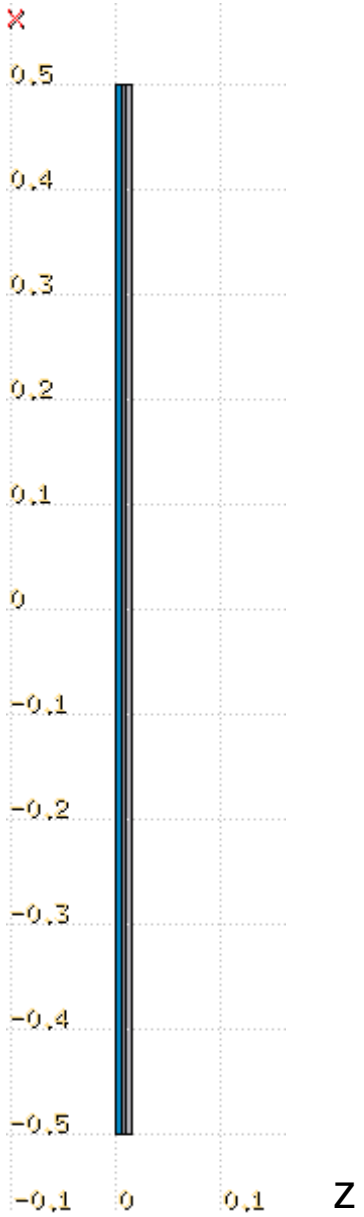
Exercise: EM thresholds

Aim of the exercise:

- Examine the effect of setting different threshold values
- Further interaction with the FLUKA manual
- Practice the use of preprocessor directives
- Strengthen plotting skills

Input file

- 10 MeV electron beam
  - Annular beam with 2 mm radius
  - Starting at x = 0 cm, y = 0 cm, z = -1 cm
- Cylindrical target along z, 5-mm radius, split in three layers, each 50 μm thick
  - Set to H_2O – Pb – Al
- Thin layers require high tracking precision. Thus, we set
  - **`DEFAULT PRECISIOn`**
- Notice that three preprocessor variables are defined
  - HI-THR, LOW-THR, VLOW-THR
- **`USRBIN`** scoring DOSE over the entire target
  - 1 μm bins in z, 1 bin in R, saved to unformatted (BIN) unit 55



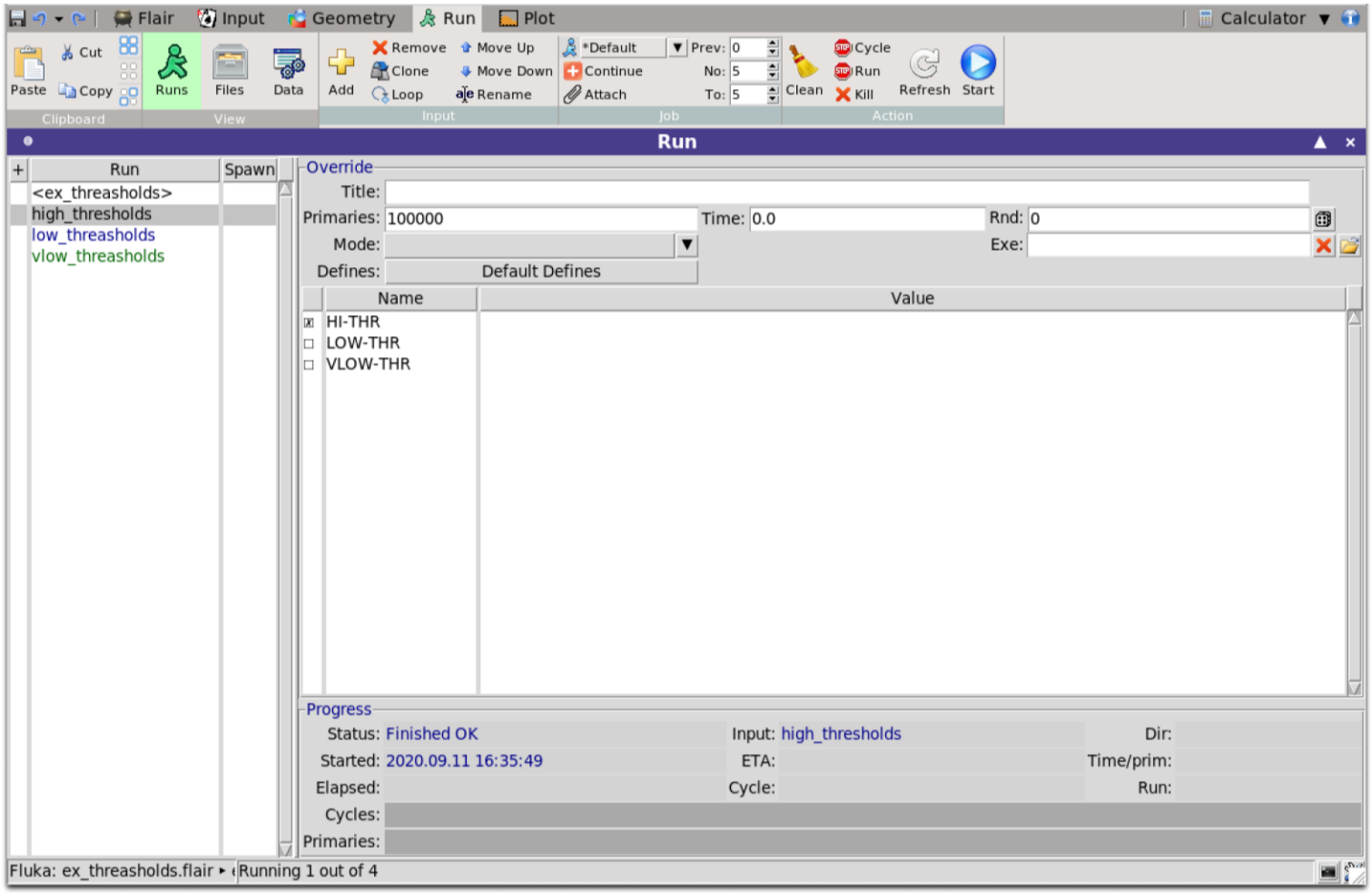
Add EMFCUT cards

- Set both production and transport thresholds in all materials
  - Hint: when specifying the range of materials/regions, use @LASTMAT/@LASTREG as needed to refer to the last material or region, respectively
- Use preprocessor instructions to prepare three runs, one for each threshold case, exploiting the already defined preprocessor variables:

```
#if HI-THR
      photons: 1 keV ,      electrons: 1 MeV kinetic energy,      FUDGEM=1
#elif LOW-THR
      photons: 1 keV ,      electrons: 100 keV kinetic energy,    FUDGEM=1
#elif VLOW-THR
      photons: 1 keV ,      electrons: 10 keV kinetic energy,     FUDGEM=0.5
#endif
```

- Note that the electron threshold is 100 keV in case of **PRECISIOn**, corresponding to our LOW-THR case
- Reminder: stopping powers and ranges for electrons, protons, and He ions are available on the NIST webpage: https://physics.nist.gov/PhysRefData/Star/Text/intro.html

Run



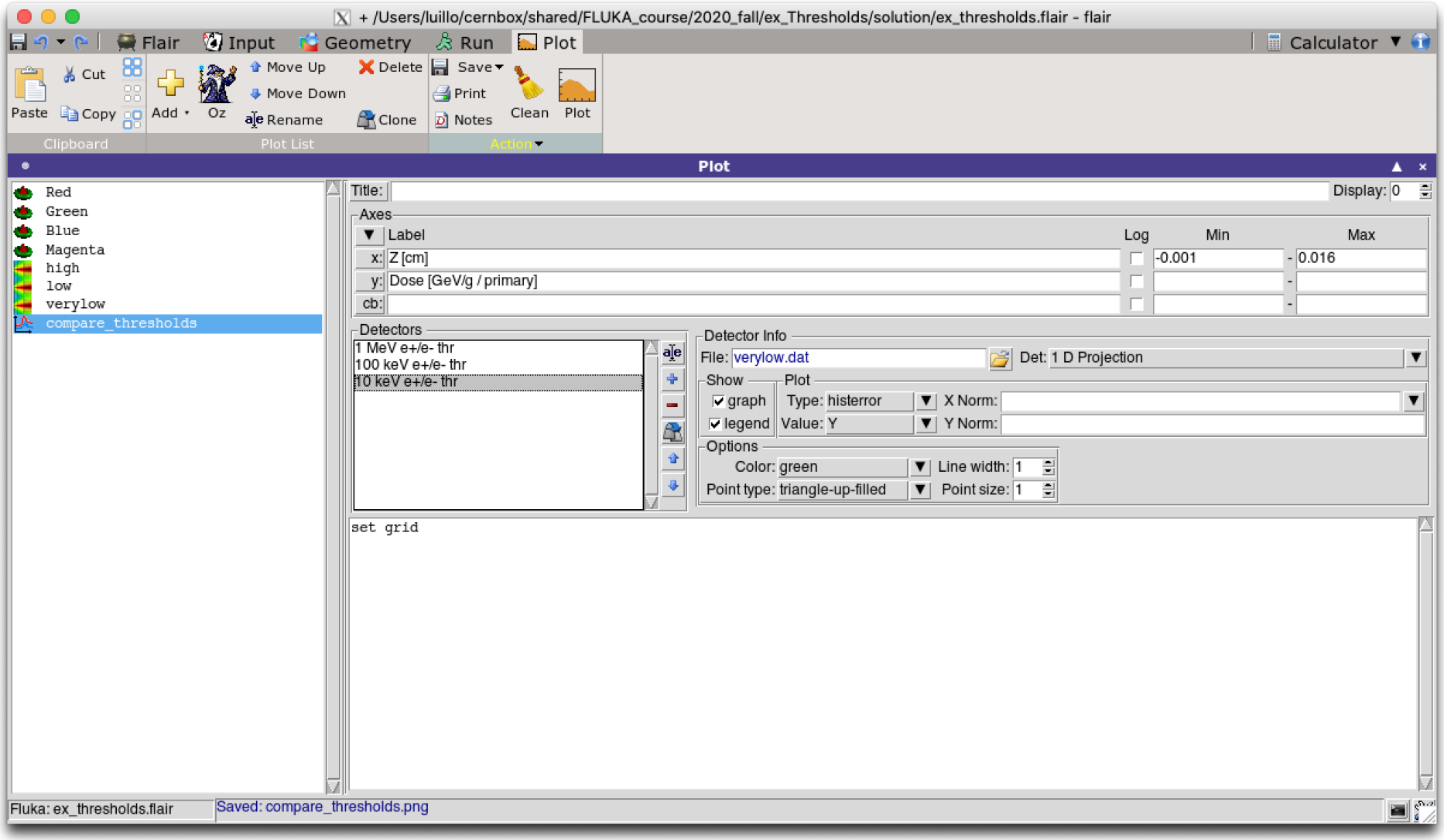
- Run three simulations corresponding to high, low and very low threshold values, with 5 cycles × 100000 primaries for each case
- The three runs are already set up in the Flair project
- Should take less than ~5 minutes on a reasonably up-to-date machine.

Plot and compare the results

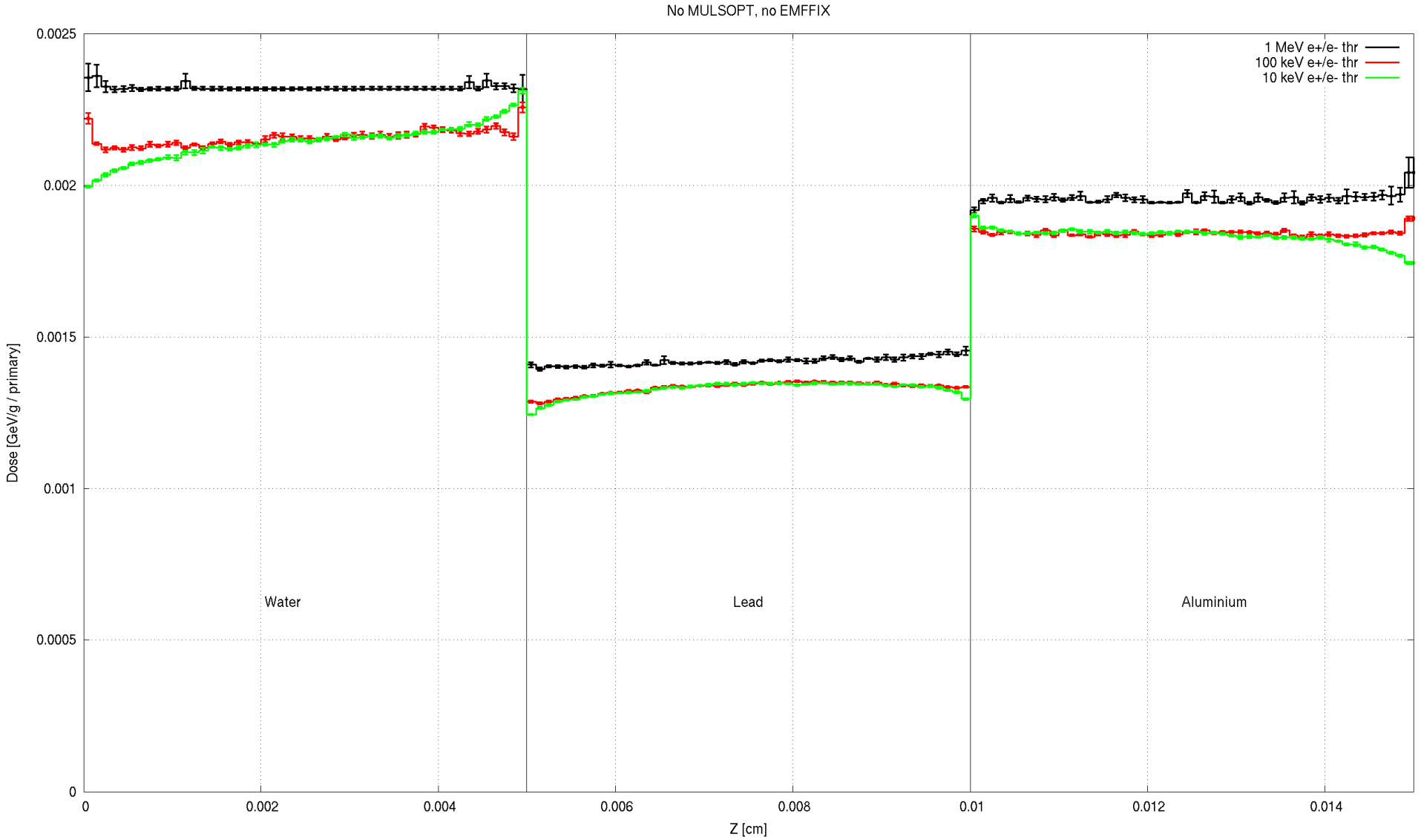
Plots are already set up in the Flair project

First plot these three…

…to make sure all needed files are there for the comparison plot!



Depth-dose distribution for various threshold settings



Compare depth-dose curve for various thresholds

- For 1-MeV threshold: premature dose deposition
- Correct deposition on average for 100-keV threshold (the value with DEFAULTS → PRECISION), but lacking details
- More refined result for 10-keV threshold

- Net flow of low energy electrons across boundary from high Z to low Z materials
- Physical effect!

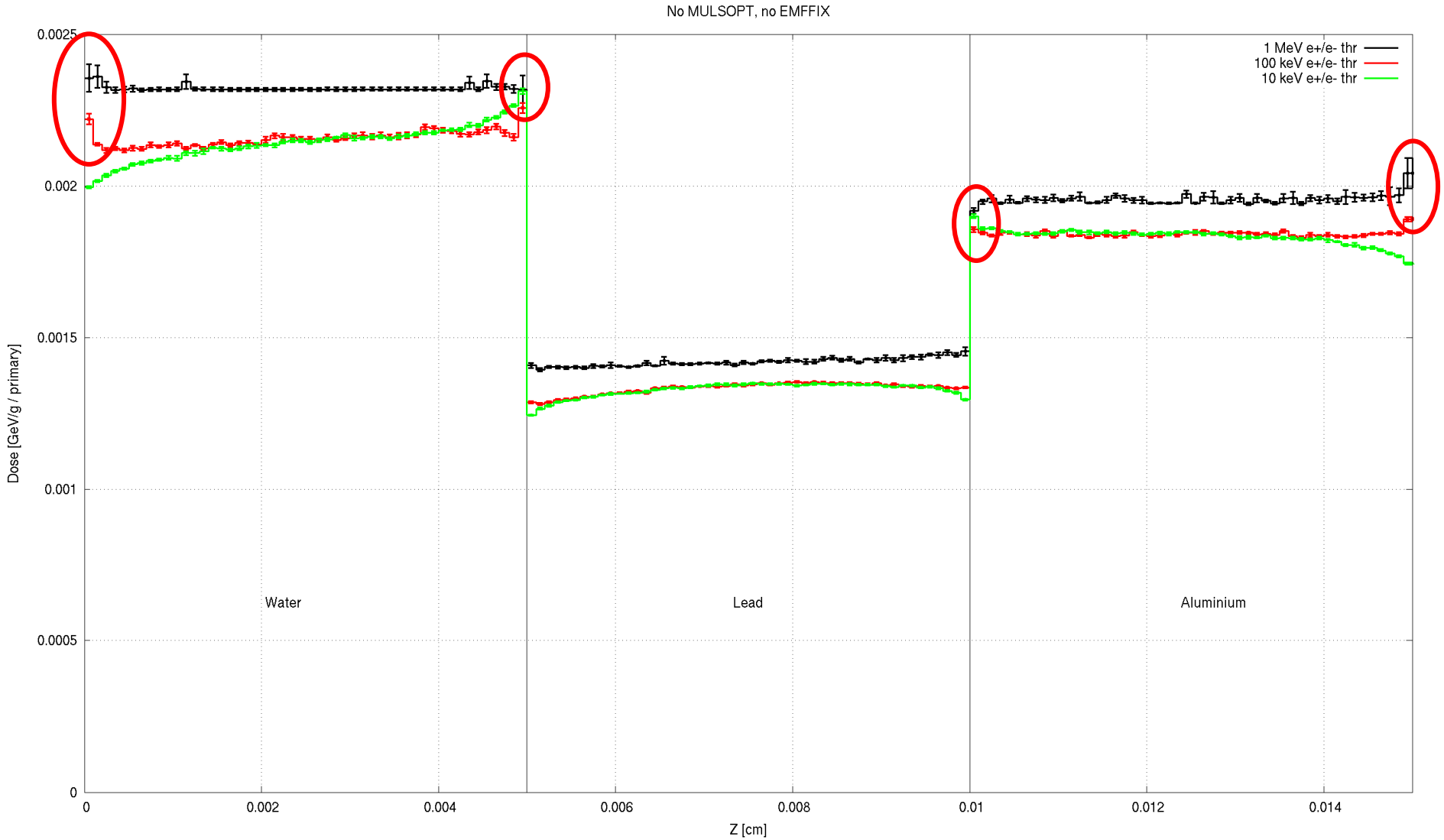
Note

- Correct threshold values depend on the granularity of your geometry/scorings
- Do not blindly rely on default values
- Carefully set threshold values accordingly (range tables are helpful!)
- Do not forget to set the FUDGEM parameter

This concludes the exercise…

…but there’s more!

Boundary artifacts (last bin before interface)



Further single scattering near boundaries (+MULSOPT)

Further restriction of stepsize (+EMFFIX)