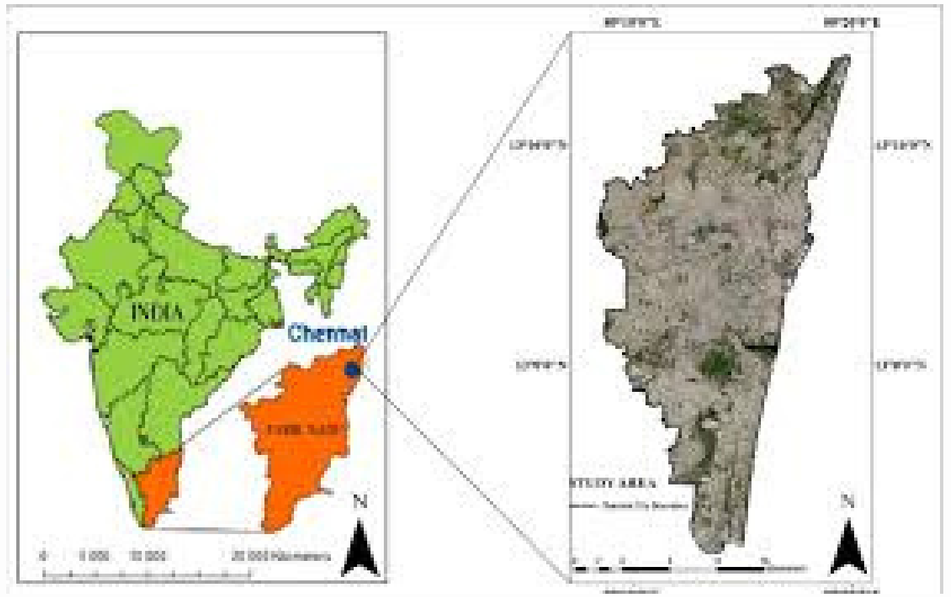
SCINTILLATOR SIGNAL STUDY

Sodium Iodide and LYSO crystal analysis

By:- OME BHARATH J

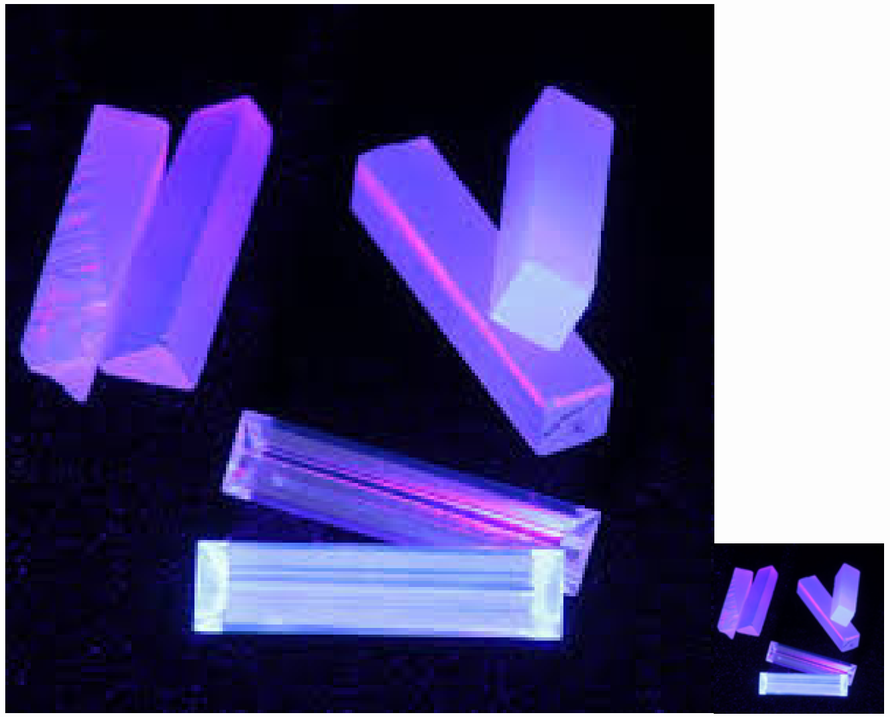
ABOUT MYSELF

I am an Engineering Physics undergrad from IIT, Hyderabad with a minor in Aerospace Engineering.



INTRODUCTION

Over two weeks, I worked with NaI and LYSO scintillators to study their response to radiation.

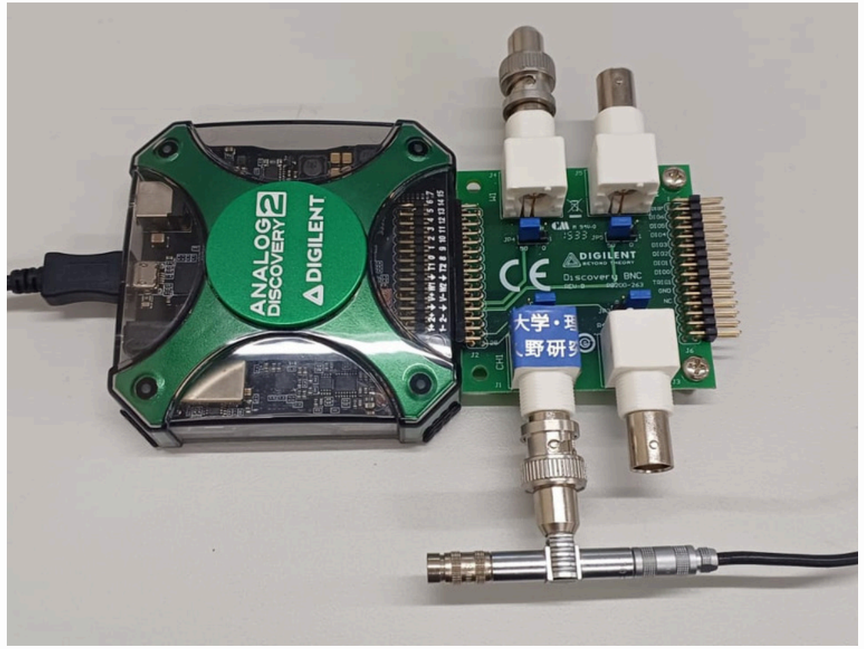


LYSO

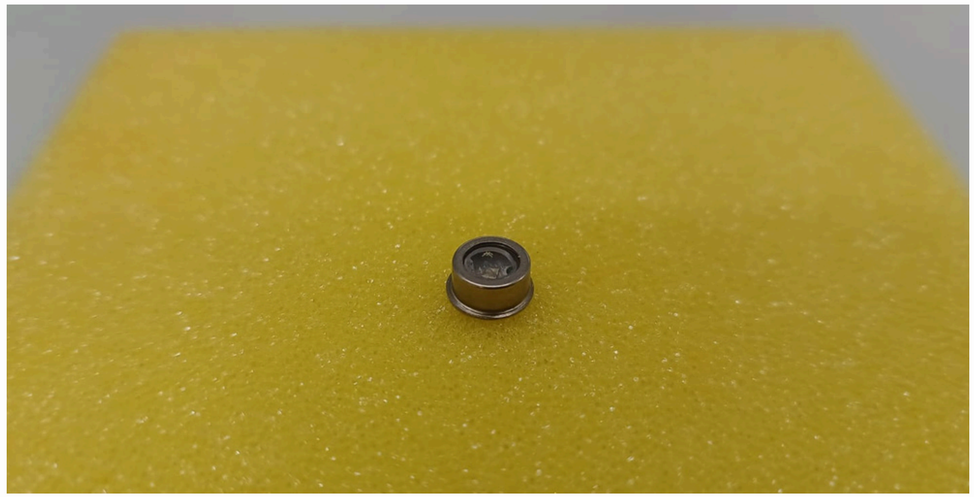
NaI,Sodium Iodide

TOOLS USED

- Analog Discovery 2 (AD2)
- NaI(Tl) and LYSO crystals
- Am-241 radioactive source
- Hamamatsu H3165-01 PMT
- WaveForms Software



TOOLS USED



The NaI scintillator has a built-in Am-241 radioactive source embedded inside the crystal for consistent gamma/alpha-ray emission.

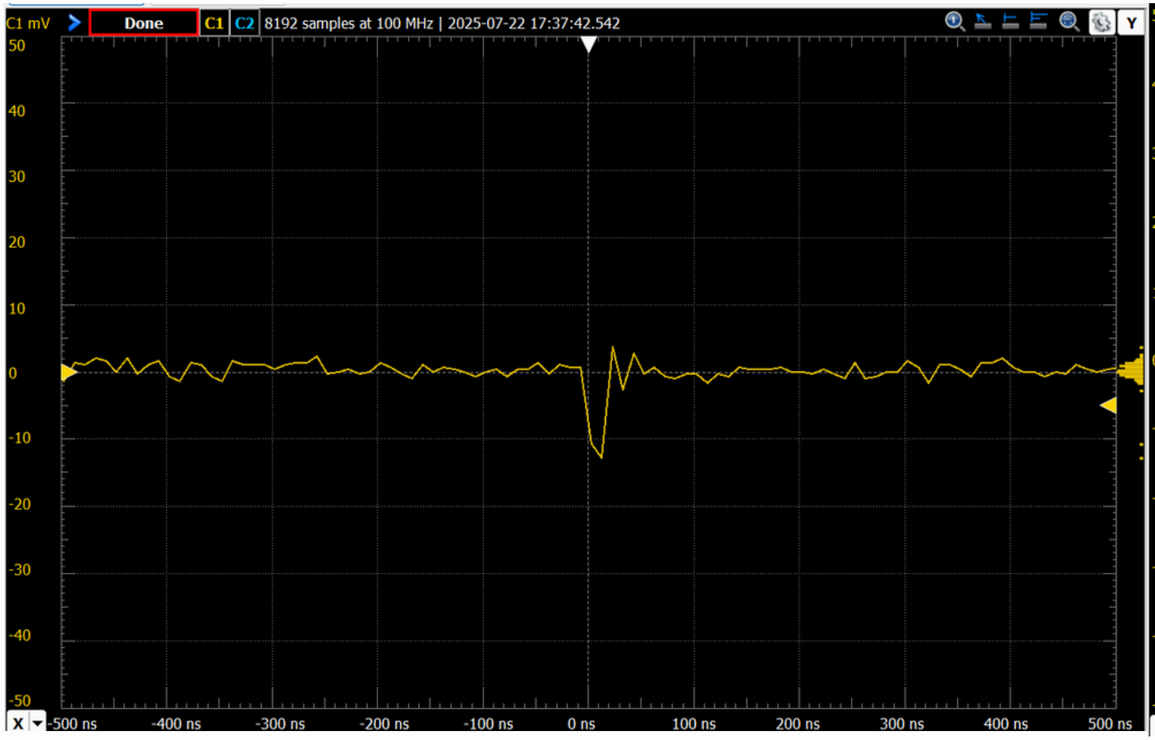
LYSO Scintillator, 2cm x 2cm x12cm

PMT

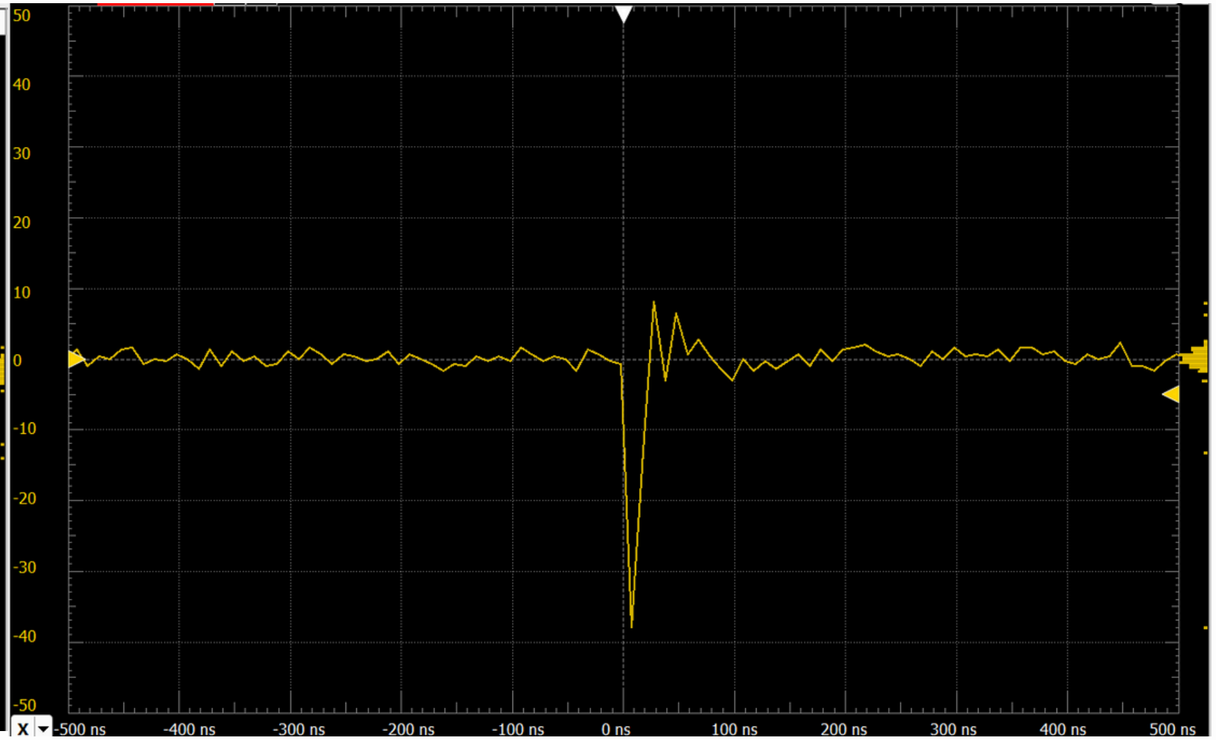
AMPLIFICATOIN GAIN OF PMT

Before testing the scintillators, I measured the amplification gain characteristics of the Hamamatsu H3165-01 PMT

900v input voltage

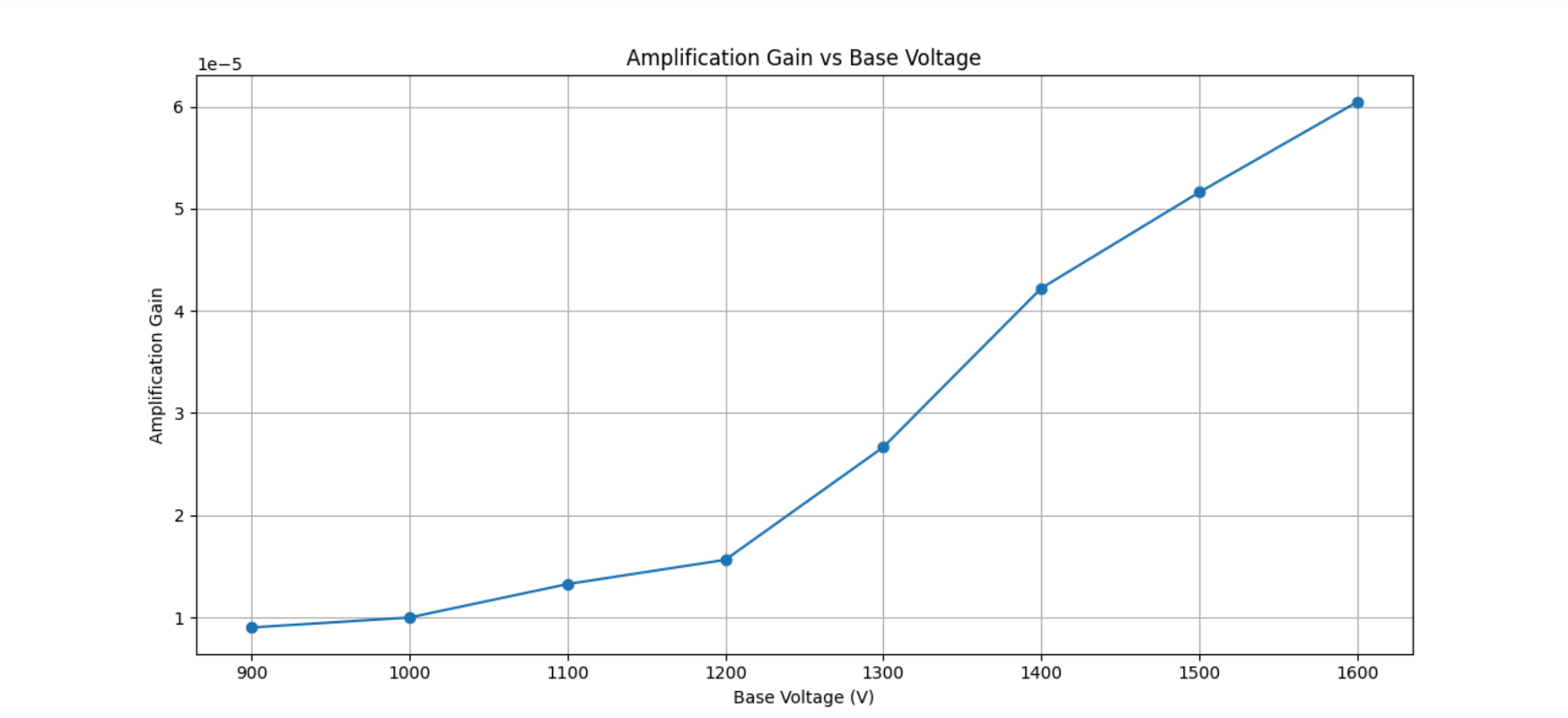


1400v input voltage

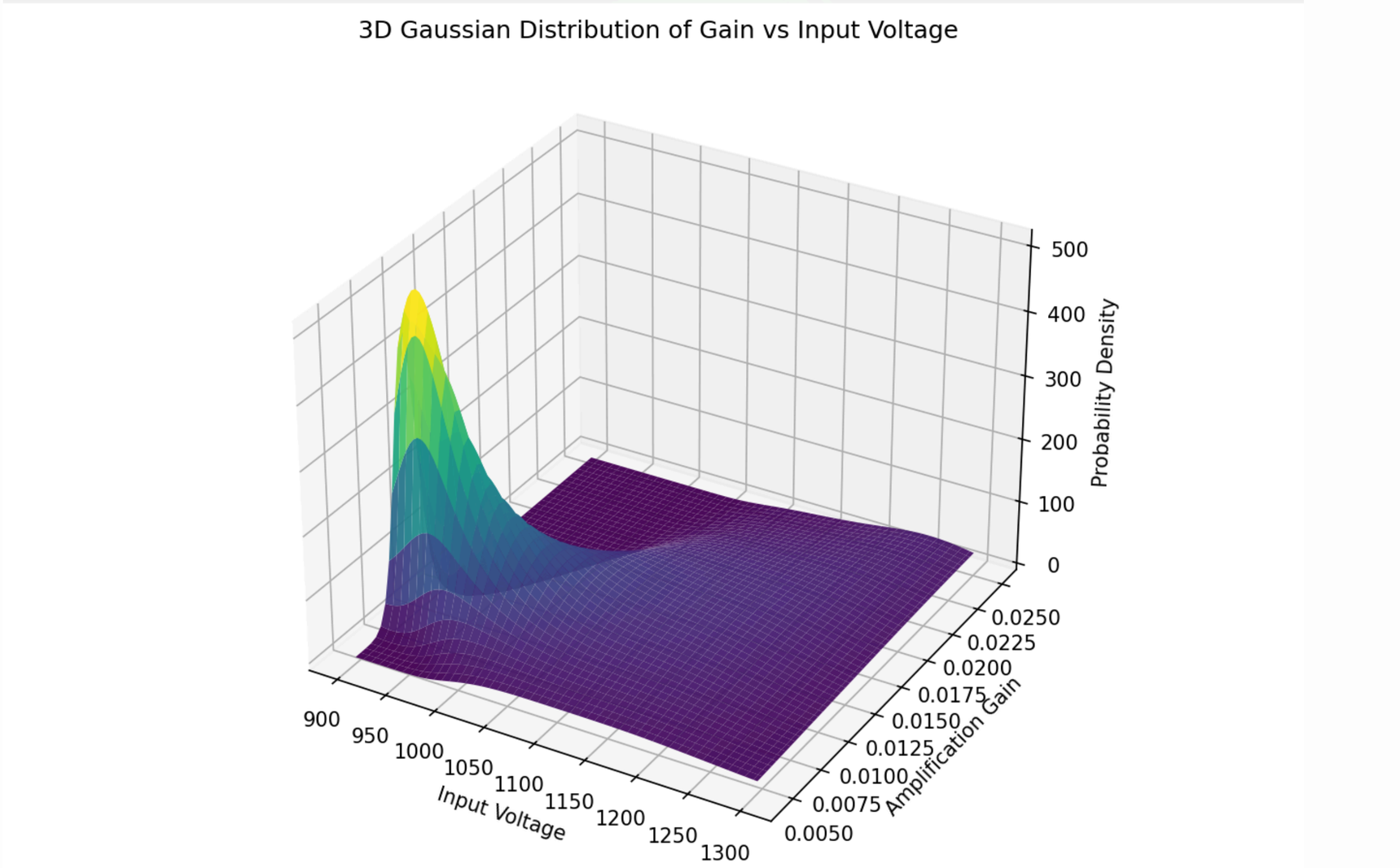


AMPLIFICATOIN GAIN OF PMT

Small external disturbances (like ambient light leaks, dark current, or low-level background radiation) can produce measurable pulses at the PMT output. While these aren't ideal signals, they still go through the same amplification chain



AMPLIFICATOIN GAIN OF PMT

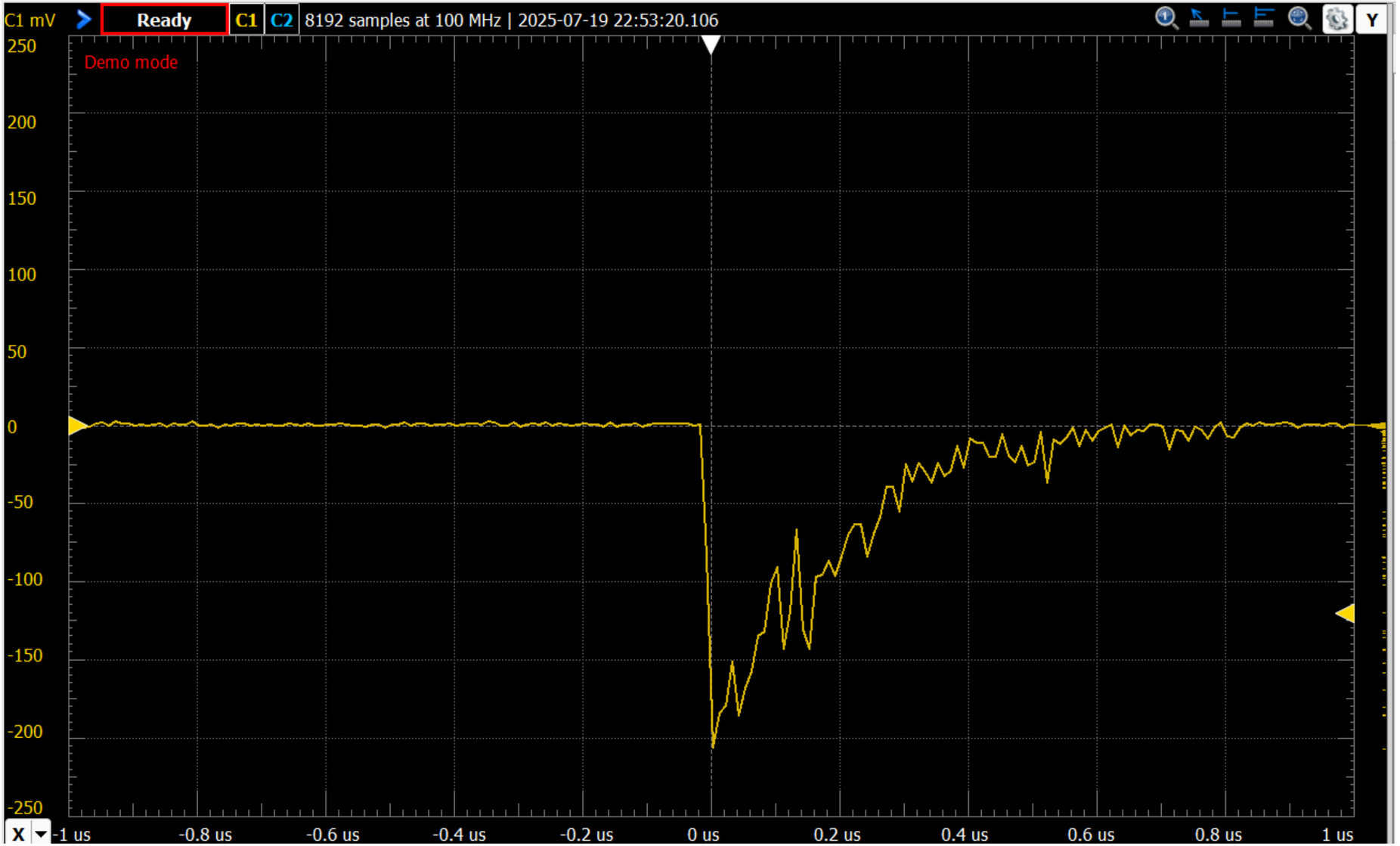


NaI

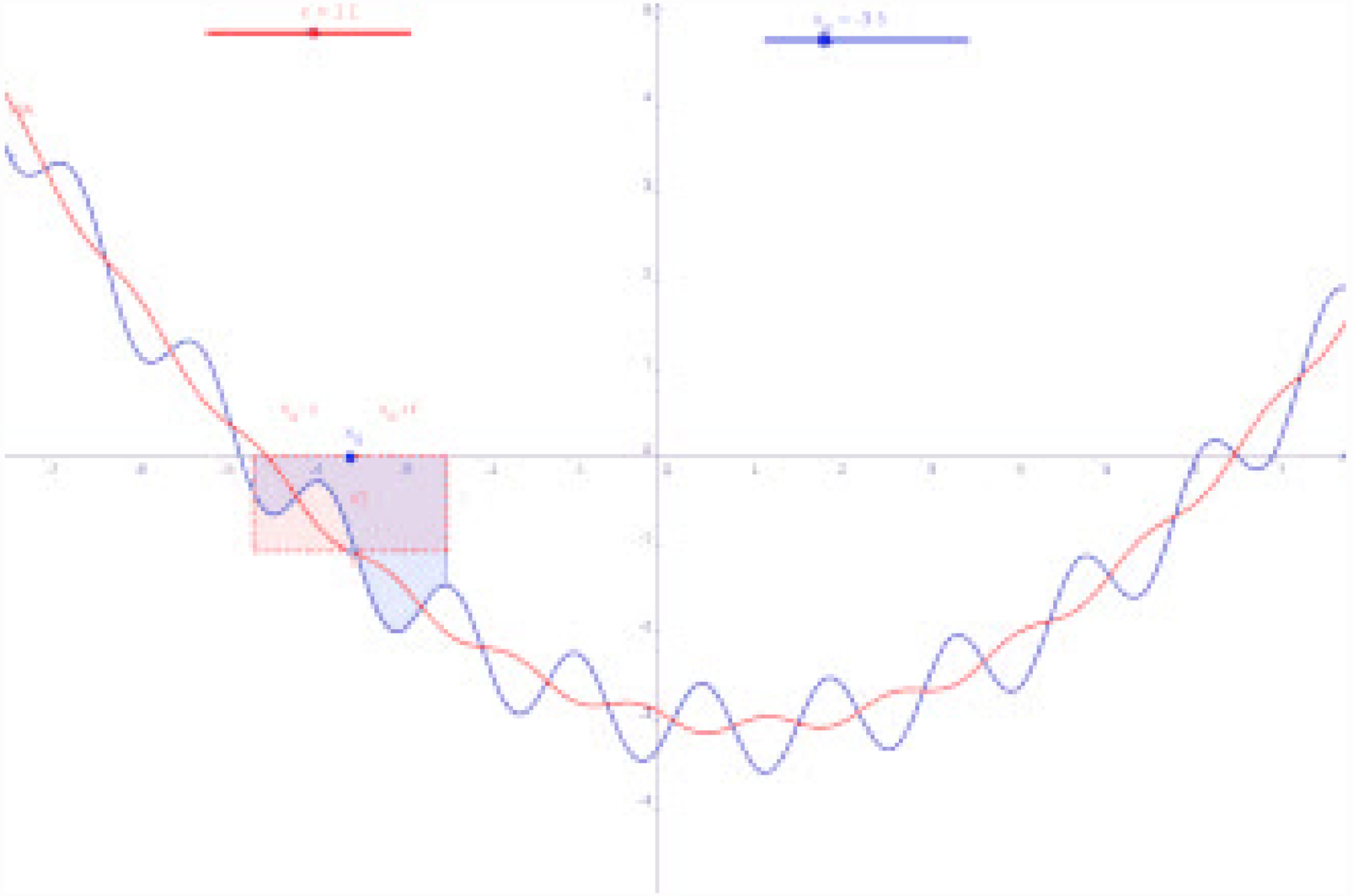
NaI SCINTILLATOR

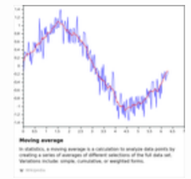
- Connected NaI(Tl) crystal to PMT; exposed it to Am-241 alpha source.
- Recorded voltage pulses and applied baseline subtraction.
- Used smoothing/filtering to reduce noise and extract clean waveforms.
- Decay time was measured by exponential fit on trailing edge.
- Photon yield was estimated using known PMT gain and peak voltage.

NaI SCINTILLATOR

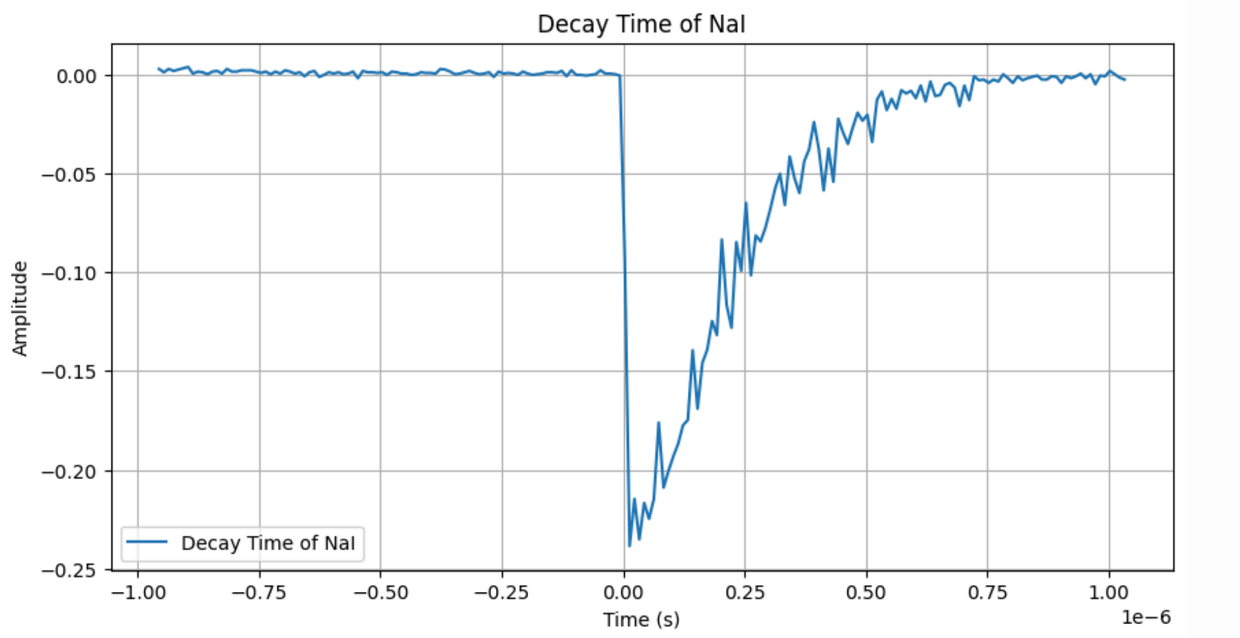


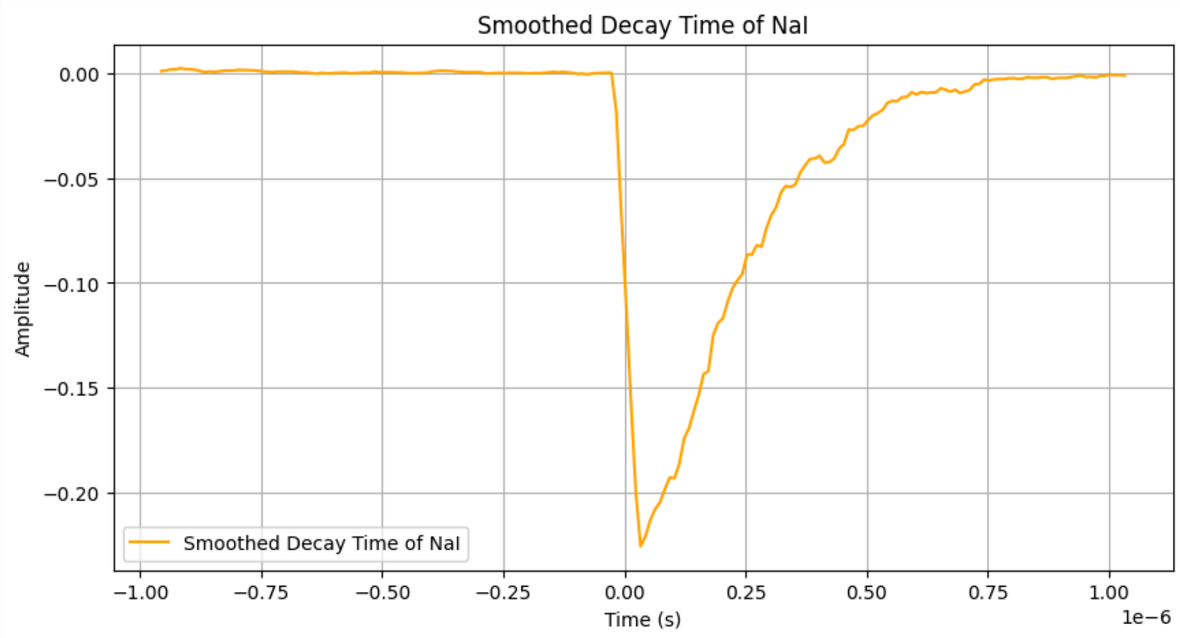
NaI SCINTILLATOR



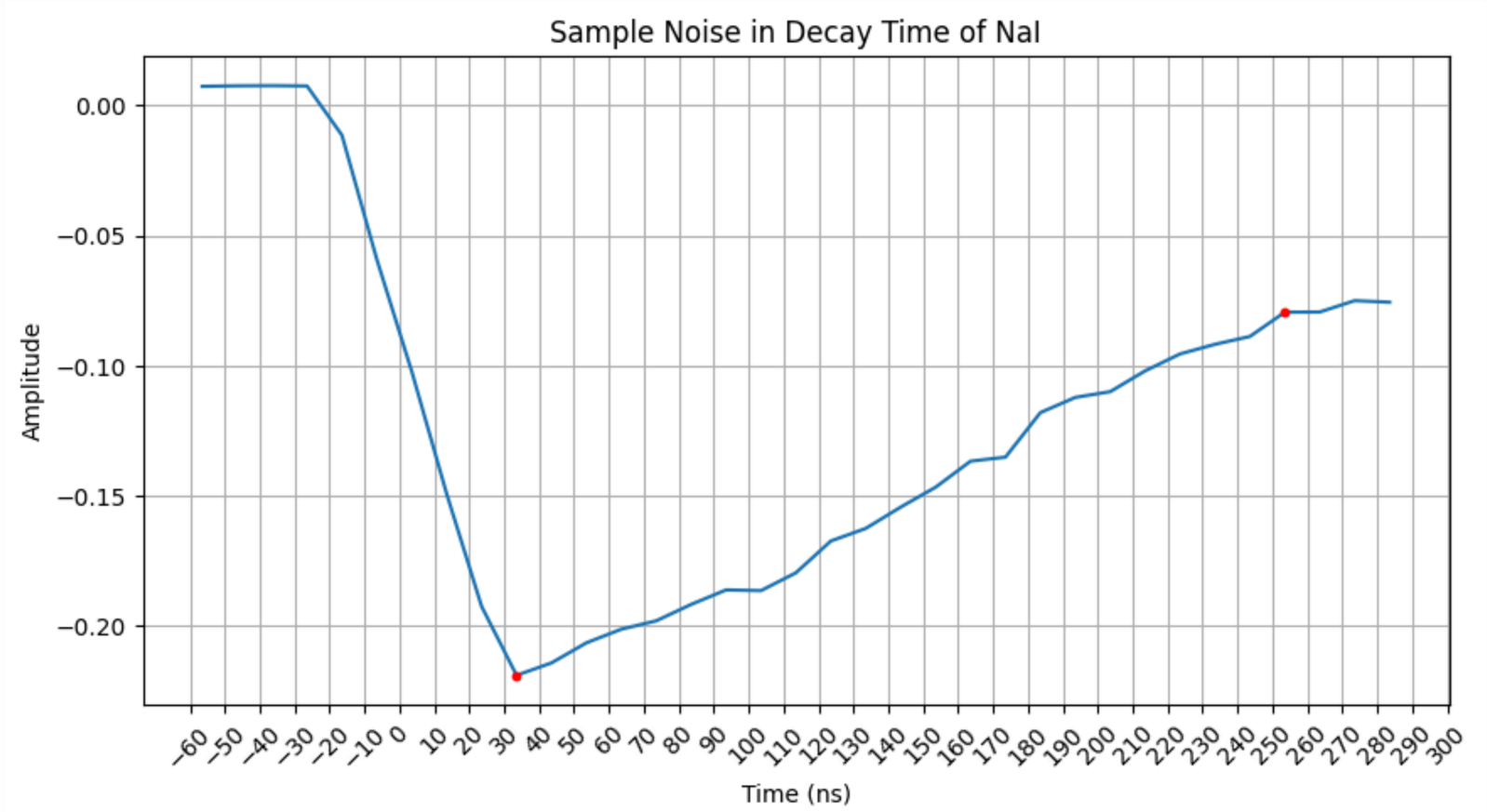


NaI SCINTILLATOR

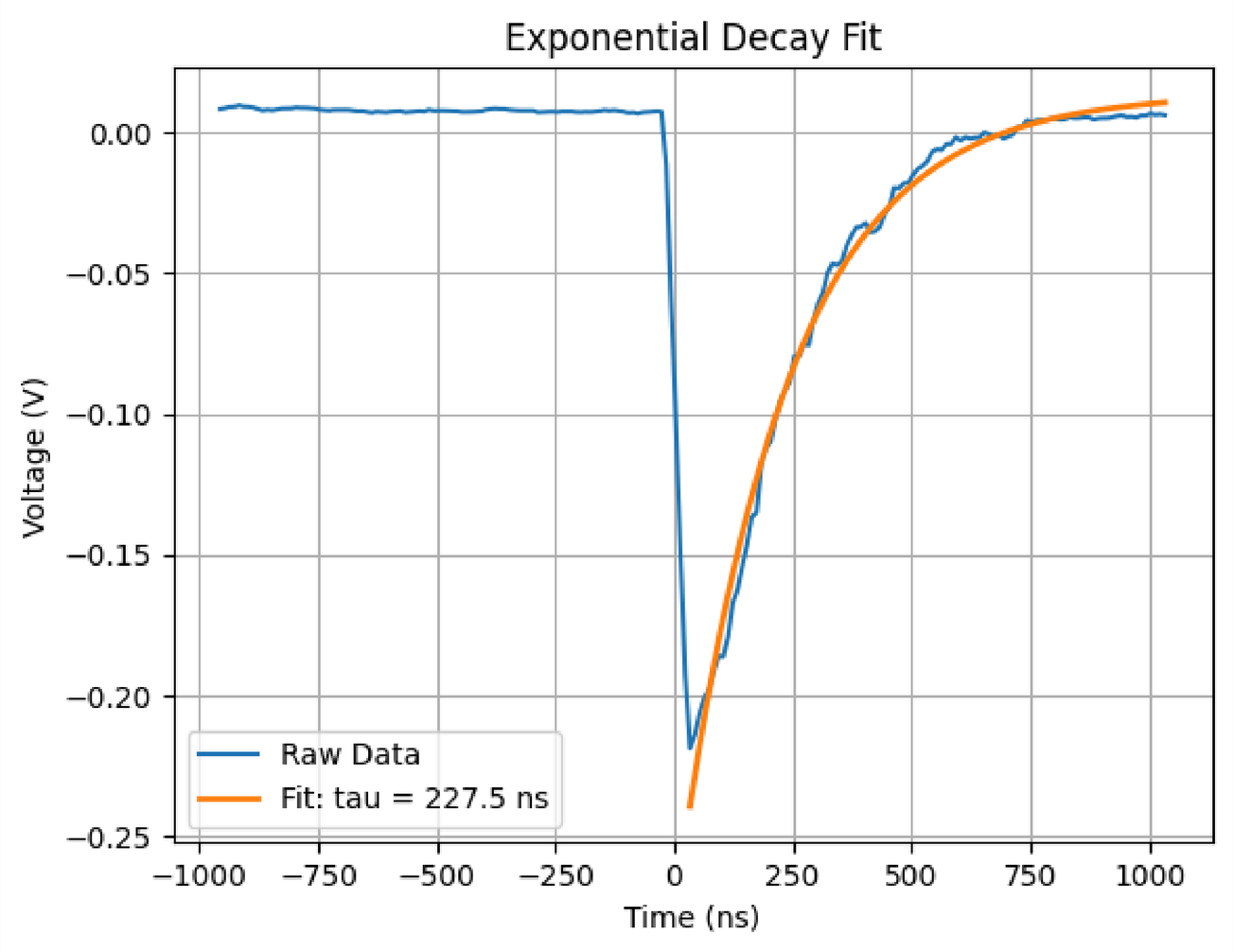




NaI SCINTILLATOR



NaI SCINTILLATOR



NaI SCINTILLATOR

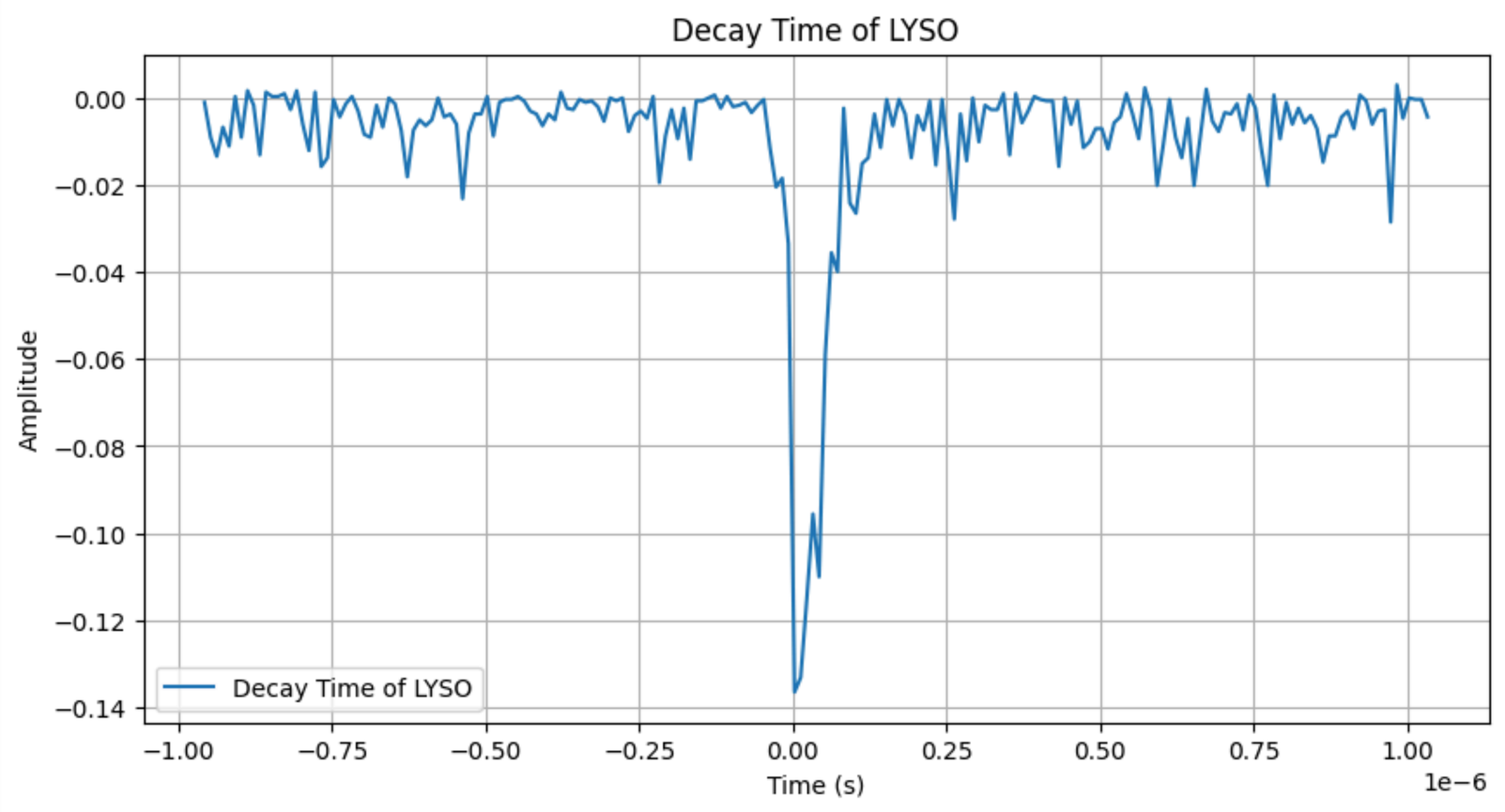
- Measured Values:
- Decay Time: 227 ns
- Integrated Charge (Area under pulse): Qtotal=4.8×10^9
- Taking the PMT Quantum Efficiency: 30%
- Alpha Particle Energy: 5.5 MeV (from Am-241)
- The value of photons/MeV comes out as 5182Photons/Mev.

LYSO

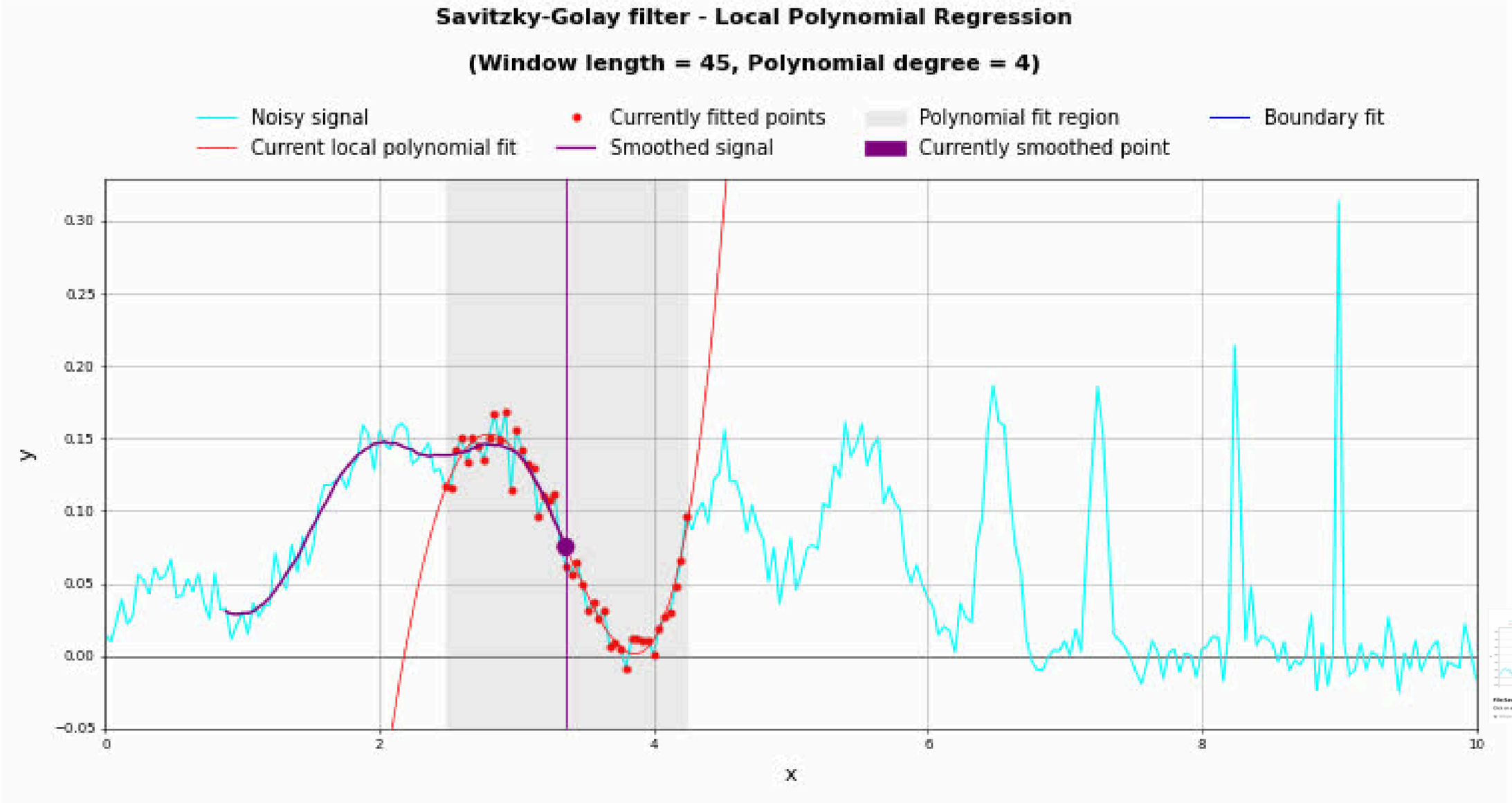
LYSO

- Coupled LYSO crystal to PMT with only one face open.
- Measured signal without any external radioactive source.
- Detected pulses from intrinsic Lutetium-176 decay and cosmic muons.
- Applied Savitzky-Golay filter instead of moving average for better smoothing.
- Performed decay time estimation.

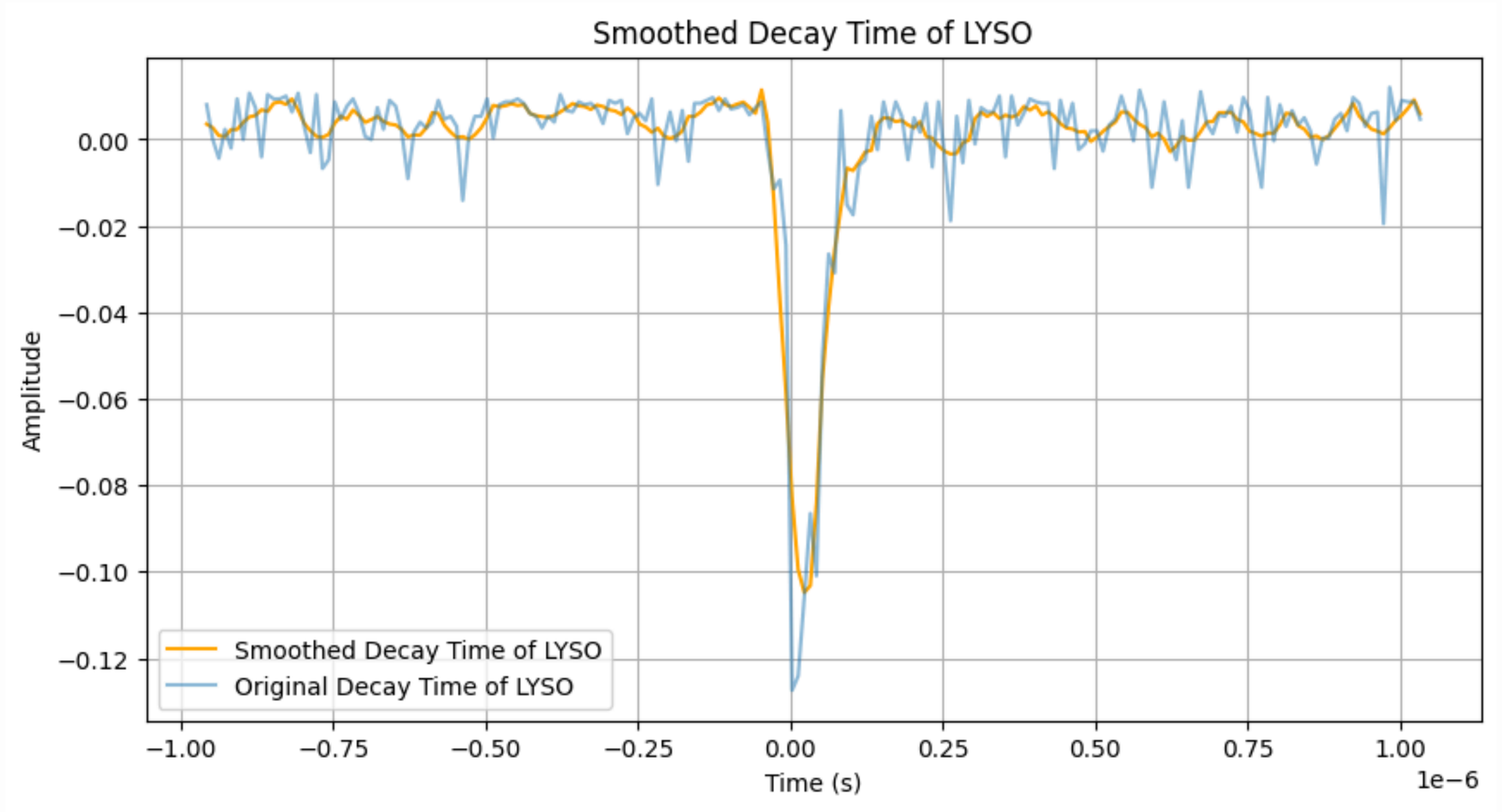
LYSO


Decay Time of LYSO
0.00
−0.02
−0.04
−0.06
−0.08
−0.10
−0.12
−0.14
Amplitude
Decay Time of LYSO
−1.00
−0.75
−0.50
−0.25
0.00
0.25
0.50
0.75
1.00
1e−6
Time (s)

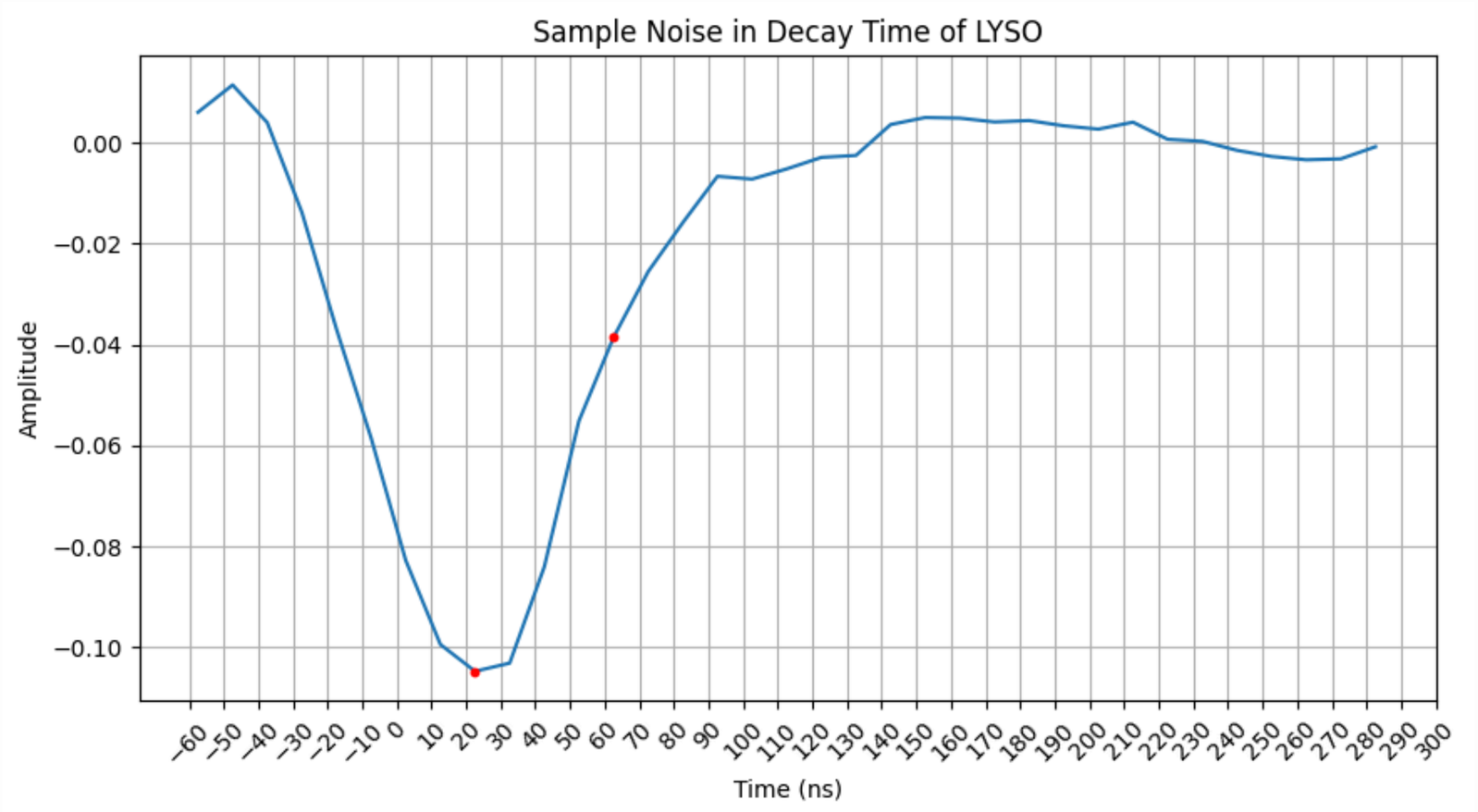
LYSO


Savitzky-Golay filter - Local Polynomial Regression
(Window length = 45, Polynomial degree = 4)
Noisy signal
Current local polynomial fit
Currently fitted points
Smoothed signal
Polynomial fit region
Currently smoothed point
Boundary fit
y
x
0.30
0.25
0.20
0.15
0.10
0.05
0.00
−0.05
0
2
4
6
8
10

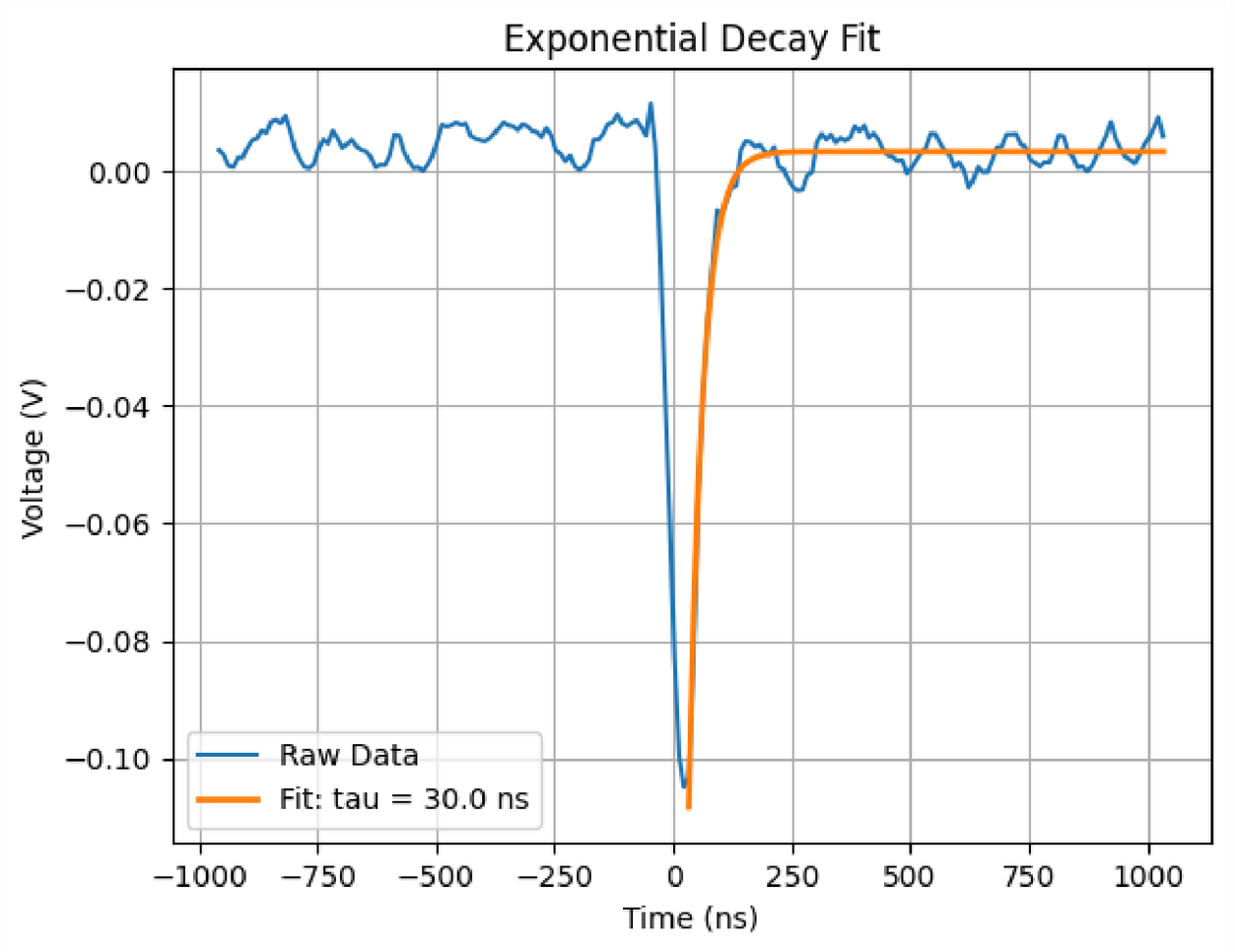
LYSO


Smoothed Decay Time of LYSO
Amplitude
0.00
−0.02
−0.04
−0.06
−0.08
−0.10
−0.12
−1.00
−0.75
−0.50
−0.25
0.00
0.25
0.50
0.75
1.00
1e−6
Time (s)
Smoothed Decay Time of LYSO
Original Decay Time of LYSO

LYSO


Sample Noise in Decay Time of LYSO
Amplitude
0.00
−0.02
−0.04
−0.06
−0.08
−0.10
−60 −50 −40 −30 −20 −10 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300
Time (ns)

LYSO


Exponential Decay Fit
0.00
−0.02
−0.04
−0.06
−0.08
−0.10
Voltage (V)
−1000
−750
−500
−250
0
250
500
750
1000
Time (ns)
Raw Data
Fit: tau = 30.0 ns

LYSO

- Measured decay time ≈ 30 ns.
- Typical pulse peak ≈ 150 mV.
- Verified signal was from radiation, not ambient light leakage.

THANKYOU