Q- A collimated gamma ray beam consists of equal numbers of 0.1 MeV and 1.0 MeV photons. If the beam enters a 15cm thick concrete shield, what is the relative portion of 1 MeV photons to 0.1 MeV photons in the emergent beam?

Let the mono energetic and homogeneous beam of gamma ray having intensity I be incident on a thin absorbing sheet. It has been observed experimentally that the intensity of the emergent beam is decreased. The change in intensity dI is directly proportional to the thickness dt of the sheet and to the intensity I of the incident beam, i.e.

$$dI \propto -I.dt$$
$$\Rightarrow dI = -\mu I dt$$

Here μ is proportionality constant and is called as absorption coefficient.
Integrating above equation

$$\frac{dI}{I} = -\mu dt$$
$$\Rightarrow \int \frac{dI}{I} = -\mu \int dt + C$$
$$\Rightarrow \ln I = -\mu t + C$$

At t = 0, I = I_0, the initial intensity C = ln I_0 and therefore

$$\ln I = -\mu t + \ln I_0$$
$$\Rightarrow I = I_0 e^{-\mu t}$$

Here the thickness of the film can be calculated by knowing the density of the lead and the rate of absorption per unit area can be calculated by the difference of incident and emergent intensities.

(the absorption coefficient μ is determined experimentally and is a constant for the substance)

Now I = n E where n is the number of photons crossing per unit area per second and E is the energy of each photon. Therefore

$$\frac{I_1}{I_2} = \frac{n_1 E_1}{n_2 E_2} = \frac{n_{01} E_1 e^{-\mu t}}{n_{02} E_2 e^{-\mu t}}$$

but as $n_{01} = n_{02} \Rightarrow n_1 = n_2$

Therefore. the number of both types of photons emerging per unit area per second is equal i.e. the ratio is 1:1.

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