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A Study of a Gamma Camera in Nuclear Medicine

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Abstract— The purpose of this paper is to describe the gamma camera device for medical imaging and to show how nuclear medicine helps in diagnostic.

Index Terms— Collimators, technetium-99m and crystal.

Figure 1 – Gamma Camera

I.INTRODUCTION

Nuclear Medicine is a medical specialty containing the application of radioactive isotopes in order to both diagnosis and treatment of disease [1]. Using isotopes we are able to produce radiation which is created in the body of the patient, which can image the exact, invisible for us, situation in the patient's body. As we know, there are three different types of nuclear radiations. Alpha particles consist of two protons and two neutrons bound together.

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This type of radiation is very dangerous for human organism due to the high relative biological effectiveness of alpha radiation to cause biological damage. Second one – Beta particles is just another name of electrons, which are also harmful. The third kind of radiation is gamma ray – electromagnetic radiation of high frequency and therefore high energy, which is commonly used in nuclear medicine because gamma ray in relevant amount is not so hazardous. The most commonly used isotope is technetium-99m - a metastable nuclear isomer of technetium-99. Its unique half-life for gamma emission is approximately 6 hours, which means that almost 94% it decays in 24 hours.

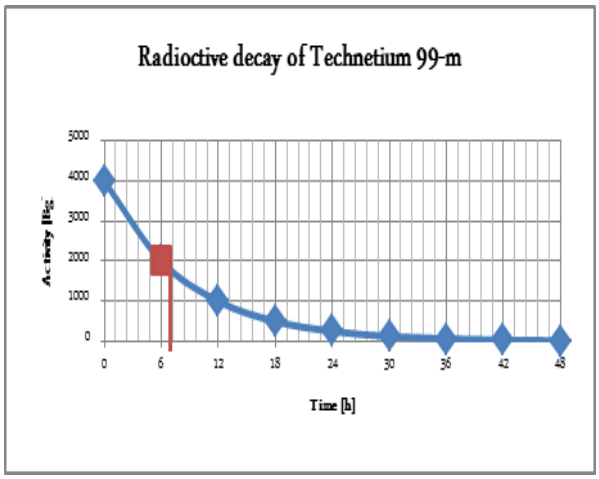

Figure 2 – Half-life – 6 hours

Another commonly used isotope is Iodine-131 which half-life is 8.1 days. Moreover it is named as high energy isotope. These two are bounded to variety of proteins to get special movement of isotope in human body.

II .GAMMA CAMARA'S CONSTRUCTION

Gamma Camera is a device designed to catch the gamma rays created in patient's body [2]. The crucial part of the machine is detection crystal. Its feature is extraordinary scintillates. Whereas it is on influence of gamma ray it emits sparks of light. The reason of that process is a knock, of a gamma photon, an electron loose from an iodine atom in the crystal. To boost the light signals above of the crystal there is

an array of vacuum tube photomultipliers arranged in hexagon configuration.

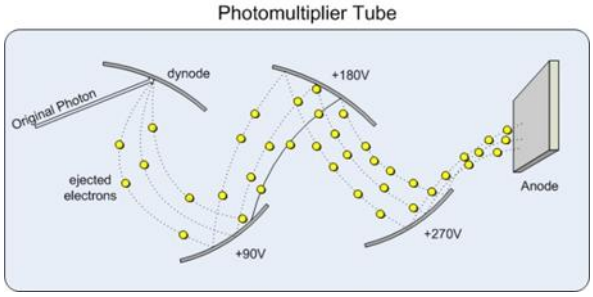

Figure 3 – Photomultiplier tube

This arrangement helps to improve the resolution of image. The exact location of the flash can be found by weighting the position of each photomultiplier tube and the signals' amplitudes to calculate the mean position between them.[3].

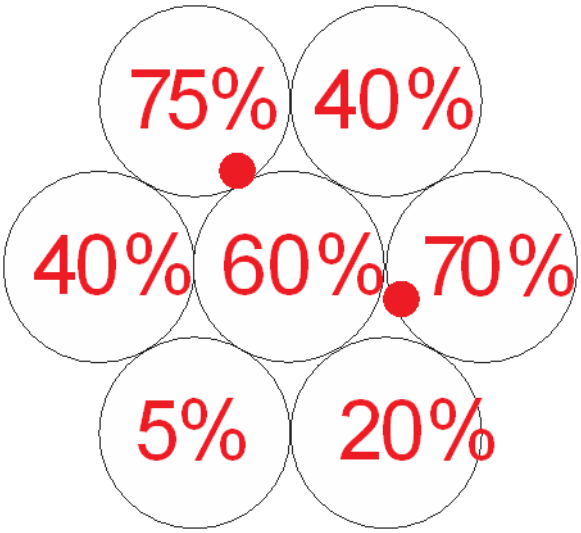

Figure 4 – Calculating mean position

Position logistic circuits are used in order to digitalize the results from the photomultipliers. Its main task is to gather the signals (mentioned before position calculation takes place here) and send information to the computer where full image is processed .Preventing lead shield is rounded the whole camera.

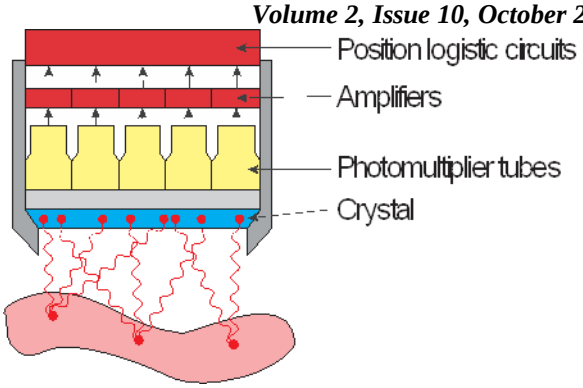

Figure 5 – Gamma camera construction (without collimator)

III COLLIMATORS

Figure 6 – Part of parallel collimator

Whereas the patient body is generating gamma rays, from every position of isotopes gamma rays are radiating in every single direction which makes "false flashes" produced by the crystal[4]. To prevent that situation between the patient and the crystal there is collimator. It is a device designed to filter every radiation stream that is non-parallel.

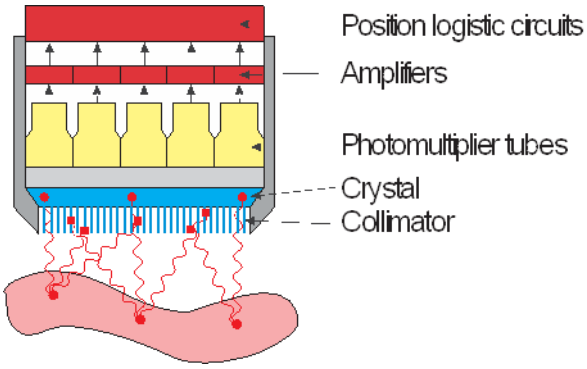

Figure 7 – Gamma camera construction (with collimator)

There are four standard (parallel hole) types of collimators:

- LEAP – Low Energy All-Purpose

- LEHR – Low Energy High-Resolution
- MEGP – Medium Energy General Purpose
- HEGP – High Energy General Purpose

In those designs all holes are parallel to each other. LEAP collimators have holes with a large diameter, which makes it both high sensitivity one and with modest resolution. LEHR collimators are enhanced from LEAP ones[7]. They have smaller-diameter holes, which allow them to adjacent closer to each other, which provides the higher resolution. In that type the holes are also deeper which increase the accuracy of image. MEGP and HEGP are used to medium and high energy photons of nuclides. These collimators have thicker septal than previous ones in order to reduce septal penetration, which simultaneously makes them less accurate.

Gamma camera uses collimator thus the image is made by isomeric projection [6]. However, it doesn't make the result inefficient. The closer the camera is to the patient's body, the less noise is generated but the area of examination is the same. Noise is read because of non-parallel stream of gamma rays. The further the collimator is the readable area of one hole extends.

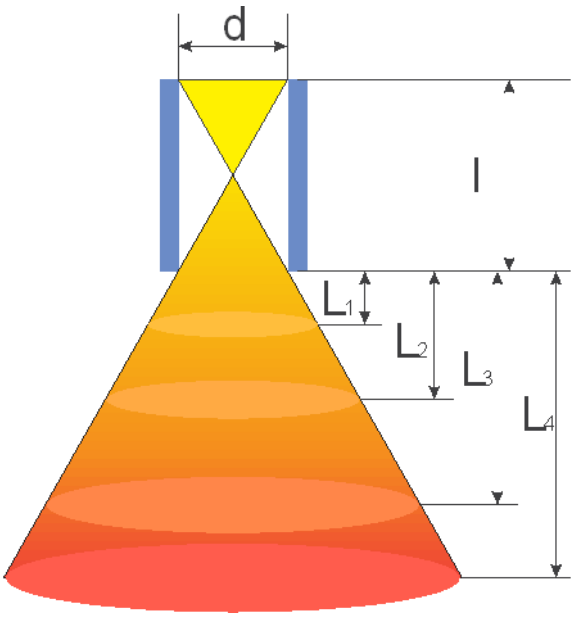

Figure 8 – Readable area dependent on hole deep and diameter, and distance object from collimator

IV. IMAGE PROCESSING

Very first image that is processed through device is layered grayscale file. Every layer consists of points that were read in a period of time. These layers are laid one on another which makes whole grayscale picture. To improve visibility image processing programs use two main functions. The firs one is improvement of the contrast. It can show thinks that were not seen before and emphasis the main problem. Another type of increasing availability of data in the picture is using false color picture. Algorithm uses few colors in the grayscale section. The images are falsely colored but they can provide new information.

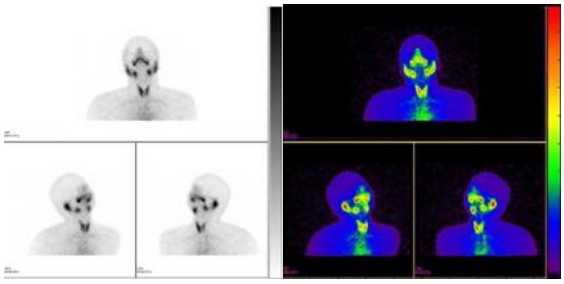

Figure 9 – On the left clear image from gamma camera, on the right false colored image

V. RESULTS

Thanks to gamma camera we can acquire much information about situation inside the body, which first was invisible. Figure 9 shows thyroid scan. To examine that organ technetium-99m was used. On Figure 10 is placed bone scan, where was used iodine-131. Figure 11 contains information about kidneys operation. Graph shows how many isotopes particles are in kidney through the time.

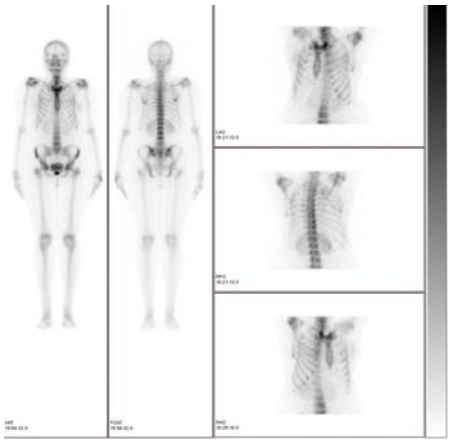

Figure 10 – Bone scan

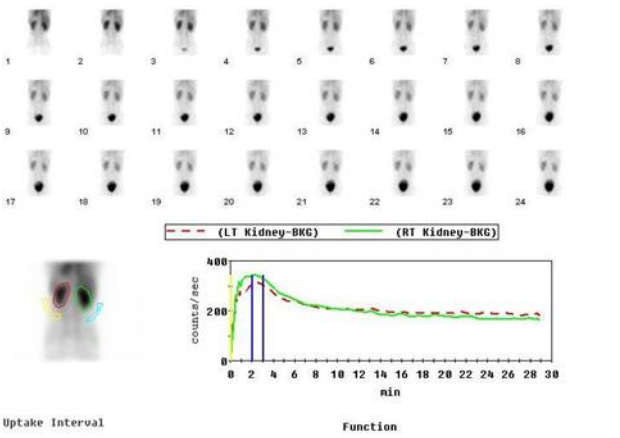

Figure 11 – Kidney scan

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VIII. ACKNOWLEDGEMENT

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