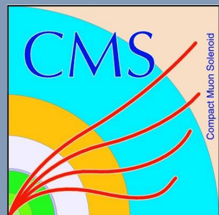


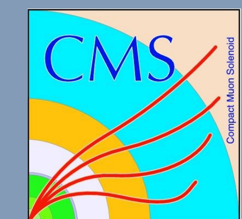
ETH Zürich

CMS Upgrade Phase I: pixel modules testing

Vittorio Raoul Tavolaro

Eidgenössische Technische Hochschule Zürich

SPS Annual Meeting, Fribourg 30.06-02.07 2014



Overview

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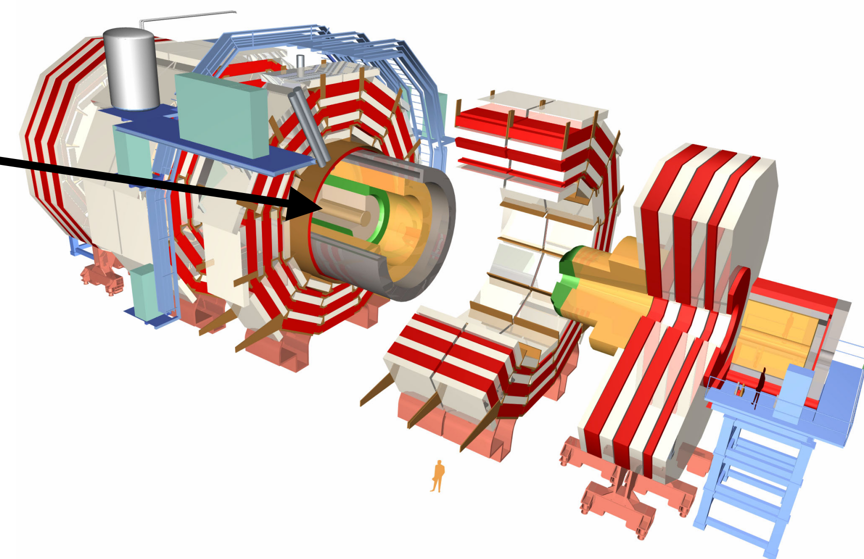
- Pixel Modules overview
- Goals of the tests
- Testing setup
- Cooling Box and DAQ
- X-ray setup
- Results overview
- Conclusions

Pixel Modules Overview

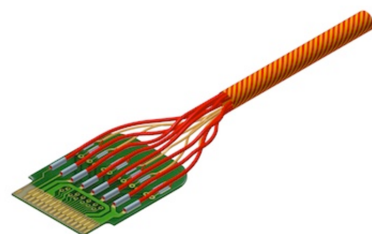
- Innermost component of CMS detector
- Modular structure



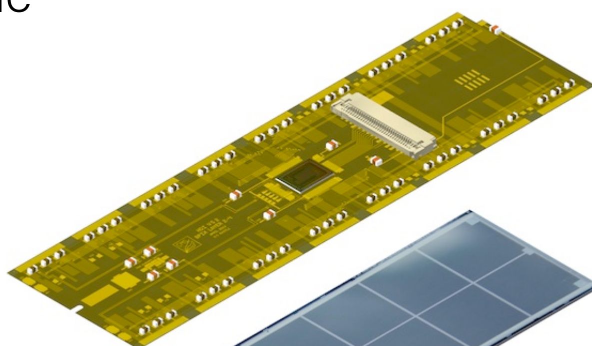
crucial role in the **tracking** system

Module layout

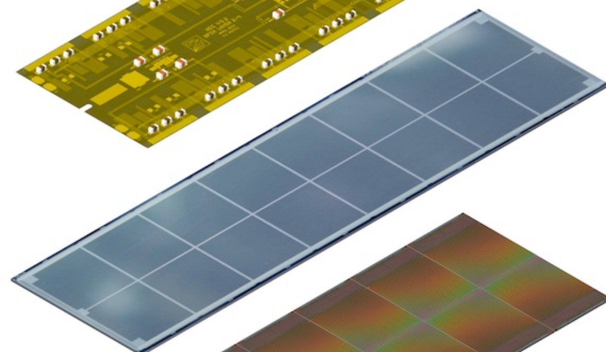
Micro twisted pair cable



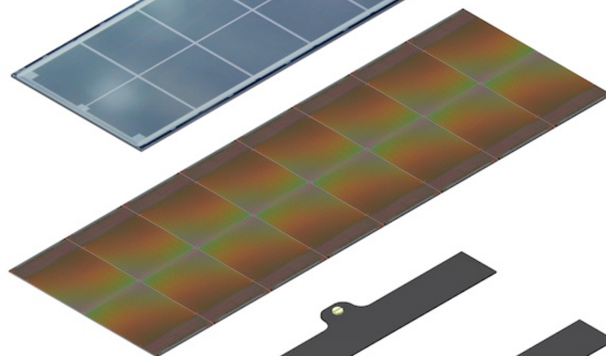
High density interconnect



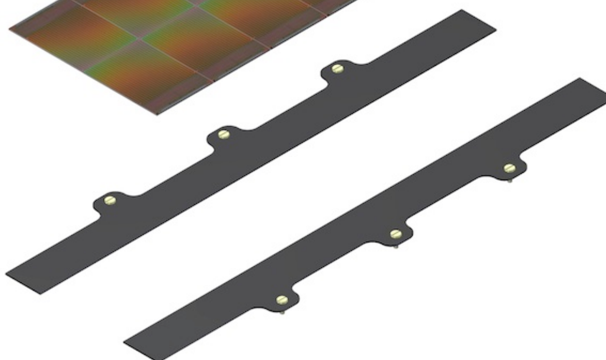
Silicon sensor



16 ReadOut chips



Mounting strips

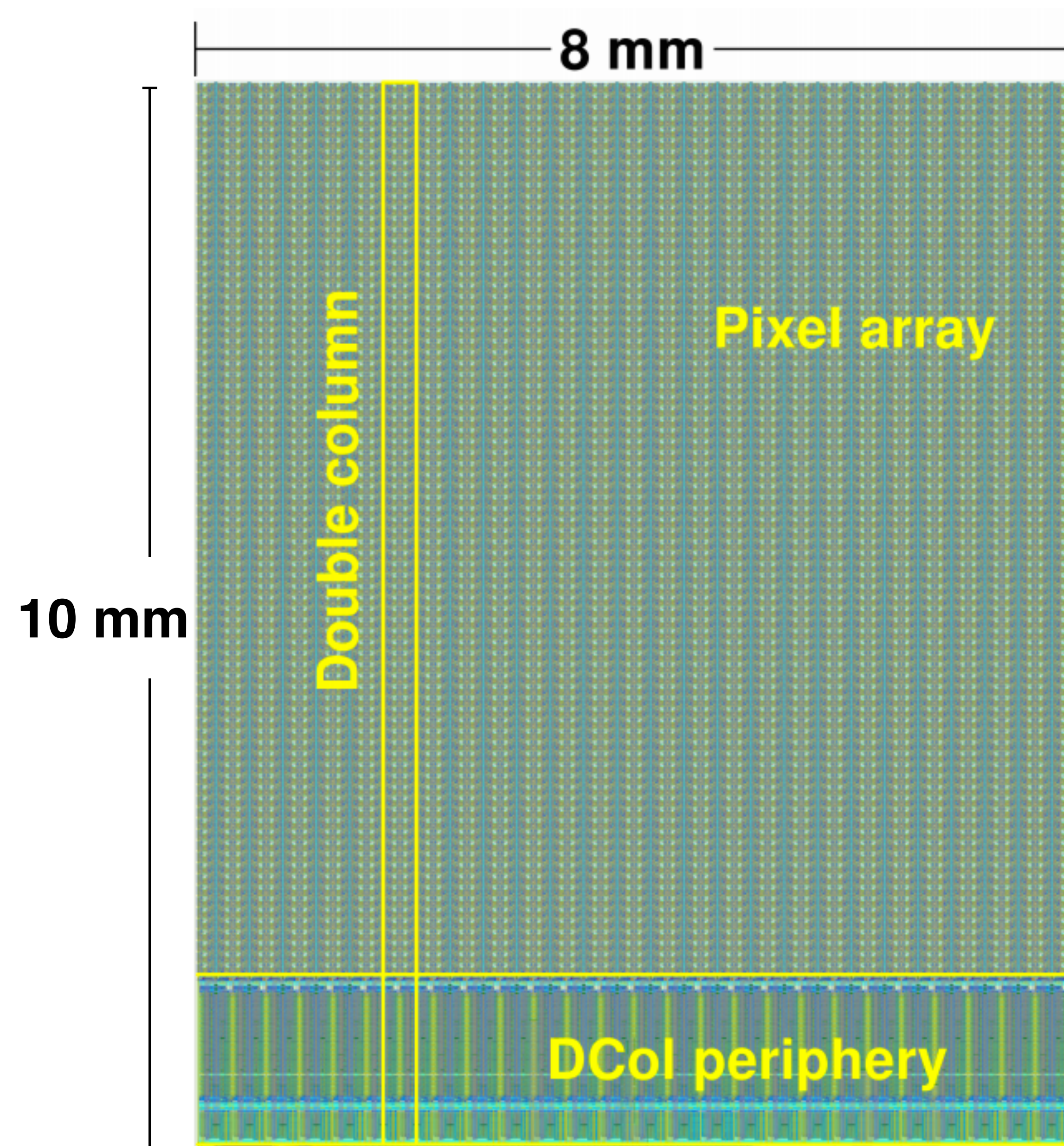


New ReadOut Chip (ROC) will be installed in Pixel Upgrade Phase I:

- larger buffers
- faster

New ROC design and prototypes need to be tested and validated to have fully operational detector after Upgrade

ReadOut Chip: what's new?



52x80 = 4160 pixels
single pixel 150 μm x 100 μm

- 40 MHz **analog** → 160 MHz **digital** readout speed
- 2x data throughput per fiber
- additional FIFO buffer stage
- increased data and timestamp buffer sizes

- higher efficiency in hit transfer to DC periphery
- lower charge threshold now possible
  - 3.5 ke^- → 1.5 ke^-
- improved performances after radiation damage

Goals of Module Testing

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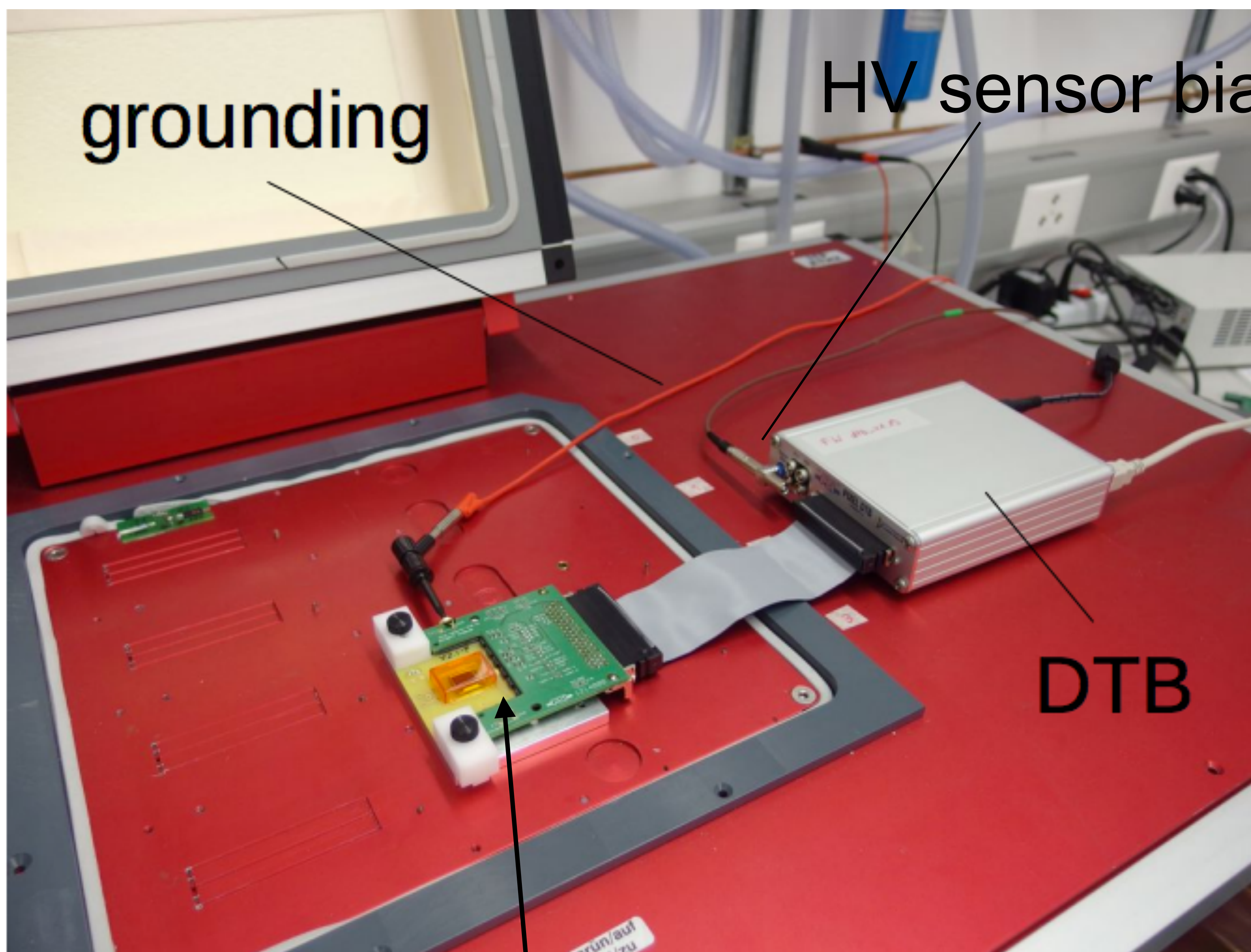
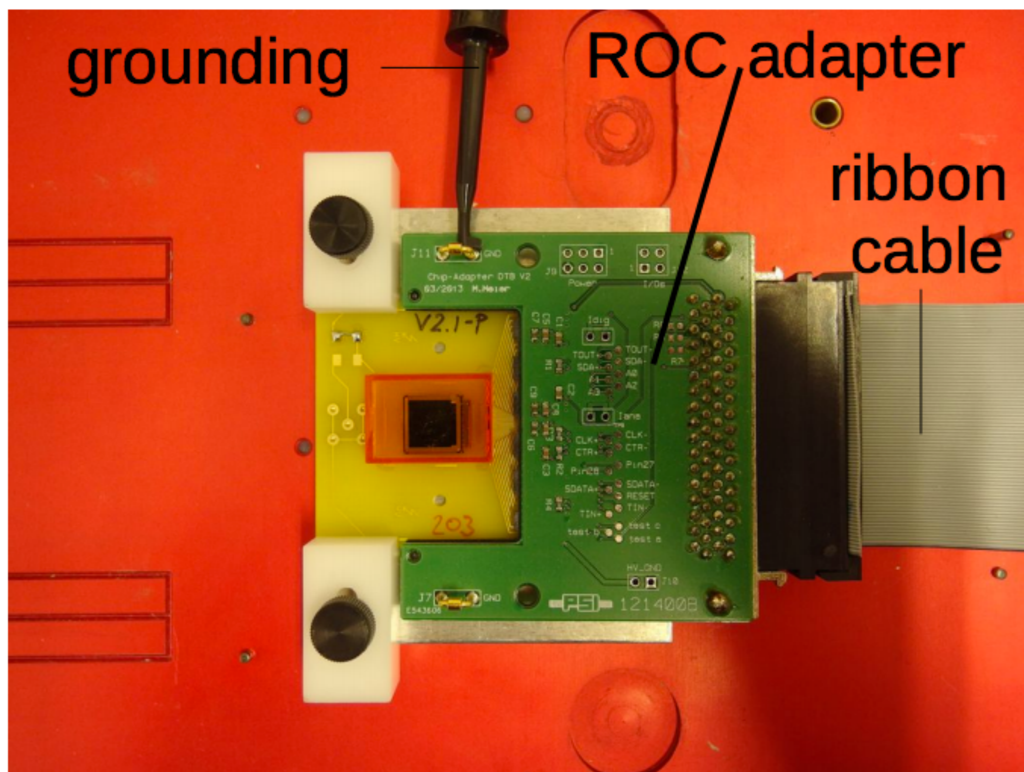
- Verify electrical functionality
- Chips are responding and programmable
- Calibration of I/O parameters
- Operational at different temperatures
- Survive thermal stress test
- Optimize DAC parameters at different T
- Grading modules

Testing setup

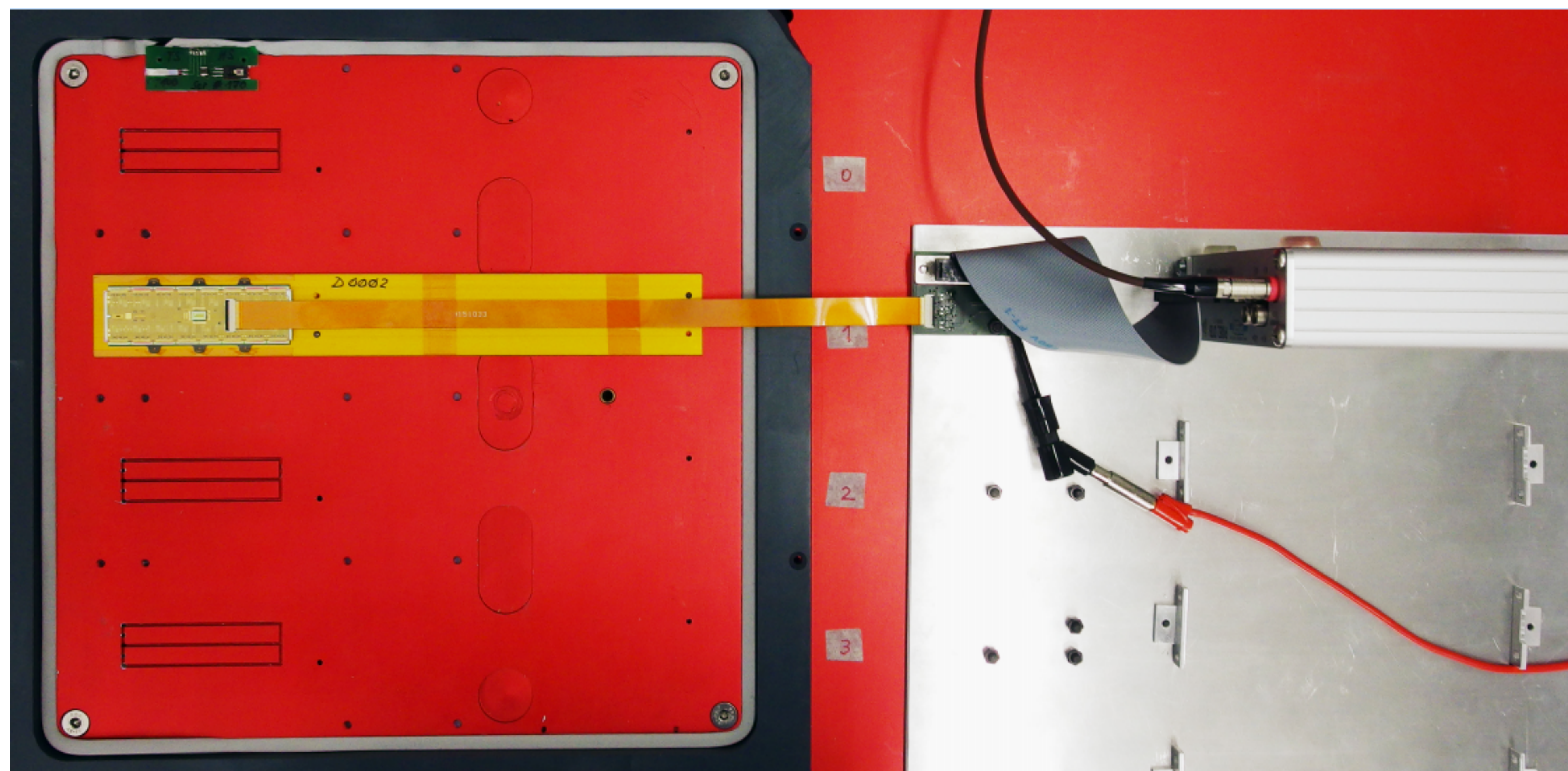
- ROC sensor biased with HV
- Digital TestBoard allows Data Acquistion and communication with PC



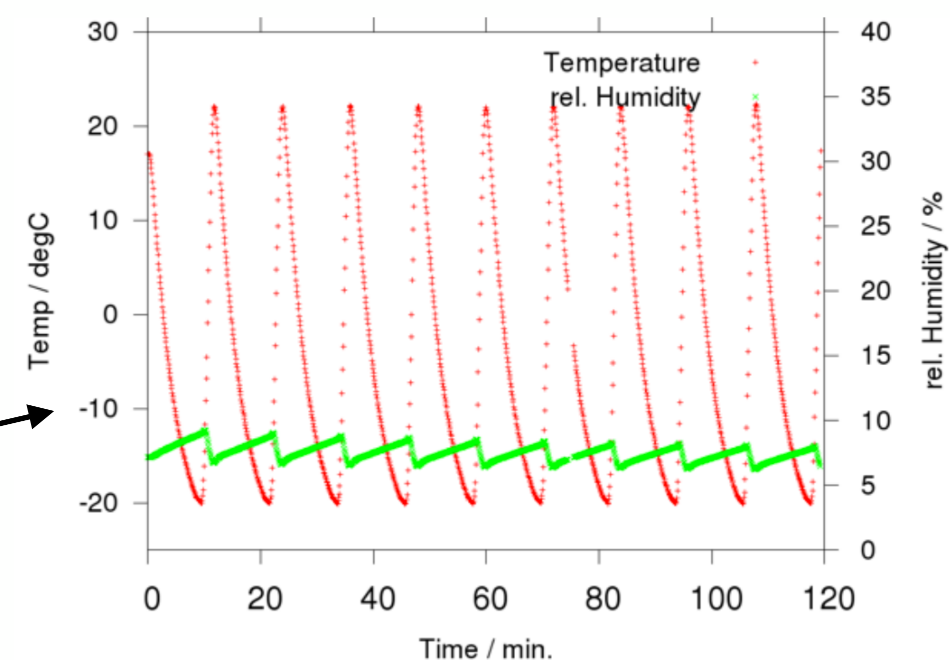


Possibility to test single ROC chip or full modules

Cooling box



- four slots available for devices under test
- temperature control down to -25° C
- humidity control <10%
- thermal cycling to stress device



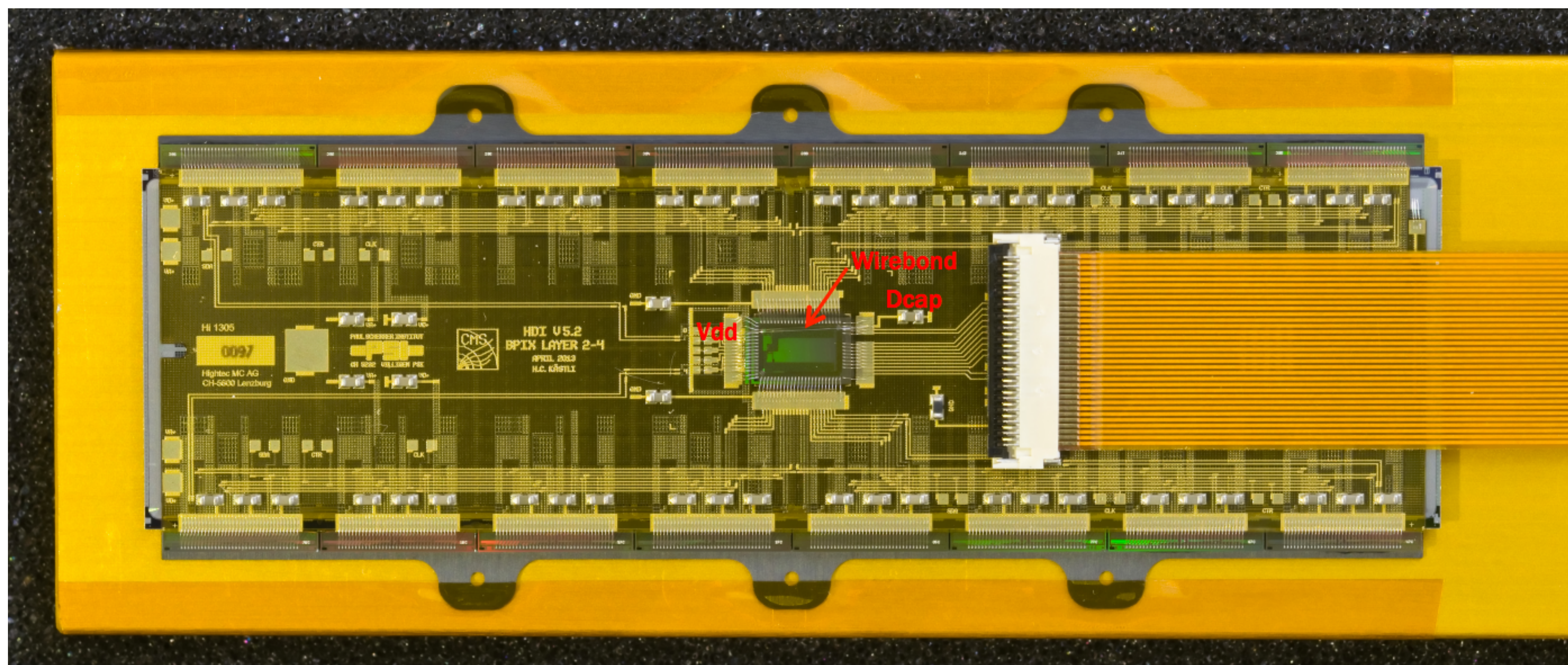
Test overview

Two tests chosen as examples:

- Bump Bonding Test
- Trimming

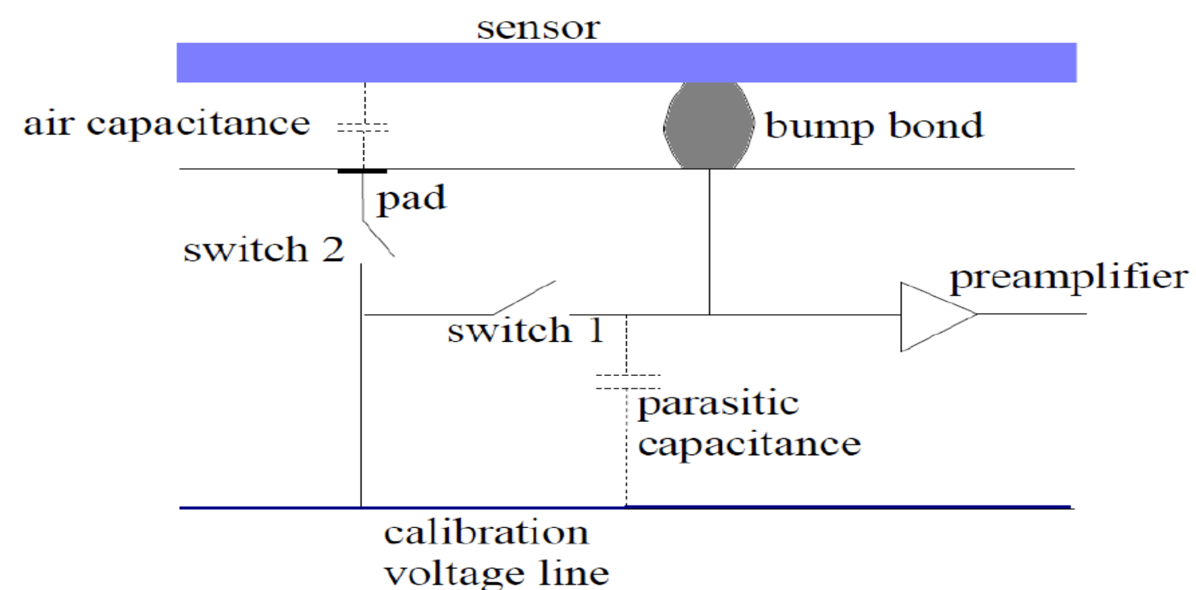
Some results are shown for the prototype (D0002) of module production for Pixel Detector Upgrade

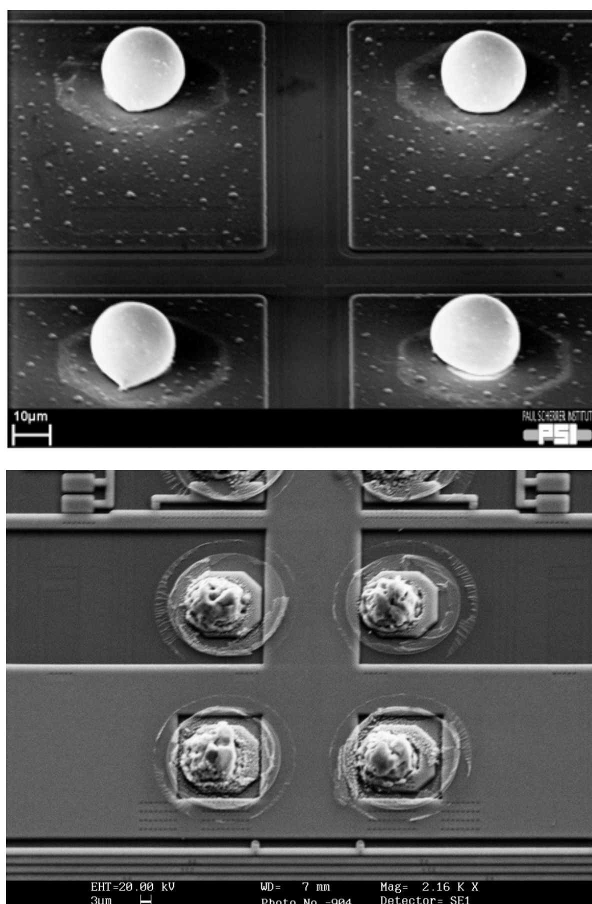
P.Eller



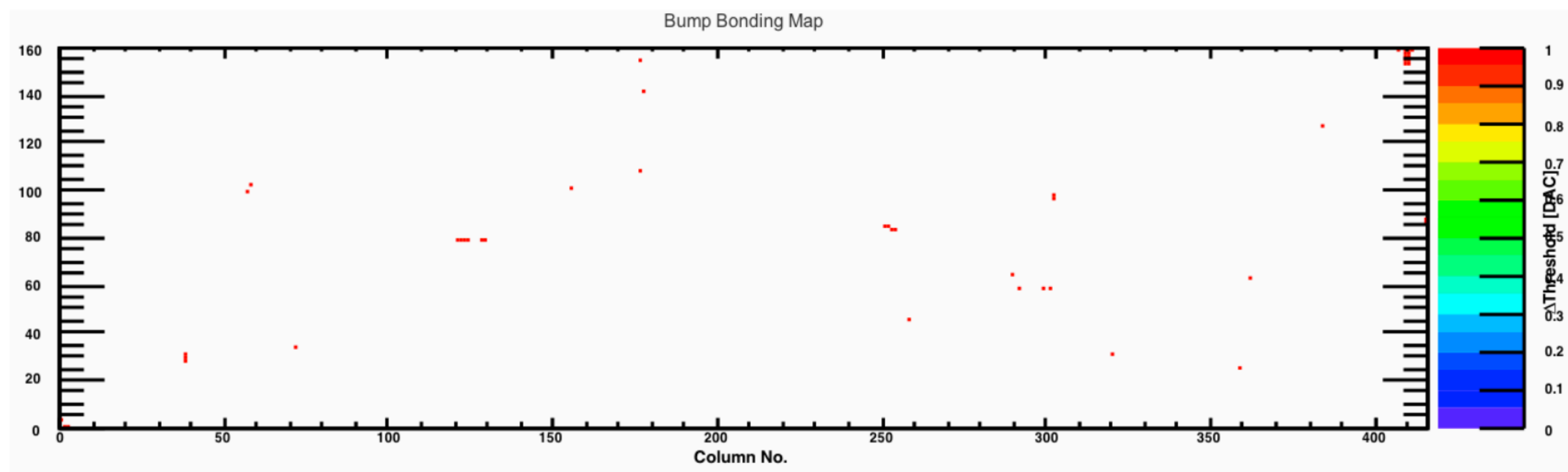
Test example: Bump Bonding Test

- Every pixel is connected to its sensor through an Indium bump bond
- These connections might be not perfect or missing
- Bump Bonding test: inject the internal calibration signal through the sensor and try to read it out



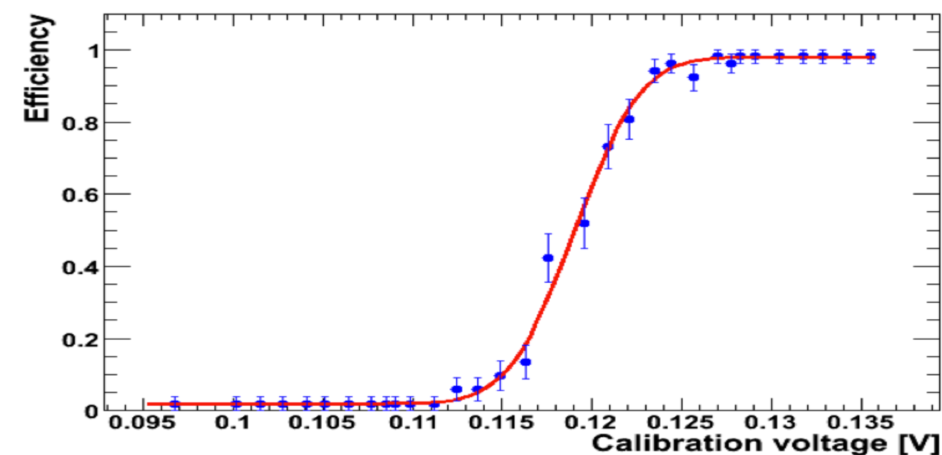


56 dead bonds on the whole module D0002
→ ~2.4×10^{-4} dead bond rate

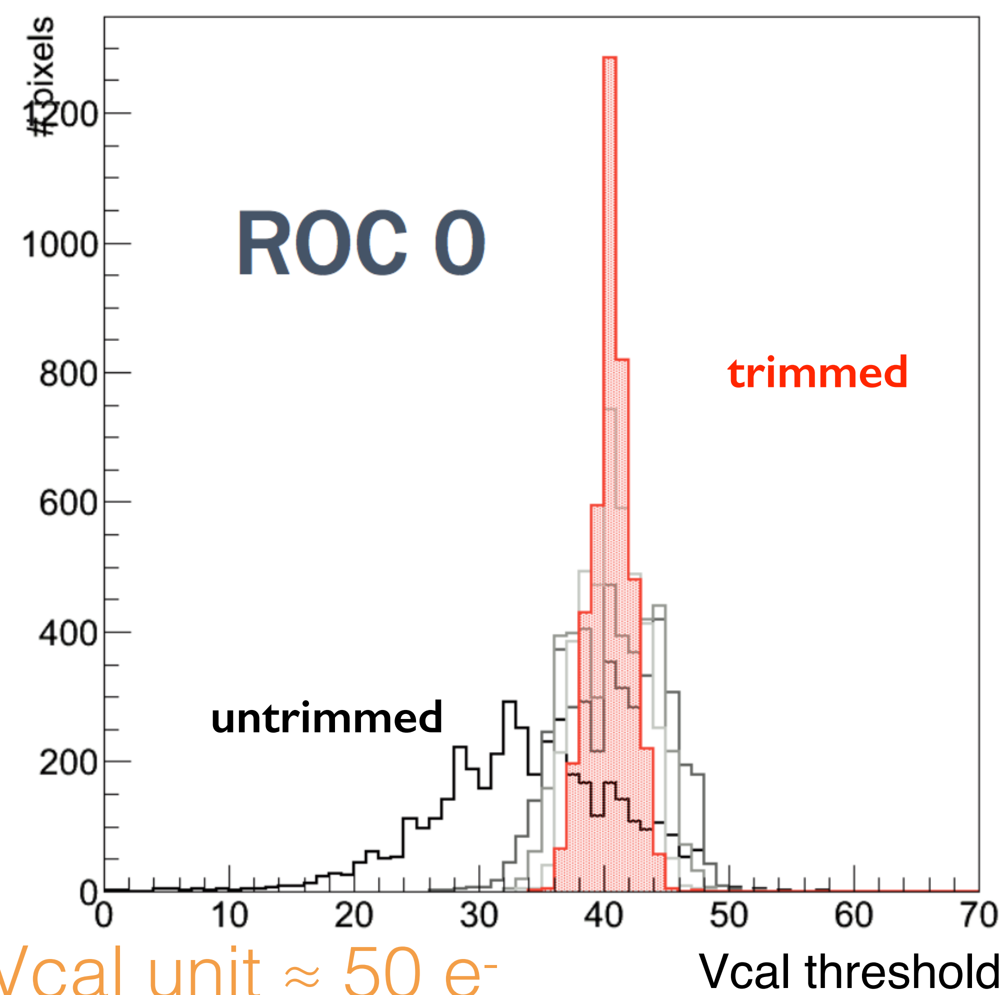


Trimming

- Pixels start to respond, in principle, at different thresholds
- Goal of the test: obtain **unified** threshold for all pixels



Vcal dist for each trimming step

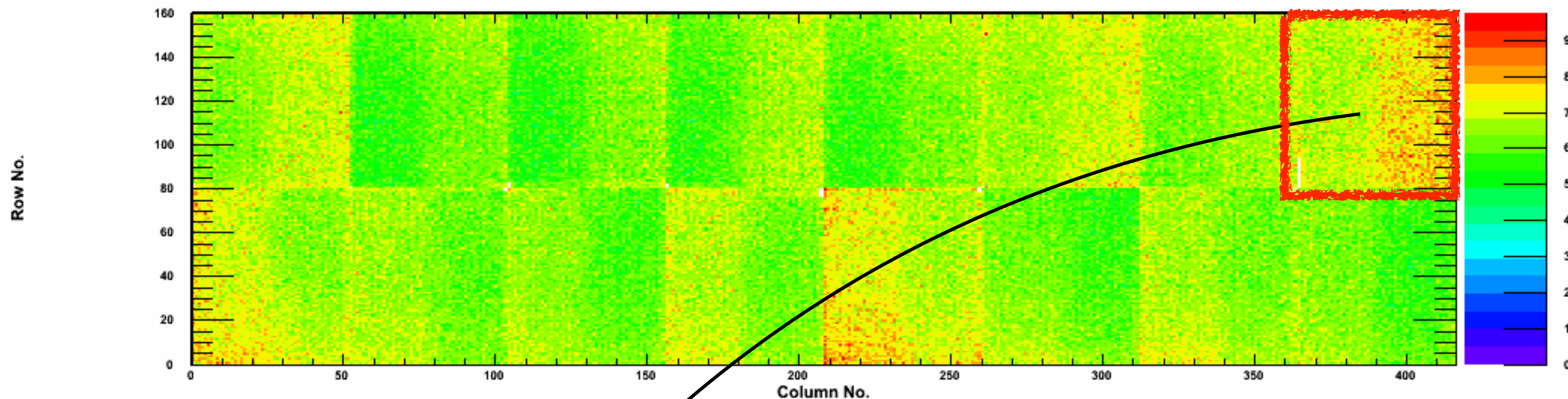


1 Vcal unit ≈ 50 e⁻

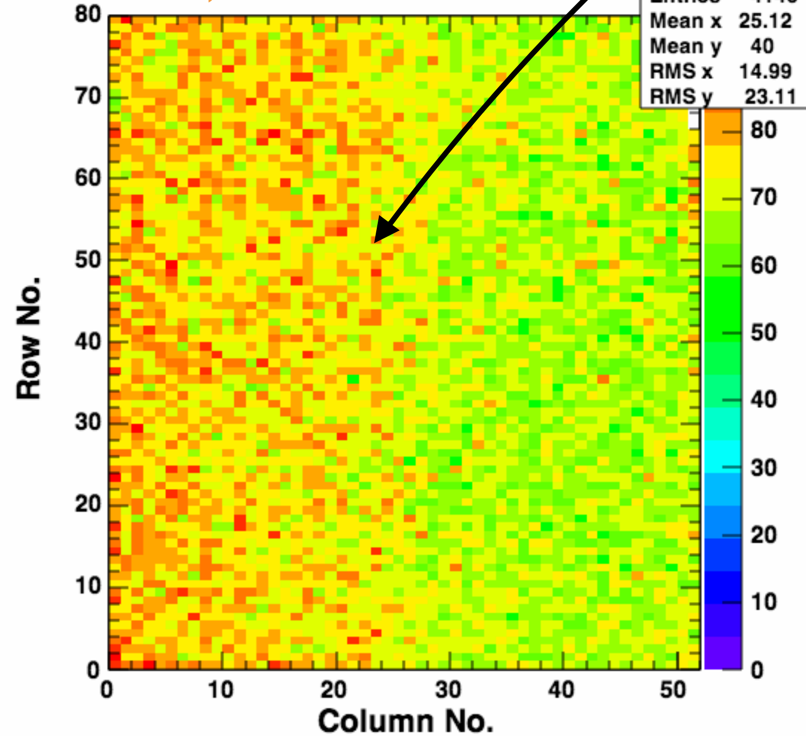
- use internal calibration signal (Vcal) to measure threshold
- trim bits allow to tune the threshold per single pixel

Trimming (II)

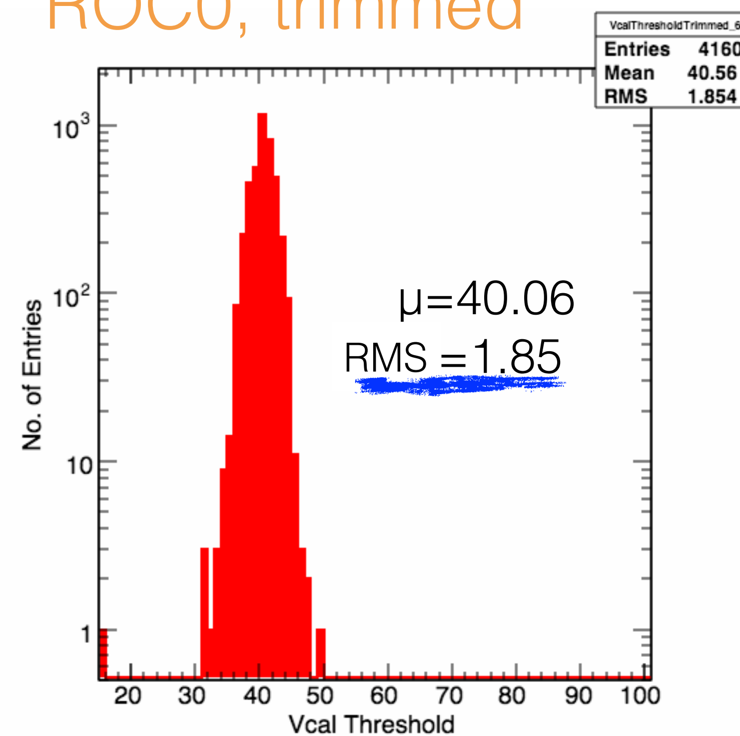
Module D0002



ROC0, untrimmed



ROC0, trimmed



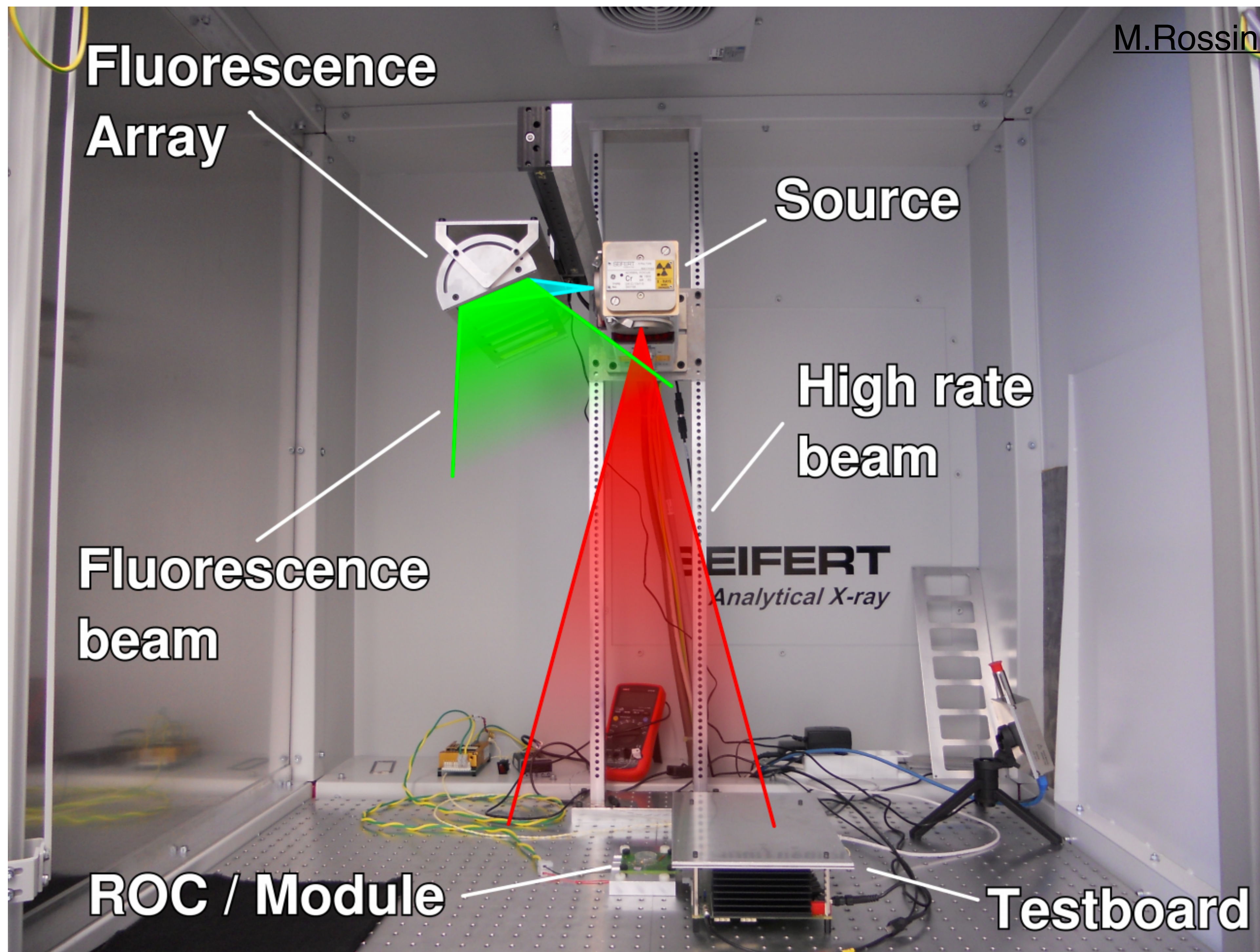
X-ray setup

Possibility to test devices with external source

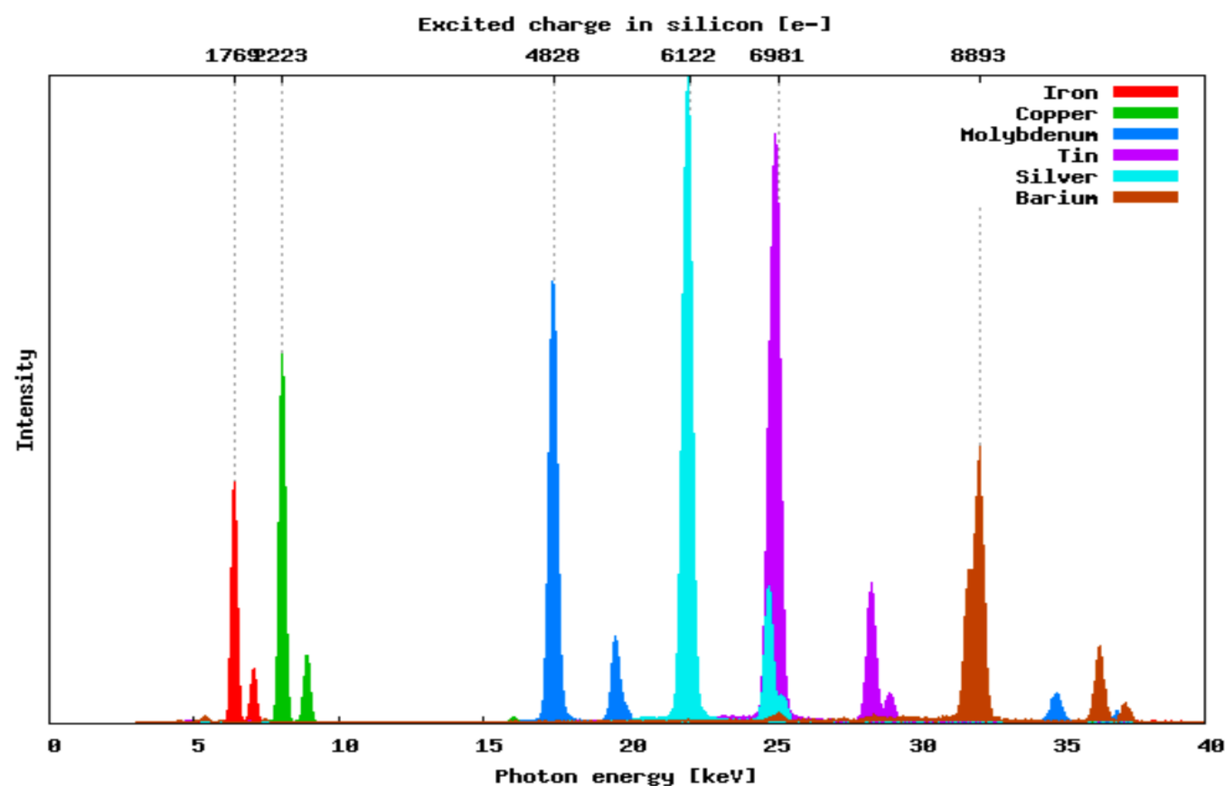
ROC or module can be exposed to:

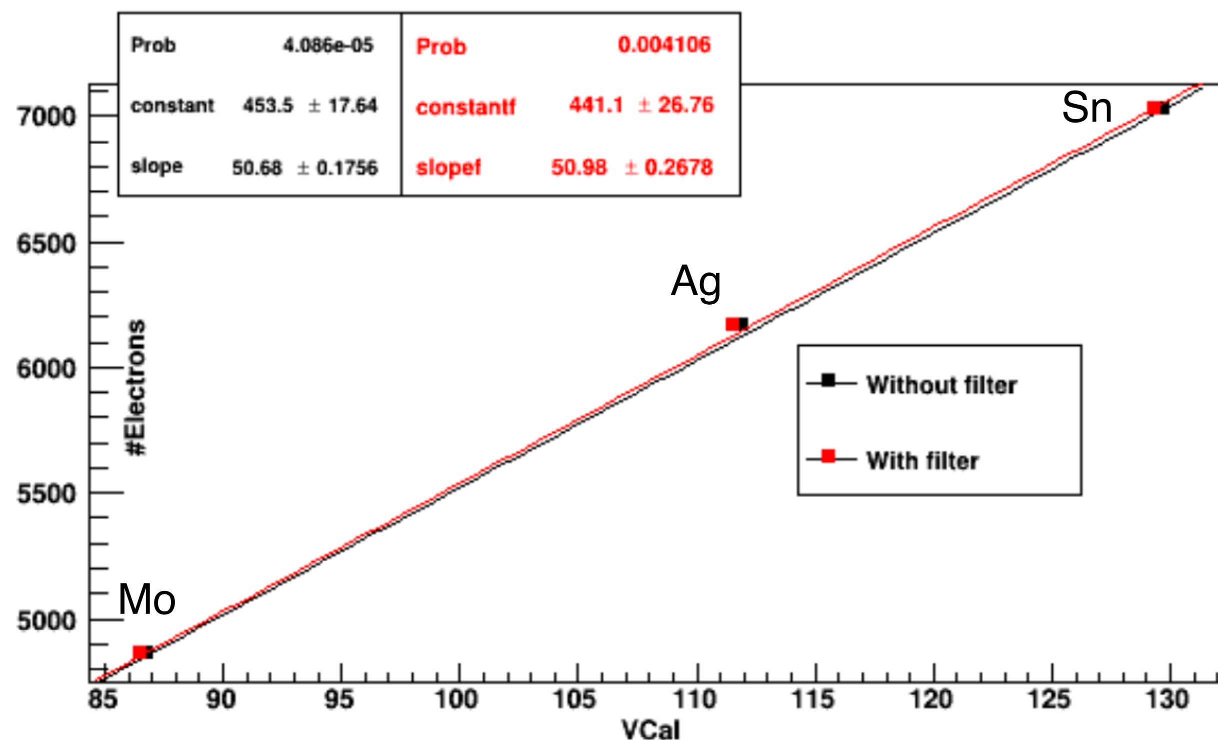
- high rate beam
- fluorescence beam

Temperature control



X-ray measurements





M.Meinhard, ETH semester student

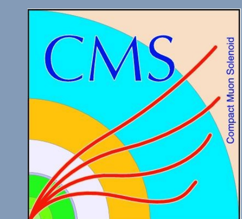
Fluorescence light has known spectrum lines

6 fluorescent targets:

- Iron (1769e$^-$)
- Copper (2223e$^-$)
- Molybdenum (4828e$^-$)
- Silver (6122e$^-$)
- Tin (6981e$^-$)
- Barium (8893e$^-$)

Internal calibration signal can be calibrated on the external sources

Comparison between thresholds determined with X-ray and with Vcal



Conclusions

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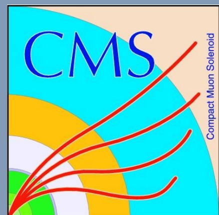
- Testing setup ready to test modules for Pixel Upgrade
- Analysis and testing softwares are in place
- Prototype module showed reasonable behaviour
- Pre-production modules testing expected in fall 2014
- ~500 modules will be tested



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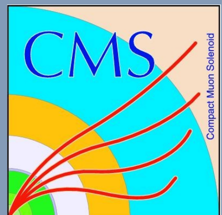
Backup



Tests

Testname	Subtests
Pretest	
	setVana
	setVthrCompCalDel
	setVthrCompId
	setCalDel
(Pixel)Alive	
	MaskTest
	AddressDecoding
PH optimization	

Testname	Subtests
CurVsDac	
DacScan	
DacDacScan	
Scurves	
GainPedestal	
Setup	
Tbm	
Trim	
	TrimBits
BBMap	
DAQ	

Bump bonding technique