

Dosimetry for synchrotron imaging techniques

Presentation preferred: oral (x) or poster ()

Topics preferred: (a)

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Introduction

X-Ray imaging techniques are commonly used for medical diagnosis [1] and represent the largest part of non-natural ionizing radiation exposure to people with associated risk of radio induced cancer. To properly assess this risk, there is a necessity to estimate the dose delivered to the patients. Furthermore, beside conventional absorption technique, innovative high resolution methods based on phase contrast imaging are developed and lead to improved contrast in the images [2]. These techniques, such as speckle imaging [3] need proper dose calculation for being safely used *in vivo*. In this study, we propose a method based on Monte Carlo simulations to provide quick 3D dose distributions calculations in synchrotron radiation CT imaging modalities.

Materials & Methods

The goal of this study is to estimate doses maps on images acquired on the medical beam line at the European Synchrotron Radiation Facility (ESRF). This dose calculation is applied on absorption based images (SR-CT imaging of a rat brain) and phase contrast imaging (6 μm pixel size speckle imaging of mouse knees).

Those doses maps calculations are performed by Monte-Carlo simulations with a variance reduction technique called Track Length Estimator (TLE), using Gate, a Monte Carlo calculation platform, based on Geant4. The TLE method is a Kerma based methods, so no track of electrons is performed [4, 5]. A comparison between this method and a full Monte-Carlo technique is also performed to test its validity in high resolution images.

Results & Discussion

A Monte-Carlo (with the TLE method) dose simulation is performed for the rat brain experiment (fig.1). In that case, a mean dose of 103mGy in soft tissue, 90 mGy in brain and 360 mGy are obtained for an energy of 35keV (350x350 μm^2 pixel size). These doses are similar to the ones observed in conventional CT imaging modalities. In a second time our model is used on phase contrast image at a 6x6 μm^2 resolution (fig.2) and much higher doses are observed in water (mean dose of 31.7Gy) and bone (272Gy). This clearly shows the need of technique optimization to consider an *in vivo* application of the technique at that resolution.

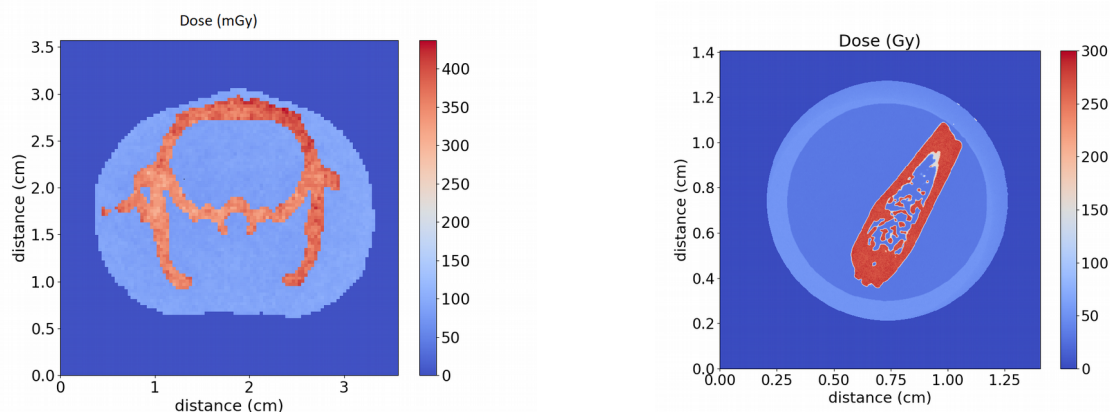


Fig.1. Dose map of a rat brain slice with a pixel size of 337 μm at 35keV **Fig.2.** Dose map of a mouse knee slice with a pixel size of 22 μm at 52keV

Conclusion

A model of dose map calculation is developed in the particular case of synchrotron radiation CT. It allows to determine the doses distributions after the images have been acquired. This model confirms the realistic dose delivery in SR-CT imaging and give us a first dose idea in the case of speckle imaging. This study is a good start to work on dose reduction for high resolution phase-contrast imaging to reach a dose value in agreement with a clinical imaging. Moreover it would be interesting to compare these doses with

usual dose indexes measured before SR-CT imaging experiments, such as entrance dose, Kerma-surface product, Computed-Tomography dose indexes, etc.

Acknowledgment

This research was undertaken on the medical beamline at the European Synchrotron, Grenoble France and we thank the work and support of the ID17 staff. We also acknowledge financial support from LabEx PRIMES (ANR-11-LABX-0063/ANR- 11-IDEX-0007). Nicolas Rosuel is funded by a master scholarship provided by the LabEx PRIME.

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