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# Assessing the influence of CT acquisition parameters on flaw detectability through simulation

Caroline Vienne<sup>1</sup>, Julie Escoda<sup>1</sup>, Anthony Touron<sup>1</sup>, Marius Costin<sup>1</sup>

<sup>1</sup>Université Paris-Saclay, CEA, List, F-91190, Palaiseau, France, e-mail : caroline.vienne@cea.fr

## Abstract

CIVA is a multi-technique Non-destructive testing simulation software [1], which integrates in particular a radiographic and computed tomographic (RT/CT) module, allowing the modeling of a complete chain for Nondestructive Testing (NDT) inspection with X-ray CT. In this paper, we present the multitude of parameters and possible configurations available for parametric studies and apply this simulation framework for assessing the influence of such parameters on the detectability of a given flaw inserted in a 3D object. A 3D detectability criterion is proposed and will be integrated in the next versions of CIVA to establish probability of detection curves.

**Keywords:** CT simulation, probability of detection, NDT

## 1 CIVA-CT module presentation

The X-ray simulation code models the physics of photon-matter interaction in the range of 1 keV to 100 MeV, through the three most important processes: photoelectric effect, scattering (coherent and incoherent) and pair production. A fast computation of the attenuation is performed with the Beer-Lambert law, to which a Monte Carlo computation is combined in order to estimate the scattering phenomena. Distinct images are computed and fused into a final one, which integrates the influence of the X-ray source (size, spectrum and filtering), the attenuation and scattering of the beam, the photonic noise and the detector response (modulation transfer function, noise model).

The object to inspect is defined as a simple parametric object or using a CAD model and flaws of different shapes can be included and positioned inside it. Figure 1 presents a 3D view of the simulated configuration with a classical circular path and a projection without and with noise.

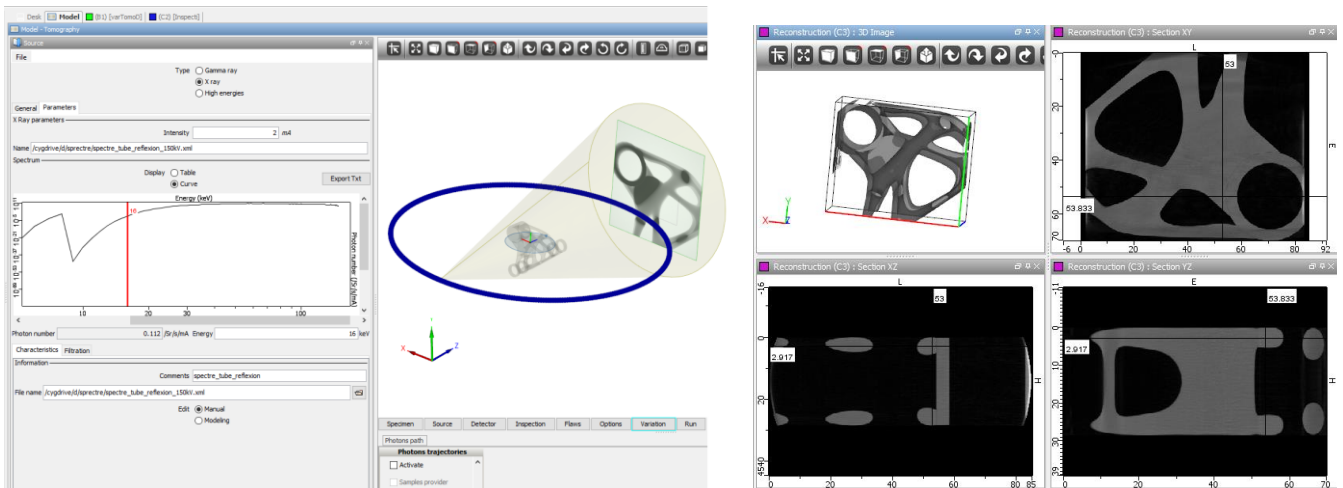


Figure 1: Overview of CIVA CT scene (left) and visualisation of the reconstruction result (right).

## 2 Simulation study

As a first step towards Probability of Detection studies of Computed Tomography using CIVA, we present here a parametric variation of different acquisition parameters of the CT setup (scene geometry, trajectory, X-ray source, etc...) and their influence on the detectability of different flaws.

### 2.1 Use case and variation parameters

We consider here a classical CT configuration for the NDT inspection of a complex aluminium part coming from Additive Manufacturing. To try to answer to the common question on the detectability limit, we integrate in this part several flaws of spherical shape and increasing size. Variations are applied on the location of the flaw in the part as well as on the main acquisition parameters (X-ray tube voltage and filter, number of projections, orientation of the part with respect to the X-ray system ...).

One of the new functionality of CIVA 2021 concerns the application of the reconstruction algorithm (FDK) directly following the generation of the simulation results. Therefore, when running batches of simulation, it is now possible to access the 3D image in addition to the set of radiographic images. As a further step, we aim at integrating a detectability criterion applied to such 3D image, similar to the 2D “Rose” criterion already implemented in CIVA for radiographic configurations [2].

### 2.3 Defining a detectability criterion

The objective of a detectability criterion is not to automatically detect a flaw in a reconstructed image but rather to quantify the detectability of an existing flaw in this image. We use the knowledge of the flaw we have modeled, such as its shape and location in the 3D volume, to build our new criterion. The proposed criterion involves the contrast value (mean grey value difference between the flaw and its neighborhood), the noise and a weighting factor linked to the size of the flaw in terms of pixels (see Figure 2).

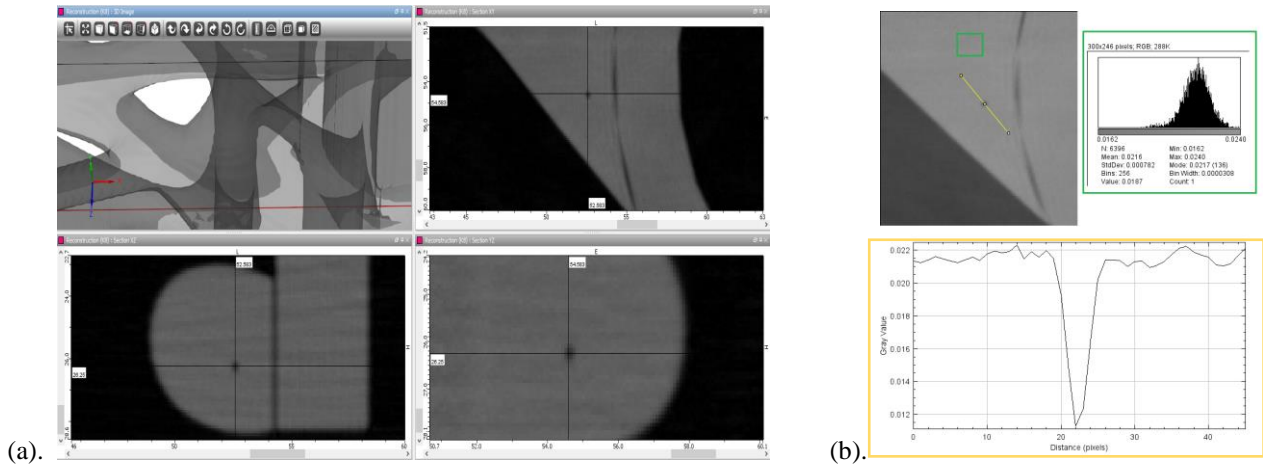


Figure 2: Visualisation of the simulated flaw in the reconstructed image (a) and quantitative values computed from the 3D image to compute the detectability criterion (b).

### 3 Preliminary results

Figure 3 shows one slice of the CT reconstruction result around the region of interest of one inserted flaw of 300 μm diameter for three configurations corresponding to different X-ray source parameters. The detectability criterion C computed on these images is displayed for each configuration and gives a first estimation of the best X-ray settings for the detection of this porosity.

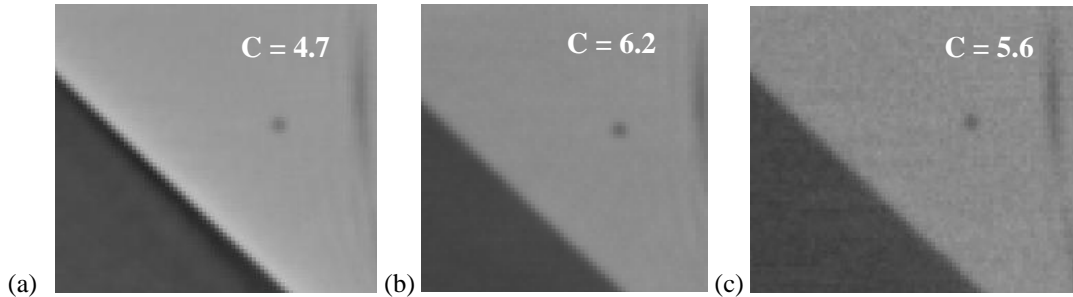


Figure 3: CT reconstruction results obtained with three different source tension / filter, respectively 100 kV without filter (a), 150 kV with 0.5 mm Cu (b) and 250 kV with 0.5 mm Ta

### 4 Conclusion

We present here the potential of using X-ray simulation for conducting first assessment of the detectability of a specific flaw in a part, based on the chosen X-ray settings but also for helping in the optimization of the X-ray parameters. A detectability criterion is proposed and applied on simulated results obtained with CIVA.

### References

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