# FOURIER TRANSFORMATION ON LIGHT EVENTS

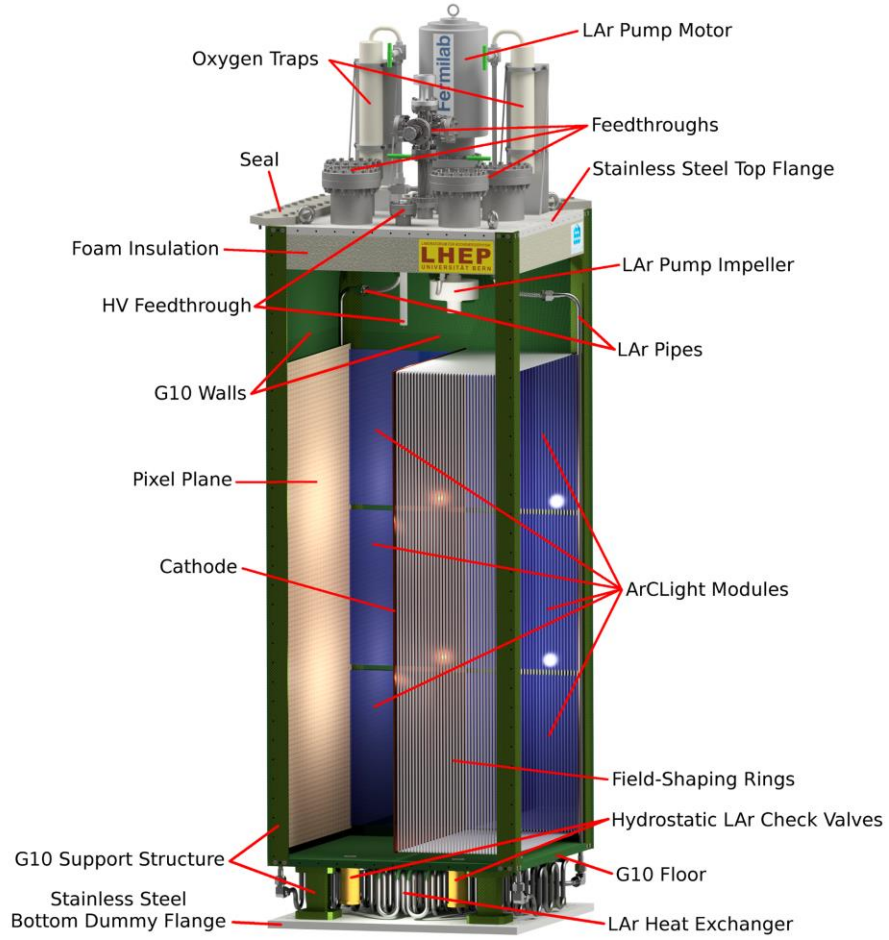
BY FRANCESCA FEMIA

# THIS IS ME!

This is me!

- My name is Francesca.
- 18 years old.
- Proud Italian.
- Passionated about stars and black holes.
- Aspirant physicist.

- New designed tool for building Liquid Argon Time Projection Chambers (LarTPCs).
- Detector modularization.
- Scalability to large active detector masses.




# WHAT IS ARGON CUBE?

# WHY LIQUID ARGON?

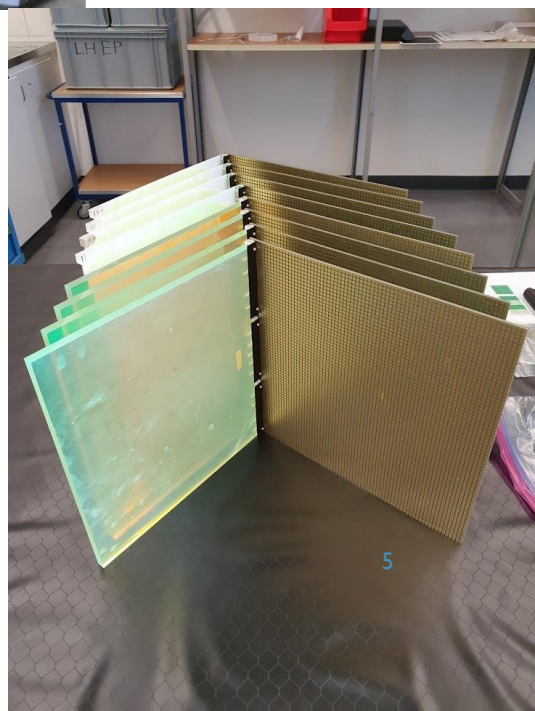
- Denser than water or oil.
- Temperature of 80K.
- Noble element.
- Cheap.
- Transparent.
- Two separate kinds of signals:
  1. *Ability to record the charged particles' trajectories.*
  2. *A flash of light.*

| Property | Value |
|---|---|
| Atomic number | 18 |
| Atomic weight [g/mol] | 39.95 |
| Boiling point [K] @ 1 atm | 87.3 |
| Density [g/cm$^3$] @ 1 atm | 1.394 |
| Dielectric constant | 1.505 |
| Radiation length [cm] | 14.0 |
| Molière radius [cm] | 10.0 |
| W-value for ionization [eV/pair] | 23.6 |
| Minimum specific energy loss [MeV/cm] | 2.12 |
| Electron transverse diffusion coef. [cm$^2$/s] | 13 |
| Electron longitudinal diffusion coef. [cm$^2$/s] | 5 |

# NEW TECHNOLOGIES FOR ARGONCUBE: ARCLIGHTS & LCM.

- Light readout technologies from the University of Bern and the JINR of Dubna
- Working principle (Bern): trapping of wavelength-shifted photons with the aid of dichroic mirrors.
- Working principle (JINR): wavelenght-shifting light guiding fibres.

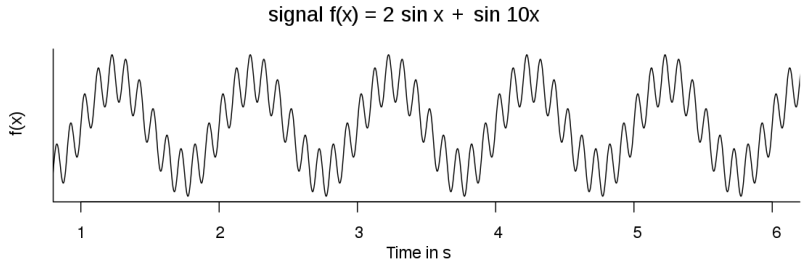
*Prototype from the JINR of Dubna*

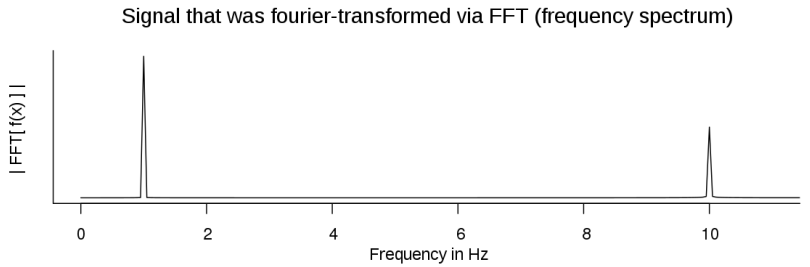


*Prototype from the University of Bern*

# WHAT IS THE FOURIER TRANSFORMATION?

- The Fourier transform (FT) is a mathematical transform that decomposes functions depending on space or time into functions depending on frequency.




*Example of the same event in two different domains*

$$F(x) = \int_{-\infty}^{\infty} f(x)e^{-x}\,dt$$

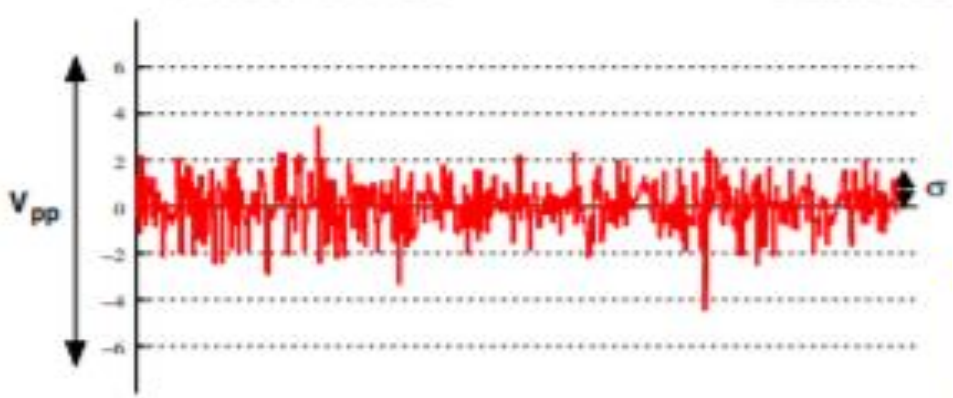
*Fourier Transformation*

$$f(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} F(x)e^{-ixt}\,dx$$

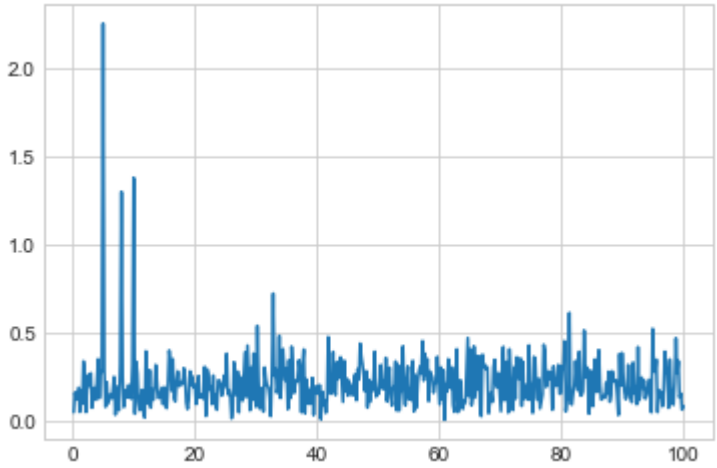
*Inverse Fourier Transformation*

# NOISE

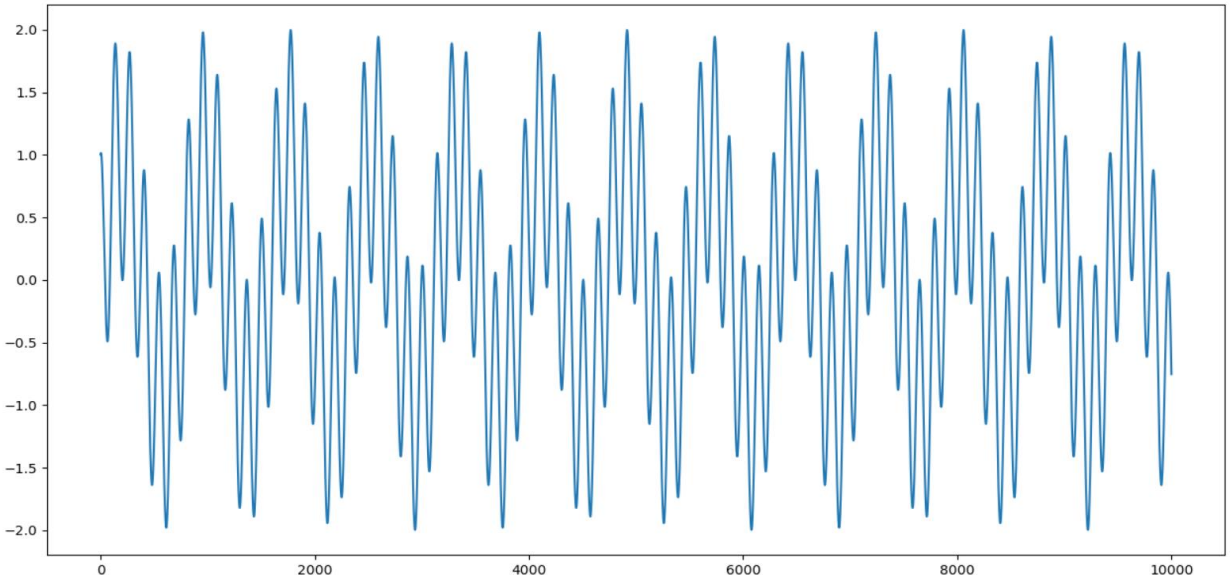
- Electrical noise is the lower boundary for a communications signal, and forms the noise.
- Noise is a fluctuation on the input signal which can come from different sources, have different spectral components and is unwanted.
- It can cover the information you want to extract from the signal



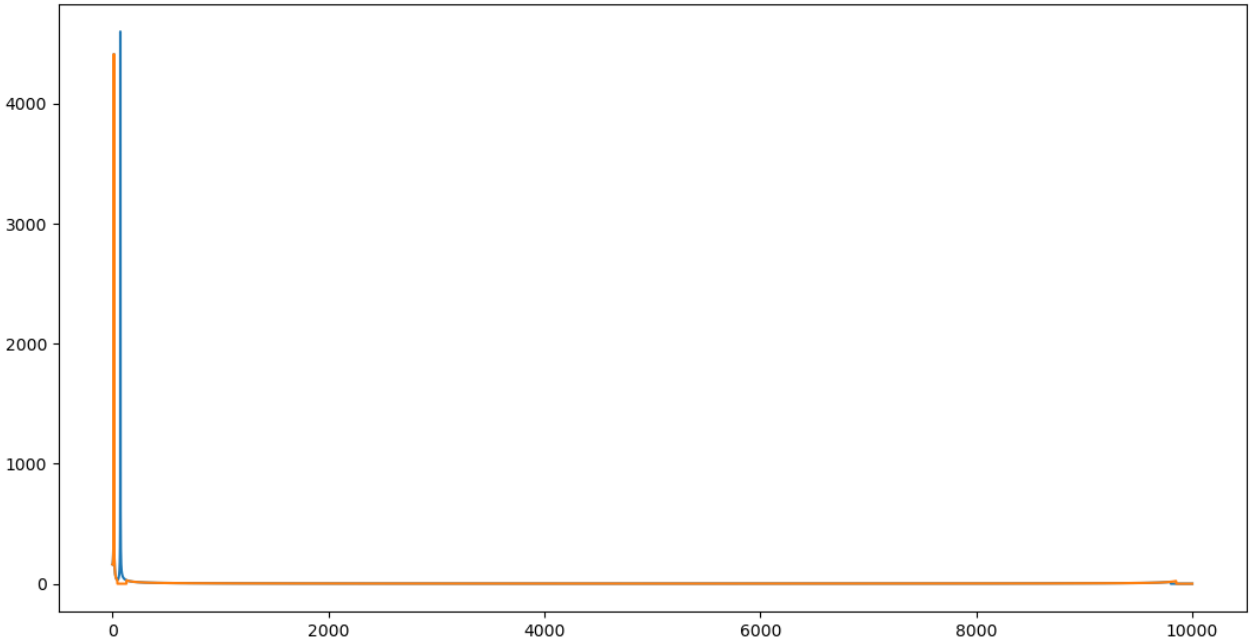

*Amplitude characteristics of a noise signal*




*Visible noise peaks in the FT of a general wave*

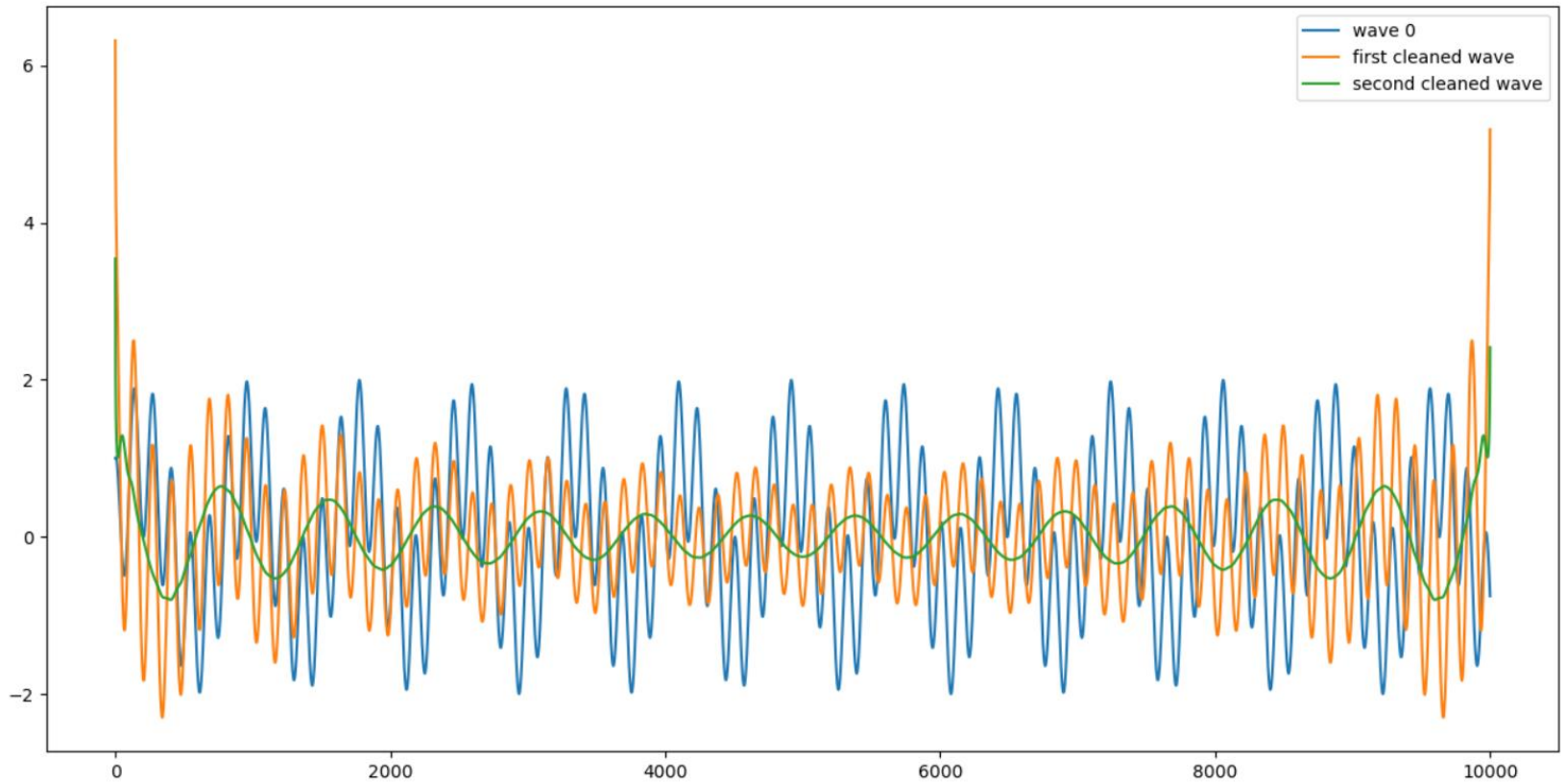



*The sum of two waves with different wave-lengths*




*waves on the frequency domain after the FT*

# EXAMPLE OF A FOURIER TRANSFORMATION

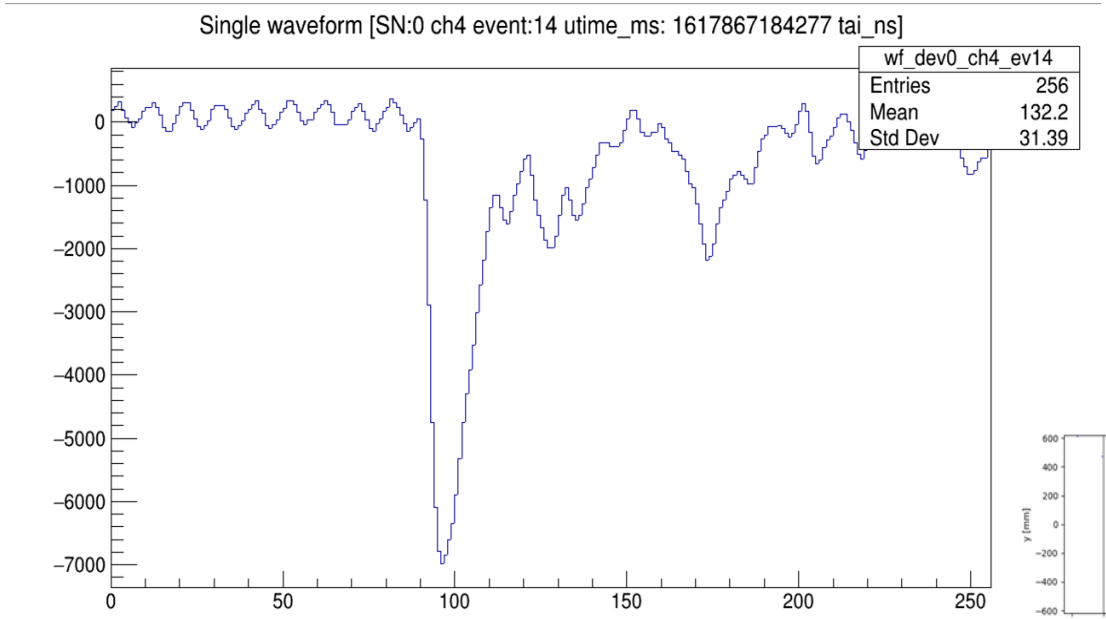



*The inverse Fourier Transformation shows the differences between the wave 0 and the other two*

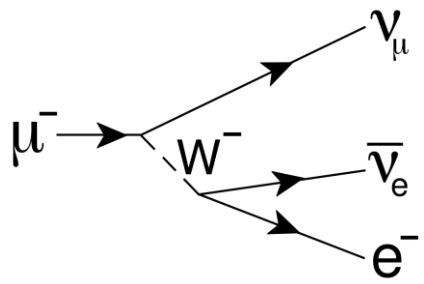
# THE INVERSE FOURIER TRANSFORMATION

# ARGON CUBE'S LIGHT EVENTS AND PEAKS

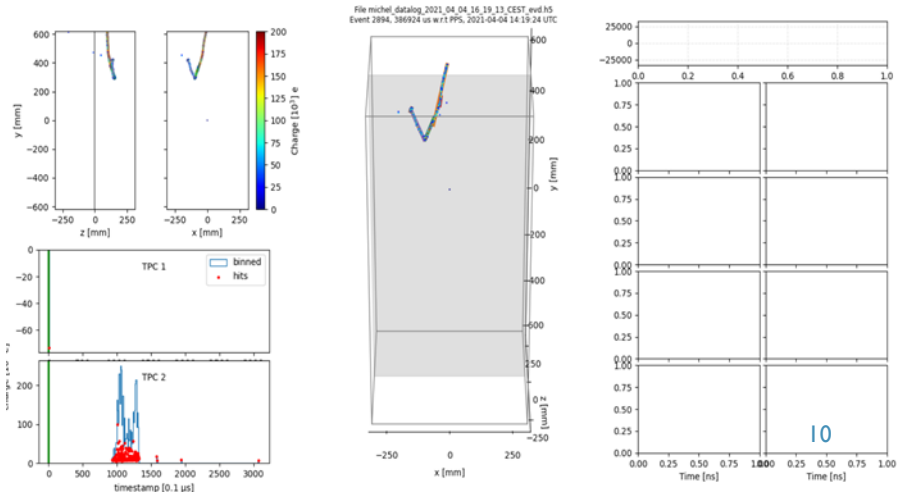
- The file given are not always clear due to the excess of noise that has to be deleted.
- When a muon decays the shape of the event will show one deep peak and smaller ones, but to understand it the noise must be deleted.



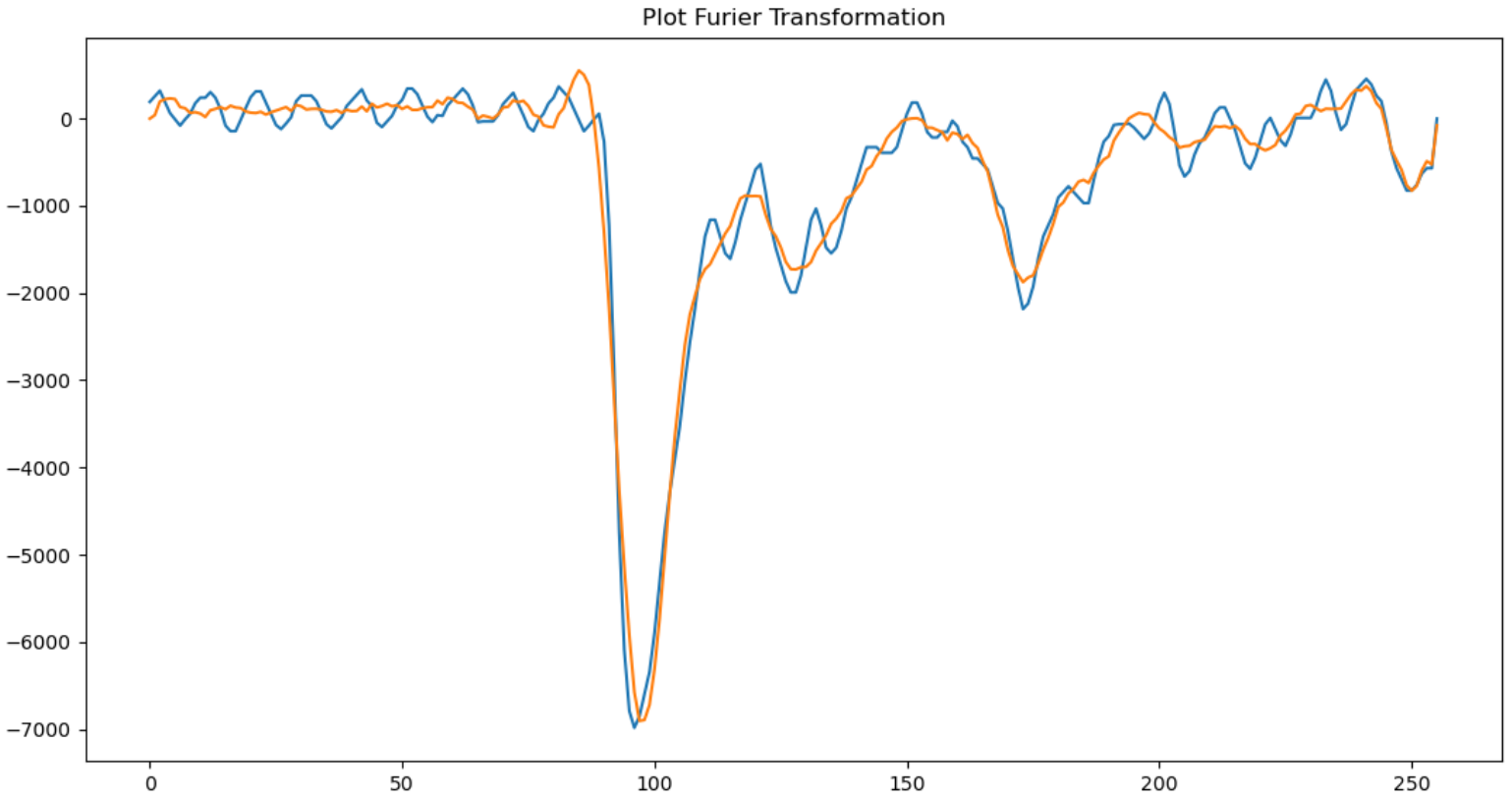

*Possible light-event candidate for a Michel Electron*




*Feynman diagram for a muon decay*




*Charge event of a muon decay*



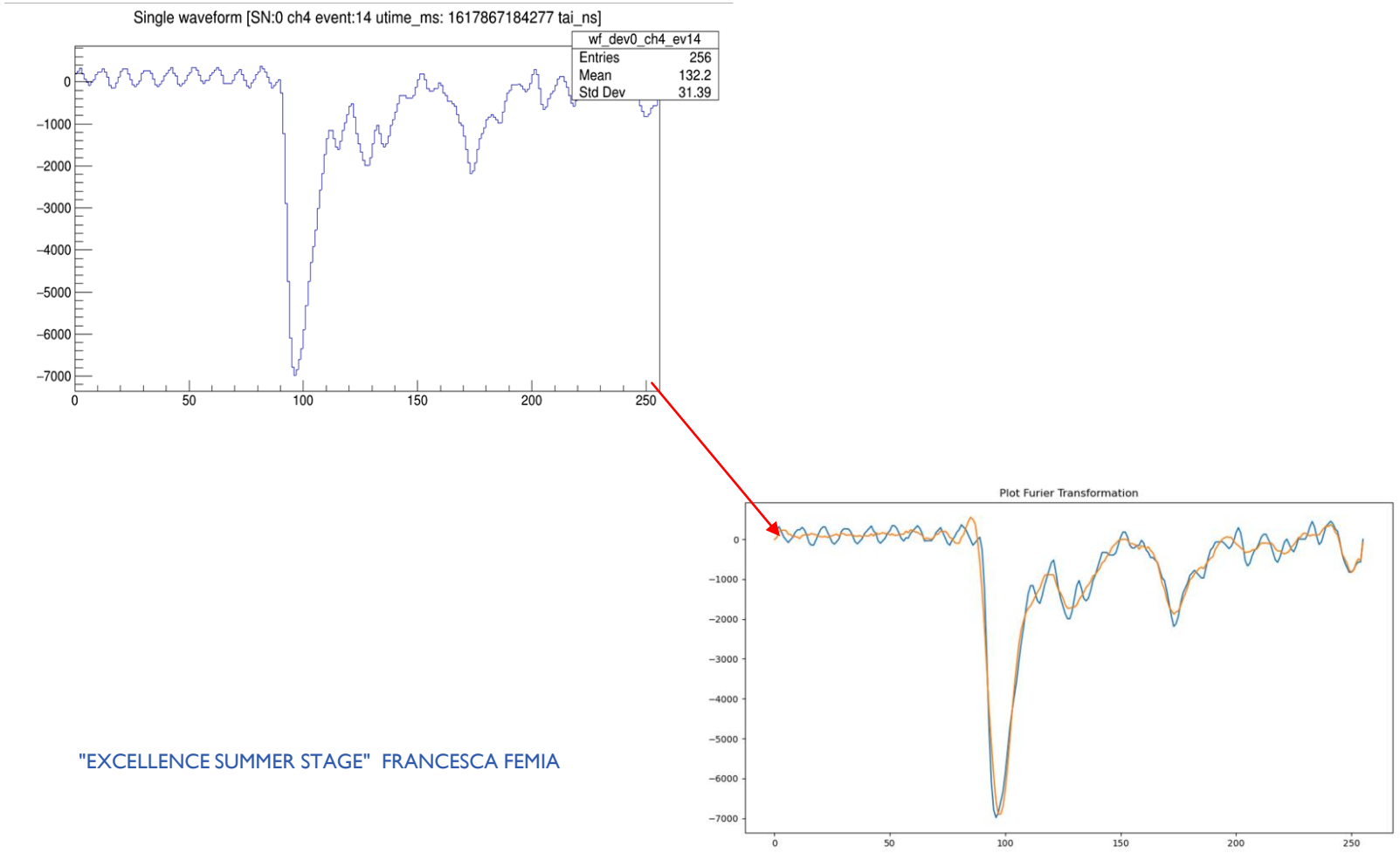

*A comparison between the normal light event (blue wave) and the inverse of the Fourier Transformation (orange wave) applied on it to set the noise peaks to zero.*

# THE FOURIER TRANSFORMATION AND INVERSE FOURIER TRANSFORMATION ON LIGHT EVENTS

# WHAT HAVE I ACCOMPLISHED?

- I have found a light event and a charge event for the Muon decay.
- I have applied the FFT on the light event.
- I have cleaned the signal in the frequency domain and applied the IFFT to come back to the original signal.
- I have found a clean signal to compare with the first one.

This technique will be part of an automated script that will clean up automatically future light events.




# FUTURE APPLICATION

# THE END