LCWS10
Beijing
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Scintillator tile-SiPM system development for CALICE Engineering AHCAL Prototype

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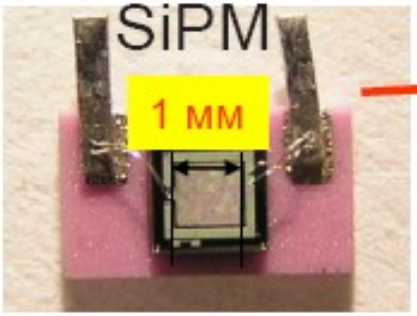
Outline

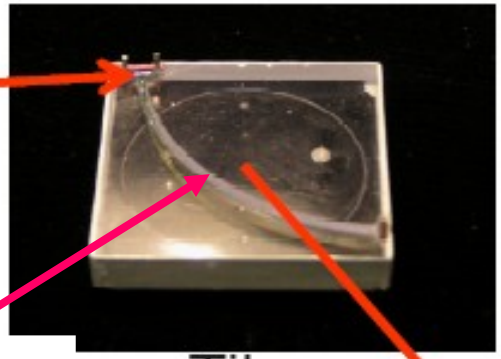
New scintillator tile for CALICE engineering prototype

New SiPM for CALICE engineering prototype

Development of direct (without WLS fiber) tile readout

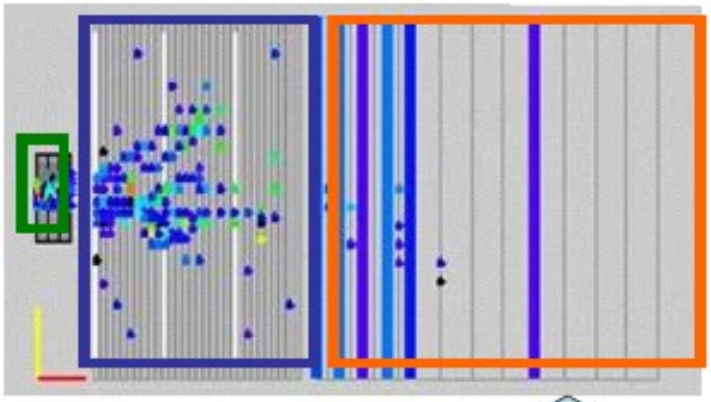
CALICE ILC-AHCAL prototype built in 2005-2007

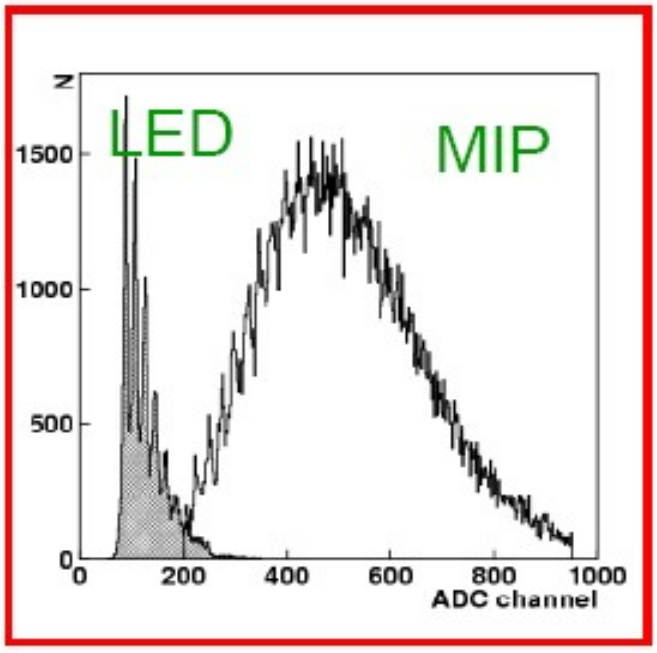


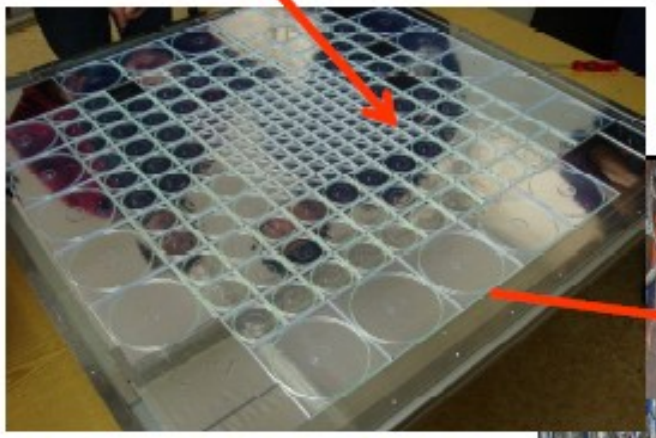


WLS fiber

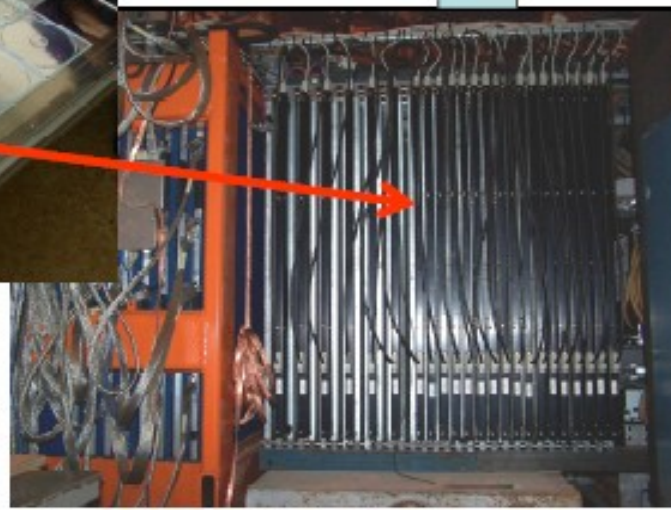
Tile







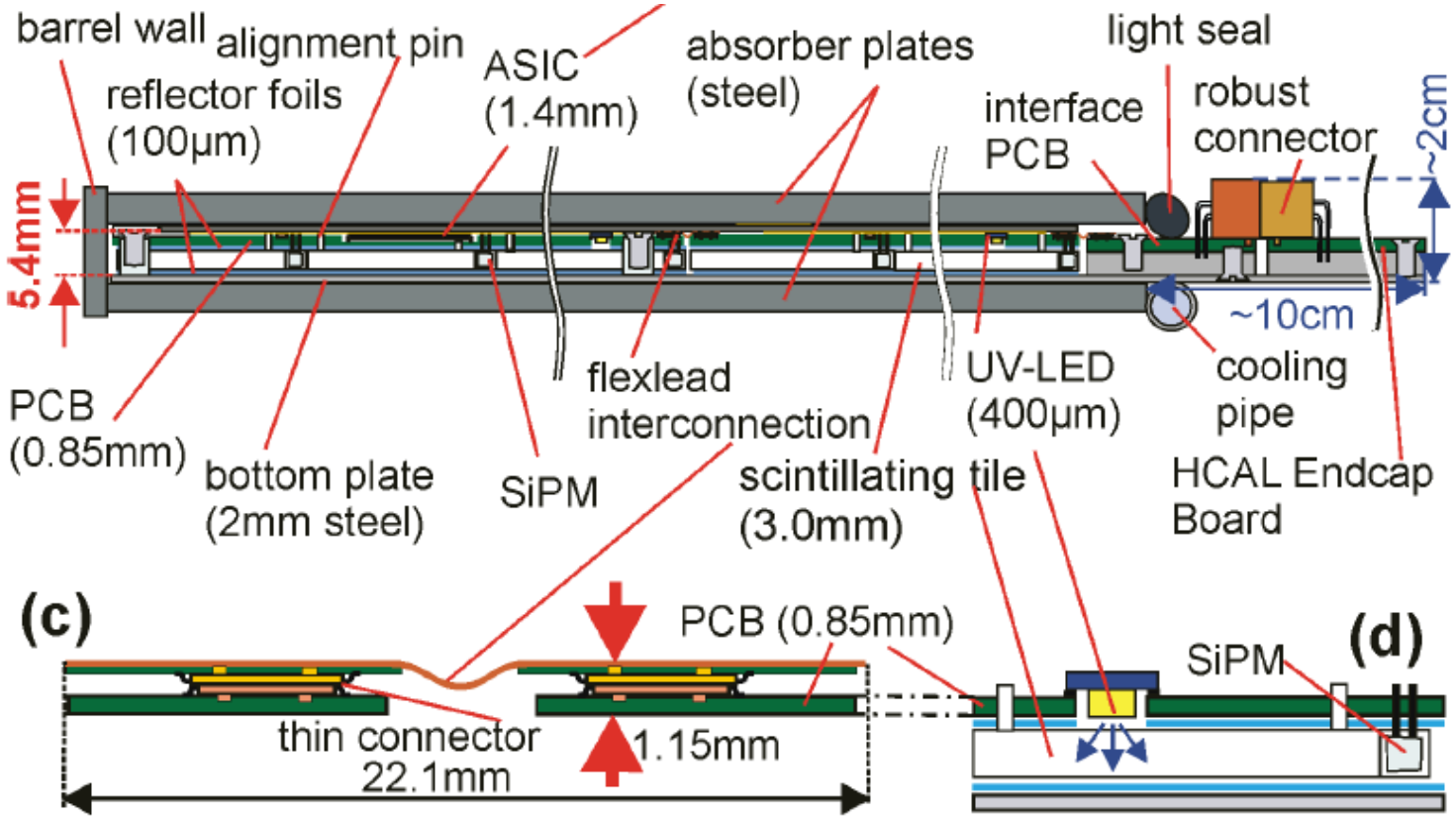
Calorimeter plane



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

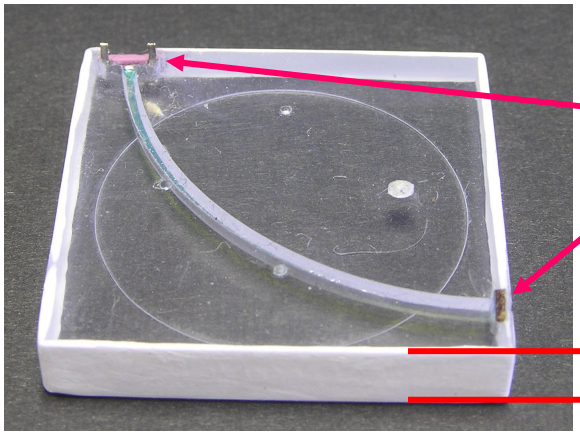


A new compact tile-SiPM system is requiered

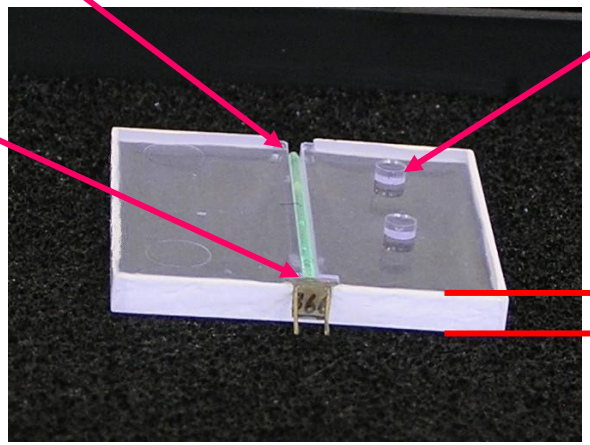
New tile layout

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

OLD



Silver paint mirror NEW



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

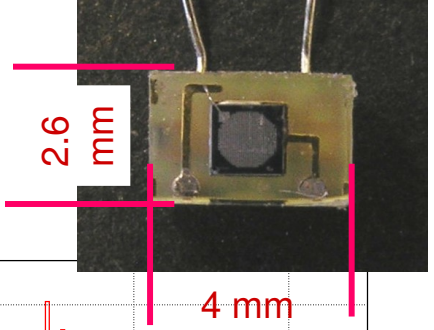
Tile width can be reduced by cutting

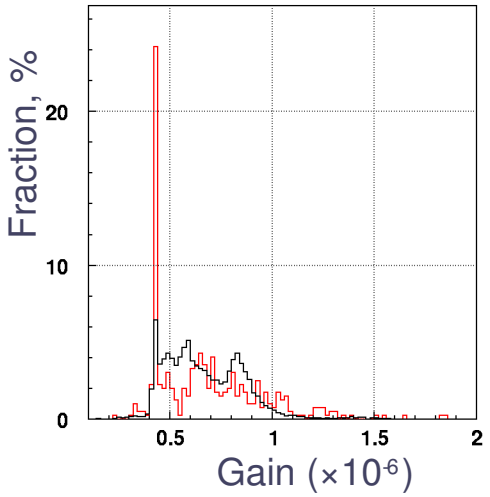
Long term stability OK

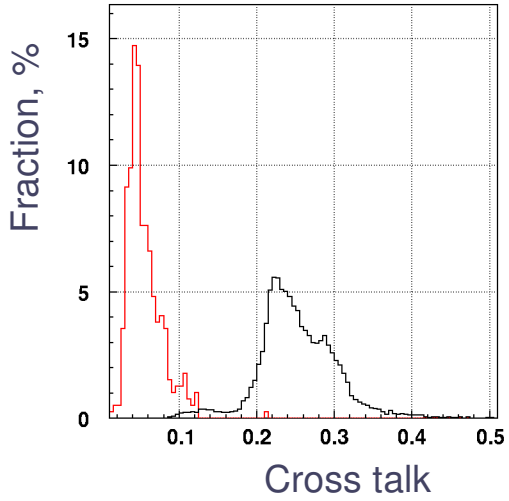
Measured in one and the same tile using 90Sr.
Accuracy ~10%

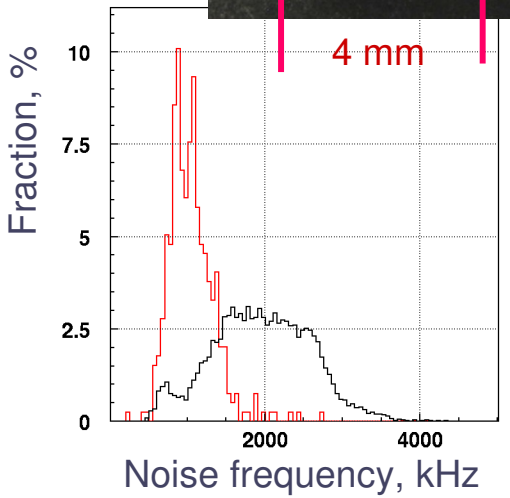
New photo sensor for engineering prototype

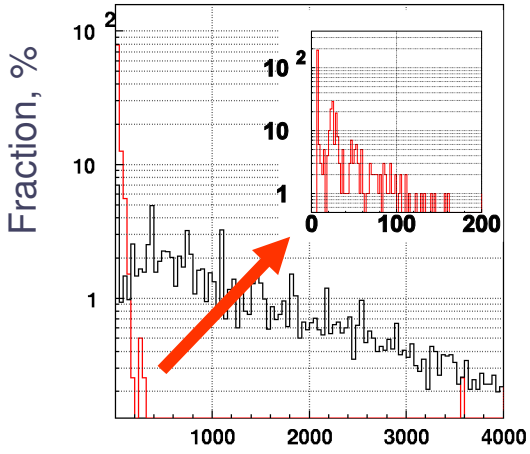
Comparison of parameters of old MEPhI/Pulsar and CPTA SiPMs.

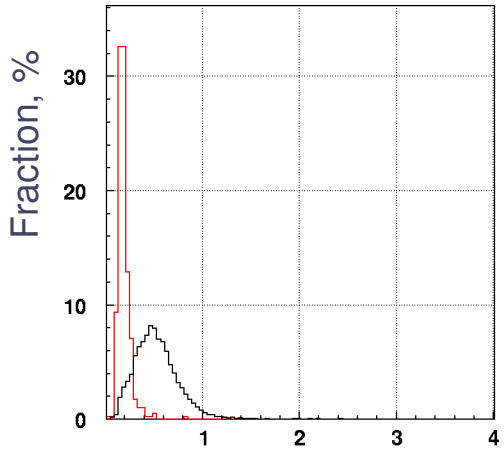


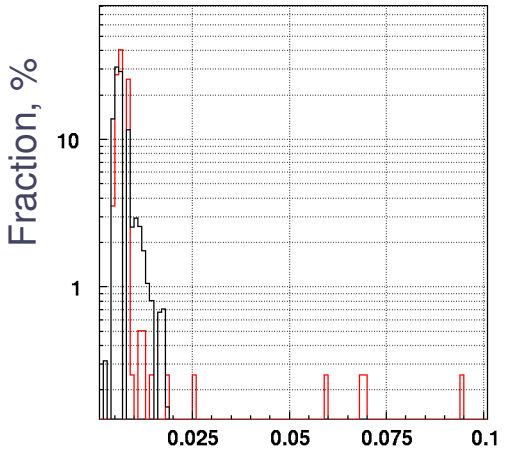












CPTA SiPM is much better. New compact casing

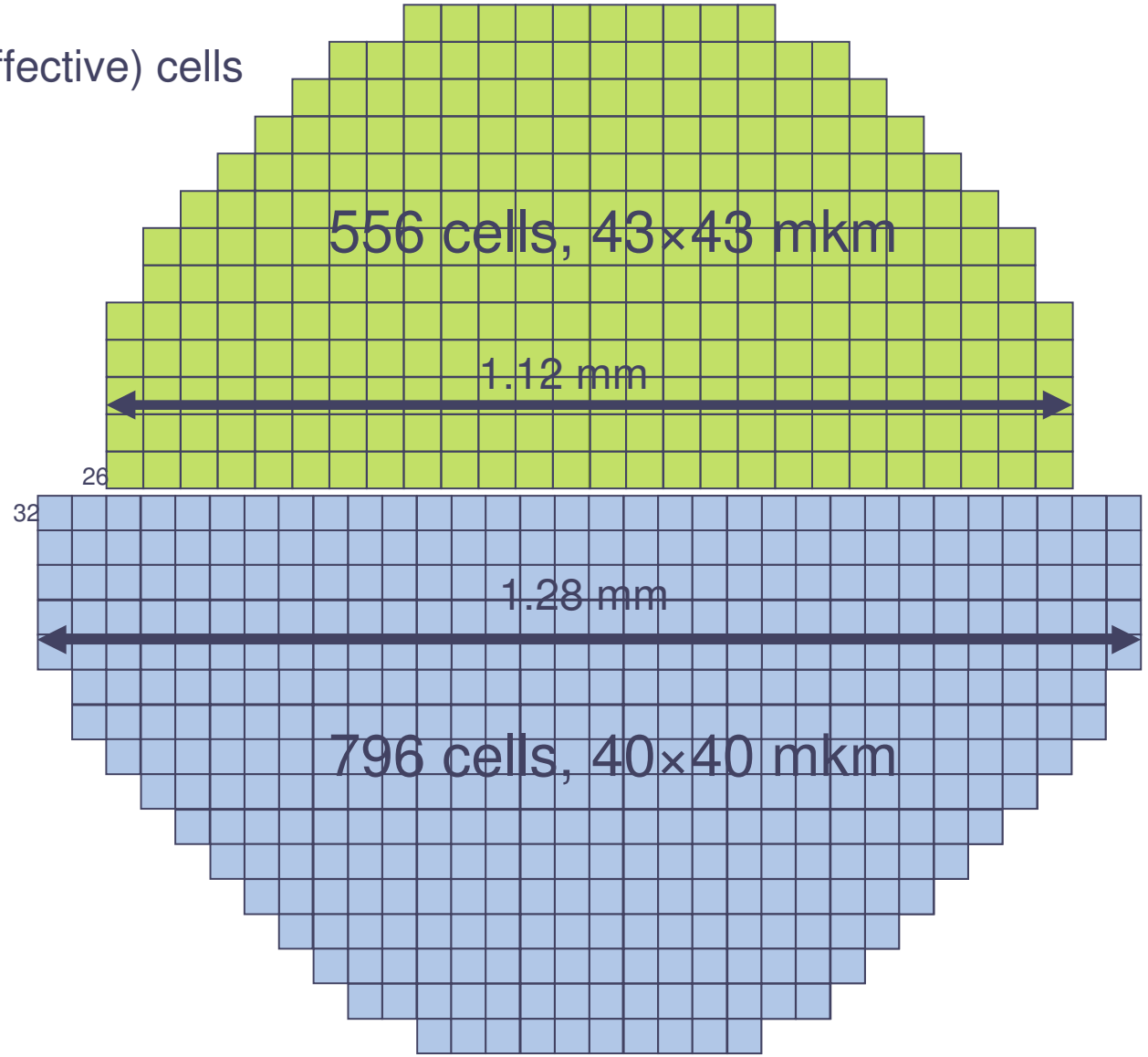
Development of new CPTA photosensor

CPTA SiPM – 556 cells
MEPhI/Pulsar – 1156 (900 effective) cells

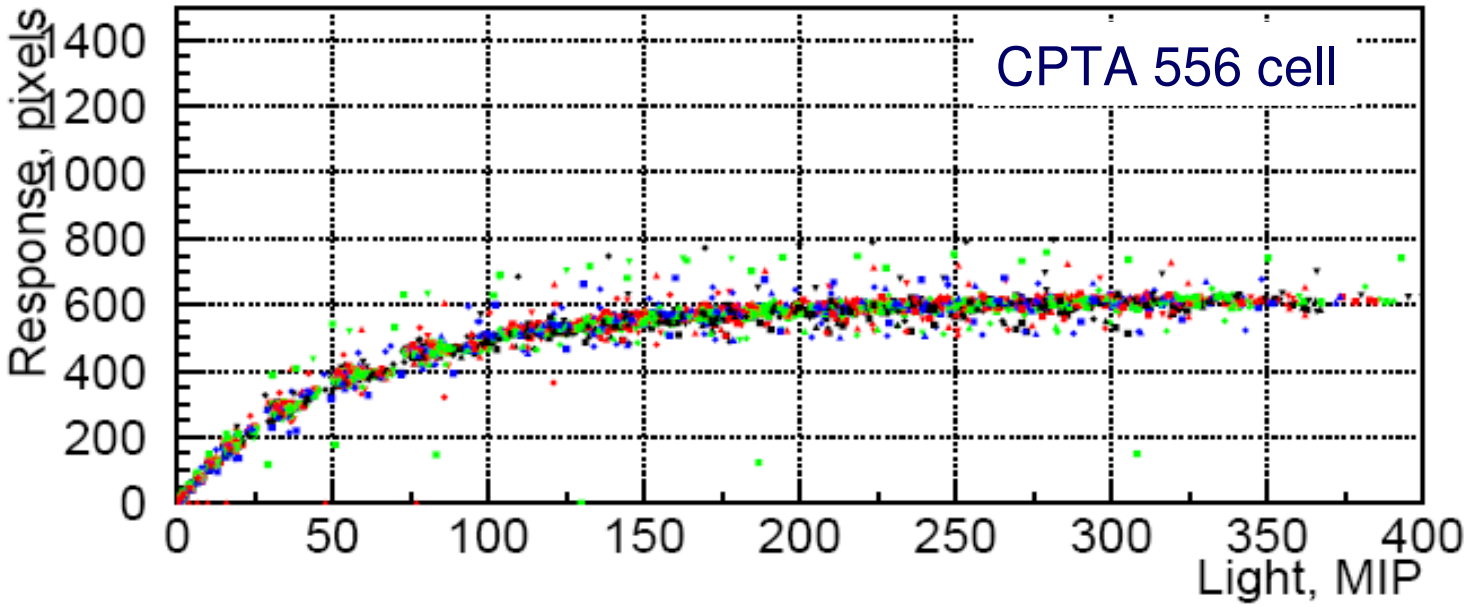
To improve dynamic range:

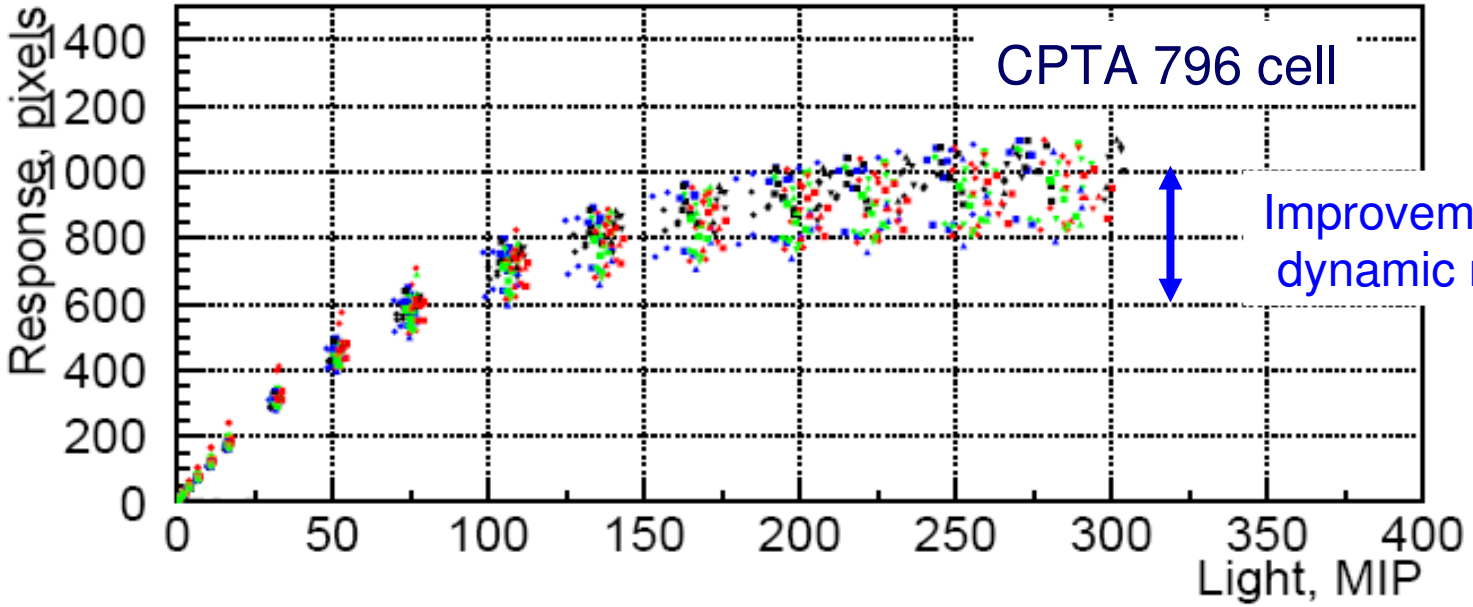
working point 13p.e. /MIP
→ 10-11p.e. /MIP

New sensor



SiPM saturation curves

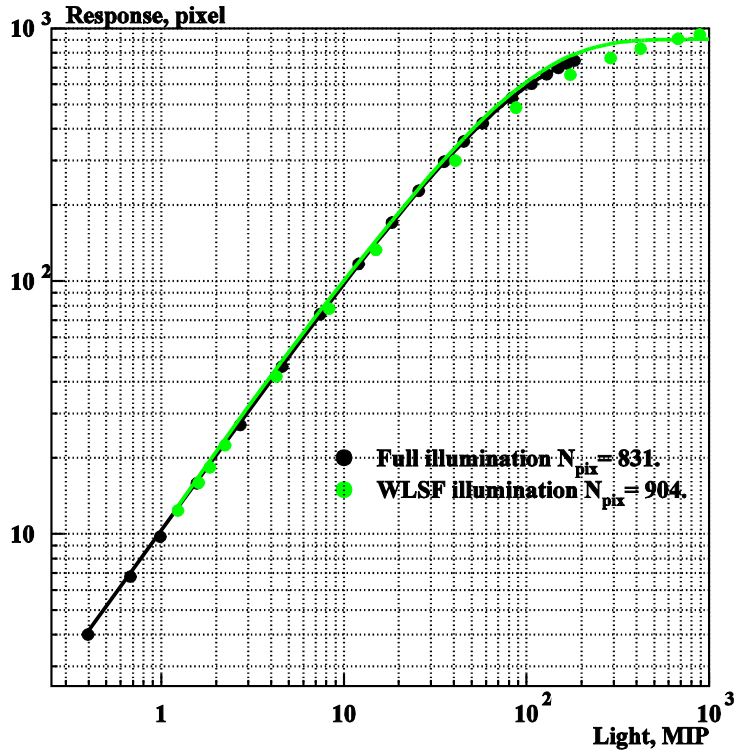


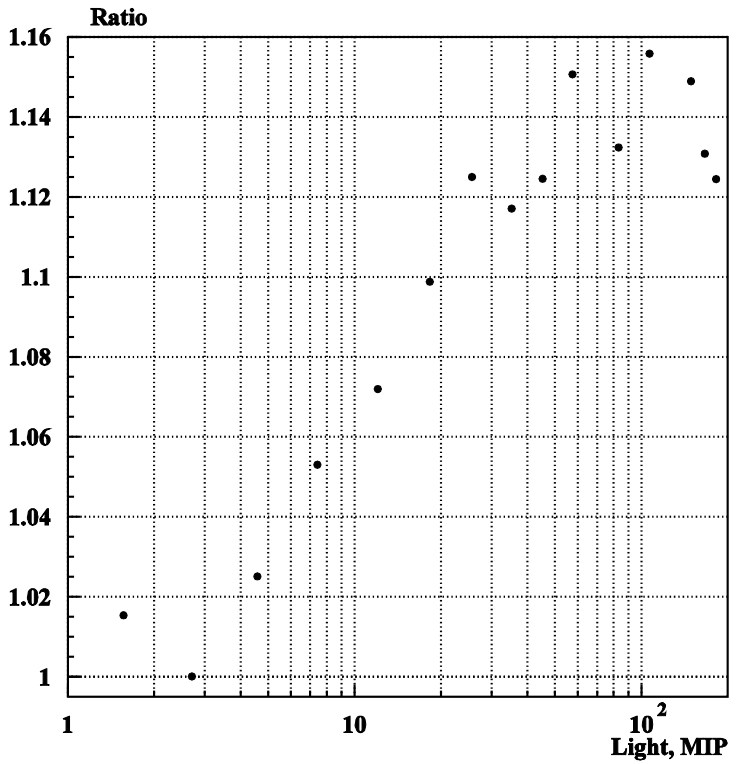


WLS fiber in tile illuminates SiPM not uniformly.

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)

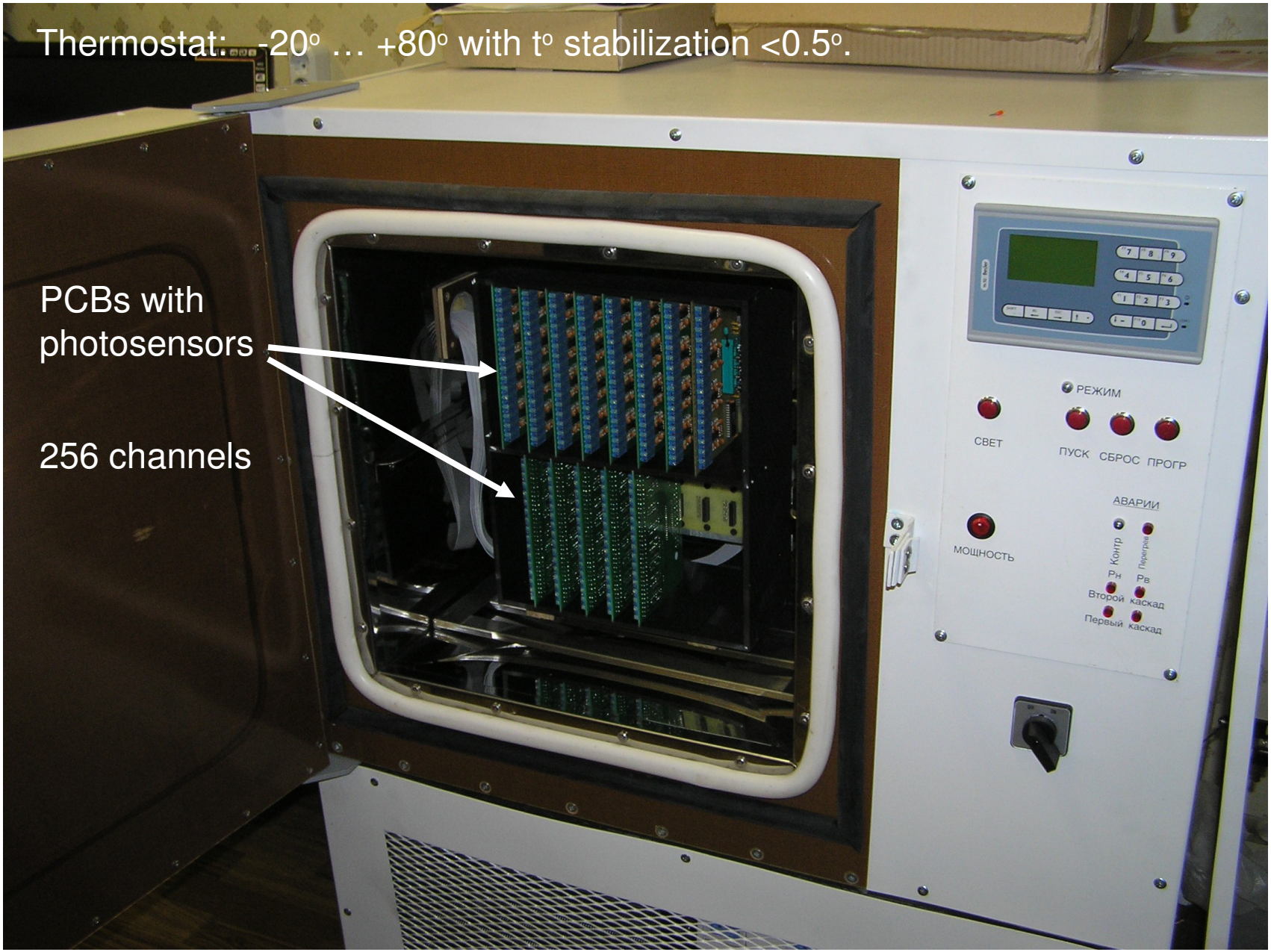




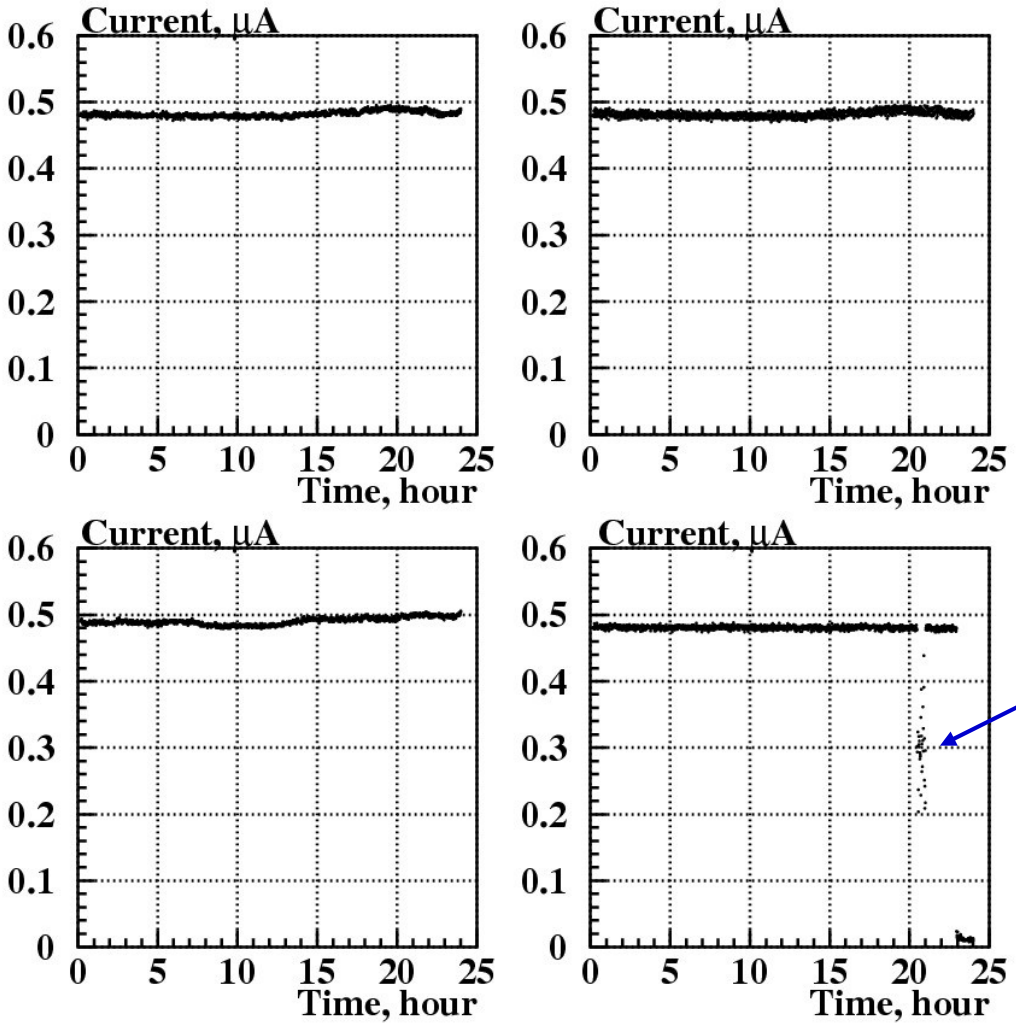
Response for uniform illumination is well described by

R= Npix (1-exp(-Npe/Npix)) / (1-Xtalk (1-exp(-Npe/Npix))

Setup to measure SiPM long term stability



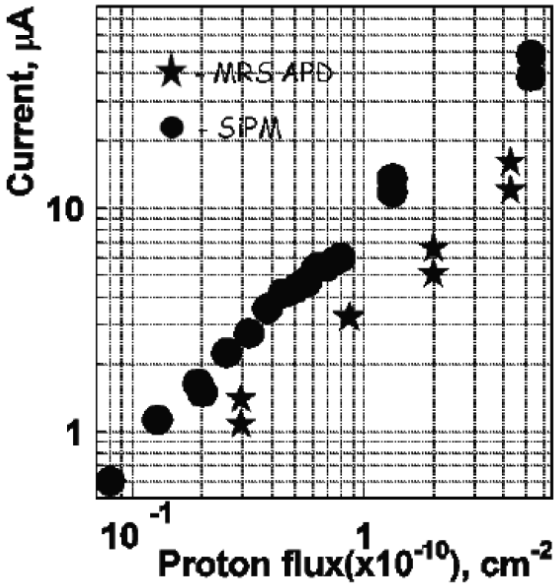
SiPM long term stability at T=35 C (initial studies of 796 pixel MRS APD)

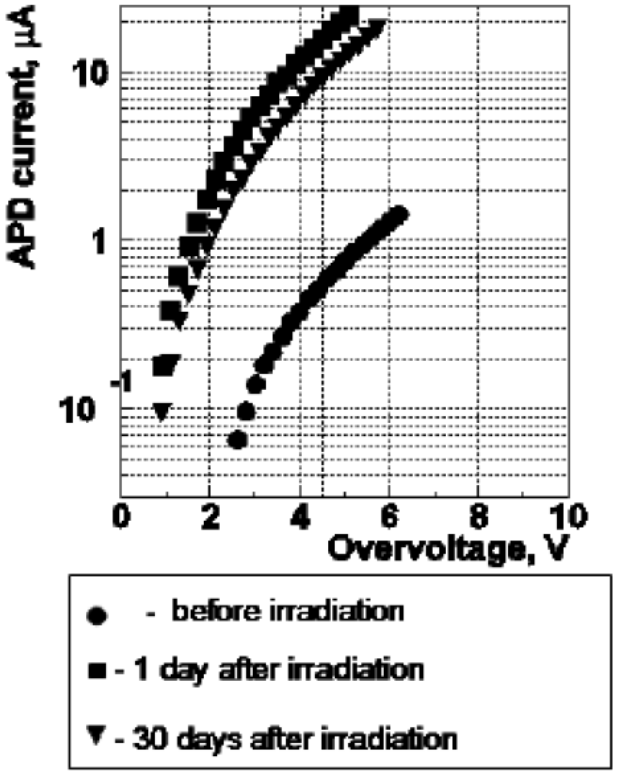


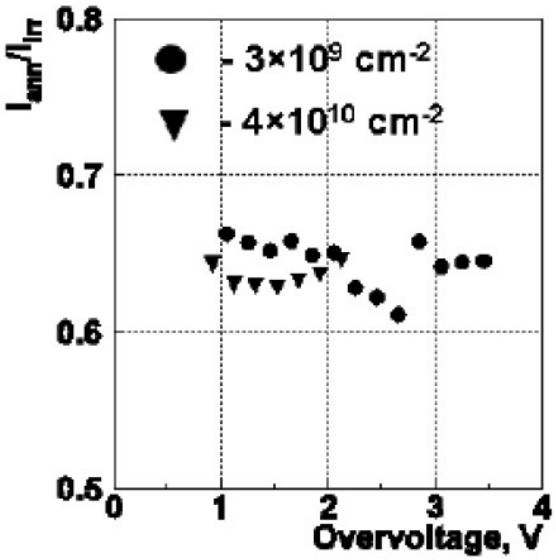
Reason not clear

Radiation hardness is sufficient for ILC HCAL application

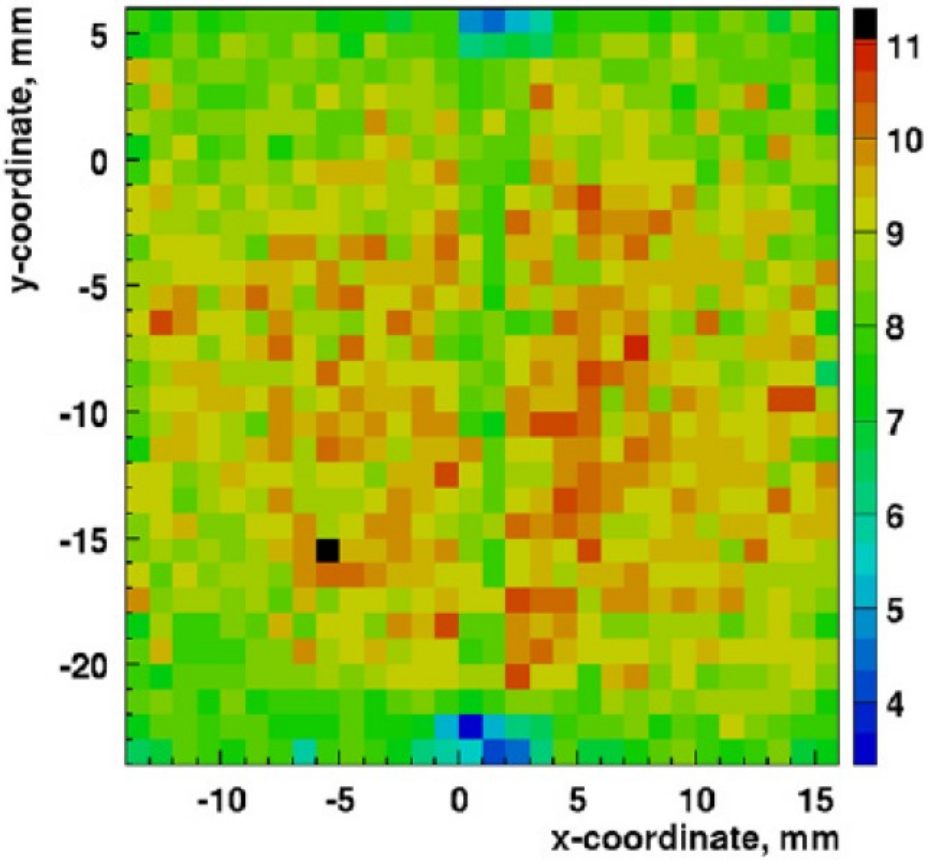
Measurements with 200MeV protons from ITEP synchrotron







Uniformity of response for 3 mm thick tile is good enough



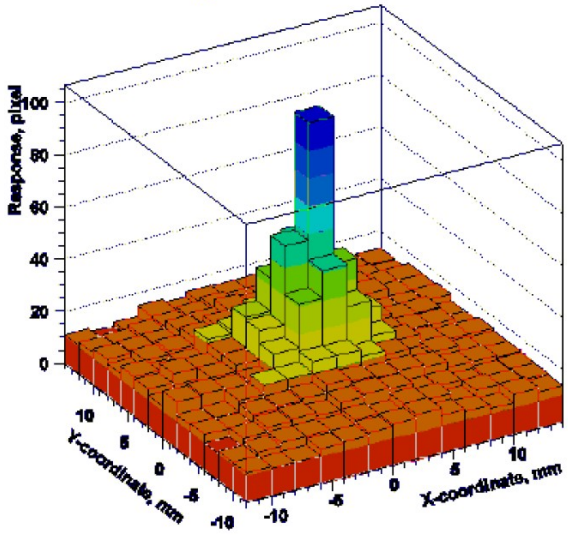
Total efficiency at 0.4 MIP threshold is about 96%

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

Direct tile readout without WLS fiber can simplify mass production

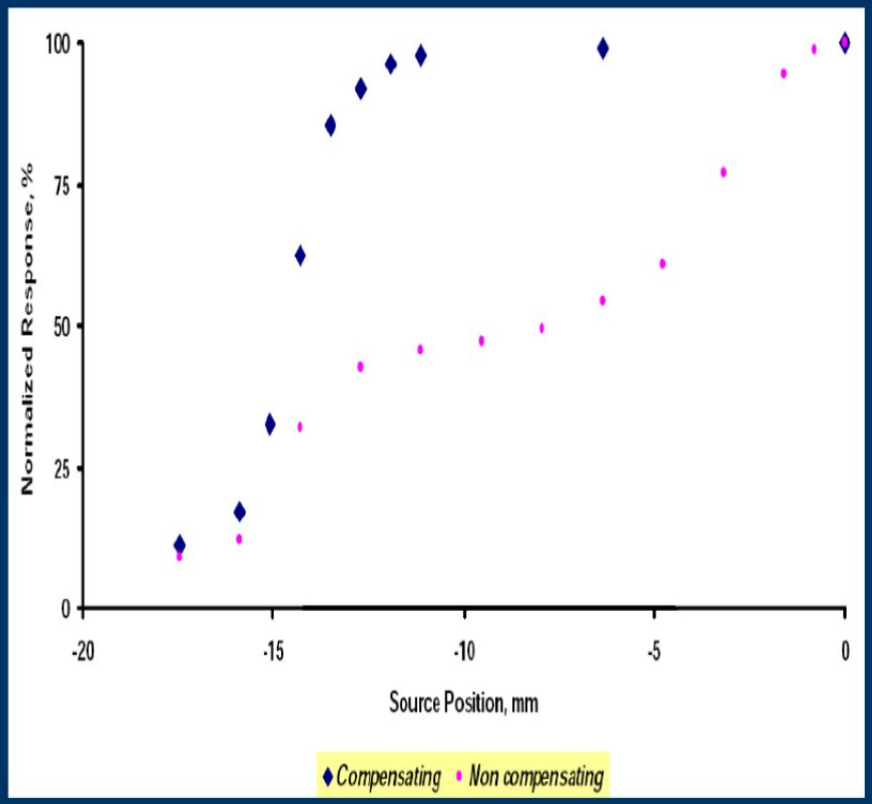
Good uniformity of response can be restored by using a dimple (NIU Proposal NIM A 605 277(2009))

Measurement of 30x30x5 mm^3 tile response uniformity at ITEP test beam



NIU

Adequate Uniformity

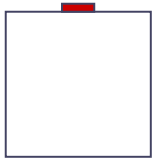


Unfortunately light yield is only 10 p.e. for 5mm thick tile and MPPC 050

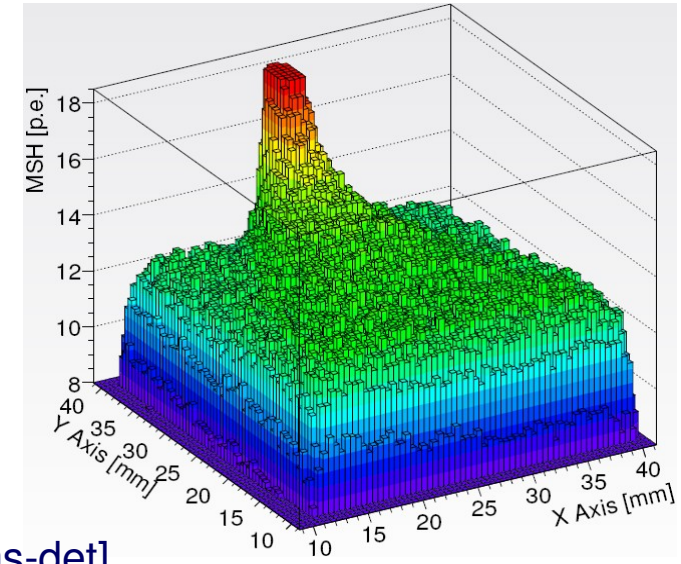
Factor of ~3 larger photodetector would solve the problem

Direct (WLS fiber free) readout with side dimple

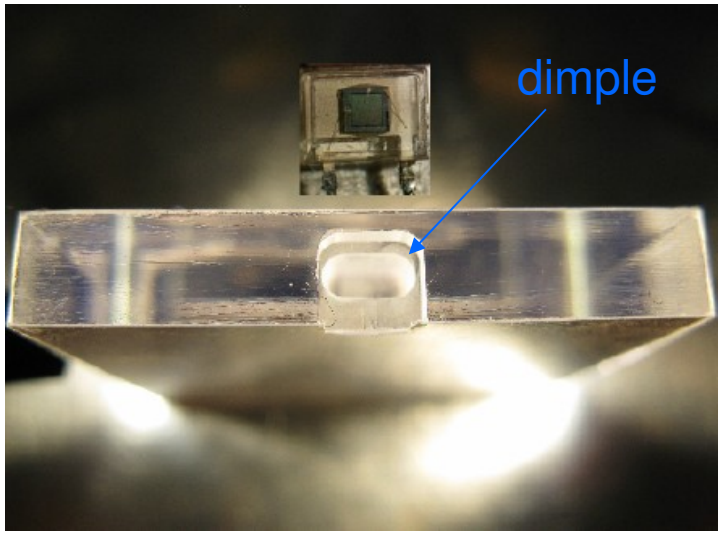
(MPI Munich Proposal)



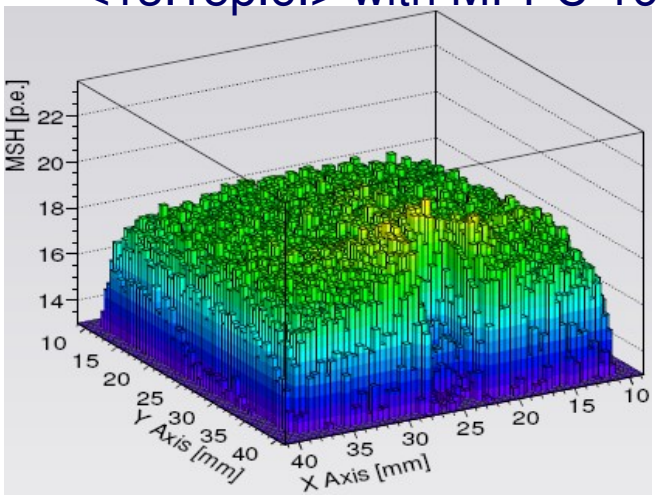
+ simplification of mass production
– non-uniformity, smaller light yield



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

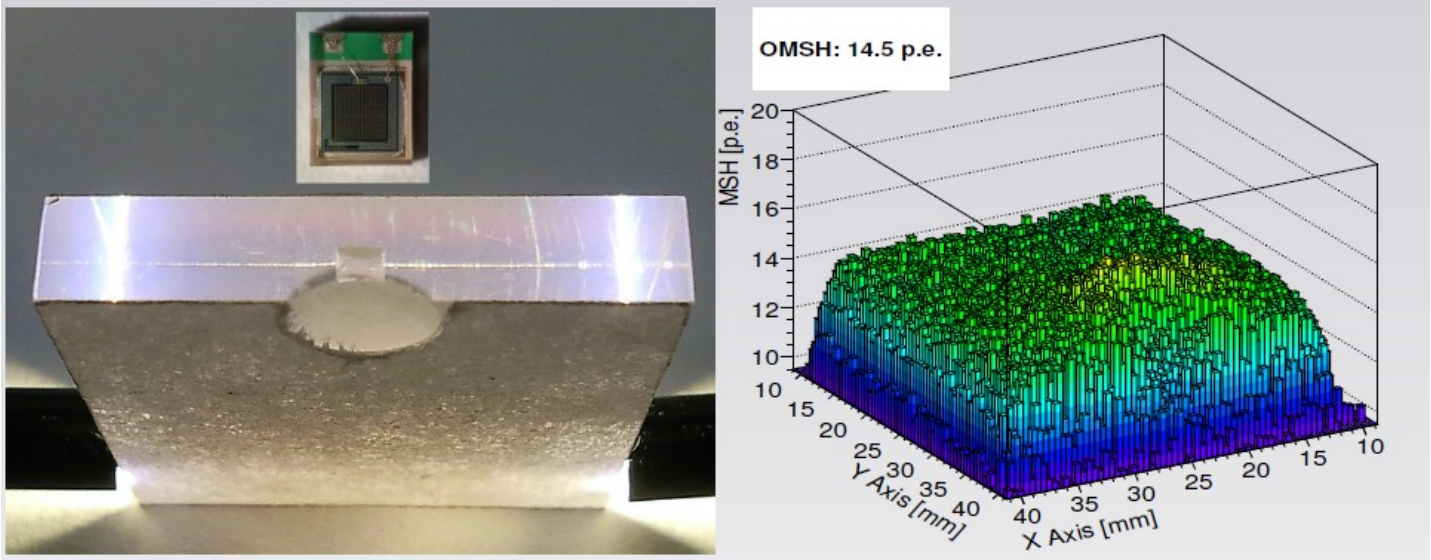


<13.15p.e.> with MPPC-1600

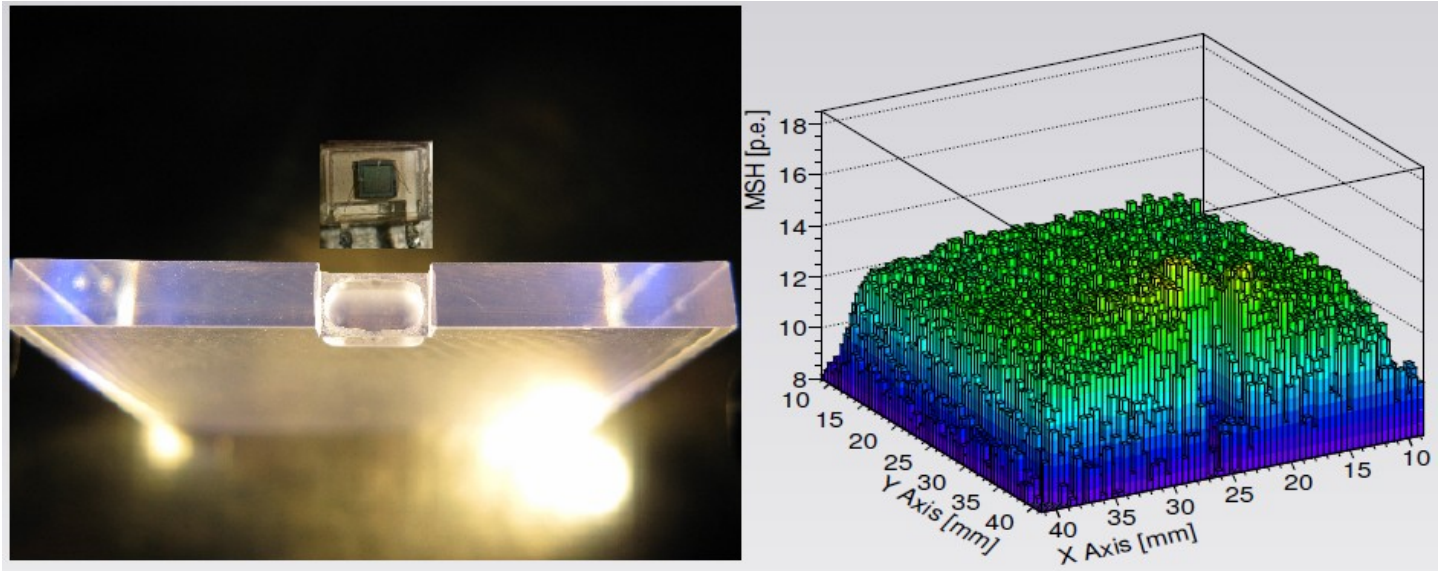


“ideal tile” – polished, wrapped from all sides in 3M foil

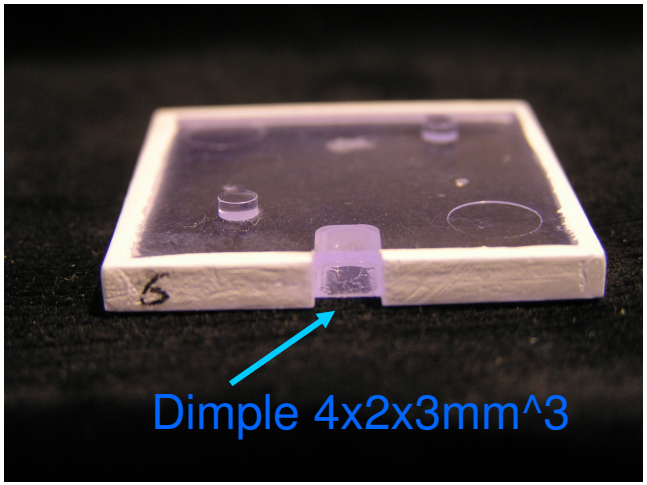
Bottom Dimple (simpler for molding)

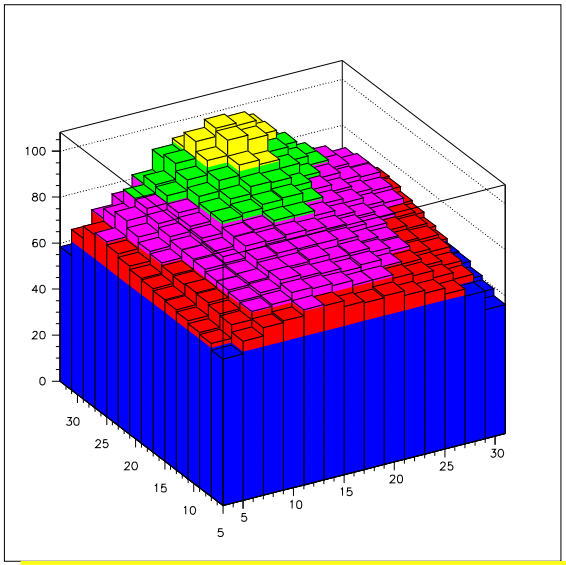


3mm thick “ideal” tile



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





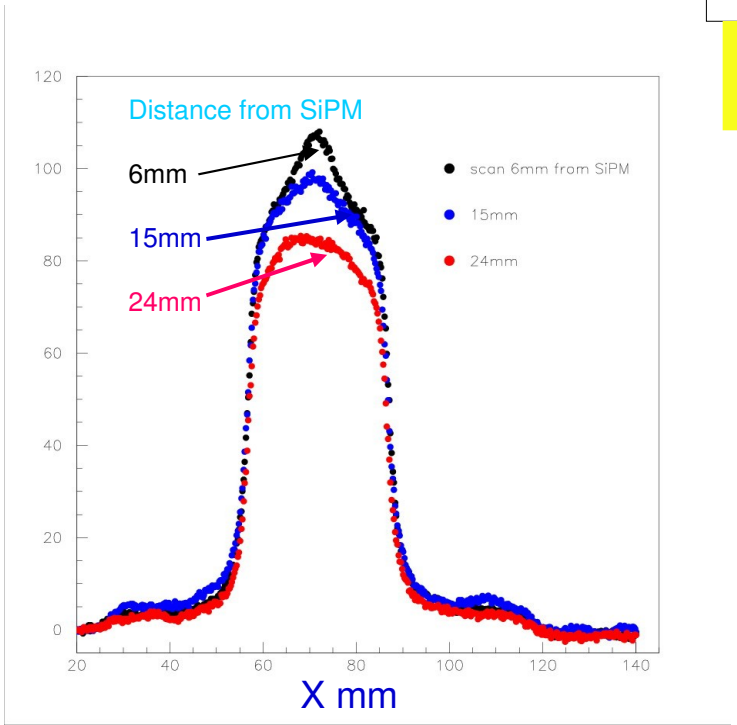
Possible reasons

Worse scintillator?

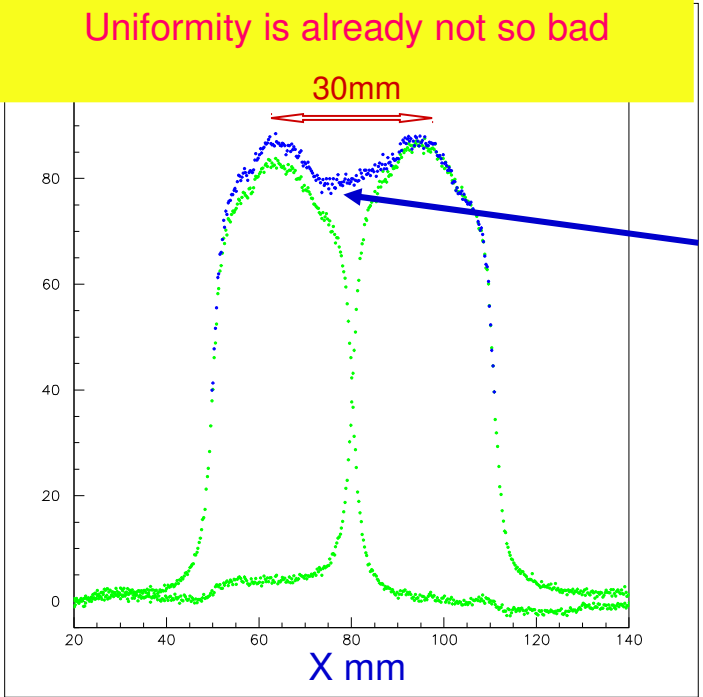
Worse side reflections?

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		
Voltage	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