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FORSCHUNGSZENTRUM

MR-PET

A new module for the EduGATE Project

part **two**: ion sources

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Mirjam Lenz, Uwe Pietrzyk

Institute of Neurosciences and Medicine (INM)
Research Center Juelich, Germany

Department of Mathematics and Natural Sciences
University of Wuppertal, Germany

Contact: u.pietrzyk@fz-juelich.de or uwe.pietrzyk@uni-wuppertal.de

Basic Paper
„Zeitschrift für Medizinische Physik“ (Z. Med. Phys. 23 (2013) 65-70)

- ***Long is the way of theory,***

short and effective by examples –

(Lucius Annaeus Seneca (the Younger),
Epistulae morales)

MR-PET

- Introduces to the *basic physical effects* in MR-PET hybrid imaging

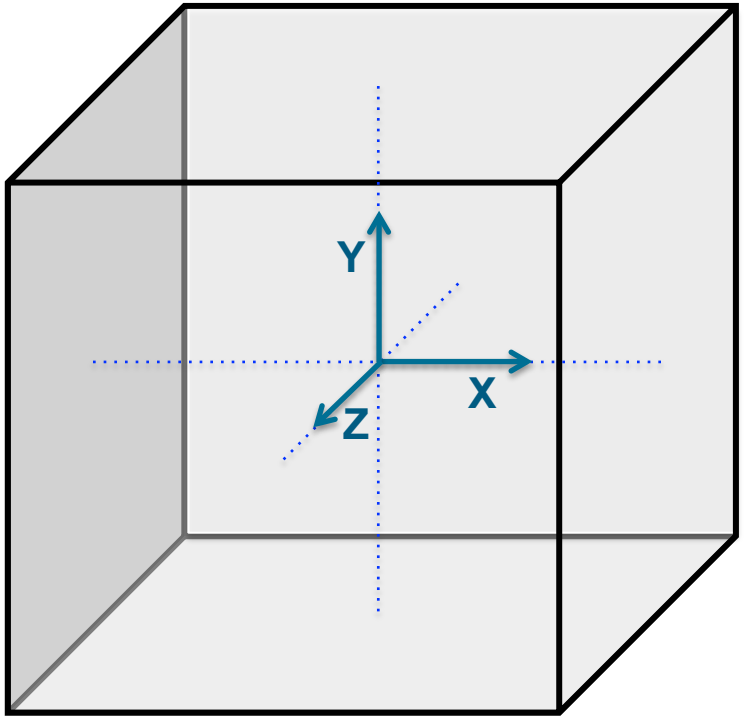
- Provides with GATE-macros

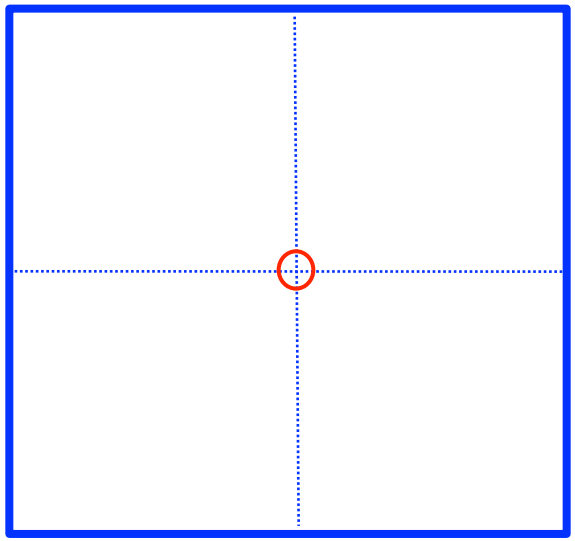
- Provides programme code for ROOT to visualize basic behaviour of charged particles in the magnetic field of a MR System

general setup of the MR-PET module

- ion source emits charged particles or photons
- particles interact with surounding medium (impact ionisation, compton scattering, annihilation of positrons with electrons...)
- additional deviation due to magnetic field (B_0)
- detection of particles in surrounding medium

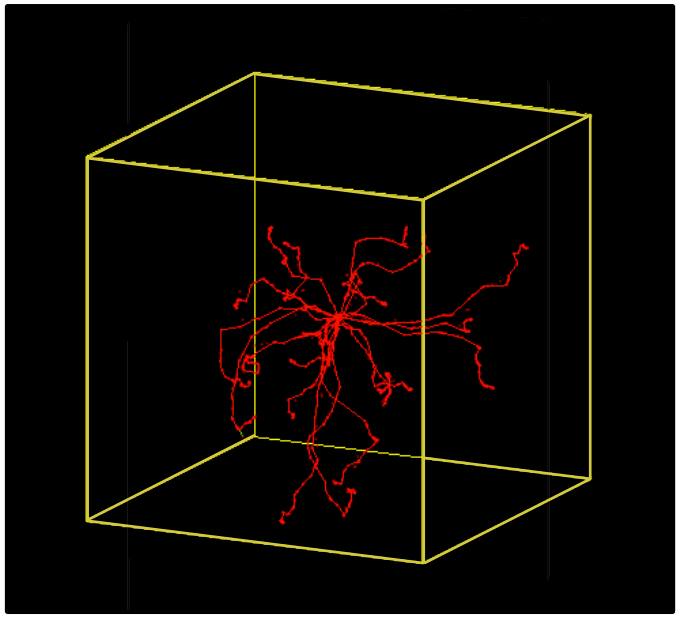
orientation of the coordinate system





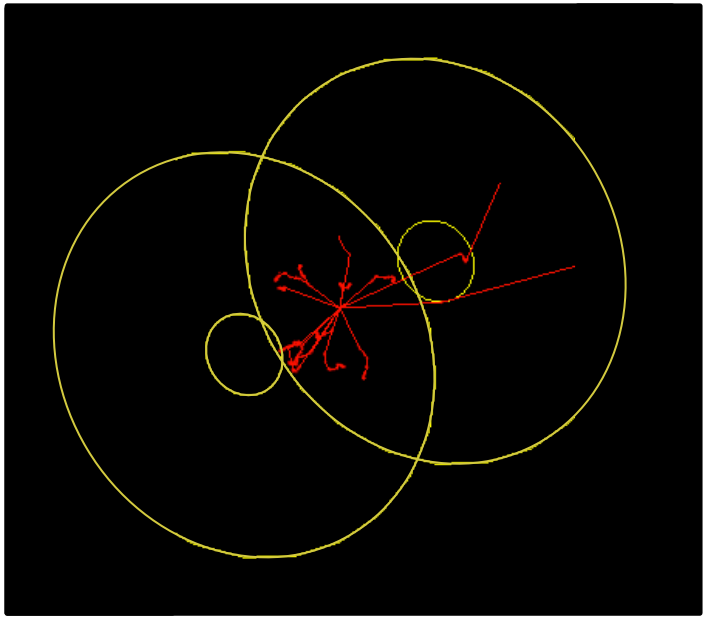
point-like source at center (x = y = z = 0)

shapes of surounding medium



cube

particles interact immediately within medium



cylinder

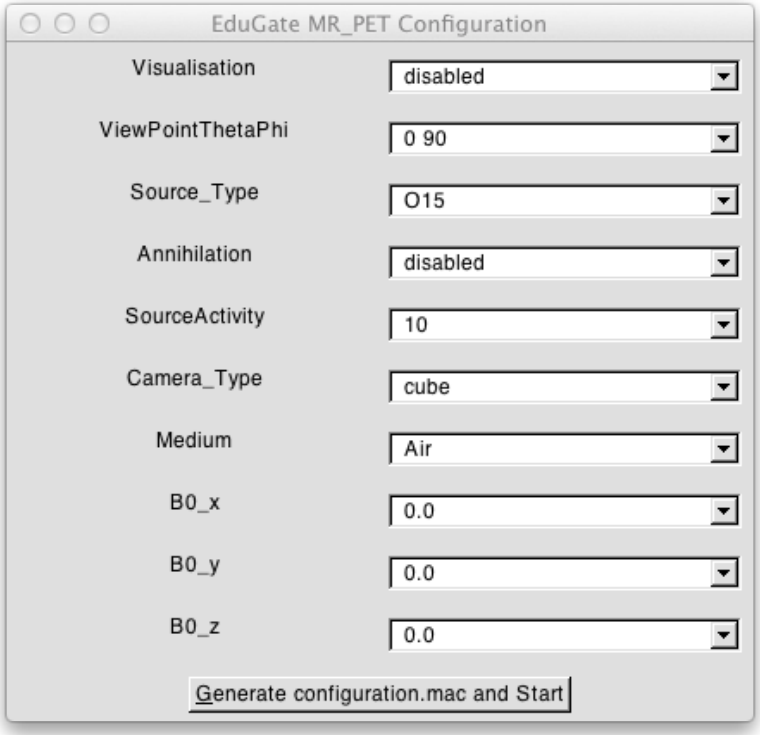
initial deviation due to magnetic field visible (if enabled), followed by interaction within medium

Please note:

- Within GATE ‚crystal' denomiates the volume in which particles are **detected**
- it does not have to be a crystal (like a scintillator) but consists of air, water or lung tissue, etc.
- to prevent misunderstanding the 'crystal' is called ‚**medium**' in this macro

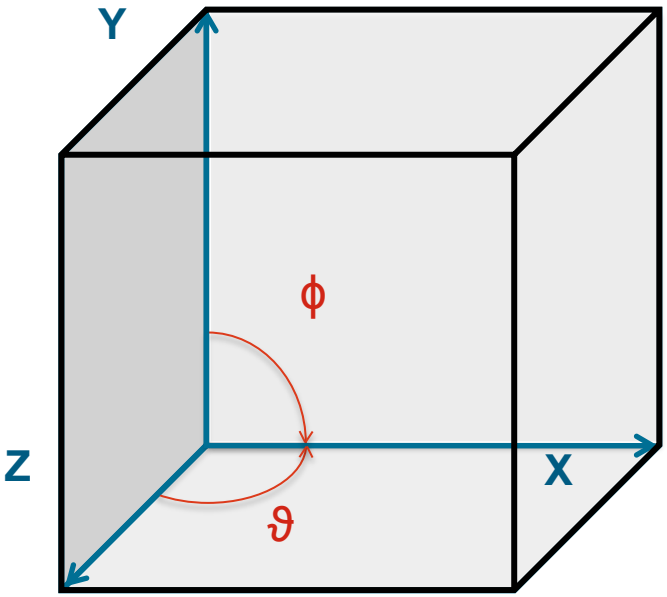
user interface (Gate_v7.0 or 7.1)

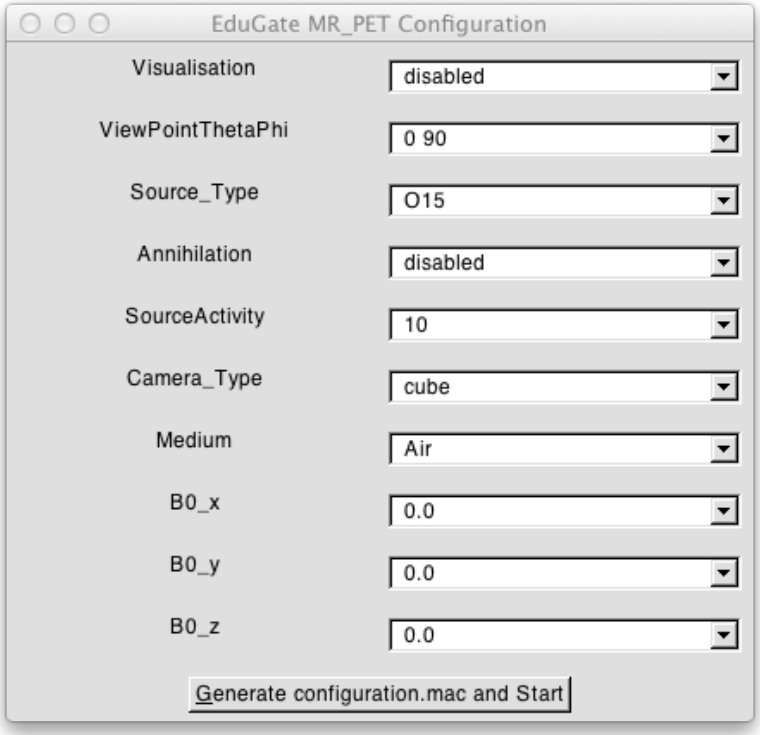
- type „./config_starter_mac_70.csh“ in a terminal window
- specify parameters like source type, source activity, medium etc.
- choose point of view if visualisation is enabled
- generate configuration and start simulation



user interface (Gate_v7.0 or 7.1)

- take a look at the scene under different angles by changing (ϑ,ϕ)





user interface (Gate_v7.0 or 7.1)

selection presets can be modified in „MR_PET.txt“

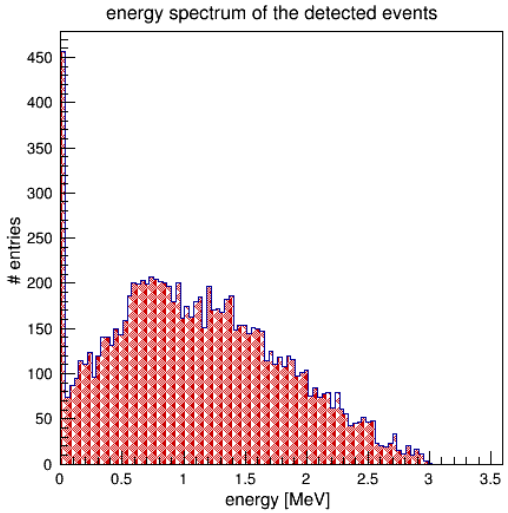
Visualisation: disabled; enabled;
ViewPointThetaPhi: 0 90; 30 30; 90 0; -90 0; 89 90; 15 30; 30 30; 45 45; 60 60;
Source_Type: O15; C11; F18; Mn52; I124;
Annihilation: disabled; enabled;
SourceActivity: 10; 50; 100; 500; 1000; 10000; 20000; 100000;
Camera_Type: cube; cylinder;
Medium: Air; Water; Lung; Liver; Vacuum;
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;

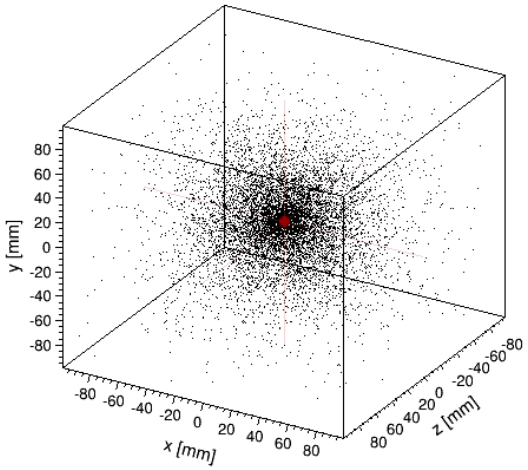
user interface (Gate_v7.0 or 7.1)

- use „MR_PET.C“ to evaluate a specific .root file (file browser opens automatically after simulation)
- further information in terminal window

```
[Acquisition-0] ============= Acquisition starts! =============
[Acquisition-0] Simulation start time = 0 sec
[Acquisition-0] Simulation end time   = 100 sec
[Acquisition-0] Simulation will have  = 10 run(s)
…
##### Reading from file: MR_PET_cube_Water_100_O15_0.0_0.4_0.0_enabled.root
…
##### Number of emitted particles  :  10034
##### Number of detected events    :  10020
##### ratio detected/emitted       :  99.8605 %
```

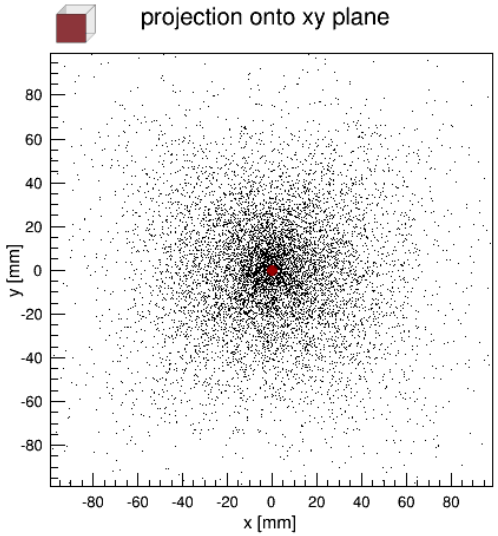
example: ^{52}Mn source in water

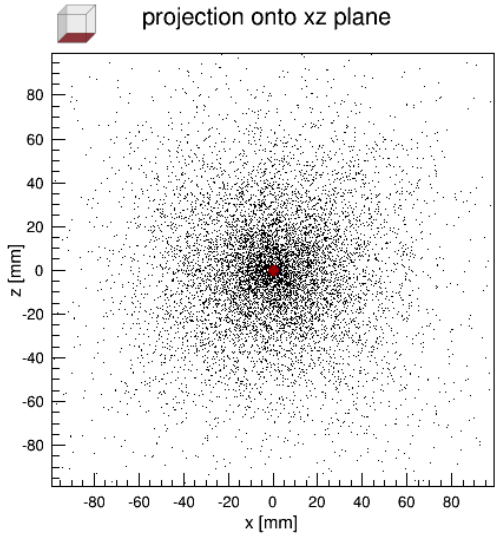


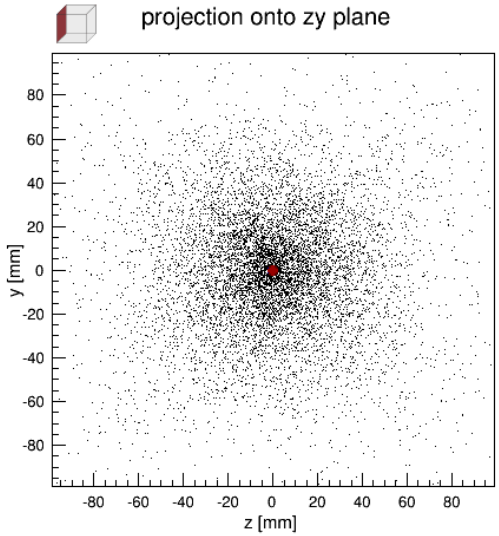


- Ion: Mn52
- camera type: cube
- medium: Water
- source activity: 100 Bq
- $B_{0,x}$: 0.0 T
- $B_{0,y}$: 0.4 T
- $B_{0,z}$: 0.0 T
- positron annihilation: disabled

source position



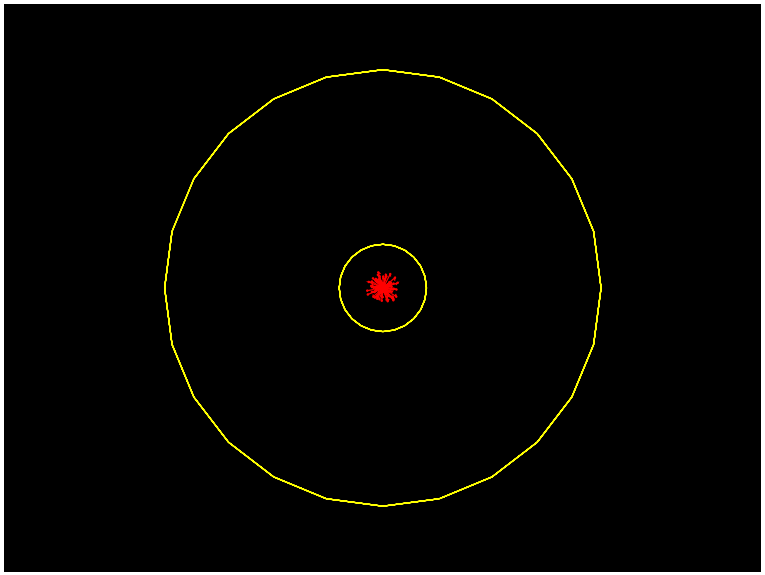


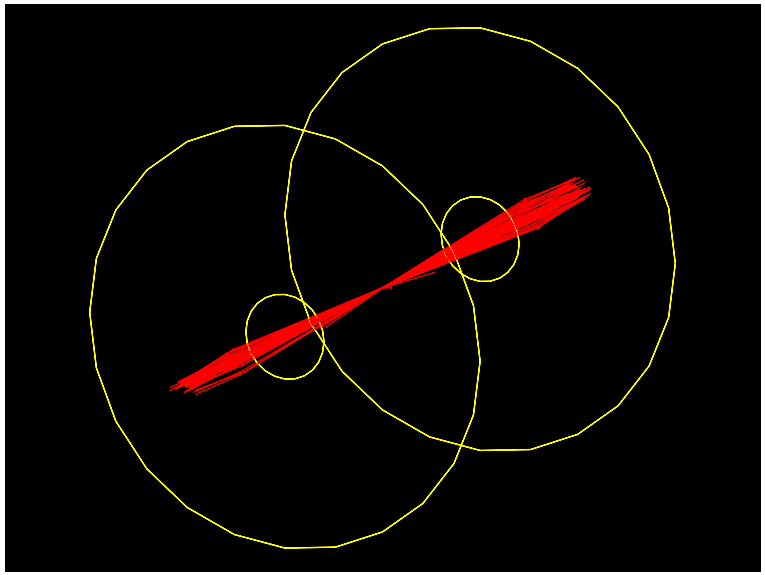


troubleshooting

```
Error: illegal pointer to class object hi_energy 0x0
157  MR_PET.C:172
```

The leaves of the branch you are investigating seem to have no content.
Check your simulation settings: can particles be stopped within the medium or can they leave the medium without being detected?





Example: electron source (100 keV) within a cylindrical medium (Air), magnetic field in z direction (0.3 T). The electrons can't even enter the medium due to deviation caused by presence of magentic field.