

Scintillator/MPPC units for ScECAL

2013-12-18

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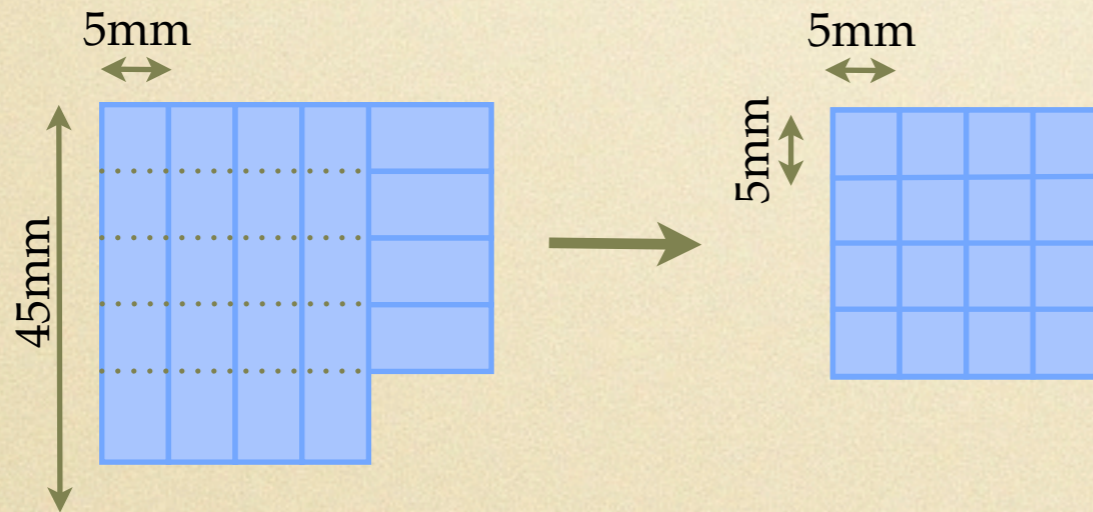
Shinshu University

Outline

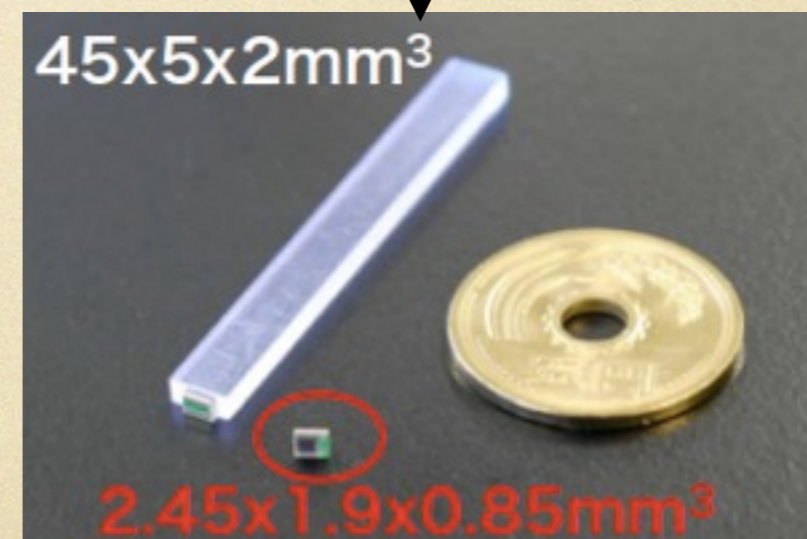
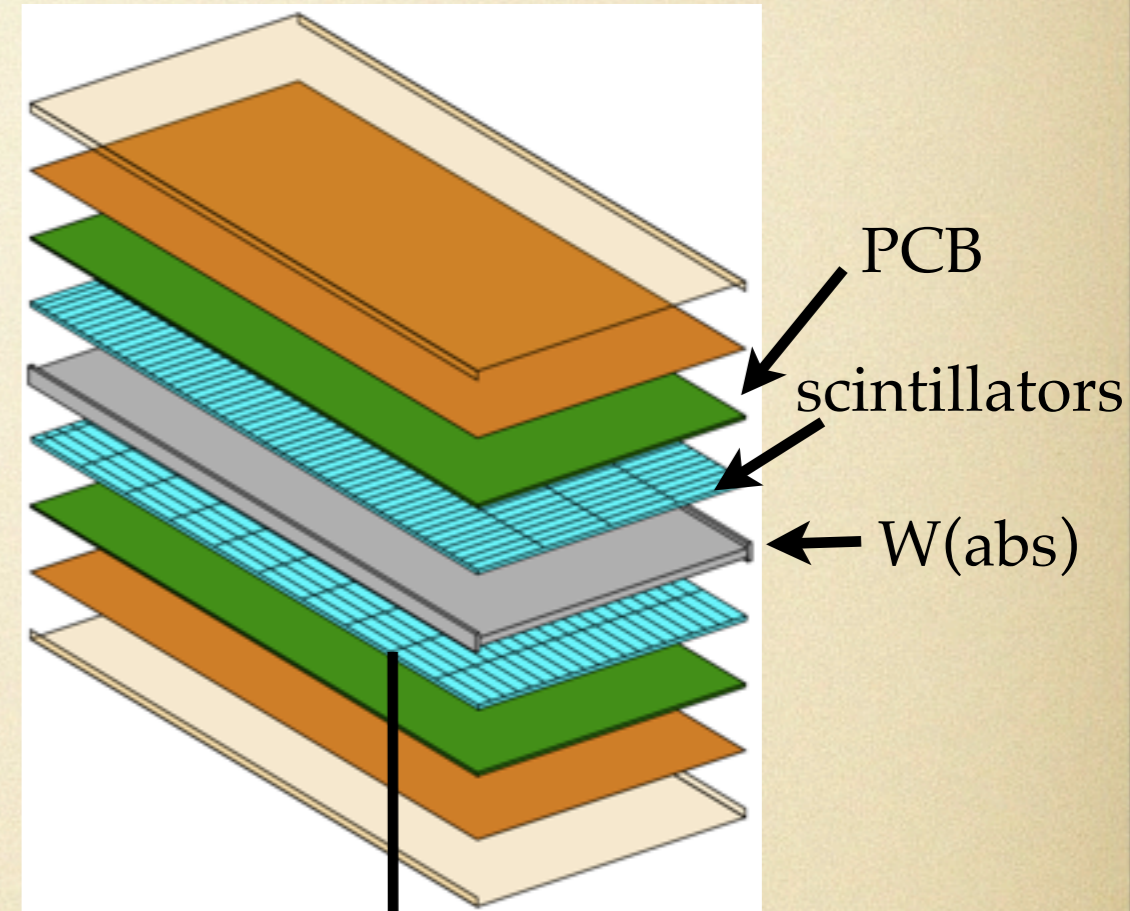
- Scintillator / MPPC units for ScECAL
- Motivation
- Measurements & simulation
 - Reflector effects
 - Surface smoothness of scintillator
 - Ideas for improve uniformity
- Summary & future plan

Scintillator/MPPC

- Each layer of ScECAL is filled with scintillator strip / MPPC units.
- Strip directions are orthogonal to each other.
->imaginary $5 \times 5 \text{mm}^2$ granularity(SSA)

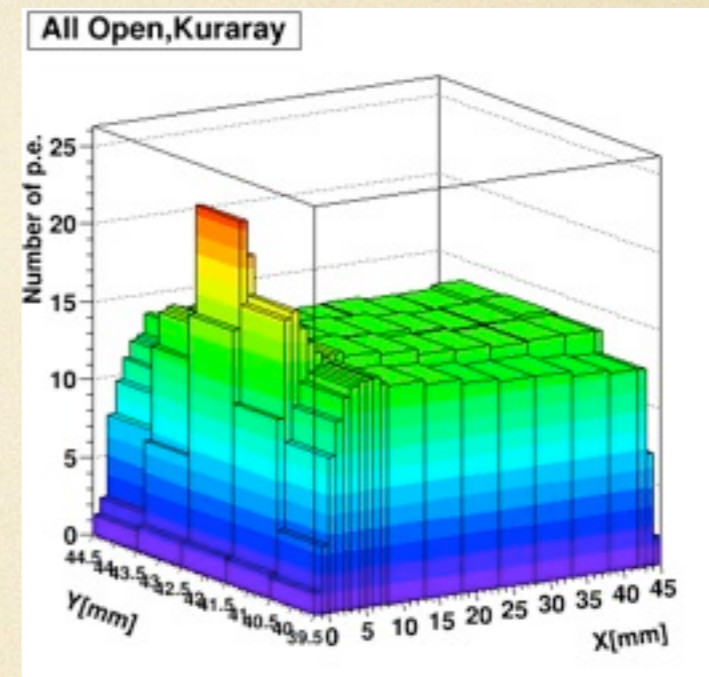
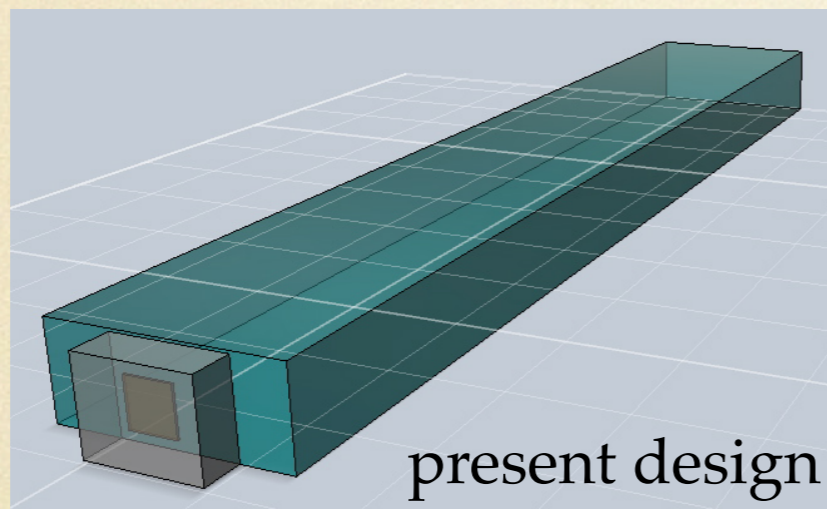


- Scintillation photon is read out by MPPC put on end side of strip.



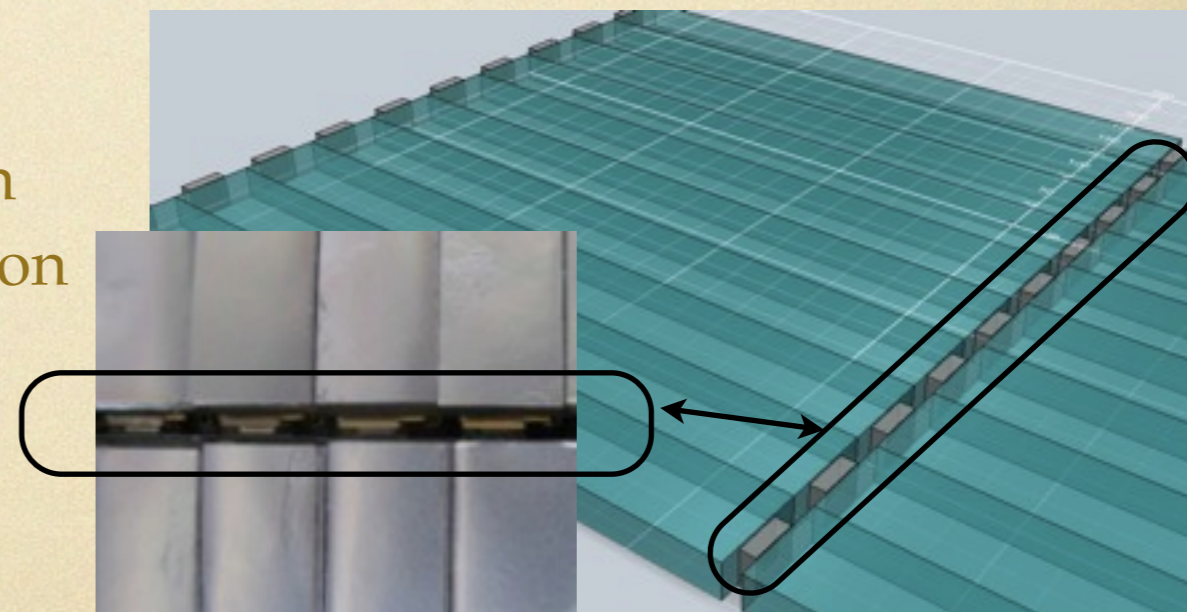
Motivation

- Non-uniformity in near MPPC area.



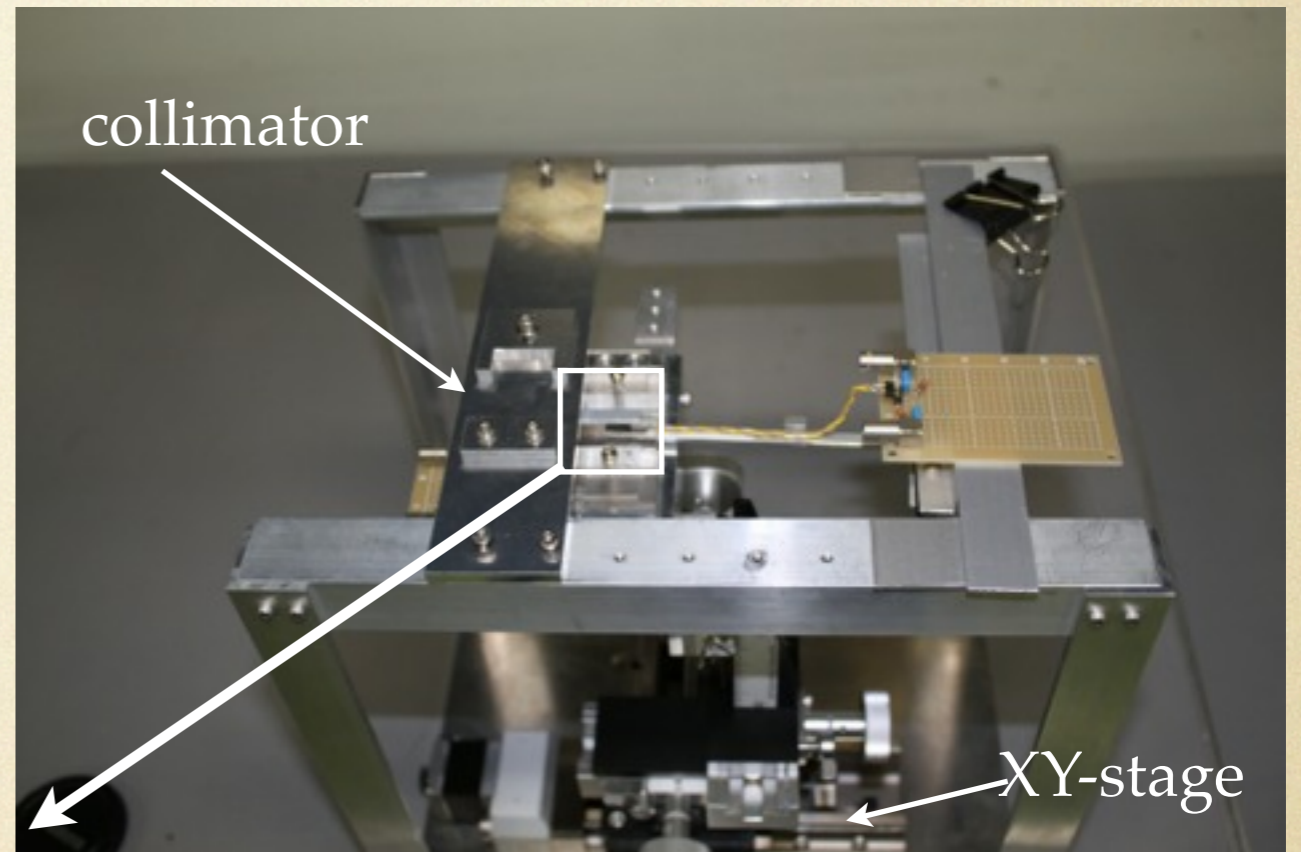
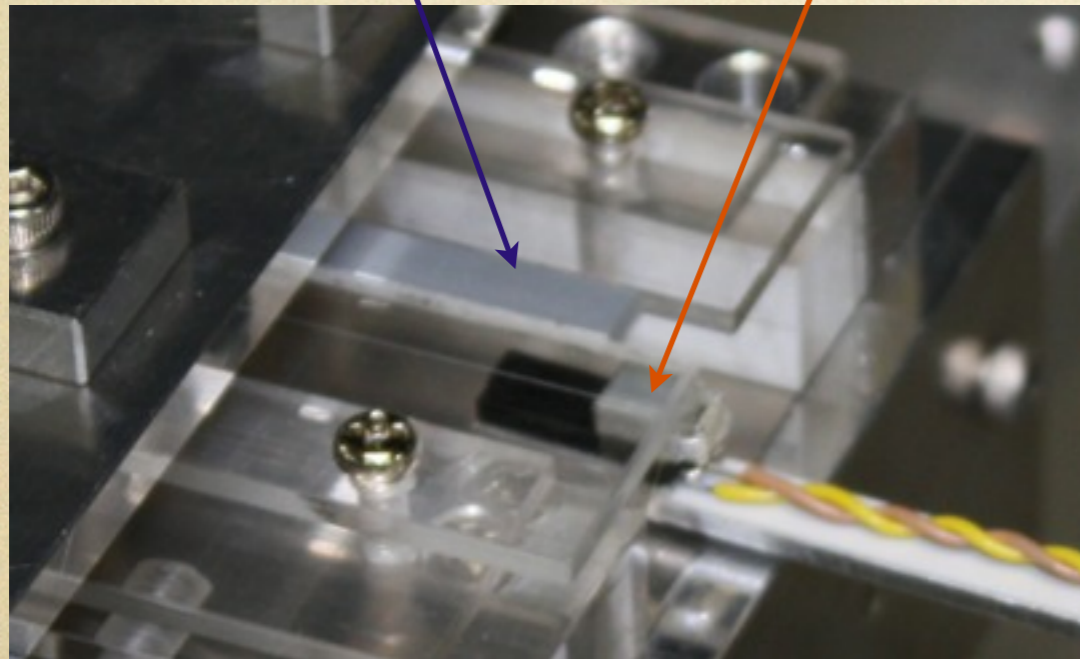
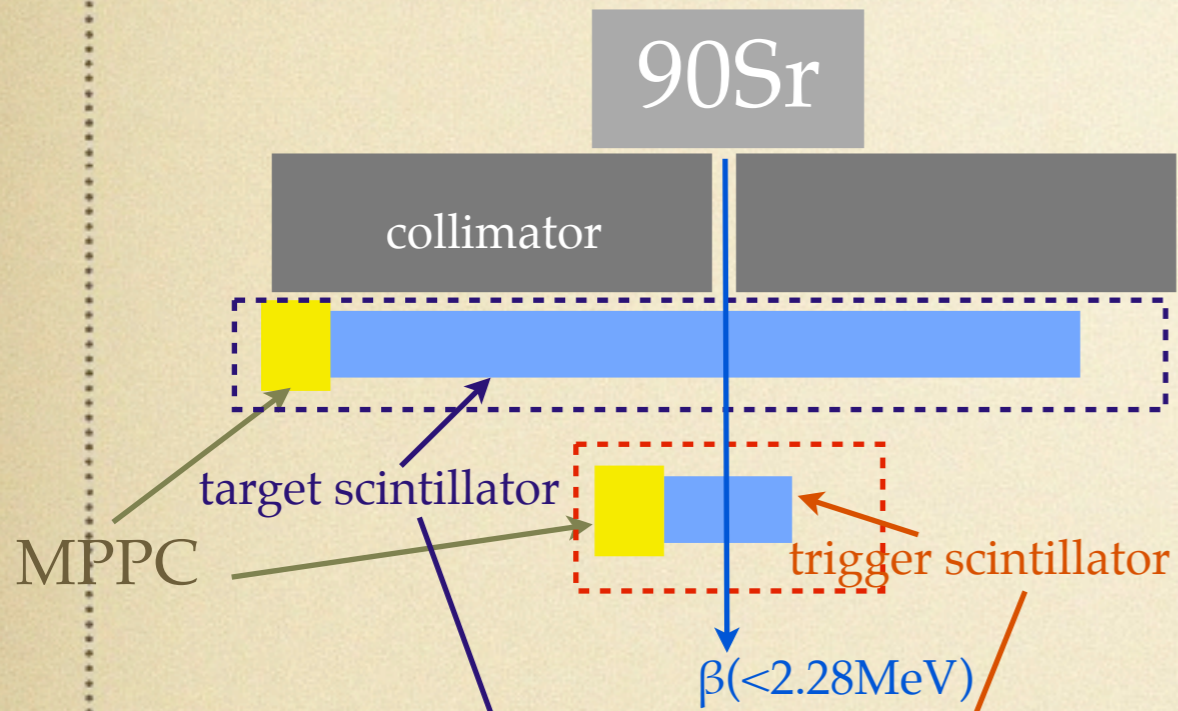
A result of the unit used to the preset engineering prototype.
I found the non-uniformity in near MPPC area and uniformity in other location.

- About 2% dead volume between scintillator strip due to installation upright MPPC .



- we need to develop scintillator/MPPC unit improving these problems.

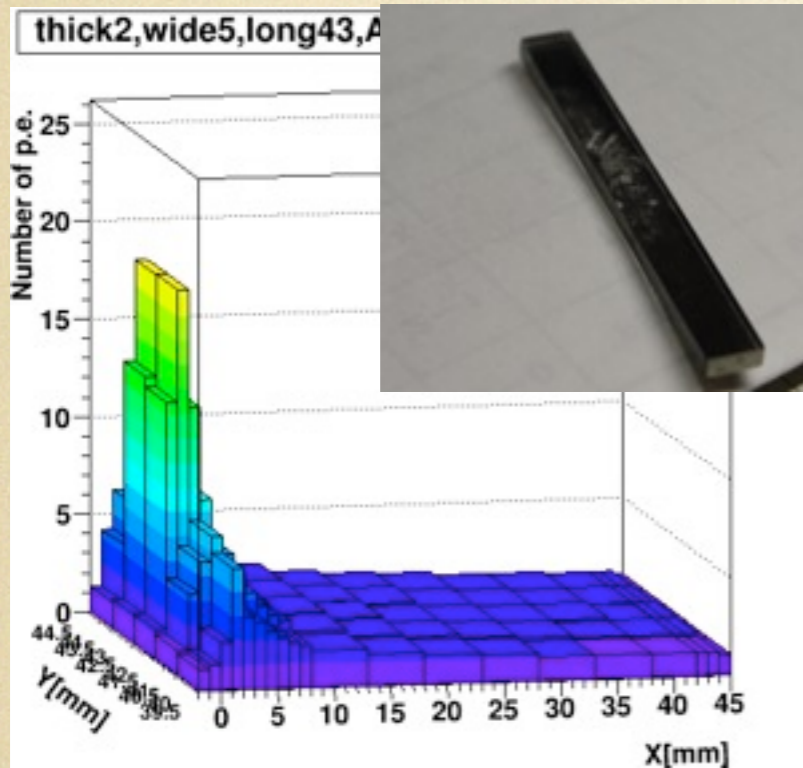
measurement set up



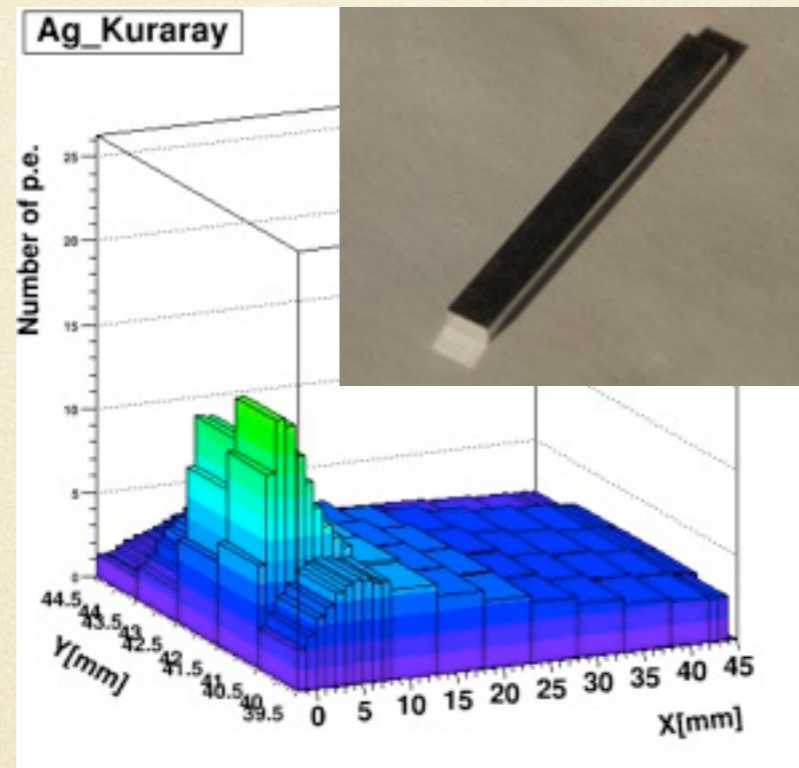
- Collimator diameter : 0.5mm
- Target is fixed to XY-stage we can control from PC.

Reflector effects

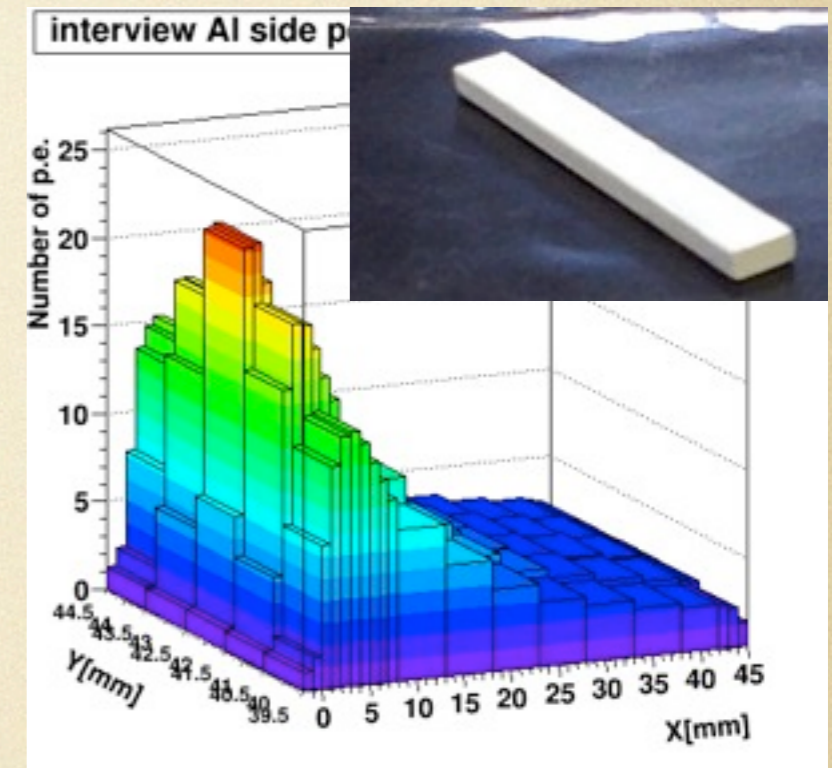
Al spattering



Ag spattering



white painting



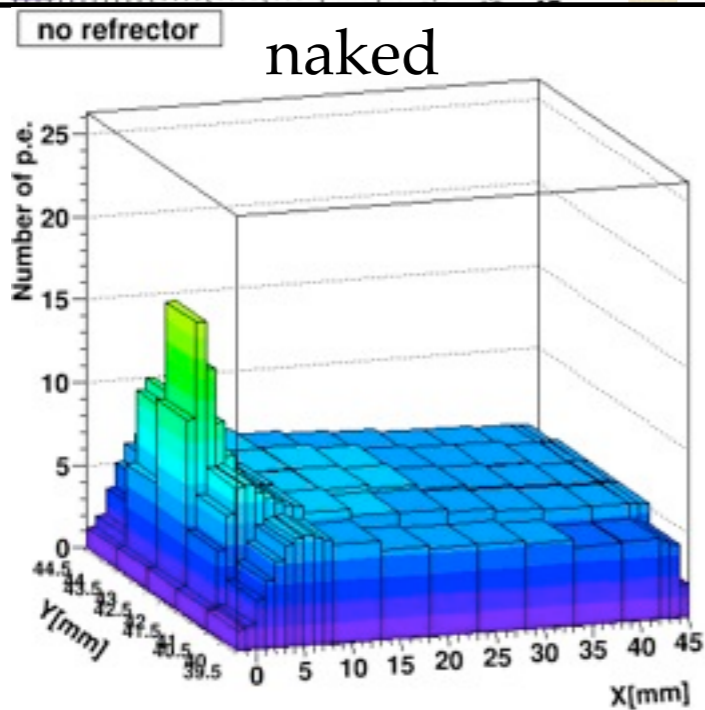
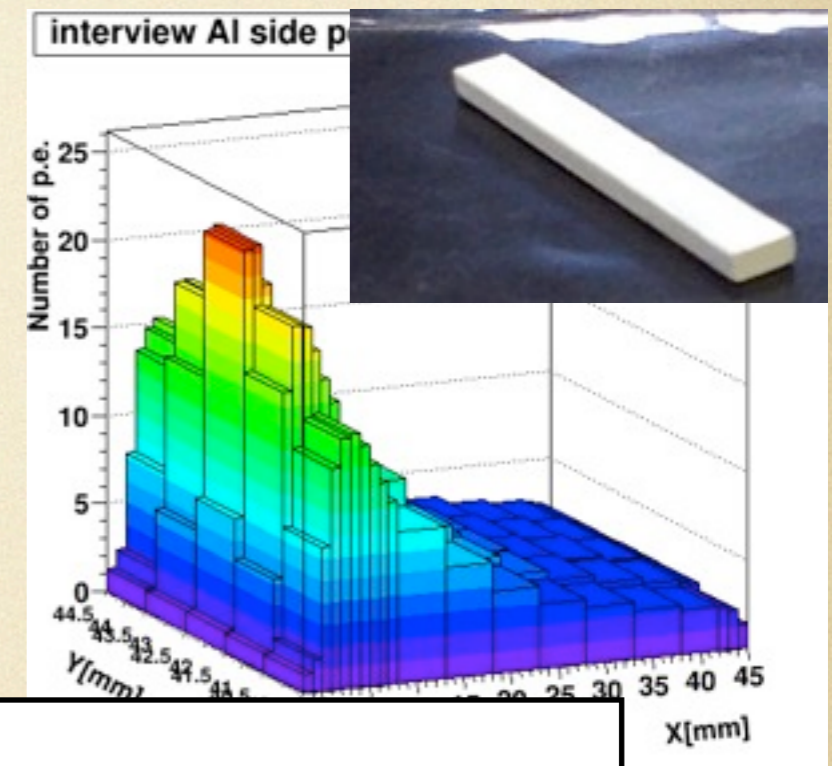
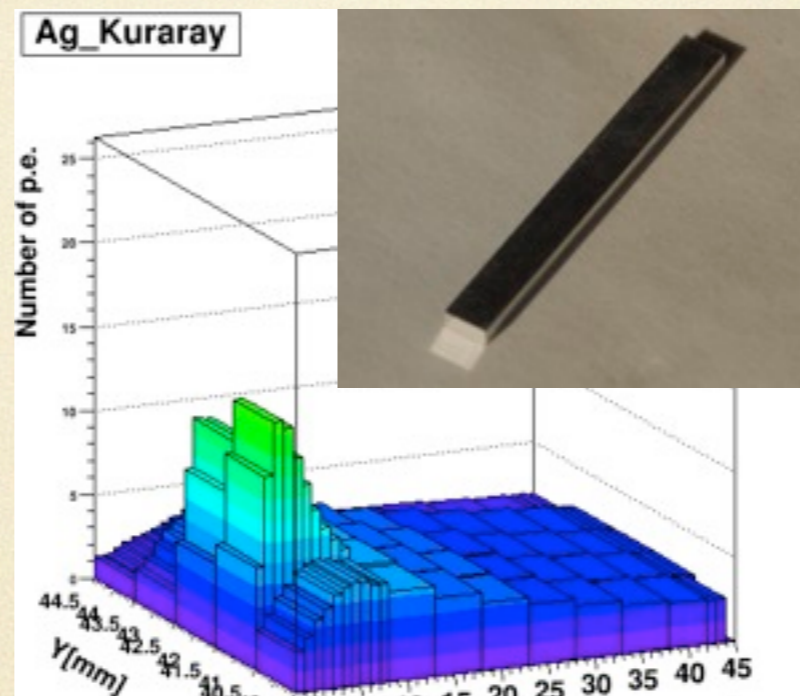
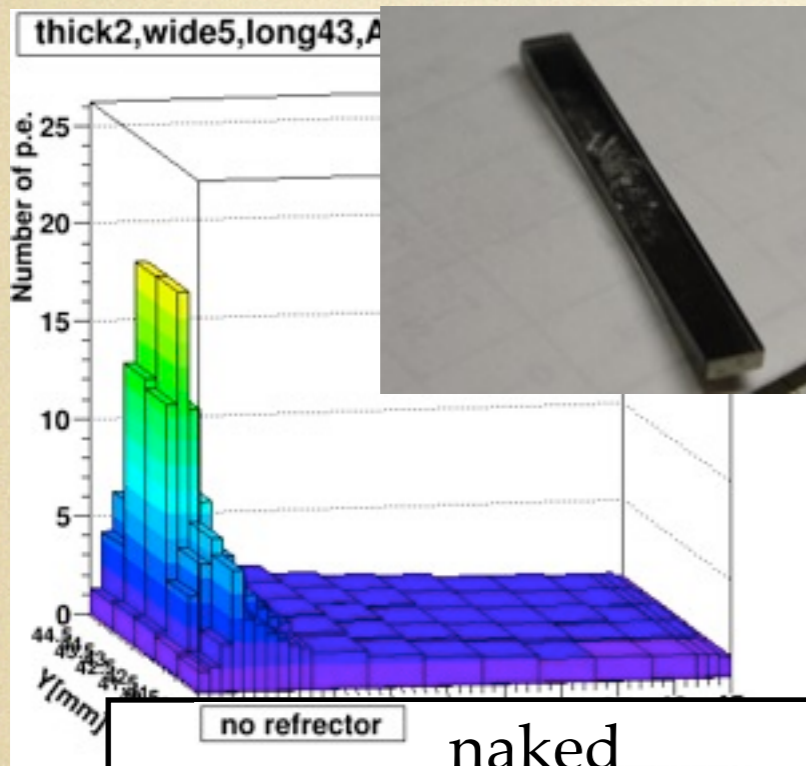
- Spattering and painting methods are easy to make reflectors.
- But these methods do not work well.
 - Low photon detection from distant location.
 - Efficiency changes rapidly.(large non-uniformity in near MPPC area.)

Reflector effects

Al spattering

Ag spattering

white painting



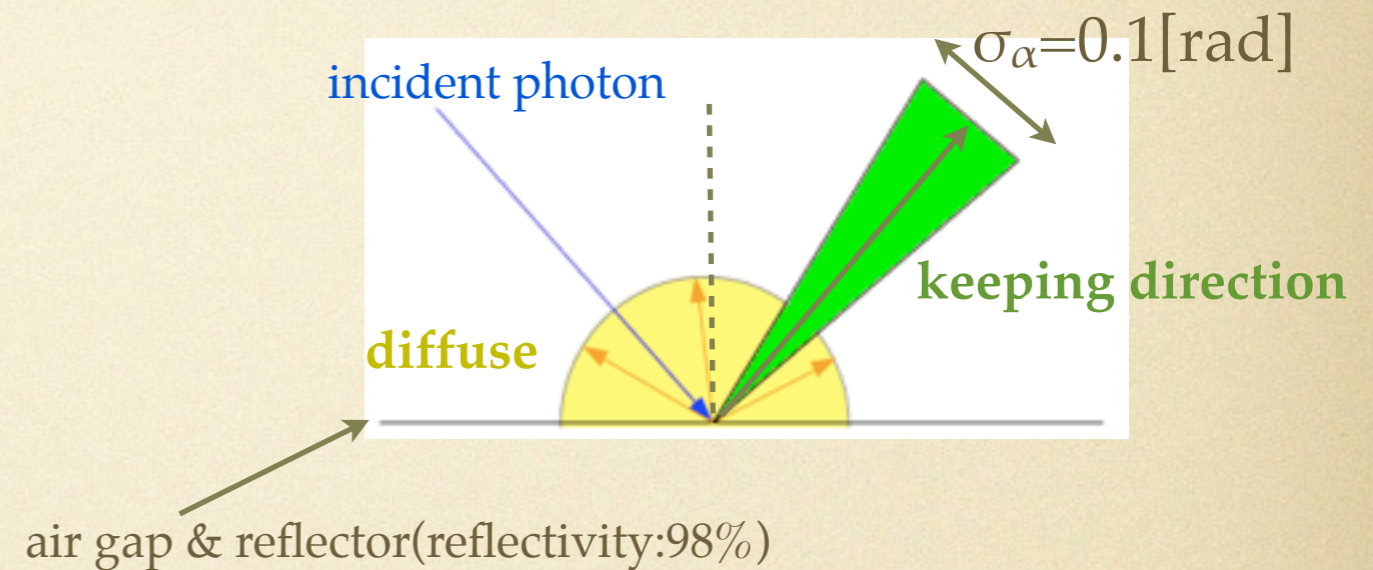
Even a strip not covered by any reflector has more photon yield & uniformity

Total reflection on surface between strip and air gap is very important.

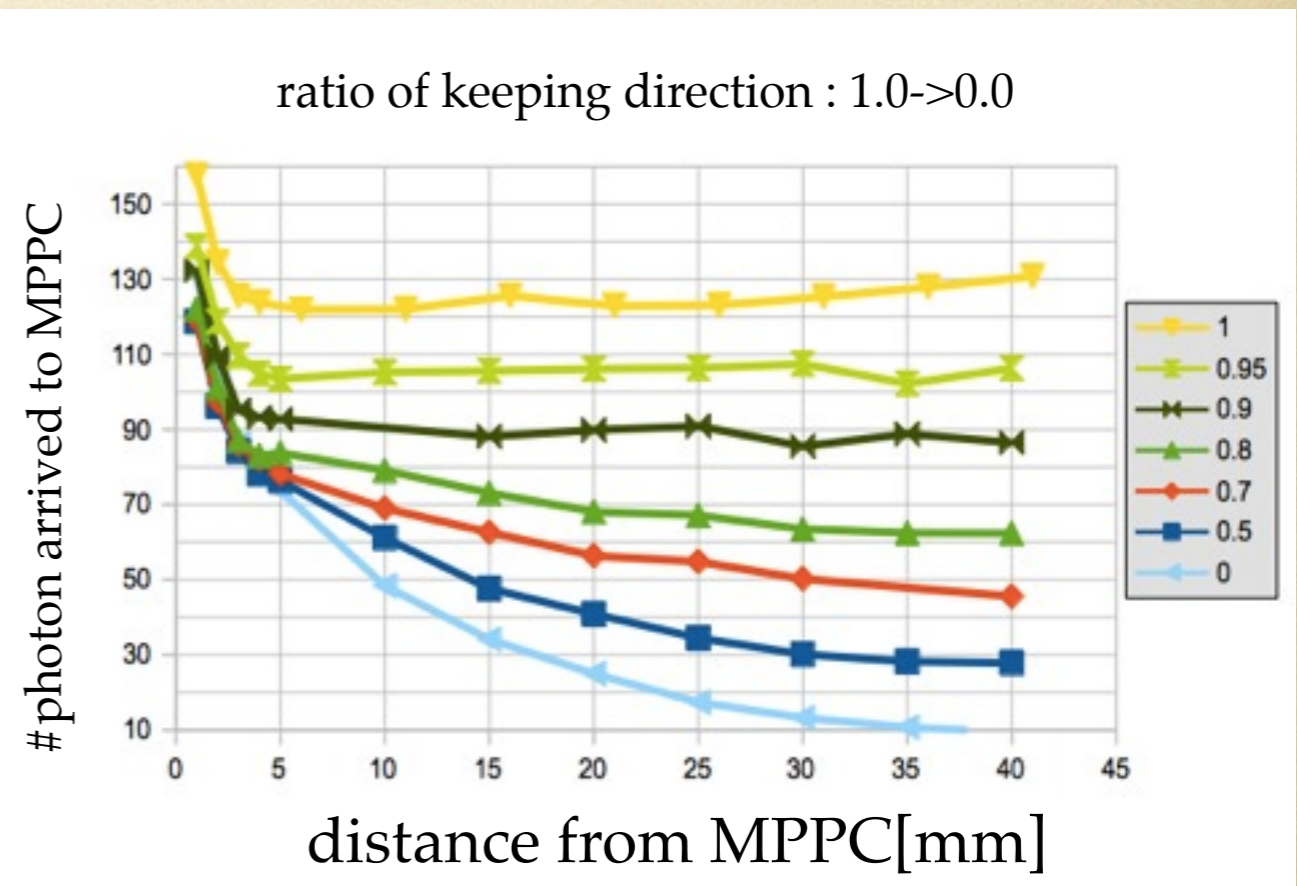
Surface smoothness

scintillation light simulation with Geant4

I investigate the effect of surface smoothness on Geant4 simulation changing surface property : ratio of keeping direction(1.0->0.0).

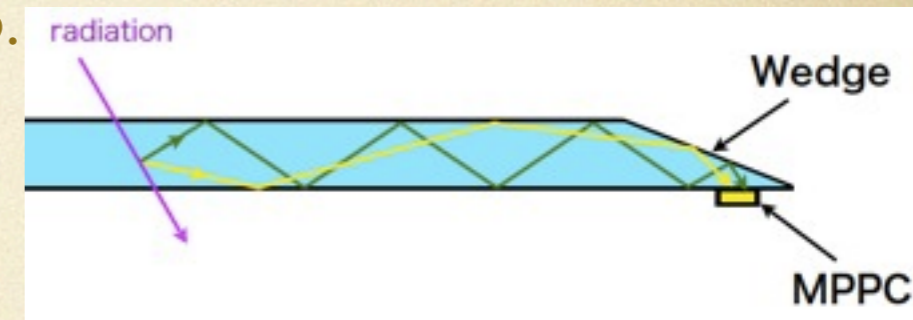


Photon collection depends on surface smoothness , even reflector has similar & high reflectivity. (We need to investigate these effects by experiment.)



Idea to improve uniformity

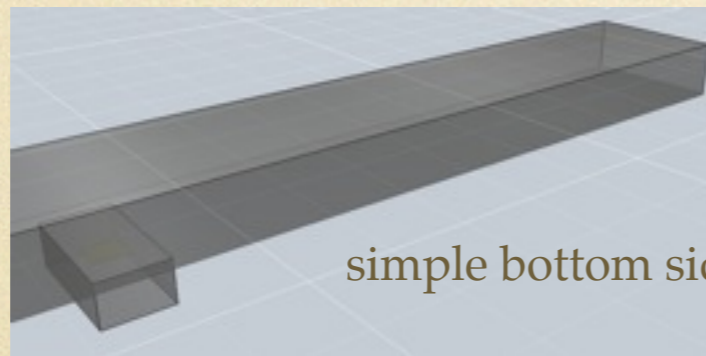
- Wedged shaped strip was proposed by Tokyo group.



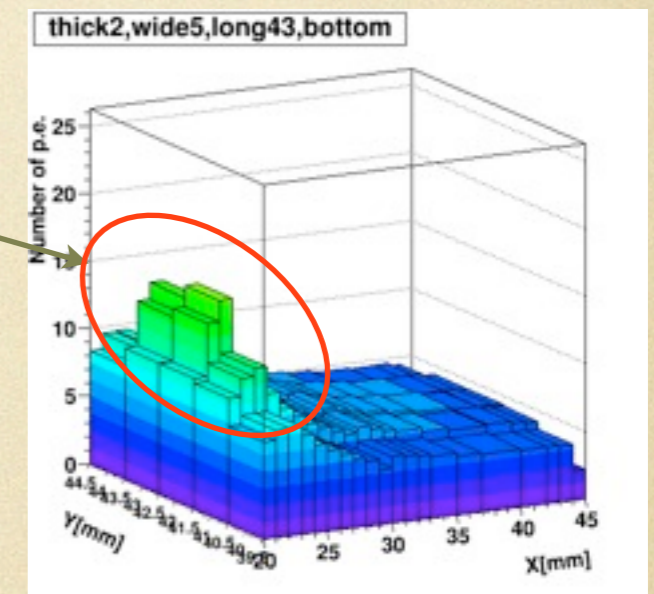
- Merits

- Wedge guides photons to a MPPC attached on bottom side of strip.
->get enough photon yield & make the fabrication easier.

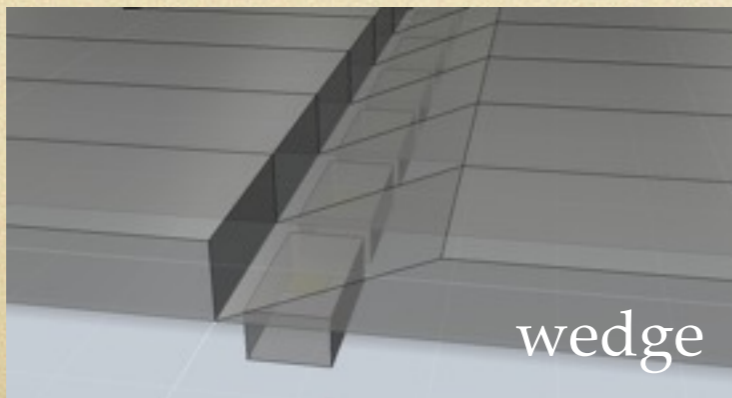
- In near MPPC area, particle through shorter length.
-> reduce peaky response near MPPC area.



simple bottom side read out



- No dead volume between strip.

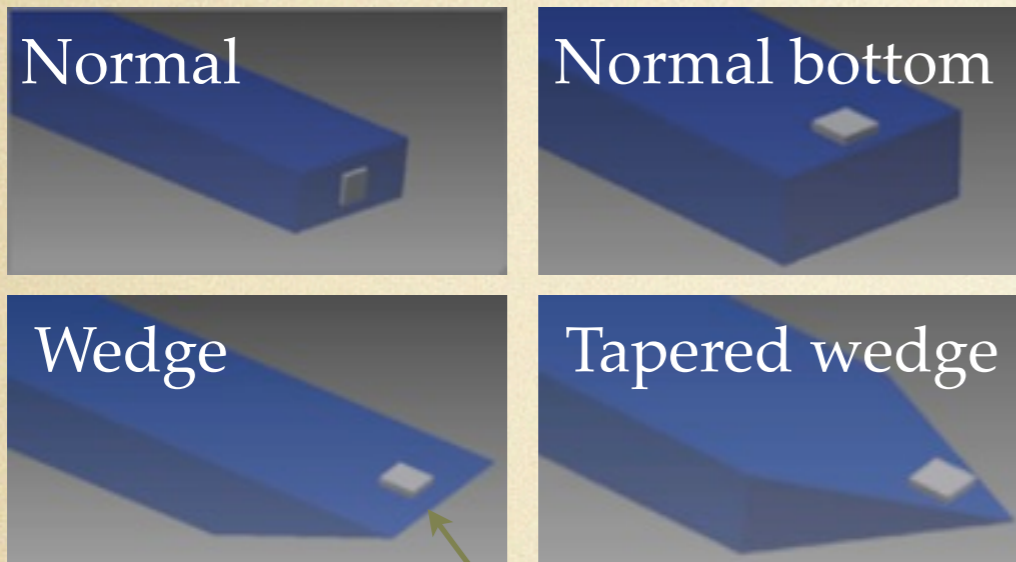


wedge



tapered wedge

Idea to improve uniformity



1*1mm²MPPC

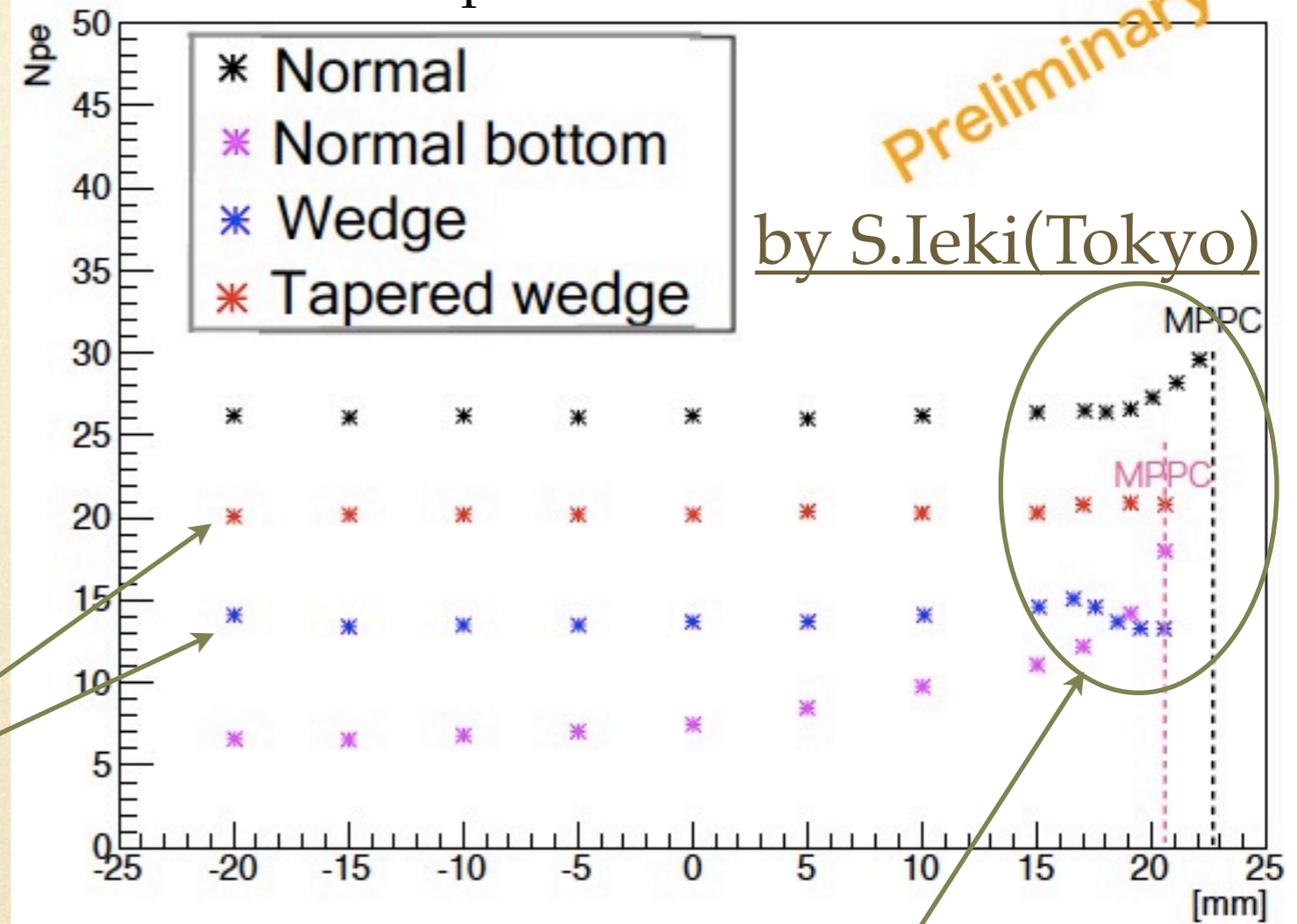
Photon collection efficiency

Tapered wedge : 70~80% of normal

Wedge : 60% of normal

It is reasonably high.

experimental results

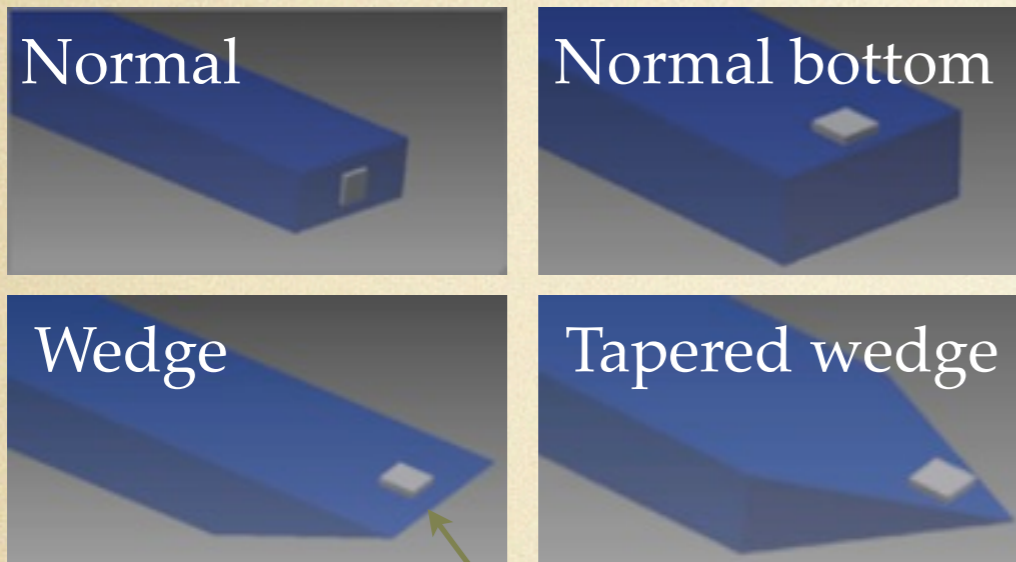


by S.Ieki(Tokyo)

peaky response in near MPPC area is improved

- Wedge & tapered wedge have good uniformity & photon yield. These idea is one of the candidate for our ScECAL.

Idea to improve uniformity



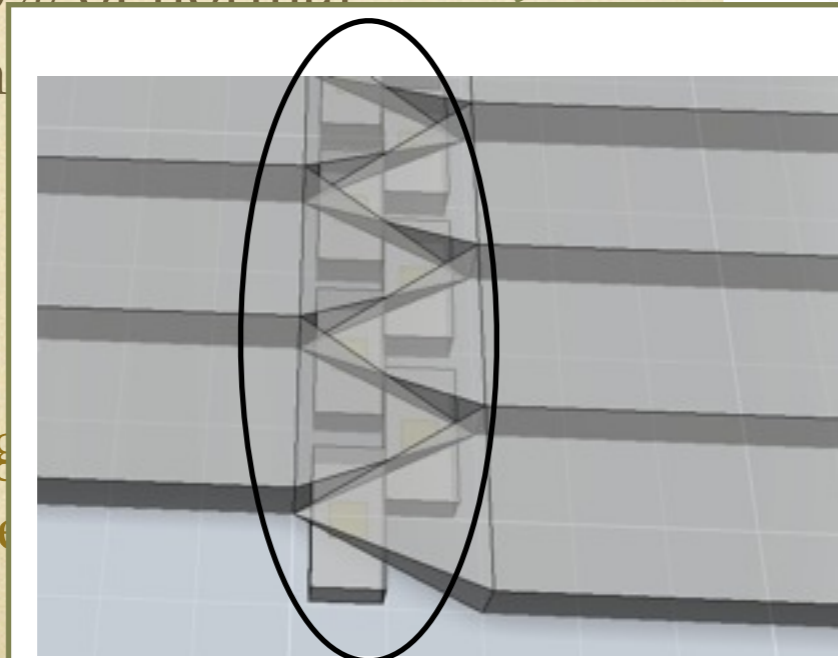
1*1mm²MPPC

Photon collection efficiency

Tapered wedge : 70~80% of normal

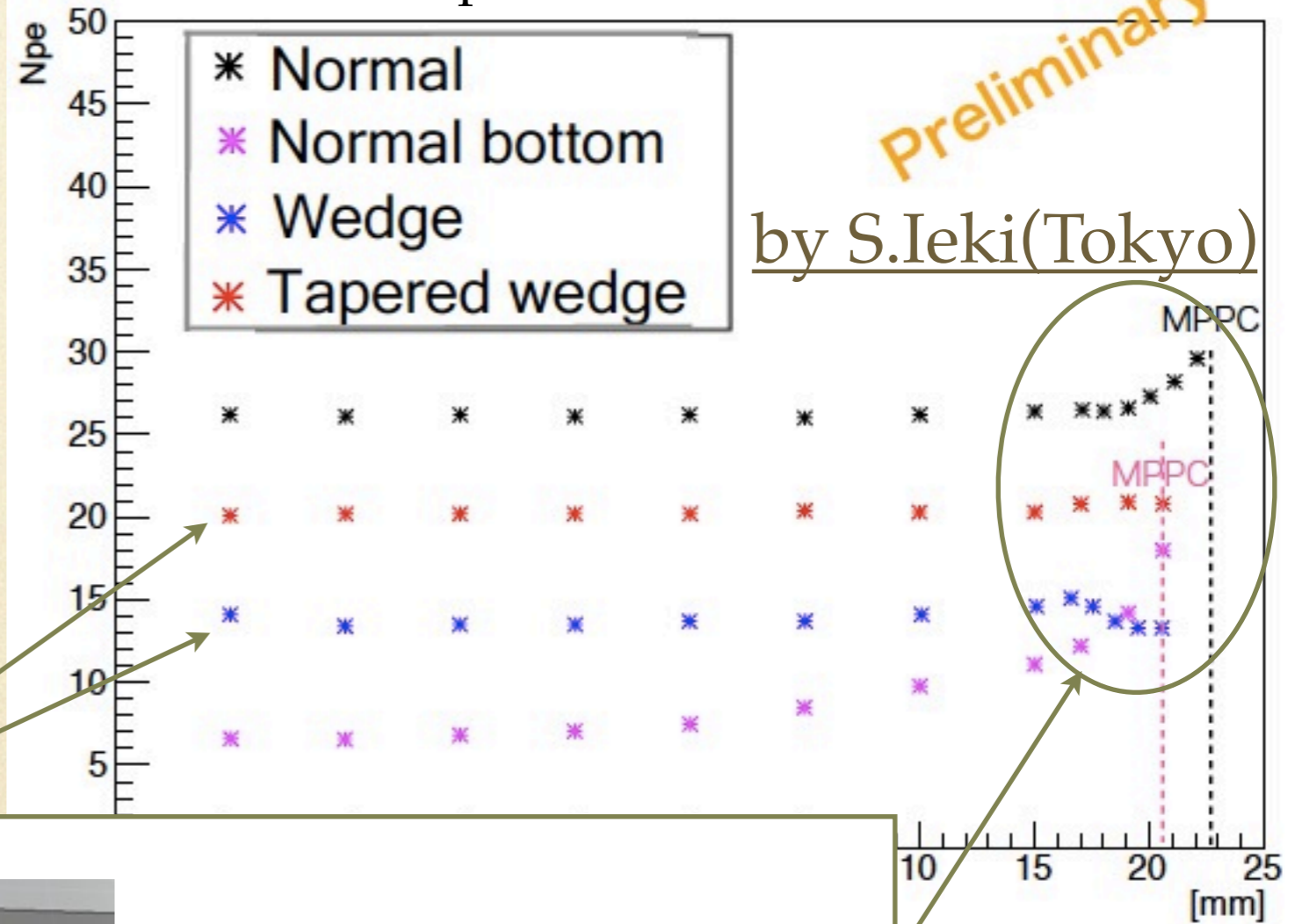
Wedge : 60% of normal

It is reasonable



- Wedge
- These

experimental results



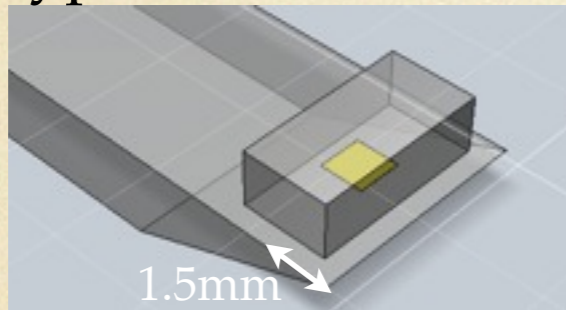
by S.Ieki(Tokyo)

Tapered wedge is essentially no problem, but this will create a very complex MPPC area on the PCB.

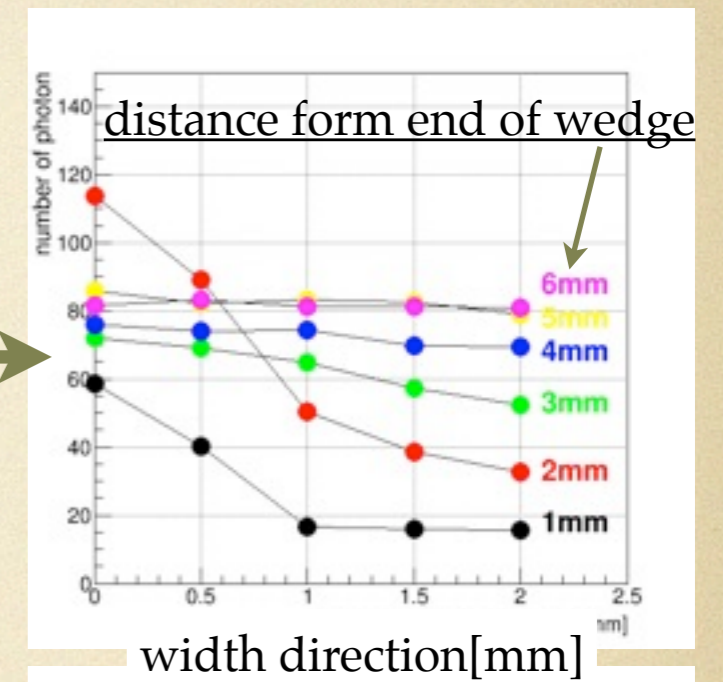
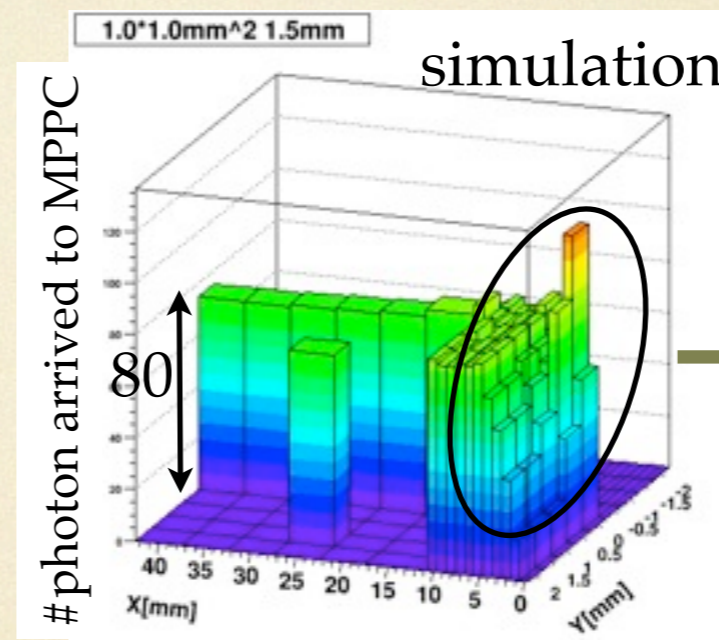
is improved

simulation of rectangular MPPC

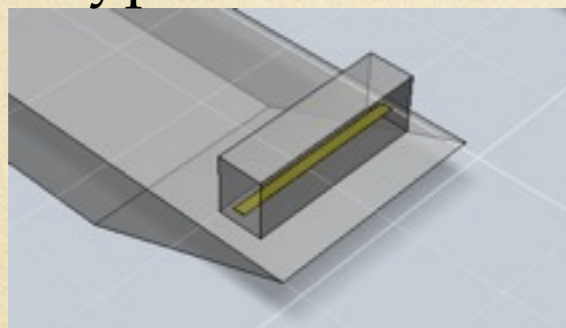
normal type MPPC



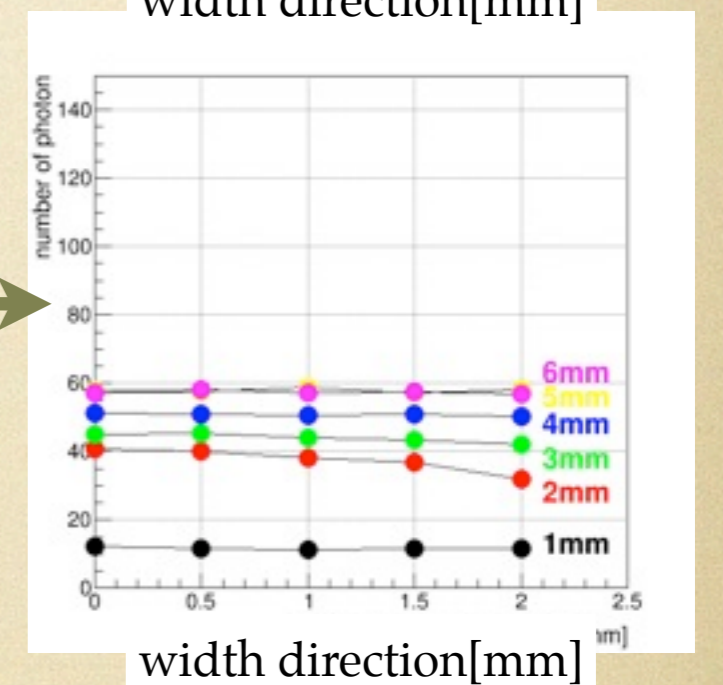
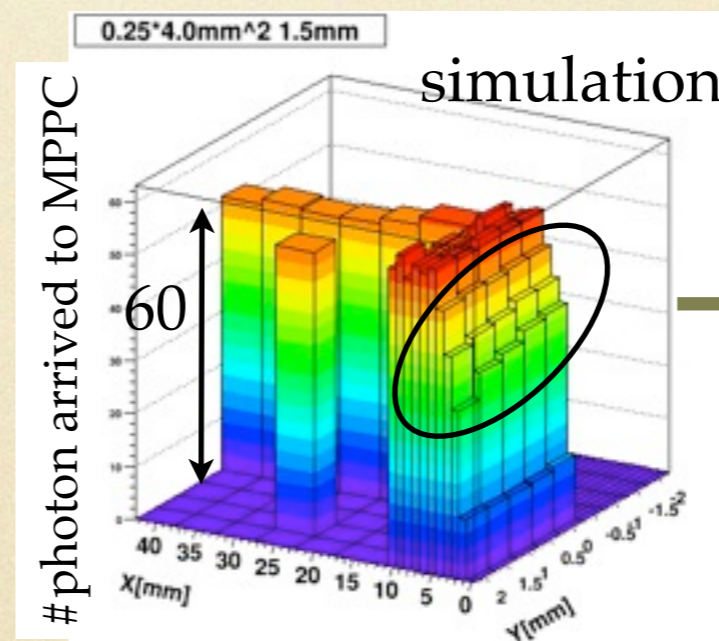
wedge using $1 \times 1 \text{mm}^2$ MPPC has non-uniformity in width direction in near MPPC area



rectangular type MPPC



MPPC: $0.25 \times 4 \text{mm}^2$
same position (temporary)



- Non-uniformity in width direction can be removed by using slender MPPC. But photon collection efficiency is decreased to 75% of $1 \times 1 \text{mm}^2$ MPPC. I think it can be improved by optimization.

Summary

- Even though reflector has high reflectivity, total reflection with air gap & surface smoothness is important to keep photon yield & uniformity in almost area.
 - At present, the only promising method is covering the strip by reflector film.
- Wedge & tapered wedge type strip has good photon yield & uniformity.

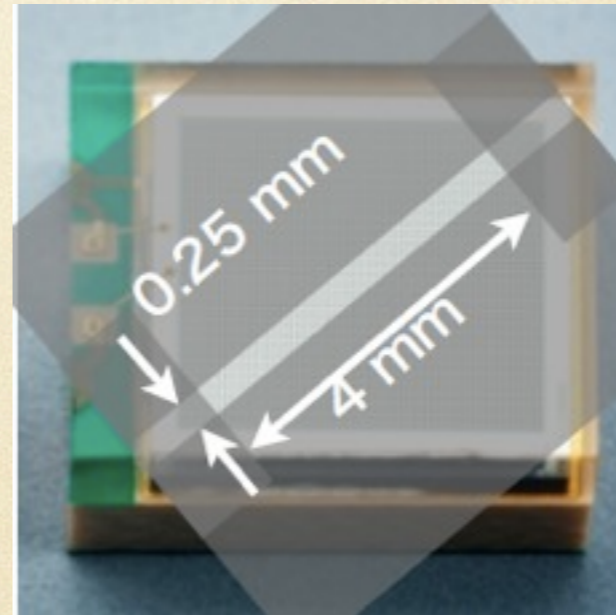
future plan

- Both experimental and simulation
Wedge & tapered wedge

wedge length , position of MPPC, etc...

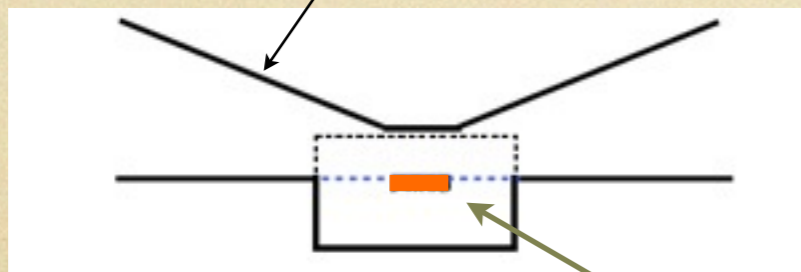
- Investigate the effect of slender MPPC in experiment.

using 3×3 [mm²] MPPC with a slit →
to make rectangular shape instead of
real slender MPPC immediately.



- Other design

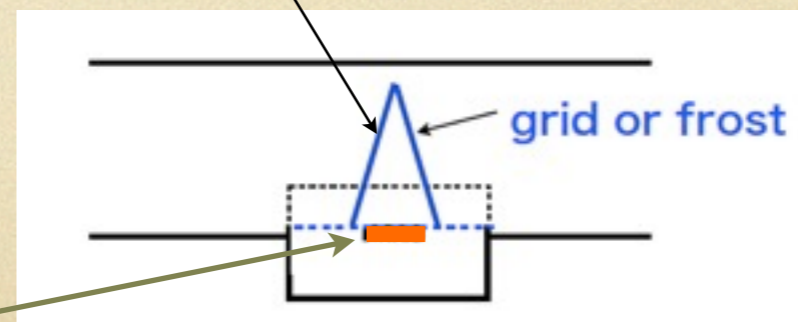
work as prism guid photon to a MPPC



dip

MPPC(sensitive area)

random reflection

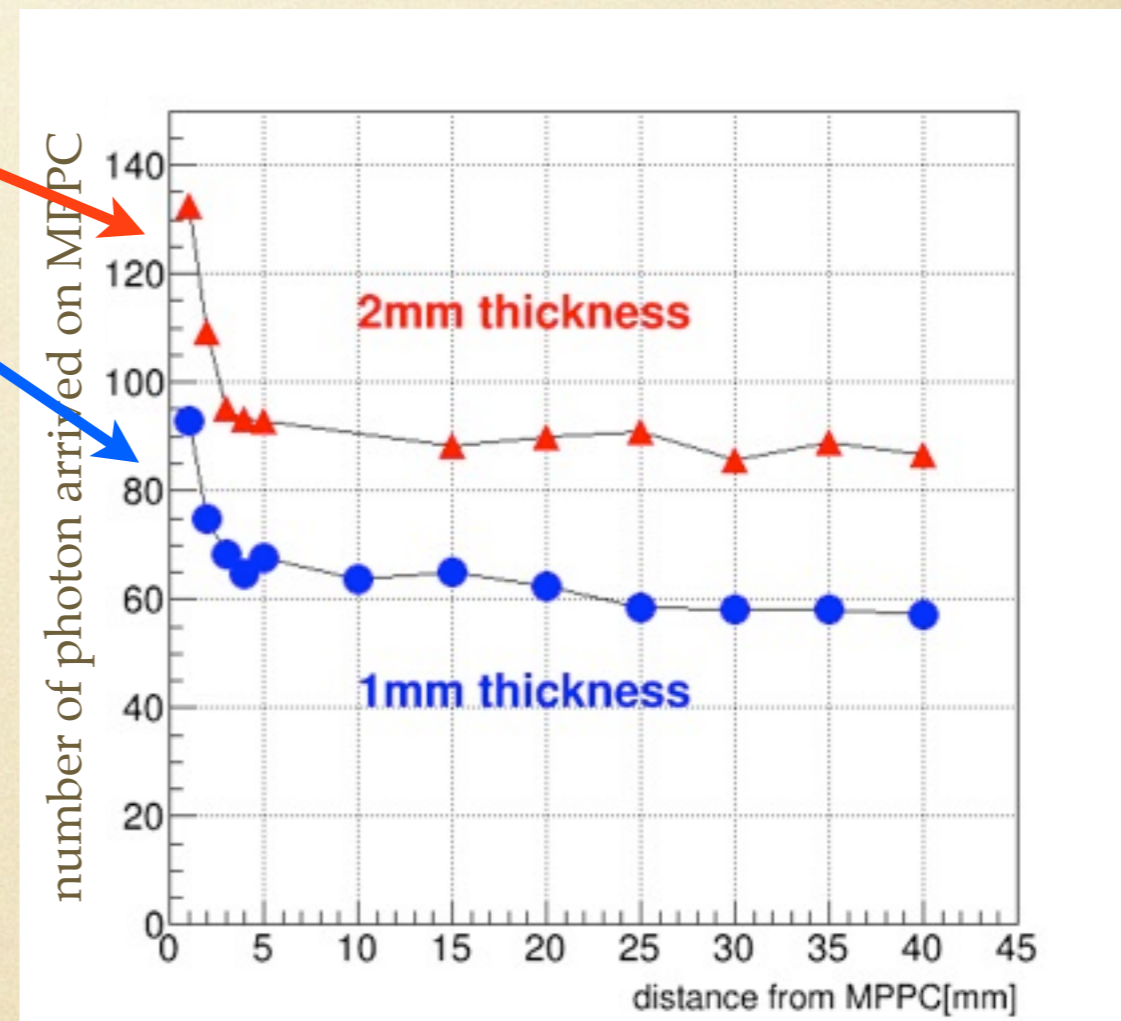


dimple

thank you for listening

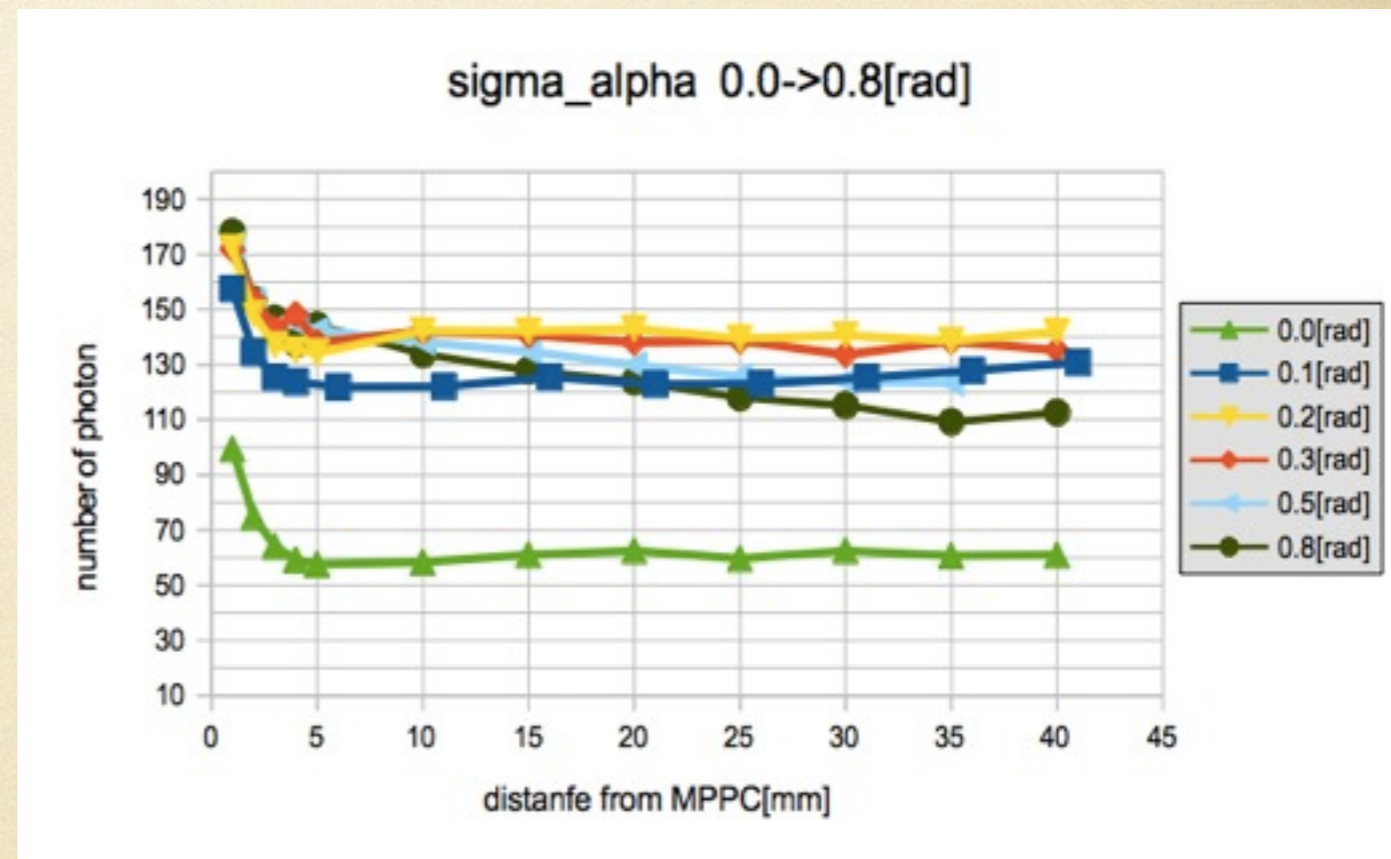
1mm thickness

- size : $45*5*2\text{mm}^3$
 $45*5*1\text{mm}^3$
- Photon yield is 60~70% of 2mm thickness type. It is consistent with our experiment.



sigma_alpha dependence

- keep direction : 1.0(const)
- normal type strip.
- sigma_alpha : 0.0->0.8[rad]



- Few effect of sigma_alpha in a range of 0.1-0.5[rad].