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DEVELOPMENT OF A PORTABLE GAMMA PROBE FOR REGISTRATION AND LOCALIZATION OF RADIATION SOURCE, INCLUDING MEDICAL APPLICATION

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Self-powered portable gamma probe has been developed on the base of silicon planar uncooled detector and CsI(Tl) scintillator. The device is designed for interoperative and extraoperative search for differences in the concentration of radiopharmaceuticals in the energy range from 100 to 360 keV. Test stand was developed for determining the angular resolution of the gamma probe.

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INTRODUCTION

In recent years, the use of radiopharmaceuticals and gamma probes for the detection and localization of lymph nodes affected by cancer has been expanding in medicine [1–3].

The goal of this work is the development of a portable gamma probe for the registration and localization of radiation source, including medical application.

A silicon planar uncooling detector, electronic modules of a charge-sensitive preamplifier, power supply and shaper preamplifier, designed at the NSC KIPT, and a CsI(Tl) scintillator were used for research.

The development of electronic modules of a charge-sensitive preamplifier and a shaper preamplifier with a digital display module and a power supply block for a mockup model of an autonomous portable gamma probe for registration and localization of the radiopharmaceuticals radiation source was carried out.

The device under development is designed for interoperative and extraoperative search for differences in the concentration of radiopharmaceuticals in the energy range from 100 to 360 keV (^{99m}Tc, ^{123}I, ^{111}In, ^{131}I).

Radiation in such a range is effectively registered using a complex detector, consisting of a scintillator and a photodetector, as which a silicon planar uncooling detector is used. The efficiency of the combination of silicon detector and scintillator is ensured due to the fact that the sensitivity of the silicone detector reaches 70% of maximum radiation of the scintillator.

1. STRUCTURAL DIAGRAM OF A GAMMA PROBE

Structurally, the portable gamma probe consists of two functionally completed units – a detection unit and a main unit. The detection unit contains silicon detector, scintillator, collimator, and charge-sensitive preamplifier [4]. The main unit includes a shaping preamplifier, a discriminator, a central processor unit (CPU), a power supply and an LCD indicator (Fig. 1). The units are interconnected by a flexible cable 1.5 m long.

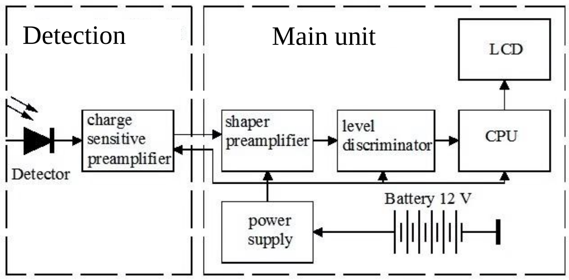

Fig. 1. Structural diagram of a portable gamma probe

The discriminator, which is part of the portable gamma probe, has two thresholds, upper and lower. This allows to get rid of background pulses and increase the measurement accuracy. The portable gamma probe is powered by a 12 V battery, which solves the problem of electrically safe use of the device.

The spectrometric characteristics of the developed electronic system are shown in [4].

2. DESIGN OF THE DETECTION UNIT

The design of the detection unit for a portable gamma probe is made up of a complex detector of the type "unpackaged silicon uncooled detector – scintillator" and a collimator, which forms the angular characteristics of a gamma probe, as well as a charge-sensitive preamplifier (CSP).

A draft design of a portable gamma probe detection unit construction with a conditionally cut out housing, collimator and electronic board is shown in Fig. 2.

Part of the technological solutions was developed during the development and preparation of detecting modules for the registration of ionizing radiation on the basis of bare silicon uncooled detectors [5-7].

The diameter of the cylindrical part of the detecting unit housing is 18 mm, the length is 140 mm. Scintillator and silicon detector with an active area of (2x2) mm^2 are surrounded on all sides by a collimator that shields the scintillator and a detector from radiation from the side directions.

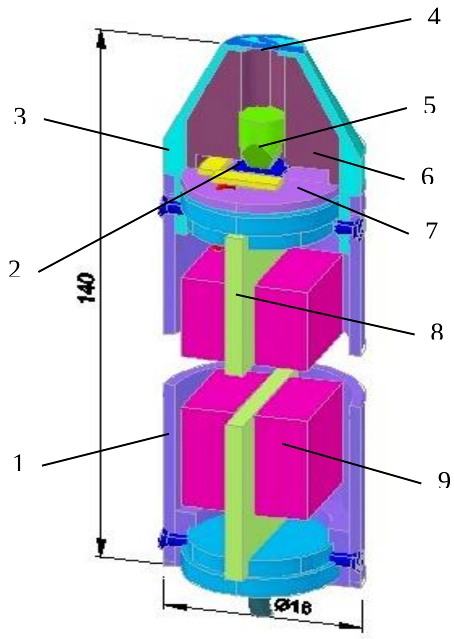

Fig. 2. Detection unit design: 1 – cylindrical part of the housing; 2 – silicon detector; 3 – conical part of the housing; 4 – inlet window; 5 – CsI(Tl) scintillator; 6 and 7 – collimator; 8 – CSP board; 9 – CSP components

The collimator is made of lead or tungsten, which have a high half-value layer of the attenuation of X-ray and gamma radiation. Silicon detector, CsI(Tl) scintillator and collimator are housed in the conical steel part of the hermetic housing, which protects sensitive for mechanical and chemical damage bare silicon detector, scintillator and wire loops for electrical connection detector with CSP against damage. The electronic board of the detection unit CSP is housed in the cylindrical part of the housing.

The value of the half-value layer of lead is 4.8 mm, of tungsten – 3.3 mm [8]. The scintillator and the detector are located opposite the inlet window with a diameter of 3 mm, through which the registration of the radiation is performed. To ensure tightness, the inlet window is closed with 7 um aluminum foil.

The electrical connection of the detector pads with the gold-plated copper intermediate terminals is bonded with 25 μm diameter aluminum wire by the ultrasonic bonding machine. The intermediate terminals are connected with CSP by the MGTF 0.12 wire by soldering [6].

Before manufacturing the detection unit, the static characteristics of the silicon detectors were tested using the equipment described in [9] and selected for the manufacture of the detection units research samples [6].

3. MEASURING THE ANGULAR RESOLUTION OF A GAMMA PROBE

To measure the angular resolution of the detection unit a design of a measuring stand was developed. The chart of measuring stand is shown in Fig. 3.

The stand consists of boards on which a detection unit, a paraffin unit, and a radiation source are installed. Source ^{57}Co is used as the radiation source. The paraffin block is used as a tissue equivalent phantom.

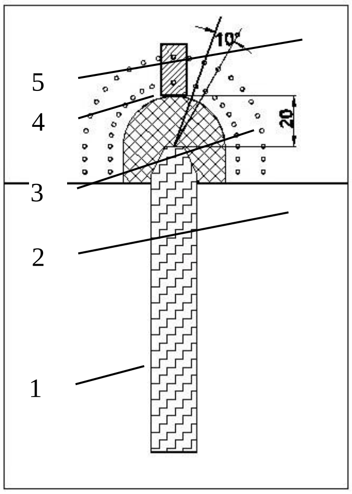

Fig. 3. Chart of stand for measuring the detection unit angular resolution: 1 – detection unit mounting board; 2 – detection unit; 3 – paraffin block; 4 – radiation source board; 5 – radiation source

The radiation source has two pins and can be placed into the holes in the board around the inlet window of the detection unit with the same distance to the inlet window with a resolution of 10º.

In the above chart, the distance between the source and the inlet window of the detection unit is 20 mm. In a real application, the distance from the radiation source can vary, and therefore, exchangeable source boards and paraffin blocks of a similar design have also been developed. They allow more advanced measurements of the angular resolution at a distance of 10, 30, and 40 mm.

CONCLUSIONS

Testing of static characteristics of bare silicon planar uncooled detectors and analysis of detectors characteristics and CsI(Tl) scintillators for using in the portable gamma probe for registration and localization of radiation source was performed.

Design of the detection unit for the portable gamma probe for registration and localization of X-ray and gamma radiation consists of a detecting module and a charge-sensitive preamplifier.

The design of the main unit that includes a shaping preamplifier, a discriminator, a processor unit, a power supply and an LCD indicator was developed.

The software for registration and visualization of the results was developed.

Test stand for measuring the angular resolution of the detection unit of the portable gamma probe has been developed.

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РОЗРОБКА ПОРТАТИВНОГО ГАММА-ЗОНДУ ДЛЯ РЕЄСТРАЦІЇ І ЛОКАЛІЗАЦІЇ ДЖЕРЕЛ ВИПРОМІНЮВАННЯ, У ТОМУ ЧИСЛІ ДЛЯ МЕДИЧНОГО ЗАСТОСУВАННЯ

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На базі кремнієвого планарного неохолоджуваного детектора і сцинтилятора CsI(Tl) розроблений портативний гамма-зонд з автономним живленням. Прилад розрахований на інтероперативний та екстраоперативний пошуки відмінностей у концентрації радіофармацевтичних препаратів у енергетичному діапазоні 100 до 360 кеВ. Розроблено тестовий стенд для визначення кутового розподілу гамма-зонда.