Study of strip scintillator for ScECAL

20/Feb/2009 Calice Meeting at KNU,

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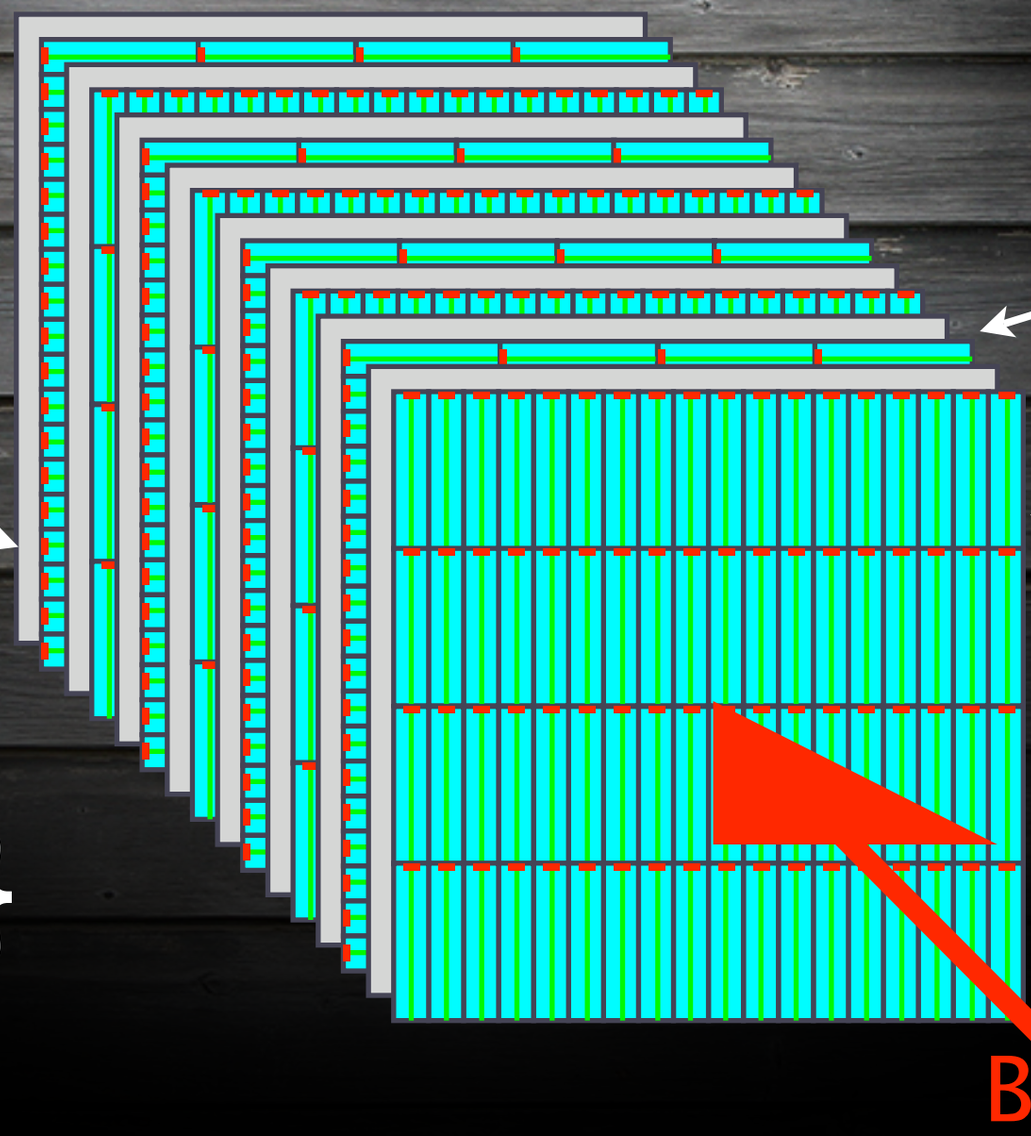
SHINSHU UNIVERSITY

Calice ScECAL @ FNAL beam test

KNU extruded
scintillator strip
10 mm x 45 mm x 3 mm

2160 channels
MPPC with WLS fiber readout



3.5 mmt W
absorber

15 x layer
15 y layer

Modifications of Strip-scintillator for FNAL beam test

- Attenuation length of extruded scintillator (KNU).
- Each strip was hermetically covered by reflector.
  - There was an idea to use white paint on small surface instead of reflector to reduce the cost, but...
- Each WLS fiber was fixed to each scintillator strip.
- A device to shade photons come to MPPC from scintillator directly was adopted to modify the uniformity of response.
- ...

Modifications of Strip-scintillator for FNAL beam test

- Attenuation length of extruded scintillator (KNU).

- Each strip was hermetically covered by reflector (1).

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- Each WLS fiber was fixed to each scintillator strip.

- A device to shade photons come to MPPC from scintillator directly was adopted to modify the uniformity of response (2).

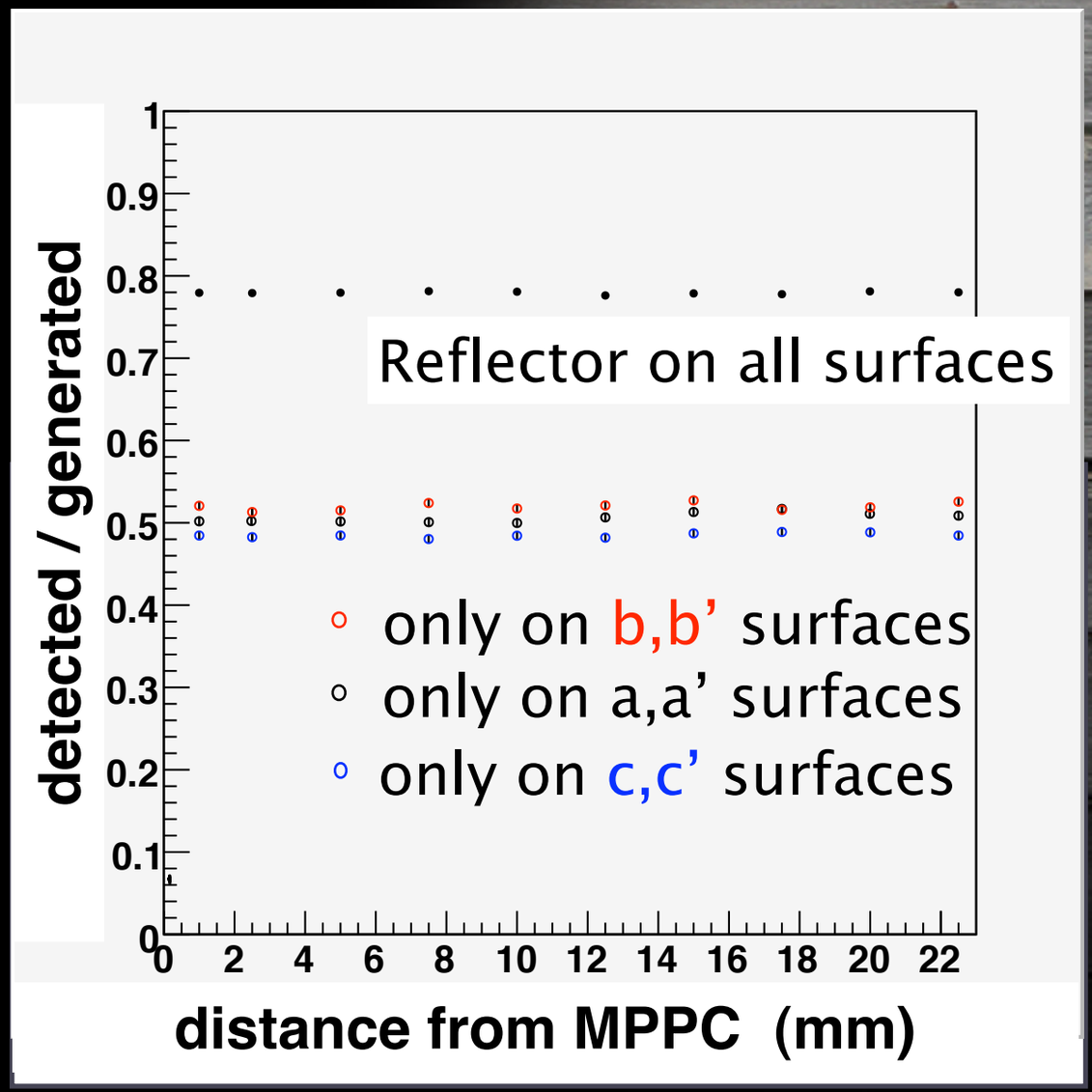
for future...

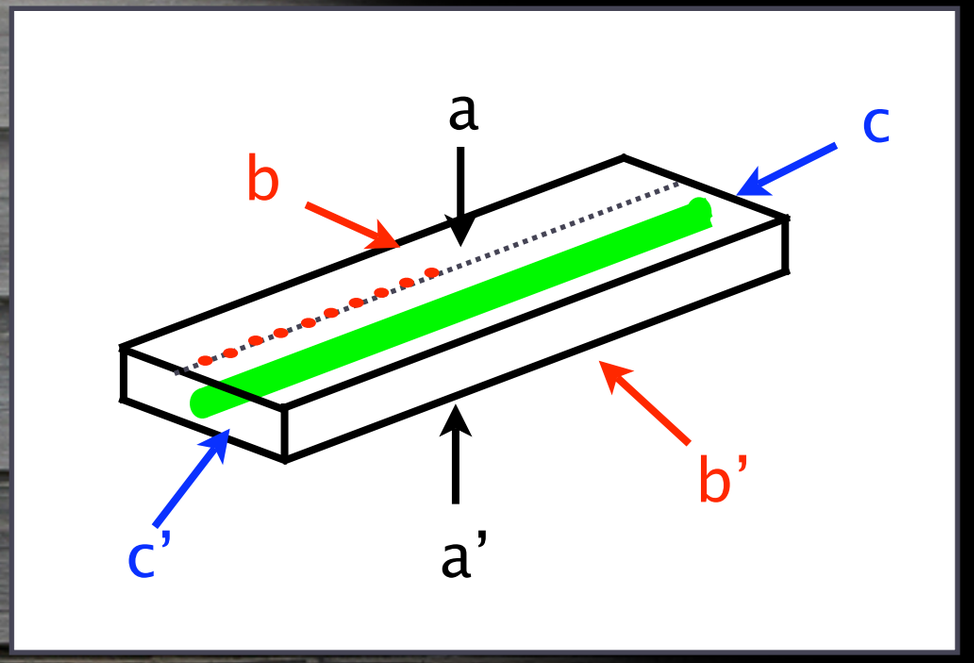
- 5 mm*W* scintillator without fiber readout (3).

(1) *Effect of reflector* : simulation

- Where covering with reflector?

responses depending on
distance from MPPC

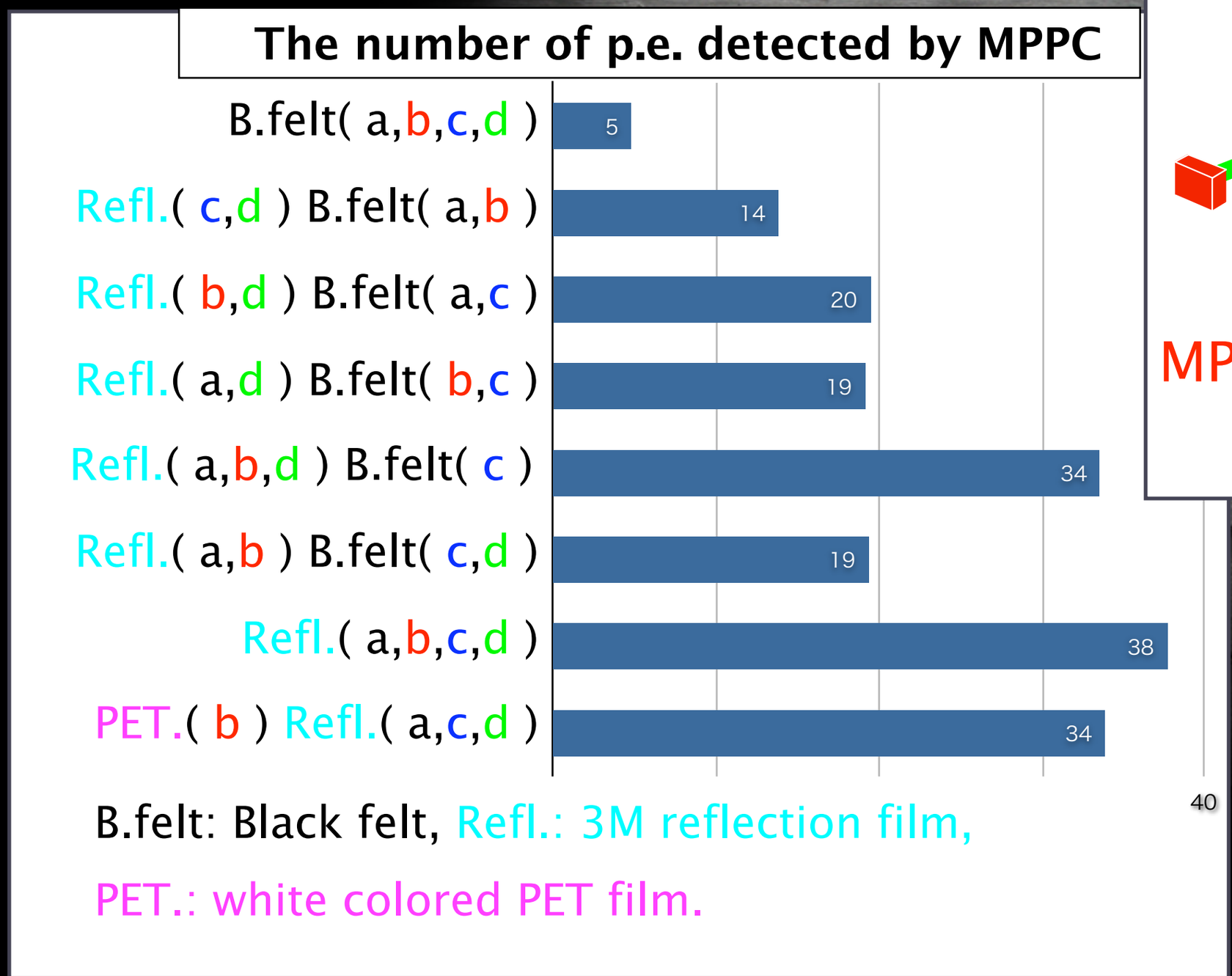


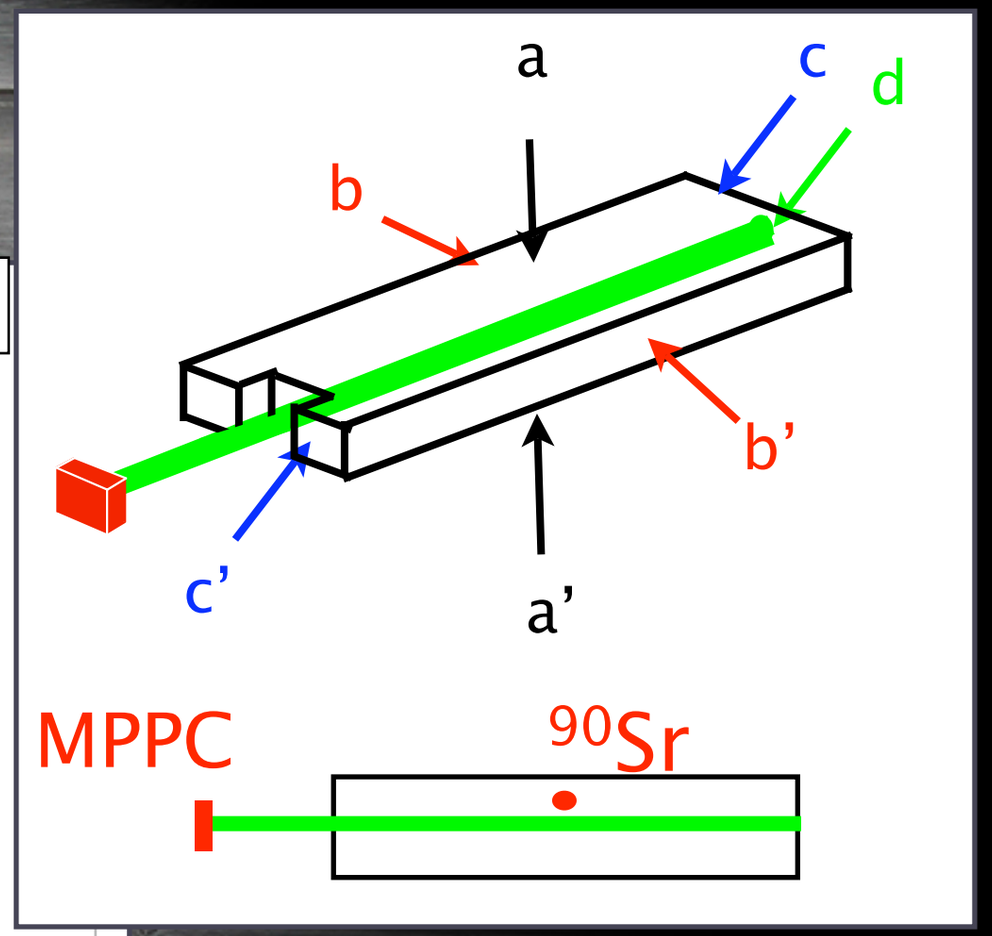


- good uniformity with fiber readout.
- effect of reflector is independent on size of surface

(1) *Effect of reflector* : experiment

- confirm Simulation results

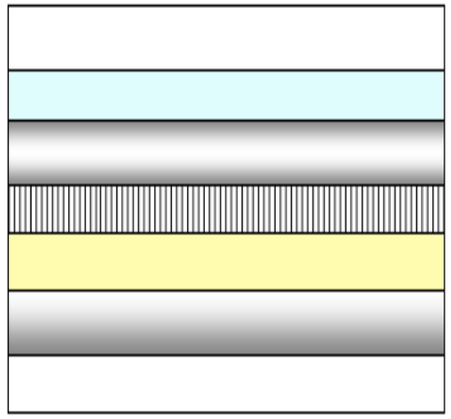




- independence on surface size.
- reflector on the end of fiber is important.

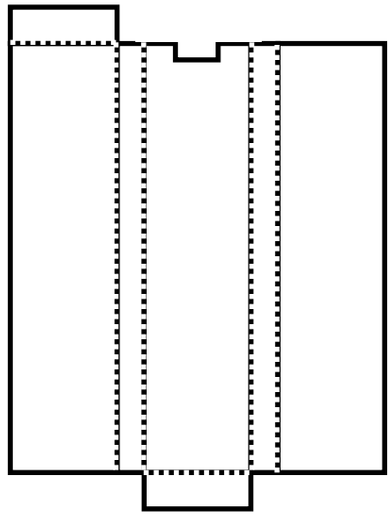
(1) *Effect of reflector* : Calice ScECAL @ FNAL beam

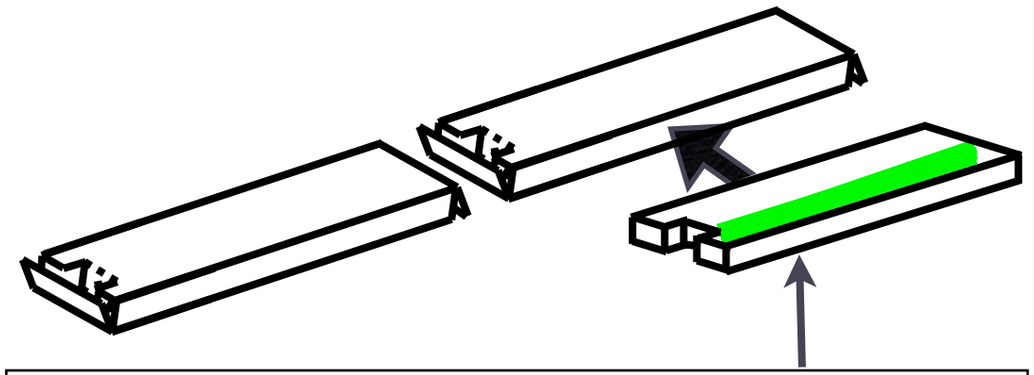
→Each strip was hermetically covered with reflector.



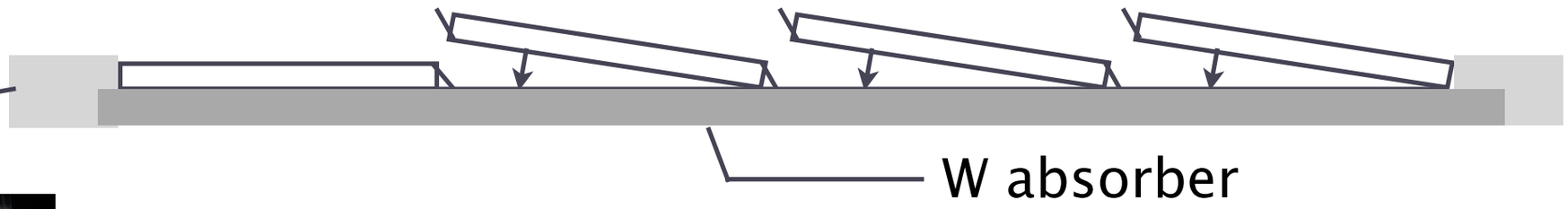
PET (25μm)
Anchor layer
Evaporated Ag layer
Top coat layer
Adhesive layer
Evaporated Al layer
PET(25μm)

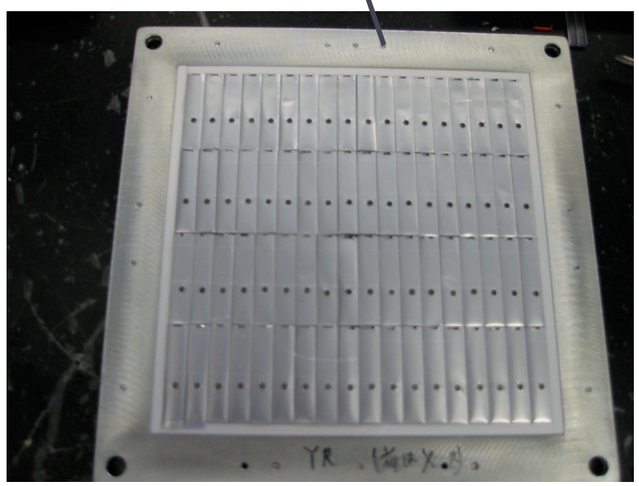
Total 57μm thickness Kimoto reflector





KNU extruded scintillator





- Kimoto 57μm film is the best, so far.

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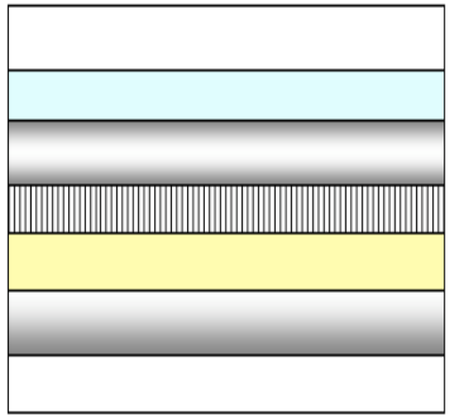

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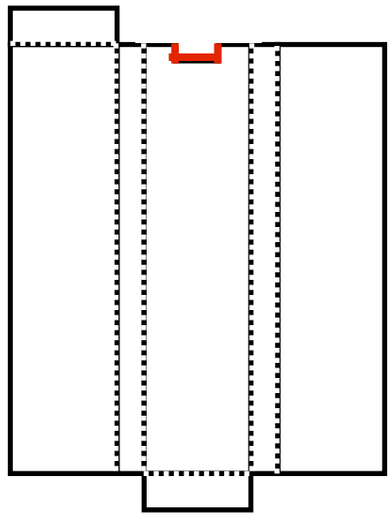
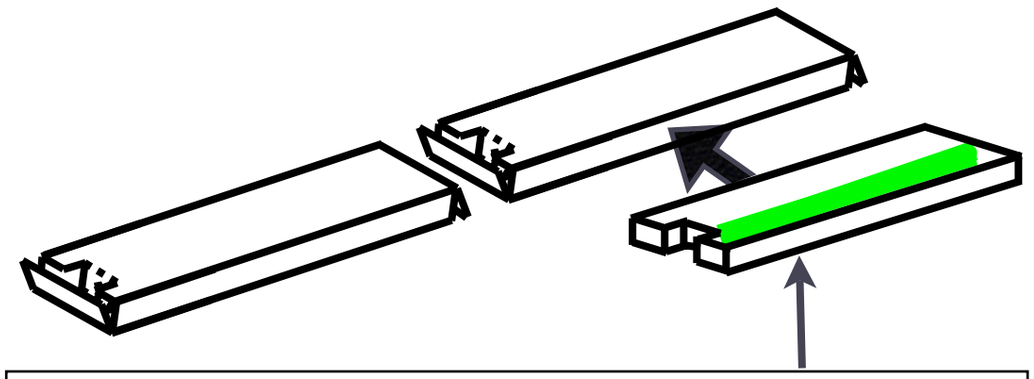
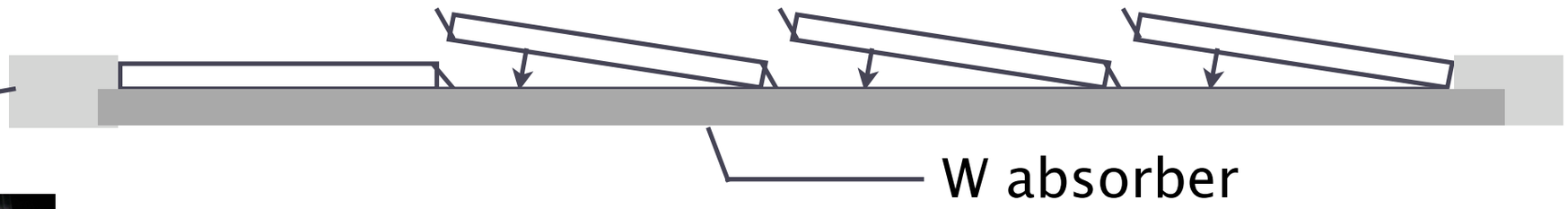
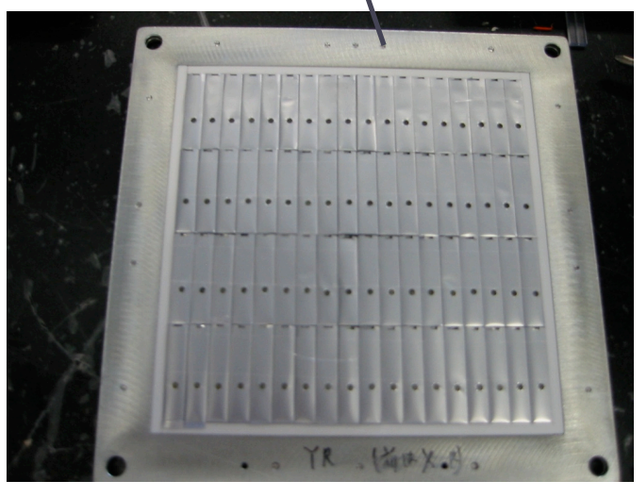




KNU extruded scintillator

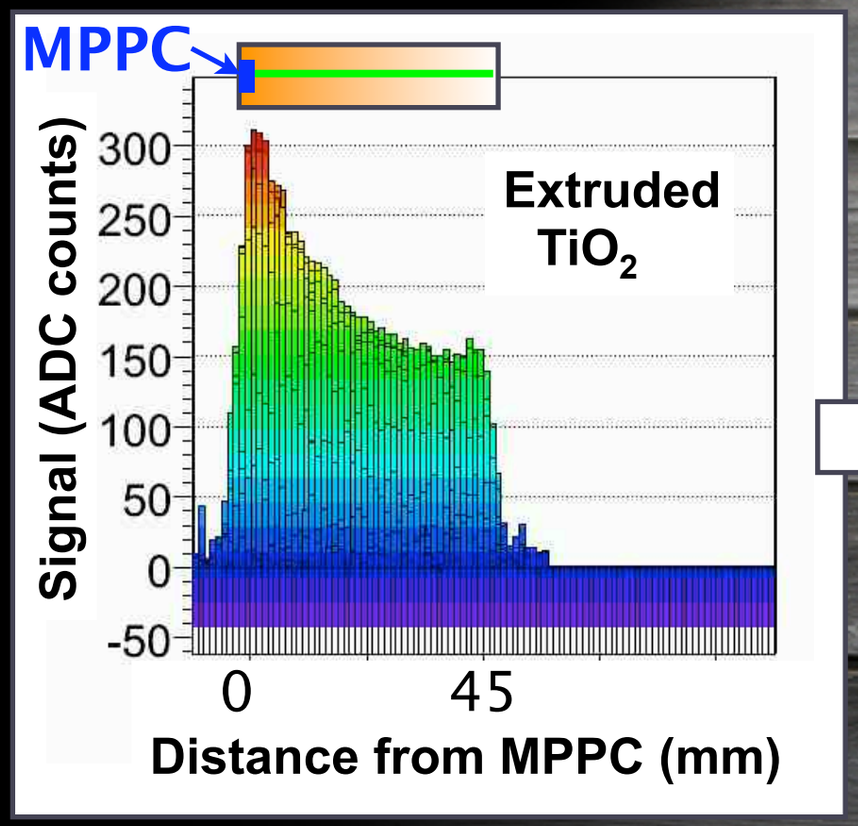




- Kimoto 57μm film is the best, so far.
- It has conductivity in middle layer.

(2) *Uniformity* : at DESY beam test in 2007

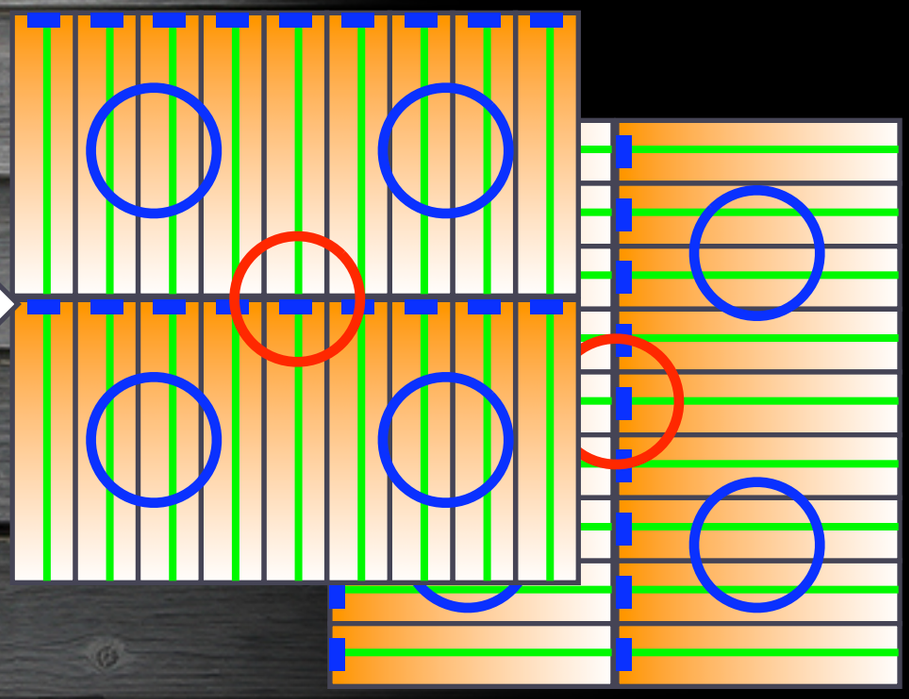
- non uniformity is concerned for ScECAL



regions;

uniform

non-uniform



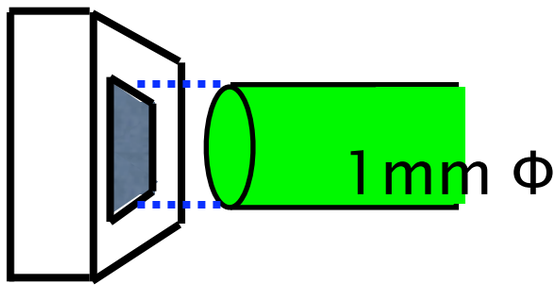
Effect of uniformity on energy resolution

beam region	constant term(%)
○ uniform (quarter)	2.35±0.12
○ non-uniform (center)	7.26±0.05

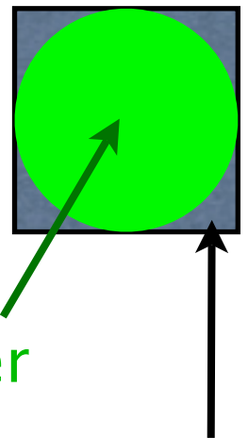
strips must have uniform response.

(2) *Uniformity* : Reason of uniformity

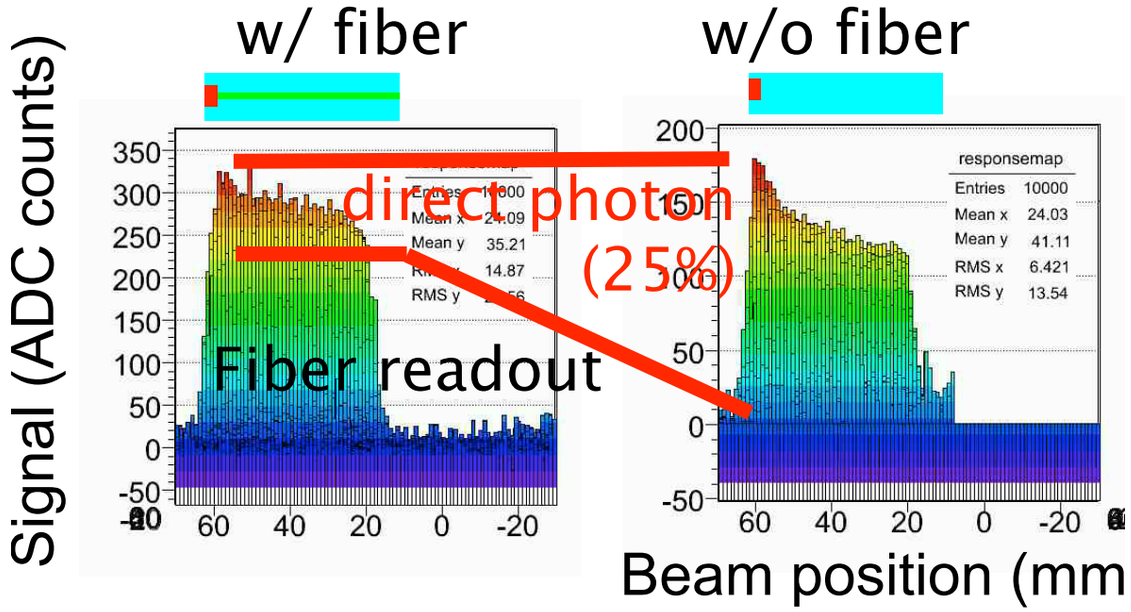
- Although we use fiber readout, why non-uniformity?

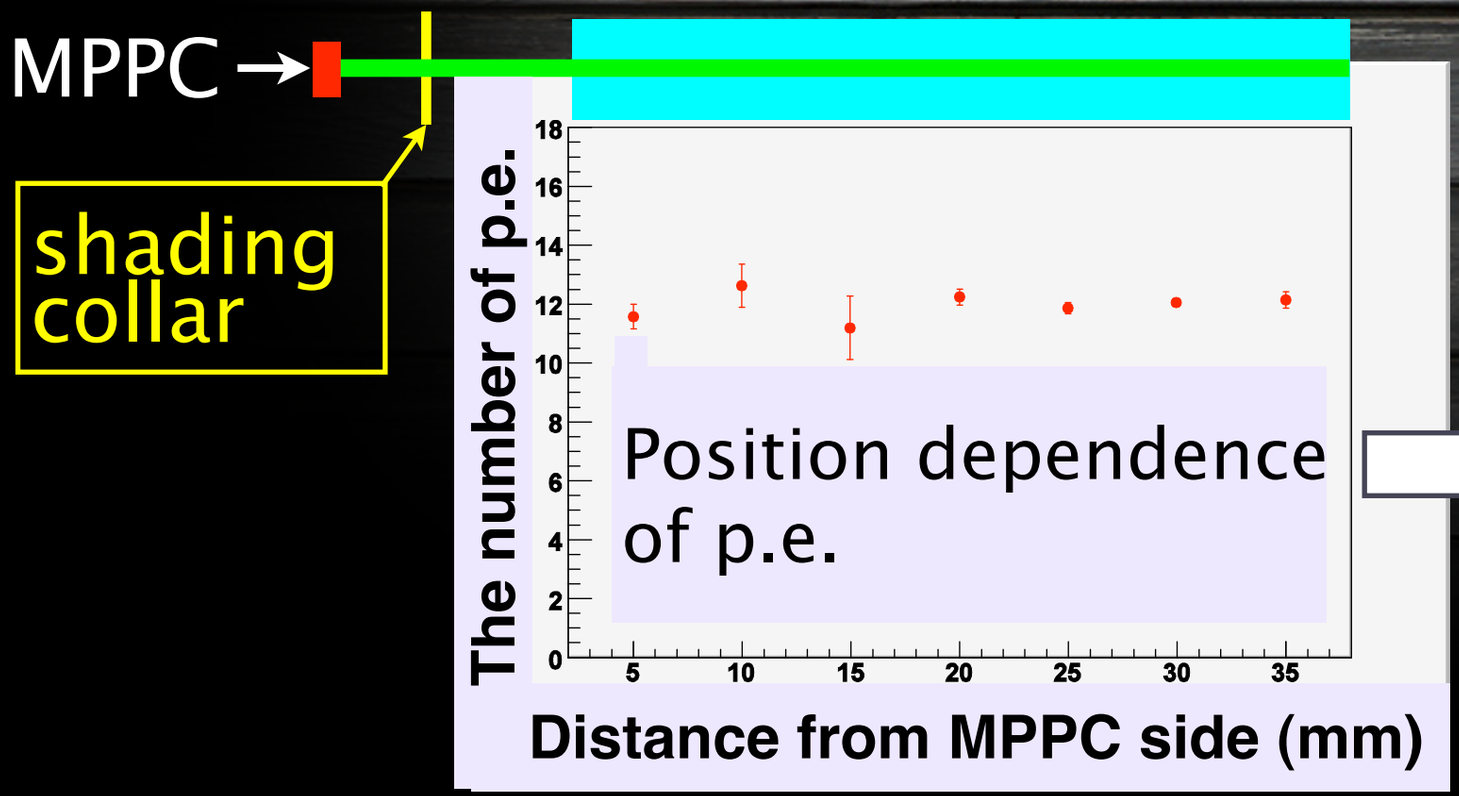


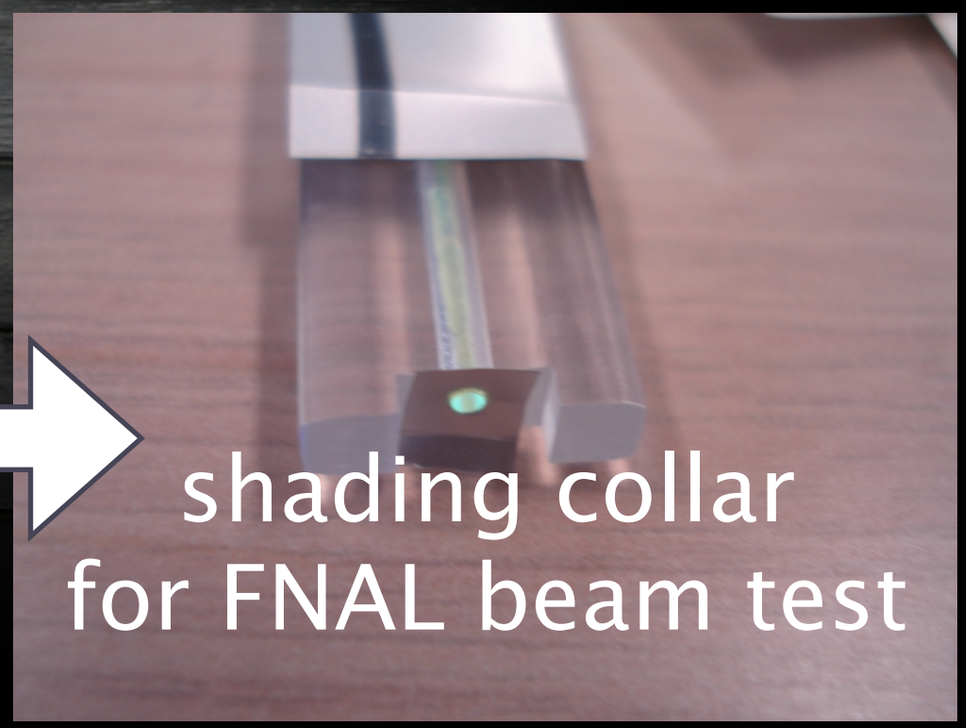
1mm x 1mm MPPC
sens.area



~25% of MPPC



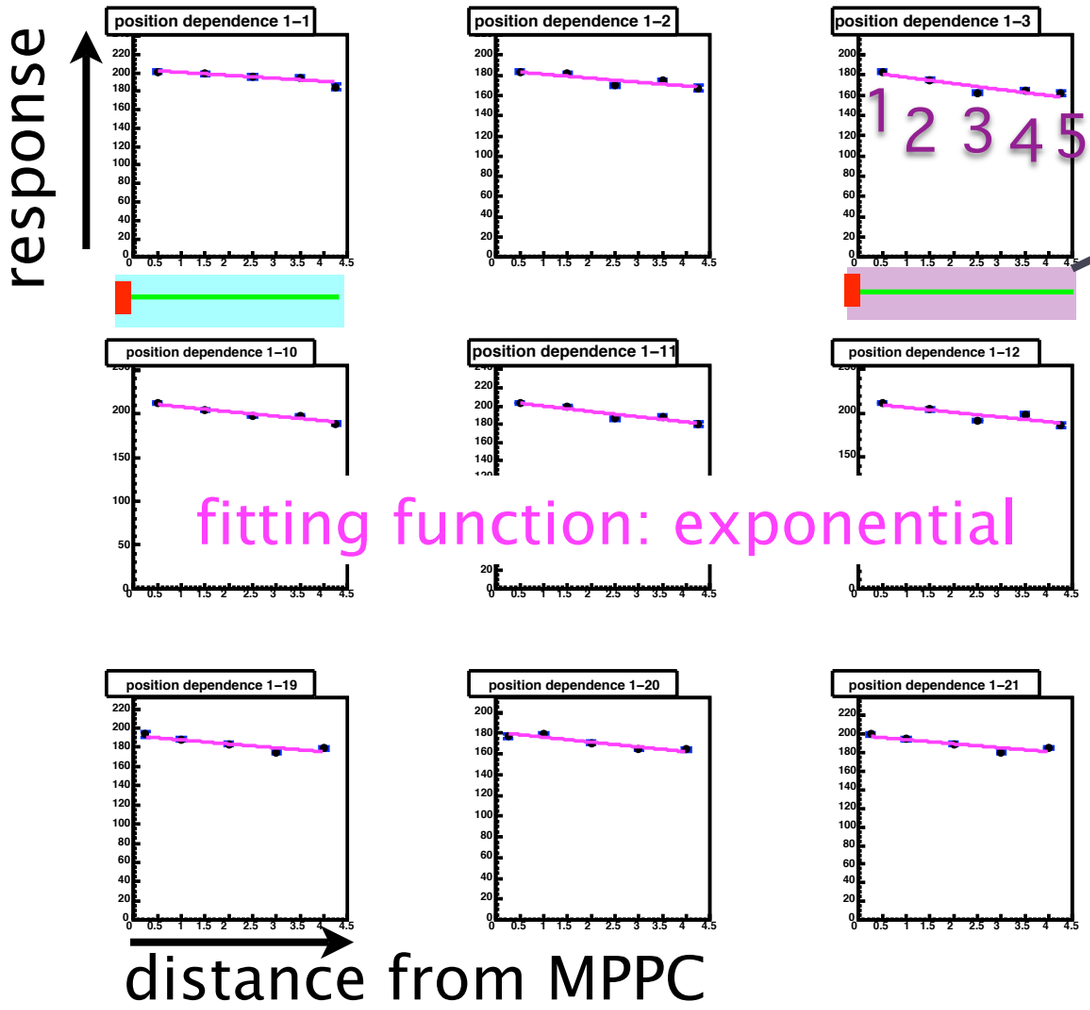


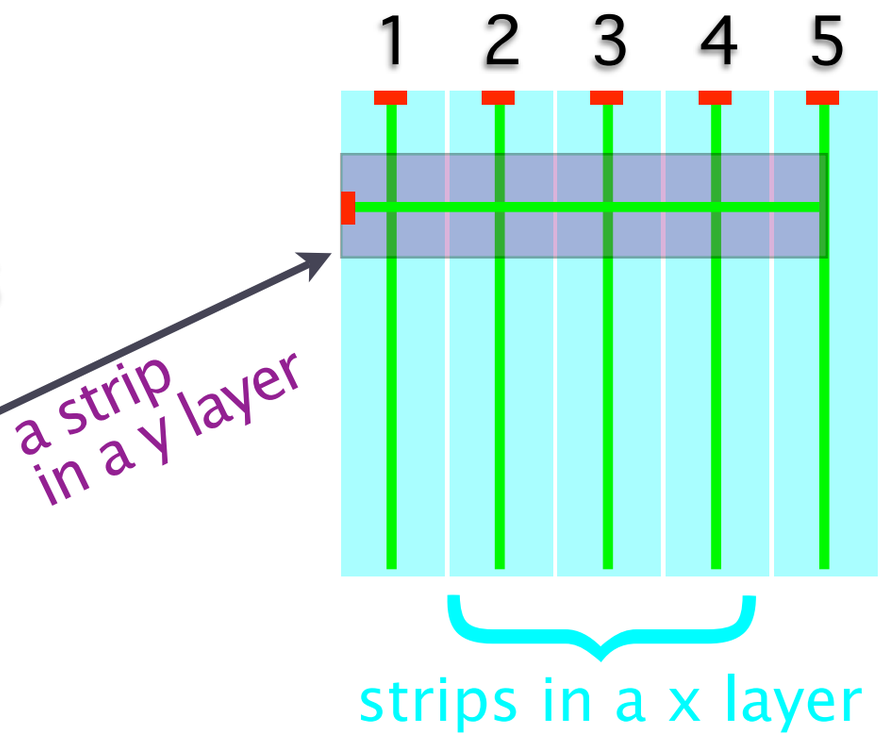


(2) *Uniformity* : at FNAL beam test

- Using MIP events,

position dependences of MIP responses (9/2160)





- MIP selection;
  - > 11 layer hits in the same x and y positions, respectively.
- Strips in x layers are used to determine x position in strips of y layers.

(2) *Uniformity* : at FNAL beam test

- Using MIP events,

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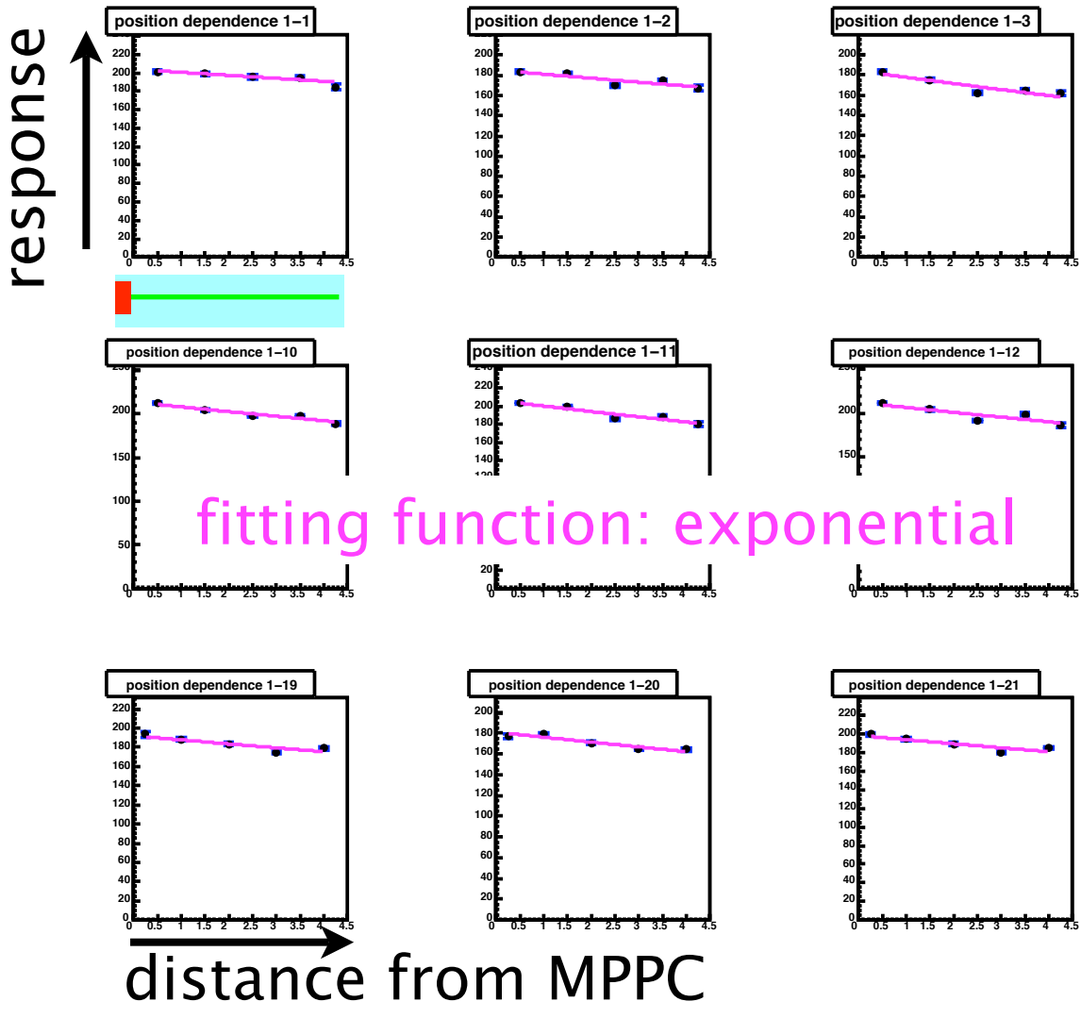
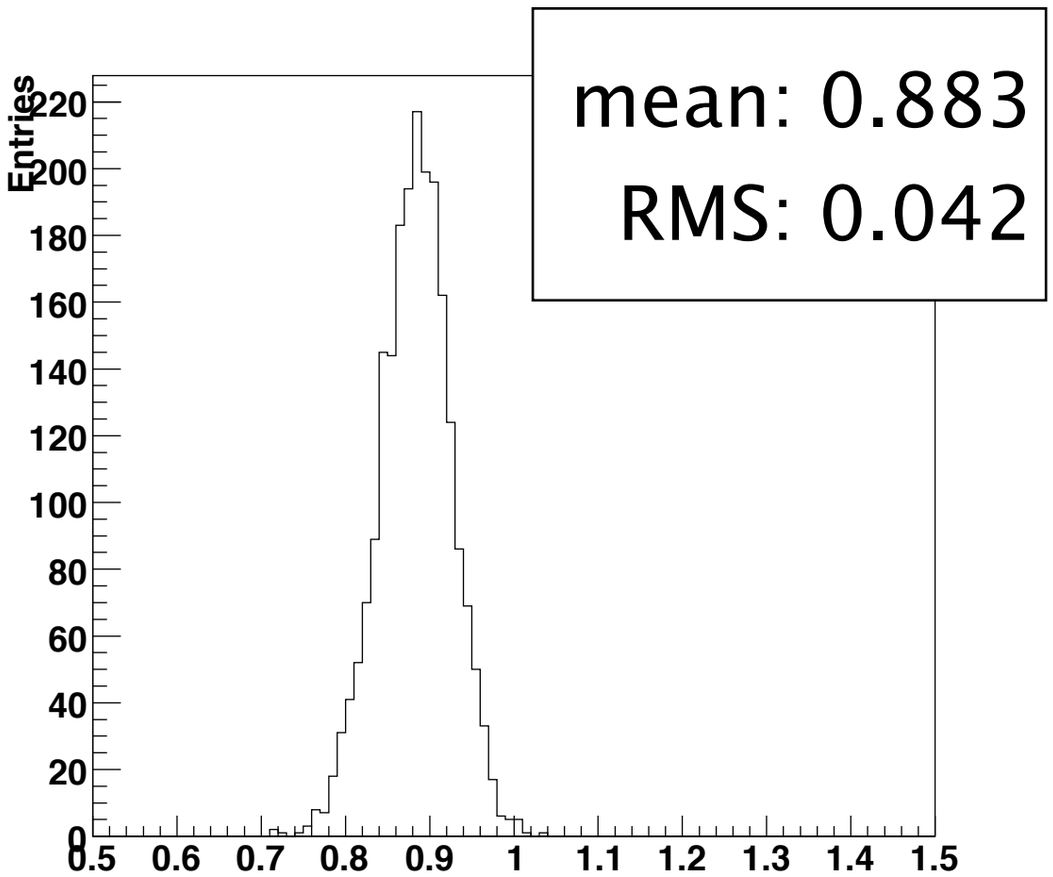


All 2160 channels

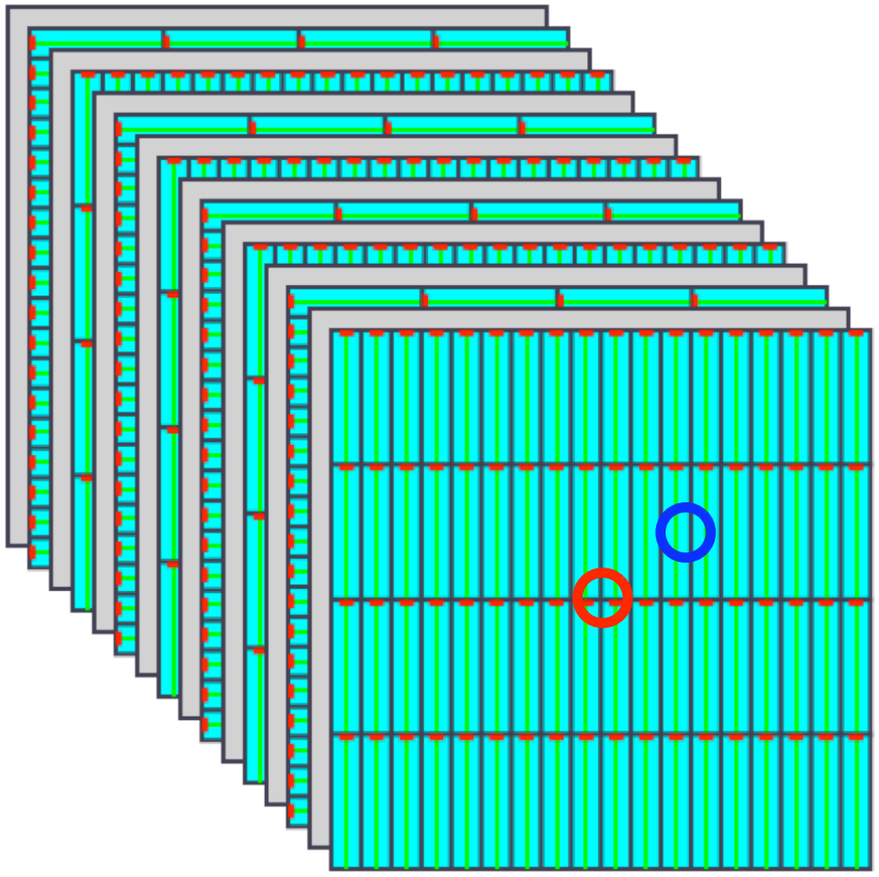


Ratio of response at 45 mm/0 mm

(responses: results of fitting function)

(2) *Uniformity* : at FNAL beam test

- Electron shower response,

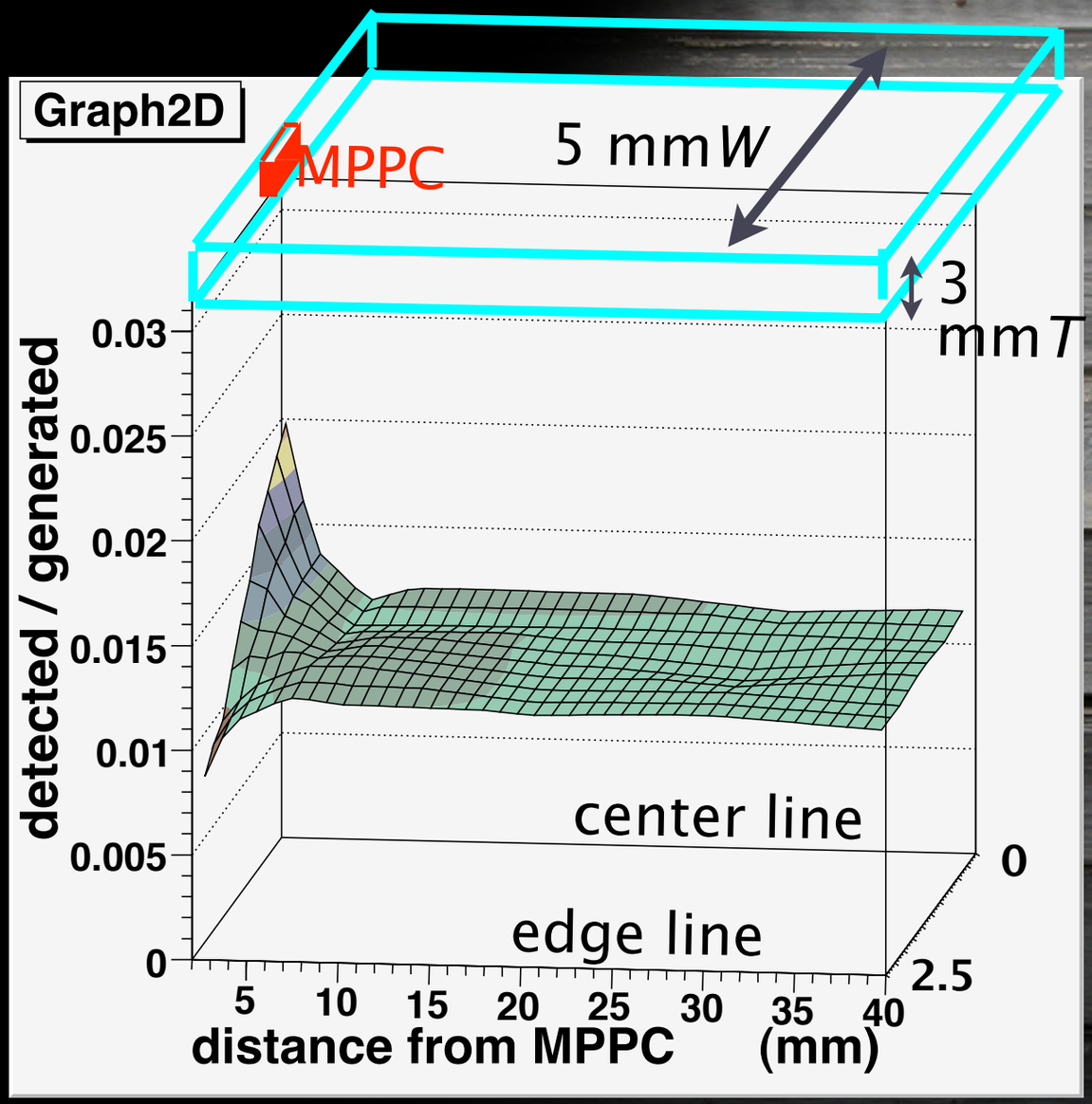


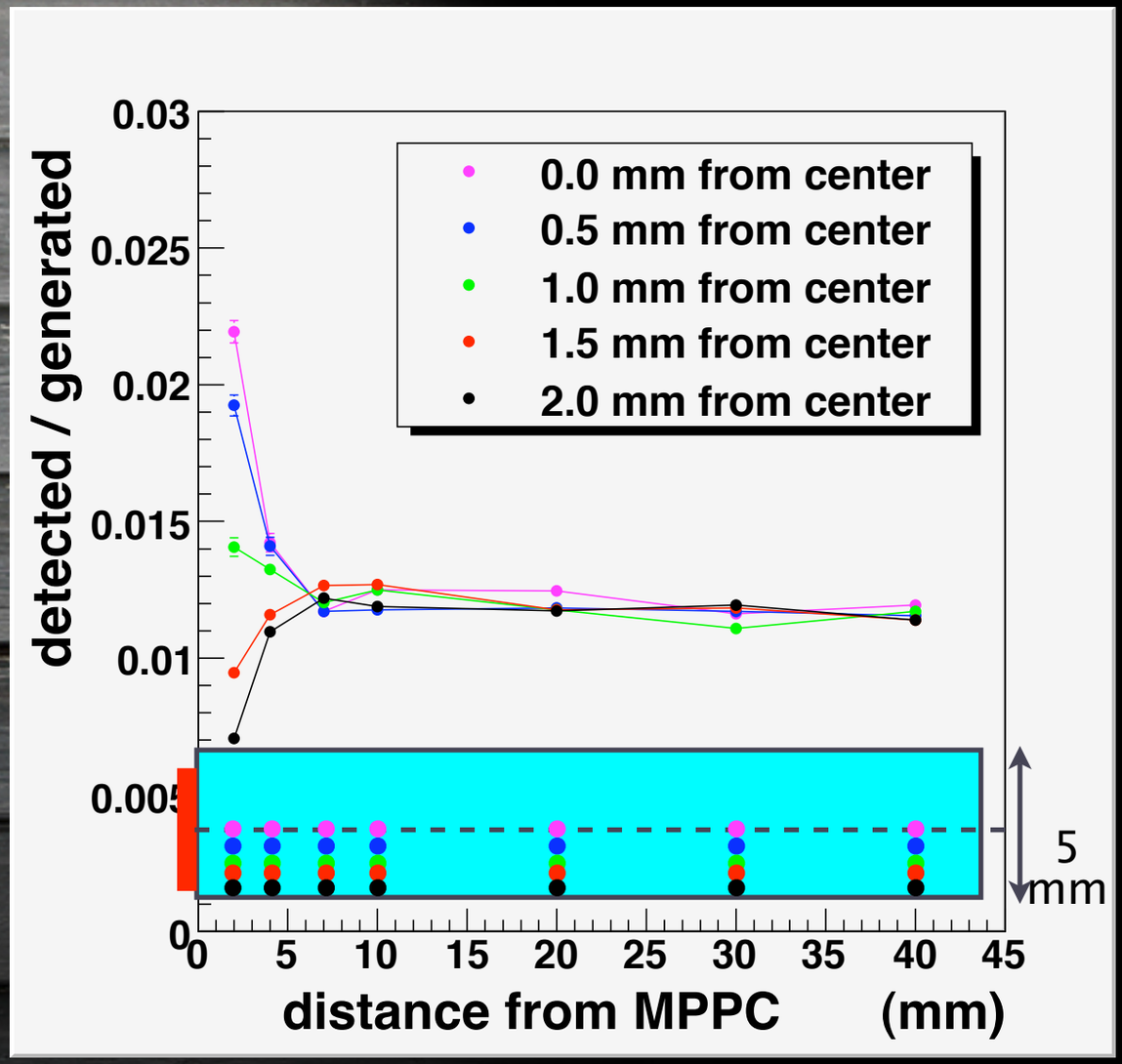
beam region	constant term(%)
○ uniform	1.86±0.09
○ non-uniform	2.12±0.09

- Effect of non-uniformity on the constant term of Energy resolution almost vanished
- detailed position dependence using drift chamber is being analyzed now.

(3) *5 mm width scintillator* : simulation

- corresponding to make 5 mm segmentation.

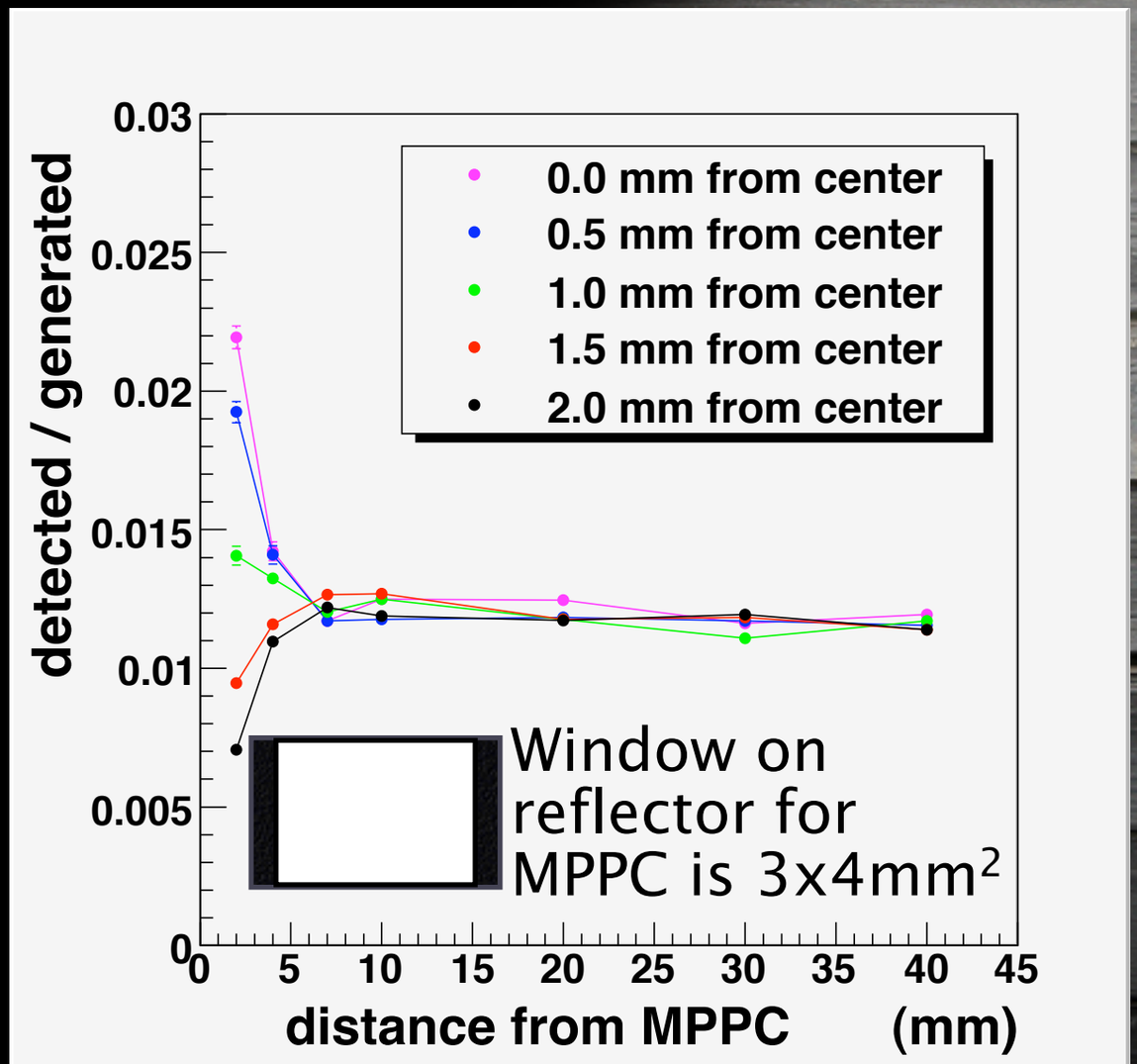


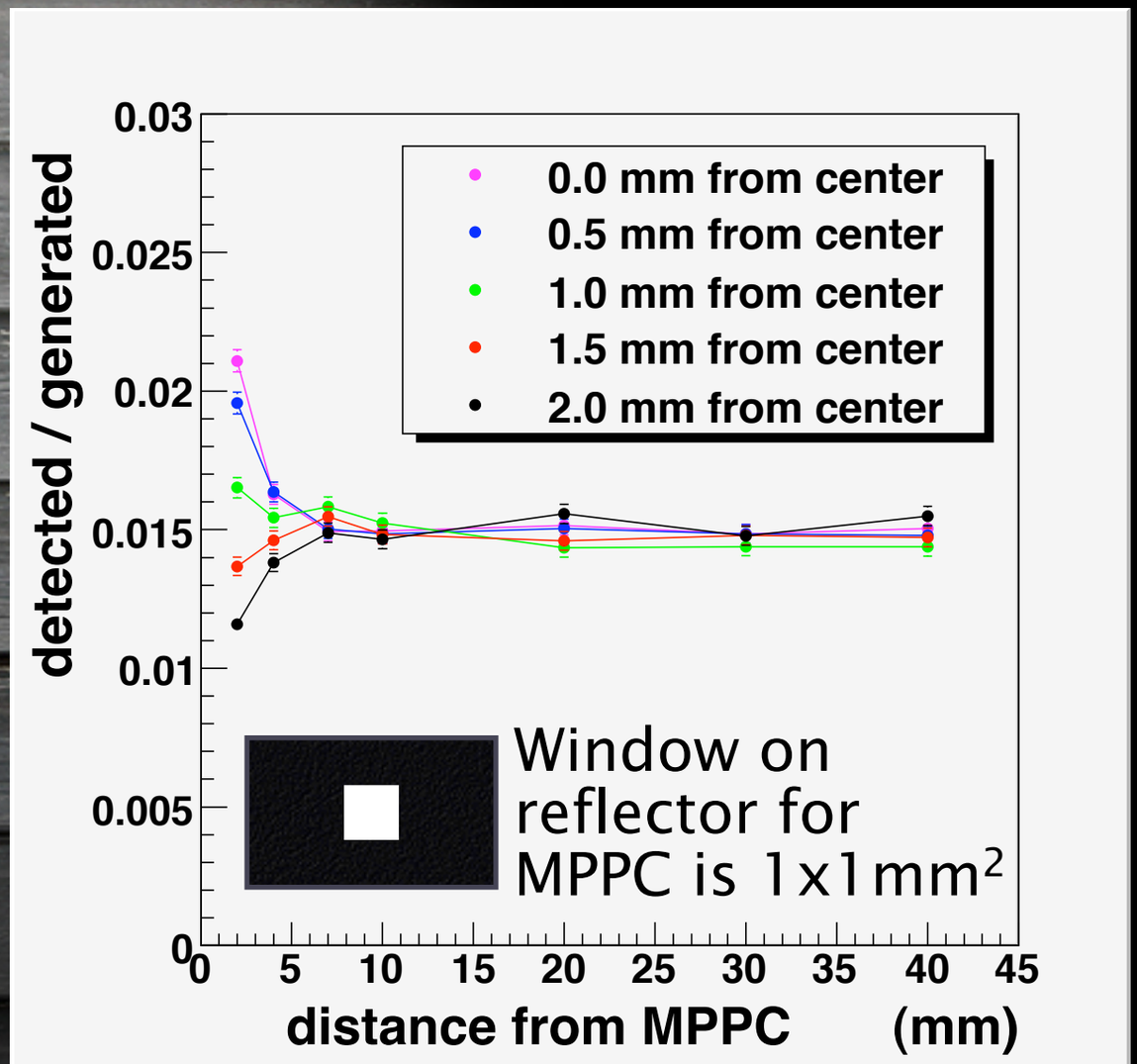


- Uniformity of 5 mm scintillator without fiber-readout is not so bad.
- near MPPC (< 7 mm), lateral direction dependence is large.

(3) *5 mm width scintillator* : simulation

- MPPC window on reflector

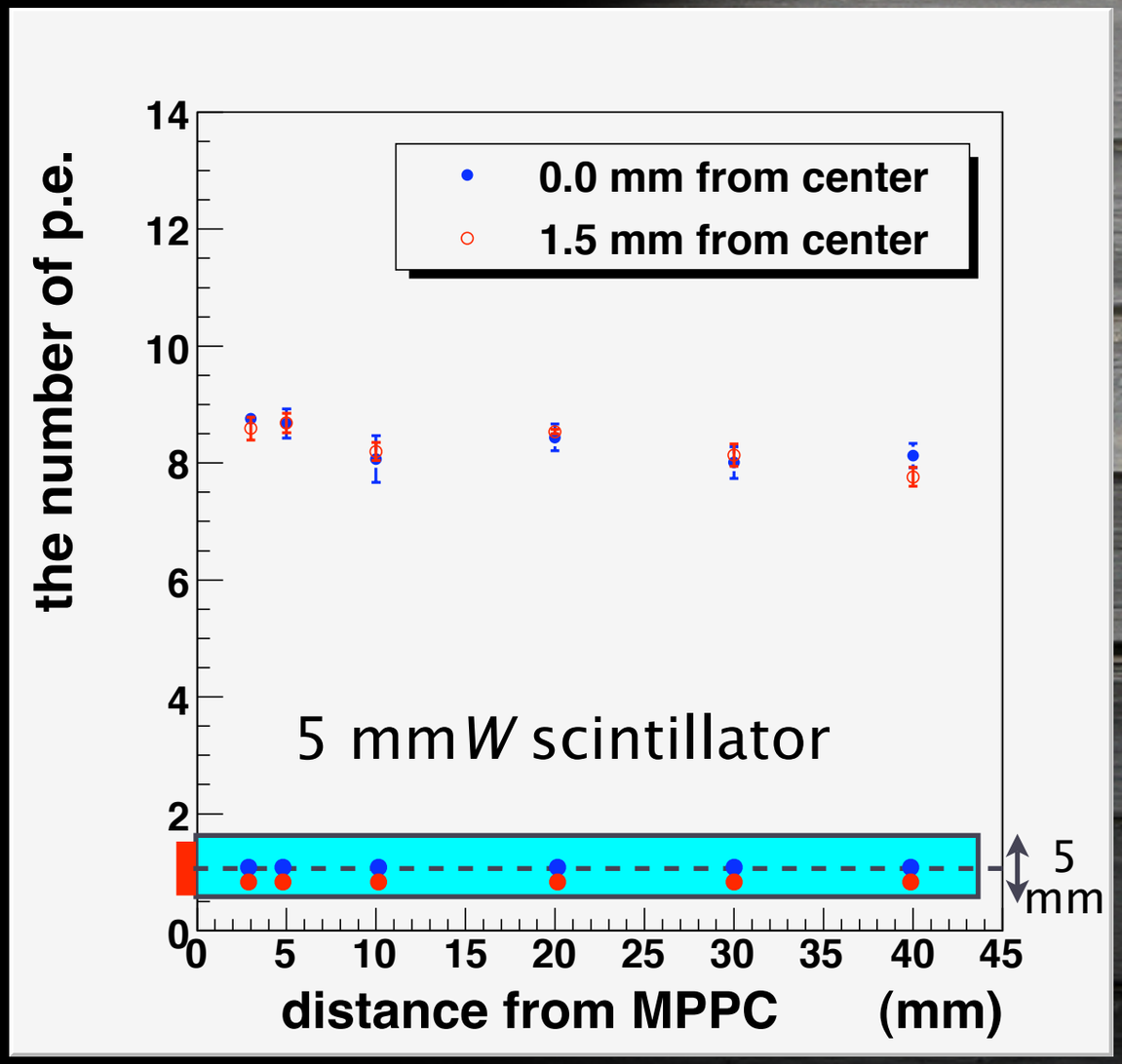


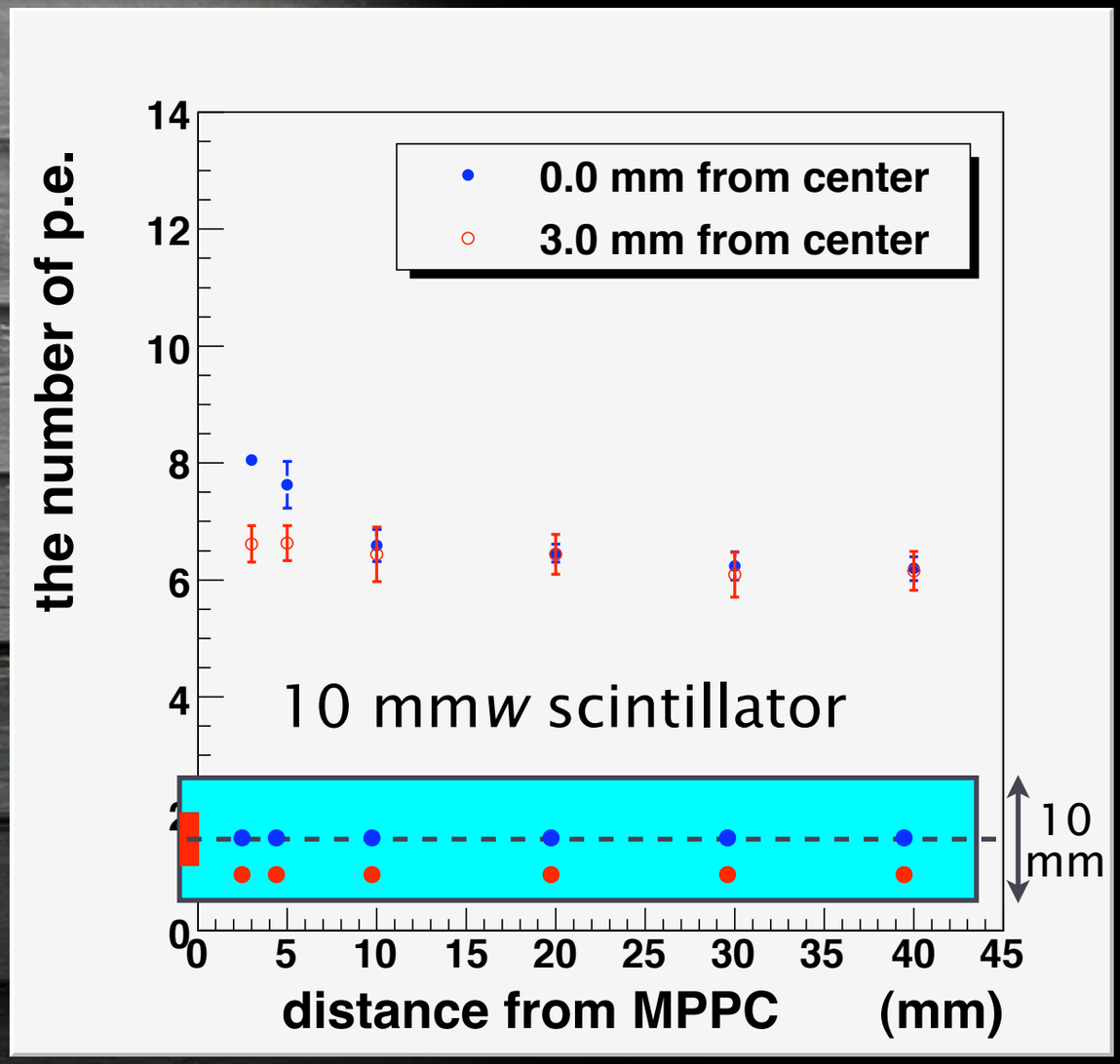


- small MPPC window on reflector increases uniformity and photon yield.

(3) *5 mm width scintillator* : Bench test

- Experiments (Bench test,Kuraray)

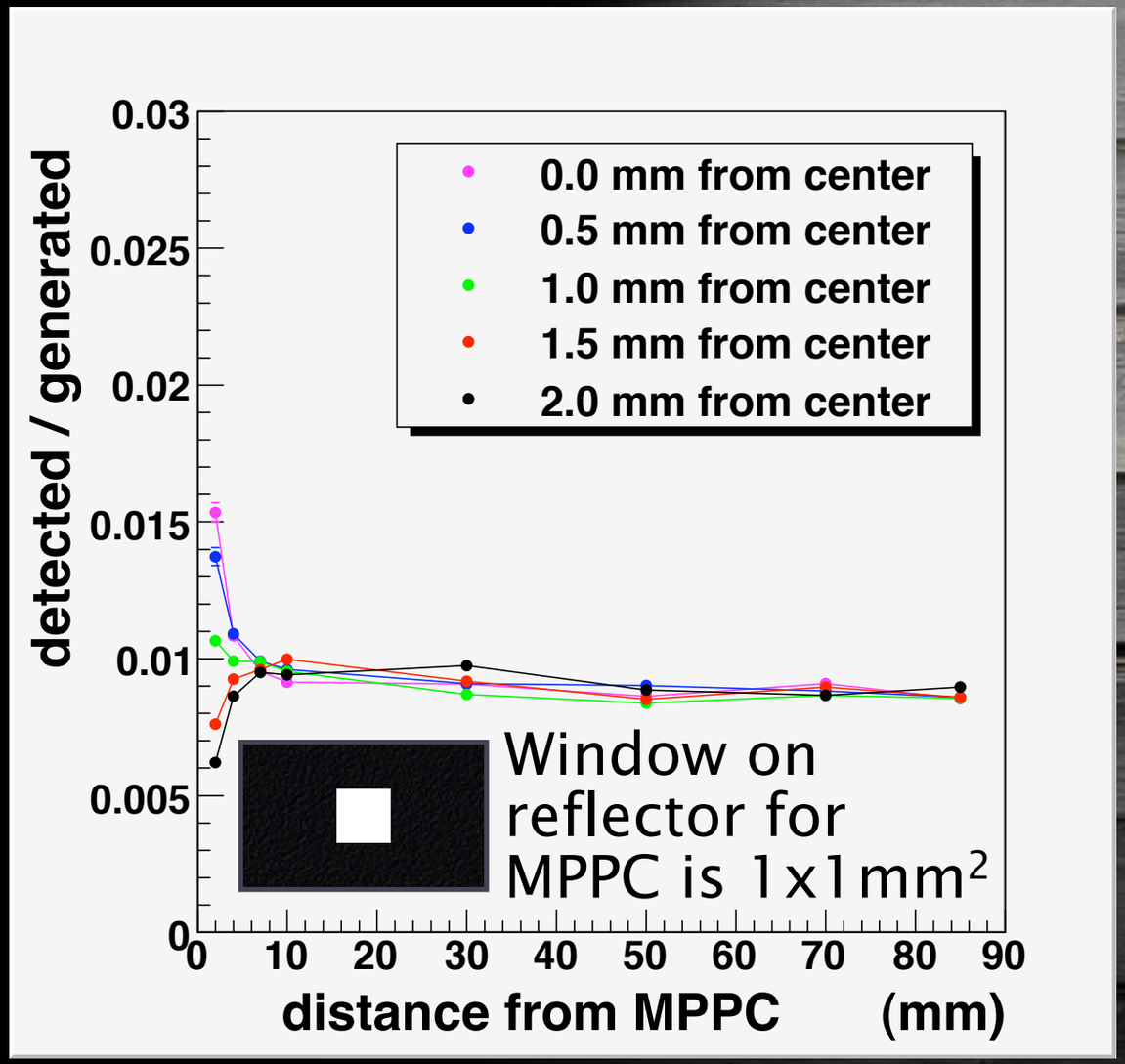




- 5 mm*W* scintillator without fiber-readout has good uniformity.
- lateral direction dependence in front of MPPC is seen.
- less photon yield (1/4) than fiber-readout.

(3) *5 mm width scintillator*

- 90 mm long scintillator (simulation)



- It's worthwhile to develop longer strips than current 45 mm strip.
- photon yield with 90 mm strip is 2/3 times less than 45 mm strip.

→Wide sensitive area MPPC can help us?

Summary

- We discussed;
  - how to use reflector;
    - whole of surfaces must be covered with the best reflector (so far Kimoto).
  - uniformity;
    - how to keep uniformity→using collar shade.
    - status → drastically modified.
- 5 mm*W* scintillator;
  - without fiber readout and,
  - with small MPPC window→ good uniformity.

Plan

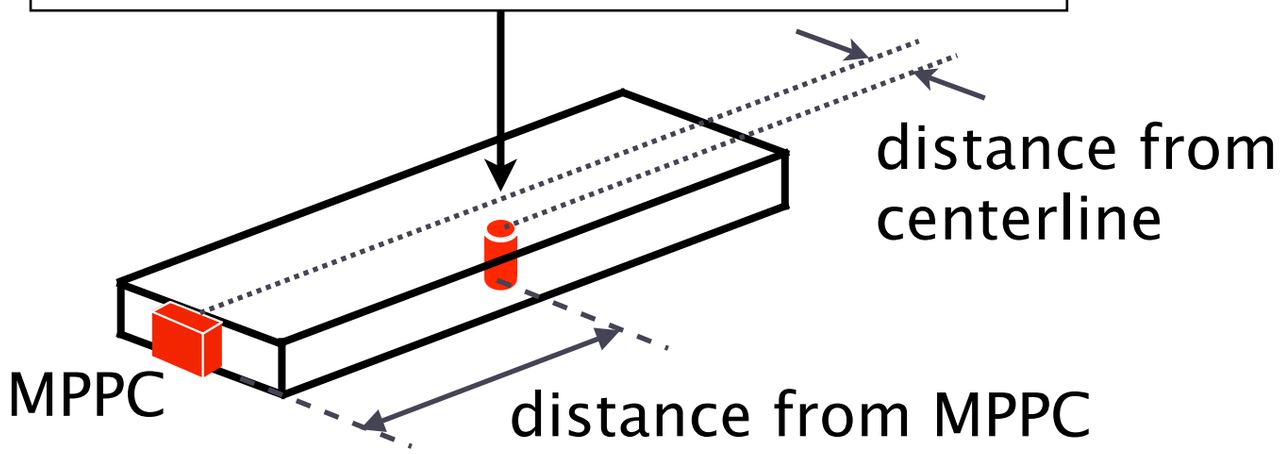
- Experimental study on non-uniformity near MPPC.
- Bench test with 50-90 mm long scintillator.
- Study with 1.4 mm x 1.4 mm sense area MPPC.
- Study with 5 mm*W* extruded scintillator.
- Study of clustering method with 5 mm W scintillator.

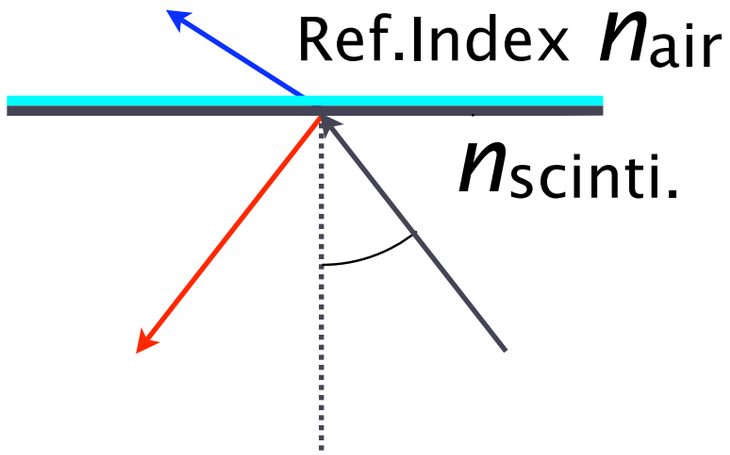
Backup

(0) Simulation used in this Study

- photon transportation

photons are scattered randomly
4π direction from 1mm Φ cylinder





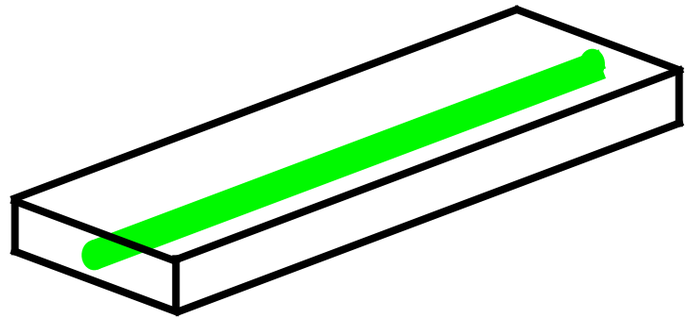
- Calculated reflectance, transmittance

$$\mathbf{R} = \frac{1}{2}(\mathbf{R}_{\perp} + \mathbf{R}_{||})$$

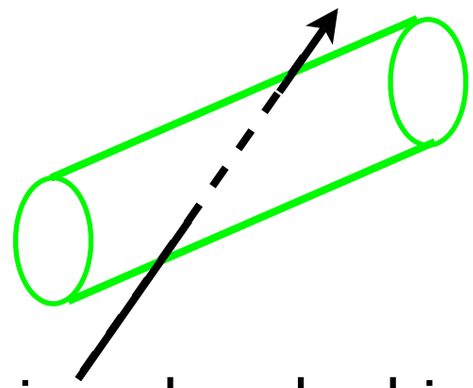
$$\mathbf{T} = \frac{1}{2}(\mathbf{T}_{\perp} + \mathbf{R}_{||})$$

- reflection ratio of reflector; 97%.
- no dispersion so far.

In case to use WLS fiber



- attenuation length in fiber is infinite.



- ratio being absorbed in fiber depends on the length of

Measured energy resolution

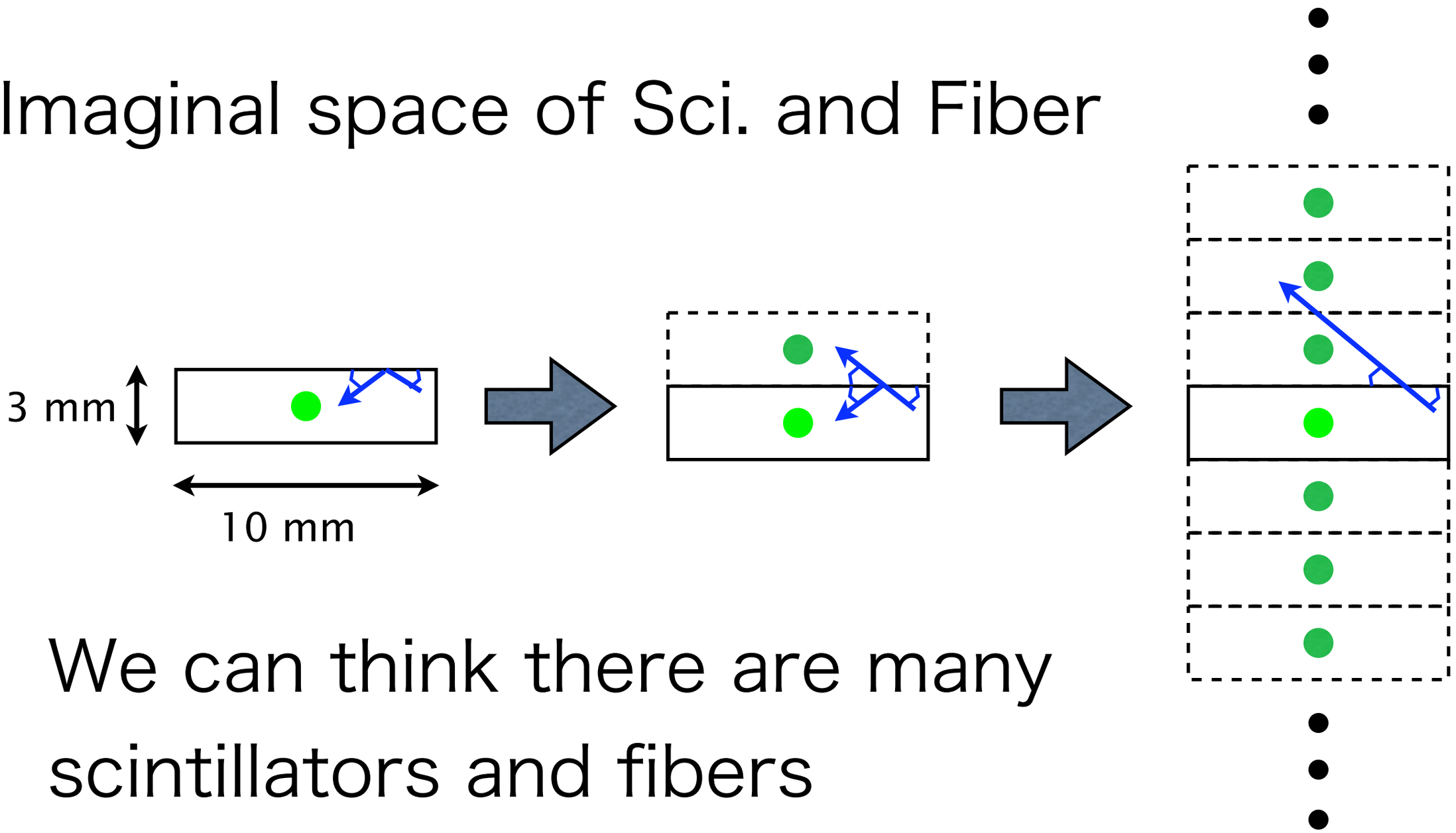
	quarter regions		central region	
	stoch. term(%)	const term(%)	stoch. term(%)	const term(%)
fibre+direct:	13.98 ± 0.07	1.96 ± 0.12	13.39 ± 0.05	2.57 ± 0.07
direct+fibre:	13.83 ± 0.07	2.58 ± 0.09	13.70 ± 0.06	3.39 ± 0.05
extruded+fibre:	14.61 ± 0.08	2.35 ± 0.12	14.52 ± 0.09	7.26 ± 0.05

Shower leakage gives significant contribution to constant term

Non-uniformity gives large constant term in central region

Simple simulation

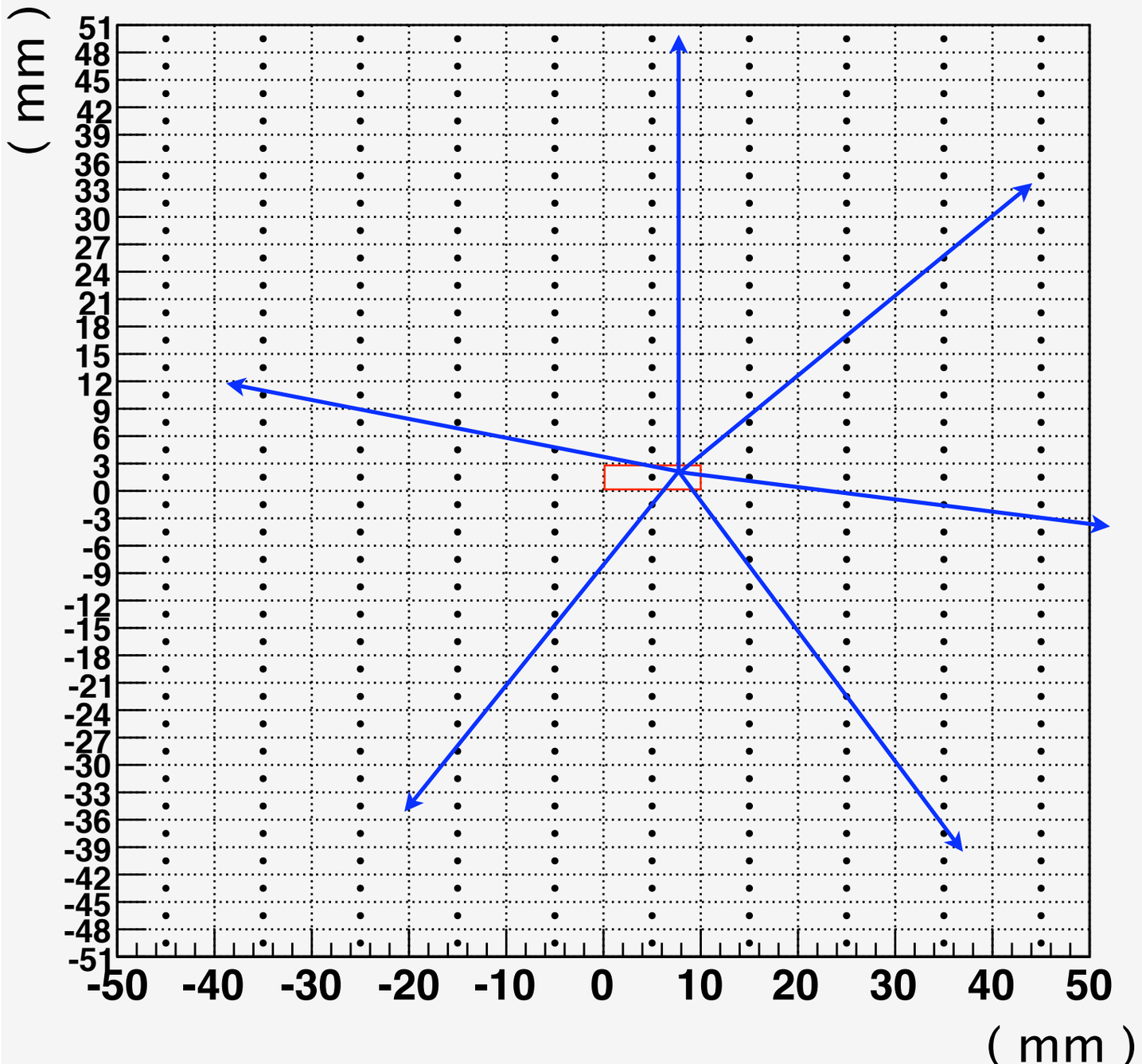
Imaginal space of Sci. and Fiber



We can think there are many scintillators and fibers

Simple simulation

A photon goes through such fiber-sea

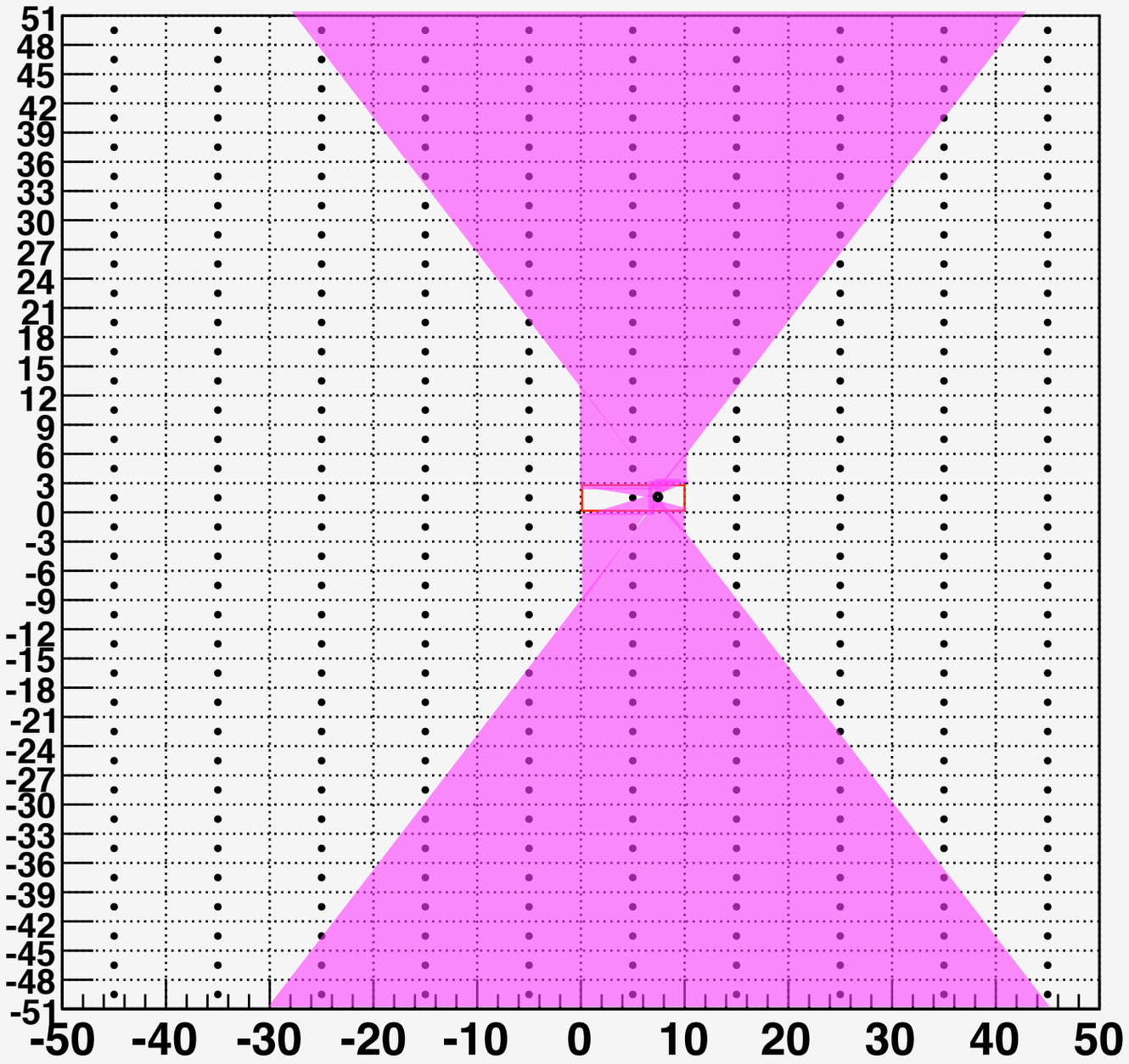


we can easily imagine what direction has many fibers, with this model.

On surface, reflection ratio, transmission ratio depending on incident angle and reflective index, is calculated.

Simple simulation

th fiber-sea



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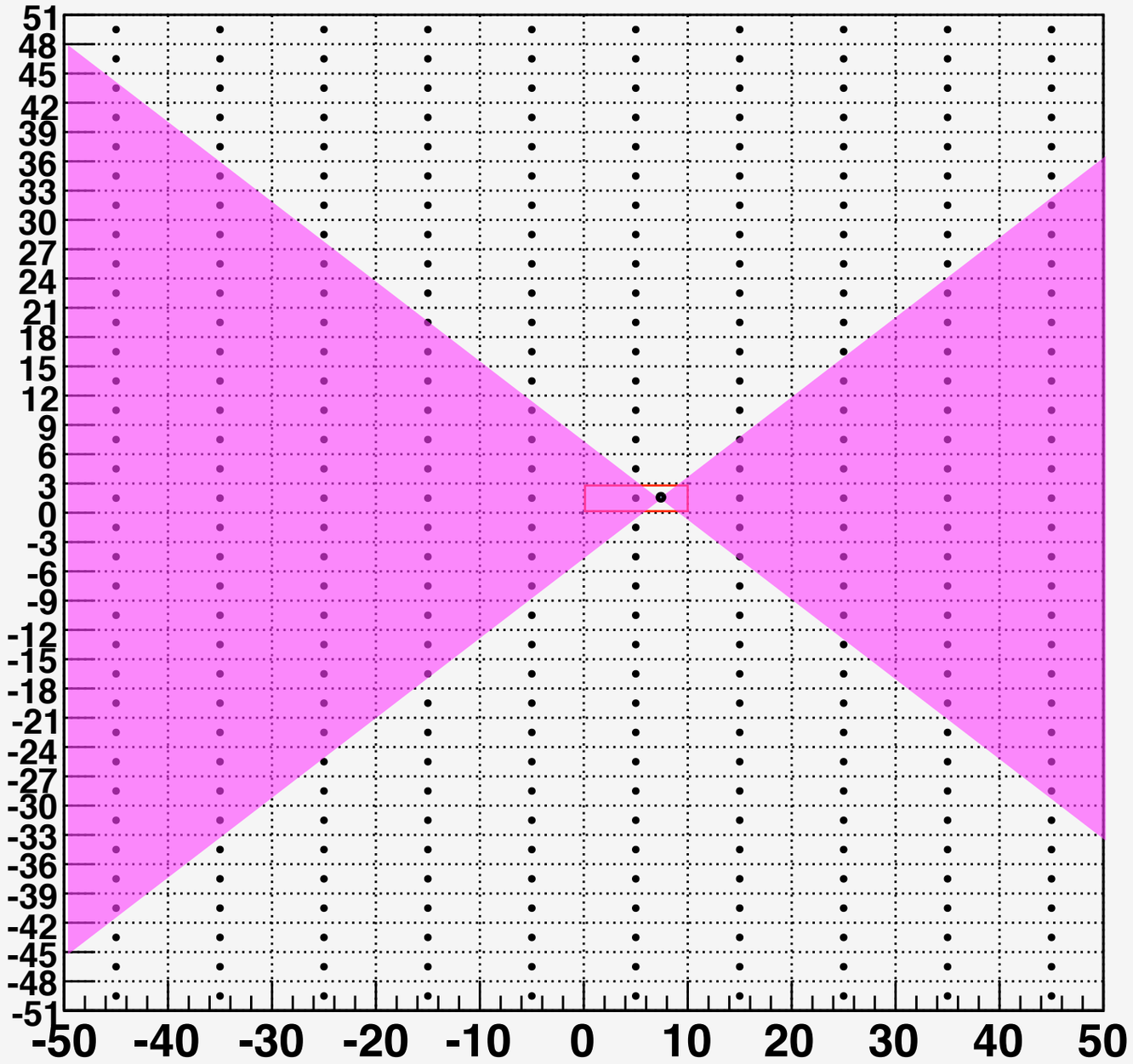

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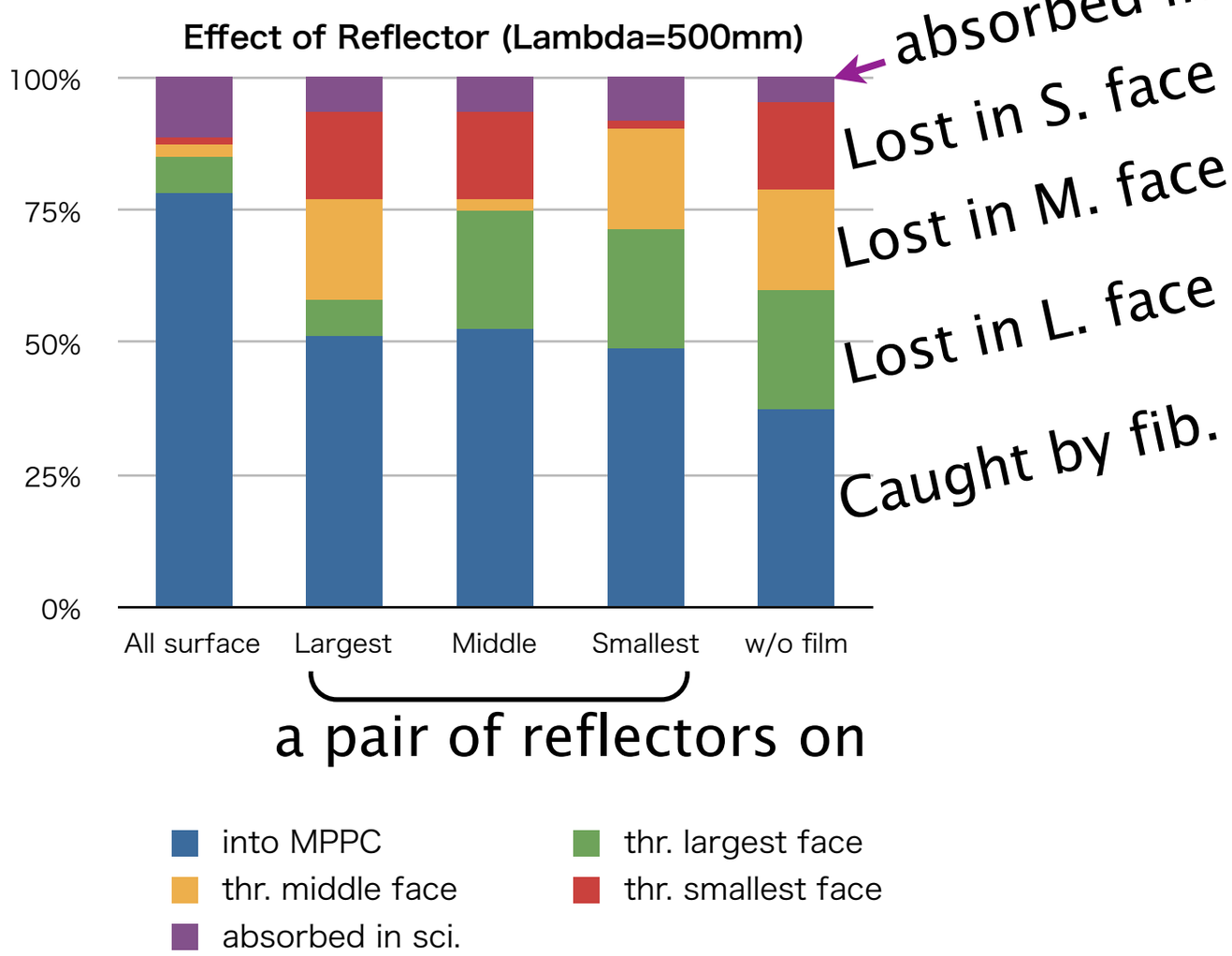
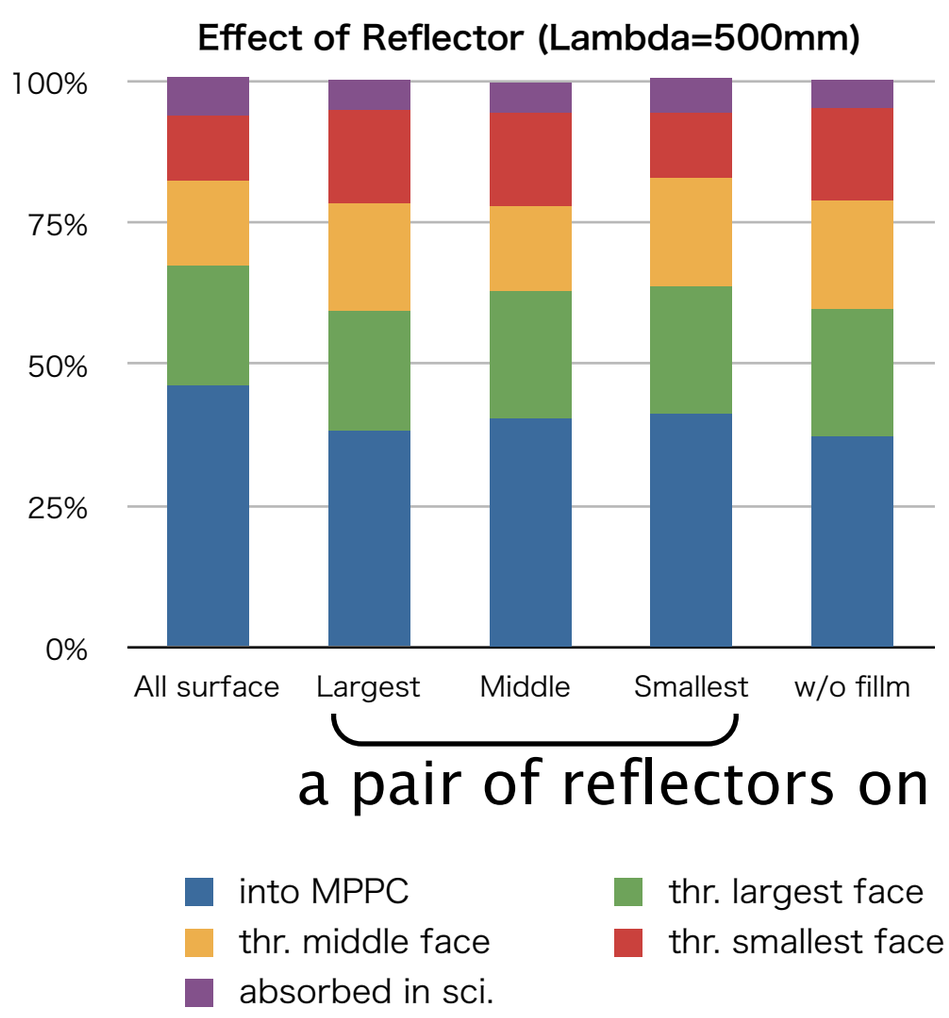
Destinations of photons

Attenuation length: 500 mm

Reflection ratio: 97%

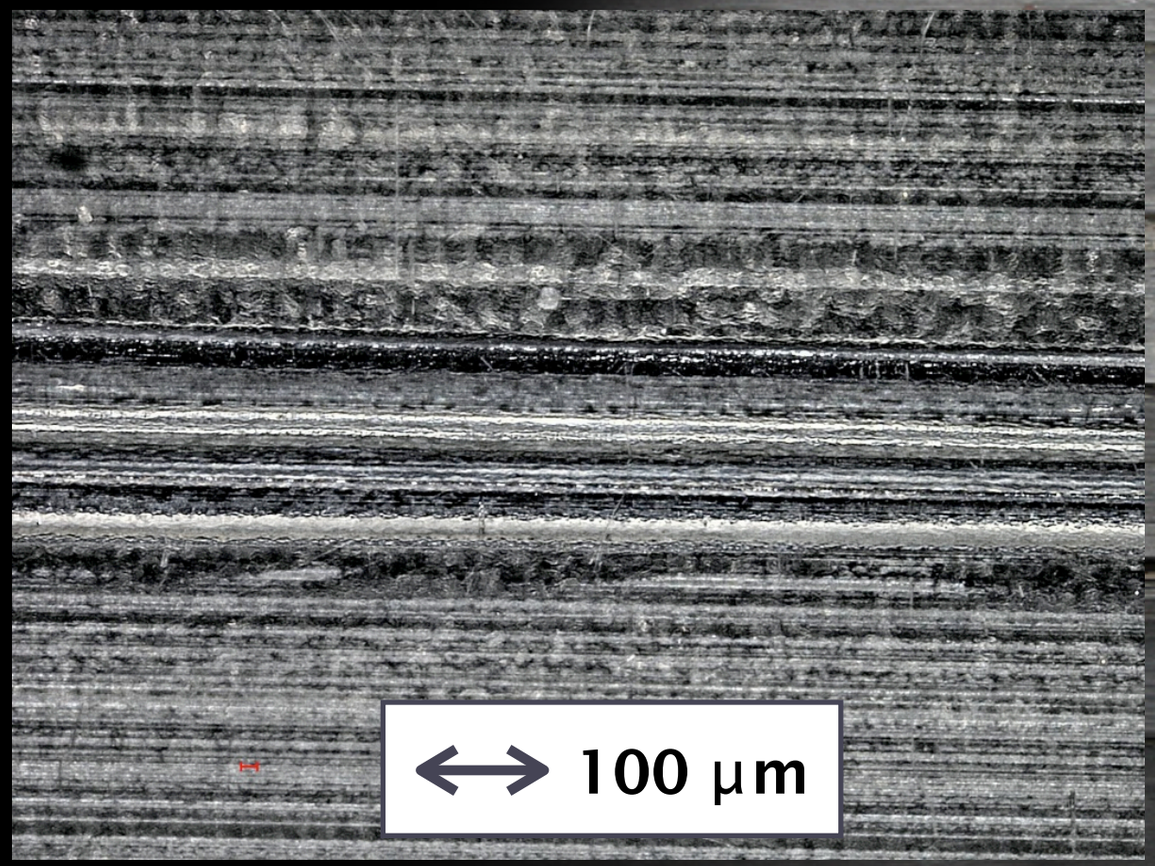


Reflection ratio: 50%

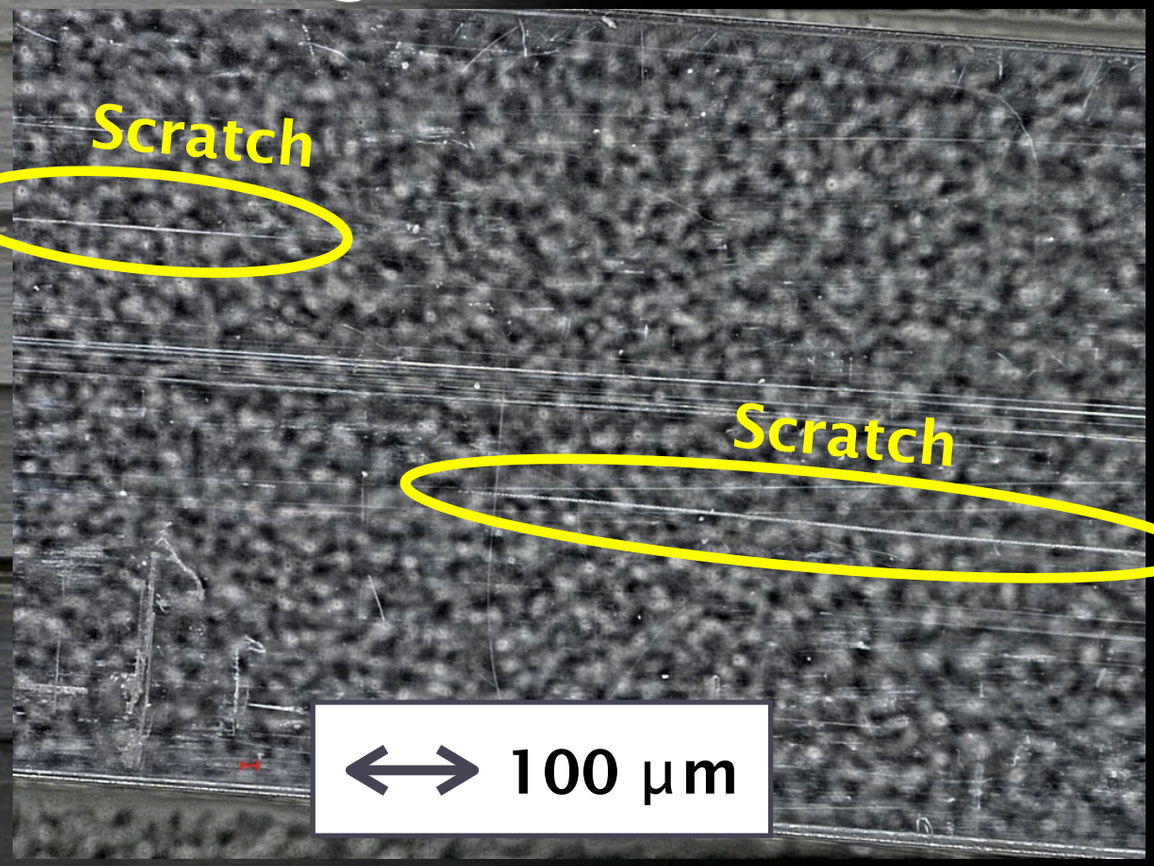


Micrograph of Strip Scintillator

Extruded



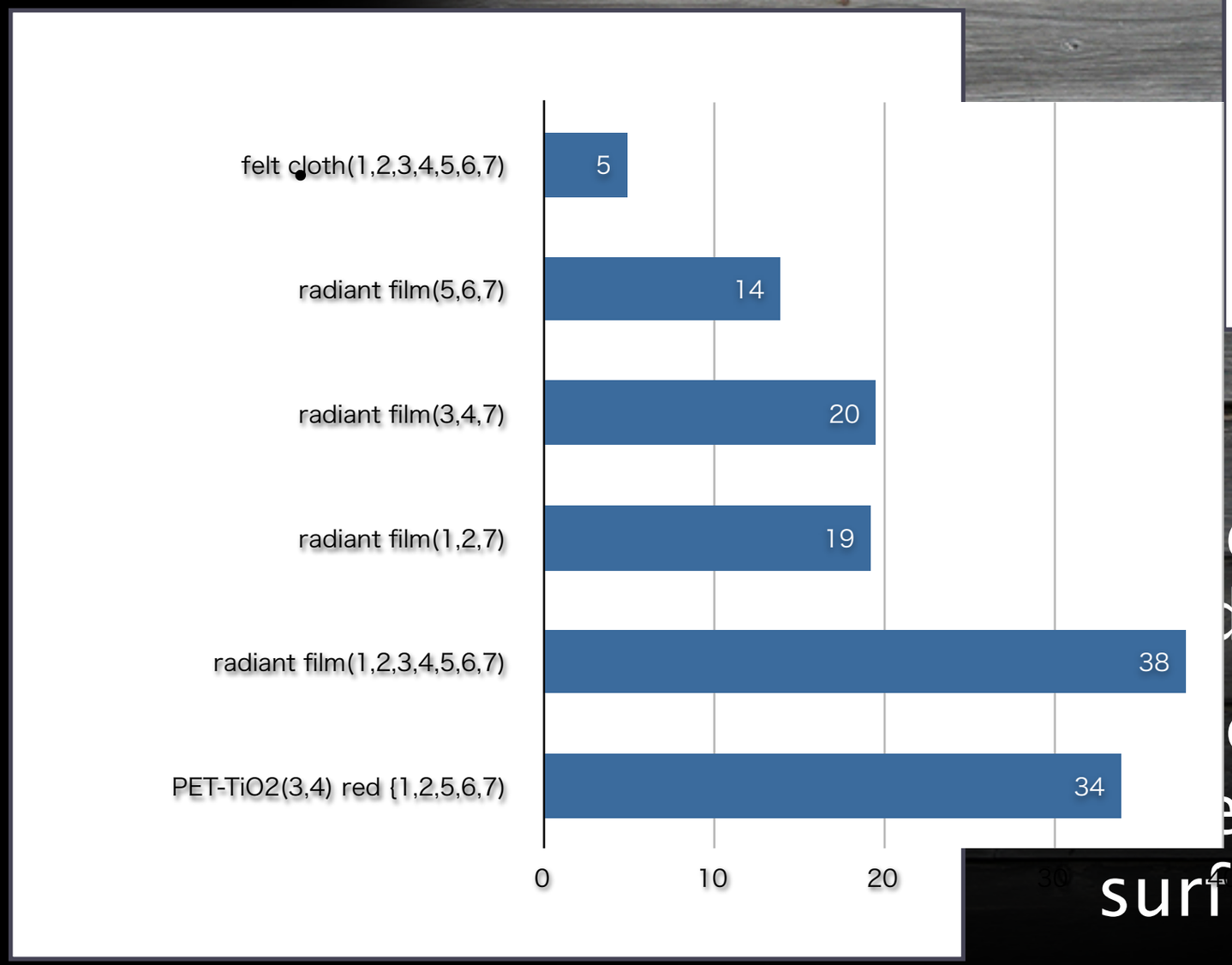
Casting

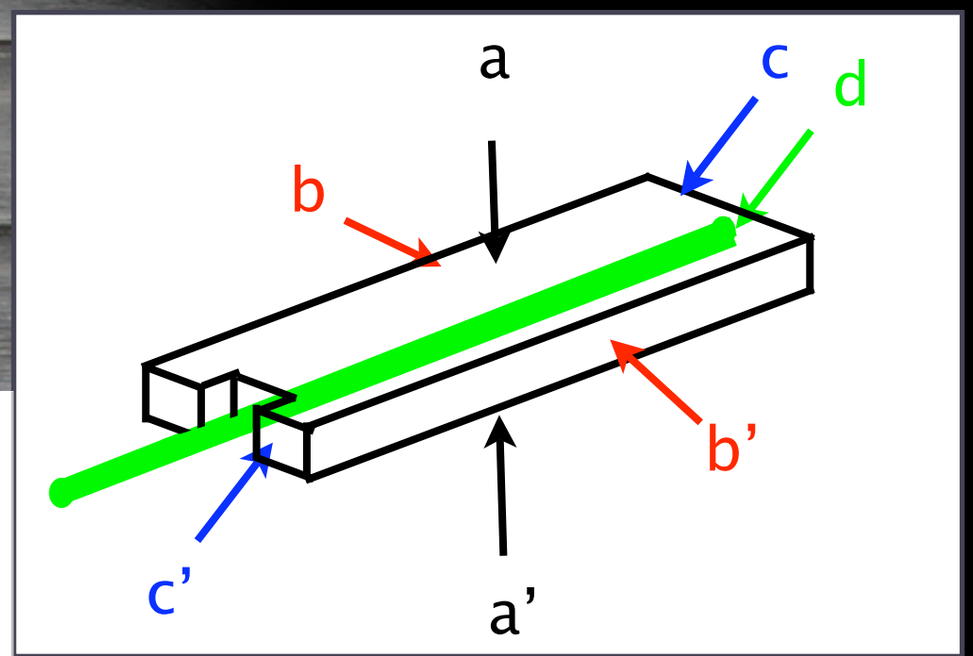


- b/w mottling is the stage of microscope seen transparently.

Experiment : effect of reflector.

responses depending on
distance from MPPC





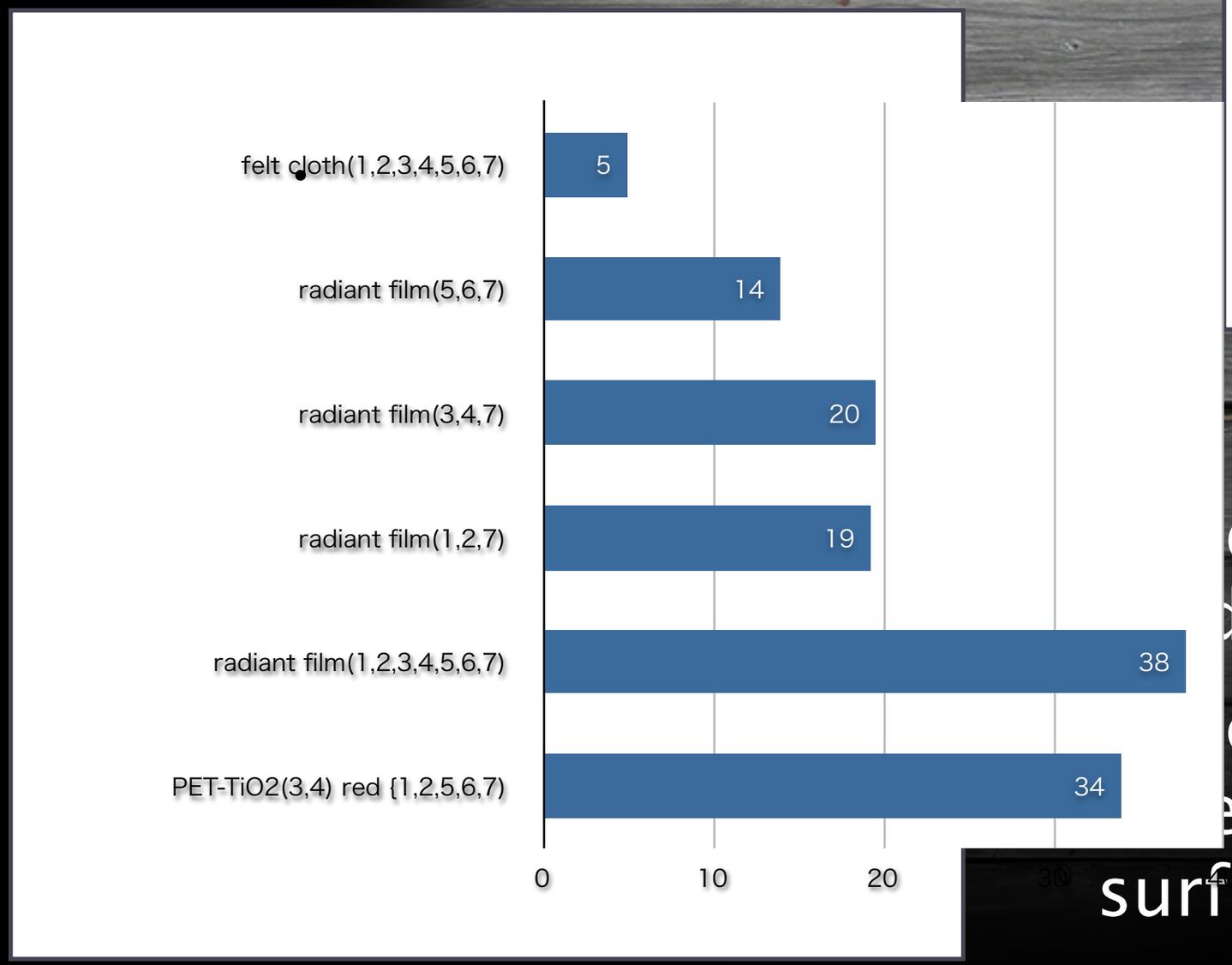
d uniformity with fiber
dout.

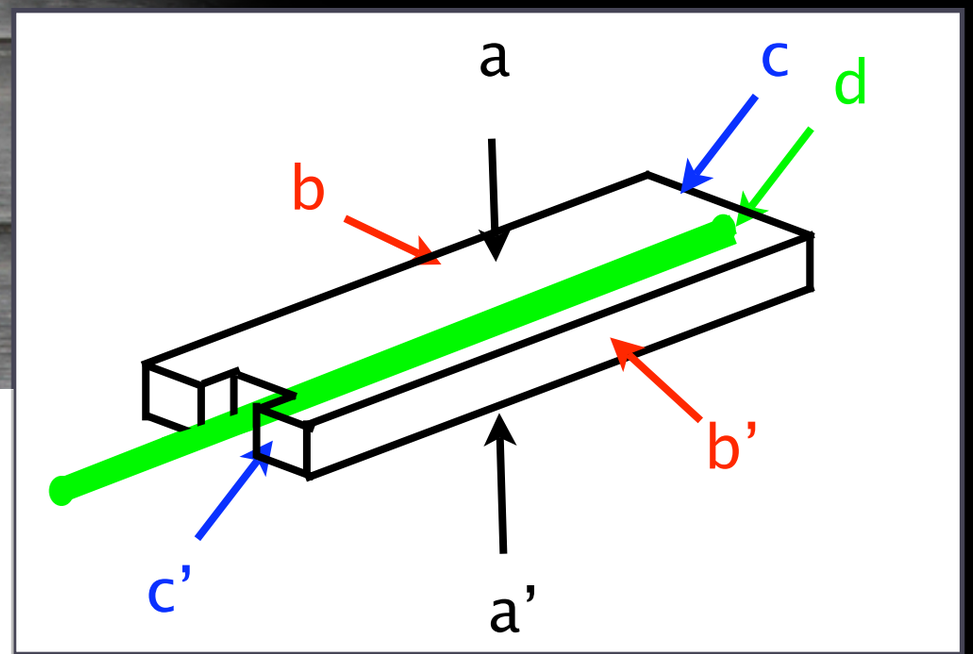
ct of reflector is
ependence on size of
surface

Experiment : effect of reflector.

- Where covering with reflector?

responses depending on
distance from MPPC





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