Qualification of pixel detector modules for CMS Upgrade Phase I

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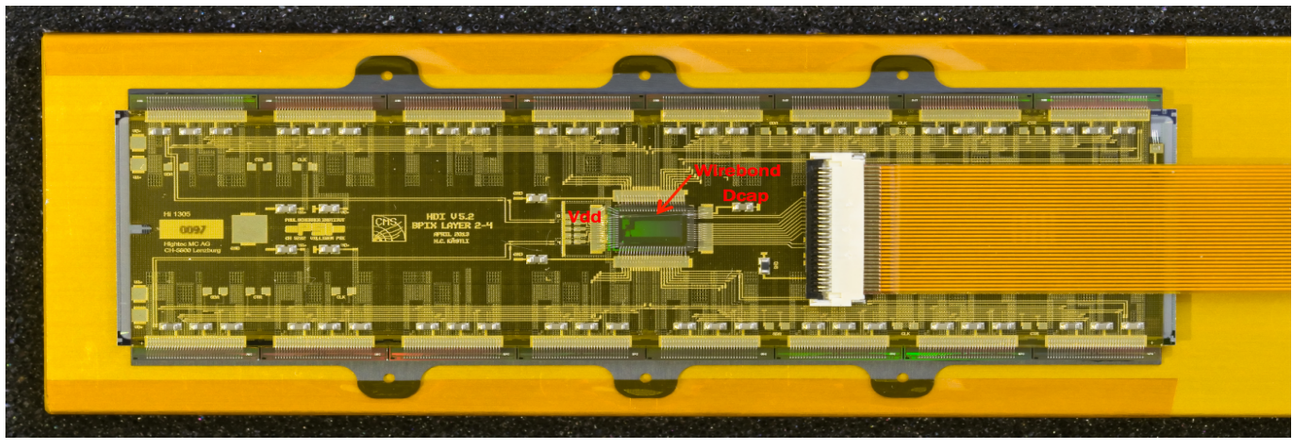
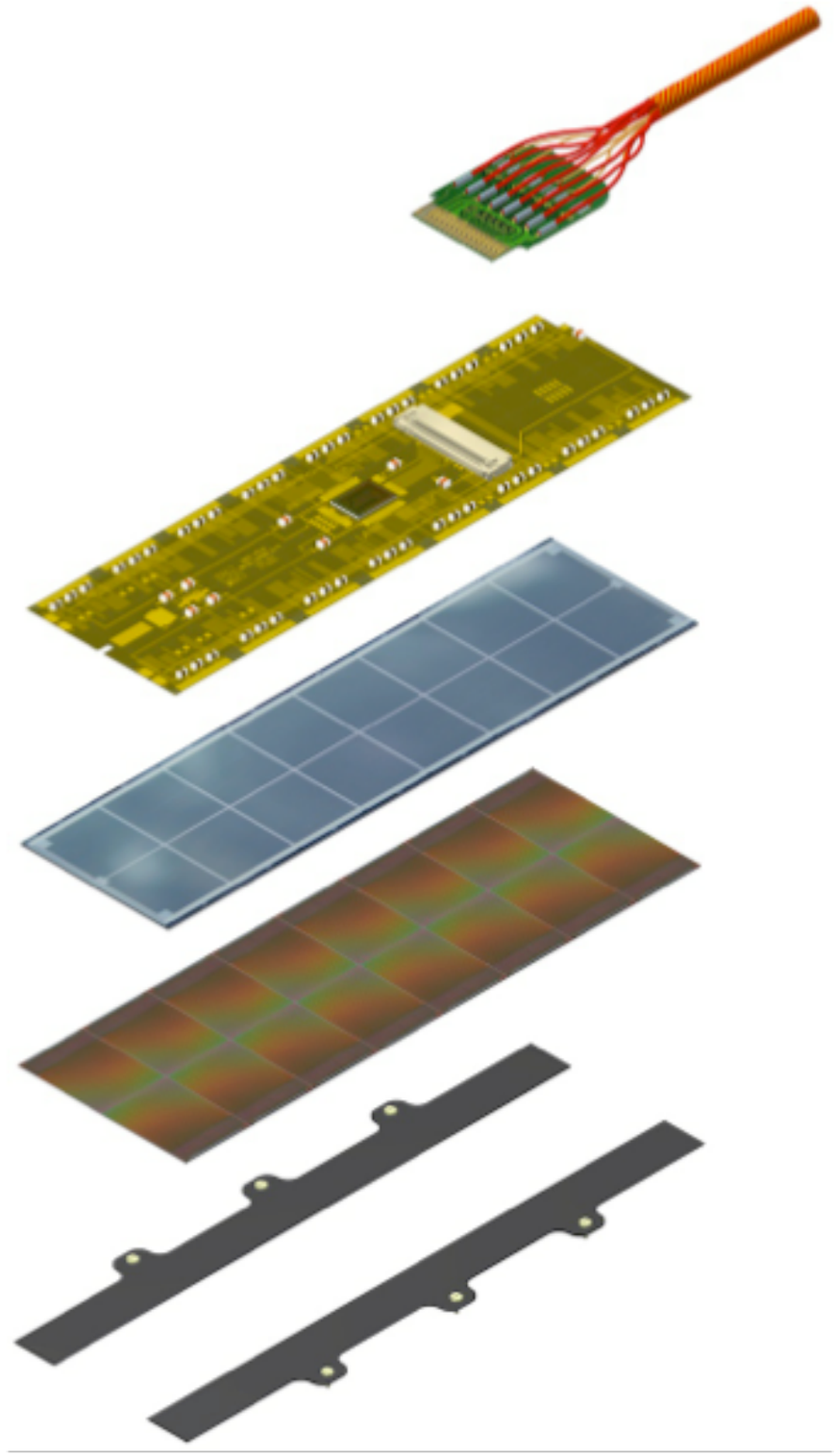
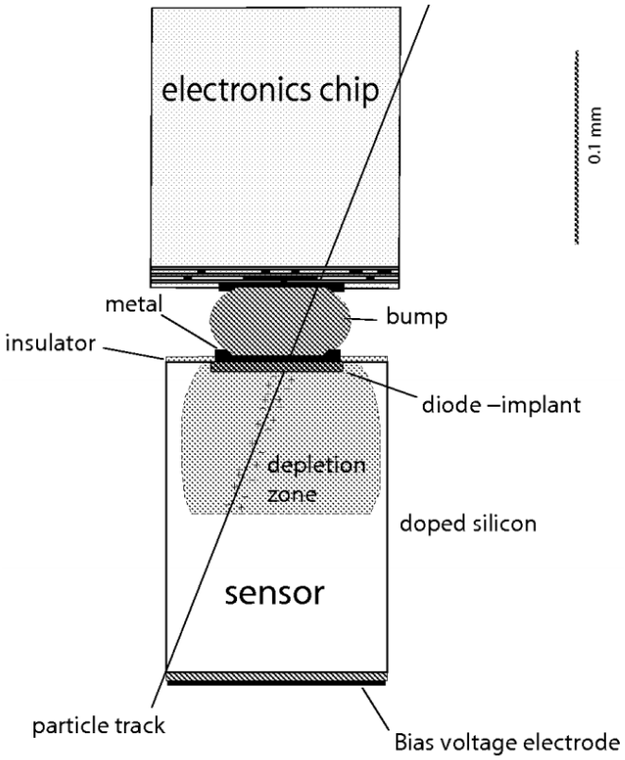
Pixel detector modules

- Power and readout cable
- High Density Interconnect (HDI) distributing signal and power to all chips
- Silicon sensor segmented in pixels of size 100x150 μm^2
- Array of 2X8 digital ReadOut Chips (ROCs)
- base strips for mechanical stability and mounting

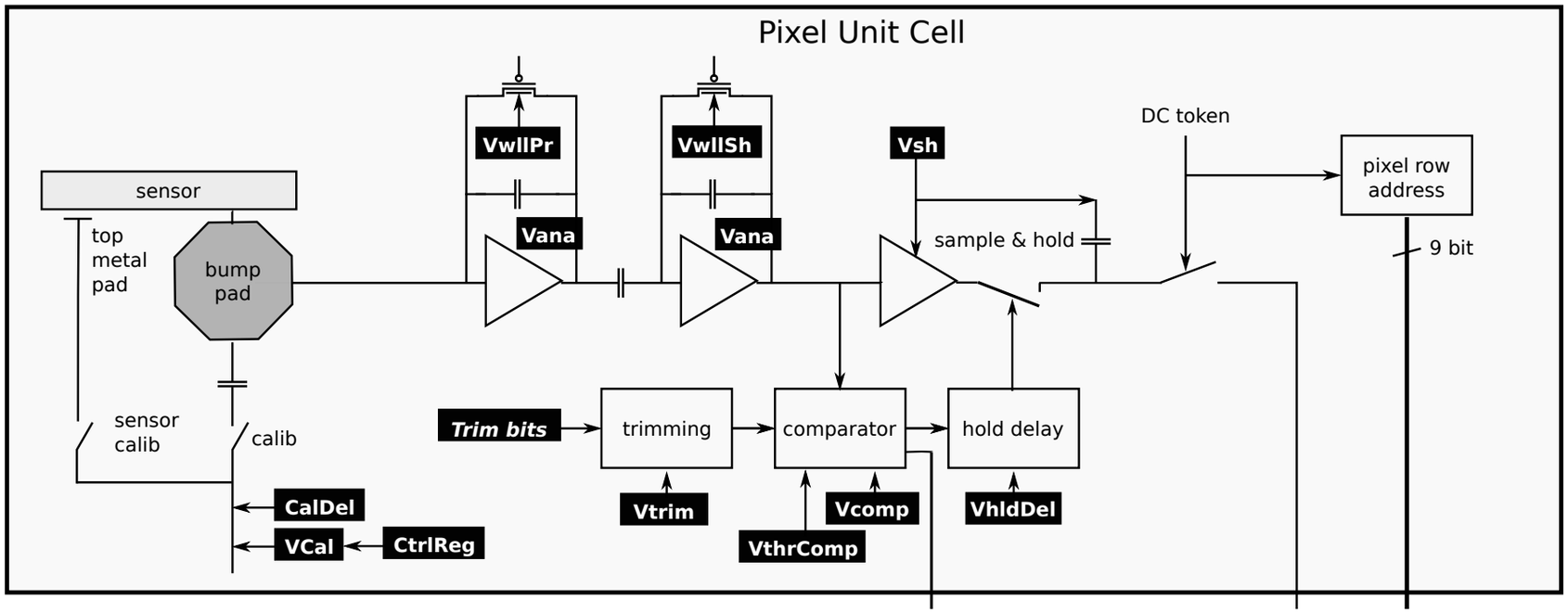




Pixel Unit Cell

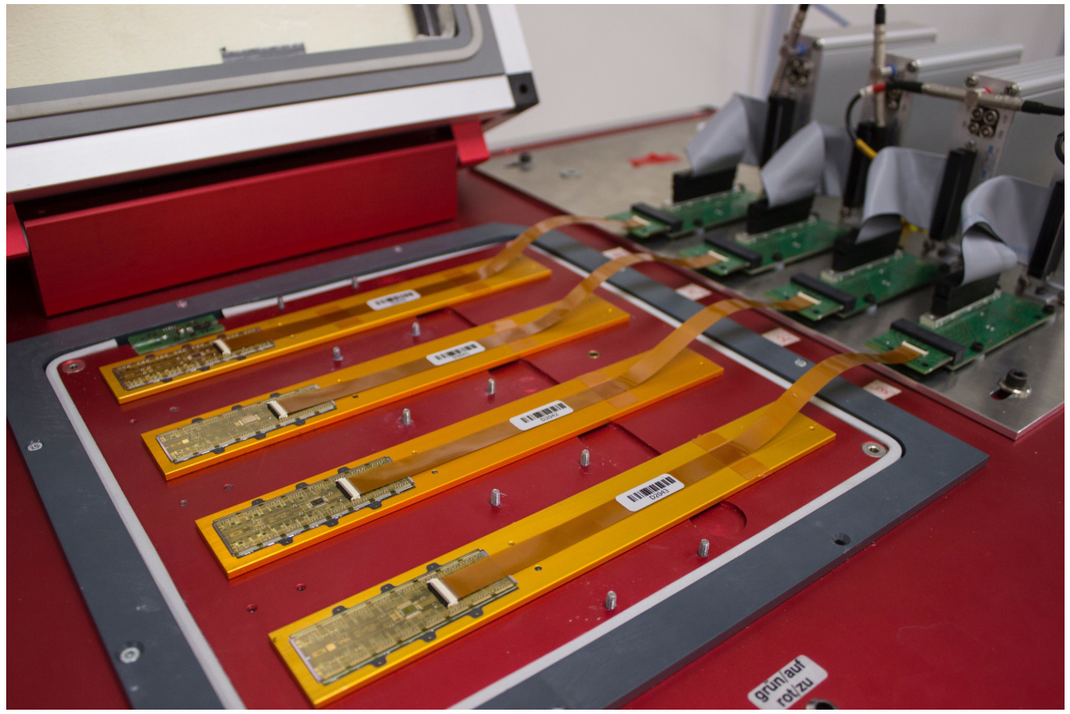


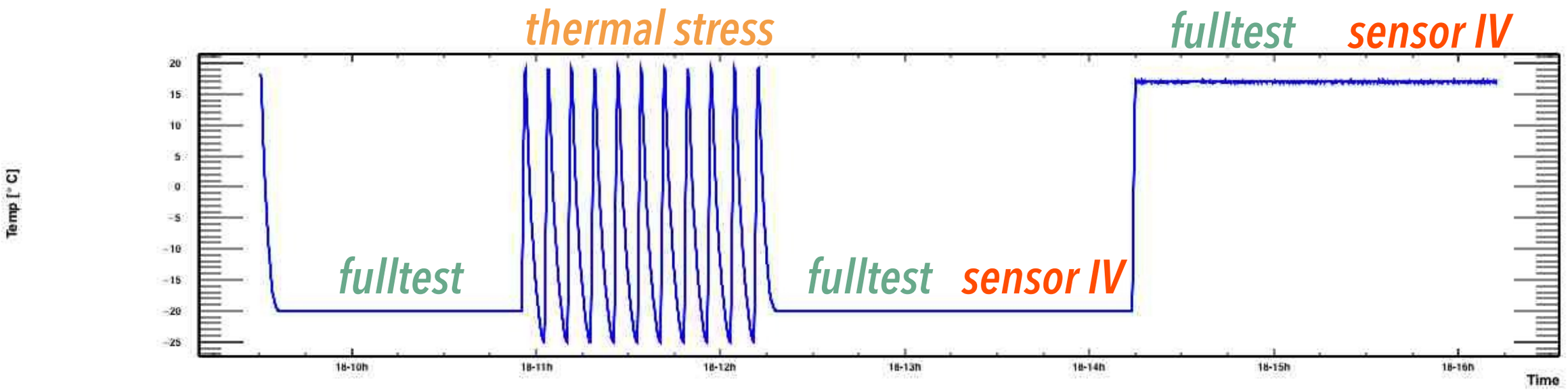
- Charge collected in the sensor is readout and processed by the Pixel Unit Cell
- 19 DACs can be set on the chip to affect its behaviour and control and calibrate the readout chain



Coldbox setup

Setup and qualification procedure





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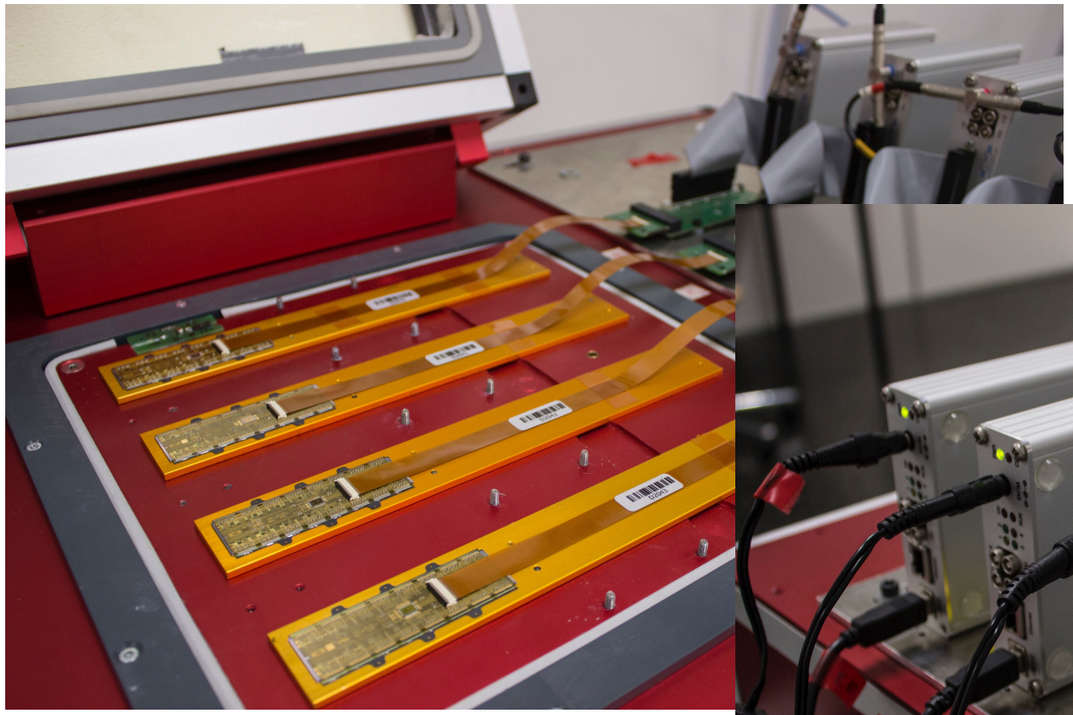

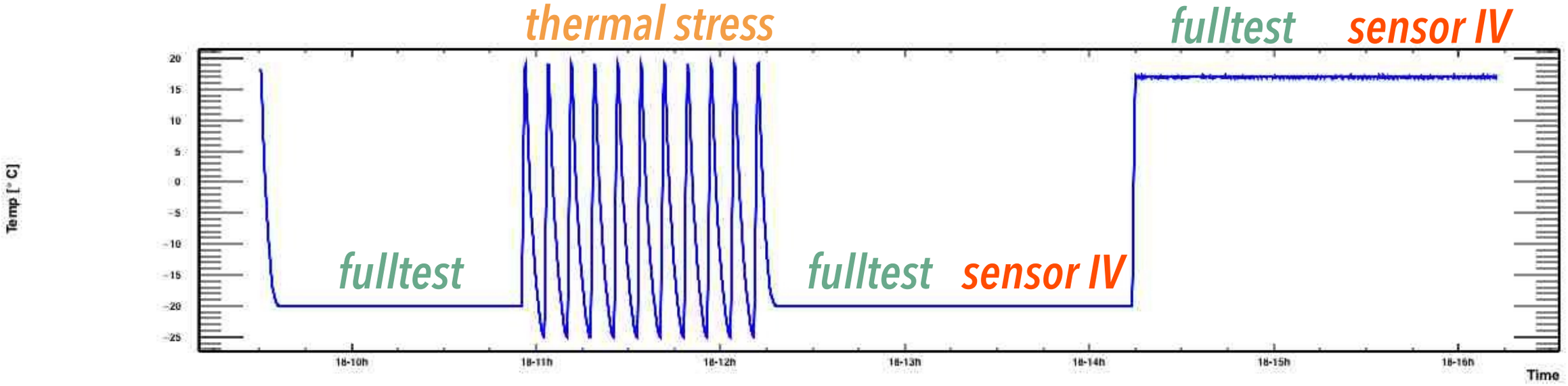

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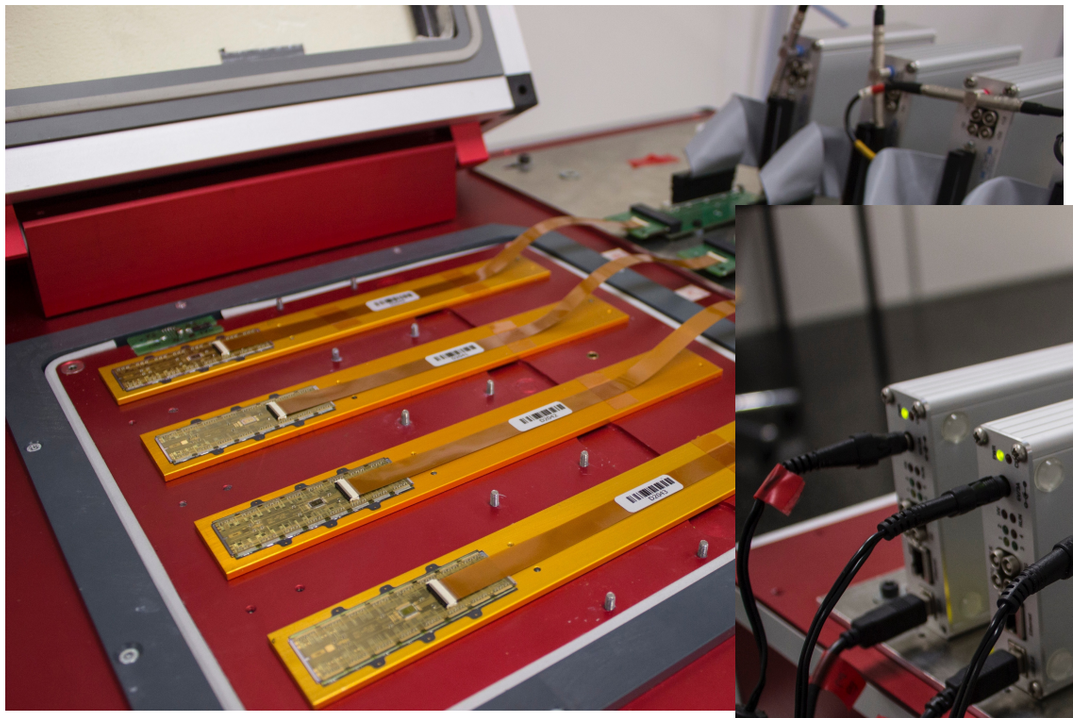
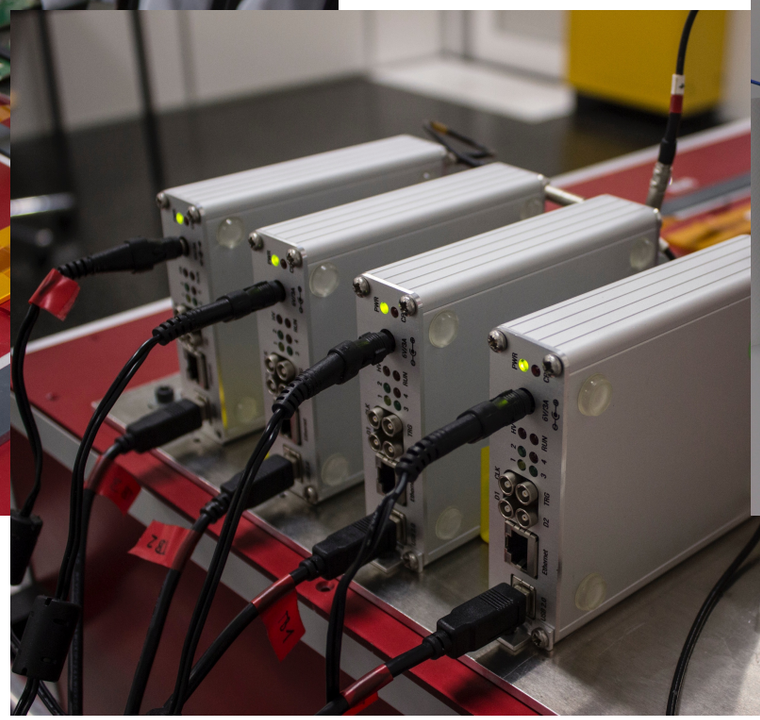
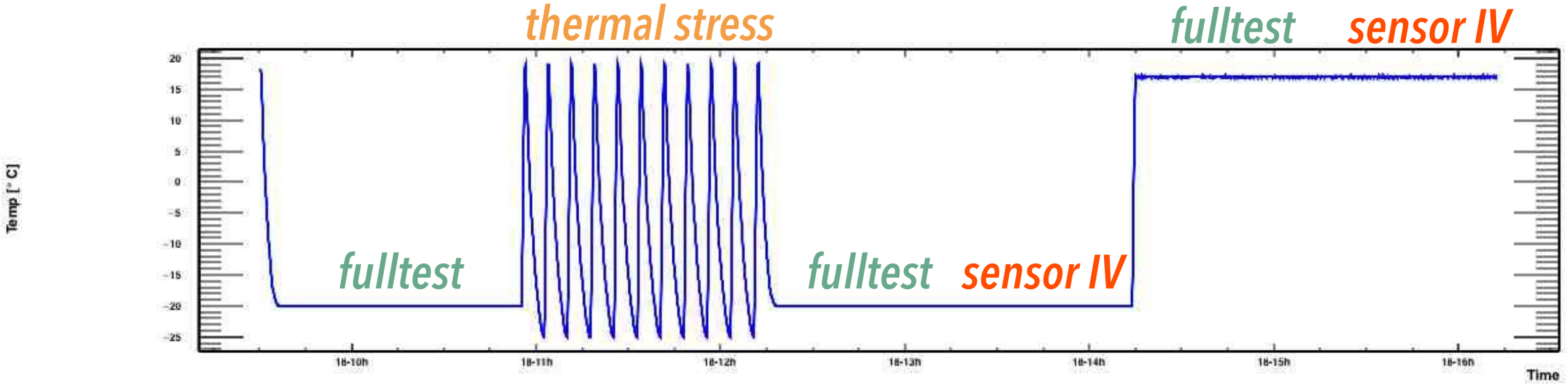






Fulltest chain

- Software suite for testing:
  - client-server supervisor controlling setup components
  - readout and testing sw
  - test results analysis framework
- Fulltest goal:
  - verify and assess module's performances
  - calibration for operation

Module fulltest

check ROC programmability, adjust analog current and timing

Check individual pixel electrical functionality

Identify defective bump bond connections

Measurement of single pixel noise

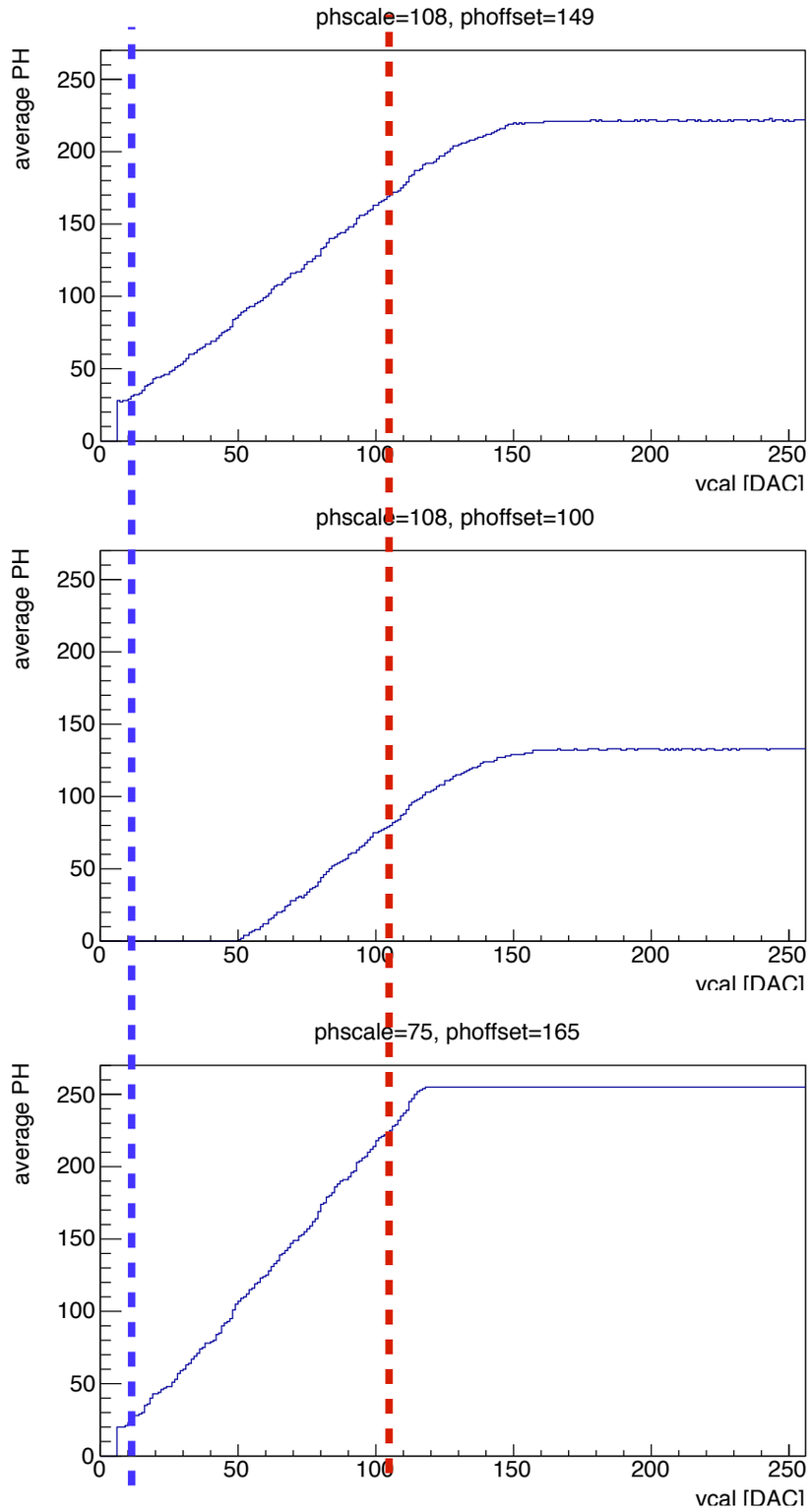
Threshold setting and unification

Pulse-height range optimisation

Fit individual pixel response to signal

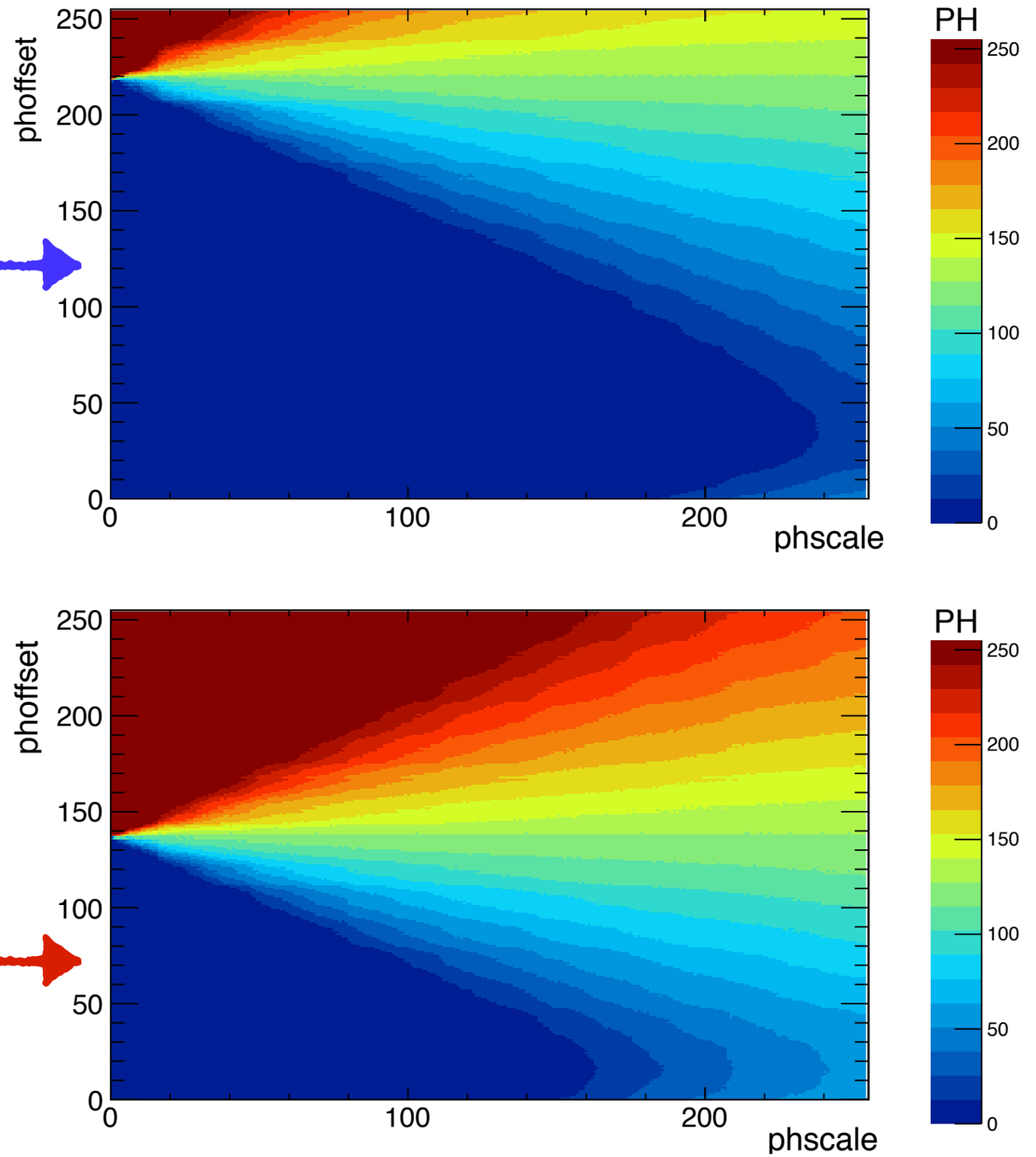
PH optimisation

- 8-bit ADC measuring signals' PH has to be tuned for operation
- PH gain (**phscale**) and offset (**phoffset**) can be adjusted per ROC to obtain optimal PH range
- No per-pixel adjustment is possible, only **2 global chip settings** for 4160 pixels
- Goal: **all pixels** see non-zero PH **from *threshold*** level up to ***maximum charge*** of interest
- Using internal calibration signal (**vcal DAC**) to stimulate PH response from pixels



PH DACs optimisation

- PH for **all** pixels sampled at small and large signals
- Two pixels are sought after:
  - smallest PH for **small signals**
  - largest PH for **large signals**
- 2-D optimisation performed against these two cases



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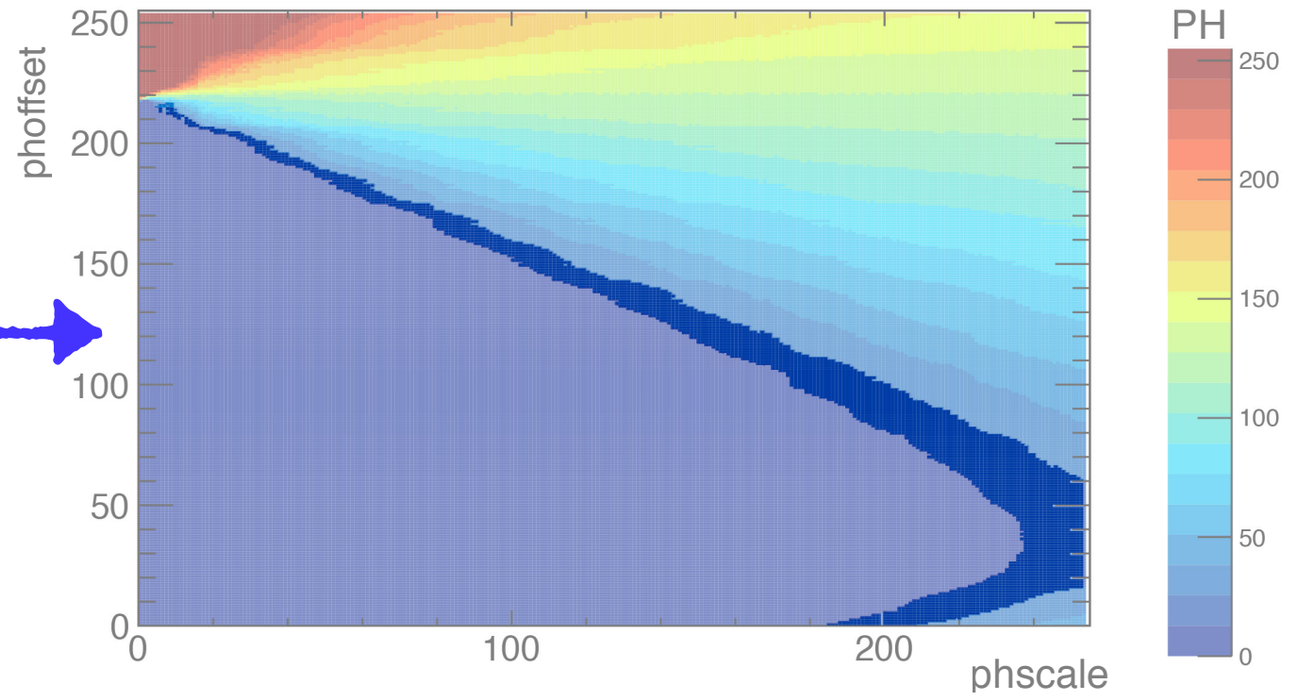

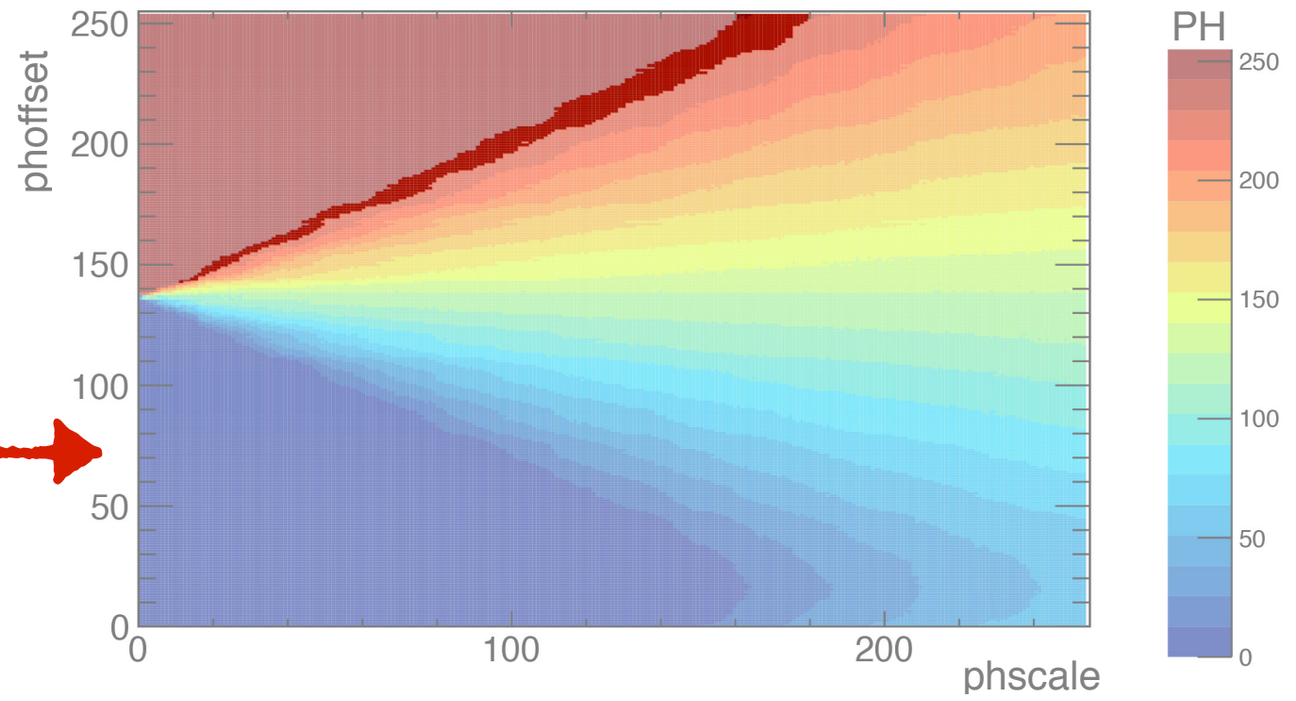

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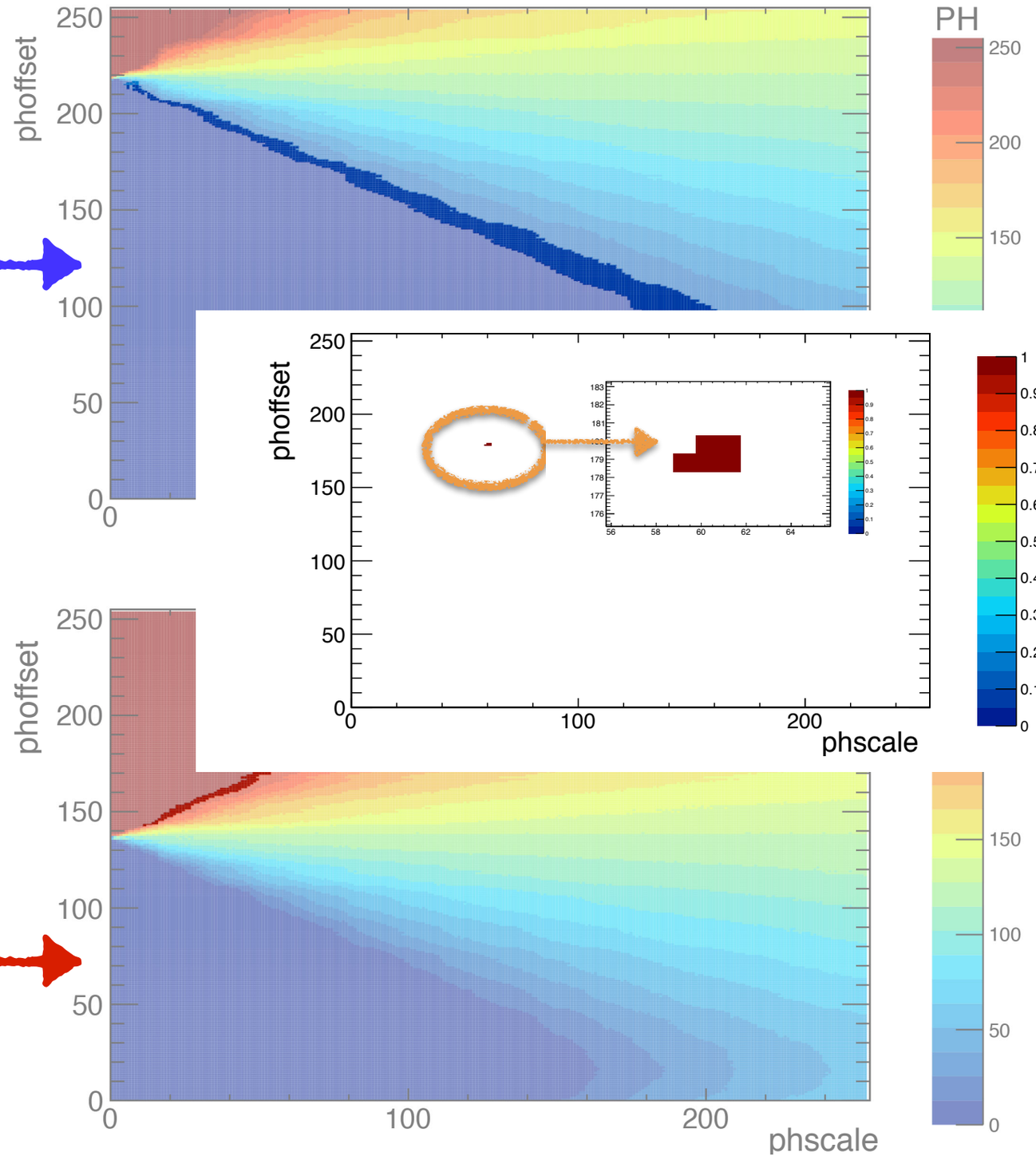
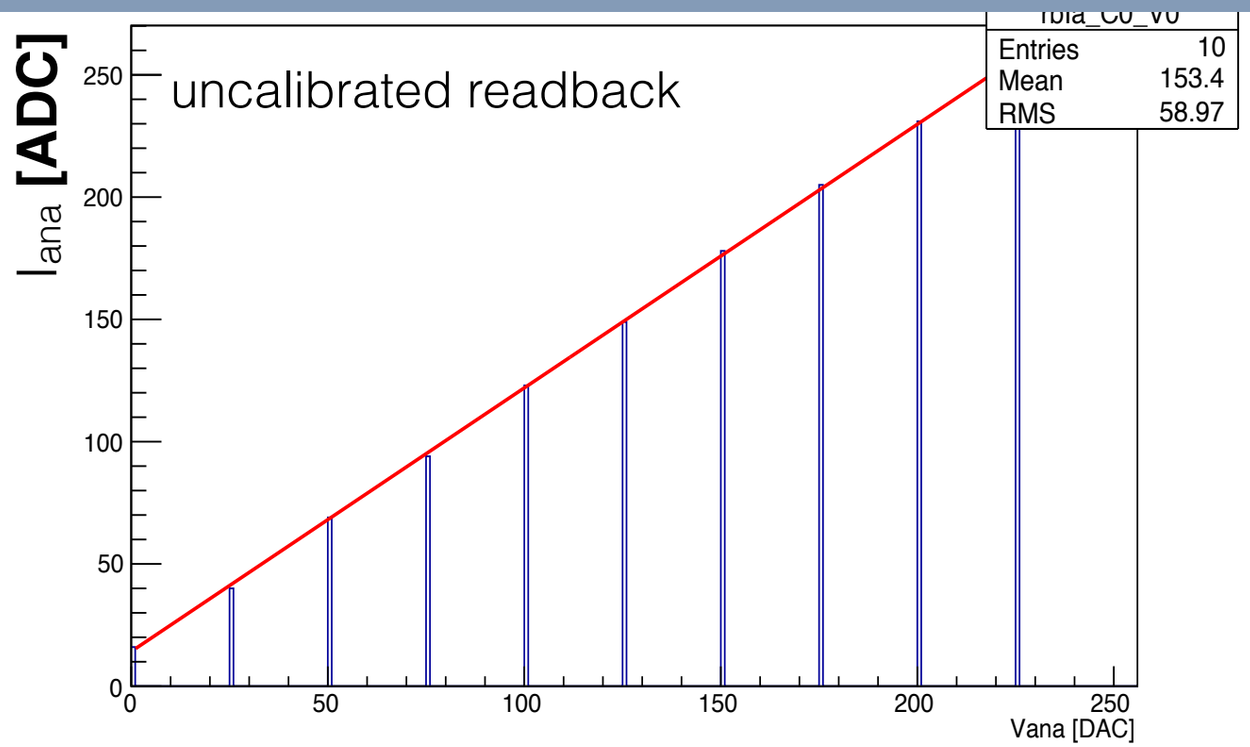


Readback register

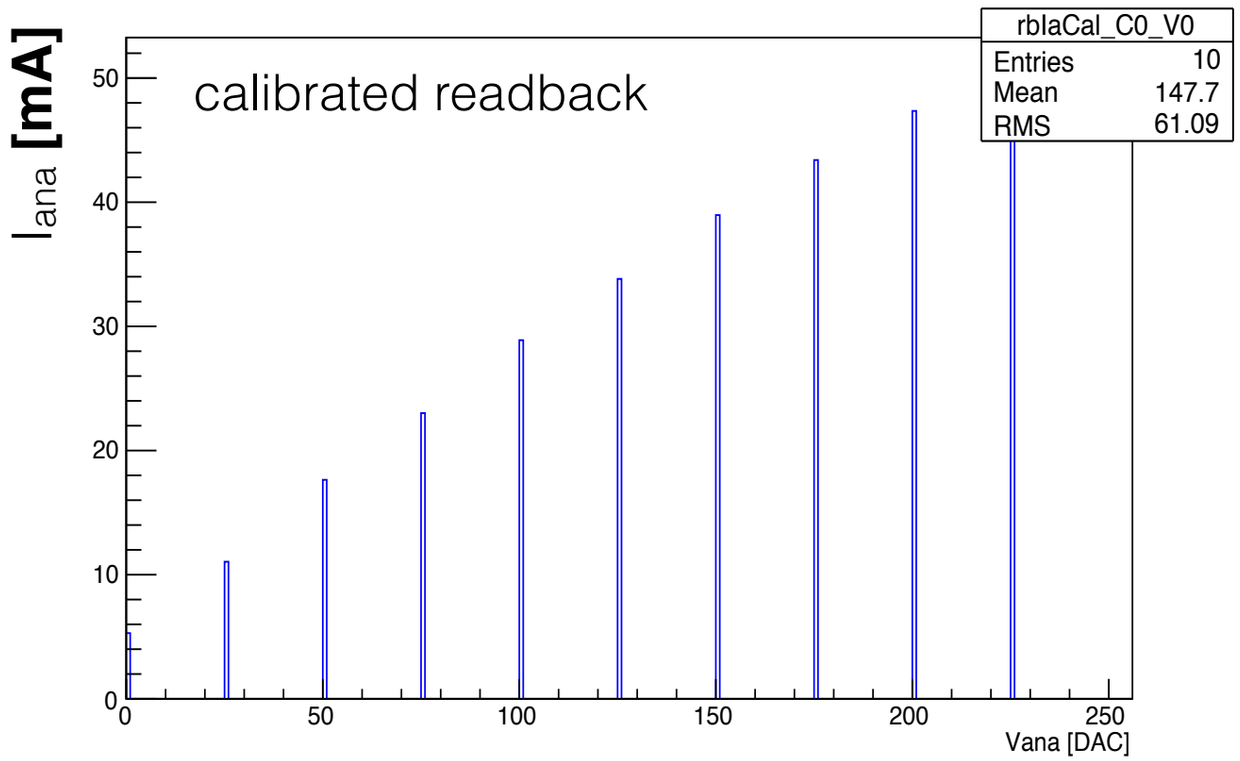
- New digital chips feature a **readback** mechanism to perform on-chip measurements of chip parameters

- Measurement of **analog current** is of crucial importance for detector operation, since it needs to be readjusted after irradiation



- **No possibility** to measure single chip/ module current in the detector

- Readback ADC calibration needed **before module installation**, through I_{ana} measurement from electronic board



Summary

- Digital modules are qualified and calibrated in a controlled environment

- Fulltest procedure checks module's quality and performs calibrations in view of detector's operation

- PH range optimisation adjusts PH gain and offset at chip level in order to optimally exploit pixel PH information

- Analog current readback calibration allows re-adjustment after detector installation