

GATE Scientific meeting 2023



Rapport sur les contributions

ID de Contribution: 40

Type: **Non spécifié**

Introduction to Gate for newcomers - discussion

mardi 25 avril 2023 09:00 (40 minutes)

Orateur: Dr MAIGNE, Lydia (University Clermont Auvergne)

Classification de Session: GATE scientific meeting 2023

ID de Contribution: 41

Type: **Non spécifié**

Gate Simulations of a Novel Positron Emission Tomography based on Liquid Opaque Detection

mardi 25 avril 2023 09:40 (20 minutes)

The main experimental challenging developments in positron emission tomography (PET) are currently focusing on improving the sensitivity either by pushing the time of flight (ToF) performances or extending the axial field of view. As an alternative the use of 3γ detection capability enables several extra advantages, including the possible enhancement of the ToF information to better locate the annihilation vertex or enabling tissue probing through positonium study. We propose the LiquidO-PET (LPET) projet which aim to develop of a demonstrator to explore our ability to meet the aforementioned capabilities through a novel PET system paradigm. It is based on opaque scintillation of a liquid medium. The enormous light scattering forces the emission photons to stay around their source into a stochastically confined trajectory or “light ball” with a radius in the order of the centimeter and collected and mapped through a lattice of wavelength-shifting fibers embedded in the scintillator and read out by silicon-photomultipliers coupled to sub-100 ps read-out electronics on both ends. The liquid scintillator medium with low-z and low density, causes the γ detection to be largely dominated by Compton scattering. Thus, a 511 keV γ manifests a sequence of several Compton scatters up to 50 cm from the injection point, each scatter leading to a point-like light ball, thus enabling the Compton interactions to be characterized by two specific signatures: i) the clear identification of the first Compton vertex (FCV), which is most precious for PET imaging and ii) the full Compton tracking (FCT) providing complementary tracking information for the full event as well as allowing 3γ detection capabilities. We present here the GATE simulations of the preliminary design and the projected performances of the demonstrator based notably on optical simulations in a diffusive medium. Expected performances range from a radial spatial resolution of a few mm to a few cm in the axial direction, a ToF resolution of 100-300 ps and a sensitivity of 200-700 kcps/MBq for an axial FoV in the 50-200 cm range.

Orateur: Dr VERDIER, Marc-Antoine (IJCLab - Université Paris Cité)

Classification de Session: GATE scientific meeting 2023

ID de Contribution: 42

Type: **Non spécifié**

Monte Carlo research activities at the Institute of Nuclear Physics PAS in Kraków

mercredi 26 avril 2023 09:20 (20 minutes)

Orateur: Dr GAJEWSKI, Jan (Institute of Nuclear Physics PAN, Krakow, Poland)

Classification de Session: GATE scientific meeting 2023

ID de Contribution: 43

Type: **Non spécifié**

General Electric Signa PET-MR simulations: validation with GATE

mardi 25 avril 2023 10:00 (20 minutes)

PET imaging is undergoing continuous improvements thanks to developments of new detection approaches, new designs and new electronic chains. For example, whole-body scanners' geometries, advances in detectors' time resolution, and improvements in TOF image reconstruction are hot topics for dynamic acquisitions.

Monte Carlo GATE simulations can be used to quantify the impact of these improvements before or with prototype experimentations. The simulation must be validated against state-of-the-art imaging devices to produce realistic data. In this work, we model the GE SIGNA PET-MR system using GATE 9.1. The image reconstruction, including normalization and attenuation corrections, is done with CaSTOR 3.1.1.

We present the simulation validated for spatial resolution, sensitivity, noise equivalent count rate (NECR) and image quality with and without TOF information. Furthermore, by using improved coincidence time resolution (CTR) promised by new detection prototype systems, we show the potentially achievable impact on image quality for clinical applications. We also discuss the perspectives of a whole-body scanner simulation based on the GE SIGNA PET-MR technologies and other new PET detector approaches.

Auteur principal: M. PAILLET, Adrien (BioMaps-Université Paris-Saclay-SHFJ-CEA)

Co-auteurs: KOCHEBINA, Olga (BioMaps/Université Paris-Saclay/SHFJ/CEA); JAN, Sebastien (BioMaps-Université Paris-Saclay-SHFJ-CEA)

Orateur: M. PAILLET, Adrien (BioMaps-Université Paris-Saclay-SHFJ-CEA)

Classification de Session: GATE scientific meeting 2023

ID de Contribution: 44

Type: **Non spécifié**

GATE simulated phantom studies on Positrigo's NeuroLF, Siemens' Biograph Vision and Quadra

mardi 25 avril 2023 11:10 (20 minutes)

Co-auteurs: M. DAO, Viet (University Medical Center Groningen); M. LI, Zekai (University Medical Center Groningen)

Orateur: M. MOHR, Philipp (University Medical Center Groningen)

Classification de Session: GATE scientific meeting 2023

ID de Contribution: 45

Type: **Non spécifié**

Simulation of a neuroimaging experiment with MAPSSIC, a β^+ sensitive intracerebral microprobe

mardi 25 avril 2023 11:30 (20 minutes)

The correlation of molecular neuroimaging and behavior studies in the preclinical field is of major interest to unlock progress in the understanding of brain processes and assess the validity of pre-clinical studies in drug development. However, fully achieving such ambition requires being able to perform molecular images of awake and freely moving animals whereas currently, most of the preclinical imaging procedures are performed on anesthetized animals. To achieve such a combination, we propose MAPSSIC, a pixelated intracerebral probe based on the CMOS technology implantable in rat brains. This probe provides real time images of β^+ radioisotopes concentrations along its axis. Thanks to its in situ position, the probe is able to directly detect positrons. We present the simulations

with GATE of a typical animal experiment using a widely used β^+ radiotracer with a fully voxelized rat phantom to assess the capacities expected with the probe.

We show that, at the optimal radiotracer distribution time point, 99.52 % \pm 0.10 % of the events recorded in the specific probe come from the skull area. Moreover, nearly 90 % of the events are from a direct detection of positrons which ensures the recording of local information.

Orateur: EL KETARA, Samir (IJCLab, Université Paris-Saclay)

Classification de Session: GATE scientific meeting 2023

ID de Contribution: 46

Type: **Non spécifié**

New Digitizer in Gate 9.3

mardi 25 avril 2023 16:30 (20 minutes)

Digitizer in the current GATE plays an important role for PET, SPECT, CT, Compton Camera detectors or more generally for imaging system modeling. It simulates the response of the photodetection components by a sequence of analytical models. Digitizer takes as input a list of interactions, Hits, within a crystal or detector element and generates digital pulses. In a digitization, the last one represents a detector output, such as an ADC/TDC count or a trigger signal. The first step of Digitizer is to construct Singles with a help of a set of dedicated modules, each of them mimics one specific hardware response with their associated uncertainty. In the case of PET imaging, a specific Digitizer part for constructing Coincidences exists.

Digitizer was written for the first versions of GATE, about 20 years ago. Since then it has grown in a part of the code that can be hardly maintained: some of the digitizer modules are not used anymore or duplicated by mistake and some of functionalities are not in working order anymore. Therefore, its update is required in order to adapt it to the novelties of Geant4, to clean up its current version and add new features.

In this talk, the GATE New Digitizer implementation (since version 9.3) will be presented. Added functionalities, the impact of changes on users, current status of the work and perspectives will be discussed.

Auteur principal: KOCHEBINA, Olga

Co-auteur: JAN, Sebastien (BioMaps-Université Paris-Saclay-SHFJ-CEA)

Orateur: KOCHEBINA, Olga

Classification de Session: GATE scientific meeting 2023

ID de Contribution: 47

Type: **Non spécifié**

Using Gate to predict clonogenic alteration in radiosensitization studies

mardi 25 avril 2023 14:00 (20 minutes)

As part of the european project RXNanoBRAIN, the image-guided radiation therapy and the radiosensitization by Gadolinium and Bismuth hybrid nanoparticles are investigated for the treatment planning of the glioblastoma brain tumor. In this context, we performed Gate Monte Carlo simulations to assess the deposited dose in clusters of Bismuth-Gadolinium nanoparticles in U251 glioblastoma cells. Ionization process, created secondary particles and their maximal range were analyzed in the presence of nanoparticles. We also studied the mount of ionization into cells nucleus in presence or absence of nanoparticles. In parallel, we performed biological experiments, including

DNA damage assessment by immunofluorescence technique and clonogenic assay (from 0 up to 10 Gy). Then, biological and numerical results were compared and we observed that radiosensitization was not due to a DNA damage increase. We also propose a general prediction model taking into account the nanoparticle concentration and the planed deposited dose in water. Further biological alterations in these condition are currently investigated to better understand the radiosensitization process to include it into a more biological dosimetry model.

Orateur: Mlle BLIND, Sarah (CRAN, BioSiS, Université de Lorraine)

Classification de Session: GATE scientific meeting 2023

ID de Contribution: 48

Type: **Non spécifié**

BioDose actor implementation and validation in GATE9.3 and GATE10

mardi 25 avril 2023 14:20 (20 minutes)

Orateur: Dr PEREDA, Alexis (LPC UMR 6533 CNRS)

Classification de Session: GATE scientific meeting 2023

ID de Contribution: 49

Type: **Non spécifié**

The Cell Population platform (CPOP), Geant4DNA chemistry module

mardi 25 avril 2023 14:40 (20 minutes)

Orateur: Dr MAIGNE, Lydia (University Clermont Auvergne)

Classification de Session: GATE scientific meeting 2023

ID de Contribution: 50

Type: **Non spécifié**

Verification of proton treatment planning by means of Monte Carlo

mercredi 26 avril 2023 10:00 (20 minutes)

In Proton Therapy Center in Prague we have developed a method for patient based quality assurance. Our project is based on Monte Carlo (MC) and is built on Gate. By means of MC, dose computational algorithms of local treatment planning systems XiO 5.1 (Elekta, Sweden) and RayStation 11B (RaySearch, Sweden) can be verified as MC method provides the highest calculation accuracy. It provides complementary information to QA measurement in water as dose distribution is calculated in real inhomogeneous patient environment. Linear energy transfer distribution in patient can be simulated alongside. High computation time is reduced through parallel computing with HTCondor (<https://htcondor.org>) –an open-source high-throughput computing software. Currently we compute on 204 CPU cores.

Orateur: Dr BADARAOU CUPROVA, Klara

Classification de Session: GATE scientific meeting 2023

ID de Contribution: 51

Type: **Non spécifié**

GATE RTion v1/IDEAL v1 for independent dose calculation in carbon ion beam therapy

mercredi 26 avril 2023 09:40 (20 minutes)

The IDEAL project aims to substitute the patient specific quality assurance (PSQA) measurements for light ion beam therapy by independent dose calculation (IDC) using Gate-RTion. In this contribution, the commissioning status of the IDEAL v1 at MedAustron Ion Therapy center will be discussed including a physics settings variation study. Further, the status of the integration of IDEAL v1 into the commercial software myQA-iON (IBA Dosimetry, Germany) will be presented.

To find an optimal balance between calculation time and dose calculation accuracy, physics settings in GATE-RTion were varied and compared to dose commissioning data of the MedAustron carbon ion beam line. Four reference nuclear physics lists, two EM physics lists and secondary particle settings were compared against 16 measured depth dose profiles in water, lateral profiles at various distances in air and absolute dose in reference condition, respectively, with and without range shifter. Calculation times varied considerably for the different settings, while the dose calculation accuracy was in all tested cases within tolerances. Combining the fastest options could speed up the simulations by up to a factor 10 in some scenarios compared to the current default settings in IDEAL 1.

Orateur: RESCH, Andreas (MedAustron Ion Therapy Centre)

Classification de Session: GATE scientific meeting 2023

ID de Contribution: 52

Type: **Non spécifié**

In-beam and post irradiation measurement of proton treatments with the PETITION PET detector

mercredi 26 avril 2023 10:50 (20 minutes)

The PETITION PET detector, has been developed for in-beam use at Gantry 2 at PSI, with an open ring design allowing for measurement of patient activation both during and following proton therapy treatment. Tools for time resolved simulations of patient treatments have been implemented using Gate. Intra-field imaging in the dead time between delivery of each energy layer, approximately 100 ms, can be performed for measurement of short-lived isotopes such as ^{12}N ($t_{1/2} = 11$ ms). Following this inter-field imaging of the produced isotopes, primarily ^{15}O and ^{11}C ($t_{1/2} = 122$ s and 20.3 min respectively), can be performed between delivery of subsequent fields to generate 3D images of the induced activity distribution. We also consider a scenario in which the PET scanner is rotatable, moving the opening of the ring to allow for delivery of each new treatment field. If coincidences are recorded while the scanner rotates, the loss of spatial resolution due to the opening of the scanner may be compensated, allowing for possible detection of anatomical changes in the patient. Imaging for approximately 30 seconds, during the couch and gantry repositioning, provides sufficient counts for reconstruction of the activity. The activity fall off of short lived isotopes produced during delivery of the first treatment field is well correlated to the dose fall off ($R^2=0.947$). Imaging of the field while rotating the scanner leads to a reduction in the mean-absolute-error by 54-70% compared to imaging at a fixed angle for each field. Development of a new PET reconstruction software for the purpose of inter-field imaging allows for fast reconstruction times, and could potentially provide validation of treatments within clinically relevant time frames. In beam measurements with phantoms are currently being performed, and comparison with Gate simulations is ongoing.

Auteur principal: MCNAMARA, Keegan (Paul Scherrer Institute)

Orateur: MCNAMARA, Keegan (Paul Scherrer Institute)

Classification de Session: GATE scientific meeting 2023

ID de Contribution: 53

Type: **Non spécifié**

Towards GATE 10 for ion beam therapy applications

mercredi 26 avril 2023 11:10 (20 minutes)

In ion beam therapy, Monte Carlo (MC) particle transport simulations are being increasingly used to perform independent dose calculation (IDC) for quality assurance in light ion beam therapy. In practice, IDC consists in recomputing the dose in the patient starting from the treatment plan specifications, with a Monte-Carlo engine. The results can be compared with the planned dose as a verification of the treatment before delivery to the patient.

As a carbon ion treatment plan (TP) consists typically in the order of several 10⁴ single Pencil Beams (PBs), small errors in the description of a single PB may add up to a considerable discrepancy in the treatment plan. Therefore, first we implemented the PB source into GATE 10. A single PB is characterized with 3 parameters to describe the particle type, mean energy and energy spread and 8 parameters to describe the (correlated) beam optics (spot size, divergence, emittance, convergence flag; each for the x and y direction). The implementation on the C++ side follows what was already existing in GATE 9, however substituting the external CLHEP library to sample from a correlated bivariate Gaussian distribution with a custom implementation. The implementation was verified on 5 test cases agreeing within tolerances with GATE v9.3 and GATE-RTion v1.

In a second step a beamline model class was introduced. As in the previous version, the energy dependent parameters of a specific beamline can be described with a polynomial function of n-th order.

In the third step, the TP source was implemented initiating several PB sources using the parameters calculated from the beamline model. Test cases created to verify absolute dose, optics and rotations of the TP source simulations, are in good agreement with GATE-RTion v1.

The PB source, ion source description (beam model) and TP source were successfully translated from Gate 9 to Gate 10 making use of the new python interface and new features were added and verified.

Orateur: Mlle FAVARETTO, Martina (MedAustron GmbH)

Classification de Session: GATE scientific meeting 2023

ID de Contribution: 54

Type: **Non spécifié**

Gate 9.3 and 10.beta releases

mardi 25 avril 2023 16:50 (40 minutes)

Orateur: SARRUT, David (CNRS)

Classification de Session: GATE scientific meeting 2023

ID de Contribution: 55

Type: **Non spécifié**

Dose activities boosted with AI from lab LaTIM

mercredi 26 avril 2023 09:00 (20 minutes)

Dose distribution is simulated by Monte Carlo (MC) method generally. However, due to its data dependency, complex model, long computational time, instead, our work utilize AI models to predict dose distribution in real time, which is a series of mathematical operations that fit on a wide range of data and flexible in handling new cases. Furthermore, this work compares the MC simulation (OpenGate based on Python) and DL methods (3D U-Net) for predicting dose maps. And the preliminary results are promising.

Orateur: Dr ZHANG, Jing (LaTIM, UBO)

Classification de Session: GATE scientific meeting 2023

ID de Contribution: 56

Type: Non spécifié

Validation of TEPCActor for slab detectors in microdosimetry

mercredi 26 avril 2023 11:30 (20 minutes)

Monte Carlo (MC) simulations of microdosimetric spectra are available for different codes, detectors and particle types/energies. While good results can be achieved if the detector geometry is modelled in detail [1, 2], a simpler approach can also result in very good agreement.

At five positions along a 238.6 MeV/u carbon ion pencil beam, spectra were collected using the Silicon MicroPlus probe. The measurements were collected along CAX as well as 10 mm off-center. The MC was performed with GATE/Geant4, using our validated beam model and a simplified detector geometry. Only the 400 sensitive volumes (diameter = 20 μm , thickness = 10 μm , spaced 50 μm apart) were simulated, none of the housing/surrounding materials.

The off-center measurements show a higher contribution of secondary particles, which we were able to reproduce in the MC (Figure 1). The agreement of the shape of the spectra is excellent for all positions along the Bragg peak. Especially in the fragmentation tail, where we were able to measure and simulate the boron edge with high accuracy.

This simplified detector geometry could be implemented in future GATE installation checks, to perform a validation down to the microdosimetric scale. MC also offers a spectrum down to very low keV/ μm values, which can be used to complete any experimentally obtained spectrum.

[1] David Bolst et al 2020 Phys. Med. Biol. 65 045014

[2] Anna Bianchi et al 2023 Phys. Med. Biol. 68 034001

Auteur principal: Mlle BARNA, Sandra (Medizinische Universität Wien)

Orateur: Mlle BARNA, Sandra (Medizinische Universität Wien)

Classification de Session: GATE scientific meeting 2023

ID de Contribution: 57

Type: **Non spécifié**

The benefits of particle transport simulations in a web browsers.

mardi 25 avril 2023 15:20 (20 minutes)

Orateur: Dr GRZANKA, Leszek (IFJ PAN Krakow)

Classification de Session: GATE scientific meeting 2023

ID de Contribution: 58

Type: Non spécifié

Monte Carlo Simulation of Elekta Geometry: Effect of Flattened Filter on Dose Distribution in a Heterogeneous Phantom

mardi 25 avril 2023 15:00 (20 minutes)

In this study, we aimed to investigate the effect of flattened filter on dose distribution in a heterogeneous phantom using Monte Carlo simulation. The GATE Monte Carlo code was used to simulate photon beams of 6 MV in a heterogeneous phantom consisting of lung and breast tissues. The electrons accelerated by 6MV in flattened and unflattened modes were configured in Gaussian parameters. The accuracy of the simulations was validated by comparing the results with experimental measurements. All Monte Carlo simulations were performed using the HPC-Marwan high computing grid, which allowed us to simulate several parallel jobs. The statistical uncertainty was less than 2% for all results with high correspondence between the simulations and experimental measurements. The results showed that the dose in the flattened filter-free (FFF) mode was significantly higher compared to the flattened filter (FF) mode.

Auteur principal: M. ASSALMI, Mustapha (Universite Mohammed First)

Co-auteur: DIAF, El Yamani (Laboratory of Biology, Geoscience, Physics and Environment (LBGPE), Multidisciplinary Faculty of Nador)

Orateur: M. ASSALMI, Mustapha (Universite Mohammed First)

Classification de Session: GATE scientific meeting 2023

ID de Contribution: 59

Type: **Non spécifié**

Recent developments of CASToR at J-PET: an overview for GATE users

mardi 25 avril 2023 16:10 (20 minutes)

Orateur: COUSSAT, Aurélien (Jagiellonian University)

Classification de Session: GATE scientific meeting 2023

ID de Contribution: **60**

Type: **Non spécifié**

Welcome

mardi 25 avril 2023 08:40 (20 minutes)

Orateurs: Prof. MOSKAL, Pawel; STEPIEŃ, Ewa

Classification de Session: GATE scientific meeting 2023

ID de Contribution: 61

Type: **Non spécifié**

Towards Total-Body J-PET

mardi 25 avril 2023 10:50 (20 minutes)

Orateur: KRZEMIEN, Wojciech (National Centre for Nuclear Research)

Classification de Session: GATE scientific meeting 2023

ID de Contribution: 62

Type: **Non spécifié**

Modelling and corrections of random & scatter coincidences in J-PET

mercredi 26 avril 2023 11:50 (20 minutes)

Orateur: PARZYCH, Szymon (Jagiellonian University)

Classification de Session: GATE scientific meeting 2023