Josh Whitehead
u1069343
Nucl 3100

HW 3

1) $$\frac{-dE}{dx} = 0.3071 \rho \frac{Zq^2}{A\beta^2}\left(\ln\left(\frac{W_{max}}{I}\right) - \beta^2\right)$$

$Z = 3$

$A = 7$

$q = 3$

$E = 30\,MeV$

$\rho = 2.26 \frac{g}{cm^3}$

$$I = \frac{Z(12 + 7Z^{-1})}{1000000}$$

$$W_{max} = 2m_ec^2(\gamma\beta)^2$$

$$\beta = \left(1 - \left(\frac{m_oc^2}{m_oc^2 + \frac{E}{A}}\right)\right)^{1/2}$$

$$\gamma = \frac{1}{(1-\beta^2)^{1/2}} \qquad m_oc^2 = 931.5\,MeV$$

$$\frac{-dE}{dx} = 0.3071(2.26)\frac{(3)(3)^2}{7\beta^2}\left(\ln\left(\frac{W_{max}}{I}\right) - \beta^2\right)$$

$$\boxed{= 7128.321 \frac{MeV}{cm}}$$

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2) for α:

Eq 2.4.25 $R_\alpha^{Al} = 3.37\times10^{-4}\ R_\alpha^{air} \frac{\sqrt{A_{Al}}}{\rho_{Al}}$

$A_{Al} = 27$

$\rho = 0.0027 \frac{g}{mm}$

~~$R_\alpha^{air} = 1.24(10) - 2.62$~~

$R_\alpha^{air} = (0.05(10) + 2.85)\, 10^{3/2} = 105.93\ mm$

$\therefore\ R_\alpha^{Al} = 68.706\ mm$

$R_p^{air} = \left(\frac{E_p}{9.3}\right)^{1.8}\ [m]$

~~$R_{Al} = R_{air}\ \rho_{air}$~~

and

~~$R^{Al} = R^{air} \frac{\rho_{air}}{\rho_{Al}} \left(\frac{A_{Al}}{A_{air}}\right)^{1/2}$~~

$R_{air} = R_{Al} \frac{\rho_{Al}}{\rho_{air}} \left(\frac{A_{air}}{A_{Al}}\right)^{1/2} = \left(\frac{E_p}{9.3}\right)^{1.8} \cdot 1000$

$\rho_{air} = 1.225\times10^{-6}\ \frac{g}{mm^3}$

$A_{air} = 14.6$

$\therefore\ \boxed{E_p = 0.762605\ MeV}$

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3) $I = I_0 \exp(-\mu_t x)$

$-\mu_t x = \ln\left(\frac{I}{I_0}\right) \rightarrow x = \frac{\ln\left(\frac{I}{I_0}\right)}{-\mu_t}$

$\mu_t = \rho \mu_m = 11.3 \frac{g}{cm^3} \cdot 0.069 \frac{cm^2}{g} = 0.7797 \frac{1}{cm}$

$\therefore x = \frac{\ln\left(\frac{1}{10^5}\right)}{-\mu_t} \boxed{= 14.765\ cm}$

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4) Most of the energy is deposited @ $\boxed{36.2\ uM}$

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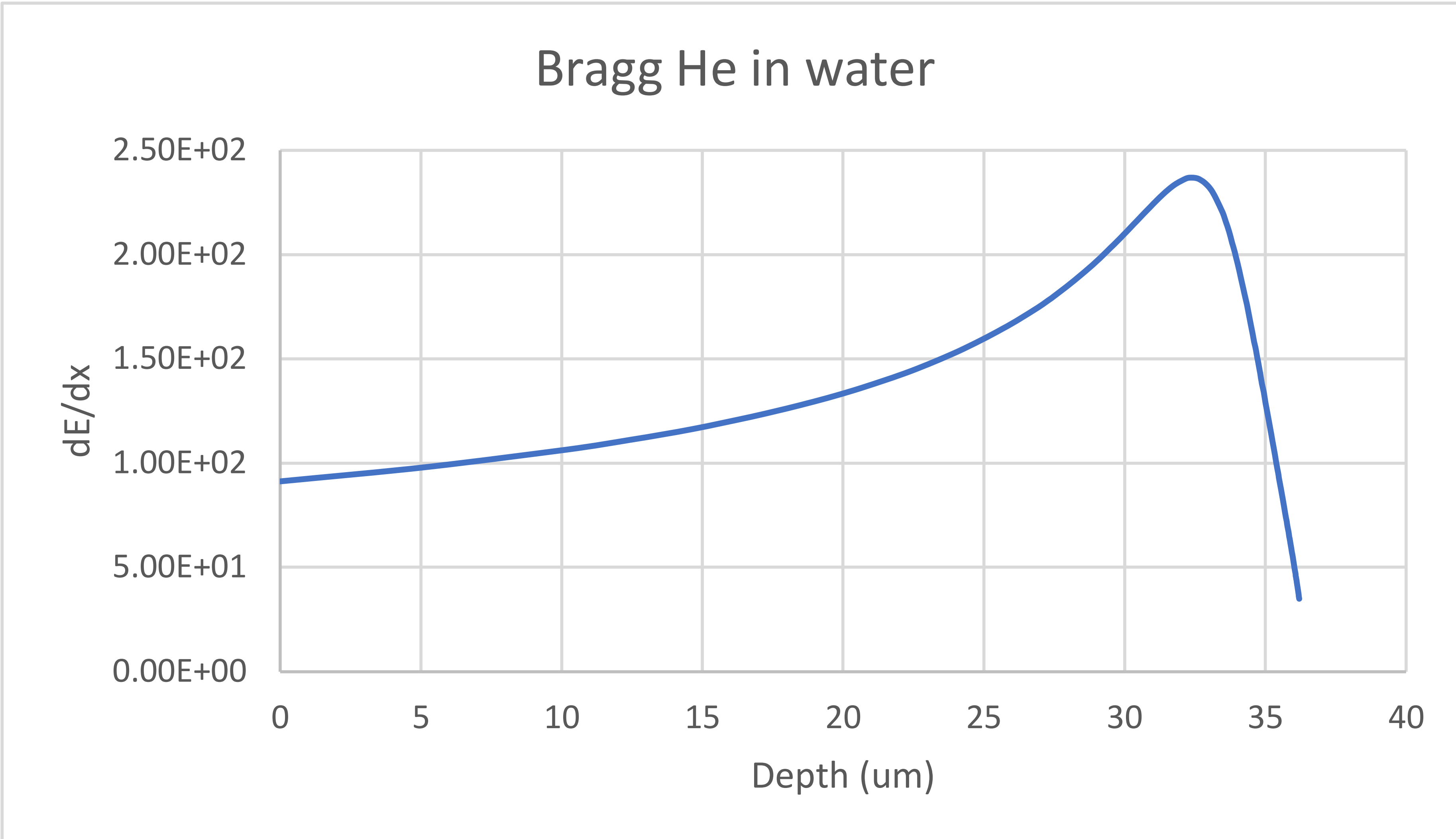
5) Alpha particles have a lower range in matter than protons with the same speed. This is because alpha particles are much larger than protons so they interact with other particles more frequently and therefore lose energy faster.

Protons have a longer range because they don't lose energy as quickly


Bragg He in water
dE/dx
2.50E+02
2.00E+02
1.50E+02
1.00E+02
5.00E+01
0.00E+00
0
5
10
15
20
25
30
35
40
Depth (um)

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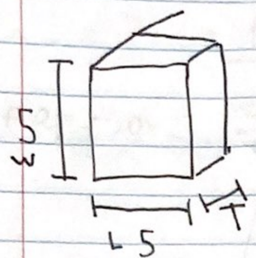
6) $\rho = \frac{m}{V} = \frac{m}{L \cdot W \cdot T} = 19.32 \frac{g}{cm^3} = 19.32 \frac{mg}{mm^3}$



$\therefore T = \frac{m}{L \cdot W \cdot \rho} = \frac{500 \, mg}{5 \, mm \cdot 5 \, mm \cdot 19.32 \frac{mg}{mm^3}}$

$= 1.034126 \, mm$

$\boxed{= 1.03 \, mm}$

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7) $S_{nuc} << S_{elec} \therefore -\frac{dE}{dx} \approx S_{elec}$

the electronic components contribute more to the stopping power because it can contribute by colliding directly, and by coulombic attraction since electrons are charged, they can change direction and energy without directly interacting with the particle. The nucleus ~~only~~ mostly contributes by direct collisions

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8) Heavy, more energetic Particles lose energy faster than less energetic particles because they interact with more particles in a shorter amount of time

Part of the Stopping power equation shows

$$\frac{-dE}{dx} \propto \frac{Aq^2}{2E} \ln\left(\gamma^2 \frac{2E}{A}\right) g(Z)$$

$$\therefore \frac{-dE}{dx} \propto \frac{1}{E}$$