XV Seminar on Software for Nuclear, Subnuclear and Applied Physics

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Geant4 Installation

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Geant4 tutorial

Installation process

1) Check that you meet all the requirements
2) Download Geant4 source code
3) Configure the build using CMake
4) Make & install
5) Configure your environment to use Geant4

https://geant4.web.cern.ch/geant4/UserDocumentation/UsersGuides/InstallationGuide/html/index.html

① Supported platforms & requirements

- **Operating system**
  - "recent" Linux (e.g. CentOS 7), best support
  - macOS 10.10+
  - Windows 7+ (limited support, not recommended)
- **Compilers**
  - C++11 compliance
  - such as GCC 4.8.5+, clang 3.6+, Visual C++ 14.0 (2015)
- **CMake** (configuration generation tool) 3.3+
- System libraries (as development packages):
  - expat, xerces-c

Virtual Machine:
CentOS 7 with gcc 4.8.5

These may or may not be necessary. Just keep this in mind when compilation fails.

CMake installation (if not provided)

- Depending on the OS installation, CMake may not be installed by default. In that case you have to install it:
  - **Linux**: it is recommended to use the CMake provided by the package management system of your distribution.

    If version 3.3+ is not available:
    1. download the latest version *(http://www.cmake.org/)*
    2. unzip the tar-ball
    3. **./bootstrap, make, make install**
  - **macOS**: install it using the Darwin64 dmg installerpackage
  - **Windows**: install it using the Win64/32 exe installerpackage

Note: You may also want to install **ccmake** and/or **cmake-gui** tools for user-friendly configuration

Optional libraries

- **X11** for simple graphical user interface and ray-tracing
- **OpenGL** for visualization
- **Qt4** or **Qt5** for graphical user interface
- **ROOT** for data analysis (even inside Geant4)

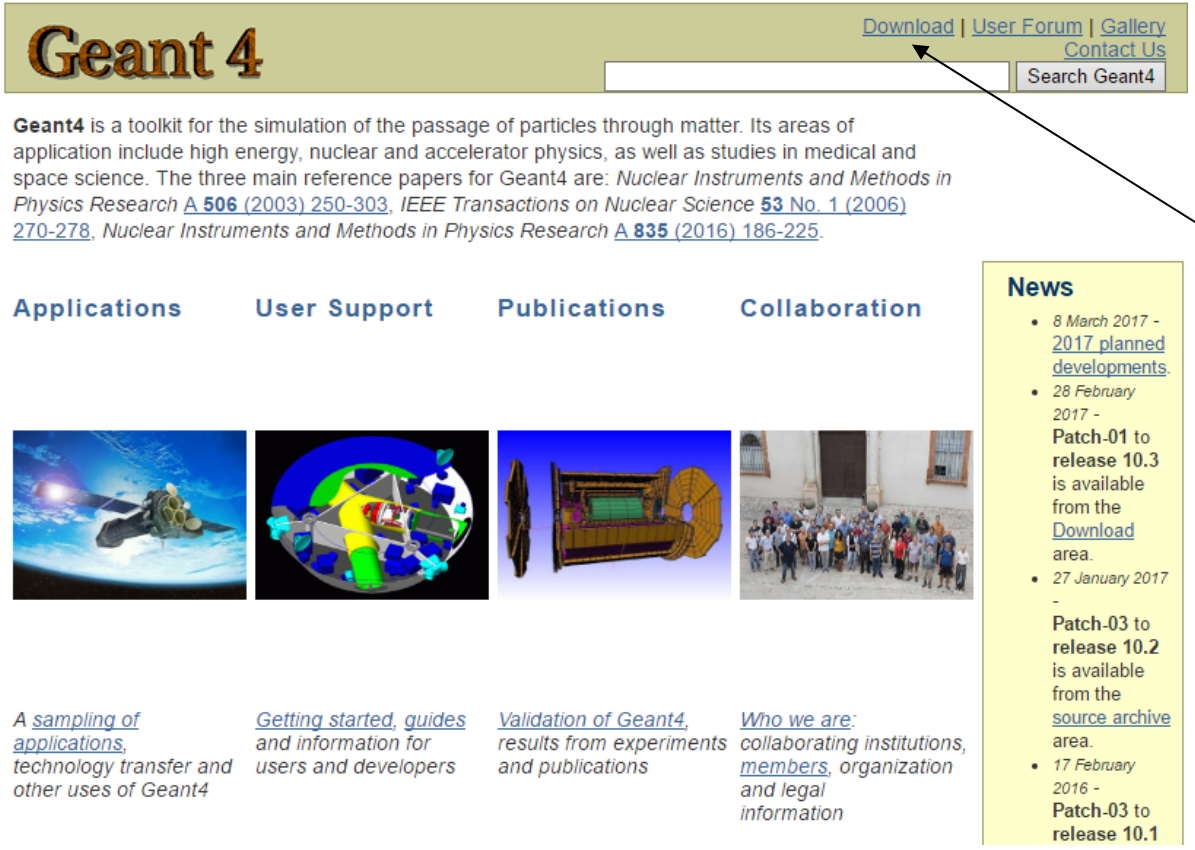
Less frequently used libraries/tools:

Motif, OpenInventor, DAWN, RayTracer X11, HepRApp, WIRED JAS Plug-in, AIDA, VRML browser, (external) CLHEP, Wt...

② Download Geant4…

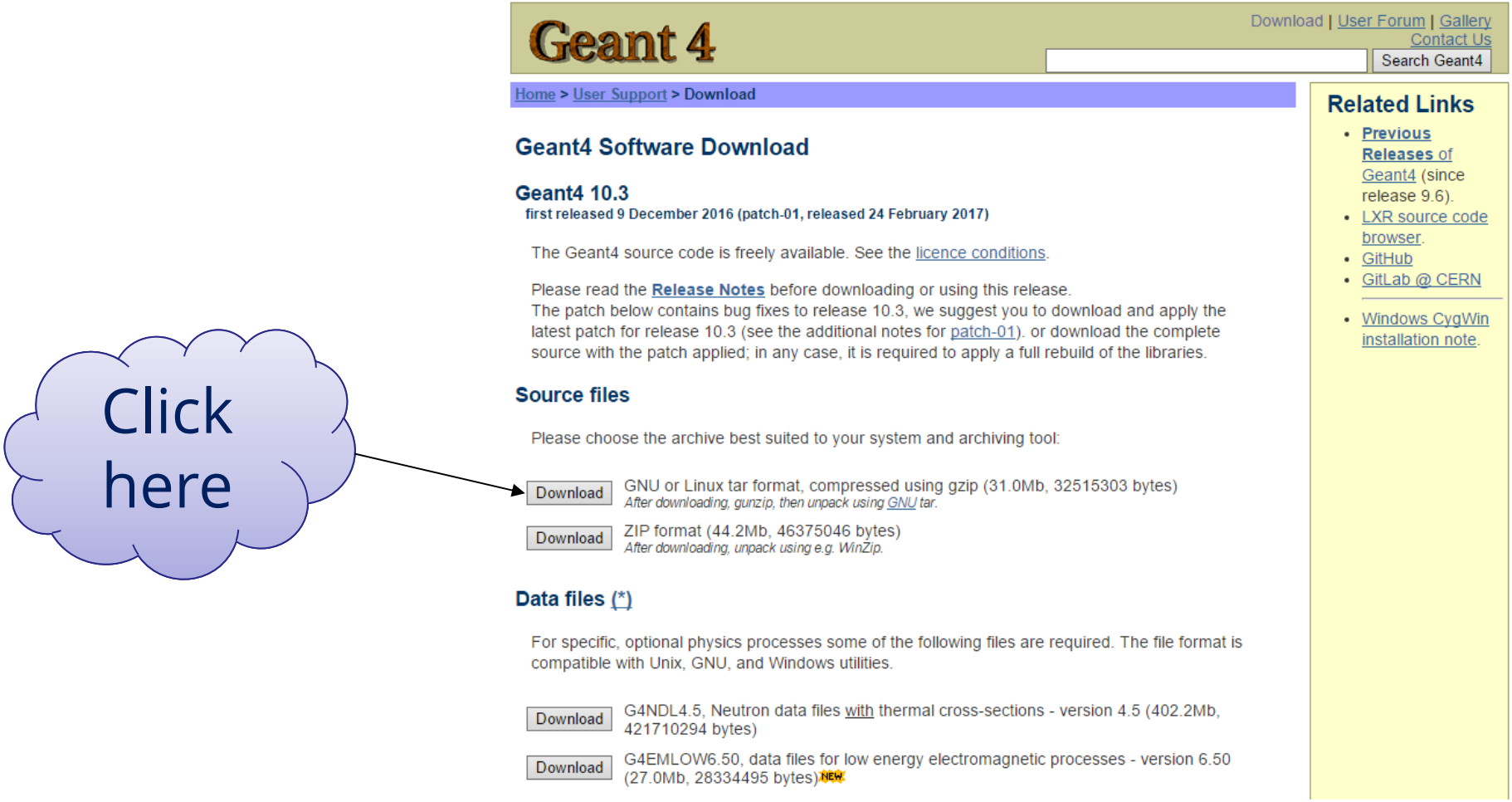
- Go to the Geant4 webpage:

  http://geant4.web.cern.ch/geant4/



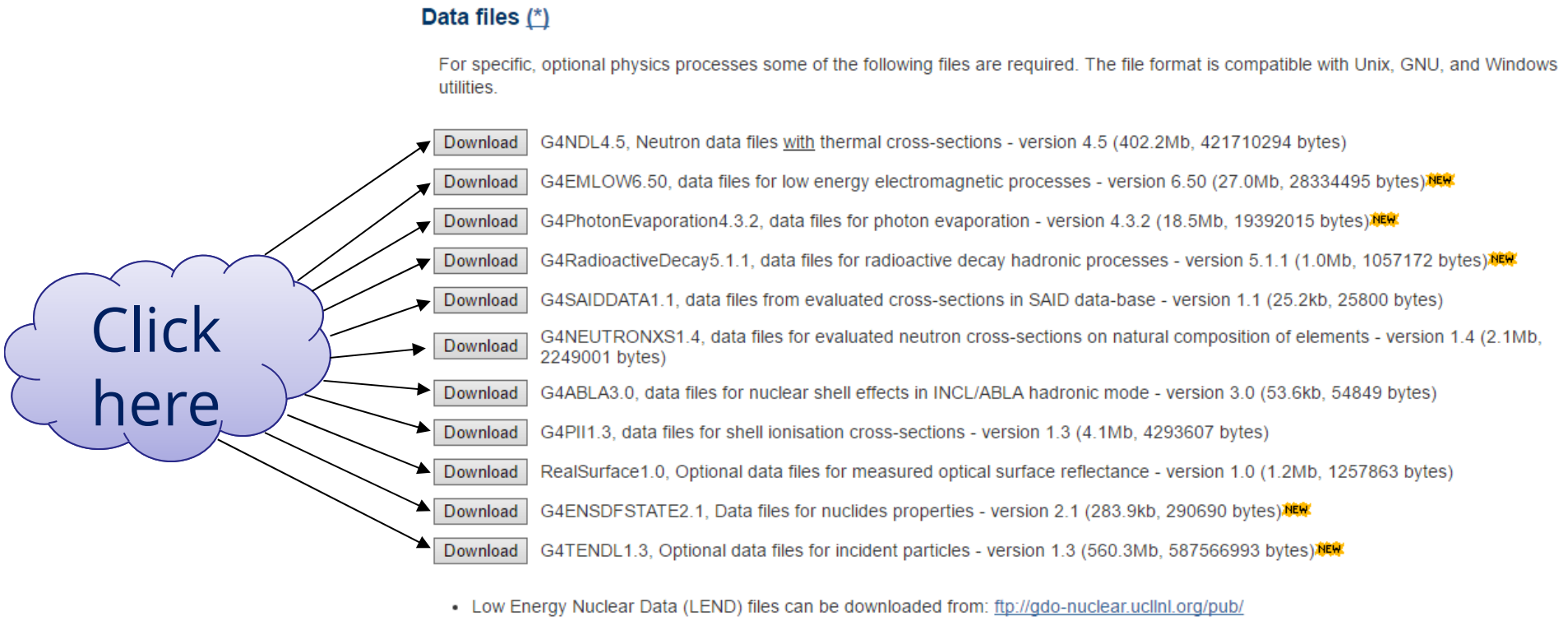
…download Geant4…

http://geant4.web.cern.ch/geant4/support/download.shtml



Download data (optional)

Alternative 1: download everything (slow connections)



Alternative 2: use **CMake** to download data automatically (preferred)

③ Configuration with CMake

- Extract the package into **source directory**

```
tar xzvf geant4.10.04.tar.gz
```

- Create the **build directory**

```
mkdir geant4-build
```

- Run CMake in the **build directory**

```
cd geant4-build
cmake [options...] ../geant4.10.04
```

See next slide for directory explanation...

Choose name to your liking

Directories for installation

Source directory: where you unpack the source

`/usr/local/geant4/geant4.10.04` VM

Build directory: where you run CMake and build Geant4 (“working directory”)

`/usr/local/geant4/geant4.10.04-build` VM

Installation directory: where you install Geant4 to and which the applications compile against

`/usr/local/geant4/geant4.10.04-install` VM

Only the installation dir is necessary to compile & run user apps.

CMake configuration options

Important options:

- -DCMAKE_INSTALL_PREFIX=*...installation_path...*
- -DGEANT4_INSTALL_DATA=ON/OFF
- -DGEANT4_BUILD_MULTITHREADED=ON/OFF

Further options:

- -DGEANT4_USE_OPENGL_X11=ON/OFF
- -DGEANT4_USE_QT=ON/OFF
- ...

https://geant4.web.cern.ch/geant4/UserDocumentation/UsersGuides/InstallationGuide/html/ch02s03.html

Running CMake

CMake configures the build and generates Unix **Makefiles** to perform the actual build:

```
cmake -DGEANT4_INSTALL_DATA=ON -DGEANT4_BUILD_MULTITHREADED=ON -DCMAKE_INSTALL_PREFIX=
/usr/local/geant4/geant4.10.04-install /usr/local/geant4/geant4.10.04
```

```
-- The C compiler identification is GNU 4.8.5
-- The CXX compiler identification is GNU 4.8.5
-- Check for working C compiler: /usr/bin/cc
-- Check for working C compiler: /usr/bin/cc – works
-- Detecting C compiler ABI info
-- Detecting C compiler ABI info - done
-- Detecting C compile features
-- Detecting C compile features - done
...(~50 lines)...
-- Configuring done
-- Generating done
-- Build files have been written to: /usr/local/geant4/geant4.10.04-build
```

If you see that, you are successful !!!

If you see errors at this point, carefully check the messages output by CMake

④ Compile…

- Run `make` (and get a cup of coffee)

Tip: If you have a multi-core machine, you can run the compilation in parallel using multiple jobs. Just add the `-jN` parameter, where N is the required number of jobs (it is recommended to set this to the number of your processor's cores), e.g.:

```
make -j2
```

```
Scanning dependencies of target G4ENSDFSTATE
Scanning dependencies of target G4NDL
[  0%] Creating directories for 'G4ENSDFSTATE'
[  0%] Creating directories for 'G4NDL'
[  0%] Performing download step (download, verify and extract) for 'G4NDL‘
...(4029 lines, ~1 hour of execution)
[100%] Built target G4visXXX
[100%] Building CXX object
source/visualization/gMocren/CMakeFiles/G4GMocren.dir/src/G4GMocrenIO.cc.o
[100%] Building CXX object
source/visualization/gMocren/CMakeFiles/G4GMocren.dir/src/G4GMocrenMessenger.cc.o
[100%] Linking CXX shared library ../../../BuildProducts/lib64/libG4GMocren.so
[100%] Built target G4GMocren
```

If you see that, you are successful !!!

...and install

- Run `make install` (this takes much less time)

```
make install
```

```
[  0%] Built target G4ENSDFSTATE
[  0%] Built target G4NDL
[  0%] Built target PhotonEvaporation
[  0%] Built target RadioactiveDecay
[  0%] Built target G4ABLA
...(42830 lines, ~2 minute of execution)
-- Installing: /usr/local/geant4/geant4.10.04-install/include/Geant4/G4VModelCommand.hh
-- Installing: /usr/local/geant4/geant4.10.04-install/include/Geant4/G4VModelFactory.hh
-- Installing: /usr/local/geant4/geant4.10.04-install/include/Geant4/G4VTrajectoryModel.hh
-- Installing: /usr/local/geant4/geant4.10.04-install/include/Geant4/G4VisTrajContext.hh
-- Installing: /usr/local/geant4/geant4.10.04-install/include/Geant4/G4VisTrajContext.icc
```

Tip: If you want to combine the two steps (compilation + installation) into one, you can leave out the first step.

(Random) installation notes

- **Windows:** See the installation guide

https://geant4.web.cern.ch/geant4/UserDocumentation/UsersGuides/InstallationGuide/html/ch02s02.html

- **Binary packages:** Installation without compiling Geant4 is possible (but not recommended)
- **Data packages:** If you haven't used CMake to download them, unpack the downloaded files in the share/Geant4-10.4.0/data/ sub-directory of your installation

⑤ Set-up environment

- Geant4 need properly set environment variables:

```
G4ABLADATA="/usr/local/geant4/geant4.10.04-install/share/Geant4-10.4.0/data/G4ABLA3.0"
G4ENSDFSTATEDATA="/usr/local/geant4/geant4.10.04-install/share/Geant4-10.4.0/data/G4ENSDFSTATE2.1"
G4LEDATA="/usr/local/geant4/geant4.10.04-install/share/Geant4-10.4.0/data/G4EMLOW6.50"
G4LEVELGAMMADATA="/usr/local/geant4/geant4.10.04-install/share/Geant4-10.4.0/data/PhotonEvaporation4.3.2"
G4NEUTRONHPDATA="/usr/local/geant4/geant4.10.04-install/share/Geant4-10.4.0/data/G4NDL4.5"
G4NEUTRONXSDATA="/usr/local/geant4/geant4.10.04-install/share/Geant4-10.4.0/data/G4NEUTRONXS1.4"
G4PIIDATA="/usr/local/geant4/geant4.10.04-install/share/Geant4-10.4.0/data/G4PII1.3"
G4RADIOACTIVEDATA="/usr/local/geant4/geant4.10.04-install/share/Geant4-10.4.0/data/RadioactiveDecay5.1.1"
G4REALSURFACEDATA="/usr/local/geant4/geant4.10.04-install/share/Geant4-10.4.0/data/RealSurface1.0"
G4SAIDXSDATA="/usr/local/geant4/geant4.10.04-install/share/Geant4-10.4.0/data/G4SAIDDATA1.1"
LD_LIBRARY_PATH="...:/usr/local/geant4/geant4.10.04-install/lib64"
PATH="...:/usr/local/geant4/geant4.10.04-install/bin"
```

- To set them up properly in your shell, run the script in Geant4 installation directory:

```
source /usr/local/geant4/geant4.10.04-install/bin/geant4.(c)sh
```

- You can put this line your `~/.bashrc` file (or similar for other shells)

Your Geant4 is ready now.

Can we continue to…
build an application?

Build a Geant4 application

Application build process

1) Properly organize your code into directories
2) Prepare a CMakeLists.txt file
3) Create a build directory and run CMake
4) Compile (make) the application
5) Run the application

Note: Recommended, not enforced!

① Application source structure in Geant4

Official basic/B1 example:

```
2,4K  4 Dic 14:48 CMakeLists.txt
475B  4 Dic 14:48 GNUmakefile
2,8K  4 Dic 14:48 History
7,5K  4 Dic 14:48 README
4,0K  4 Dic 14:48 exampleB1.cc
226B  4 Dic 14:48 exampleB1.in
 35K  4 Dic 14:48 exampleB1.out
272B  4 Dic 14:49 include
338B  4 Dic 14:48 init_vis.mac
553B  4 Dic 14:48 run1.mac
448B  4 Dic 14:48 run2.mac
272B  4 Dic 14:49 src
3,8K  4 Dic 14:48 vis.mac
```

The text file CMakeLists.txt is the CMake script containing commands which describe how to build the exampleB1 application

contains main() for the application

Header files

```
2,2K  4 Dic 14:48 B1ActionInitialization.hh
2,4K  4 Dic 14:48 B1DetectorConstruction.hh
2,4K  4 Dic 14:48 B1EventAction.hh
2,7K  4 Dic 14:48 B1PrimaryGeneratorAction.hh
2,5K  4 Dic 14:48 B1RunAction.hh
2,4K  4 Dic 14:48 B1SteppingAction.hh
```

Source files

```
2,9K  4 Dic 14:48 B1ActionInitialization.cc
7,7K  4 Dic 14:48 B1DetectorConstruction.cc
2,6K  4 Dic 14:48 B1EventAction.cc
4,3K  4 Dic 14:48 B1PrimaryGeneratorAction.cc
5,8K  4 Dic 14:48 B1RunAction.cc
3,2K  4 Dic 14:48 B1SteppingAction.cc
```

Macro file containing the commands

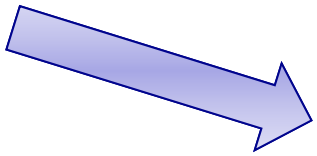
② CMake (again)

- **CMake** is a build configuration tool
  - it takes configuration file (CMakeLists.txt)
  - it finds all dependencies (in our case, Geant4)
  - creates **Makefile** to run the compilation itself
- You have to write this CMakeLists.txt file
  - take inspiration in examples directories
  - be sure to set the name of your application correctly
  - specify all auxiliary files you need

Note: It is possible but **discouraged** to base build on GNU make instead of CMake.

CMakeLists.txt

```
cmake_minimum_required(VERSION 2.6 FATAL_ERROR)
project(B1)
option(WITH_GEANT4_UIVIS "Build example with Geant4 UI and Vis drivers" ON)
if(WITH_GEANT4_UIVIS)
  find_package(Geant4 REQUIRED ui_all vis_all)
else()
  find_package(Geant4 REQUIRED)
endif()

include(${Geant4_USE_FILE})
include_directories(${PROJECT_SOURCE_DIR}/include)

file(GLOB sources ${PROJECT_SOURCE_DIR}/src/*.cc)
file(GLOB headers ${PROJECT_SOURCE_DIR}/include/*.hh)

add_executable(exampleB1 exampleB1.cc ${sources} ${headers})
target_link_libraries(exampleB1 ${Geant4_LIBRARIES})

set(EXAMPLEB1_SCRIPTS
  exampleB1.in
  exampleB1.out
  init_vis.mac
  run1.mac
  run2.mac
  vis.mac
  )

foreach(_script ${EXAMPLEB1_SCRIPTS})
  configure_file(
    ${PROJECT_SOURCE_DIR}/${_script}
    ${PROJECT_BINARY_DIR}/${_script}
    COPYONLY
    )
```



File structure

1) Cmake minimum version and **project name**
2) Find and configure G4
3) Configure the project to use G4 and B1 headers
4) List the **sources**
5) Define and link the **executable**
6) Copy any macro files to the build directory

③ Build directory and CMake

1) If modifying the Geant4 examples, copy them to your $HOME first:

```
cp -r /usr/local/geant4/geant4.10.04/examples/basic/B1 ~
```

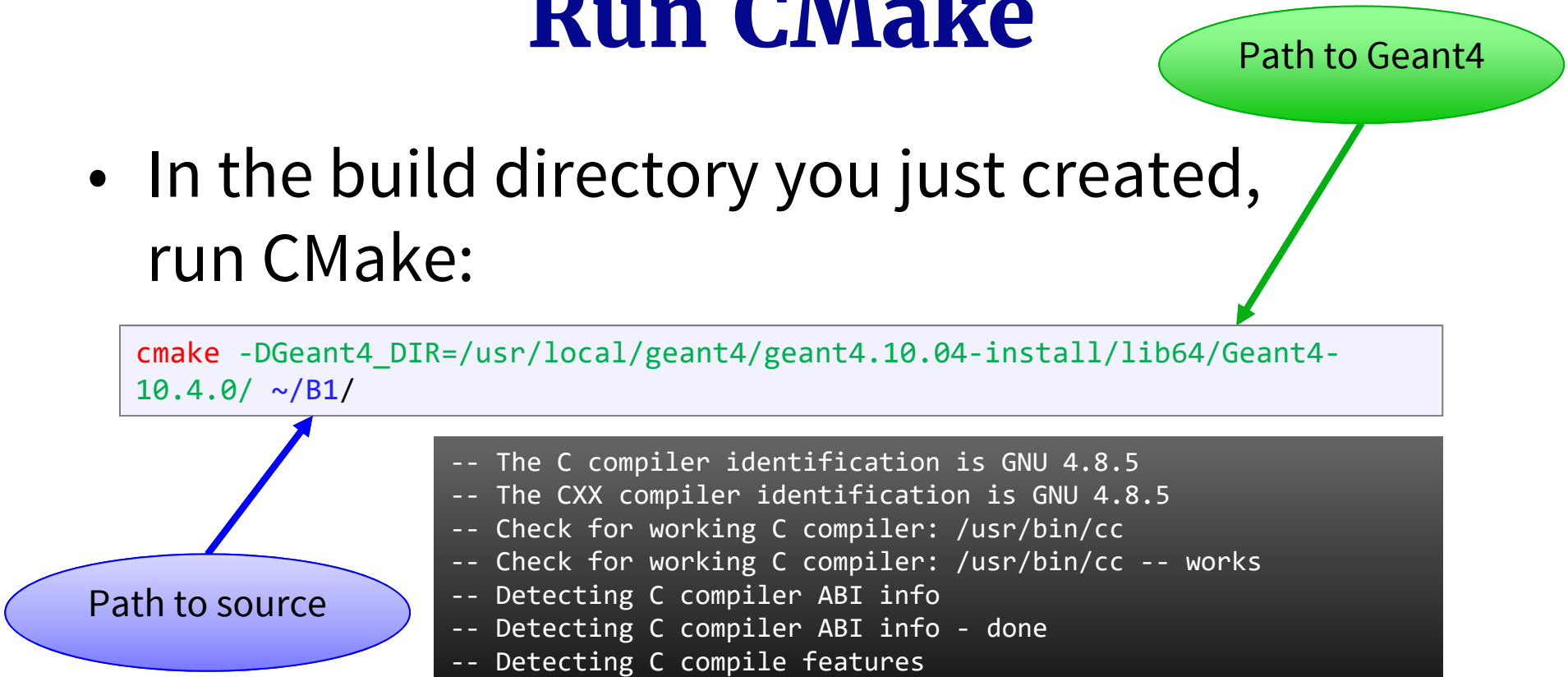
2) Create a **build directory***, where the compiled application will be put:

```
mkdir -p ~/B1-build
cd ~/B1-build
```

***Note:** It is possible (though not recommended) to compile **inside** source directory.

Run CMake

- In the build directory you just created, run CMake:



④ Compilation

- In the build directory, run `make`

  (and don't get a cup of coffee)

  - You have only a couple of files, it should be ready in a minute or two
  - An **executable** with the name of your application is created (e.g. exampleB1) in build directory
  - **Macros** and other auxiliary files are copied into build directory

`make -j2`

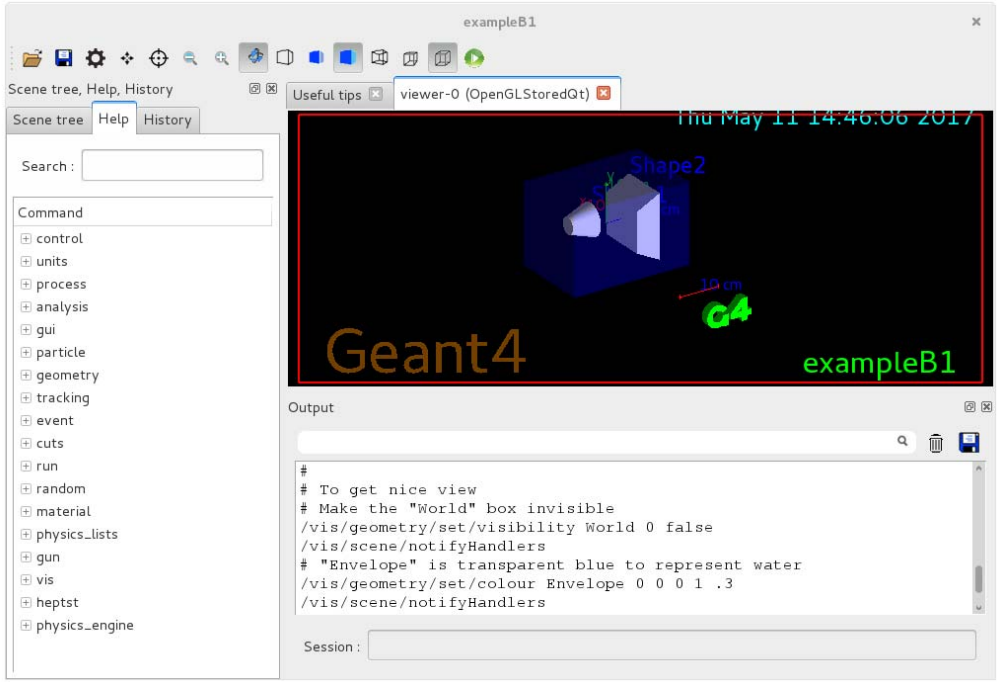
```
Scanning dependencies of target exampleB1
[ 12%] Building CXX object CMakeFiles/exampleB1.dir/exampleB1.cc.o
[ 25%] Building CXX object CMakeFiles/exampleB1.dir/src/B1RunAction.cc.o
[ 37%] Building CXX object CMakeFiles/exampleB1.dir/src/B1SteppingAction.cc.o
[ 50%] Building CXX object CMakeFiles/exampleB1.dir/src/B1DetectorConstruction.cc.o
[ 62%] Building CXX object
CMakeFiles/exampleB1.dir/src/B1PrimaryGeneratorAction.cc.o
[ 75%] Building CXX object CMakeFiles/exampleB1.dir/src/B1EventAction.cc.o
[ 87%] Building CXX object CMakeFiles/exampleB1.dir/src/B1ActionInitialization.cc.o
[100%] Linking CXX executable exampleB1
[100%] Built target exampleB1
```

⑤ Run the application – GUI

- Just type the name of your application, including the **./** identifier of current directory (e.g. ./exampleB1)
- By default, **graphical user interface** is started*

```
./exampleB1
```

```
Available UI session types: [ Qt, GAG, tcsh, csh ]
```



***Note:** Depends on your application main(), Geant4 configuration, etc.

Conclusion

Building an application is easy ☺