Assessment of a shielding for a portable thyroid uptake system using Monte Carlo simulation

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Introduction

Scintillation detectors are still mostly used in detection probes for applications involving diagnostic and therapy of thyroid uptake tests in nuclear medicine (NM) exams. The use of this type of detector is justified by its high energy detection efficiency as compared with other devices.[1]

The diagnosis of thyroid disease using thyroid uptake systems in NM is performed as follow: first it is important to measure the incorporation of iodine by the gland, obtained through the use of capture probes. This probe is a simple system composed by a conventional crystal detector optically coupled to one photomultiplier tube. This set up is enclosed by a shielding of lead to avoid undesirable radiations that hits the detector window excepts the radiation coming directly from the thyroid gland. The photons that reach the detector are processed by an electronic counting system of nuclear events. The Figure 1 shows a typical room used for thyroid uptake tests in hospitals.

Fig. 1: Thyroid uptake system for "in-vivo" tests used in Nuclear Medicine Services.

Due to the high efficiency detection characteristic, the detector should be shielded as well to avoid or to reduce the background and undesirable radiation. We have acknowledged that a typical shielding is a very heavy device. Nevertheless, it is possible to simulate the best geometry that fits the desirable characteristics in order to obtain a light and portable equipment easily handled in therapy intensive units (ITU) or patients rooms. The Figure 2 shows a proposed application for thyroid uptake systems in patient or ITU found in most hospitals.

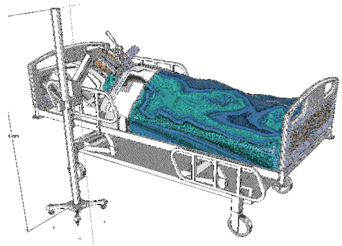

Fig. 2: A possible arrangement for thyroid uptake tests used in hospital room.

Materials and methods

The detector used is a typical solid crystal monoline model 1M1/1.5, crystal size 1" x 1", hermetically coupled to a 1.5" photomultiplier.

This specific detector model was used for simulation due to its smaller dimensions in order to reduce the total weight of the probe.

All the presented results have been achieved with simulated point source using detail physics and material data from the standard interaction libraries from MCNPX code.

Our goal is to reduce the original beam intensity (coming from source without shielding) up to 50% at least. Simulations have been performed using a spherical model layers and a point radioactive source pointed toward to detector center. The result is based on system response as a function of deposited energy (MeV/g) in the scintillation detector and the shielding layer thickness for a point source energy. The code output is presented in graphics as shown in the Figure 3. This work aims to optimize the shielding heavier material (Pb) thickness, so it becomes most efficient and light as possible. Further studies will be performed on a cylindrical model for detector and shielding instead of a spherical modeling used in the present work.

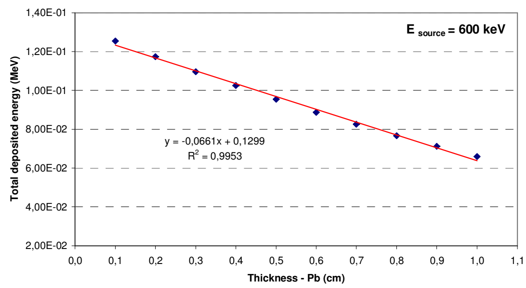

Fig. 3: Dependency of total deposited energy in detector as a function of lead thickness.

References

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