Visualize Particle Radiation in Physics Education

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***Abstract**: The Hunveyor-4 educational space probe being built at the Óbuda University, Alba Regia University Center, Székesfehérvár is, among other things, equipped with a particle radiation detector. This is intended to turn the students' attention towards the study of physics. Because we recorded the ticks using an audio processing program, the frequency and random behavior of the beats can be easily visualized, visually compared, processed and statistically analyzed.*

***Keywords**: particle radiation, physics education, Hunveyor*

1 Introduction

While we have no sensors with the ability to detect particle radiation, we have no firsthand experience about this phenomena and thus we have no fear when it would be necessary. The media tend to overreact and cause panic, even when there is no reason for it. That is why in education important to adequately deal with the issue.

The typical ticks of GM tubes, which is mostly used for detecting particle radiation, were recorded on a computer. We measured the background radiation on different locations such as in the house, in a basalt mine, and on a high flying plane. Because we recorded the ticks using an audio processing program, the frequency of the beats can be easily visualized and visually compared. Moreover, because the time of the ticks can be exported to a text file, the recorded data can be processed and statistically analyzed.

2 Historical Background

2.1 The Accidental Discovery of Radioactivity

The discovery of radioactivity - as well as several other incidents in the science of Physics - happened purely by accident. The French physicist Henry Becquerel in early 1896, after having heard the German physicist Wilhelm Conrad Roentgen discovery one year earlier regarding the passage of X-rays through cardboard, black paper, and even the human body is decided to examine the fluorescent materials. He wanted to know whether the fluorescent materials emit something like X-ray.

Figure 1
Fluorescent rocks

Since Becquerel thought that the emission of light resulted from external exposure of the sunlight, on a sunny day he put some strong fluorescent uranyl crystals to the window over black paper wrapped in a photographic plate. After development of the plate, the crystals were clearly visible as gray spots.

On February 26 and 27 in 1896th the sky over Paris were covered with dark clouds, so Becquerel put the wrapped plates and the crystals into the drawer of his desk. After a few days he continued his experiment, and on 1st of March he developed the plates. As a big surprise, instead of some gray shadows he found pitch black spots. Soon it became clear that the radiation apparently had nothing to do for lighting [1], [2].

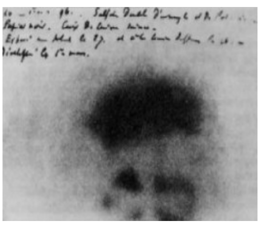

Figure 2
Original plate of Becquerel

2.2 Particle Radiation is Coming from Space too

The Earth's atmosphere is continuously bombarded by particles coming from space. One type of corpuscular radiation is called cosmic radiation which was discovered in 1911 by Hess and Kohlhörster. The velocity of these particles are close to the speed of light, and their energy falls to the range of $10^9 – 10^{20}$ eV. (From the measurements of the space probes we know that the intensity of the cosmic radiation increases with the distance from the Sun.)

The primary cosmic ray, which hits the outer boundary of the atmosphere cannot be detected directly at the Earth's surface because the particles interact with atoms and molecules of the atmosphere in a very complex way, triggering many different processes. The resulting secondary radiation has a soft and a hard component. A single primary particle can cause a whole cascade.

The hard component of secondary cosmic ray consists of mesons, and they have so much energy that they can penetrate the earth's crust in several hundred meters, or up to a mile deep in the sea.

The other type of particle or corpuscular radiation is known as solar wind, which consists of protons and electrons. (The Sun launches about a million metric ton of atomic material into space in each second. From this material less than half a kilogram per second hits the Earth. The speed of these particles are different, but the average is between 500 km/s and 700 km/s.) [4]

2.3 Early Experiments

Under the leadership of Ernest Rutherford at the Manchester University, Hans Geiger and Ernest Marsden set out to explore the structure of the matter conducted scattering experiments. The experiments were carried out in the basement of the University in total darkness. They had to count the faint scintillations for weeks and months as the α-particles hit the screen. To facilitate the nerve-racking and soul breaking job, Geiger worked out the idea of a counter in 1908, which was improved later by Walther Müller, a PhD student of Rutherford.

Figure 3

The Geiger-Müller tube

3 Detecting Corpuscular Radiation

There are a variety of detecting radiation, such as scintillation, cloud chamber, spark chamber, solid state detectors, films and different gas filled tubes, such as GM-counter.

The Geiger counter is still one of the most important tools of radiation detection and measurement. If an ionizing particle passes through the counter tube, the generated ions greatly accelerate in the strong electric field around the central electrode, resulting in more secondary ions. [5.] The secondary ion current makes a power peak on the resistor, which is counted and converted to an audible click.

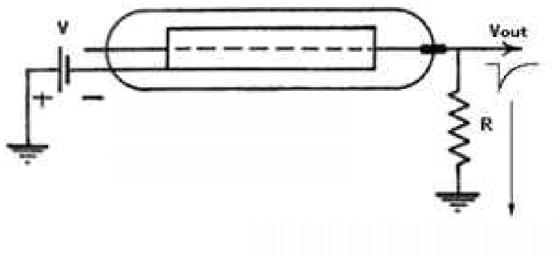

Figure 4
The principle of the GM tube

The Geiger counter, which also exists in several types, falls into the gas-filled counters. The devices we use in classroom demonstration contain GM tube and Trinitron tube, while the detector placed to Hunveyor-4 has a solid-state sensor. The semiconductor detectors operate in the same way in principle as the ionization chambers, i.e. a charged particle interacts with the semiconductor material releasing electric charges, resulting in an electric impulse. The semiconductors have a great advantage over the GM tubes. While in the tube we need 30 eV for freeing up an electron, in the semi-conductors only 3.6 eV is required in average.

4 Recording and Visualizing the Particle Radiation

We can have a graphic, or even quantitative results recording the ticks of the radiation monitor device using a sound processing program, putting the device against a microphone of the laptop. The records can be played back later, or the sound tracks can be placed under each other and visually compared, or even zoomed in for details. In the followings we show the results for some records lasted about ten minutes each. The pictures speak for themselves.

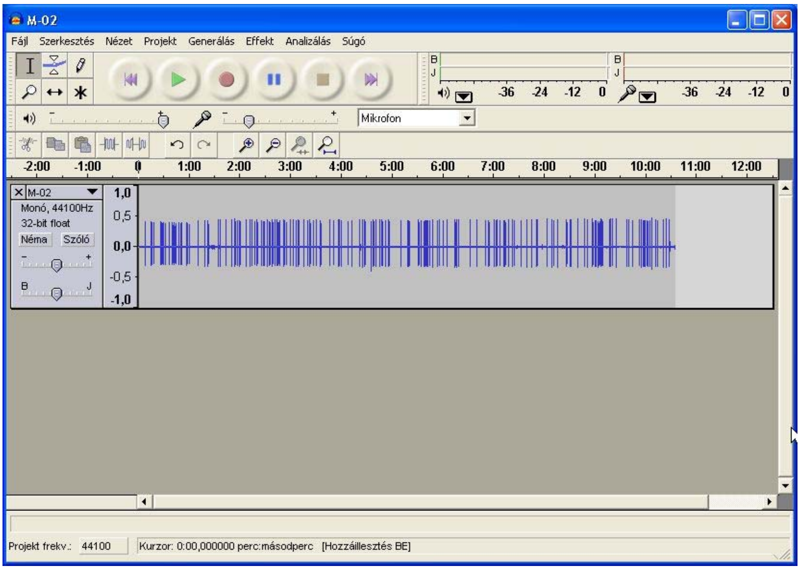

Figure 5

Background radiation recorded in a building

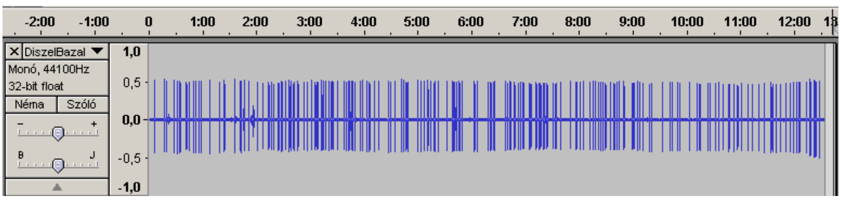

Figure 6

Background radiation recorded in a basalt mine in Diszel, north of Balaton, Hungary

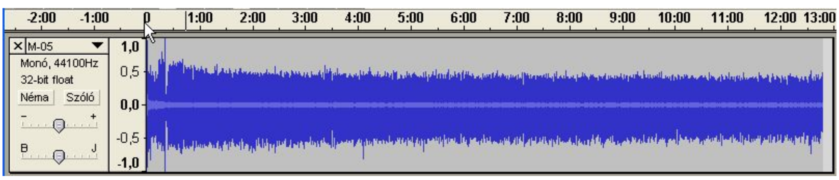

Figure 6

Background radiation recorded in a plane, at about 11 thousand meters altitude

However, the used program can do much more. The time of the beats from the beginning of the recording can be saved into a data file. The portion of the resulted file is shown here:

…...................................		
…...................................		
8,408000	8,408000	B
15,638000	15,638000	B
16,362000	16,362000	B
16,923000	16,923000	B
18,219000	18,219000	B
18,406000	18,406000	B
…...................................		
…...................................		

Figure 7
The portion of the data file

The first data gives the start, the second gives the end time an accuracy of thousandth of seconds, from the beginning of the record, while the "B" is simply a label. The resulting data can be processed and evaluated with an appropriate or self-made program. The theory and practice of the evaluation of random data can be found in [3], in a deep and detailed scientific level which is beyond of scope of this paper.

Conclusions

Studying the frequency, distribution, and evaluation of the statistical nature of the radiation can help in everyday life in the correct interpretation of half-understood, or intentionally misinterpreted information, coming from sensation hungry news channels. The method described above has been successfully tested for electrical engineering students under the Hunveyor project, and reported in conference MAFIOK [6].

Acknowledgement

I am grateful to Obuda University, and I offer my regards to all of those who supported me in any respect during the project.

References

[1] G. Gamow: A fizika története, Gondolat, Bp. 1965

[2] G. Gamow – J. M.Cleveland: Fizika, Gondolat, Bp. 1973

[3] Jánossy Lajos: Mérési eredmények kiértékelésének elmélete és gyakorlata, Akadémiai Kiadó, Bp. 1968

[4] Kulin György – Róka Gedeon: A távcső világa, Gondolat, Bp. 1980

[5] Wolfgang Finkelnburg: Bevezetés az atomfizikába, Műszaki Könyvkiadó, Bp. 1958

[6] Hudoba Gy.: A Novel and Expressive Way of Detection and Evaluation of Particle Radiation in Physics Education, Perspective 2010, Szent István University (pending)

Online resources:

http://hmika.freeweb.hu/Erdekes/Html/Sugarzas.htm

http://hu.wikipedia.org/wiki/Kozmikus_sugárzás

http://hu.wikipedia.org/wiki/Rutherford-kísérlet

http://iqdepo.hu/dimenzio/02/12.html

http://www.ejf.hu/oktkut/kiallitas/Oldalak/Eszkozok.htm

http://www.elektroncso.hu/cikkek/gmcso.php

http://www.hobbielektronika.hu/forum/topic_2454_3_ASC.html

http://www.klte.hu/~wwwinorg/essays/essay036.html

http://www.korunk.org/?q=node/8&ev=1929&honap=6&cikk=4884

http://www.kzs.hu/tudastar/fizika/radioaktivitas.ppt#20

http://www.mimi.hu/csillagaszat/kozmikus_sugarzas.html

http://www.omegalabs.eu/html/geiger_szamlalo.html

http://www.sg.hu/cikkek/38494/a_kozmikus_sugarzas_szab_hatart_az_urutazas_hosszanak