Ασκήσεις Ανιχνευτές καλορίμετρα – από κεφ. 6, από το βιβλίο του Tavernier

1. Assume a detector for gamma rays consisting of LSO scintillator and a photomultiplier tube. The signal is taken from the anode of the PMT with a 50 Ω coax cable and brought to an oscilloscope. The input impedance of the oscilloscope is 50 Ω and the gain of the PMT is 10^5. What will be the signal amplitude when observing gamma rays of 1 MeV? Note: assume a light collection efficiency 50% and a photocathode quantum efficiency of 25%.

   Solution: From Table 6.2, obtain the light yield and decay time of LSO: 28,000 photons/MeV and 40 ns. The total charge in the pulse is $Q_t = 5.6 \times 10^{-11}$ coulomb.

   The current pulse generated by the PMT is given by

$$i(t) = Q_t \frac{1}{\tau} e^{-t/\tau}$$

   The peak value of the current pulse is $i = Q_t/\tau$ and the peak voltage

$$V_{\max} = 50 Q_t/\tau = 70\text{mV}.$$

2. Consider a source emitting gamma rays of 511 keV. Calculate the energy where you expect the backscatter peak in the pulse height spectrum.

   Solution: Using Eq. (2.10), we calculate the energy of the scattered photon for $\theta = 180°$. This gives 511/3 = 170 keV.

3. Consider a CsI:Tl scintillator. What fraction of the energy lost due to the interactions with the electrons in the material is converted to scintillation light?

   Solution: The CsI:Tl emits 65,000 scintillation photons per MeV of energy lost. The wavelength of the scintillation light is $\lambda = 565$ nm. The energy of each photon is

$$E = \frac{hc}{\lambda} = \frac{1.242[\text{eV}\,\mu\text{m}]}{0.565} = 2.19\,\text{eV}$$

   The total energy in the scintillation light is 143,000 eV or 14.3% of the energy lost in ionising and exciting electrons.

5. Consider a PET scanner with a solid angle covering around its centre point of $\Omega = 10\%$. Assume the detection efficiency for a gamma ray of 511 keV and within the solid angle is $Eff = 20\%$. Assume you place a point source in its centre with an activity of 1 mCi. What will be the single count rate and the coincidence count rate?

   Solution: An activity of 1 mCi is the same as 37×10^6 Bq.

   Single rate $= 37 \times 10^6 \times 2 \times \Omega \times Eff = 1.48\ 10^6$ Hz

   Coincidence rate $= 37 \times 10^6 \times \Omega \times Eff^2 = 1.48\ 10^5$ Hz