HCAL meeting, 11 December 2008

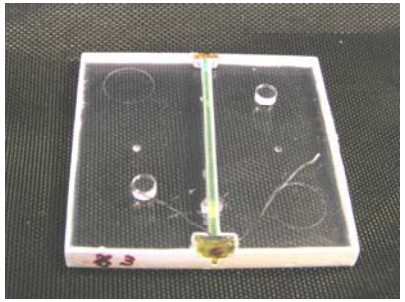
Tiles and SiPMs

Roman Mizuk (ITEP, Moscow)

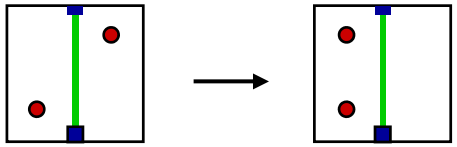
- Tile production plans
- Measurements of tile uniformity
- Studies of sensors

Tile Production Plans

150 fully equipped tiles in January



150 next version tiles – beginning of summer



groove and holes milled →
produced during casting

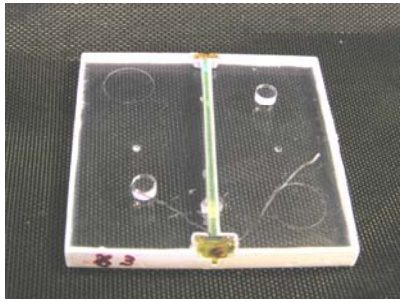
WLS fiber : 1mm → 1.2mm

MRS APD : #pixels 556 → 796 *x1.43*
pixel size 43μ → 40μ
sensitive area ∅ 1.1mm → 1.28mm

1500 next version tiles – end of 2009

Tile Production Plans

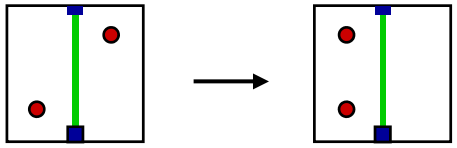
150 fully equipped tiles in January



all parts available

150 next version tiles – beginning of summer

casting form in production



groove and holes milled →
produced during casting

WLS fiber : 1mm → 1.2mm

MRS APD : #pixels 556 → 796 *x1.43*
pixel size 43μ → 40μ
sensitive area ∅ 1.1mm → 1.28mm

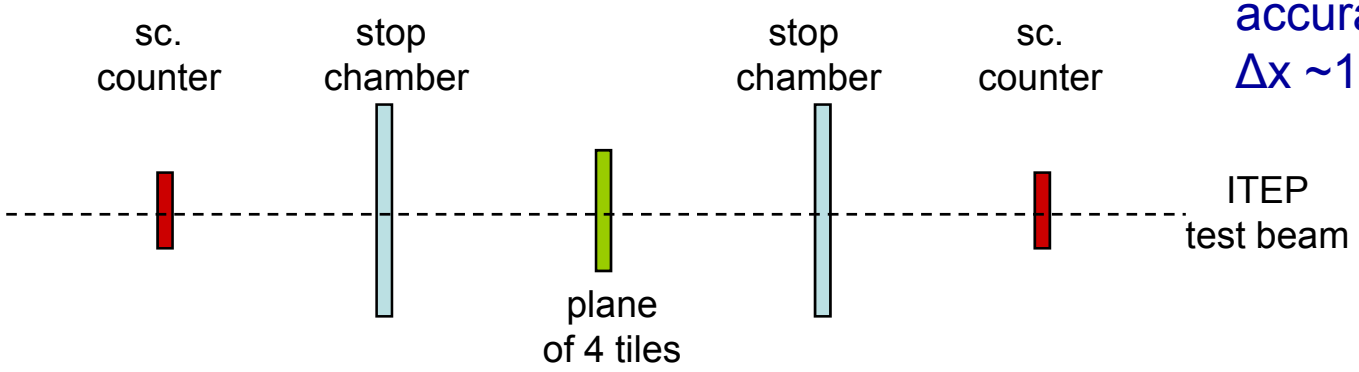
started developm. of new MRS APD

1500 next version tiles – end of 2009

optimistic

Measurements of tile uniformity at ITEP proton test beam

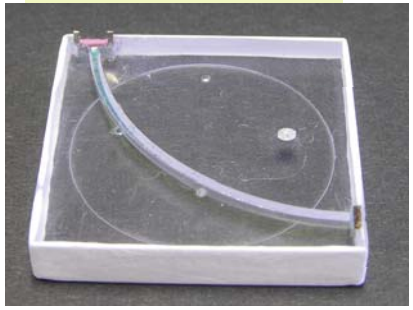
Shematic view of test setup



accuracy of track position
Δx ~1mm, Δy~0.5mm

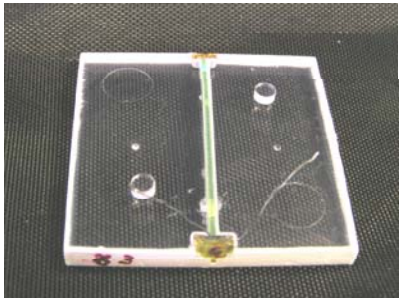
Studied tiles

CALICE HCAL



30 x 30 x 5 mm^3
1mm WLS fiber
MIP @ 15p.e.

EUDET

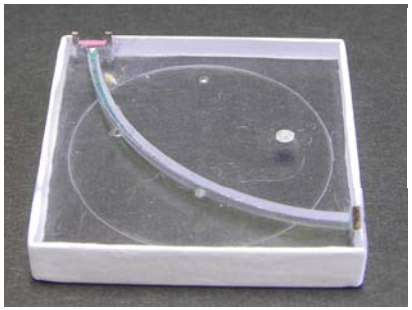


30 x 30 x 3 mm^3
1mm glued WLS fiber
MIP @ 10p.e.

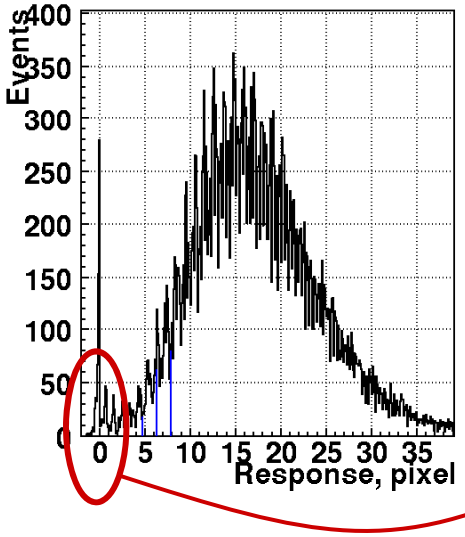
5mm tile uniformity

Preliminary

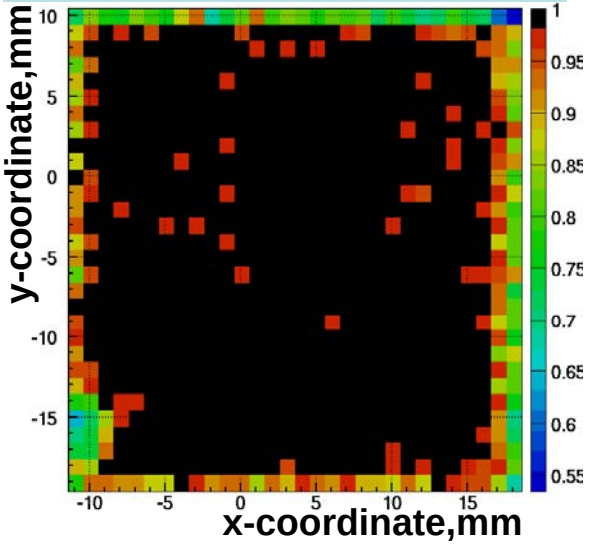
CALICE HCAL tile
MIP at 15p.e.



Response to beam particle



Efficiency at 3 pixel threshold



<Eff> = 98.3%

Holes in acceptance of tile:

edges 120 x 0.1 = 12mm^2 ← 1.3% *(matting of two tiles + gap)*

SiPM 6 x 2 = 12mm^2

mirror 3 x 1 = 3 mm^2

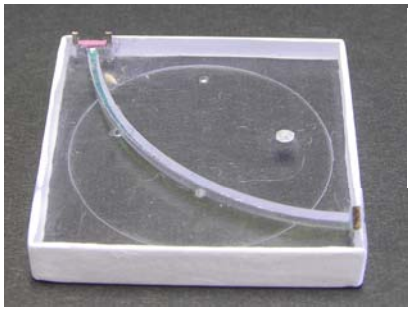
} 1.6% *partly sensitive*

} consistent with measured 1.7%

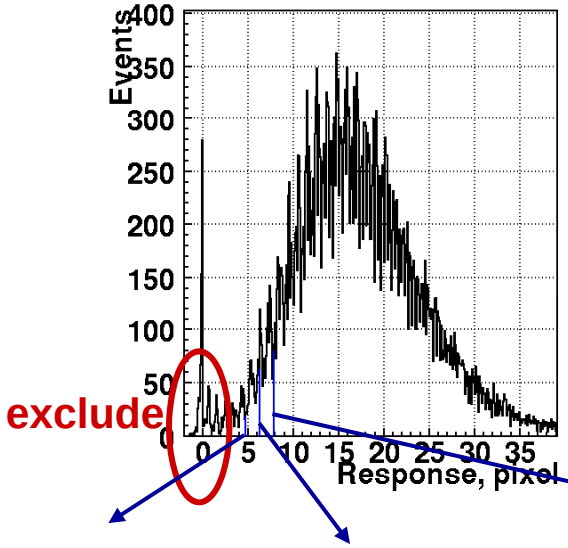
Inefficiency at edge is shared by two tiles ⇒ should be divided by two.
⇒ Total geometrical efficiency of 5mm tile is close to 99%.

5mm tile uniformity

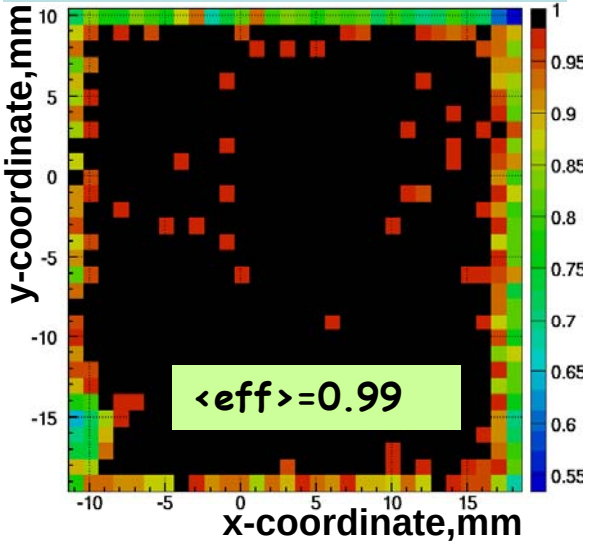
CALICE HCAL tile
MIP at 15p.e.



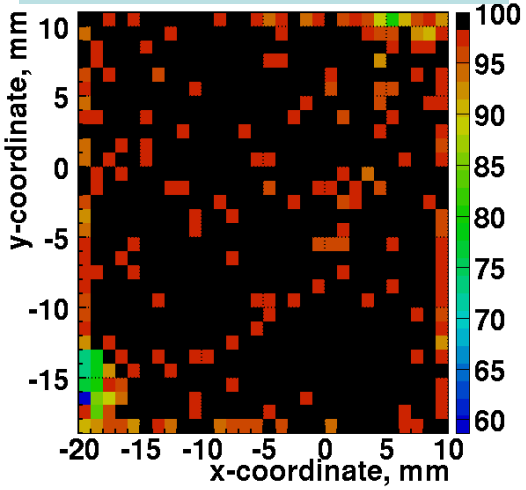
Response to beam particle



Efficiency at 3 pixel threshold

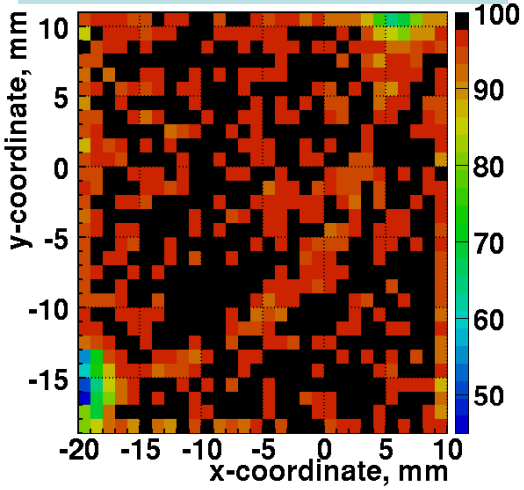


Eff. at 0.3 MIP thresh.



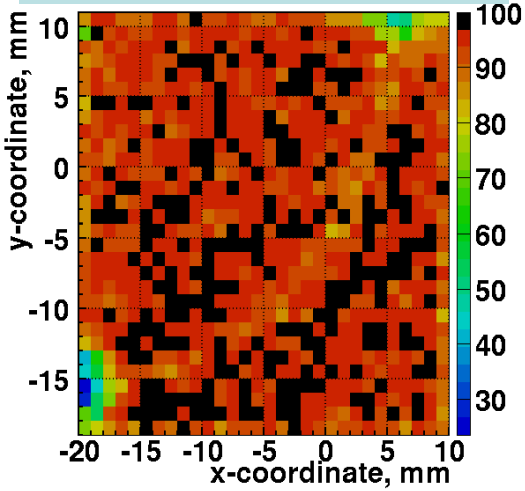
<eff>=0.98

Eff. at 0.4 MIP thresh.



<eff>=0.97

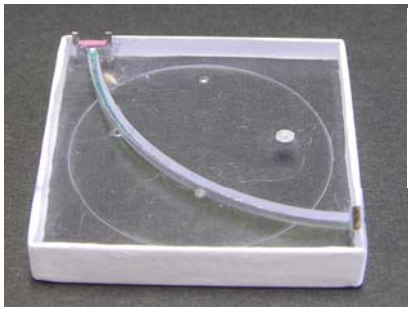
Eff. at 0.5 MIP thresh.



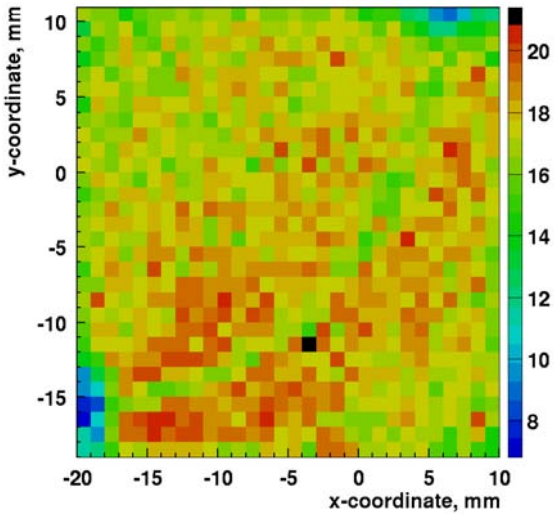
<eff>=0.94

5mm tile uniformity

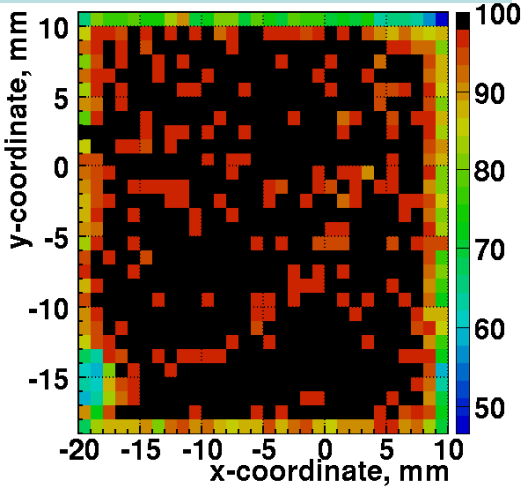
CALICE HCAL tile
MIP at 15p.e.



Response map

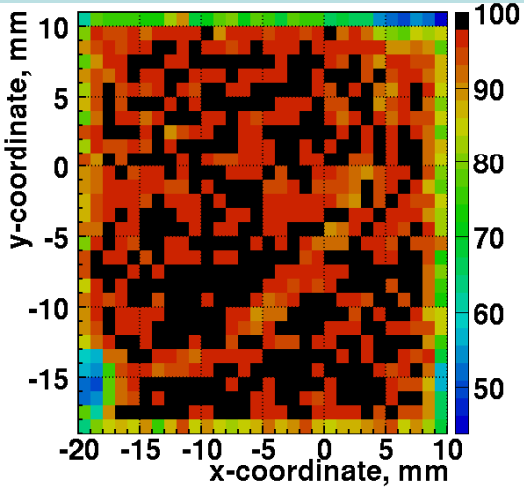


Total eff. at 0.3 MIP thr.



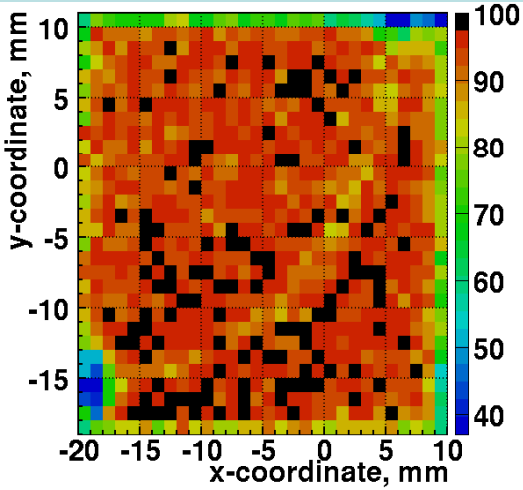
<eff>=0.97

Total eff. at 0.4 MIP thr.



<eff>=0.96

Total eff. at 0.5 MIP thr.

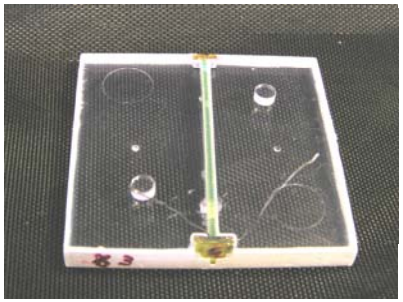


<eff>=0.93

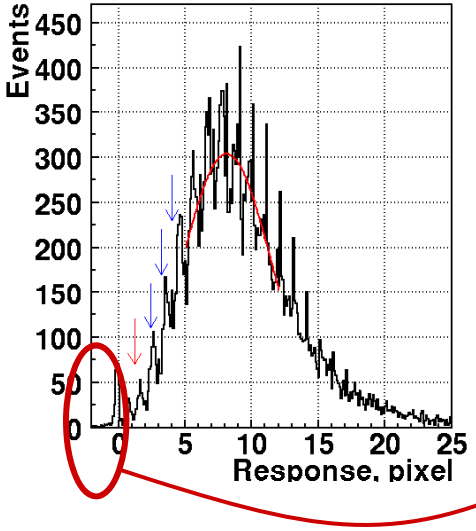
Input for MC.

3mm tile uniformity

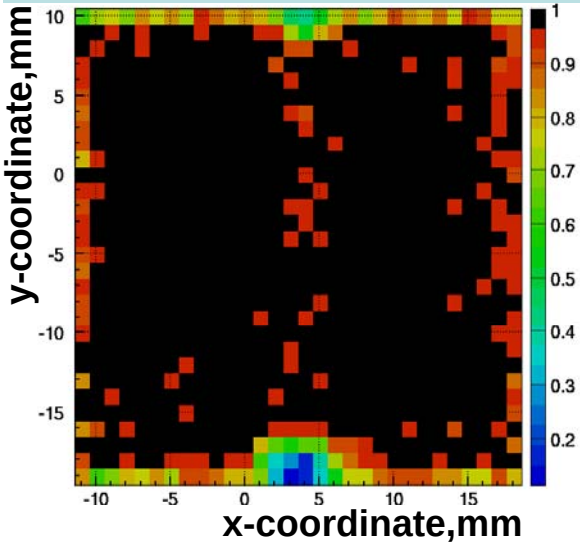
EUDET tile
MIP at 10p.e.



Response to beam particle



Efficiency at 0.5 pixel threshold



<Eff> = 97.1%

Holes in acceptance of tile:

edges 120 x 0.15= 18mm^2 ← 2.0% *(matting of two tiles + gap)*

SiPM 5 x 1.6 = 8 mm^2

mirror 3 x 1 = 3 mm^2

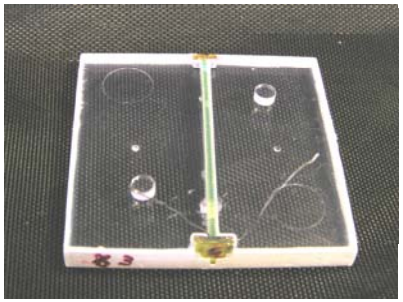
} 1.2%

} consistent with measured 2.9%

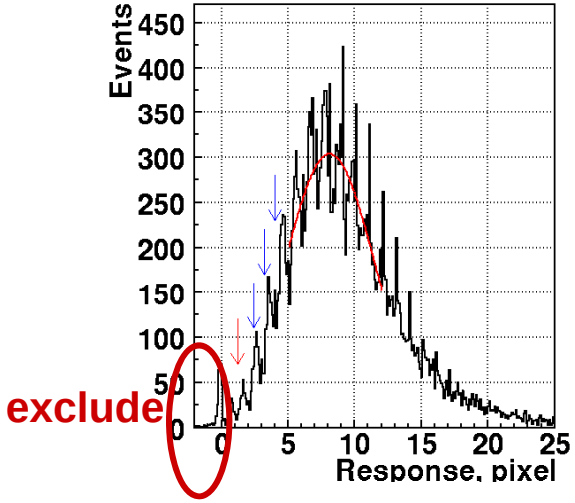
Inefficiency at edge is shared by two tiles ⇒ should be divided by two.
⇒ Total geometrical efficiency of 3mm tile is close to 98%.

3mm tile uniformity

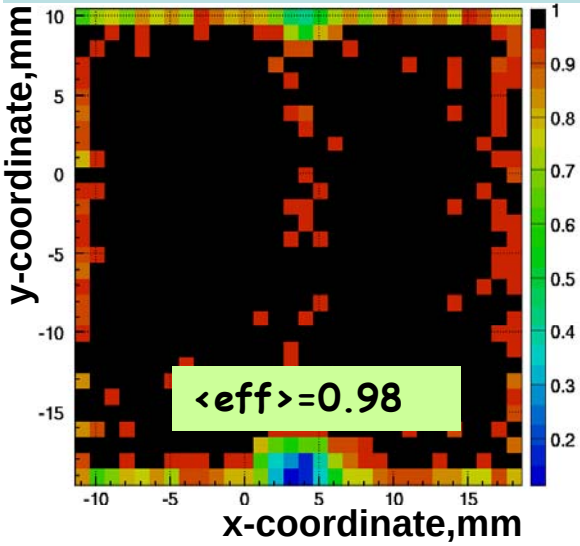
EUDET tile
MIP at 10p.e.



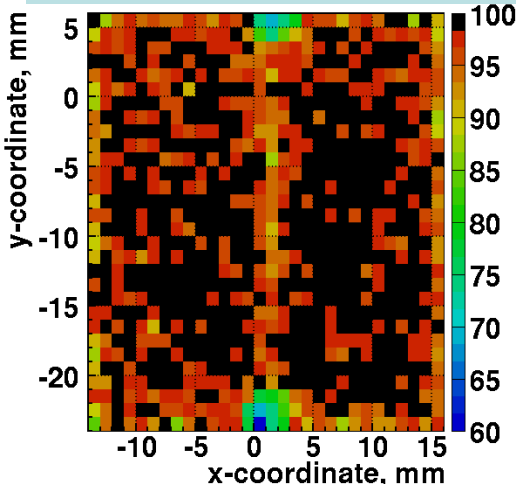
Response to beam particle



Efficiency at 0.5 pixel threshold

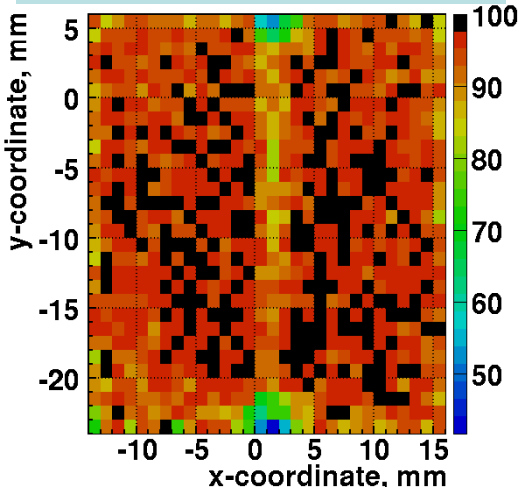


Eff. at 0.3 MIP thresh.



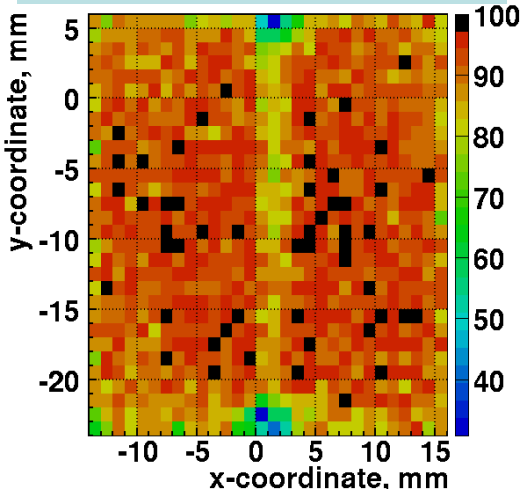
<eff>=0.96

Eff. at 0.4 MIP thresh.



<eff>=0.94

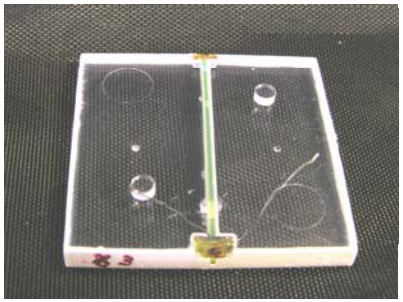
Eff. at 0.5 MIP thresh.



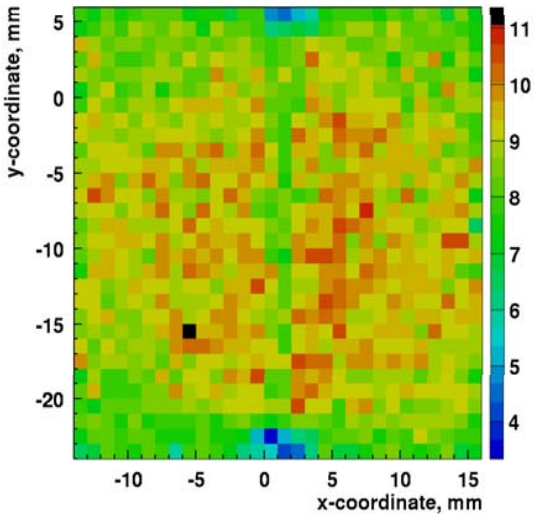
<eff>=0.90

3mm tile uniformity

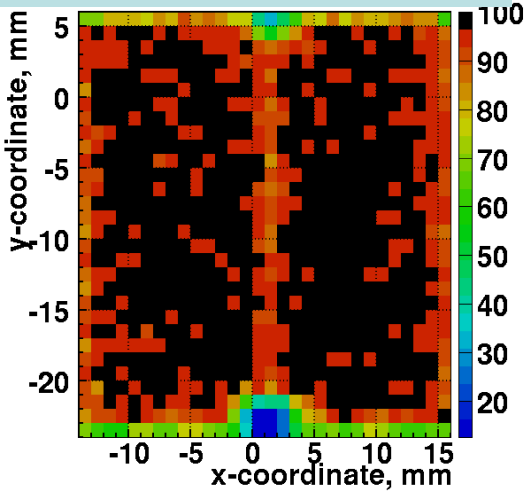
EUDET tile
MIP at 10p.e.



Response map

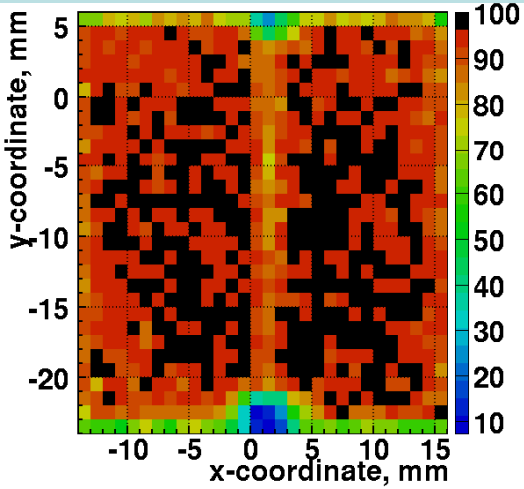


Total eff. at 0.3 MIP thr.



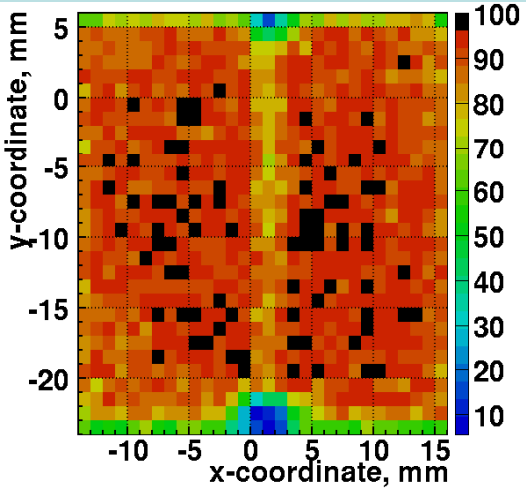
<eff>=0.94

Total eff. at 0.4 MIP thr.



<eff>=0.92

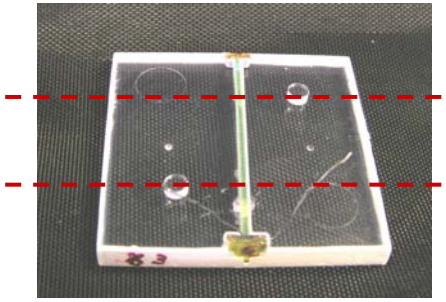
Total eff. at 0.5 MIP thr.



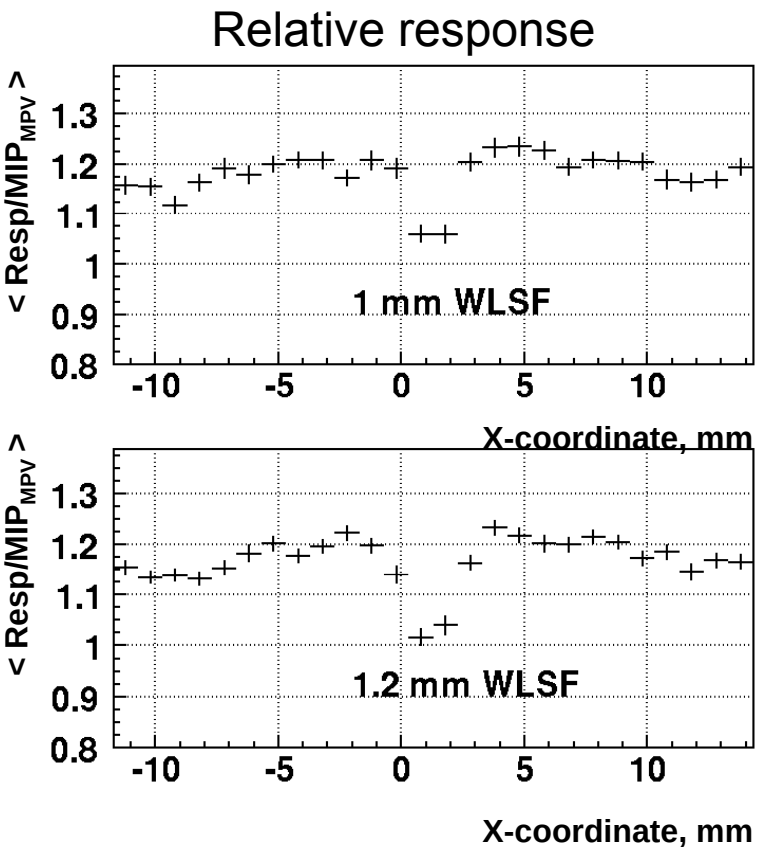
<eff>=0.88

Efficiency is small because tile had only 8p.e./MIP instead of 10p.e.

Response uniformity: 1mm vs. 1.2mm WLS fiber



⇒



⇒ No significant efficiency drop due to change 1.0 → 1.2mm in WLS fiber diameter is expected.

Implications of new tile design

WLS fiber : 1mm → 1.2mm

MRS APD : #pixels 556 → 796 *x1.43*
pixel size 43μ → 40μ
sensitive area ∅ 1.1mm → 1.28mm

Change working point from 10 to 11-12 p.e./MIP.

decrease voltage (more light)
efficiency at 5p.e. threshold ~97%
dynamic range close to HCAL CALICE

CALICE: 1156 pixels / 15 p.e. = 77
EUDET : 798 pixels / 11 p.e. = 73

Comparison of MEPhI SiPM's and CPTA MRS APD's

More than 10000 SiPM's have been tested during CALICE prototype production

Several hundreds MRS APD's were tested during this year

The following parameters of photo-detectors at the working point have been compared:

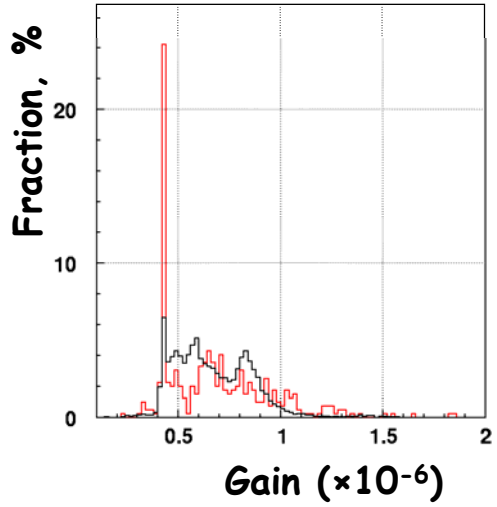
- ✓ Gain
- ✓ Cross talk
- ✓ Noise frequency at zero level
- ✓ Noise frequency at $\frac{1}{2}$MIP threshold
- ✓ Current
- ✓ Current stability

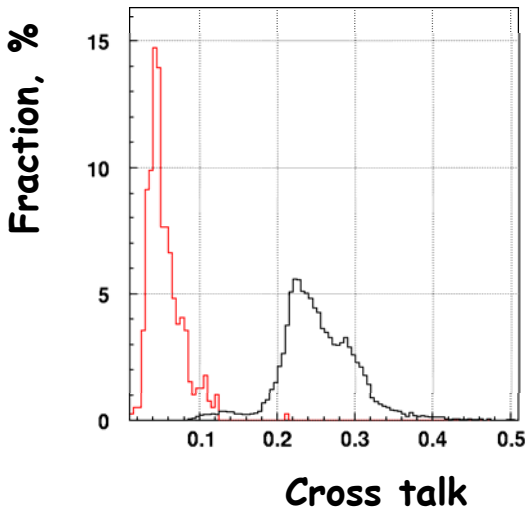
Working point for SiPM's was taken as 15 pixels per MIP in 30×30×5 mm^3 tile with arc like WLSF - chosen for tiles in CALICE HCAL prototype

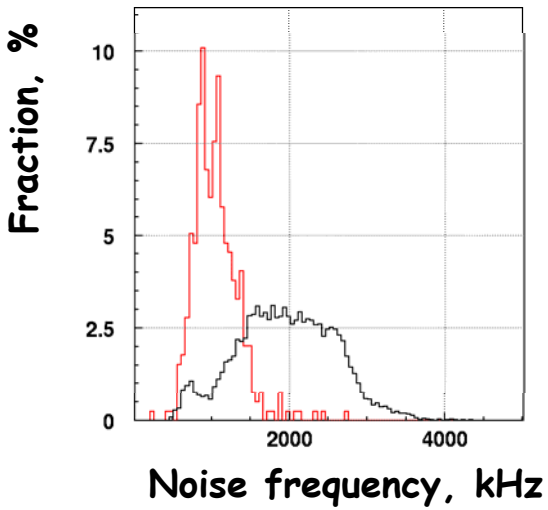
For MRS APD's it was 10 pixels per MIP in 30×30×3 mm^3 tile with glued in straight WLSF as a compromise between wishes to have high MIP registration efficiency and dynamic range as wide as possible

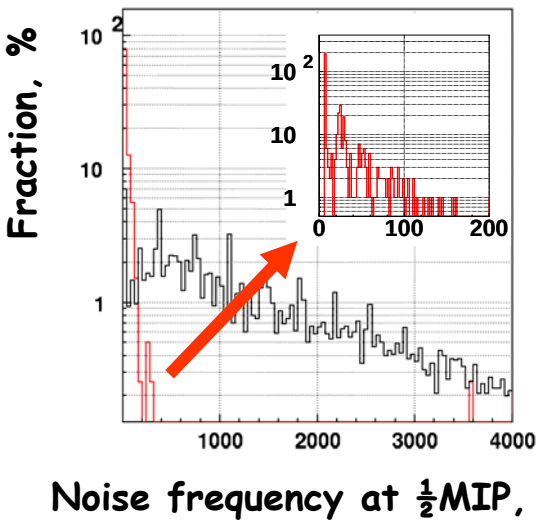
Distribution of parameters for MEPhI SiPMs (black) and MRS APDs (red)

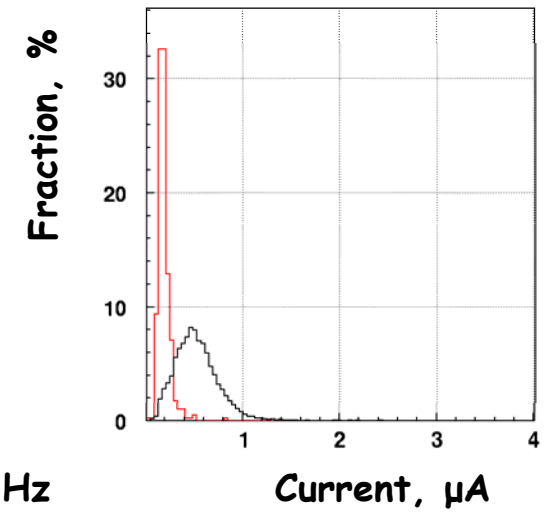
(normalized to 100%)

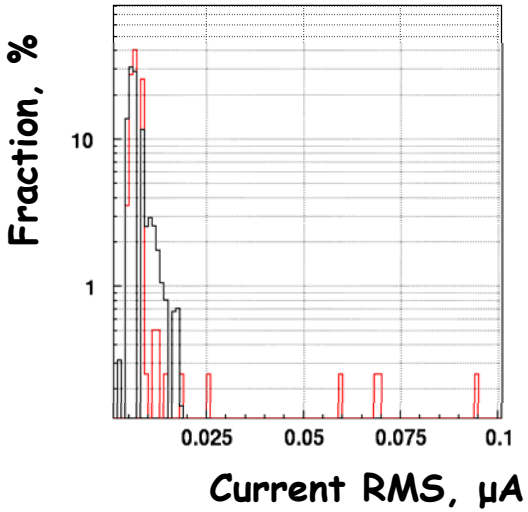




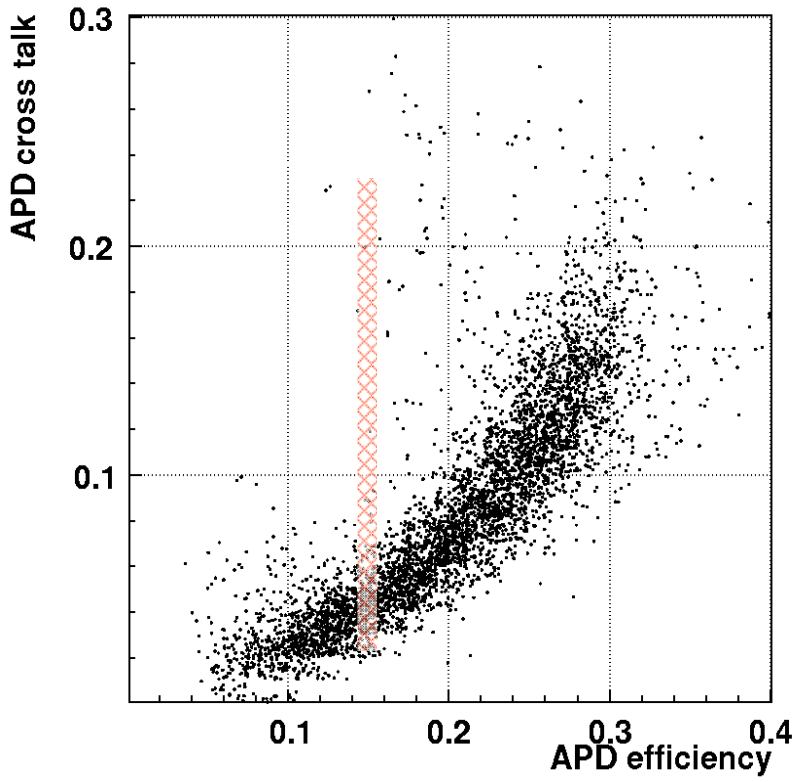


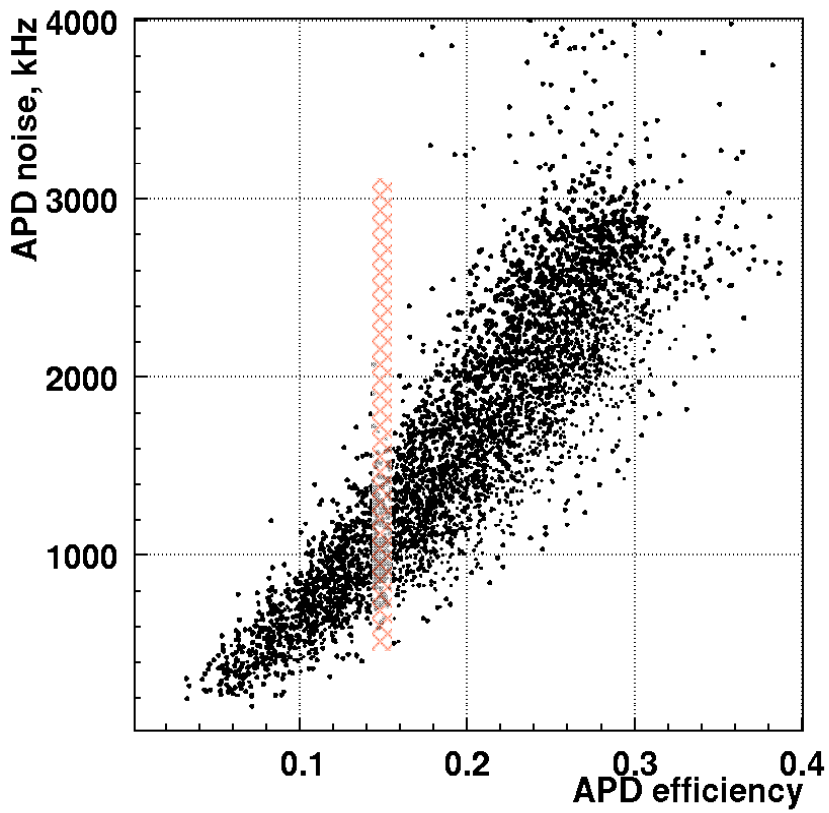






X-talk and noise frequecy vs photo-detector efficiency for tested MRS APD. Hatched area shows 15 ± 1% range of efficiency chosen for working point.

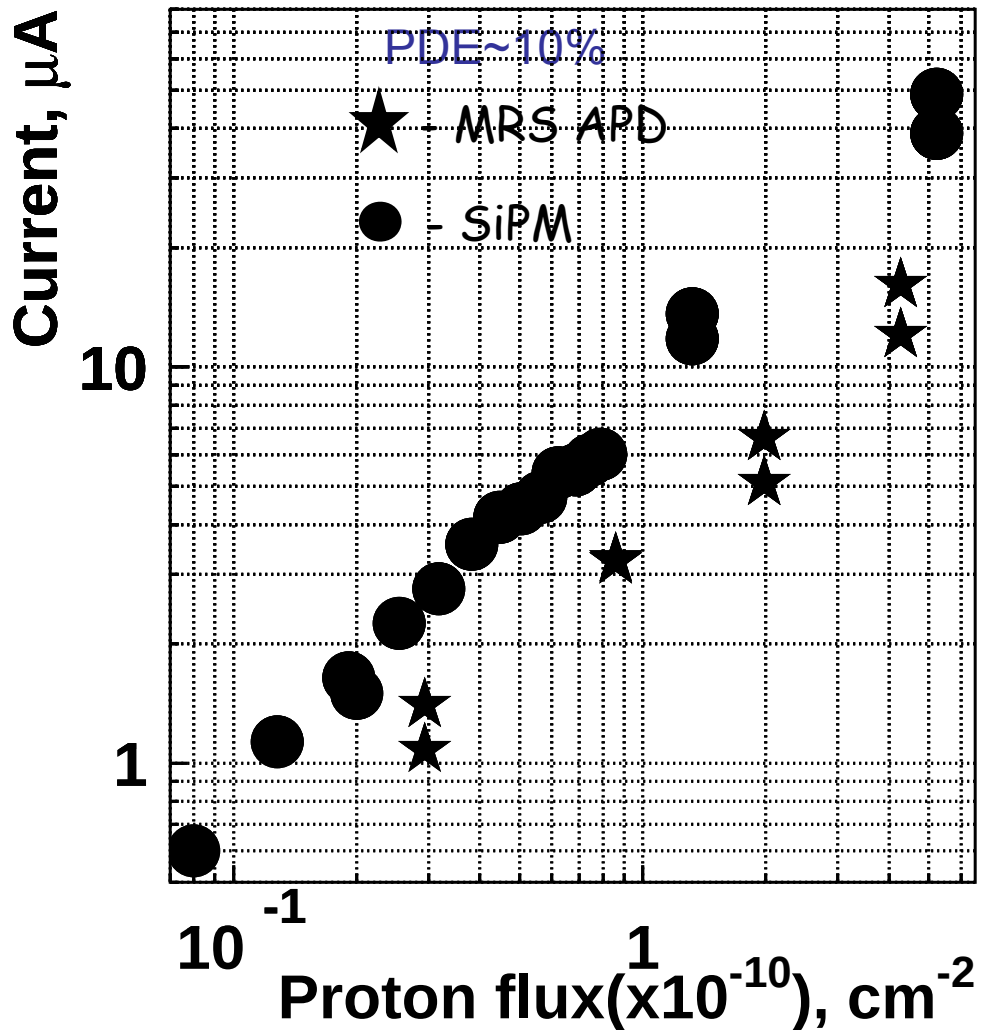




☺ CPTA MRS APD at chosen working point are far from operation limit.

Radiation hardness of SiPMs

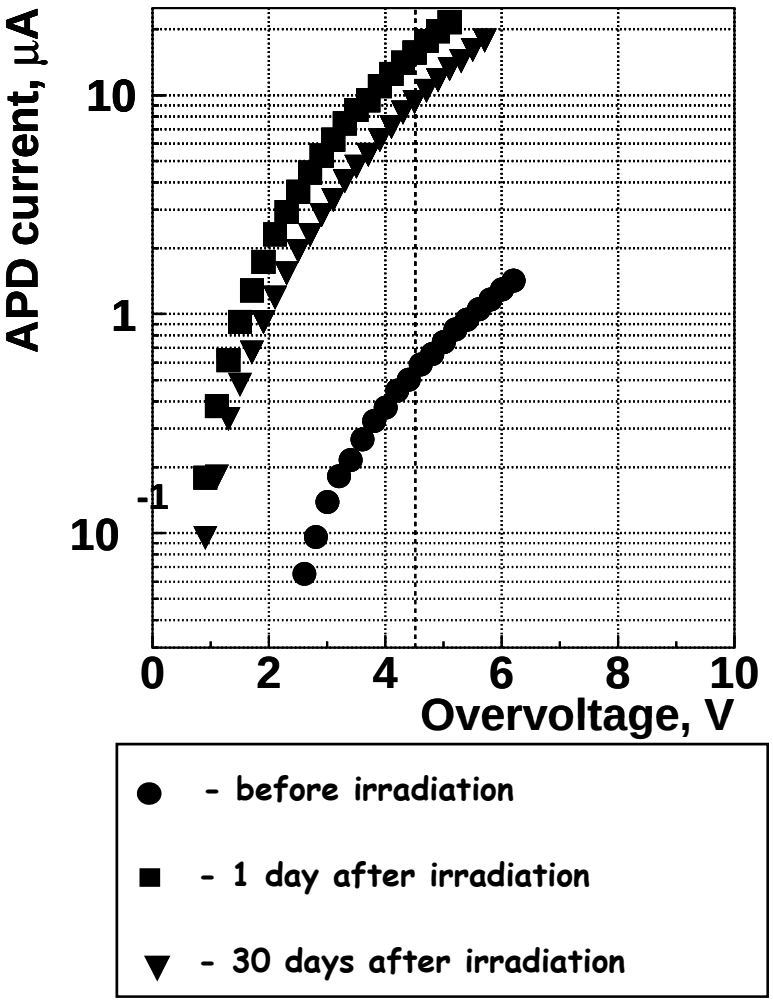
Comparison of radiation damage of MRS APD and SiPM with low energy protons



MRS APD has better rad. hardness at the same PDE

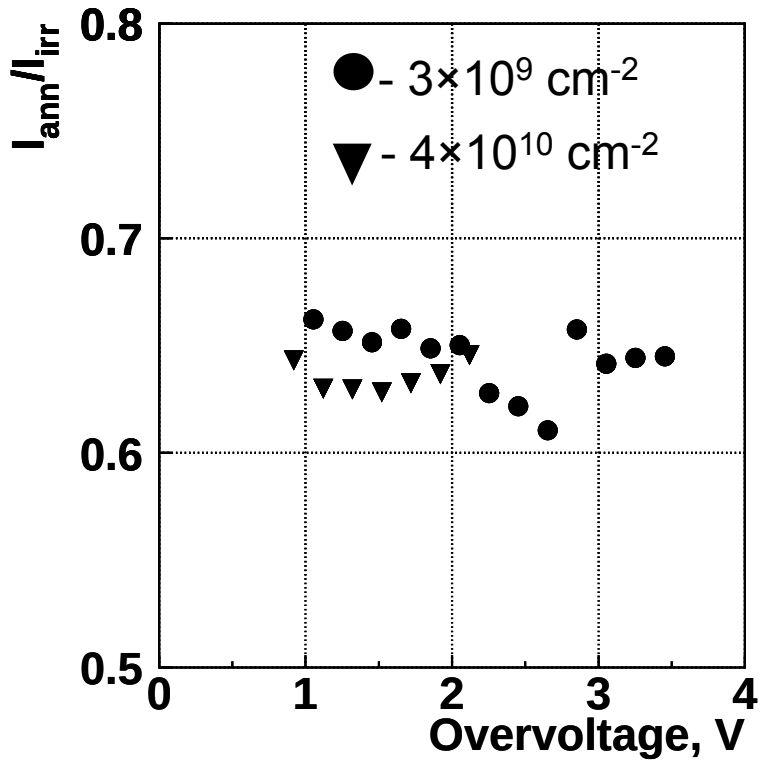
However at higher PDE
CPTA and MEPhI SiPMs are similar

Annealing of MRS APD



Fluence 3×10^9 /cm-2 protons

Annealing does not depend on fluence nor overvoltage



Conclusions

Optimistic plans for tile-SiPM production match well EUDET schedule

The response uniformity is good enough

The efficiency is expected to be quite high ~95%

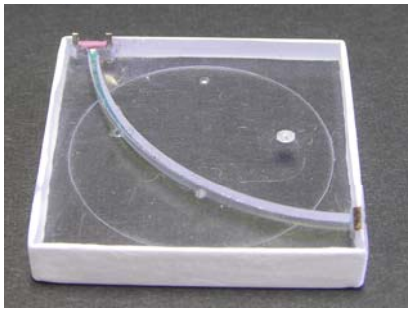
Radiation hardness is somewhat better for CPTA SiPMs in comparison with MEPhI SiPMs

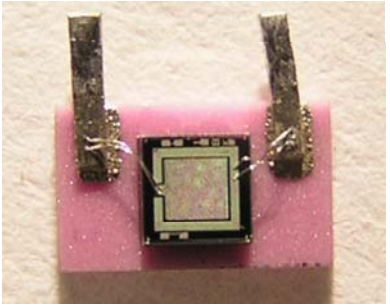
Back-up

Measurement of response and efficiency map at proton test beam

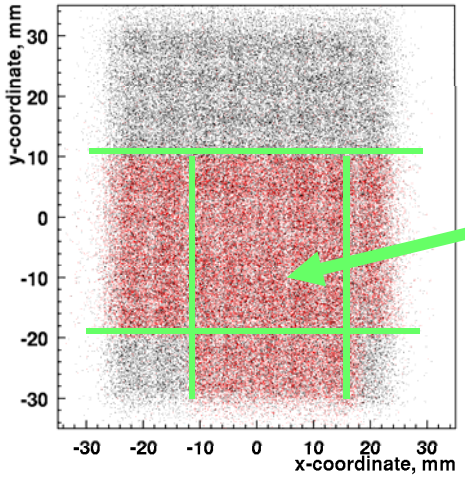
(Very Preliminary!)

1. Tiles and photo-detectors for CALICE HCAL prototype

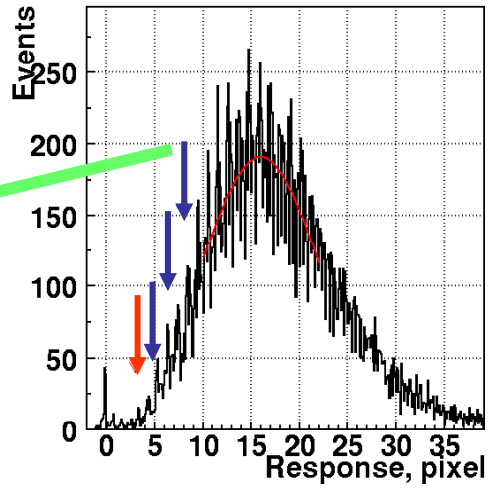




Position of tested tiles in the beam



Response to beam particle

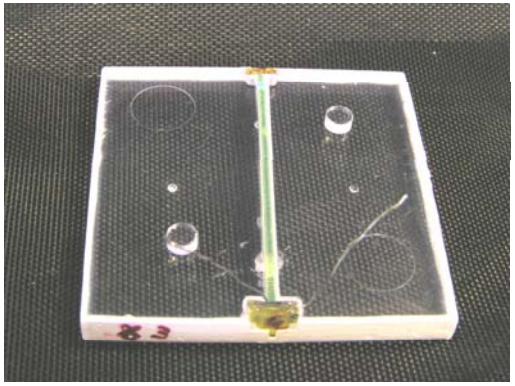


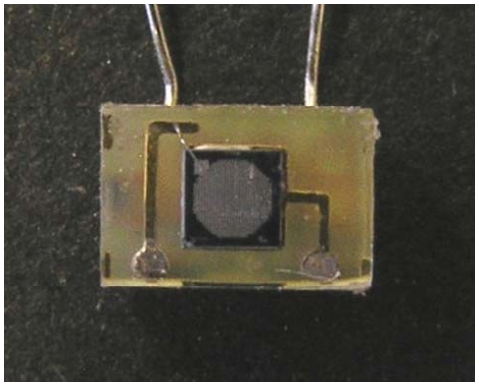
4 tiles of 30×30×5 mm^3 tiles with arc-like 1 mm dia WLS fiber

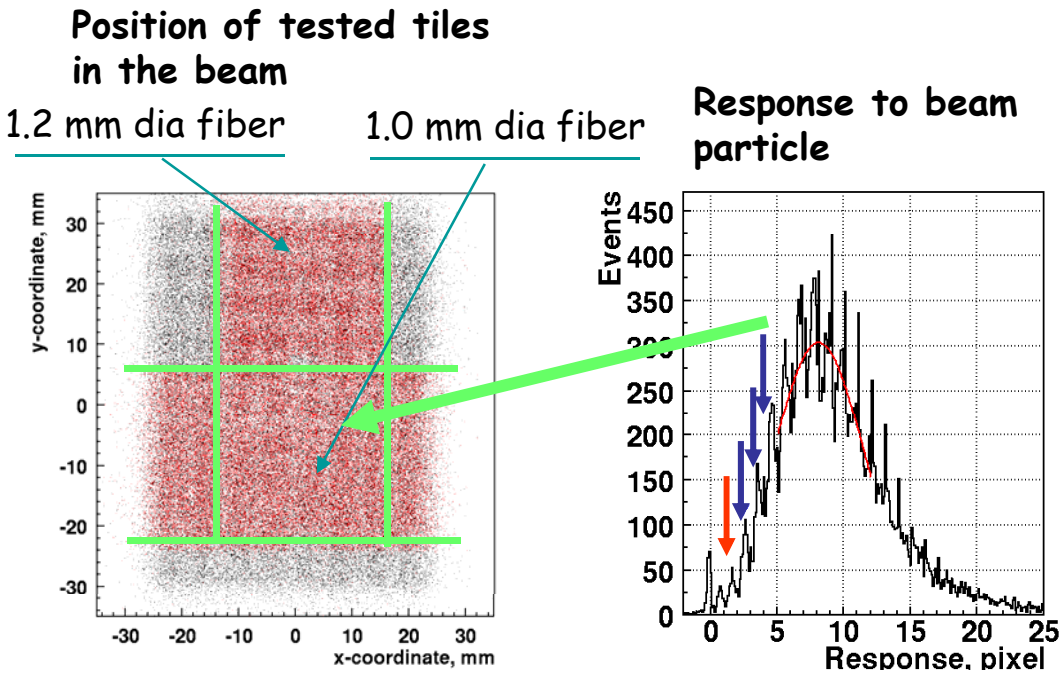
Readout via 1.06×1.06 mm^2 1156 pixel SiPM from MEPhI-Pulsar

15pixels per MIP working point is chosen as a compromise between wishes to have high detection efficiency and dynamic range as wide as possible

2. Tiles and photo-detectors for EUDET prototype







4 tiles of 30×30×3 mm^3 tiles with 1(1.2) mm dia WLS fiber

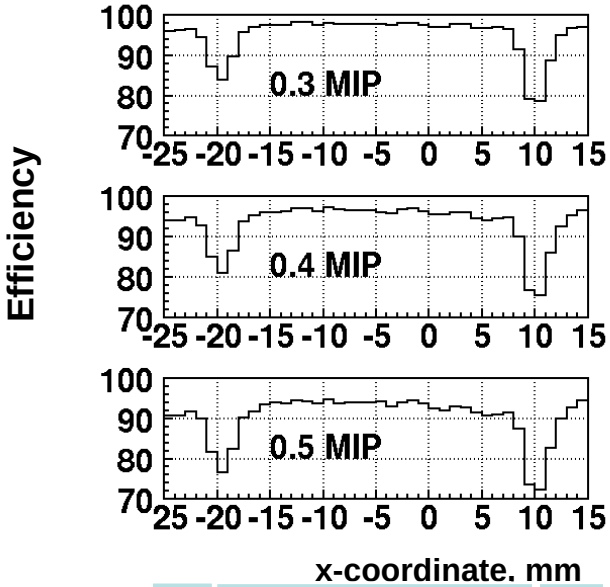
Readout via 556 pixel MRS APD from CPTA

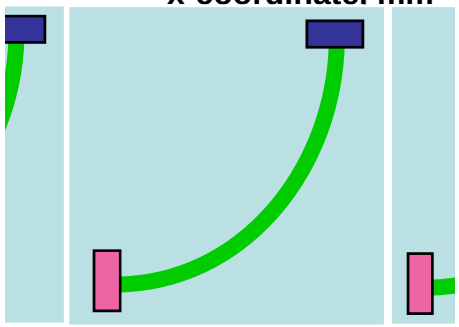
Fiber and photo-detector are glued in the tile

Working point for these tiles is chosen MIP=10 pixels, this corresponds to ~15% PDE

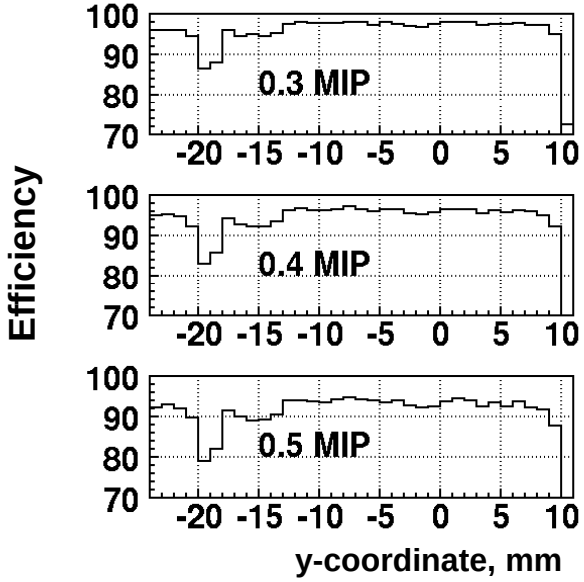
Profiles of MIP registration efficiency

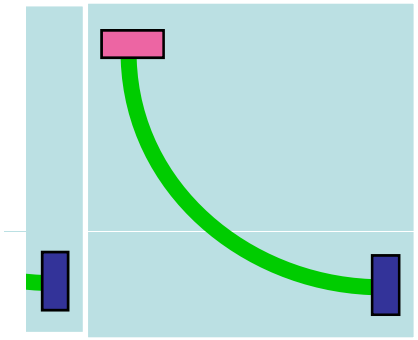
X-profile





y-profile





Results on response uniformity and tile efficiency will be used in CALICE test beam data analysis