Geant4 9.4

A SHORT GUIDE TO CHOOSING PHYSICS LISTS

Slides prepared by
Dennis Wright (SLAC) & Sébastien Incerti (CNRS/IN2P3)

Introduction

- Building a physics list or choosing from already built physics lists is highly dependent on your use-case
- In either case, you need to be familiar with the major physics processes used to build them
  - the process-model catalog is useful for this
  - see Geant4 web page under User Support, item 10b
- Geant4 provides several "reference physics lists" which are routinely validated and updated with each release
  - these should be considered only as starting points which you may need to modify for your application
- There are also many physics lists in the examples which can copy
  - these are usually very specific to a given use-case

Introduction

- There are currently 28 "packaged" physics lists available
  - but you will likely be interested in only a few, namely the "reference physics lists"
  - many physics lists are either developmental or customized in some way, and so not very useful to new users
- All but one of the packaged physics lists use templates
  - the LBE physics list is the old-style "flat" physics list without templates or physics builders
- Reference physics lists
  - QGSP_BERT, QGSP_BERT_EMV, QGSP_BERT_HP, QGSP_BIC, FTFP_BERT, LBE, LHEP
  - plus a few more

Physics List Naming Convention

- "QGS" Quark gluon string model (>~20GeV)
- "FTF" Fritiof Model (>~10GeV)
- "LHEP" Low and High energy parameterization model
- "BIC" Binary Cascade Model (<~10 GeV)
- "BERT" Bertini Cascade Model (<~10 GeV)
- "HP" High Precision Neutron Model (<20MeV)
- "PRECO" Pre compound Model (<~150MeV)
- "EMV(X)" Variation of Standard EM package

Reference Physics Lists

- LHEP
  - fastest of all physics lists
  - not the most precise
  - contains standard EM processes
  - good at describing showers in detectors

- QGSP_BERT
  - the physics list most recommended for HEP
  - used by ATLAS
  - contains standard EM processes
  - uses Bertini cascade for hadrons of energy below ~10 GeV
  - uses QGS model for high energies (> 20 GeV)

Reference Physics Lists

- QGSP_BERT_EMV
  - also recommended for HEP
  - same as QGSP_BERT, but with EM processes tuned for better CPU performance
    - increase in speed comes with a slight decrease in EM precision
  - used by CMS

- QGSP_BERT_HP
  - same as QGSP_BERT, but with high precision neutron model
  - used for neutrons below 20 MeV
  - significantly slower than QGSP_BERT when full thermal cross sections used
    - can speed up significantly by turning off thermal scattering
  - can be used for radiation protection and shielding applications

Reference Physics Lists

- QGSP_BIC
  - uses Binary cascade, precompound and various de-excitation model for hadrons
  - standard EM
  - recommended for use at energies below 200 MeV (medical)

- QGSP_BIC_HP
  - same as QGSP_BIC, but with high precision neutron model used for neutrons below 20 MeV
  - use for radiation protection, shielding and medical applications

- For more see
  - http://geant4.web.cern.ch/geant4/support/proc_mod_catalog/physics_lists/referencePL.shtml

Other Physics Lists (based on use-case)

- If energy of primary particle in your application is < 5 GeV (for example, clinical proton beam of 150 MeV)
  - start with physics list which includes "BERT" or "BIC"
  - e.g. QGSP_BERT, QGSP_BIC, FTFP_BERT, etc.
- If your application requires detailed neutron transport
  - start with physics list which contains "HP"
  - e.g. QGSP_BERT_HP, QGSP_BIC_HP, etc.
- If you are interested in Bragg curve physics
  - start with physics list which includes "EMX" or "EMV"
  - e.g. QGSP_BERT_EMV, QGSP_BERT_EMX
- If your application deals with nucleus-nucleus interactions
  - contact Tatsumi Koi @ SLAC (custom physics list required)

Other Physics Lists (based on use-case)

- If your application needs optical photon transportation
  - only LBE physics list is suitable
- If your application needs "radioactive decay"
  - only LBE physics list is suitable
- If your application needs detailed line emissions from EM processes
  - use the LowEnergy EM package
  - LBE maybe be suitable
- If you want to use LowEnergy EM package
  - try LBE
  - see following slides

1) How to use the already available Electromagnetic Physics lists ?

- These Physics list classes derive from the G4VPhysicsConstructor abstract base class
- A good implementation example of PhysicsList class that uses these already available Physics lists is available in

  $G4INSTALL/examples/extended/electromagnetic/TestEm2

  - In your PhysicsList class, you need to :
    - Create a dynamic Physics List object in the constructor
      - For eg. `emPhysicsList = new G4EmLivermorePhysics();`
    - Delete it in the destructor
    - Define particles in the `PhysicsList::ConstructParticle()` method
    - Eventually set your production cuts

- The source code for these Physics lists is available in the following directory $G4INSTALL/source/physics_list/builders

Alternative EM Physics Lists

- Up to now, most physics lists mentioned have used the "standard" EM processes,
  - G4EmStandardPhysics – default
  - G4EmStandardPhysics_option1 – HEP, fast but not precise
  - G4EmStandardPhysics_option2 – experimental
  - G4EmStandardPhysics_option3 – medical, space
- but several "low energy" EM builders are available
  - G4EmLivermorePhysics
  - G4EmLivermorePolarizedPhysics
  - G4EmPenelopePhysics
  - G4EmDNAPhysics
  - These are recommended for low energy EM & radiobiology applications
  - For examples using the « DNA » physics list, go to
    - geant4/source/examples/advanced/dnaphysics
    - geant4/source/examples/advanced/microdosimetry

2) Usage of pre-packaged Physics lists

- How to use these Physics lists ?
  - Directly in your main()

```
G4PhysListFactory *physListFactory = new G4PhysListFactory();
G4VUserPhysicsList *physicsList =
            physListFactory->GetReferencePhysList("QGSP_BERT");
runManager->SetUserInitialization(physicsList);
```

- To print them

```
const std::vector<G4String> v =
          physListFactory->AvailablePhysLists();
```

- See description of Physics Lists

http://geant4.web.cern.ch/geant4/support/proc_mod_catalog/physics_lists/referencePL.shtml

Thank you for your attention