

# Scintillator tile-SiPM system development for CALICE Engineering AHCAL Prototype

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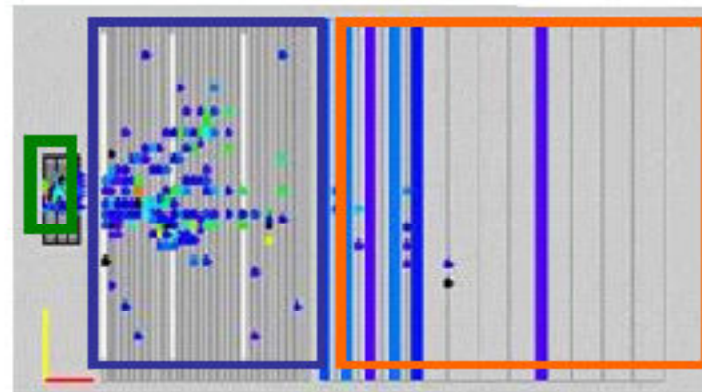
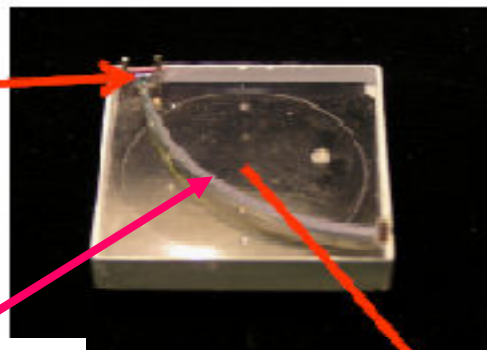
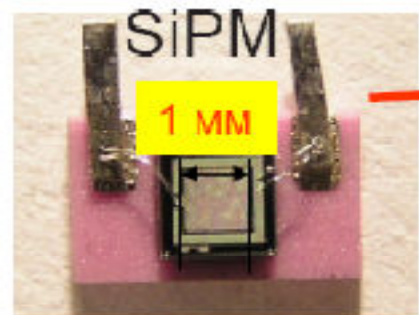
## Outline

New scintillator tile for CALICE engineering prototype

New SiPM for CALICE engineering prototype

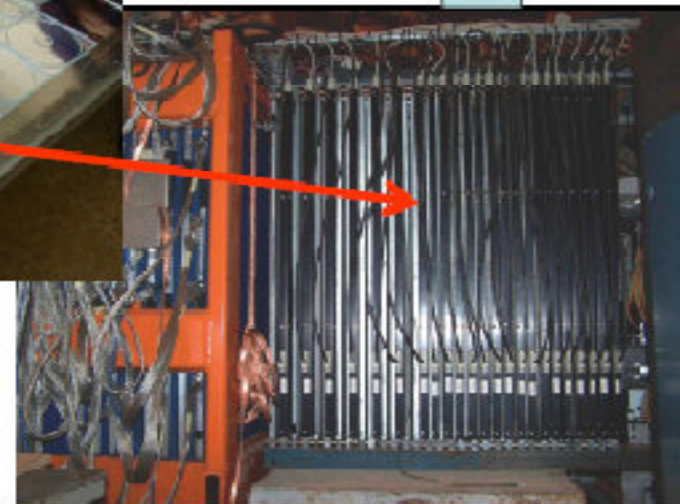
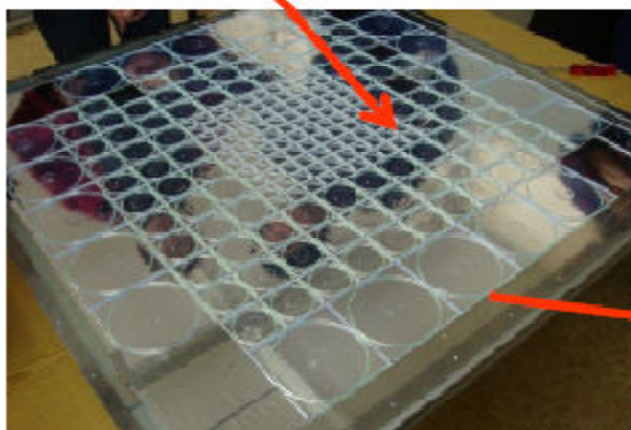
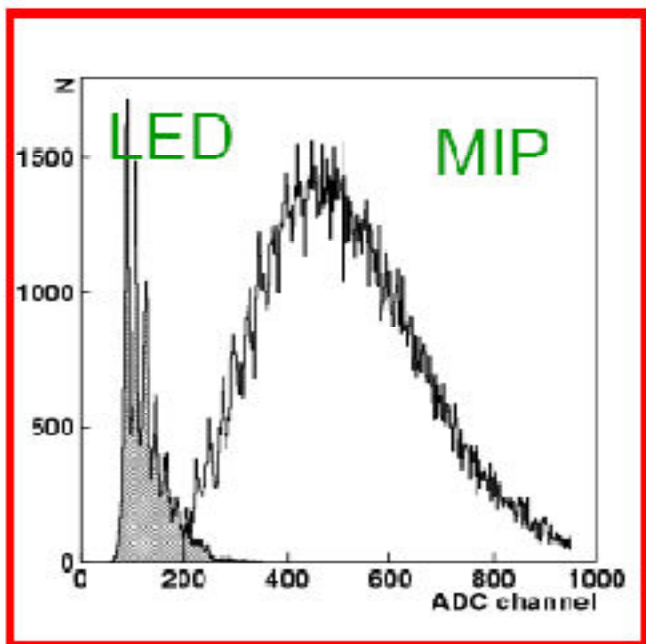
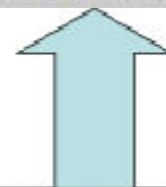
Development of direct (without WLS fiber) tile readout

# CALICE ILC-AHCAL prototype built in 2005-2007



WLS fiber

Tile

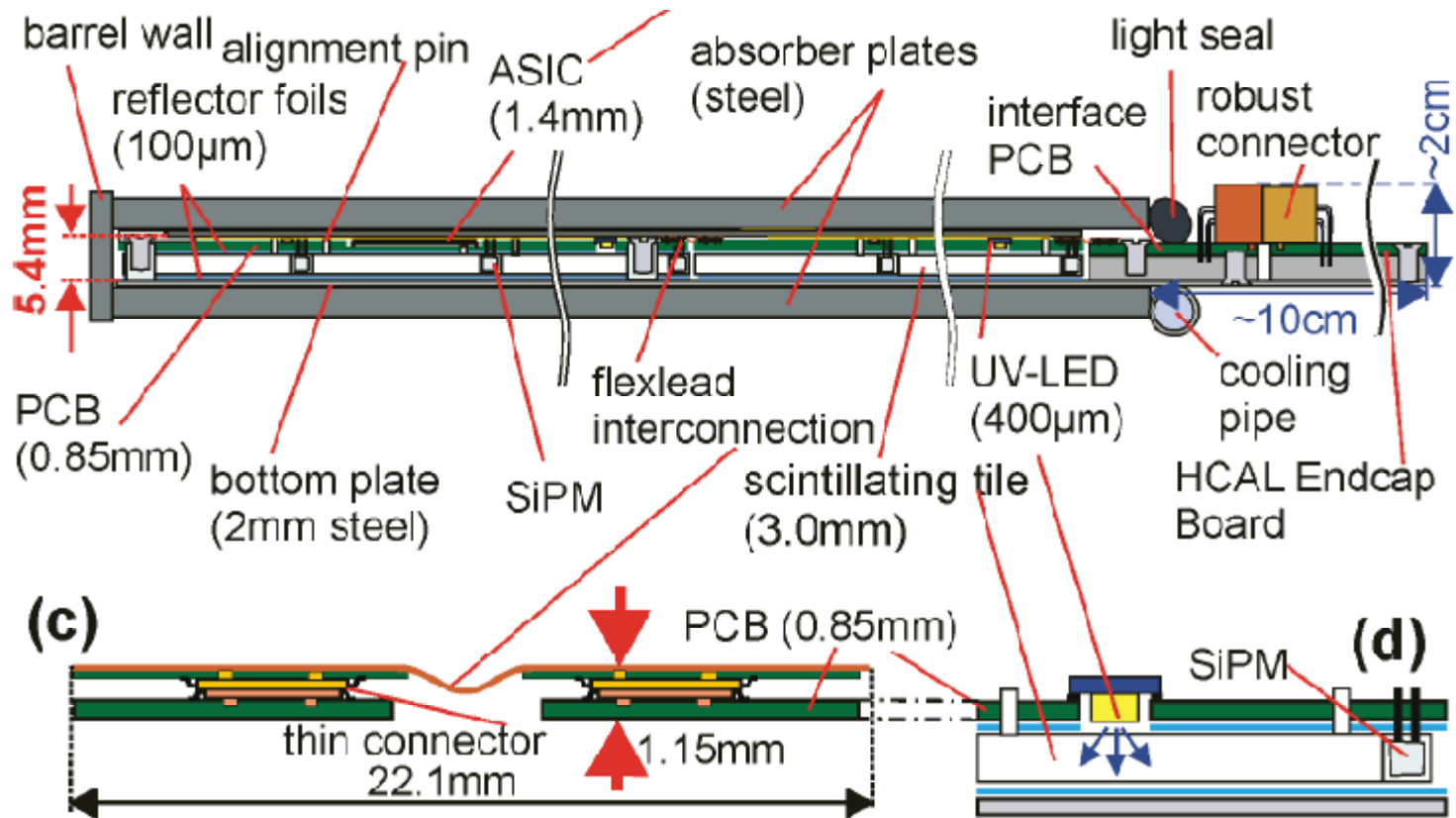


Calorimeter plane

AHCAL with novel SiPM readout demonstrated very reliable performance during beam tests at CERN and FNAL in 2007-2009.

## New engineering prototype

A step towards a scalable and compact detector  
Embedded front end ASICs  
Mechanical structure with minimum dead space

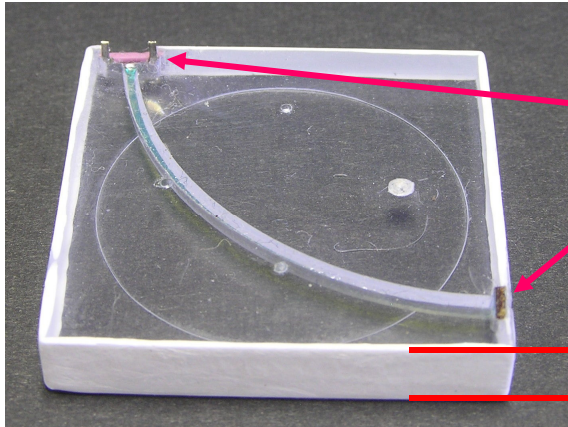


A new compact tile-SiPM system is required

# New tile layout

Tile thickness: 5mm → 3mm, straight fiber, alignment pins, silver mirror

**OLD**



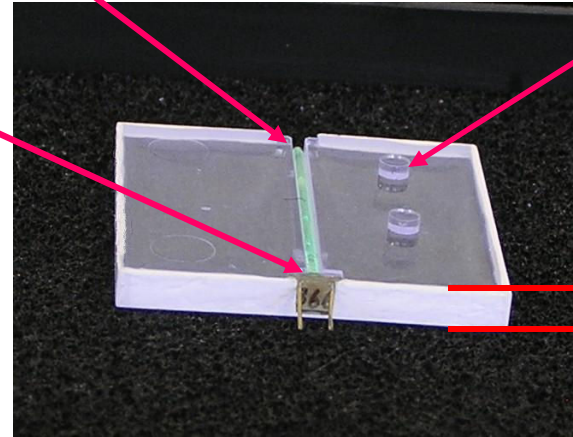
SiPM

3M Mirror

5mm

Silver paint mirror

**NEW**



Alignment pin

3mm

Painting with silver shine paint gives >90% reflectivity

Ratio of light yields for mirrored and blackened fibers

Date	Fiber1	2	3	4	5	6
23/09		1.85	1.98	1.89	1.97	2.06
27/09	1.98	1.86	1.90	1.94	2.01	1.86
15/10	1.93	1.81	2.03	1.90	2.07	1.89
18/11	1.91	1.78	1.91	1.94	1.98	1.89
05/01	1.91	1.75	1.84	1.84	1.91	1.86
21/03	1.86	1.76	1.87	1.83	1.89	1.86

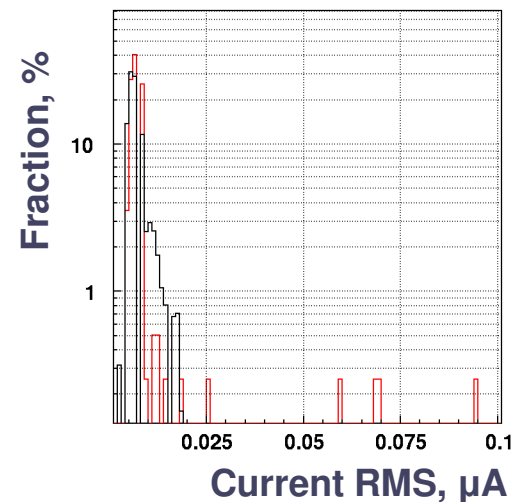
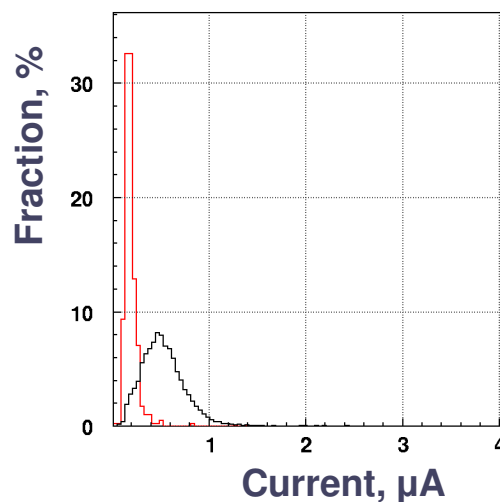
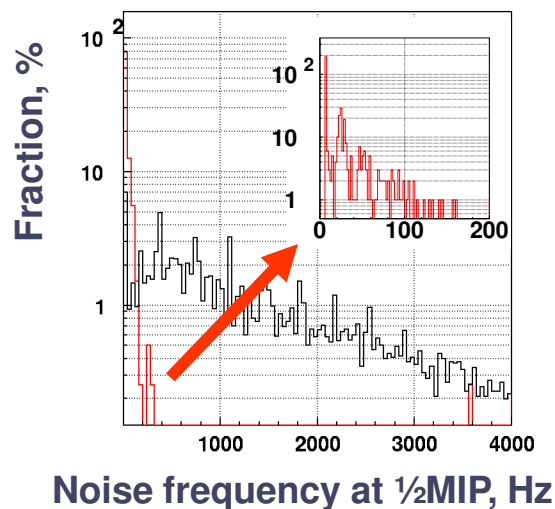
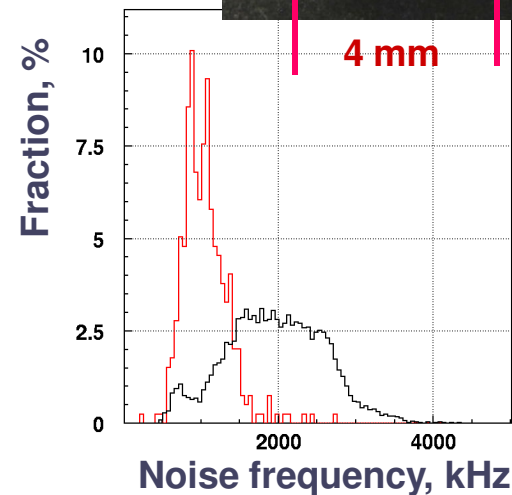
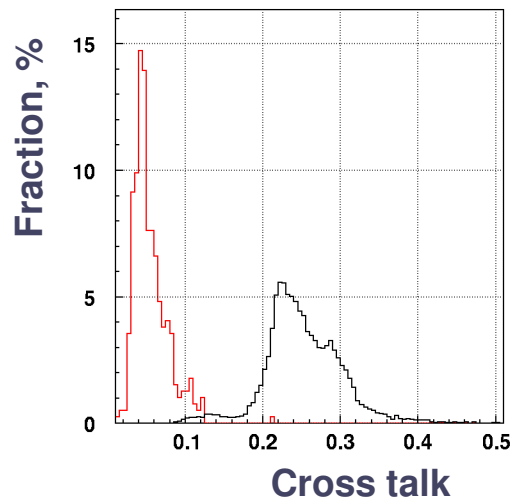
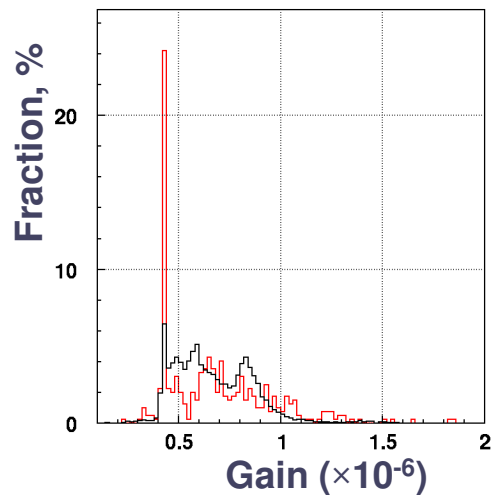
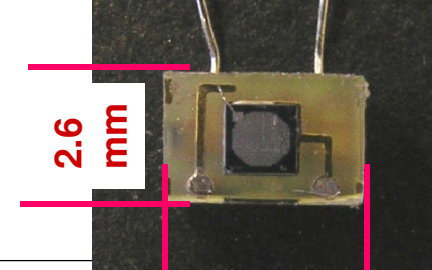
Tile width can be reduced by cutting

Long term stability OK

Measured in one and the same tile using <sup>90</sup>Sr.  
Accuracy ~10%

# New photo sensor for engineering prototype

Comparison of parameters of **old** MEPhi/Pulsar and **CPTA** SiPMs.



**CPTA SiPM is much better. New compact casing**

# Development of new CPTA photosensor

**CPTA SiPM** – 556 cells

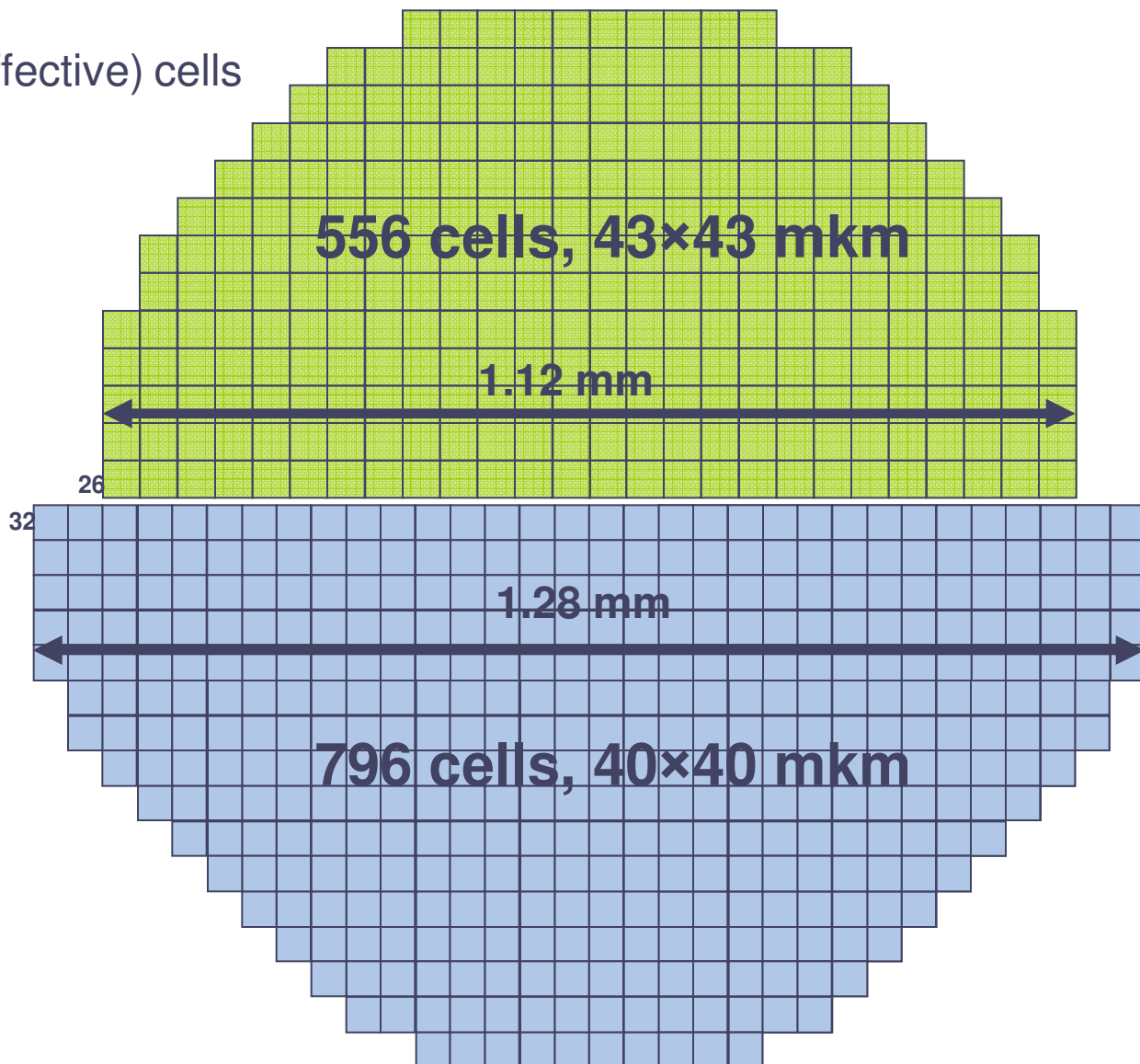
**MEPhI/Pulsar** – 1156 (900 effective) cells

To improve dynamic range:

working point 13p.e. /MIP

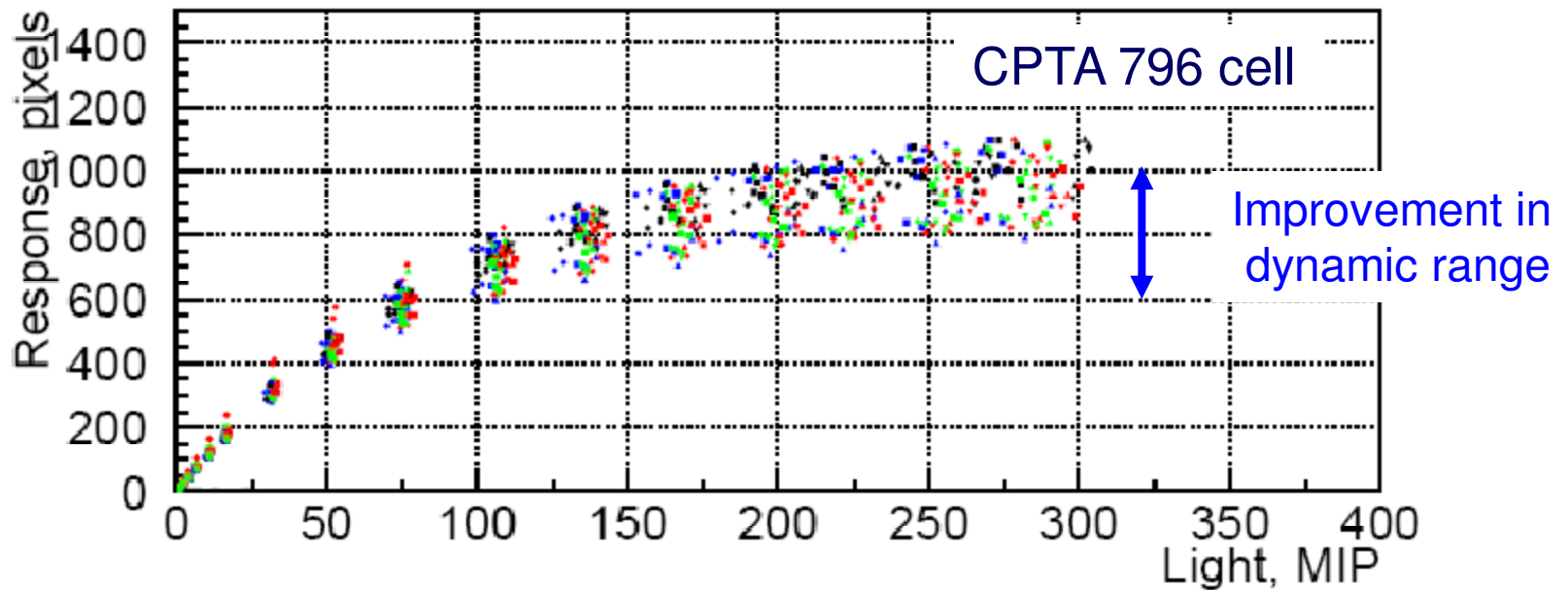
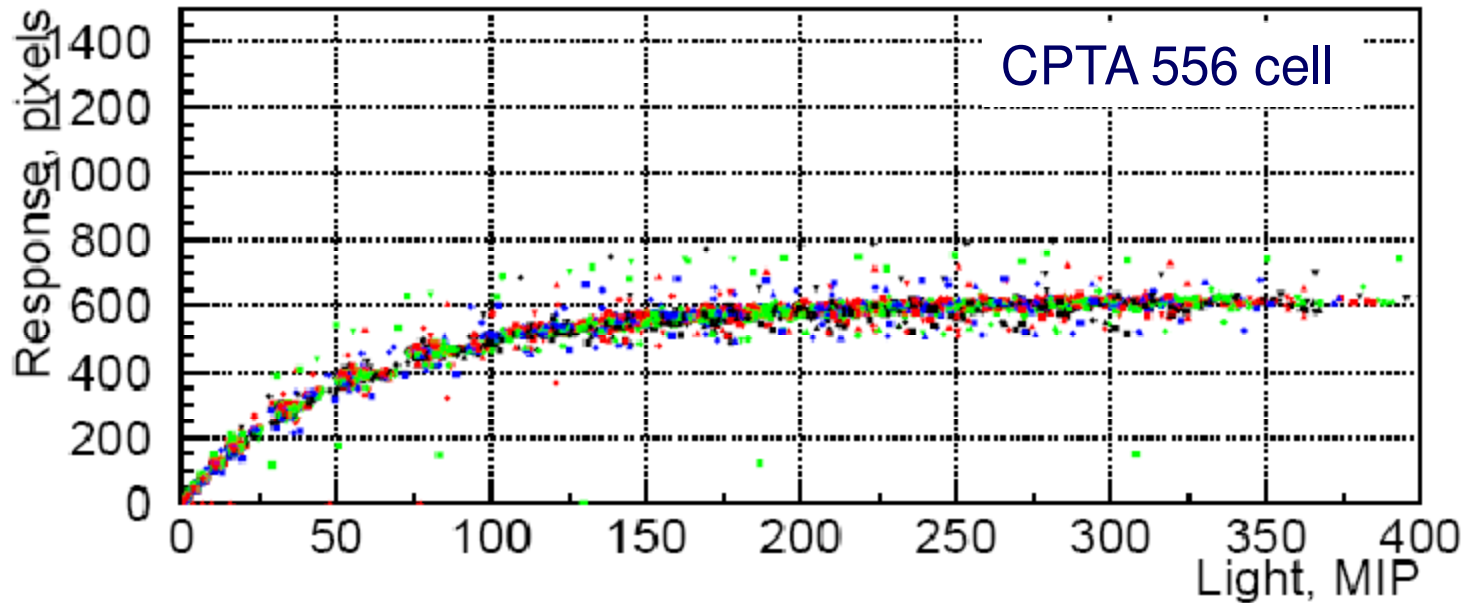
→ 10-11p.e. /MIP

**New sensor**





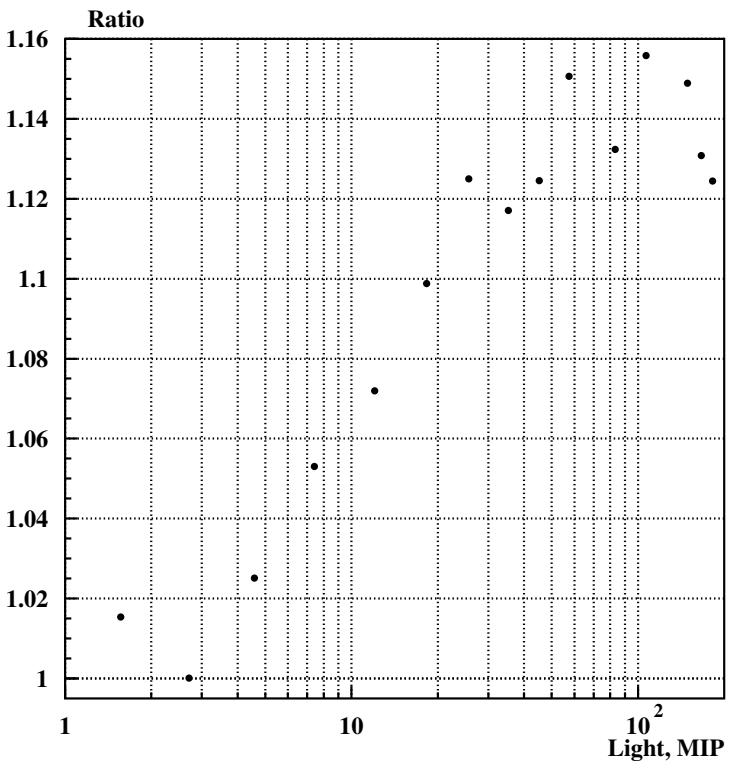
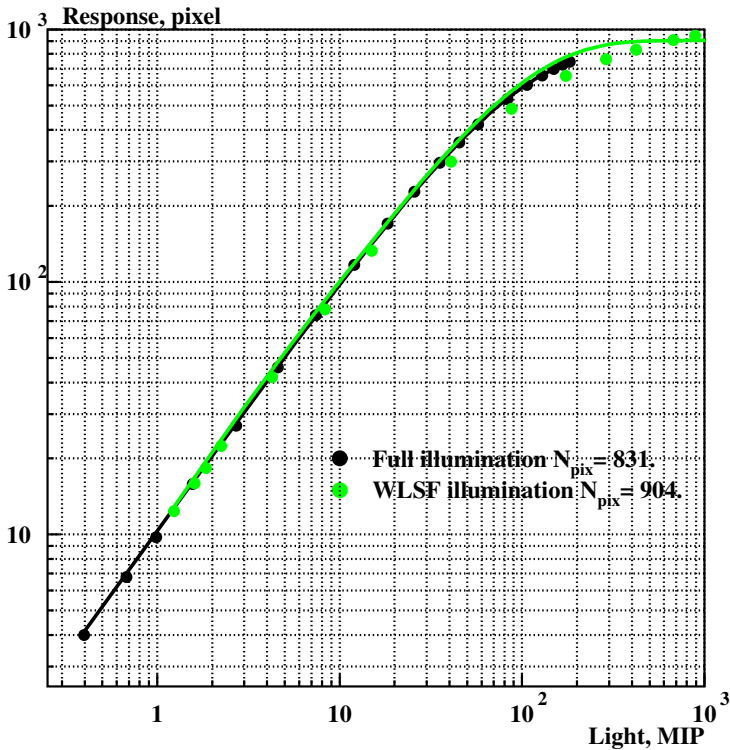
# SiPM saturation curves



WLS fiber in tile illuminates SiPM not uniformly.

Therefore saturation curve for uniform illumination of SiPM lies above points measured in tile

However asymptotic levels are most probably similar (unfortunately it was not possible to achieve more than 200 MIP equivalent for uniform illumination)



Response for uniform illumination is well described by

$$R = N_{pix} (1 - \exp(-N_{pe}/N_{pix})) / (1 - X_{talk} (1 - \exp(-N_{pe}/N_{pix})))$$

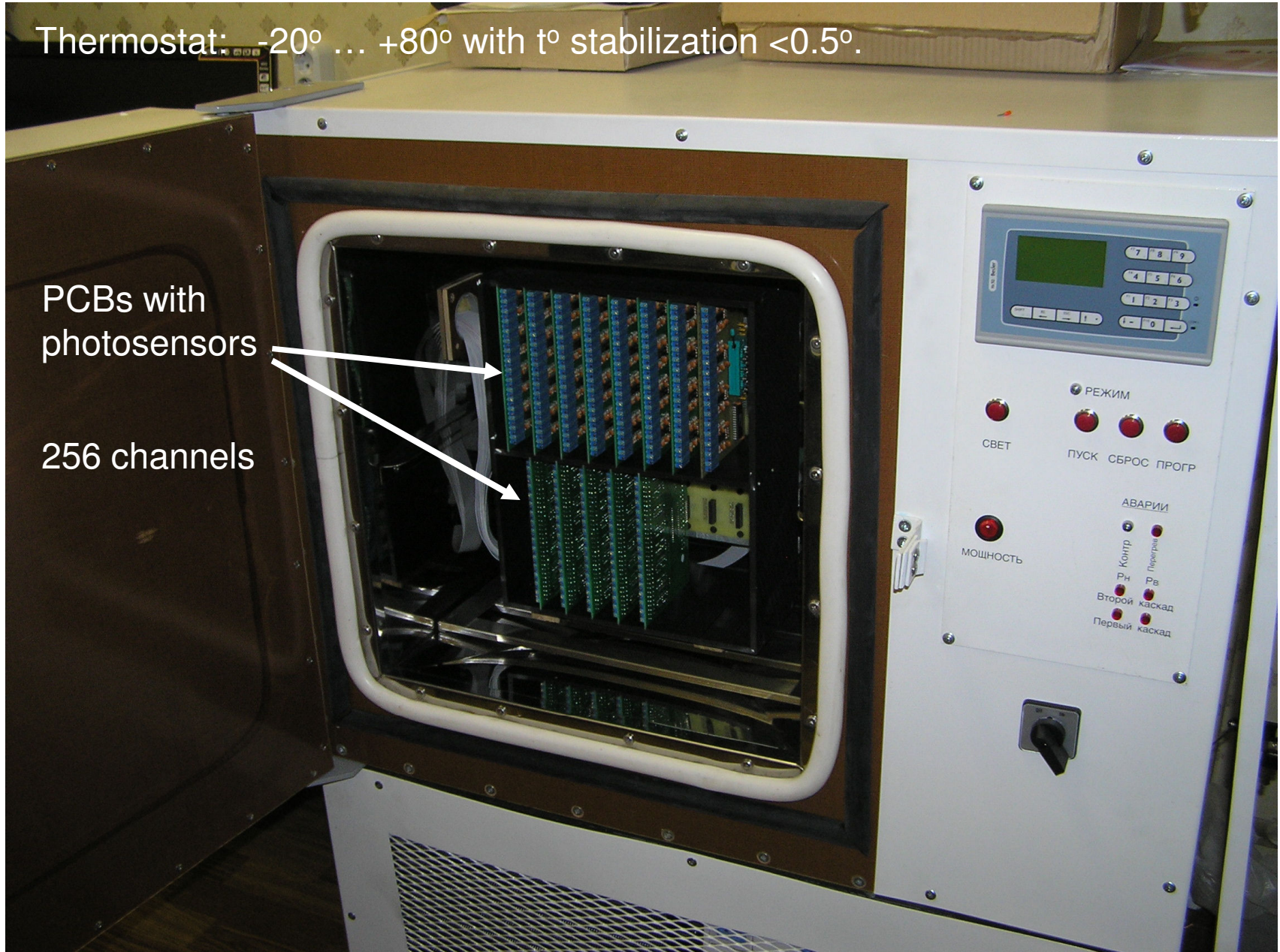


# Setup to measure SiPM long term stability

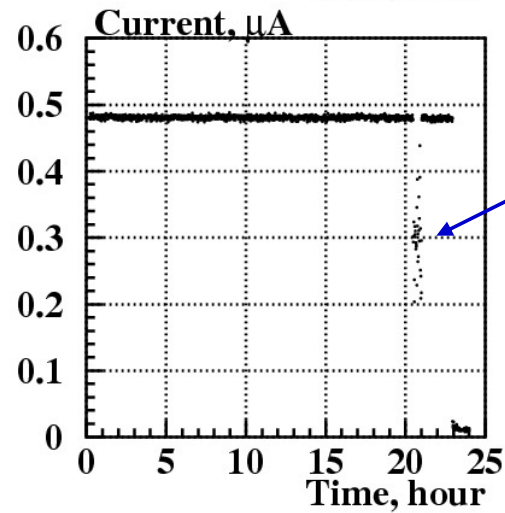
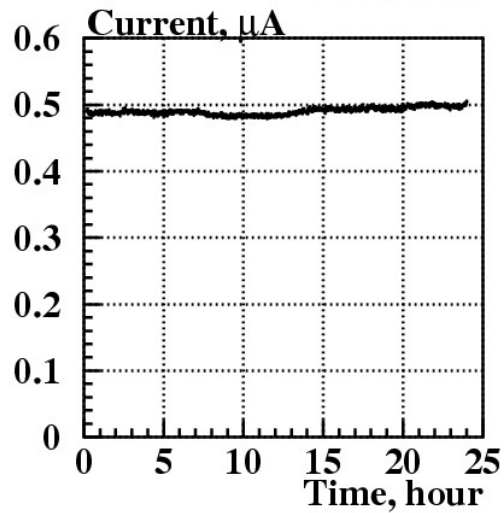
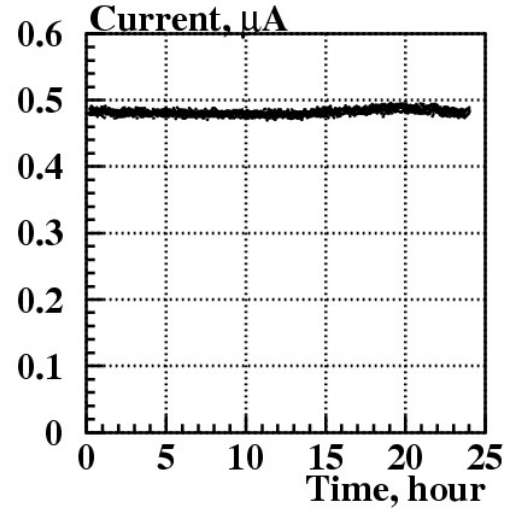
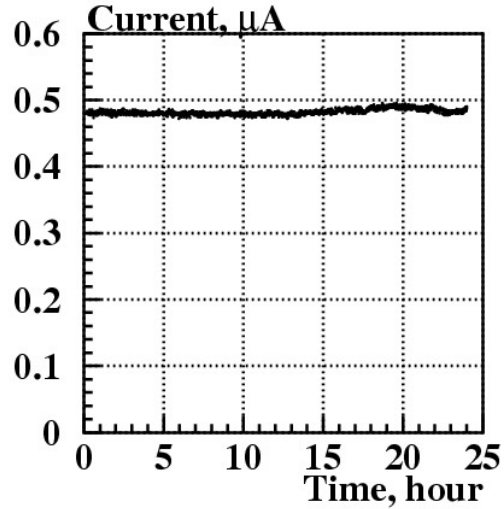
Thermostat:  $-20^{\circ}$  ...  $+80^{\circ}$  with  $t^{\circ}$  stabilization  $<0.5^{\circ}$ .

PCBs with  
photosensors

256 channels



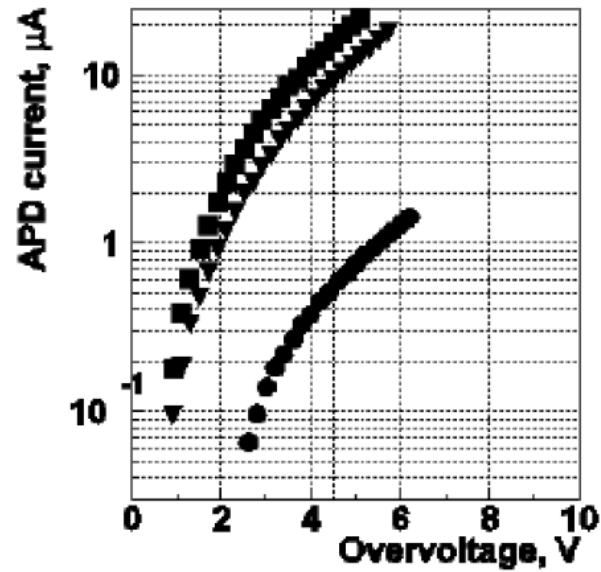
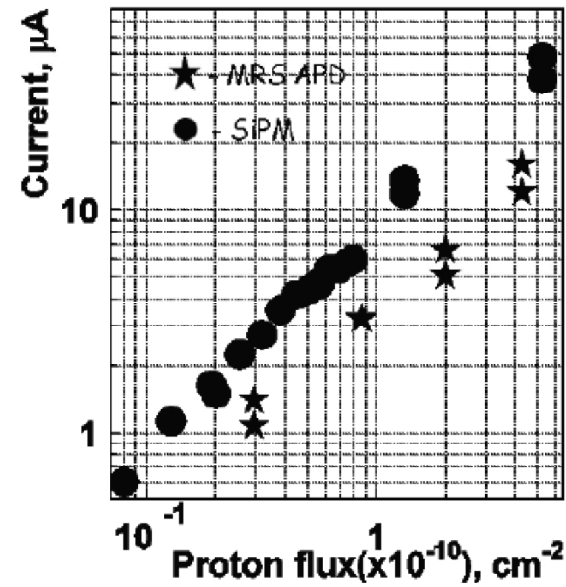
# SiPM long term stability at T=35 C (initial studies of 796 pixel MRS APD)



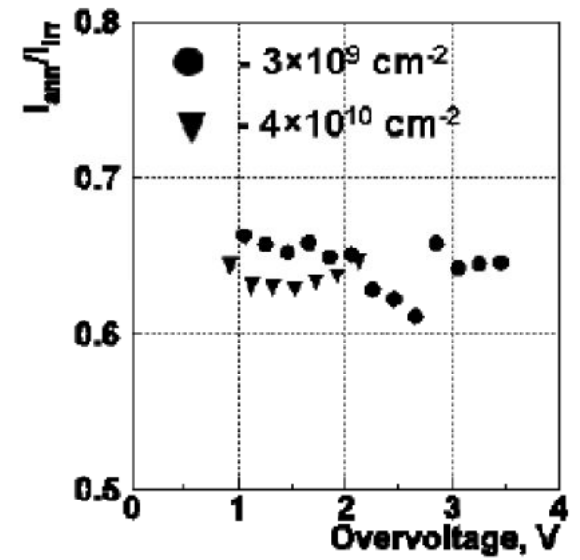
Reason not clear

# Radiation hardness is sufficient for ILC HCAL application

Measurements with 200MeV protons from ITEP synchrotron

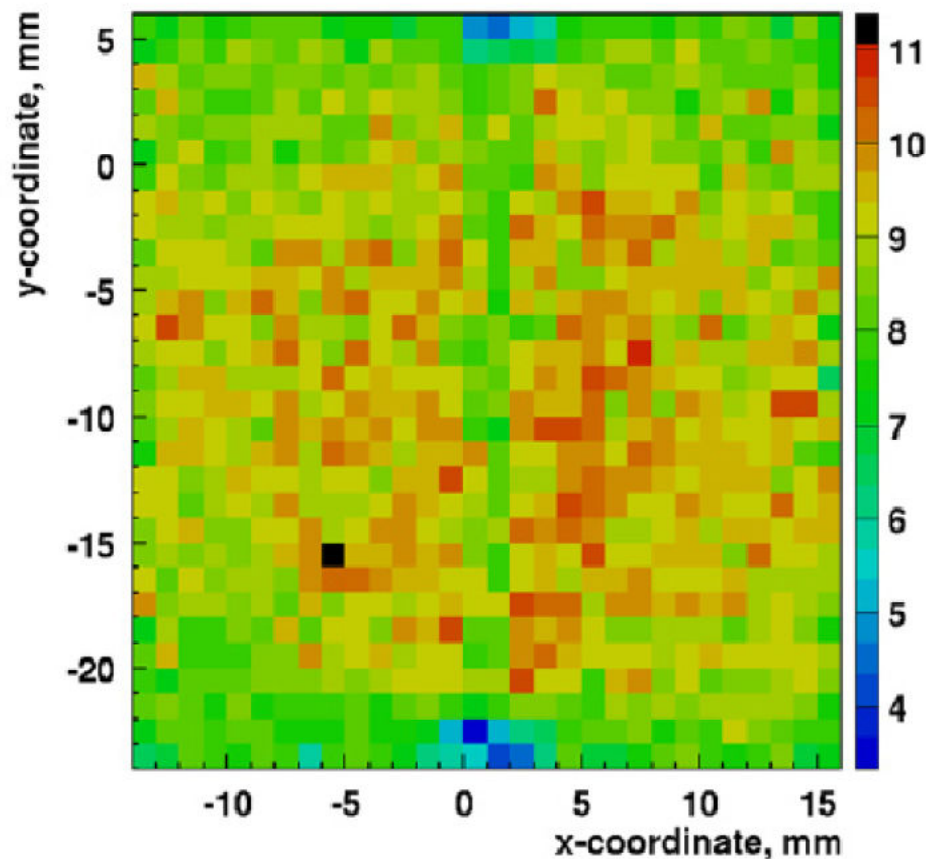


- - before irradiation
- - 1 day after irradiation
- ▼ - 30 days after irradiation





## Uniformity of response for 3 mm thick tile is good enough



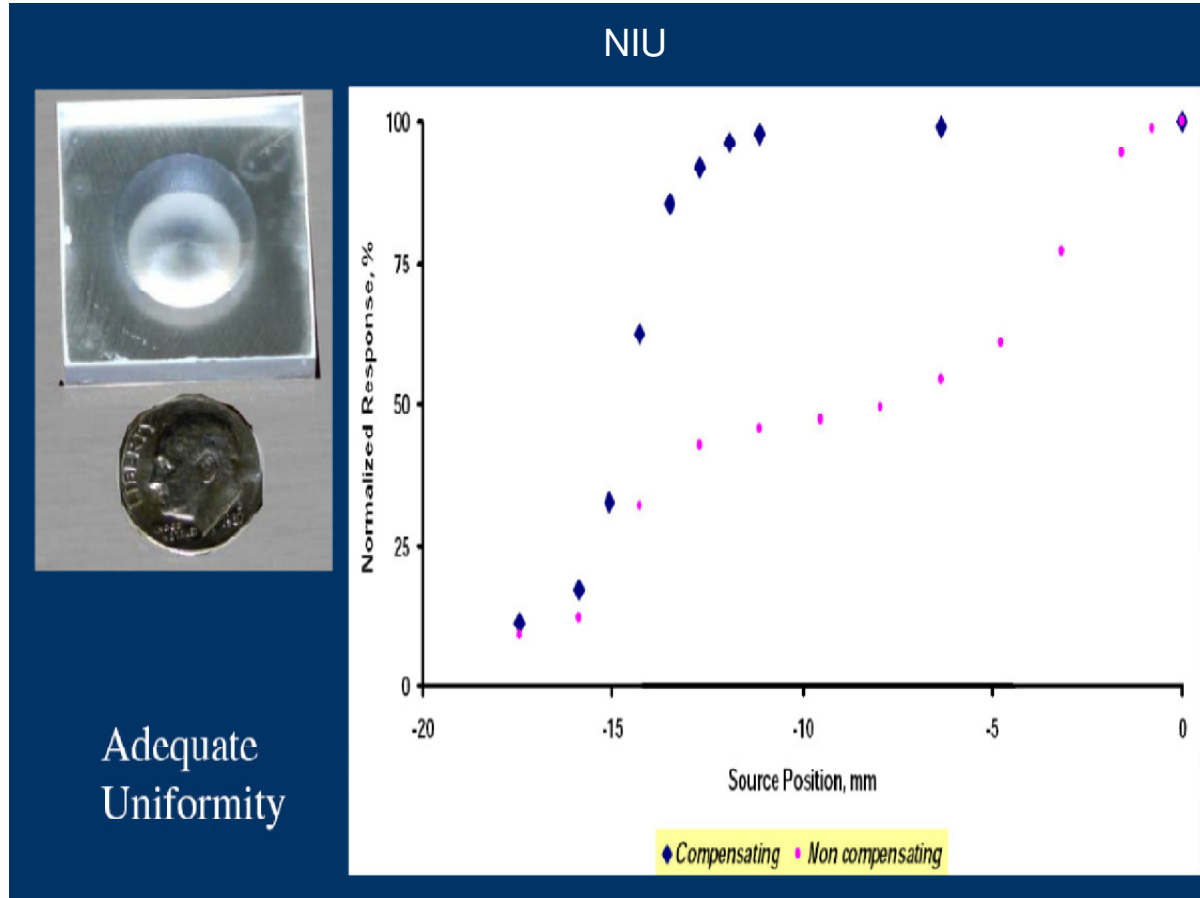
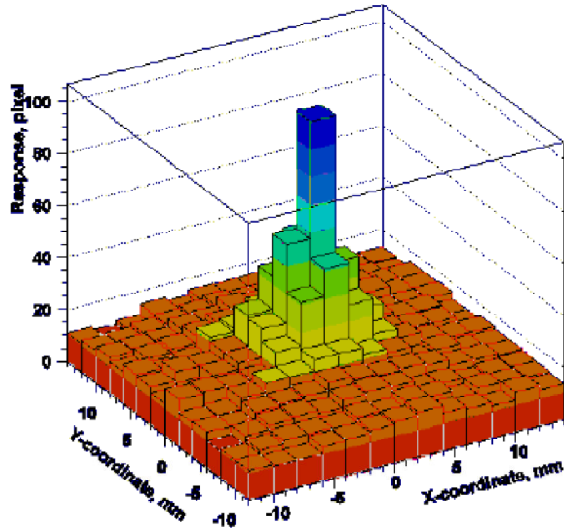
Total efficiency at 0.4 MIP threshold is about 96%

The proposed Tile-SiPM system is adequate to the ILC HCAL requirements

# Direct tile readout without WLS fiber can simplify mass production

Good uniformity of response can be restored by using a dimple (NIU Proposal NIM A 605 277(2009))

Measurement of 30x30x5 mm<sup>3</sup> tile response uniformity at ITEP test beam



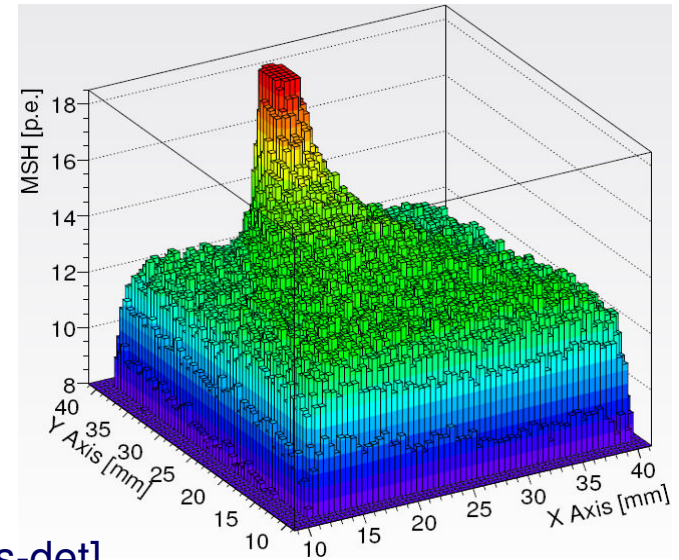
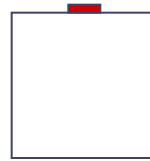
Unfortunately light yield is only 10 p.e. for 5mm thick tile and MPPC 050

Factor of ~3 larger photodetector would solve the problem

# Direct (WLS fiber free) readout with side dimple

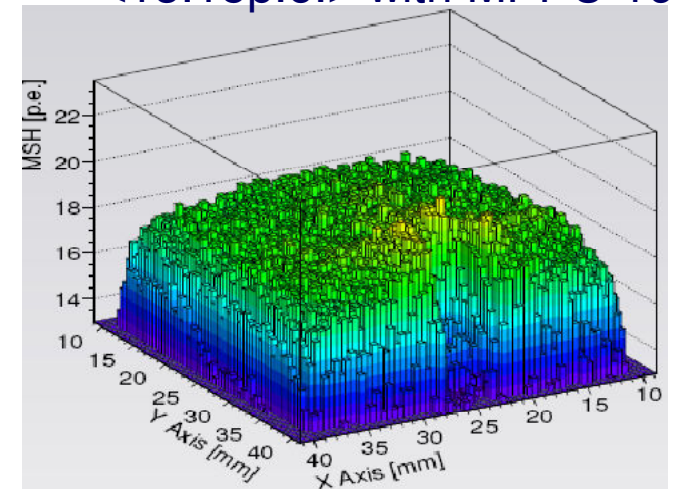
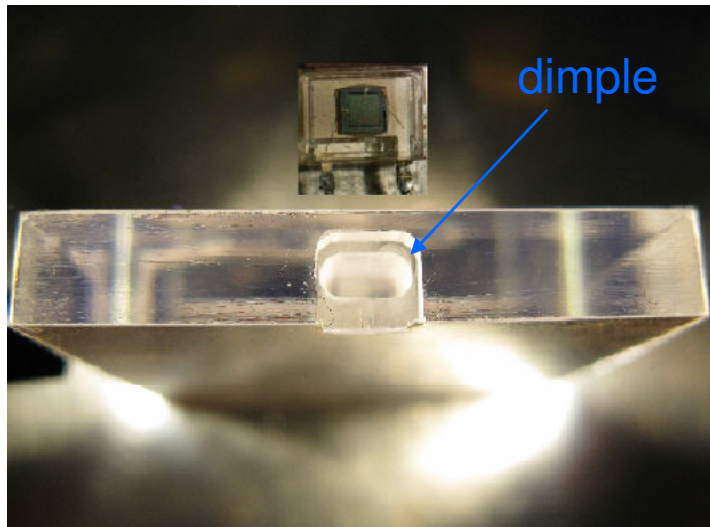
(MPI Munich Proposal)

- + simplification of mass production
- non-uniformity, smaller light yield



C.Soldner, SiPM Workshop, arXiv:1001.665 [physics.ins-det]

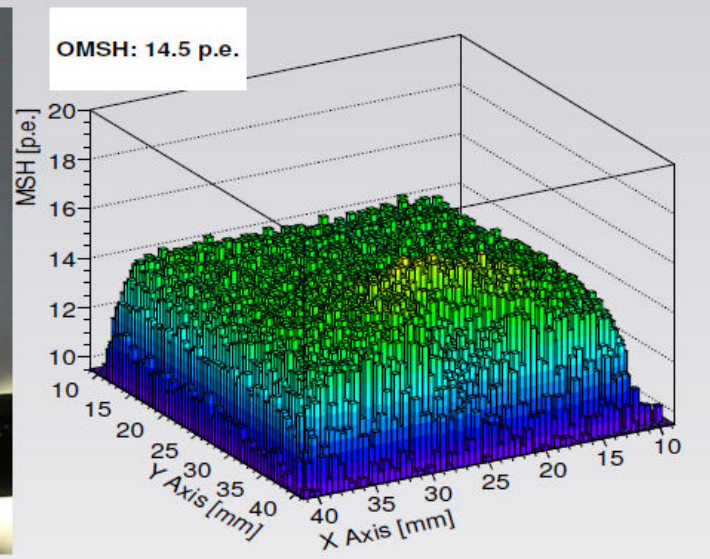
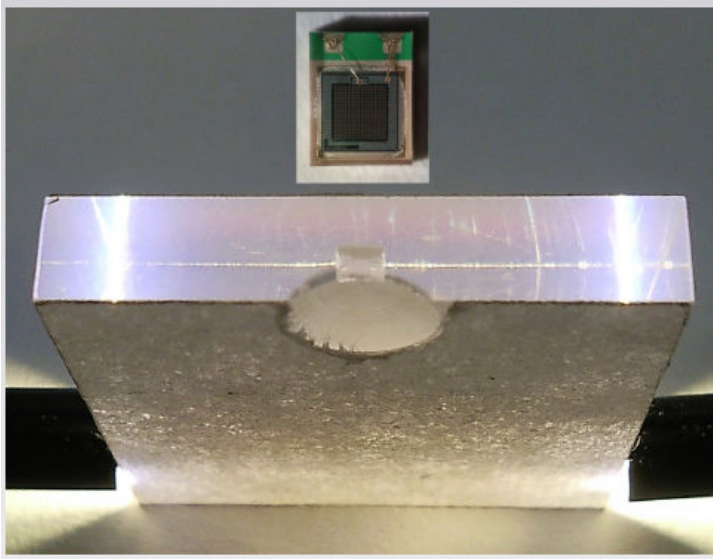
$\langle 13.15 \text{ p.e.} \rangle$  with MPPC-1600



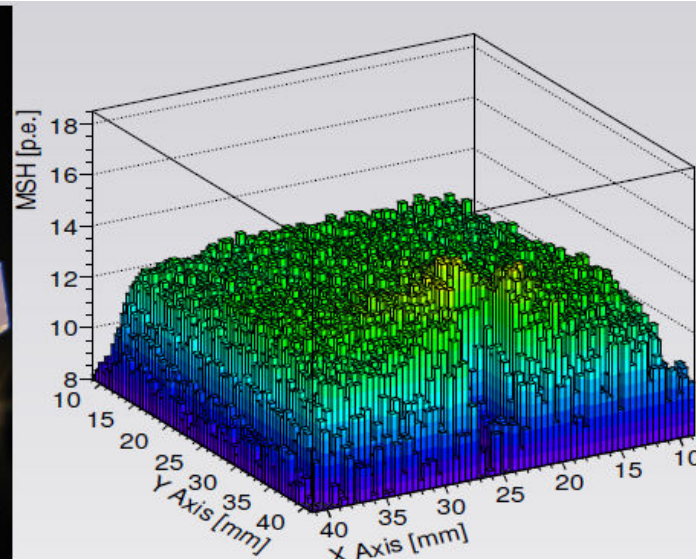
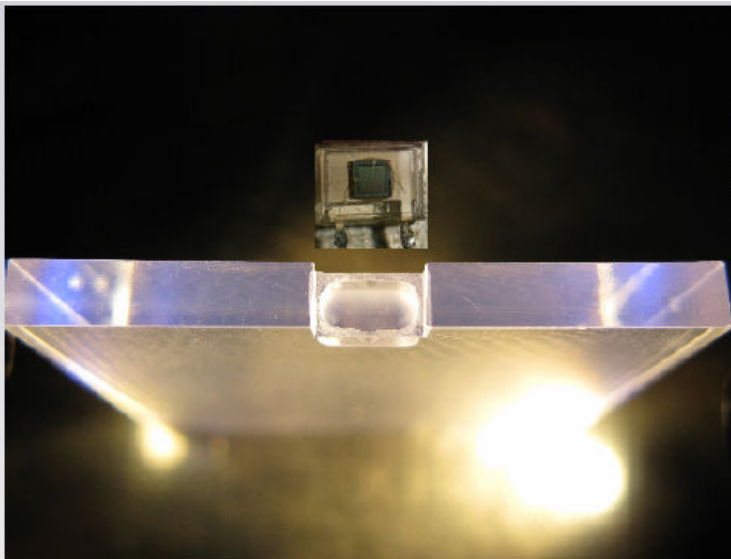
“ideal tile” – polished, wrapped from all sides in 3M foil



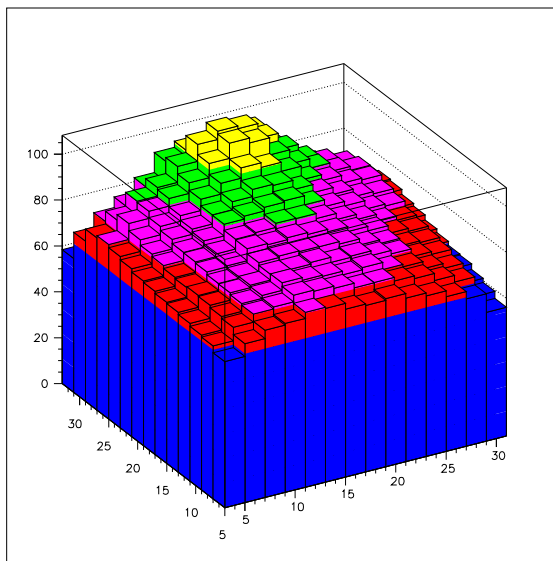
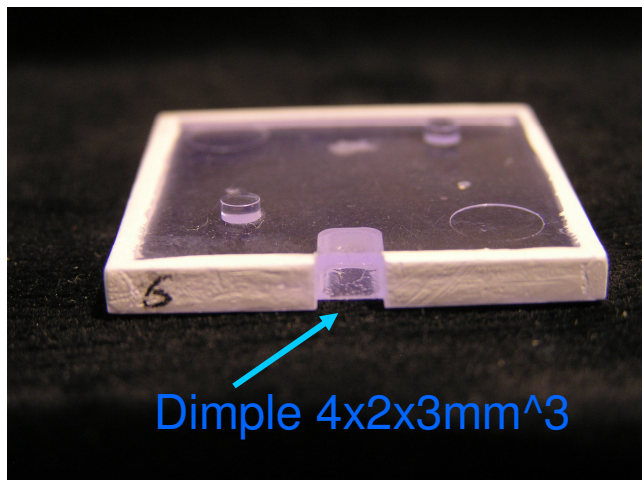
## Bottom Dimple (simpler for molding)



## 3mm thick "ideal" tile



# Uniformity of 3 mm thick molded tile is not yet as good as for the “ideal” tile



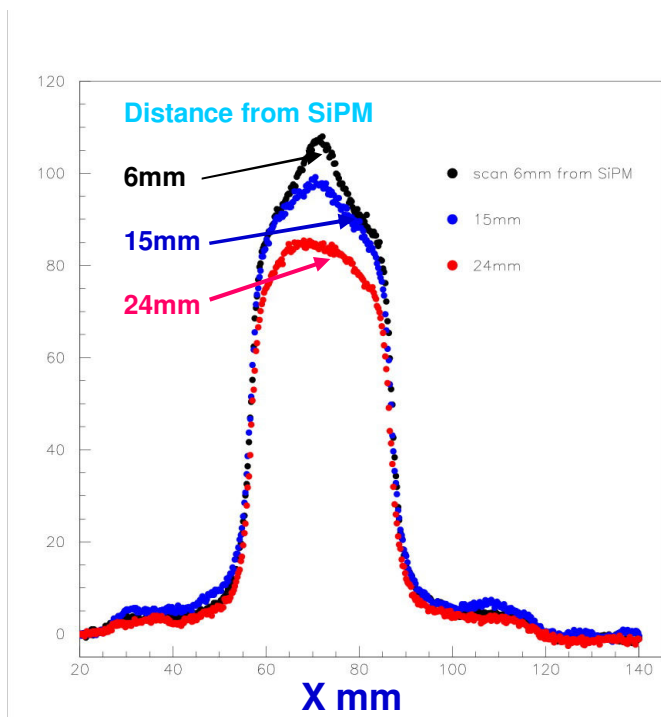
## Possible reasons

Worse scintillator?

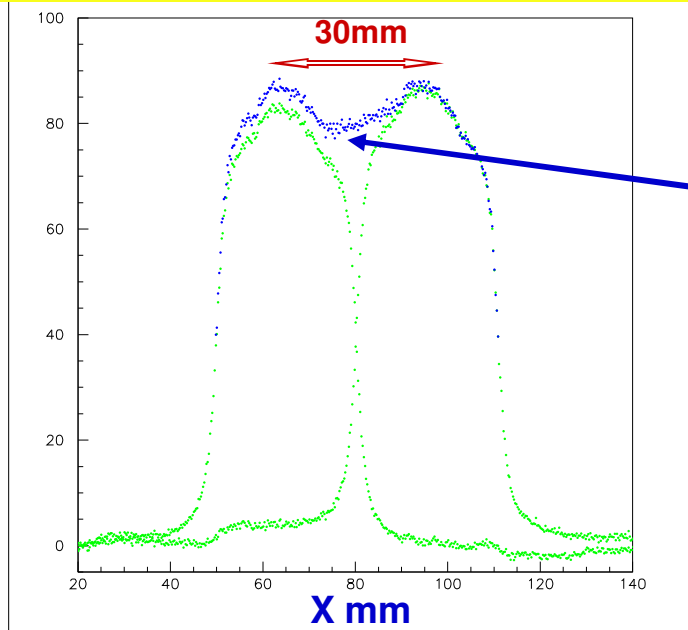
Worse side reflections?

Shape (surface) of dimple?

Sr90 beam without trigger?



## Uniformity is already not so bad



Sum of signals from 2 neighbor tiles.  
Scan at 15mm from SiPM

## Light yield in tile center (pixels)

SiPM	MPPC 050P			MPPC 025P		
	passport	+ 0.3V	+ 0.6V	passport	+ 0.3 V	+ 0.6 V
Vladimir, mated edges	9.6	12.	14.8	8.5	9.5	10.9
Vladimir, 3M edges	8.			8.1		
Bicron, 3M edges	15.9	20.		16.2	18.4	

For scintillator produced by molding technique light yield is much smaller but still almost sufficient at large over-voltage with MPPC 025P

# Conclusions

New scintillator tile geometry is optimized for the engineering AHCAL prototype

New CPTA photosensor is produced with increased number of cells 556 → 796.

about 300 produced

characteristics – OK

long term stability – to be started soon

Radiation hardness of 796 cell CPTA SiPMs is the same as for 556 cell SiPMs

It is sufficient for ILC HCAL.

**All tile-SiPM systems for the engineering prototype will be ready this year**  
**They are already adequate for the full ILC HCAL**

**Direct readout can simplify mass production and improve timing resolution**

Very encouraging results obtained with top and side dimples

Possibility to use tiles produced by molding is still to be demonstrated