Multiple Scattering in Geant4 V8.0

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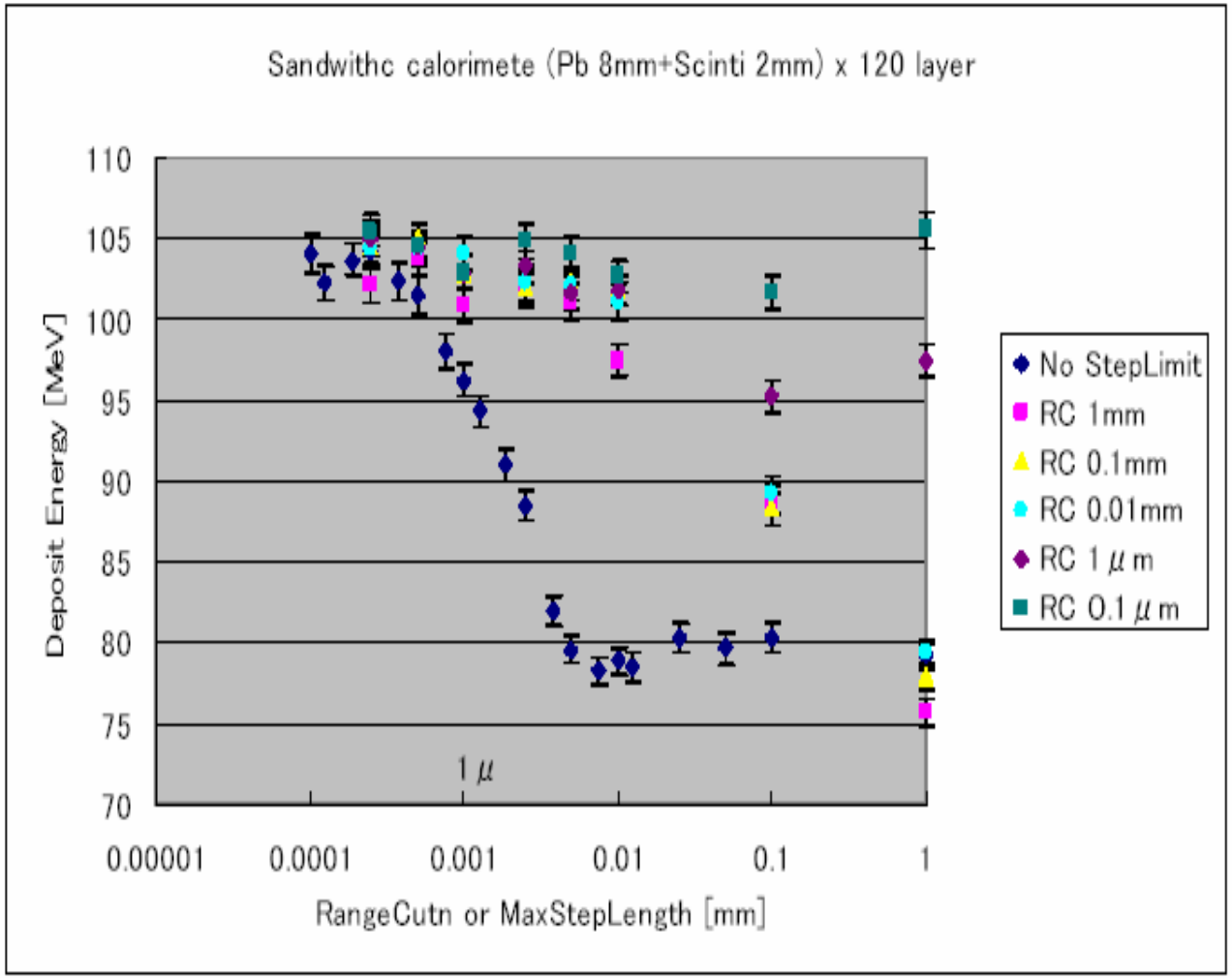
Outline

- Motivation
- The changes
- Few results
- Backard compatibility

Sampling calorimeter : cut dependance



- Evis constant if msc off

Step limitation in Geant4 (1/2)

- Ionization and brems
  - Production threshold aka *CutinRange*
  - Indirect : the mean free path depend of CutinRange

- Ionization and brems
  - Max energy loss per step. dR/R < *dRoverRange*

- Multiple scattering
  - Limits the step after a boundary, to allow back scattering of low energy e-
  - Step = fr.Range fr = *facRange* = 20%

Step limitation in Geant4 (2/2)

- Tracking
  - Direct step max ‘by hand’.
  - Utility class *G4StepLimiter*

- Tracking in magnetic field

- Geometry
  - Volume boundaries
  - *Voxelisation*. Popular to compute dose distribution in quasi homogeneous media

Consistency test of the electron transport algorithm in the GEANT4 Monte Carlo code

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Abstract

In this work, the condensed history algorithm in GEANT4 (version 4.6.2.p01) is examined. We performed simulations of an ionization chamber composed of water for 1.25 MeV incident photon beams under Fano conditions, and evaluated the consistency of the cavity response for several combinations of electron transport parameters. GEANT4 permits electrons to reach geometric boundaries in large steps, and underestimates lateral displacement near interfaces. Step size artefacts due to distortions in electron fluence and angular distributions reduce the cavity dose by up to 39%. Accurate cavity response can be achieved using severe user-imposed step size restrictions. We suggest that improvements in the electron transport algorithm in GEANT4 should address the handling of boundary crossing.

(Some figures in this article are in colour only in the electronic version)

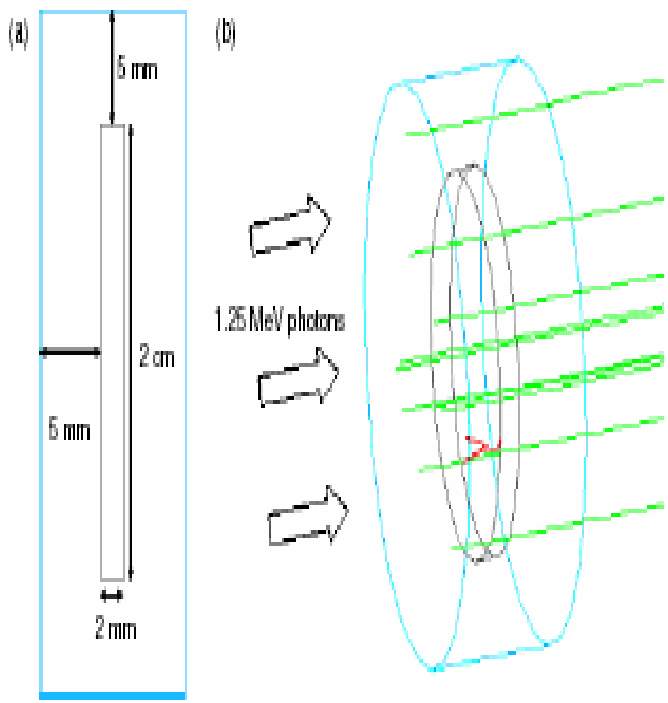


Figure 1. (a) Dimensions of pancake ion chamber for Fano cavity study. The entire chamber is composed of water, and the cavity has a reduced density of 0.001 g cm^{-3}. (b) A 1.25 MeV photon broad beam impinges on the flat end of the chamber. The photon regeneration technique is used to restore the photon energy and direction to its original states at every interaction site.

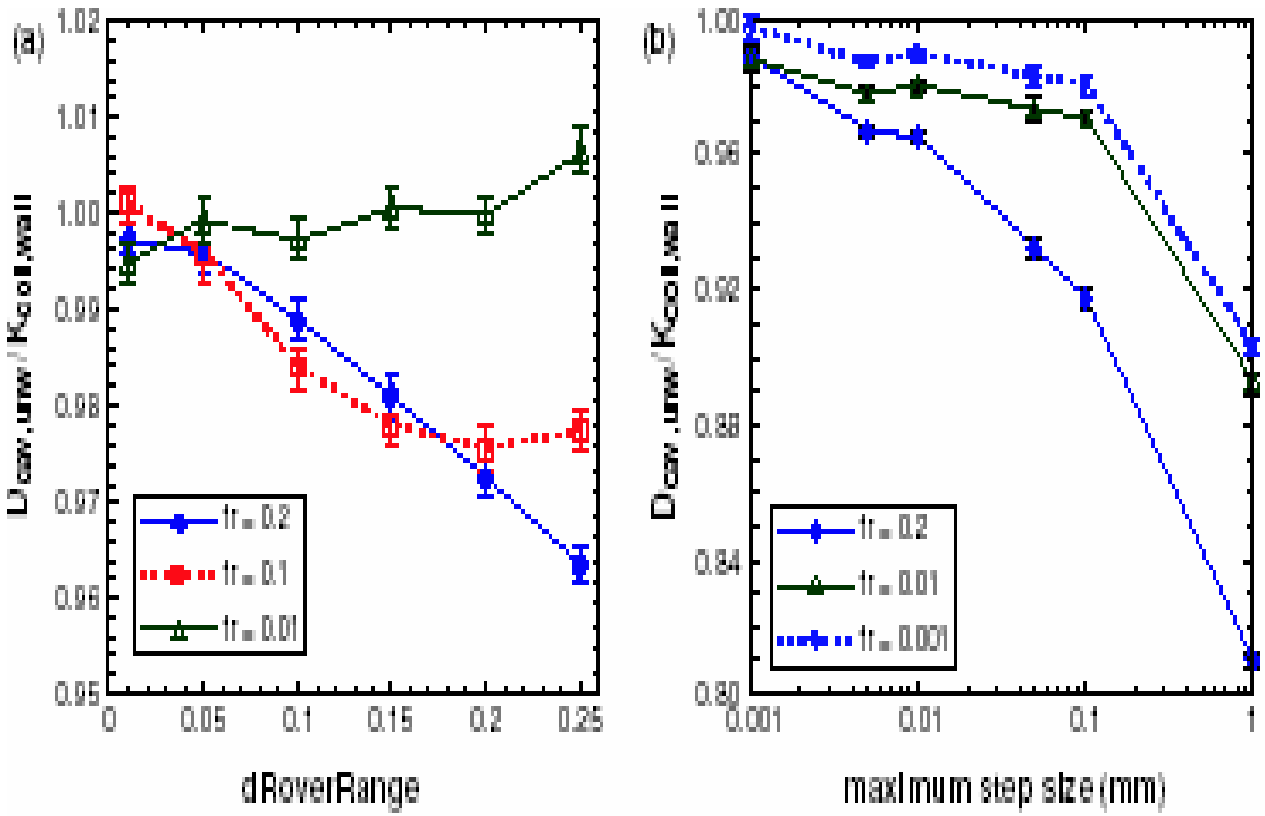


Figure 2. Fano cavity response of 1.25 MeV incident photons as a function of (a) *dRoverRange* (maximum electron step = 1 m), and (b) maximum electron step size (*dRoverRange* = 1). For the default case (*dRoverRange* = 1, unlimited maximum electron step, f_r = 0.2) the cavity response is 0.609 ± 0.002. Simulations were run using the CSDA approximation. Error bars represent the standard errors of the mean.

Step Limitation from MSC

- Limit the step from the beginning of track
  - Not only after a boundary
- Step = fr . Max (range, lambda)
  - New default fr = 0.02 (instead of 0.2)
  - Strong constraint only for low energy particles
- Ensure that a track always does few steps in any volume

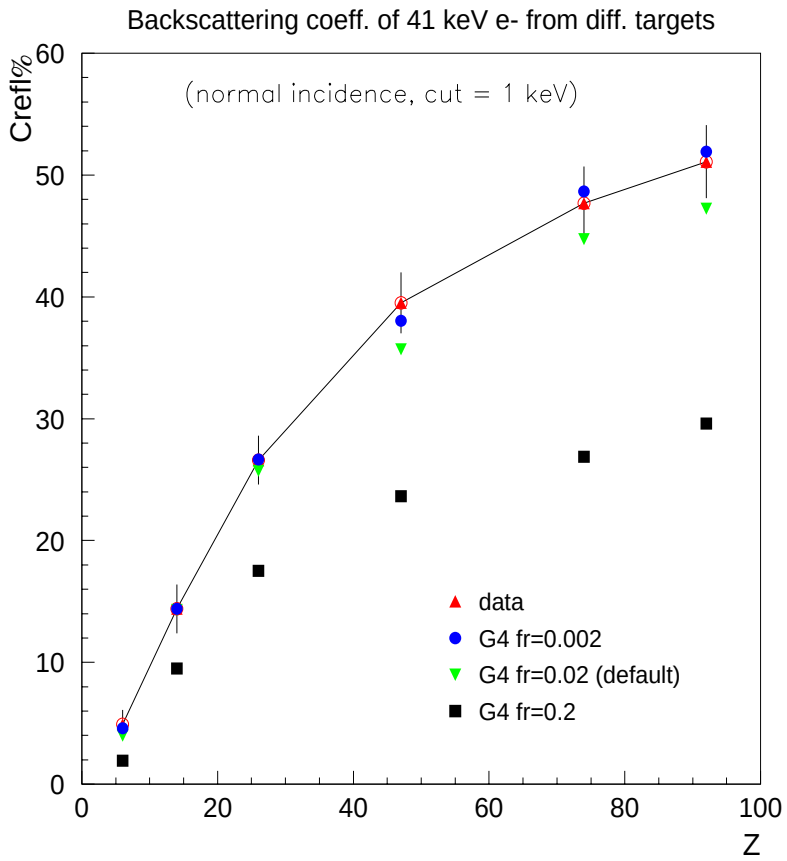
  more than 1

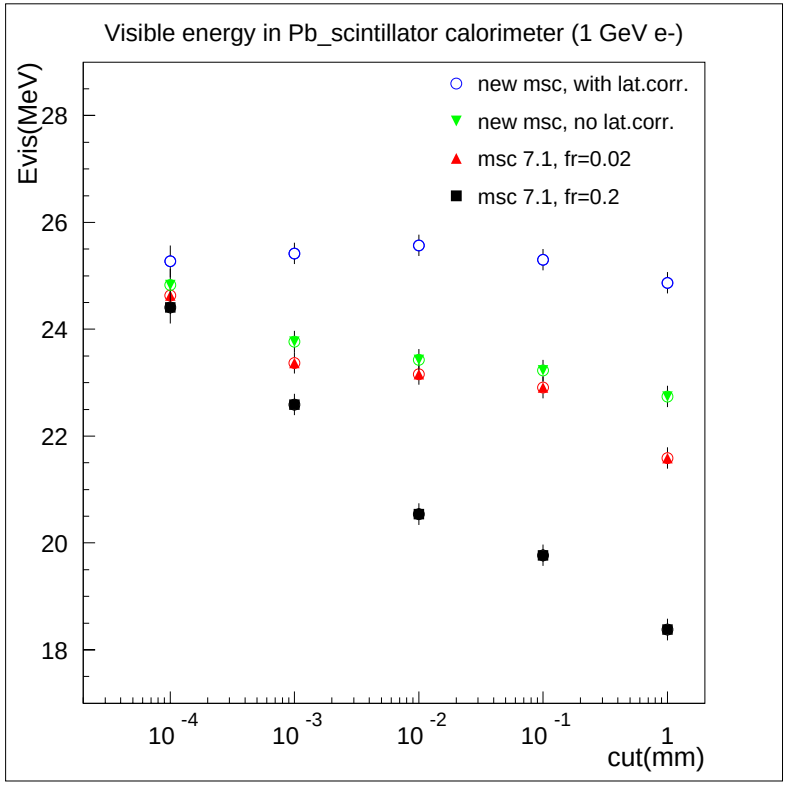
Final state for MSC

- Reevaluate safety radius before to perform lateral displacement
  - d < safety (*safefy is often underestimated*)

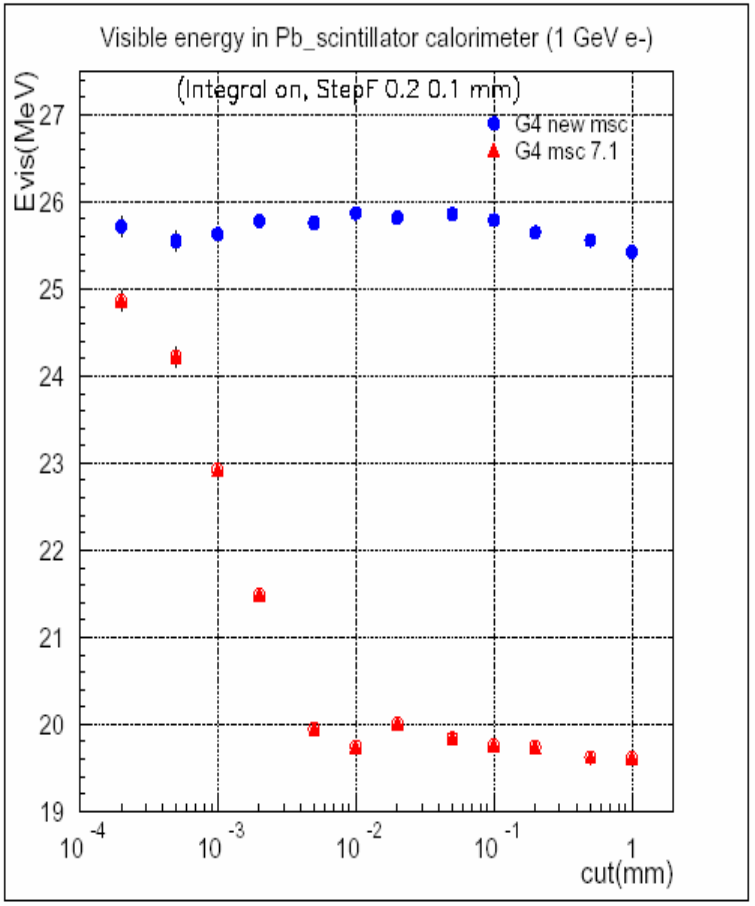
- Correlate final direction with lateral displacement
  - u.d = f (lambda) taken from Lewis theory

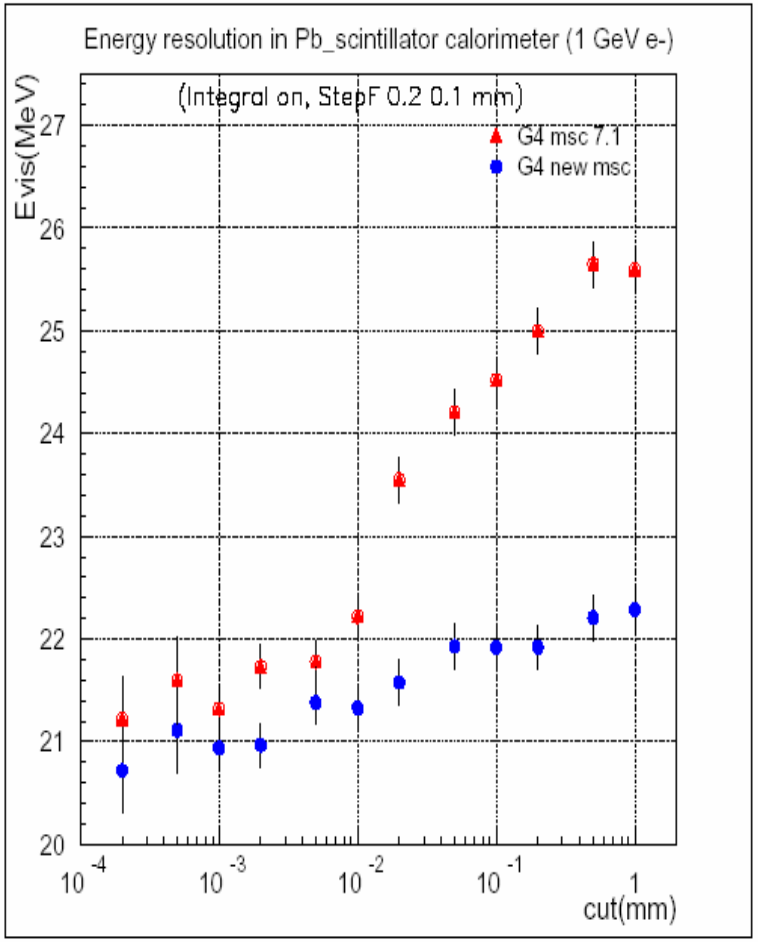
Result of Upgrades



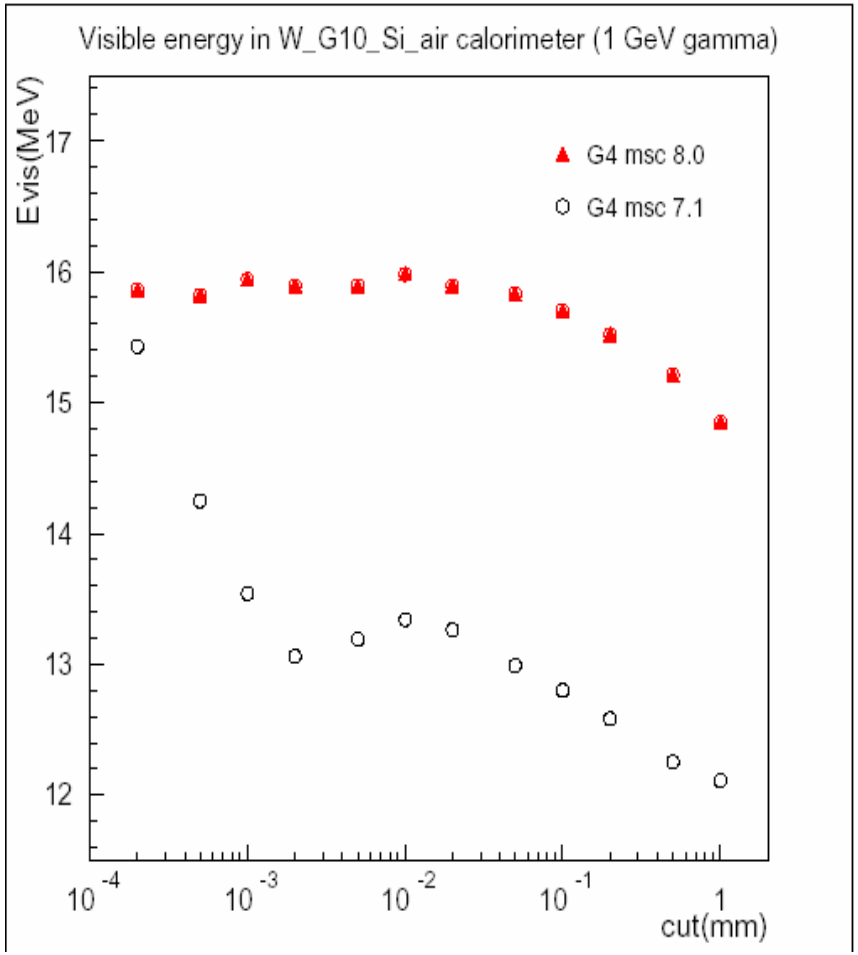


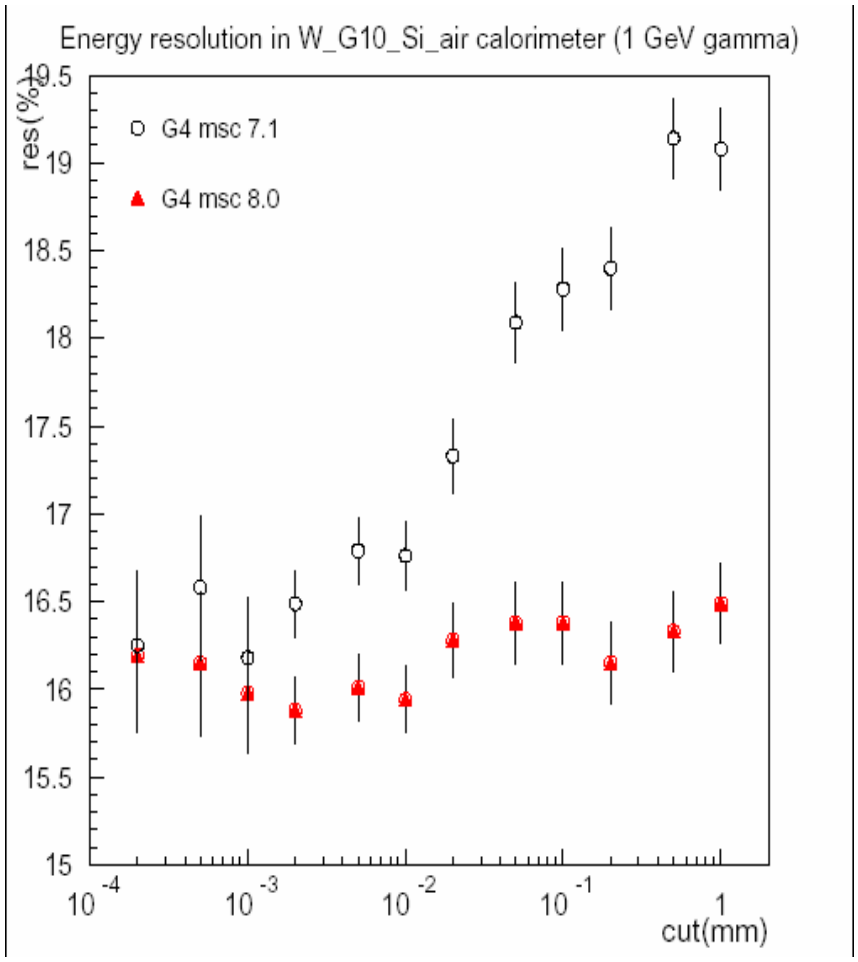
ILC : Pb(8mm)-Sc(2mm)





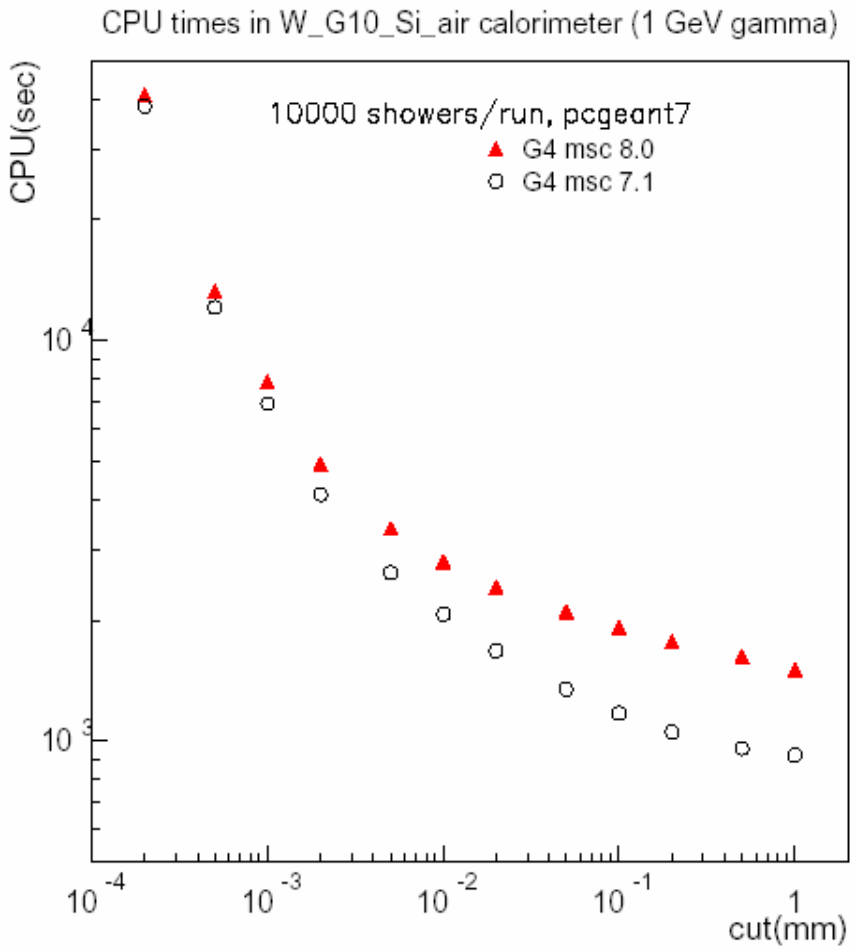
ILC : W(2.5mm)-Si(0.32mm)



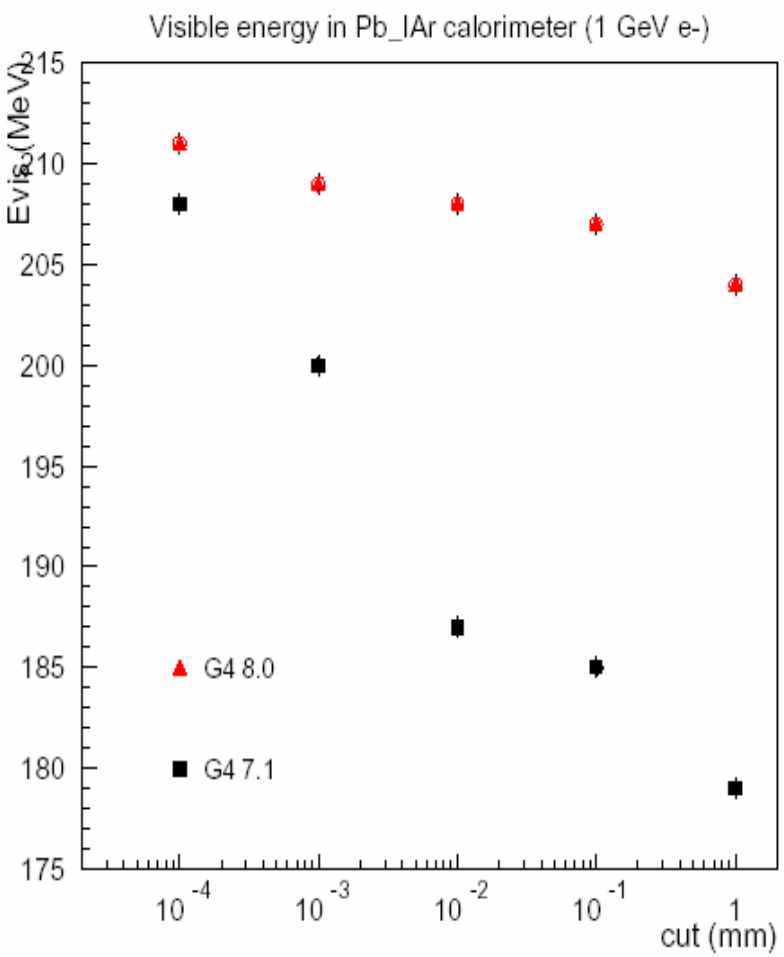


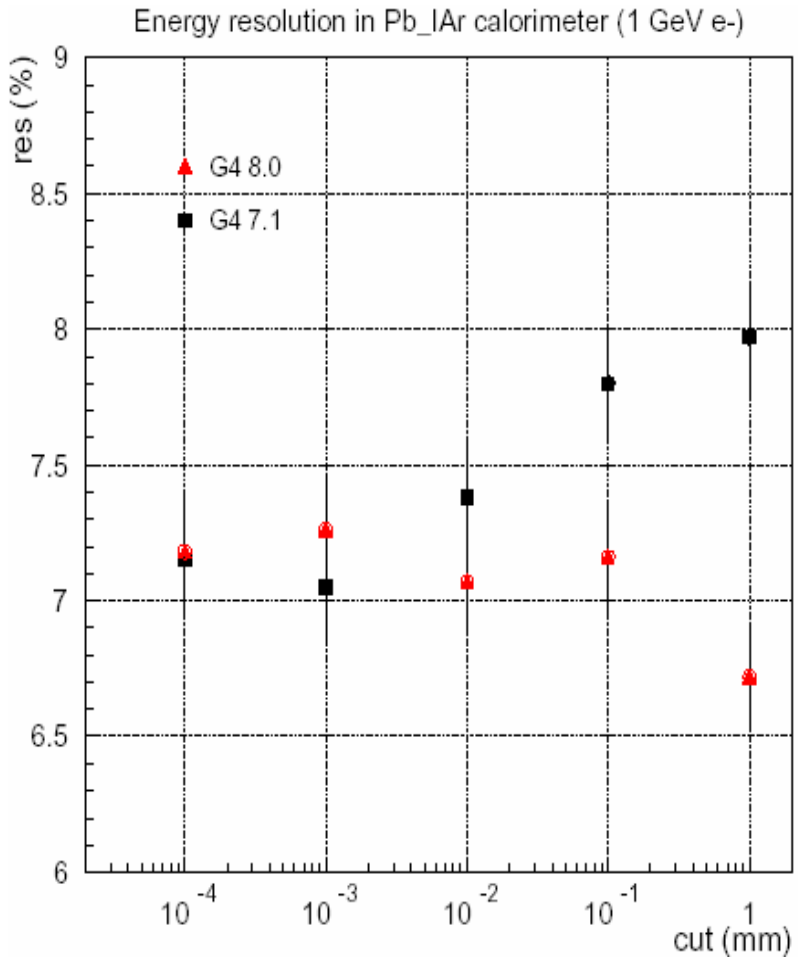
ILC : W(2.5mm)-Si(0.32mm)

- cpu penalty :
  - 70 % at 1mm
  - 10 % at 1um

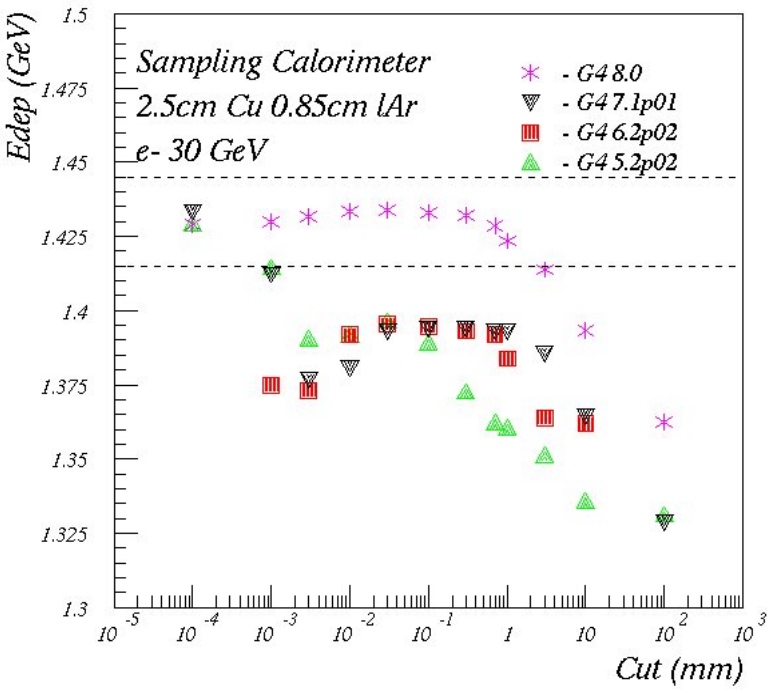


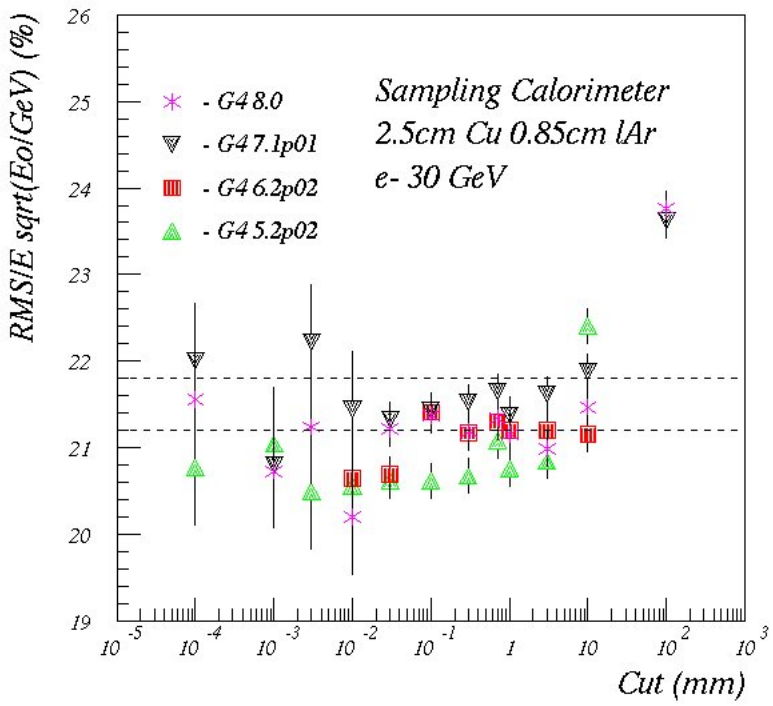
Pb (2.3 mm) – lAr (5.7 mm)



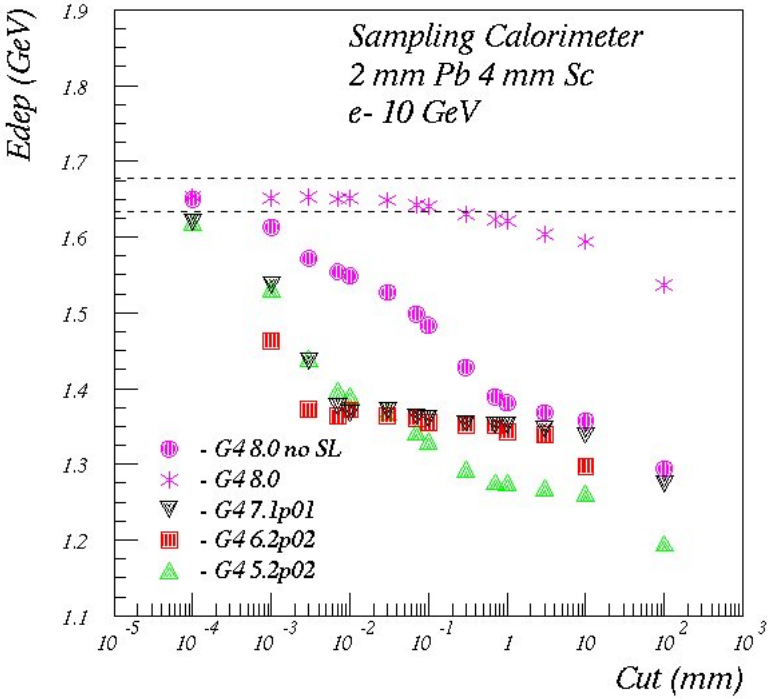


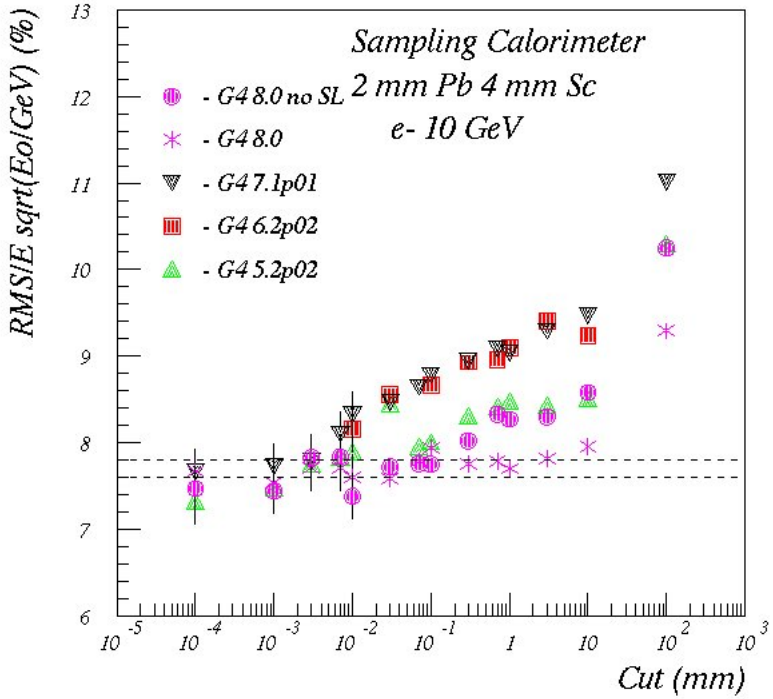
Atlas HEC : Cu(25mm)-lAr(8.5mm)



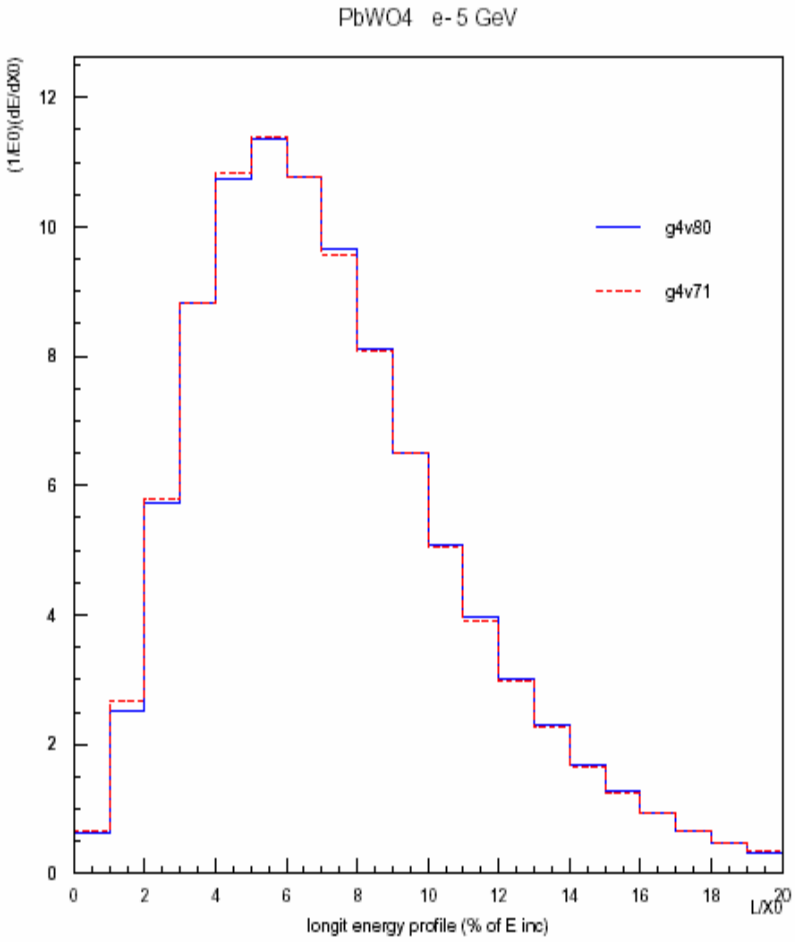


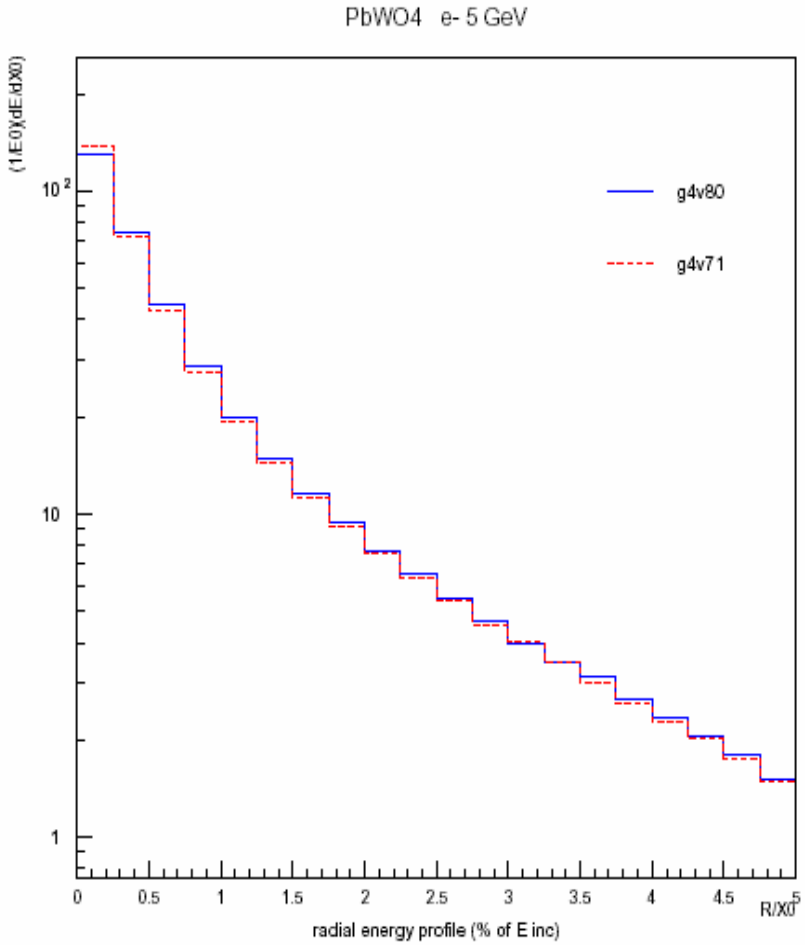
LHCb : Pb(2mm)-Sc(4mm)



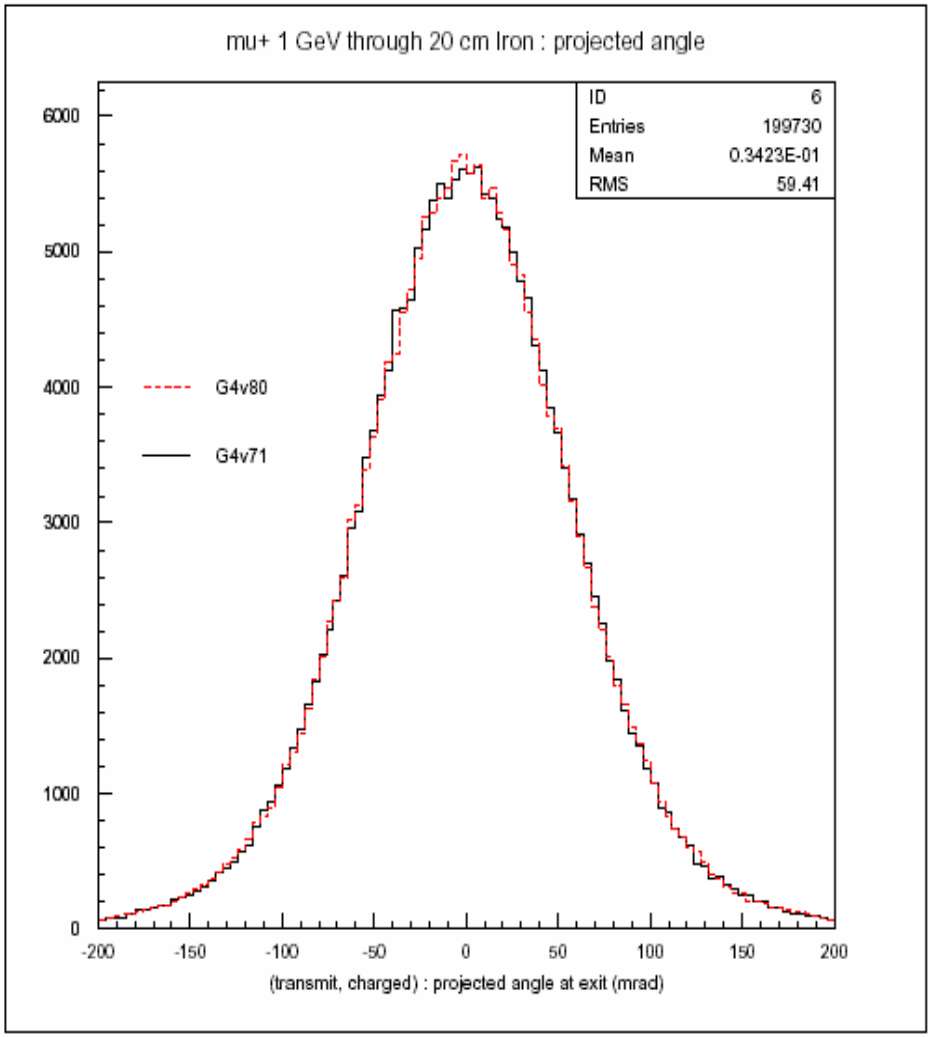


PbWO4


PbWO4 e- 5 GeV
(1/E0)(dE/dX0)
g4v80
g4v71
L/X0
longit energy profile (% of E inc)


PbWO4 e- 5 GeV
(1/E0)(dE/dX0)
g4v80
g4v71
R/X0
radial energy profile (% of E inc)

- Model of angular distribution remains unchanged



Backward compatibility

- New Multiple Scattering is the default
- There are 2 equivalent possibilities to restaure old behaviour :
  - muls -> MscStepLimitation (*false*)
  - old code frozen as G4MultipleScattering71

Summary

- Now, Multiple Scattering is a process which limits the step size systematically
  - → *time penalty*

- The model is the same as before, with lateral correlation in addition

- Old code is available