PHYS 20323: Fall 2023 - Final Project

1 Introduction

The following simulation involved Monte-Carlo simulations to model the below radioactive decay process and its decay energies. The flow chart and respective energies are as follows:

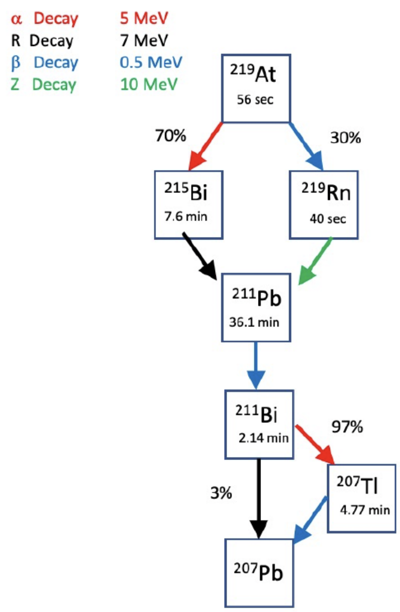


Figure 1: Decay chain

2 Procedure

Allowing At-219 to have 20,000 initial atoms, and setting the maximum time to 15,000 seconds (this was found through trial and error to observe where Pb-207, the element that all the atoms eventually decay into, reaches its peak), the graph follows the decay path of every element, with the colors corresponding in the following manner:

At-219 = Magenta

Bi-215 = Blue

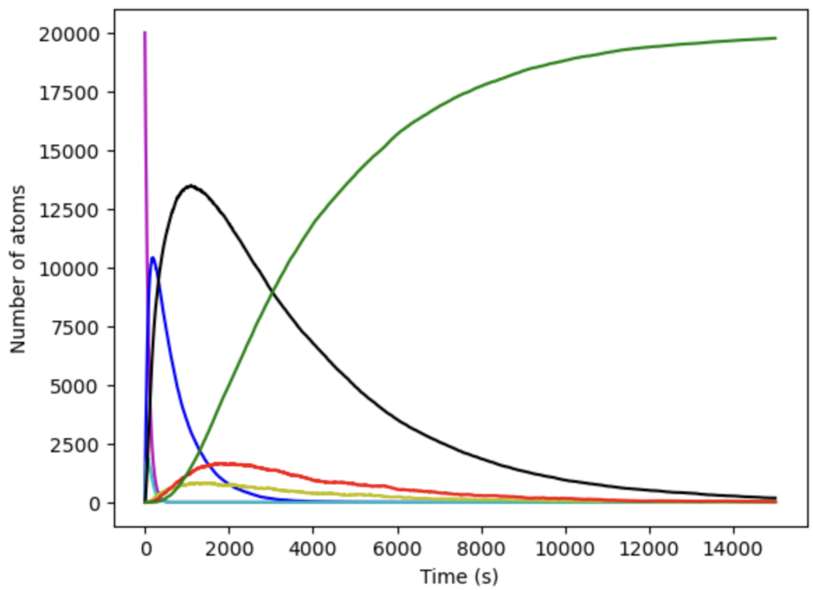
Rn-219 = Cyan

Pb-211 = Black

Bi-211 = Yellow

Tl-207 = Red

Pb-207 = Green

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Alpha decay = 166075 MeV
R decay = 102571 MeV
Beta decay = 22463.0 MeV
Z decay = 59670 MeV
Total Energy = 350779.0 MeV
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Figure 2: Decay graph, with individual and total energies

With the individual energy decays put into a list, we ran a loop 10 times so we would get 40 values that changed slightly every time, with which we then computed the average and standard deviation of the total decay energies giving us the following:

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The average of the total decay energies produced is: 87651.687 MeV
The Standard Deviation of the total decay energies produced is: 53319.411 MeV
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We then took the average and standard deviation of the individual decay energies in separate lists and ran it 10 times in a loop, giving us ten slightly different values because of the Monte-Carlo simulation

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The average of the Alpha decay energies produced is: 165841.385 MeV
The Standard Deviation of the Alpha decay energies produced is: 295.269 MeV

The average of the R decay energies produced is: 102140.446 MeV
The Standard Deviation of the R decay energies produced is: 563.904 MeV

The average of the B decay energies produced is: 22483.531 MeV
The Standard Deviation of the B decay energies produced is: 41.779 MeV

The average of the Z decay energies produced is: 60141.385 MeV
The Standard Deviation of the Z decay energies produced is: 669.680 MeV
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The last part of the project involved using 3-sigma deviations of the average α-decay energy to determine how thick of a shield would be needed to safely block all α particles. This is while assuming that 1 cm of shield blocks 2,200 MeV. The results were as follows:

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To safely block 166727.193 MeV of Alpha decay energy, we need a 75.785 cm thick shield.
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