Radiation Education with Radon Detector

- Detector Development and Implementation at High School -

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3.11 Fukushima Nuclear Power Station Accident

http://ja.wikipedia.org/wiki/

http://photo.tepco.co.jp/

Tsunami

Meltdown

Hydrogen explosion

Dispersion of Cs, I

Misinformation in Media and Internet

Why such rumor spread??

Radiation Education in Japan

Japanese don't have enough knowledge about radiation.

Now **education of radiation literacy** is regarded as important.

Course of Study ← Published by a ministry of education, culture, sports, science and technology

原子核の構成、原子核の崩壊、半減期、核分裂、核融合、原子核反応を扱い、質量とエネルギーの等価性にも触れる。例えば、放射線計測、霧箱を用いた 放射線の観察 などを行うことが考えられる。

...learn **construction** and **decay of nuclei, a half-life, nuclear fission**...For example, a cloud chamber and GM counter are introduced as radiation detector...

Cloud chamber

Geiger-Mueller counter

Understanding of decay of nuclei, a half-life and energy of radiation

Radon Detector

Criteria as a Teaching Material for Radiation Education

① To be able to learn about a half-life and radioactive disintegration.

② To be easy to handle for students and teachers.

③ To be Safe, low cost and compact.

+

Active learning program

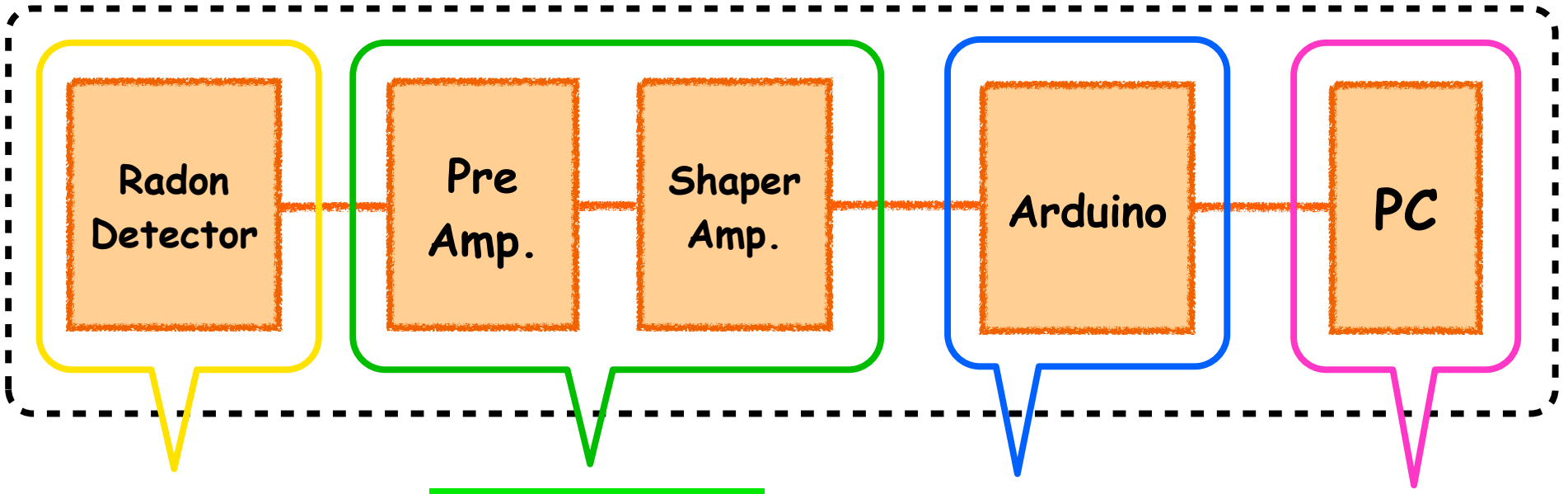
Purpose

i) To develop a **safe** and **compact** **Radon Detector** in **low cost** as **a teaching material**.

ii) To implement **education of radiation literacy** with it in physics club of high school.

iii) To promote student's **ability of treating** and **understanding** information(data) correctly, and **deciding** what to do by themselves through **active learning program**.

General View of Radon Detector

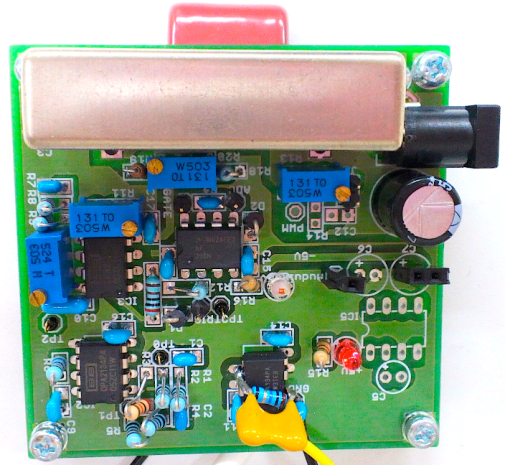


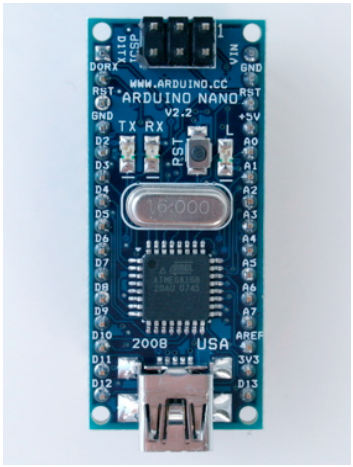
α -ray Detection

Pulse Height Analysis

Data Control

Data Collection

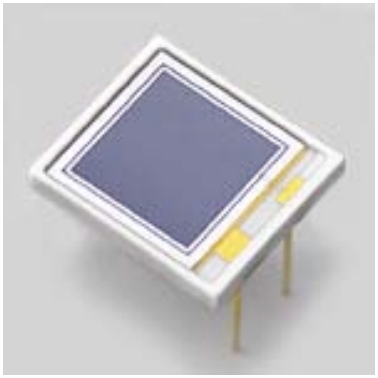




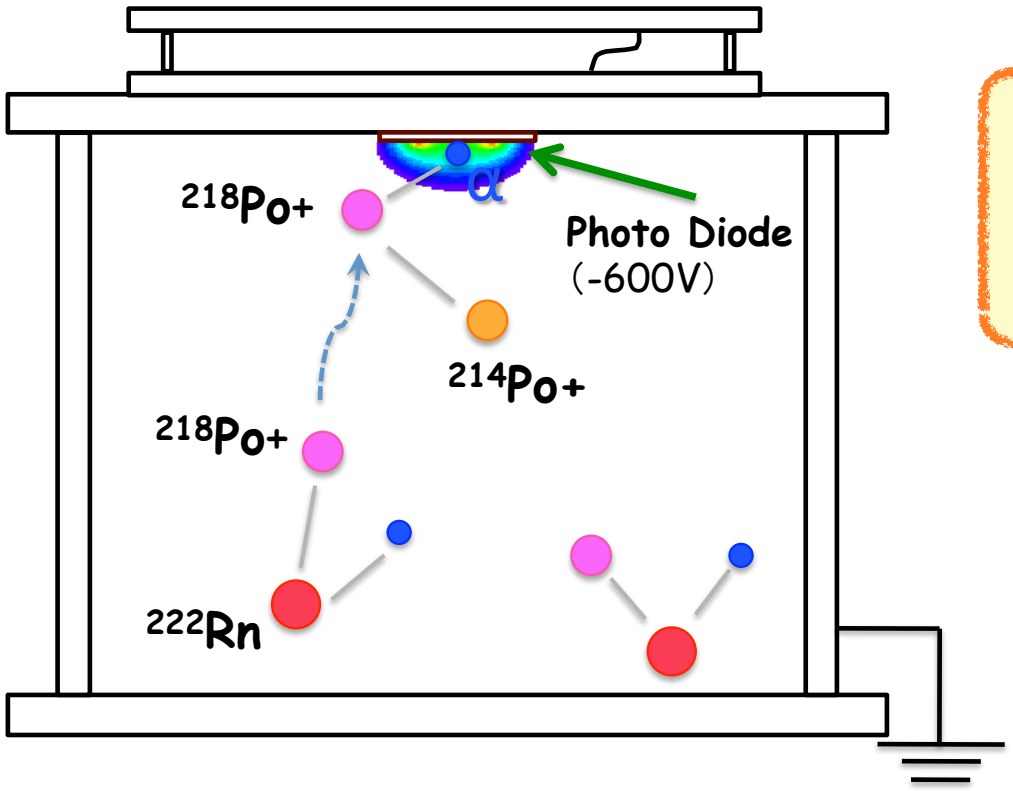
α-ray Detection

P-I-N Photo Diode for α-ray detection

Reflexible Surface : 10mm×10mm



【S3590-09 HAMAMATSU made】



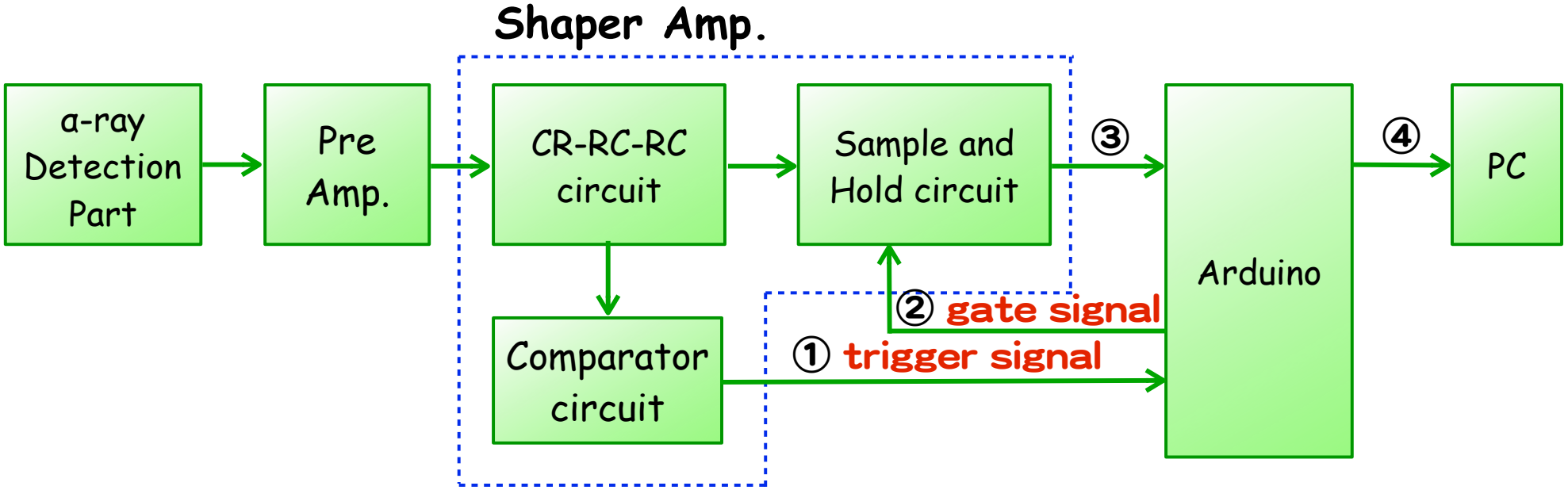
Electrostatic Collection*

to collect cations effectively
(The range of α-ray is 2~3cm in air.)

Collect ^{218}Po and ^{214}Po cations of daughter nucleus by electrostatic field on the surface of Photo Diode

Nucl. Instrum. Methods Phys. Res., A 421 , 1-2 (1999) 334-341

Pulse Height Analysis



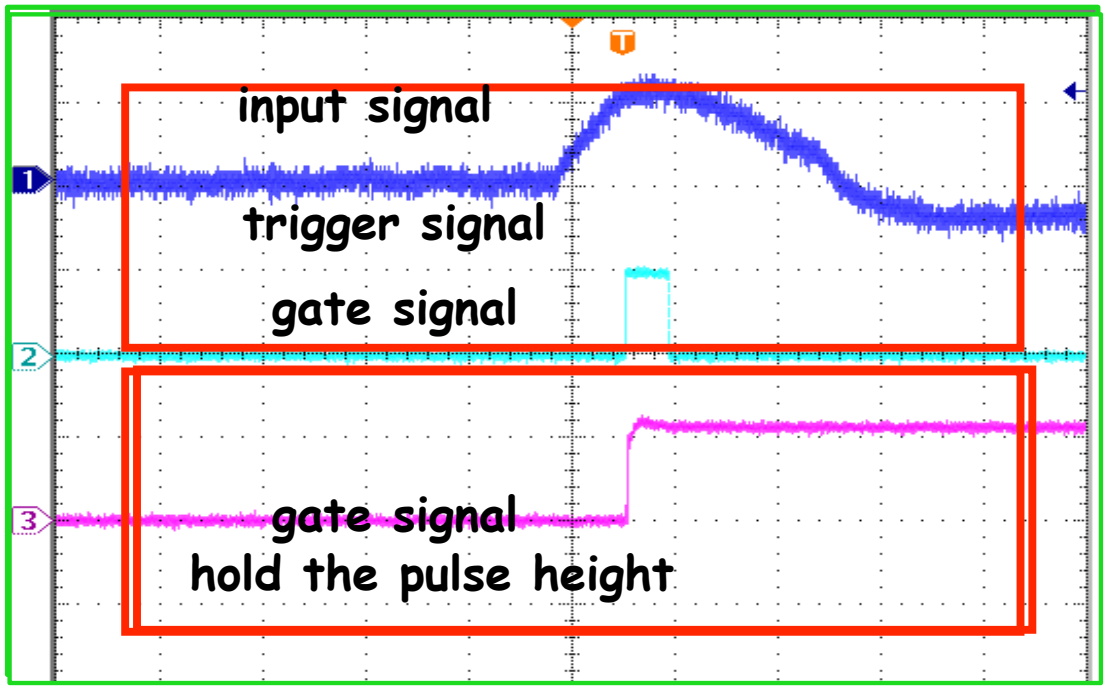
Input signal...

① Send trigger signal

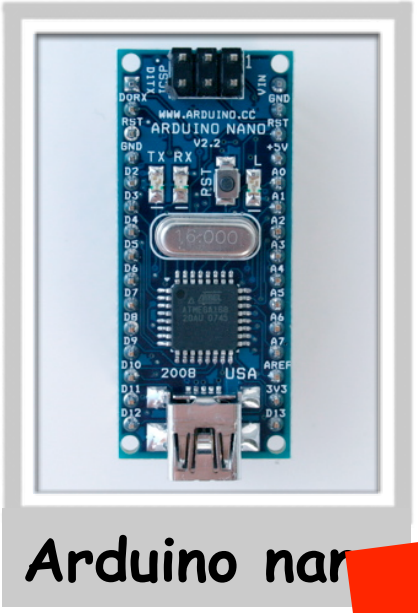
② Send gate signal

③ Send the held pulse height of the signal

④ Send the held pulse height data to PC



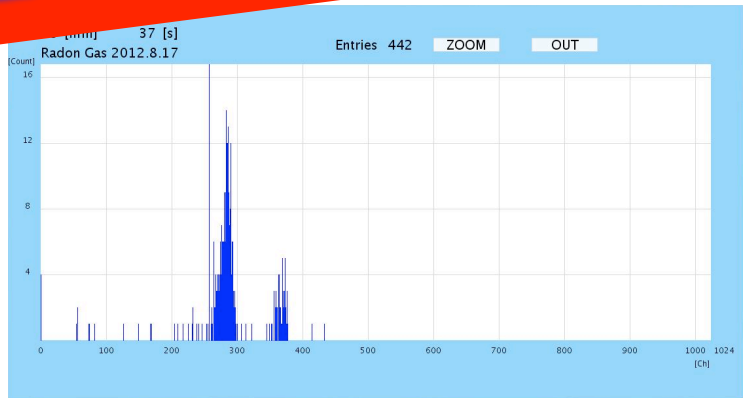
Data Control



Arduino nan

- ☑ 8bit microco… called ATME… …th 10bit ADC in circuit board is used.
- ☑ To able to upload program from PC to ATMEGA through a USB port
- ☑ Input and output of digital / analog signal

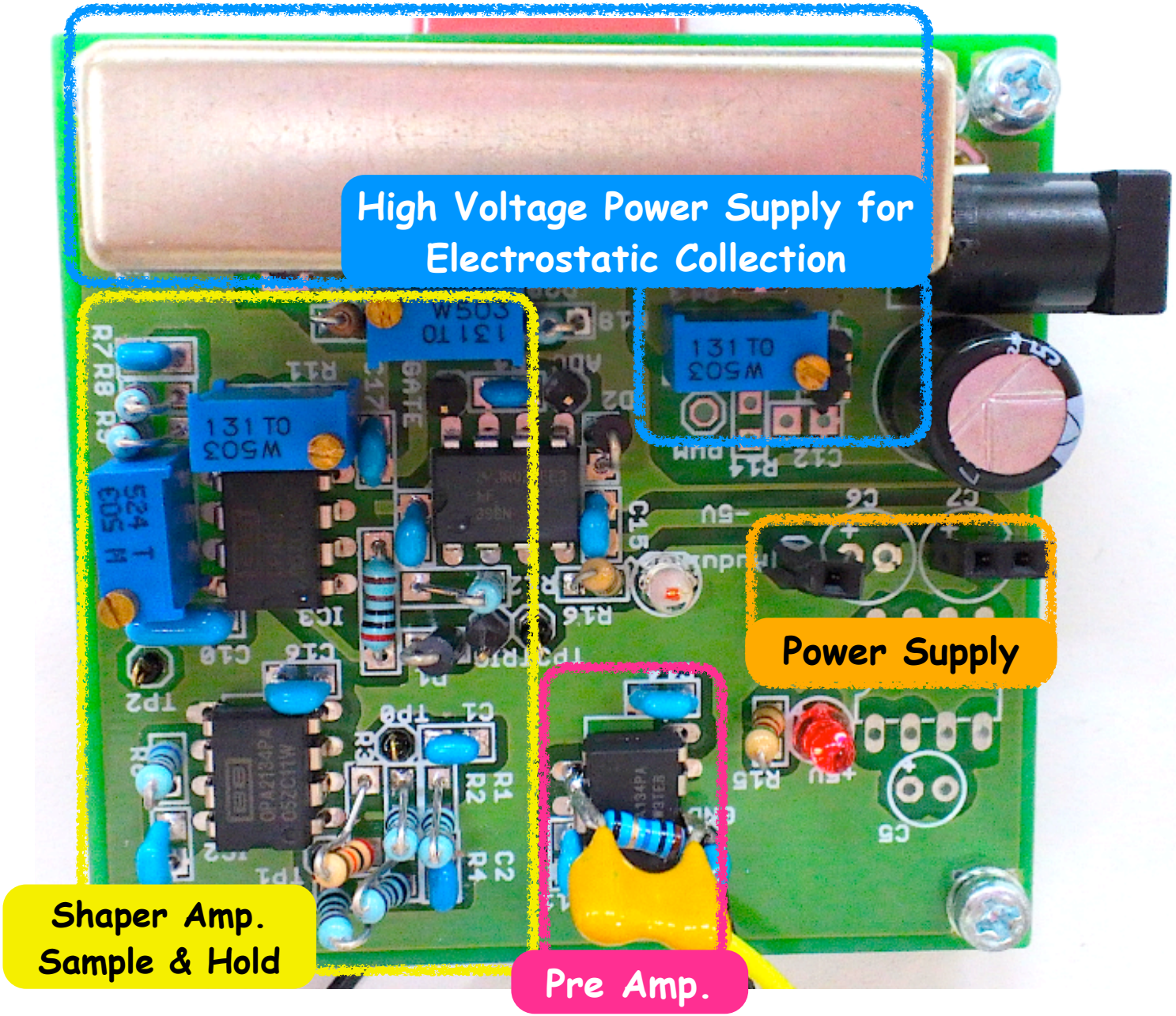
Data Collection



- ☑ Online monitoring

Open source

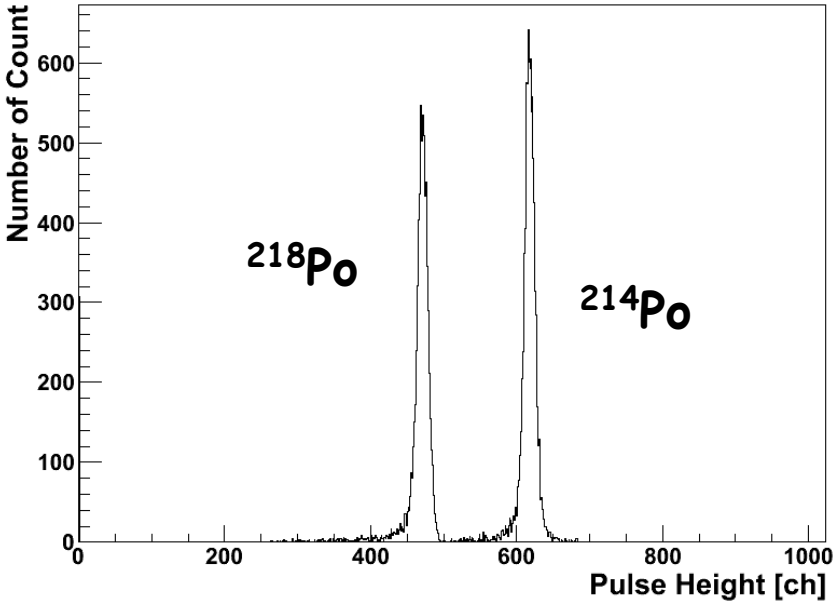
Circuit Board



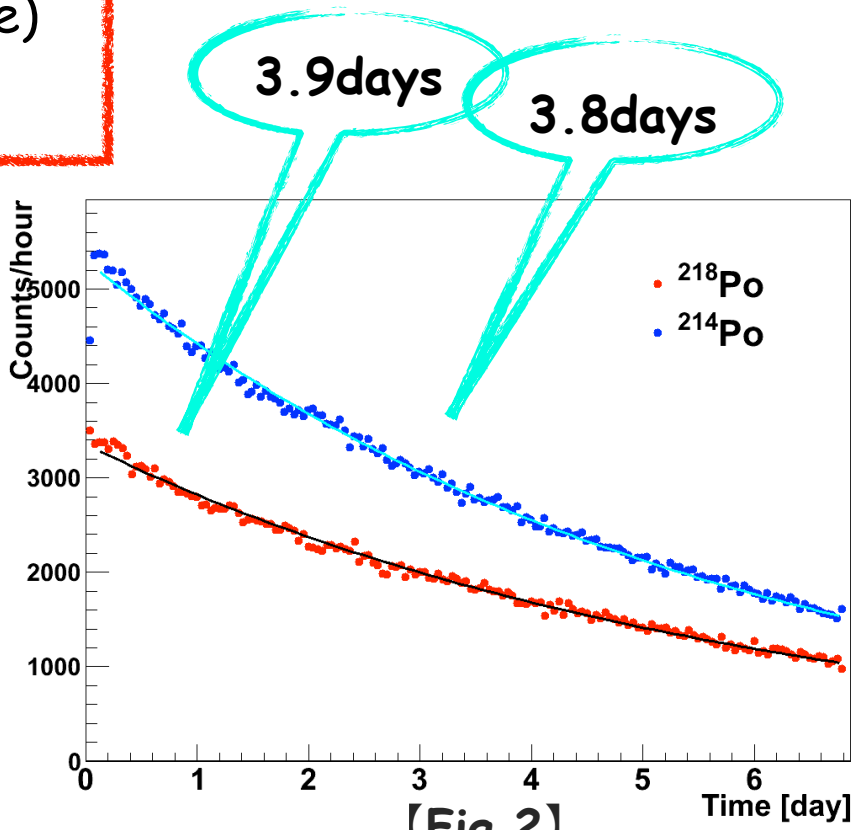
Results of Radon Measurement

Object : **Radon Gas** (gathered from ore)

Time : **7days**



【Fig.1】



【Fig.2】

We can measure
a half life
by using right equations!!

^{222}Rn: $dN_1 = -\lambda_1 N_1 dt$

^{218}Po: $dN_2 = (\lambda_1 N_1 - \lambda_2 N_2)dt$

.....

^{214}Po: $dN_4 = (\lambda_3 N_3 - \lambda_4 N_4)dt$

(^{214}Po ~ ^{214}Bi)

Characteristics of Radon Detector as teaching material and Effect expected

① To be able to **measure** α-ray **energy** and a **half-life**.

② To be able to **identify nuclide** of a radioactive element by the measured half-life and energy.

③ Students **make detector** by themselves.

- Promote student's deeper understanding about radioactive material by the measurement
- Promote student's ability of treating and understanding information(data) correctly, and deciding what to do by themselves

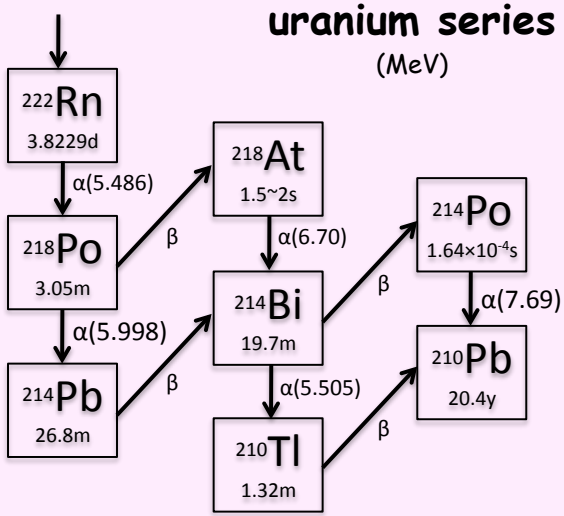
The Guidance Plan

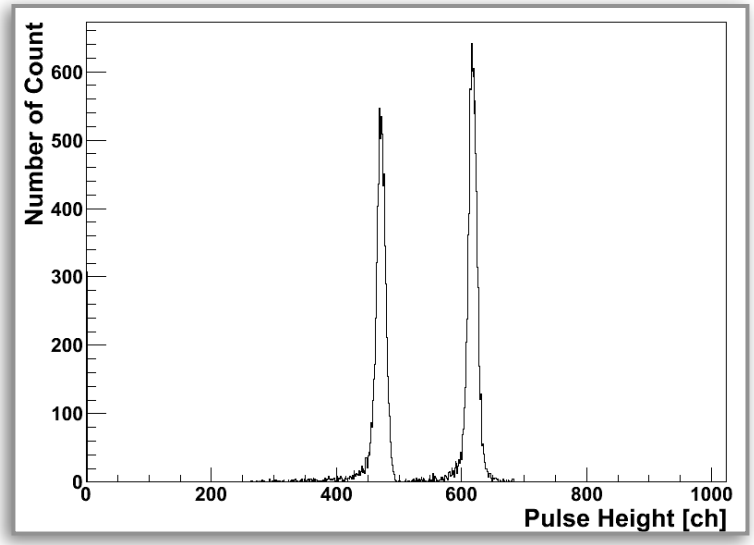
Target	Physics Club of High School
Time	11hours
Guidance Form	Team-Teaching
Object	◉Feel that there is radiation around us. ◉Make students more interested in making things by hand. ◉Learn and understand correct knowledge of nucleus and radiation. ◉Promote scientific ability to think and expressiveness. ◉Promote student's ability of treating and understanding information (data) correctly, and deciding what to do by themselves.
Composition	① Discussion (theme is the radiation) ② Lecture by a teacher ③ Making the Radon Detector ④ Measurement and Data Analysis ⑤ Presentation ⑥ Discussion ※Discuss simply after every class

Method of Identify Nuclide at High School

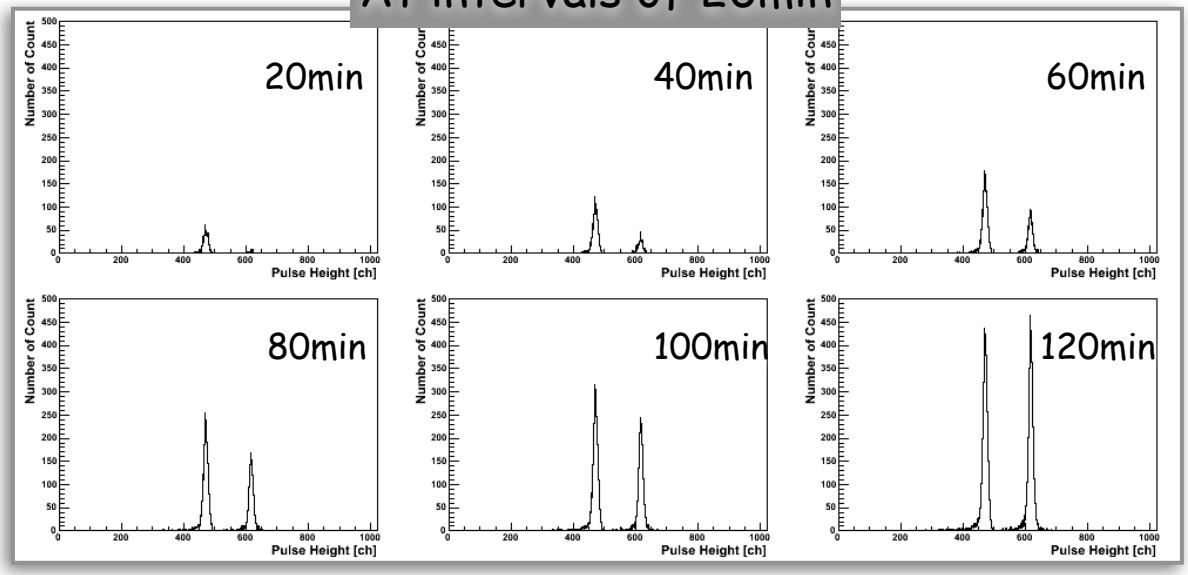
How to identify nuclide of a radioactive element…

① Which nuclide can be observed within measurement time in terms of a half-life??
② Which energy peak of a-ray can be observed first, lower or higher peak??
③ Students compare the ratio of a-ray energy for 2 peaks with the known value.





At intervals of 20min



Implementation and Questionnaire

High School

It is good...

...To be able to experience many fields such as hardware, software, data analysis and so on.

...To have opportunity to identify nuclide from decay chain.

...To be able to consider various things from the measured data.

As to a question that what the most interesting work for you is, they answered it was soldering of the circuit board, Arduino, data analysis, discussion and so on.

Summer Challenge Project at KEK

It is good...

...To be able to understand radiation measurement intuitively by making detector.

...To feel a sense of achievement which wrestle from measurement to analysis ourselves.

Summary

- ✓We have developed safe and compact radon detector with low cost as a teaching material for radiation education.
- ✓We have implemented radiation education with it in physics club of high school.Students made it by themselves and could measure the radon gas with it.
- ✓Improvement to smaller radon detector is on going.

Check!!

Our HP URL (Sorry in Japanese…)

http://utkhii.px.tsukuba.ac.jp/~radon/

Thank you for your kind attention.