The answer should be in min/count.

The true counting rate, R, can then be determined for an observed counting rate, R_0, from the following formula:

$$R = \frac{R_0}{1 - R_0 T_R} \text{ counts/min} \quad (3)$$

Equation (3) should be used to correct any counting rate that is above 5000 counts/min.

EXPERIMENT 2.4

Linear Absorption Coefficient

Purpose

When gamma radiation passes through matter, it undergoes absorption primarily by Compton, photoelectric, and pair-production interactions. The intensity of the radiation is thus decreased as a function of distance in the absorbing medium. The mathematical expression for intensity, I, is given by the following expression:

$$I = I_0 e^{-\mu x}, \quad (4)$$

where

I_0 = original intensity of the beam,

I = intensity transmission through an absorber to a distance, depth, or thickness x,

μ = linear absorption coefficient for the absorbing medium.

If we rearrange Eq. (4) and take the logarithm of both sides, the expression becomes

$$\ln (I/I_0) = -\mu x. \quad (5)$$

The half value layer (HVL) of the absorbing medium is defined as that thickness, $x_{1/2}$, which will cut the initial intensity in half. That is, $I/I_0 = 0.5$. If we substitute this into Eq. (5),

$$\ln (0.5) = -\mu x_{1/2} . \quad (6)$$

Putting in numerical values and rearranging, Eq. (6) becomes

$$x_{1/2} = 0.693/\mu \text{ or } \mu = \frac{0.693}{x_{1/2}} . \quad (7)$$

Experimentally, the usual procedure is to measure $x_{1/2}$ and then calculate μ from Eq. (7).

Procedure

1. Set the voltage of the Geiger tube at its operating value.

2. Place the ^{60}Co source (from SK-1G) about 3 cm from the window of the GM tube and make a 2-min count. Record the number of counts.

3. Place a sheet of lead from the absorber kit between the source and the GM window and take another 2-min count and record the value.

4. Place a second sheet on top of the first and make another count.

5. Continue adding lead sheets until the number of counts is 25% of the number recorded with no absorber.

6. Make a 2-min background run and subtract this value from each of the above counts.

EXERCISE

Record the density-thickness of the lead in g/cm^2 and plot on semilog paper the corrected counts as a function of absorber density-thickness in g/cm^2. The density-thickness is defined as the product of density in g/cm^3 times the thickness in cm of the absorber. Draw the best straight line through the points and determine $x_{1/2}$ and μ. How do your values compare with those indicated in ref. 8? See also Experiment 3 in this manual, in which this same experiment is done with a sodium iodide detector.

EXPERIMENT 2.5

Inverse Square Law

Purpose

There are many similarities between ordinary light rays and gamma rays. They are both considered to be electromagnetic radiation, and hence they obey the classical equation

$$E = h\nu, \quad (8)$$

where

E = energy of the photon in ergs,

ν = the frequency of the radiation in cycles/s,

h = Planck's constant (6.624×10^{-27} ergs · s).

Therefore in explaining the inverse square law it is convenient to make the analogy between a light source and a gamma-ray source.

Let us assume that we have a light source that emits light photons at a rate N_0 photons/s. It is reasonable to assume that these photons are given off in an isotropic manner, that is, equally in all directions. If we place the light source in the center of a clear plastic spherical shell, it is quite easy to measure the number of light photons per second for each cm^2 of the spherical shell. This intensity is given by

$$I_0 = \frac{N_0}{A_0}, \quad (9)$$

where N_0 = total number of photons/s from the source, and A_0 = total area of the sphere in cm^2.

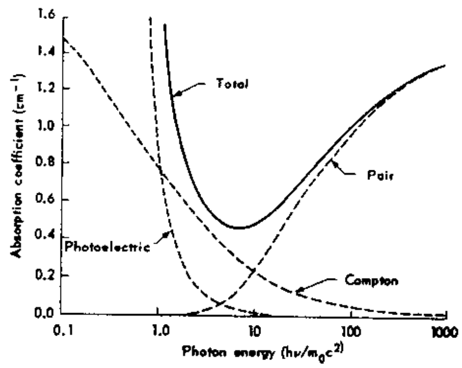


Fig. 15-7. Total absorption coefficient of lead, showing the contributions (photoelectric absorption, Compton scattering, and pair formation.

TABLE 15-5

VALUES OF THE ABSORPTION COEFFICIENTS FOR LEAD
(in units of 10^{-24} cm^2/atom)

Photon energy (Mev)	Photoelectric $_a\tau$	Compton $_a\sigma$	Pair-formation $_a\kappa$	Total $_a\mu$	Coefficient per cm μ(cm^{-1})	Mass coefficient μ/ρ (cm^2/gm)
0.1022	1782	40.18		1822	59.9	5.30
0.1277	985	38.01		1023	33.6	2.97
0.1703	465	35.04		500	16.4	1.45
0.2554	161	30.70		192	6.31	0.558
0.3405	75.7	27.63		103.3	3.39	0.300
0.4086	47.8	25.74		73.5	2.42	0.214
0.5108	27.7	23.50		51.2	1.68	0.149
0.6811	14.5	20.73		35.2	1.16	0.102
1.022	6.31	17.14		23.45	0.771	0.0682
1.362	3.86	14.81	0.1948	18.87	0.620	0.0549
1.533		13.91	0.3313			
2.043	2.08	11.86	1.247	15.19	0.499	0.0442
2.633						
3.065		9.313	3.507			
4.086	0.869	7.761	5.651	14.28	0.469	0.0415
5.108	0.675	6.698	7.560	14.93	0.491	0.0434
6.130		5.917	9.119			
10.22	0.316	4.115	14.04	18.47	0.607	0.0537
15.32	0.206	3.042	18.00	21.25	0.698	0.0618
25.54	0.122	2.044	23.24	25.41	0.835	0.0739

Procedure

1) Make sure the Geiger counter is held securely in the clamp above the source holding fixture. Leave approximately 3 cm between the Geiger Counter and the location of the source.

2) Have your inscructor place a Cs137 source in the holder. Make sure the aluminum Beta sheld is in place.

3) Take a 1 minute (try to get more than 1000 counts) run and record the number of counts.

4) Place a sheet of lead (you may want to use gloves, and you definitely should wash your hands after since lead can be nasty stuff) on top of the aluminum sheet as indicated. Take a 1-min count and record the value

5) Place a second sheet on top of the first and take another count.

6) Continue adding sheets until you have used all the sheets.

7) Have your instructor place the Cs137 source back in the source cabinet.

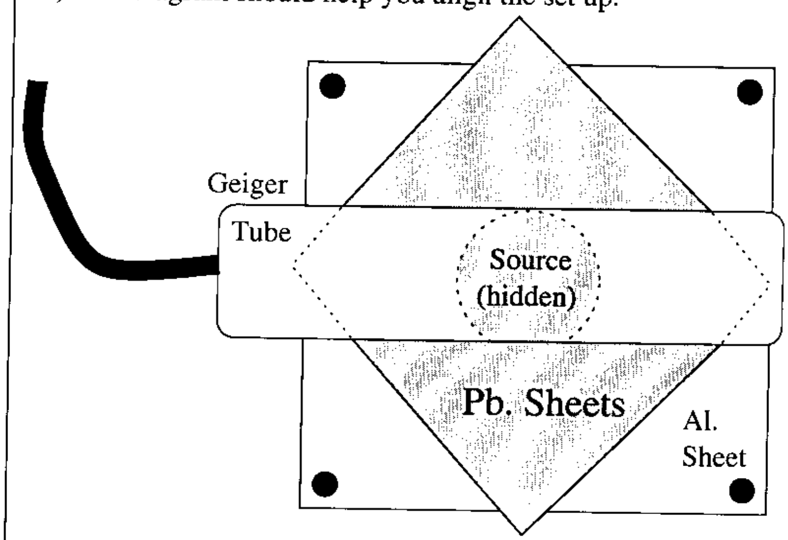
8) Take a 2-3 min count of the background.

9) If you are real energetic. Repeat this process with the aluminum sheets.

Notes:

i) Those lead sheets are tough to measure. An average thickness of 0.85 +/- 0.04 mm for each should suffice. (you can't trust the numbers written on the lead)

ii) This diagram should help you align the set up.



Notice how the lead fully covers the source and the active part of the Geiger counter. I.e. it would be really tough for a gamma ray to pass into the Geiger counter without passing through the lead first.

Exercise

Be sure to record the length of time for each separate data "run" that you make. Record how many sheets are present between the source and the detector for each "run". After subtracting the expected background from each point, plot your points on semilog paper: Counts vs. Thickness. Did you get a straight line? Determine u from your data. Include an error estimate. Using the table supplied on the next page, determine the energy of the gamma rays coming from Cs137. You will probably need to interpolate. This method is not as precise as some, but you can get accurate results without a lot of equipment just the same! If you did the experiment with aluminum, there is a table that will allow you to compare your results to lead.