Absorption of β-rays

β-rays arise during the conversion of a neutron into a proton in the radioactive nuclei having a relative excess of neutrons. The energy of the β-particles emitted in this type of nuclear conversion is distributed constantly between a maximum value and the zero value. While passing through matter the β-particles release their energy through scattering processes whereby their intensity and also the energetic composition of the β-ray changes in favor of the more energetic particles.
Materials with a lower atomic number are preferably used for absorbing the β-rays, in order to avoid the generation of X-rays during the deacceleration of electrons.

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
Source holder on fixing magnet	09202.00	1
Plate holder on fix. magnet	09204.00	1
Counter tube Type B	09005.00	1
Geiger-Müller-Counter	13606.99	1
Absorption material, Student exp.	09014.03	1
Demo board for Physics with stand	02150.00	1
Radioactive sources, set	09047.50	1

Set-up

Fig.1

— Set the plate holder, source holder with the radiation source Sr-90 and counter-tube holder with the counter tube without the protective cap as shown in Fig.1 on the demo board.

— Select the measurement time “Auto/10 s”

Procedure

1. *Experiment: Comparison of the absorption properties of different materials:*

— First determine the counting rate thrice without the insulation material and enter the values in Table 1.

— Now fix 1 mm absorption plates made of different materials, in the plate holder, determine and note down the count rate three times.

Fig. 1: Experimental setup

2. *Experiment: Dependence of the radiation intensity on the thickness of the absorption plates:*
— Fix aluminum plates having the thicknesses specified in Table 2 in the plate holder and determine the count rate three times for each plate thickness.

Result
Table 1

	$\frac{Z}{\text{Imp/10s}}$				
Material	without	Plexiglas	Al	Steel	Lead
Z_1	2600	1625	690	14	11
Z_2	2527	1668	727	17	9
Z_3	2534	1607	631	14	5
$\overline{Z}$	2569	1633	683	15	8

Table 2
Absorbermaterial: Aluminium

x/mm	$\frac{Z_1}{\text{Imp/10 s}}$	$\frac{Z_2}{\text{Imp/10 s}}$	$\frac{Z_3}{\text{Imp/10 s}}$	$\frac{\overline{Z}}{\text{Imp/10 s}}$
0	2614	2673	2634	2640
0.3	1782	1756	1777	1772
0.5	1374	1376	1379	1376
0.8	970	969	981	973
1	725	699	729	717
1.3	463	463	429	452
1.,5	335	343	314	330
1.8	228	211	208	216
2	134	125	131	130

Evaluation
The mean values of the impulse rates for the different materials as well as for the different coating thicknesses is calculated and entered in the Tables 1 and 2.

Experiment 1:
It can be seen from the mean values of the counting rates in Table 1, that the absorption ability of the material is related to its density ρ. For this reason one does not use the material thickness x for describing the absorption of β-rays, but instead the area mass $f = x \cdot \rho$, (mg/cm^2).

Instruction: Metals with a higher atomic number like iron or lead are not used for the absorption of β-rays despite their good absorption properties because of the risk of the generation of a hard X-radiation.

Experiment 2:
The mean values of the count rates are represented in a linear and simple logarithmic coordinate system in dependence on the coating thickness of the aluminum plates. (see Fig. 2 and Fig. 3)
The absorption curve of Fig. 2 permits one to presume an exponential relationship between the coating thickness and the impulse rate.
The absorption law applies to the absorption of mono-energetic radiation by an absorber having the thickness x

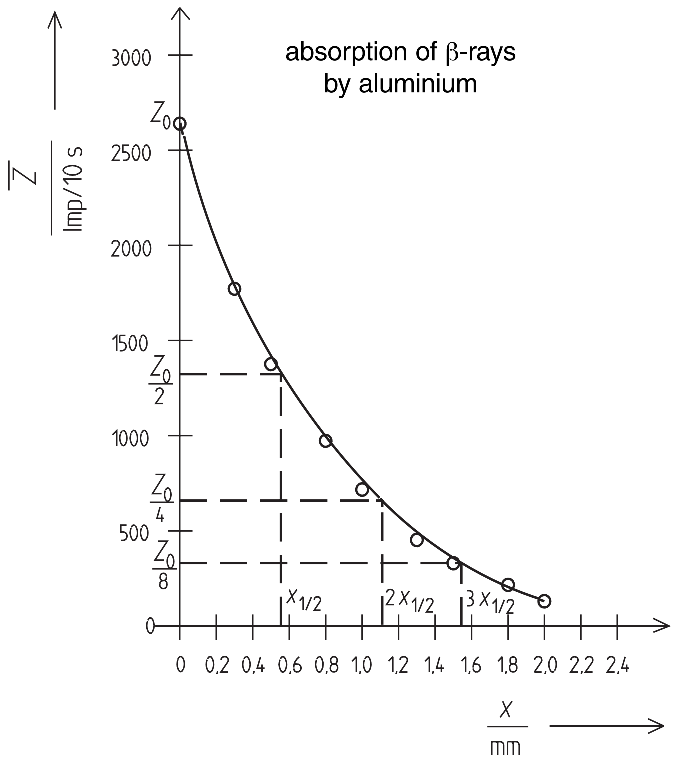
$$I(x) = I_0 \, e^{-\mu x}.$$

with
I_0 = primary intensity
$I(x)$ = intensity allowed to pass through
μ = absorption coefficient

By applying logarithms one gets:

$$\ln(I(x)) = \ln(I_0) - \mu x$$

Fig. 2



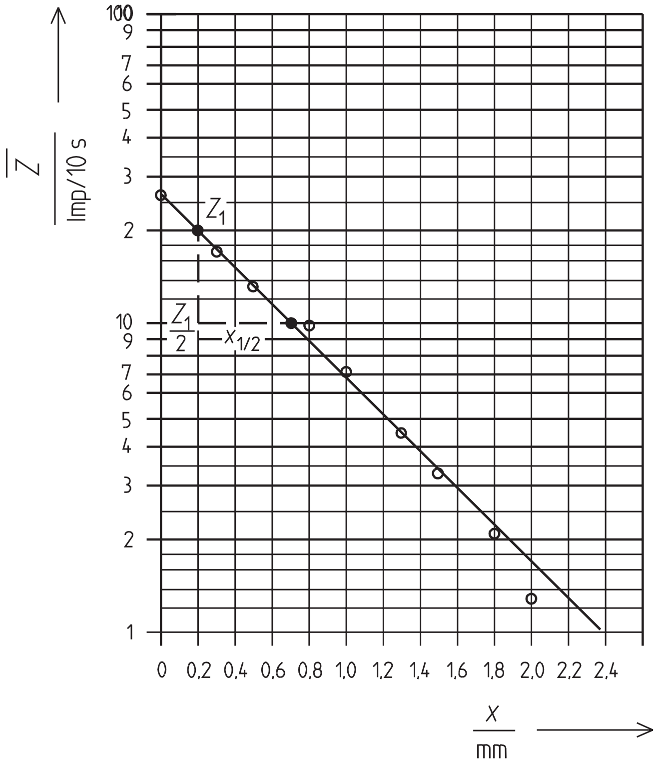


Fig. 3

This equation represents a falling line, whose negative rise is due to the absorption coefficient.

In the simple logarithmic representation of Fig. 3, the dependence of the count rate on the coating thickness of the absorbers represents a linear function.

One uses the term half-value thickness $x_{1/2}$ for practically dealing with ionized radiation. Its value can be deduced from the graphic representation of the dependence of the count rate and material thickness. One gets the value $x_{1/2}$ = 0.5 mm for aluminum from Fig. 2 and Fig. 3.

Room for notes