# General Science 181 Laboratory
## Nuclear Radiation: Attenuation of $\gamma$ rays by lead absorbers

**Objective**

1. To study the attenuation of nuclear radiation i.e. $\gamma$ rays, by different thicknesses of lead absorbers. ($\alpha$ radiation sources are not readily available)

2. To investigate the interaction of these particles with matter i.e. the lead absorbers.

3. To learn the operation of the Geiger-Mueller counter.

4. To learn how to use a micrometer.

**Apparatus**

Geiger-Muller tube and counter, $\gamma$ ray sources, sets of plastic, aluminum and lead absorbers, and micrometer.

**This is the Geiger-Mueller tube (Cylindrical Object at the top) and the stage. The stage holds the sample carrier and radioactive source.**

**This is the sample carrier and a Radioactive source.**

**Theory**

Nuclear radiation is classified into three types: α**,** β **and** γ **rays**. The α ray is a beam of helium nucleus with charge +2 and mass 4; (Two protons and two neutrons). The β ray is a beam of electrons with charge -1 and a mass that is about eight thousand times lighter than the mass of a α particle; The γ ray is a charge-less and mass less light wave. The γ ray and X-ray are essentially the same thing -- both are electromagnetic waves with very short wavelengths, and are highly penetrating.

In terms of penetrating power, the α particles are the softest due to its heavy mass, and the γ rays are the hardest due to its zero mass and electrical neutrality.

The α radiation can be stopped by a piece of paper, and the β radiation can be stopped by a thin film of metal (~ 1 mm thick), but the γ radiation can penetrate through a few centimeters of lead!

When nuclear radiation (α, β and γ rays) passes through a layer of absorber with thickness **X,** its ray intensity will reduce from its original value **Io** to some smaller value **I.** The relationship is given by

$$I = Io\ e^{[-X / Xo]} \qquad (1)$$

where Xo is called the range of the ray in that matter.
From Eq. (1) we know that the range Xo is the thickness at which the ray intensity is reduced to 37%. of Io

If we plot the intensity of the radiation that gets through the absorber I, as a function of the thickness of the absorber, a decaying exponential curve is obtained, and the range Xo can be determined from the exponential curve.

**Procedure**

1.**Testing the equipment**

**Set the high voltage knobs to 0 volts. Then turn on the Geiger-Muller counter.**

Reset the counter to zero. Set the time dial to 0.5 minutes (30 seconds) and turn on the test button. Hit the start button to start the test. At the end of thirty seconds the display should read 3600. If the display does not show 3600 repeat the test. If the second attempt does not work let your lab instructor check out the equipment.

2. **Finding the background count**

Turn off the test mode. Set the course voltage to 400 volts. Set the time for a 5-minute count. Reset the display to zero and hit the start button to begin the count. **While taking the background count of the cosmic rays, keep all the radiation sources away from the GM tube. You must do this since we are interested in how much natural radiation there is.** This background count must be subtracted from the radiation counts throughout the whole experiment. Calculate the number of counts per minute and record this in your data table where it says background count.

3. **Finding the Intensity Io of the γ ray source**

Place a γ source at the lowest position of the sample holder. Place a thin piece of Aluminum over the gamma ray source and place the sample holder in the third slot from the top in the stage. Count for two minutes and record the number of counts. Calculate the number of counts per minute and record this in your data table.
**To find the intensity Io you must subtract the background count from the total count**

This is the initial ray intensity Io, when there is no shielding material between the source and the counter. **The Aluminum is used to block out any β particles that are also emitted by the radioactive source. You must keep the Aluminum shield over the γ source during the rest of the experiment**

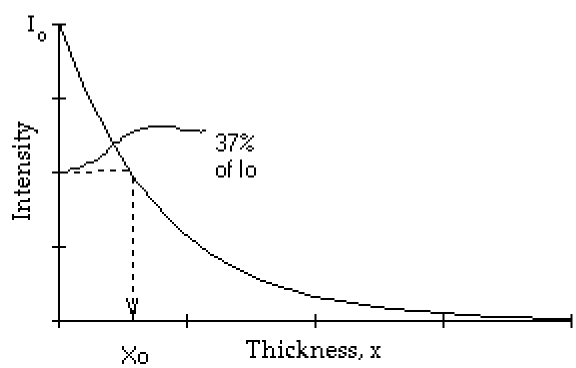
4. Place lead absorbers on top of the $\gamma$ ray source and the Aluminum shield. Place the sample holder in the third slot from the top in the stage. The thickness of the absorber can be measured with the micrometer. (**Note: measure each of the absorbers at three different places and find an average thickness)**
Count for two minutes and record the counts corresponding to the different thicknesses and record this in your data table. Calculate the number of counts per minute and record this in your data table.

5 Repeat step four for two other thicknesses of lead absorber.

**Data Analysis**

1. Plot the intensity of the g ray as a function of the thickness of the lead absorbers. Connect the data points with a smooth curve. This is the exponential attenuation curve.

2. Draw a horizontal line at the 37% of the initial ray intensity **Io**. The intercept of this line and the exponential curve indicates the range of the beta ray in this absorber. Report the range.




**DATA TABLE**

**5 minute Cosmic Ray background count________________**
**Background count $I_b$ in units of counts /minute_________________**

**Total two minute count of Intensity of γ ray source _________________**

**Total $I_{bs}$ Intensity of γ Ray source and in units of counts /minute__________________**

**Intensity $I_o$ of γ Ray source: $I_o = I_{bs} - I_b$ in counts per minute__________________-**

| THICKNESS (mm) of lead absorber | $I_{bs}$ 2 minute count | $I_{bs}$ (c/m) | Intensity I<br>$I_{bs} - I_b$ (c/m) |
|---|---|---|---|
| 0 | | | Io |
| | | | $I_1$ |
| | | | $I_2$ |
| | | | $I_3$ |

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