

# **Multiple Scattering Update**

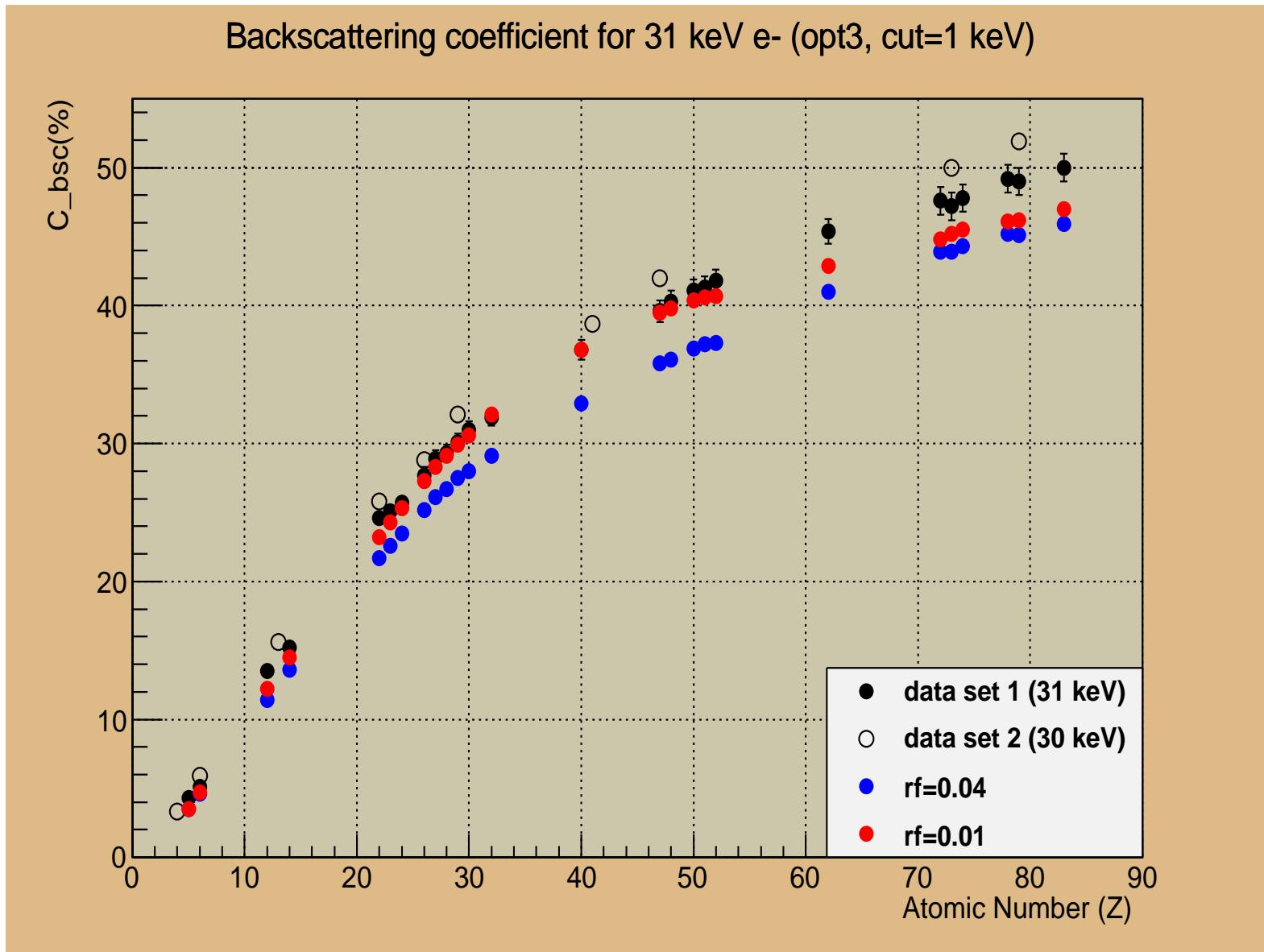
**László Urbán**

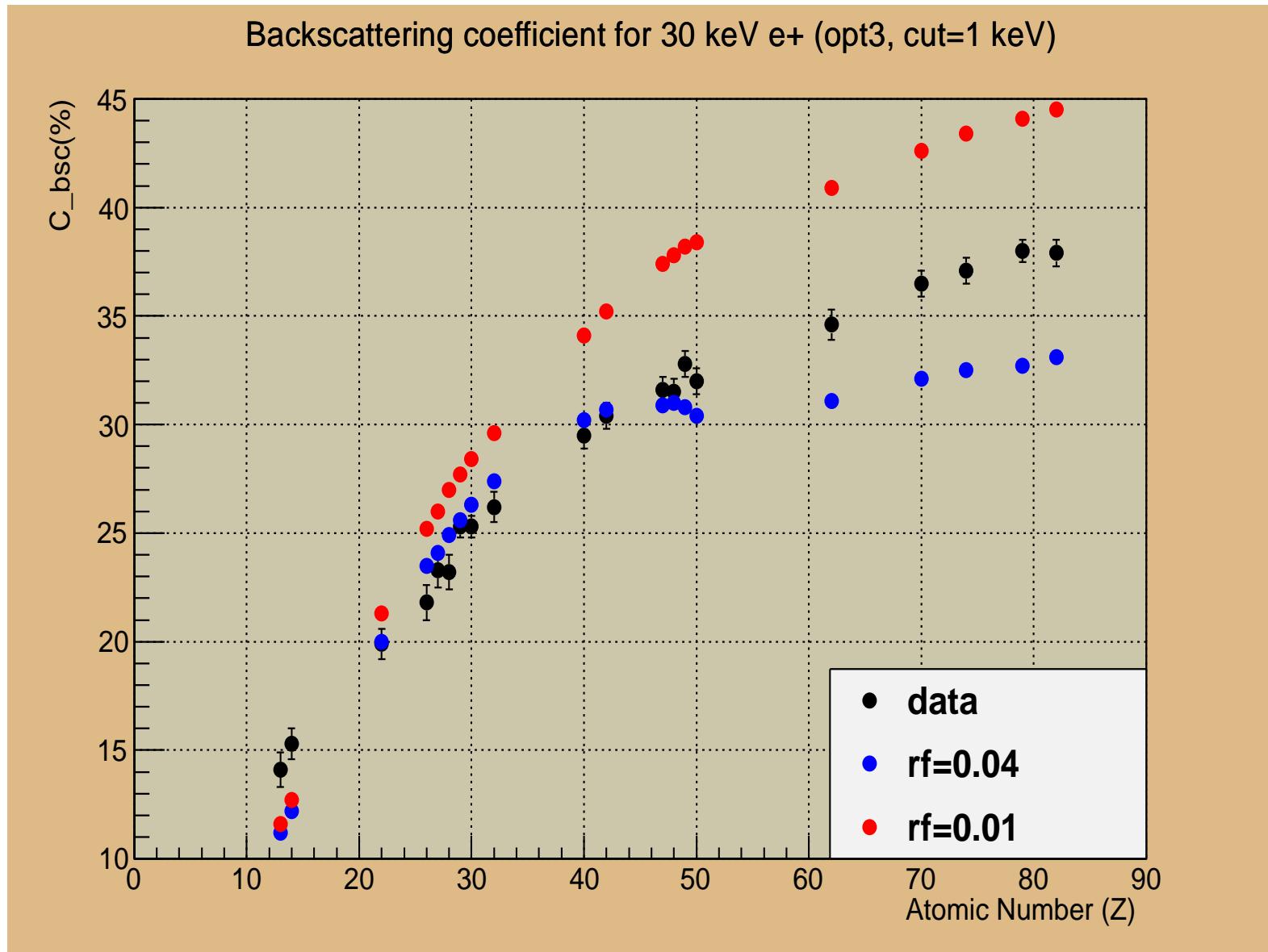
**Geant4 Associates International**

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**motivation :**

- e- and e+ backscattering simulations behave differently see plot1, plot2  $\Rightarrow$  correction needed for e+
- sampling of lateral displacement/lateral correlation is crude  $\Rightarrow$  improvement needed





### e+ correction

In many places in the msc model correct transport mean free path values are used (different mfp for e-/e+), but in the model function describing the central part of the scattering angle the same formula is used for e- and e+.

Try : correction of the  $\theta_0$  formula for positrons , the correction parameter is the ratio of the e+/e- transport mean free path.

### **lateral displacement/lateral correlation sampling :**

Lewis's theory gives the mean lateral displacement/mean lateral correlation but not their distribution.

I take the shape of these distributions from single scattering simulations.

Tool : modified version of TestEm5 , primary particle followed until the true path length reaches a given  $t_{fix}$  value + some new histograms.

The primary particle starts from (0.,0.,0.) and the initial direction vector is (0.,0.,1.), i.e. the particle goes to the  $z$  direction.

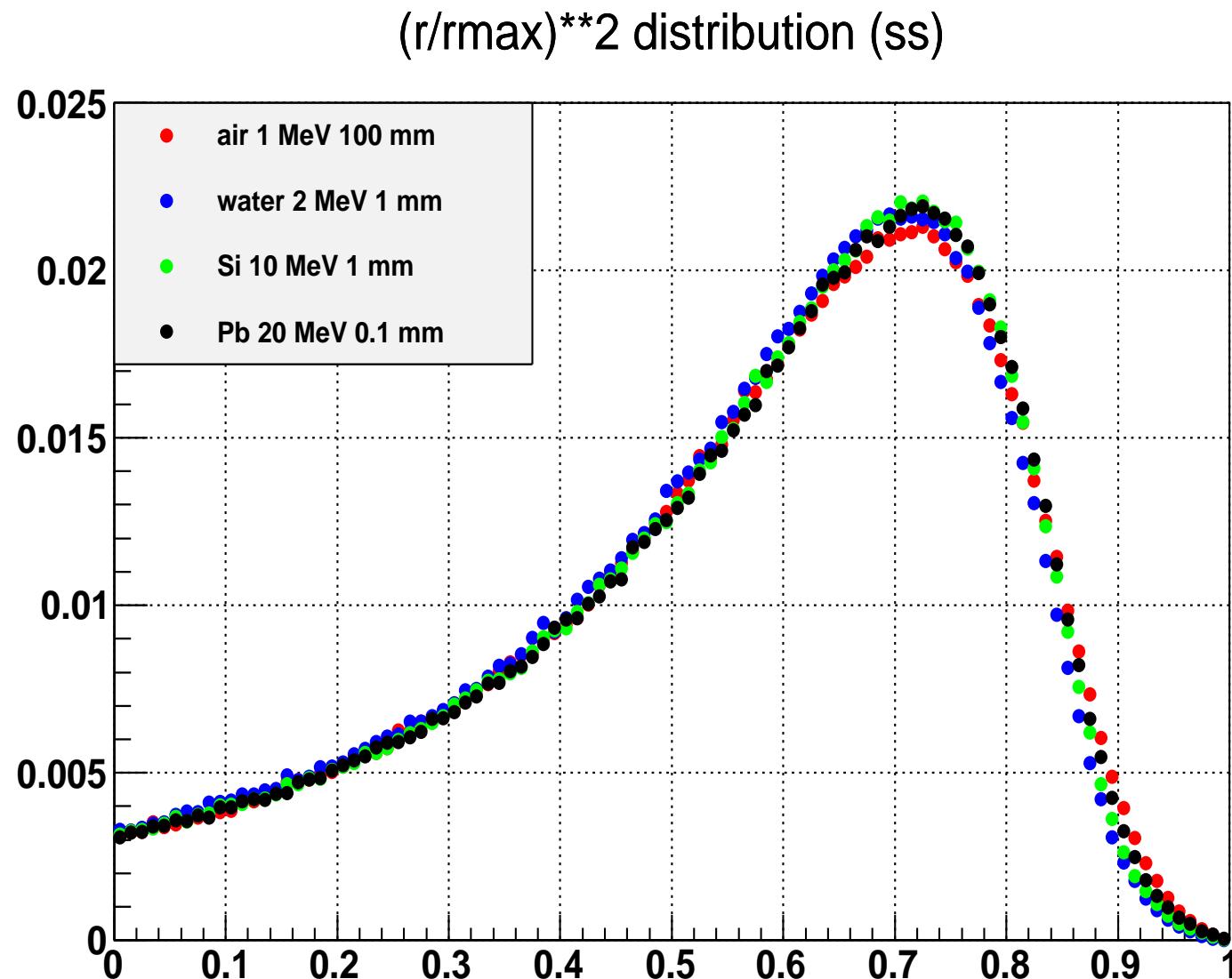
After travelling a pathlength  $t$  the direction vector is

$dir = (\sin\theta\cos\phi, \sin\theta\sin\phi, \cos\theta)$ , the position is  $(x, y, z)$ . The lateral displacement can be defined as  $r = \sqrt{x^2 + y^2}$  and the lateral correlation as  $lc = xdir_x + ydir_y$  .

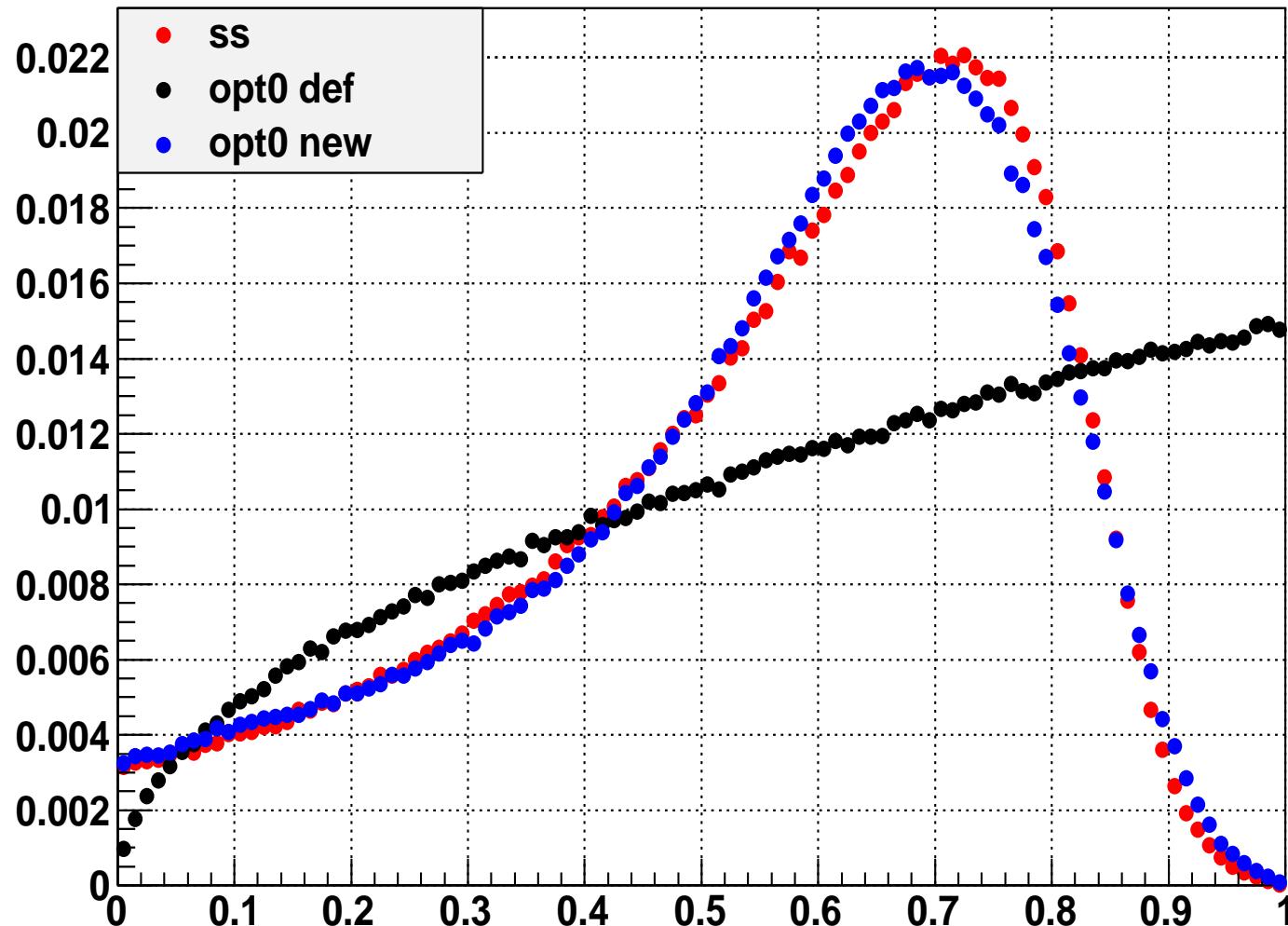
### lateral displacement:

The quantity  $(\frac{r}{r_{max}})^2$  has a universal distribution (i.e. the distribution does not depend on the material, kinetic energy and  $t = t_{true}$ ), where  $r_{max} = \sqrt{t^2 - z^2}$ . This distribution can be seen on the next plot3.eps for a few cases.

In the "new" version of the msc model the parametrized form of this distribution is used to sample the lateral displacement  $r$ . This can be seen on plot4.eps together with the ss and default msc result for Si.



$(r/r_{\max})^{*2}$  distribution (10 MeV e-, 1 mm Si)



## lateral correlation

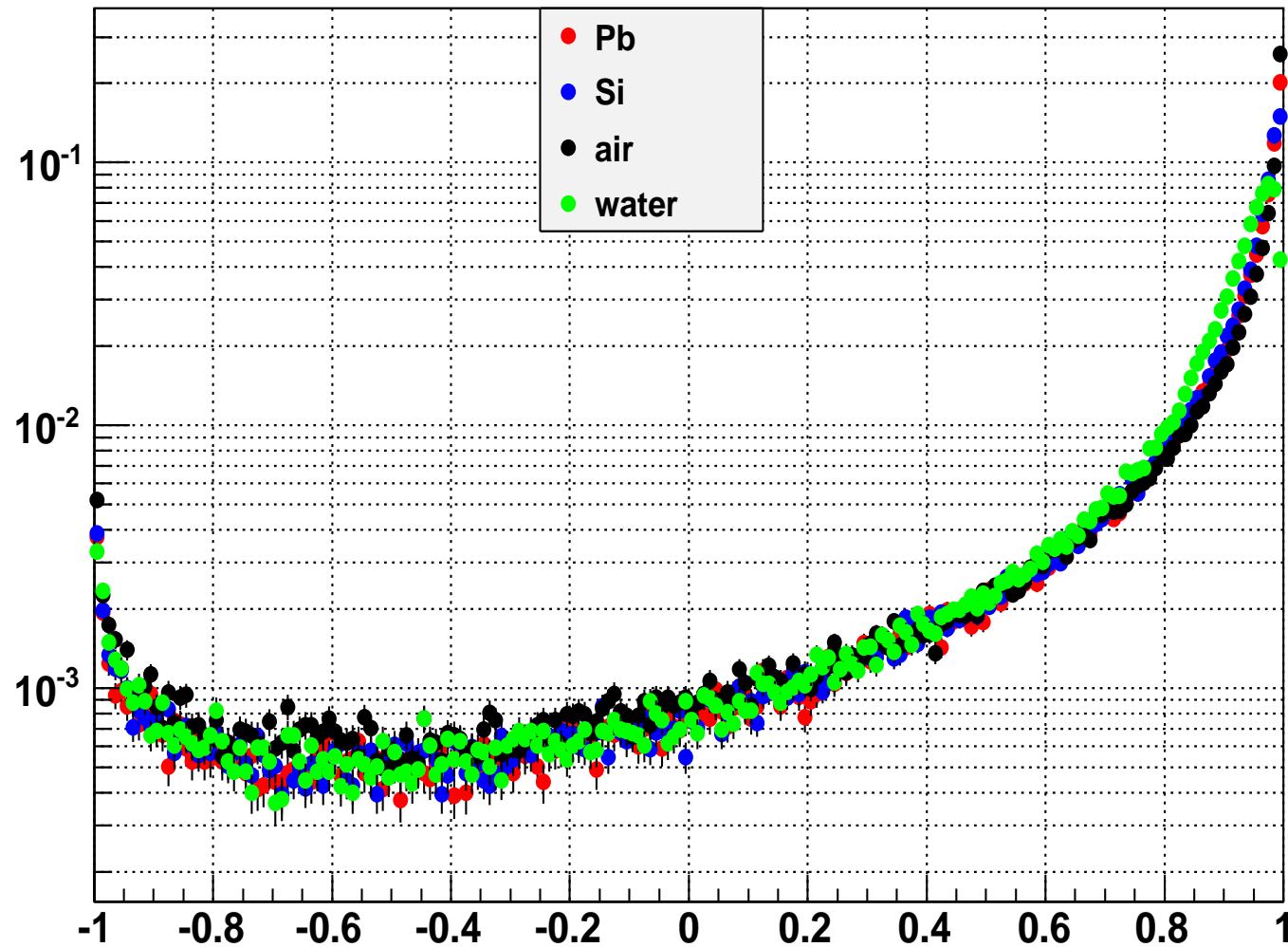
We need a universal distribution for this case too. The quantity

$$\frac{x\text{dir}_x + y\text{dir}_y}{r \sin \theta}$$

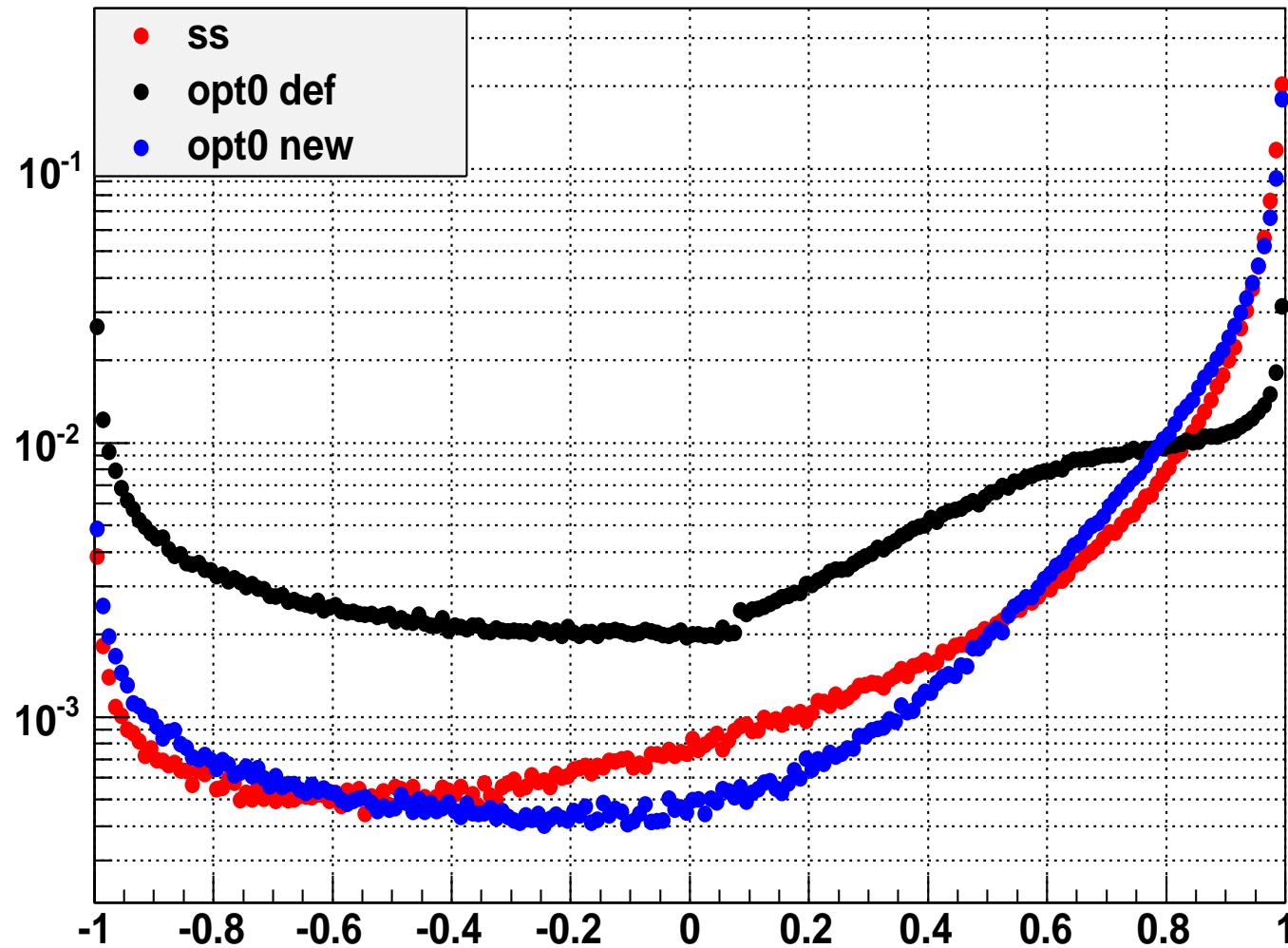
has a distribution which does not depend on material, energy and  $t.$ , see next plot.

In the new msc version the sampling reproduces approximately this distribution which is not the case for the default version, see plot.

$(x^*vx + y^*vy)/(r^*sth)$  distribution (ss)



$(x^*vx + y^*vy)/(r^*sth)$  distribution (20 MeV e-, 0.1 mm Pb)



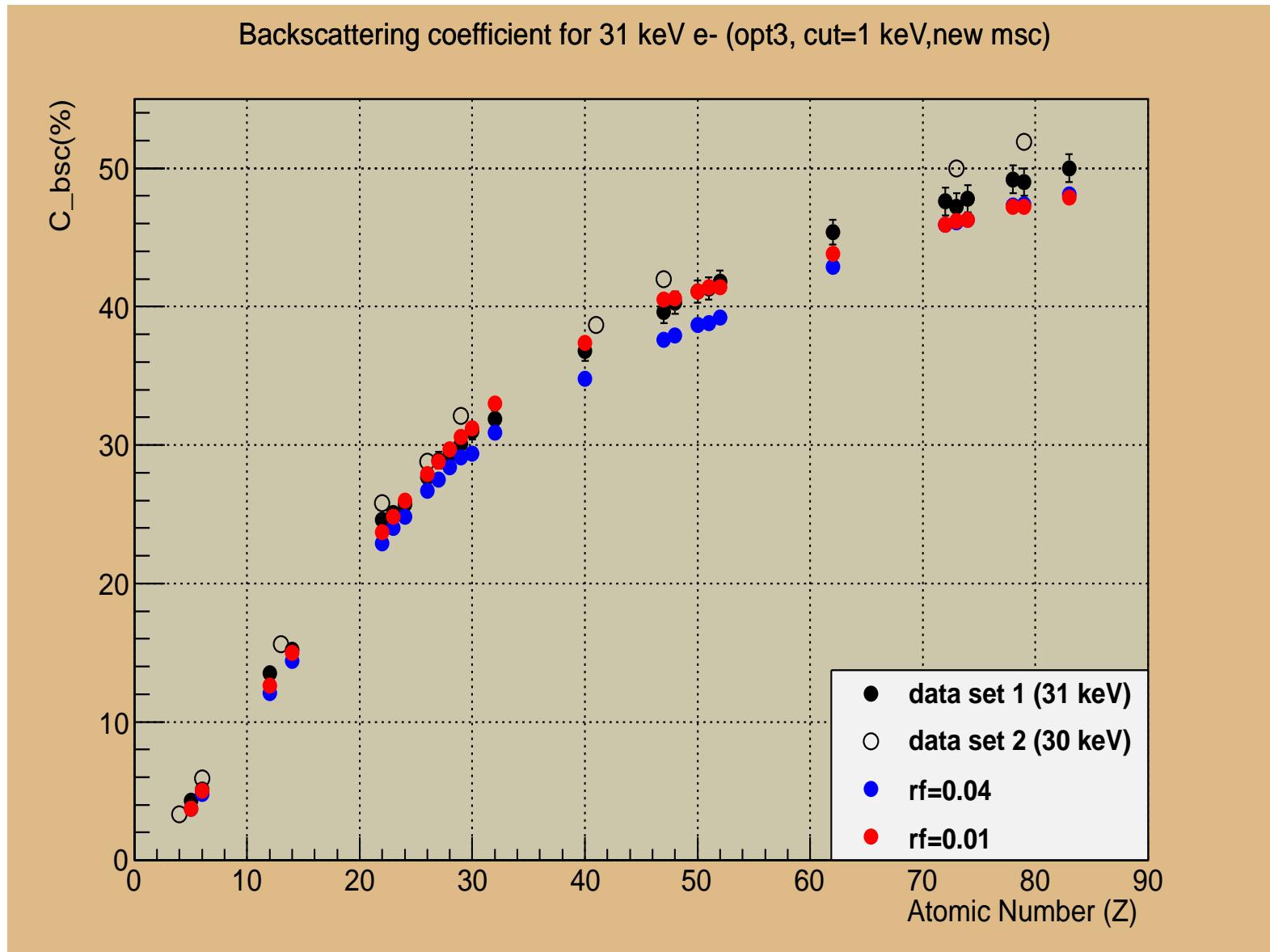
### Test, validation :

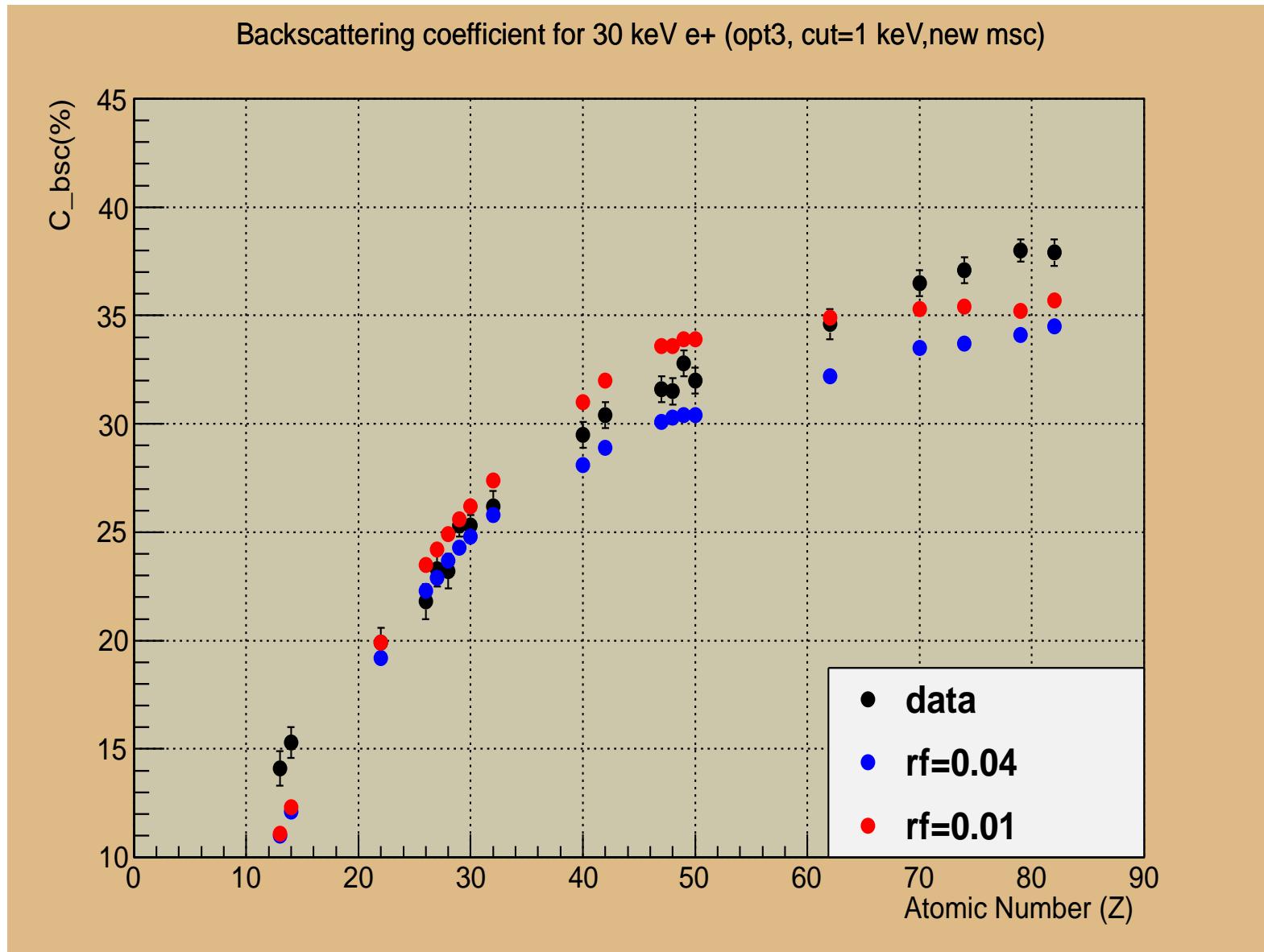
The next two plots show the e-/e+ backscattering results with the new msc model.

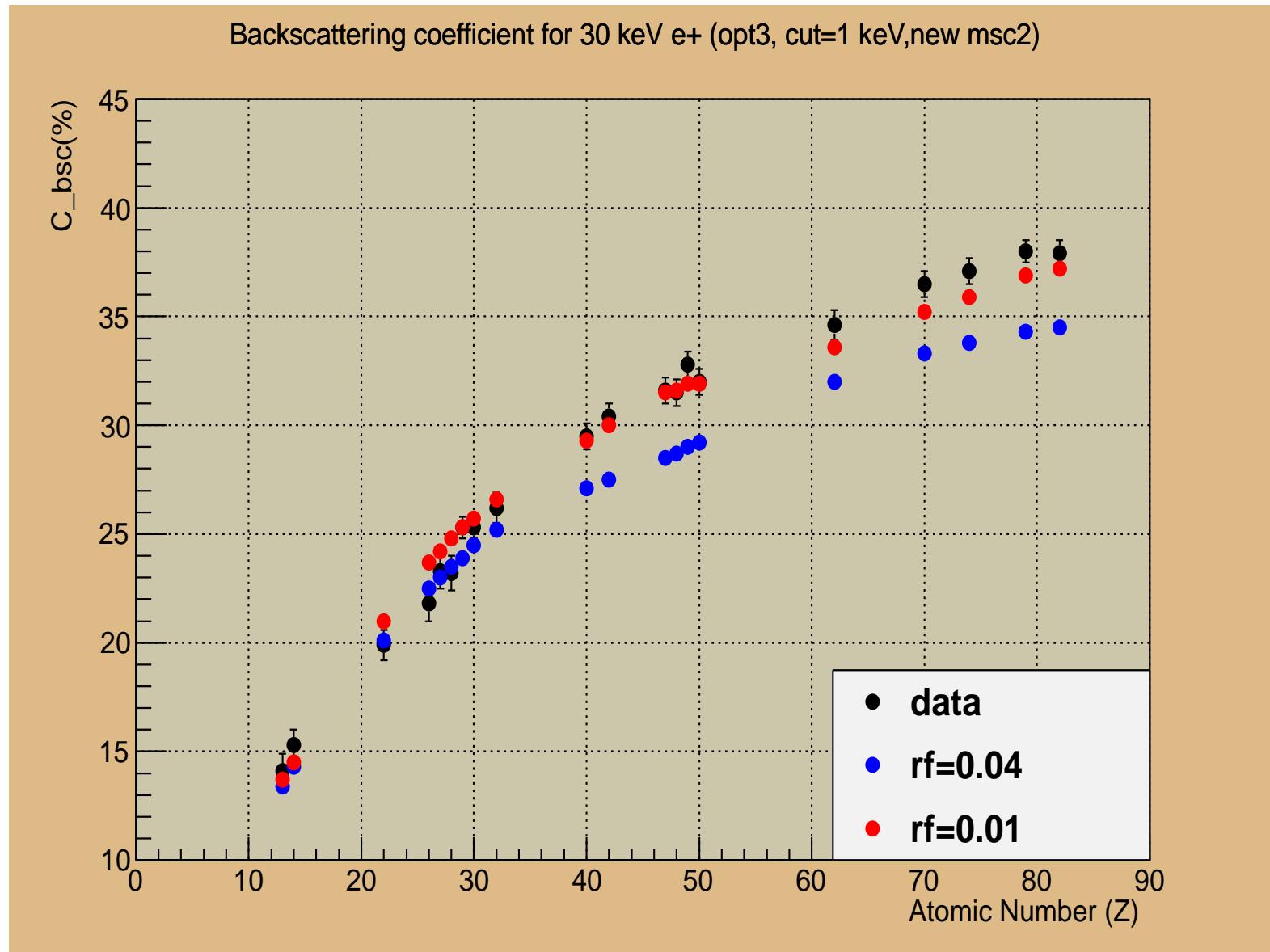
As it can be seen, the e- results are quite good. This is purely due to the better sampling of the lateral stuff, there are no positrons here.

The e+ results are definitely better than the results of the default msc model, but the picture is not so nice than in the case of e-.  $\Rightarrow$  better e+ correction needed ?

better(?) e+ correction , see the 3rd plot from now ...





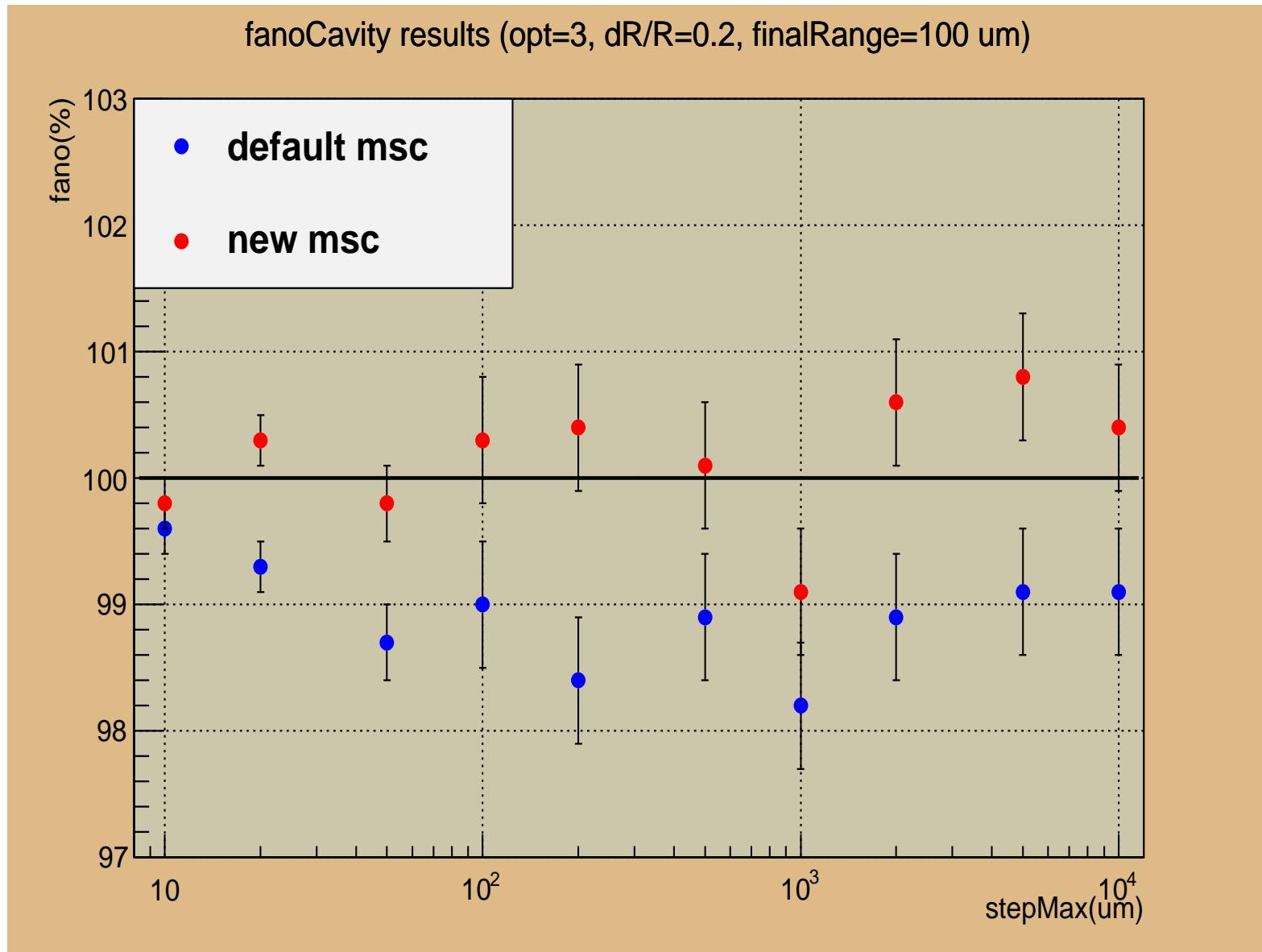


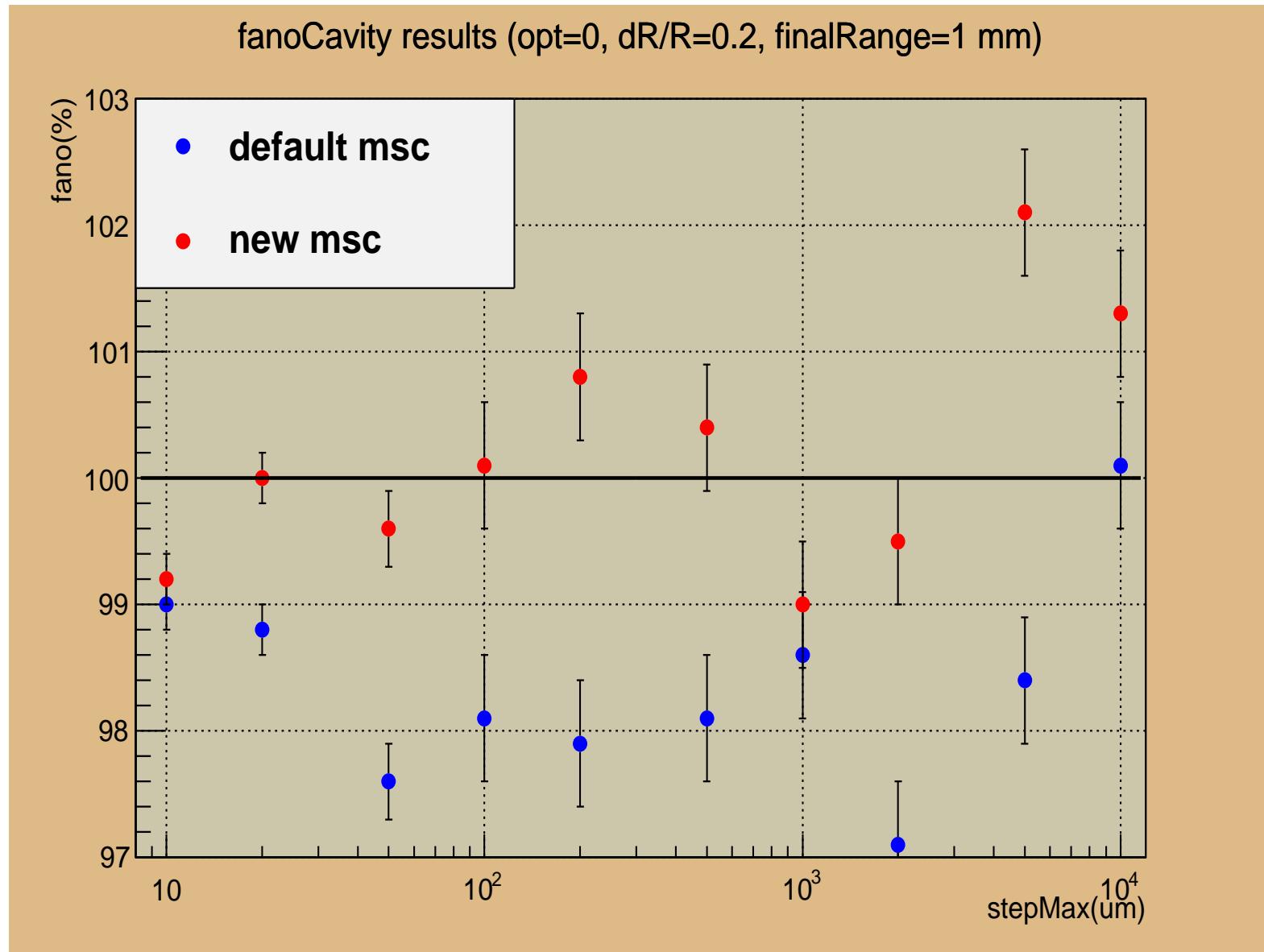
### Fano cavity test :

The next plot shows the Fano cavity test results for opt3. This is not the usual Fano plot (as it is used in G4), here I used a step function with dRoverRange=0.2, finalRange=100 um (these are the default values for opt3) and plotted the simulation results as function of the max.allowed step (stepmax).

You can see that the new msc version performs better.

The plot after the next shows the results using opt0. Here for big stepmax the default msc is better but for  $stepmax < 5mm$  the new msc looks better. It is worth to note that the mean number of steps in the cavity 1 for big stepmax and  $> 2$  for  $stepmax < 2mm$ .





tests where default and new models give same results:

- scattering on thin layer (TestEm5 , Hanson's data)
- depth dose profile for low energy electrons (TestEm11, Sandia data)
- e.m. showers in homogenous medium (TestEm2 )

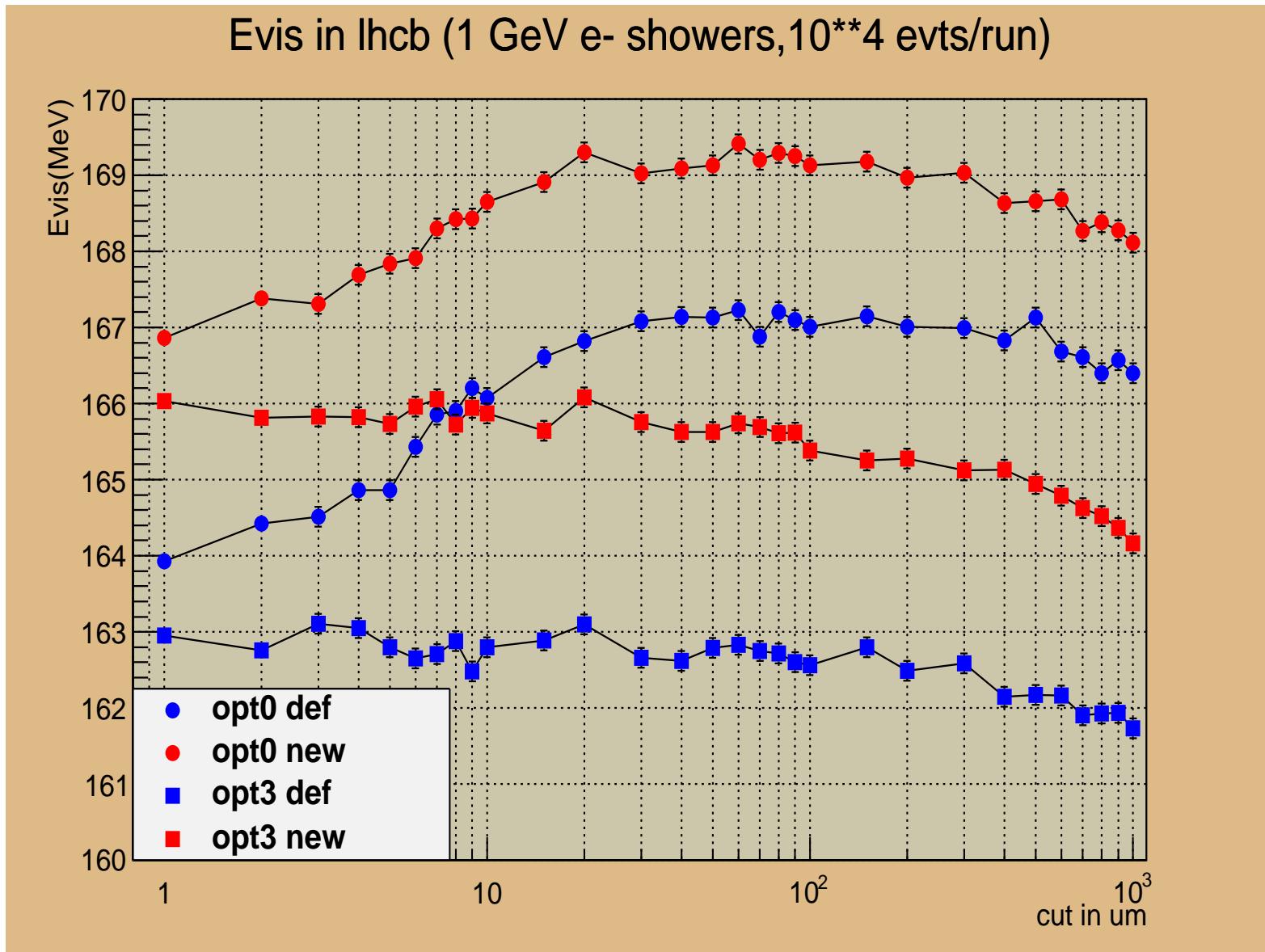
test where default and new models give different results:

- sampling calorimeter (TestEm3 , lhcb i.e. Pb-scintillator calorimeter)

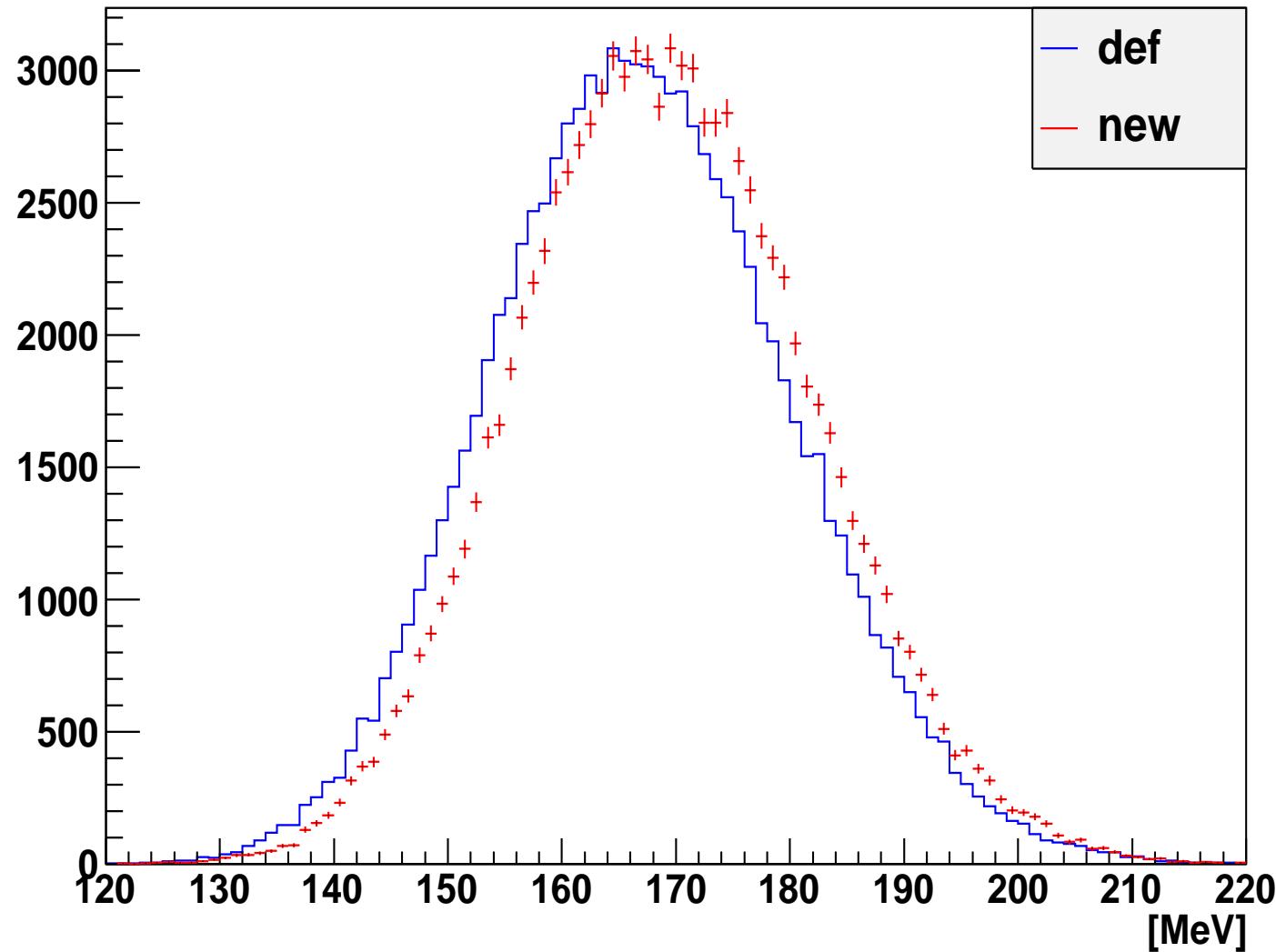
Here new version gives more visible energy, than the default one  
cut dependence of the results are similar in def/new

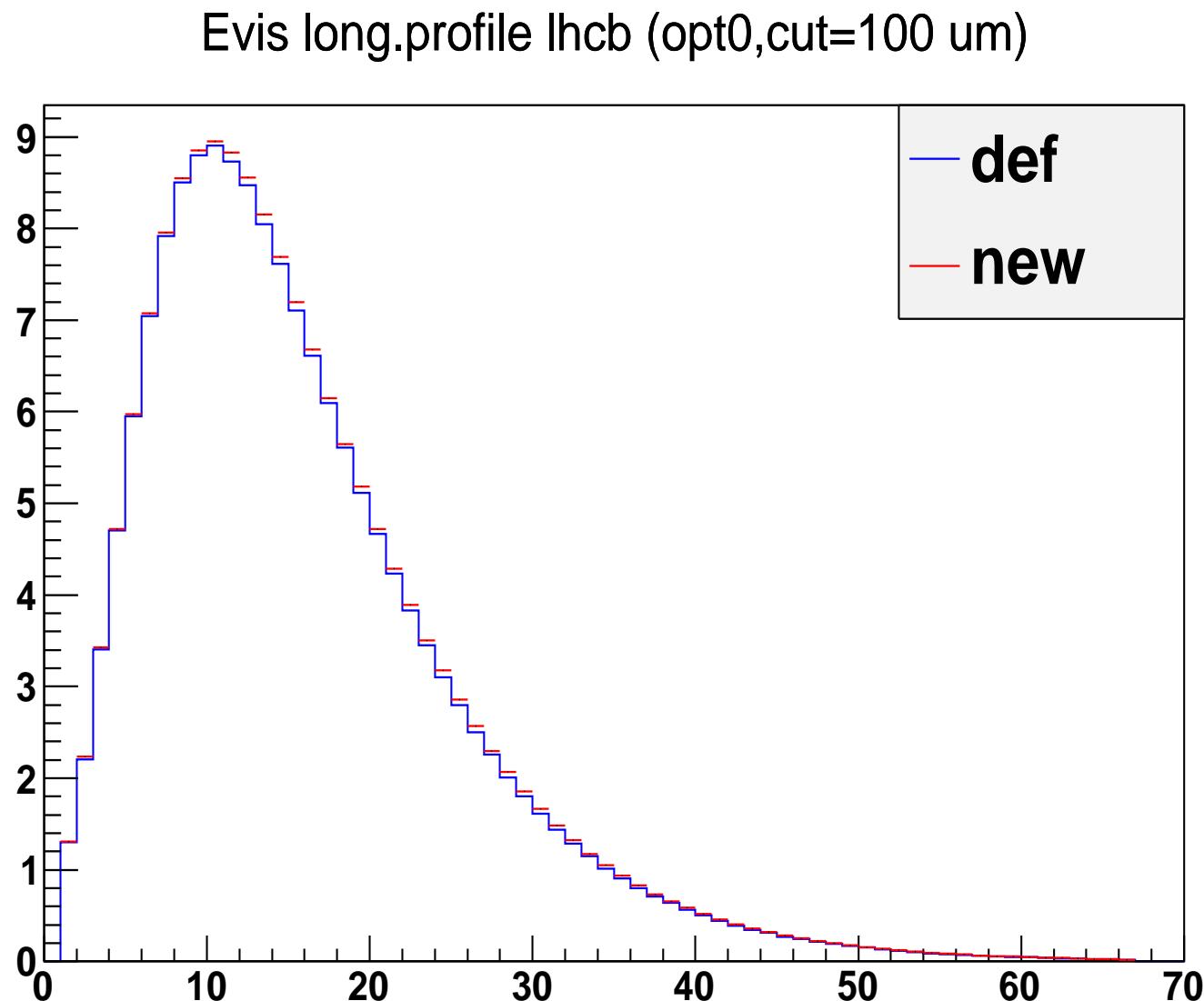
Some lhcb results can be seen on the next 4 plots:

- cut dependence of  $E_{vis}$  in def/new (opt0 and opt3)
  - $E_{vis}$  plot for opt0, cut=100 um
  - longitudinal profile in scintillator (opt0, cut=100 um)
  - difference of the new and def long. profile
- ⇒ slightly longer showers in new?

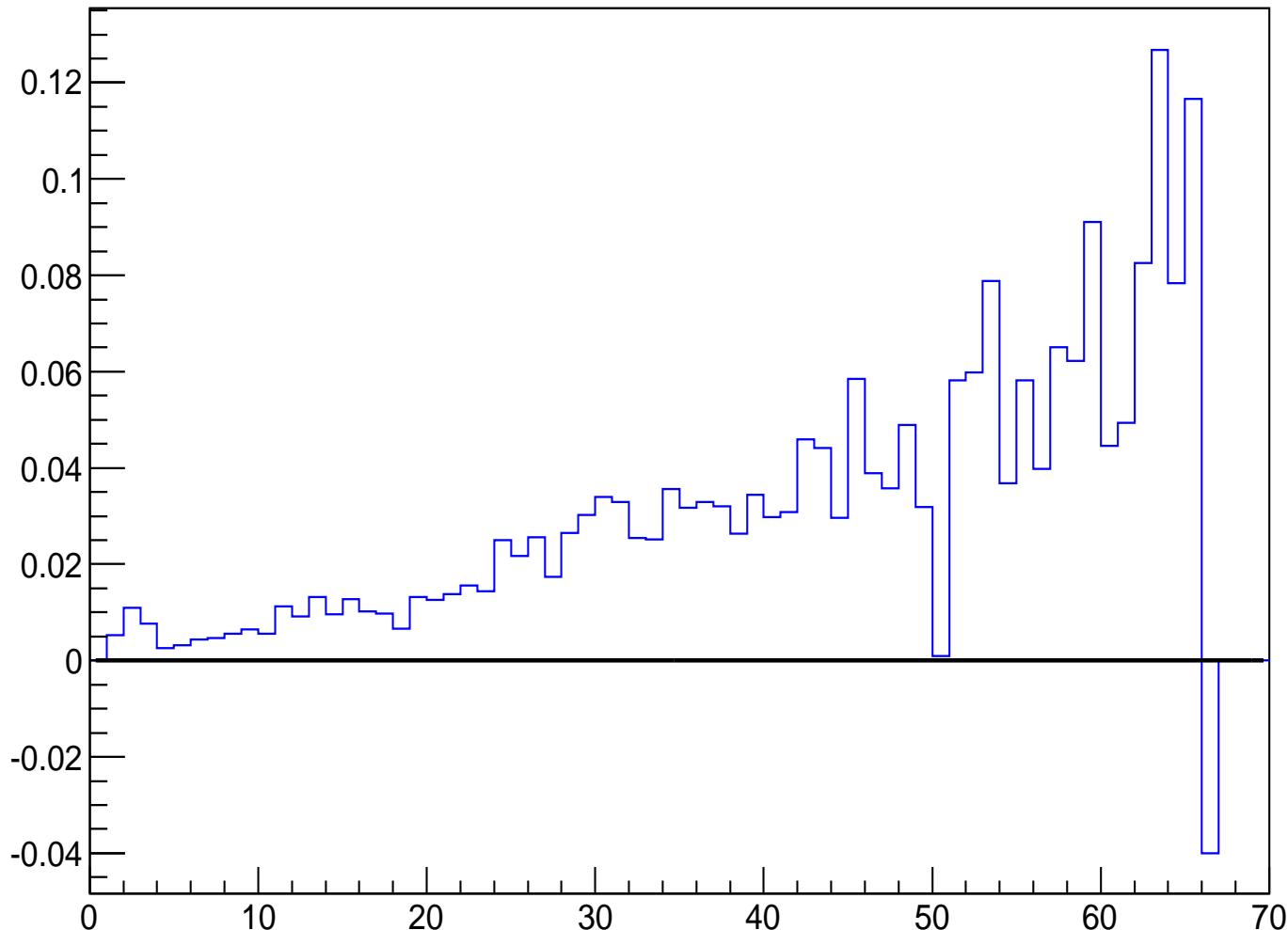


E\_vis in lhcb (1 GeV e- showers,opt0,cut=100um)





Diff. in longit. profile (new-def)/(0.5\*(new+def),opt0 cut=100 um)



### plans :

- better (more precise) e+ correction (?)
- faster sampling algorithm for the r sampling (now new is slower by about 3 % for lhcb showers)
- some more testing
- ????????