Experiment 5

Name:
……………………………………………..

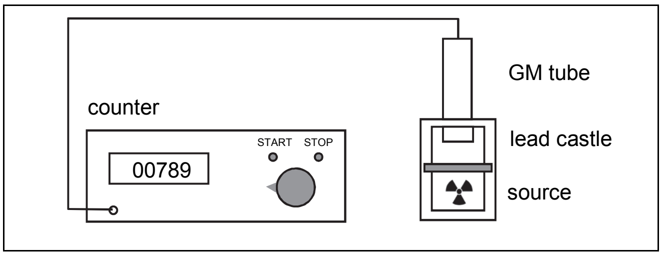
Absorption of Beta Particles in Aluminium and Perspex

Aim

- To determine the relation between mass per unit area (the product of thickness and density) of the absorbing material and intensity of the transmitted β radiation.
- To measure the universal range and the range of β particles in aluminium and perspex.
- To measure the maximum energy of β particles, emitted by a source of strontium-90.

Set-up

The set-up consists of a Geiger-Müller tube mounted in a 'lead castle', a pulse counter, and a source of strontium-90 (^{90}Sr) that emits mostly β radiation. Sheets of aluminium and perspex can be inserted between the GM tube and the source in the lead castle.



Read the introduction on page 7 of the booklet *ISP Experiments* about the absorption of β radiation. See also the background information on the information sheet for this experiment.

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.

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

2 After removing the top cover, position the source inside the lead castle.

3 Insert the thinnest aluminium sheet in the set-up and measure the intensity I of the transmitted radiation (in pulses per 10 s). Repeat this with the other aluminium and perspex sheets of varying thickness d. Record your measurements in the table below. Do *not* correct for the background radiation: this will be done in Assignment 2.

Aluminium		
d (cm)	I (pulses/10s)	m/A (mg/cm^2)
0.024		65
0.034		92
0.051		138
0.067		181
0.095		256
→ 0.120		324
→ 0.160		432
0.201		543
→ 0.259		699
0.322		869
* 0.379		1023
* 0.419		1131

Perspex		
d (cm)	I (pulses/10s)	m/A (mg/cm^2)
0.1		120
0.2		240
0.3		360
0.4		480
0.5		600
0.6		720
0.7		840
0.8		960
0.9		1080
1.0		1200
1.1		1320
1.2		1440

* Combine two of the sheets indicated with an arrow.

4 Take the source out of the set-up and put the lid back on.

Assignments

1 Plot your measurements of the intensity on the single logarithmic paper below, for both aluminium and perspex. On the horizontal axis, plot the mass per cm^2 m/A (mass m over surface area A) instead of the thickness d. See the orange booklet *ISP Experiments* (page 31-32) for the reasons of using single logarithmic graph paper.
When using single logarithmic graph paper, the first part of the line will be linear. The second part of the line will show some abnormalities because of the measured ‘braking radiation’ (see the booklet ISP *Experiments*, page 33) and statistical measuring errors. Disregard these abnormalities when drawing the graph. What do you notice when both graphs are drawn?

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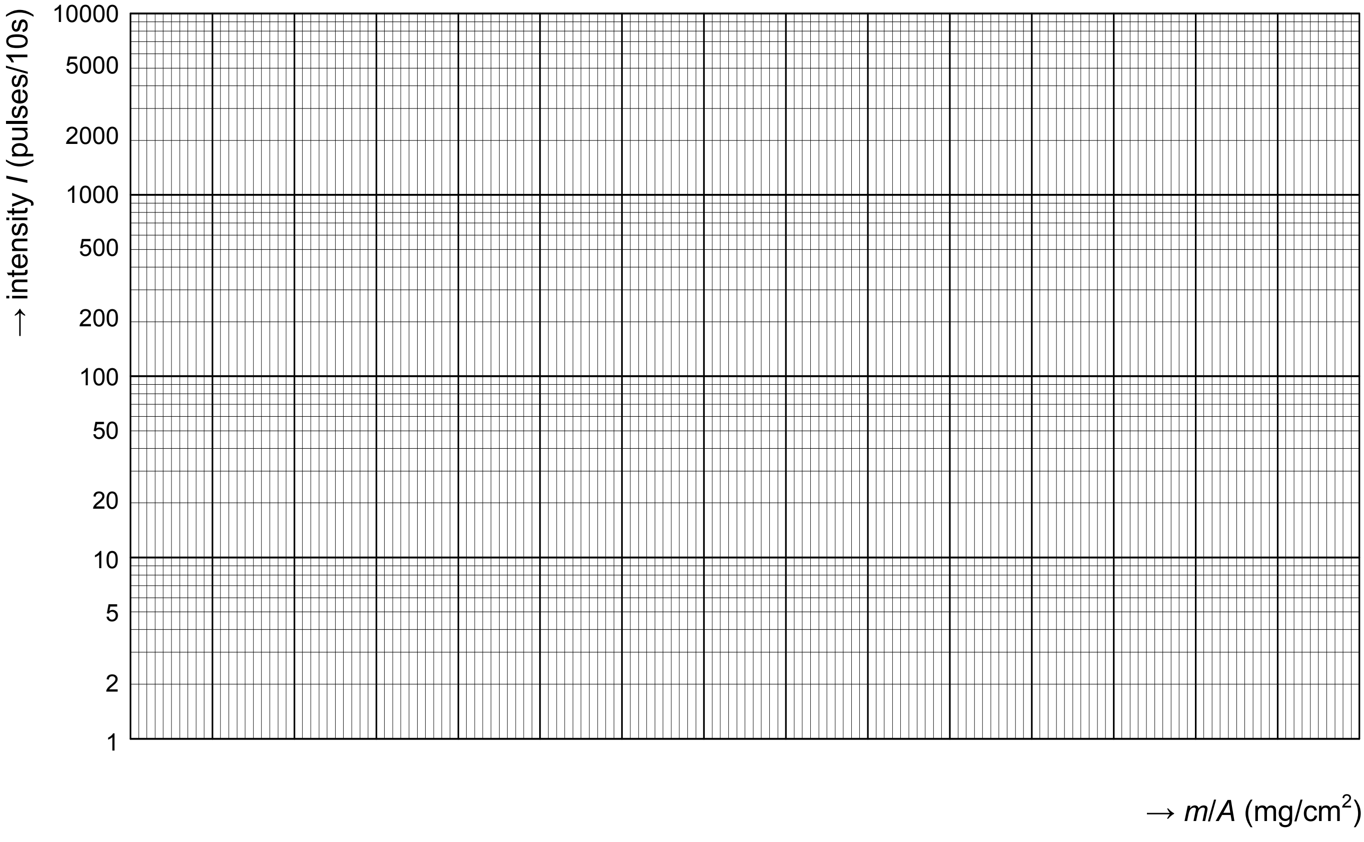

Depending on their energy, β particles travel a certain distance in which they completely transfer their energy to the absorbing material. This distance is called the *range R*. The value of this range is different for each material. However, when we look at the mass per cm^2 of the absorbing material we will see that for roughly the same value of m/A each material has fully absorbed the β particles. We call this value of m/A the *universal range* R_u.

2 In the graph, draw a horizontal line representing the average intensity $I_{b,avr}$ of the background radiation.

3 Determine the universal range R_u of β particles by extrapolating both graphs to the line representing the average background radiation.

R_u = ……… mg/cm^2

4 Calculate the range R of the β particles in the two materials using the formula $R_u = \rho \cdot R$. Use the following values for the density ρ: aluminium 2700 mg/cm^3, perspex 1200 mg/cm^3.

aluminium: R = ……… cm

perspex: R = ……… cm

5 Calculate the range R of β particles in the human body with a density of 1000 mg/cm^3.

body: R = ……… cm

6 The universal range R_u depends on the maximum energy E of the β particles, as given by the following formula: R_u (mg/cm^2) = $500 \cdot E$ (MeV)
Calculate the maximum energy of the β particles from the ^{90}Sr source.

E = ……… MeV