

## An extension of the GATE Monte Carlo simulation toolkit to model Compton Camera systems

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**Introduction:** Compton Cameras (CCs) are gamma-ray imaging devices which usually consist of two position and energy sensitive detectors working in time coincidence. Ideally, the gamma-ray undergoes a Compton interaction in the closest detector layer which is referred to as scatterer and deposits the rest of the energy in the second detector which is called the absorber. Using the kinematics of Compton scattering, the origin of the gamma-ray can be constrained to a cone surface. As a result of the intersection of different cones, information of the activity distribution can be obtained.

CCs have been originally designed for astronomy applications. Their application in medical imaging was first proposed in [1]. Thenceforth there has been a growing interest in their application in the field of medical imaging and therapy monitoring. Since Monte Carlo (MC) simulations play an essential role in the design and optimization of a system, we present in this work an extension of GATE [2] with the aim of supporting CC simulations. GATE is an open-source simulation toolkit based on Geant4, dedicated to medical physics applications, that already contains modules for SPECT and PET imaging simulations.

**Materials and Methods:** A Compton Camera actor has been developed into GATE v8.0. In terms of GATE macros, the actor must be attached to a volume inside which the geometry of the CC is simulated. The actor enables detector layers to be treated as sensitive detectors, in the sense that particle interaction information (referred to as hit) is stored. The processing from hits to cone information is divided into three different steps: digitization of the hits in each detector layer, time coincidence sorter between the digitized signals and the processing of the sorted coincidences. Depending on the applied modules in the processing chain, the resulting data can mimic the detector response or it can provide the information to recover the ideal Compton kinematics. The latter is referred to as the ideal processing. All processing steps may be performed during the simulation ('on-the-fly' mode) or on simulation output files ('offline' mode).

The ideal processing has been preliminary validated against the ideal analyzer of MEGALib [3] simulation toolkit, which is a well-validated software specialized in simulating Compton telescopes for astrophysics. The simulation set-up consists of a 2 cm length line source emitting 511 keV mono-energetic gamma-rays located parallel to the CC at a perpendicular distance of 5 cm from the first scatterer layer. The CC geometry is shown in figure 1.a. The validation has been made through the comparison of position interaction distributions, energy spectra and reconstructed images. Image reconstruction has been implemented with the MLEM method described in [4].

**Results:** A good agreement has been obtained between both simulation toolkit. The results of the comparison of the energy deposition in the first interaction and the profiles through the reconstructed line source are shown respectively in figure 1.a and 1.b with good agreement.

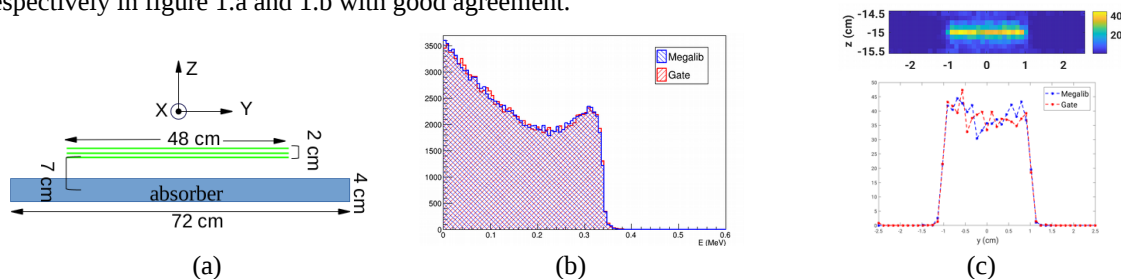


Figure 1: (a) Geometry of the Compton Camera. (b) Comparison of the deposited energy in the first interaction. (c) Comparison of the profiles through the reconstructed line source.

**Conclusion and future work:** An extension of GATE toolkit to support the simulations of Compton Cameras in a flexible and straightforward way has been implemented and preliminary validated against MEGALib ideal analyzer software. It will be available in the next GATE release. In future work, further validations against experimental data will be carried out.

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