

# **Geant4 Physics Work Plan for 2016**

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# Outline

Summary of the program of work for 2016 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 10.3.beta release)

(2) means second semester  
(i.e. to be included in December G4 10.3 release)

(\*) means may or may not be achieved in 2016

# STANDARD ELECTROMAGNETIC PHYSICS

# Multiple and Single Scattering

- Review and fix of the multiple scattering algorithm for displacement at the boundary (1)
- Updates of the Goudsmit-Saunderson msc model (1)
- Study the effect of high-energy radiative processes on muon scattering (1)
- Review of single scattering models for high-energy projectiles (2)
- Evaluation of WentzelVI msc model performance with 2nd order corrections enabled (2)

# Ionisation Processes

- Review of the model of sampling fluctuations for electrons and positrons (1)/(2)
- 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  $\sim 100$  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 bremsstrahlung model (2)/(\*)
  - The current model is using a simplified non-relativistic correction factor for positrons
  - Likely relevant for  $\sim 1\text{-}30$  MeV positrons
- Update of radiative corrections to Compton scattering model (2)/(\*)
- Improve the electron-positron pair-production by high-energy electrons and positrons (2)/(\*)

# High-Energy Processes

- Use of rare processes for muon background studies for CLIC and FCC studies (1)/(2)
- Extension of the internal table grid for muon-nuclear interactions (2)

# Optical Photon Processes

- Extension of 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 range and energy loss in G4EmCalculator (1)
- Introduction of C++11 features in the code (1)/(2)
- EM shower shape validation and improvement (1)/(2)

# LOW-ENERGY ELECTROMAGNETIC PHYSICS

# Livermore Models

- Upgrade of Livermore electron ionisation (2)
- Implementation of sub-cut producer (2)
  - Produce electrons below production threshold (G4VSubCutProducer interface)
- Finalize migration of the polarized gamma models to the same software design as the non-polarized Livermore models (2)
- Implementation of pair-production in the electron field (2)

# Penelope Models

- Update of physics processes (2)

# Monash University Models

- Complete re-calculation of atomic electron momentum PDFs and Compton profiles for elements from  $Z=1$  to  $Z=100$  (2)
- Implementation of a new low-energy photoelectric absorption model (2)

# Atomic De-excitation

- Extension of the M-shell ionization cross-section approximations for protons and alpha-particles up to 1.0 GeV (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
- New chemistry models (2)
- Updated LEPTS models (2)
  - Molecular-level interactions



# Others

- Approximate model for electron stopping for energies below 30 keV (2)

# HADRONIC PHYSICS

# String Models (1/2)

- **FTF** (Fritiof model)
  - Validation & tuning for nucleus-nucleus interactions (1)
  - Tuning to improve baryon spectra in proton-proton, antiproton-proton, proton-nucleus, antiproton-nucleus, and nucleus-nucleus interactions (1)/(2)
  - Tuning and validation for strange meson and hyperon production in nucleon-nucleon, and nucleon-nucleus interactions (1)/(2)
- **QGS** (Quark-Gluon-String model)
  - Tuning and improvement for hadron-nucleon and hadron-nucleus interactions (1)

# String Models (2/2)

- General
  - Code improvements of string models (1)/(2)
  - Hadronic shower effects of string models (1)/(2)
  - Development and validation of the low-mass diffraction dissociation model, and low-energy extension of hadron string models (1)/(2)

# Cascade Models

- **BERT** (Bertini-like model)
  - Parameter tuning (1)
  - Completion of kaon improvements (2)
- **INCL++** (Liege intranuclear cascade model)
  - Implementation of Eta and Omega production (1)/(2)

# PreCompound / De-excitation Models

- Migration of Fermi break-up, GEM, Evaporation, and PreCompound models to use the common data on nuclear levels (which also allows production of isomers) (1)
- Further tuning of de-excitation models (1)/(2)
- Revision of Fermi break-up (1)/(2)
- Inclusion of simulation of correlated gamma emissions (1)/(2)

# Radioactive Decay Model

- Extensions to allow the simulation of Super Heavy Elements (SHE) (1)
- Achieve event reproducibility for IT reactions (1)/(2)
- Inclusion of beta-delayed emissions of protons and neutrons (2)
- Make it easier the simulation of new level scheme, including E0 transitions and angular effects (2)

# High-Precision (HP) Models

- Inclusion of the interference term for charged particles in particleHP (1)/(2)
  - Interference between hadron elastic and Coulomb elastic
- Improvements in the treatment of inelastic reactions in C12 (1)/(2)
- Model low-energy ( $\sim$ meV) neutron scattering in both poly- and single-crystals (1)/(2)
- G4LEND/GIDI : further developments (1)/(2)



# Elastic , Quasi-Elastic , Charge-exchange Models

- Development and validation of hadron elastic scattering (1)/(2)
- Implementation of charge-exchange model (2)/(\*)

# Cross Sections

- Inclusion of fast hadronic cross-section system and its validation (1)/(2)
- Complete test suite for hadronic cross sections (with data) (1)/(2)

# Others

- Neutrinos: complete the Geant4 interface to GENIE (1)
- Investigation of problems in selection of elemental scatterings in QMD (1)/(2)
- Muon stopping code-factorization and introduction of muonic atoms (1)/(2)
- HIJING : updated version - which describes both RHIC and LHC nucleus-nucleus data - available in Geant4 through the interface: (1)/(2)  
**examples/extended/hadronic/Hadr02**

LPCC

# LPCC Detector Simulation Workshop

- We should start thinking & planning for the next LPCC Detector Simulation Workshop
  - When would it be more convenient for the experiments?
  - Topics:
    - Physics (EM & HAD) performance
    - Multi-threading and its integration in the experiment frameworks, CPU & memory performance, reproducibility
    - Fast simulation
    - ...