



PRINCETON
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Status of 11.1 developments: Electromagnetic physics part

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Updates for materials

- Problems #2346, #2474, #2486 are fixed
 - handling of complex materials and parameterization of density effect correction
- Mean ionization potential for carbon is changed from 81 to 78 eV
 - Choice what NIST data to take
- G4MaterialPropertyVector, G4OpticalMaterialProperties:
 - Insist material property vectors are in increasing order of energy (PR #42);
 - default verbosity=1 as everywhere in Geant4 physics
- G4DensityEffectData:
 - Matthew Strait fix typos in the density effect data table (#2423) for 8 materials, the most significant fix for G4_Tm, small for G4_Be, G4_Mg, G4_Fe, and G4_Y.

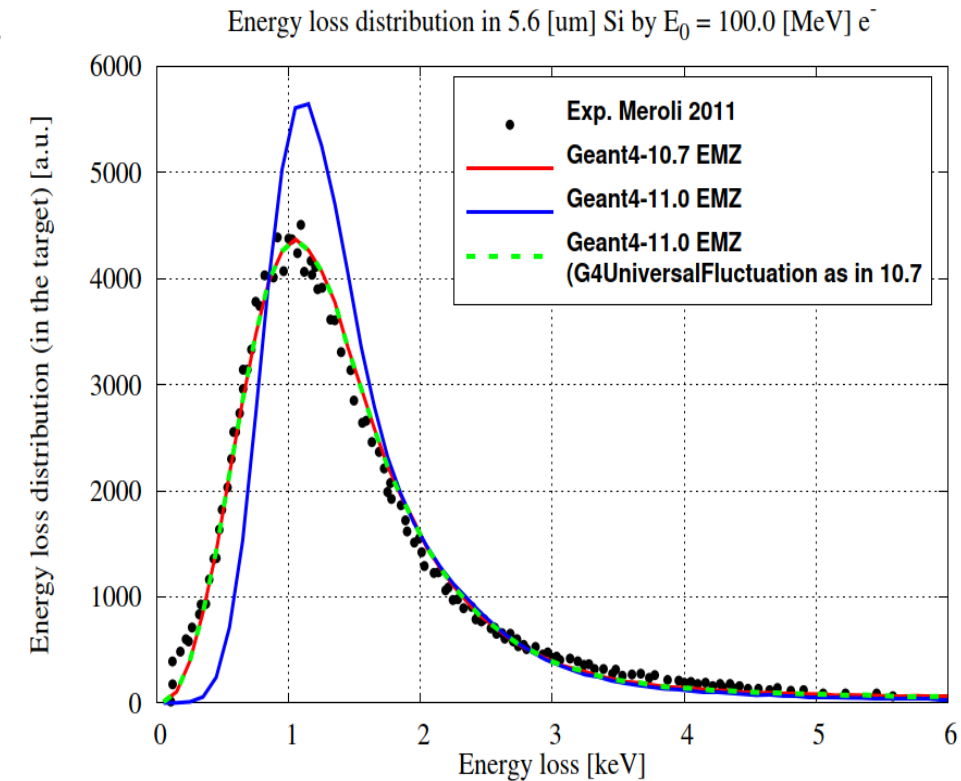
Updates in base EM classes inside electromagnetic/utils

- **G4VEmProcess, G4VEnergyLossProcess, G4VMultipleScattering:**
 - Moved general part of initialisation to G4EmTableUtil and G4EmUtility
 - 27-30% class length reduction – easier to navigate inside classes
 - Implement integral method for cross sections without precomputed tables
- **Physics improvements**
 - Using new utilities implemented general selection of G4Element and G4Isotope for all EM models
 - Added new UI command and C++ interface to define type of fluctuation model in all physics lists
 - G4UniversalFluctuation and G4IonFluctuations (for ions) are the default
 - G4UrbanFluctuation and G4LossFluctuationDummy are alternatives
 - Change the default Livermore DB from EPDL97 to EPICS2017
 - Removed dependence on G4magneticfield
- **Fixed problems:**
 - #2495 – definition of StepFunction for ions, which is important for low-energy applications
 - #2492 – fixed typo in the messenger
 - #2480 – energy shift in CMS HCAL due to multiple scattering
 - Fixed pointer to fluctuation model if a model is added for G4Region
 - Fixed typo in bremsstrahlung model name in the model catalogue

Updates in standard EM processes/models electromagnetic/standard

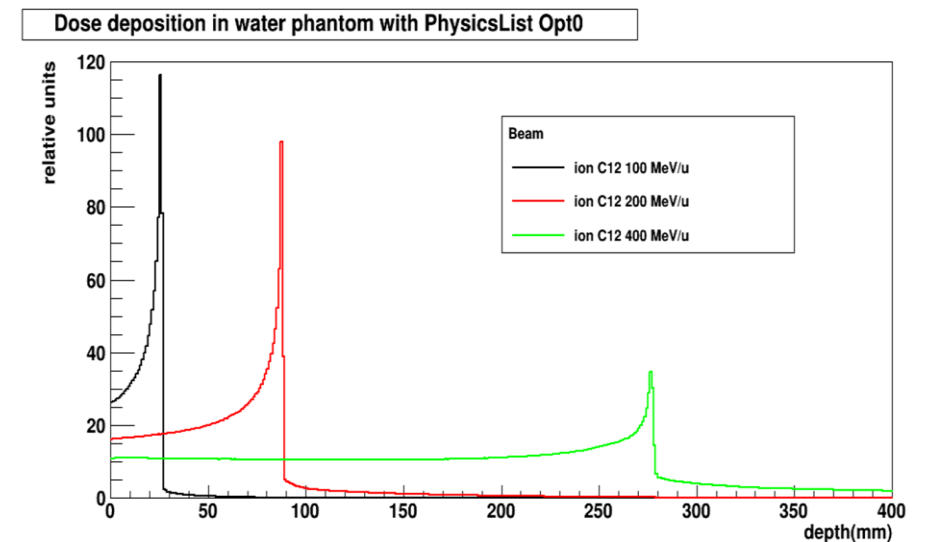
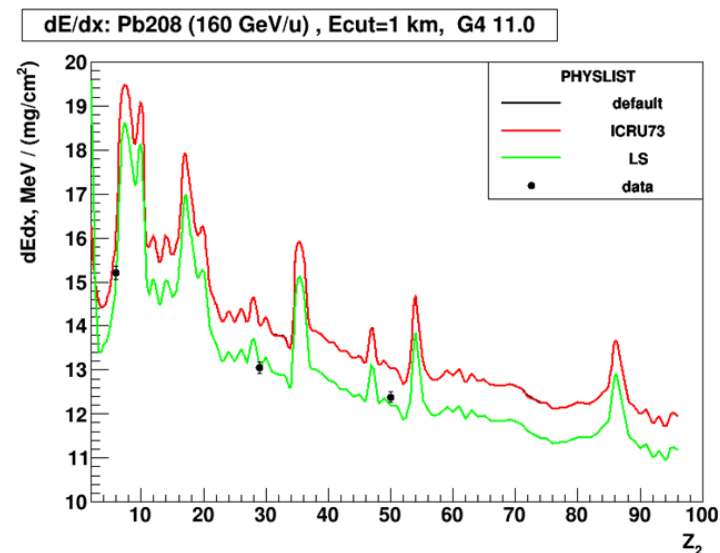
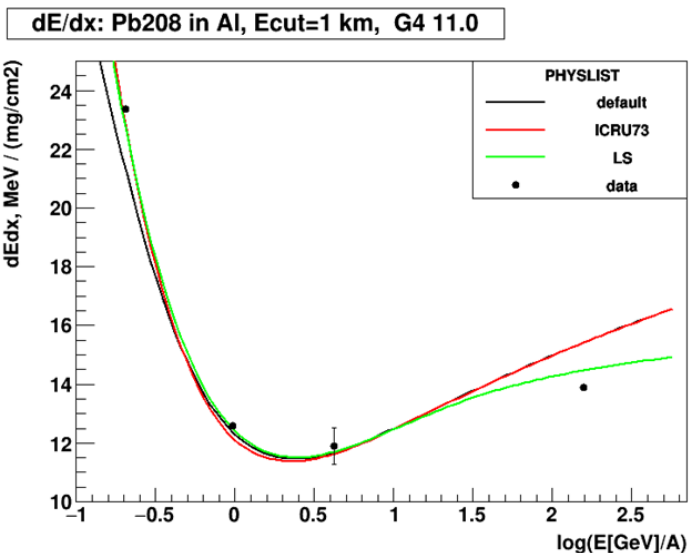
- Review was done of all processes and helper classes
 - Linear interpolation of tables are used for smooth cross sections
- Introduced choice of model of fluctuations (fix #2466)
 - **G4UniversalFluctuation** – default fast
 - **G4UrbanFluctuation** – most accurate model
 - **G4IonFluctuations**
 - **G4LossFluctuationDummy**
 - Now an external model of fluctuation may be used
- **G4UrbanMscModel** – technical improvements
 - Extended precomputed data structure
 - Reduced number of instructions
 - Laszlo Urban has prepared updates with modification of few parameters
 - Not yet integrated and may be left for the next year

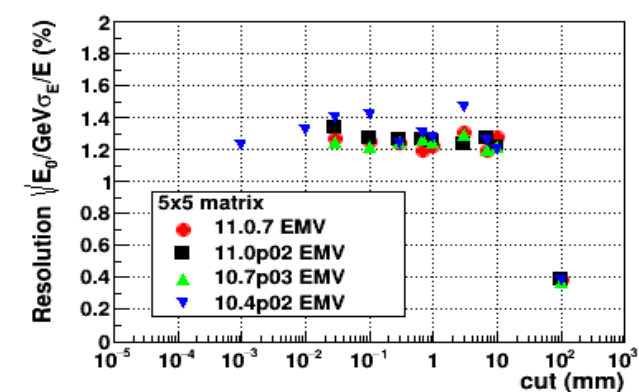
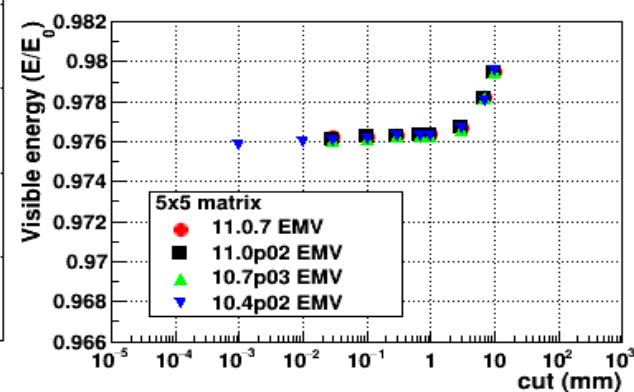
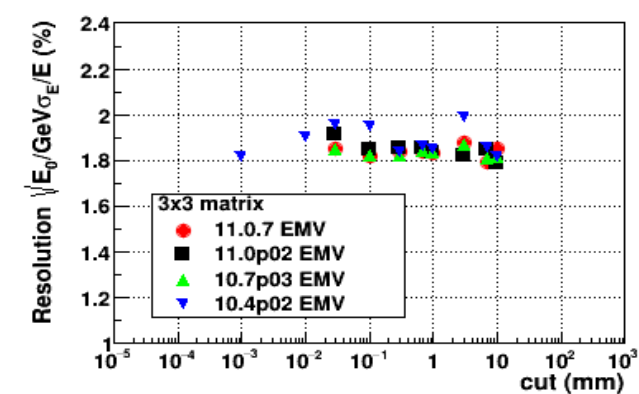
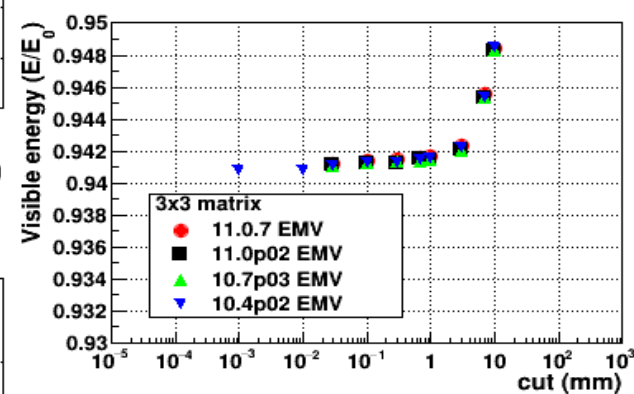
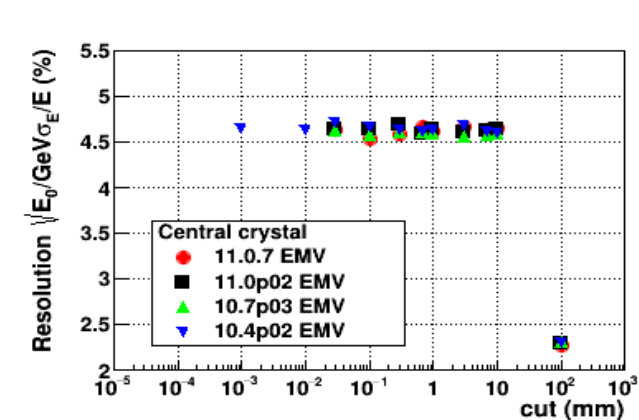
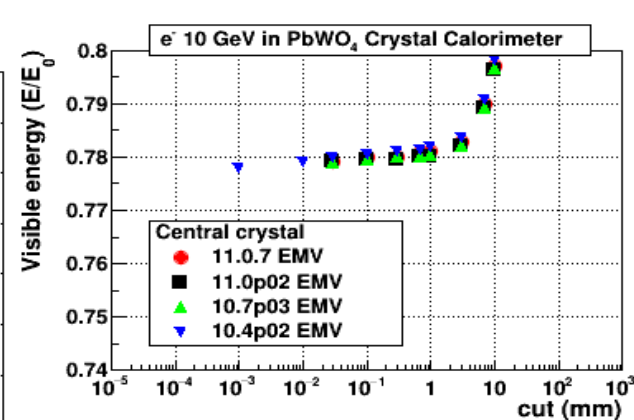
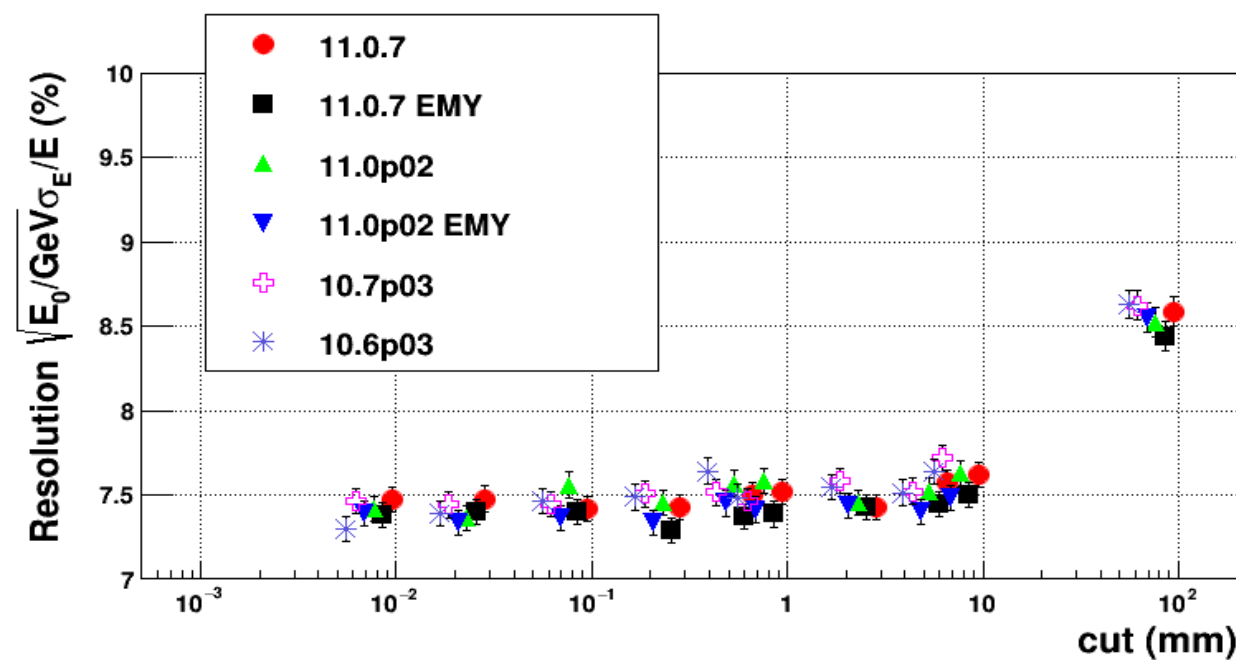
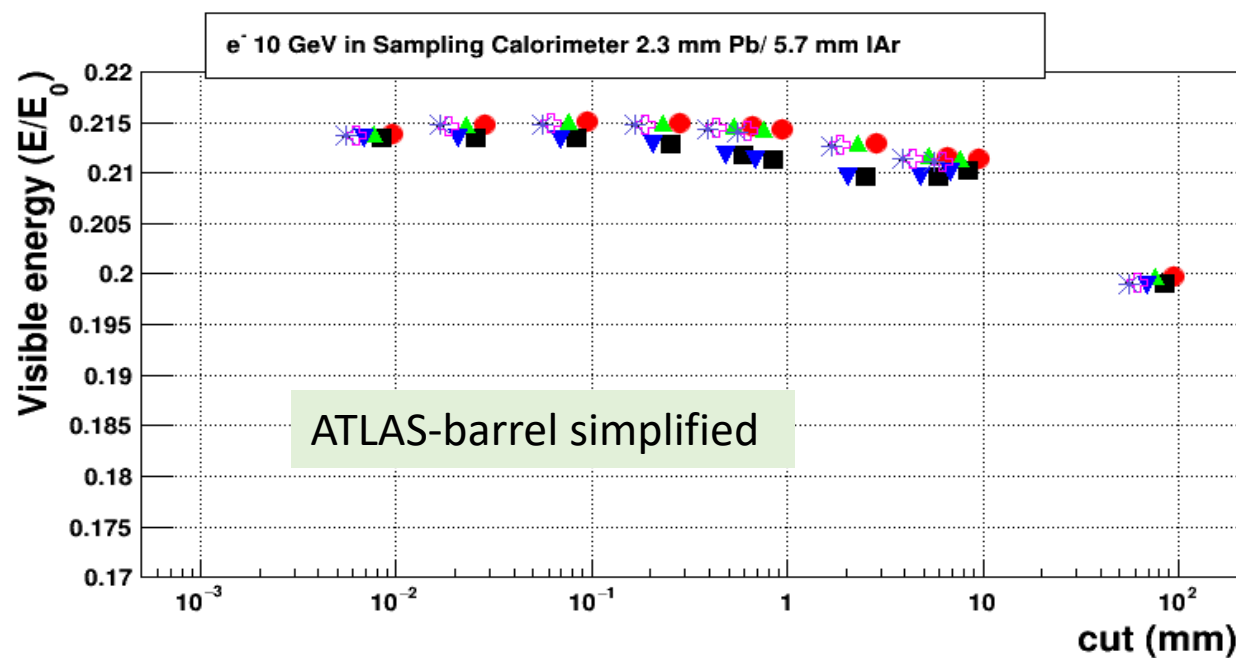
M. Novak



Lindhard-Sorensen ion ionization model

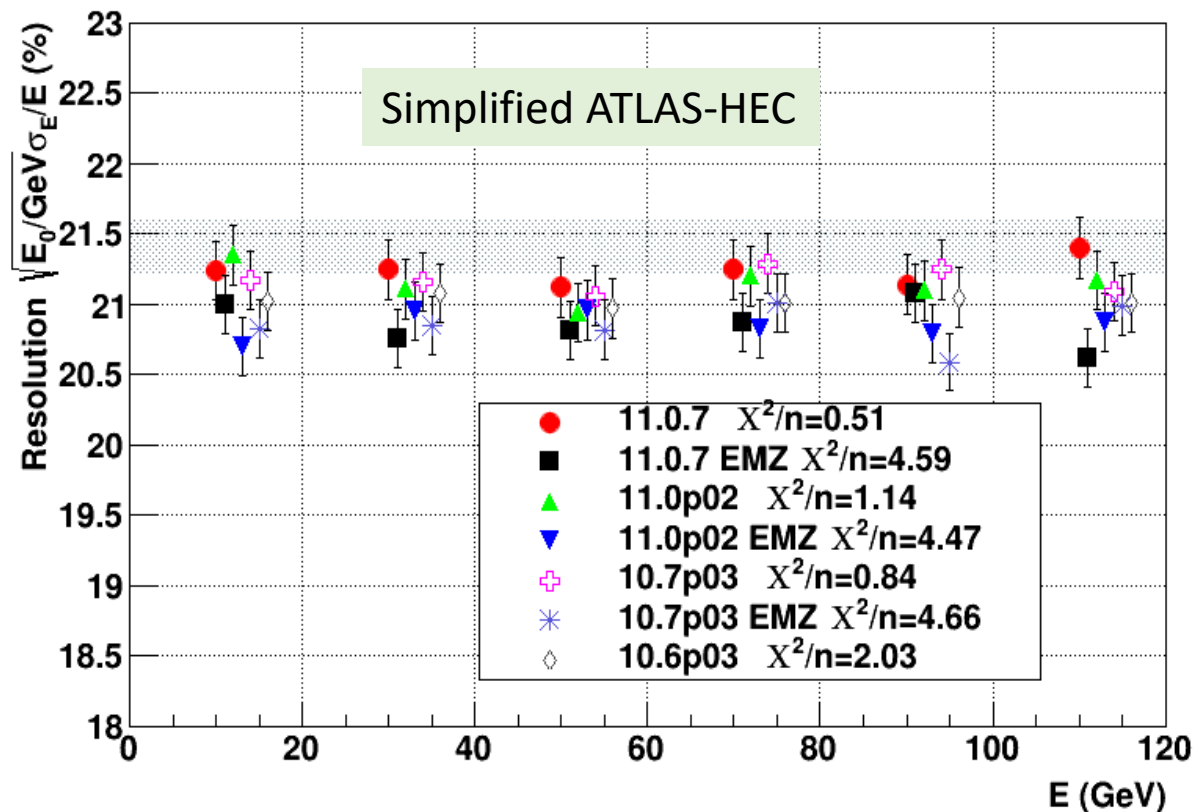
- G4LindhardSorensenIonModel is a combined models for the full energy range
 - Lindhard-Sorensen model above (*J. Lindhard & A.H. Sorensen, Phys. Rev. A 53 (1996) 2443-2455*)
 - Data are shared between threads, optimization of data access
 - Is significantly faster than the old G4ParametrizedIonModel, which were used in medical applications but includes extended data
 - ICRU73 and ICRU90 data at low energy below 2 MeV/amu
 - Model is working and reproducing ion Bragg peak



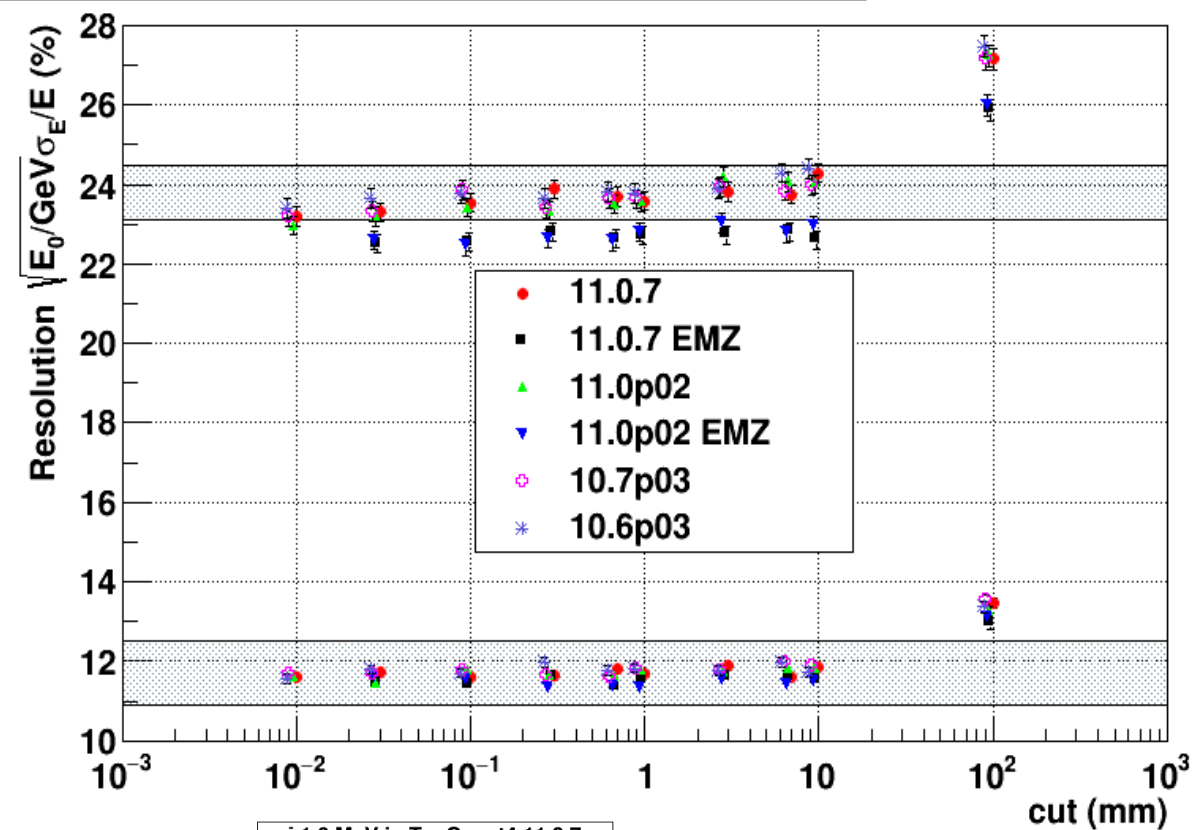


CMS ECAL simplified

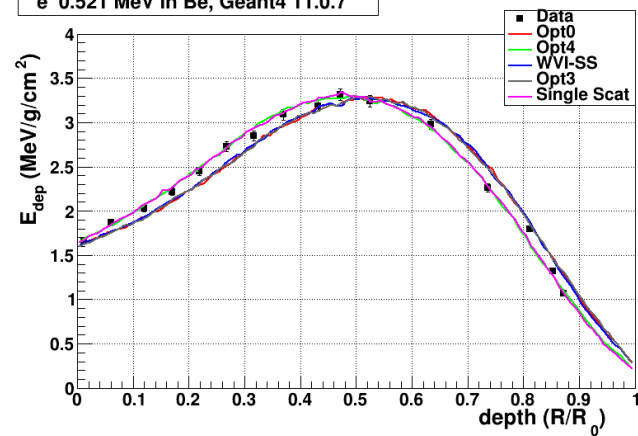
e^- in Sampling Calorimeter 2.5 cm Cu/ 0.8 cm IAr, cut = 0.7 mm



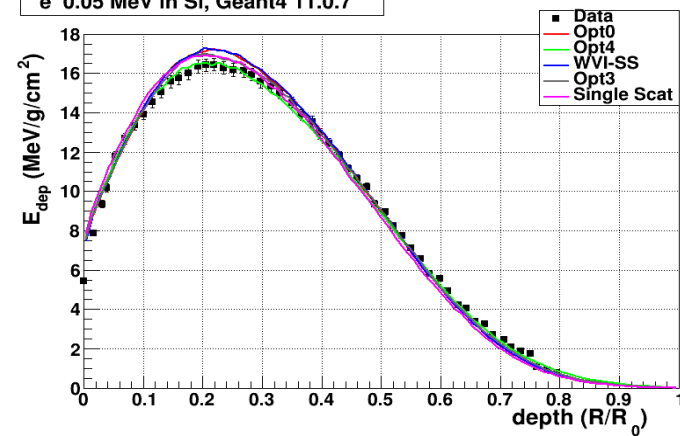
e^- 10 GeV in Pb/Scin Sampling Calorimeters



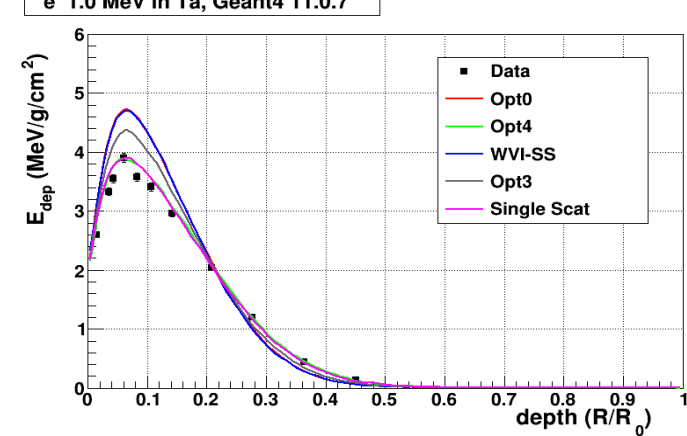
e^- 0.521 MeV in Be, Geant4 11.0.7



e^- 0.05 MeV in Si, Geant4 11.0.7

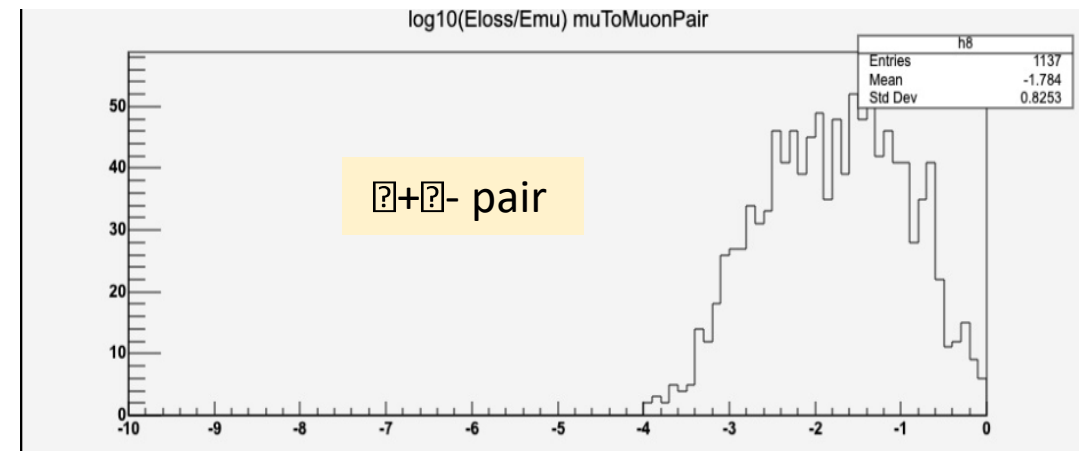
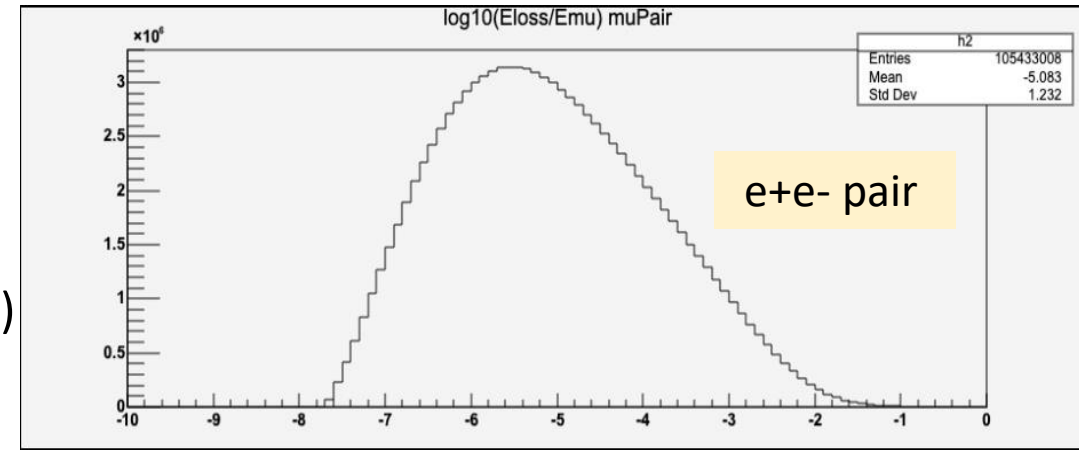


e^- 1.0 MeV in Ta, Geant4 11.0.7



Updates in muons processes/models electromagnetic/muons

- Review was done of all processes
 - Linear interpolation of tables are used for smooth cross sections
- Reduced low-energy limits
 - **G4MuBetheBlochModel** – down to 0.2 MeV (was 100 MeV)
 - **G4MuBremsstrahlungModel** – down to 100 MeV (was 1 GeV)
 - **G4MuPairProductionModel** – down to 850 MeV (was 1 GeV)
- New process/model (CERN summer student S. Yajaman)
 - **G4MuonToMuonPairProduction**
 - **G4MuonToMuonPairProductionModel**
 - Cross section is $\sim 10^{-5}$ of e^+e^- pair production
 - Spectrum of muons is much harder
 - High energy muon pair may be produced by energetic muon is a calorimeter



New approaches for EM physics

- **G4GammaGeneralProcess**
 - Adopted both by ATLAS and CMS
 - Is current Geant4 default
 - fixed problem of sampling of the Compton scattering below 150 keV
 - Use spline interpolation of x-section tables below 150 keV and above 100 MeV
 - Woodcock tracking for gamma is currently implemented for ATLAS
 - Inherit of G4GammaGeneralProcess
 - Allowed gamma not to stop at boundaries between volumes inside ATLAS EMEC
- **G4TransportationWithMSC (J. Hahnfeld)**
 - New combined process
 - User may enable this process via UI command and/or C++ interface
 - Cannot work with G4CoupleTransportation
- **G4HepEM (J. Hahnfeld, B. Morgan, M. Novak)**
 - Alternative EM physics library in progress
 - 1st release is expected soon

Modifications in EM physics for 11.1

- **G4EmStandardPhysics**
 - Gamma general process
 - G4UrbanFluctuation
- **G4EmStandardPhysics_option1**
 - G4TransportationWithMsc
- **G4EmStandardPhysics_option3**
 - Gamma general process
 - G4UrbanFluctuation
 - G4LindhardSorensen ion ionisation model
 - MSC RangeFactor=0.03
- **G4EmStandardPhysics_option4**
 - Gamma general process
 - Penelope (instead of Livermore) ionisation for e- below 100 keV
 - G4UrbanFluctuation
 - G4LindhardSorensen ion ionisation model
- **G4EmLivermorePhysics**
 - G4UrbanFluctuation
 - G4LindhardSorensen ion ionisation model
 - EPICS2017 gamma cross sections
- **G4EmPenelopePhysics**
 - G4UrbanFluctuation
 - G4LindhardSorensen ion ionisation model

Summary

- Active developments were carried out in different EM physics domains
 - Improved code quality
 - Improvement of CPU efficiency for HEP applications
 - New model of muon pair production by muons
 - Addition of new models for DNA physics and chemistry
 - Improved Physics List configurations
- Recommendation for users
 - Geant4 11.0p03 or 11.1beta should be used for EM physics instead of earlier versions of 11.X release series
- Geant4 11.1 is in general in a good shape