
Simulation of alpha particles and length systematics

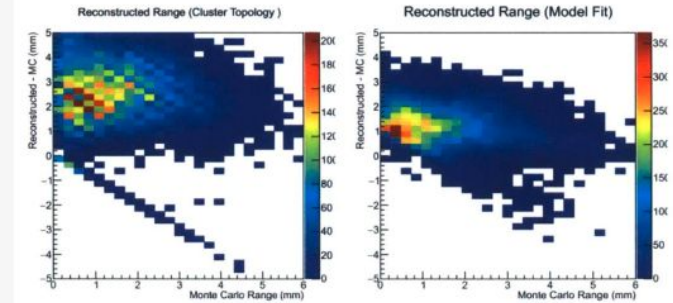
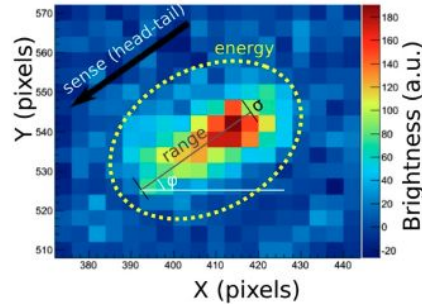
Stefano Piacentini • 23.01.2025

Motivation

- Mismatch observed between the measured and the predicted 3D length for alpha particles
- Report on GSSI activities about that

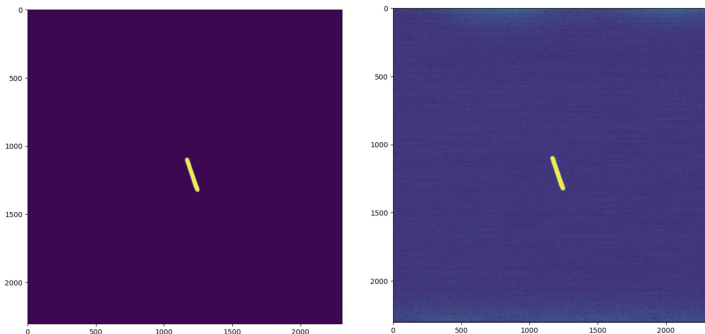
Minimal length

- It's not a matter of minimal length, but the systematics associated to track reconstruction
- See in DMTPC for example (*Phys.Procedia* 61 (2015) 39-44)



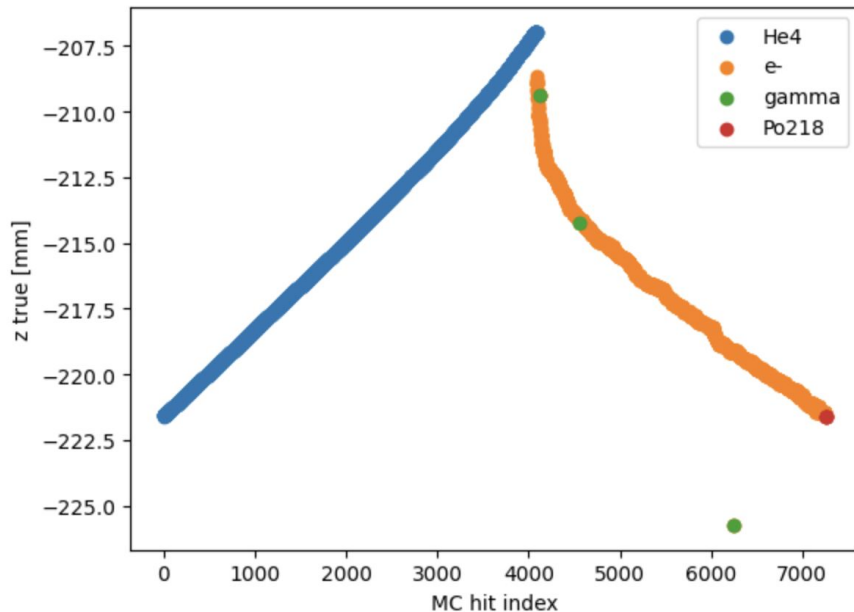
Our reconstruction algorithm gives us the "energy" cluster where track length is defined as the major axis, but the actual track length is "range". Something similar will happen for the PMT reconstruction.

2D length: MC-truth vs digitized tracks



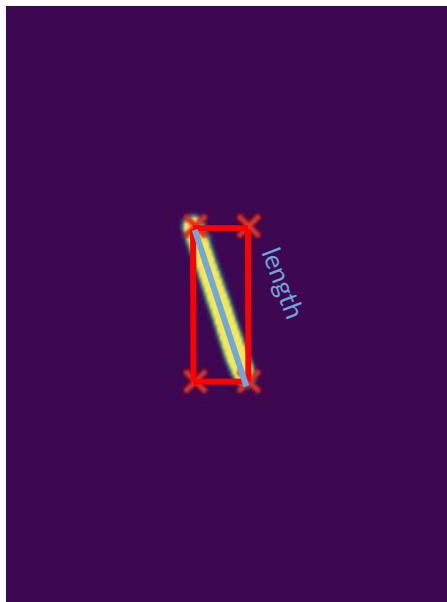
- Melba provided a sample with **1000 ^{222}Rn alpha decays**
- Yesterday I was able to digitize:
 - 100 tracks with ped
 - 100 tracks w/o peds
- Quick analysis on the length (see next slide)

2D and 3D length [MC-truth]



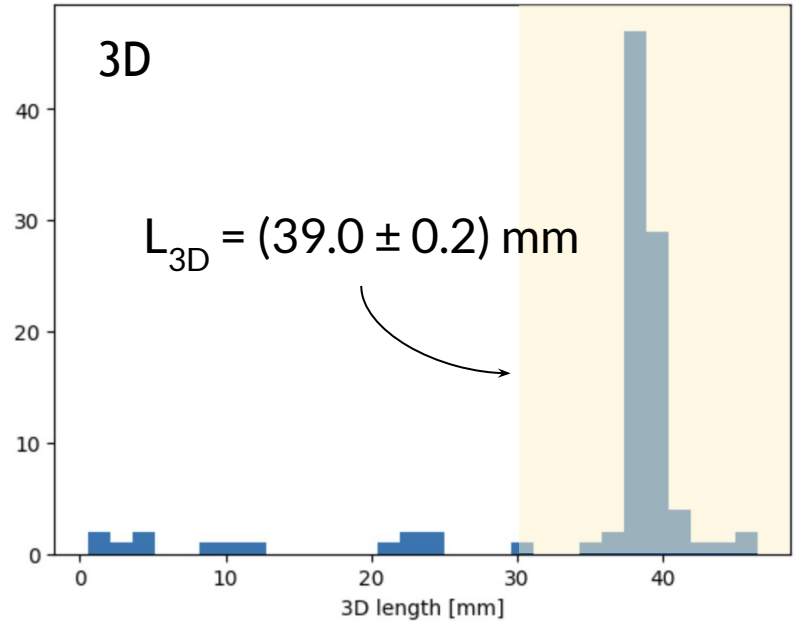
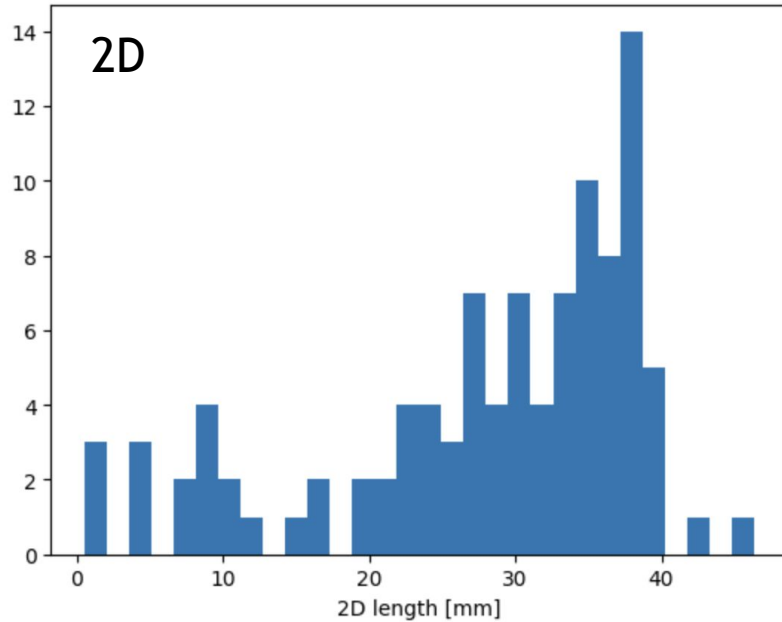
- A bit of care in the definition of 2D and 3D length in the MC-truth

2D and 3D length [MC-truth]

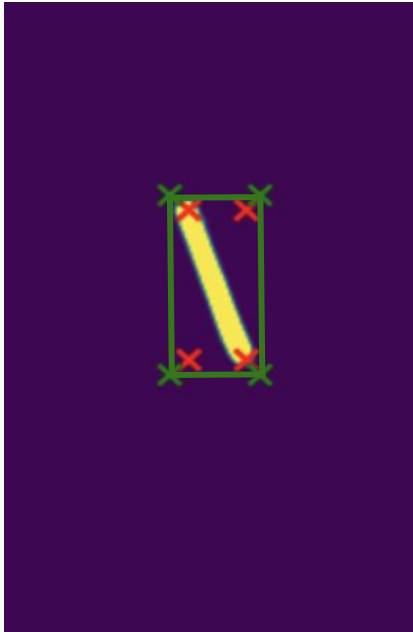


- A bit of care in the definition of 2D and 3D length in the MC-truth
- Solution:
 - compute the length of the smallest box (rectangle if 2D) containing the track in x , y and z
 - The length is the diagonal of this box (rectangle if 2D)

2D and 3D length [MC-truth]

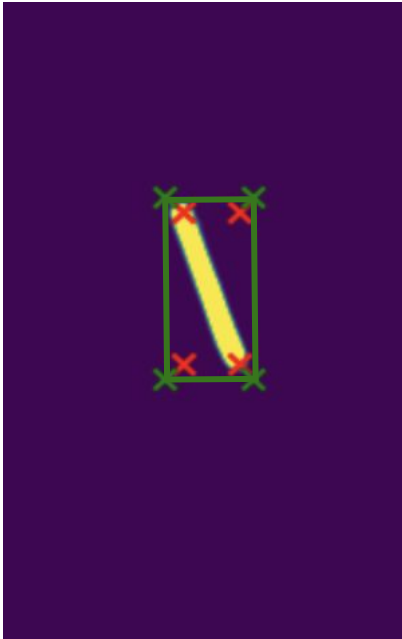


2D length [post digit.]



- I could look just at the 2D length (output of digitization is pictures)
- First order definition of 2D length:
 - I consider all the pixels of the track having at least 1 photon recorded in the picture
 - compute the length of the smallest box (rectangle if 2D) containing the track in x , y and z
 - The length is the diagonal of this box (rectangle if 2D)

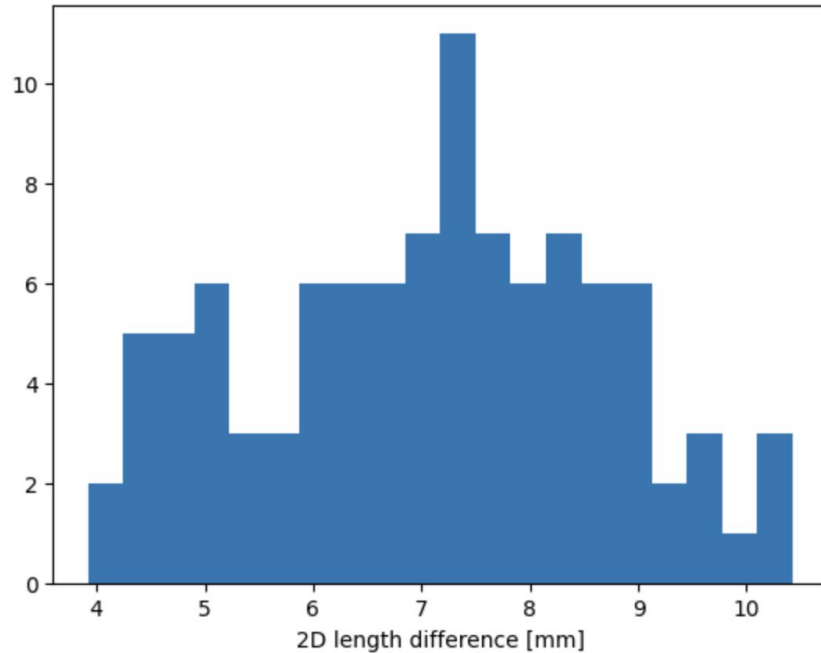
2D length [post digit.]



- This is for sure an overestimation, but gives the size of the impact of the diffusion in gas + GEM*
- It's also an underestimation: we don't simulate track enlargement due to repulsion
- So probably, by chance, we are more or less getting the correct order of magnitude of the problem

- Now let's look at the absolute difference between 2D length in MC-truth and 2D length after digitization... [next slide]

2D length [MC-truth vs post digit.]



$$L_{2D}^{\text{Digi}} - L_{2D}^{\text{MC-truth}} = (7.10 \pm 0.16) \text{ mm}$$

- Is this enough? [To be checked with David's numbers]
- More refined analysis could be done, but... [next slide]

Improvements and limitations

- **Time** to digitize one alpha track: >1 min @ VGEM = 420 V, >2.5 min @ VGEM = 440 V
- I had to use **my laptop** because it's a long calculation and there's no possibility of launching this in the queues → no parallelization
- **Additional steps** to be done to fully include any aspect of the David's algorithm:
 - **Reconstruction** of simulated files [need exact same configuration of detector to be reliable]
 - Application of the **analysis code** to extract the exact same information from the reco files, and adapt it to use only images (see next bullet) [need somebody to use this code and need David to match from the point of view of the parameters]
 - **PMT simulation** to include all the possible systematics for the 3D [not existing so far]
- **Conclusion:** in order to do it in the most clean way we can in a reasonable amount of time, we need a person doing this full time. Submit this task to simulation / analysis group?

