Determination of the thickness of an aluminum sample using the MCNPX code

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Keywords: MCNPX code, thickness, attenuation coefficient.

This report aims to present one experiment to determine the thickness of an aluminum sample, comparing simulated results in MCNPX code [1] with results obtained experimentally, recording the uncertainty associated with these measurements. Some steps are essential for carrying out the practice, such as checking the operating voltage of the detector; the energy window that corresponds to the photoelectric absorption region with a source of ^{137}Cs using the mono channel and also the multichannel; perform the measures with Al sample; calculate the sample thickness; measure the thickness of the sample; compare the values obtained in the experimental mode and also in the simulated. The experiment was carried out on the date of 09/27/2019, with a source of ^{137}Cs. The measurement of its activity dates from 06/21/2018 and had an activity of 23.308 kBq. According to information taken from the National Institute of Standards and Technology (NIST) [2], the value of the mass attenuation coefficient (μ_m) for Al is 0.074 cm^2.g^{-1}. The density of Al is 2.6989 g.cm^{-3}. These two quantities are multiplied, reaching a value of 0.19972 cm^{-1} to get the linear attenuation coefficient. For the calculation of the linear attenuation coefficient (μ¿, the Beer-Lambert formula was used as shown in the Equation 1.

$$I(x) = I_0 e^{-t}$$

Equation 1

Where I_0 and I are the incident and transmitted beam intensities, respectively. t is the thickness of the sample material. Using this procedure, it was possible to calculate the Al thickness: t = 0.341 cm. In the output file of the MCNPX code, the response obtained by the simulation is the pulse height distribution, registered in the detector using the tally F8 (that also gives the efficiency value). The number of stories used in the simulations, NPS, was 2E7, ensuring a generally reliable record quality. The detector model used in this study is shown in Figure 1.

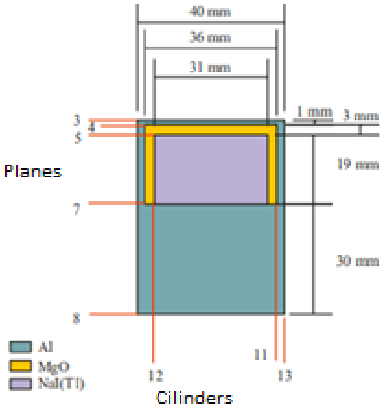

Figure 1. Detector model developed in MCNPX

The input file generated the following geometry in the MCNPX code is shown in Figure 2.

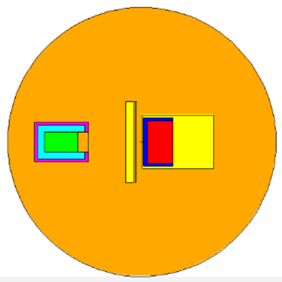

Figure 2. Geometry proposed

Simulations were made, for a pencil-beam, with an Al disk and without it, generating the results through the tally F8: 0.132877 (with Al) and 0.141992 (without Al). Using the Equation 1, the value of the μ for a pencil-beam was 0.194 cm^{-1}, with error of 2.51% relative to the value in the NIST table. New simulations were made, this time for an isotropic beam, generating the results: 2.582E-4 (with Al) and 2.762E-4 (without Al). Using the simulated values for an isotropic beam in Equation 1, an aluminum t thickness of 0.337 cm is obtained, representing an error of 1.17% relative to the analytically calculated value. The values found on both simulations are acceptable in view of the low relative error between the modeled and the experimental, although the pencil bean results should be the reference.

References

[1] PELOWITZ, D. B. “MCNPX TM User's Manual,” Version 2.5.0, LA-CP-05-0369, Los Alamos National Laboratory, 2005.
[2] NIST – National Institute of Standards and Technology.Webpage:https://www.nist.gov/pml/x-ray-mass-attenuation-coefficients.