PMT Signal Characterization

Presented by: ***Rafael A. Nóbrega***
Universidade Federal de Juiz de Fora (UFJF)

with ***Davide Pinci*** *(INFN-Roma I),* ***Luan Gomes*** *and* ***Mariana Migliorini*** *(UFJF)*

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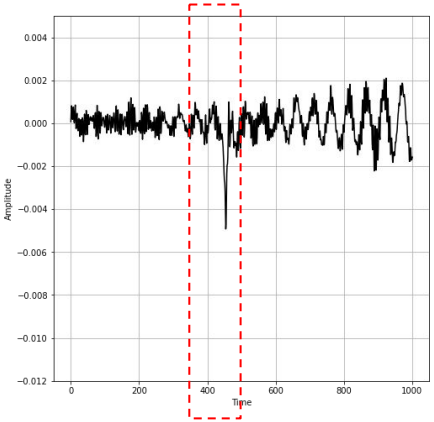
Introduction

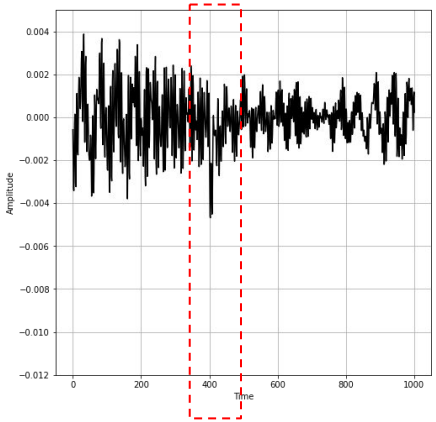
- **We need to characterize noise and SPE signal of the PMTs**
  - For the SPE signal, we need:
    - Amplitude distribution
    - Signal shape

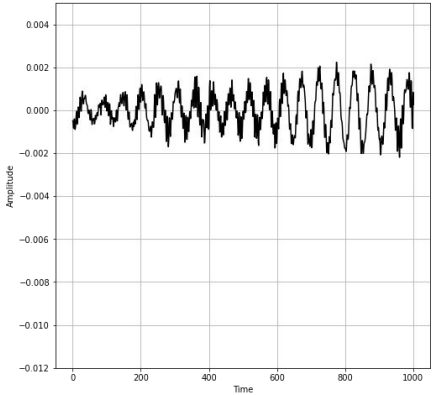
- **Used database:** …/PMT-Test-270922/BA1642_single_photoelectron
  - LED emitting photons to a PMT
  - Sampling rate 1 GS/s
  - ~1000 acquisitions

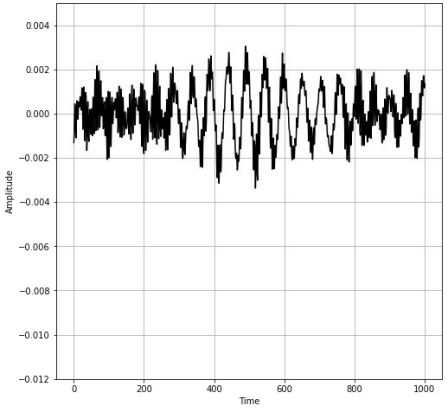
Introduction

Typical signals





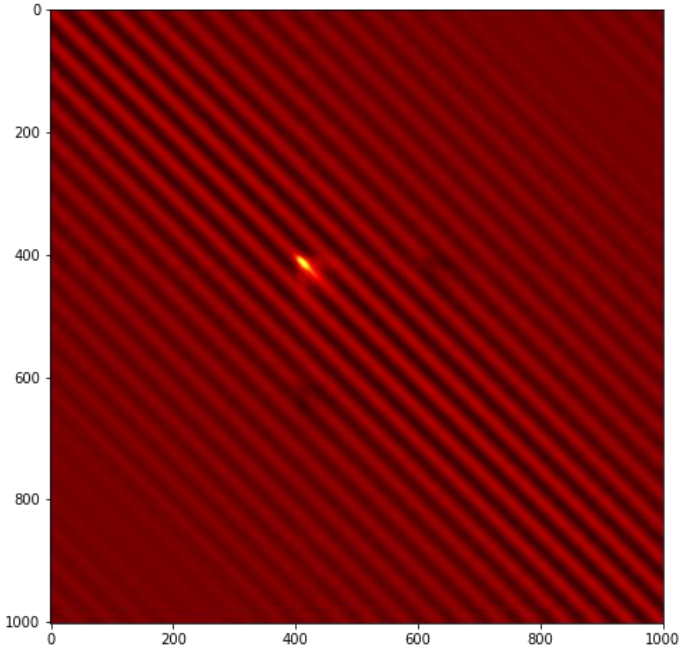




Noise characterization

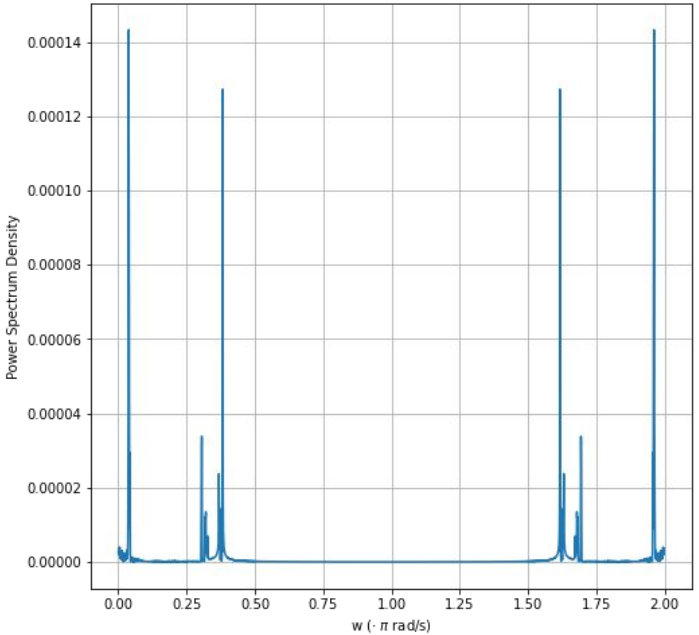
Noise characterization

Covariance matrix of the noise+signal



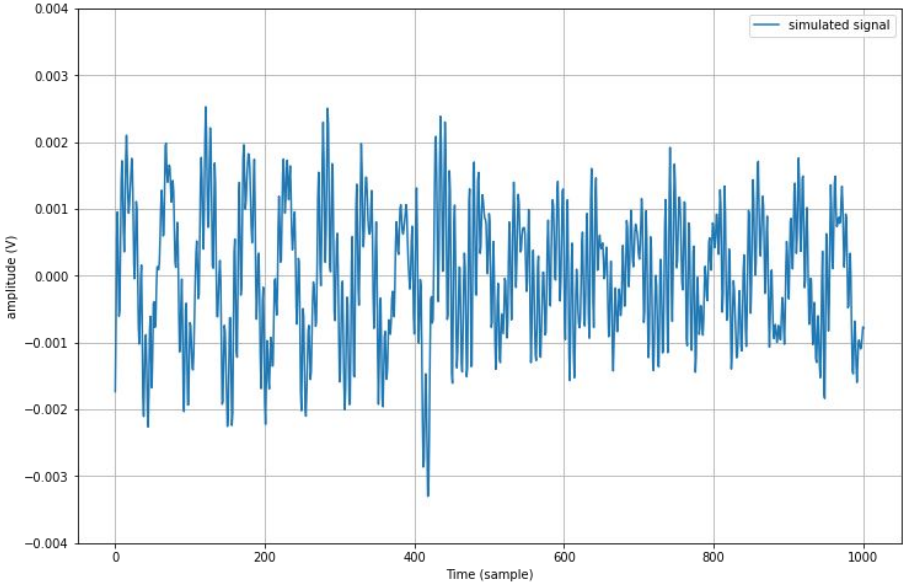
WSS process (taking out the signal component)

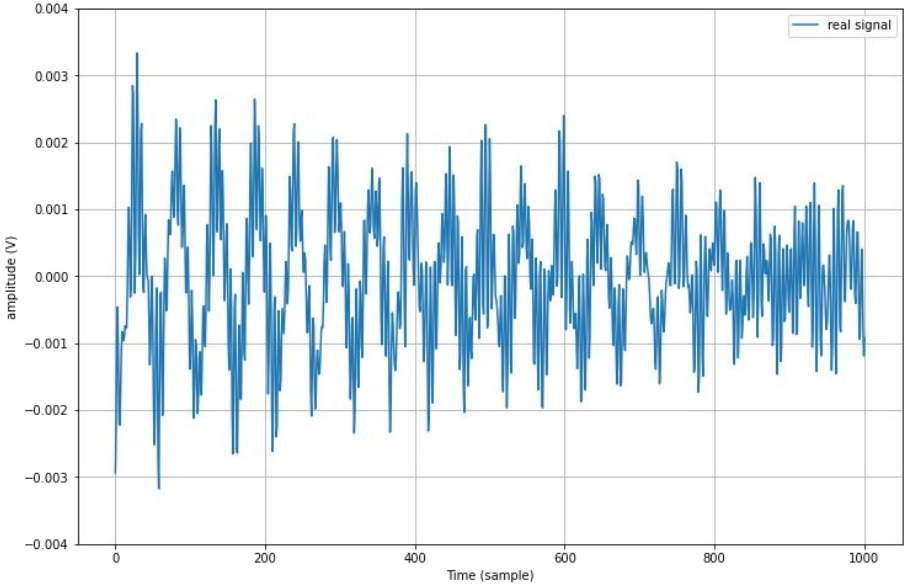
Power Spectrum Density of the noise+signal



Noise characterization

One simulation example (*x* real signal)



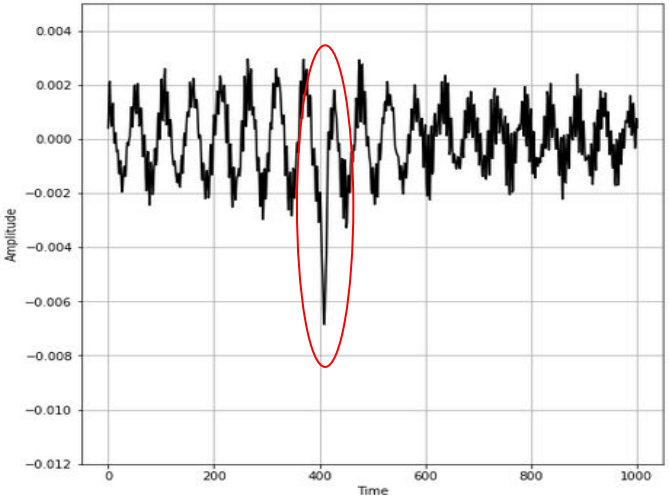


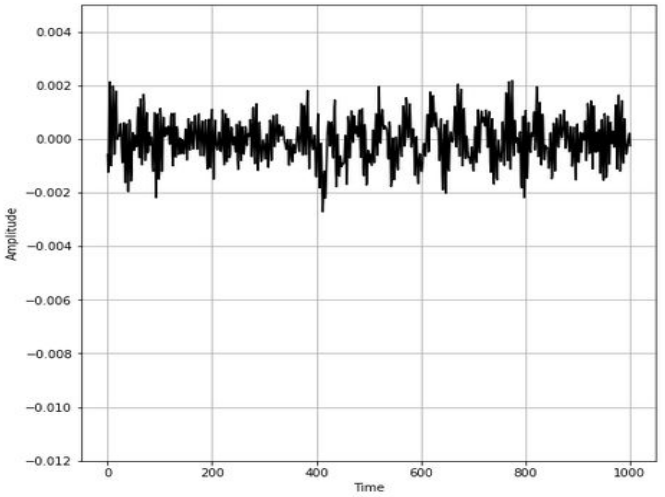
SPE signal characterization

SPE Signal characterization

We need to measure the SPE signal

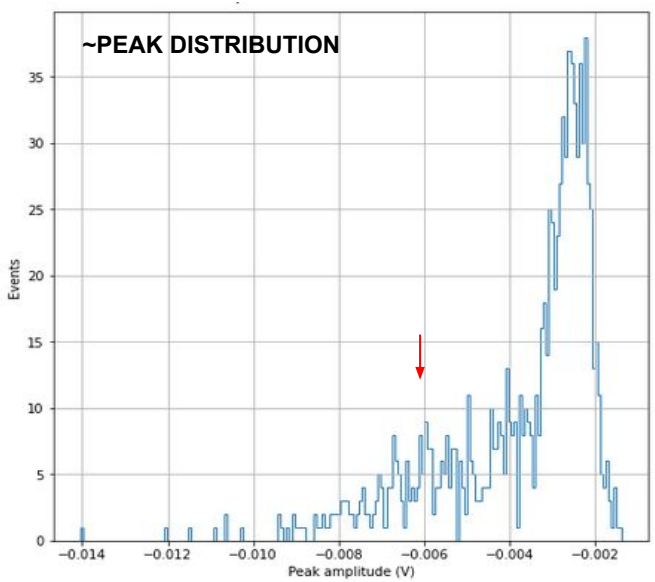
- Amplitude distribution
- Signal shape (if Gaussian → sigma)

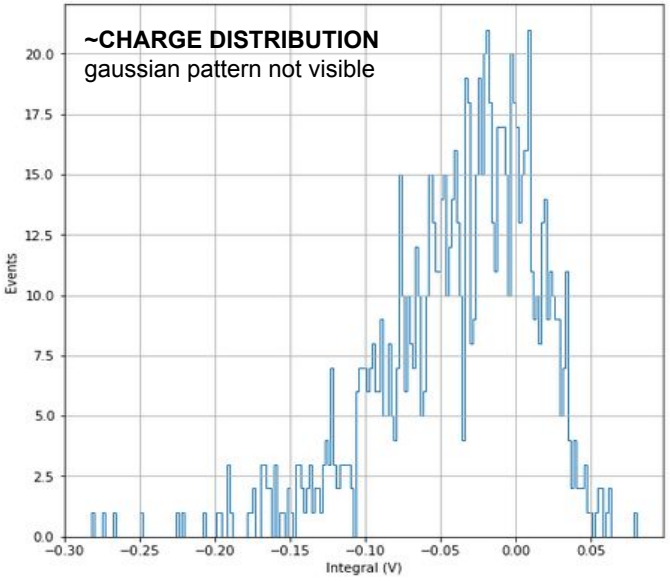




SPE Signal characterization

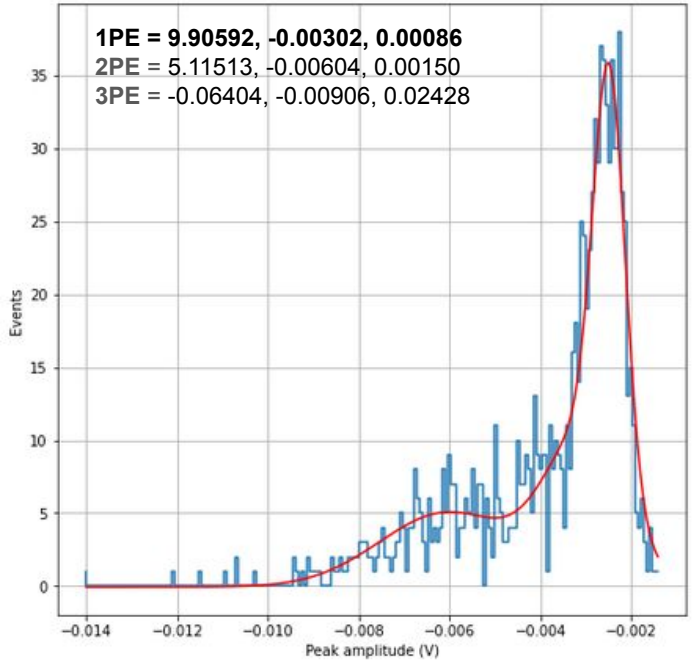
Peak amplitude and ~charge distributions





SPE Signal characterization

Peak amplitude fit with 3 SPE gaussians + noise

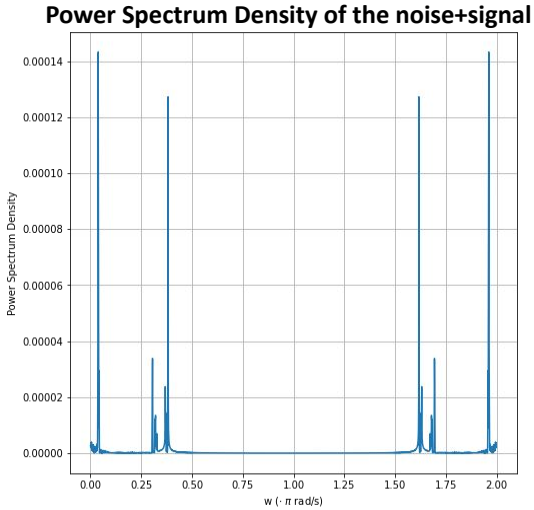


Without any kind of pre-processing…

SPE Signal characterization

With some pre-processing

→ fit signal with $A_1 \sin_1(w_1 n + p_1) + A_2 \sin_2(w_2 n + p_2)$ + Gaussian



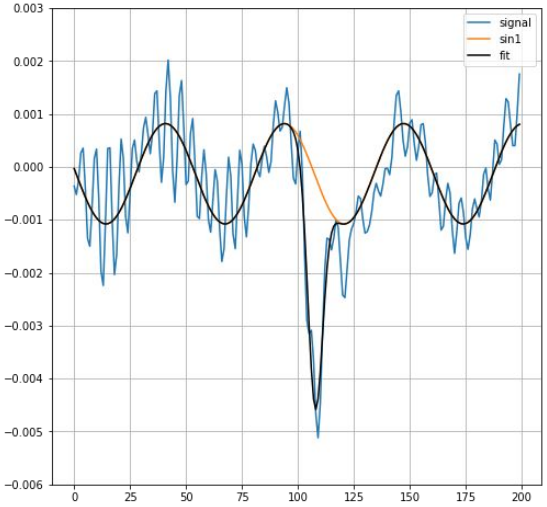
The PSD helps to give initial values for the regression procedure

SPE Signal characterization

With some pre-processing (2 sin + gaussian fit)

sin(wn) → w values → 0.1185

sin_1 + gauss fit

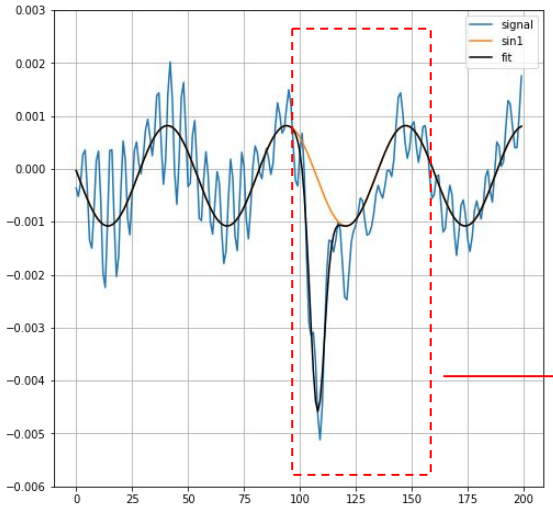


SPE Signal characterization

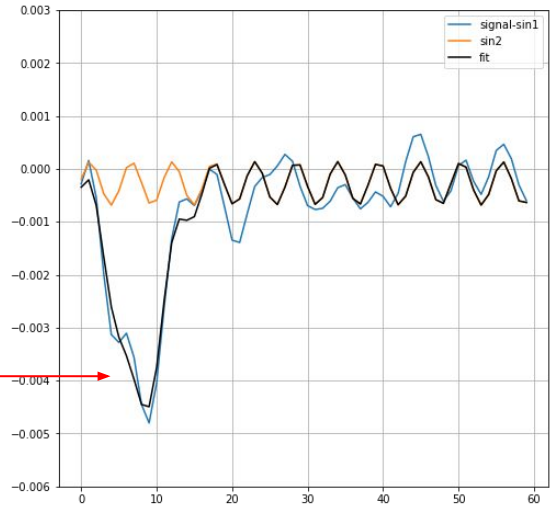
With some pre-processing (2 sin + gaussian fit)

sin(wn) → w values → 0.1185 and 1.177

sin_1 + gauss fit



sin_2 + gauss fit



SPE Signal characterization

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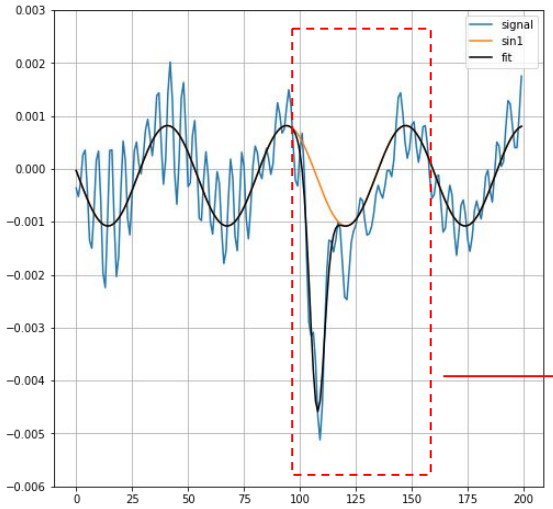
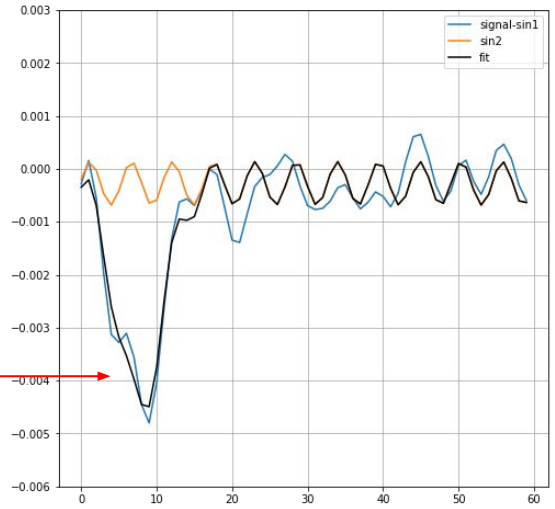
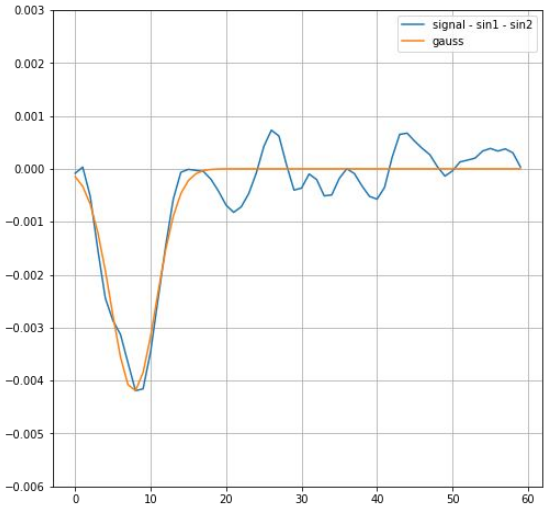


sin_2 + gauss fit



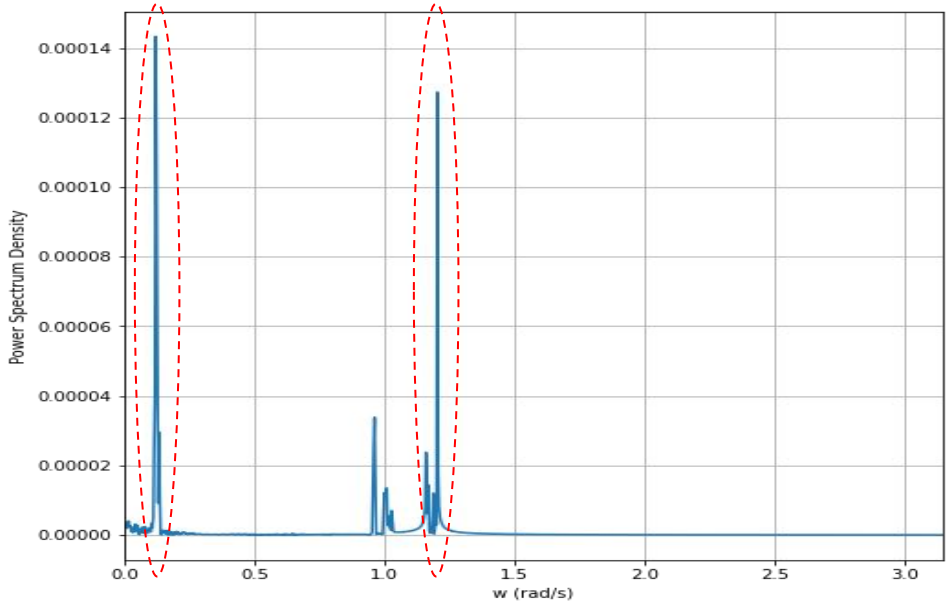
final result



SPE Signal characterization

With some pre-processing (2 sin + gaussian fit)

sin(wn) → w values → **0.1185** e **1.177**

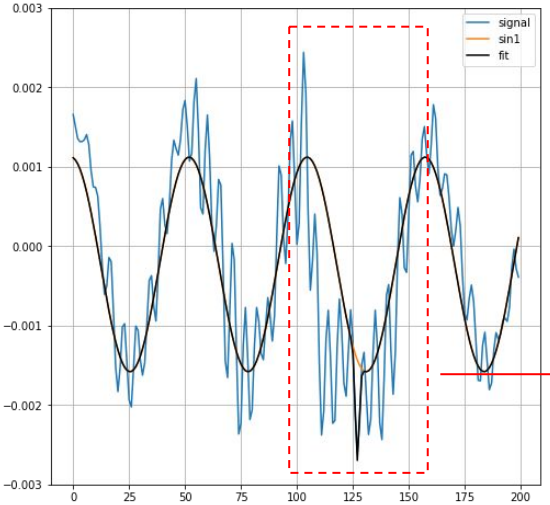


SPE Signal characterization

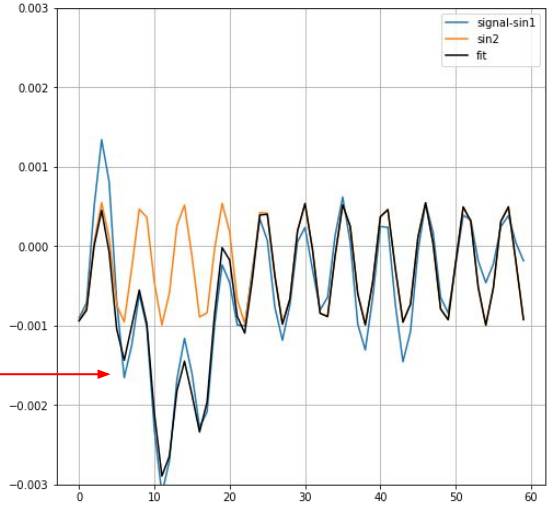
With some pre-processing (2 sin + gaussian fit)

Another example *(low amplitude signal)*

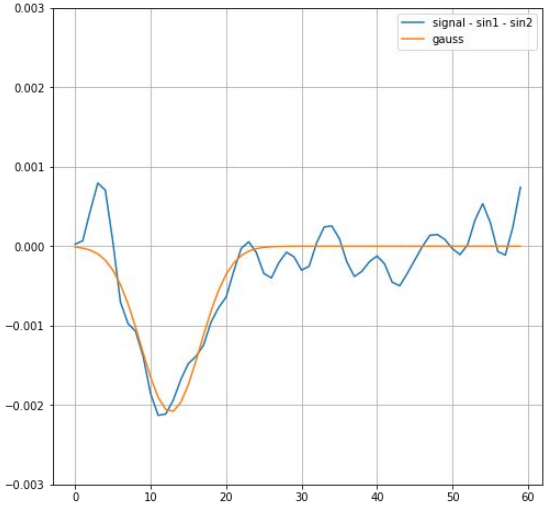
sin_1 + gauss fit



sin_2 + gauss fit



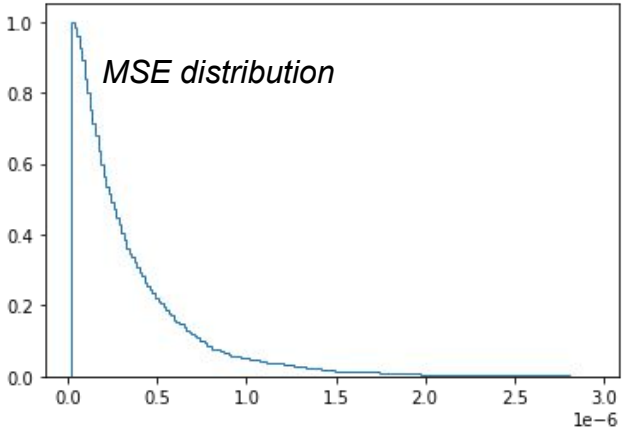
final result



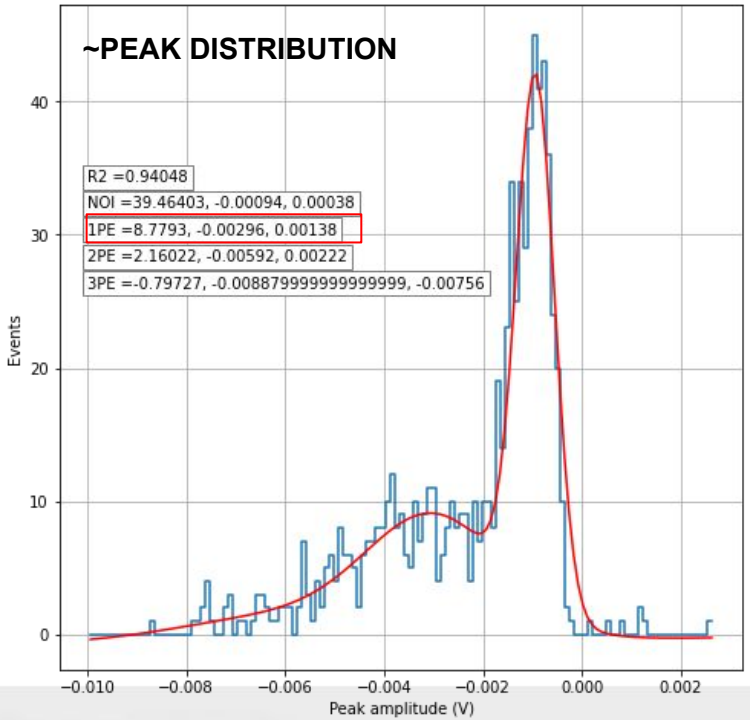
SPE Signal characterization

With some pre-processing (2 sin + gaussian fit)

Now selecting only fits with MSE < 0.5e-6

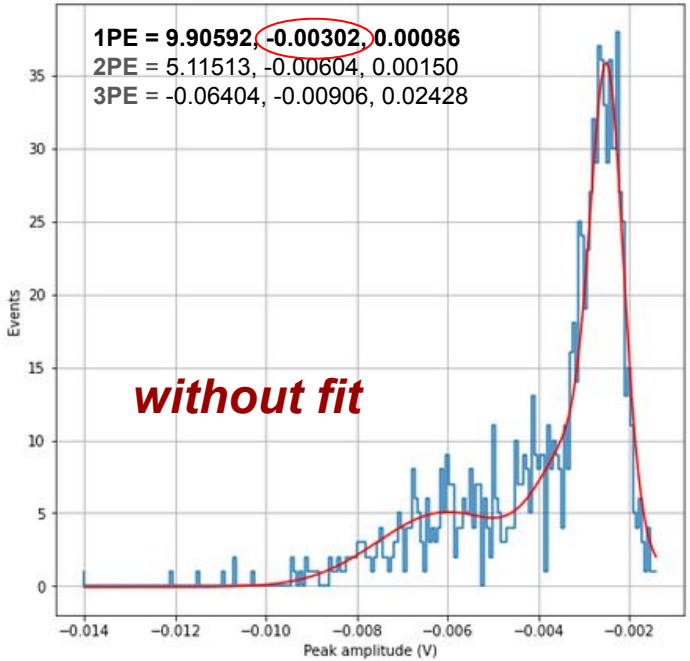


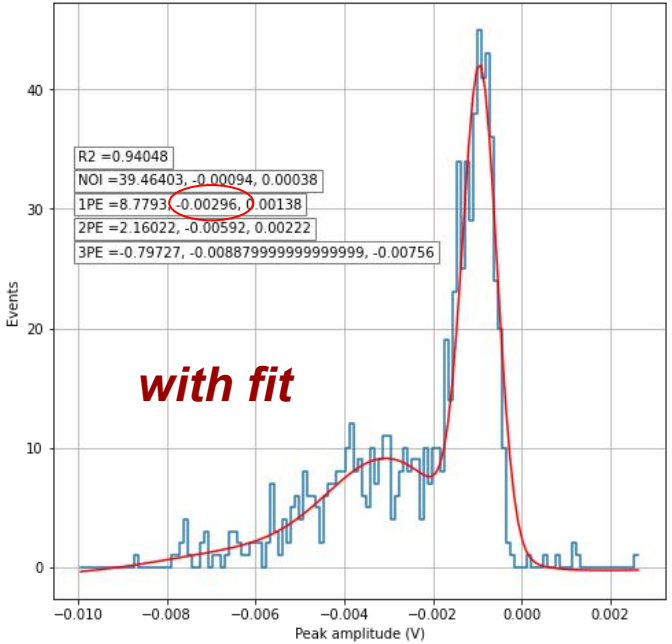
and fitting with 3 SPE Gaussians →



SPE Signal characterization

Comparing without and with fit … *(similar mean, larger sigma)*





Conclusions

Conclusions

- **We are pretty satisfied with the noise characterization and simulation procedures**
- **For the SPE signal, we have something to start but there are other few thing we can try**
  - *the pre-processing procedure seems to be a good way to increase SNR*
- **Some fine tuning need to be done in both cases**