Exercise A Calculation of the theoretical value for the energy loss E_{Th} can be done by two methods. These are the range method (Exercise a) and the $(dE/dx)_{av}$ method (Exercise b).

As mentioned in the preliminary discussion eq. (5), the range of an alpha particle can be determined by integrating the (dE/dx) of the alpha over its path length from E_0, the initial energy, to zero, the final energy. Figure 4.7 shows the range that results from this integral for incident alphas between 0.10 and 6 MeV. From this curve it can be seen that the range of an alpha from ^{210}Po that has an energy of 5.31 MeV corresponds to a range in copper of 9.3 mg/cm^2. Assume that the first copper foil used was 2.0 mg/cm^2. Figure 4.7 can be used to find the final energy E_f of the alpha after it has passed through the foil. This is done by subtracting the foil thickness from the 9.3 mg/cm^2 and then reading the energy E_f of the alpha from fig. 4.7. Example:

$$R_f = (9.3 - 2.0)\ \text{mg/cm}^2 = 7.3\ \text{mg/cm}^2 \qquad (6)$$

From fig. 4.7, the energy E_f of an alpha whose range is 7.3 mg/cm^2 is 4.2 MeV. Therefore, E_f, the energy that the alpha gives ΔE_{Th} = 5.30 MeV — 4.2 MeV = 1.1 MeV. This value would then be entered into Table 4.3 as ΔE for that foil.

Compute ΔE_{Th} for all of the copper foils that the instructor provides. Repeat these calculations for any other foils that the instructor may provide.

Exercise B The theoretical (dE/dx) may also be determined by using the average (dE/dx) method.

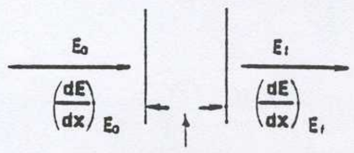

Figure 4.8. Illustration showing an alpha of energy E_0 entering a foil and leaving with an energy E_f.

The value of $(dE/dx)_{E0}$ at the incident energy can be found from Table 4.2. When the alpha leaves the foil, its energy is E_f and the $(dE/dx)_{Ef}$ can also be found from Table 4.2. Since the foil is fairly thin, it can be assumed the (dE/dx) change across the foils is approximately linear. It is thus possible to write:

$$\left(\frac{dE}{dx}\right)_{Av} = \frac{\left(\frac{dE}{dx}\right)_{E0} + \left(\frac{dE}{dx}\right)_{Ef}}{2} \qquad (7)$$

The theoretical energy loss using $(dE/dx)_{Av}$ is then given by:

$$(\Delta E)_{Th} = \left(\frac{dE}{dx}\right)_{Av} \cdot \Delta X \qquad (8)$$

Note, that since the units of dE/dx are in MeV/mg/cm^2 and the foil thickness ΔX is in mg/cm^2, the resultant product in eq. (8) has units of MeV.

Use eq. (8) to calculate $(\Delta E)_{Th}$ for all of the foils that are provided for this experiment. Record these values in Table 4.3.

Exercise C The last column in Table 4.3 is the % difference. Since the ΔE_{Th} obtained by the range method (exercise a) should be more accurate, use it as the accepted value. If the student is very careful with the measurements and accurately reads the graphs, tables, and calibration curves, these % differences should be less than 10%.

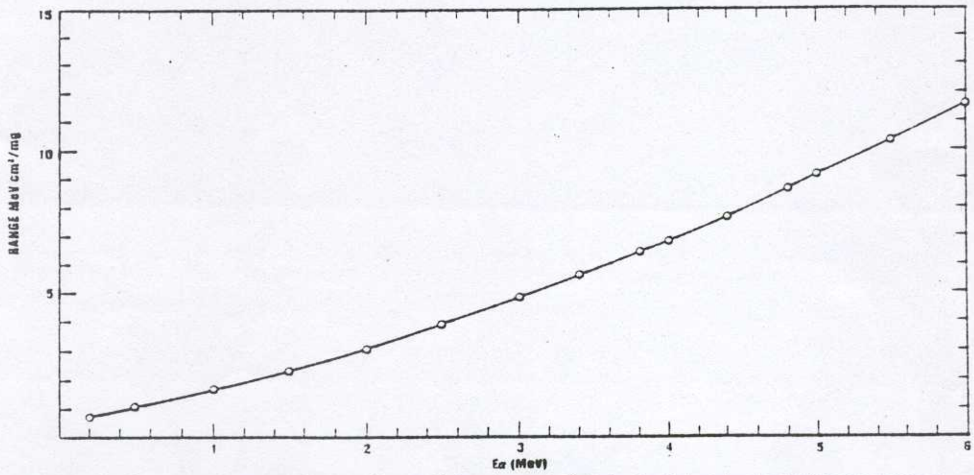

Figure 4.7. Energy vs Range for Alphas in Copper (taken from ref. 7). Note, the student should plot this range curve on graph paper from the data in Table 4.1 The range numbers can then be accurately read from the graph.