Highlights of version 10.3 – EM physics part

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Outline

- List of modifications
  - EM standard sub-libraries
  - EM lowenergy sub-libraries
  - Technical improvements and fixes
- EM parameters
- EM physics constructors
- Some validation results

Hightlihgts for EM standard sub-libraries

- Completed migration of EM parameters management via G4EmParameters class
  - Essential for configuration of EM physics in MT mode
- The default upper energy of EM physics 100 TeV
  - Needed for FCC design study
  - Can be changed via G4EmParameters interface or via UI
- Ionisation:
  - ASTAR, PSTAR and other ionisation data structures now use float static data shared between threads
  - G4UniversalFluctuations – small fix for Glandz part
- Bremsstrahlung:
  - G4eBremsstrahlungRelModel – improved LPM effect treatments
  - G4SeltzerBergerModel – fixed for Z > 92
- New process is added of e+e- pair creation by e+ and e-
- Multiple scattering – moved final position change from PostStep to AlongStep
  - Before sampling was done AlongStep but position was changed only PostStep
- G4UrbanMscModel – a new algorithm for sampling of lateral displacement is added.
  - Providing similar results as GS and WVI models
  - Added to Opt3, Opt4, Livermore and Penelope Physics Lists
- Three different parameterisations of nuclear formfactors
  - Used by single scattering models
- Fixed correlations of linear polarizations of gamma from two gamma annihilation
- Polarisation sub-library:
  - Fixed long standing problem of computation of number of interaction length when a particle penetrates via boundary

Highlights for EM low-energy sub-libraries

- Atomic de-excitation
  - Fixed initialisation/activation per G4Region
  - fluorescence and Auger cascade are now activated by default in all Geant4-DNA constructors.
- MicroElec models for Silicon
  - acceleration of single elastic scattering for electrons.
- Fixed several DNA classes, including G4ITNavigator, G4MolecularCounter and G4DNATransformElectronModel
- G4EmDNAPhysicsActivator is a new class for easier Geant4-DNA physics models configuration per particle type. The « dnaphysics » example illustrates its usage.
- Provided a new example application (« chem4 ») for the simulation of radiochemical yields for water radiolysis simulation and benchmarking.
- Published a usage review on Geant4-DNA (Phys. Med. 32 (2016) 1187-1200)

Technical improvements and fixes

- Elements of C++11 features and keywords are added to all EM sub-libraries:
  - nullptr, explicit, override, delete, final
  - internal data are now 'const static' or 'constexpr'
  - some usage of of other C++11 features
- Fixed few cases of data race at initialisation in MT mode
  - Significant modifications for G4EmSaturation to make it thread safe
- Fixed bugs #1870, #1874, #1876
- Data set G4EMLOW-6.50 is required

Electromagnetic parameters

- In previous versions of Geant4 EM parameters were defined via UI commands and C++ interface G4EmProcessOptions
  - Via this class each EM process was accessed one by one in order to set parameter value
- After Geant4 10.0 we faced some limitation in MT mode and decided to switch to G4EmParameters class, which requires a reorganization of initialization for EM processes/models:
  - All EM classes at initialization read parameters from G4EmParameters
  - Now UI command order become not so important as before
    - Commands should be issued in the PreInit state from the master thread
    - For the concequtive runs commands may be issued in the Idle state
  - Information on set of EM parameters for the run is available via Dump() method
  - G4EmProcessOptions class is still exist but we recommend do not use it anymore

EM physics configuration

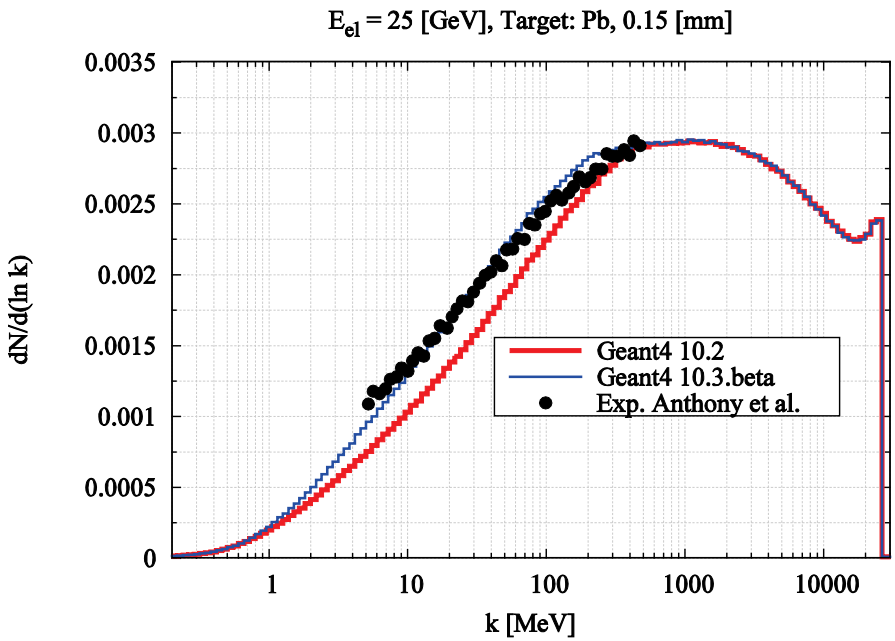
- There are many various Geant4 applications where of top of reference EM constructors a user needs
  - Different models for G4Region
  - Different model options for G4Region
- Until 10.2 such customization were possible only by an expert user but was problematic even for top experts
- For 10.2 we provide new UI commands:
  - /process/em/AddPAIREgion all myregion pai
  - /process/em/AddMicroElecRegion myregion
  - /process/em/AddDNARegion myregion DNA_Opt0
- For 10.3 we provide a new UI command:
  - /process/em/AddEmRegion myregion myphys
  - Here 'myphys' is the name of Physics constructor (for example, G4EmStandard_Opt3)
- This is not exactly PhysicsList per G4Region:
  - By this new command we do not fully emulate Opt0, Opt1.. But mainly multiple scattering models and their parameters and parameters of atom de-excitation

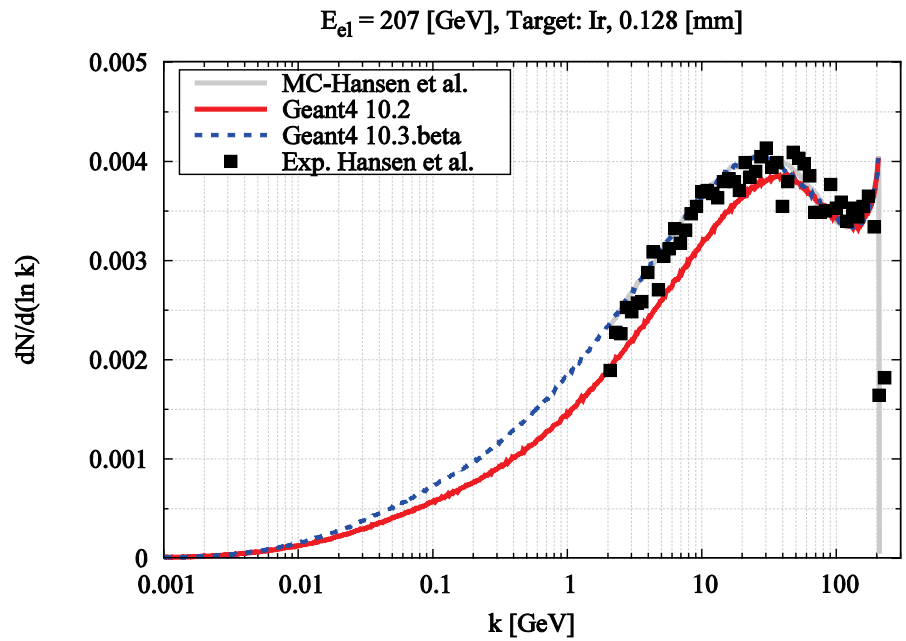
Some validation results

Full set of EM validation suite url:

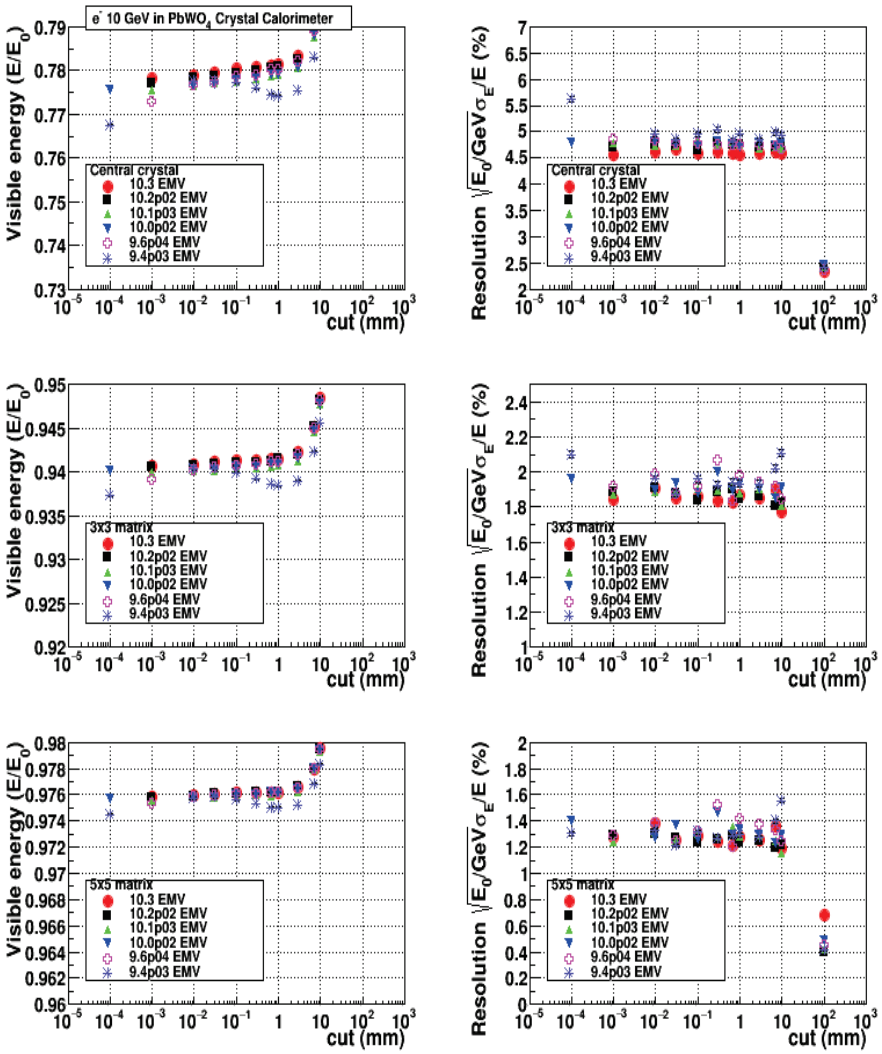
http://vnivanch.web.cern.ch/vnivanch/verification/verification/electromagnetic/

Bremsstrahlung: improved implementation of the LPM effect

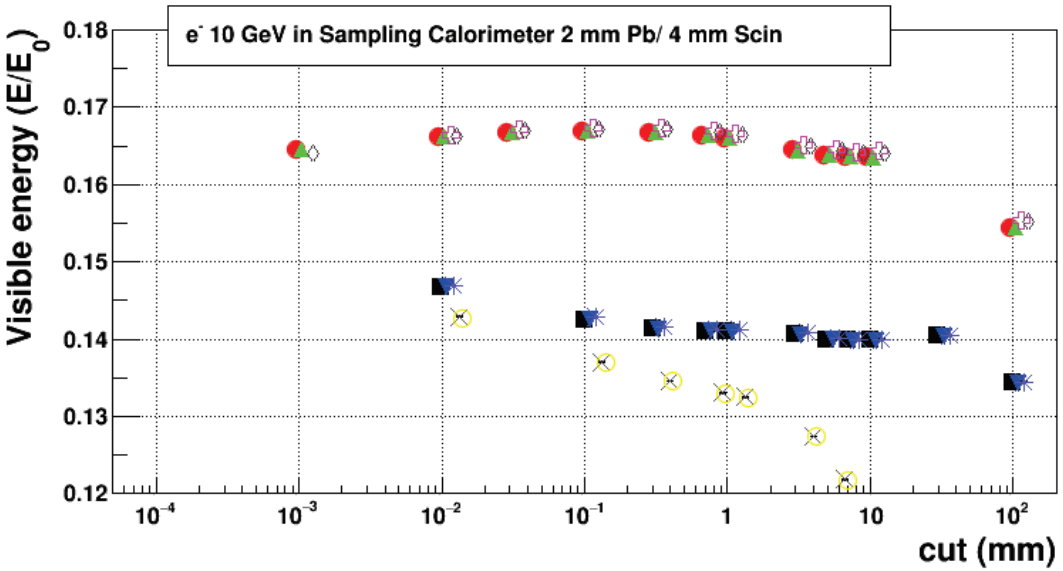


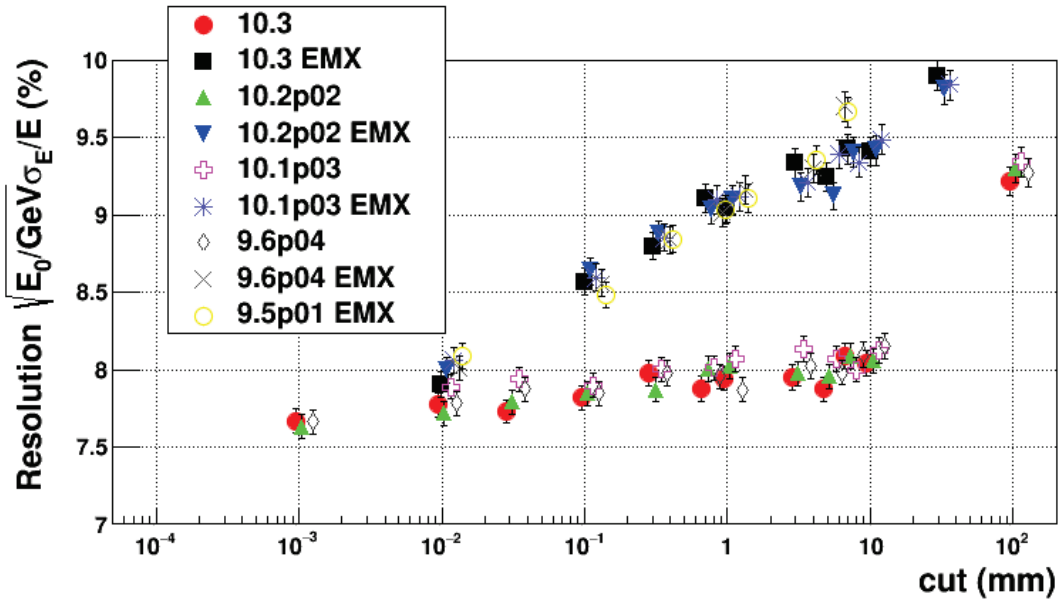


Simplified CMS-type crystal calorimeters



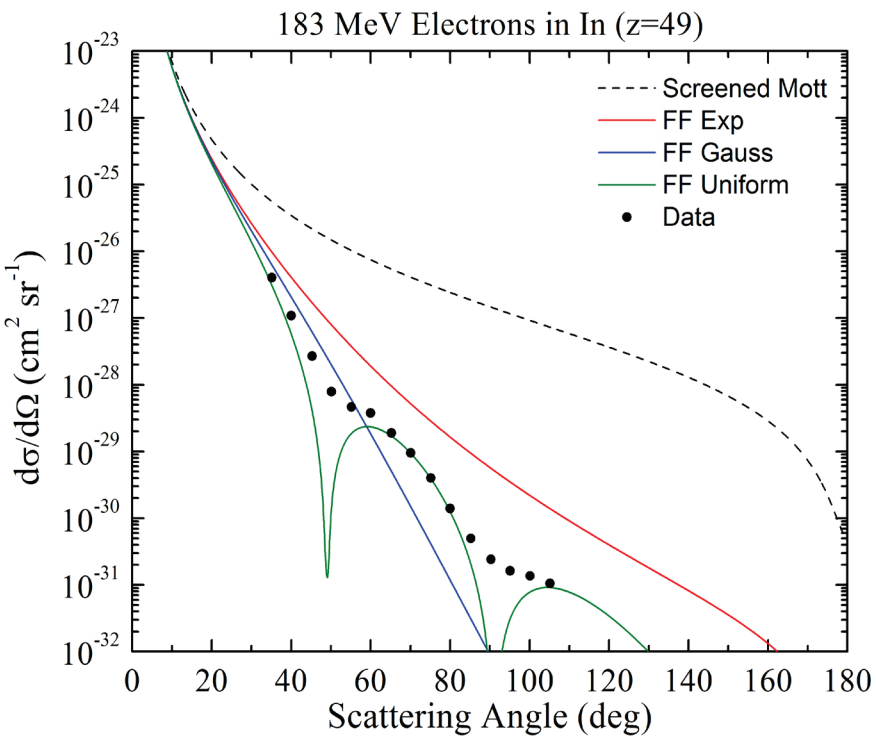
- Modification of LPM effect implementation provides modification of EM shower shape:
  - Energy deposition is larger inside central crystal of the 5x5 matrix on per mille level
  - No change is expected for R_9 parameter (E_{3x3}/E_{5x5})





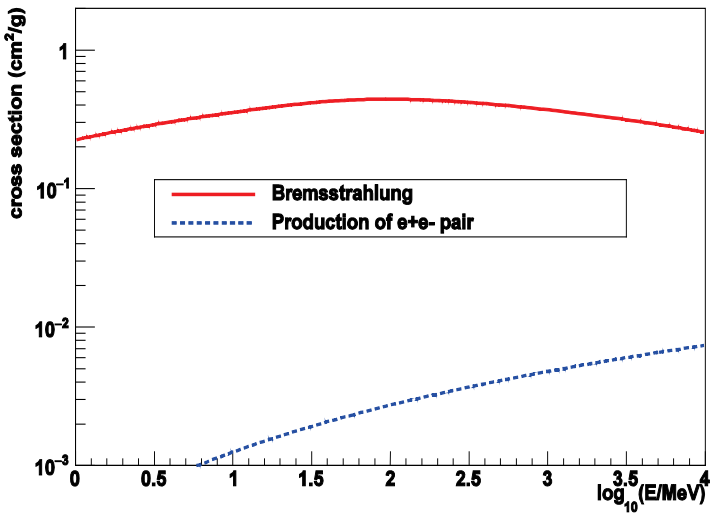
Response and resolution of Lead-Scintillator sampling calorimeter is stable

Nuclear form-factors



- Effects of different parameterisation of nuclear formfactors can be seen in high precision scattering experiments
  - This developments main be relevant to very high energy simulations

Cross section of e+e- pair production



- In this plot partial cross sections are shown for energy transfer > 10 MeV
- The cross section of e+e- pair production is significantly lower than bremsstrahlung
- This new process is not important for simulation of EM shower shape but may be a background in an experiment for a dark matter search
- This new process is included in Opt3 and Opt4 Physics Lists