Effect of structural material of SPD ECAL on the energy resolution

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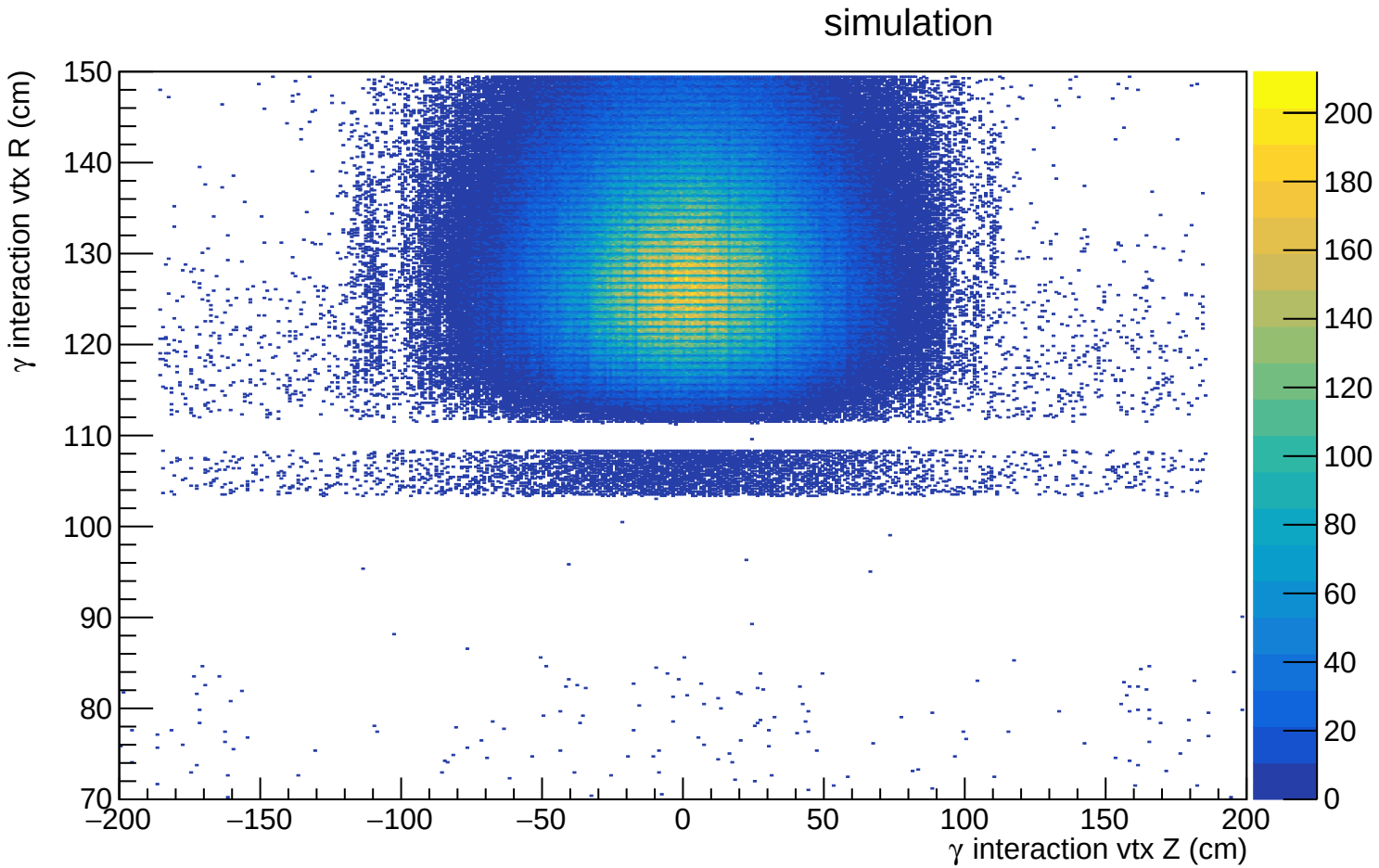
Part 1: material before ECAL

- how is energy resolution impacted?
- two interesting regions:
  - above 5 GeV (prompt photons)
  - below 1 GeV (decays of charmonia states)

The task and the setup

- Structural material in front of ECAL (preliminary carbon fiber): $\sim$ 5 cm
- Task: consider different materials (carbon, iron, etc.) and different thicknesses to see impact on energy resolution of ECAL
- SPDROOT version 4.1.6 (using docker jemtchou/spdroot:4.1.6)
- This exercise $\rightarrow$ photons hitting perpendicularly to ECAL (to do: investigate case of larger angles)
- Three photon energies: 0.5 GeV, 1 GeV, 6 GeV

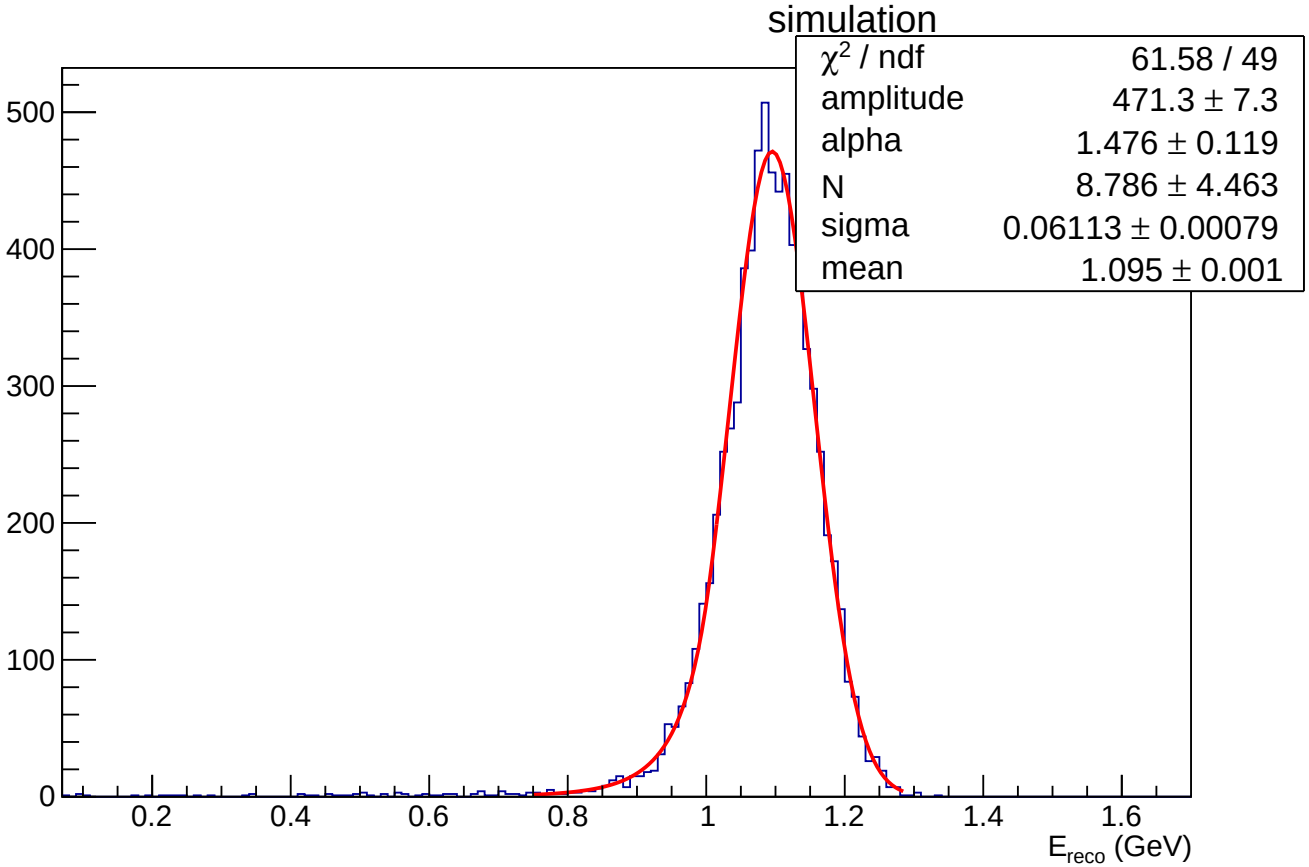
The methodology



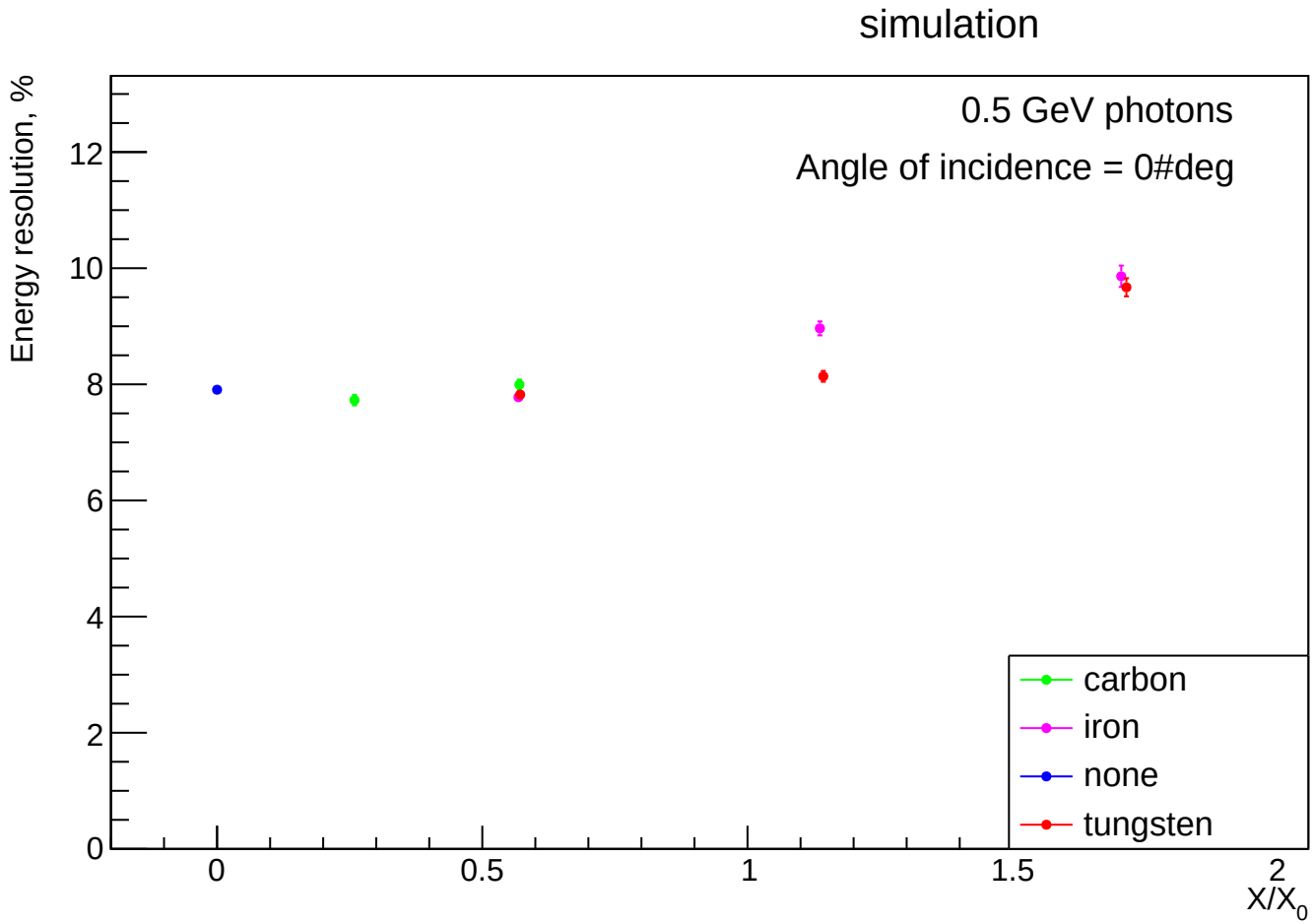
- material with given density placed $\approx$ 10 cm before ECAL barrel

Obtaining energy resolutions

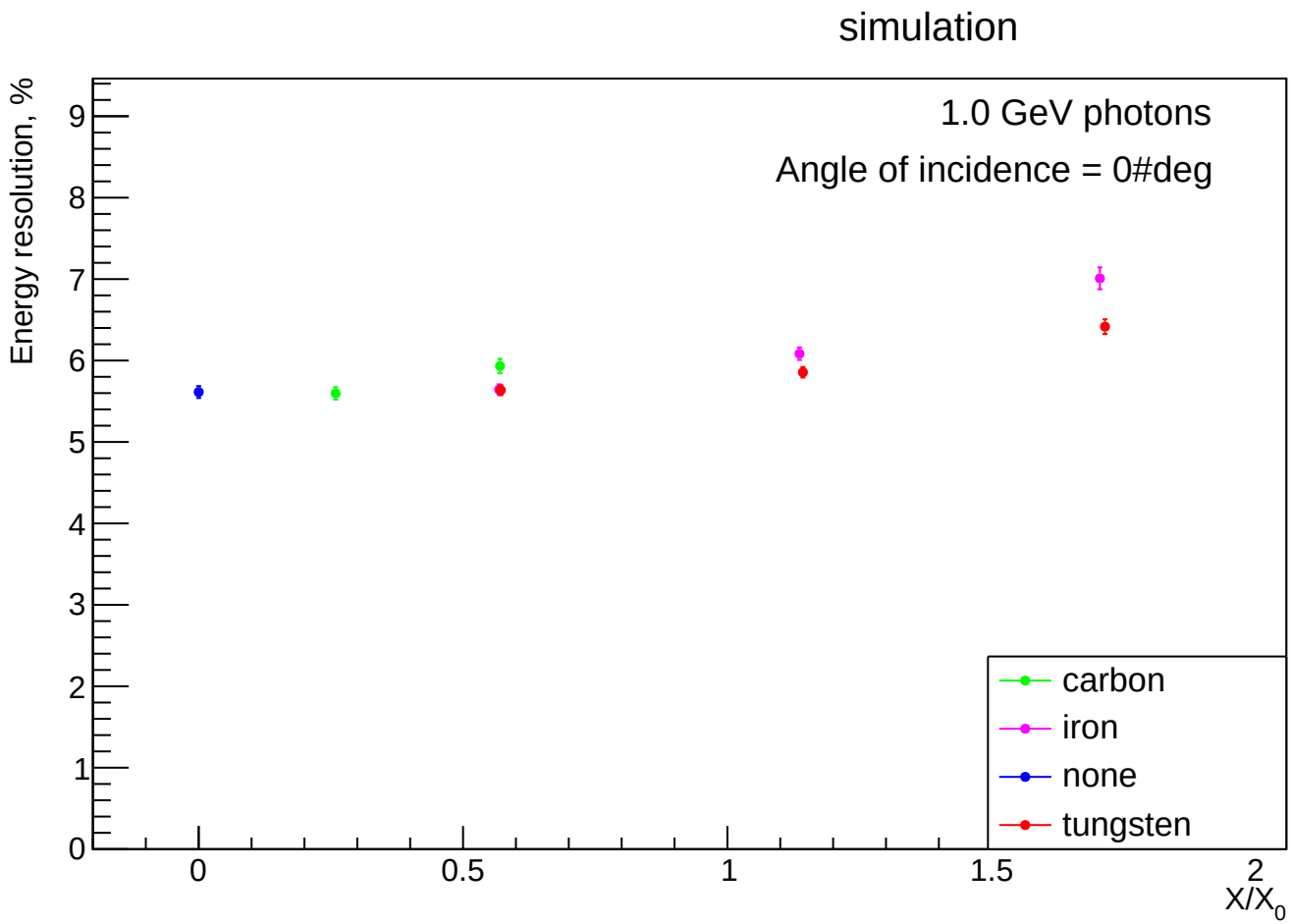
- Gaps in azimuthal angle $\rightarrow$ non-gaussian tail towards lower energies $\rightarrow$ fitting the gaussian part to get energy resolution
- Energy resolution = (width of peak) / (position of peak), no postprocess calibrations applied
- 5 cm carbon, 1 GeV



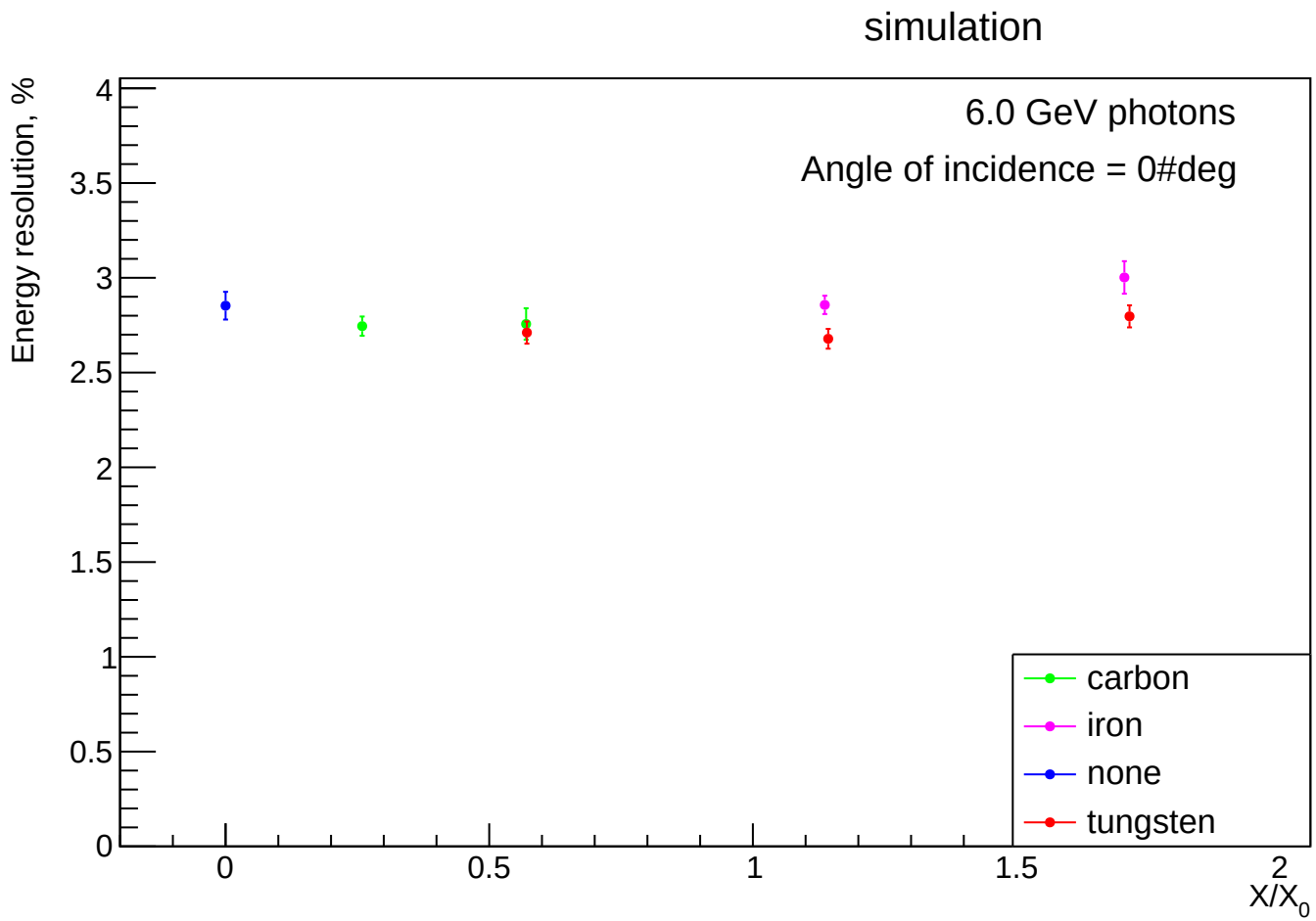
Results


simulation
0.5 GeV photons
Angle of incidence = 0#deg
Energy resolution, %
0
2
4
6
8
10
12
0
0.5
1
1.5
2
X/X0
carbon
iron
none
tungsten

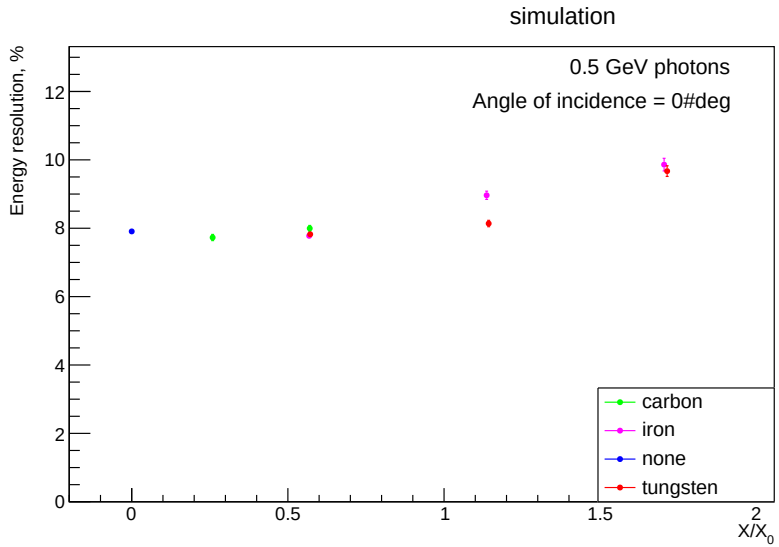
Results

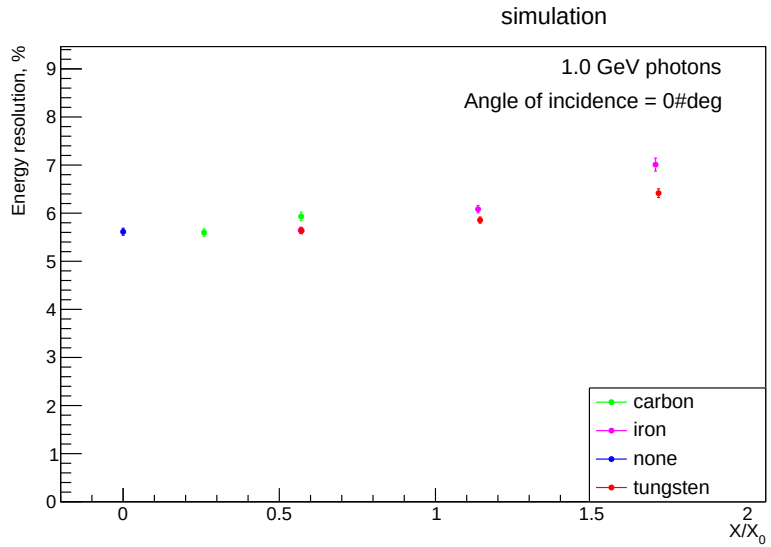

simulation
1.0 GeV photons
Angle of incidence = 0#deg
Energy resolution, %
X/X0
carbon
iron
none
tungsten
0
0.5
1
1.5
2
0
1
2
3
4
5
6
7
8
9

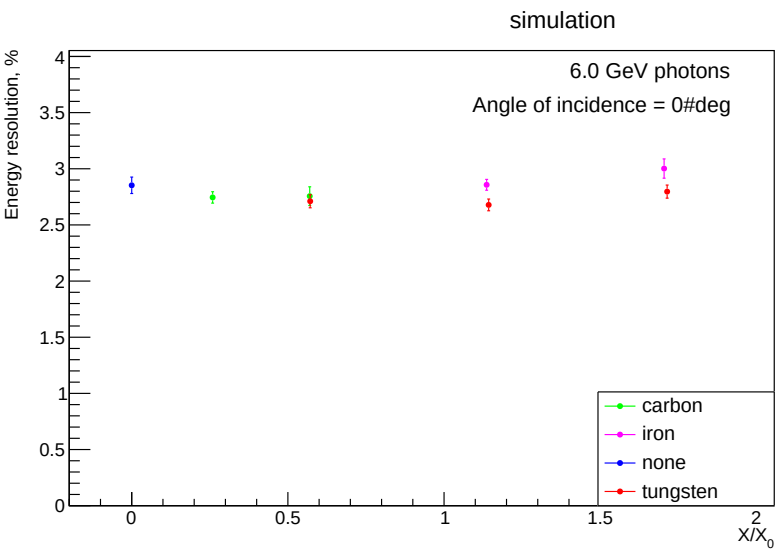
Results


simulation
6.0 GeV photons
Angle of incidence = 0#deg
Energy resolution, %
X/X0
carbon
iron
none
tungsten
0
0.5
1
1.5
2
2.5
3
3.5
4

Results


simulation
0.5 GeV photons
Angle of incidence = 0#deg
Energy resolution, %
X/X0
carbon
iron
none
tungsten


simulation
1.0 GeV photons
Angle of incidence = 0#deg
Energy resolution, %
X/X0
carbon
iron
none
tungsten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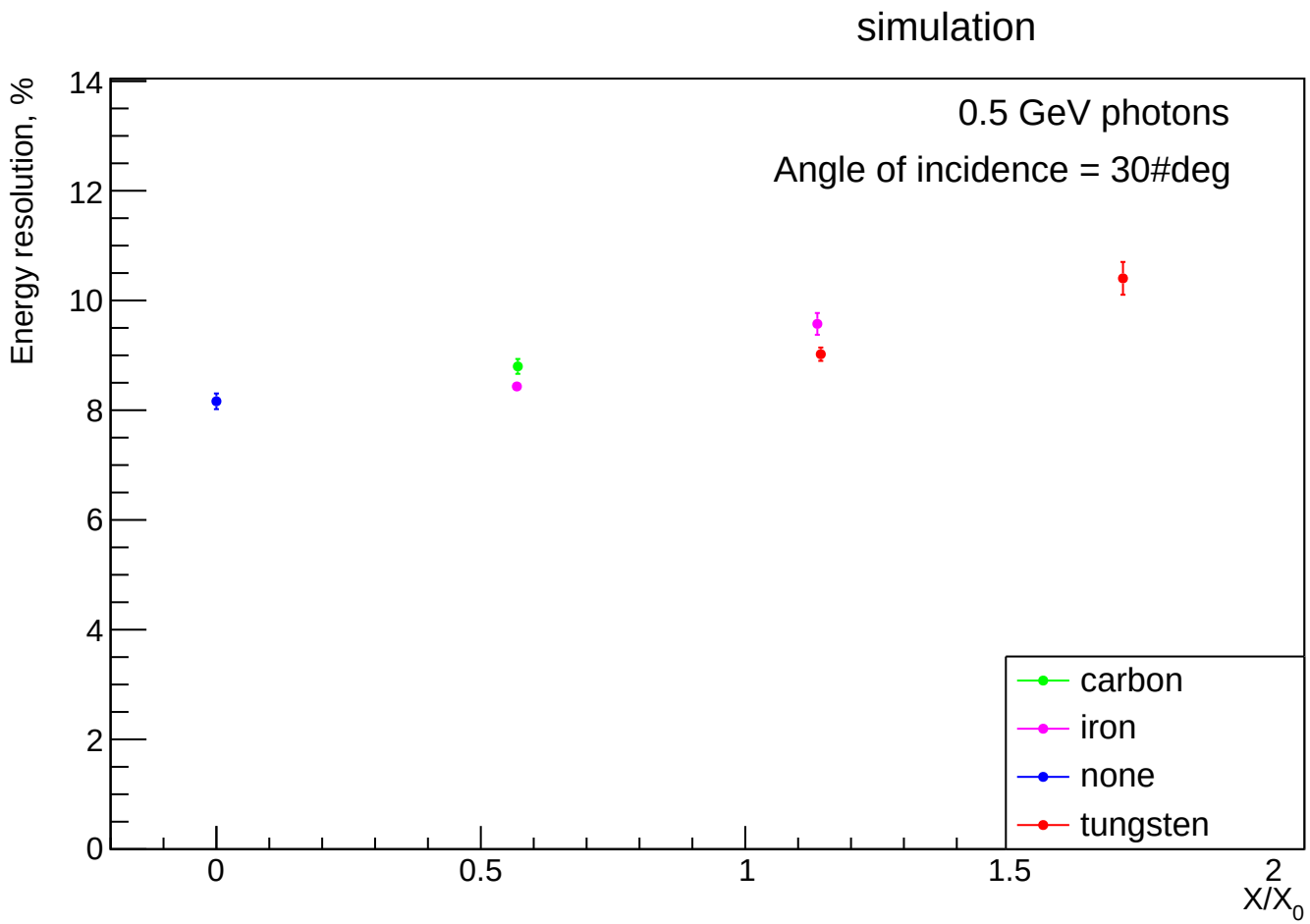
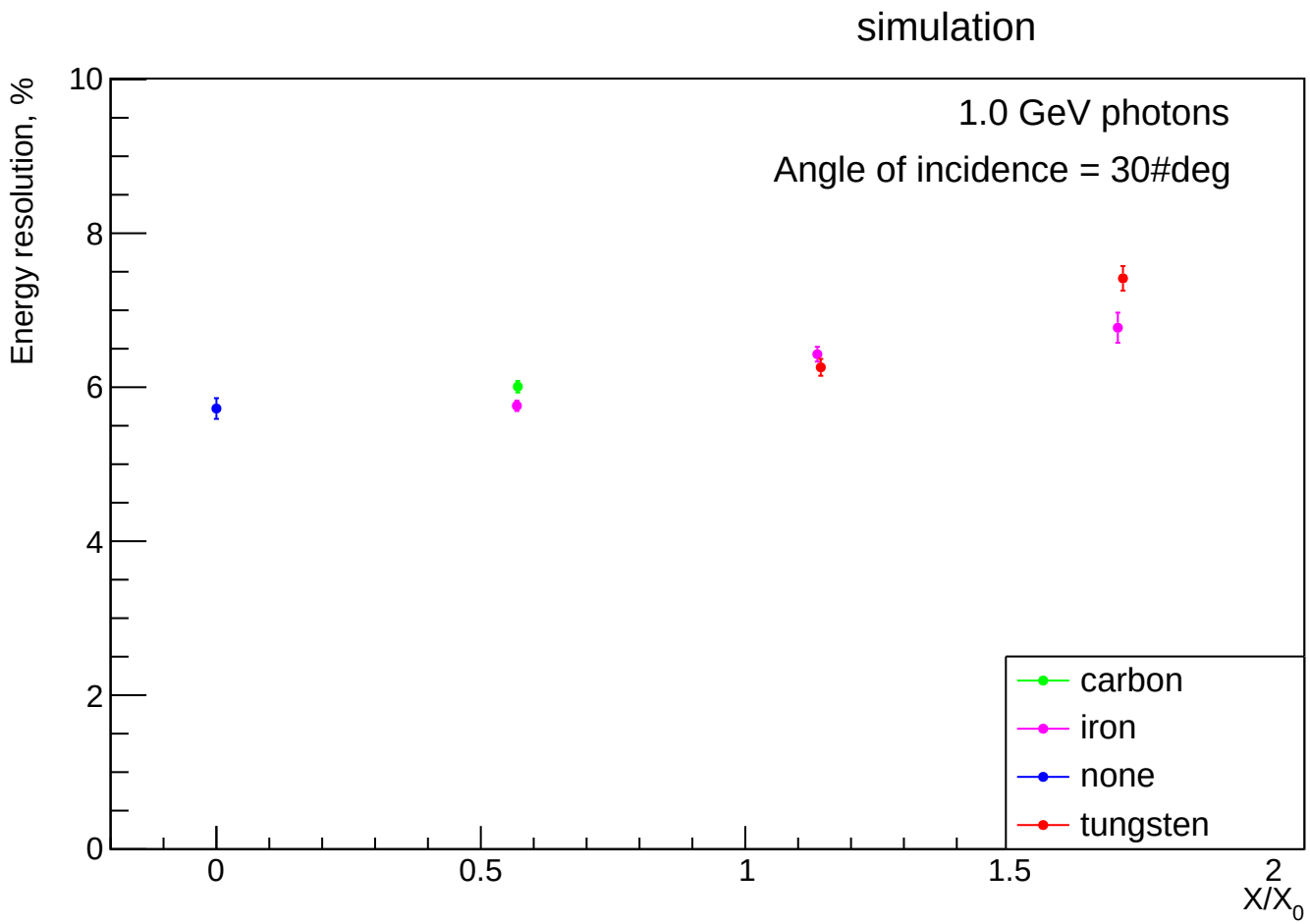
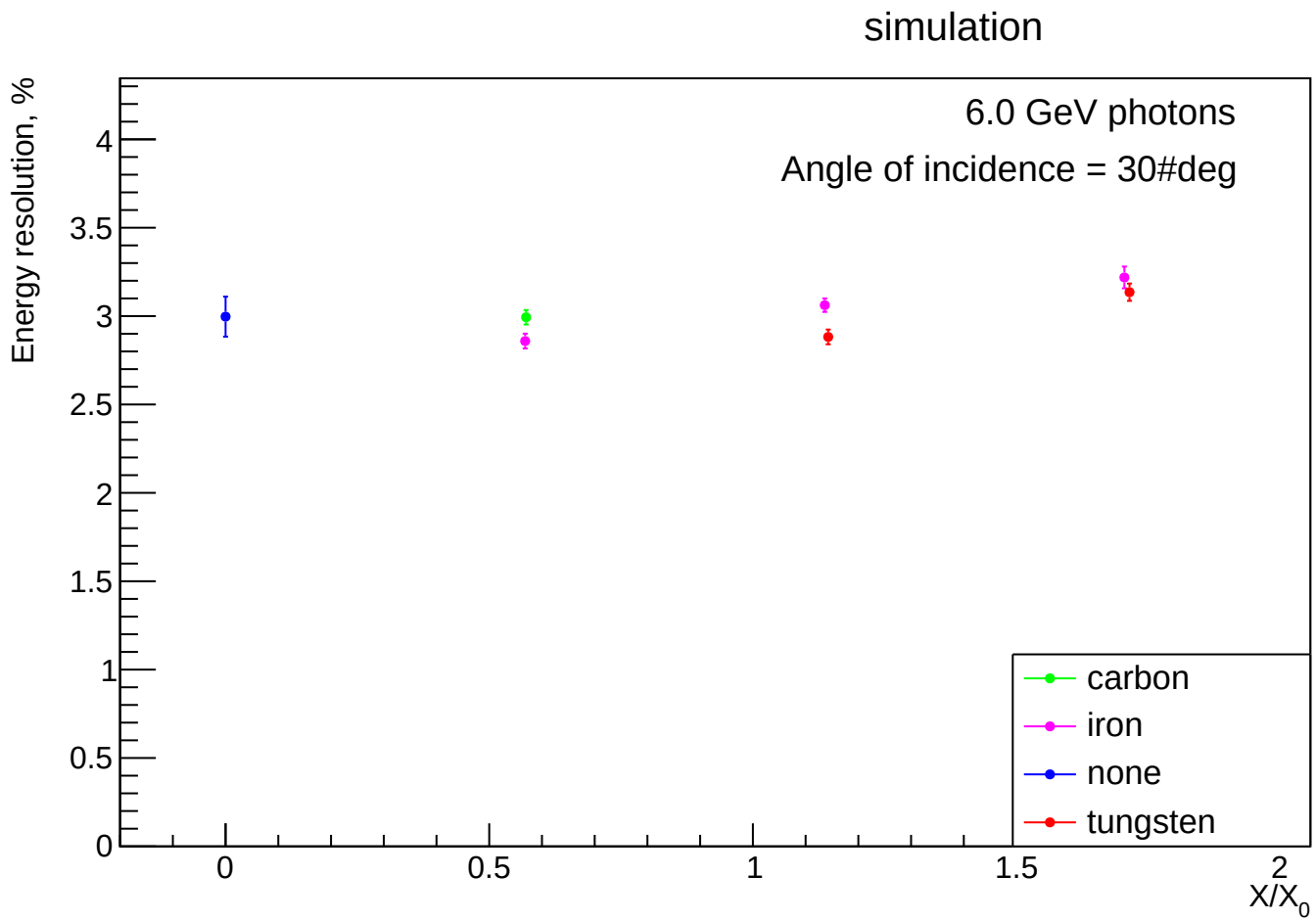
Results (30 degrees)



Results (30 degrees)



Results (30 degrees)



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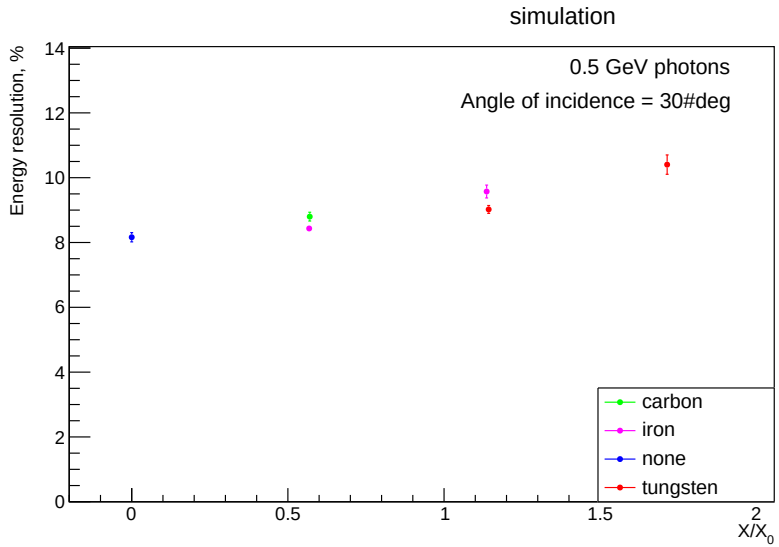
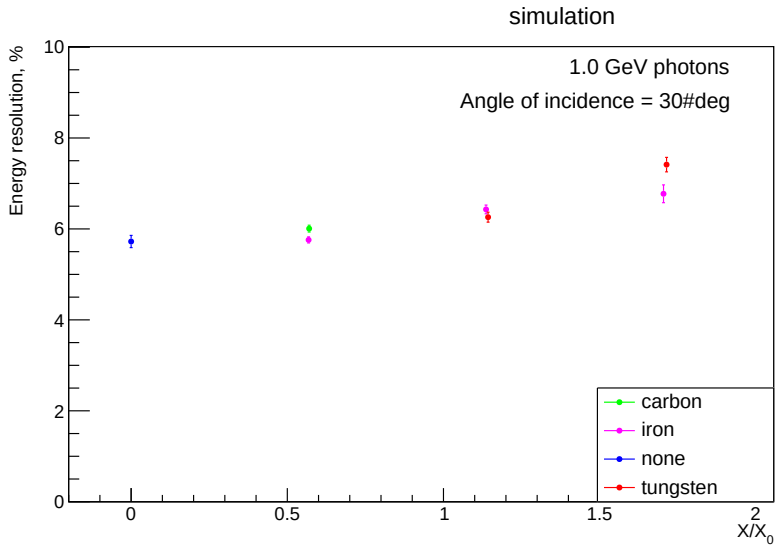
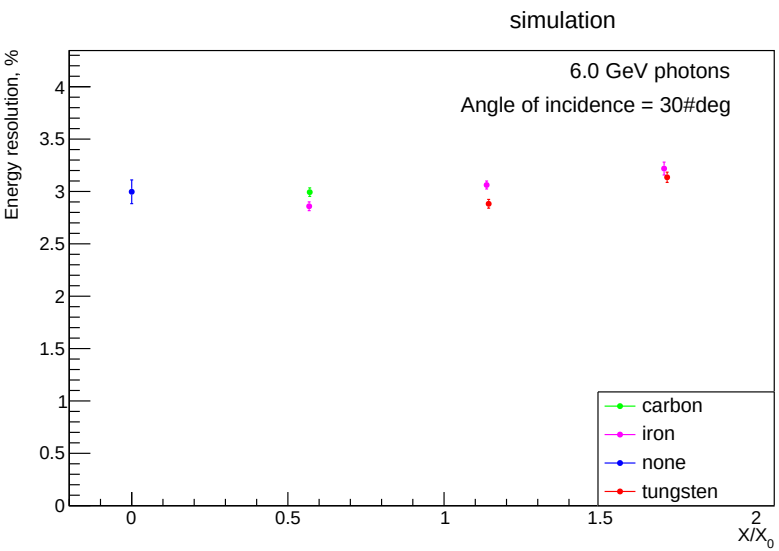


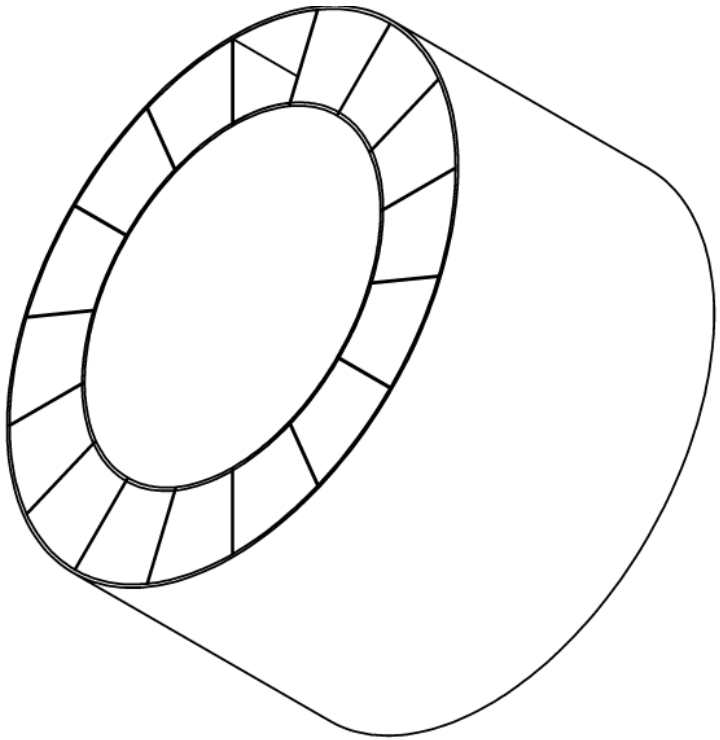




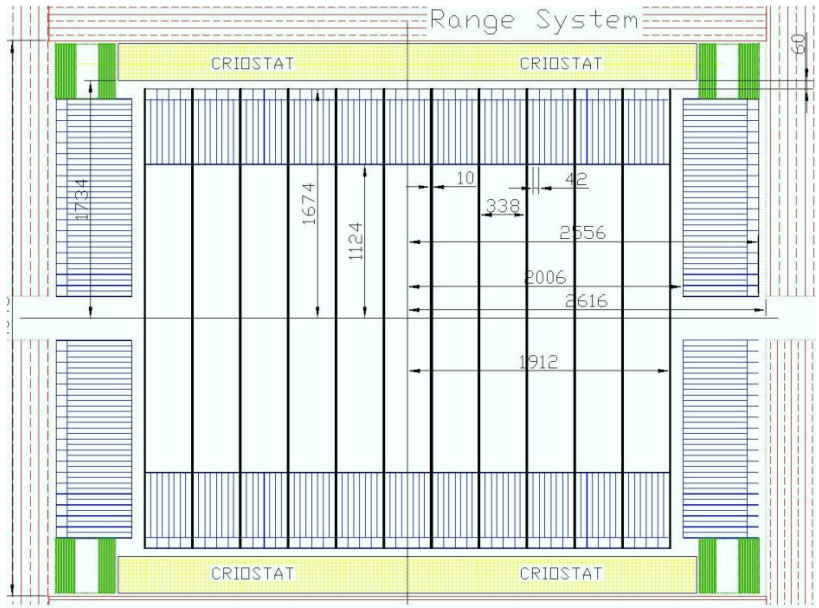
Part 2: Comparison of the energy resolution for the two geometry options: Z-slices, ϕ-sectors

Comparison of the energy resolution for the two geometry options: Z-slices, ϕ-sectors

The two options:

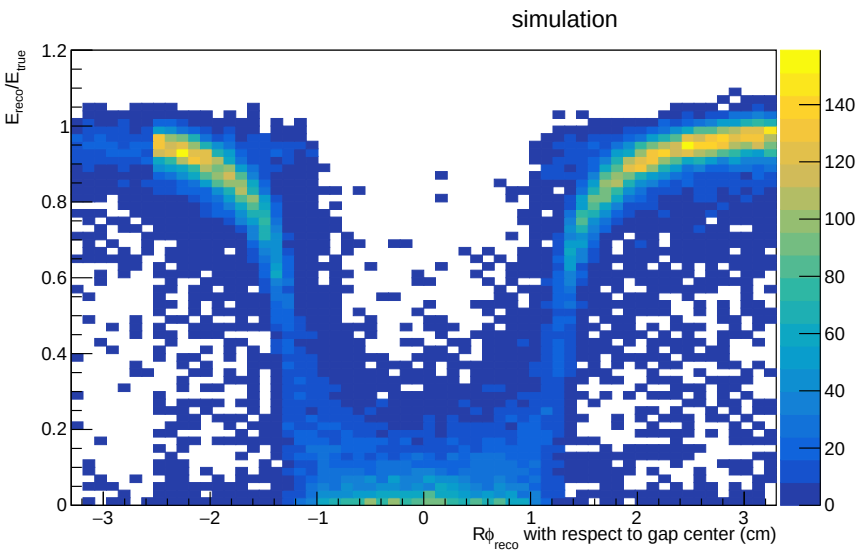


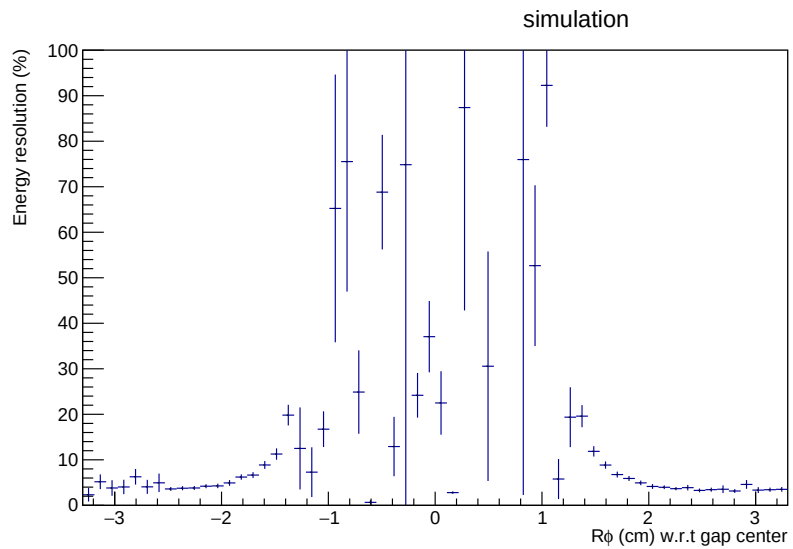
In total (basket walls + structural material): 24 mm of carbon fiber, 16 sectors



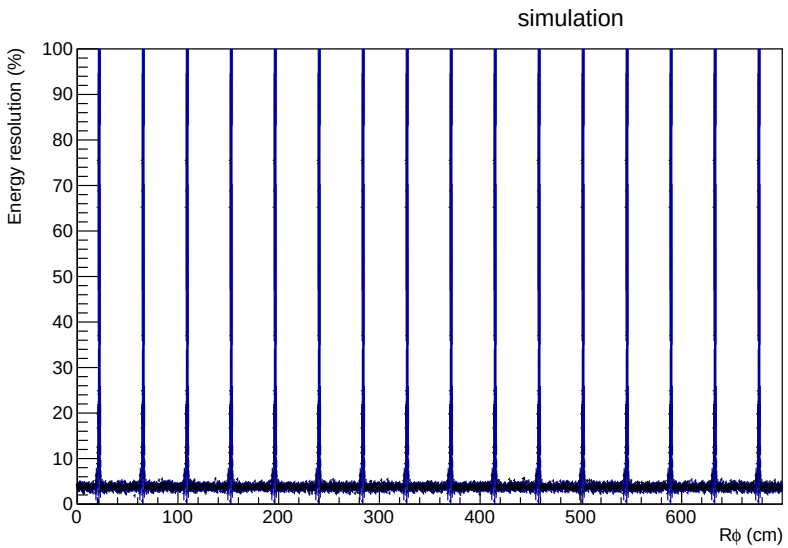
In total (basket walls + structural material): 20 mm of carbon fiber

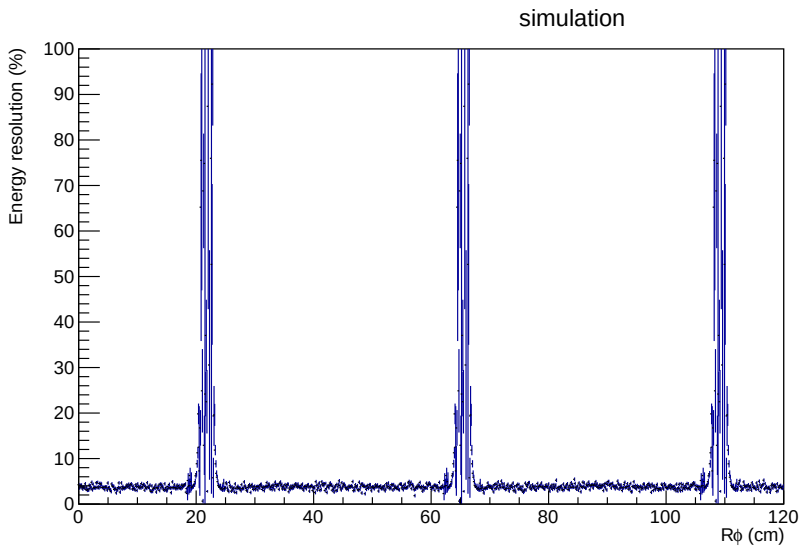
The ϕ-sectors option





The ϕ-sectors option: picture for full barrel





Approximately 5.8% of the azimuthal coverage is affected

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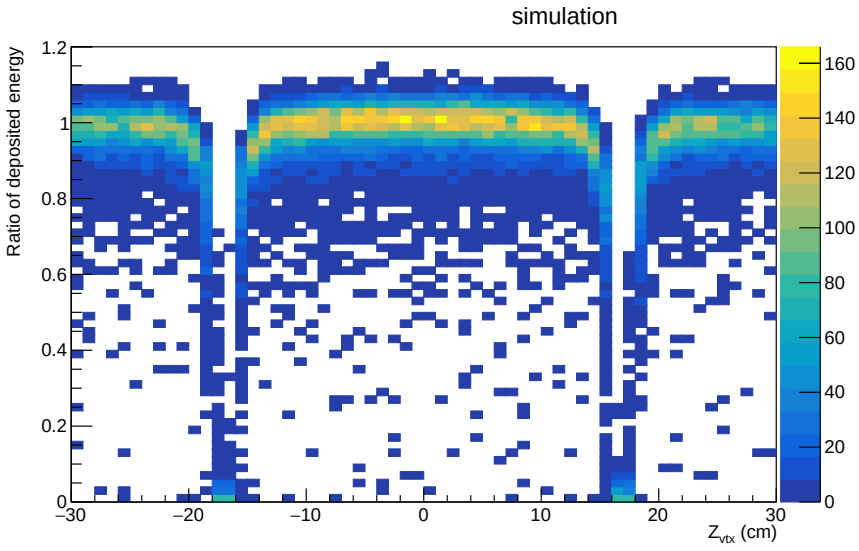
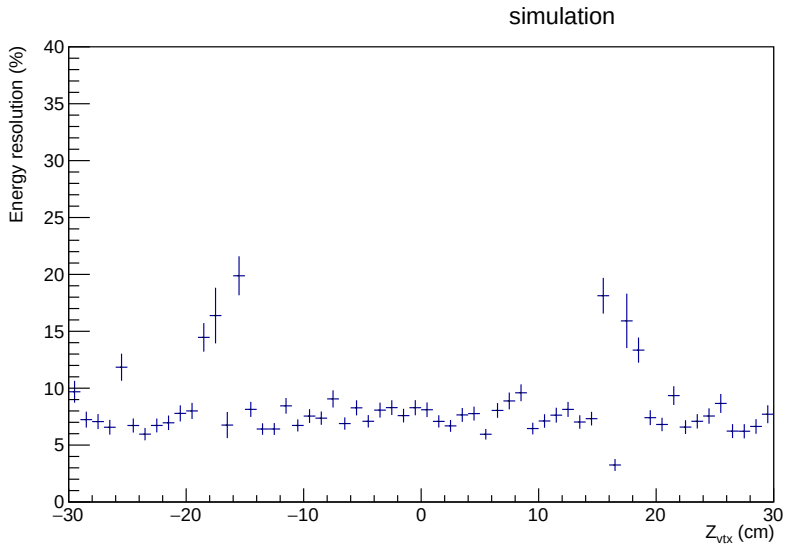
The Z-gaps option:



0 degree incidence angle



0 degree incidence angle

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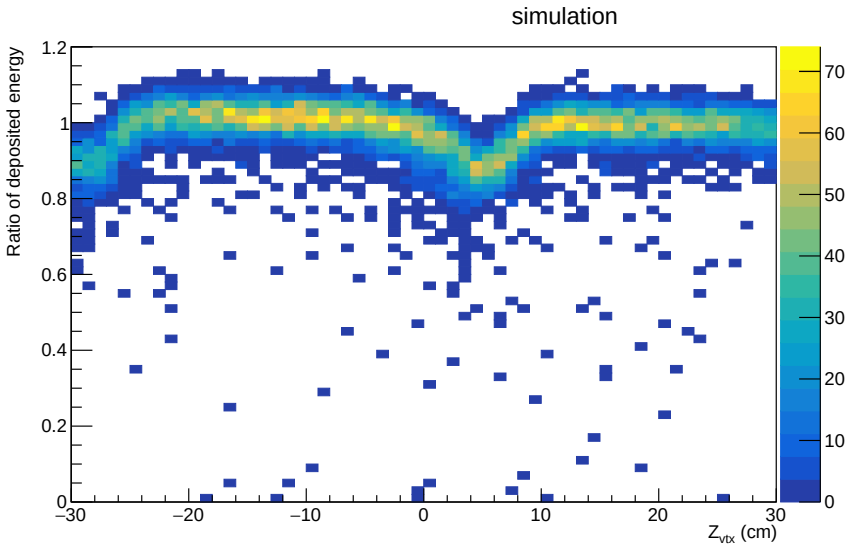
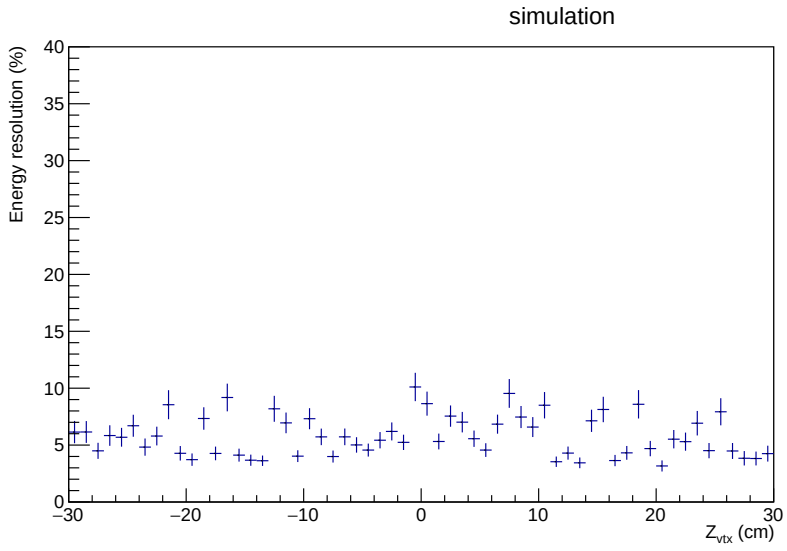


20 degree incidence angle



20 degree incidence angle

Conclusions

- Material below 0.25 X_0: no significant impact on energy resolution
- 0.5 X_0 of extra material: energy resolution at low energies worse by 0.2 – 0.3%
- With more material, heavier material seems to be preferrable
- option of ϕ sectors influences azumuthal coverage of approx. 5.8% independent of polar angle – very poor energy resolution $\sim$ 50%)
- option of Z gaps: 5% for events are affected, but only events close to 90($\pm$ 10 degrees) are very difficult to resolve