Comparison Between Two Monte Carlo Simulations of Angiographic Phantom Coupled to Silicon Strip Detector

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Abstract. Preliminary results of a dual energy angiography simulation using the Monte Carlo package GEANT 3.2113 \cite{1} are presented and compared to Monte Carlo MCNP-4C \cite{2} results reported before \cite{3}. The simulation is based on an experimental set up consisting of a Plexiglas-aluminium step wedge phantom with 4 cylindrical cavities filled with iodated contrast medium. The silicon 384 microstrip detector was set into edge-on configuration (incoming X-rays parallel to longitudinal axis of the strips) and the properties of the simulated detector just resemble the ones of the real detector. Monochromatic photon beams of 31.5keV and 35.5keV are used to take advantage of the discontinuous variation of the iodine photon absorption at the energy of the K-shell, the key to dual energy subtraction imaging.

INTRODUCTION

Research in the fields of acquisition and processing of radiological images aims improvement of their quality while reducing the morbidity of the procedures, which includes reduction of the radiation doses to the patients and devising less invasive techniques (for example for the cases in which contrast media must be used). As a
whole, these improvements will mean a better diagnosis which will not constitute an extra threat to the patient’s health.

Development of silicon microstrip detectors to be used in dual energy imaging is part of these efforts, and the Monte Carlo simulations here presented aim to contribute to the designing of such detectors. The simulations correspond to an angiographic set up which uses an iodated solution as contrast medium. Results obtained with the transport code GEANT 3.21 are compared to the results obtained with the code MCNP-4C.

**SET UP**

The geometry set up specified in GEANT consists of the phantom and the detector. The phantom (see Fig. 1) has four levels, each one composed of a 0.2 cm aluminium layer and a 1 cm Plexiglas layer, except the first one which lacks aluminium. Tubes are contained in the first level and are made up of a solution defined as a mixture of water and iodine with a concentration of 370 mg I/ml. The detector is placed directly under the phantom and both objects are in contact.

The detector was defined as a uniform silicon box with dimensions (1.153 x 3.91 x 0.03) cm³. The perimetrical zone of this box is taken as the dead region of the detector, and has a width of 0.0765 cm, so that the region where particles are counted (active region) is (1 x 3.838 x 0.03) cm³. (See Fig. 2 and Table 1)

<table>
<thead>
<tr>
<th>TABLE 1. Detector Characteristics.</th>
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<tr>
<td>Item</td>
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<td>Strip Length</td>
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<tr>
<td>Thickness</td>
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<tr>
<td>Dead Region (edge – on config.)</td>
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<tr>
<td>Strip Pitch</td>
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<td>Strip Width</td>
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<td>Channels</td>
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**FIGURE 1.** Schematic representation of the phantom.  
**FIGURE 2.** Silicon microstrip detector with 384 strips connected to electronic board.
RESULTS

Once the material and volume parameters have been defined, we set monochromatic incident beams of photons from point sources with two energies, 31.5 keV and 35.5 keV. Photons that interact in the active region of the detector producing electrons are counted so that a profile is obtained for each energy, then a background factor is calculated for each step for the highest energy, in order to obtain the same level of background in the profiles of both energies (background is understood as the signal due to other materials than the iodated solution). This makes that after the K-shell subtraction the background levels cancel each other and the resulting profile shows four absorption peaks with approximately the same height on a nearly flat background level around zero Y-axis.

Figure 3 shows the profiles for 35.5 keV obtained with MCNP-4C and from measurement [3]. Figure 4 has the profiles from GEANT for both energies. We can observe the absorption of the tubes in the middle of every step of the phantom.
CONCLUSION

Comparison of the K-shell subtractions of these two Monte Carlo simulations shows that the results obtained are very similar and that both packages simulate comparatively well the interaction of X-rays with the set up. This comparison also suggests that GEANT is able to perform good simulations to be used in the field of diagnosis radiology; however, the specific conditions of a simulation, such as the energy range used, could make that the limitations of GEANT as a high-energy oriented package could not be overcome. In this specific simulation in which incident particle energies were above 30 keV, GEANT has proved to be useful.

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REFERENCES