

Study of Scintillator-MPPC unit

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K. Kotera

Shinshu university

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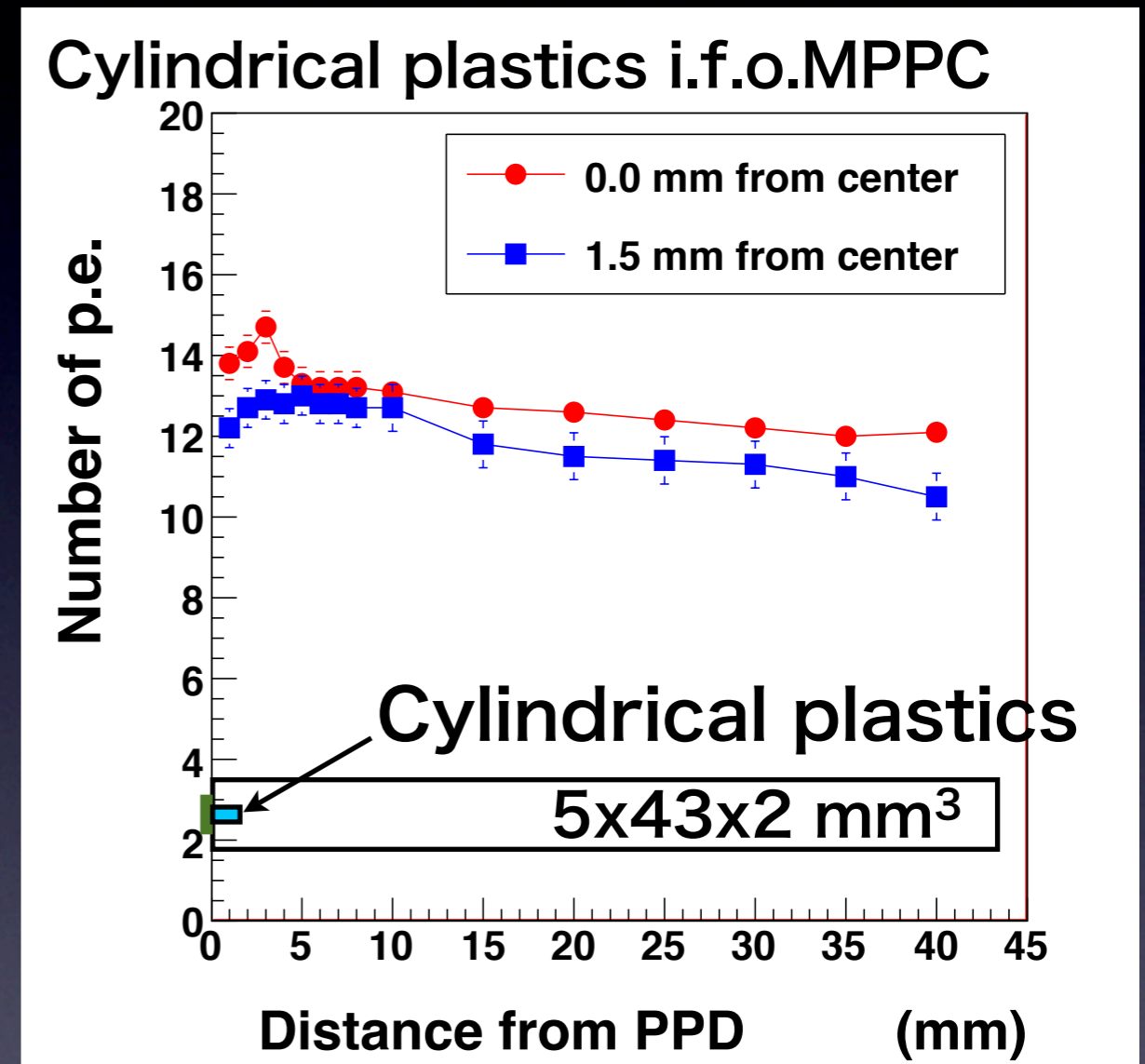
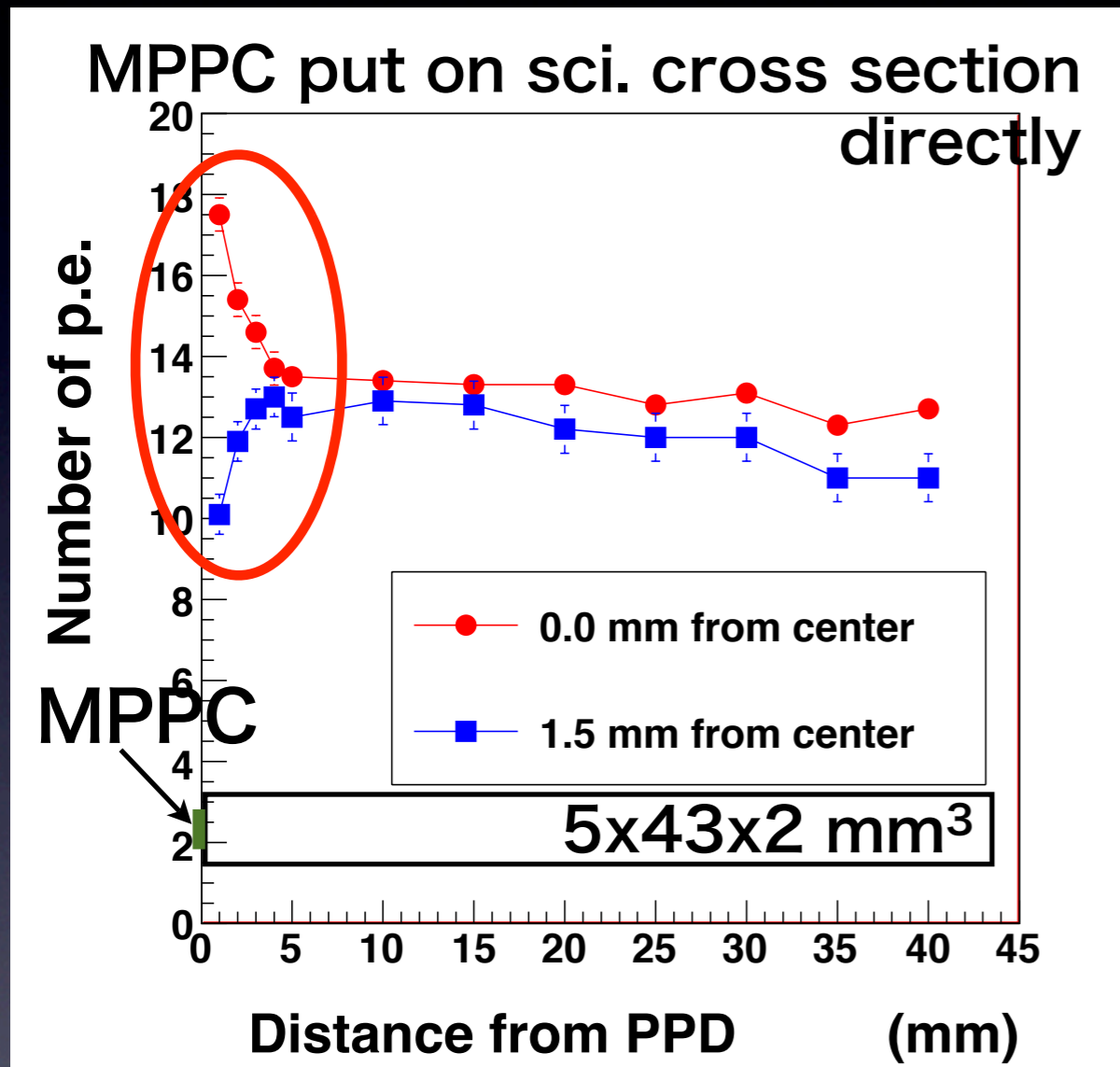
Situation

- We need to develop Scintillator-MPPC strip unit which has;
 - good uniformity of response to have good energy resolution,



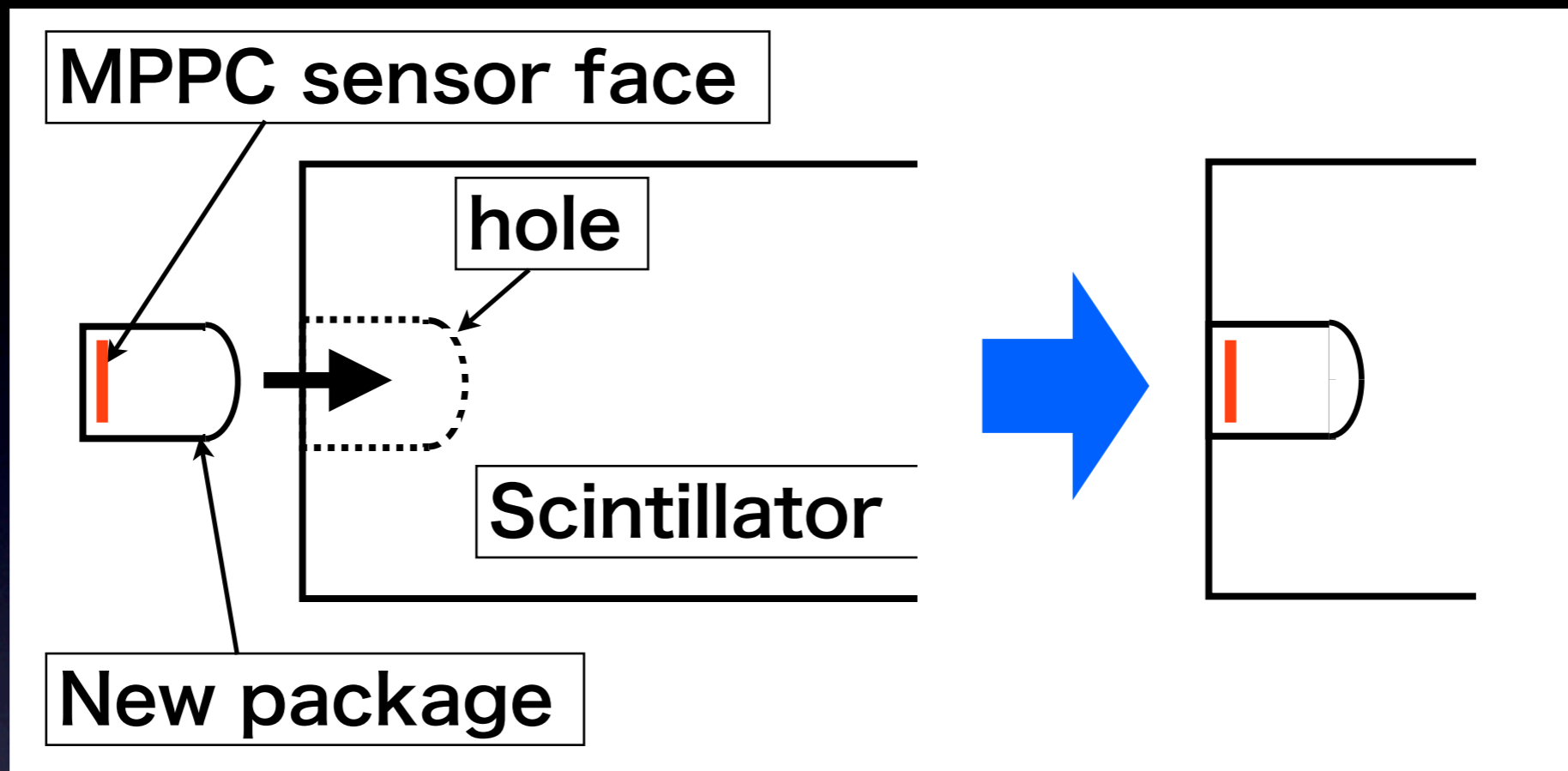
- 10 x 45 mm² x 3 mm ► 5 x 45 mm² x 2 mm
- we cannot use WLS fiber for 5x2 mm² cross section of scintillator anymore,
- greater than seven photon yield at MPPC by MIP, considering noise effects from 10⁷ channels.
- reduction of dead space from MPPCs, and
- rigidity of set of units on PCB.

A method to keep uniformity



- Direct readout makes large fluctuation of response in front of MPPC
- Plastic cylinder in front of MPPC potentially improves uniformity.

Acrylic socket MPPC package



We need to optimize the shape of socket to have uniform response.

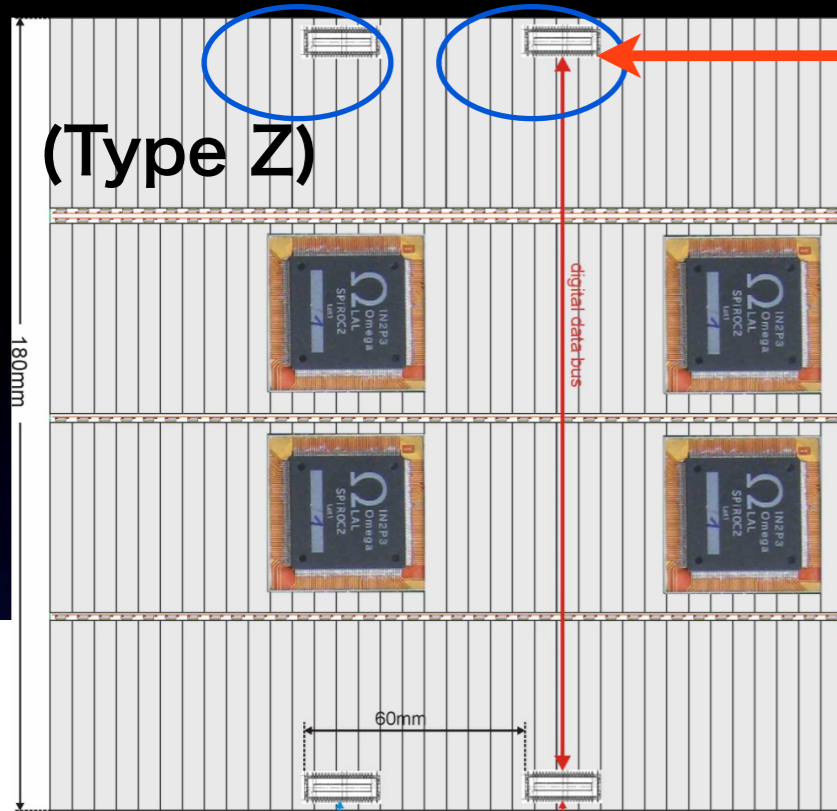
Problem?:

This makes Complex procedure, dig hole, put on in ...

How can we make some trial version? die is expensive, ...

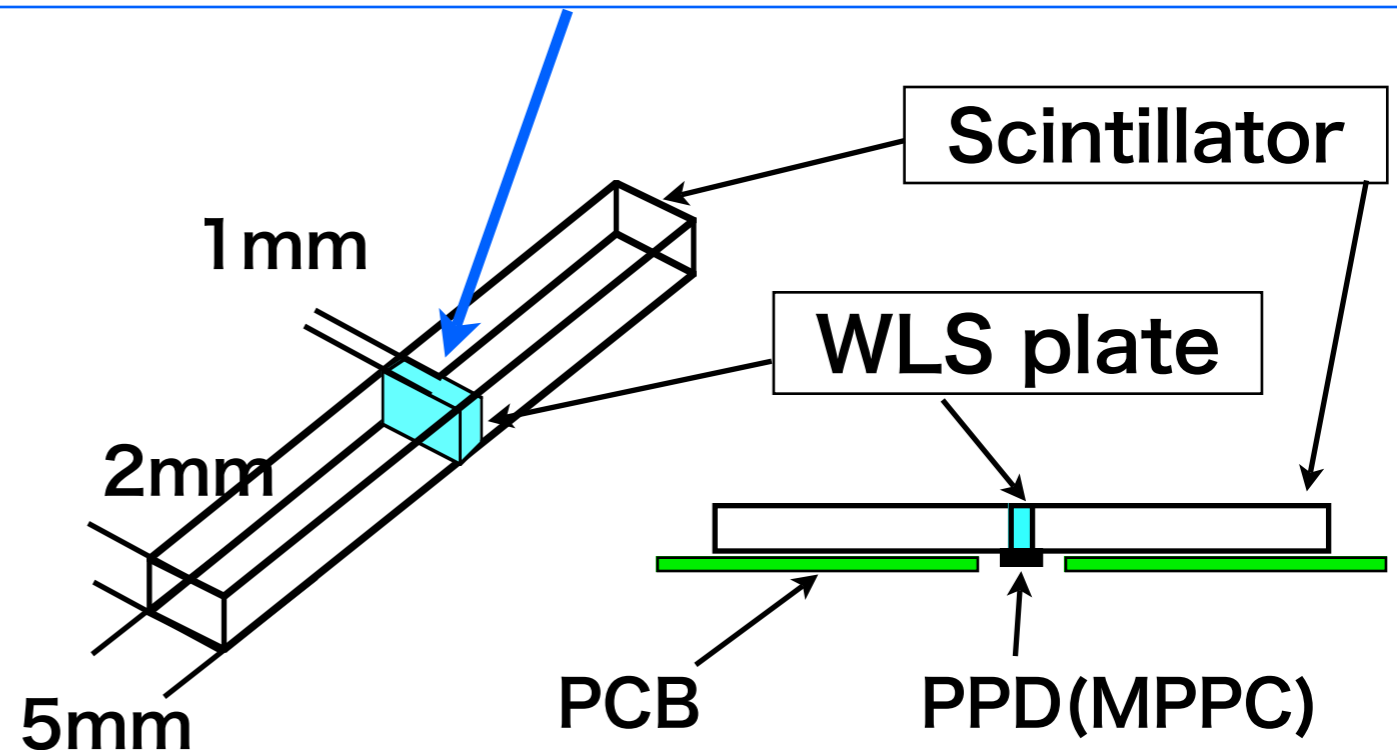
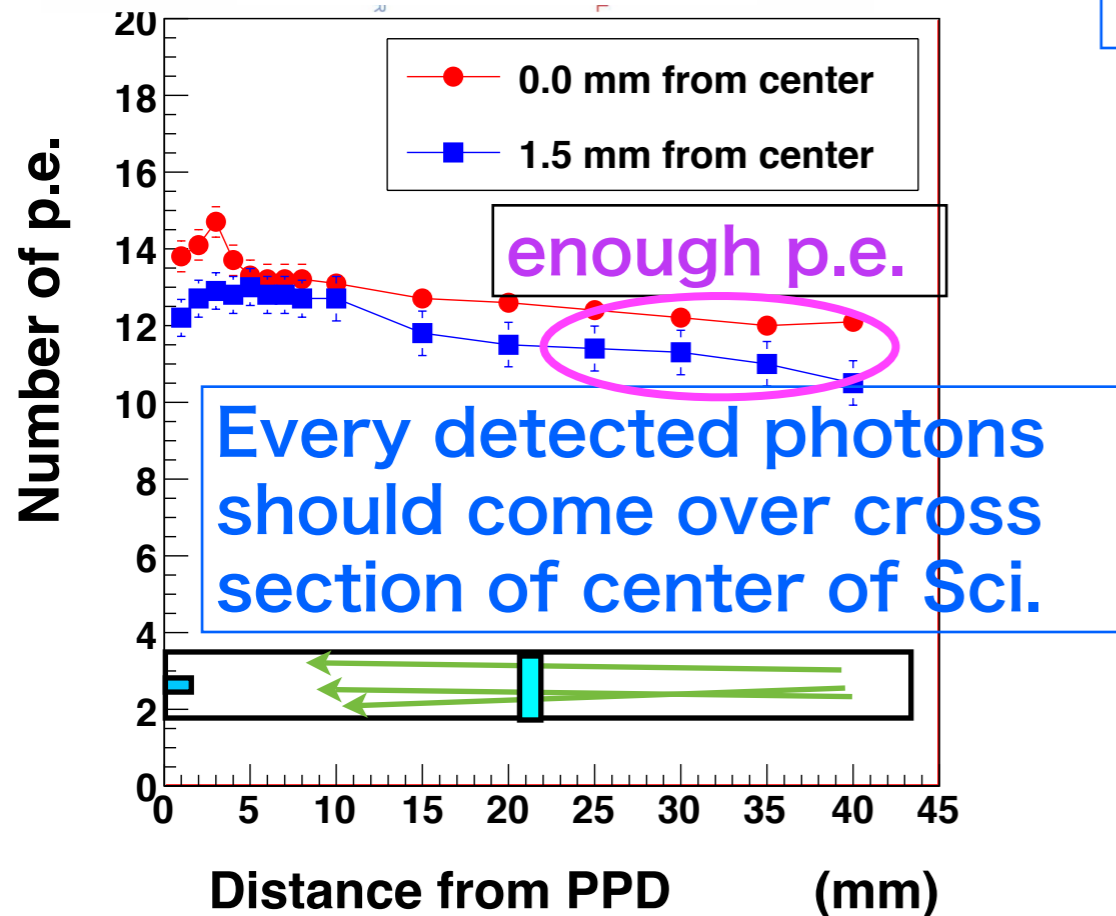
Maybe by using Monte Carlo etc or we make it by hand.

Another idea ... 'seeing from the bottom



-To avoid flat cable goes over MPPC pins,
-strips only this row are flipped so that the dead volume from MPPC becomes 2 mm width

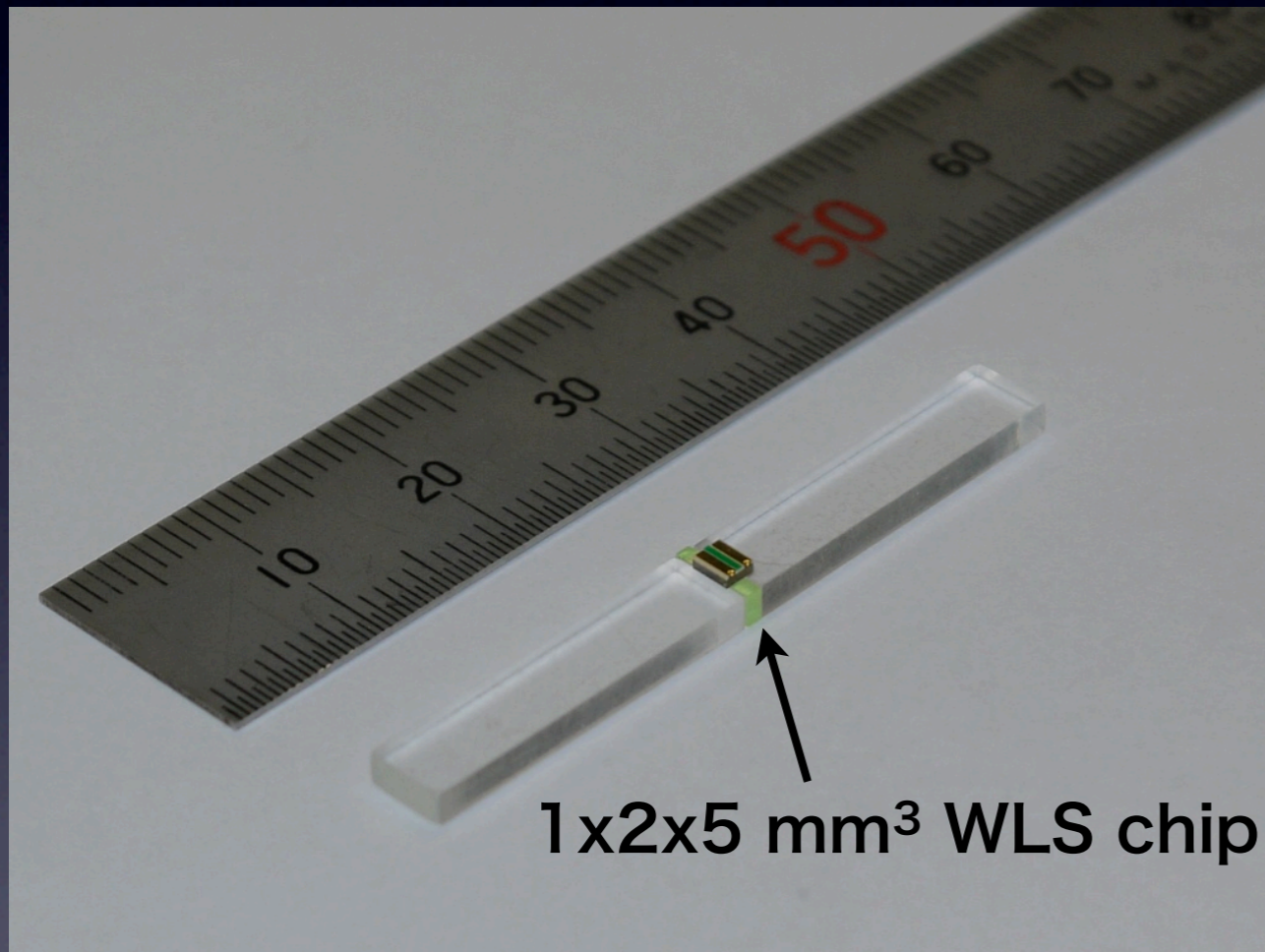
We can effectively catch the photons here by using something covering whole cross section of the scintillator.



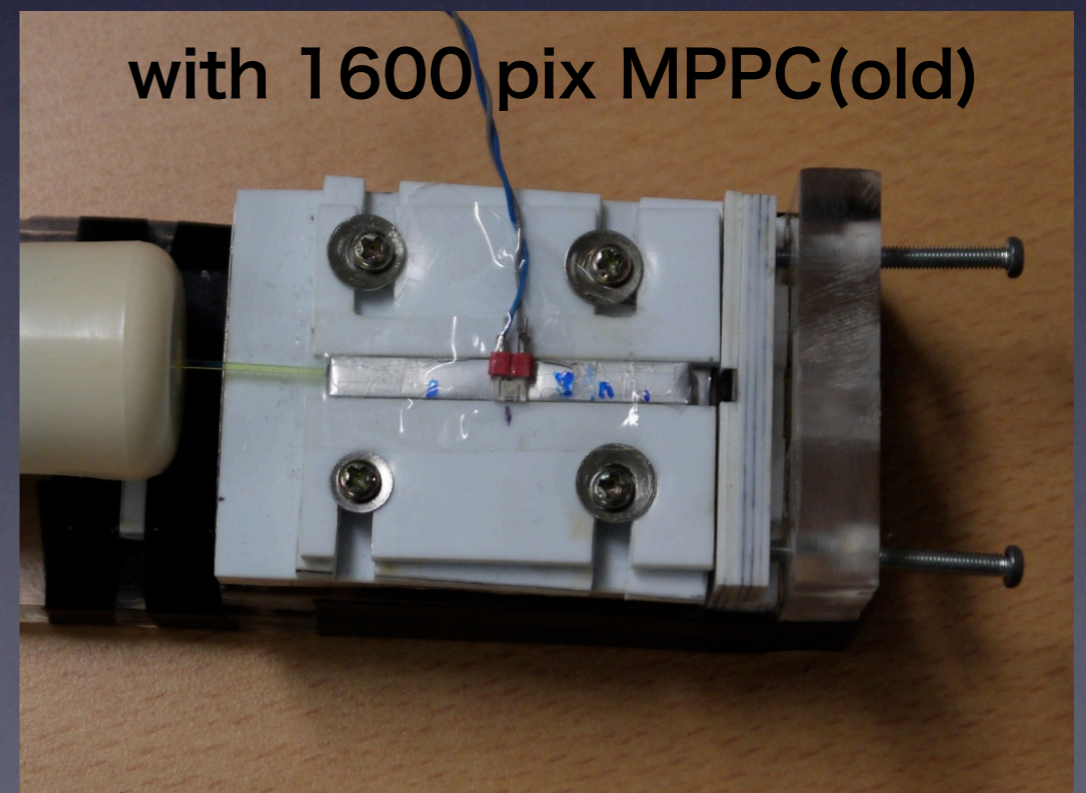
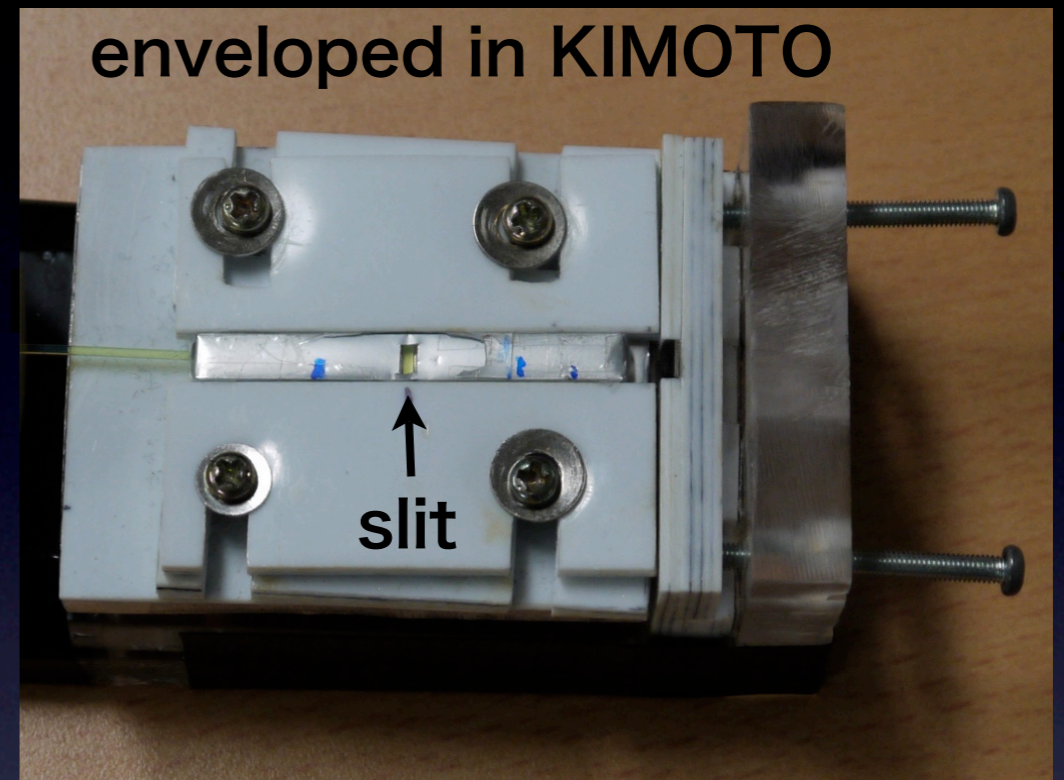
note:
this still has 1 mm width dead space

A trial has been done.

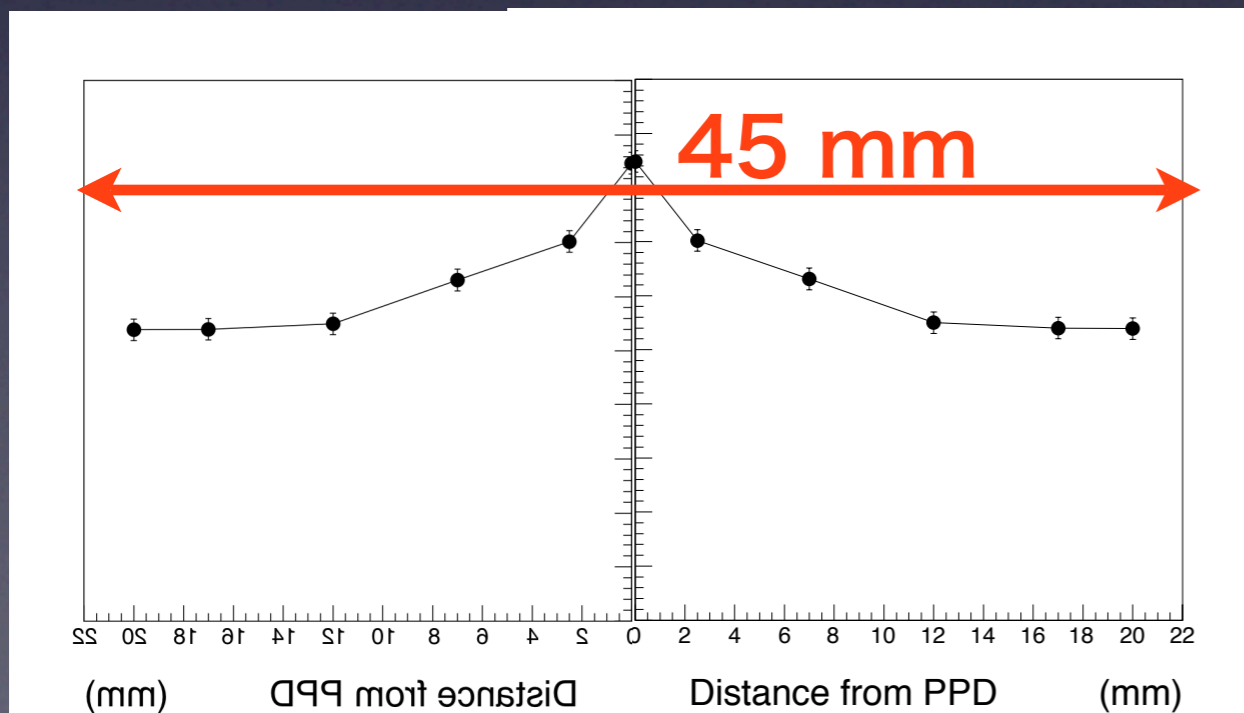
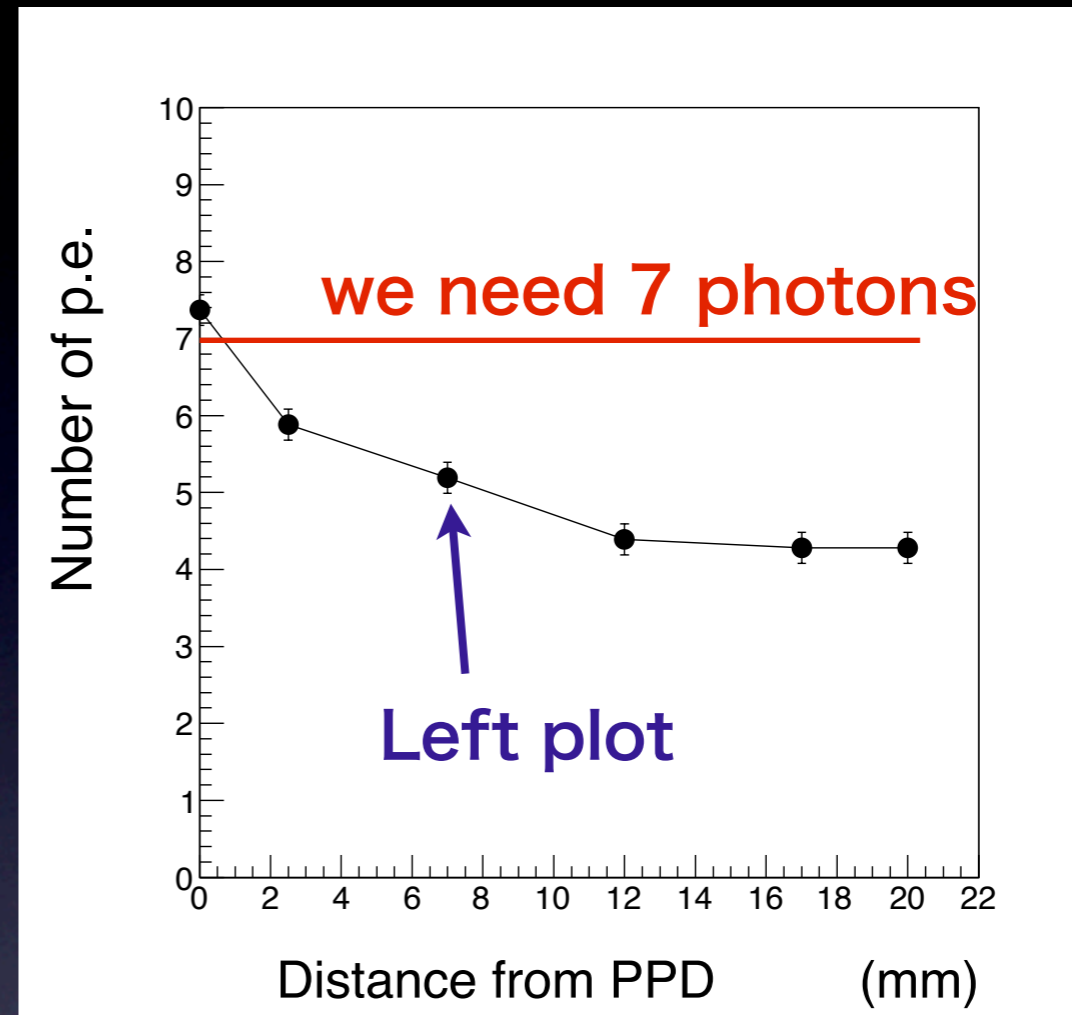
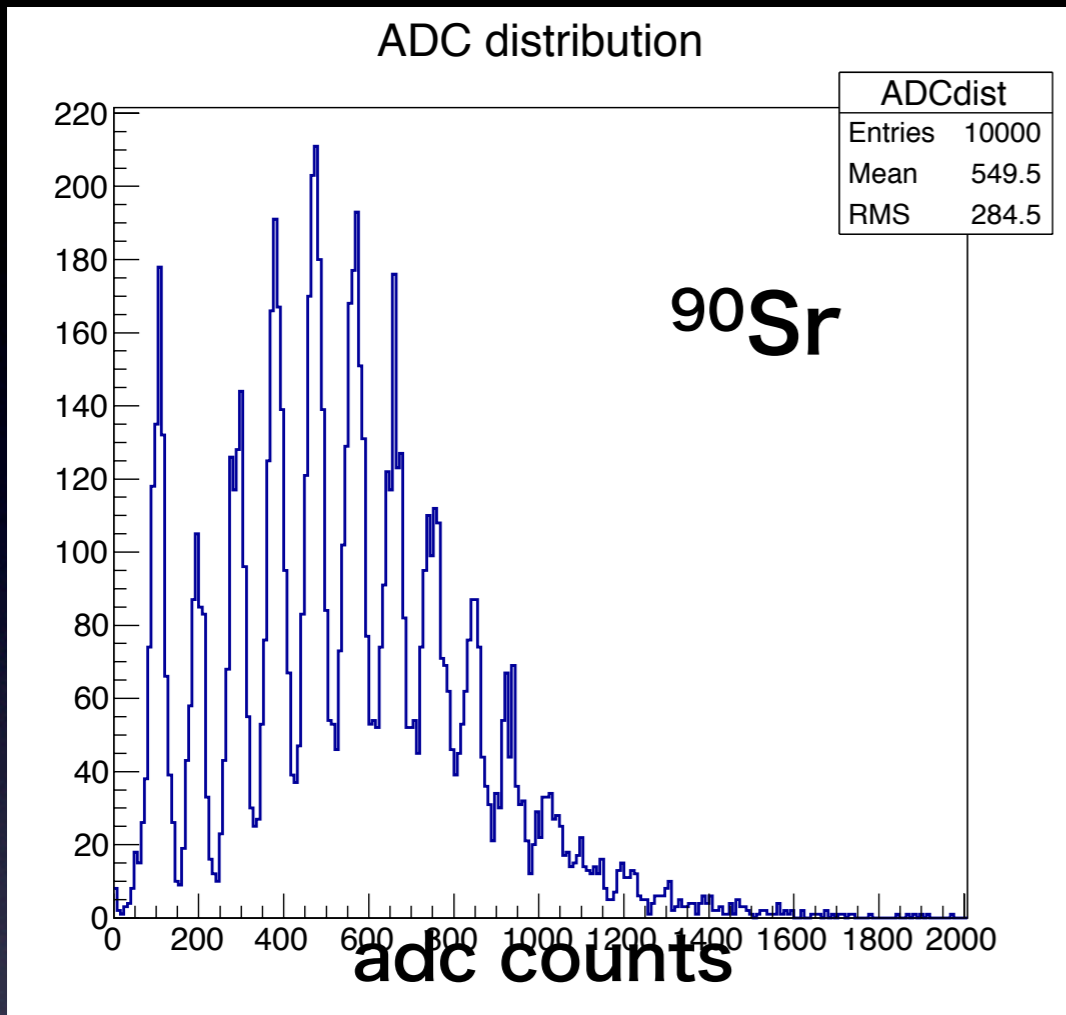
Scintillator strip with WLS chip



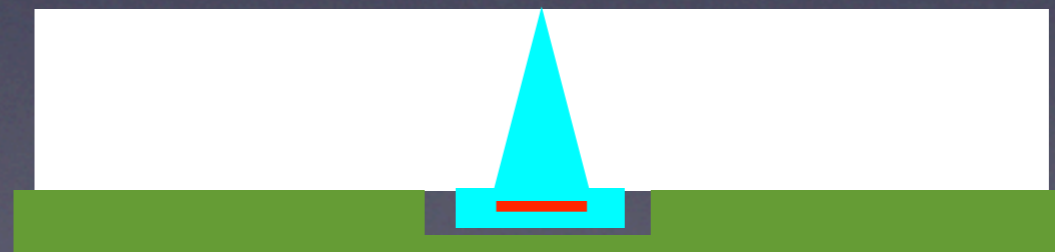
w/o any grease or glue



First results of “seeing from the bottom method”



From the first result of trial,
 - we need more light,
 - we need more flatness.

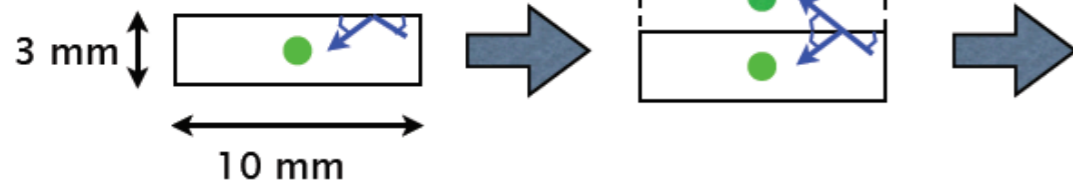


MPPC package-WLS plate unification

Which surfaces are Important for reflection

Imaginal space of Sci. and Fiber

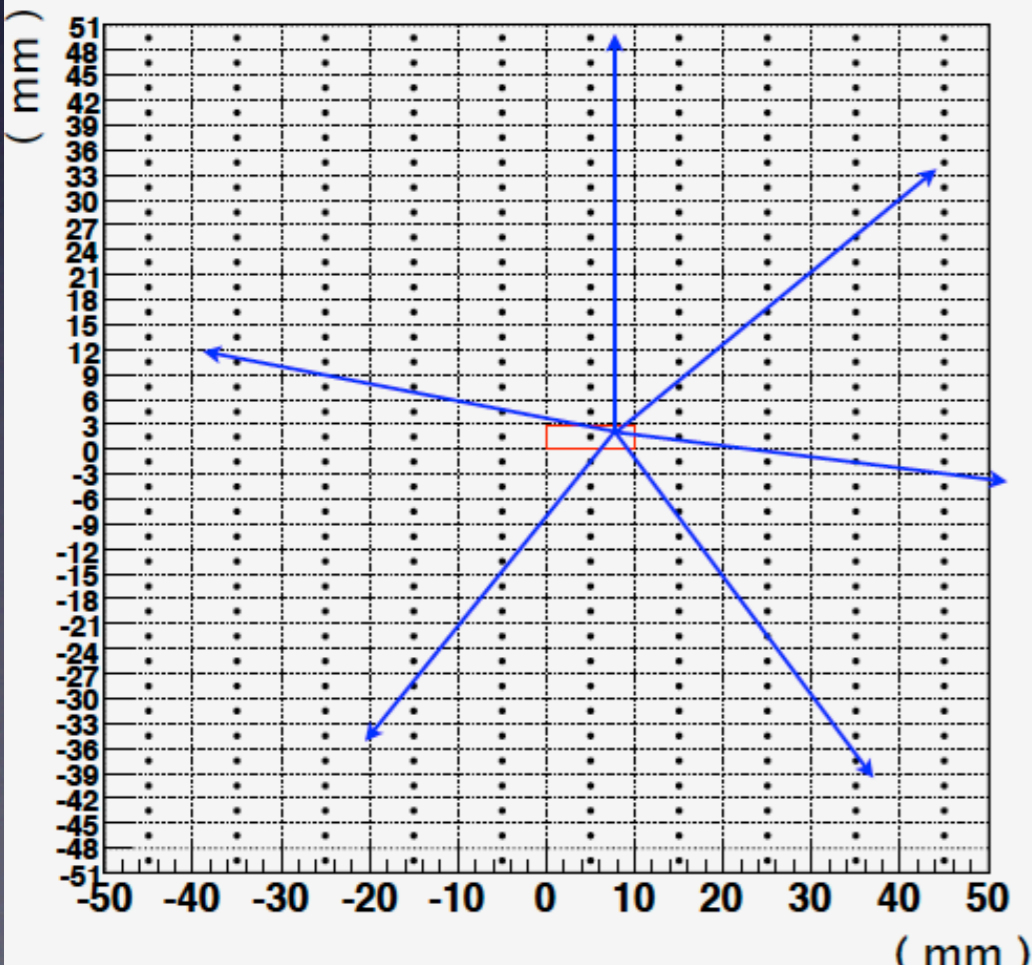
equivalent to have



We can think there are many scintillators and fibers

In the case with WLS fiber:
a reflecting face makes a lot of imaginary scintillators behind the face.

A photon goes through such fiber-sea



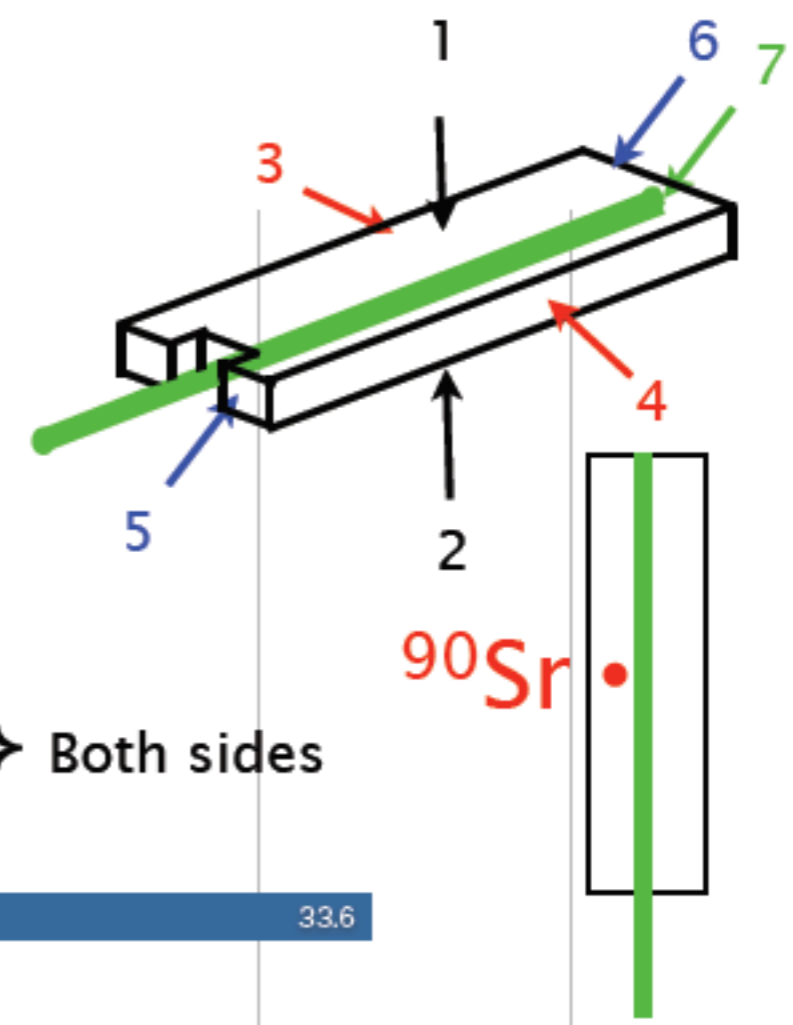
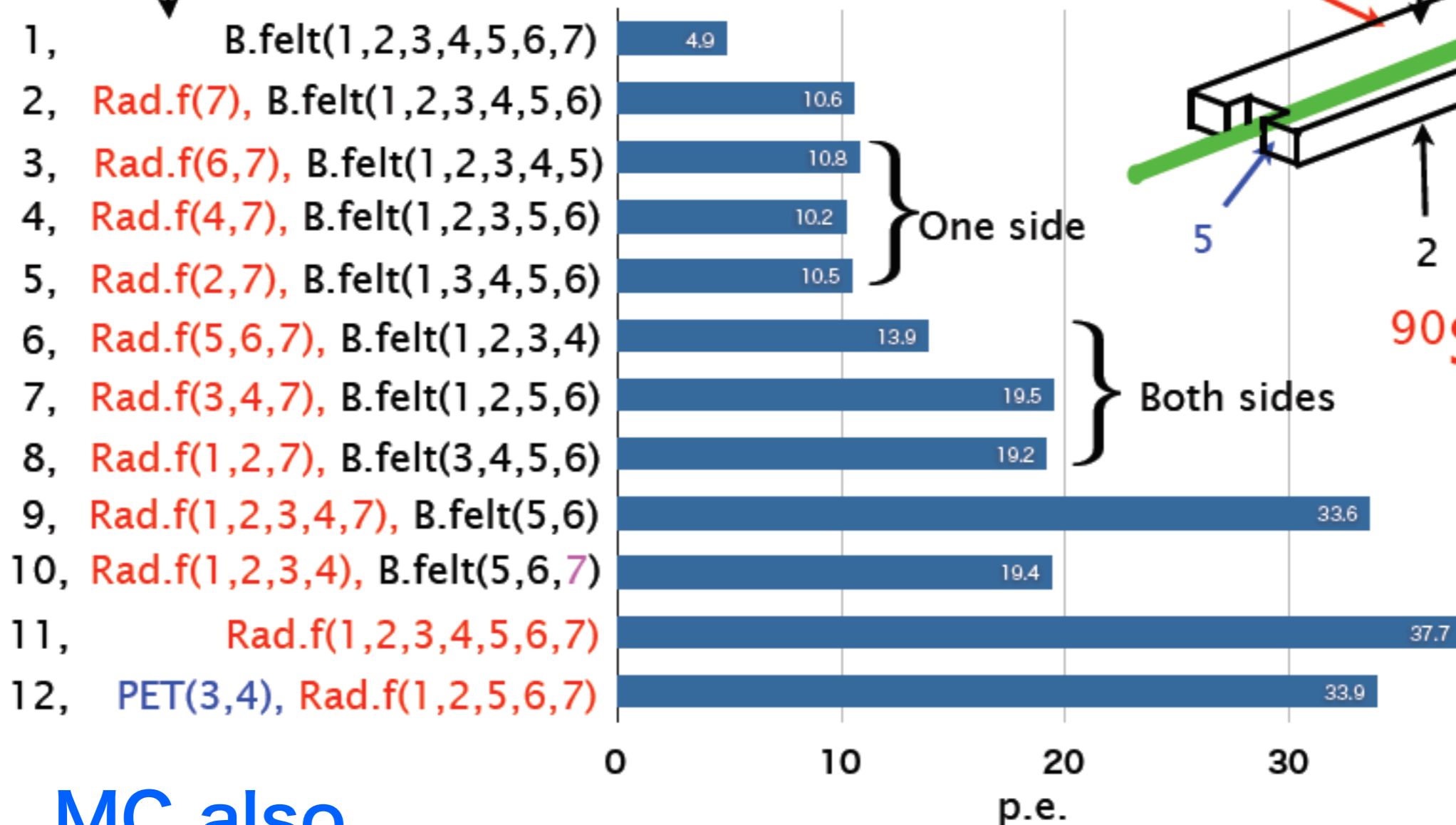
- Larger surface has much probability to make reflection--> reflector on larger surface is important.
- Direction to small surface has much probability of photons caught by WLS--> reflector on small surface is important.
- Those effects are compensated by each other --> Reflector on the small surface and larger surface have similar effect.

Reflector effect (w/ WLS fiber)

By Experiment, (taken in 2008)
Effect of reflector on the surfaces of Sci.(Kurare)

* B.felt(face#)=Black felt, Rad.f() \rightarrow 3M Radiant film, PET() \rightarrow PET film cont.TiO₂

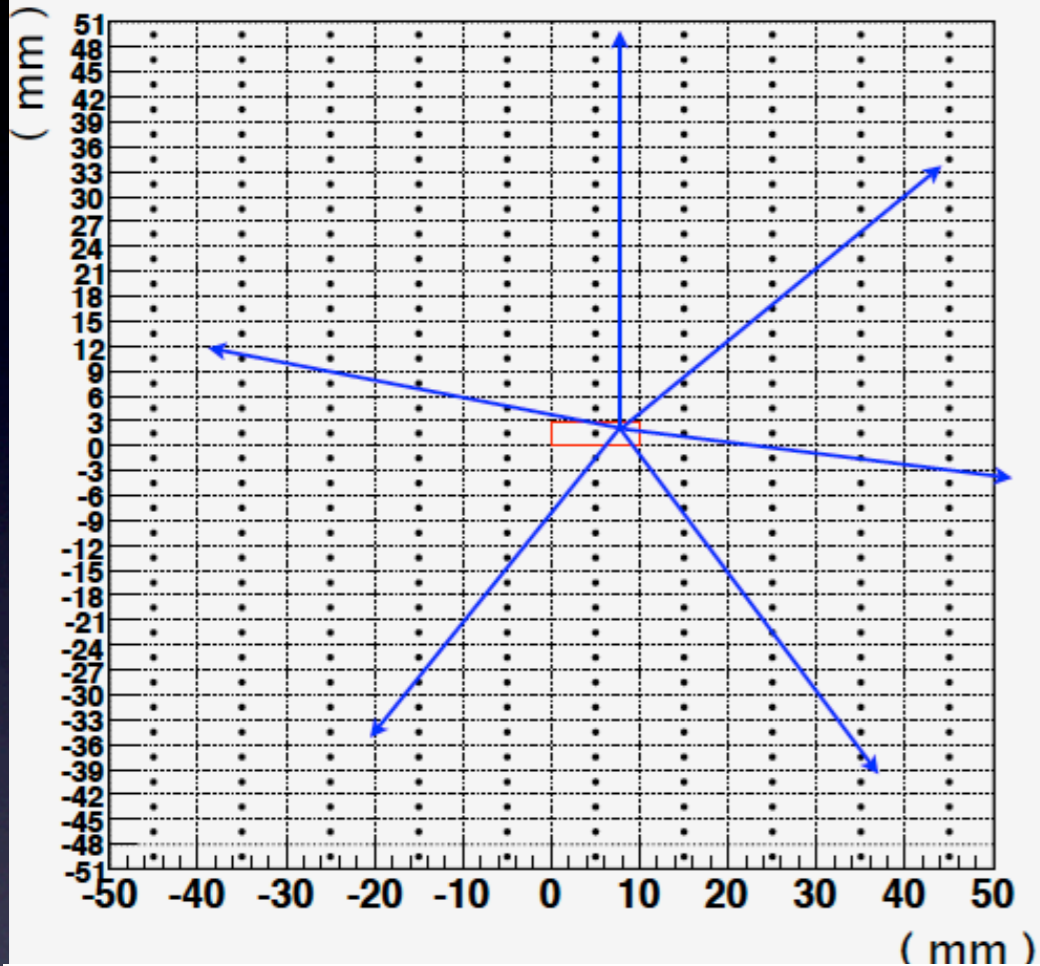
The number of p.e. detected by MPPC



MC also,

Reflector effect (w/o WLS fiber)

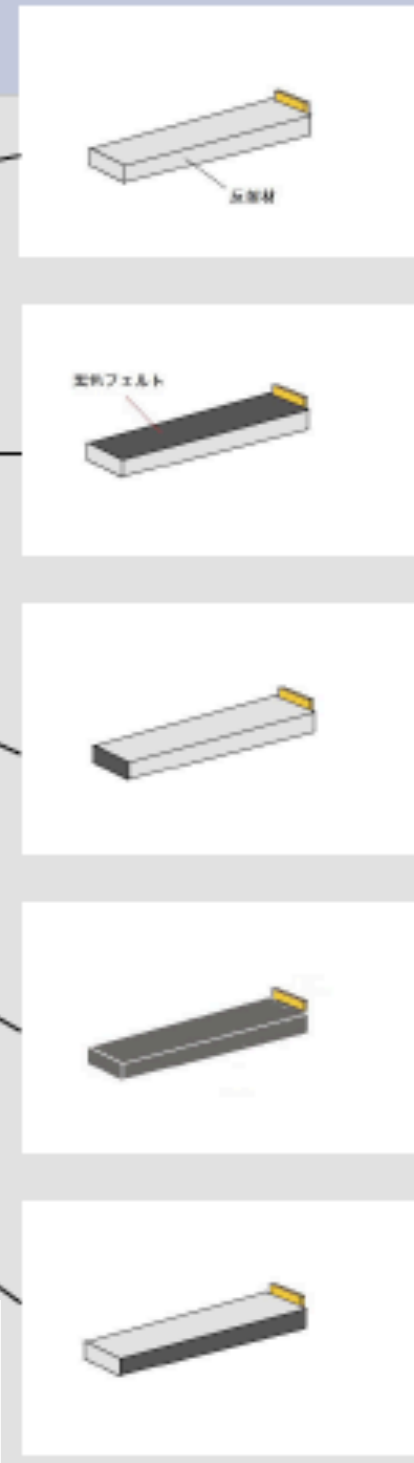
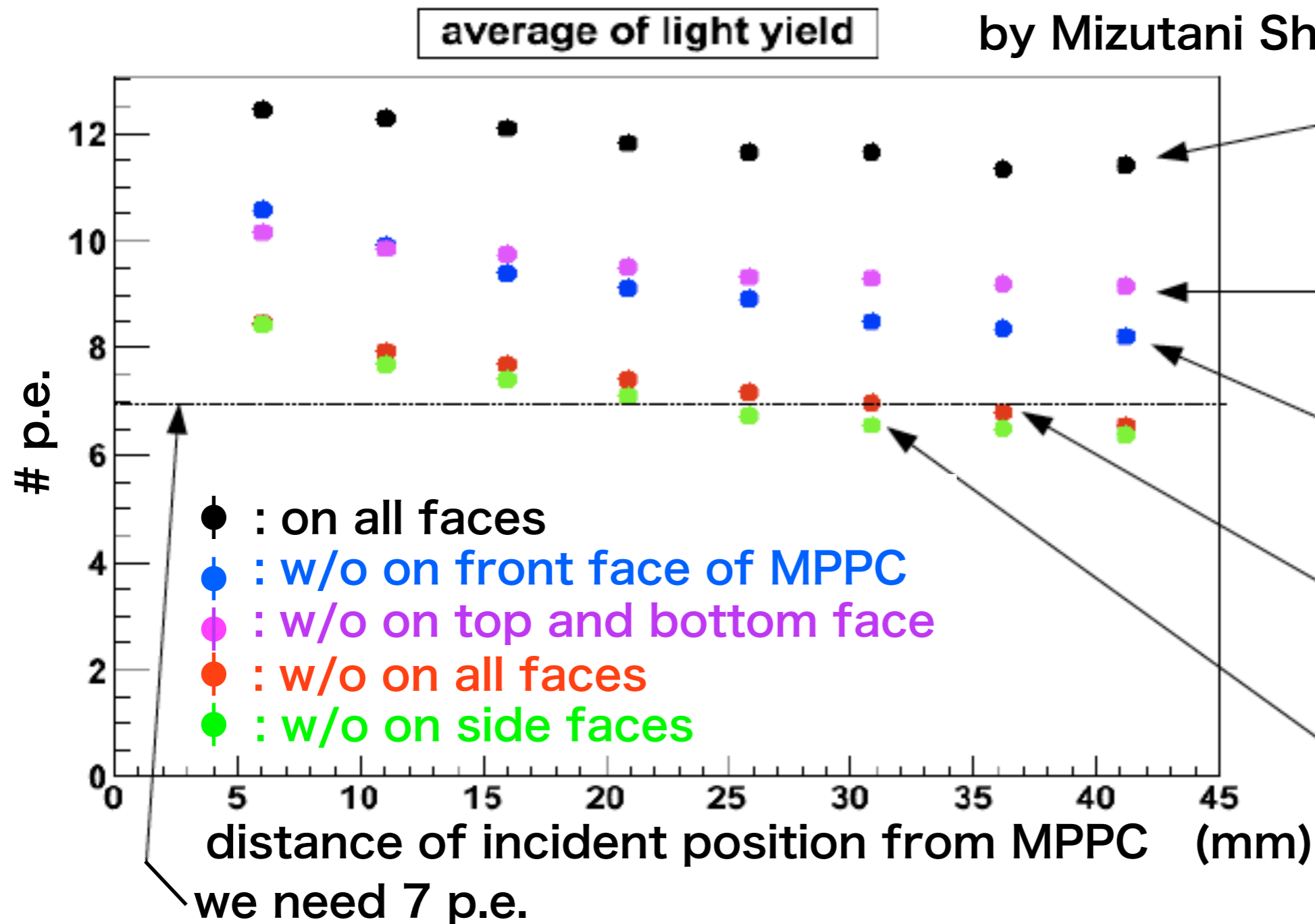
A photon goes through such fiber-sea



In this case black dots are one real and many imaginary 1mm x 1mm MPPCs instead of the cross section of WLS fiber.

Larger different from the case using the WLS fiber is that the detectable photons are required to have the momentum composition which is perpendicular with respect to this slide plane (with large incident angle in front of MPPC, photon is reflected against inside of scintillator again).

Experimental results (w/o WLSF)



- Without reflector on top and bottom surface, more than 80% of photon yield is kept.
- Did you notice a logical discrepancy in those results?

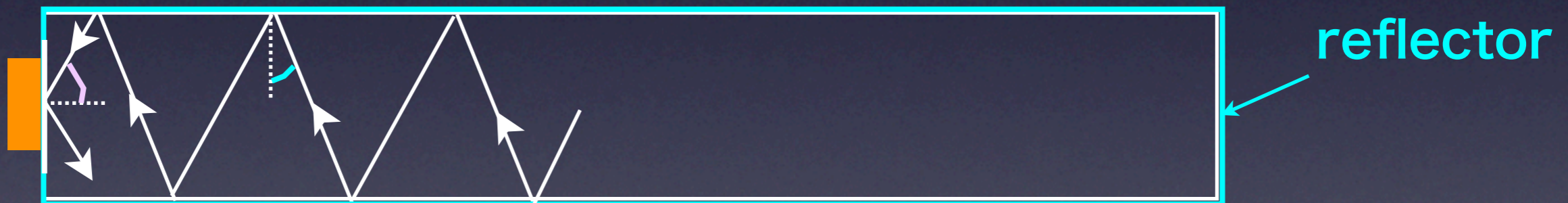
Why effect of reflector decreases w/o WLS fiber

Large incident angle makes reflection without reflector (by total reflection)



Photon can be detected with small incident angle

Reflector helps photons with small incident angle to reflect.



But the photon should be also reflected in front of MPPC by the total reflection phenomenon.

This means that the reflector on top/bottom and side faces does not so much affect to increase the photon yields at MPPC

Summary

- An idea to make good uniformity of response of scintillator without WLS fiber are suggested (cylindrical package of MPPC)
- A new readout method from scintillator by using MPPC was suggested (using WLS plate),
 - Photon yield and uniformity of response are not enough.
 - Some modification is expected.
- Effects of reflector on surfaces of scintillator without WLS fiber were studied and discussed.
 - Without the reflectors on the largest surfaces (top and bottom), more than 80% of photon yield at MPPC is kept. > 7 photons.
 - → We can choose from many materials for the largest surface including materials which does not have reflecting function.

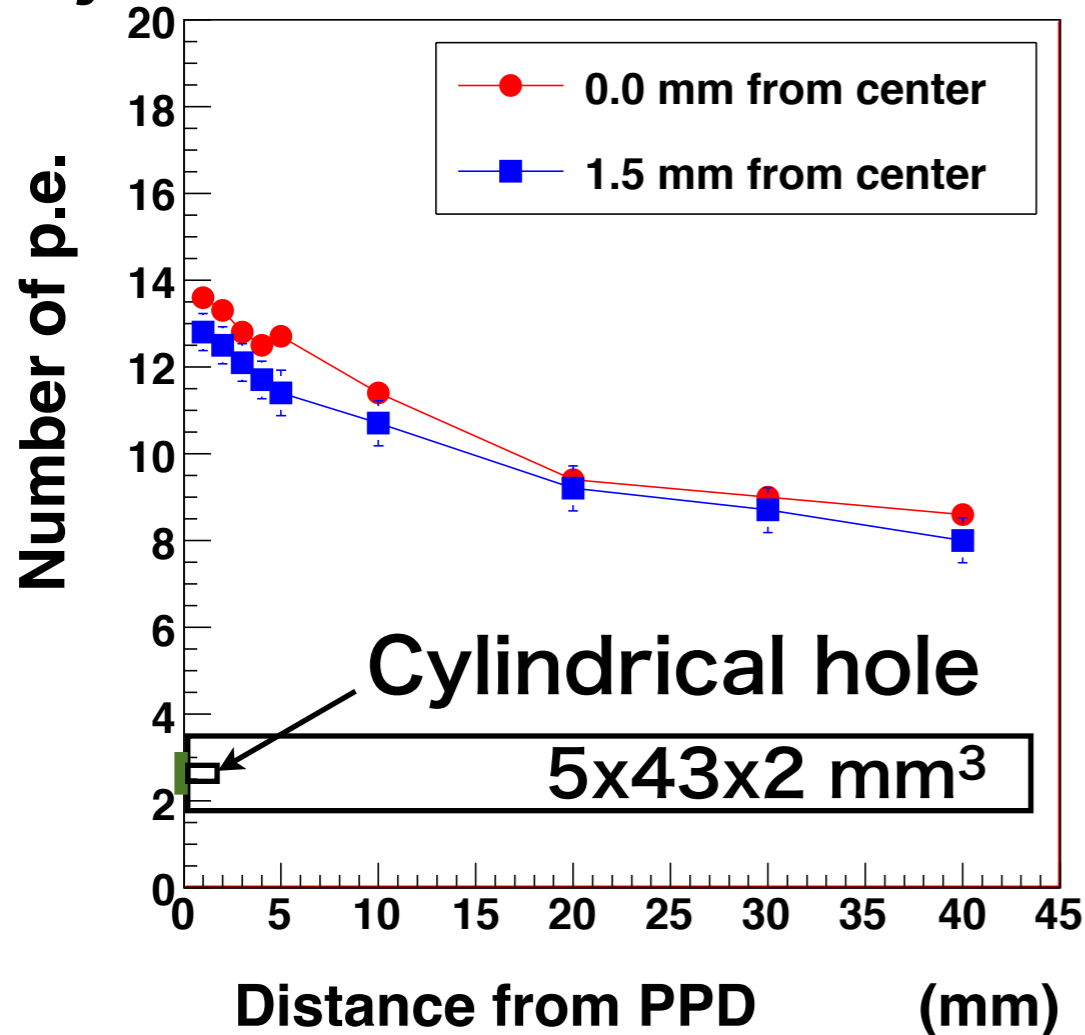
Backup

R&D of Detector element

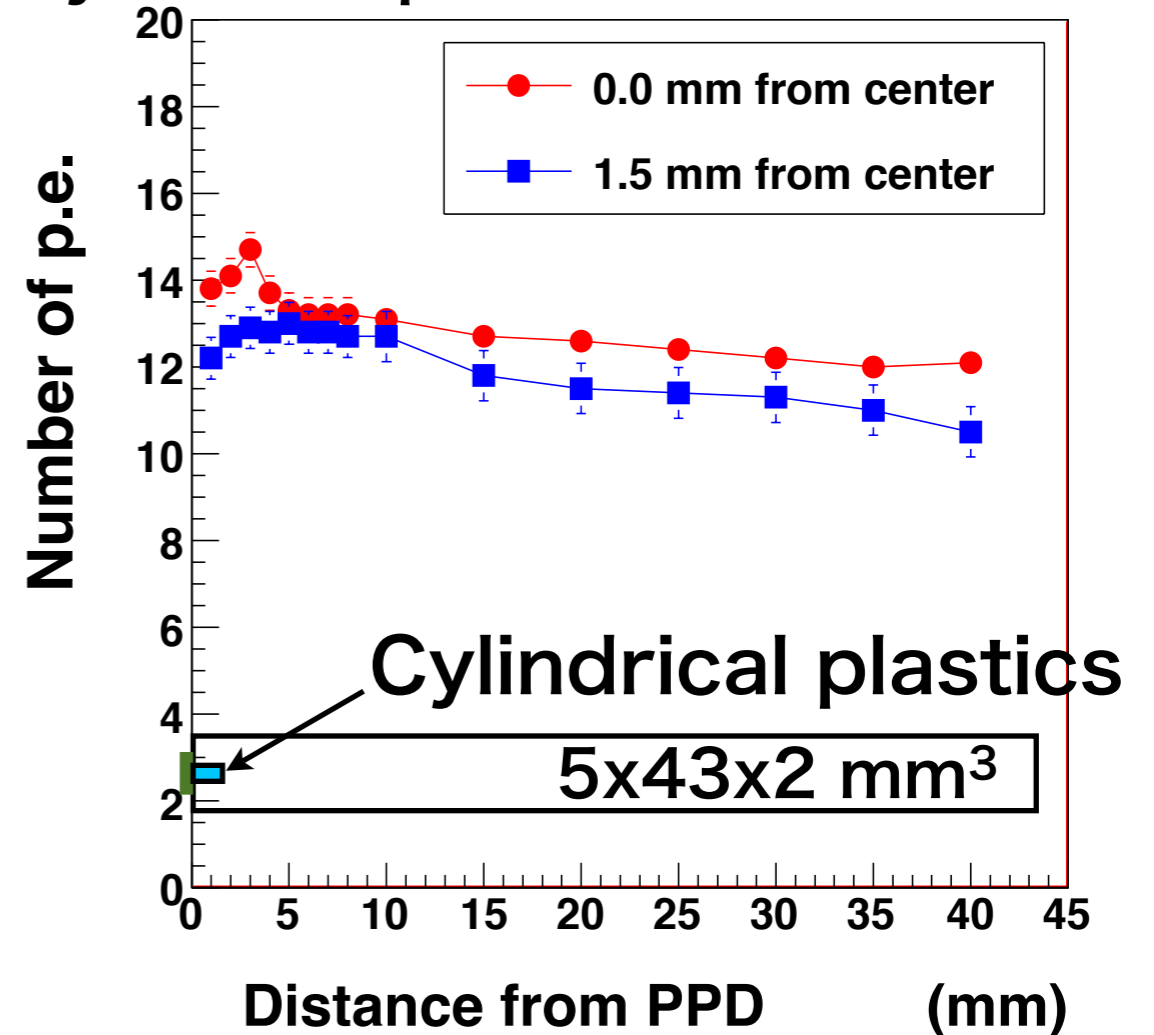


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Cylindrical hole in front of MPPC



Cylindrical plastics i.f.o.MPPC



- cylindrical hole removes large non-uniformity in front of MPPC, but it grows non-uniformity far from MPPC.
- Plastic cylinder in front of MPPC potentially improves uniformity totally.