



Geant4 Reverse MC status

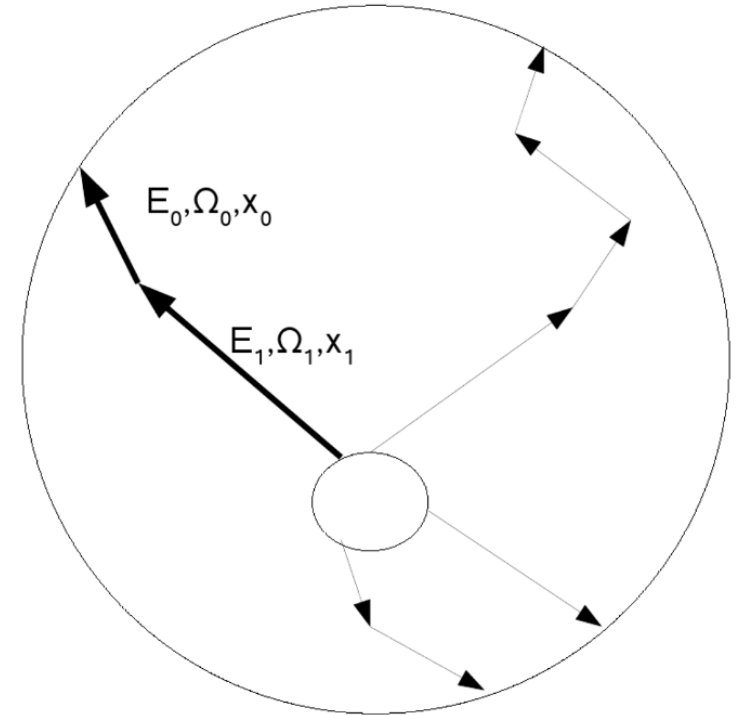
L. Desorgher

Radiation Physics Institute, IRA-CHUV, Lausanne



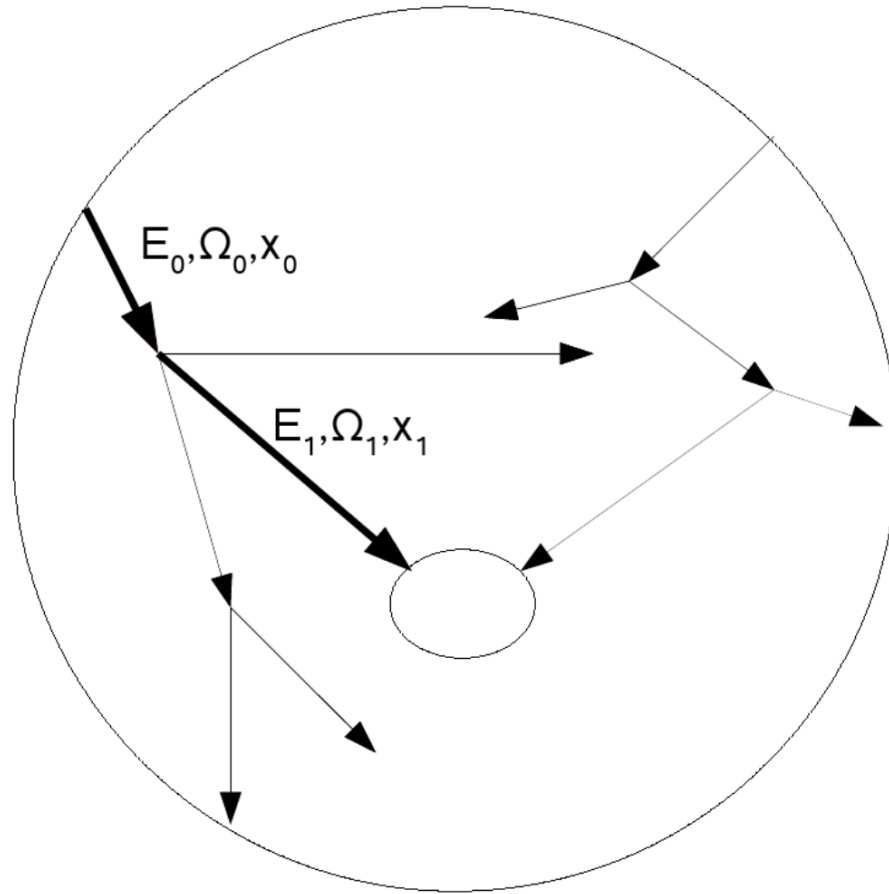
Geant4 Reverse MC

- Introduction
- Improvement electron dose computation for thick shielding
- Test with complex geometry
- Problem on proton dose computation
- Test in multithreading mode
- Verification of precision computation



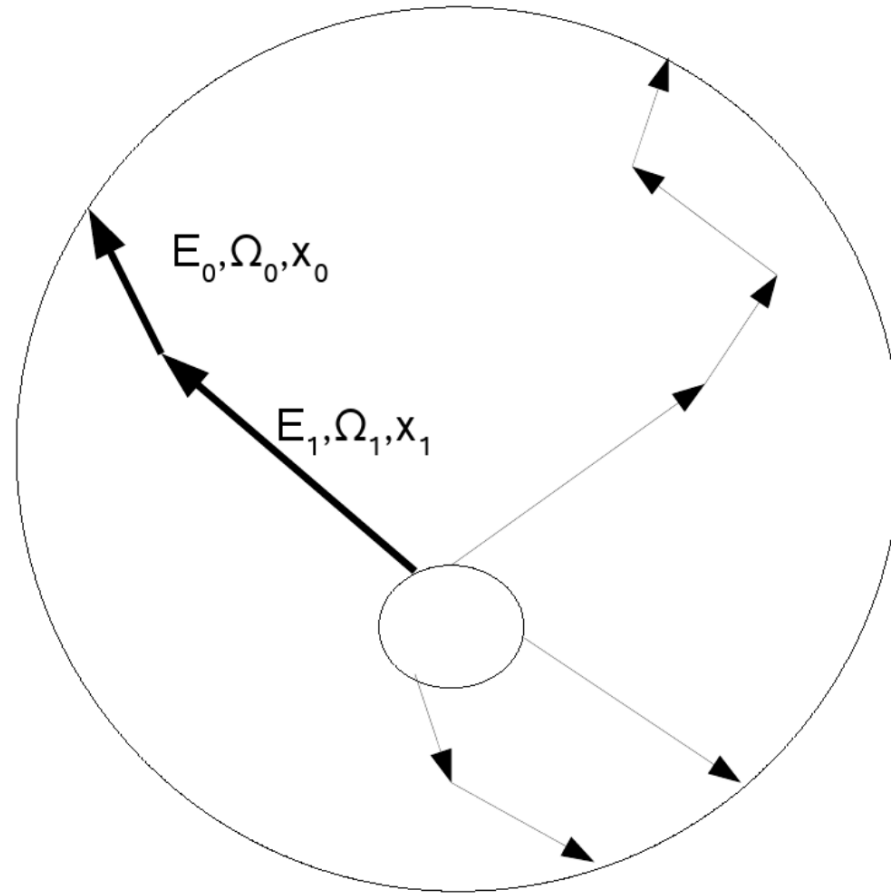
Reverse Monte Carlo method

Forward MC Mode



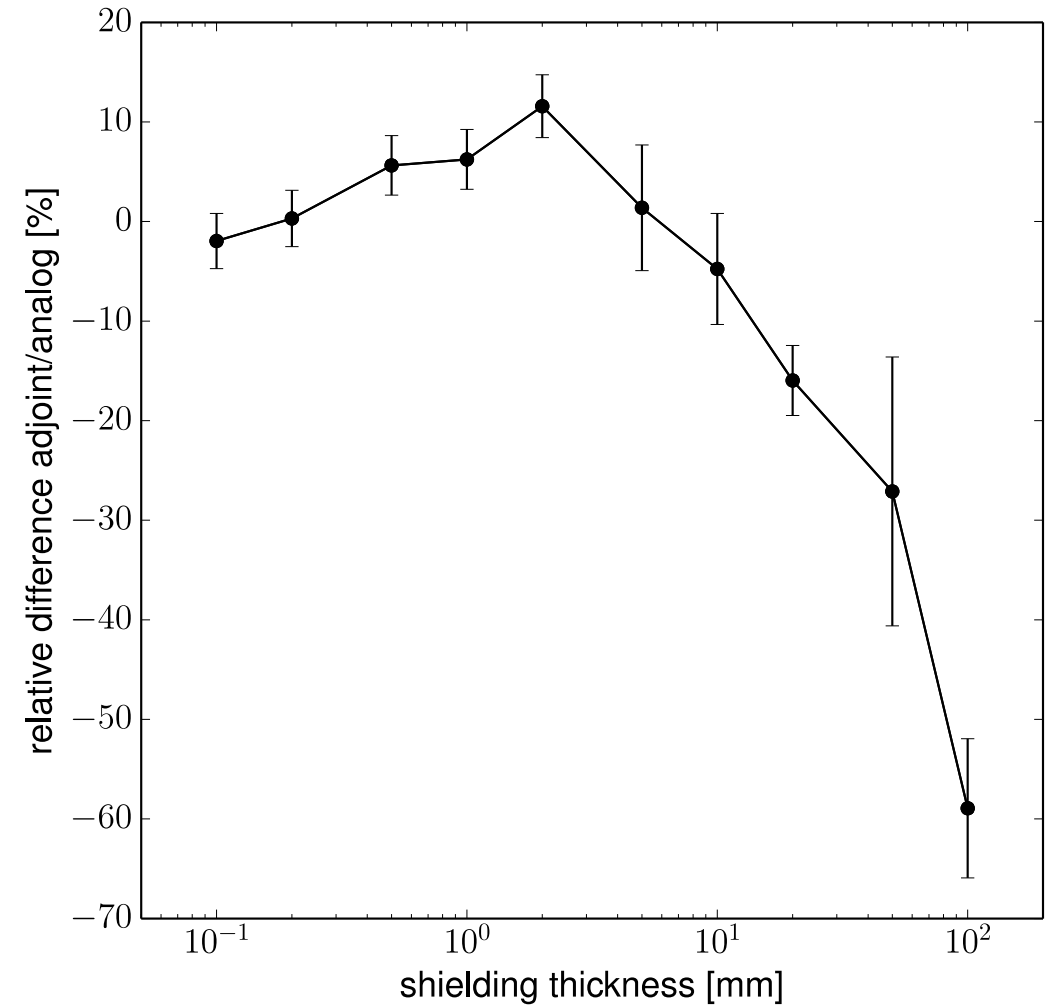
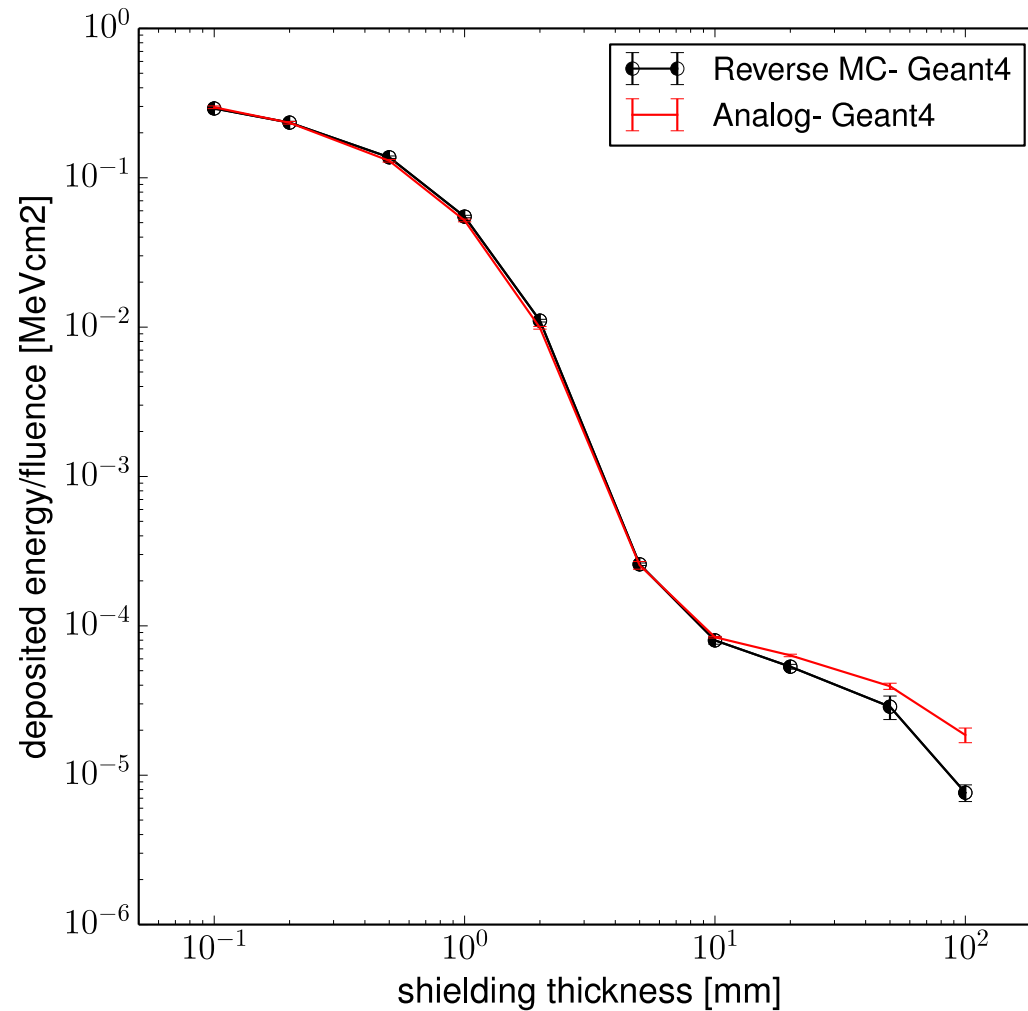
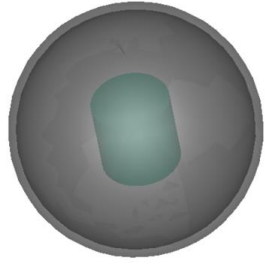
- **Start from the external source**
- **Wasted Computing time for tracks that do not reach the sensitive region**

Adjoint/Reverse MC Mode



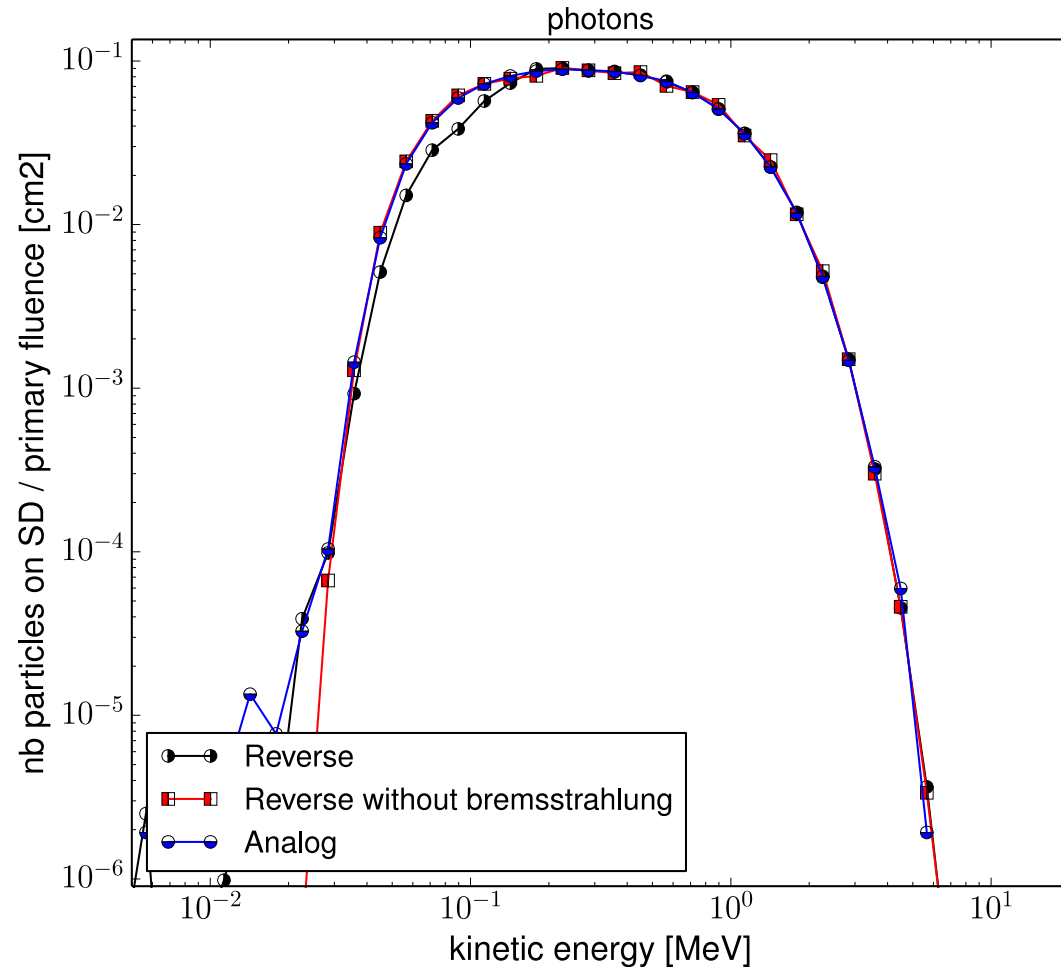
- **Start from the sensitive region and compute reverse tracks till the external source**
- **Computing time focuses mainly on tracks that reach the sensitive region**
- **Much more rapid than forward MC for example to compute e-dose in tiny electronic components**

Energy deposited in sensitive volume behind Al shielding



Discrepancy between Geant4 Reverse MC and Geant4 analog at thick shielding where the dose from secondary gamma dominates

photon fluence at 2 cm thick shielding from photon source



- Discrepancy in photon fluence at low energy
- Discrepancy disappears when the bremsstrahlung is switched off
- Seem to indicate that the Compton is not properly sampled when the bremsstrahlung is switch on

Modification in the reverse photon forced interaction

Analysis Reverse photon forced interaction

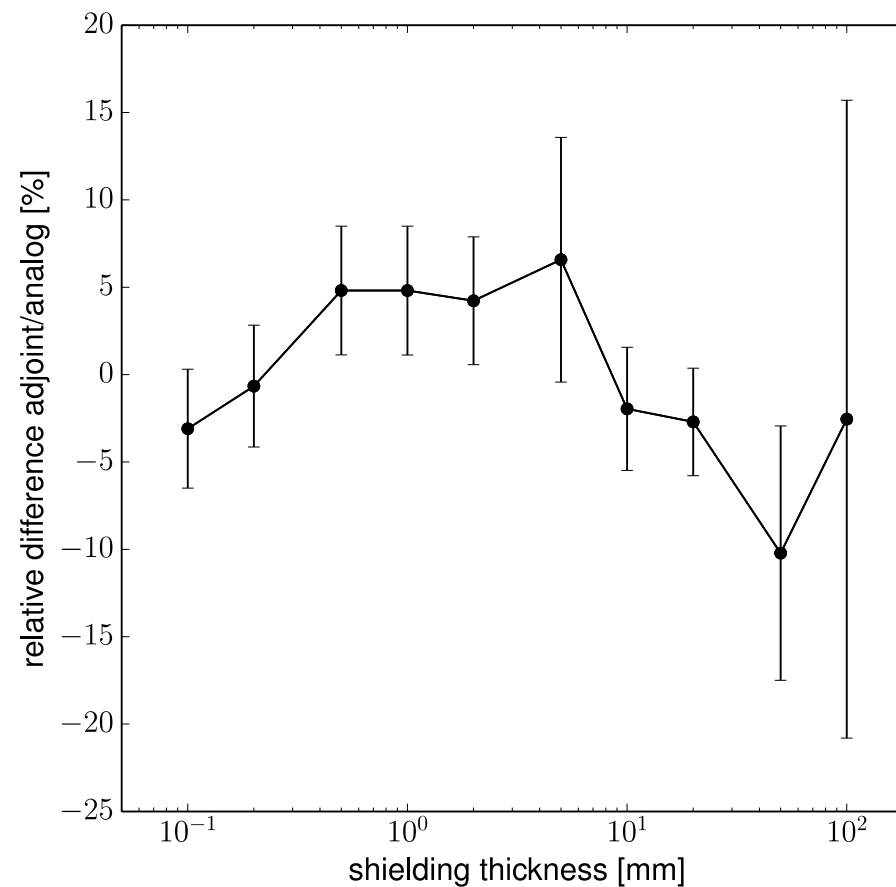
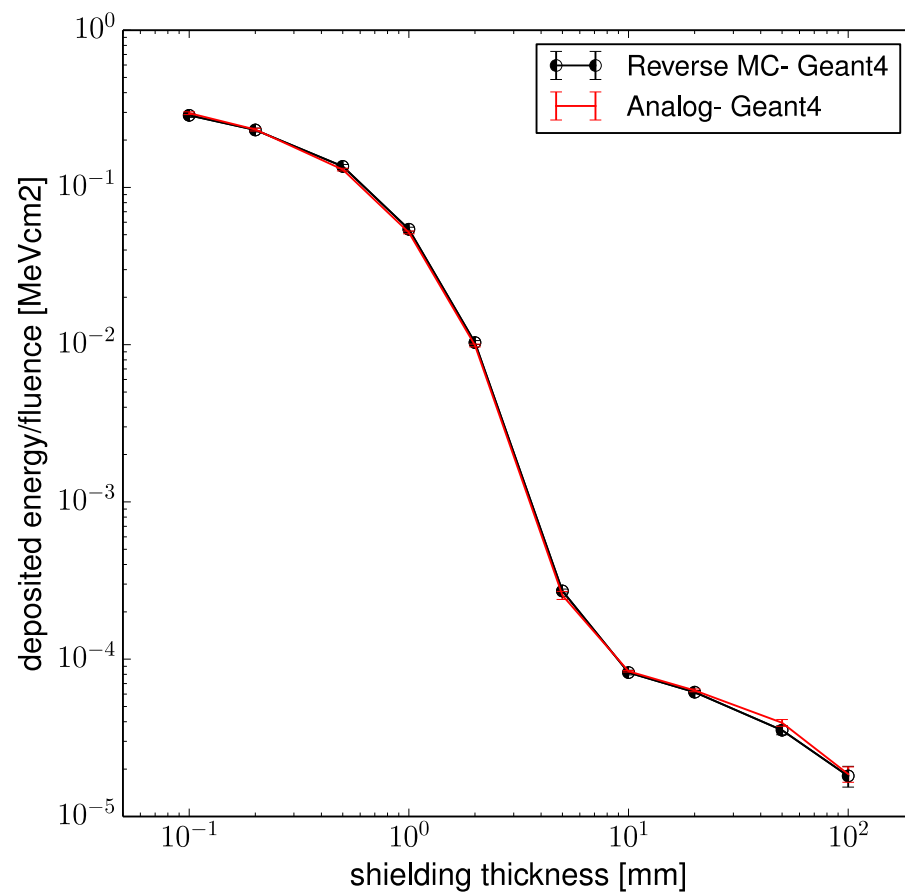
- Reverse bremsstrahlung is sampled much more often during the reverse forced interaction compared to the reverse Compton
- Reverse photon processes are sampled more often in the inner part of the shielding

Applied modifications

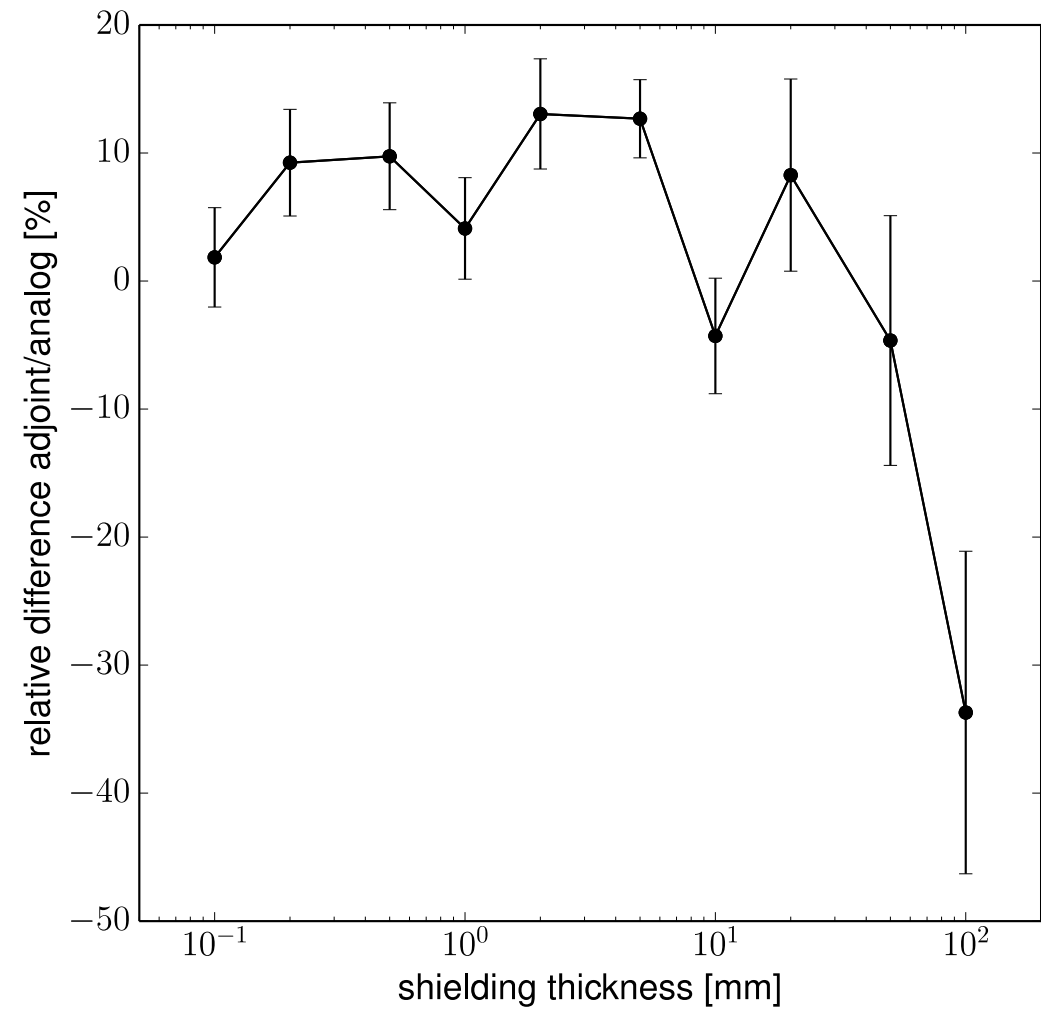
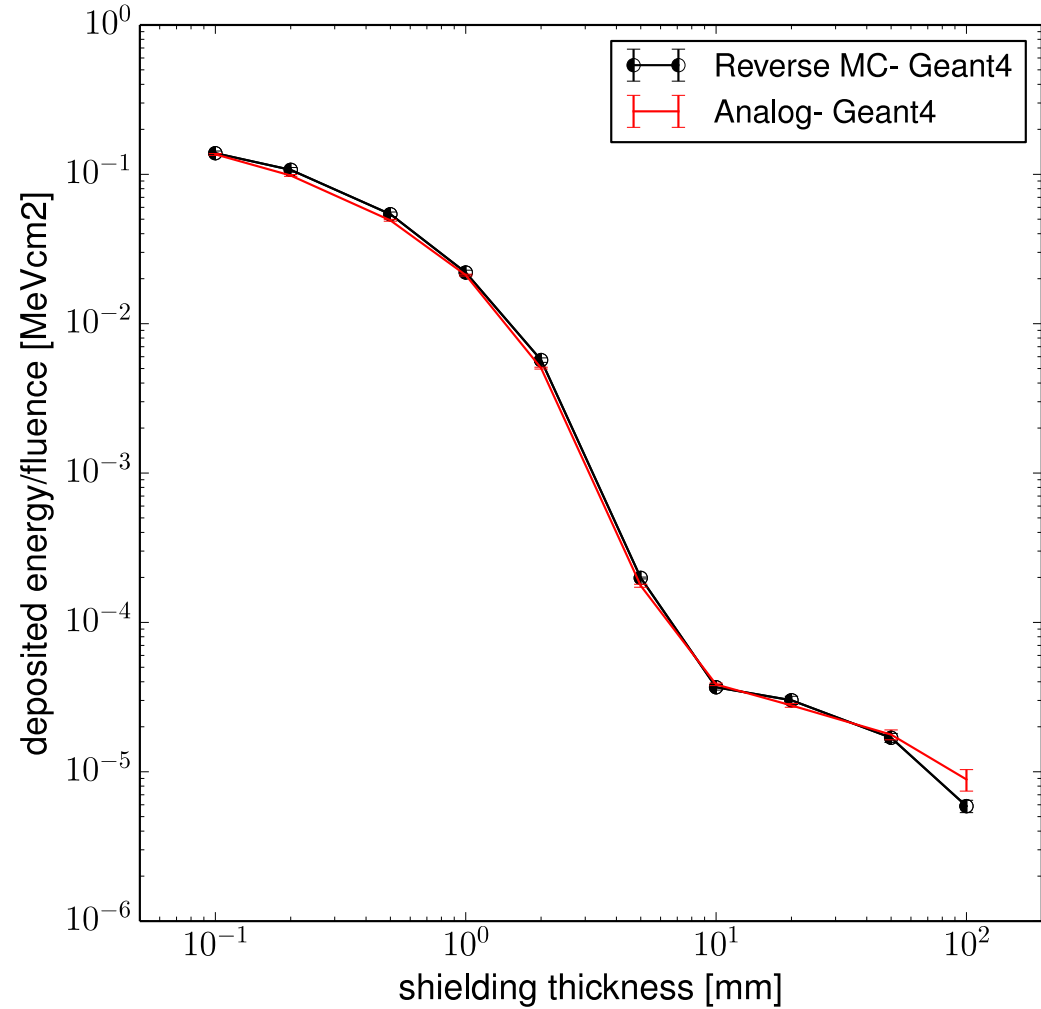
- Sample reverse bremsstrahlung and Compton with a 50-50% probability
- Sample linearly the occurrence of reverse processes along the reverse tracking path

Dose vs Al shielding thickness after modifications

Spectrum exp(-E/0.4 MeV)

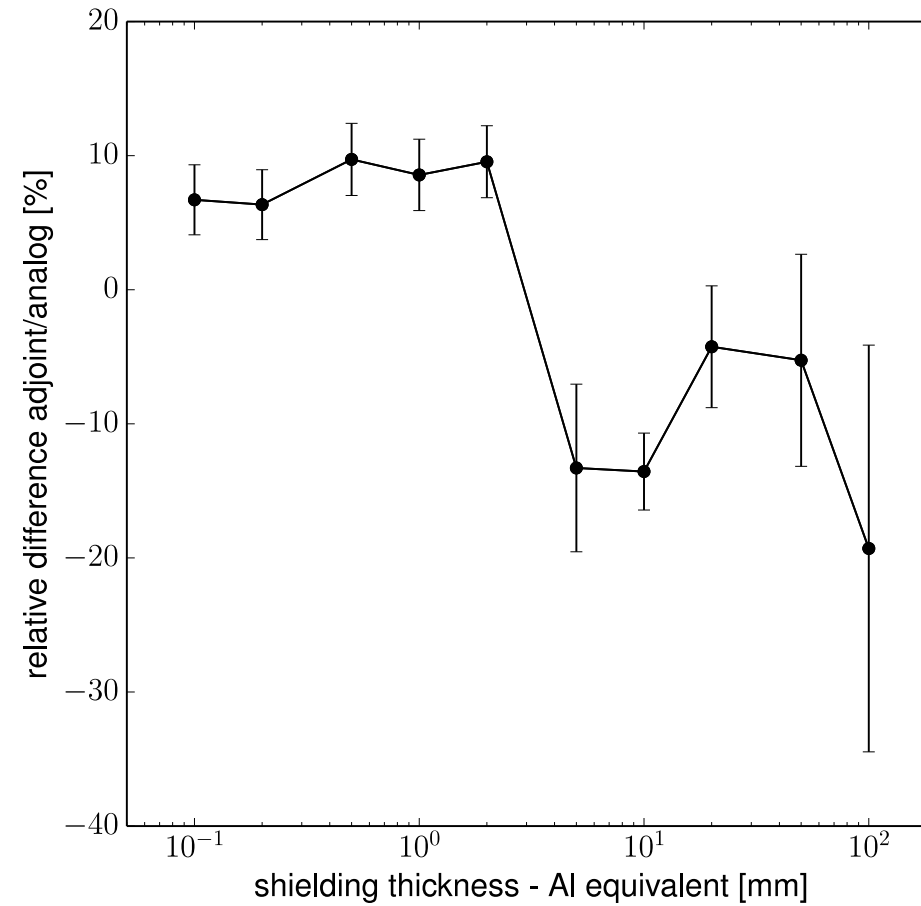
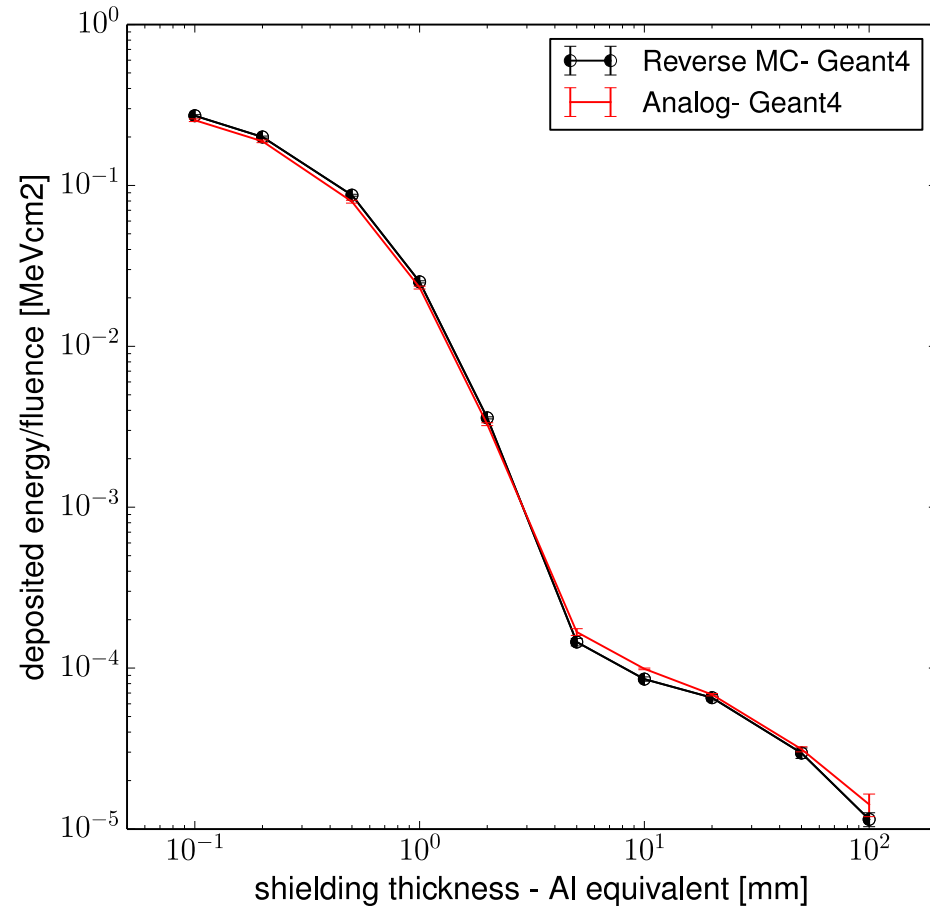


Dose vs Al shielding thickness – MEO spectrum



Dose vs Ta shielding thickness after modifications

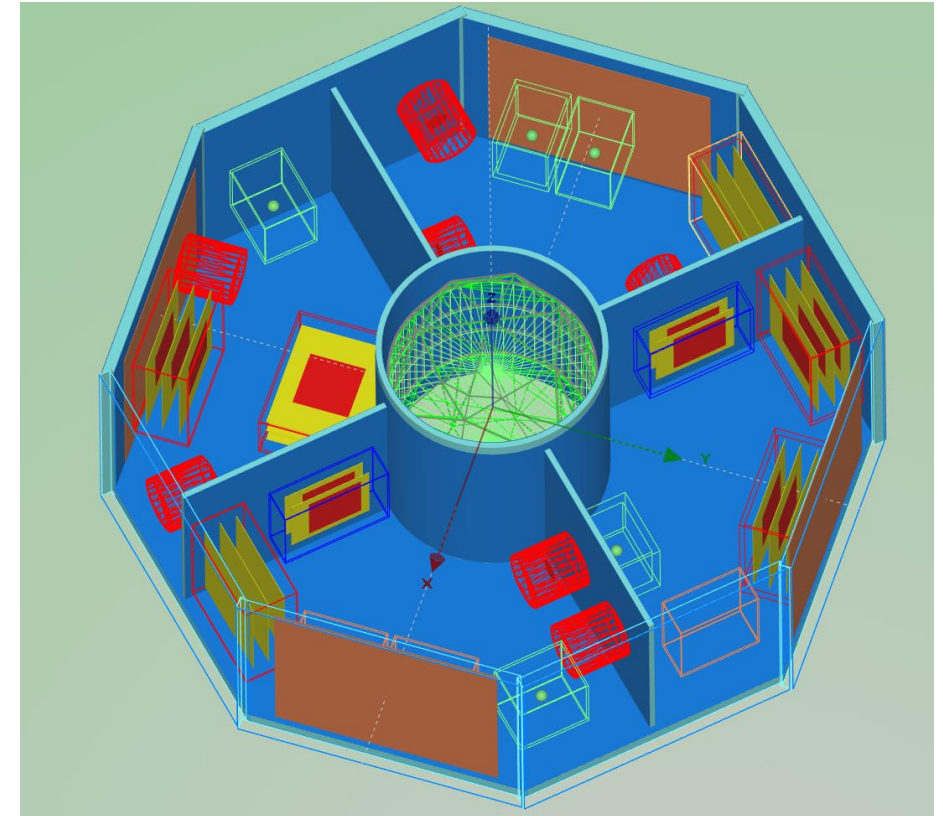
Spectrum $\exp(-E/0.4 \text{ MeV})$



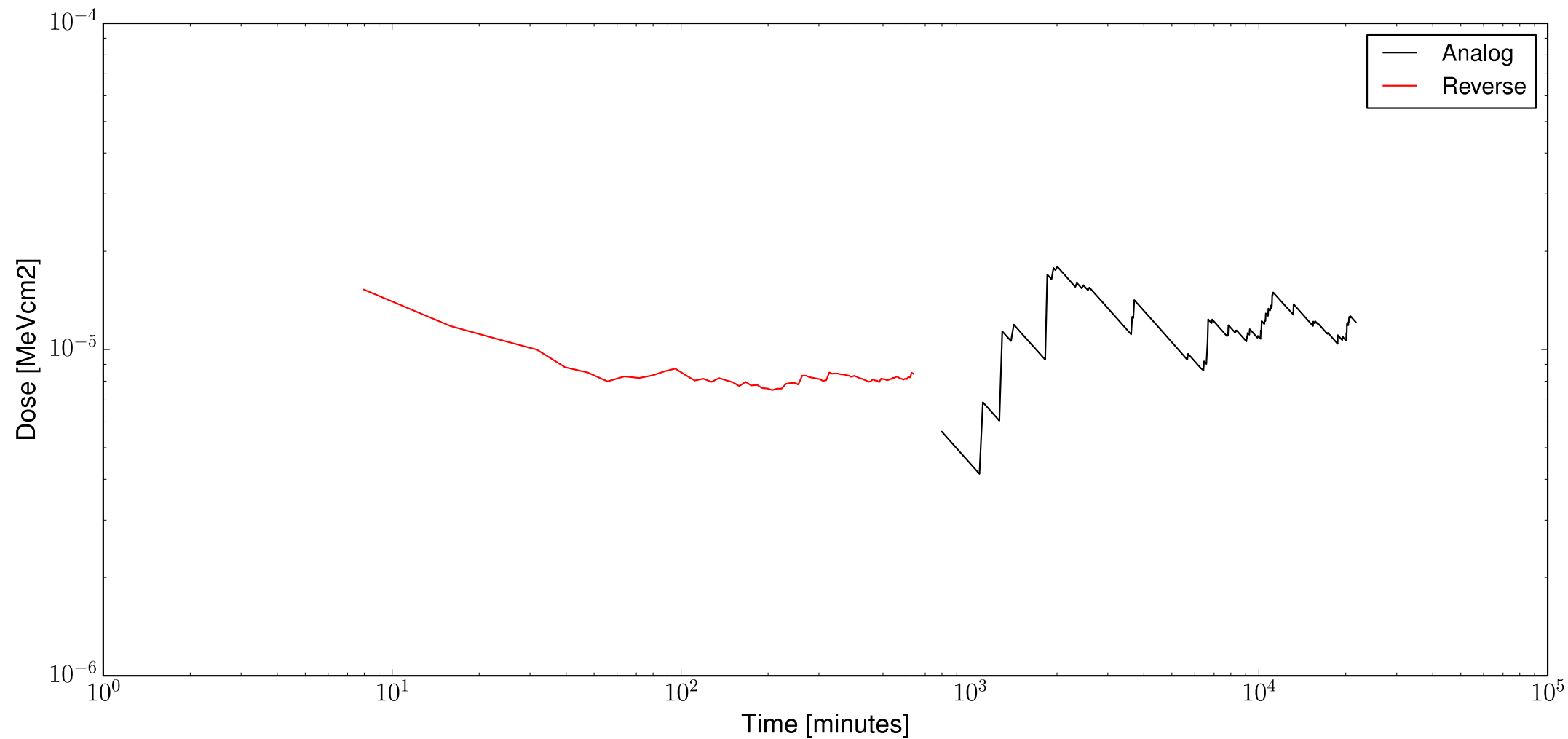
Electron dose with ESA Spacecraft_test geometry

Middle Erath Orbit spectrum

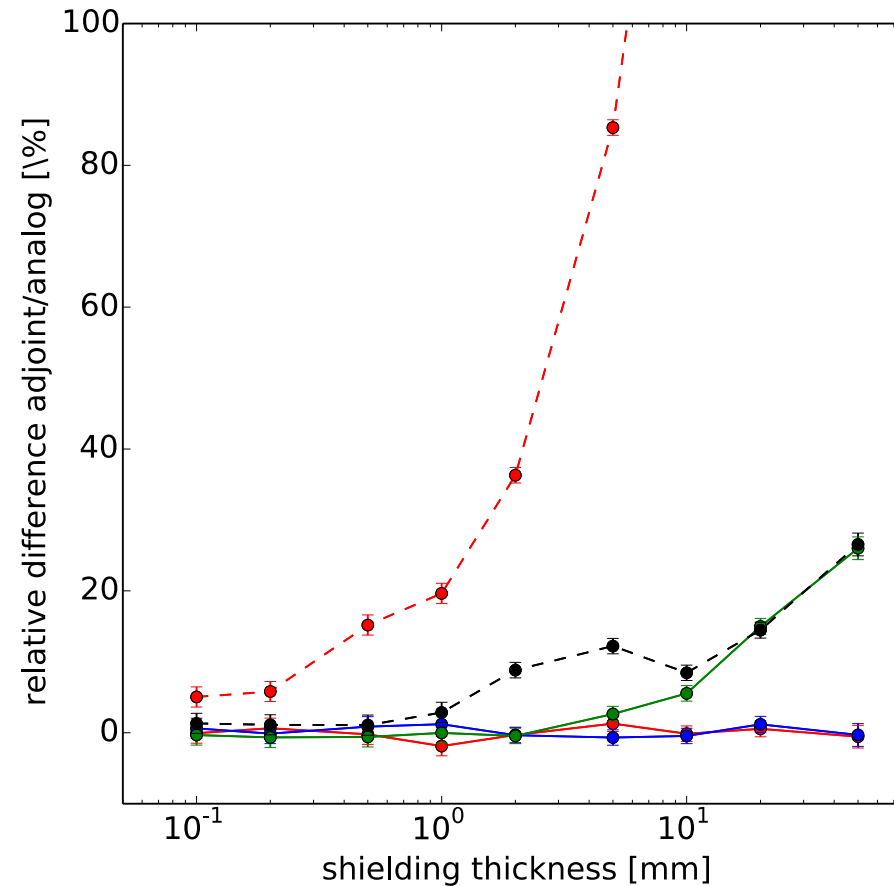
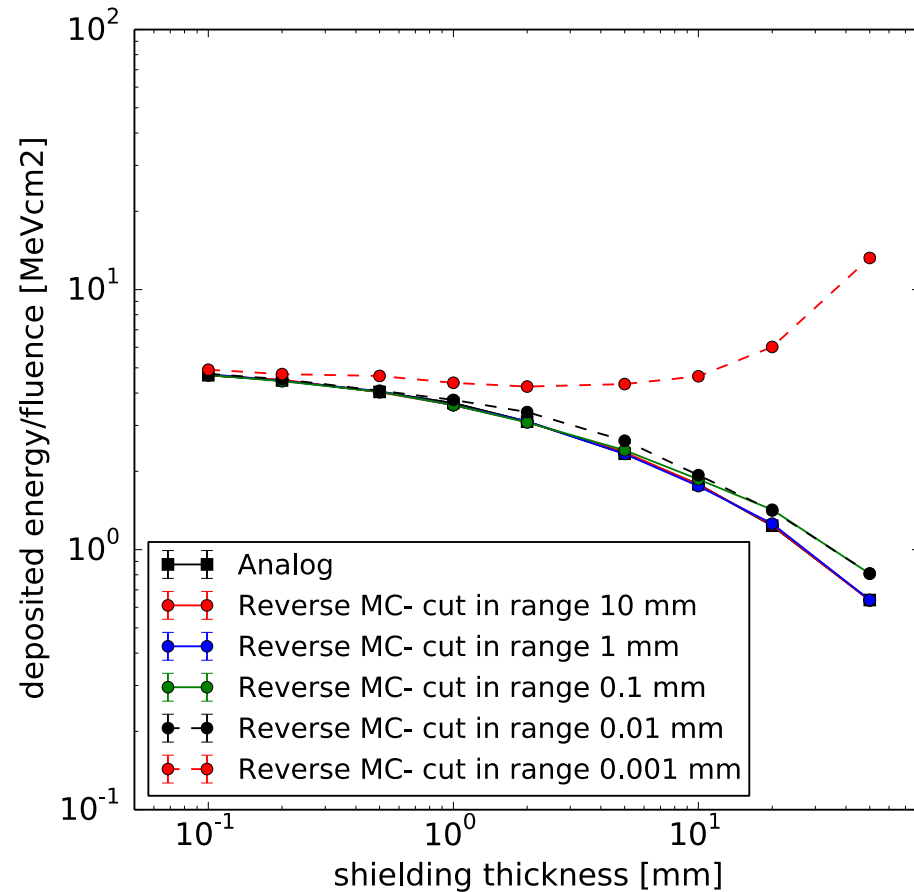
Name Det	Shielding	Analog dose (MeVcm ²)	Reverse dose (MeVcm ²)
det_4_2_fwd	Al 7 mm	$3.88 \cdot 10^{-5}$ (0.5)	$4.15 \cdot 10^{-5}$ (0.25)
det_5_2_fwd	Al 1 mm	$3.58 \cdot 10^{-3}$ (0.2)	$4.03 \cdot 10^{-3}$ (0.06)
det_7_2_fwd	Pb 4 mm	$1.21 \cdot 10^{-5}$ (0.2)	$8.44 \cdot 10^{-6}$ (0.6)



Convergence of dose results – det7



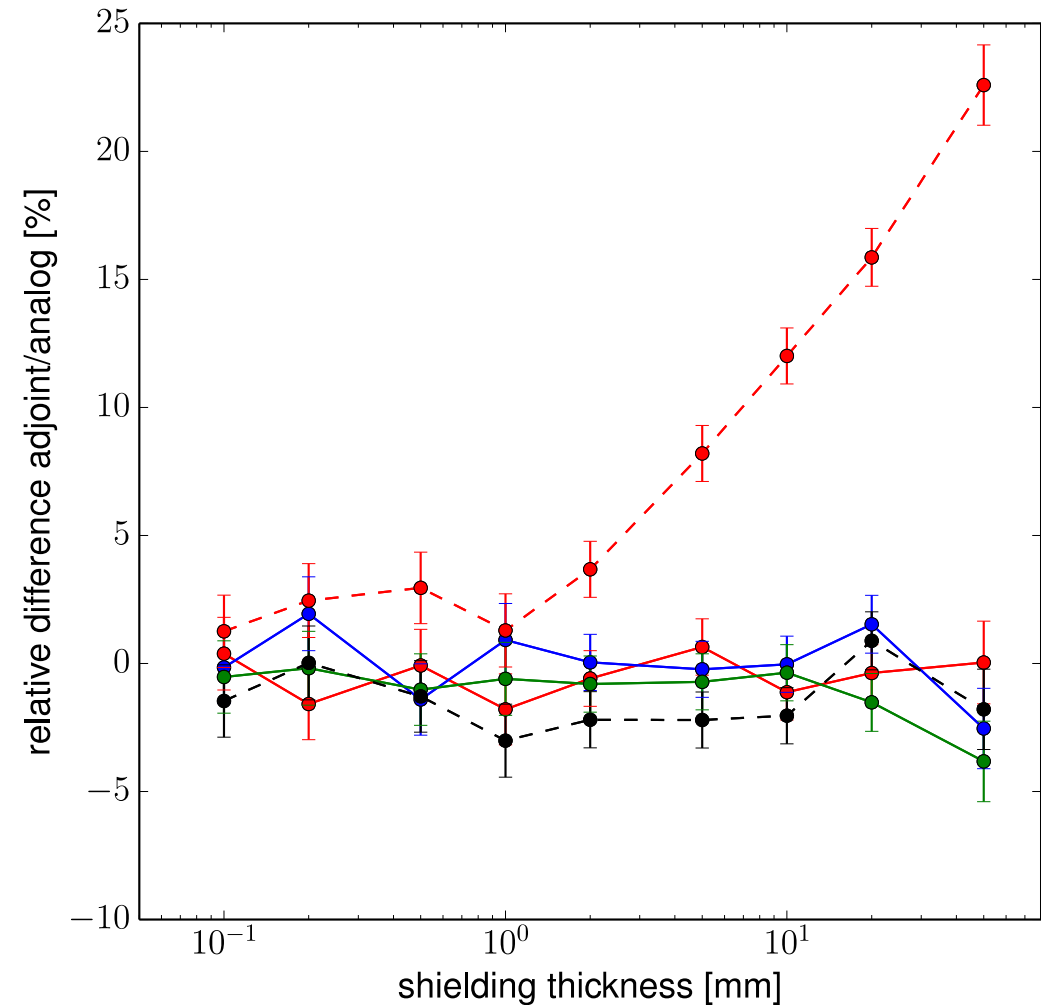
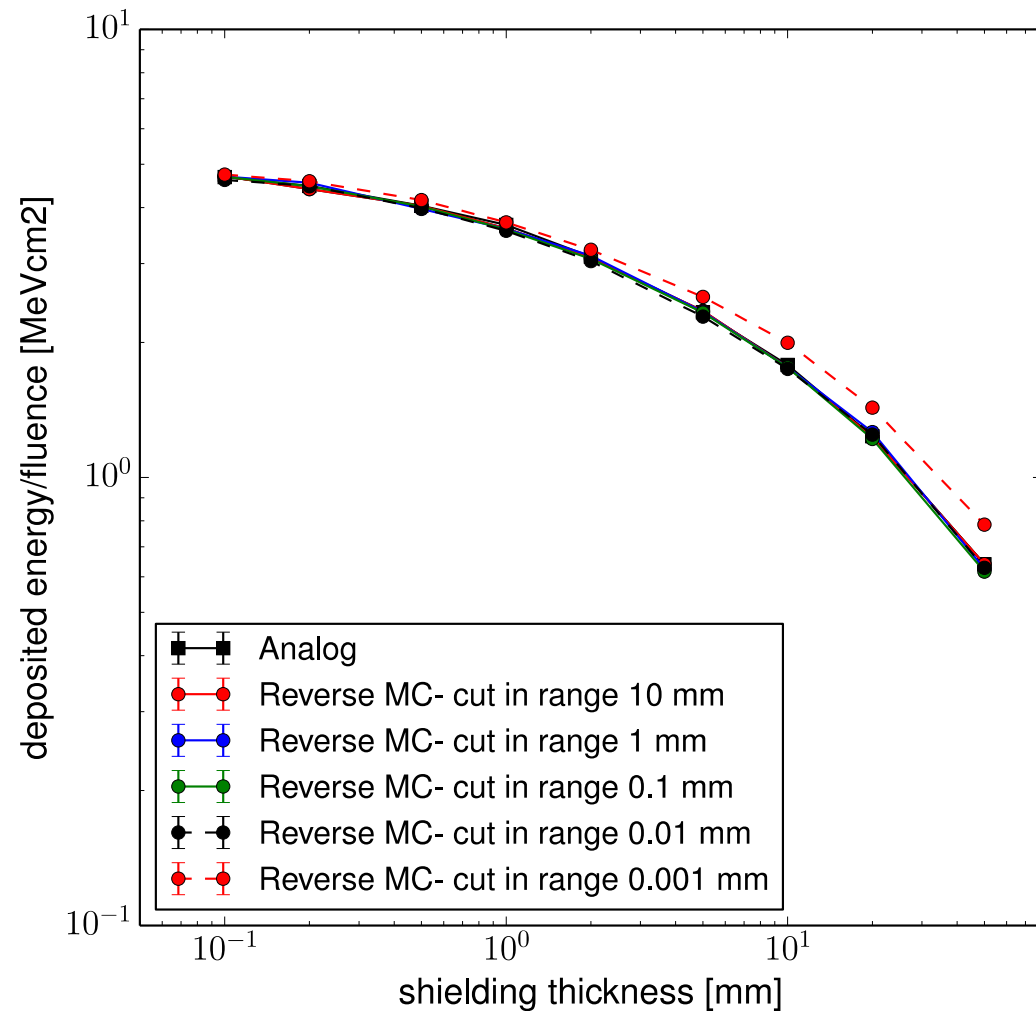
Energy deposited in sensitive volume behind Al shielding



proton spectrum $1/E$
dependence of the results on the cut in range

Energy deposited in sensitive volume behind Al shielding

Without post step weight correction

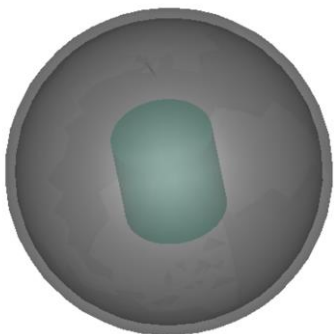


Post step weight correction for reverse proton not necessary up to 0.01 mm cut in range

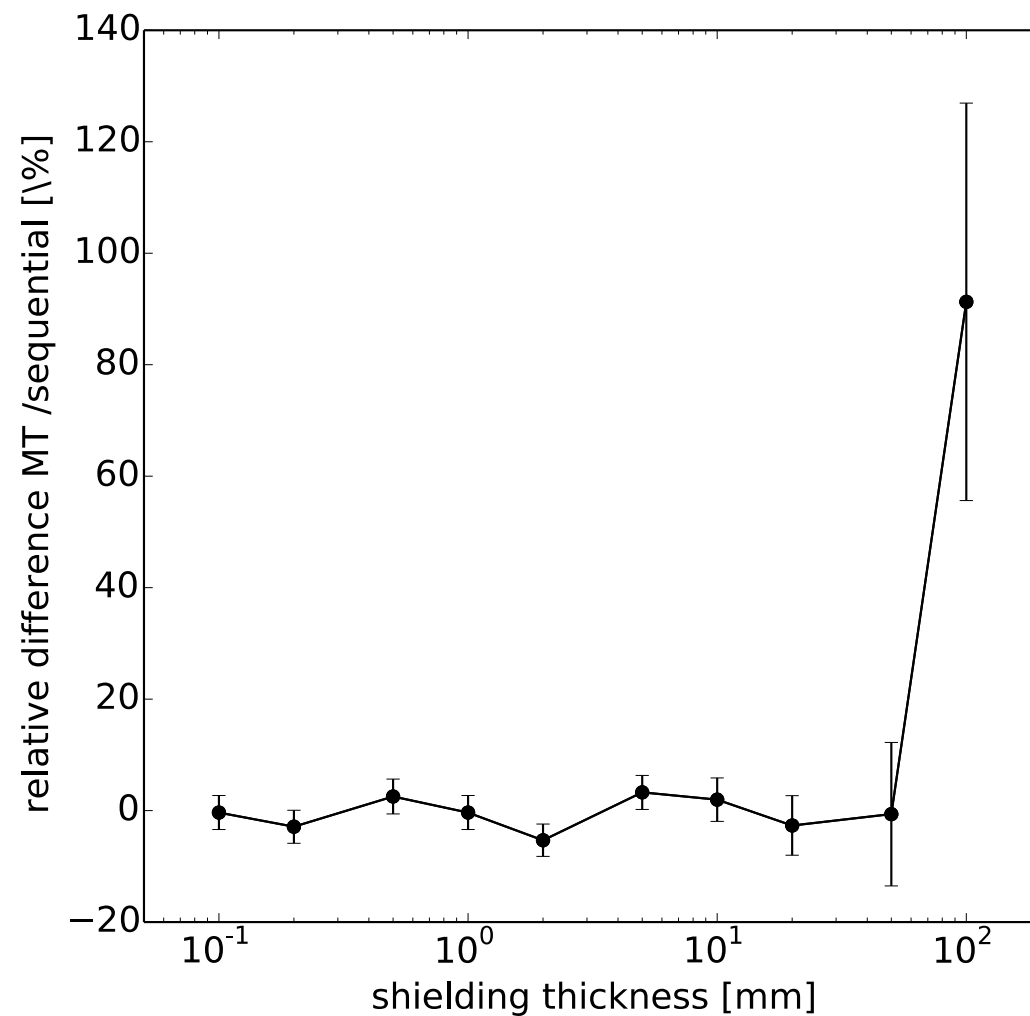
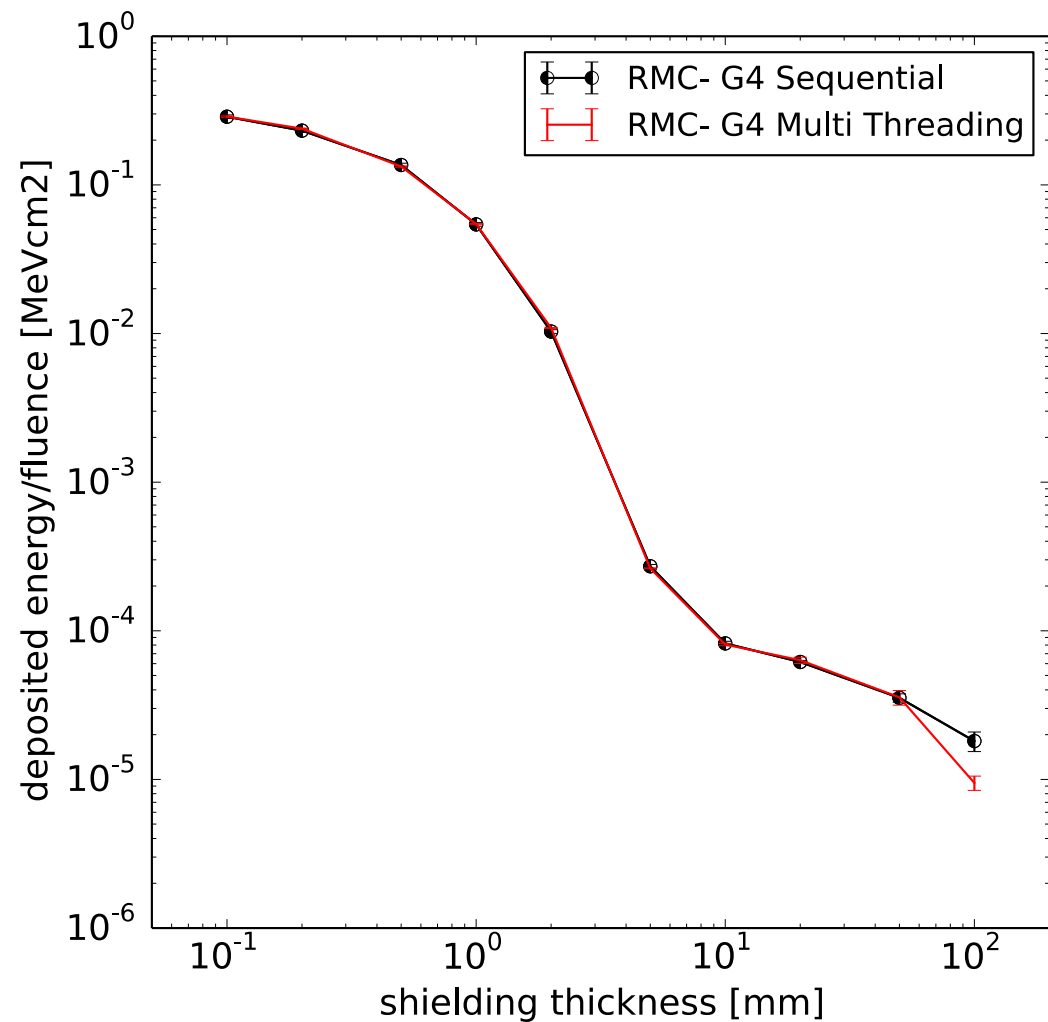
At smaller cut in range more discrete ionisation occur and the weight correction should be applied

Geant4 exampleRMC1 in multithreading mode

- Add the capability of using GDML file for the geometry definition
- Porting of the G4RMC example in MT mode. Thanks to M. Axiotis
- Need to use `/run/setCut` command before `/run/initialize` in MT mode
- Convergence file and precision test in MT mode
 - One convergence file per working thread
 - Precision test at the level of working thread
 - Merging of the results by the master at end of run

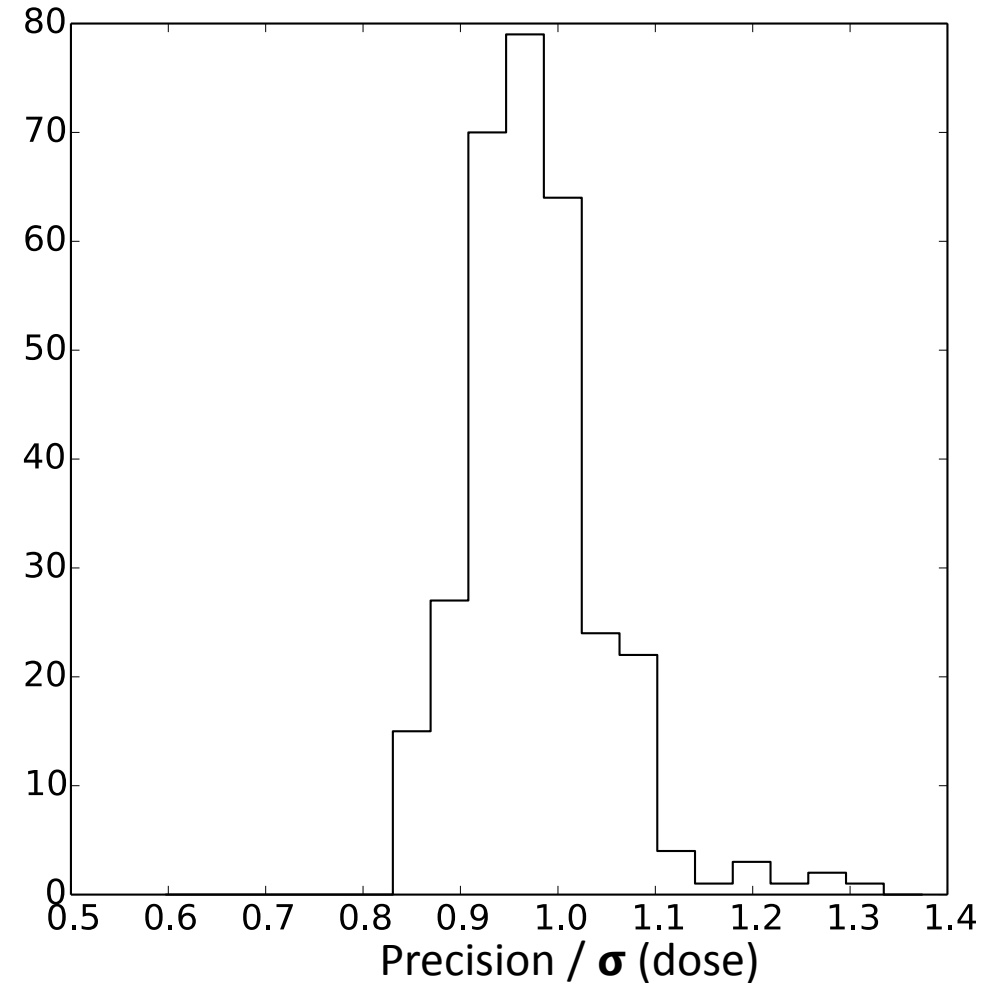
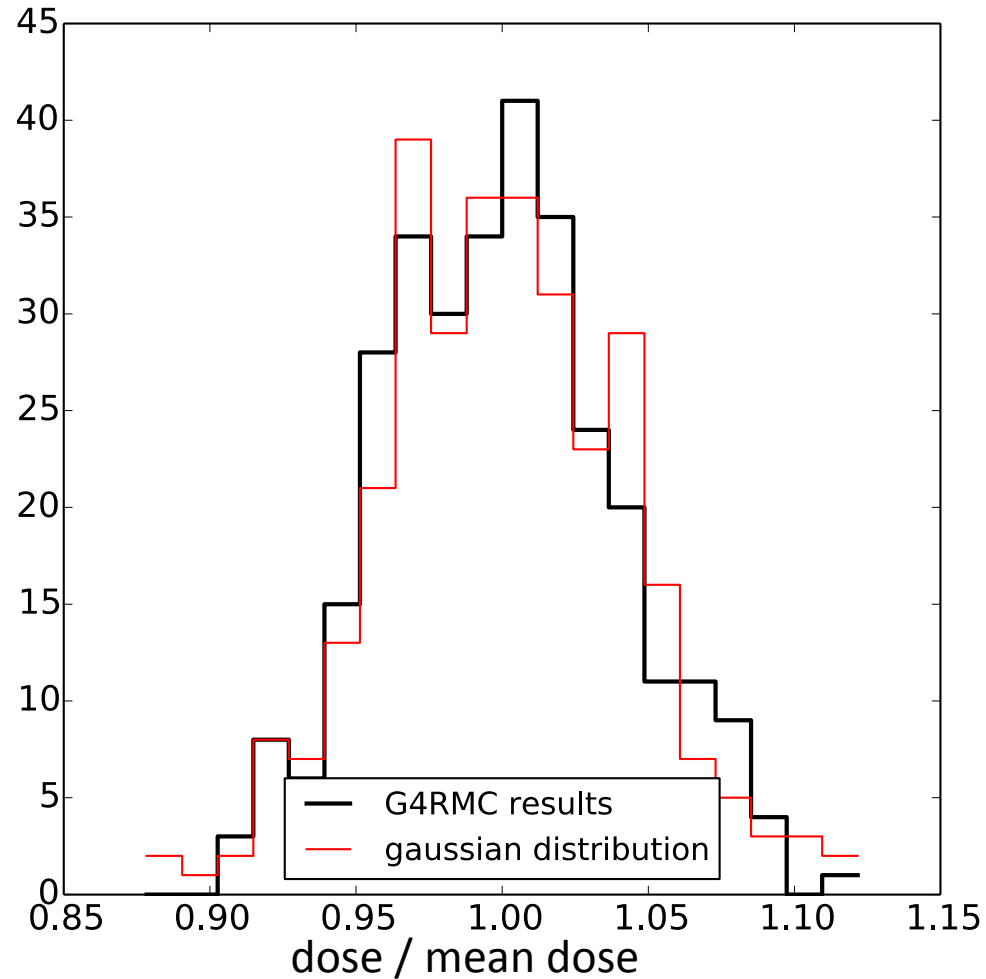


G4RMC MT vs sequential mode



Verification of precision computation in G4 RMC example

350 simulations with $5 \cdot 10^4$ events - 5 mm Al shielding



Computation of dose and dose precision follows the central limit theorem!

Conclusions

- Gamma Reverse tracking algorithm based on forced interaction has been modified to improve the e- dose computation under thick shielding
- Geant4 Reverse MC is now working in multithreading mode
- Ongoing investigation on proton bug
- Updated G4Adjoint classes and exampleRMC1 will be provided in Geant4.11 release