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.
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 (>~20 GeV)
- "FTF" Fritiof Model (>~10 GeV)
- "LHEP" Low and High energy parameterization model
- "BIC" Binary Cascade Model (<~10 GeV)
- "BERT" Bertini Cascade Model (<~10 GeV)
- "HP" High Precision Neutron Model (<20 MeV)
- "PRECO" Pre compound Model (<~150 MeV)
- "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 \( \sim 10 \) 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 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)
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()

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

- To print them

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

- See description of Physics Lists

Thank you for your attention