Universiteit Utrecht

Faculty of Science
Ionising Radiation Laboratory | ISP

Experiment 11

Detection of Lead

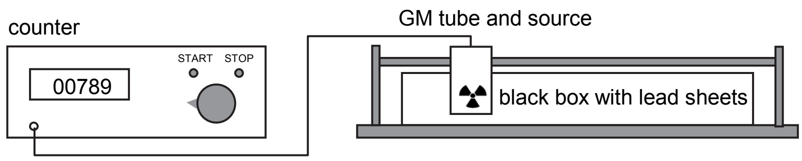
Name:
……………………………………………...

Aim

- To determine the location of several sheets of lead, hidden in a black box of plastic.
- To estimate and calculate the thickness of these sheets.

Set-up

The set-up consists of a rectangular black box of plastic, in which the sheets of lead are hidden. A Geiger-Müller tube and a source of cobalt-60 (^{60}Co) are mounted on opposite sides of a slide bar. The GM tube is connected to a pulse counter.



Read the introduction on page14 of the booklet *ISP Experiments* about the absorption of γ radiation in materials.

Measurements

1 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. While measuring the background radiation, make sure that the source is at approximately 1 m distance from the GM tube.

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

2 Position the source in the set-up (opposite of the GM tube), and put the slide on the 0-mark of the scale. Measure the intensity I of the transmitted radiation (in pulses per 10 s) twice, 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 results in the table below.

3 Repeat these measurements and calculations for the other locations as indicated in the table.

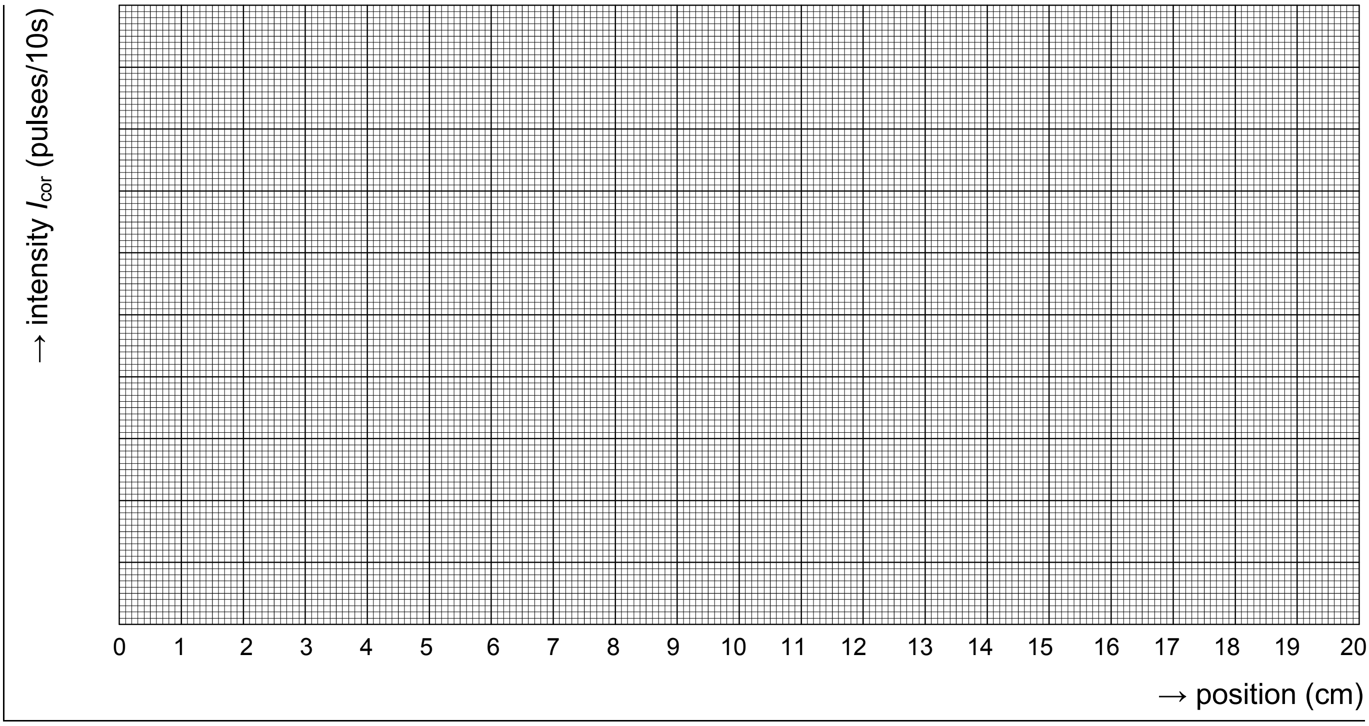
position (cm)	I (pulses/10 s)		I_{avr}	I_{cor}
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

position (cm)	I (pulses/10 s)		I_{avr}	I_{cor}
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

4 Put the source back in its container and store it at a distance of 1 m from the GM tube.

Assignments

1 Display the data from the table (I_{cor}) in the form of points in the graph below.



2 In the graph, draw the following lines (using a different colour):

- a horizontal line for the intensity I_0 of the incident radiation. So: a line giving the average intensity at those positions where no sheet of lead is present.
- a horizontal line for the intensity I_d of the transmitted radiation if the thickness of the absorbing material equals its half-value thickness $d_{1/2}$. So: $I_d = ½·I_0$.
- two horizontal lines giving the average intensity of the transmitted radiation at those positions where the sheets of lead are located.

Use the graph and the known half-value thickness of lead (1.2 cm) to estimate the thickness of the two hidden sheets of lead.

Lead sheet 1: *d* = ……… cm

Lead sheet 2: *d* = ……… cm

The absorption of γ radiation in a material follows the following rule: the larger the thickness of the absorbing material is, the smaller is the intensity of the transmitted radiation. In a formula:

$$I_d = I_0 \cdot \left(\tfrac{1}{2}\right)^{d/d_{1/2}}$$

In this formula, I_d is the intensity of the transmitted radiation, I_0 is the intensity of the incident radiation, d is the thickness of the absorber, and $d_{1/2}$ is the half-value thickness of the absorber (the thickness when the intensity of the transmitted radiation is half the intensity of the incident radiation). The half-value thickness of lead is 1.2 cm.

3 Use the formula to calculate the thickness of the two hidden sheets of lead, and check whether your estimates in Assignment 2 are correct. Note: If necessary, use the intersect function of the graphic calculator.

Lead sheet 1: *d* = ……… cm

Lead sheet 2: *d* = ……… cm

4 Lead is often used for shielding γ sources. An example. At a distance of 1 m from a radioactive source the radiation dose is 2.56 mSv per hour. After shielding the source with lead ($d_{1/2}$ = 1.2 cm) this has decreased to 0.32 mSv per hour. Calculate the thickness of the lead shield.

Lead shield: *d* = ……… cm