Determination of the thickness of an aluminum sheet

P2525500

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/65685a4634fd590002398261

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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 fact that this radiation cannot be seen or felt by the human being and that the effects of this radiation are still not fully explored yet, causes emotions like no other scientific subject before.

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.

This experiment estimates the thikness of aluminium foil using alpha radiation.

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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 range of alpha radiation depends on both the energy of the alpha particles and the material in which they move. In principle, however, the range of alpha radiation is short, especially in comparison with beta and gamma radiation.

Other information (2/3)

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Learning objective

Determining the range of thikness of aluminium foil using alpha radiation.

Tasks

1. Start the radiation detector.
2. Collection of data on the thickness of the aluminum foil.
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 (1/3)

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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 use to come from space down to every part of our terrestrial atmosphere. 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.

In the atmosphere layers close to earth one can observe only one secondary kind of radiations brought up by the numerous interaction-processes in the superior layers of the atmosphere.

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Theory (2/3)

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1.2 Terrestrial radiations

All materials on Earth 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. 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. 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.

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.

Theory (3/3)

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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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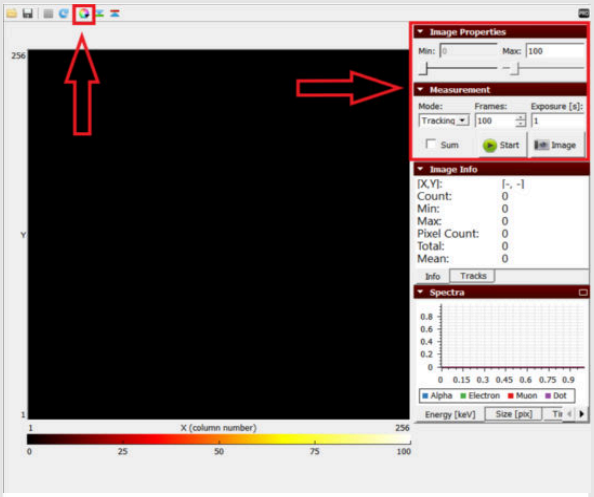

The settings can be modified.

- 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: 600
  - Exposure: 1 s
  - Sum: check
  - Color Map: Hot

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Setup and procedure (2/2)

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- Mount the MiniPix EDU camera and polonium wrapped in a single layer of aluminum foil on the stage.
- Keep the source and camera as close as possible and click on the play button.
- Next, wrap two foils of aluminum and without moving the stage, collect the data again.
- 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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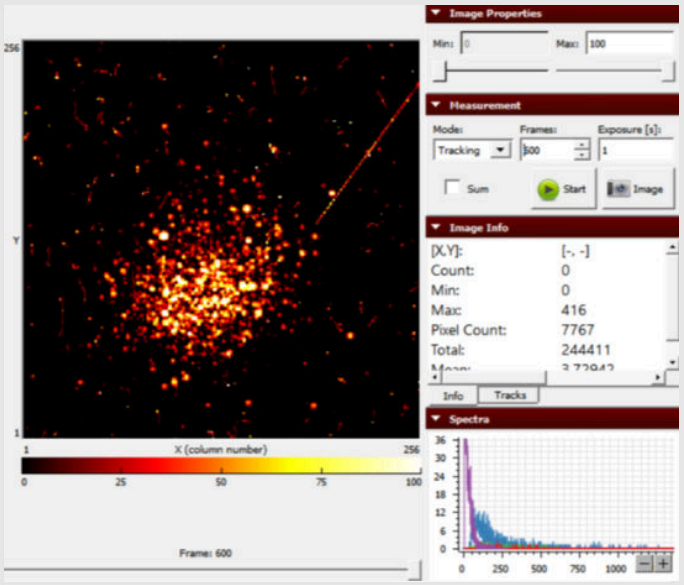
- Initially, we observe some traces of alpha particle blobs. The muon (a long streak) observed is not because of aluminum foil but is a rare observation which we may have in any experiment we perform. Basically, it is part of background radiation.
- The blobs of alpha particles disappear when two layers of foil are used.



Evaluation (2/3)

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The mean linear range (R) of alpha particles in the air can be calculated using the following equation:

$$R_{air} \approx 0.31[E_k]^{3/2} = 0.31 \times 4.2^{1.5} = 2.67\ cm$$

where E_k is the kinetic energy of alpha particles in MeV. From the previous experiments, we know that the energy of alpha particles is approximately 4.2 MeV when the source and cameras are placed as close as possible. Thus, considering the E_k to be 4.2 MeV, we will calculate the mean linear range of alpha particles in aluminum (Z=13) using the following formula:

$$R_{material}(cm) \approx \frac{0.56 R_{air} \sqrt[3]{Z}}{\rho(kg/m^3)} = \frac{0.56 \times 2.67 \times \sqrt[3]{13}}{2700} = 13.02\ \mu m$$

where Z is the atomic number and ρ is the density of the substance blocking material (ρAl = 2700 kg/m3).

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Evaluation (3/3)

- Since the alpha particle was able to go through a single layer of foil, that means the foil is thinner than 13.02 µm (Fun f*act: Human hair diameter is ≈ 70 µm*).
- But, two layers of foil were able to block the alpha particles, which means that the foil is thicker than 6.5 µm. Thus we can conclude that the thickness is within the range of 6.5 µm to 13.02 µm.

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