



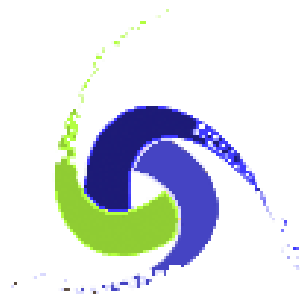
What's new in 10.7

Electromagnetic physics part

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for the Geant4 Collaboration

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GEANT4
A SIMULATION TOOLKIT

Outline

- List of important modifications for EM physics in Geant4 10.7
- Selected validation results

- EM developments for Geant4 10.7 was focused on:
 - Technical improvements of code
 - CPU performance for HEP applications
 - New features for medical and low-energy applications
 - Extension of capabilities for optical photon transport

Materials

- Added two new methods (ATLAS request):
 - void AddElementByNumberOfAtoms(G4Element* elm, G4int nAtoms)
 - void AddElementByMassFraction(G4Element* elm, G4double frac)
 - We recommend using them instead of AddElement(...)
- Updated G4MaterialPropertiesTable:
 - added new properties for scintillation allowing 3 time constants
 - added new properties for allowing a second wavelength shifter in the same material
 - added new methods to access/add properties with G4String and std::vector
 - added method G4bool ConstPropertyExists(G4int)
- G4OpticalSurface:
 - store REALSURFACE optical data files zlib-compressed

EM physics for HEP

- **Urban multiple scattering:**
 - Tuned parameterization of maximal step limit
- **G4UniversalFluctuation:**
 - Optimized two internal parameters of the model
- **G4eDPWACoulombScatteringModel:**
 - A new class that implements single Coulomb scattering model for e-/e+ based on the numerical DCS provided by Dirac Partial Wave Analysis using ELSEPA
- **G4ModifiedMephi:**
 - new angular generator for muon/hadron bremsstrahlung
- **G4MuPairProductionModel, G4MuBremmstrahlungModel:**
 - sampling of angles of secondaries using G4ModifiedMephi
 - Implemented check on energy transfer and if beyond the threshold, kill primary particle and add it to the list of secondary particles
 - Improved initialization for pair production model and allowed restore double differential tables from G4LEDATA
 - These new features also available for hadron bremsstrahlung and pair production
- **Added new advanced example HGCal_testbeam**
 - based on https://github.com/ThorbenQuast/HGCal_TB_Geant4

EM physics for medical and other low-energy applications

- Added two extra sets of StepFunction:
 - For light ions and generic ions
 - Allowing fine tuning of simulation parameters for hadron/ion therapy using UI commands
- G4eeToTwoGammaModel:
 - introduce thermal model of positronium decay to two gammas, when the positronium acquires a mean kinetic energy on formation, which contributes to a small non-collinearity of the gammas, detectable and significant in PET. To activate this material property should be defined:
 - `material->GetIonisation()->SetMeanEnergyPerIonPair(meanKE)`
- G4LivermoreGammaConversion5DModel - new model
- Technical clean-up of Penelope and Livermore models
 - Use G4Log, GetZasInt(), C++11 keywords
- Updated JAEA models for gamma scattering:
 - Updated data format
 - Added data for polarized scattering
- Added set of the new MicroElec models, which can be applied not only to Silicon but also to several other materials
 - Work in progress

DNA Physics and Chemistry

- Added classes for IRT (Independent Reaction Time method) simulation of chemical phase
 - Alternative to step-by-step method
 - G4ITReaction, G4ITModelProcessor ...
- Extended description of molecules for DNA models:
 - Added features in G4DNAMolecularReactionTable
 - Added molecules of Plante et al. (2017) (Oxygen, O2, O3, HO2)
- G4DNAMolecularMaterial:
 - Extended and fix a problem at destruction
- New extended example chem6:
 - Demonstrates scoring of the radiochemical yield G defined as a function of time and LET
 - The example uses the IRT approach by default.

Simulation of Optical Photons

- **G4OpBoundaryProcess:**
 - increase geometry tolerance to kCarTolerance
- **G4OpWLS2:**
 - added second wavelength shifting process
- **G4OpticalParameters:**
 - new class to control parameters used in:
 - G4OpRayleigh, G4OpAbsorption, G4OpMieHG, G4OpWLS, G4OpWLS2
- **PDG code = -22 for optical photons (was 0 before)**
 - Useful for tracking and may be used in user actions

EM Physics Lists

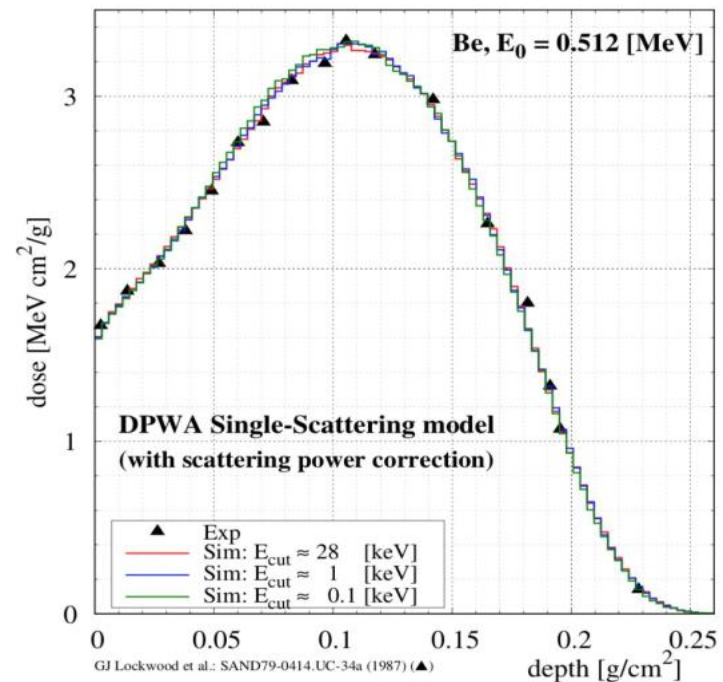
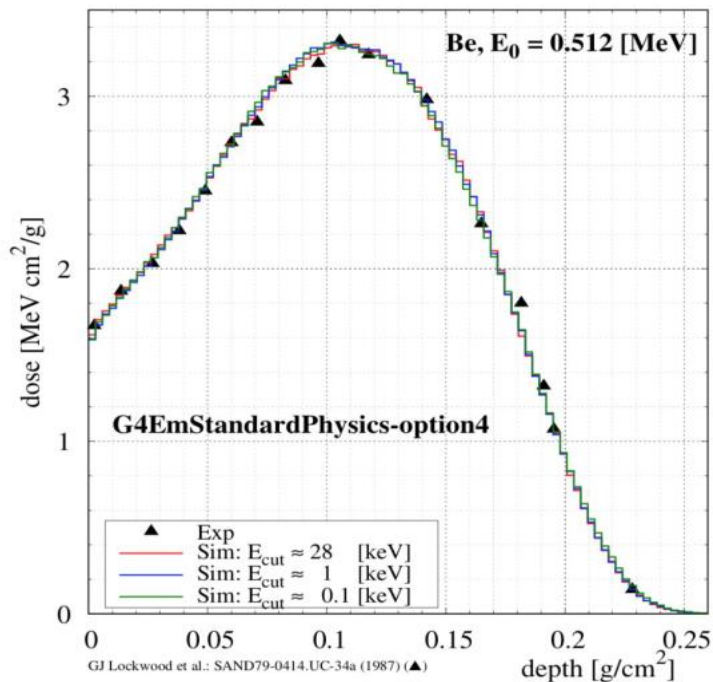
- **G4EmBuilder:**
 - A new utility class which will allow reduce code duplication for standard and low-energy EM physics constructors
 - Added extra feature: if maximum energy of simulation is below 1.1 GeV, no EM physics is instantiated for hyperons, b- and c- particles, and no radiation processes for muons/hadrons
- **G4GammaGeneralProcess:**
 - Is available as an option in any standard Physics List
- **G4EmModelActivator:**
 - Fixed/improved configuration of physics per region
- **G4EmStandardPhysicsSS:**
 - By default, using G4eDPWACoulombScatteringModel for e-/e+ below 100 MeV
- **G4EmDNAModelActivator:**
 - M.J. Pietrzak extended to extra available DNA options
 - DNA_Opt2, DNA_Opt4, DNA_Opt4a, DNA_Opt6, DNA_Opt6a, DNA_Opt7

Selected validation results



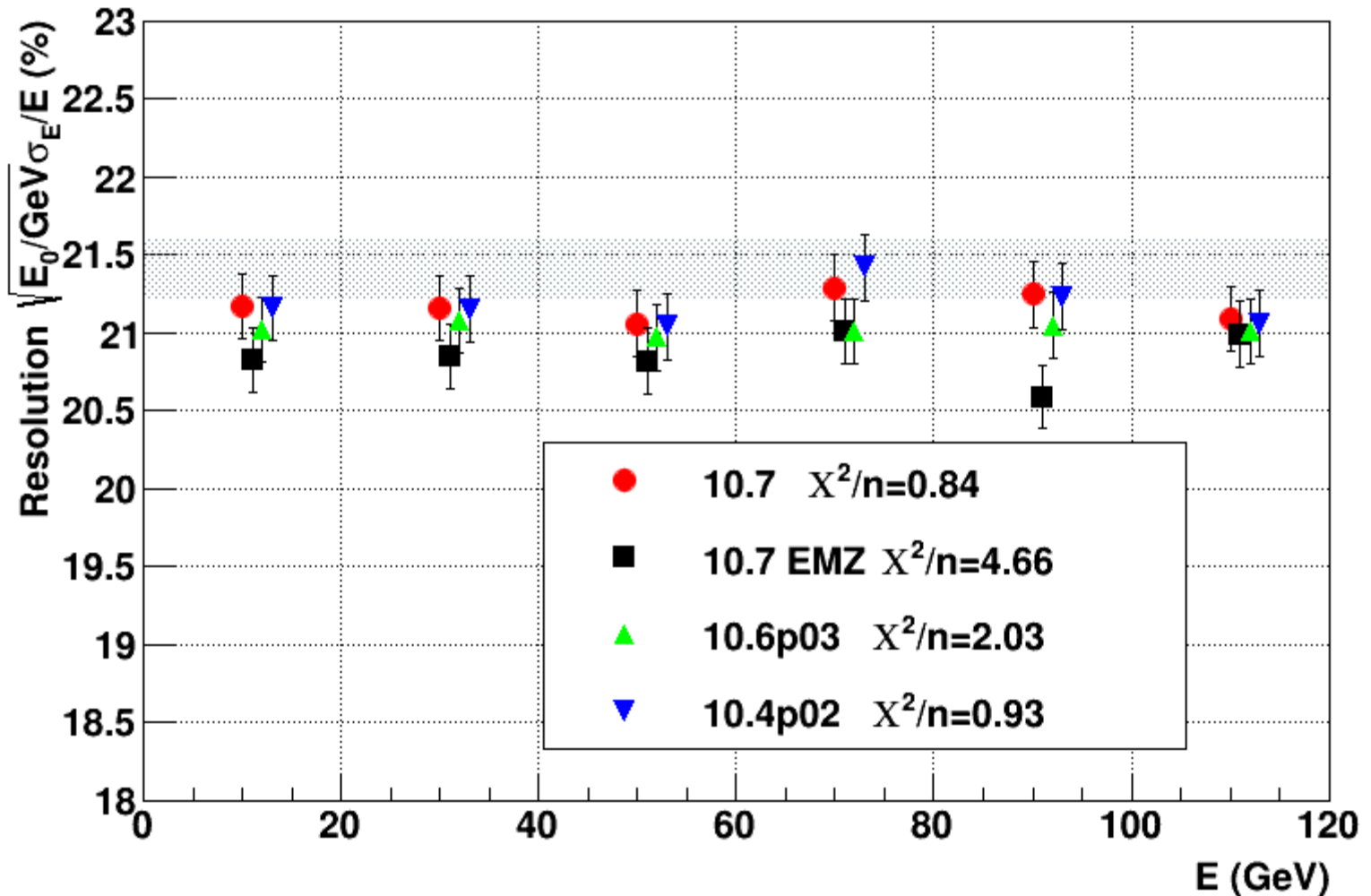
Energy profile in a light media

- New fully theory based e⁺/e⁻ scattering model provided results independent on Geant4 cuts and other parameters
- Option4 (EMZ) physics configuration provides similar results
 - This is a new strong argument for usage of EMZ option as a baseline

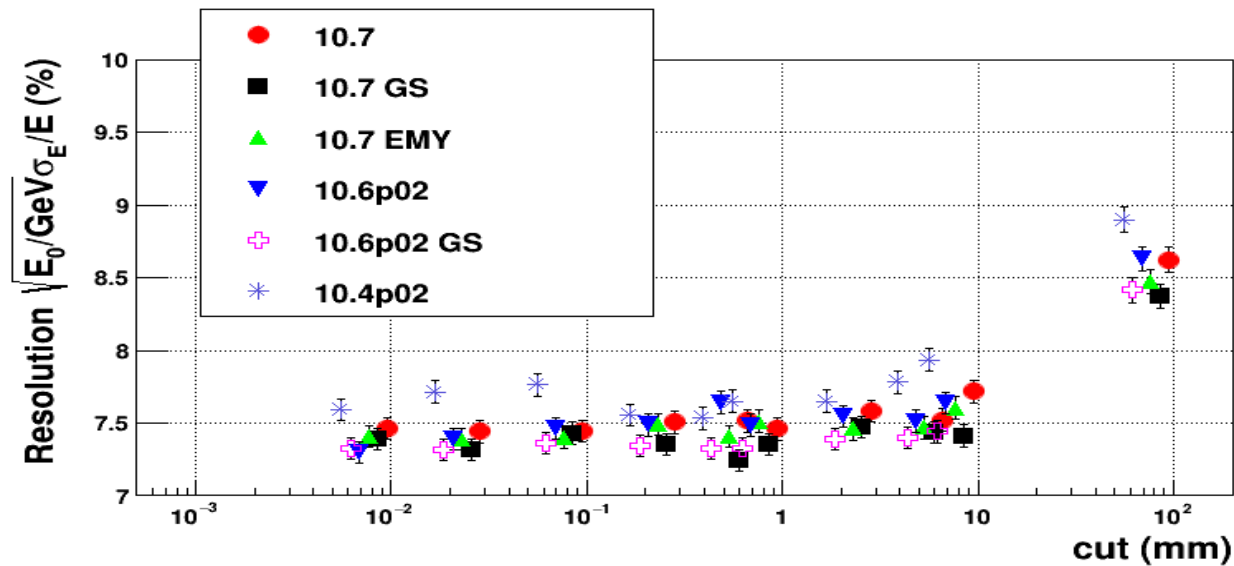
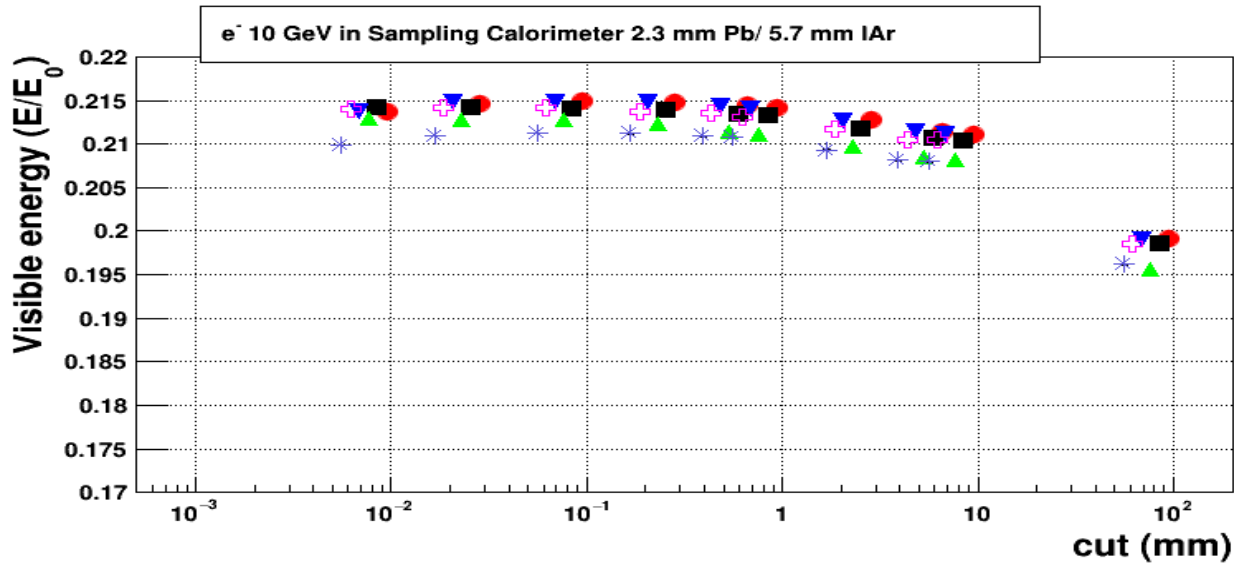


Simplified ATLAS HEC

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



Simplified ATLAS barrel

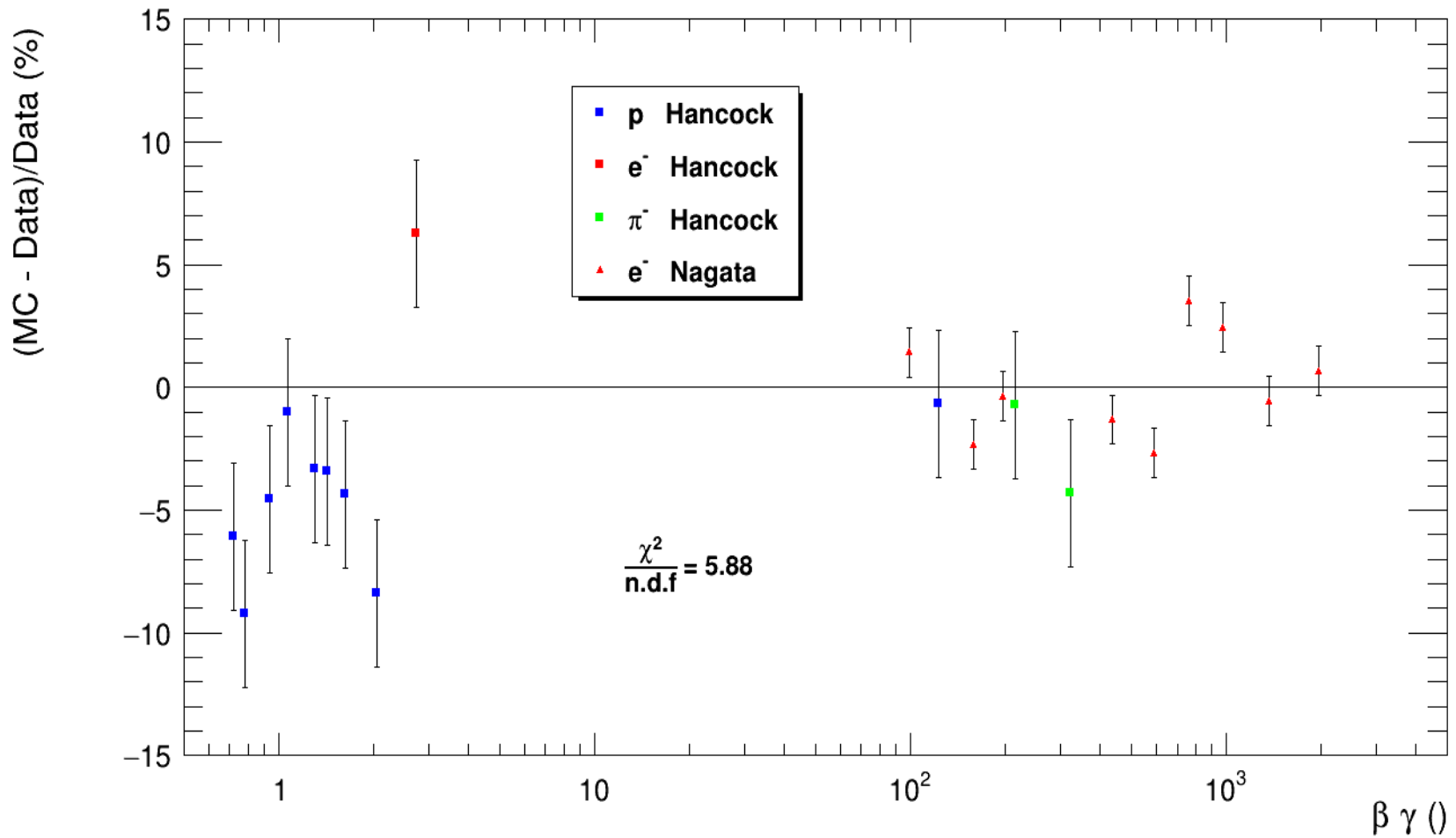


Geant4 10.6 and 10.7 provide very closed results for EM showers.

More visible energy compared to 10.4, lower RMS

Silicon detector response

Comparison of Most Probable Energy Deposition Δ between GEANT4 10.7 and Bichsel data with Gauss fit, emstandard_opt0 & Cut = 100 um



Thank you for your attention!

