

Geant4 Physics Work Plan for 2014

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Outline

Summary of the program of work for 2014 for the following areas of Geant4, related to **physics**:

- Standard Electromagnetics Physics
- Low-Energy Electromagnetic Physics
- Hadronic Physics
- Physics Lists
- Validation

Note: (1) means first semester
(i.e. to be included in June G4 10.1beta release)

(2) means second semester
(i.e. to be included in December G4 10.1 release)

(2+) means starting in the second semester but could
continue next year

STANDARD ELECTROMAGNETIC PHYSICS

Multiple and Single Scattering

- Finalize the multiple scattering migration to ***AlongStep*** (1)
- Add lateral displacement option **at boundary** (1)
- Addition of the next order corrections to **WentzelVI** model (1)
- Review and fix of **Goudsmit-Saunderson** model (2+)
 - Potentially the most accurate model for low-energy (≤ 100 MeV) electrons and positrons

Ionisation processes

- Improve **Urban fluctuation** model (1)
- Refinement of the **effective ion charge** approach (1)
 - To be applicable simultaneously for both dense and low-density media (including vacuum)
- Refinement of **Birks effect** in helper class (1)
- Investigation of **alternative fluctuation models** (1 & 2)
 - Currently the default model is Urban, and a more precise (but slow) alternative is PAI. We are looking for something in between...
- **Alternative ion ionisation models for moderate energies** (2+)
 - More accurate than Bethe-Bloch model for ~ 100 MeV/u heavy ions

Bremsstrahlung and Gamma models

- Improvement of the parameterisation of the **positron** cross sections in the Seltzer-Berger model (2+)
 - Likely important for \sim MeV positrons
- Update of the **Compton** scattering model, with the addition of radiative corrections (2+)
- Updated **gamma conversion** model below 10 MeV (2+)

High Energy processes

- Improvement of the cross section for **photo-nuclear** production by **muons** (2)
- Migration of gamma to $\mu^+\mu^-$ production process to model design (2)

Optical photon processes

- Extension to the unified surface model to have both **specular** and **diffuse** components for the transmitted photons (2)
- Modeling of optical transport in a volume that has different **optical treatments** on different **sides** (2)

Others

- Further code cleanup for **multi-threading** (1)
- Review the behavior of **EM options** in multi-threading and sequential mode (1)
- Infrastructure: introduction of range computation in G4EmCalculator (2+)

LOW-ENERGY ELECTROMAGNETIC PHYSICS

Livermore models

- Migration of Livermore **ionisation** to standard EM interfaces and tools (2)
- Migration of **polarized gamma** models to the same software design as non-polarized Livermore models (2+)
- Improvement of **polarized gamma** models: pair production by polarized gamma rays, pair production in electron field, radiative correction in pair production (2+)

Monash University models

- Migration of Monash U. models to standard EM interfaces and tools (2)
- Development of **photoelectric** and **polarized** version of the Monash Compton model (2)

Atomic Deexcitation

- Semi-empirical corrections for **K, L and M cross sections** up to 100 MeV (2+)
- Calculations of **low-energy transitions**, including Auger yields (2+)
- Migration of atomic de-excitation package to standard EM interfaces and tools (2+)

RBE (Relative Biological Effectiveness)

- Development of classes for **dose average LET** (Linear Energy Transfer) computing (2)

MuElec (micro-electronics) models

- Addition of model for **SiO₂** (2)
- Migration of MuElec models to standard EM interfaces and tools (2+)

Geant4-DNA

- Geant4-DNA example for **radiolysis** modelling (1)
- Development of **alternative** Geant4-DNA physics models (2)
- Physics models for **DNA bases and backbone** for protons and electrons (2)
- Development of a **multiple scattering** process **below keV** range (2)
- Include **low-energy photoelectric** effect model for water with new data (2)
- Migration of Geant4-DNA models to standard EM interfaces and tools (2+)

Others

- Further code cleanup for **multi-threading** (1)

HADRONIC PHYSICS

String models

- **FTF** (Fritiof model)
 - Improvement of diffraction dissociation (1)
 - Further validation and tuning (1 & 2)
 - **Code** improvement (1 & 2)
 - Study of **re-scattering** with Bertini and Binary (2)
- **QGS** (Quark-Gluon-String model)
 - Extension to lower energy with **Reggeon Cascade** (2)
 - Study of **diffraction** dissociation and **validation** (2)

Cascade models

- **BERT** (Bertini-like model)
 - New two-body angular distributions for pi-N (1)
 - Parameter **tuning** (1)
 - Update and improvement of kaon physics (2)
- **BIC** (Binary Cascade model)
 - Add **coalescence** (2)
 - Investigate BIC for pi- **stopping** at rest and **gamma-nuclear** (2)
- **INCL++** (Liege intranuclear cascade model)
 - High-energy **extension** up to **12 GeV** (1 & 2)
 - Automatic physics testing (1)

Precompound / de-excitation models

- Design **code** review aimed to CPU & memory optimization (2)

Radioactive Decay model

- Refactoring and **code** improvements (2)
- Fix **reproducibility** problems in MT mode (1)
- **Validation** tests (2)

High-Precision (HP) neutron model

- Improve **MT-behaviour** of neutronHP (1)
- Add interpolation of cross sections following ENDF-6 (1)
- Merging **neutron_hp** and **particle_hp** (1 & 2)
- Further development of the new (Wendt) fission fragment model (1 & 2)
- Revision of the thermal transport energy processes and libraries (1 & 2)
- Extensive **validation** (1 & 2)
 - Cross section data libraries
 - Models

Elastic , Quasi-Elastic , Charge-Exchange models

- Development and validation of hadron **elastic** scattering (1)
- Code improvement of CHIPS-extracted **quasi-elastic** (2)
- Evaluate and eventually implement the **charge-exchange** process (2)

Cross Sections

- **Design and code** improvements of hadronic cross sections (1)
- **Complete test suite** (with data) for hadronic cross sections (1)
- **Validation of hadron elastic** cross sections (1)

PHYSICS LISTS

Physics Lists

- Inclusion of **muon-nuclear** interactions in physics lists (1)
- Revision of **hadron elastic** scattering treatment in physics lists (1 & 2)
- Development of a physics list for the **Intensity Frontier** experiments (1 & 2)
- Improvement in the **documentation** (1 & 2)
- Support for **factory** mechanism in **multi-threaded** mode (2)
- Deletion of **builders** in multi-threaded mode (2)
- Improved configuration of **Geant4-DNA** physics list (2+)

VALIDATION

Validation & Testing

- Continuous effort to **extend** and **improve** the tests (1 & 2)
- Improvement of **tools** for physics validation (1 & 2)
- Deployment of the new tools for testing of physics performance on the **Grid** (1 & 2)
- Further developments of the **FNAL Validation Framework** (1 & 2)