The radioactive elements Uranium, Thorium and their by-products are found in a lot of minerals like pitchblende, monazite sand or columbite in relatively high concentrations. The radioactivity of these materials, which can be proved externally, is very low because of the self-absorption in the material. The results acquired with the help of a Geiger-Müller counter must also be interpreted with great care, since the sensitivity of the counter for γ-radiation is very low and the α- and β-rays from the interior of the samples are absorbed by the upper layers. Essentially therefore, only the surface activity is registered.
The columbite sample is mixed with different stone samples brought by the students and is to be detected as "radioactive substance" through the experiment. If the knowledge of the penetration properties of the 3 types of radiation is already available, the type of radiation contained can be explained in another experiment.

Equipment

Support clamp for small case	02043.10	1
Clamp on holder	02164.00	1
Support rod, stainless steel	02030.00	1
Counter tube holder on fix. magnet	09201.00	1
Support plate on fixing magnet	02155.00	1
Counter tube Type B	09005.00	1
Geiger-Müller-Counter	13606.99	1
Demo-Board for Physics with stand	02150.00	1
Absorption material, for student experiments	09014.03	1
Colombite, low radioactive mineral	08464.01	1

Set-up and procedure

Fig. 1

— Keep the first stone sample on the support plate on the demo board.

Fig. 1: Experimental setup

— Fix the counter tube vertically in the holder, remove the protective cap and move it near the sample upto a distance of 1-2 cm.
— Select a measurement time of 60 s and make at least 3 measurements. Enter the values in Table 1.
— Each time when changing the stone sample, move the counter tube up and restore the original distance only after placing the new sample.
— After investigating all the stone samples, determine the zero rate three times with the same measurement time and note the readings.
— After concluding the experiment place the protective cap back on the counter tube.

Result

Table 1

No. of stone samples	Z_1 Imp/60s	Z_2 Imp/60s	Z_3 Imp/60s	$\overline{Z}$ Imp/60s
1	18	21	17	19
2	22	16	17	18
3	145	138	125	136
4	23	20	17	20
Zero rate	18	15	21	18

Evaluation

The mean value $\overline{Z}$ is determined for each stone sample. In this experiment, radioactivity was registered only for the columbite sample 3, while the impulse rates determined for all other samples were within the statistical error of the zero rate.

The impulse rate generated by the columbite sample was about 6-times the zero rate.

Additional experiment.

Studying the type of radiation emitted by the columbite sample:

— Place the columbite sample in an open container on the support plate, remove the protective cap from the counter tube and move it near the columbite sample upto a distance of 1 cm.
— Select a measurement time of 100 s and determine the impulse rate three times; Enter the values in Table 2.
— Insert a piece of paper and then an aluminium-sheet with a thickness of 5 mm between the columbite sample and the counter tube and determine the counting rate three times; Enter these values also in Table 2.

Result

Table 2

	Z_1 Imp/100s	Z_2 Imp/100s	Z_3 Imp/100s	$\overline{Z}$ Imp/100s
Columbite sample				
No insertion	289	271	262	274
with paper insertion	239	255	246	245
with Pb-insertion	87	98	85	90

Evaluation

The inserted piece of paper does not cause any noteworthy reduction in the impulse rate. Hence, the columbite sample does not emit any α-particles or else a number of α-particles that cannot be demonstrated with the help of this experiment. The Al-sheet strongly reduces the impulse rate. The cause for this reduction is the β-radiation, which is completely absorbed by the Al-sheet.

Only a very small portion of the γ-radiation is allowed to pass through the Al-sheet.