

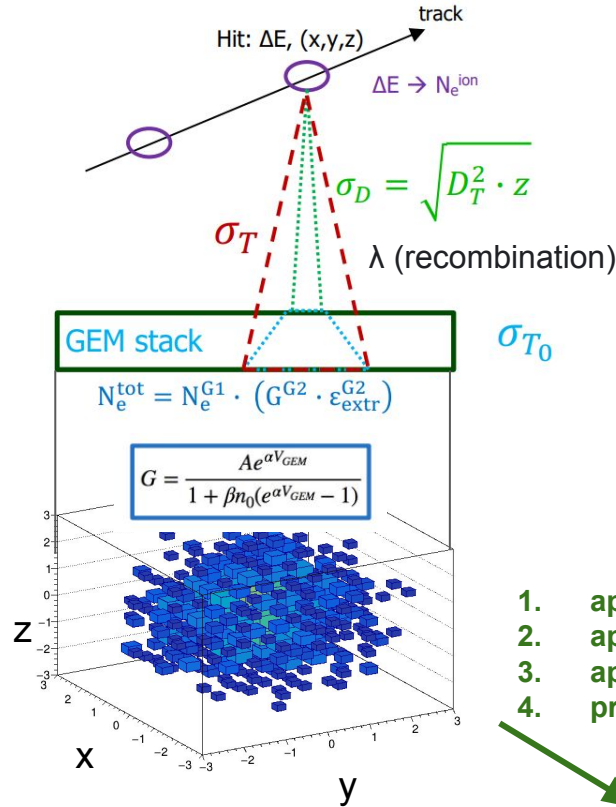
Update on PMT and CMOS simulation

Presented by: Pietro Meloni

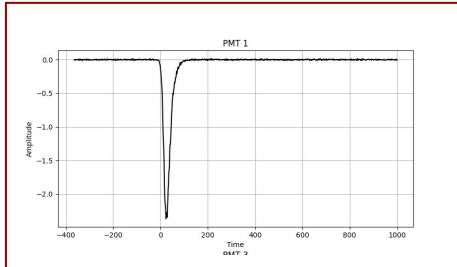
With: Fabrizio Petrucci, Luan Gomes, Davide Pinci, Mariana Migliorini and
Rafael A. Nóbrega

30-05-2023

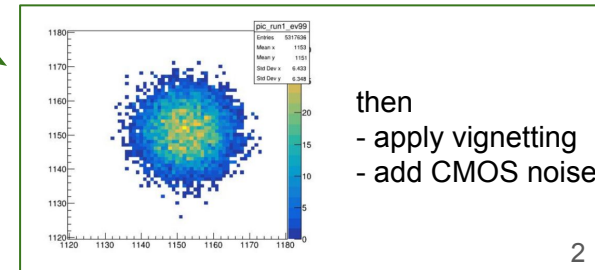
General scheme: PMT + CMOS simulation



1. apply electron-photon factor
2. convert z into t (with drift velocity)
3. for each voxel (x,y,t, N) propagate each photon to each PMT
4. generate PMT waveforms according to number of hits at given times



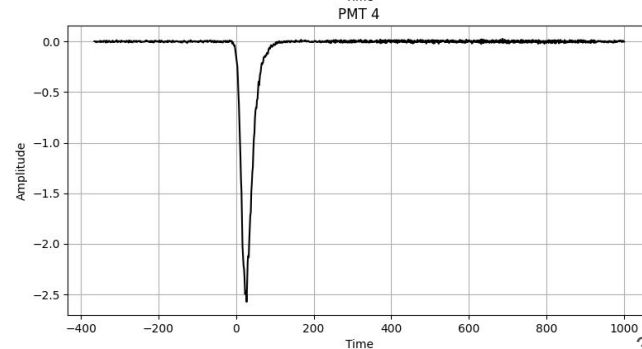
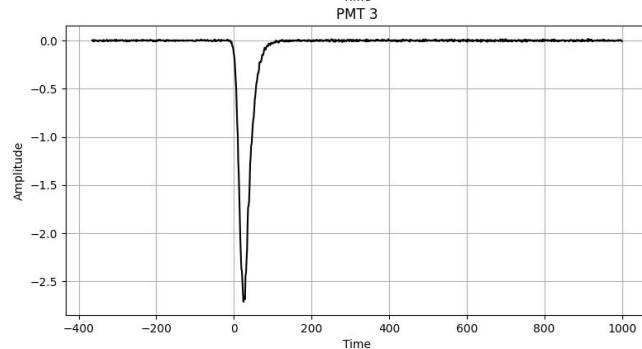
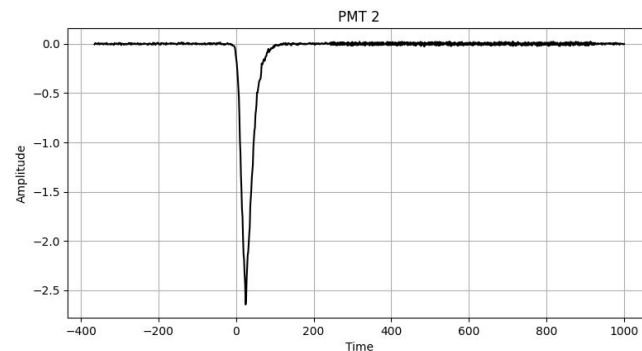
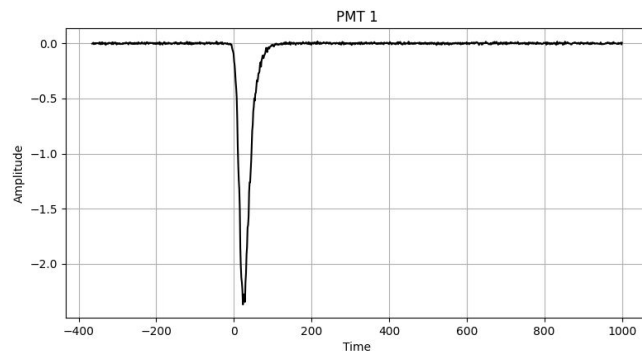
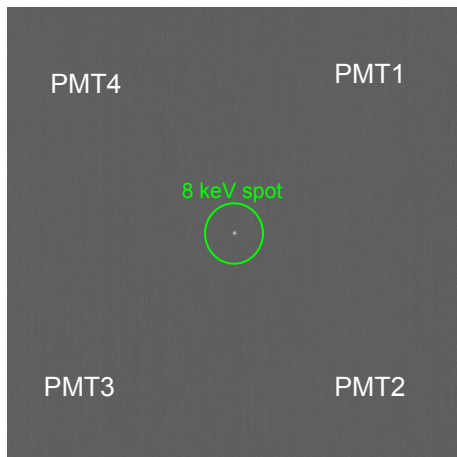
1. apply electron-photon factor
2. apply acceptance factor omega
3. apply photon-counts factor
4. project along z (drift direction)



Example 1 (8 keV ER spot at $z = 450$ mm)

Number of voxels is $\sim 50k$ (it increases with z because of diffusion)

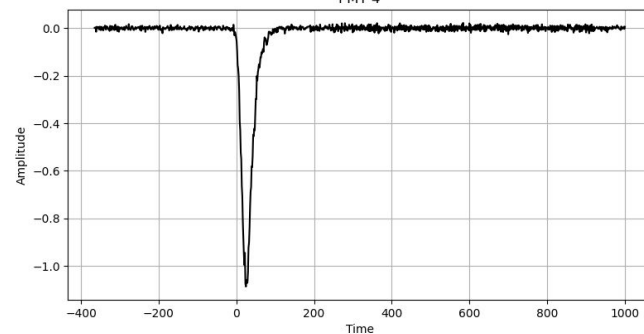
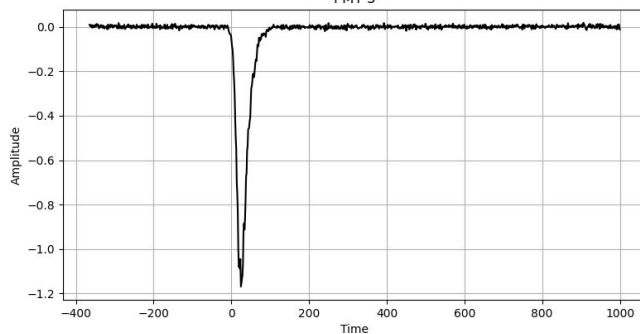
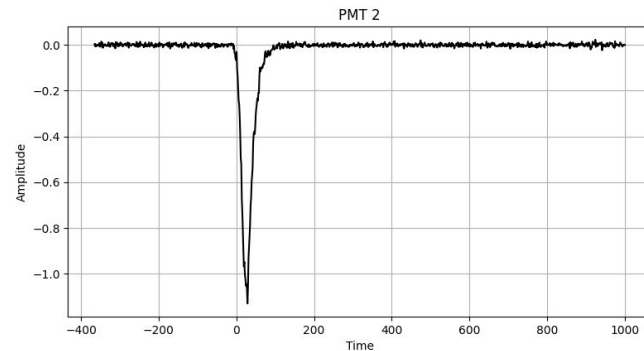
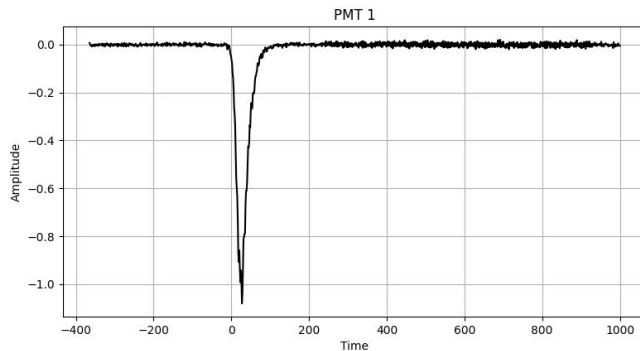
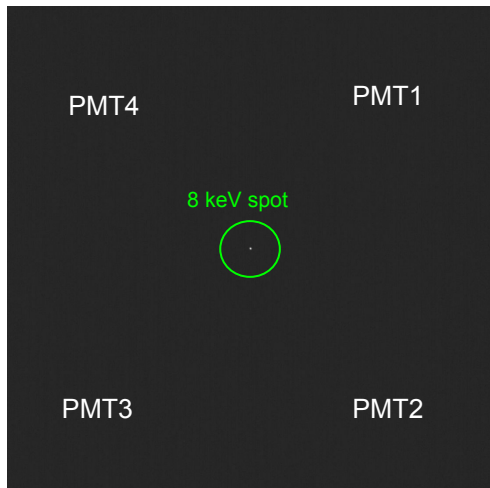
Each voxel contains ~ 1000 photons. It takes **6 hours** for one event.



Example 2 (8 keV ER spot at $z = 50$ mm)

Number of voxels is $\sim 10k$ (it increases with z because of diffusion)

Each voxel contains ~ 2000 photons. It takes **20 min** for one event.



Example 3 (non-centered 8 keV ER spot at $z = 50$ mm)

Number of voxels is $\sim 10k$

Each voxel contains ~ 2000 photons. It takes **20 min** for one event.

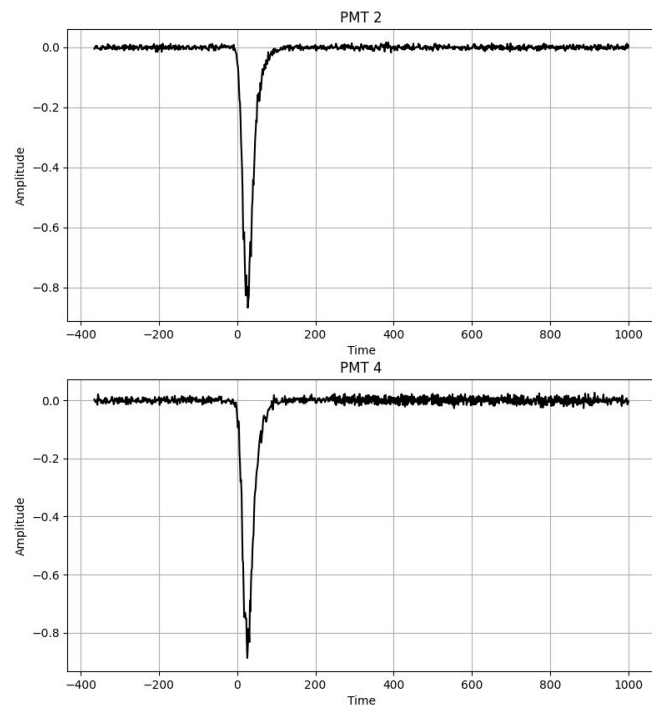
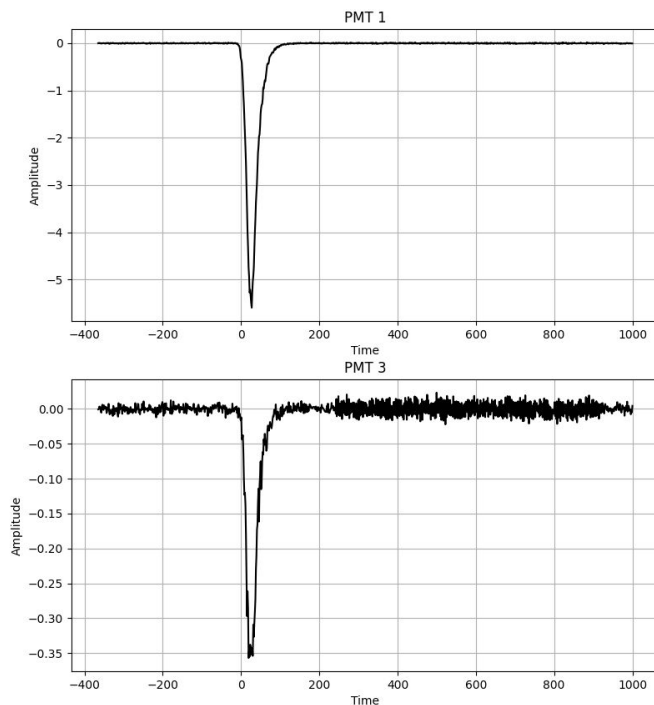
PMT4

8 keV spot

PMT1

PMT3

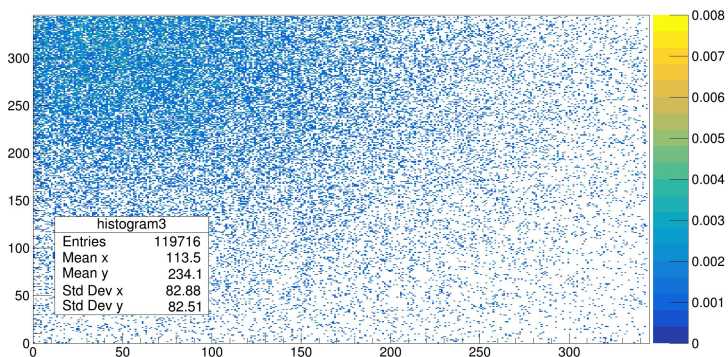
PMT2



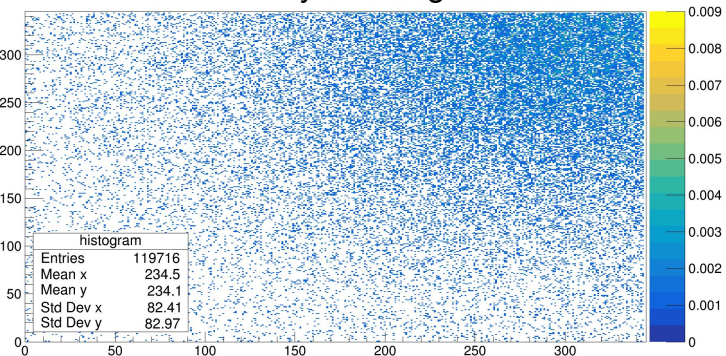
Idea: using a map to speed up the code

We can compute one time the probability of a photon with coordinates x,y to hit a given PMT.

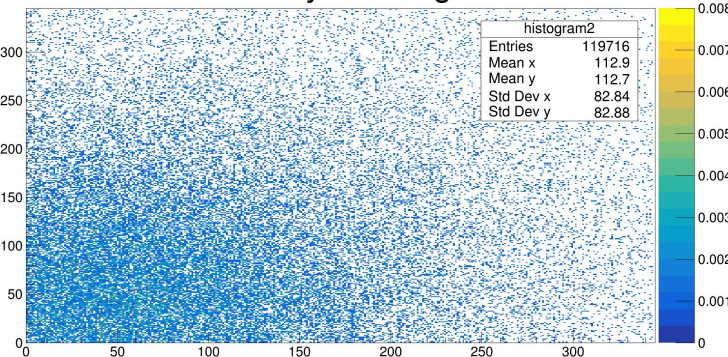
Probability of hitting PMT4



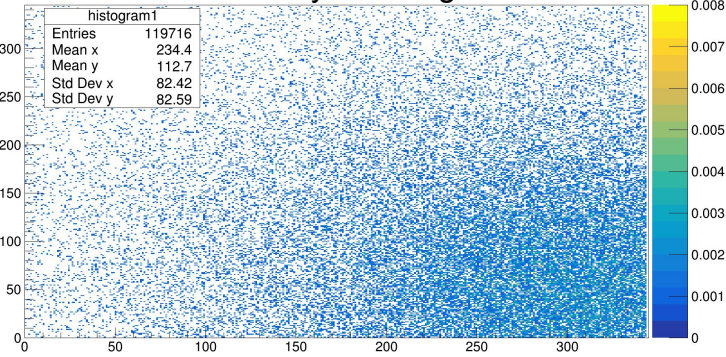
Probability of hitting PMT1



Probability of hitting PMT3



Probability of hitting PMT2

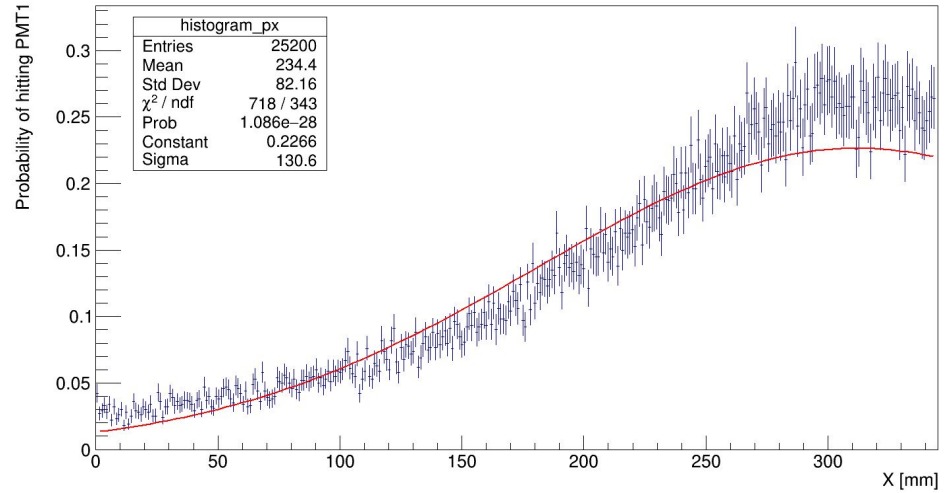


Example of maps with a resolution of 1mm x 1mm. And 1000 photons in each position. (computing time for 346mm x 346mm is **4 hours**)

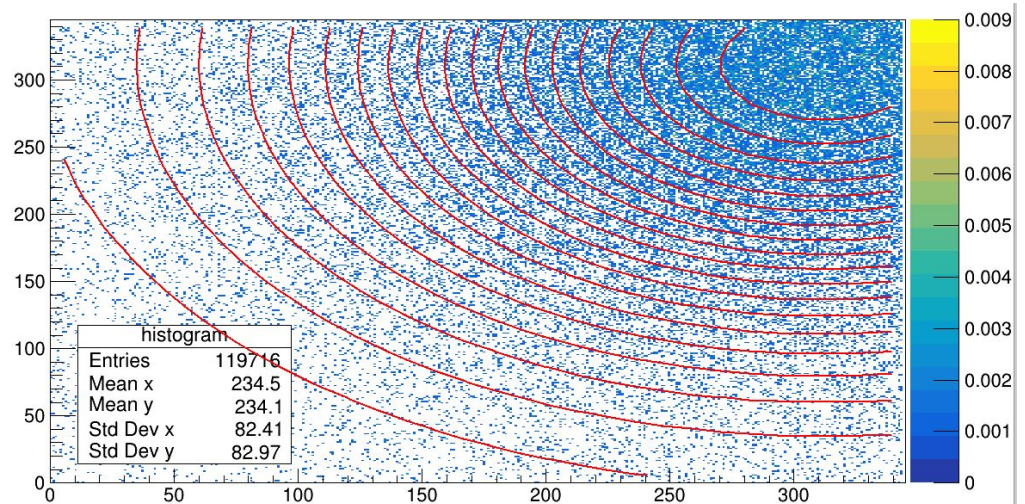
Fitting the map

First, fitted the x profile with gaussian (the map is completely symmetric). Fixing $x_{\text{mean}}=312$ (PMT position)

Then used mean and sigma to fit with 2D gaussian

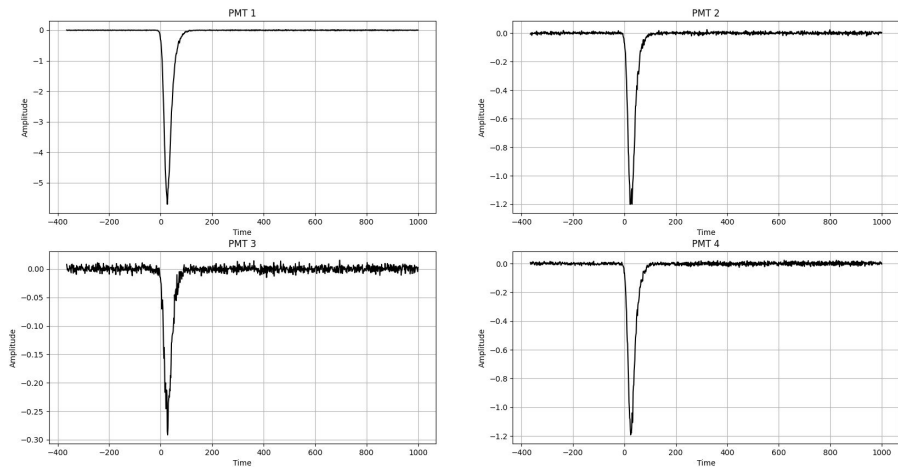


EXT NO.	PARAMETER NAME	VALUE	ERROR	STEP SIZE	FIRST DERIVATIVE
1	Constant	1.68744e-03	1.12062e-05	3.00000e-04	3.58004e-02
2	MeanX	3.12000e+02	fixed		
3	SigmaX	1.30000e+02	fixed		
4	MeanY	3.12000e+02	fixed		
5	SigmaY	1.30000e+02	fixed		

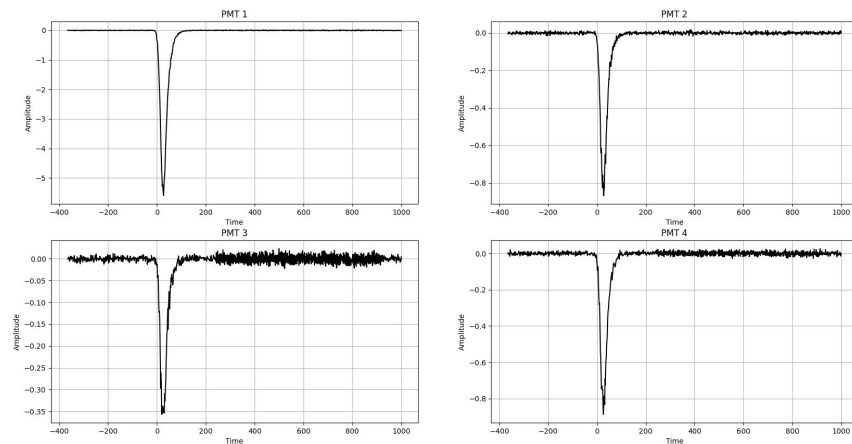


PMT Simulation with map (non-centered 8 keV ER spot at $z = 50$ mm)

With map (15 min/event)



Without map (20 min/event)



Conclusions

- PMT simulation is now integrated in the main simulation
- We need to make it faster (especially signal generation)
- Maybe parallelize signal generation on 4 cores, one for each PMT
- Decide how to save the final PMT waveforms (in root?)