# Validation of MCNP-X geometry to measurement linear attenuation coefficient

P. N. B., Peixoto[1], C. M., Salgado[2]
e-mail: phbelache@hotmail.com, otero@ien.gov.br

*[1]PUC-RJ; [2]DIRA, IEN*

*Keywords*: linear attenuation coefficient, gamma ray attenuation, MCNP-X code.

This paper presents a methodology for the determination of the linear attenuation coefficient. For this, it is necessary to know precisely the distance between the source-detector system and estimate the divergence of the source for solution by means of an analytical equation. A lead collimator with aperture of 4.75 mm in order to obtain adequate divergence of gamma radiation beam was used at this stage of the work.
In order to validate the alignment and collimation of the geometry of the measurement for the calculation of the linear attenuation coefficient, a study was carried out with a reference material, a tantalum sheet with purity of 99.9% and thickness of 0.010 mm, supplied and measured by *GoodFellow*. The linear attenuation coefficient found experimentally was compared with the value of the literature [1].
The counting time of the measurements was 7200 seconds using a source of $^{137}Cs$ (662 keV). The alignment of the detector with the source was done by positioning a laser through the opening of the collimator.
The procedure used to calculate the linear attenuation coefficient was to measure the initial emission ($I_0$), then the emission measurement with the tantalum sheet (I), as shown in Figure 1. The calculation of the linear attenuation coefficient is done using Equation 1.

$$I = I_o . e^{-\mu . x} \tag{1}$$

Where:
I: transmitted intensity of gamma rays (photons.cm$^{-2}$.s$^{-1}$);
$I_o$: initial incident intensity of gamma rays (photons.cm$^{-2}$.s$^{-1}$);
x: thickness of the absorber (cm);
μ: total linear attenuation coefficient (cm$^{-1}$).

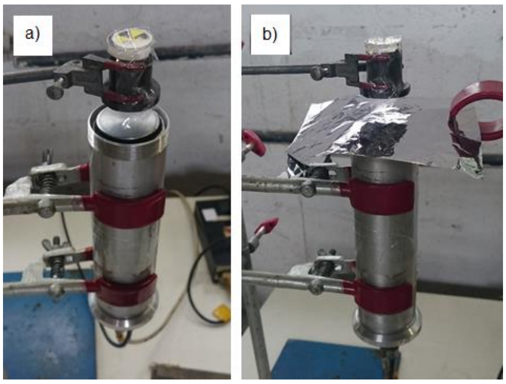

Figure 1. Measuring geometry for tantalum: a) Initial emission; b) Final emission

A comparison of the experimental results obtained with a geometry developed in the MCNP-X code was done, in order to validate the geometry model for future calculations of total linear attenuation coefficients in other energies and in other hydrocarbons.
Following the steps described, the linear attenuation coefficient of the tantalum was measured. In the experiment, the value of the attenuation coefficient equal to 1.467 cm$^{-1}$ ± 0.76 was obtained and through the simulation a value of 1.454 cm$^{-1}$ ± 0.002. In the literature the linear attenuation coefficient of tantalum is 1.504 cm$^{-1}$ for energy of 662 keV [1].
The relative error of this value compared to the simulated was 3.33%. The relative error of the coefficient obtained in the computational simulation relative to the experimental data was 0.89%.
From the experimental validation of the mathematical model, it is possible to calculate the linear attenuation coefficient of the tantalum in a wide range of energy without the need of sources of radiation.

## References

[1] HUBBELL, J. H.; SELTZER, S. M. **Tables of X-ray mass attenuation coefficients and mass energy-absorption coefficients**. Version 1.03. Gaithersburg: National Institute of Standards and Technology. 1997. Disponível em: <http://physics.nist.gov/xaamdi> Acesso em: 9 mar. 2018.
[2] PEIXOTO, P. N. B. **Determinação de frações de volume em fluxos bifásicos óleo-gás e água-gás utilizando redes neurais artificiais e densitometria gama**. 2016, 91 f. Dissertação (Mestrado em Ciência e Tecnologias Nucleares)-, Instituto de Engenharia Nuclear da Comissão Nacional de Energia Nuclear, Rio de Janeiro, 2016.