Exercise 2: Thresholds

FLUKA Advanced Course

Exercise 2: Thresholds

Aim of the exercise:

1. Brief reminder on heavy-ions and efficient use of Flair (in order to be fast)

2. Have a critical look on observed results

3. Try finding out a reason for the seemingly non-physical behavior

4. Try to simplify the problem in order to understand

5. Apply lessons from lecture before

Exercise 2: Thresholds- Part I

Start with a new example (flair template: **heavy-ions)**

Instructions: settings and geometry

- Change defaults to NEW-DEFAULTS (hint: not default in FLAIR!)
- Change the radius of the body void to Radius: 1000cm
- Change the body target to Height: 1cm, Radius: 0.3cm
- Assign material AIR to region VOID
- Assign material ALUNINUM to region TARGET
- Beam:
  - Shoot (z-direction) with an Uranium (238) beam on the target
  - Energy: 950MeV per nucleon (in fact per nmu)
  - Beam-width: sigma 0.2 x 0.2 cm^2 (x and y)

Note: **Don't forget (for consistency, not really required for this example)**
...to link the DPMJET/RQMD event generators for enabling ion-ion interactions above 125MeV/n either using FLAIR or **$FLUPRO/flutil/ldpmqmd**
Reminder: the BME event generator, covering the low energy range up to 150MeV/n (125MeV/n is the default threshold, that you can change through PHYSICS/SDUM=DPMTHRES), does not need to be linked since it's already embedded in the main FLUKA library.

Exercise 2: Thresholds- Part I

Scoring instructions:

- Score with USRBIN dose deposition in the air around the target
  - Dimensions (X × Y × Z): **40** x 200 x 200cm Bins: **1** x 100 x 100
- Add additional dose scoring looking separately for the contribution of: heavy-ions, protons, neutrons, photons, electrons and pions
- For the same particle types, score the particle fluence exiting the target (USRBDX from target to air)
hint: standard USRBDX (then looking only as a function of energy)

Run/Analysis instructions:

- Run about 100-200 particles 5 cycles
- Process the results and produce the plots of the above scoring (hint: use automatic plot generation of flair)
- Try to explain the dose/energy results
- Find out which particle/energy is driving the observed result
- In case you agree that it's not physical, how can you solve it?

Exercise 2: Thresholds- Part II

Start with the same example at before, but with no target (set it to AIR)!

Instructions: settings and geometry:

- Create a uniform source in the center of your geometry
- Particle type: what you think is the responsible for Part-I
- Energy: choose roughly the most contributing (for the particle you've identified)

Scoring instructions:

- Use the same scorings as before

Run/Analysis instructions:

- Run about 100-200 particles in a few cycles
- Process the results and produce the plots of the above scoring (hint: use automatic plot generation of flair)
- Do you observe the same effect?
- Try solving it (applying the lessons learned in the lecture before!)

Exercise 2: Thresholds- Part III

Reminder from the beginners course (only for demonstration) (start with the standard beginner's course example):

Instructions: changes to beam and geometry

- 10 MeV electron beam (hint: use #define PROTON)
- Beam size: circular with 2 mm radius
- Change the 3 targets 5mm radius and 50 microns thickness
- Change surrounding CO2 into VACUUM
- Swap material for TARGS2 and TARGS3
- (i.e.: target is made of H_2O – Pb – Al)

Instructions: general settings

- Reminder: thin layers require high tracking precision
  therefore DEFAULT PRECISIO is needed (is already there)
- Turn on single scattering at boundaries (find out how)

Exercise 2: Thresholds – Part III

Instructions: set thresholds

- Define 3 preprocessor variables: HI-THR, LOW-THR, VLOW-THR
- Use EMFCUT and DELTARAY cards to set both production and transport thresholds in all materials

#if HI-THR

photons: 5 keV , electrons: 1 MeV kinetic energy

#elif LOW-THR

photons: 5 keV , electrons: 100 keV kinetic energy

#elif VLOW-THR

photons: 5 keV , electrons: 10 keV kinetic energy

#endif

Reminder: stopping powers and ranges for electrons, protons, and Helium ions are available on the NIST webpage:

www.nist.gov/pml/data/star/index.cfm

Exercise 2: Thresholds – Part III

Instructions: scoring

- 1 USRBIN scoring DOSE over the target
  (1um bins in z, 5um bins in R, unformatted unit 55)
- 1 USRBDX scoring backscattered electrons & positrons fluence
  (i.e. from TARGS1 to INAIR)
  1 linear bin in angle, 100 linear bins in energy, unformatted unit 56

Instructions: running

- For each threshold setting run 5 cycles x 100000 primaries
- Remember not to overwrite results

Plot the results

- Plot the three backscattered electron cases on the same plot
- Dose: 1D-proj in z (fix y-scale: gnuplot option `set yscale[xx:yy]`)

Exercise 2: Thresholds- Part III

Instructions: use proton beam

- 4 MeV proton beam (use #define PROTON)
- For HI-THR, LOW-THR, and VLOW-THR set proton threshold at 10 MeV, 100 keV, and 1 kev respectively
- 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) Unformatted unit 57

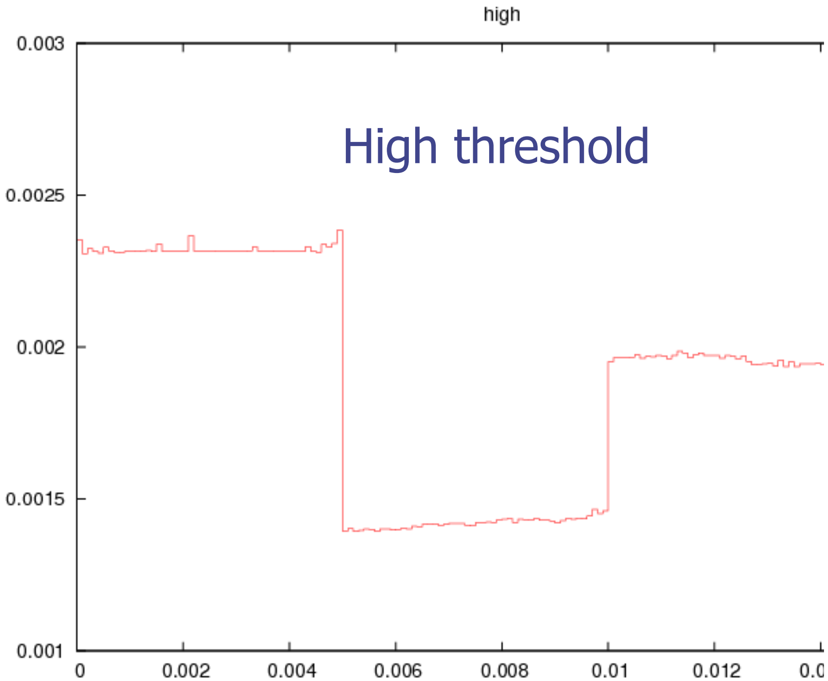
Exercise 2: Thresholds – Part III

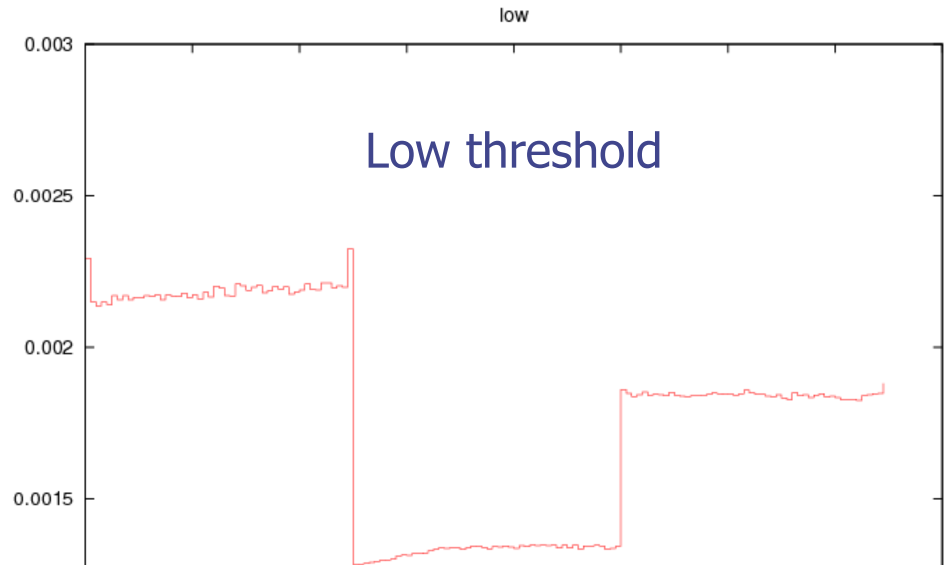
Questions

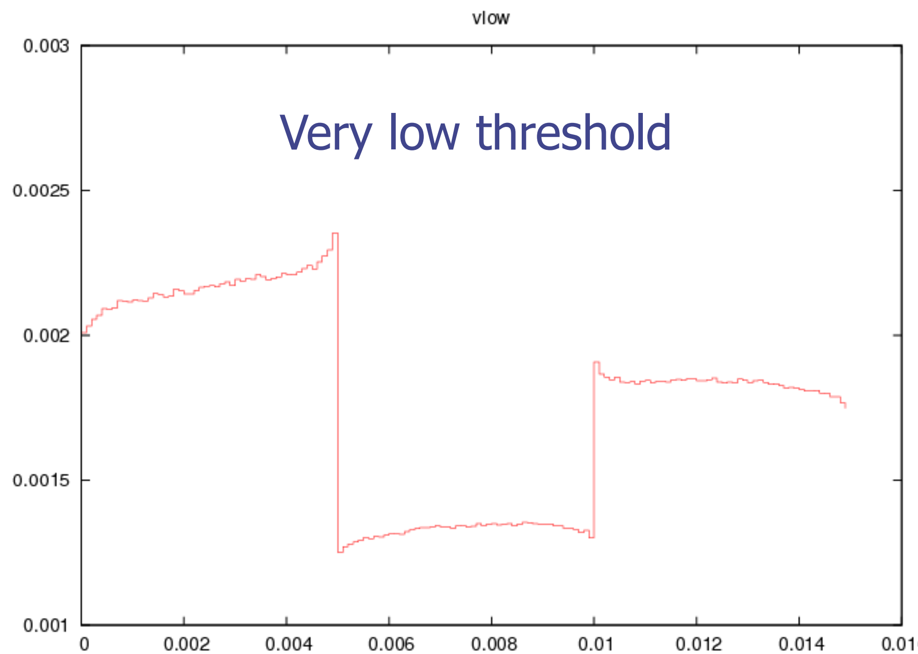
- Why not scoring on water?
- For HI-THR and LOW-THR case, plot the dose and see the difference

  Can you explain the effect of the different thresholds?

Exercise 2: Part III Solution1







Exercise 2: Part III Solution1

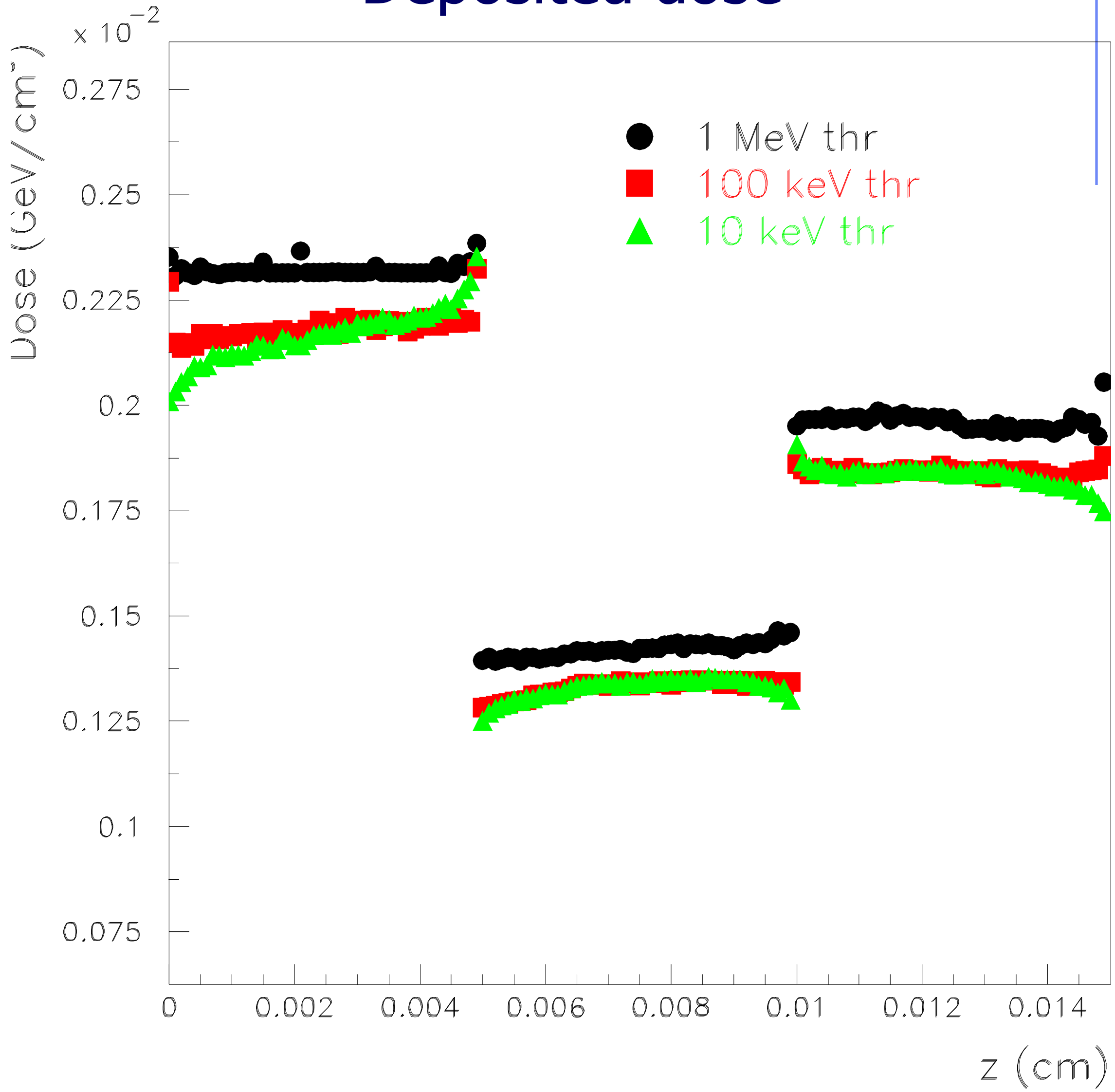
Water- Lead-Aluminum layers
50 microns each

25μ Pb = 2.8 10^{-2} g/cm^2
➔ 100 keV

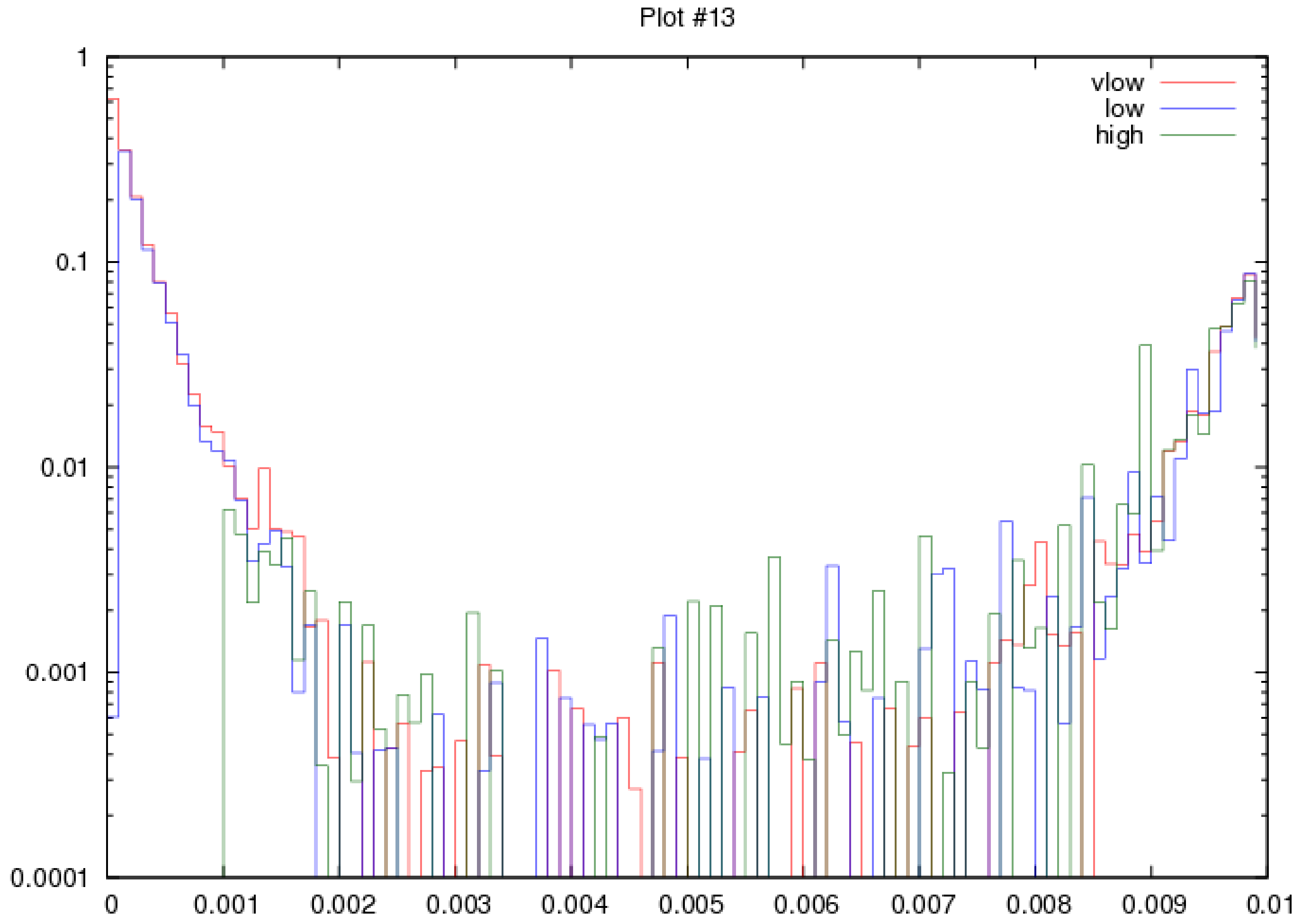
1μ Pb = 1.1 10^{-3}g/cm^2
→ 12keV

- High threshold gives overestimated results because electrons cannot escape
- Medium threshold is reasonable for average value in layer
- Low threshold needed if scoring grid is fine

Deposited dose



Exercise 2: Part III Solution 2



Energy [GeV]

Exercise 2: Part III Solution2