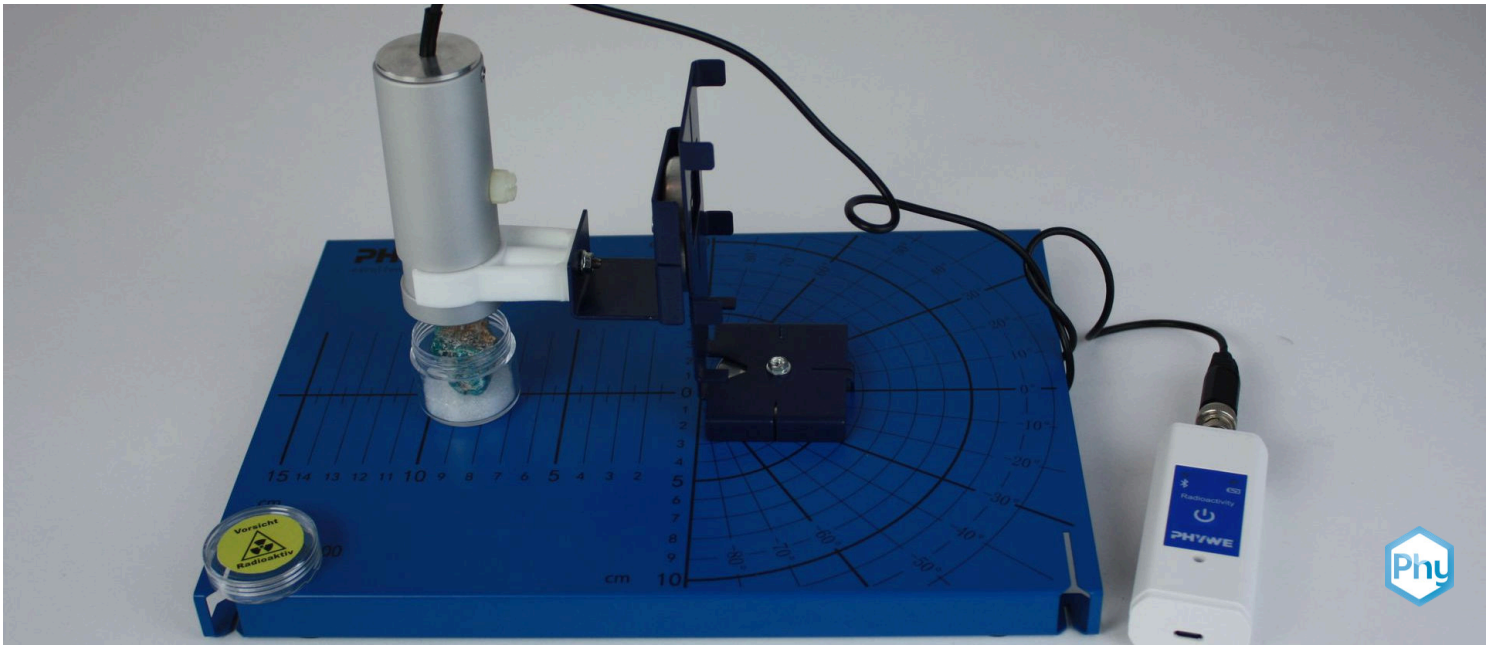
Statistical fluctuations in the count rates with Cobra SMARTsense



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/5f4bda587b2768000356b6bb

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Teacher information

Application

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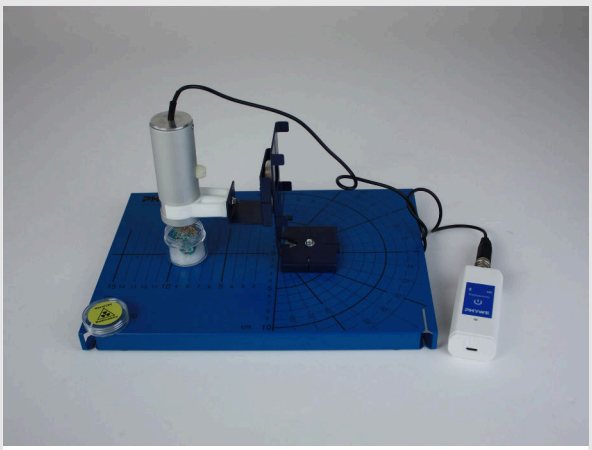

Measurement of the activity of a radioactive sample

Observations of radioactive processes are particularly suitable for familiarising pupils with the particularities of statistically fluctuating processes. The statistical character of the decay processes can be clearly recognized already by the acoustic proof of the pulses of the counter.

The fluctuations of the count rates registered under the same conditions lead to the question of the "correct" measured value. The evaluation of the measurement results can be limited to the observation of the fluctuations in the measured value, the calculation of the mean value and the determination of the statistical error and the maximum deviation from the mean value, or, by dividing the counting rate into intervals, introduce the student to the approach of statistics.

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Other teacher information (1/2)

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Prior knowledge

As previous knowledge, students should be familiar with and able to calculate basic stochastic concepts such as mean value and statistical errors.

Scientific principle

With the help of the Geiger-Müller counter tube, the number of pulses of the columbit sample is to be measured and then the statistical fluctuation and relative error calculated.

Other teacher information (2/2)

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Learning objective

The special features of radioactivity are the statistically fluctuating processes. These should be made clear to the students in the experiment. Furthermore, the students should gain the insight that the relative statistical error of the individual measurement is smaller the more impulses are registered by the Geiger-Müller counter tube.

Tasks

The students investigate the fluctuations in the registered count rates of the Geiger-Müller counter tube.

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Safety instructions

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- The columbit sample remains in the container without lid during the measurement, because this makes it easier to bring the sample into the desired position.
- In order to understand the relationship between the number of pulses and the pulse rate, the students should first determine the number of pulses and then calculate the pulse rate. Alternatively, the pulse rate can also be determined. For this purpose, it is recommended to set the measuring range to pulses per minute and the gate time to 10 s. The displayed value is the pulse rate per minute extrapolated from a 10 second measurement.
- The general instructions for safe experimentation in science lessons apply to this experiment.

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Student Information

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Motivation

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Geiger-Müller detector with visual display and acoustic signal

If radioactive processes are observed, it is noticeable that the individual measured values fluctuate statistically. This is already clearly recognizable by the acoustic proof of the pulses of the counter tube.

Investigate how large the fluctuations in the count rates registered by a Geiger-Müller counter are.

Tasks

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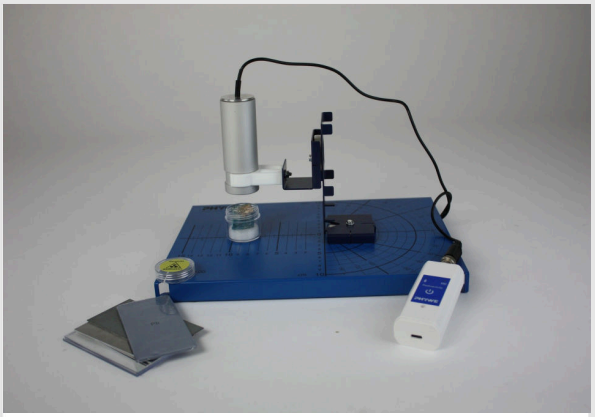

Test setup with different absorption materials

- Measure and record the pulse rates of a radioactive sample
- Calculate the mean value and statistical error of the measured values and investigate the stochastic nature of the test results

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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	Columbite, natural mineral	08464-01	1
6	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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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 (2/3)

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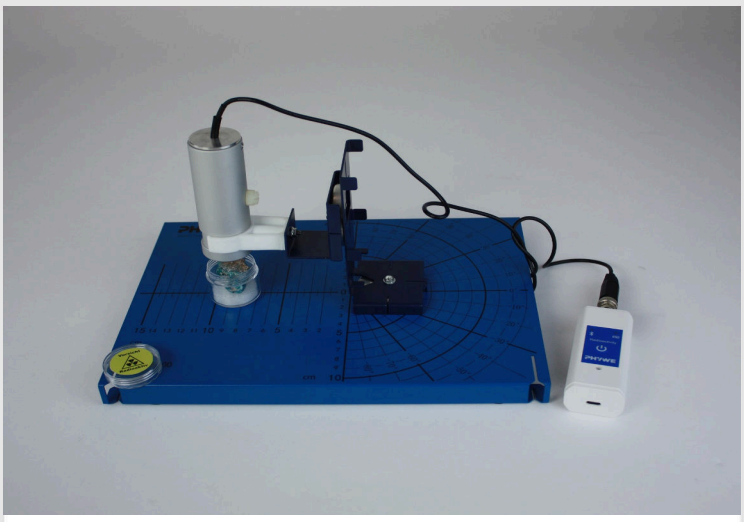

Experimental set-up with one sample of salt

- 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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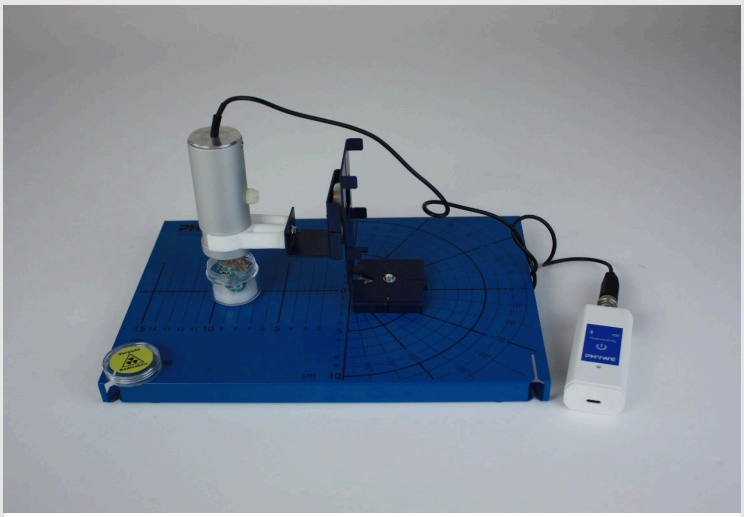

Experimental set-up with one sample

- Connect the Geiger-Müller counter tube to the sensor unit.
- Place the container with the columbit sample under the counter tube. Carefully move the Geiger-Müller counting tube so that the distance between the counting tube and radioactive sources is about 1 cm.

Procedure (1/2)

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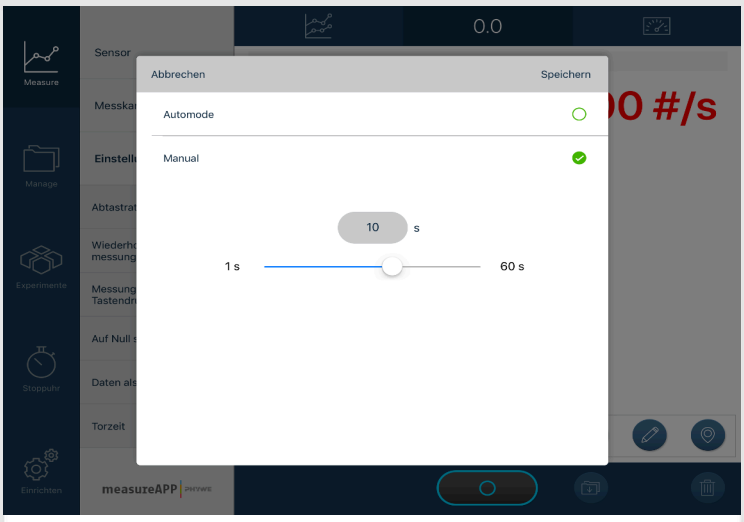

Setting the gate time for a single measurement

- 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.
- To set the gate time, go to Settings, then Gate time and move the controller to 10 s.

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Procedure (2/2)

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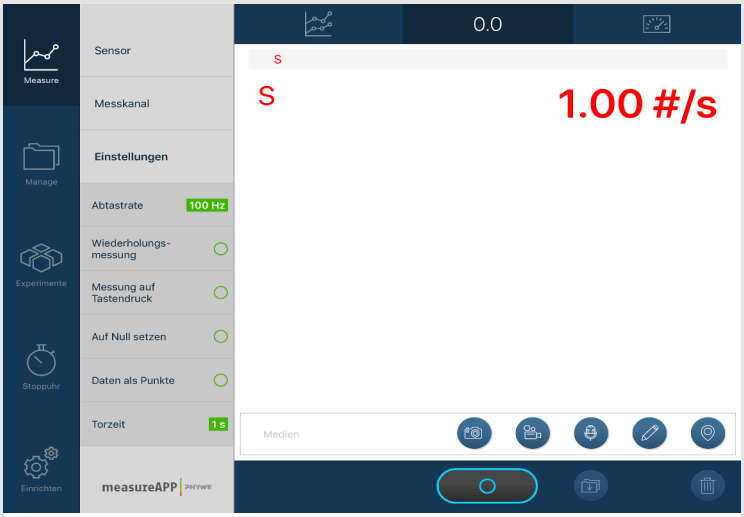

Measuring the pulse rate of a salt sample

- Acquire measured values over a period of 500 s. Every ten seconds, note the new measured value in Table 2 in the protocol.

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Report

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Monitoring

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Note the measured values in the table.

Measurem.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Z_0 in Imp/10s																	

Measurem	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Z_0 in Imp/10s																	

Measurem	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Z_0 in Imp/10s.																

Task 1

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1. calculate the average value of all 50 measured values

The average value is Imp/10s.

2. calculate the mean statistical error of the measured values

The mean statistical error s is

Imp/10s.

3. which value deviates most from the mean value?

Measurement with Imp/10s

Mean value:

$$\bar{Z} = \frac{\sum_{i=1}^{n} Z_i}{n}$$

statistical error:

$$s = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(\bar{Z} - Z_i)^2}$$

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Task 2

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1. divide the range of measured values into seven sub-ranges of equal size Determine how many measured values belong in each subrange and enter the results in the table. Also determine the percentage share of the measured values in the total number.

Subarea	1	2	3	4	5	6	7	
range of... to...								Imp /min
Number of measured								
Percentage share								

Solutions | Repeat | Exporting text

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