Silicon Photomultiplier/Scintillator Study

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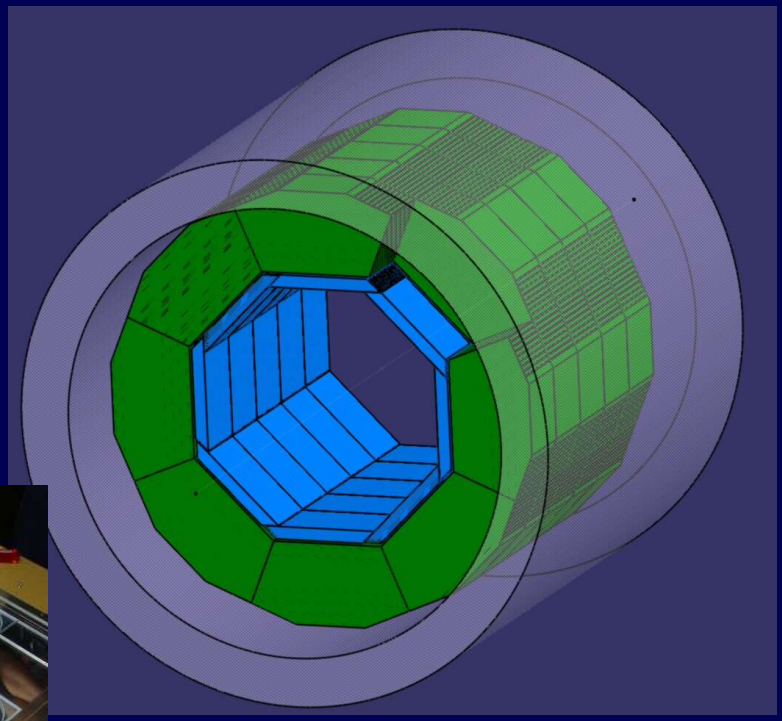
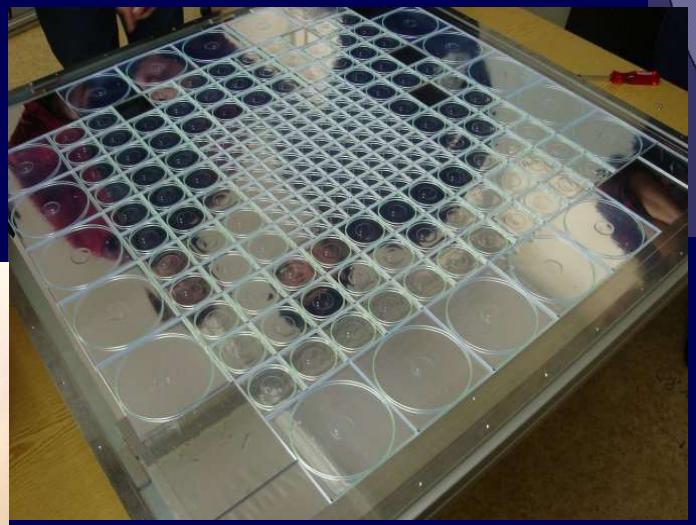
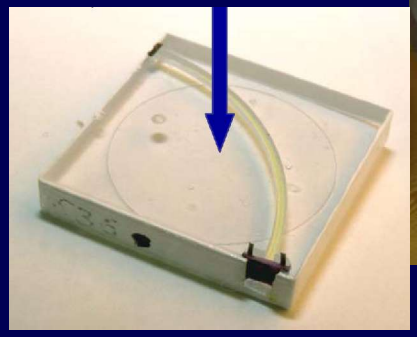
ILC Hadron Calorimetry Concept

Novel Type Sensor - Silicon Photomultiplier is one of the key point of New Technologies for International Linear Collider in particularly Hadron Calorimetry System



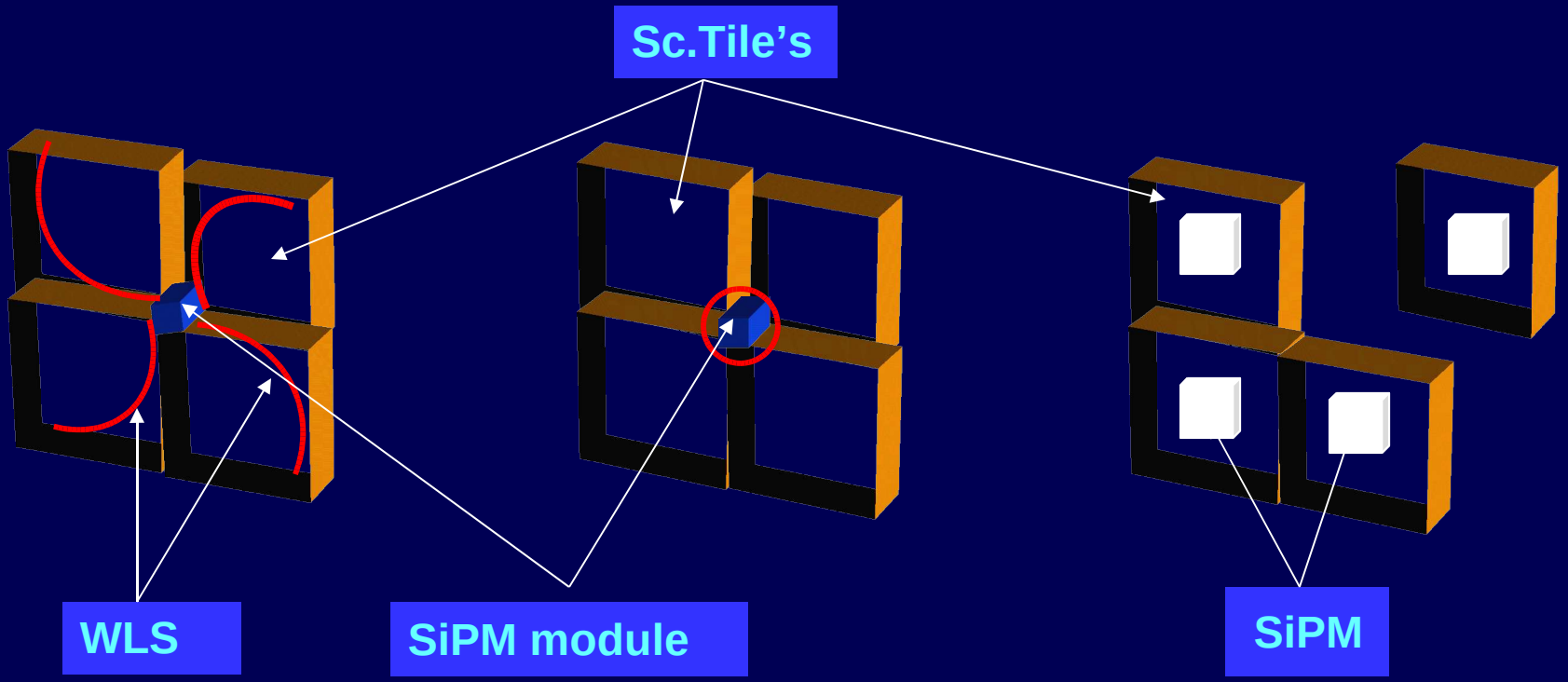




Present Design
Can we improve ?

New R&D on the Photo Sensor and Scintillator

Main Goal: Direct Readout of Scintillation Tile of ILC Hadron Calorimeter by Silicon Photomultiplier



New R&D Project on the Photodetector for Hadron Scintillation Calorimetry

Main Goal: Direct Readout of Scintillation Tile of ILC Hadron Calorimeter by Silicon Photomultiplier

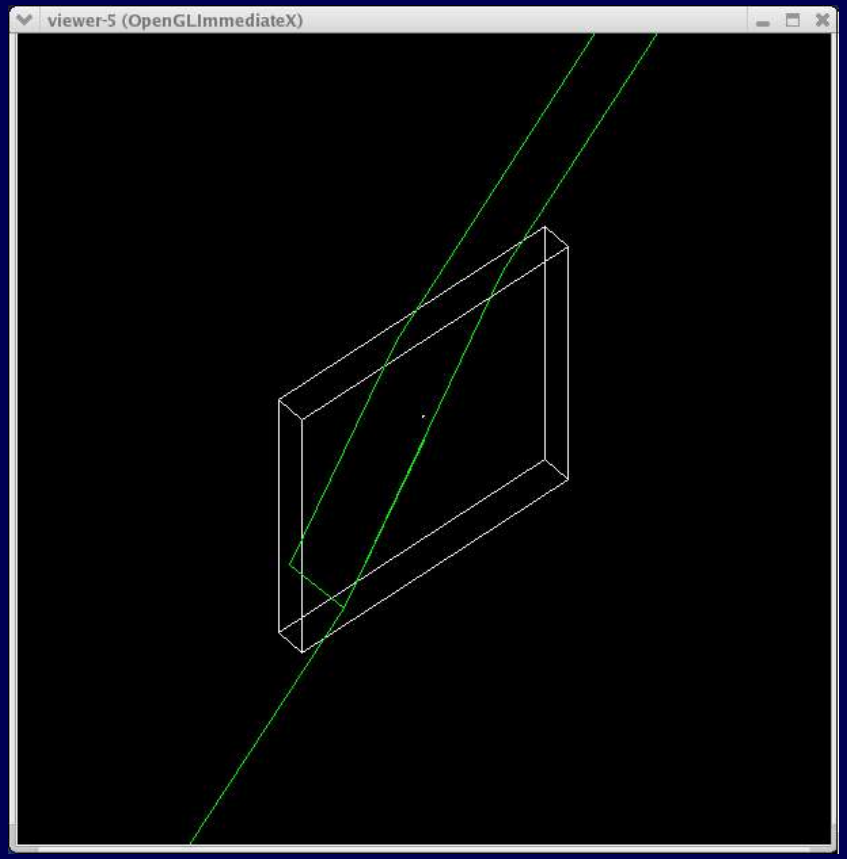
- Study of the Light Balance and Propagation in the Scintillation Tails for the ILC Hadron Calorimeter (Geant4 Simulation)
- Development of the Advance Silicon Photomultipliers
- Test setup for the Testing of the Scintillation Tail – Advance Silicon Photomultiplier
- Prototyping and Test of the Scintillation Tile - Silicon Photomultiplier Hadron Calorimeter Modules

New R&D Cooperation

- Obninsk State University
- SensI, Cork, Ireland,
- Moscow State University,
- DESY

Simulation of the Tile/Photosensor Modules

GEANT_4, Optical Photons Interaction



Optical Photon Production:

- scintillation;
- Cherenkov Effect;

Optical Photon Interaction:

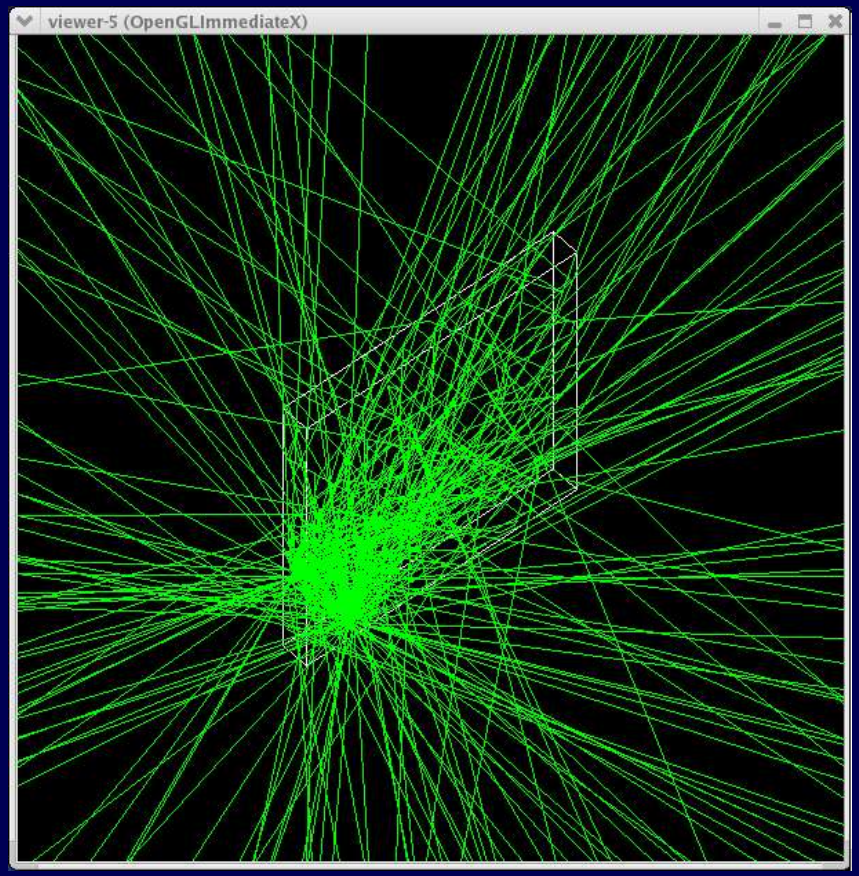
- elastic (Rayleigh) scattering;
- absorption
- medium Boundary Interactions.

Medium Boundary Effect:

- dielectric/dielectric;
- dielectric/metal;
- dielectric/black material

Full Simulation of Tle/Photosensor Modules

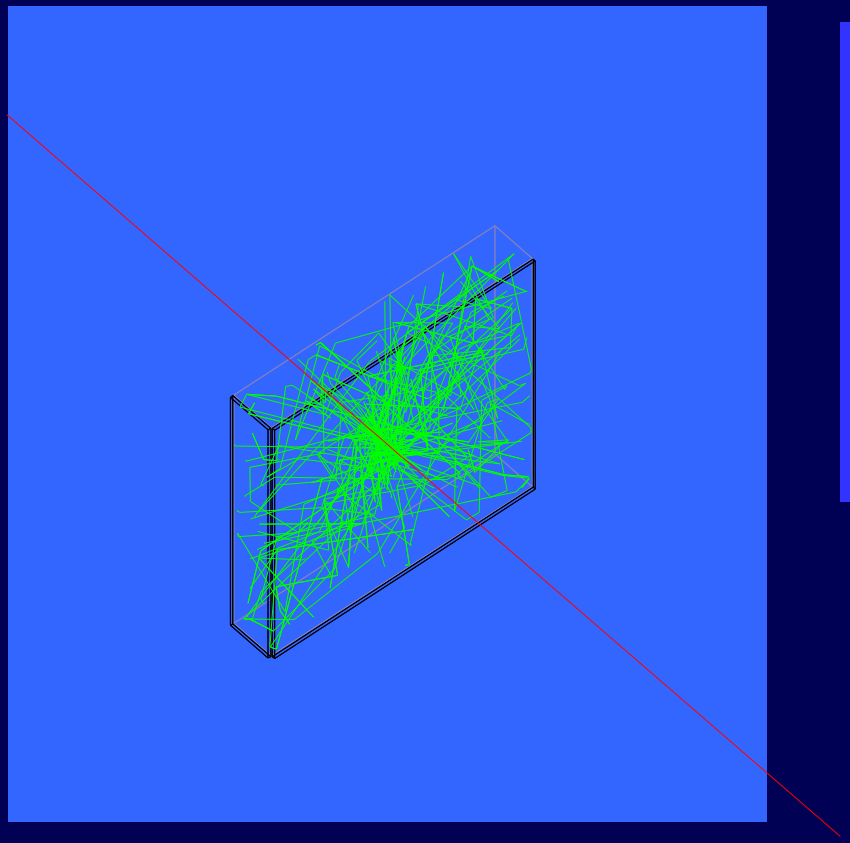
GEANT_4, Optical Photons Physics



Full simulation of the Light propagation in the Scintillation Tile/Photosensor Module

Full Simulation of Tle/Photosensor Modules

GEANT_4, Optical Photons Physics

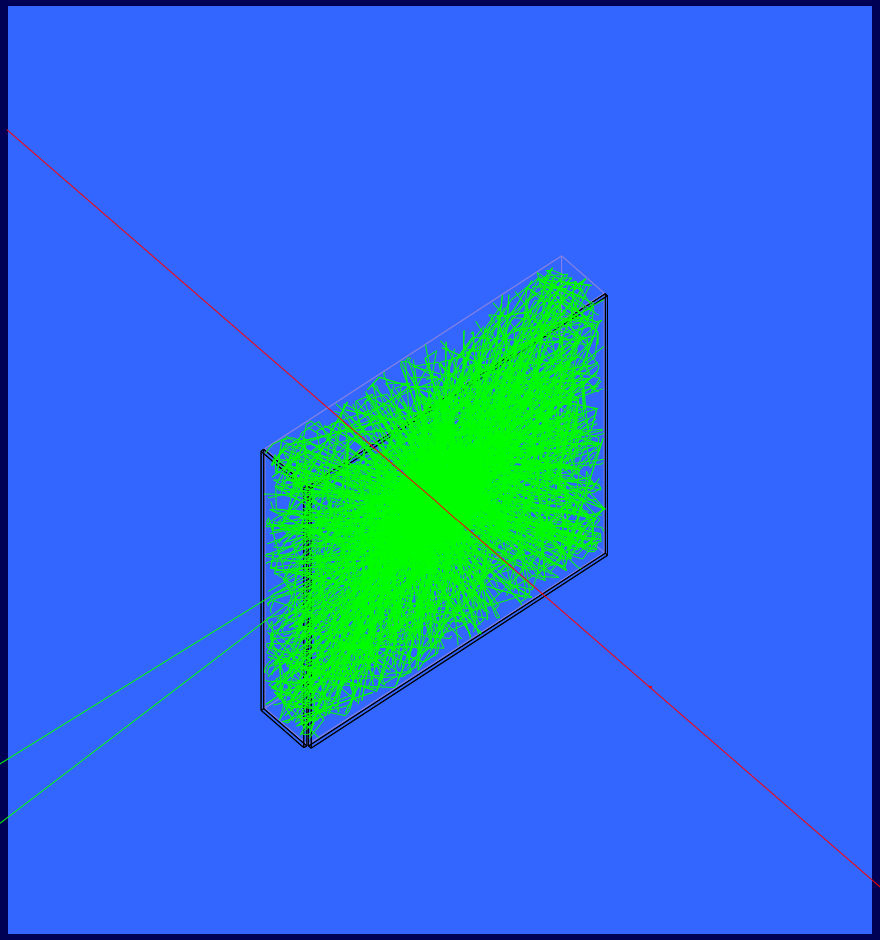


Full simulation of the Light propagation in the Scintillation Tile/Photosensor Module

6 GeV muons cross the tile

Full Simulation of Tle/Photosensor Modules

GEANT_4, Optical Photons Physics



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Full Simulation of Tle/Photosensor Modules

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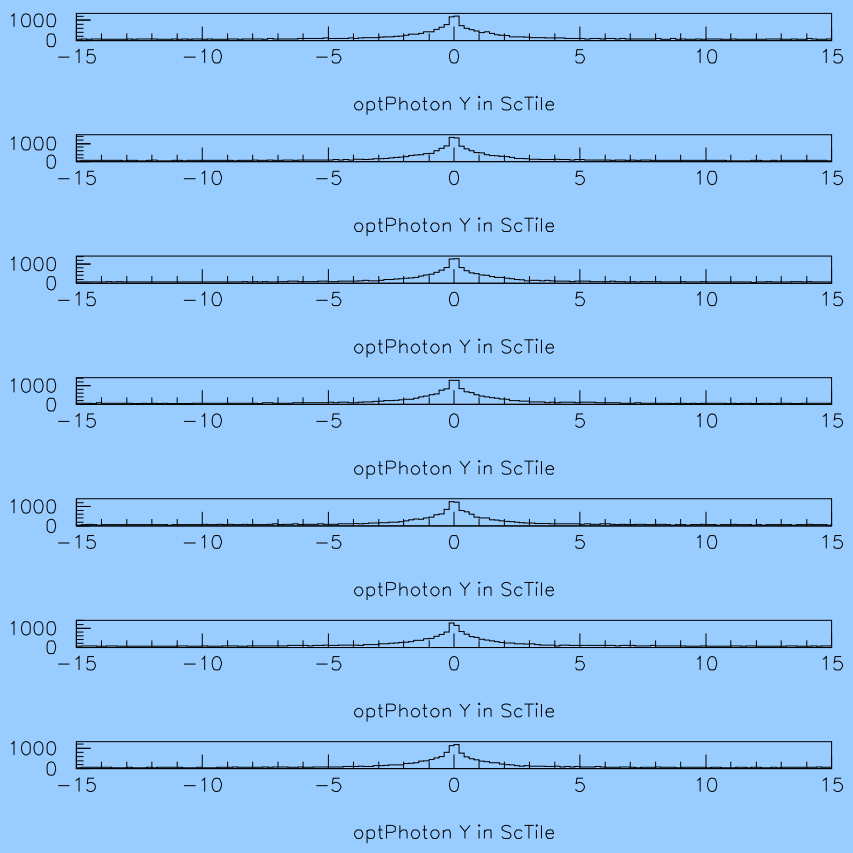
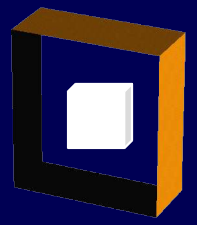


Full simulation of the Light propagation in the Scintillation Tile/Photosensor Module without reflection cover

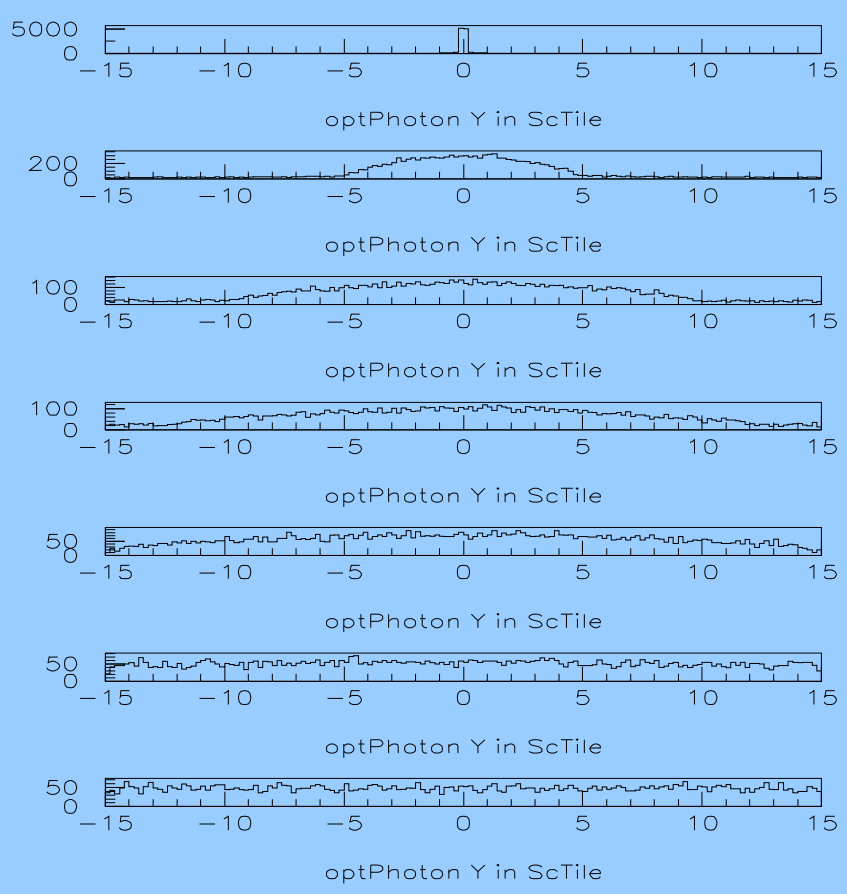
6 GeV muons cross the tile In x direction and y = 0

Light output from face



Full Simulation of Tile/Photosensor Modules

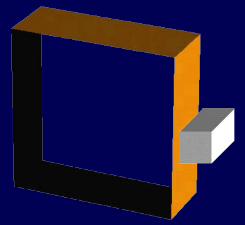
GEANT_4, Optical Photons Physics



Full simulation of the Light propagation in the Scintillation Tile/Photosensor Module without reflection cover

6 GeV muons cross the tile In x direction and y = 0

Light output from side



Advance Silicon Photomultiplier Development

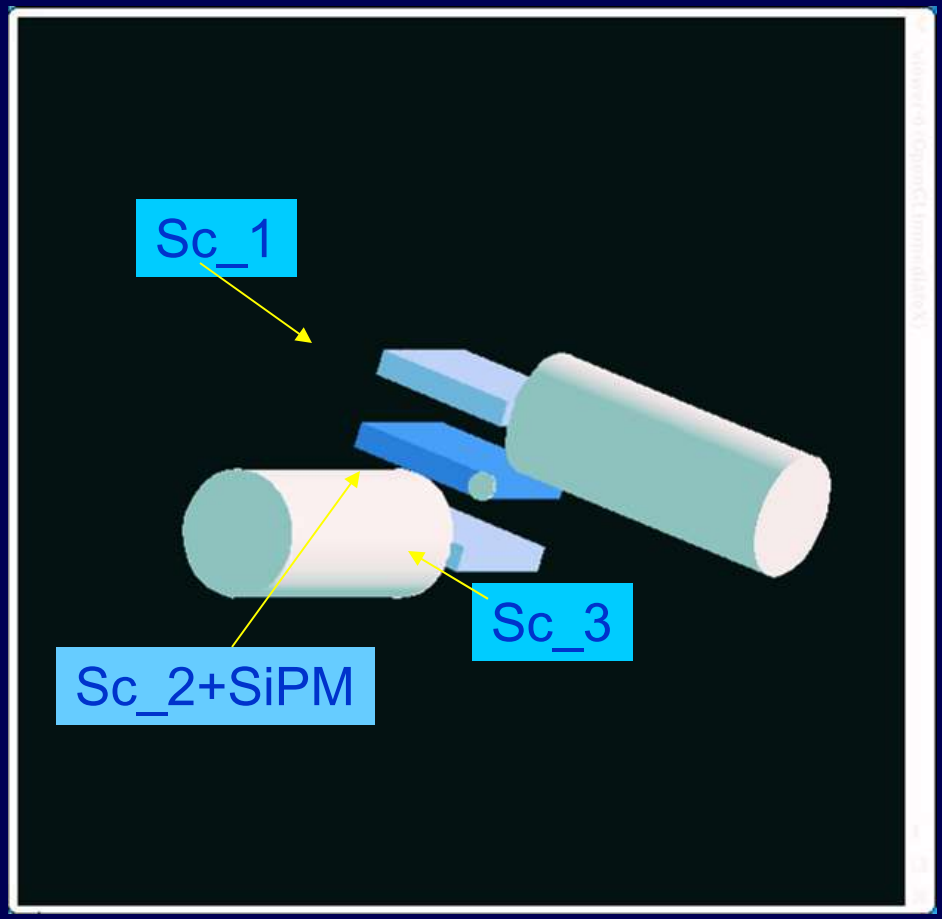
Main Goal:

- Blue range sensitivity of the Advance Silicon Photomultiplier
- Large area of the Advance Silicon Photomultiplier

Direct Measurement of Light Out by Silicon Photomultiplier

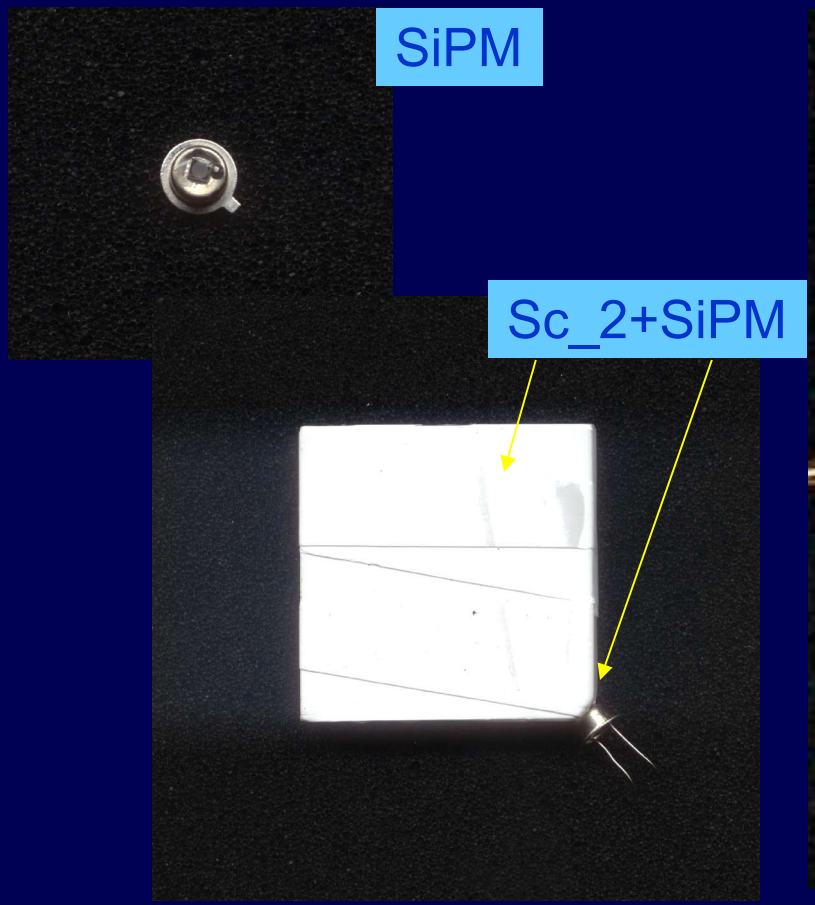
Test Setup G4_model

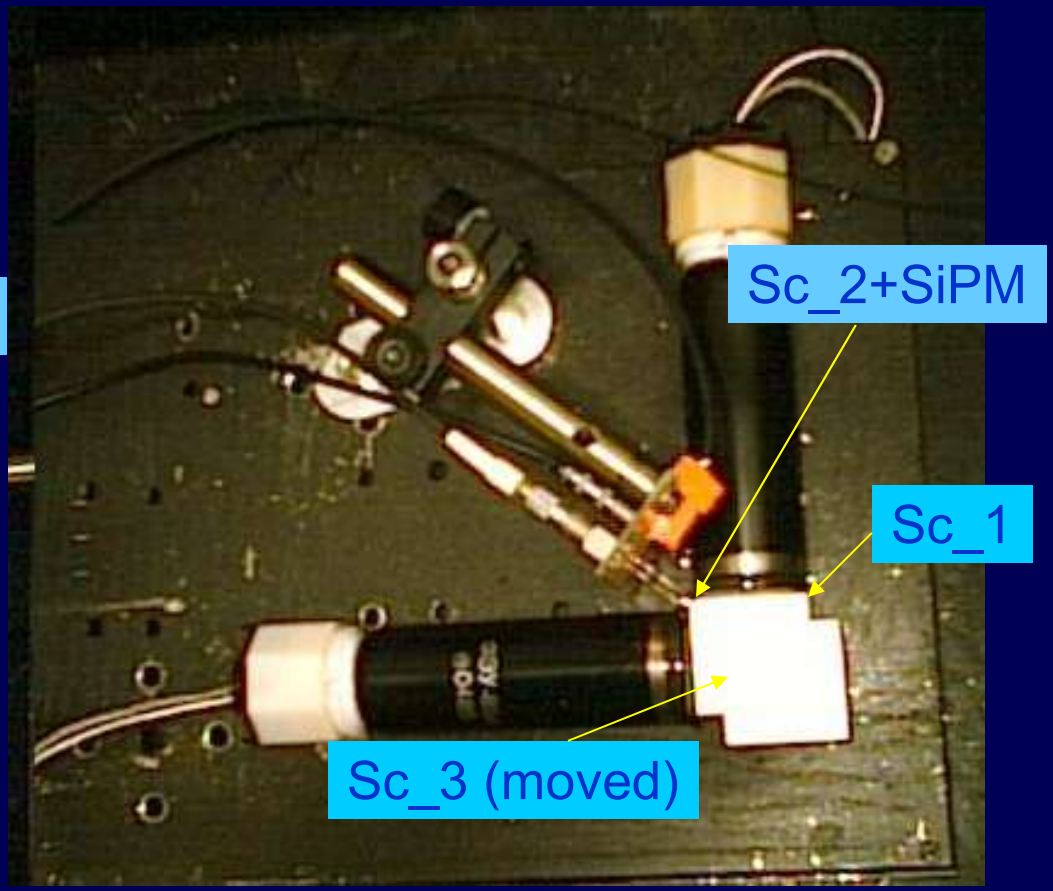
Cosmic Muons Telescope



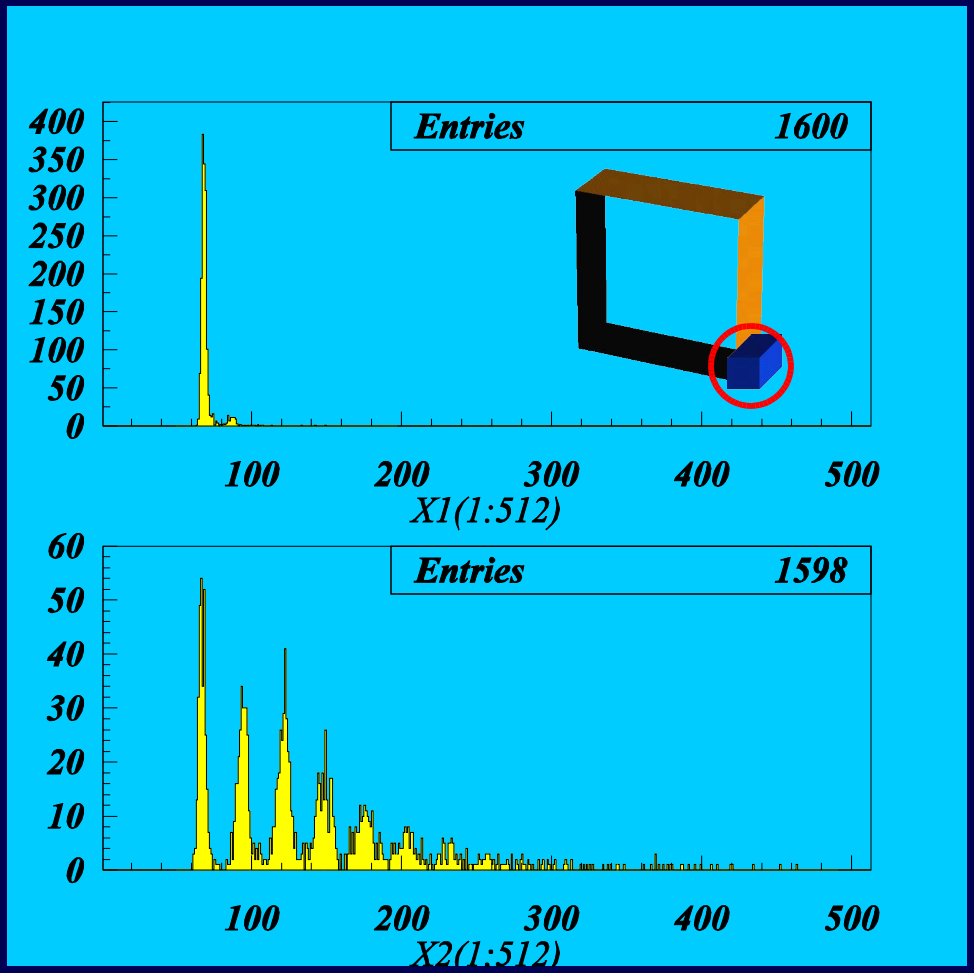
Direct Measurement of Light Out by Silicon Photomultiplier

The direct measurements of the Light output from Plastic Scintillation Tiles by SiPM – Test Setup – Cosmic Muons Telescope





Direct Measurement of Light Out by Silicon Photomultiplier



Direct Readout of Scintillation Tile (3x3 cm, 5mm) with Teflon Reflectors by SiPM size 1x1 mm (CPTA Moscow)

Cosmic Muons

Efficiency of registration of MIP is 80%

Mean value is 1.8 of photoelectrons/mip (from Poisson Distribution)

Direct Measurement of Light Out by Silicon Photomultiplier

Two main direction:

4. Increasing the sensitive area of Silicon Photomultiplier

6. Increasing sensitivity to blue region of light

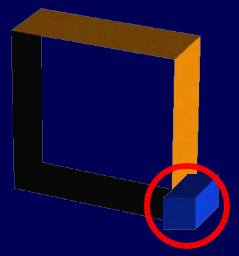
Direct Measurement of Light Out by Silicon Photomultiplier (Sensitive Area)

95% of the MIP efficiency detection, no optical cross talk

Required: Threshold of 0.5 photoelectron,
and the min average of 3 photoelectrons per MIP

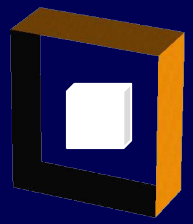
More save:
Required: Threshold of 1.5 photoelectrons,
and min average of 5 photoelectrons per MIP

is necessary to increasy the sensitive area on factor 3
up to 1x3 mm



Direct Measurement of Light Out by Silicon Photomultiplier (Sensitive Area)

From the geometrical optics (raw estimation) for the 3x3 cm2 tile thickness 5 mm, the light output is factor 3 less in comparison to the side readout,

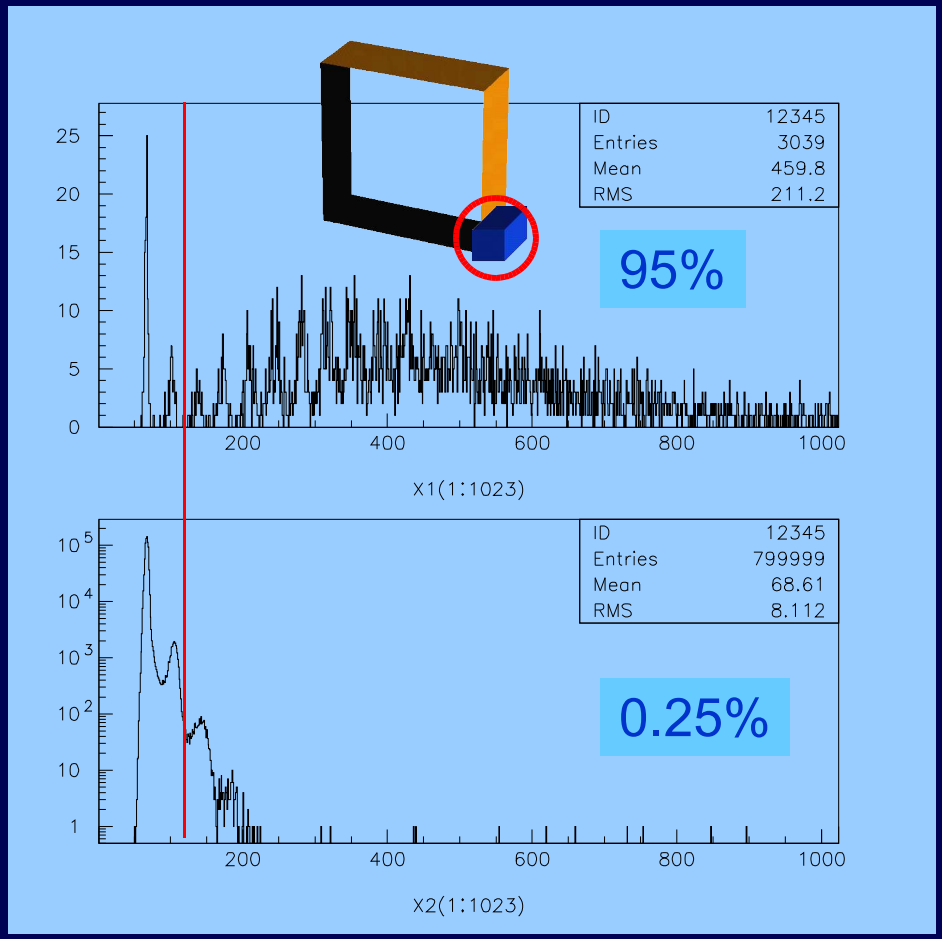


95% of the MIP efficiency detection
No optical cross talk

Threshold of 0.5 photoelectron, and the min average of 3 photoelectrons is necessary to increasy the sensitive area on factor 2x3 = 6

Threshold of 1.5 photoelectrons, and min average of 5 photoelectrons per MIP is necessary to increase the sensitive area on factor 3 x 3 = 9 up to 3x3 mm

Direct Measurement of Light Out by Silicon Photomultiplier



Direct Readout of Scintillation Tile (3x3 cm, 5mm) with Teflon Reflectors by SiPM size 1x1 mm (HAMAMATSU, Japan)

Cosmic Muons

Efficiency of registration of MIP is 95% with threshold 1.5
Background contribution 0.25%

Conclusions

- New concepts of Direct Readout of Scintillation Tile by Silicon Photomultipliers is promising
- Already existing Silicon Photomultiplier (HAMAMATSU) is sutable for Direct Readout of 3x3 Scintillation Tiles