

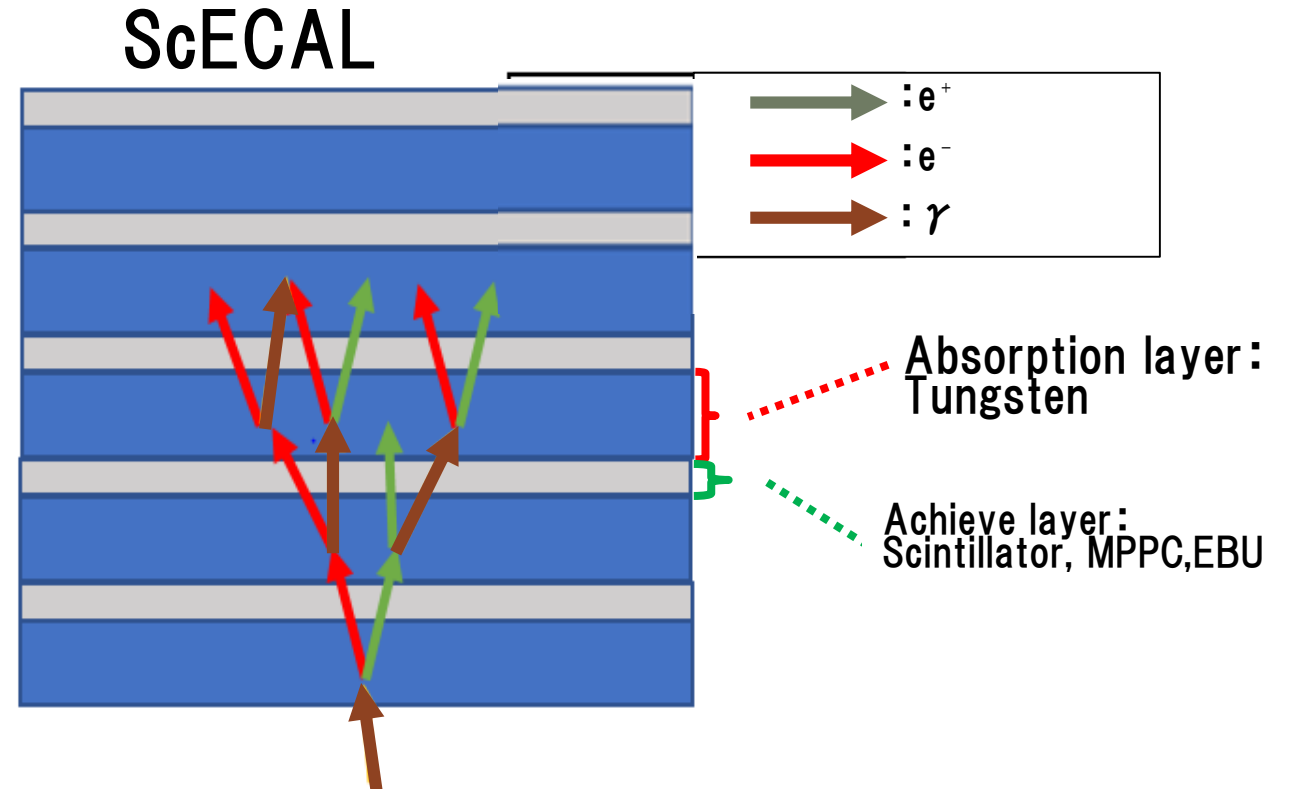
Optimization for Center hole scintillator strip with simulation

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SEPTEMBER 6, 2019

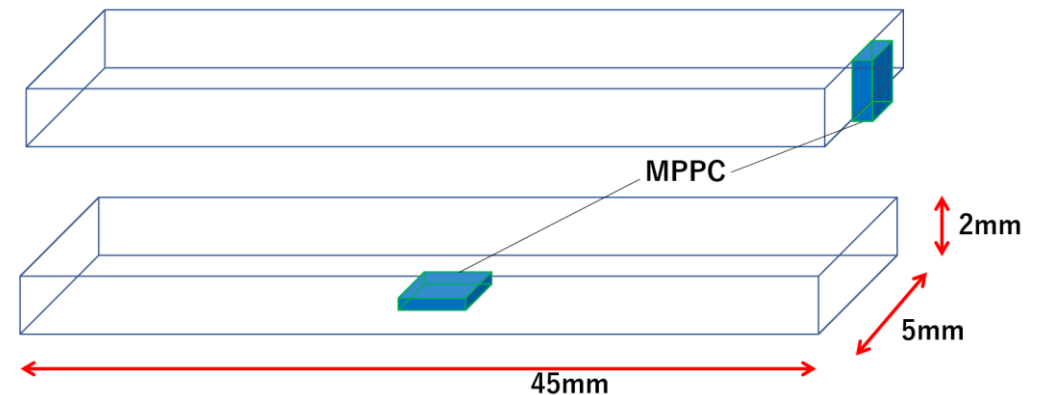
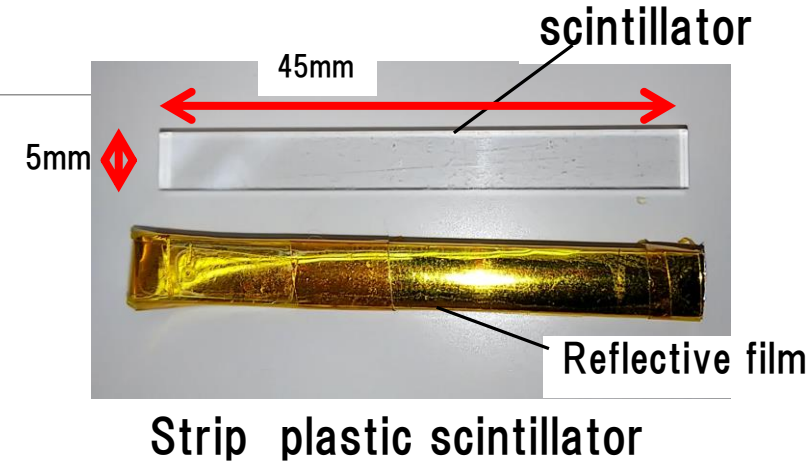
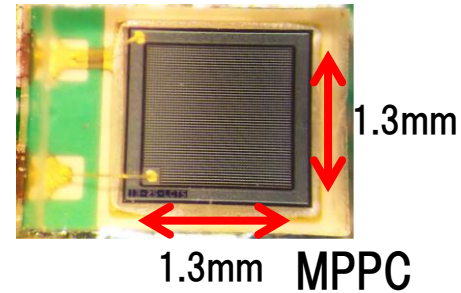
Scintillator electromagnetic calorimeter

- Sampling calorimeter, candidate for ECAL for ILD.
- Particles generate electromagnetic showers in the absorption layer, and the particles in the shower are measured by detection layer.
- The number of shower particles is measured by detecting the response of scintillation light with an optical sensor on EBU.



MPPC and Scintillator

- EBU
 - Circuit board used for the achieve layer.
 - A large amount of scintillator and MPPC are installed.
- MPPC
 - Semiconductor light sensor developed by Hamamatsu Co. and Japanese universities including Shinshu.
 - The light-receiving surface is a matrix of micro APDs.
 - MPPC works at room temperature and in a magnetic field.
 - Excellent photon counting ability.
- Strip plastic scintillator
 - Unit price is cheap.
 - Scintillation response is fast.
 - The shape is a strip of $2 \times 5 \times 45 \text{ mm}^3$.
 - Candidates are side ($2 \times 5 \text{ mm}^2$) surface readout type or bottom ($5 \times 45 \text{ mm}^2$) readout surface type.
 - A position resolution of $5 \times 5 \text{ mm}$ is required. Achieve the required performance by crossing 2×5 x 45 mm scintillators.



Problems of side lead-out type scintillator

The particle in the shower is measured by scintillator and MPPC.
If the amount of light detected by MPPC is different, the number of particles in the reconstructed shower will fluctuate.
This also fluctuates the reconstructed energy.

Side-reading type that was a conventional candidate. This type has disadvantages.

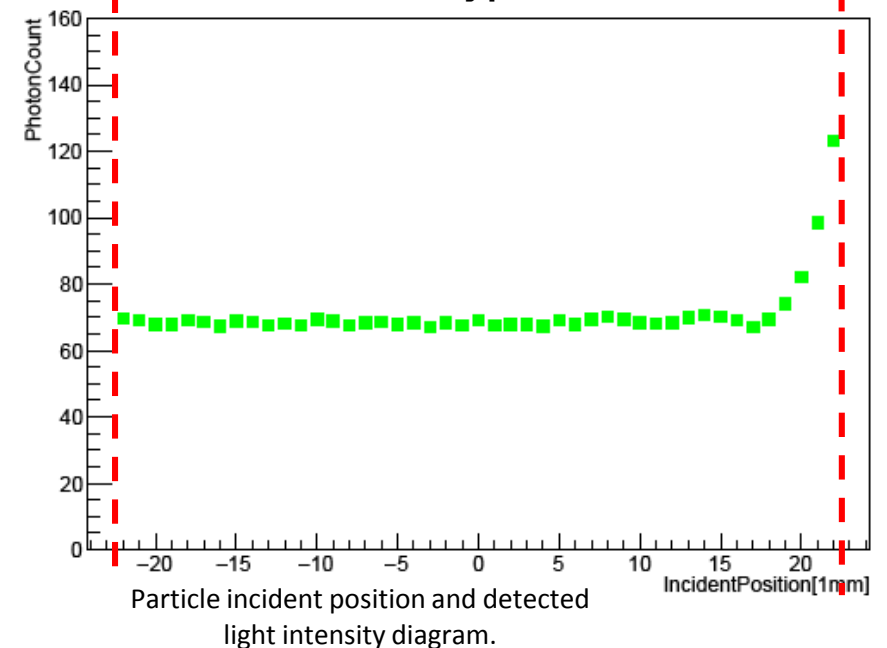
- Photons generated near MPPC are more detected.
- There is a blind spot for MPPC installation.

It is necessary to use a scintillator with excellent uniformity in the particle incident position for further improve accuracy with ECAL.

The light intensity uniformity of the bottom-readout type scintillator was tested in multiple shapes using geant4 because this type scintillators are no blind spot for MPPC installation.



Side readout type scintillator



Geant4 simulator

- Scintillator
 - EJ204
 - Average light output 5000photon/MeV
- Reflective sheet :
reflectivity 98%
- Light sensor :
MPPC Effective photon sensitive area $1.3 \times 1.3\text{mm}^2$
- Beta ray fixed at 2.2MeV(Sr90)

Geant4 simulation

©Model

①Base Model :

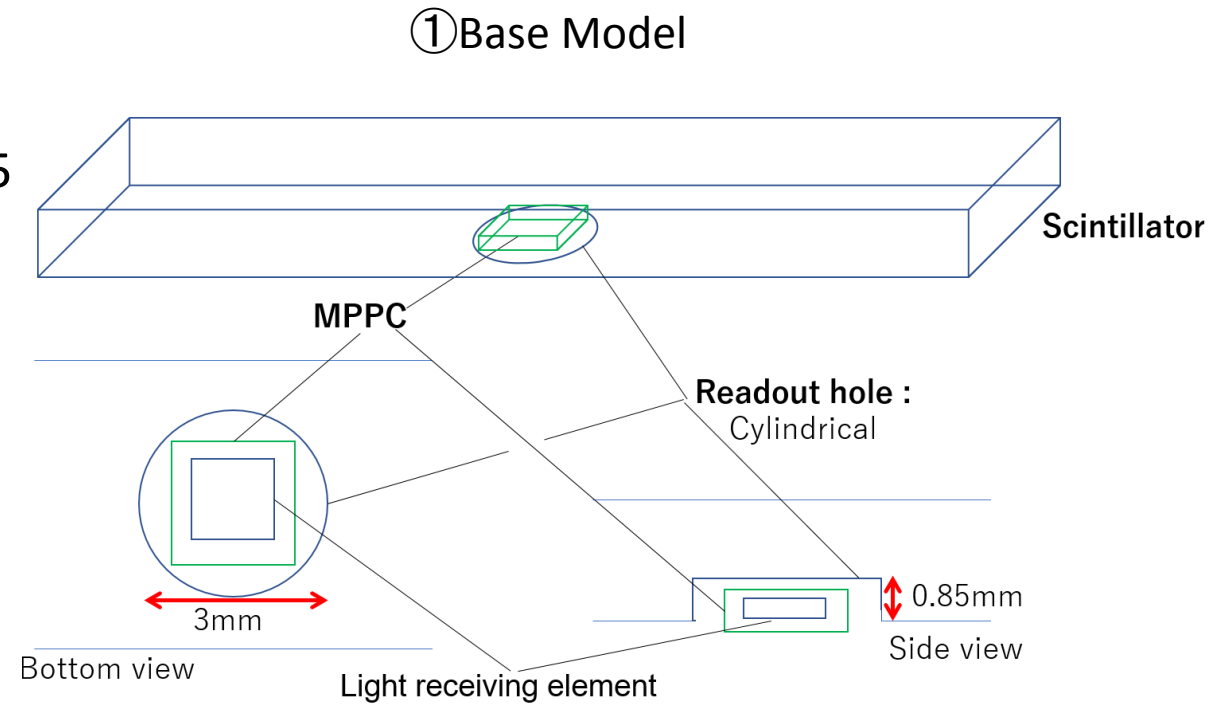
A cylindrical hole is made in the MPPC mounting part.

The cylindrical hole shape has a radius of 1.5 mm and a depth of 0.85mm.

The effect on light intensity was tested at three points:

- 1 ,Hole depth
- 2, Hole edge shape
- 3 ,Hole bottom shape.

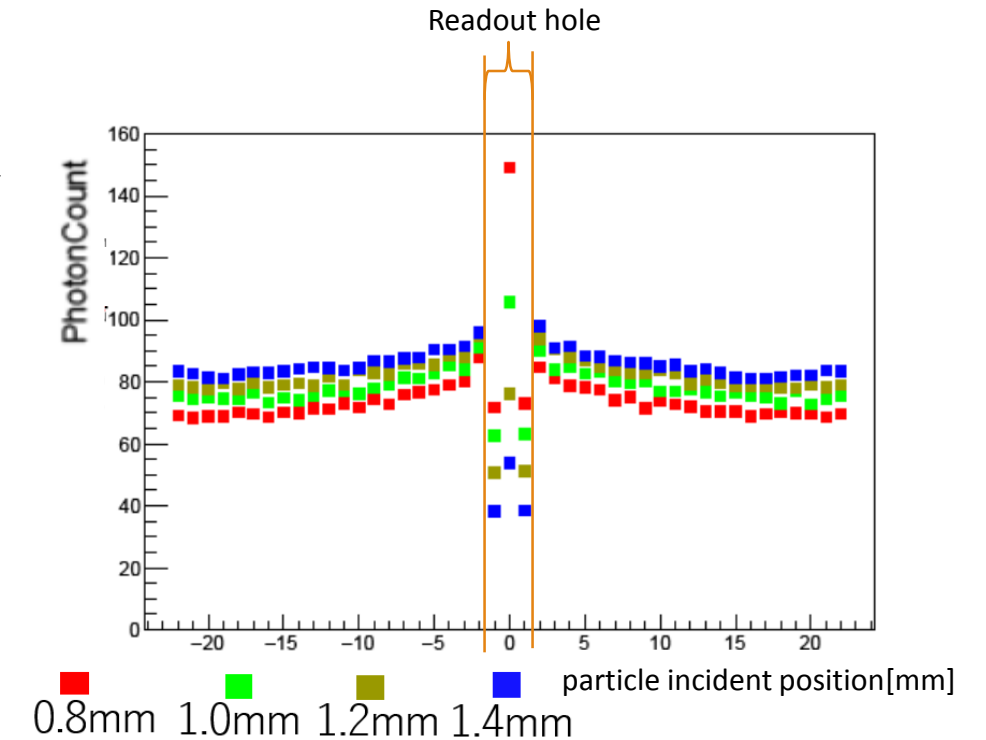
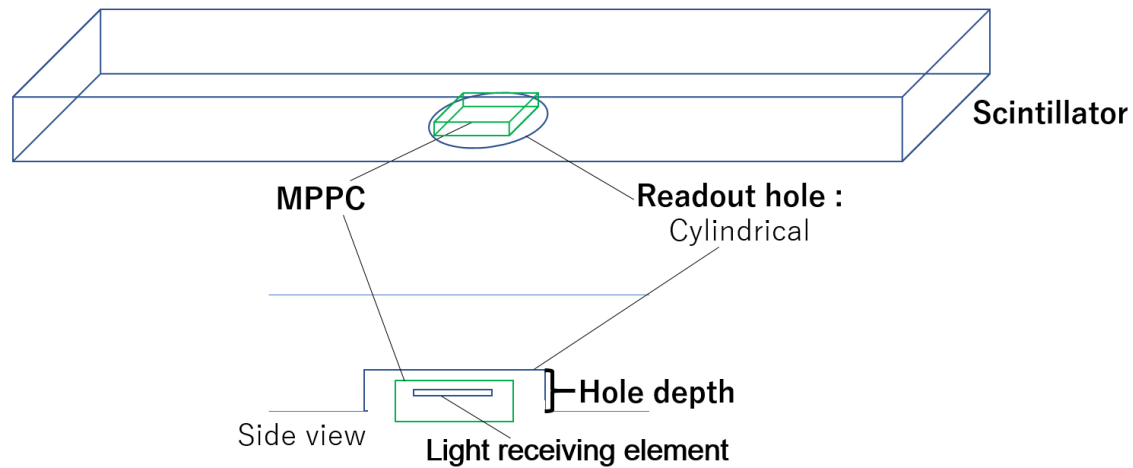
Define evaluation value A $A = \sum \left[\frac{\text{Standard deviaton}}{\text{Average}} \right]$



Geant4 simulation

1, Change hole depth

- Hole shape:
 - Depth : Change from 0.8mm to 1.4mm every 0.2mm



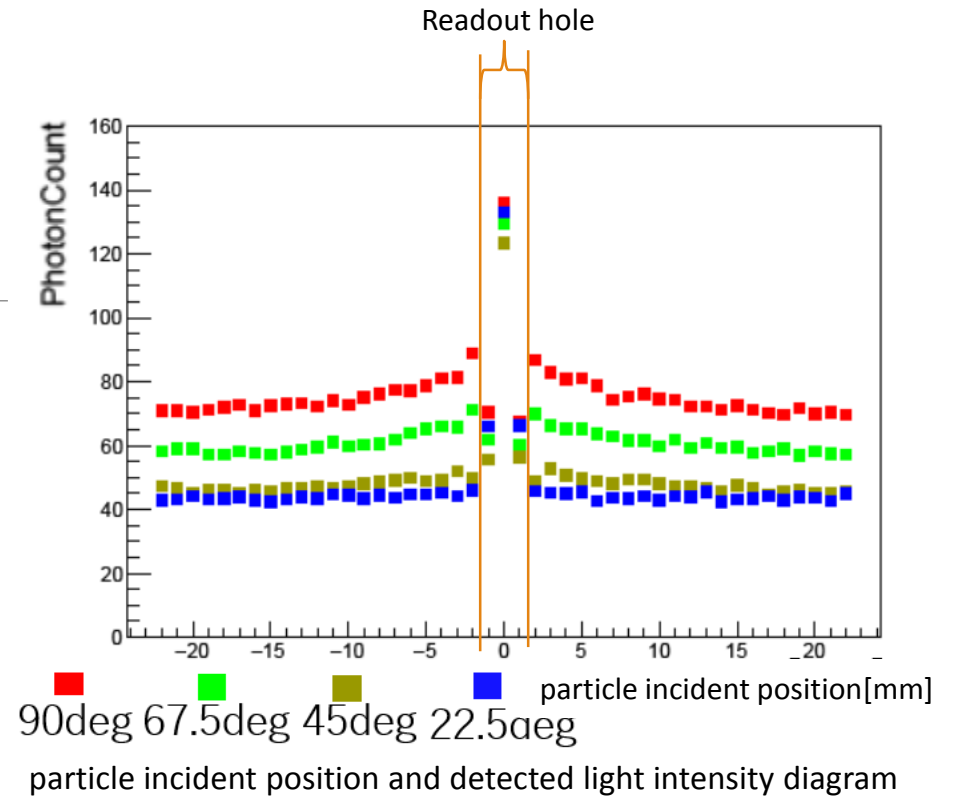
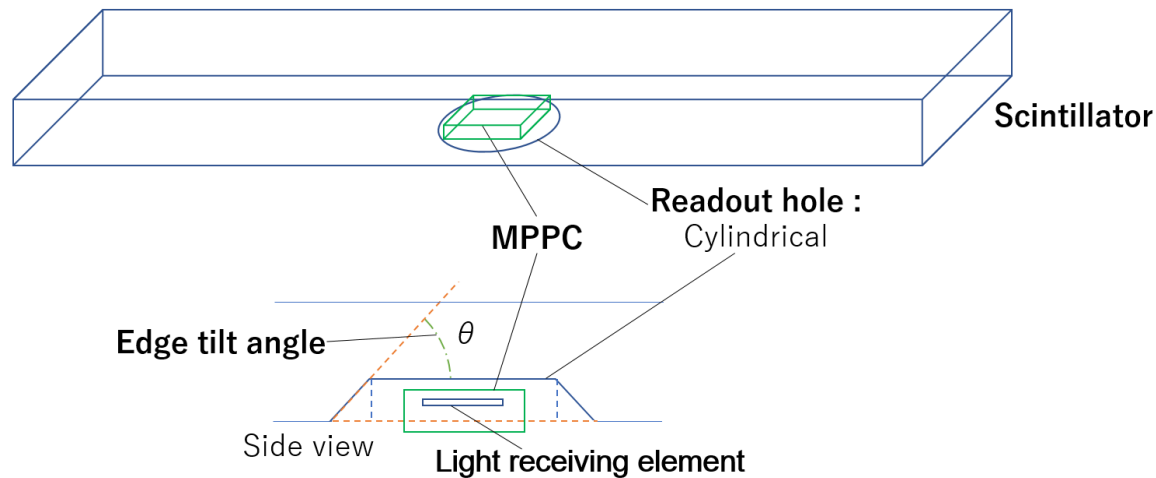
particle incident position and detected light intensity diagram

Hole depth	A
0.8mm	1.61×10^{-1}
1.0mm	8.60×10^{-2}
1.2mm	9.60×10^{-2}
1.4mm	1.36×10^{-1}

Geant4 simulation

2, Change Hole edge slope

- Hole shape:
 - Hole edge slope: 22.5 deg to 90 deg with respect to the bottom, changed every 22.5 degrees

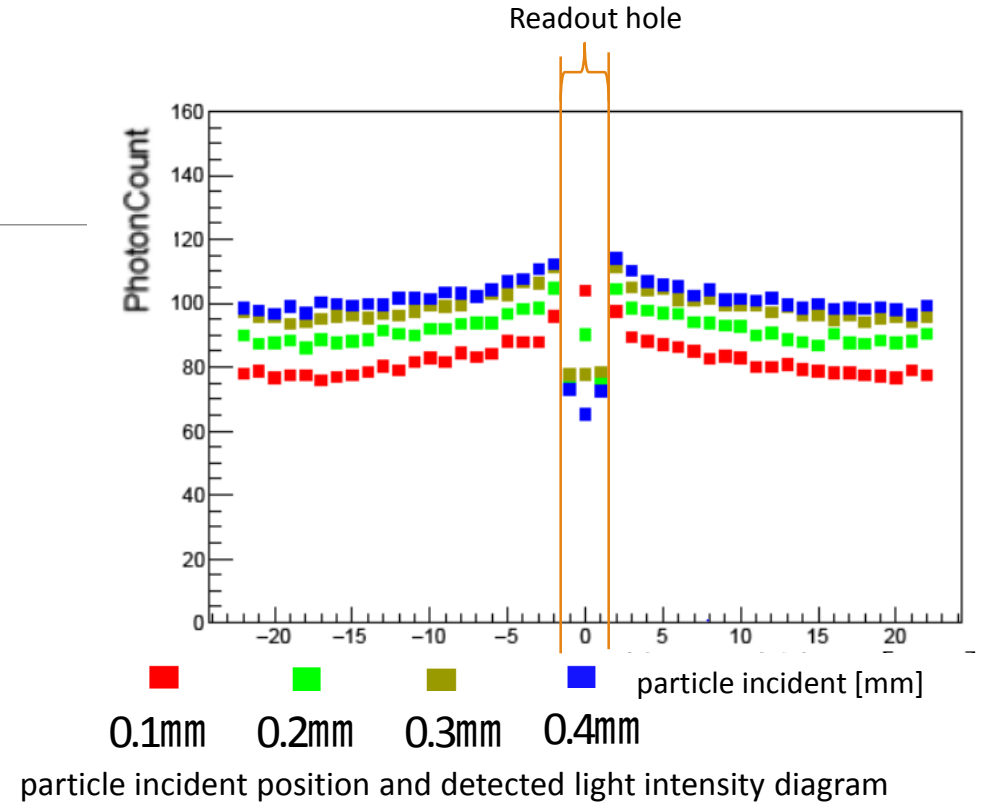
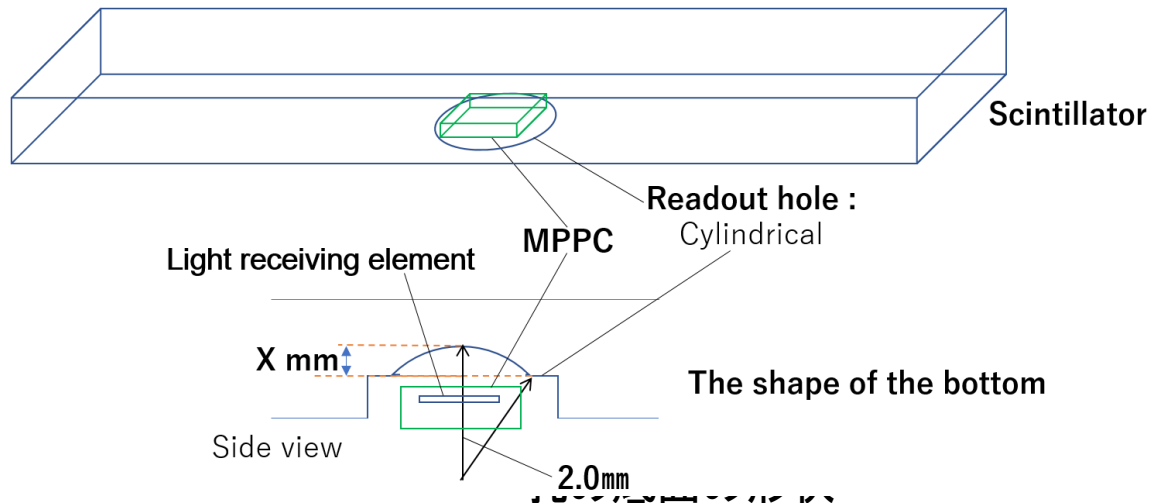


Hole edge shape	A
90deg	1.34×10^{-1}
67.5deg	1.71×10^{-1}
45deg	2.30×10^{-1}
22.5deg	2.94×10^{-1}

Geant4 simulation

3, Change bottom shape

- Hole shape:
 - Partial sphere depth : $X=0.1\text{mm}$ to 0.4mm changed every 0.1mm .



Hole bottom shape	A
0.1mm	7.43×10^{-2}
0.2mm	6.01×10^{-2}
0.3mm	6.95×10^{-2}
0.4mm	8.99×10^{-2}

Geant4 simulation

Result

Side readout	1.31×10^{-1}
Hole depth:1.0mm	8.60×10^{-2}
Hole edge shape:90deg	1.34×10^{-1}
Hole bottom shape:0.2mm	6.01×10^{-2}

Bottom-readout type is better than Side-readout type scintillator.

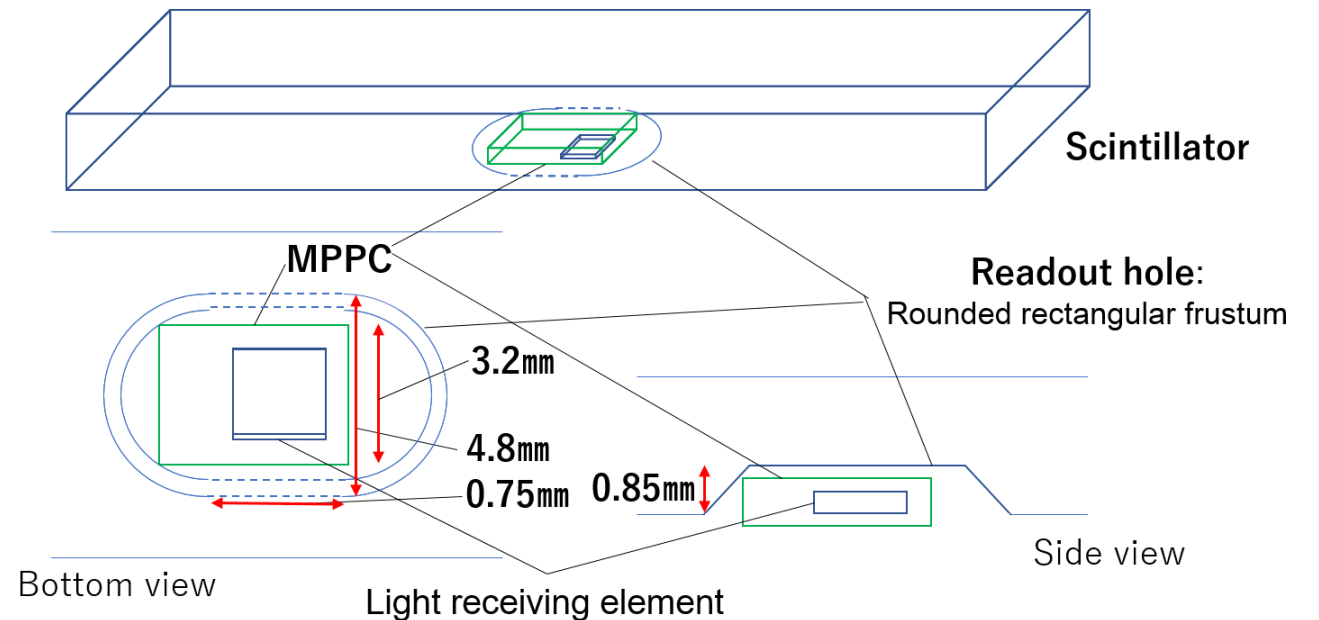
Difference of result.

USTC Model

Tendency of result is different at center hole region .

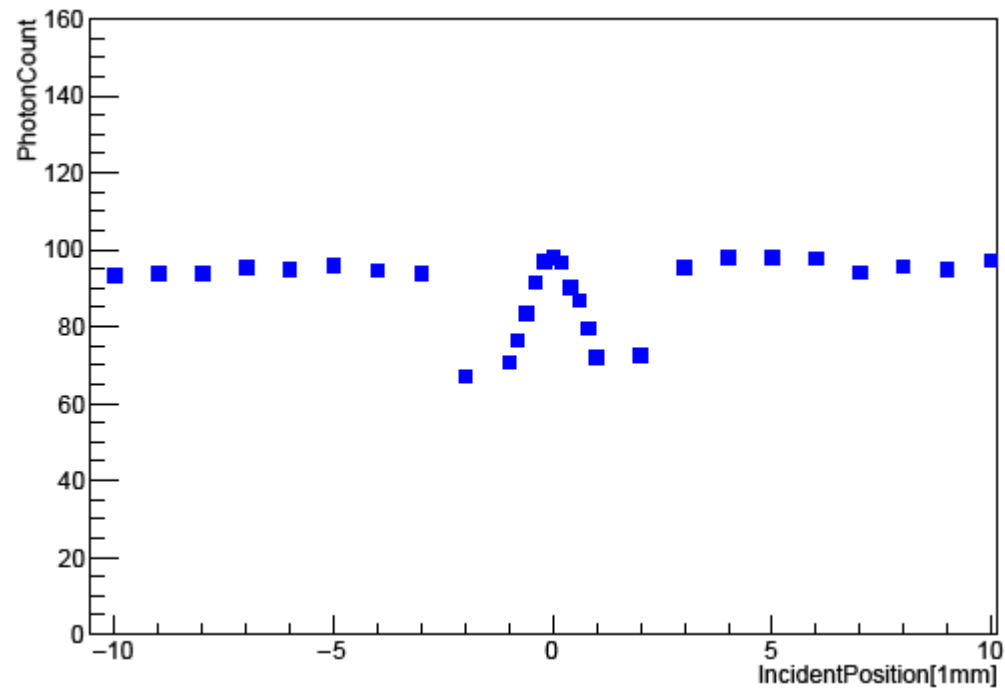
② USTC Model :

Developed by USTC (Chinese University of Science and Technology).



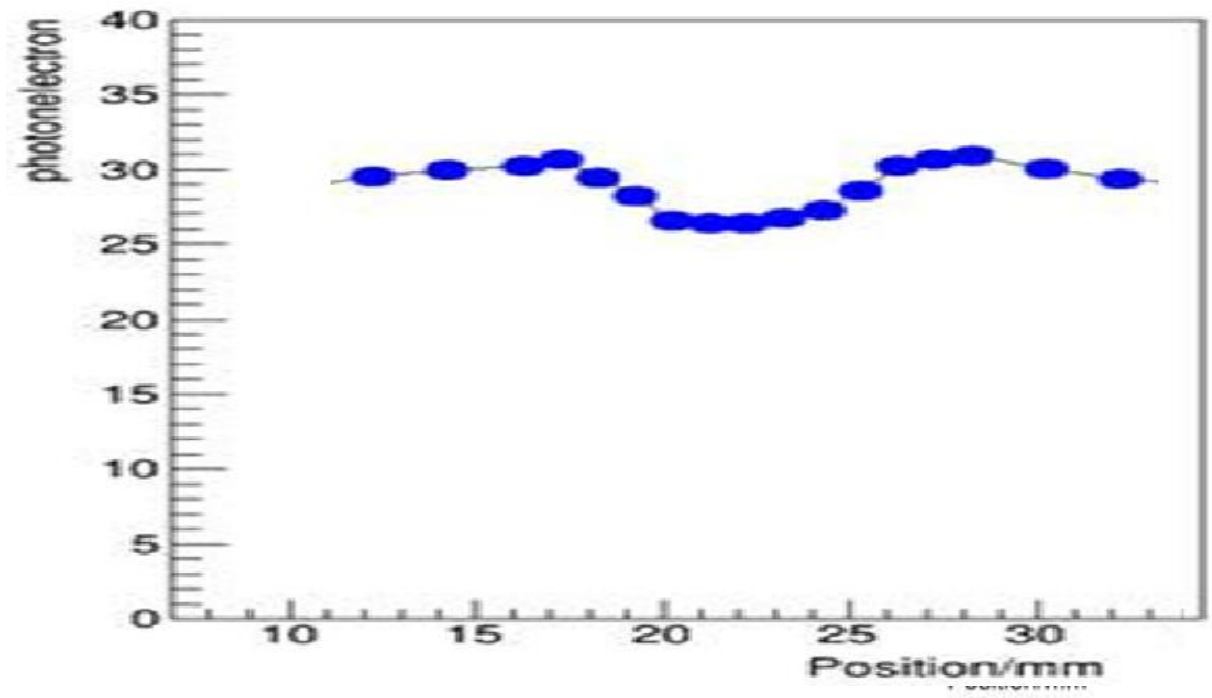
Result Geant4 simulation and USTC

Simulation result



USTC result

: actual measurement value by USTC



Summary

Using Geant4, I investigated the position dependence of the particle incident position and the detected light quantity for the strip scintillator for ILD ScECAL.

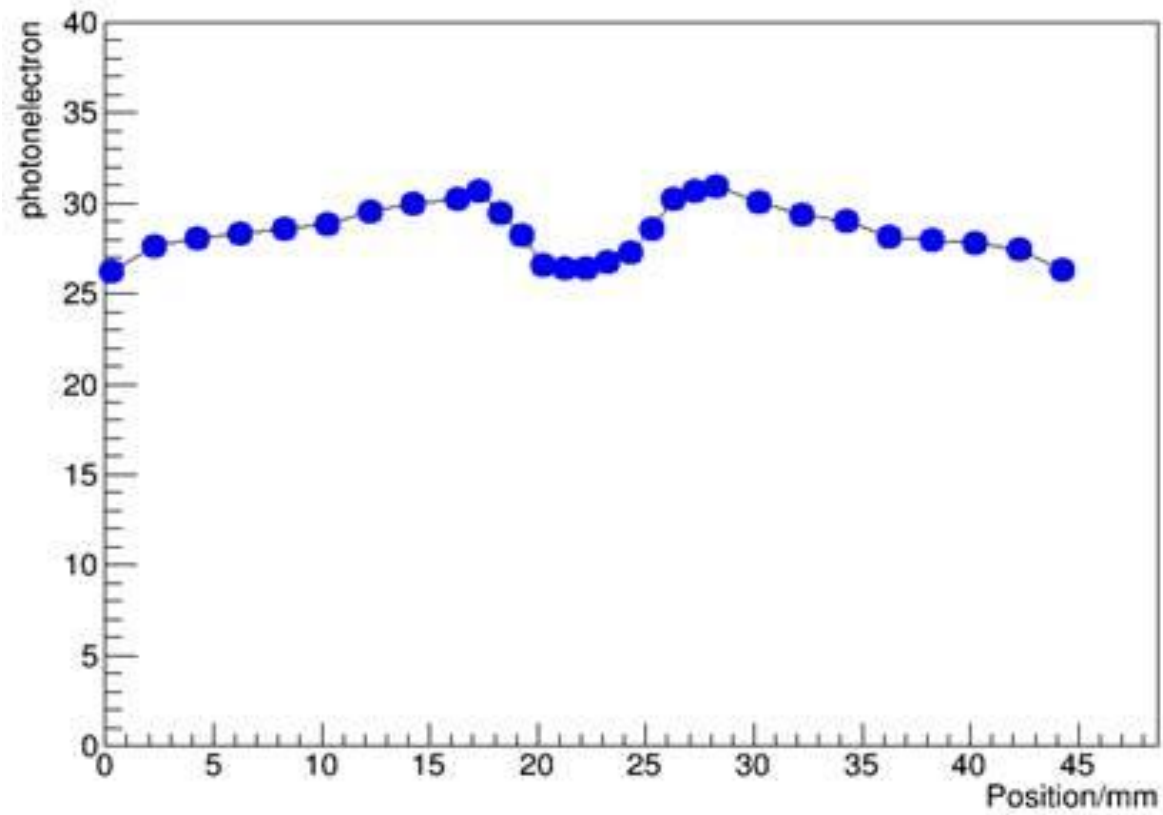
In the simulation, it was found that the uniformity of the light amount changes depending on the shape of the hole.

In the USTC Model, there was a difference in trend between the real-world experiment and the simulation results.

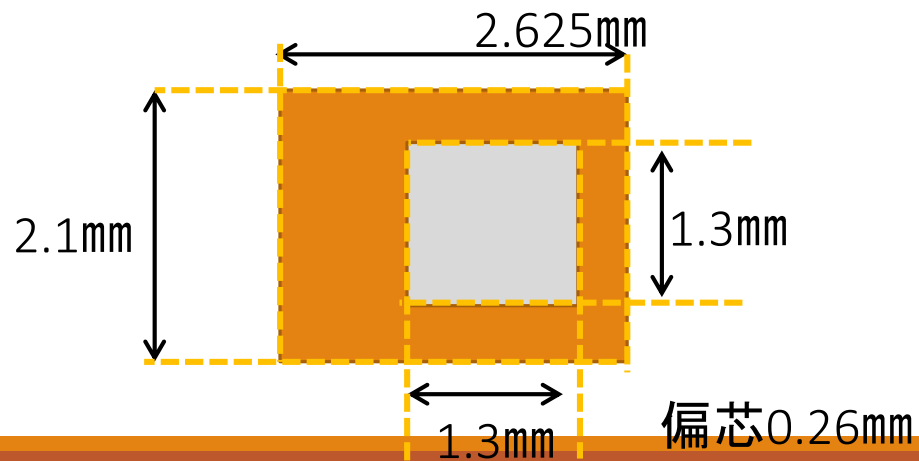
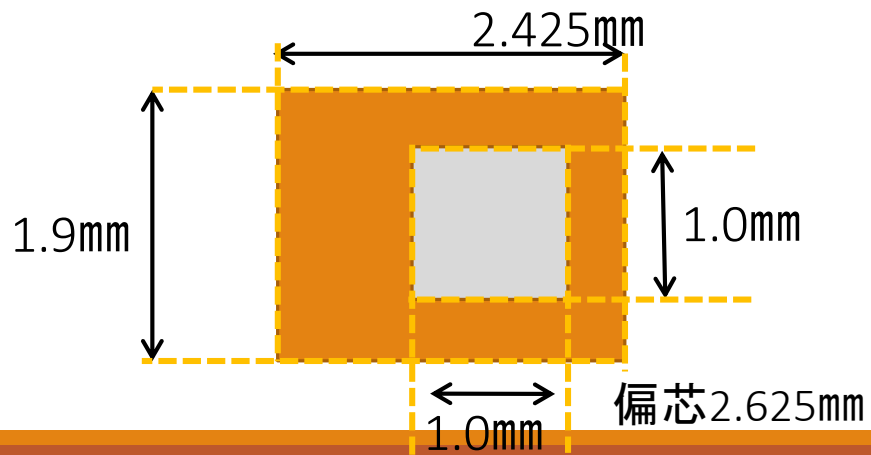
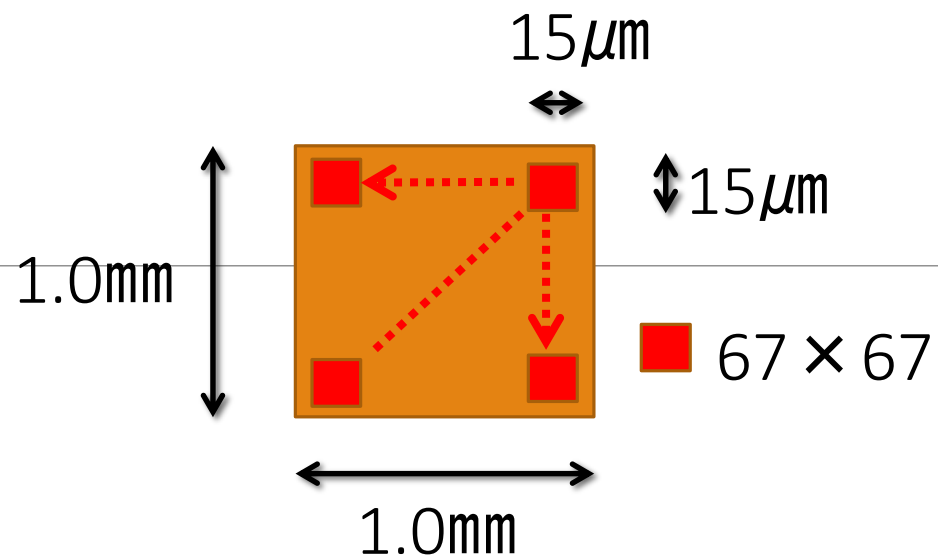
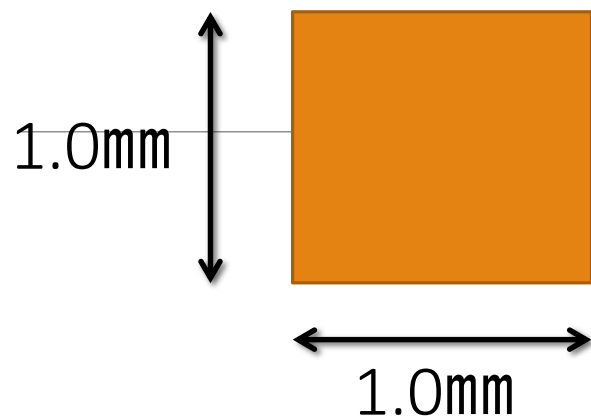
I will to investigate the cause of difference from the experiment and simulation on USTC model, and test to hole shape change effect to light uniformity on Base model at real model.

Backup

USTC



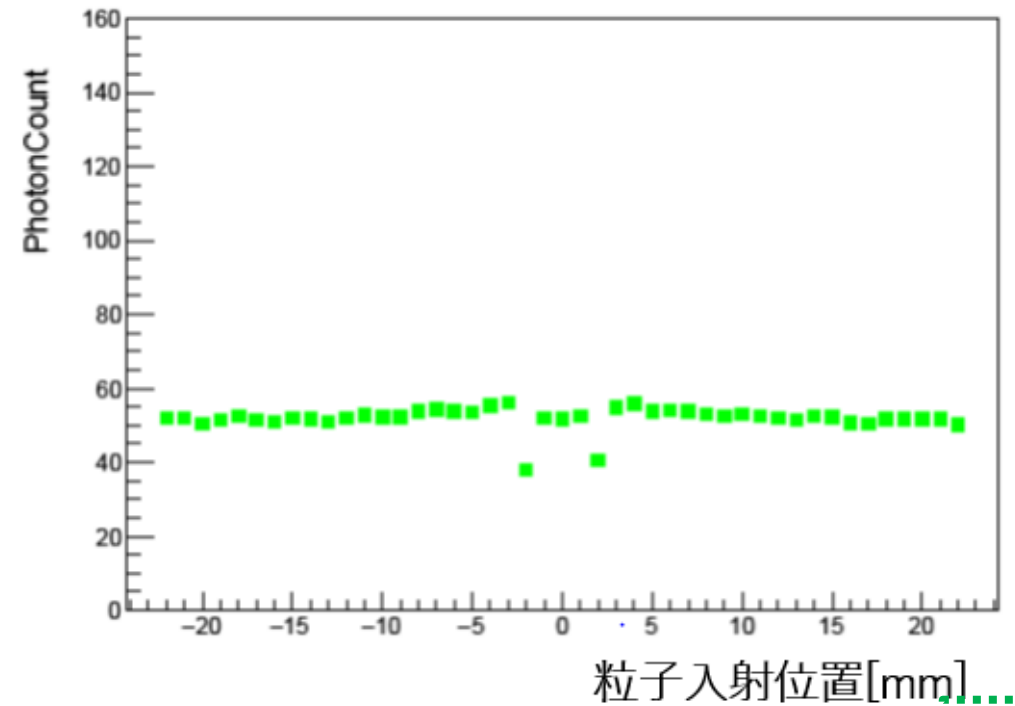
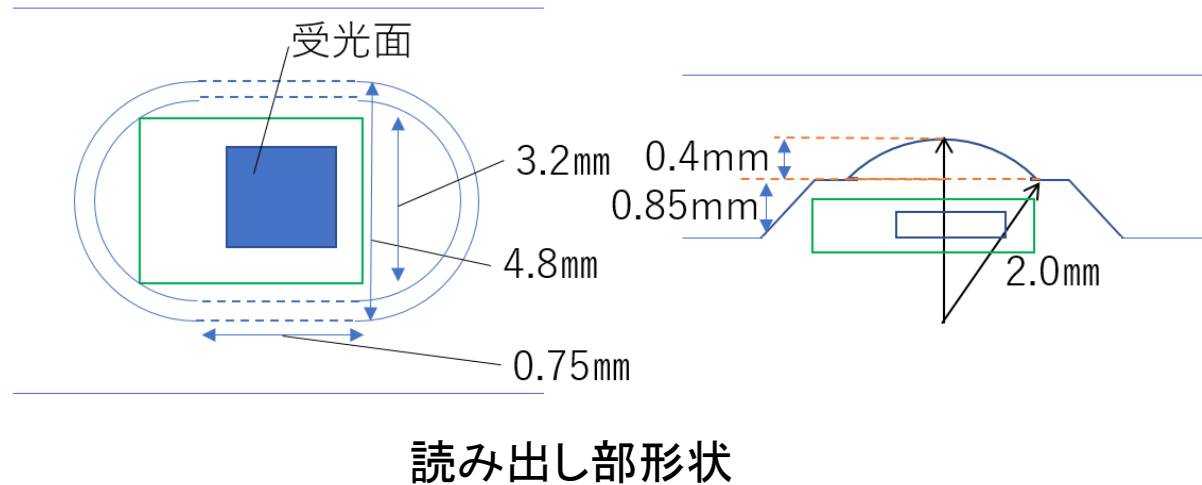
受光面設定



Geant4シミュレーション

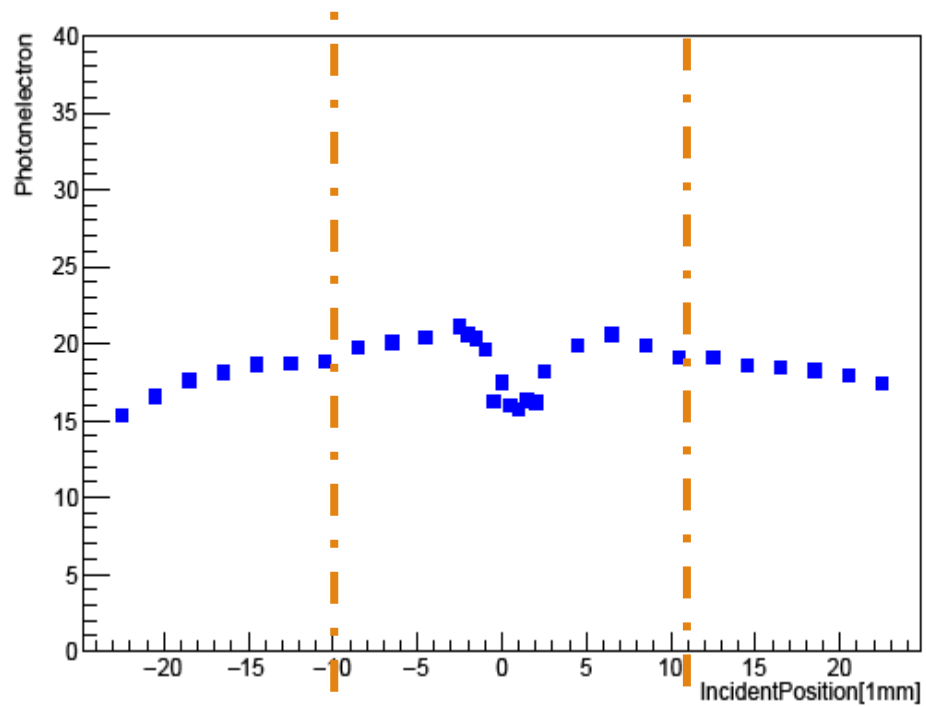
① Default Model

形状変化の合成

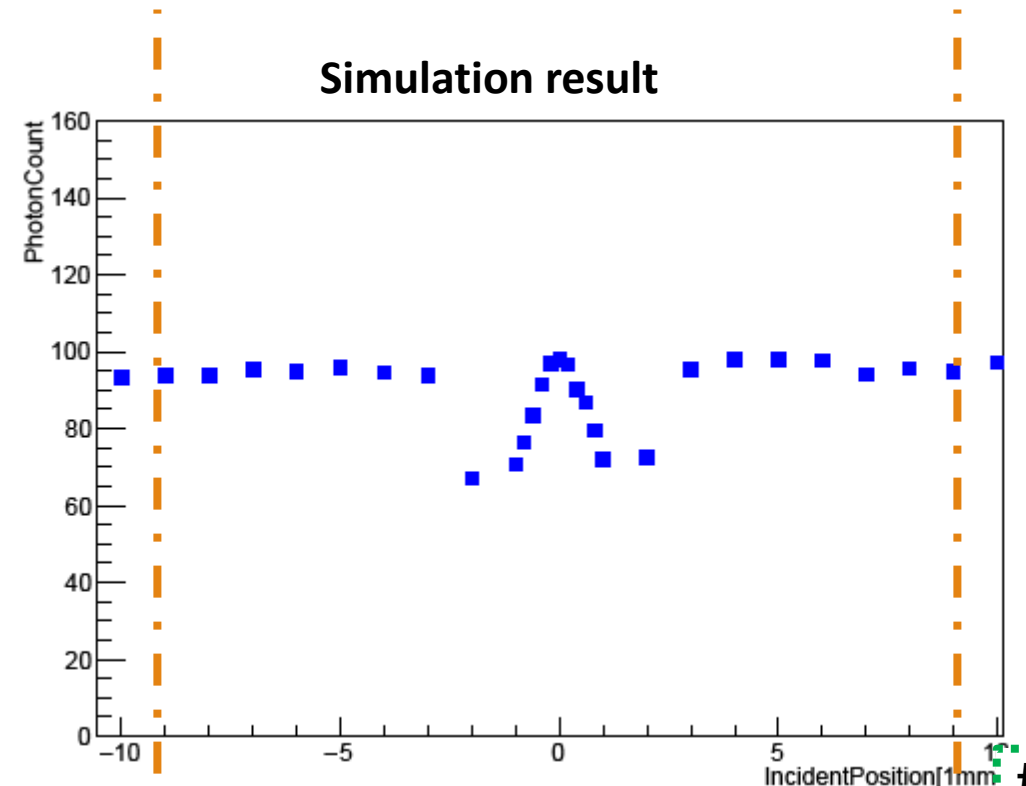


Difference in results

My measurement value result



Simulation result



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