Isotope Diagnostics

1. The diameter of the detector ring of a PET scanner is 1.5 m.
   a) What should be the time window of the coincidence circuit within which two photons colliding into detectors may be considered coming from the same annihilation process?
   b) Two gamma photons collide into two opposing detectors with 3 ns time difference. Find the place of the annihilation where they come from.

2. The most widely used tracer in PET diagnostics is fludeoxyglucose (2-deoxy-2-[^{18}F]fluoroglucose, usual abbreviation: FDG). What is the decay equation of the incorporated radionuclide?

Formulæ

$v = \frac{\Delta x}{\Delta t}$ (velocity)

Solutions

1. a) $v = \frac{\Delta x}{\Delta t} \Rightarrow \Delta t = \frac{\Delta x}{v} = \frac{1.5m}{3 \cdot 10^8 \frac{m}{s}} = 5 \cdot 10^{-9} s = \underline{\underline{5ns}}$

b) The 3 ns time difference corresponds to

$v = \frac{\Delta x}{\Delta t} \Rightarrow \Delta x = v \cdot \Delta t = 3 \cdot 10^8 \frac{m}{s} \cdot 3 \cdot 10^{-9} s = 0.9m$ track difference. Since the photons collide into two opposing detectors, the annihilation happened somewhere along the section (i.e. the 1,5 m-long diameter) connecting them: one photon covers *x* meters, the other *x* + 0.9 meters, the two of them is 1.5 m altogether. Therefore:

$x + 0.9m + x = 1.5m$

$2x = 0.6m$

$x = 0.3m$

that is, the annihilation happened 0.3 m away from that endpoint of the diameter which is at the detector activated earlier. So the first photon covered 0.3 m (in 1 ns), and the second photon covered 1.2 m (in 4 ns).

2. ${}^{18}_{9}\mathrm{F} \rightarrow {}^{18}_{8}\mathrm{O} + \mathrm{e}^+ + \nu_\mathrm{e}$ (in 97%, but 3% of decays is K-capture)