GATE advances

Lydia Maigne
On behalf of the OpenGATE collaboration
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The collaboration

25 members, public laboratories and companies developing an open source platform

Spokesperson: Lydia Maigne
Technical coordinator: David Sarrut

France

10 labs

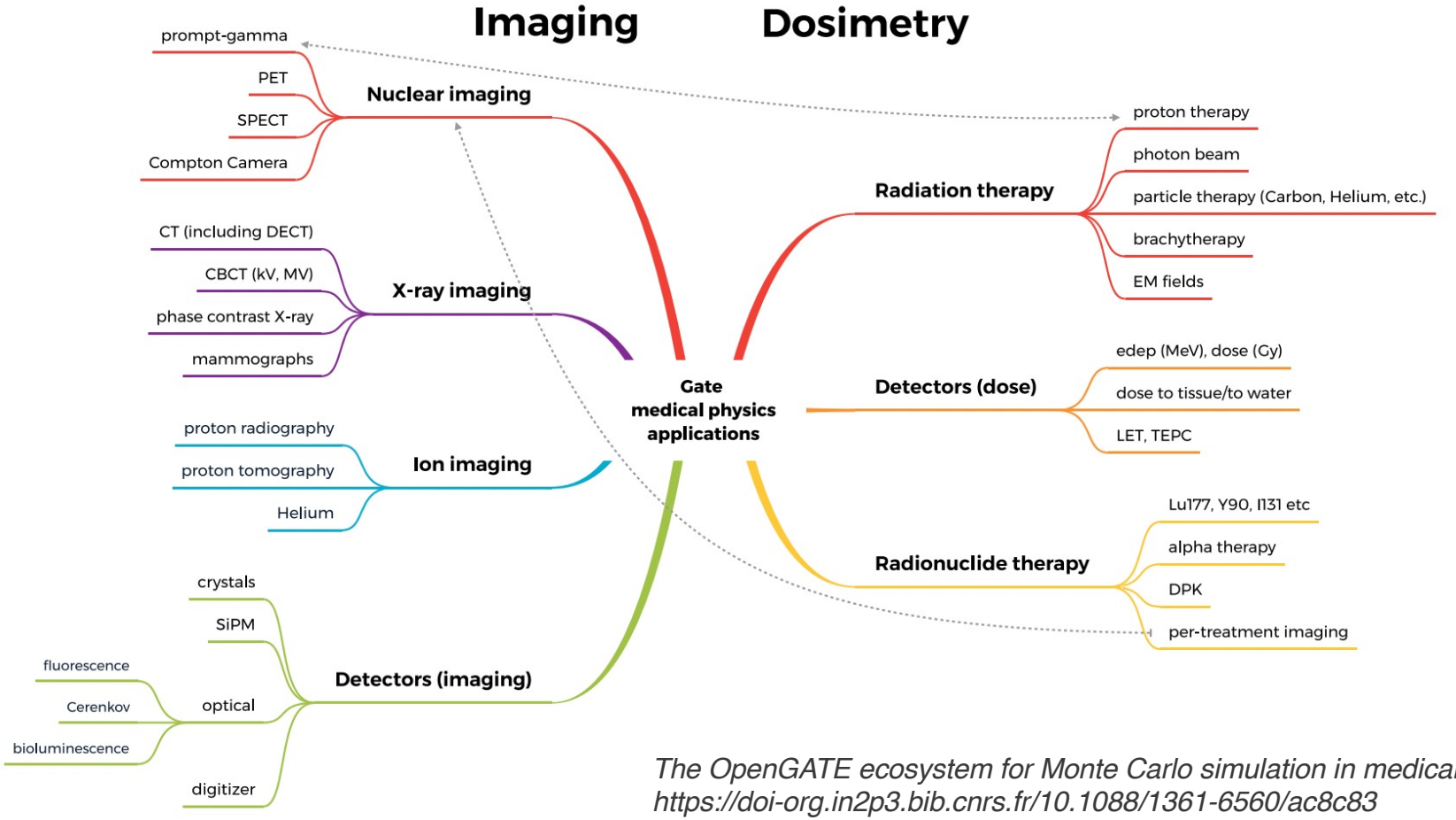
Europe

FH Aachen, University of Applied Sciences, Julich, Germany
Medisip, Ghent University, Belgium
Medical University of Vienna, Wiener Neustadt, Austria
MedAustron, Wiener Neustadt, Austria
Christie Medical Physics & Engineering, Manchester, UK
JPET collaboration, Poland
Institute of Nuclear Physics Polish Academy of Sciences, Poland
Univ. of Patras, Dept of Med. Phys., Greece
BioemTech, Athens, Greece
Paul Scherrer Institute (PSI), Switzerland

Elsewhere

MSKCC, New York, USA
UC Davis, Davis, USA
Sogang University, Seoul, South Korea
QST, Chiba, Japan

Applications



The OpenGATE ecosystem for Monte Carlo simulation in medical physics - https://doi-org.in2p3.bib.cnrs.fr/10.1088/1361-6560/ac8c83

GATE talks @ IV Geant4 User conference

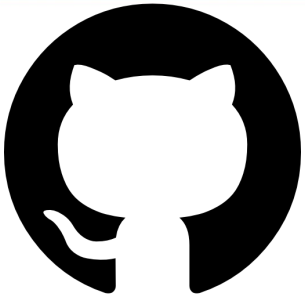
IMAGING

- **24/10 14:00 – D. Sarrut** Artificial Intelligence
- **24/10 11:46 – G. Raymond** Siemens Somatom go.Open Pro CT scanner
- **24/10 12:11 – A. Sarno** in-silico x-ray breast images
- **25/10 12:00 – S. Makkar** in-beam PETITION PET scanner
- **25/10 14:00 – P. Papadimitroulas** γ-eye preclinical system
- **25/10 14:12 – D. Pistone** PSMA-targeted PET/CT
- **25/10 14:49 – Z. Ahmadi Ganjeh** N-12 imaging to the clinic

DOSIMETRY

- **24/10 16:53 – Andreas Resh (3 talks)** Validation for PBS carbon ion beam
- **24/10 18:29 – Lydia Maigne** Biological dose estimation in hadrontherapy
- **25/10 11:23 – B. Doignies** Investigating Quasi-Monte Carlo (QMC) methods
- **25/10 12:23 – M. Salas Ramirez** Absorbed Dose Coeff. for Internal Ex Vivo Irradiation
- **25/10 14:25 – G. Di Domenico** Personalized dosimetry in radionuclide therapy
- **25/10 17:40 – G. Di Domenico** Validation for IORT
- **26/10 09:40 – S. Kolovi** Dose rates on microorganisms
- **26/10 10:05 – G. R. Fois** FLASH therapy

Open-source Code – Examples - Tools



Source code - https://github.com/OpenGATE/**Gate**

Examples - https://github.com/OpenGATE/**GateContrib**

Python tools - https://github.com/OpenGATE/**gatetools**

Docker + VM - https://opengatecollaboration.org

GATE 9.2 release (April 2022)

Compatible with G4 11
More than 70 contributors (since 2012)
25+ benchmarks

GATE10 - https://github.com/OpenGATE/opengate

Official release Mid 2023

GATE USERS MAILING LIST - Information, job offers, bug reports, help http://opengatecollaboration.org/mailinglist

GATE 10 in a nutshell

- **pip install opengate**
  - Install Geant4 + ITK + QT + GATE + data
- **Writing in Python >> Writing with macros**
  - Simplified sharing : users-developed modules (e.g. IEC phantoms, detectors, linac etc.)
  - Easy access to whole Python ecosystem (AI !)
- **Speed**
  - Python is slow ? NO ! Still same G4 engine: **no time penalty**
  - G4 multithread
- **Faster development time, better separation**
  - Python: user parameters, initialisation, options, I/O etc
  - C++: core processing only
- **Advanced features**
  - Dynamic trigger: call user function during runtime (time penalty)

GATE 10 - STATUS

60% already developed

- **Available** (among others)
  - Time slicing, basic volumes, voxelized volumes, boolean volumes, repeaters
  - All G4 physics lists, production cuts in volume, spliting/Russian Roulette (partial)
  - Generic source, voxelized source, beta+ source, confine, motion source, GAN source
  - DoseActor, PhaseSpaceActor (root), Adder (digitizer), AcceptanceAngle

- **Not yet available** (among others)
  - STL volume
  - Tracking cuts, advanced cuts, Optical, Polarization, DNA
  - Back to back gamma source, Y90 source
  - Digitizer modules, LET, TLE, ARF, FFD

GATE 10 - Try it

Create a Python environment (optional, but highly recommended)

```
pip install opengate
opengate_tests
```

See: https://github.com/OpenGATE/opengate
Docs https://opengate-python.readthedocs.io (wip)

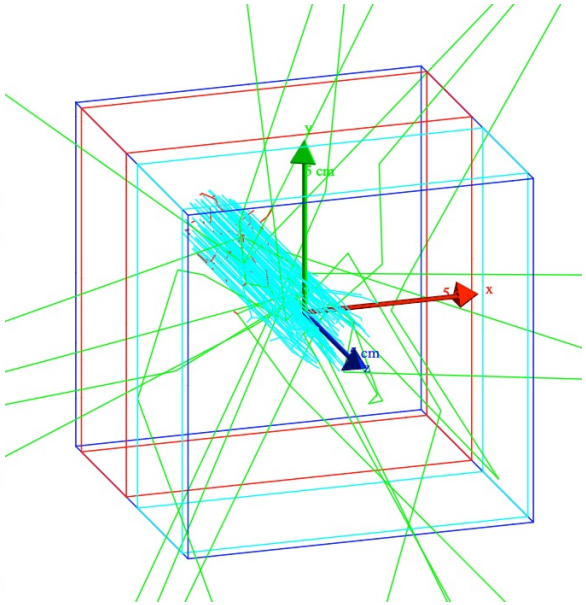
More than 70 tests (example) available

GATE 10 Simulation example

```python
#!/usr/bin/env python3
# -*- coding: utf-8 -*-

import opengate as gate

paths = gate.get_default_test_paths(__file__, "gate_test008_dose_actor")

# create the simulation
sim = gate.Simulation()
```

```python
# main options
ui = sim.user_info
ui.g4_verbose = False
ui.g4_verbose_level = 1
ui.visu = False
ui.random_seed = 123456

# units
m = gate.g4_units("m")
cm = gate.g4_units("cm")
mm = gate.g4_units("mm")
MeV = gate.g4_units("MeV")
Bq = gate.g4_units("Bq")
```

```python
#  change world size
world = sim.world
world.size = [0.5 * m, 0.5 * m, 0.5 * m]

# waterbox
waterbox = sim.add_volume("Box", "waterbox")
waterbox.size = [10 * cm, 10 * cm, 10 * cm]
waterbox.material = "G4_WATER"
waterbox.color = [0, 0, 1, 1]

# lungbox
lungbox = sim.add_volume("Box", "lungbox")
lungbox.mother = waterbox.name
lungbox.size = [10 * cm, 10 * cm, 4 * cm]
lungbox.translation = [0 * cm, 0 * cm, 2.5 * cm]
lungbox.material = "G4_LUNG_ICRP"
lungbox.color = [0, 1, 1, 1]

# bonebox
bonebox = sim.add_volume("Box", "bonebox")
bonebox.mother = waterbox.name
bonebox.size = [10 * cm, 10 * cm, 4 * cm]
bonebox.translation = [0 * cm, 0 * cm, -2.5 * cm]
bonebox.material = "G4_BONE_CORTICAL_ICRP"
bonebox.color = [1, 0, 0, 1]
```




```python
# physics
p = sim.get_physics_user_info()
p.physics_list_name = "QGSP_BERT_EMV"
sim.set_cut("world", "all", 1 * mm)
```

```python
# default source for tests
source = sim.add_source("Generic", "mysource")
source.energy.mono = 115 * MeV
source.particle = "proton"
source.position.type = "disc"
source.position.radius = 1 * cm
source.position.translation = [0, 0, -80 * mm]
source.direction.type = "momentum"
source.direction.momentum = [0, 0, 1]
source.activity = 5000 * Bq
```

```python
# add dose actor
dose = sim.add_actor("DoseActor", "dose")
dose.output = paths.output / "test041-edep.mhd"
dose.mother = "waterbox"
dose.size = [10, 10, 50]
mm = gate.g4_units("mm")
ts = [200 * mm, 200 * mm, 200 * mm]
dose.spacing = [x / y for x, y in zip(ts, dose.size)]
print(dose.spacing)
dose.uncertainty = True
dose.gray = True
dose.hit_type = "random"

# add stat actor
s = sim.add_actor("SimulationStatisticsActor", "Stats")
s.track_types_flag = True
```

```python
# create G4 objects
sim.initialize()

# start simulation
sim.start()

# print results at the end
stat = sim.get_actor("Stats")
print(stat)

dose = sim.get_actor("dose")
print(dose)
```

GATE 10 - The source code

g4_bindings/ — Geant4 binding from C++ to Python (expose functions, classes) ; *pybind11*

opengate_lib/ — Core classes (running): source, scorers etc

opengate/ — User UI (initialisation)

One main object : Simulation
4 sub-main concepts: volume source physics actors
All users parameters like “dictionary” structure
Stored in user_info object

Events 2022 -2023

2022 IEEE NSS-MIC conference

Workshop on Thursday 10 November (lunchtime)

2023 AAPM Annual Meeting (Houston, TX • July 23 - 27)
Educational session with GATE

Scientific meetings:

- May 2022, Talks available - **https://indico.in2p3.fr/e/gate2022**
- **25-26 April 2023, in Krakow (Poland), information coming soon**

Next GATE trainings

- GATE training for beginners **22-24 November 2022**
- Python data analysis for GATE simulations **March 2023**
- **GATE trainings in master programs (on demand)**