PSD ACTIVTY @ Bari

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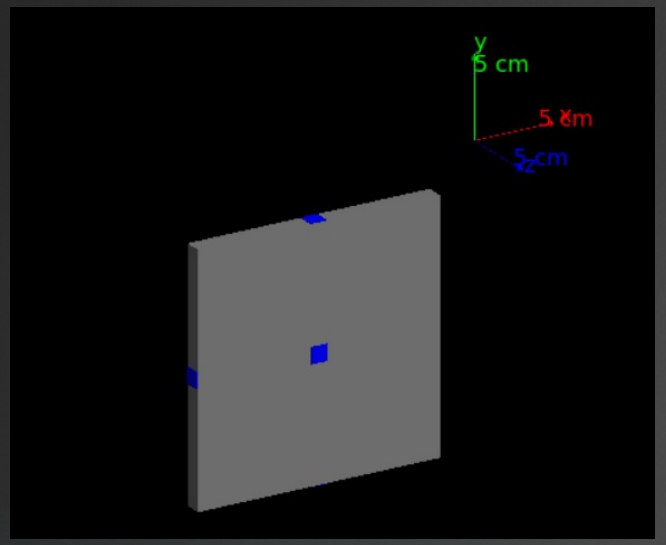
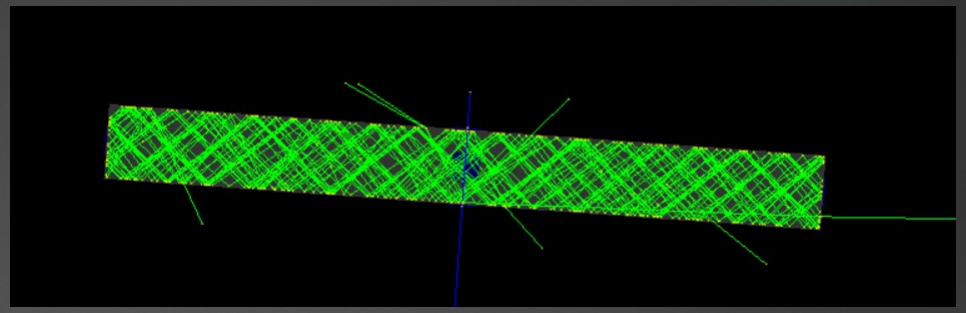
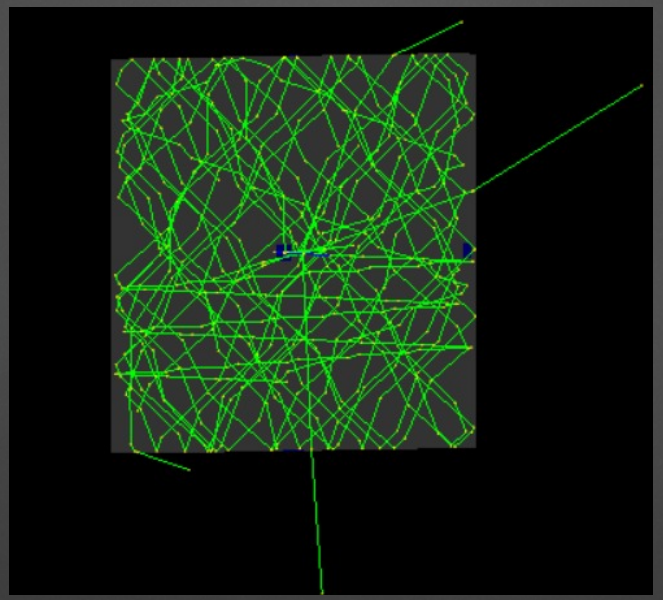
GEANT4 simulation of optical photons

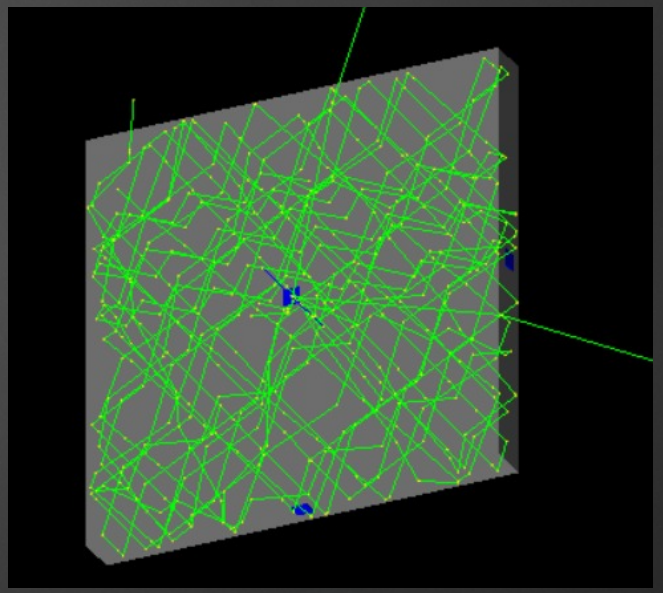
- We are working on a simulation of the tile that tracks every single optical photon
- We have simulated a tile 10x10x1 cm^3
- The tile is equipped with 6 SiPM 4x4 mm^2 placed on the four sides and on the top and bottom face
- In this simulation we can change a lot of parameters such as
  - Tile size
  - Number and position of SiPMs
  - Light Yield and attenuation length of the scintillator
  - Physical parameters of the wrapping





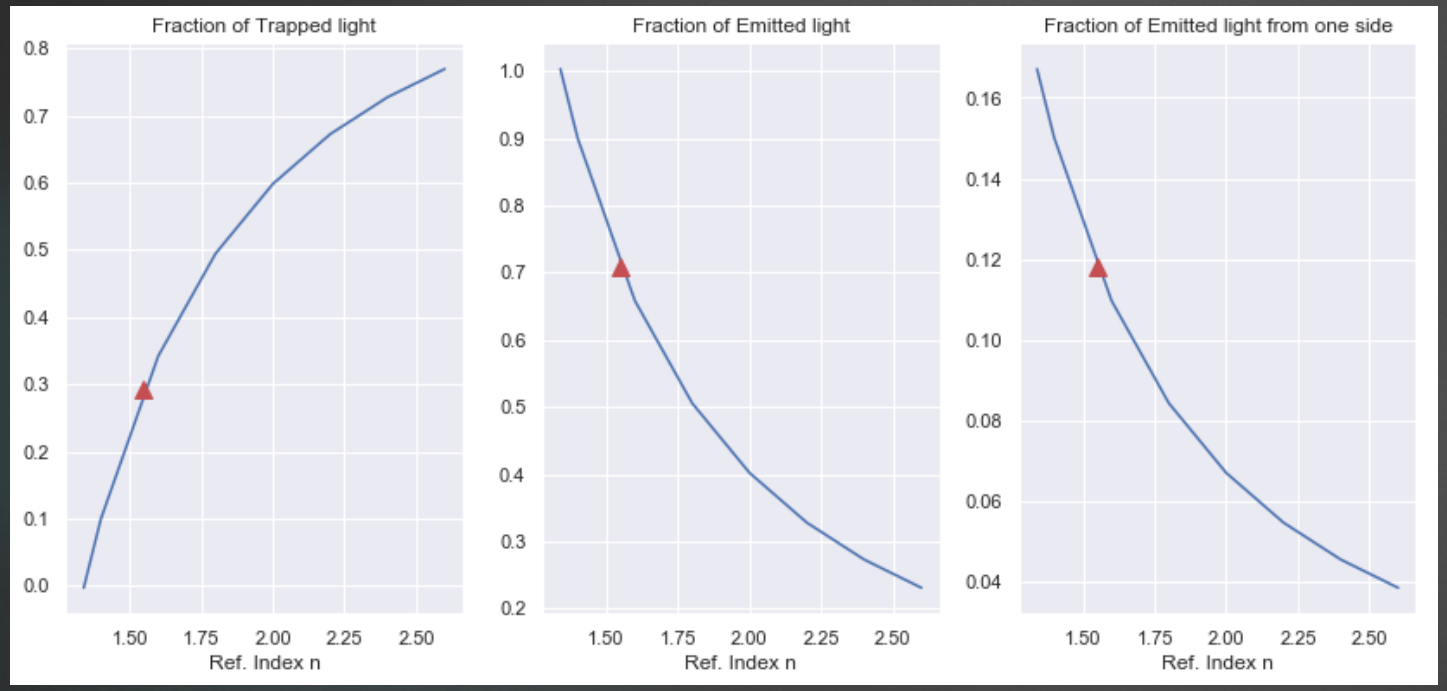
1/100 photon is drawn

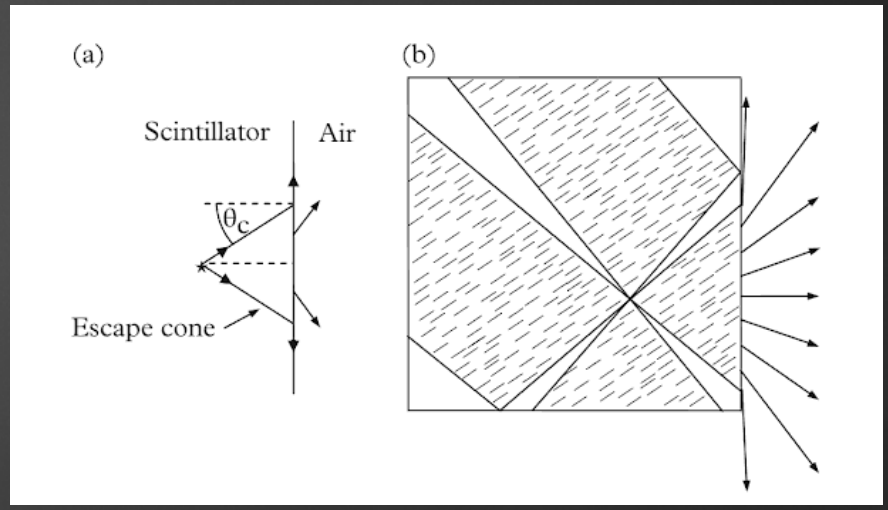




Some estimation before starting…

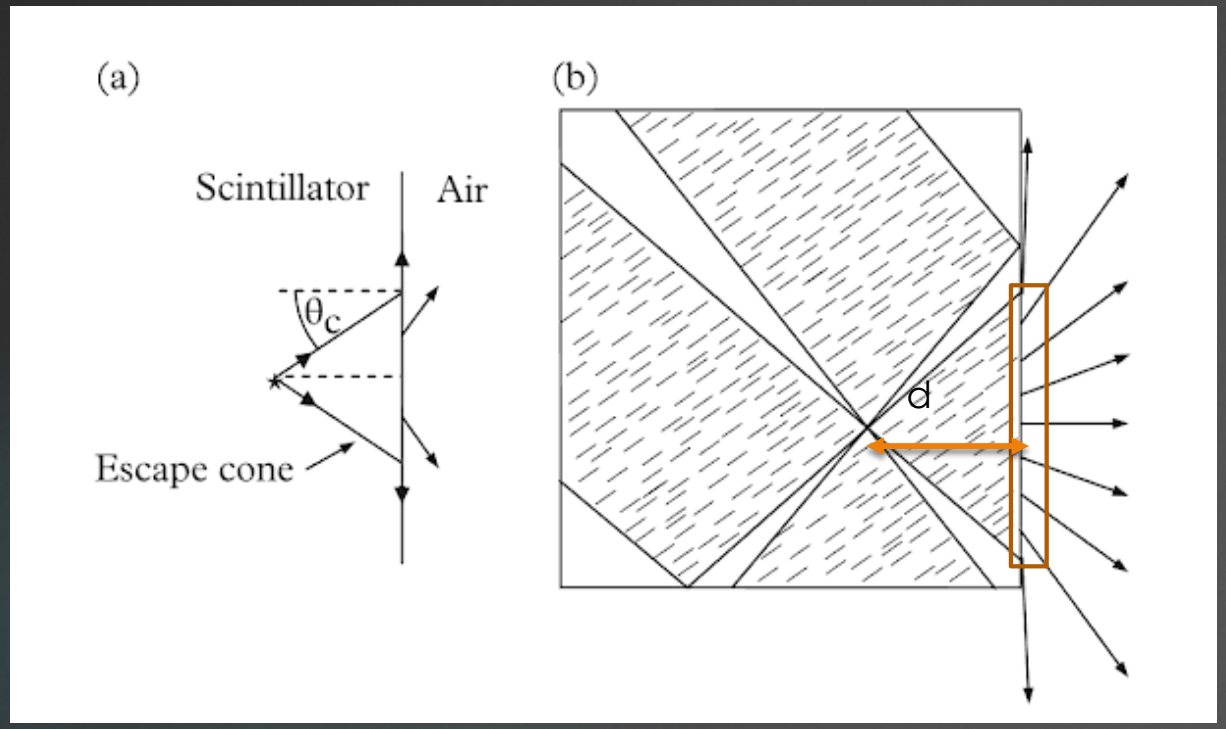
- No wrapping … only direct light is collected



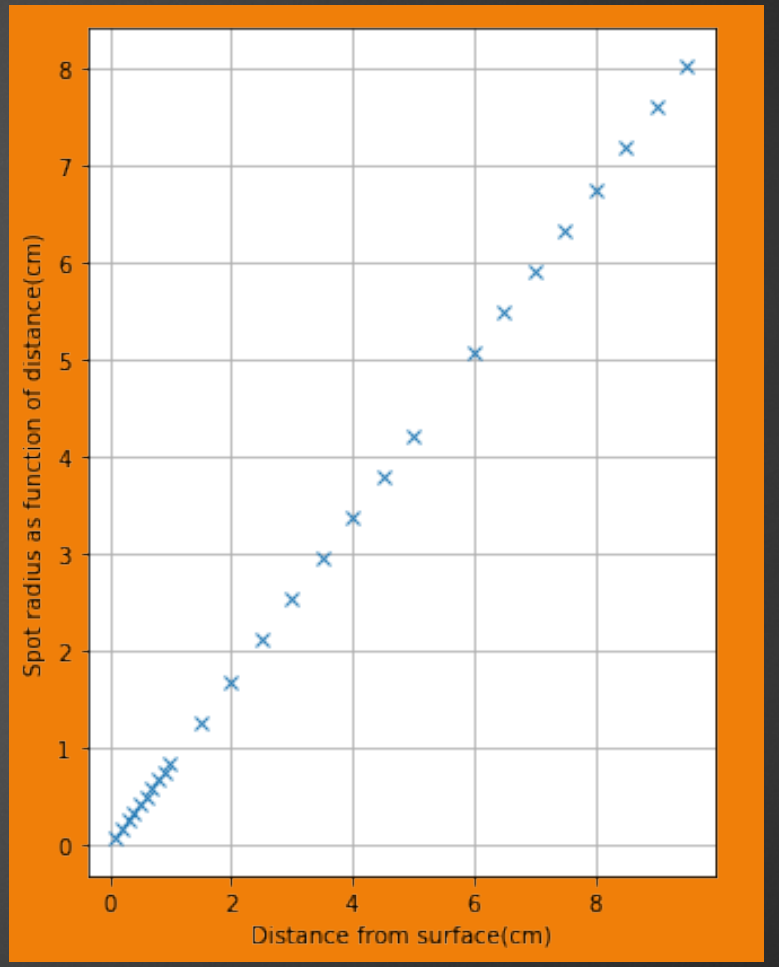


$n=1.55\ \vartheta_c=40°$

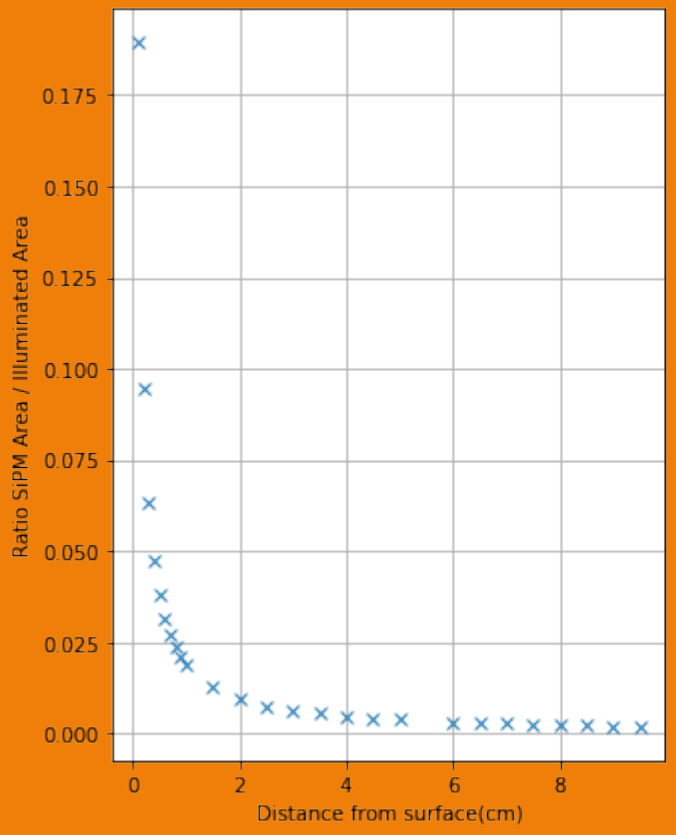
Some estimation - Direct photons

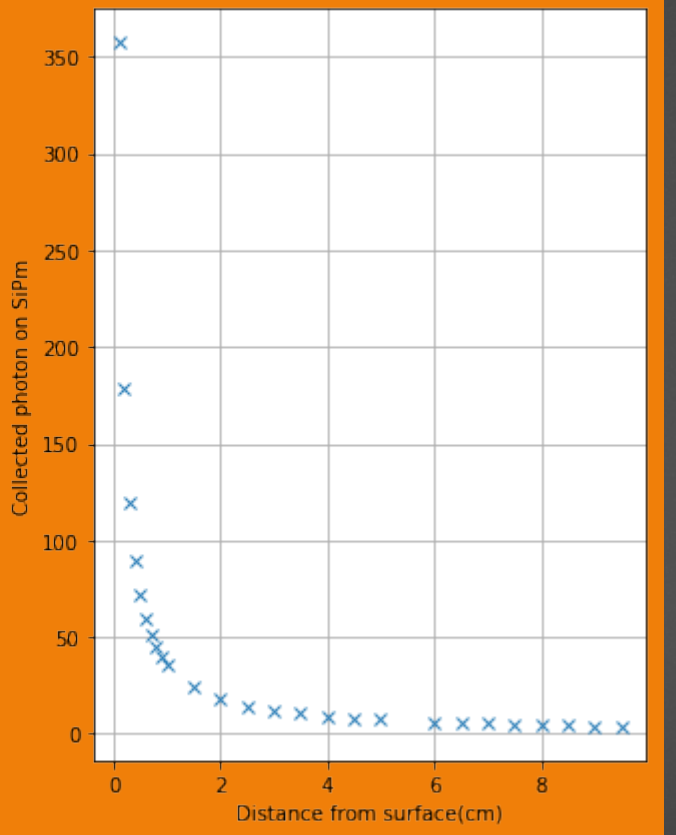


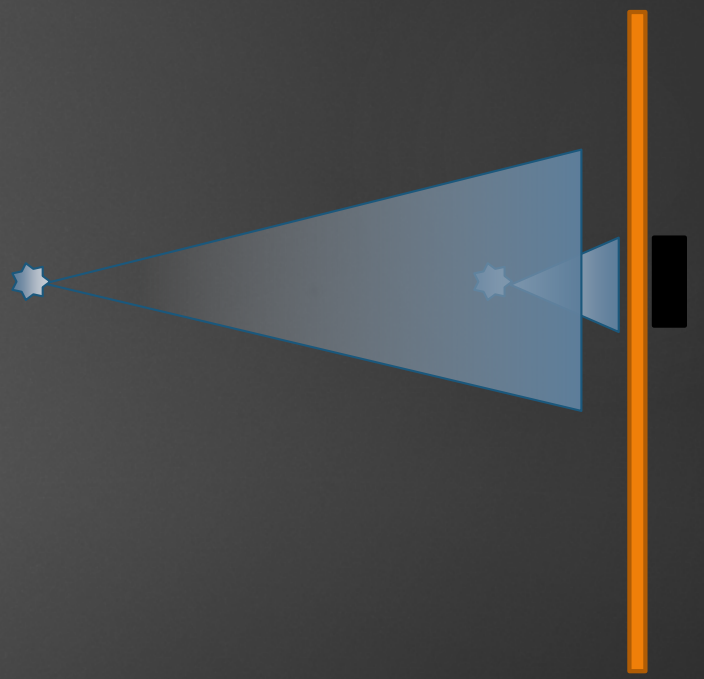

```
Critical Angle (rad) 0.7012343645830686
Critical Angle (deg) 40.177769540147885
```



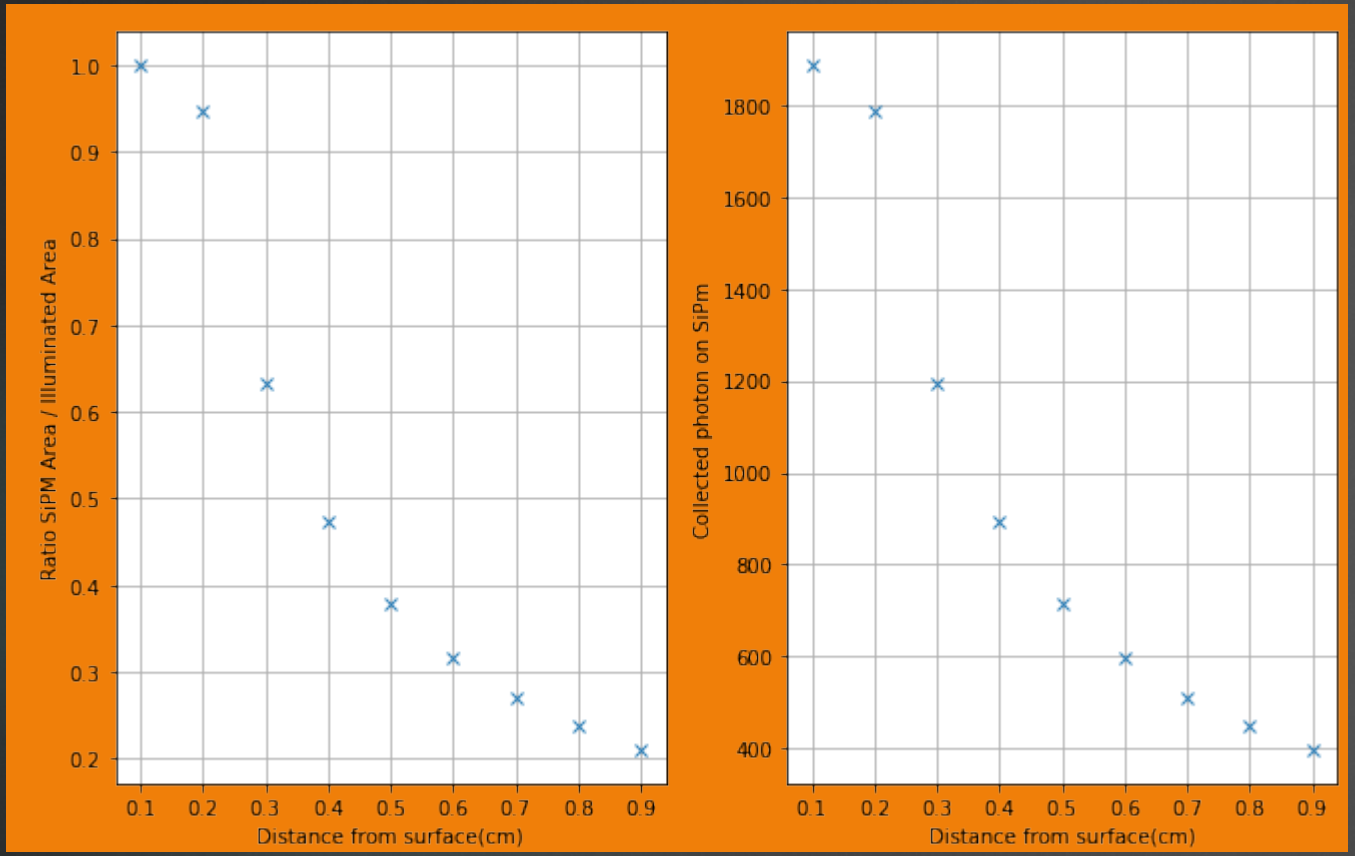
SIDE - Direct photons

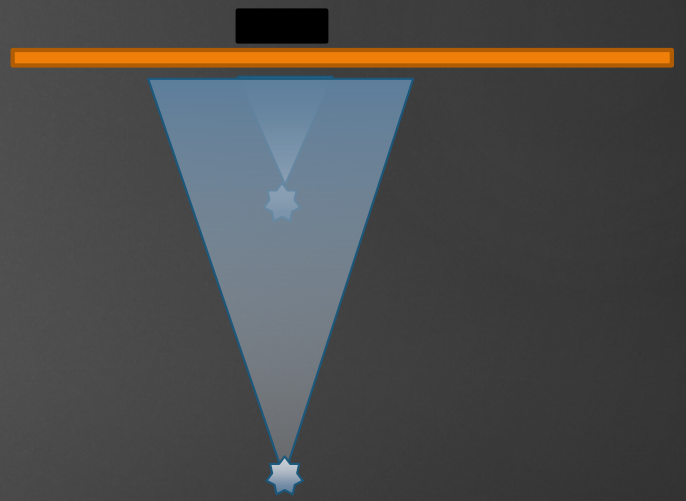






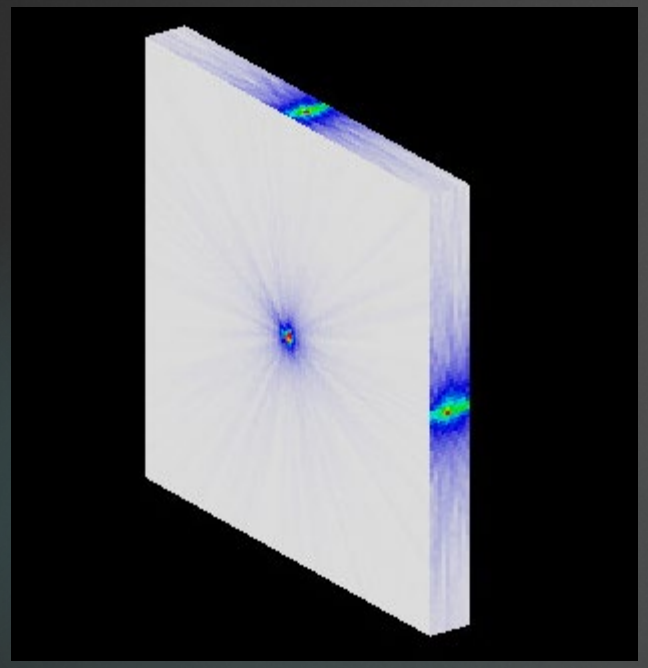
TOP - Direct photons



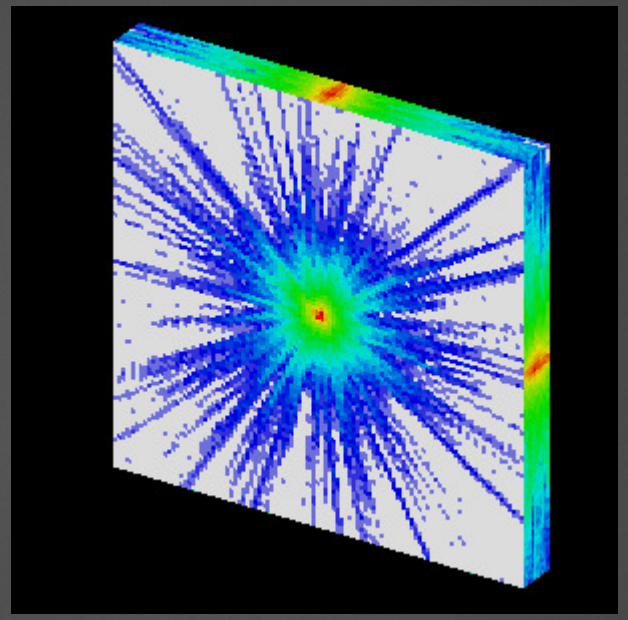


To detect the particle the scintillation event should occur just below the SiPM

Simulation
Vertical Muons @ 1 GeV



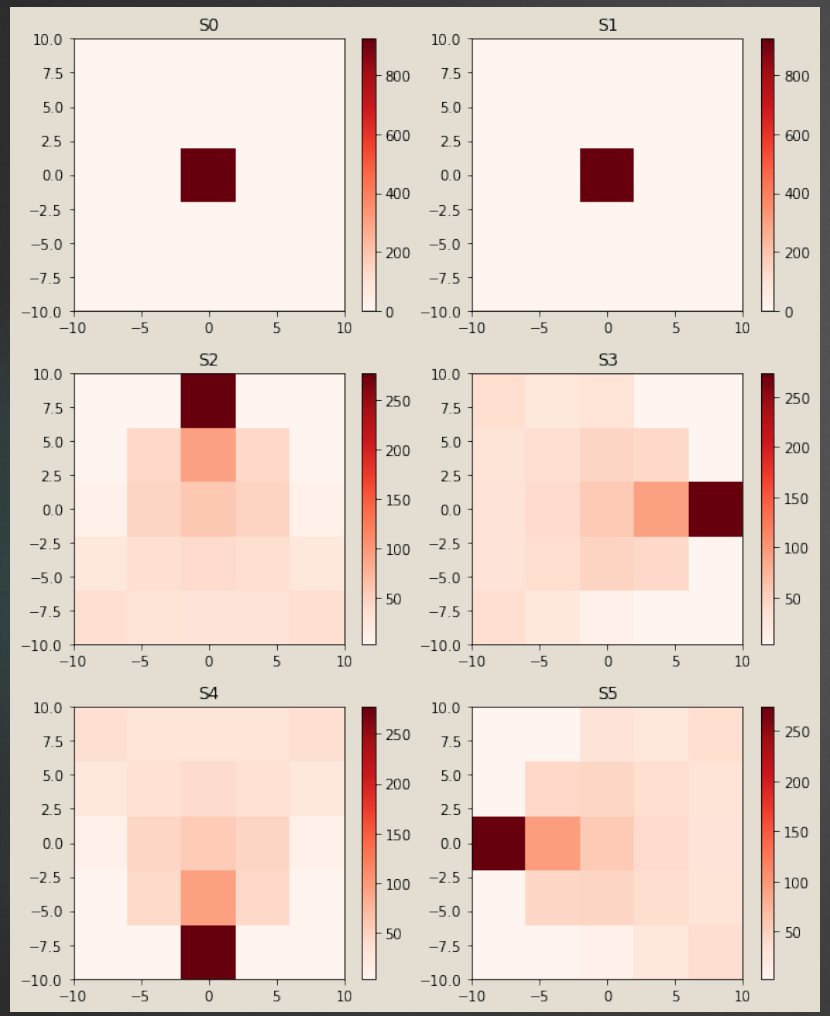
Linear scale



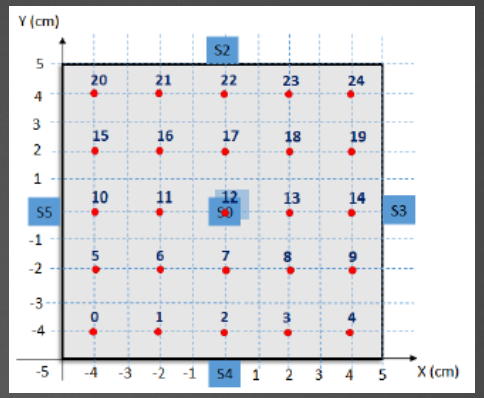
Log scale

Simulation Results – Direct photons

Total number of detected photons



Vertical muons 1GeV/c

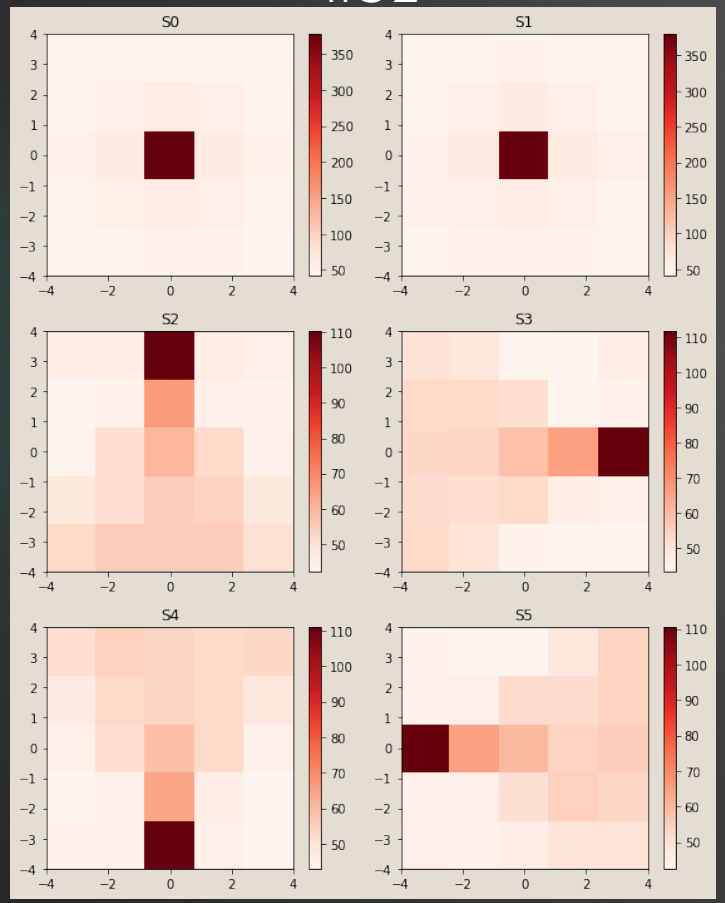


- The PDE is not taken into account
- As expected the SiPM on TOP side are sensitive only to the area just below the sensor
- Non-Uniformity on SIDEs

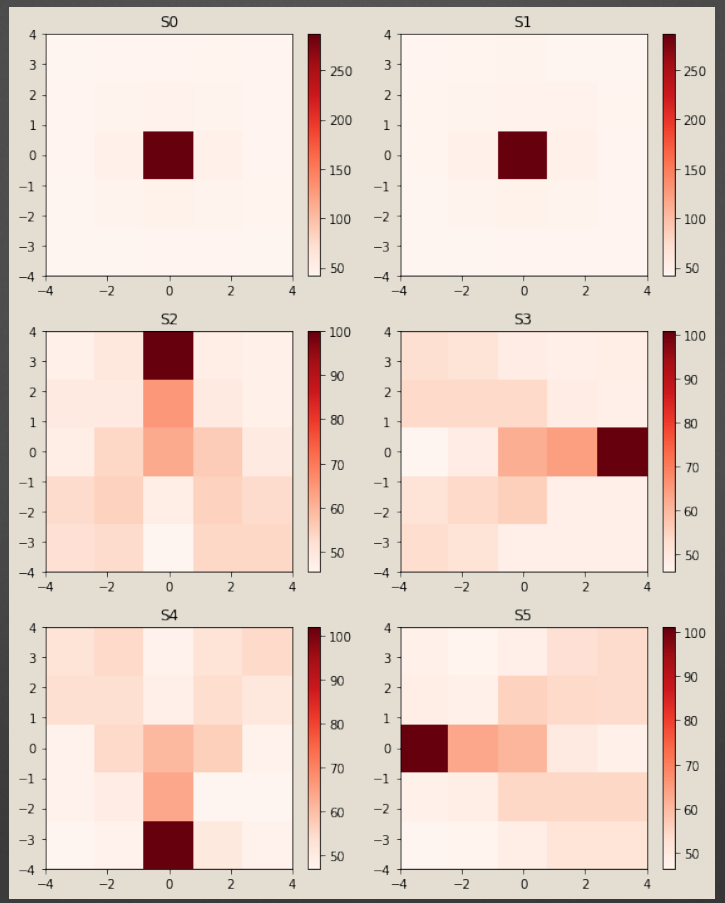
Specular vs Diffuse reflector

- To increase collection uniformity we have used reflectors based on LUT models
- A model for optical transport called the LUT Davis model [Roncali& Cherry(2013)]. The model is based on measured surface data and allows the user to choose from a list of available surface finishes.
- We have compared TiO2 (diffuse) and Mylar (specular)

TiO2

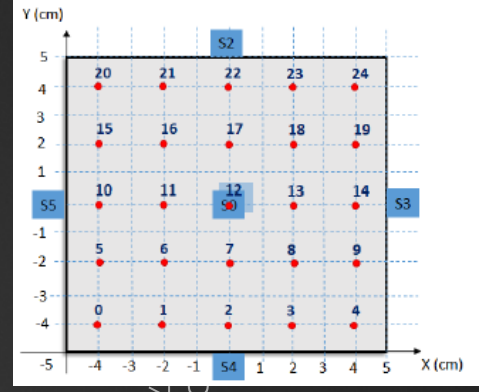


Mylar

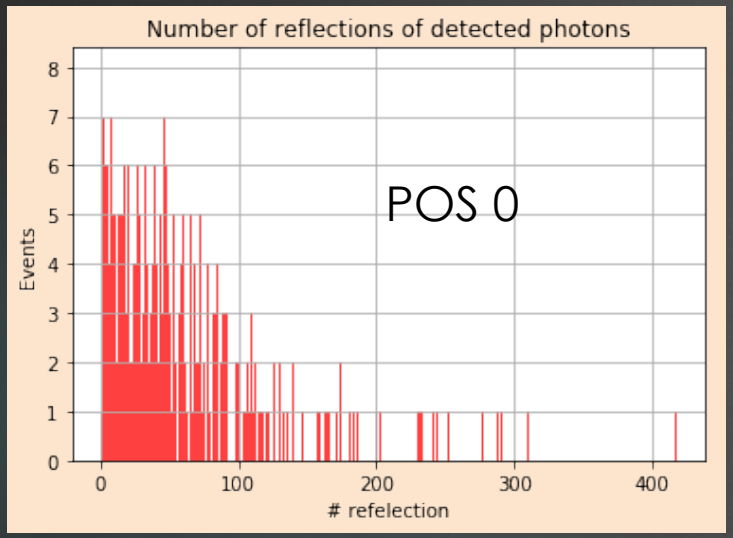


- PDE taken into account
- With specular reflector the collection uniformity is slightly worst

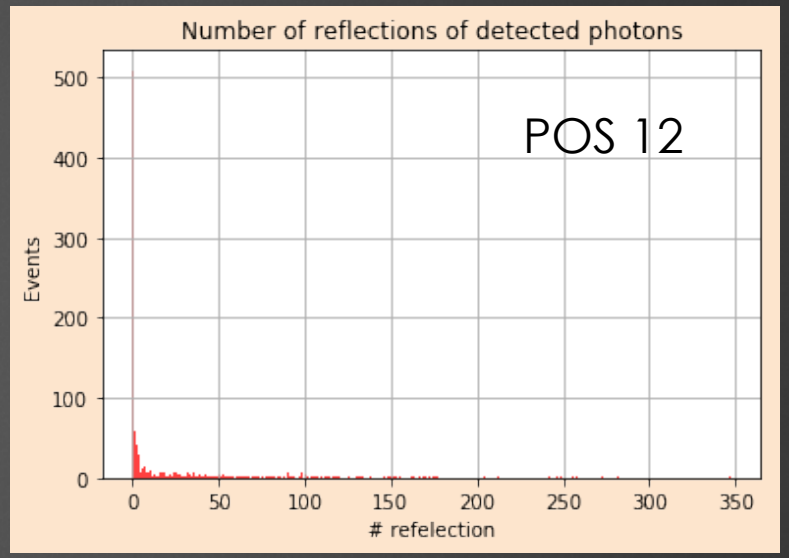
Studies on single photons path



- As reference we will use the TiO2 simulation
- Only 1 event in a corner and central position (pos0-pos12) taken into account

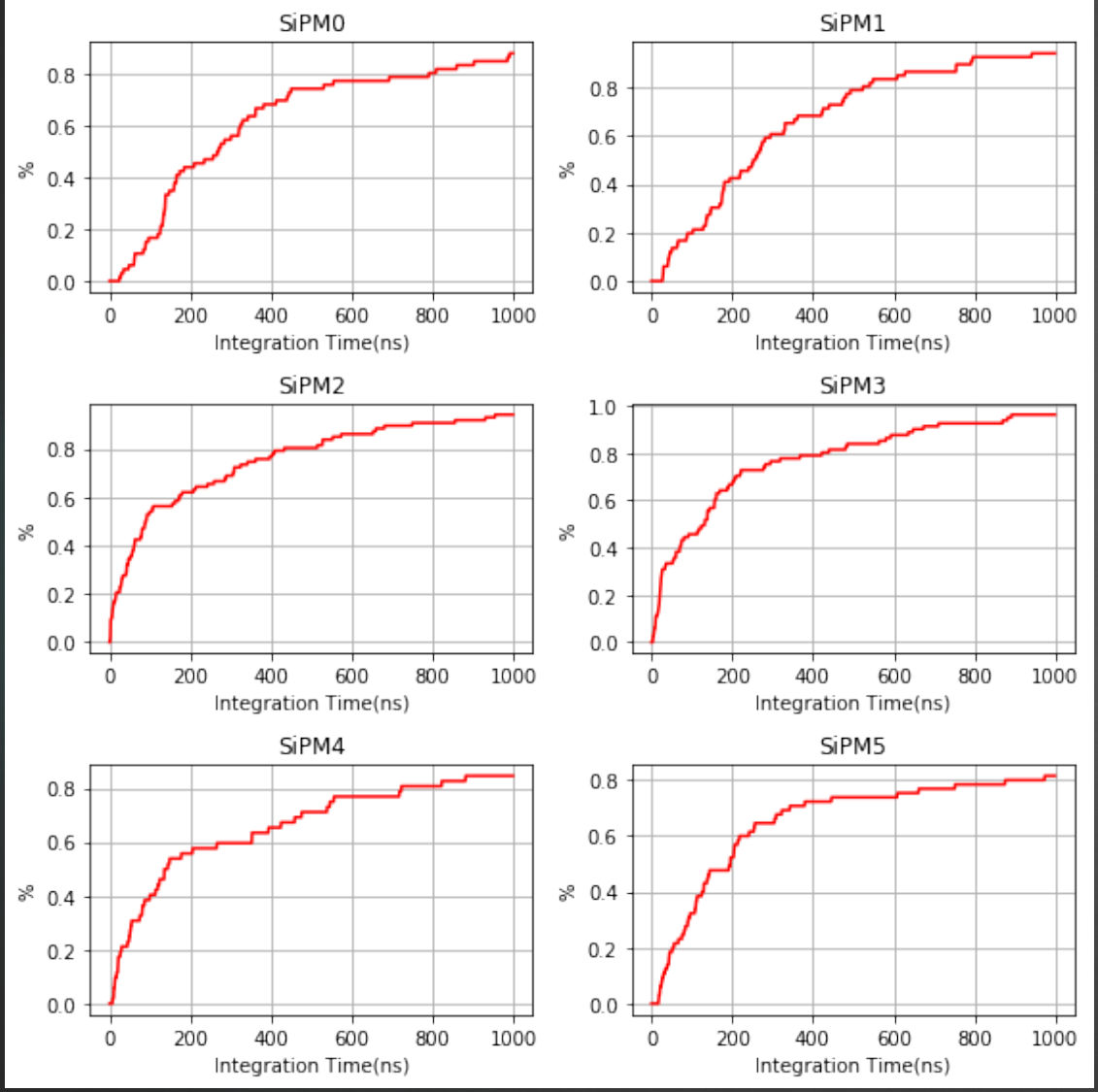



```
Number of direct photons   (NReflection=0) =   1
Number of indirect photons (NReflection>0) = 416
```



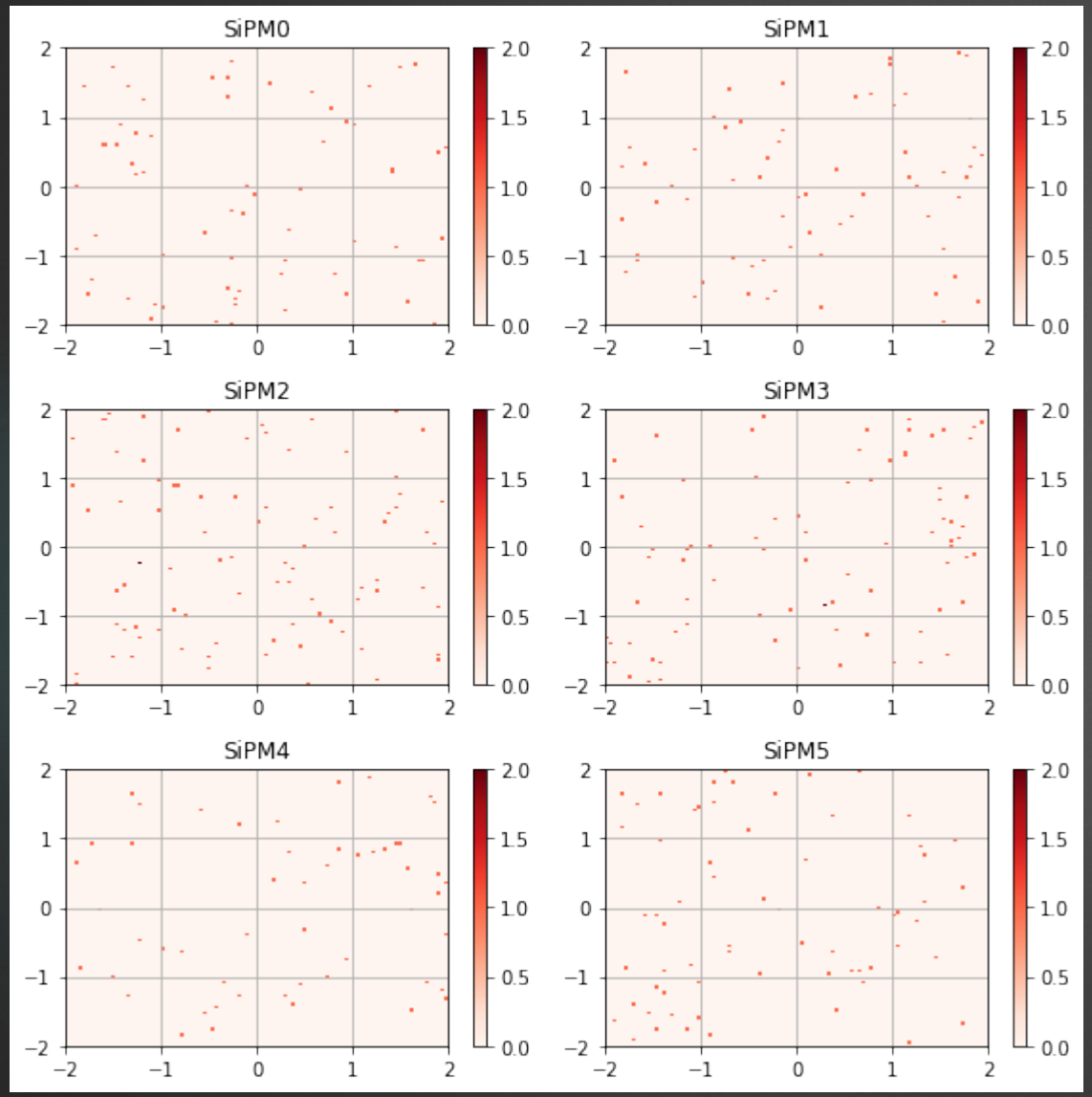

```
Number of direct photons   (NReflection=0) = 509
Number of indirect photons (NReflection>0) = 508
```

Timing –POS 0



- The time of detection of each single photons depends on the number of reflection and of its path
- This is very important to define the integration time of the read-out electronics and to understand the impact of the pile-up on the charge resolution

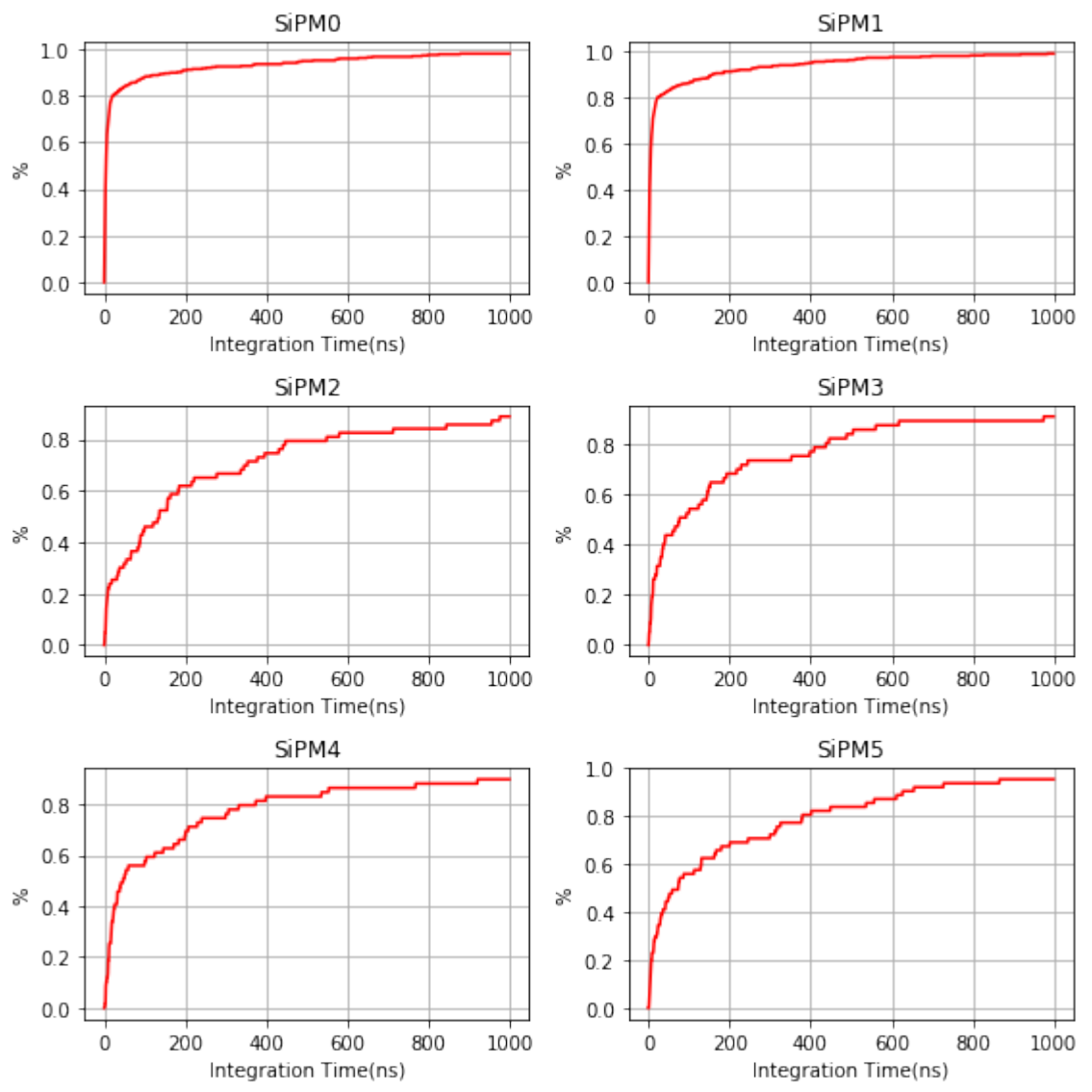
Position – POS0



- The detected photons are uniformly distributed on the SiPMs
- Each cell (40μm) hit by only one photon

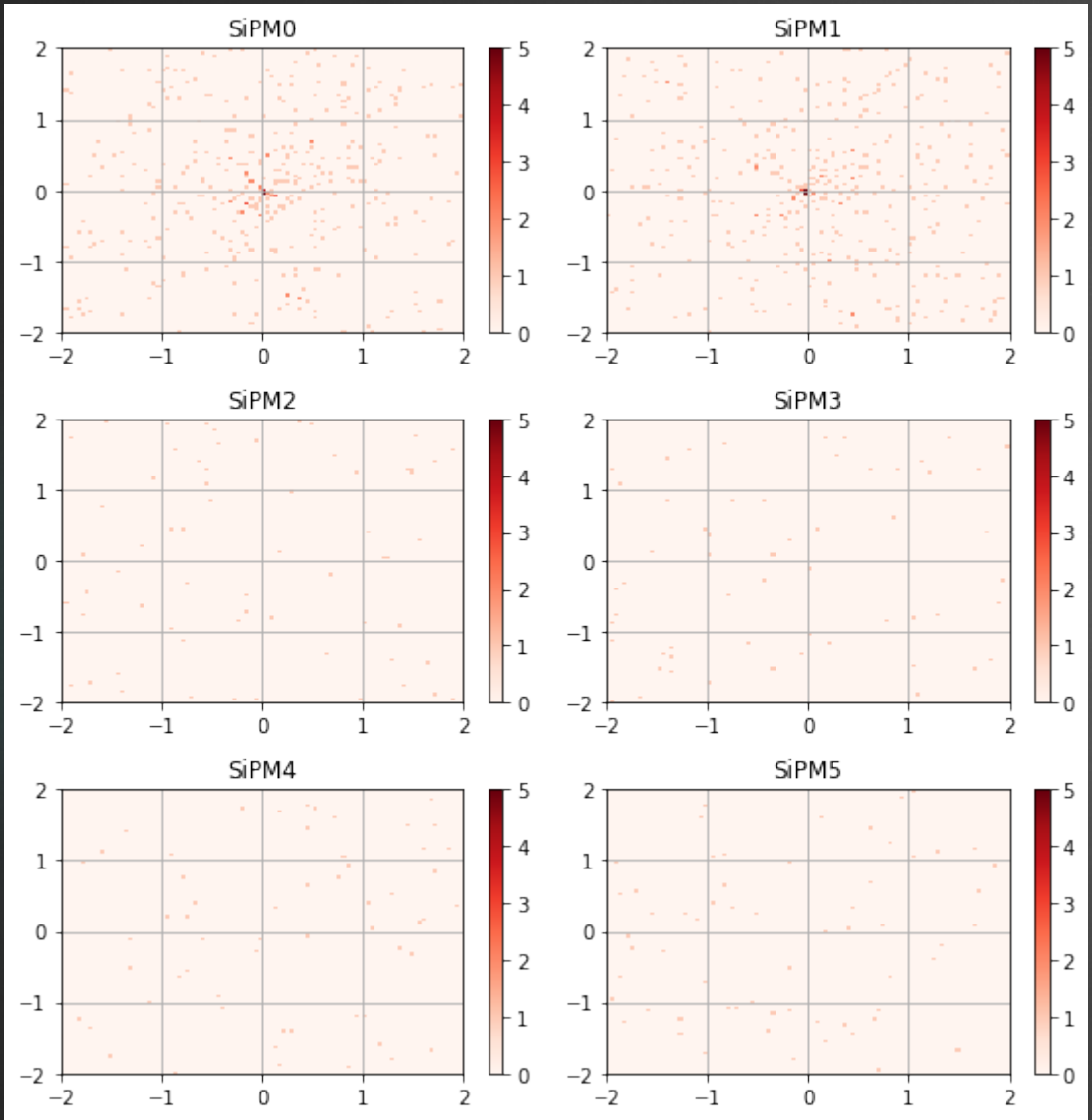
Number of direct photons (NReflection=0) 1
Number of indirect photons (NReflection>0) 283
Max number of photons in the same cell for sipm 0 1.0
Detected photons in sipm 0 46.0
Max number of photons in the same cell for sipm 1 1.0
Detected photons in sipm 1 39.0
Max number of photons in the same cell for sipm 2 1.0
Detected photons in sipm 2 58.0
Max number of photons in the same cell for sipm 3 1.0
Detected photons in sipm 3 61.0
Max number of photons in the same cell for sipm 4 1.0
Detected photons in sipm 4 34.0
Max number of photons in the same cell for sipm 5 1.0
Detected photons in sipm 5 46.0

Timing –POS 12



- The time of detection of each single photons depends on the number of reflection and of its path.
- Direct photons are faster

Position – POS12



- The photons are clustered on TOP SiPM (direct light)

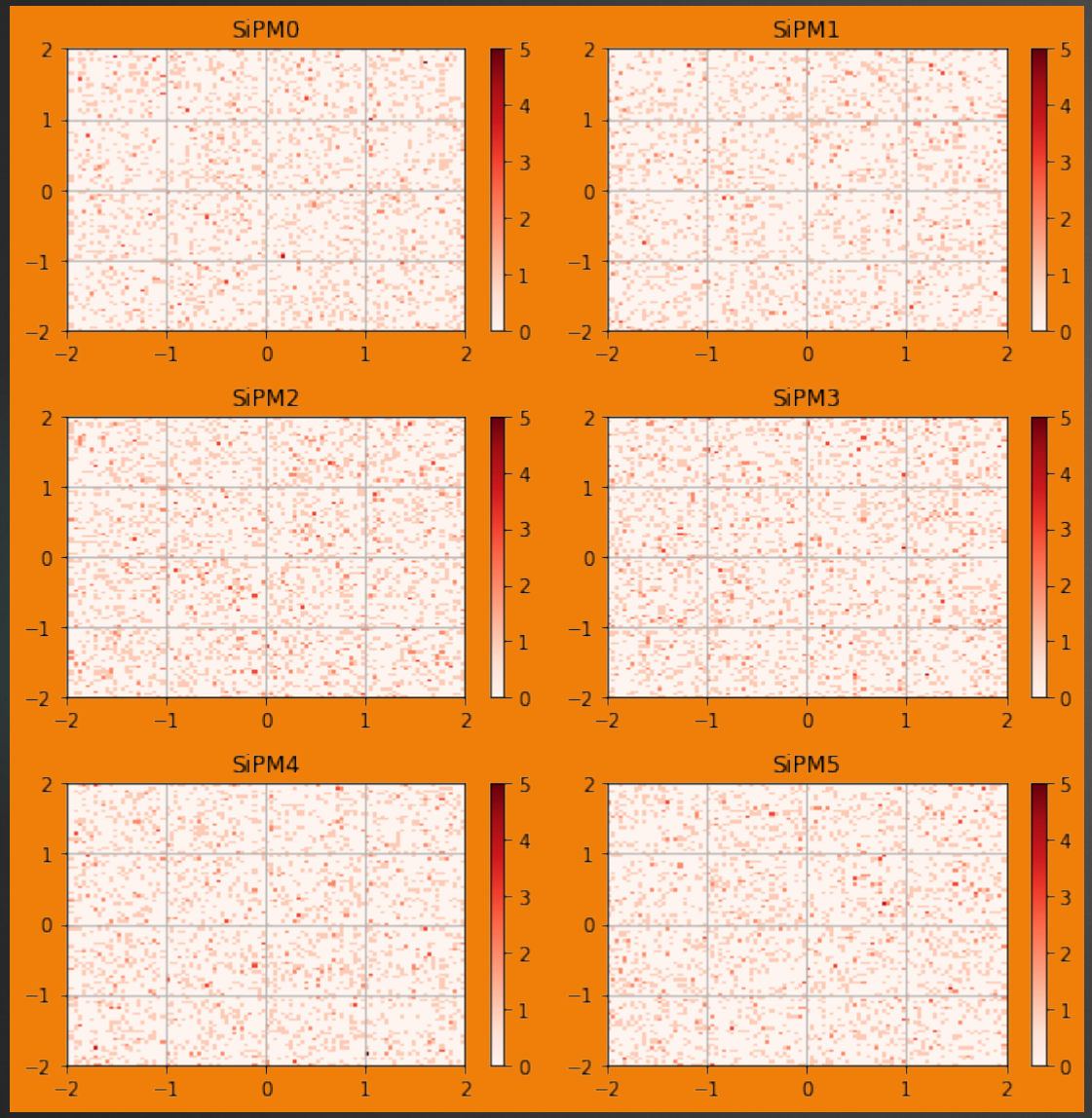
```
Number of direct photons (NReflection=0) 509
Number of indirect photons (NReflection>0) 508
Max number of photons in the same cell for sipm 0 7.0
Detected photons in sipm 0 379.0
Max number of photons in the same cell for sipm 1 12.0
Detected photons in sipm 1 398.0
Max number of photons in the same cell for sipm 2 1.0
Detected photons in sipm 2 63.0
Max number of photons in the same cell for sipm 3 1.0
Detected photons in sipm 3 57.0
Max number of photons in the same cell for sipm 4 1.0
Detected photons in sipm 4 59.0
Max number of photons in the same cell for sipm 5 1.0
Detected photons in sipm 5 61.0
```

Very preliminary test with ions

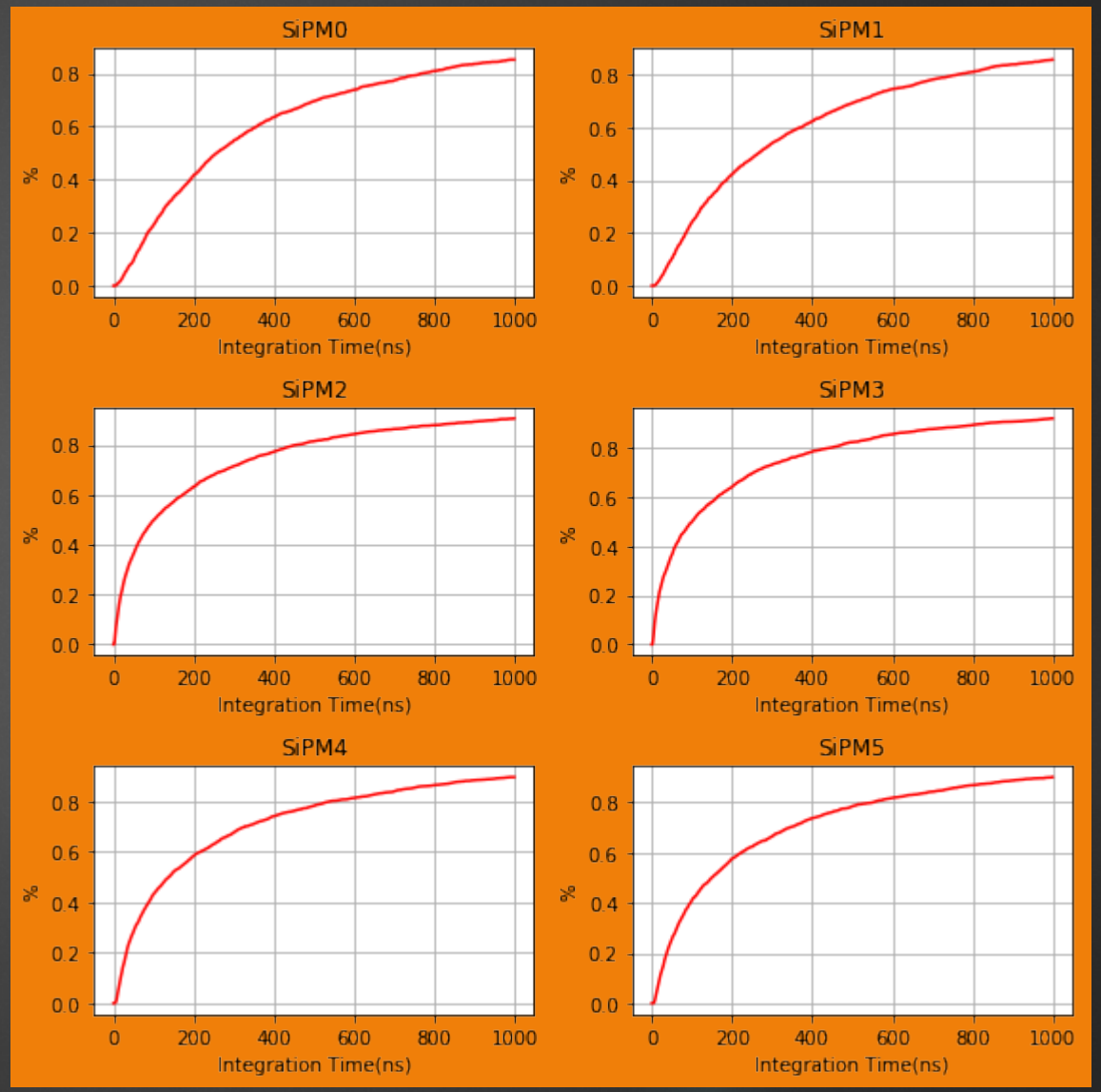
- We have done some test with ions but we need to verify and improve the results
- In the next slides I will show result form 14N

N14

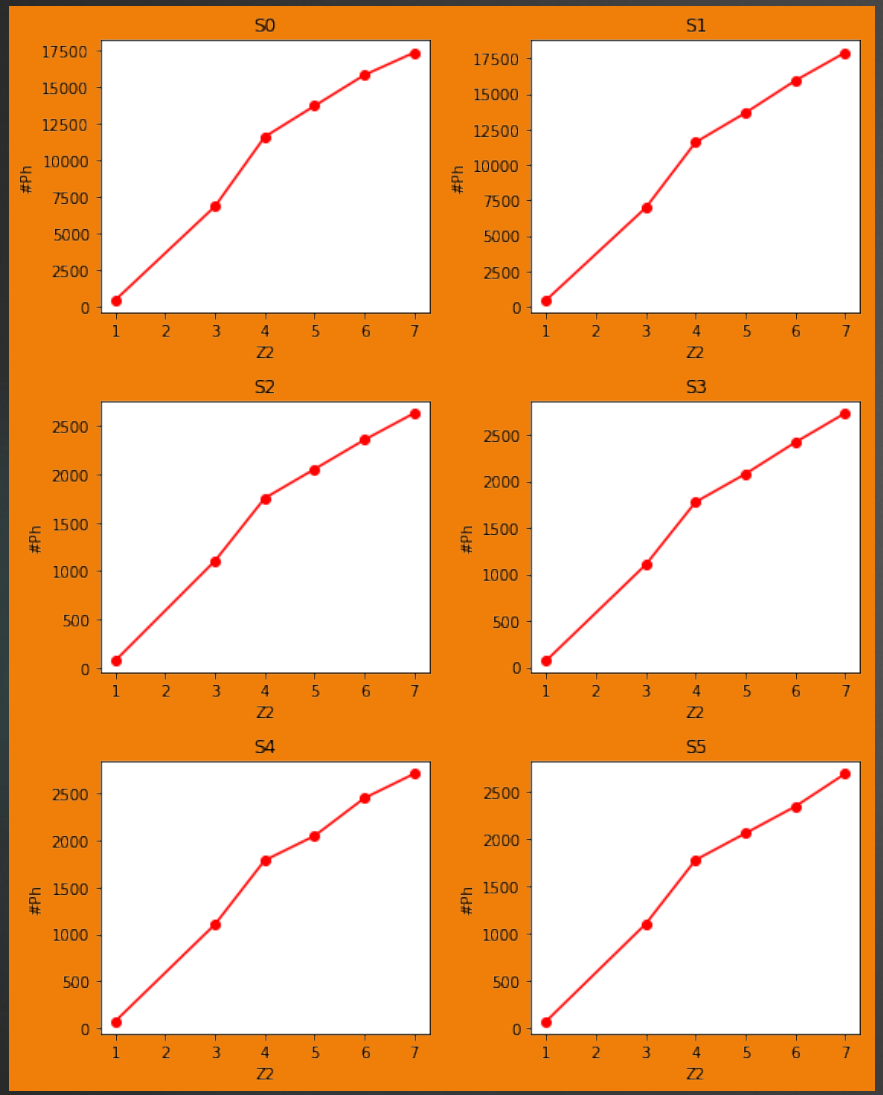
Max number of photons in a single cell:4



Particle crossing in a corner



Photons vs Z



- Birks parameters seems to be wrong (no Z2 relation)
- Results shown only for central position

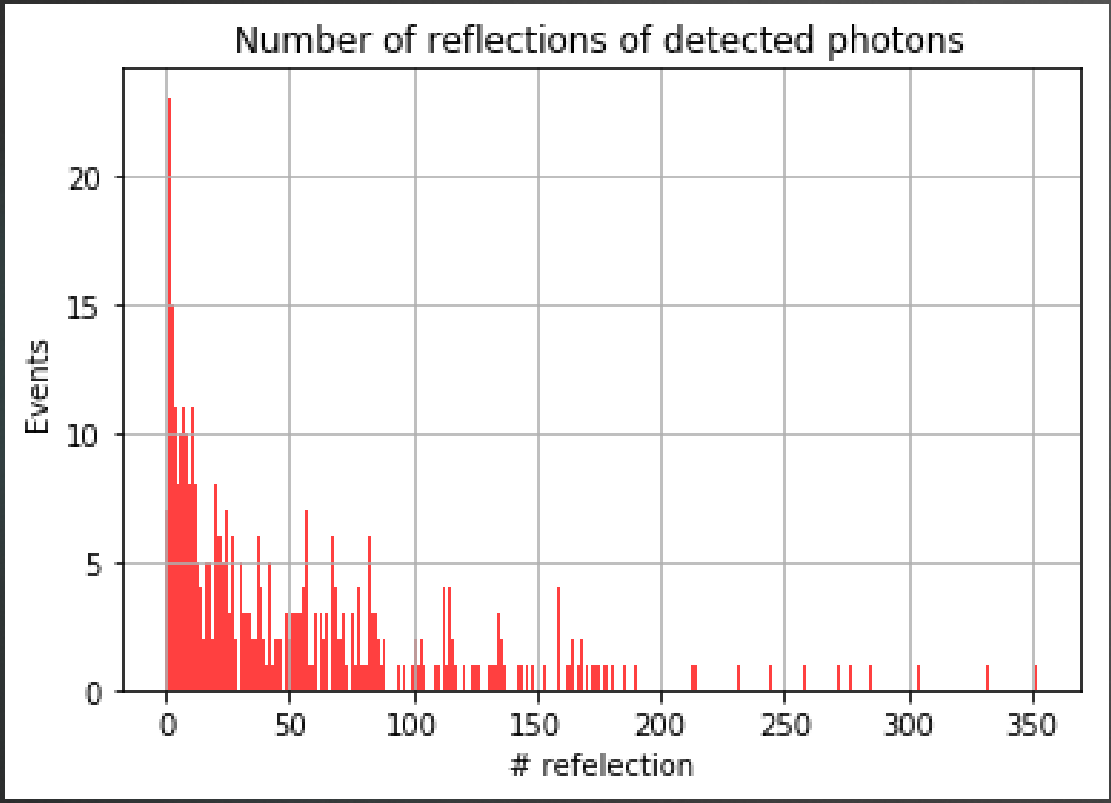
Conclusion

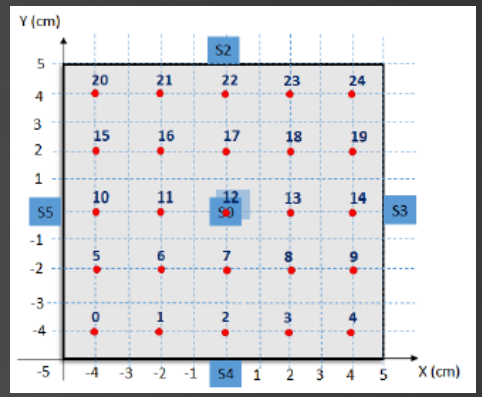
- We need to check
  - Birks parameter
  - parametrization of the wrapping
  - parametrization of the surface quality
- We plan to implement different geometries for the tiles (and bars)
- We plan to add the option for a WLS readout of the tile

Backup

Studies on single photons path

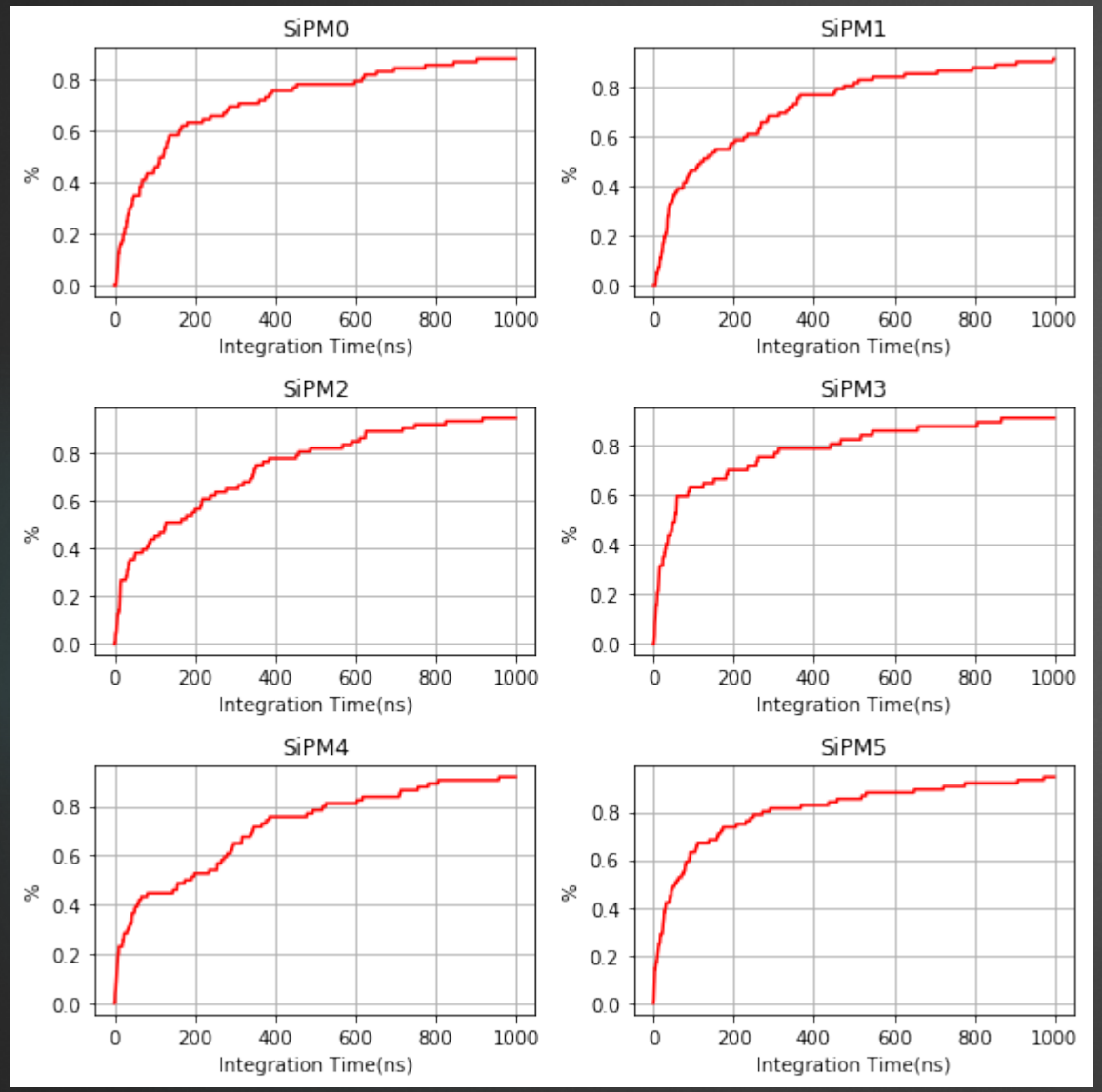
- As reference we will use the TiO2 simulation
- Only 1 event in a corner (pos11) taken into account





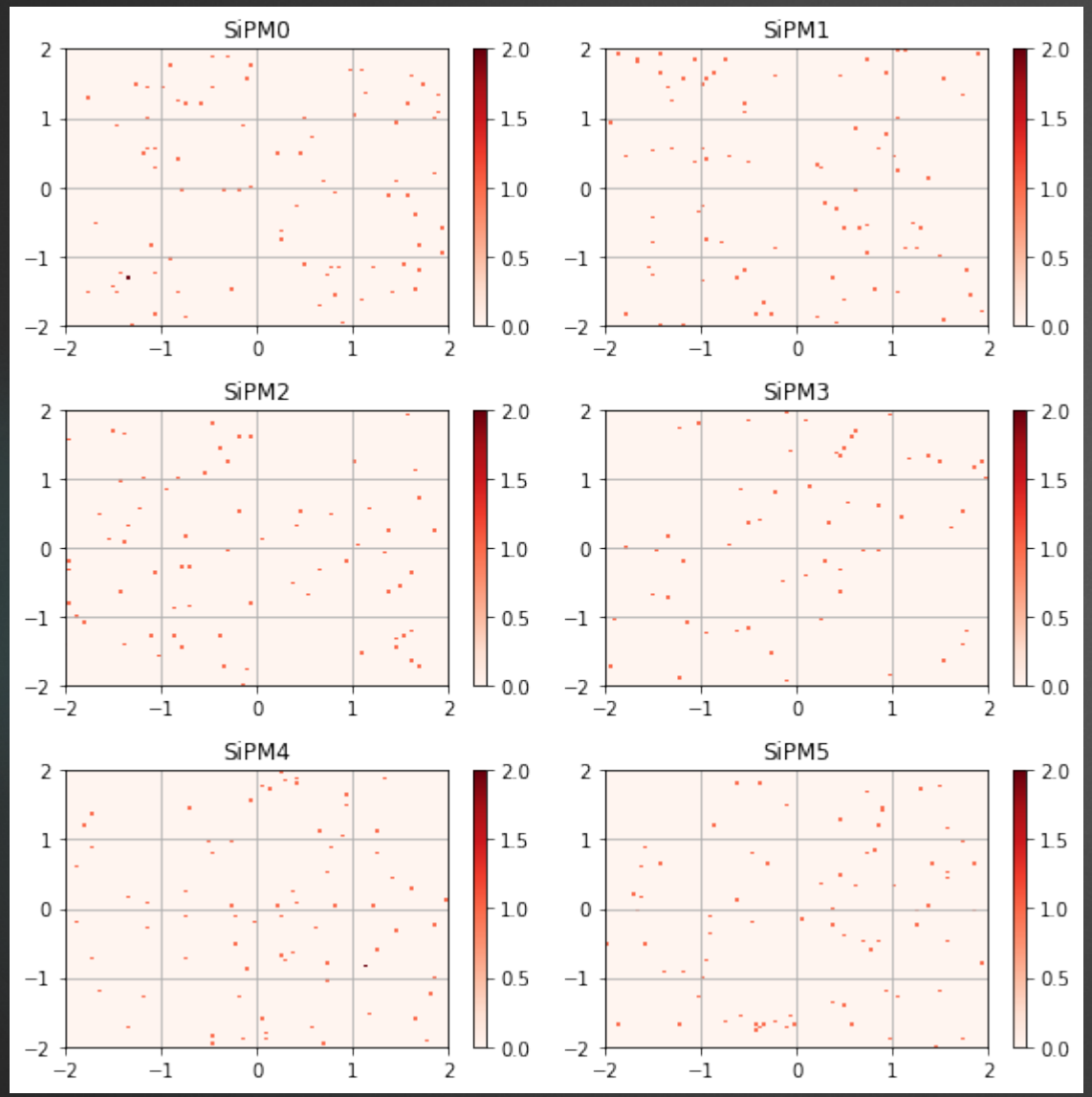

```
Number of direct photons    (NReflection=0) = 7
Number of indirect photons  (NReflection>0) = 434
```

Timing



- The time of detection of each single photons depends on the number of reflection and of its path
- This is very important to define the integration time of the read-out electronics and to understand the impact of the pile-up on the charge resolution

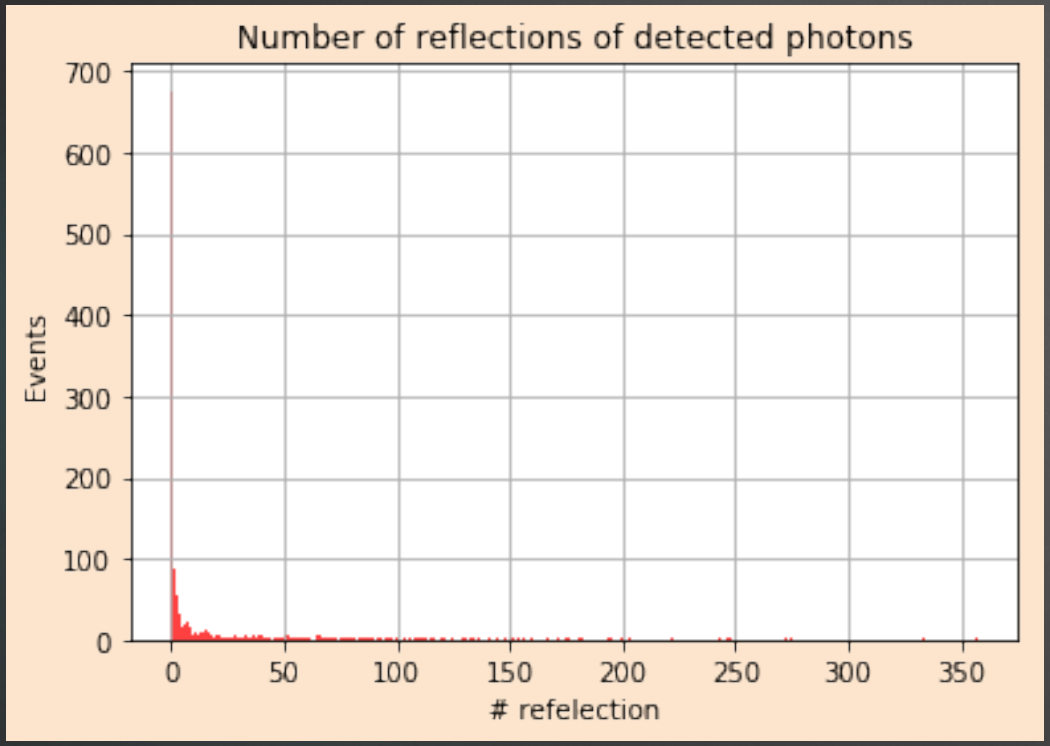
Position

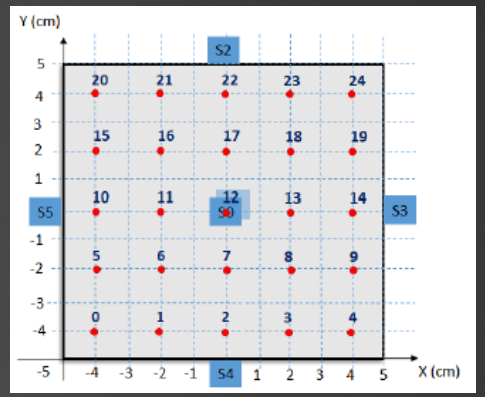


- The detected photons are uniformly distributed on the SiPMs
- Some of cells (40μm) of the TOP/BOTTOM SiPM are hit by more than 1 photons

Studies on single photons path

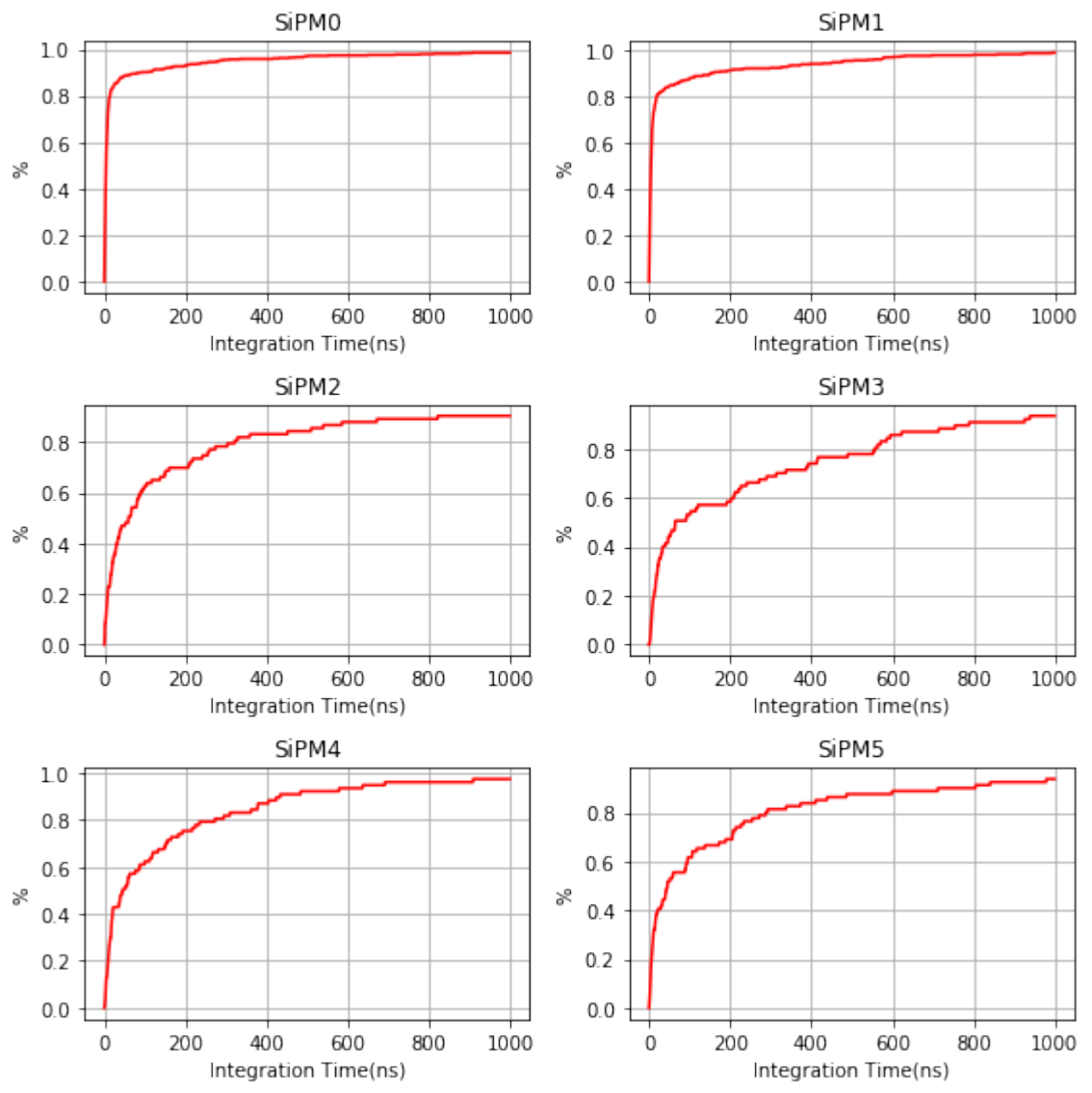
- As reference we will use the TiO2 simulation
- Only 1 event in a corner (pos12) taken into account






```
Number of direct photons    (NReflection=0) = 676
Number of indirect photons  (NReflection>0) = 626
```

Timing



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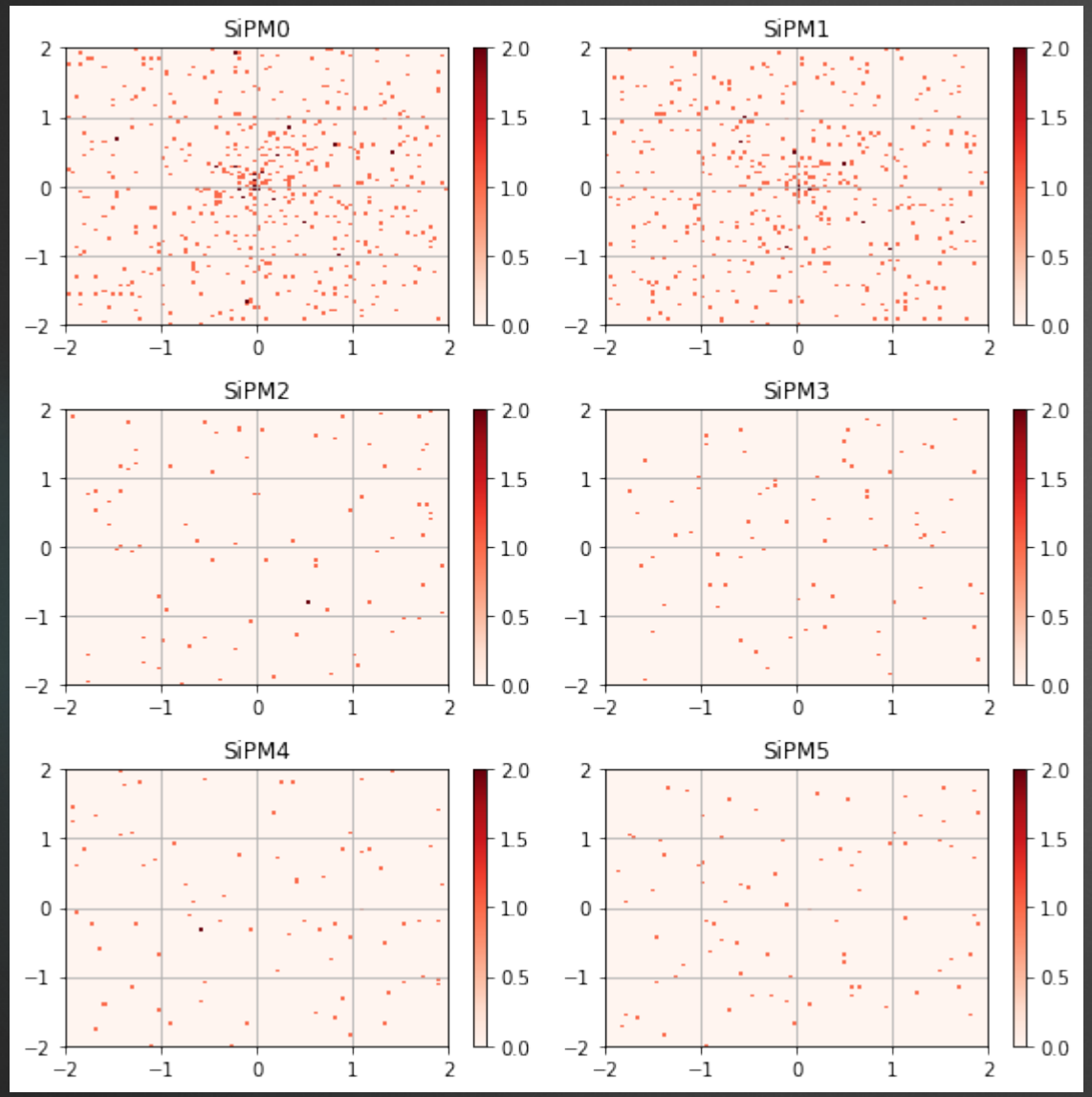
Position



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- Some of cells (40μm) of the TOP/BOTTOM SiPM are hit by more than 1 photons