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#04-21 Characterization of the X-ray spectrum of a linear electron accelerator

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The Nuclear Measurement Laboratory (LMN) at CEA Cadarache in France uses high-energy electron linear accelerators, LINAC (9-20 MeV), to characterize nuclear waste drums or study corium-water interaction. These high-energy accelerators allow to explore new examination modalities, such as active photon interrogation or dual-energy CT to scan large concrete objects with diameters up to 140 cm. These techniques require precise awareness of the photon spectrum emitted by the LINAC. However, direct measure of this photon energy spectrum (for example, with a hyper-pure germanium spectrometer) can not be achieve because of the accelerator pulses causing detector saturation. During the last few years, a large number of indirect methods have been developed. Some employ Monte-Carlo simulation to determine precisely without experimental protocol the accelerator photon energy spectrum. Nevertheless, these methods require a precise knowledge of the accelerator characteristics including electron beam energy spectrum, difficult to assess accurately experimentally or numerically. Other indirect methods are based on an experimental protocol using energy spectrum from the spectroscopy of Compton-scattered photons, or transmission measurements through different thicknesses of a well known material. The latter is the simplest indirect method from an experimental point of view because it can be set up easily and accurately using an ionization chamber as well as an appropriate screen. The obtained transmission curve depends on the photon energy spectrum which can be estimated using inverse models.

In this paper, we present the development of a numerical model to determine energy spectrum from attenuation curve via transmission measurements which combines two types of inverse models: a continue model and a discrete model. The continue model consist in estimating spectrum shape via a continue mathematical function, in our model we use a log-normal function. Photon energy spectrum is first estimated from discrete log-normal equation which gives us the initial spectrum shape and the associated transmission curve. Then, the discrete model consist in tweaking spectrum values channel by channel with an iterative process to minimize cost function between analytical transmission curve of the reconstructed spectrum and the measured curve.

We validate this tool using a test spectrum and its transmission curve obtained via Monte-Carlo simulation (MCNP6). This qualification allowed us to determine its sensitivity (signal-to-noise ratio, SNR) in order to have a good convergence. We show that if the SNR is less than 4%, we have a good estimation of the photon energy spectrum. Then, it was experimentally tested with a transmission curve obtained at the laboratory.

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