Abstract

The frequent comorbidity of cardiovascular diseases and cancer necessitates the use of radiotherapy in patients with cardiac conditions who have implanted devices for heart stimulation. These devices are susceptible to various types of radiation damage during exposure to therapeutic radiation. Particularly hazardous may be neutron radiation, which occurs as a side effect of radiotherapy. This primarily concerns thermal neutrons, which can cause so-called single-event effects, i.e., events triggered by a single particle. In microprocessors, a single neutron passing through RAM memory can lead to a change in the state of a memory bit, resulting in device malfunction or permanent damage. In response to this problem, the aim of this doctoral thesis was to design a neutron shield intended to protect implanted cardiological devices during radiotherapy.

The thesis includes a literature review based on scientific publications. It presents issues related to neutron radiation, its characteristics, occurrence in radiotherapy, and its impact on heart stimulation devices. A concept for the design of a neutron shield is presented. Computer simulations, including the Monte Carlo method, its application in neutron physics, and the Geant4 programming environment, are also described.

In the research part, the methods of measurement and data analysis are discussed. The structure of the simulation programs related to the design of the neutron shield, such as the selection of the appropriate material and its thickness, is detailed. The process of prototyping the designed shield using 3D printing technology is presented. Experimental methods used to verify the effectiveness of the shield are described. The measurement setup for relative neutron and photon detection using the InSpector1000 detection system, consisting of a helium chamber and a NaI scintillation detector, is explained. Using a semiconductor germanium detector HPGe, neutron absorption in a boron carbide-filled shield was measured, and the gamma radiation attenuation coefficient was determined. The results were analyzed using a spreadsheet and programs written in C++.