NaI(Tl) detector response functions using mathematical modeling

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This report presents a method to calculate the NaI(Tl) detector response function using the radioactive sources and MCNPX code [1]. The detector must be modeled as accurately as possible because variations in detector dimensions and characteristics can introduce large errors in determining [2]. In order to estimate the actual active volume of the crystal, which may differ from the manufacturers stated data, two-point sources were used, ^{241}Am and ^{137}Cs. The geometry was reproduced by simulation and the results were compared with the experimental values. The procedure performs an interactive process between the counts obtained in the simulation and the variation of crystal thickness [3]. The detector model proposed is shown in Figure 1.

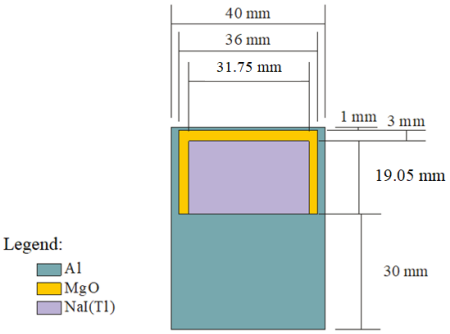

Figure 1. NaI(Tl) detector model.

The pulse height distribution (PHD) due to photons and electrons in the sensitive region of the crystal was obtained using the F8 tally. To experimentally validate the mathematical model of the NaI(Tl) detector developed in the MCNPX code, the photopeak absolute efficiency (PAE) was used using calibrated radiation sources in the investigated energy range. The PAE curve obtained experimentally and by mathematical modeling as a function of energy are shown in Figure 2. The experimental and simulation efficiencies showed good agreement and present a maximum relative error of 11.7% for the energy of 356 keV of the ^{133}Ba.

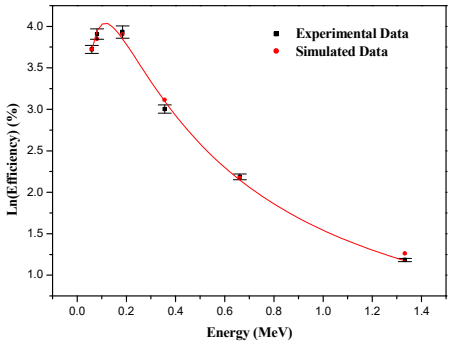

Figure 2. Efficiency curve.

In order to consider the energy resolution of detector in the MCNPX code it is necessary to use a special treatment for the PHD in which the peaks behave as a Gaussian broadening using GEB command of the FTn card. It is necessary to use the experimental curve FWHM on the energy function (at each photopeak region). The results are represented in Figure 3.

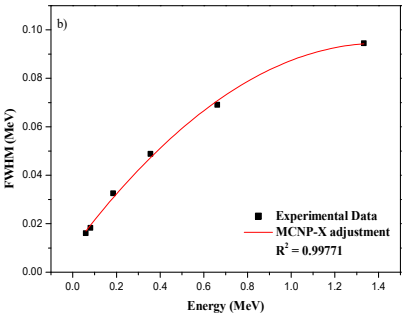

Figure 3. FWHM Function response curve.

The final results show acceptable concordance in the photopeak region, but for the low energy range the PHD has some discrepancy, which is commonly reported as inaccuracy in low energy electron simulation and photon scattering on shield and holder of detector.

References

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