PMT Simulation
sim/data comparison

Z diffusion analysis

Presented by: Luan Gomes
Universidade Federal de Juiz de Fora (UFJF)

*with **Davide Pinci** (INFN-Roma I), **Mariana Migliorini** and **Rafael A. Nóbrega** (UFJF)*
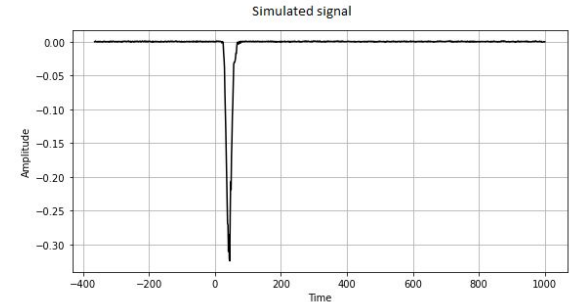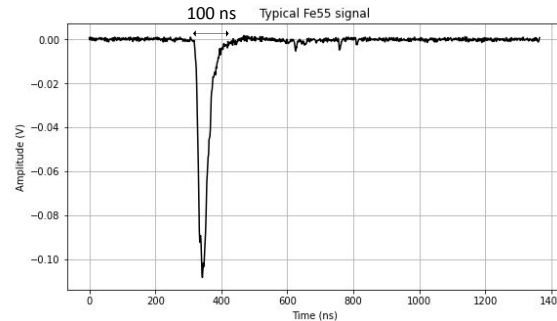
October 30, 2023

Introduction

In my last presentation… the signal width problem:

Proposed solutions:

- Verify the longitudinal diffusion parameters

- Review the SPE characterization

- New dispersion study

Was not considering the Z distance from the GEM!!!

Introduction

In this analysis:

- Based on runs of Fe55 source

- Selected just events with <u>one cluster</u>

- Used PMT reco code for real data analysis

- 12170: Step 1 = 5.0 cm

- 12245: Step 1 + 6 divisions = 11.0 cm

- 12171: Step 2 = 15.1 cm

- 12246: Step 2 + 6 divisions = 21.1 cm   **Fe55 runs**

- 12172: Step 3 = 25.1 cm

- 12173: Step 4 = 35.1 cm

- 12174: Step 5 = 46.6 cm

Introduction

Points to consider in this analysis:

- Focusing on the Z distance from the GEM

  - Not considering the X-Y position of the tracks

- Not associating channels with PMTs

- Simulated centered 6 keV tracks

General analysis to verify the Z diffusion

Parameters to be verified:

- Full width at half maximum (FWHM)

- Full width
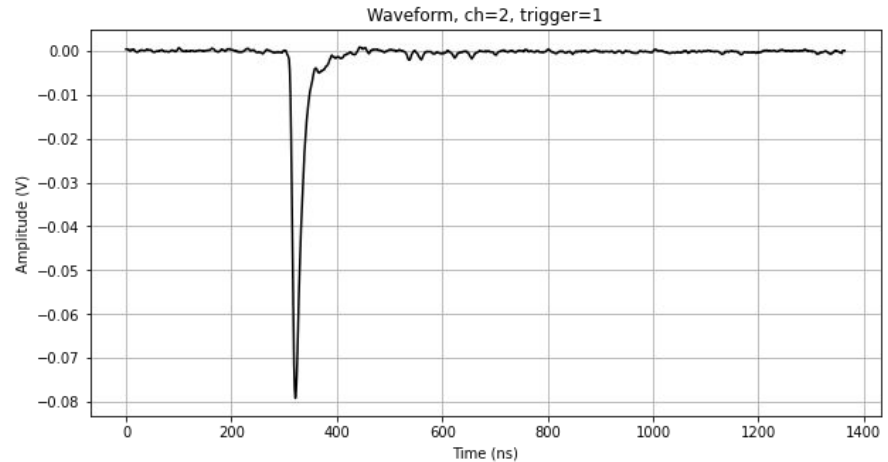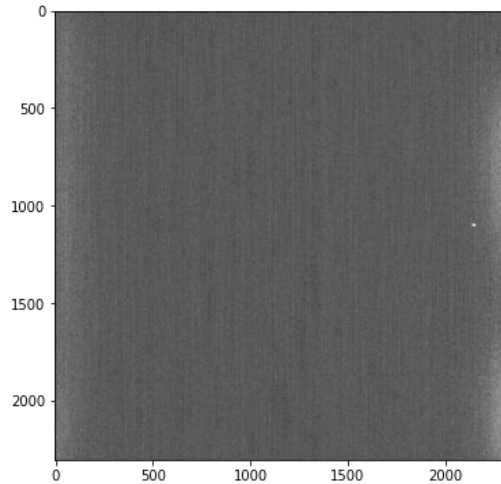
  Using Exp. Gaussian fits

Z diffusion coefficients

'diff_const_sigma0L': 0.0676, # diffusion constant [mm]^2

'diff_coeff_L' : 0.00978, # diffusion parameter [mm/sqrt(cm)]^2 for 1 kV

ConfigFile_Fe55_5867-5911.txt

Real data analysis

Run 12170: Step 1 = 5.0 cm | 401 events

One cluster events: [11, 23, 27, 49, 50, 63, 94, 103, 148, 188, 200, 204, 228, 283, 345, 356, 375, 386, 397]
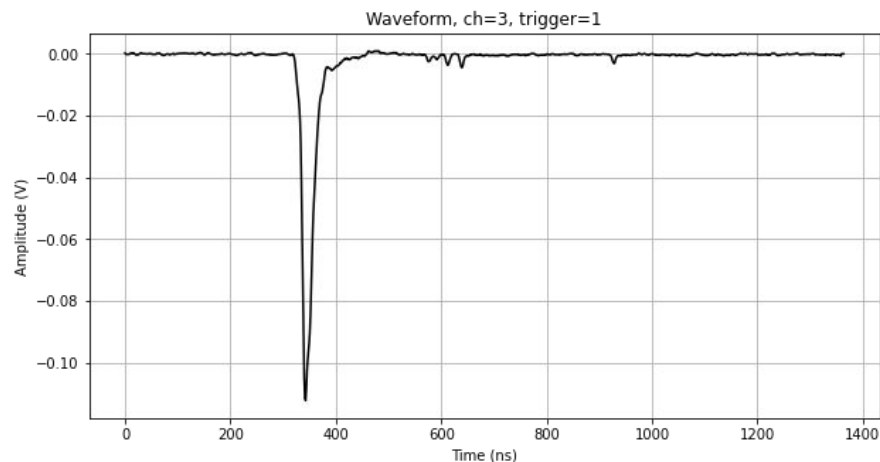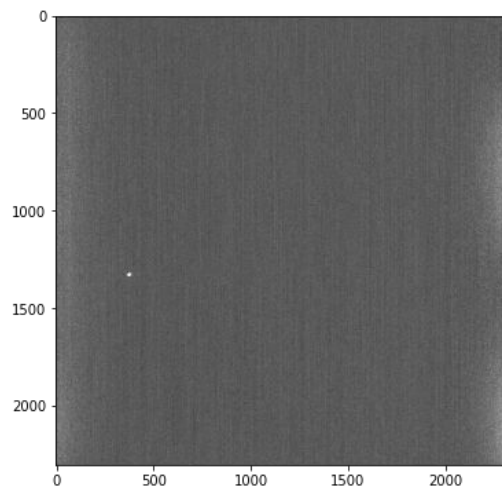
Example: event 11

Real data analysis

Run 12245: Step 1 + 6 divisions = 11.0 cm | 401 events

One cluster events: [53, 68, 99, 122, 125, 183, 188, 212, 254, 288, 298, 307, 333, 400]
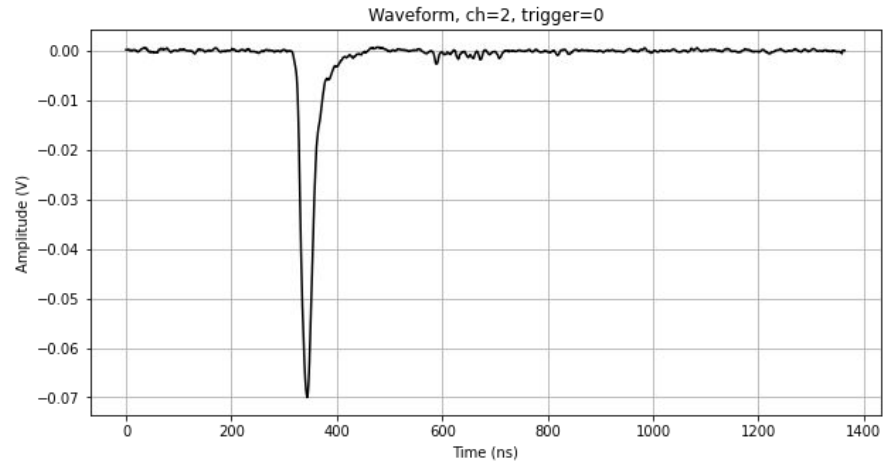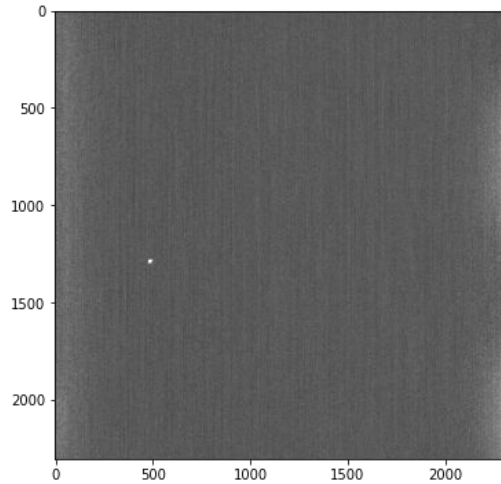
Example: event 53

Real data analysis

Run 12171: Step 2 = 15.1 cm | 403 events

One cluster events: [15, 34, 47, 63, 104, 119, 154, 194, 197, 204, 235, 251, 265, 276, 277, 287, 298, 334]

Example: event 15

Real data analysis

Run 12246: Step 2 + 6 divisions = 21.1 cm | 403 events

One cluster events: [33, 215, 274, 318, 326, 362, 397]

Example: event 33
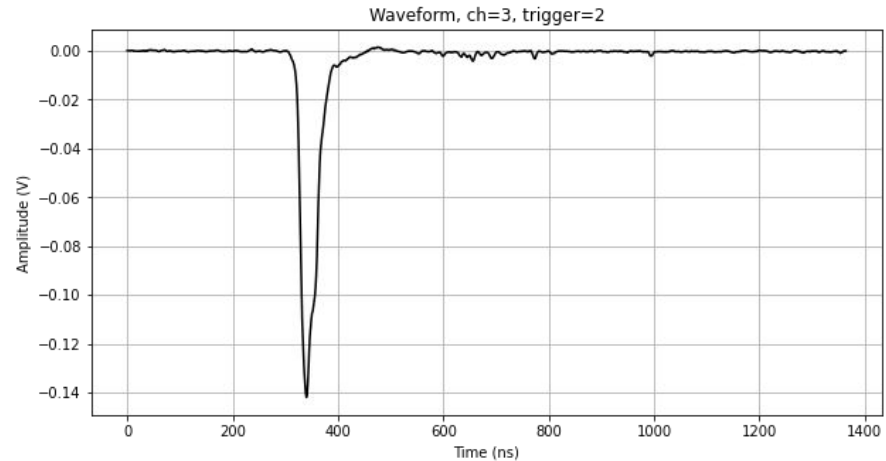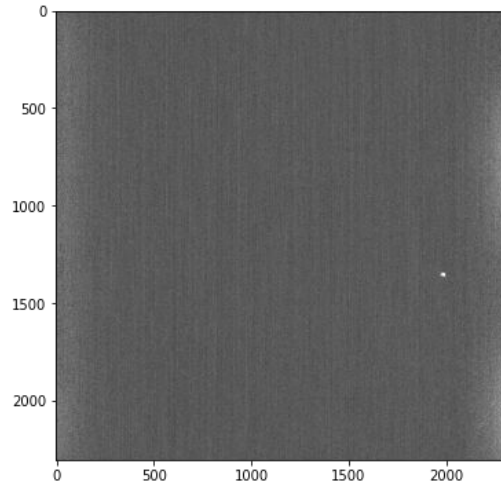
Real data analysis

Run 12172: Step 3 = 25.1 cm | 403 events

One cluster events: [87, 89, 103, 125, 135, 168, 193, 211, 241, 244, 251, 257, 288, 323, 342, 357, 366]

Example: event 87
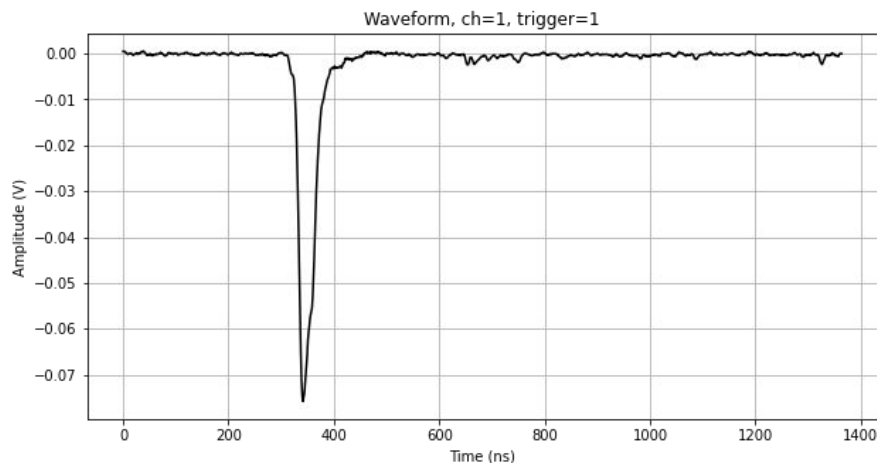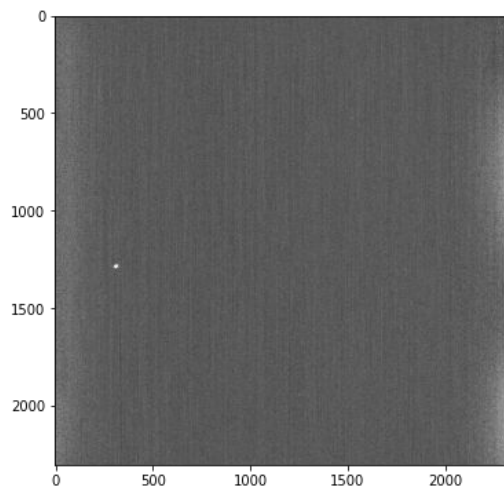
Real data analysis

Run 12173: Step 4 = 35.1 cm | 404 events

One cluster events: [13, 25, 68, 93, 154, 156, 168, 177, 178, 186, 194, 203, 224, 247, 252, 262, 266, 268, 303, 394]
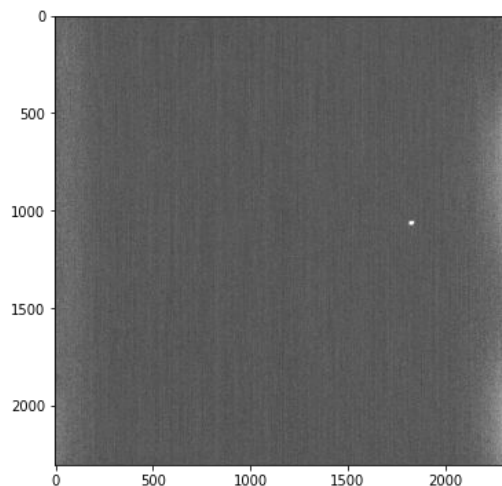
Example: event 25
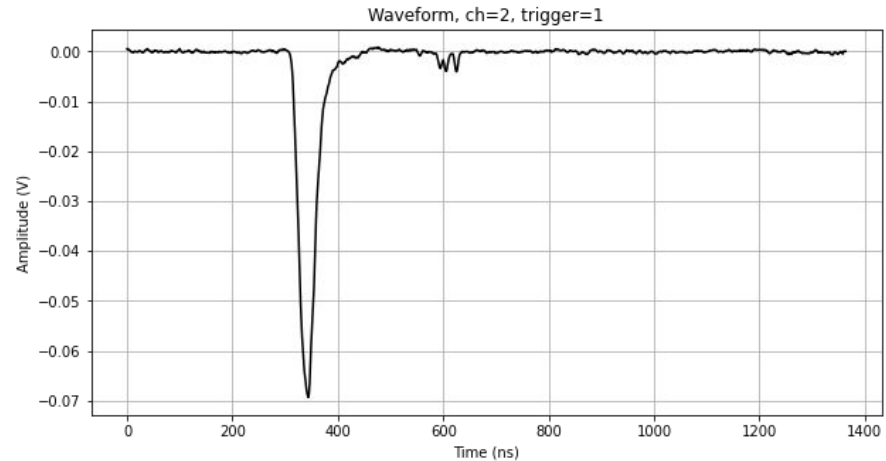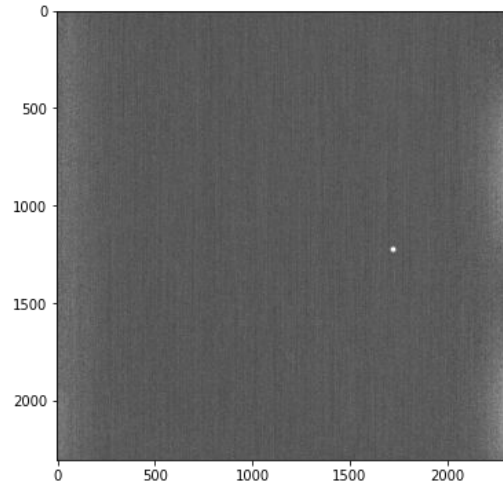
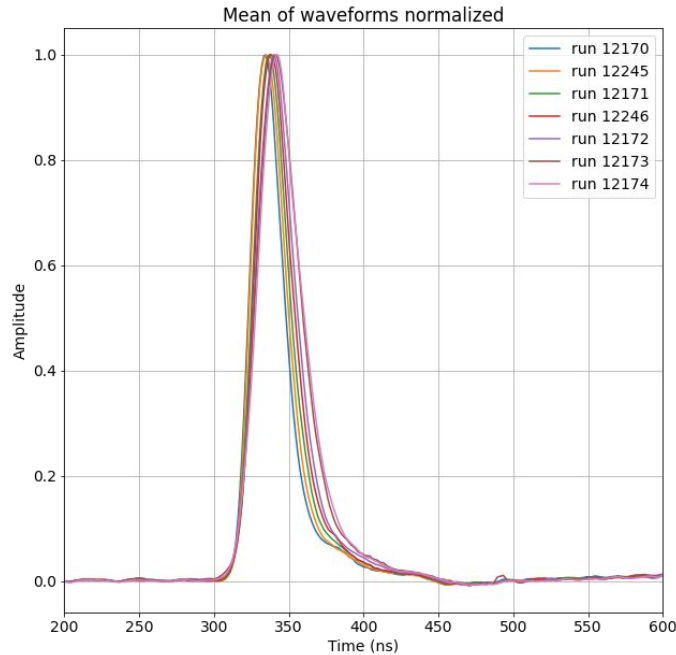# Real data analysis

Run 12174: Step 5 = 46.6 cm | 402 events

One cluster events: [42, 51, 53, 63, 103, 112, 141, 237, 265, 272, 306, 328, 332, 334, 335, 339, 357, 366, 383, 388]

Example: event 53
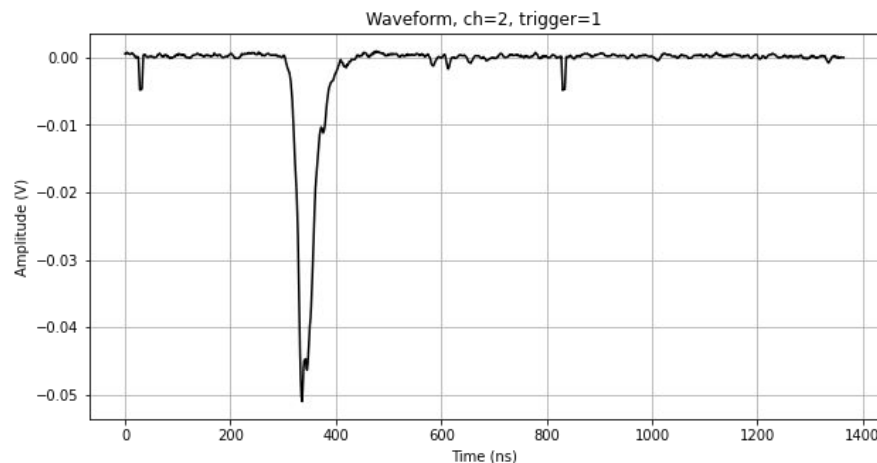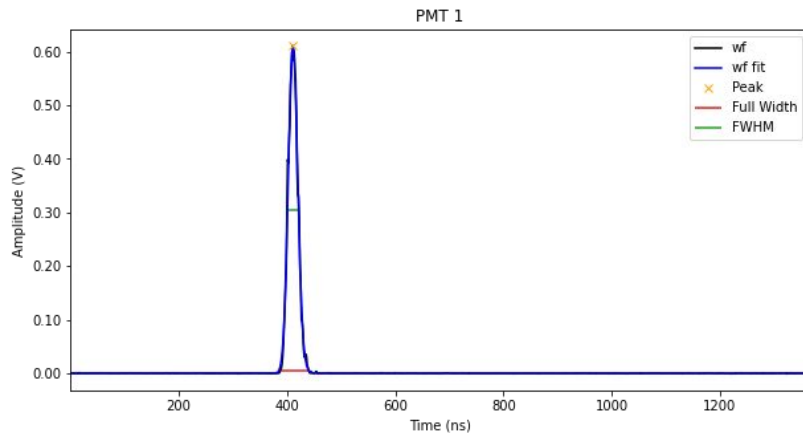
Comparison of the mean of one cluster waveforms

Mean of waveforms normalized

Sim/Real data analysis

Step 1 = 5.0 cm

One event example

Simulation

Real data

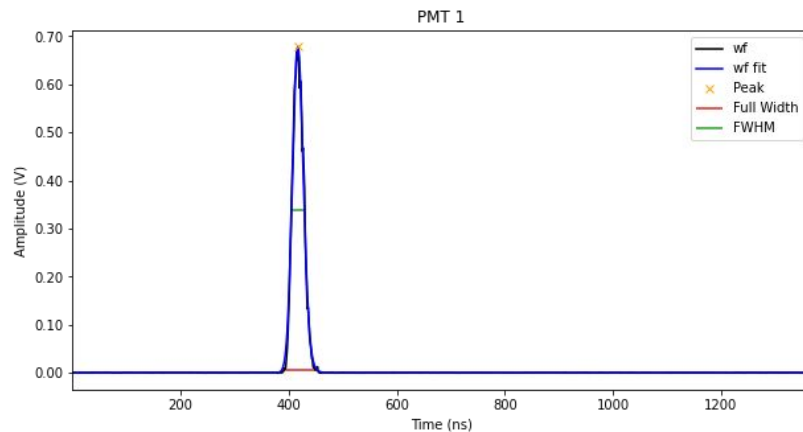FWHM = 20.4 ns
Full width = 54.4 ns
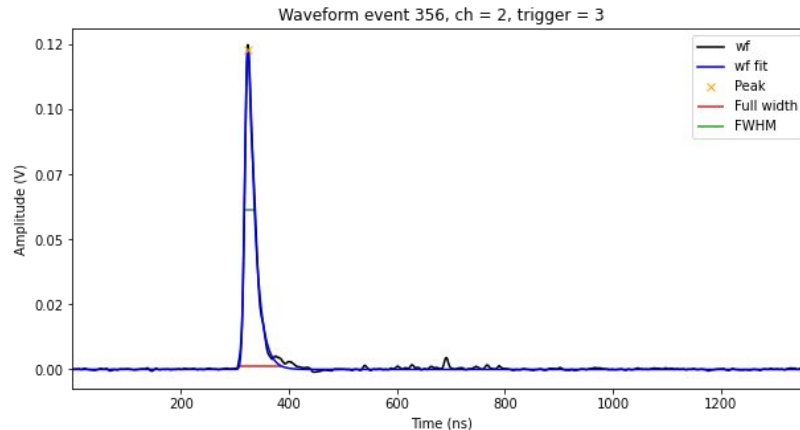
FWHM = 18.8 ns
Full width = 78.8 ns

Sim/Real data analysis

Step 1 + 6 divisions = 11.0 cm

One event example

Simulation

Real data

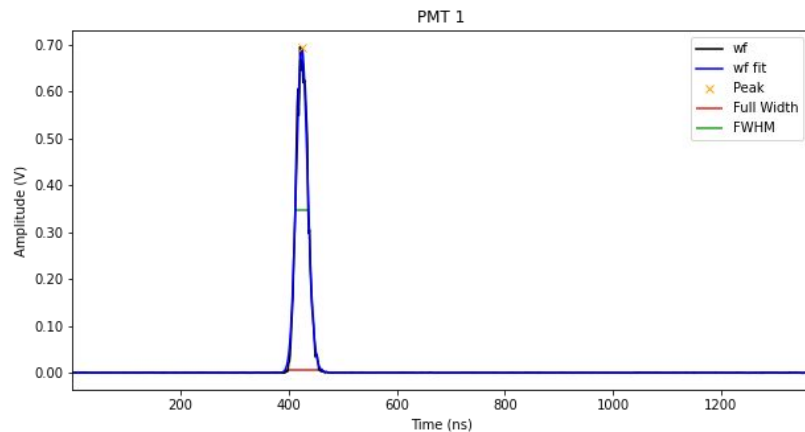FWHM = 23.6 ns
Full width = 64.2 ns
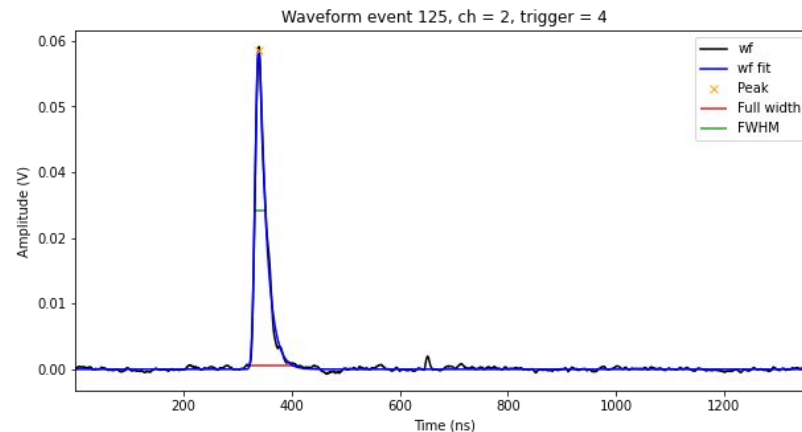
FWHM = 19.8 ns
Full width = 83.1 ns

Sim/Real data analysis

Step 2 = 15.1 cm

One event example

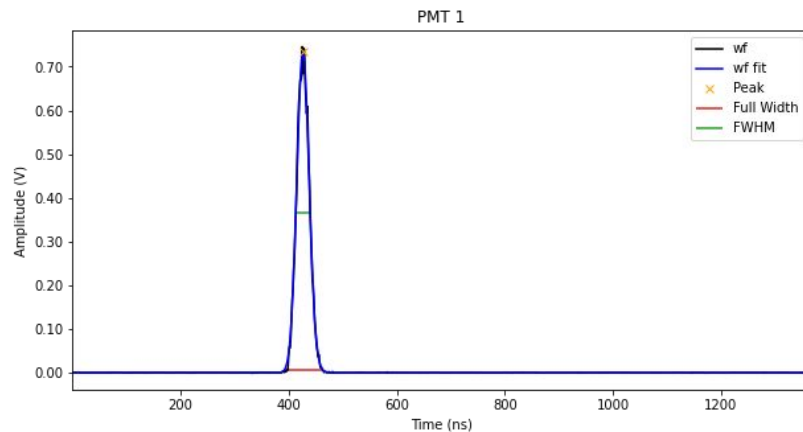Simulation

Real data

FWHM = 24.6 ns
Full width = 66.2 ns
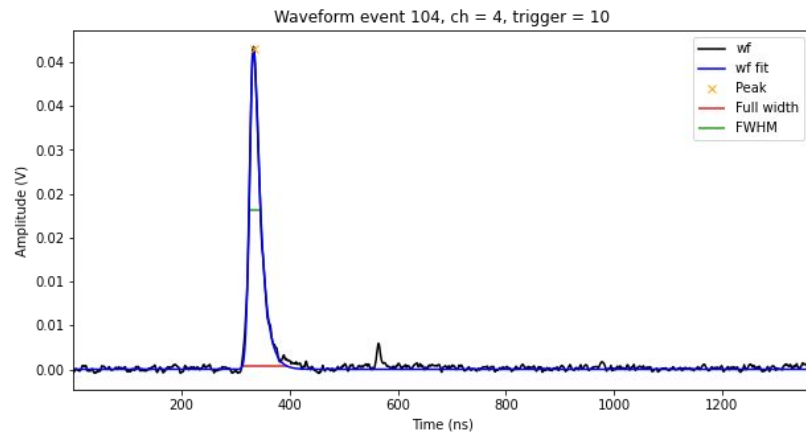
FWHM = 21.5 ns
Full width = 82.9 ns

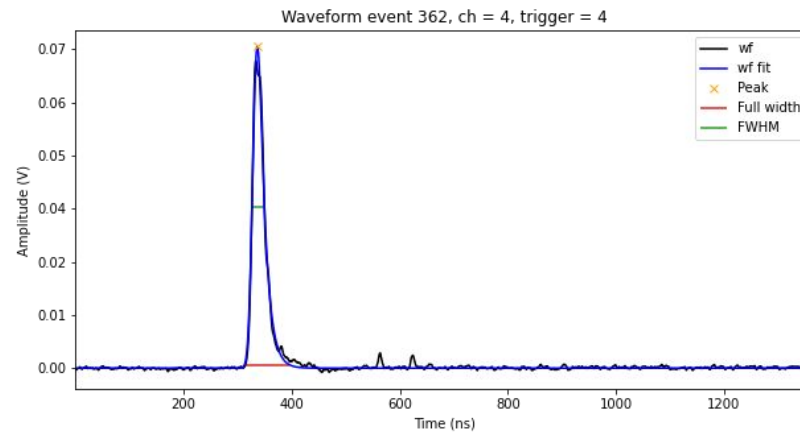# Sim/Real data analysis

Step 2 + 6 divisions = 21.1 cm

One event example

Simulation

Real data

FWHM = 26.7 ns
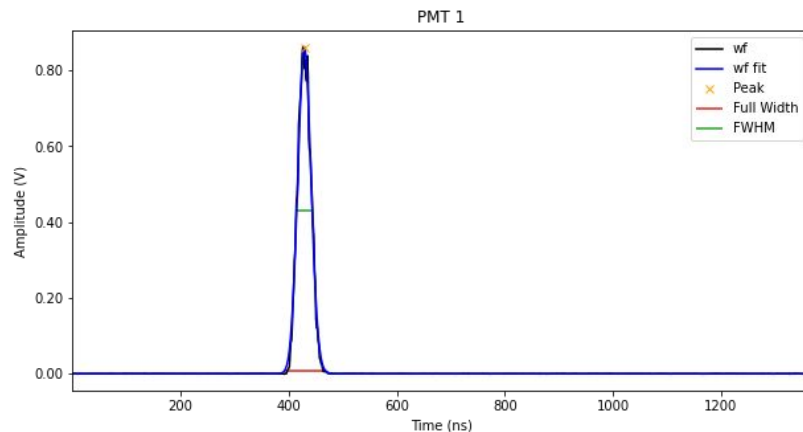Full width = 70.1 ns

FWHM = 23.18 ns
Full width = 83.1 ns

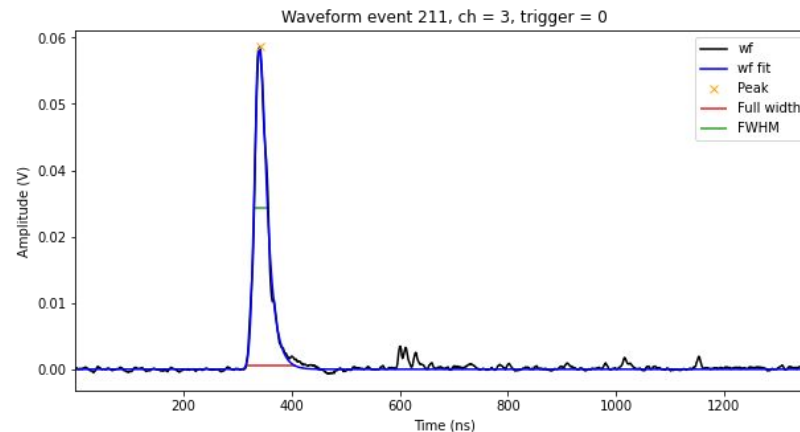# Sim/Real data analysis

Step 3 = 25.1 cm

One event example
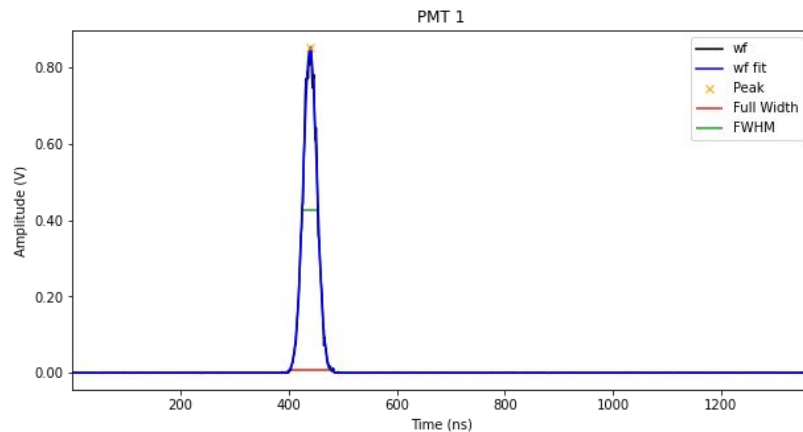
Simulation

Real data

FWHM = 28.7 ns
Full width = 75.1 ns

FWHM = 25.3 ns
Full width = 92.5 ns

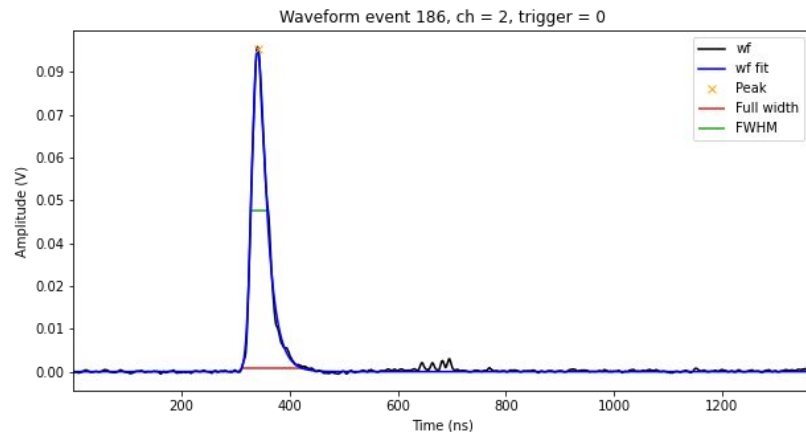# Sim/Real data analysis

Step 4 = 35.1 cm

One event example

Simulation
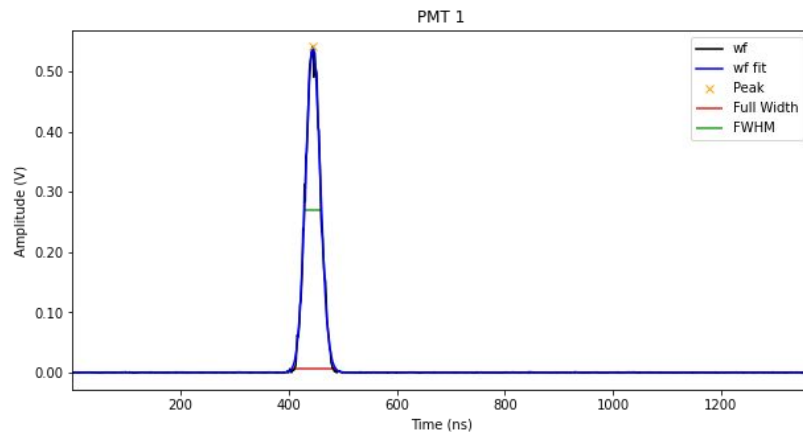
Real data

FWHM = 29.6 ns
Full width = 76.5 ns

FWHM = 30.1 ns
Full width = 112.9 ns

Sim/Real data analysis
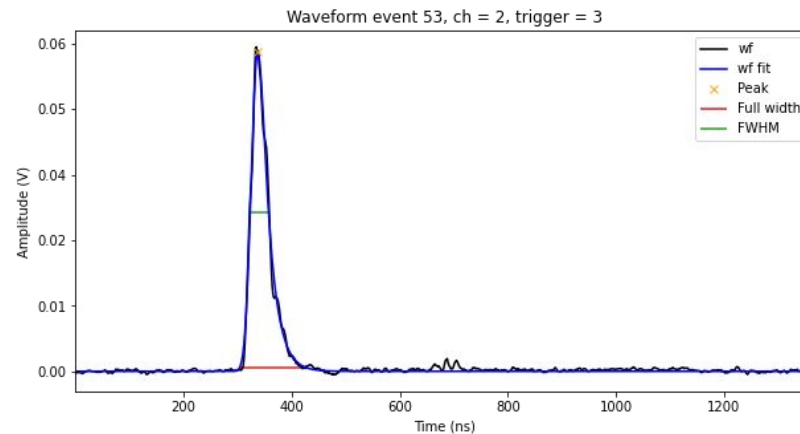
Step 5 = 46.6 cm

One event example
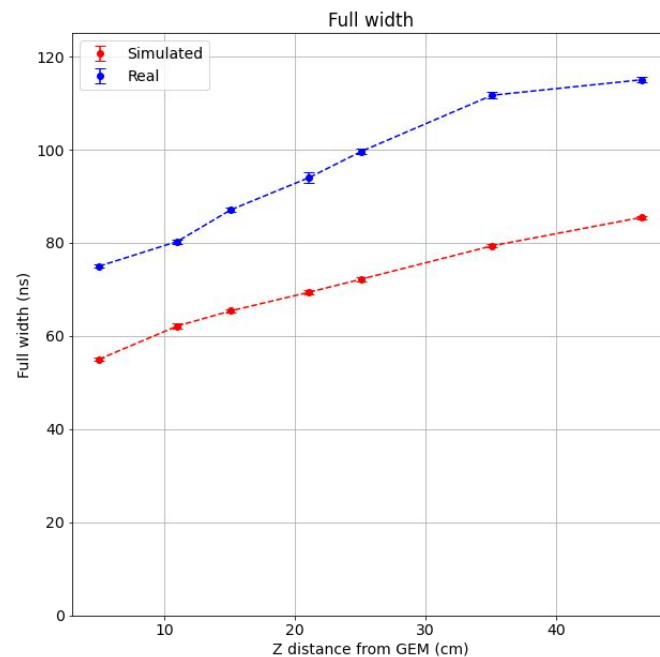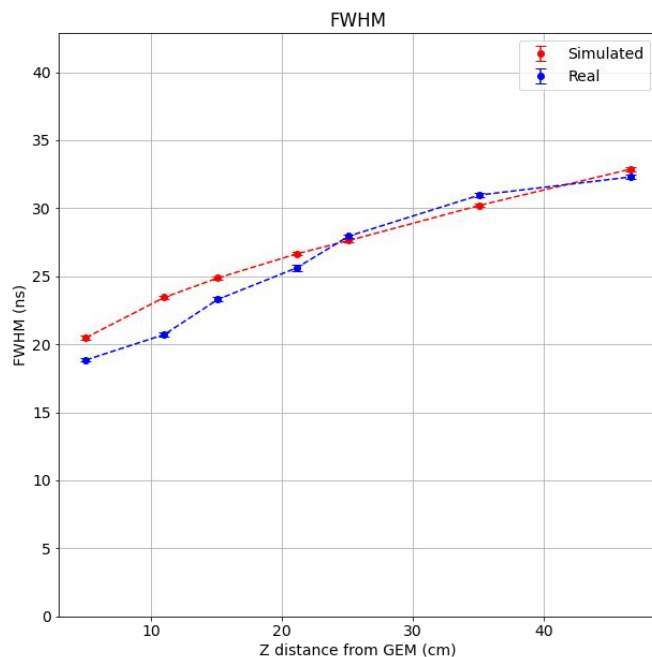
Simulation

FWHM = 31.5 ns
Full width = 82.9 ns

Real data
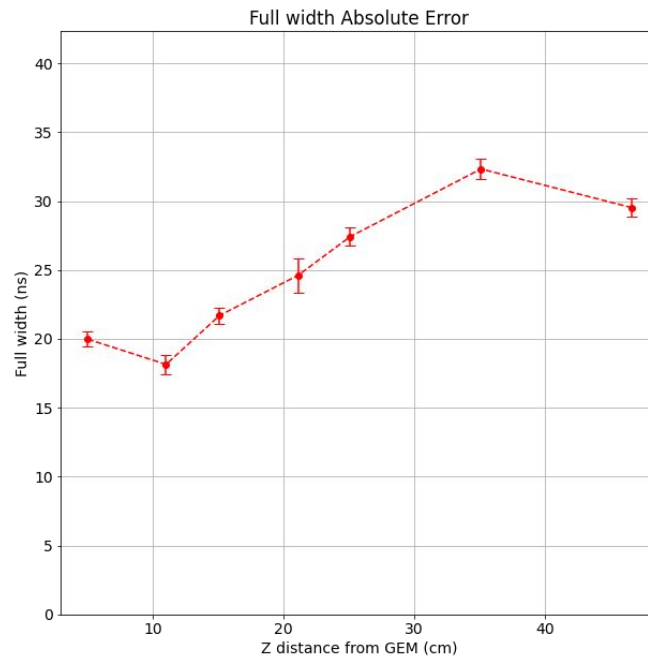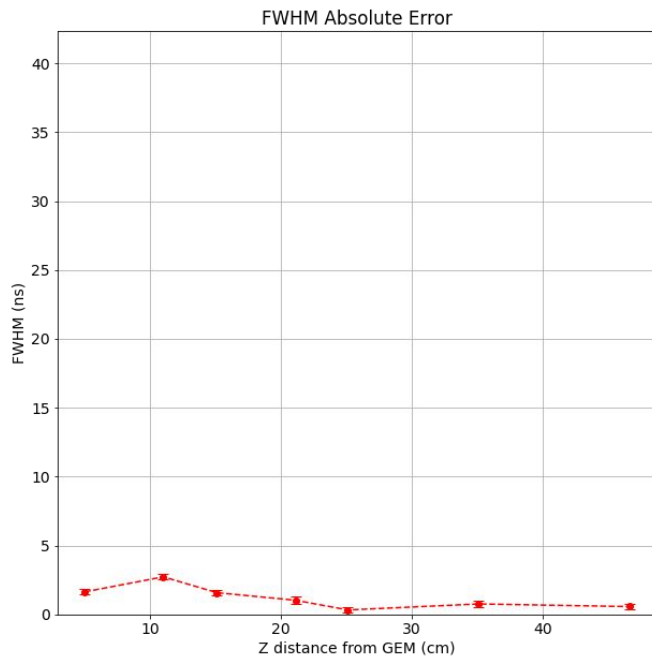

FWHM = 34.1 ns
Full width = 126.6 ns

Sim/Real data analysis

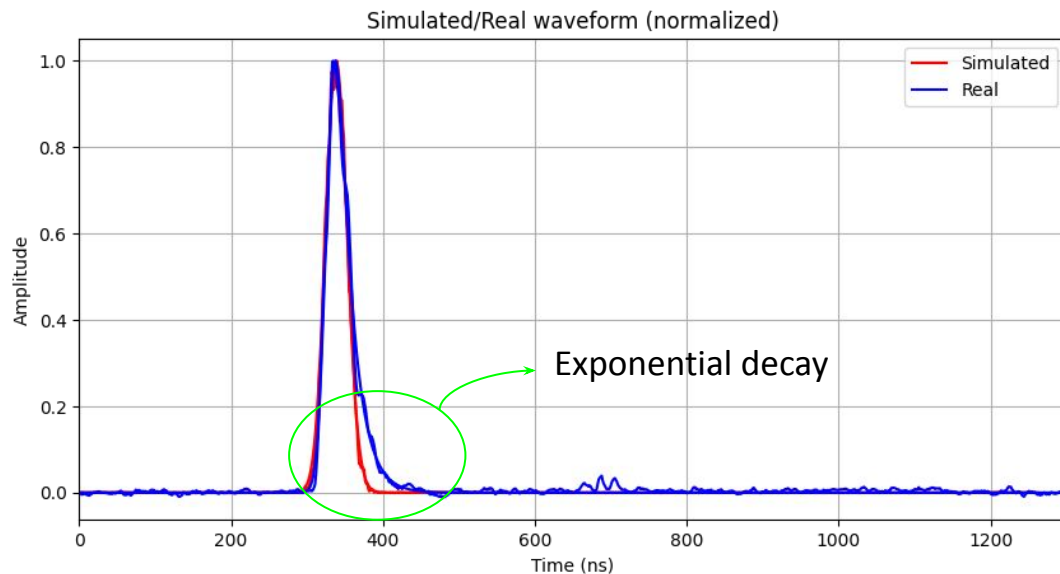**Signal width in function of the Z distance from GEM**

Sim/Real data analysis

Absolute Error of signal width in function of the Z distance from GEM
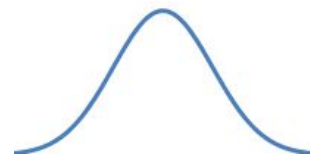
Sim/Real data analysis

Big difference between the full widths

- Example for Step 5:
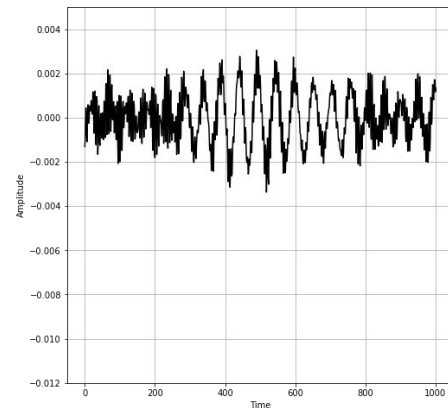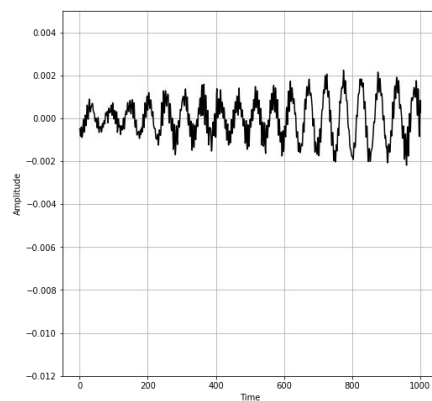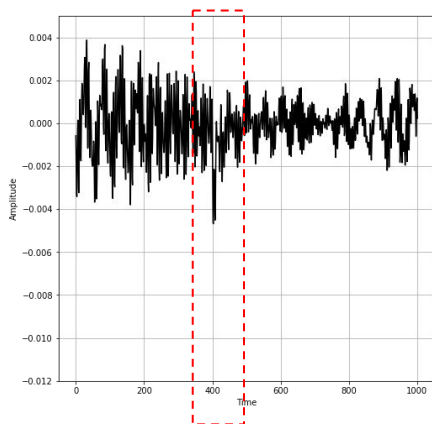

Current SPE signal shape:
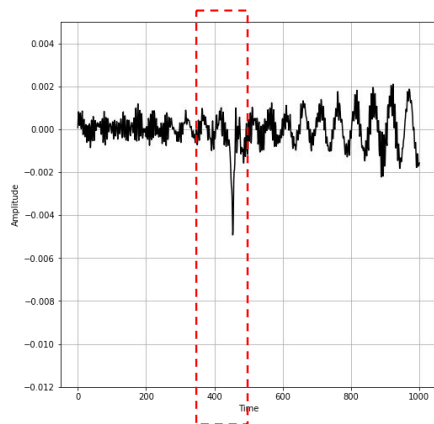
- Gaussian

Maybe:

- Exp. Gaussian

- Lognormal

The SPE characterization

● Typical signals

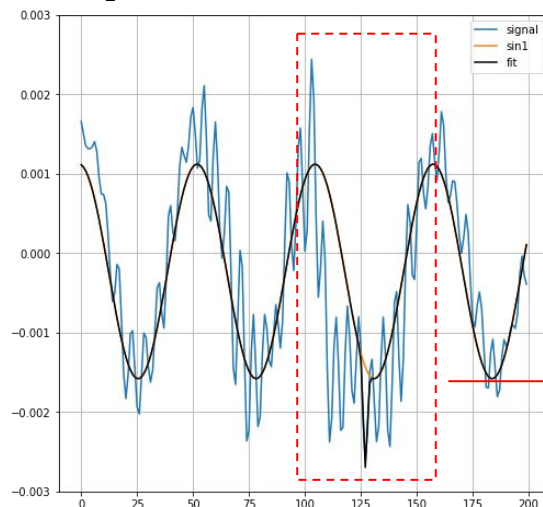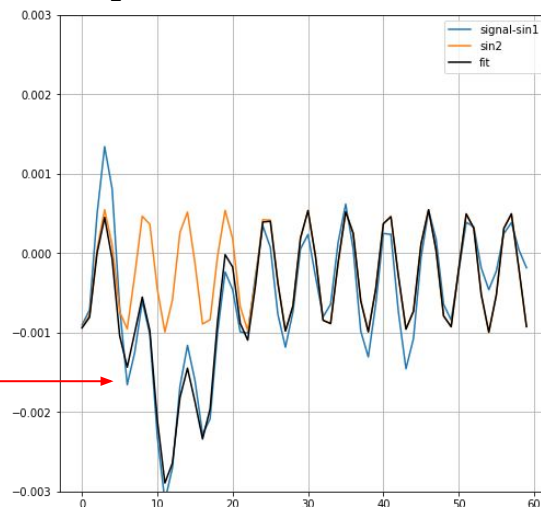…/PMT-Test-270922/BA1642_single_photoelectron

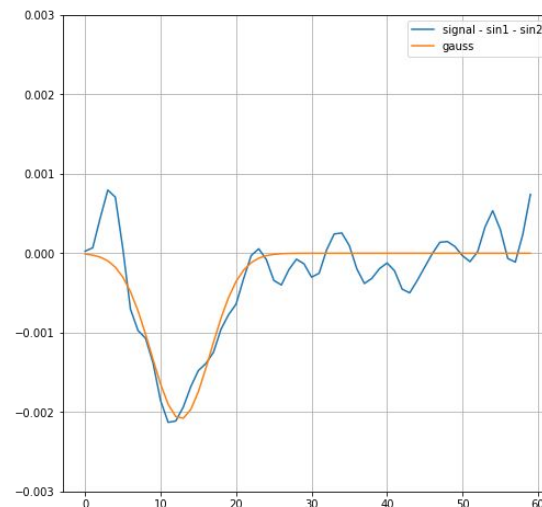# Sim/Real data analysis

The SPE characterization

- Procedure

sin₁ + gauss fit

sin₂ + gauss fit

final result

Conclusion

Conclusions

- FWHM is very similar

- Full width has a large difference due exponential decay in the real waveform shape

  ○ PMT saturation, SPE signal shape, missing dispersion ? ? ?

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   Verify SPE amplitude distribution

- Simulate different tracks with different energies