Beam test of scintillator strips

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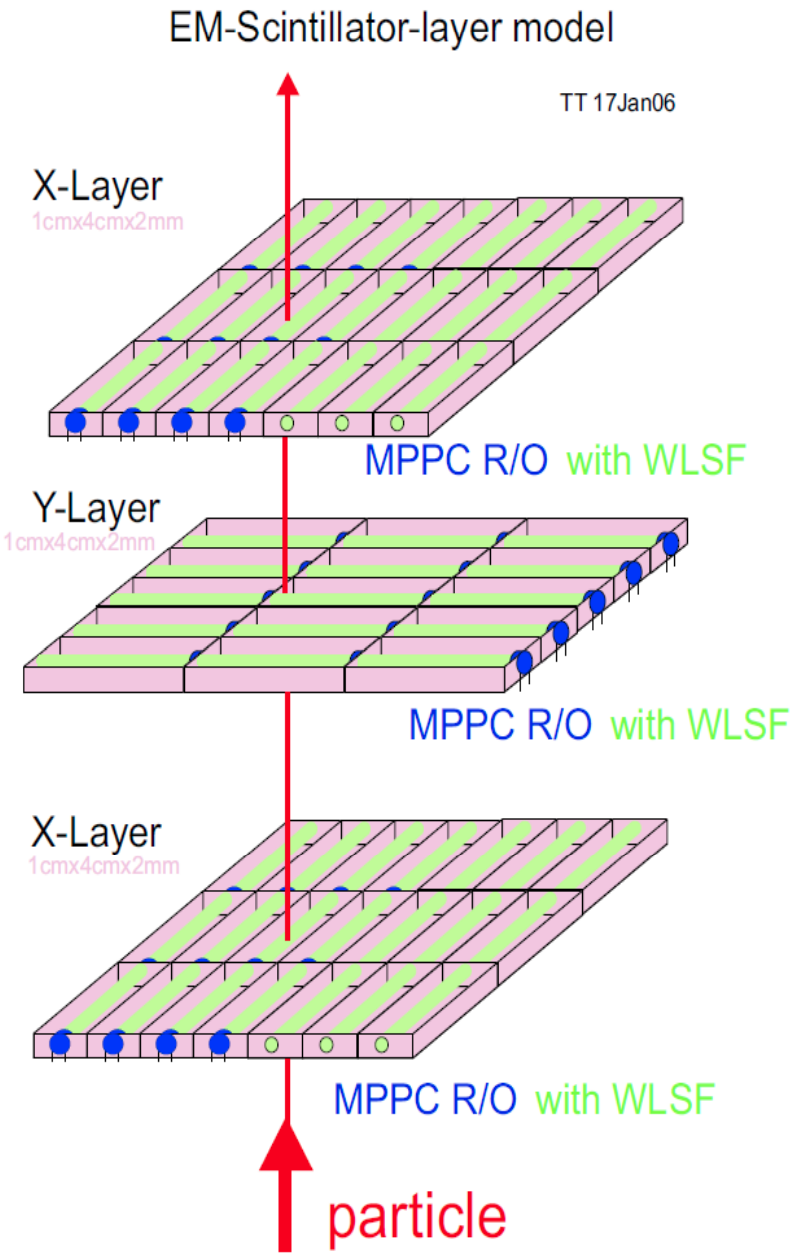
- scintillator strip calorimeter
- Kuraray scintillator strips and KNU extruded
- the result of DESY beam test
- KEK beam test
- conclusion and plan

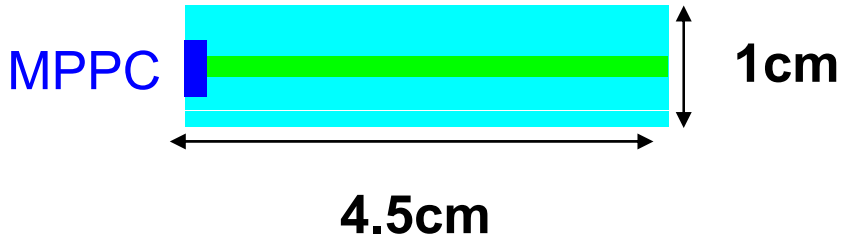
Scintillator strip calorimeter



- sampling calorimeter （33layers）
  scintillator strip＋W (absorber)

- PFA → scintillator fine segmented
  → We need 10M scintillator strips.
  → Production cost of the scintillator strips must be cheap.

Scintillator strip



Comparison of Kuraray scintillator strips and KNU extruded

Kuraray

- Casted and machined
- High accuracy for the hole size and position
- Expensive

KNU Extruded

- Extrusion
- Simultaneously the fiber hole is made and scintillator strips can be covered with TiO_2 at the same time
- Cheap
- Low accuracy for the fiber hole size and position

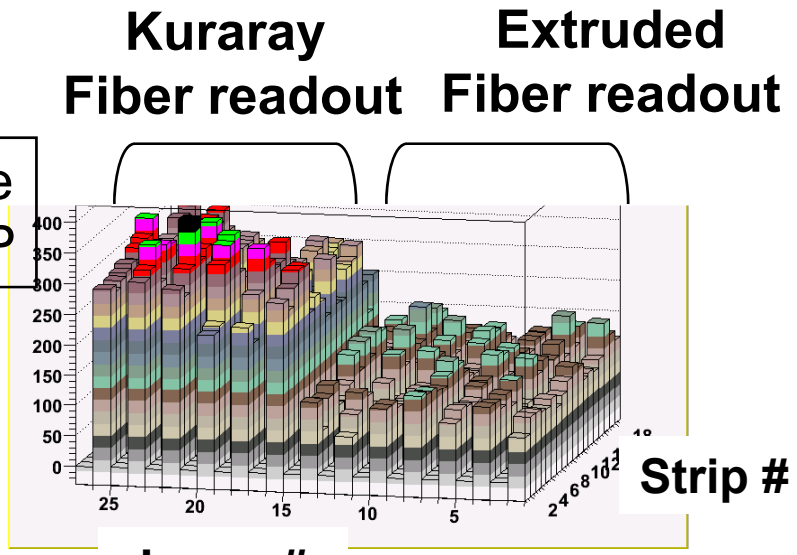
Extruder

These pictures were taken
at Misung Chemical Company,
Korea.

These pictures show the extruder machine.

At the last DESY Beam Test…

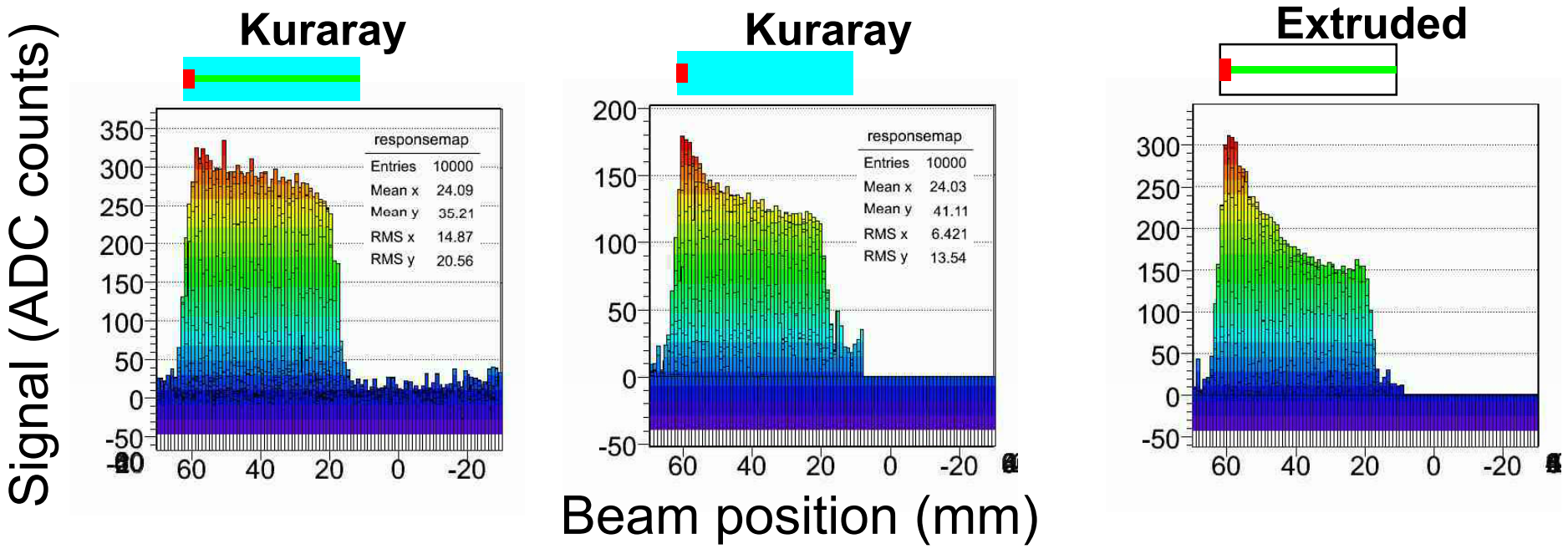
Response for MIP



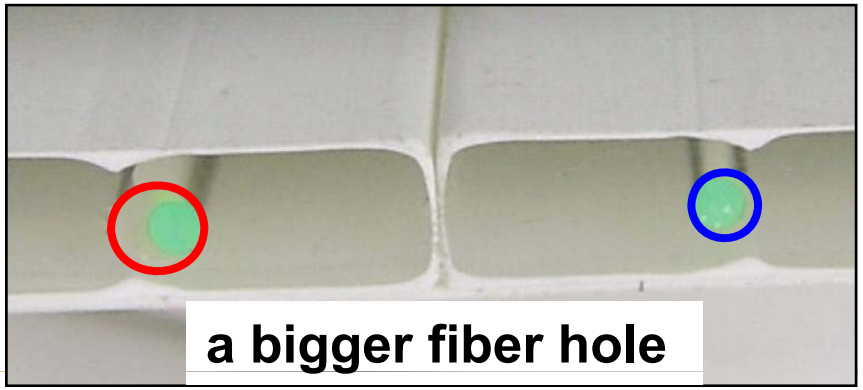
Extruded scintillator strips

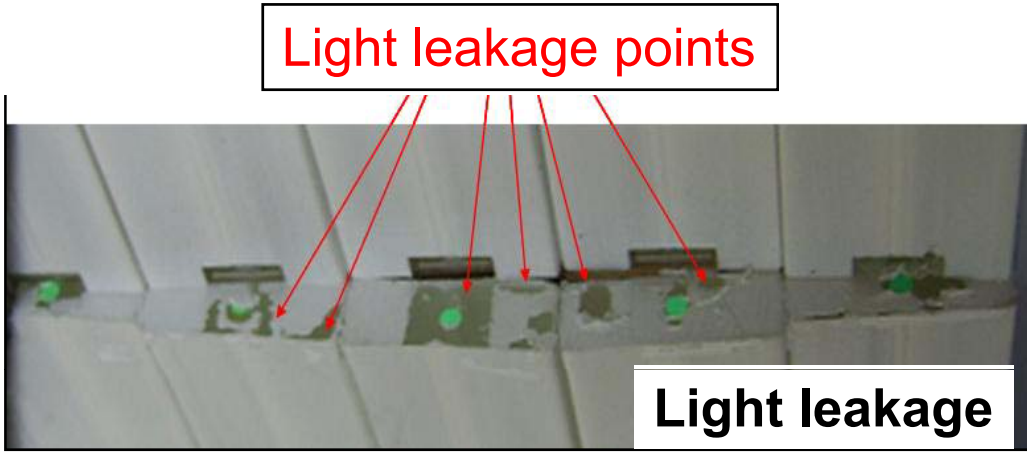
- The light yield is low.
- Light yield of MPPC side is good.
- Uniformity is bad.

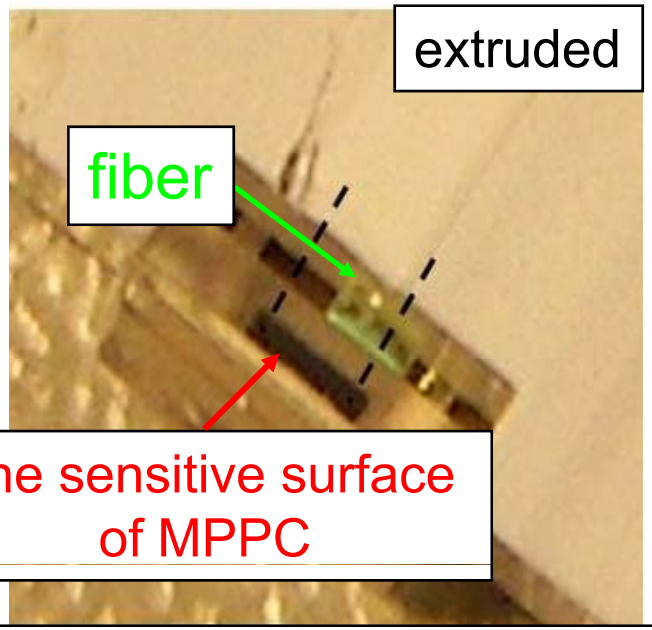
Uniformity of 3 different types of scintillators



Why the extruded scintillator strips showed such low light yield and non-uniformity?







fiber – MPPC bad matching

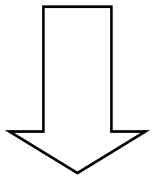
- **Some extruded scintillator strips have a bigger hole.**
- **Sometimes the hole isn't correctly centered.**
- **Some extruded scintillator strips have leakage points.**

The objectives of KEK beam test

- We need extruded scintillator strips because their cost of manufacturing is much cheaper than that of Kuraray.
- From the result of DESY beam test, extruded scintillator strips have good light yield of MPPC side.
- Extruded scintillator strips have some problems.

  the position of fiber and MPPC, the size of hole

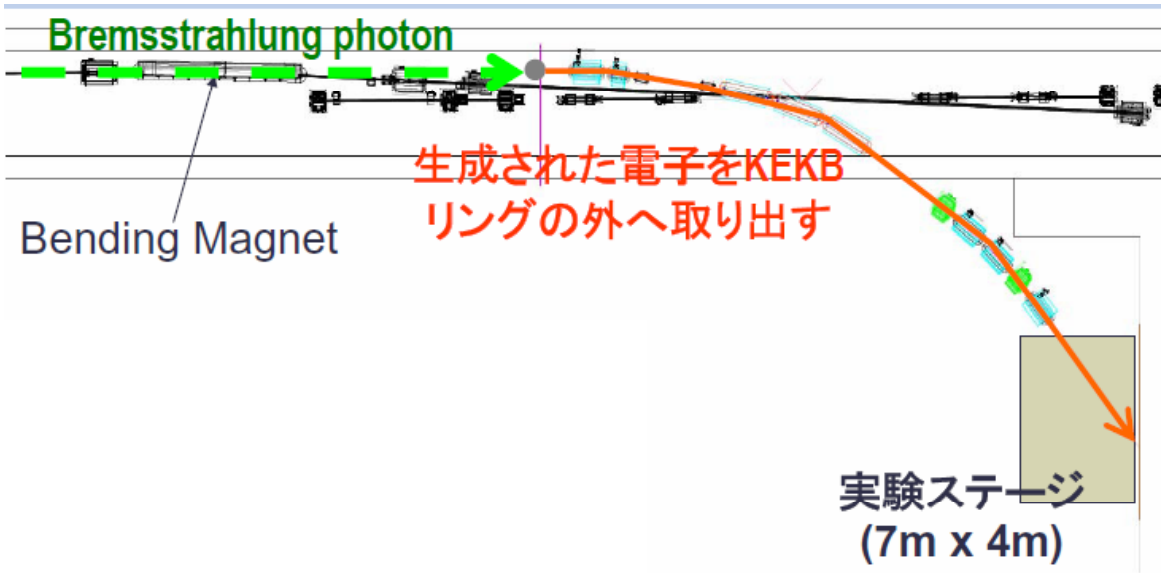
  the possibility of being easy to exfoliate TiO_2 paint

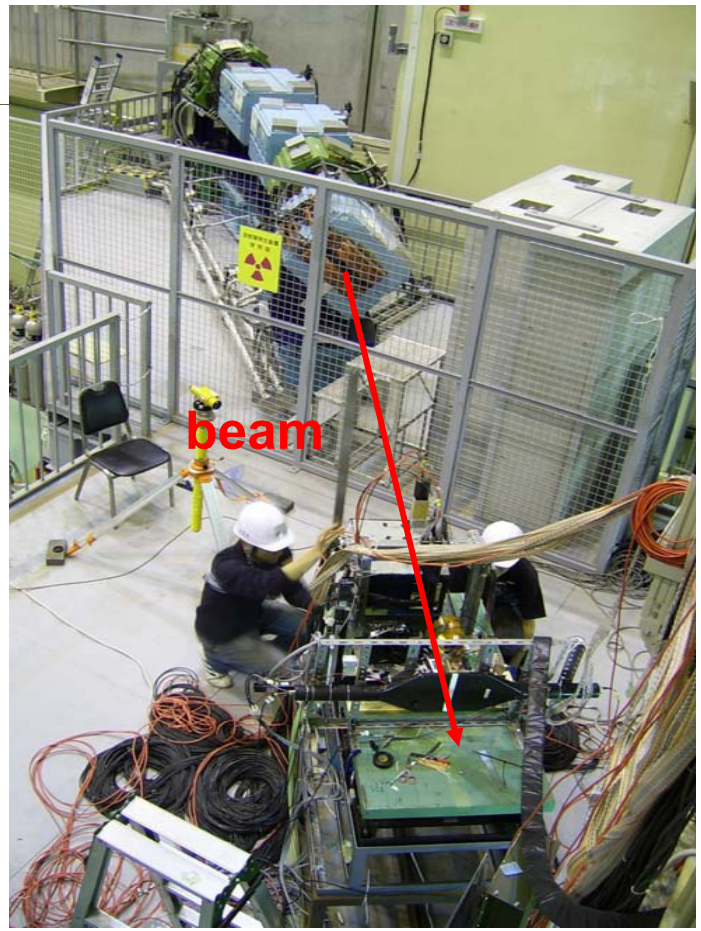


Beam test with using carefully chosen extruded scntilltor strips was carried out and compared with Kuraray.

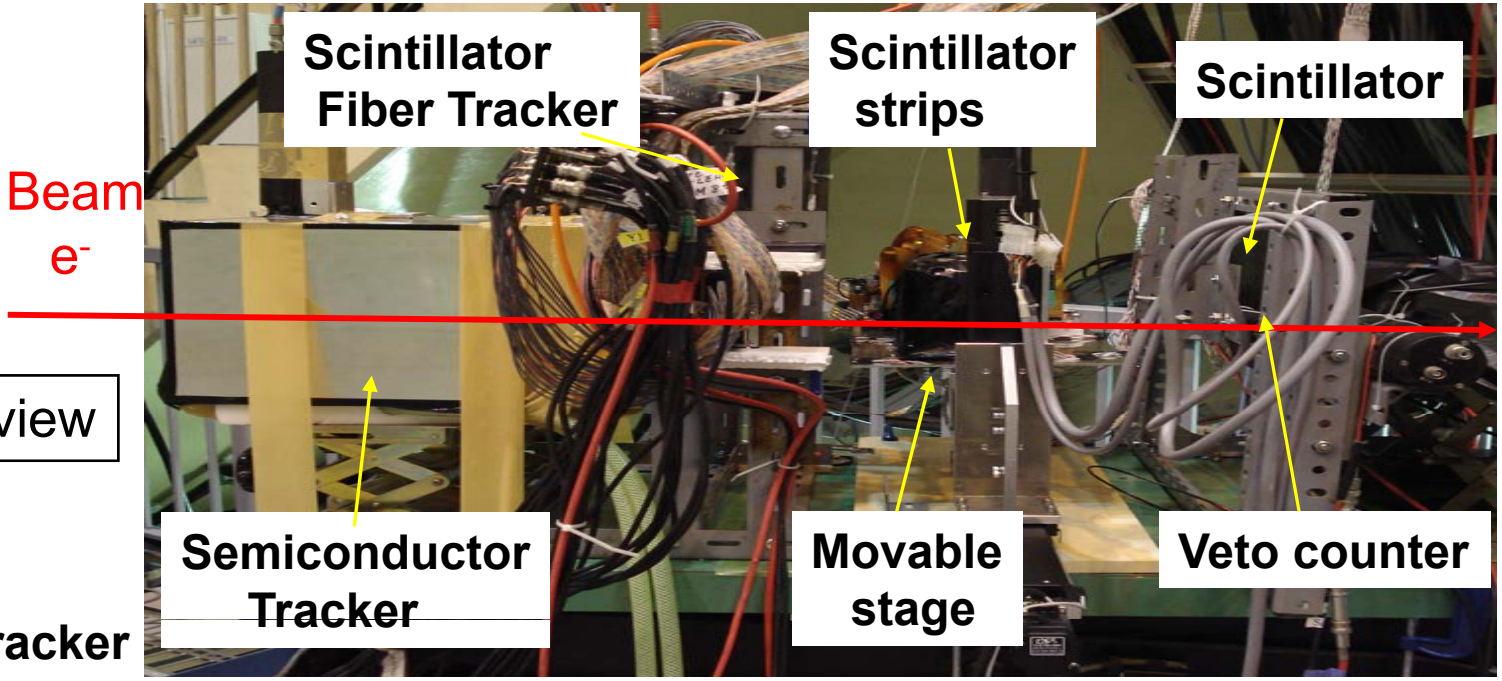
KEK Fuji beam line

- Electron beam
- This beam is made form bremsstrahlung photons from KEKB ring
- Beam spot size: ~ 3cm x 4 cm
- Beam energy : 3 GeV
- Rate: 15Hz @ 3 GeV



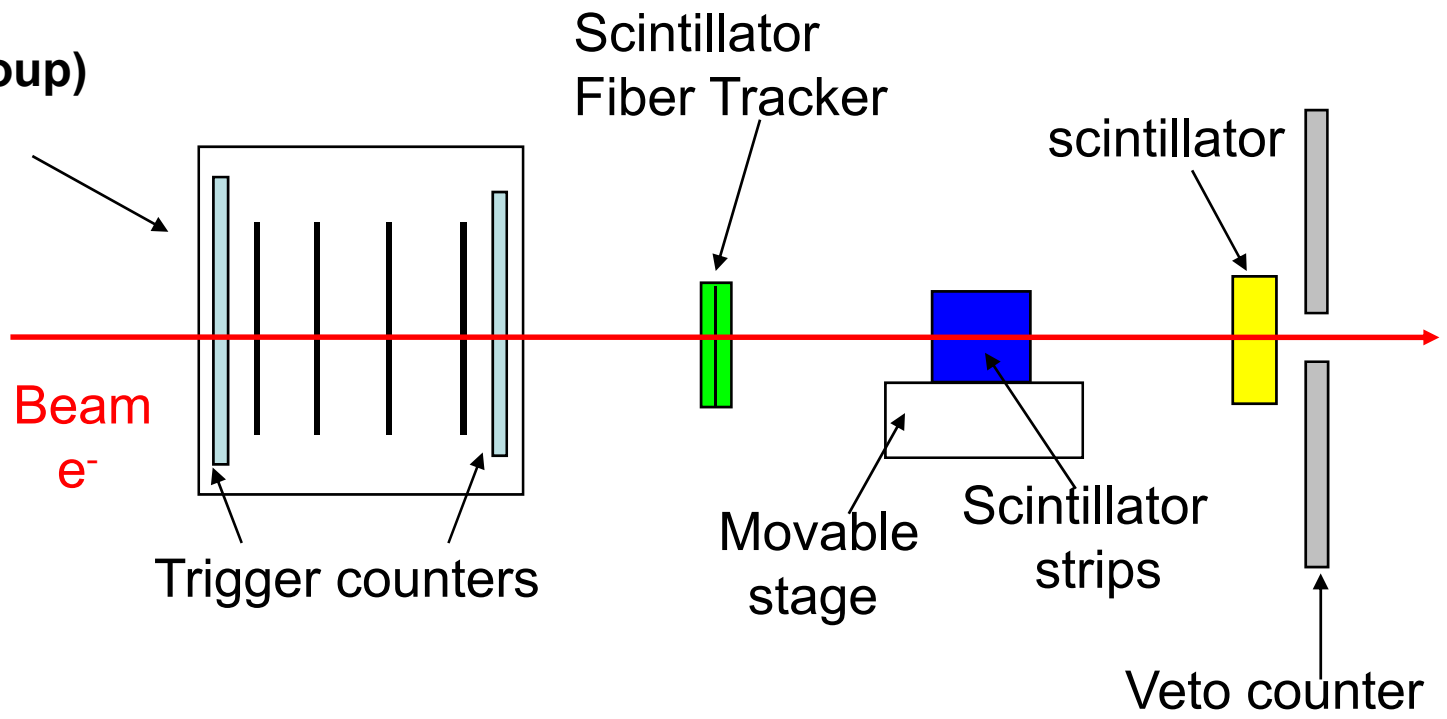


Setup

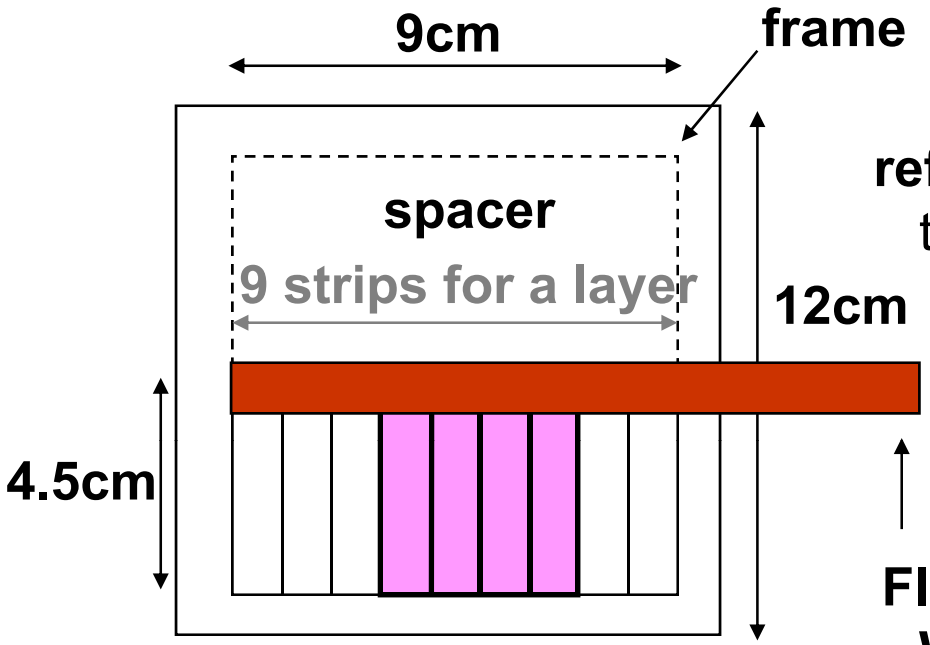


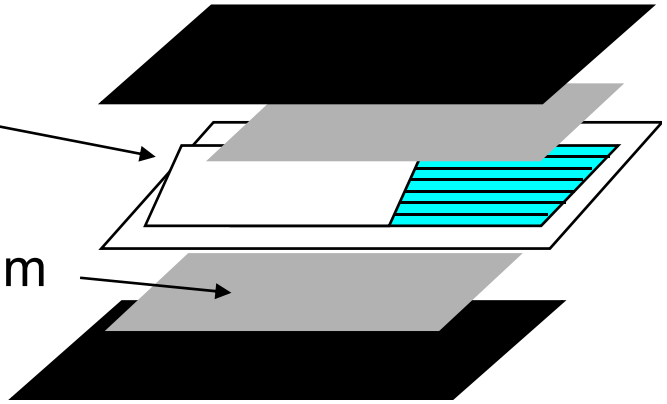
Setup of side view

Semiconductor Tracker
(borrowed by
ATLAS Group)
12cm×6cm
Resolution
vertical : 23μm
horizontal: 580μm



Scintillator Assembly



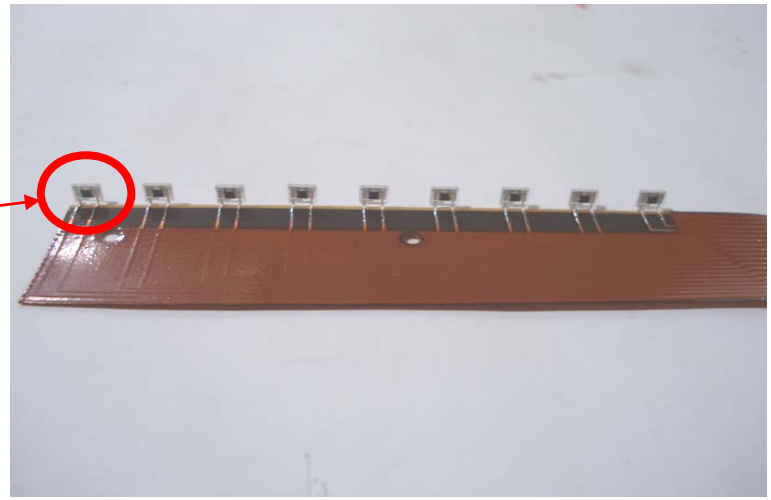


reflector film
thickness 57μm

black sheet

Flexible Cable With MPPC

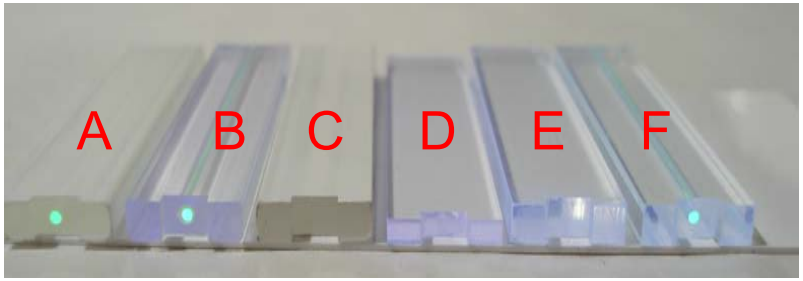
scintillator strips



MPPC

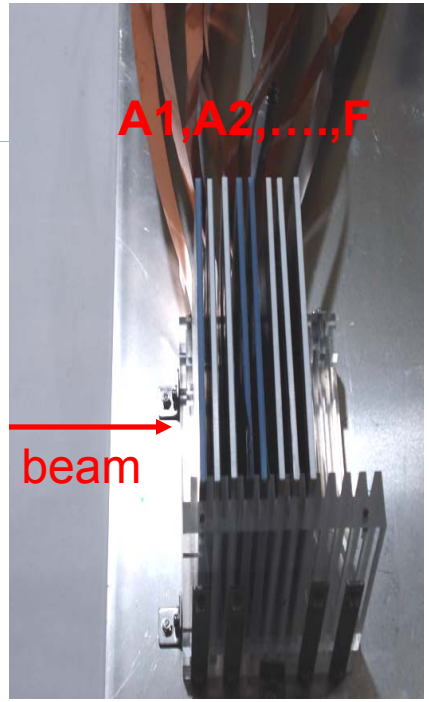
scintillator strip size

Scintillator Strips



- 8 layers with different types of strips
- 4 strips per one layer were read out.

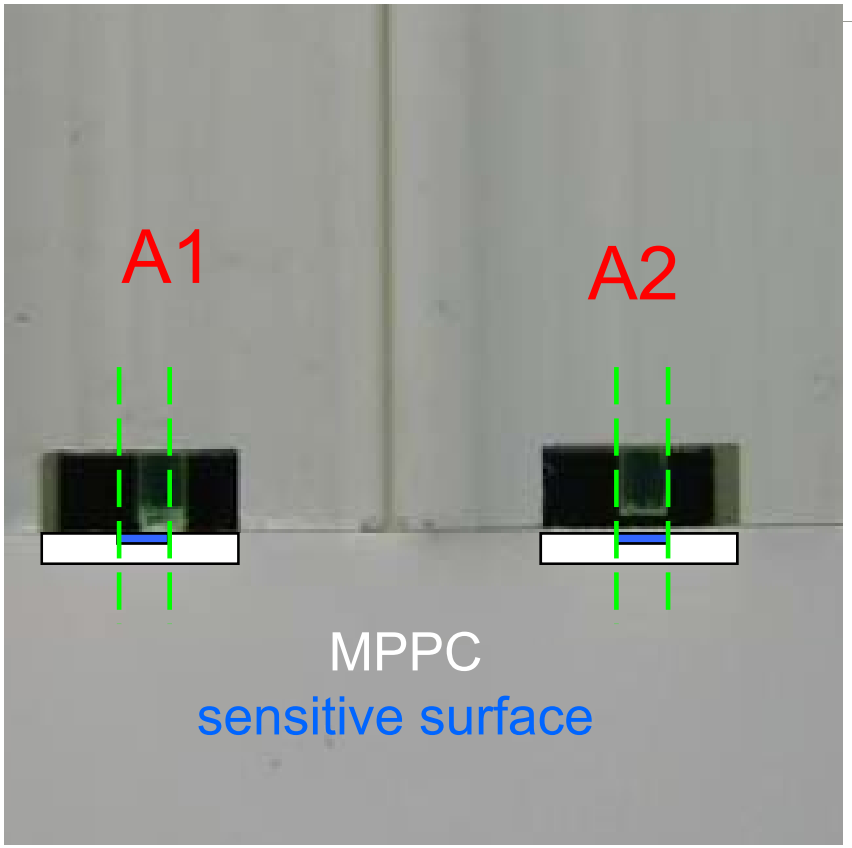
type	Method	Read-out	Cover	**Thickness**(mm)	
A1	Extruded	Fiber	TiO_2	3	No fiber !
A2					good matching
B1			**Reflector**		bigger hole
B2					matched hole
C		Direct	TiO_2		
D	Kuraray	Direct	**Reflector**	2	
E				3	
F		Fiber			**reference**

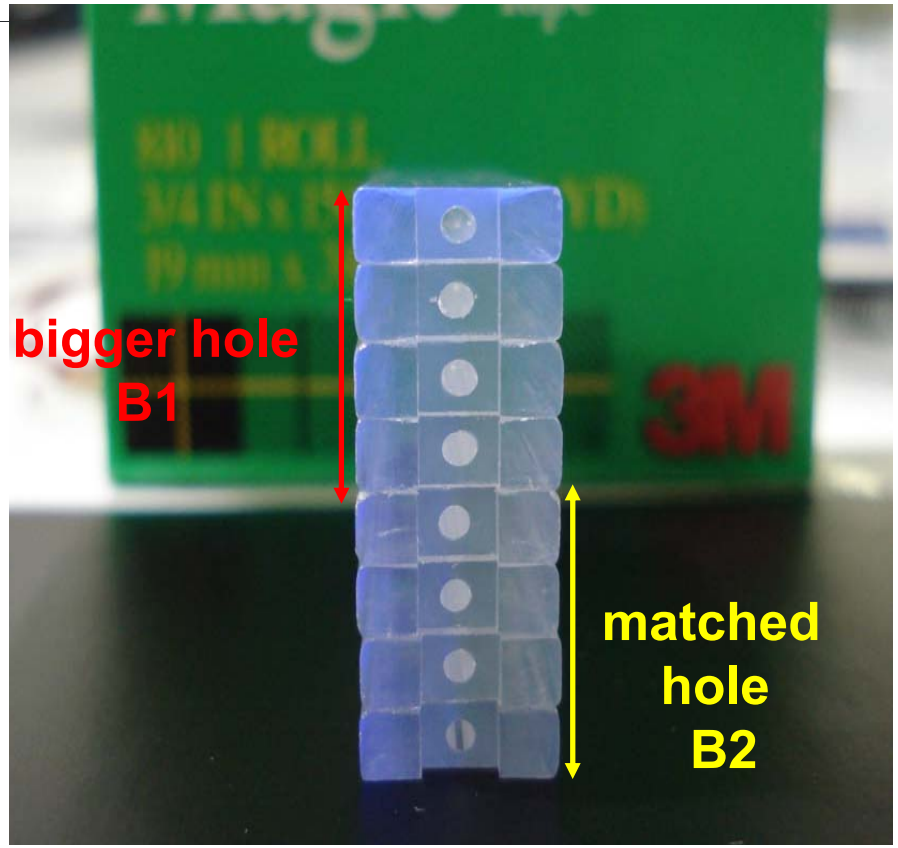


Extruded scintillator strip with a fiber hole (A,B)

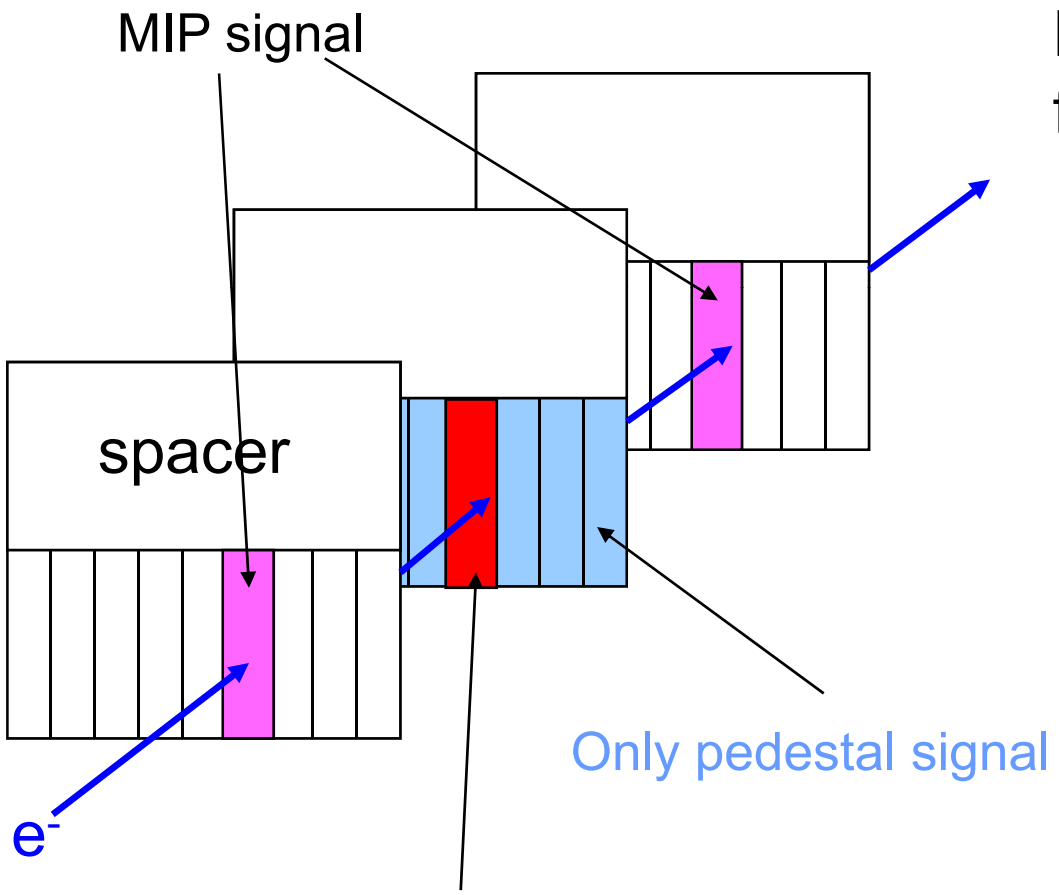
Type : A
covered with TiO2
A1 : fiber - MPPC bad matching
A2 : fiber – MPPC good matching

Type : B
covered with KIMOTO reflector film
B1 : bigger hole
B2 : matched hole





MIP selection

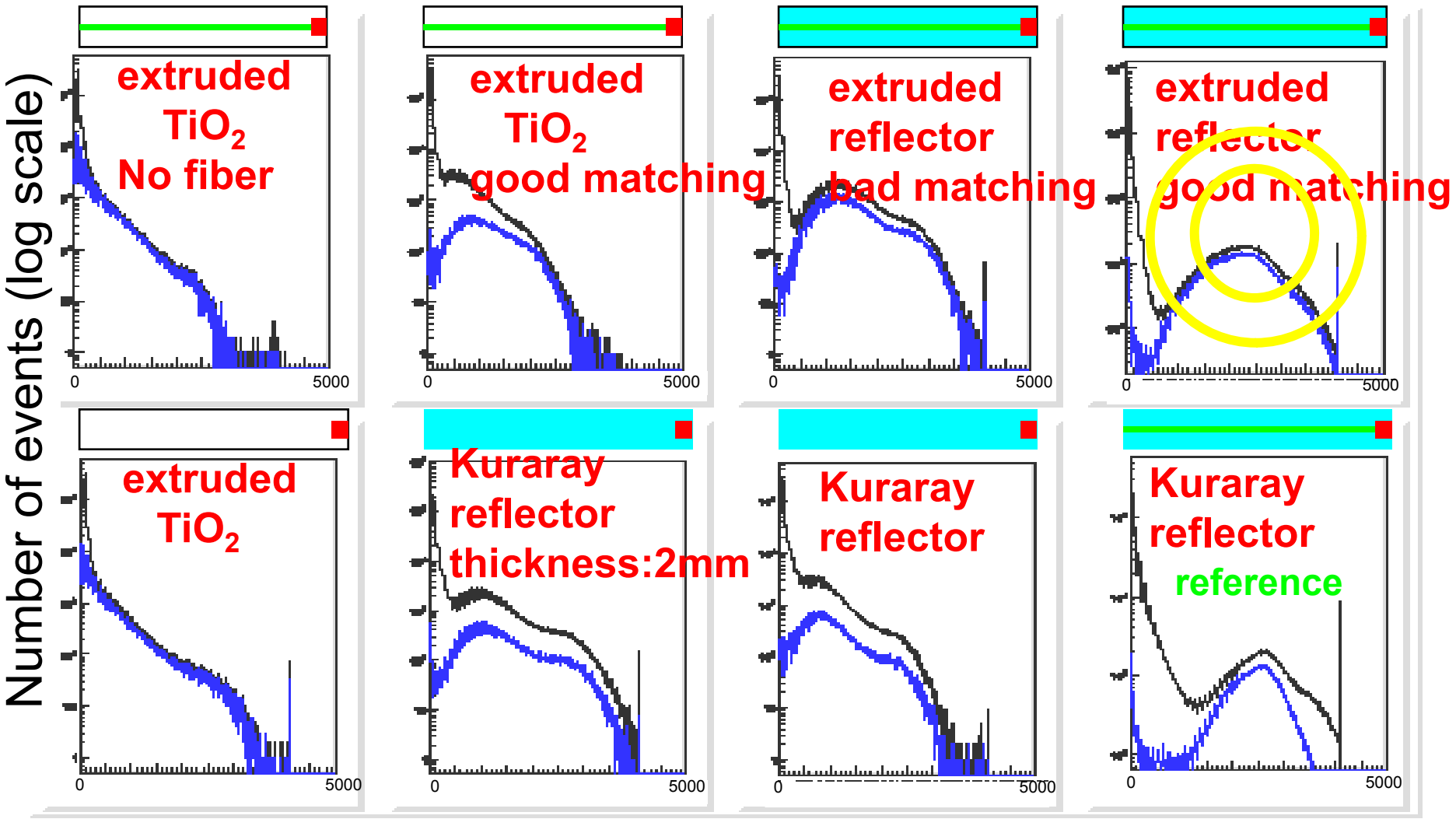


For the selected strip, MIP event must satisfy following conditions:

- In the same layer, strips show the pedestal signal but the selected strip.
- In the front and the rear layer, the strips at same position of the selected strip show the MIP signal.

Response for MIP

All collected events
MIP events

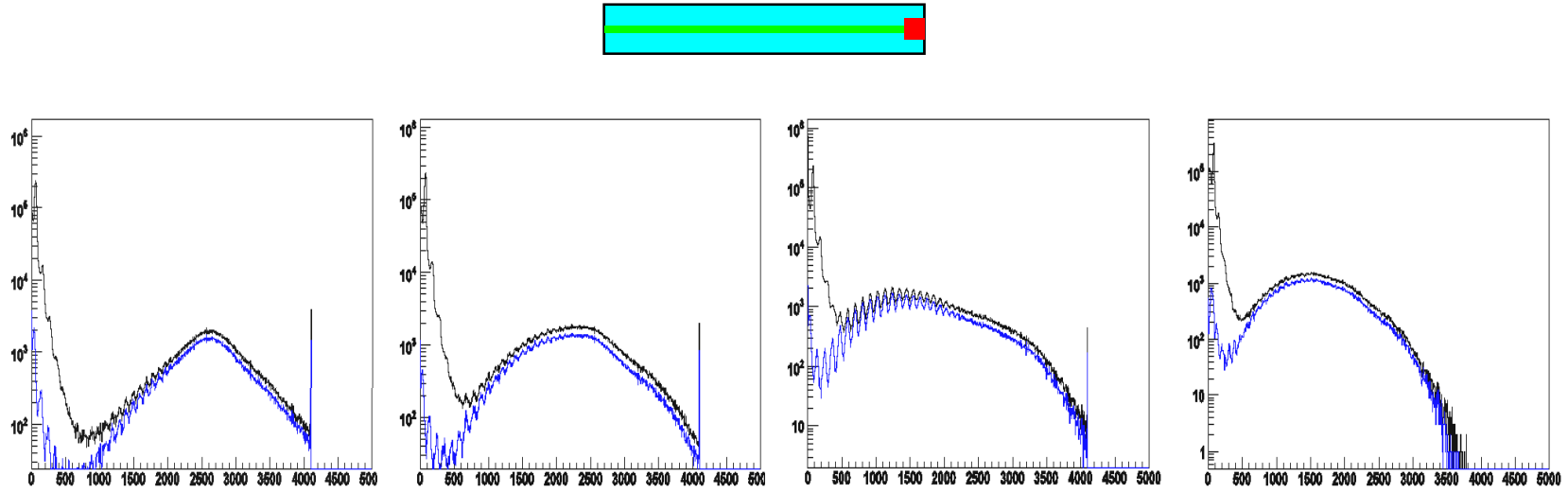


Response for MIP
Variation of strip by strip

There are 4 results since we've prepared 4 strips read out per one layer.

Extruded scintillator strip＋reflector film
good matching

All collected events
MIP events

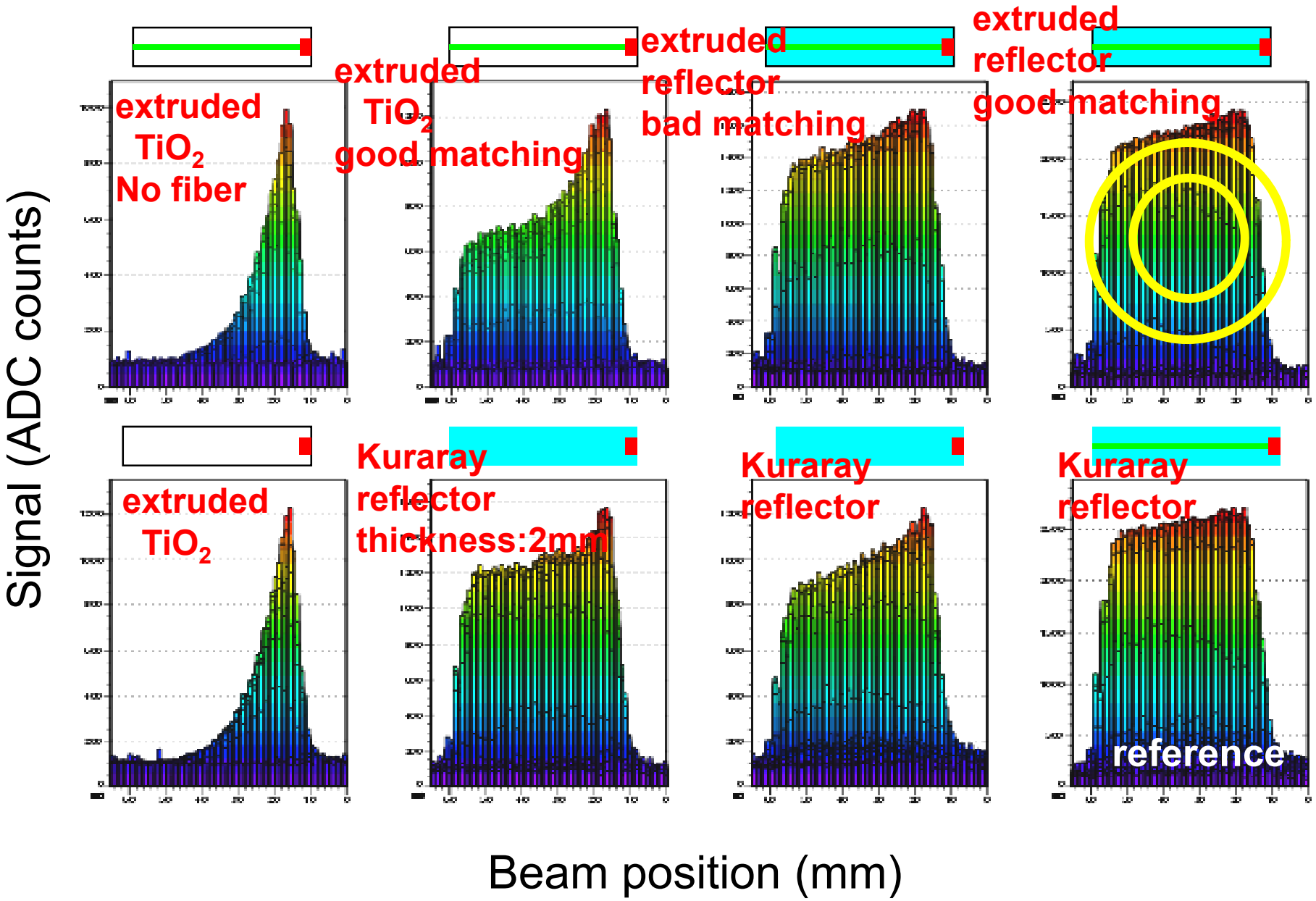


Number of events (log scale)

Signal (ADC counts)

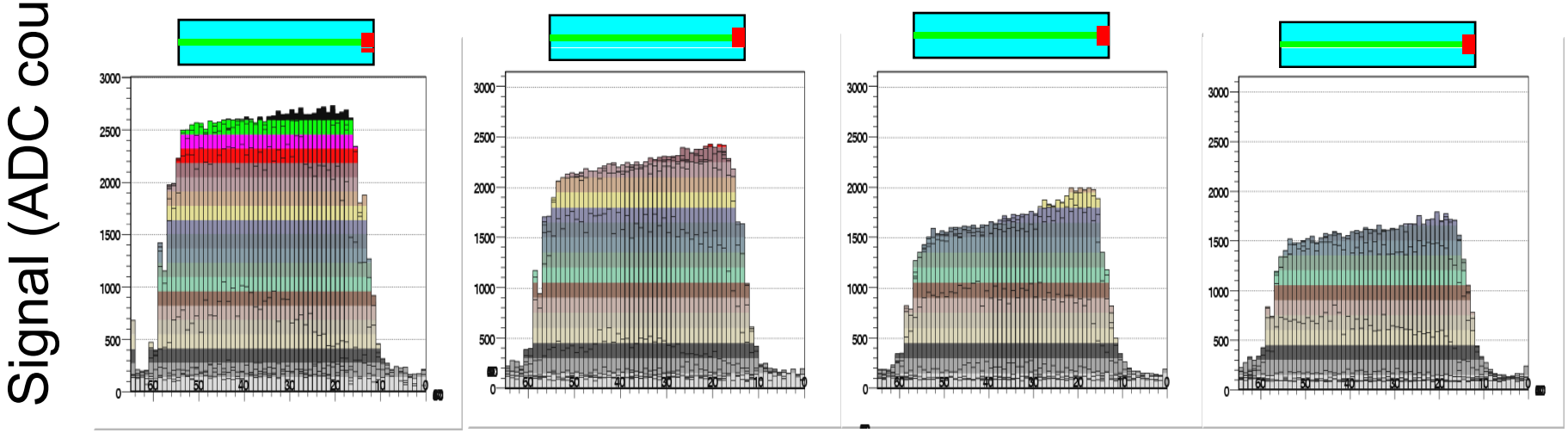
These plots show the variation of strip by strip is big.

Uniformity


extruded
TiO2
No fiber
extruded
TiO2
good matching
extruded
reflector
bad matching
extruded
reflector
good matching
extruded
TiO2
Kuraray
reflector
thickness:2mm
Kuraray
reflector
Kuraray
reflector
reference
Signal (ADC counts)
Beam position (mm)

Uniformity
Variation of strip by strip

Extruded scintilattor strip＋reflector film
good matching



These plots show the variations of the uniformity aren’t so big.
However light yields aren’t same.

Conclusion

- Position between fiber and MPPC is important.
- The reflector film works better than TiO_2 for uniformity.

⇒ We asked KNU to make extruded scintillator strips with the precise size of fiber hole and position without TiO_2.

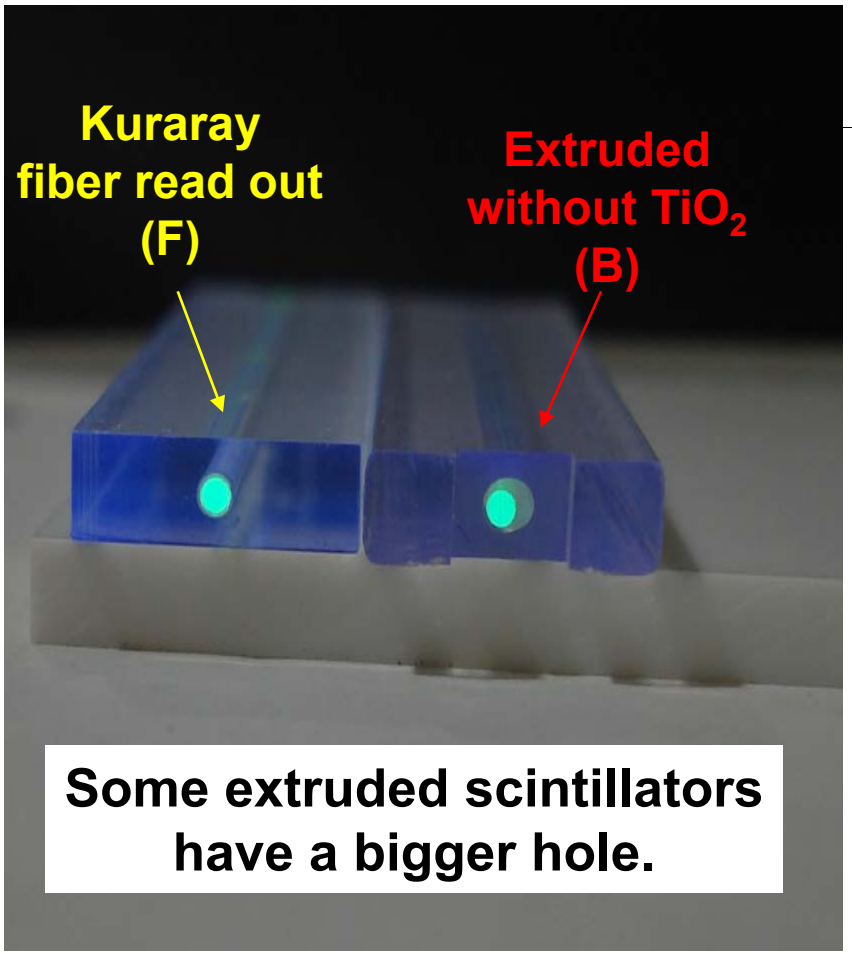
Plan

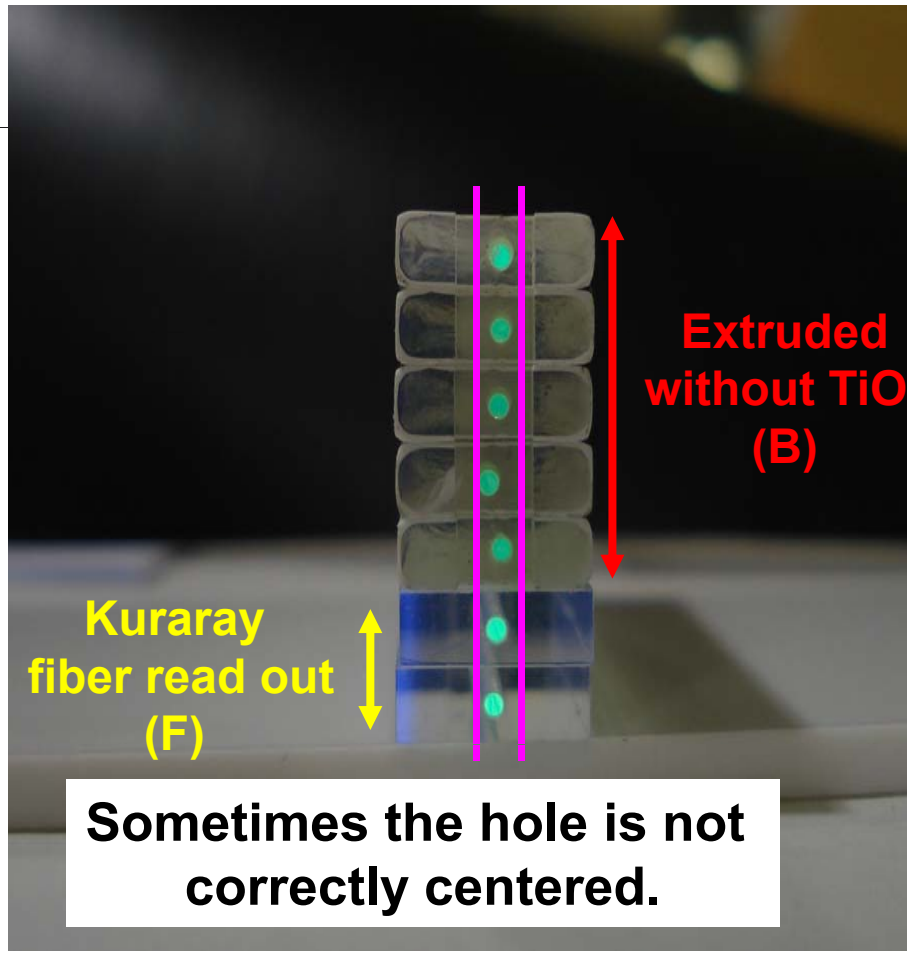
- More detail analysis about KEK beam test is neccesary.
  - look into two peaks in the response for MIP
- In this summer, FNAL beam test will be carried out using improved extruded scintillator strips.

Back Up

Comparison between Kuraray and extruded scintillator strips

Extruded scintillators have some problems.

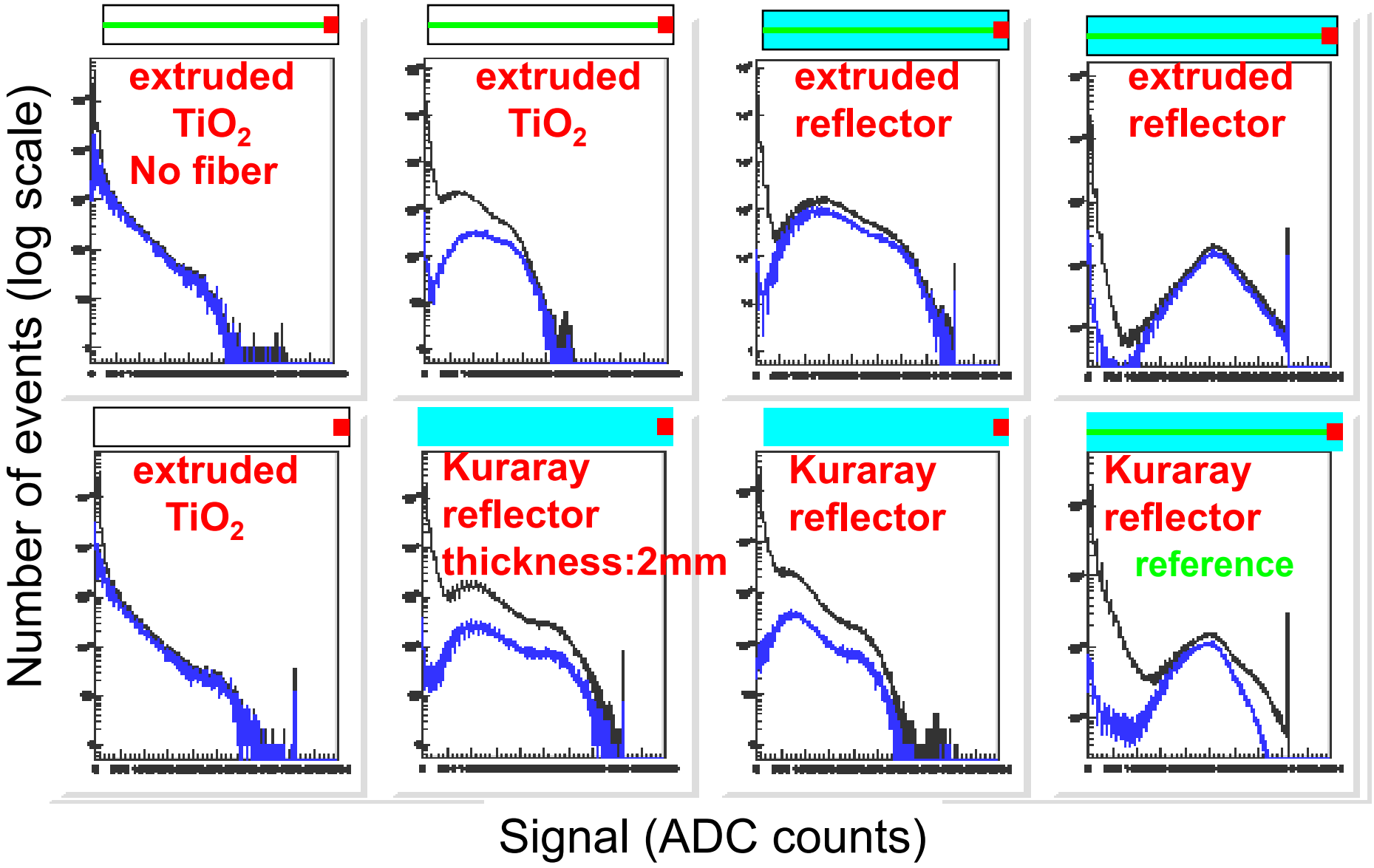




Response for MIP(strip1)

All collected events

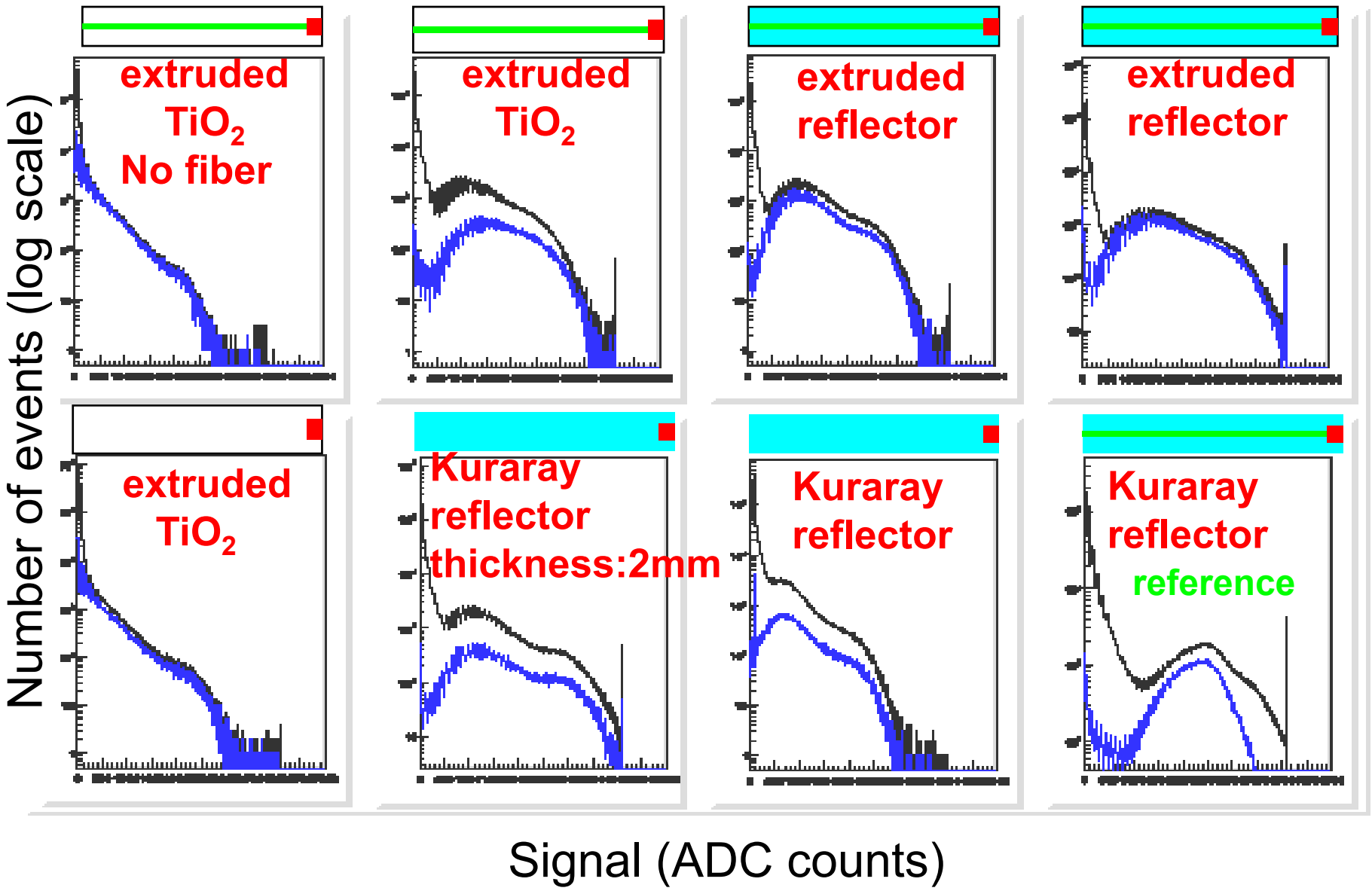
MIP events



Response for MIP(strip3)

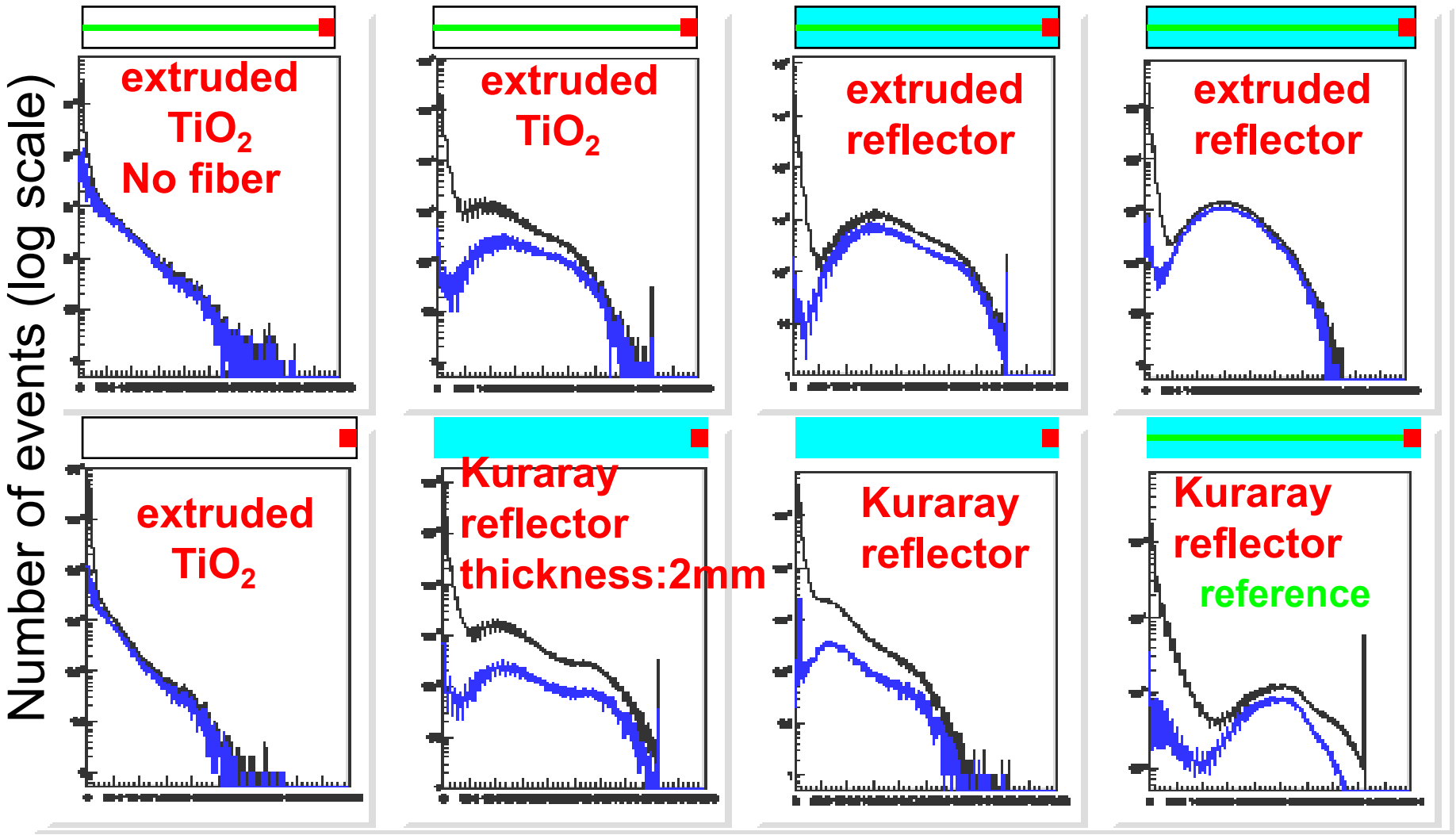
All collected events

MIP events

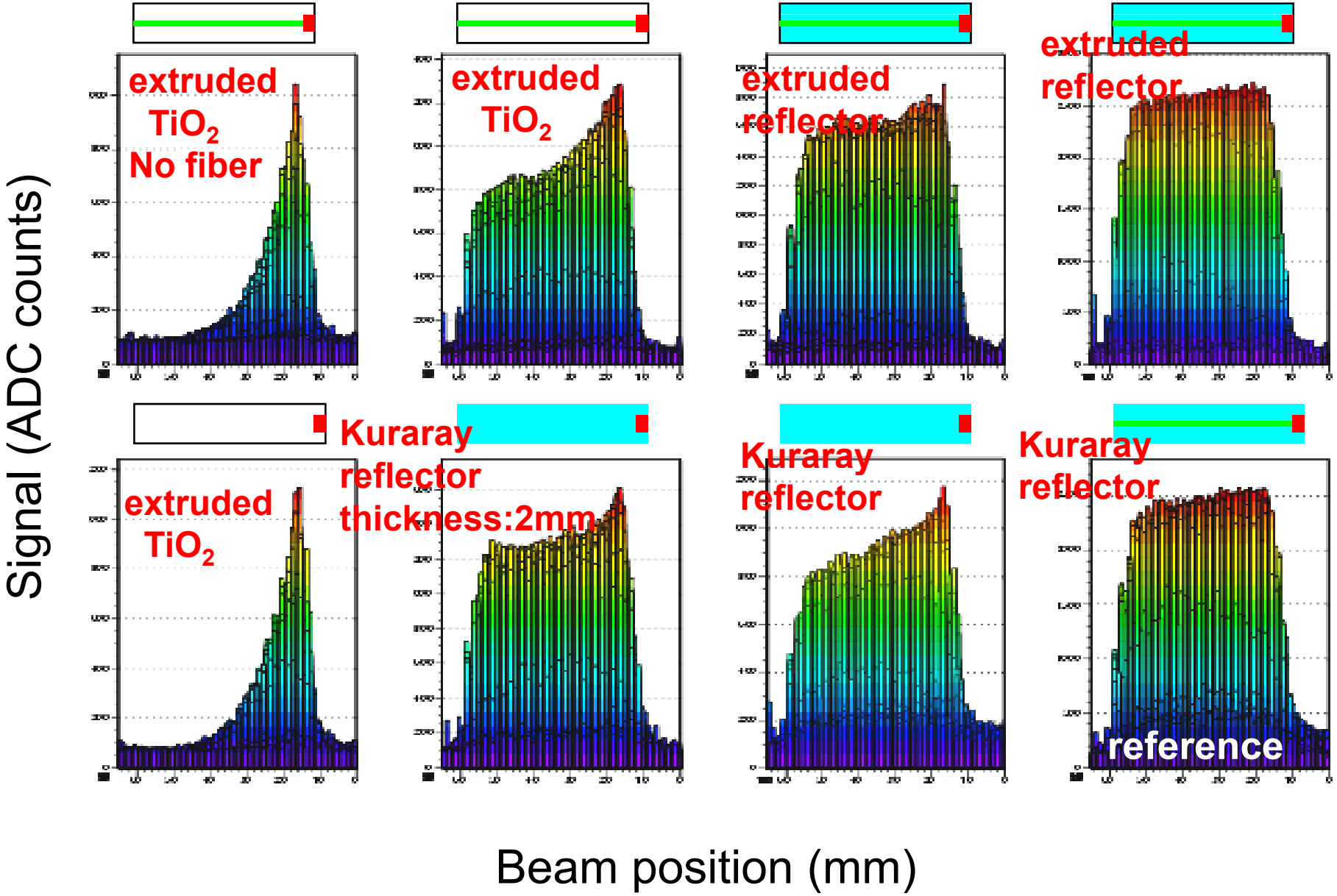


Response for MIP(strip4)

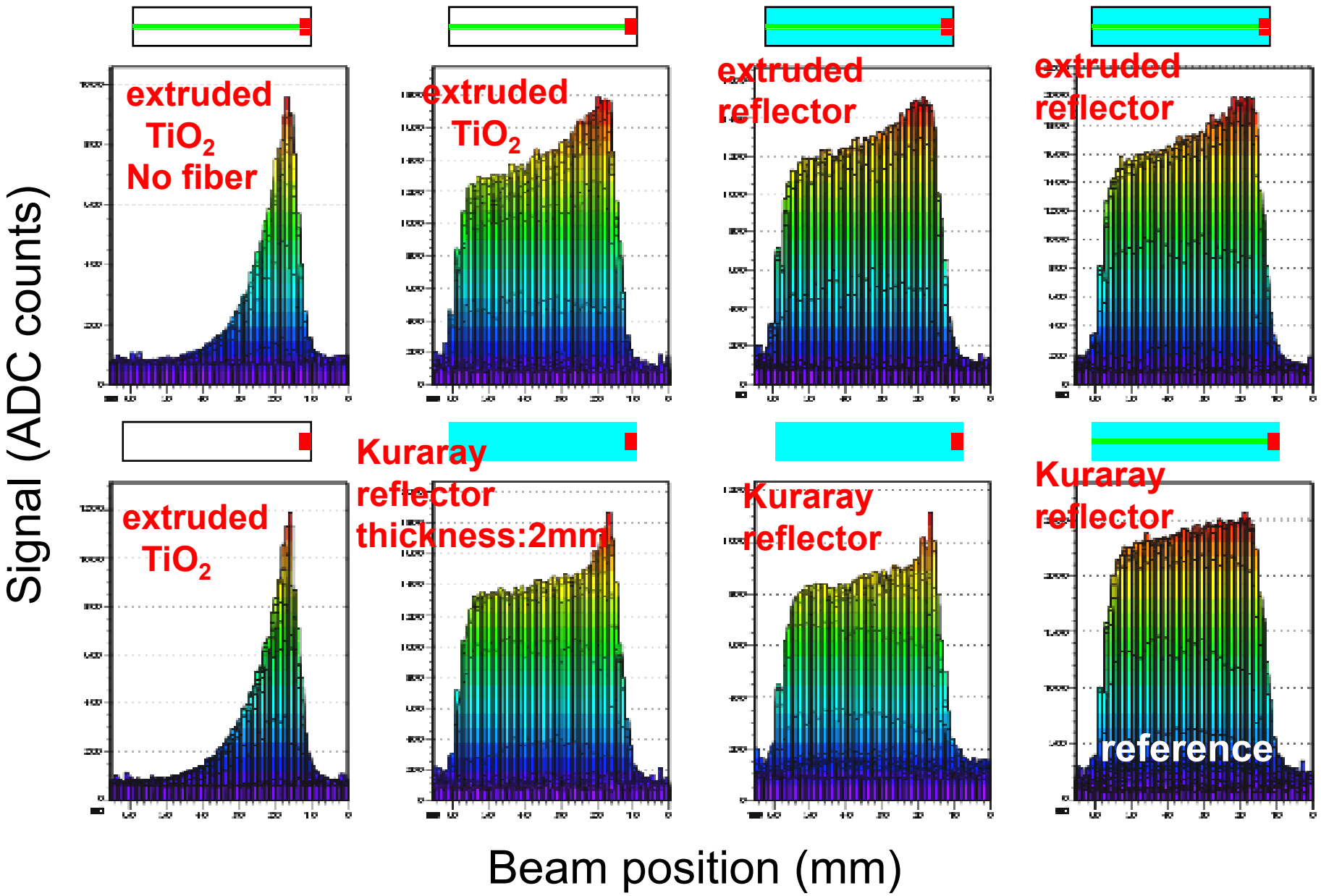
All collected events
MIP events



Response Uniformity (strip1)



Response Uniformity (strip3)



Response Uniformity (strip4)