

# ECAL hits position distribution in Geant4 simulation.

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LUXE Calorimeter Meeting

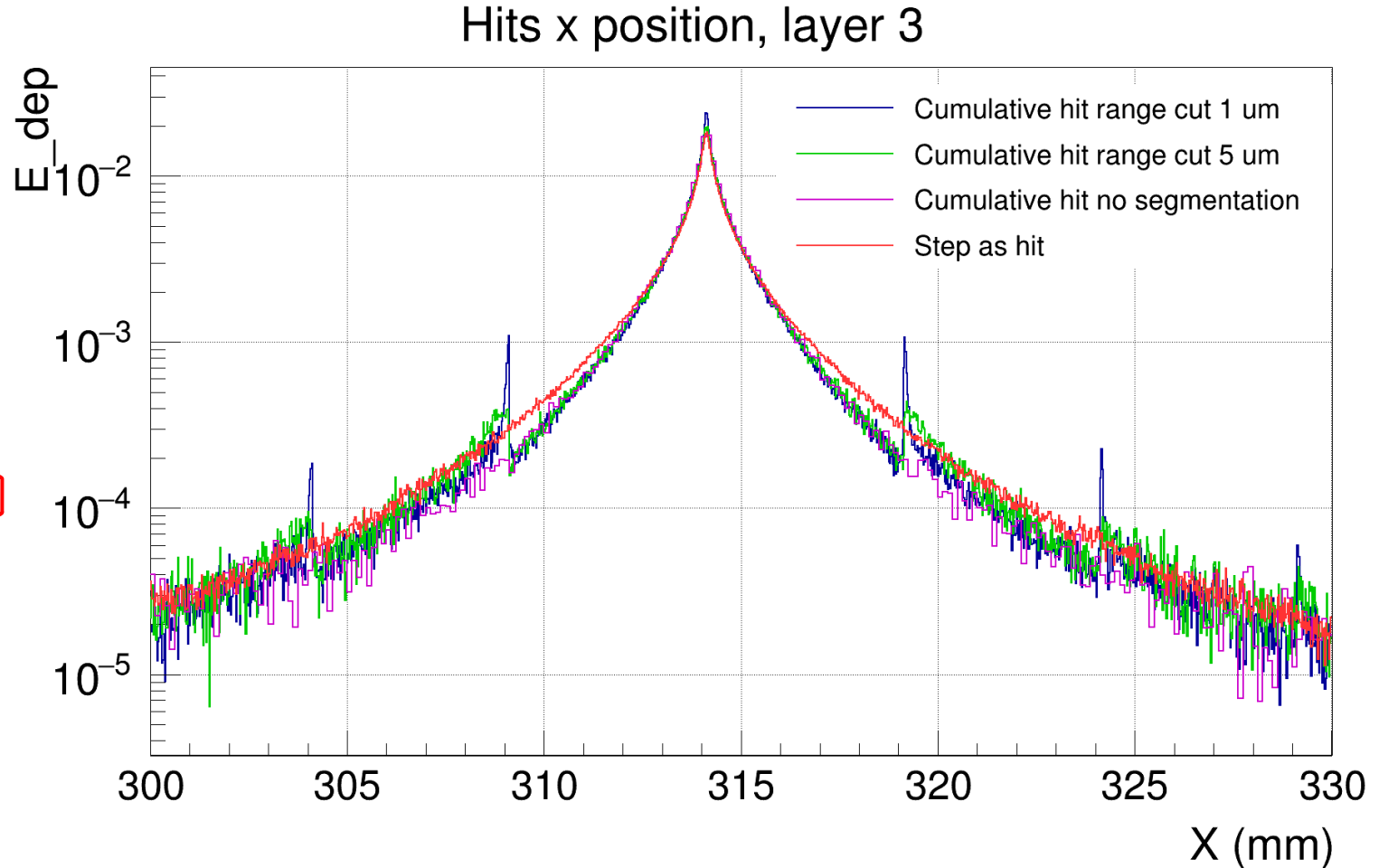
January 24, 2024

# Track hits x distribution

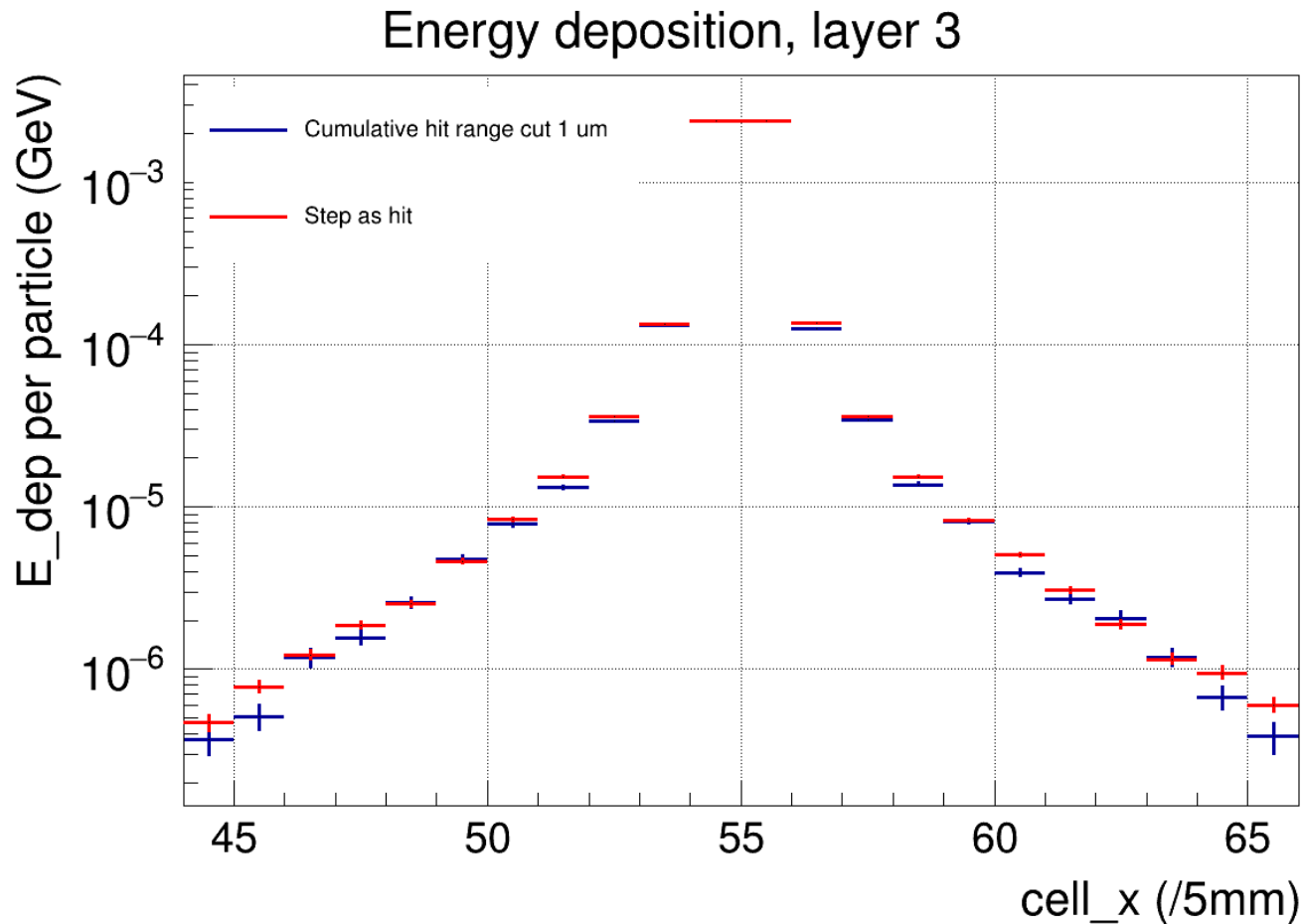
Branches in Hits  
tree in simulation  
output:

cellx  
celly  
layer

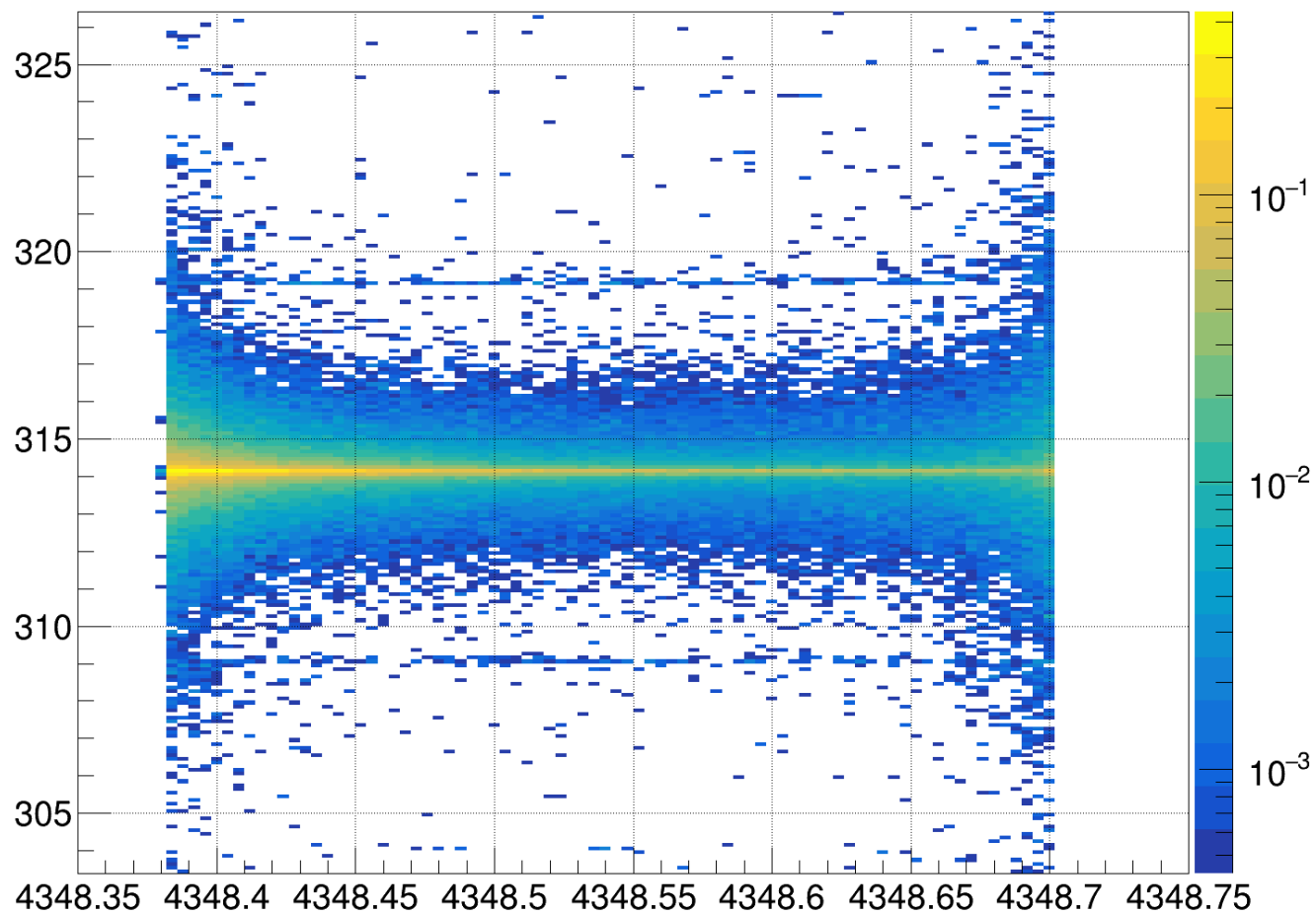
```
vector<> track_id  
vector<> track_x  
vector<> track_y  
vector<> track_z  
vector<> track_t
```



# Energy deposited in ECAL pads



trackx:trackz {trackedep\*((detid==2000)&&(layerid==1))}



# Geant4 particle transport

GEANT4 simulation of particle transport is performed step by step [SA03]. A *true step length* for a next physics interaction is randomly sampled using the *mean free path* of the interaction or by various *step limitations* established by different GEANT4 components. The smallest step limit defines the new true step length.

Computation of mean free path of a particle in a media is performed in GEANT4 using cross section of a particular physics process and density of atoms. In a simple material the number of atoms per volume is:

$$n = \frac{\mathcal{N}\rho}{A}$$

$\mathcal{N}$  = Avogadro's number  
 $\rho$  = density of the medium  
 $A$  = mass of a mole

In a compound material the number of atoms per volume of the  $i^{th}$  element is:

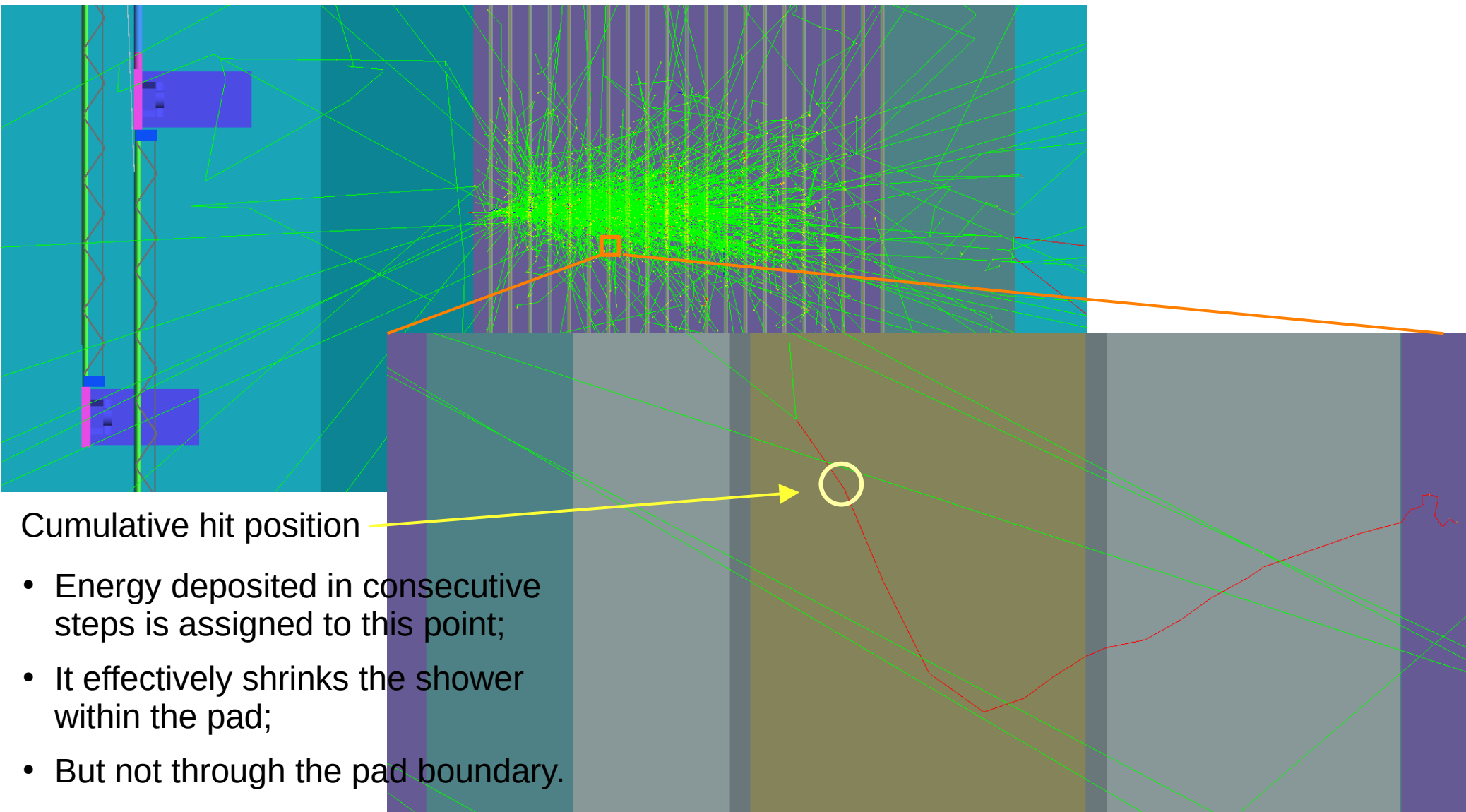
$$n_i = \frac{\mathcal{N}\rho w_i}{A_i}$$

$w_i$  = proportion by mass of the  $i^{th}$  element  
 $A_i$  = mass of a mole of the  $i^{th}$  element

The **mean free path** of a process,  $\lambda$ , also called the **interaction length**, can be given in terms of the total cross section:

$$\lambda(E) = \left( \sum_i [n_i \cdot \sigma(Z_i, E)] \right)^{-1}$$

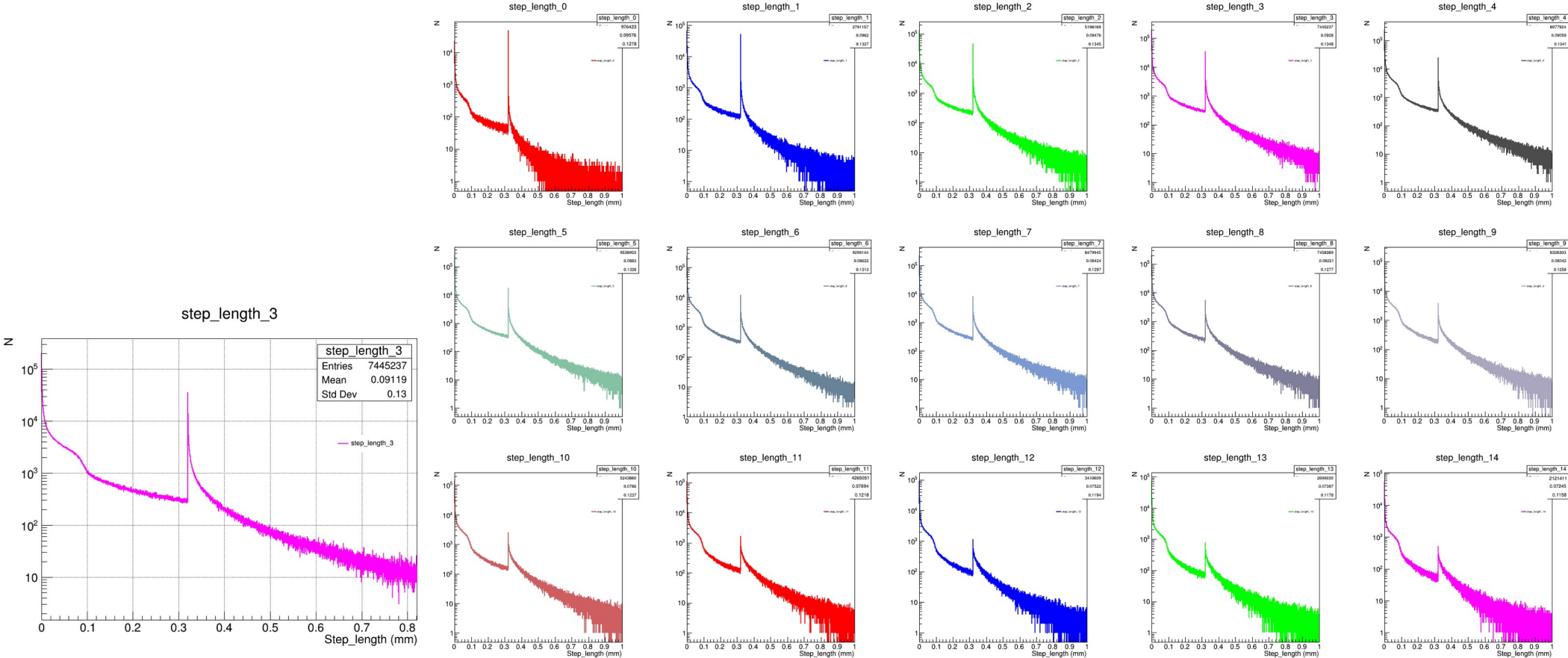
where  $\sigma(Z, E)$  is the total cross section per atom of the process and  $\sum_i$  runs over all elements composing the material.



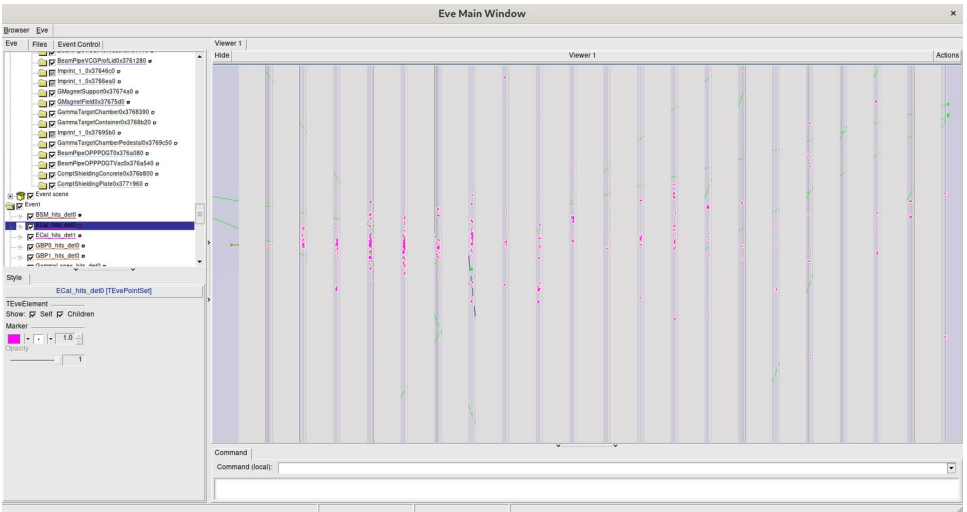
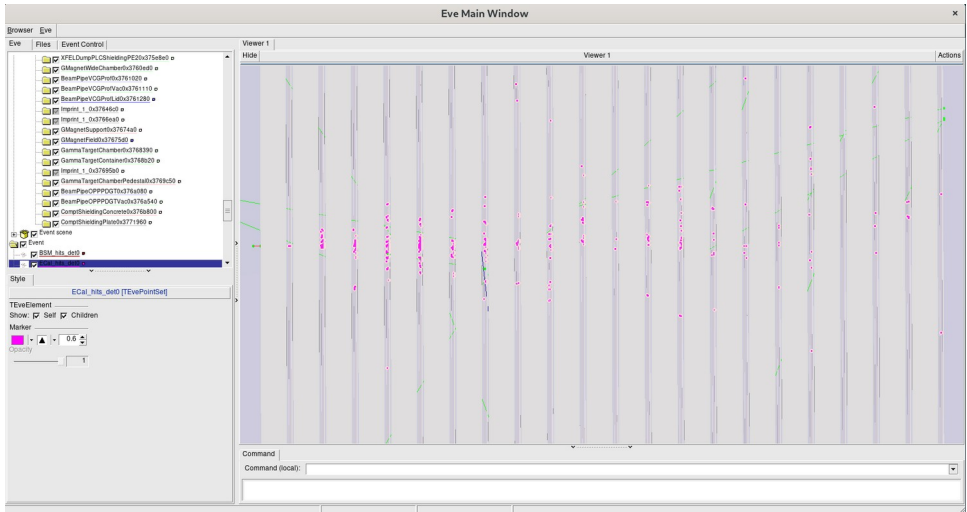
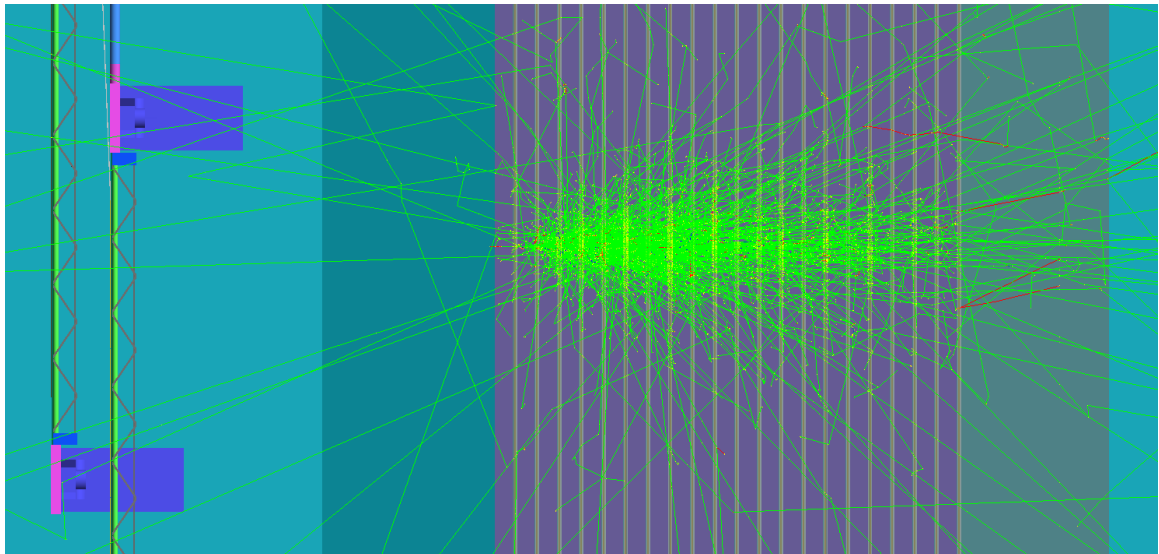
# Notes on cumulative hits

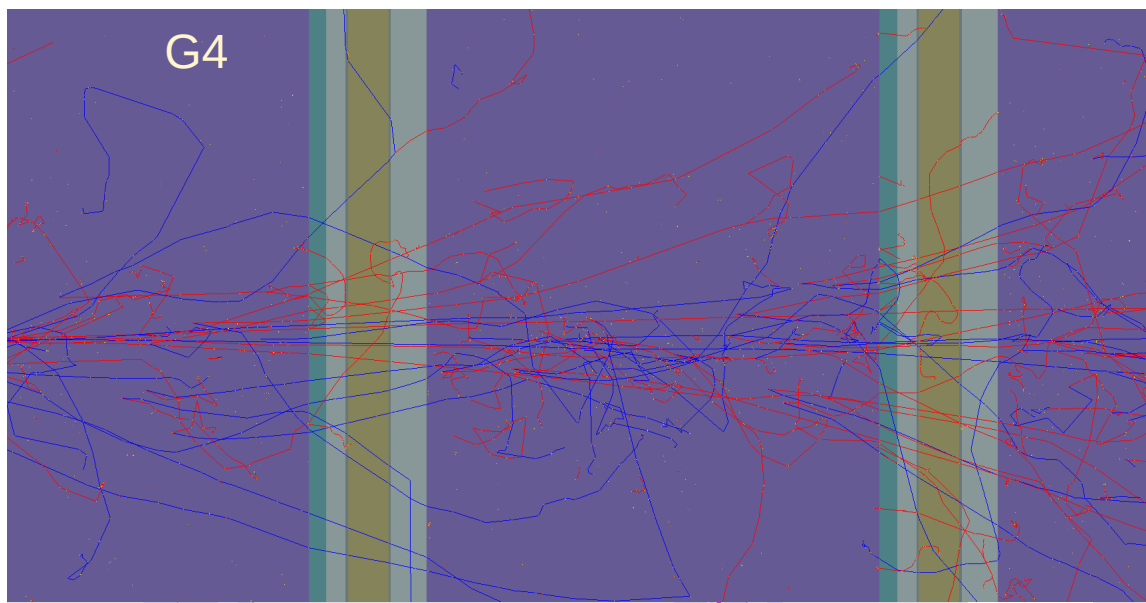
- Cumulative hits were added to use timing information and subtract the deposition which occurred after a certain threshold time.
- Spacial distribution of the hits is not observable, each pad is read as a whole and the deposited energy is assigned to the middle of the pad in x, y and z.
- Some study was made to optimize the pad size (Mykyta).
- In LUXE ECAL case the segmentation is fixed to CALICE sensor.
-

# Step length distributions

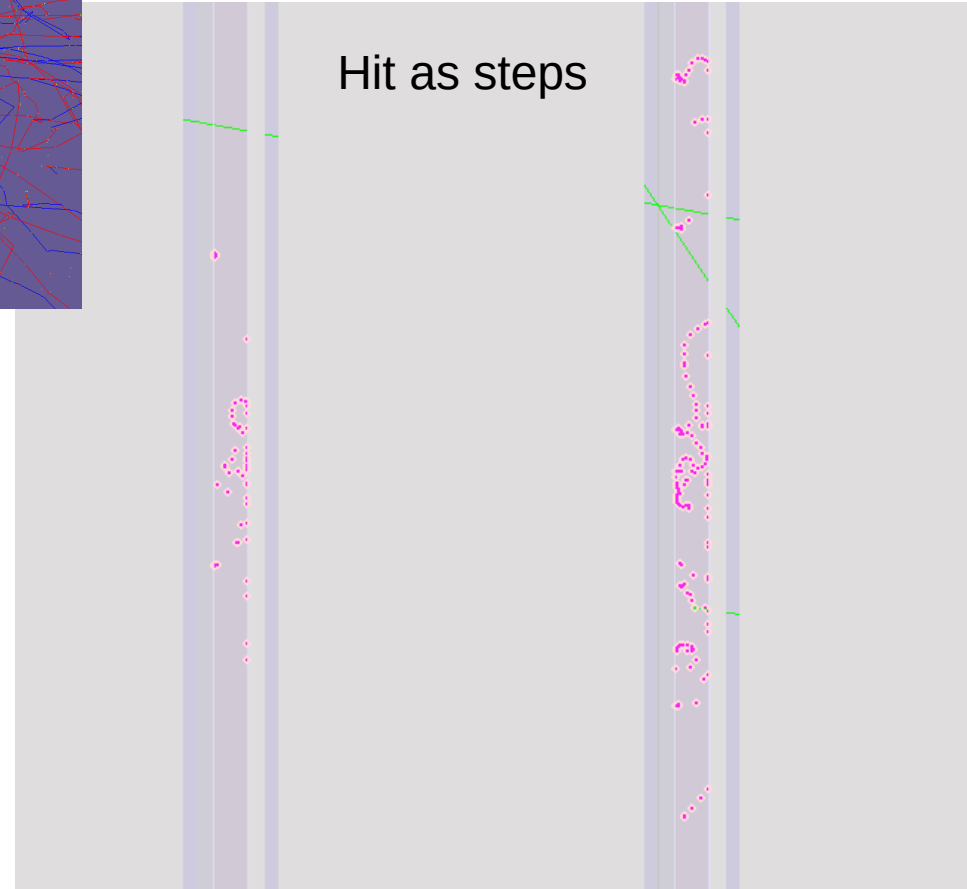
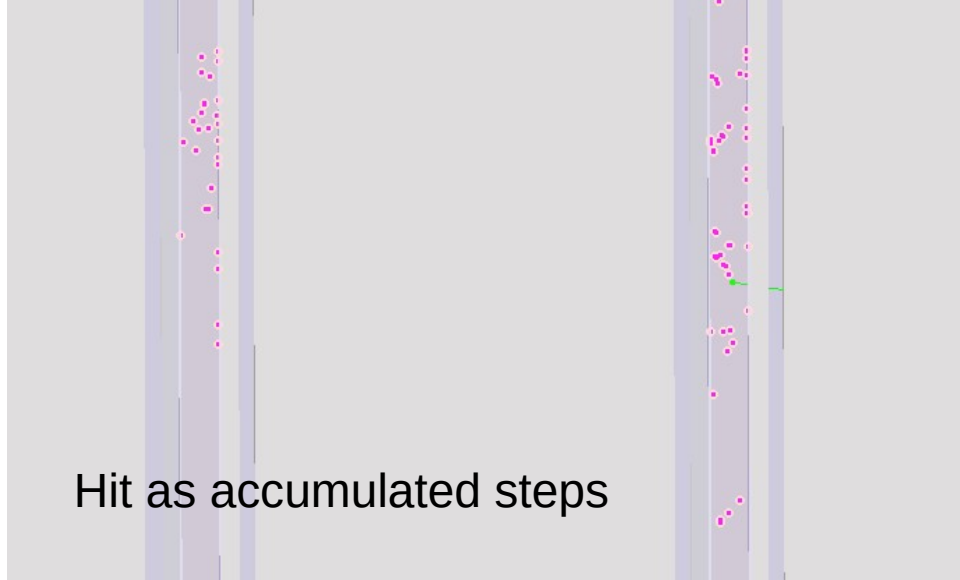








Same event in G4 and  
event displays

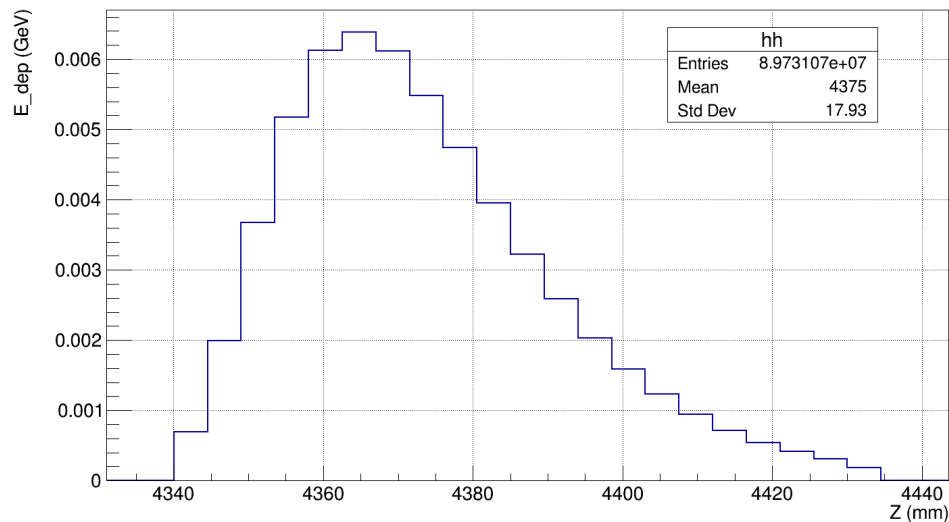


# Summary

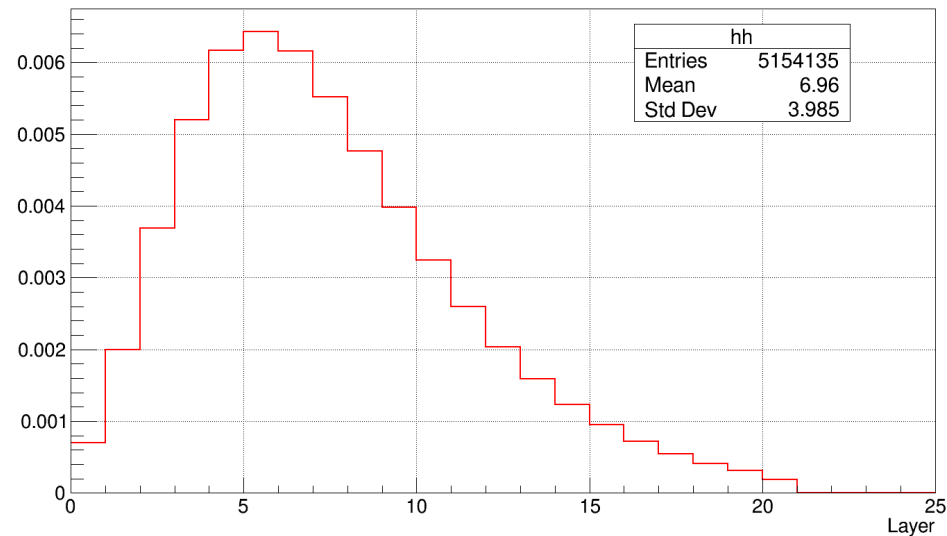
- Peaks on the edges of the pads in cumulative hits distribution are expected considering the hit position is assigned as an position of the end point of the first step of the particle within the pad.
- Saving each step as a hit gives smooth position distribution of the hits, mainly because the steps are small.
- Requires more disk space.

# Longitudinal shower profile, track\_z vs layer

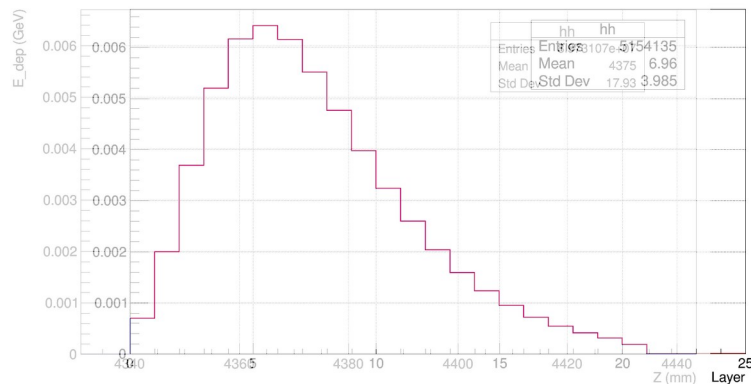
trackz {trackedep/50000.0\*(detid==2000)}



layerid {edep/50000.0\*(detid==2000)}



trackz {layerid {edep/50000.0\*(detid==2000)}}



trackz {layerid(lep/50000.0\*(detid-20000))}

