New Physics Lists under development

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- Note: talk restricted to reference physics lists

Introduction - 1

Physics List is a set of **consistent physics models** for **each particle** in application

- Physics List is responsibility of user
- Users need guidance or help
- Geant4 provided physics lists offer starting points
- Responsibility of application developer
  - To choose and, if needed, further develop
  - To validate for his use case

Introduction - 2

- Goal
  - Improve modeling of hadronic showers
    - Shower shape
    - Resolution
    - Response, ie. e/π ratio
- Follow evolution of physics modeling
  - New developments offered in experimental lists first
  - Adopt mature improvements
- Change key options
- Obsolete and delete superfluous lists, or when better options exist

Plans for 9.1

- These ideas are still under discussion!
  - Comments and feedback is welcome

- Physics lists to drop
  - QGSP_EMV_NQE and QGSP_BERT_NQE
    - Provided in 8.3 as backward compatibility option
    - Quasi-elastic turned off
  - QGSP_BERT_TRV
    - Added on request in 8.3
    - Lowers Transition from LEP to BERT for p,n,pi,K to (5.0-5.4) GeV, default is (9.5-9.9) GeV

Plans for 9.1 – New Lists

- New physics lists, current status of discussion
  - Feedback
- Provide new lists minimizing use of parameterized modeling
  - QGSC_BERT
    - QGSC in thin target does reasonably well even at 4GeV
    - Switch from G4 Bertini to QGSC between 6-9 GeV
  - FTFP_BERT and/or FTFC_BERT
    - FTF modeling revised for 9.0
    - FTFP/FTFC is now used down to 4GeV
  - Existing experimental list QBBC
    - Configurations with minimal use of parameterized models exist

Plans for 9.1 – New Lists (cont)

- New developments in Binary Cascade
  - Start to use for pion incident up to about 1.3 GeV
  - New for rescattering of string model secondaries

→ New lists QGS_BIC and FTF_BIC

  - Experimental, more testing needed
  - Nuclear de-excitation through implicit use of precompound and deexcitations models via BIC
  - Shall replace QGSP_BIC

- Or QGSP_BIC2
  - Like QGSP_BIC, and add using BIC for pions
  - Fallback solution, in case of problems with QGS_BIC

Plans for 9.1 – Diffraction ?

- Projectile diffraction and
- Coherent target nucleus diffraction

Not well modeled in QGS and FTF, though FTF slightly better

- Should affect shower shape
- Plan to include projectile diffraction
  - Code ~exists, testing required
  - Tight schedule
  - Can only be done in approximate way

Documentation - web

- Physics lists
  - New draft pages: Hadronic
- Process model catalog
  - List of all processes
    - Applicability details

Summary

- For 9.1 several new lists planned
  - Reducing the use of parameterized modeling
  - Including new model developments
- Documentation is improving
- Feedback welcome
  - Proposed changes
  - New requirements

Backup slides.....

Inventory of Reference PL (G4 8.3)

- LHEP
- LHEP_EMV
- LHEP_BERT
- LHEP_BERT_HP
- *LHEP_BIC*
- *LHEP_BIC_HP*
- *LHEP_PRECO*
- LHEP_PRECO_HP
- *LHEP_HP*
- *LHEP_LEAD*
- *LHEP_LEAD_HP*

- QGSP
- QGSP_EMV
- QGSP_EMX
- QGSP_NQE
- QGSP_EMV_NQE
- QGSP_BERT
- QGSP_BERT_EMV
- QGSP_BERT_HP
- QGSP_BERT_NQE
- QGSP_BERT_TRV
- QGSP_BIC
- QGSP_BIC_HP
- *QGSP_HP*
- QGSP_QEL
-

- QGSC
- QGSC_EMV
- QGSC_EFLOW
- *QGSC_LEAD*
- *QGSC_LEAD_HP*

- LBE

- FTFC
- FTFP_EMV
- FTFP

- QBBC

Lists in italic deleted in 9.0

Obsolete and removed Lists

- Starting with 8.2, declare several lists obsolete
- In 9.0, deleted the following:
  - All 4 lists using Mars leading particle bias …_LEAD
    - Due to removal of Mars code itsself
  - LHEP_BIC and LHEP_BIC_HP
    - use QGSP_BIC or QGSP_BIC_HP
  - LHEP_HP and QGSP_HP
    - use QGSP_BERT_HP or QGSP_BIC_HP
  - LHEP_PRECO
    - use QGSP_BIC

Updates in 8.0

- Use EM builder from EM standard
  - Removed template meta programming based class plist.tmp
- Gamma Nuclear physics enabled by default
  - Remove obsolete lists with gamma nuclear
- Added physics lists with 7.1 multiple scattering
  - QSQP_EMV and LHEP_EMV
- Added list for radiation studies
  - QGSP_BERT_HP

- Revision of particles

Updates in 8.1

- Added list with more performant em options QGSP_EMX
- Introduce Chips modeling for stopping particles in all physics lists based on QGS and FTF.
  - Replaces capture processes for μ-, pi-, and K-
  - Replaces annihilation at rest for anti-proton and anti-neutron
- Updated elastic scattering in all physics lists based on QGS and FTF using improved multiple scattering
- Use Bertini for Kaons in BERT lists
- Use Binary for ions in BIC lists
- New experimental physics list QBBC, minimizing use of LHEP models

Updates in 8.2

- Integrate physics lists into Geant4 source code and build system
- Neutron tracking cut
- New lists
  - QGSC_EFLOW using new CHIPS energy flow
  - QGSC_EMV
  - QGSP_BIC_HP
  - QGSP_QEL variant using CHIPS systematics for elastic scattering
- Declare several lists obsolete
  - LHEP: _HP, _BIC, _BIC_HP, _PRECO, and QGSP_HP

Updates in 8.3

- Add quasi-elastic scattering to all QGS physics lists
  - For backward compatibility and for testing, new temporary lists **without** quasi-elastic scattering: QGSP_NQE, QGSP_EMV_NQE, and QGSP_BERT_NQE
- QGSC lists use new CHIPS model for muon capture at rest
- Use HElastic model for all particles with kinetic energy T> 1GeV, except in Hydrogen
- Skin parameter of multiple scattering set to 0
  - No computation of linear distance to boundary
- FTFP and FTFC use revised FTF model
- New QGSP _BERT_TRV
  - Restrict use of Bertini cascade to particles with T<5.4GeV, by default it is used up to T=9.9 GeV

Updates in 9.0

- Rename components for EM physics
  - G4EMStandardPhysics, the default EM option
  - G4EMStandardPhysics_option1, used by _EMV variants
    - Was G4EMStandardPhysics71
  - G4EMStandardPhysics_option2, used by _EMX variants
    - Was G4EMStandardPhysics72
- Removed obsolete lists
  - LHEP_BIC, LHEP_BIC_HP, QGSP_HP
  - All lists relying on the Mars5 rewrite (*_LEAD*)
- Threshold for use of FTF model lowered to 5GeV
  - FTF is under development