METHODS OF TEACHING THE BIOLOGICAL EFFECTS OF NUCLEAR RADIATION BASED ON THE INTEGRATION OF NUCLEAR PHYSICS AND MEDICINE

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Abstract. *This article describes the methodology of teaching the biological effects of nuclear radiation based on the integration of nuclear knowledge and medicine in the training of future physics teachers. The physical foundations of nuclear technology are analyzed.*

Keywords: *nuclear physics, nuclear knowledge, nuclear radiation, biological effects, medicine, nuclear technology, computed tomography, proton therapy.*

INTRODUCTION

Currently, the use of nuclear energy and nuclear technologies is increasingly entering the life of mankind. If in the early period the nuclear industry was understood only as nuclear power plants and nuclear weapons, at present it is difficult to imagine human life without nuclear technologies. Now, when it comes to nuclear technologies, we are faced with scientific research ranging from the origin of the Universe to trips on nuclear icebreakers to places inaccessible to humans on the globe, as well as a variety of ways to treat various ailments. The development of nuclear technologies requires the training of personnel who are proficient in these technologies. From this point of view, a detailed analysis of physical processes and their patterns used in nuclear technologies in teaching atomic and nuclear physics in the process of training future physics teachers contributes to improving the competence of trained specialists and, subsequently, training the necessary personnel for the nuclear industry.

This article describes the methodology for implementing the integration of education and production by analyzing the nuclear processes underlying nuclear technologies used in modern medicine. In the course of atomic and nuclear physics, X-ray radiation emitted at the atomic level, high-frequency gamma radiation emitted by the atomic nucleus, elementary particles and their antiparticles are studied as separate topics. The analysis of the main properties and patterns of these processes in physical education, and the areas of their application leads to an in-depth study of the topic, a creative and innovative approach to these topics, which, in turn, forms students' motivation and views on subjects from a scientific point of view.

RESEARCH METHODOLOGY

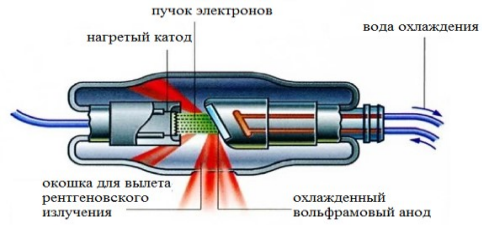
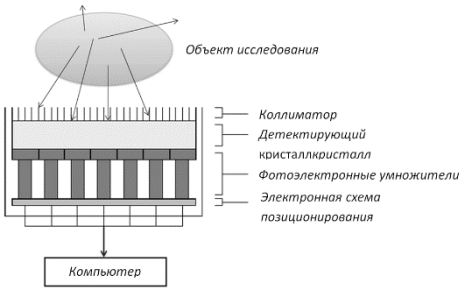
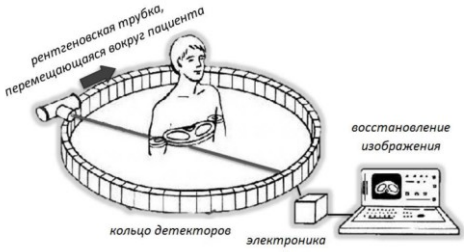
Nuclear medicine is one of the most innovative and rapidly developing areas of modern medicine. Nuclear medicine methods help doctors to identify malignant cancer cells at an early stage of the disease development, which makes it possible to be treated with confidence. Nuclear medicine is the diagnosis and treatment of diseases using pharmaceuticals containing radioactive isotopes, called radiopharmaceuticals. Diagnosis at the early stages of any disease is important, and the uniqueness of nuclear medicine methods allows you to identify abnormalities of vital organ functions in the early stages of cancer, that is, during the period when a person does not feel the symptoms of the disease. This is convenient for saving treatment costs, allowing you to quickly identify and treat various diseases.

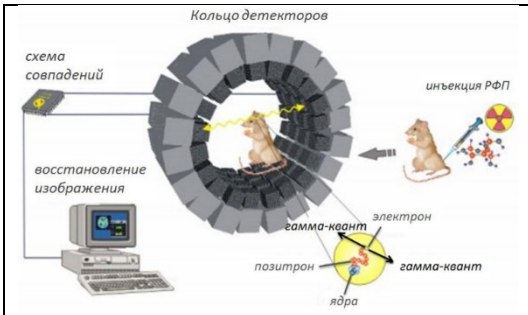
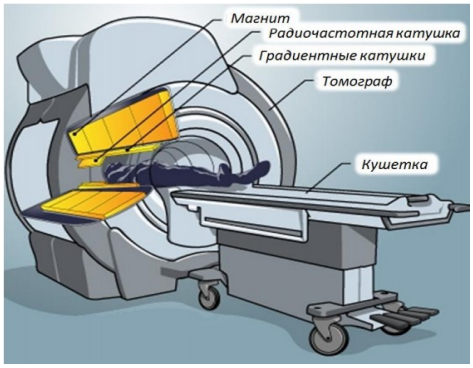
ANALYSIS AND RESULTS

In modern medicine, nuclear technologies mainly pursue two goals: they are used for diagnostic and therapeutic purposes. Single-photon computed tomography (SPECT), computed tomography (CT), positron emission tomography (PET) and magnetic resonance imaging (MRI) are used for diagnostic purposes. Table 1 summarizes the structure, the principle of operation of nuclear diagnostic devices in medicine and the physical processes underlying the principle of operation of this device.

Table 1

Nuclear diagnostics devices in medicine

Name of the device	Operating principle	Application
Radiography 	is based on the high absorption capacity of X-rays, as well as on different absorption in different environments	Determination of changes in the human body caused by colds, poisoning and other factors
OFEKT-single-photon emission tomography 	The device works on the basis of registration through a scintillation detector of gamma radiation from a radioactive source coming from into the blood. The radionuclides used in this device include ^{99m}Tc, ^{201}Tl, ^{123}I,^{131}I, , ^{131}I,11in and ^{67}Ga	It is widely used for the diagnosis of Alzheimer's disease, traumatic brain injury, cancer, as well as for the examination of patients after a heart attack, the study of blood flow in the heart and vascular system
Computed tomography (KT) 	To obtain a three-dimensional image of the area under study, the device uses an X-ray tube rotating around the ring of detectors, as well as a sliding table with a certain step	.With the help of computed tomography, you can study almost all areas of the human body. This method can also be used to check the performance of blood vessels and heart muscle in " real time"mode
Positron emission tomography (ПЭТРЕТ), two-photon tomography	The operation of the device is based on the annihilation of positrons emitted by a short-lived radioisotope introduced into the human body with electrons of the medium. In this process, gamma rays	This device is used to diagnose changes in the brain and heart, as well as to detect various tumors and metastases

	emitted in opposite directions are detected on detectors connected to the corresponding matching scheme,and thus it is possible to determine the direction of annihilation, as well as the location of detection of the included radioisotope. Mainly used radioisotopes ^{13C}C, ^{13N}, 15O are mainly used, ^{15O}O	
MRT-Magnetic resonance imaging (nuclear magnetic resonanceimaging) 	The operation of the device is based on the absorption of radio-frequency radiation in the magnetic field of some atomic nuclei and the emission of radiation of the same frequency after the exposure is stopped. For the phenomenon of nuclear magnetic resonance, the nuclei ^{1H}H, ^{13C}C, ^{23N}N, ^{31}P, 31P in the human body are used.	This device is mainly used to study bone structures in the brain and spinal cord, as well as to check the blood flow rate and activation of the cerebral cortex.

Radiotherapy uses X-rays, gamma rays, a stream of electrons, protons and neutrons. Currently, proton therapy is considered the most effective method of treating oncological diseases due to the possibility of accurately selecting the irradiation point.

Standard radiation therapy has evolved and improved over the years. It is an effective remedy for many types of cancer. However, radiation therapy also has a negative impact. The energy of primary photons and secondary electrons diverges along the entire path of radiation, as a result of which radiation affects both healthy tissues before the tumor and beyond. This dose of radiation harms normal cells and can subsequently lead to additional health problems. The advantage of proton therapy is that protons emit most of their energy at the end of their run. That is, when moving through the body, protons slow down, interact with electrons and emit maximum radiation at the end of the path. The point at which protons emit the most energy at the end of their motion is called Bragg's Peak. With the help of theoretical calculations, the doctor can calculate the proton energy required for the Bragg peak to coincide with the cancer center in the patient's body. The action of protons fully corresponds to the shape and depth of the neoplasm, while not affecting healthy tissues and organs. When teaching the topics “Interaction of nuclear radiation with substances”, “Biological effect of nuclear radiation”, in order to explain the effectiveness of various radiations in the treatment of oncological diseases, we use the graphs in Figure 1.

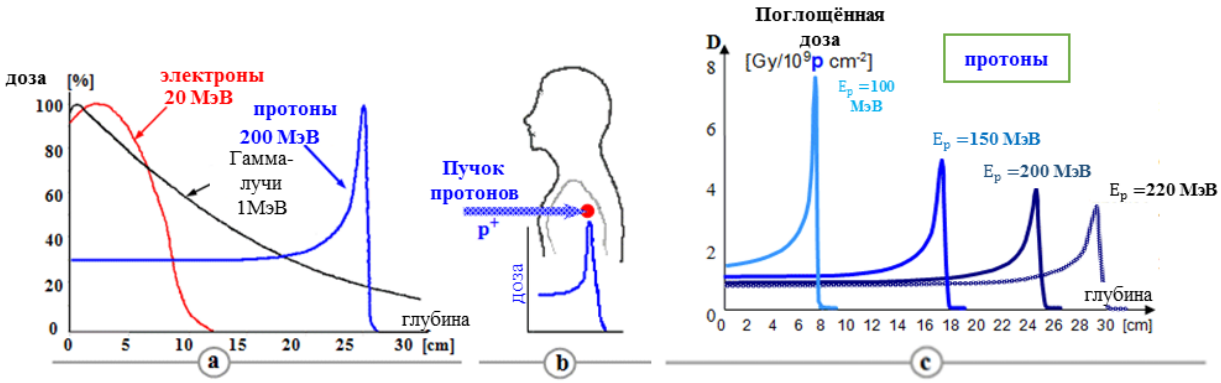


Figure 1. Application of proton therapy in cancer treatment and comparison with electron and gamma therapy

CONCLUSION/RECOMMENDATIONS.

The implementation of the integration of science and nuclear technologies in the teaching of topics in the lessons of atomic and nuclear physics, in-depth study with special attention to the physical laws underlying nuclear technologies, will contribute to improving the effectiveness of teaching. This, in turn, will contribute to the development of the state and society by training highly qualified specialists.

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