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STUDY OF DIFFERENT PARAMETERS IN THE SIMULATION OF DIAGNOSTIC X-RAY SPECTRA USING THE MCNPX CODE

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Introduction: In this work, diagnostic X-ray spectra were simulated through the Monte Carlo method, using the MCNPX code, which were compared to those obtained by the SpekCalc and xpecgen softwares (semi-empirical models), for validation purposes. Variation of X-ray tube parameters such as energy, filtration and anode angle were taken. Furthermore, analyzes were carried out regarding changes in the PHYS card, specific to the MCNP, due to discrepancies between the methods, found in the literature, related to the production of characteristic X-rays.

Material and method: Monte Carlo simulations were performed by introducing X-ray tube specifications as the electron source, electron beam incidence angle, the target material, the anode angle and the aluminum filtration, in the MCNPX code. The tube's geometry was modeled, using a lead-coated cylinder, where, in its interior under vacuum, a tungsten target and the source were inserted.

For the analyses, the energy was varied between 50 and 140 keV. With the energy fixed at 110 keV, the anode angle was varied between 8º and 22º and the aluminum filtration thickness was also varied by 1, 1.5, 2 and 2.5 mm. In addition, the sixth (bnum) and seventh (xnum) entries of the PHYS:E card have been changed to evaluate their influence in the spectra.

The X-ray spectra were measured using a point detector (tally F5) with a radius of 0.5 cm at a distance of 100 cm from the focal spot. This tally measures the photon flux at one point (MeV/cm^2).

The simulated spectra were compared to those obtained in SpekCalc and xpecgen, through a normalization over the total area of the curve and the conformity between them, expressed through the percentage difference between their areas.

Results: Figure 1 shows the comparison between the X-ray spectra for electron energy of 110 keV. The relative error (R) ranged around 1% for 1e7 stories. The F5 tally requires a statistical uncertainty of less than 5%; therefore, the simulations carried out in this work produced satisfactory results.

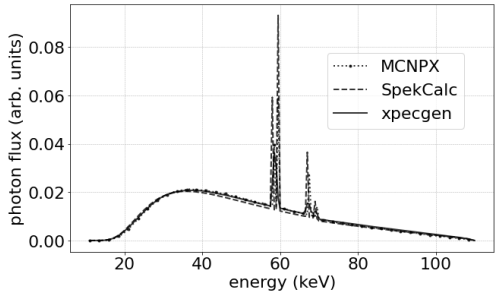

Figure 1: Comparison of simulated X-ray spectra using MCNPX code and SpekCalc and xpecgen softwares, for 110 keV.

The difference between the simulated spectrum in MCNPX and the spectra of commercial softwares for 110 keV energy was 5% and 3.4%, respectively.

The percentages of 7.7% (SpekCalc) and 5% (xpecgen) for the energy of 140 keV were the largest differences obtained in this study. Furthermore, the increase in aluminum thickness resulted in an increase of the difference between spectra.

The difference increased with the increase of the anode angle for xpecgen, while for SpekCalc there was a reduction. The largest differences presented in each of them correspond to 3.67% and 4.79%.

Changes to the PHYS:E card inputs had no impact on the simulated spectra.

Conclusions: Most of the differences between spectra were below or close to 5%, with the exception of the higher energy (140 keV), due to the intensity of characteristic X-ray peaks, which concentrate almost all differences obtained. The (bnum) and (xnum) entries of the PHYS:E card do not influence the spectra shape or intensity, but do improve the simulated statistics. The results of this study are in good agreement with commercial X-ray spectra generators.