II International Scientific Conference «Innovative Technologies of Nuclear Medicine and Radiation Diagnostics and Therapy»

Prompt gamma-ray spectrometry for boron-neutron capture therapy

V. Konovalova[1,2], D. Kasatov [1,2], E. Sokolova[1,2], Ia. Kolesnikov [1,2], I. Schudlo[1,2], P. Ponomarev[1], S. Taskaev[1,2]

[1] Budker Institute of Nuclear Physics, Novosibirsk, Russia
[2] Novosibirsk State University, Novosibirsk, Russia
e-mail address: v.konovalova1@g.nsu.ru

Boron neutron capture therapy (BNCT) is a promising method for the treatment of malignant tumors. In 94% of cases, as a result of the nuclear reaction $^{10}B(n,\alpha)^{7}Li$, a lithium nucleus in an excited state is born, which instantly (in a time of about 0.1 psec) emits a gamma-quantum with an energy of 478 keV. At the same time the lithium nucleus with energy 0.84 MeV and the α-particle with energy 1.47 MeV lose their energy in a volume of the order of the size of one cell. Gamma-quantum has a path length of about 20 cm in water or human tissues. So the energy released in the nuclear reaction is localized in the area of high concentration of boron-10, it allows to destroy cells of malignant tumor by selective way and minimize the impact of radiation on healthy tissues. Currently, the issue of neutron generation for BNCT has been successfully solved. In this work, neutrons were generated using the compact accelerator-based neutron source VITA, which allows generating neutrons of a wide range of energies.

An important unresolved problem for realization of the BNCT method is the control of the dose received during irradiation by the patient's tissues. This work is dedicated to finding a solution to this problem. A promising solution to this problem is the method of prompt gamma spectrometry. The method is based on the registration of prompt gamma-quanta with energy 478 keV as a result of the reaction

$^{10}B(n,\alpha)^{7}Li$. So far, the method of prompt gamma-ray spectrometry has not been introduced into practice due to the complication of its realization.

In this paper we propose a scheme of realization of the prompt gamma spectrometry method on the VITA accelerator-based neutron source. Problems of realization of this method are discussed and the ways of their solution are proposed. The results of experiments on registration of gamma quanta with energy 478 keV, passed through boron-containing samples and different volumes of water, are presented and discussed. The obtained spectra are discussed with a clearly distinguishable 478 keV line with the predicted Doppler broadening. A linear dependence of the radiation intensity on the concentration of boron-10 isotopes and an exponential dependence on the volume of water which the radiation passed through are presented.

The possibility of using a semiconductor detector made of high purity germanium for boron dose measurement in boron neutron capture therapy by prompt gamma spectrometry is demonstrated.

This research was funded by Russian Science Foundation, grant number 19 72 30005, https://rscf.ru/project/19-72-30005.