Experiment 12

Absorption of Gamma Radiation by Lead

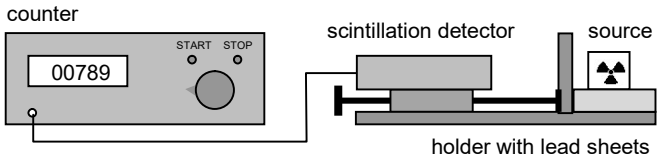
First read the introduction at experiment in the booklet ISP Experiments about absorption of γ radiation by materials.

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). The counter can be set to an automatic measuring time of 10 s or to 'continuous'. In the latter case, after starting the counter will continue counting until the stop button is pressed. For measuring time, then use a stopwatch.
Sheets of lead of different thickness can be inserted in the equipment set-up between the detector and the source. The thickness of the absorbing lead can be varied further by combining sheets of different thickness.



With the equipment set-up, the intensity *I* (in pulses per unit of time) of the transmitted γ radiation can be measured as a function of the thickness *d* of the absorbing material.
The source emits γ radiation. This radiation can affect measurements of the background radiation. Therefore, position the source (when not in use) in its lead container at a distance of approximately 1 m from the scintillation detector.

Research Question

- Draw up a research question fitting the aim and equipment set-up of this experiment.

Hypothesis

- Draw up an argued hypothesis about the relation between the intensity *I* of the transmitted γ radiation and the thickness *d* of the absorbing material.
- Give this hypothesis also in the form of a sketch of the relation between these quantities in an *I*,*d*-graph.

Plan of Work

- Draw up a plan of work for the investigation with the given equipment set-up.
- In this plan of work, indicate how you will vary which quantities in order to be able to check your hypothesis.
- Indicate how you will correct your measurements for the background radiation.
- Prepare an (empty) table for recording your measurements.
- Indicate whether the experiment will contribute to the radiation dose you receive during the laboratory session. And, if so: how you can take care that this radiation dose stays as low as possible.
- Discuss your research question, hypothesis and corresponding plan of work with your teacher or the school's laboratory technician.
- If necessary, review your research question, hypothesis and/or plan of work.

Investigation

- Carry out the investigation according to your plan of work. During the laboratory session, take care of an adequate radiation protection.

Data Processing

- Process your measurements in order to check your hypothesis, and to answer your research question. The box below gives some instructions for such data processing.

Instructions

- Plot your measurements in a graph.

> From this graph, determine the half-value thickness $d_{1/2}$ of lead for the γ radiation of ^{60}Co.

- Information about an accurate way of determining the half-value thickness from a graph on single logarithmic graph paper can be found in the booklet *ISP Experiments*.

> Compare the accuracy of determining the half-value thickness $d_{1/2}$ of lead from your measurements when using a graph on normal, linear graph paper and on single logarithmic graph paper.

- The half-value thickness of lead as found in this experiment can be used to calculate the half-value thickness of other materials. The half-value thickness $d_{1/2}$ appears to be inversely proportional to the density ρ of the absorbing material. This means: a material with a twice as large density has a twice as small half-value thickness.

> Calculate the half-value thickness of aluminium and of water with the help of the half-value thickness of lead as found in this experiment.

Extra question

A lead apron contains a layer of about 3 mm worth of lead, to protect against radiation. Why is a lead apron not useful for gamma radiation that has an energy of more than 2,0 MeV?

Report

- Write a report about this investigation. This report presents your *research question*, *hypothesis*, (processed) *measurements* and *conclusion* about the hypothesis being confirmed or not.