A Short Guide to Choosing Physics Lists

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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 10a.

• 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 40 “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
Other Physics Lists (based on use-case)

• If the energy of primary particle of your application is below 5 GeV (for example clinical proton beam of 150 MeV)
  – start with physics list which includes abbreviation “BERT” or “BIC”
  – E.g. QGSP_BERT, FTFP_BERT, QGSP_BIC and so on

• If your application needs detailed neutron transportation
  – start with physics list which contains abbreviation “HP”
  – E.g. QGSP_BERT_HP, QGSP_BIC_HP and so on

• If you are interested in “Bragg Curve”
  – start with physics list which has abbreviation “EMX(V)”
  – E.g. QGSP_EMV, QGSP_EMX and so on

• If your application needs nucleus-nucleus interactions
  – none of the physics lists in the physics_list directory is suitable for you
  – contact T. Koi
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
Alternative EM Physics Lists

- Up to now, most physics lists mentioned have used the “standard” EM processes, but several “low energy” EM builders are available
  - G4EmLivermorePhysics
  - G4EmLivermorePolarizedPhysics
  - G4EmPenelopePhysics
  - G4EmDNAPhysics
- These are recommended for micro-dosimetry applications
- For examples using a DNA physics list, go to
  - geant4/source/examples/advanced
How to use the already available EM 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

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