Starting your first experience with GATE

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Workflow

- How to define your simulation:
  - no coding, no compilation
  - simple text file (.mac) with macro commands

```
gate@vgate: ~/school_vietnam/Ex1-dose1D
File  Edit  View  Search  Terminal  Help
#================================================
# GEOMETRY
#================================================

/gate/geometry/setMaterialDatabase data/GateMaterials.db

# World
/gate/world/geometry/setXLength 1 m
/gate/world/geometry/setYLength 1 m
/gate/world/geometry/setZLength 1 m
/gate/world/setMaterial Air


# Water Box
/gate/world/daughters/name              waterbox
/gate/world/daughters/insert            box
/gate/waterbox/geometry/setXLength      40 cm
/gate/waterbox/geometry/setYLength      40 cm
/gate/waterbox/geometry/setZLength      40 cm
/gate/waterbox/setMaterial Water
/gate/waterbox/vis/setColor blue

#================================================
# PHYSICS
#================================================

/gate/physics/addPhysicsList emstandard_opt4
```

- How to run a simulation:

```
gate@vgate: ~/school_vietnam/Ex1-dose1D
File  Edit  View  Search  Terminal  Help
[2077] 16:51 vgate:~ >
[2077] 16:51 vgate:~ > cd school_vietnam/Ex1-dose1D/
[2078] 16:51 vgate:~/school_vietnam/Ex1-dose1D > ls
data  mac  output
[2079] 16:51 vgate:~/school_vietnam/Ex1-dose1D > Gate mac/main.mac
```

Structure of a macro file .mac

1. Geometry
   - ➔ define the geometry of your experiment
2. Physics
   - ➔ setup the physics you want to account for
3. Scorers, output
   - ➔ define the information you want to collect
4. Initialisation
   - ➔ set the random seed and initialize the simulation
5. Sources
   - ➔ define the source of particles
6. Start
   - ➔ set the number of particles and start the simulation

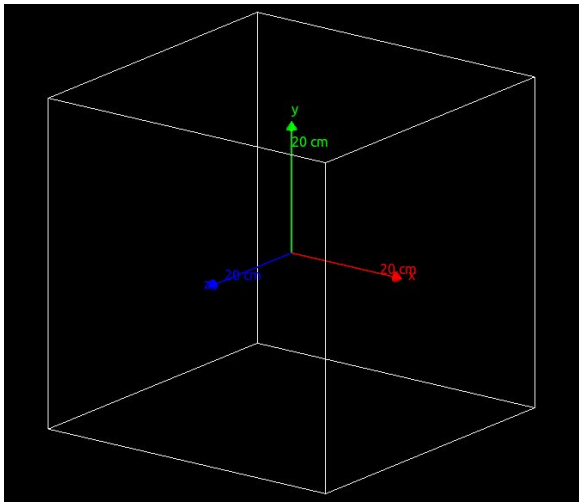
The order is important

```
#=========================
# GEOMETRY
#=========================

#=========================
# PHYSICS
#=========================

#=========================
# SCORERS, OUTPUT
#=========================

#=========================
# INITIALISATION
#=========================

#=========================
# SOURCES
#=========================

#=========================
# START
#=========================
```

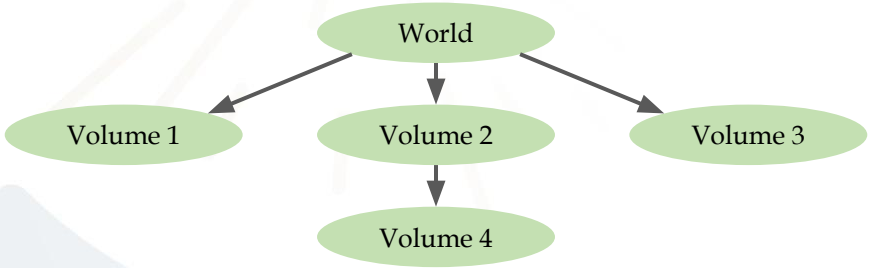
1. Geometry

- ***The World*** : required volume, define the limits of the simulation
  - ➔ you need to set its size and composition:

```
/gate/world/geometry/setXLength      2.0 m
/gate/world/geometry/setYLength      2.0 m
/gate/world/geometry/setZLength      2.0 m
/gate/world/setMaterial              Air
```



- All volumes are daughters or little-daughters of the world



1. Geometry

- To insert a volume in a simulation:

➔ Give a new name

```
/gate/world/daughters/name                    volume_name
```

➔ Assign a shape

```
/gate/world/daughters/insert                  box
```

➔ Define its size

```
/gate/volume_name/geometry/setXLength         20. cm
/gate/volume_name/geometry/setYLength         40. cm
/gate/volume_name/geometry/setZLength         50. cm
```

➔ Place it

```
/gate/volume_name/placement/setTranslation    40. 0. 0. cm
```

The position is given with respect to the center of the mother volume

➔ Assign a material

```
/gate/volume_name/setMaterial                 Air
```

The list of the available materials is in the GateMaterials.db file

http://wiki.opengatecollaboration.org/index.php/Users_Guide:Defining_a_geometry

1. Geometry

- To set the material database:

```
/gate/geometry/setMaterialDatabase  GateMaterials.db
```

- To define a new material, edit the file GateMaterial.db:

```
[Elements]
 Hydrogen:    S= H   ; Z=  1  ; A=   1.01  g/mole
 Carbon:      S= C   ; Z=  6  ; A=  12.01  g/mole

[Materials]
 NaI: d=3.67 g/cm3; n=2;  state=solid
      +el: name=Sodium ; n=1
      +el: name=Iodine ; n=1

 CsITl: d=4.51 g/cm3; n=3; state=solid
      +el: name=Cesium ; f=0.511
      +el: name=Iodine ; f=0.488
      +el: name=Thallium ; f=7.86e-04
```

Create a new element

Create a new material

Compound with elements added by atom number

Compound with elements added by mass fraction

2. Physics

- As in Geant4, you can use predefined physics lists (recommended):

```
/gate/physics/addPhysicsList              emstandard_opt4
```

- You can add processes to it:

```
/gate/physics/addProcess                  RadioactiveDecay
```

- And set production cuts (do not produce secondaries if below threshold):

```
/gate/physics/Gamma/SetCutInRegion        world 1 mm
/gate/physics/Electron/SetCutInRegion     world 1 mm
/gate/physics/Positron/SetCutInRegion     world 1 mm

/gate/physics/Gamma/SetCutInRegion        waterbox 0.1 mm
/gate/physics/Electron/SetCutInRegion     waterbox 0.1 mm
/gate/physics/Positron/SetCutInRegion     waterbox 0.1 mm

/gate/physics/displayCuts
```

http://geant4-userdoc.web.cern.ch/geant4-userdoc/UsersGuides/PhysicsListGuide/html/index.html

3. Scorers, output

- "Actor" concept to get specific information:
  - DoseActor : store deposited dose
  - SimulationStatisticActor : store number of events, tracks, steps
  - KillActor : kill a particle when passing through a volume
  - TrackLengthActor : store the length of a track
  - EnergySpectrumActor: store energy distribution
  - ProductionAndStoppingActor: store positions of produced secondaries
  - PhaseSpaceActor: store the particle's type, position, direction, energy, ...
- Raw outputs (more details tomorrow):
  - store all interactions in a volume (needs to be attached to a "system")

http://wiki.opengatecollaboration.org/index.php/Users_Guide:Tools_to_Interact_with_the_Simulation_:_Actors

3. Scorers, output

- Dose Actor:
  - Store the deposited energy (Edep), absorbed dose (Dose) in a given volume
- Several files types:
  - ASCII file (.txt): only for 1D distribution
  - Root file (.root): for 1D and 2D distributions
  - Analyze (.hdr/.img) and MetaImage (.mhd/.raw) for 3D distributions

```
/gate/actor/addActor                          DoseActor MyActor
/gate/actor/MyActor/save                      MyOutputFile.mhd
/gate/actor/MyActor/attachTo                  MyVolume
/gate/actor/MyActor/stepHitType               random
/gate/actor/MyActor/setSize                   5 5 5 m
/gate/actor/MyActor/setResolution             1 1 3000
/gate/actor/MyActor/enableEdep                true
/gate/actor/MyActor/enableUncertaintyEdep     true
/gate/actor/MyActor/enableSquaredEdep         false
/gate/actor/MyActor/enableDose                false
```

4. Initialisation

- Geometry, Physics tables are initialized with:

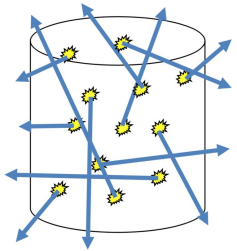
```
/gate/run/initialize
```

The geometry and physics list cannot be modified after this step

- The random engine and seed:
  - JamesRandom, Ranlux64 or MersenneTwister
  - the seed can be set to a fixed integer or random (auto)

```
/gate/random/setEngineName          MersenneTwister
/gate/random/setEngineSeed          auto
```

5. Sources



- General Particle Source (GPS)
- Define: particle, energy, shape, direction, intensity, etc …

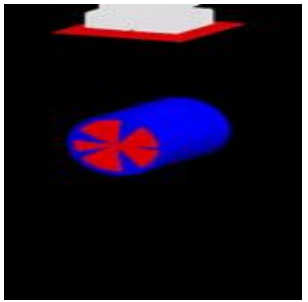
```
/gate/source/addSource                      mysource gps
/gate/source/mysource/gps/particle          gamma
/gate/source/mysource/gps/energy            140. keV
/gate/source/mysource/gps/type              Volume
/gate/source/mysource/gps/shape             Cylinder
/gate/source/mysource/gps/radius            0.1 cm
/gate/source/mysource/gps/halfz             9. cm
/gate/source/mysource/gps/centre            2. 0. 0. cm
/gate/source/mysource/setActivity           200000. Bq
/gate/source/mysource/angtype               iso
```

http://wiki.opengatecollaboration.org/index.php/Users_Guide:Source

6. Start

- GATE is designed to run for a ‘real life’ equivalent time, splitted in slices.
  The time is used for source activity and motion of your geometry.
- During one Slice:
  - the geometry is static
  - only particle transport and data scoring

```
/gate/application/setTimeStart      0 s
/gate/application/setTimeStop       15 s
/gate/application/setTimeSlice      5 s
/gate/application/start
```



- When the source has no activity or defined with a list (PhSp file), you can set the number of particles to simulate:

```
/gate/application/setTotalNumberOfPrimaries 500
/gate/application/start
```

Hands-on

Hands-on: water box and dose actor

In the folder school_vietnam/Ex1-dose you will find three folders: `/data /mac /output`

In the /mac folder, open the file main.mac : look for the different sections of this course. You will find some parts missing that you have to complete:

- ➔ Geometry:
  - define a box of 40 cm made of water
- ➔ Physics:
  - setup the physics list emstandard_opt4
- ➔ Scorers, output:
  - define a dose actor attached to the waterbox of resolution 1 1 100, enable the dose output
- ➔ Source:
  - define a source of 100 keV gamma particles positioned at 0 0 40 cm and in the direction of the waterbox (-Z direction)
- ➔ Start:
  - set the number of particles to simulate to 500

➔ Save the file and execute the simulation with **`Gate --qt mac/main.mac`**

➔ Look at the folder output to see what files have been produced

➔ Visualise the results with **`vv output/result-Dose.mhd`**. What do you see ?