CPU performance of Geant4 EM Physics

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Outline

- Introductory remarks
- Geant4 electron and positron transport
- CPU performance for LHC calorimetry
- Prospects for future
- Summary

Introductory remarks

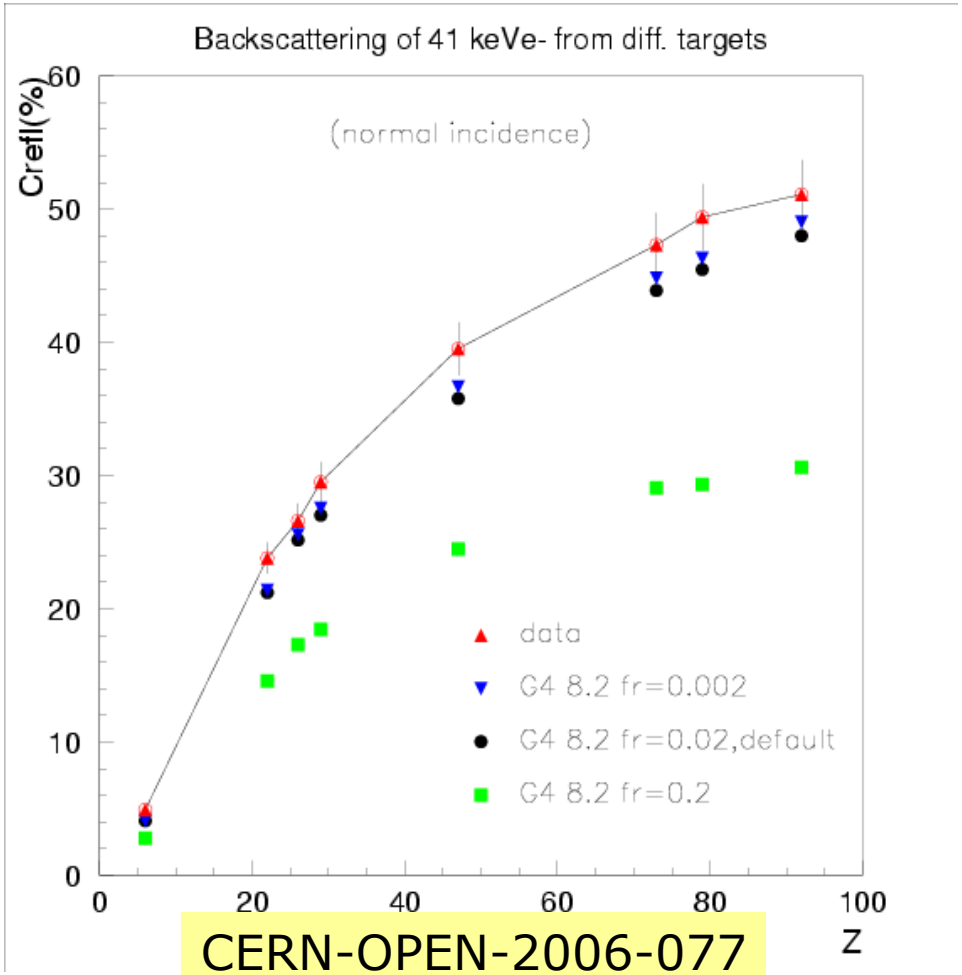
- The CPU performance is an important characteristic of a simulation tool
  - EM physics group permanently control CPU
- Many small mistakes and big errors were done in past in G3/G4 comparisons
- To make a fair benchmark on CPU performance a number of conditions are required:
  - software platform, processor, compiler flags
  - physics quality condition (not the same cuts!)

EM transport simulation simplifications

- Cross sections of δ-electron production and bremsstrahlung rapidly increase for low-energy secondary production
  - Sampling of fluctuations
  - Production threshold – unique range cut
  - Tracking cuts – is not active by default
- EM elastic cross sections rapidly increases when energy decreases
  - Multiple scattering
    - Geometrical->True length conversion
    - Lateral displacement

Multiple scattering step limitation

- MSC process limit step base on following parameters:
  - FactorRange
    - default 0.02
    - 0.2 for EMV Physics List
  - FactorGeom
    - default 3.5
  - Skin
    - default 0 for reference Physics Lists (magnetic field)
    - default 1 for medical applications



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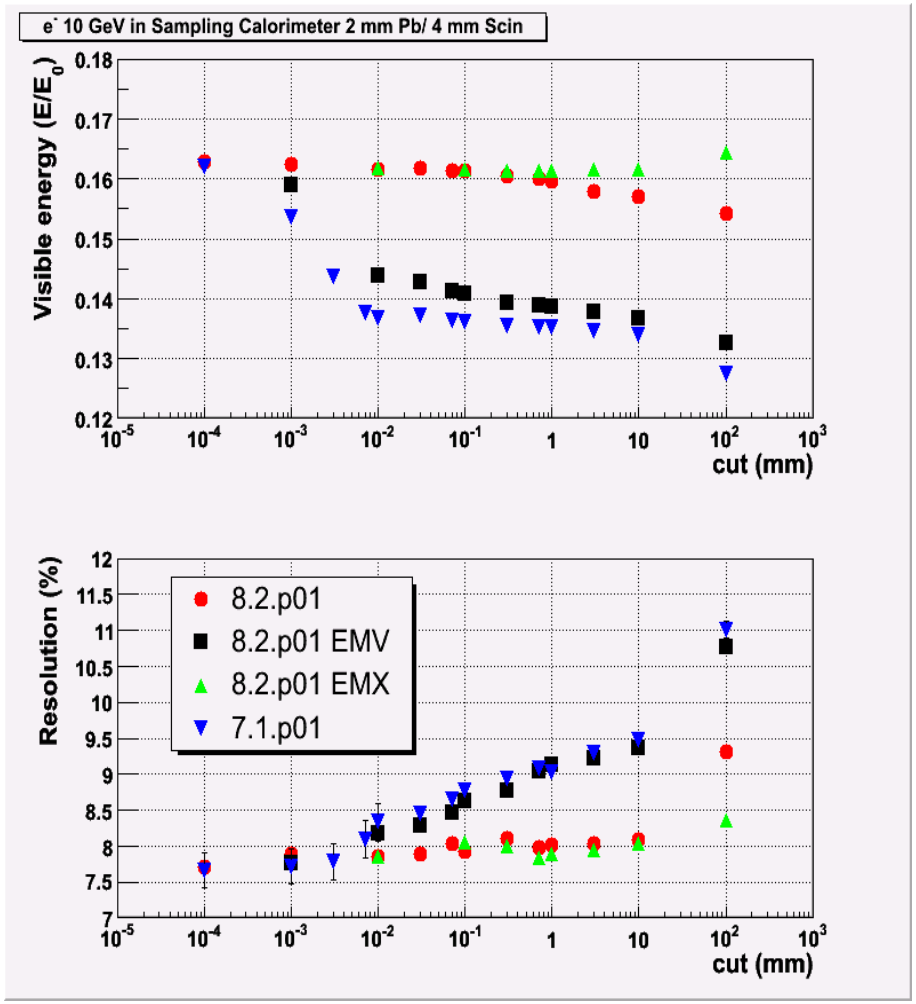
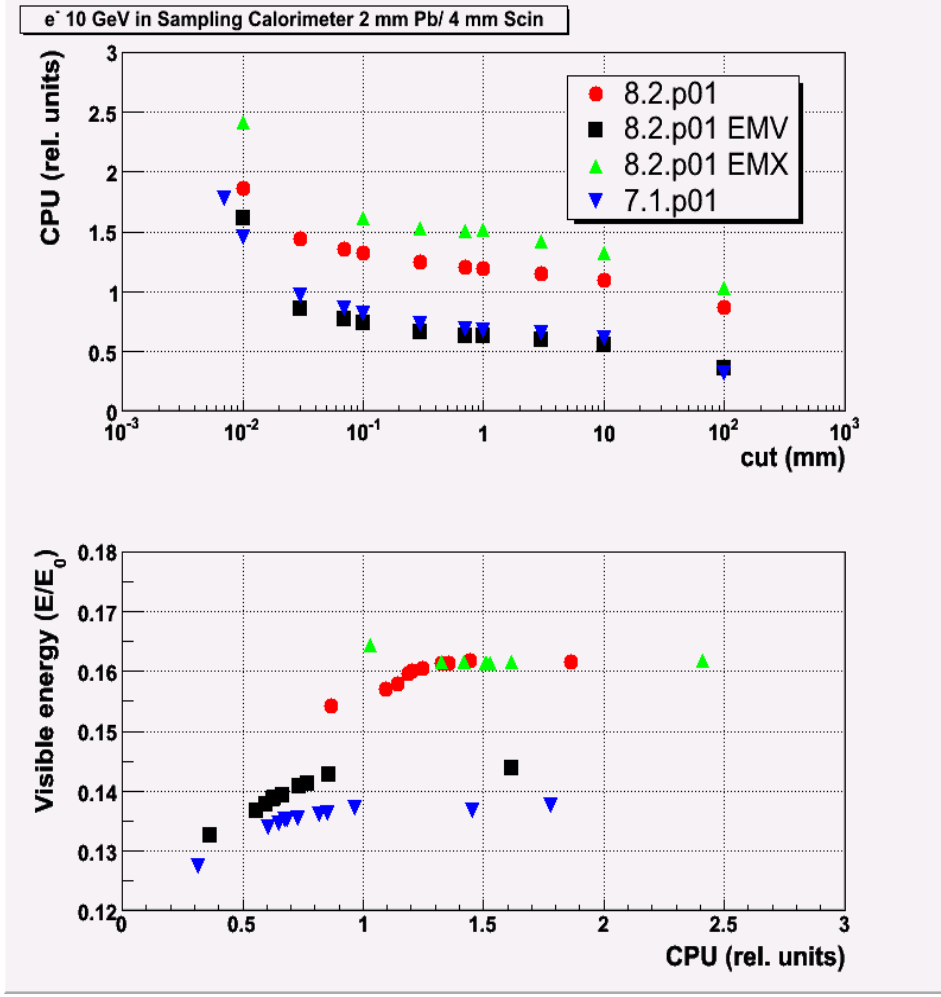
Physics List

- Three components for Reference Physics Lists:
  - "G4standard" – default EM configuration (LHEP, QGSP)
  - "G4standard_fast" – configuration providing faster simulation (QGSP_EMV)
  - "G4standard_exp" – experimental (QGSP_EMX), currently uses sub-cutoff option
  - Names are subject of redefinition in next releases
- Which Physics Lists should be frozen?
  - What is needed in 8.3 if it will be provided?
  - What is needed for 9.0?

LHCB type calorimeter

(Testing suite results – effect of msc model evolution)

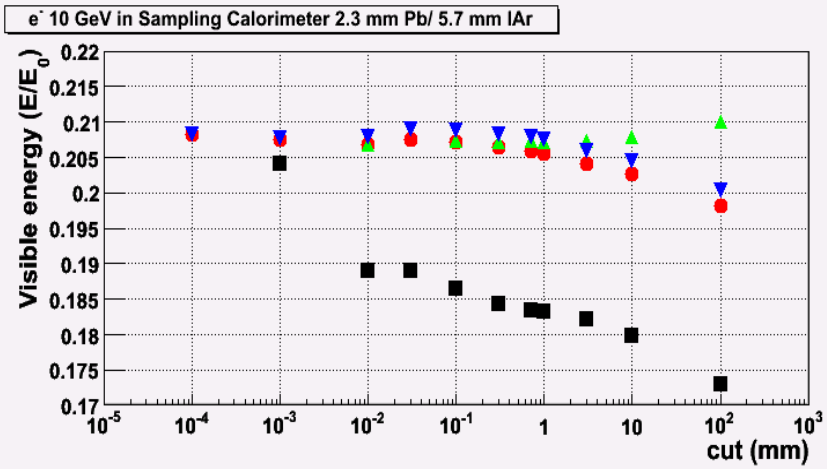


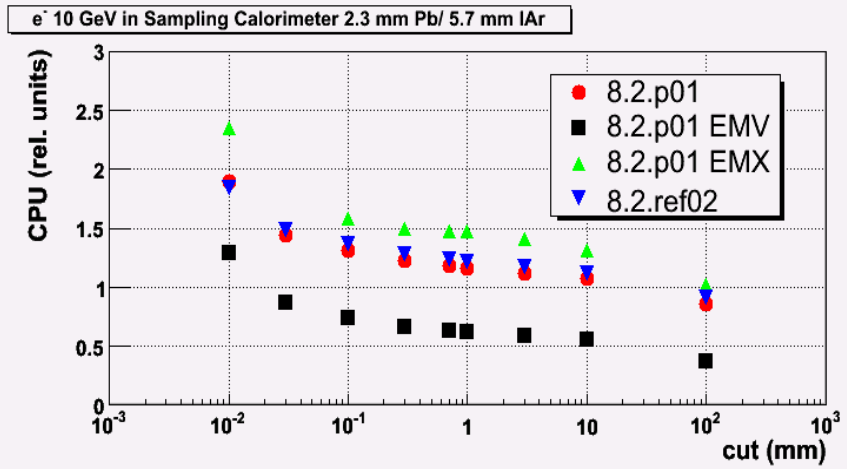


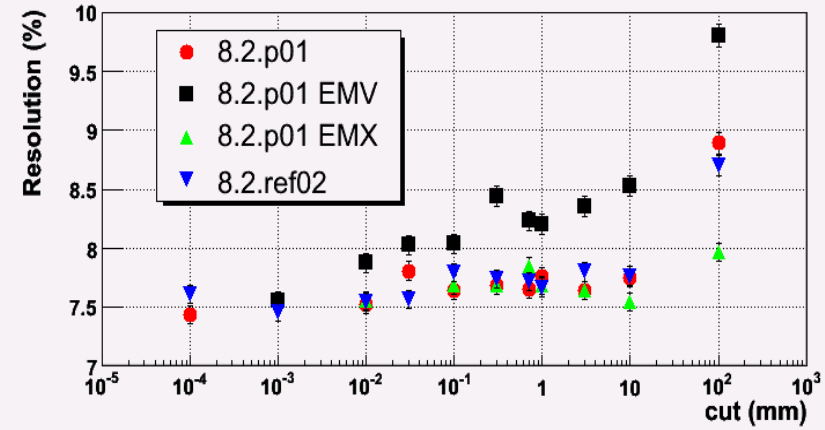
8.2p01, 1 mm cut – optimal point

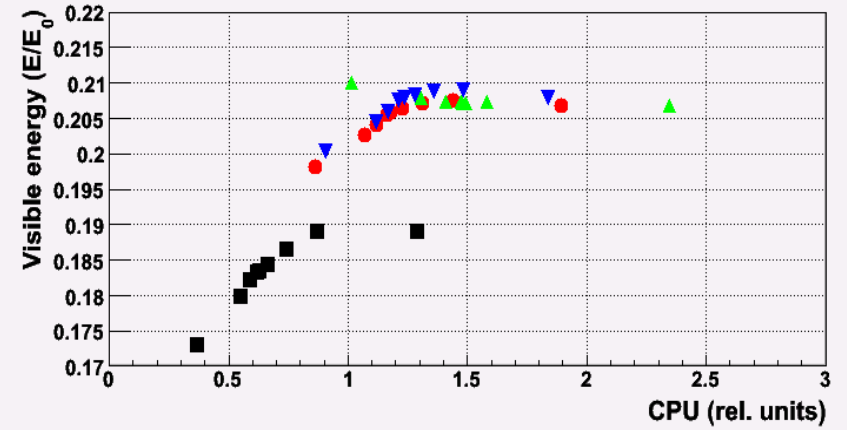
ATLAS barrel type calorimeter

(Reference version 8.2ref02 – safe version of msc model (skin=0))









<1% difference for 8.2p01 and 8.2ref02 for visible energy/resolution

What CPU optimization of EM physics can offered today?

- Physics Lists
  - QGSP_EMV – good choice for CMS, biased results for LHCb and ATLAS
    - Can be used with correction factors
- Cuts per detector region
  - already used in CMS and ATLAS
- Multiple scattering models per particle type and detector region
  - Expert support may be provided
- Sub-cutoff option per detector region
  - Expert support may be provided
- Tracking cuts in non-important part of geometry

Near future (June 2007)

- G4UrbanMscModel code cleanup
  - done after 8.2 (see talk A.Ribon)
- Optimization of multiple scattering interaction with G4Navigator and geometry
  - Common project with geometry group
  - Basic idea – do not repeat similar computations

To do: speedup one step and reduce number of steps

- Optimization of algorithms
  - profiling tools should few places taking major part of CPU
    - G4UrbanMscModel (g->t conversion, …)
    - G4UniversalFluctuations
    - log and exp frequently used
- Specialization of classes
  - msc per particle type (G4hMultipleScattering)
  - fluctuations per particle type
- Sub-cutoff for bremsstrahlung
  - will allow to increase cuts
- Optimization of number of steps

Prospects for non LHC applications

- Biasing methods
  - in collaboration with other G4 groups, which are doing major part of work

Summary

- Testing suite of EM group allows control physics quality and CPU performance
- EM group provides alternative Physics Lists components
  - requirements from experiments welcome
- There is to do list with high priority
- We will interact with other Geant4 groups on event biasing