GATE

Simulations of Preclinical and Clinical Scans in Emission Tomography, Transmission Tomography and Radiation Therapy

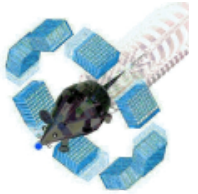
Using GATE as an educational tool

EduGATE

IEEE MIC 2016, Strasbourg

Irène Buvat
IMIV, Inserm – CEA – CNRS – Université Paris Sud
Université Paris Saclay
irene.buvat@u-psud.fr

EduGATE developers

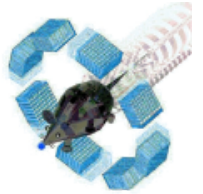


JÜLICH
FORSCHUNGSZENTRUM

Uwe Pietrzyk
with contributions from
Mirjam Lenz, Liliana Caldeira, Michaela Gaens

Institute of Neurosciences and Medicine (INM-4), Research Center Juelich, Germany
School of Mathematics and Natural Sciences, University of Wuppertal, Germany

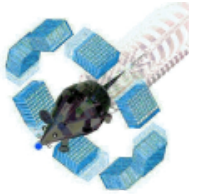
Motivation to start the EduGATE project



- GATE is powerful but also complex…
- To provide very **simple introductory examples** to assist GATE newcomers
- To offer materials useful during **lectures** regarding basic detector and imaging physics
- Some examples are "inspired" by specific topics from the book:
  "Physics in Nuclear Medicine" by Cherry et al, Saunders – Elsevier edition

JÜLICH
FORSCHUNGSZENTRUM

General concept of EduGATE



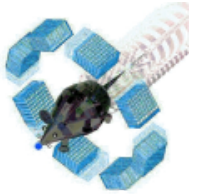
- All examples follow a similar workflow:

  - Use of a **simple interface** to set parameters (materials, energy, particle type, etc., pre-set with useful values)

  - Essential parameters are used as "aliases" to derive the **name of the output files** that can be easily recognized
    - standard ROOT-file
    - sinogram / projections

  - All examples come with dedicated **ReadMe files** in PDF format

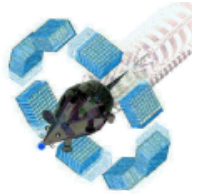
Six currently available EduGATE modules



1. **Coin_Chan**
   From coincidence channel to a PET system
2. **Gamma_Camera**
   Describes the basic imaging features of a gamma camera
3. **SPECT_to_Reco**
   Including reconstruction from projections
4. **Spectro**
   Analysing energy spectra of radioactive isotopes
   Linking to the book "Physics in Nuclear Medicine" of Cherry et al, chap 10
5. **Spectrometry_Gamma**
   Introduction to the basics of gamma spectra obtained from a scintillation detector
   Linking to the book "Physics in Nuclear Medicine" of Cherry et al, chap 10
6. **MR_PET** (since fall 2015)
   Explore the fate of positron or electron in a MR system
   Two modules (particle & ion source)

JÜLICH
FORSCHUNGSZENTRUM

Typical workflow for lectures and hand-on



1. Download EduGATE examples

2. Run EduGATE first example: Coincidence Channel (Coin Chan)

3. Ask students to change parameters and run simulation with different parameters
   - Which parameters can be changed, which will change the simulation results?
   - Which geometry does the scanner have?
   - Which source is placed in the middle of the scanner?
   - Which phantom is placed inside the scanner?

4. Then ask the students to compile their observations

JÜLICH
FORSCHUNGSZENTRUM

Typical workflow for lectures and hand-on

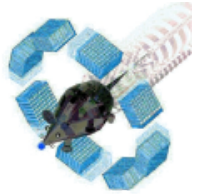
- Task: fill in the following tables

Sim	Source Activity	Number Detectors	Crystal Material	Phantom Material	Phantom Rmax/Rmin	Source Material	Source Energy

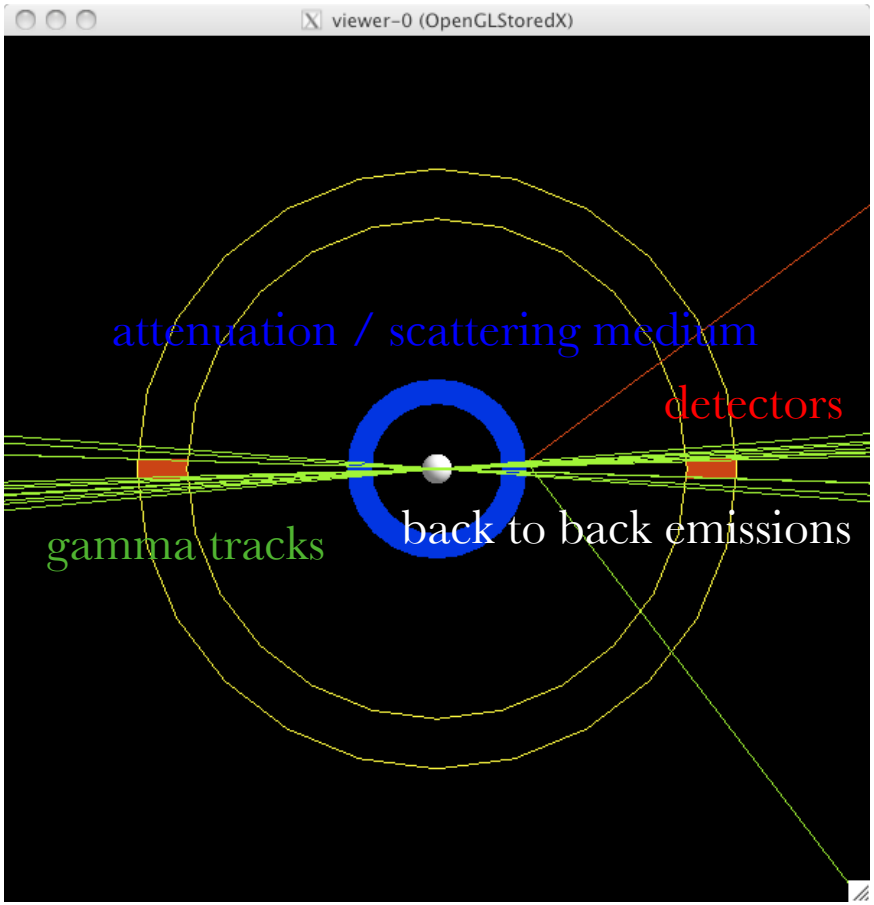
- If you run the same simulation again: are the results identical or different?

# Simulation	Total Coincidences	True unscattered	Random Coincidences	Scatter/True

Examples of the coincidence channel module



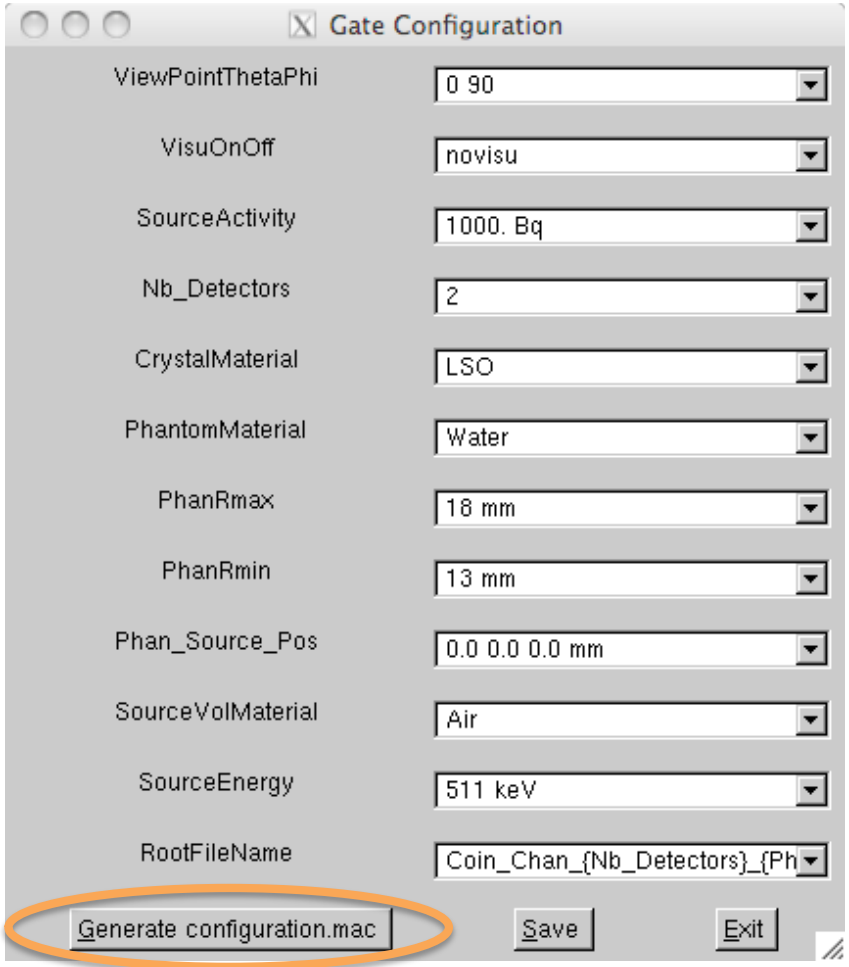
- Coin_Chan_Release_2014
  - AAA_README.doc
  - AAA_README.pdf → explains the basic setup
  - camera.mac
  - Coin_Chan_64_Water.gif
  - Coin_Chan_64_Water.root
  - Coin_Chan.C
  - Coin_Chan.mac
  - Coin_Chan.txt
  - config_starter_62.sh
  - config_starter_70.sh
  - configuration.mac
  - digitizer.mac
  - G4OpenGL_0.eps
  - G4OpenGL_1.eps
  - GateMaterials.db
  - GenerateGateConfiguration.C
  - Materials.xml
  - novisu.mac
  - phantom_point.mac
  - phantom.mac
  - physics.mac
  - sources_point.mac
  - sources.mac
  - visu.mac
- Gamma_Camera_Release_2014
- SPECT_to_Reco_Release_2014
- Spectro_Release_2014
- Spectrometry_Gamma_Release_2014

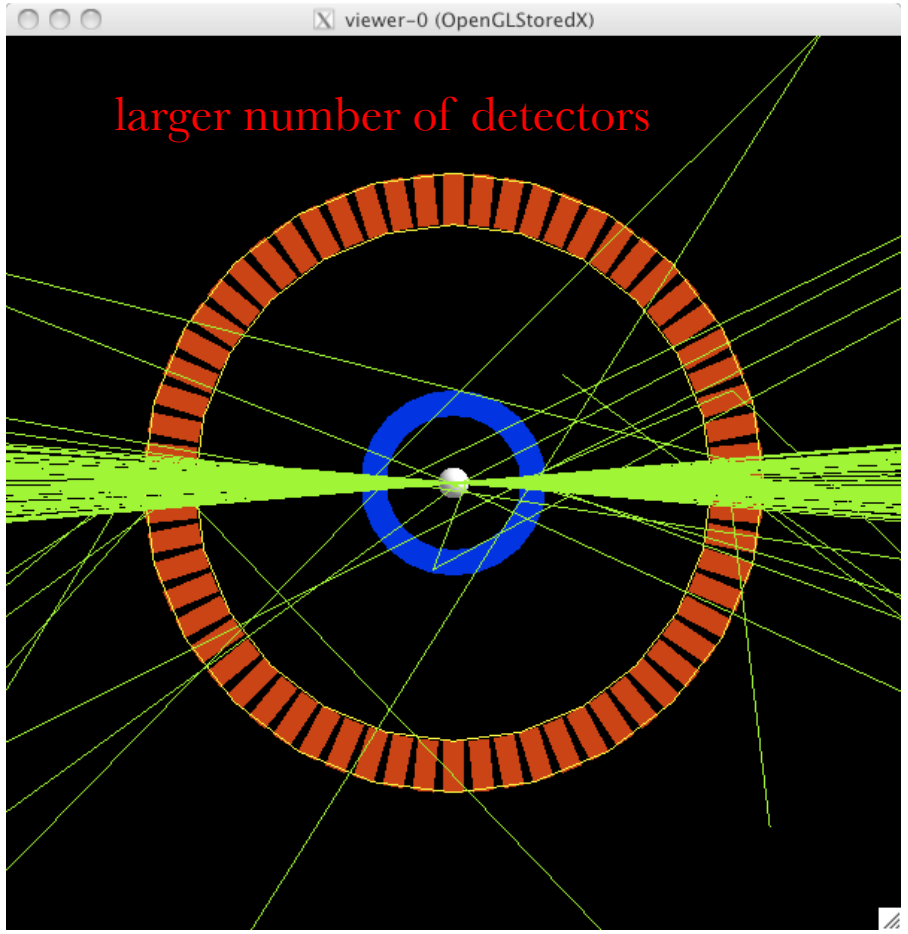


JÜLICH
FORSCHUNGSZENTRUM

Examples of the coincidence channel

- Run `config_starter.sh` to get a user-friendly interface to change the parameters



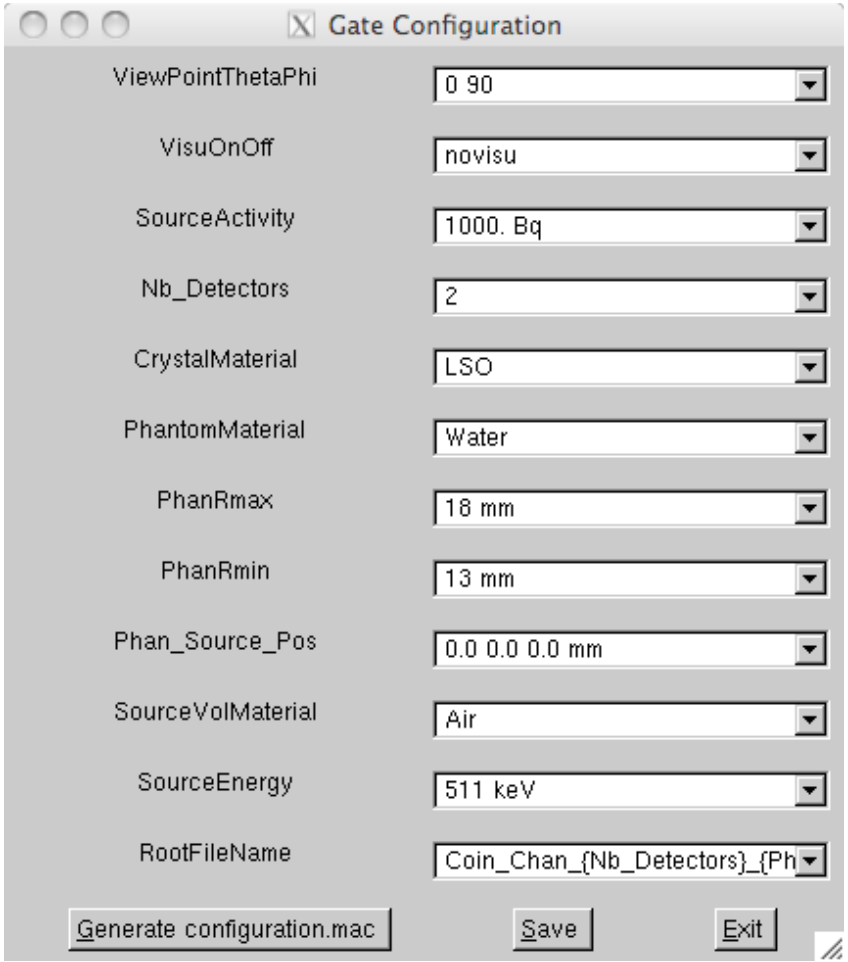


Creates the GATE macro: `Gate Coin_Chan.mac`

JÜLICH FORSCHUNGSZENTRUM

Examples of the coincidence channel

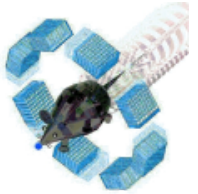
- A text file can be edited to change the possible parameters to be chosen from the menu



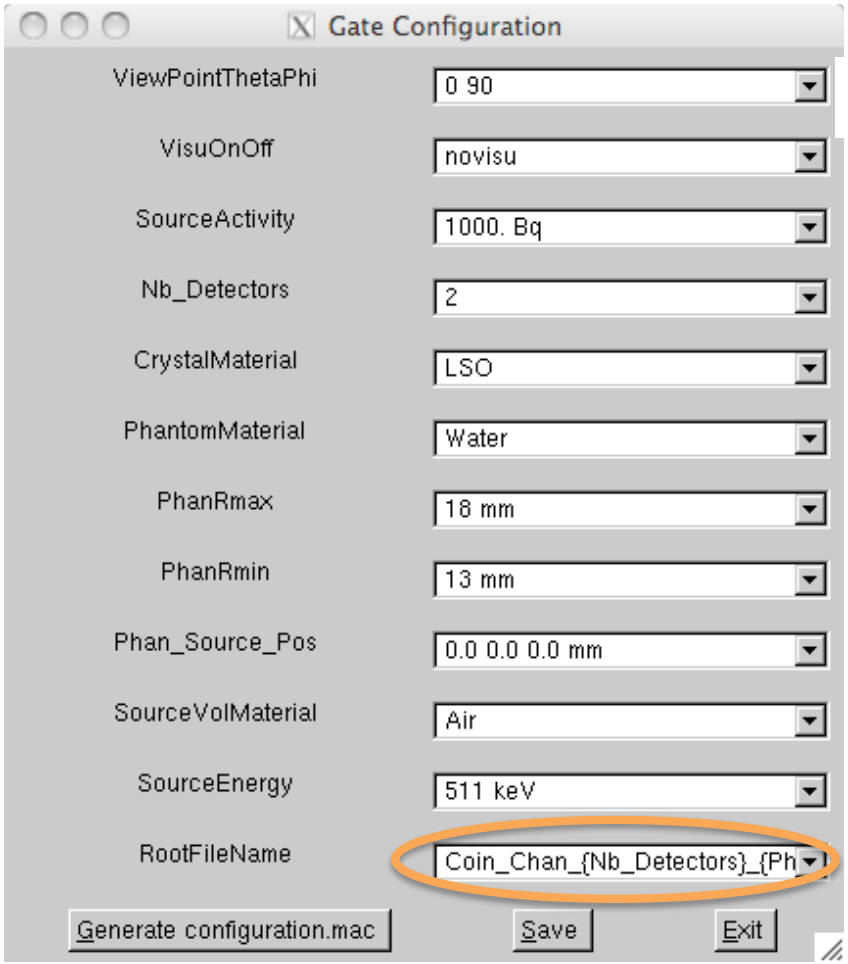
File: Coin_Chan.txt

ViewPointThetaPhi: 0 90; 90 0; 89 90; 30 30;
VisuOnOff: novisu; visu;
SourceActivity: 1000. Bq; 40. Bq; 100000. Bq;
Nb_Detectors: 2; 64;
CrystalMaterial: LSO; BGO; NaI;
PhantomMaterial: Water; Air; Vacuum; Lead; PVC; Plexiglass;
PhanRmax: 18 mm;
PhanRmin: 13 mm;
Phan_Source_Pos: 0.0 0.0 0.0 mm;
SourceVolMaterial: Water; Air; Vacuum; PVC; Plexiglass;
SourceEnergy: 511 keV; 100 keV;
RootFileName: Coin_Chan_{Nb_Detectors}_{PhantomMaterial};

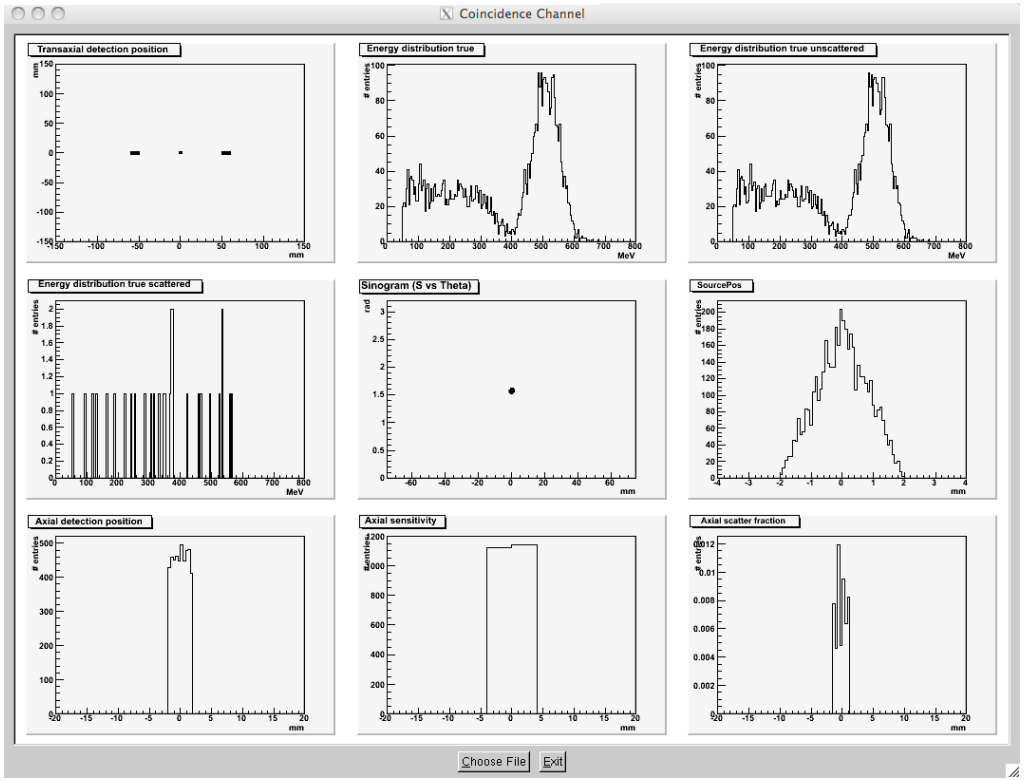
Examples of the coincidence channel



- `Gate Coin_Chan.mac:` A ROOT file is created with the name specified in the menu window

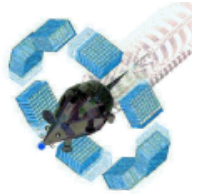


`root -l Coin_Chan.C`



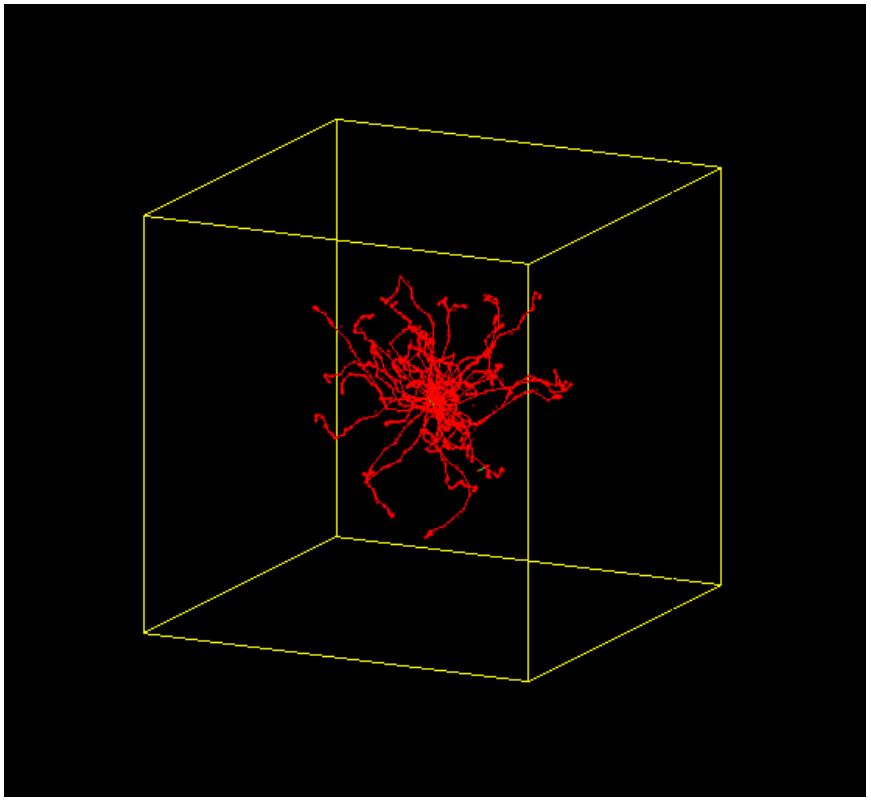
JÜLICH
FORSCHUNGSZENTRUM

Another example: PET-MR module

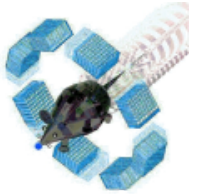


- Initial set-up

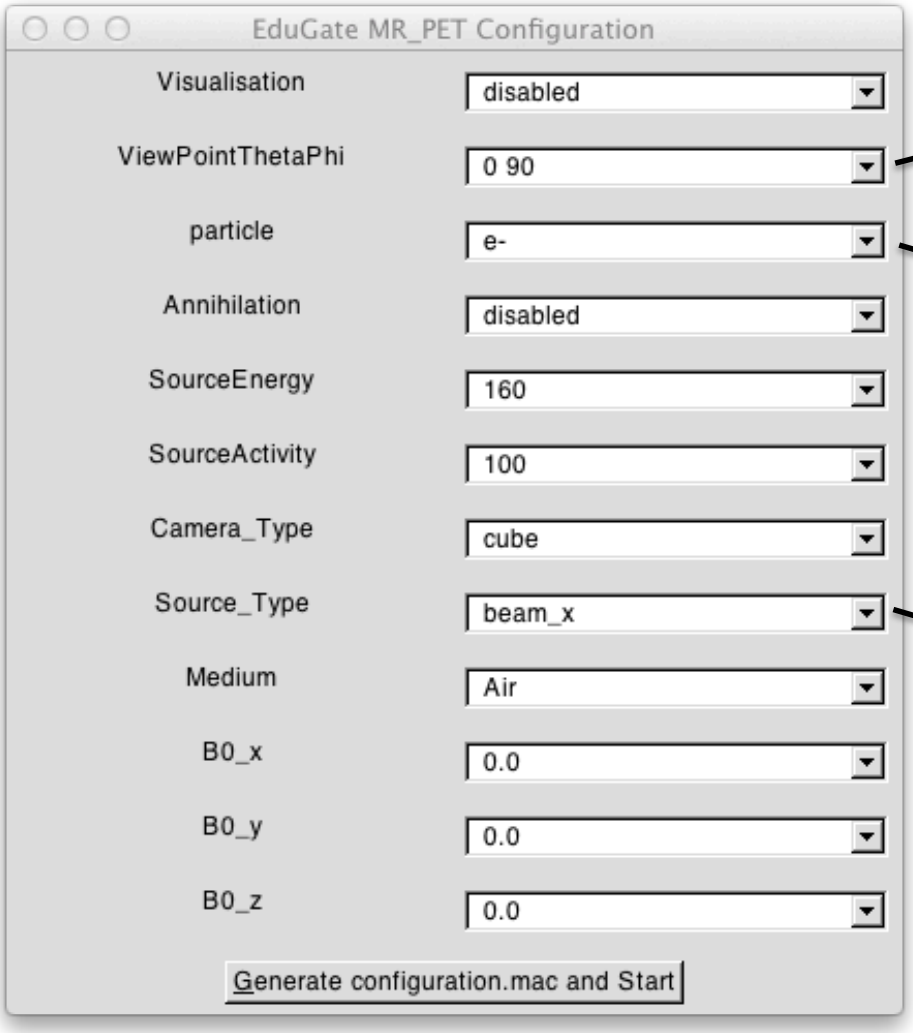
  - Electrons (80 keV) are emitted from an isotropic source (positioned at the origin)
  - Electrons interact with the medium (air), annihilation turned off
  - Trajectories of electrons are plotted as red lines
  - **No** additional magnetic field



Another example: PET-MR module



- Parameters that can be changed:



From which viewpoint you want to see the scene

Can be electrons, positrons or gammas or
O15, C11, F18, Mn52, I124

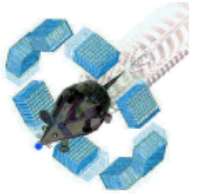
Specify the type of particle propagation (istotropic or beam source)

Another example: PET-MR module

- Parameters that can be changed: MR_PET.txt

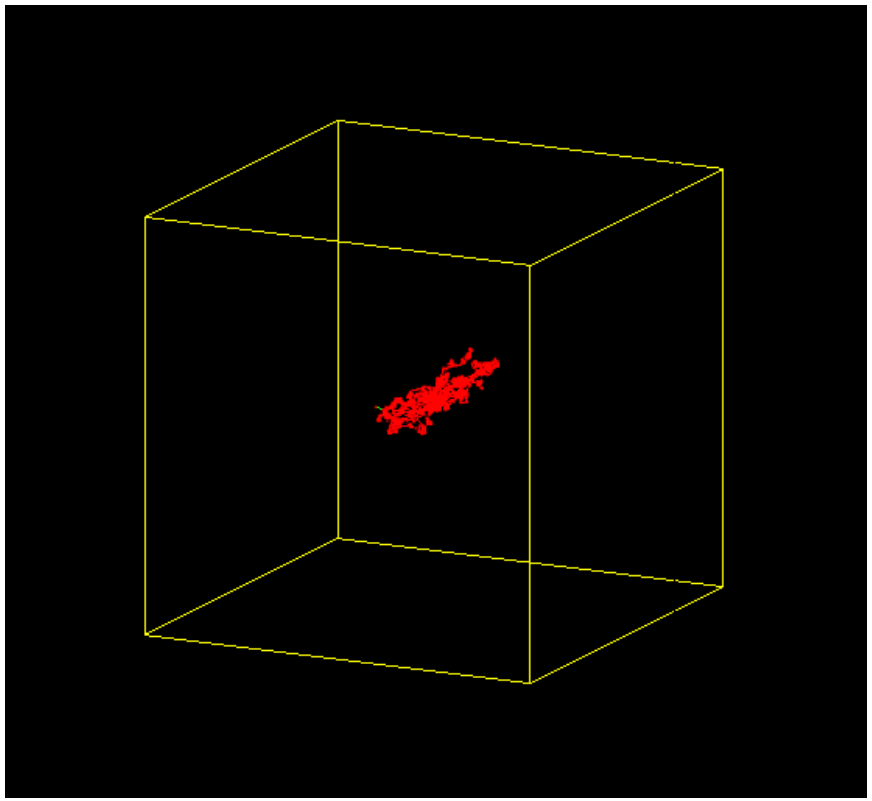
```
Visualisation: disabled; enabled;
ViewPointThetaPhi: 0 90; 30 30; 90 0; -90 0; 89 90; 15 30; 30 30; 45 45; 60 60;
particle: e-; e+; gamma;
Annihilation: disabled; enabled;
SourceEnergy: 10; 30; 50; 80; 90; 100; 120; 140; 160; 200; 240; 400; 600; 800; 1000; 1600;
SourceActivity: 100; 1000; 10000; 100000;
Camera_Type: cube; cylinder;
Source_Type: beam_x; beam_y; beam_z; iso;
Medium: Air; Water; Lung; Liver;
B0_x: 0.0; 0.1; 0.2; 0.3; 0.4; 0.5; 1.0; 3.0; 7.0; 9.4; 12.0; 15.0; 20.0;
B0_y: 0.0; 0.1; 0.2; 0.3; 0.4; 0.5; 1.0; 3.0; 7.0; 9.4; 12.0; 15.0; 20.0;
B0_z: 0.0; 0.1; 0.2; 0.3; 0.4; 0.5; 1.0; 3.0; 7.0; 9.4; 12.0; 15.0; 20.0;
```

Another example: PET-MR module

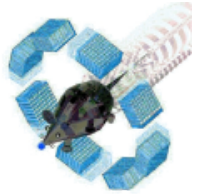


- Turning the magnetic field on

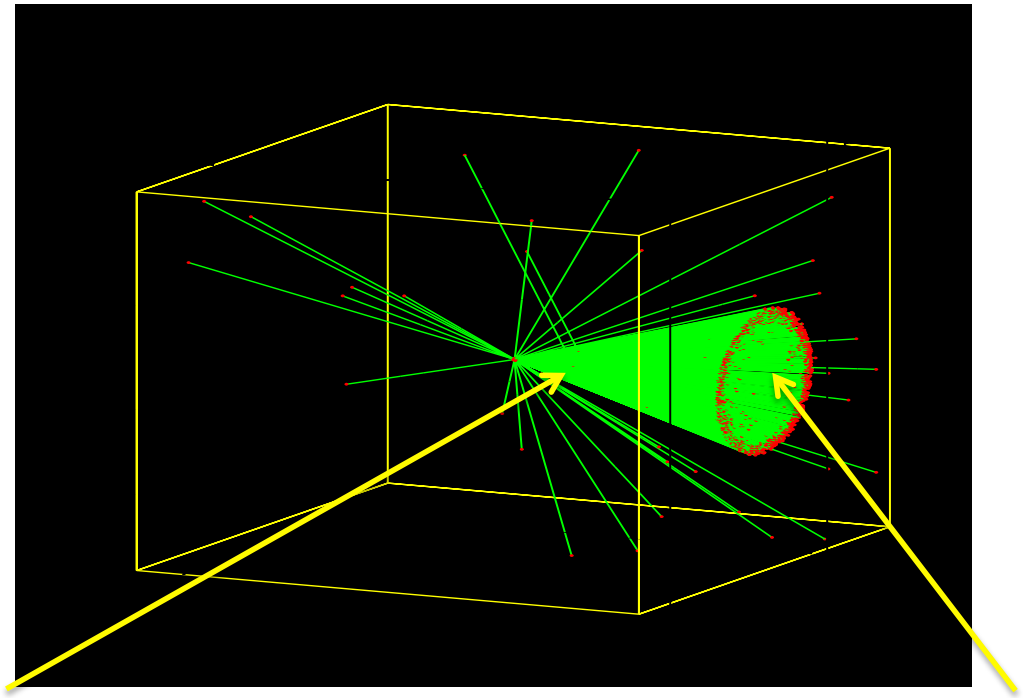
  - Electrons (80 keV) are emitted from an isotropic source (positioned at the origin)
  - Electrons interact with the medium (air), annihilation turned off
  - Trajectories of electrons are plotted as red lines
  - **Magnetic field in the z direction: B_0= 0.5 T**



In progress



- Example demonstrating the signals from ^{176}Lu background in LSO crystals
- Example of Cerenkov radiations



400 keV electron beam source in water

Typical Cerenkov radiation cone

JÜLICH
FORSCHUNGSZENTRUM

Conclusion

- EduGATE is open to feedback and suggestions
- Please contact Uwe Pietrzyk: U.Pietrzyk@fz-juelich.de

ELSEVIER

Zeitschrift für Medizinische Physik

Volume 23, Issue 1, February 2013, Pages 65–70

TECHNISCHE MITTEILUNG

EduGATE – basic examples for educative purpose using the GATE simulation platform

EduGATE – einfache lehrreiche Beispiele zum Zweck der Ausbildung basierend auf der GATE Simulationsplattform

Uwe Pietrzyk[1, 2], Abdelhamid Zakhnini[2, 3], Markus Axer[1, 2], Sophie Sauerzapf[2, 4], Didier Benoit[5], Michaela Gaens[1]