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The Optimization of Gamma Camera Using Changed the Area of Semiconductor Detectors by MCNP Code

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Abstract

In this paper we tried to substitute an appropriate detector instead of NaI. The features of semiconductor detectors were studied to find a detector which works at the ordinary temperature, has less FWHM and more resolution. Therefore HgI_2 and CZT detectors were selected and studied. The gamma camera with three difference detectors (NaI, HgI_2 and CZT detectors) were simulated. We have shown that the resolution of HgI_2 and CZT detectors are better than NaI. Studding of area variation of CZT, HgI_2 and NaI detectors, the minimum FWHM and maximum resolution obtained at4.8 mm × 4.8 mm area. Finally the area of detectors hole were modified in order to gain the best possible pictures.

Keywords-:*Semiconductor; gamma camera; detector.*

I. Introduction

In this paper we tried to substitute an appropriate detector instead of NaI that has better qualities as follows.

a- It should have more sensitivity by comparison with NaI.

b- It should record more radiations for a given radioactivity and decrease the patient's exposure by improving the detector efficiency , practically.

c- It should be able to do detection at the ordinary room temperature.

d- It should has better efficiency.

e- It should has better resolution relative to NaI or in other word its FWHM is smaller than NaI FWHM.

II. Simulating gamma camera by NaI detector

In this experiment, we have simulated a gamma camera that consists of a tungesten collimator, NaI(TL) detector and a photomultiplier tube [1].

talium impurity in NaI(TL) detector results in more light in photography and because the amount of talium in sodium crystal was negligible it has been left out.

We have defined some parameters in simulation programs as the following: the collimator is 2.504 cm high, every wall is of 0.16 cm tick with octagon holes that the distance between two sides is 0.111 cm. the NaI detector has a rectangular cubic shape. It is 61.4 cm long, 61.4 cm width and 0.95 cm high. After the detector there is a photomultiplier tube and this arrangement comprises the gamma camera [1-6].

While taking pictures the gamma camera is placed 10 cm above the capillary tube and NaI detector is supposed as a lattice structure crystal that consists of 128*128 single crystals [1].

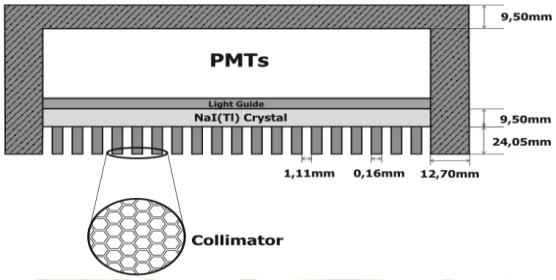

Figure 1. The cross section of the SIEMENS gamma camera.

III. The comparison between NaI, CZT and HgI_2 simulation results

By comparing the results that are gained by simulating NaI, CZT and HgI_2 detectors it can be shown that the FWHM of CZT and HgI_2 detectors are lower than sodium iodide FWHM and therefor the resolution of them is more than sodium iodide.

Table 1. The results of gamma camera with different detectors.

Detector type	The FWHM of photopeak(KeV)
NaI	23.3
HgI_2	16.5
CZT	10.5

In this stage the size, the shape and the material type of collimator and also the detector height(thickness) are constant but the size (area) of detector is variable [4,5].

IV. The investigation of the variations in the size of HgI_2 Detector

By keeping the height of HgI_2 detector constant we investigate the variations of the detector size[5].

Table 2. The results of gamma camera simulation by changing the size of HgI_2 detector.

the sizes of collimator (mm)	the size and the height of detector (mm)	The FWHM of photopeak (KeV)
The Aperture (hole) diameter 1.11, the height 24.05	3.6×3.6 and the height 9.5	18.5
The Aperture (hole) diameter 1.11, the height 24.05	4.8×4.86 and the height 9.5	16.5
The Aperture (hole) diameter 1.11, the height 24.05	9.6×9.6 6 and the height 9.5	42.5

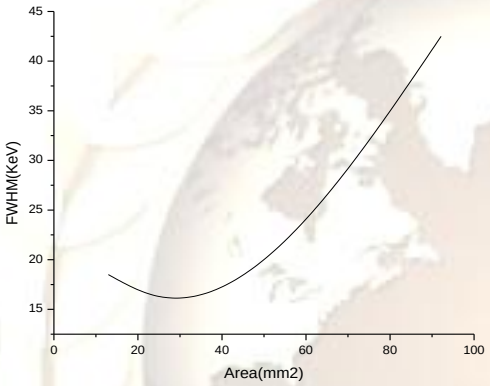

Figure 2. FWHM versus the area of HgI_2 detector.

V. The investigation of the variations in the size of CZT detector

By keeping the height of CZT detector we study the variations of the detector size [2,3].

Table 3. the results of gamma camera simulation by changing the size of CZT detector.

the sizes of collimator (mm)	the size and the height of detector (mm)	The FWHM of photopeak (KeV)
The Aperture (hole) diameter 1.11, the height 24.05	3.6×3.6 and the height 9.5	26.1
The Aperture (hole) diameter 1.11, the height 24.05	4.8×4.86 and the height 9.5	10.5
The Aperture (hole) diameter 1.11, the height 24.05	9.6×9.6 6 and the height 9.5	21

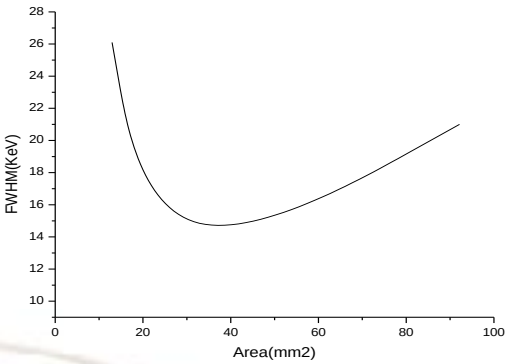

Figure 3. FWHM versus the area of CZT detector.

VI. The investigation of the variations in the size of NaI detector

By keeping the height of NaI detector constant we study the variations of the detector size [1].

Table 4. the results of gamma camera simulation by changing the size of NaI detector.

the sizes of collimator (mm)	the size and the height of detector (mm)	The FWHM of photopeak (KeV)
The Aperture (hole) diameter 1.11, the height 24.05	3.6×3.6 and the height 9.5	24
The Aperture (hole) diameter 1.11, the height 24.05	4.8×4.86 and the height 9.5	23.3
The Aperture (hole) diameter 1.11, the height 24.05	9.6×9.6 6 and the height 9.5	32.3

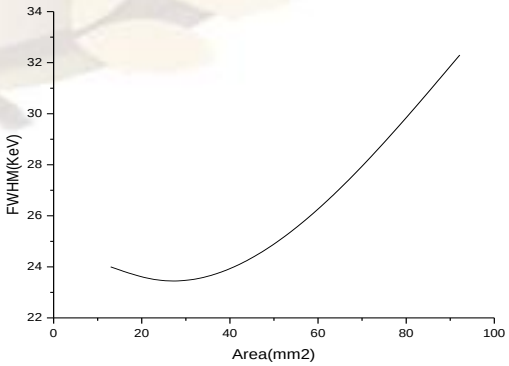

Figure 4. The FWHM against the size NaI detector

VII. Conclusion

According to the obtained results , the full width at half maximum of CZT and HgI_2 is less than NaI detector and therefor their resolution. Also by studying the size variations in these three detectors, the least FWHM and the highest resolution for the size of 4.8mm ×4.8mm was gained. In the new generation of gamma cameras that are designed for taking pictures of a human's whole body, the standard size of detector crystal is 4.8mm×4.8mm in order to the gamma rays scatter just one time and there exist a high probability for leaving off the crystal before they could react again. and this conforms to the obtained result. Finally the best picture was obtained after optimizing the detector features.

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