Overview

Part I – Starting and familiarising

- Where is your installation ?
- Getting the example programs
- Running examples

Part II – Looking into Geant4, trying it out with exercises

- Play with basic UI commands
- Examine cross sections
- Compute photon attenuation coefficient
- Simulate depth dose curve
- Compute and plot Bragg curve
- Hadronic physics list

Addenda: other examples, histogramming

Part I

Starting, first trials

Find your installation

Copy example programs into your area

Compile and run examples

Copy selected Geant4 examples

- The Geant4 system (source and libraries) is already installed on your computer
  - find it at $G4INSTALL (= /cern/2007/geant4.8.2)
  - prompt> cd $HOME

  → get a copy of g4env.csh (or g4env.sh)
  - prompt> source g4env.csh (or prompt> ./*g4env.sh)

  → $G4WORKDIR is $HOME/geant4
  - prompt> env |grep G4

  - prompt> mkdir geant4
  - prompt> cd geant4
- Copy following examples
  - prompt> mkdir examples
  - prompt> cp –r $G4INSTALL/examples/novice $G4WORKDIR/examples
  - prompt> cp –r $G4INSTALL/examples/extended $G4WORKDIR/examples
  - prompt> cd examples

Compile and run first example

- Compile and run N01 (in batch mode)
  - prompt> cd $G4WORKDIR/examples/novice/N01
  - see README
  - prompt> gmake
    - » compile and link – create the executable called ‘exampleN01’
      - *uses the recipe how to do this in GNUmakefile*
  - prompt> rehash (*on tcsh only*)
    - » make the new executable visible for the next command
  - prompt> exampleN01
    - » runs Geant4 for simple setup, gives you some output

- When you are done
  - prompt> gmake clean
    - » this deletes the executable – as exampleN01 is very limited

User Classes

- examine N03
  - prompt> cd $G4WORKDIR/examples/novice/N03
  - see README (in particular : how to start ?)
  - prompt> nedit exampleN03.cc&
- main()
  - The toolkit does not provide *main().*
  - There are more 70 examples
- initialization classes
  - Detector Construction
  - Physics List
- action classes
  - Invoked during an event loop
    - » Primary Generator Action
    - » Run Action
    - » Event Action
    - » Tracking Action
    - » Stepping Action
    - » Stacking Action

Note : classes written in red are mandatory.

- you can define VisManager, (G)UI session, optional user action classes, and/or your persistency manager in your *main()*.

Compile and run novice example

- Compile and run N03
  - prompt> cd $G4WORKDIR/examples/novice/N03
  - see README (in particular : how to start ?)
  - prompt> unsetenv G4UI_USE_XM
  - prompt> gmake
  - prompt> rehash
  - execute N03 in batch mode *(see README. Look at the macro file "run1.mac")*
    - » prompt> exampleN03 run1.mac
  - execute N03 in interactive mode
    - » prompt> exampleN03
    - » try the commands you see in run1.mac
  - have a look at the macro newgeom.mac
    - » Idle> control/execute newgeom.mac
    - » Idle> exit
    - » prompt> gmake clean

Part II

Looking into Geant4, trying it out with exercises

- Proton stopping
- Muon physics
- EM shower
- Production thresholds
- Magnetic field
- Examine cross sections
- Compute photon attenuation coefficient
- Simulate depth dose curve – and plot it
- Compute and plot Bragg curve
- Hadronic physics list

electromagnetic/TestEm3

- examine TestEm3
  - prompt> cd $G4WORKDIR/examples/extended/electromagnetic/TestEm3
  - see README
  - see TestEm3.cc
  - prompt> ls src
- visualize few events interactively
  - prompt> gmake
  - prompt> rehash
  - prompt> TestEm3
    - » PreInit> control/execute vis.mac
    - » Idle> run/beamOn
    - » Idle> run/beamOn 5
    - » Idle> exit
  - Note: the commands above are common for Geant4 interactive programs
    - » Some parameters can change (eg vis.mac, the name of an input file)
- execute TestEm3 in batch mode
  - prompt> TestEm3 TestEm3.in |tee result.out
  - prompt> nedit result.out&

exercise 1 : proton stopping

- start TestEm3 in interactive session
  - prompt> cd $G4WORKDIR/examples/extended/electromagnetic/TestEm3
  - prompt> nedit emtutor.mac &
  - prompt> TestEm3
    - » Idle> control/execute emtutor.mac
    - » Idle> gun/particle proton
    - » Idle> gun/energy 1 GeV
    - » Idle> run/beamOn
    - » Idle> run/beamOn 10
    - » Idle> gun/energy 200 MeV
    - » Idle> run/beamOn 10
  - *Question : estimate energy below which protons stop*
    - » ……
    - » Idle> exit

exercise 2 : muon physics

- start TestEm3 in interactive session
  - prompt> cd $G4WORKDIR/examples/extended/electromagnetic/TestEm3
  - prompt> nedit emtutor.mac &
  - prompt> TestEm3
    - » Idle> control/execute emtutor.mac
    - » Idle> gun/particle mu+
    - » Idle> gun/energy 1 GeV
    - » Idle> run/beamOn 10
    - » Idle> gun/energy 10 GeV
    - » Idle> run/beamOn 10
    - » Idle> gun/energy 100 GeV
    - » Idle> run/beamOn 10
    - » Idle> gun/energy 50 MeV
    - » Idle> run/beamOn 1
  - *Question : explain the last event*
    - » Idle> tracking/verbose 2 can help
    - » Idle> run/beamOn
    - » ……
    - » Idle> exit

exercise 3 : EM shower

- TestEm3 was created for simulation of sampling calorimeters. There are number of macro files for differents configurations.
- start TestEm3 in interactive session
  - prompt> cd $G4WORKDIR/examples/extended/electromagnetic/TestEm3
  - prompt> TestEm3
    - » Idle> control/execute emtutor.mac
    - » Idle> gun/particle gamma
    - » Idle> gun/energy 1 GeV
    - » Idle> run/beamOn 1
    - » Idle> run/beamOn 10
    - » Idle> gun/particle e-
    - » Idle> run/beamOn 1
    - » Idle> run/beamOn 10
    - » Idle> gun/energy 500 MeV
    - » Idle> run/beamOn 10
  - *Question : estimate energy below which e- shower will not be developed*
    - » ……..
    - » Idle> exit

exercise 4 : production threshold

- start TestEm3 in interactive session
  - prompt> cd $G4WORKDIR/examples/extended/electromagnetic/TestEm3
  - prompt> TestEm3
    - » Idle> control/execute emtutor.mac
    - » Idle> gun/particle e-
    - » Idle> gun/energy 200 MeV
    - » Idle> run/beamOn 10
    - » Idle> ls /testem/phys

  ls and also tab can be used to see available UI commands
    - » Idle> testem/phys/setCuts 1 mm
    - » Idle> run/beamOn 10
    - » Idle> testem/phys/setCuts 1 cm
    - » Idle> run/beamOn 10
    - » Idle> testem/phys/setCuts 10 cm
    - » Idle> run/beamOn 10
  - *Question : estimate cut for which no secondary particles will be produced*
    - » ……
    - » Idle> exit

exercise 5 : UI commands

- start TestEm3 in interactive session
  - prompt> cd $G4WORKDIR/examples/extended/electromagnetic/TestEm3
  - prompt> TestEm3
    - » Idle> control/execute emtutor.mac
    - » Idle> ls /material
    - » Idle> material/g4/printMaterial Water

  material is defined via its elements and isotopes

    - » Idle> material/nist/listMaterials

  about 300 predifined materials

    - » Idle> particle/list

  shows particles defined in current physics list

    - » Idle> process/list

  shows processes defined in current physics list

  - *Question : which processes are defined for pi+ ? Gamma ?*
    - » ……
    - » Idle> exit

exercise 6 : magnetic field

- start TestEm3 in interactive session
  - prompt> cd $G4WORKDIR/examples/extended/electromagnetic/TestEm3
  - prompt> TestEm3
    - » Idle> control/execute emtutor.mac
    - » Idle> testem/det/setField 1 tesla
    - » Idle> gun/particle proton
    - » Idle> gun/energy 200 MeV
    - » Idle> run/beamOn 10
    - » Idle> testem/det/setField 5 tesla
    - » Idle> run/beamOn 10

  Play with magnetic field for different particles at different energies

    - » ……..
    - » Idle> exit

TestEm0 : read cross sections

- access cross sections and others data with TestEm0
  - prompt> cd $G4WORKDIR/examples/extended/electromagnetic/TestEm0
  - see README
  - prompt> gmake
  - prompt> rehash

  in batch :
  - prompt> TestEm0 TestEm0.in

  interactively :
  - prompt> TestEm0
    - » Idle> ……
    - » Idle> exit
  - prompt> gmake clean

TestEm13 : attenuation of photon beam -1

- evaluate attenuation coefficient from transmission ratio
  - prompt> cd $G4WORKDIR/examples/extended/electromagnetic/TestEm13
  - see README
  - prompt> gmake
  - prompt> rehash
- visualize few events interactively

  (*by default TestEm13 shoots 1 MeV gamma through 1cm of Water)*
  - prompt> TestEm13
    - » PreInit> control/execute vis.mac
    - » Idle> gun/energy 100 keV
    - » Idle> run/beamOn 10
  - *Question : count transmitted gamma and evaluate attenuation coefficient*
    - » Idle> run/beamOn 10

    ……..
    - » Idle> exit

TestEm13 : attenuation of photon beam -2

- evaluate attenuation coefficient from transmission ratio
  - prompt> cd $G4WORKDIR/examples/extended/electromagnetic/TestEm13
- run high statistic in batch
  - prompt> nedit gamma.mac&
  - prompt> TestEm13 gamma.mac |tee result.out
  - *Question : evaluate attenuation coefficient from run2 and compare with run1*
  - *Question : compute attenuation coefficient for gamma 1 MeV in Be, Fe, Pb*

TestEm11 : depth dose didtribution - 1

- Compute and plot depth dose curve with TestEm11
  - prompt> cd $G4WORKDIR/examples/extended/electromagnetic/TestEm11
  - see README
  - prompt> gmake
  - prompt> rehash
- Visualize few events interactively

  (*by default TestEm11 fires 500 keV e- onto 1mm Silicon)*
  - prompt> TestEm11
    - » PreInit> control/execute vis.mac
    - » Idle> run/beamOn
    - » Idle> run/beamOn 50
    - » Idle> exit
  - Note: the commands above are common for Geant4 interactive programs
    - » Some parameters can change (eg vis.mac, the name of an input file)

TestEm11 - 2

- Make histogram of the depth dose distribution

  (see README and slide : histograms management)

  to force the recompilation of the class HistoManager :
  - uncomment G4ANALYSIS_USE in GNUmakefile (*take out the #*)
  - prompt> gmake histclean
  - prompt> gmake
  - run the macro TestEm11.in (have a look in it)
    - » prompt> Testem11 TestEm11.in
- The program produces an histogram file (testem11.hbook) which can be viewed with a specific tool, called PAW
  - prompt> paw
    - » PAW > h/file 1 testem11.hbook
    - » PAW > h/list
    - » PAW > h/plot 1
    - » PAW > h/plot 3
    - » PAW > h/plot 5
    - » PAW > option logy
    - » PAW > h/plot 5
    - » PAW > exit

TestEm11 - 3

- Exercise : write a macro to compute and plot the depth dose curve of 5 MeV e- in water

TestEm7 : Bragg curve - 1

- Compute and plot Bragg curve with TestEm7
  - cd $G4WORKDIR/examples/extended/electromagnetic/TestEm7
  - see README
  - prompt> gmake
  - prompt> rehash
- Visualize few events interactively

  (*by default TestEm7 is proton beam, 160 MeV, in 20 cm of water)*
  - prompt> TestEm7
    - » PreInit> control/execute vis.mac
    - » Idle> run/beamOn
    - » Idle> run/beamOn 50
    - » Idle> process/inactivate msc
    - » Idle> run/beamOn 50
    - » Idle> exit

TestEm7 - 2

- Make histogram of the Bragg curve
  (see README and slide : histograms management)
  to force the recompilation of HistoManager :
  - uncomment G4ANALYSIS_USE in GNUmakefile
  - prompt> gmake histclean
  - prompt> gmake
  - run the macro tallies.mac (have a look in it)
    - » prompt> Testem7 tallies.mac
- The program produces an histogram file (testem7.hbook) which can be viewed with a specific tool, called PAW
  - prompt> paw
    - » PAW > h/file 1 testem7.hbook
    - » PAW > h/list
    - » PAW > h/plot 1
    - » PAW > exit

Hadr01 : hadronic physics

- This example shows hadronic beam interaction with a target
  - prompt> cd $G4WORKDIR/examples/extended/hadronic/Hadr01
  - see README
  - prompt> gmake
  - prompt> rehash
- visualize few events interactively
  - prompt> hadr01
    - » PreInit> control/execute vis.mac
    - » Idle> /testhadr/Physics QGSP
    - » Idle> gun/particle proton
    - » Idle> gun/energy 1 GeV
    - » Idle> run/beamOn 1
    - » Idle> run/beamOn 10

Question : compare proton and e- showers for different energies and targets

- » Idle> ……
- » Idle> exit

Note : to change predefined physics list you must exit and start new session

Hadr01 : hadronic physics

- visualize few events interactively
  - prompt> hadr01
    - » PreInit> control/execute vis.mac
    - » Idle> /testhadr/Physics QGSP_BERT
    - » Idle> gun/particle pi+
    - » Idle> gun/energy 10 GeV
    - » Idle> run/beamOn 10
    - » Idle> gun/particle proton
    - » Idle> run/beamOn 10

Question : compare proton and pi+ interaction for different energies and targets, estimate nuclear interaction length

- » Idle> ……
- » Idle> exit

Note : to change predefined physics list you must exit and start new session

Addenda

1. Verifying other interactions
2. More global verifications
3. Histogramming

Photon interactions

Unpolarized, no fluorescence

	Total cross sections, mean free paths …	Em0, Em13, Em14
DCS		
	Final state : • energy spectra • angular distributions	Em14

Charged particle interactions

Unpolarized, no fluorescence

	Total cross sections, mean free paths …	Em0, Em13, Em14
DCS	Stopping power, range …	Em0, Em1, Em5, Em11, Em12
	Final state : • energy spectra • angular distributions	Em14

With cuts

More global verifications

Single layer : transmission, absorption, reflexion	Em5
Depth dose distribution, tallies Bragg curve	Em11, Em12 Em7
Shower shapes, Moliere radius	Em2
Sampling calorimeters, energy flow	Em3
Crystal calorimeters	Em9

Histograms management

- Creating histograms is always optional, under the control of G4ANALYSIS_USE
  → need at least one AIDA implementation
- A set of 1D histograms is predefined in an HistoManager class
  → only 1D histograms; no ntuples, no hits structures.
- Booking, Filling
  - a given histogram is selected and booked via UI command
  - his binning is defined via UI command
- Output
  - the name of the file and its format are defined via UI command
  → xml, root, hbook