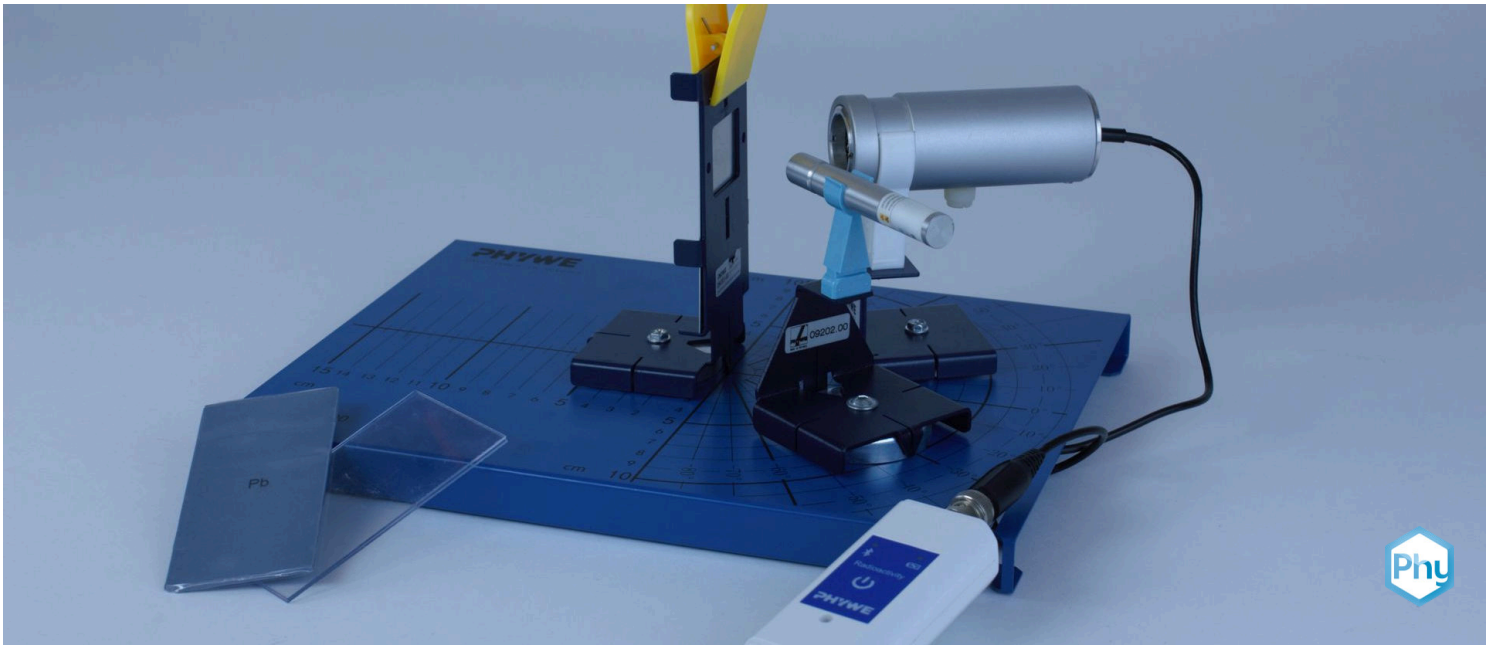
The back-scattering of beta radiation with Cobra SMARTsense



Physics > Modern Physics > Radioactivity

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

This content can also be found online at:

http://localhost:1337/c/5f4c2d467b2768000356b898

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Teacher information

Application

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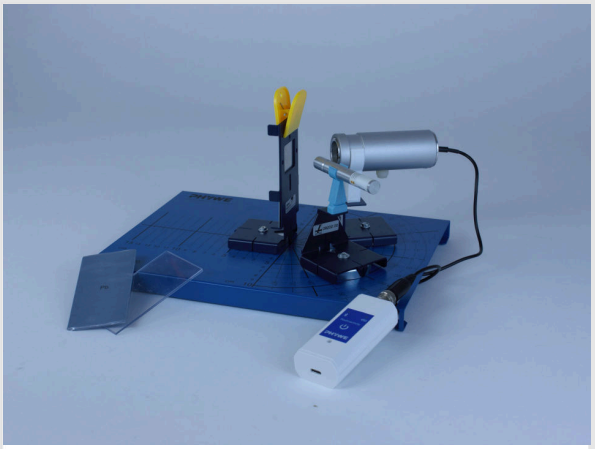

Test setup for backscattering

β particles are deflected as a result of their charge when they interact with the electric fields of the atomic shell or nucleus of the substance being irradiated. Backscattering occurs if the scattering angle is greater than 90°.

The backscatter rate depends mainly on the nuclear charge number Z of the backscattered material. On atoms with a high nuclear charge number, scattering occurs at larger scattering angles and with less energy loss. The backscattering factor R is approximately proportional to the root of the atomic number Z.

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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, scatter and the use of the Geiger-Müller counter. In addition, the different types of radiation and their properties should be known. To interpret the experiment, the structure of different materials should be known (particle model).

Scientific principle

The intensity of the backscattering of β rays is investigated as a function of different materials.

Other teacher information (2/2)

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Learning objective

With the help of the experiment, the students determine the dependence of the intensity of the backscattering on the material used.

Tasks

The students investigate the backscattering of beta rays by detecting the scattering rate on different materials using the Geiger-Müller counter tube.

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Safety Instructions (1/2)

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- Since even small changes in distance in this experiment lead to considerable changes in the count rates, care should be taken to ensure that the counter tube, the radiation source and the plate holder are not moved when changing the backscatter plates.
- In order to limit the influence of the radiation that hits the counter tube directly from the radiation source, even without shielding measures, it is recommended that the angle of incidence and reflection is not greater than 40° and that the distance to the backscatter plates is about 2 cm.
- The protective lacquer layer on the lead plate already leads to a slight reduction of the backscatter rate by absorption.

Safety instructions (2/2)

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- The activity of the radiation source used is quite low at 3 kBq, but the source should only be removed from the storage container for the duration of the experiment.
- The generally applicable rules for handling radioactive preparations according to the Radiation Protection Ordinance must be observed.
- The general instructions for safe experimentation in science lessons apply to this experiment.

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Student Information

Motivation

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An alarm clock with in the dark luminous dial

Radium is a radioactive element that emits α and β radiation. It was discovered in the early 1900s and mixed with paint to create luminous dials for clocks or aircraft cockpits that glow in the dark. In 1925, a group of painters who worked with the paint complained that working with radium was harmful to their health. But are all wearers of a watch with radium paint on the dial at risk?

To use radioactive elements it is important to know how the radiation can be shielded. In this experiment we investigate which materials β scatter back radiation and for which the intensity of the backscattered radiation is highest.

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Tasks

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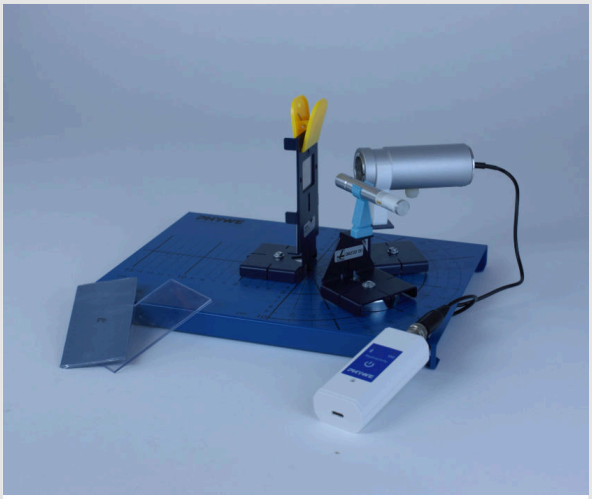

Test setup with different absorption materials

- Record the backscatter rates of β radiation on various materials using a Geiger-Müller detector.
- Explain the backscatter rates of the different materials.
- Explain the physical process of backscattering.

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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	Source holder on fixing magnet	09202-00	1
5	Plate holder on fixing magnet	09203-00	1
6	Absorption material f.student exp	09014-03	1
7	Radioactive source Ra-226, max. 4 kBq	09041-00	1
8	measureAPP - the free measurement software for all devices and operating systems	14581-61	1

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Structure (1/4)

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For measurement with the **Cobra SMARTsense sensors** the **PHYWE measureAPP** is required. The app can be downloaded free of charge from the relevant app store (see below for QR codes). Before starting the app, please check that on your device (smartphone, tablet, desktop PC) **Bluetooth** is **activated**.

iOS

Android

Windows

Set-up (2/4)

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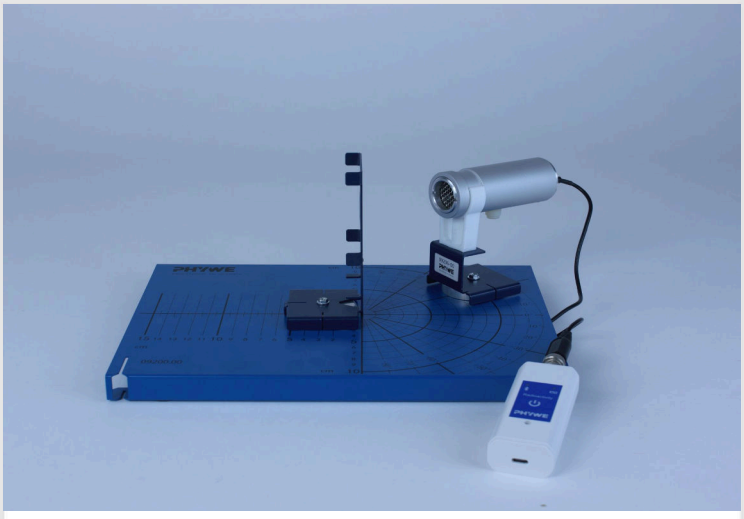

Mounting the Geiger-Müller counter tube

- Place the plate holder on the zero mark of the mounting plate.
- Clamp the Geiger-Müller counter tube into the counter tube holder, place it on the 30° angle division of the mounting plate, push it up to about 2 cm from the plate holder.

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Set-up (3/4)

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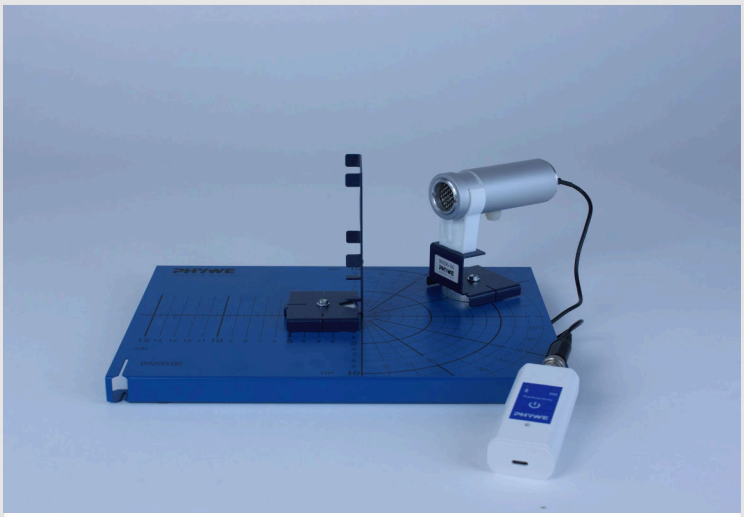

Connection of the Geiger-Müller counter tube to the sensor

- Connect the sensor to the PHYWE Measure App by pressing the Bluetooth button for 3 seconds. Then the radioactivity sensor can be selected in the App.
- First note three measured values for the zero rate in the table (slide 17).

Set-up (4/4)

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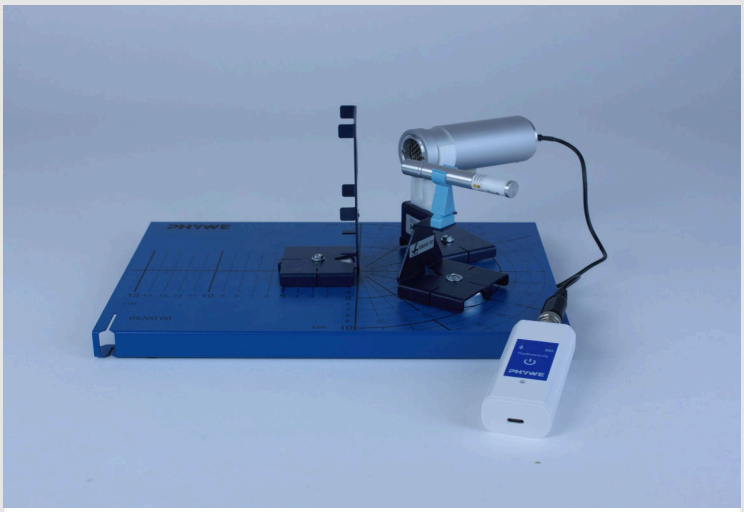

Mounting the sample

- Clamp the specimen in the specimen holder.
- Place the specimen holder on the mounting surface, place it on the 30° angle of the mounting plate, slide it to about 2 cm from the plate holder.

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Procedure (1/2)

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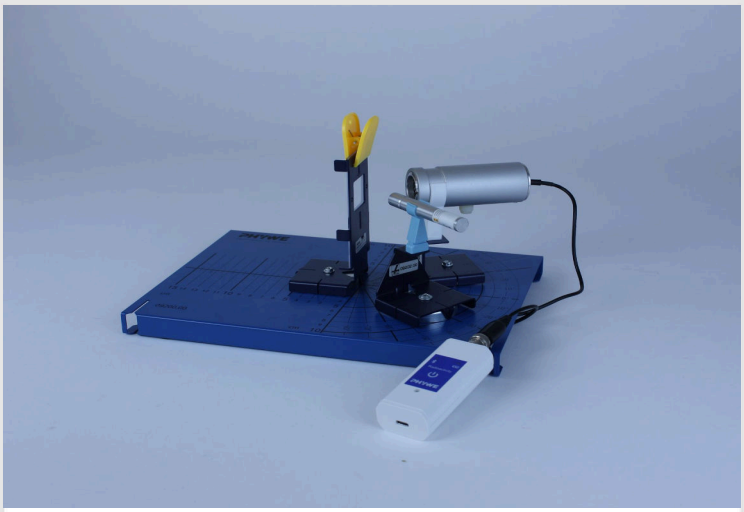

Test setup for shielding

- Slide the plexiglass disk into the plate holder, making sure that the distance between the plate holder, radiation source and counter tube does not change.
- Determine three measured values for backscatter rate and note them in the table (slide 17).

Procedure (2/2)

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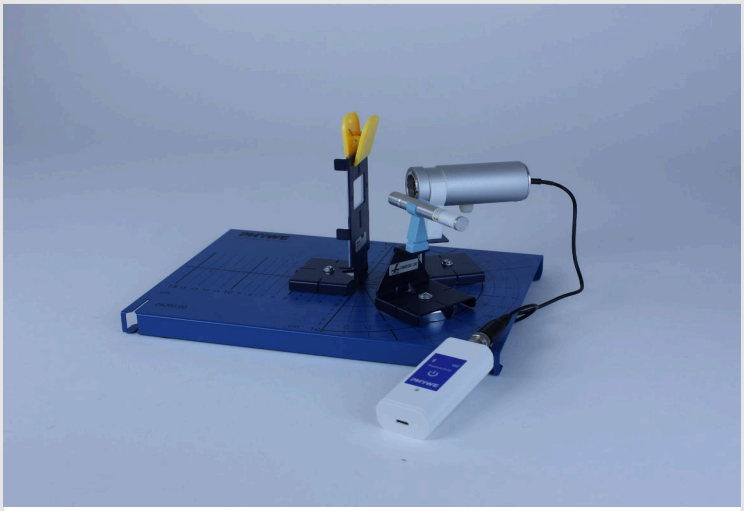

Dependence on the absorption material

- Repeat the measurement with different absorption materials and note the measured values in the table (slide 17).
- After finishing the series of measurements put the radiation source back into the storage container.

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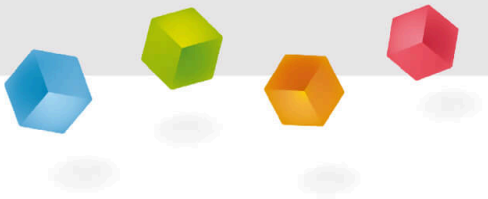

Report

Monitoring

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Note the measured values for the zero rate and the different sample materials. Then determine the mean value as well as the difference between the mean values and the zero rate.

Measure	Z_0	$Z_{Plexi.}$	$Z_{Alum.}$	Z_{Iron}	Z_{lead}	in imp/min
1						
2						
3						
Average						
Difference						

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Task 1

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1. compare the results. For which material is the backscatter rate the highest? Sort the materials from the highest to the lowest rate.

1. _____ 2. _____ 3. _____ 4. _____

aluminum | lead | iron | plexiglass

Check

2. compare the materials sorted by rate with the densities in from the table Find possible causes for the backscatter. Then edit the gap text on the following slide.

Equipment	Density
Plexiglas	$1.18 g/cm^3$
Aluminium	$2.7 g/cm^3$
Iron	$7,874 g/cm^3$
Lead	$11.34 g/cm^3$

Density of the tested materials

Task 2

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Edit the cloze text by dragging the words into the correct gaps.

A material emitting β radiation emits _____. Thus it concerns a _____. Since electrons and positrons have _____ they can interact with the _____ of the atoms in the scattering material. The higher the _____ of the material, the more protons it contains in its nuclei. Therefore, materials with low atomic numbers have _____ backscattering, whereas the backscattering rate for materials with high atomic numbers is _____.

low | electrical charge | higher | electrical field | particle radiation | electrons or positrons | order number

Check

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Slide	Score / Total
Slide 19: Listing of the materials used according to backscatter rates	0/4
Slide 20: Physical principle behind the scattering	0/7

Total amount 0 / 11

Solutions | Repeat | Exporting text

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