Nuclear Physics - Problem Set 3 - Solution

Problem 1)

Starting from the end, since each deuteron has a charge $Q = e$, 2 μA of current correspond to $1.25 \cdot 10^{13}$ deuterons/s impinging on the target. Since the atomic mass number of tritium is 3.016 g/mol, the target has a density of $4.0 \cdot 10^{19}$ atoms/cm^2 and the luminosity is hence $5 \cdot 10^{32}$. Meanwhile, the cross section is $1.3 \cdot 10^{-26}$ cm^2 / sr and the solid angle subtended by the detector is 0.002 m^2 / (3 m)^2 = $2.22 \cdot 10^{-4}$ sr for an integrated cross section Ds = $2.9 \cdot 10^{-30}$ cm^2 and a count rate of 1440 neutrons per second.

Problem 2)

a) The density of carbon is 2.265 g/cm^3, and the atomic weight (by definition) is exactly 12, so the areal density is τ = 2.265 g/cm$^3 \cdot$ 1 cm $\cdot$ 1mol/12g $\cdot$ $6.022 \cdot 10^{23}$/mol = $1.137 \cdot 10^{23}$/cm^2. To stay below the stated luminosity, we need less than $10^{34}/1.137 \cdot 10^{23}$ electrons/s = $8.798 \cdot 10^{10}$ electrons/s. Each electron has a charge of $1.602 \cdot 10^{-19}$ C, so this corresponds to a current of 14.1 nA (pretty low compared to the 100 μA that the accelerator can deliver). CLAS12 makes up for the low luminosity by its large solid angle (approximately 2π sr as opposed to a few msr for most spectrometers).

b) 100 M events in 24 hours of running corresponds to 1157 events per second. Since dN/dt = L*$\Delta\sigma$, I conclude that $\Delta\sigma$ equals $\Delta\sigma = 1.157 \cdot 10^{-31}$cm^2 = 0.1157 μb.