Measurement of muon's lifetime

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Cosmic rays

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Scintillation detectors

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$$\text{Scintillation detector} = \text{Scintillator} + \text{Light sensor}$$

Multi Pixel Photon Counter

A MPPC is a light detector made of several diodes in Geiger mode

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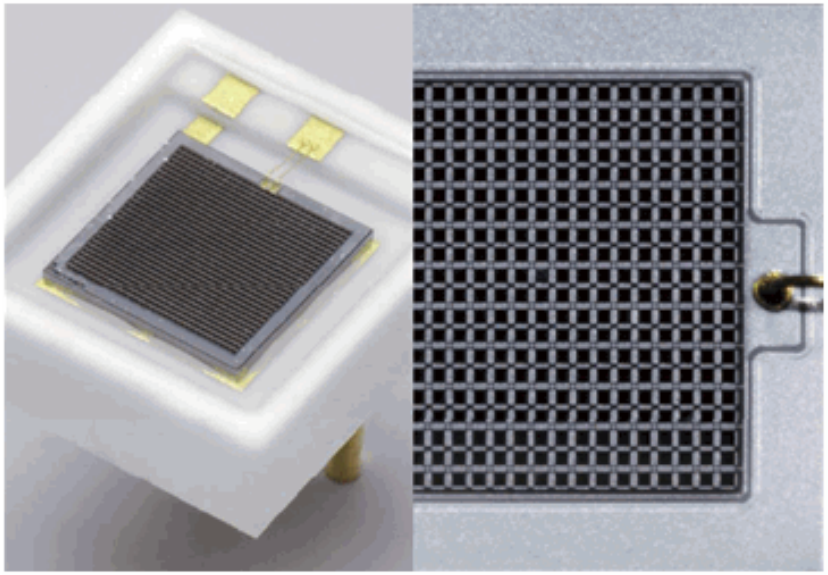

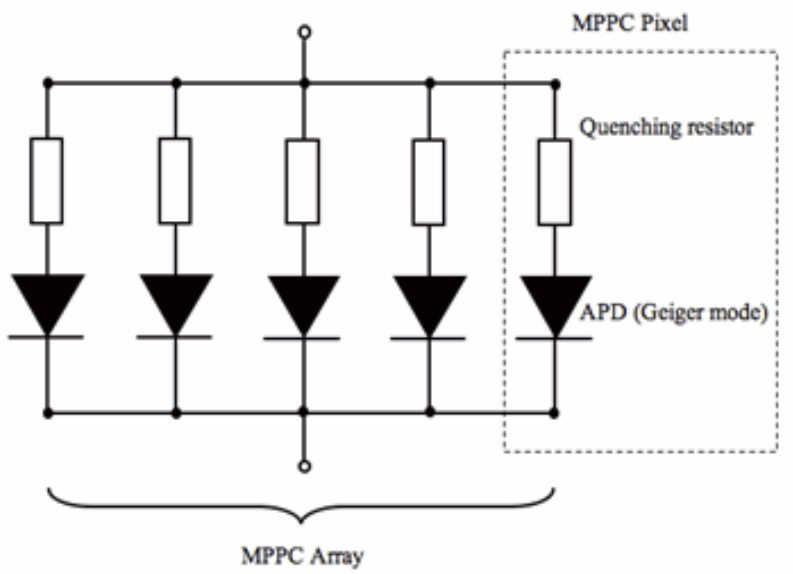

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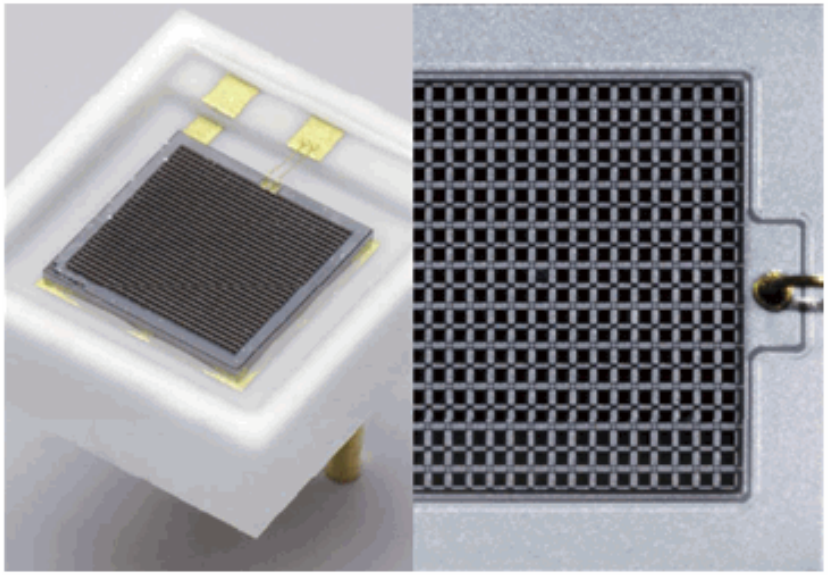

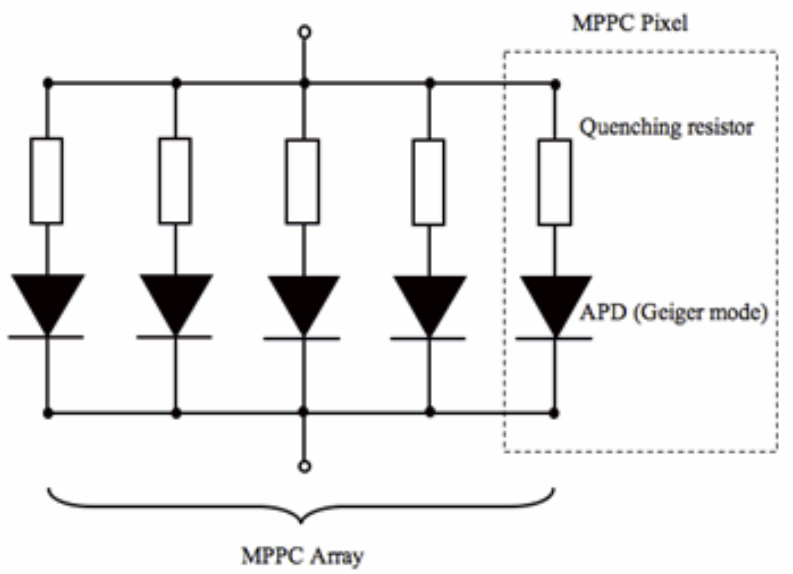

Output signal $\propto$ Number of hitted diodes $\propto$ Light intenisty

MPPC pros and cons

Pros:

- Higher quantum efficiency
- Lower voltage
- Lower power consumption
- Rugged

Cons:

- High dark rate
- Smaller active area

Gain measurement

To learn the basics of MPPC I started with a gain vs. bias voltage measurement

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$$G = \frac{Q}{q} = \frac{CV_{\text{ov}}}{q}$$

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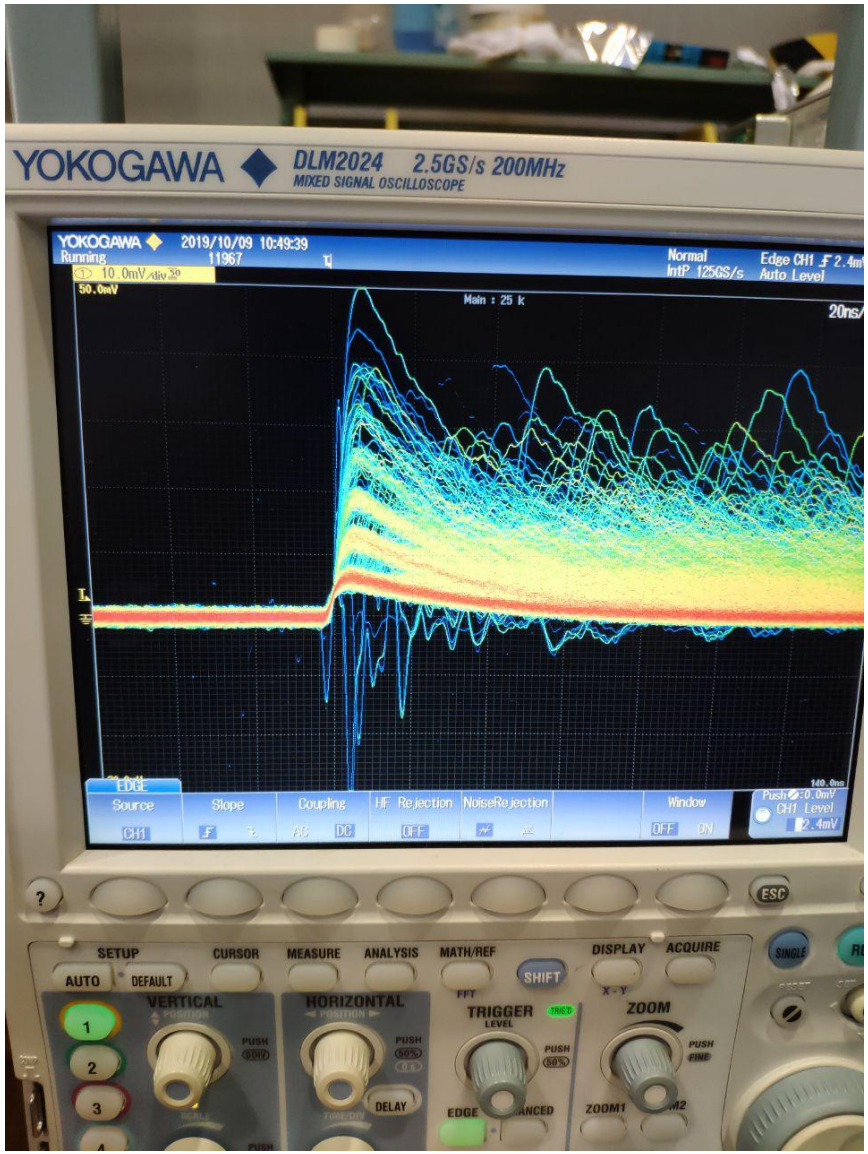

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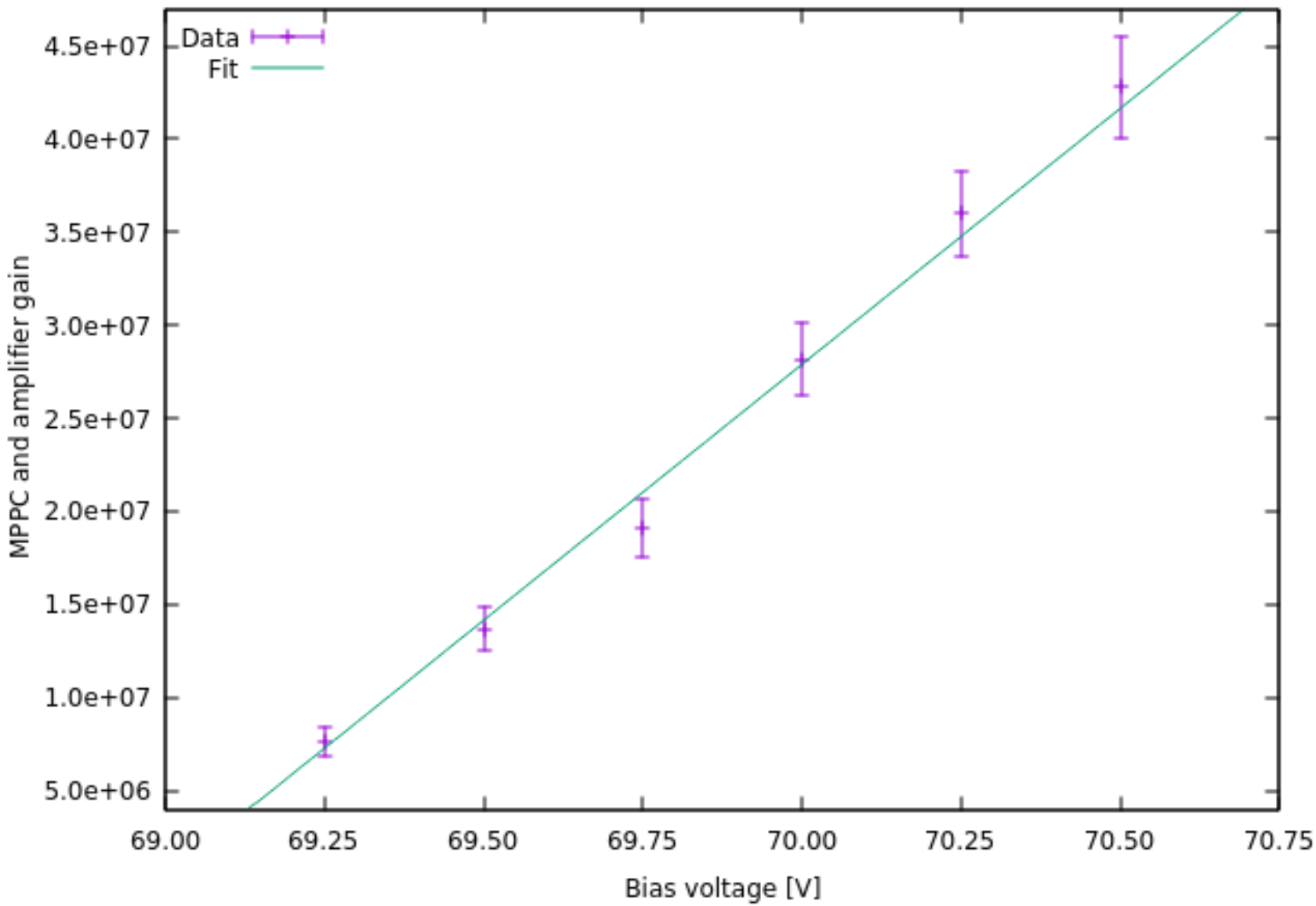

Histogram of noise

Histogram of the amplitude of produced signals

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Used oscilloscope as MCA, used signal standard deviation for pile-up removal

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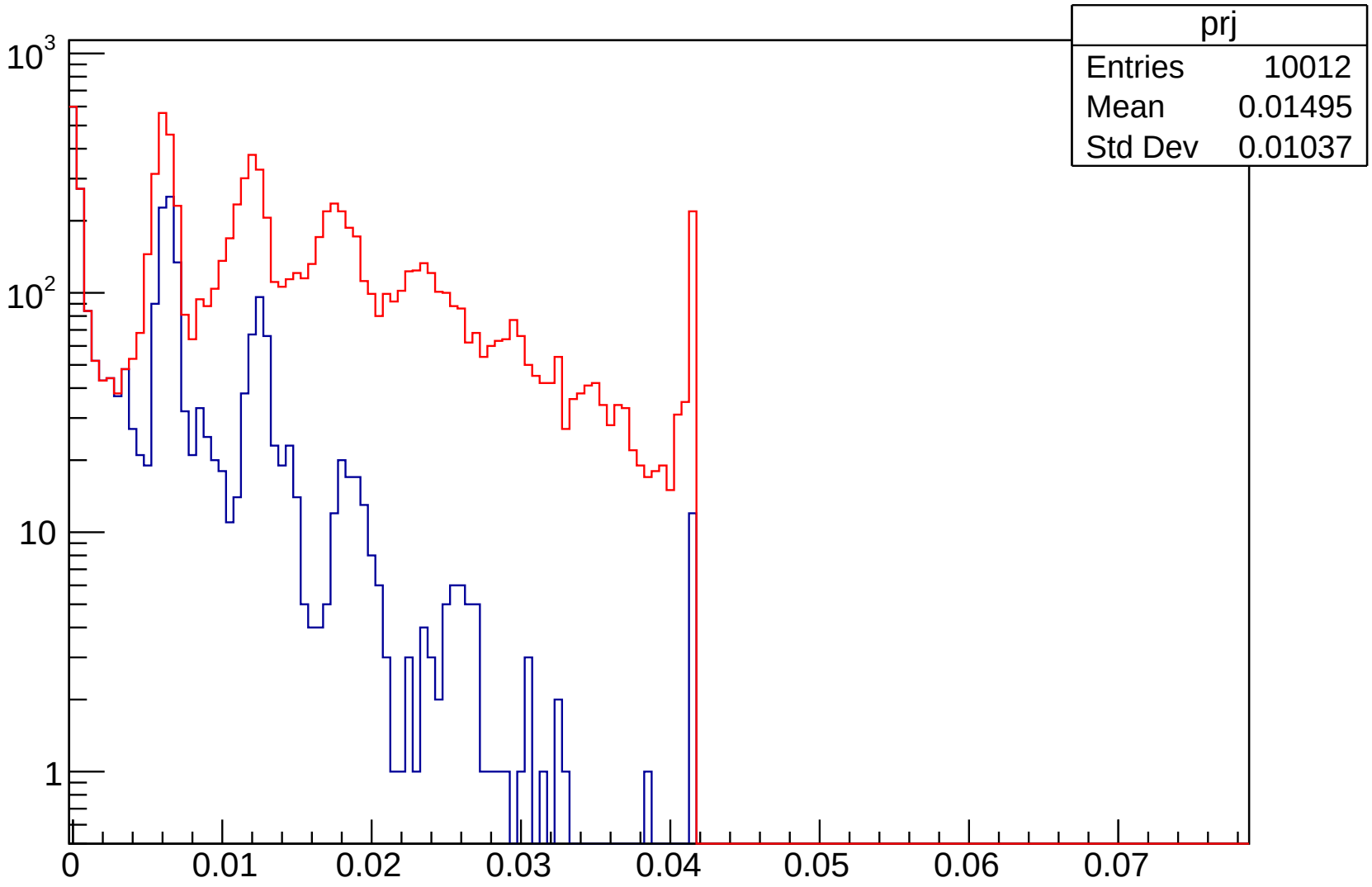

Coincidence measurement

As a test, two scintillators (120 cm $\times$ 5 cm $\times$ 1 cm) where put into coincidence mode.

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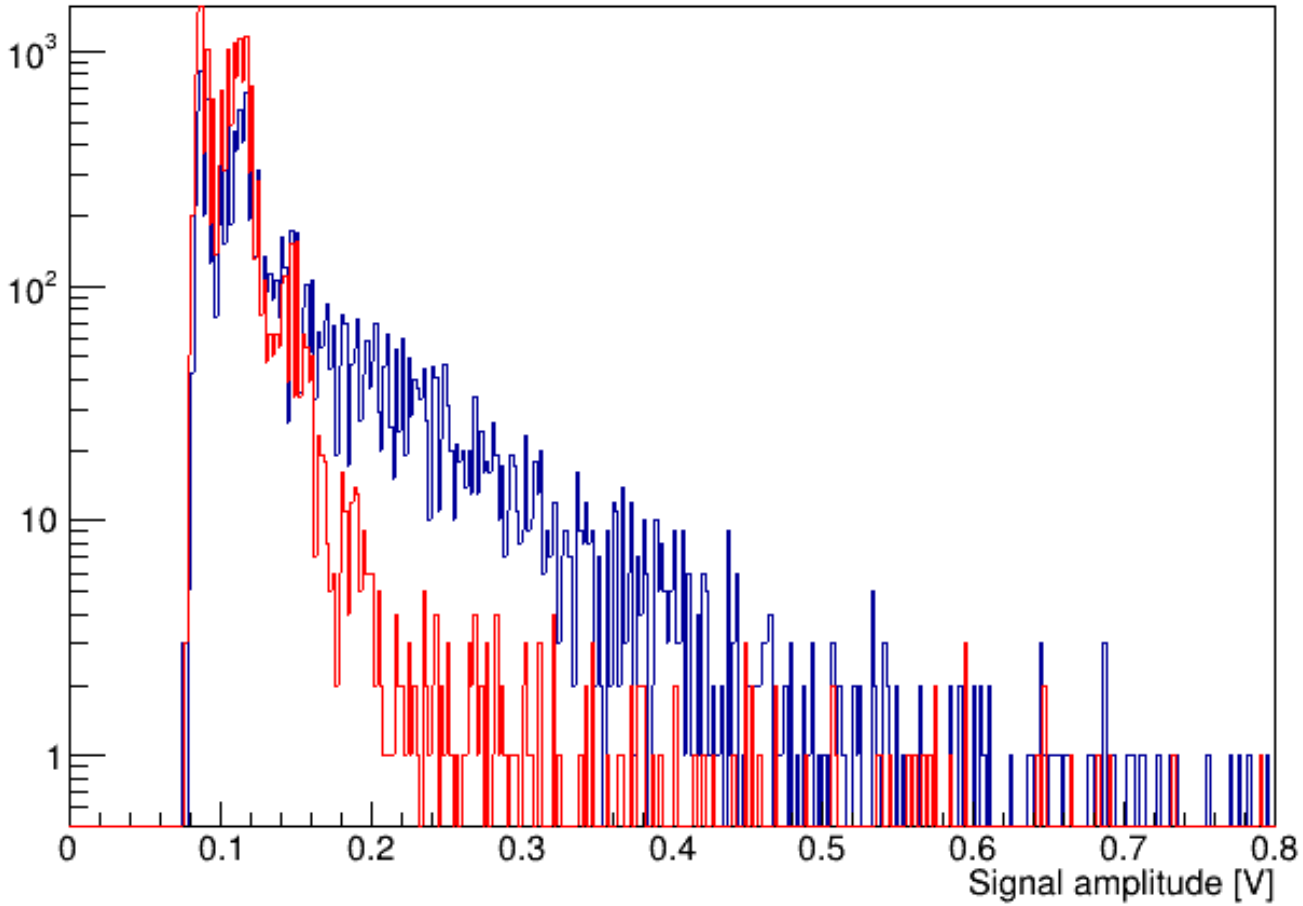

Muon lifetime setup

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Each slab is read with a fiber. We have to find a way to read a bundle of fiber with a single MPPC

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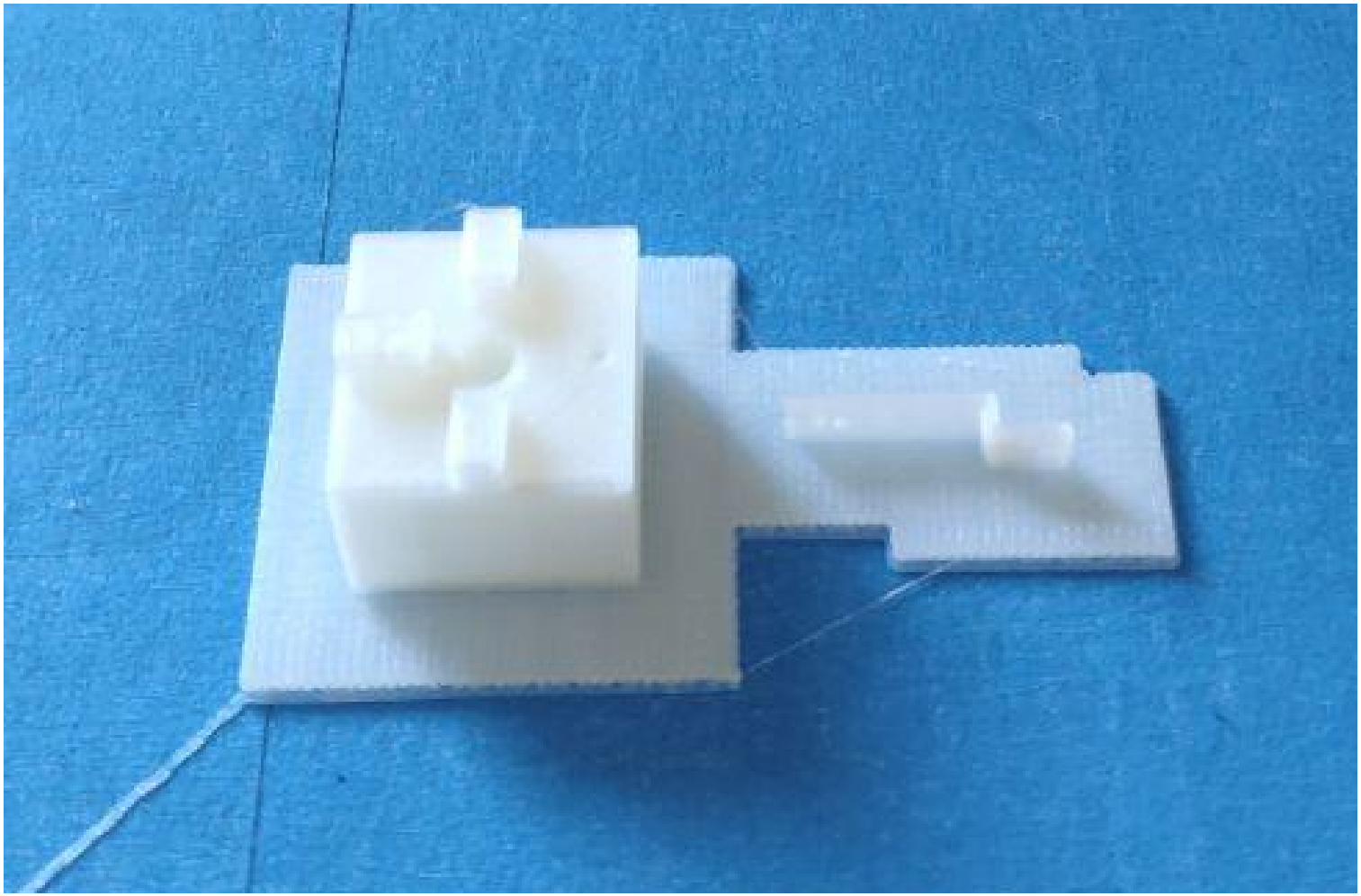

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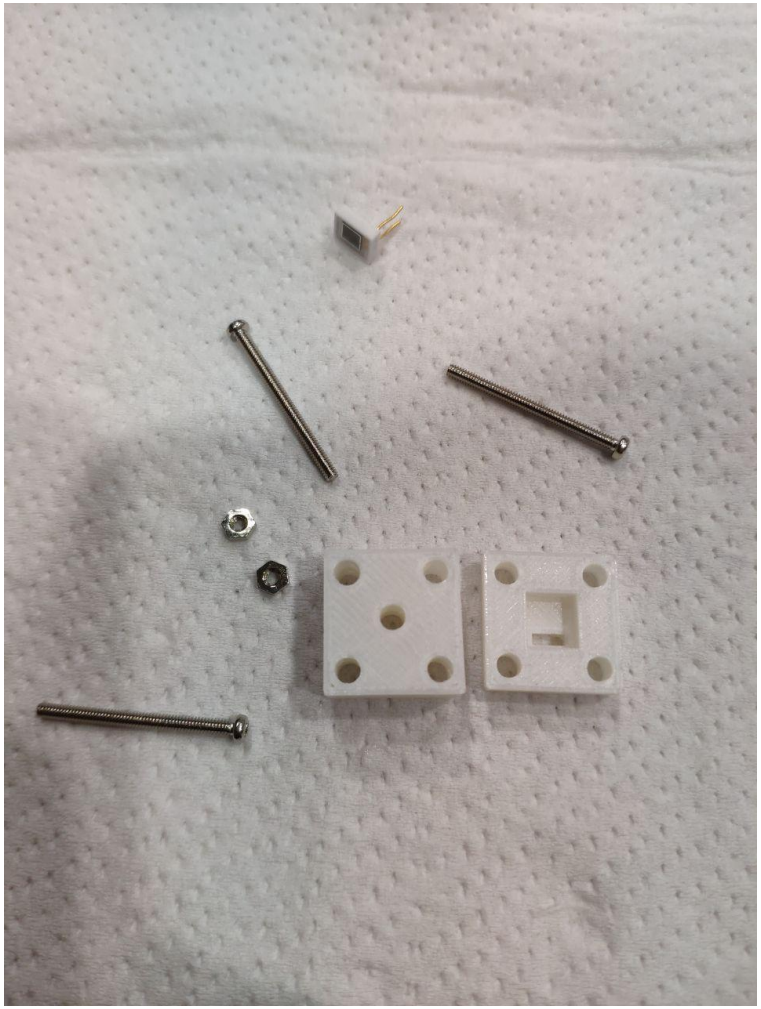

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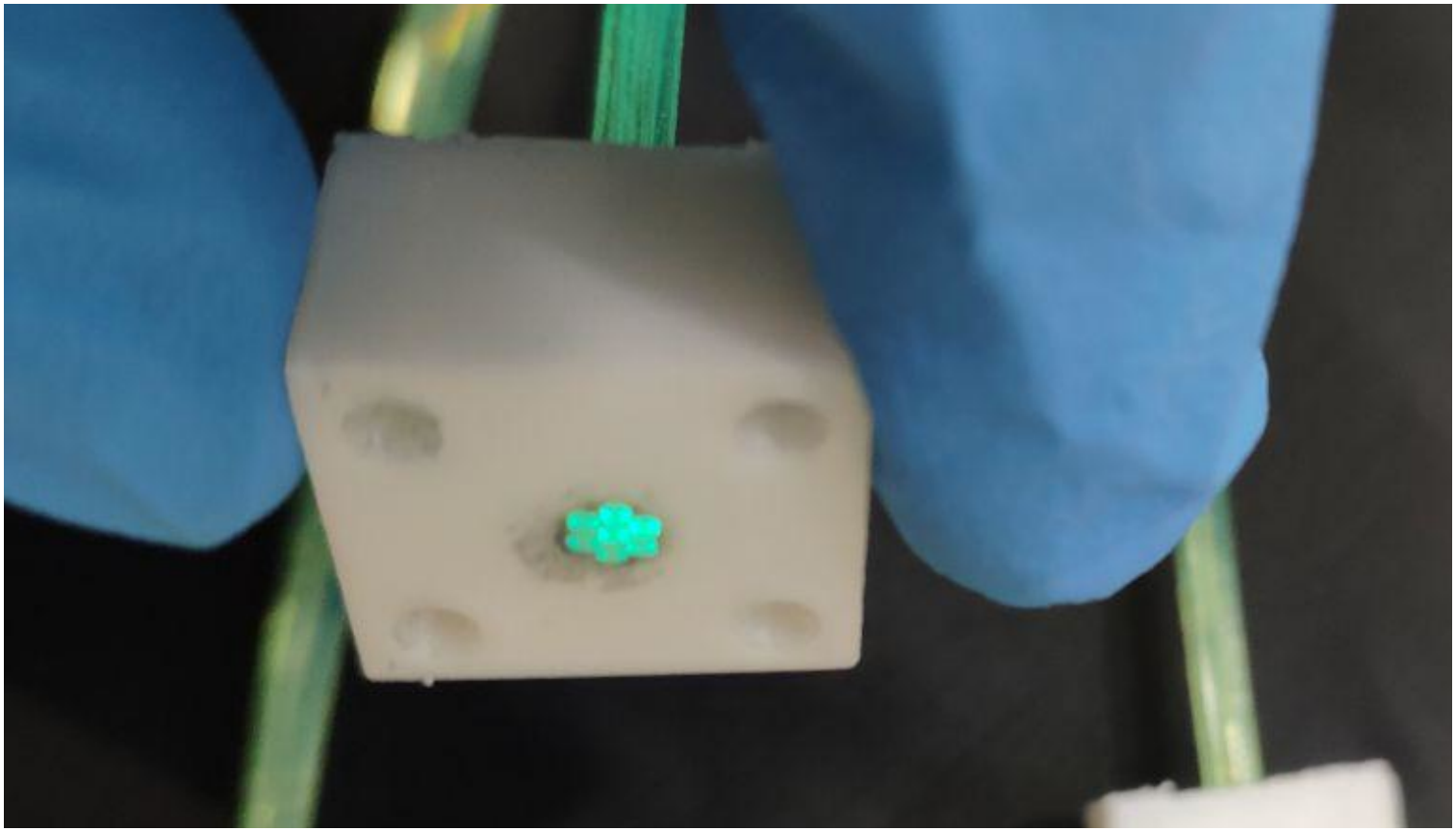

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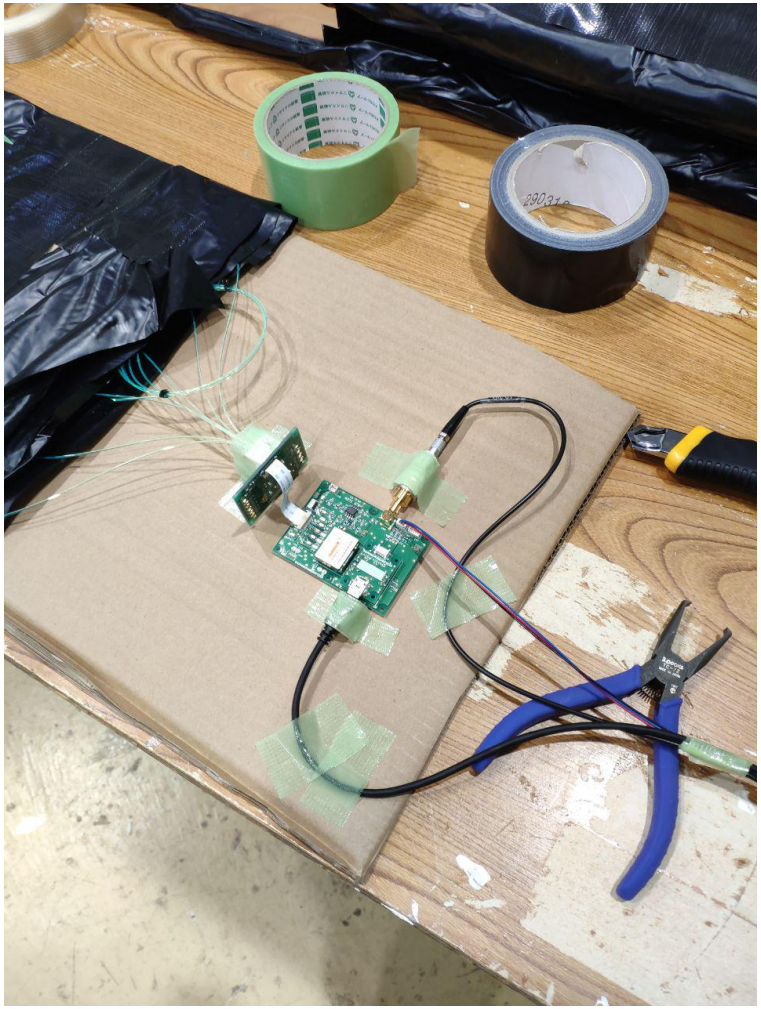
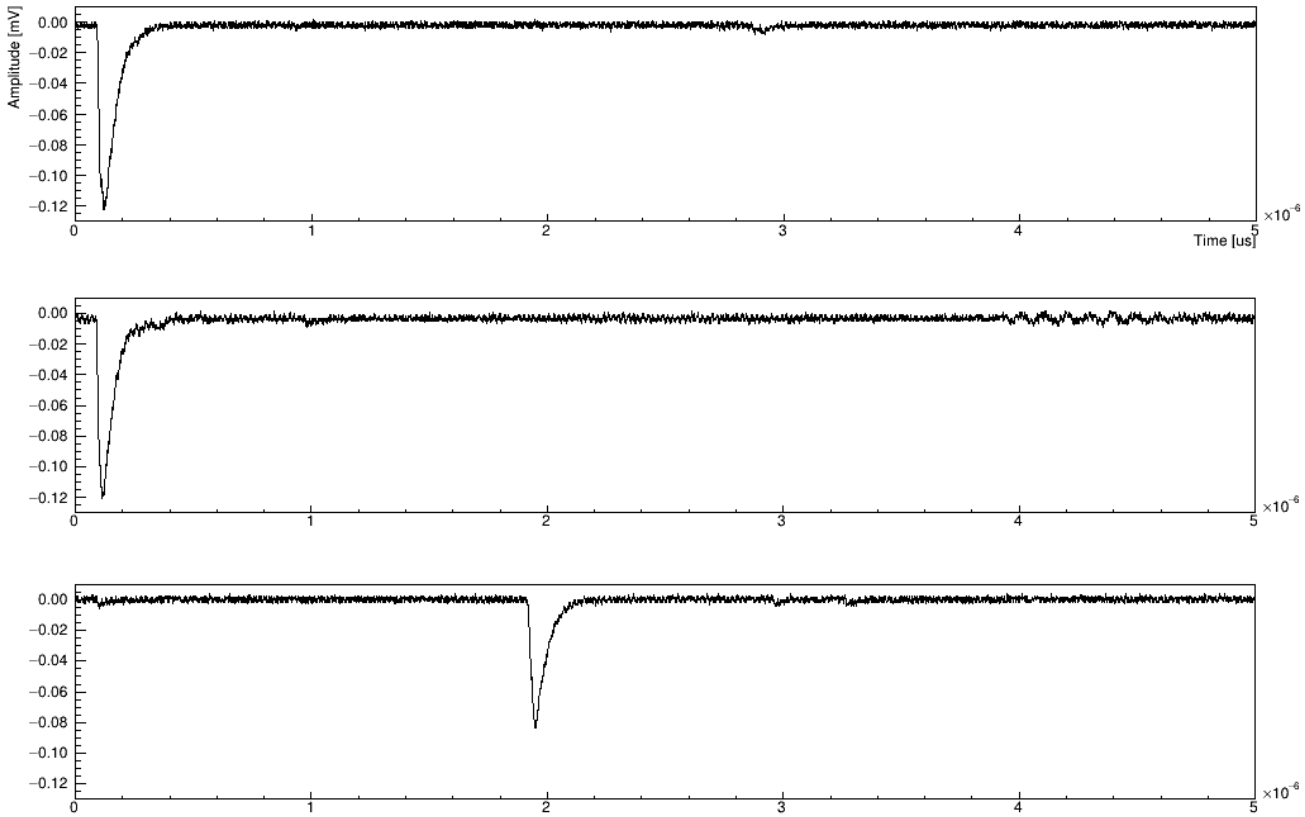


Trigger electronics



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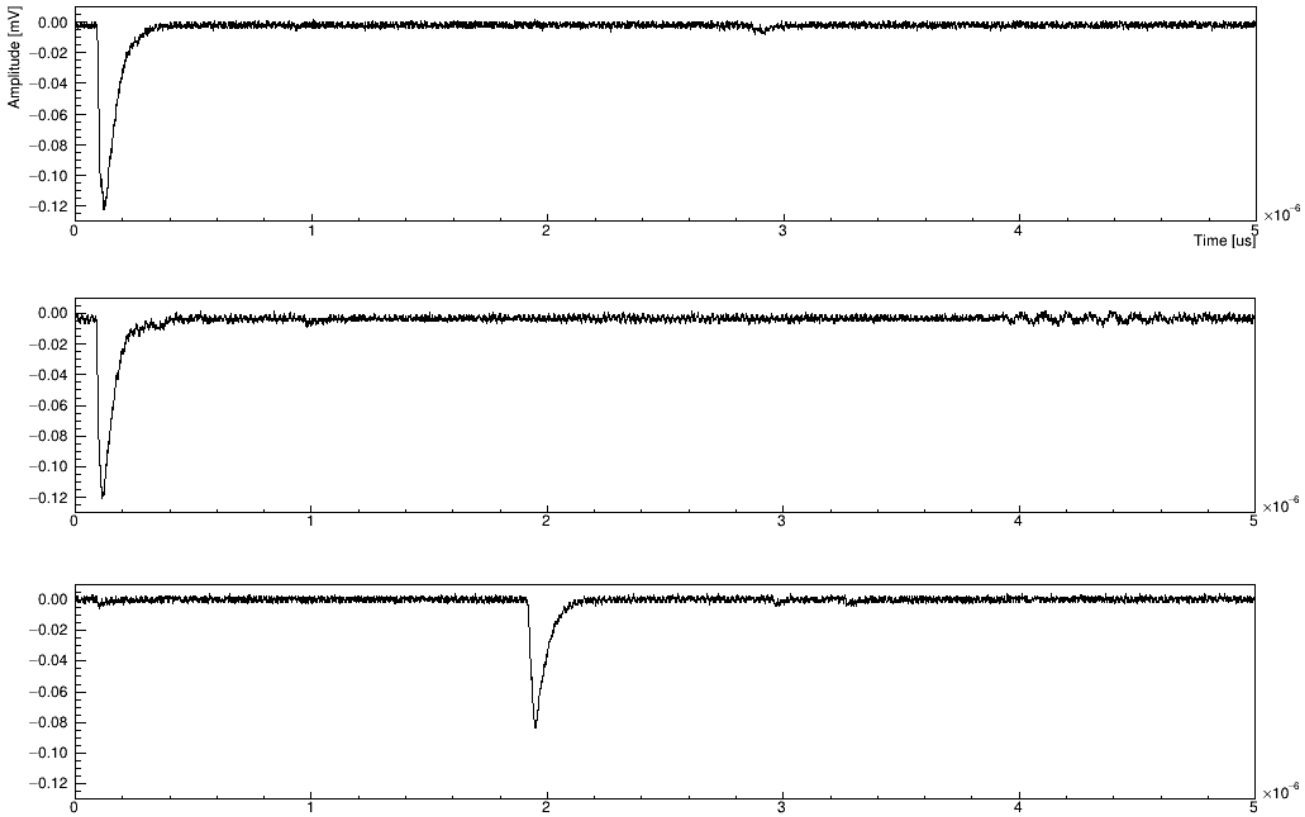
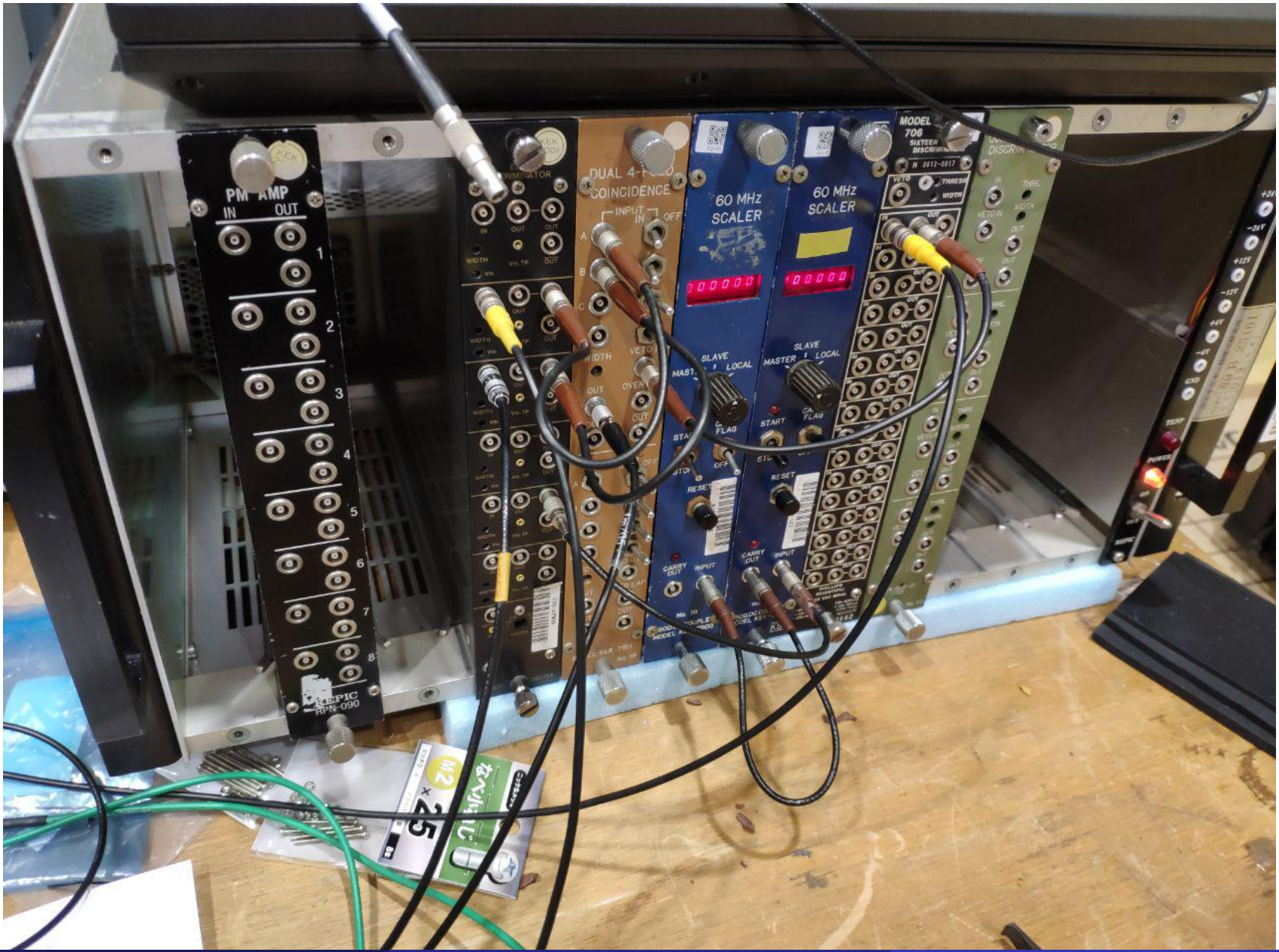


Coincidence between 1 and 2 with veto on 3

Trigger electronics



Oscilloscope DAQ

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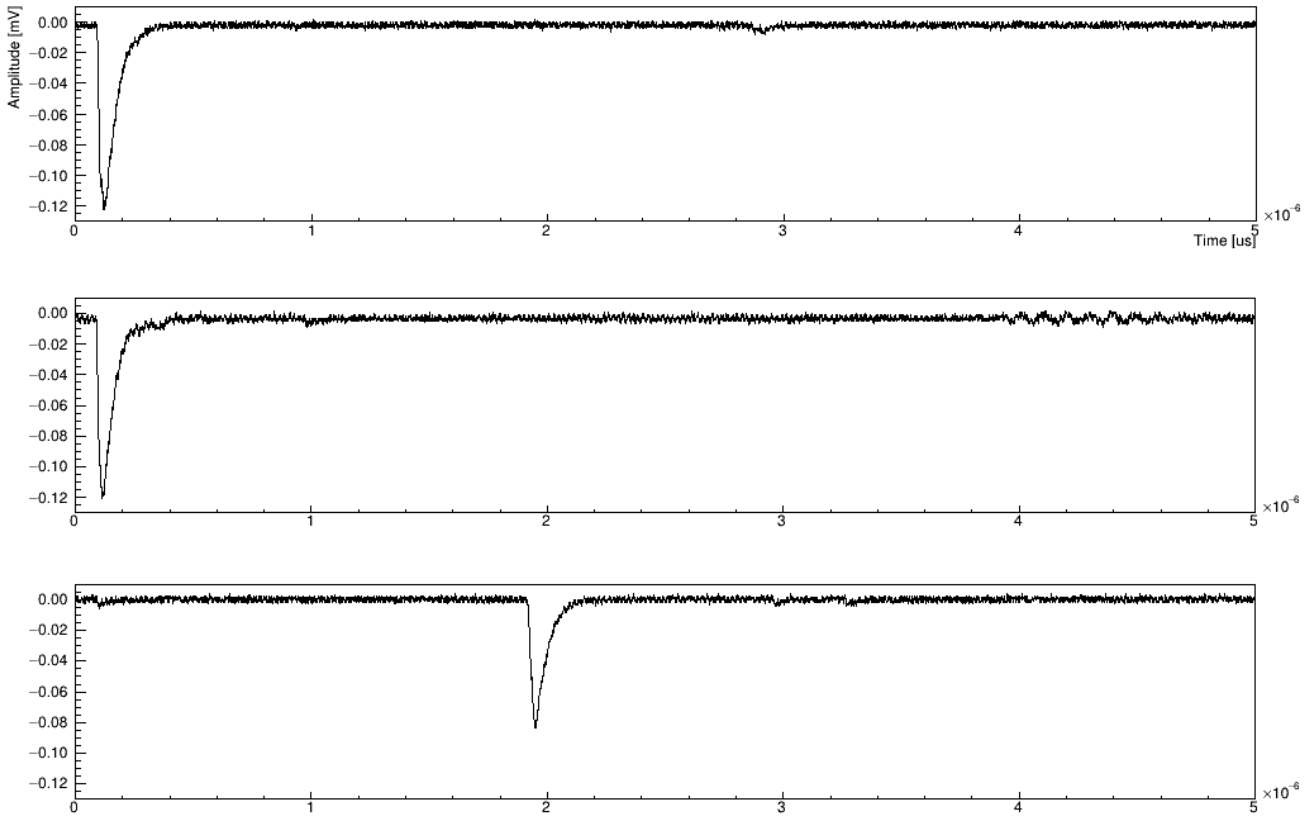
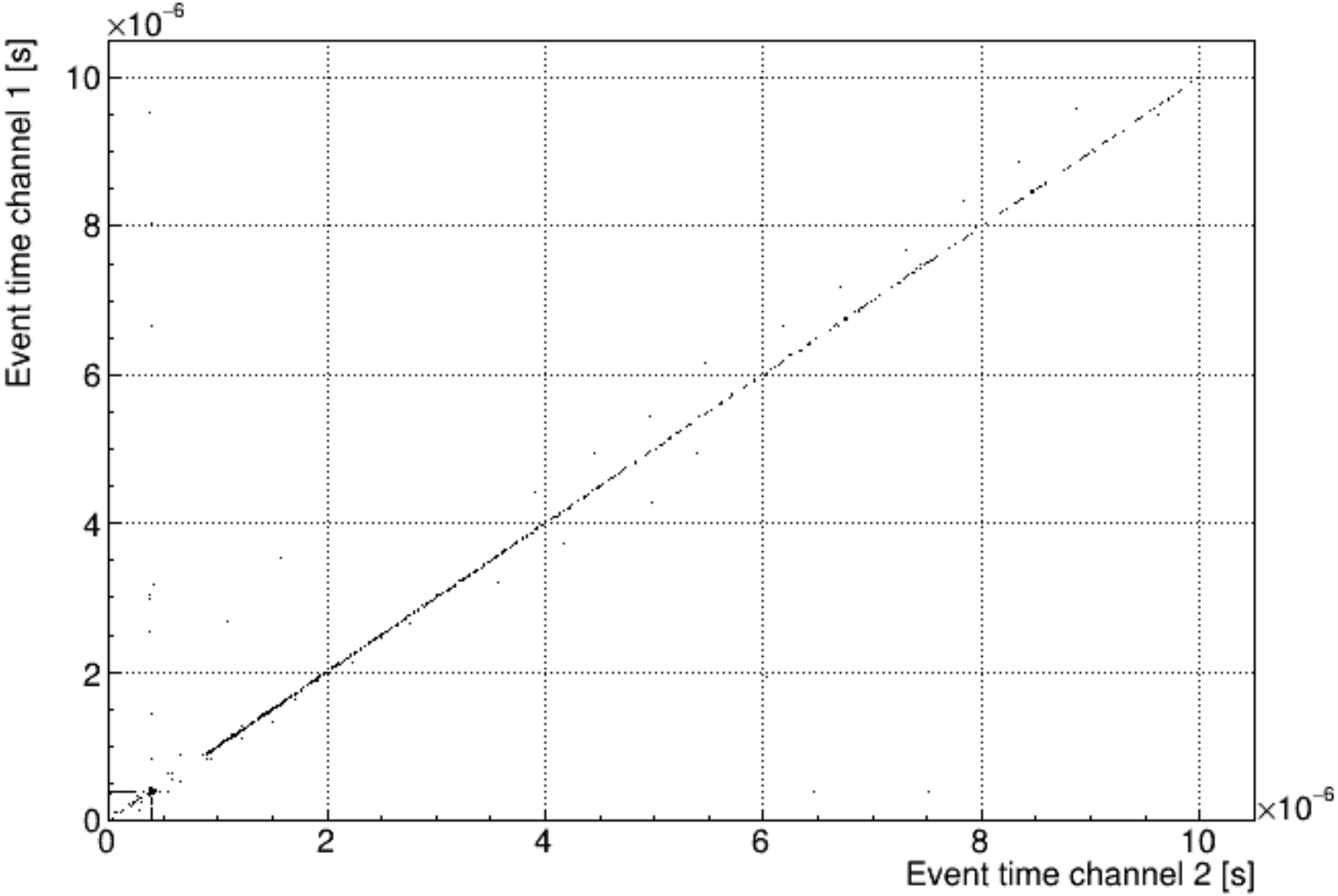
A program was written that read the waveforms and stored them into a ROOT TTree

Waveform analysis



Data quality



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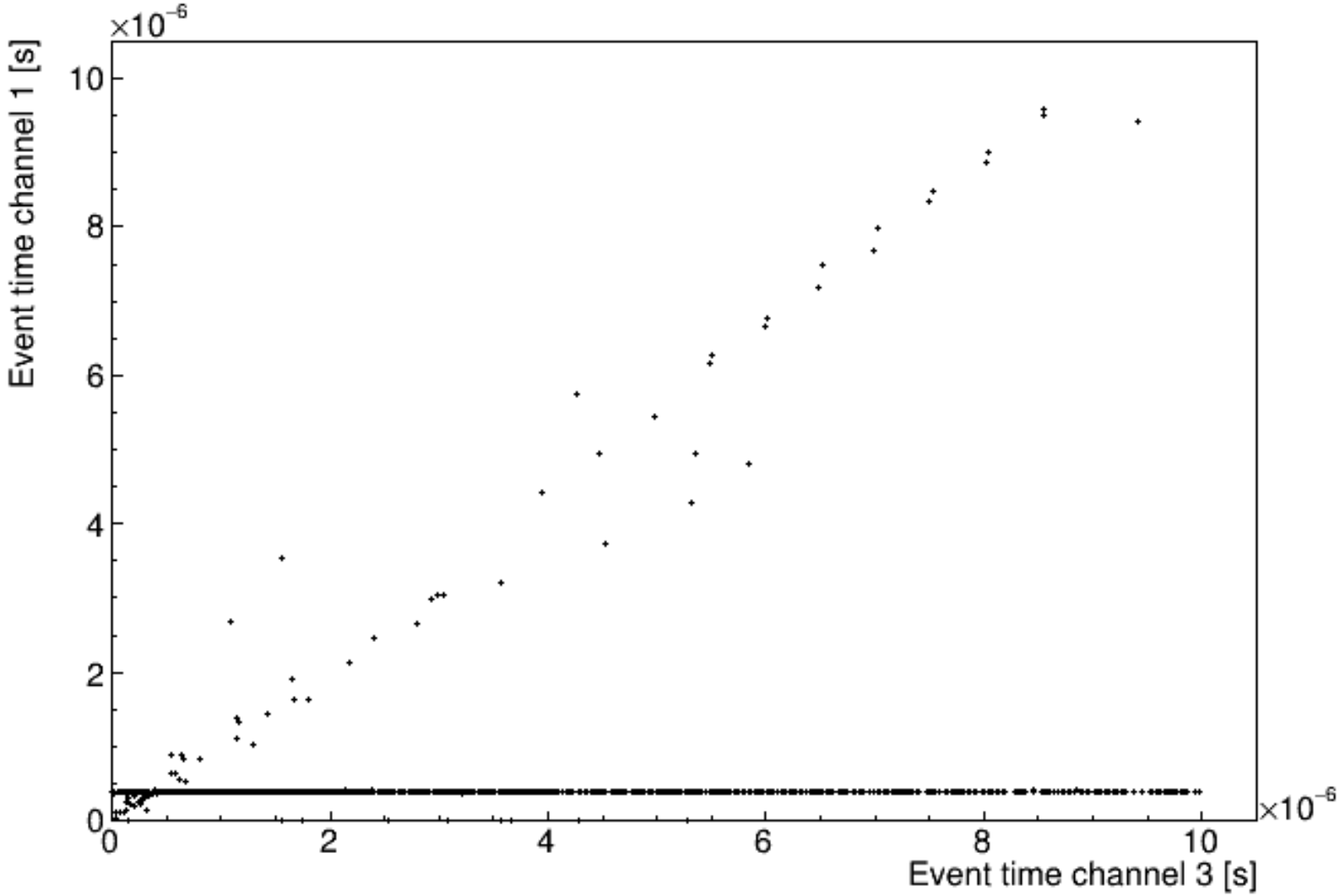

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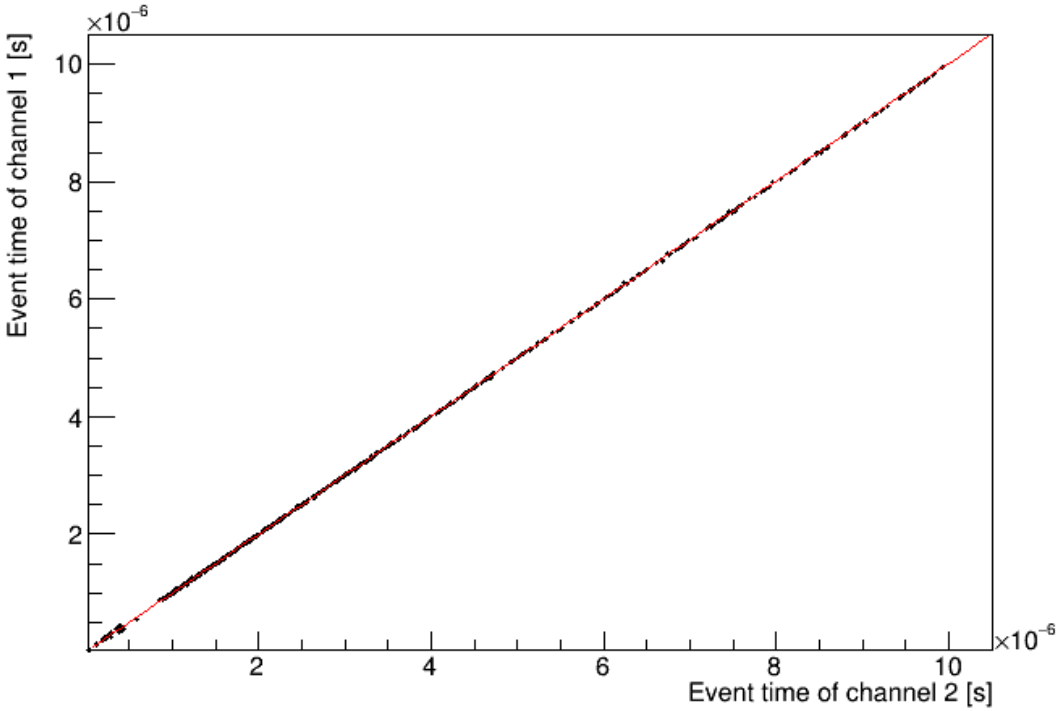

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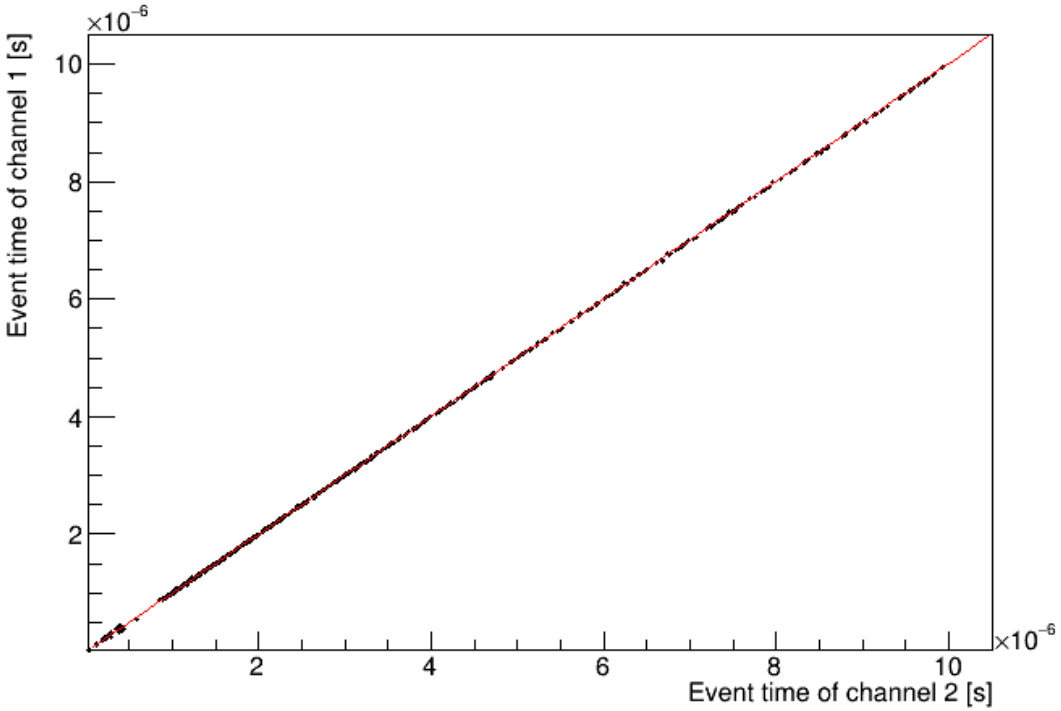
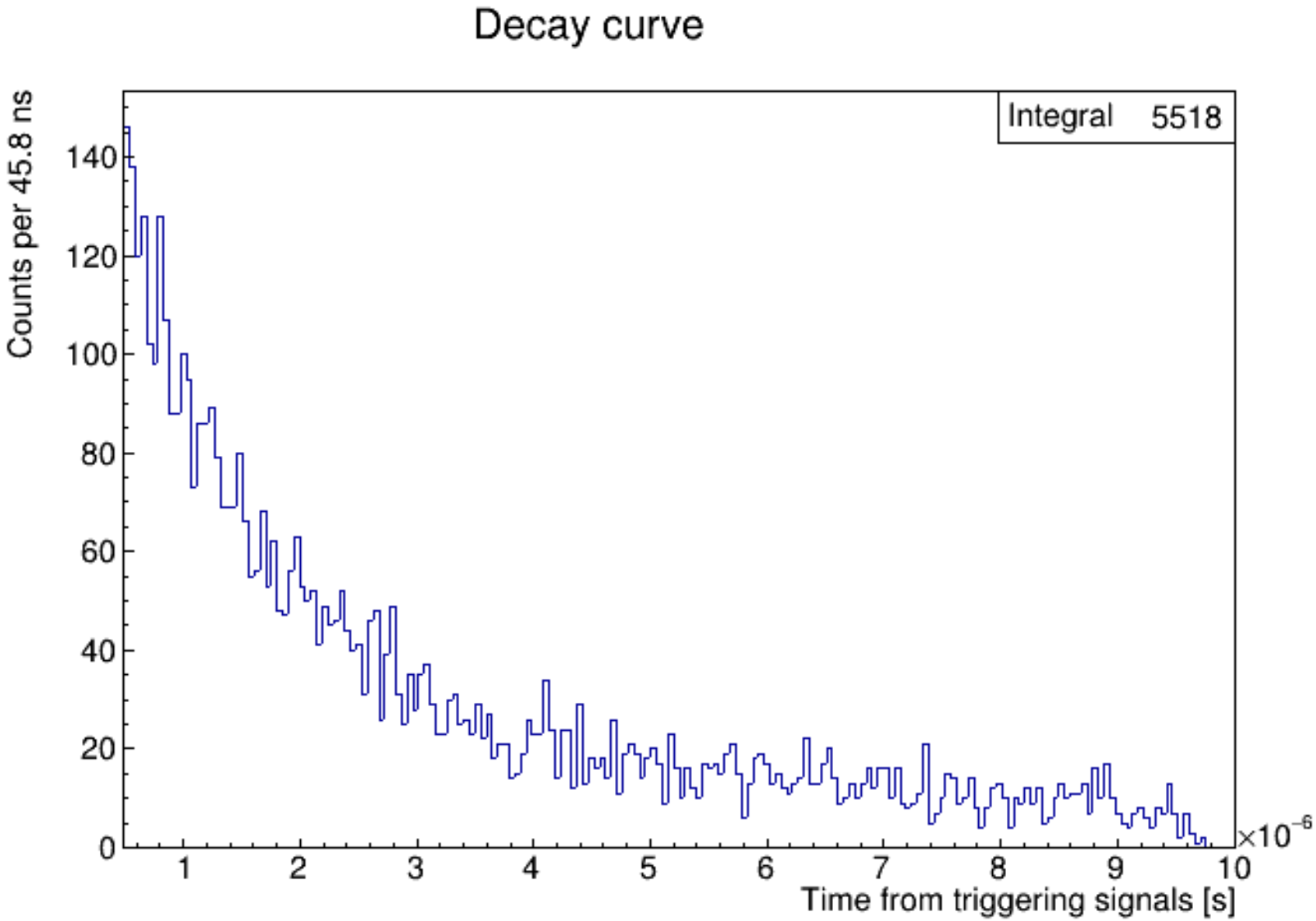


Remark

During the 3 days of measurement the difference between channel 1 and 2 remained less than 1 ns

Estimation of muon lifetime



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Binned likelihood fit with the function $N(t) = k(e^{-\frac{t}{\tau_-}} + e^{-\frac{t}{\tau_+}}) + b$
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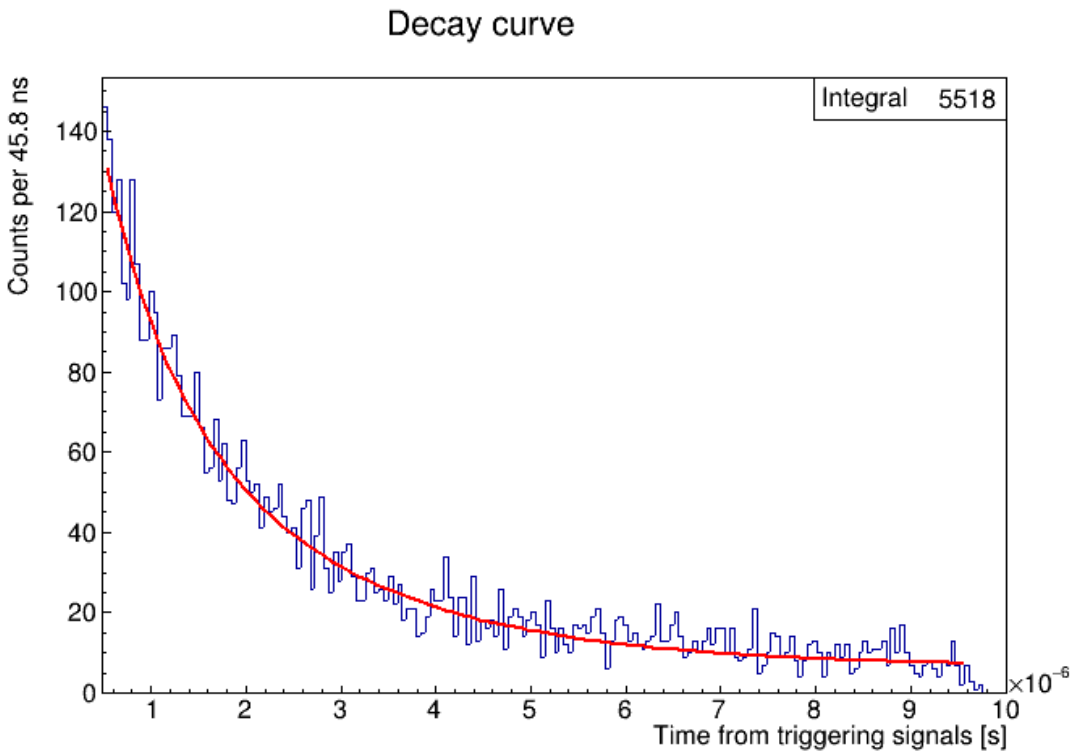

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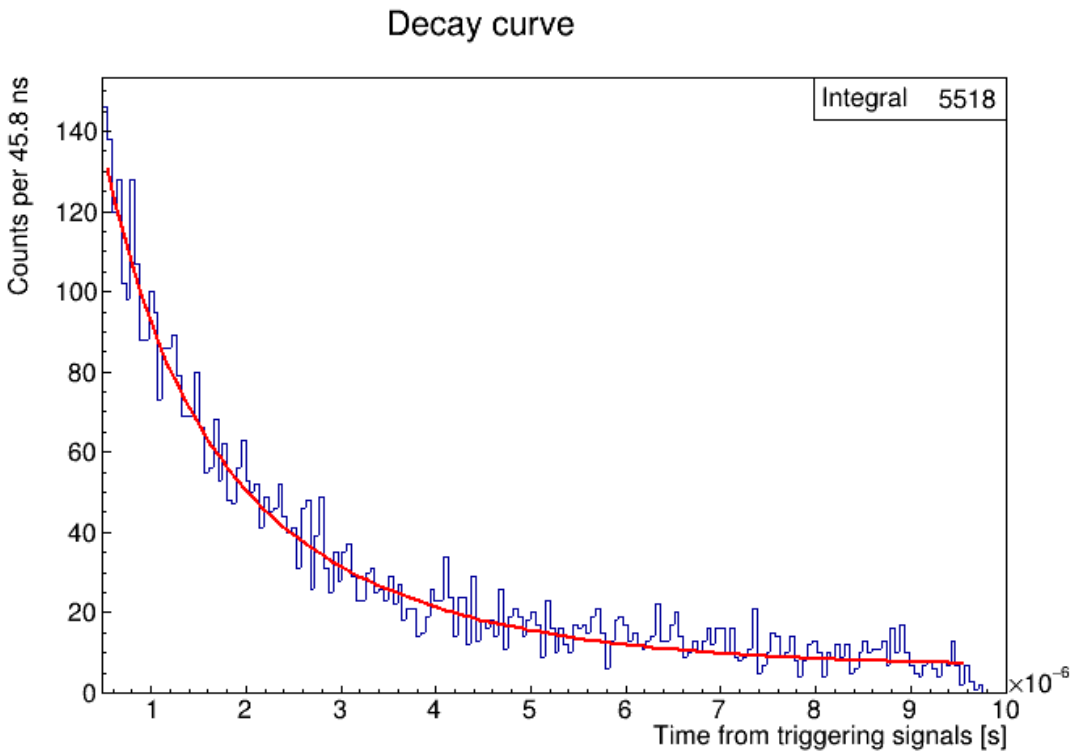

$\tau_+ = 2.1 \pm 0.1\ \mu s$

$\tau_- = 0.7 \pm 0.1\ \mu s$

$k = (1.0 \pm 0.1) \times 10^2$

$b = 7.5 \pm 0.6$

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- On a long run, a magnetic field