THESIS

CREATIVE TITLE

Submitted by

Noah J. Blar

Department of Environmental and Radiological Health Sciences

In partial fulfillment of the requirements

For the Degree of Master of Science

Colorado State University

Fort Collins, Colorado

Spring 2024

Master's Committee:

Advisor: Dr. Alexander Brandl

Dr. Ralf Sudowe Second Member Copyright by Noah J. Blair 2024 All Rights Reserved

ABSTRACT

CREATIVE TITLE

The purpose

ACKNOWLEDGEMENTS

I would

DEDICATION

To my grandfather and dear friend Bo7b, whose love of learning and guidance helped me become	ne
the man I am today.	

TABLE OF CONTENTS

ABSTRACT	
ACKNOWLE	DGEMENTS
DEDICATION	N
LIST OF TAE	SLES v
LIST OF FIG	URES
Chapter 1	Introduction
1.1	Sources of Ionizing Radiation
1.2	Radiation Interactions
1.3	Radiation Detection
1.4	Portal Monitors
1.5	Monte Carlo Methods
Chapter 2	Methodology
Chapter 3	Results
Chapter 4	Discussion
Chapter 5	Conclusion
Bibliography	1

LIST OF TABLES

LIST OF FIGURES

Introduction

1.1 Sources of Ionizing Radiation

Though it is possible to generate ionizing radiation through machine sources, the scope of this thesis will only include unstable nuclei and atoms. If there is an energy difference between configurations of a nucleus, there exists the possibility for the nucleus to transform into a more stable configuration and emit radiation in the processes. This may be in the form of particles, such as heavy ions or electrons, or in the form of electromagnetic radiation. The heavy ions are typically either alpha-rays or fragments from fission reactions. The light ions include electrons and their anti-matter equivalent, positrons. The electromagnetic radiation includes gamma-rays, characteristic x-rays, bremsstrahlung x-rays, and annihilation radiation, [Johnson and Cember, 2017].

- 1.1.1 Alpha-Decay and Spontaneous Fission
- 1.1.2 Isobaric Decays
- 1.1.3 Isomeric Transitions
- 1.1.4 Atomic Transitions
- 1.1.5 Mathematical Description of Radioactive Decay

- 1.2 Radiation Interactions
- **1.2.1** Heavy Ion Interactions
- 1.2.2 Light Ion Interactions
- 1.2.3 Photon Interactions

1.3 Radiation Detection

- **1.3.1** Aspects of Counting Statistics
- 1.3.2 Minimum Detectable Activity
- 1.3.3 Bayesian Approach to MDA
- 1.3.4 Geiger-Mueller Counters
- 1.3.5 Sodium-Iodide Detectors

1.4 Portal Monitors

- 1.5 Monte Carlo Methods
- 1.5.1 Monte-Carlo Integration
- 1.5.2 The Linear Boltzmann Equation for Radiation Transport
- 1.5.3 Monte-Carlo Applied to Radiation Transport
- 1.5.4 Monte-Carlo Neutral Particle Transport Code
- 1.5.5 Tool For Particle Simulation

Methodology

Results

Discussion

Conclusion

Bibliography

[Johnson and Cember, 2017] Johnson, T. E. and Cember, H. (2017). *Introduction to health physics*. McGraw-Hill Education, New York, fifth edition edition. OCLC: 994629366.