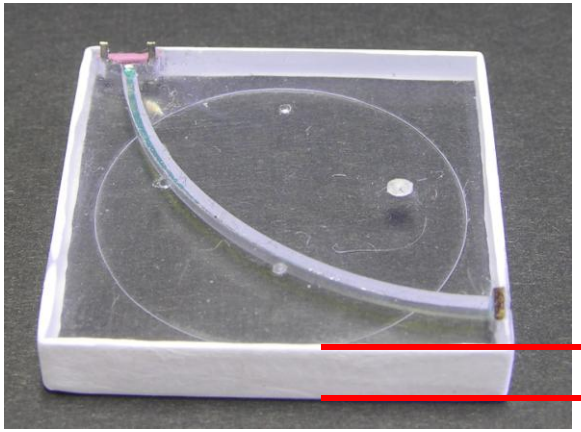
CALICE Meeting, Casablanca, 23 Sep 2010

Scintillator tile – SiPM development at ITEP

Michael Danilov, ITEP

Development of new tile

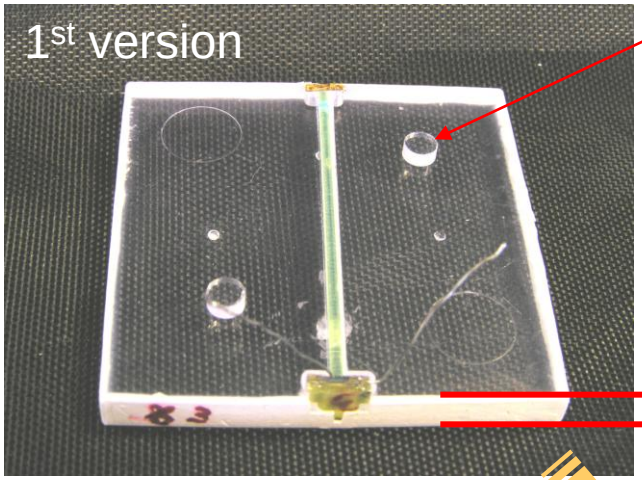
CALICE



5mm

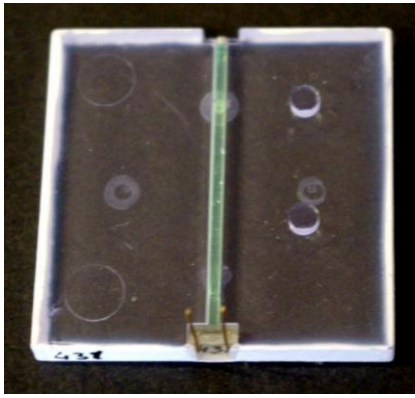
EUDET

1st version



3mm

2nd version



Tile thickness: 5mm → 3mm ***(smaller total HCAL thickness).***

Alignment pins

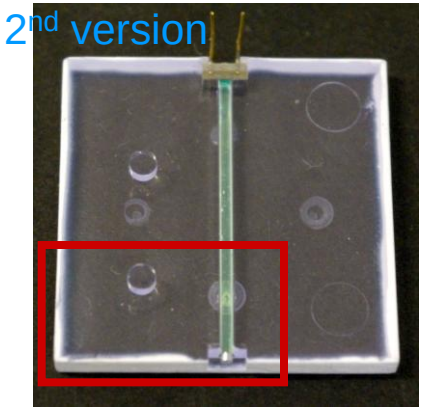
(for simple and reliable connection to PCB).

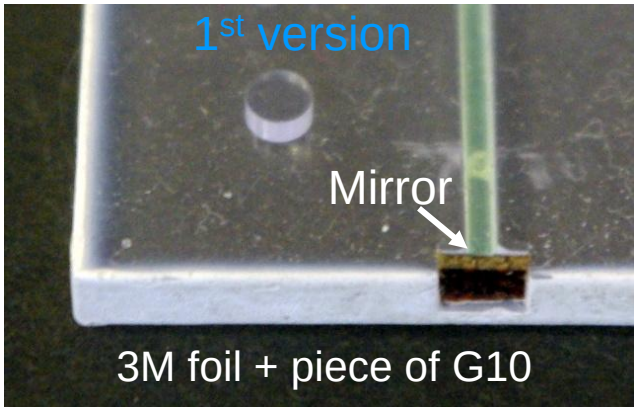
Less labor active production

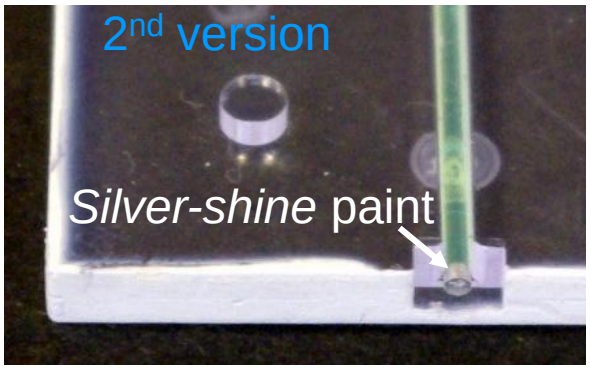
(milling *→ casting, silver paint mirror).*

Mirror at far end of WLS fiber

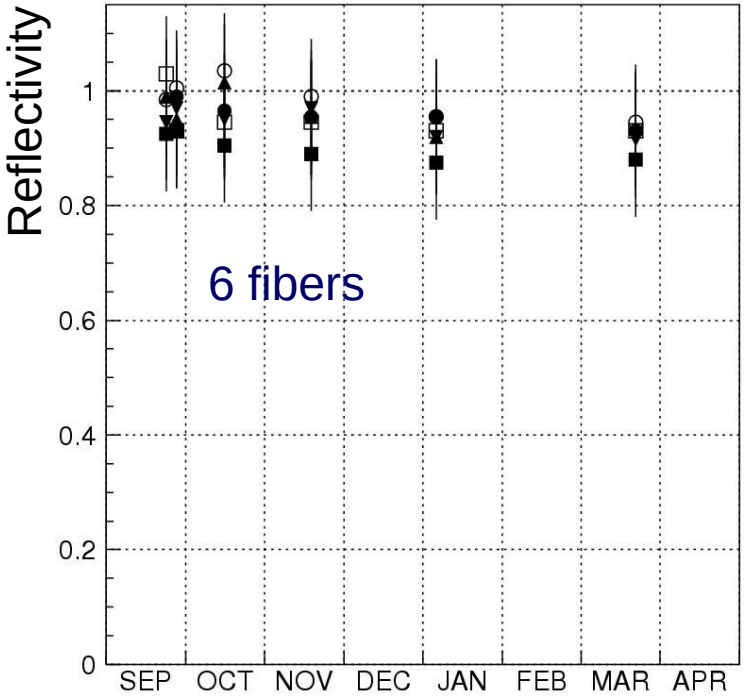
∅ 1mm Kuraray







Reflectivity ~ 90%

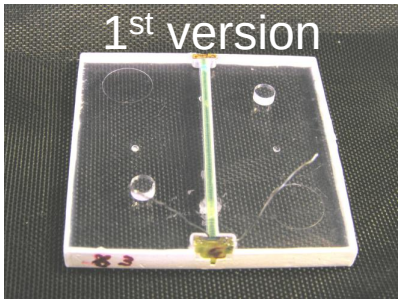


Long term stability

Reflectivity measured using tile and ^{90}Sr
(mirrored and blackened fibers light yield ratio)

Enormous simplification of mass production.

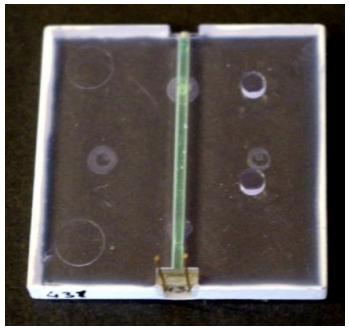
Tiles production status



144 tiles in Dec 2008

(used in engineering prototype)

2nd version



Test samples of new tiles were sent to DESY
to check mechanical tolerances.

20 fully equipped 2nd version tiles have been sent to DESY in September

~1000 next version tiles – Feb 2011

All SiPMs are delivered

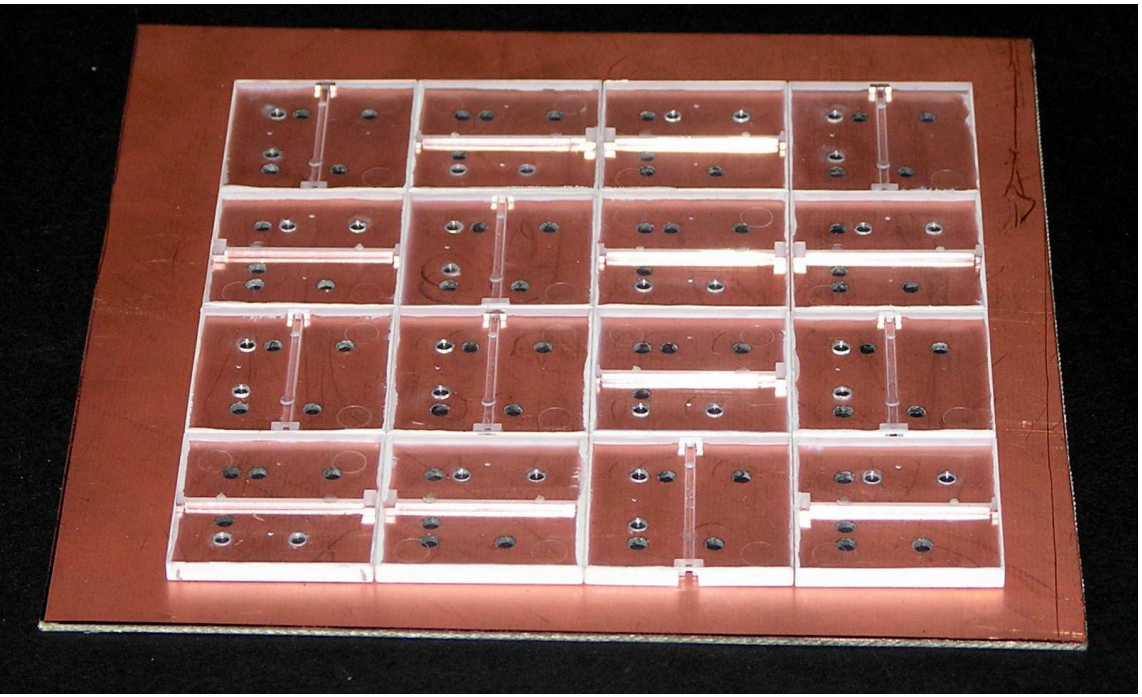
All tiles are produced and edges matted

Now final assembly at ITEP

Accuracy in tile sizes

Measurements at DESY indicated wrong tile sizes – excitement at last HCAL meeting

Fortunately it was just a measurement error



Model of tile connection to PCB

- plate produced by programmable milling machine *(accuracy 10μm)*
- pitch 30.10mm (nominal size + 100μm tolerance)
- extra holes to allow arbitrary orientation of tile

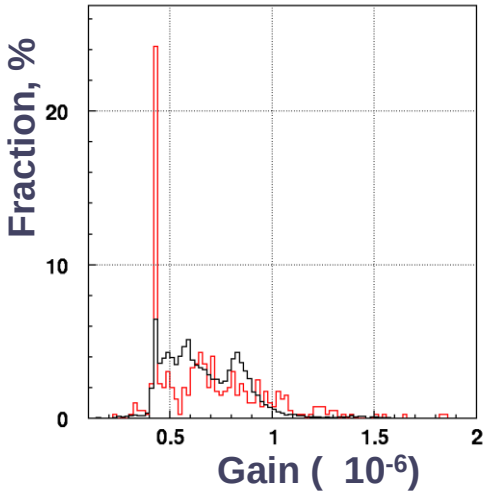
tiles with matted edges

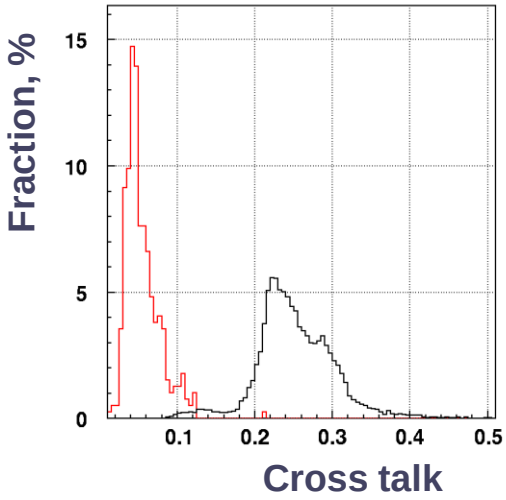
Good accuracy in tile sizes achieved.

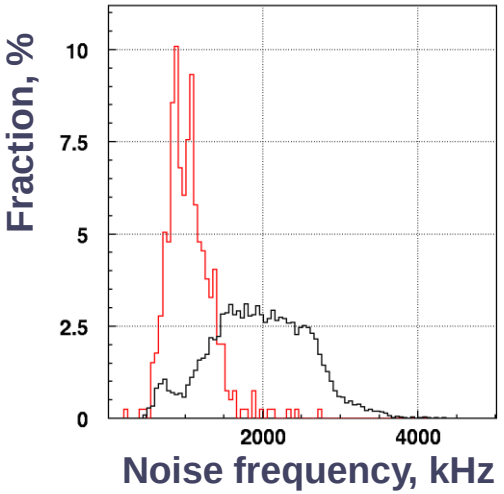
Detector plane can be assembled assuming 100μm tolerance.

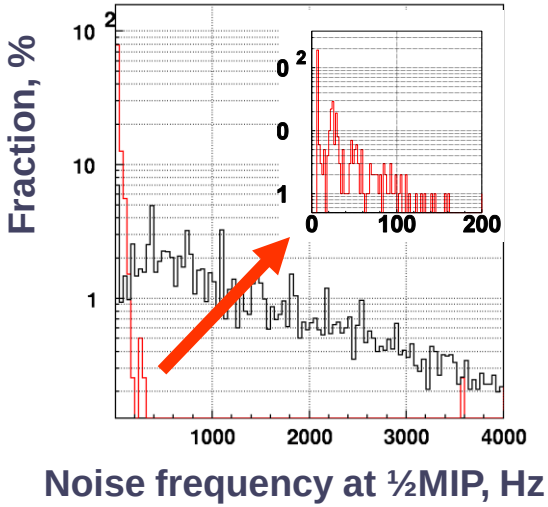
Final hole pattern will be selected using test PCBs

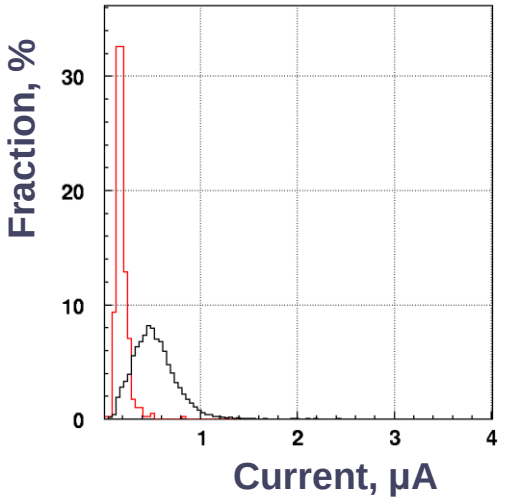
Comparison of parameters of **MEPhI/Pulsar** and **CPTA** (556pixel) SiPMs.

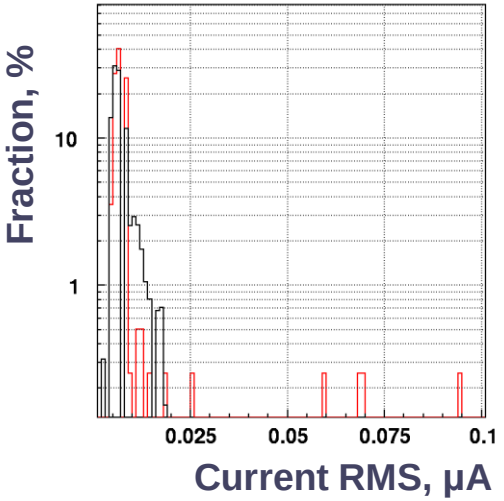












CPTA SiPMs are next generation devices.

Development of new CPTA photosensor

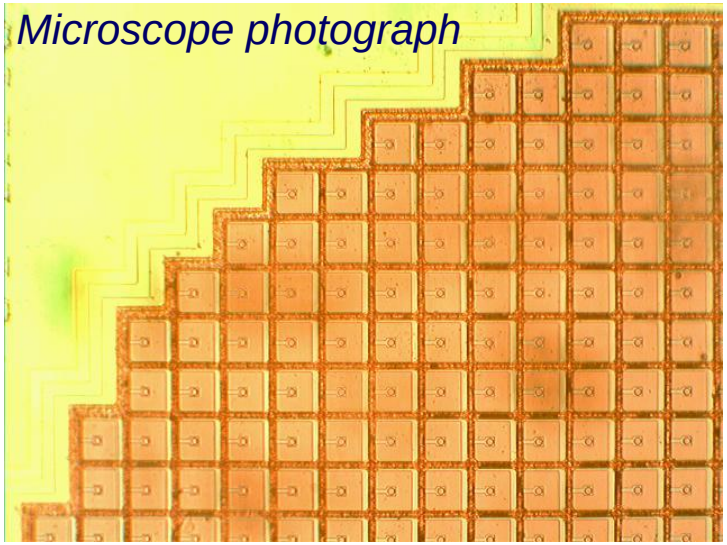
CPTA SiPM – 556 cells
MEPhI/Pulsar – 1156 (900 effective) cells

To improve dynamic range:

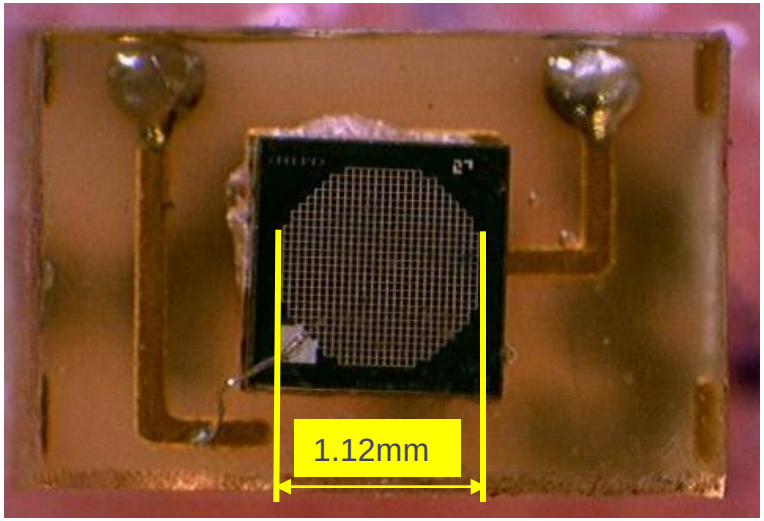
working point 13p.e. /MIP
→ 10p.e. /MIP

New sensor

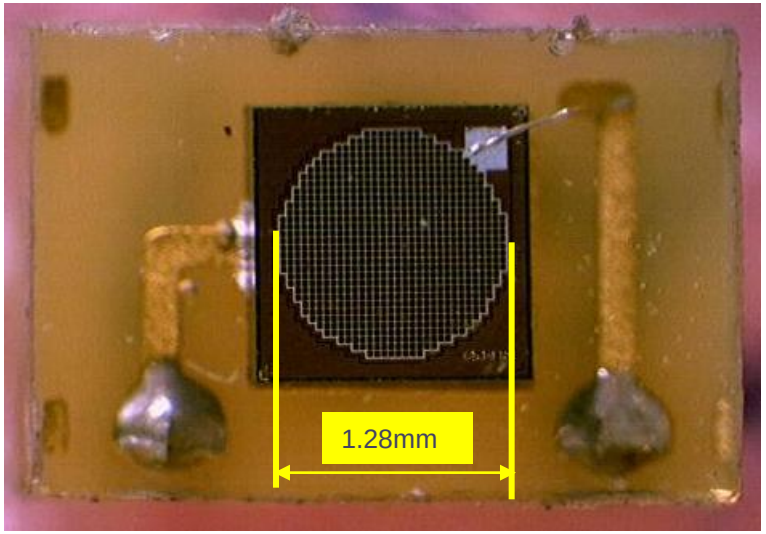
#pixels 556 → 796
pixel size 43μ → 40μ
sensitive area ∅ 1.1mm → 1.28mm



556 pixel MRS APD

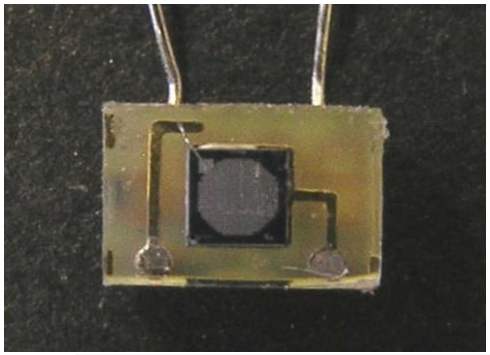


796 pixel MRS APD



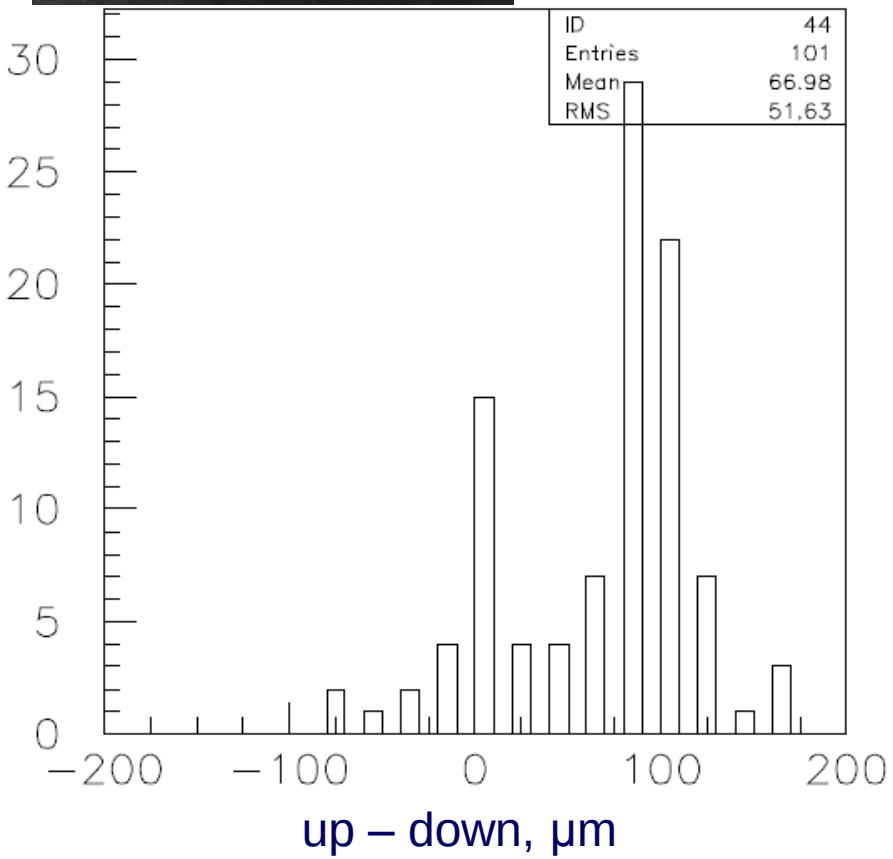
- Better matching to 1.2 mm WLS fiber
- Increase dynamic range
- Better parameters

New package

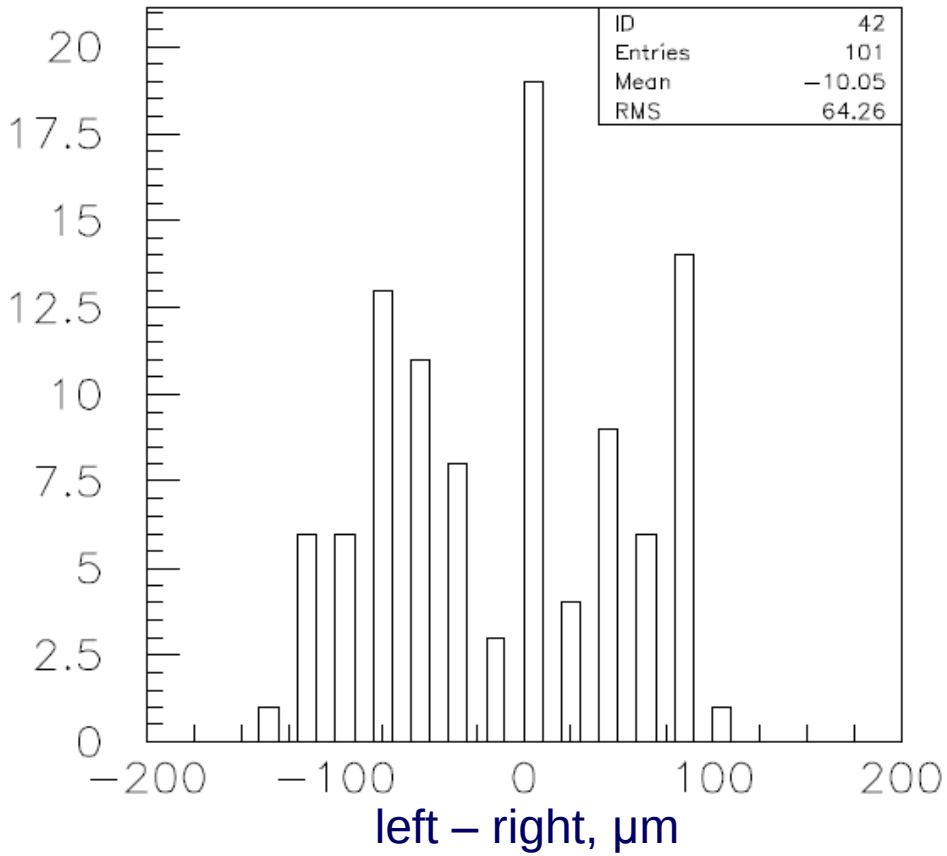


Size: 4 x 2.6 x 1.6 mm^3 ← **tolerance** 20μm

Shifts of sensitive area relative to package edges measured using microscope



up – down, μm

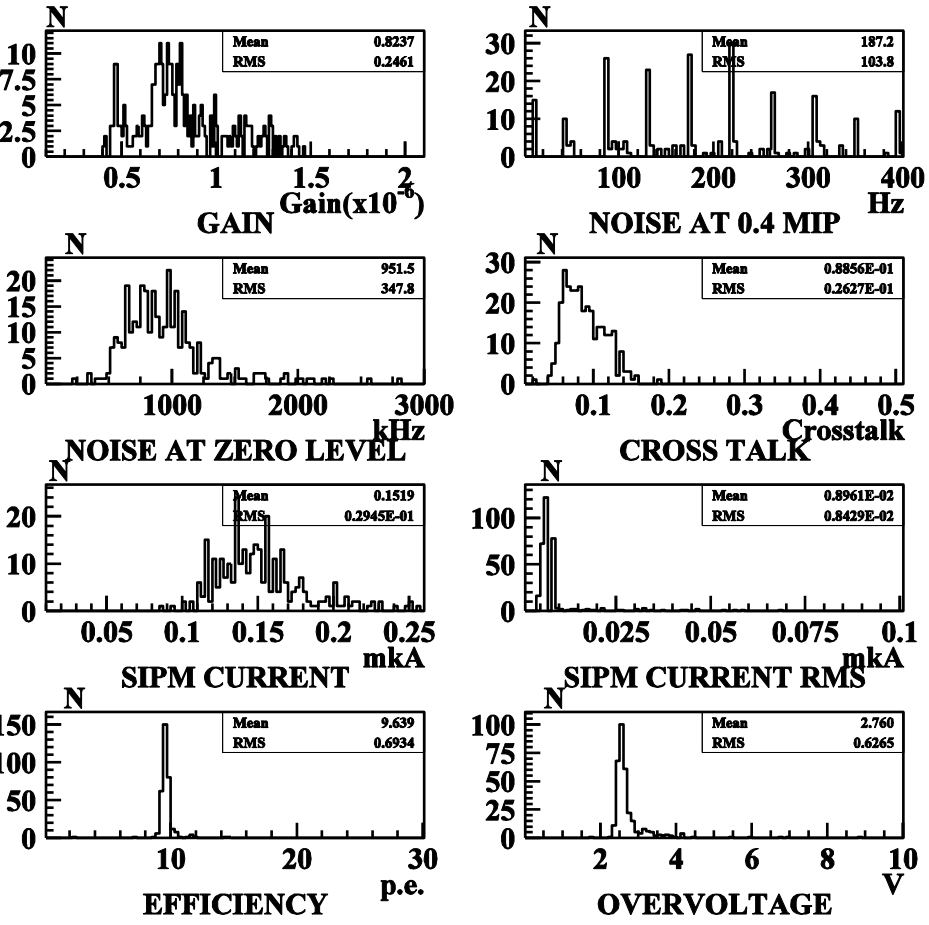


left – right, μm

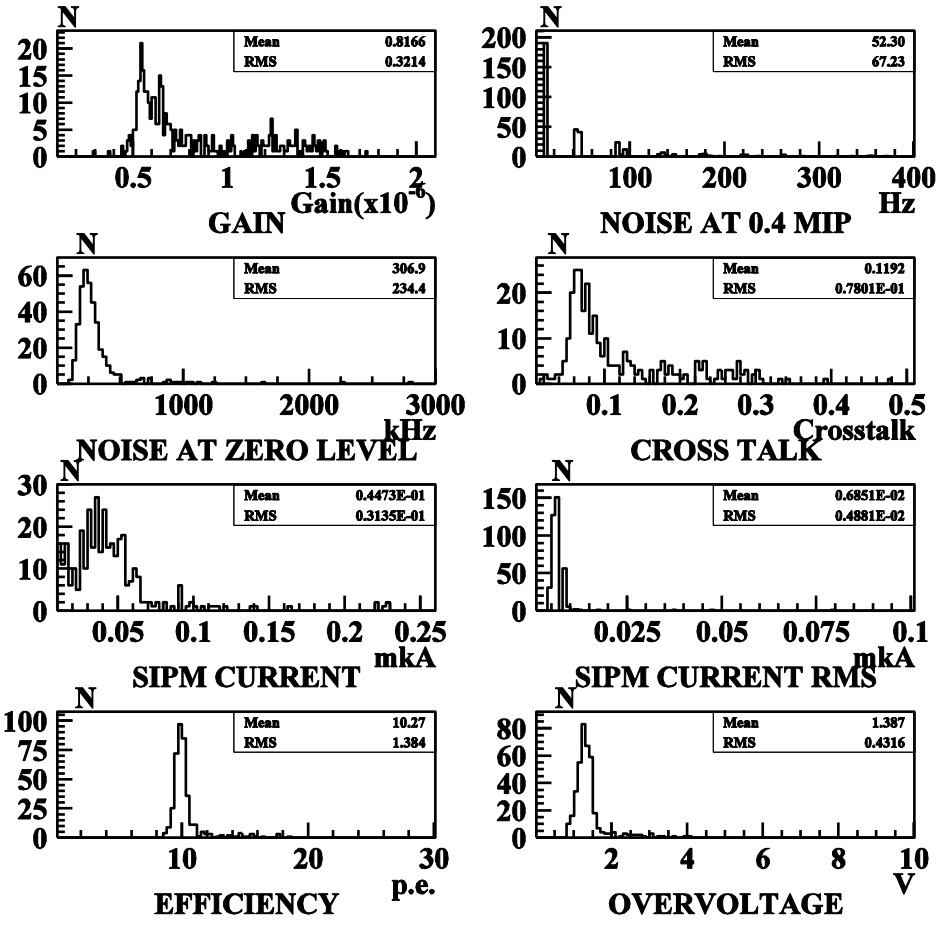
Tolerance is about 100μm.

Distribution of MRS APS parameters at operating bias voltage

556 pixel MRS APD

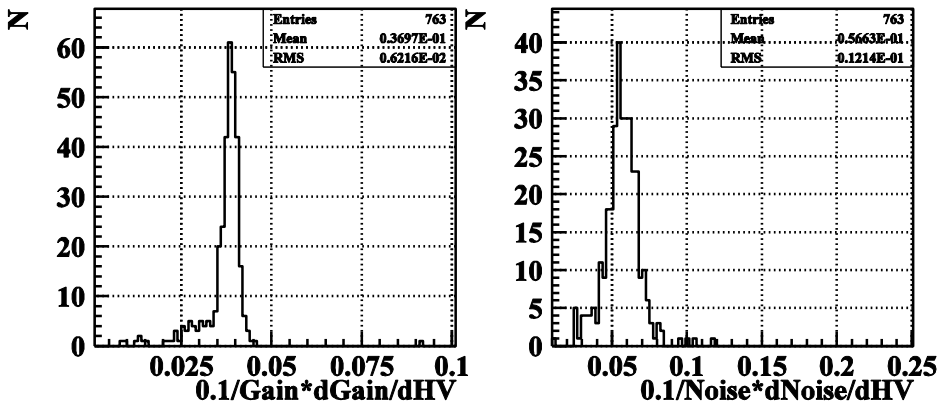


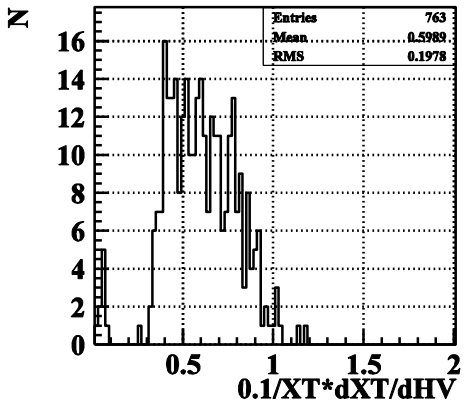
796 pixel MRS APD

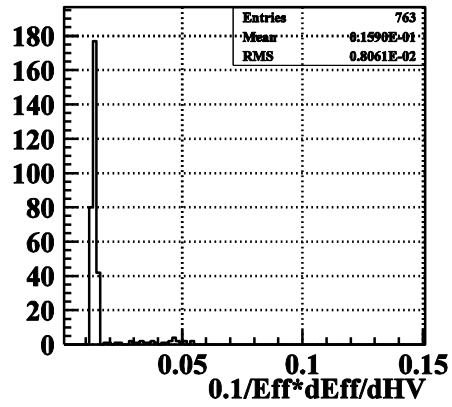


Variation of APD MRS parameters at bias voltage variation

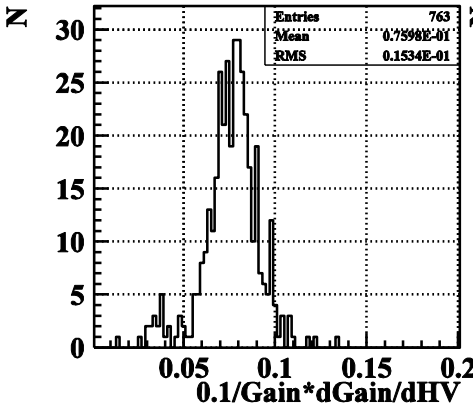
556 pixel MRS APD

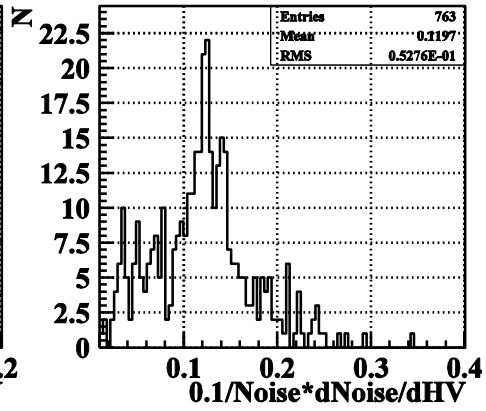


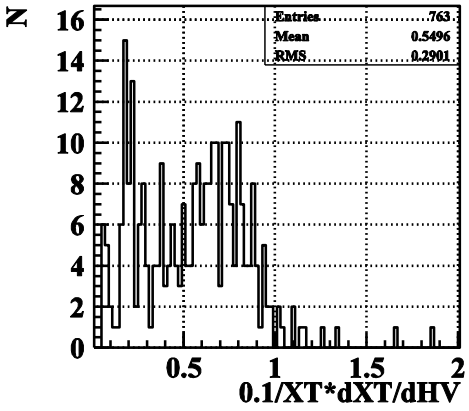


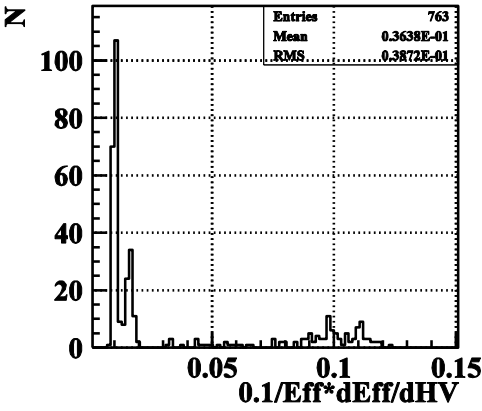


796 pixel MRS APD



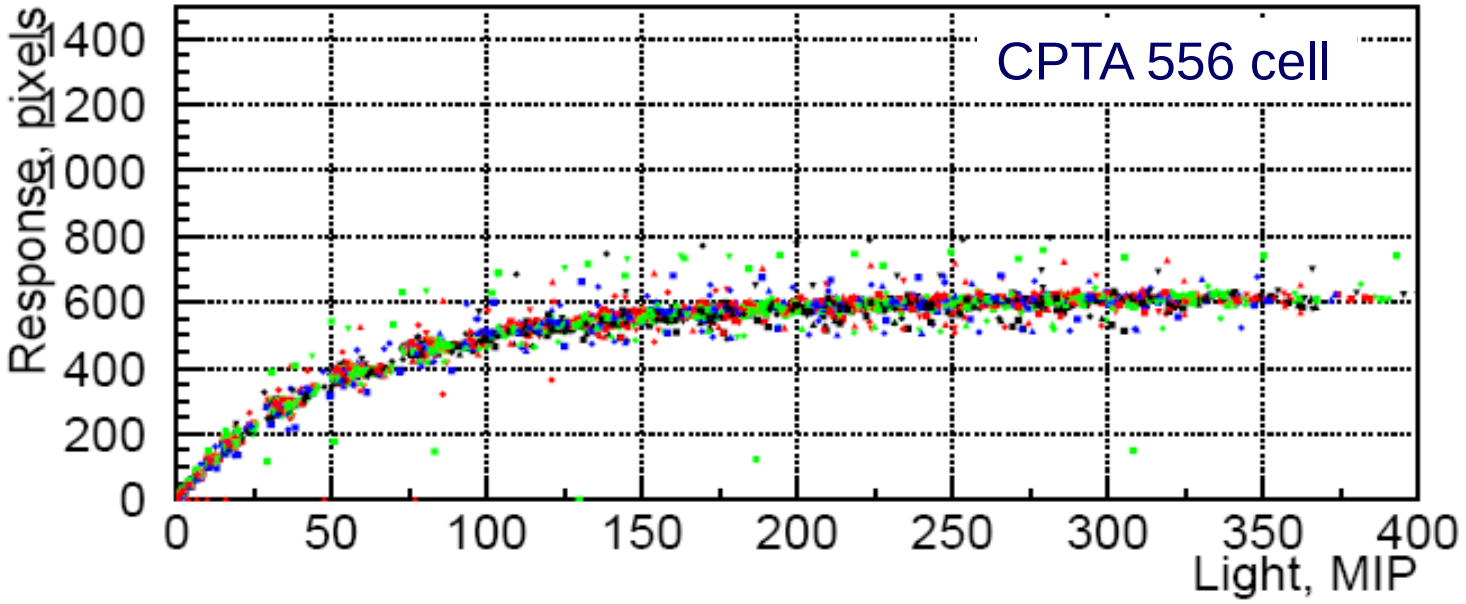


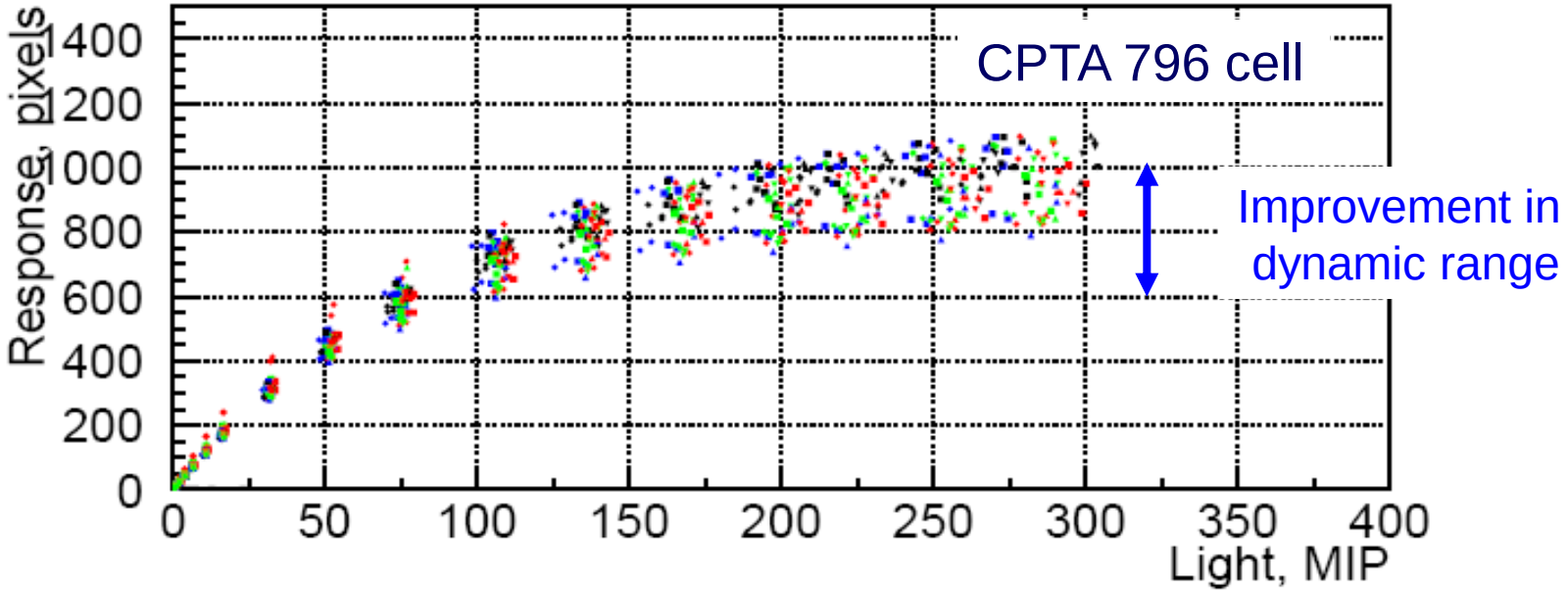




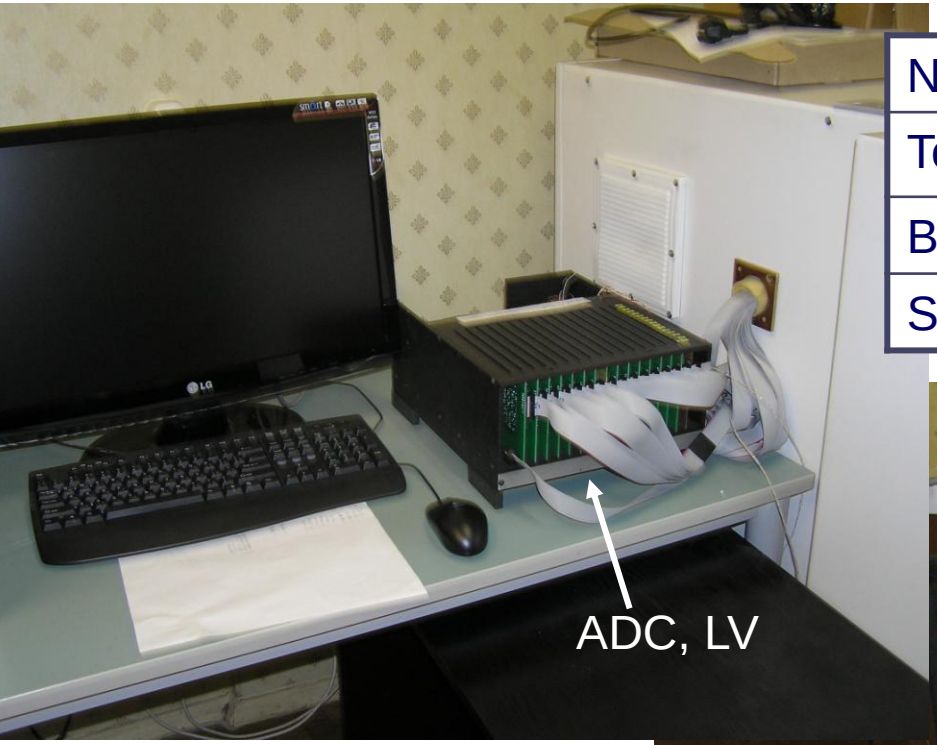
Larger sensitivity of 796 pixel SiPMs to ΔV due to smaller overvoltage (because of too high efficiency!)

SiPM saturation curves

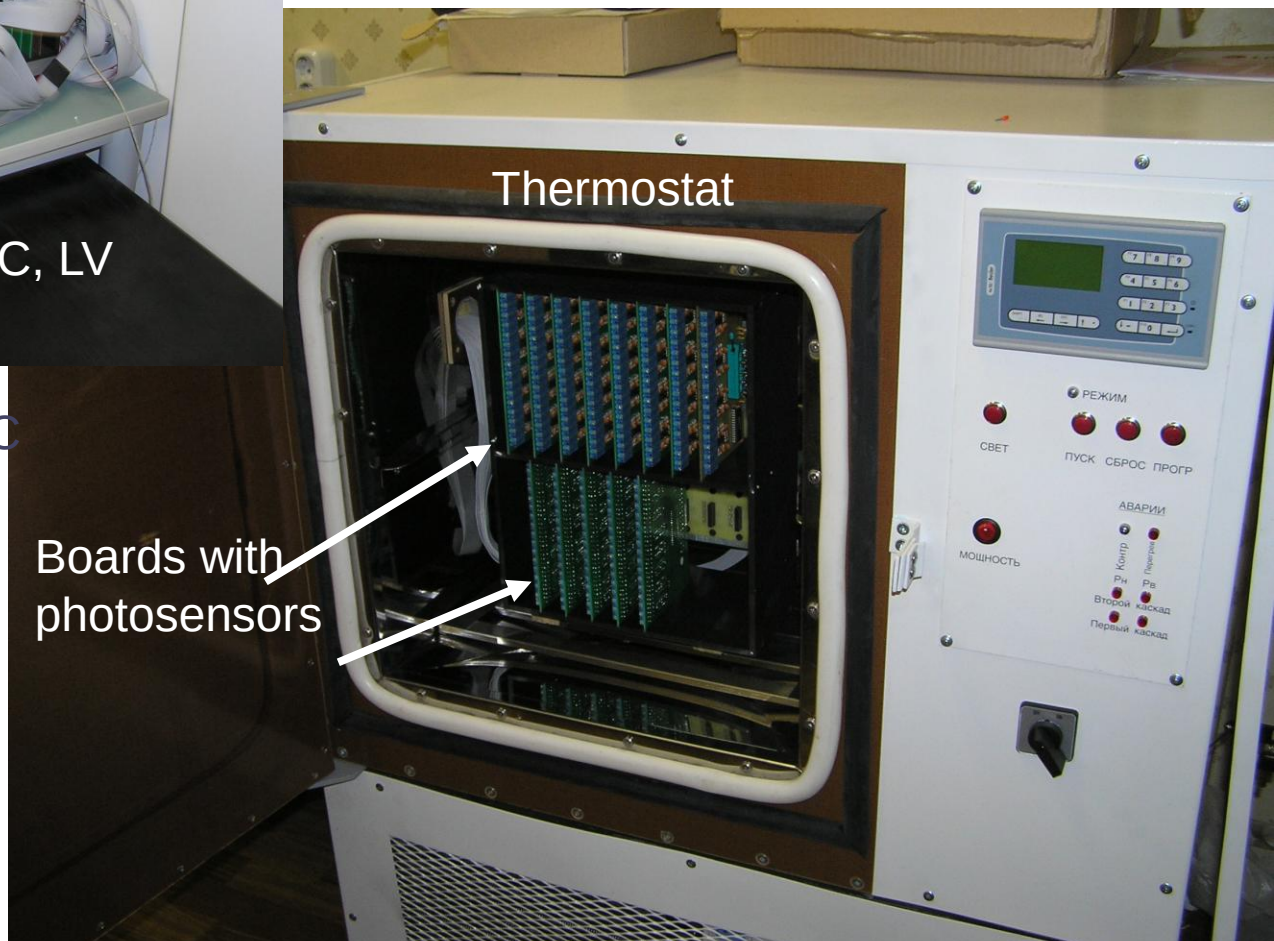




Test of SiPM long term stability



Number of channels	256
Temperature stability	0.2°C
Bias voltage accuracy	20mV
SiPM current measurement accuracy	1nA

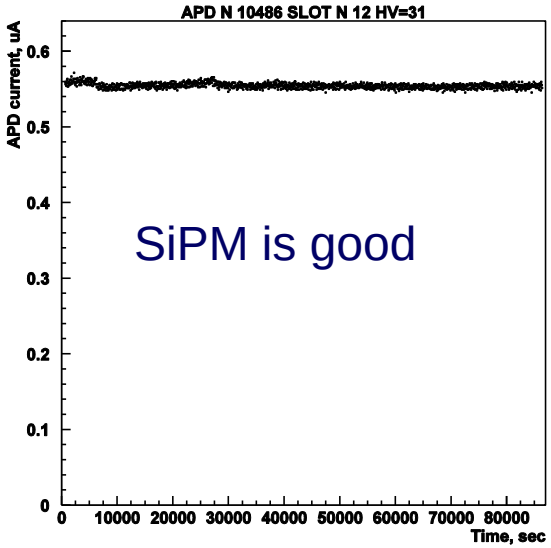


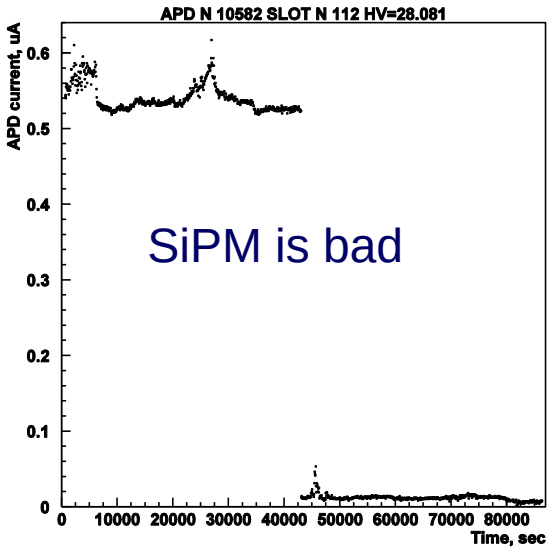
@ elevated temperature +35°C
for 3-4 days

Setup commissioned.

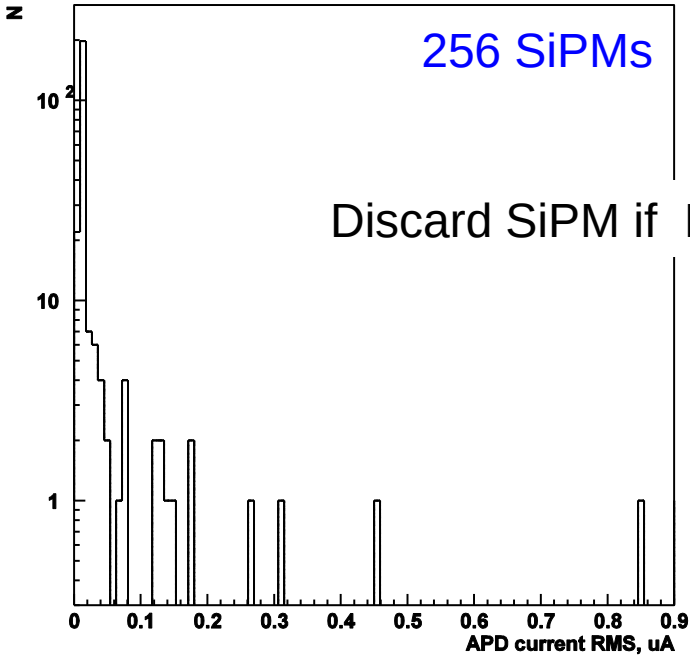
Test of SiPM long term stability (2)

Examples:





RMS of SiPM current over time



Discard SiPM if RMS>20nA

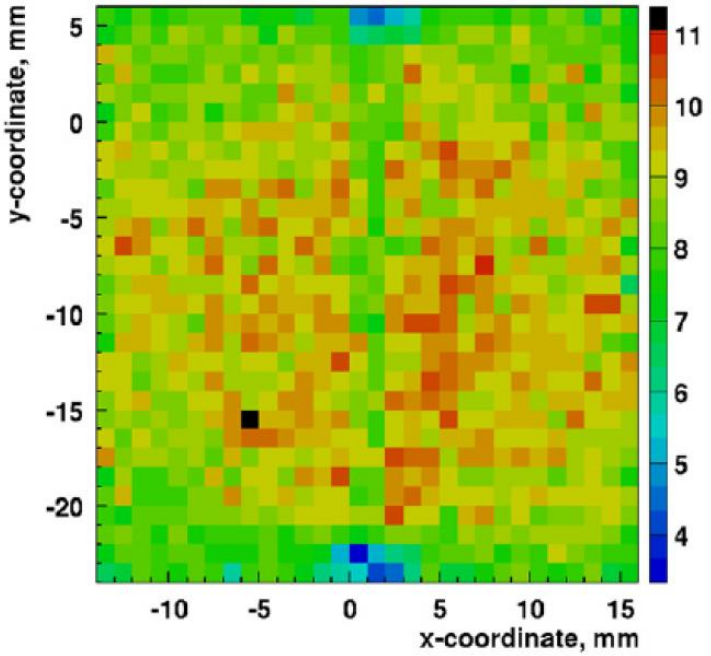
percent level

Yield of SiPMs is high.

Efficiency and uniformity

Measurements at ITEP test beam

Response map



Geometrical efficiency is 98%.
(will be even higher with silver paint morror)

Total efficiency @ 10p.e./MIP and
0.4 MIP threshold is about 96%.

Uniformity of response for 3mm thick tile is good.

Conclusions

Scintillator tile – WLS fiber – SiPM system has been developed adequate for LC HCAL requirements.

Scintillator tile : thickness 3mm
accuracy adequate
technology is suitable for mass production

SiPM : low noise
developed new package and new sensor
ageing, long term stability OK

Efficiency for MIP registration is 96%, good uniformity of response.

20 fully equipped tiles delivered to DESY.
~1000 to be delivered to DESY in Feb 2011.