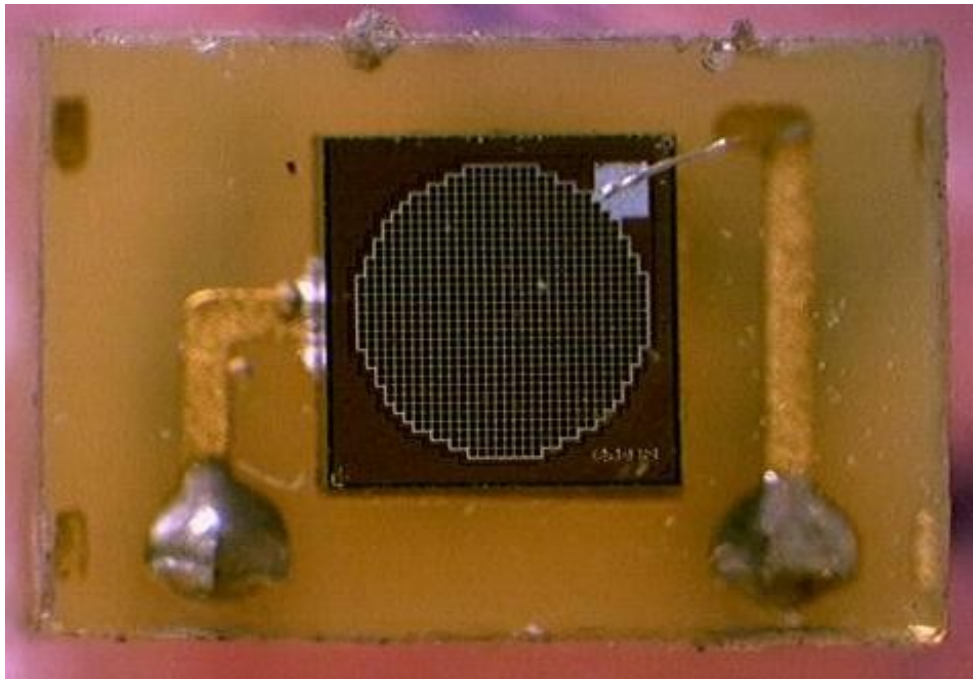
HCAL meeting
DESY 20.01.2011

Status of Scintillator tile&SiPM R&D and Production

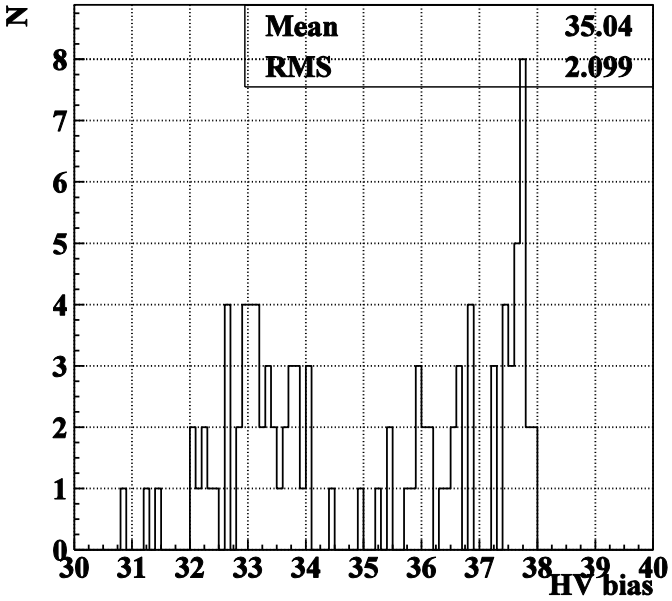
Michael Danilov
ITEP

796 pixel SiPMs have been developed in 2009
1000 SiPMs have been produced in 2010

796 pixel APD



We adjust HV to have 13 pixels from triggered electrons from Sr90
This corresponds to about 11 pixels/MIP (Frank's simulation)



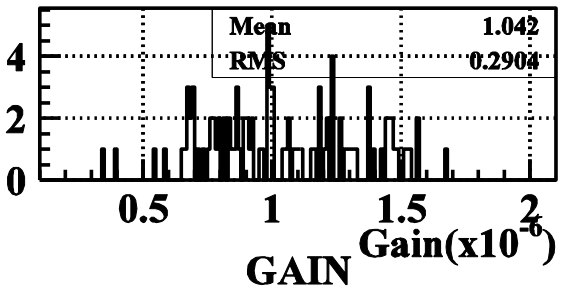
We require

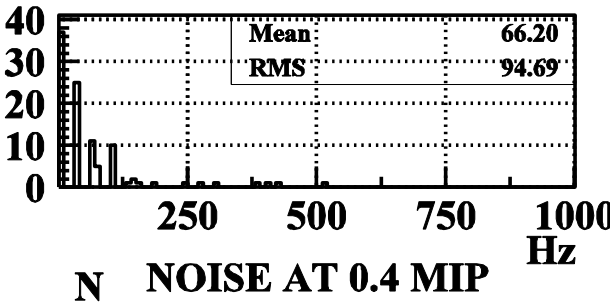
Minimal gain – 5×10^5 (in 140 ns gate)

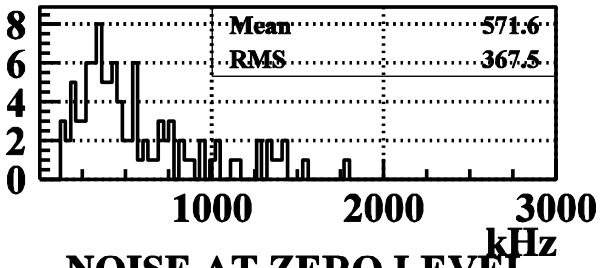
Noise rate at 0.5 pixel < 2 MHz

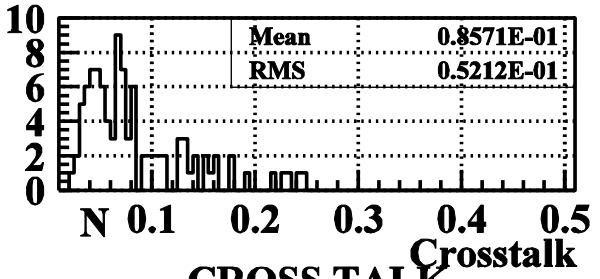
Current stability < 20 nA RMS

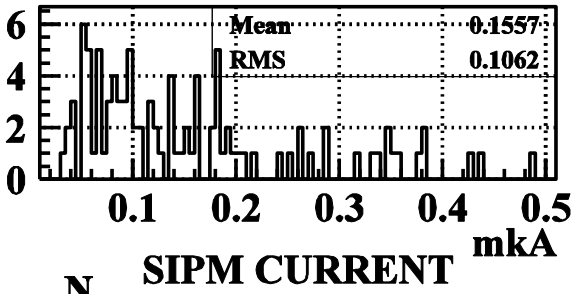
SiPM Parameters

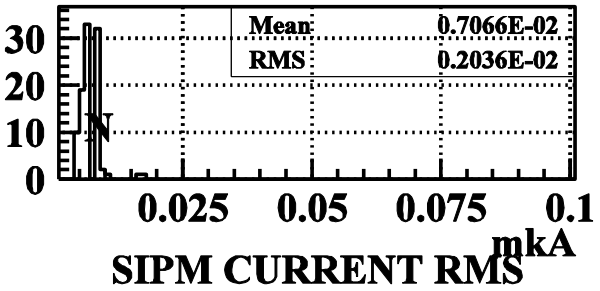


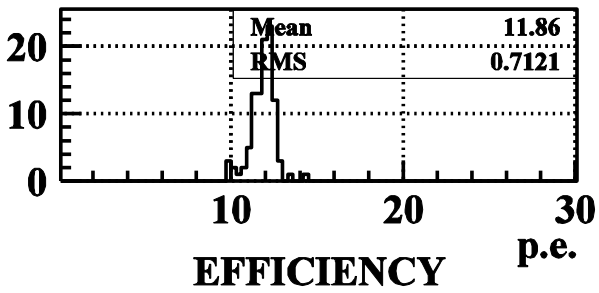


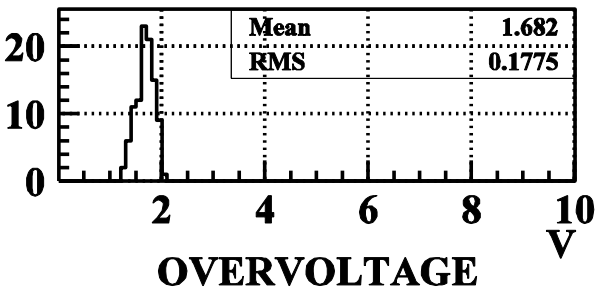








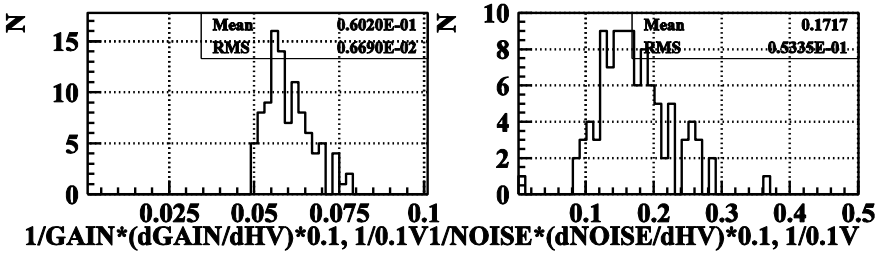


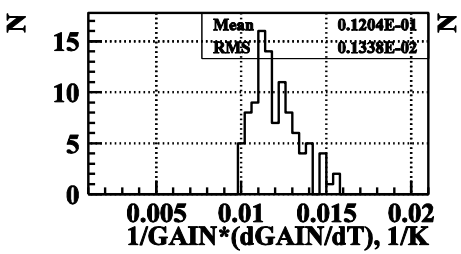


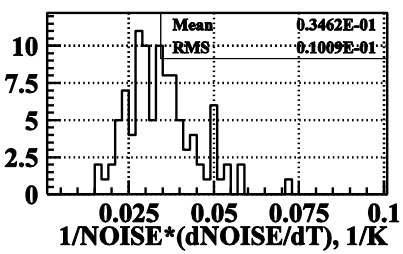
SiPM parameter variation

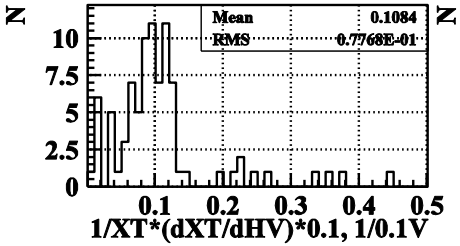
Parameter variation for 0.1 V HV variation : gain, noise, xt, efficiency,response, Npix/MIP

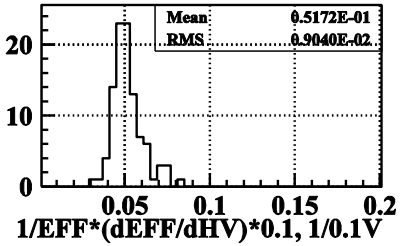
Parameter variation for 1° temperature variation : gain, noise, xt, efficiency,response, Npix/MIP

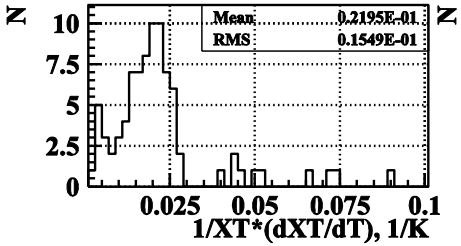


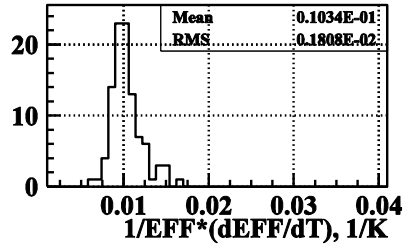


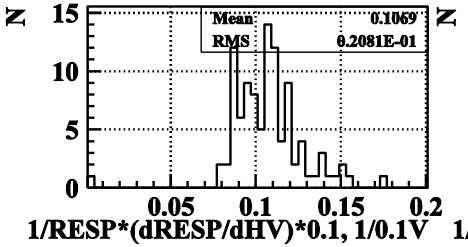


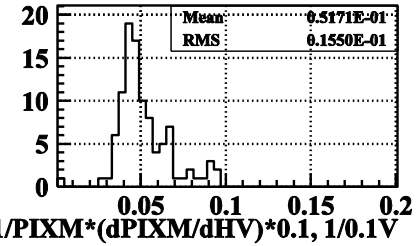


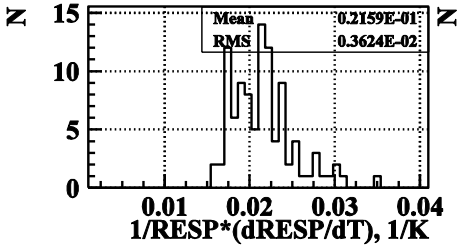


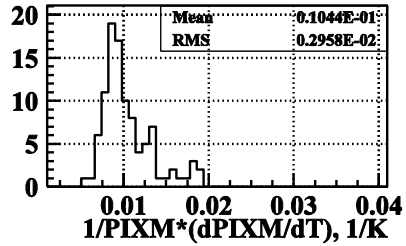




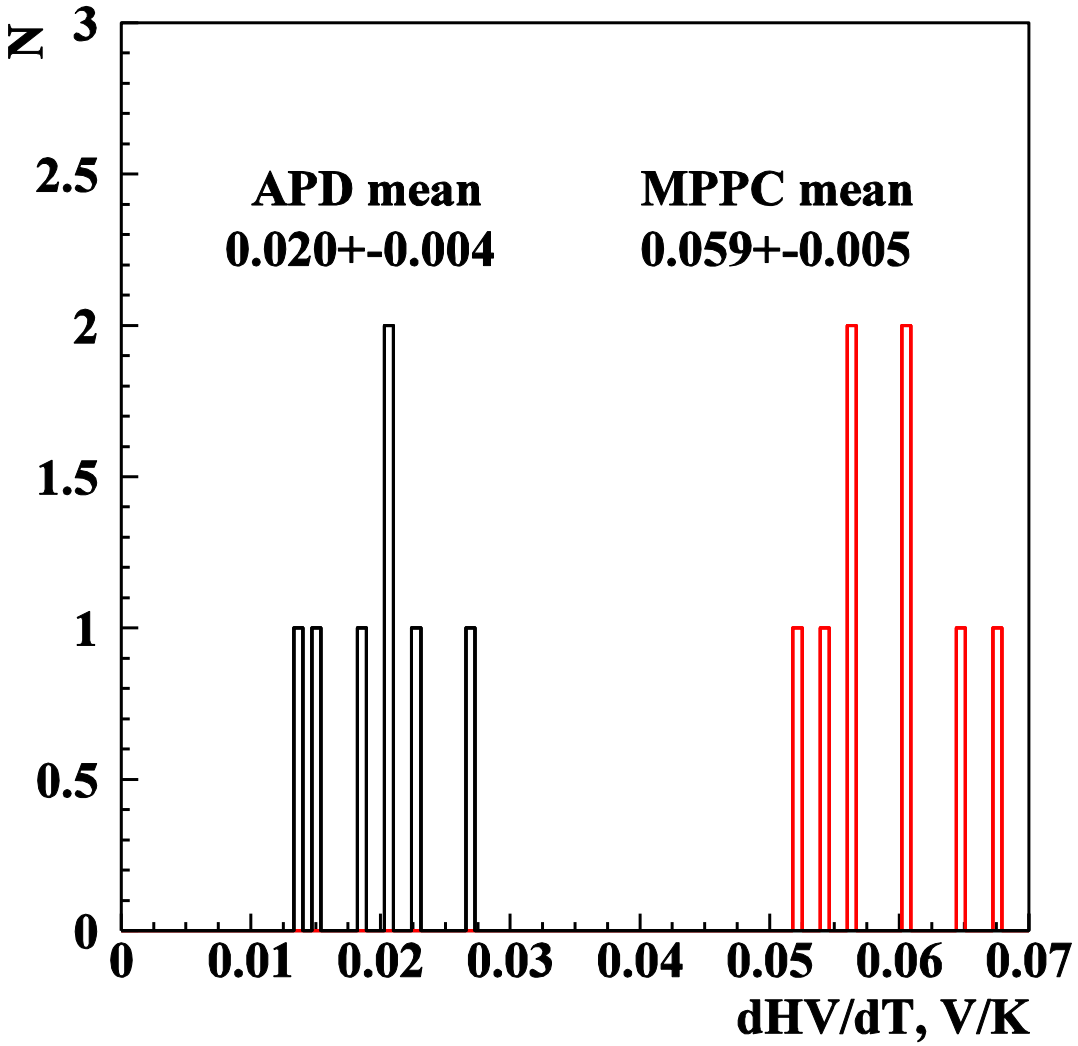




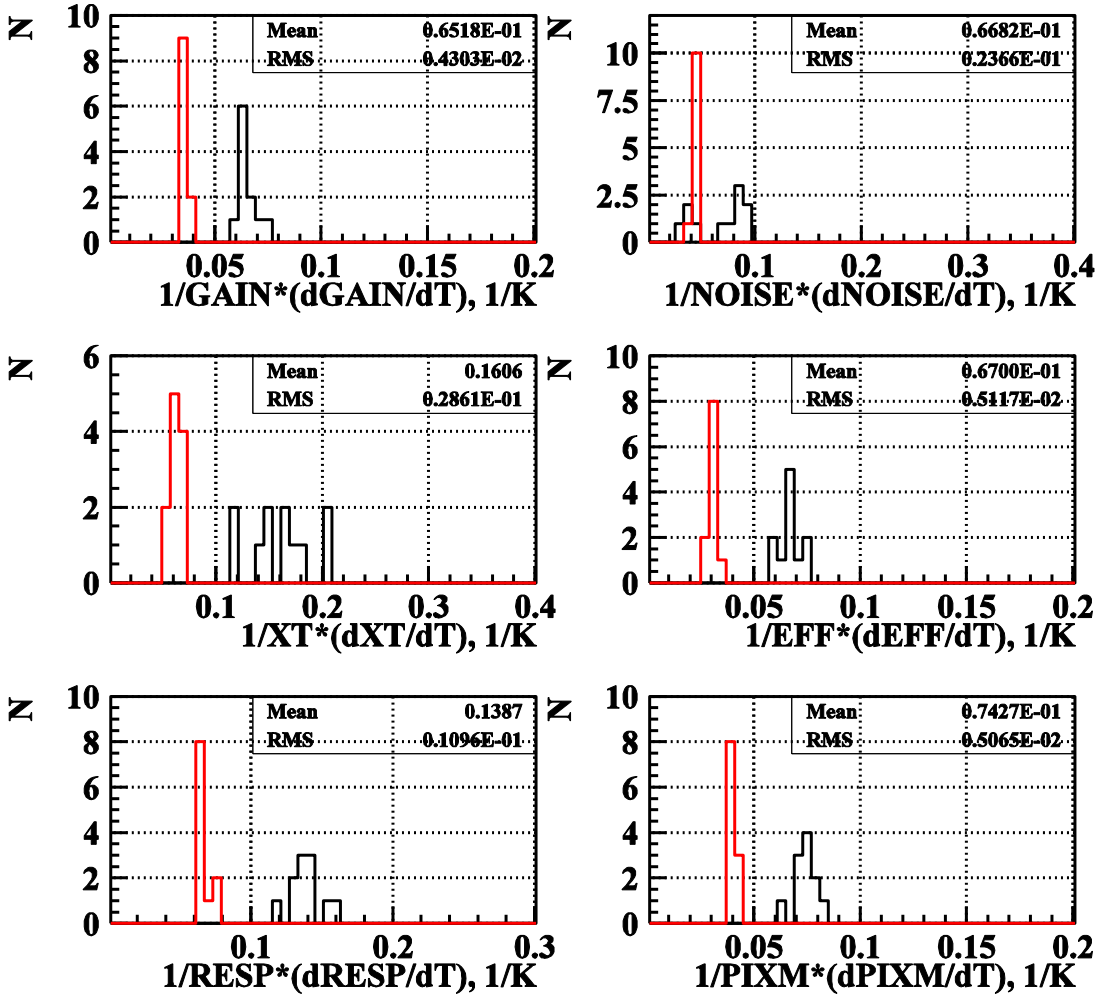




Shift of breakdown voltage due to temperature variation is 3 times higher for MPPC (50micron pitch)



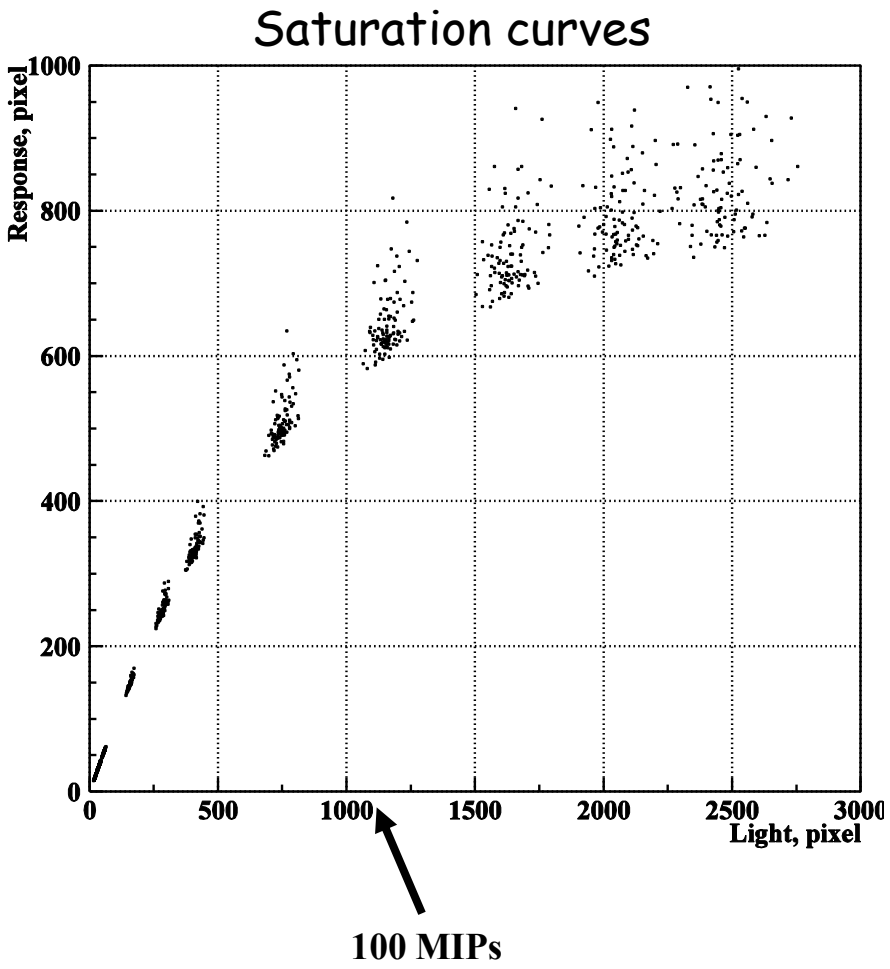
Sensitivity to temperature changes is much higher for MPPC

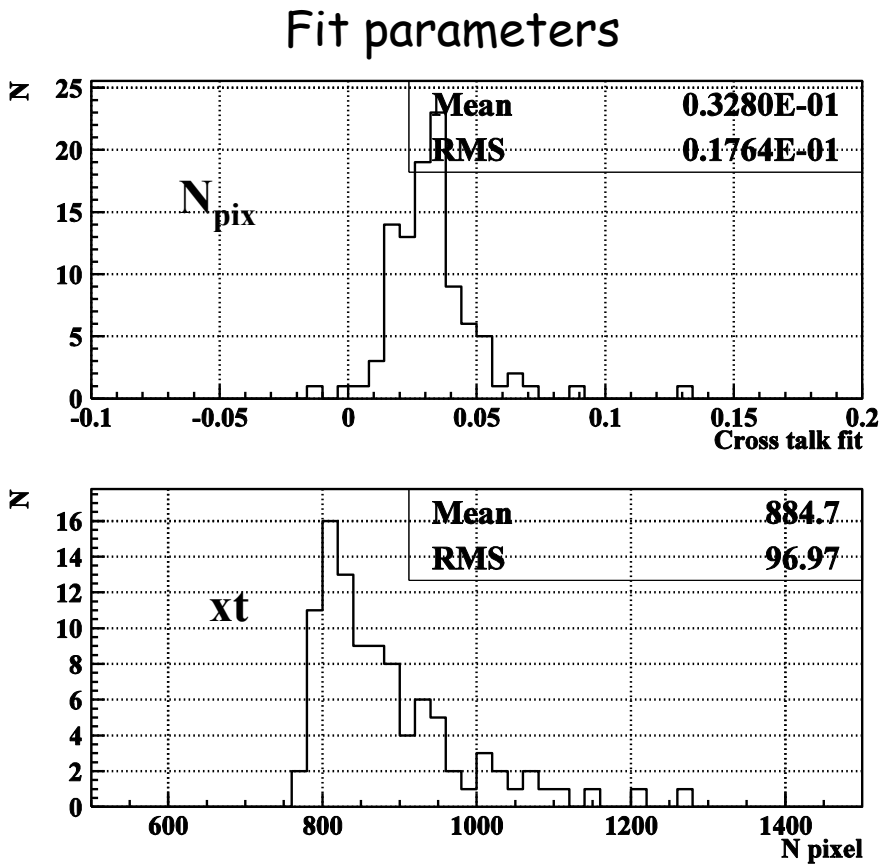


Black histograms – measurements for 50μ pitch MPPC

Red histograms – extrapolation to 25μ MPPC

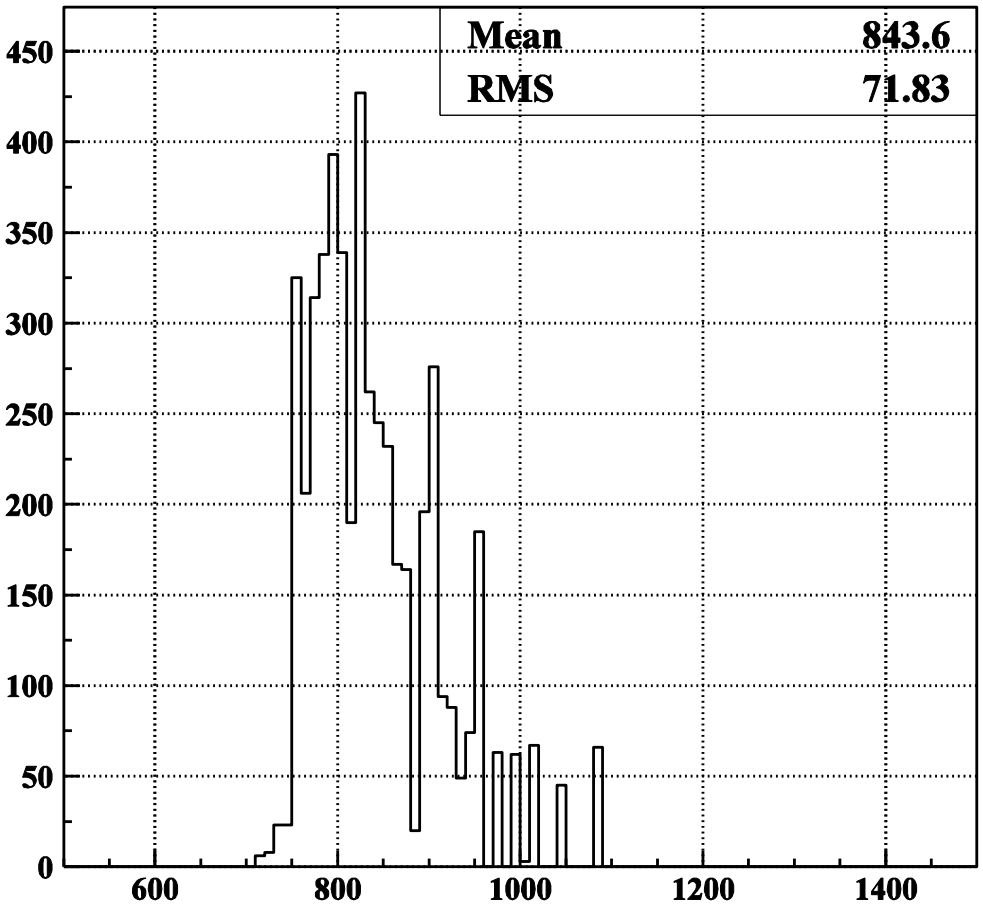
Saturation curves





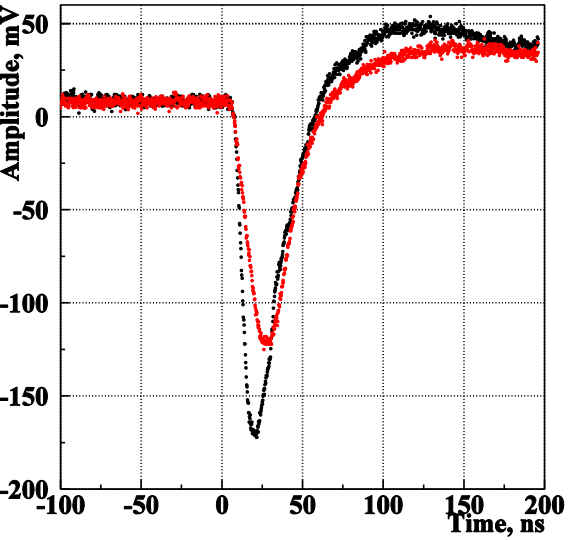
Fitting function $y=N_{pix}*(1-\exp(-x/N_{pix}))/(1-xt*(1-\exp(-x/N_{pix}))$

Number of pixels at light ~200 MIP

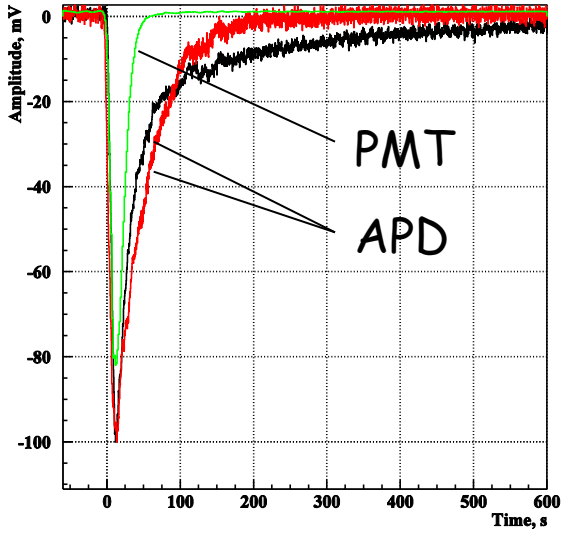


Pulse shape

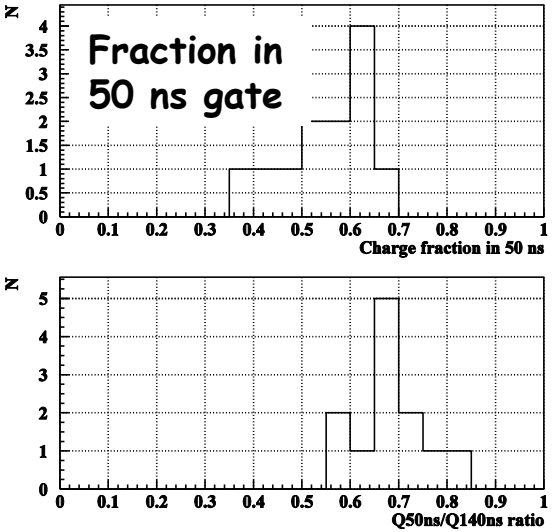
tile + β-source + amplifier



Without amplifier LED+WLSF



Charge distribution



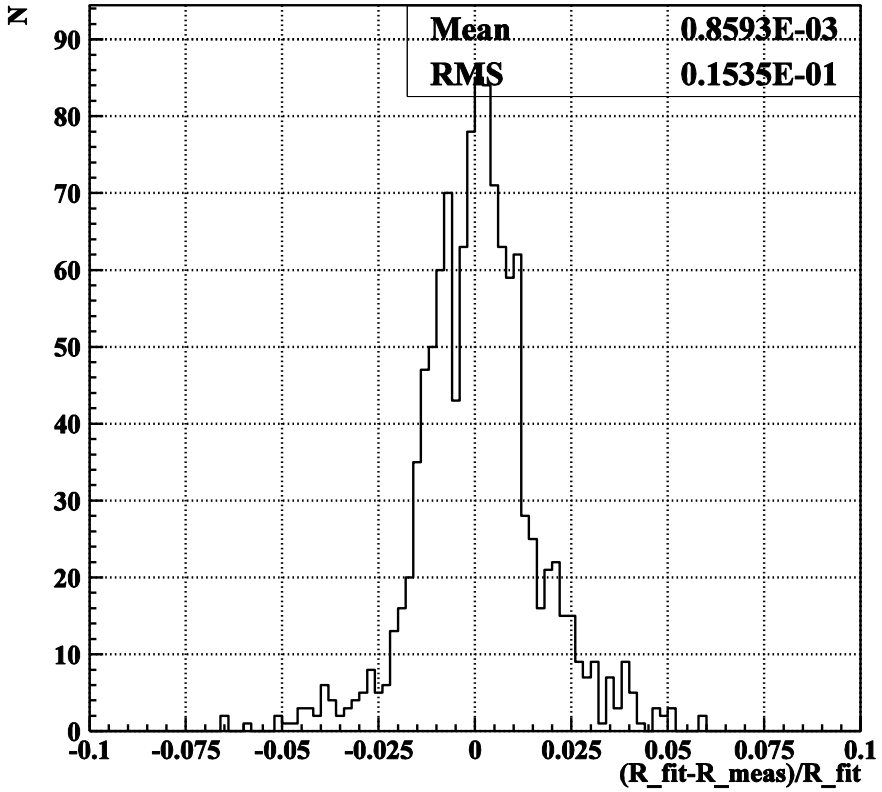
50 ns fraction to 140 ns fraction ratio

Some spread in pulse shapes is probably the reason for different saturation curves

Should not be a problem – calibration will take it into account

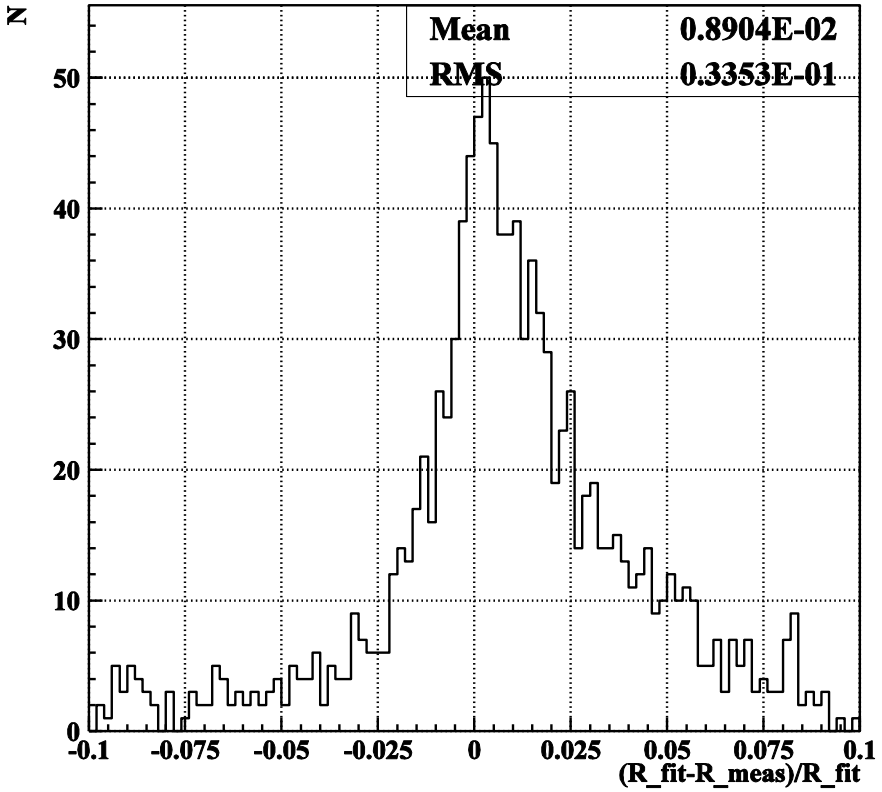
Accuracy of fit (below 240 MIP)

Individual fit parameters



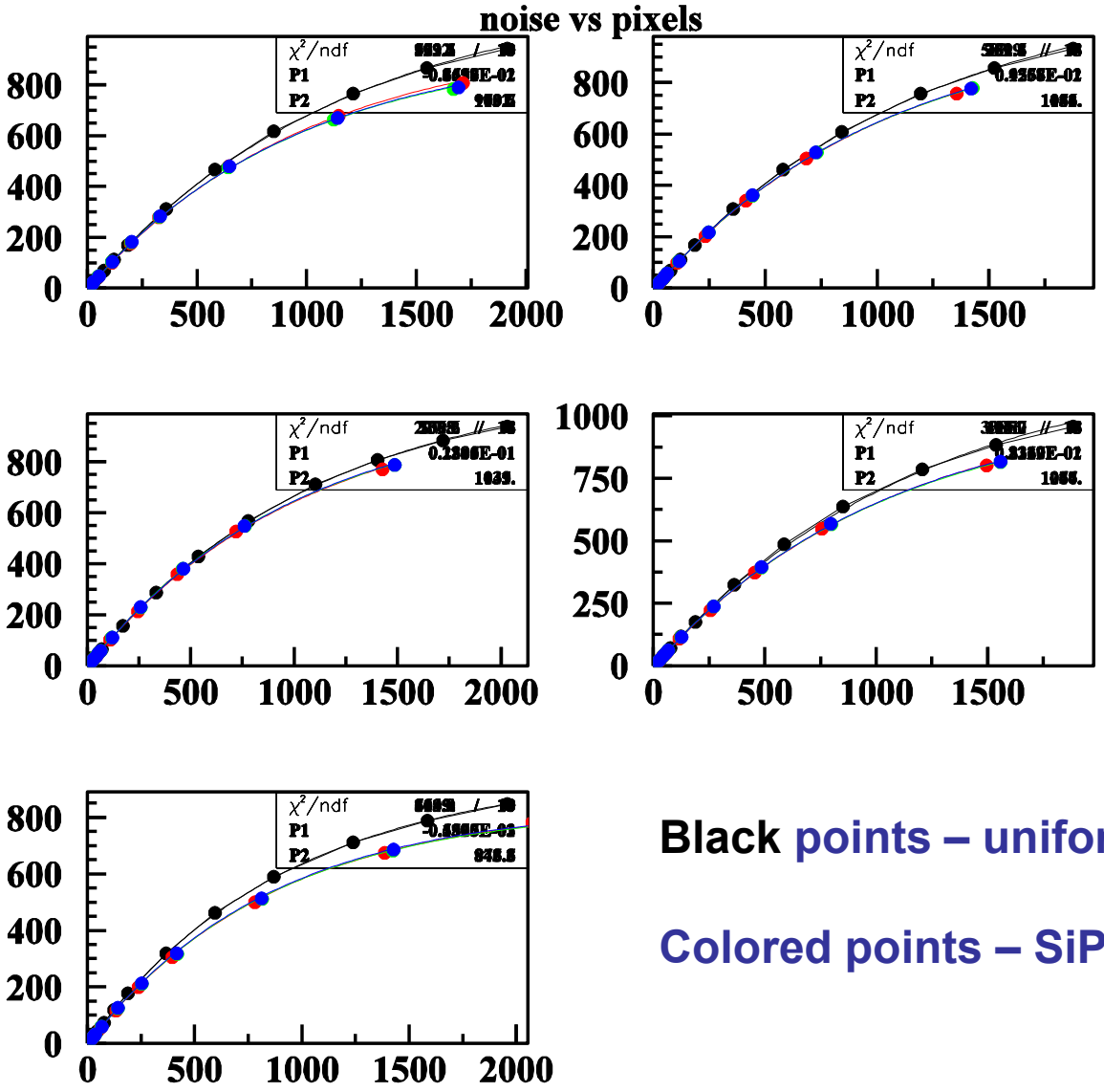
Common fit parameters

N_{pix}=880 xt=0.034



Deviation from the fit is only 1.5%

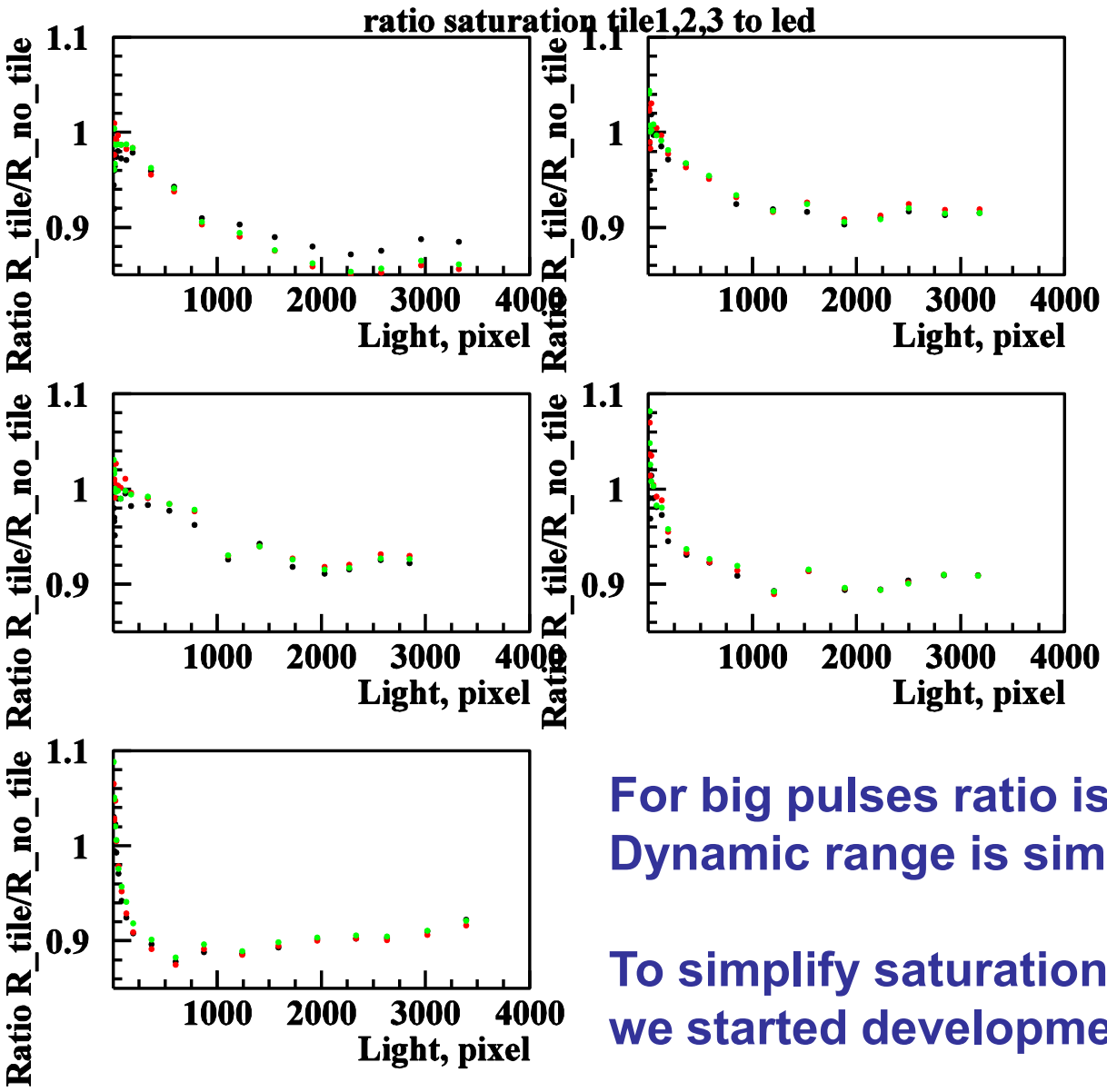
Saturation curves in tiles



Black points – uniformly illuminated SiPM

Colored points – SiPM response in tiles

Ratio of response in tile to uniformly illuminated SiPM
(different colors – different measurements of the same tile)



For big pulses ratio is about 0.9
Dynamic range is similar to existing AHCAL

To simplify saturation correction
we started development of SiPM with 2000 pix

Summary

The present tile&SiPM systems are by far better than those in existing AHCAL: 40% thinner, much lower noise, lower threshold, wide operating plateau, similar dynamic range.

There is still some spread in parameters but it will be taken into account by calibration

Fit with 2 parameters provides good description of saturation curves
(so far for uniform illumination of SiPMs).
Saturation curves in tiles differ by < 10% from uniform illumination case

MRS`APD are 4-5 times less sensitive to temperature than MPPC

All tiles have been produced and meet the required accuracy in dimensions

1000 SiPMs have been produced and tested

100 tile-SiPM systems have been produced

2000 pixel SiPM is being developed

Saturation curves in tiles

Test was done with LED illuminating a tile. LED light was monitored by a PMT.

Measurements in tile were made with bias voltage at which tile response to β-particle is R_β

Tile response in pixels was calculated as R(pix) = R(ADC)/gain(ADC)

R(ADC) – response, ADC chan.

gain(ADC) – distance between peaks at LED spectrum, ADC chan

1st measurement was done with low light - one determines gain, $R(pix)_1$ and PMT_1

From this we could normalize the PMT: $PMT(ADC)_{MIP}=PMT(ADC)_1/R(pix)_1*R_\beta$

Then tile and PMT responses were measured at several low light LED flashes with and w/o amplifier to determine amplifier gains of APD and PMT channels (G_{APD} and G_{PMT})

Measurement of saturation curve was done w/o amplifier

Response $R_i(pix)=R_i(ADC)/gain*G_{APD}$

Amount of light is determined as $L_i=PMT(ADC)_i/PMT(ADC)_{MIP}*G_{PMT}$