How to check the electron csda range ?

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LAPP (Annecy)

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G4 example gives STRANGE energy loss and csda range

Base: Physics List
Date: Thu, 12 Jan 2006 05:25:30 GMT
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Experts,
  A simple simulation adapted from "geant4.7.0/examples/extended/
electromagnetic/TestEm1" shows STRANGE energy loss and csda range
with low-energy physcics package and penelope package. The simulation
with standard physics package goes rightly. Relevant aspects are
listed below.

Could anyone give some suggest or instruction?
Is there something wrong with the G4LowEnergyIonization class and
G4PenelopeIonization class ?

Thanks in advance.

os: redhat 9.0
G4: 4.7.1.p01

adaption: When TestEm1 has been compiled, thr micro file run01.mac
was used to calculate the csda range.

DETAILS below

Simulation with STANDARD package ===>>> things OK

//
//
#run01.mac

/testem/phys/setGCut 95 cm
/testem/phys/setECut 95 cm

/run/initialize

 The Box is 10 m   of Water
PhysicsList::SetCuts:CutLength : 1 mm

Csda range

$$R(E) = \int_{e=0}^{e=E} \frac{1}{f(e)}\, de \qquad f(e) \equiv \left(\frac{dE}{dx}\right)_{full} = \text{Berger - Seltzer formula}$$

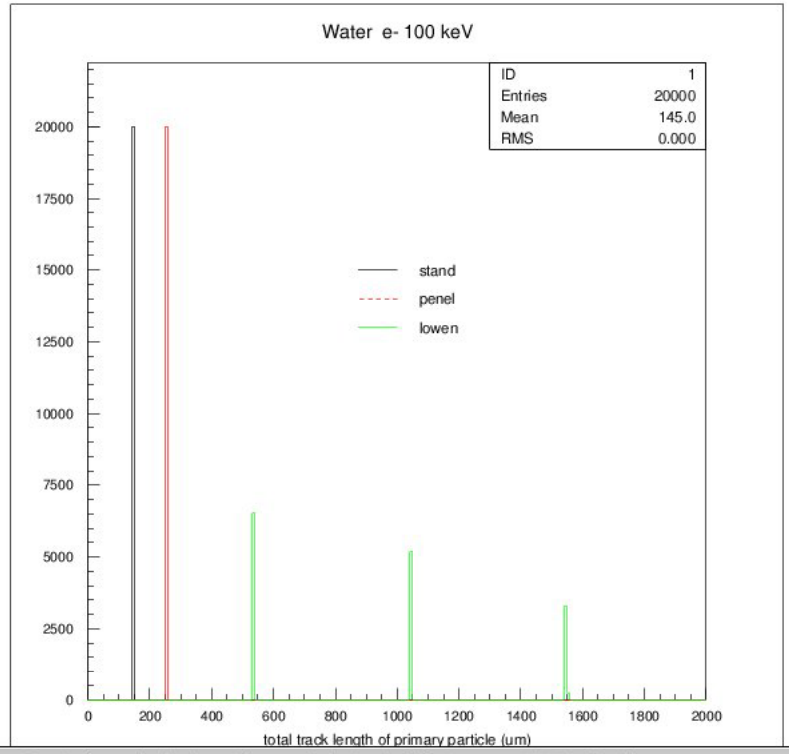
- Full = unrestricted = no delta-rays generation

  → infinity cut (> maximum transferable energy)

- In addition :

  no energy fluctuation (straggling)

  no multiple scattering




```
# $Id: erange.mac,v 1.5 2006/01/19 12:14:24 ma
#
# Macro file for "TestEm1.cc"
#
# compute the csda range of primary particle
#
/control/verbose 2
/run/verbose 2
#
/testem/det/setMat Water
#
/testem/phys/addPhysics  standard
###/testem/phys/addPhysics  penelope
###/testem/phys/addPhysics  livermore
#
/run/initialize
#
/testem/phys/setCuts 1 km
#
# eliminate straggling
/process/inactivate msc
/process/eLoss/fluct false
#
/testem/gun/setDefault
/gun/particle e-
/gun/energy 100 keV
#
/tracking/verbose 1
/run/beamOn 1
```

erange2.out - /home/maire/geant4/examples/extended/electromagnetic/TestEm1/

File Edit Search Preferences Shell Macro Windows Help

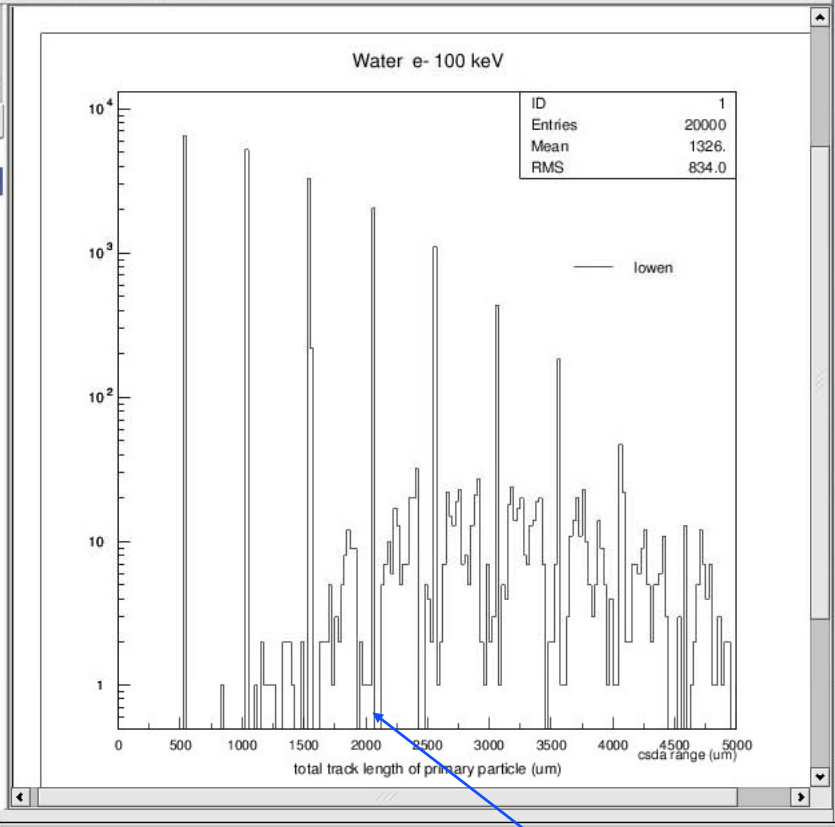
```
**********************************************************************************************************
* G4Track Information:   Particle = e-,   Track ID = 1,   Parent ID = 0
**********************************************************************************************************

Step#      X          Y          Z         KineE    dEStep   StepLeng  TrakLeng    Volume     Process
    0     -5 m        0 fm       0 fm     100 keV     0 eV      0 fm       0 fm       Water    initStep
    1     -5 m        0 fm       0 fm       0 eV    100 keV   143 mum    143 mum      Water       eIoni

 total energy deposit: 100 keV

-------------------------------------------------------
 Primary particle :
 true Range = 143.09 mum   rms = 1144.3 fm
 proj Range = 143.09 mum   rms = 672.54 fm
 proj/true  = 1
 transverse dispersion at end = 0 fm
      mass true Range from simulation = 14.309 mg/cm2
       from PhysicsTable (csda range) = 14.309 mg/cm2
```

xterm <2>




```
 1 # $Id: erange.mac,v 1.5 2006/01/19 12:14:24 m
 2 #
 3 # Macro file for "TestEm1.cc"
 4 #
 5 # compute the csda range of primary particle
 6 #
 7 /control/verbose 2
 8 /run/verbose 2
 9 #
10 /testem/det/setMat Water
11 #
12 ###/testem/phys/addPhysics  standard
13 ###/testem/phys/addPhysics  penelope
14 /testem/phys/addPhysics  livermore
15 #
16 /run/initialize
17 #
18 /testem/phys/setCuts 1 km
19 #
20 # eliminate straggling
21 /process/inactivate msc
22 /process/eLoss/fluct false
23 #
24 /testem/gun/setDefault
25 /gun/particle e-
26 /gun/energy 100 keV
27 #
28 /run/beamOn 20000
29
```

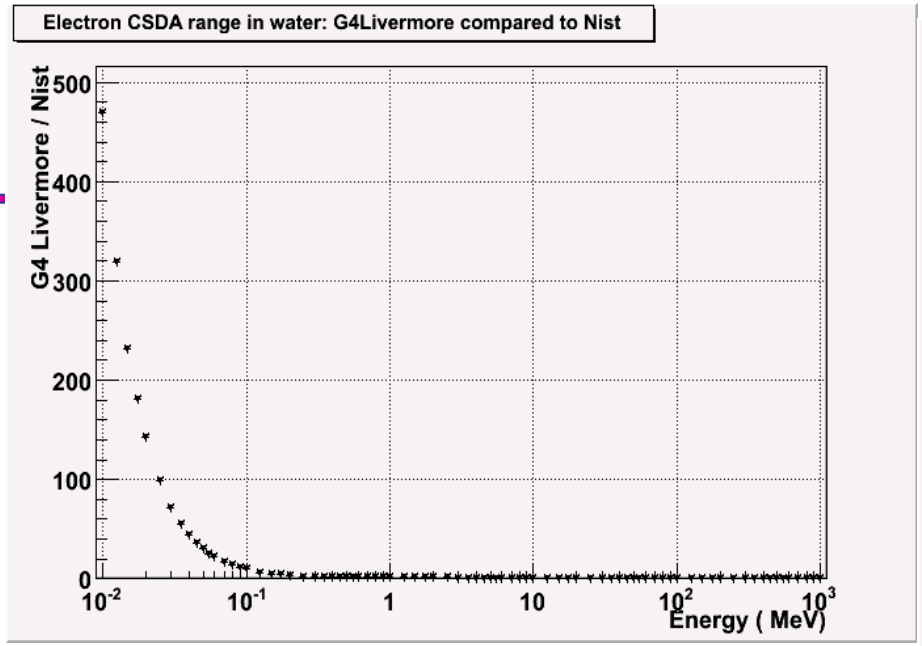
liver.out - /home/maire/geant4/examples/extended/electromagnetic/TestEm1/

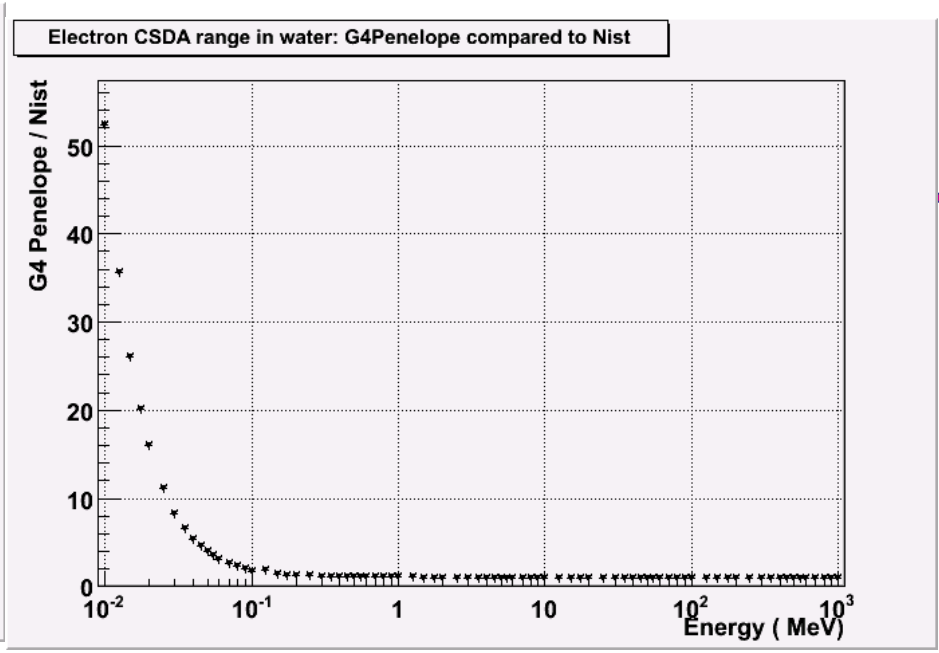
File Edit Search Preferences Shell Macro Windows Help

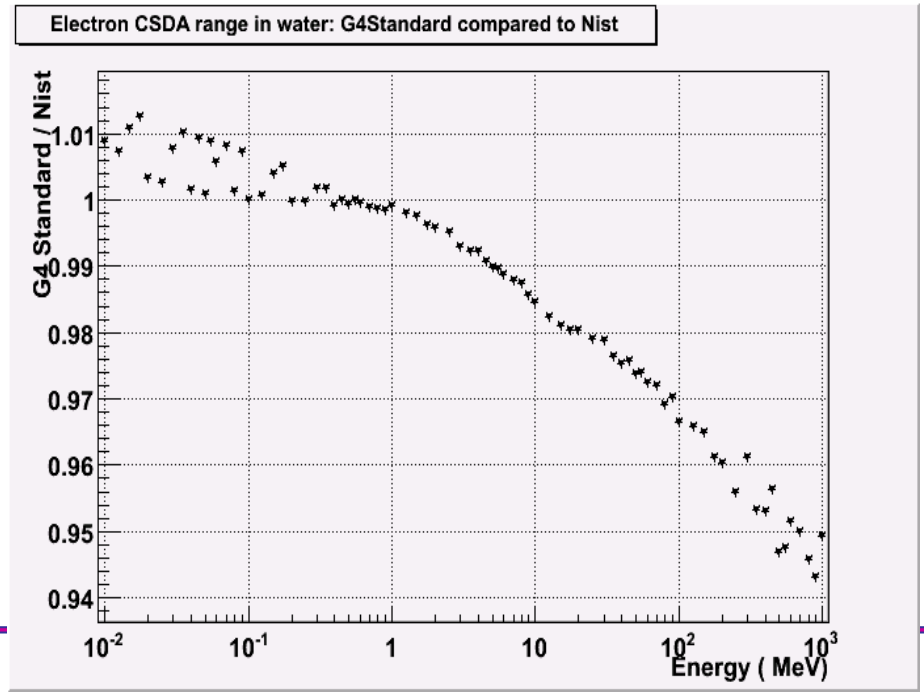
```
 2 ******************************************************************************************************
 3 * G4Track Information:   Particle = e-,   Track ID = 1,   Parent ID = 0
 4 ******************************************************************************************************
 5
 6 Step#      X          Y          Z          KineE     dEStep    StepLeng  TrakLeng     Volume     Process
 7     0      -5 m       0 fm       0 fm     100 keV      0 eV       0 fm       0 fm        Water    initStep
 8     1      -5 m       0 fm       0 fm    7.42 keV   92.6 keV    537 um     537 um        Water  LowEnergyIoni
 9     2      -5 m       0 fm       0 fm     322 eV     7.1 keV    506 um    1.04 mm        Water  LowEnergyIoni
10     3      -5 m       0 fm       0 fm      66 eV     256 eV     505 um    1.55 mm        Water  LowEnergyIoni
11     4      -5 m       0 fm       0 fm       0 eV      66 eV     505 um    2.05 mm        Water  LowEnergyIoni
12
13 ******************************************************************************************************
14 * G4Track Information:   Particle = e-,   Track ID = 1,   Parent ID = 0
15 ******************************************************************************************************
16
17 Step#      X          Y          Z          KineE     dEStep    StepLeng  TrakLeng     Volume     Process
18     0      -5 m       0 fm       0 fm     100 keV      0 eV       0 fm       0 fm        Water    initStep
19     1      -5 m       0 fm       0 fm       0 eV    100 keV    537 um     537 um        Water  LowEnergyIoni
```

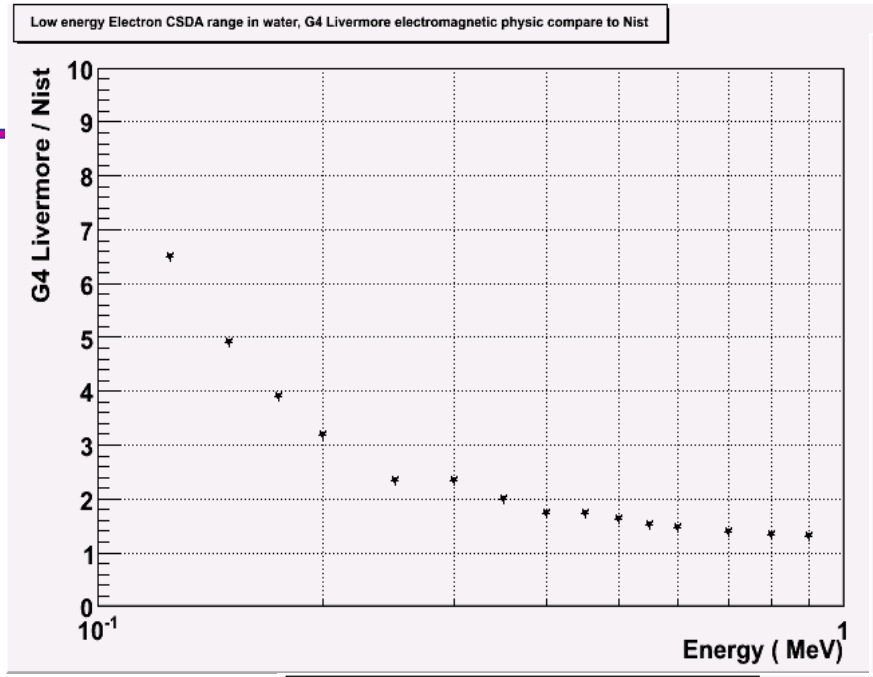
xterm <2>

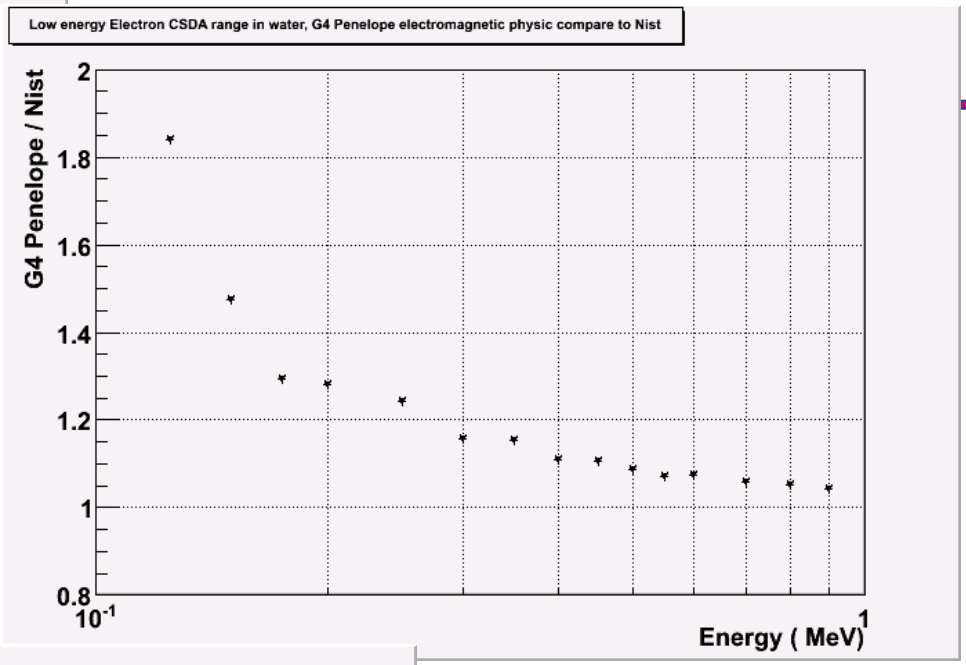
```
On this machine the G4LIB
/home/maire > import -win
oot screnn.jpeg
```

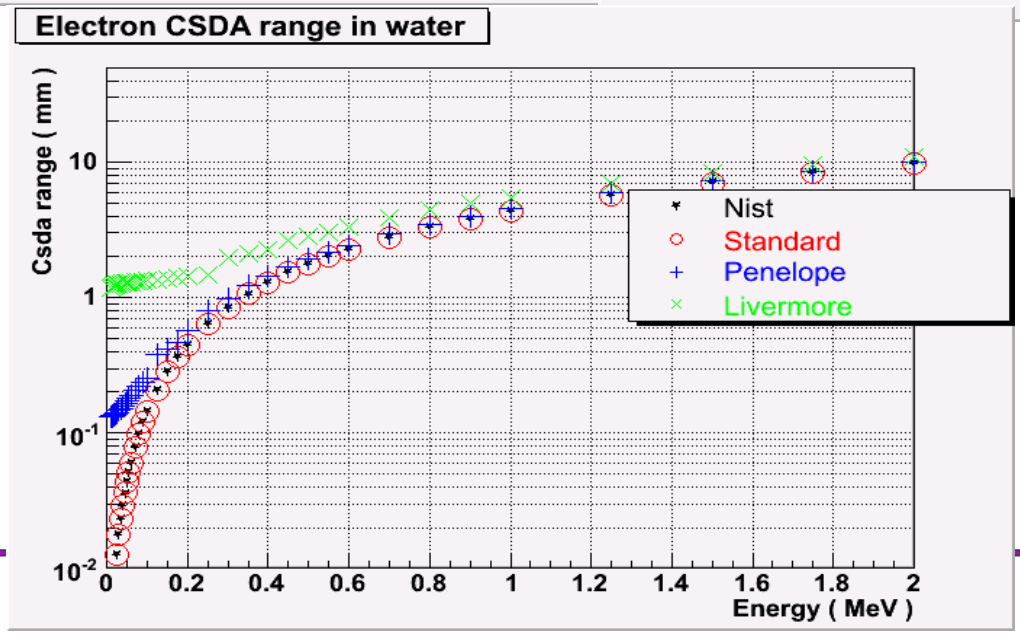

Electron CSDA range in water: G4Livermore compared to Nist
G4 Livermore / Nist
0
100
200
300
400
500
10^{-2}
10^{-1}
1
10
10^{2}
10^{3}
Energy (MeV)


Electron CSDA range in water: G4Penelope compared to Nist
G4 Penelope / Nist
0
10
20
30
40
50
10^{-2}
10^{-1}
1
10
10^{2}
10^{3}
Energy (MeV)

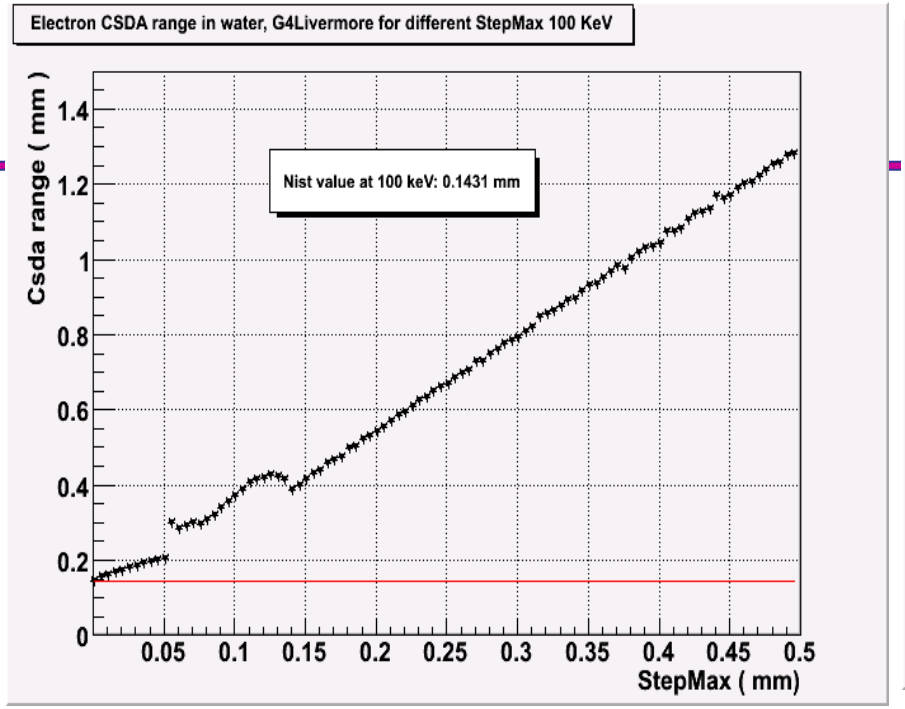

Electron CSDA range in water: G4Standard compared to Nist
G4 Standard / Nist
0.94
0.95
0.96
0.97
0.98
0.99
1
1.01
10^{-2}
10^{-1}
1
10
10^{2}
10^{3}
Energy (MeV)

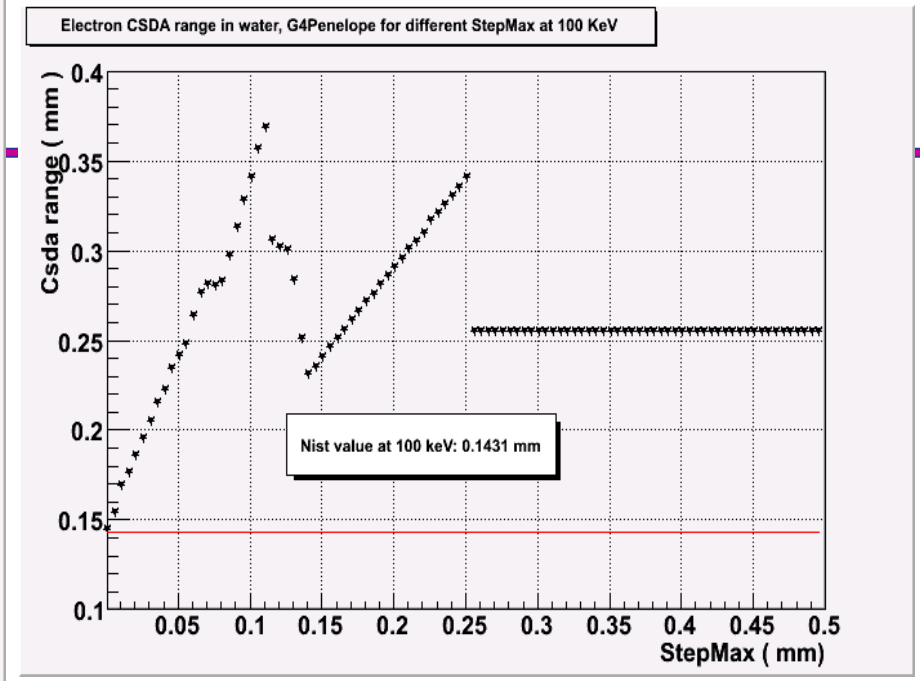

Low energy Electron CSDA range in water, G4 Livermore electromagnetic physic compare to Nist
G4 Livermore / Nist
Energy (MeV)

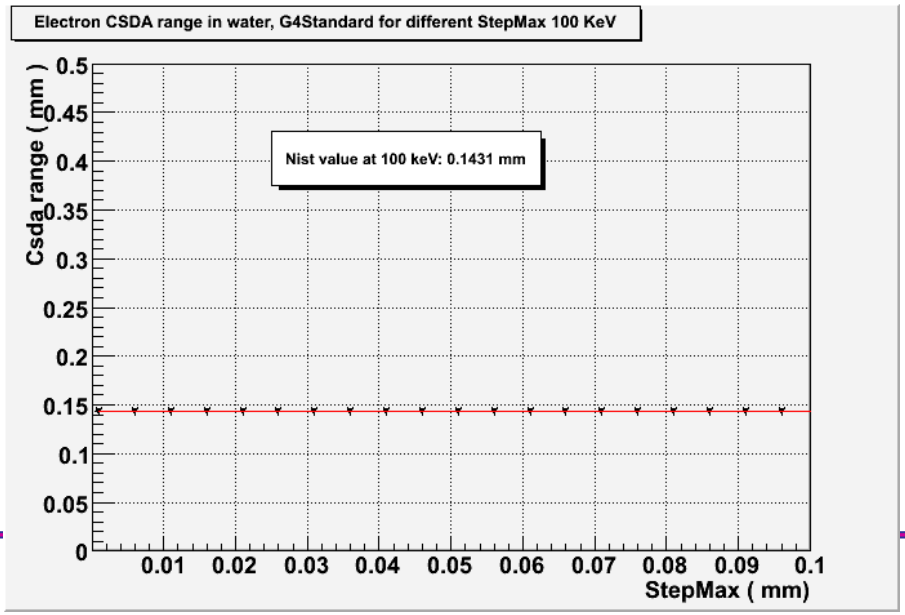

Low energy Electron CSDA range in water, G4 Penelope electromagnetic physic compare to Nist
G4 Penelope / Nist
Energy (MeV)

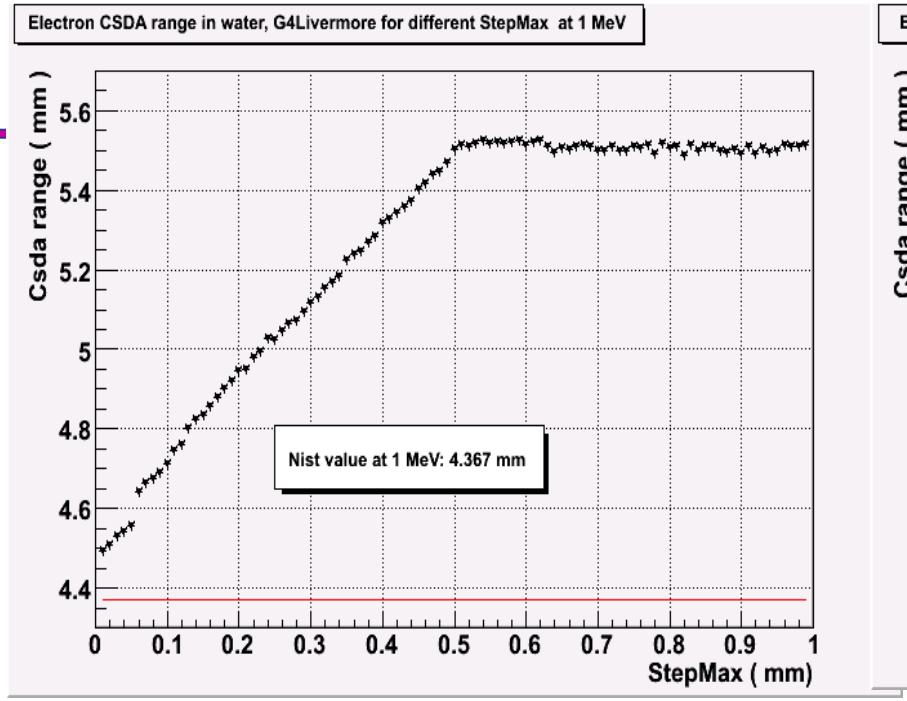

Electron CSDA range in water
Csda range (mm)
Energy (MeV)
Nist
Standard
Penelope
Livermore

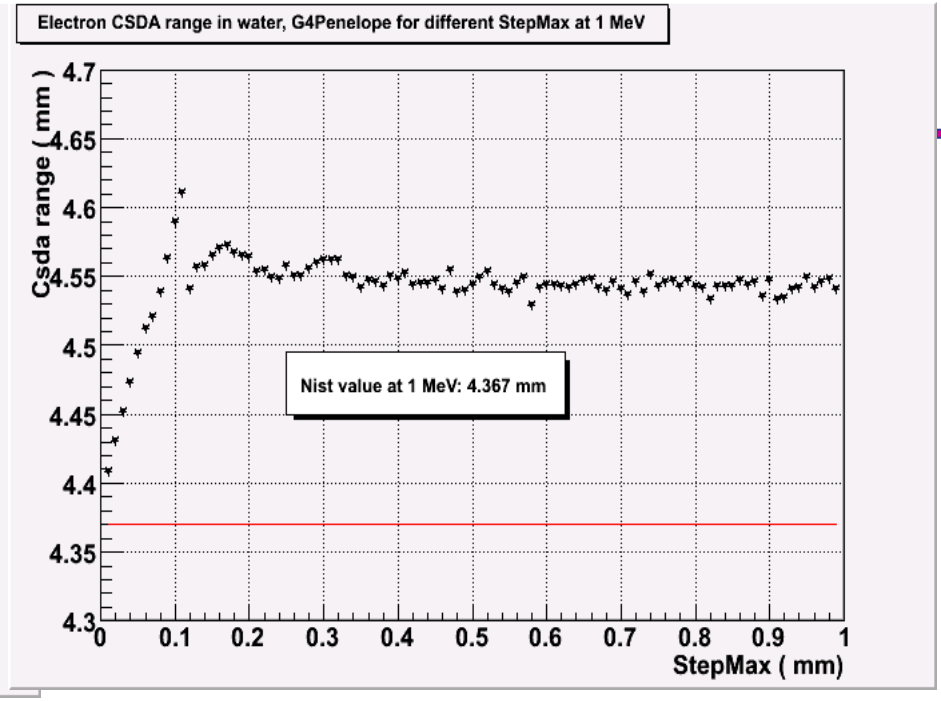
Step Limitation ?

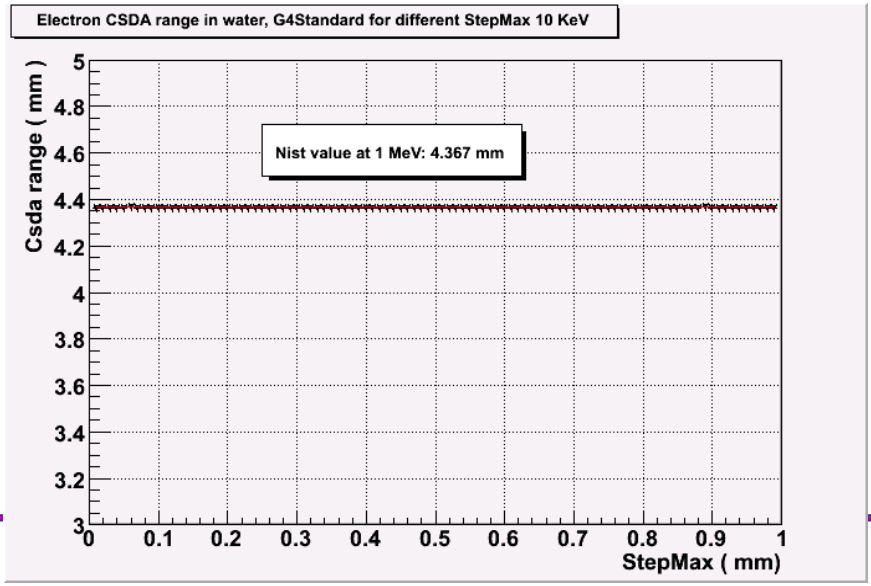

Electron CSDA range in water, G4Livermore for different StepMax 100 KeV
Nist value at 100 keV: 0.1431 mm
Csda range (mm)
StepMax (mm)

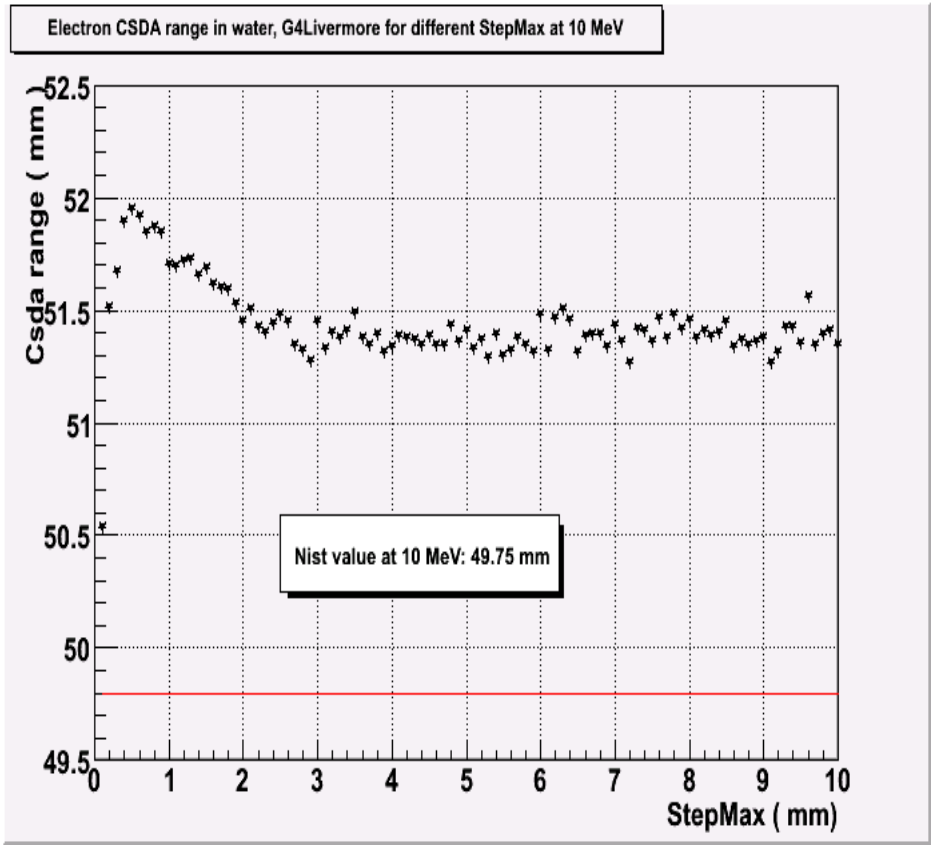

Electron CSDA range in water, G4Penelope for different StepMax at 100 KeV
Nist value at 100 keV: 0.1431 mm
Csda range (mm)
StepMax (mm)

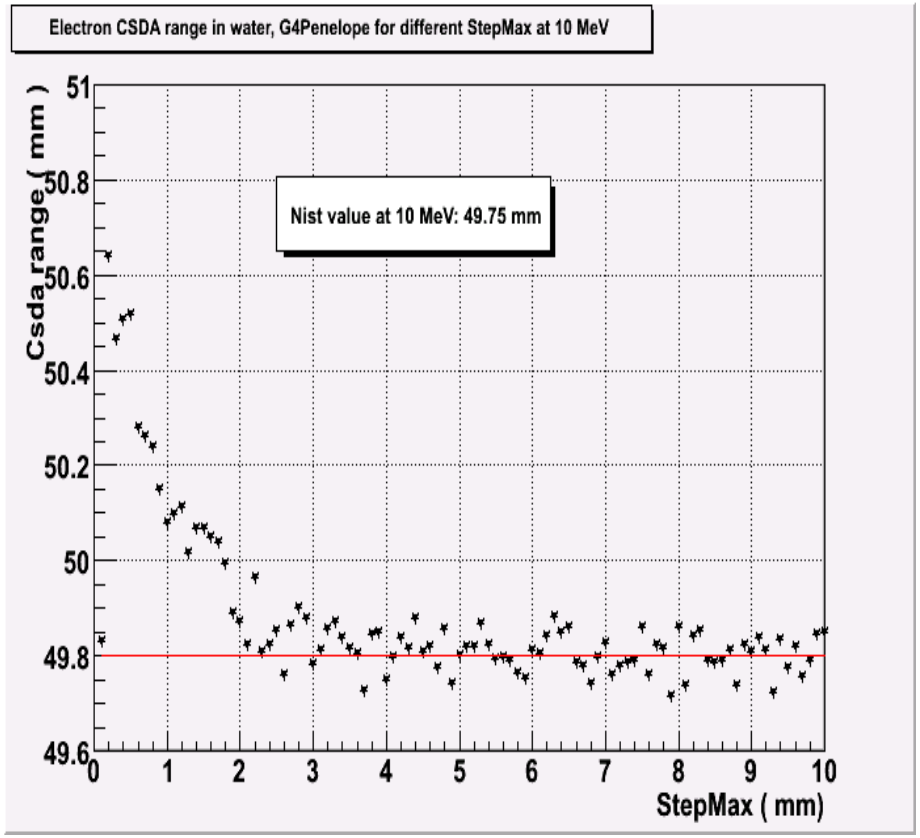

Electron CSDA range in water, G4Standard for different StepMax 100 KeV
Nist value at 100 keV: 0.1431 mm
Csda range (mm)
StepMax (mm)


Electron CSDA range in water, G4Livermore for different StepMax at 1 MeV
Csda range (mm)
StepMax (mm)
Nist value at 1 MeV: 4.367 mm


Electron CSDA range in water, G4Penelope for different StepMax at 1 MeV
Csda range (mm)
StepMax (mm)
Nist value at 1 MeV: 4.367 mm


Electron CSDA range in water, G4Standard for different StepMax 10 KeV
Csda range (mm)
StepMax (mm)
Nist value at 1 MeV: 4.367 mm

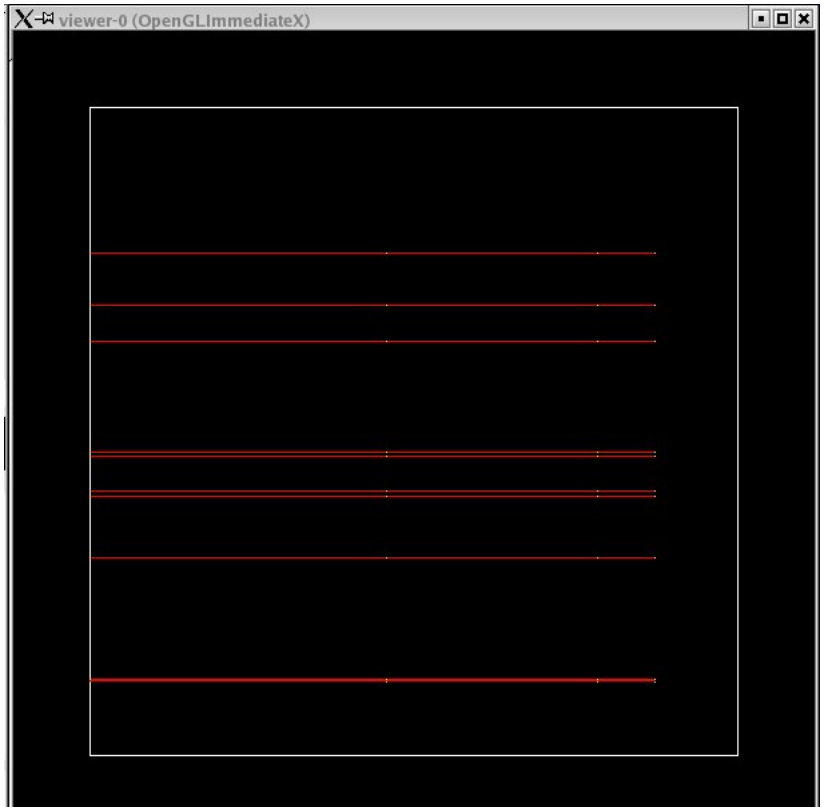

Electron CSDA range in water, G4Livermore for different StepMax at 10 MeV
Csda range (mm)
StepMax (mm)
Nist value at 10 MeV: 49.75 mm
52.5
52
51.5
51
50.5
50
49.5
0
1
2
3
4
5
6
7
8
9
10


Electron CSDA range in water, G4Penelope for different StepMax at 10 MeV
Csda range (mm)
StepMax (mm)
Nist value at 10 MeV: 49.75 mm
51
50.8
50.6
50.4
50.2
50
49.8
49.6
0
1
2
3
4
5
6
7
8
9
10

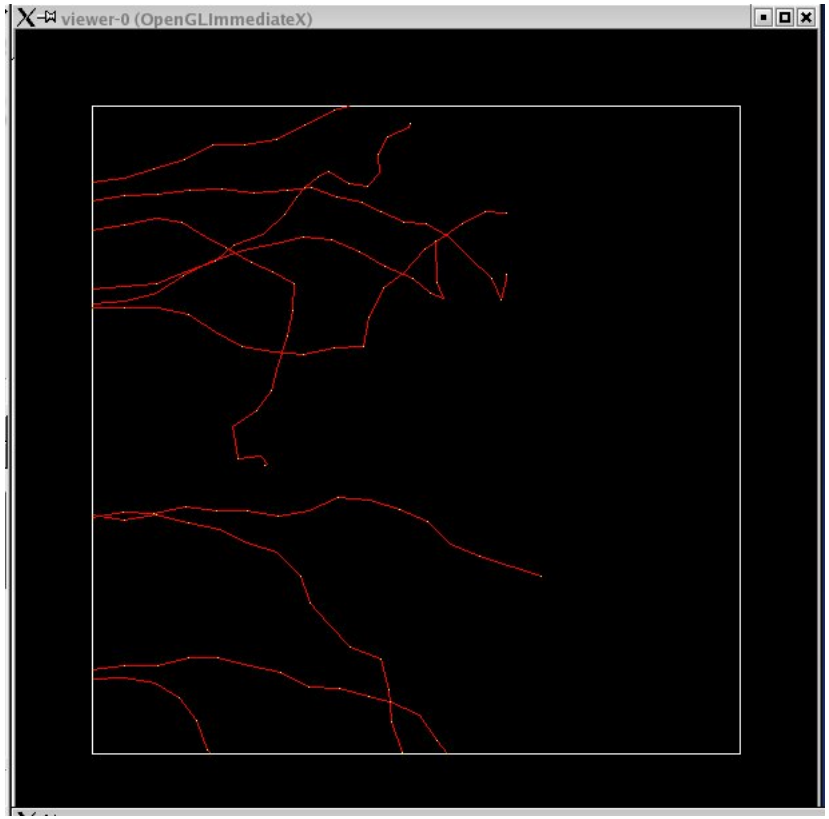
Multiple scattering ?

Electron 500 keV in water

No muls

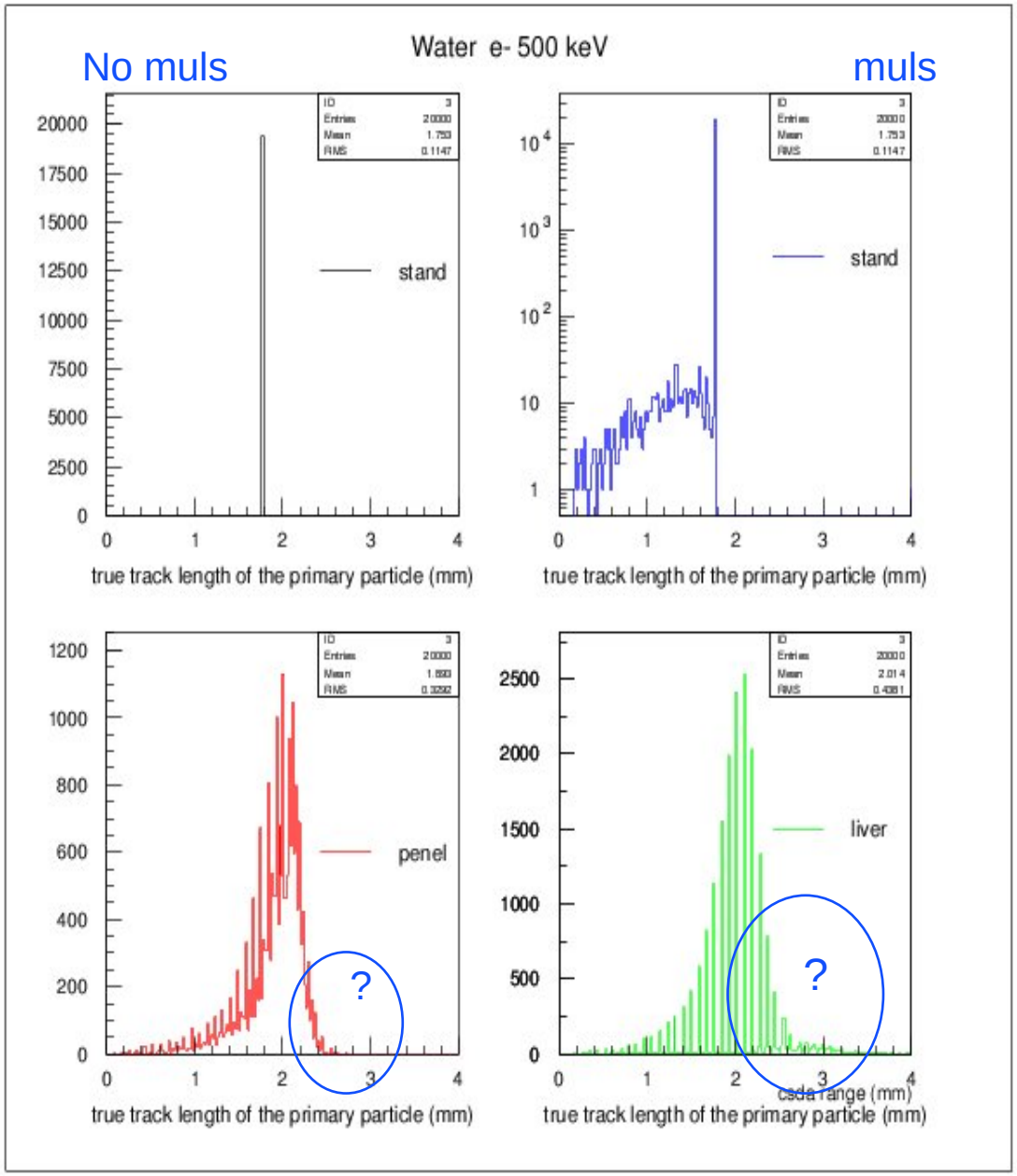


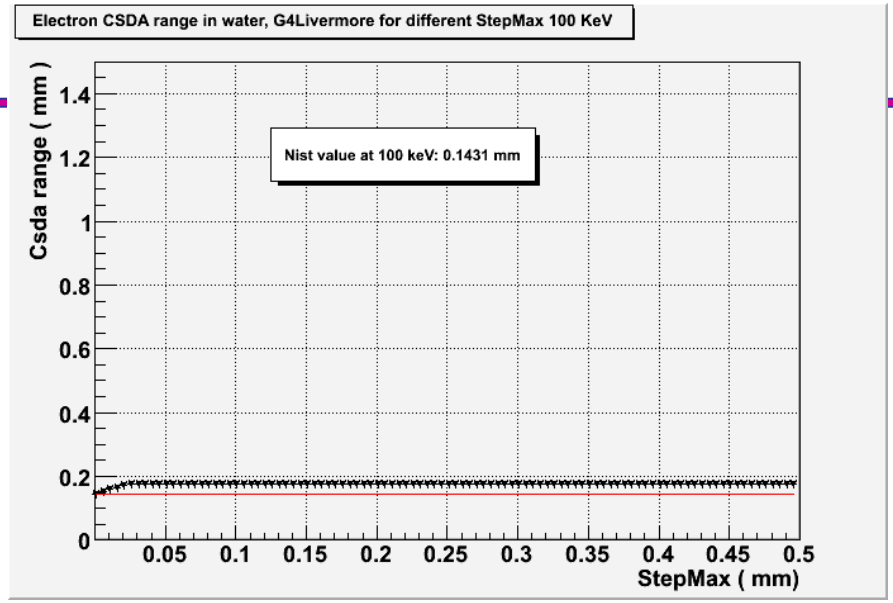
muls

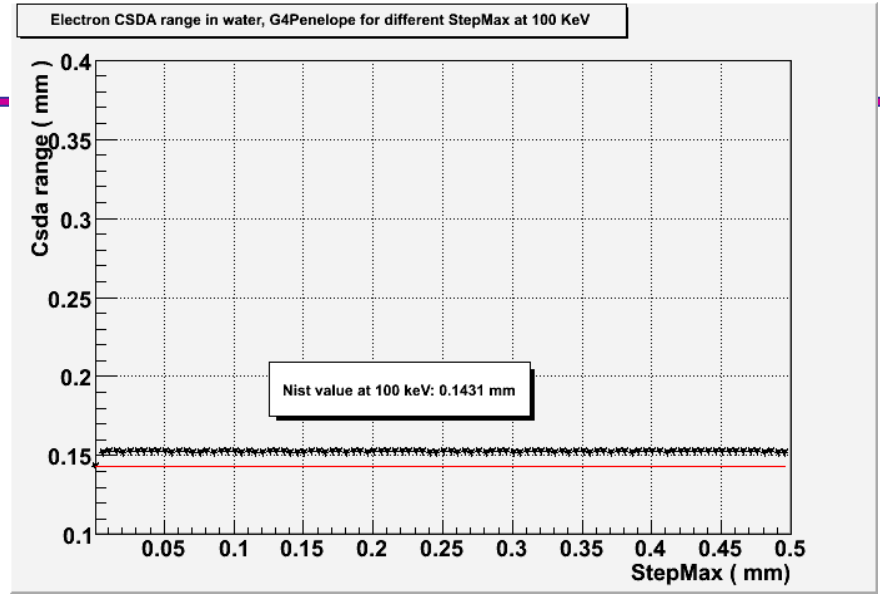


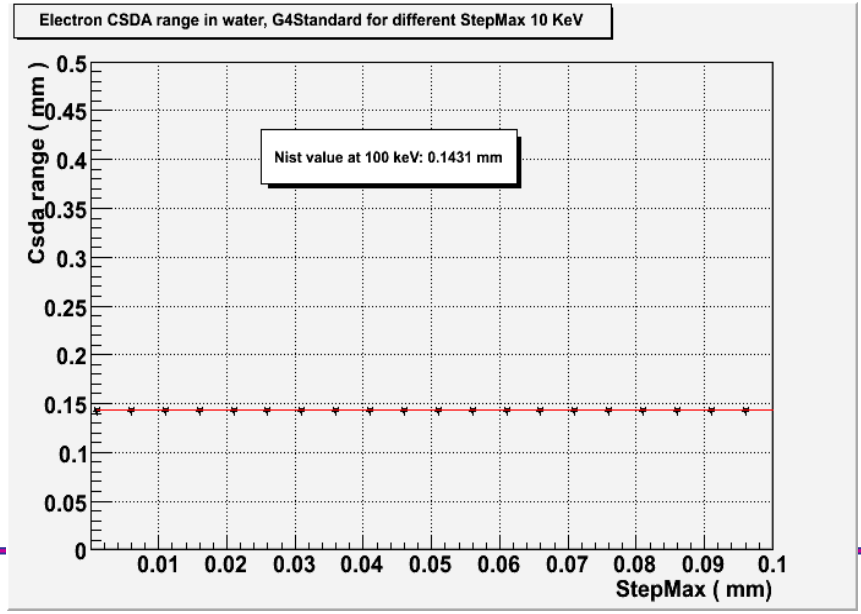
The total track length must be the csda range

Nist : 1.77 mm

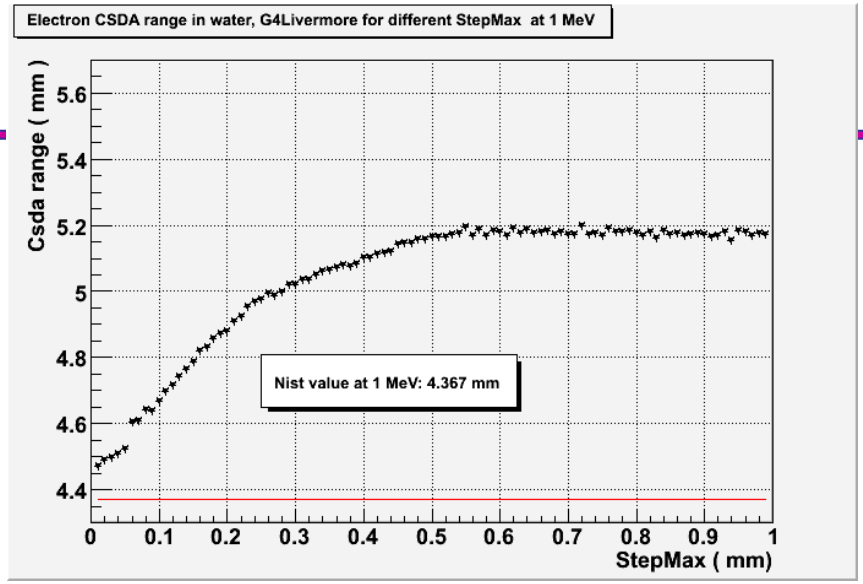

Water e- 500 keV
No muls
muls
stand
stand
penel
liver
?
?
true track length of the primary particle (mm)
true track length of the primary particle (mm)
true track length of the primary particle (mm)
true track length of the primary particle (mm)
csda range (mm)

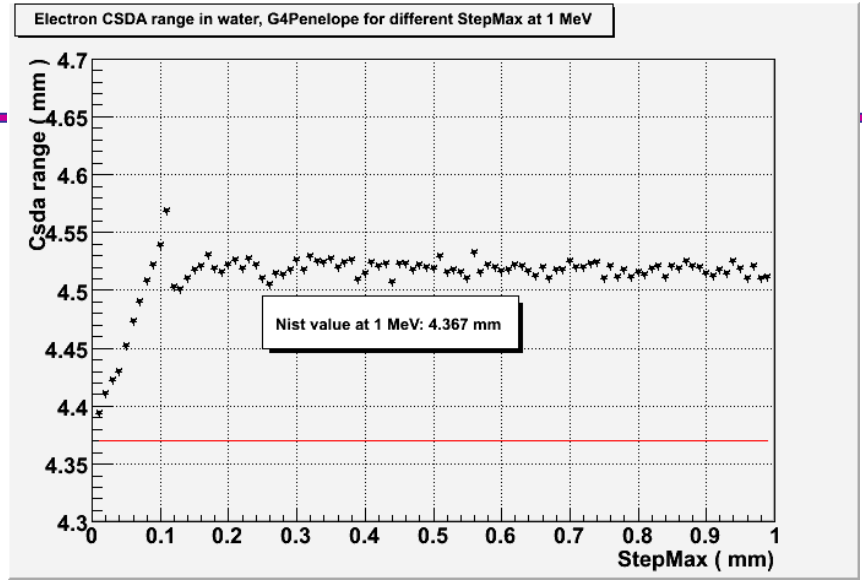

Electron CSDA range in water, G4Livermore for different StepMax 100 KeV
Csda range (mm)
Nist value at 100 keV: 0.1431 mm
StepMax (mm)

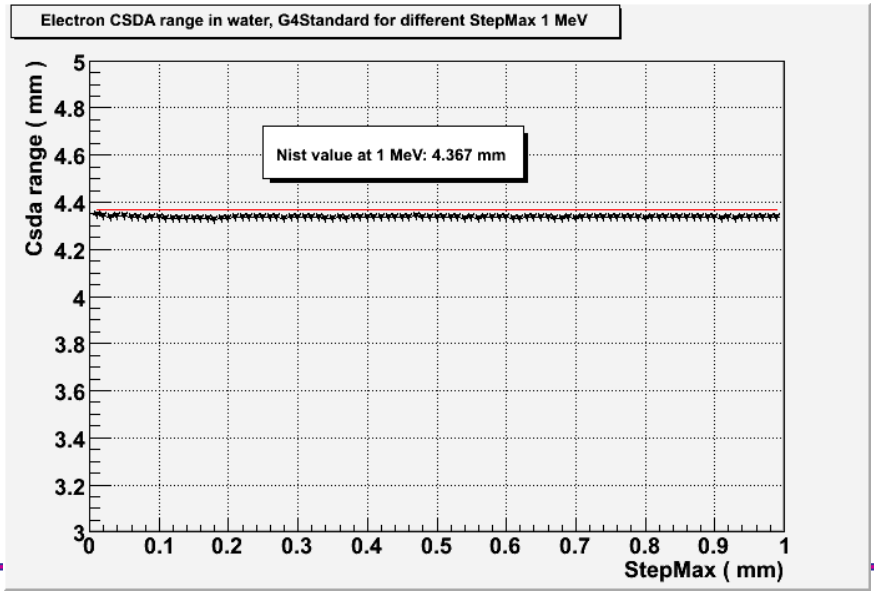

Electron CSDA range in water, G4Penelope for different StepMax at 100 KeV
Csda range (mm)
Nist value at 100 keV: 0.1431 mm
StepMax (mm)


Electron CSDA range in water, G4Standard for different StepMax 10 KeV
Csda range (mm)
Nist value at 100 keV: 0.1431 mm
StepMax (mm)

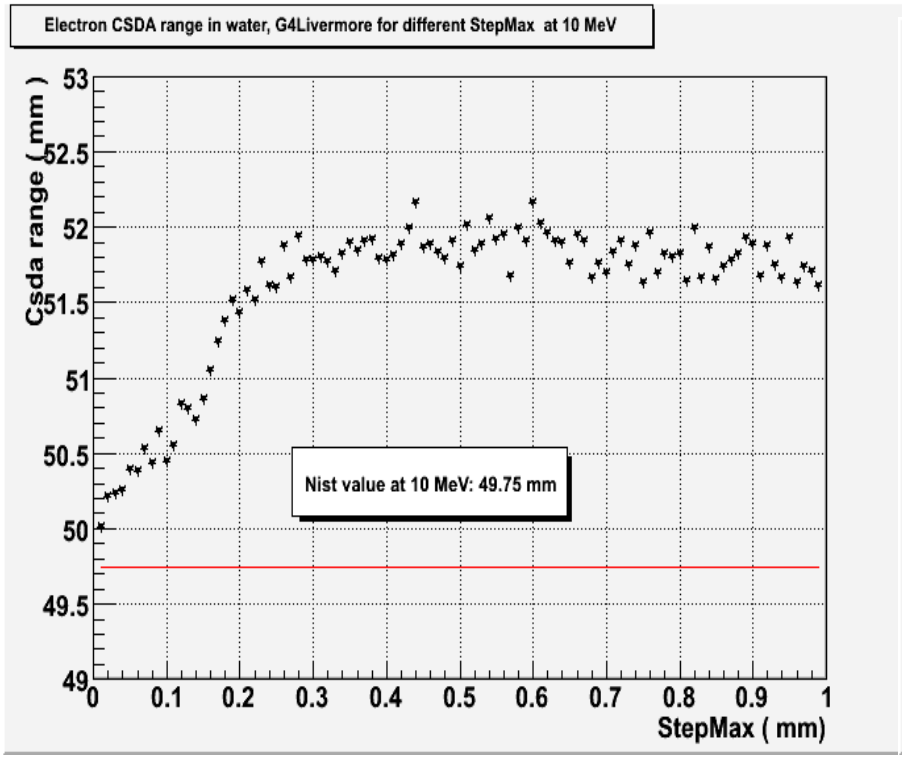
with muls

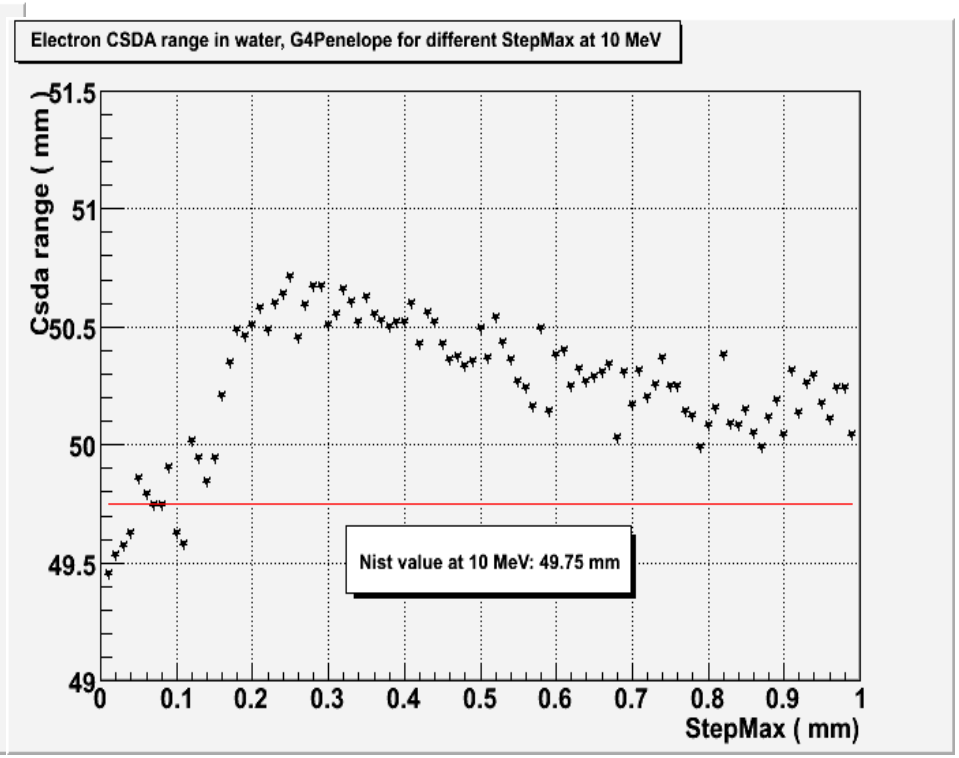

Electron CSDA range in water, G4Livermore for different StepMax at 1 MeV
Csda range (mm)
StepMax (mm)
Nist value at 1 MeV: 4.367 mm


Electron CSDA range in water, G4Penelope for different StepMax at 1 MeV
Csda range (mm)
StepMax (mm)
Nist value at 1 MeV: 4.367 mm


Electron CSDA range in water, G4Standard for different StepMax 1 MeV
Csda range (mm)
StepMax (mm)
Nist value at 1 MeV: 4.367 mm

with muls


Electron CSDA range in water, G4Livermore for different StepMax at 10 MeV
Csda range (mm)
StepMax (mm)
Nist value at 10 MeV: 49.75 mm
53
52.5
52
51.5
51
50.5
50
49.5
49
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1


Electron CSDA range in water, G4Penelope for different StepMax at 10 MeV
Csda range (mm)
StepMax (mm)
Nist value at 10 MeV: 49.75 mm
51.5
51
50.5
50
49.5
49
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

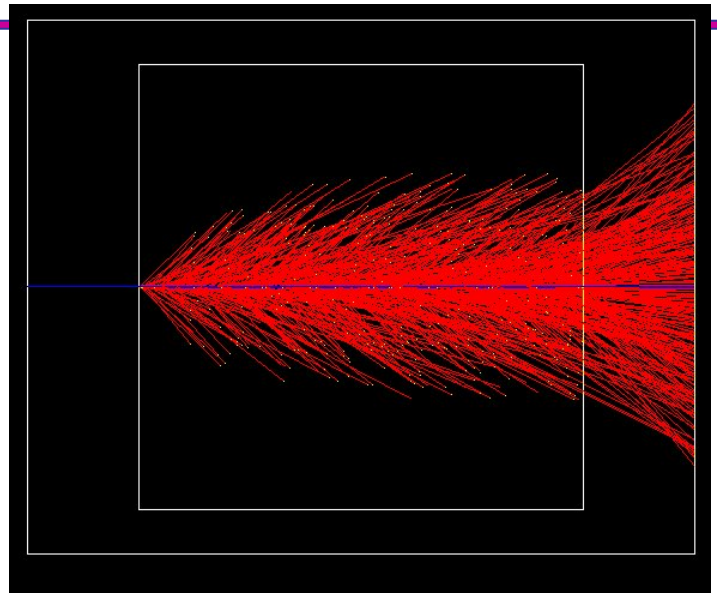
with muls

Ionization

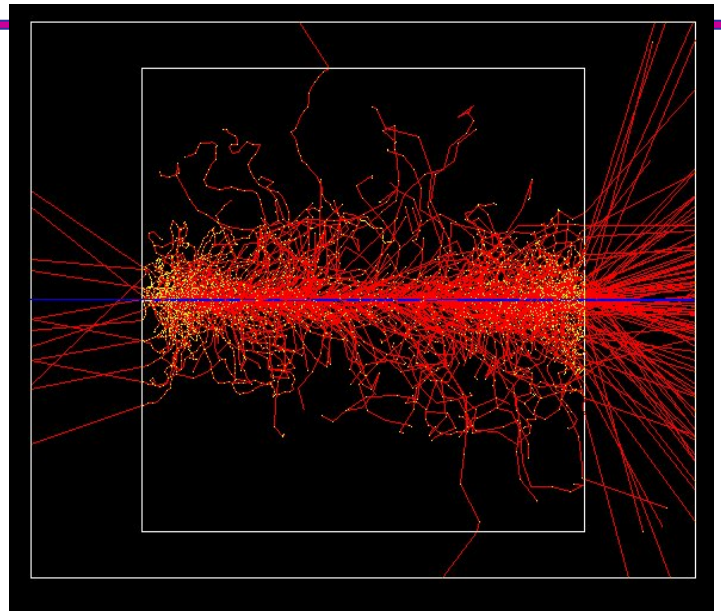
Ion C12 (100 MeV) in 5 um Silicon

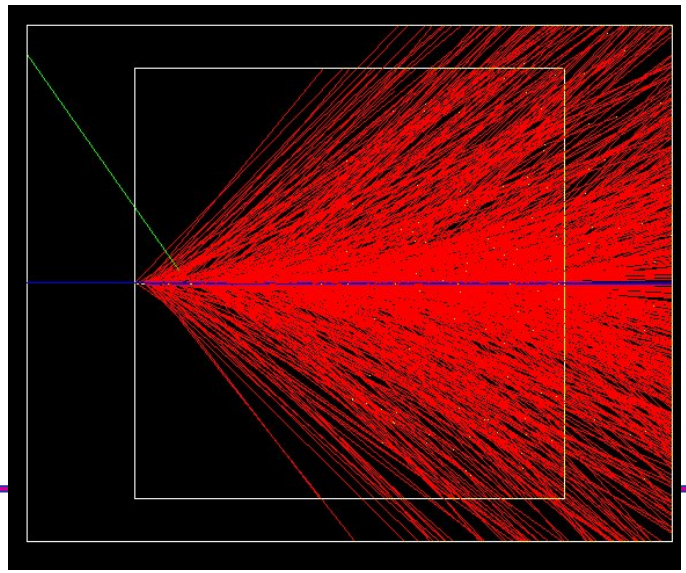
No muls

muls

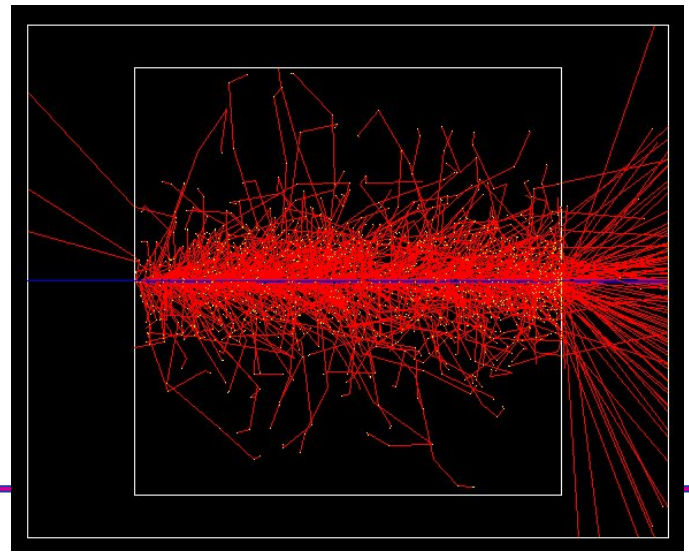


stand





penel

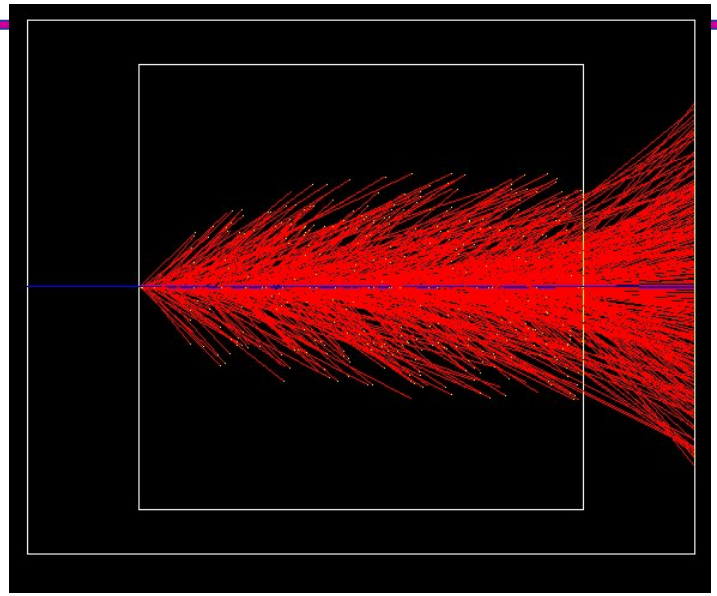


R. Weller, Vanderbilt U.

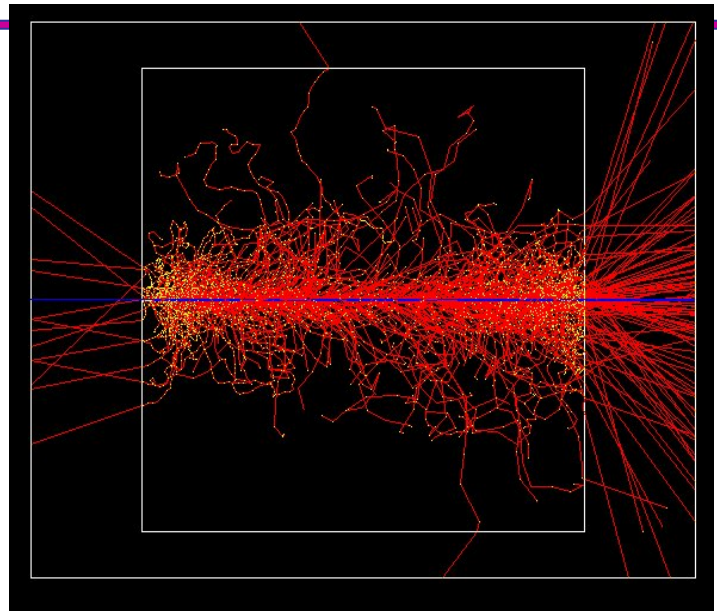
Ion C12 (100 MeV) in 5 um Silicon

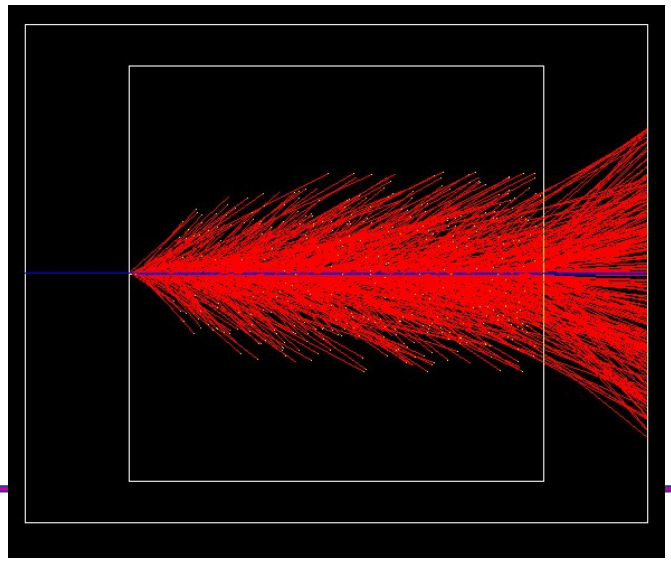
No muls

muls

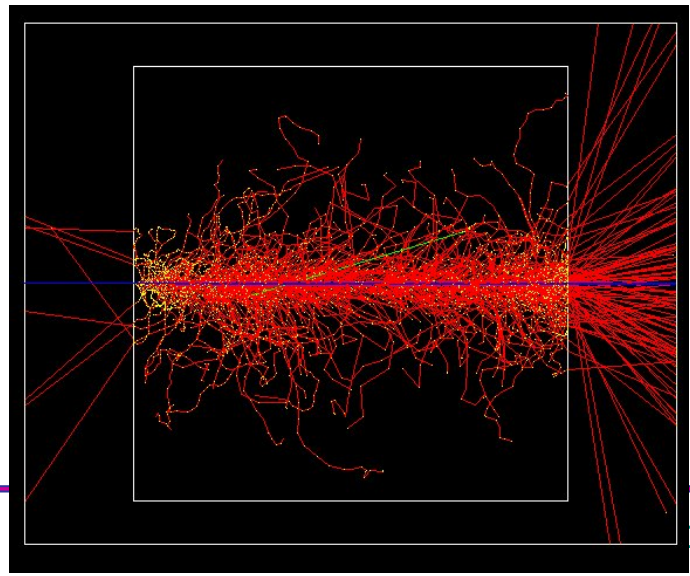


stand

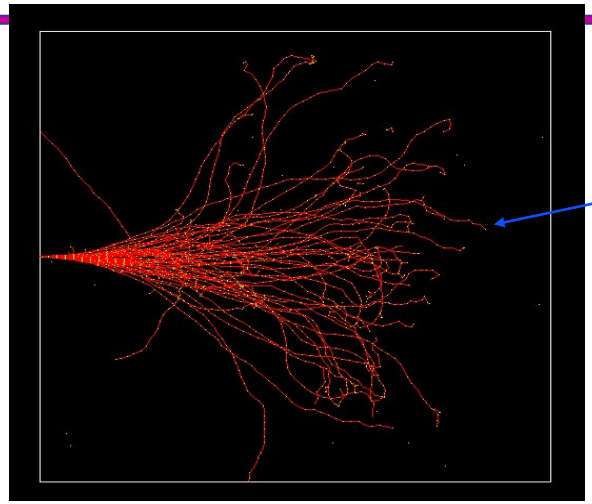




liver

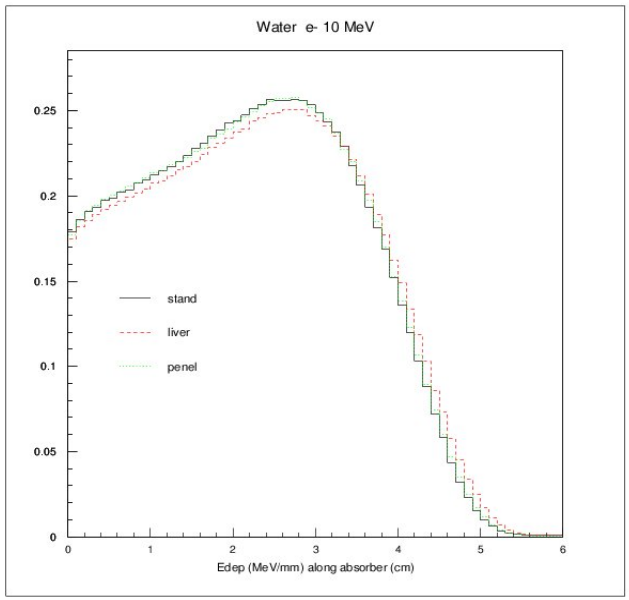


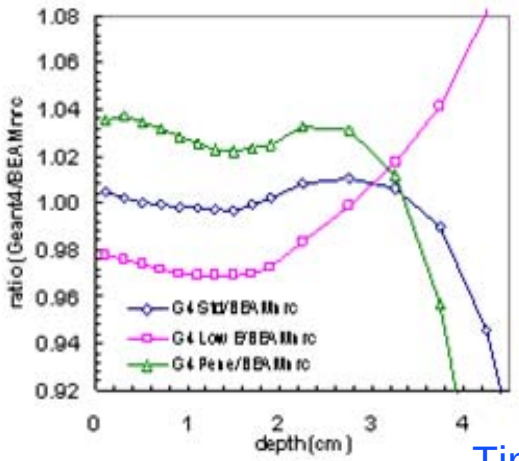
Depth dose profile (TestEm11)



```
#
/control/verbose 2
/run/verbose 2
#
/testem/det/setMat G4_WATER
/testem/det/setSizeX  6 cm
/testem/det/setSizeYZ 6 cm
#
/testem/phys/addPhysics  standard       # em physics
### /testem/phys/addPhysics  livermore  # em physics
### /testem/phys/addPhysics  penelope   # em physics
#
/run/initialize
#
/gun/particle e-
/gun/energy 10 MeV
#
/testem/histo/setFileName stand
/testem/histo/setFileType hbook
/testem/histo/setHisto 1 60 0  6 cm     #edep profile
#
#/run/beamOn 100000

```





Geant4 / EGSnrc

(E. Poon, McGill univ.)

Timing : lowE/stand ~ 2

conclusion

In low energy Em packages, the electron transport works – *approximatively* – well, thanks to the MultipleScattering (since V8.0)