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Simulation of a TH-GEM based detector for standard mammography-quality beam dosimetry using the MCNP5 code

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Introduction

The GEM based detectors have found applications in many areas due to their simplicity of construction, low cost, ruggedness and diversity of shape. A dosimeter with these qualities presents utility in several applications, as for example in diagnostic and therapeutic medicine and industrial radiography. Furthermore, the high sensitivity provided by GEM detectors may extend their applications in low dose dosimetry [1]. With the aim of producing a prototype of a TH-GEM based detector with characteristics suitable for dosimetric use in low and medium energy X-rays, the components were simulated, using the MCNP5 code, to determine the geometries and materials suitable for its use. Precise determination of the dosimeter characteristics is very important for instrument calibration laboratories as well as to determine how the various components of the detector may influence the energy deposited on the sensitive volume. The results obtained are presented on the influence of each of the components present in this type of detector in standard mammography beams. The results allowed the adaptation of the detector to the conditions of interest.

Methods

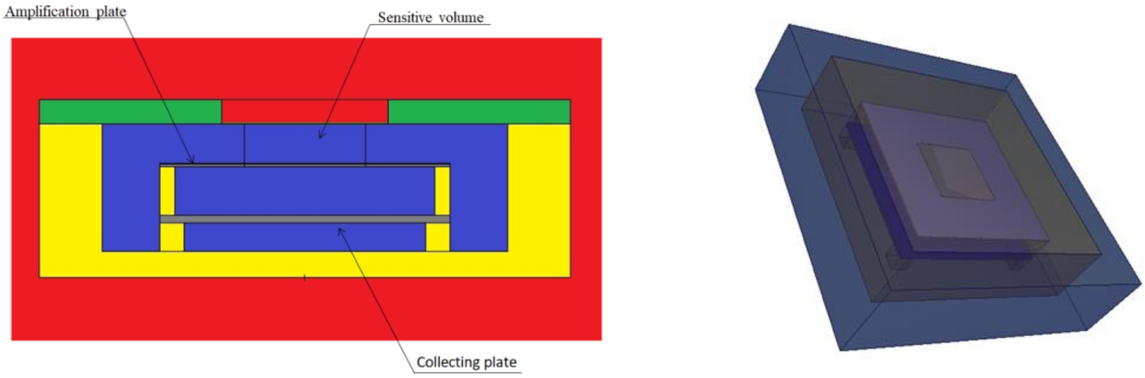
In this work the MCNP5 (Monte Carlo N-Particle) radiation transport code, developed by the Los Alamos National Laboratory (LANL), was used to determine the influence of each component on the energy deposited in the sensitive volume, due to its versatility and simplicity in the construction of geometries and sources [2]. The MCNP code works with a system of importance that defines how the particles interact with the medium. By using zero importance in a given environment, particles entering this space will be eliminated. In other words, space with zero importance will behave as an ideal absorber, not generating transmission or scattering. Thus, to evaluate the influence of each component on the detector response, some simulations were performed alternating their importance to zero and comparing them with the value obtained with importance one. The tally used was F8, for photons and electrons, which provides the energy deposited in MeV.

The radiation beam was simulated in a conical format with a diameter of 12 cm. The focal point of the radiation source was placed at a distance of 100 cm from the detector entrance window. The standard radiation quality used was WMV28, which uses a tube voltage of 28 kV, a current of 10 mA and a filtration of 0.07 mm of molybdenum.

Results

Figure 1(a) shows the geometry used in the simulation of the TH-GEM detector with the materials of each component. The input window and the copper coating of the printed circuit boards are not visible in the figure. The sensitive volume is the region where the energy deposited in the simulation is obtained. It refers to a parallelepiped in front of the region of the orifices of the amplification plate. A three-dimensional view is shown in Figure 1(b).

Figure 1 - (a) Transverse section of the TH-GEM detector modeled by the MCNP5 code, visualized with Vised X22S software. The color Red represents dry air; Green: aluminum shielding; Blue: Argon gas filling the detector; Yellow: Poluoxymethylene enclosing and separators; Gray: fiberglass amplification and collecting plate. (b) Three-dimensional view of the TH-GEM detector.



(a) (b)

The influence values on the response of the detector for each component obtained are: enclosure: 0.09%; collecting plate: 0.01%; shielding: 1.50%; and amplification plate: 44.0%. It is possible to observe that the TH-GEM detector enclosure and the collecting plate present insignificant influences. The thickness of the shielding was chosen in order to minimize the radiation transfer to the sensitive volume other than the one incident on the entrance window (efficiency value of 98.5%). The amplification plate presented a considerable influence. This result takes into account the secondary electrons emitted.

A concrete wall of 15 cm thickness was simulated behind the detector at distances of 50 cm, 30 cm, 10 cm, 5 cm and 1 cm and no difference was observed. The difference between the energy deposited in the sensitive volume obtained with the simulation, with and without the entrance window was: 8.9% for the aluminium entrance window and 0.33% for the aluminized Mylar entrance window.

Conclusions

The aluminum shield of 6 mm showed an efficiency of 98.5%. The TH-GEM detector enclosure and the collecting plate presented insignificant influence on the energy deposited at the sensitive volume of the detector. No influence for the transmission of photons in the environment was observed on the energy deposited in the sensitive volume, showing that an extra shield is not necessary. The TH-GEM detector enclosure and collecting plate presented insignificant influences on the energy deposited on the sensitive volume. The available detector entrance window that showed the best result was the aluminized Mylar case.

References

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