

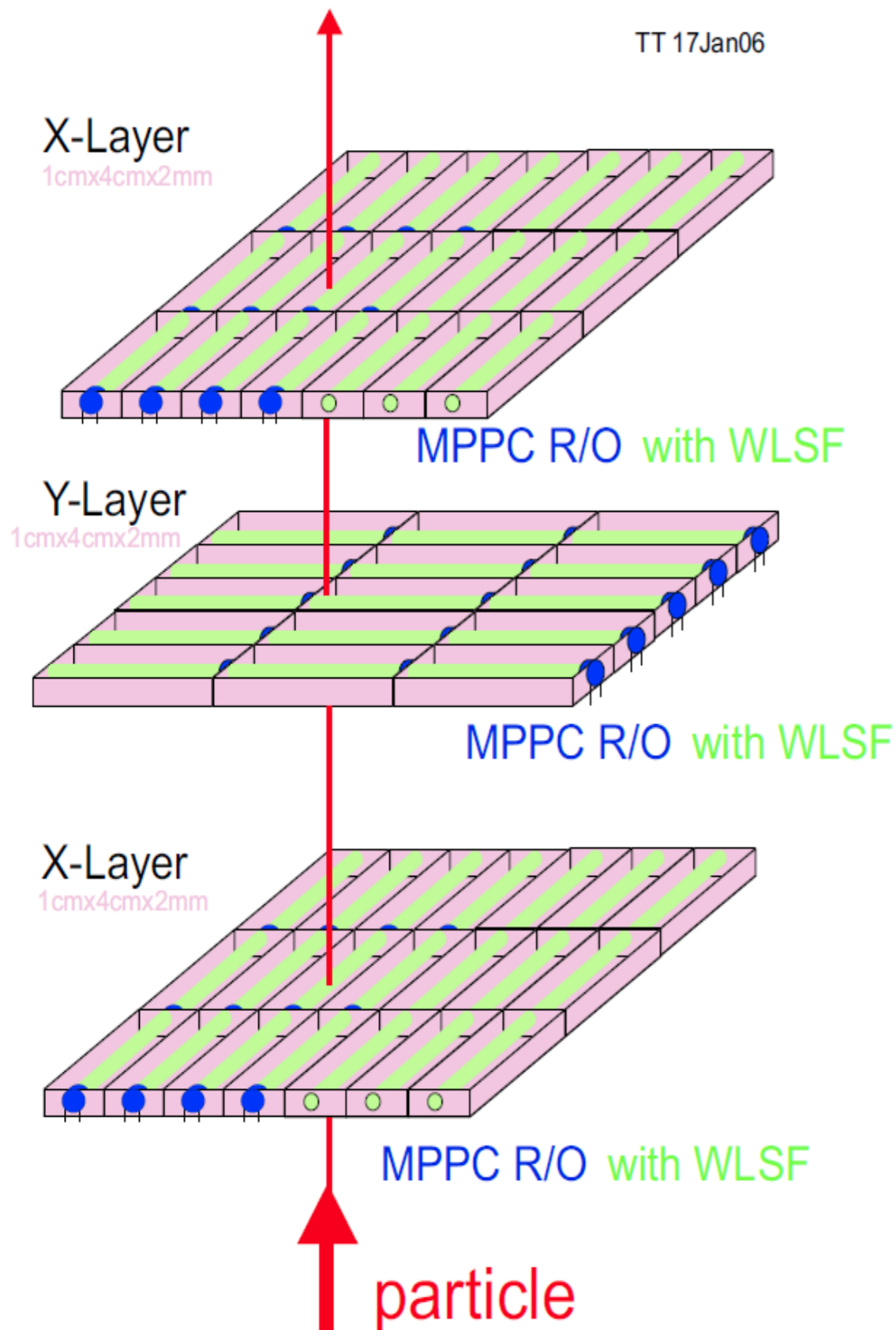
# Study of Strip Scintillator with MPPC readout

K. Koterá (Shinshu university), GLD-CAL group  
ILC ECFA Workshop 2008 in Warsaw

# Scintillator strip calorimeter

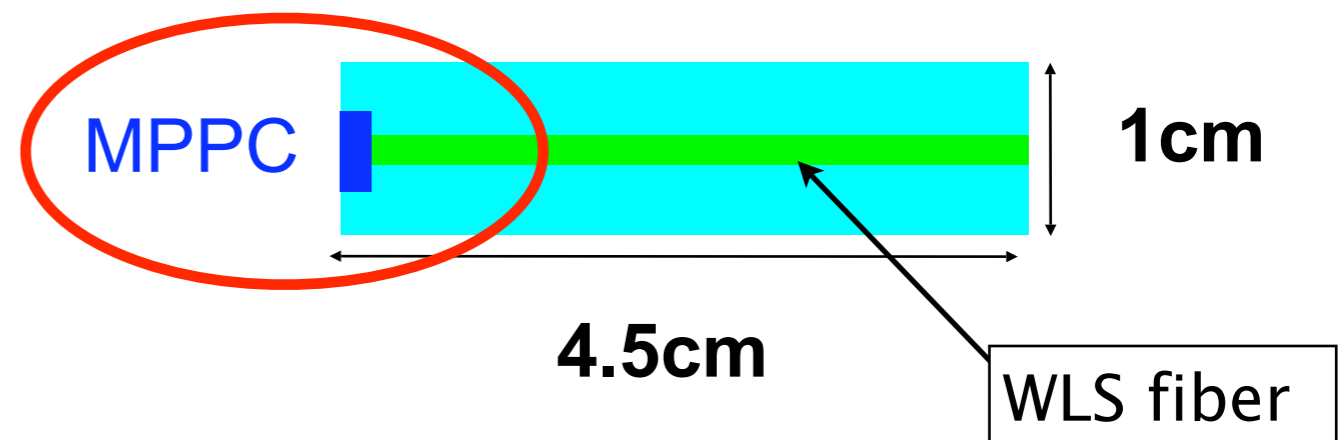
EM-Scintillator-layer model

TT 17Jan06

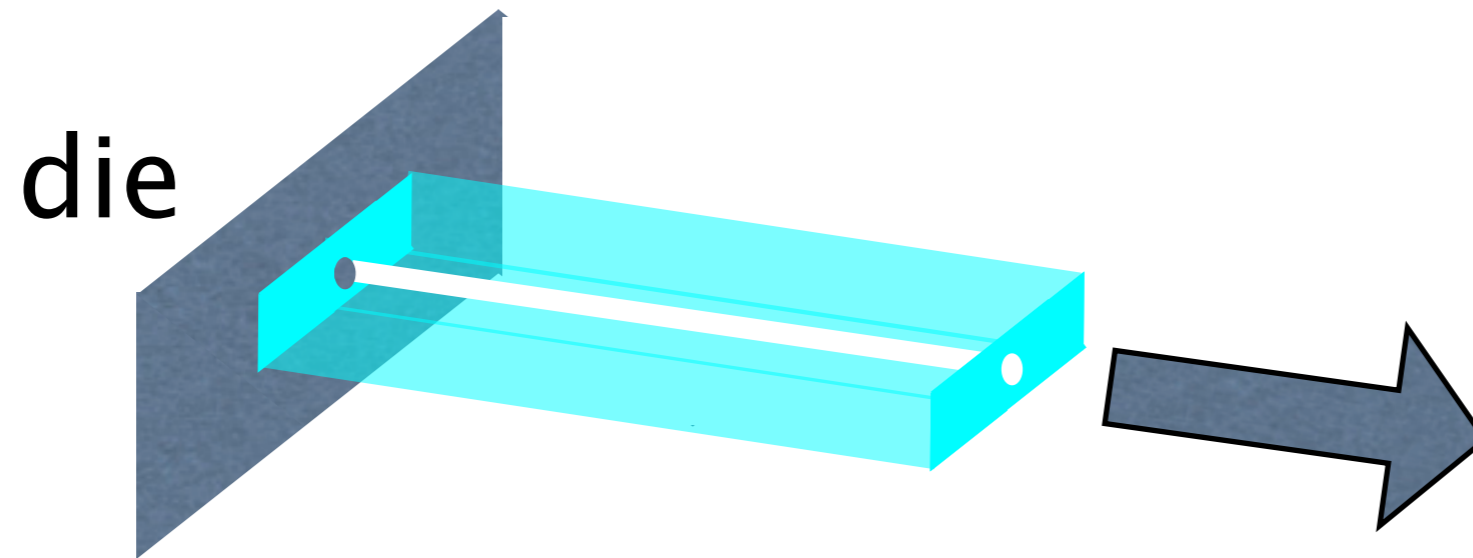


- sampling calorimeter (33 layers)  
scintillator strip + W (absorber)
- PFA → scintillator fine segmented  
→ We need **10M** scintillator strips.  
→ Production cost of the scintillator strips must be cheap.

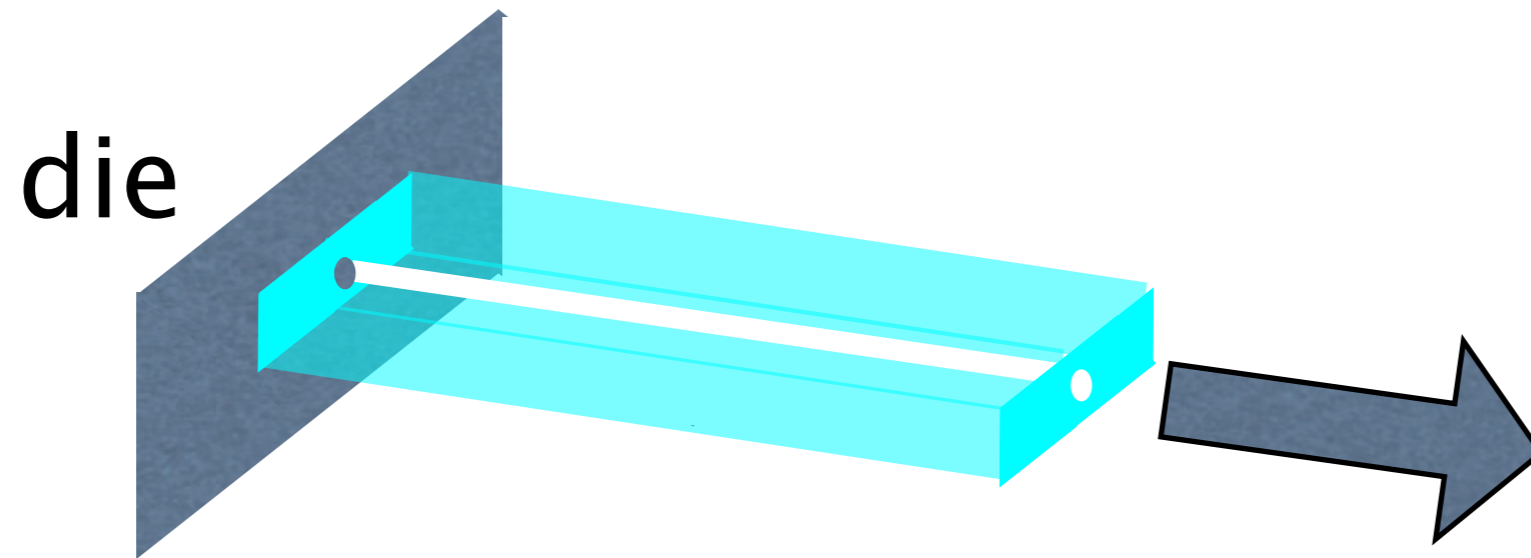
Scintillator strip



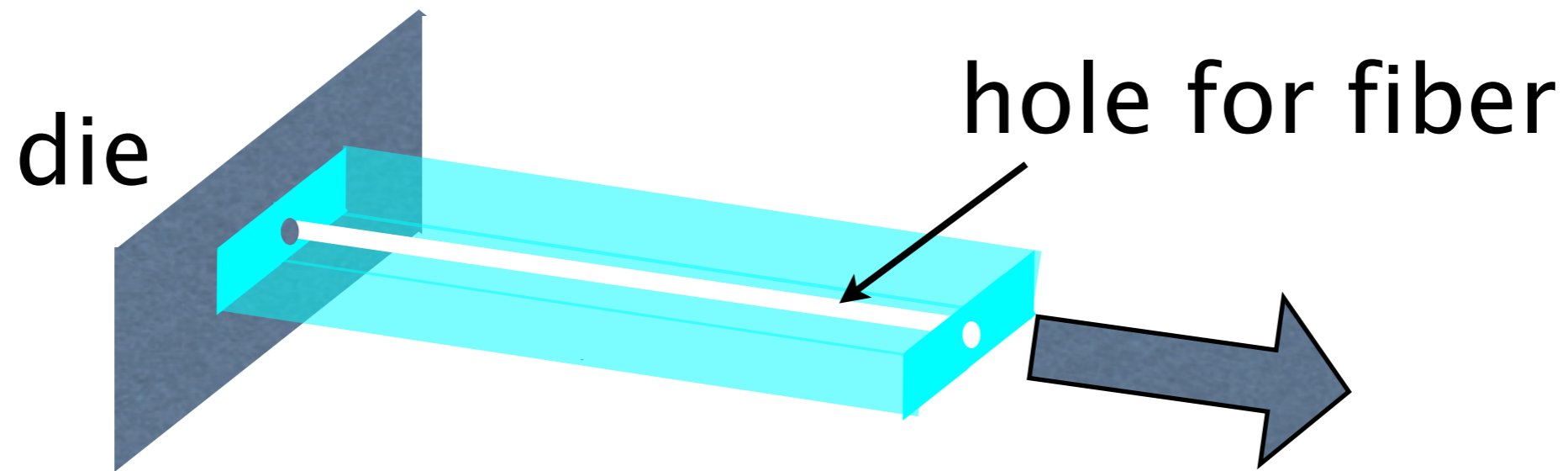
# Extruded scintillator



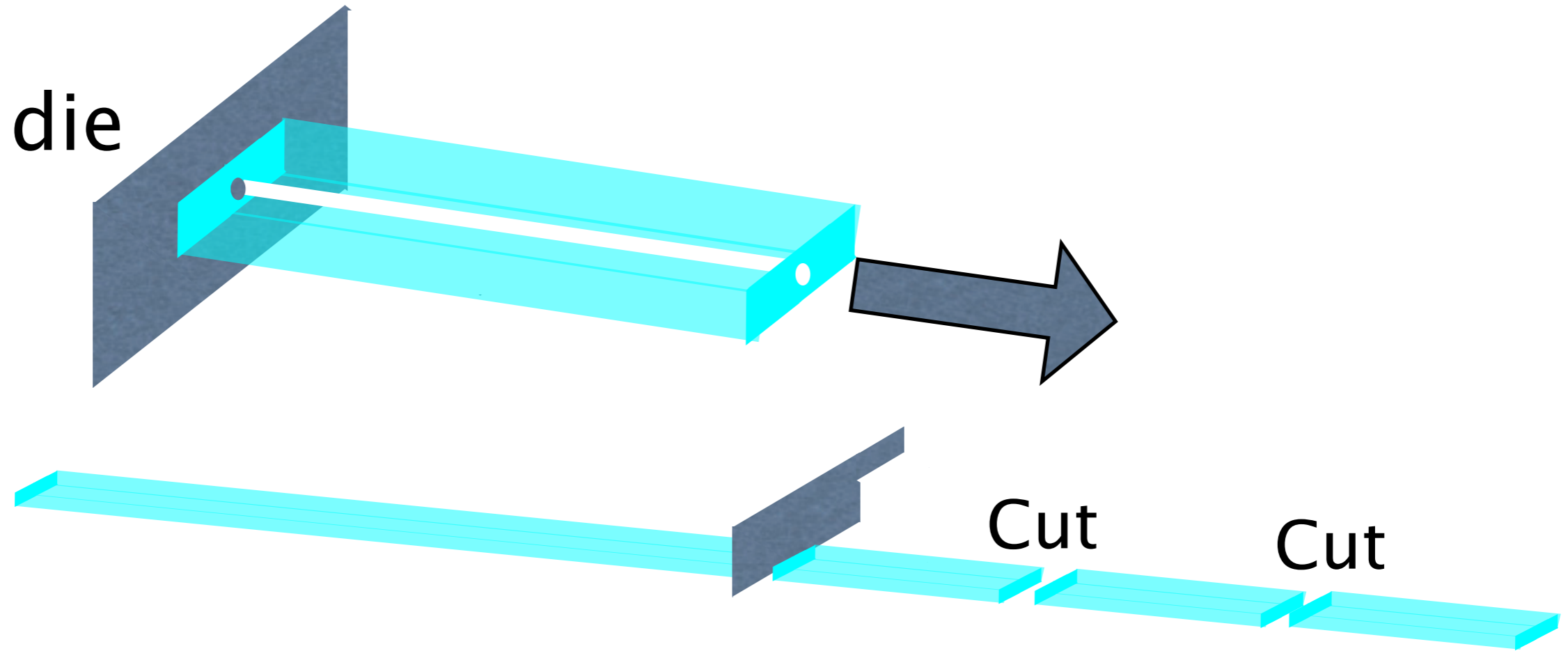
# Extruded scintillator



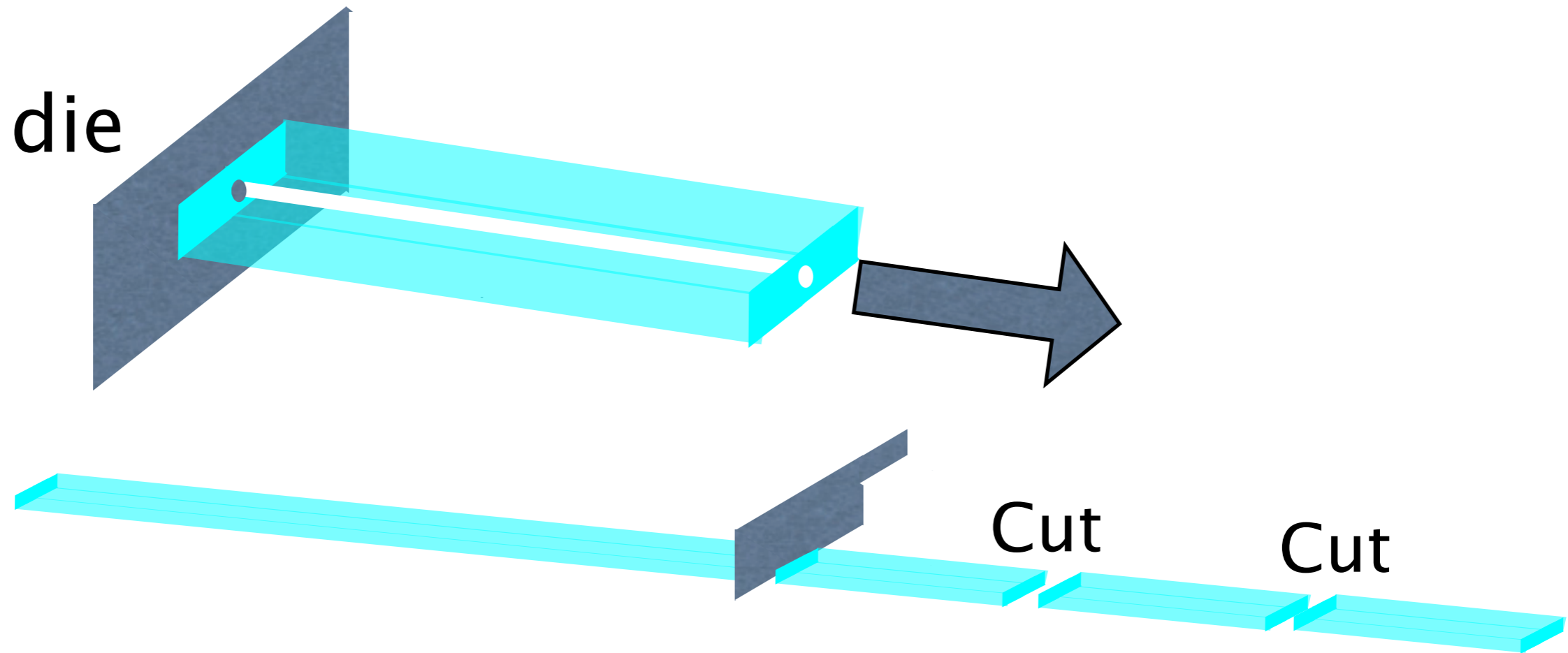
# Extruded scintillator



# Extruded scintillator

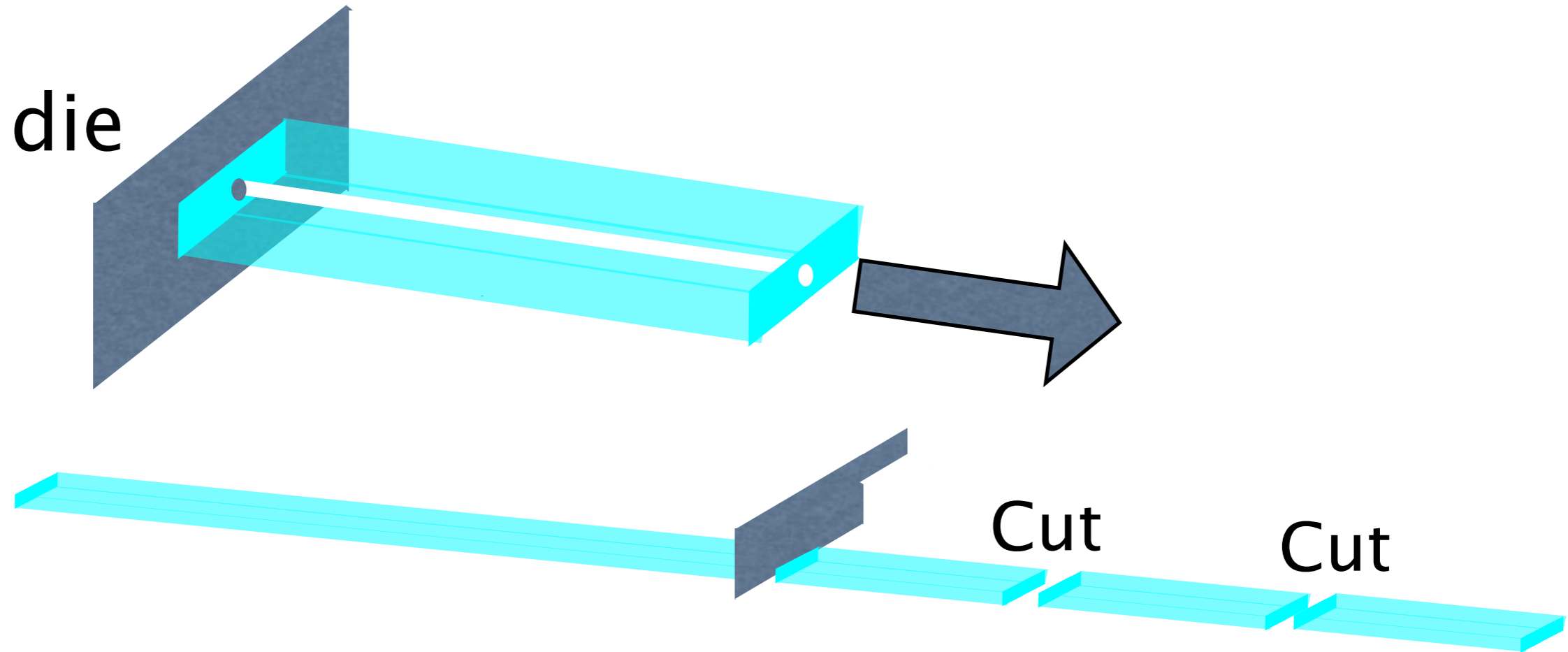


# Extruded scintillator



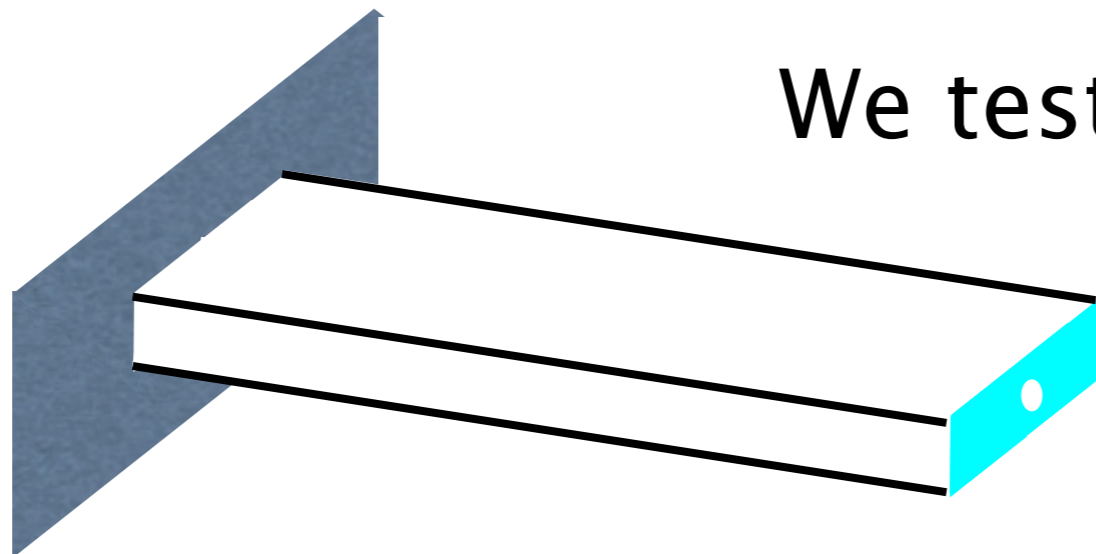
- Symmetry along the longitudinal direction of strip scintillator allows us to use extrusion method.

# Extruded scintillator



painting some reflector is allowed simultaneously

We test white paint ( $\text{TiO}_2$ )





# Test extruded strip scintillator

## Comparison of scintillators between:

### Mechanical cutout

- Made by Kuraray Co.,
- precise cutting and drilling are easy
- a radiant film by 3M Co.
- Expensive

### Extruded



- Developed by KNU with Misung Chemical Co.,
- difficult to keep precise hole size and hole position so far
- painted  $\text{TiO}_2$  for reflector
- Low cost

# Two beam tests and some bench tests.

Ecal beam test @ DESY

- low response of extruded Sci. 
- non uniformity of strip Sci. 

Strip scintillator beam test @ KEK

- found causes of low response. 
  - uniformity problem remains. 
- very important for  $\sigma E$

Bench test with beta source

- we fixed uniformity problem. 

FNAL beam test ( Sep.2008 )

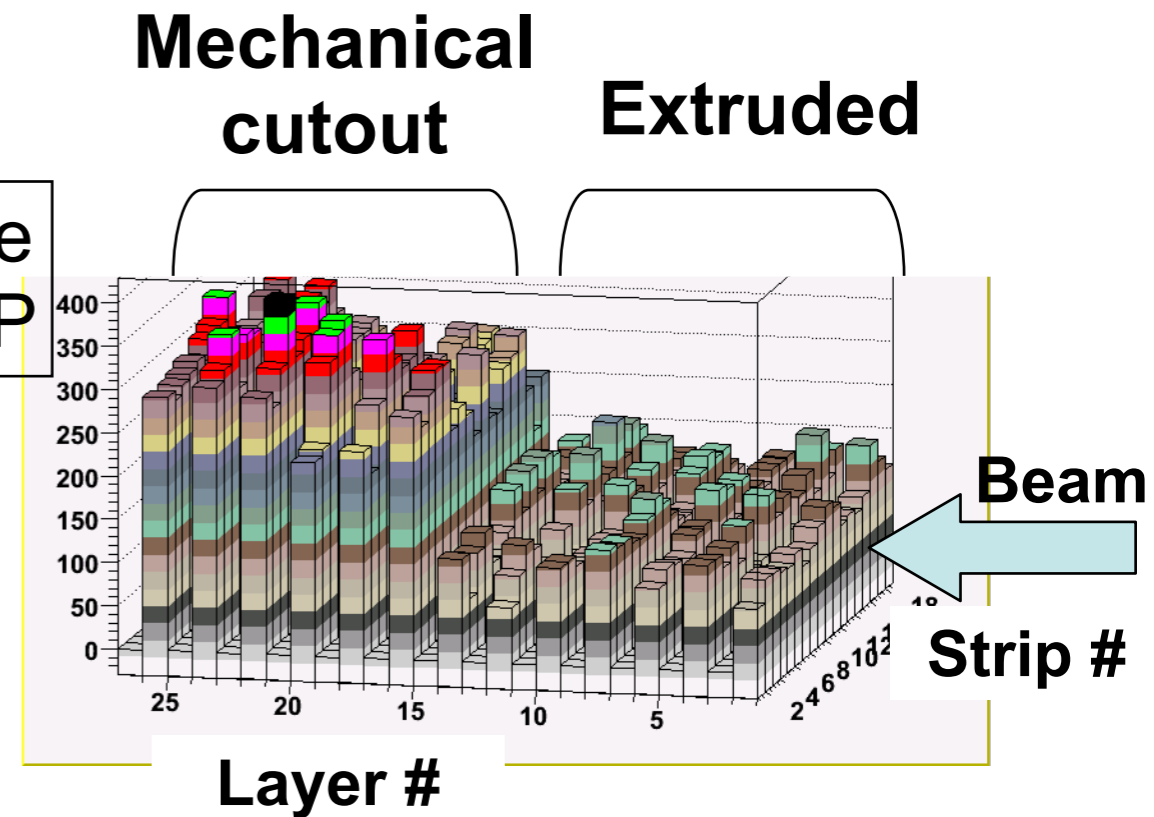


# Ecal Beam Test at DESY...

## Extruded scintillator strips

- The light yield is low.
- Light yield of MPPC side is good.
- Non-uniformity

Response for MIP

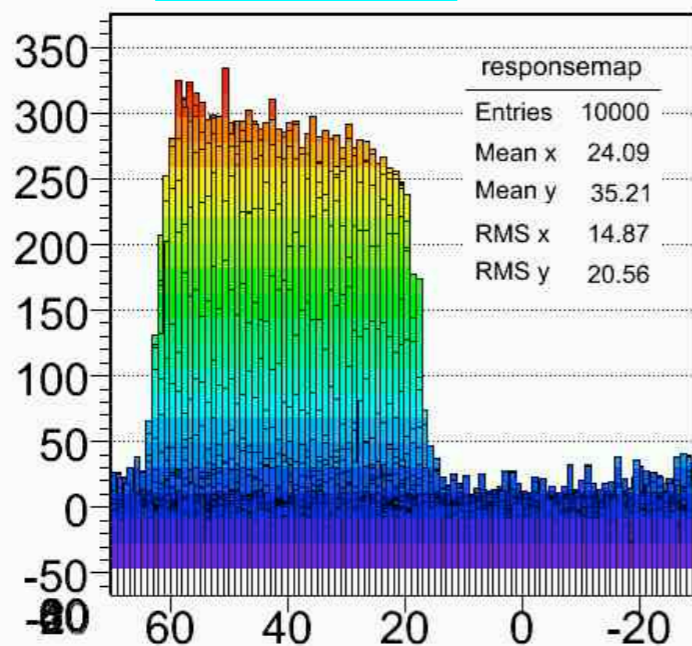


Uniformity of 2 different types of scintillators

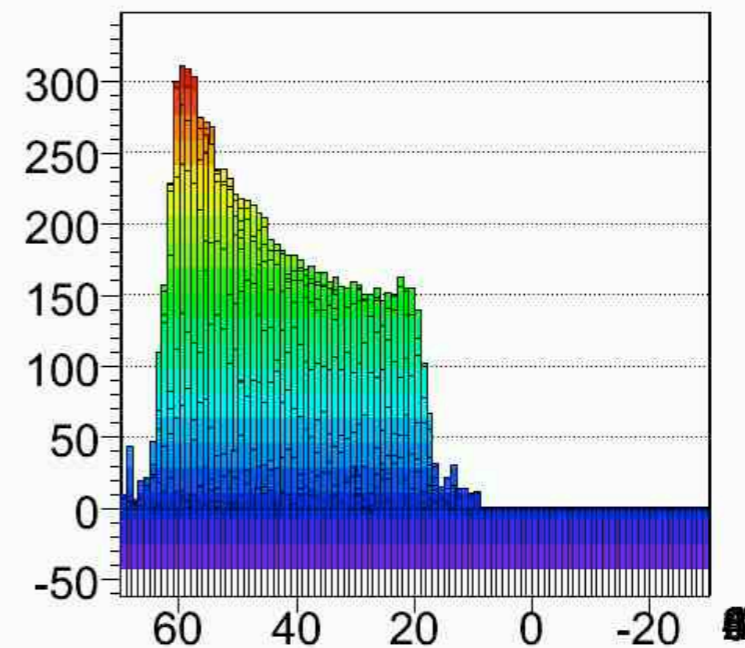
Extruded

Signal (ADC counts)

Mechanical cutout



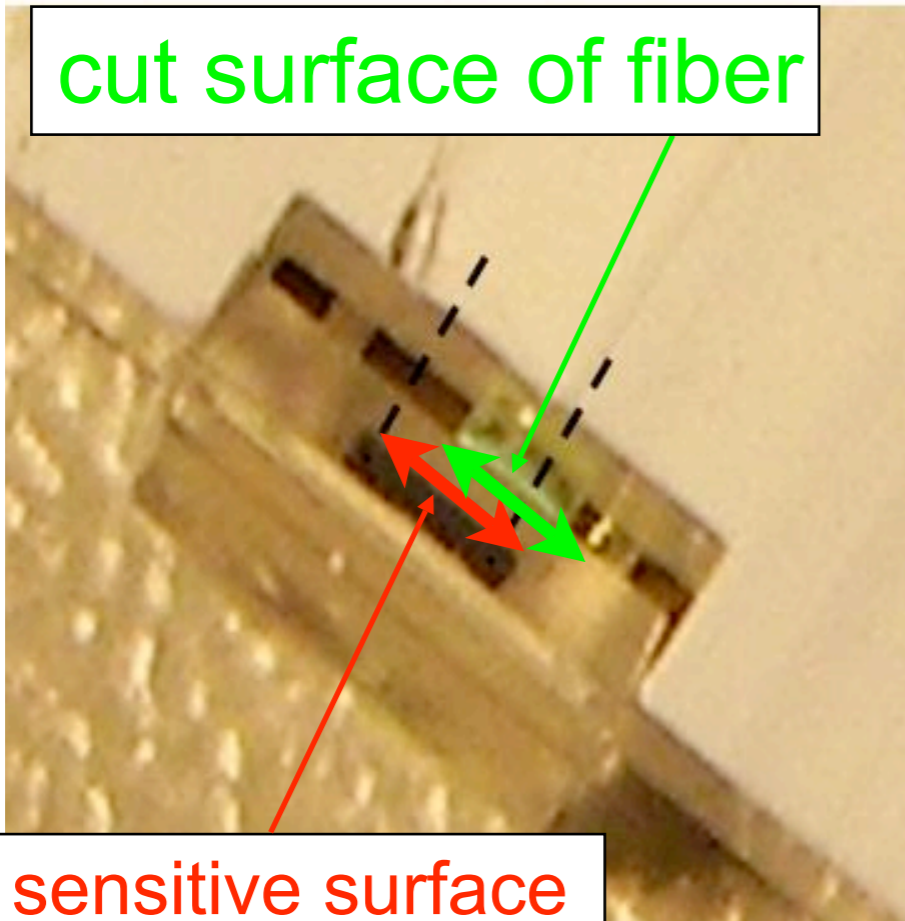
Beam position (mm)



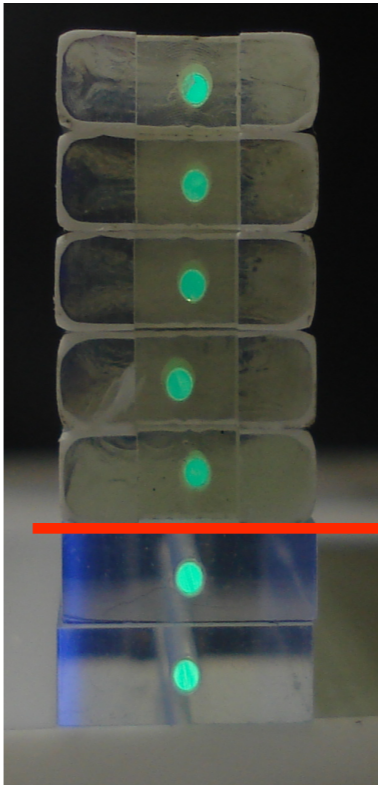
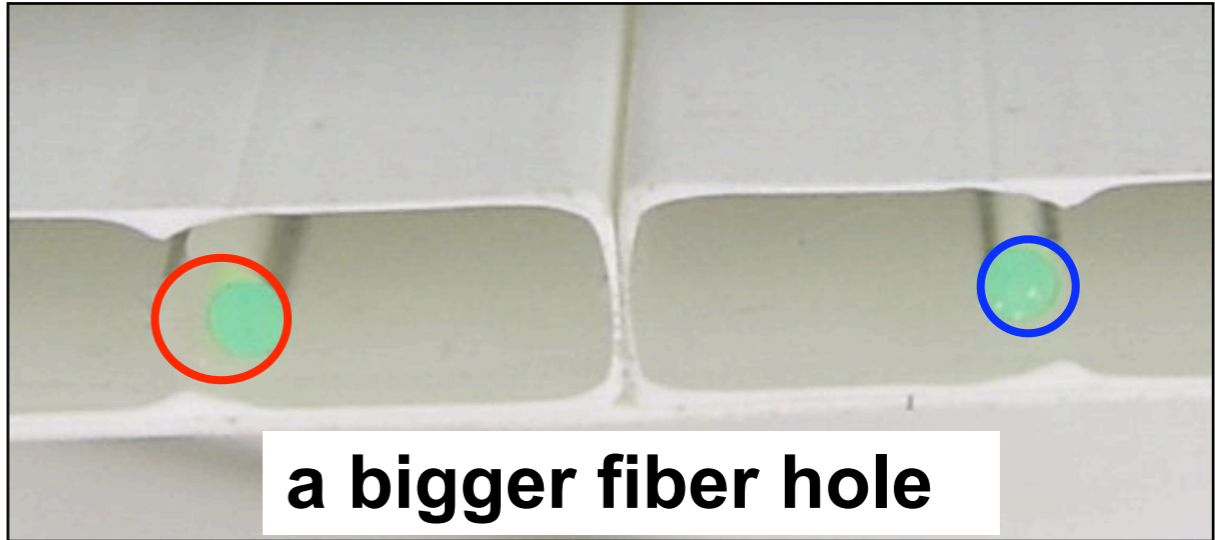
# serious but trivial reason of these result

## MPPC-fiber mismatching

cut surface of fiber



The sensitive surface of MPPC



Extruded

Mechanical cutout



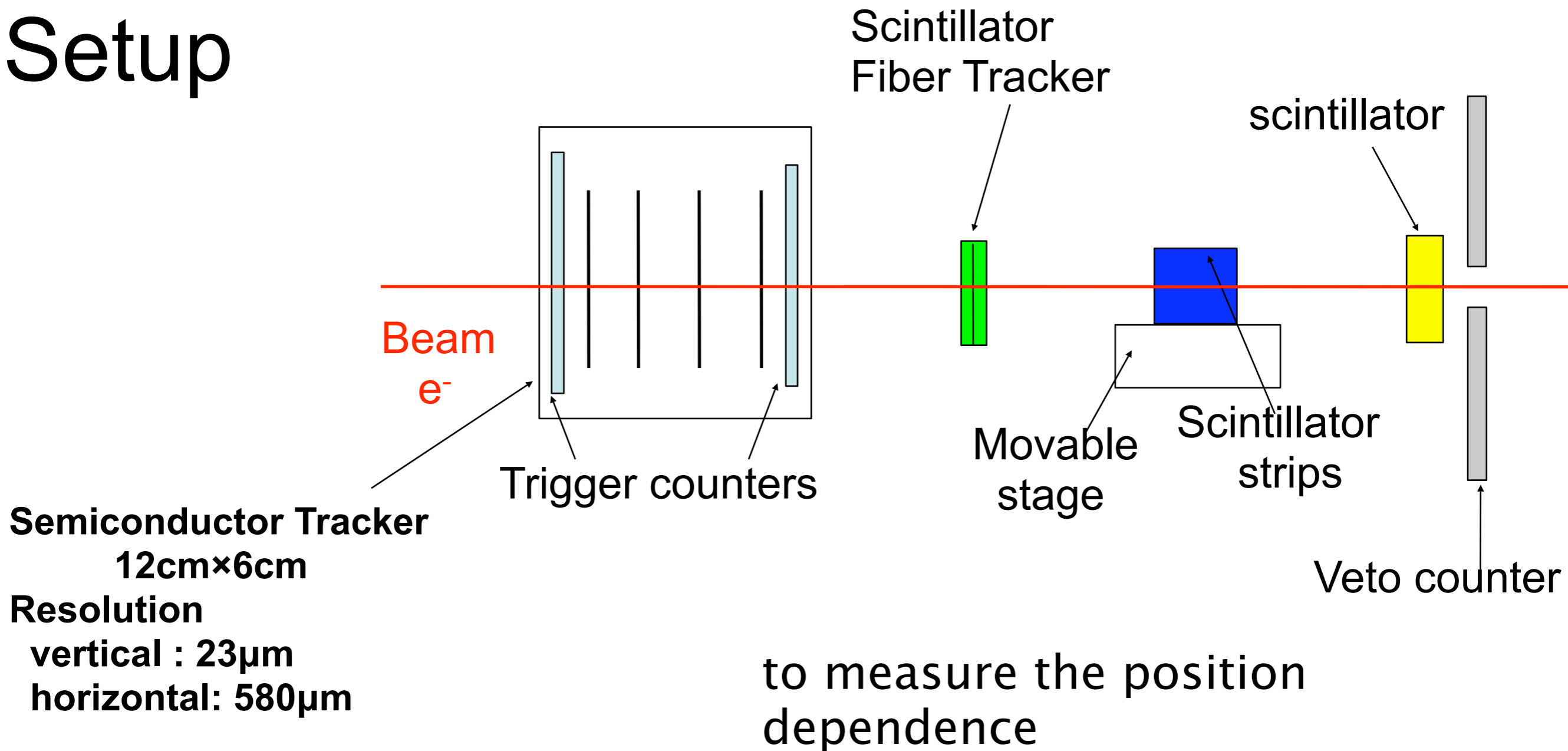
# Tested Strip Scintillator at KEK

Type	Scintillator	reflector	fiber-MPPC matching
A	extruded	Painted TiO <sub>2</sub>	good
B1		film reflector K	good
B2			bad
reference	mechanical cutout	film reflector M	good

film reflector K: Kimoto co., 86% of reflector M  
film reflector M: 3M co., radiant film

- Electron beam
- Beam spot size:  $\sim 3\text{cm} \times 4\text{cm}$
- Beam energy : 3 GeV
- Rate: 15Hz @ 3 GeV

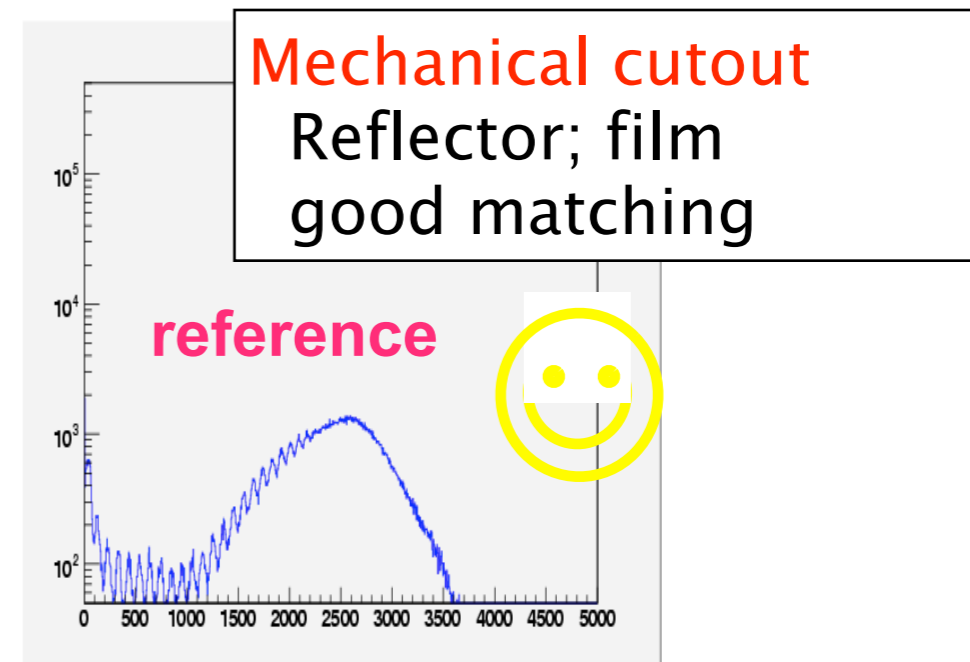
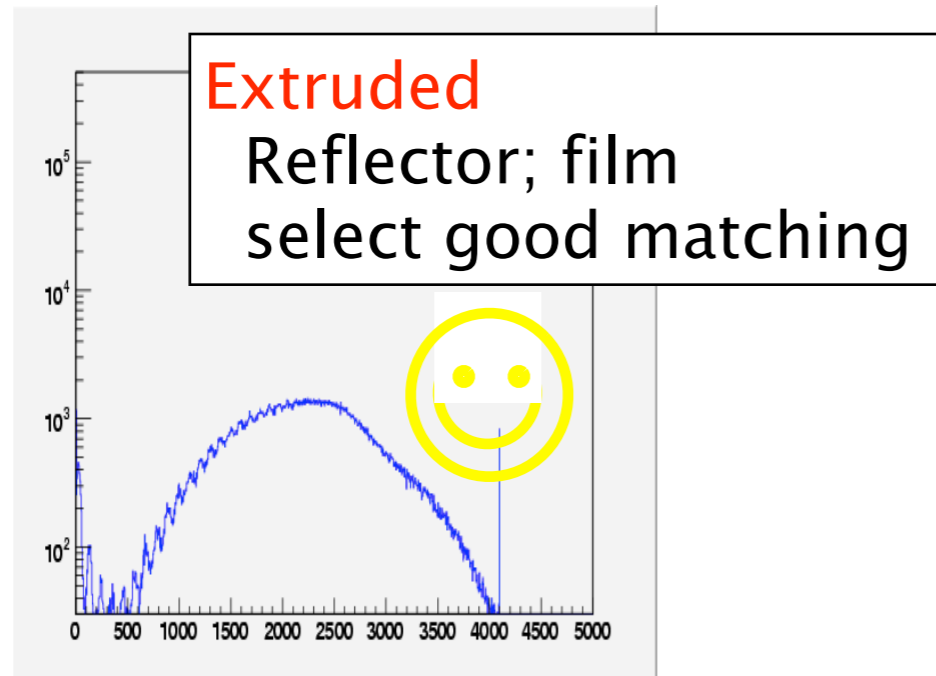
# Setup



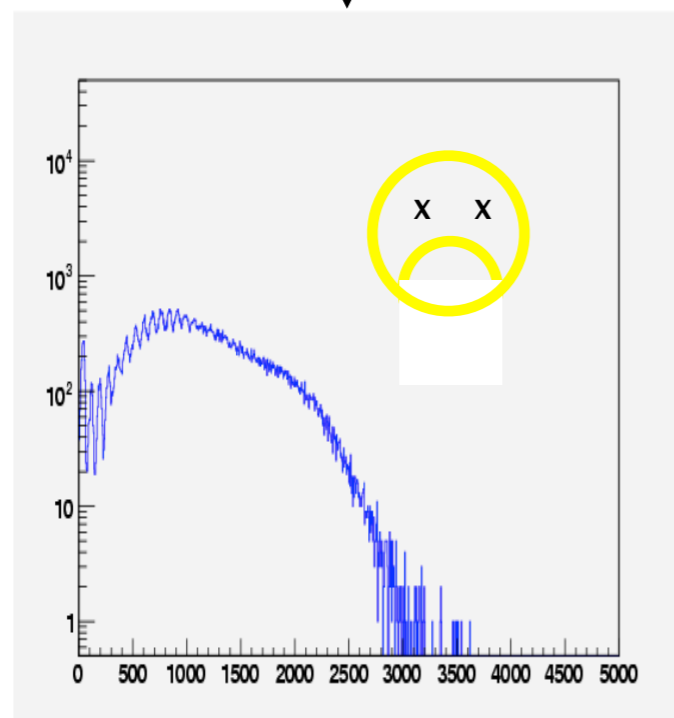
# Response for MIP

## MIP events

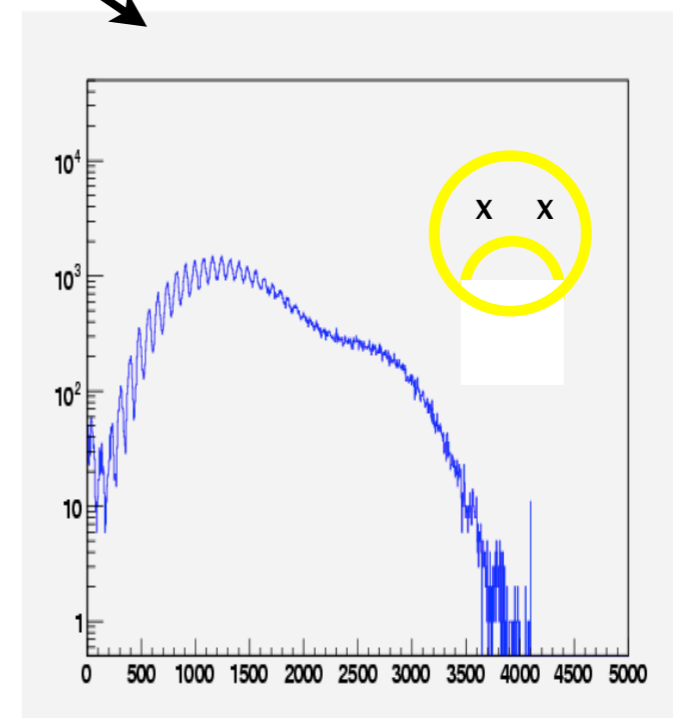
Number of events (log scale)



MPPC-fiber;  
→ mismatching



reflector;  
film → TiO<sub>2</sub> paint

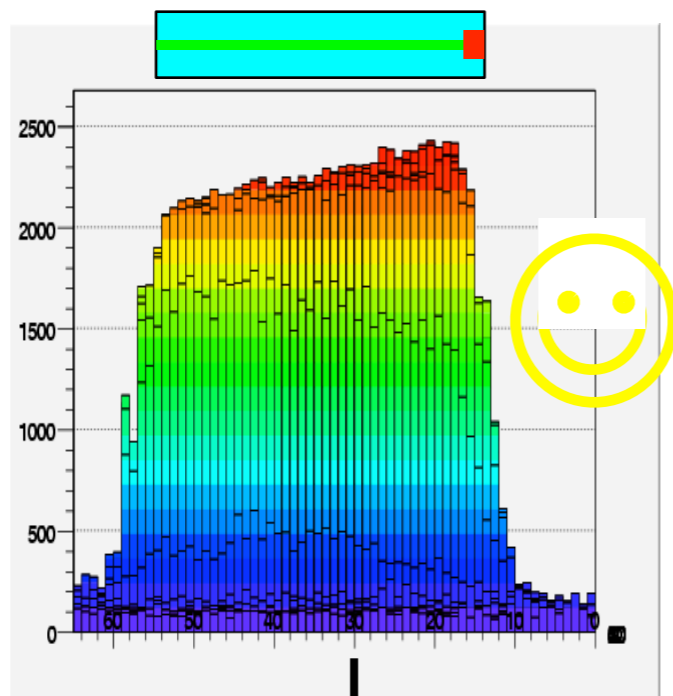


Signal (ADC counts)

# Uniformity by Scintillator beam test @KEK

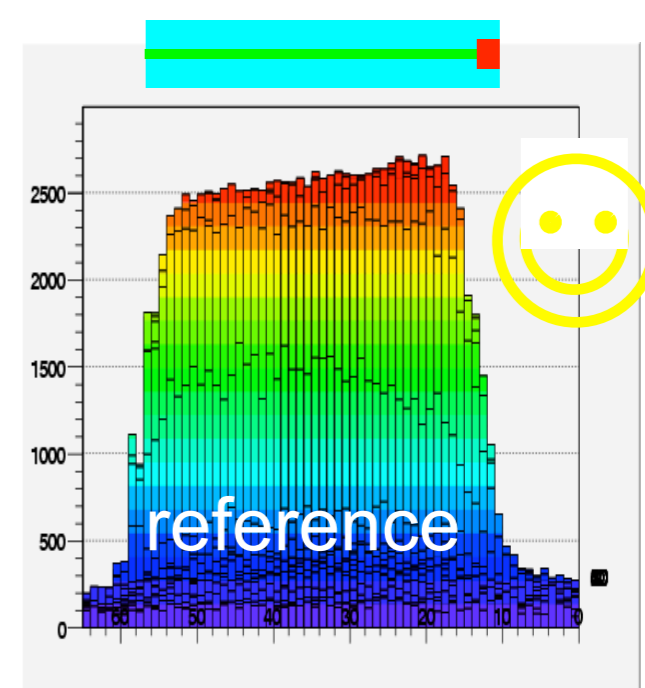
Extruded

Reflector; film  
select good matching

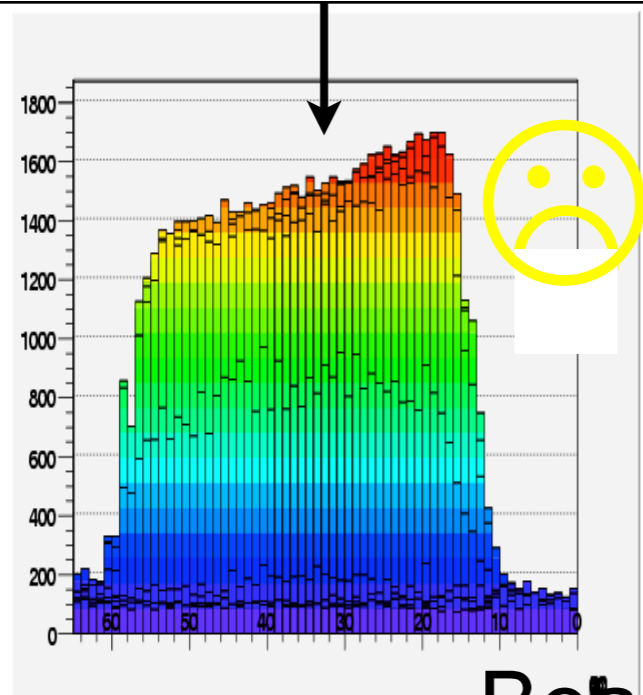


Mechanical cutout

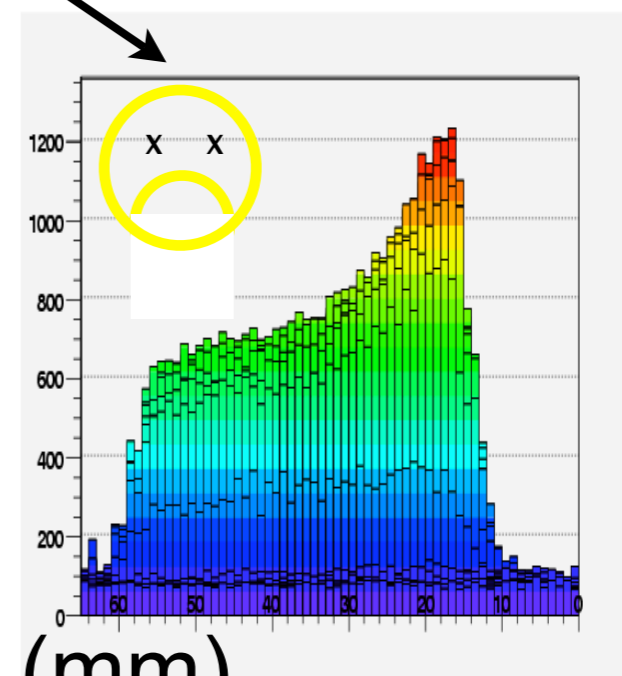
Reflector; film  
good matching



MPPC-fiber mismatching



film  $\rightarrow$  TiO<sub>2</sub> paint



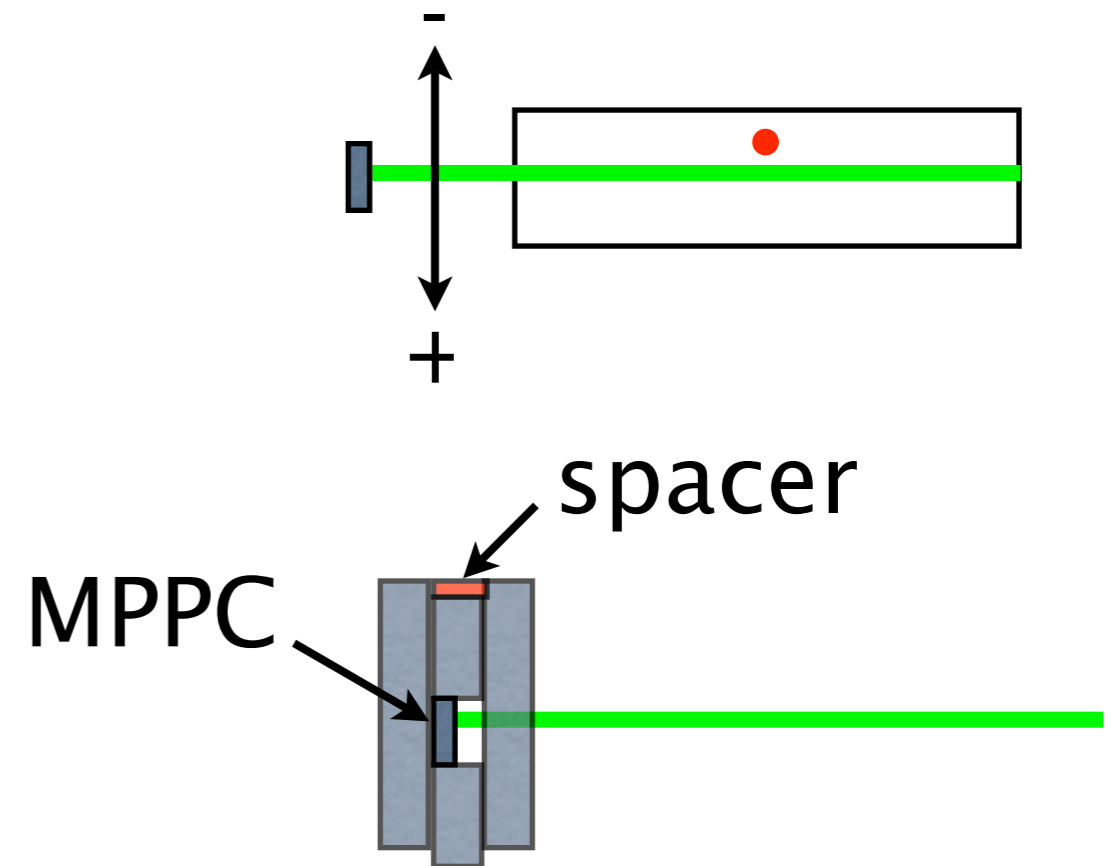
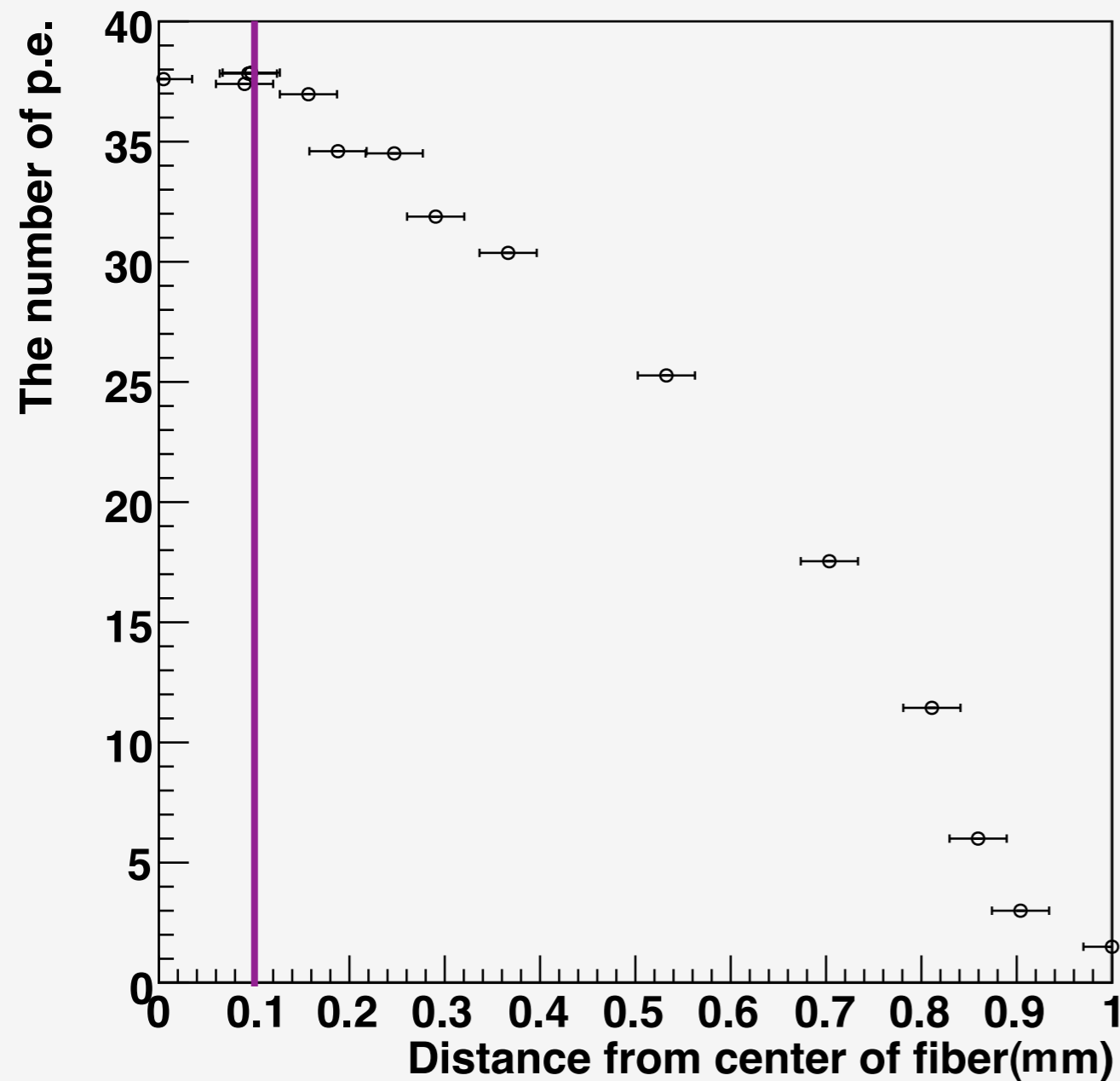
Signal (ADC counts)

Beam position (mm)



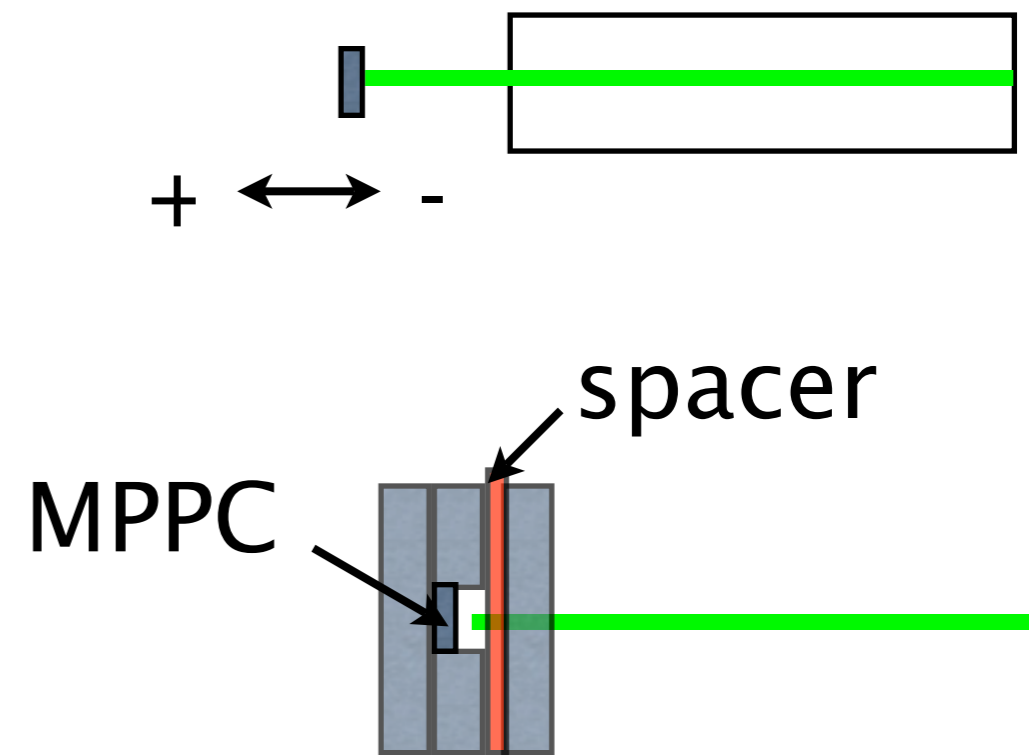
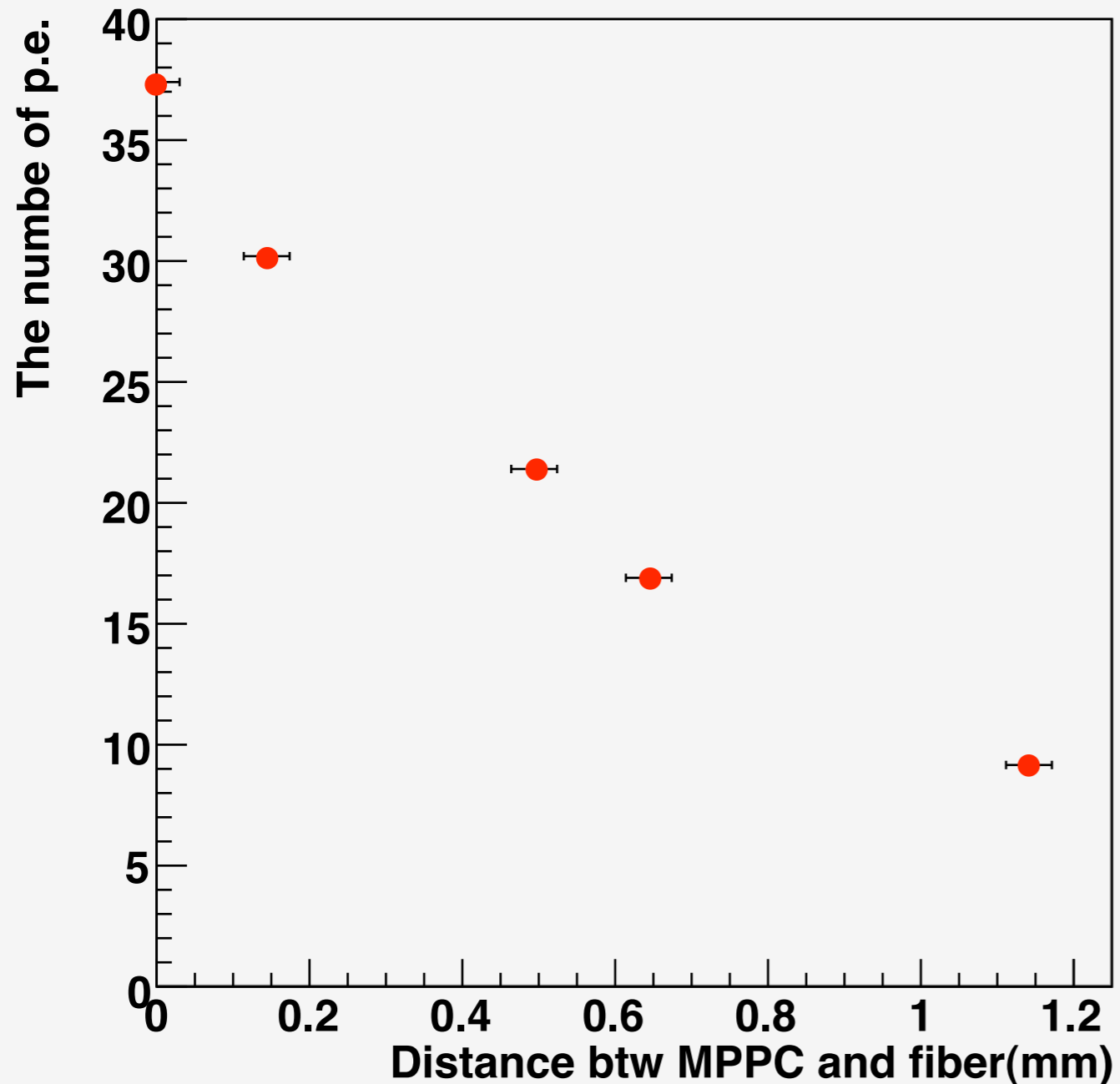
How much is MPPC-fiber mismatch allowed?

# dependance on MPPC - Fiber position /crosswise direction



within 100 $\mu$ m, # of p.e.  
does not decrease.

# dependance on MPPC - Fiber position /lengthwise direction



The number of p.e. absolutely depends on the distance between MPPC and cut surface of fiber

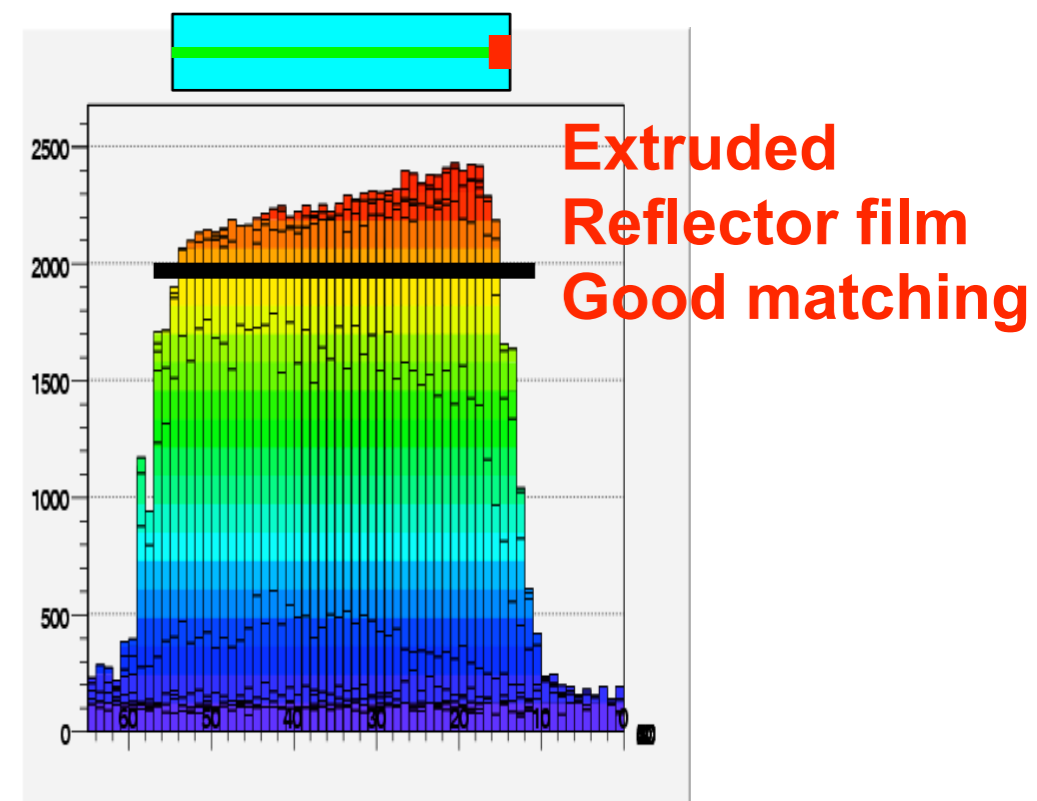
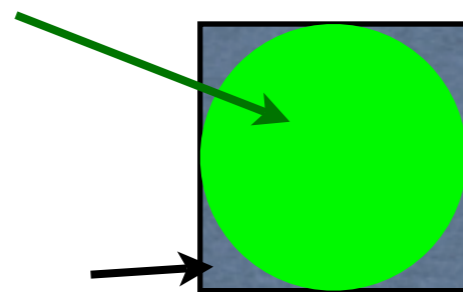
## Results from KEK beam test

- Position mismatching between MPPC and Fiber is allowed within  $100\mu\text{m}$ .
- with good matching between MPPC and Fiber and using film reflector, extruded scintillator works well.
- Why does non-uniformity still remain even with fiber readout?

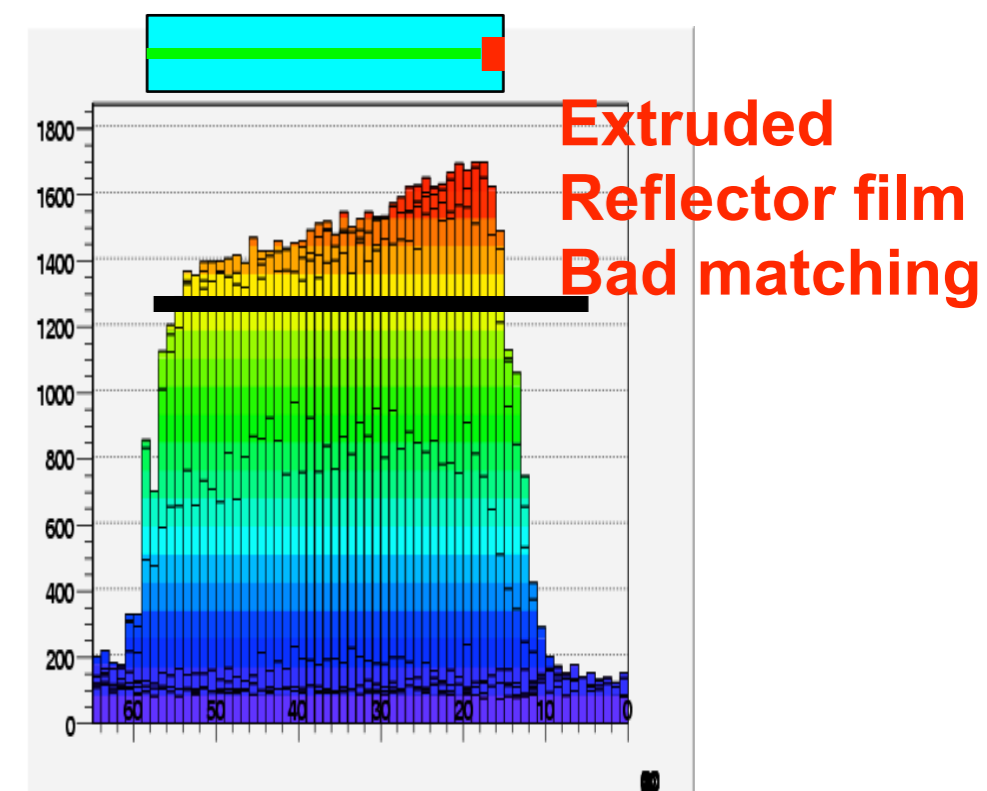
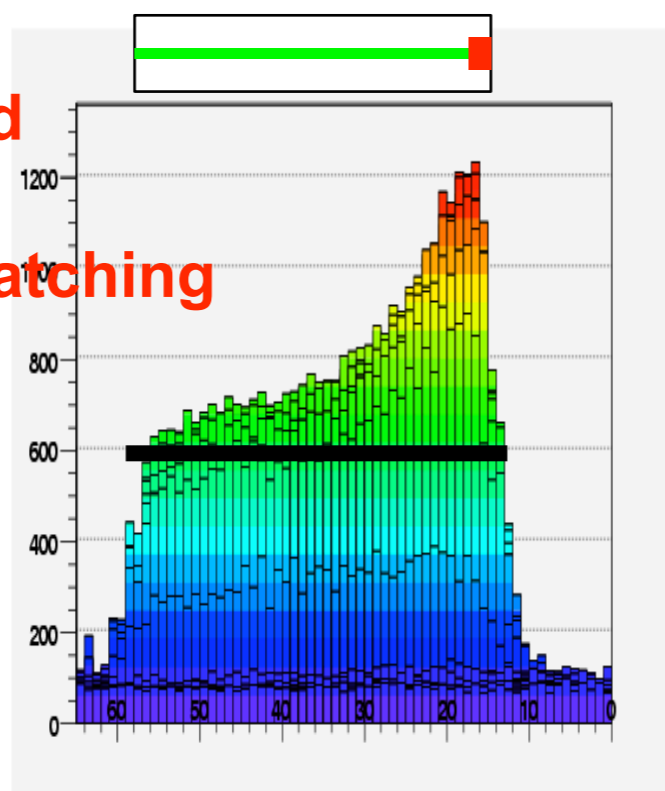
# An assumption for cause of non-uniformity

Fiber  
cut surface

25% of MPPC  
sensitive area



Extruded  
 $\text{TiO}_2$   
Good matching

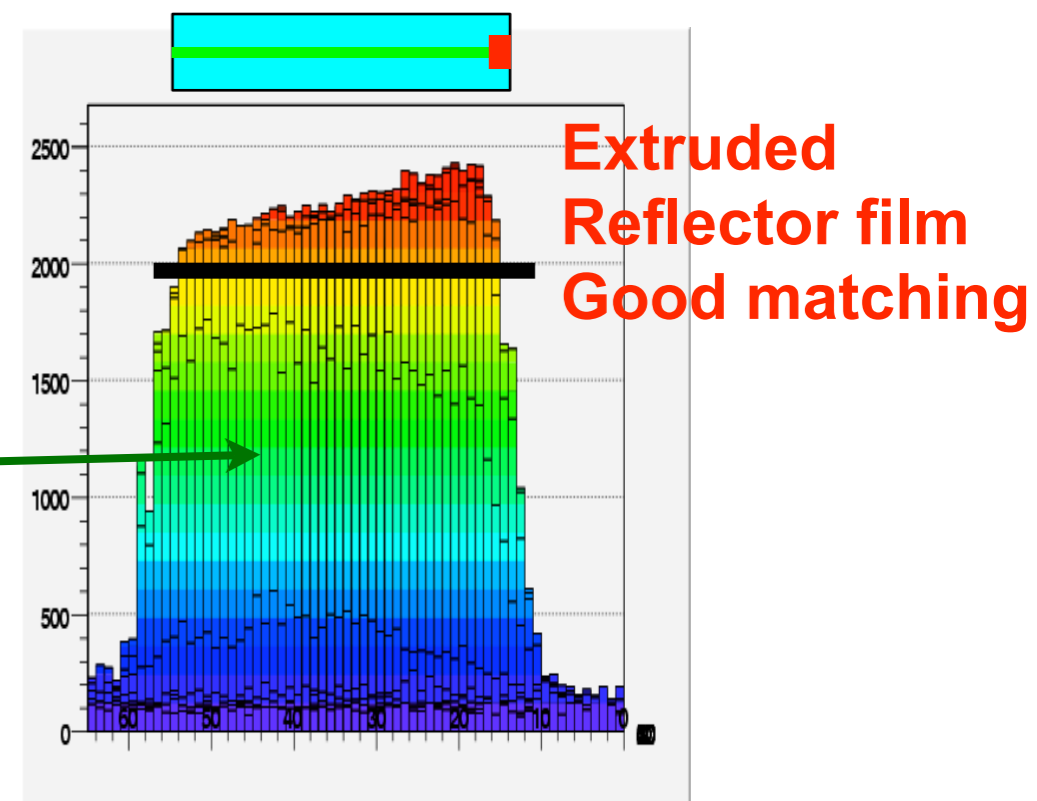
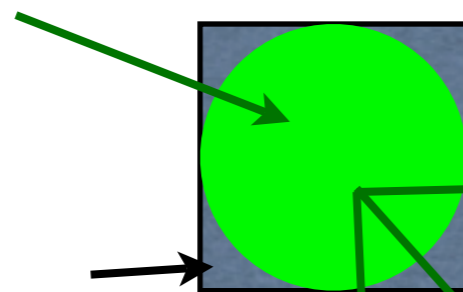


Beam position

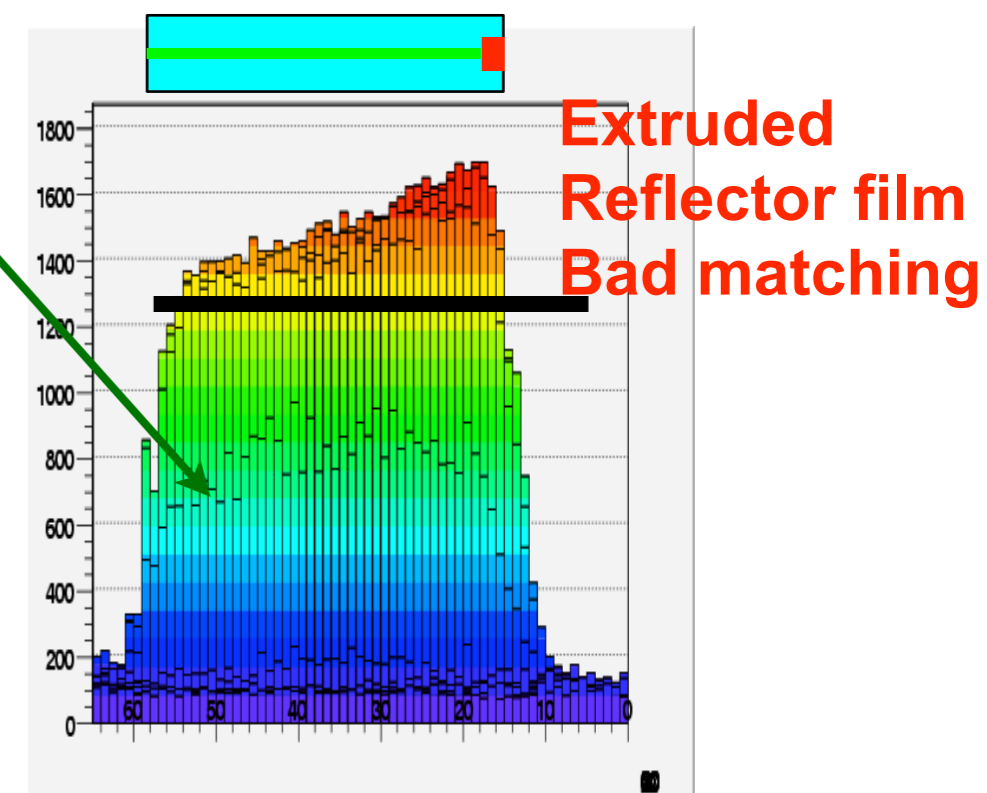
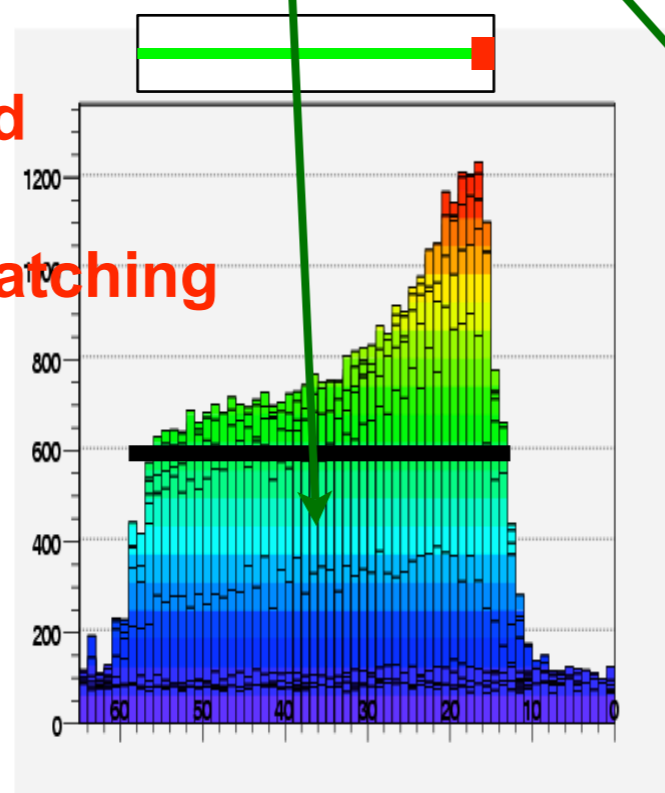
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Extruded  
 $\text{TiO}_2$   
Good matching

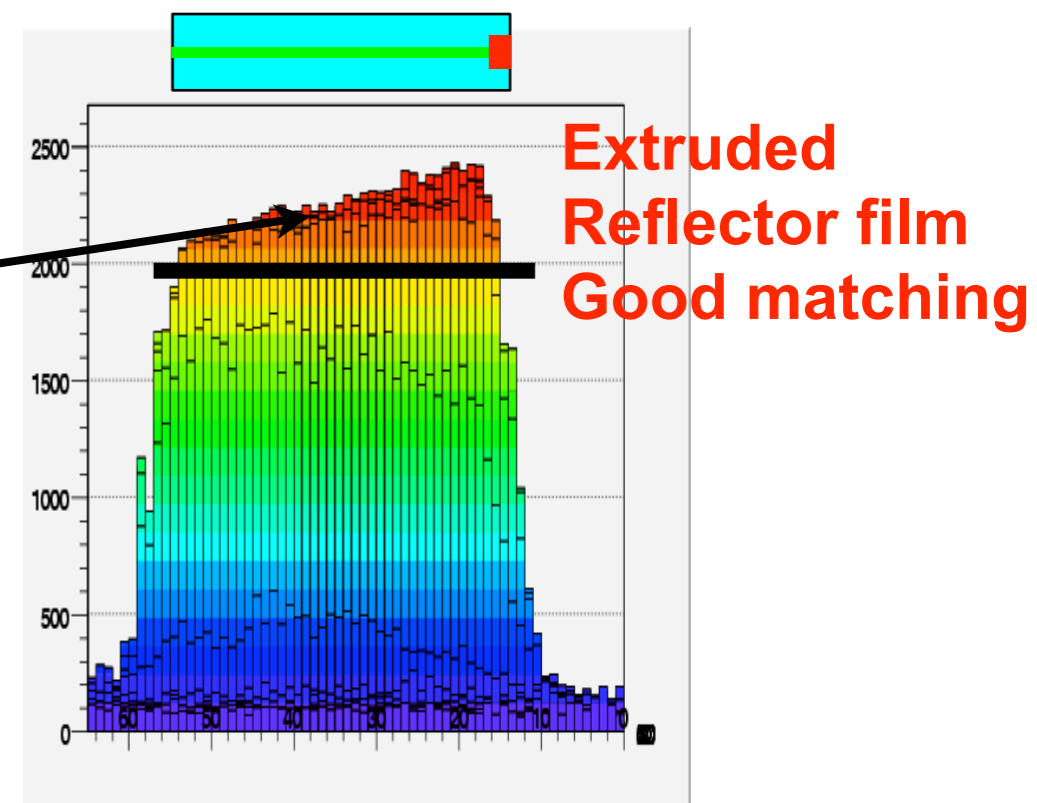
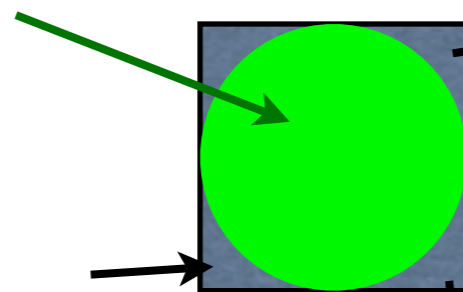


Beam position

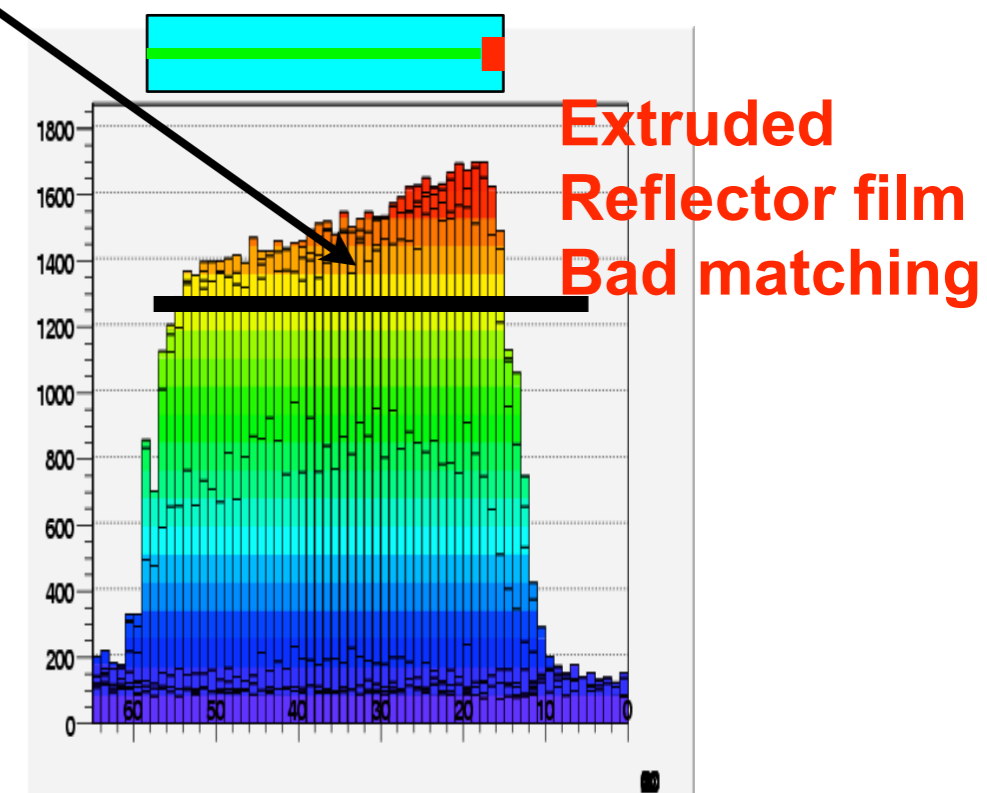
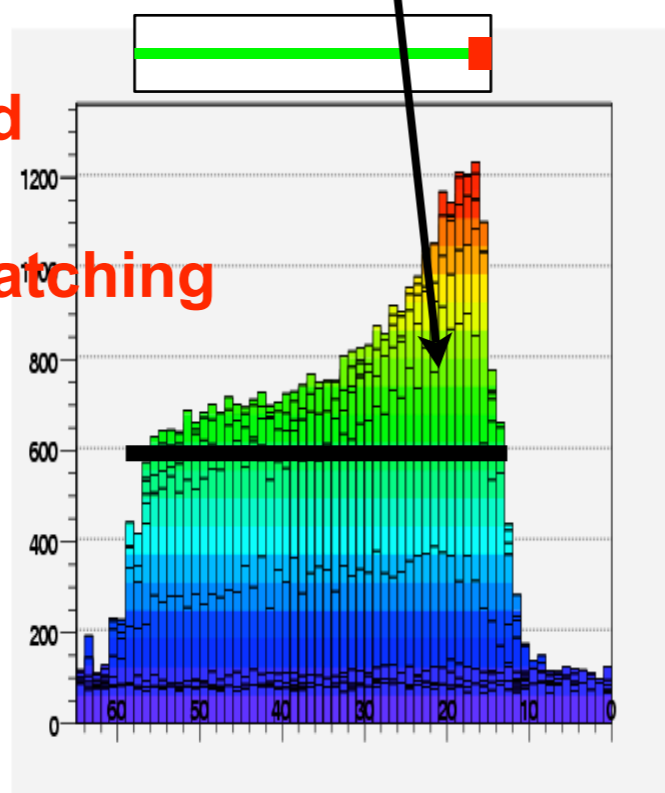
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Fiber  
cut surface

25% of MPPC  
sensitive area

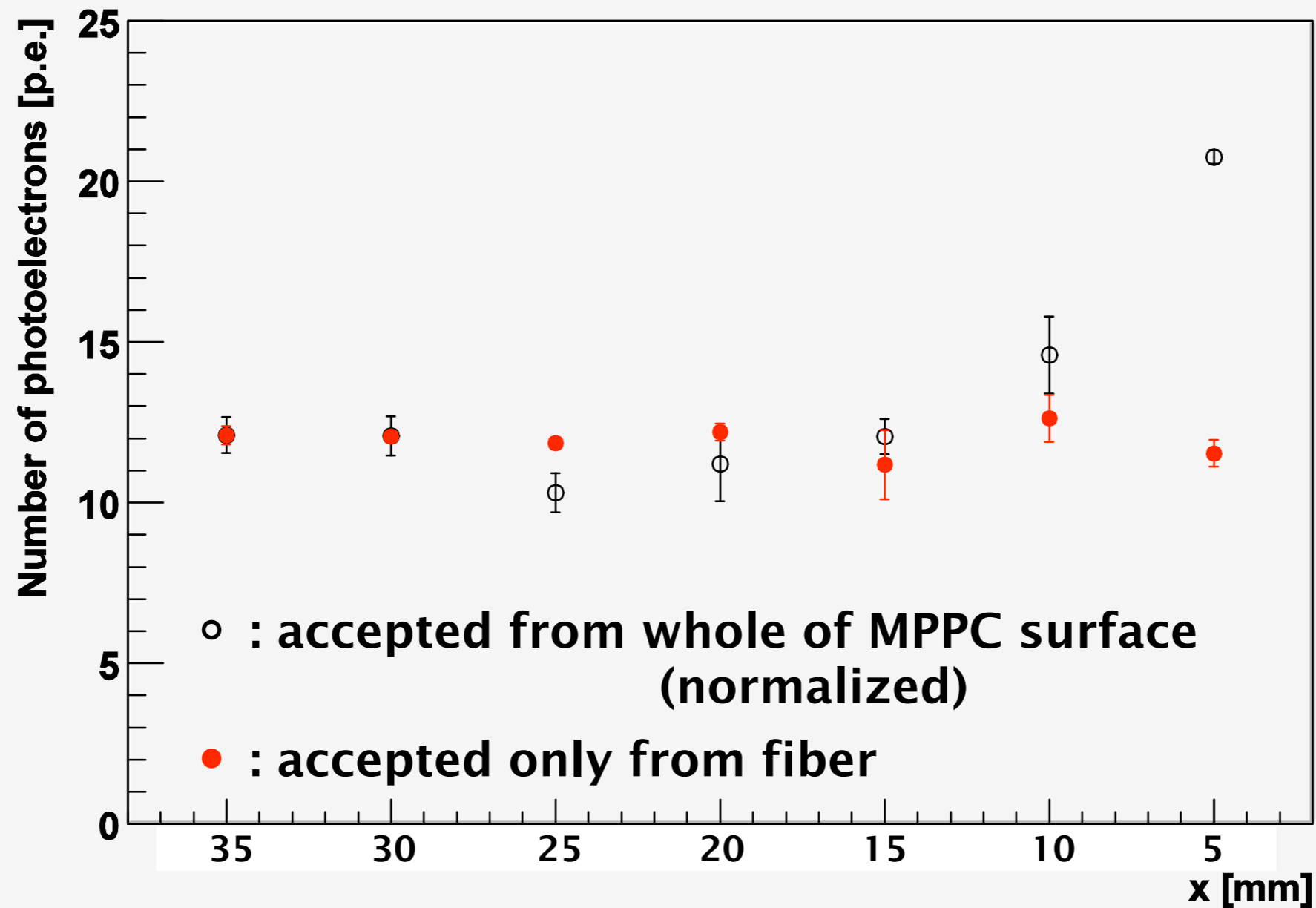
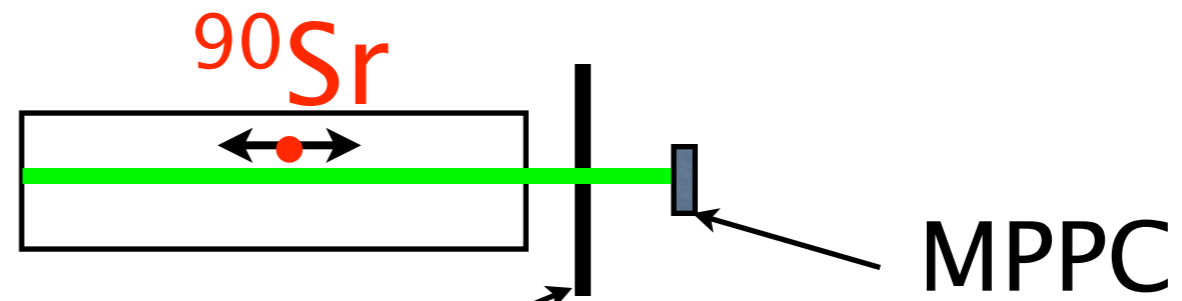


Extruded  
 $\text{TiO}_2$   
Good matching



Beam position

# ☺ Uniformity was established by a bench test





# Summary

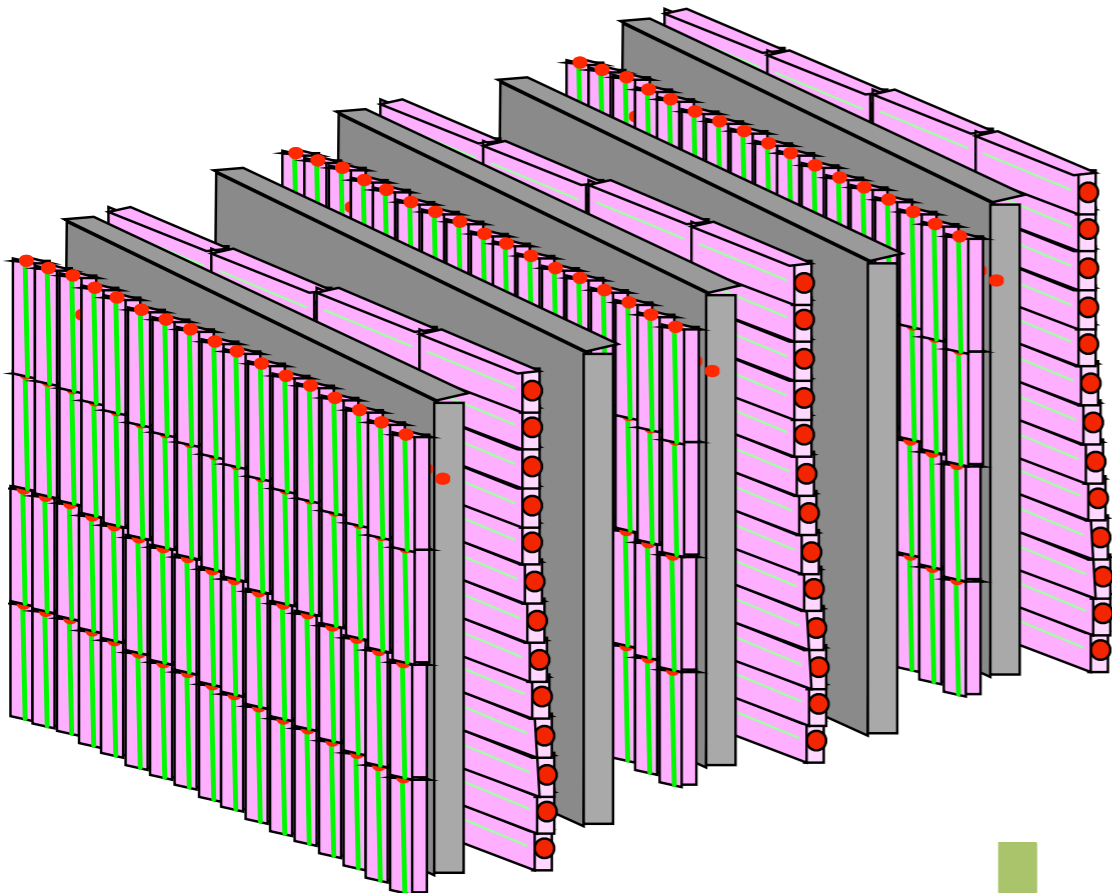
- Extruded scintillator work as well as mechanical cutout scintillator.
- From a bench test, uniformity of strip scintillator is expected by avoiding photons come from scintillator directly.

# Plan

- 72 extruded strip scintillator/ plane x 30 layer prototype E-cal beam test at Fermilab. the scintillators are:
  - provided with precise hole size and position,
  - enveloped by film reflector,
  - and attached a collar to avoid direct photon.

# The Scintillator–ECAL Beam Test

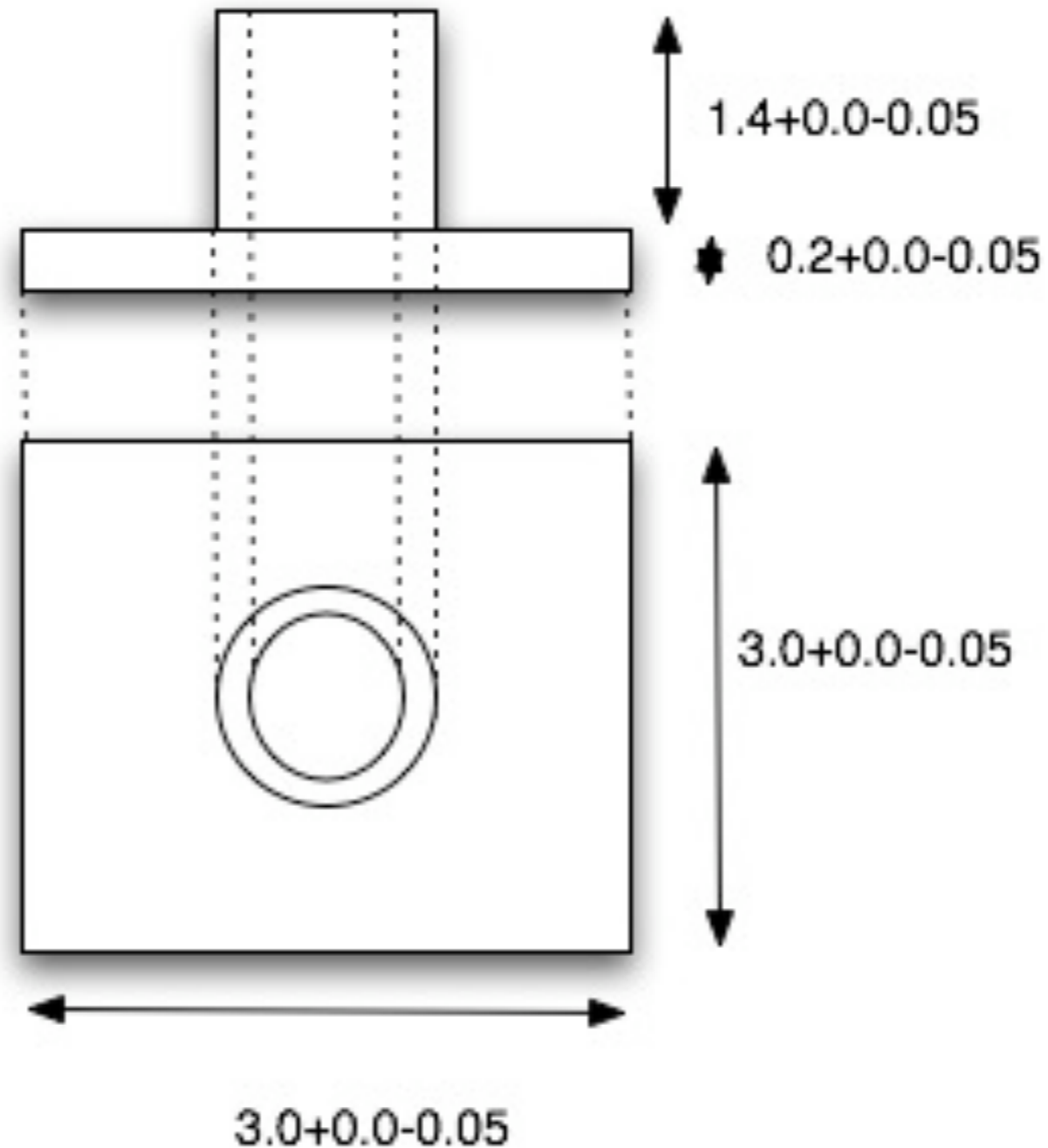
- Establish the Scintillator–strip ECAL technology
  - Test linearity of the ScECAL with high energy beam.
  - Evaluate all the necessary performances using various beams ( $\pi, K, e, \mu, \dots$ ) with wider energy range
- Combined test with the Analog HCAL
- Test  $\pi^0 \rightarrow 2\gamma$  reconstruction (simulation study necessary beforehand)
- Measure hadron shower to test simulation model



- The 2<sup>nd</sup> prototype will be 4 times larger than the DESY BT module.  
(20 x 20 cm, 30 layers)
- Fully adopt the extruded scintillators.
- 2160 readout channels.

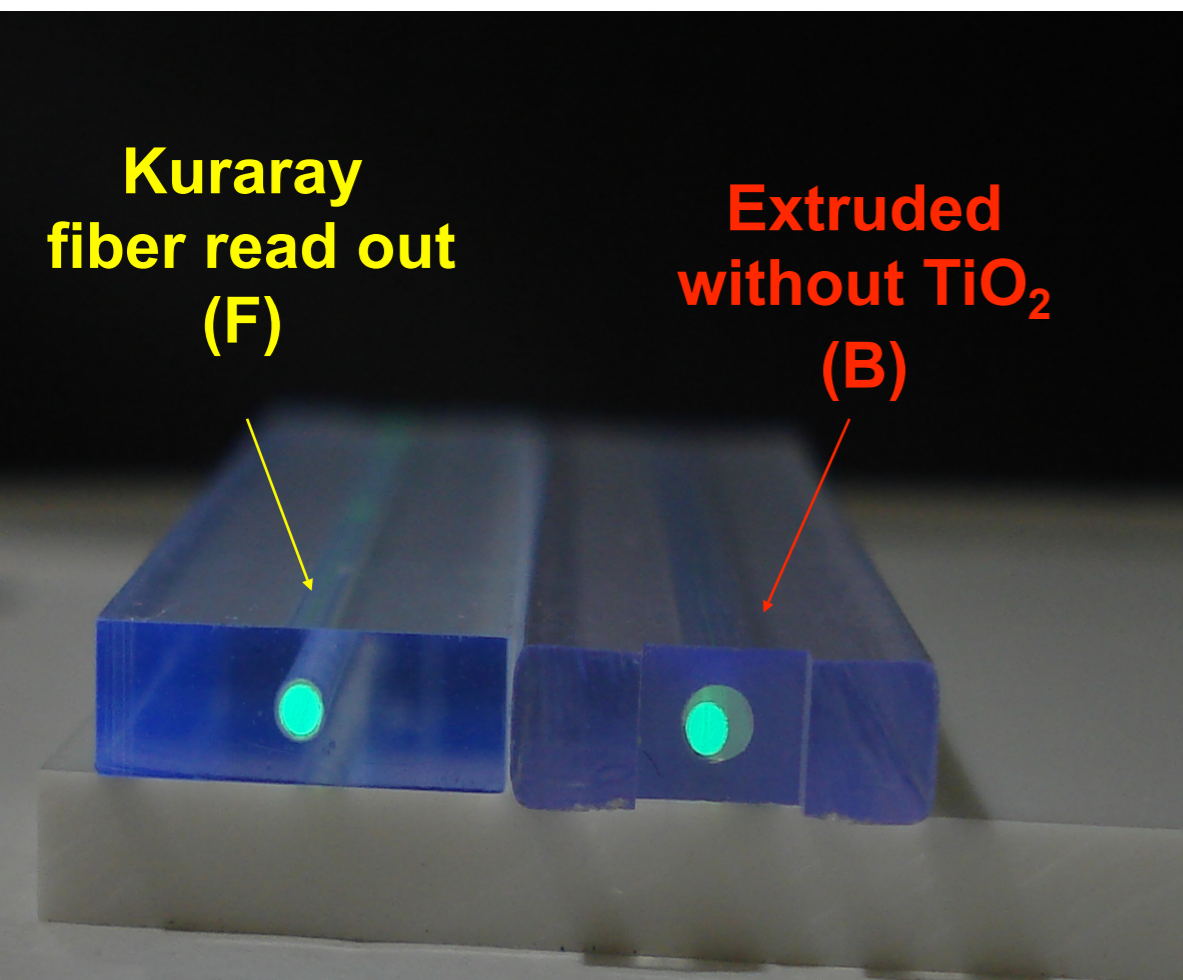
Back up

# an idea to fix MPPC-fiber position relation

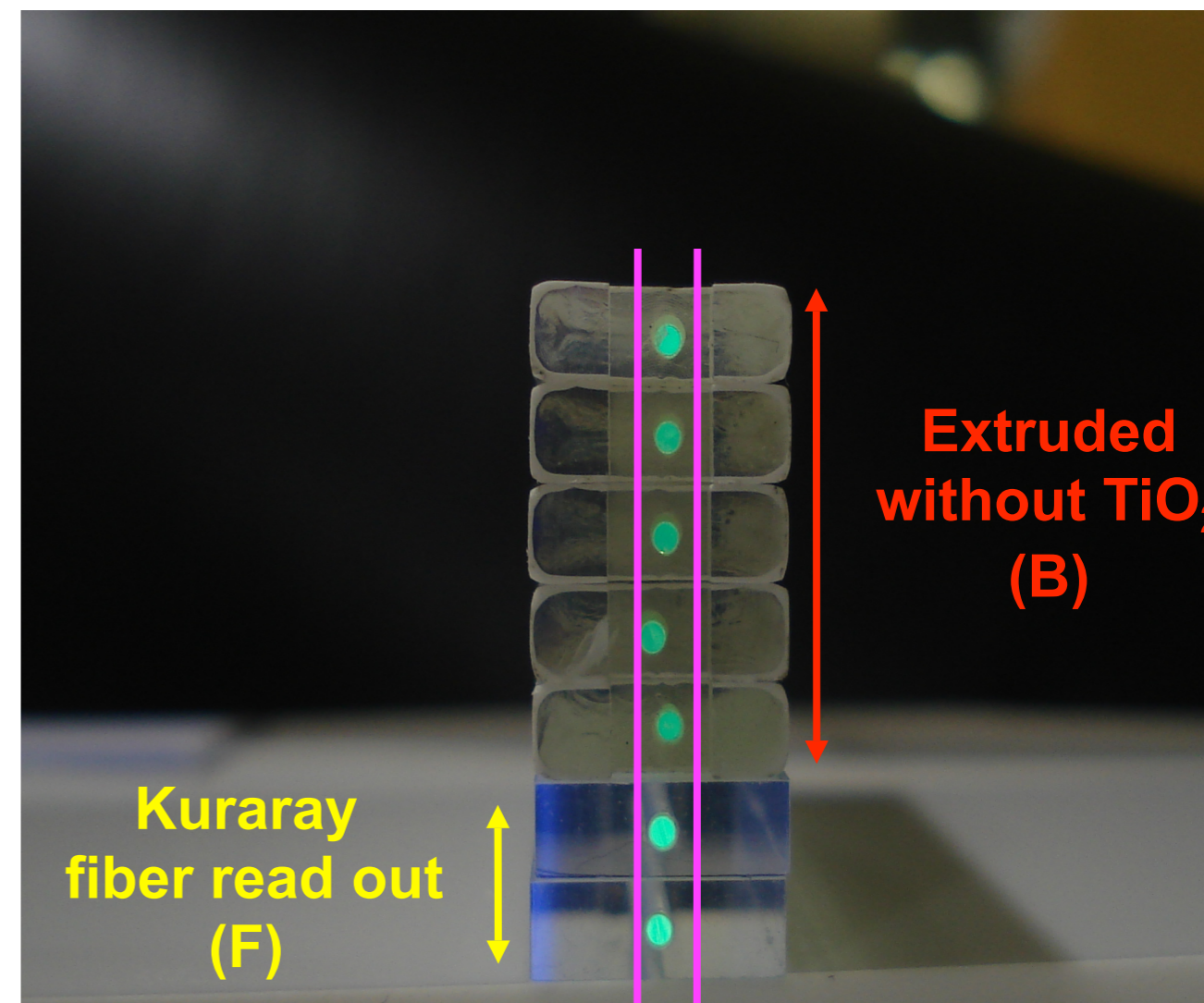


# Comparison between Kuraray and extruded scintillator strips

Extruded scintillators have some problems.



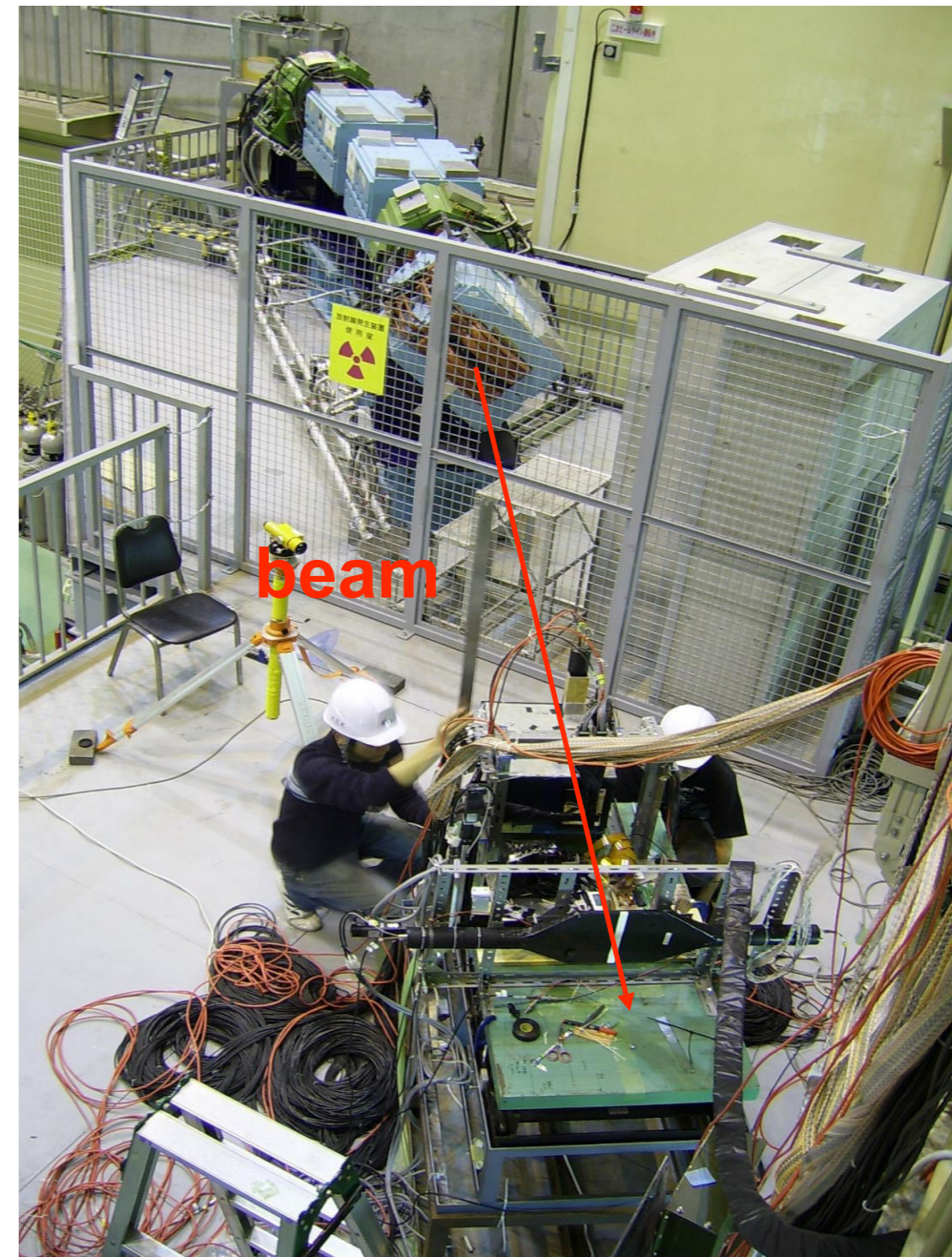
**Some extruded scintillators have a bigger hole.**



**Sometimes the hole is not correctly centered.**

# KEK Fuji beam line

- Electron beam
- This beam is made from bremsstrahlung photons from KEKB ring
- Beam spot size:  $\sim 3\text{cm} \times 4\text{ cm}$
- Beam energy : 3 GeV
- Rate: 15Hz @ 3 GeV



# Extruded scintillator strip with a fiber hole (A,B)

Type : A

covered with TiO<sub>2</sub>

A1 : fiber - MPPC bad matching

A2 : fiber - MPPC good matching

Type : B

covered with KIMOTO reflector film

B1 : bigger hole

B2 : matched hole

