TEXAS CHRISTIAN UNIVERSITY
COLLEGE OF SCIENCE AND ENGINERING

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Scientific Analysis and Modeling: FINAL PROJECT report

by

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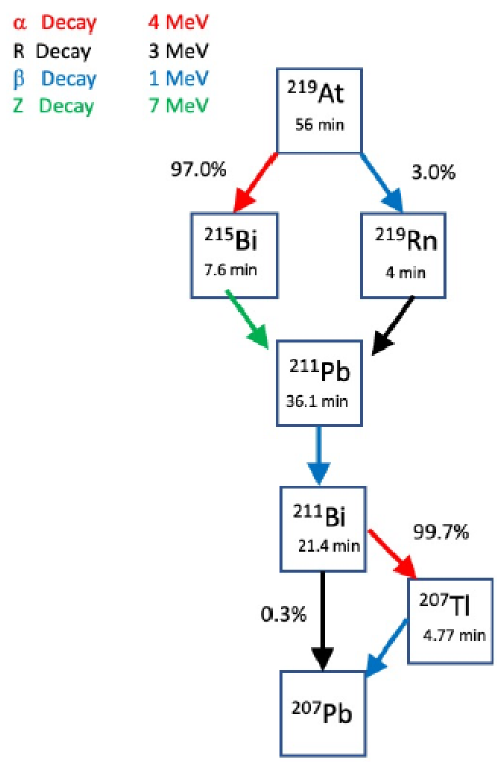

TEXAS CHRISTIAN UNIVERSITY – 2023

1 Goal of project

To model a program of the decay and energy resulting of 20,000 atoms over time and to study the attached radioactive decay from this process.

- To plot the number of atoms of each isotope over time.
- Calculate the number and energy generated from each of the decay processes.
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- To find the average and standard deviation of the total and individual decay energies produced with the radioactive decay chain.
- To find the thickness of a shield that will be able to safety block all of the α-particles.

2 Procedure

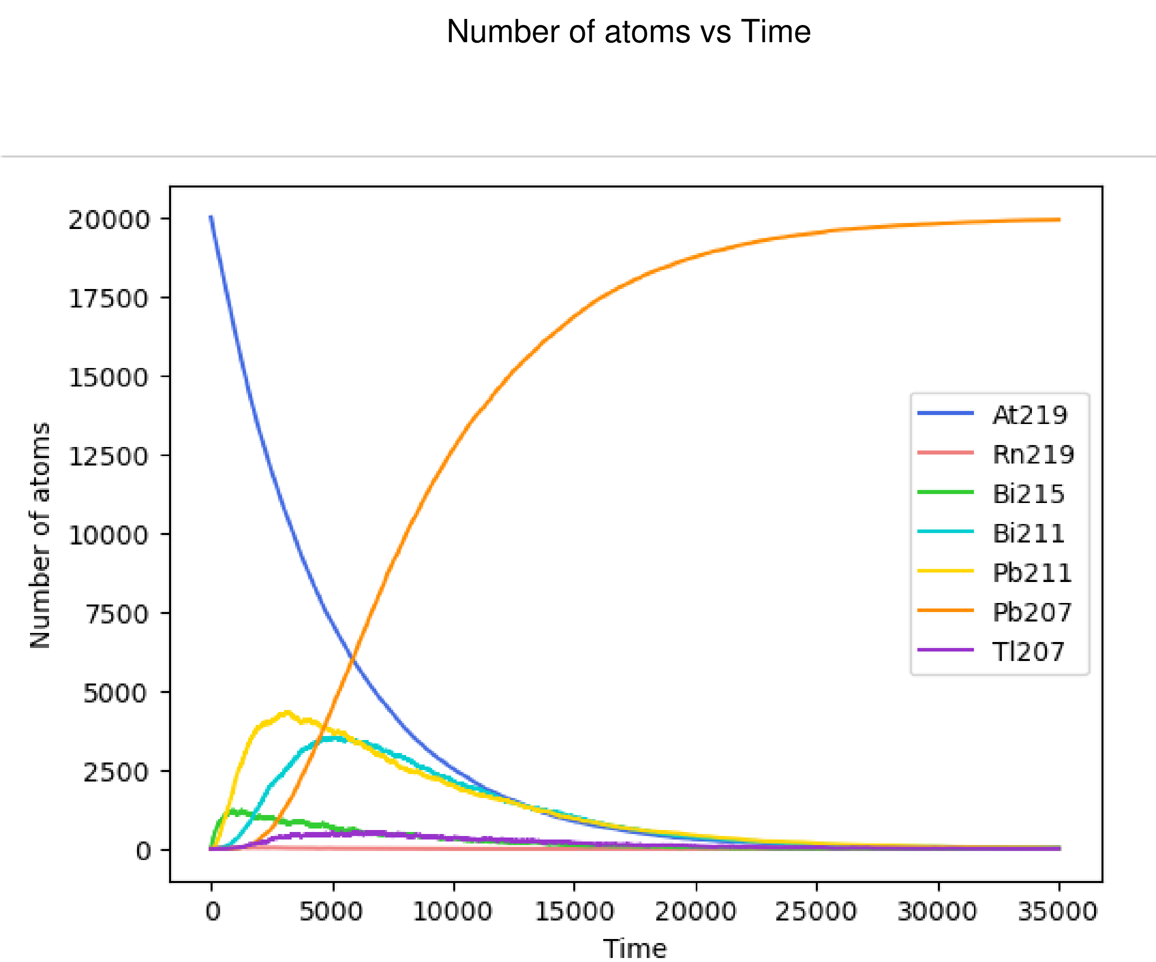
Started with a for-loop of 10 runs. Within each run I made a graph of the number of atoms of each isotope over time and found the total energy decay of each run. The total energy decay of each run was then used to compute an average total energy decay and a standard deviation of each energy decay process using *numpy*-functions. I then calculated the shield thickness, using the average (α_{avg}) and standard deviation (α_{std}) of the α-particle decay process.
The shield thickness was calculated with the equation : $thickness_{shield} = \frac{\alpha_{avg}+3(\alpha_{std})}{1250}$

3 Results and Conclusions

Constants

- Started out with 20,000 At^{219}-atoms & 0 atoms of each of the other isotopes.
- Over a total time of 35,000 seconds with a 1 second time-step.

3.1 Graph



The results represented by the graph are as expected, with a gradual change in the number of atoms of each of the different types of isotopes, always having a constant of 20,00 atoms at any given time.
Starting with 20,000 A^{219}-atoms and 0 atoms of each of the other isotopes at t_0, and ending with 20,000 Pb^{207}-atoms and 0 atoms of each of the other isotopes at t_f also is also as expected.

3.2 Table of Energy decay (in MeV)

Run	α	R	β	Z	$Total$
1	$157,064$	$1,848$	$28,761$	$89,796$	$277,469$
2	$157,112$	$1,878$	$28,762$	$90,461$	$278,213$
3	$157,052$	$1,899$	$28,808$	$89,537$	$277,296$
4	$156,968$	$1,971$	$28,785$	$89,747$	$277,471$
5	$156,972$	$1,953$	$28,800$	$90,188$	$277,913$
6	$157,036$	$1,914$	$28,728$	$90,006$	$277,784$
7	$157,000$	$1,959$	$28,697$	$89,831$	$277,487$
8	$156,984$	$1,941$	$28,708$	$89,782$	$277,415$
9	$157,148$	$1,824$	$28,749$	$90,076$	$277,797$
10	$156,952$	$1,986$	$28,734$	$89,586$	$277,258$
$\bar{x}$	$157,028.8$	$1,917.3$	$28,753.2$	$89,901.0$	$277,600.3$
σ	62.143	51.552	35.448	268.913	284.566

The results of the individual and total energy decays are as expected, with α-particles contributing for majority of the total energy and with all of the results being quite precise.

3.3 Calculating shield thickness to block all of the α-particles

Average α-particle decay energy: α_{avg} = 157,028.8
Standard Deviation of α-particle decay energy: α_{std} = 62.143
A shield thickness of 1 cm safety blocks 1,250 MeV.
Equation:

$$thickness_{shield} = \frac{\alpha_{avg}+3(\alpha_{std})}{1250}$$

$$thickness_{shield} = \frac{157{,}028.8+3(62.143)}{1250}$$

$$thickness_{shield} = 125.772183346 \text{ cm}$$

Therefore we can conclude that a shield with an approximate thickness of 126 cm would be able to safety block all of the α-particles that decay from this process