

Report on EM Group Activity

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CERN, EMSU

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Portugal

Outline

- ▶ List of main upgrades for the release 8.1
- ▶ Recent validation results
- ▶ Current activity
- ▶ Perspectives
- ▶ Conclusions

Upgrades for the Release 8.1

- ▶ Ionization processes for hadrons and ions
- ▶ Multiple scattering (next talk)
- ▶ Sub-cutoff regime was restored
- ▶ Improved infrastructure
- ▶ Access to stopping power and cross sections
- ▶ Synchrotron radiation (parallel session)
- ▶ Transition radiation
- ▶ Extrapolator
- ▶ Examples (next talk)
- ▶ Testing suite
- ▶ **Three variants of EM standard Physics List for LHC**
- ▶ Minor fixes and refinements...

Ionization Processes Update for 8.1

- ▶ **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 light ions in 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
- ▶ **Fixing PAI models**
 - in regime with small or zero cuts – important for XTR simulation
 - For sampling of large transfers
- ▶ **More details and plots at parallel sessions**

New Regimes of Energy Loss Processes for 8.1

- ▶ **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**
- ▶ **Substituted PreciseRange by CSDARange**
- ▶ **RandomStep** regime reviewed and updated:
 - Introduced straggling of range for the last step instead of straggling of energy
 - **Prototype version – need evaluation**

Energy Loss for Extrapolator in 8.1

- ▶ Important fixes are done
- ▶ Muon tables are included
- ▶ Is exercised in regular test for muons
- ▶ Thanks P.Arce for the feedback

Gamma and X-ray Processes for 8.1

- ▶ **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
 - **More details in V.Grichine talk at parallel session**

New Implementation of Synchrotron Radiation by H.Burkhardt for 8.1

SG4INSTALL/examples/extended/electromagnetic/TestEm16

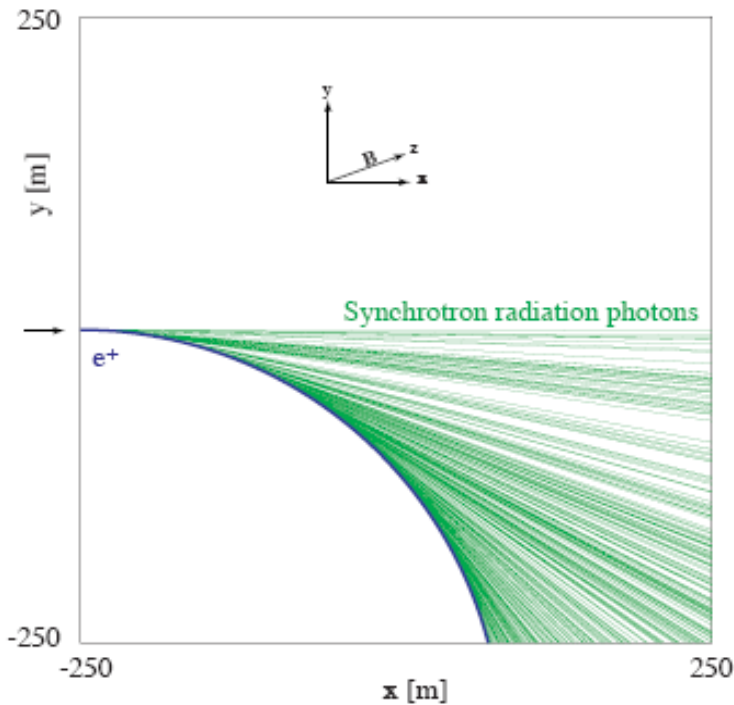


Figure 3: Geant4 display. 10 GeV e^+ moving initially in x -direction, bend downwards on a circular path by a 0.1 T magnetic field in z -direction.

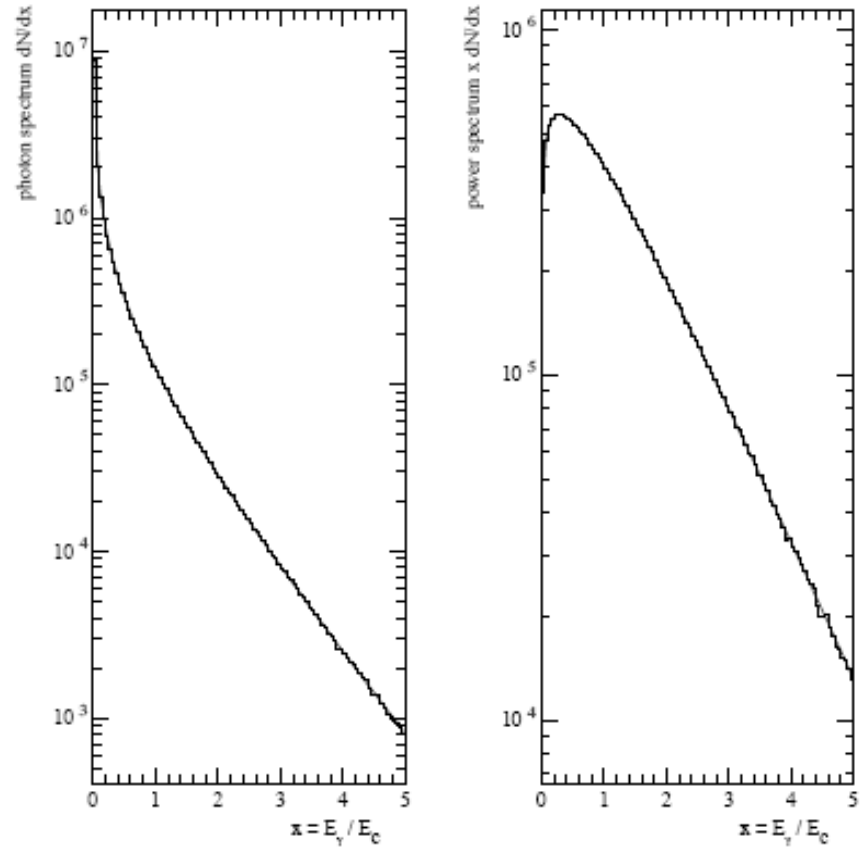


Figure 2: Comparison of the exact (smooth curve) and generated (histogram) spectra for 2×10^7 events. The photon spectrum is shown on the left and the power spectrum on the right side.

Infrastructure and Steering in 8.1

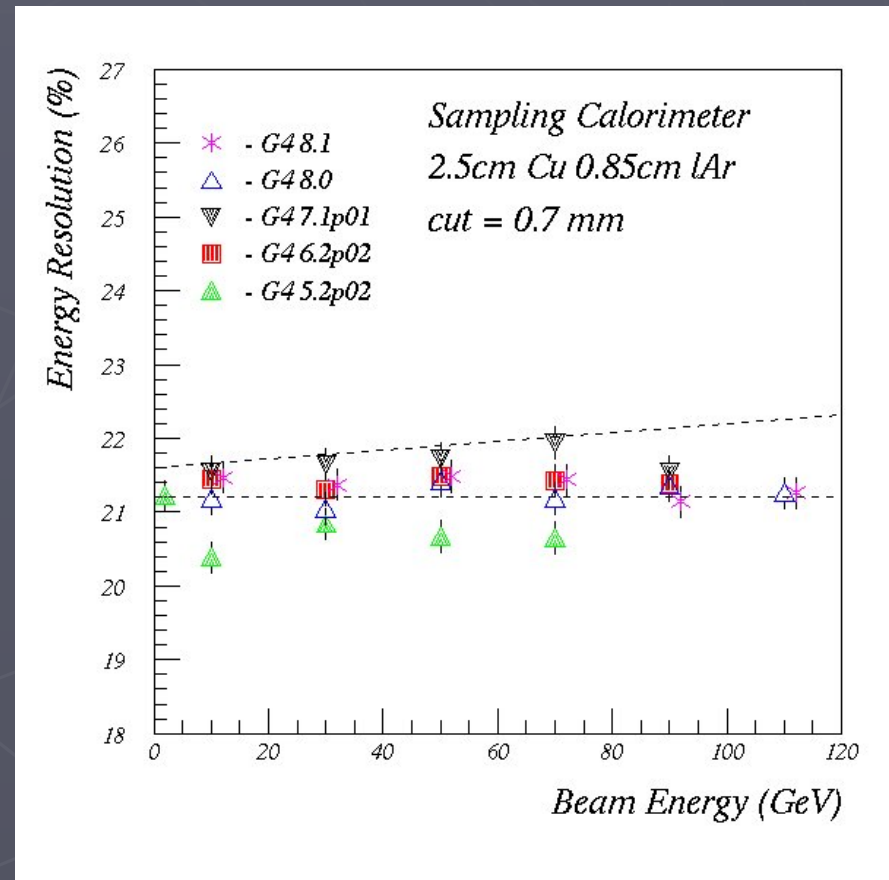
- ▶ Extend number of public methods for G4EmProcessOptions class and for UI messenger
 - Gamma threshold in bremsstrahlung
 - LPM effect activation
 - Msc step limitation
 - Subcutoff
- ▶ Unification is achieved for standard EM components of Physics Lists inside physics_lists tree and in examples
 -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

Infrastructure Upgrade for 8.1

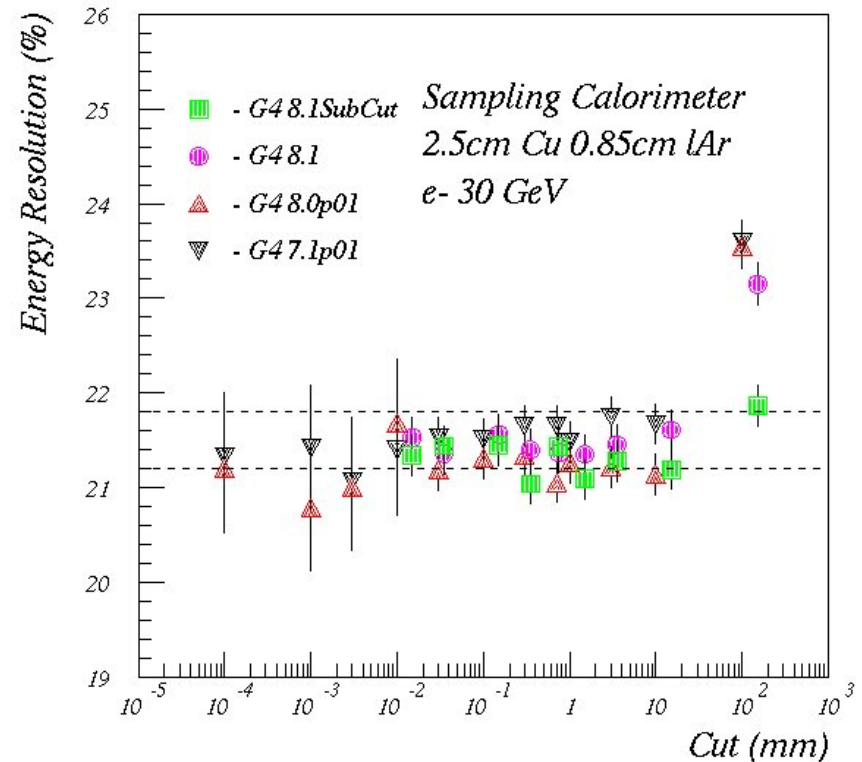
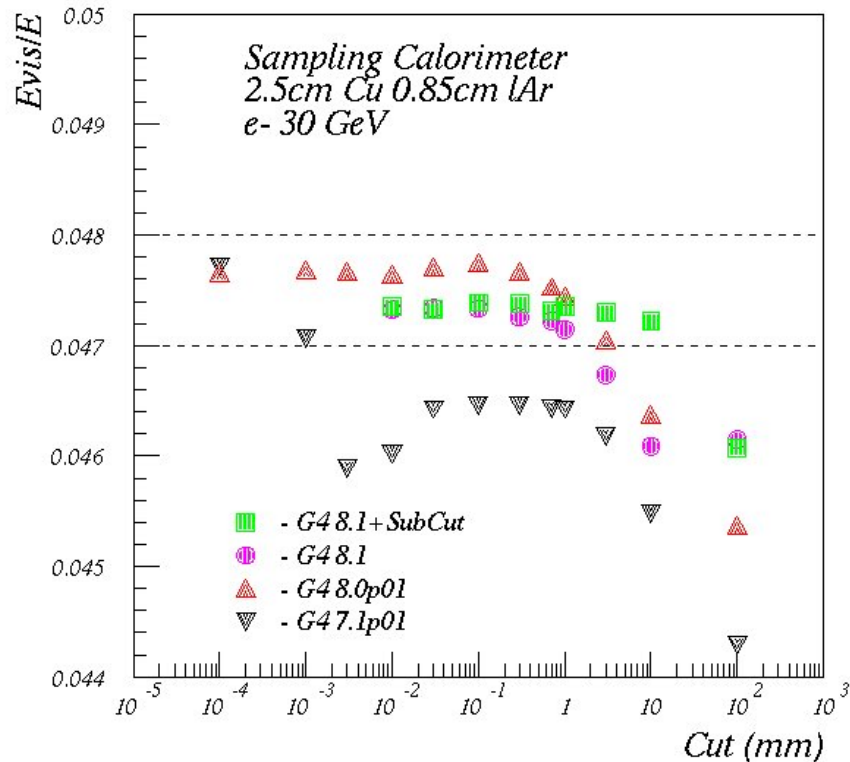
- ▶ Completed the set of public methods to access cross sections and stopping powers:
 - For all processes: `ComputeCrossSectionsPerAtom`
 - For all models:
 - ▶ `ComputeCrossSectionPerAtom`
 - ▶ `CrossSectionPerVolume`
 - ▶ `ComputeDEDXPerVolume`
- ▶ **G4EmCalculator** – helper class to compute cross sections and stopping power
 - Extend and cleanup interfaces
 - Provided examples (`TestEm0`, `TestEm14...`)

Testing Suite Evolution

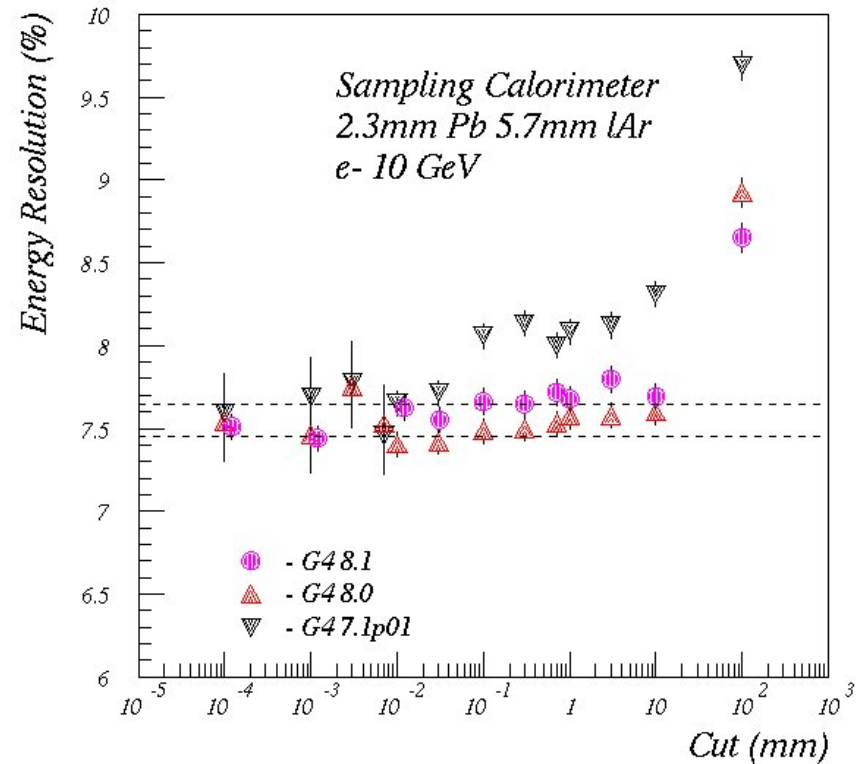
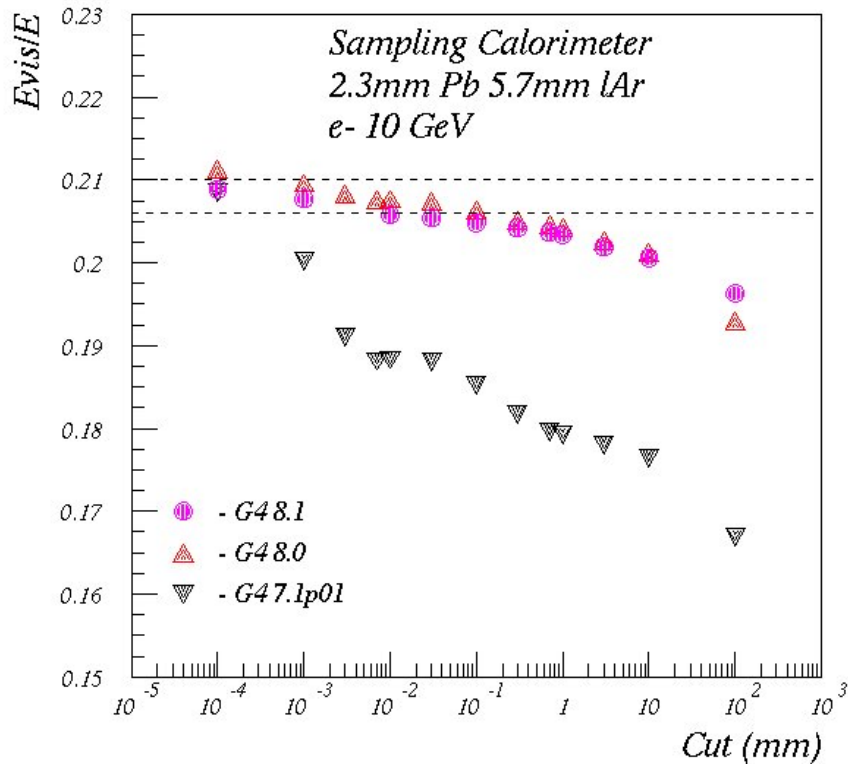
- ▶ Started as a project from Geant4 5.1
 - Results are saved per Geant4 release/reference tag
 - Control on main physics quantities
 - Cover practically EM physics processes
- ▶ Large statistic tests for major LHC calorimeters:
 - ATLAS Barrel Pb/IAr
 - ATLAS HEC Cu/IAr
 - CMS crystal calorimeter PbWO_4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



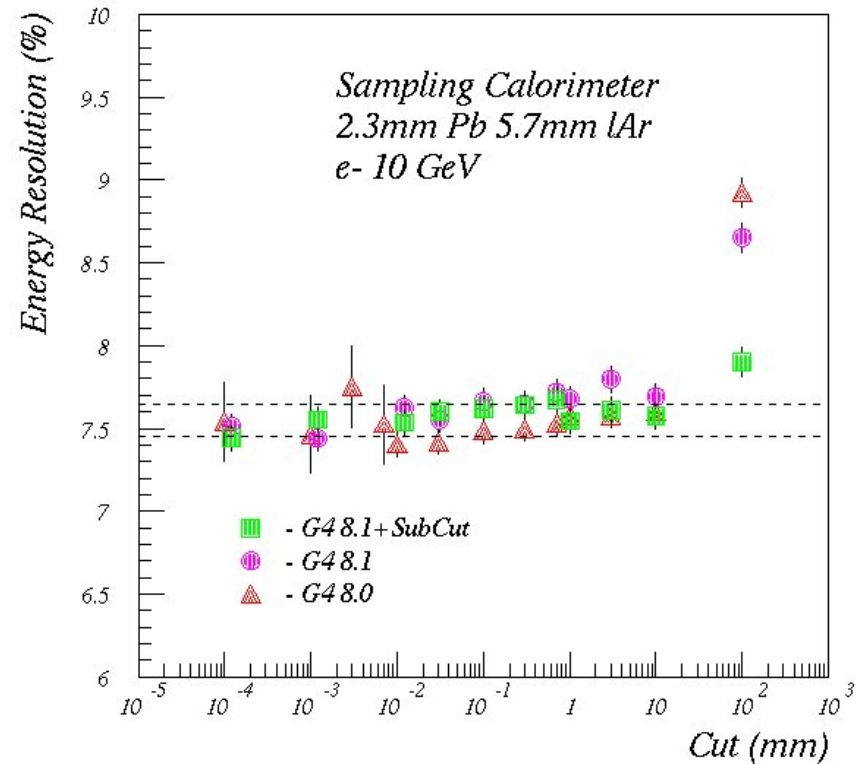
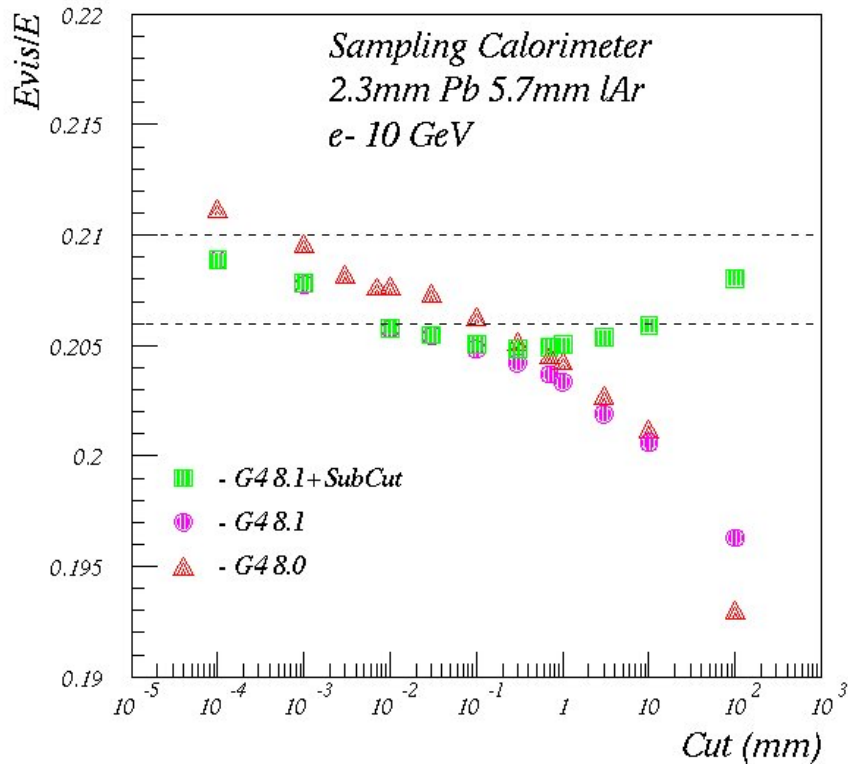
ATLAS HEC Type Calorimeter



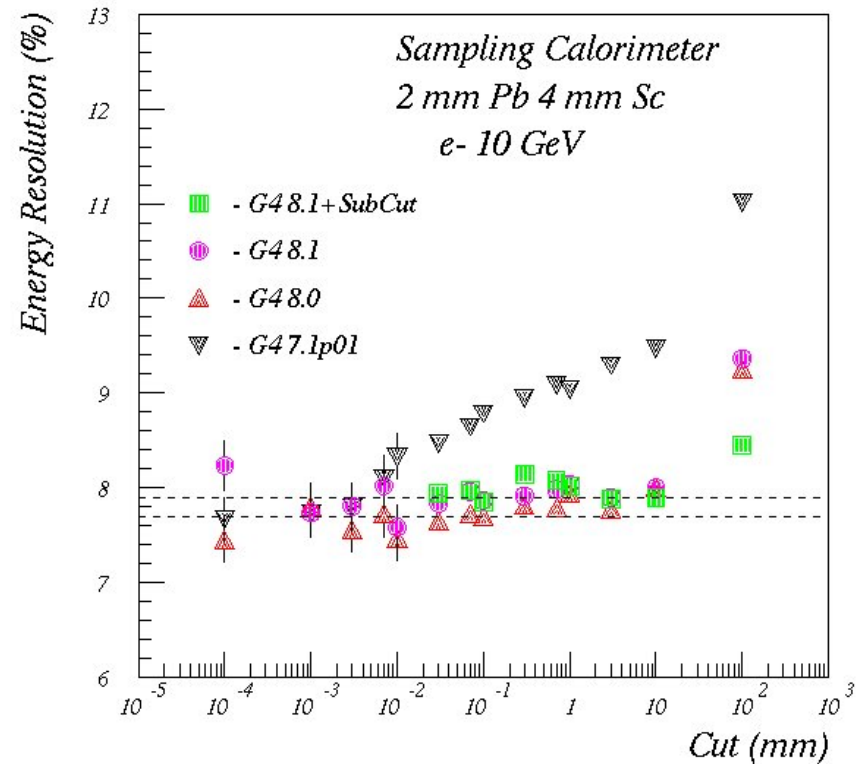
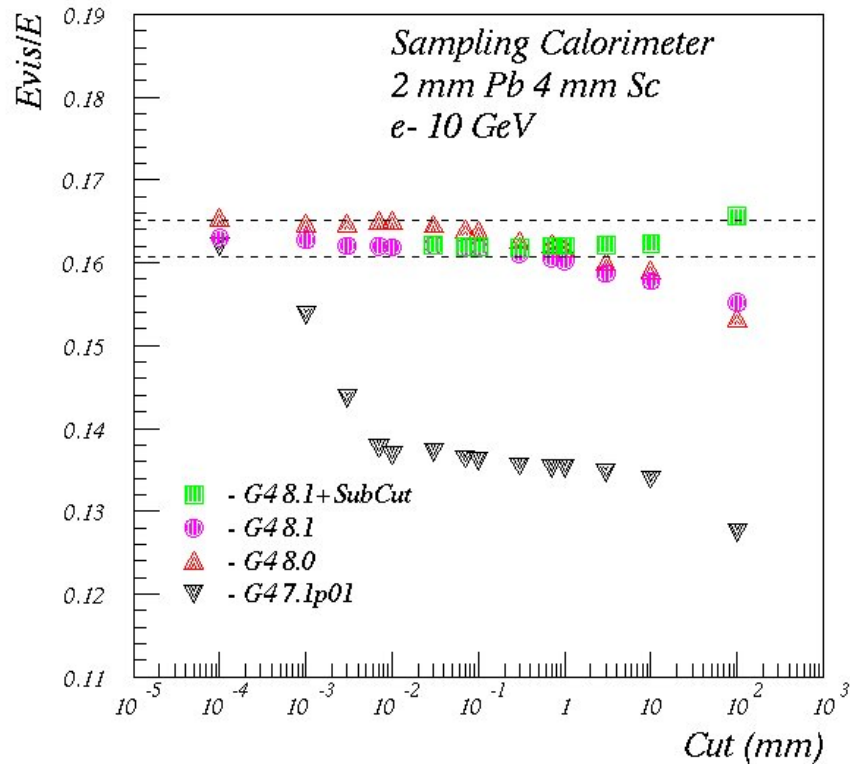
ATLAS Barrel Type Calorimeter



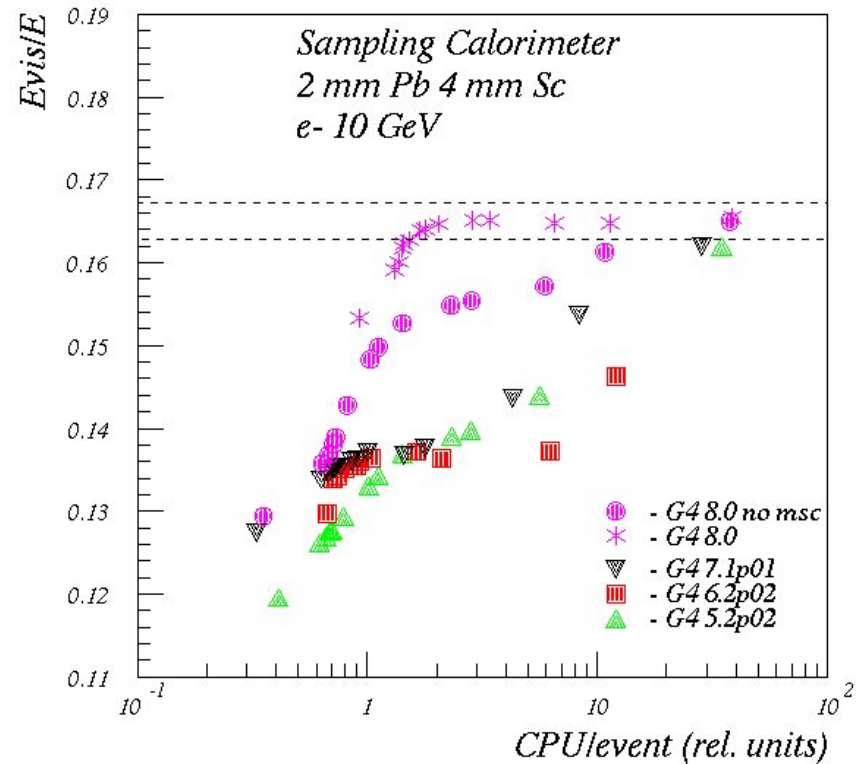
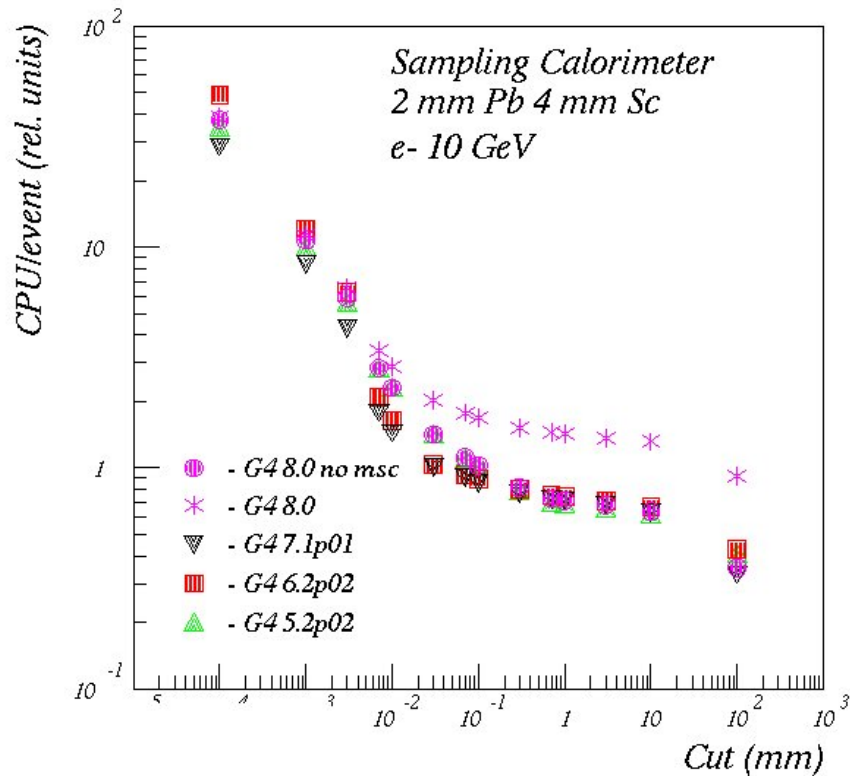
ATLAS Barrel Type Calorimeter



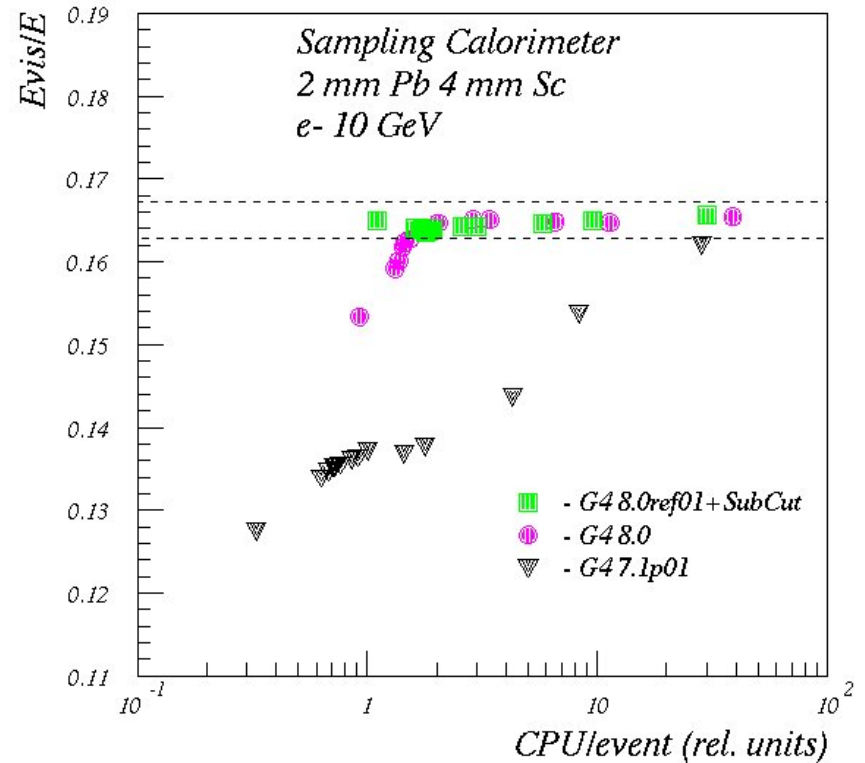
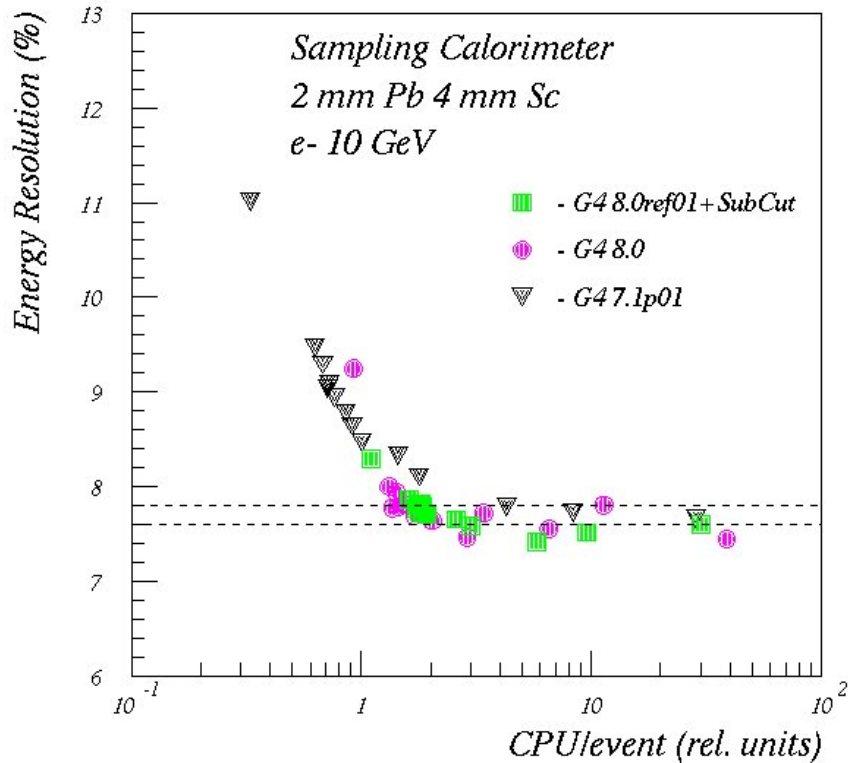
LHCb Type Calorimeter



CPU Optimization

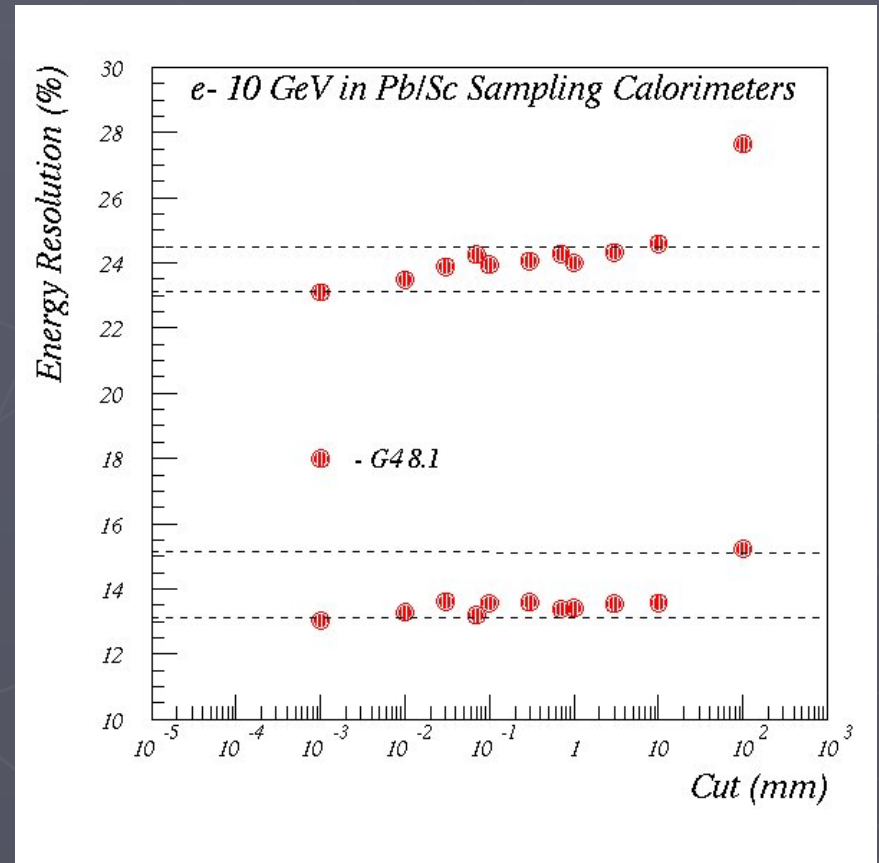


CPU Optimization



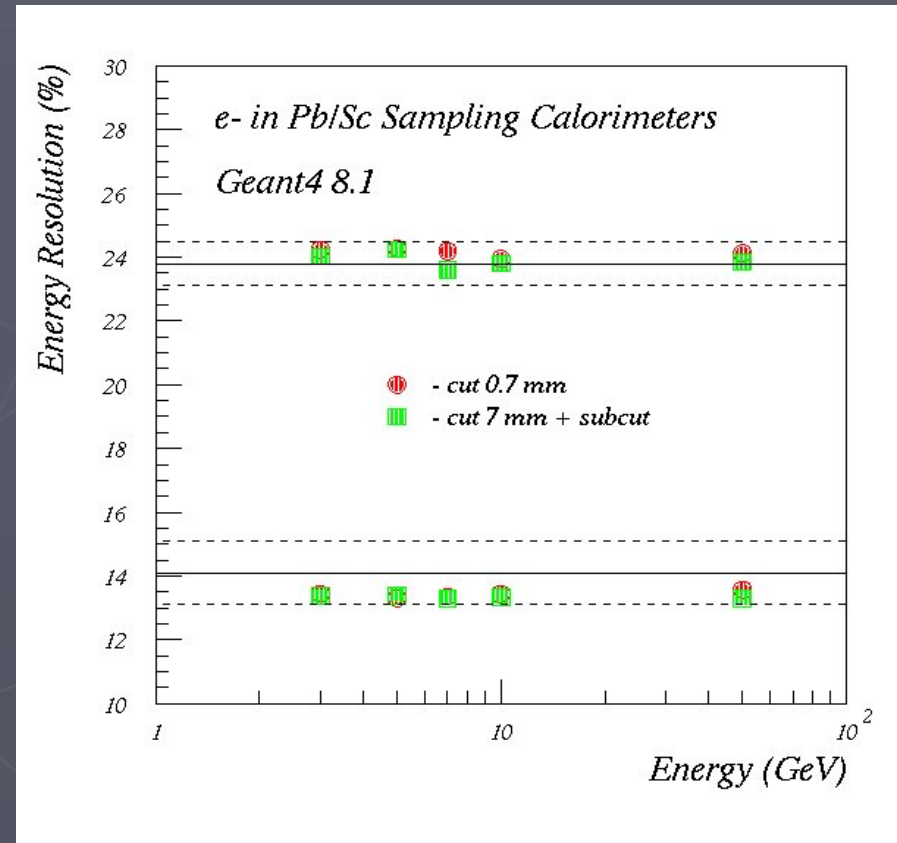
Comparison with Published Data

- ▶ ZEUS calorimeter test beam data
 - NIM A262 (1987) 229
 - NIM A274 (1989) 134
 - E. Bernardi thesis
 - PS CERN measurements
- ▶ Two calorimeter structures:
 - ▶ 5mm Pb/5mm Sc
 - ▶ 10 mm Pb/2.5 mm Sc
- ▶ Accurate description of sizes and materials was needed!



Comparison with Published Data

- ▶ The results with standard cut 0.7 mm and higher cut and subcutoff regime are similar
- ▶ The EM calibration of these data are done – hadronic comparisons need to be performed



Current Activity in EM Physics Group and foreseen delivery in December

- ▶ **Validation and verification**
 - ▶ Permanent activity in LAPP and CERN
 - low-energy group
 - others G4 members welcome
 - Tunisia group express interest
 - User contribution
 - ▶ Extensions and autoimmunization of the testing suite
- ▶ Fine tuning of msc (L.Urban)
- ▶ **Single elastic scattering process**
- ▶ New polarization library for beam applications (next talk)
- ▶ **New EM group web page**

Perspectives

- ▶ G4 EM standard packages in general provide physics of a good quality
- ▶ Existing theories, parameterizations, and data allowed extend and improve models
 - Radiative corrections
 - High energy effects
 - Atomic effects
- ▶ CPU performance deeply connected with understanding of physics and its simulation

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