1. $$SA(t=8hr) = SA(t=0)e^{-8hr/\tau}$$

$$SA(t=0) = 90{,}000 \frac{mCi}{\mu g} \times 37 \frac{MBq}{mCi} = 3\,330\,000 \frac{MBq}{\mu g}$$

$$\tau = \frac{T_{1/2}}{\log(2)} = \frac{110\,min/60\,min/hr}{0.693} = 2.645\,hr$$

$$SA(t=8hr) = 3.33 \times 10^6 \frac{MBq}{\mu g} \exp(-8/2.645) = 161\,766 \frac{MBq}{\mu g}$$

$$440\,MBq = m \times SA \quad \therefore \quad m = \frac{440\,MBq}{161766\,MBq/\mu g} = 2.72\,ng$$

here, $m = 2.72\,ng$ is the mass of ^{18}F

molecular mass of $^{18}F \simeq 18\,g/mol$ and of FDG/glucose is $\approx 180\,g/mol$

$\therefore$ we need 27.2 ng of FDG

2. From NIST site

	ρ (g/cm^3)	μ/ρ (cm^2/g) @ 500 keV
Cortical bone	1.92	0.0902
Soft tissue	1.06	0.0960

$T_{1/2} = 110\text{min}$, $\tau = \dfrac{T_{1/2}}{\log(2)} = 158.7\text{ min}$

$A(0) = 0.25\text{ MBq}$

Total # of decays over 2min: $N_d = \int_0^{2\text{min}} dt\, A(t) = A_0 \int_0^{2\text{min}} dt\, e^{-t/\tau}$

$$= -A_0 \tau e^{-t/\tau}\Big|_0^{2\text{min}} = A_0 \tau \left(1 - e^{-2\text{min}/\tau}\right) = A_0\, 1.99\text{ min} \times \frac{60\text{ s}}{\text{min}}$$

$N_d = 29.8 \times 10^6$ decay events

$$N_c = N_d \exp\left[-\int_L ds\, \mu(s)\right]$$

$$= 29.8 \times 10^6 \exp\left[-\int_0^{2\text{cm}} ds\, \mu_{bone} - \int_{2\text{cm}}^{20\text{cm}} ds\, \mu_{ST}\right]$$

$$= 29.8 \times 10^6 \exp\left[-2\text{cm}\left(0.0902 \frac{\text{cm}^2}{\text{g}}\right)\left(1.92 \frac{\text{g}}{\text{cm}^3}\right)\right]$$

$$\times \exp\left[-18\text{cm}\left(0.096 \frac{\text{cm}^2}{\text{g}}\right)\left(1.06 \frac{\text{g}}{\text{cm}^3}\right)\right]$$

$N_c = 3.38 \times 10^6$ coincidence detections

3.

a) ^{99m}Tc emits γ-photons with energy = 140 keV

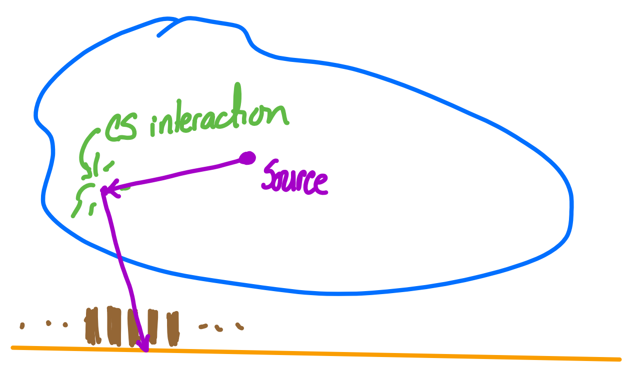
From your text, the energy window used for NaI(Tl) is ±10%.

$$\therefore \quad 140 \text{ keV} \pm 14 \text{ keV}$$

$$= 126 \text{ to } 154 \text{ keV}$$

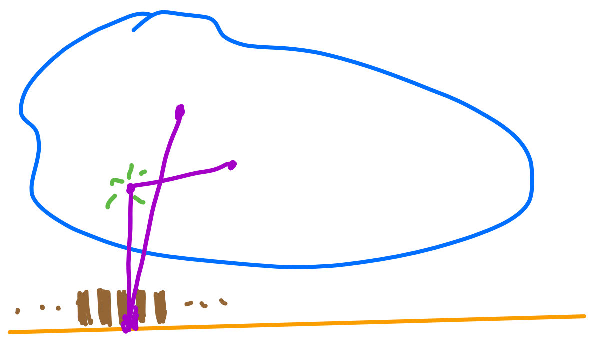
b) Scintillation events measuring < 126 keV likely come from γ-photons that have been scattered by a Compton interaction. These photons will degrade image quality.

E.g.



c) scintillation events measuring >154 keV likely came from more than 1 γ-photon hitting near the same point on the screen at near the same time. Because these photons are unlikely to have travelled the same path, the resulting detection will also degrade image quality

E.g.



4. Cumulated activity, $\tilde{A} = 1.44\, T_{1/2}\, A$

$\therefore$ The cumulated activity for the 3 source organs is

$$\tilde{A}_{liver} = 1.44 \times 6\,hr \times 0.6 \times 100\,MBq$$
$$= 518.4\ MBq \cdot hr$$

$$\tilde{A}_{spleen} = 1.44 \times 6\,hr \times 0.3 \times 100\ MBq$$
$$= 259.2\ MBq \cdot hr$$

$$\tilde{A}_{marrow} = 1.44 \times 6\,hr \times 0.1 \times 100\ MBq$$
$$= 86.4\ MBq \cdot hr$$

The average dose to the liver from each source is $\bar{D}(source \rightarrow liver) = \tilde{A}_{source} \times S(source \rightarrow liver)$

From table

$$S(liver \Rightarrow liver) = 3.23 \times 10^{-6} \frac{mGy}{MBq \cdot sec}$$

$$S(spleen \rightarrow liver) = 7.2 \times 10^{-8} \frac{mGy}{MBq \cdot sec}$$

$$S(marrow \rightarrow liver) = 8.93 \times 10^{-8} \frac{mGy}{MBq \cdot sec}$$

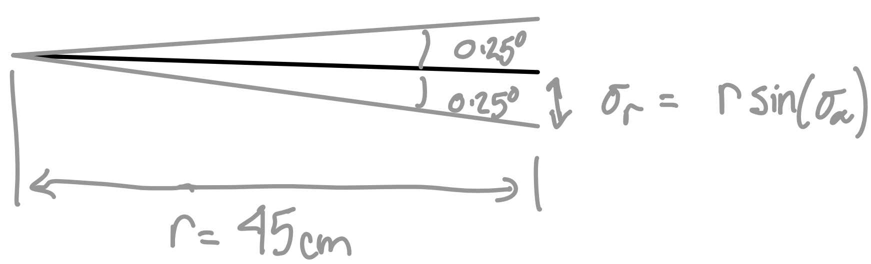
∴ Total dose to the liver

$$\bar{D}_{liver} = \left[\tilde{A}_{liver}\, S(liver \Rightarrow liver) + \tilde{A}_{spleen}\, S(spleen \Rightarrow liver) + \tilde{A}_{marrow}\, S(marrow \Rightarrow liver)\right] \times 3600 \frac{sec}{hr}$$

$$= \underline{\underline{6.12 \text{ mGy}}}$$

5. ^{18}F emits relatively low energy positrons with rms range ≈ 0.1 mm. Thus, the resolution of ^{18}FDG PET is limited by variance in the angle separating γ-photon emission.

Using $\sigma_\alpha = 0.25°$



$$\sigma_r = r\sin(\sigma_\alpha) = 45\text{cm}\,\sin(0.25°) = \underline{\underline{1.96 \text{ mm}}}$$