PHYSICS 20323: Scientific Analysis & Modeling - Fall 2024
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PROJECT INFORMATION:

Radioactive decay is a process that can be modeled. Python software can be utilized to run large numbers and simulations that depict the randomness of radioactive decay along with calculating energy and standard deviation.

PURPOSE:

This project serves to model the radioactive decay process and the resulting energies as well as determine the correct thickness of a shield that protects from α-particle radiation.

PROCEDURE:

- Build a Python program in a Jupiter Lab Notebook to model the decay of 20,000 atoms.
  1. Allow sufficient time to show all atoms decaying into the final element.
     - Add a plot with a logarithmic y-scale to show smaller amounts of elements if they cannot be seen on the larger plot.
  2. Incorporate randomness through half-lives and percentages given through project sheet (Fig. 1).
- Add on to the program to calculate the energy generated from each decay process (Fig. 1)
  - Calculate the total energy and standard deviation of individual decay energies.
- Determine how thick of a shield (cm) is necessary to protect humans from α-particle decay if 1cm blocks 1750 MeV.

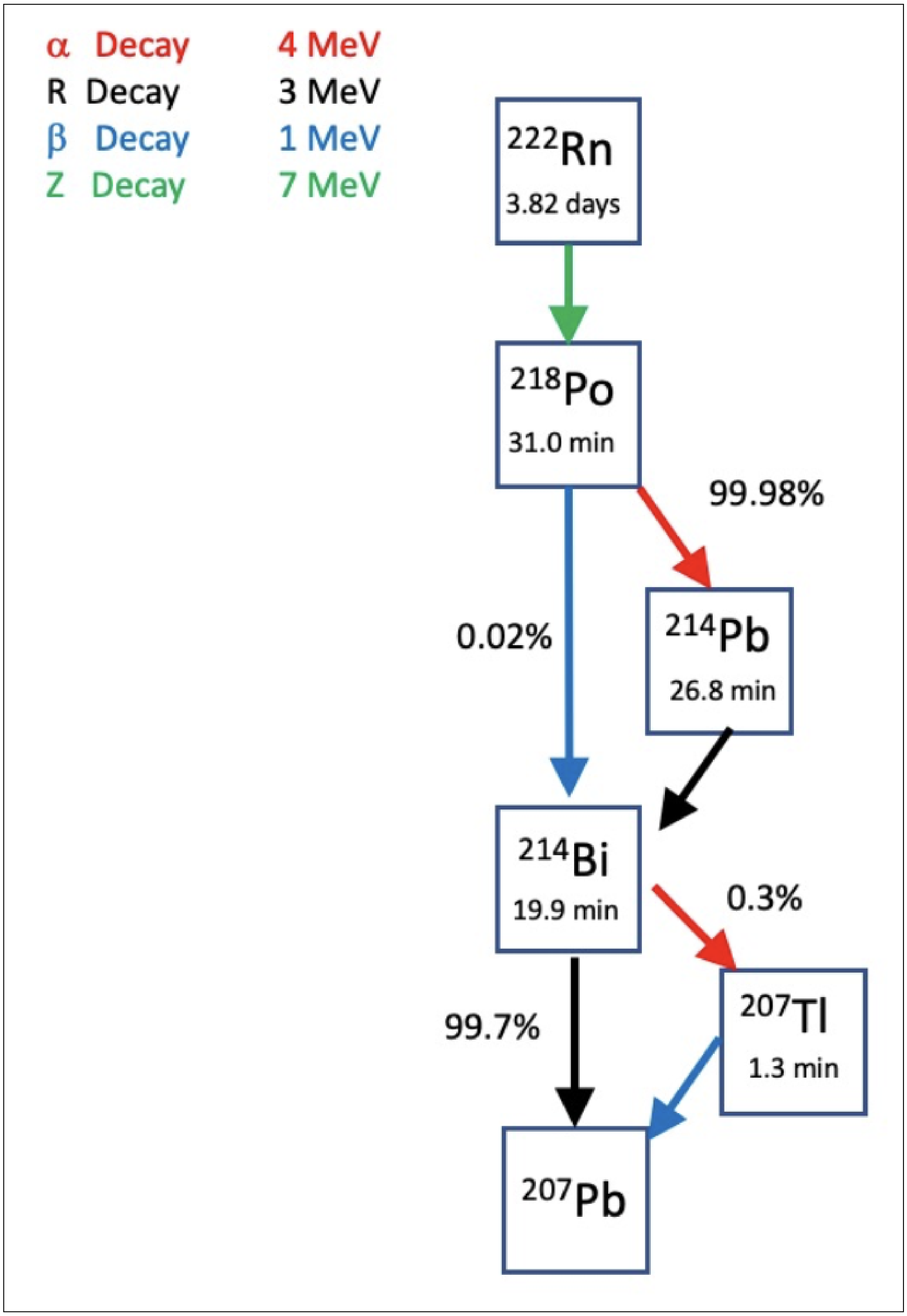

Figure 1: Diagram showing half-lives and process of decay

RESULTS:

The decay process of 20,000 atoms of ^{222}Rn is displayed in Fig. 2. ^{222}Rn is in black and ^{207}Pb is in magenta.

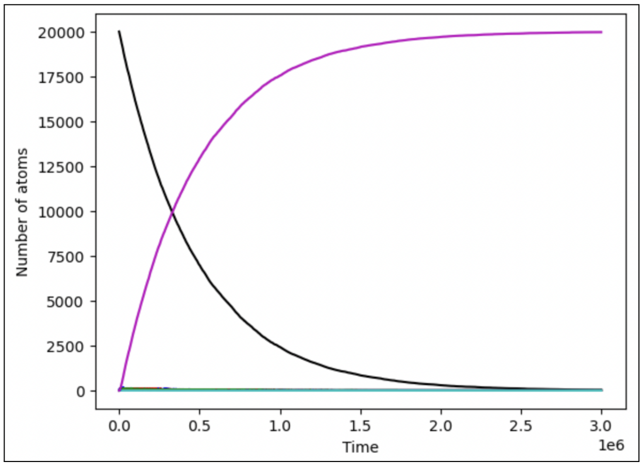

Figure 2: Python-generated plot of decay process

A logarithmic scale is used to show the decay of atoms that had low percentages of occurrence. ^{214}Bi is in green, ^{207}Tl is in teal, ^{214}Pb is in red, and ^{218}Po is in blue.

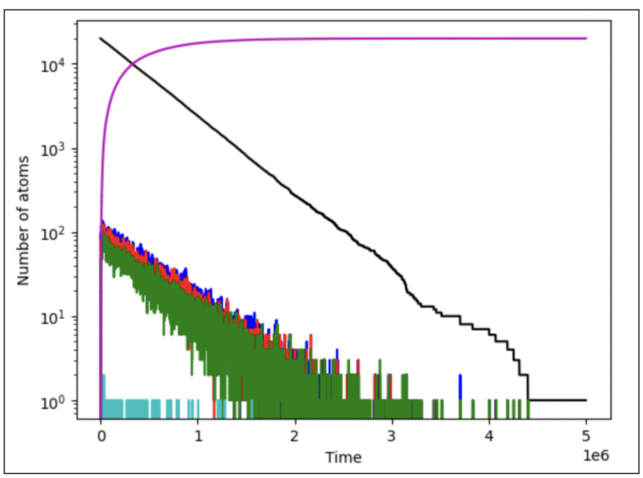

Figure 3: Python-generated logarithmic plot of decay process

The energy generated from each type of decay process and total energy, along with standard deviation for each, is listed in the table below.

Decay Type	Avg. Decay Energy	Standard Deviation
α	80089.2	37.99
R	119607.6	37.54
β	62.5	9.12
Z	139765.5	26.42
Total	339524.8	67.85

A 45.83 cm shield would be necessary to protect humans from α-particle radiation. This is found from:

$$E_{blockedenergy} = \frac{80089.2}{3 * 37.99} = 80203.17 \;\; MeV \tag{1}$$

$$Thickness = \frac{80203.17}{1750} = 45.83 \;\; cm \tag{2}$$

where 80089.2 is the Average Decay Energy of the α-particles and 37.99 is the Standard Deviation. 1750 is the provided numerical value of how much MeV is blocked per 1cm.

CONCLUSION:

The process of the decay of 20,000 atoms of ^{222}Rn is properly modeled. The average and total energies from each type of decay is calculated, along with standard deviation for each. A 45.83cm shield is necessary to protect from α-particle radiation generated from this radioactive decay chain.