

# **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

### Beginner course – CERN, December 2024

# Innut file

input me	×
<ul> <li>10 MeV electron beam</li> <li>Annular beam with 2 mm radius</li> <li>Starting at x = 0 cm, y = 0 cm, z = -1 cm</li> </ul>	0.5 0.4 0.3
<ul> <li>Cylindrical target along z, 5-mm radius, split in three layers, each 50 µm thick</li> <li>Set to H<sub>2</sub>O – Pb – Al</li> </ul>	0,2 0,1
<ul> <li>Thin layers require high tracking precision. Thus, we set</li> <li>DEFAULT PRECISION</li> </ul>	0 -0.1 -0.2
<ul> <li>Notice that three preprocessor variables are defined</li> <li>HI-THR, LOW-THR, VLOW-THR</li> </ul>	-0.3 -0.4
<ul> <li>USRBIN scoring DOSE over the entire target</li> <li>1 µm bins in z, 1 bin in R, saved to unformatted (BIN) unit 55</li> </ul>	-0.5



Ζ

### 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: <u>https://physics.nist.gov/PhysRefData/Star/Text/intro.html</u>



### Run

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low_threasholds		Mode:		▼	Exe:		× 🗃
vlow_threasholds			Default Defines				<u> </u>
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	U VLOW-THR						
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		Primaries:					
Fluka: ex_threasholds.flair							<b>I</b>
		20001					

- 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**

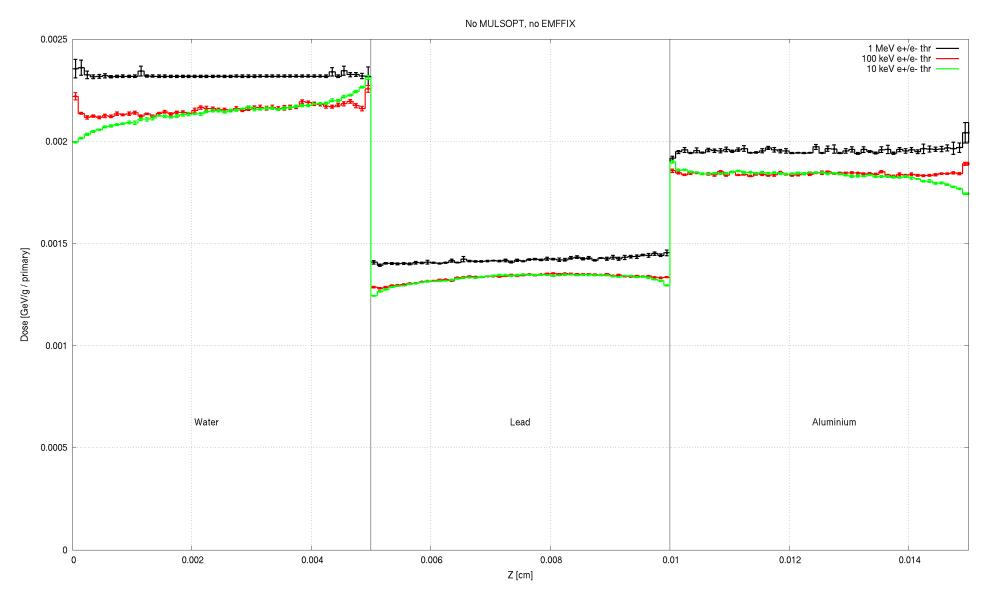
### Plots are already set up in the Flair project

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	Clipboard	Plot List Action		
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	Magenta	▼ Label x: Z [cm]		Log Min Max
	high low	y: Dose [GeV/g / primary]		
×	verylow	cb:		
	compare_thresholds	Detectors	Detector Info	
to make sure all needed		1 MeV e+/e- thr 100 keV e+/e- thr		: 1 D Projection ▼
to make sure all needed		10 keV e+/e- thr	Show Plot	
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			Options	
comparison plot!				
			Point type: triangle-up-filled V Point size: 1	
		set grid		
	Fluka: ex_thresholds.flair	Saved: compare_thresholds.png		



#### **Exercise: EM Thresholds**

### **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!





- 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

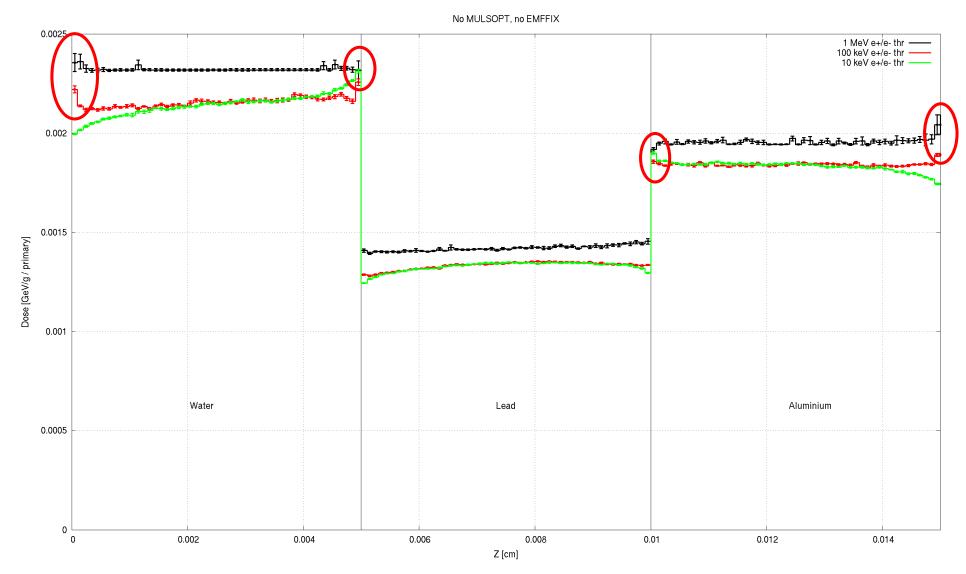


This concludes the exercise...



...but there's more!

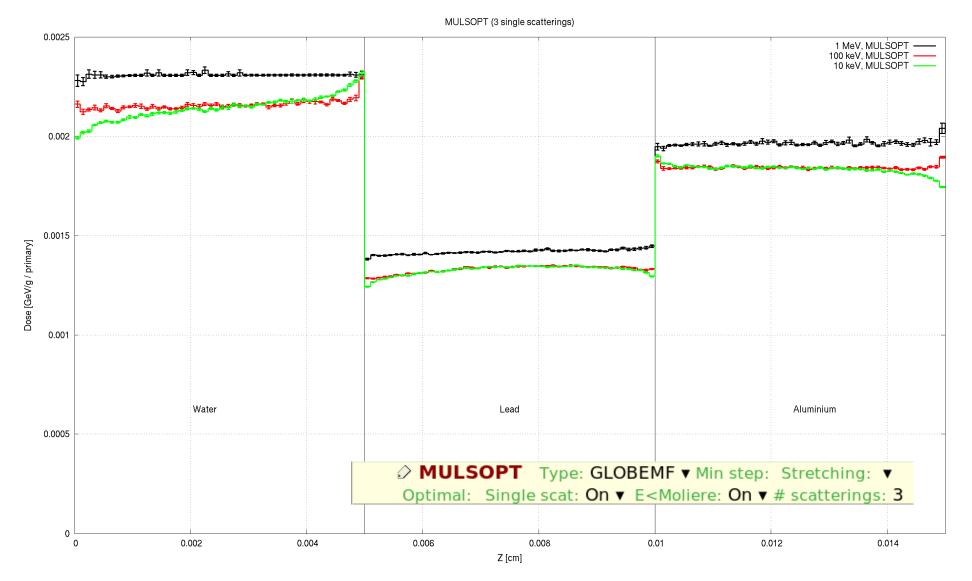
# **Boundary artifacts (last bin before interface)**





**Exercise: EM Thresholds** 

### Further single scattering near boundaries (+MULSOPT)





## **Further restriction of stepsize (+EMFFIX)**

MULSOPT (3 single scatterings) and EMFFIX

