EASYPET-EDUGATE SIMULATION TOOLKIT

Prague IEEE NPSS EDUCOM International Summer School, July 2025

1. Install the vGate virtual machine with EasyPET-EduGate Simulation Toolkit

This exercise is designed based on the simulation and data analysis program for a two-detector PET system. The program operates on a virtual machine with the following software:

- Ubuntu LTS 18.04 with VirtualBox (40GB virtual HD)
- GATE 8.2
- GateContrib: a user-oriented public repository for Gate (macros, examples, and user contributions)
- Geant4 10.05.0
- Root 6.14.00
- Anaconda3 (Python 3.5, PyQt4, NumPy, SciPy, Matplotlib, scikit-image, scikit-learn)
- EasyPET-EduGate Simulation Toolkit

Step 1: Install Virtual Box

Go to Download VirtualBox page to download VirtualBox binaries
https://www.virtualbox.org/wiki/Downloads

Download and install **VirtualBox 7.0.18 platform** and **VirtualBox 7.0.18 Oracle VM VirtualBox Extension Pack** (for USB 2.0 and USB 3.0 devices, VirtualBox RDP, disk encryption, NVMe and PXE boot for Intel cards).

Step 2: Add the vGate 8.2 with EasyPET Simulation toolkit

Copy the virtual machine image file and import to the VirtualBox.

Adjust the "Appliance Import Settings" depending on your computer settings. For instance, if your computer has 8 GB RAM, you can dedicate only 4 GB to the virtual machine, and 2 GB if your computer has only 4 GB RAM. Dedicating too much or too few RAM to the VirtualBox will slow down your computer.

Login credentials are:

- user: gate
- password: virtual

2. Running simulation and analyzing data

To start the EasyPET-EduGate Simulation Toolkit, you should go to the easyPET-EduGate-master directory and call the Simulation GUI:

- cd easyPET-EduGate-master
- python SimulationGUI.py

The EasyPET-EduGate Simulation Toolkit has two menus, 'Simulation' and 'Data analysis' as shown in Figures 1 and 3. Figure 2 shows the real EasyPET toolkit and description of the rotation angles.

2.1 Running simulation

Step 1: Select simulation output folder

Click on the ‘Select simulation output’ button to choose an output folder:

➢ '/home/gate/EasyPET_sim/Outputs'

Note: The toolkit won't be able to create necessary macros for Gate if you don't select proper simulation output directory.

Good practice: The output directory should be outside the 'easyPET-EduGate-master' folder for easily upgrading the codes in the future.

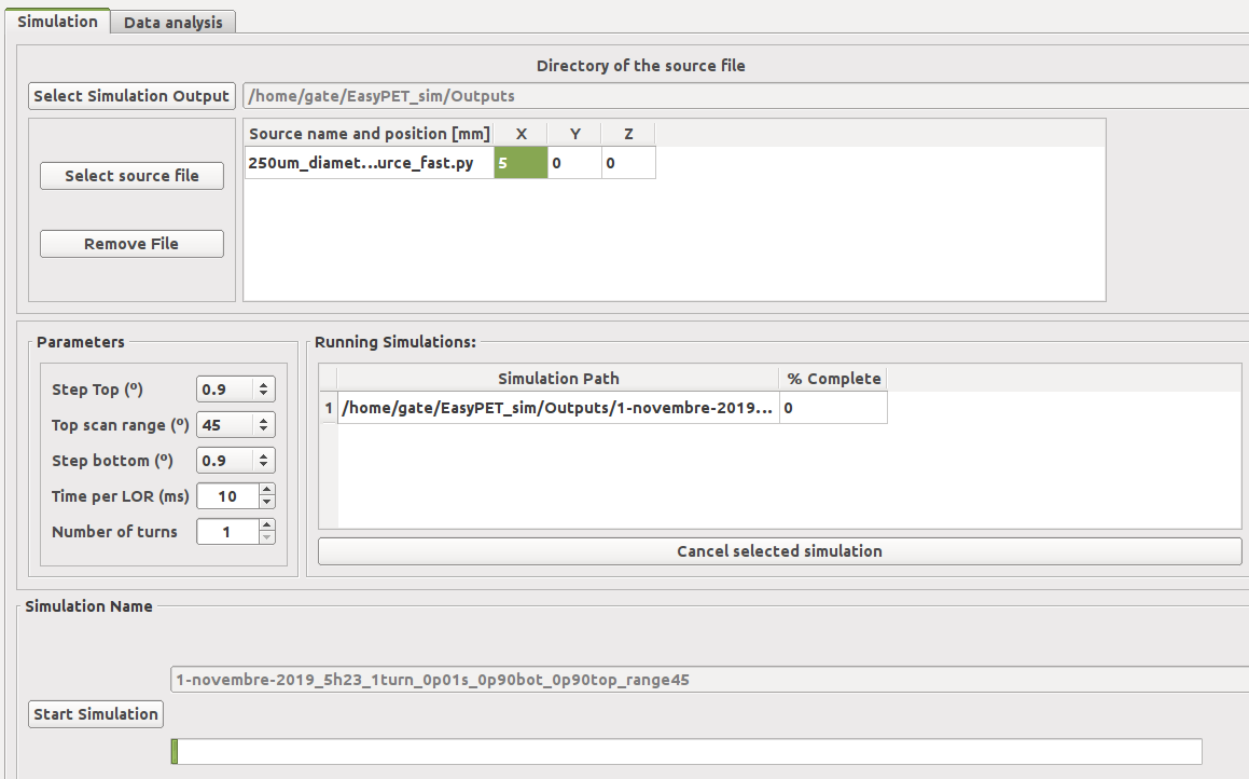


Figure 1. Simulation menu on the EasyPET Simulation GUI

Step 2: Select source

Click on the 'Select source file' button and choose the necessary source file.

For example, the source file '250um_diameter_10uCi_1cmAcrylicNa22Source_fast.py' means there is a Na-22 source (10 uCi, a disk with diameter of 250 um) placed in an acrylic holder (diameter of 1 cm). The simulation starts with annihilation gammas (511 keV) instead of positrons from Na-22 for fast simulation.

Step 3: Choose a source position

Change the three-coordinate position (x, y, z mm) next to the selected source name. The coordinate origin is at the center of the EasyPET machine as shown in Figure 2.

Example: (5 0 0) means the source is at the position (x = 5 mm, y = 0 mm, z = 0 mm)

Step 4: Choose EasyPET angle parameters

Step top: the angular increments in the fan rotation of Detector 1 (9°)

Top scan range: the angular arc covered by the rotation of Detector 1 (45°)

Step bottom: the angular increments in the axial rotation of Detector 2 (9°)

Time per LOR: simulation time for each LOR in ns (10 ms)

Number of turn: the number of turns of Detector 2

Step 5: Run simulation

Click on the 'Start Simulation' button and check the error files in the output folder.

Note: It takes time to finish the simulation (30 minutes or more depends on the configuration of the virtual machine).

TIPS: When the simulation finishes, there is no message either on the GUI or the terminal. You should compare the time of the 'easyPETSimulationGate.out' file with the time of the machine. If the 'easyPETSimulationGate.out' file keeps updating, the simulation is running. When the simulation stops, the 'easyPETSimulationGate.out' will end with the line, 'Visualization Manager deleting ...'. The simulation data are stored in 'easyPET.root' file.

Analyzing Data

Step 1: Open the root file from the simulation

Click 'Select results file' and looking for the simulation root file 'easyPET.root'

Step 2: Choose parameters for image reconstruction

Filter type: the filter for image processing.

It could be None/ramp/shepp-logan/cosine/hamming/hann

Interpolation: the algorithm to interpolate data for image reconstruction, linear/nearest/cubic.

Pixel size (mm): 0.1/0.25/0.5/1/2

Gauss filter: the parameter for a Gauss filter in FBP

Colormap: color maps for visualization (sinogram and reconstructed image)

Coincidence window (ns): the time window to select coincidence events

Energy window (keV): the energy window of selected events

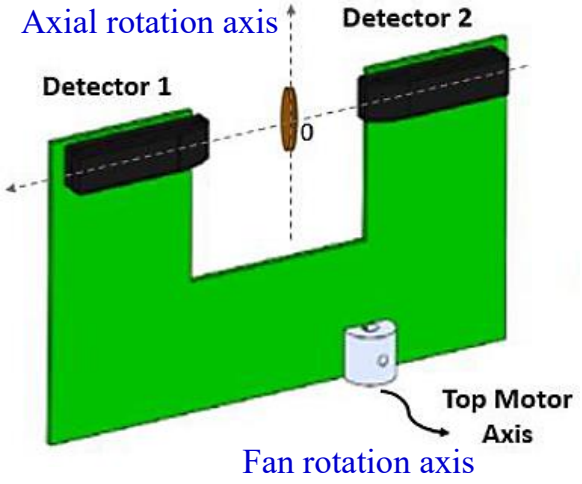
Step 3: Data analysis and image reconstruction

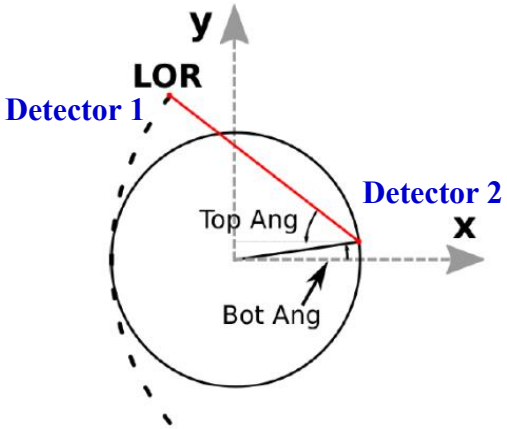
Click on the 'Start Analysis' to run the analysis program.

A sinogram and the reconstructed image will be shown on the left pad, and the energy spectrums of the annihilation gammas are shown on the right pad.

(a)

(b)





(c)

Figure 2. (A) EasyPET kit, (B) Rotation axes, (C) Rotation angles [1].

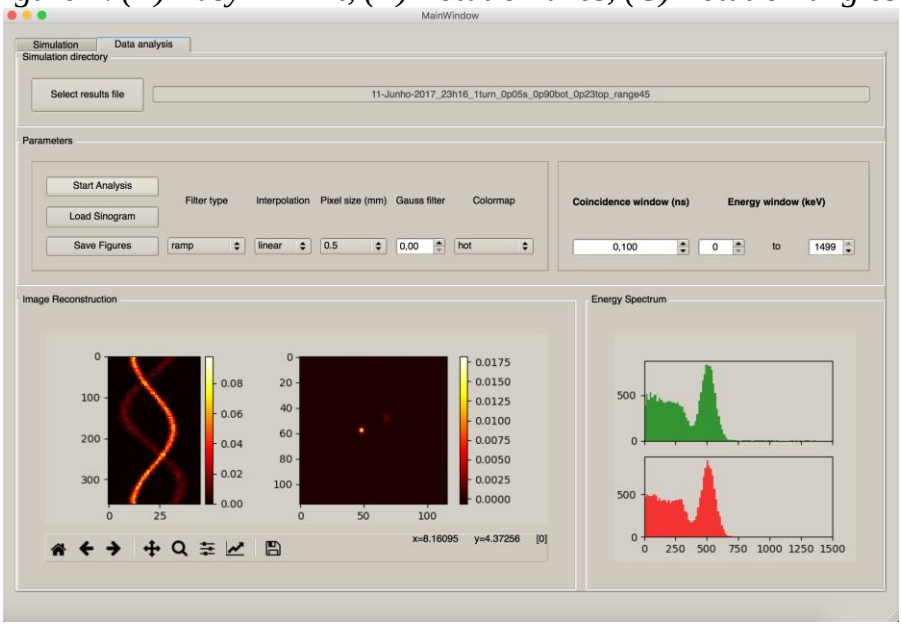


Figure 3. Data Analysis Menu

References

1. CAEN 2018 SP5700 EasyPET Guide, https://www.caen.it/products/sp5700/

2. Correia, Pedro Manuel Mendes, et al. "An EDUGATE simulation toolkit based on the educational easyPET." *Biomedical Physics & Engineering Express* 5.2 (2019): 025009.