PSD ACTIVTY @ Bari

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OUTLOOK

- Preliminary Test with CITIROC
- Alpha version of the tile simulation tool

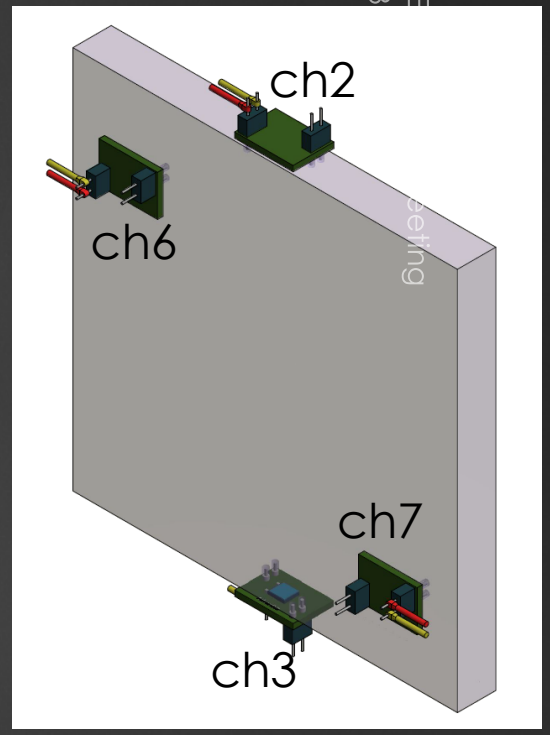
CITIROC – CAEN A1702

- We are still waiting for the CAEN evaluation board with 4 CITIROC
- In the mean time we are using the CAEN A1702 with 1CITIROC (32ch), and a non re-programmable FPGA

- Provides bias voltage in the range of 20-90 V individually adjustable for each of 32 SiPMs
- Amplification and shaping of the SiPMs output pulse on each of 32 channels
- Discrimination of shaped signal at configurable level from 0 to 50 SiPMs photo-electrons
- Providing basic coincidence of signals from each pair of adjacent even-odd channels
- Allows to trigger only on events that happen in coincidence with event in a group of other A1702 (event validation)
- Formation of the trigger for digitization of the signal amplitude
- Formation of the time stamp with respect to an input reference signal with 1 ns accuracy
- Digitization of signal amplitude of all 32 channels

Test setup

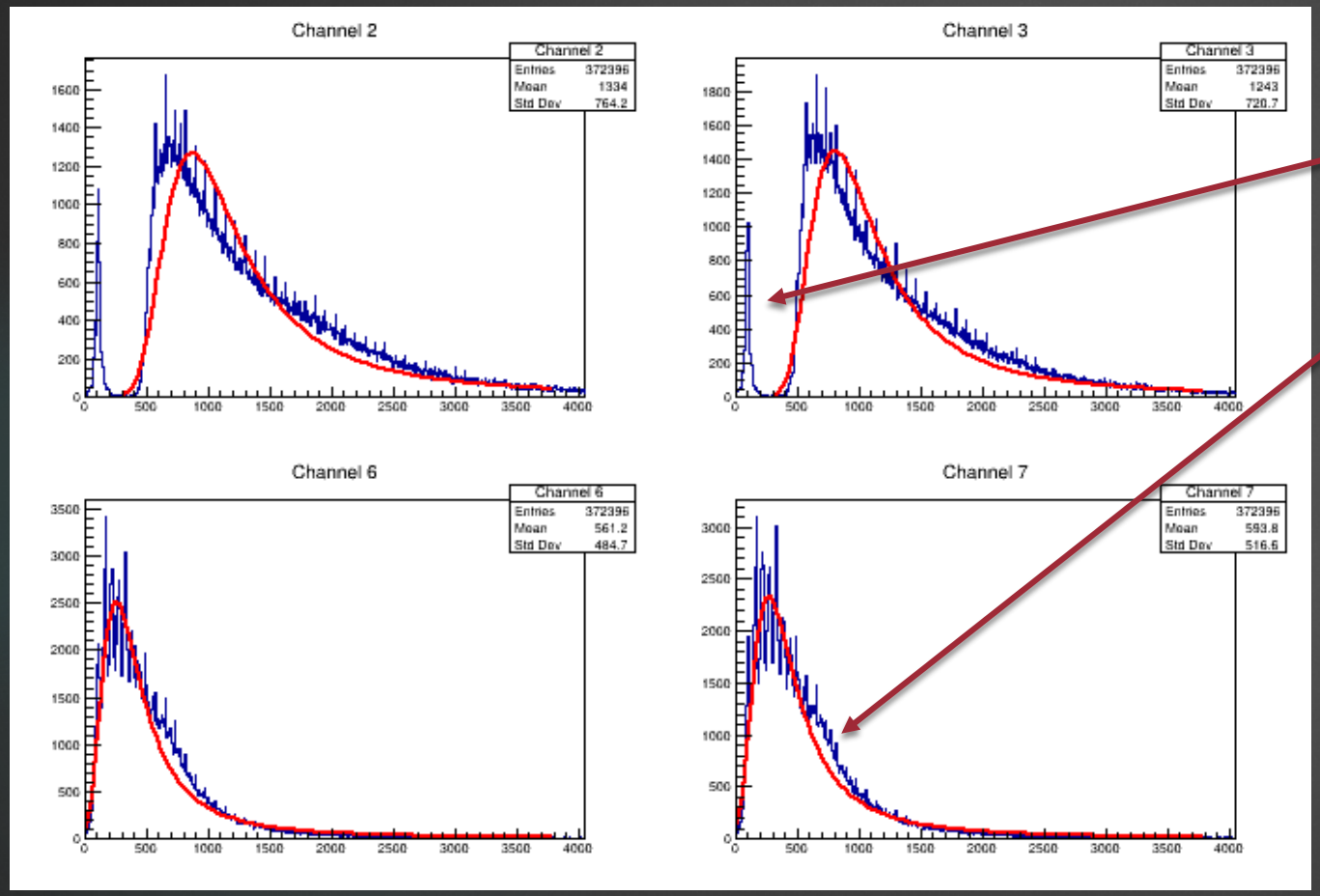
- Scintillator tile 10 cm x 10 cm
- Tile equipped with 4 FBK NUV 4x4mm^2 SiPMs:
  - 2 SiPMs on the sides and 2 SiPMs on the top
- All 4 SiPMs connected to CaenA1702:
  - SiPMs on side : channels 2-3
  - SiPMs on top : channels 6-7
- Gain setup:
  - ch2, ch3 : DAC=40 (gain 26)
  - ch6, ch7 : DAC=51 (gain 46) because we expect fewer photons (1/10)
  - From measurements on ch1 we know that:
    - pedestal is around 100 ADC channel
    - Gain for DAC=40 is 47 ADC/p.e.
    - Gain for DAC=50 is 79 ADC/p.e.



Cosmic-rays test

- All 4 SiPMs connected
- Trigger: ch2 && ch3 (SIDE)
- Threshold : 280 DAC
- Ch2 and Ch3 dark noise rate @ 280DAC = 300Hz
- Noise coincidence rate= R_1 * R_2 * coincidence_window = 300 Hz * 300 Hz * 30 ns = 3mHz well below the expected cosmic-ray rate (1Hz)
- Ch6 and Ch7 are not in the trigger so they are not affected by the threshold effect

Individual channel distributions

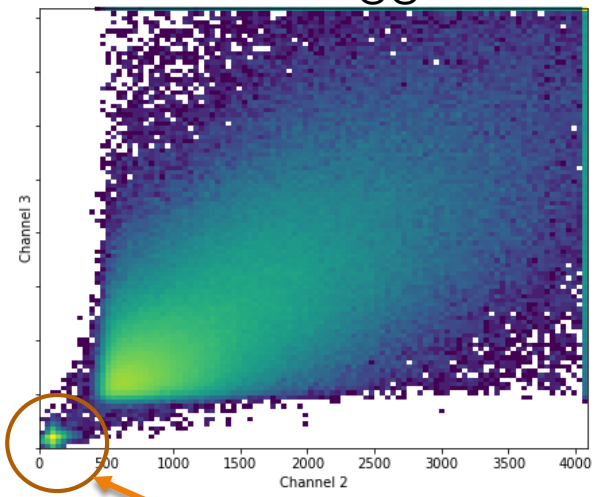


- Ch2 and Ch3 do not show a Landau distribution, probably due to some effect of the threshold
- They show strange events below threshold

- Ch6 and ch7 are well fitted by a Landau distribution, but some positive residuals are found between 500 and 1000 ADC counts ('bump')

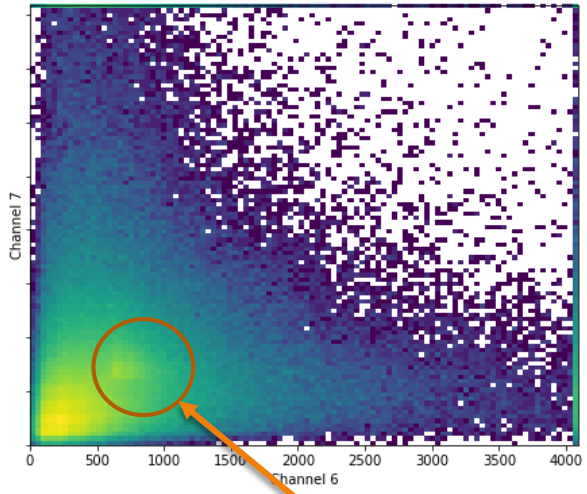
- Gain:
  - ch2 & ch3: peak @700 ADC, ped @100 ADC → peak is @ 13 p.e.
  - ch6 & ch7: assuming first peak is pedestal (should be since it is around 100 ADC), the peak is around 2-3 p.e
  - This is roughly in agreement with expectation

SiPMs in trigger

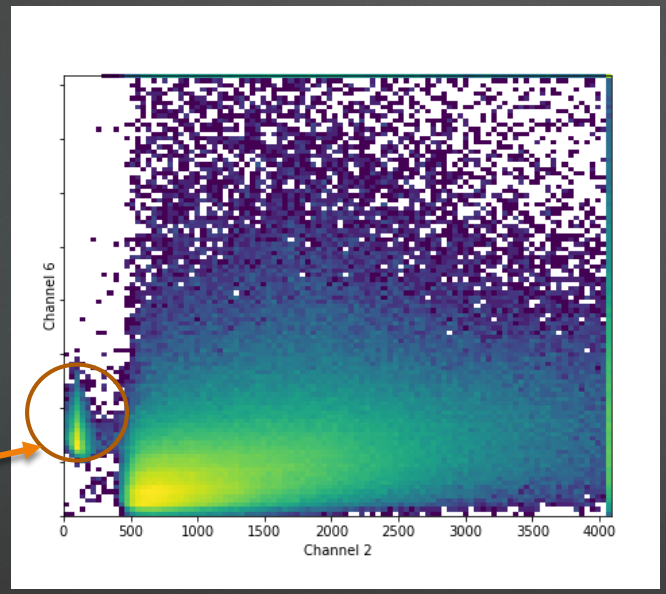


… some problem in DAQ?

SiPMs not in trigger



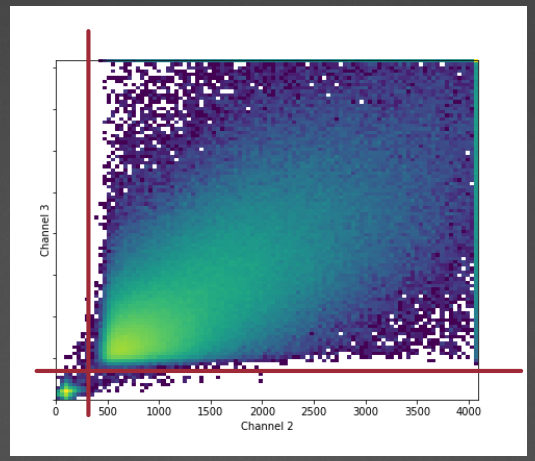
Bump in previous plots

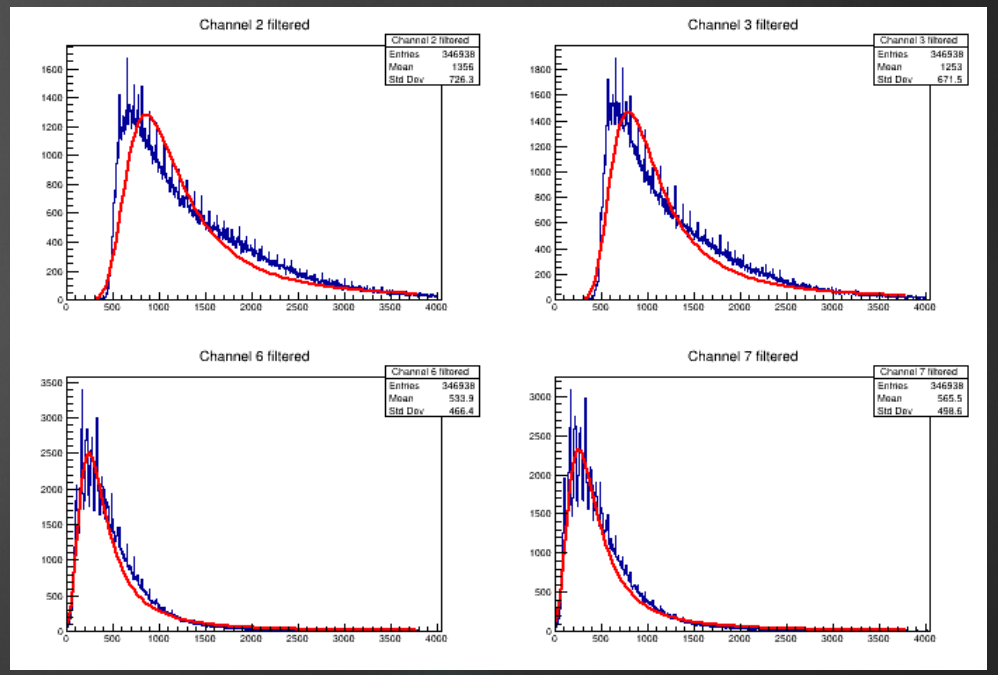


These events are correlated

Individual channel distributions - filtered

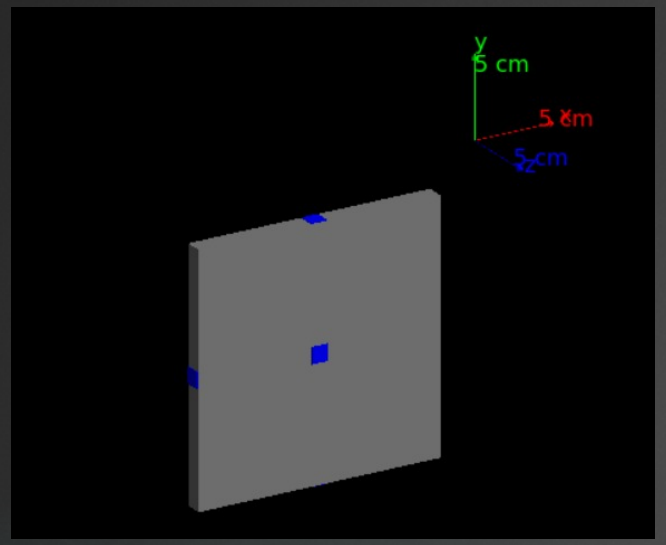
- Filtered events to get rid of the strange events: ch2 >=300 & ch3>=300
- Cutted events: 7%
- The ‘bump’ in ch6 and ch7 is reduced but does not disappear
- We are investigating on the origin of this kind of events

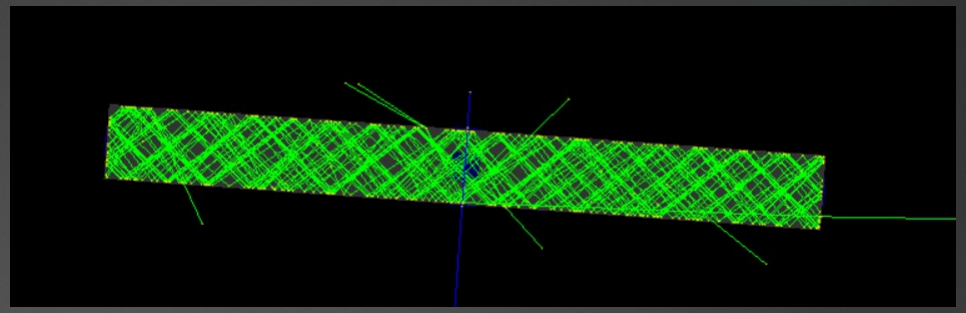




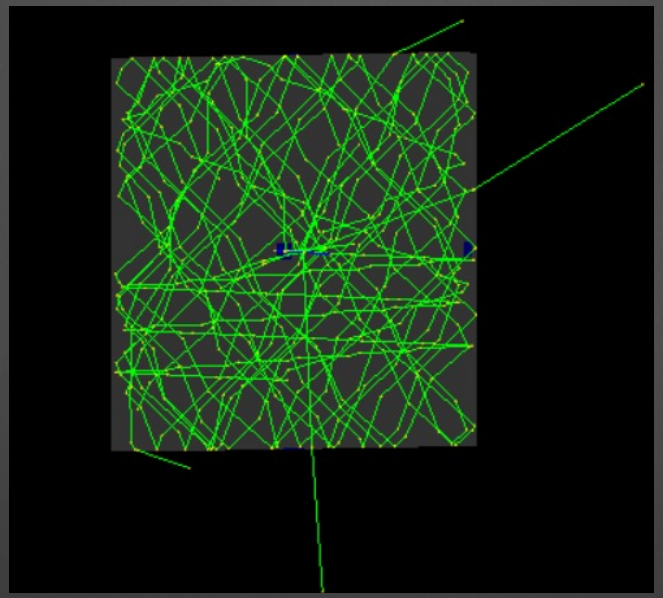
GEANT4 simulation of optical photons

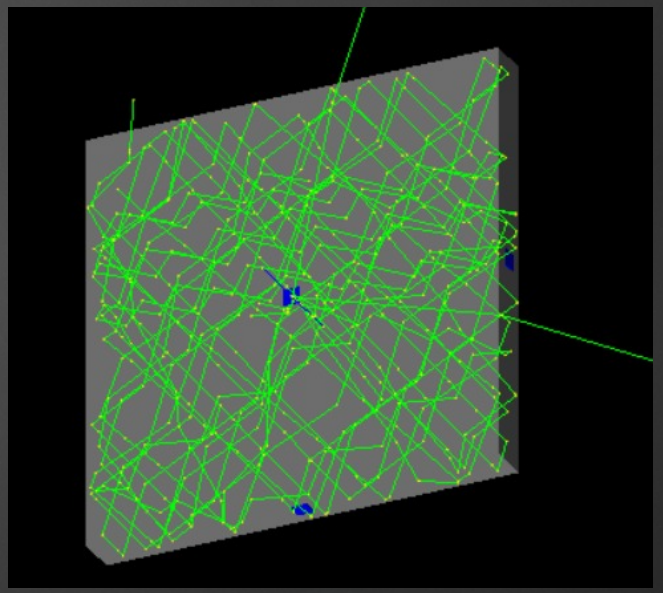
- We are working on a simulation of the tile that tracks every single optical photon
- We have simulated a tile 10x10x1 cm^3
- The tile is equipped with 6 SiPM 4x4 mm^2 placed on the four sides and on the top and bottom face
- In this simulation we can change a lot of parameters such as
  - Tile size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





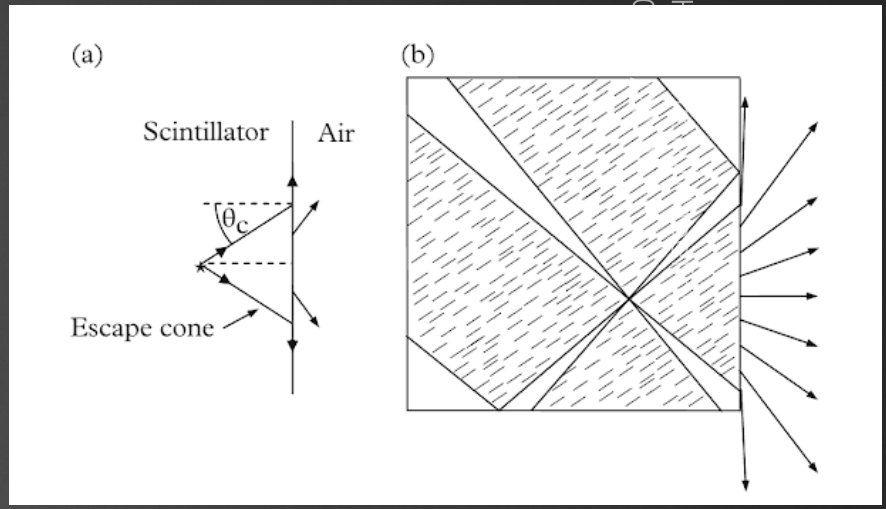
1/100 photon is drawn

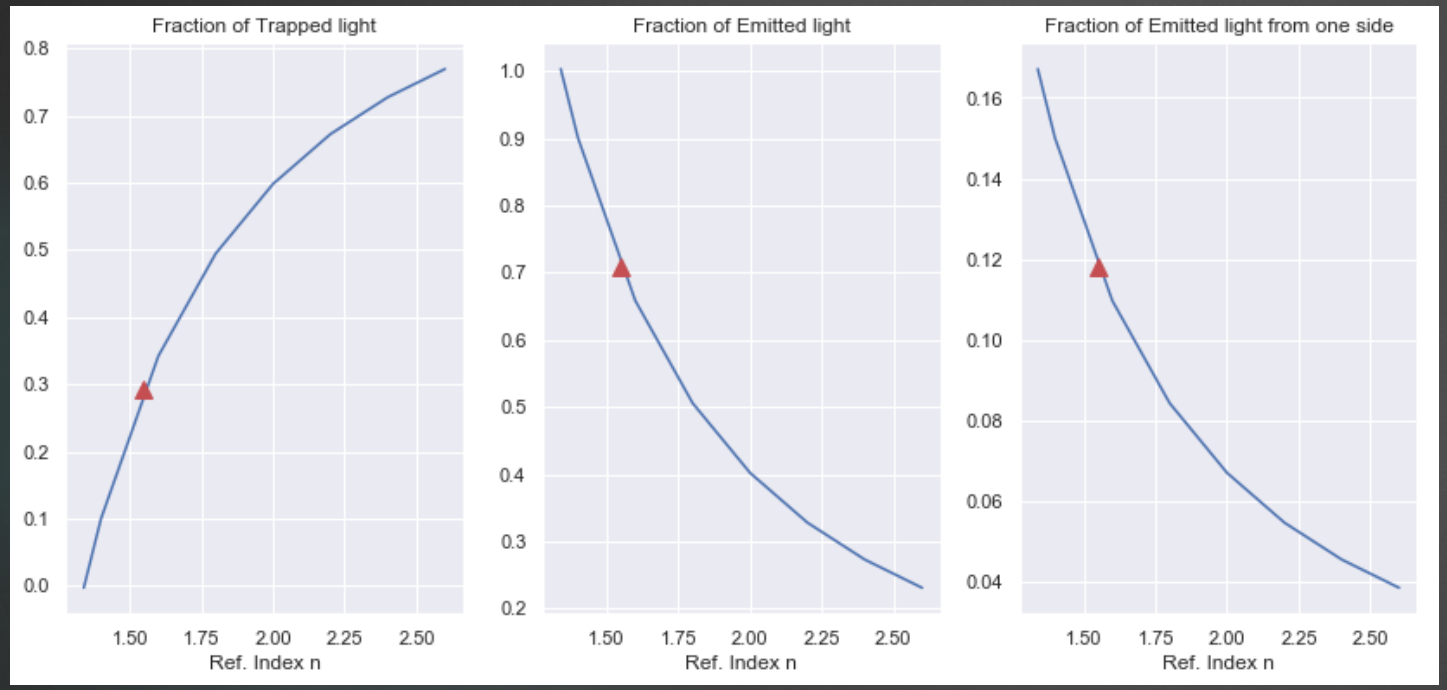




Some estimation before starting…

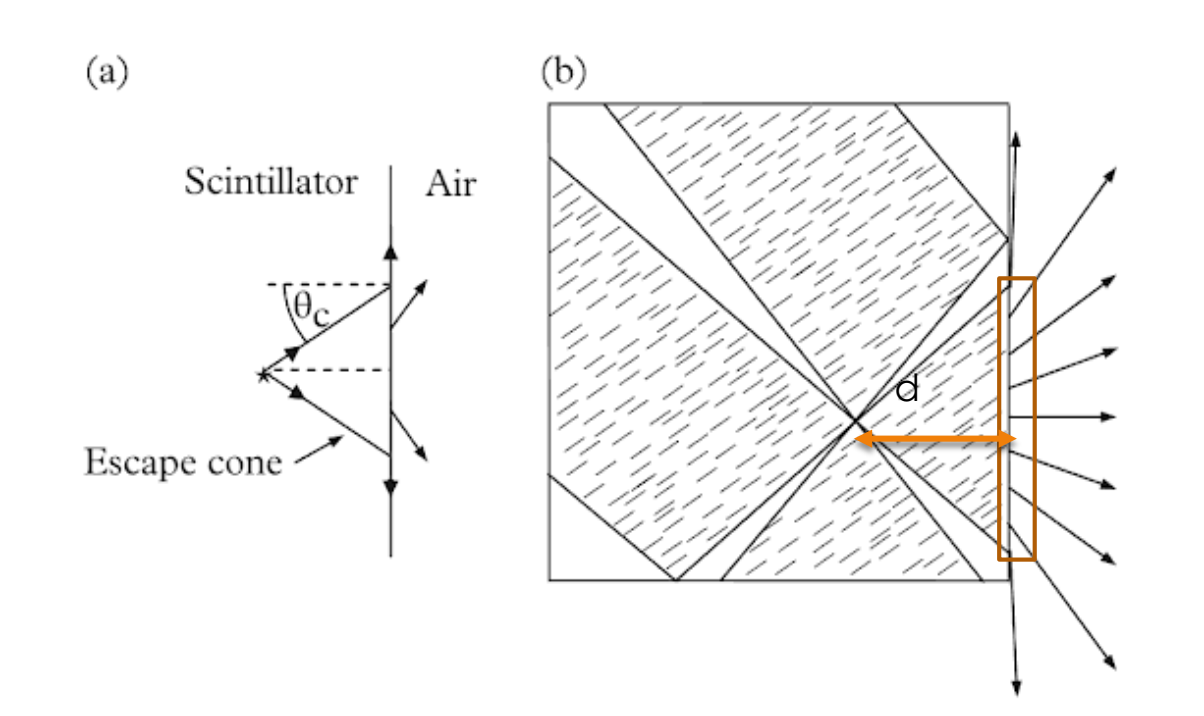
- No wrapping … only direct light is collected





n=1.55 ϑ_c=40°

Some estimation - Direct photons

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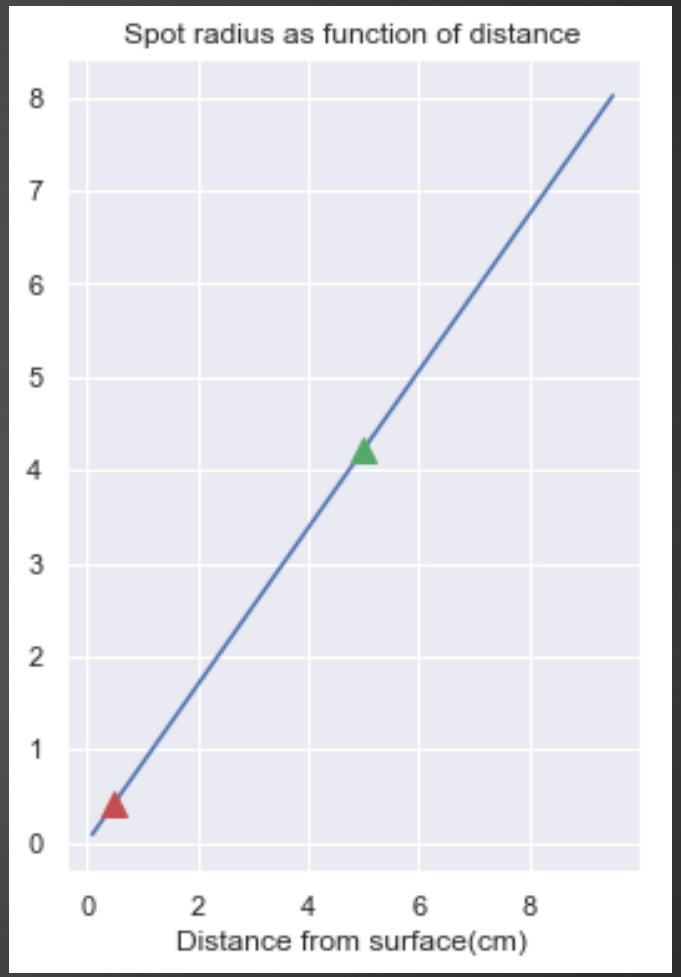
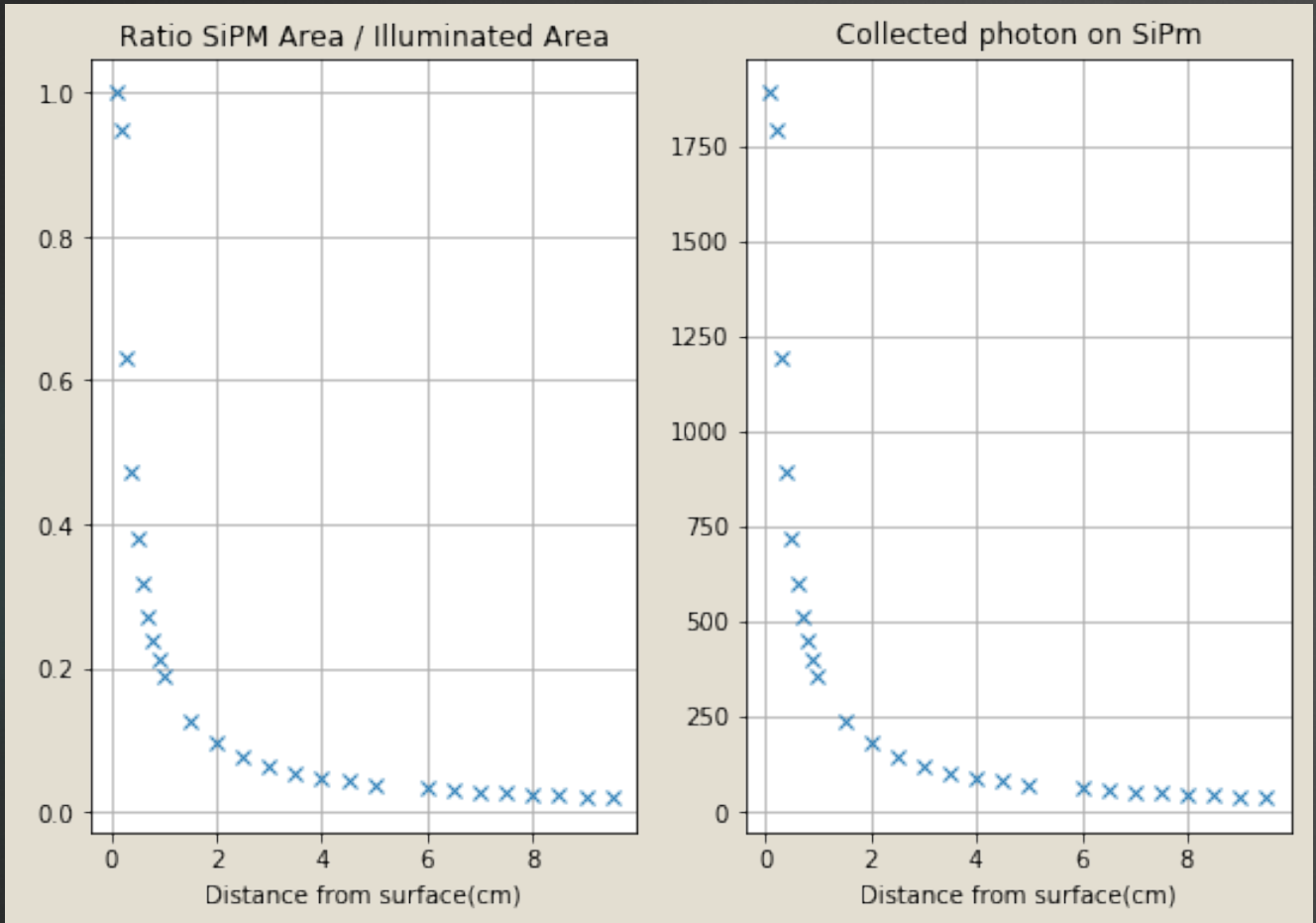
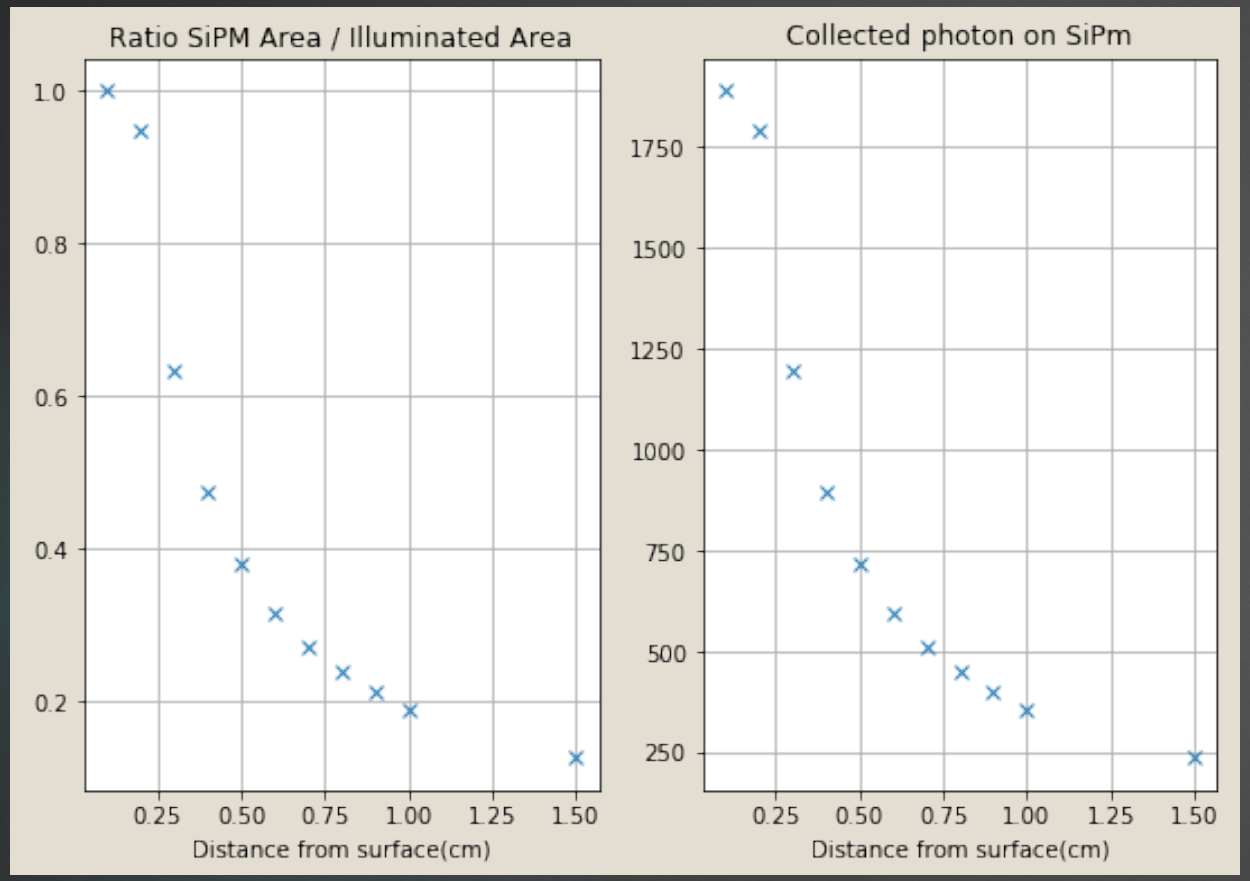


SIDE - Direct photons

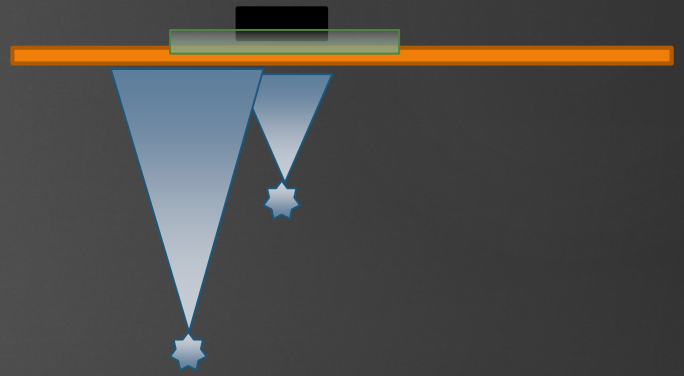


@1cm 300 photons
@5cm 80 photons
@9cm 20 photons

TOP - Direct photons

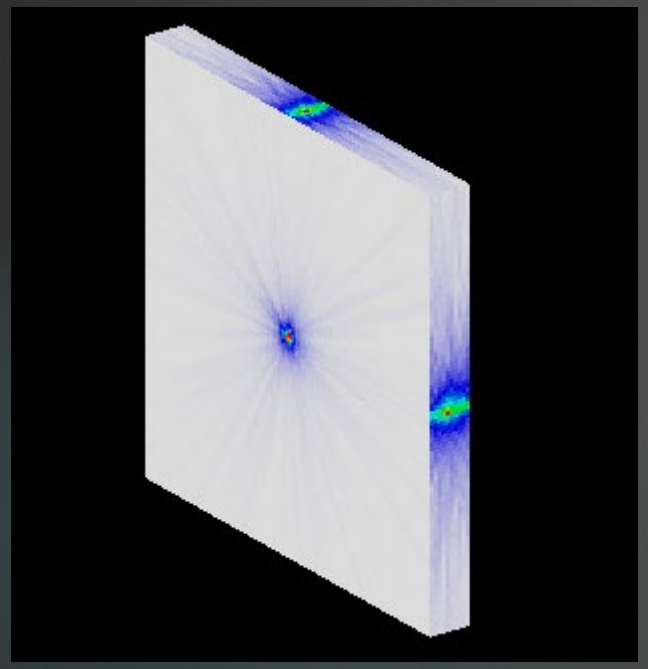


@1mm 500 photons
@5mm 80 photons
@10mm 20 photons

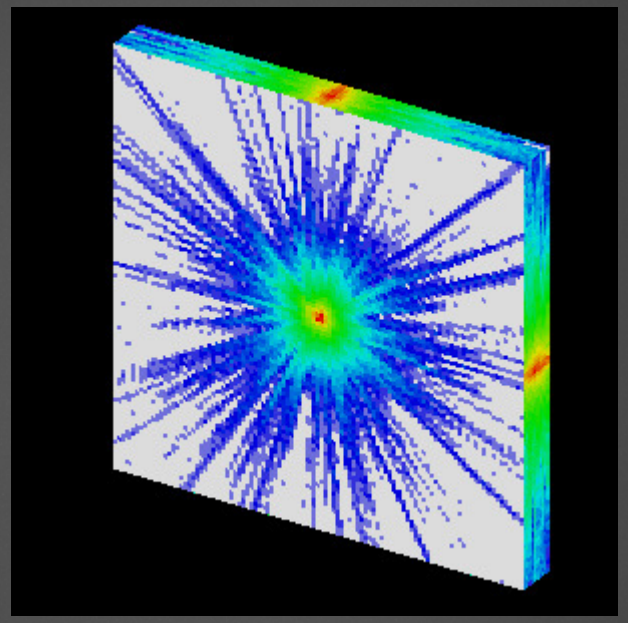


To detect the particle the scintillation event should occur just below the SiPM

Simulation
Vertical Muons @ 1 GeV



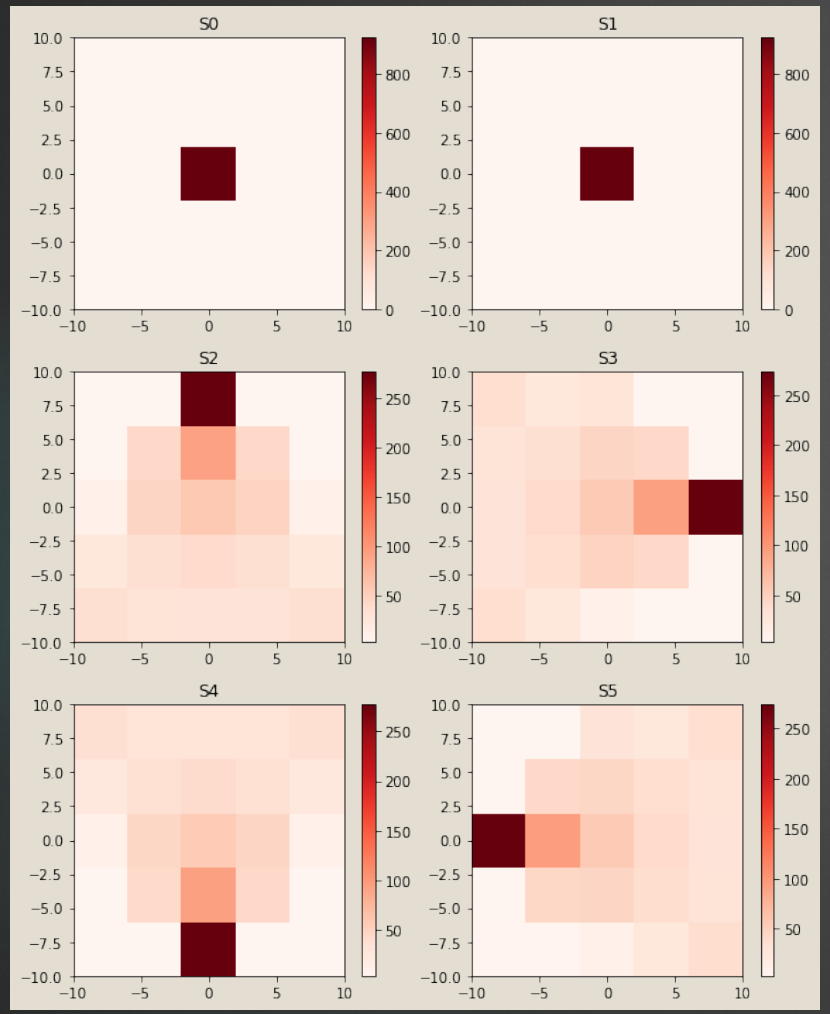
Linear scale



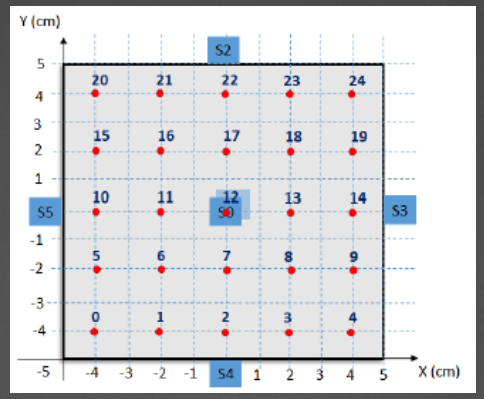
Log scale

Simulation Results

Total number of detected photons

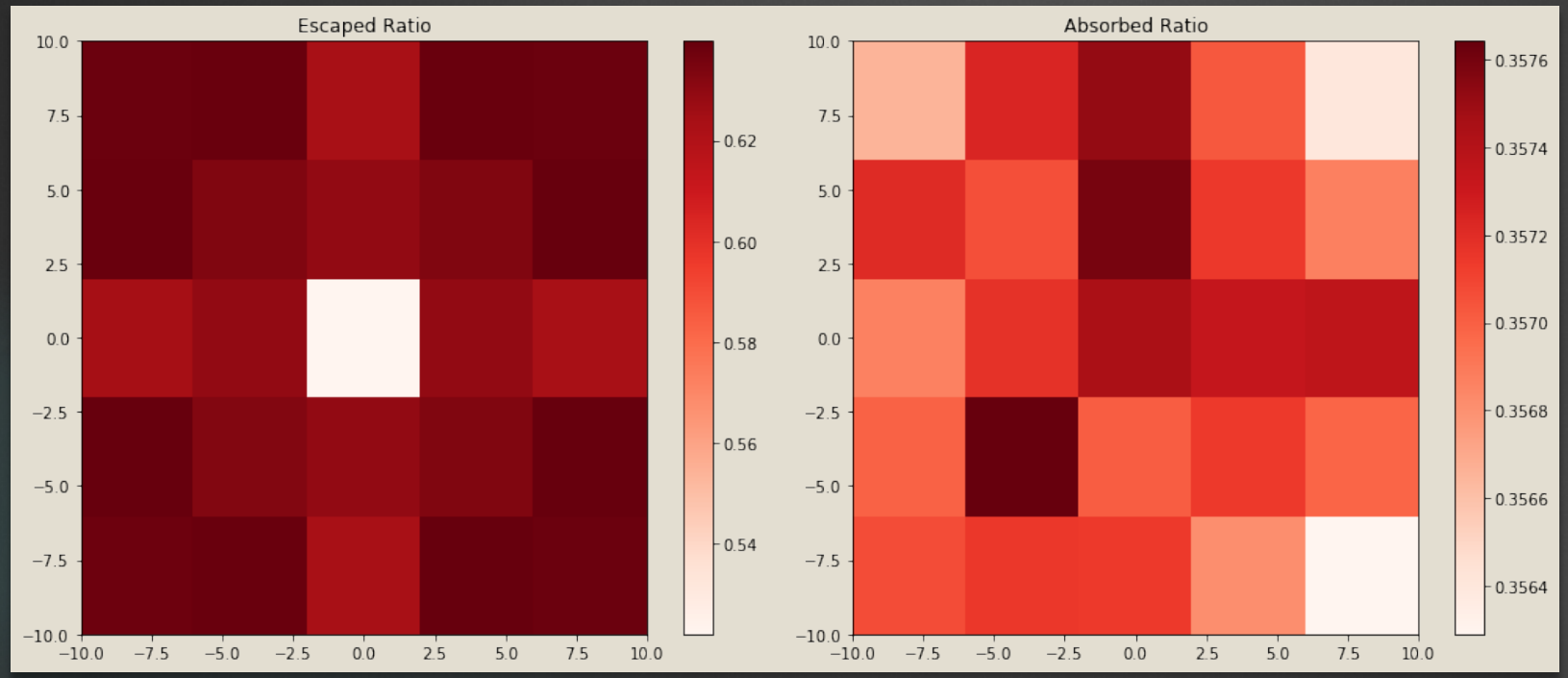


Vertical muons 1GeV/c



- 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

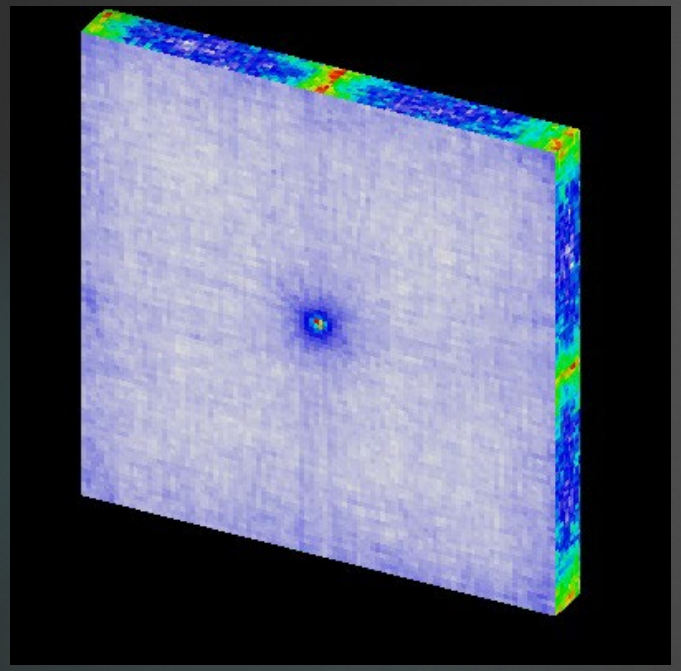
Absorbed-Escaped



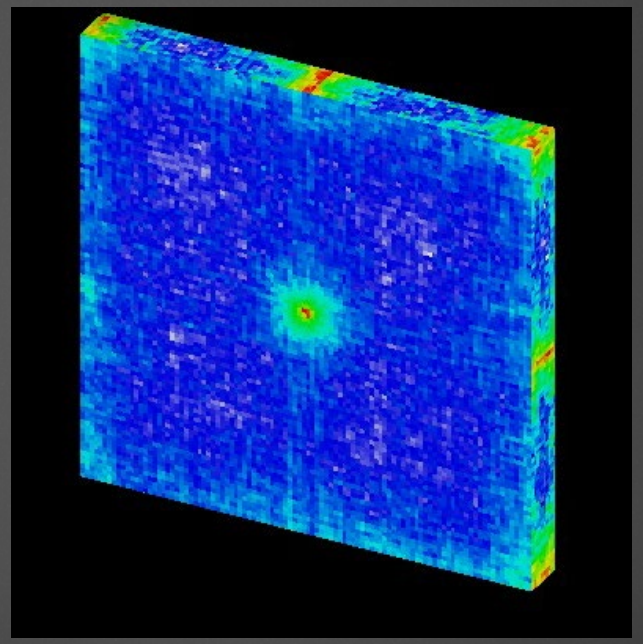
- Absorption in the tile is almost flat on the tile (35%)
- Most of the photons escape form the corners (60%)

TiO2 wrapping – polished surface

- To increase collection uniformity

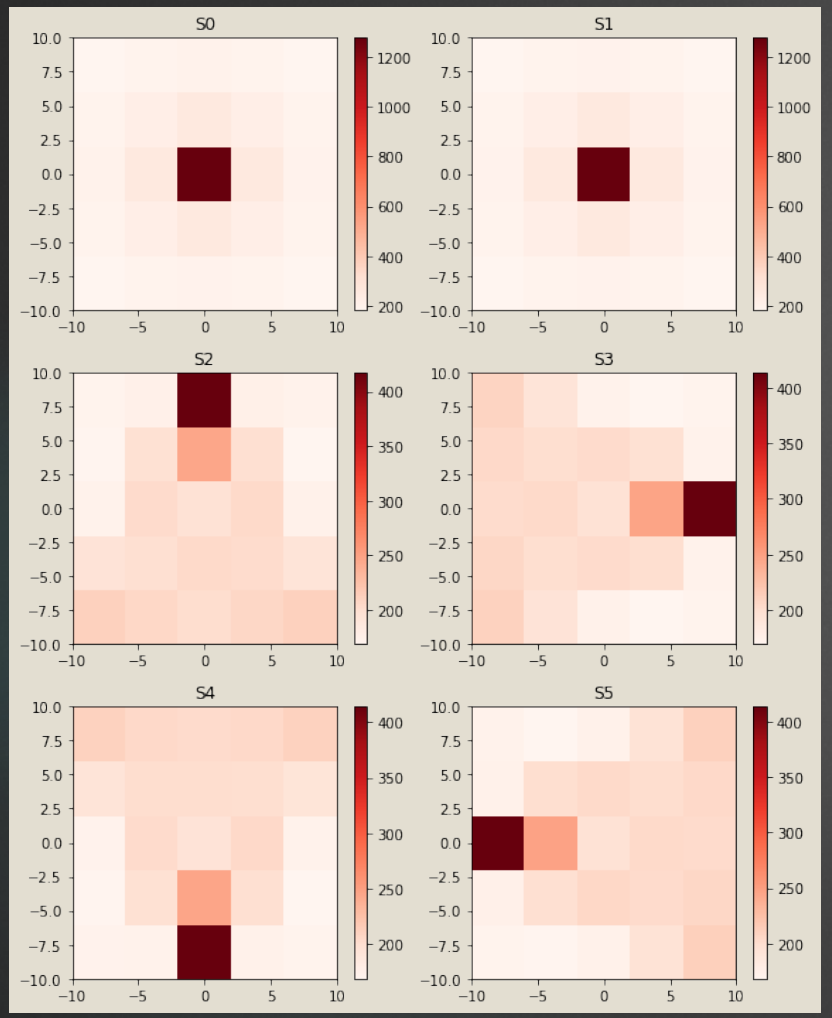


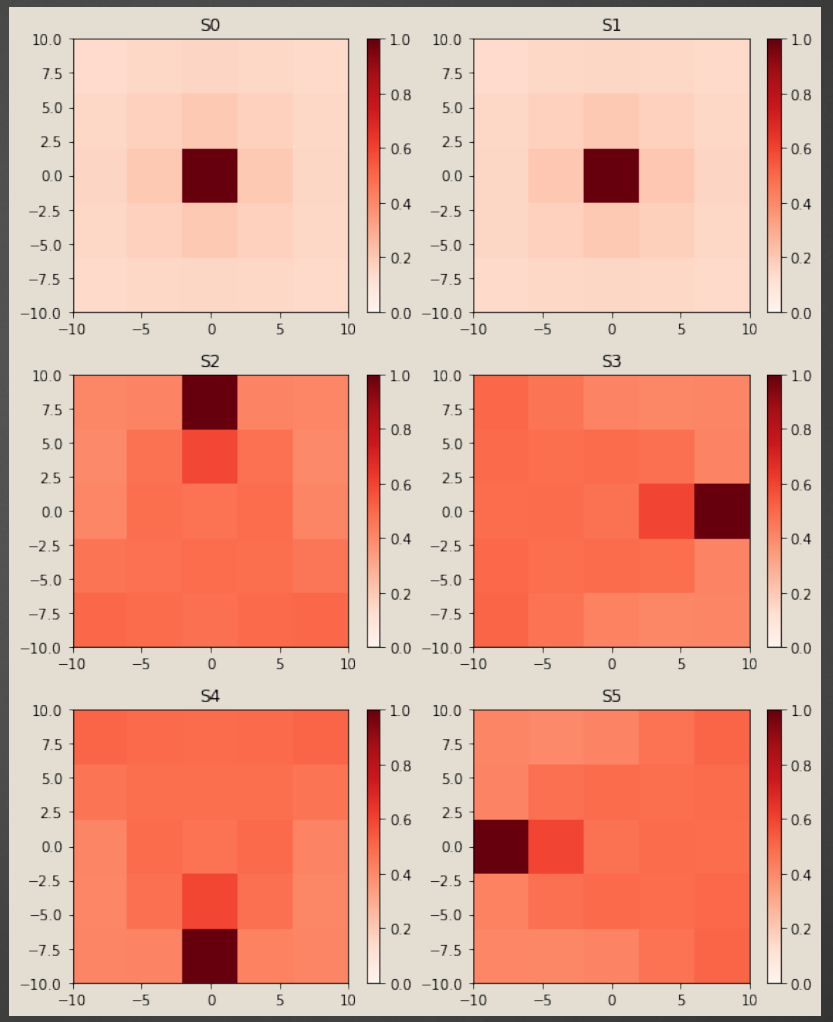
Linear scale



Log scale

TiO2 wrapping – Polished Surface

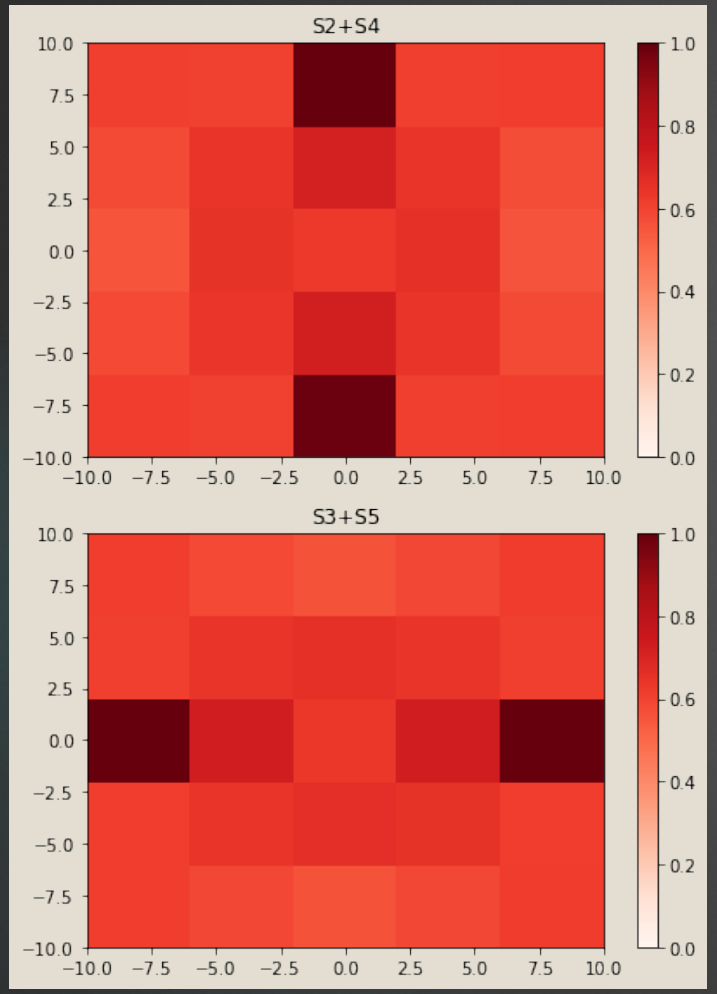




TiO2 reflector increase collection uniformity and the absolute number pf photons detected

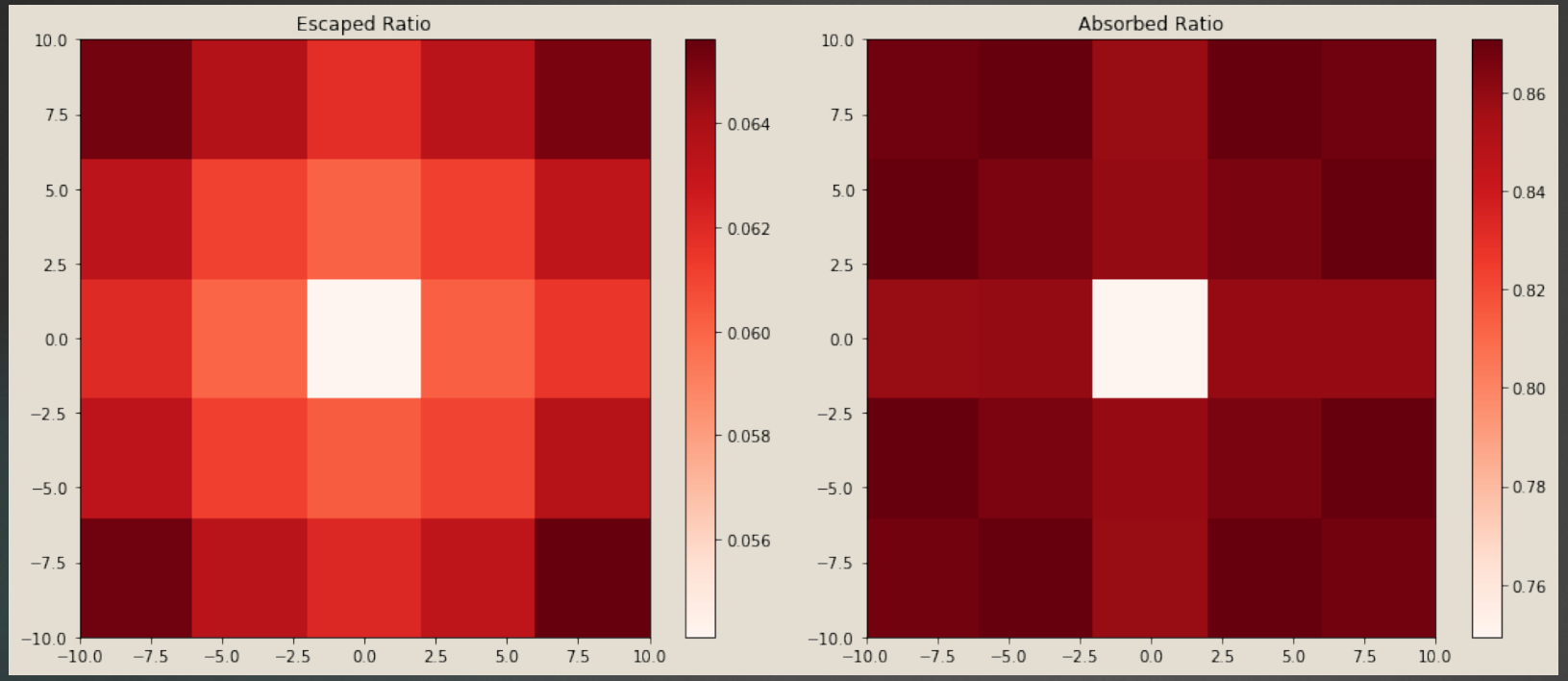
TOP Ratio 0.2 (min/max)
SIDE Ratio 0.5 (min/max)

TiO2 wrapping – polished surface



- If we sum the signal from SiPM on opposite sides the uniformity increase as expected
- SIDE Ratio 0.6 (min/max)

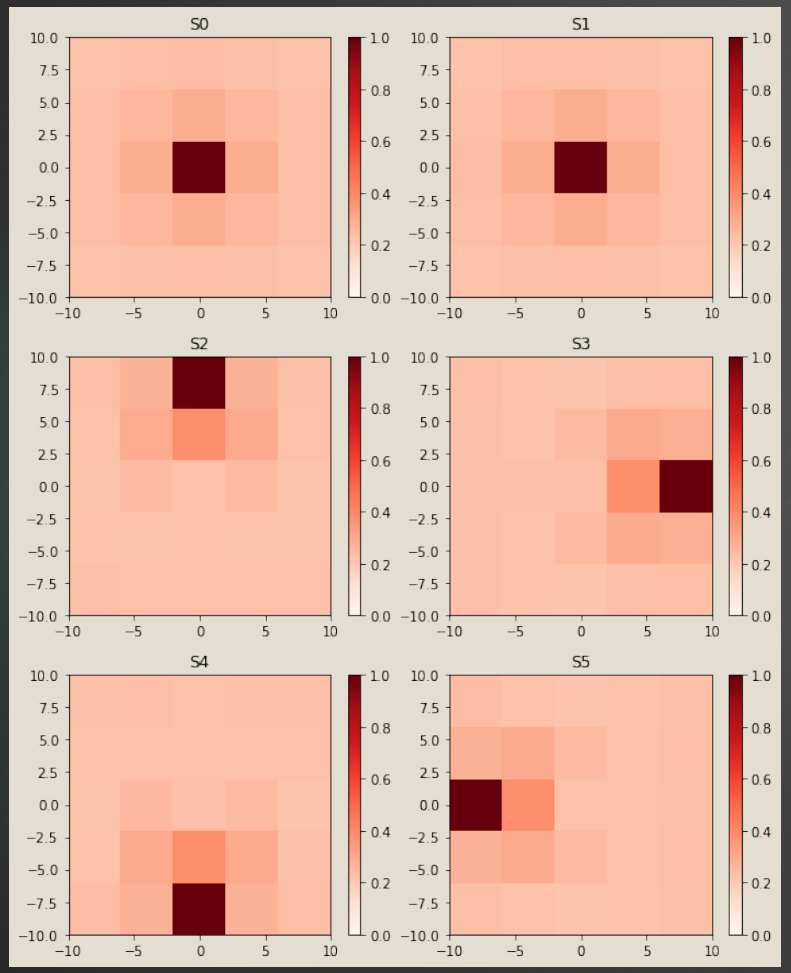
TiO2 wrapping – polished surface



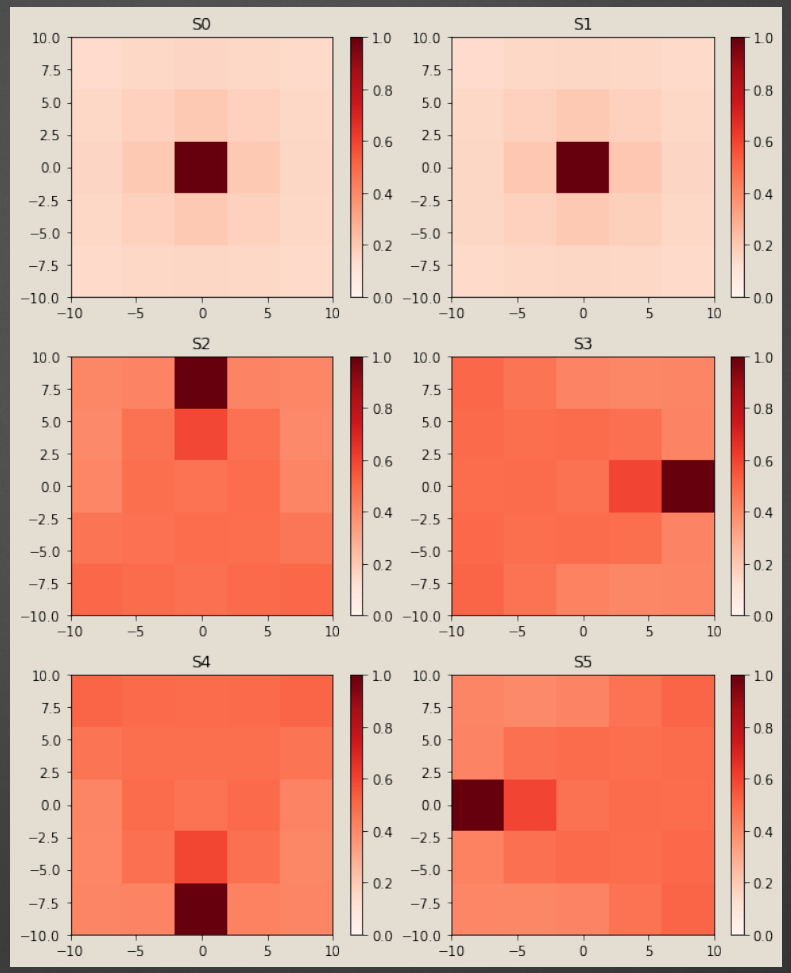
- Absorption in the tile is almost flat (85%)
- Very few photons escape form the tile (6%)

TiO2 wrapping – NOT polished surface

NOT Polished



Polished



- If we left unpolished the tile surfaces light collection uniformity decrease on the SIDE but increase on TOP
- TOP Ratio 0.25(min/max)
- SIDE Ratio 0.25 (min/max)

Needed improvements

- Add different wrappings
- Add the detection efficiency of the SiPM
- Add the timing information for each photon
- Add noise to SiPMs