max # hits for on a tile for a single event is 1
- We can adjust # hits by adding an energy threshold to the hits to turn it into a rate of channel firings
- **Detector Occupancy** (over an event): # total tiles hit / total tiles available
- **Rate of a tile**: Occupancy / 2us

CALOROC

- Readout / Element: CALOROC (36 Channel)
- Maximum data rate / element: 2.52 Gb/s
- Maximum hit rate / element: 7.8 MHz
- Minimum distinguishable hit spacing: 125 ns
- Likely aggregation bottleneck: RDO
- Rate capability incl. aggregation: 975 kHz
- Bits / hit: 320

Thoughts

- Can we estimate rate using the Reconstructed Hits? What would we have to consider?
- No gap in the center of the nhcal?
- Turning these signals into a relative bit rate for the calorock