Setups for SiPM+Tile mass characterisation

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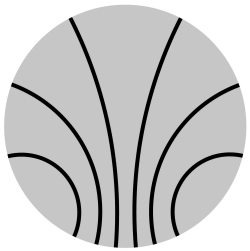


Outline

- Introduction
- Small Tile Testing System
  - Setup, Measurement
  - Analysis
  - Results
- Large Tile Testing System
  - Setup
  - Status
- Summary & Conclusion

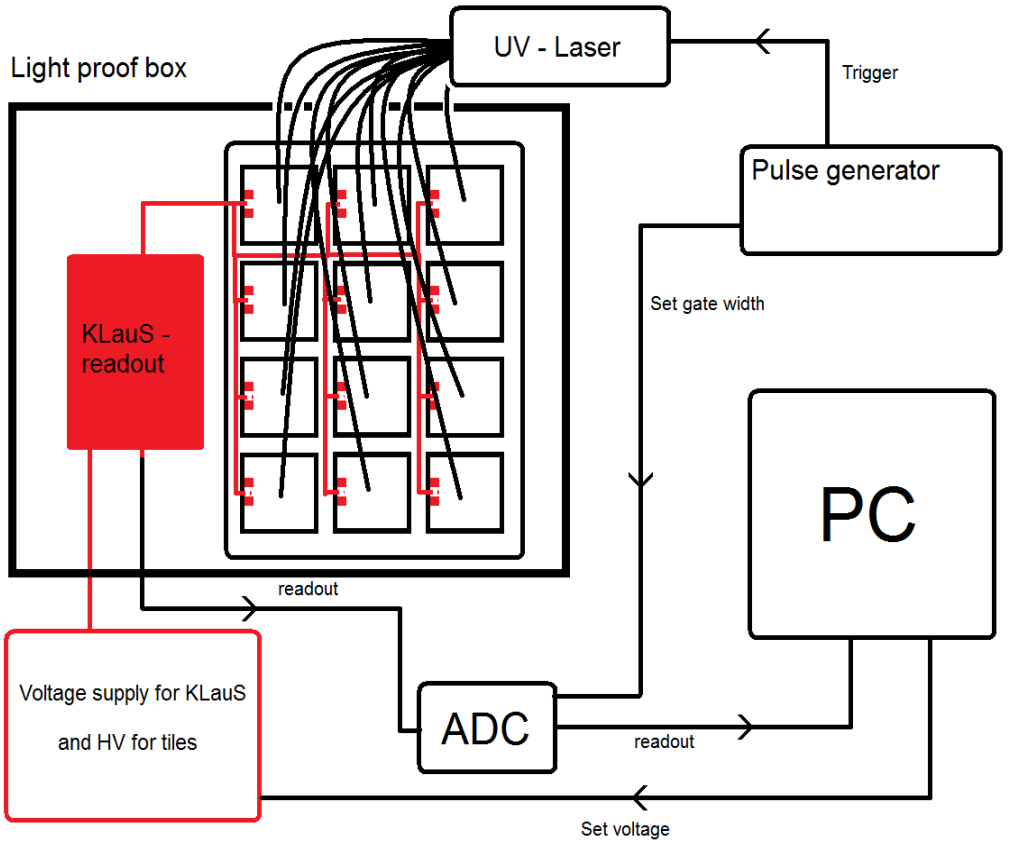
SiPM+Tile Characterization

- SiPM parameters vary from tile to tile
- Each SiPM+Tile has to be characterized individually
- Temperature variations affect SiPM parameters,
  but characterization of temperature coefficients not possible
  on a large scale [O(10^9) tiles]

  → Temperature measurement and correction necessary during characterization
- Two similar setups of different size built in Heidelberg
- O(100) wrapped tiles from Uni HH to be characterized

Small Tile Testing System

Setup:



Characteristics:

- KLauS ASIC for readout
- 12 channels
- UV-Laser and fiber system
- External peak sensing ADC
- Common HV source

Improvements:

- Readout software
  - Speed increase - single point Measurements in ≈ 2s
  - ~~Labview~~ → ROOT & bash/tcl
  - Online analysis

- Reduced electronic noise
- Temperature Monitoring
- Tuning of system parameters
- Good spectra for both MEPHI and Uni Hamburg tiles

Measurement procedure

- SiPM bias voltage scan (typ. 15 points)
- Single photon spectra (SPS) and dark rate spectra (DRS) recorded for each point
- Laser intensity fixed
- Temperature monitoring

Goal:

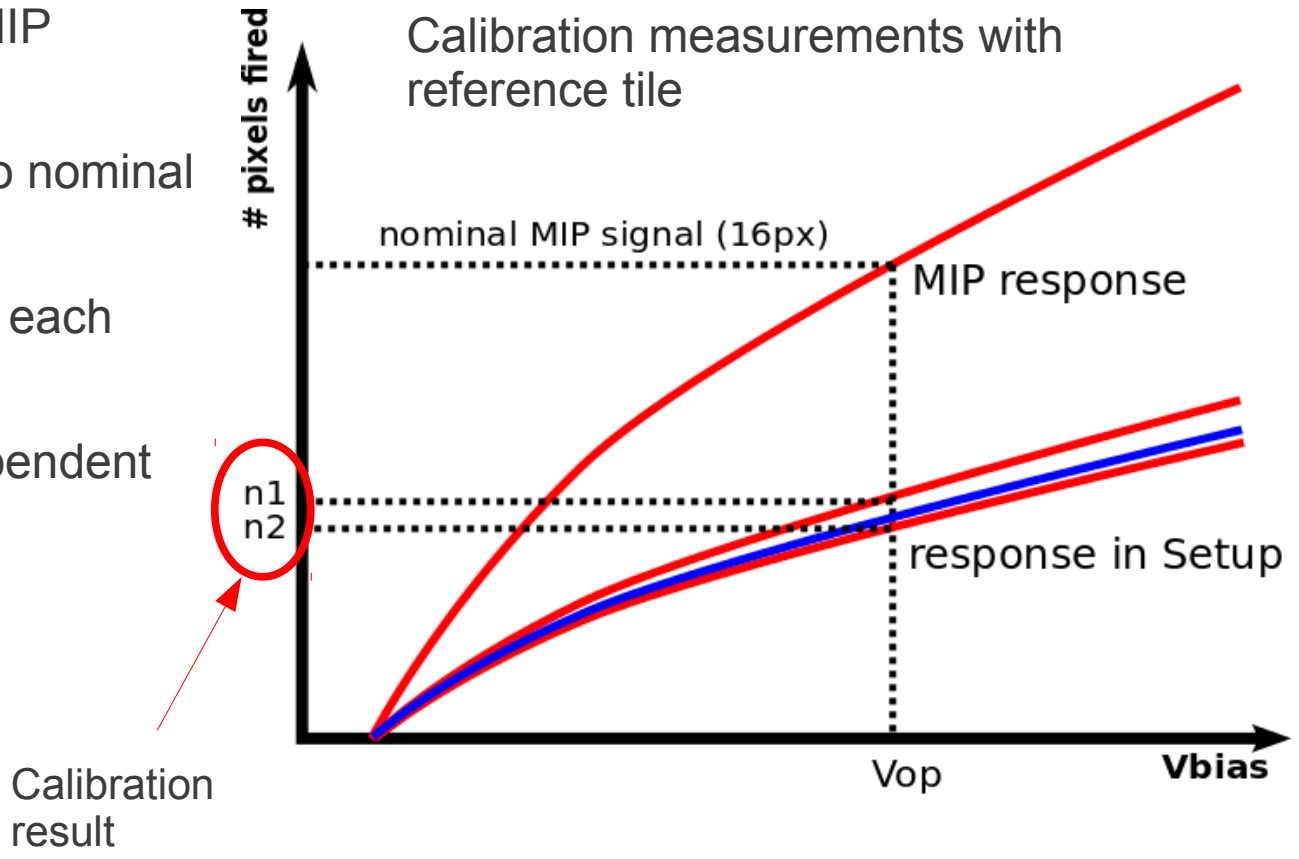
- Determination of breakdown voltage and number of fired pixels
- Estimation of operating voltage for a uniform MIP response

  → Knowledge of incident light yield necessary

  → Intercalibration of fiber system needed

Measurement procedure: System calibration

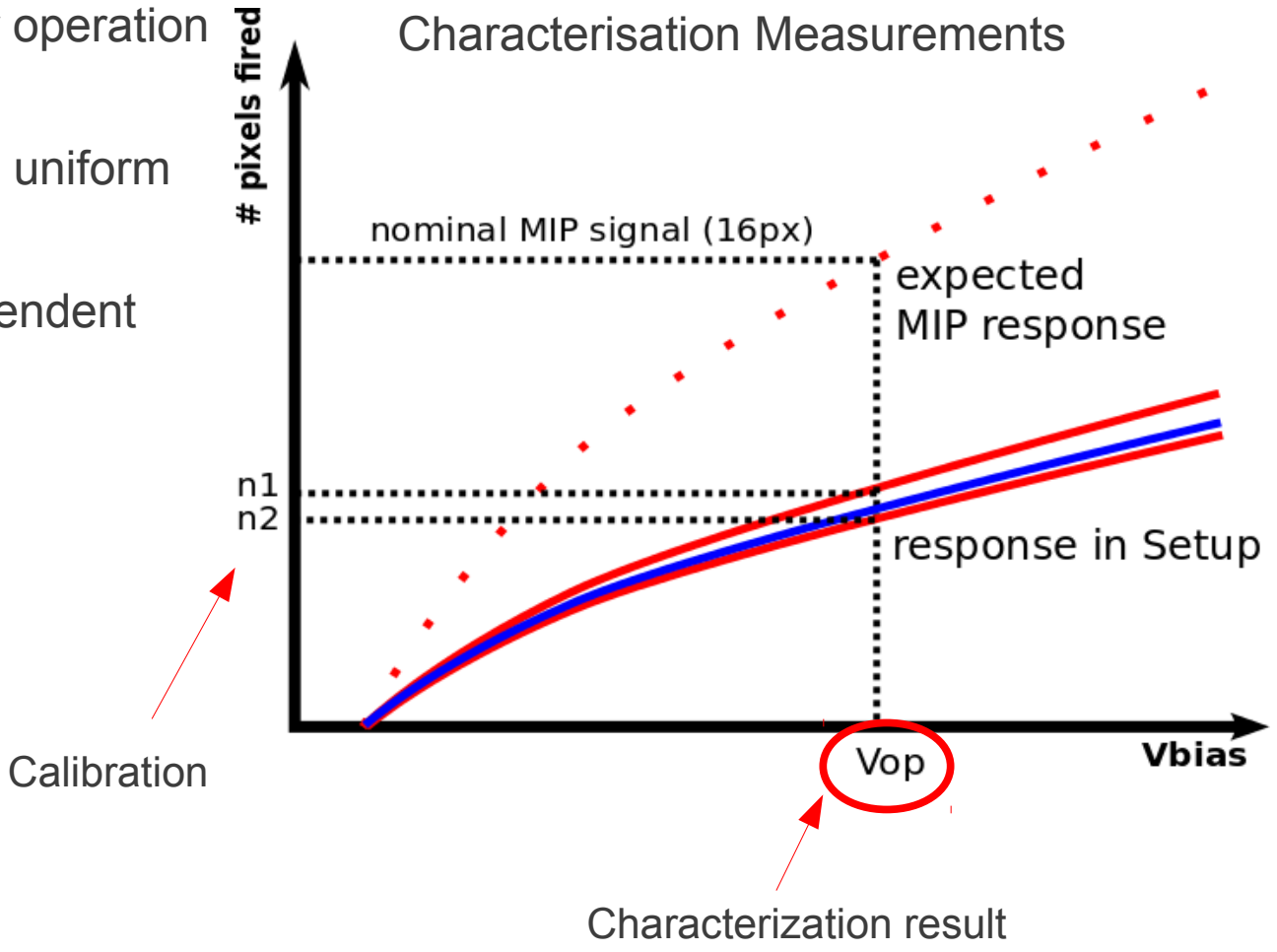
- Use reference tile with known MIP response
- Use operating voltage leading to nominal MIP response for calibration
- Measurement of mean signal in each channel
- Calibration yields a channel dependent expected signal



Measurement procedure: Operating voltage estimation

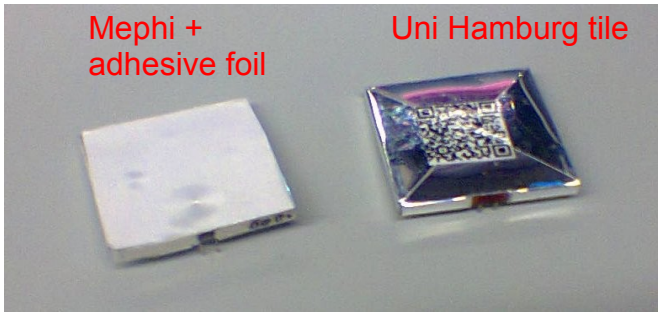
- Silicon Photomultipliers in linear operation region
- Estimate operation voltage for a uniform MIP response:

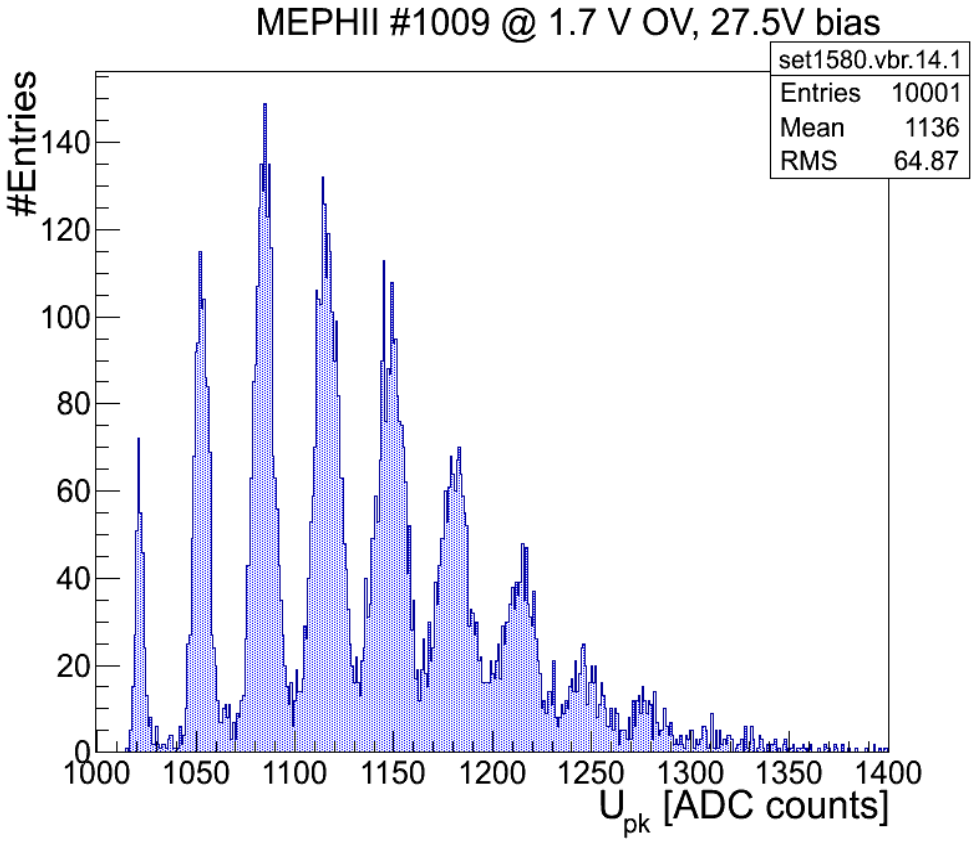
  Bias voltage at the channel dependent expected signal from calibration measurements

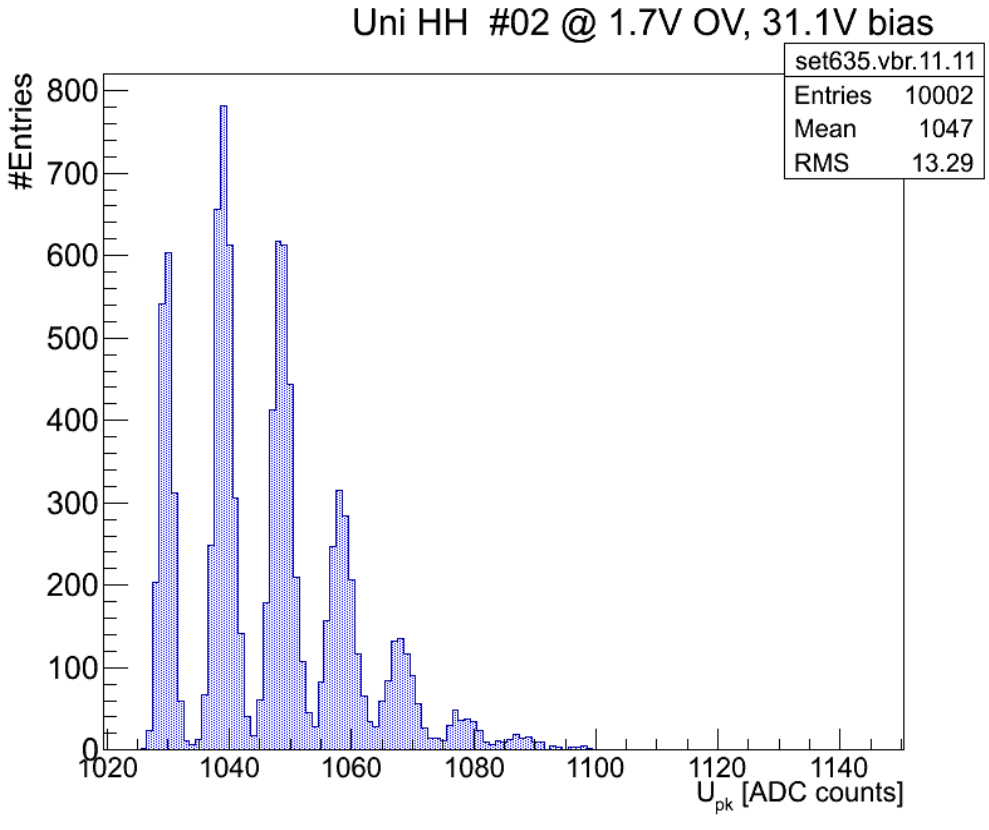


Results

- Characterization of O(100) wrapped tiles from Uni HH planned
- Commissioning of system concentrated on Tiles with reflecting foil on top, shooting light through foil



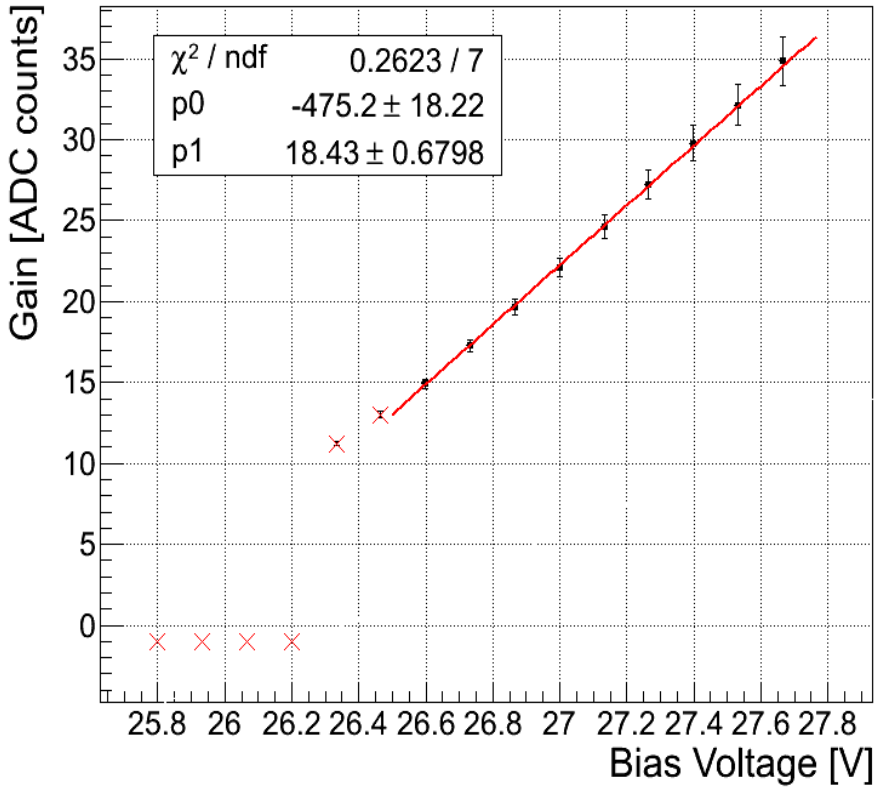




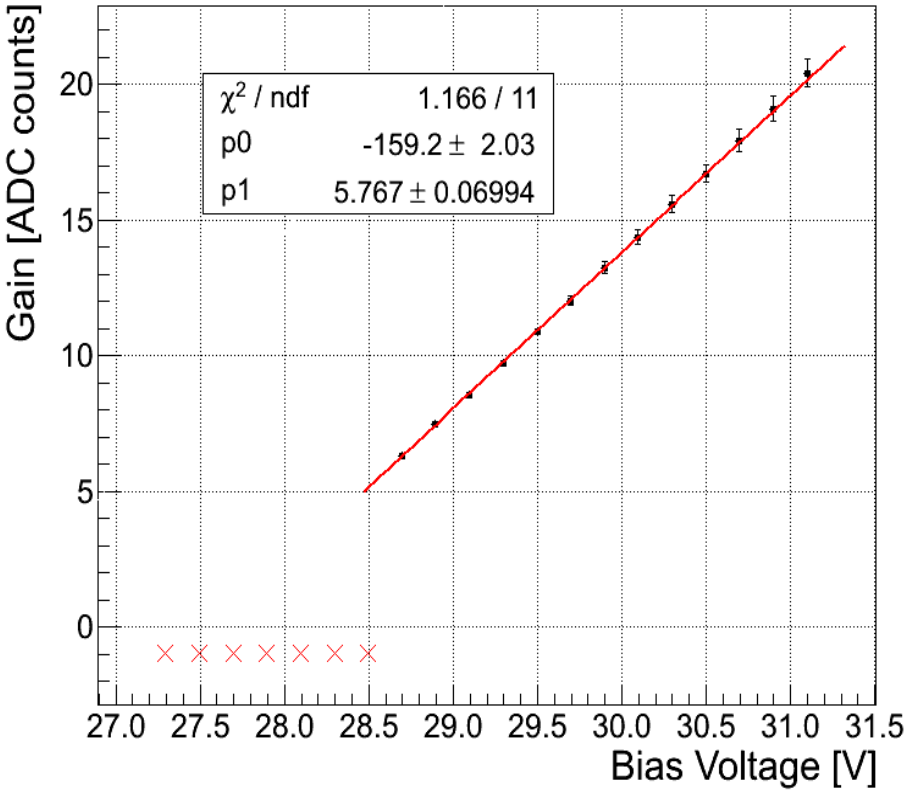
Results

Gain and breakdown voltage estimation

MEPHI tile w. foil



Uni HH wrapped tile



Breakdown Voltage:

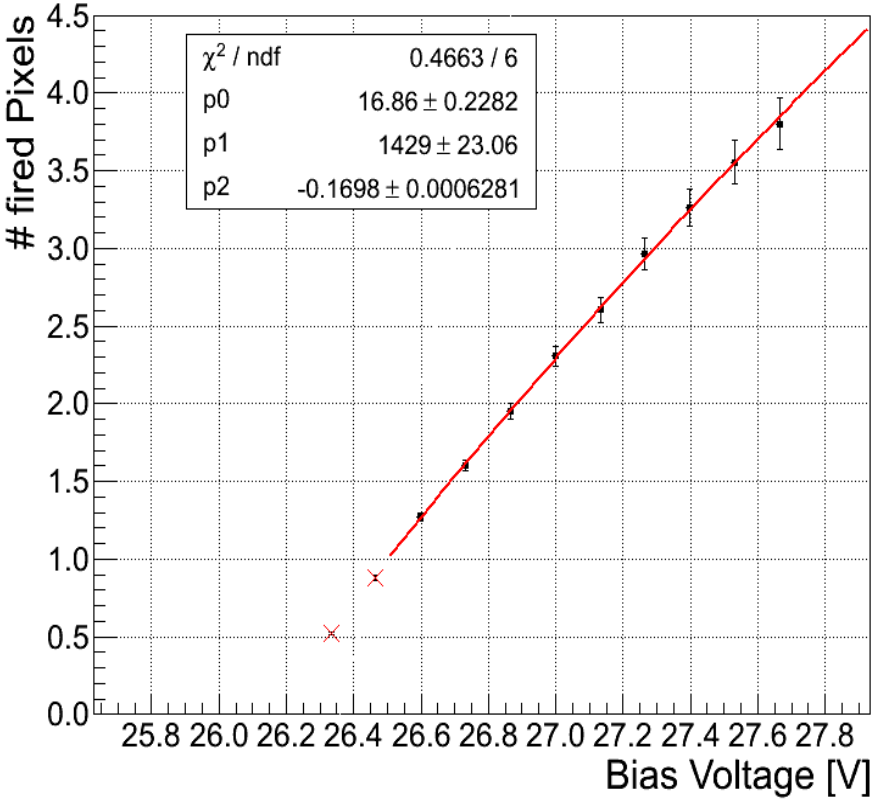
MEPHII 25.8V

Uni HH 27.6V

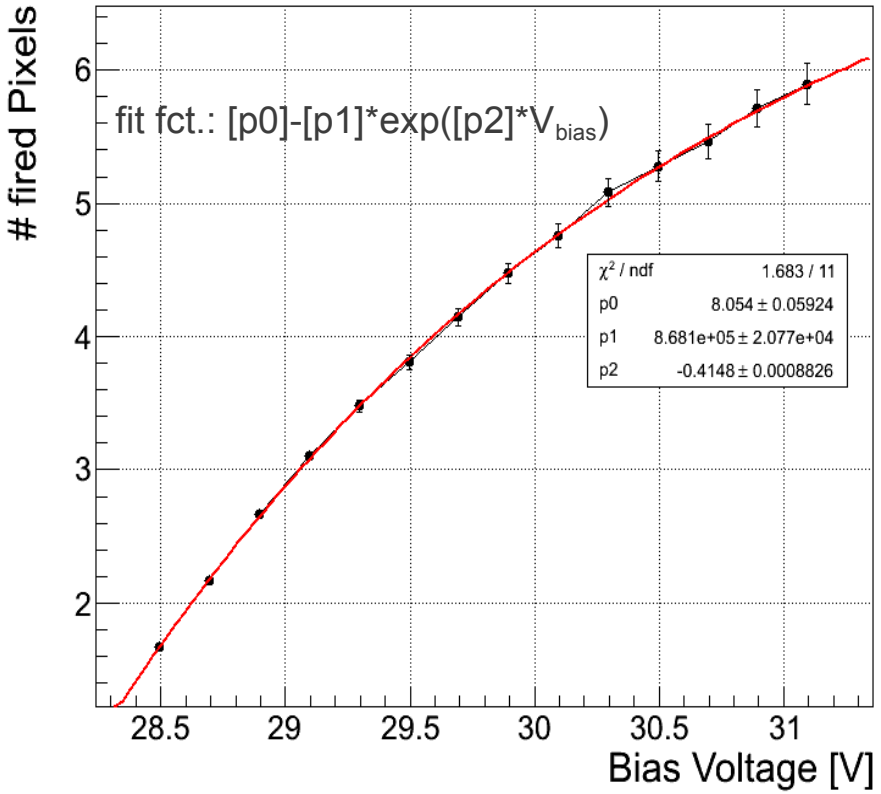
Results

Number of fired Pixels

MEPHI tile w. foil



Uni HH wrapped tile



Breakdown Voltage:

MEPHI 25.8V

Uni HH 27.6V

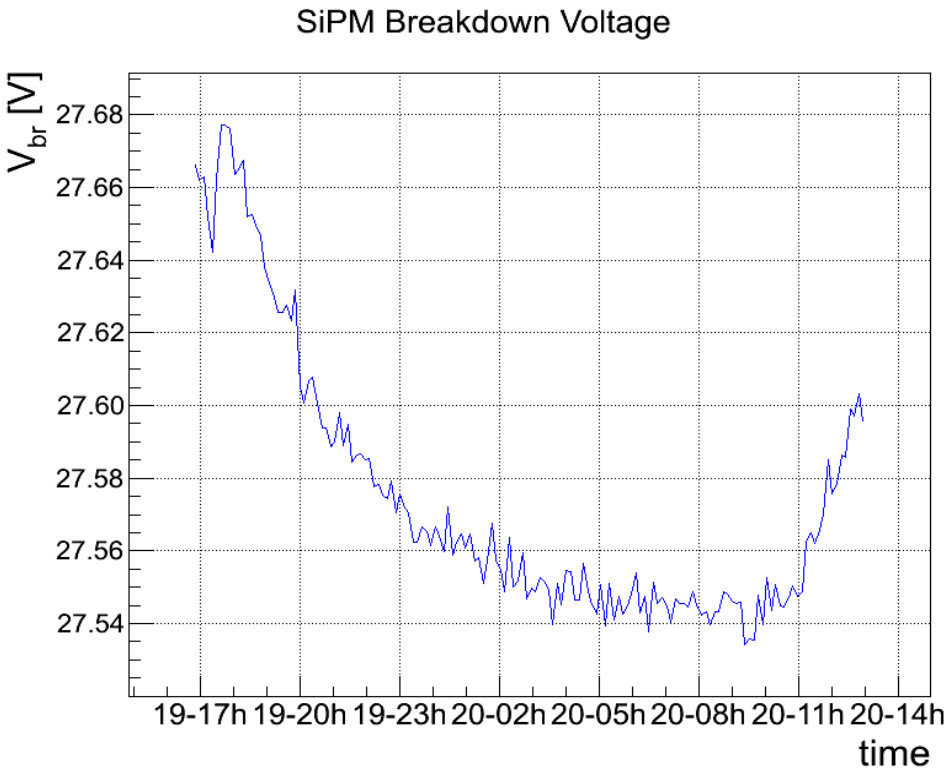
Fired pixels for 2V Overvoltage:

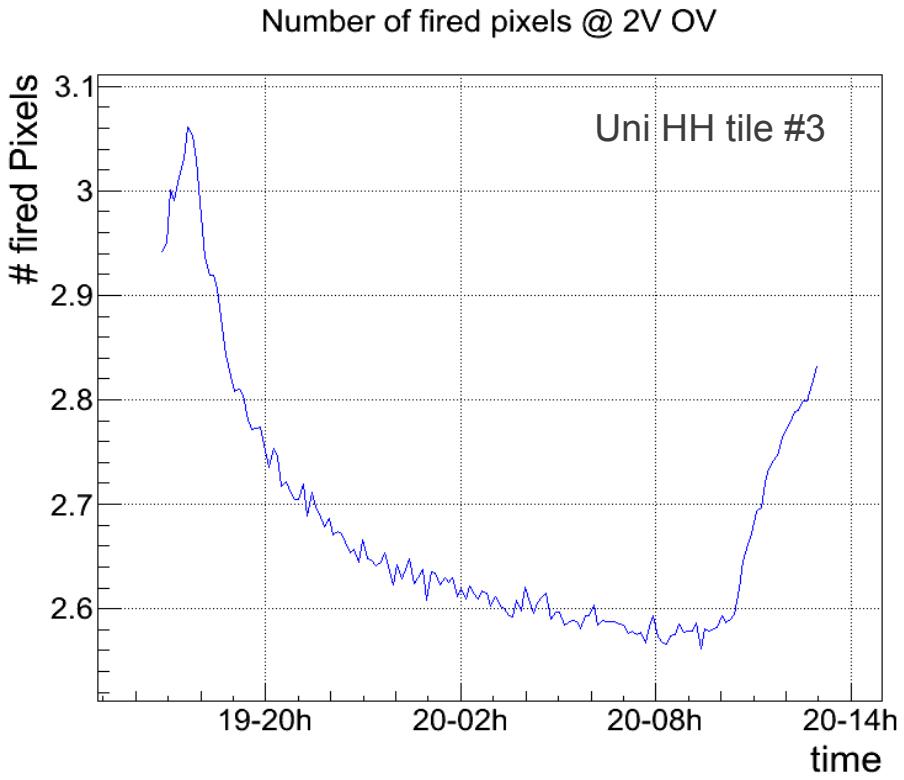
MEPHI 4.15px

Uni HH 4.02px

Temperature effects

- Measure over a longer time period
- Temperature changes induced by changing AC temperature in the lab
  → larger than in reality!
- Breakdown voltage and Number of fired pixels show systematic variations over time due to temperature changes





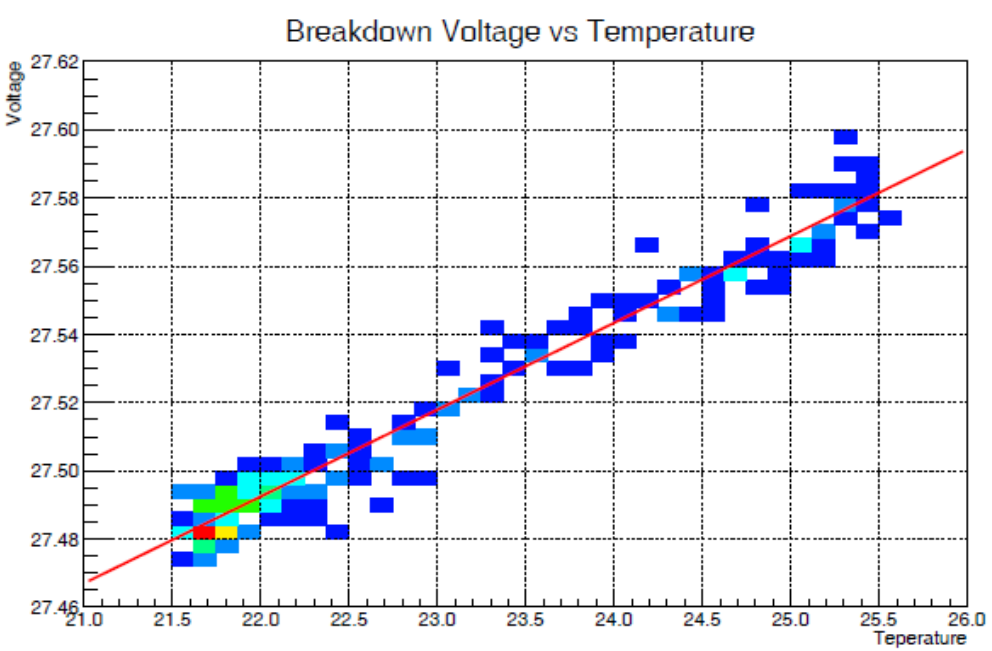
Temperature correction

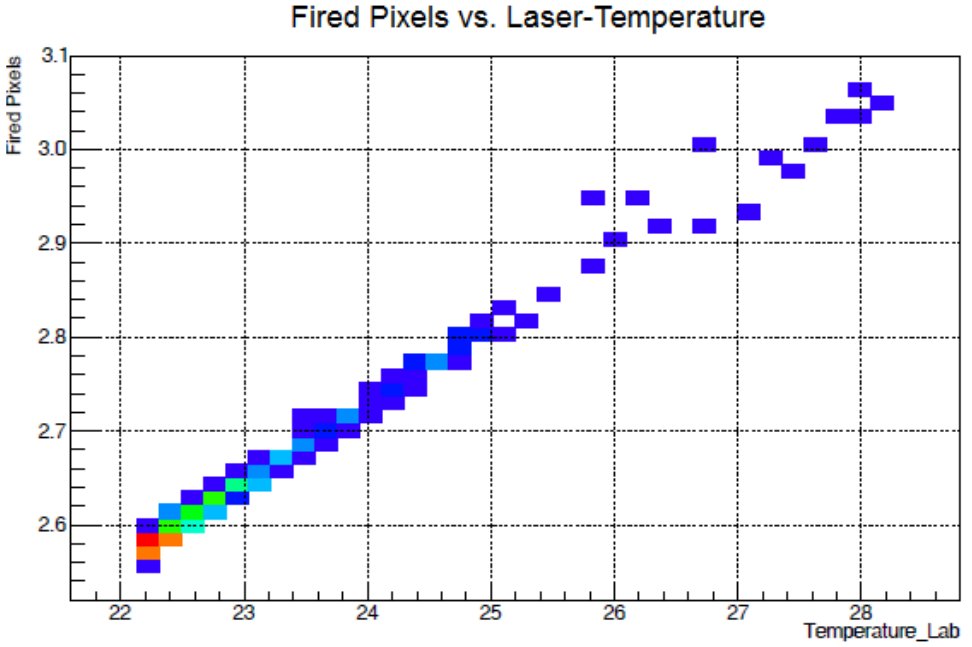
Temperature Correlated effects

- Breakdown voltage shows good correlation with Temperature in SiPM box
- Temperature differences between lab (Laser)
- and SiPM box for fast temperature changes.

  → number of fired pixels does not correlate with SiPM box temperature (but w. ambient lab/laser temperature)

  → additional temperature monitoring of ambient lab temperature





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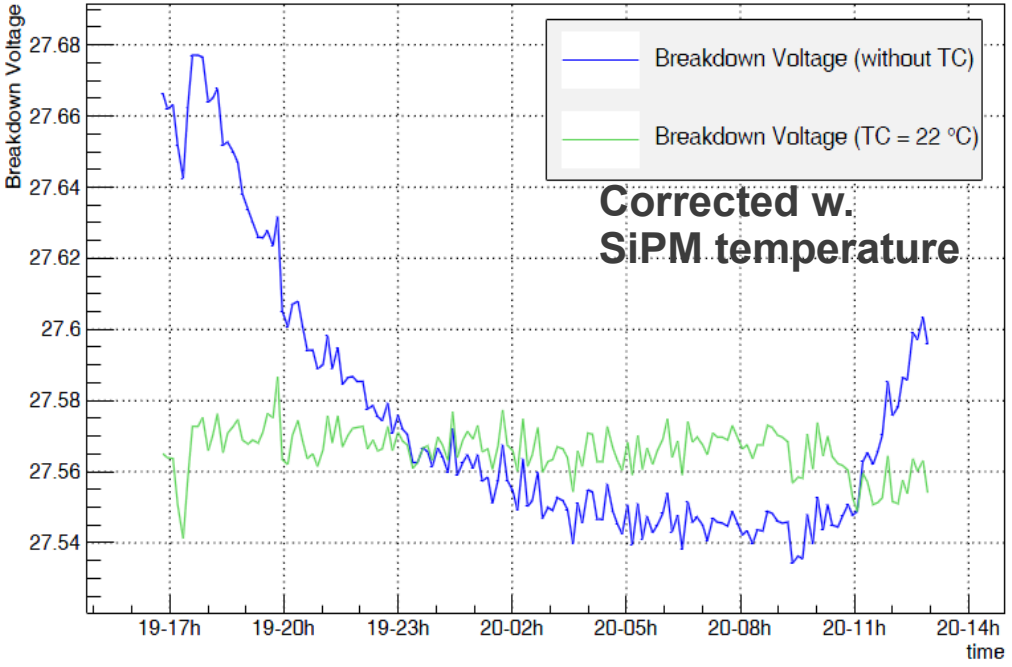
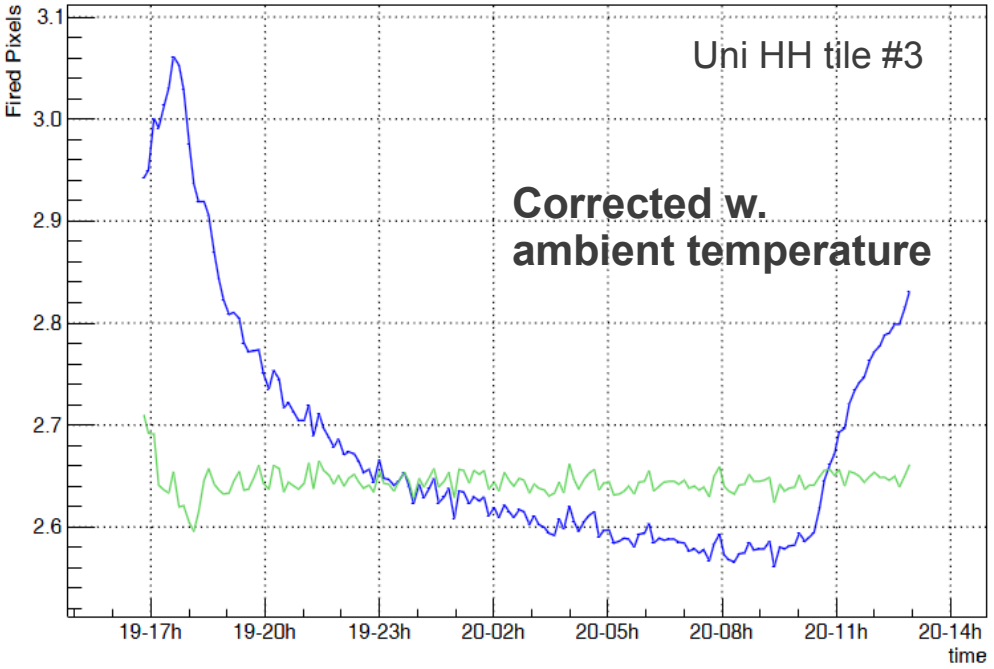
Parameter Spread after Correction:

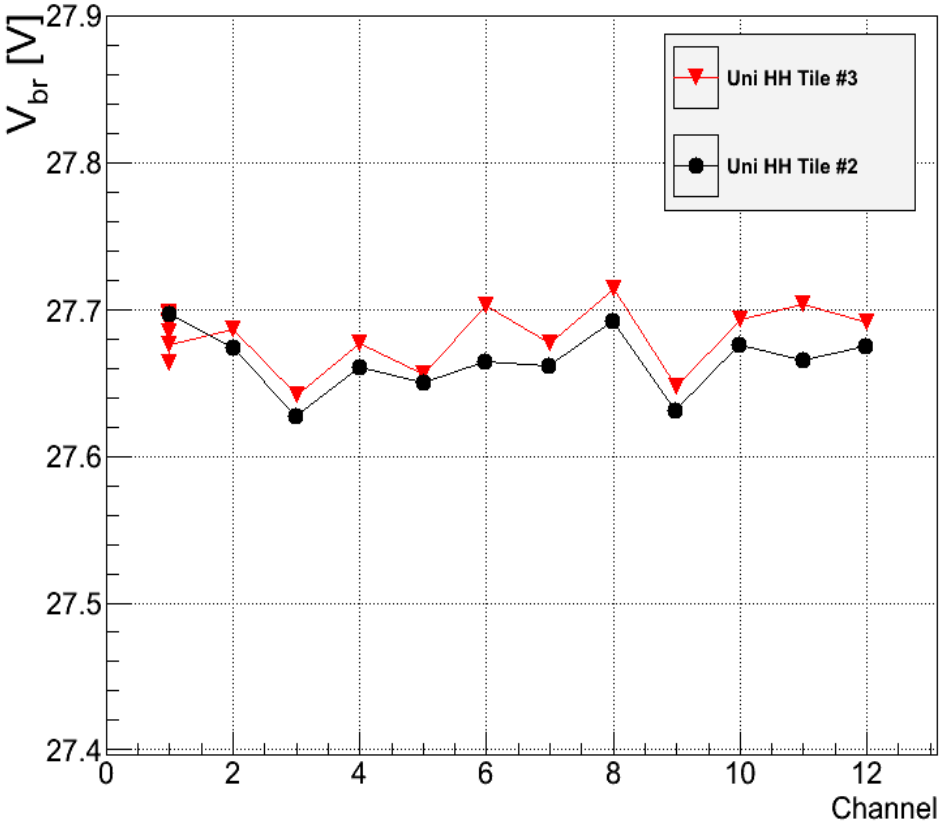
- Spread of breakdown voltage: 6.5mV RMS
- Spread of mean Signal: 0.013px RMS (mean signal 2.65px)





Fiber system intercalibration

Breakdown voltage measurements



Same tiles measured in each channel of the system

Slight channel to channel variations

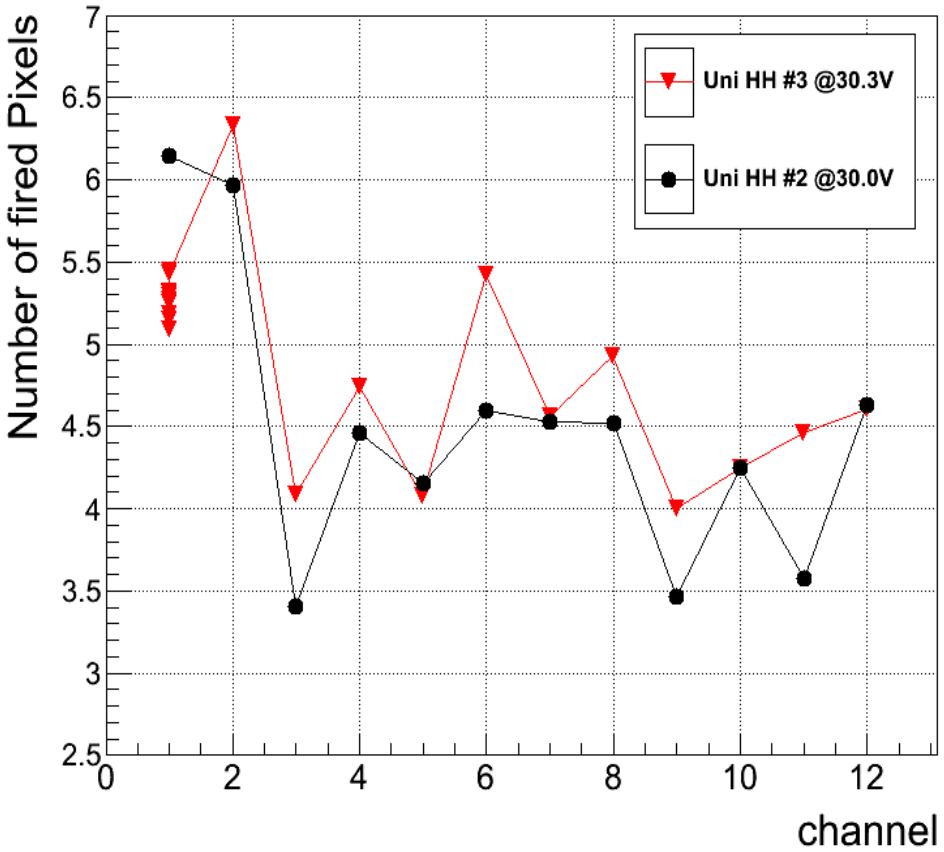
Tile insertion and measurement repeated several times in Channel 0

All variations < 80mV$_{pp}$

Fiber system intercalibration

Two characterized tiles from Uni HH

- Known voltage to MIP response and Temperature dependence
- Measure Tile signal response for both tiles
- Using one as reference, the calibration can be tested with the other tile

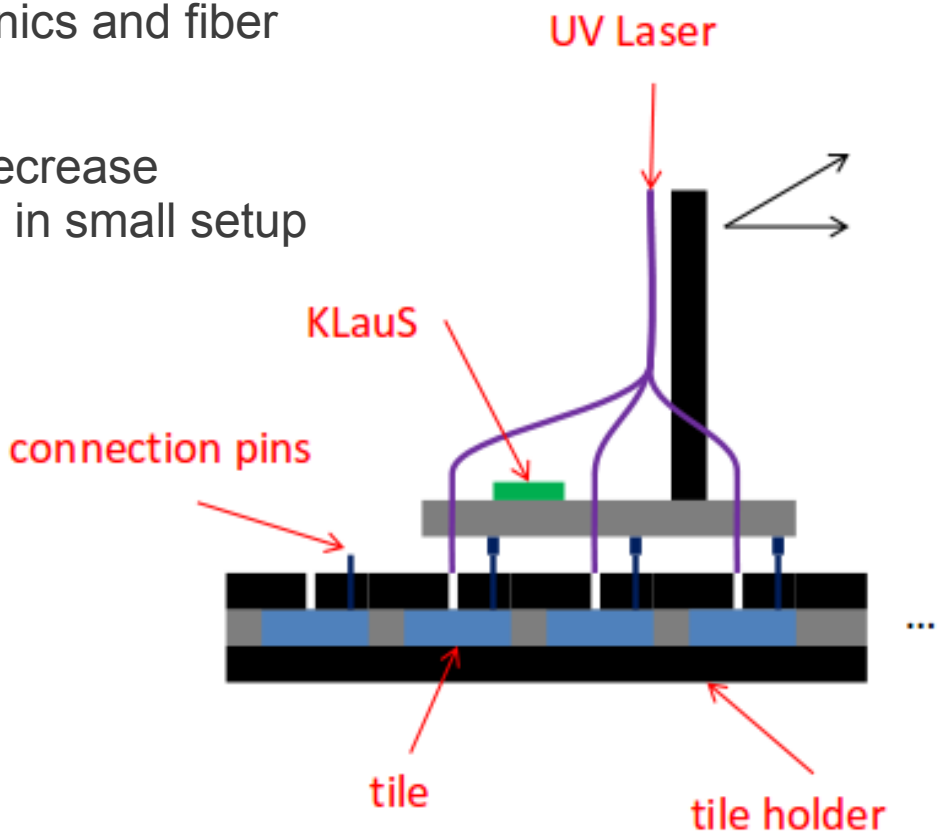


- Used operation voltages from measurements in Hamburg
- Measured signal for operation voltage with uniform MIP response (30V and 30.3V resp.)
- Response should be the same for both tiles
- Deviations lead to large spread of estimated operation Voltage from channel to channel
- Corresponding peak to peak spread in MIP response of ≈1px/MIP
- Seems to be a reproducibility issue!
- Mechanical flaws of the system/Tile?
- Smaller Variations for MEPHI Tiles (→ Backup)

Large Tile Testing prototype

Setup:

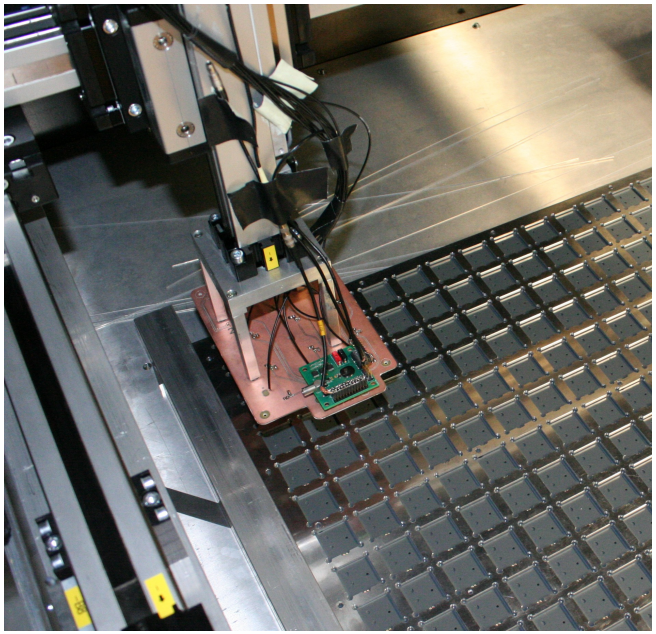
- Semi automated version of the 12 channel setup
- 216 tiles can be inserted in tile holder plate
- Positioning head moves readout electronics and fiber system to the 18 measurement stations
- Base plate is screwed together, might decrease mechanics-related reproducibility issues in small setup



Status of the LTT Prototype

- Movement and measurement fully automatized
- Synchronization between positioning and measurement working
- Electronic noise levels as expected
- Stable Alignment of Readout head to pins on tile palette

→ ready for first dark spectra measurements



To do:

- Validate stable electric connectivity
- Optical fibers to be reattached and optimized for uniformity
- System for reading QR codes of tiles.
- Scripts for parsing initial database informations (e.g. Tile ID from QR code)

Summary and Outlook

- Small scale system rebuild,

  large scale system ready for first tests.
- Temperature correction or further stabilization needed for optimal results.
- Measured channel to channel breakdown voltage variations within 80mVpp
- Reproducibility issue in measurement of number of fired pixels with small scale system.

  → leads to high uncertainties in the estimated operation voltage.
- Some work on fiber system and tile holder needed to increase stability.
- Large system might not have these problems.

Backup

Analysis

Determine gain, pedestal, and Npe from SPS and DS for each bias voltage

Gain:

- Fourier transformation of SPS
- Find first mode peak
- Select center of highest bin

Selection

- Minimum rms & gain & fired pixels cut
- 'Noise cut' in FFT spectrum (number of peaks above threshold limited)

Pedestal position (ped):

- Gaus-fit to pedestal in Dark rate spectrum

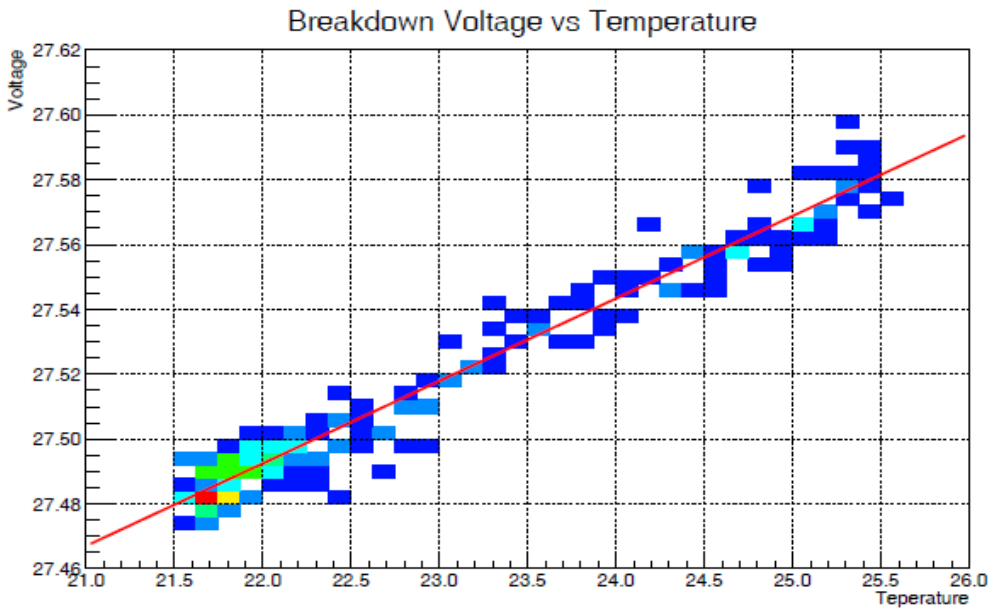
Number of fired Pixels:

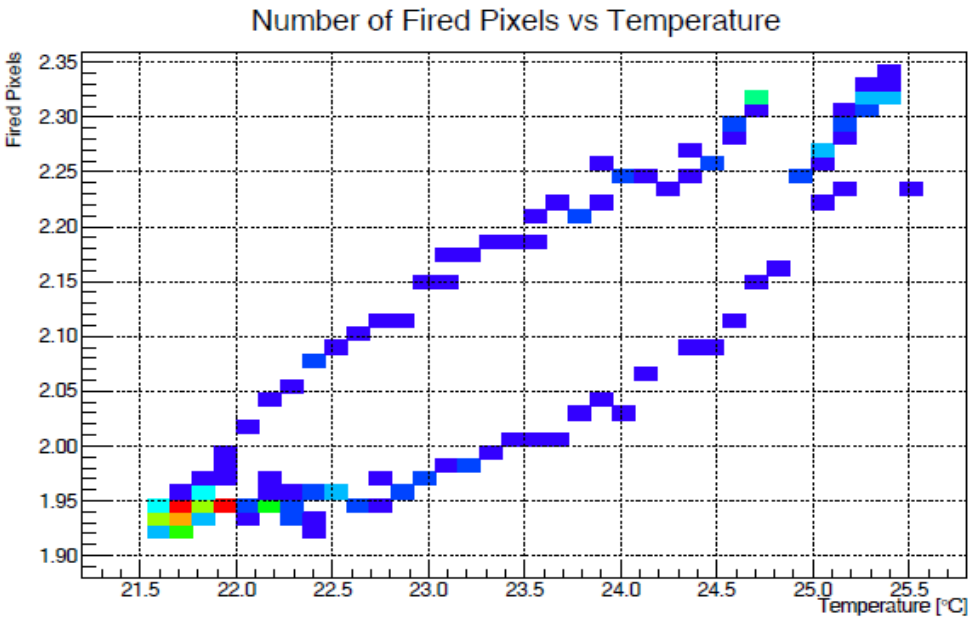
$$\mathrm{Npe} = \frac{\langle \mathrm{SPS} \rangle - \mathrm{ped}}{\mathrm{gain}}$$

Parameter extraction

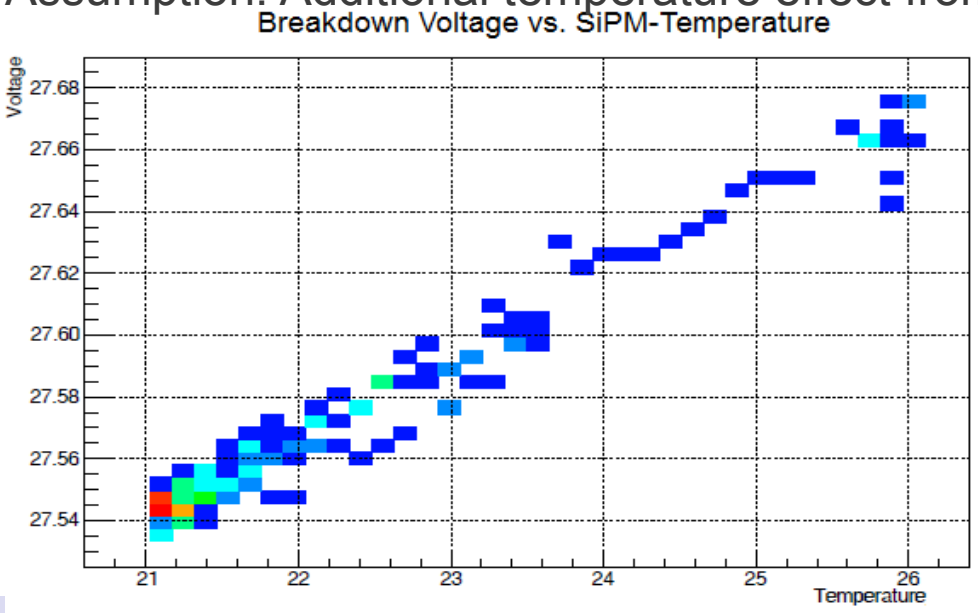
- Breakdown voltage determined from gain vs. V_{bias} plot
- Number of fired pixels determined from Npe vs. V_{bias} plot

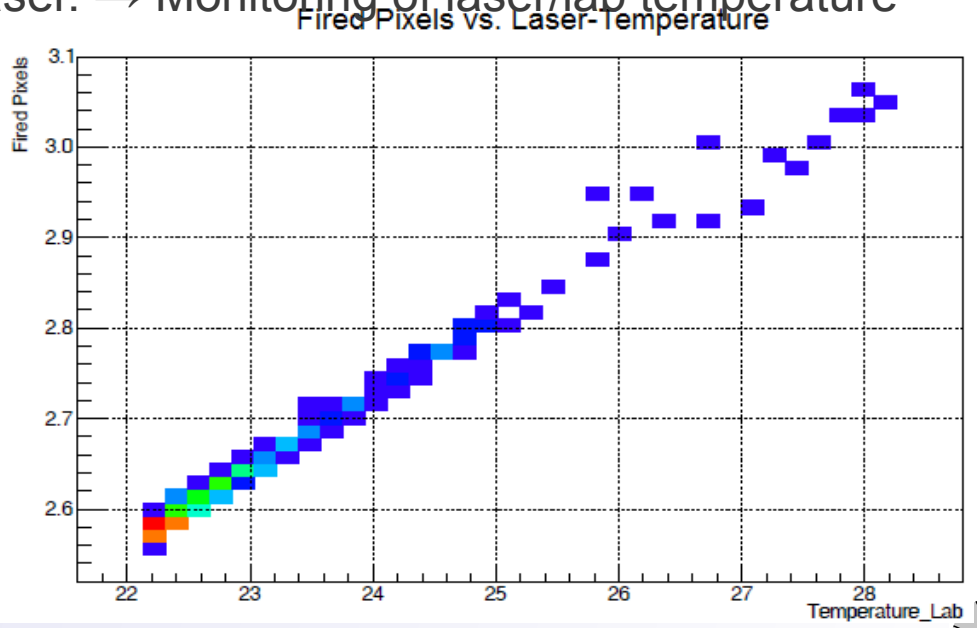
Temperature correlations





Number of fired pixels show no clear temperature relation when plotted against SiPM-Temperature
Assumption: Additional temperature effect from laser. → Monitoring of laser/lab temperature





System calibration for MEPHI tile

- Differences to other Measurements - fiber system and system parameters!
- Reproducibility variations in the mean number of fired pixels seem to be smaller

- Only one tile measured – no cross calibration test performed