Japanese-Style Compact Cosmic-Ray Muon Detector for Outreach and Education

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Outline

- Introduction
- Compact Cosmic-ray Muon Detector, OSECHI
- Outreach & Education
- Summary

Introduction

Particle Physics, Astro-physics …

- Expensive
- Large scale

Students & general public

note: This is one example from Japan.

Not easy to join.

Introduction

Recently...

- Technological advancement
- Enhancing outreach and education

- Low-cost detector is achieved.
  - Cosmic-ray(CR) muon is easy to touch.
- Several groups are working on its development.

We have decided to enter the field as well.

Our work

Launched Outreach & Education program

Tan-Q (探Q=探求=quest, research)

- Since 2019
- Voluntary base by researcher and graduate students
  (KEK/Sokendai, Osaka, Kyushu, Nagoya, Yamagata, Miyazaki, Toyama)
- Activities
  - Development of compact CR muon detector
  - long-term program
  - mini workshop

Development of CR muon detector

Existing detector

- expensive : difficult to join
- large : hard to find installation space
- foreign-made: hard to maintain

Concepts

- low-cost : easy to join
- compact : easy to install & friendly design
- domestic : easy to maintain

+α : incorporating cutting-edge technology

Development of CR muon detector

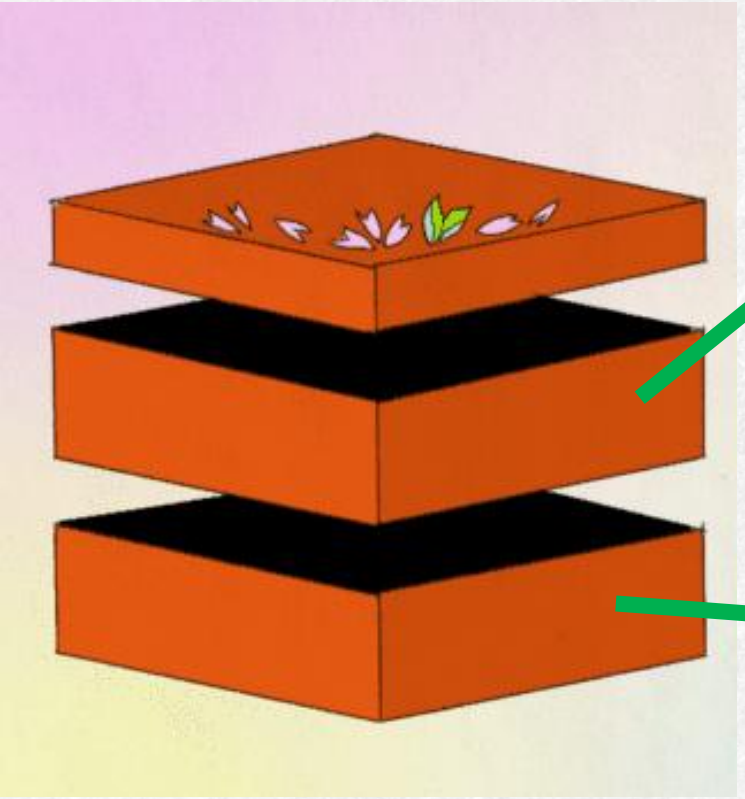
- Started with leftover and borrowed components, + personal funding to build prototypes step by step.
- Collaborating with graduate students through hands-on trial and error.

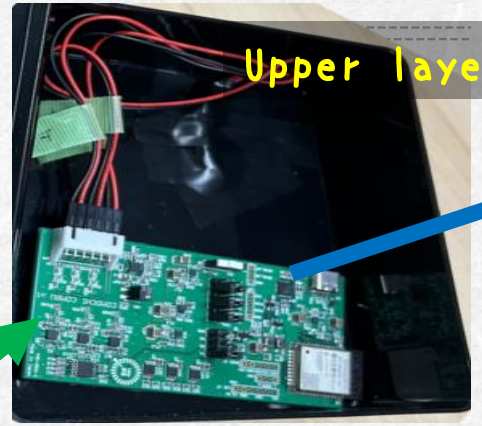
Development is ongoing up to version 2.

I personally thinking it would be exciting if we could involve students or general public in this kind of development as well.

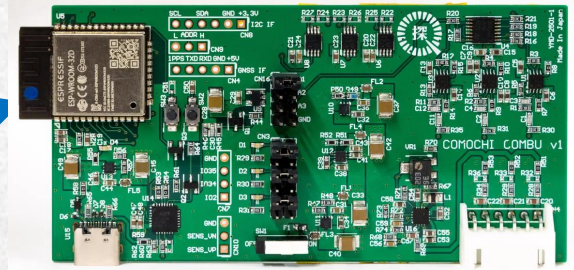
Development of CR muon detector

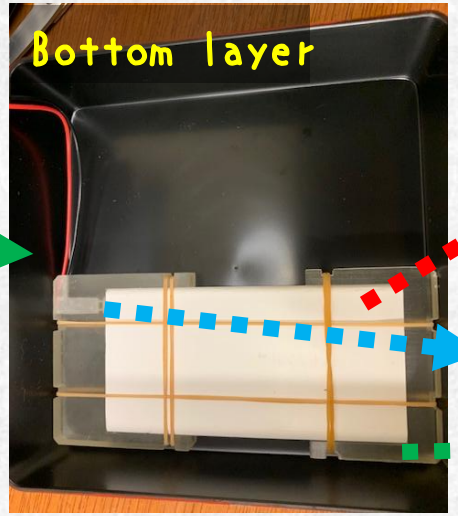
OSECHI (Outreach and Science Education Cosmic-ray Hunting Instrument)
ver. 2 (latest ver.)



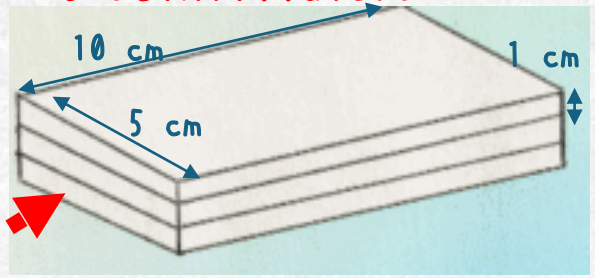


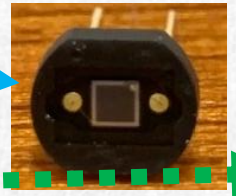
PCB





3 scintillators





SiPM

Support structure

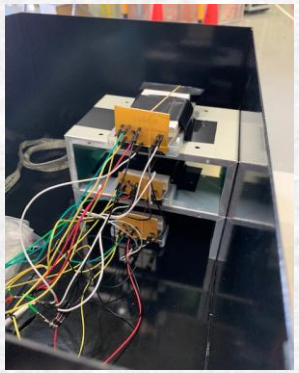
- Jubako friendliness in mind
- Plastic scintillator
- SiPM
- Original PCB

Signal processing
-> Micro computer
Power, DAQ
-> USB-C

* "OSECHI" is Japanese traditional food which is eaten on New Year's day. Many kinds of Japanese traditional foods are packed together in "Jubako" which is a special bento box

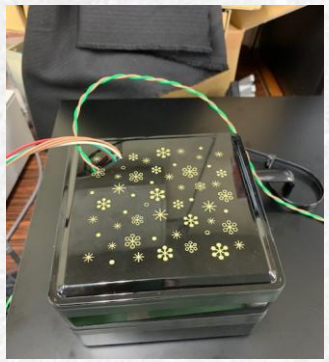
Development history of OSECHI

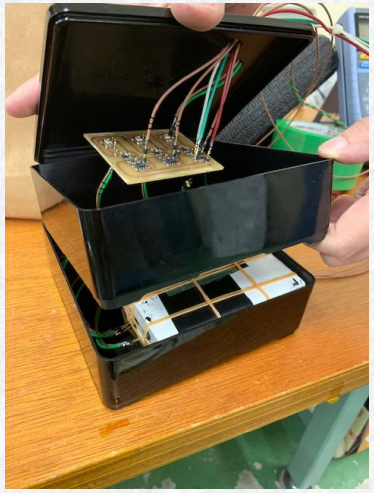
ver. 0



- large size
- Hand-maid elec. incl. substrate
- Power required
- LED lighting with muon detection

ver. 0.1





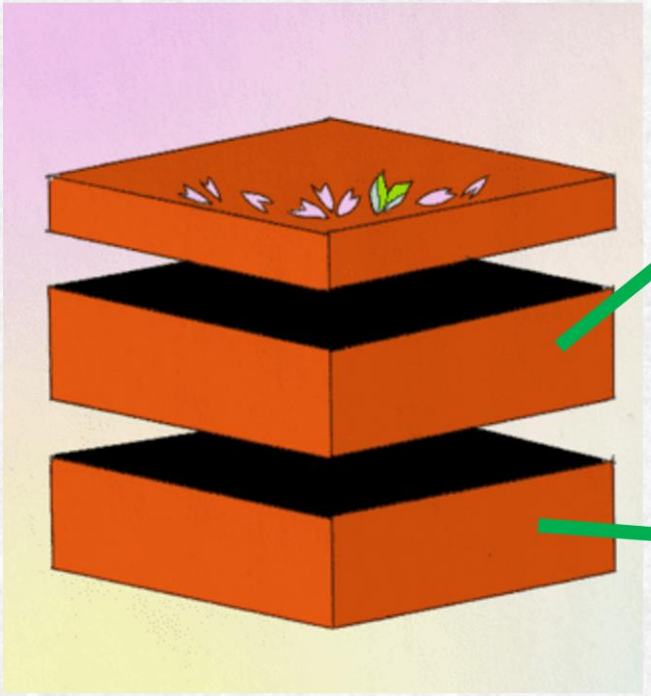
- Adoption of Jubako
- Power still required
- LED lighting

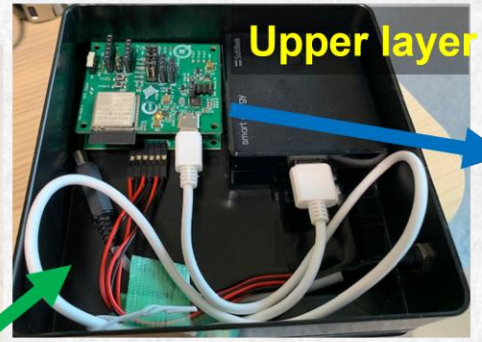
ver. 0.2

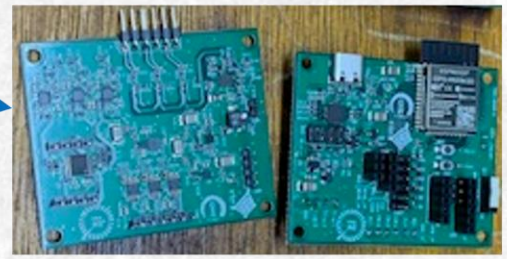
- DAQ with FPGA
- Power line added
- Manufactured elec.

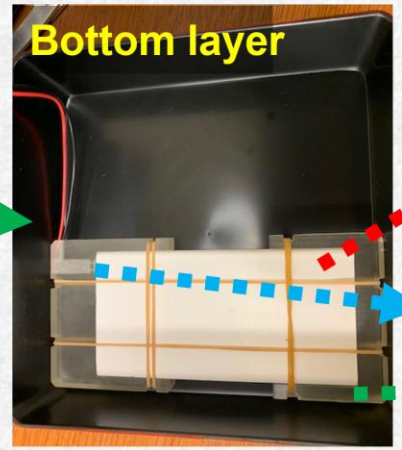
Development history of OSECHI

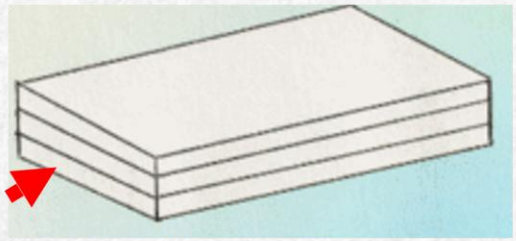
ver. 1

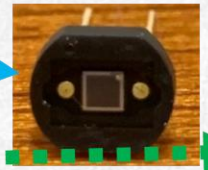












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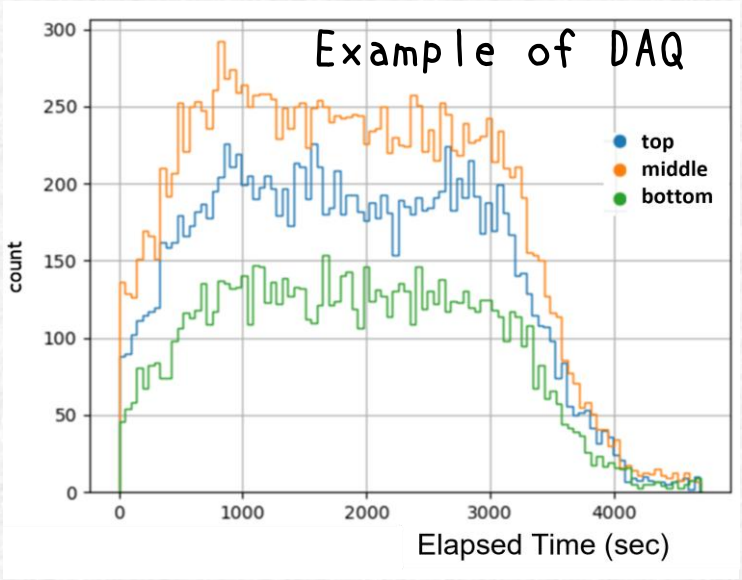
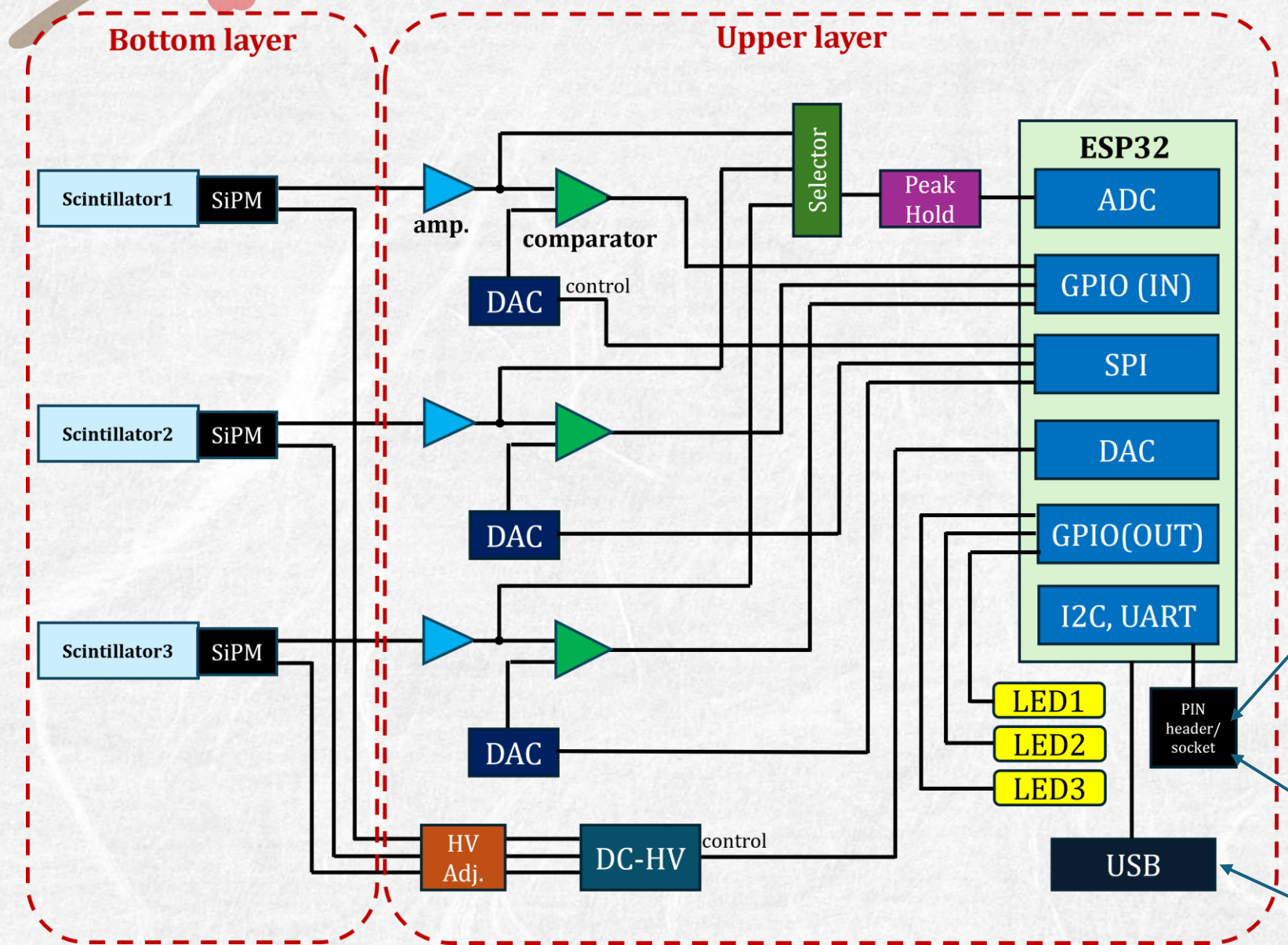
Micro computer was adopted to reduce the cost.

PCBs for analog/digital parts were developed.



Hit counts during flight

Signal processing



Very simple flow

- Adjust HV using DAC.
- Record timing of signal exceeding threshold.
- Record pulse height of selected channel with ADC.
- Can add the other sensor
  - thermometer, GPS, etc...

Sensor

temperature, humidity, and pressure sensor like Bosch BME280

GPS mod.

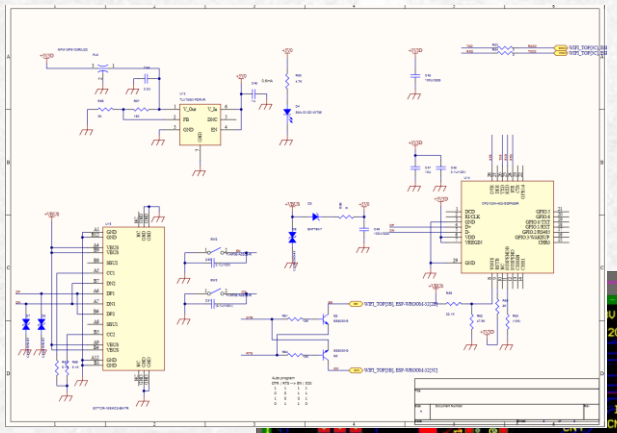
PC

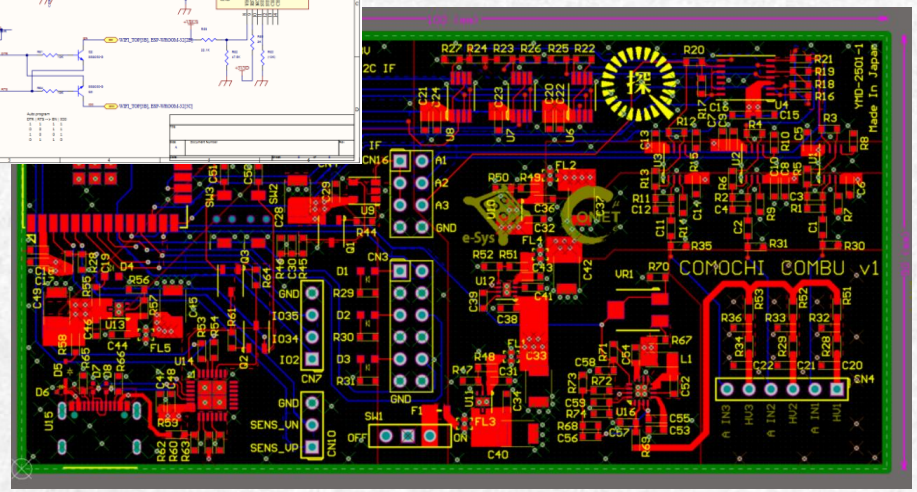
PCB development

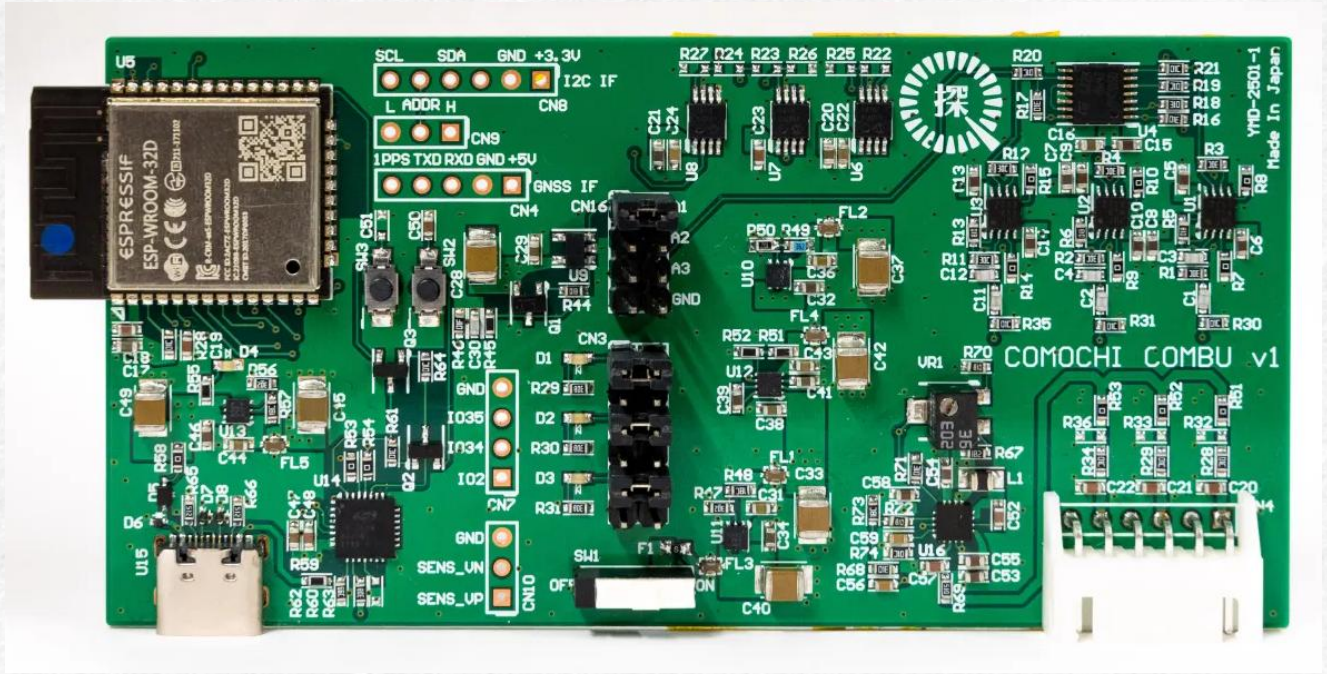
Graduate student mainly designed the PCB with helps of engineer.

COMOCHI COMBU =子持ち昆布, one of the Japanese traditional foods

(COsmic MuOn CHaining Interface, Control Operation & Measurement Board Unit)

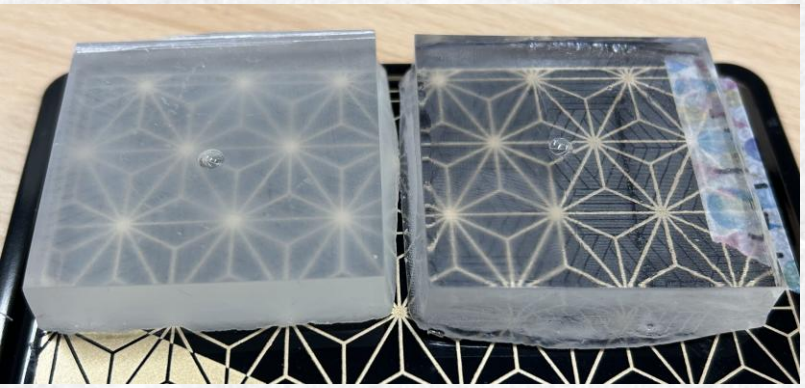


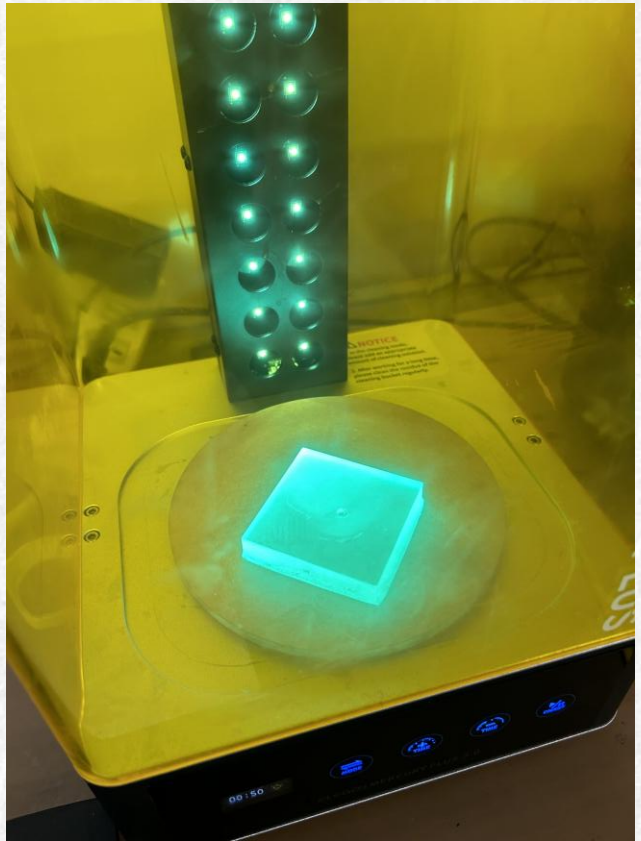




Implementation of new tech.

To reduce cost and to incorporate cutting-edge technology, we are trying to use 3D printing scintillator.





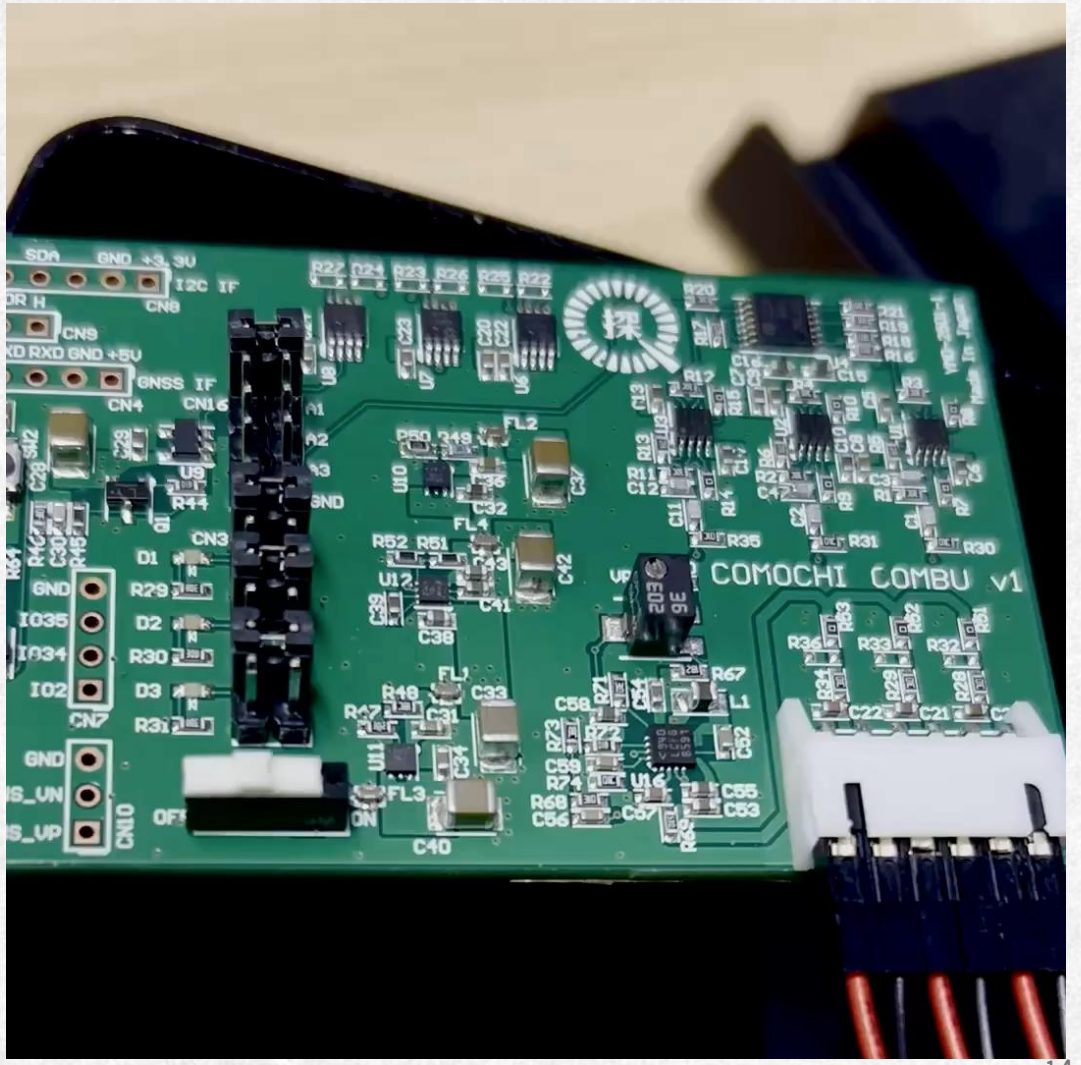
Based on the previous research,
we have tried to make the scintillator.

some issues...

but, tried to implement it, anyway.

Operation of OSECHI ver. 2

- Using OSECHI ver. 2 including COMOCHI COMBU and 3D printing scintillator, operation test was done.
- When CR muon passes through the 3 scintillator, 3 LEDs light up.



(movie)

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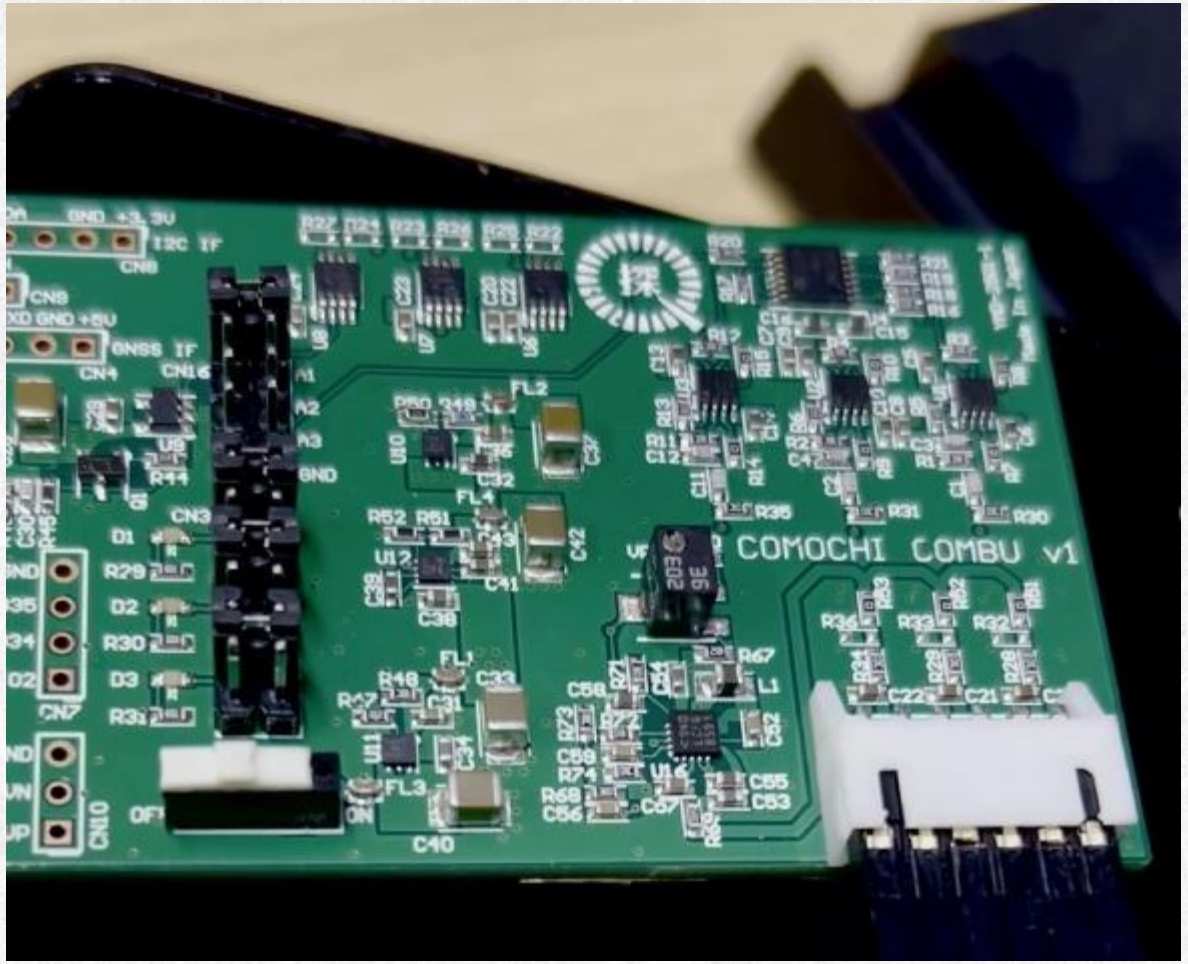

(photo: no signal)

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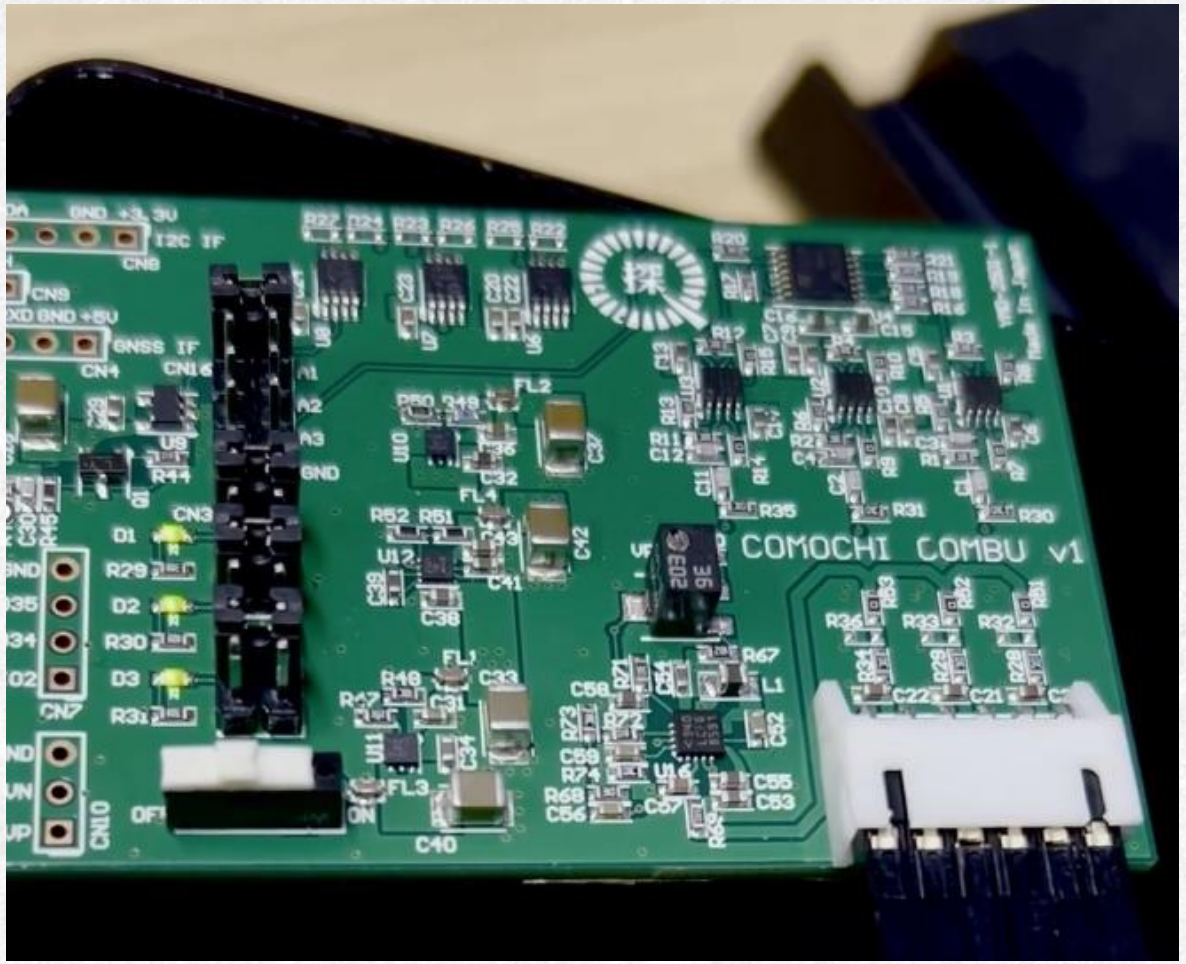


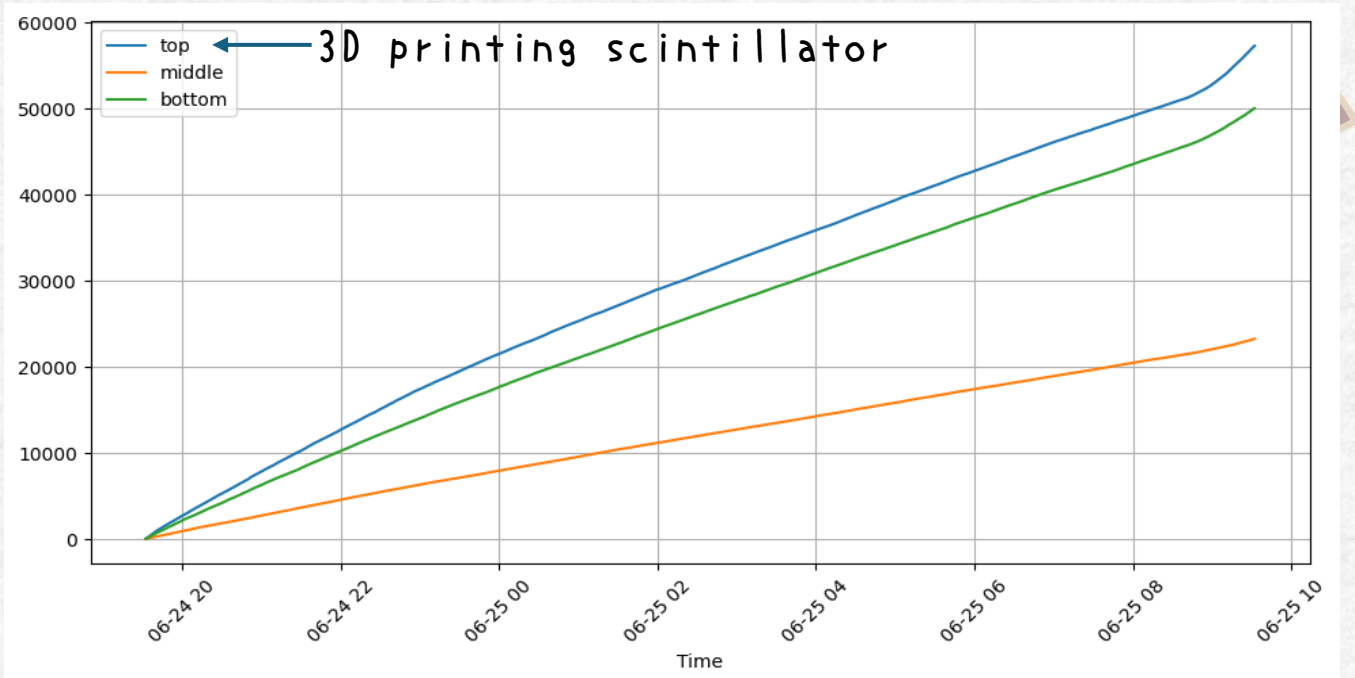
(photo: CR muon like event)

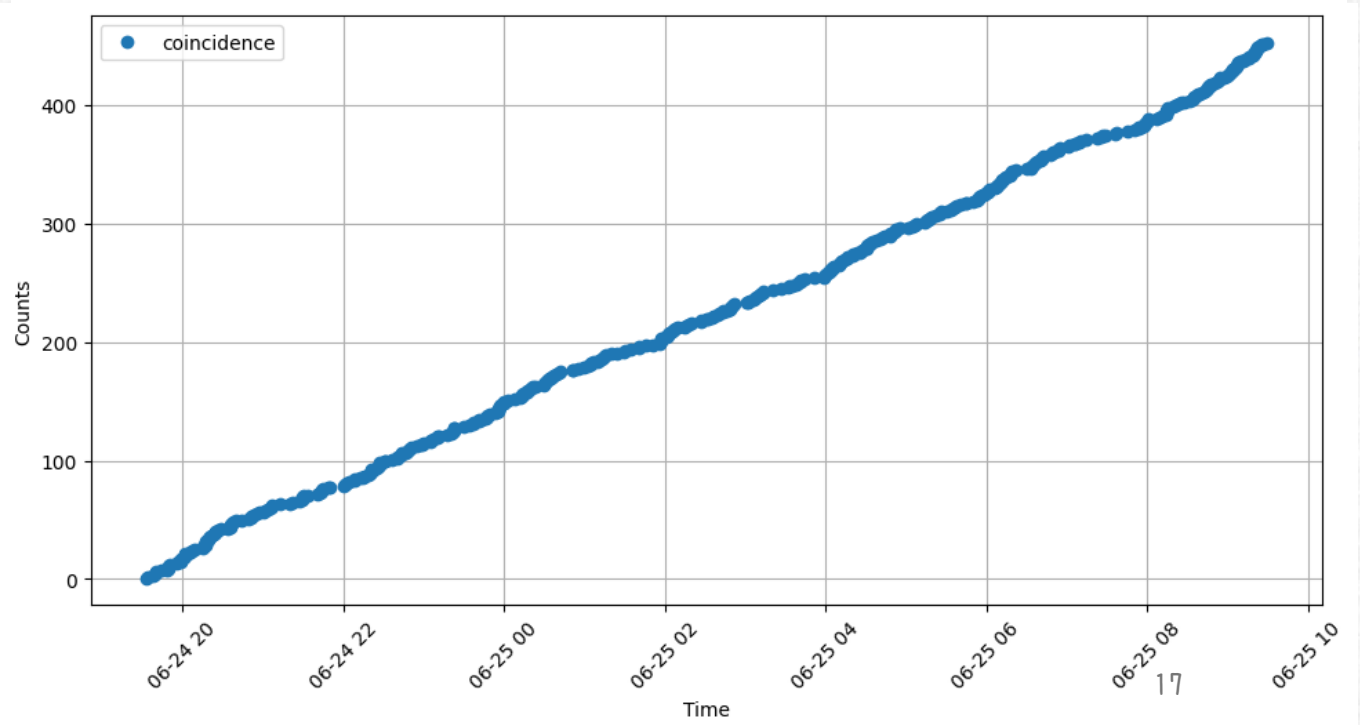
Hit counts

- We tried collecting data for about 50k sec.
- Hit counts for each channel were checked.

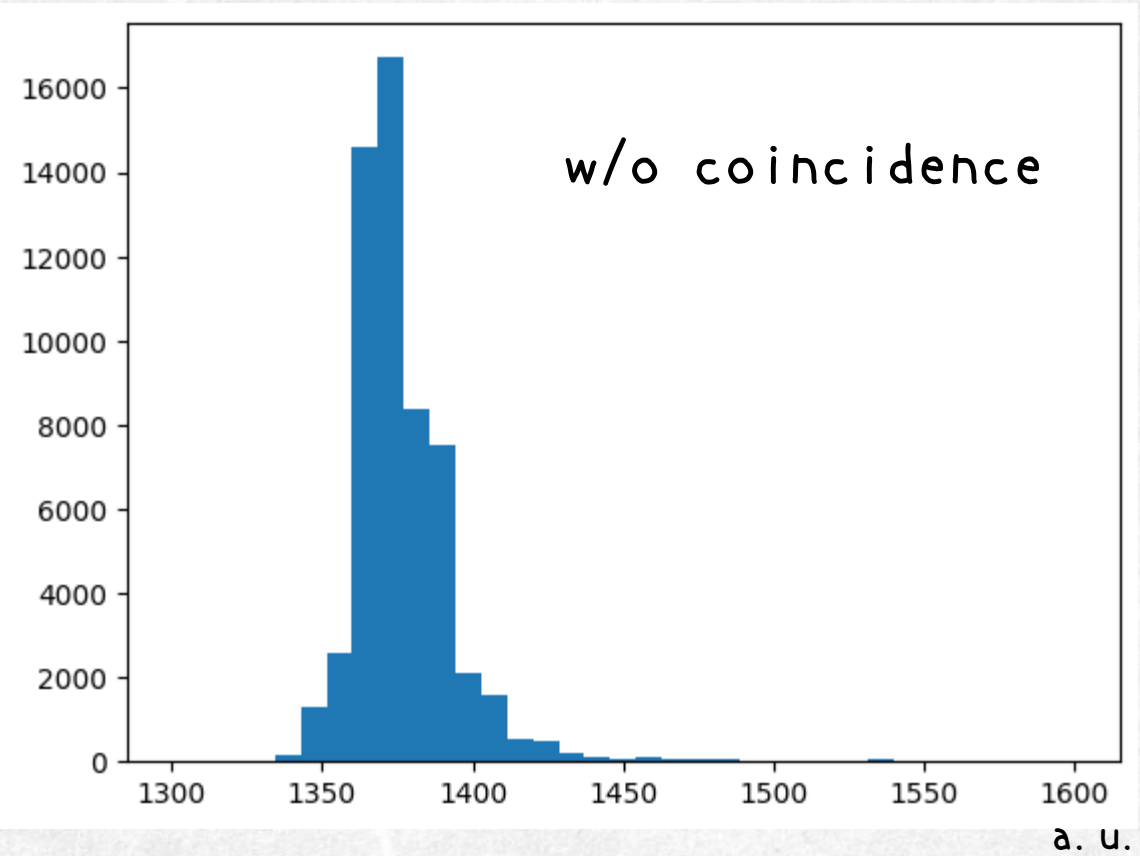
  note: threshold adjustment was rough.
- Coincidence hit counts were also checked.

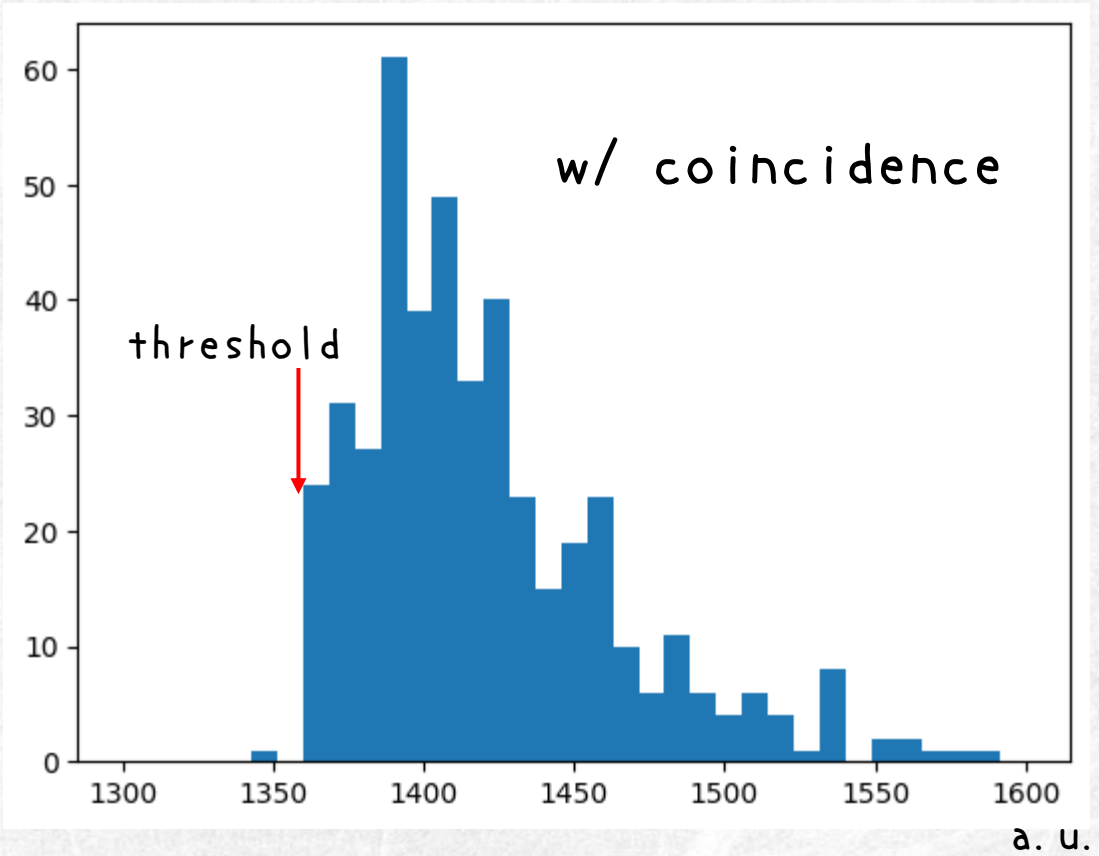
Successfully worked!





ADC distribution for 3D printing scintillator





Landau like distribution was obtained!

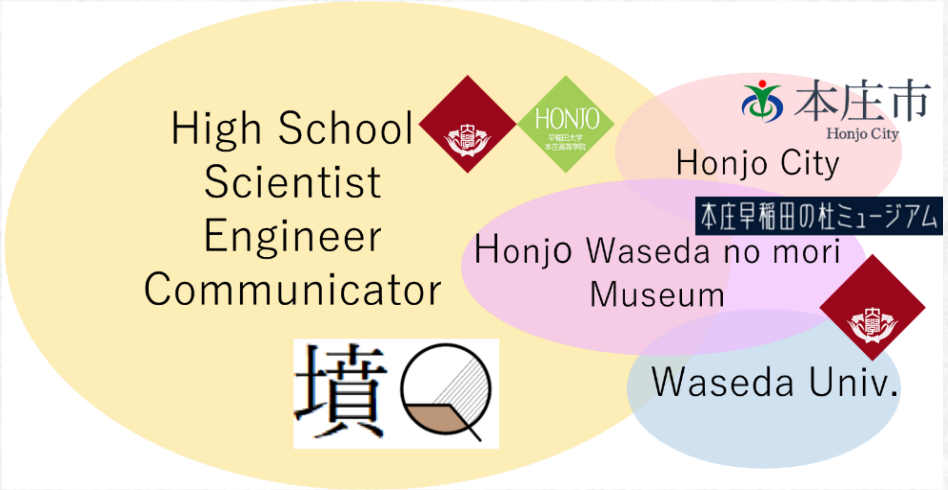
Successfully worked!

OSECHI ver. 2

- It was found OSEHI ver. 2 works well.
- Detailed adjustments and investigations are needed.
- More tests will be done.

Long-term program with OSECHI

- Fun-Q(墳Q):Muography project in high school in Japan.
  - The target of the muography is “Kofun” which is Japanese tumulus.
  - This project is organized in cooperation with researchers in Tan-Q team, teachers in high school, Honjo city, and experts in history museum.



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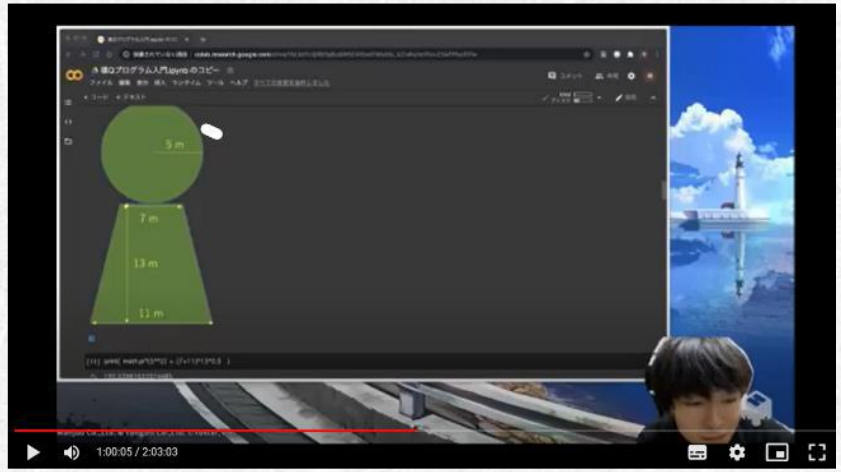
Long-term program with OSECHI

- Fun-Q(墳Q)
  - Providing OSECHI and related technology.
  - Online support.
  - Measurement.



online support

inside of Kofun

Mini workshop with OSECHI

- Held once or twice a year.
- Two-part structure
  - Part1 : Short lecture from researcher
    - to spark interest in particle & astro-physics
    - to lead into part2
  - Part2 : Measurement using OSECHI
    - to experience the world of particle & astro-physics firsthand

Mini workshop with OSECHI

- Measurement using OSECHI
  - Zenith angle distribution of CR muon
  - Visually count of 3 LEDs light-up
  - Group work
  - Research experience
    - measurement -> graphing -> discussion -> presentation




Summary

- Outreach and education program, Tan-Q, is ongoing.
- Development of Japanese style CR muon detector, OSECHI, is ongoing.
- We conduct long-term program and mini workshop using OSECHI.