Experiment 12

Absorption of Gamma Radiation by Lead

Name:
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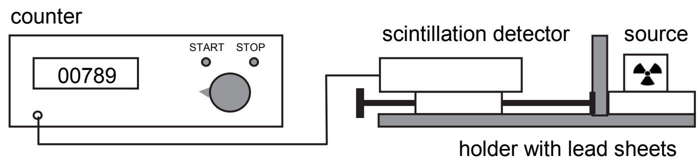
Aim

- To determine the relation between thickness of the absorbing material and intensity of the transmitted γ radiation.
- To measure the half-value thickness of lead for the γ radiation emitted by a source of cobalt-60.

Set-up

The set-up consists of a scintillation detector, a pulse counter and a source of cobalt-60 (^{60}Co). Sheets of lead of different thickness can be inserted in the set-up between the detector and the source.



Read the introduction on page 15 of the booklet *ISP Experiments* about the absorption of γ radiation in materials.

Measurements

1 Position the source in its lead container at a distance of approximately 1 m from the scintillation detector. Measure the intensity I_b of the background radiation (in pulses per 10 s) three times, and record your measurements in the table below. Calculate the average intensity $I_{b,avr}$ of the background radiation (in pulses per 10 s), and record the result in the table below.

I_b (pulses/10s)				$I_{b,avr}$ (pulses/10s)	

2 Remove the lid from the container, and insert the container (with the source) in the set-up. Clamp the lead absorption sheet with thickness d = 0.30 cm between the source and the detector. Measure the intensity I of the transmitted radiation (in pulses per 10 s) three times, and record your measurements in the table below. Calculate the average intensity I_{avr} (in pulses per 10 s) and make a correction for the background radiation: $I_{cor} = I_{avr} - I_{b,avr}$. Record the result in the table below.

3 Repeat these measurements and calculations with sheets of lead of different thickness as indicated in the table below. For the thicknesses marked with an * you need to combine two sheets.

d (cm)	I (pulses/10 s)			I_{cor}
0.3				
0.5				
0.6				
1.0				
1.2				

d (cm)	I (pulses/10 s)			I_{cor}
* 1.5				
* 1.7				
* 1.8				
* 2.2				

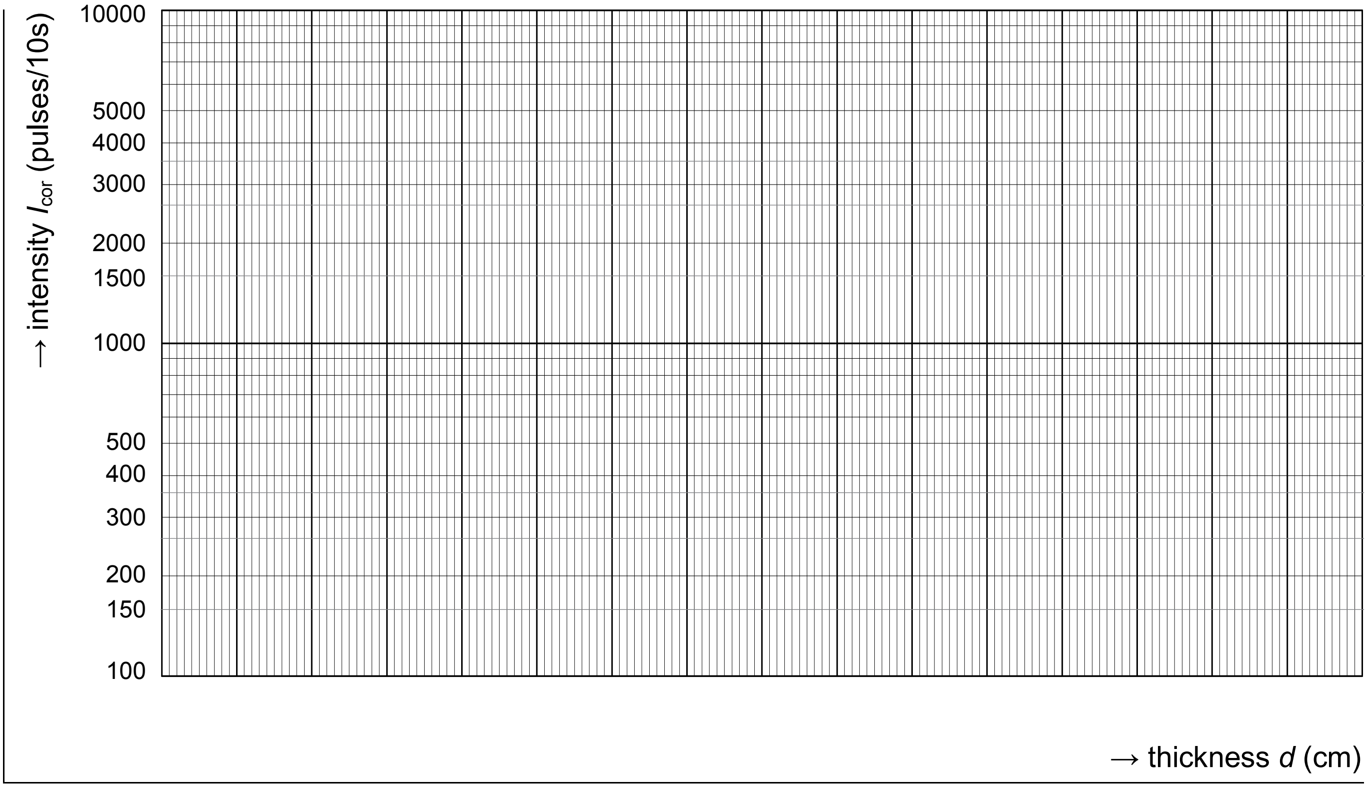
4 Take the container out of the set-up, put the lid back on, and store it at approximately 1 m distance from the scintillation detector.

Assignments

1 Plot your measurements (intensity I_{cor} as a function of thickness d) on the single logarithmic graph paper on the other side of this worksheet. See the booklet *ISP Experiments* (page 31-32) for the reasons of using single logarithmic graph paper.

2 The half-value thickness $d_{1/2}$ of a material is the thickness when the intensity of the transmitted radiation is half the intensity of the incident radiation. From the graph, determine the half-value thickness of lead for the γ radiation emitted by ^{60}Co.

Half-value thickness of lead: $d_{1/2}$ = ……… cm



3 Would a layer of material with equal thickness but lower density allow for the transmission of more or less γ radiation? Compare, for example, water and lead.

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4 The half-value thickness is inversely proportional to the density of the absorber. This means: a material with a density that is twice as large has a half-value thickness that is twice as small. Calculate the half-value thickness of water. In doing that, use the following data: the density of lead is 11.3 g/cm^3, whilst the density of water is 1.0 g/cm^3. You did determine the half-value thickness of lead in Assignment 2.

Half-value thickness of water: $d_{1/2}$ = ……… cm

5 Lead is often used for shielding γ sources. An example. A γ source of 370 MBq gives a radiation dose of 24 mSv per hour at a distance of 20 cm. One wants to shield this source so that the radiation dose falls to 1% (0.24 mSv per hour).

How many half-value thicknesses are needed here? And if lead is used for the shielding, which thickness is minimally required?

Number of half-value thicknesses: ………

Thickness of lead shielding: d = ……… cm

6 In the absence of shielding, the radiation dose can also be lowered by enlarging the distance to the source. Calculate the distance required to lower the radiation dose from 24 mSv to 0.24 mSv per hour. In doing this, use the inverse square law (see Experiment 8 and/or page 34 of the booklet *ISP Experiments*).

Distance: r = ……… m