AN OVERVIEW OF MONTE CARLO (MC) SIMULATION METHOD AND BASIC PRINCIPLES IN MEDICAL RADIATION AND RADIATION DETECTORS

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Abstract: Monte Carlo (MC) method is a numerical test to simulate an event by using the numbers from 0-1. Monte Carlo method in studies for optimizing the device to be used in experimental studies, or studies to be carried out before it is used extensively as experimental. Also widely used in the medical imaging field next to the particle detectors in nuclear physics studies. Monte Carlo method extensively in studies for optimizing the device to be used in experimental studies or studies to be carried out before it is used as experimental. In recent years, MC method is widely used to simulate interaction of medical radiation with tissues and environment. In this study we discussed some specific samples along with general information. It can be concluded that MC is a powerful tool for pre-experimental studies.

Key words: Monte Carlo Simulation, Medical Radiation, Radiation Detectors

Introduction

The Monte Carlo (MC) technique has become ubiquitous in medical physics in the last years. There are many different applications of this technique but the major focus of this article will be the use of Monte Carlo to simulate radiation transport and basic principles and roadmap for design a radiation detector by using MC code. MC method was named by Von Neumann. In subsequent periods it was being used in different areas such as medical and nuclear physics (Andreo, 1991). There has been serious developments and evolutions especially all aspects of nuclear medicine, radiation studies, diagnostic radiology, medical physics nuclear physics and radiation protection. Although we had growth in application areas, some technical limitations also occurred. In parallel with the development of technology and computer systems to overcome step by step in this limitations. We know that many laboratories have their own MC staff in recent years (https://laws.lanl.gov, 2015). These staff provides the code development and solving the errors in program.

The aim of this paper is to supply an overview of MC simulation principles and basic steps especially on medical radiation and radiation detectors. In this study we introduced the modeling of High Purity Germanium Detector (HPGe) geometry by using MC code. High Purity Germanium (HPGe) is the only radiation detection technology that provides great information to identify radionuclides and medical radiation from their passive gamma ray emits. Since we know that each isotope has their own characteristic energy peak which also called as “fingerprint”, the importance of determining the characteristic energy level increased. The figure 1 is a comparison of three peaks of plutonium and iodine captured by three different detector. Regions are printed as NaI (blue), HPGe (red) and CZT (black) (https://ortec-online.com, 2015)

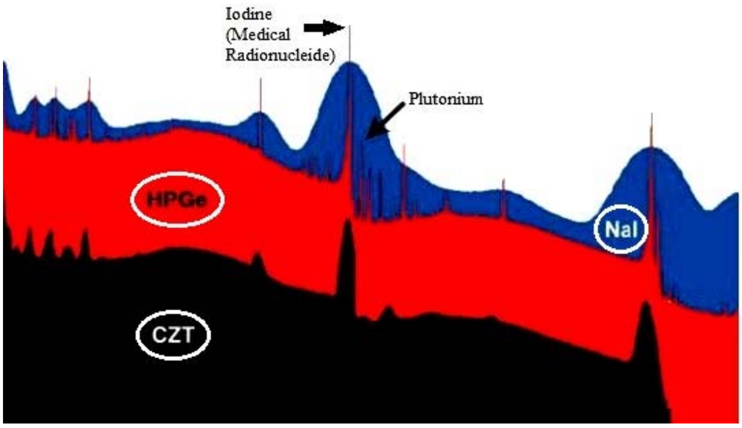

Figure 1: Radioactive material fingerprints viewed with three type detector

The characteristic peaks from iodine and plutonium are very close to one another. However, in the blue (NaI) and black (CZT) graphs, they appear like one peak, whereas in the red graph (HPGe) the peaks are clearly sharp and recognizable. As we see from the sample above, HPGe detectors has a very important place in the field of medical radioisotopes. For that reason the importance of optimization of HPGe detector's efficiency and other features became important working area by using MC codes.

The Study

As a code we used the MCNP program which developed in Los Alamos National laboratory. MCNP is capable to simulate with neutron, gamma and secondary gamma rays production and transport which occur as a result of neutron interactions (Hançerlioğulları, 2006). We developed an input for modeling HPGe detector. Modeling of the detector geometry as cross-sectional view shown in below. In figure 2, there are 2 main environments such as germanium and vacuum.

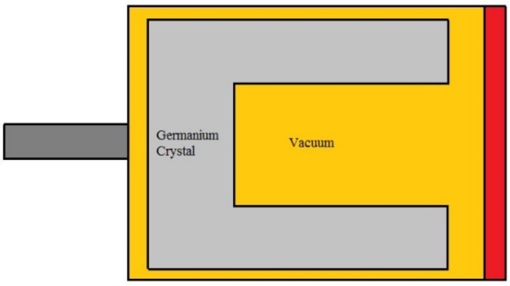

Figure 2: Modeled HPGe detector by using MC code

We introduced each environment physical quantities and requested pulse height distribution data from detector volume cell. To request different information from the MCNP code in output file, we need to introduce different tally. In this study, we used the F8 tally for MCNP output data which gives the pulse height distribution in a cell (Shultis, 2011).

Findings

In this study we made some studies after modeling HPGe detector. As a first step of these studies, we directed 4MeV energy photon beam onto detector volume. We know that an energetic photon beam loses energy in detector volume after some physical interactions with detector materials (Watson, 2009). We can see that in the simulation process this physical rule is taking place and photon energy decreases. We can see in figure 3, the energy-count spectrum of the photon beam and also we can see the fingerprint energy peak of 4 MeV photon in the spectrum

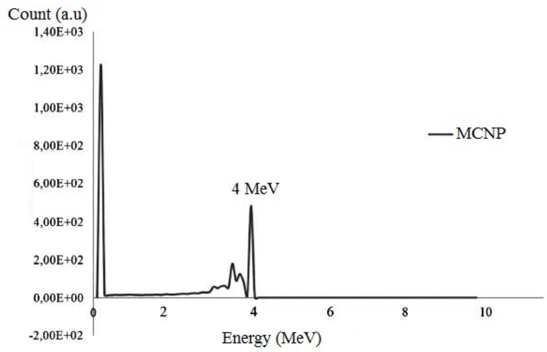

Figure 3: Energy-count spectrum of 4 MeV photon beam

Conclusions

In the field of medical radionuclides the importance of HPGe detectors were discussed. The geometry modeling process and main steps were also introduced. As we see from this work, MC method is an effective method that can simulate the HPGe detectors efficiently. It was found from this work that for future studies such as detector material and volume optimization MC can be used for these studies.

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