# European Summer School

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# GATE Monte Carlo Simulation
## *An introduction*

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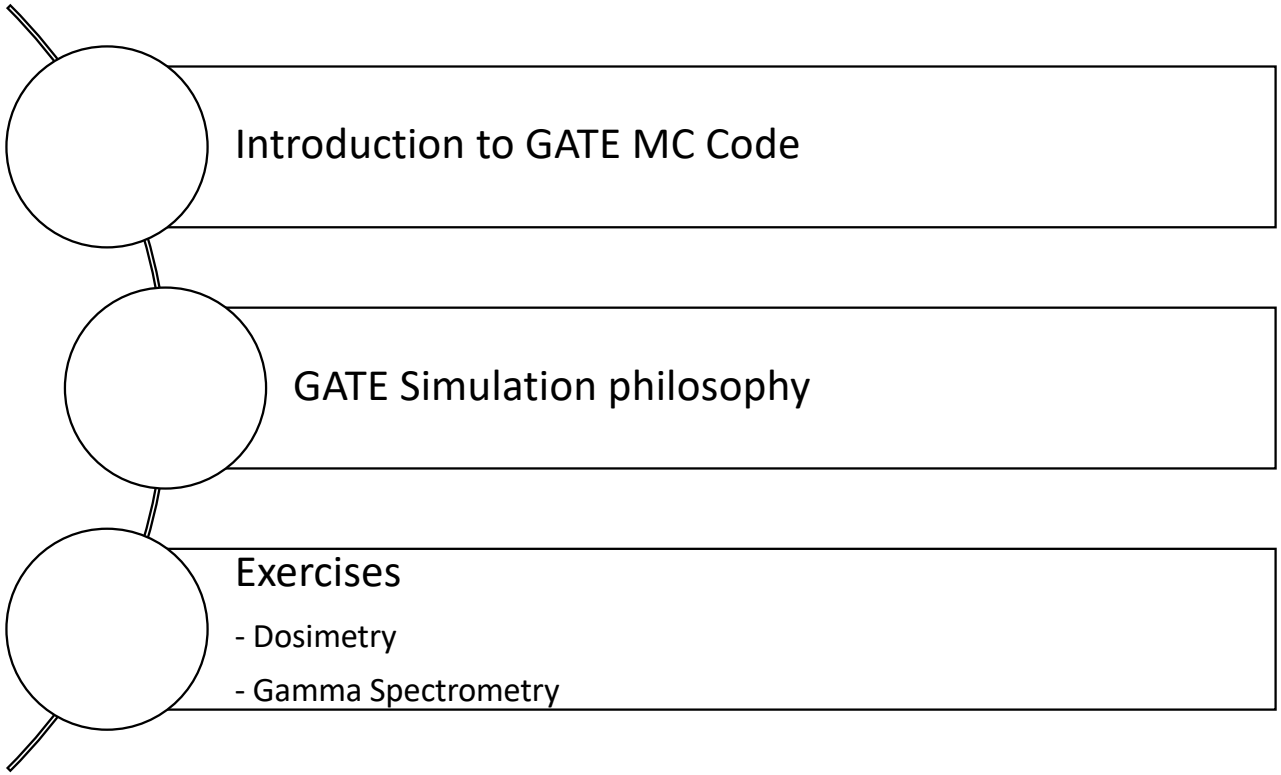
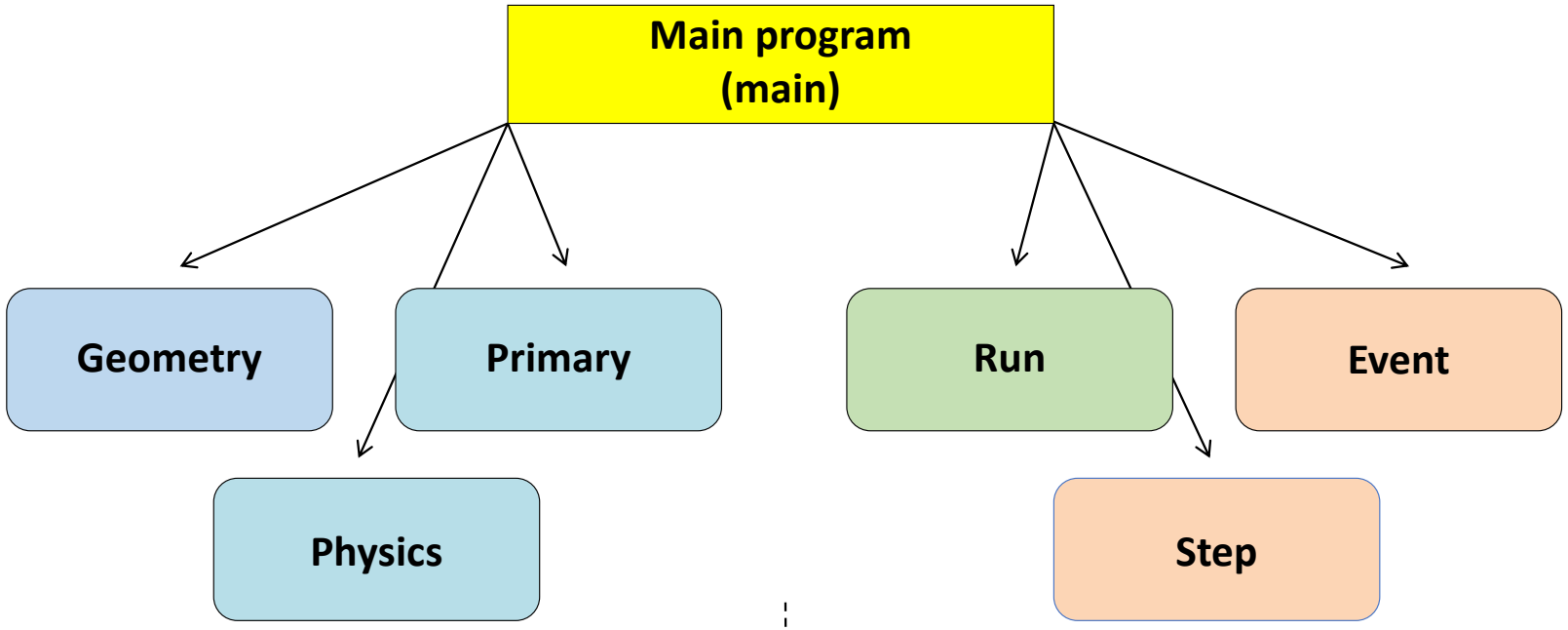
# Outline


Introduction to GATE MC Code
GATE Simulation philosophy
Exercises
- Dosimetry
- Gamma Spectrometry

# GATE MC Code

- GATE (**G**eant4 **A**pplication for **T**omography **E**mission) – developed in 2002 via international collaboration
- Open source simulation software based on GEANT4
- Provides non (computing)-experts simplified tools for applying Geant4 (C++ based) to radiation-matter simulations
- Broad range of applications
  - Detector design and calibration
  - Radiation therapy
  - Medical imaging
  - Radiation protection
  - Dosimetry, etc


# GATE Simulation Philosophy




Geometry = volumes + materials

Primary = particle sources

Physics = interaction processes

**Macros**

Run = set of events

Event = set of primary particle interactions

Step = particle propagation step by step

**Actors**

# Geometry

Elements / Materials/Volumes:

- Materials must be defined in the *GateMaterials.db* (directory *data*)
- Materials are based on pre-defined elements. Parameters include

- density (d) - number of elements (n) - state (optionnal) - composition (mass fraction of each element or atomic composition)

# Physics

- The Physics describes a physical process which corresponds to:
  - a physical model
  - an effective cross-section

  Eg. **/gate/physics/addPhysicsList emstandard_opt3**

# Actors

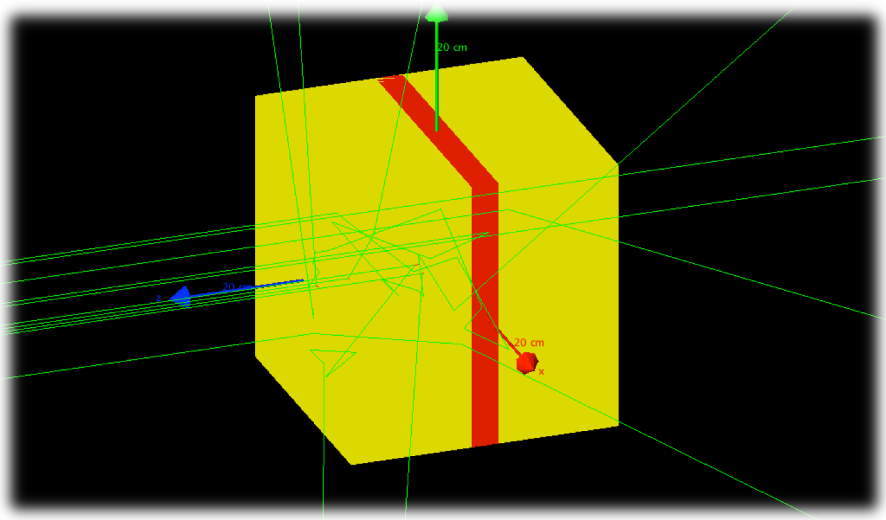
- Pre-defined actors (otherwise Tallies) register useful information from the simulation:
  - energy / dose deposited in a given volume
  - Fluence (number of particles crossing a volume)

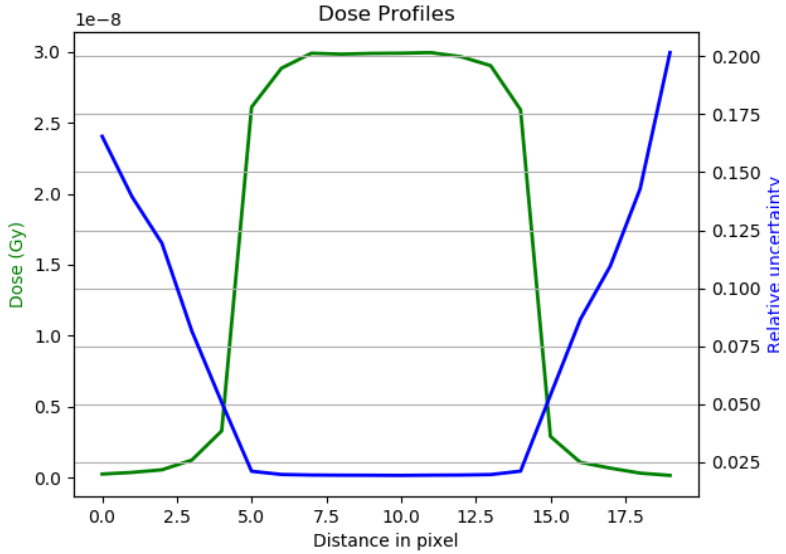
# Example: main.mac

```
#=====================================================================================================
# World
#=====================================================================================================

/gate/geometry/setMaterialDatabase  data/GateMaterials.db
/gate/world/setMaterial           Air
/gate/world/geometry/setXLength    5. m
/gate/world/geometry/setYLength    5. m
/gate/world/geometry/setZLength    5. m

#=====================================================================================================
# Geometry
#=====================================================================================================

/gate/world/daughters/name                  WaterCube
/gate/world/daughters/insert                box
/gate/WaterCube/geometry/setXLength     20. cm
/gate/WaterCube/geometry/setYLength     20. cm
/gate/WaterCube/geometry/setZLength     20. cm
/gate/WaterCube/setMaterial                                          Water
/gate/WaterCube/placement/setTranslation                 0. 0. 0. cm
/gate/WaterCube/vis/setVisible          1
/gate/WaterCube/vis/setColor            yellow
/gate/WaterCube/vis/forceSolid

#=======================================================
# INITIALIZATION
#=======================================================

/gate/run/initialize
```

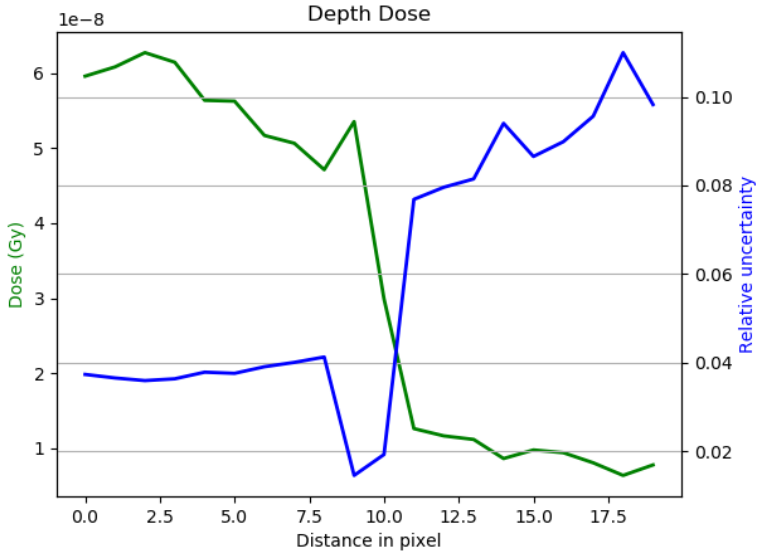
# Exercise 1: Dosimetry

- Add a 2 cm layer of lead at the center of the water phantom
- Cs-137 point source
- Plot the effect on the depth-dose distribution

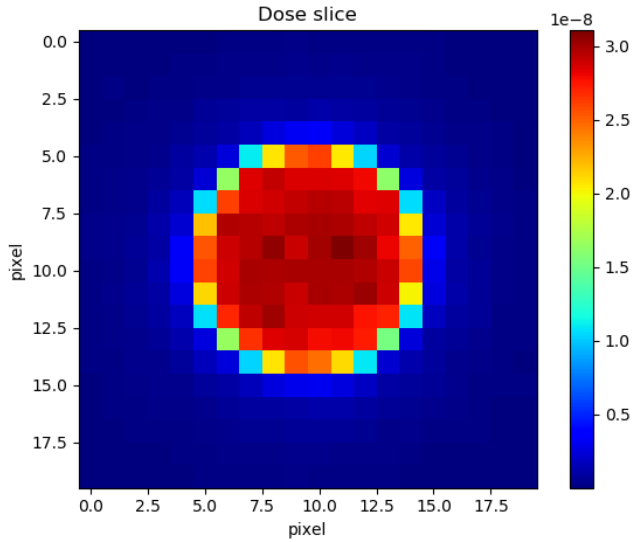





Without lead block




With lead block

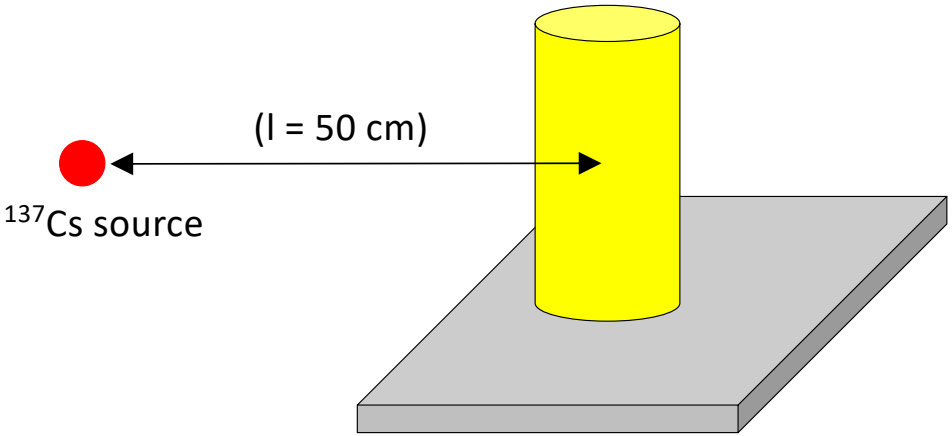


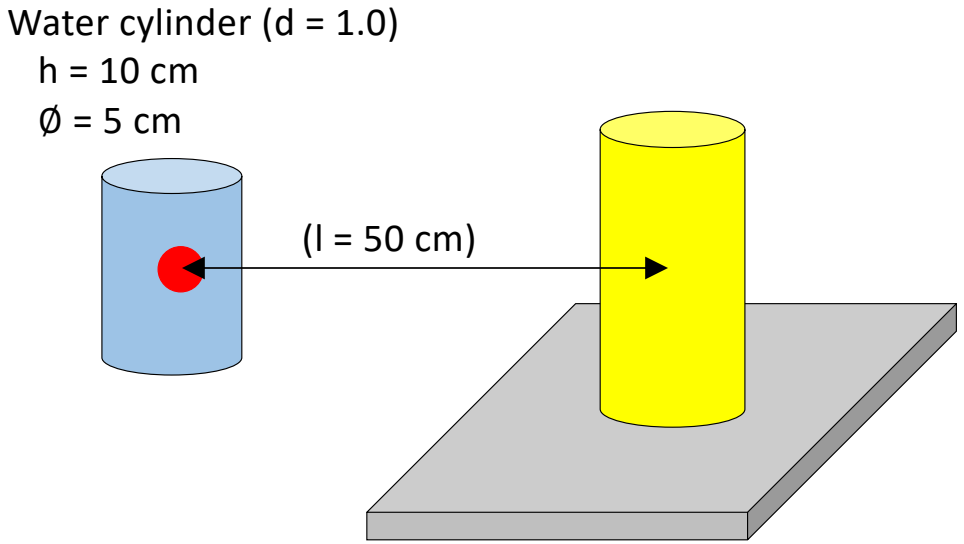
# Exercise 2: Gamma Spectrometry

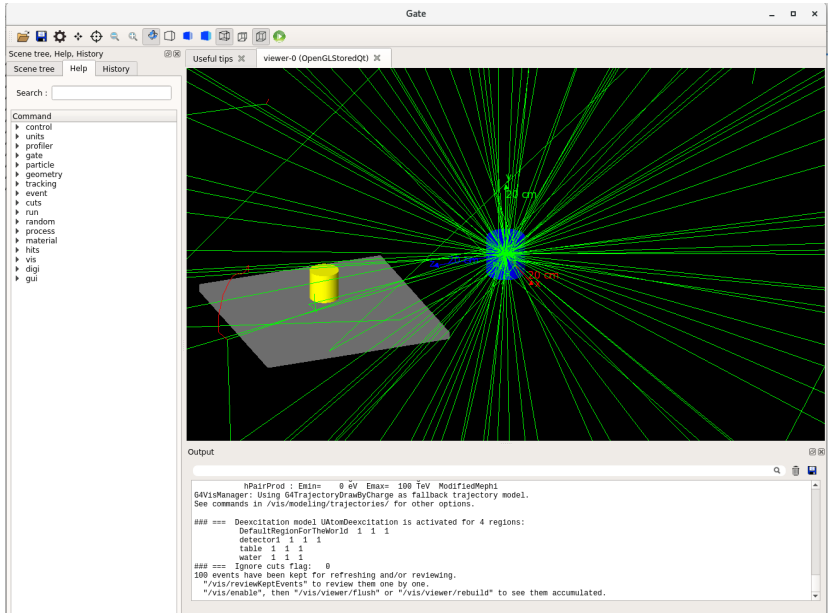
- Scintillating detector (3 ’’ x 3 ‘’ NaI)
- *EnergySpectrum* actor (spectrum of deposited energy per incident particle)  text file with counts per bin
- Point source of $^{137}$Cs (istoropic photon source with E = 662 keV)

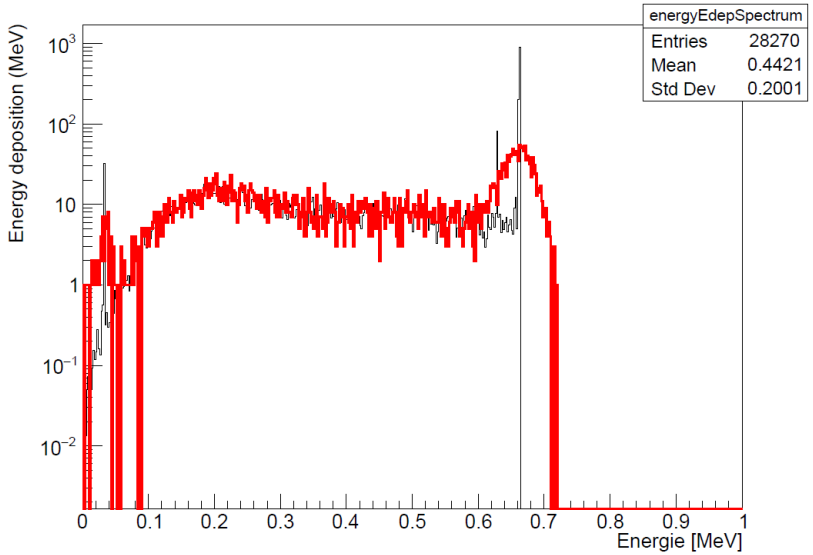
(1) Estimate the detection efficiency for the configuration below

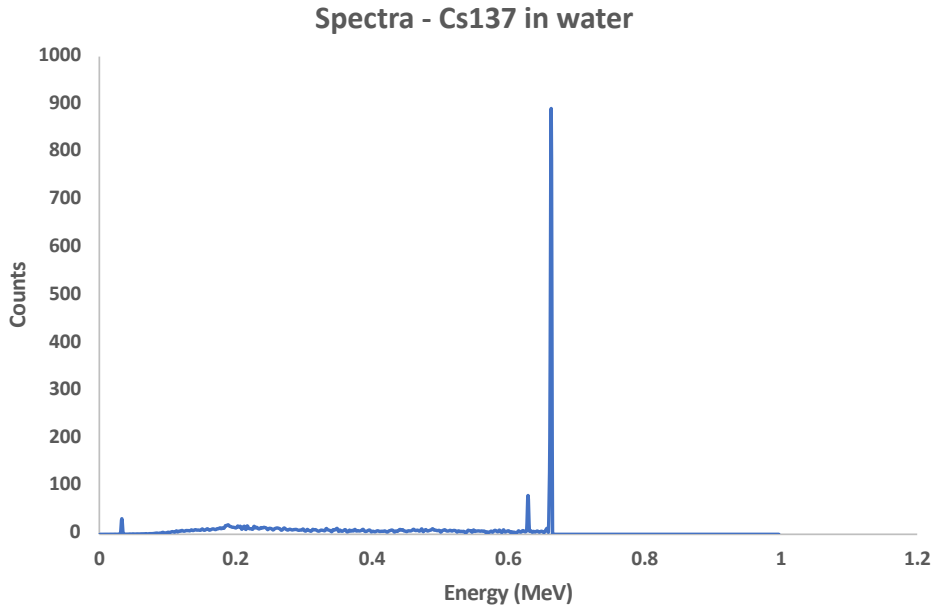
(2) Calculate for the same conditions the spectrum for a source in a water cylinder






Case 1: Detector efficiency ~ 35%

Case 2: Detector efficiency ~ 22%

**Vielen Dank!**

Merci!