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Optimization studies for single tile design

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CALICE collaboration Meeting
Matsumoto, 06/03/2012

Overview

- SiPM characterization
  - Gain
  - Breakdown voltage
  - Capacitance and Current curves
- Tiles + SiPM:
  - Light Yield measurements
  - light cross-talk
  - Coatings & connectors studies
- New setup

SiPM Characterization

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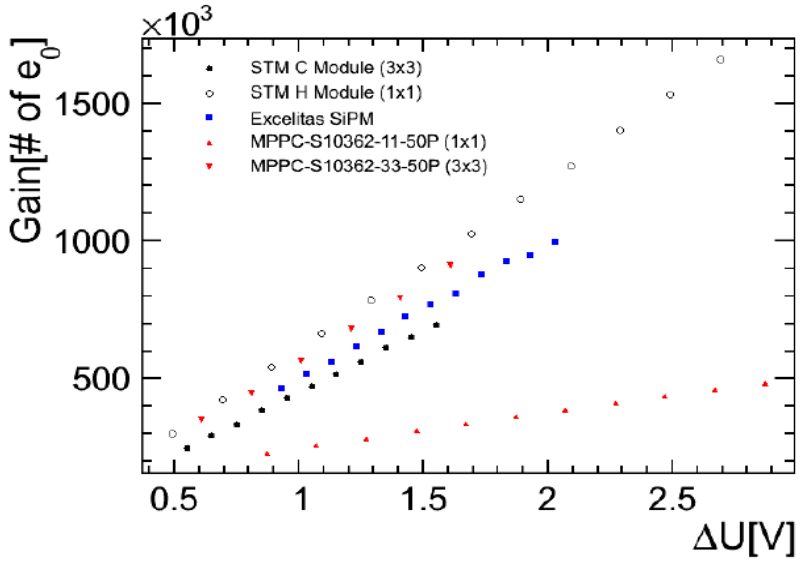
Consolidated SiPM characterization protocol at UniHH:

- Gain
- I-V curves
- Breakdown Voltage
- C-V curves (gain measurement)
- Quenching Resistance measurement
- Dark Count Rate and Optical Cross-Talk

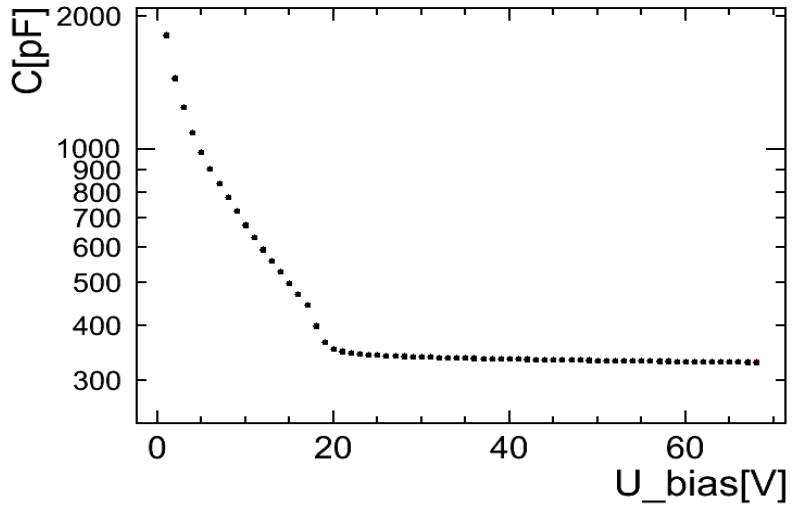
All setups are temperature monitored



MPPC -S10362 -33-50P

Easy performance comparison:

	U_{bd}(V)	DCR(Mcps)	PDE
MPPC(1x1)	75.5~78.5	0.1-0.4	~32%
MPPC(3x3)	66.5~69.5	1~3	~32%
STMicro	28.7~29.5	0.2~1	~8.5%
Excelitas	33.5~33.7	6.3~7.3	
MAPD	~90	0.9~9	

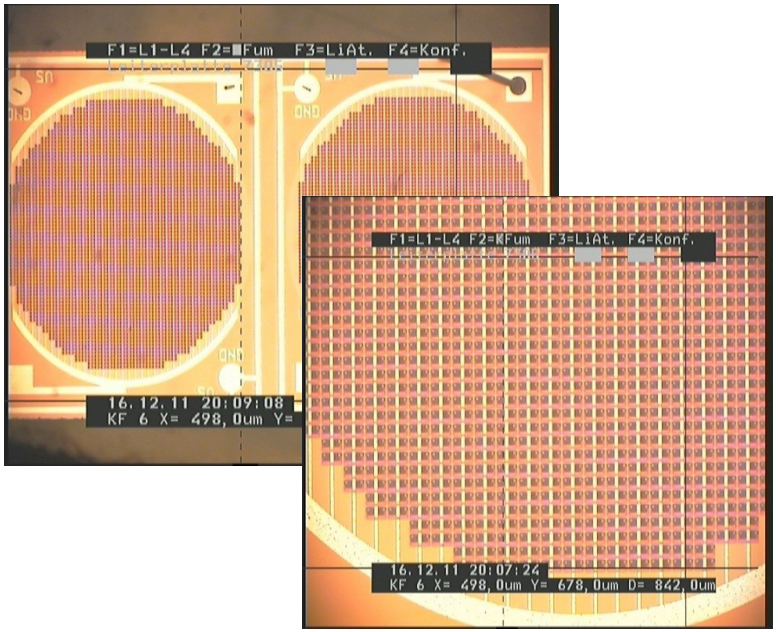


Gain = $(C_{depl} * \Delta V)/e^- = 8.6 \times 10^5$ (@ +1.5 V)

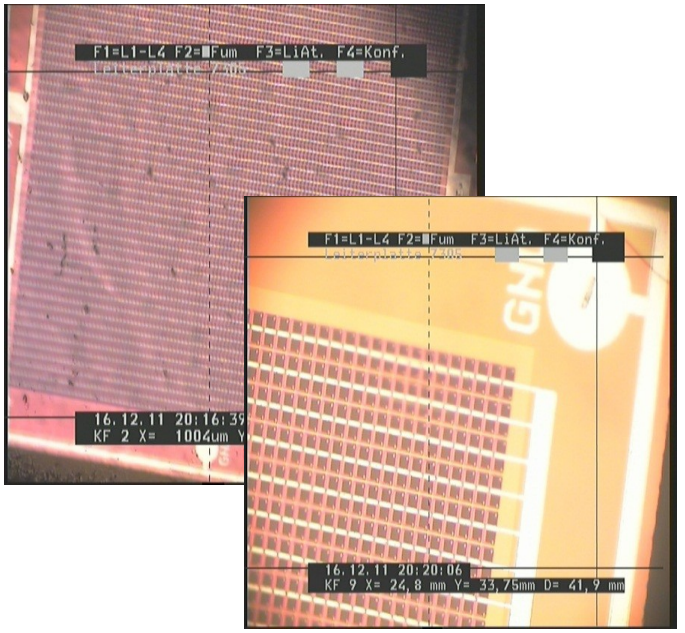
Ketek SiPMs

Two different Ketek SiPM models under characterization (4 items per type):

Type I
- circular surface
- 1 mm diameter
- 1900 cells
- cell pitch 20 µm



Type II
- square surface
- 2.25 mm x 2.25 mm area
- 12000 cells
- cell pitch 20 µm

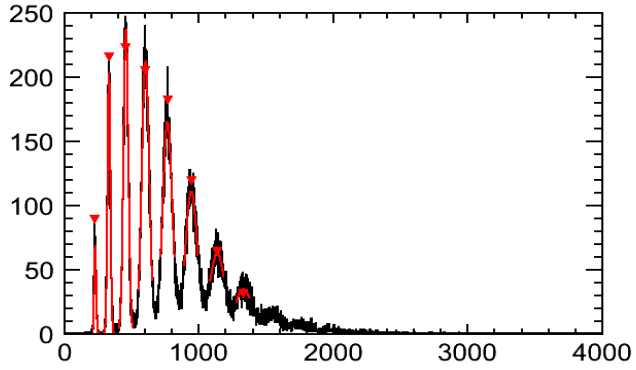


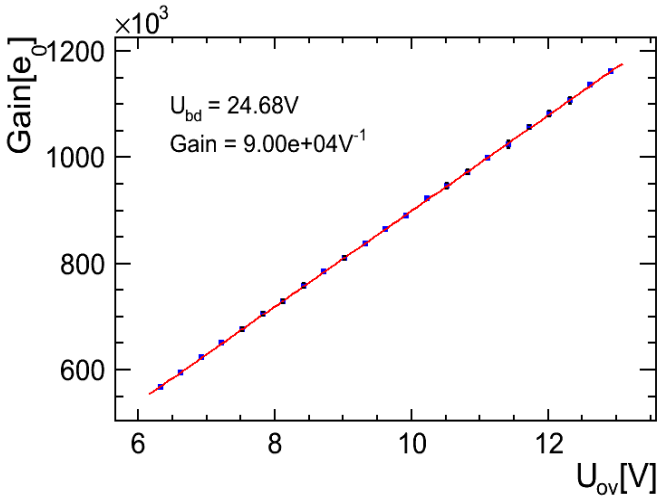
Breakdown V ~ 24.6 V

Gain Characterization

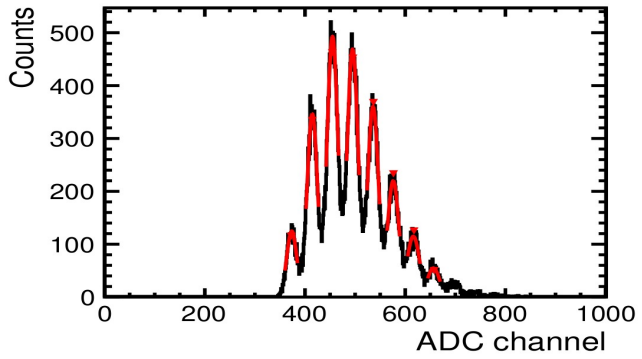
- Gain estimated from peak-to-peak distance obtained with multi-gaussian fit
- Performed at different bias voltages
- Correction for breakdown voltage

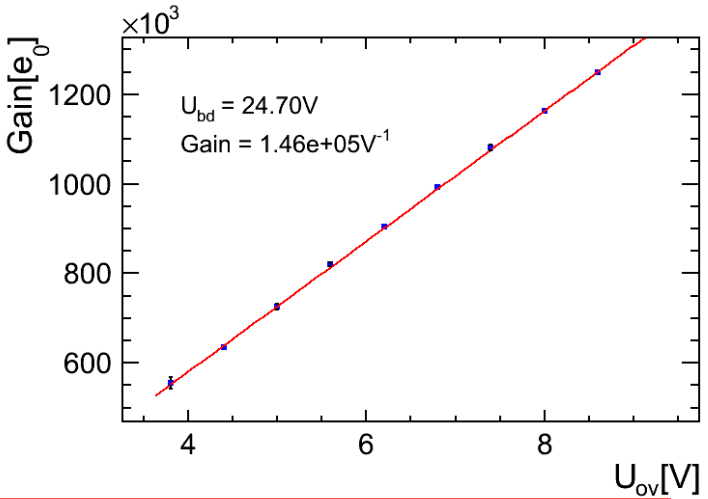
Type I



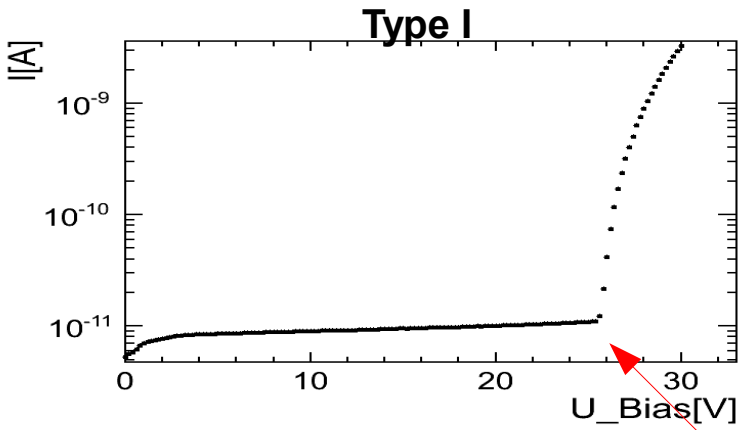


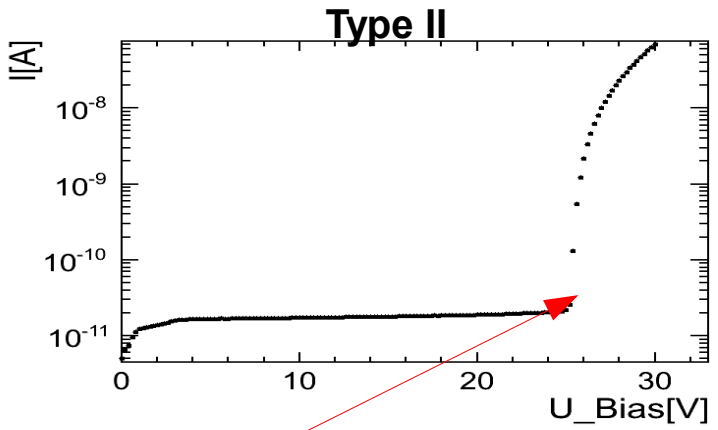
Type II



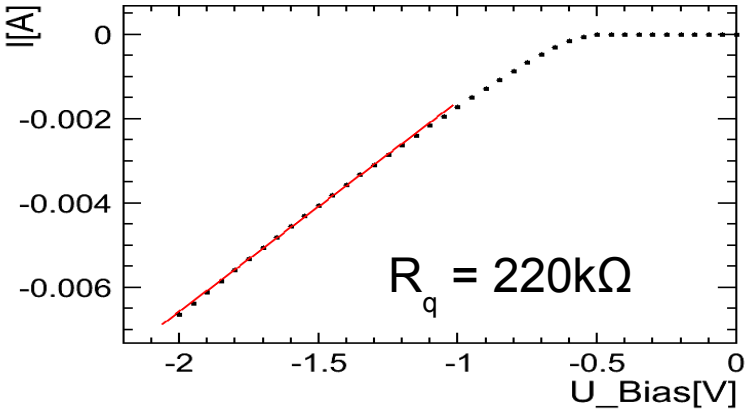


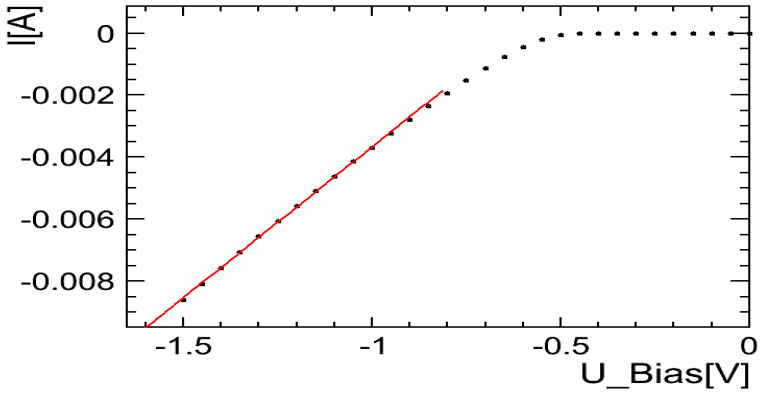
I-V and Resistor measurements...





Breakdown ~ 26 V

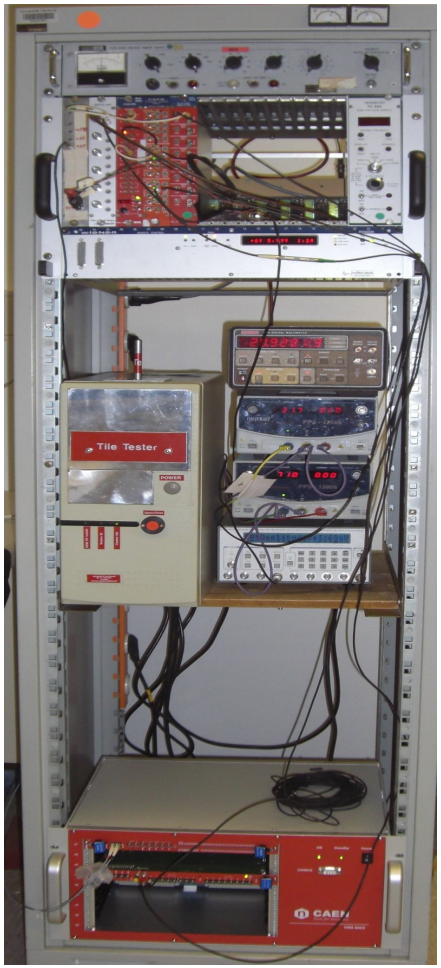




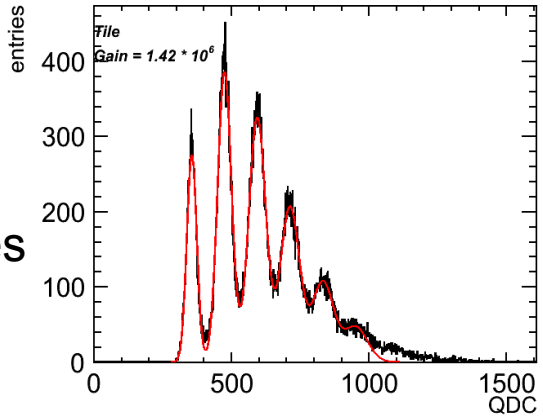
After characterization, use Ketek SiPMs in combination with a tile

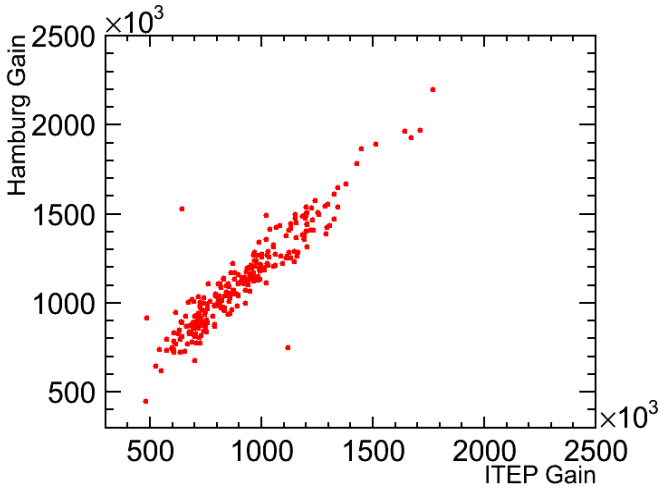
Tile+SiPM: Tiletester

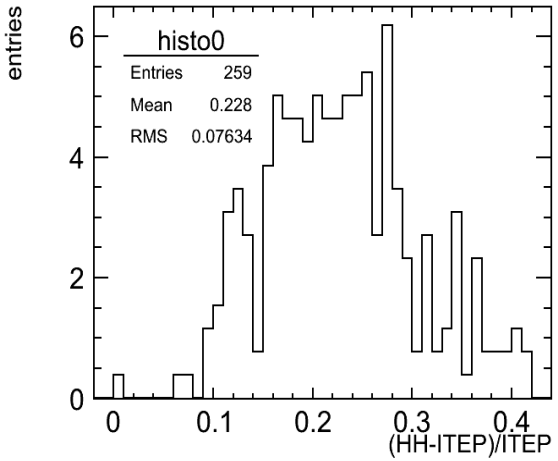
built in 2005 by K. Gadow for quick characterization of 5mm thick tiles
Should provide:
•Gain measurement
•Light Yield measurements



With AHCAL technological prototype tiles only Gain measurements possible!

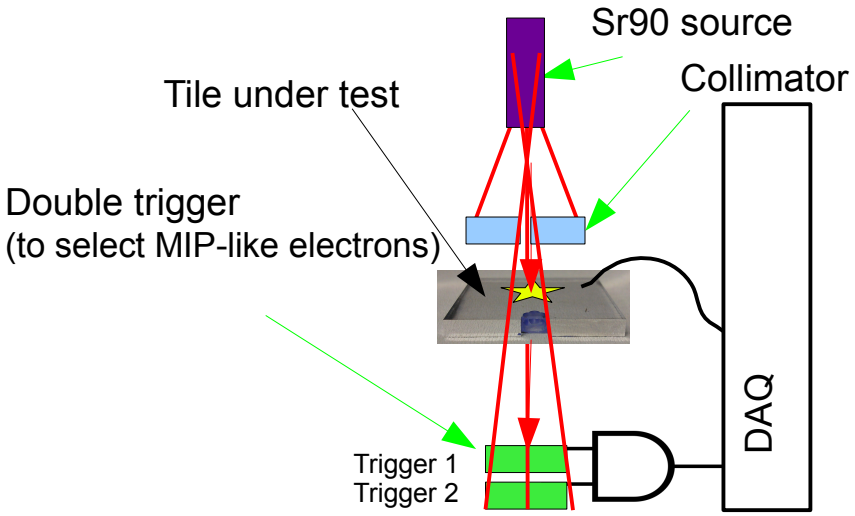






•Correlation spread of 7%
•HH gain overestimated of ~ 20%
not in use anymore ...

Light Yield measurements

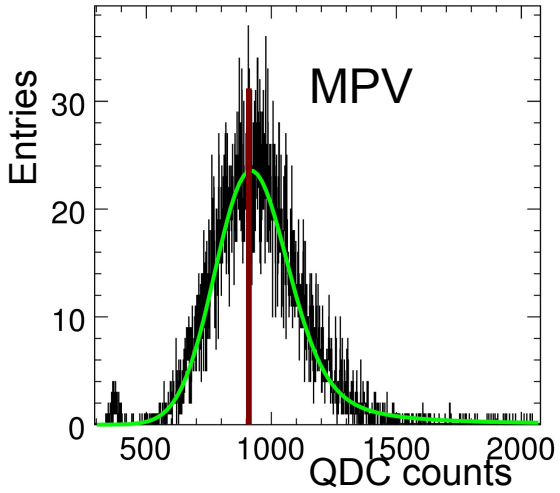


Setup for measurements of average tile Light Yield :

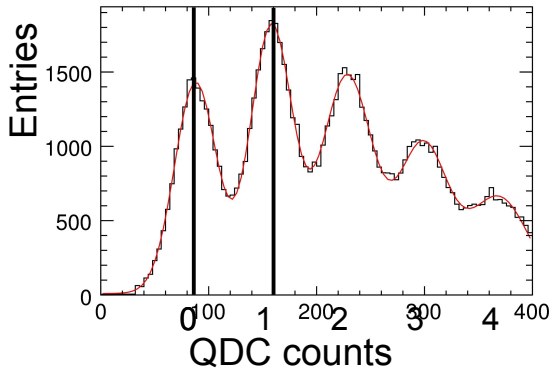
- Sr90 source, emission mechanically collimated
- Trigger: two ITEP tiles in coincidence
- LED for Gain measurement

LY [pix] = (MPV [QDC] - ped[QDC])/Gain[QDC/pix]

MPV from Landau-Gaussian convolution fit



Gain from multi-gaussian peak fit



Test different combinations of:

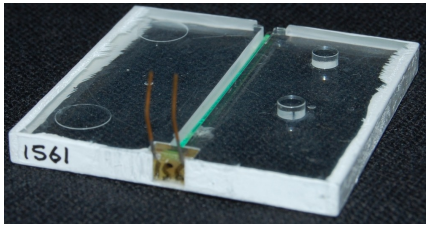
- Coatings
- SiPMs

Coatings

The setup has been optimized with an ITEP tile (delivered at DESY in November 2011)

ITEP Standard tile:

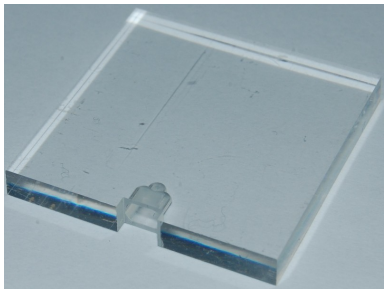
SiPM	Tile	border	surface	LY (Pixel)
CPTA	ITEP 1235	Acid polish	3M	15,4±0,4



a first tile had been modeled from **Bicron BC-400**
dimple for **direct coupling** to SiPM designed by MPI Munich
coupled to **Hamamatsu MPPC S10362-11-50P**

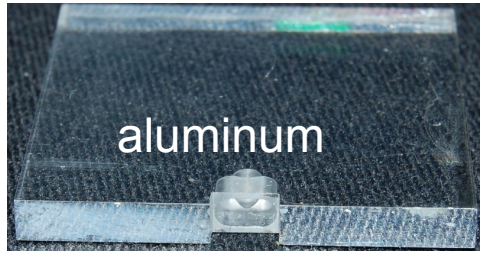
} reference for comparison

a second tile had borders coated with aluminum evaporation



Reference tile+SiPM:

SiPM	Tile	border	surface	LY (Pixel)
MPPC	BC-400	air	3M	10,4±0,4
MPPC	BC-400	Al	3M	9,3±0,4



direct aluminum deposition shows less average LY value!

… more coatings

Several complete tile coatings have been studied:

Direct deposition on tile surface:

SiPM	tile	borders	surface	LY (Pixel)
MPPC	BC-400	Al	Al	~5
MPPC	BC-400	TiO2	TiO2	8,7

(from C.Soldner)

wrapping:

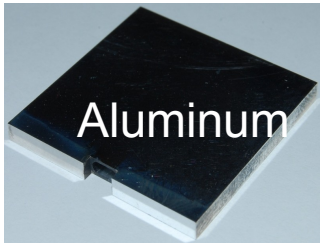
Reference:

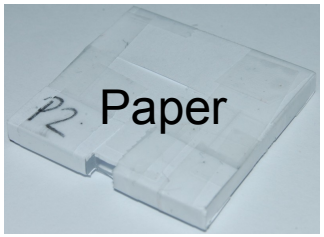
SiPM	tile	borders	surface	LY (Pixel)
MPPC	BC-400	air	3M	10,4±0,4
MPPC	BC-400	3M	3M	28,8±0,4
MPPC	BC-400	paper	paper	19,7±0,4

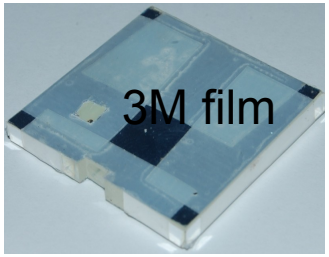
With a different SiPM:

SiPM	tile	borders	surface	LY (Pixel)
Ketek II	BC-400	3M	3M	33,7±0,4

~15 % higher LY value due to better Ketek PDE







Wrapped tiles show promising results:
consistent with previous CALICE studies on coatings (e.g. Shinshu 2008 ScECAL studies, MPI Munich 2011 studies)

Next step: uniformity scan at MPI Munich
Though it has extensively demonstrated that tile non-uniformity have small impact on energy reconstruction of hadronic showers (see for example F.Simon talk on AHCAL meeting @ DESY, 13 December 2011)

Tile Light Cross-Talk

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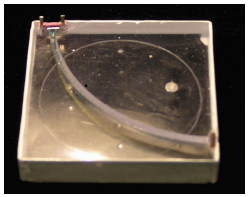
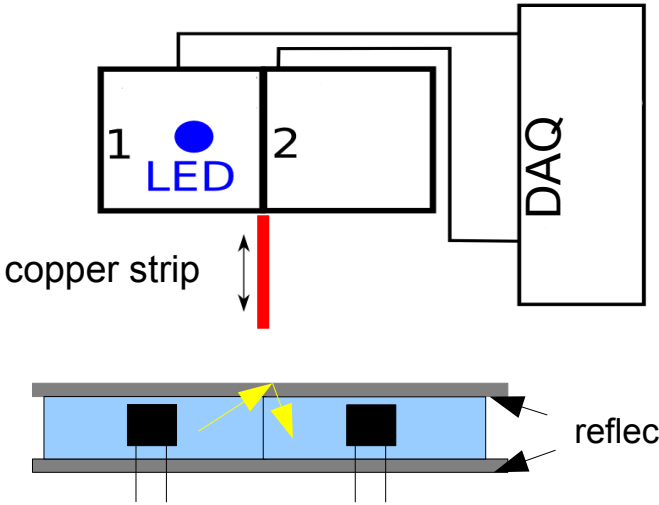
cross-talk value per tile edge had been evaluated from calibration runs as
C = 4.5% ± 0.2% for the ITEP tiles 3 cm x 3 cm x 5 mm with WLS fiber



New setup for dedicated cross-talk measurements:



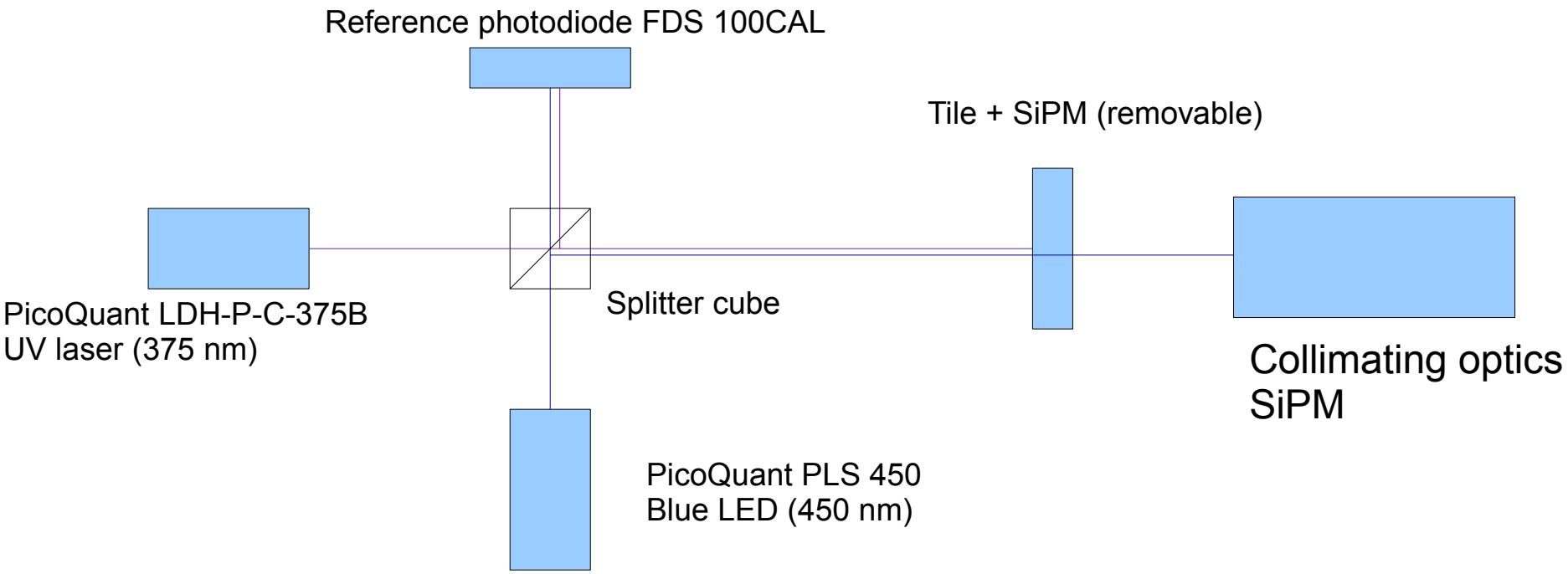
- Two tiles coupled with SiPMs
- Tile 1 directly illuminated with LED blue light delivered via fiber
- Signal from both tiles acquired
- Light cross-talk between tiles calculated according to :

$$C = \frac{I_2}{I_1 + 4 \cdot I_2}$$

First preliminary results new ITEP 3 cm x 3 cm x 3mm tiles give us **C ~ 4%**
Inserting a copper strip between tiles (no light cross-talk) still **C ~ 1% is measured** due to back reflection of the 3M foil (greater than the entity of electronic cross-talk)

Total tile wrapping would prevent this effect!

Saturation



Perform saturation measurements with a flexible setup
Study saturation for:
•Different SiPM models
•Different SiPMs coupled with different tiles

Items freshly arrived at our new (almost ready) laboratories ...

Summary & Outlook

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- SiPM characterization:
  - Full characterization measurement of two Ketek SiPM models
- Tile + SiPM characterization:
  - Light Yield setup well functioning
  - Tile Light Cross-Talk setup only preliminary results
- Both setups actively used for coating studies:
  - Direct deposition of reflective material gave poor results
  - Best results obtained with wrapping (due to air layer?)
  - Next step: Characterize uniformity of total wrapping;
- New incoming saturation measurements setup

Thanks to:
- Karsten Gadow for the tiletester setup;
- Mark Terwort for tiletester data acquisition.

Backup Slides

C-V curves

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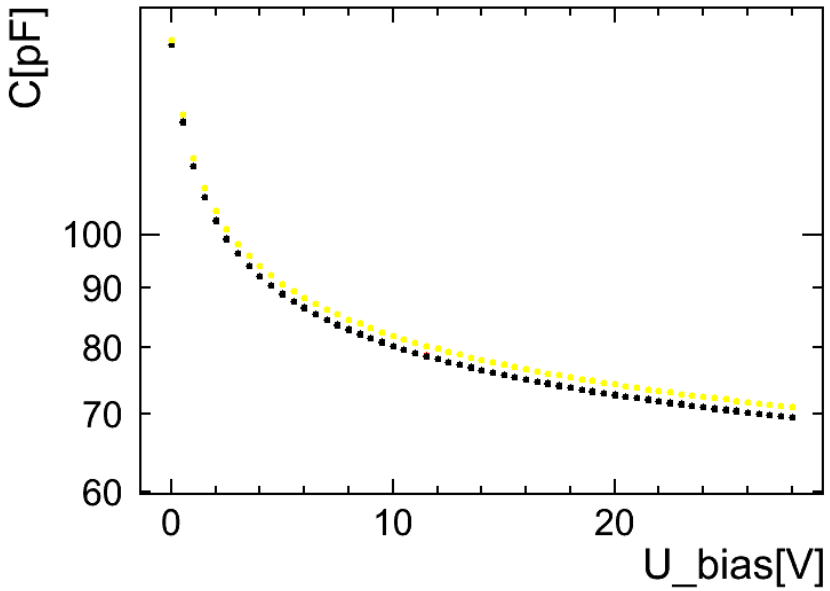
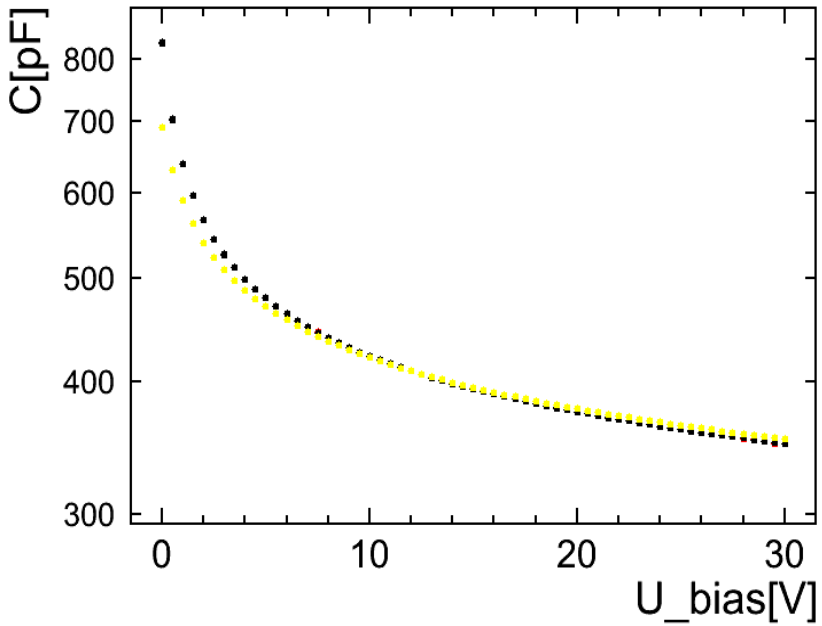
Type I



Type II



Gain estimation from the fully depleted capacitance value (dividing by the cell number):

$$Gain = (C * \Delta V)/e^-$$

$Gain_{TypeI}$ (@ +4V) = 9.5×10^5

$Gain_{TypeII}$ (@ +4V) = 7.3×10^5

… not much consistent with previous Gain measurements

Double Trigger