Exercise 9: Cutoffs

Beginners FLUKA Course

Exercise: Thresholds

First part

Aim: "see" the effect of different threshold settings

- Easier with thin layers and with interfaces between strongly different materials → change the layout
- Observables:
  - Dose deposition
  - Fluence of backscattered electrons

Exercise: Thresholds

Instructions: changes to the geometry/beam

- Create a folder called **ex9** and start there a new flair project based on the **course** template (as before)
- Save the input as ex9.inp and the flair project as ex9.flair
- Change the beam into 10 MeV electron beam (hint: use #define PROTON)
- Change the beam size to a circular one with 2 mm radius
- Change the target 3 layers thickness to 50 microns each
- Change the target radius to 5 mm
- Change the surrounding air into Vacuum
- Change the materials of the region *TARGS2* to Lead.
- Change the material of region *TARGS3* to Aluminum

(i.e.: target is made of H_2O – Pb – Al)

Exercise: Thresholds

Instructions : general settings

- thin layers and low thresholds → need for high tracking precision
- set PRECISIO as default
- Switch on single scattering at boundaries (find how..)

Instructions: prepare a set of different thresholds, using "#define"

- Define 3 preprocessor variables, e.g.: HI-THR , LOW-THR, VLOW-THR
- Use EMFCUT and DELTARAY cards to set threshold in all materials:
  - #if HI-THR
    - Electrons: 1 MeV kinetic energy
    - Photons: 5 keV
  - #elif LOW-THR
    - Electrons: energy corresponding to a range ≈ ½ of the Pb thickness
    - Photons: 5 KeV
  - #elif VLOW-THR
    - Electrons: energy corresponding to a range ≈ z bin size, in Pb
    - Photons: 5 keV
  - #endif

SAME energy thresholds in all materials!

- HINT: go to http://physics.nist.gov/PhysRefData/Star/Text/contents.html

Exercise: Thresholds

Instructions : scoring

- One USRBIN scoring DOSE over the target:
  1 micron bins along z, 5 microns bins in the radial direction
- One USRBDX to score fluence of electrons and positrons
  EXITING from the target first layer BACK into vacuum;
  one single linear bin in angle, linear binning in energy.

Instructions: running

in the RUN window of Flair

- click on the **+** button in the Run/Input frame
- choose a name for the first threshold option , i.e. ex8_hi-thr
- select the correct directive in the "Defines" frame
- run 5 runs , 100000 primaries each
- repeat for the other thresholds defined

Exercise: Thresholds

Instruction: looking at the results

PLOT for each threshold

- 1-d projection along z of the dose
  try to set the same y-scale for the three plots
  (set yscale [xx : yy] in the gnuplot options)
  compare the results for the 3 thresholds

- the usrbdx output (try to put all three on the same plot)

Exercise: Solution - settings

Results

- "low threshold"

  25μ Pb = 2.8 10^{-2} g/cm^2 → 100 keV

- very-low threshold

  1μ Pb = 1.1 10^{-3} g/cm^2 → 10 keV

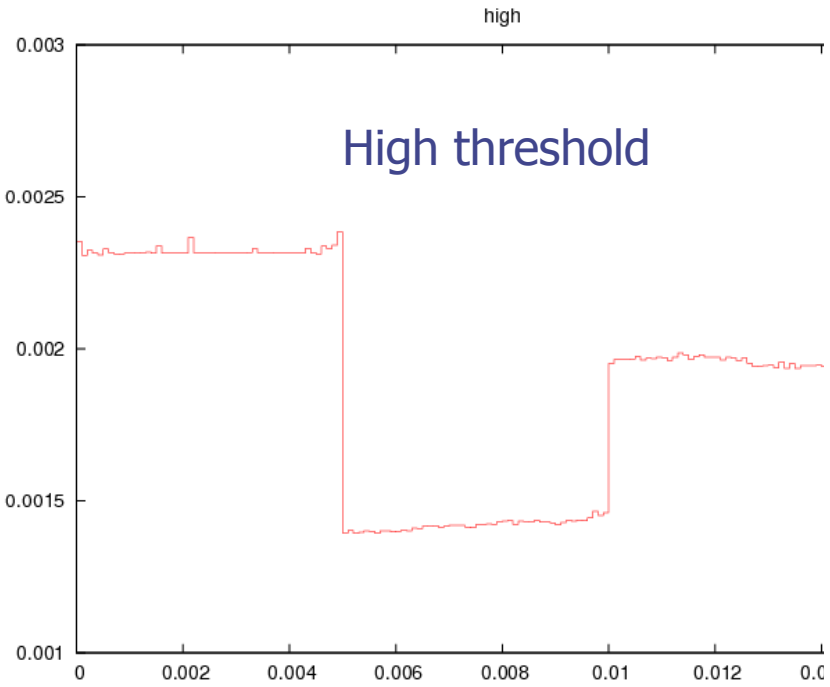
  (or 12, but we choose a round number for ease)

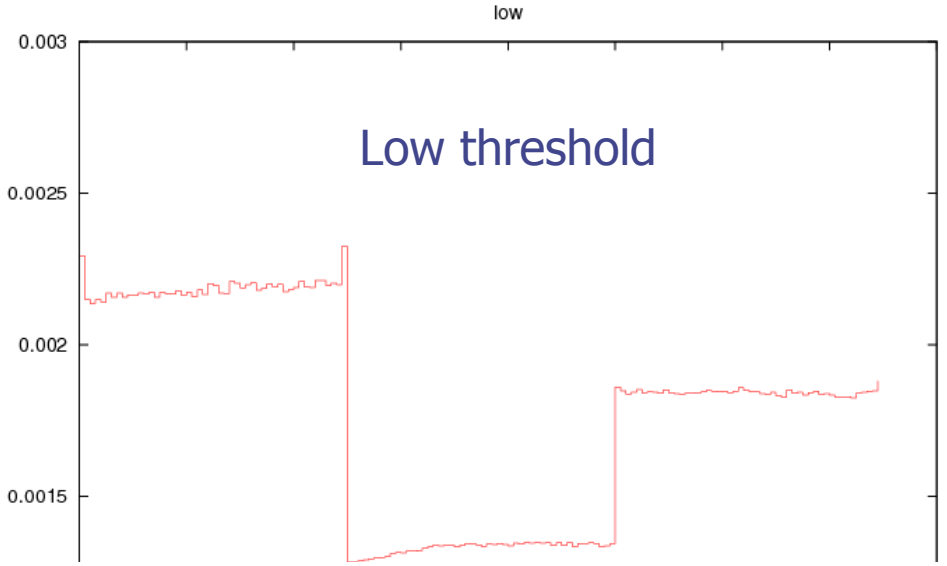
- to be set:
  - EMFCUT with PROD-CUT (set production threshold)
  - EMFCUT with BLANK (set transport threshold)
  - DELTARAY (in case we run protons later..)

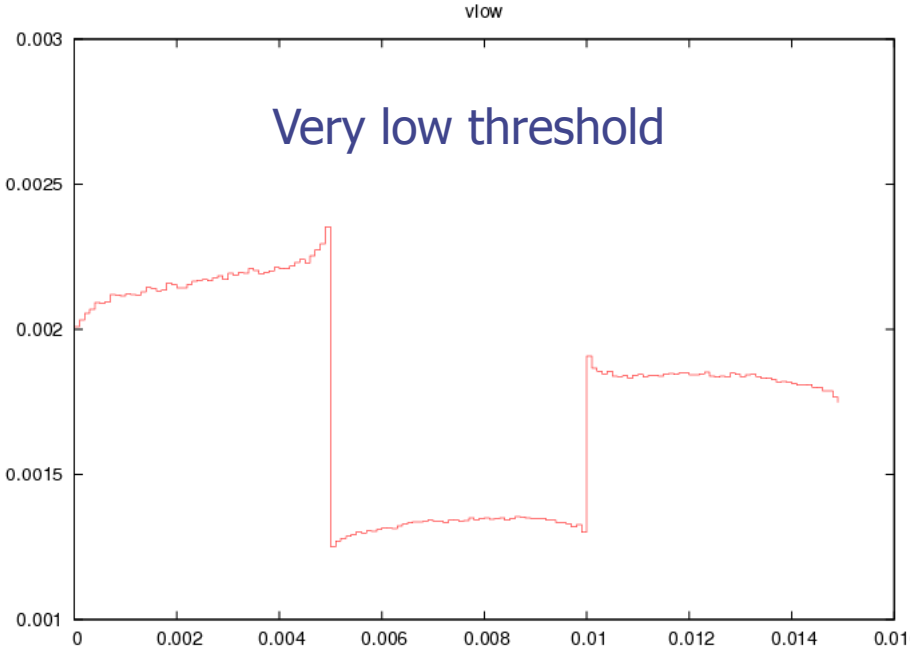
  Warning:

  to set KINETIC energy in EMFCUT the WHAT(1) value must be NEGATIVE, otherwise it sets the TOTAL energy

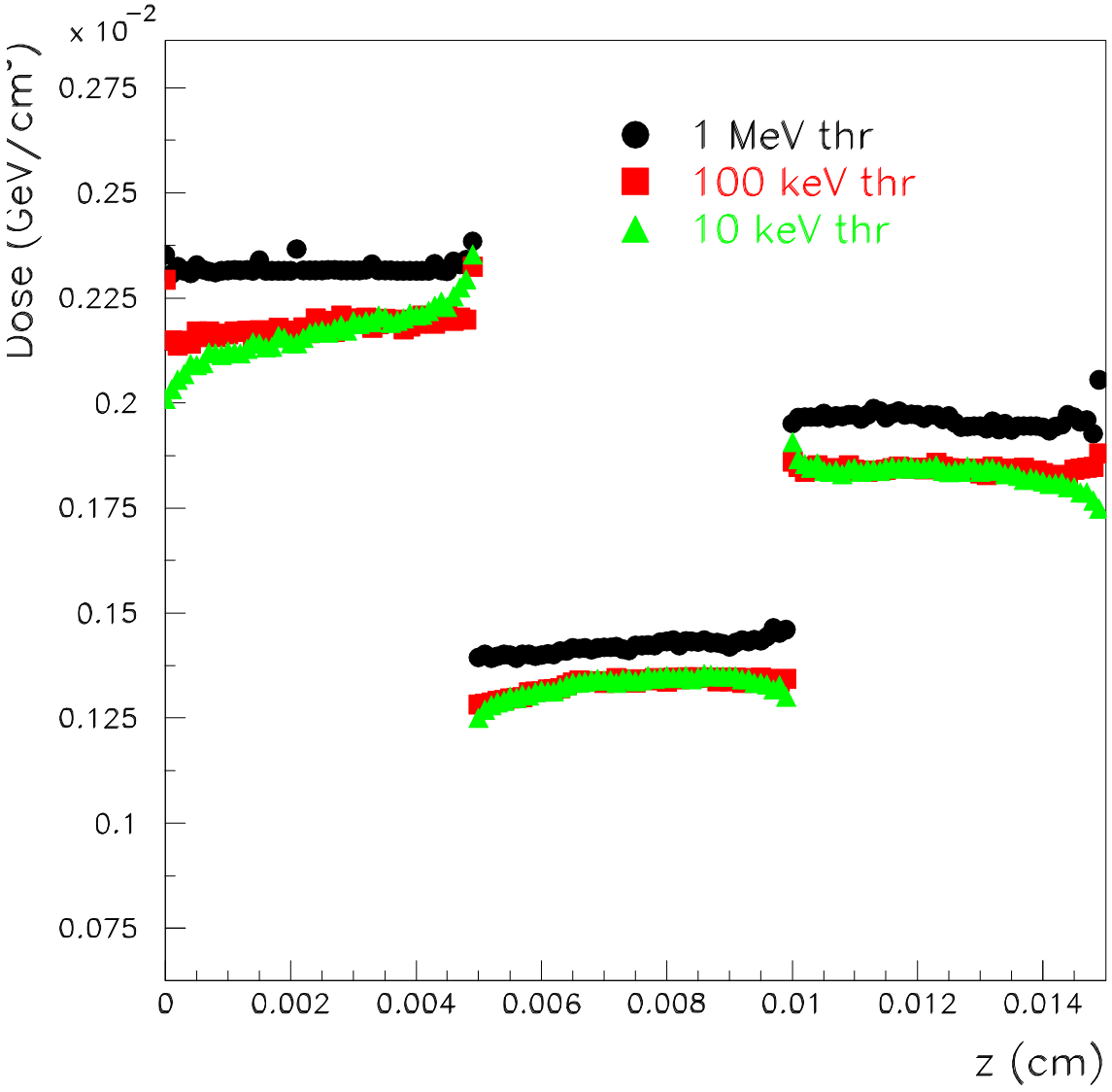
Exercise: Solution - electrons



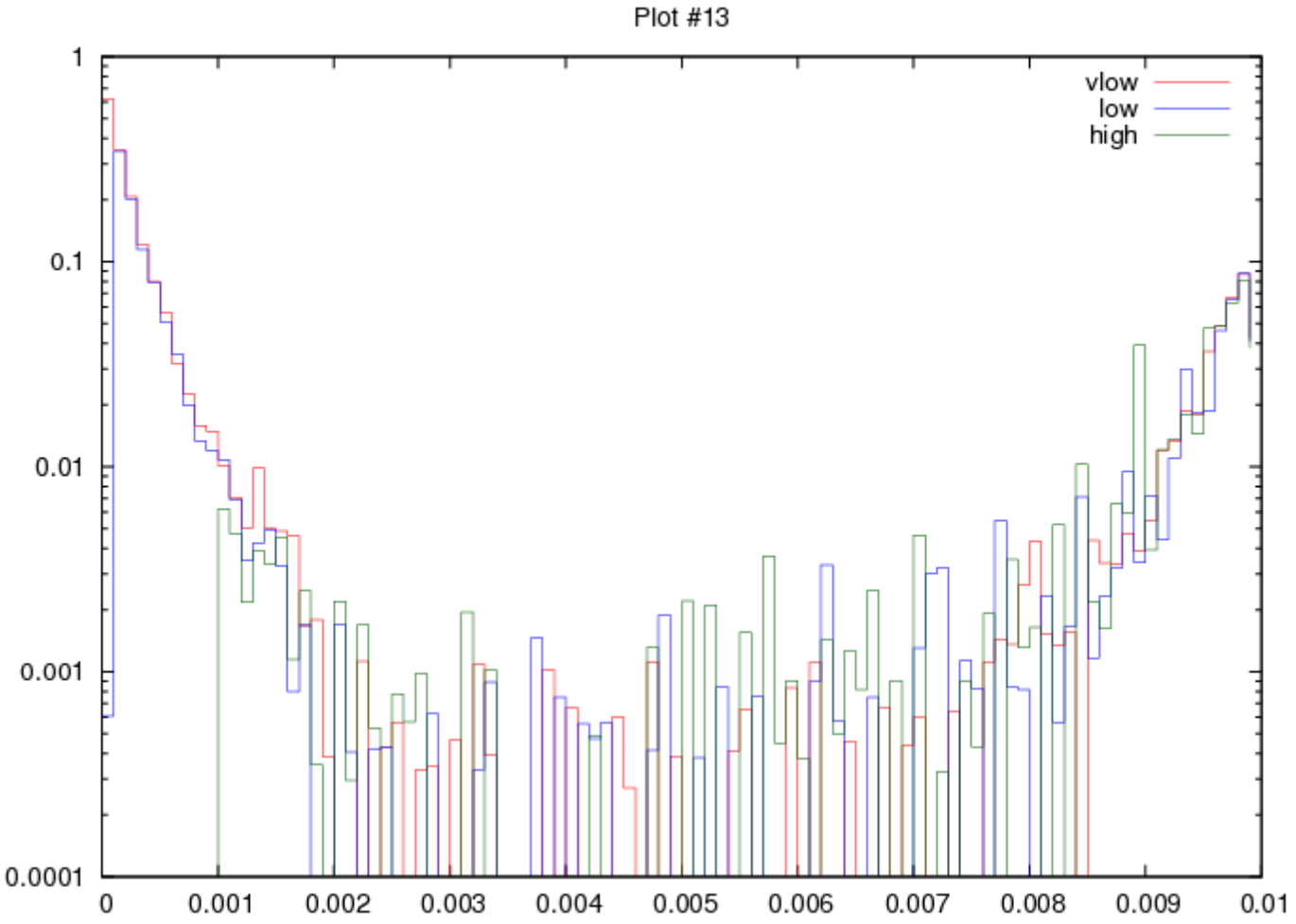




Exercise: Solution - electrons



Exercise: Solution - backscattering



Exercise: Thresholds

Second part, protons!

Aim: learn more about thresholds and getting familiar with DPA (Displacement Per Atom)

Instructions: settings

Change the BEAM to 4 MeV protons (#define PROTON)

For HI-THR, LOW-THR, and VLOW-THR cases, set proton threshold at 10 MeV, 100 keV, and 1 KeV respectively

Add MAT-PROP cards specifying a DPA-ENERergy threshold of 25 eV for lead and 27 eV for aluminum

Exercise: Thresholds

Second part, protons!

Instructions: results

Add one single USRBIN grid (having 50 bins in radius, 1 bin in Φ, and 100 bins in Z) on the aluminum and lead targets scoring DPA-SCO and NIEL-DEP (Non Ionizing Energy Loss) "with a suitable resolution" (it depends on the beam size)

Question: why not scoring on water?

Evaluate the average number of Displacements Per Atom (DPA) for a 100 day long beam time and 1μA proton current

Plot the dose deposition (HI-THR and LOW-THR only) and see the difference; can you see and explain the effect of the different thresholds?

Exercise: Solution – proton beam