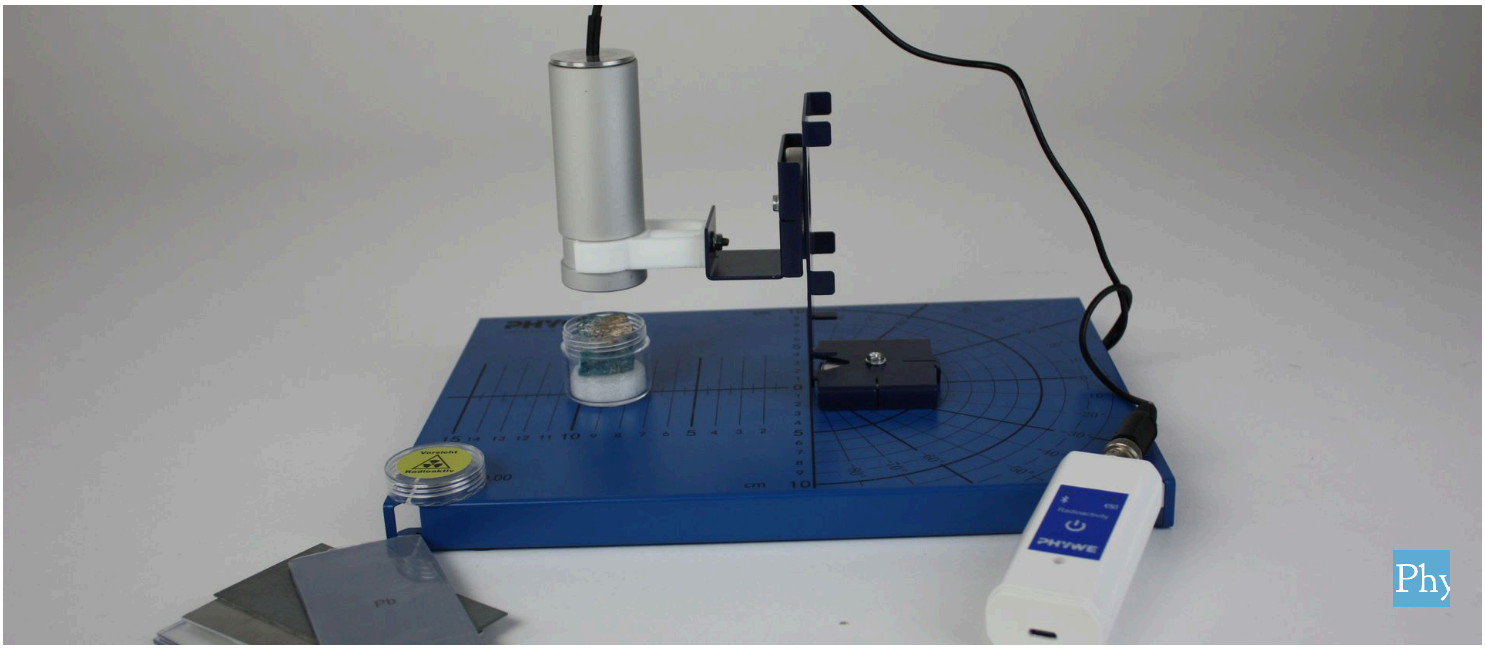
Shielding of beta radiation with Cobra SMARTsense



Physics | Modern Physics | Radioactivity

Difficulty level	Group size	Preparation time	Execution time
medium	2	10 minutes	10 minutes

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Teacher information

Application

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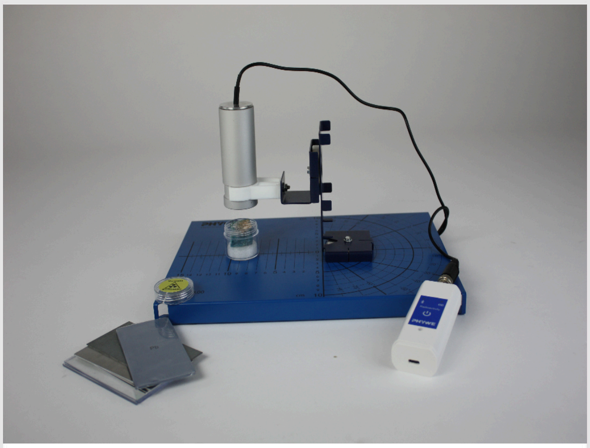

Experimental setup for shielding of radioactive radiation

Since the energy values of the β rays are continuously distributed in the range from 0 to a maximum value, the dependence of radiation intensity and material thickness can only be described approximately by the exponential law

$$I(d) = I_0 e^{-\mu \cdot d}$$

, where μ is the attenuation coefficient and d is the material thickness.

For the practical handling of ionizing radiation, the term half-value thickness x1/2 is used, and its value can be read from the graphic representation of the dependence of the counting rate and material thickness.

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Other teacher information (1/2)

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Prior knowledge

As previous knowledge, the students should have mastered terms such as counting rate, zero rate and the use of the Geiger-Müller counter. Furthermore, the students should be aware that radioactivity is a natural process and that it is a statistically fluctuating process. Furthermore, the different types of radiation should be known.

Scientific principle

The shielding of the beta rays is investigated with the help of different materials such as aluminium, plexiglass. The material thickness is also varied to determine the half-value thickness x1/2.

Other teacher information (2/2)

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Learning objective

Students recognize the influence of the material and the material thickness to shield beta rays.

Tasks

The students investigate the influence of different materials such as aluminium, Plexiglas, index cards and their material thickness on the shielding of beta rays.

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Safety Instructions (1/2)

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- In the preparatory lessons, the students can be encouraged to prepare strips of 50 mm - 100 mm in size from various materials for the examination. Card index cards, projection foils and aluminium foils are well suited for this.
- Projection foils are particularly suitable for this test because their low material thickness in the range up to half thickness x1/2 allows several measurements to be taken.
- The material thickness can also be approximately determined without the use of calipers or micrometers if a sufficiently large number of these films are combined.

Safety instructions (2/2)

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- If there is not enough time for the experiments, it is of course possible to do without repeating the measurements and averaging, at the expense of accuracy. Furthermore, the number of measurements can be reduced by combining several shielding plates.
- The general instructions for safe experimentation in science lessons apply to this experiment.

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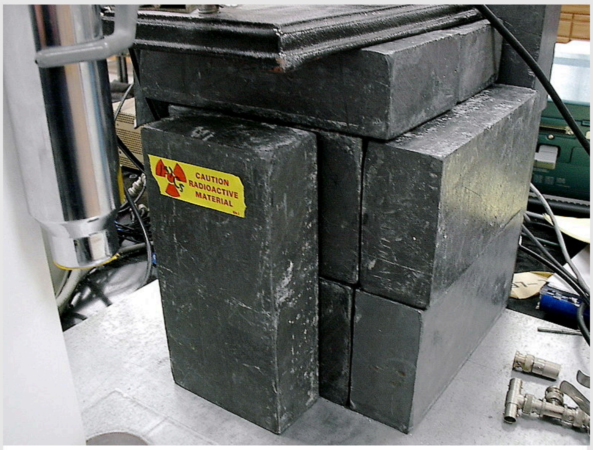
Student Information

Motivation



Radioactive material shielded by lead

If you think of range and shielding of radioactive radiation, as well as radiation protection, thick protective layers of concrete or lead quickly come to mind. But which materials are suitable for shielding against beta rays and how does their thickness affect the radiation?

Investigate the strength of different materials needed to reduce the intensity of beta rays from a radioactive source by half.

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Tasks

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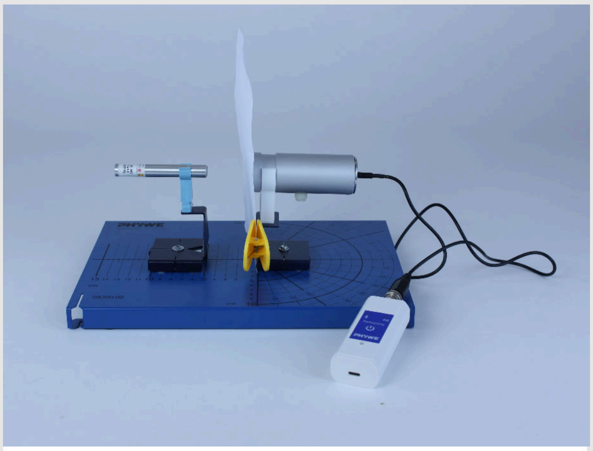

Experimental set-up with a sheet of paper in the beam path

- Record the pulse rate of a α emitter for different ranges first in the air and then with a sheet of paper in the beam path
- Compare the measurement series and conclude on the range of α particles.
- Explain what determines the range in the air.

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Equipment

Position	Material	Item No.	Quantity
1	Cobra SMARTsense- Radioactivity (Bluetooth + USB)	12937-01	1
2	Base plate for radioactivity	09200-00	1
3	Holder for SMARTsense counter tube on holding magnet	09207-00	1
4	Plate holder on fixing magnet	09203-00	1
5	Absorption material f.student exp	09014-03	1
6	Columbite, natural mineral	08464-01	1
7	measureAPP - the free measurement software for all devices and operating systems	14581-61	1

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Set-up (1/3)

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The Cobra SMARTsense and measureAPP are required to measure radioactivity. The app can be downloaded free of charge from the App Store - QR codes see below. Check whether Bluetooth is activated on your device (tablet, smartphone).

iOS

Android

Windows

Set-up (2/3)

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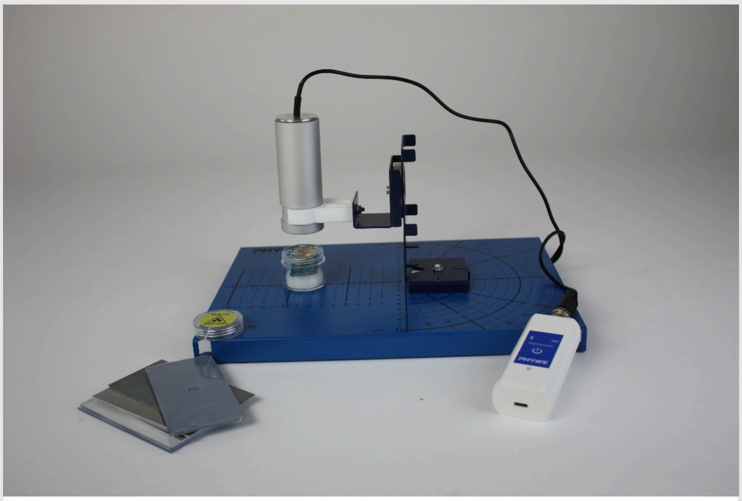

Complete test setup with radioactive sample

- Place the plate holder on the mounting plate.
- Clamp the Geiger-Müller counter tube into the counter tube holder, place it on the plate holder so that it is vertically above the mounting plate.

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Set-up (3/3)

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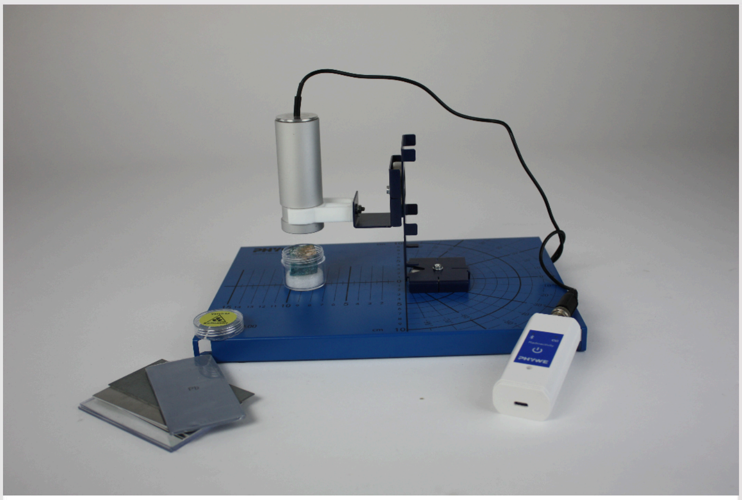

Complete test setup with radioactive sample

- Connect the Geiger-Müller counter tube to the sensor unit.
- Connect the sensor to the PHYWE Measure app on the tablet by pressing the Bluetooth button for 3 seconds. Then the radioactivity sensor can be selected in the app.

Procedure (1/2)

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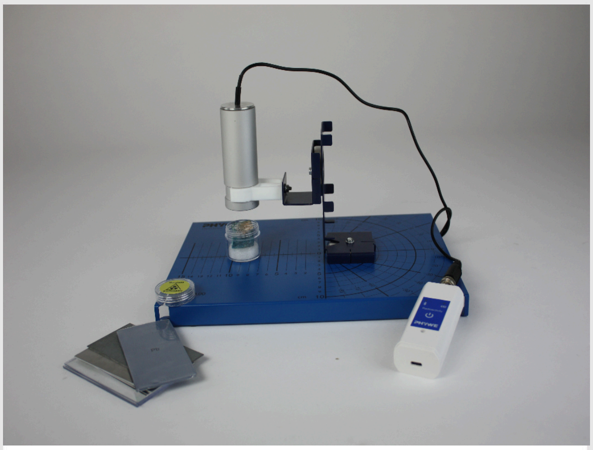

Test setup without absorber material in the beam path

- First determine the zero rate. To do this, read three measured values without the sample and enter them in the table in the protocol.
- To examine the sample, push the columbit sample under the Geiger-Müller counter tube. Push the counting tube down until the distance to the columbit sample is about 1 cm.
- Record three measured values and note them in the table in the protocol.

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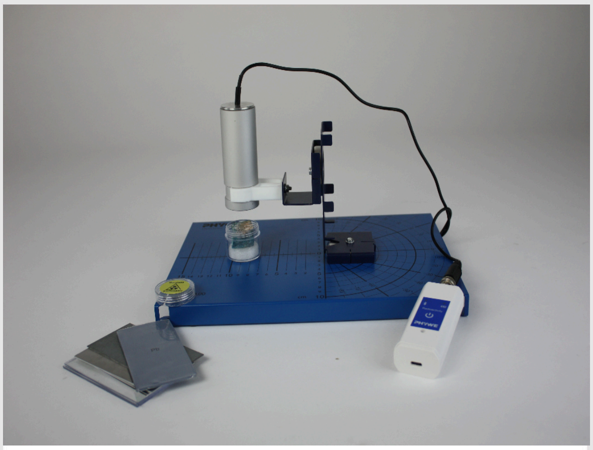
Procedure (2/2)



Test setup without absorber material in the beam path

- Cover the columbit probe with an aluminium plate and record the pulse rate three times. (Figure 3) Repeat this measurement with several aluminum plates and note the measured values in the table in the protocol.
- Carry out the same series of experiments with the Plexiglas plates and index cards. Note the results in the table as well.

Report

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Monitoring

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Note the measured values for aluminium. Calculate the mean value and the difference of the mean value to the zero rate.

Measurement	Zero	0	1	2	3	4	Plates
1							Imp/min
2							Imp/min
3							Imp/min
Average							Imp/min
Difference							Imp/min
Thickness							cm

Monitoring

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Note the measured values for Plexiglas. Calculate the mean value and the difference of the mean value to the zero rate.

Measurement	Zero	0	1	2	3	4	Plates
1							Imp/min
2							Imp/min
3							Imp/min
Average							Imp/min
Difference							Imp/min
Thickne:							cm

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Monitoring

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Note the measured values for paper. Calculate the mean value and the difference of the mean value to the zero rate.

Measurement	Zero	0	1	2	3	4	Plates
1							Imp/min
2							Imp/min
3							Imp/min
Average							Imp/min
Difference							Imp/min
Thickne:							cm

Monitoring

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1. calculate the ratio of the differences to the thickness of the absorber materials used

	Aluminium			Plexiglas		
Number of plates	Thickness	Difference Imp/min	ratio	Thickness	Difference Imp/min	ratio
0						
1						
2						
3						
4						

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Task 1

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1. calculate the ratio of the differences to the thickness of the absorber materials used

Number of plates	Thickness	Difference Imp/min	ratio
0			
1			
2			
3			
4			

2. what law can be read from the ratio of the thickness D and the difference Z?

$$Z = Z_0 \cdot e^{-\mu \cdot D}$$

$$Z = \mu Z_0 \cdot D$$

$$Z = Z_0 / D$$

Slide	Score / Total
Slide 21: Regularity: thickness and pulse rate	0/1

Total amount 0/1

Solutions Repeat Exporting text

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