Geant4 Hands-on Exercises

Workshop on Use of Monte Carlo Technique for Design and Analysis of Radiation Detectors

15-17 September, 2006, Coimbra, Portugal

Introductory Remarks

► This short tutorial supposed to be an introduction to the Geant4 toolkit

► Today only Linux

► More detailed tutorial materials are available in Geant4 web: http://cern.ch/geant4

► Complete documentation is also available in the web

Installation

► Geant4 toolkit requires installation procedure

► The only mandatory external library CLHEP

► Today you will use Geant4 already installed in the server polaris.fis.uc.pt

Geant4 Environment

► Login

► Define G4 environment:

. /opt/g4tutorial/setup.sh

pwd

env | grep G4

► You see in the screen the list of G4 environment variables

► Copy first example to your directory

cp –r /opt/g4tutorial/temp/TestEm3 .

User Classes

cd TestEm3
less TestEm3.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
    - ► Stacking Action
    - ► Tracking Action
    - ► Stepping Action
- ► You can define VisManager, (G)UI session, optional user action classes, and/or your persistency manager in your *main()*.

Note : classes written in yellow are mandatory.

Compile, link and run

cd   TestEm3

► It is an example of G4; to see its components:

ls src

► To see the main():

less TestEm3.cc

► To run in batch mode:

gmake

TestEm3 TestEm3.in >& result.out

less result.out

Exercise 1: Proton stopping

► Start interactive session:

TestEm3

/control/execute tutor.mac

/gun/particle proton

/gun/energy 1 GeV

/run/beamOn

/gun/energy 200 MeV

/run/beamOn

/run/beamOn 10

► Question: estimate energy below which protons stopped

Exercise 2: Muon physics

/gun/particle mu+
/gun/energy 1 GeV
/run/beamOn 10
/gun/energy 10 GeV
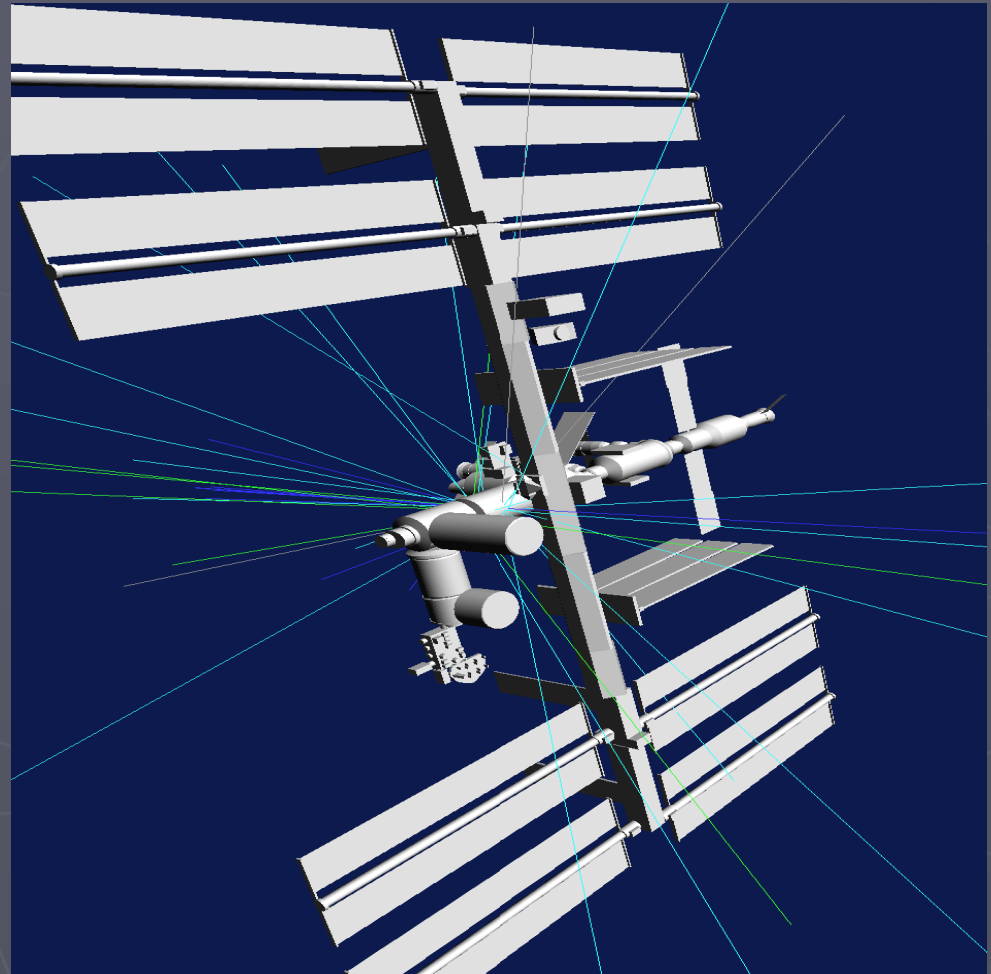/run/beamOn 10
/gun/energy 100 GeV
/run/beamOn 10
/gun/energy 100 MeV
/run/beamOn 10
► Question: explain the last plot
/tracking/verbose 1 can help

Terminology (G4 jargons)

- ► Run, event, track, step, step point
- ► Geometry volumes:
  - ▪ Solid, Logical, Physical
- ► Media:
  - ▪ Material, element, isotope
- ► Particle:
  - ▪ Particle Definition – static parameters
  - ▪ Dynamic Particle – dynamic parameters
- ► Track ←→ trajectory, step ←→ 2 trajectory points:
  - ▪ PreStepPoint, PostStepPoint
- ► Process = Physics
  - ▪ At rest, along step, post step
- ► Cut -> production threshold!
- ► Sensitive detector, hit, hits collection

Geant4 Tutorial   Courtesy T. Ersmark, KTH Stockholm

Exercise 3: EM shower

► TestEm3 was created for simulation of sampling calorimeters – there are number of macro files for different configurations and there is a standard output of calorimeter response

/gun/particle e-

/gun/energy 1 GeV

/run/beamOn 1

/run/beamOn 10

/gun/particle gamma

/run/beamOn 1

/run/beamOn 10

► Question: estimate energy below which electron shower will not be developed

Exercise 4: Production Thresholds

ls /testem/phys
► Unix command ls and also tab can be used to see available Geant4 UI commands

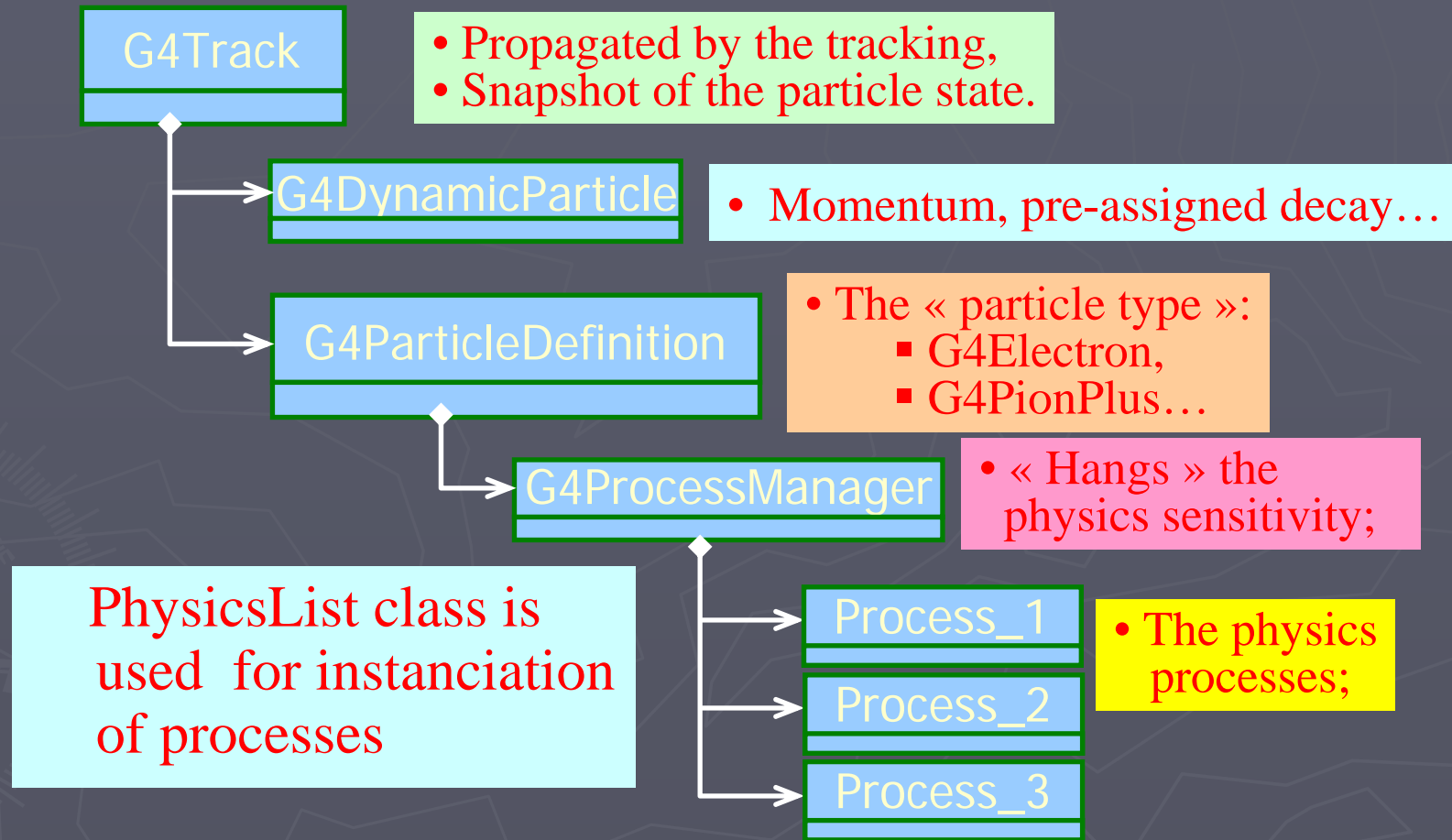/testem/phys/setCuts 0.1 mm

/gun/particle e-

/gun/energy 0.5 GeV

/run/beamOn 10

► Physics tables have been recalculated

/testem/phys/setCuts 1 cm

/run/beamOn 10

► Question: estimate cut in range for which no secondary particles will be produced

What is tracked in Geant4?

G4Track

- Propagated by the tracking,
- Snapshot of the particle state.

G4DynamicParticle

- Momentum, pre-assigned decay…

G4ParticleDefinition

- The « particle type »:
  - G4Electron,
  - G4PionPlus…

G4ProcessManager

- « Hangs » the physics sensitivity;

PhysicsList class is used for instanciation of processes

Process_1

Process_2

Process_3

- The physics processes;

Exercise 5: UI interface

ls /material

/material/g4/printMaterial Lead

► Material is defined via its elements and isotopes

/material/nist/listMaterials

► About 300 predefined materials are available

/particle/list

► Shows particles defined in current Physics Lists

/process/list

► Shows particles defined in current Physics Lists

► Question: which processes are defined for pi+? Gamma?

/testem/det/setField 1 tesla

► Try out different particles at different energies

► Try out to switch on magnetic using /testem/det subdirectory

Exercise 6: EM processes

Exit

ls

TestEm3

/control/execute exo3q1.mac

► Only processes on gamma conversion, ionisation and pair production are active

► Only one thick absorber Al; Magnetic field is on.

/run/beamOn 1

/run/beamOn 1

/tracking/verbose 1

/run/beamOn 1

/gun/particle e-

/gun/position 0 0 0

/run/beamOn 1

/run/beamOn 1

/gun/particle e+

/run/beamOn 1

/run/beamOn 1

► Question: select energy, which will allow to see e+ annililation

Exercise 7: Attenuation of photon beam in absorber

exit

cd ../

cp -r /opt/g4tutorial/temp/TestEm14 .

cd TestEm14

gmake

TestEm14 TestEm14.in >& res.out

less res.out

► Example demonstrate several ways of computing of gamma attenuation in media

► Question: compute attenuation coefficient in Be, Fe, Pb, water for gamma energy 1 MeV

Exercise 8: Different Visualization Commands

exit

cd ../

cp /opt/g4tutorial/temp/TestEm9 .

cd TestEm9

gmake

TestEm9 TestEm9.in >& res.out

less res.out

► Example demonstrate cuts per region facility for setup, which includes vertex detector and crystal calorimeter

TestEm9

/control/execute vis.mac

/run/beamOn

► Only charged tracks are shown

ls /testem/event

► Question: find out a command to switch on neutral tracks

ls /vis/viewer/set

► Question: find out a command to change viewpoint and display the setup

Exercise 9: Hadronic Physics

exit

cd ../

cp -r /opt/g4tutorial/temp/Hadr01 .

cd Hadr01

gmake

hadr01 hadr01.in >& res.out

less res.out

► Example demonstrate hadronic beam interaction with a target

hadr01

/control/execute vis.mac

/testhadr/Physics QGSP

/run/beamOn

/run/beamOn 10

► Question: compare electron and proton showers for different energies and targets

► Note: to change predefined Physics List you have to exit and start new session