Calibration and Monitoring of the analogue HCAL prototype

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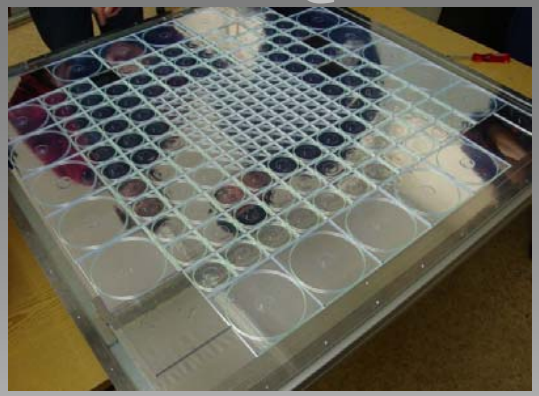
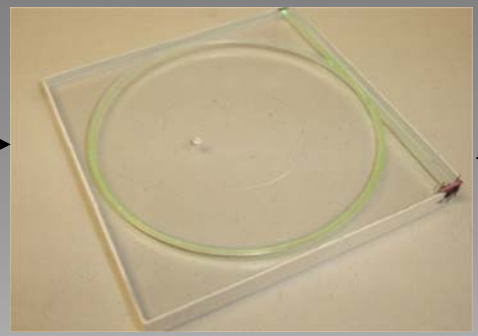
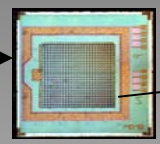
on behalf of the CALICE analogue HCAL group

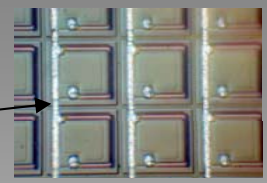
Calibration procedure
Monitoring system

Quick system overview





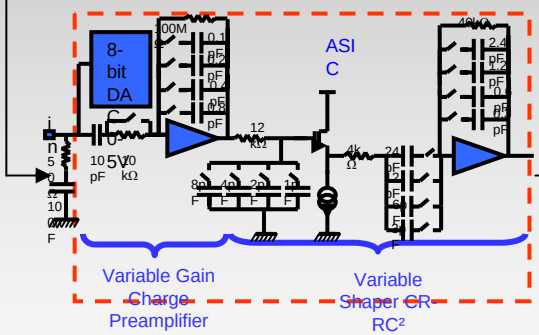


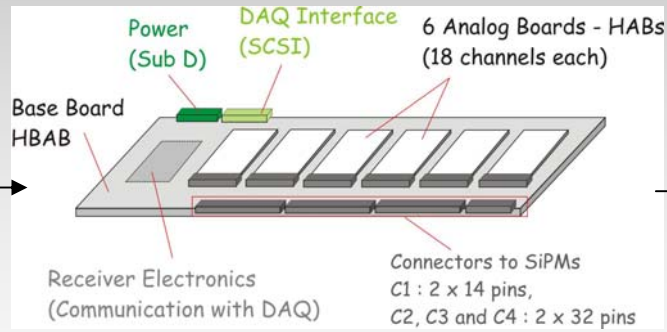


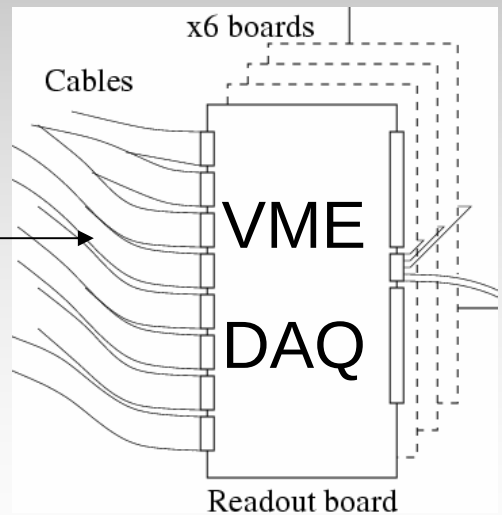
Read out 220 tiles/module
~8000 channels

Single tile readout with SiPM

SiPM: pixel device operated in Geiger mode



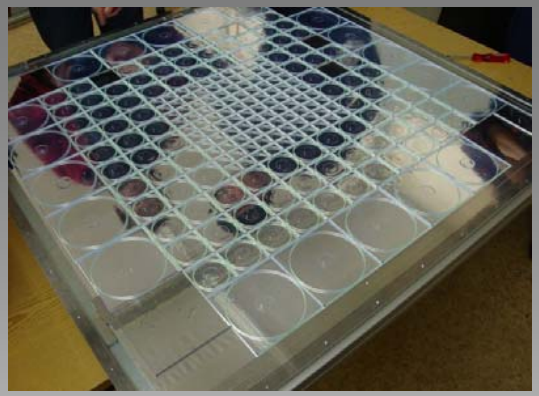




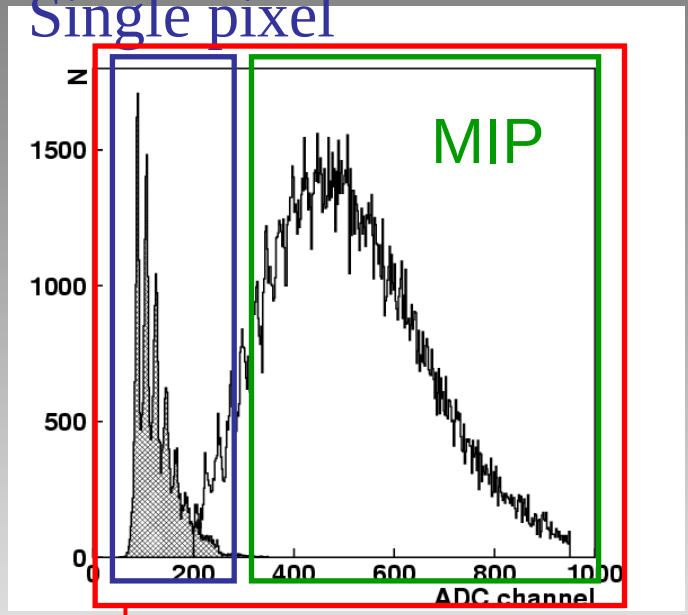
ASIC: amplification + shaping + multiplexing

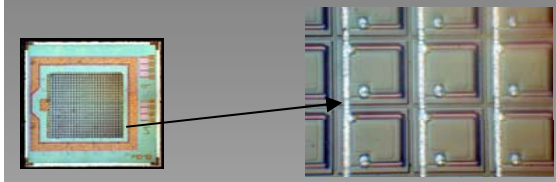
VFE: control 6 ASICs connect to SiPM

HCAL Calibration

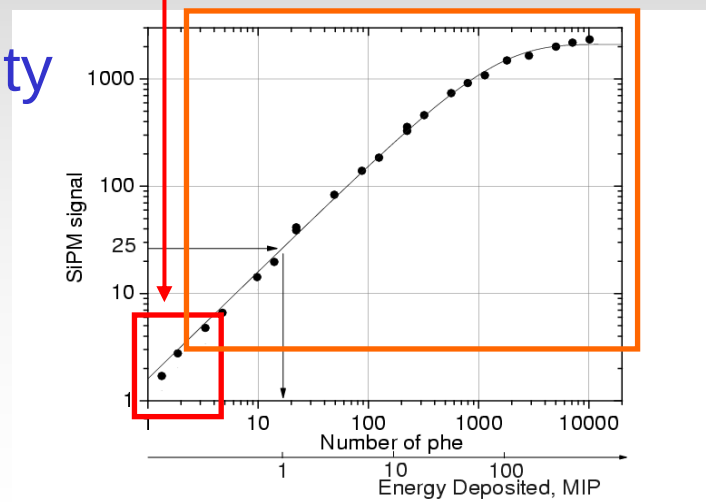


Single pixel





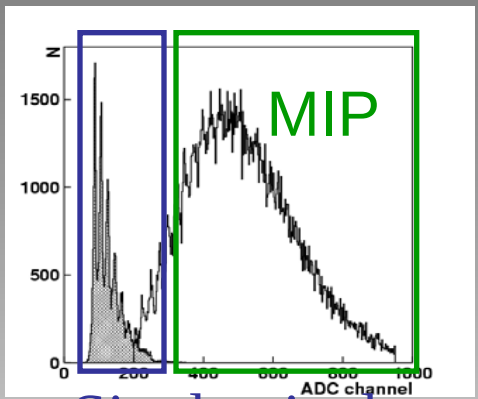
- MIP calibration
- Pixel calibration: SiPM non-linearity
- SiPM response function



E (GeV) = A(ADC) *
px/ADC *
pe (px) *
MIP/pe *
GeV/MIP

Energy = ADC-count *
electronics *
SiPM response *
Light yield *
sampling

Calibration: more technically



Single pixel

-Cosmics

➔ # events: 10^5/tile ~ 4 10^7

➔ time 4-5 days assuming 100Hz DAQ

- broad muon beam

- hadron beam + brick

➔ # events: 6 10^5

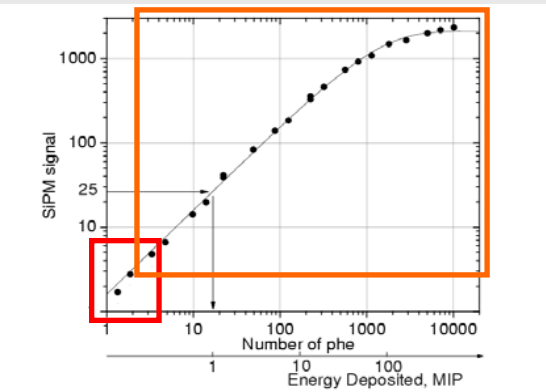
➔ time 1-2 hours

➔ weekly / monthly

-Low intensity LED light

➔ # events: 10^5 , time: ~20 min

➔ daily



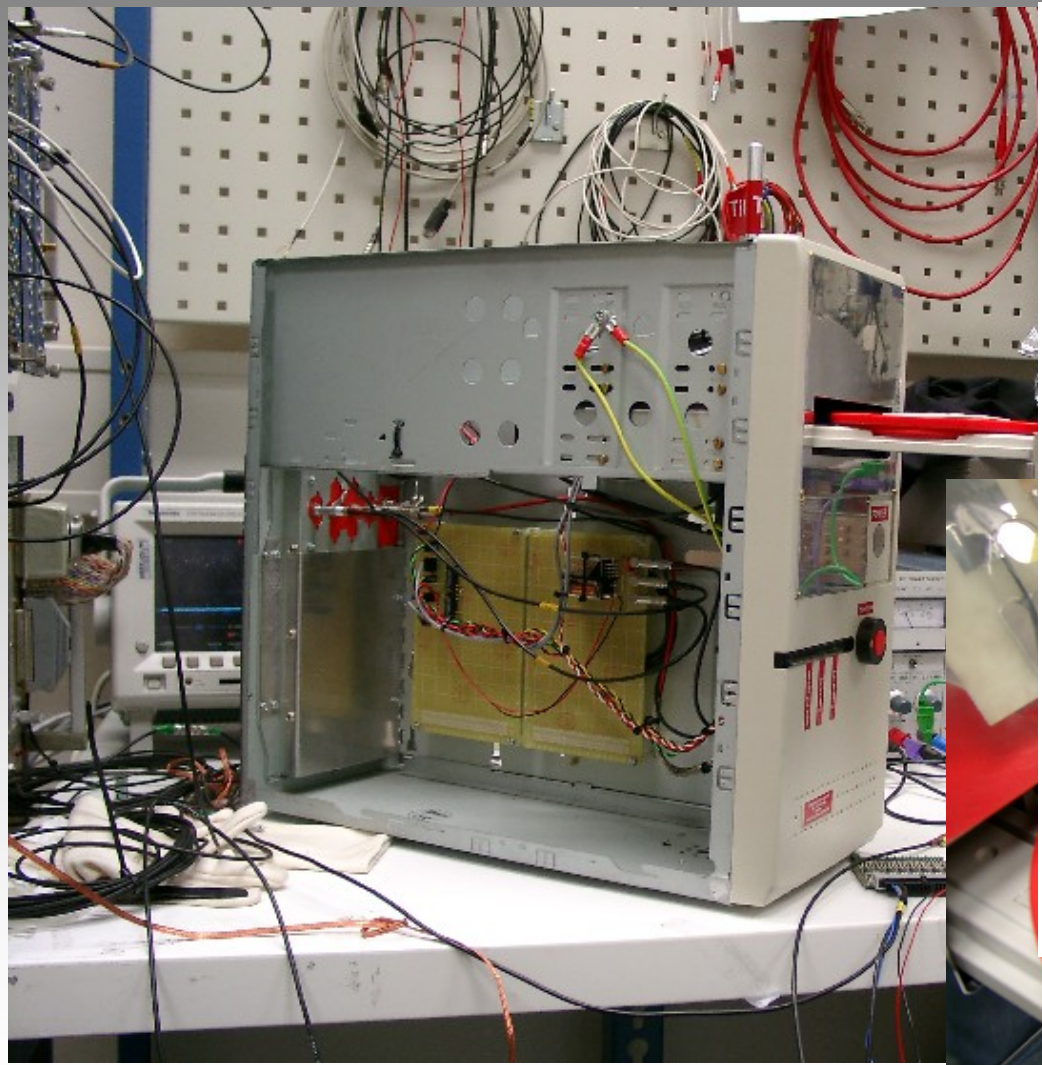
-Variable LED light of stable short duration

➔ universal curve f(T,V)

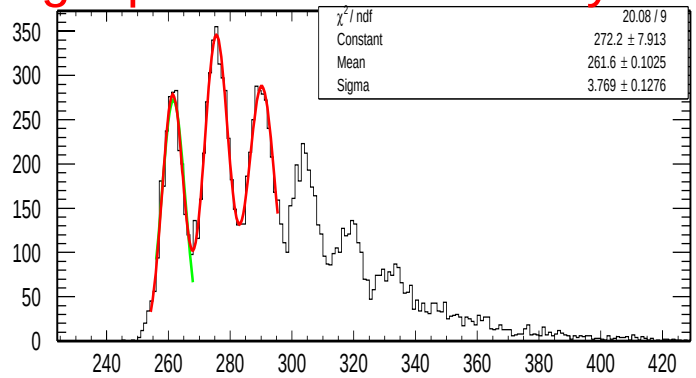
➔ monthly crosscheck

➔ large dynamic range

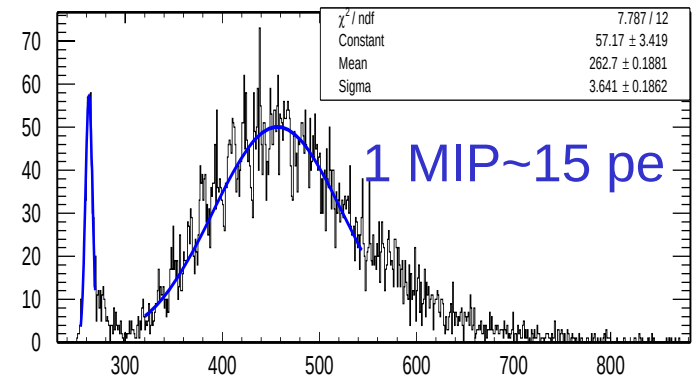
Light yield



Single pe from low intensity LED

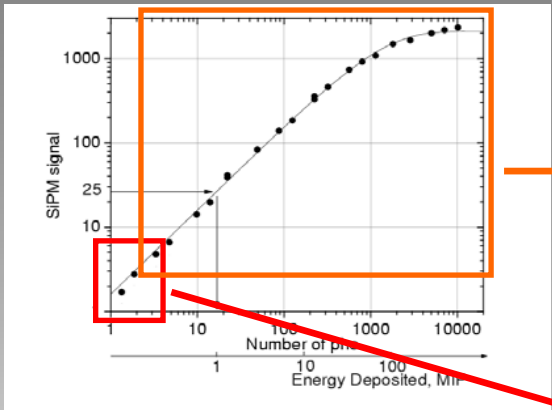


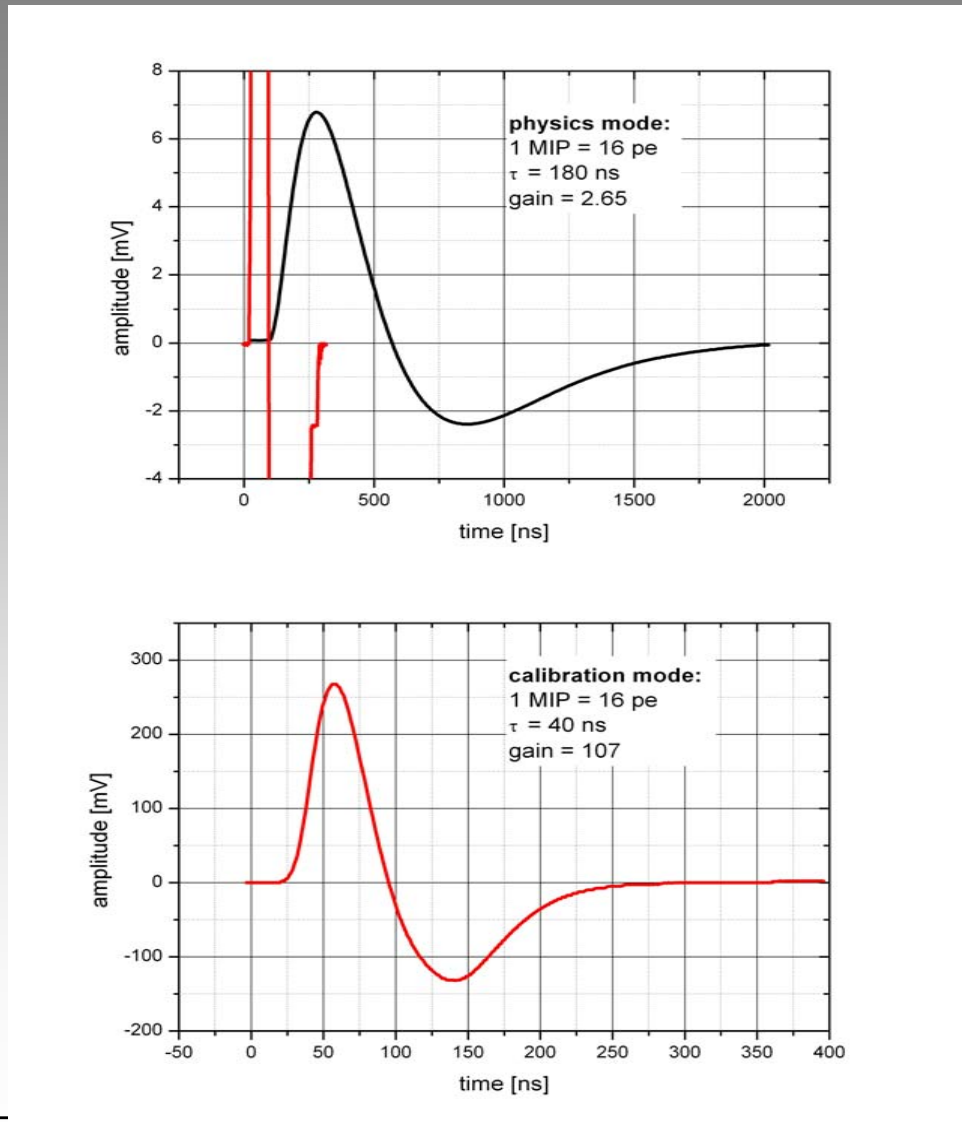
MIP from source



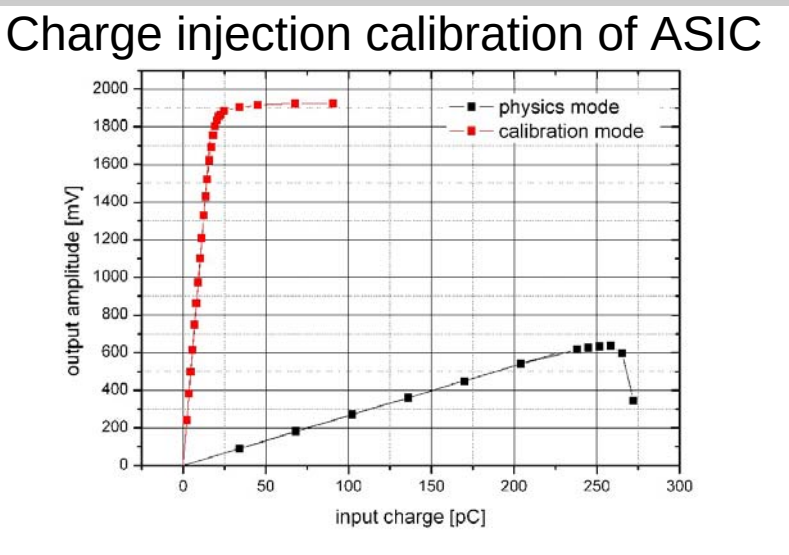
1 MIP~15 pe

Calibration: electronics

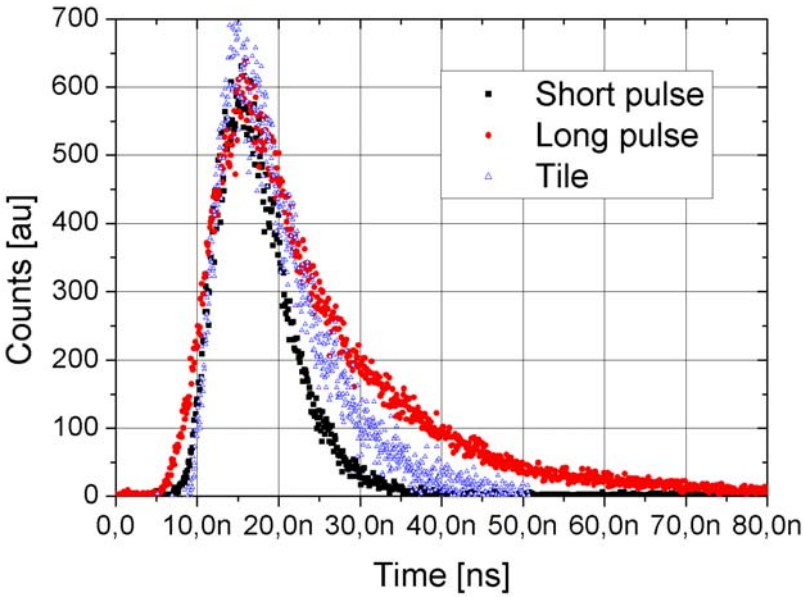


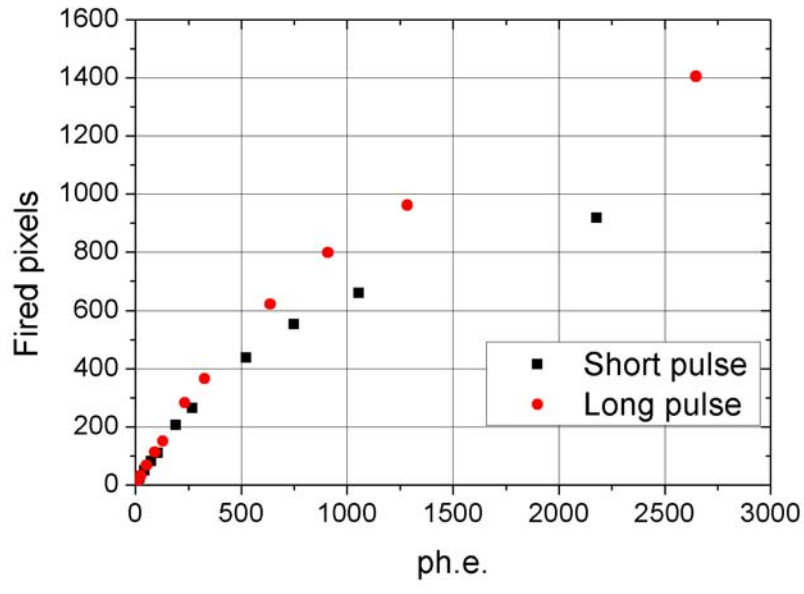


Charge injection calibration of ASIC



SiPM response function

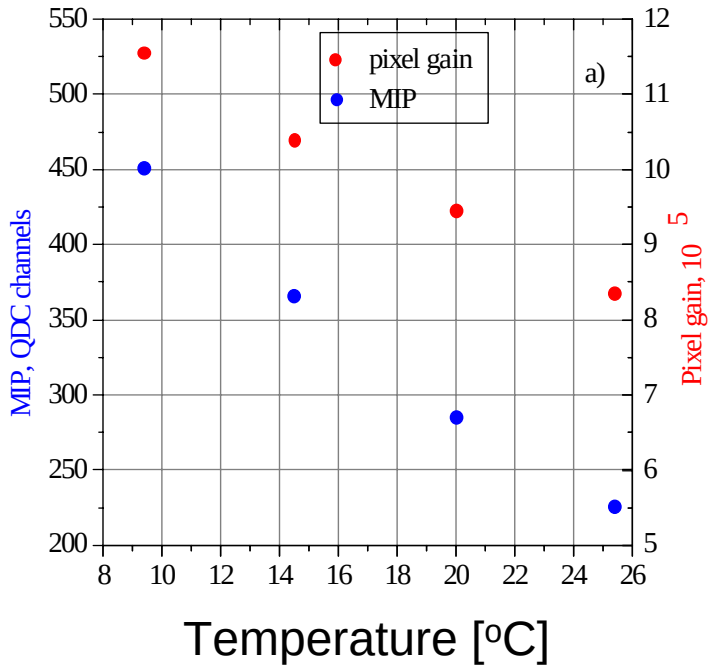


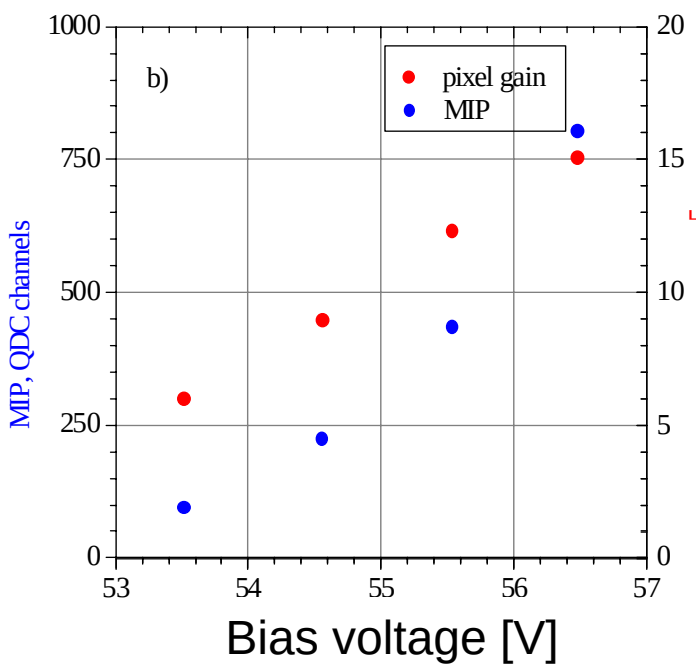


Fast pixel recovery time ~ 10 ns → Strong dependence of response function on duration of light pulse

Monitoring

SiPM T and V dependence





Gain ➔ 1.7% / K , 2.5% / 0.1V

Signal Amplitude ➔ 4.5% / K , 7% / 0.1V

The HCAL module

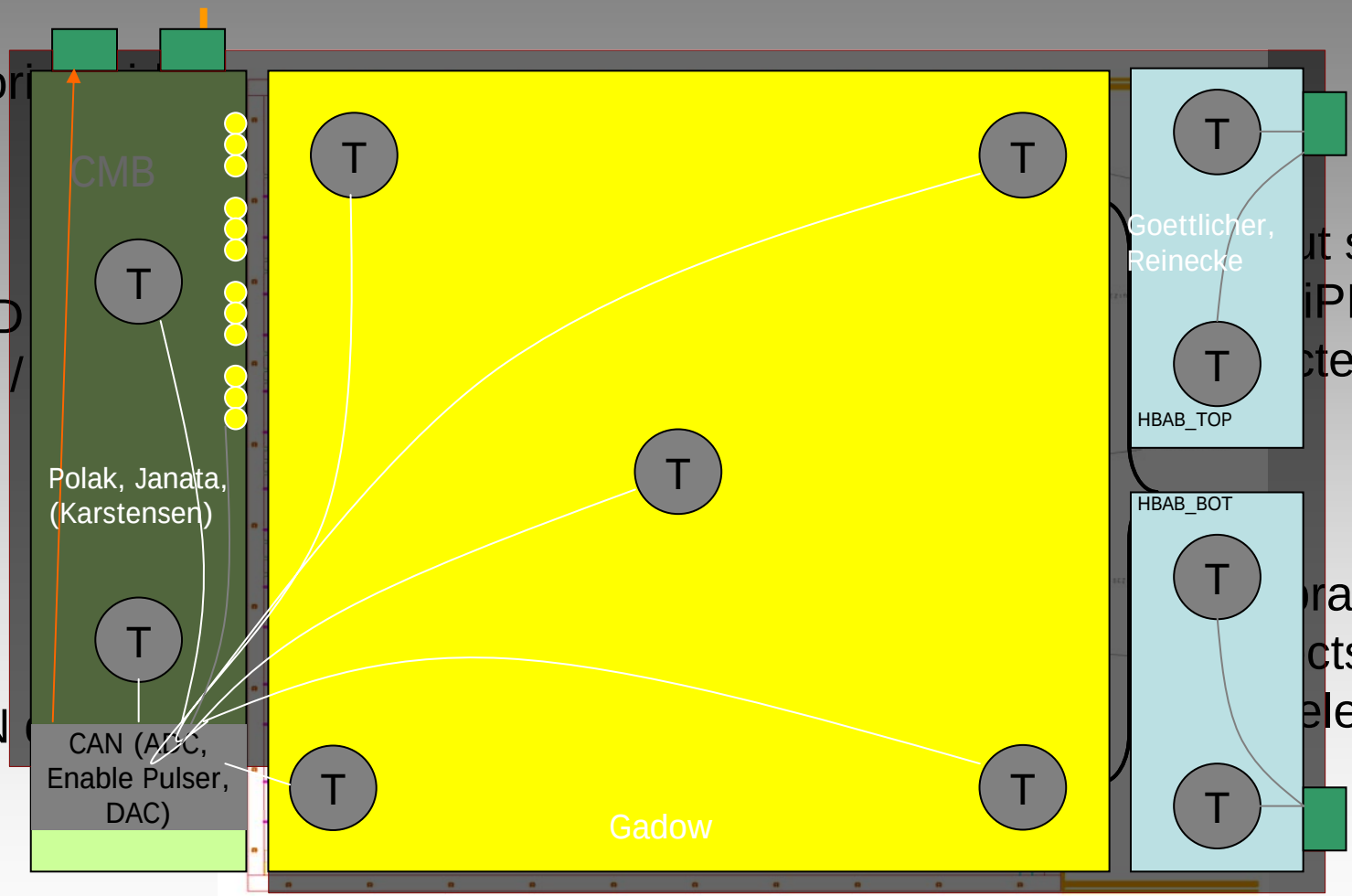
Monitori

12 LED
1 fiber /

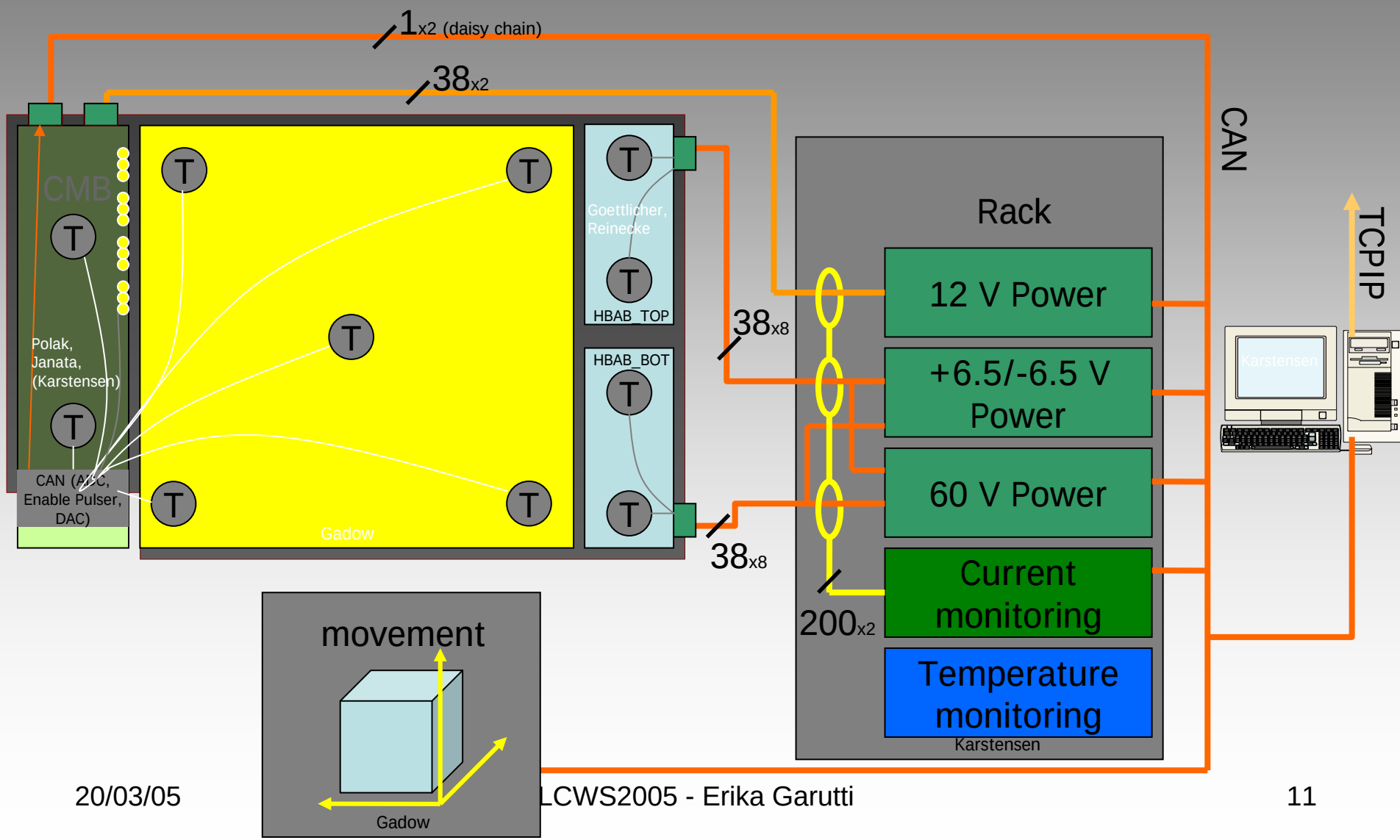
12 PIN

ut side:
iPM
cted to VFE

oration
cts of SiPM
electronics



Slow Control System



Redundant monitoring system

The stability of the system in within MIP calibrations is checked by the monitoring system:

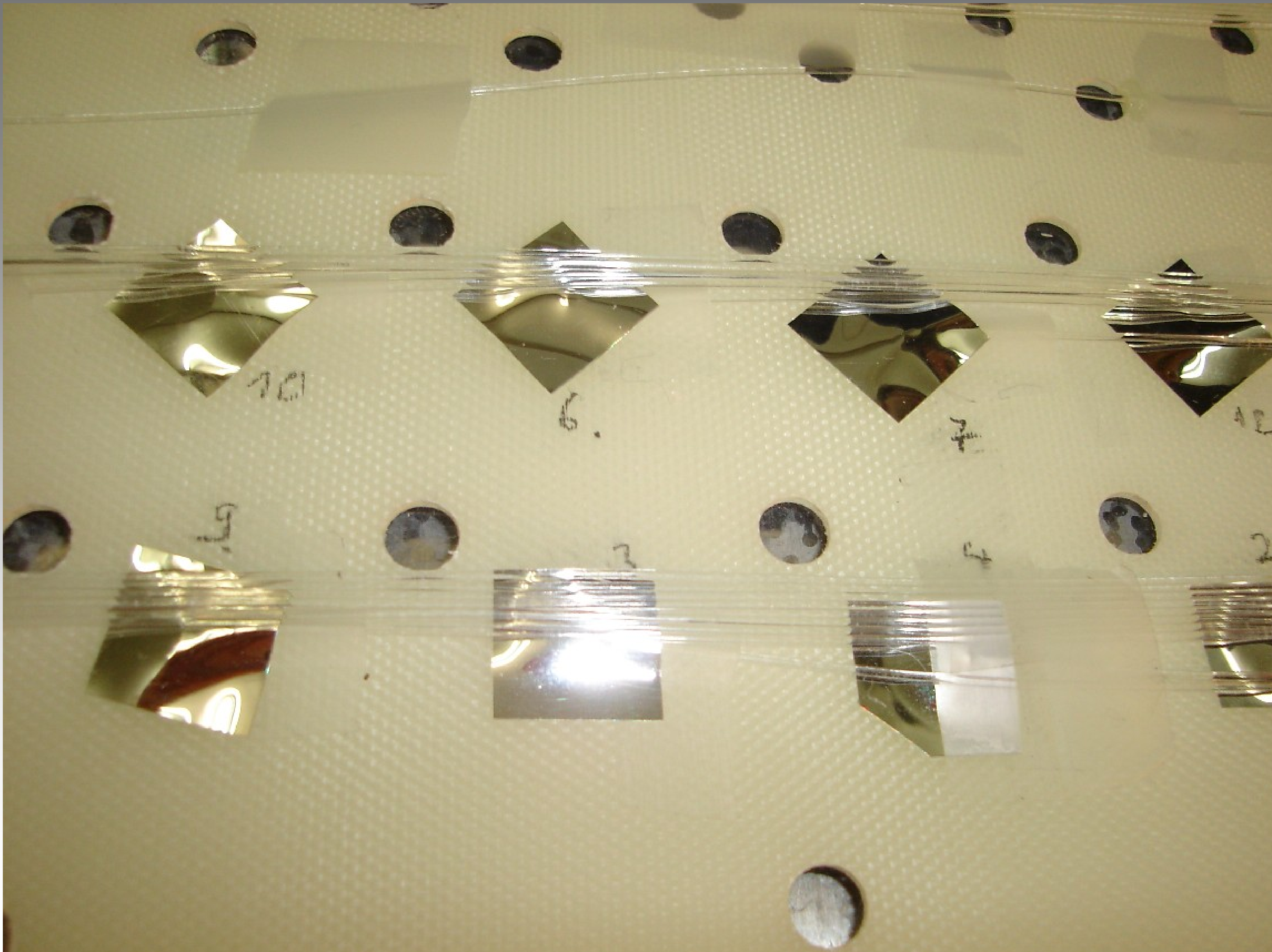
1. Reference LED light pulse
   ➔ stability of LED system after PIN diode correction <1%

2. Gain calibration of SiPM
   variation of gain ➔ 1.7% / K , 2.5% / 0.1V

3. Temperature and voltage monitoring from slow control
   variation of signal amplitude ➔ 4.5% / K , 7% / 0.1V

➔ compare the 3 correction factors

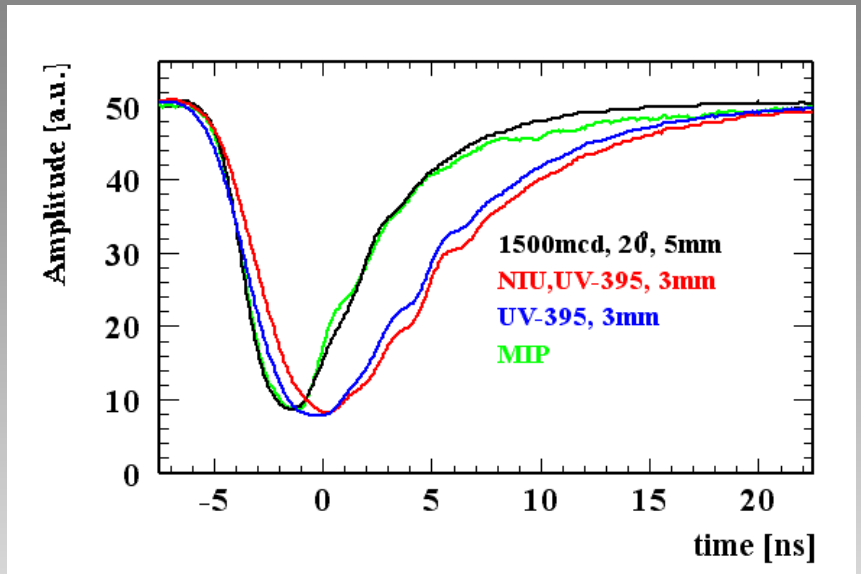
➔ apply correction if 2 / 3 agree



LED system

LED choice:

➔best matching to MIP shape

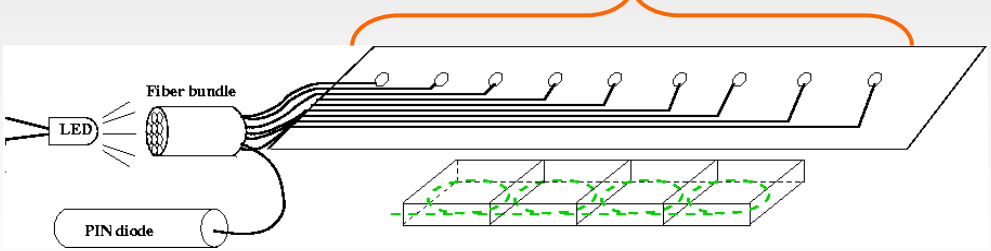


Fiber bundle production:

18 to tiles + 1 to PIN diode

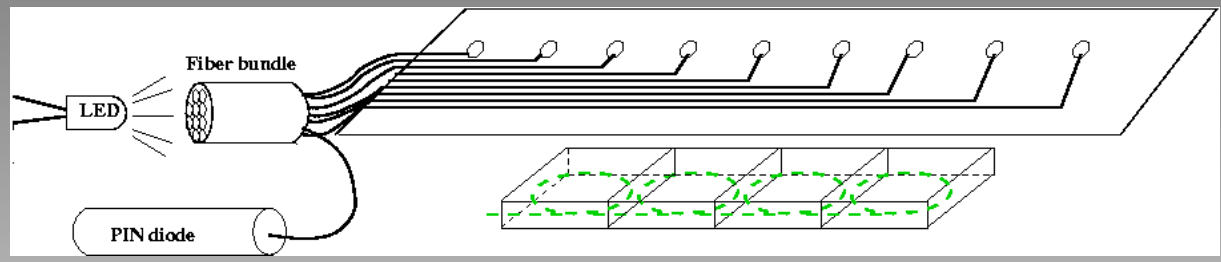
◈2-3 LY variation brightest/darkest

20-30% RMS



PIN diode readout

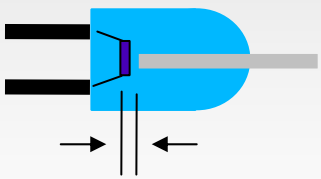
PIN diode: G = 1
SiPM: G = 10^6



Due to WLS fiber + scintillator tile:

$LY_{PIN} \approx 200\ LY_{SiPM}$

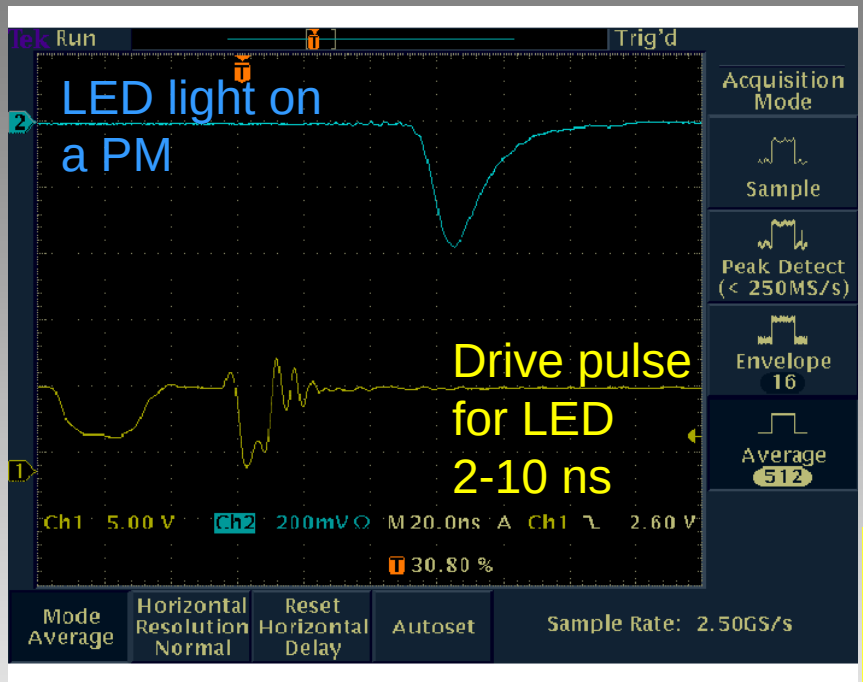
➔large pre-amplification needed for PIN diode signal: ~500

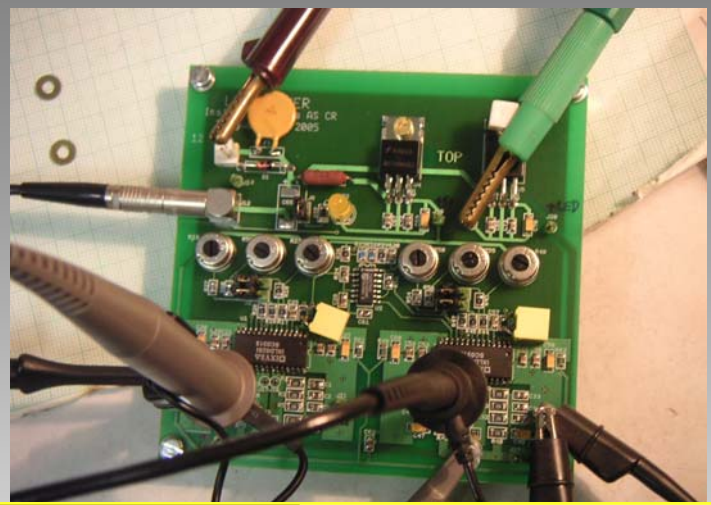


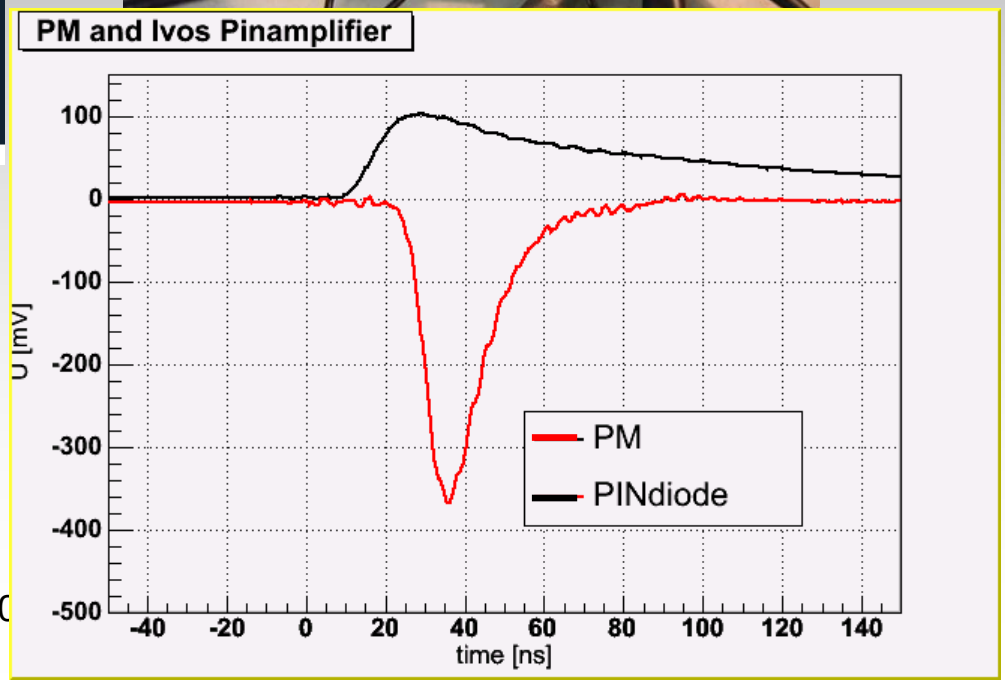
➔ observed strong LY reduction for increased fiber/PIN distance: ~30% / mm

➔ constraint on alignment tolerances

Calibration & Monitoring board







LED driver allows controlled pulse steering over the range 1-100 MIP with same rise and fall tile

PIN diode signal ~ 4 < PM signal
➔Can be readout on the ASIC

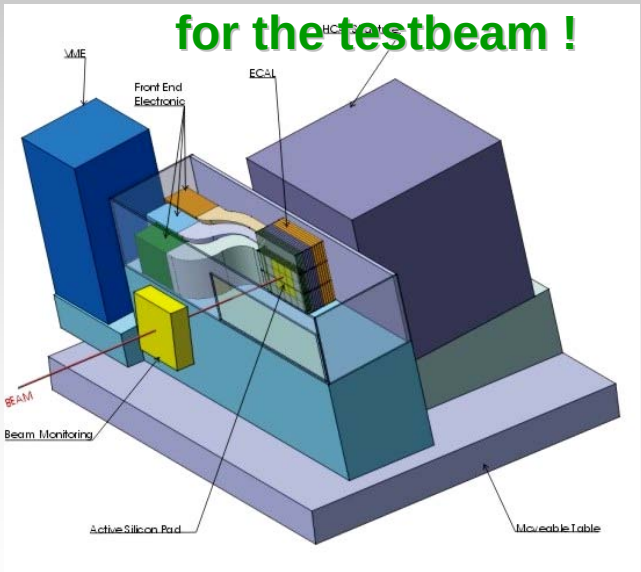
Conclusion & Outlook

Established calibration procedure

- already successfully applied to 100 ch. technical prototype
- now to be extended to 8000 ch.

Very ambitious monitoring system required … on its way

We are actively preparing for the testbeam !



The very popular plot…

$$e^+e^- \to WW\nu\bar{\nu} \quad , \quad e^+e^- \to ZZ\nu\bar{\nu}$$