PMT Simulation
Quantum efficiency

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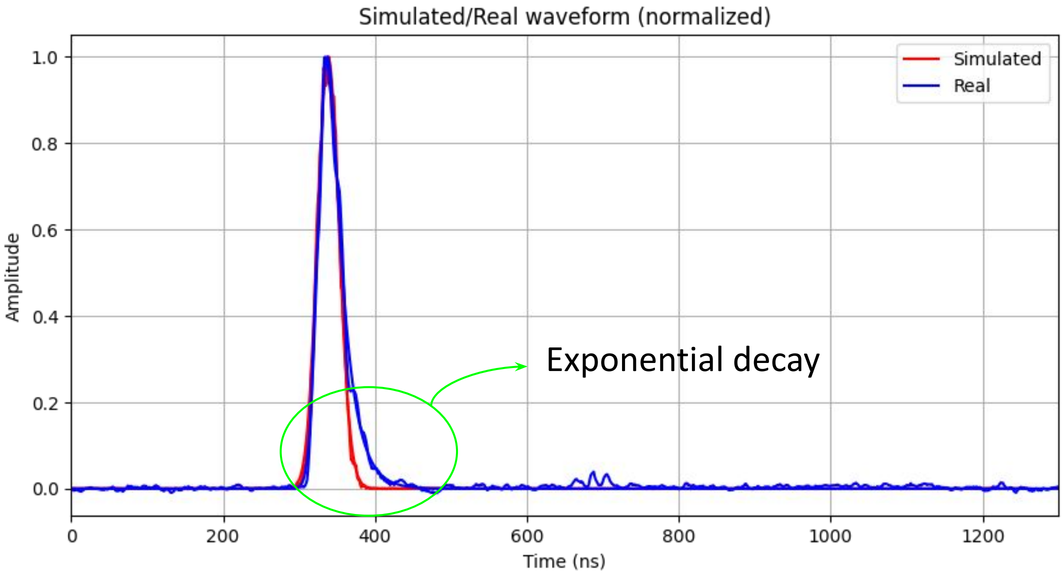
Introduction

In my last presentation…

- Difference between the full widths of the waveforms



Next steps

- Do a complete analysis
  - Average width, integral, amplitude, RMS, SNR, as a function of the position of the iron source (X , Y , Z)
  - Camera + PMT reco codes
- Simulate different tracks with different energies

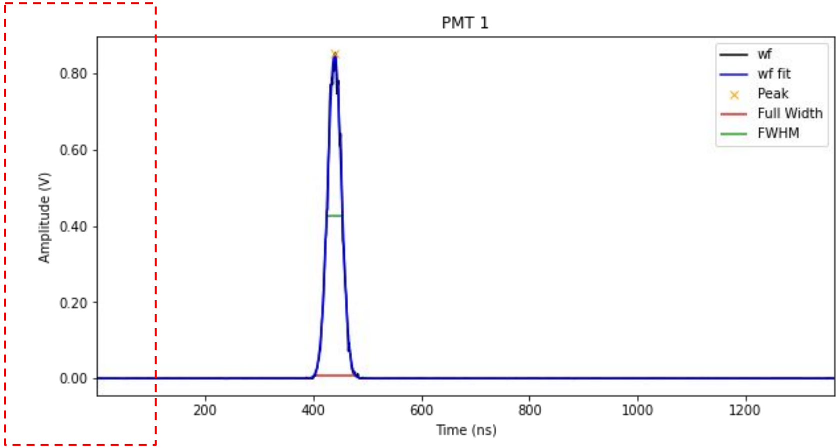
Introduction

Knew problem:

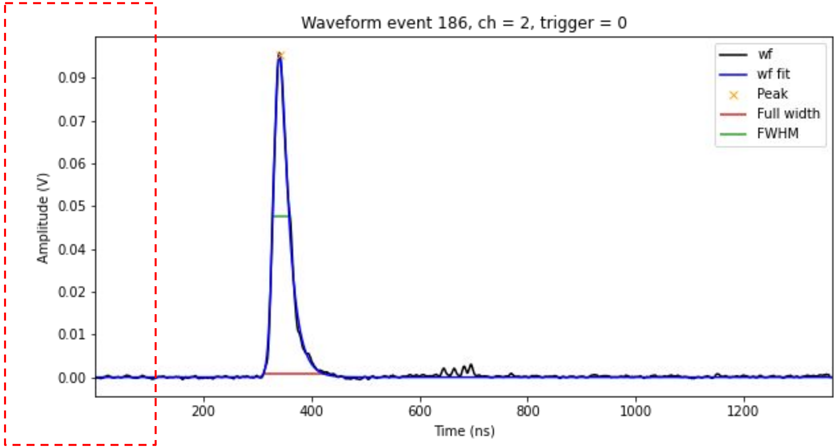
- 55Fe waveforms height peaks

Example (Step 5 = 46.6 cm)

Simulation



Real data



Introduction

The waveform amplitude is related to:

- SPE amplitude distribution
- Number of photons produced by the GEMs
- Photon propagation
- PMT quantum efficiency
- Gain of the GEMs
- X-Y-Z position

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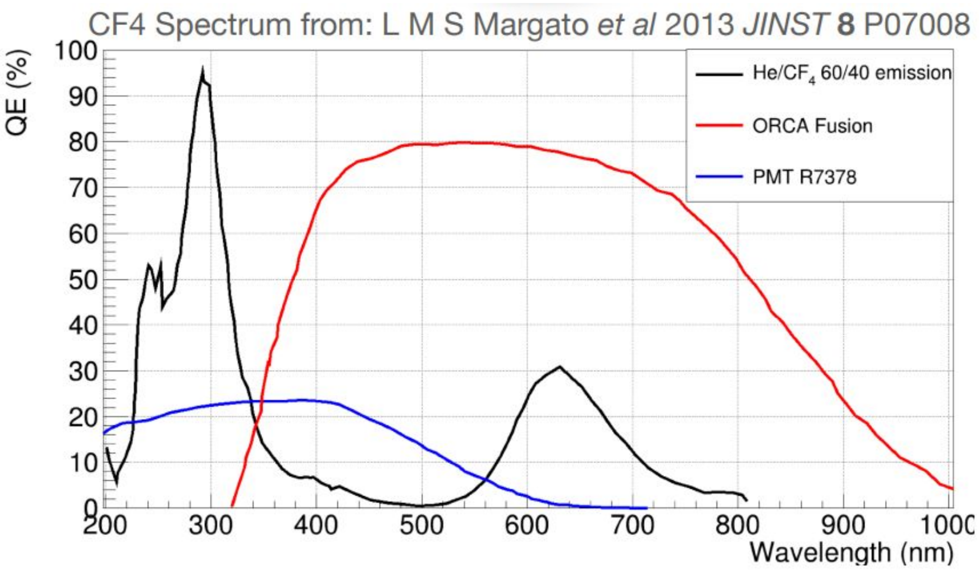
In this presentation

PMT quantum efficiency tuning

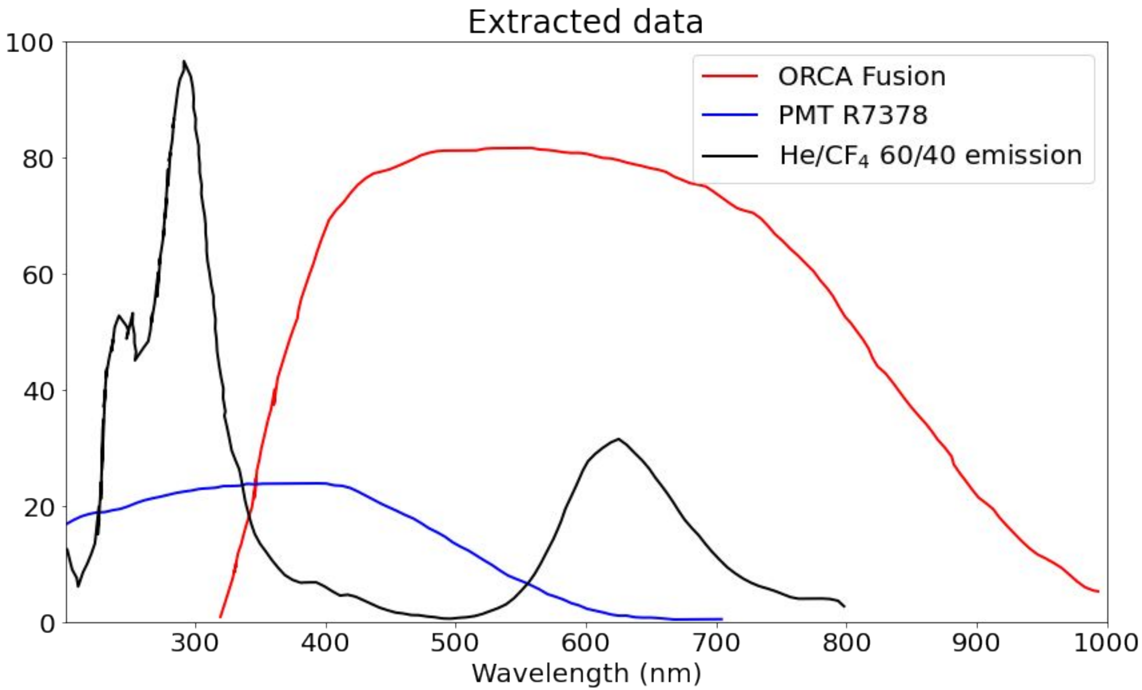
Spectrum analysis



Reference

- Spectrum of the produced light
- Camera quantum efficiency
- PMT quantum efficiency

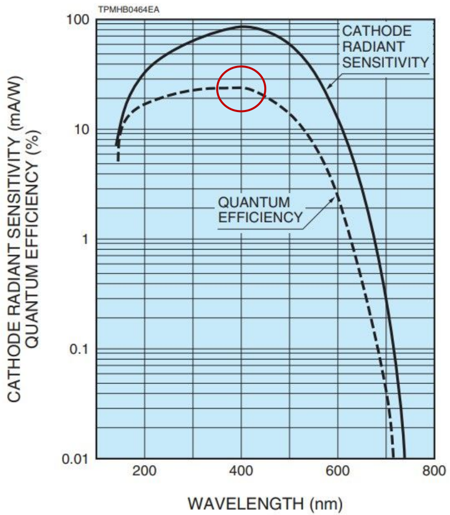
Spectrum analysis



Method

Current method

- Unique value of quantum efficiency for all photons

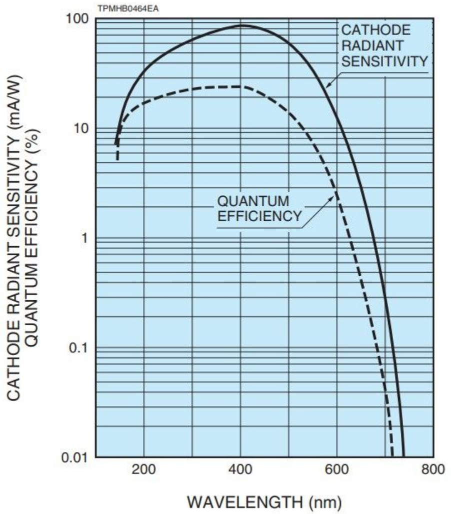


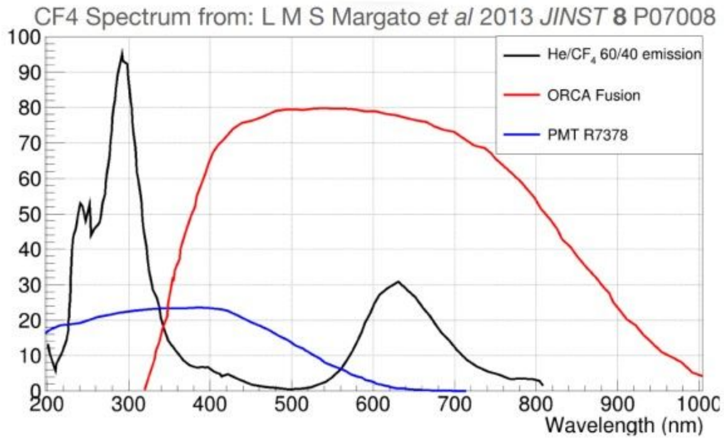
- Wavelength = 400 nm
- Quantum efficiency = 26%

Method

Verifying the spectrum

- Most of the produced photons are around 200-350 nm and 500-800 nm





New method

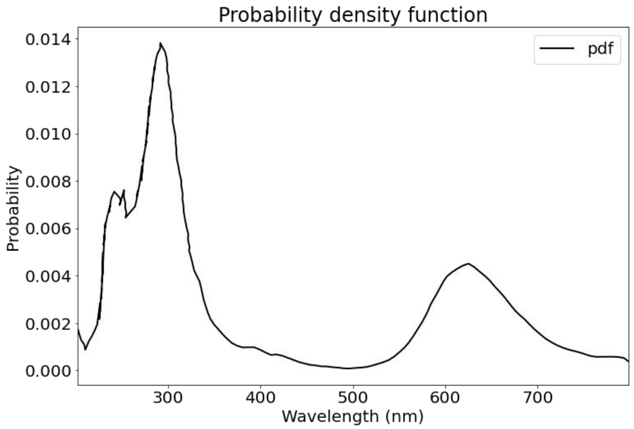
Method 1 (photon by photon)

1. Create a probability density function from light spectrum;
2. Draw a random wavelength from the pdf;
3. Get the quantum efficiency for the drawn wavelength sample (pmt quantum eff. plot)
4. Apply the quantum efficiency for the photon

New method

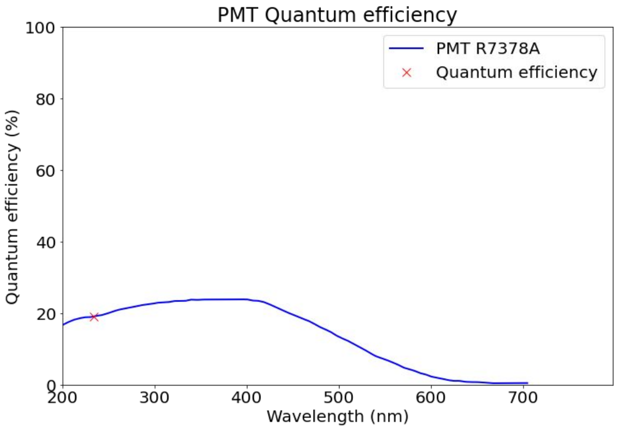
Method 1 example

Step 1



Drawn wavelength = 234 nm

Step 2



Quantum efficiency = 19.07%

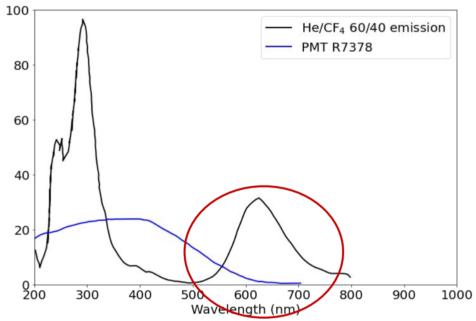
Step 3

Unsuccessful hit

New method

Method 2 (all photons)

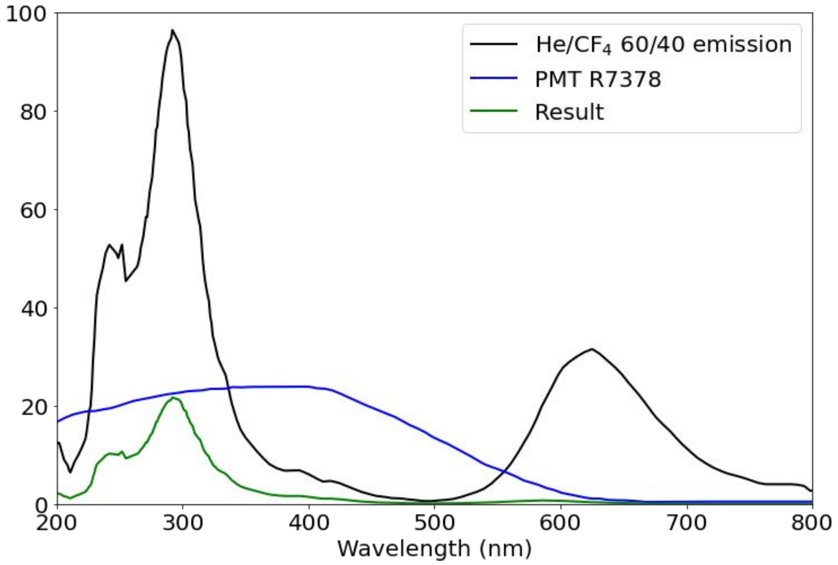
1. Multiply light spectrum and PMT quantum efficiency
2. Calculate area under resulted curve
3. Get percentage of photons that successful hit the pmt
4. Apply the percentage to all photons produced by the GEMs



→ Photons above 600 nm will be almost completely eliminated

New method

Method 2 (all photons)



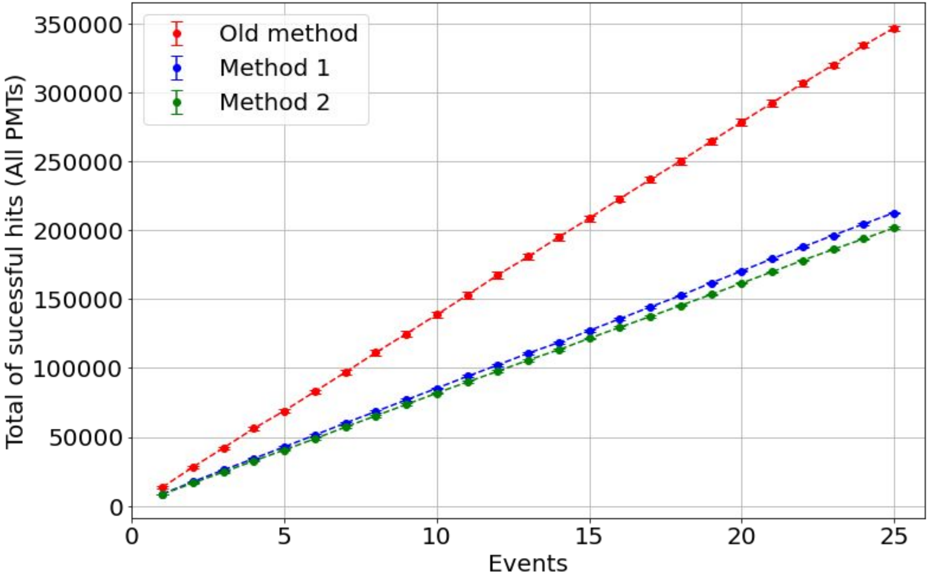
$$\frac{Area_{green\_curve}}{Area_{black\_curve}} = 15\%$$

15% of produced photons by the GEMs will hit the PMT successfully

Multiply the number of produced photons by this value before simulating the PMT

Method comparison

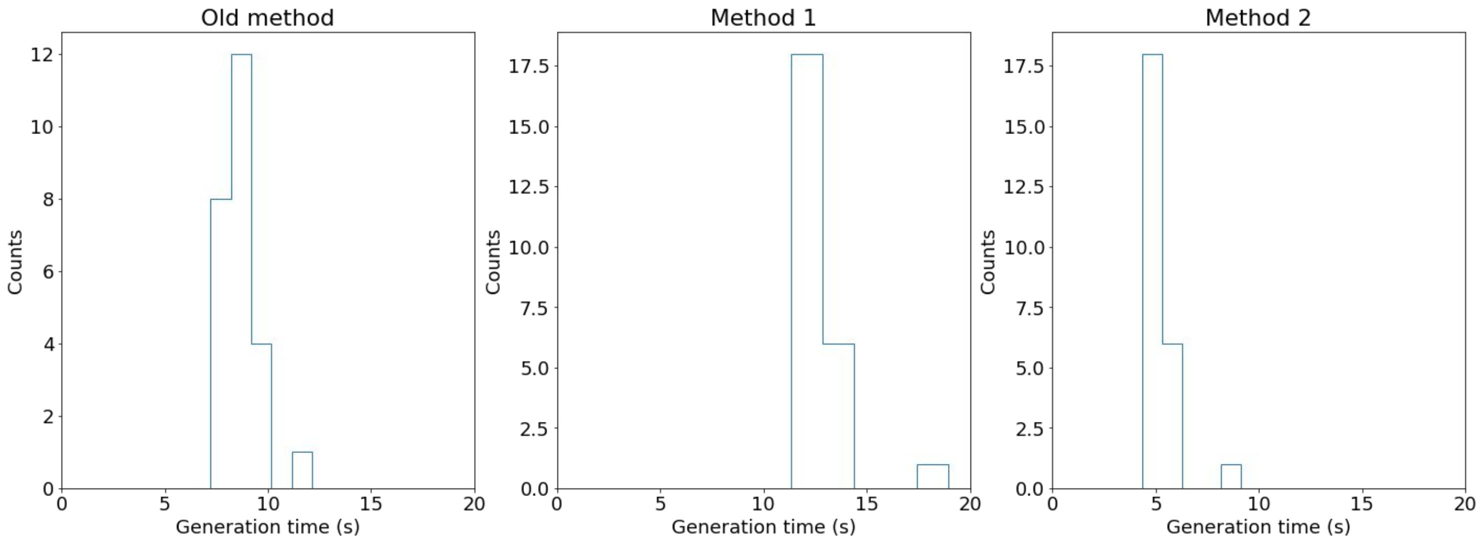
Total of successful hits x Events (cumulative)



Events: centered 55Fe spots at z = 100mm

Method comparison

Generation time comparison

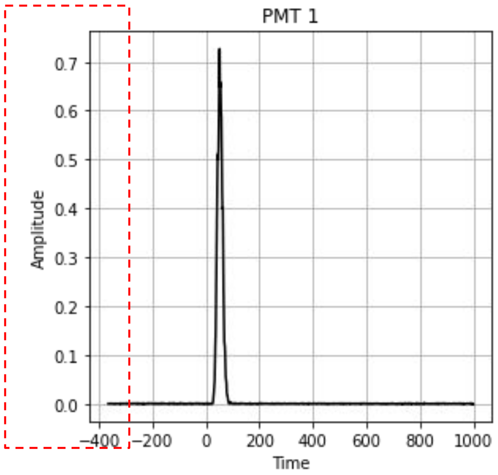


Events: centered 55Fe spots at z = 100mm

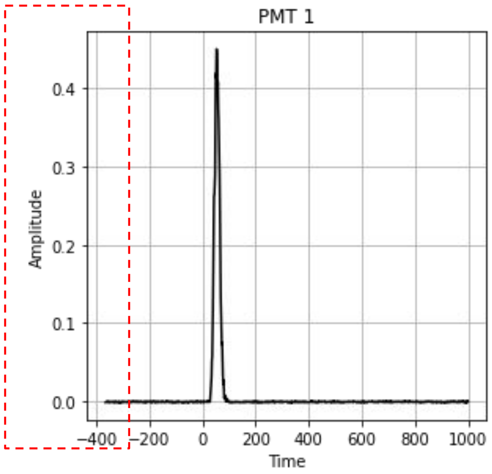
Method comparison

Amplitude comparison
(centered 6 keV spot at z = 100mm)

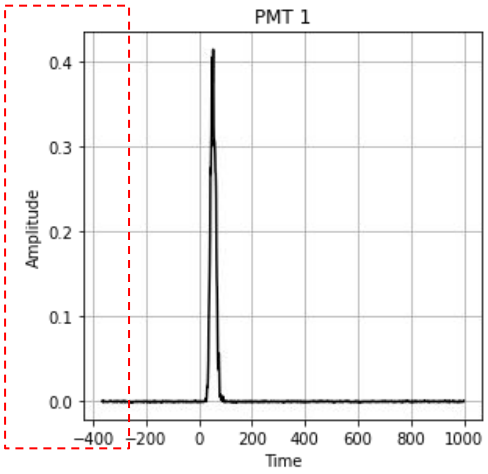
Old method



Method 1



Method 2



Events: centered 55Fe spots at z = 100mm

Conclusion

Method 1

- Slower than old method
- Generation time increases with the number of photons of each voxel
    - Due photon by photon procedure
- Creates the possibility of labeling the wavelength of each photon
    - Might be useful in the future

Method 2

- Faster than old method
- Similar result to method 1