HARDWARE CAMP 2024

MPPC ARRAYS

GROUP B

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OUTLINE

I. Introduction

II. Investigate the optical fiber profile

III. Measuring muon rate

IV. Need to improve

OUTLINE

I. Introduction

II. Investigate the optical fiber profile

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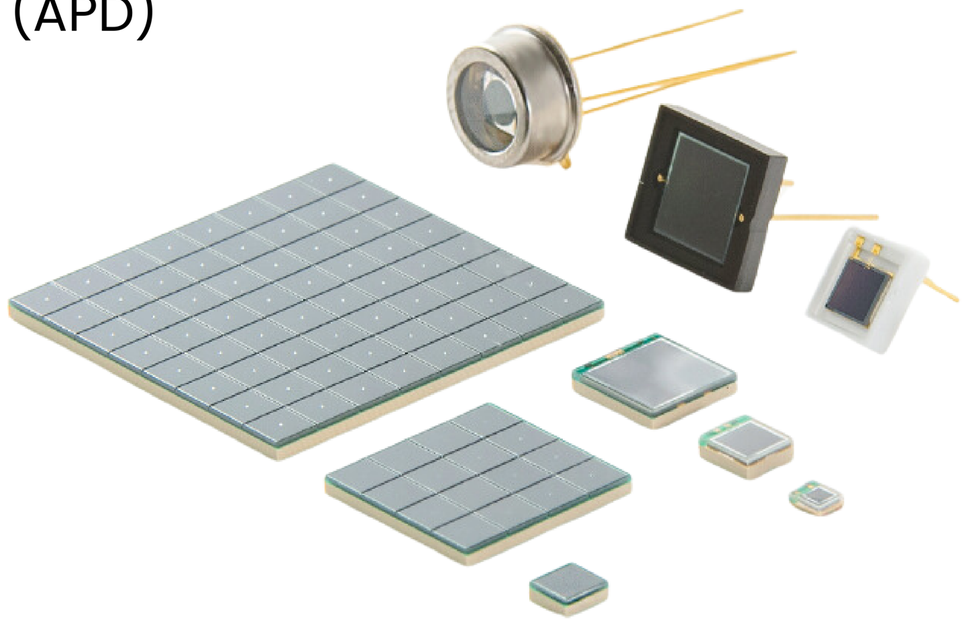
IV. Rooms for improvement

Introduction

1. MPPC

- Stands for Multi-Pixel Photon Counter, also known as Silicon Photomultiplier (SiPM)
- A solid state photodetector
- Made up of a matrix of avalanche photodiodes (APD)
- Operated in Geiger mode
- Detect low-intensity light signal



Introduction

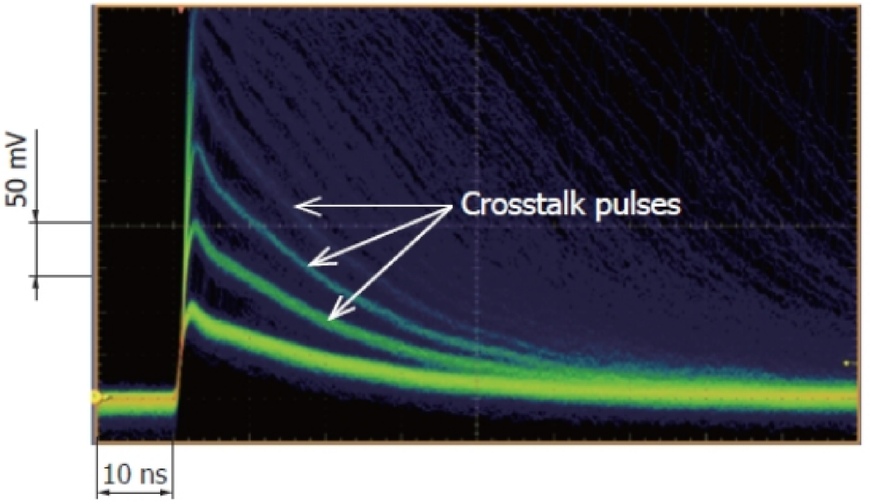
2. MPPC Array

- MPPC array 4x4, model Hamamatsu S13361-3050AE-04
- Our MPPC Array contains 16 pixels which can connect to 16 channels
- We only use 4 pixels at a time

4	8	12	16
3	7	11	15
2	6	10	14
1	5	9	13

3. Crosstalk

- Crosstalk in MPPC occurs when a single photon detection event in one pixel influences the signal in neighboring pixels, leading to the false registration of additional photon detections
- Impact on image resolution and accurate photon counting



Investigate the optical fiber profile

I. Introduction

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IV. Rooms for improvement

Investigate the optical fiber profile

1. Measuring 1 PE charge

- A photon-electron signals is a signal of one photon when it’s hit the MPPC pixel.
- The signal we observe has been pre-amplified (multiply with gain) before entering the Oscilloscope.

Investigate the optical fiber profile

1. Measuring 1 PE charge

- **Experiment design**

MPPCs array
Oscilloscope

→

- Power on -> MPPCs array follow in order
- Setup->choose edge function-> trigger level at 0.5pe for low and 1.5pe for high.
- Acquire -> Average 1024.
- Save-> type(CSV) -> press to save.

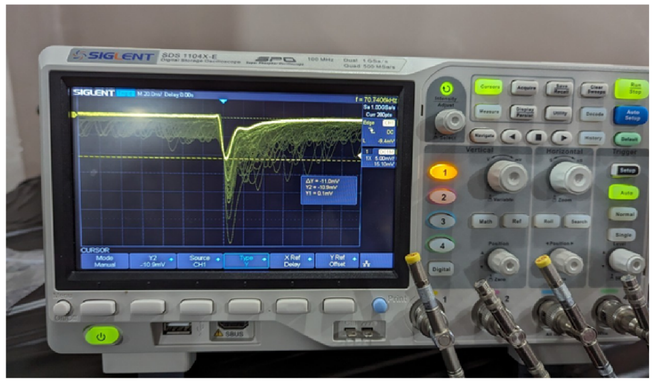
→

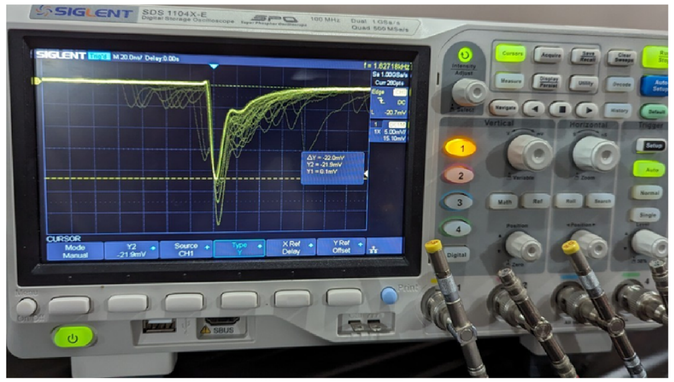
Measure frequency and charge each signal by calculating the area of signal

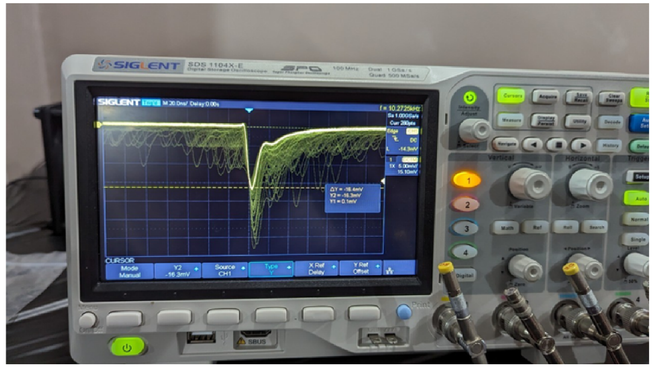
Setup of the experiment

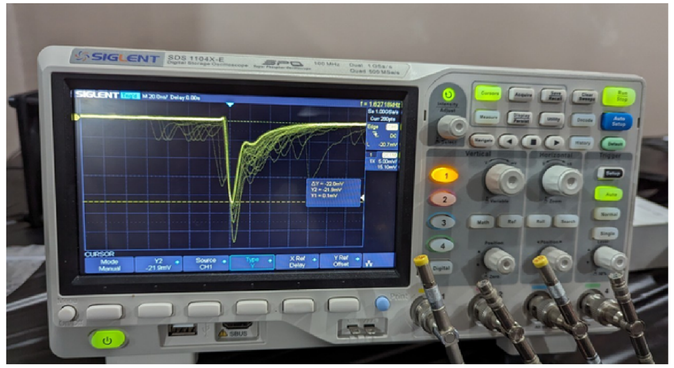
Investigate the optical fiber profile

1. Measuring 1 PE charge









Area of signal correspond to charge of each channel

Single photon electron Charge Results			
CH1	CH2	CH3	CH4
-1.3E-10	-1.2E-10	-2.5E-10	-1.3E-10

Investigate the optical fiber profile

1. Measuring 1 PE charge

- **Electronic gain experiment set up**

LED
Optical fiber
Oscilloscope
Pulse generator

→

- Connect LED and optical fiber and MPPCs arrays
- Trigger edge: 0.5pe (Average 128)
- Voltage: 3.0-3.2V (Adjuted)
- Frequency: 100Khz
- Duty cycle: 0.4%

→

- Convert Area of each channel to the gain of MPPCs
- Connect light source to each channel and observe signal

- **Calculated results**

CH1=1	CH2=5	CH3=9	CH4=13
8.00E+07	7.54E+07	1.56E+08	7.89E+07

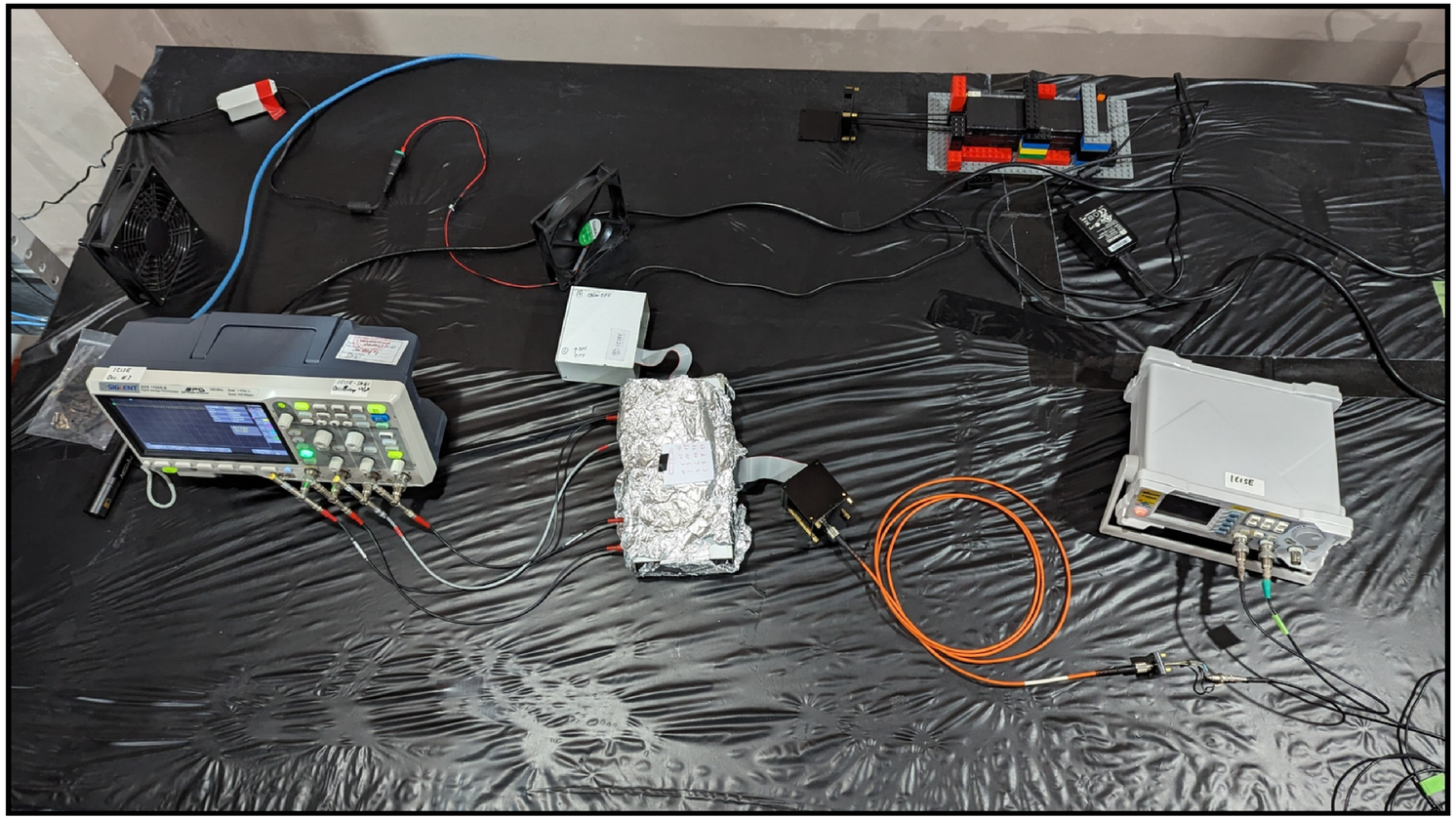
Investigate the optical fiber profile

2. Experiment

2.1. What to measure?

LED Optical fiber profile

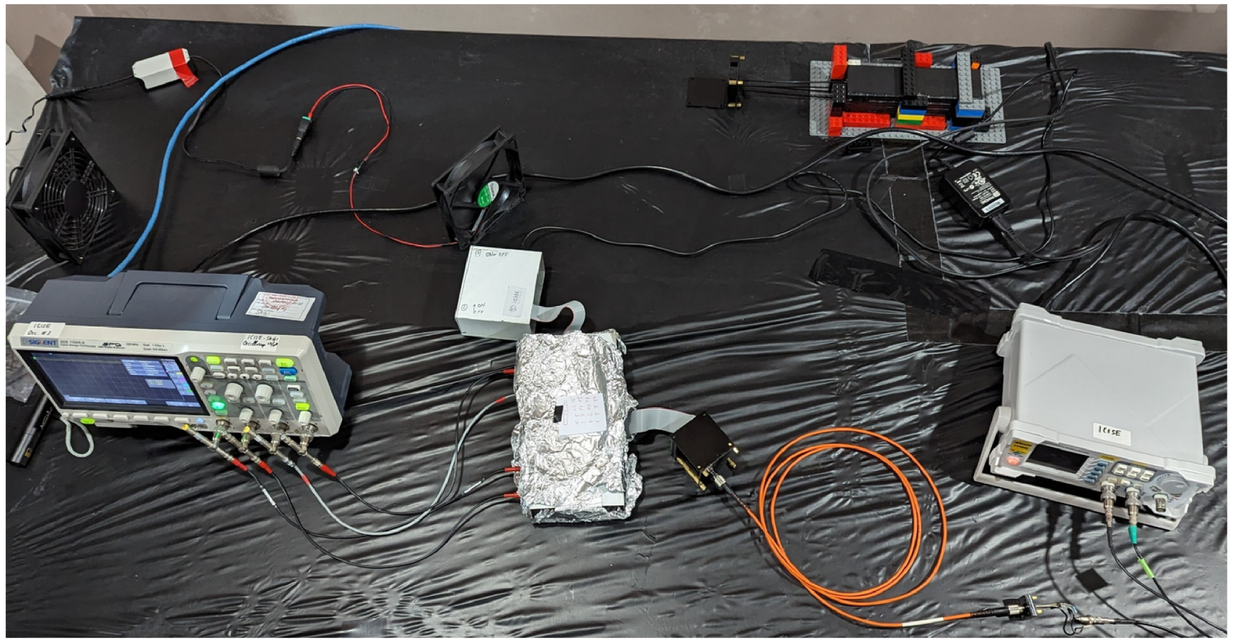
- Center position
- Width

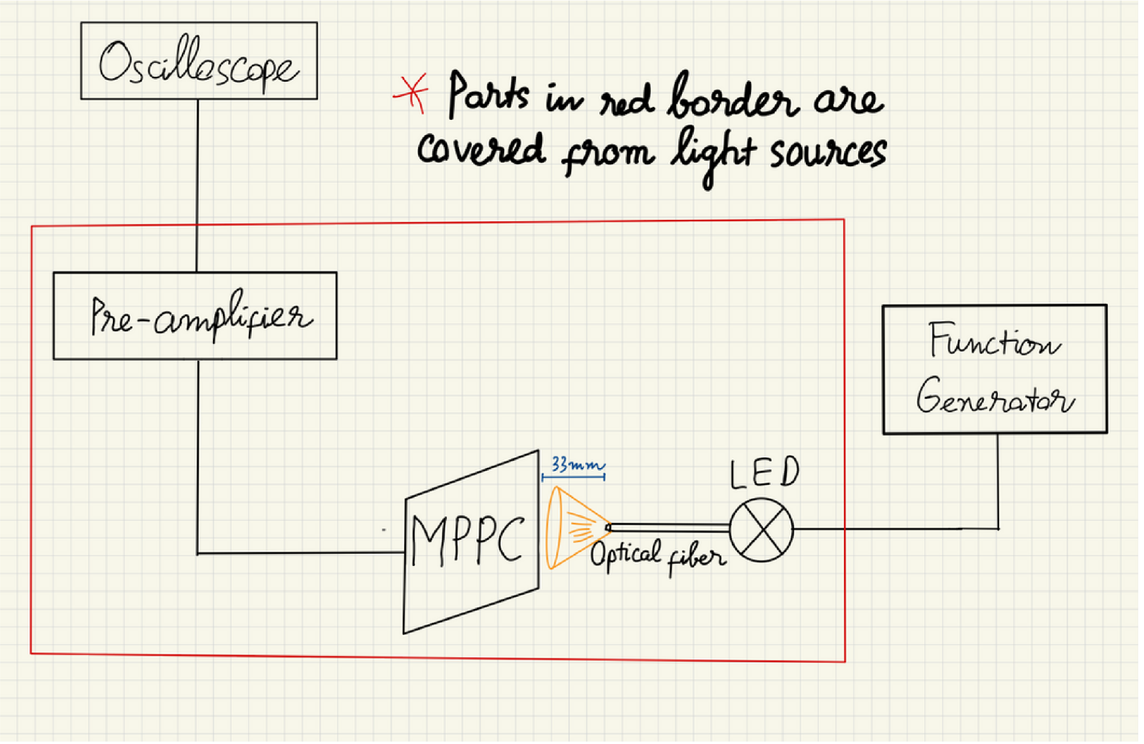


A full fiew of the experiment setup from above

2. Experiment

2.2. Instrument and setup





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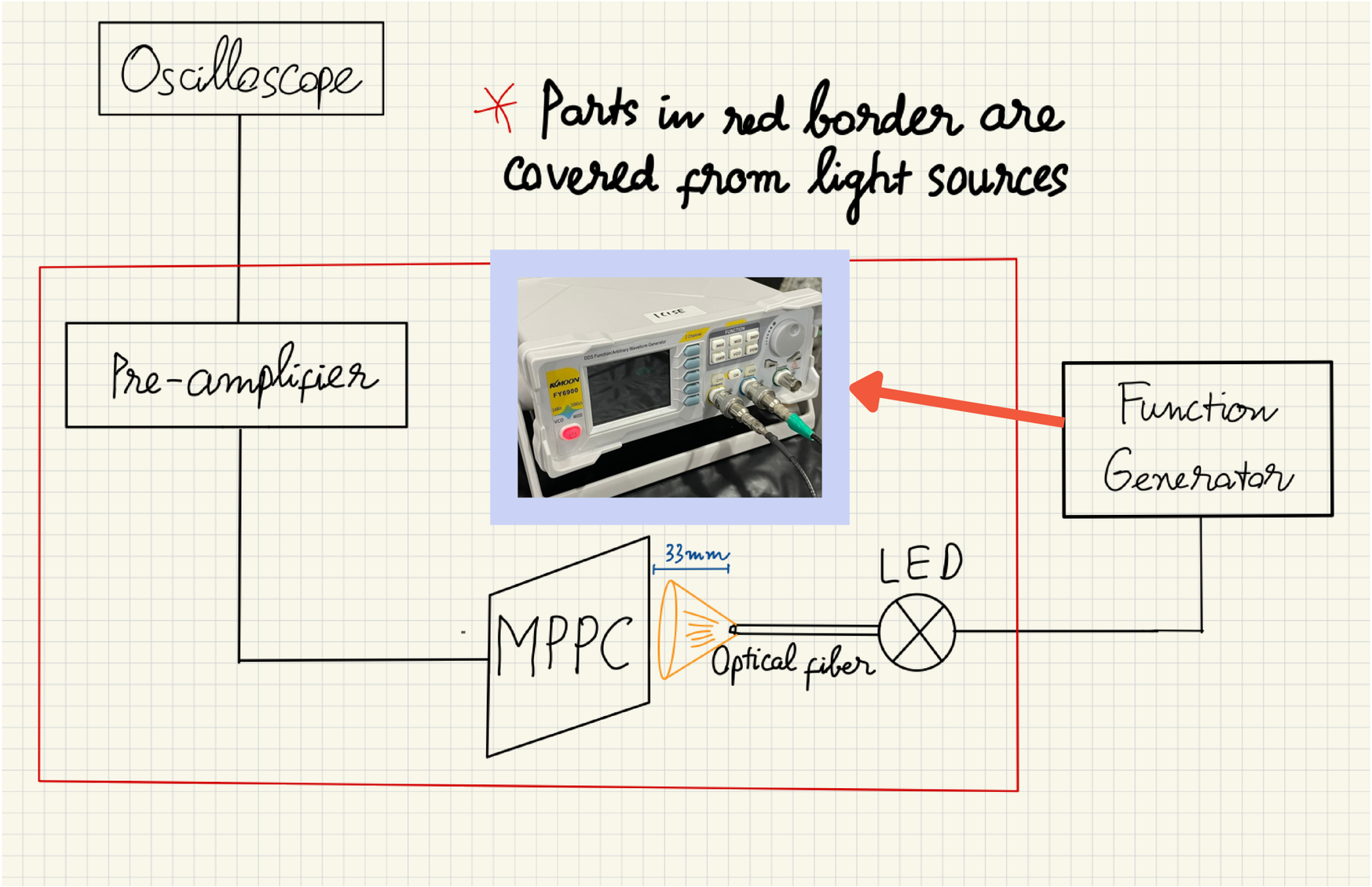

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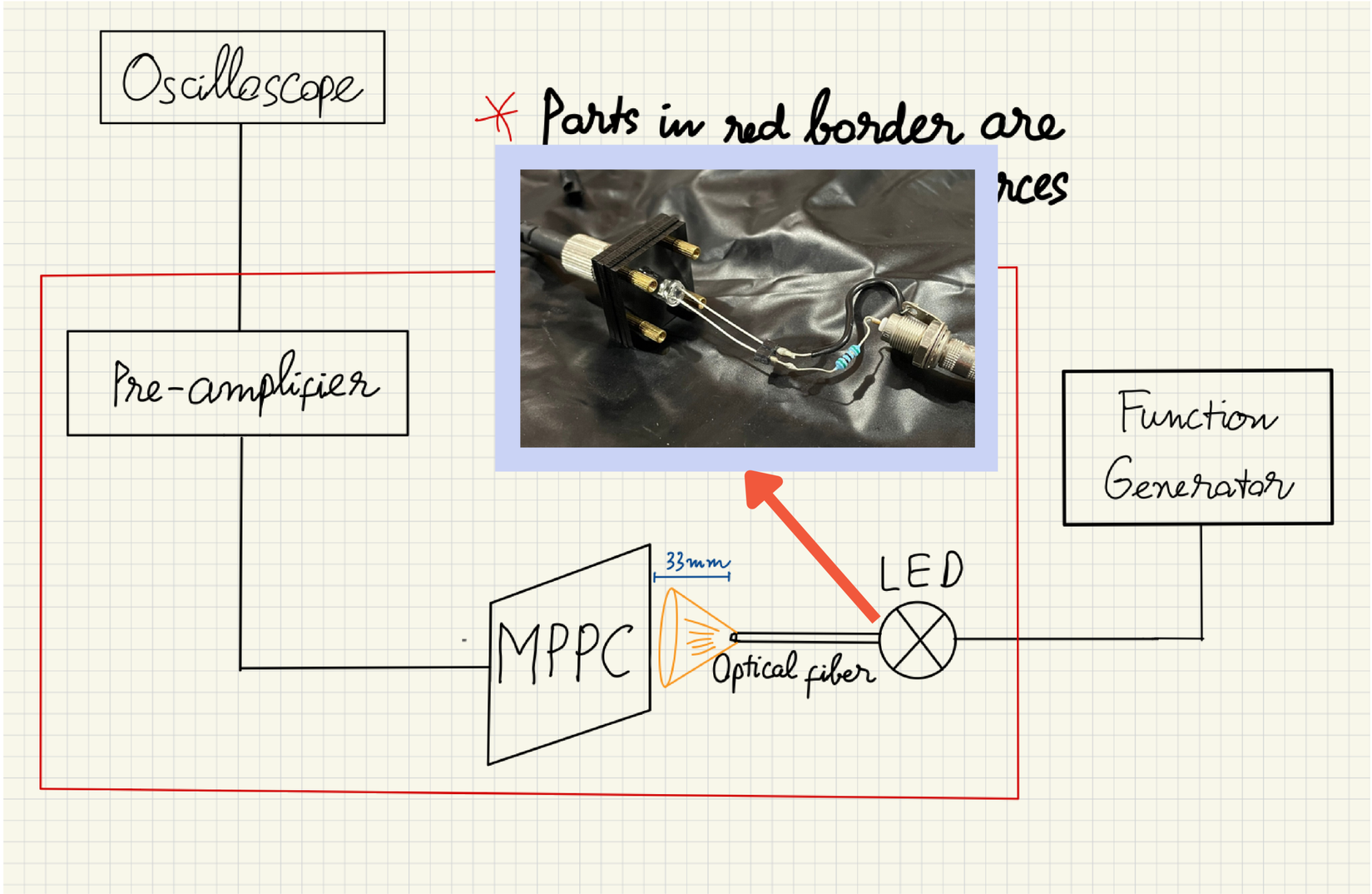

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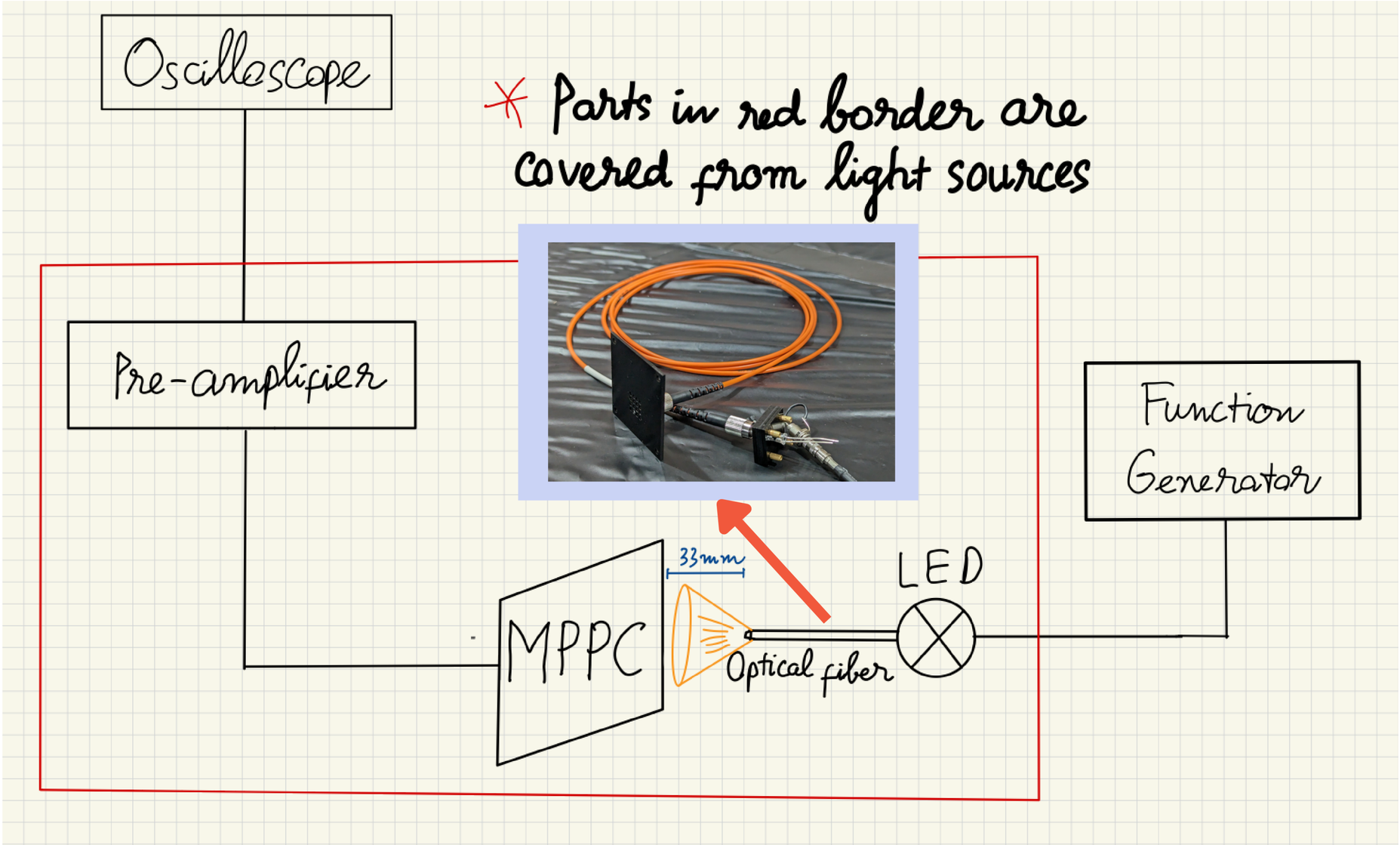

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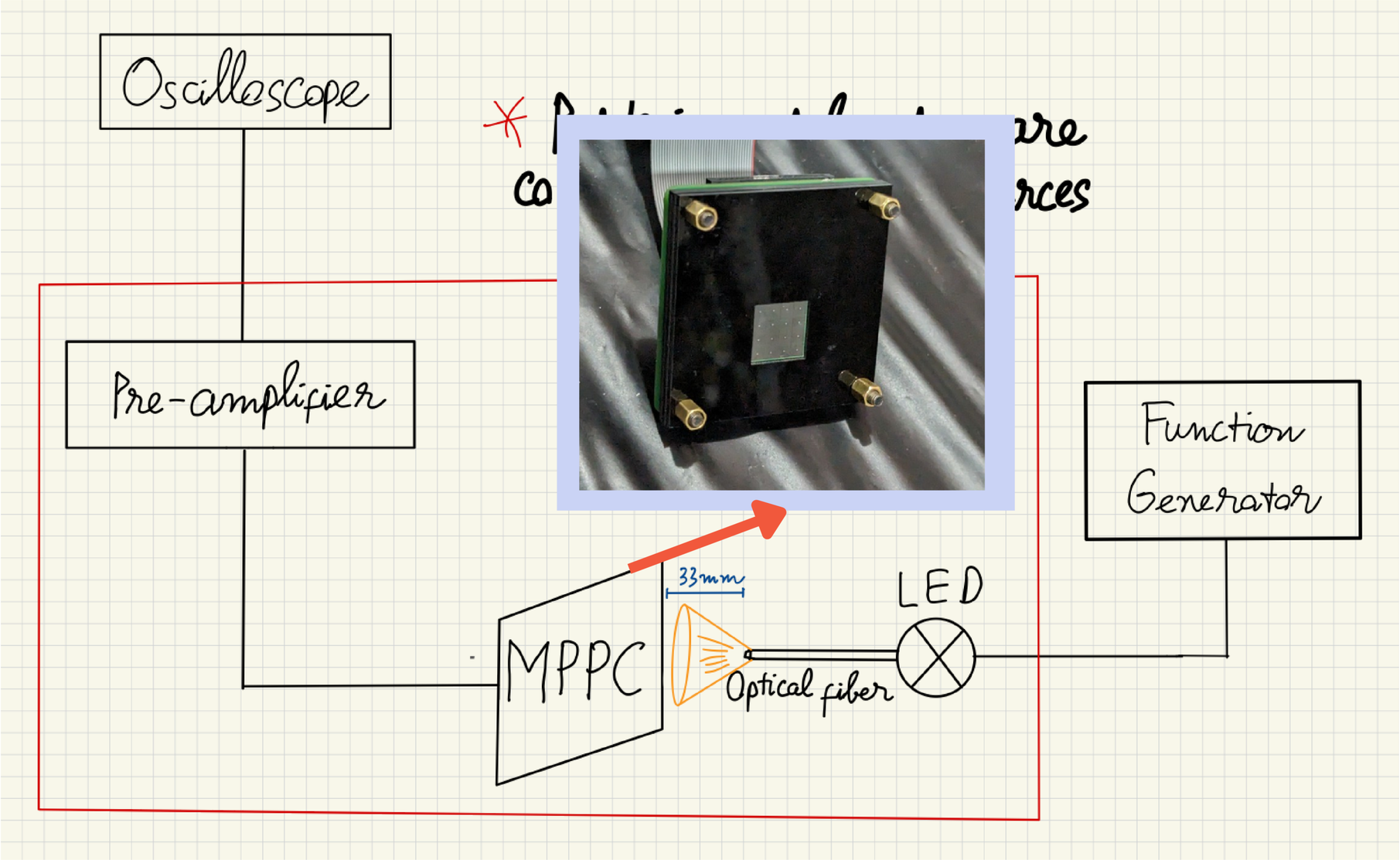

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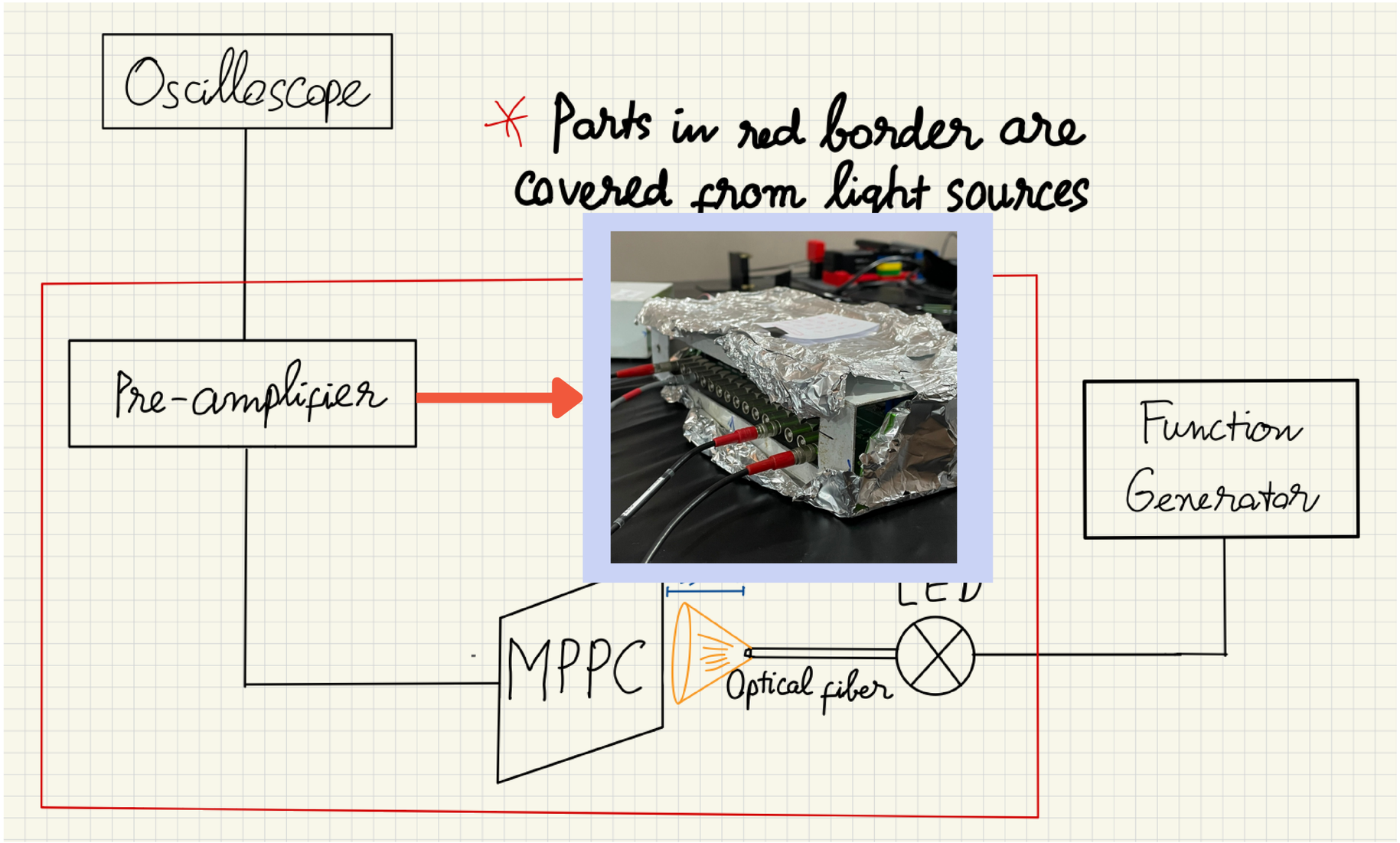

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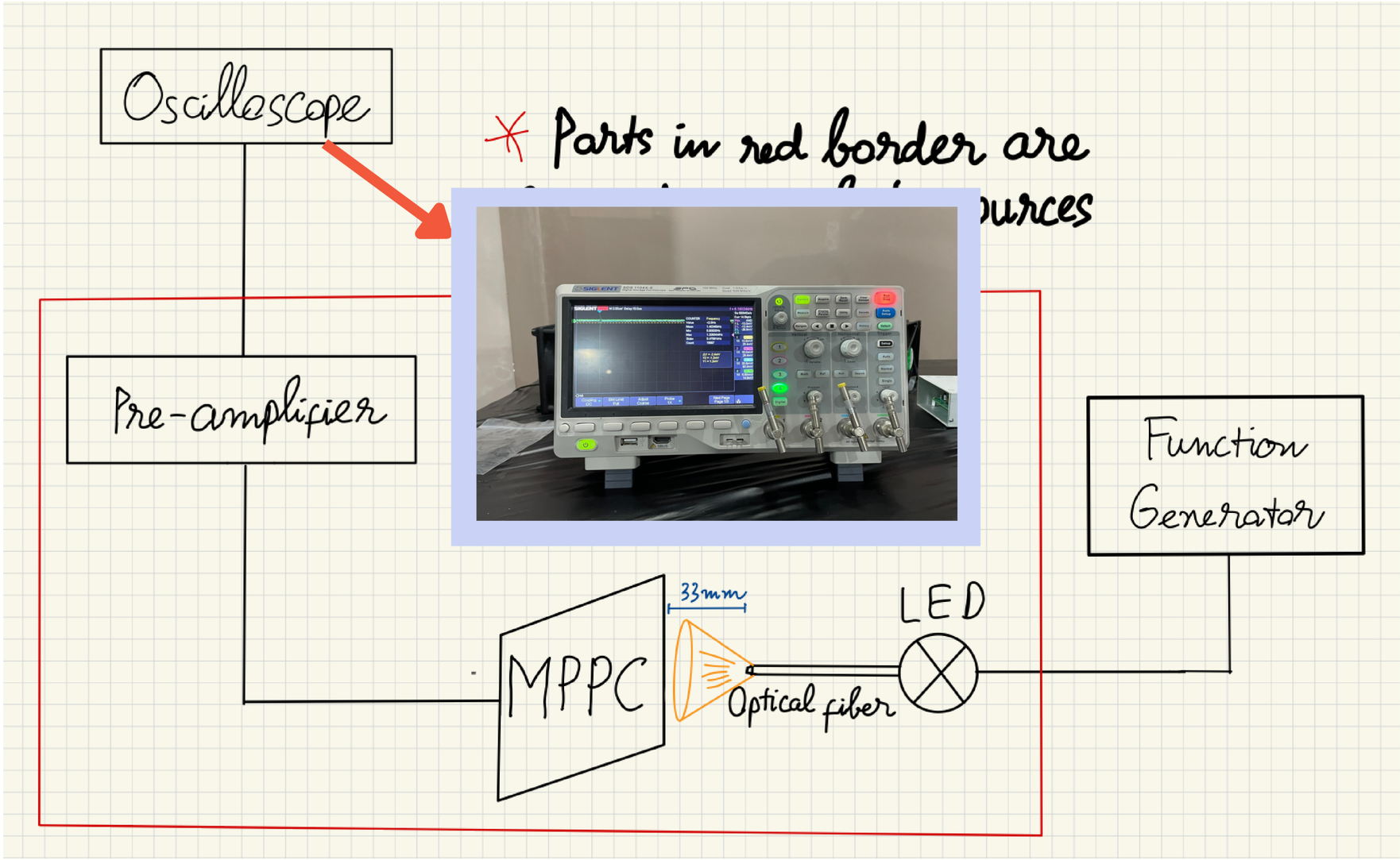


Investigate the optical fiber profile

2.3. Results and data analysis

CH1	CH2	CH3	CH4
-1.2795 E-10	-1.2E-10	-2.5E-10	-1.3E-10
-1.3769 8E-10	-1.3E-10	-2.6E-10	-1.3E-10

Single photon electron charge

		CH1	CH2	CH3	CH4
Light source at channels	CH1	-6.01E-09	-2.8E-09	-9.2E-10	-4.5E-10
	CH2	-3.91E-09	-6.3E-09	-6.5E-09	-7E-10
	CH3	-4.61E-09	-1.1E-08	-2.7E-09	-2.7E-09
	CH4	-3.63E-10	-1.7E-09	-9.9E-09	-5.5E-09

Charge at each pixel
when optic fiber is pointing at

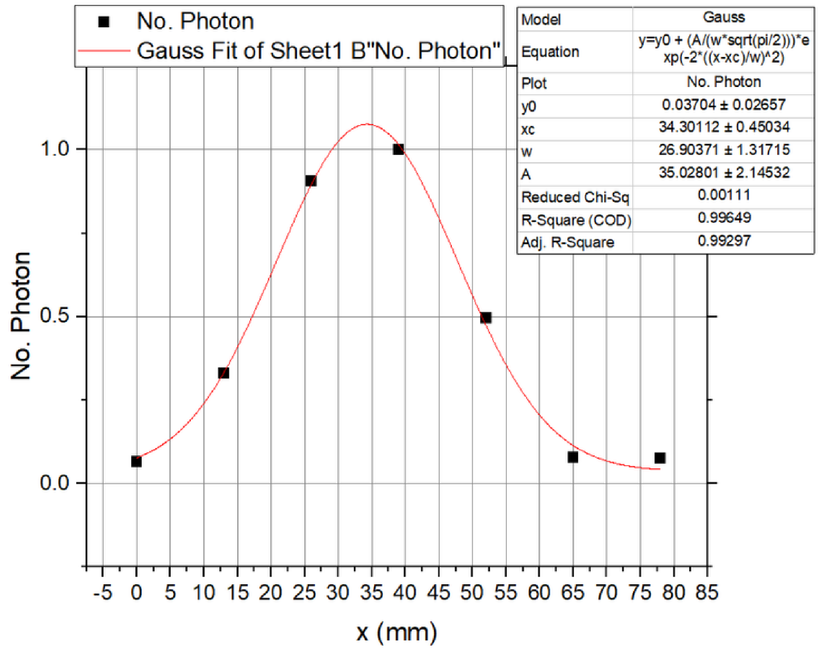
4	8	12	16
3	7	11	15
2	6	10	14
1	5	9	13

CH1 CH2 CH3 CH4

Investigate the optical fiber profile

		CH1	CH2	CH3	CH4
Number photons at channels	CH1	46.94	23.29	3.69	3.57
	CH2	30.54	52.57	26.01	5.53
	CH3	36.02	92.10	10.76	21.29
	CH4	2.84	14.41	39.58	43.70

Area of each channels
(charge of pixels)



photon distribution
(optic fiber profile)

Peak center: 34.3 +/- 0.5 (mm)
Width: 26.9 +/- 1.3 (mm)

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Measuring muon rate (Task 3: Cosmic ray muons)

3.1. Measuring method

- Coincident event of 3 plastic scintillators.
- Examine the noise to find the suitable threshold (trigger).
- Start measuring and analyzing the data.

Measuring muon rate (Task 3: Cosmic ray muons)

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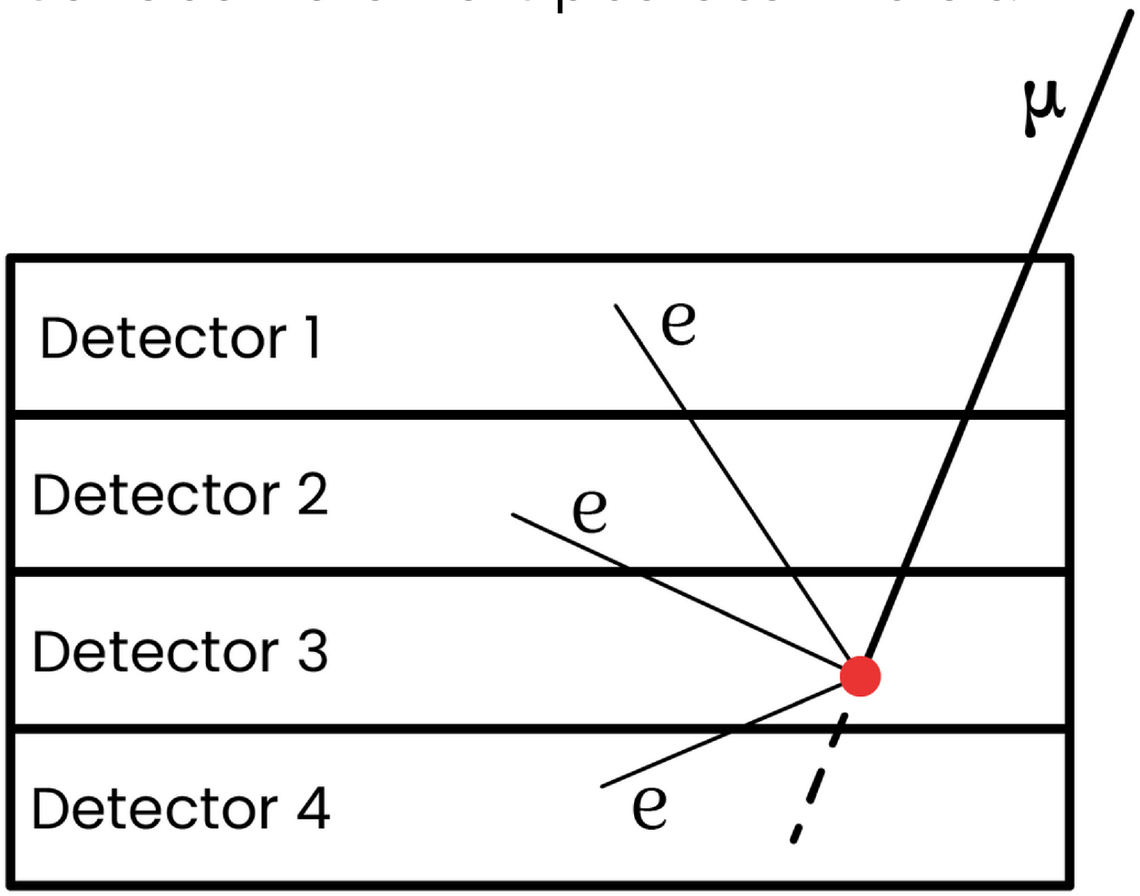
Measuring muon rate (Task 3: Cosmic ray muons)

Coincident event of 3 plastic scintillators.



- If a muon passthrough, a coincidence signal of 3 (or 4) detector will appear.
- **Rate of muon must be at least 100 times higher than rate of noise (dark count).**

Measuring muon rate (Task 3: Cosmic ray muons)

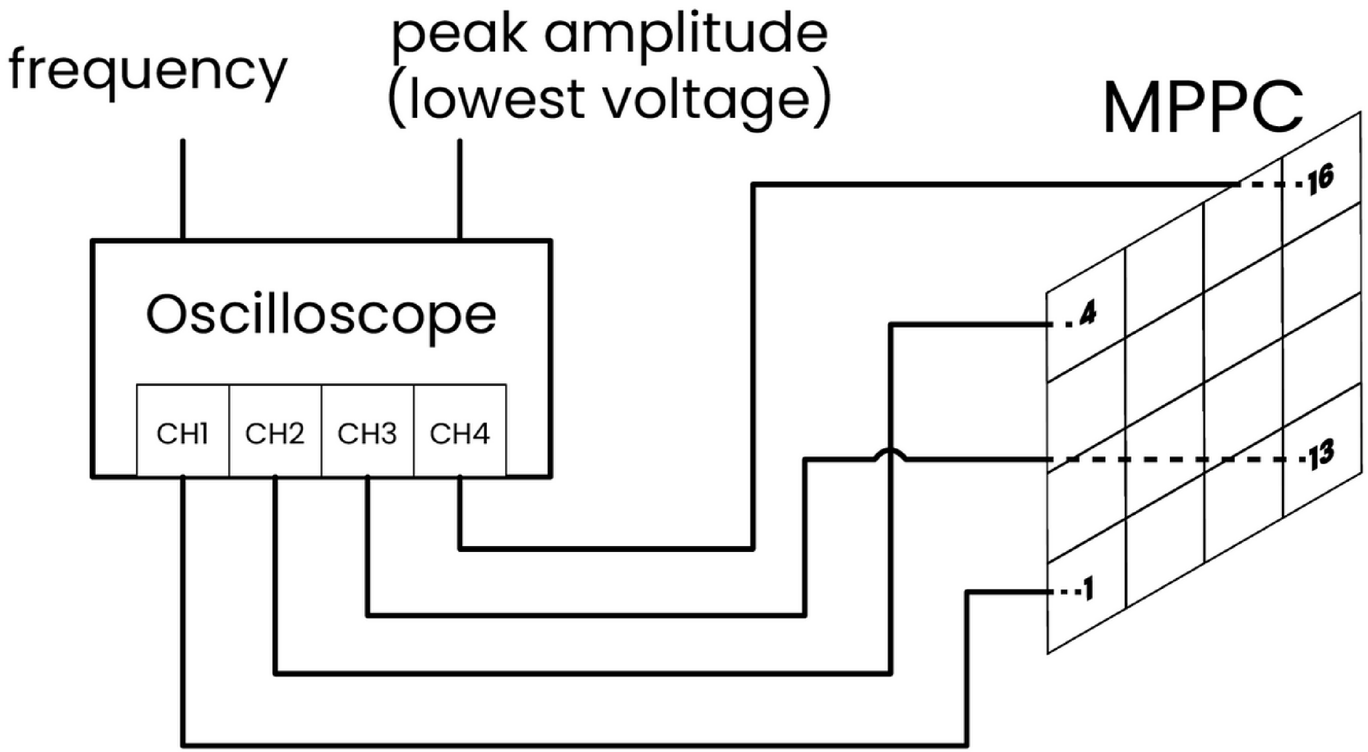
3.1. Measuring method

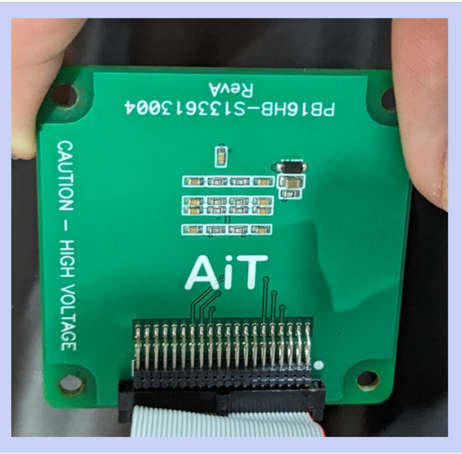
- Coincident event of 3 plastic scintillators.
- Examine the noise to find the suitable threshold (trigger).
- Start measuring and analyzing the data.

Measuring muon rate (Task 3: Cosmic ray muons)

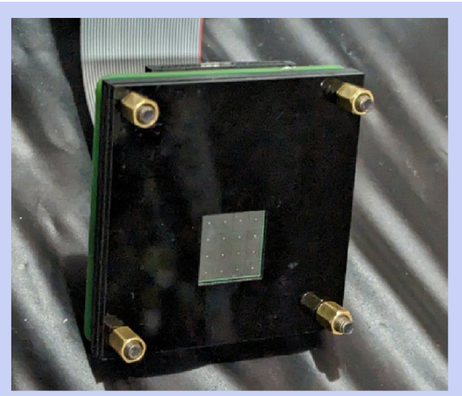
3.2. Measuring MPPC noise (dark count)

- **Setup**





Back of MPPC



Front of MPPC

Measuring muon rate (Task 3: Cosmic ray muons)

Examine the noise to find the suitable threshold (trigger).

- **Result**

Peak voltage			
Number of photon-electron	1	2	3
	mV		
CH1-1	6.24	11.72	16.6
CH2-4	5.96	11.8	16.8
CH3-13	11.2	22.3	32.4
CH4-16	6.08	12.0	18.2

Measuring muon rate (Task 3: Cosmic ray muons)

Examine the noise to find the suitable threshold (trigger).

- **Result**

Frequency of a single channel			
Number of photon-electron	1	2	3
	kHz	kHz	kHz
CH1-1	619.8	80.11	9.85
CH2-4	720.1	80.39	10.66
CH3-13	673.6	73.05	10.01
CH4-16	531.7	57.34	7.06

Measuring muon rate (Task 3: Cosmic ray muons)

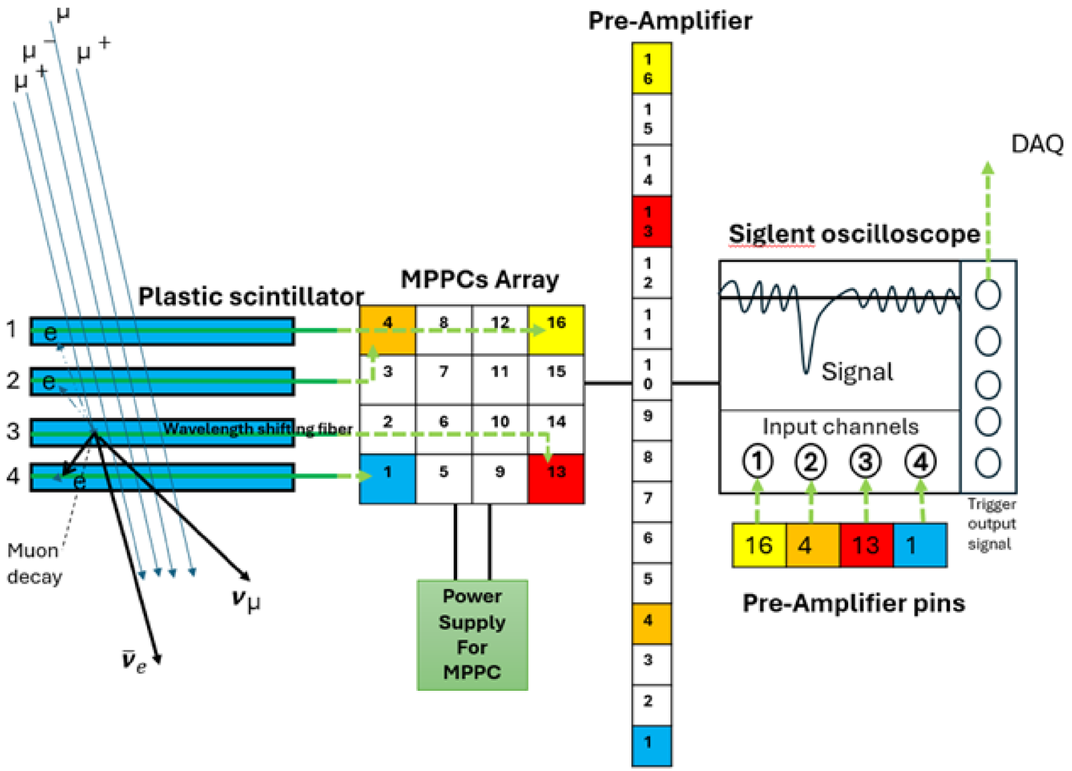
Examine the noise to find the suitable threshold (trigger).

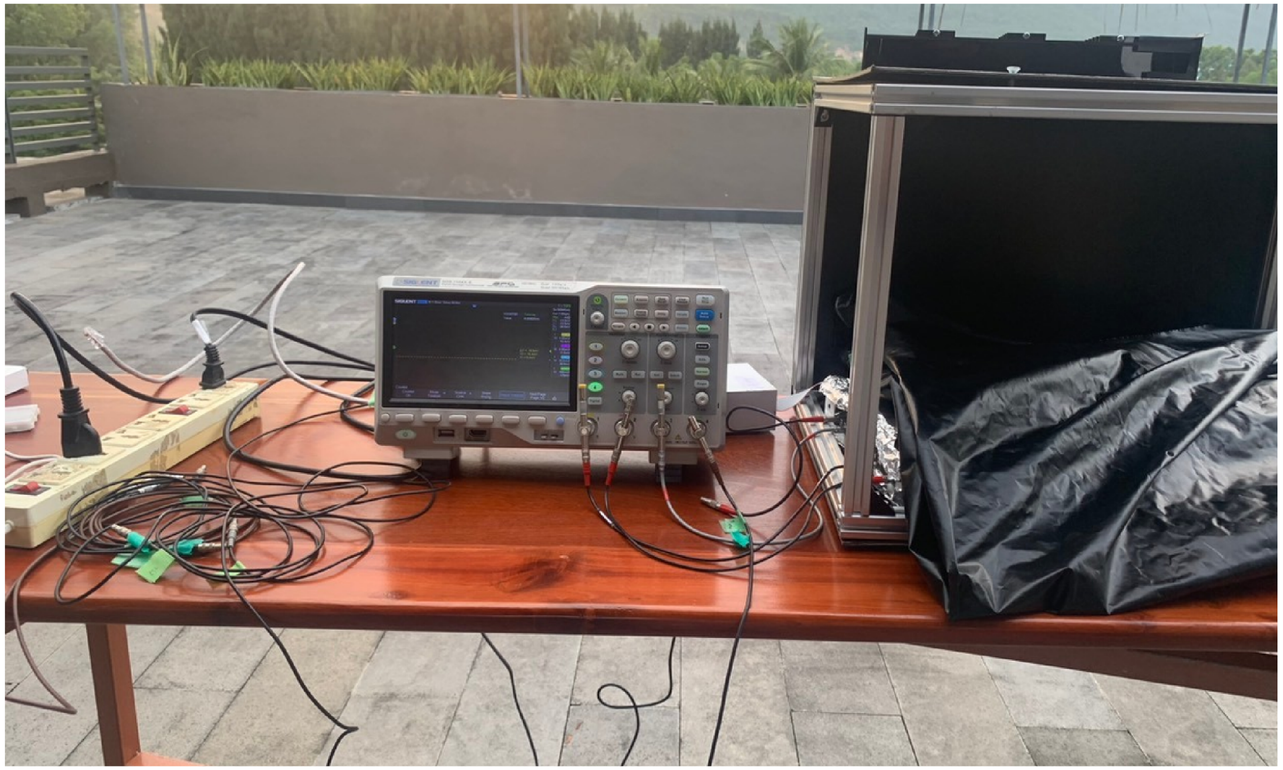
- **Result**

Frequency of coincident			
Number of photon-electron	1	2	3
CH1 & 2	1.346 kHz	61.73 Hz	403 mHz
CH1 & 2 & 3	91.81 Hz	20 mHz	**<0.1 mHz**

Measuring muon rate (Task 3: Cosmic ray muons)

Experiment set up

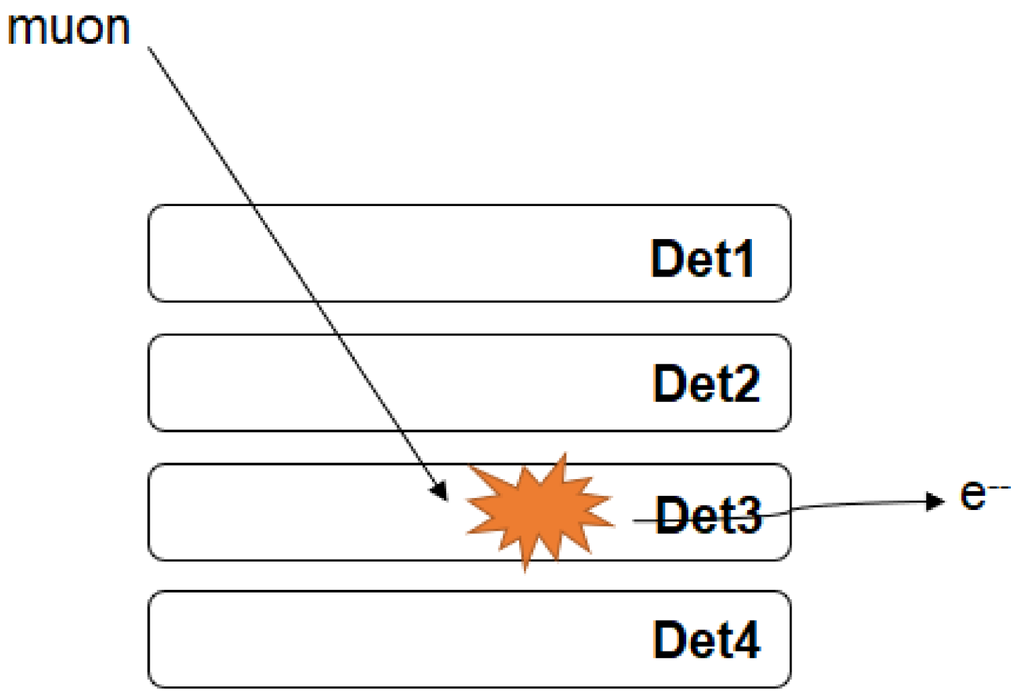




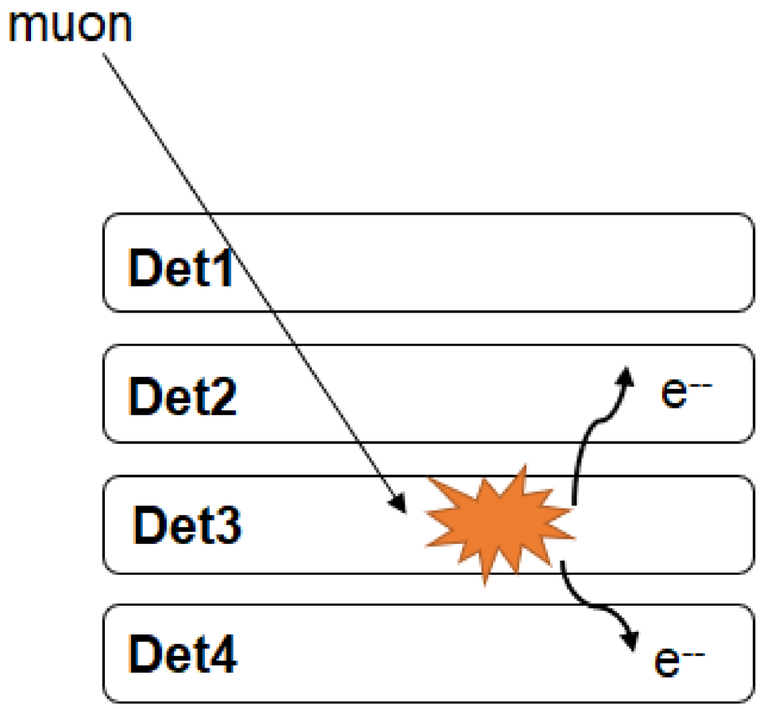
Measuring muon rate (Task 3: Cosmic ray muons)

3.3. Measurement and results

- There are **2** scenarios



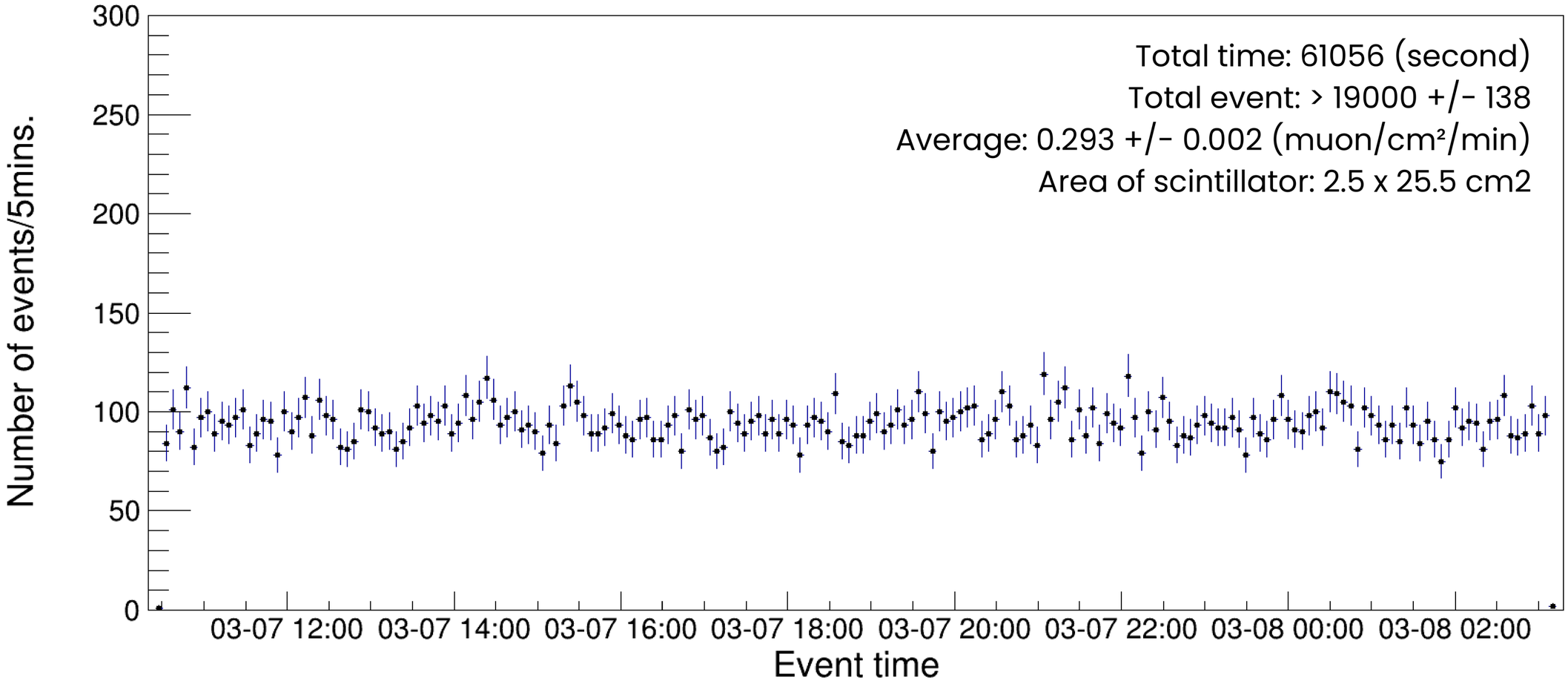
Case 1



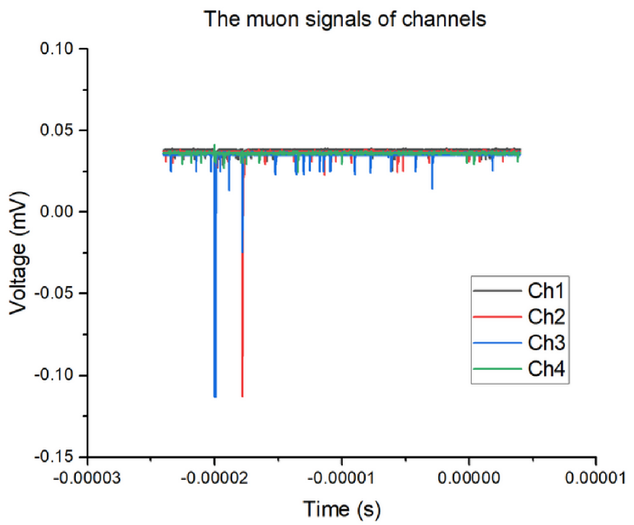
Case 2

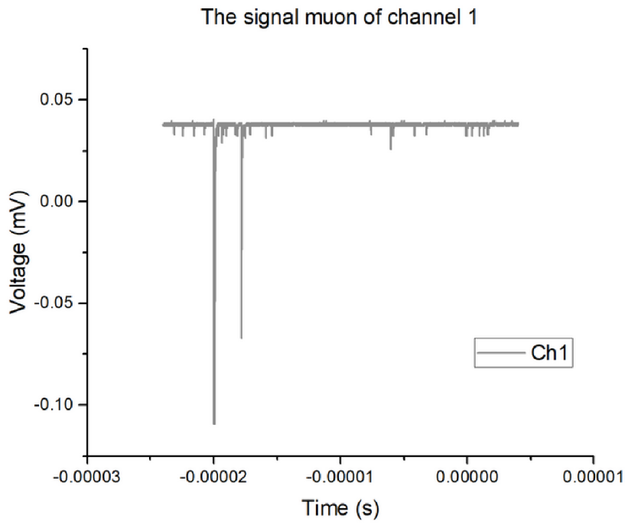
Measuring muon rate (Task 3: Cosmic ray muons)

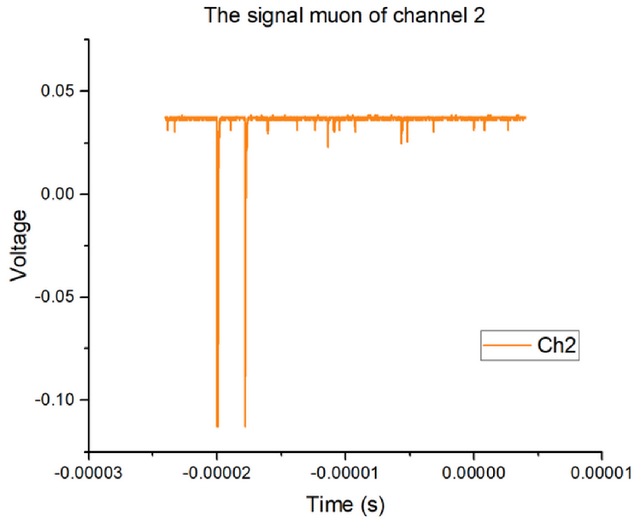
Muon rate

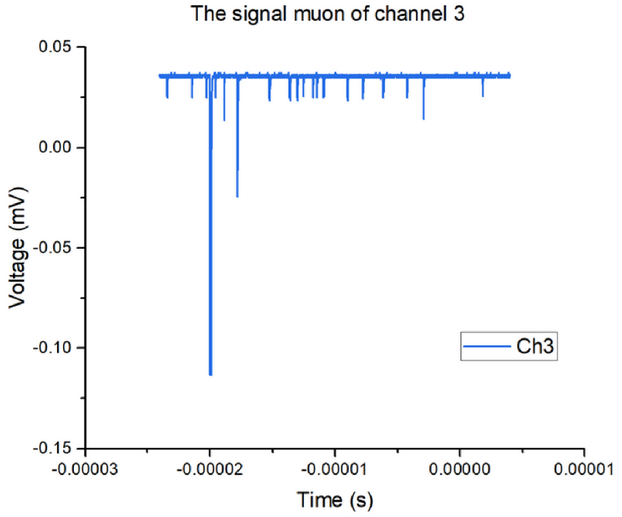


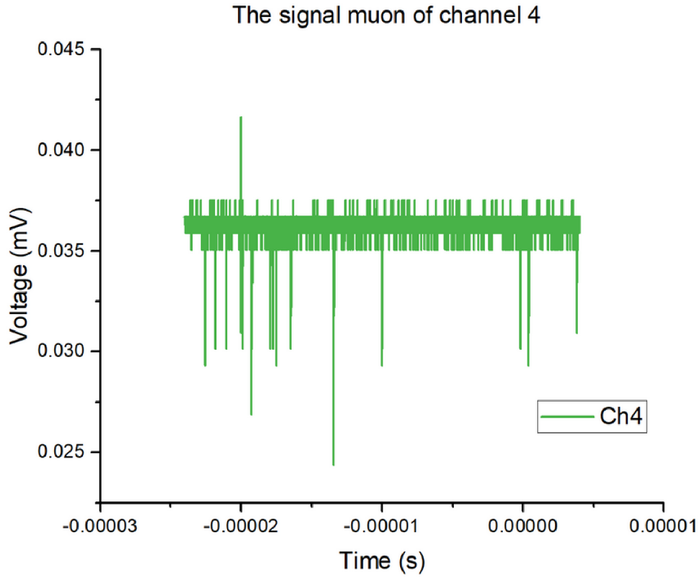
1st Muon decay



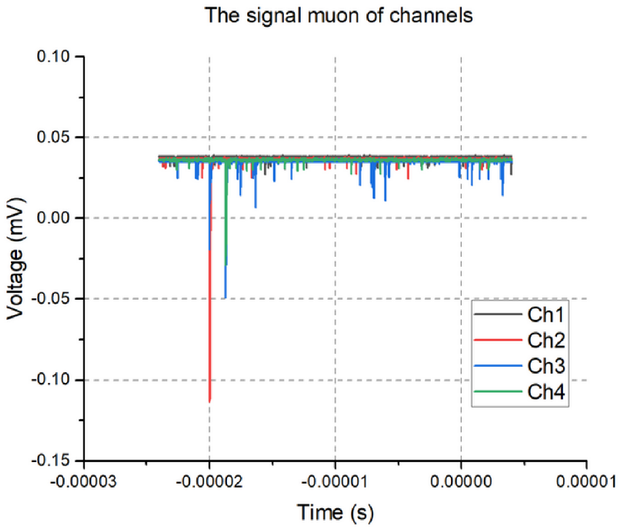


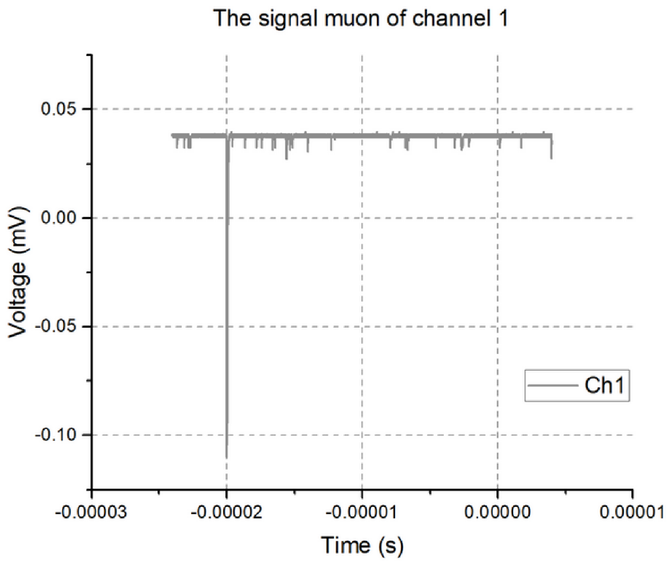


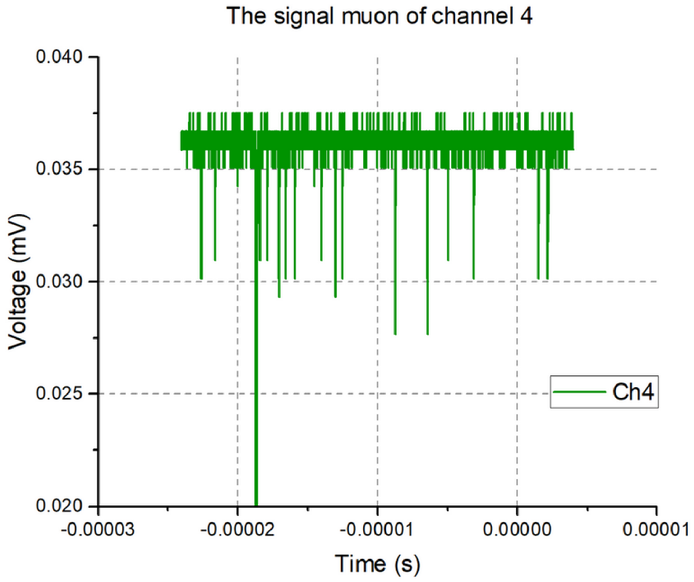


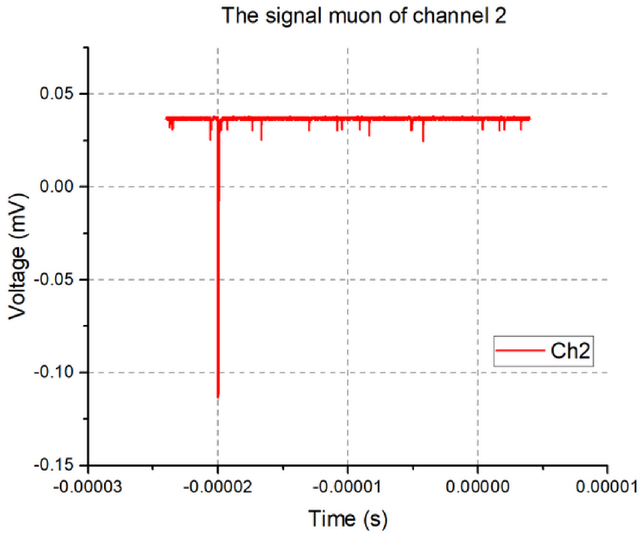


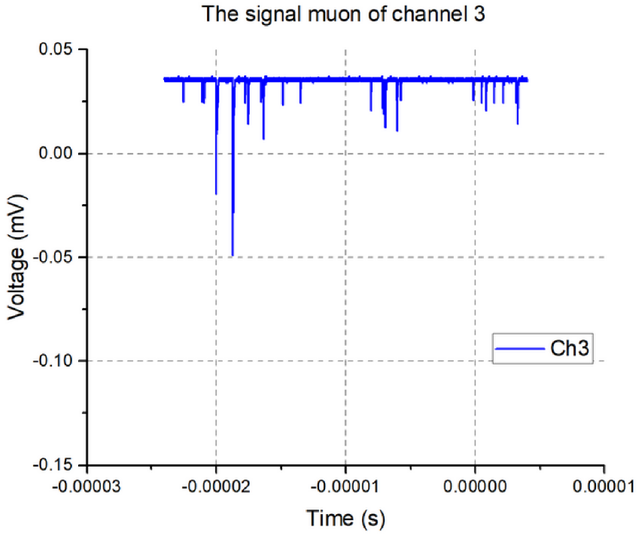
2nd Muon decay



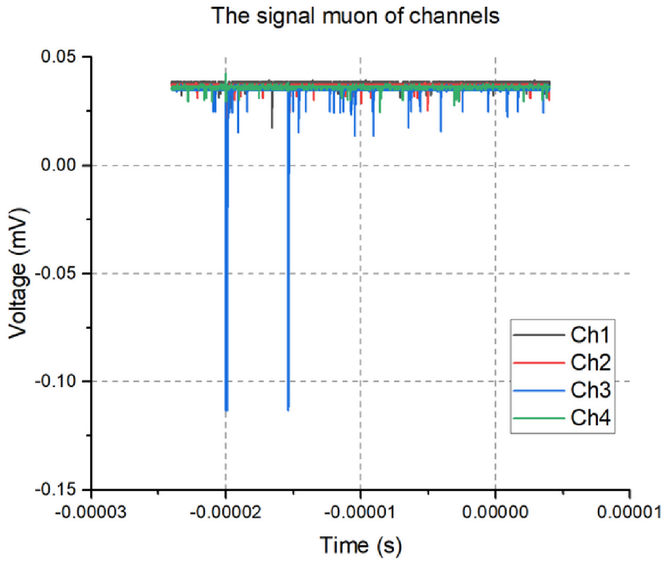


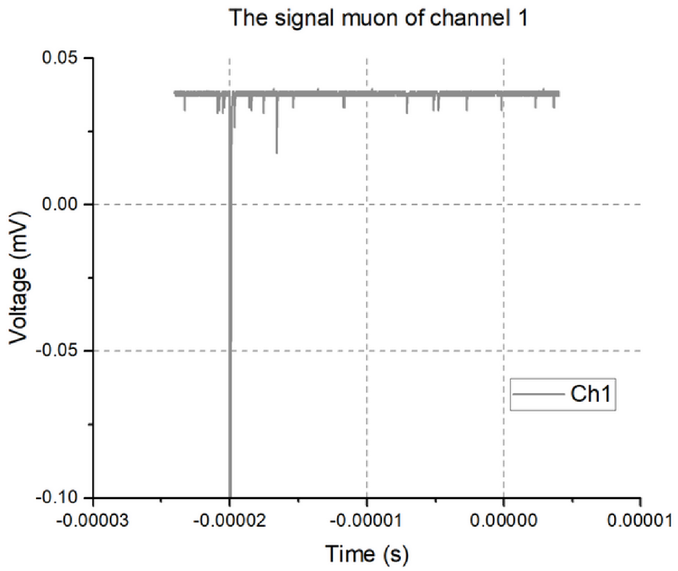


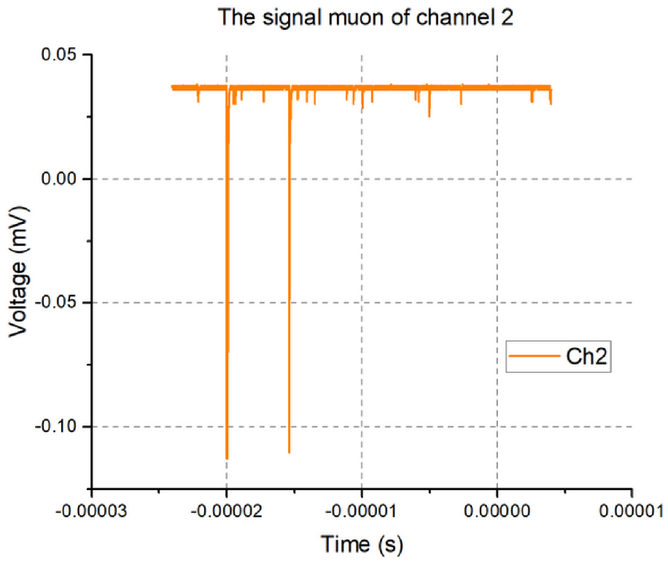


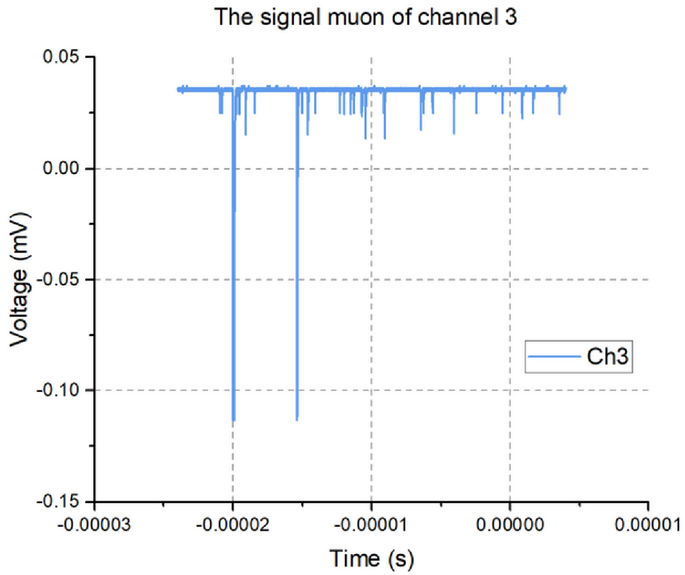


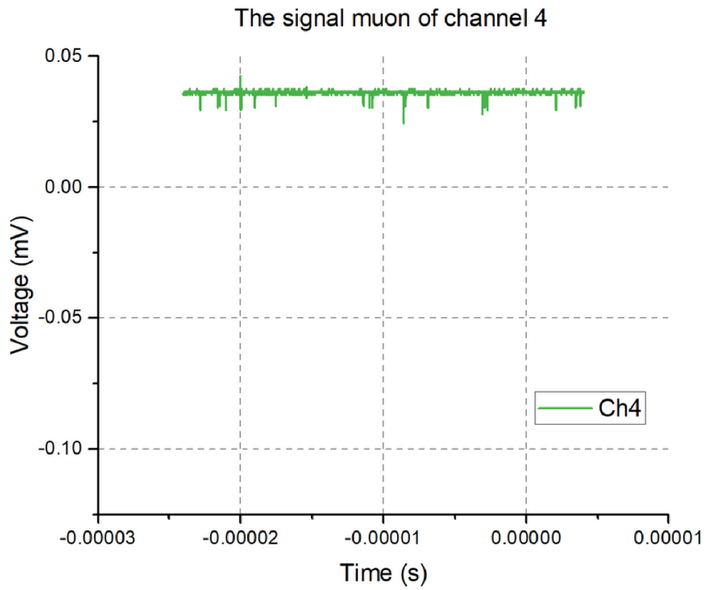
3rd Muon decay



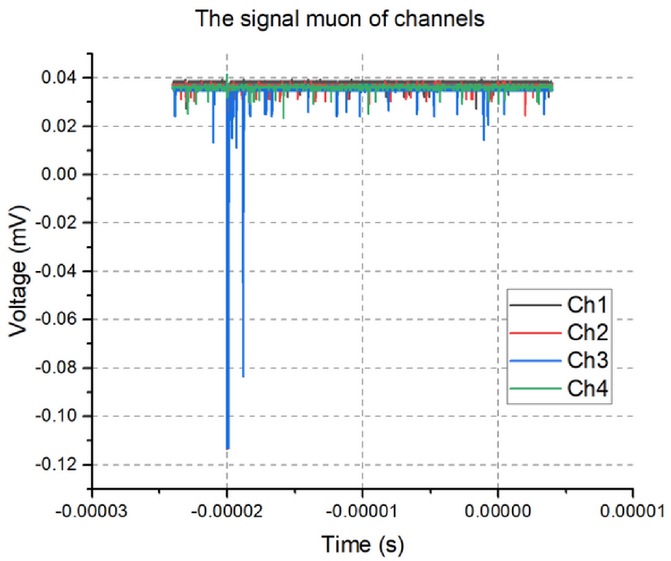


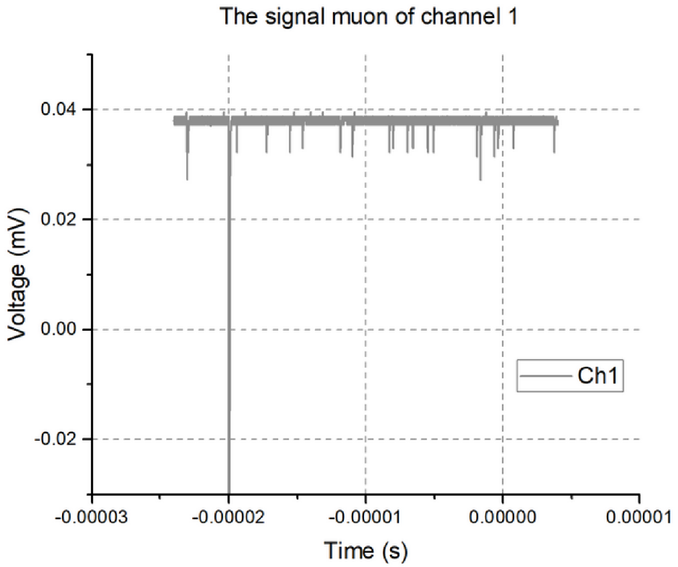


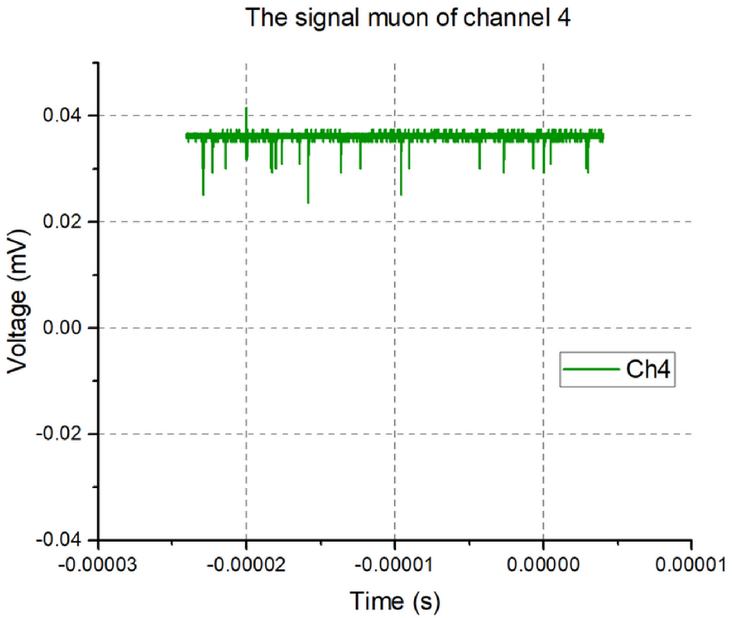


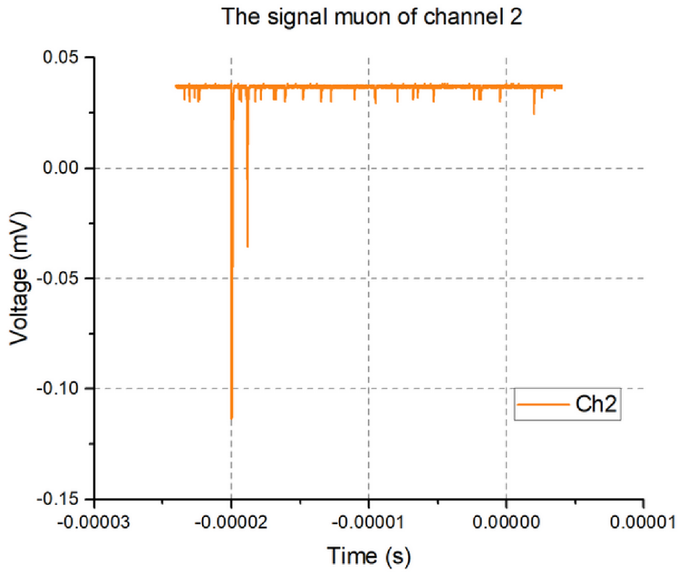


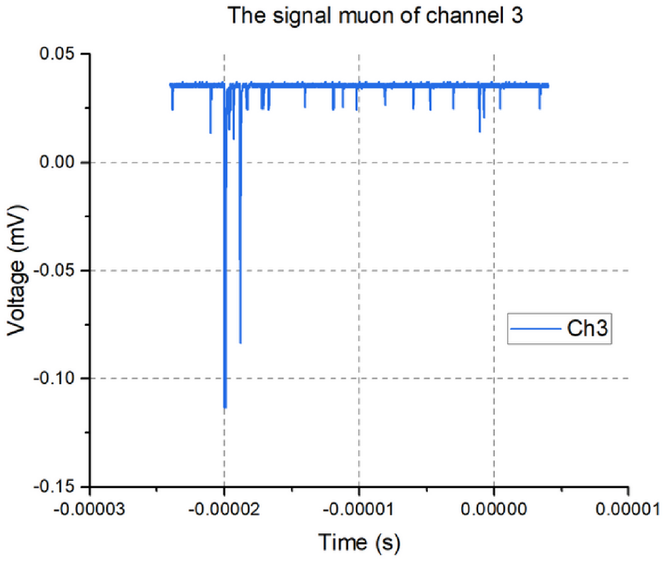
4th Muon decay











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III. Measuring muon rate

IV. Rooms for improvement

Rooms for improvement

- The pulse generator should produce pulses at a faster rate for the LED light to emit photons more quickly.
- The signals received from the MPPC arrays have a notable amount of noise.
- The surface processing stage of the organic scintillator is fairly demanding.
- The data acquired is limited due to restricted time of the sessions and the overall camp.
- There are still substantial human errors during the conduct of experiments and data processing.
- The experiment geometry is not good enough.
- No 100% sure if the captured muon decay is a true muon decay.


THANK YOU FOR YOUR ATTENTION
ANY QUESTIONS?

THANKS FOR LISTENING