

Introductory training on Geant4

ANSTT5 Workshop 15-19 April 2024

1 Introduction

Geant4 is a toolkit for simulating the interaction of radiation or particles with matter using Monte Carlo methods. It was developed by CERN and is maintained by the international Geant4 collaboration, that is, many specialized working groups (around the globe) that are responsible for the various components of the toolkit (<https://geant4.web.cern.ch/>). It is widely used today in high energy, nuclear, medical and accelerator physics, as well as in space science. It is built using object-oriented C++ programming language.

2 Installing Geant4

Geant4 can be installed on many platforms. Depending on the operating system there may be slight variations in the install process. Follow the Geant4 installation guide here <https://geant4-userdoc.web.cern.ch/UsersGuides/InstallationGuide/html/index.html>. In general, to install Geant4, the following are the steps:

1. Install the pre-requisites or Geant4 pre-install packages.
2. Install the right (recommended) version of C++ compiler.
3. Download and install the recommended CMake version. <https://cmake.org/download/>
4. Download the Geant4 installer at <https://geant4.web.cern.ch/download/11.2.1.html>

In this workshop, we are mainly going to use Geant4.11.2 on Linux based (Ubuntu to be specific) platform.

2.1 Geant4 on virtual machines

- For training purposes, Geant4 can be installed on a virtual machine with an operating system of choice to circumvent installation problems on individual computers and on different operating systems.
- One can either install their preferred version of Geant4 on a pre-configured VM, or can download a portable pre-configured VM, with all the Geant4 prerequisite software and Geant4 installation already on it.
- CENBG and CNRS have, since 2004, developed and keep updating the GEANT4 VIRTUAL MACHINE (see here <https://geant4.lp2ib.in2p3.fr/>), which they avail to the public for free. Virtual Machines hosting various versions of Geant4 over the years are available here <https://extra.lp2ib.in2p3.fr/G4/download/> for download.

- Organisers of the annual course on Geant4 at CERN have put together clear instructions on how to install and use the Geant4 Virtual Machine here <https://indico.cern.ch/event/1370034/page/32238-geant4-virtual-machine>.
- In preparation for this component (Geant4 training) of the ANSTT5 Workshop we encourage attendees to follow these instructions to setup the Geant4 VM on their computers and test it to ensure that it works perfectly days ahead of the training.

2.2 On Linux: Ubuntu, etc.

For a very long time now, Linux environments have been among the most convenient operating systems to install and run Geant4. The steps given above are followed here.

1. Some of the software/packages needed to install Geant4 or to successfully run Geant4 applications.

```
# prerequisites:
sudo apt-get -y install build-essential openssl libssl-dev libssl1.0 libgl1-mesa-dev
libqt5x11extras5

# qt:
sudo apt-get install qtbase5-dev
sudo apt-get install qtdeclarative5-dev

# On Debian platforms
sudo apt-get install -y qt3d5-dev

# libxmu
sudo apt-get install -y libxmu-dev
```

You may also follow this link to build Coin3D SoXt from the source https://sourceforge.net/p/coin3d-soxt/wiki/SoXt_Build_Environment/. And also https://wiki.qt.io/Install_Qt_5_on_Ubuntu for installing Qt5 on Ubuntu.

2. Download and install Geant4

Assuming you have downloaded geant4 in the folder called Geant4, extract (unzip) it. Along side this folder (the source), create another folder and name it geant4-build.

```
# In the terminal
$ ls
  geant4-v11.2.0
$ mkdir geant4-build
$ ls
geant4-build geant4-v11.2.0

# Go into the folder geant4-build
$ cd geant4-build

# Now run cmake:
$ cmake ../geant4-v11.2.0

# cmake-curses-gui will open as in the Fig 1 below
```

```

CLHEP_DIR                                CLHEP_DIR-NOTFOUND
CMAKE_BUILD_TYPE                          Release
CMAKE_INSTALL_PREFIX                      /home/maluba/Geant4_11
Coin_DIR                                  /usr/lib/x86_64-linux-
Coin_LIBRARY                              optimized;Coin;debug;C
GEANT4_BUILD_MULTITHREADED                ON
GEANT4_INSTALL_DATA                       OFF
GEANT4_INSTALL_DATADIR                   /home/maluba/Geant4_11
GEANT4_USE_G3TOG4                         OFF
GEANT4_USE_GDML                           ON
GEANT4_USE_INVENTOR                       OFF
GEANT4_USE_INVENTOR_QT                   OFF
GEANT4_USE_OPENGL_X11                     ON
GEANT4_USE_QT                              ON
GEANT4_USE_RAYTRACER_X11                  ON
GEANT4_USE_SYSTEM_CLHEP                   OFF
GEANT4_USE_SYSTEM_EXPAT                   ON
LHEP DIR: The directory containing a CMake configurati
eys: [enter] Edit an entry [d] Delete an entry
    [l] Show log output   [c] Configure
    [h] Help              [q] Quit without generating
    [t] Toggle advanced mode (currently off)

```

Figure 1: ccmake gui.

```

# If you run into compiler errors, you can try
$ cmake -DCMAKE_CXX_COMPILER=/usr/bin/g++
  -DCMAKE_C_COMPILER=/usr/bin/gcc ../geant4-v11.2.1/

# Replace /usr/bin/g++ or gcc with the path to the location of these
compilers on your system.

```

3. When ccmake-curses-gui is open as in Fig. 1,
 - you can navigate up and down using the up/down keyboard arrows and press the “Enter” key to switch ON/OFF some required software.
 - You also need to set up the “install” directory following the “CMAKE_INSTALL_PREFIX” line, and this should be within the parent directory Geant4, for example.
 - Typically, this directory is created using the absolute path like so “/home/yourusername/Geant4/geant4-install”.
 - Similarly, a path to the folder containing the datasets can be given as “/home/yourusername/Geant4/geant4-install/share/Geant4/data” against the line “GEANT4_INSTALL_DATADIR”.
 - As stated in the Geant4 installation guide, the datasets can be downloaded and placed in the this folder. Make sure to extract (unzip) them.
 - Note that if the software you have switched on is not installed or has some missing dependencies it may give an error when you try to compile. You should either ensure all required software is installed or just leave it OFF is not mandatory.
4. Finally, once the above is done, you can press keyboard character “c” (see the bottom of the ccmake screenshot in Fig. 1) to configure, if everything goes well (it doesn’t complain about anything), then you can press “g” to generate the make file. Can press “e” when it is done to exit ccmake.

5. Next you type `make -j4` and enter to compile,
6. When it is done, type and enter `make install` to install Geant4. When it has finished running, you have installed Geant4 successfully, but you need to test it.
7. Before compiling an example to test whether your Geant4 installation is working properly, you need to run one of these scripts in the terminal:
 - (1) `./geant4.sh` which is located in the directory `/home/yourusername/Geant4-parent-directory/geant4-install/bin/`
Alternatively, you can source it like so
`source /home/yourusername/Geant4-parent-directory/geant4-install/bin/geant4.sh`
in the `.bashrc` file so that everytime you start a new terminal Geant4 is ready for use.
or
 - (2) `./geant4make.sh`, located in the directory `/home/yourusername/Geant4-parent-directory/geant4-install/share/geant4make/`
Similarly, you may want to put the line
`source /home/name/Geant4-parent-directory/geant4-install/share/geant4make/geant4make.sh`
in the `.bashrc` file.
Either of these scripts will set up the needed environmental variables required for execution of Geant4 programs.
8. To test your Geant4 installation, create a `buildb1` folder within the parent Geant4 folder, in the terminal

```
# navigate to the Geant4 parent directory, if you list, ls command
$ ls
geant4-build  geant4-install  geant4-source

# make the buildb1 directory
$ mkdir buildb1

# If you list again, you have
buildb1 geant4-build  geant4-install  geant4-source

# Now cd into buildb1
$ cd buildb1
$ cmake -DCMAKE_PREFIX_PATH=/home/yourusername/Geant4-parent-directory
/geant4-install/lib/cmake/Geant4/
/home/yourusername/Geant4-parent-directory/geant4-source/examples/basic/B1/
$ make -j4
```

9. At this point cmake will have generated a lot of files in the `buildb1` directory, including an executable (in green) “`exampleB1`” which you can run in the terminal by simply `./exampleB1`.

2.3 On Mac Os.

In addition to the official Geant4 installation guide (<https://geant4-userdoc.web.cern.ch/UsersGuides/InstallationGuide/html/index.html>), there are plenty other resources online, for example, Youtube videos that can help you install Geant4 on macOS. For example, the following Youtube videos by Jing (aka Physino):

1. Geant4.10.7– https://www.google.com/search?client=ubuntu&sca_esv=236e917ef57ab2a8&

channel=fs&cs=0&q=How+to+install+Geant4+on+Mac&sa=X&ved=2ahUKEwixvcSLu5GFaxXMW0EA
biw=1540&bih=807&dpr=1.2#fpstate=ive&vld=cid:088160b8,vid:Qk34s9xIF_4,st:
0

2. Geant4.11.0– <https://www.google.com/search?channel=fs&client=ubuntu&q=how+to+install+Geant4+11.2+on+macOs#fpstate=ive&vld=cid:b93c8f0b,vid:PrRFIhoT9Bw,st:0>

2.4 On Windows.

Similarly, there are Youtube videos that one can follow to install Geant4 on Windows operating systems, such as

1. a Youtube video by John Francis, which can be followed when attempting to build Geant4 from the source: <https://www.google.com/search?channel=fs&client=ubuntu&q=Geant4+installation#fpstate=ive&vld=cid:a1f68088,vid:w7k9PK1Ipv8,st:0>, and
2. another Youtube video by Jing (aka Physino) that one can follow when installing a pre-compile Geant4 (Binary file) on Windows OS <https://www.youtube.com/watch?v=XdzFsVGTbLc>.