Geant 4 Examples

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Introduction

The purpose of the exercise is to simulate the passage of particles through matter by means of the toolkit Geant4 that stands for GEometry And Tracking and uses Monte Carlo methods. It includes facilities for handling geometry and tracking among others, so that an analysis of the physical layout of the experiment (e.g. detectors, absorbers, etc) considering how this layout will affect the path of particles in the experiment, as well as a simulation of the passage of a particle through matter considering possible interactions and decay processes can be carried out.

Two examples have been done. The first of them simulates a simplified fixed target experiment where the primary kinematics consists of a single proton which hits the target perpendicular to the entrance face. On the other hand, the second one simulates schematically a positron emitted tomography system where the default particle beam is an ion, at rest, randomly distributed within a zone inside a patient.

Installation

The OS used for the installation of *Geant4* was *Ubuntu 18.04* and it was necessary the installation of some packages described below,

```
$ sudo apt-get install libxerces-c-dev qt4-dev-tools freeglut3-dev libmotif-dev tk-dev cmake libxpm-dev libxmu-dev libxi-dev
```

Then, a directory called *geant4* in the path `/opt/applications` was created.

```
$ cd /opt/ ; sudo mkdir /applications; cd applications/
$ sudo mkdir geant4
```

Afterwards,it was proceeded with the downloading of Geant4, unpacking and creation of `geant4-build` directory,

```
$ sudo mv ~/Path/to/geant4.10.04.p01.tar.gz /opt/applications/geant4/.
$ cd /opt/applications/geant4/
$ sudo tar -xvzf geant4.10.04.p01.tar.gz
$ mkdir geant4.10.04.p01-build
```

Here `~/Path/to/` is the direction where it was downloaded the `.tar` file. Last, it is required to configure the build and run `CMake`.

```
$ mkdir geant4.10.04.p01-build ; cd geant4.10.04.p01-build
$ sudo cmake -DCMAKE_INSTALL_PREFIX=/opt/applications/geant4/geant4.10.04.p01-install -DGEANT4_USE_GDML=ON -DCMAKE_BUILD_TYPE=Debug -DGEANT4_INSTALL_DATA=ON -DGEANT4_USE_OPENGL_X11=ON -DGEANT4_USE_XM=ON -DGEANT4_USE_QT=ON -
```



```
DGEANT4_BUILD_MULTITHREADED=ON /opt/applications/geant4/geant4.10.04.p01
$ make -jN
$ make install -jN
```

> `N` refers to the number of cores available in the pc (i.e `make -j4`)

Finally, for `bash` users:

```
$ vim ~/.bashrc

#geant4
source /opt/applications/geant4/geant4.10.04.p01-install/bin/geant4.sh
```

This implementation was used following (Geant4 Handbook)[1].

For `zsh` users, the `source` could be written in the `.zshrc` as well. If any errors appear, best thing to do is *source* from the directory of installation (`.../geant4-install/bin/geant4.sh`).

Running an example

Create a folder and copy one of the examples in that directory.

```
$ mkdir ~/workspace
$ mkdir ~/workspace/G4WORK
$ cp -R ~/geant4/geant4.10.04.p01/examples/basic/B1/ ~/workspace/G4WORK/.
```

To compile,

```
$ cd ~/workspace/G4WORK/
$ mkdir B1-build
$ cd B1-build
$ cmake ../B1
$ make -jN
$ ./exampleB1
```

Example `B2/B2a`

This example simulated a simplified fixed target experiment

Geometry definition: Regarding the geometry of the first example, the set-up consists of a target followed by six chambers of increasing transverse size at defined instances from the target. They are located in a region called the Tracker region and their shapes are cylinders.

There are useful commands in order to modify parameters of the simulation as required or desired, some of them are illustrated in *Table 1*. All the commands for each example are located in the GUI with their explanation.

In addition, an uniform magnetic field can be applied using the command `/globalField/setValue <value> <unit>`, which for this example was 2.0 T as well as changing the materials of the targets and the chambers via `B2/det/setTargetMaterial G4_Pb`, `B2/det/setChamberMaterial G4_Ar`.

Parameters	Values
`globalField`	2.0 T
`gun/energy`	1.0 GeV
`gun/particle`	p
`run/beamOn`	1 (Fig. 1), 100 (Fig. 2)

Table 1. Parameters modified example B2a

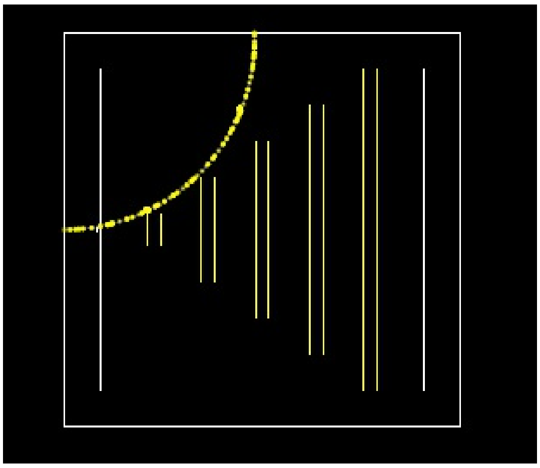

Figure 1. Side view of detector for 1 Event

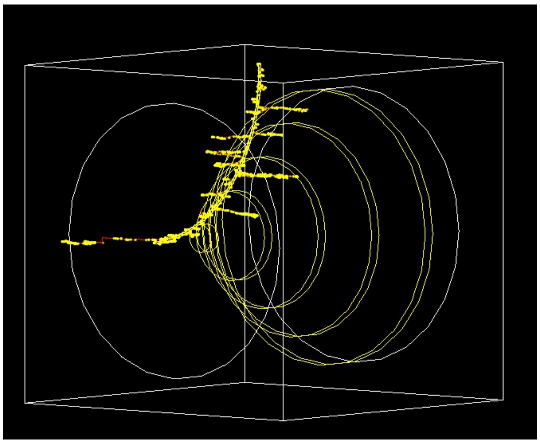

Figure 2. Side view of detector for 100 Events

Material	Density [mg/cm3]	RadL	Nucl.Int.Length [m]	Imean [eV]	Temperature [K]	Pressure [atm]
G4_AIRm	1.205	303.921	710.095	85.700	293.15	1.00
G4_Pb	11.350	5.613	0.18248	823.000	293.15	1.00

Table 1a. Some materials example B2a

Example `B3/B3a`

This example simulates schematically a positron emitted tomography system

Geometry definition:In regard to the set-up geometry corresponding to the second example, scintillating crystals are used for gamma detection. The crystals are described by a matrix and are circularly arranged to form a ring. Few rings make up the full detector.

Parameters	Values
`globalField`	off
`gun/energy`	1.0 eV
`gun/particle`	e+
`run/beamOn`	100 (Fig. 3)

Table 2. Parameters modified example B3a

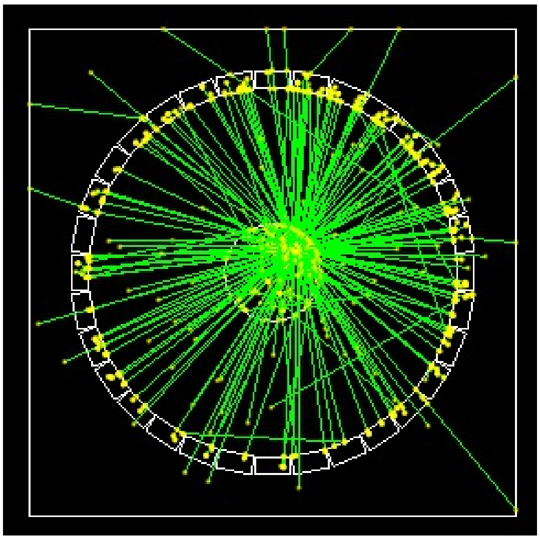

Figure 3. Front view of detector for 100 Events

Material	Density [mg/cm3]	RadL [m]	Nucl.Int.Length [m]	Imean [eV]	Temperature [K]	Pressur [atm]
G4_BRAIN_ICRP	1.040	0.35403	0.72156	73.300	293.15	1.00
G4_AIR	1.205	303.921	710.095	85.700	293.15	1.00

Table 2a. Some materials example B3a

The `output` obtained:

```
The run was 100 events ; Nb of 'good' e+ annihilations: 16 Total dose in patient : 1.25761 picoGy
```

References

[1] geant4.10.04 Installation Handbook v04, Andrés C. Sevilla, José M. Sevilla, *Universidad Nacional de Colombia*

[2] Geant4 installation guide, Geant4 Collaboration

[3] Twiki Allpix , John Idarraga