

Which Physics List To Use

Geant4 PHENIICS & IN2P3 Tutorial,

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Orsay

Marc Verderi

LLR, Ecole polytechnique

Credits...

- Dennis Wright (SLAC), Alberto Ribon (CERN),
Davide Mancusi (CEA)

Choosing a Physics List

- Which physics list to use depends on the use-case
- It is convenient and recommended to start with one of the 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 validate or modify for your application
- There are also many physics lists in the examples, which you can copy and then eventually modify
 - These are often specific to a given use-case
- There are currently **19** packaged physics lists, of which **6** are reference physics lists
 - **FTFP_BERT, FTFP_BERT_HP**
 - **QGSP_BERT, QGSP_BERT_HP, QGSP_BIC**
 - **QGSP_FTFP_BERT**

Physics List Naming Convention

- The following acronyms refer to various hadronic options
 - **FTF** -> Fritiof string model ($>\sim 3$ GeV)
 - **QGS** -> Quark Gluon String model ($>\sim 12$ GeV)
 - **BERT** -> Bertini-style Cascade ($\sim < 10$ GeV)
 - **BIC** -> Binary Cascade ($\sim < 10$ GeV)
 - **P** -> Precompound model used for nuclear de-excitation ($\sim < 150$ MeV)
 - **HP** -> High Precision neutron model (< 20 MeV)
- EM options designated by
 - No suffix : standard EM physics
 - **_EMV** , **_EMX** : fast options for high-energy physics
 - **_EMY** , **_EMZ** , **_LIV** , **_PEN** : more precise options, for medical and space science applications

When the application starts...

- Large amount of information displayed by the physics list

```
...
FTFP_BERT : new threshold between BERT and FTFP is over the interval
  for pions :    3 to 12 GeV
  for kaons  :    3 to 12 GeV
  for proton :    3 to 12 GeV
  for neutron :  3 to 12 GeV
...
conv:   for gamma      SubType= 14  BuildTable= 1
        Lambda table from 1.022 MeV to 100 TeV, 18 bins per decade, spline: 1
        ===== EM models for the G4Region DefaultRegionForTheWorld =====
          BetheHeitler : Emin=          0 eV   Emax=          80 GeV
          BetheHeitlerLPM : Emin=         80 GeV  Emax=         100 TeV
...
Hadronic Processes for anti_deuteron

Process: hadElastic
  Model:          hElasticLHEP: 0 eV /n ---> 100.1 MeV/n
  Model:          AntiAElastic: 100 MeV/n ---> 100 TeV/n
  Cr_sctns:       AntiAGlauber: 0 eV ---> 2.88022e+295 J
  Cr_sctns:       GheishaElastic: 0 eV ---> 100 TeV

Process: anti_deuteronInelastic
  Model:          FTFP: 0 eV /n ---> 100 TeV/n
  Cr_sctns:       AntiAGlauber: 0 eV ---> 2.88022e+295 J
  Cr_sctns:       GheishaInelastic: 0 eV ---> 100 TeV

Process: hFritiofCaptureAtRest
...

```

- The most up-to-date information you can find on a given physics list is here !

Reference Physics Lists (1/3)

- **FTFP_BERT**

- Recommended by Geant4 for HEP
- Contains all standard EM processes
- Uses Bertini-style cascade for hadrons < 5 GeV
- Uses Fritiof model for high energies > 4 GeV
- Uses Precompound + evaporation for nuclear de-excitation
- Includes neutron capture
- Includes nuclear stopping at rest of negatively charged hadrons
- Includes gamma- and electro-nuclear
- No neutron-HP, radioactive decay, optical photons

Reference Physics Lists (2/3)

- **QGSP_FTFP_BERT**

- All standard EM processes
- Bertini-style cascade for hadrons < 8 GeV
- Quark Gluon String model for high energies > 12 GeV
- Fritiof model in between 6 – 25 GeV

- **QGSP_BERT**

- All standard EM processes
- Bertini-style cascade for hadrons < 9.9 GeV
- Quark Gluon String model for high energies > 12 GeV
- Fritiof in between 9.5 – 25 GeV
- NB) We are working to extend QGS at lower energies, so that the transition with BERT can be done directly, without FTF (in this physics list)

Reference Physics Lists (3/3)

- **QGSP_BIC**

- Same as QGSP_BERT, but replaces Bertini-style cascade with Binary cascade model (+ Precompound model)
- Recommended for use at energies below 200 MeV
 - Many medical applications
 - Suggested EM option: _EMY or _EMZ

- **FTFP_BERT_HP (QGSP_BERT_HP)**

- Same as FTFP_BERT (QGSP_BERT), but with the high-precision neutron model used for neutrons below 20 MeV
- Significantly slower than FTFP_BERT (QGSP_BERT), especially when Doppler broadening on-the-fly is used
 - There is an option to turn this off
- For radiation protection and shielding applications

Other Physics Lists (1/2)

- **Shielding**

- Based on FTFP_BERT_HP with improved neutron cross sections from JENDL
- Better ion nuclear interactions using QMD model
- Radioactive decay model activated
- Currently used by SuperCDMS dark matter search
- Recommended for:
 - Shielding applications
 - Space physics
 - HEP

- **FTFP_INCLXX , FTFP_INCLXX_HP**

- Like FTFP_BERT(_HP), but with Bertini-style cascade replaced by INCLXX (Liege) cascade model below 3 GeV

Other Physics Lists (2/2)

- **QBBC**

- Uses both Bertini-style and Binary cascade models
- Latest coherent elastic scattering
- Neutron XS approach (fairly accurate, but faster than HP)
 - Since G4 10.0 adopted also in other non-HP physics lists

- **QGSP_BIC_HP**

- Same as QGSP_BIC, but with the high precision neutron model used for neutrons below 20 MeV
- Recommended for:
 - Radiation protection
 - Medical applications

Other Physics Lists (based on use-case)

- If primary particle energy in your application is < 5 GeV (for example, clinical proton beam of 150 MeV)
 - start with a physics list which includes BIC or BERT
 - e.g. **QGSP_BIC**, QGSP_BERT, FTFP_BERT, etc.
- If neutron transport is important
 - start with a physics list containing “HP”
 - e.g. QGSP_BIC_HP, FTFP_BERT_HP, etc.
- If you are interested in Bragg curve physics
 - use a physics list ending with **_EMY** or **_EMZ**
 - e.g. QGSP_BIC_EMY
- For detailed line emission from EM processes
 - EM options : **_EMY** , **_EMZ** , **_LIV** , **_PEN**

Using Geant4 Validation to Choose Physics Lists

- Ultimately you must choose a physics list based on how well its component processes and models perform
 - Physics performance
 - CPU performance
- Geant4 provides validation (comparison to data) for most of its physics codes
 - Validation is a continuing task, performed at least as often as each release
 - More validation tests added as time goes on
- To access these comparisons, go to
 - <https://geant-val.cern.ch/>

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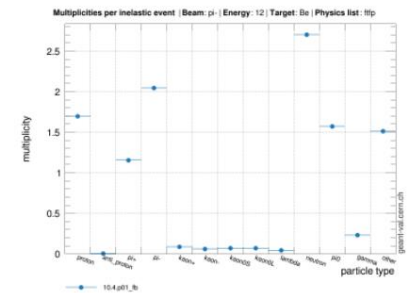
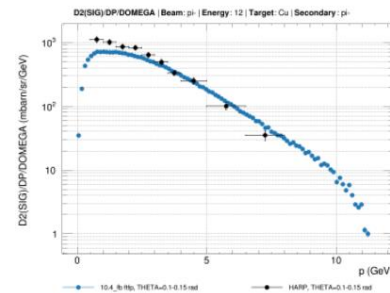
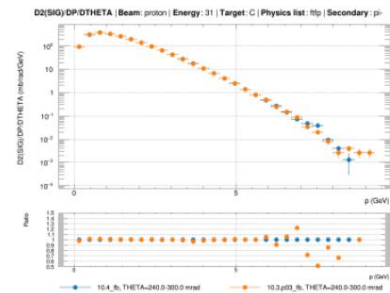
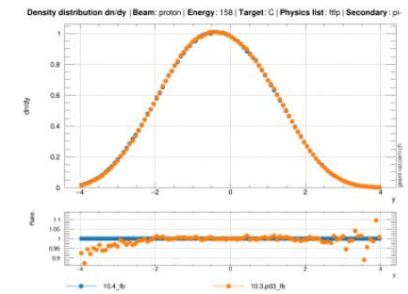
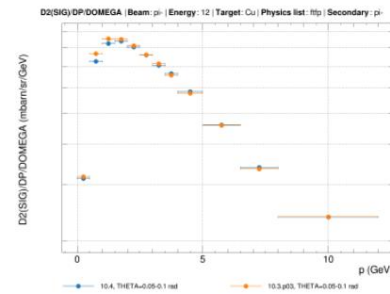
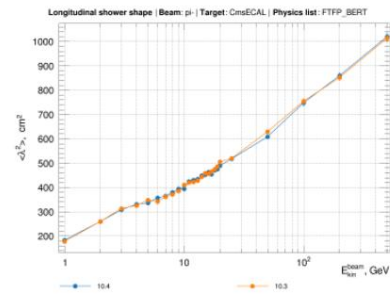
Geant Validation Portal

User Layouts

Stat comparison

Summary

Lookup tables



CERN SFT 2016-2020

Summary

- Choosing a physics is a critical decision you have to make when building your application.
- Reference physics lists exist to guide your choice
 - They are continuously monitored
 - And are recommended to start with
- Physics lists can easily be customized using the `G4PhysicsListFactory`
 - Allowing you to compose your physics list using a few tags
- If you need to go to more specific physics, you will have to tailor your physics list
 - And numerous examples are demonstrating this