Summary

Radioisotopes of some elements play an important role in nuclear medicine – including medical diagnostics. Currently, there is a risk of a supply crisis in the molybdenum isotope ^{99}Mo, whose daughter isotope is ^{99m}Tc, which is one of the most commonly used isotopes for diagnostic tests. In the light of rapidly changing global conditions, the continuity of supply of this isotope may be threatened for many reasons. It is therefore important to provide an alternative route for isotope production at a relatively low operating cost of the production method. So far, crises in the global production of radioisotopes have been mainly related to the operation of nuclear reactors of a research nature (e.g. the reactor in Canada in 2008). Another reason may be endangered transport routes due to wars. The answer to potential problems with ensuring the availability of radionuclide ^{99}Mo may be an alternative way of producing technetium for nuclear medicine. The method of obtaining ^{99}Mo using a linear accelerator was investigated.

The experiments were carried out on a proprietary measuring system enabling the manipulation of electron beam energy, using a linear accelerator. The subject of the research was the study of the production of the isotope ^{99}Mo from ^{100}Mo, which was primarily aimed at making the production of technetium ^{99m}Tc independent of the nuclear reactor. The experiments may contribute to the future use of the most popular isotope technetium ^{99m}Tc in nuclear medicine. The production of the isotope ^{99}Mo by electron beam in a natural molybdenum disk was investigated. As part of the doctoral thesis, the possibility of using the available linear electron accelerator was investigated. By using a conversion disc (e.g. tungsten or tantalum of appropriate thickness), high-energy photons are obtained and can trigger photonuclear reactions leading to the formation of radioactive isotopes. In order to detect and verify the radioisotopes resulting from irradiation, semiconductor radiation spectrometers like germanium HPGe detector with Tukan8k software were used. The research was based on simulations conducted using the Monte Carlo method. Numerical calculations were carried out in FLUKA with flair interface. Additional verification (comparison of expected activities) was verified using the GEANT4 code version 4.9.2 installed on the Linux platform. Due to the fact that the most popular radionuclide in nuclear medicine is technetium ^{99m}Tc, the production of the "mother" isotope (molybdenum ^{99}Mo) is crucial from the point of view of supplying centers (hospitals, medical centers). The Technetium isotope commonly used for diagnostic tests (e.g. cardiac perfusion tests, cancer detection) has a half-life of about 6 hours. Currently, nuclear reactors are mainly used for the production of the isotope, such as the Polish research reactor MARIA. ^{99}Mo is obtained primarily by reactor. The daughter isotope production method requires the extraction and separation of the molybdenum ^{99}Mo isotope from other uranium fission products. This requires cooperation with laboratories with access to expensive technology for the treatment of highly radioactive materials. Samples irradiated in the Maria reactor must travel a long way (to the Netherlands and back) in order to be cleaned of unnecessary fission products. For example, the POLATOM Radioisotope Centre receives a finished and pure ^{99}Mo product and then uses it to prepare molybdenum-technetium generators. The methods proposed in the

paper do not generate high-level radioactive waste, as in the case of uranium fission. The 99Mo production method is a competitive production path to reactor production, due to the relatively higher availability of materials and linear accelerators and the relatively low costs of the method itself. In addition, a nuclear reactor is much more expensive in terms of maintenance, unlike an accelerator that can be turned on or off at any time.

The first part of this doctoral dissertation is based on literature and available scientific articles. The introduction contains a concise outline of the problem and focuses on showing the characteristics of the proposed production method. The descriptive part presents issues related to the knowledge of current methods of radioisotope production. The applications of the system for the production of radionuclides, methods of their production and brief characterization of their basic physical properties are presented. Examples of experiments as well as measurements and calculations are presented in the second part of this work. The experimental part of the dissertation presents spectra of gamma radiation (emitted by the resulting radioactive isotopes) from irradiated shields measured with a semiconductor detector (HPGe), as well as the results of experiments on irradiation of molybdenum discs (natural molybdenum). Discussion of specialist literature allows to compile and compare the results of experiments and refer accordingly to the results obtained. This allows the possibility of producing the ^{99}Mo isotope to be assessed.