Status of the standard Electromagnetic physics for the Geant4 release 8.1

21 June 2006

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Outline

- List of main upgrades for 8.1
- Multiple Scattering evolution
- Test results
- Conclusions

Ionization Processes Update

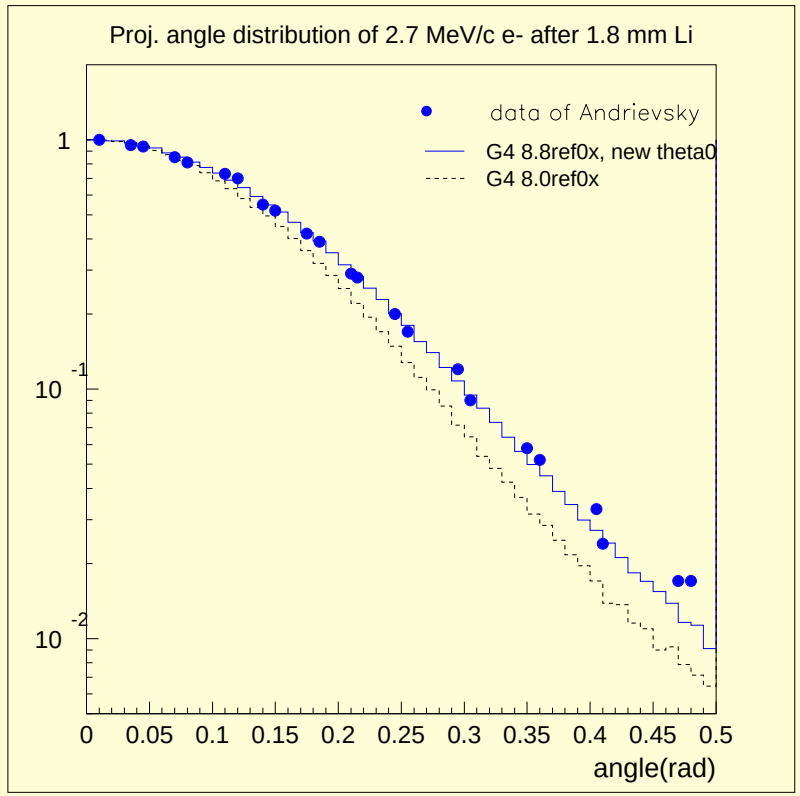
- Mass/charge/spin corrections
  - Small difference in ionization for π^-, π^+, p
  - No significant effect on shower shape
  - Main effect on heavy ion ionization
- Finite size corrections – effective to heavy ions
- NIST stopping power data for protons and He4 ions – Bragg peak simulation
- ICRU73 stopping data for water – a prototype for universal method to use measured stopping powers for specific combination ion/media
- Fixed computation of limit on cut value – important for bremsstrahlung inside high Z media and very small cuts
- Fixed PAI models in regime with small or zero cuts – important for XTR simulation
- Fixed parasitic cout

New Regimes of Energy Loss Processes

- SubCutoff regime completely reviewed and updated:
  - Lower cut values in vicinity of geometry boundary
  - Reduced mean energy loss and increased cross sections
  - May be active both for ionization and bremsstrahlung
  - Recent results will be shown below
- RandomStep regime reviewed and updated:
  - Introduced straggling of range for the last step instead of straggling of energy
  - Prototype version – need evaluation

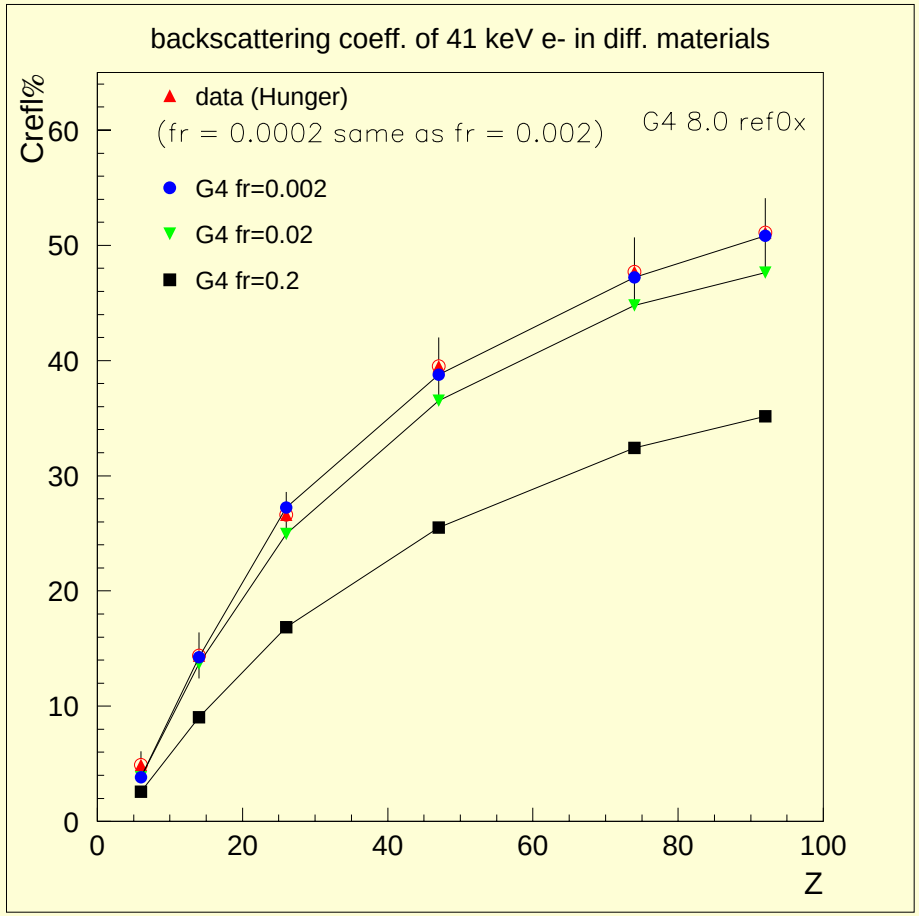
Multiple Scattering Update

- Main upgrade was done for 8.0 tuning for 8.1
- Central value of msc distribution is not changed
- Rename the model class G4UrbanMscModel
- Step limitation calculation is moved to the model class
- Optimized default values of parameters in the model



Multiple Scattering Update

- Improve sampling of tails of angular distribution that improving backscattering simulation
- Providing new prototype classes to simulate single Coulomb scattering:
  - *G4CoulombScattering*
  - *G4CoulombScatteringModel*
  - *G4eCoulombScatteringModel*



Gamma and X-ray Processes

- Compton – remove internal limit on energy providing smooth cross section for high Z media
- Transition Radiation classes reviewed and updated
  - New algorithm for transparent radiators
  - Tuning of angular distribution of XTR photons
- Synchrotron Radiation reviewed and updated
  - Moved to xrays sub-package and split to two alternative processes
  - Analytical formula for sampling of gamma energy
  - Simulation of energetic tail of the spectrum - important for linear collider study

Infrastructure and Steering

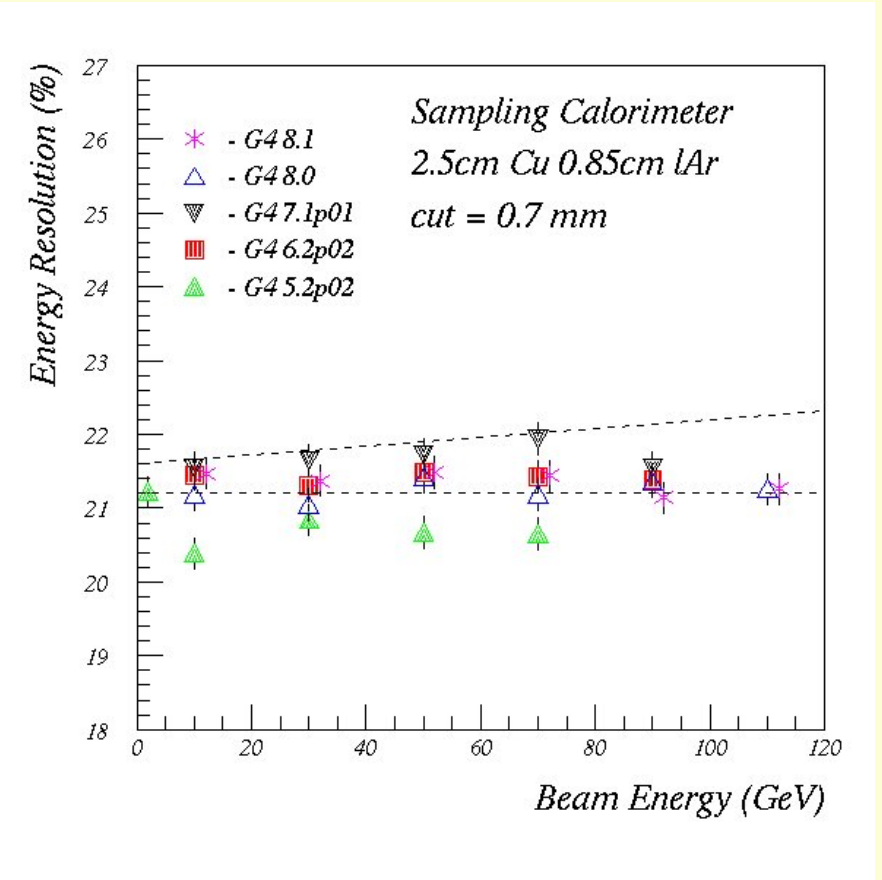
- Extend number of public methods for G4EmProcessOptions class and for UI messenger
  - Gamma threshold in bremsstrahlung
  - LPM effect activation
  - Msc step limitation
  - Subcutoff
- Unification is achieved for standard EM components of Physics Lists inside physics_lists tree and in examples

Examples

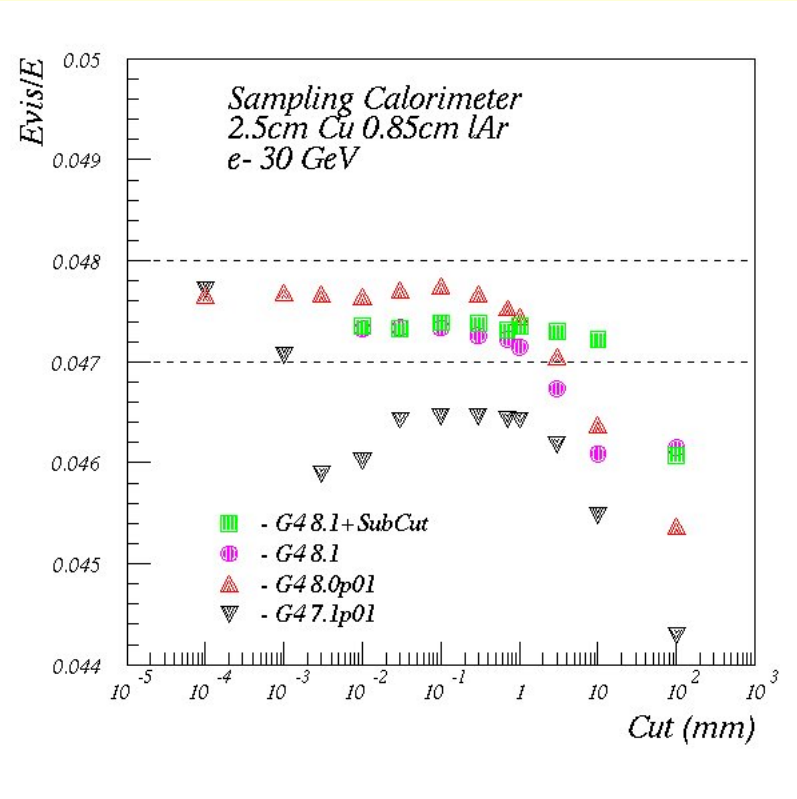
- Completed the set of Geant4 extended examples (18 different EM use-cases
  - Used in regular G4 tests
  - Used by verification suite for standard EM
- G4EmCalculator – helper class to compute cross sections and stopping power
  - Extend and cleanup interfaces
  - Provided examples

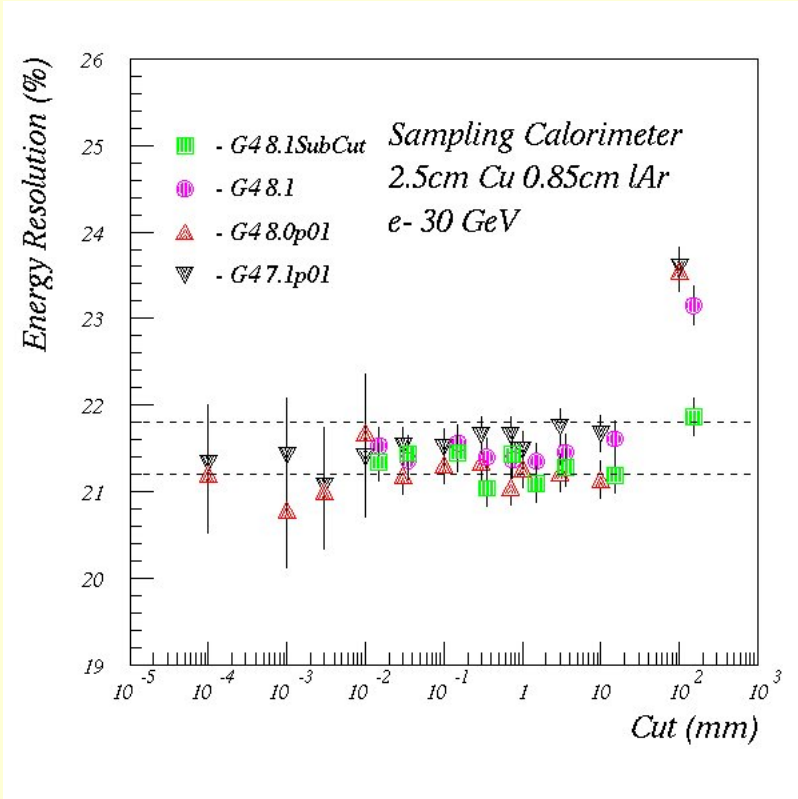
Testing Suite Evolution

- Started as a project from Geant4 5.1
  - Results are saved per Geant4 release/reference tag
  - Control on main physics quantities
  - Cover practically EM physics processes
- Large statistic tests for major LHC calorimeters:
  - ATLAS Barrel Pb/lAr
  - ATLAS HEC Cu/lAr
  - CMS crystal calorimeter $PbWO_4$
  - LHCb Pb/Sc calorimeter

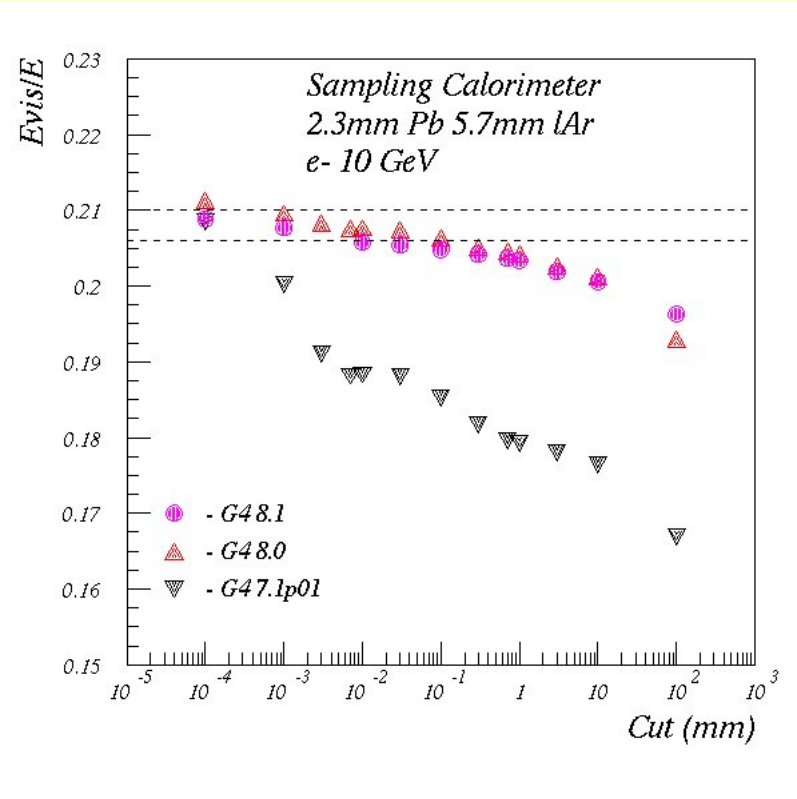


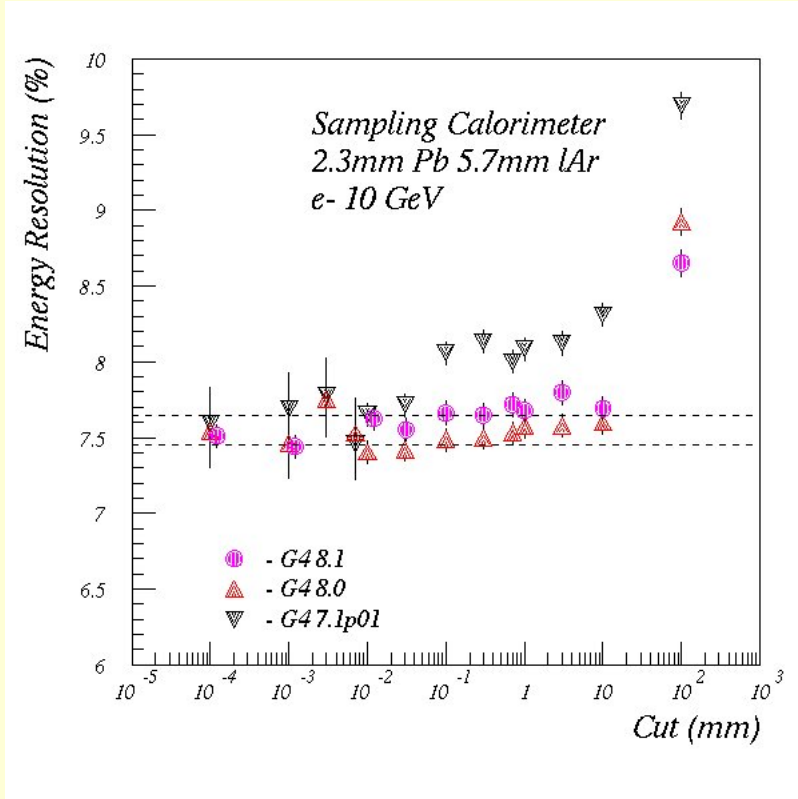
ATLAS HEC Type Calorimeter



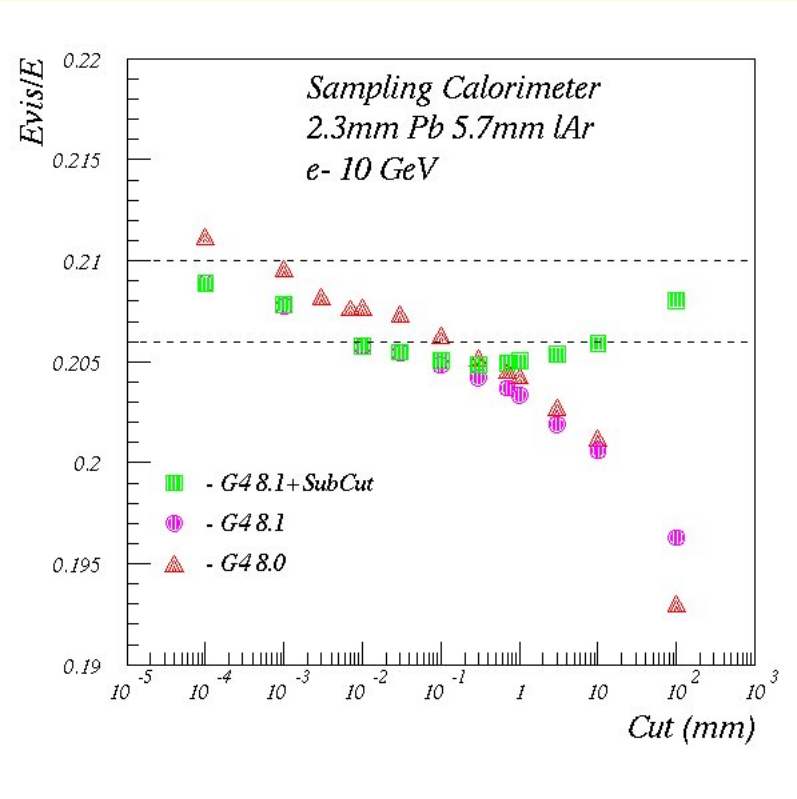


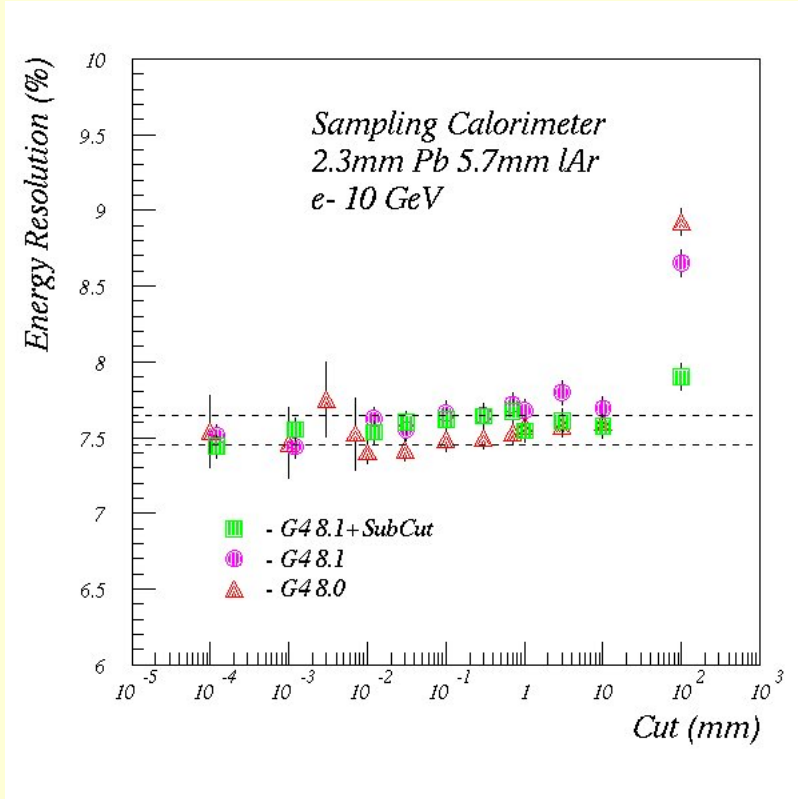
ATLAS Barrel Type Calorimeter



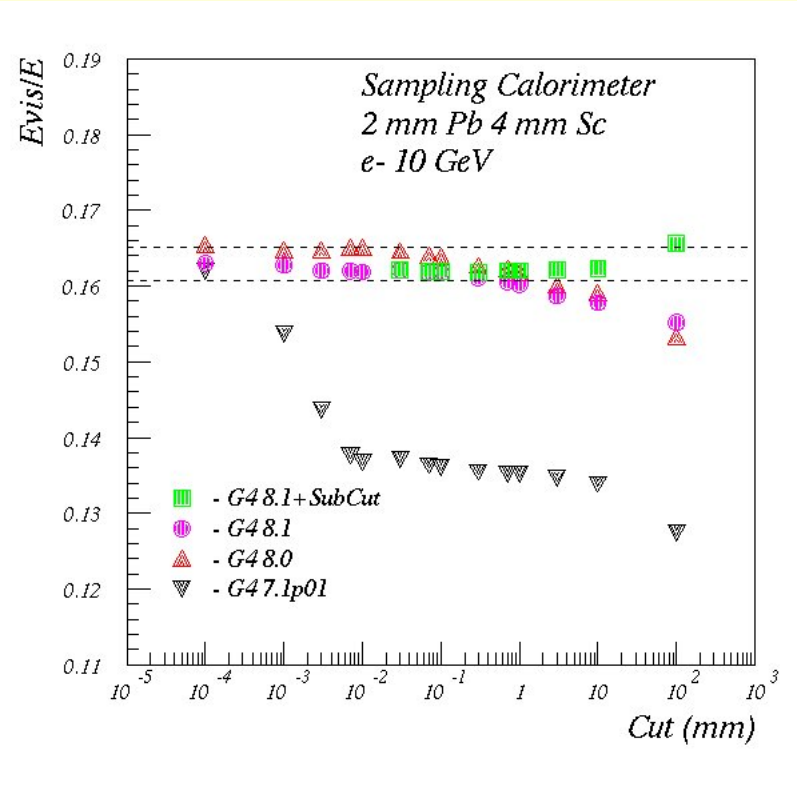


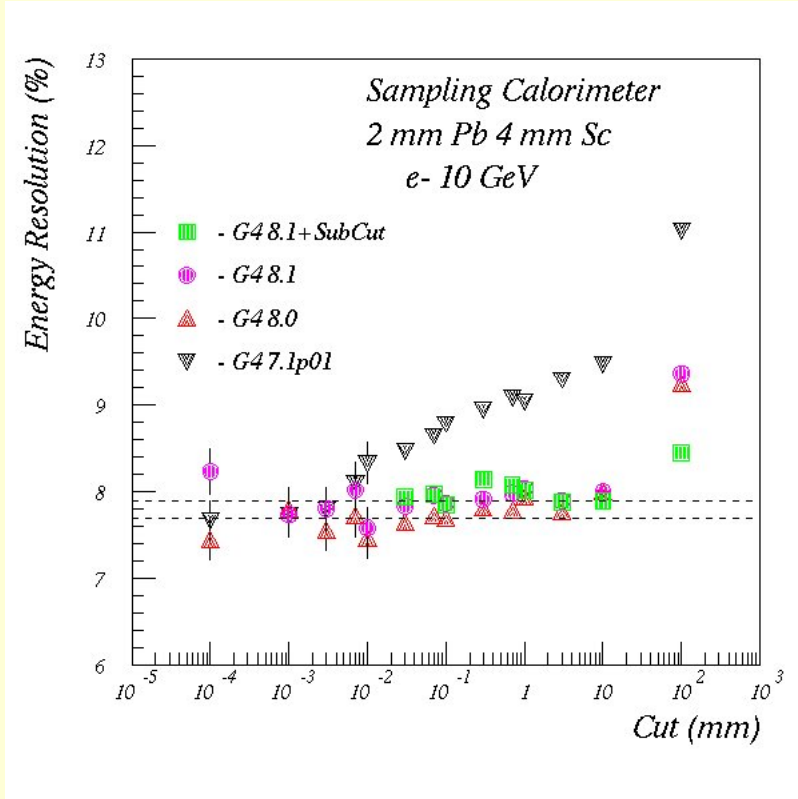
ATLAS Barrel Type Calorimeter



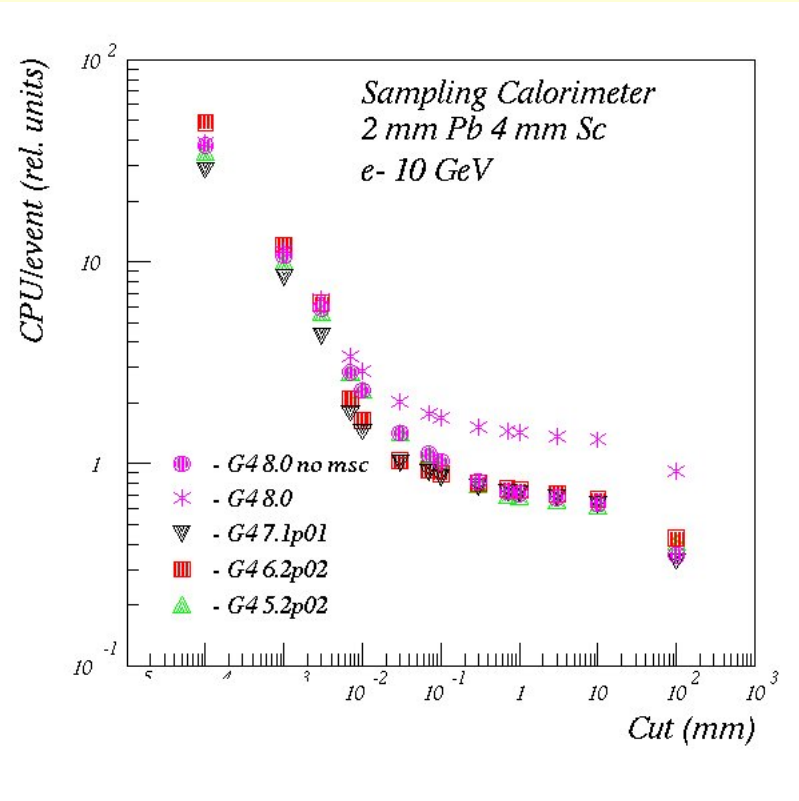


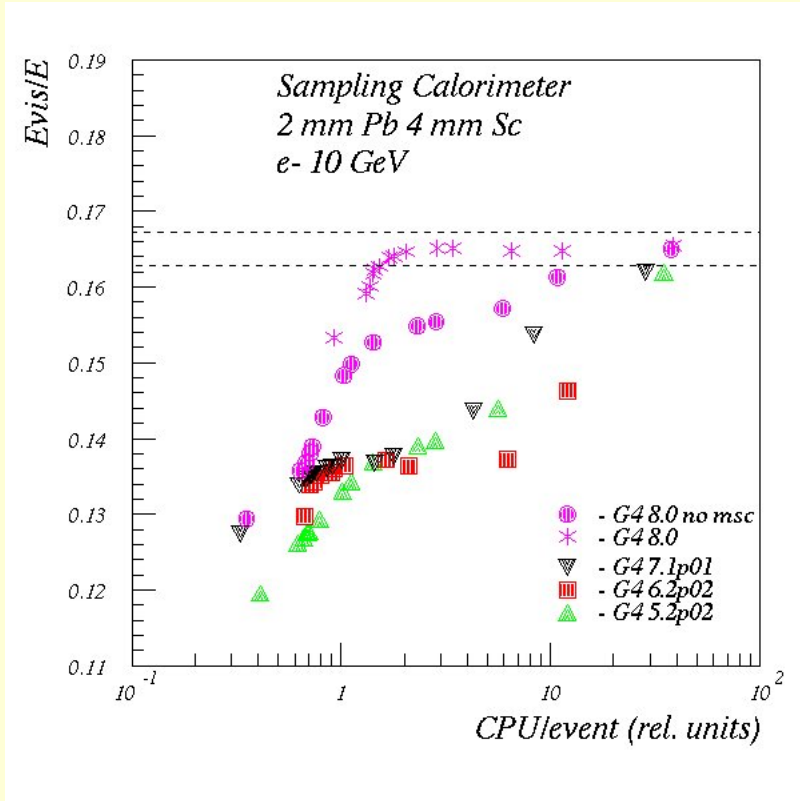
LHCB Type Calorimeter





CPU Optimization





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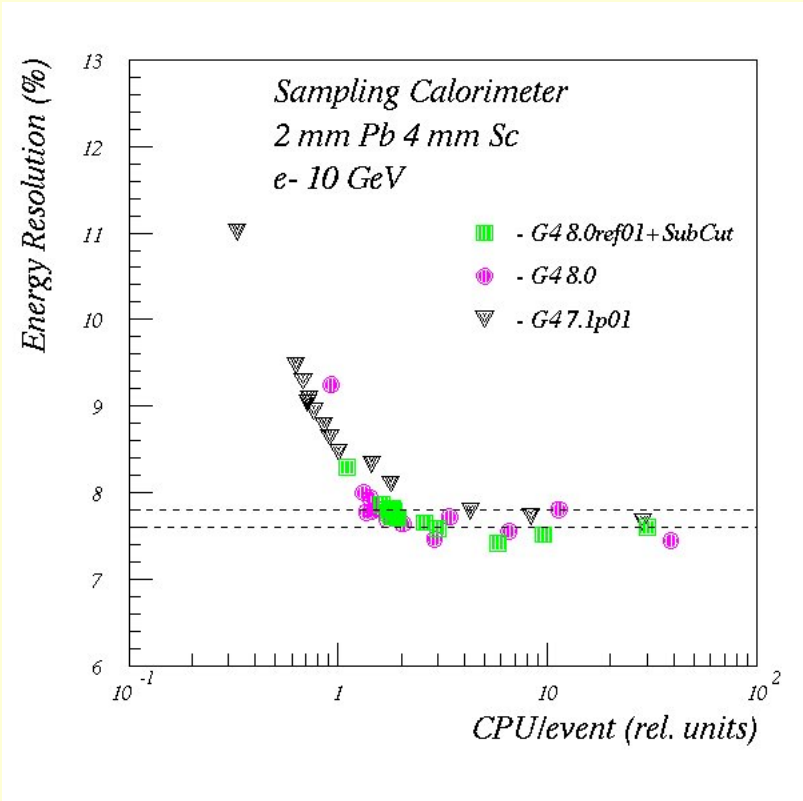
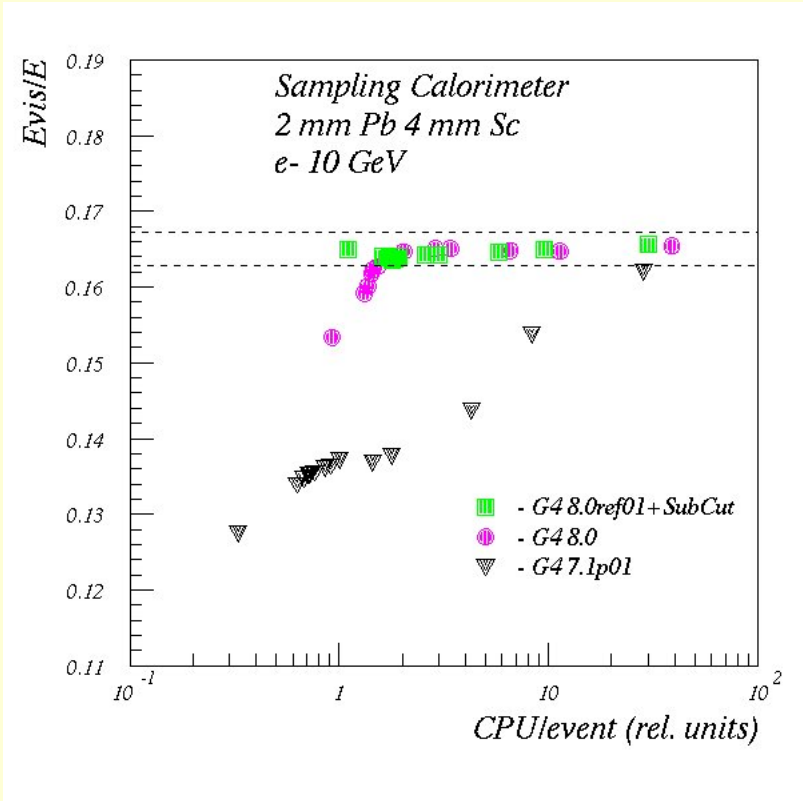
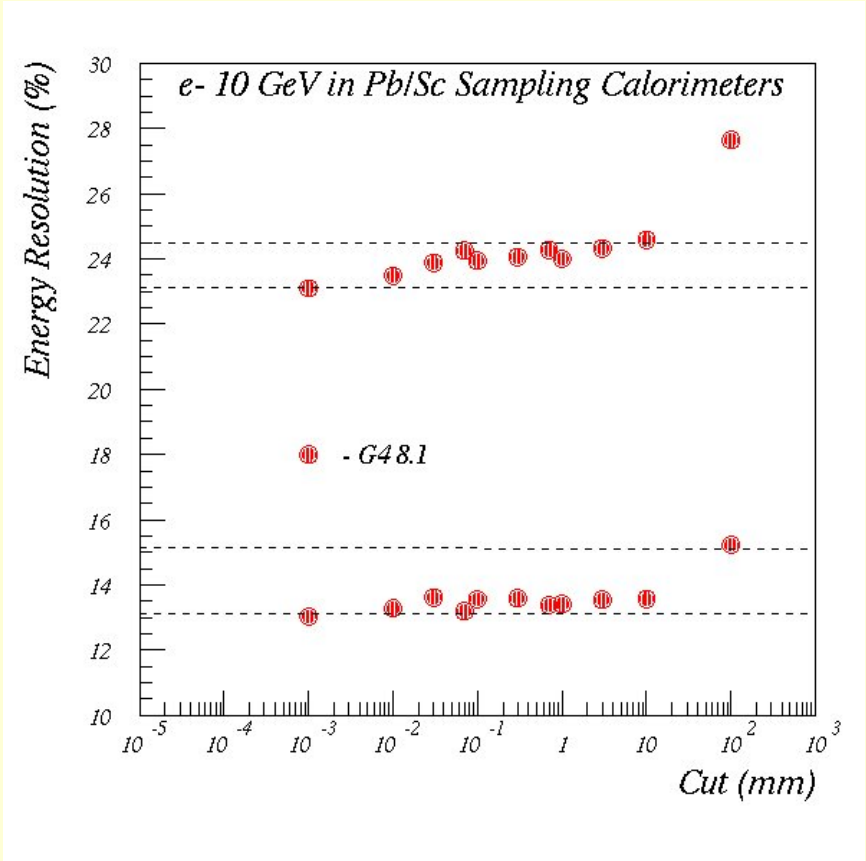




Comparison with Published Data

- ZEUS calorimeter test beam data
  - NIM A262 (1987) 229
  - NIM A274 (1989) 134
  - E.Bernardi thethis
  - PS CERN measurements
- Needed accurate description of sizes and materials
- Results are preliminary



Conclusions

- EM standard package have been significantly updated for the release 8.1
  - Tuning of multiple scattering
  - SubCutoff and Random step
  - Ionization corrections
  - XTR and SR updated
  - Number of fixes
- User interfaces and examples significantly improved
- Tests shows stability of results
- CPU performance is an issue and we have new instruments to tune EM physics
  - Close cooperation with experiments may be useful