Homework 3

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My particle is a kaon with energy 15 MeV. Solving for energy loss by hand, we have

$$-\frac{dE}{dx} = \frac{\mathcal{K}}{A}\frac{z^2 Z}{\beta^2}\ln\frac{2\gamma^2 m_e \beta^2 c^2}{I}$$

with

$$A = 1, Z = 1, m_e c^2 = 0.511 MeV, I = 21.8 eV$$

$$\gamma = \frac{K.E.}{mc^2} + 1 = \frac{15 MeV}{498 MeV} + 1 \sim 1 = \frac{1}{\sqrt{1-\beta^2}}$$

$$v^2 = \frac{2K.E.}{m} = \frac{2 \cdot 15 MeV}{498 MeV/c^2} = 6 \times 10^{-2} c^2 \Rightarrow \beta^2 = \frac{v^2}{c^2} = 6 \times 10^{-2}$$

$$\frac{dE}{dx} = \left(0.307 \frac{MeV \cdot cm^2}{g}\right)(1)^2(1)\frac{1}{6 \times 10^{-2}}\ln\left(\frac{2(1)(0.511 MeV)(6 \times 10^{-2})}{21.8 eV}\frac{10^6 eV}{MeV}\right)$$

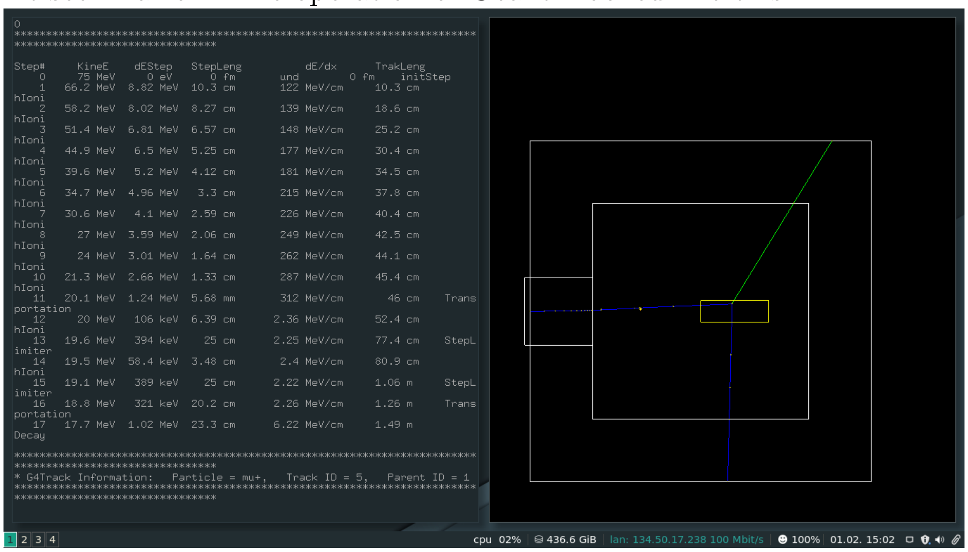
$$\frac{dE}{dx} = 41 \frac{MeV cm^2}{g}$$

Plugging in the density of the target material to see how much energy is lost after the kaon has travelled .5 cm through it, we get

$$\rho_{LH_2} = 0.07 \frac{g}{cm^3}$$

$$\Delta E = (41 \frac{MeV cm^2}{g})(0.07 \frac{g}{cm^3})(0.5 cm) = 1.4 MeV$$

The values I was seeing for $\frac{dE}{dx}$ in Geant4 seemed to vary pretty wildly (I suppose due to the simulations stochasticity), but the hand-calculated value didn't seem far off. The operation of Geant4 looked like this:



My plot of energy loss ($\frac{MeV \cdot cm^2}{g}$) as a function of energy (MeV):