The MC simulation of WIDMApp: an innovative approach for individual dose monitoring in Molecular Radiotherapy

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Background: The precise estimation of dose absorbed by the target and healthy organs is essential to increase therapeutic effectiveness, optimize the treatment planning and establish dose-effect relationships for tumor and normal tissues. Moreover, the European regulations (EU Directive 59/2013) considers mandatory treatment planning and verification in all patients' exposures for radiotherapeutic purposes, including Molecular Radiotherapy (MRT). To meet this need we proposed WIDMApp (Wearable Individual Dose Monitoring Apparatus), a multi-channel detector and data processing system [1]. One of the key component of the WIDMApp approach is the MC simulation, which will be tailored on each patient.

Material and Methods: To infer the Time-Activity Curves (TAC) of each organ from the Time dependent Counts Curves (TCCs) measured in each detector, it is necessary to estimate the probability of each organ to produce a signal in each detector. To do so, we developed a MC simulation with Geant4. The simulation takes in input the Computed Tomography (CT) of the patient, to reproduce the patient's body, in DICOM format. The code also imports the Regions of Interest (ROI) from the DICOM files, to identify the organs. We implemented the winding number algorithm to sample the primaries starting points inside these ROIs. To represent the detectors in the MC simulation we profited of the Geant4 capabilities of tracking particles in parallel worlds, being one world the one with the CT geometry and the second one with the detectors.

Preliminary results: We tested the simulation and all the workflow with a NEMA IEC PET Body Phantom. We will present the results and the comparison of the MC simulations with experimental data, acquired with the NEMA phantom. As the DCMTK is a dependency for our application, we developed and published a Docker container to run this simulation, with all the dependencies installed.

[1] S. Morganti et al. 2021, Med. Phys. 48(12), pp. 8117–8126