



PLUME Module tests @IPHC
PLUME CERN meeting

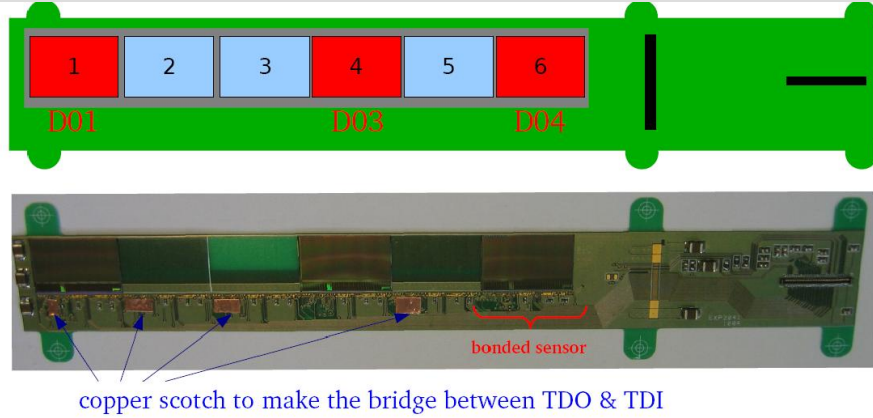
CHON-SEN Nathalie

9-10 June 2011

PLUME module production : where are we now ?



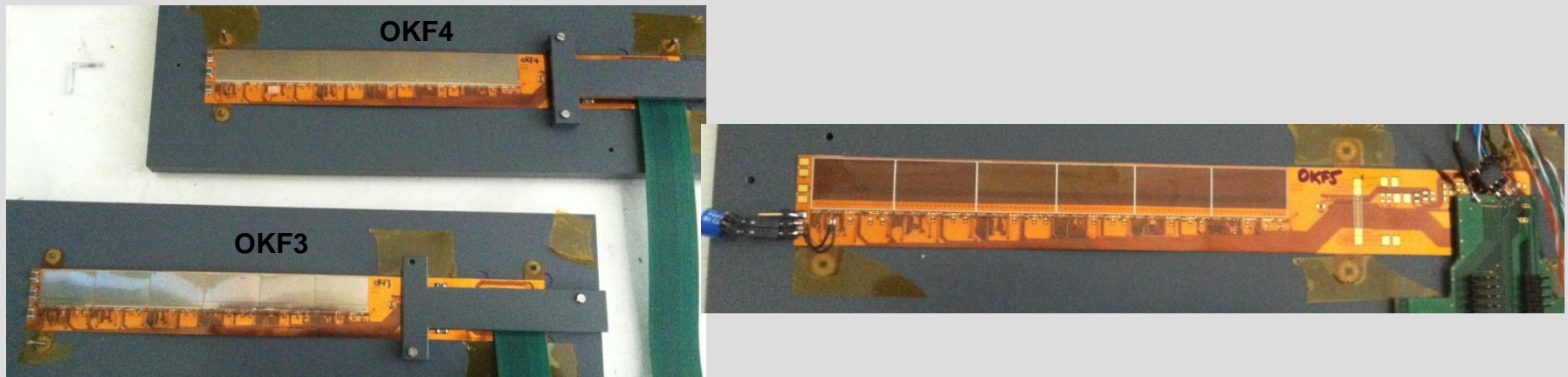
GRAPHIC PCB Flex :



GRAPHIC Kapton Flex :



OPTIPRINT Kapton Flex :



PLUME module production : where are we now ?



- **GRAPHIC PCB Flex :**
 - 4 flexes produced
 - 1 equipped with 3 MIMOSA-26 (120 μ m thick) sensors (**GPF1**)
 - 1 used to measure the impedance of the LVDS differential lines (**GPF2**)
- **GRAPHIC Kapton Flex :**
 - 12 flexes produced
 - 2 used to measure the impedance of the LVDS differential lines (**GKF3, GKF5**)
- **OPTIPRINT Kapton Flex :**
 - 12 flexes produced
 - 3 equipped with 6 MIMOSA-26 (50 μ m thick) sensors (**OKF3, OKF4, OKF6**)
 - 1 used to measure the impedance of the LVDS differential lines (**OKF5**)

PLUME modules tests : what is done in IPHC Strasbourg ?



- **Module calibration :**
 - « smoke tests » :
current consumption + JTAG slow control protocol
 - discriminators + pixels scan
 - fake hit rate estimation
 - pixel particle sensibility with a radioactive source

- **Differential impedance measurement**

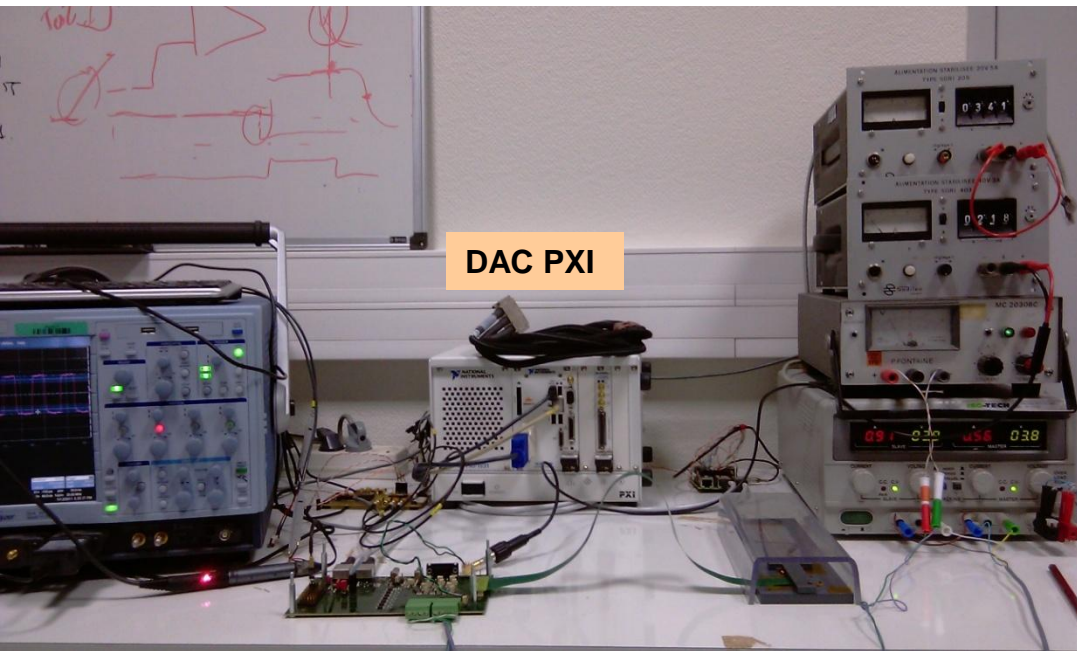
- **Temperature diode calibration**
- **Thermal measurements :**
module temperature map while sensors are operating



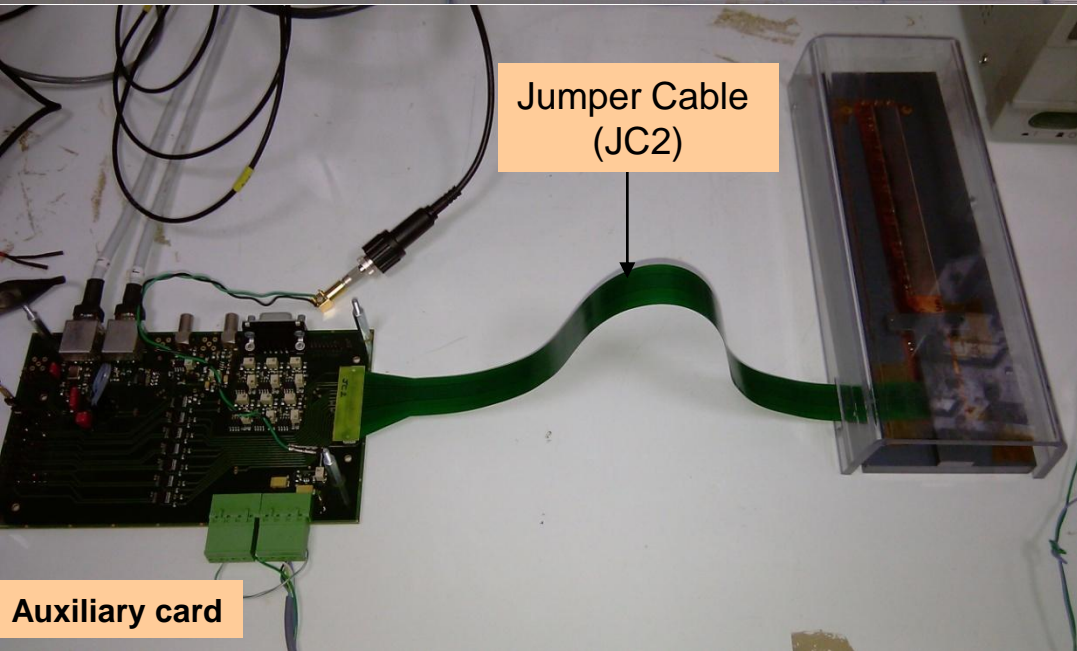
PLUME module calibration results

Dicriminator + pixels scan

PLUME General Test Bench 2011

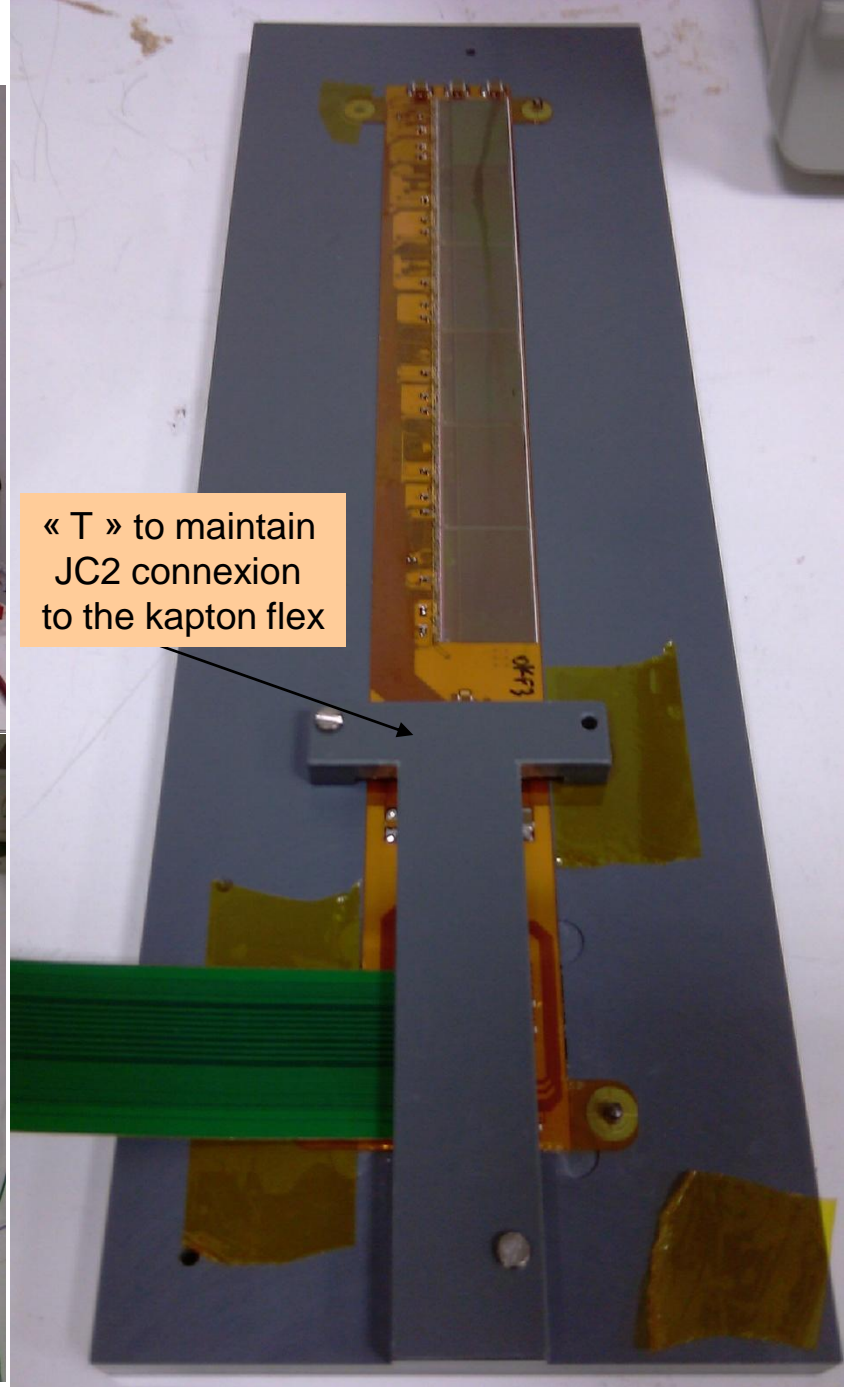


DAC PXI



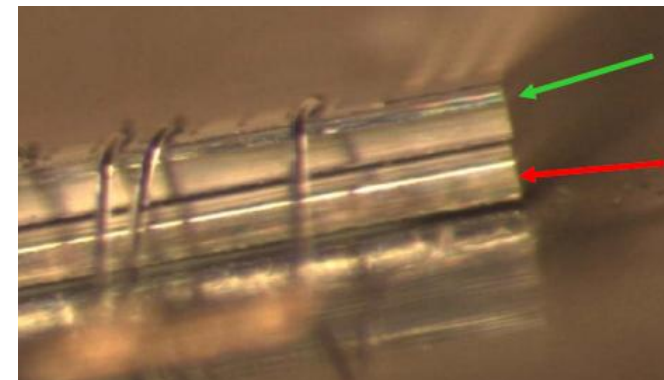
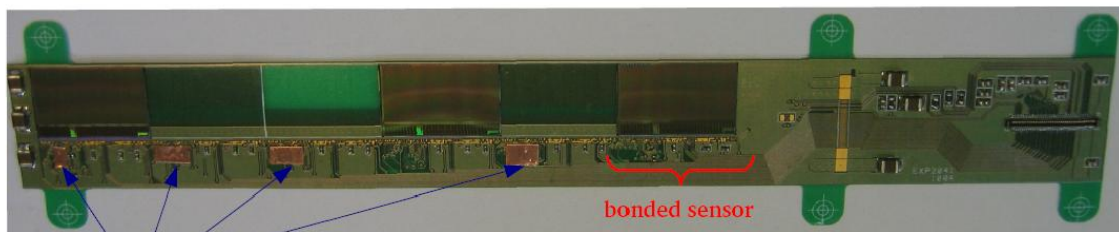
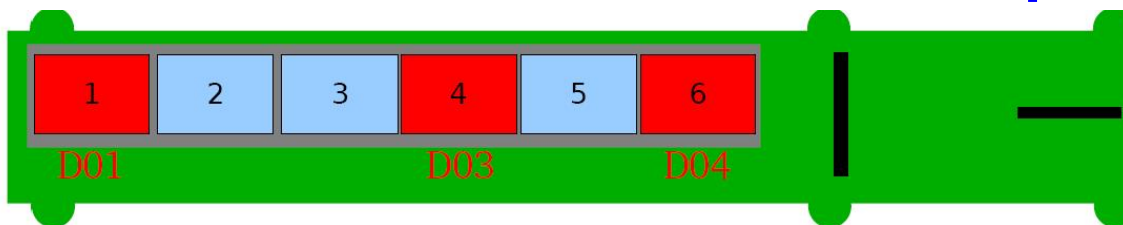
Jumper Cable (JC2)

Auxiliary card



« T » to maintain JC2 connexion to the kapton flex

GPF1 : the first prototype



copper scotch to make the bridge between TDO & TDI

- Sensors gluing procedure, handling
- Connection/assembly/ preliminary tests of the different parts composing the PLUME test bench (auxiliary board, Jumper cable, DAQ)
- TESTS :
 - design validation
 - sensors main output signals/data displayed on the oscilloscope
 - discriminators+ pixels scan
 - **DAC calibration only for GPF1 (check)**
 - Reminder : 8 bondings lines (reference lines) that we bond/unbond to one sensor after another to characterize the DAC.*
 - thermal measurements

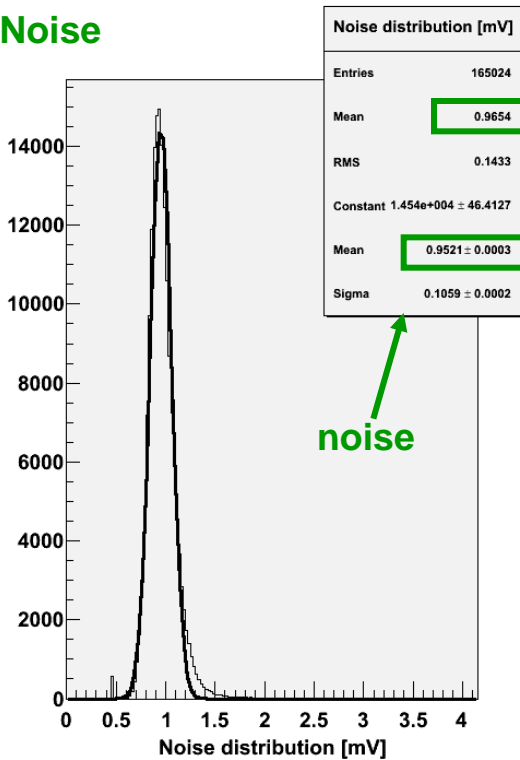
What are the calibration parameters ?



- Calibration done for each of the 4 submatrices of a sensor
- Noise (TN= temporal noise) ~ 1 mV
- Offset which is important to determine the discriminator threshold S
- Approximation : only mean values are taken into account
- **S = offset + n × noise**

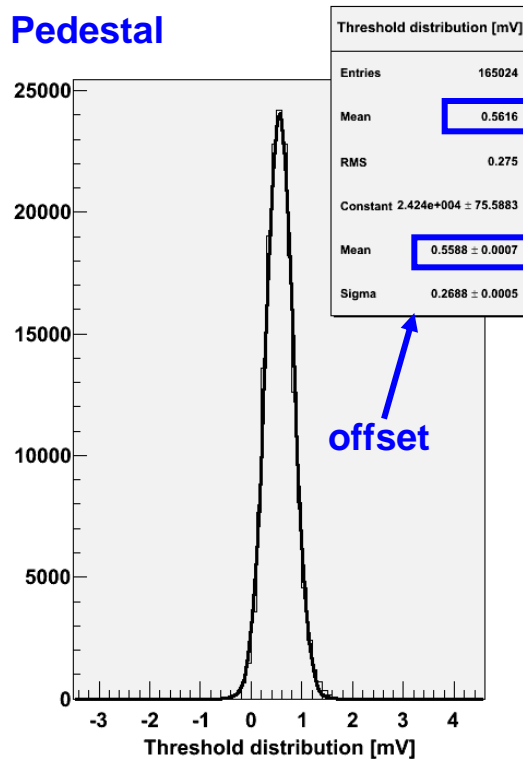
Parameters histograms for all pixels of one sub-matrix

Noise

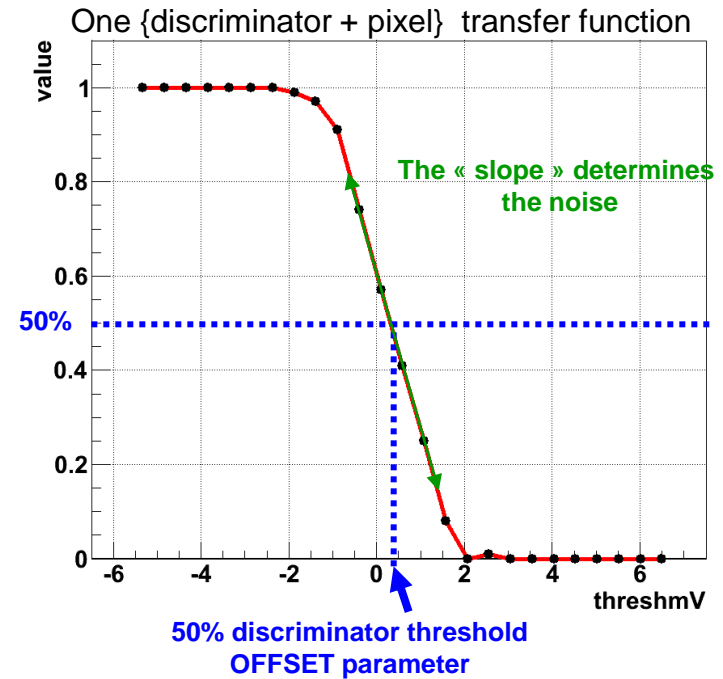


noise

Pedestal



offset



Reminder : MIMOSA26 counts 1152 columns × 576 lines = 663 552 pixels

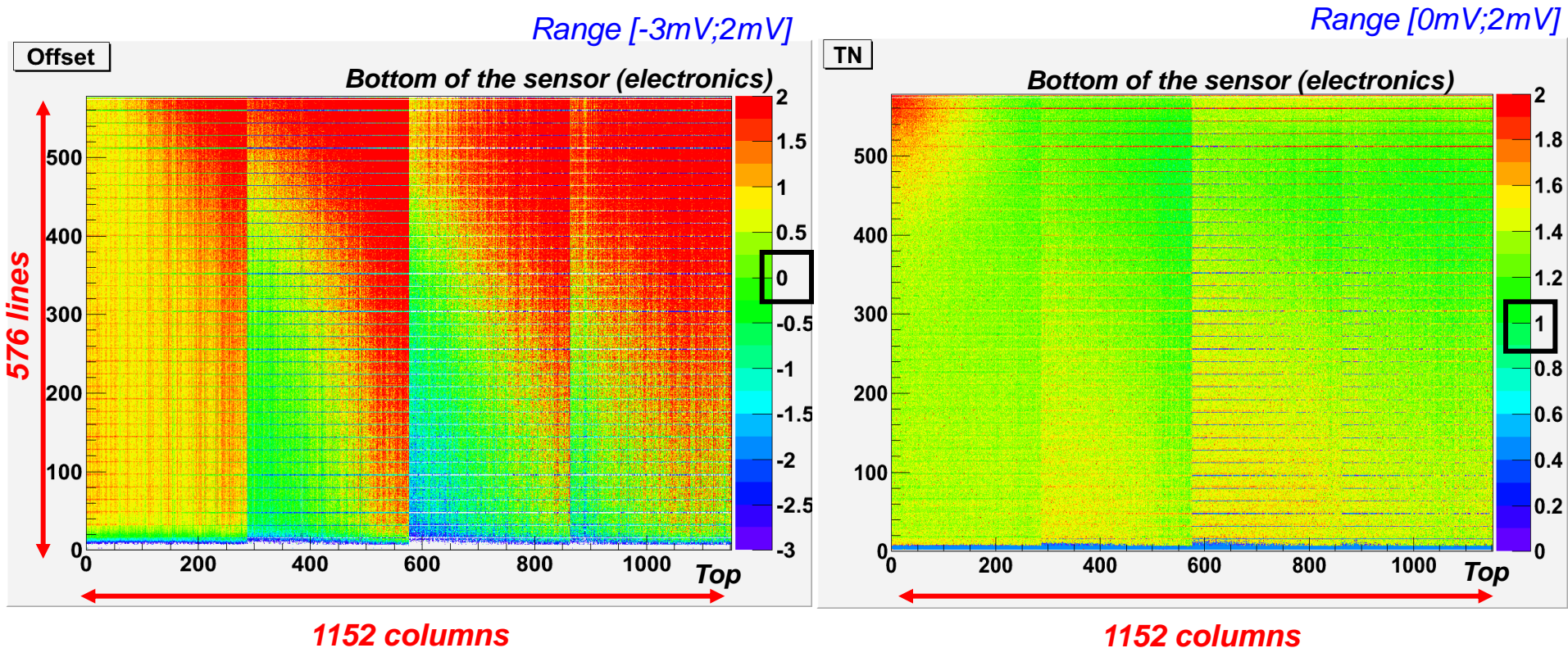
PLUME OKF calibration results



- 2 calibration summarizing plots (examples for OKF3 chip2 no cooling)
- Criteria : offset homogeneity per submatrix, noise (TN) ~ 1mV

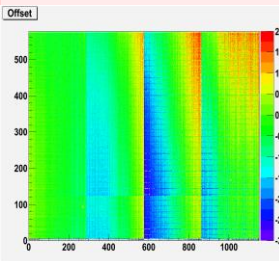
An example below for a sensor without cooling :

- Hot spots at the bottom of the sensors and end of the submatrix
- Offset shift every 16 lines
- 10-15 first lines are out of range [blank area] (discriminator mode, power ON signal stability)

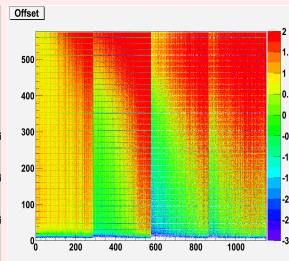


All calibration results are stored in a dedicated file per module

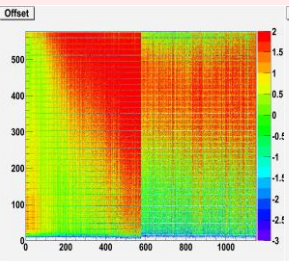
No cooling 1



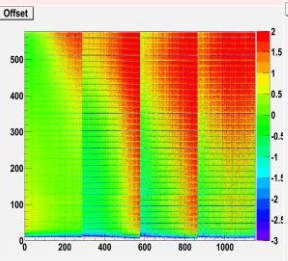
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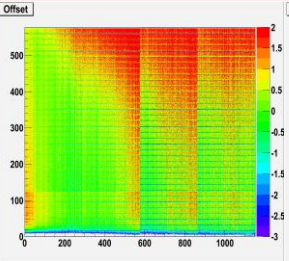
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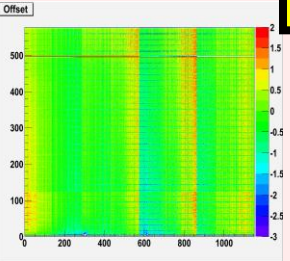
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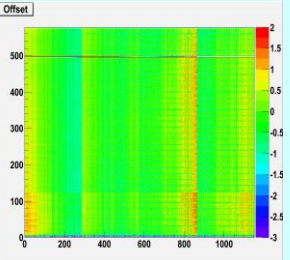
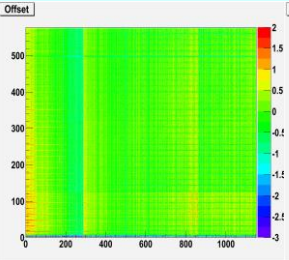
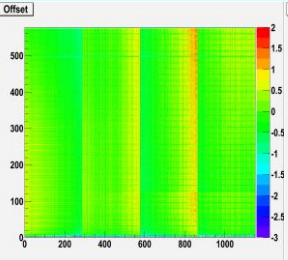
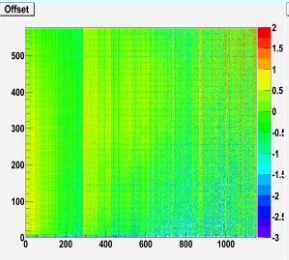
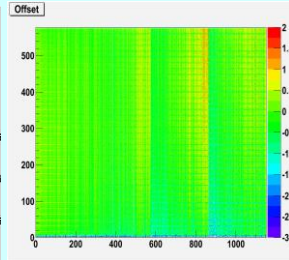
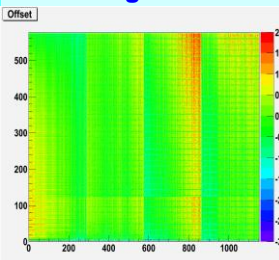
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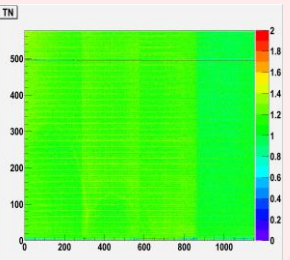
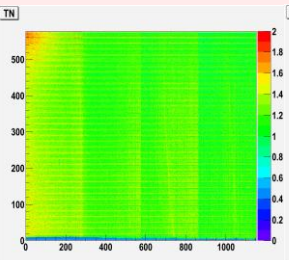
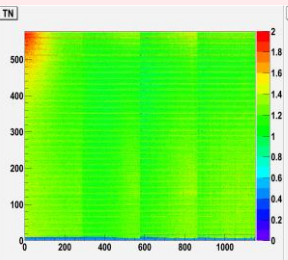
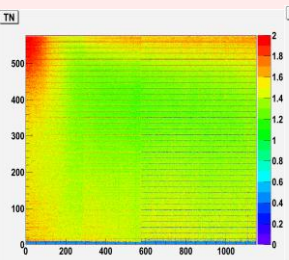
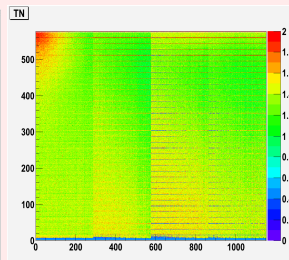
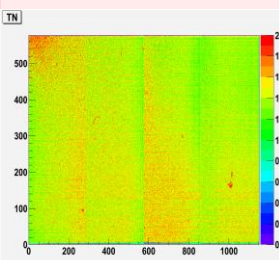
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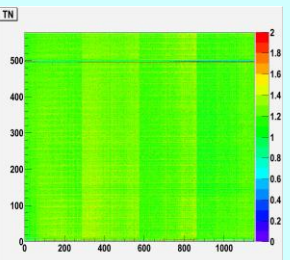
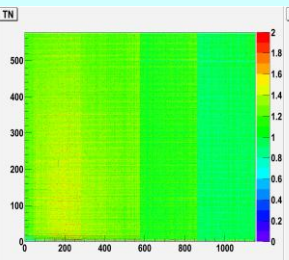
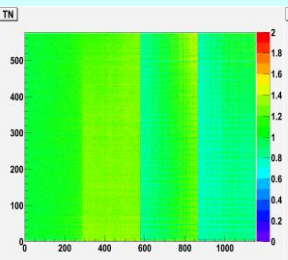
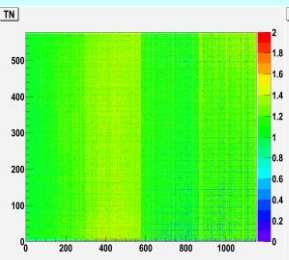
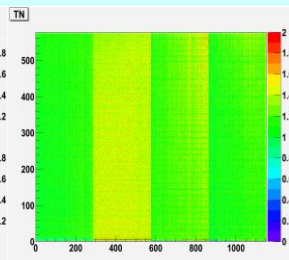
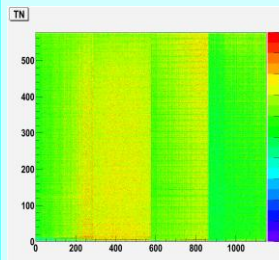
Cooling



No cooling



Cooling



No cooling 1

2

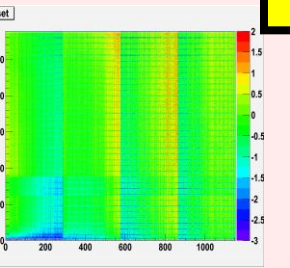
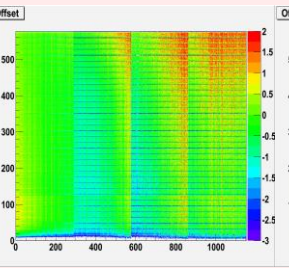
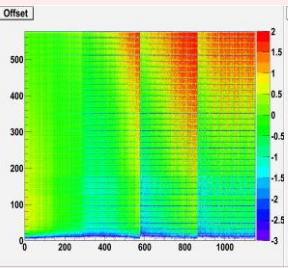
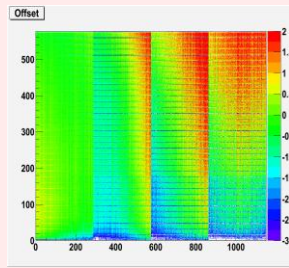
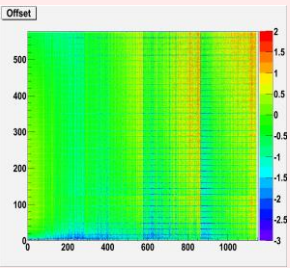
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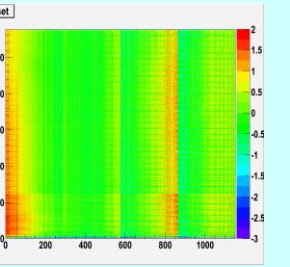
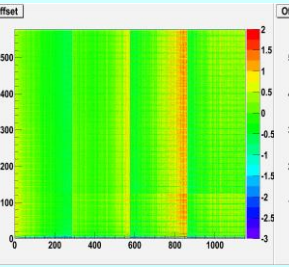
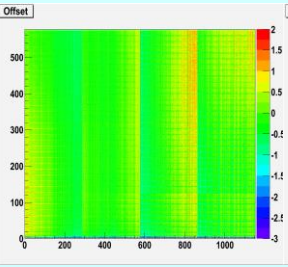
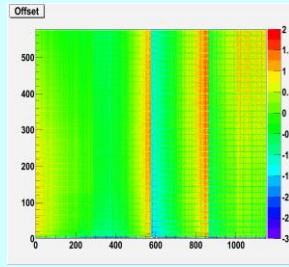
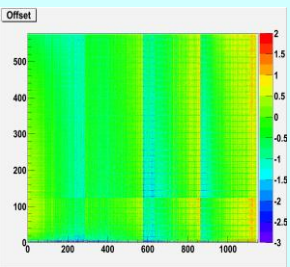
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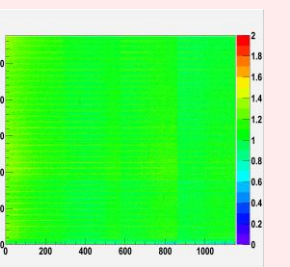
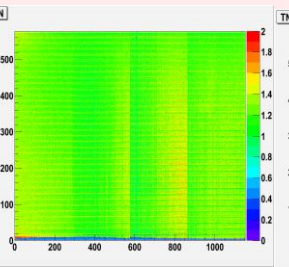
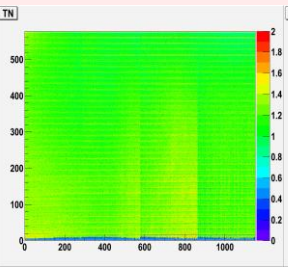
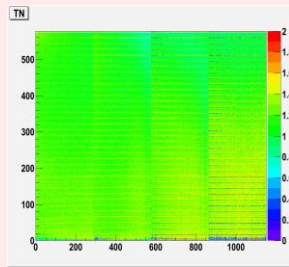
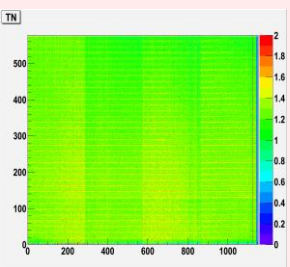
OKF4



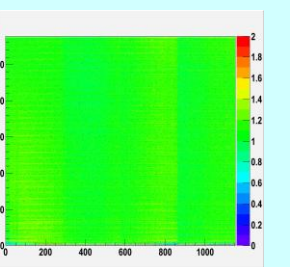
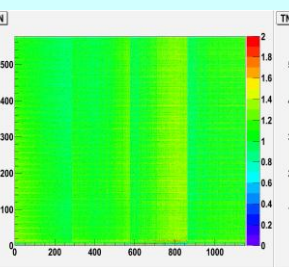
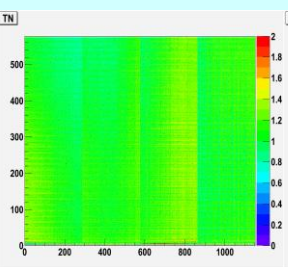
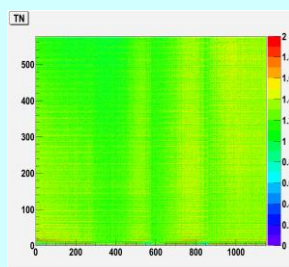
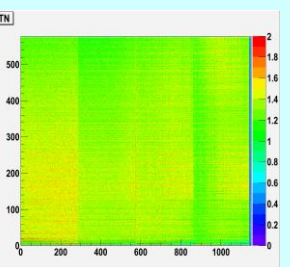
Cooling



No cooling



Cooling



No cooling 1

2

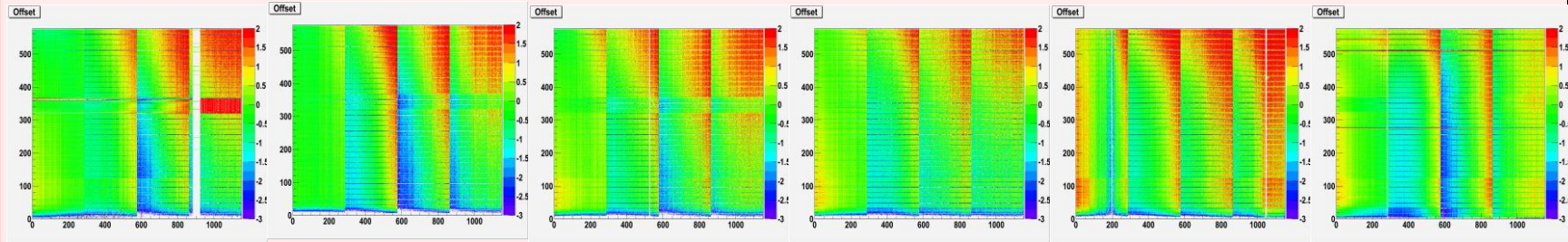
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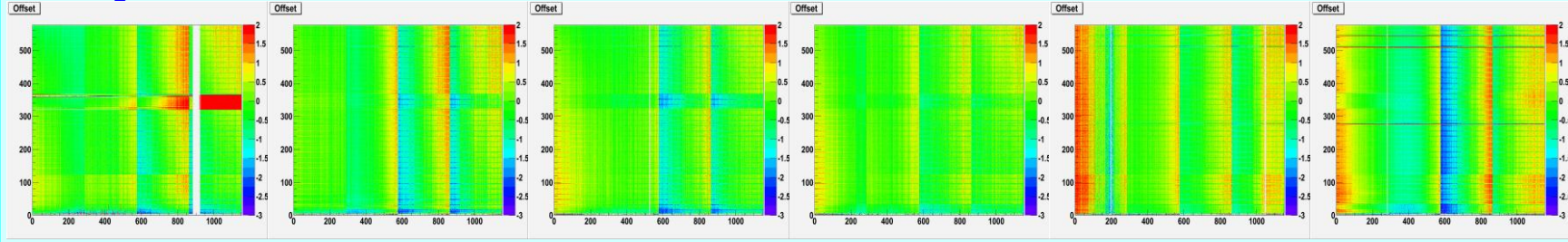
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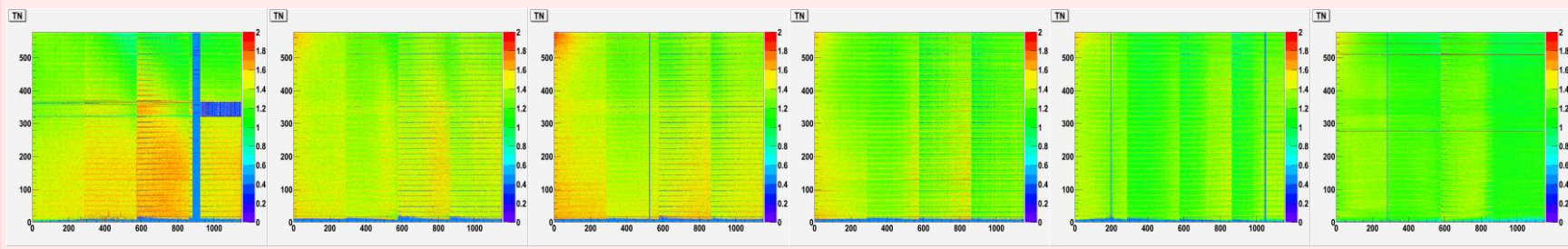
OKF6



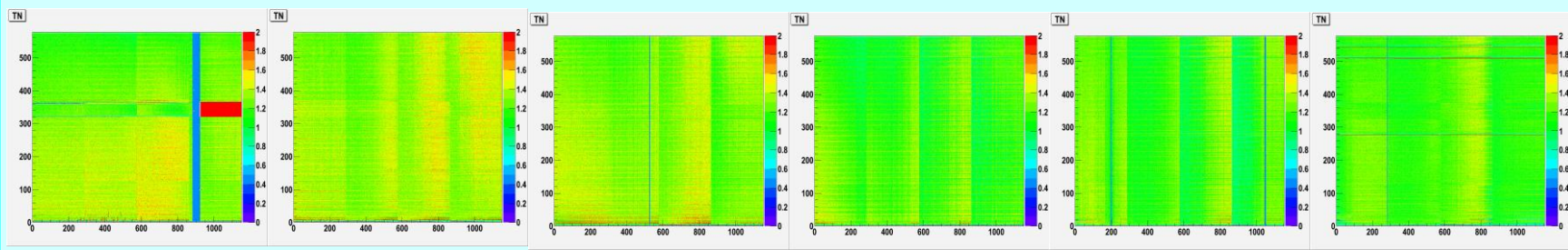
Cooling



No cooling



Cooling



No cooling 1

2

3

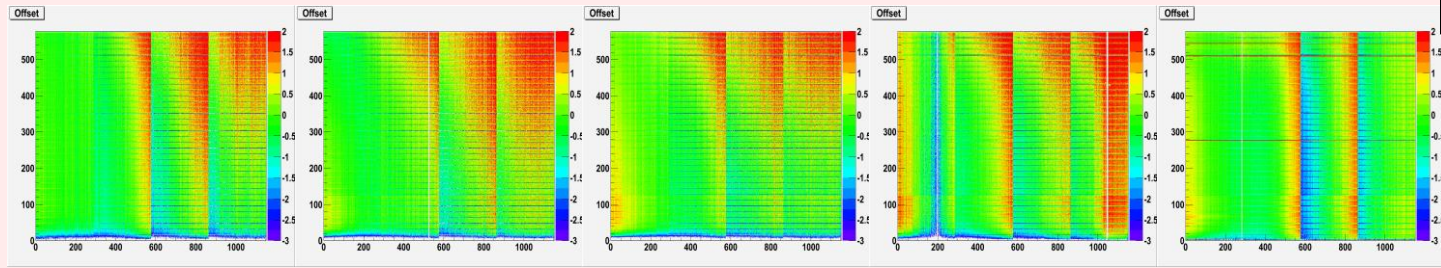
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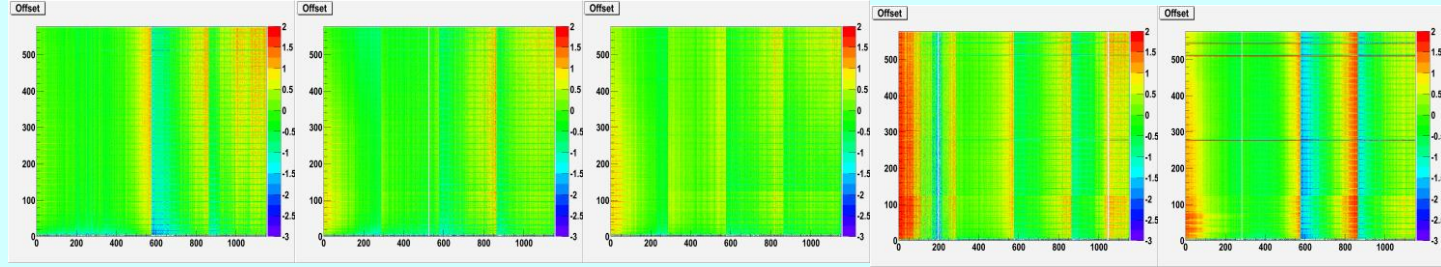
OKF6

Nochip1 M00



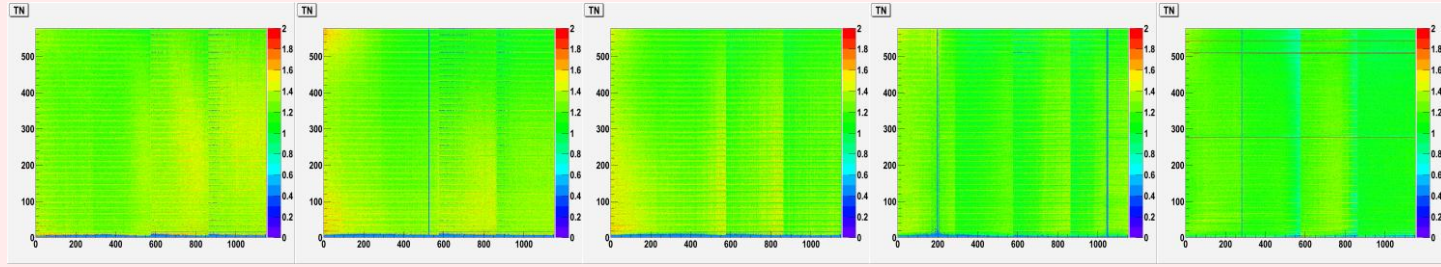
Cooling

Nochip1 M00



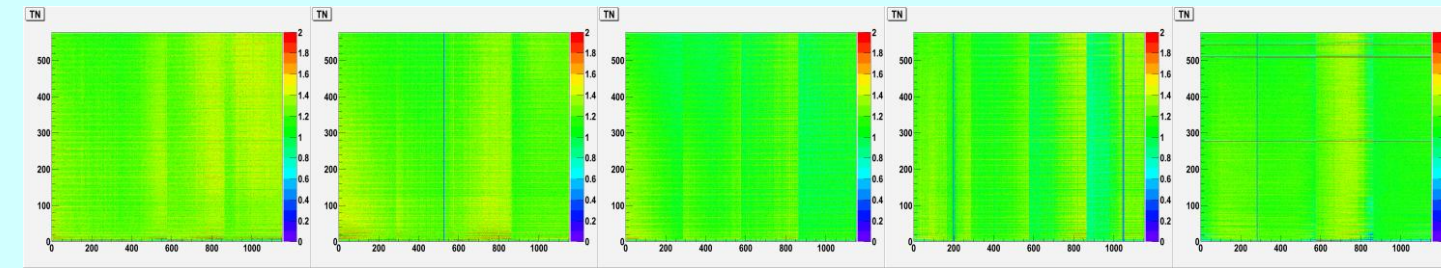
No cooling

Nochip1 M00



Cooling

Nochip1 M00



Fake hit rate = FHR (hits/pixel/frame)

Beam test 6σ : $7e-5$ hits/pixel/frame

8σ : $1e-5$ hits/pixel/frame

| OKF3 FHR | 6 sigma | | 8 sigma | |
|----------|------------|-----------|------------|-----------|
| | No cooling | cooling | No cooling | cooling |
| chip6 | 1e-04 | 1e-04 | 8 x 1e-05 | 6 x 1e-05 |
| Chip5 | 6 x 1e-06 | 3 x 1e-06 | 2 x 1e-06 | 2 x 1e-06 |
| Chip4 | 1 x 1e-05 | 5 x 1e-07 | 9 x 1e-08 | 4 x 1e-08 |
| Chip3 | 8 x 1e-06 | 5 x 1e-07 | 2 x 1e-07 | 8 x 1e-08 |
| Chip2 | 8 x 1e-06 | 5 x 1e-07 | 2 x 1e-07 | 4 x 1e-08 |
| chip1 | 3 x 1e-06 | 6 x 1e-07 | 2 x 1e-07 | 6 x 1e-08 |

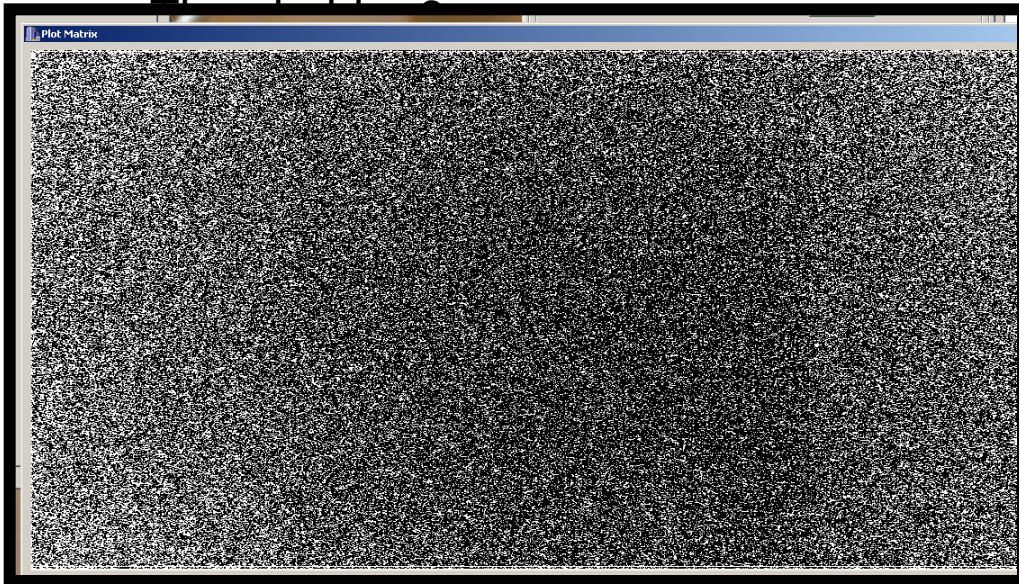
| OKF4 FHR | 6 sigma | | 8 sigma | |
|----------|------------|-----------|------------|---------|
| | No cooling | cooling | No cooling | cooling |
| chip6 | 3 x 1e-05 | 9 x 1e-06 | | |
| Chip5 | 4 x 1e-05 | 4 x 1e-06 | | |
| Chip4 | 6 x 1e-03 | 6 x 1e-03 | | |
| Chip3 | 5 x 1e-05 | 2 x 1e-06 | | |
| Chip2 | X | X | X | X |
| chip1 | 7 x 1e-04 | 6 x 1e-03 | | |

| OKF6 FHR | 6 sigma | | 8 sigma | |
|----------|------------|-----------|------------|-----------|
| | No cooling | cooling | No cooling | cooling |
| chip6 | 5 x 1e-04 | 7 x 1e-04 | 3 x 1e-03 | 2 x 1e-04 |
| Chip5 | 1e-04 | 1e-05 | 6 x 1e-06 | 6 x 1e-06 |
| Chip4 | 2 x 1e-06 | 6 x 1e-06 | 1e-07 | 5 x 1e-07 |
| Chip3 | 1e-06 | 3 x 1e-06 | 1e-07 | 3 x 1e-07 |
| Chip2 | 7 x 1e-07 | 3 x 1e-06 | 1e-07 | 3 x 1e-07 |
| Chip1 | 3 x 1e-03 | 3 x 1e-03 | 3 x 1e-03 | 3 x 1e-03 |

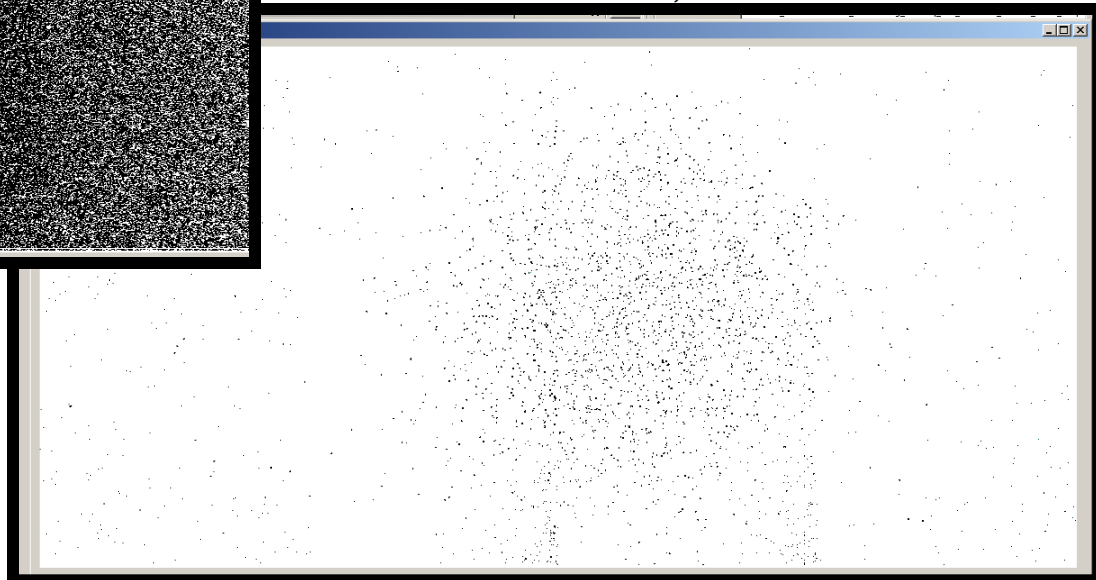
Pixel Validation with a Fe55 source



- The study has just started
- To check that all pixels are responsive to particles (5.9 keV β for Fe55)
=> qualitative criteria for the moment (data acquisition limitation)
- SUZE data acquisition mode



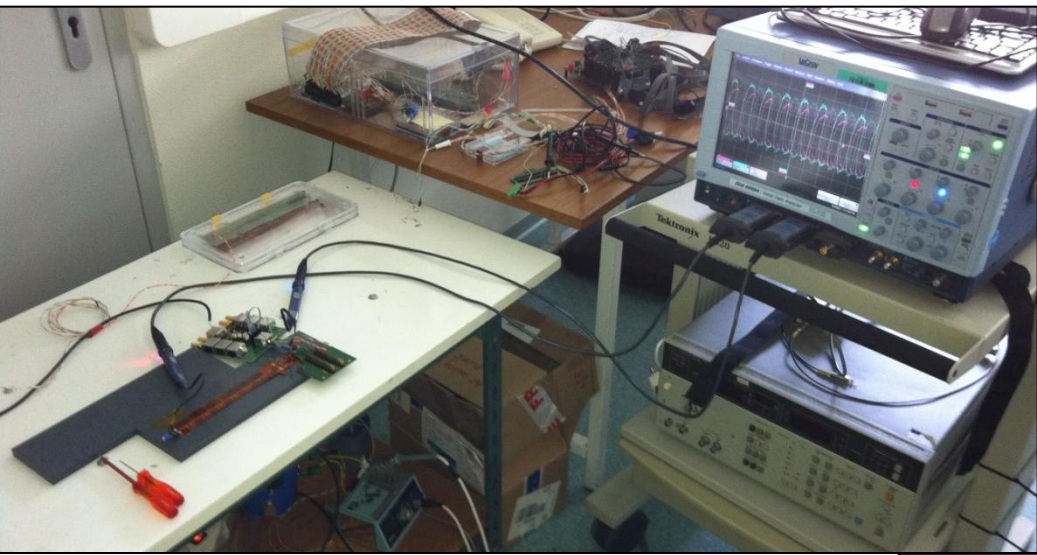
Collimated source, hole $\varnothing \sim 1\text{mm}$





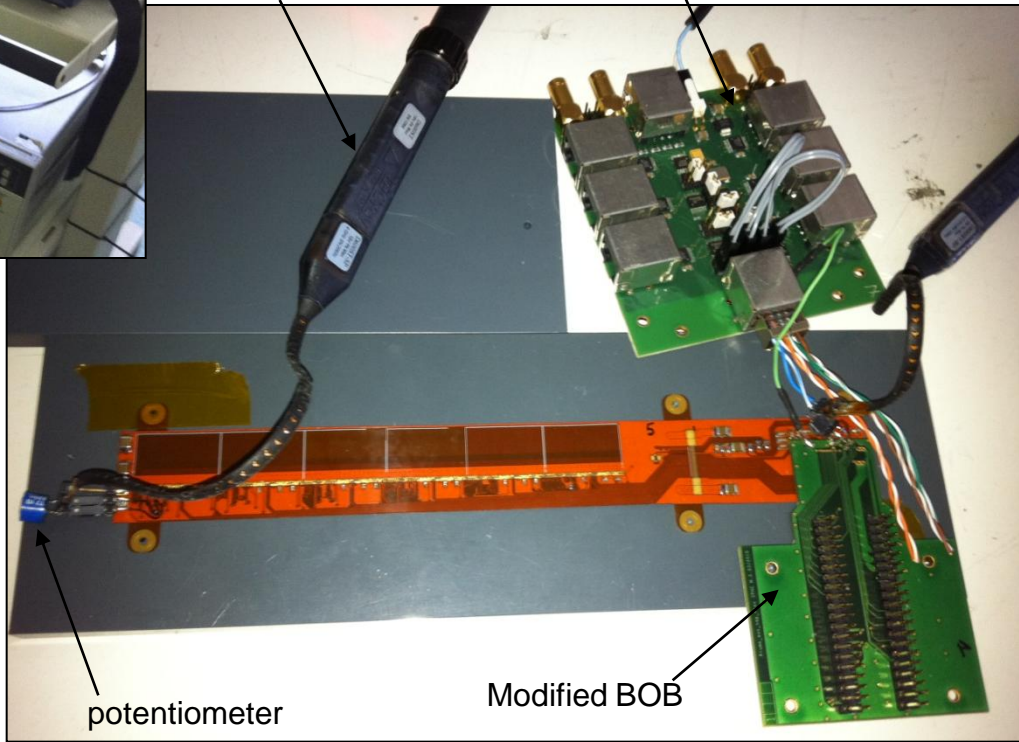
PLUME module impedance measurements

PLUME LVDS traces Impedance measurement test bench



Probe at the CLK termination resistor

CLK distribution PCB



potentiometer

Modified BOB

- Lecroy SDA6000A oscilloscope
- 4GHz D600ST-SP Lecroy probes
- T7YB 220Ω potentiometer

- 80MHz CLK signal generated by a Quartz on the CLK distribution PCB

- BOB modified (CLK trace cut to reduce the trace influence trace on BOB PCB)

PLUME modules features & impedance summary



| | GPF2 | GKF5 | OKF5 | OKF2011 |
|---|------------|-----------|--------|---------|
| Metal | Copper | Copper | Copper | Alu |
| Trace thickness (μm) | 17 | 17 | 20 | 13 |
| Substrate | FR4 | kapton | kapton | kapton |
| Subst. Thickness (μm) | 200 | 50 | 25 | 12 |
| Cover layer (μm) top | 25 | 25 | 38 | 20 |
| Cover layer (μm) bottom | 0 | 0 | 38 | 20 |
| Trace Width (μm) (design rules/real) | 75/60 | 75/40 | 75/75 | 60 |
| Trace Spacing (μm) (design rules/real) | 90/105 | 90/125 | 90/90 | 75 |
| Diff. Impedance measured (Ω) 80MHz | 99.8 | 114.5 | 65 | ? |
| Diff. Z0 web (Ω) | 137.5 | 97 | 49/60 | 13 |
| Diff. Z0 (Ω) cadence : section/ trace | 127-152 /? | 114-171/? | 140/74 | 160/90 |

Remarks



- Measurements done by observing the signal shape and adjusting the impedance via the potentiometer (visual criteria : incertitude $\pm 10\Omega$)
- Differences between estimations made on online calculators on the web and CADENCE. And also differences inside CADENCE itself if using the section features tool or calculations tool inside CADENCE.
- Software on the web doesn't take into account
 - cover layer
 - trace material (copper, aluminium)
 - the real positioning of these traces on the design
- With the online calculator on the web, the most critical parameter is the kapton thickness. Decreasing it decreases the differential impedance.



- **Conclusion on calibration :**
 - We clearly see an effect of the cooling on the offset
 - One sensor activity impacts on the behaviour of the other sensors
 - fake hit rates compares to typical fake hit rates in beam test
 - Modules are « operational »
 - except from chip1 of OKF6 that has blocks of active lines on matD
 - except that we can't monitor the discriminators of OKF4
 - we have 2 modules with 5 sensors (OKF4 & OKF6)
 - 1 module with 6 sensors (OKF3)

=> which ones do we send to Bristol to be mounted in the first ladder ?
- **Conclusion on flex impedances measurements :**

Decreasing the kapton thickness seems a bad idea concerning the impedance required for the differential signals.

=> Which tool can be trusted to estimate the differential impedance ?

Next steps



- ***Flex design :***
what is the effect of removing the 3 decoupling capacitors (10 μ F) at the very end of the flex (on VddA, VddD, Vclp) ? Do we need 3 \times 100nF decoupling capacitors (VddA/VddD/Vclp) for each sensor ?
- ***PXI Data acquisition :***
To acquire data from 6 sensors at the same time.
The software should be updated this summer so that 6 sensors can be handled and so that it would be possible to store data in SUZE mode
=> influence of one sensor on the others
=> cluster size study with respect to thresholds
- ***3V/3V power supply study :***
Does the pixel have the same performances ? Do we lose efficiency ?
- Laser calibration ?
- Redo all these measurements for the 1st ladder