Geant4 Physics
Work Plan for 2015

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Outline

Summary of the program of work for 2015 for the following areas of Geant4, related to physics:

- Standard Electromagnetics Physics

- Low-Energy Electromagnetic Physics

- Hadronic Physics

- Physics Lists

Note: (1) means first semester
(i.e. to be included in June G4 10.2beta release)

(2) means second semester
(i.e. to be included in December G4 10.2 release)

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

STANDARD ELECTROMAGNETIC PHYSICS

Multiple and Single Scattering

- Review and fix the algorithm for displacement beyond boundary (1)

- Review and fix the **Goudsmit-Saunderson** model (1)

  - Potentially a more accurate and parameter-free model for low-energy (<= 100 MeV) electrons and positrons

- Improve the sampling of lateral displacement and backscattering (1)

- Single-scattering models for high-energy projectiles (2)

- Performance evaluation of the WentzelVI model with 2nd order corrections enabled (2)

Ionisation Processes

- Refinement of the **effective ion charge** approach (2+)

    - To be applicable simultaneously for both dense and low-density media (including vacuum)

- Alternative **ion ionisation** models for moderate energies (2+)

    - More accurate than Bethe-Bloch model for ~100 MeV/u heavy ions

Bremsstrahlung and Gamma Models

- Incorporation of positron annihilation into three gammas (2)

- Improve the parameterisation of the positron annihilation cross section in the Seltzer-Berger model (2+)

  - The current model is using a simplified non-relativistic correction factor for positrons

  - Likely relevant for ~1-30 MeV positrons

- Addition of radiative corrections to Compton scattering model (2+)

- Improve the e+e- pair-production by high-energy electrons and positrons (2+)

High-Energy Processes

- Use of rare processes for **muon backgrounds** for CLIC and FCC studies (1)/(2)

- Extension of the internal table grid for **muon-nuclear** interactions (1)/(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)

Infrastructure

- Improve the computation of the range and energy loss in G4EmCalculator (2)

LOW-ENERGY ELECTROMAGNETIC PHYSICS

Livermore Models

- Creation of a **sub-cutoff** producer (1)

    - Produce electrons below production threshold (*G4VSubCutProducer* interface)

- Modeling of **pair-production** in the electron field (2)

- Migration of Livermore electron ionisation (2+)

- Migration of polarized gamma models to the same software design as the non-polarized Livermore models (2+)

Penelope Models

- Update of physics processes (2)

Monash University Models

- Extension to G4LowEPComptonModel polarisation (2)

- Migration of Monash U. models to standard EM interfaces and tools (2+)

Atomic De-excitation

- Extension of M-shell ionization cross-section approximations for protons and alpha-particles up to **1.0 GeV** (2)

RBE (Relative Biological Effectiveness)

- RBE modules for biological damage computation (2)

MicroElec (micro-electronics) Models

- Update to more easily implement different materials (2+)

Geant4-DNA

- Cross-section models for other biological materials and incident particles (2+)

  - More than electrons, protons and a few ions on liquid water

HADRONIC PHYSICS

String Models

- **FTF** (Fritiof model)

  - Improvement of **Reggeon cascading** (1)

  - Validation & tuning of FTF for **ion-ion** interactions (1)/(2)

  - Tuning of FTF model for **p̲**-p, **p̲**-A and
    light antinucleus-nucleus interactions (1)/(2)

  - Tuning and validation of FTF model for **strange mesons**
    and **hyperons** production in p-p, p-A, p̲-p and p̲-A (1)/(2)

- **QGS** (Quark-Gluon-String model)

  - Revision, low-energy extension, improvement
    and tuning of QGS model (1)

Cascade Models

- **BERT** (Bertini-like model)

  - Use of **pre-compound** for de-excitation (1)

  - Extend kaon and hyperon final-state tables to 32 GeV and 9-body final states (2)

  - Redesign of secondary propagation using smooth 1D nuclear potential, with step-wise curved trajectories (2)

- **INCL++** (Liege intranuclear cascade model)

  - Improve high-energy reactions (2)

Precompound / De-excitation Models

- Revision of **photon evaporation** (1)

- Improve physics performance for **de-excitation** (1)/(2)

- Revision of **statistical break-up** (2)

Radioactive Decay Model

- Achieve event **reproducibility** for IT reactions (1)/(2)

- Extension to allow for the simulation of Super Heavy Elements (SHE) (1)/(2)

- Complete the **redesign** of the package (2)

- Addition of correlations for gamma emission (2)

High-Precision (HP) Neutron Model

- Merging of **neutron_hp** with **particle_hp** (1)/(2)

- Update to JEFF 3.2 and ENDF/B-VII.1 (1)/(2)

- G4LEND/GIDI : LLNL interface to low-energy nuclear data (1)/(2)

Elastic , Quasi-Elastic , Charge-exchange Models

- Tuning for elastic interactions of anti-protons and light anti-nuclei with protons and nuclei (1)/(2)

- Validation of neutron elastic scattering with TARC (1)/(2)

- Development and validation of low-energy neutron elastic scattering (2)

- Improve Chips-extracted quasi-elastic (2)

- Implementation of charge-exchange process (2+)

Cross Sections

- Inclusion of the fast hadronic cross-section system (1)/(2)

- Complete the **test suite** for hadronic cross sections (with data) (1)/(2)

Others

- New parameter set for QMD (1)

- Reduce memory footprint and churn for hadronic processes (1)/(2)

- Muon stopping and capture development and validation (1)/(2)

- Neutrinos: complete the Geant4 interface to GENIE (2)

*Note : in **examples/extended/hadronic/Hadr02***
      *we have dropped the support for the **DPMJET interface***
      - Old Fortran code with a number of limitations
      *- Not needed any longer: **FTF** can handle high-energy*
        nucleus-nucleus interactions

PHYSICS LISTS

Physics Lists

- Implementation of **generic user-extensible** physics list **factory** (1)/(2)

- Investigation on calorimeter effects of Bertini/Binary **rescattering**, and **Bertini + Precompound** (1)/(2)

- Support for factory mechanism in multi-threaded mode (2)

- Deletion of builders in multi-threaded mode (2)