Patches 11.1.p01 & 11.0.p04, and 11.2 work-plan for the EM physics

V. Ivantchenko, CERN & Princeton University

for the Geant4 Collaboration

6 April 2023

Outline

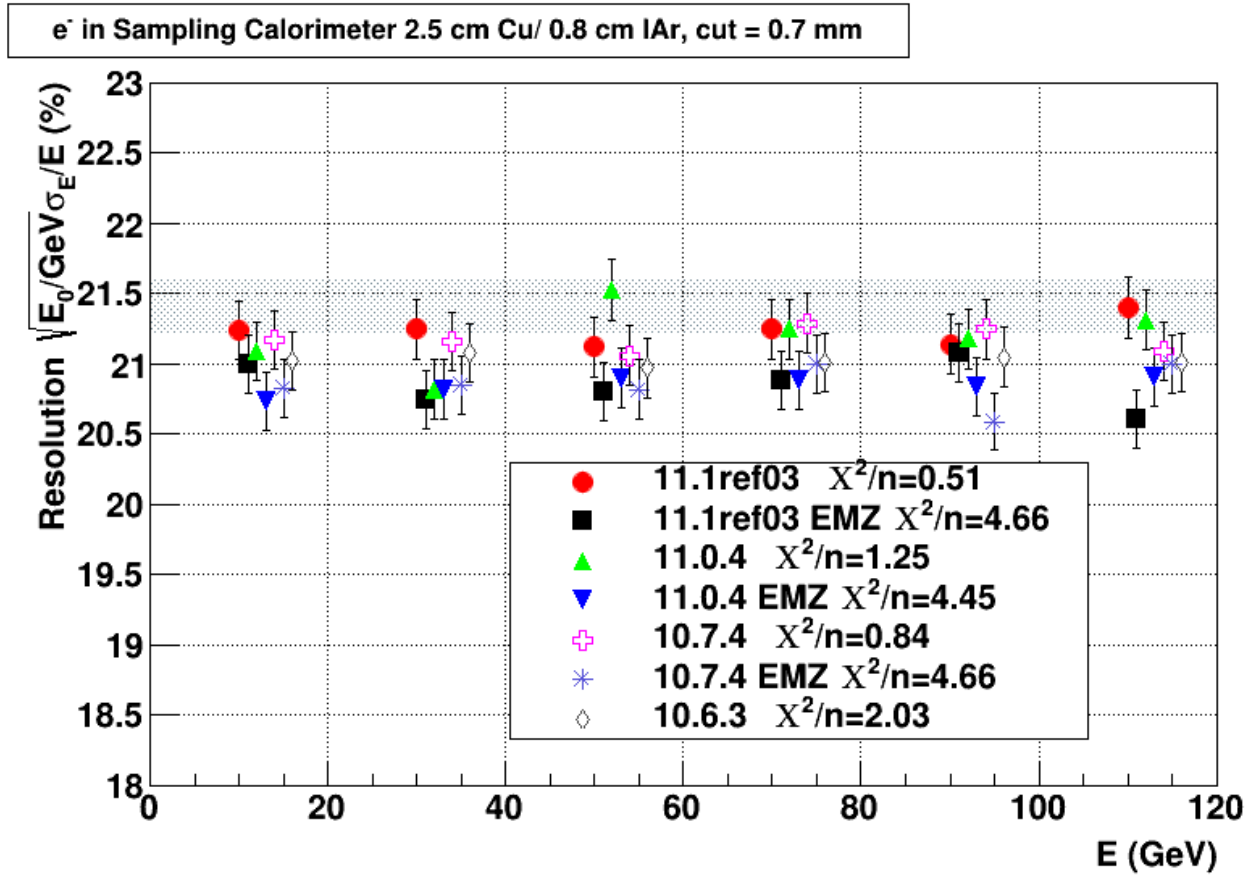
- Modifications in EM for 11.0.p04
- Modifications in EM for 11.1.p01
- 2023 plan of work for Geant4 EM physics
- Conclusion remarks

Modifications in EM for 11.0.p04

- G4WentzelOKandVIxSection
  - fixed initialisation for pure single scattering
  - fixed numerical instability for very low cut (< 1eV)

Modifications in EM for 11.1.p01

- Fix #2520 for materials – allowing recursive search for a base material
- Added extra flag Get/Set method and UI command for positron correction in G4UrbanMscModel (ATLAS request)
- Fix #2521 – in gamma general process always select a process in PostStepDoIt(..)
- Fix #2523 – updated list of processes for physics list helper
  - Forgotten muon pair production by muon and general processes



2023 plan of work for Geant4 EM physics

- (1) - June 2023
- (2) - December 2023
- (.) - manpower is not identified

Infrastructure and general support for EM physics

- Conduct regular execution and regression analysis using the existing testing suites (1/2)
- Maintenance of EM libraries (1/2)
- Reduce number of calls to environment variables (1)
- Apply clang-tidy and clang-format to EM classes (1)
- Extend functionality of combined processes - gamma general, Woodcock tracking, electron general, transportation with multiple scattering (1/2)
- Evaluate possibility for user to define production thresholds instead of cut in range - ALICE request (1)

Extended functionality of G4HepEm package

- Refactor some of the data structures in G4HepEm, especially the macroscopic cross sections: move from plain arrays to more structured data (1)
- Configuration per detector region: e.g. provide the possibility to use different MSC stepping in different detector regions (as used by CMS) (1/2)
- Add the missing gamma- and lepto-nuclear cross section and implement connection layer for tracks from G4HepEm to native Geant4 tracking for sampling of final state of nuclear processes (1/2)
- Implement the “general process”-like handling of the macroscopic cross sections (1/2)
- Implement the possibility of Woodcock tracking of gamma per region (1/2)
- Extend and optimize tracking algorithms per particle type (1/2)
- Validate developed library for ATLAS and CMS (1/2)
- Maintain the entire physics on GPU for AdePT GPU based EM shower simulation R&D project (1/2)

Developments for LHC and other HEP experiments

- Further development on EM models for beam transport and interactions in bending crystals (1/2)
- Develop methods for simulation of inverse Compton scattering (2)
- Provide an option to use EPICS-2017 data for standard gamma processes (1)
- Further development and validation of polarized EM models (1/2)
- Introduce bremsstrahlung on atomic electrons at high and moderate energies with triplet production (.)
- Migrate polarisation example to the MT mode (.)

Updates of low-energy EM models

- Using EPICS2017 cross section in G4LowEPComptonModel, improve description of Compton profile (1/2)
- Provide ionization cross-sections for 0.1 to 100 MeV for Li, C and O ions based on ECPSSR (2)
- Deployment of the model of three gamma annihilation (2)
- Maintenance of ANSTO PIXE data (1/2)
- Improve implementation of MicroElec models for electrons, protons, and ions and extend list of materials (1/2)
- Extend validation of MicroElec models, addition of a new example to study depth dose profile and another example for SEU simulation (1/2)
- Evaluate rare isotope EM interactions with matter and polarization effects (1/2)

G4-Med developments

- Validation of EM and hadronic models for medical applications (1/2)
- Extend the study on the effect of step size and cut limits to simulation at sub-micron volumes (1/2)

Optical photon and X-ray physics

- Maitenence and optimisation of optical classes (1/2)
- Continue integration of Opticks package, provide example of optical processes implemented on GPU and other processes at CPU (1/2)
- Implement X-ray refraction and reflection (2)

DNA physics and chemistry developments

- Improve DNA physics models for ions (1)
- Implement and validat electron physics models in dexorybose and phosphate below 1 MeV (1/2)
- Extension of validation of DNA physics and chemistry (1/2)
- Further development of multi-scale platfom for DNA physics and chemistry (1/2)
- Extension and benchmarking of electron models based on dielectric response function up to 10 MeV (1/2)
- Develop Geant4-DNA model for electron interactions in atmosphere (1/2)
- Development of electron models for propane (1/2)
- Validation of human normal and malignant cell irradiation with ion species for estimation of RBE dependence on LET and evaluation of DSB as a function of post-irradiation time (1/2)
- Implement a new model for the Gold target (1/2)

Conclusion remarks

- For EM physics Geant4 series 11.X started from general clean-up and reorganization of classes
  - Geant4 11.1 includes number of fixes of problems which were introduced in EM libraries during this migration
  - For coming 11.2 we not plan any reorganizations of EM libraries
  - Our focus on bug fix and new models/features development
- Special attention to development of G4HepEm external sub-library and to R&D efforts
  - ATLAS and CMS may benefit of using G4HepEm at CPU
  - For R&D projects Adept and Celeritas to implement EM simulation at GPU