DIY GEIGER COUNTER

National Taiwan University

SEPTEMBER 30, 2022

GROUP NAME: 1.67 ZHUGE LIANG

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Group members	Student ID
詹文康	B10901138
陳柏睿	B10901028
林奕樺	B10901065
劉桓誠	B10901174
林昀萱	B10901120

Abstract:

We made a Geiger Counter by some easy electronic parts and Geiger tube. It can record the count of radiation and send the data to computer. Then, we first used it to measure the relationship between distance (to the radioactive source) and the intensity. Secondly, we measure how obstacle block radiation rays.

Background:

“A Geiger counter (also known as a Geiger–Müller counter) is an electronic instrument used for detecting and measuring ionizing radiation. It is widely used in applications such as radiation dosimetry, radiological protection, experimental physics, and the nuclear industry.

It detects ionizing radiation such as alpha particles, beta particles, and gamma rays using the ionization effect produced in a Geiger–Müller tube, which gives its name to the instrument. In wide and prominent use as a hand-held radiation survey instrument, it is perhaps one of the world's best-known radiation detection instruments.”

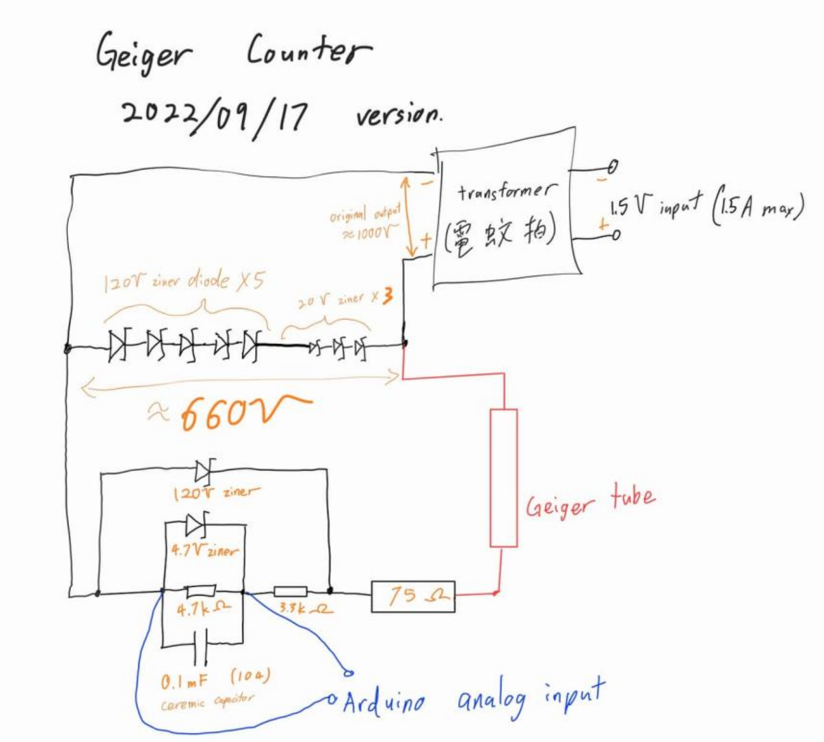
- Wikipedia

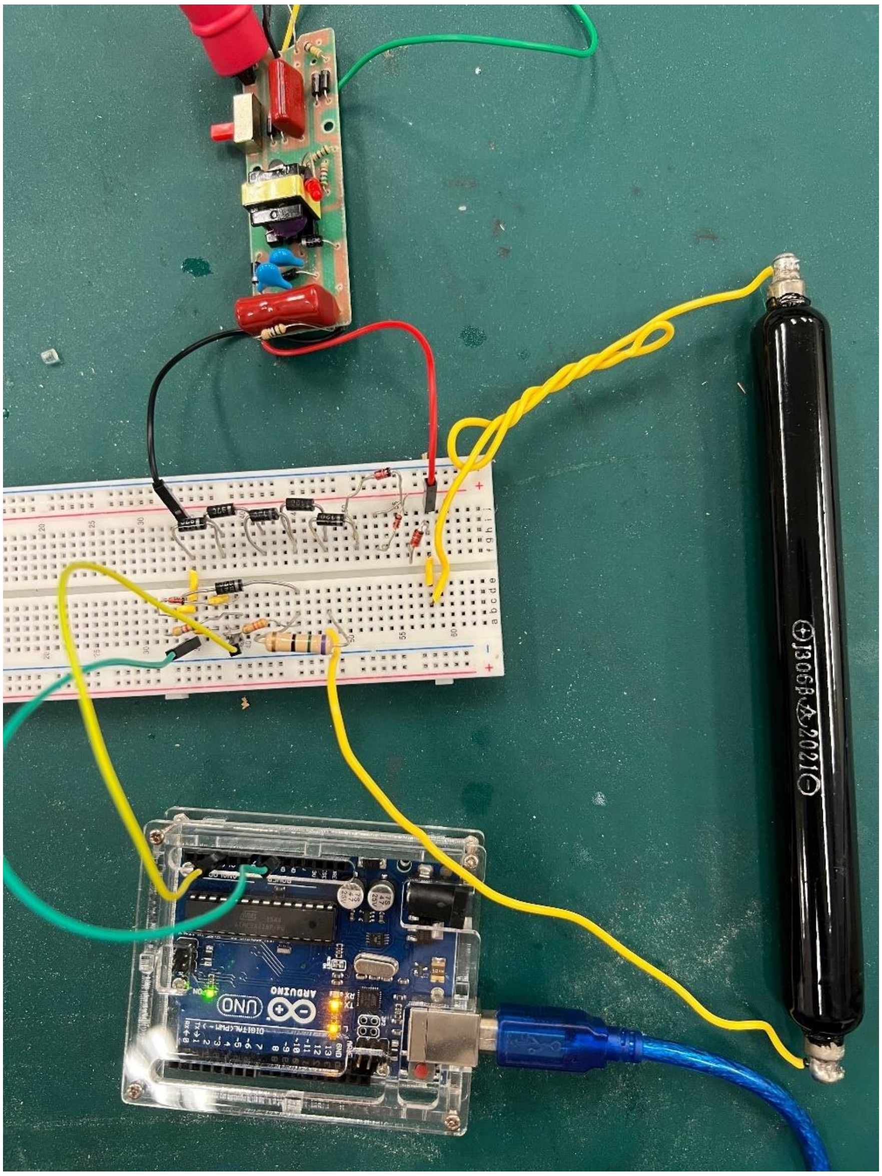
note: our introduction video: https://youtu.be/feE8TSuEfKw

Building the Geiger Counter

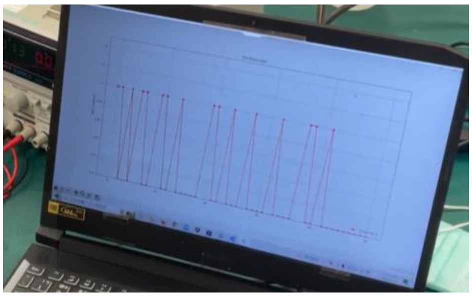
We tried to make a Geiger Counter by some easy electronic parts and Geiger tube (brought online).

After trial and error, we got this circuit that works as we expected. As shown:

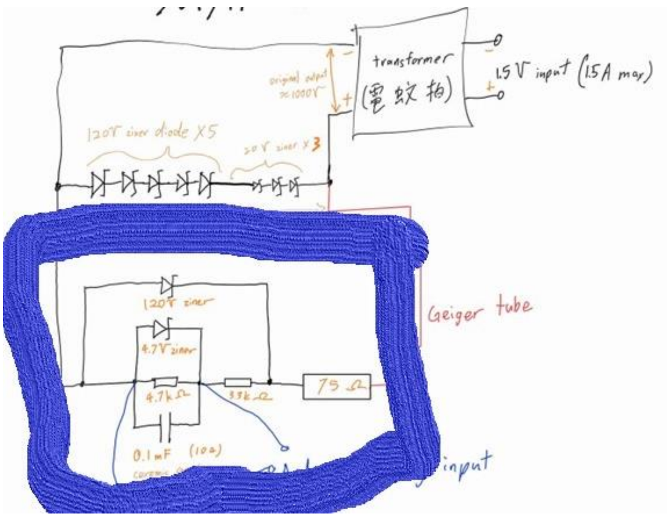




As shown, the transformer first transform the 1.5V input into a 1000V output, which is then regulated by the zener diodes into 680V for the Geiger tube. When the Geiger tube received a radiation and ionized, there will be current running through the circuit (Geiger tube and the resistors and capacitors), which then transform into a signal less than 5V, and send into Arduino. Finally, the data will be sent to computer and finally displayed by a python program.

 <-- the python program displaying the detected radiation

The Arduino code and Python code can be downloaded from the attachment section.



As a note, the circuit network that's framed in blue rectangle is the protective circuit (designed by us) to reduce the big voltage and current into a small jump in voltage (around 4.7 V). The Zener diodes' roles are to bypass the extra current. The capacitor's role is to store charges when the current "spike", because the ionization of Geiger tube happens in a extremely short time window (10^-6 second), so we need the capacitor to store the charges, and discharges slowly afterward to delay the "spike" into a 10^-3 second time window.

We used Tanner_tech's design of "Simplest Geiger Counter" (found on web, please check in citation) as a reference. But we have added Arduino board as a counter and used a transformer from a electric mosquito swatter. Overall, we have done some modification based on his design.

Note: One must be extra careful about the pinout of circuit. We have burned several Arduino Pins while building this circuit. That's due to the Zener diode being destroyed (which is used to bypass a huge current spike), lack of resistors or accidently switching the pins.

Experiment and results

We did two experiments. In both experiment, the source of radiation is Hokutolite rock, and we measure the radiation by fixing the measuring time into 30 seconds and count the radiation occurrences by a python program connected to Arduino.

When we were doing all the measure for both the control groups and experiment groups, we make sure to keep switching back and forth between two groups. The goal of switching back and forth between the control group and experimental group is to even out the effect of background radiation, which is unstable. If we measure the control group 5 times in row, then to the experimental group, then the coming result might contain a big error. That's cause by the fluctuation of background radiation. Let's say the background radiation is occasionally higher in the first 150 seconds when we measured the control group (which is just the background radiation in the first experiment), then occasionally (and unluckily) the background radiation lowered for a period of time when we measure the radiation from Hokutolite rock (next 150 seconds). In the end, we might get a weird result which is "Hokutolite rock sucks in radiation from outside". By switching measuring, we can effectively eliminate this random effect.

Experiment 1 Intensity vs Radioactive source distance

Procedure

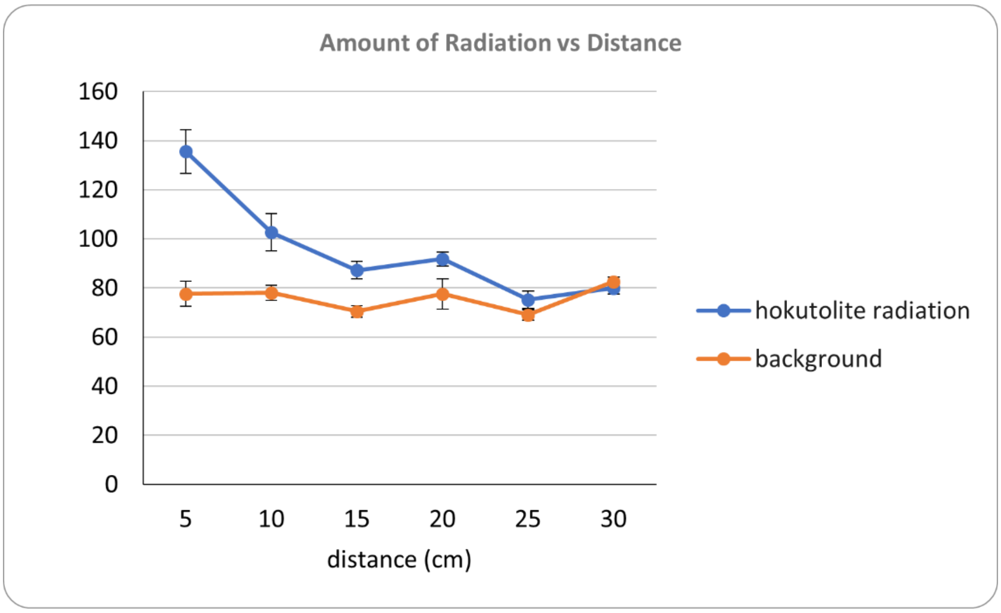
To find out the relationship between radioactive source distance and the intensity. The source of radiation is Hokutolite rock.

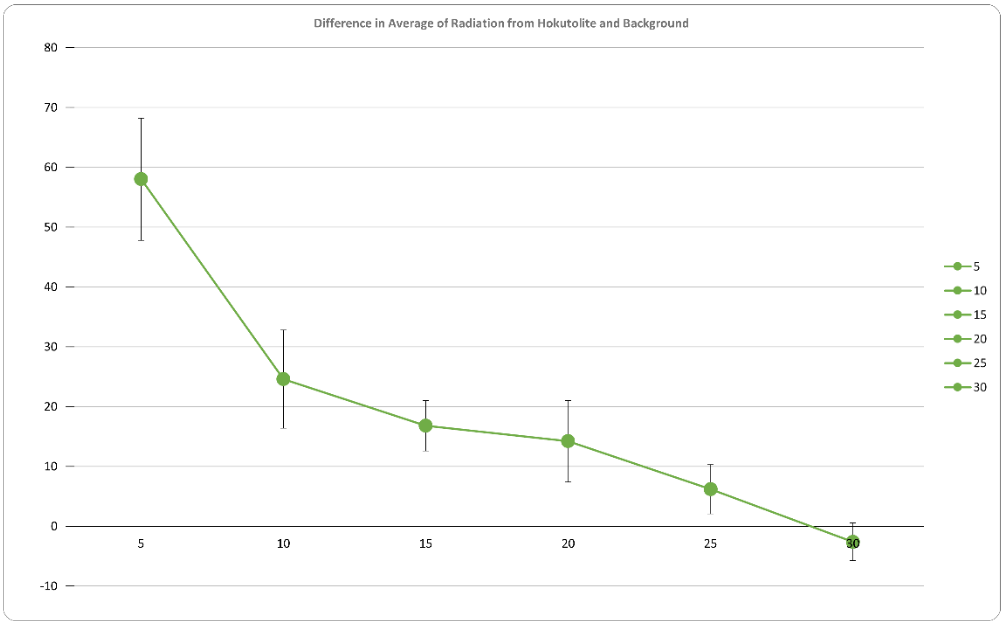
The experiment is done by switching back and forth (5 times) between the control experiment (background radiation without any other radiation source) and a source in a certain distance. After repeating this experiment with several distance, the data is attained, shown bellow. (The data can be downloaded in attachment section)

The goal of switching back and forth between the control group and our experimental group is to even out the effect of background radiation, which is unstable. If we measure the control group 5 times in row, then to the experimental group, the coming result might contain a big error. That's cause by the fluctuation of background radiation. Let's say the background radiation is high in the first 150 seconds when we measured the background radiation, when background radiation lower when we measure the radiation from Hokutolite rock (next 150 seconds). In the end, we might get a weird result which is "Hokutolite rock sucks in radiation from outside". By switching measuring, we can effectively eliminate this random effect.

Result and Analysis:

the distance between Geiger tube and the Hokutolite rock is recorded in centimetre, while the y-axis is the count of radiation detected in 30 seconds.





The result is shown in these charts. The first one consists of the average radiation count by both experimental and control group. The second one is the difference between two lines. (Theoretically it's the amount of radiation emitted by the Hokutolite rock itself)

There are five data being recorded for each set of distance. We analysed the error by assuming the data as gaussian distribution, then estimate the standard deviation of the mean. The error bar shown in graph is one standard distribution.

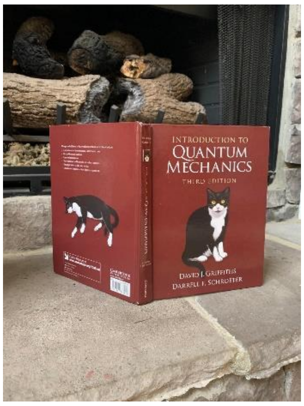
As seen, when the distance is 30 cm, the amount of detected radiation and emitted by Hokutolite rock is negative, which shouldn't be happening. but it's quite reasonable as the range is within the error bar.

Overall, we can see that amount of radiation detected (intensity) decrease when the distance between the source and Geiger tube increase.

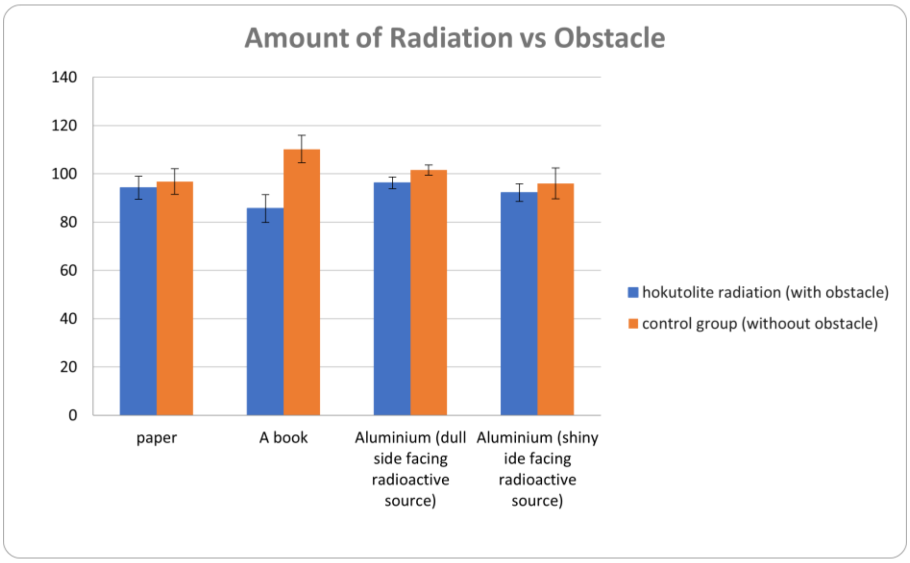
Experiment 2 Intensity vs types of obstacle

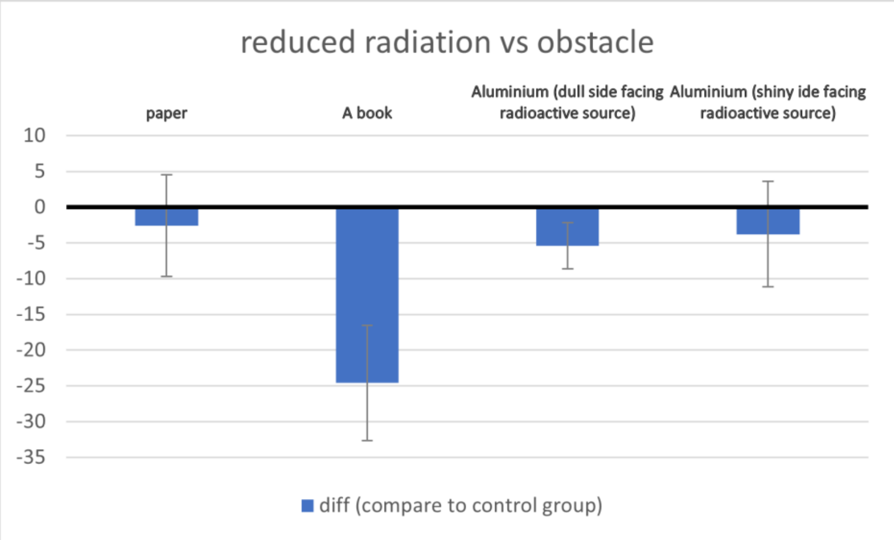
Procedure

in experiment 2, the Hokutolite rock is 15 cm away from the Geiger tube (controlled variable). The control groups in this experiment are to put no obstacle in between while the experimental groups are to put different obstacles between them (7.5 cm to the tube). The data is recorded accordingly. The obstacles are a piece of paper, a 2.45 cm thick book (picture bellow), and aluminium foil on both sides.



Result and Analysis





The first chart shows the result of both experiment and control group while the second shows their different (which is negative as radiation get blocked). The method of data analysis is same with experiment 1.

As we can see, the blocking effect of the book is most significant. The next comes the Aluminium foil with the dull side facing the radioactive source. The blocking effect of paper and the Aluminium (shiny side facing source) is quite negligible in our experiment.

As a note, the reason we tried both side for Aluminium foil is because one of our groupmates suggested that one of the sides might block radiation better than the other. But it can't be shown in this experiment.

Conclusion

We have successfully made a working DIY Geiger tube, which has given us some experimental result that fit our understanding on radiation. We have observed that the intensity of radiation decrease when the distance increase, and it can be blocked by obstacle.

Citation

(14 July 2022). Geiger counter. https://en.wikipedia.org/wiki/Geiger_counter

Tanner_tech. (2016). Simplest Geiger Counter. https://www.instructables.com/Simplest-Geiger-Counter/

ATTACHMENTS

1. all the data, videos and slides are in this link –

https://1drv.ms/u/s!AtSCEtLUhAx7gdMdscRAm2taUW_4XA?e=iwMBJd

2. our introduction video –

https://youtu.be/feE8TSuEfKw