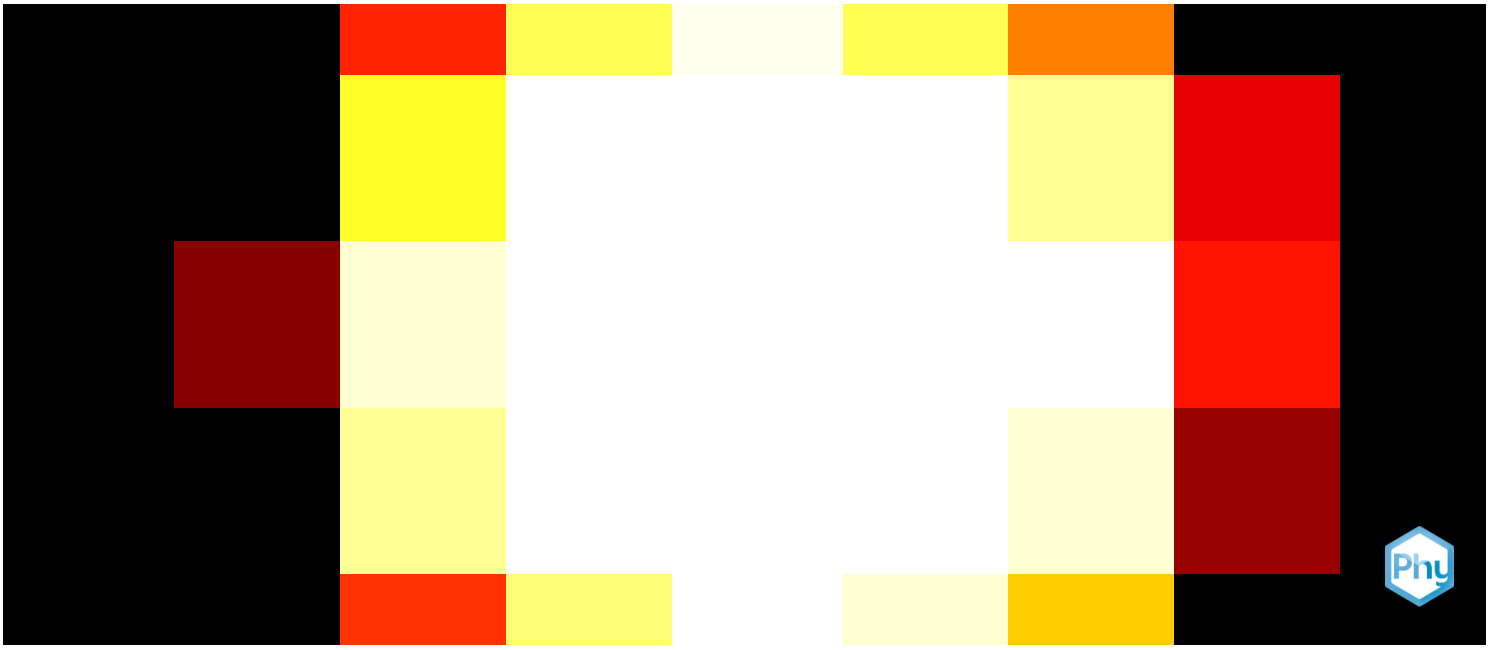
Range of an alpha particle



P2525300

Physics | Modern Physics | Nuclear & particle physics

Difficulty level	Group size	Preparation time	Execution time
-	-	45+ minutes	45+ minutes

This content can also be found online at:

http://localhost:1337/c/6565eef87ec3840002a4412a

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General information

Application

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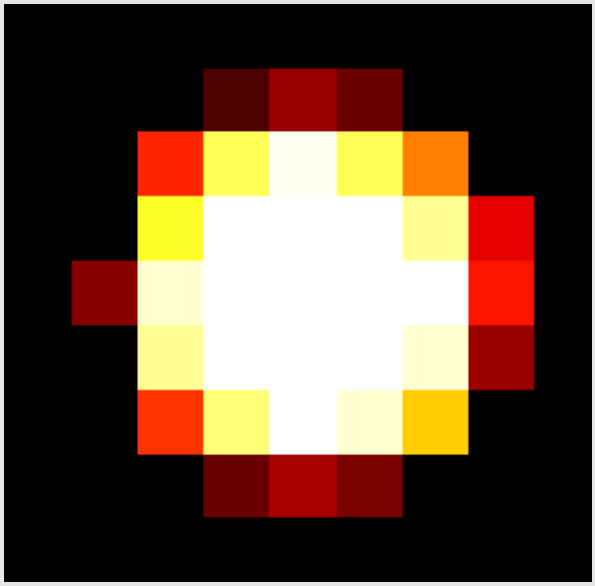

Radioactivity is a subject in our society which has been playing an important role throughout politics, economy and media for many years now.

The particular hazard when handling radioactive substances is the high-energy radiation from these substances. The hazard potential depends in particular on the type of radiation exposure: internal or external exposure; type of radiation: alpha, beta, gamma radiation, and type of handling.

In this experiment, the range of alpha particles is investigated.

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Other information (1/3)

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Prior knowledge

The prior knowledge required can be found in the theory section.

Scientific principle

The MiniPIX EDU is a modern nuclear technology of radiation imaging serves for making cosmic and terrestrial radiation visible so that a wide range of natural radiation types can be identified. Furthermore, the radiation detector offers the opportunity to carry out physical experiments with the aid of artificial radiation sources such as polonium.

Other information (2/3)

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Learning objective

How far can alpha particles travel?

Tasks

1. Start the radiation detector.
2. Collect data on alpha particles.
3. Evaluate the observations.

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Other information (3/3)

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Instructions for safe use

To avoid malfunction or damage to your $MiniPIX\ EDU$ please observe the following:

- Do not expose to water or moisture.
- Do not disassemble. Wire-bonding connection may be irreversibly damaged.
- Do not insert any object into the sensor window.
- Maximum USB cable length is 3m.
- The protection provided by this product may be impaired if it is used in a manner not described in this document.

Theory (1/5)

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The main compositions of the primary cosmic radiations.

Particles	Percentage
protons	about 90%
alpha-particles	about 9%
bigger nuclei	up to 1%

1. Natural Earth radiations

1.1 Cosmic rays

Radiations of particles with a high energy content (an exception: photon rays, which are electromagnetic waves) use to come from space down to every part of our terrestrial atmosphere (the primary cosmic radiations).

The particles penetrating into the atmosphere happen to bang into nuclei of the atmosphere and provoke nuclear reactions as well as nuclear splits. Therefore, new nuclei and elementary particles are created, go on flying and lead to other interactions.

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Theory (2/5)

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In the atmosphere layers close to earth (less than 20 km high) one can observe only one secondary kind of radiations brought up by the numerous interaction-processes in the superior layers of the atmosphere. One must differentiate four kinds of components which have a different penetrating power (see Fig. 1):

Cosmic secondary rays	Components
Nucleons	protons / neutrons
Electrons and photons	electrons / positrons / photons
Mesons	mesons of different charges
Neutrinos	neutrinos / antineutrinos

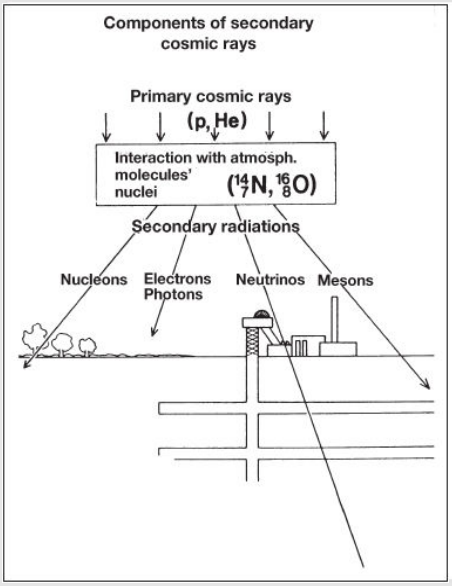

Fig. 1: Natural splitting processes

Theory (3/5)

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1.2 Terrestrial radiations

All materials on Earth (earth, water, atmosphere, animals…) contain natural radionuclides which send radiations. They have been existing since the creation of Earth (that is to say 4.5 thousand million years) or are constantly being created: U-238; Th-232; K-40 or Rb-87, for instance, belong to the natural radionuclides and have a very long radioactive period. Ra- 226; Rn-222; Po-218 or Pb-210 are constantly being created and those radionuclides have a rather short radioactive period in the three natural splitting processes. There exist also natural radionuclides with a relative short-timed radioactive period, but these do not belong to the splitting process. They are constantly being created in the upper layers of atmosphere, such as C-14 from N-14 or H-3 from N-14 or O-16, for instance.

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Theory (4/5)

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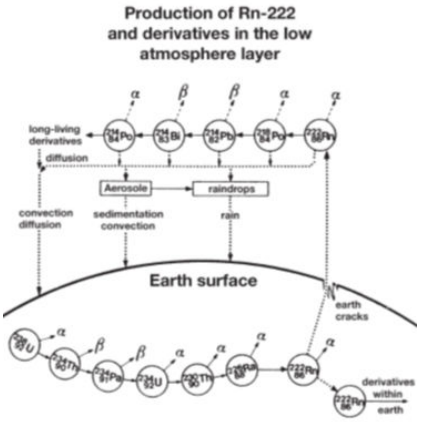
The about 100 natural radionuclides which have been existing since the creation of Earth or which are constantly being created can be found on the whole Earth in different concentrations. That is the reason why there are constant exchanges between earth, water, atmosphere and animal-life (Fig. 2).

People have therefore always absorbed natural radioactive substances into their bodies through the air they breathe and the food they eat. The radioactive gas radon and its by-products are absorbed through inhalation. Natural radionuclides from the radioactive decay series of thorium and uranium as well as potassium-40 and carbon-14 are ingested with food.



$^{14}_{7}N + {}^{1}_{0}n \rightarrow {}^{14}_{6}C + {}^{1}_{1}p$

$^{14}_{7}N + {}^{1}_{0}n \rightarrow {}^{12}_{6}C + {}^{3}_{1}H$

$^{16}_{8}O + {}^{1}_{0}n \rightarrow {}^{14}_{7}N + {}^{3}_{1}H$

Fig. 2

Theory (5/5)

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2. Radioactive substances - Polonium-210

Polonium-210 is the most common polonium isotope in nature. It is formed as the last radioactive link in the radioactive decay chain of uranium-238. Overall, the natural occurrence of polonium is extremely low. Polonium-210 has a physical half-life of 138 days. It emits alpha particles during radioactive decay, producing lead-206. Radioactive polonium can only pose a health risk if it is inhaled with food or drinking water or absorbed into the body through the skin, for example via open wounds. The quantities of naturally absorbed polonium are so small that they have practically no effect on health. Health risks can therefore only occur in the event of unintentional or intentional (deliberate) ingestion of technically produced polonium. It is used in combination with beryllium as a neutron source, in antistatic electrodes/brushes to eliminate static charges, in highly sensitive optical and mechanical measuring devices to eliminate static charges and as a lightweight thermoelectric battery in space travel.

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Equipment

Position	Material	Item No.	Quantity
1	Single photon counter MiniPIX, set	09075-00	1
2	Radioactive source Am-241, 74 kBq	09047-51	1
3	Holder for radioactive samples, used for 09075-00	09075-10	1

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Setup and procedure

Setup and procedure (1/2)

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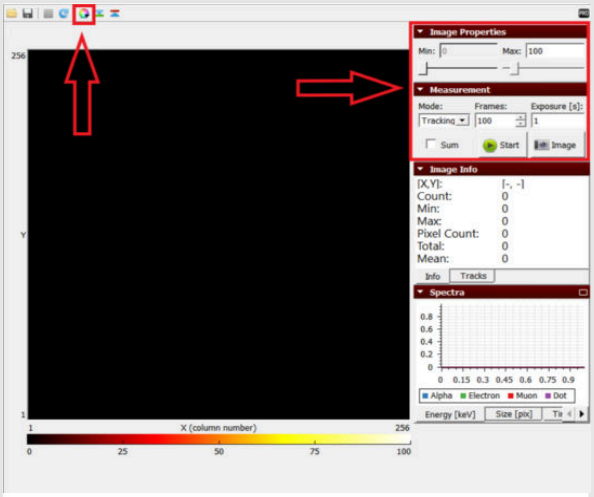

The settings can be modified.

- Connect the MiniPIX EDU camera and launch the software PixetBasic.
- Modify the settings to the following:
  - Min Level: 0
  - Max Level: 100
  - Measurement Mode: Tracking
  - Frames: 100
  - Exposure: 1 s
  - Sum: uncheck
  - Color Map: Hot

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Setup and procedure (2/2)

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- Mount the MiniPix EDU camera and the holder with polonium on the stage.
- Keep the camera and the source as close as possible and click on the play button. Next, shift the source to 2 cm and collect the data. Similarly, collect the data for 3 cm and 4 cm.
- For more information about the software and exporting of data, consult the experiment "Measurement of background radiation".

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Evaluation

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Evaluation (1/3)

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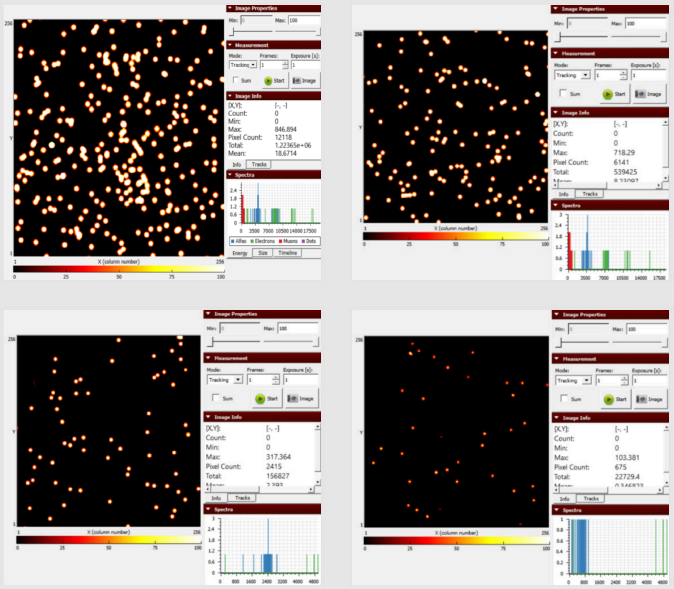
Initially, when the source is closest, the frame is full of alpha particles (top left).
As we reach ~2 cm, the number of observed particles has dropped. Also, the particles are relatively smaller which indicates further energy loss because of increased distance of the source from the camera (top right).
At 3 cm, we observe a further decrease in the size and density of observed alpha particles (bottom left).
The alpha particles losing most of their energy and almost diminishing at a distance of 4 cm and if we further increase the distance to 4.5 cm, they disappear (bottom right).



Evaluation (2/3)

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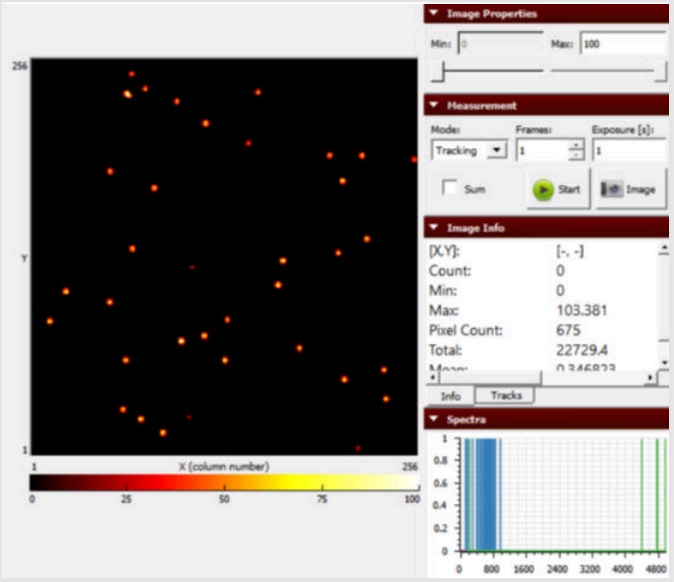
- As explained earlier, alpha particles are the heaviest among the three and are more ionizing. They quickly lose their energy in the air and thus have a very short mean linear range.
- The alpha particles from polonium-210 have only ~4.5 cm of range.



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Evaluation (3/3)

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How far can alpha particles travel?

When does alpha radiation pose a significant health risk?

- ○ When absorbed into the body through drinking or food.
- ○ On external contact.

Überprüfen

Slide	Score / Total
Slide 18: Health Risk	0/1

Total Score 0 / 1

Show solutions | Retry | Export text

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