PRELIMINARY STUDY OF THE ELECTRON INDUCED BACKGROUND

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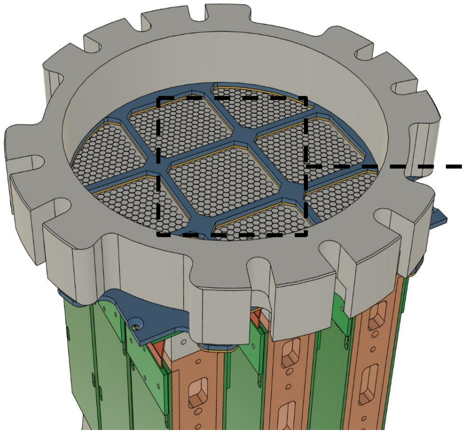
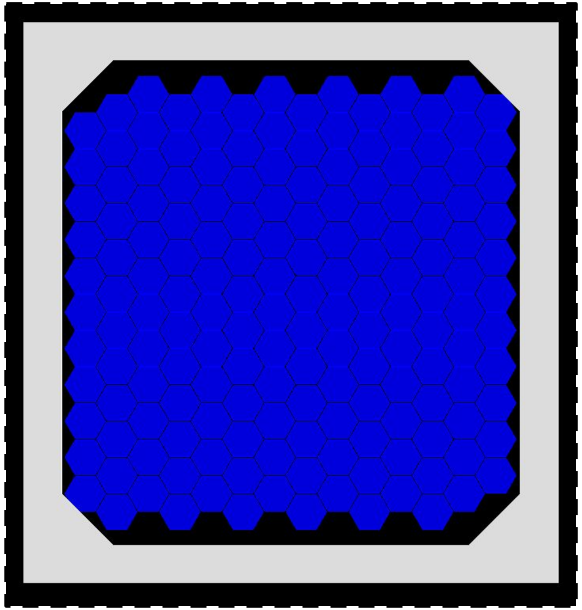
DETECTOR GEOMETRY AND GEANT4 ADAPTATION

CAD

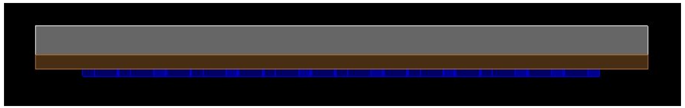


GEANT4



front view

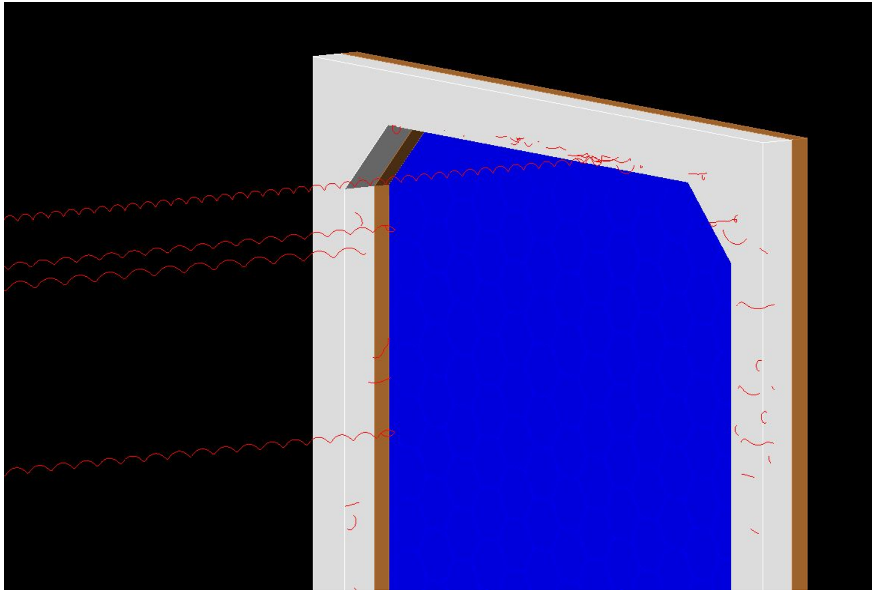
side view



one of the nine 166 pxs module simulated
all the dimensions are correctly implemented

DETECTOR GEOMETRY AND GEANT4 ADAPTATION

- magnetic field of 1 T everywhere
- pixels embedded in Silicon block
- larmor radius for electrons of 20 keV ~0.3 mm



Goal: generate electrons, following their energy and angle distributions, scattering on the grid and study the secondary radiation produced

MAIN GOALS

write a c++ code that generates coordinates, direction and energies of electrons to feed to GEANT4 simulation

the code has to
- generate events directly on the surface of the grid
- follow the energy and cos(theta) distribution of the beta electrons
- save the results in a .txt file

feed the events to GEANT4 ParticleGun() event generator

save the simulation results in a .root tree file, with one branch per SDD pixel

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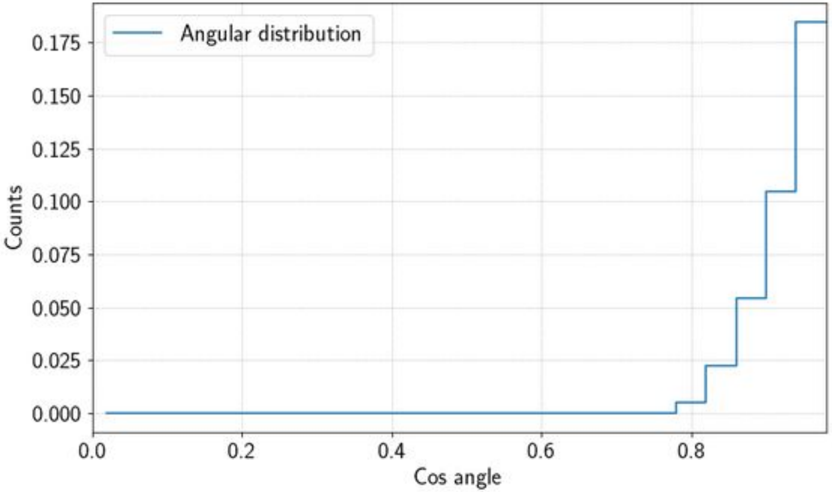
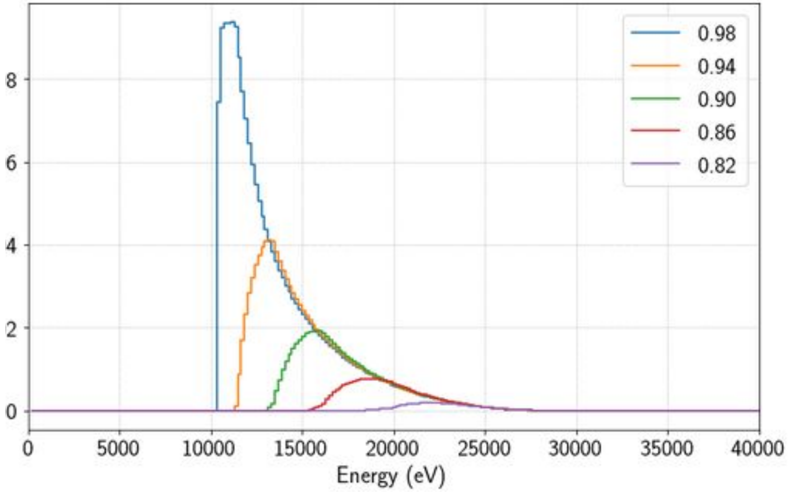
INPUT DISTRIBUTIONS

five different energy distribution for each cosθ
used to generate the events for the simulation





(cosθ, E) distribution shown are retrieved from TRModel:

- 10 kV of post acceleration
- katrin's nominal magnetic fields

GENERATING THE EVENTS FOR GEANT4

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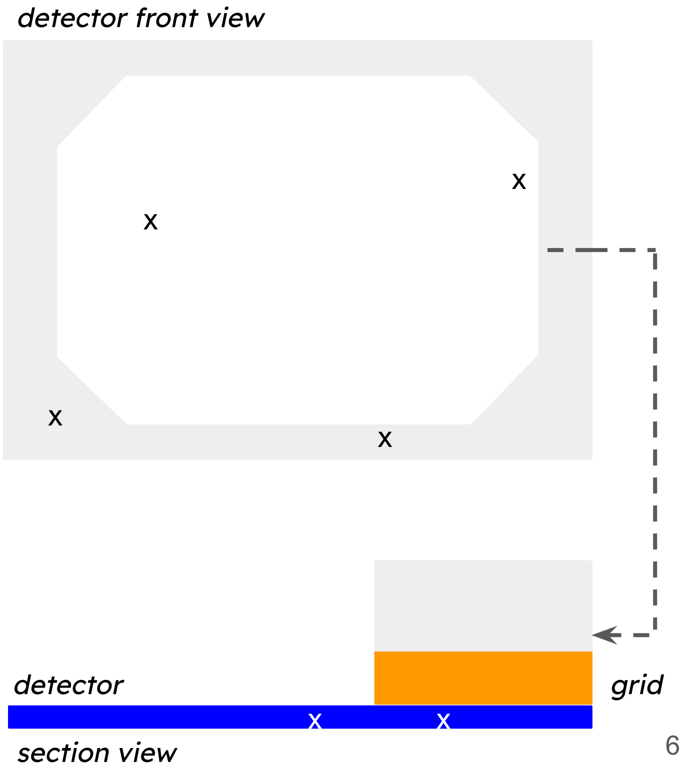
- generate events on all focal plane (*x marks*)



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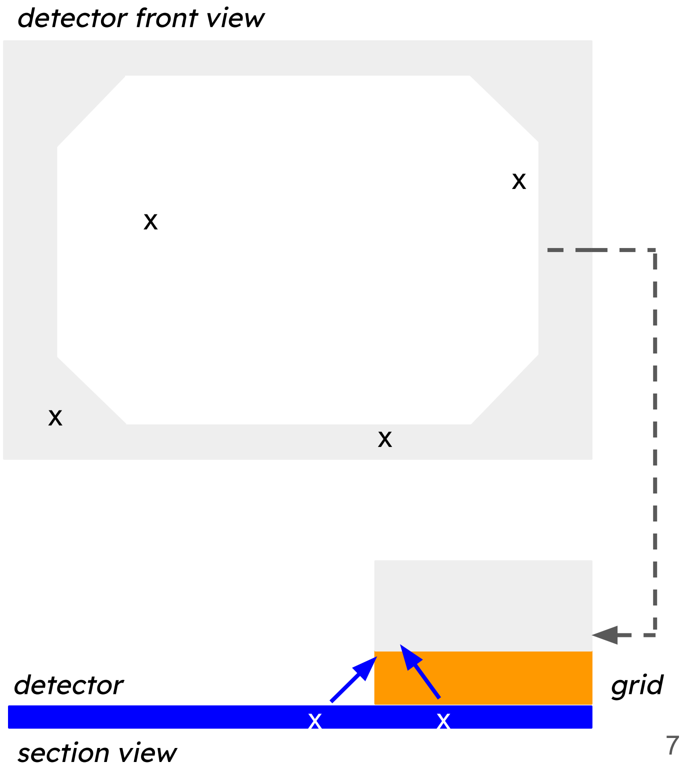
GENERATING THE EVENTS FOR GEANT4

- generate events on all focal plane (*x marks*)
- generate E,cosθ according to distributions shown above, and phi between 0 and 2π (blue arrow)



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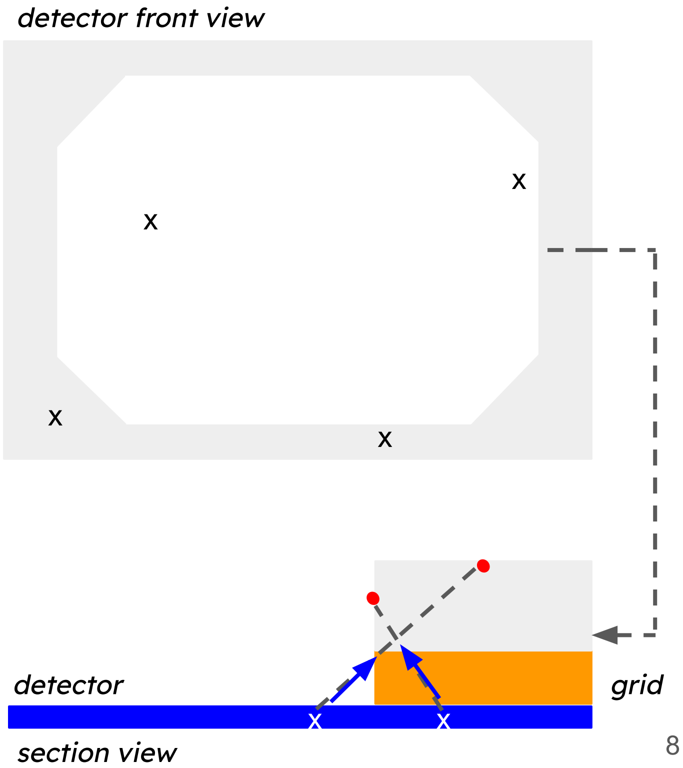
GENERATING THE EVENTS FOR GEANT4

- generate events on all focal plane (*x marks*)

- generate E,cosθ according to distributions shown above, and phi between 0 and 2π (blue arrow)

- check if the direction described by the cos(theta) and phi angles (blue arrow) intersect the grid for each event (dashed grey line and red dot)



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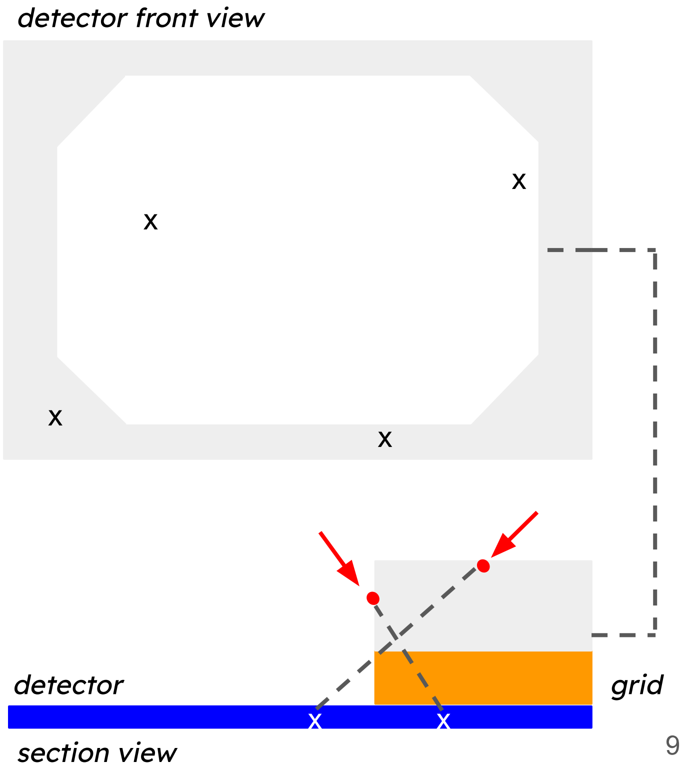

GENERATING THE EVENTS FOR GEANT4

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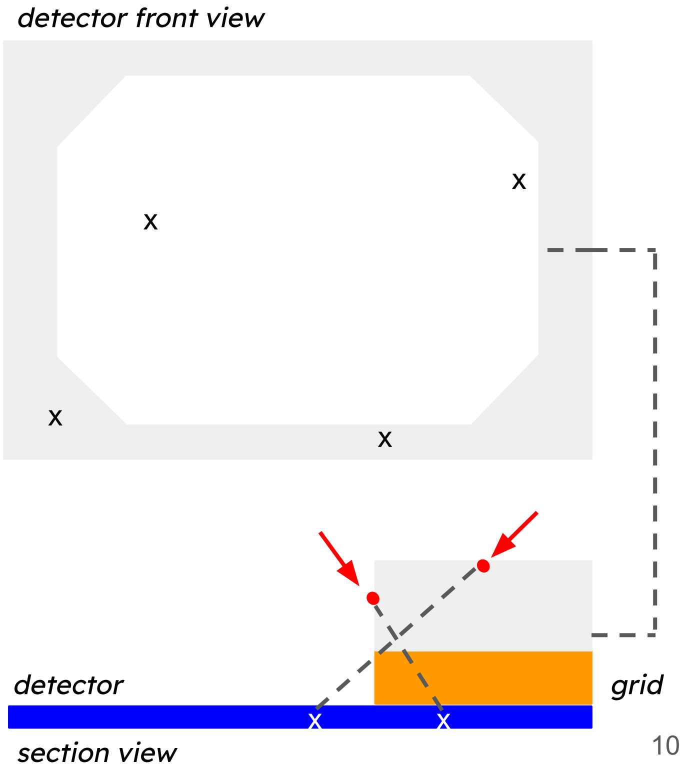
.txt file is the used to generate events in the GEANT4 simulation



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IMPROVING STATISTICS FOR GEANT4 SIMULATION

- generating events (x marks) on all focal plane is inefficient
- instead generating in a frame of optimised dimensions around the inner edge of the grid

- if intersection (*red dot*) is too far away from edge, the electron will be absorbed by material
- code selects events with a distance lower than a characterised threshold value

these selections are accounted for when retrieving the secondary electron rate per pixel with appropriated normalisation factors (backup slides)

RESULTS

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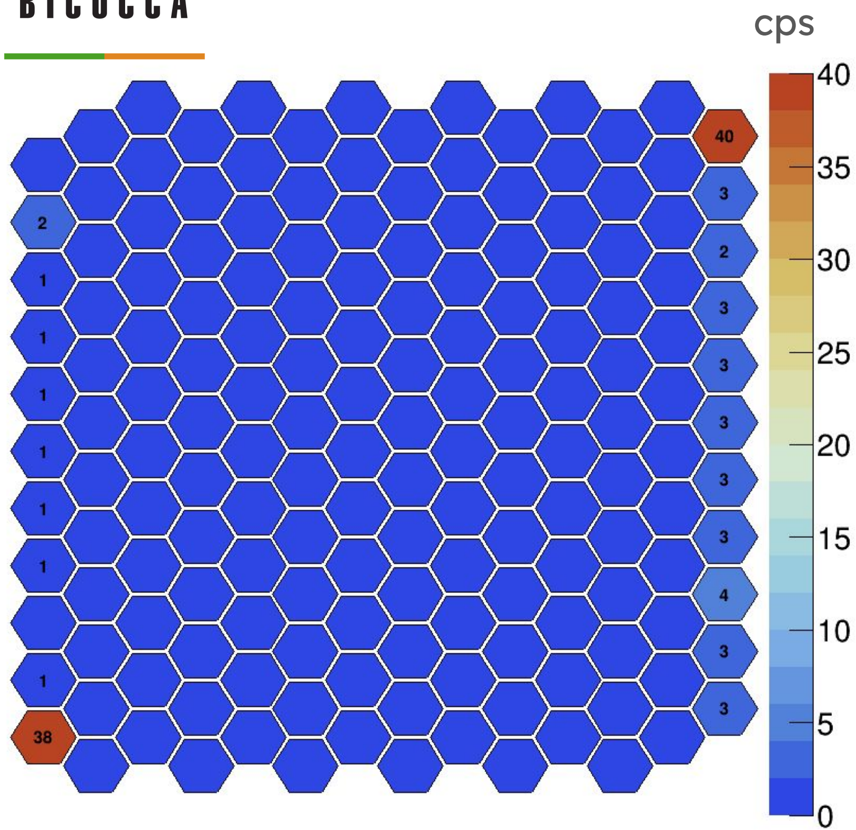
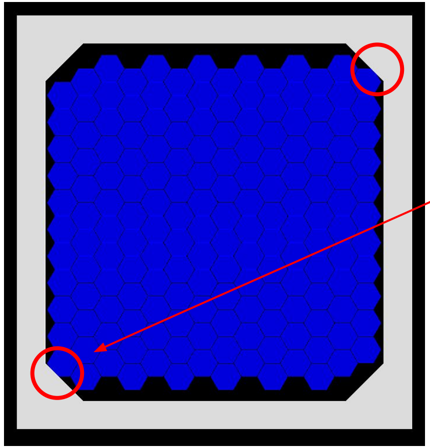


- material: inox
- grid height: 3 mm
- initial rate of electron per pixel is 10^5 cps
- 10^7 events generated

- strong cps dependance on pixel to grid distance
- pixels directly under the grid are most affected



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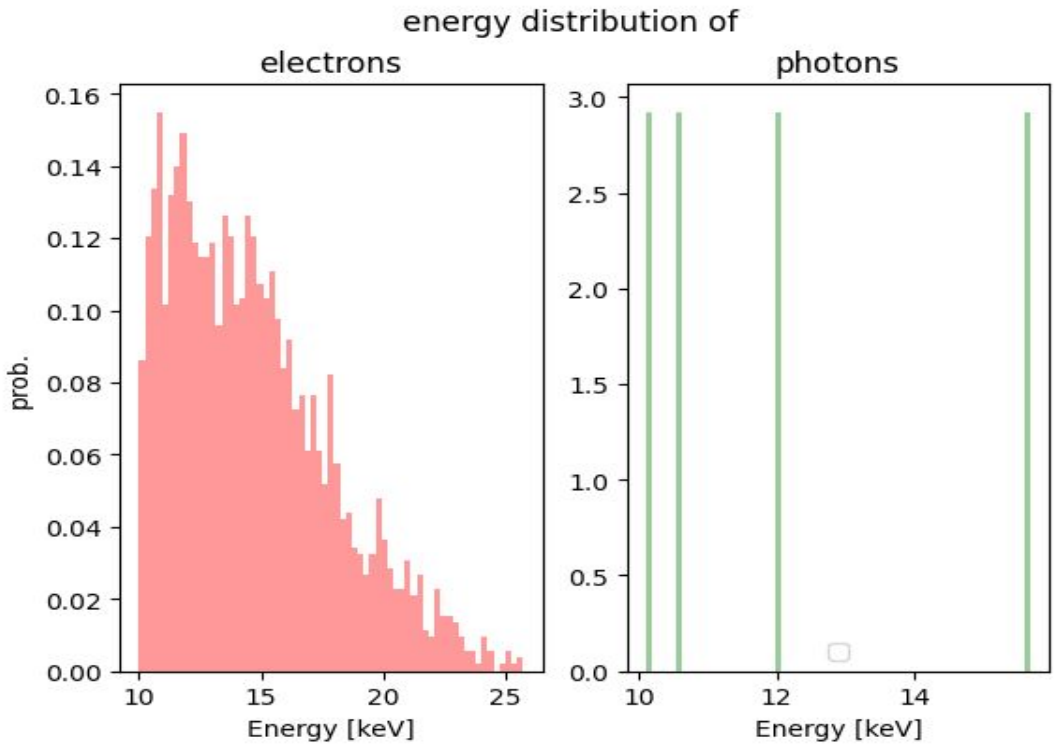
RESULTS

inox 3 mm



- output of the whole detector

- main source of secondary radiation remains electrons

RESULTS

inox 3 mm

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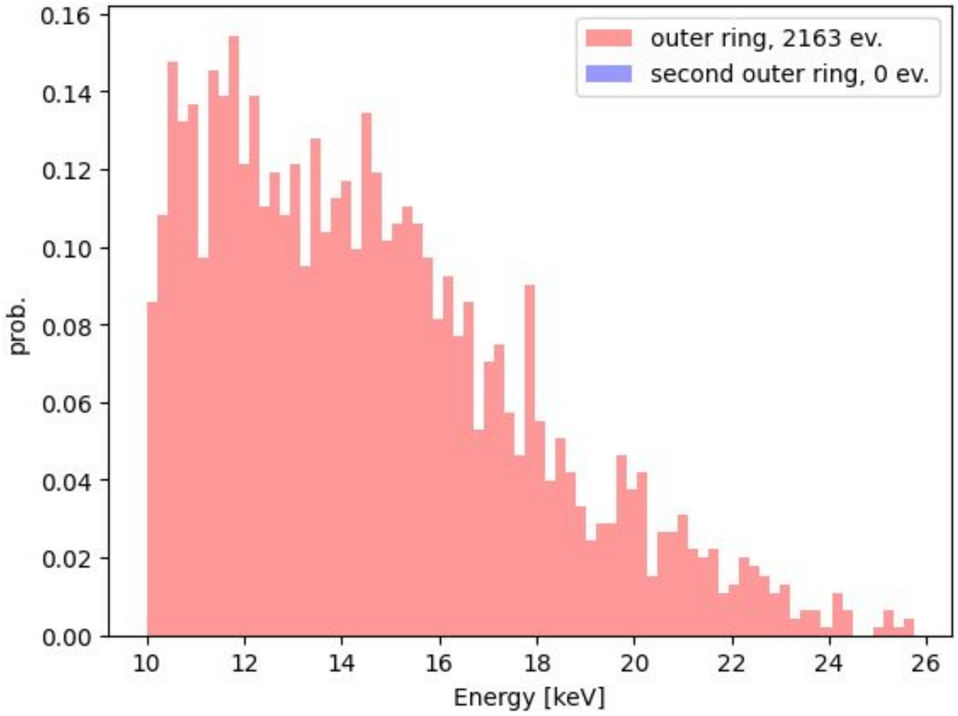
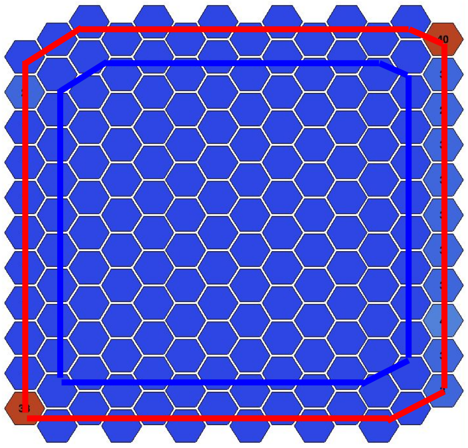


- readout of different set of rings (described by red and blue line shown below)
- only pixel ring close to the grid registers signal



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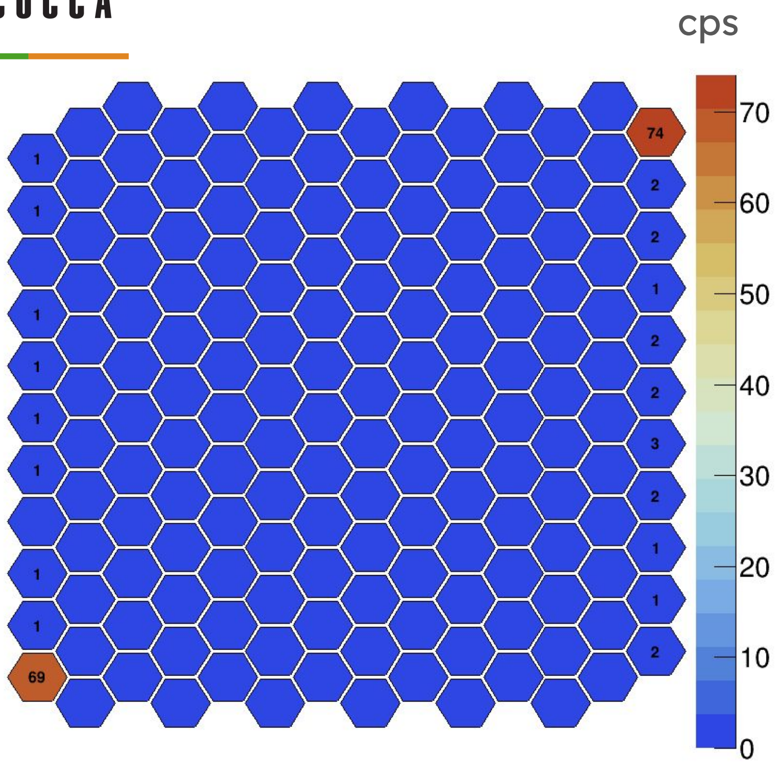
RESULTS



- material: inox
- grid height: 0.3 mm
- initial rate of electron per pixel is 10^5 cps
- 10^7 events generated

- strong dependance on pixel to grid distance
- more cps than the 3 mm stainless steel grid

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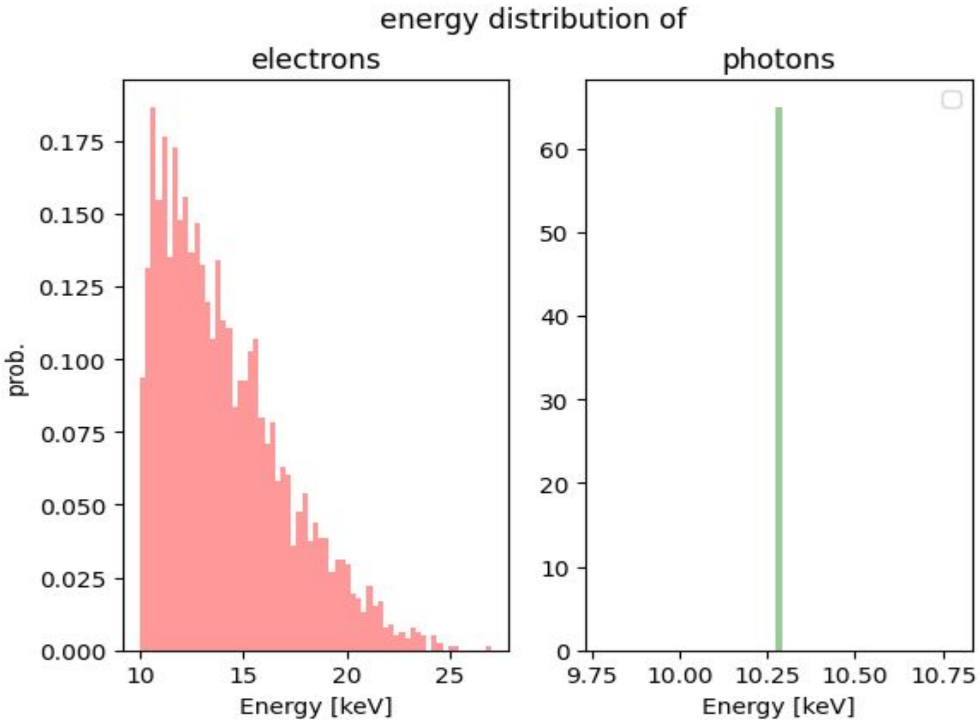
RESULTS

inox 0.3 mm



- output of the whole detector
- main source of secondary radiation remains electrons
- distributions are the same as the 3 mm gird case

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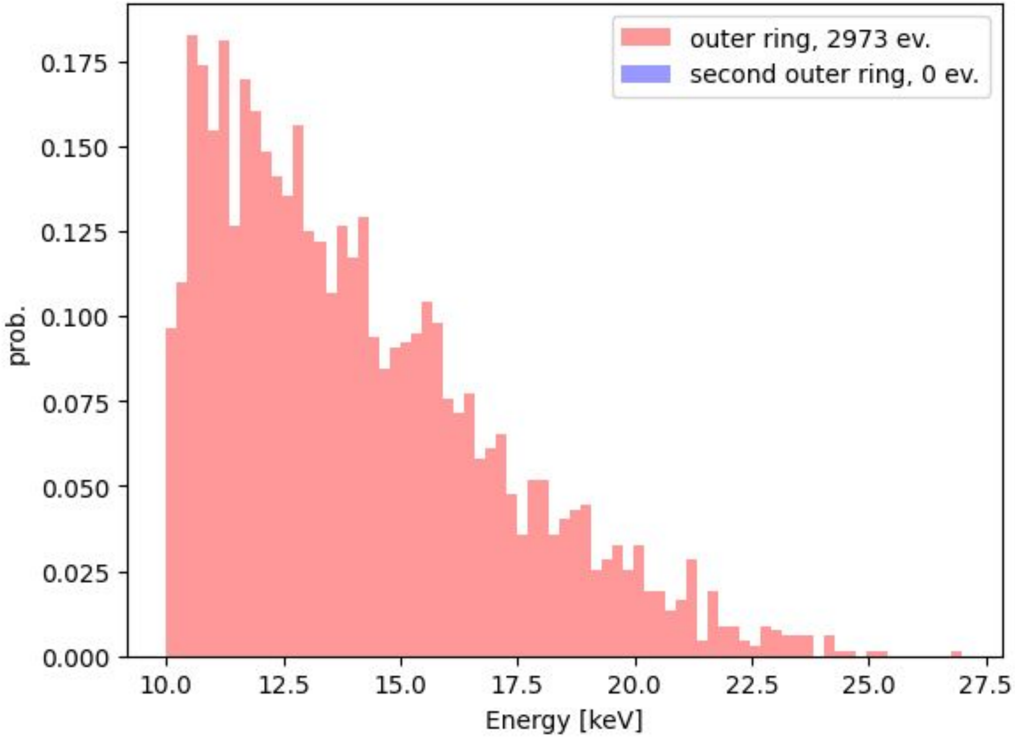
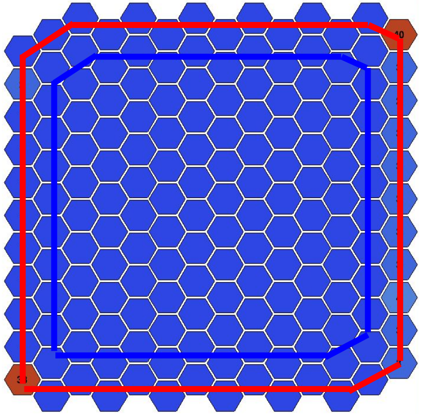
RESULTS

inox 0.3 mm



- readout of different set of rings
- events registered by outer ring are more than the 3 mm stainless steel grid case



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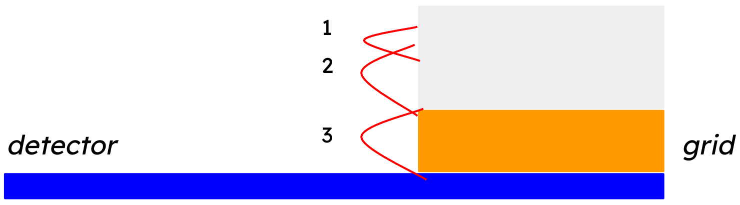
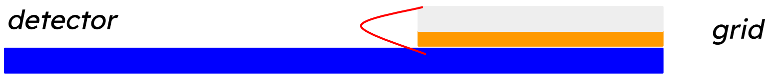
CPS DIFFERENCES - possible explanation

the simulation with 0.3 mm stainless steel grid registers more counts than the one with 3 mm grid height



side view



side view

only track 3 will deposit energy in the detector, 1 and 2 will be absorbed by the grid

here, because the height is lower, the probability of absorption by the grid is less

in the second case more tracks deposit energy in the detector because they can reach it before being absorbed by material

CPS DIFFERENCES - possible explanation

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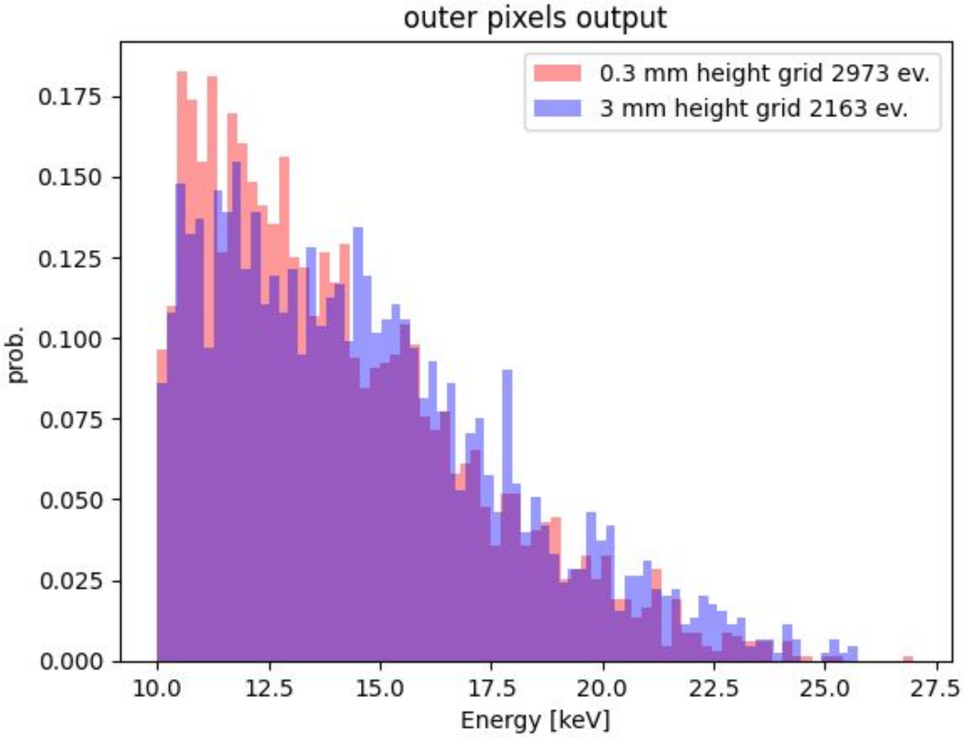

- distribution of the energy deposition seen by the outer ring of pixels in the two cases of grid height

- less probable in the 3 mm grid case to deposit low energy electrons

- low energy electron are the most affected by magnetic motion, so they get absorbed by the grid before reaching the detector

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SUMMARY AND NEXT STEPS

- full implementation of magnetic field in GEANT4 simulation

- with magnetic field only the outer ring of pixels register energy deposition by secondary radiation

- according to these simulations inner pixels are not influenced by the grid's secondary radiation production

- study the effects of a grid made with low Z material (e.g. Carbon)

- further characterization of secondary radiation

BACKUP SLIDES

SIMULATION WORKING PRINCIPLE

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WORKING PRINCIPLE

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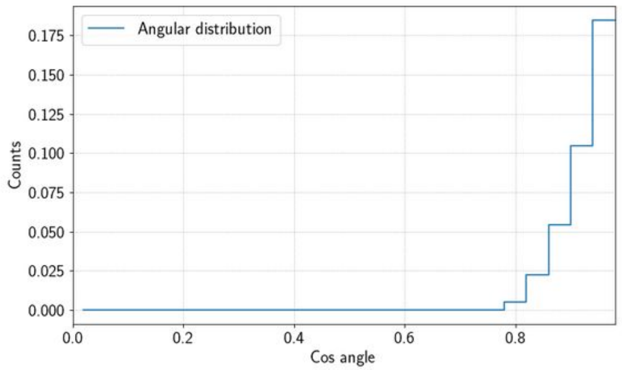
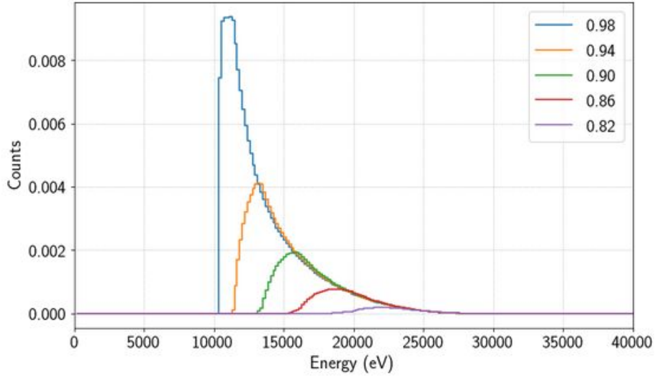
each electron has to be generated according to a (cosθ,E) 2D distribution

to do so, the C++ code randomly selects the angle, according to its weight, and then the energy according to the distribution associated with the angle

then, it generates a position on the focal plane (x,y) and a phi angle randomly between 0 and 2π





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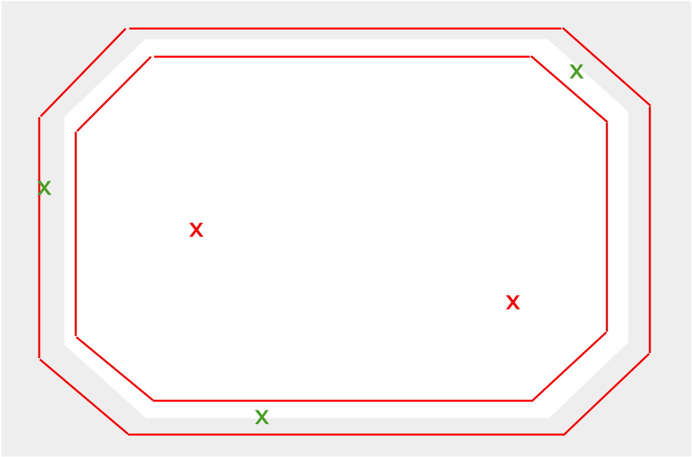
NORMALIZATION FACTORS

to optimize the generation of events on the focal plane, C++ code only produces hits inside the red frame (green marks), improving the probability that an electron hits the grid sufficiently close to scatter onto the detector

to calculate the rate in the red frame starting with the rate per pixel (R_i) the formula is

R_frame = (A_frame/A_pixel)*R_i = N1*R_i



NORMALIZATION FACTORS

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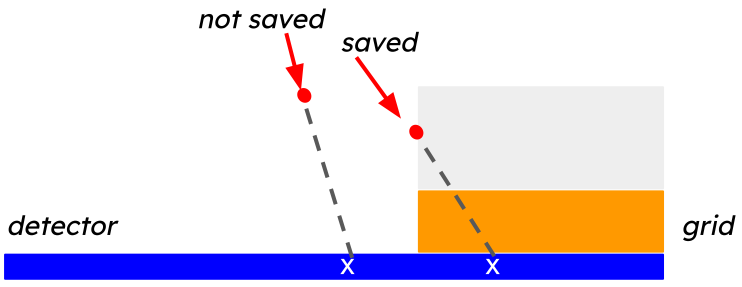
not all events on the focal plane (white x mark) will be propagated backwards to the grid, the code saves only the events that do intersect the grid. This introduces an efficiency factor given by the ratio between the events saved (red dots) and the events generated by the code (white x marks), called **N2.** Now the .txt file is used to generate events in GEANT4



side view

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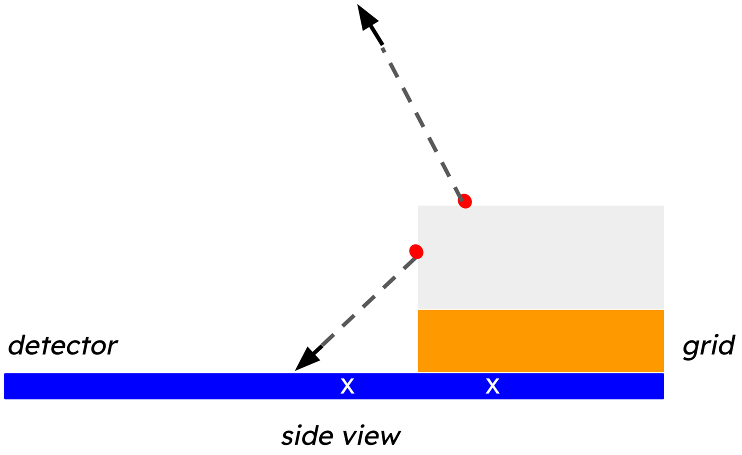
NORMALIZATION FACTORS

not all the events saved are going to generate electrons that will interact with the detector in the GEANT4 simulation, some will be absorbed by the material, or scatter in a different direction. This introduced a third factor **N3**, given by the ratio of events produced by the GEANT4 simulation (tree file dimensions) and the number of events saved by the C++ code.



CONCLUSION AND SUMMARY

Finally, the pixel's rate of secondary radiation is given by the ratio of the events the n-th pixel registers and the number of events saved by the GEANT4 simulation, called **N4_n**

So the n-th pixel's rate of secondary radiation **R_n**, starting from the initial rate per pixel **R_i**, is

R_n = R_i*N1*N2*N3*N4_n

where N1 is correlated to the area in which the events on the focal plane are generated, N2 is correlated to the fact that not all events generate an intersection with the grid, N3 is correlated to the fact that not all electrons that hit the grid are going to produce secondary radiation that reaches the detector

BACKUP SLIDES

CHARACTERISTIC THRESHOLD IN THE C++ CODE

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SETTING A THRESHOLD

the main idea behind deciding the threshold was to impose that, for each event, its maximum distance from the edge (thresh.) would be the value such that the electrons scattering in the space between the edge and this value would deposit 99 times the events deposited by the electrons scattering in the space between the threshold and 2*threshold

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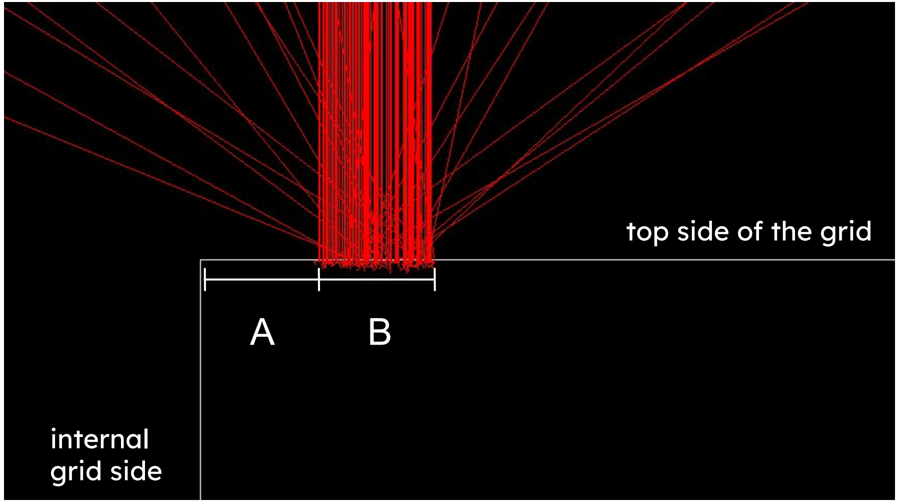
SETTING A THRESHOLD

graphically this means that



vertical slice of the simulated setup

the events recorded in the simulation with the electrons scattering in the region A are 99 times the events recorded by the run where electrons are generated in the region B

(in this case the electrons are generated vertically with a fixed energy)

SETTING A THRESHOLD

for different materials used in this study, I found the value using GEANT4 simulations, setting the direction of the electron vertical and with the maximum energy possible (around 50 keV)

then I used this value as a way to increase the statistics in generating the intersection points, because if the generation is too far away, the resulting electron would be absorbed by the material and would never reach the detector

this threshold is such as it is not too big, because it would be useless, and not too small, not to loose statistics