Tile production and test at Hamburg

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Outlook

- Introduction
- Hamburg university design
- Performance characterization
  - Gain
  - Response to MIP
  - Noise
- Results

Introduction

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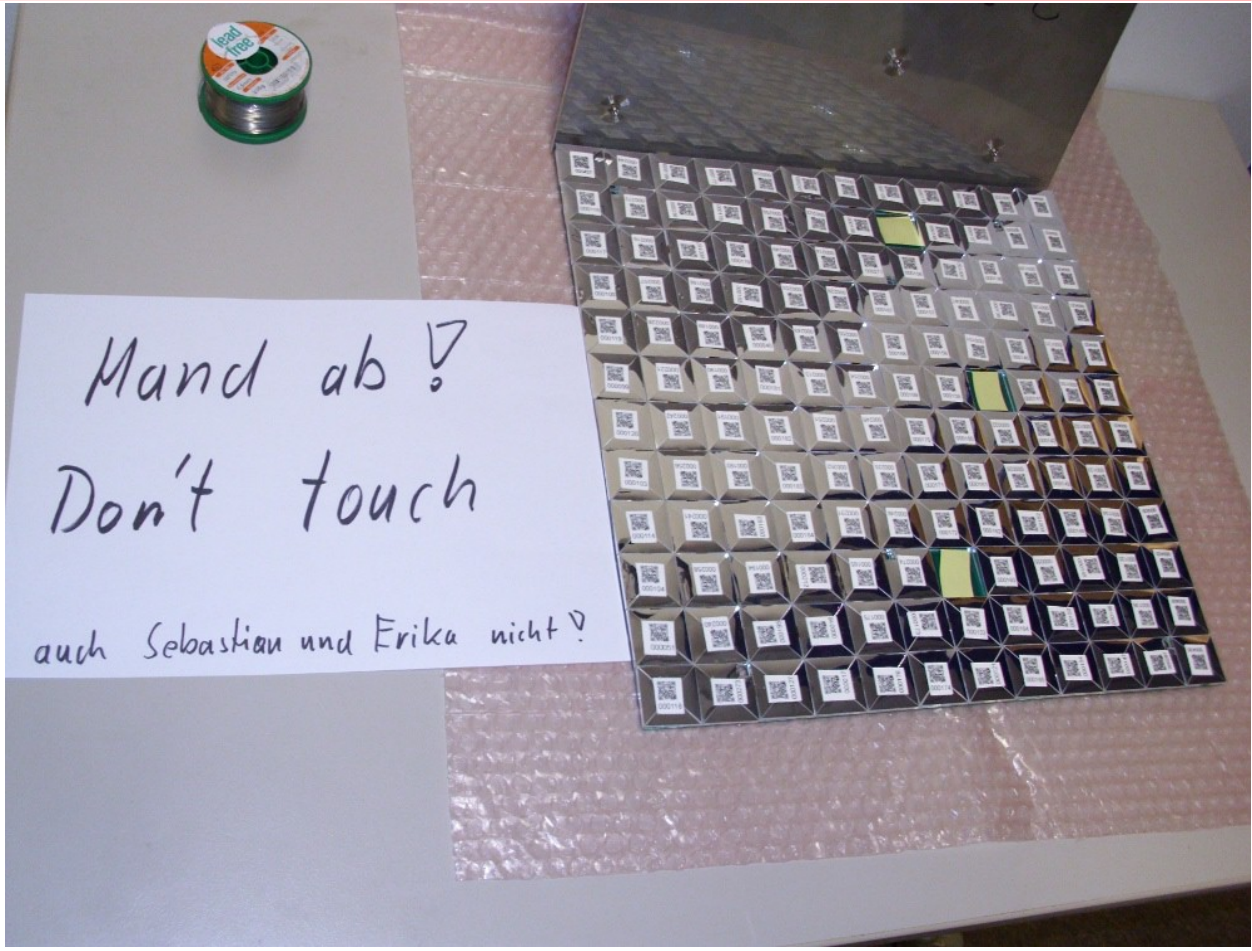
Tile design at Hamburg University
- Individually wrapped in reflector foil
- Without WLS fiber

Aim:
Optimize for mass production

Reduce spread of parameters at V_{OP}
- easier voltage setting
- easier threshold settings



Fully equip 8 HBUs (i.e. ~1200 tiles):
- Two HBUs are operating for the testbeam currently ongoing
- Two more will be ready for beginning of January

UHH tiles: the SiPM

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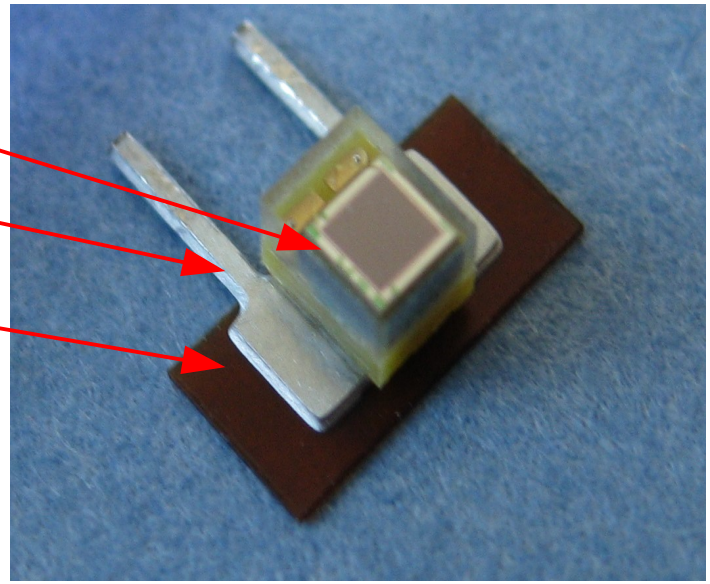
The SiPM:
- 1200 **KETEK PM1125** SMD mounted
- Peak sensitivity at λ = 420 nm
- SMD mounting soldered on copper pins
- Pins glued to Kapton foil



Constraints from electronics:
- Gain at V_{OP} > $6x10^5$ to allow gain adjustment with pre-amplifiers
- Spread in V_{OP} < 2 V

	Gain [e-]	DCR	Cross talk	dV_{BD}/dT	N of pixels
KETEK PM1125	0.7 x 10^6	0.2 Mcps	~ 5%	~15 mV/K	2300
CPTA	(0.7-2) x 10^6	1 Mcps	~ 1%	20 mV/K	798

UHH tiles: the scintillator

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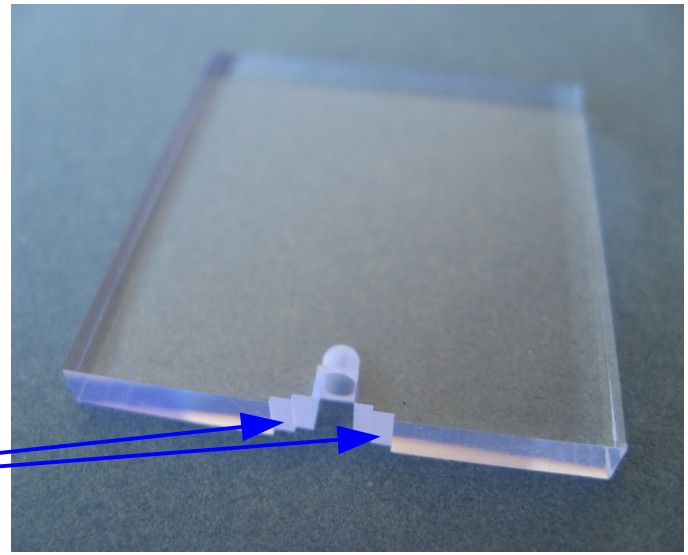
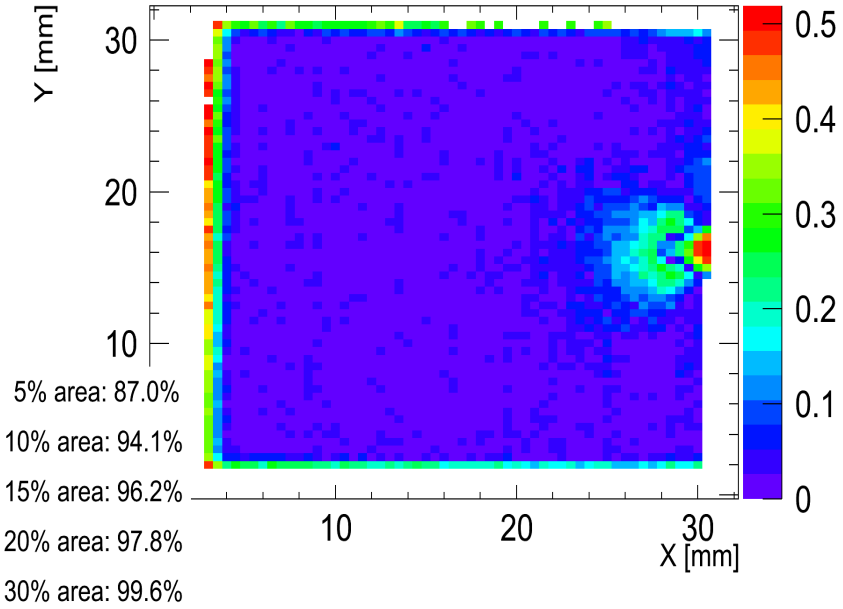
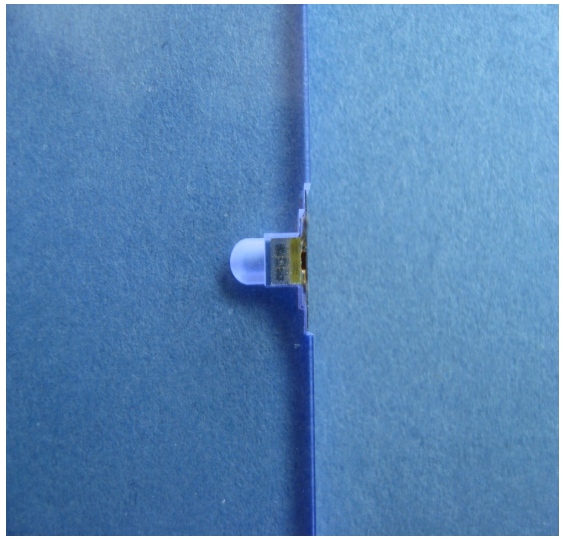
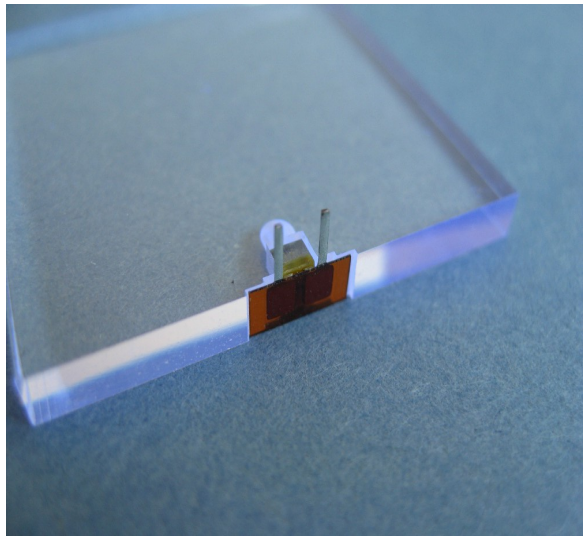
The tile:
- Bicron BC-400 Polyvinyltoluene
- Peak emission: **λ= 423 nm**
- 0.9 ns rise time, 2.7 ns pulse width (FWHM)
- **Machined** instead of molded:
  - Improve accuracy on dimensions (~ 10 μm)
- **No WLS fiber**:
  - ➔ Machined coupling to match SiPM
  - ➔ Kapton support glued to plastic tile
  - ➔ "cathedral" drill in front of the SiPM to improve uniformity









UHH tiles: wrapping

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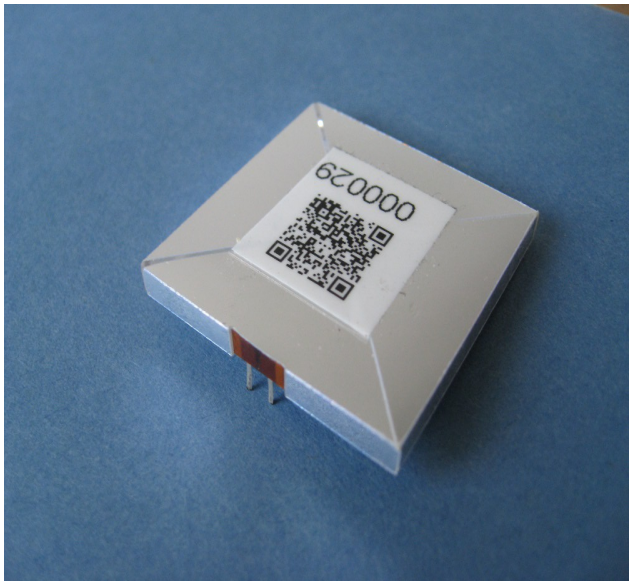
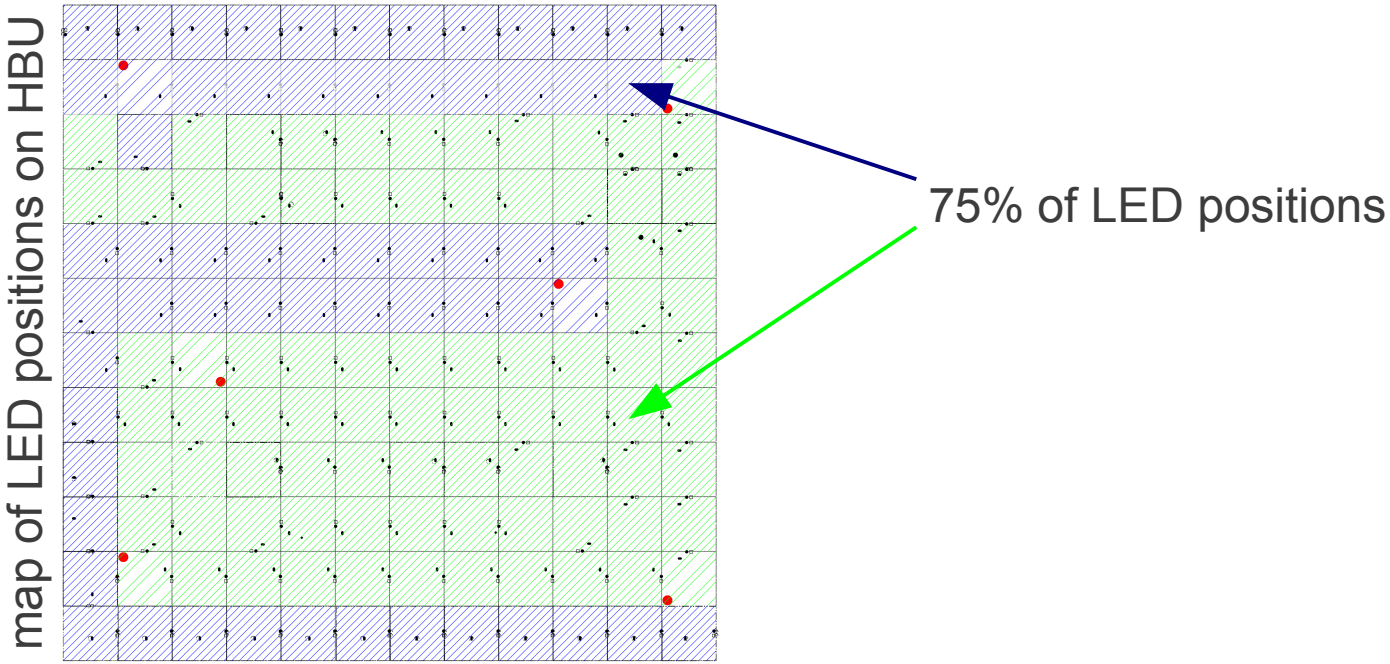
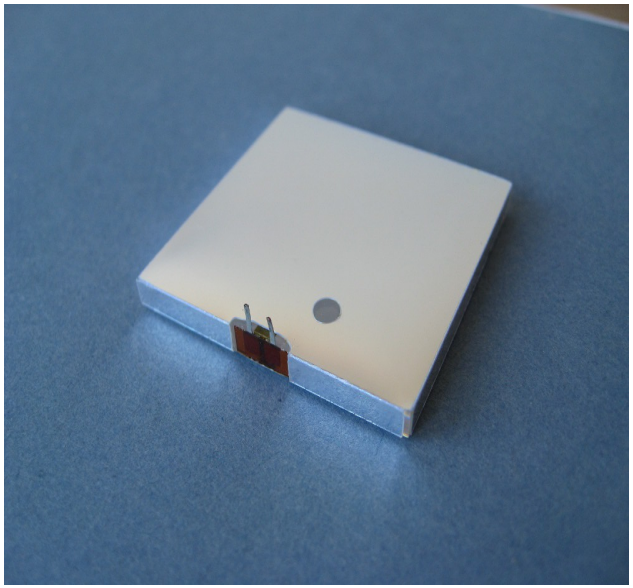
Wrapping:

- Tiles are wrapped with 3M Vikuiti reflector foil
  - 65 μm thick
  - 98% reflectivity
- Foil cut with laser cutter;
  - Hole for SiPM monitoring via LED on the HBU
  - Cut for two different hole positions
- **mechanically wrapped** around the tile;
- Fixed with sticker with QR code for unique identification

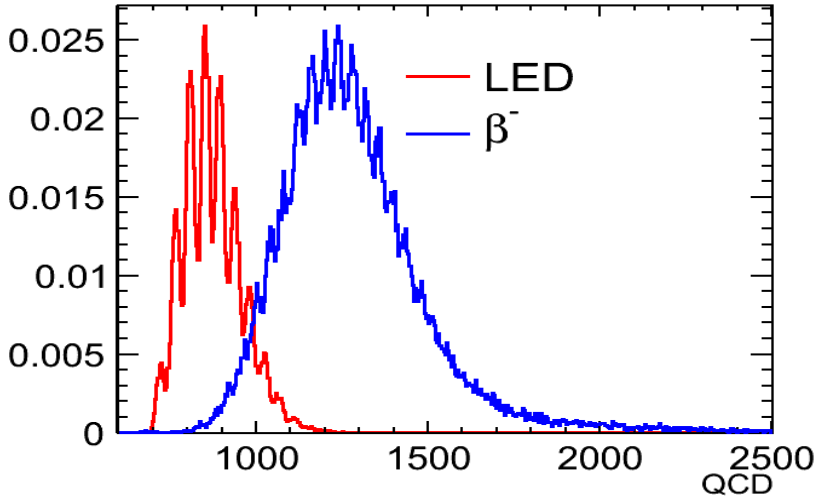


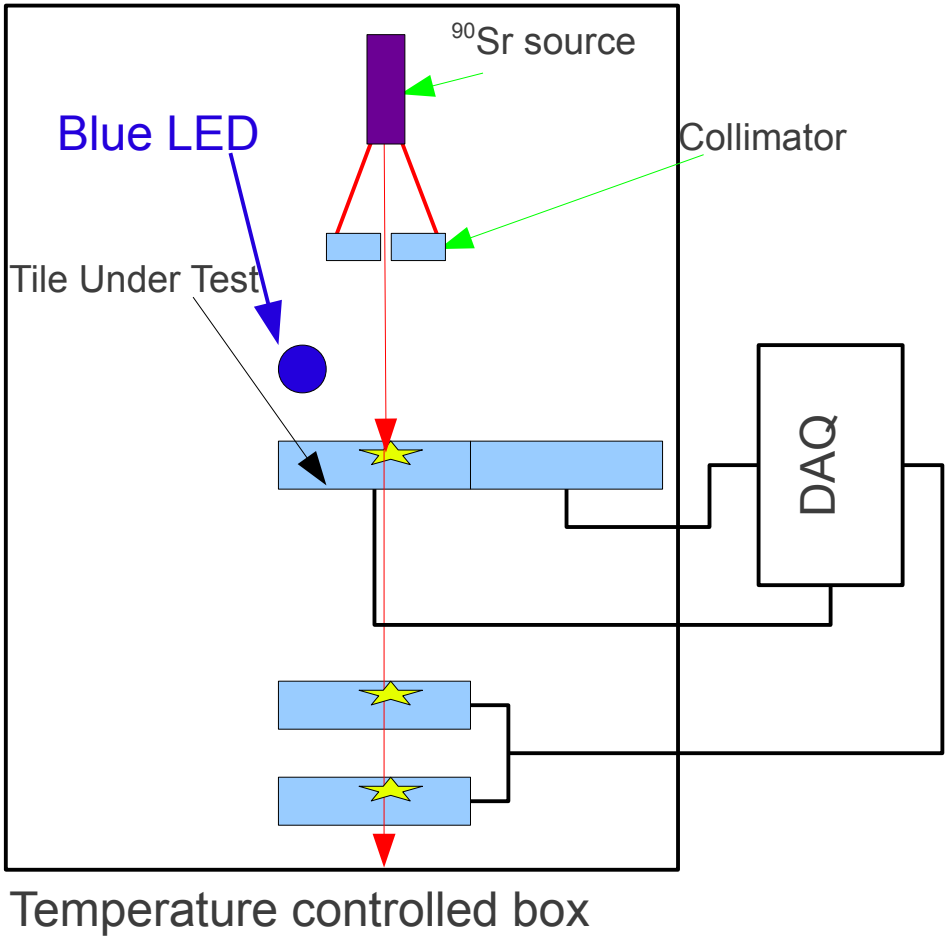




Tile performace characterization

Measure:
- SiPM parameters:
  - Gain
  - DCR
  - inter pixel cross talk
  - temperature dependence
- Response to one MIP (in n. of pixels);
- Light cross talk between tiles

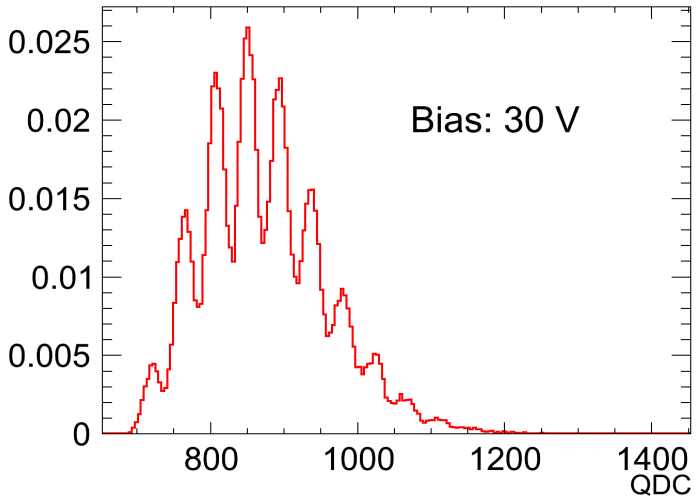




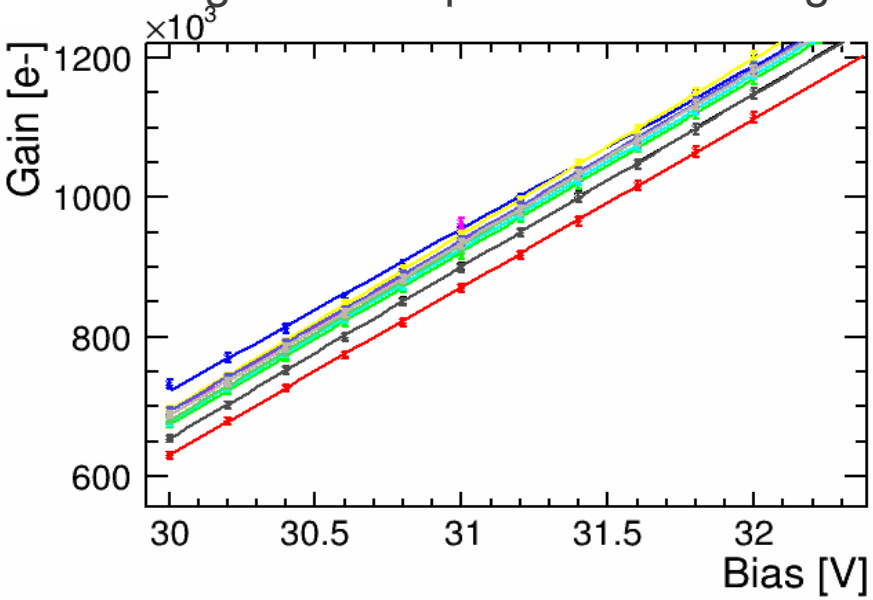
- Small batch (~100 tiles and counting) characterized at Hamburg University;
- Used as a reference for mass calibration set-up being commissioned at KIP Heidelberg

SiPM characterization: Gain

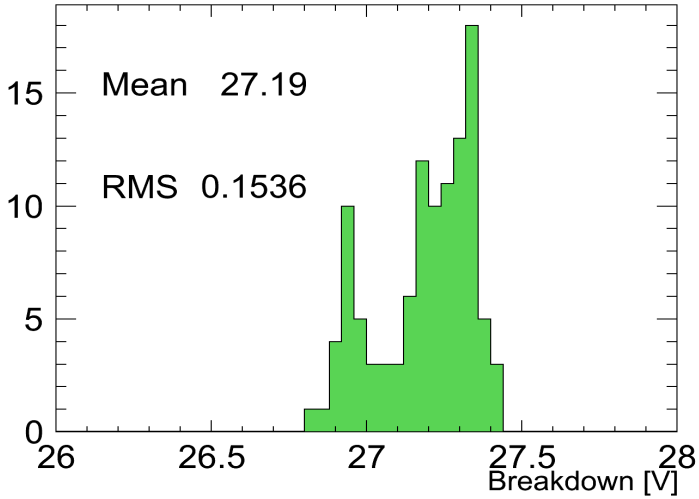
SiPM spectrum:
Gain from multi-peak fit



Voltage and temperature scan of gain



Breakdown

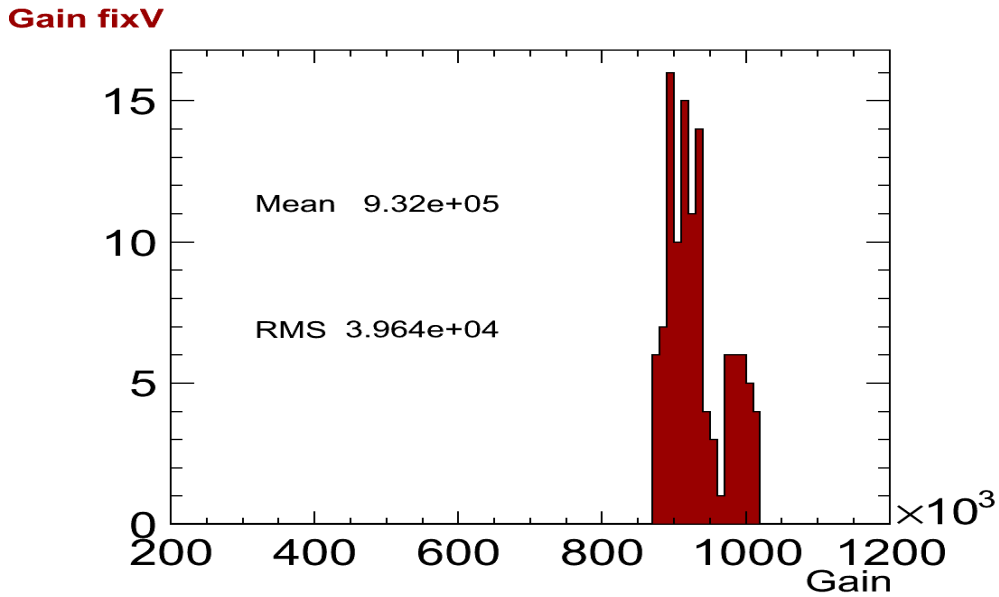


- **Min-to-max: 0.6 V**
- Two batches of SiPMs clearly visible

SiPM characterization: Gain

Set all the SiPMs at same V_{OP} (+31 V):

- Gain spread of 4%
- Min-to-max: 1.4x10^5
- Two SiPMs batches still visible



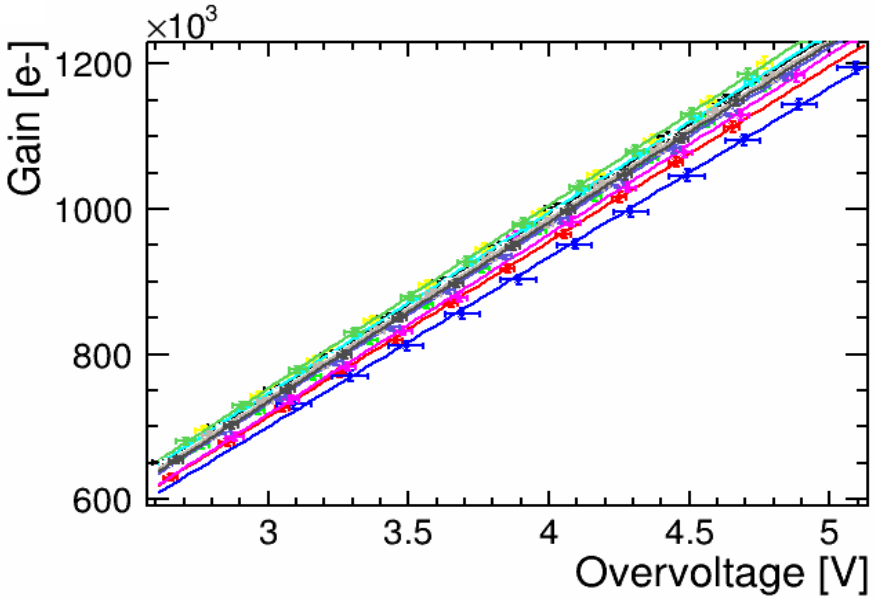
SiPM characterization: Gain

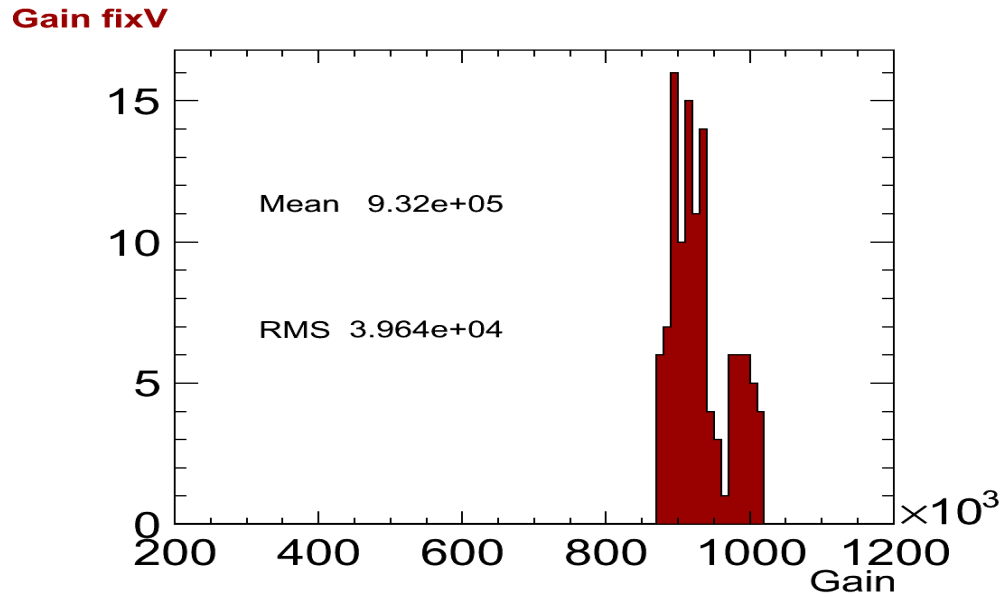
Set all the SiPMs at same V_{OP} (+31 V):

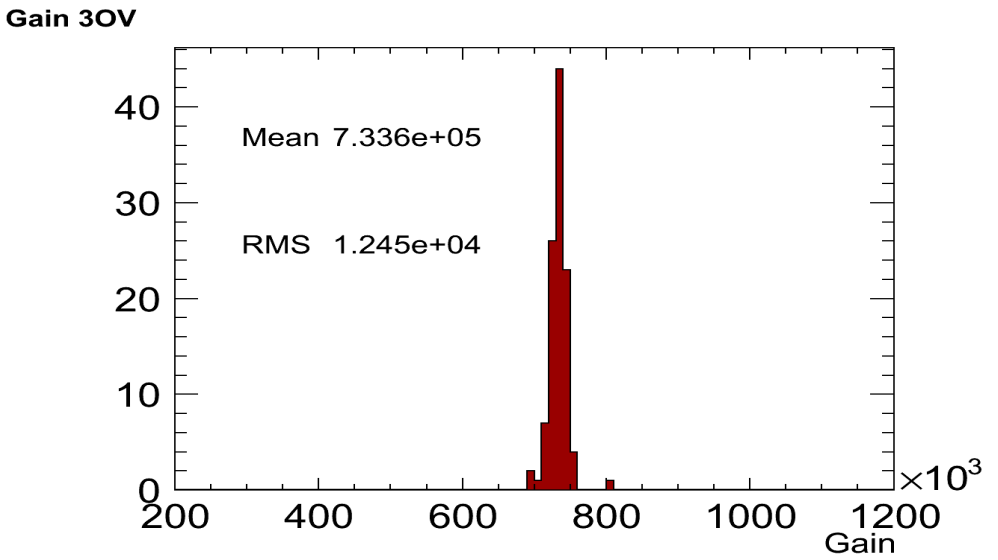
- Gain spread of 4%
- Min-to-max: 1.4x10^5
- Two SiPMs batches still visible

Set all the SiPMs at same Excess Bias (+3 V):

- Gain spread of 2%
- Min-to-max: 1.1x10^5
- Two SiPMs batches disappear



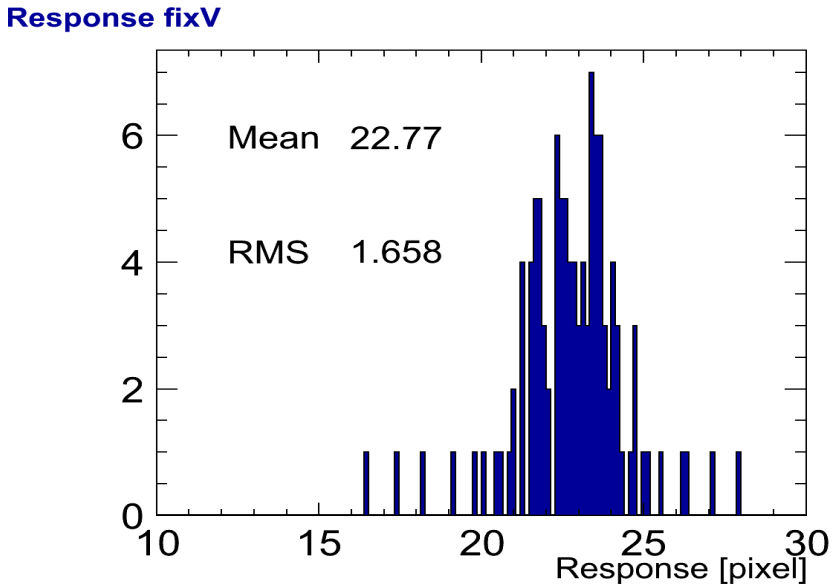




Tile characterization: Response

Set all the SiPMs at same V_{OP} (+31 V):

- Response spread of 7.5%
- Min-to-max: 11 pixels



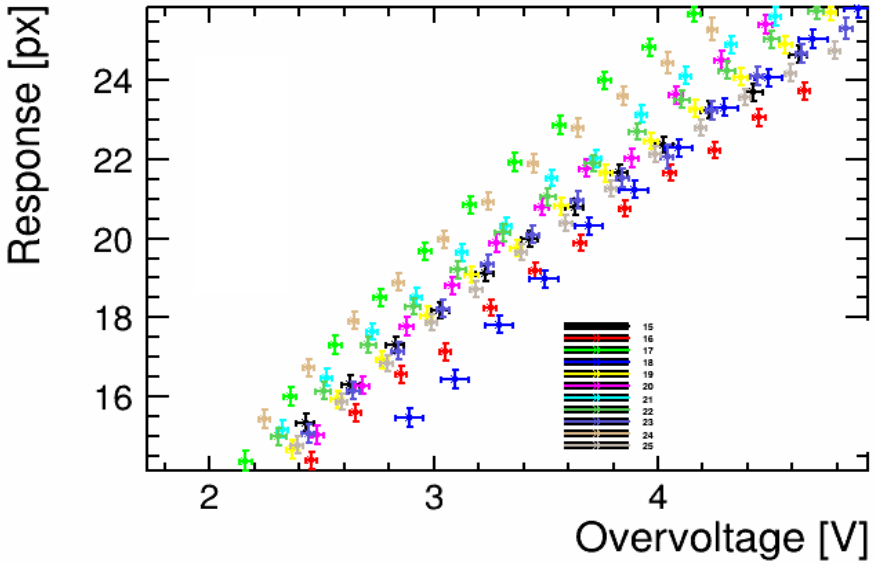
Tile characterization: Response

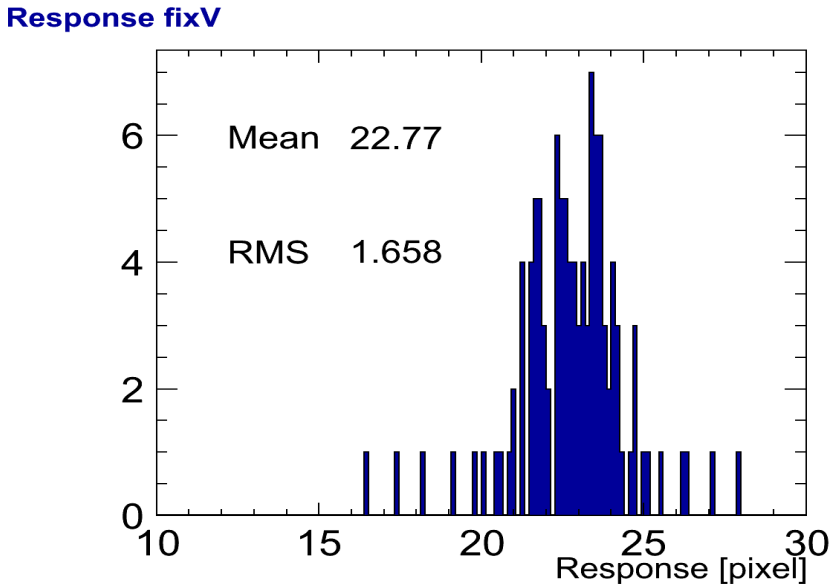
Set all the SiPMs at same V_{OP} (+31 V):

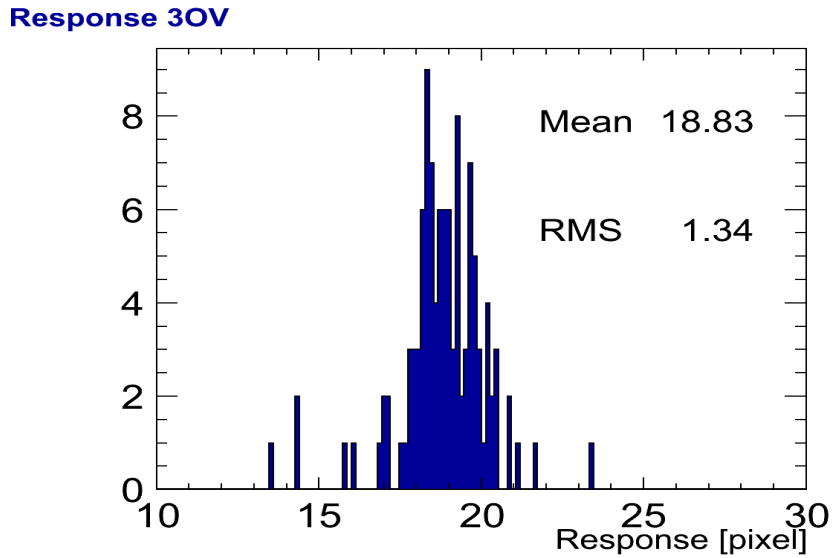
- Pesponse spread of 7.2%
- Min-to-max: 12 pixels

Set all the SiPMs at same Excess Bias (+3 V):

- Response spread of 7.1%
- Min-to-max: 10 pixels







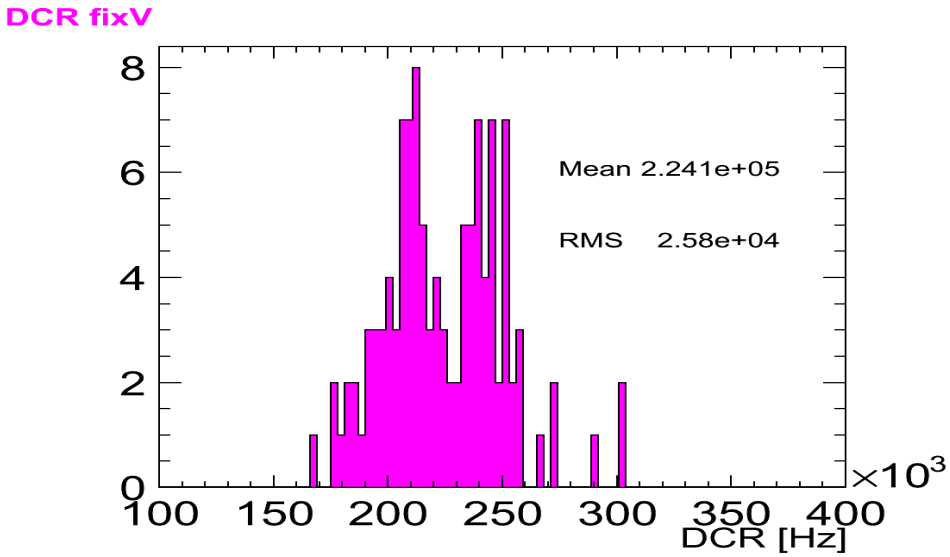
Tile characterization: Noise

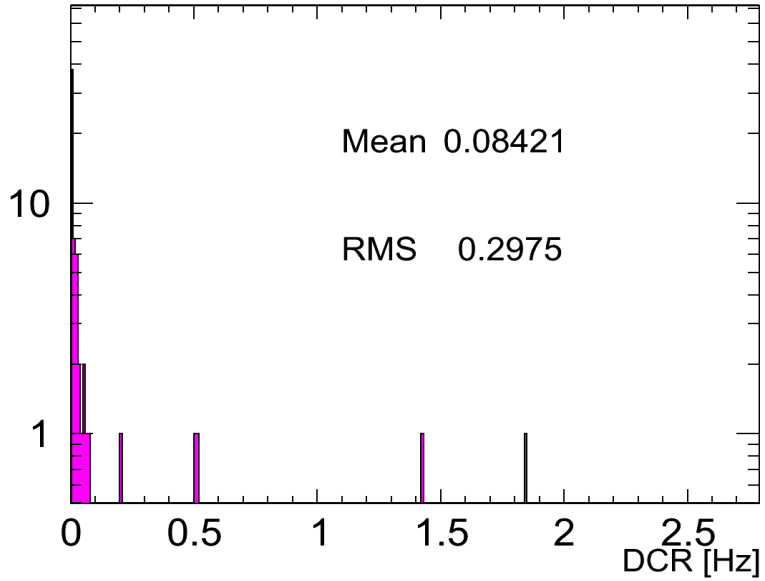
Set all the SiPMs at same V_{OP} (+31 V):

DCR at 0.5 p.e. Threshold
- Mean: 224 kHz
- Spread: 10%

DCR at 0.2 MIP Threshold
- Mean ~ 0.1 Hz

SiPM noise is negligible





Conclusions

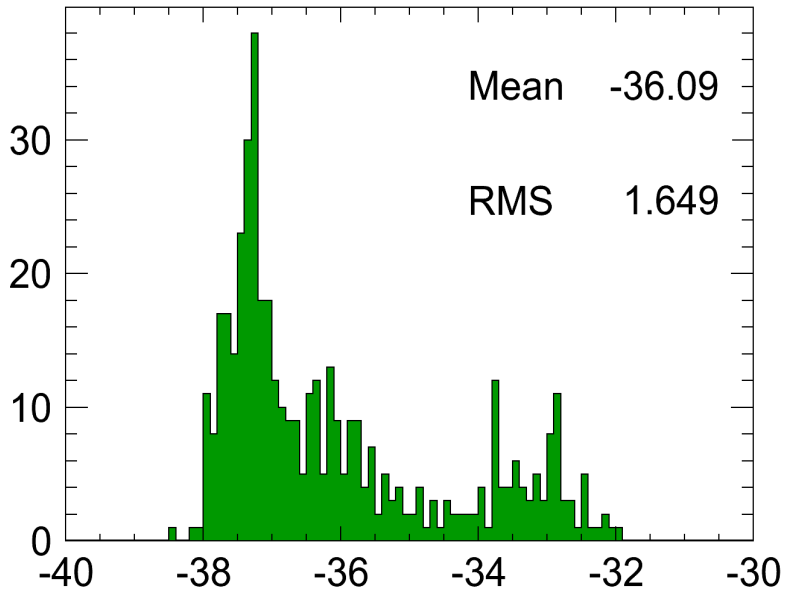
- Single channel (tile) design optimized for mass production finalized at Hamburg University
- Mass production started
- Characterization of SiPMs show small parameter spread:
  - 600 mV min-to-max spread for breakdown voltage
  - ~ 15 mV/K temperature dependence
  - Possible operation at same threshold and same V_{OP}
- If V_{OP} is set individually:
  - 2% spread on gain
  - 7% spread on response to MIP
- Noise due to SiPM DCR is negligible for thresholds > 0.2 MIP

- Outlook:
  - Mass characterization ongoing
  - Cross check results
  - Install tiles on HBUs and test performances in beam environment

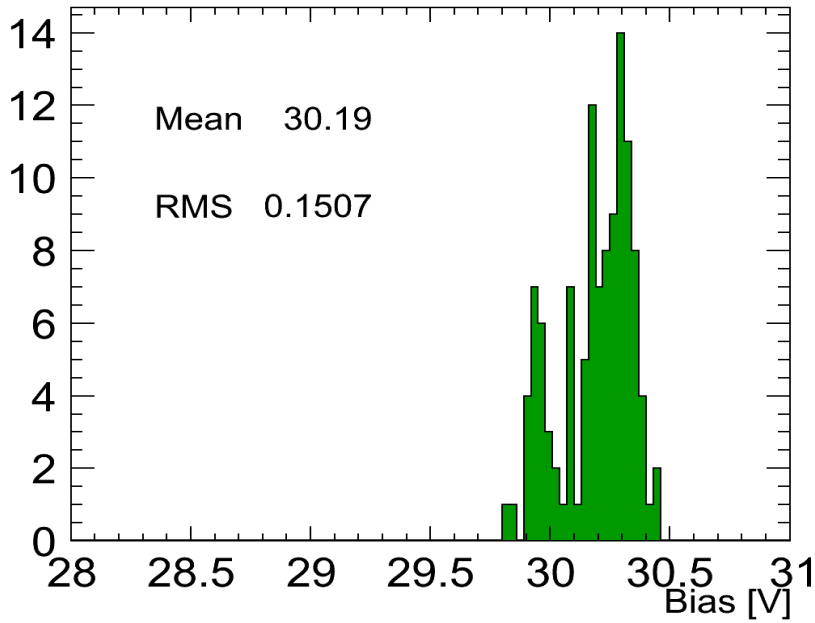
Backup Slides

ITEP Tiles: Operating Voltage

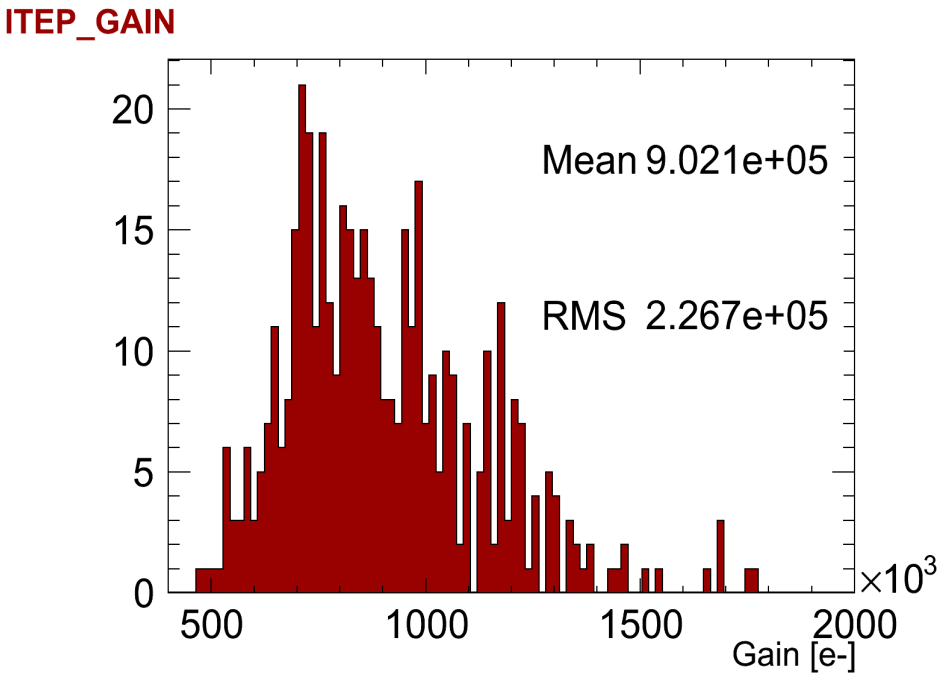
ITEP_VOP

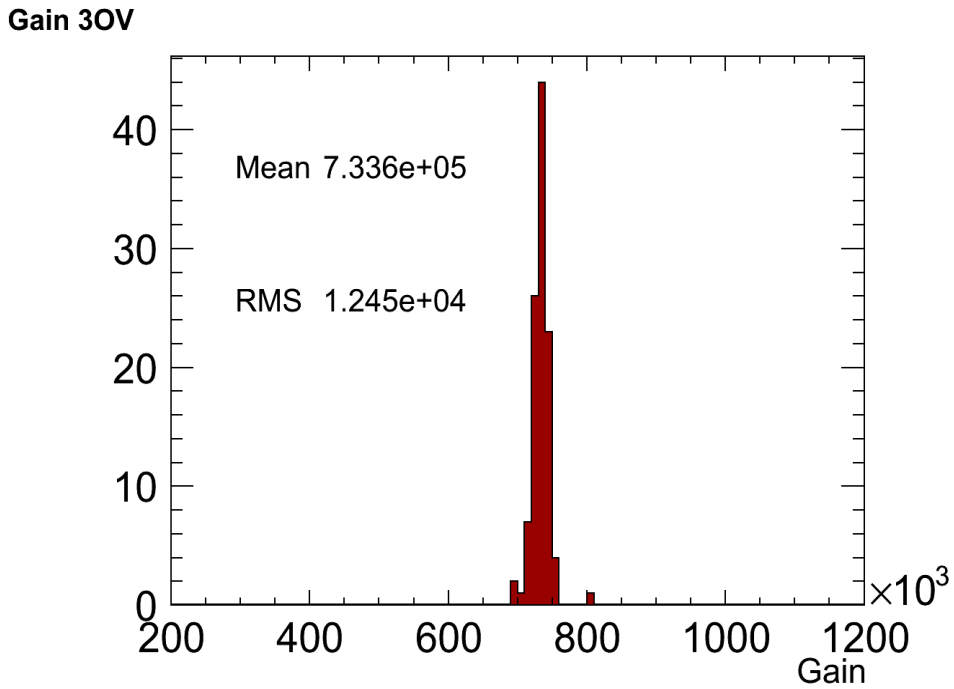


OpVOlt



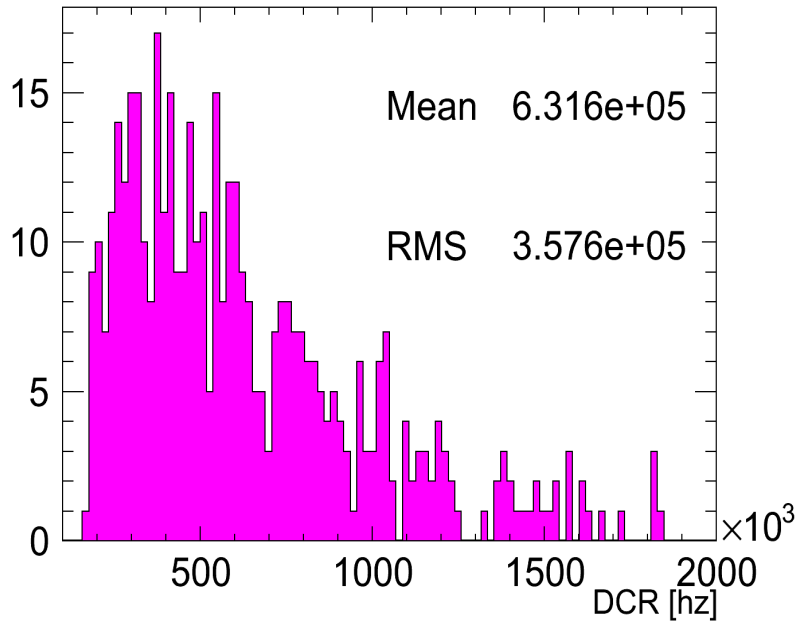
ITEP Tiles: Gain



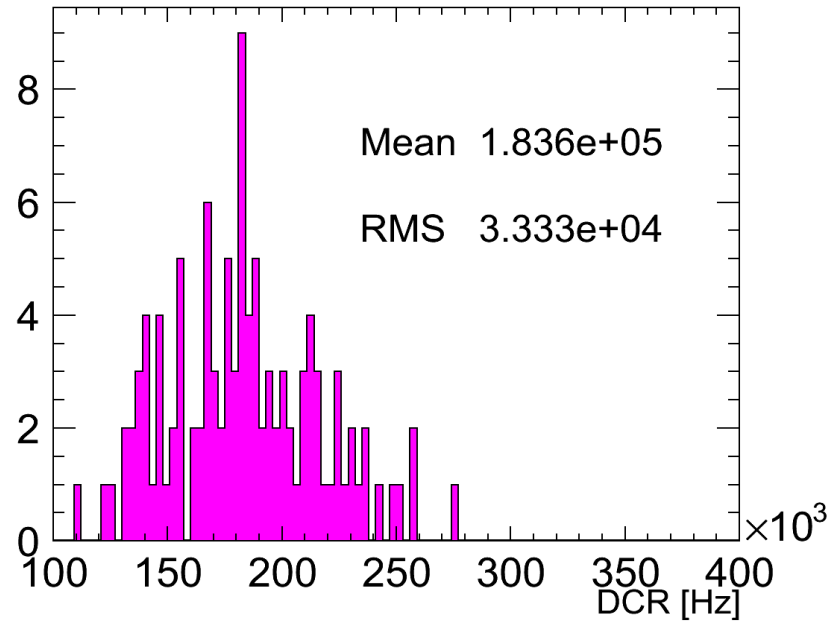


ITEP Tiles: DCR

ITEP_NOISE



DCR 3OV



Mass characterization at Heidelberg KIP

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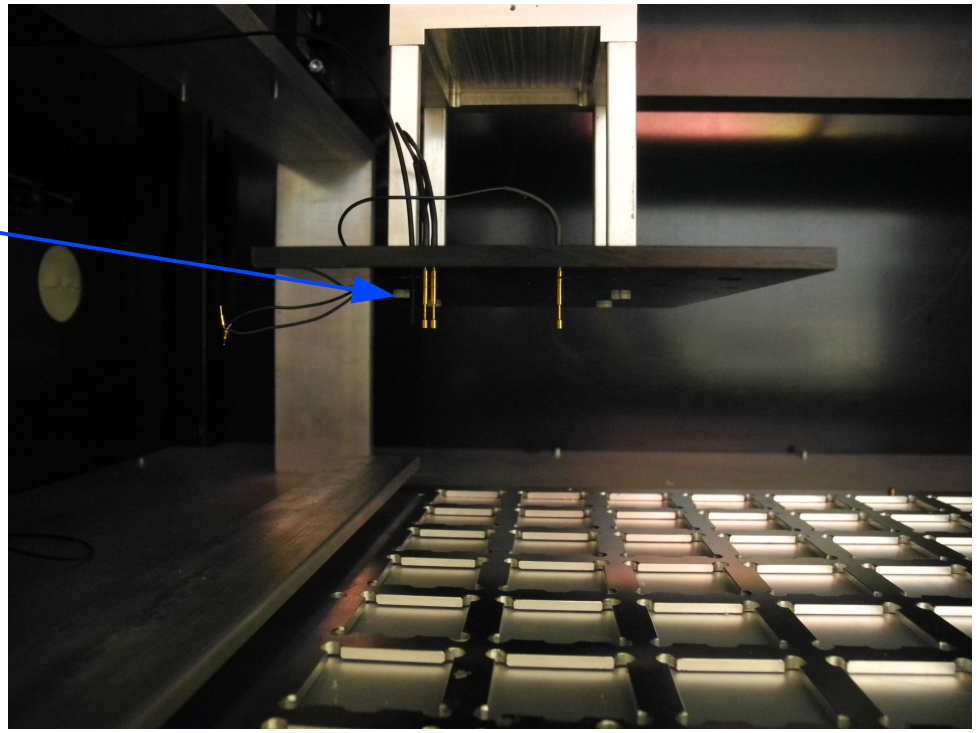
Use UV laser on tiles instead of electrons



Calibration procedure

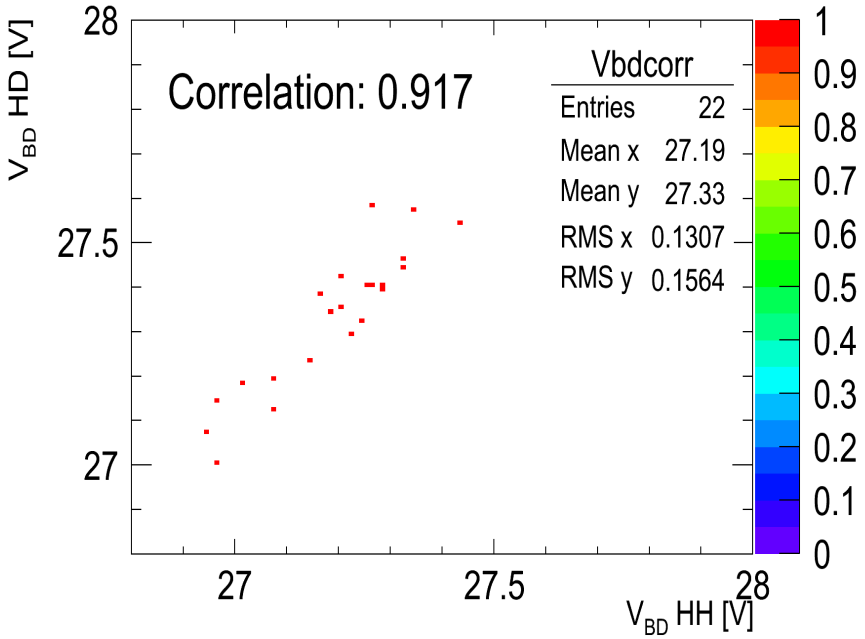
Previously characterized tile:
- Set tile voltage
- Adjust laser intensity until:

Response(Laser)[pixel] = Response(MIP)[pixel]

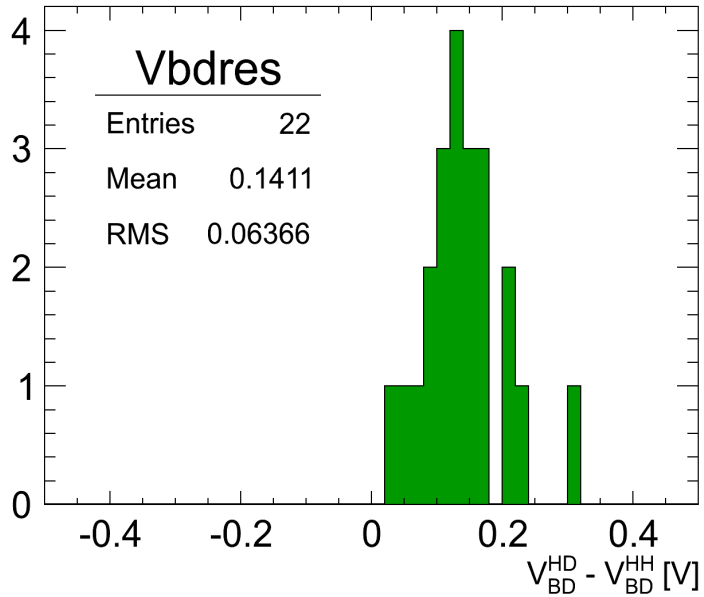
Perform voltage scan of tile response

144 tiles had been shipped to Heidelberg (of which 25 already characterized)

SiPM characterization: break down



KIP result and UHH result strongly correlated



- The two values present an offset
- Origin still to investigated