Lab 8: Radioactivity and Shielding

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1 Source Choice

Gamma has more energy than beta, and thats why we want to use a thicker material for gamma because gamma waves can pass through metal. That's why we use metal plates for cesium and it's gamma waves.

2 Raw Data

Table 1: Collected and plotted data of Strontium-90, where I_0 is the first row values.

Counts (per minute)	True Counts (per minute)	Thickness (cm)	Thickness (m)	$-\ln[I/I_0]$
73	47	0.0	0.000	0.000
44	18	0.1	0.001	0.960
51	25	0.2	0.002	0.631
37	11	0.3	0.003	1.452
34	8	0.4	0.004	1.771
34	8	0.5	0.005	1.771
34	8	0.6	0.006	1.771
37	11	0.7	0.007	1.452
34	8	0.8	0.008	1.771
26	1	0.9	0.009	3.850
38	12	1.0	0.010	1.365
23	1	1.1	0.011	3.850
39	13	1.2	0.012	1.285
32	6	1.3	0.013	2.058
26	1	1.4	0.014	3.850
24	1	1.5	0.015	3.850
29	3	1.6	0.016	2.752
18	1	1.7	0.017	3.850
32	6	1.8	0.018	2.058
28	2	1.9	0.019	3.157

Table 2: Collected and plotted data of Cesium-137, where I_0 is the first row values.

Counts (per minute)	True Counts (per minute)	Thickness (cm)	Thickness (m)	$-\ln[I/I_0]$
48	22	0.5	0.005	0.000
49	23	0.8	0.008	-0.044
37	11	1.0	0.010	0.693
36	10	1.2	0.012	0.788
41	15	1.4	0.014	0.383
27	1	1.6	0.016	3.091
28	2	1.8	0.018	2.398
37	11	2.1	0.021	0.693
29	3	2.4	0.024	1.992
33	7	2.7	0.027	1.145
37	11	3.0	0.030	0.693
24	1	3.3	0.033	3.091
20	1	3.6	0.036	3.091
29	3	3.9	0.039	1.992
33	7	4.2	0.042	1.145
26	1	4.5	0.045	3.091
23	1	4.8	0.048	3.091
25	1	5.1	0.051	3.091
22	1	5.4	0.054	3.091
23	1	5.7	0.057	3.091

3 Linearization

So I really wanted our μ as our slope. So I was thinking to just natural log both sides! Kinda like:

$$I(x) = I_0 e^{-\mu x}$$
$$\underbrace{-\ln\left[\frac{I(x)}{I_0}\right]}_{y} = \underbrace{\mu}_{\mathrm{m}} \underbrace{x}_{x} + \underbrace{0}_{b}$$

4 Graph

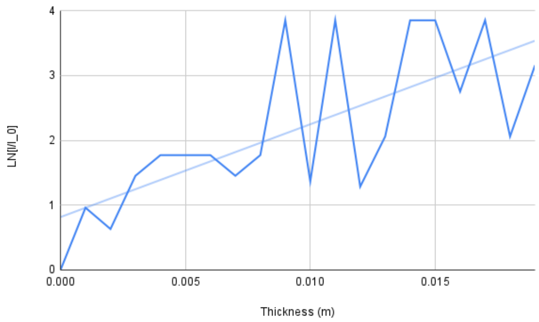

Figure 1: Strontium-90 Count Rate vs. ln(Thickness), $-\ln(I/I_0) = \mu x$ plotted with $\mu \approx (1.4 \pm 0.3) \times 10^2$

Figure 2: Cesium-137 Count Rate vs. ln(Thickness), $-\ln(I/I_0) = \mu x$ plotted with $\mu \approx (5 \pm 1) \times 10^1$

5 Thickness

We see that our strontium reaches approximately $1/e$ or $\approx 36.7\%$ of it's original intensity when the thickness is approximately 0.3 cm, or about 3 cardboard sheets. For our cesium source, we see this value to be around 2.7 cm, with 8 cardboard and 8 metal sheets.

6 Banana Equivalent

If for one year, the dosage is Activity $\times$ DCF, and 3 hours is 3/8760, then:

$$\begin{aligned}
D &= A \times DCF \times \frac{3}{8760} \\
D_{\text{Sr-90}} &= (3700 \text{ Bq})(2.8 \times 10^{-8} \text{ Sv/Bq})(3/8760 \text{ years}) \approx 3.55 \times 10^{-8} \\
D_{\text{Cs-137}} &= (185000 \text{ Bq})(1.3 \times 10^{-8} \text{ Sv/Bq})(3/8760 \text{ years}) \approx 8.24 \times 10^{-7} \\
D_{\text{total}} &= D_{\text{Sr-90}} + D_{\text{Cs-137}} = 8.59 \times 10^{-7} \text{ Sv}
\end{aligned}$$

So assuming we swallow them both, we now convert the total to our banana equivalent dosage. The lab manual states that the dosage of eating a single banana is approximately $0.0000001 = 1 \times 10^{-7}$ Sv. So, a radiation dosage of 8.59×10^{-7} would be the same as eating around 8.59 bananas, i.e. $BED = 8.59$.

References

[1] Department of Physics. *PHYS 126 Lab Manual*. University of Alberta, 2025.

[2] TA assisted with the lab, and provided guidance on the data collection and analysis.

[3] Lab partner Morgann Reinhart assisted with the data collection and analysis.