Exercise: Cutoffs

FLUKA Beginner's Course

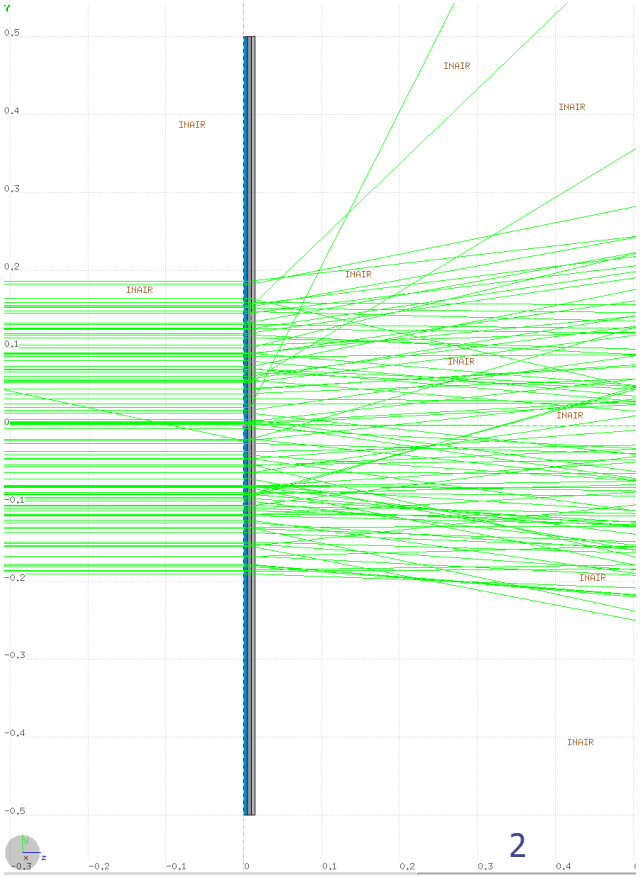
Aim of the exercise

1- Examine the effect of setting different thresholds values.

2- Further interaction with the FLUKA manual.

3- Practice the use of preprocessor directives.

4- Strengthen plotting skills.



Files

- Go to the Exercises subdirectory.

- Start from the solution of the geometry exercise, which should be under ex_Geometry1/ex_Geometry1.inp
  Should something have gone wrong in your Geometry exercise, note that there is also the file ex_Geometry1_final.inp at your disposal.

  Commands cheatsheet:

  ```
  mkdir ex_Cutoffs
  cp ex_Geometry1/ex_Geometry1.inp ex_Cutoffs/ex_Cutoffs.inp
  cd ex_Cutoffs
  flair ex_Cutoffs.inp        (and save as Flair project)
  ```

Beam and geometry

- Set a 10-MeV electron beam
- Set a circular beam with 2 mm radius.

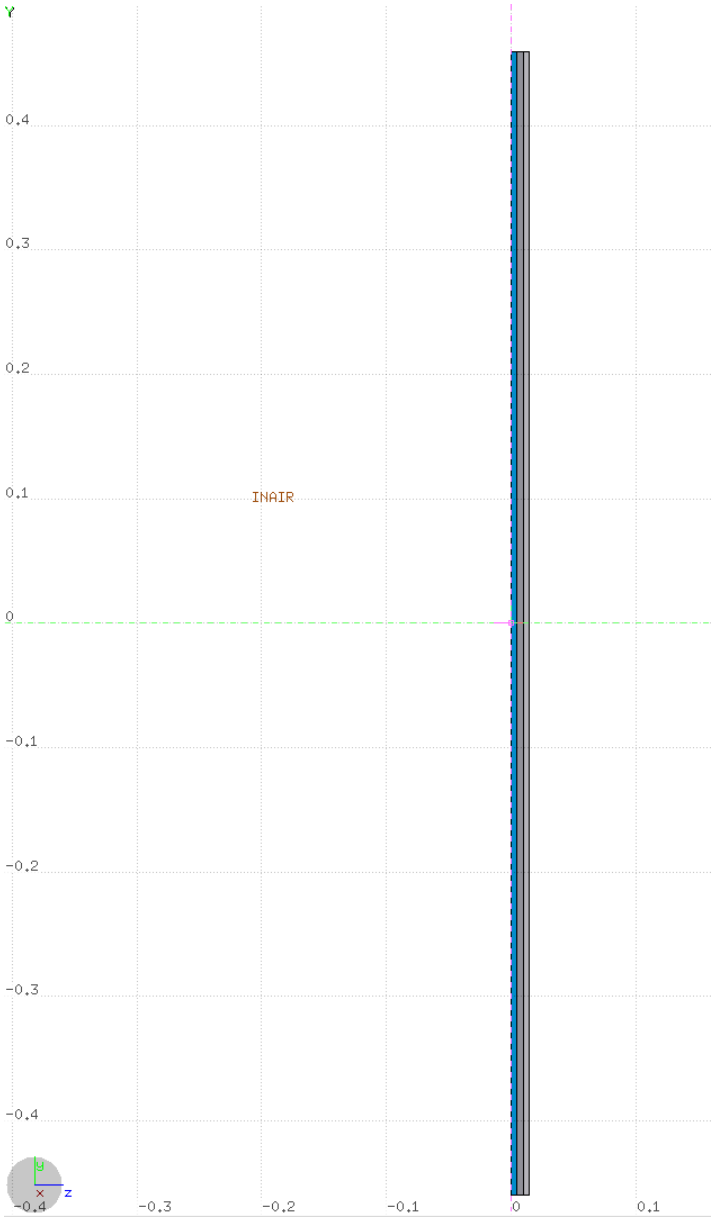
  Easily done Flair-wise, but check also the FLUKA manual, BEAM card.

  Relevant keyword for a successful search: "annular beam"

  Relevant WHATs: WHAT(6), WHAT(5), WHAT(4)
- Change target radius to 5 mm, and set the thickness of each layer to 50 μm
- Change surrounding CO2 material to VACUUM (remove CO2 cards)
- Swap material of TARGS2 and TARGS3

  It was: H_2O – Al – Pb → we redefine to H_2O – Pb – Al

Snapshot of intended geometry



General settings

- Thin layers require high tracking precision. Thus, we set
  DEFAULT PRECISIOn (should already be there)

- Turn on single scattering at boundaries for EM particles

  Find out how with the help of the FLUKA manual
  Hint: MULSOPT with SDUM=GLOBEMF

  Set the number of single scatterings when crossing a boundary to 2

- We will run three simulations corresponding to high, low, or very low threshold values.

- For this, define 3 preprocessor variables:
  HI-THR, LOW-THR, VLOW-THR

Setting threshold values

- Use EMFCUT and DELTARAY cards to 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)

Threshold cases:

```
#if HI-THR
        photons: 5 keV ,        electrons: 1 MeV kinetic energy,        FUDGEM=1
#elif LOW-THR
        photons: 5 keV ,        electrons: 100 keV kinetic energy,      FUDGEM=1
#elif VLOW-THR
        photons: 5 keV ,        electrons: 10 keV kinetic energy,       FUDGEM=0.5
#endif
```

Reminder: stopping powers and ranges for electrons, protons, and He ions are available on the NIST webpage: www.nist.gov/pml/data/star/index.cfm

Scoring

We will score the dose over the target, and also the fluence of electrons and positrons backscattered from TARGS1 back to AIR.

Thus, include:

- 1 USRBIN scoring DOSE over the target
  - Use 1 μm bins in z, 1 μm bins in R, unformatted unit 55

- 1 USRBDX scoring backscattered electron & positron fluence
  - One-way scoring from TARGS1 to INAIR
  - Use 1 linear bin in angle (you can leave the minimum and maximum solid angles blank such that default values are used), 100 linear bins in energy (between 0 and beam energy), unformatted unit 56
  - **Do not forget to enter the surface across which fluence is scored: pi*R^2+2*pi*R*h**

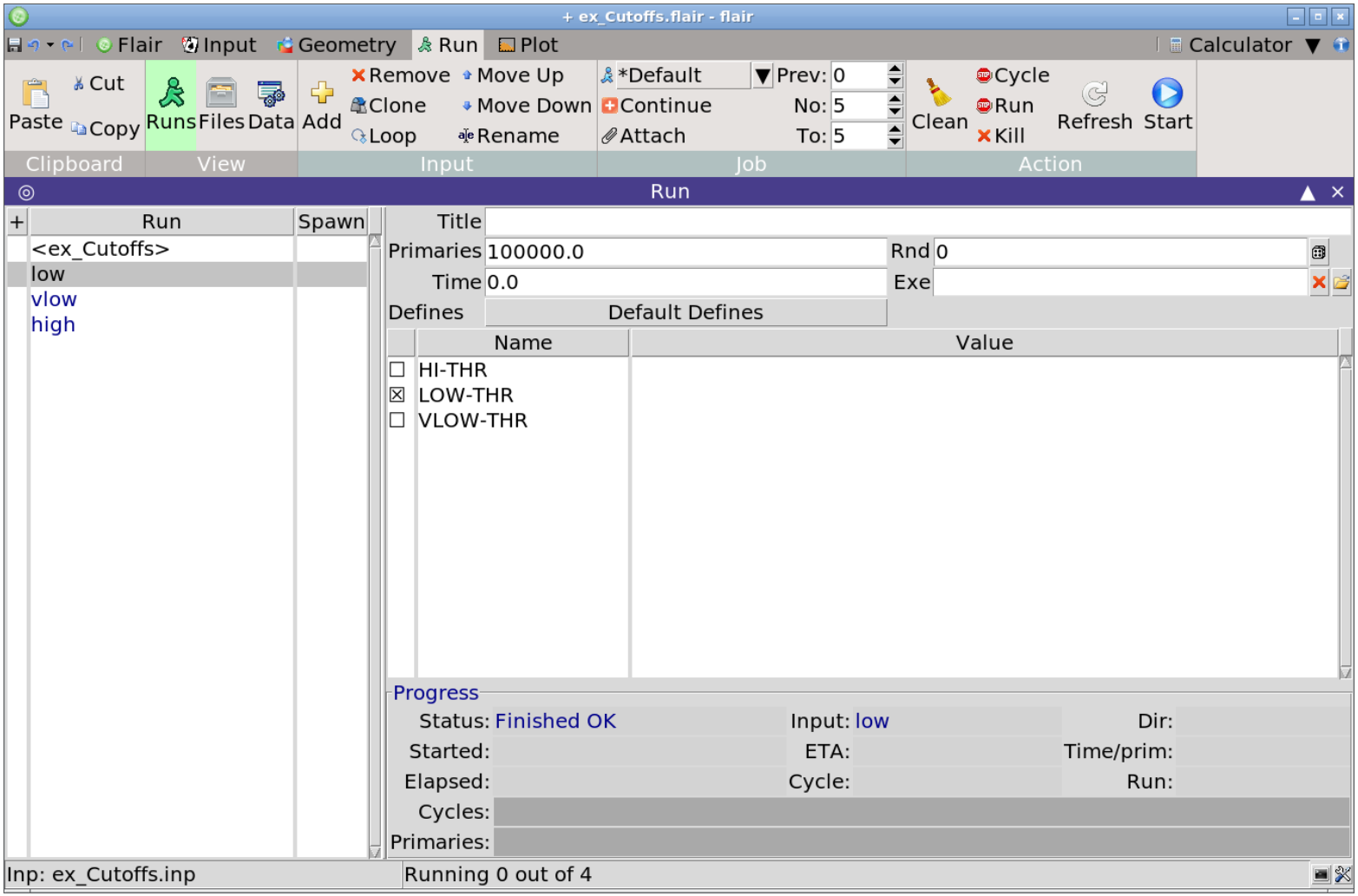
Running

- In Flair, add three runs:
  - HI-THR “on” (and the other two off)
  - LOW-THR “on” (and the other two off)
  - VLOW-THR “on” (and the other two off)

- For each threshold setting run 5 cycles x 100000 primaries

- Remember not to overwrite results (give different names to the runs)

You should get something similar to this…



Proceed to run, and process the output files. Should take less than ~5 minutes on a reasonable machine.

Examine 1D dose map for each case

- We now examine the output of each USRBIN for each case (HI-THR, LOW-THR, VLOW-THR).

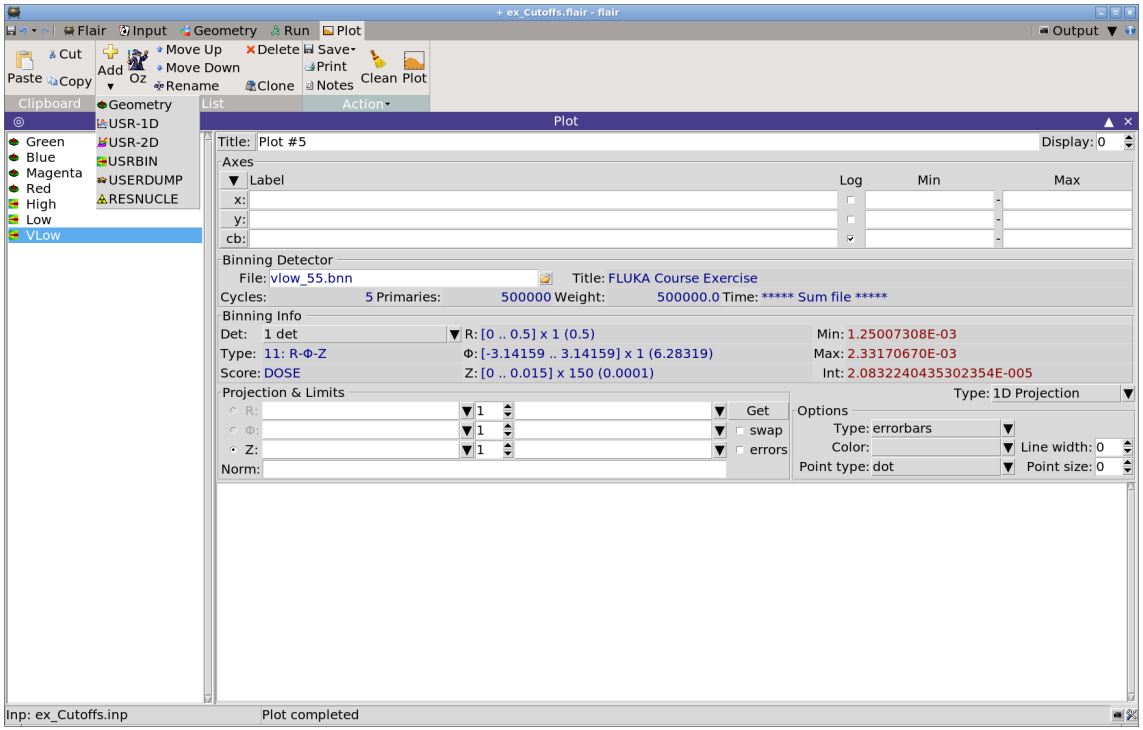
- For each case, plot the dose map:
  - Plot -> Add -> USRBIN -> Type: 1D projection.

You can fix the y-scale with
entering the following gnuplot option in the commands window:
`set yrange[xx:yy]` (replacing xx and yy as needed).

Plot all 1D dose maps on same plot

- In the previous step, a series of .dat files will have been produced in your working directory.

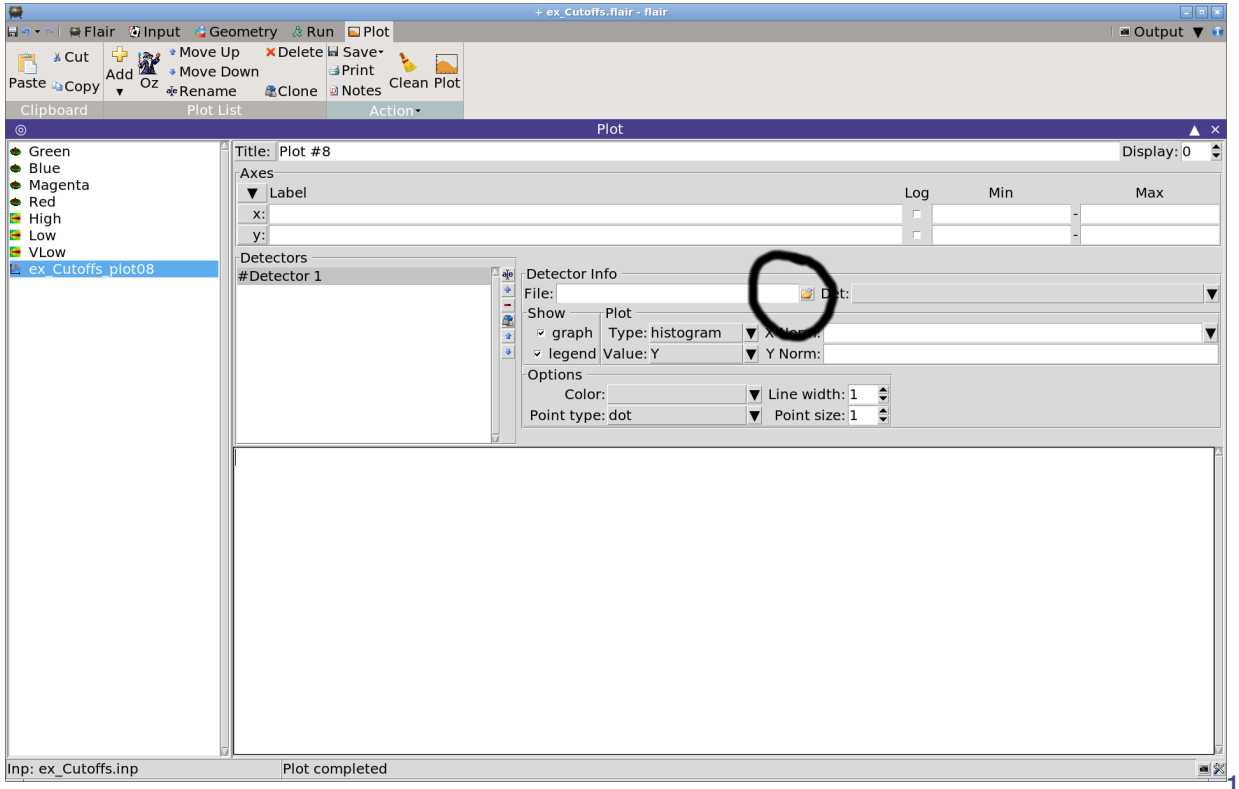
- You can combine them all into the same plot:
  - Add -> USR-1D



Plot all 1D dose maps on same plot

- In the previous step, a series of .dat files will have been produced in your working directory.

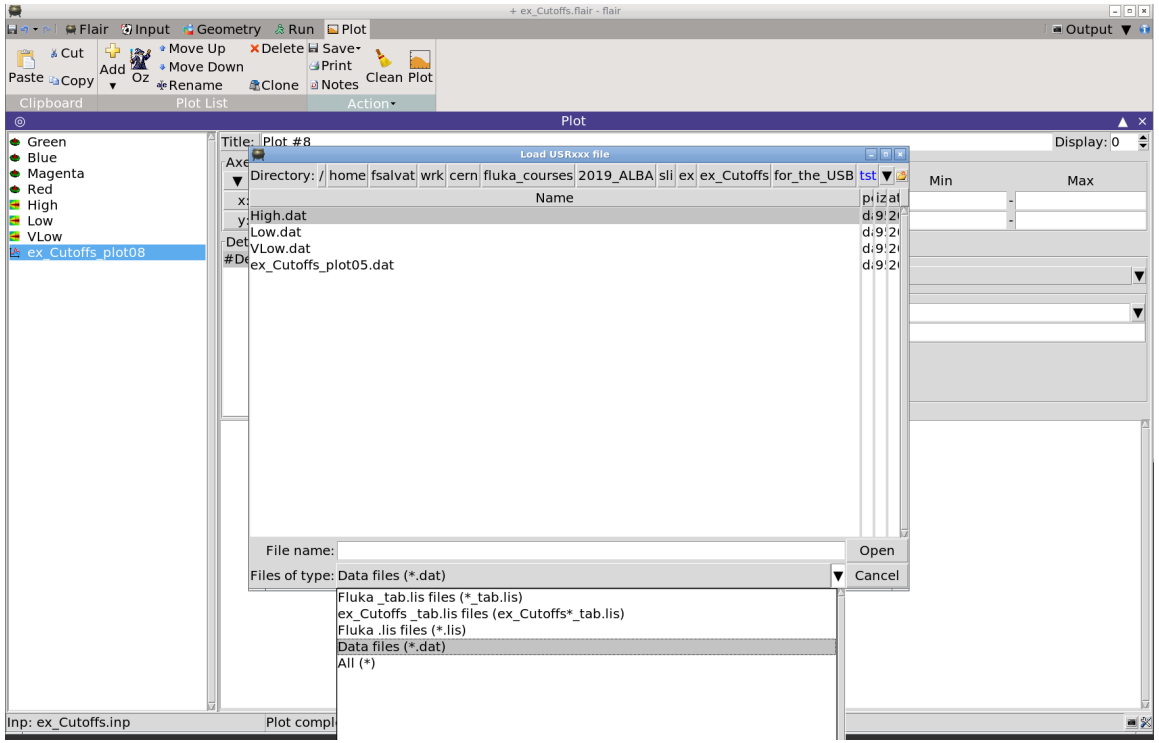
- You can combine them all into the same plot:
  - Add -> USR-1D
  - Click on Open icon



Plot all 1D dose maps on same plot

- In the previous step, a series of .dat files will have been produced in your working directory.

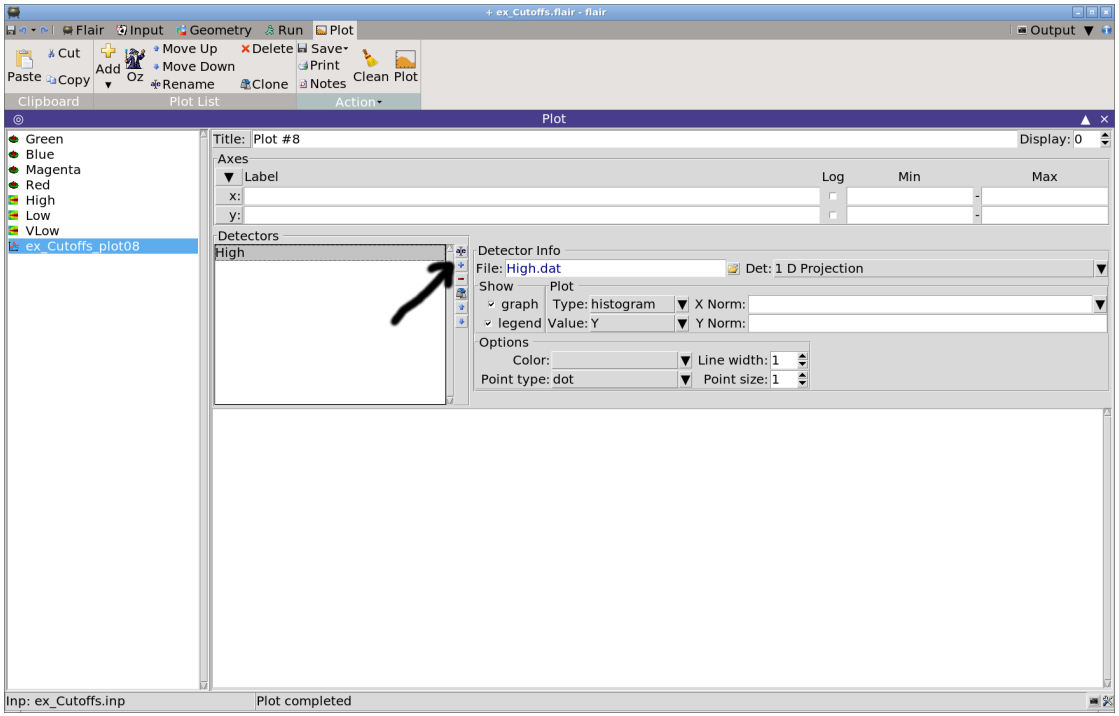
- You can combine them all into the same plot:
  - Add -> USR-1D
  - Click on Open icon
  - Select .dat



Plot all 1D dose maps on same plot

- In the previous step, a series of .dat files will have been produced in your working directory.

- You can combine them all into the same plot:
  - Add -> USR-1D
  - Click on Open icon
  - Select .dat
  - Add further curves



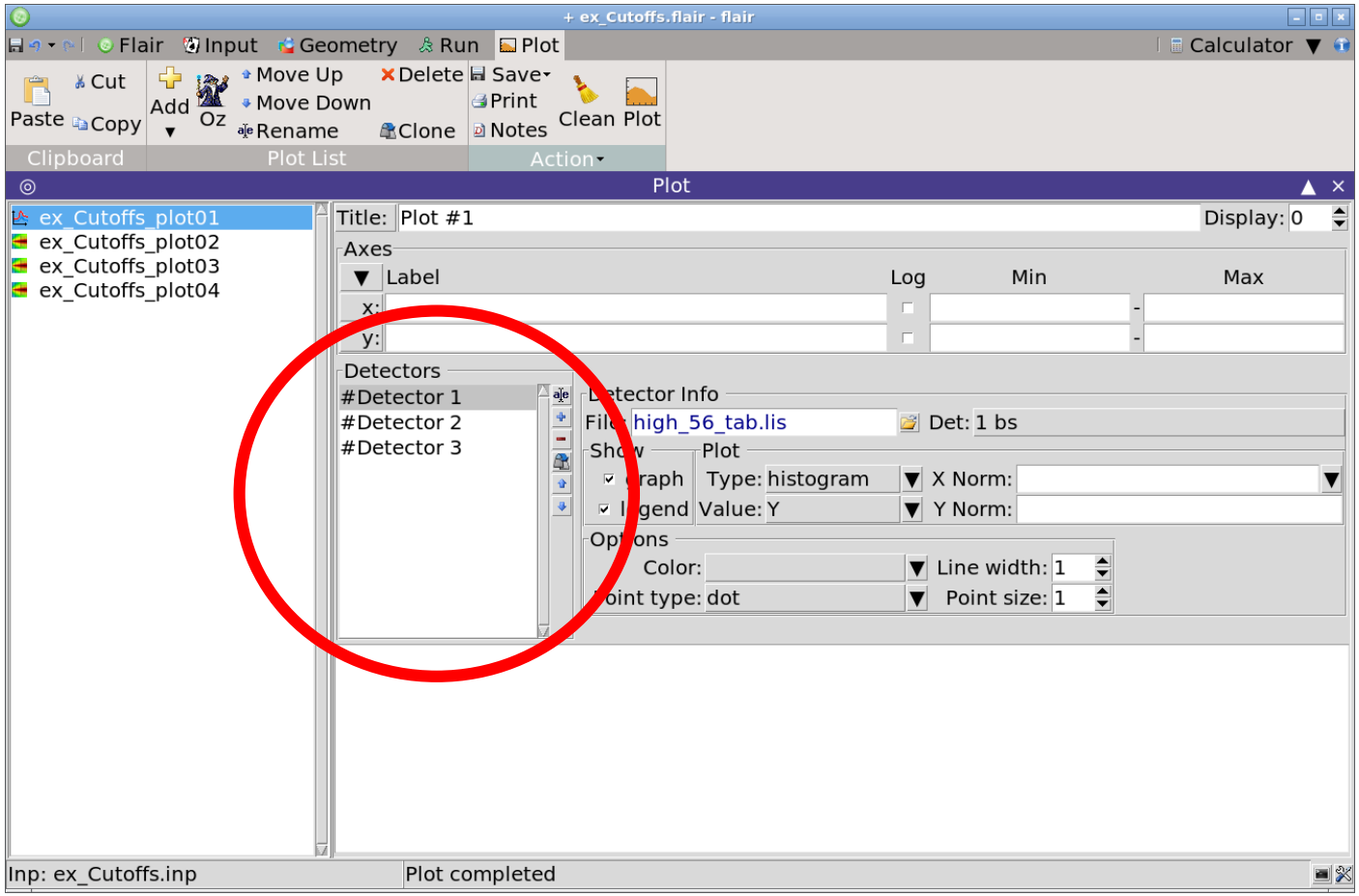
IMPORTANT

- If you plot any USRBIN 2D projection, the .dat file will be overwritten and no longer contain the 1D-plot data.

- Also, if you run again with e.g. more cycles, you will have to generate again the USRBIN 1D projection plot (Slide 11).

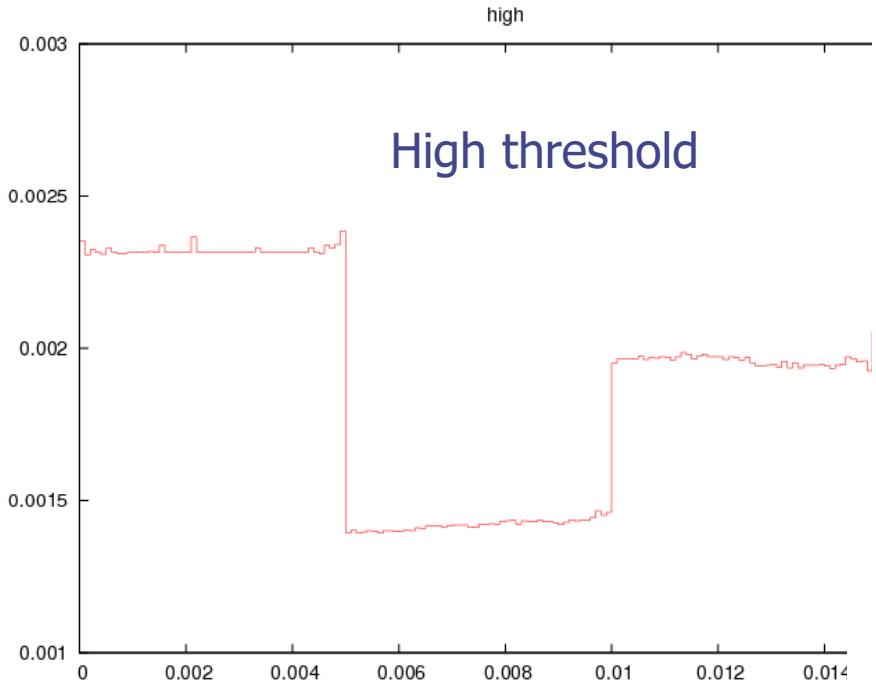
Plotting backscattered fluence

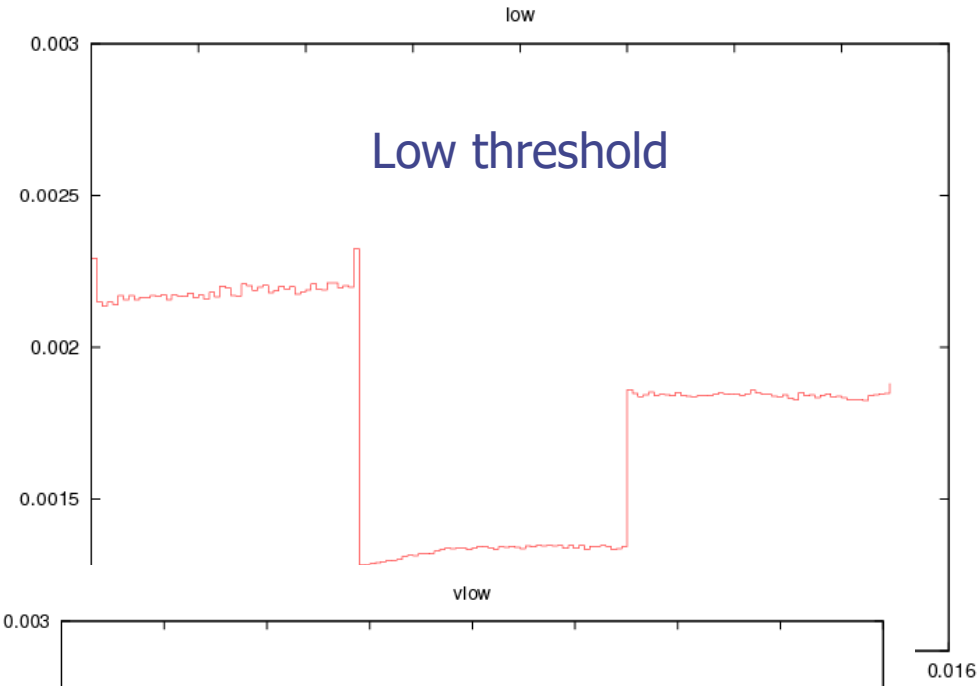
- Plot the three backscattered electron cases on the same plot. Note the effect of the threshold at the low-energy region (!)
  Hint: Add -> USR-1D and exploit the "+" icon in the Detectors box.

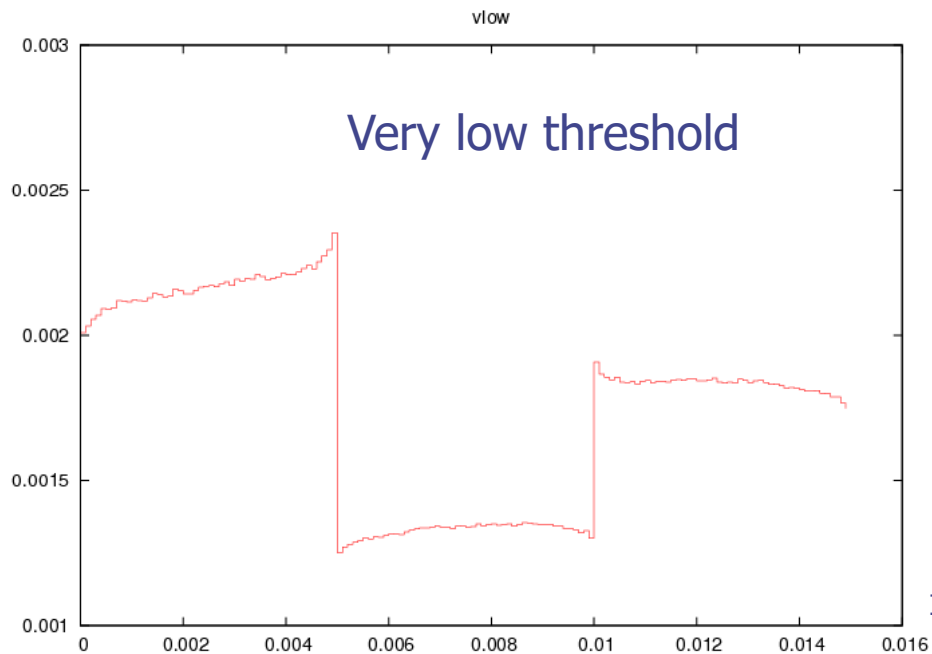


Solution

Exercise: Cutoffs – I solution

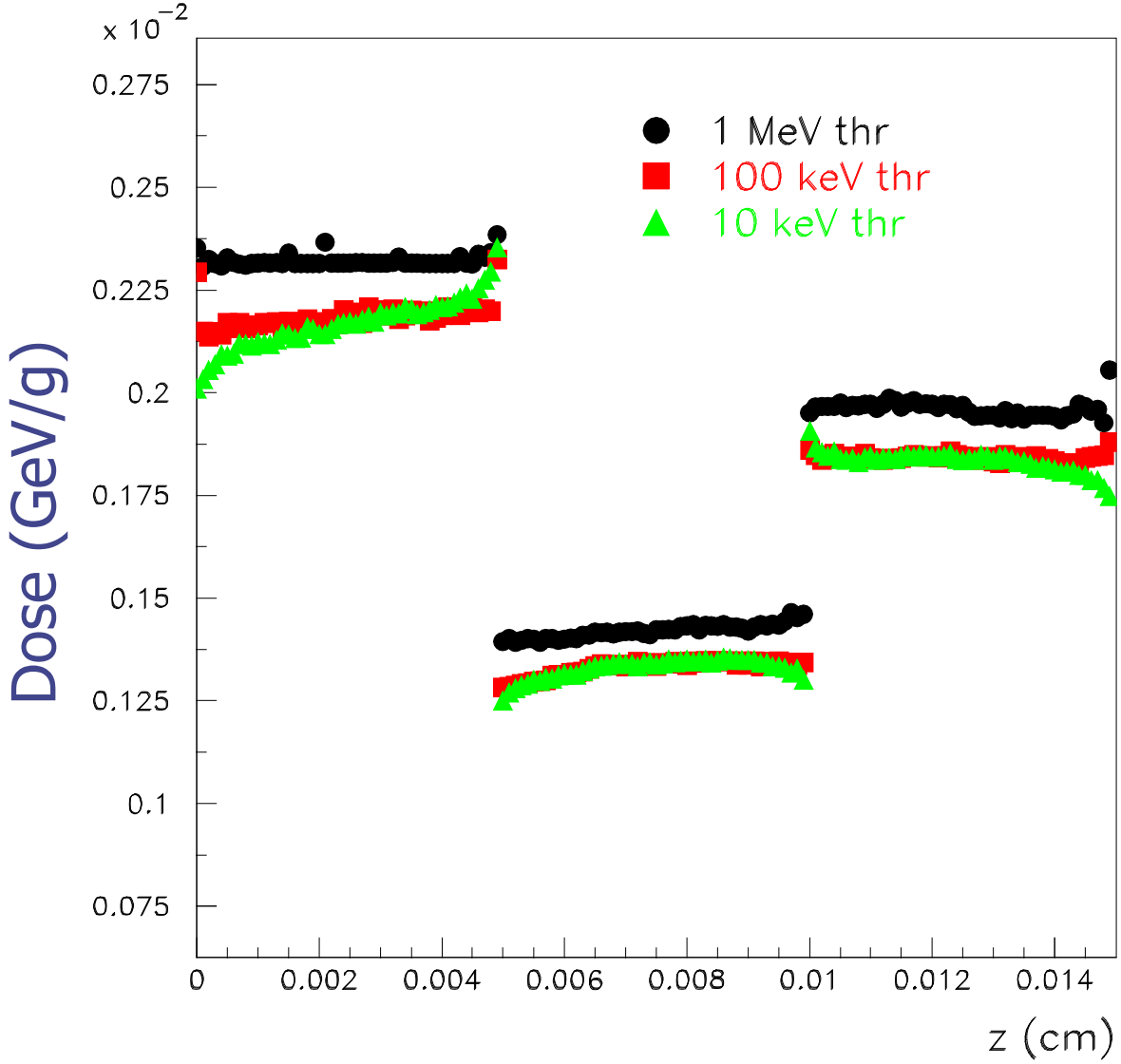






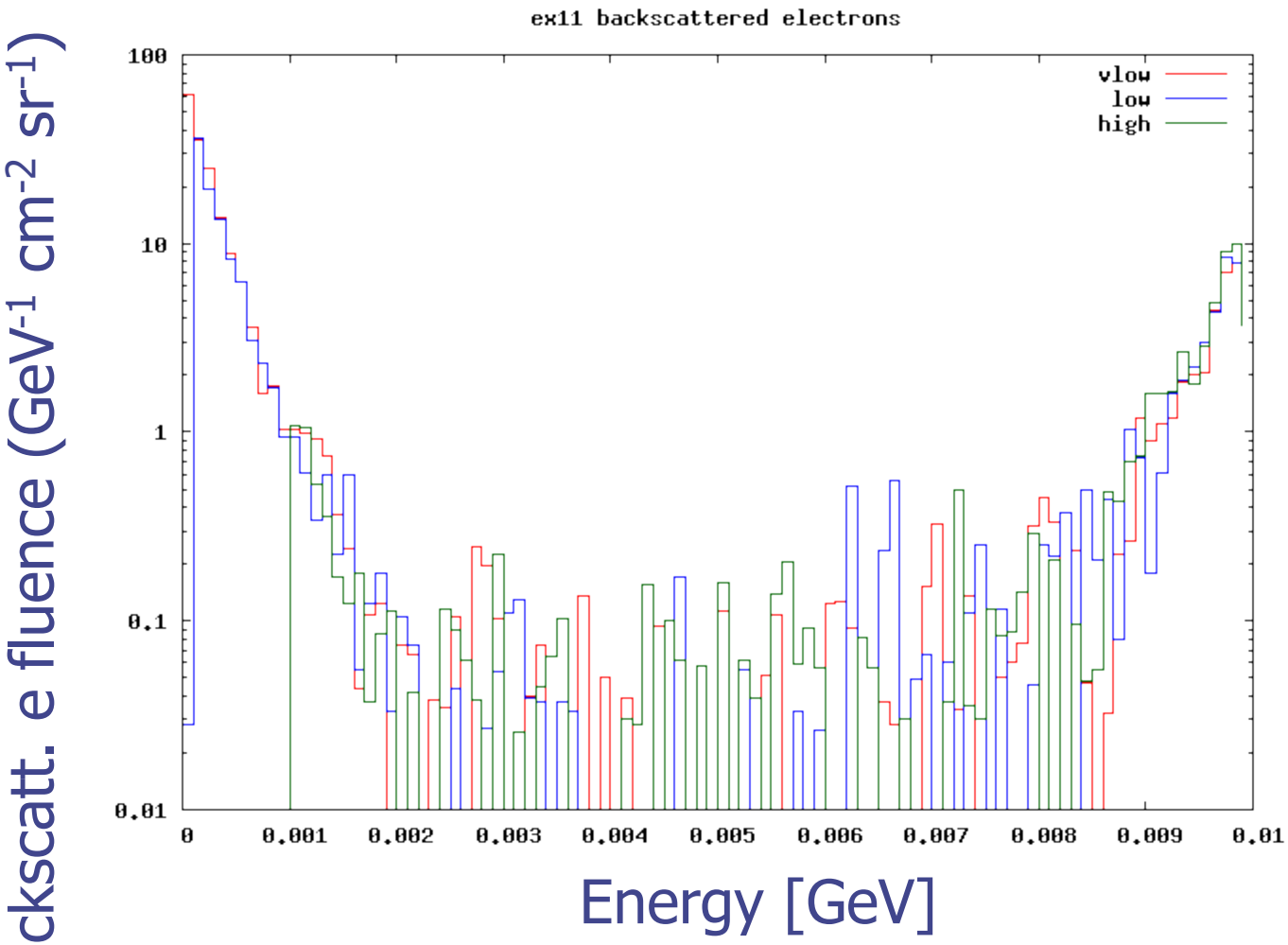
Look up units in manual!

Exercise: Cutoffs – I solution



Exercise: Cutoffs – I solution

Don't forget to enter surface in USRBDX card, otherwise units won't include 1/cm^2 !!



Exercise: Cutoffs – II (advanced)

Instructions: proton beam

- 4 MeV proton beam (use #define PROTON) using the same beam size as for the previously defined electron beam (circular with 2 mm radius) and no momentum spread and divergence.
- Add #if/#elif/#endif statements to easily select between a proton and an electron beam, e.g. by setting #define PROTON)

- For HI-THR, LOW-THR, and VLOW-THR set proton thresholds at 10 MeV, 100 keV, and 10 keV respectively (PART-THR and DELTARAY cards)
- Add MAT-PROP card specifying a DPA-ENERgy threshold of 25 eV for lead and 27 eV for aluminum (only for the VLOW-THR case)
- Add R-Φ-Z USRBIN to score Displacement Per Atom and

  Non Ionizing Energy Loss deposition over aluminum and lead

  (50 bins in R, 1 bin in Φ, 100 bins in Z)

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Exercise: Cutoffs – II solution