MSC evolution from 7.1 to 8.1

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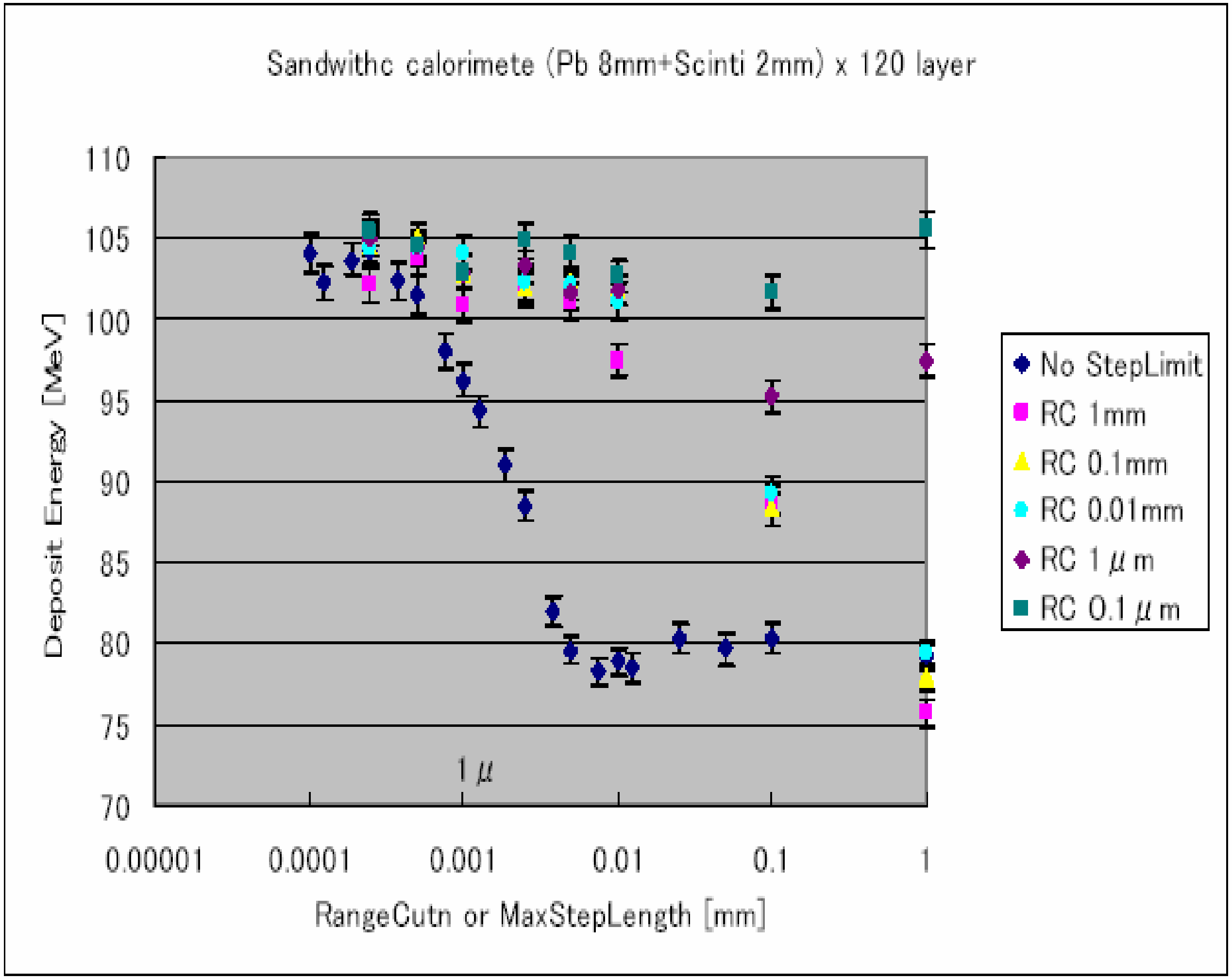
Outline

- Motivations
- The changes
- Few results
- Backard compatibility

sampling calorimeter : cut dependance



- Evis constant if msc off

Fano cavity simulation

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)

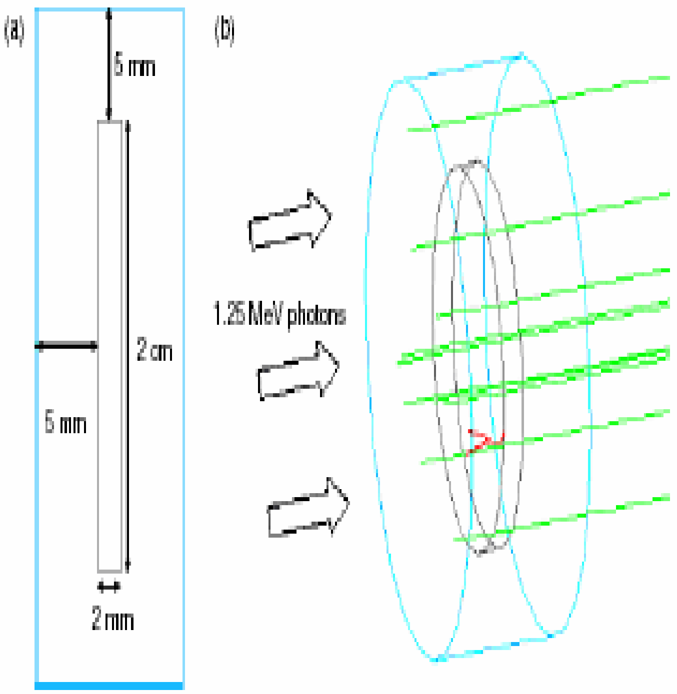


Figure 1. (a) Dimensions of pancake ion chamber for Fano cavity study. The entire chamber is composed of water, and the cavity has a reduced density of 0.001 g cm^{-3}. (b) A 1.25 MeV photon broad beam impinges on the flat end of the chamber. The photon regeneration technique is used to restore the photon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

Fano cavity : step dependance

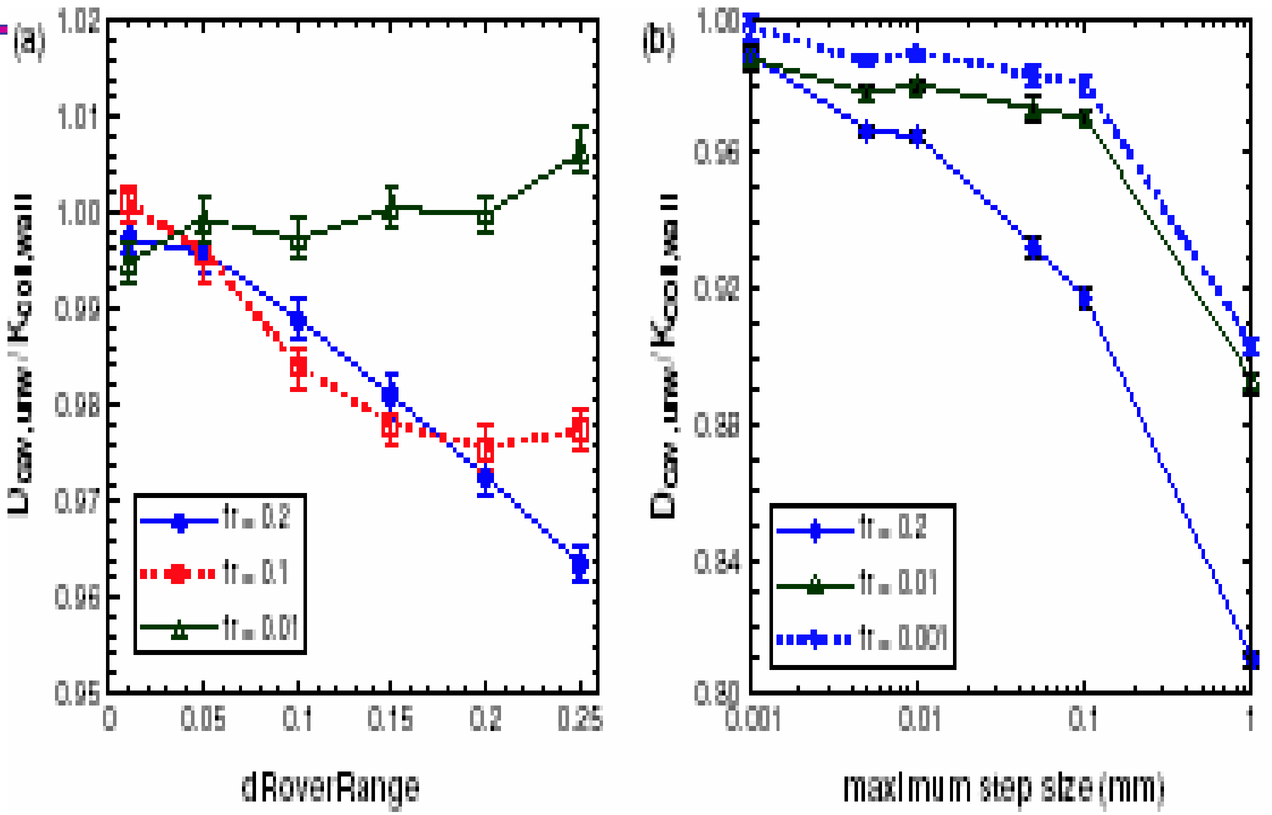


Figure 2. Fano cavity response of 1.25 MeV incident photons as a function of (a) *dRoverRange* (maximum electron step = 1 m), and (b) maximum electron step size (*dRoverRange* = 1). For the default case (*dRoverRange* = 1, unlimited maximum electron step, $f_r = 0.2$) the cavity response is 0.609 ± 0.002.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

step limitation from MSC : 7.1 → 8.1

7.1 → 8.0

- step limit defined at first step and reevaluated after a boundary
  - applied only if range > safety
- step = fr . max (range, λ)
  - new default fr = 0.02 (instead of 0.2)

    →strong constraint only for low energy particles
- step limit min = 1 um in any material
- ensure that a track always goes few steps in any volume

  → at least 3

8.0 →8.1

- step limit min becomes material dependant, via λ :

  → step limit min = max (0.04 λ, 5 nm)

Final state for MSC : 7.1 → 8.1

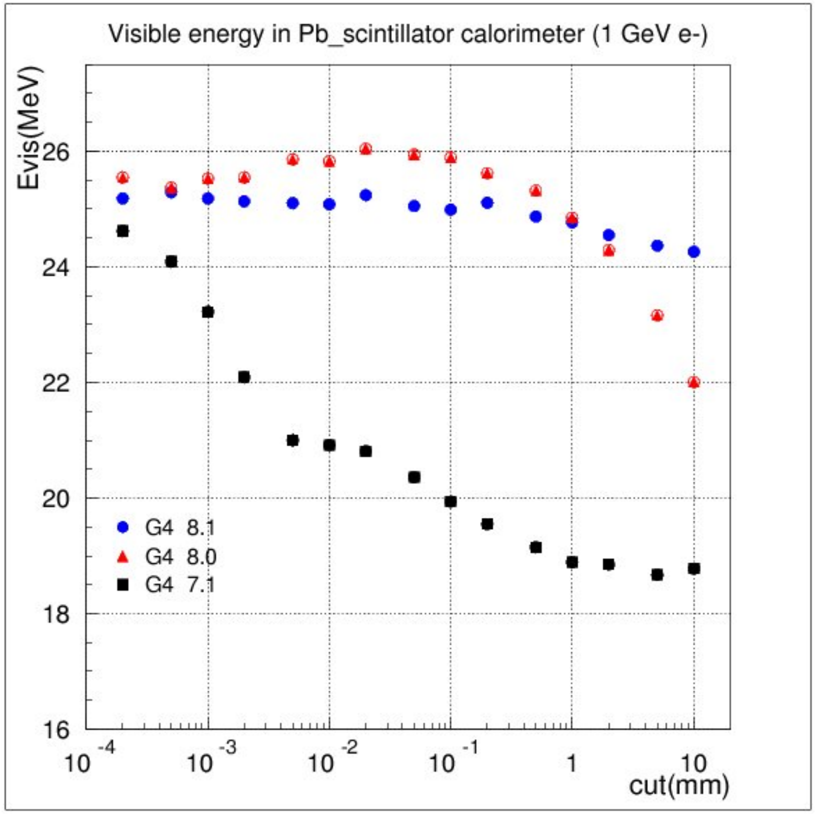
7.1 → 8.0

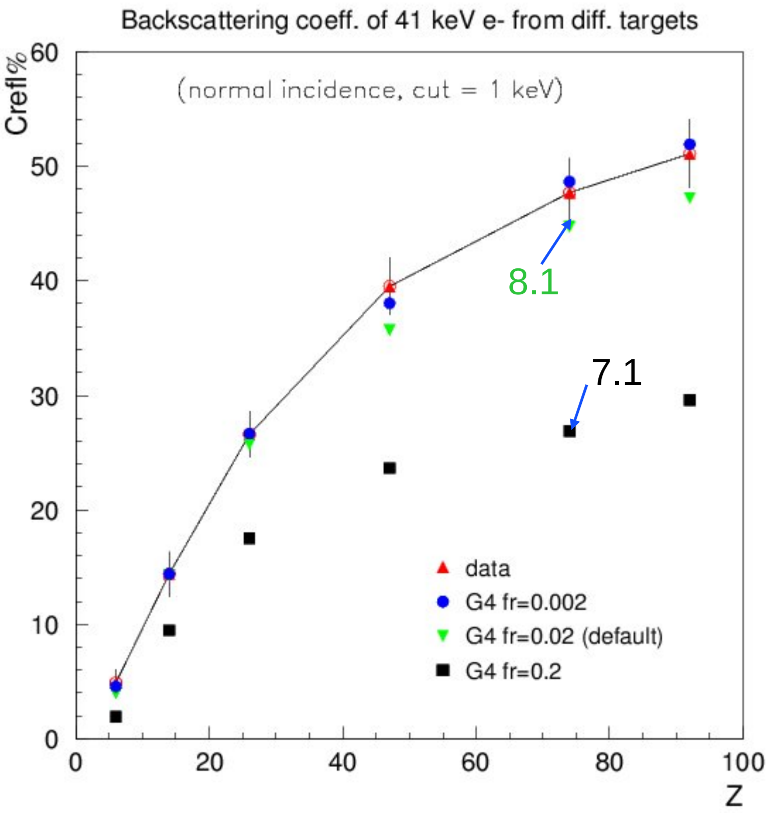
- Reevaluate safety radius before to perform lateral displacement
  - d < safety (*safefy is often underestimated*)
- Correlate final direction with lateral displacement
  - u.d = f (λ) taken from Lewis theory

8.0 → 8.1

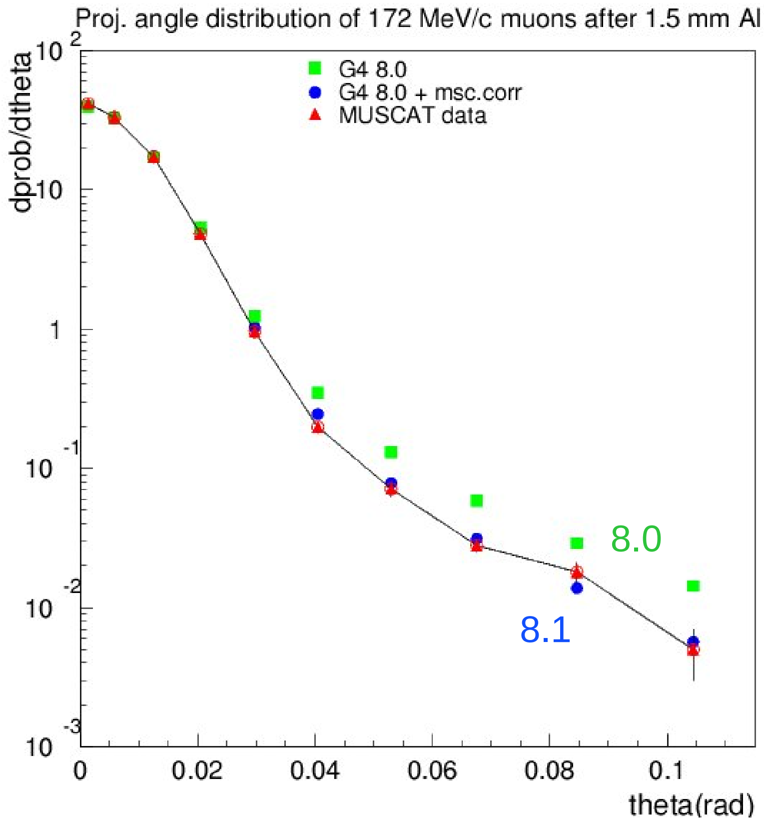
- Angular distribution : both central part and tail slightly modified

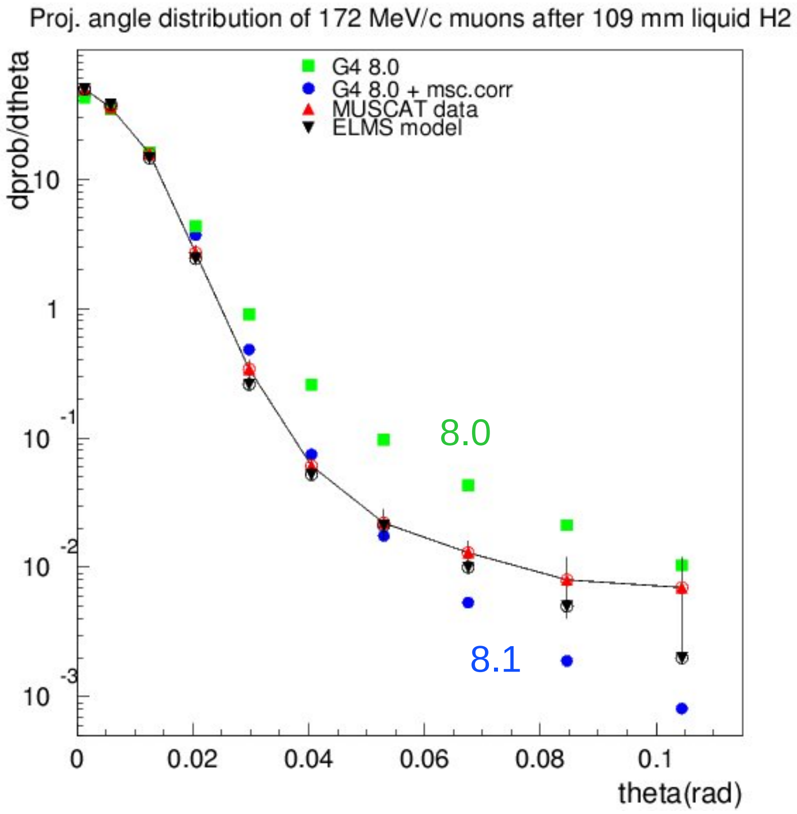
result of upgrades





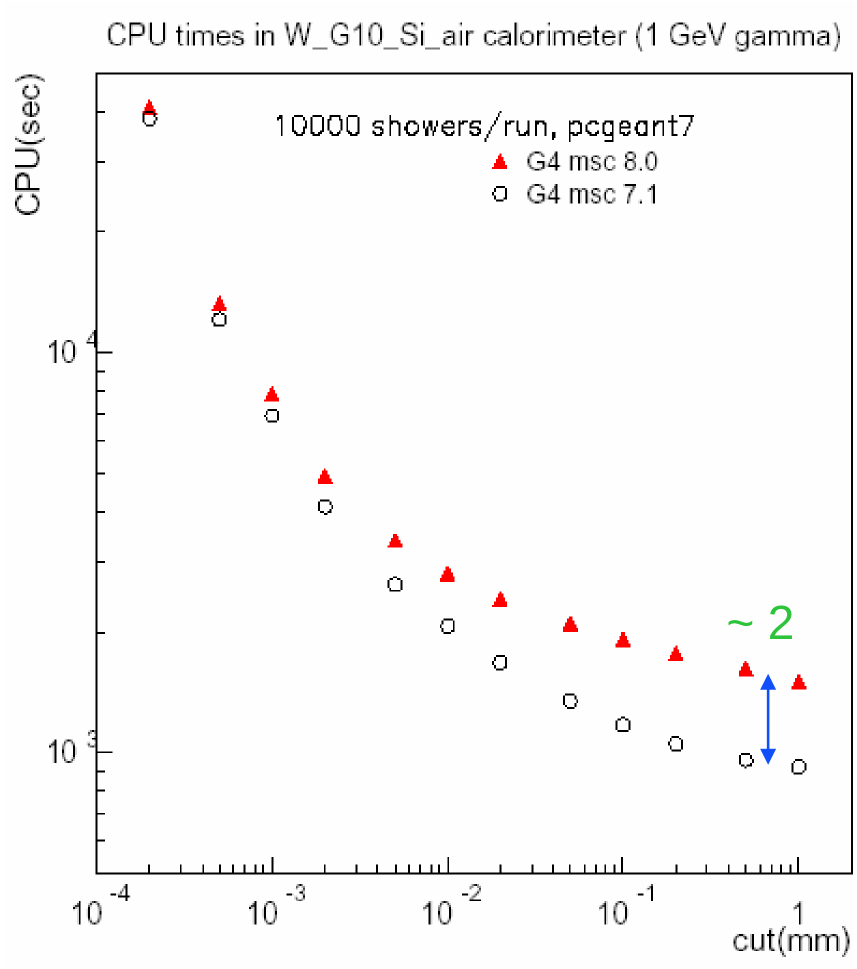
Muscat data


Proj. angle distribution of 172 MeV/c muons after 1.5 mm Al
G4 8.0
G4 8.0 + msc.corr
MUSCAT data
dprob/dtheta
theta(rad)
8.0
8.1


Proj. angle distribution of 172 MeV/c muons after 109 mm liquid H2
G4 8.0
G4 8.0 + msc.corr
MUSCAT data
ELMS model
dprob/dtheta
theta(rad)
8.0
8.1

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

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



Backward compatibility

- New Multiple Scattering is the default

- There are 2 possibilities to restaure 7.1 behaviour :
  - old code frozen as G4MultipleScattering71

    keep it temporarely to help the migration

  - muls -> MscStepLimitation (*false*)

    do not apply step limitation, but keep up to date other features of the model : angular distribution …etc…

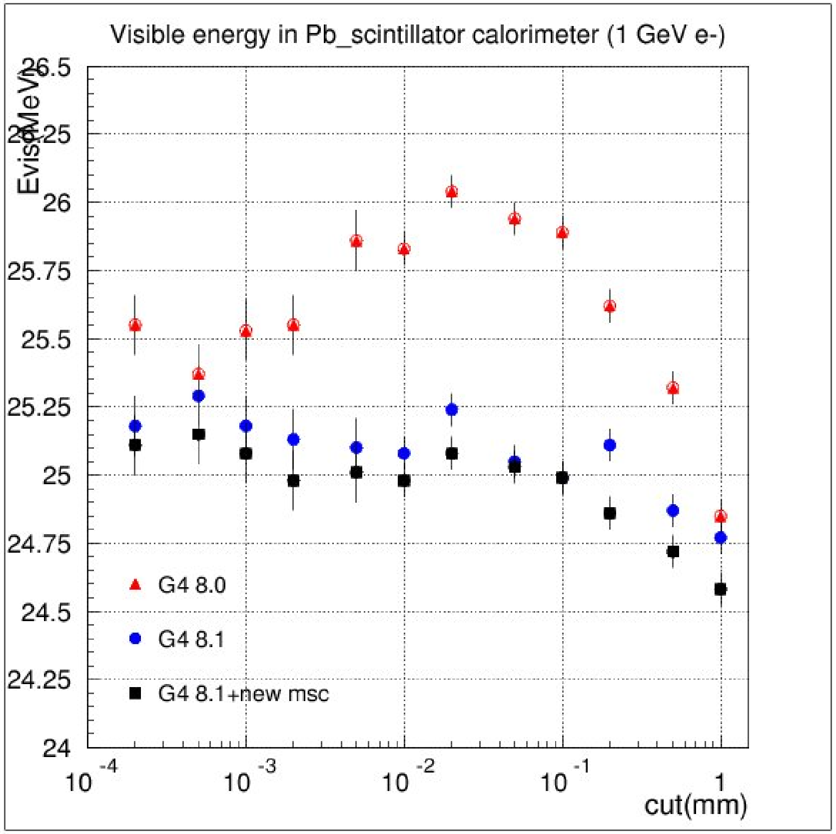
beyond 8.1

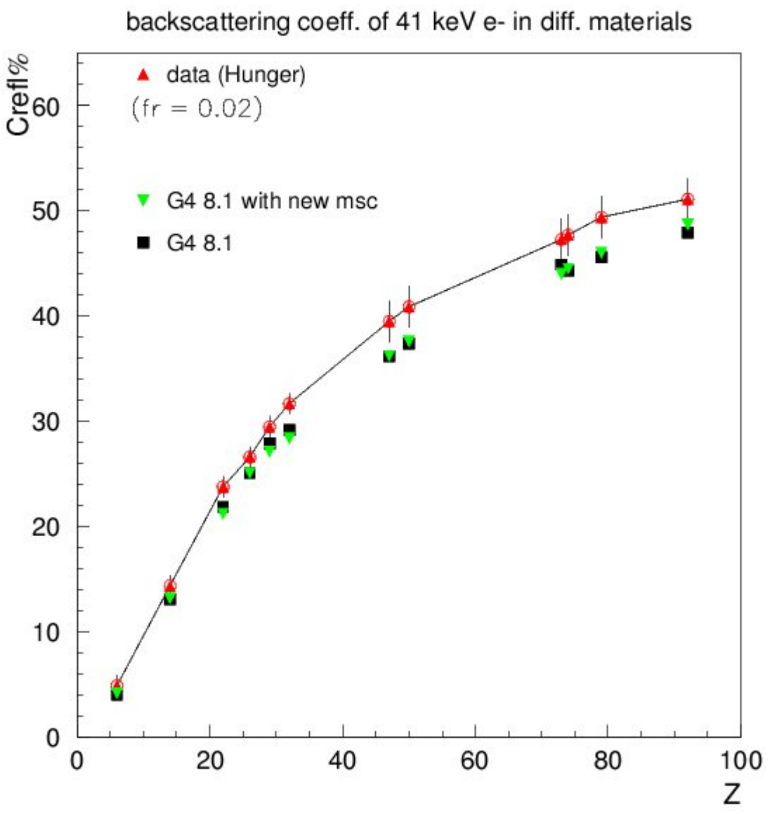
- single Coulomb scattering at boundaries
  - 1 very small step (~ λ elastic) before boundary crossing
  - apply approximate single Coulomb scattering in this step
    → reduce artefact step size dependance ?

- weaker step restriction for high energy particles
  - bigger effective facRange (→ improve speed)

- tail of angular distribution modified

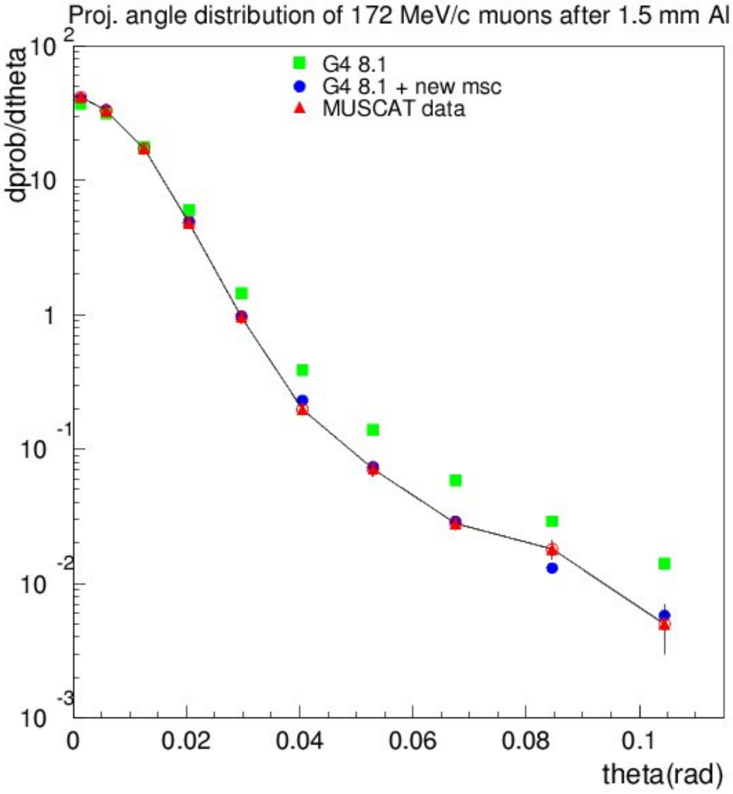
beyond 8.1 : single scattering and effective facrange

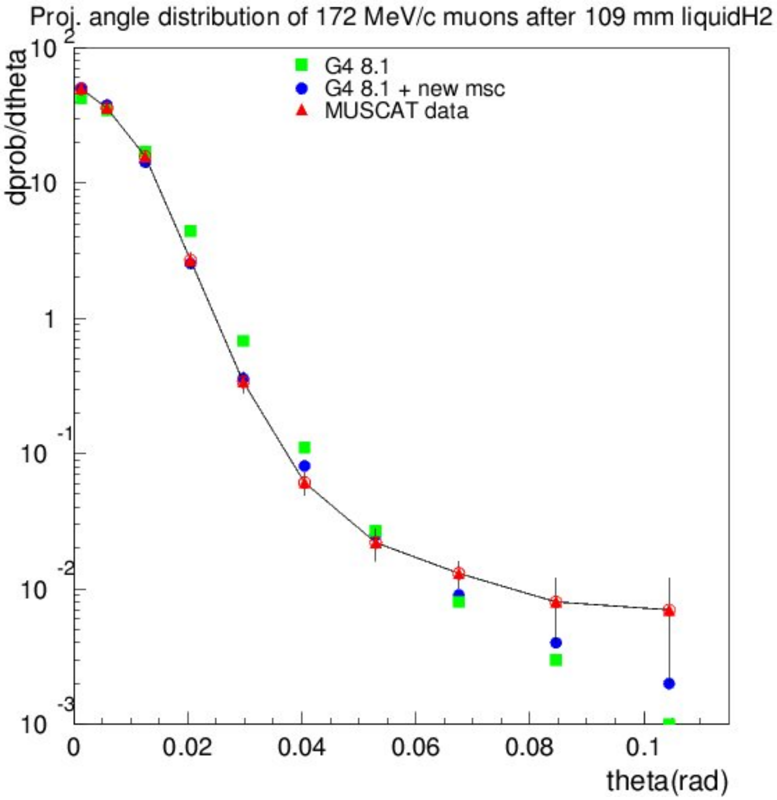




no big change, but slightly faster anyway

beyond 8.1 : tail of angular distribution





improve tail of angular distribution

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

- introduce single Coulomb scattering at boundaries in next version