GATE MONTE CARLO DOSIMETRY SIMULATION OF MARS SPECTRAL CT

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Introduction: MARS (Medipix All Resolution System) CT scanner is a spectral CT using x-ray 'colours' to differentiate between material types within the scanned object, providing improved diagnostic outcomes [1]. These diagnostic x-rays has the potential to damage tissues directly or indirectly [2]. This makes understanding energy deposition and absorbed dose a particular interest for imaging applications involving ionizing radiation, and specifically for MARS-CT scanner where the dosimetry is not yet fully explored and documented [3]. Hence, it is very crucial to know the radiation deposion either through simulation or actual measurement. The importance of the study is to reduce experimental (dosimetry) cost and to show accuracy of GATE for dosimetric applications.

Currently, Geant4 Application for Tomographic Emission (GATE) is the only open-source MC simulation platform supporting simultaneously the user-friendly simulation of imaging, radiation therapy (RT) and dosimetry [3]. We decided to use GATE toolkit because of its flexibility. The Gate simulation serves an extension of actual dosimetry measurements. The study seeks to achieve the following objectives.

- ✓ To implement a MARS-CT model into GATE
- ✓ To validate the simulated results with the experimental data.
- ✓ To determine dose distribution within a phantom/mouse.
- ✓ To integrate a voxelised phantom from MARS scans into GATE spatial dose mapping.

Materials and Methods: In this study, the GATE open-source MC toolkit (v7.2) was used for modelling pre-clinical MARS small animal spectral scanner. The MARS scanner consists of a rotating gantry, x-ray source, MARS camera, cabinet controller, computer software and hardware [4] as shown in figure 1 plus its simulated parts. Some of the specification of x-ray source are 1 mm Tungsten target, 20° anode angle, 1.8 mm Aluminium equivalent inherent filtration at 120 kVp and 0.073 mm electron focal spot (Doc. M-SB120350, Rev 3) [5].

Experimental dosimetric results will be used as a reference to validate the results of the Gate simulation. Energy spectrum from the Gate simulation will also be compared to Spekcalc [6].

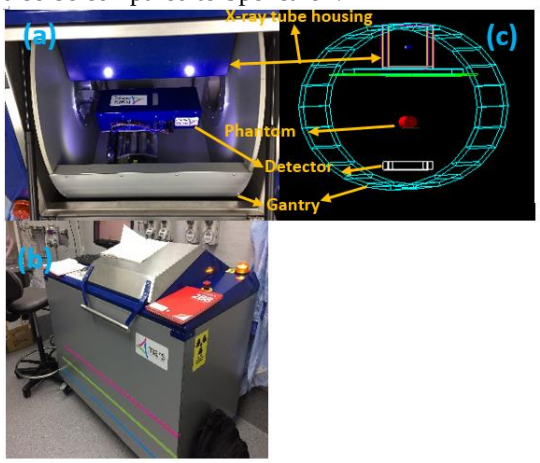

Figure 1. (a) Parts of MARS-CT, (b) MARS-CT and parts and (c) shows simulated MARS-CT

Conclusion

Preliminary x-ray energy spectrum from Gate simulation compares favourably well with Spekcalc energy spectrum.

References:

1. Clinical applications of spectral molecular imaging: Potential and challenges (Anderson, N. G. & Butler, A. P), *Contrast Media Mol. Imaging* **9,** 3–12 (2014).
2. Pediatric personalized CT-dosimetry Monte Carlo simulations, using computational phantoms (Papadimitroulas, P. *et al.), J. Phys. Conf. Ser.* **637,** 12020 (2015).
3. A review of the use and potential of the GATE Monte Carlo simulation code for radiation therapy and dosimetry applications (Sarrut, D. *et al.), Med. Phys.* **41,** 64301 (2014).
4. MARS spectral molecular imaging of lamb tissue: data collection and image analysis (Aamir, R. *et al.), J. Instrum.* **9,** P02005–P02005 (2014).
5. Installation/Operation Manual. Source-Ray, Inc (Manez R.), **(Doc. M-SB,** (2012).
6. Calculation of x-ray spectra emerging from an x-ray tube. Part I. Electron penetration characteristics in x-ray targets (Poludniowski, G. G. & Evans, P. M.), *Med. Phys.* **34,** 2164–2174 (2007).