THE PERFORMANCE CHARACTERISTIC OF A ROD WIRE PARALLEL HOLE COLLIMATOR FOR GAMMA CAMERA

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I dedicate this to my parents for their loves and kindness, my friends for their care and help and my supervisor for her care and her help to me along the project is being done.

ABSTRACT

Gamma camera or gamma detector is a device to capture the image of gamma radiation emitting radioisotopes. The gamma camera is the imaging technique used to carry out functional scan of the organ in the patient's body such as brain, thyroid, lungs, liver and others to detect the abnormal cells like a tumour or cancer. It contains of four main part, which is collimator, scintillator, photomultiplier and computer. The collimator will be the target of this project where it acts as a filter of the gamma camera. The problem with the collimator is its weight and difficult to handle. In this project is to propose the design of the rod collimator made from a series of tungsten wire with lighter weight and have a comparable performance compare to the standard parallel hole collimator. Since gamma camera involves nuclear energy radiation, preliminary work on designing the component of the device must be using simulation tools rather than real experimentation as it is involving a nuclear radiation. A low energy general purpose rod collimator was designed and simulated using MCNP5 software. Hole size, septa thickness and collimator thickness are the parameters that are needed to consider for designing of the collimator. The simulation results was then processed by MATLAB software for the image processing step. In this project, a software called MCNP5 was used to construct the gamma camera and the rod wire collimator to run

the simulation using a low energy point source. The output PTRAC file was processed by the Matlab software to generate the image and improve the image quality. The results given by the rod wire collimator is surprisingly well in which its weight reduce by 72.9% from 42kg to 11.4kg with comparable performance in term of resolution. Since the weight is reduced with comparable resolution, this collimator can be applied in the portable gamma camera

ABSTRAK

Kamera gamma atau detektor gamma adalah peranti untuk menangkap imej sinaran gamma dari radioisotop. Kamera gamma adalah teknik pengimejan yang digunakan untuk mengendalikan imbasan fungsi organ di tubuh pesakit seperti otak, tiroid, paru-paru, hati dan lain-lain untuk mengesan sel yang tidak normal seperti tumor atau kanser. Ia mengandungi empat bahagian utama, iaitu kolimator, scintillator, photomultiplier dan komputer. Kolimator akan menjadi sasaran projek ini di mana ia berfungsi sebagai penapis kamera gamma. Masalah dengan kolimator adalah berat dan sukar untuk dikendalikan. Projek ini membina reka bentuk kolimator batang yang diperbuat daripada siri wayar tungsten yang lebih ringan dan mempunyai prestasi berbanding berbanding dengan kolimator standard. Oleh kerana kamera gamma melibatkan sinaran tenaga nuklear, kerja awal untuk merancang komponen peranti mesti menggunakan alat simulasi dan bukan percubaan sebenar kerana ia melibatkan radiasi nuklear. Kolimator batang tujuan umum yang rendah akan direkabentuk dan disimulasikan menggunakan perisian MCNP5. Saiz lubang, ketebalan septa dan ketebalan kolimator adalah parameter yang perlu dipertimbangkan untuk mereka bentuk kolimator. Hasil simulasi akan diproses oleh MATLAB untuk langkah pemprosesan imej. Dalam projek ini, satu perisian yang bernama MCNP5 telah diguna

untuk membina struktur gamma kamera dan kolimator untuk diuji dengan satu titik sumber yang mempunyai tenaga yang rendah. Hasil daripada ujian MCNP5 telah diproses oleh Matlab untuk menghasilkan gambar sumber tersebut and meningkatkan kualiti gambar. Hasil daripada reka bentuk kolimator telahpun mengurangkan berat sebanyak 72.9% iaitu dari 42kg kepada 11.4kg dengan prestasi yang standing dengan standard. Berat kolimator telehpun dikurangkan dengan prestasi yang setanding, oleh itu kolimator ini boleh digunakan dalam kamera gamma mudah alih.

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LEGP	:	Low Energy General Purpose
MCNP5	:	Monte Carlo N-Particles version 5
PSF	:	Point Spread Function

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CHAPTER 1

INTRODUCTION

This chapter discusses about the project background, problem statement, objective and scope of work.

1.1 Project Overview

Gamma camera is a device that is able to image the gamma radiation that emitted by tracer introduced to patient's body. Gamma camera is applied in Scintigraphy technique among the medical imaging. In the gamma camera, the collimator will be the first component that is facing the patient's body to collect and filter the gamma

radiation[1–4]. The most common used collimator is called parallel hole collimator. However, there were still other types of collimator such as converging, diverging and pinhole collimators. Converging collimator which provided the best combination of image resolution and sensitivity in a specific distance range, but the distance of this collimator is limited to a certain distance. Then, diverging collimator offered a larger imaging area but in the exchange of resolution and sensitivity. Another type of collimator is pinhole collimators that gave a very good resolution and reasonable sensitivity to the user. The problem with this collimator is that it loses its sensitivity very fast with distance. Comparing with other collimators, parallel hole collimator had a better stability, the resolution and sensitivity are higher than diverging and pinhole collimators[3]. To design a parallel hole collimator, there are a few parameters need to consider such as hole diameter, septal thickness and collimator thickness. Different combination of parameters results in different models of collimator such as low energy high resolution (LEHR) collimator and low energy general purpose (LEGP) collimator. In this project, the design will be a focus on low energy general purpose collimator.

1.2 Problem Statement

The collimator is one of the parts of the gamma camera that is used to filter the undesirable gamma ray to improve the image quality and make sure the position of the organ is correct. There are many types of the collimator in the market where the most

common collimator is called parallel hole collimator. Since collimator is dealing with radioactive material, the wall of the collimator that absorb and attenuate those gamma rays need to have a relatively large density and atomic number so that it can perform a good work[3]. The requirement of high-density material as collimator walls make collimator must face to the problem that collimator is very bulky, weighting about 40kg and more which results in the difficulties to handle this component[5]. There was some other design to replace conventional parallel hole collimator but the problem is that the lacking of sensitivity or resolution as a trade-off for the reduction of weight[6]. A bulky collimator will cause it to a situation that it is very hard to handle. This kind of hard handling collimator will not very suitable to be applied in a portable gamma camera. The reason is that a portable gamma camera will need to change its collimator's model due to the requirement of usage, the collimator will be damaged very easily if the collimator is too hard to handle. A collimator that is too heavy is not reasonable to apply in portable gamma camera and this portable gamma camera is playing a significant role in the medical field.

1.3 Objective

This project aims to propose the optimum configuration of the low energy general-purpose wire collimator gamma camera that is a lighter and comparable performance with the standard parallel hole. In order to achieve that, the following objectives have been set: