Radiation Education with Radon Detector

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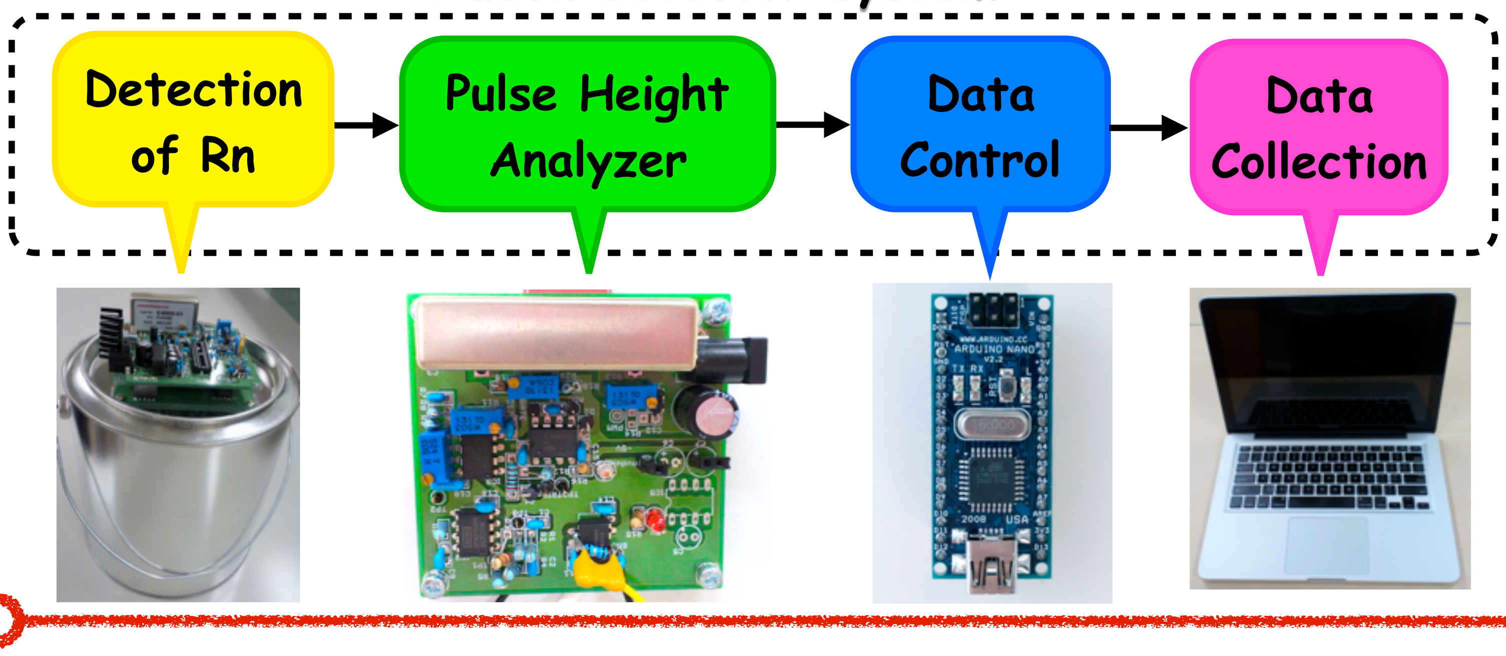
Introduction

After Fukushima nuclear plant accident occurred in Mar 2011, radioactive material flied to wide area in Japan through the wind. It was not until a people faced problems about radiation that the **lack of radiation literacy** was revealed. People need to learn the basic knowledge about radiation. At present radiation education is reconsidered in Japan. Though there is the guideline for high school education, in which GM-counter is introduced as an example of radiation detector, it's not enough to understand the properties of radiation like a decay of nuclei and half-life. So teaching materials to make it possible for students to learn such properties are needed.

In this poster, we present **a radon detector as a teaching material**, which have been developed to be effective in education.

Development of Radon Detector

Radon detector system we have developed consists of 4 parts, which is designed to be easy to understand and simple to make by hands.

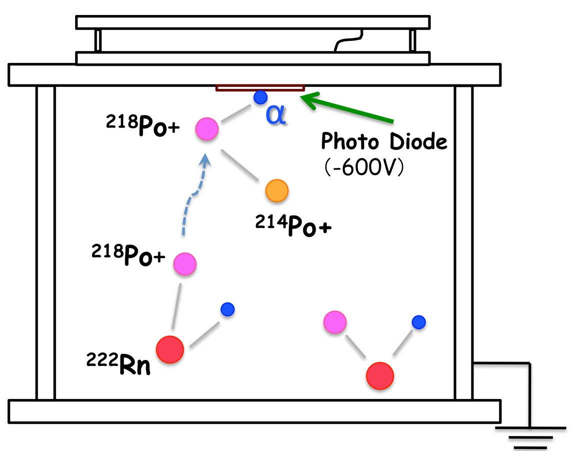


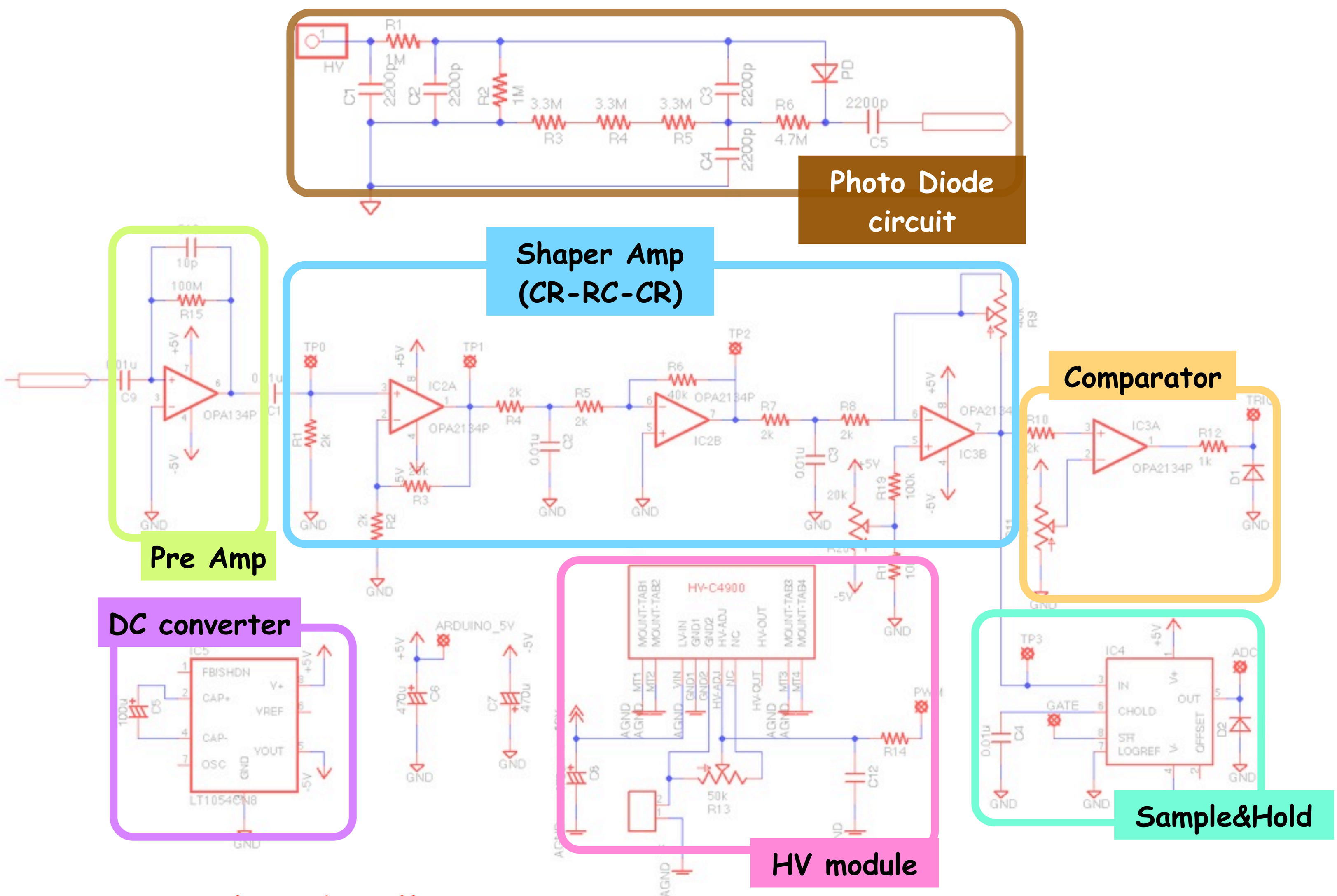
Detection of Rn

Electrostatic collection method is adopted to catch daughter nuclei decaying from Rn. PIN-PhotoDiode(s3590-09,HAMAMATSU) is used for measuring α-ray.

Pulse Height Analyzer

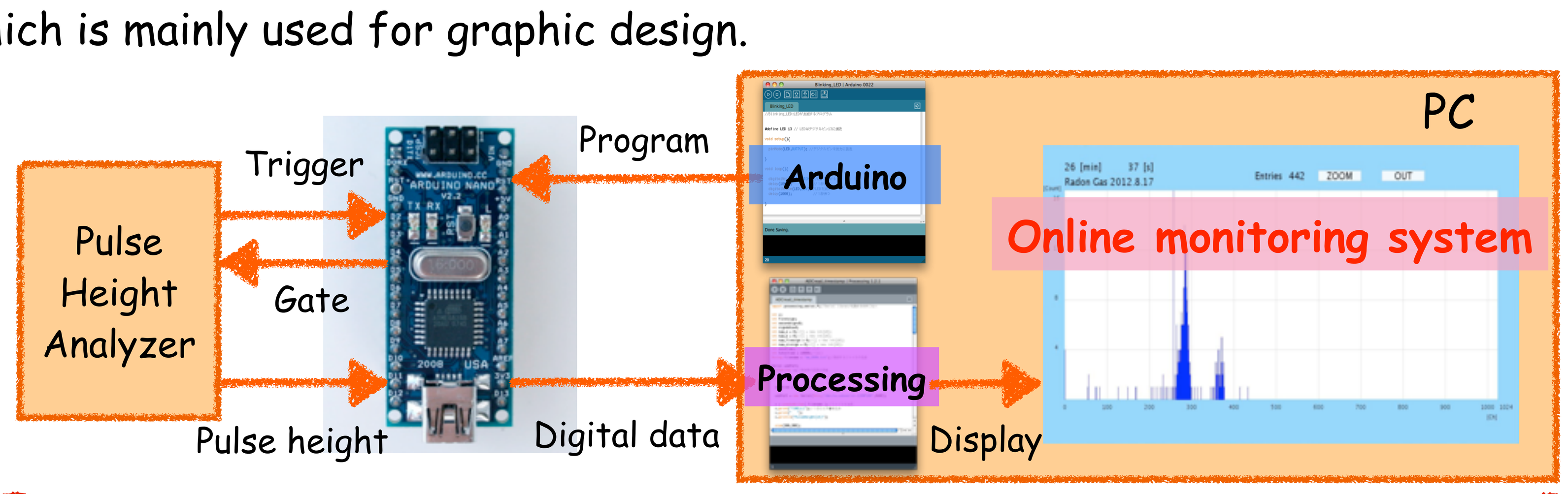
Pulse height analyzer is composed of pre-amplifier, shaper-amplifier, comparator and sample&hold, which are on the same circuit board with high voltage power supplier. Comparator gives a trigger signal to microcomputer called Arduino©. And an interrupt program in the Arduino starts up and sends gate signal to sample&hold. Then sample&hold holds the pulse height of the signal.





Data Control and Collection

Pulse height is converted to digital data by 10bit ADC within **Arduino©**. Arduino is a 8bit microcomputer and the **open source hardware and software**. Then the digital data is sent to PC via USB port. In PC, the sent data is processed by the **Processing©** application. Processing is also the **open source programming language**, which is mainly used for graphic design.



Cost: about ￥30,000 (≒300€)
(Two thirds of the cost comes from photo diode and HV module.)

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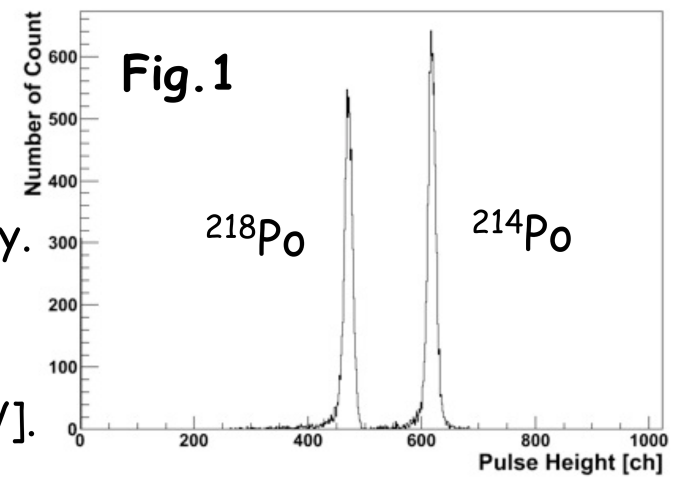
Characteristics of Radon Detector as a Teaching Material

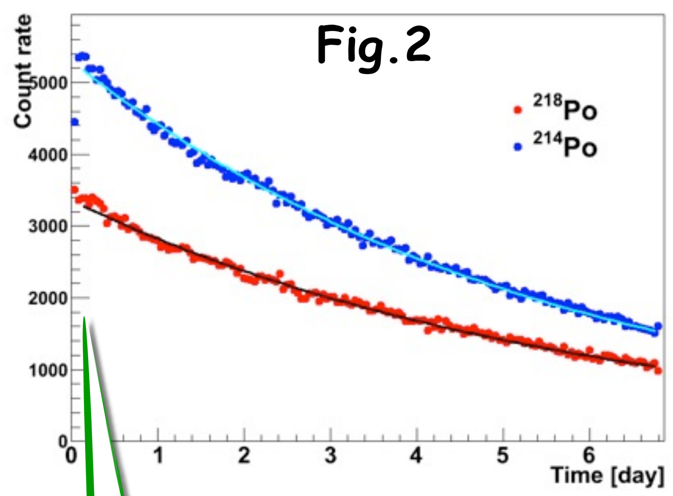
(1) Able to measure **α-ray energy** and **half-life**
(2) Able to **identify nuclide** of radioactive elements
(3) Easy for students to **make detector** by themselves

Radiation education with our radon detector leads to the understanding of radiation and gives a good opportunity to learn the mechanism of software and hardware in a system. **Active learning** consisting of making detector, measurement, data analysis and discussion leads to the promotion of the ability of treating and understanding the information correctly and problem-solving ability of students. It's also easy to handle in high school because radon exists naturally around us and we don't need any radioactive source. And we are improving it to be low cost and compact for the wide spread through high school.

Results of Radon Measurement

Radon gas collected from ores including natural uranium was measured for the performance check of our detector. Fig.1 shows the measured energy spectrum of α-ray. Two peaks can be seen, which correspond to α-rays emitted from ^{218}Po and ^{214}Po. **Energy resolution**(ΔE/E) **is about 1.1%** at 7.69[MeV].





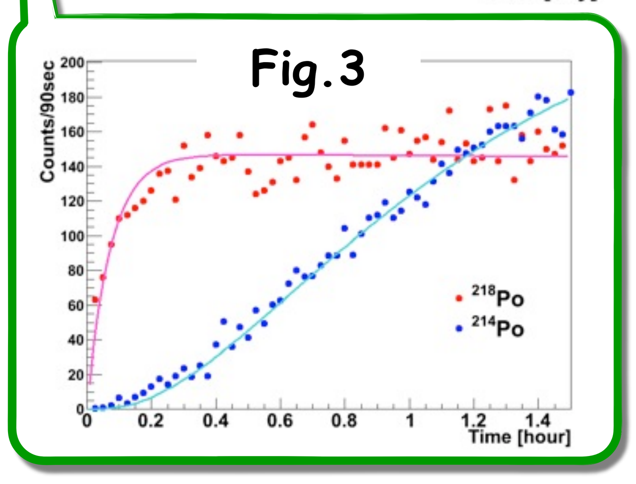
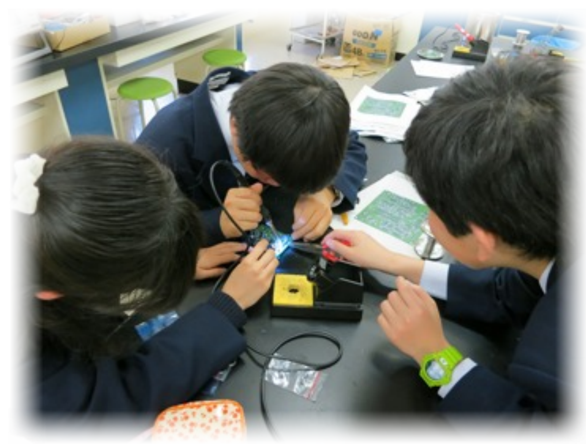


Fig.2 shows the count rates of 2 peaks in Fig.1 as a function of the time. Solid lines indicate fit function obtained by the solution of the differential equations in the below. Both count rates decrease according to the half-life of ^{222}Rn. Half-life of ^{222}Rn by fitting are **3.9 days** for red symbol and **3.8 days** for blue symbol. Fig.3 shows the count rates around the start time.

$$^{222}\mathrm{Rn}: \quad dN_1 = -\lambda_1 N_1 dt$$
$$^{218}\mathrm{Po}: \quad dN_2 = (\lambda_1 N_1 - \lambda_2 N_2) dt$$
.....
$$^{214}\mathrm{Po}: \quad dN_4 = (\lambda_3 N_3 - \lambda_4 N_4) dt$$
$(^{214}\mathrm{Po} \sim {}^{214}\mathrm{Bi})$

Implementation

Implementation of radiation education have been performed for **high school students** and **university students** so far.



Outlook

✓ Cost down to ￥10,000 (≒100€)
✓ Evaluation of the detection efficiency
✓ **Implementation at high school** with improved detector

References

1) S.Tasaka, RADIOISOTOPES. 46(1997)710
2) Y.Takeuchi, *et al*., *Nucl. Instr. Meth.*, **A 421**, (1999) 334