Korean Activities on Calorimetry in ILC

Tokubetsu-shishin kickoff meeting, Sep-13th 2011

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- History of Japan-Korea collaboration
- Current R&D and funding status
- Prospects (yet rough)

WCU CENTER FOR COLLIDER PHYSICS
KNU KYUNGPOOK NATIONAL UNIVERSITY

History

- The Japan-Korea (Kyungpook National Univ.) collaboration has more than several years of history.
- The KNU is dedicated to scintillator-strip production by extrusion technique
- It allows suppressing production costs while keeping necessary performance.

The KNU Scintillator-Lab overview

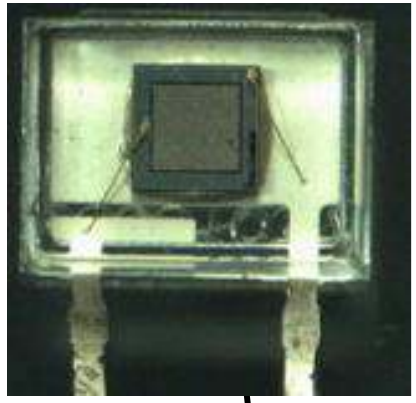
- The KNU has a production & bench-test system to develop **extruded plastic scintillator strips.**
- The laboratory is capable to study :
  - Performance of various scintillators (types, dimensions, configurations).
  - General optical simulation to reproduce the results of the measurements.
- So far we have successful to produce scintillator strips for two ScECAL technical prototypes.

Current base design of the scintillator-strip for the ILD calorimeter

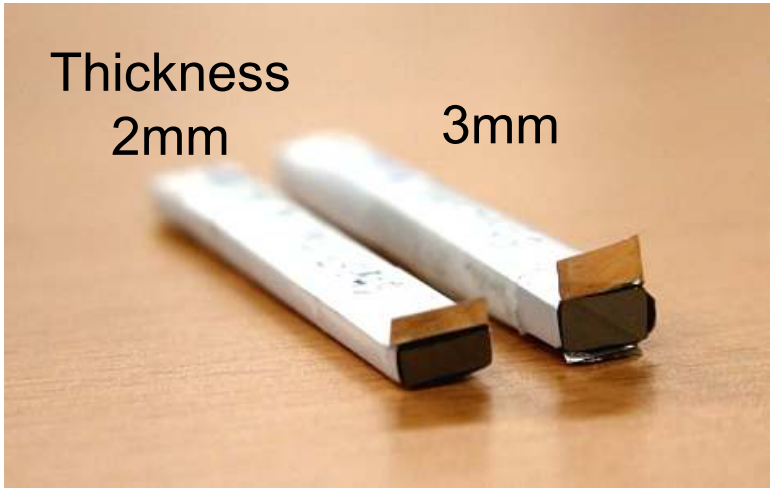
Plastic scintillator strip by extrusion technique

- **Absolute amount of light**
- **Response uniformity**
- Effect of covering material
- Transparency
- Mechanical stability
- Production cost
- Configuration change to 2mm thick with MPPC direct coupling

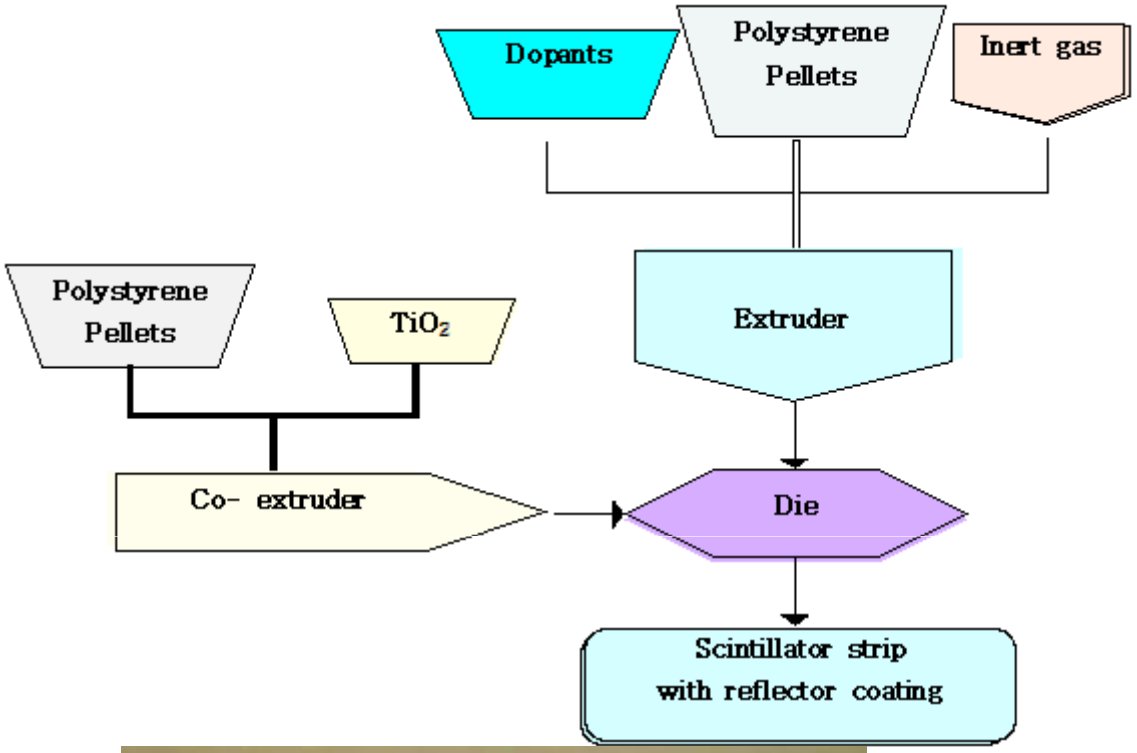
Multi-Pixel Photon Counter (MPPC)

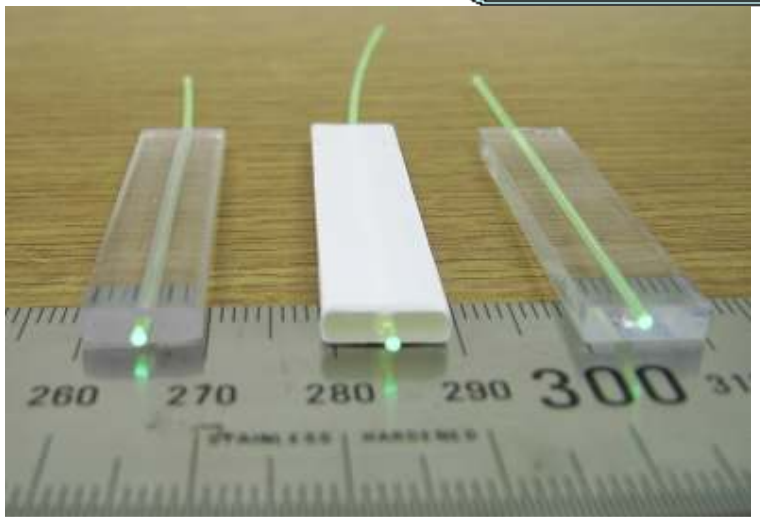


5 x 45 x 2 mm

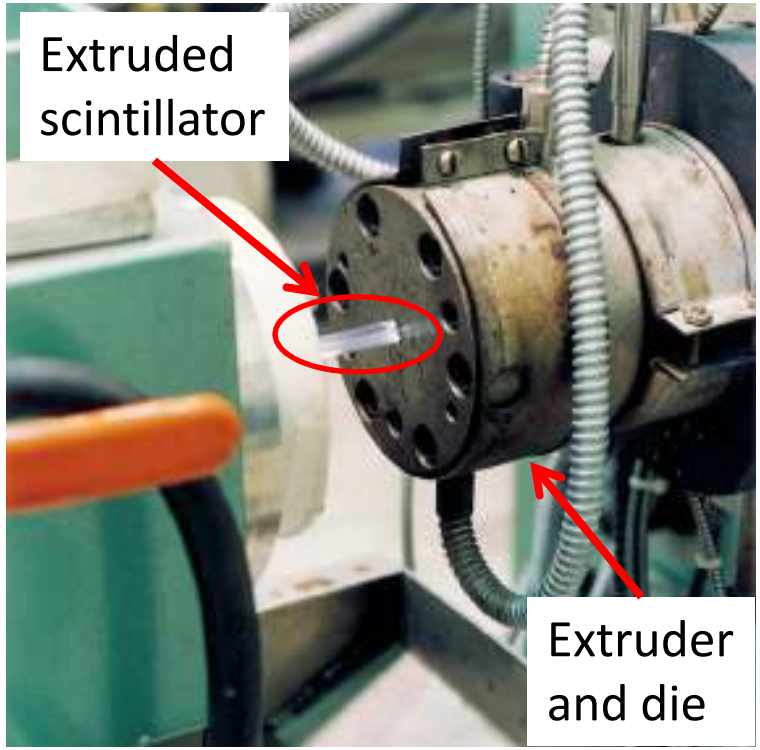


Extruded Scintillator Production by KNU



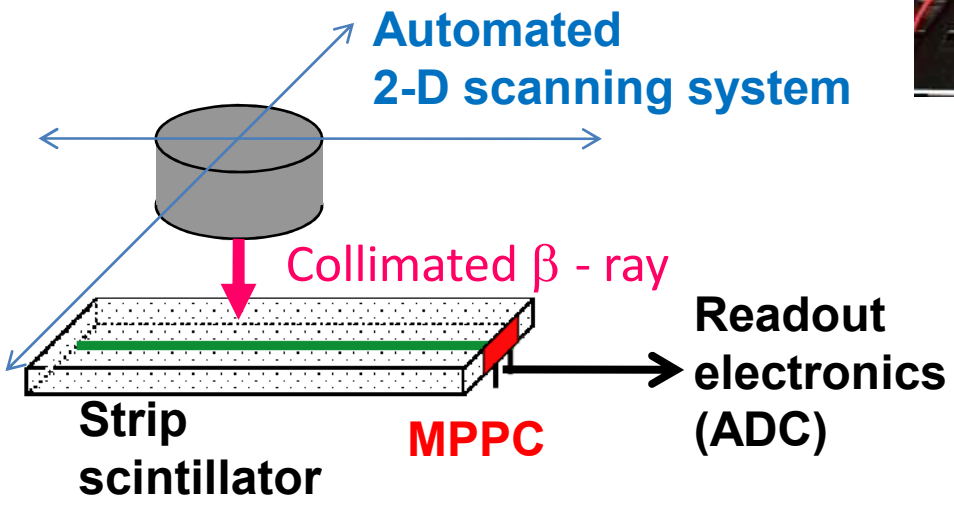


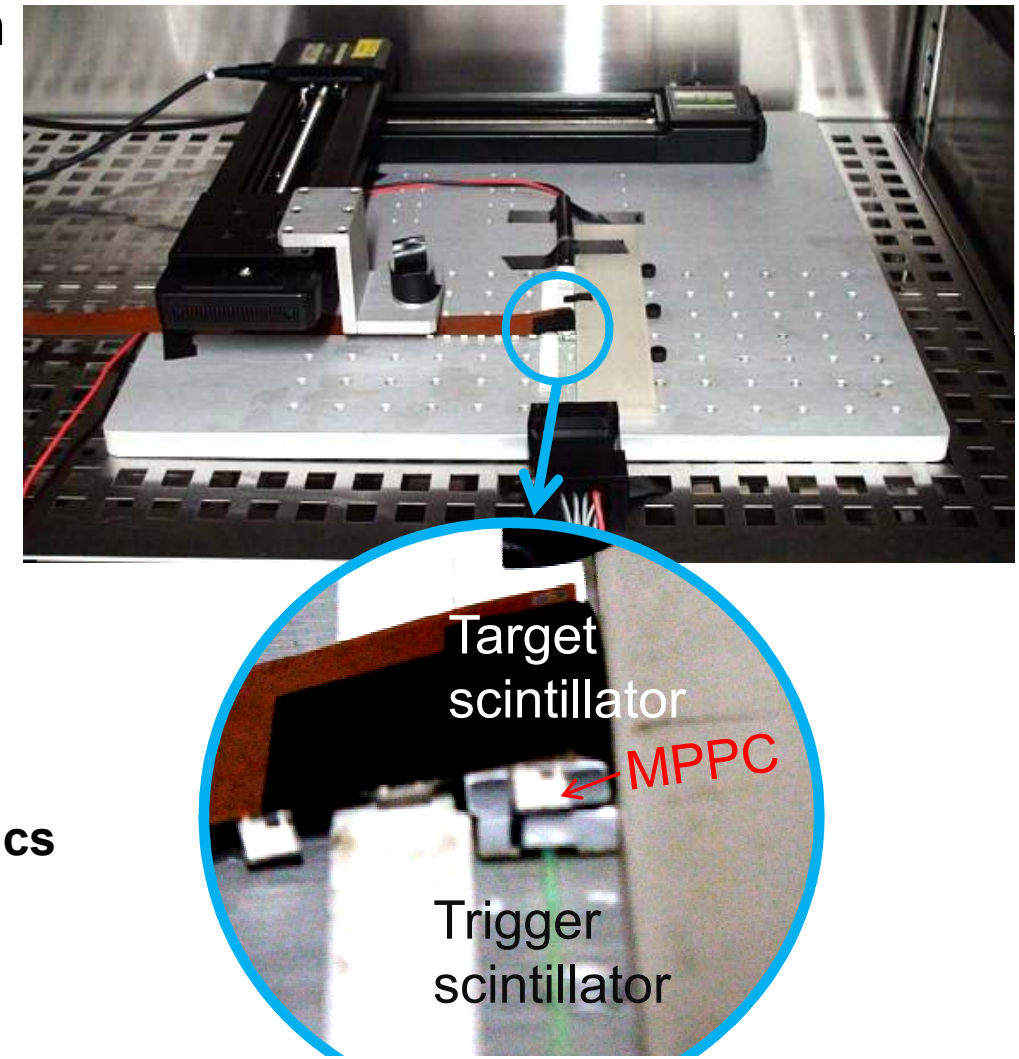
Extrusion system at Misung Co.



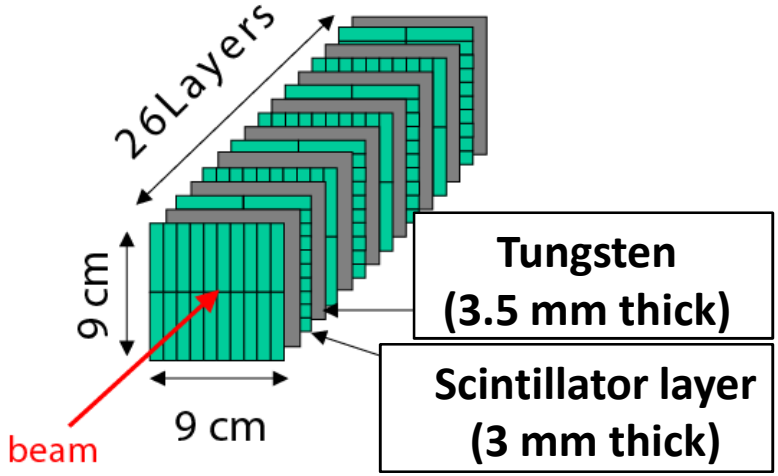
Setup of the Bench Test Systems in the Scintillator Laboratory

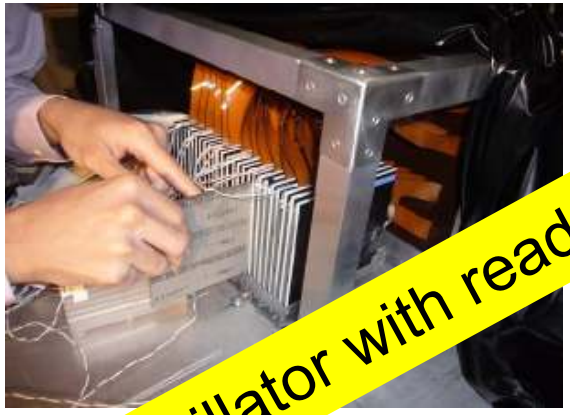
- Precise 2-D scanning system with collimated beta-ray to measure scintillator light output and its position dependence.





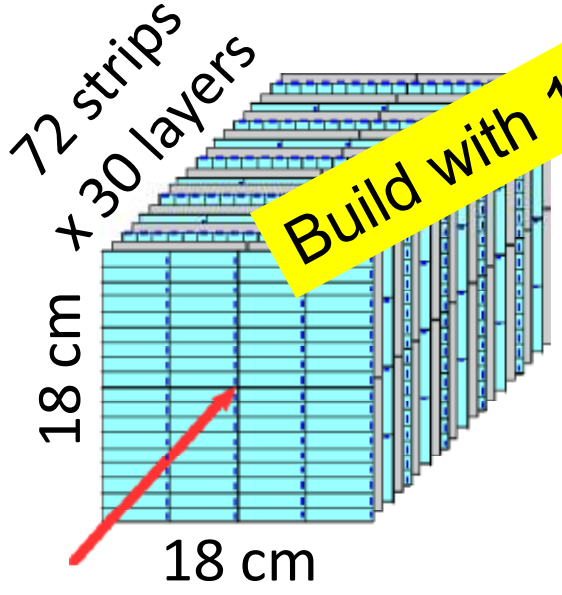
Test of the first ScECAL prototype at DESY March 2007





Build with 10 mm width scintillator with readout fiber

Test of the 2nd prototy[illegible] Fermilab Sep 2008 / May 2009



Current status in KNU lab

- Funding : World-Class University project
- Scint. Strip R&D To narrower and thinner

Funding : The WCU Collider Physics Program in KNU

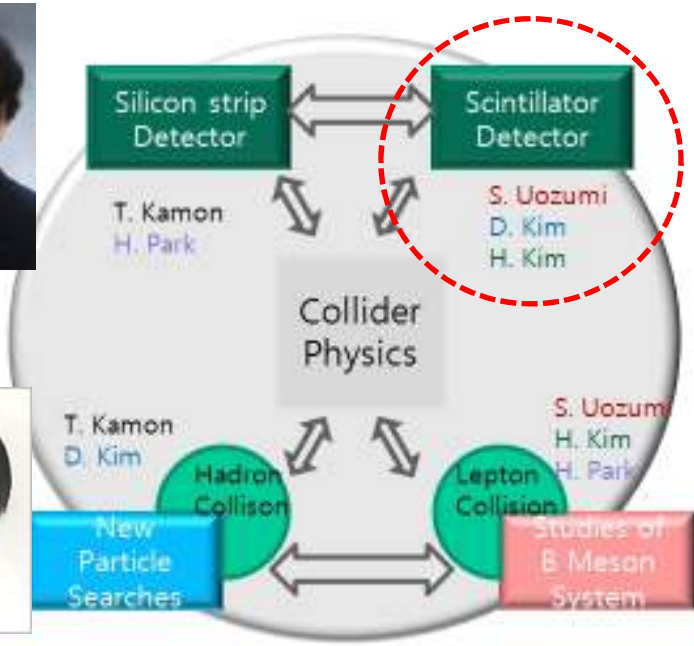
- Since 2009 till 2013 (extension is being considered)
- Funding for wide physics and detector R & D
- Several research prof., postdocs and students
- Working on CDF, CMS, ILC and Super-KEKB

WORLD CLASS UNIVERSITY
HIGH ENERGY
COLLIDER PHYSICS RESEARCH

Foreign Scholars

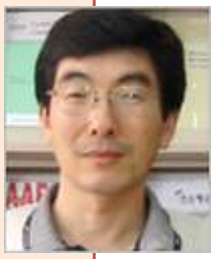
- Professor
  Teruki Kamon
  Texas A&M U/KNU

- Professor
  Satoru Uozumi
  KNU



KNU Scholars

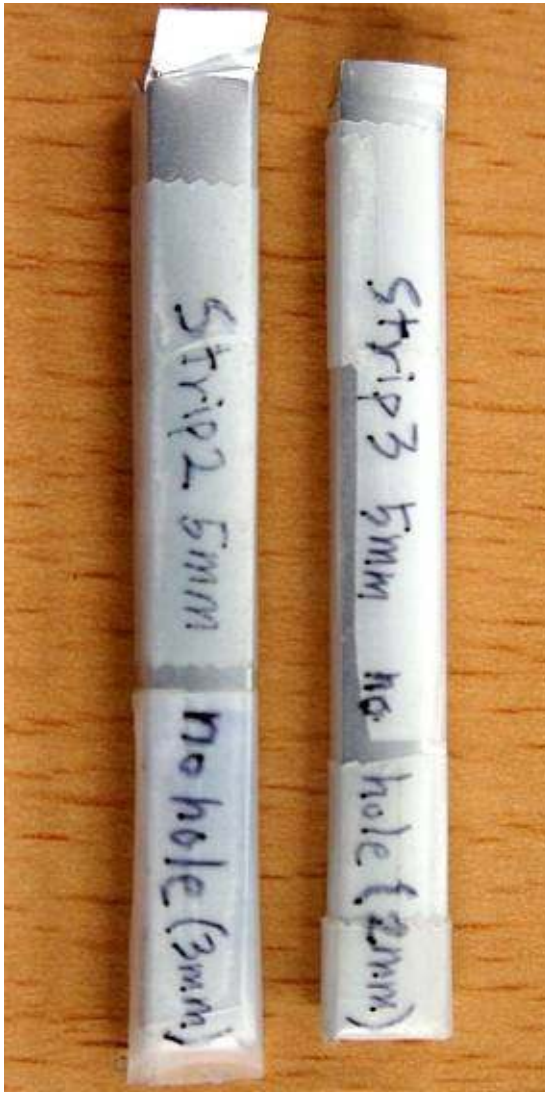
- Professor
  DongHee Kim



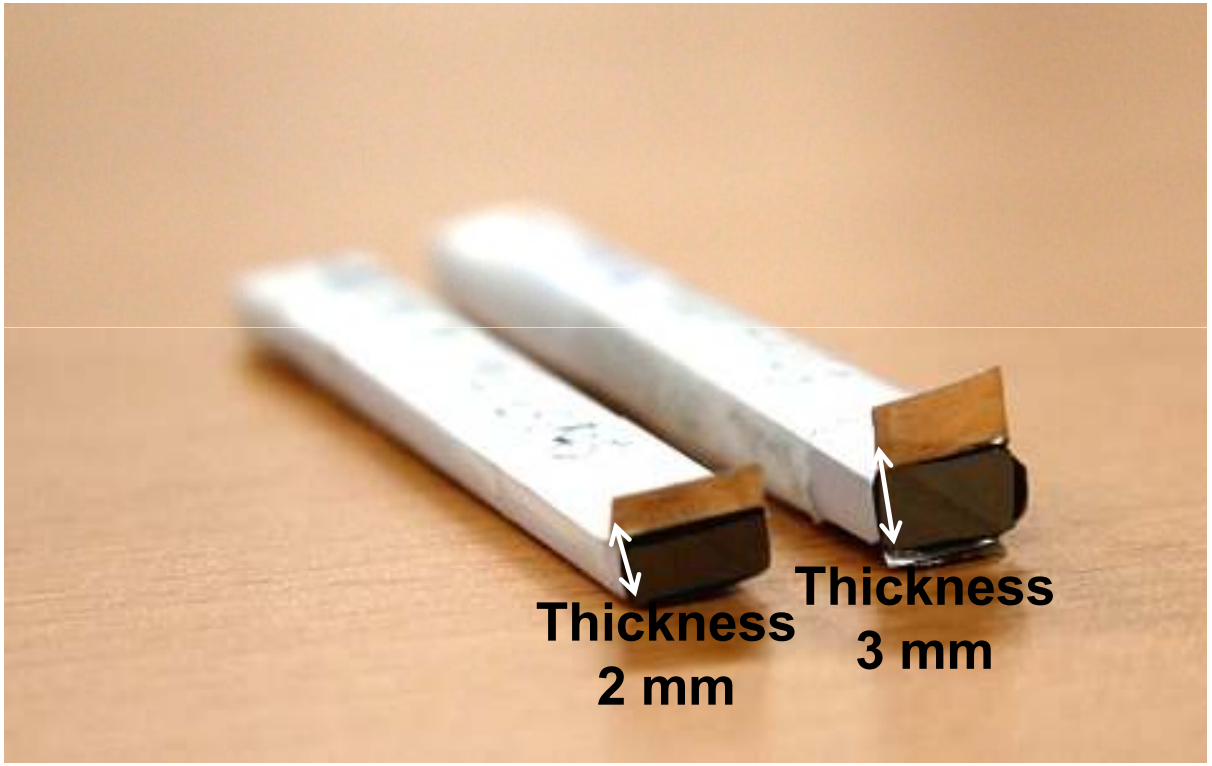
- Professor
  Hwanbae Park

- Professor
  HongJoo Kim

Current result (a highlight)



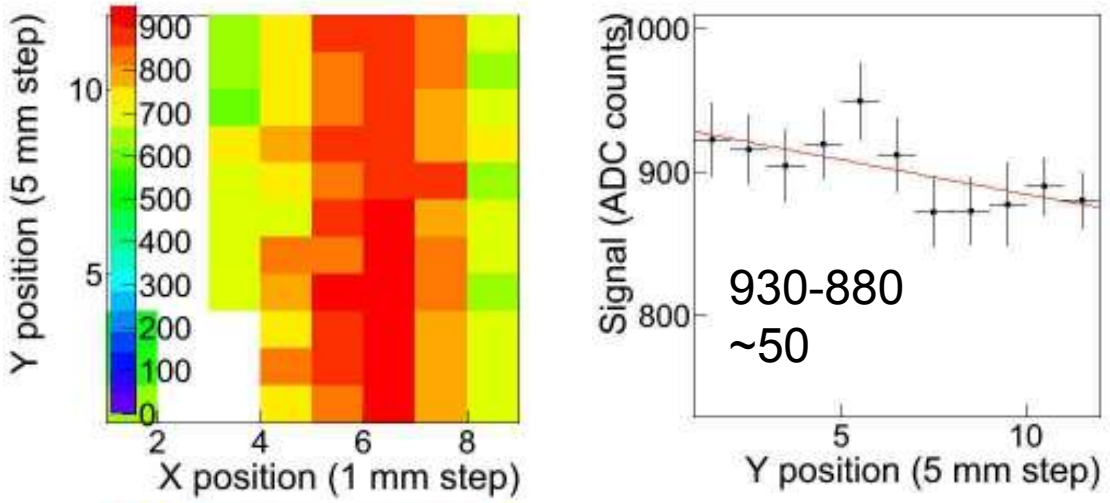
Comparison of strips with
5 x 45 mm wide, 2 and 3 mm thick



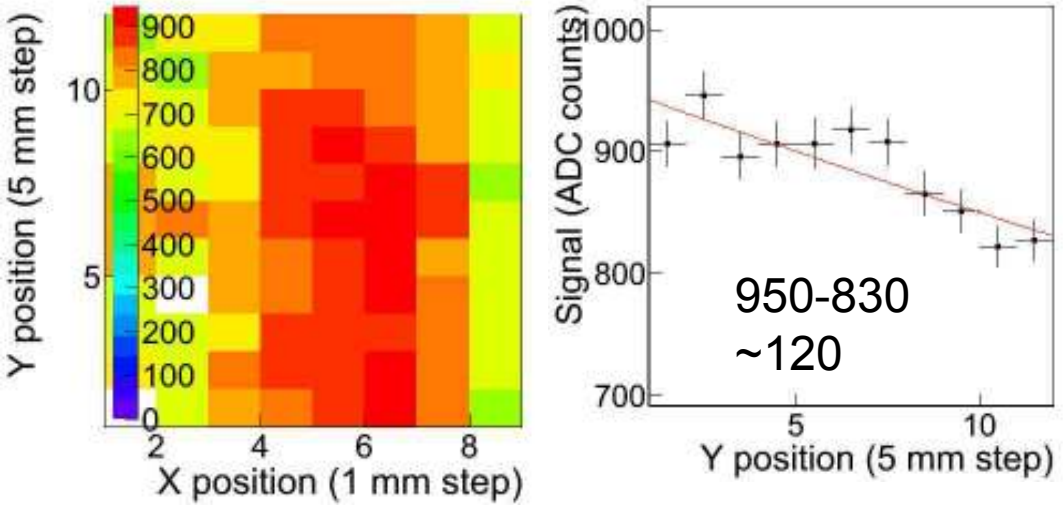
Comparison of the Thickness of strip
Keeping other configurations same

Thickness : 3mm vs 2mm(Direct readout)

Thickness 3mm



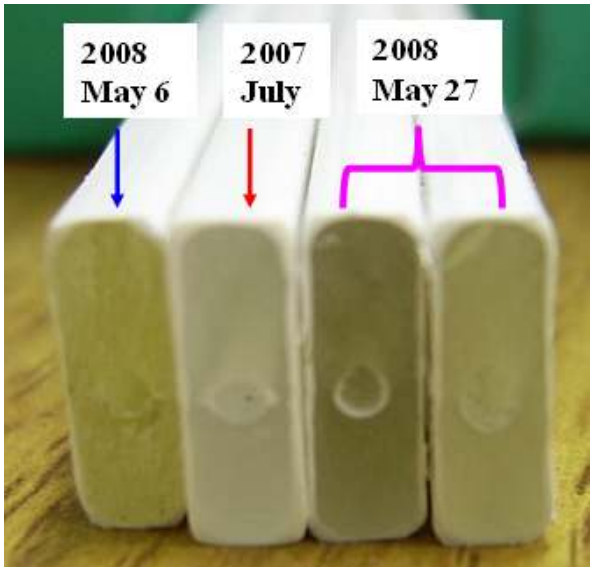
Thickness 2mm



The 5 x 45 x 2 mm strip shows almost comparable and sufficient performance with others !

Prospects (yet rough, will be discussed more)

- We are aiming to establish the scintillator strip performance by a systematic measurement with various configurations :
  - Quality of the scintillator
  - mechanical stability / precision
  - Dimensions of the strip
  - Covering materials (reflector)
  - Photo-sensor performance



- For next technological prototype, we will need detailed discussion on collaborative work betweek Japan and KNU teams.
- Songyungwan Univ. is also a member of SiW-ECAL, may have a room for future collabolative work.

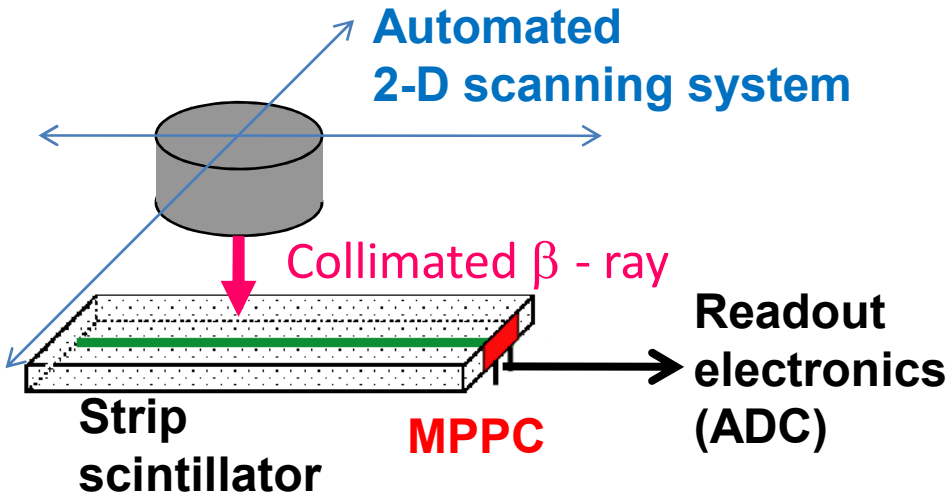
Summary

- We are having successful collaborative efforts with Japan and KNU teams to develop the ILD calorimeter.
- Extensive R&D effort is still ongoing for the test of scintillator-strip calorimeter in close collaboration.
- KNU team is aiming to establish the scintillator-strip production & performance with final strip configuration for the ILD calorimeter.
- The scintillator-laboratory is set up in KNU under WCU funding since 2009.
- Systematic measurement of various types, shapes of scintillators are ongoing. Results obtained so far shows are in good shape.
- Establishment of detailed production technology will be followed by collaborative work for next technological prototype.

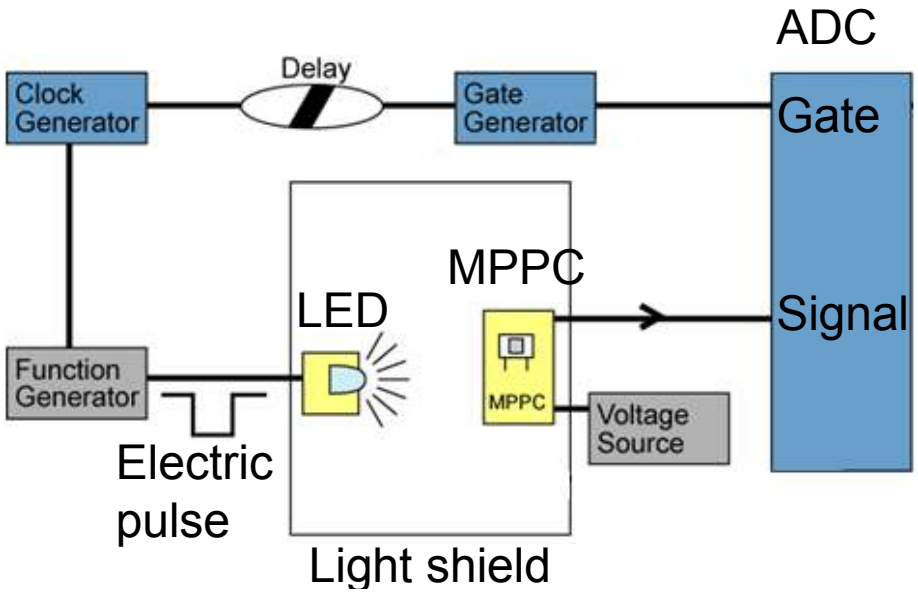
Backups

Setup of the Bench Test Systems in the Scintillator Laboratory

- Precise 2-D scanning system with collimated beta-ray to measure scintillator light output and its position dependence.

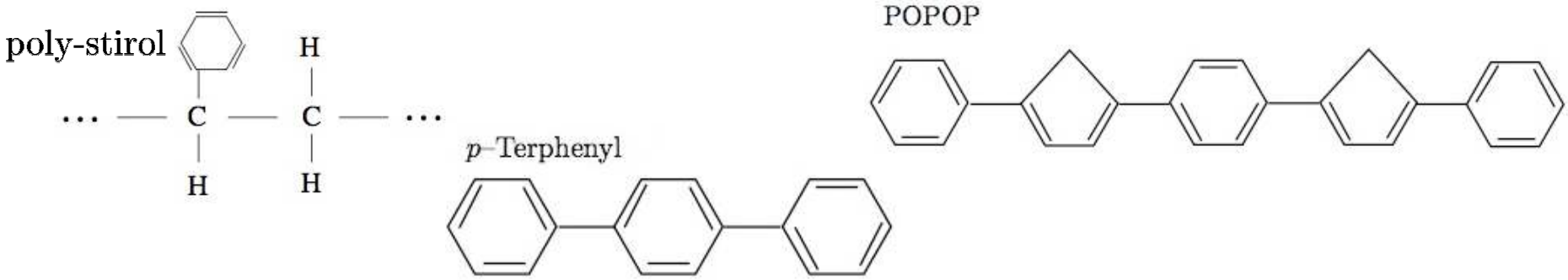


- Establishing the photo-sensor performance is also important !
- The system is capable to measure following properties of the MPPC.
  - Gain
  - Dark noise rate
  - Dynamic range



Plastic Scintillator for the strip production

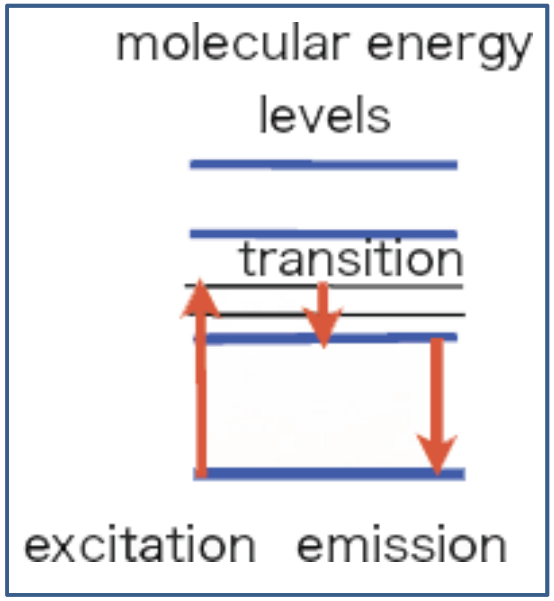
- Base transparent material : poly-stirol
  - with a dopant like p-Terphenyl or POPOP, etc ...



- Energy deposit by passing charged particles is converted to photons by those scintillation dopants.

- The molecular excitation and photon emission occur in order of sub-nano second.
  ⟶ fast response, good timing resolution

- scintillation light wavelength ~300-400nm (ultra violet – violet region).



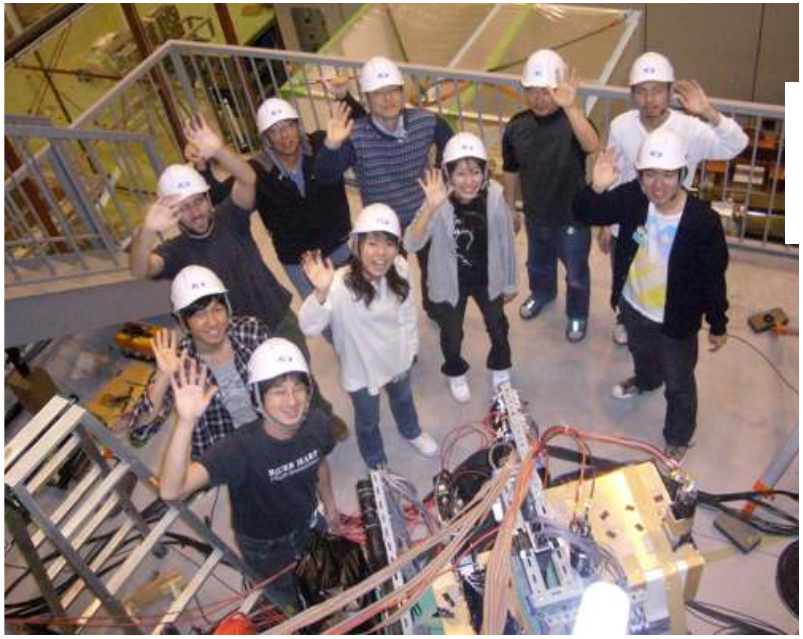
Advantages of the Scintillator-based Detector

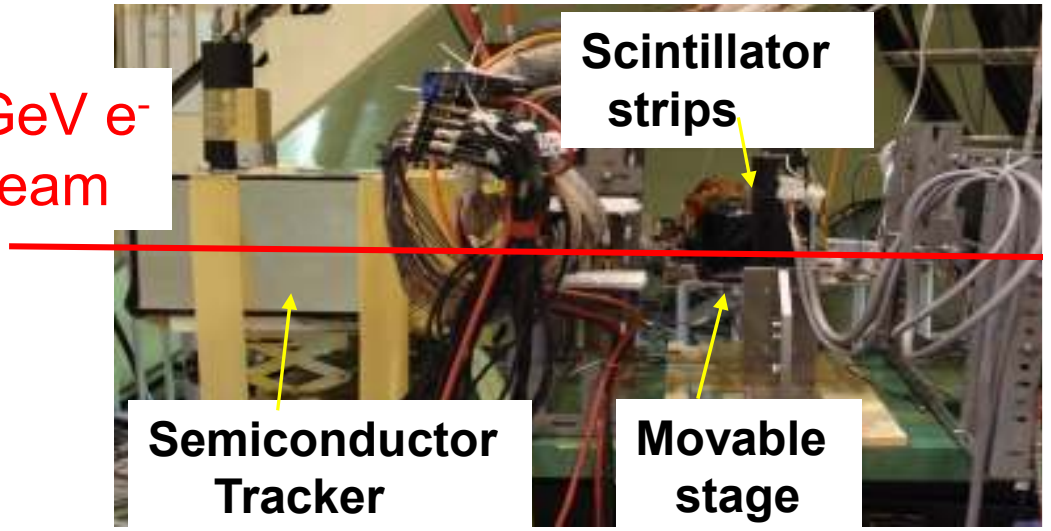
- Robustness, production and handling of the scintillators are well established in past experiments
  - Various scintillators are commonly used in last 40 years for radiation detection and high energy experiments.
- Cost effective
  - Especially for the plastic scintillators, general forming method (extrusion, injection mould) can be used.
  - Photo-sensor price will also be order of $2-3 / piece.
- Neutron sensitive (in organic scintillator case)
  - for hadronic cascade shower, neutrons bring 10-30% of whole incident particle energy. Those neutrons can be efficiently detected by the organic scintillators.

Test of scintillator-strips performance

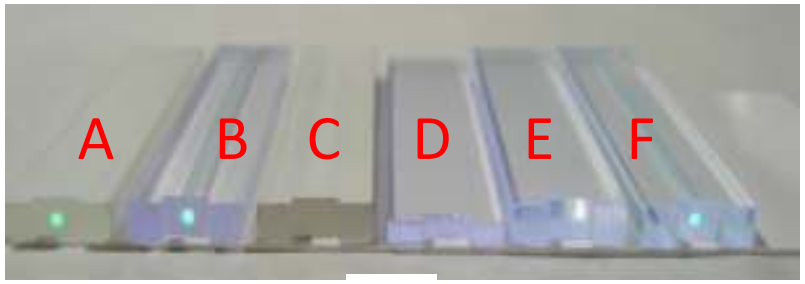
(Nov-2007 at KEK Fuji electron beamline)

- Performance of extruded scintillator-strips with various configurations has been measured at KEK .
- Precise 2-dimensional scanning has been performed to evaluate amount of light signal, hitting position dependence of the strips.

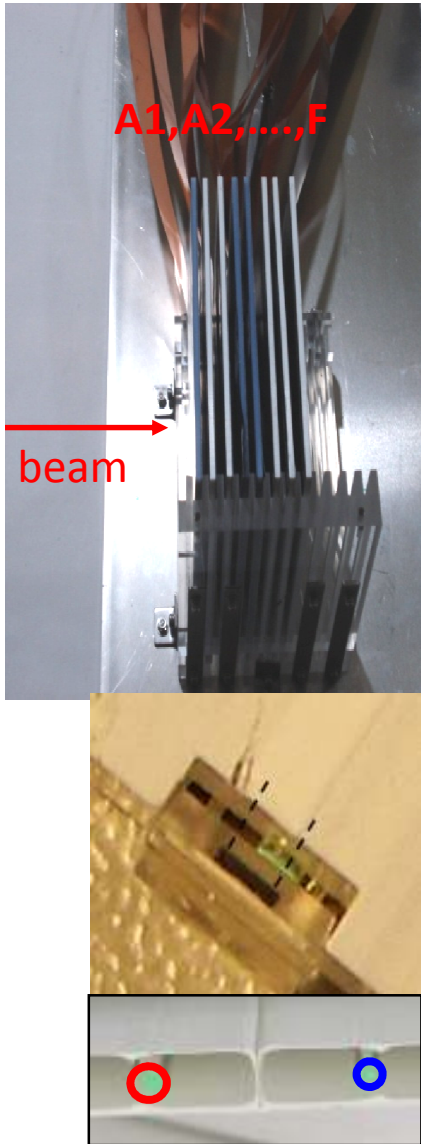




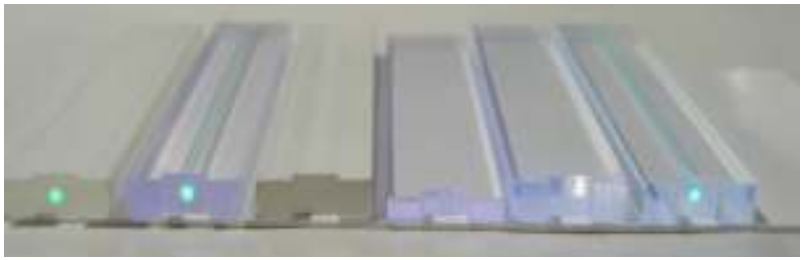
Tested Strips

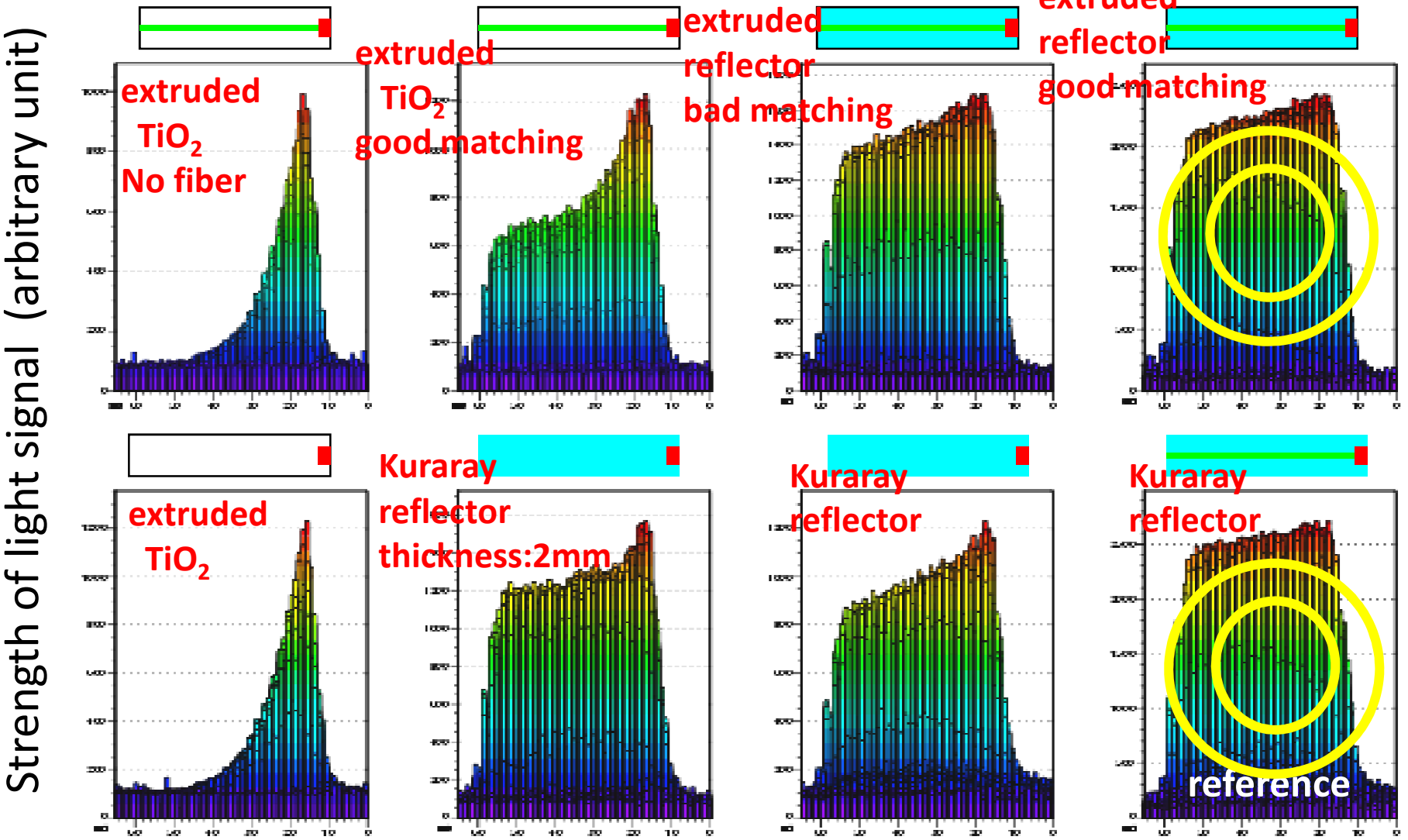


type	Method	Read-out	Cover	**Thickness** (mm)	
A1	Extruded	Fiber	TiO_2	3	No fiber
A2					good matching
B1			**Reflector**		big fiber hole
B2					matched hole size
C		Direct	TiO_2		
D	Kuraray	Direct	**Reflector**	2	
E				3	
F		Fiber			**reference**

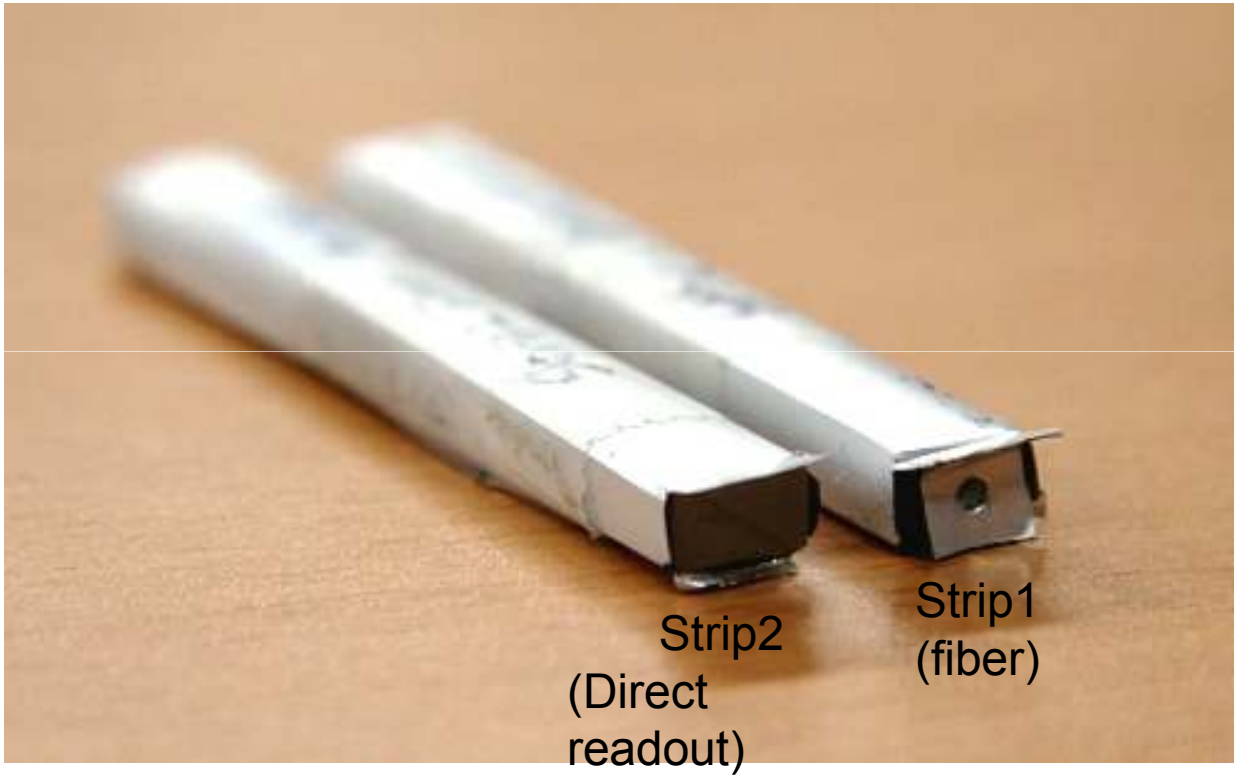


Test results so far





4) With fiber vs Direct readout (5mm)



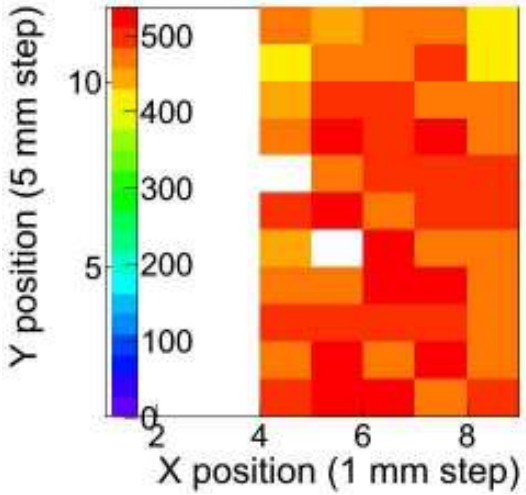
Comparison of the existence of fiber

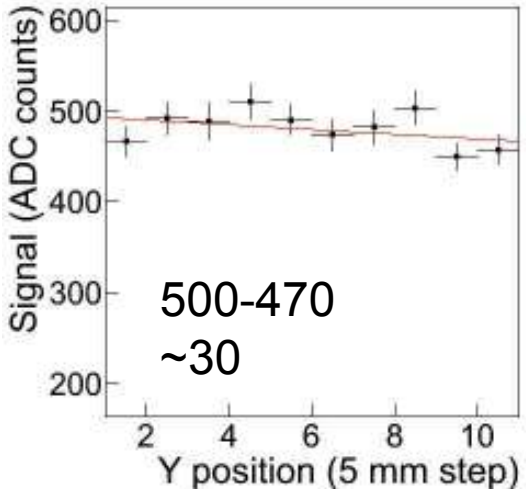
Compare strip with fiber and direct readout while other conditions are same

4) With fiber vs Direct readout(5mm)

Strip 1

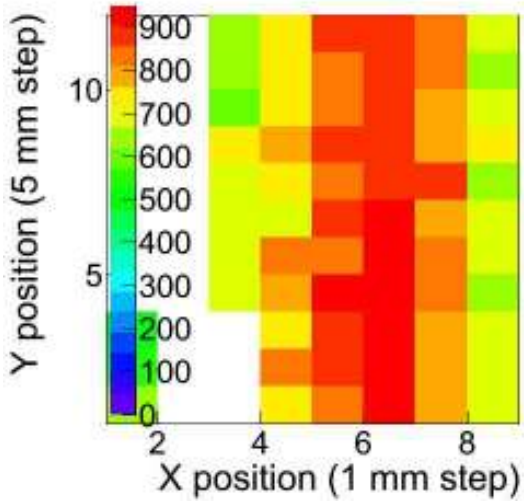
With fiber

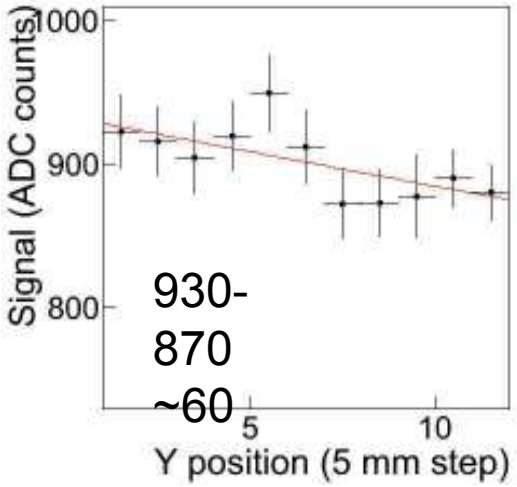




Strip 2

Direct readout





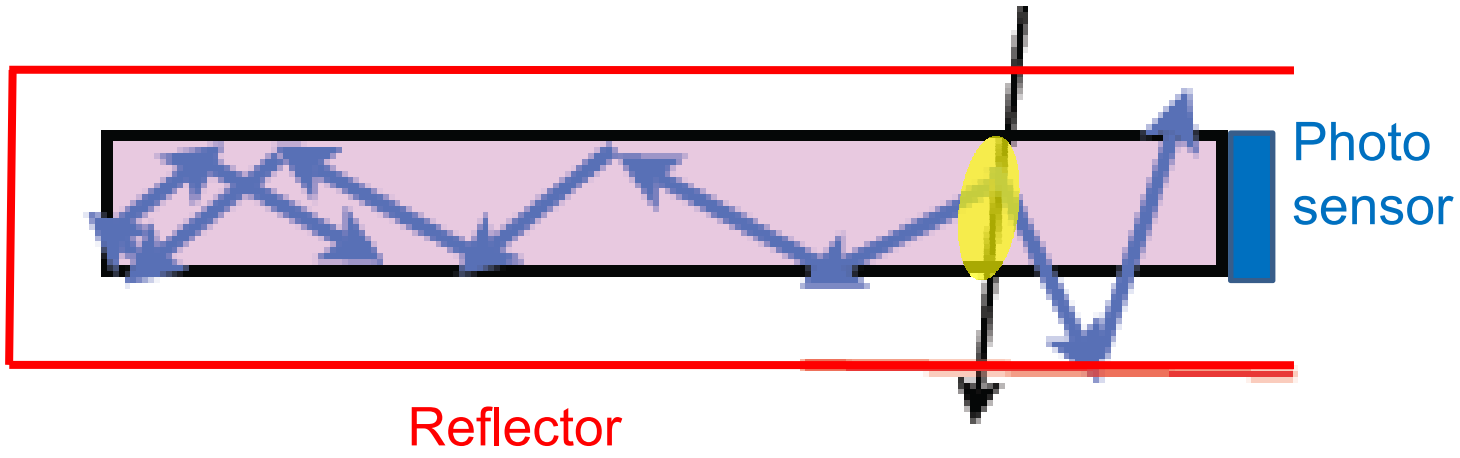
The strip1 with fiber gets lower Light yield than strip2
But uniformity is better.

What we have been done so far with the ScECAL R&D

- We have produced first version of base components (extruded scintillator strip + MPPC) with reasonable performance.
- Variation of the strip performance with some different configurations (covering material, mechanical stability, thickness, etc…) has been tested in some extents.
- Tests of the 1st and 2nd prototypes prove reasonable performance of the ScECAL.
  - Observing shower shape with the fine granular calorimeter.
  - Obtained performance comparable with computer simulation.

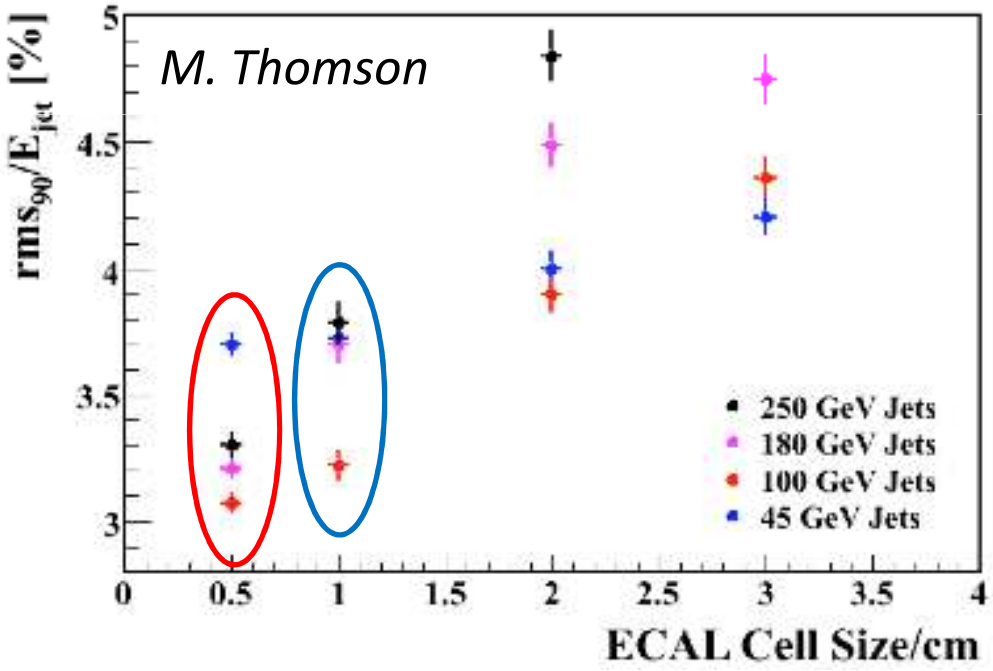
Establishment of Photon Transfer Simulation

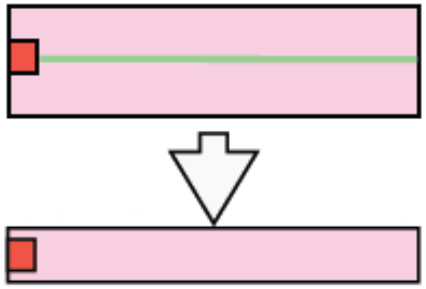
- Developing reliable optical simulation makes any scintillation detector designs much easier.
- Simulation will be based on a simple ray-tracing method with various material parameters.
- Simulation results will be compared with actual measurements at the scintillator-laboratory.



Going to even finer segmentation (1 cm→ 5 mm width, without WLS fiber)

Jet energy resolution by Particle Flow with different segmentation size





First test result with 3 mm thick machined scintillator