Physics Lists

Geant4 and its Application to HEP and Astrophysics
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Physics Lists

- Geant4 provides the possibility of simulating the physics processes of a variety of particles
  - each such particle can have interactions of different types: strong, electromagnetic or weak and each such interaction can be described by different models
  - unlike many other simulation tools, Geant4 leaves it to the user to decide on which particles, which interactions and which models are to be used during the simulation step
  - declaration of the list of particles and the choice of models is done using the physics list
  - the toolkit provides handles for a few well-defined physics lists which are suitable for certain specific types of application

Types of Physics Lists

- There are several types of modules which can be combined to define the physics list
  - electromagnetic physics
  - extra physics processes for photons and leptons
  - decays
  - hadronic elastic
  - hadronic inelastic
  - stopping particles and capture processes
  - ion nuclear interactions
  - step limits
  - others

- The others category includes optical photons, exotic physics processes, thermal neutron transport models, ….

- The user needs to define the physics list through the 3 handles:
  - RegisterPhysics
  - ReplacePhysics
  - RemovePhysics

An Example of Making a Physics List

```
// EM Physics
RegisterPhysics(new G4EmStandardPhysics(verbosity));

// Synchroton Radiation & GN Physics
G4EmExtraPhysics* gn = new G4EmExtraPhysics(verbosity);
RegisterPhysics(gn);

// Decays
this->RegisterPhysics(new G4DecayPhysics(verbosity));

// Hadron Elastic scattering
RegisterPhysics(new G4HadronElasticPhysics(verbosity));

// Hadron Physics
RegisterPhysics(new G4HadronPhysicsFTF_BIC(verbosity));

// Stopping Physics
RegisterPhysics(new G4StoppingPhysics(verbosity));

// Ion Physics
RegisterPhysics(new G4IonPhysics(verbosity));

// Neutron tracking cut
RegisterPhysics(new G4NeutronTrackingCut(verbosity));
```

Geant4 Options for EM Physics

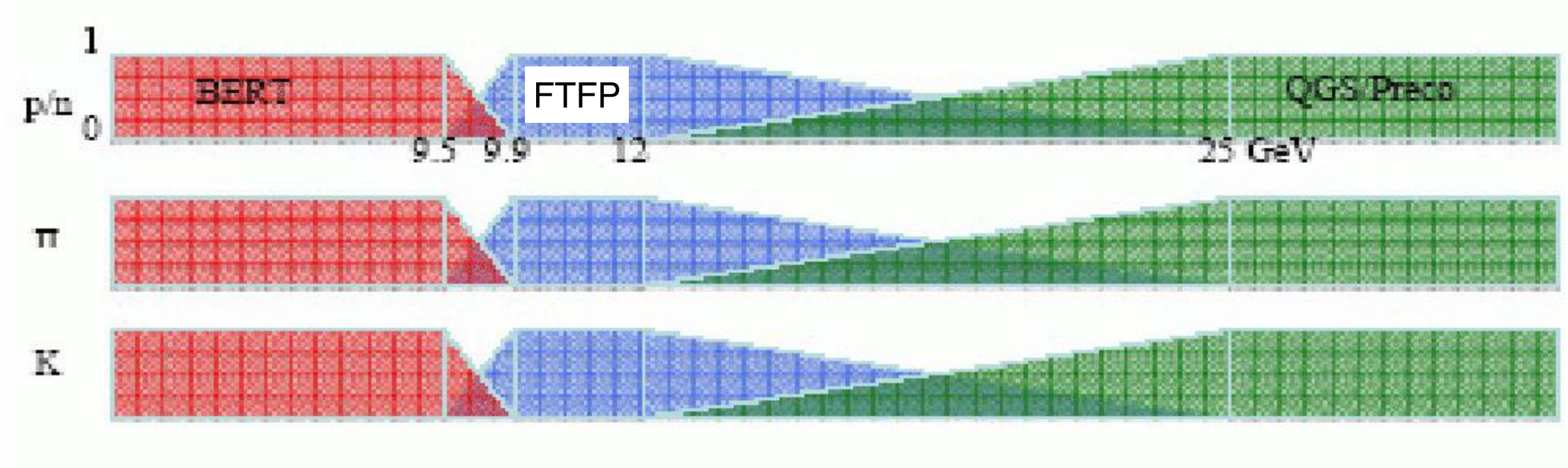
- There are 10+ options for EM physics
  - opt1 (EMV): a fast but less precise version used in HE physics lists
  - opt2 (EMX): also a fast and less precise version for HE physics lists
  - opt3 (EMY): provides a more accurate simulation of photons and charged hadrons
  - opt4 (EMZ): most precise but slow description of EM physics for HE applications
  - LIV: similar to opt3 but models for photos and electrons make use of Livermore set of models
  - PEN: similar to opt3 with models for photons and electrons making use of Penelope set of models
  - _GS: substitute Urban multiple scattering models with the Goudschmidt-Sanderson model
  - _LE: low energy WentzelVI model is used for multiple scattering
  - WVI: WentzelVI model and ATIMA ion ionisation models are used for a better description of multiple scattering
  - _SS: single scattering models used on top of standard EM configuration

- Please note that the same model describes EM physics over the entire energy region

Inelastic Hadronic Interactions

- No single model for hadron inelastic process can cover the entire energy region required in a high-energy physics experiment
  - Quark-gluon string models are good at high energies
  - Nuclear cascade models are good at medium and low energies
  - At very low energies, models for fission and pre-combination are required

- So all physics lists for inelastic hadronic interaction combine a number of models



Physics List Library

- There are a number of Physics Lists available in the Geant4 library which can be directly incorporated into the user code
  - FTFP_BERT — High Energy Experiments
  - FTFP_BERT_ATL
  - FTFP_BERT_HP
  - FTFP_BERT_TRV
  - FTFP_INCLXX
  - FTFQGSP_BERT
  - FTF_BIC
  - QBBC — Medical and Space Physics Applications
  - QGSP_BERT — Former default for High Energy Experiments
  - QGSP_BERT_HP
  - QGSP_BIC — Cosmic Ray applications
  - QGSP_BIC_AllHP
  - QGSP_BIC_HIP
  - QGSP_FTFP_BERT
  - QGSP_INCLXX
  - QGS_BIC
  - Shielding — Recommended for shielding studies
  - ShieldingLEND
  - LBE
  - NuBeam