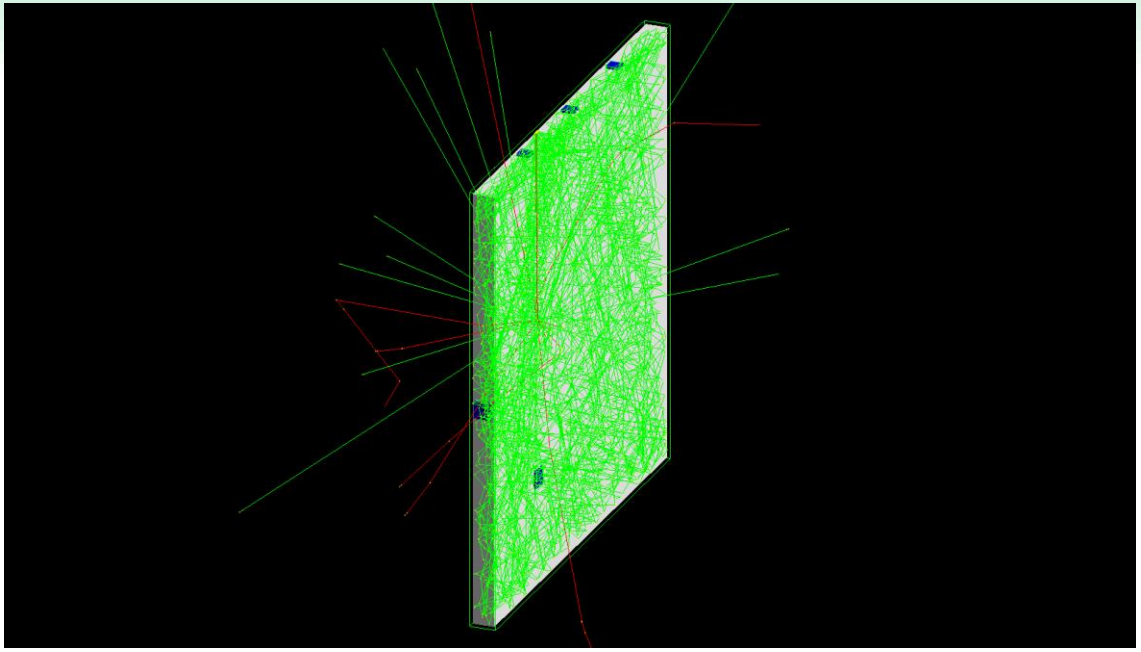
^{90}Sr Simulation update and Uniformity analysis

Bari, 9/4/2020

Corrado Altomare, Davide Serini, Fabio Gargano, Leonardo Di Venere



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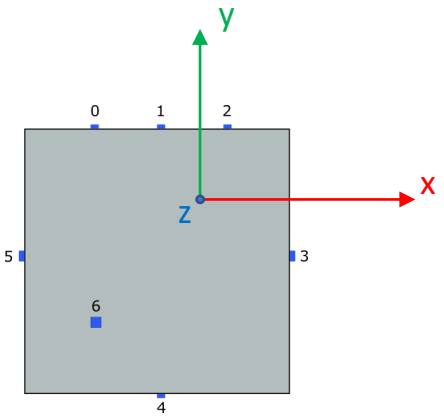
^{90}Sr Simulation

- **Physics**
  - **Physics List for Geant4 FTFP_BERT***
- **Source**
  - **^{90}Sr with G4 radioactive decay simulation**
- **Geometrical parameters**

- **Geometry B1 (5mm) :**
  - **Tile size (100x100x5) mm3**
  - **Source Position: Centered in (x,y) plane at 0.5 cm from Tile in z axes**
  - **SiPM (0,1,2,4) 3x3 mm**
  - **SiPM (3,5,6) 4x4 mm**
  - **Wrapping (Teflon) Thickness 500 um**

- **Geometry B2 (10mm) :**
  - **Tile size (100x100x10) mm3**
  - **Source Position: Centered in (x,y) plane at 0.5 cm from Tile in z axes**
  - **SiPM (0,1,2,4) 3x3 mm**
  - **SiPM (3,5,6) 4x4 mm**
  - **Wrapping (Teflon) Thickness 500 um**



*http://geant4-userdoc.web.cern.ch/geant4-userdoc/UsersGuides/PhysicsListGuide/html/reference_PL/FTFP_BERT.html#ftfp-bert

^{90}Sr Emission

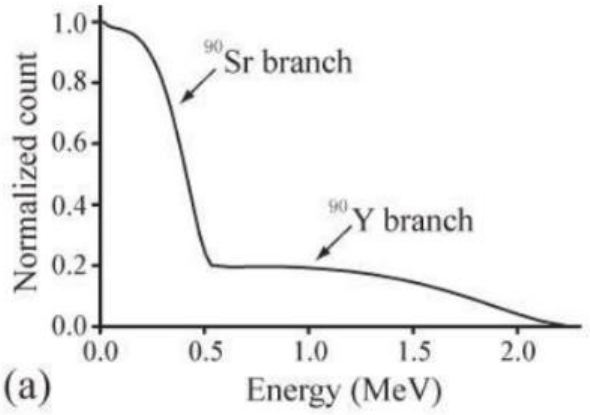
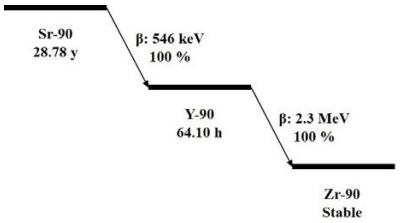
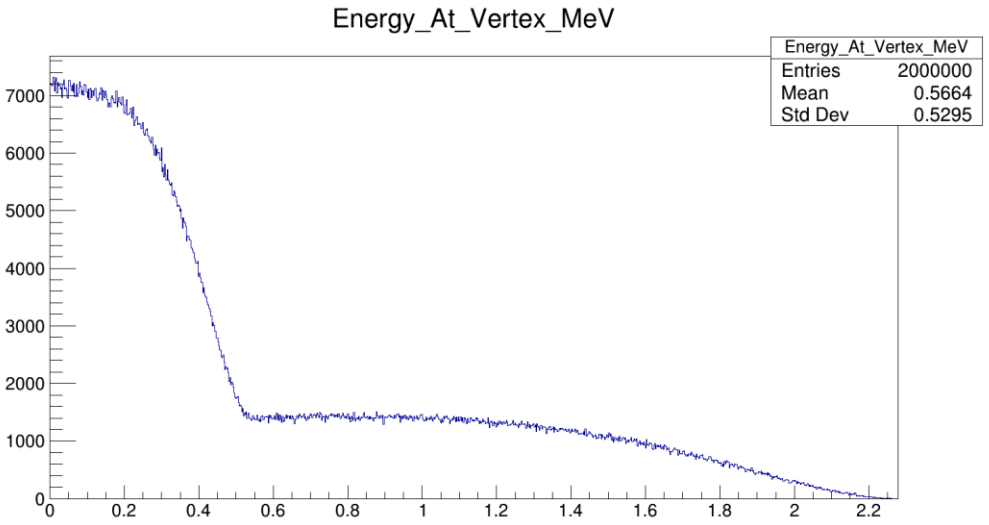


FIG. 7: (color online). (a) Theoretical energy spectra of beta particles emitted from a ^{90}Sr/^{90}Y source.

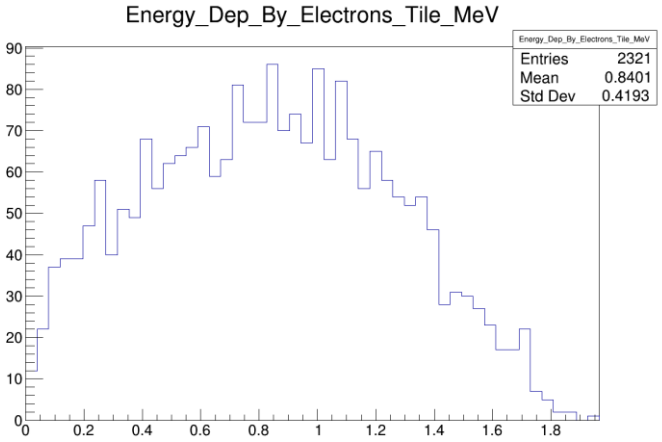




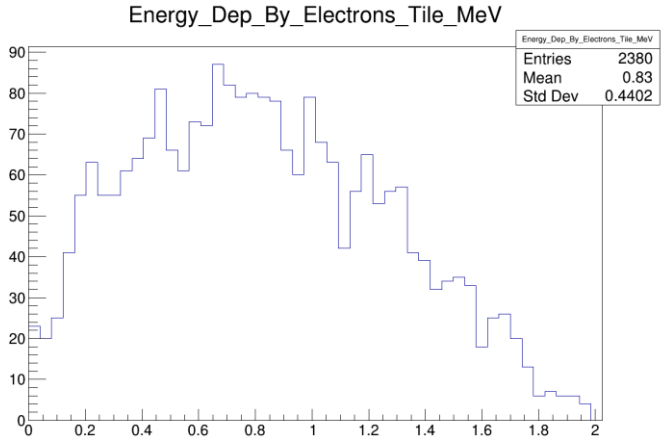
G4 Simulation 1M events -> 2M Electrons by Ions

^{90}Sr Tile Energy Absorption*

Tile B1 (5 mm)



Tile B2 (10 mm)

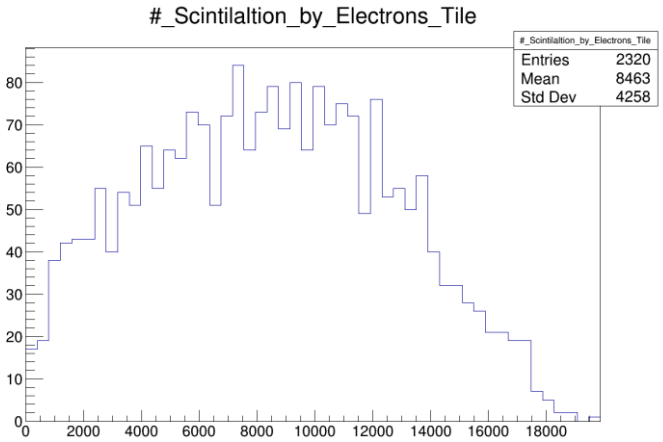


Expected Rate 23%

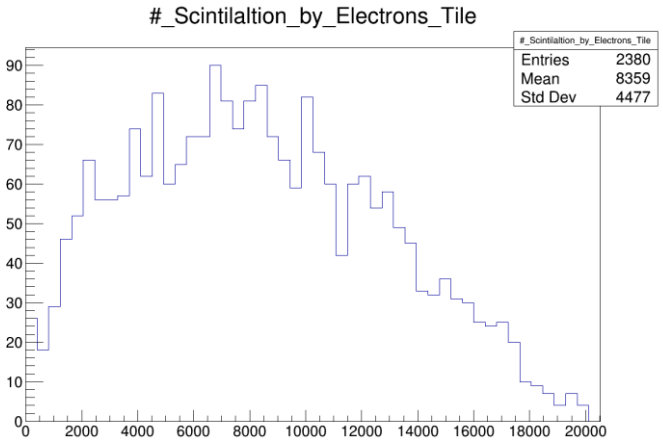
*10 k events simulated

^{90}Sr Scintillation Photons*

Tile B1 (5 mm)



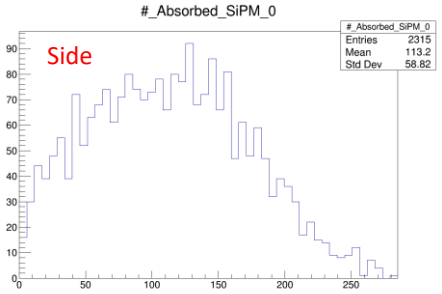
Tile B2 (10 mm)

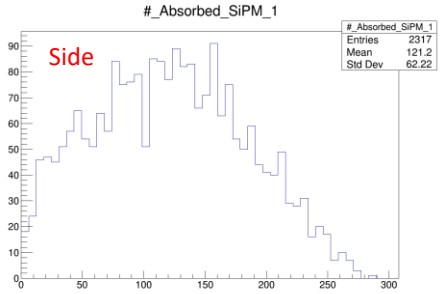


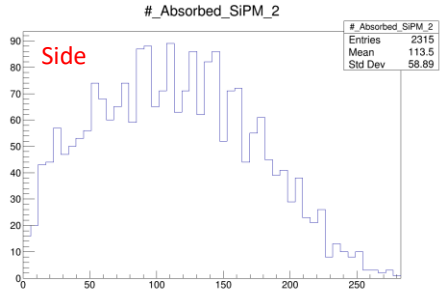
*10 k events simulated

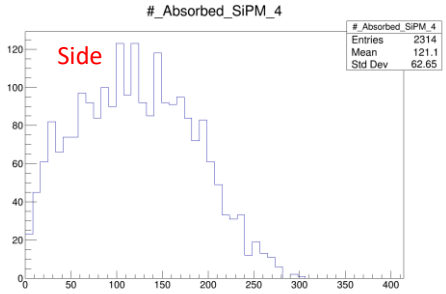
^{90}Sr Absorbed Photons*

Tile B1 (5 mm) -> 3mm SiPMs

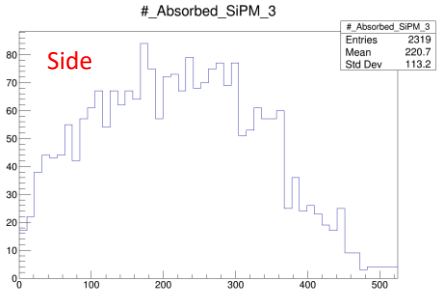


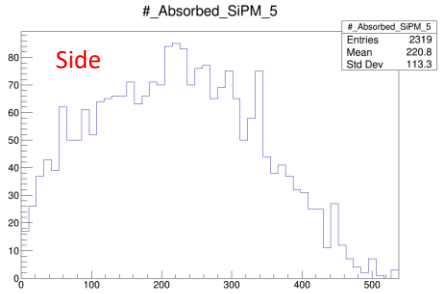


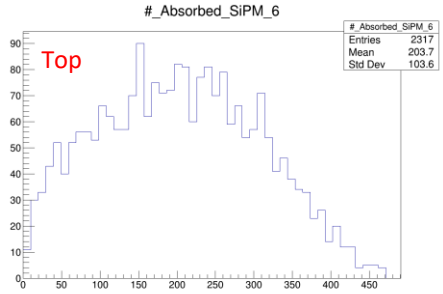




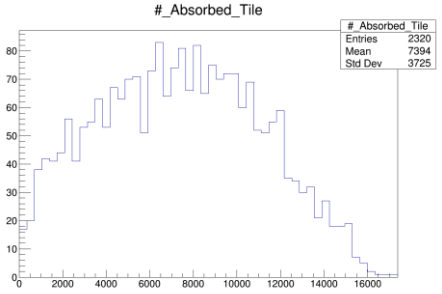
Tile B1 (5 mm) -> 4mm SiPMs

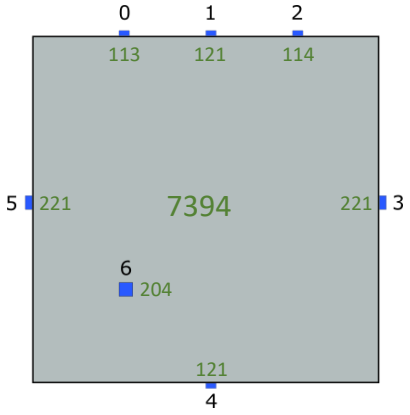






Tile B1 (5 mm) -> Tile



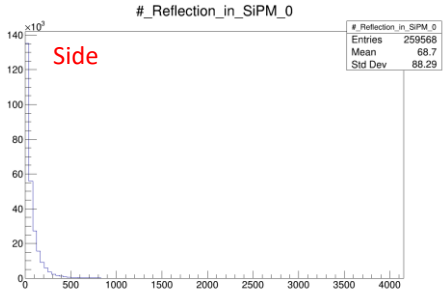


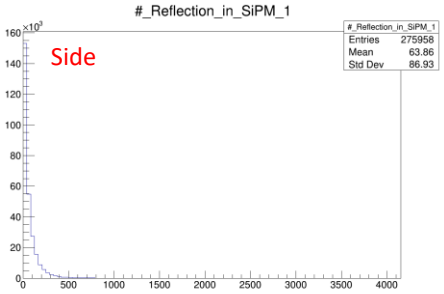
*10 k events simulated

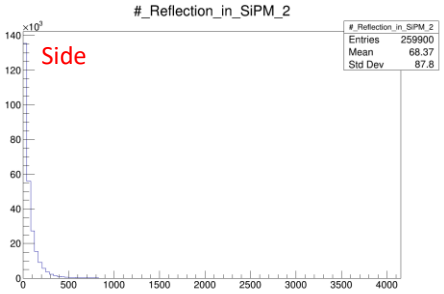
100% Reflectivity

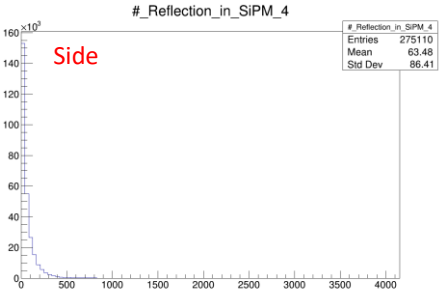
^{90}Sr Reflections*

Tile B1 (5 mm) -> 3mm SiPMs

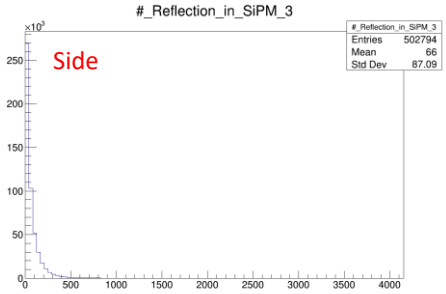


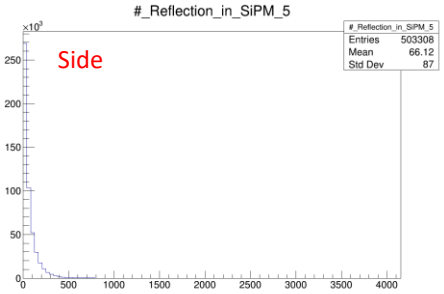


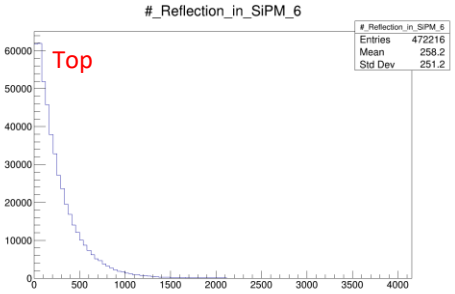




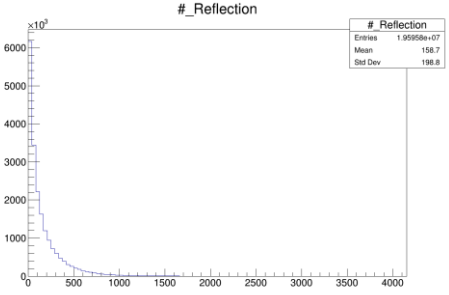
Tile B1 (5 mm) -> 4mm SiPMs

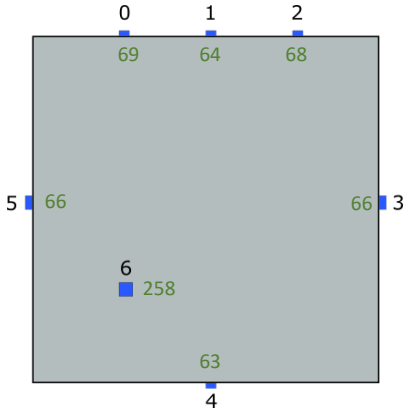






Tile B1 (5 mm) -> Total



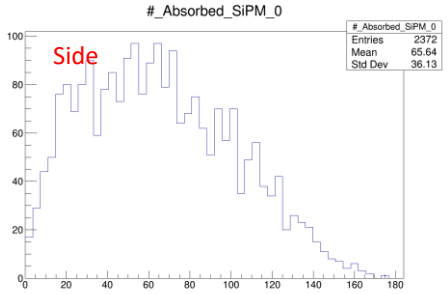


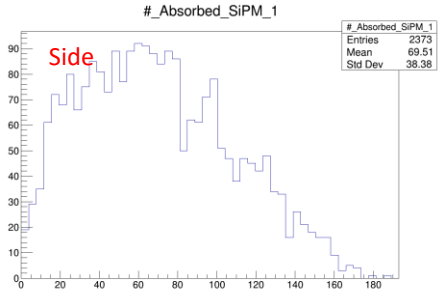
*10 k events simulated

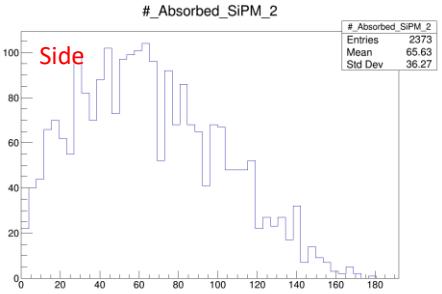
100% Reflectivity

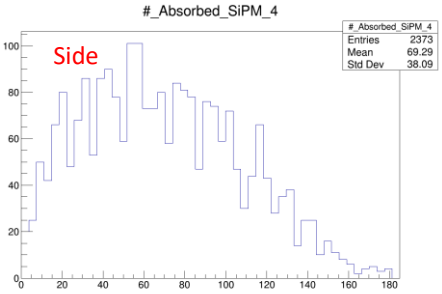
^{90}Sr Absorbed Photons*

Tile B2 (10 mm) -> 3mm SiPMs

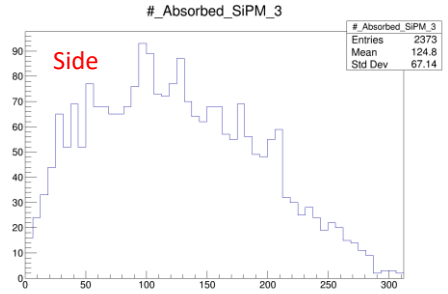


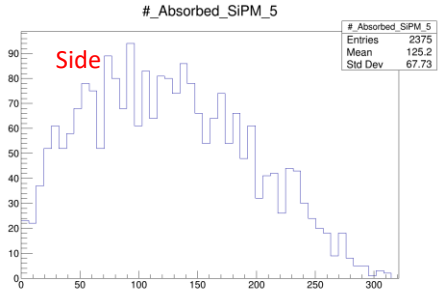


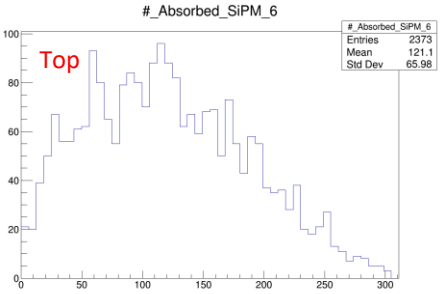




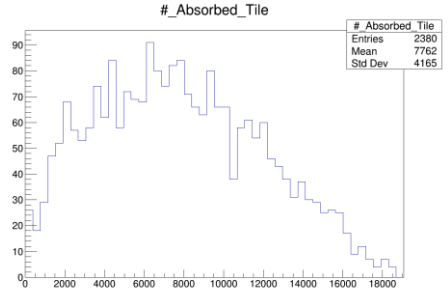
Tile B2 (10 mm) -> 4mm SiPMs

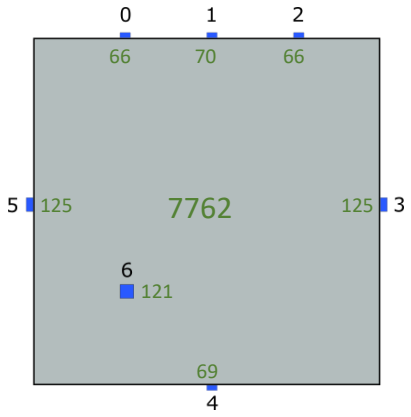






Tile B2 (10 mm) -> Tile



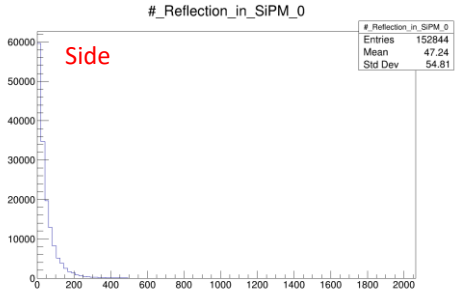


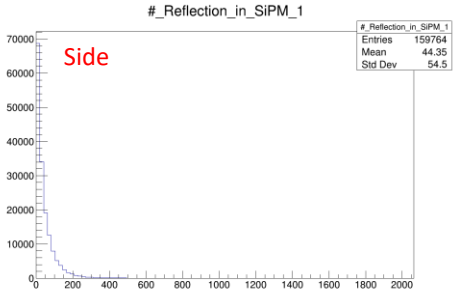
*10 k events simulated

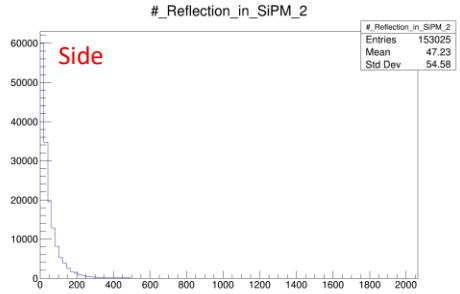
100% Reflectivity

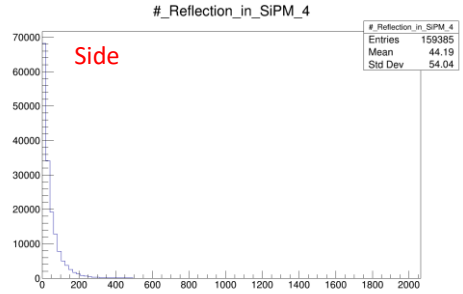
^{90}Sr Reflections*

Tile B2 (10 mm) -> 3mm SiPMs

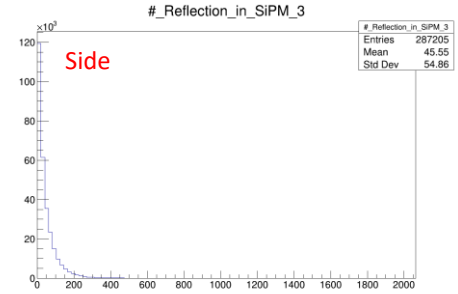


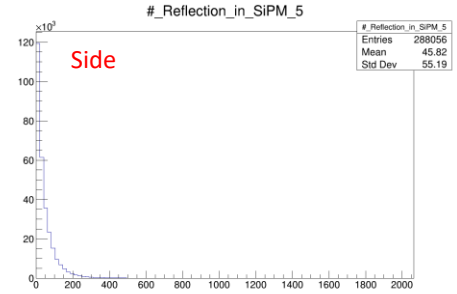


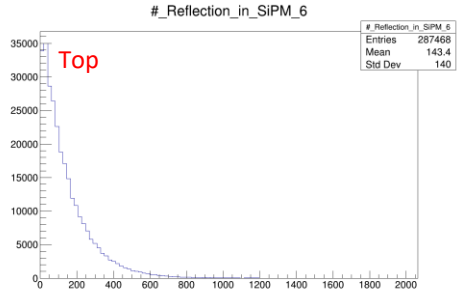




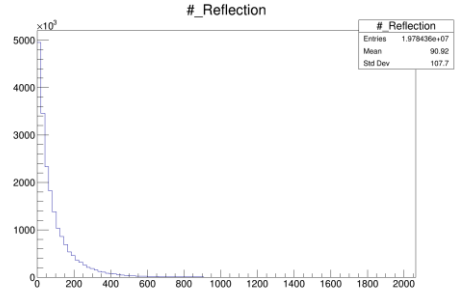
Tile B2 (10 mm) -> 4mm SiPMs

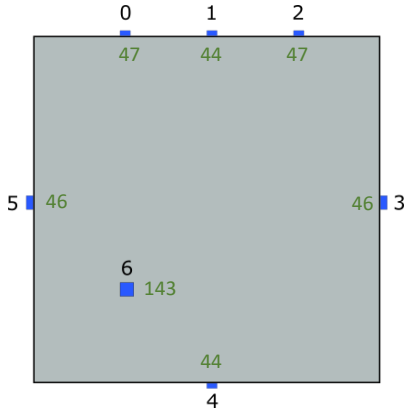






Tile B2 (10 mm) -> Total



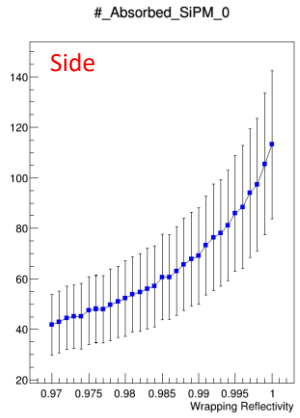


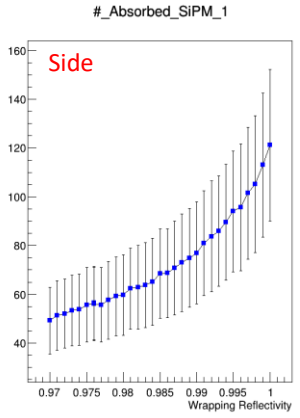
*10 k events simulated

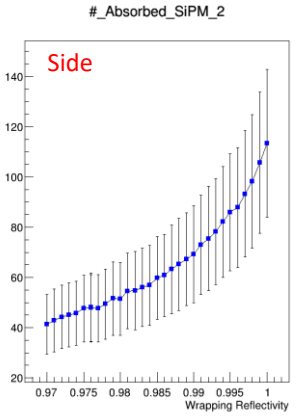
100% Reflectivity

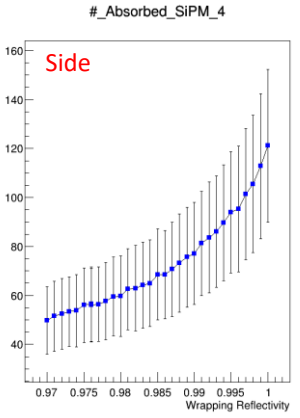
Reflectivity dependence*

Tile B1 (5 mm) -> 3mm SiPMs

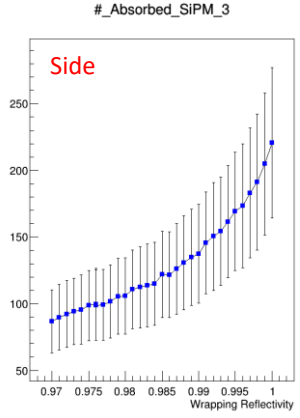


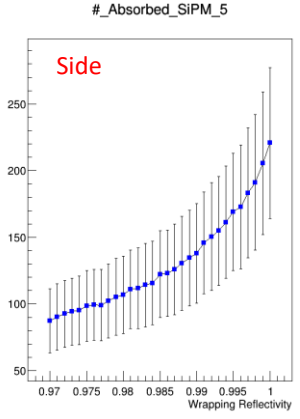


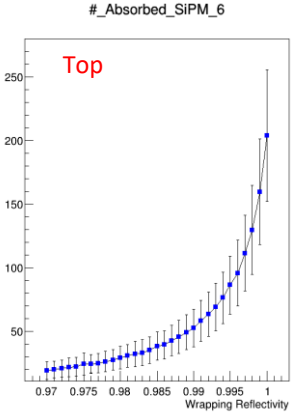


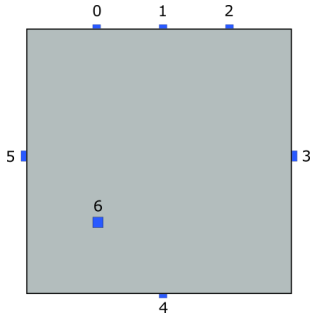


Tile B1 (5 mm) -> 4mm SiPMs





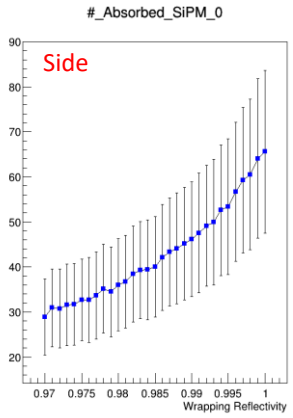


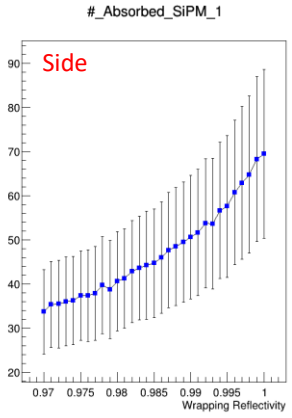


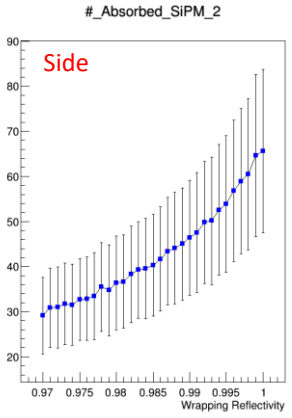
*Photons Absorbed

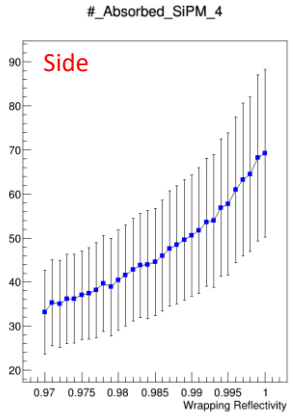
Reflectivity dependence*

Tile B2 (10 mm) -> 3mm SiPMs

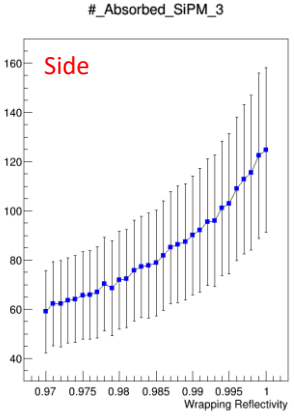


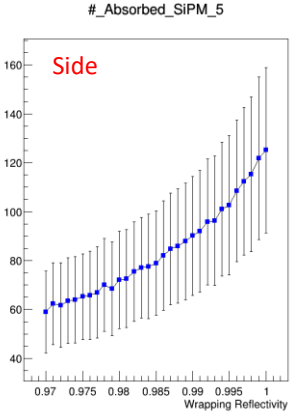


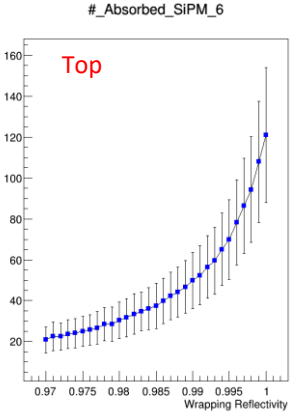


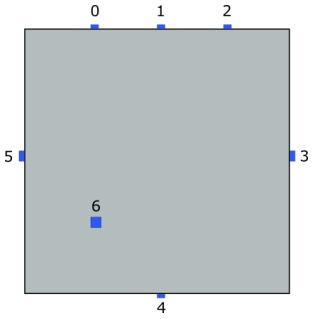


Tile B2 (10 mm) -> 4mm SiPMs





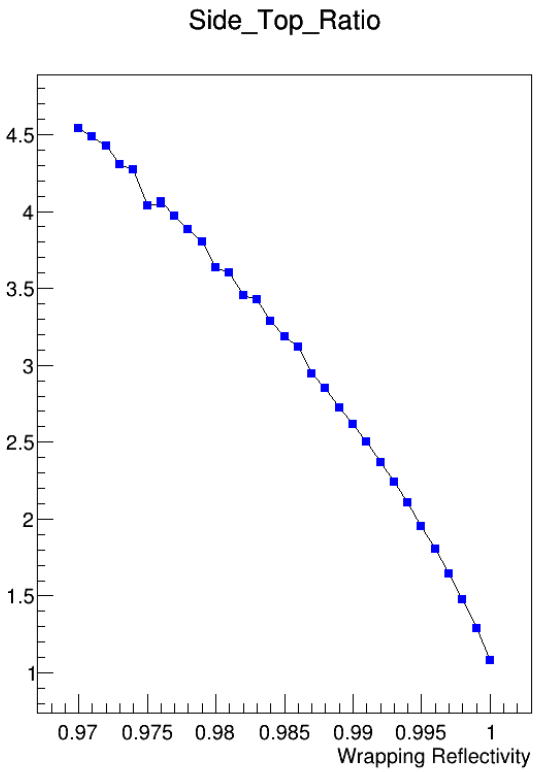




*Photons Absorbed

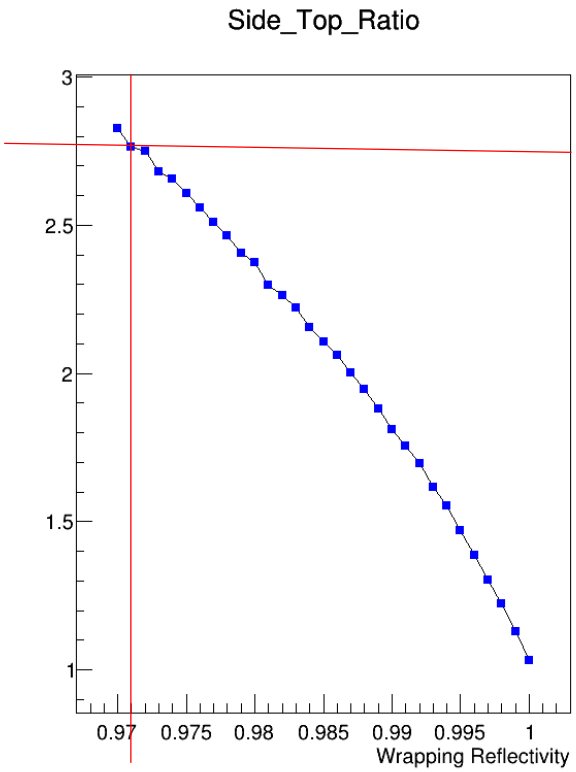
Reflectivity dependence*

Tile B1 (5mm)



Tile B2 (10mm)

2.71 Ratio from experimental data for 10 mm tile



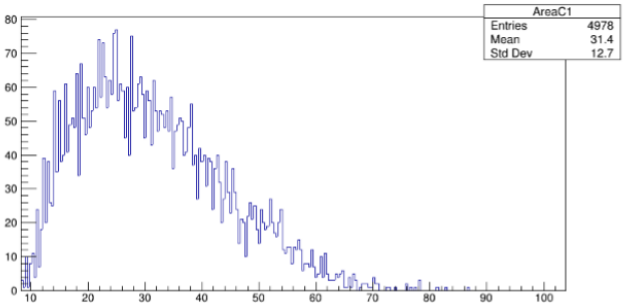
97.1% teflon reflectivity

Comparison with data

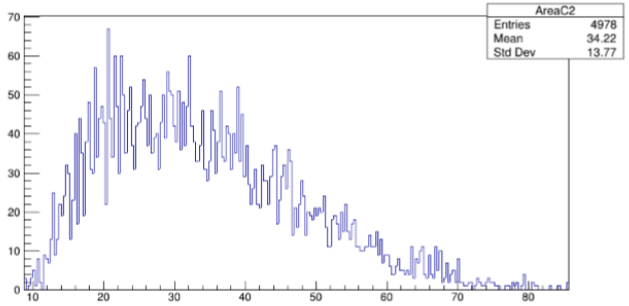
Tile B2 (10 mm)

Lab

ADV side

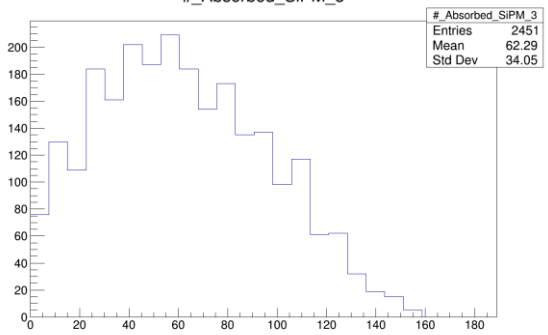


ADV side 2



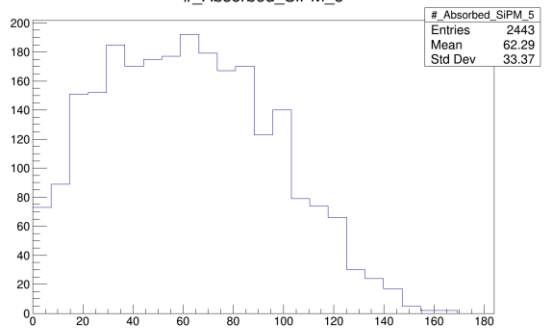
Simulation

#_Absorbed_SiPM_3



PDE 40% @400nm
25 p. e

#_Absorbed_SiPM_5

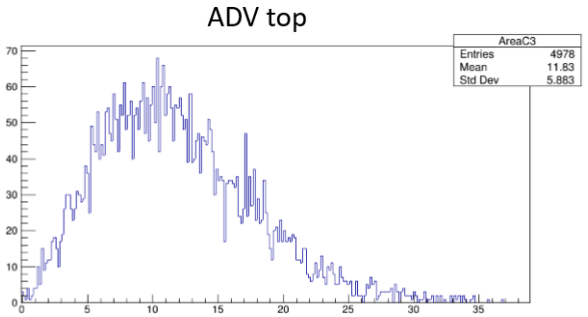


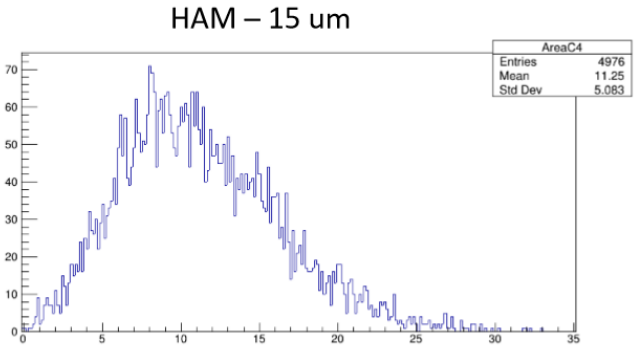
PDE 40% @400nm
25 p. e

Comparison with data

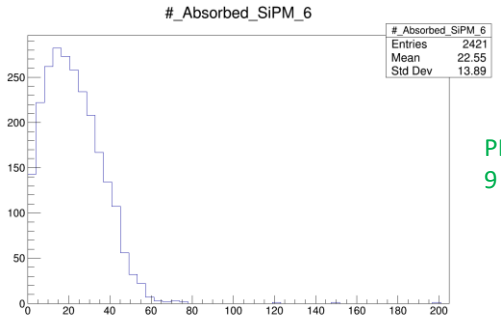
Tile B2 (10 mm)

Lab

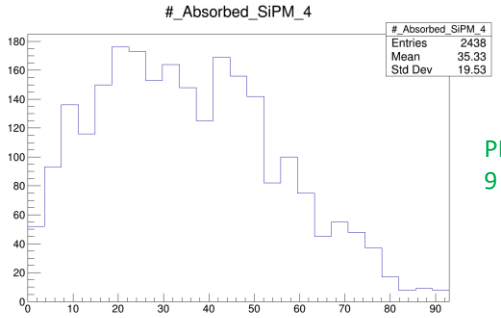




Simulation



PDE 40% @400nm
9 p. e

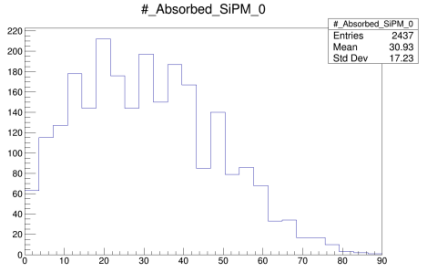


PDE 25% @400nm
9 p. e

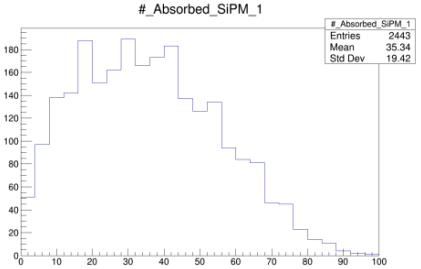
Comparison with data

Tile B2 (10 mm)

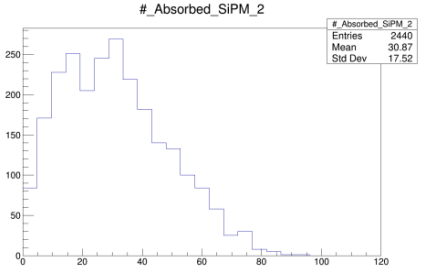
Simulation



PDE 35% @400nm
11 p. e

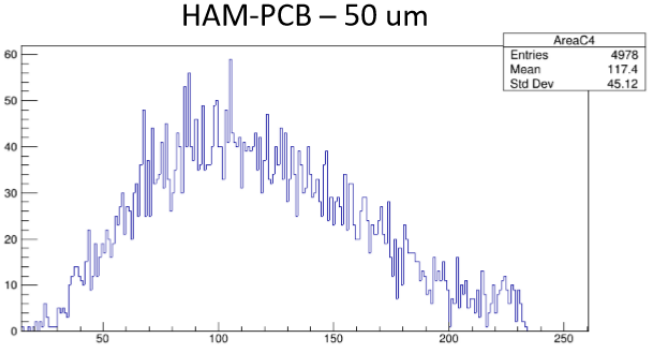


PDE 35% @400nm
12 p. e



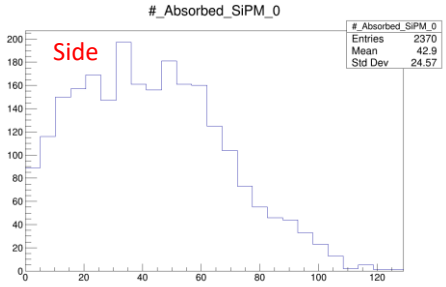
PDE 35% @400nm
11 p. e

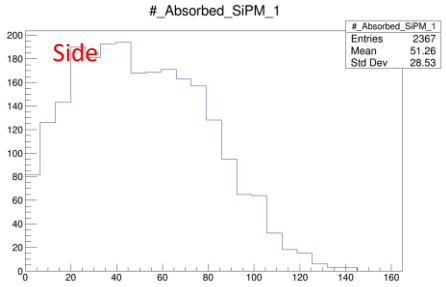
Lab

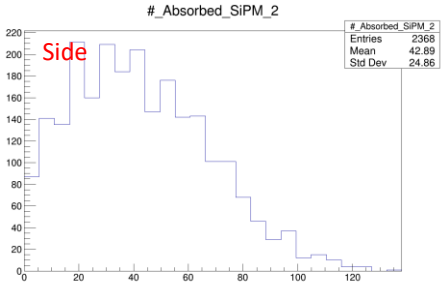


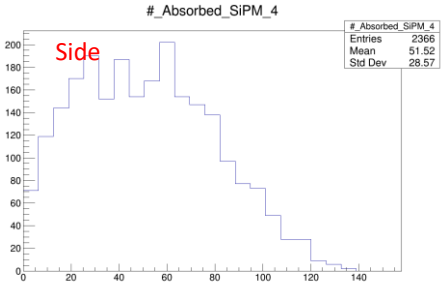
^{90}Sr Absorbed Photons*

Tile B1 (5 mm) -> 3mm SiPMs

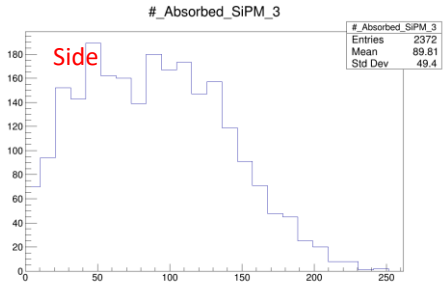


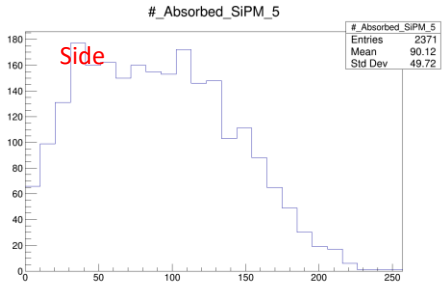


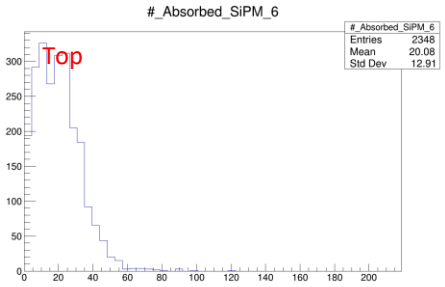




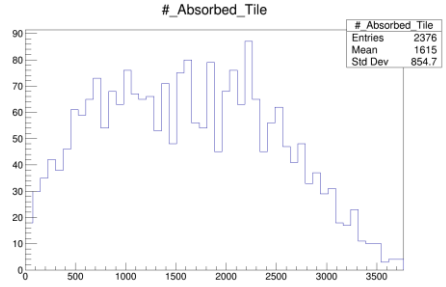
Tile B1 (5 mm) -> 4mm SiPMs

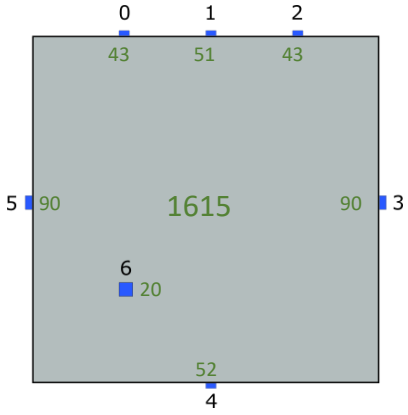






Tile B1 (5 mm) -> Tile



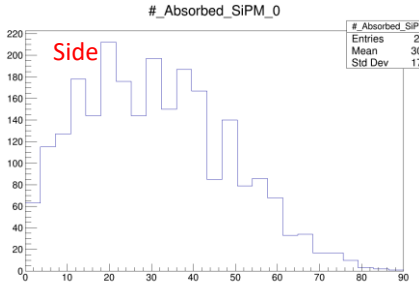


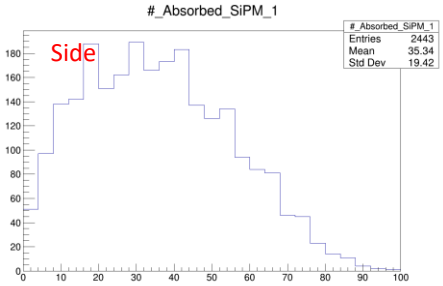
*10 k events simulated

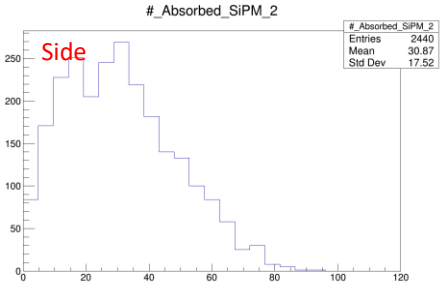
97.1% Reflectivity

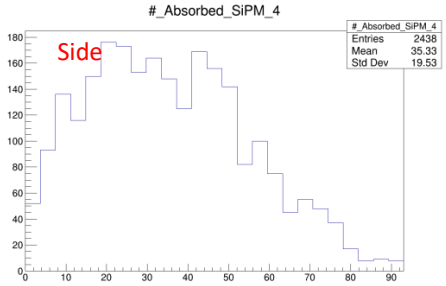
^{90}Sr Absorbed Photons*

Tile B2 (10 mm) -> 3mm SiPMs

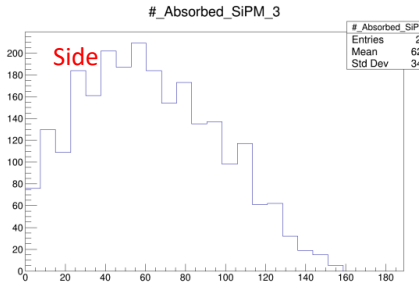


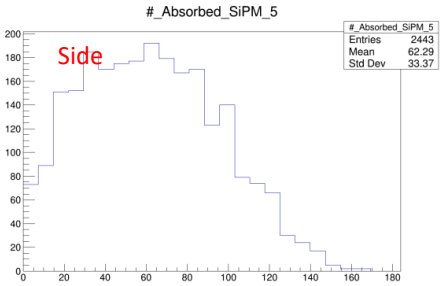


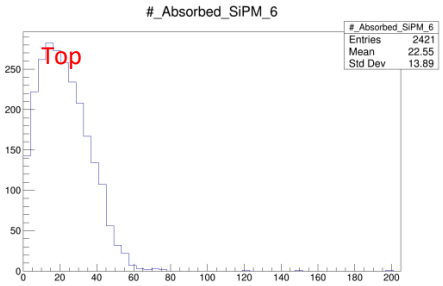




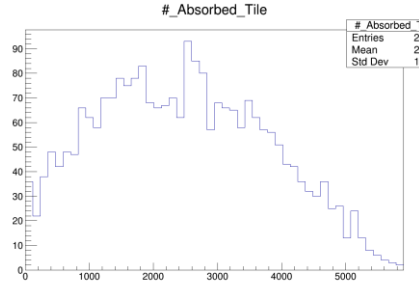
Tile B2 (10 mm) -> 4mm SiPMs

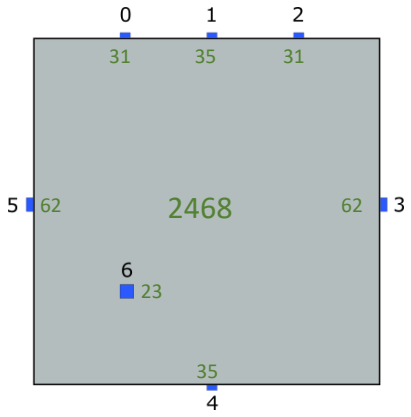






Tile B2 (10 mm) -> Tile

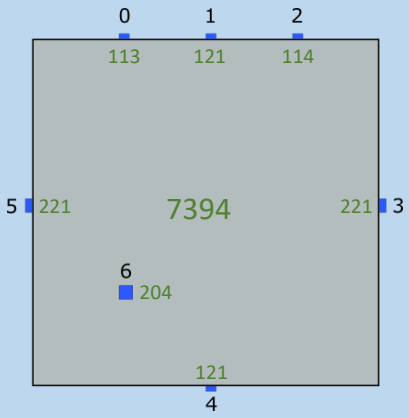
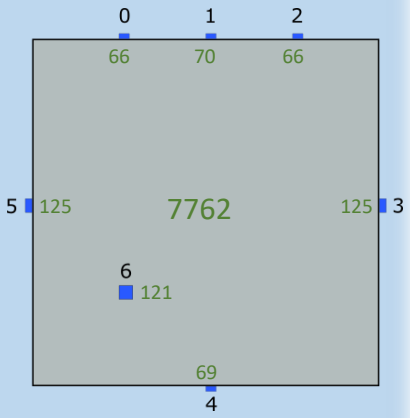
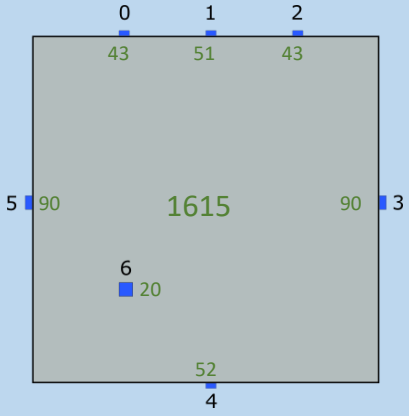
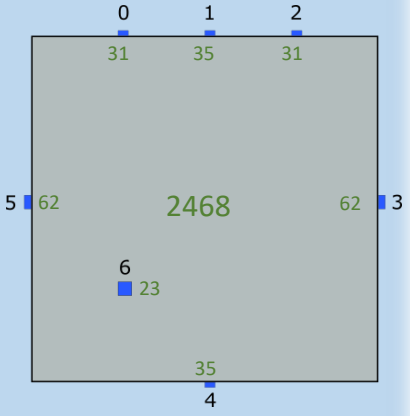




*10 k events simulated

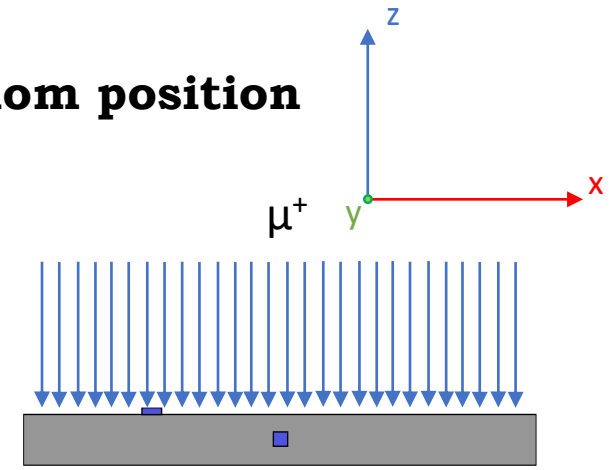
97.1% Reflectivity

Collected photons comparison

	Tile B1 (5 mm)	Tile B2 (10 mm)
100% Reflectivity		
97.1% Reflectivity		

Photon collection uniformity

- **Physics**
  - **Physics List for Geant4 FTFP_BERT***
- **Source**
  - **μ^+ @ 10 GeV Orthogonal to xy plane in random position**



- **Geometrical parameters**

- **Geometry B1 (10mm) :**
  - **Tile size (100x100x5) mm3**
  - **SiPM (0,1,2,4) 3x3 mm**
  - **SiPM (3,5,6) 3x3 mm**
  - **Wrapping (Teflon) Thickness 500 um**

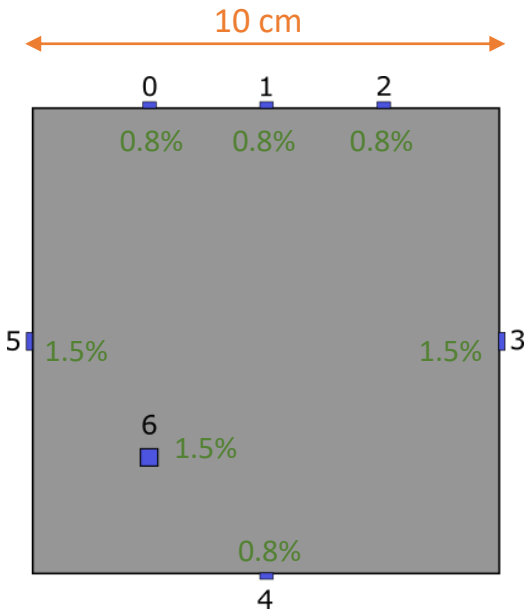
- **Geometry B1 (10mm) :**
  - **Tile size (200x200x10) mm3**
  - **SiPM (0,1,2,4) 3x3 mm (Same Position)**
  - **SiPM (3,5,6) 3x3 mm (Same Position)**
  - **Wrapping (Teflon) Thickness 500 um**

*http://geant4-userdoc.web.cern.ch/geant4-userdoc/UsersGuides/PhysicsListGuide/html/reference_PL/FTFP_BERT.html#ftfp-bert

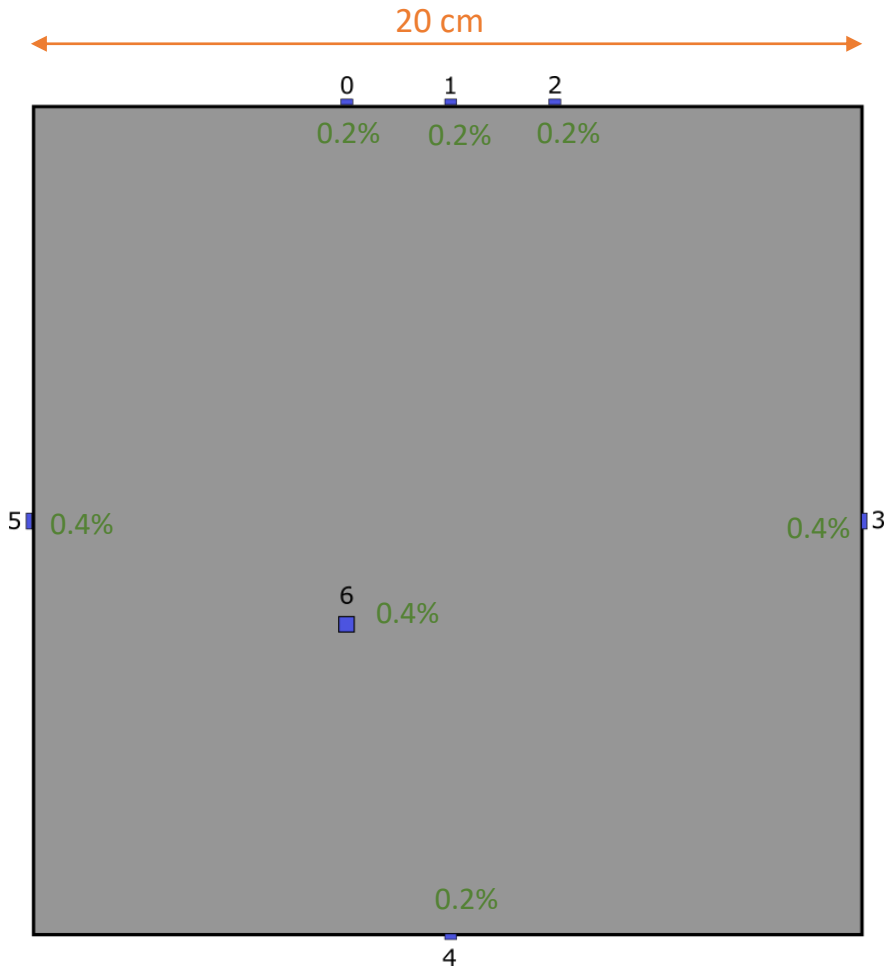
Photon collection uniformity

Average values of photons absorbed (percentage of generated)

Tile B2 (10mm)



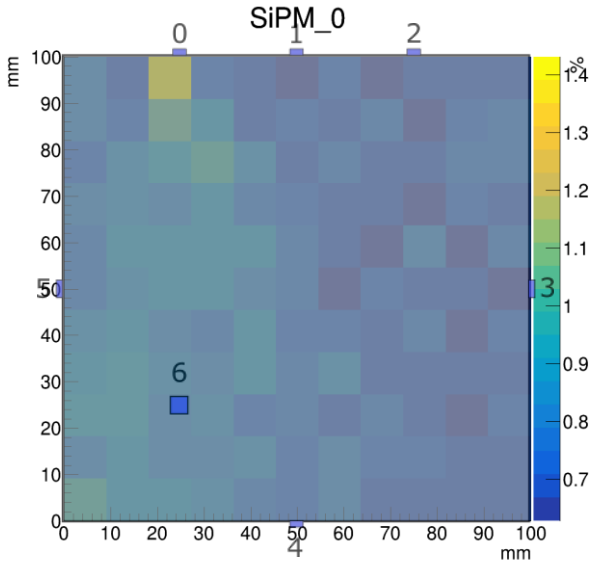
Tile B2 (10mm)



Photon collection uniformity

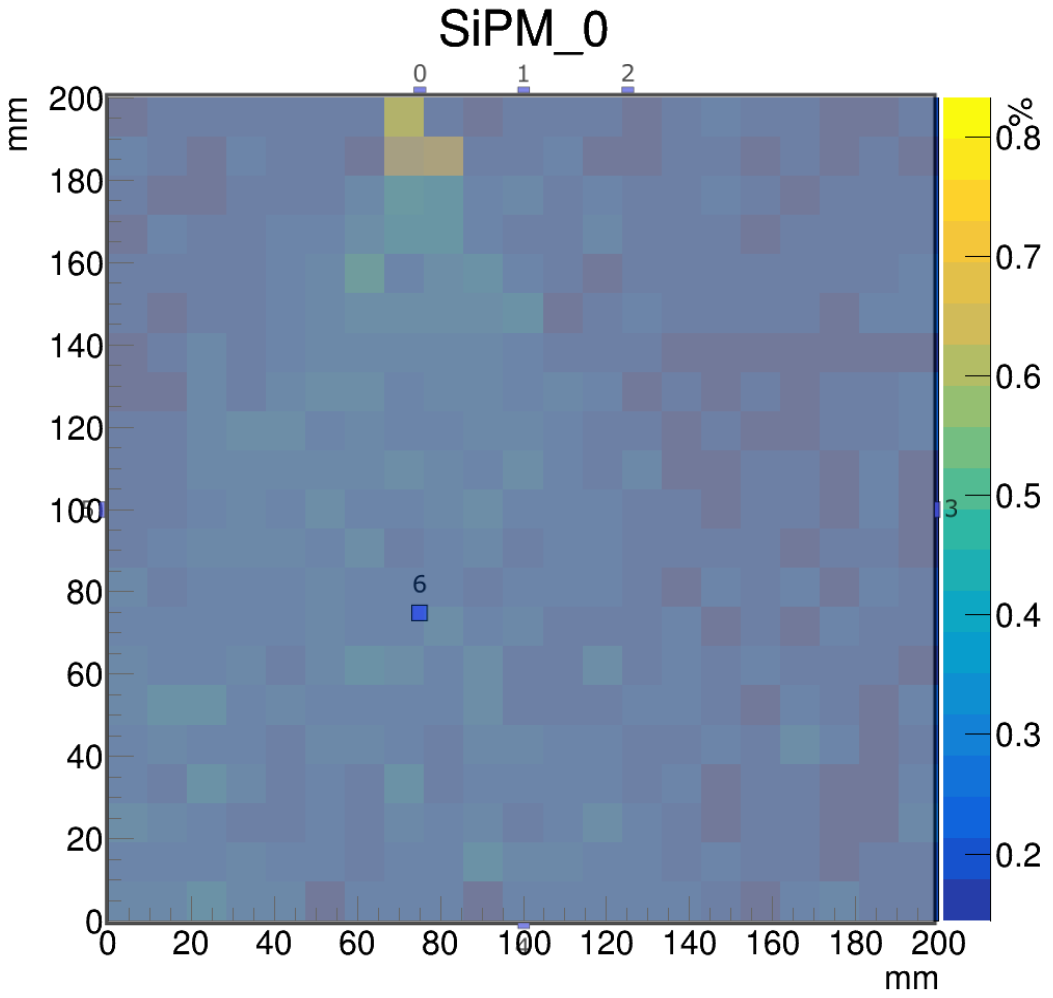
Tile B2 (10mm)

10 cm



Tile B2 (10mm)

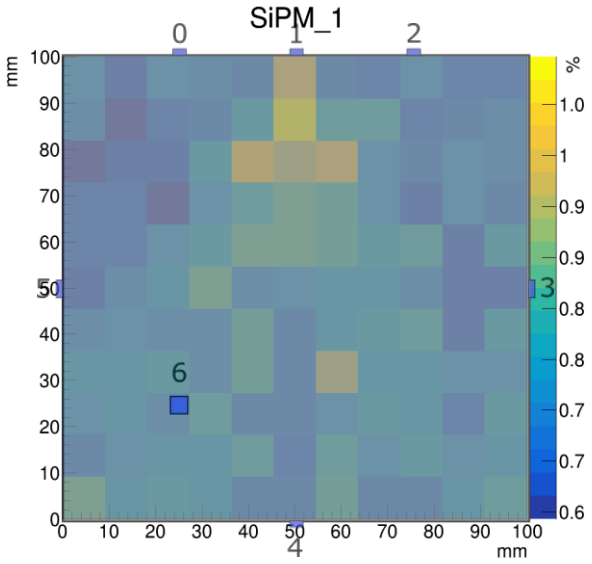
20 cm



Photon collection uniformity

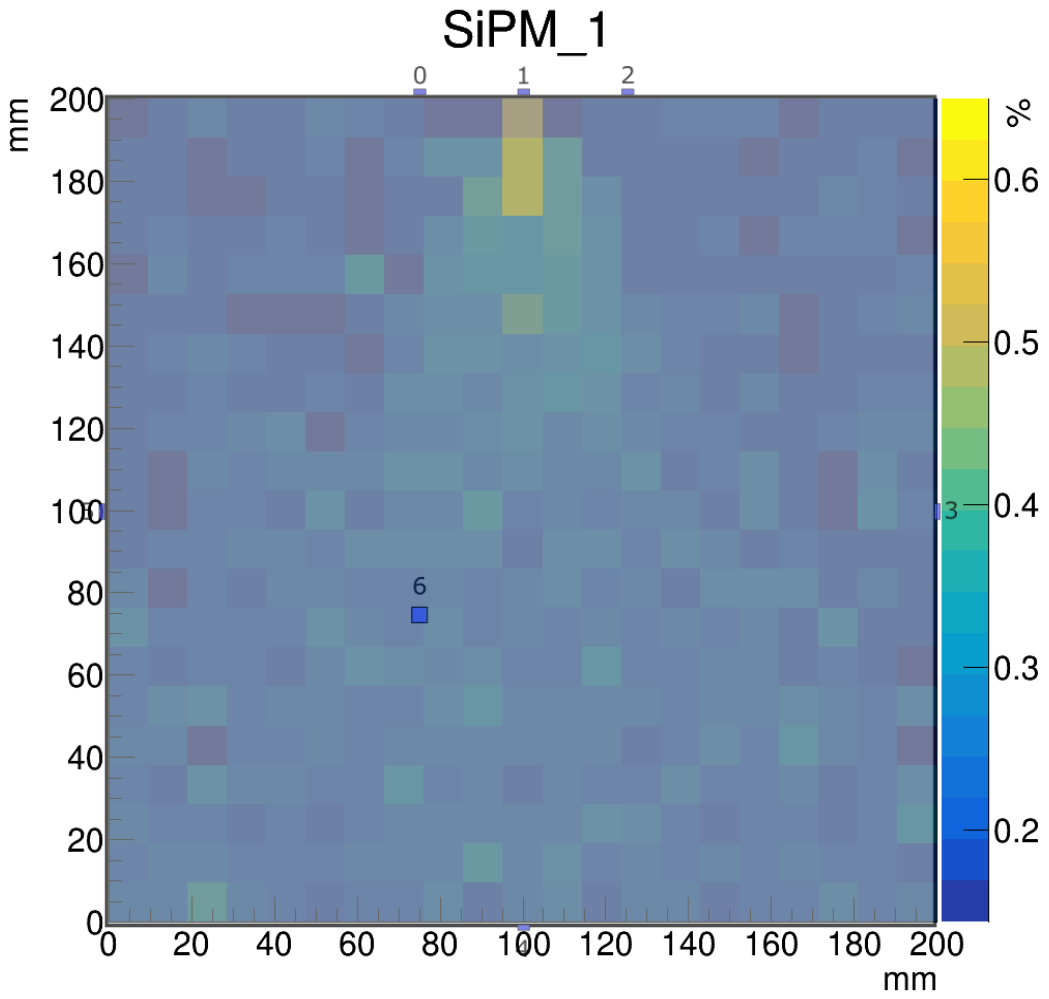
Tile B2 (10mm)

10 cm



Tile B2 (10mm)

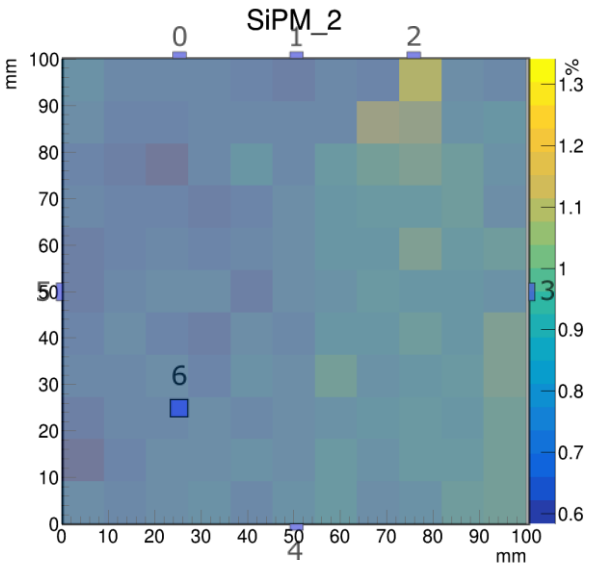
20 cm



Photon collection uniformity

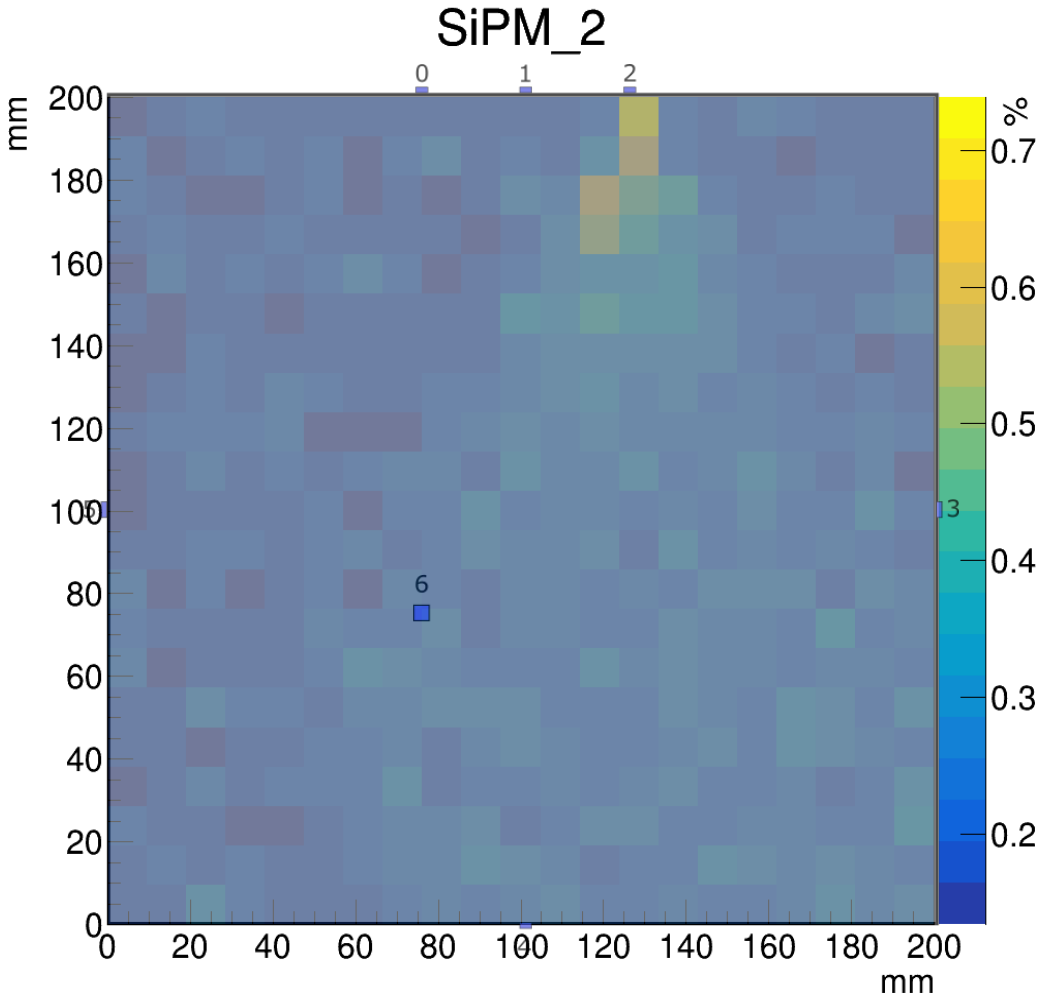
Tile B2 (10mm)

10 cm



Tile B2 (10mm)

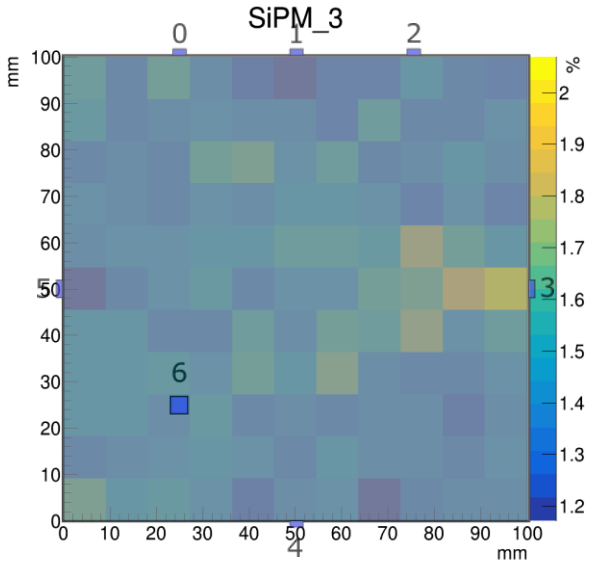
20 cm



Photon collection uniformity

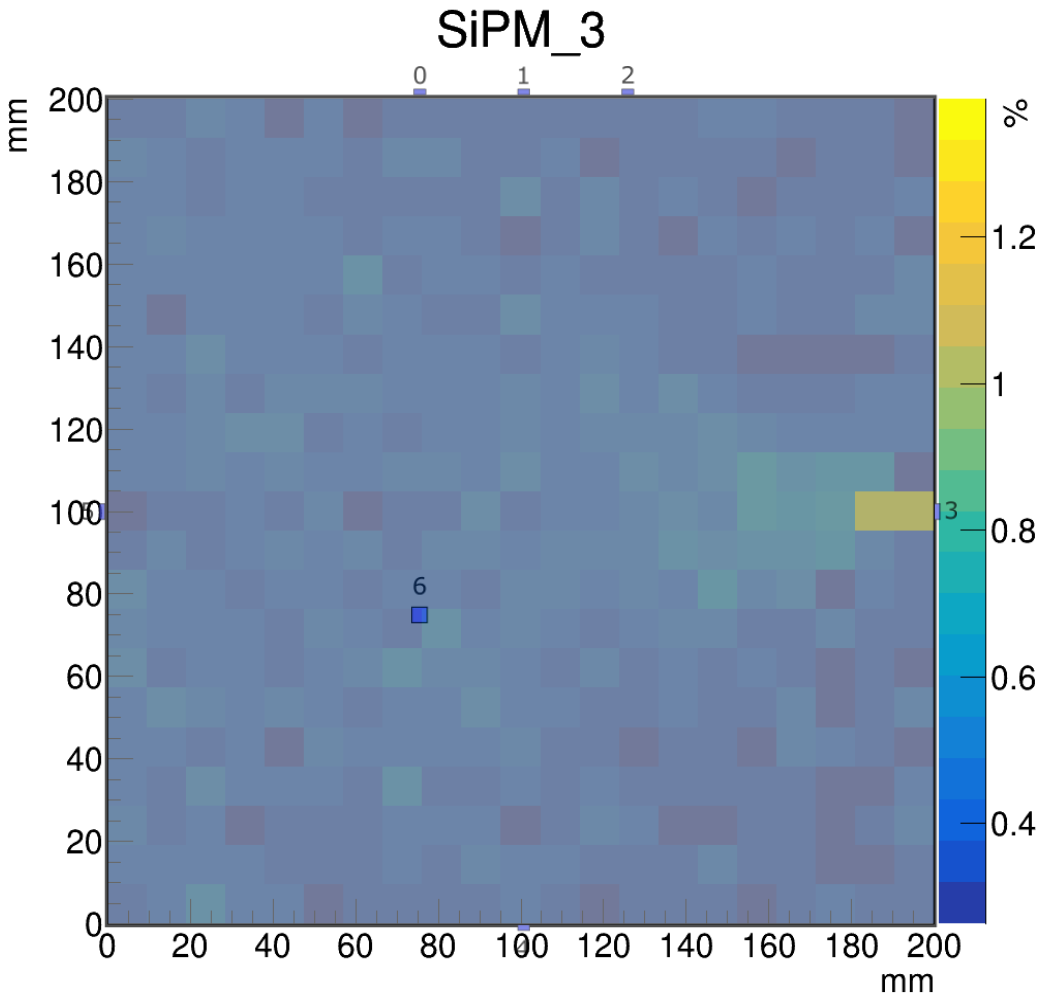
Tile B2 (10mm)

10 cm



Tile B2 (10mm)

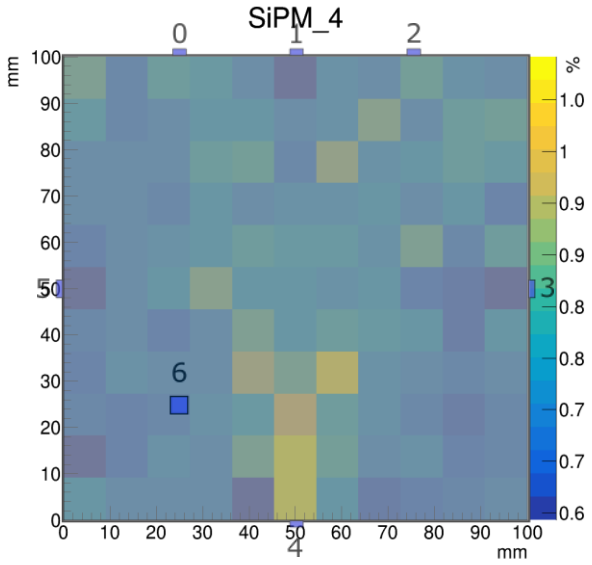
20 cm



Photon collection uniformity

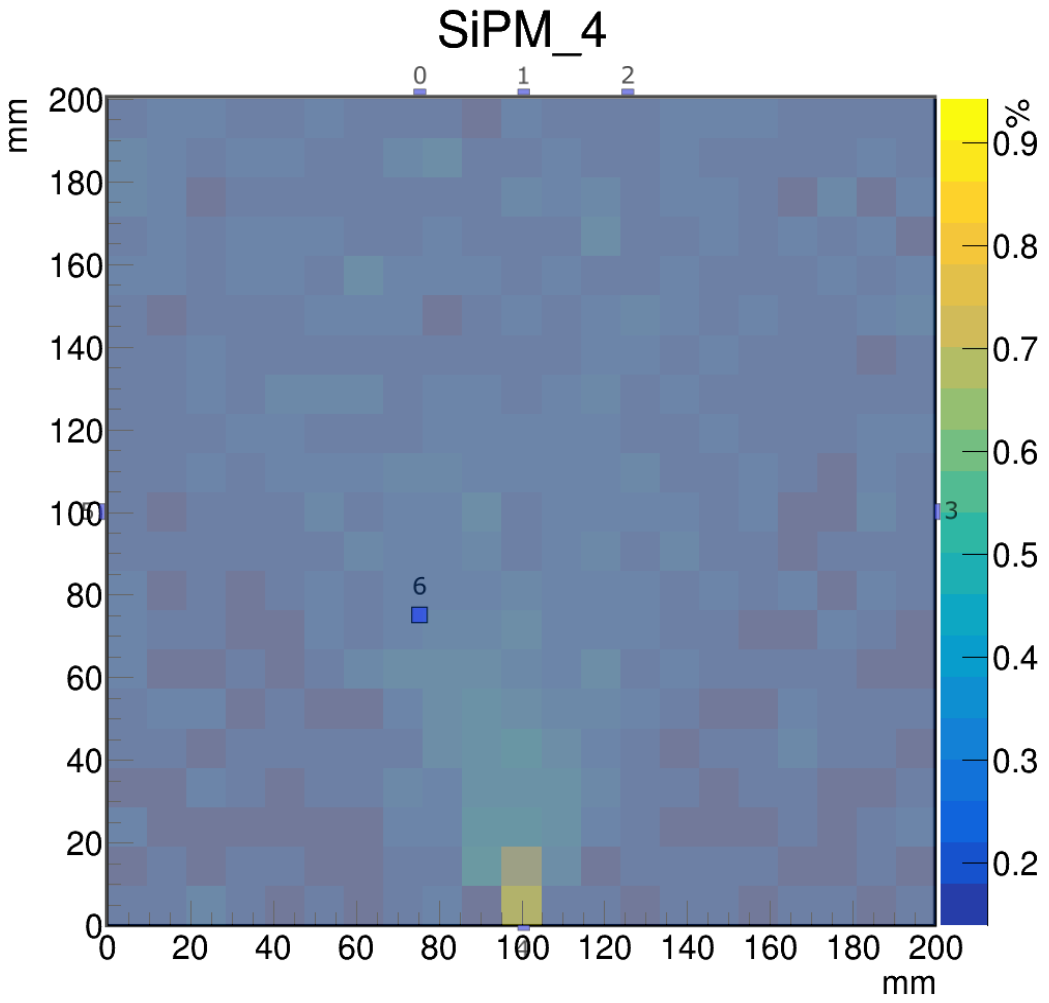
Tile B2 (10mm)

10 cm



Tile B2 (10mm)

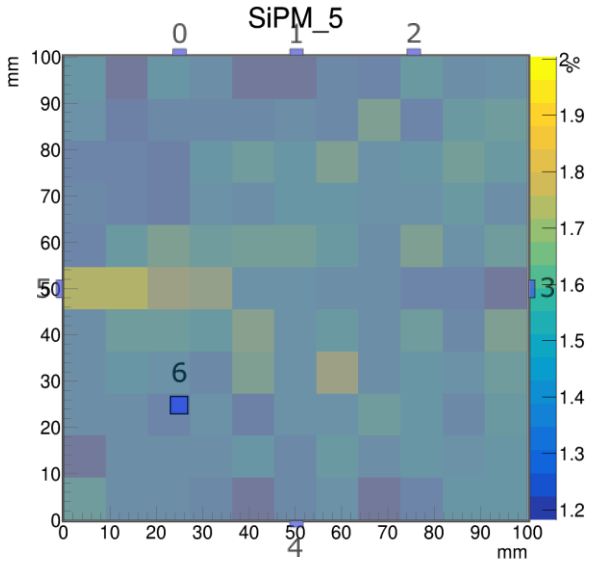
20 cm



Photon collection uniformity

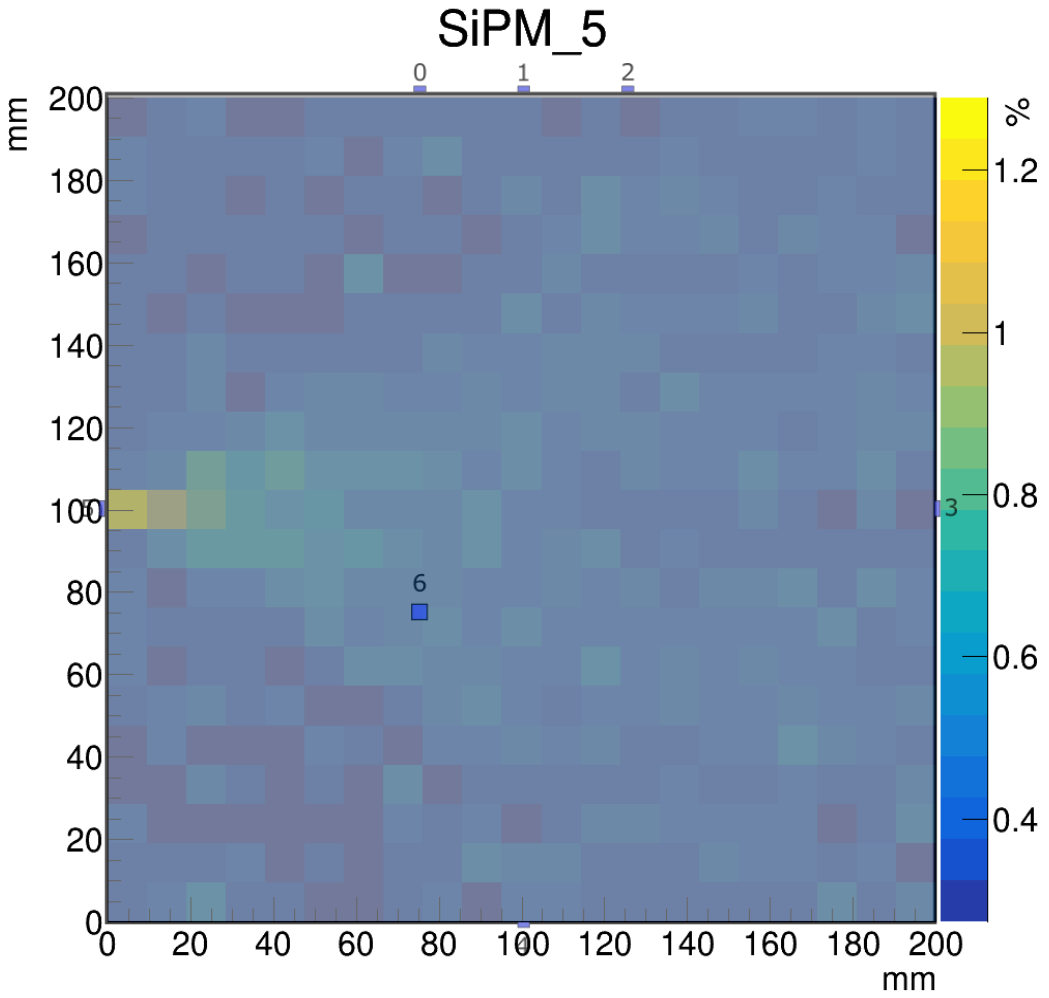
Tile B2 (10mm)

10 cm



Tile B2 (10mm)

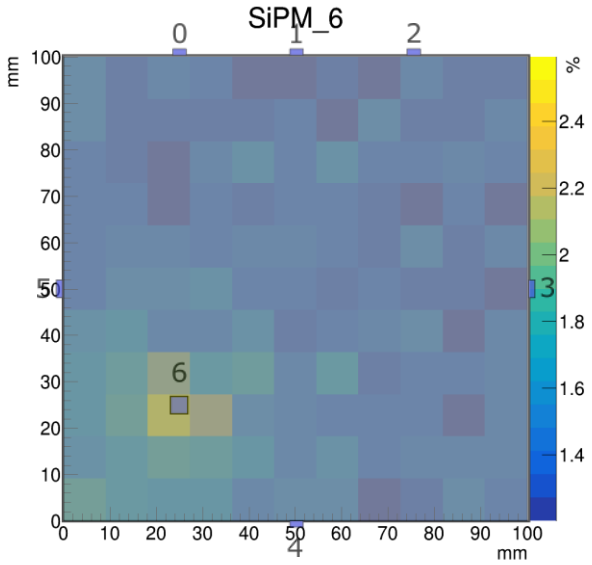
20 cm



Photon collection uniformity

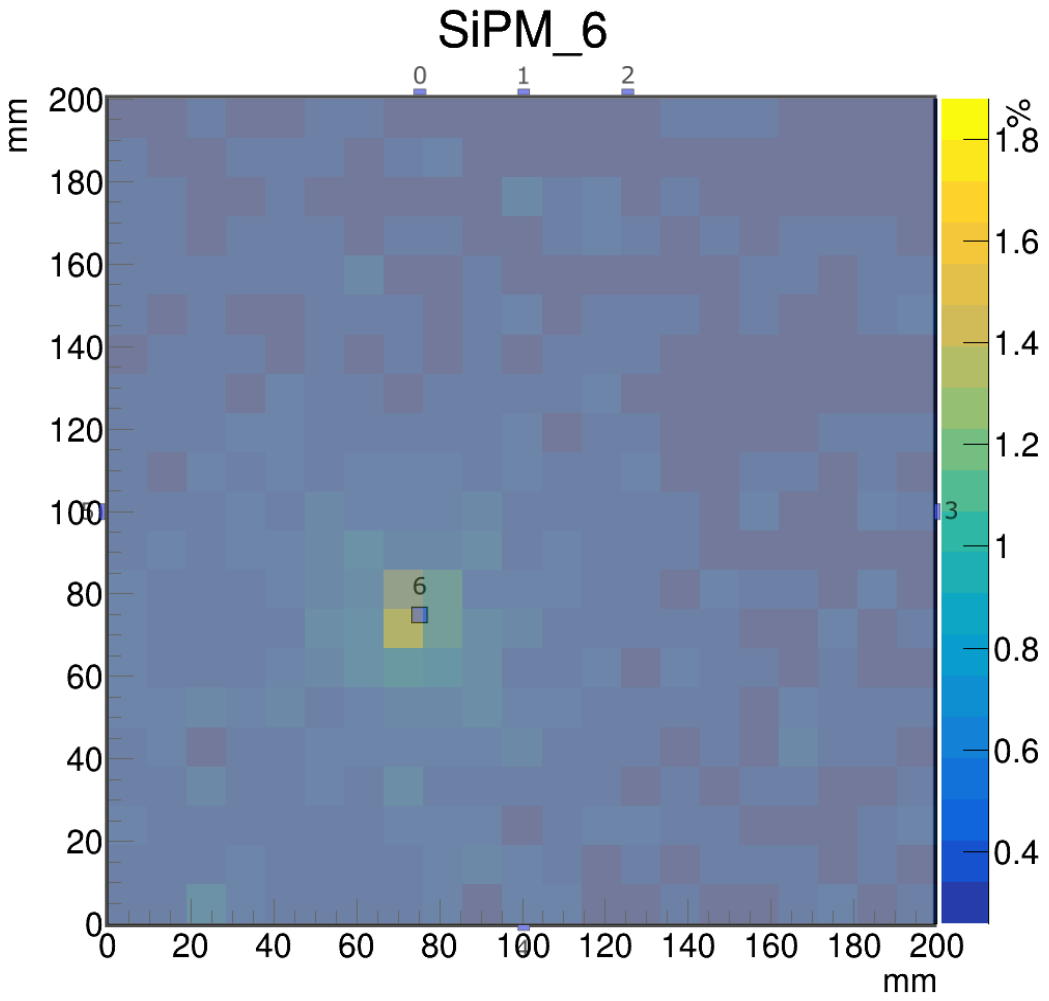
Tile B2 (10mm)

10 cm



Tile B2 (10mm)

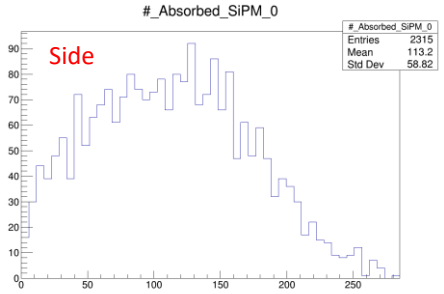
20 cm

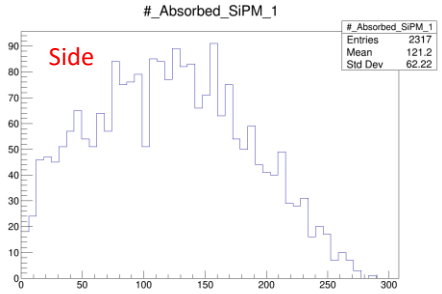


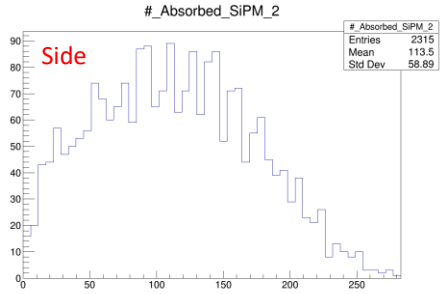
Backup

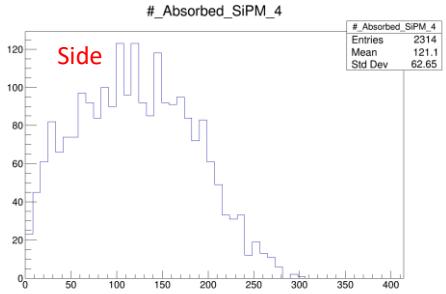
^{90}Sr Absorbed Photons*

Tile B1 (5 mm) -> 3mm SiPMs

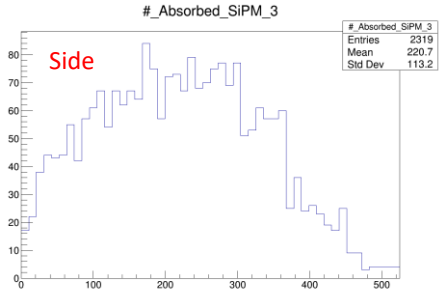


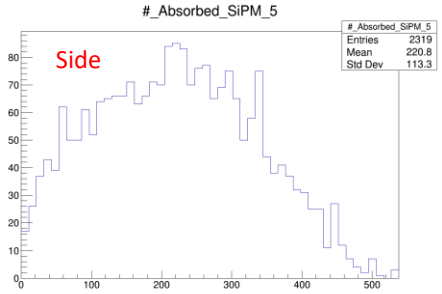


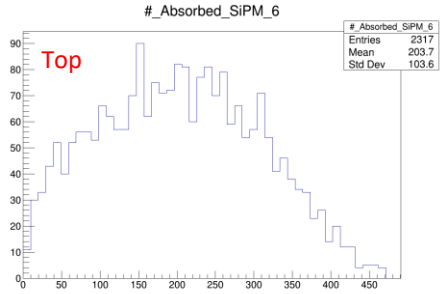




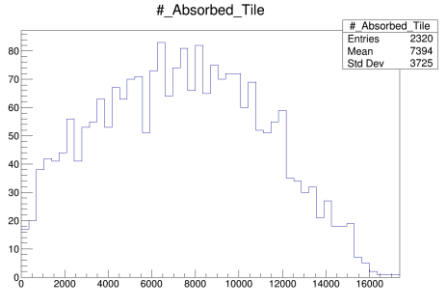
Tile B1 (5 mm) -> 4mm SiPMs

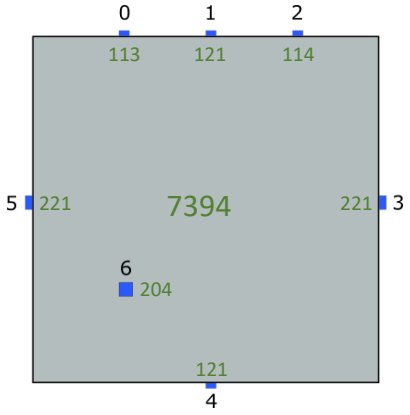






Tile B1 (5 mm) -> Tile



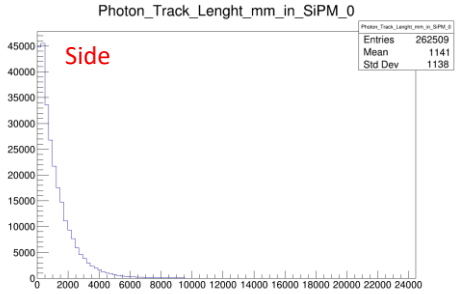


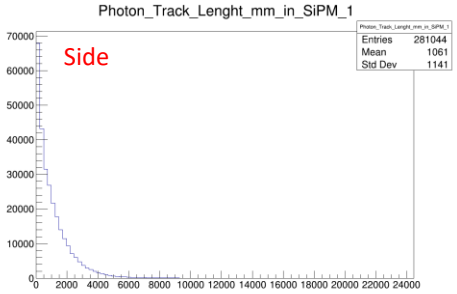
*10 k events simulated

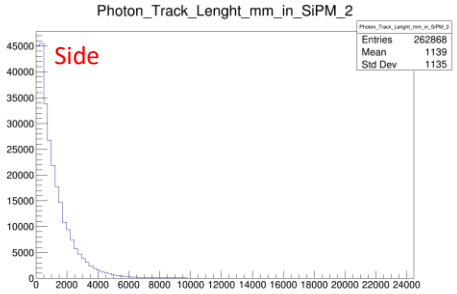
100% Reflectivity

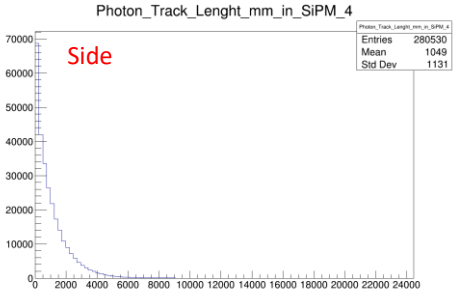
^{90}Sr Tracklength*

Tile B1 (5 mm) -> 3mm SiPMs

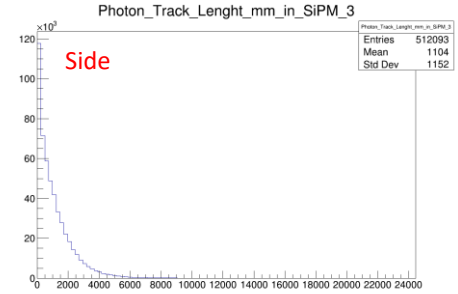


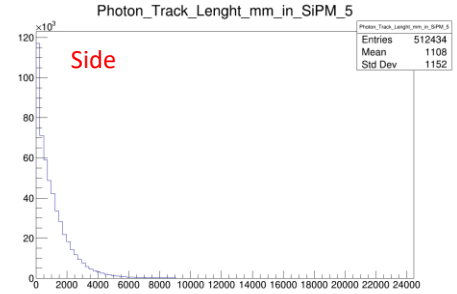


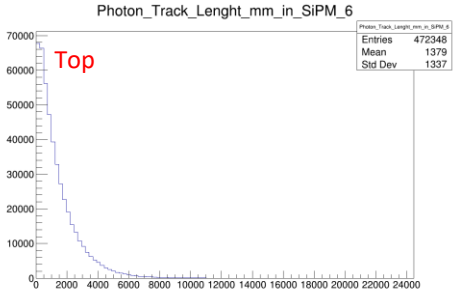




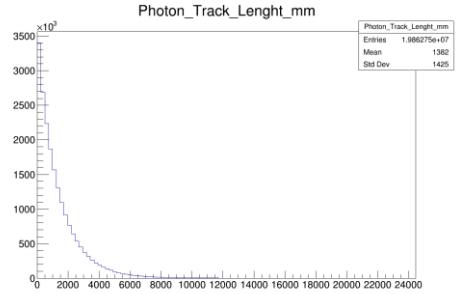
Tile B1 (5 mm) -> 4mm SiPMs

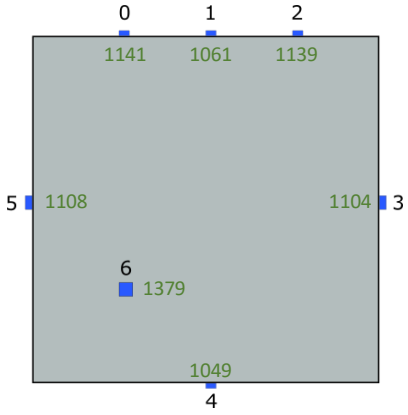






Tile B1 (5 mm) -> Total



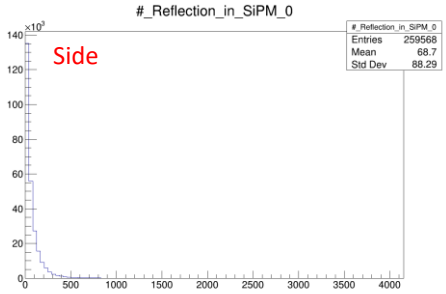


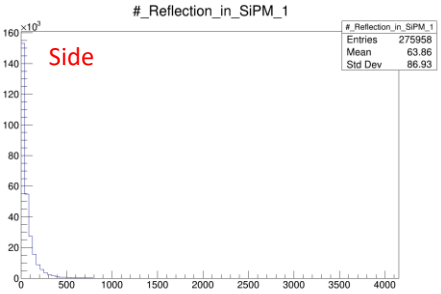
*10 k events simulated

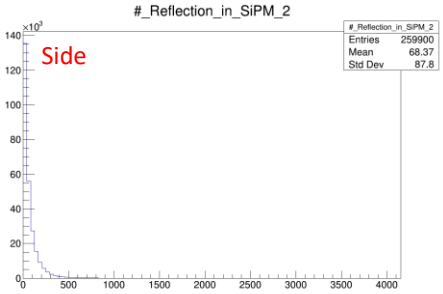
100% Reflectivity

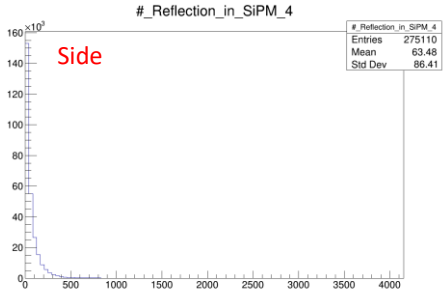
^{90}Sr Reflections*

Tile B1 (5 mm) -> 3mm SiPMs

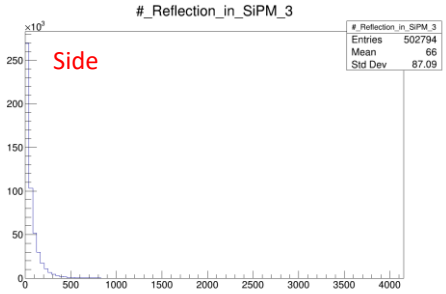


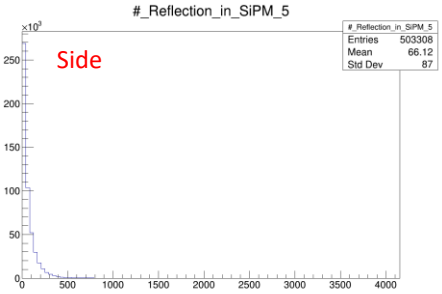


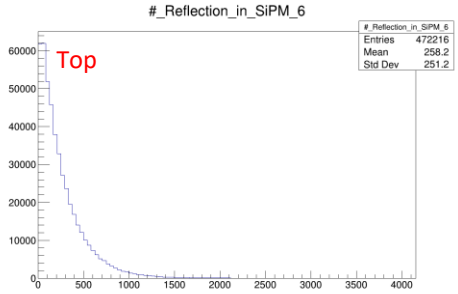




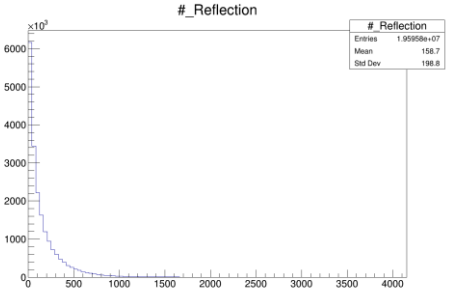
Tile B1 (5 mm) -> 4mm SiPMs

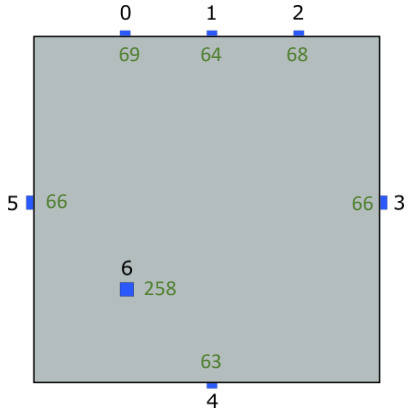






Tile B1 (5 mm) -> Total



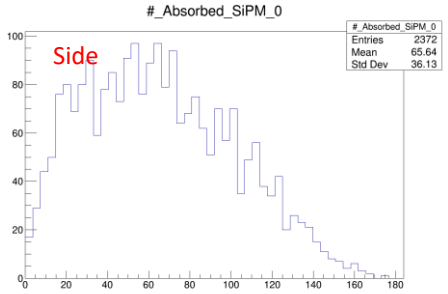


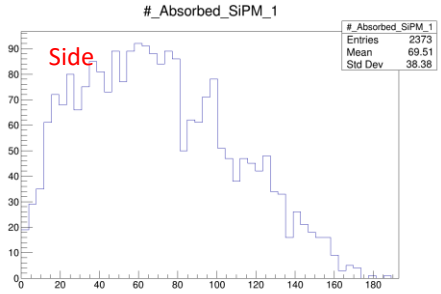
*10 k events simulated

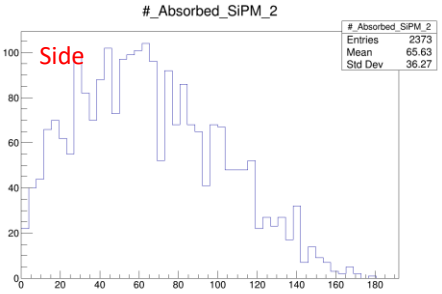
100% Reflectivity

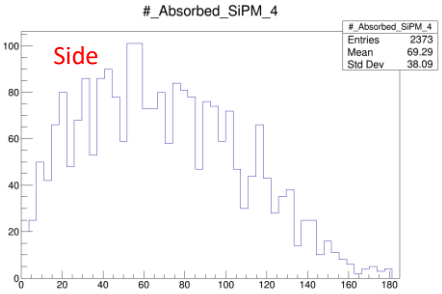
^{90}Sr Absorbed Photons*

Tile B2 (10 mm) -> 3mm SiPMs

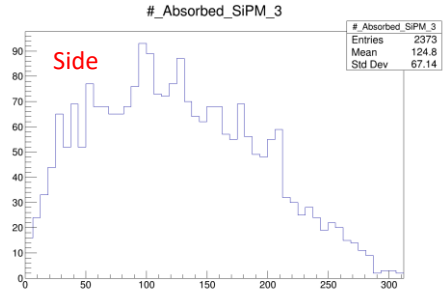


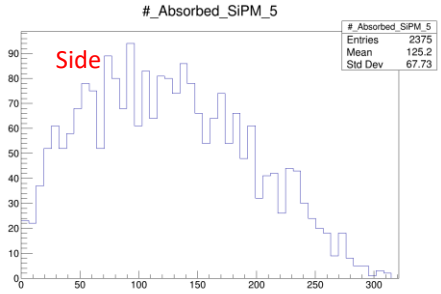


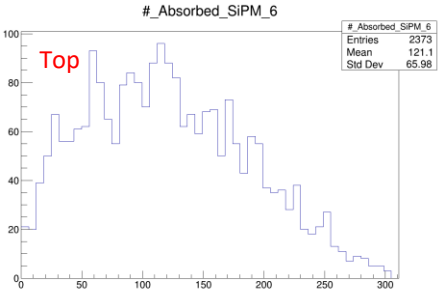




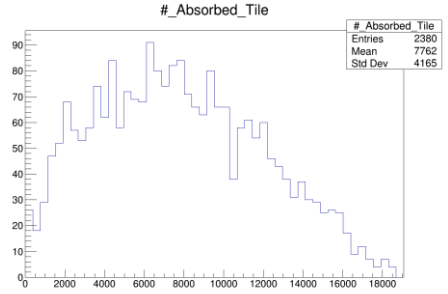
Tile B2 (10 mm) -> 4mm SiPMs

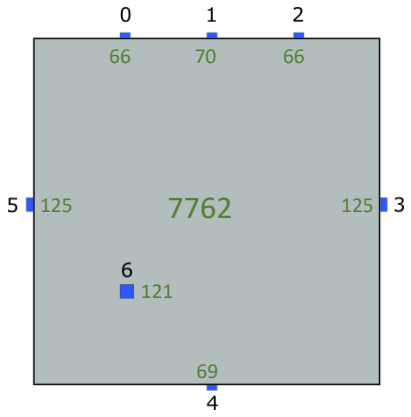






Tile B2 (10 mm) -> Tile



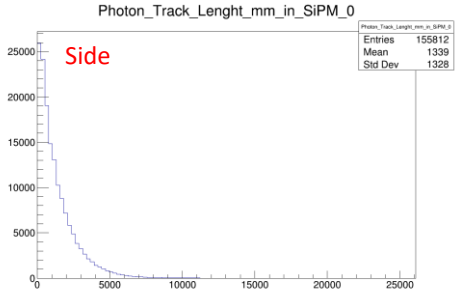


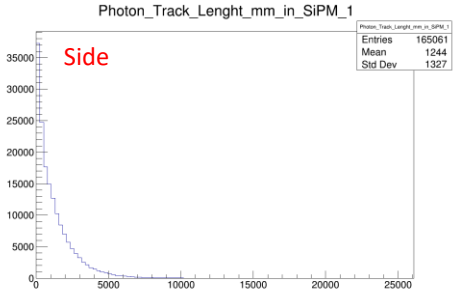
*10 k events simulated

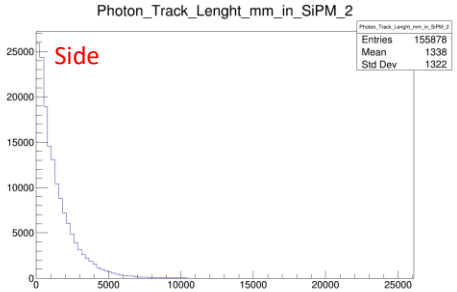
100% Reflectivity

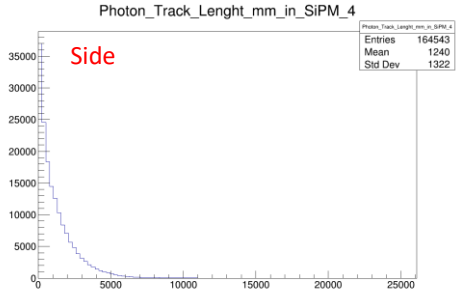
^{90}Sr Tracklength*

Tile B2 (10 mm) -> 3mm SiPMs

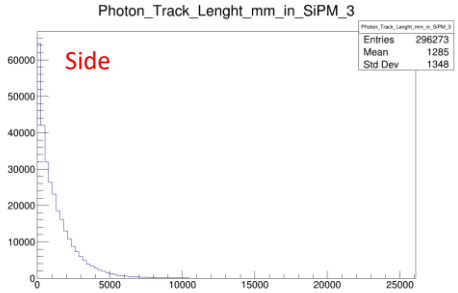


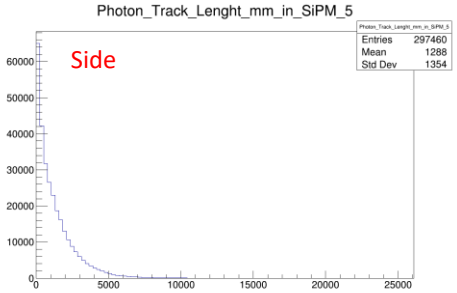


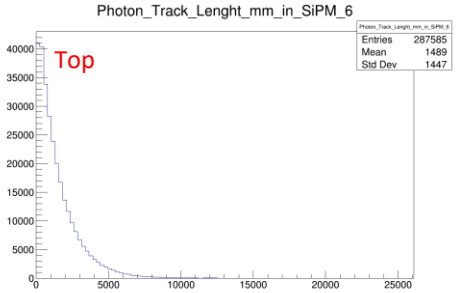




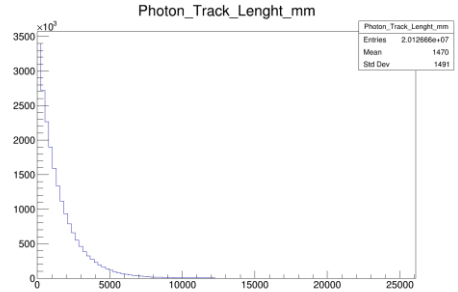
Tile B2 (10 mm) -> 4mm SiPMs

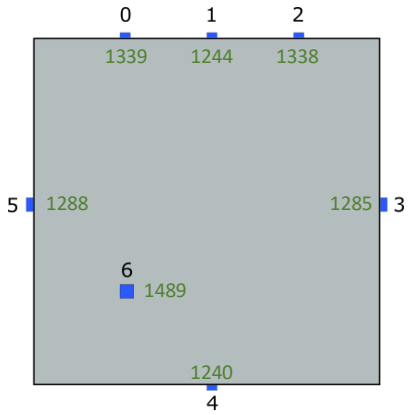






Tile B2 (10 mm) -> Total



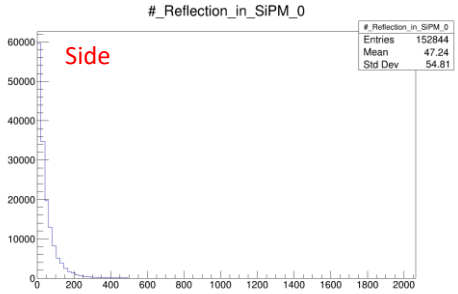


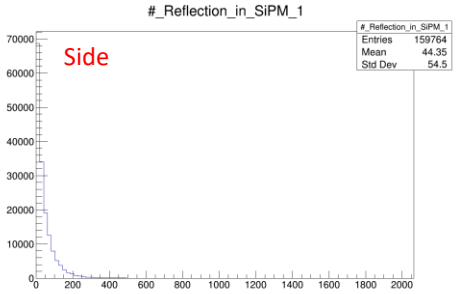
*10 k events simulated

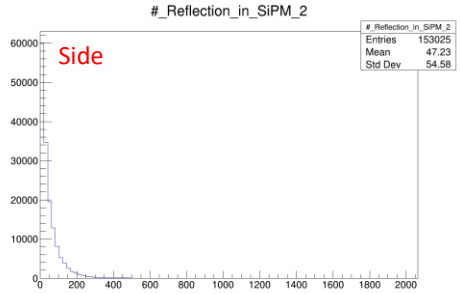
100% Reflectivity

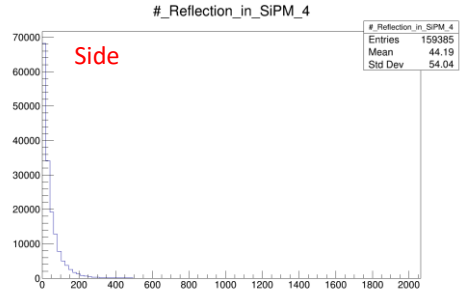
^{90}Sr Reflections*

Tile B2 (10 mm) -> 3mm SiPMs

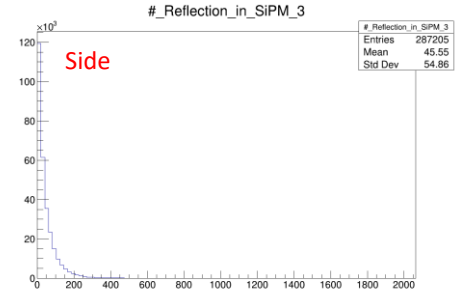


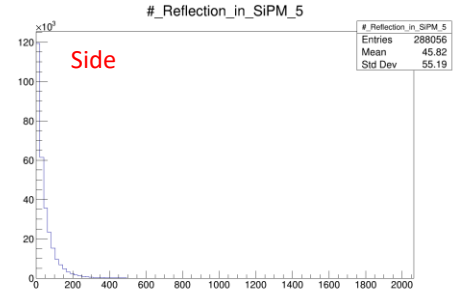


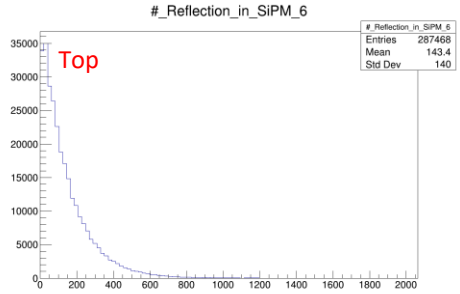




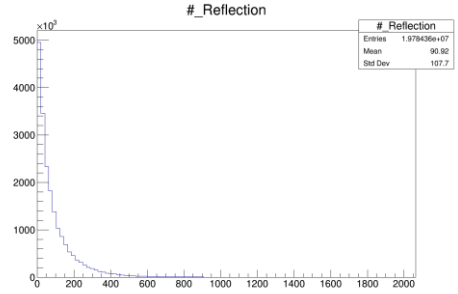
Tile B2 (10 mm) -> 4mm SiPMs

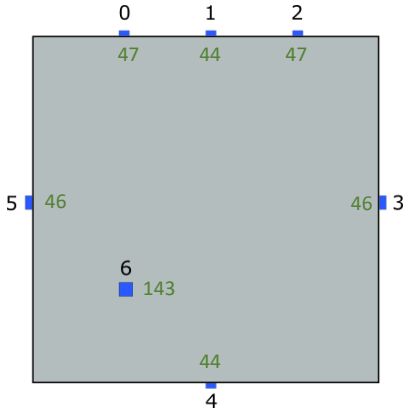






Tile B2 (10 mm) -> Total



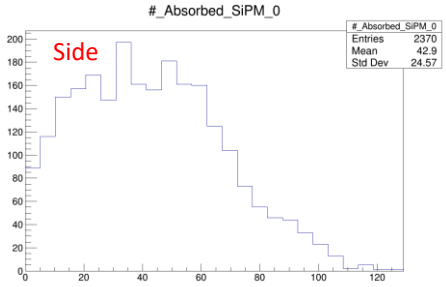


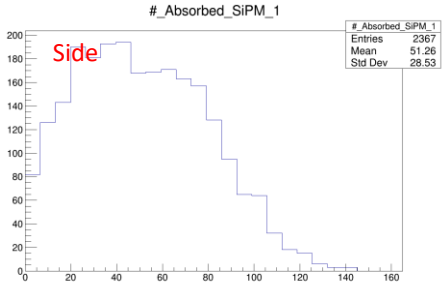
*10 k events simulated

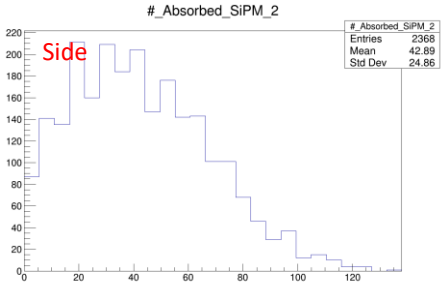
100% Reflectivity

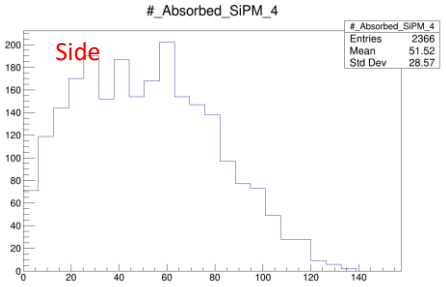
^{90}Sr Absorbed Photons*

Tile B1 (5 mm) -> 3mm SiPMs

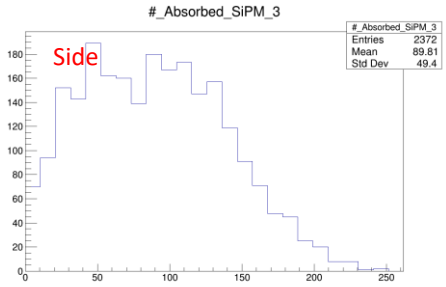


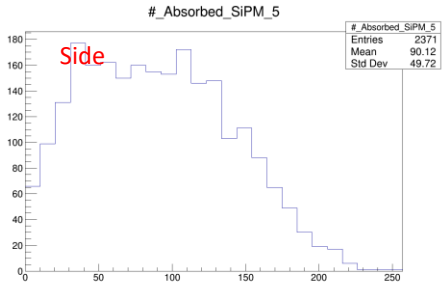


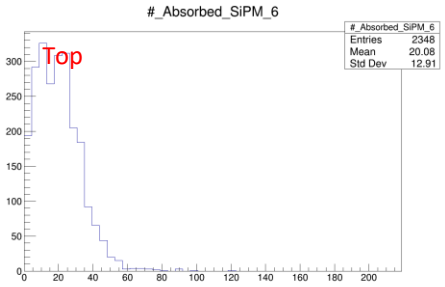




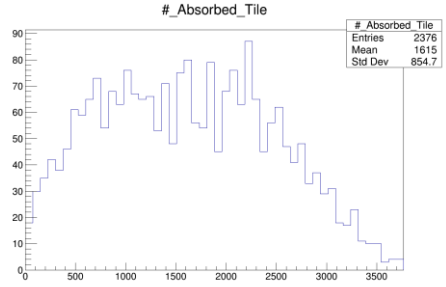
Tile B1 (5 mm) -> 4mm SiPMs

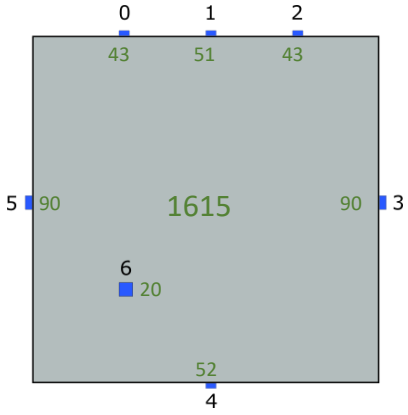






Tile B1 (5 mm) -> Tile



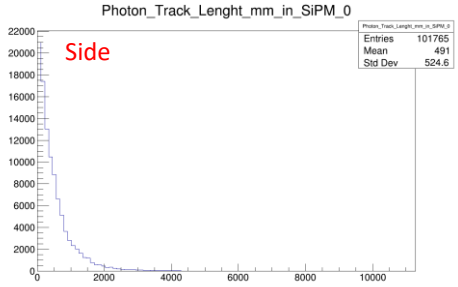


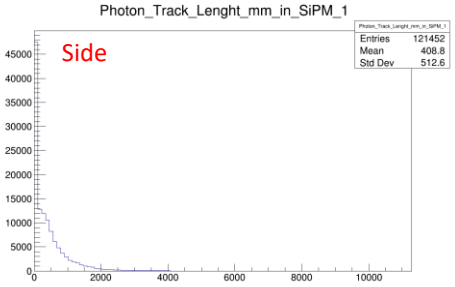
*10 k events simulated

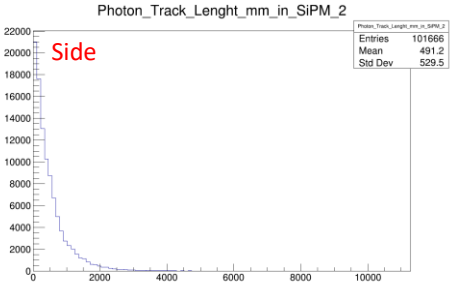
97.1% Reflectivity

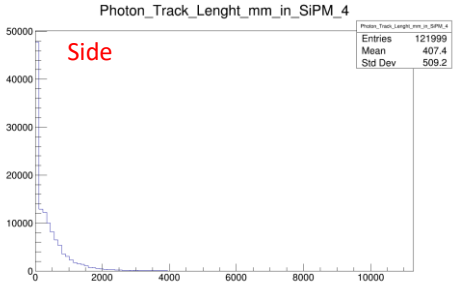
^{90}Sr Tracklength*

Tile B1 (5 mm) -> 3mm SiPMs

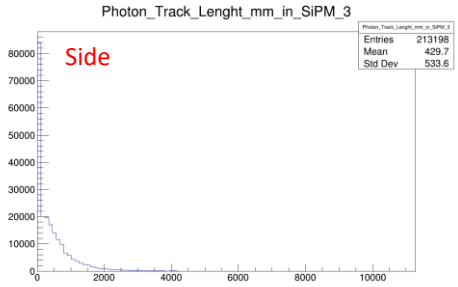


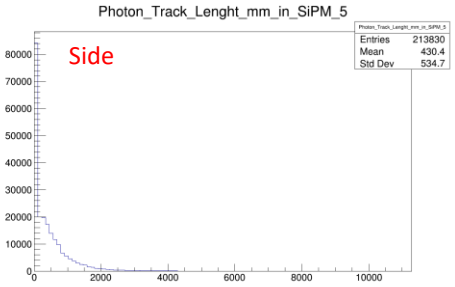


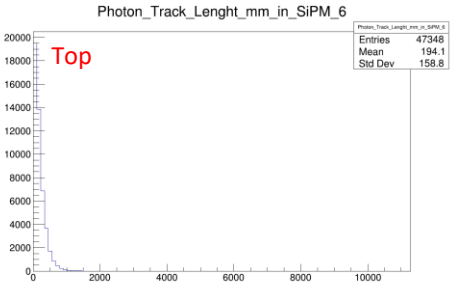




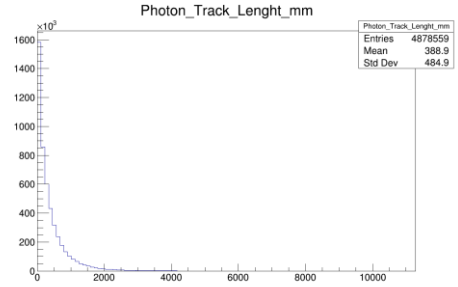
Tile B1 (5 mm) -> 4mm SiPMs

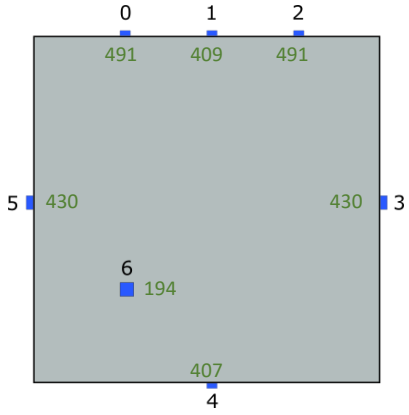






Tile B1 (5 mm) -> Total



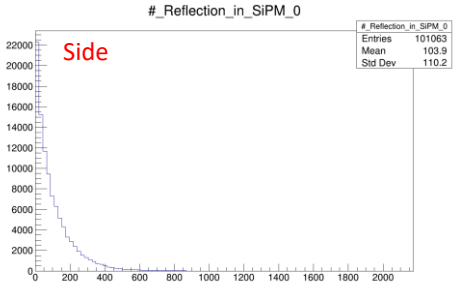


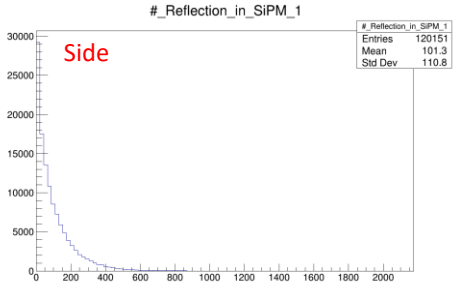
*10 k events simulated

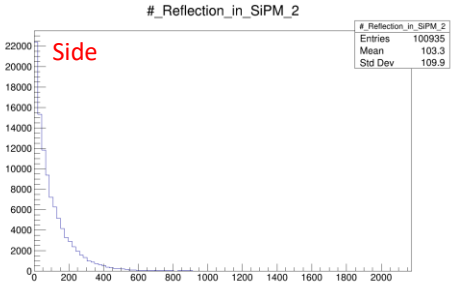
97.1% Reflectivity

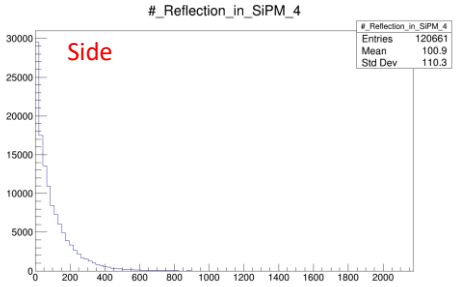
^{90}Sr Reflections*

Tile B1 (5 mm) -> 3mm SiPMs

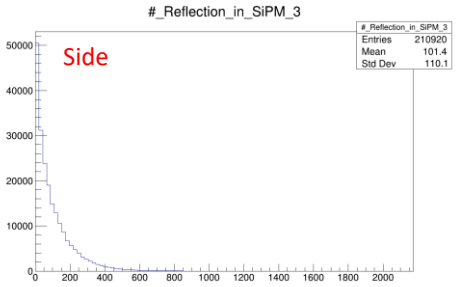


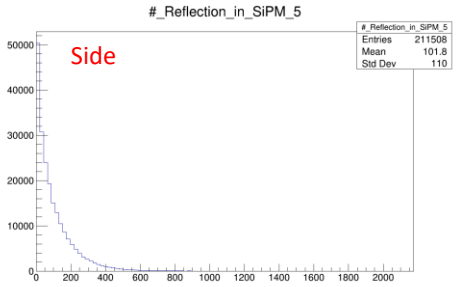


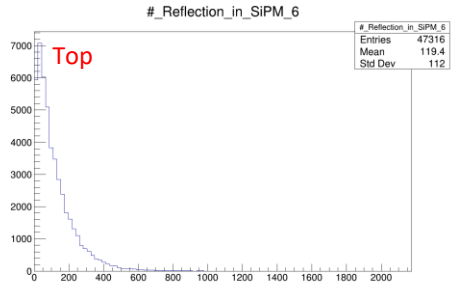




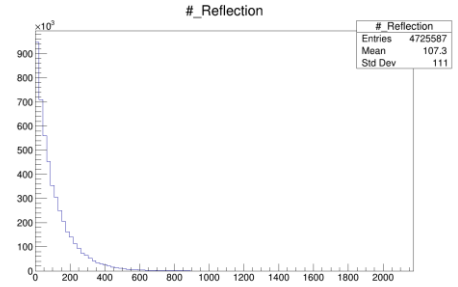
Tile B1 (5 mm) -> 4mm SiPMs

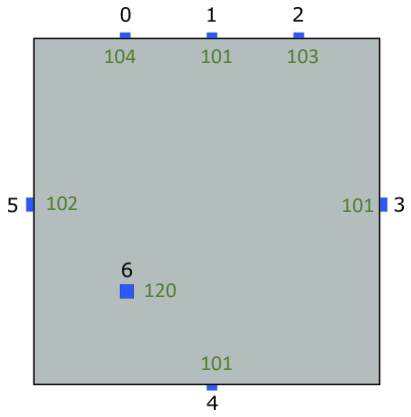






Tile B1 (5 mm) -> Total



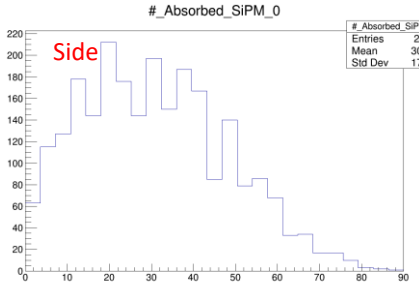


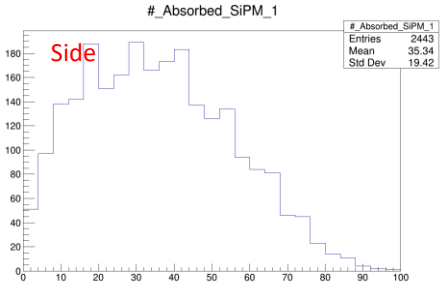
*10 k events simulated

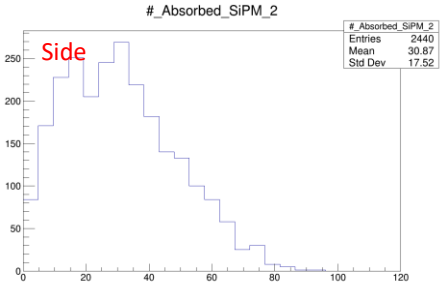
97.1% Reflectivity

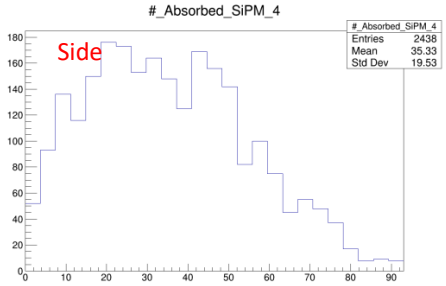
^{90}Sr Absorbed Photons*

Tile B2 (10 mm) -> 3mm SiPMs

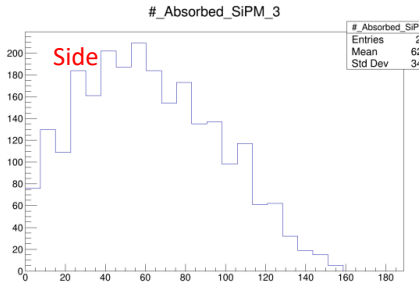


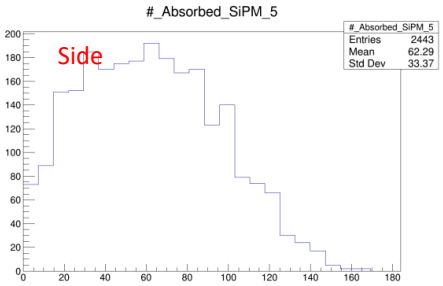


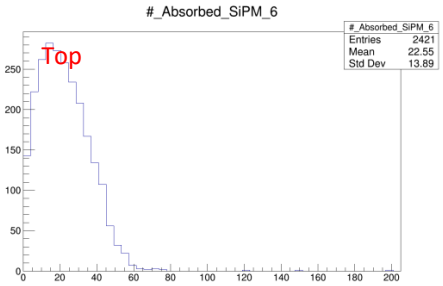




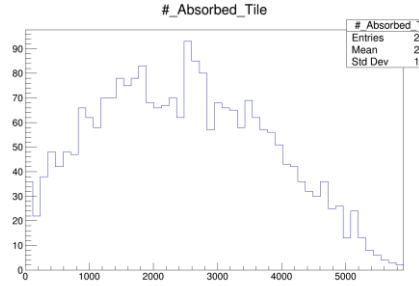
Tile B2 (10 mm) -> 4mm SiPMs

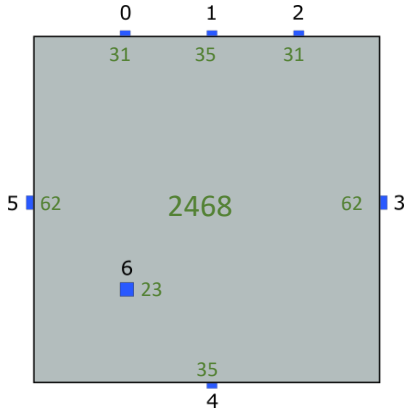






Tile B2 (10 mm) -> Tile



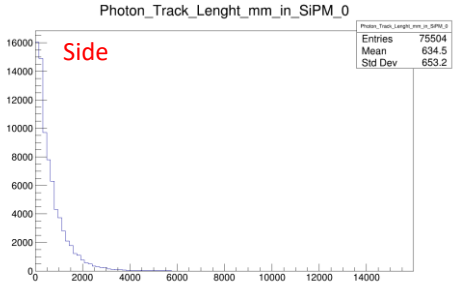


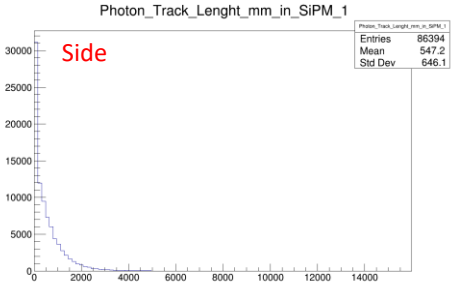
*10 k events simulated

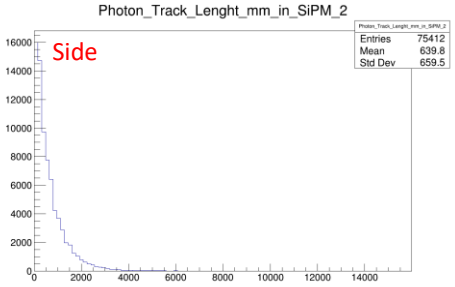
97.1% Reflectivity

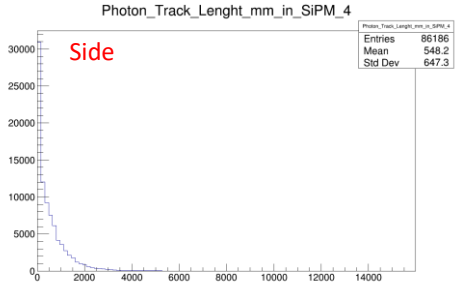
^{90}Sr Tracklength*

Tile B2 (10 mm) -> 3mm SiPMs

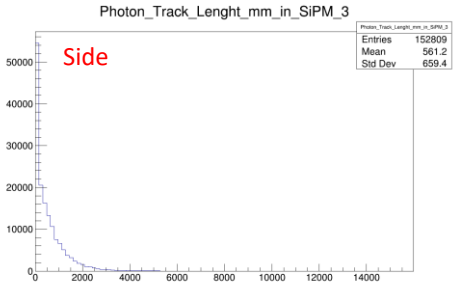


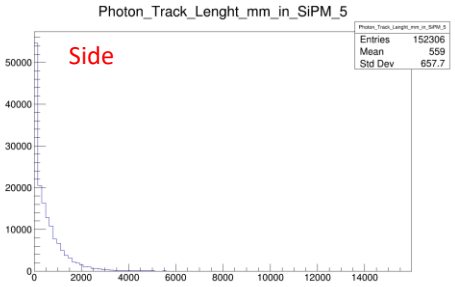


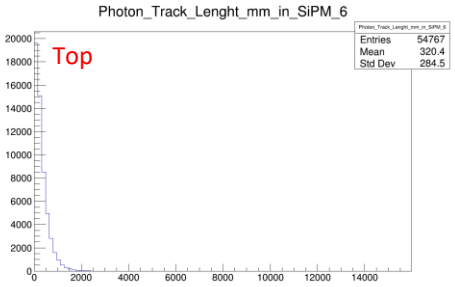




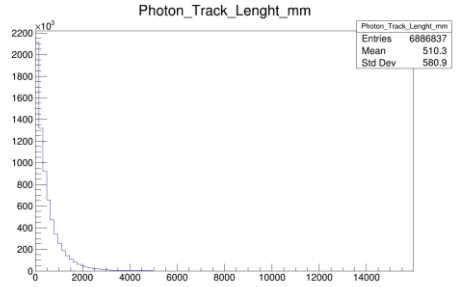
Tile B2 (10 mm) -> 4mm SiPMs

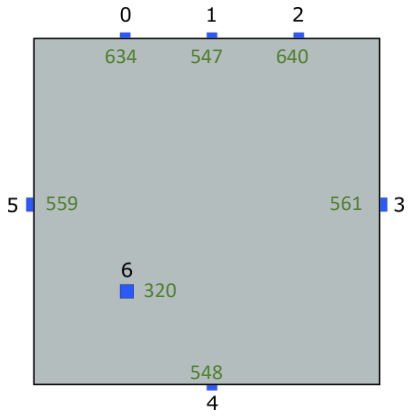






Tile B2 (10 mm) -> Total



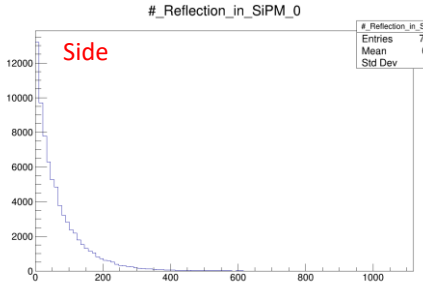


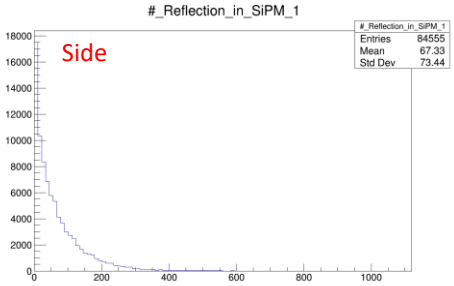
*10 k events simulated

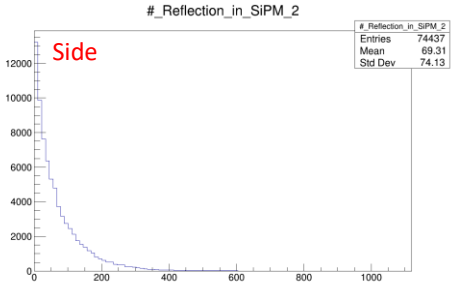
97.1% Reflectivity

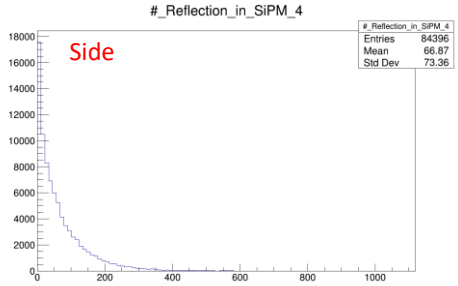
^{90}Sr Reflections*

Tile B2 (10 mm) -> 3mm SiPMs

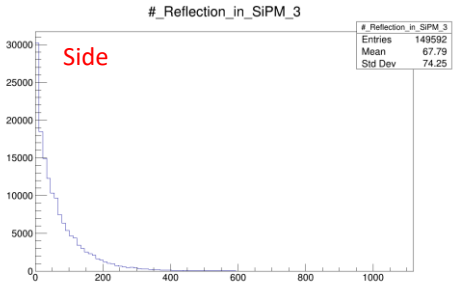


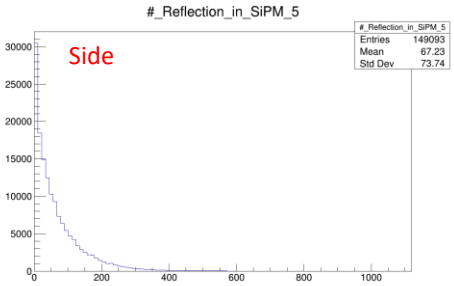


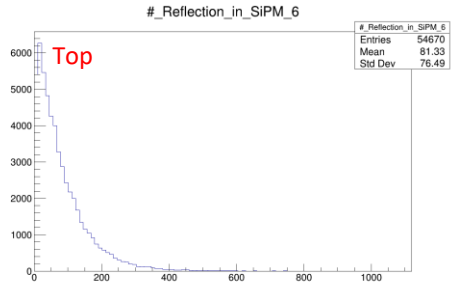




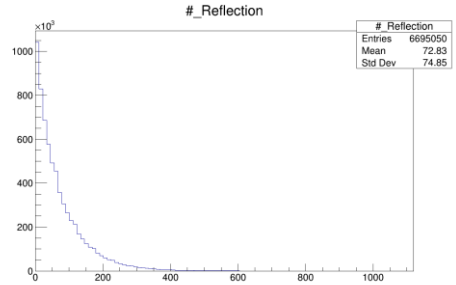
Tile B2 (10 mm) -> 4mm SiPMs

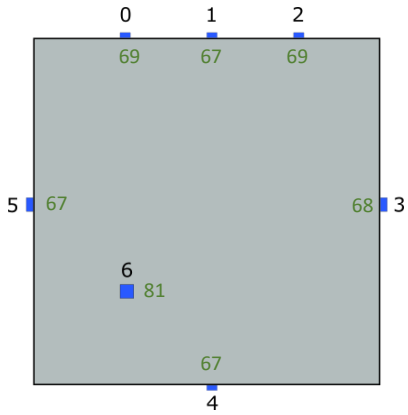






Tile B2 (10 mm) -> Total



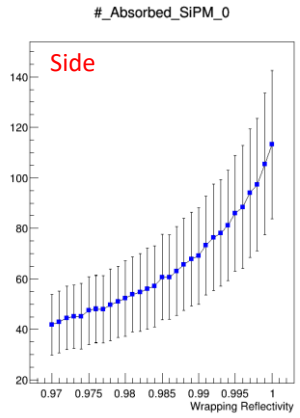


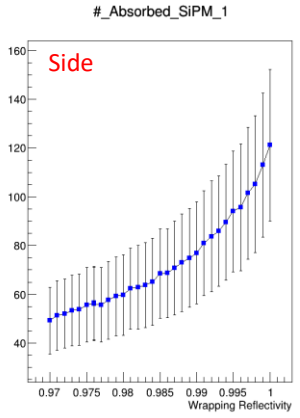
*10 k events simulated

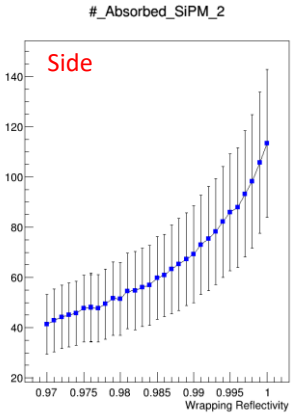
97.1% Reflectivity

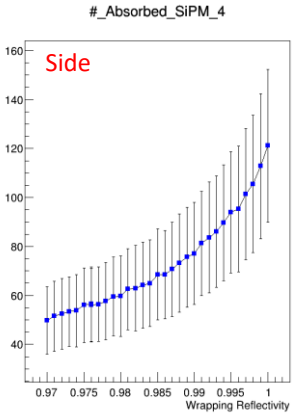
Reflectivity dependence*

Tile B1 (5 mm) -> 3mm SiPMs

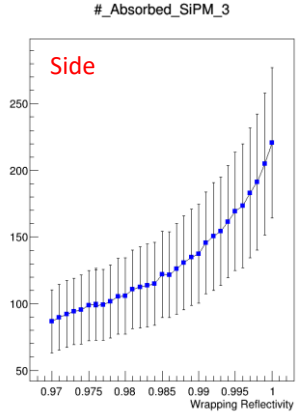


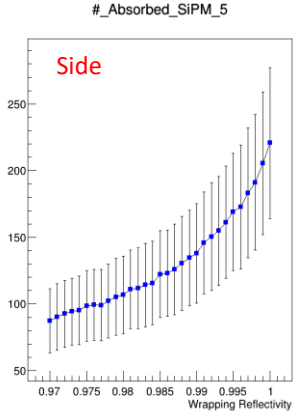


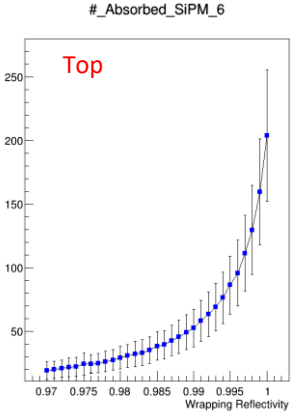


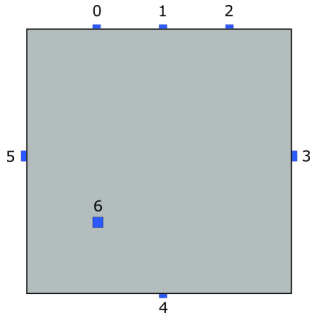


Tile B1 (5 mm) -> 4mm SiPMs





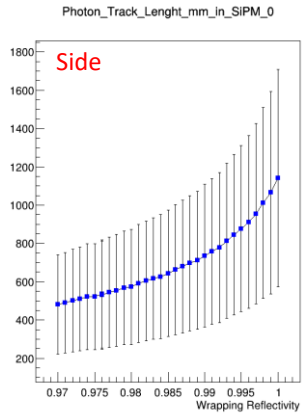


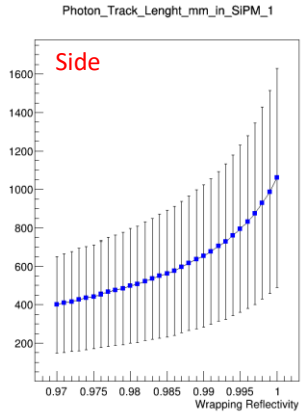


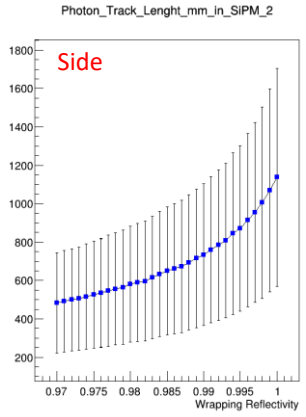
*Photons Absorbed

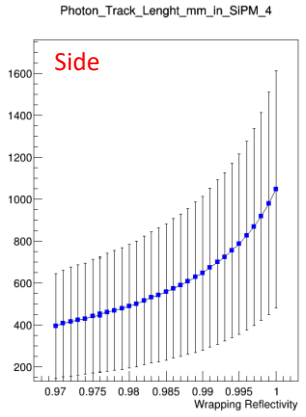
Reflectivity dependence*

Tile B1 (5 mm) -> 3mm SiPMs

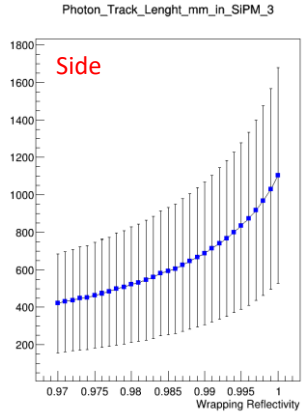


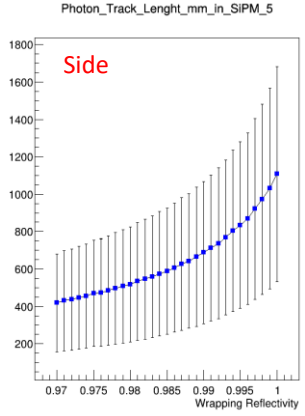


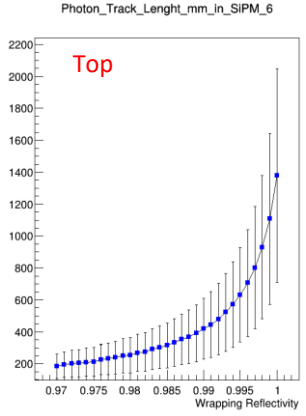


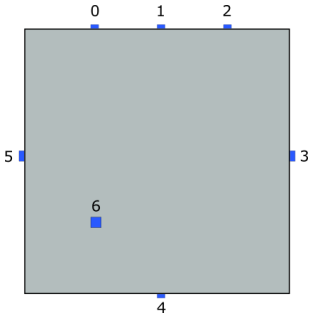


Tile B1 (5 mm) -> 4mm SiPMs





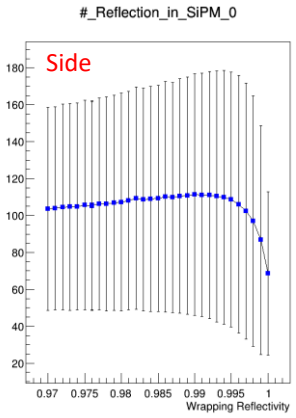


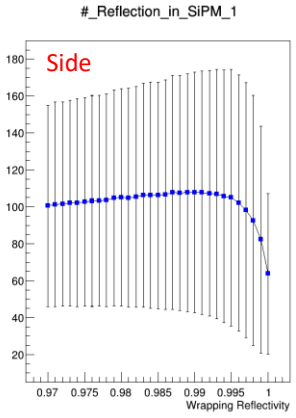


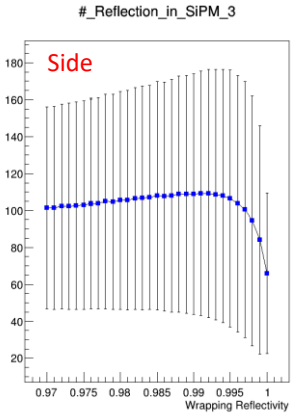
*Track Length

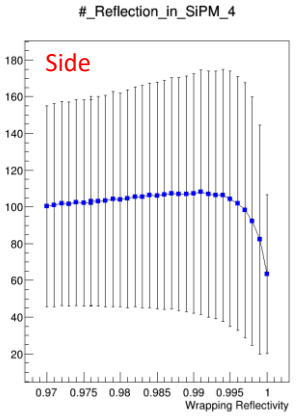
Reflectivity dependence*

Tile B1 (5 mm) -> 3mm SiPMs

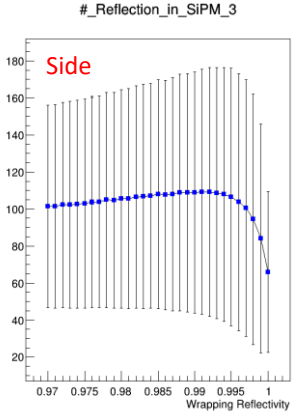


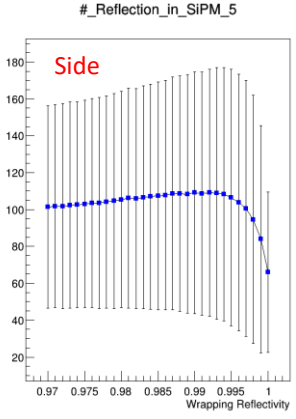


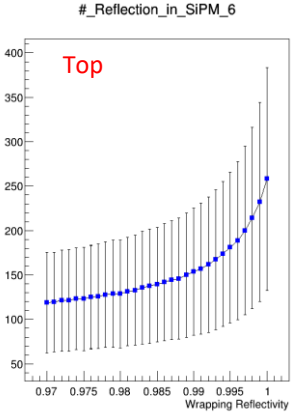


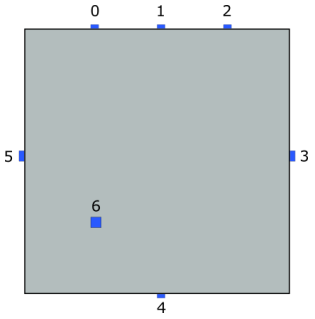


Tile B1 (5 mm) -> 4mm SiPMs





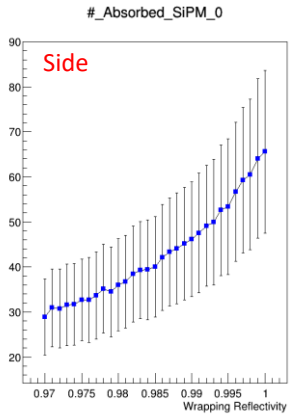


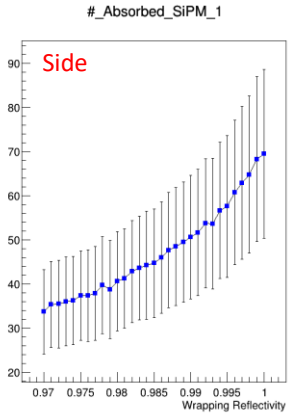


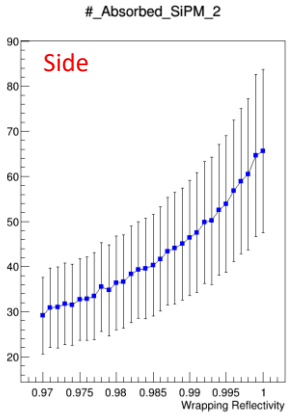
*Number of Reflections

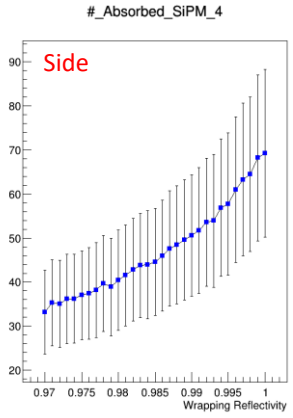
Reflectivity dependence*

Tile B2 (10 mm) -> 3mm SiPMs

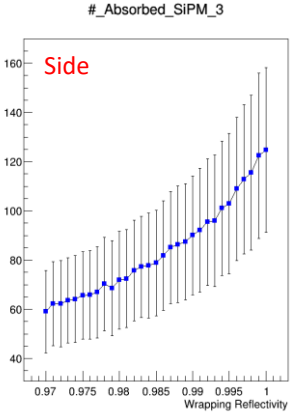


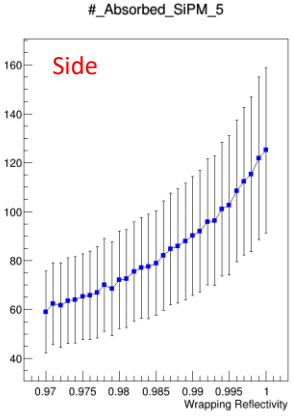


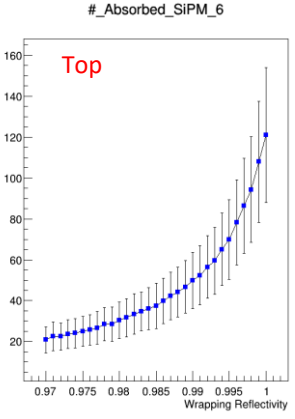


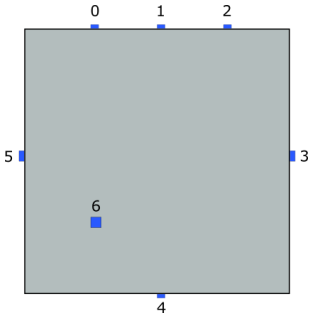


Tile B2 (10 mm) -> 4mm SiPMs





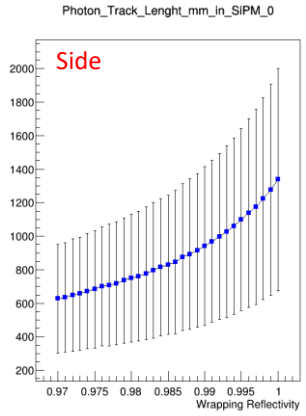


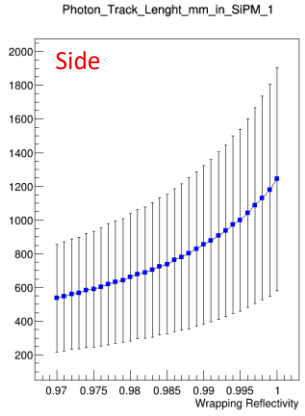


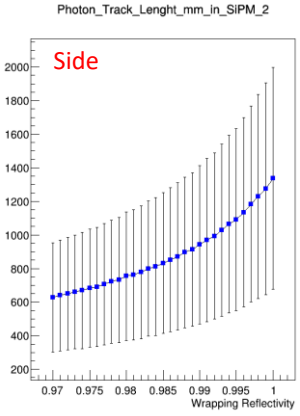
*Photons Absorbed

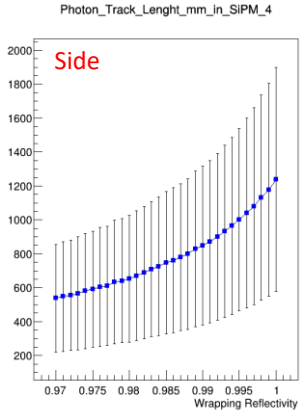
Reflectivity dependence*

Tile B2 (10 mm) -> 3mm SiPMs

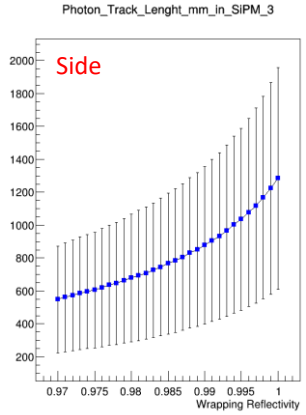


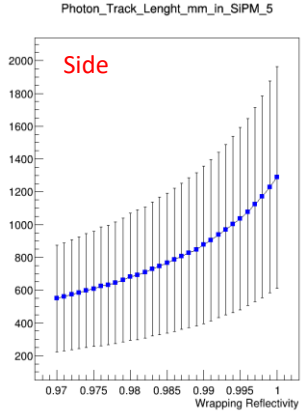


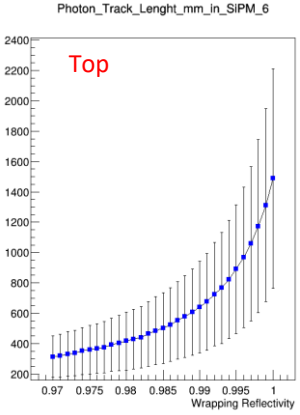


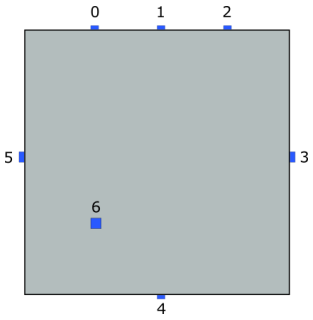


Tile B2 (10 mm) -> 4mm SiPMs





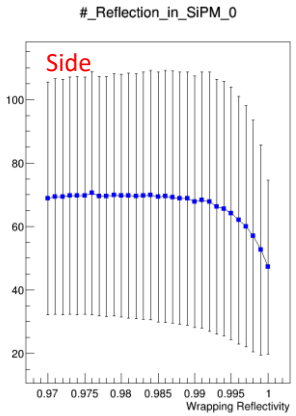


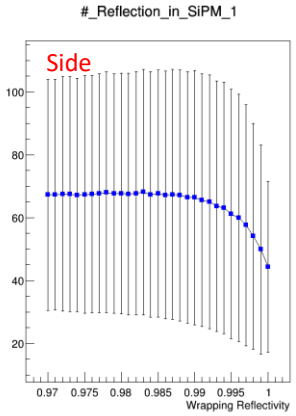


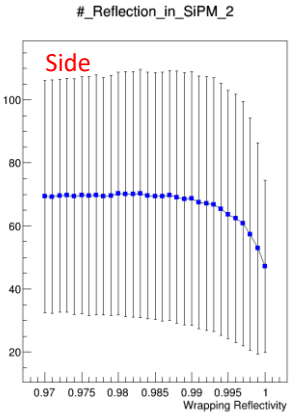
*Track Length

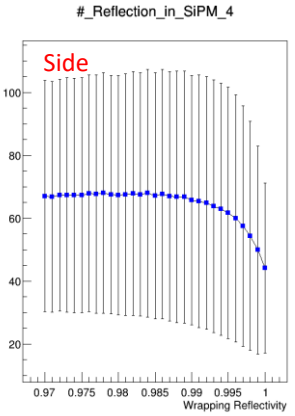
Reflectivity dependence*

Tile B2 (10 mm) -> 3mm SiPMs

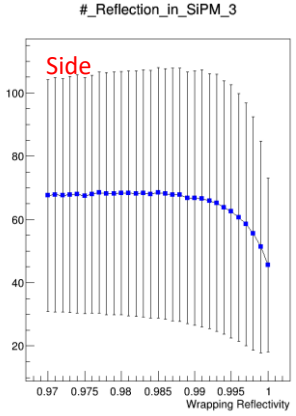


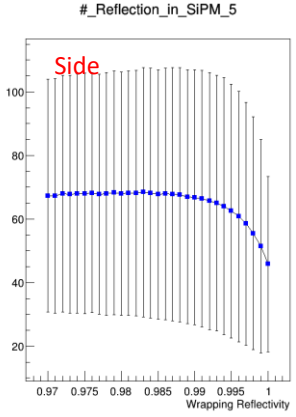


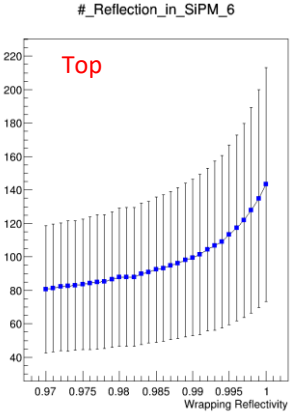


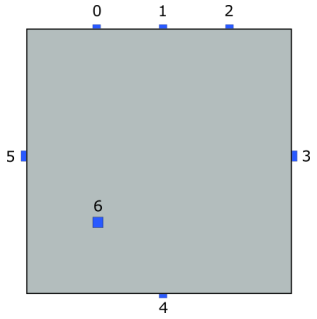


Tile B2 (10 mm) -> 4mm SiPMs









*Number of Reflections