



**OKF3 first tests
&
Thermal measurements**

PLUME Phone meeting

CHON-SEN Nathalie

28th January 2011

What are we going to talk about ?



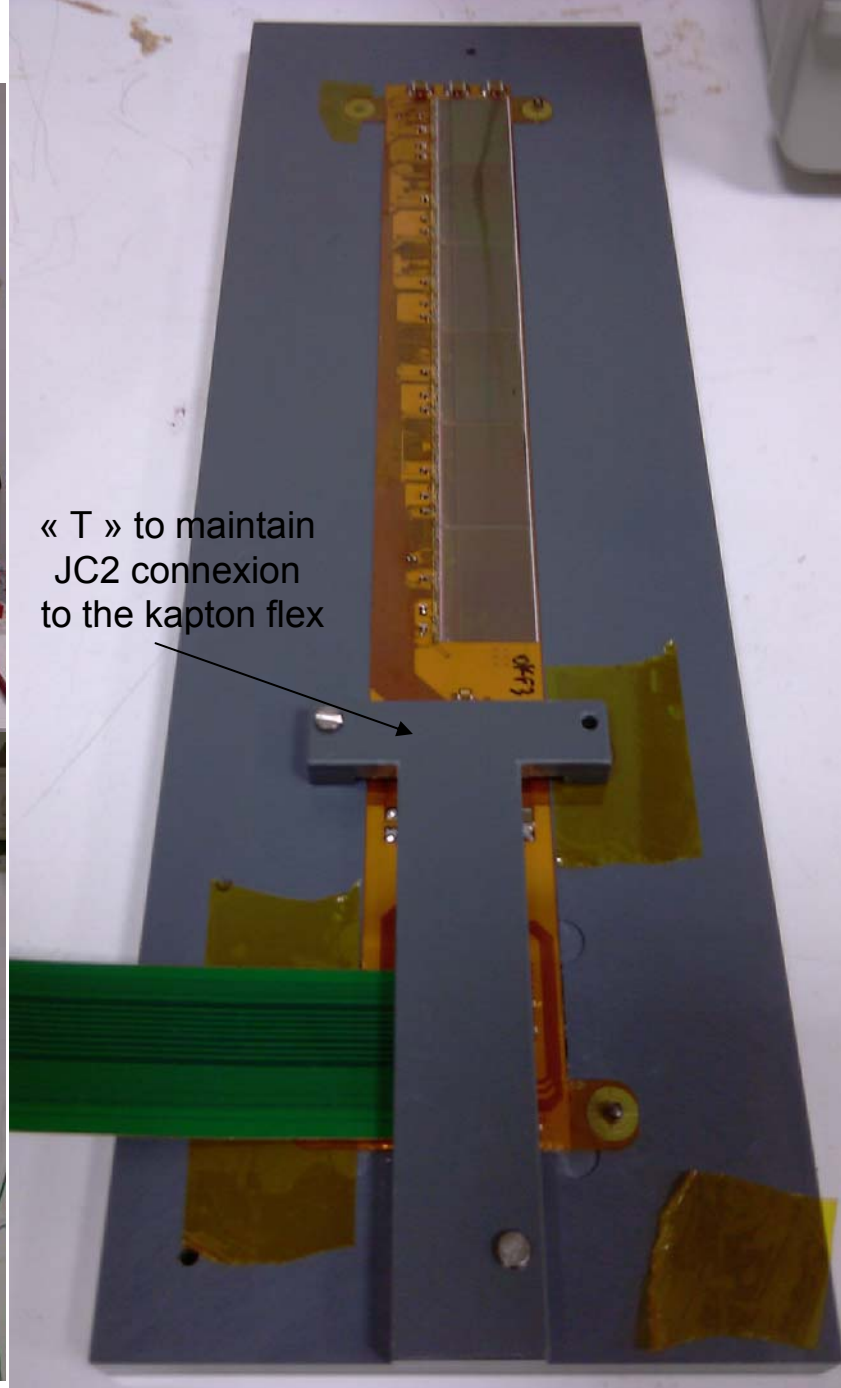
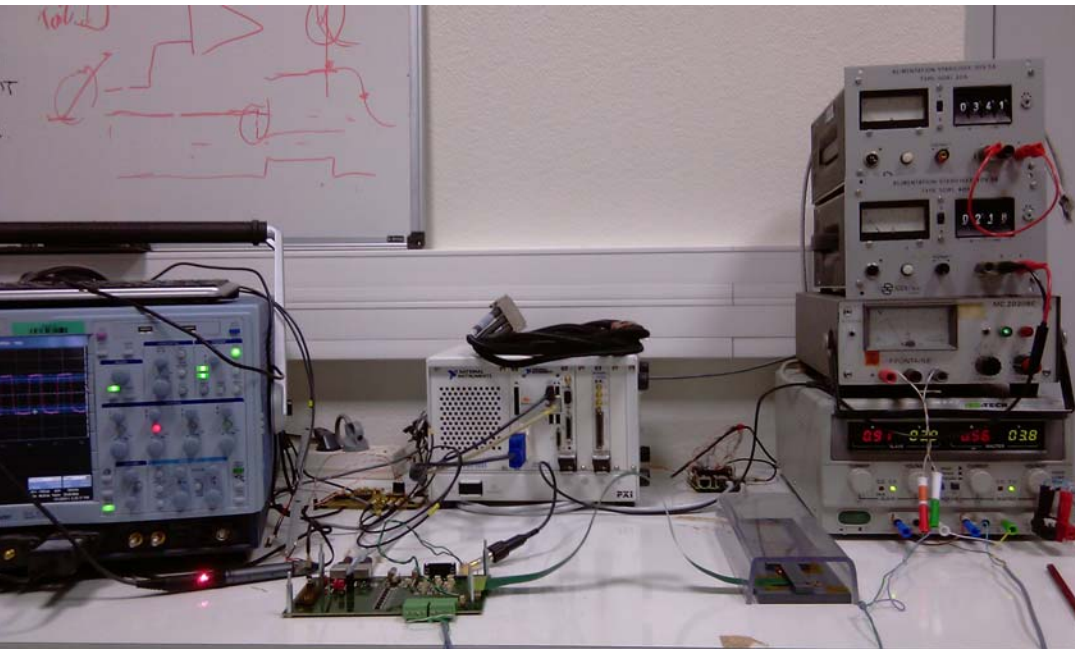
Next steps (30/11/2010) - Not a priority list

- Tests with radioactive source, cluster multiplicity, fake hits rate
 - Calibration of OKF3
 - Thermal test bench to set up (mechanical pieces to be designed for air flow cooling and devices to be bought (?))
 - We have decided not to reproduce the jumper cables for the moment => tests with the jumper cable (data of sensor 6 and sensor 1 unused, crosstalk with CLK, CLKD)
 - New soles to be made for the new OPTIPRINT flexes
- Will be reordered without any changes (satisfying tools for the flex design)

First preliminary tests

Priority point

PLUME Test Bench 2011

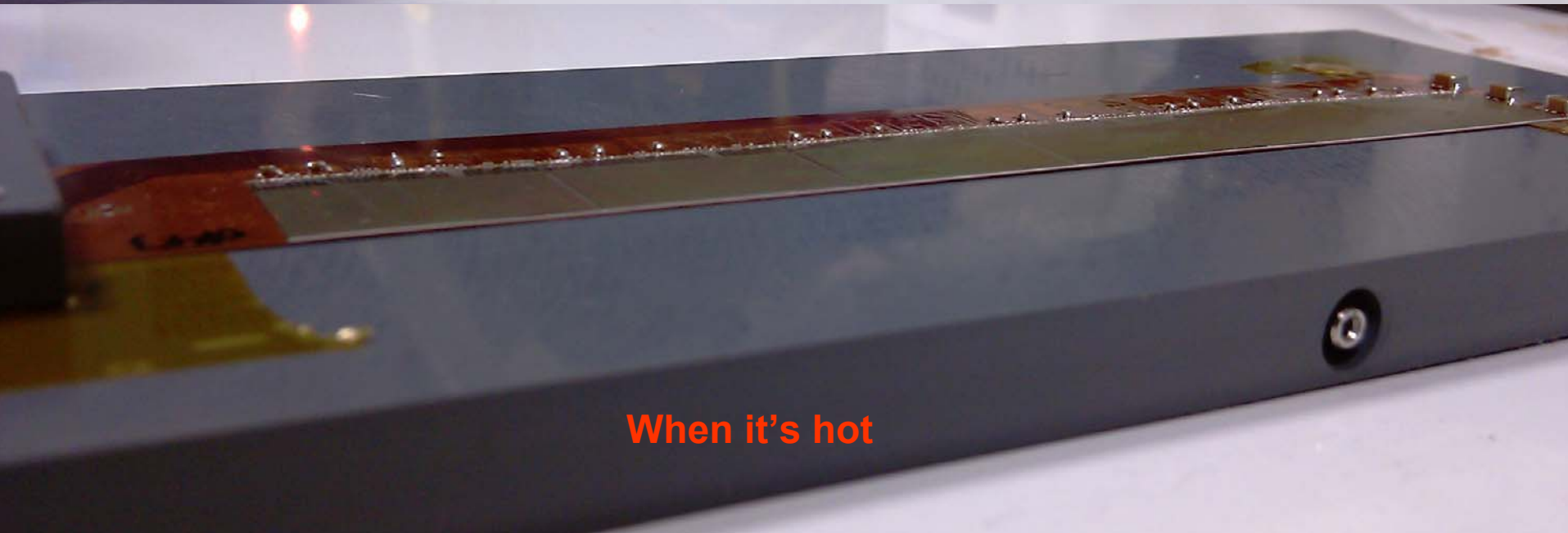
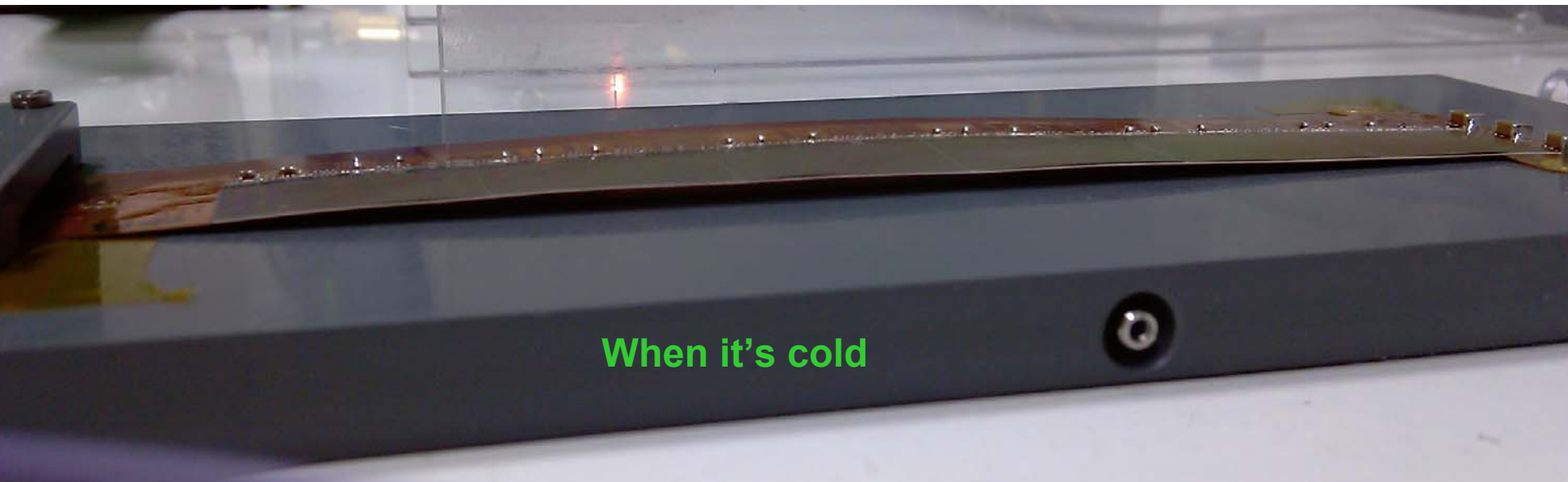


Preliminary tests on OKF3

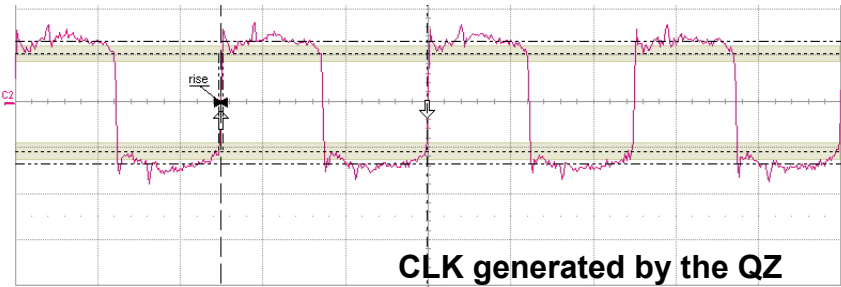


- **« Smoke tests » on OKF3**
first step consisted on only powering ON the sensors
no short cut
- **JTAG slow control protocol implementation**
use of auxiliary card + JC2 + OKF3
daisy chain OK
current consumption for 6 sensors : (All sensors ON at 50 % discri activation)
~920 mA analog (~150 mA/sensor)
and ~640 mA digital (~107 mA/sensor)
- **Data mode :**
 - **CLK, CLKD, MKD Visualization on the scope**
 - **Data Visualization on the scope** (normal mode & pattern mode)
each subarray of each sensor is working
- **Discri calib mode :**
 - **Dead pixels ?** Chip6 one line always at 1 for matB,C,D; chip5 some pixels of one column always at 0 on matA
 - **First sensors discriminators scans (D+P, Donly)**
- **Rmk : when sensors are ON, OKF3 becomes very hot !**
Visible dilatation effect of the flex

Dilatation of the flex



CLK, CLKD



CLK generated by the QZ

Measure	P1:rise(C2)	P2:fall(C2)	P3:amp(C2)	P4:duty@lv(C2)	P5:---	P6:---	P7:---	P8:---
value	238 ps	187 ps	528.0 mV	49.29 %				
mean	268.97 ps	< 233.02 ps	533.591 mV	49.2351 %				
min	161 ps	< 157 ps	517.1 mV	49.08 %				
max	661 ps	< 509 ps	548.8 mV	49.41 %				
sdev	58.41 ps	< 36.25 ps	3.707 mV	44.6 m%				
num	89.553e+3	112.956e+3	27.054e+3	51.482e+3				
status	✓	✓	✓	⚠				

C2 200 mV/div
-10.0 mV ofst
-58.9 mV
-36.5 mV

Timebase 0.0 ns Trigger C2
500 S 5.00 ns/div Auto 120 mV
10 GS/s Edge Positive
X1= -50 ps ΔX= -12.50 ns
X2= -12.55 ns 1ΔX= -80.0 MHz
1/12/2011 2:15:05 PM

LeCroy



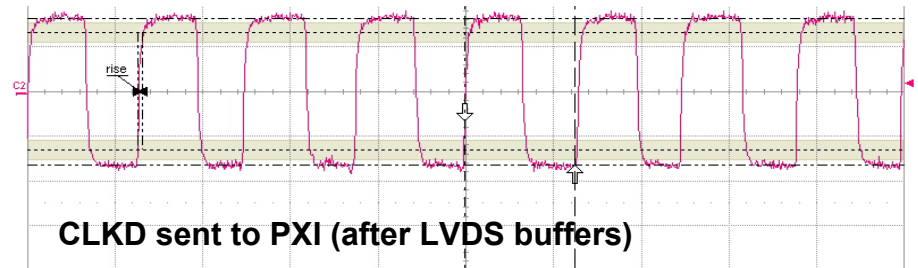
CLK back from the flex on aux. card

Measure	P1:rise(C2)	P2:fall(C2)	P3:amp(C2)	P4:duty@lv(C2)	P5:---	P6:---	P7:---	P8:---
value	225 ps	226 ps	546.6 mV	49.25 %				
mean	< 284.50 ps	< 243.94 ps	531.993 mV	49.2348 %				
min	< 83 ps	< 152 ps	38.0 mV	46.56 %				
max	< 44.954 ns	< 47.758 ns	550.0 mV	51.40 %				
sdev	< 570.80 ps	< 416.68 ps	28.199 mV	48.8 m%				
num	98.685e+3	125.070e+3	30.147e+3	57.481e+3				
status	✓	✓	✓	⚠				

C2 200 mV/div
-10.0 mV ofst
-71.0 mV
-82.3 mV

Timebase 0.0 ns Trigger C2
500 S 5.00 ns/div Auto 120 mV
10 GS/s Edge Positive
X1= -50 ps ΔX= -12.50 ns
X2= -12.55 ns 1ΔX= -80.0 MHz
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CLKD sent to PXI (after LVDS buffers)

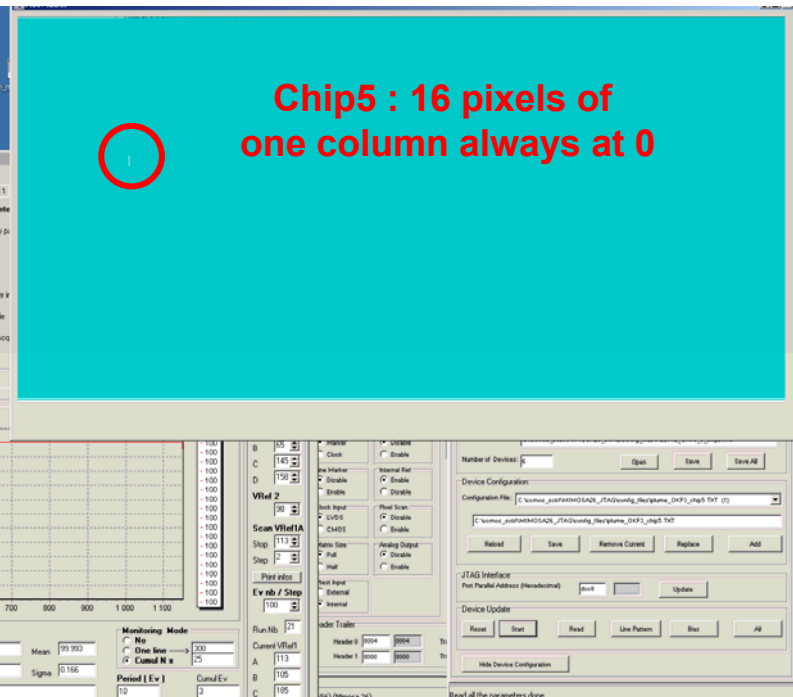
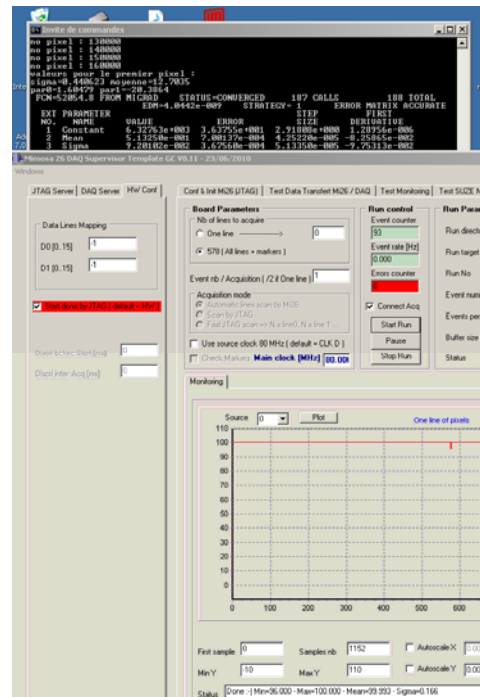
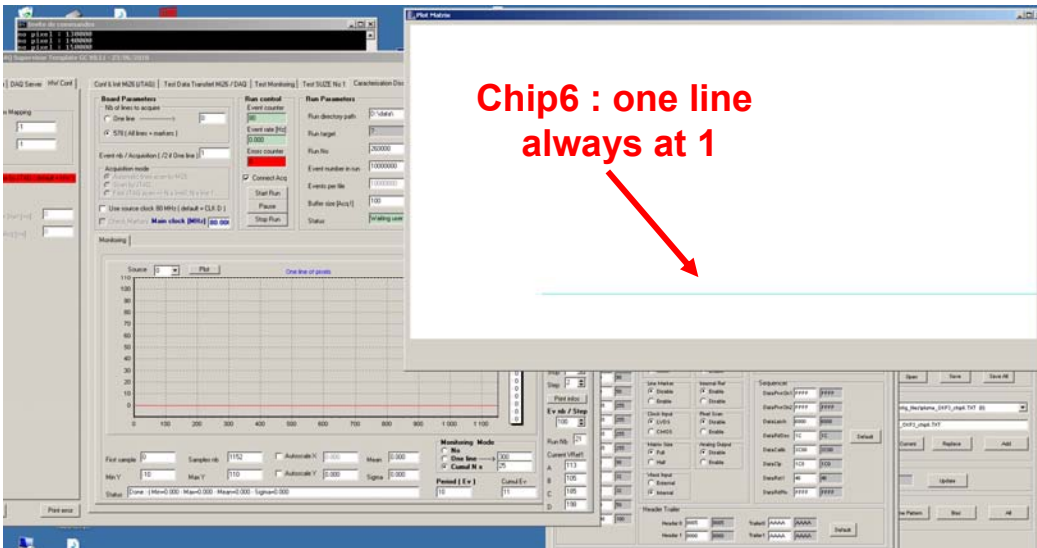
Measure	P1:rise(C2)	P2:fall(C2)	P3:amp(C2)	P4:duty@lv(C2)	P5:---	P6:---	P7:---	P8:---
value	613 ps	653 ps	658.0 mV	56.76 %				
mean	598.75 ps	618.75 ps	656.445 mV	54.6063 %				
min	405 ps	465 ps	647.8 mV	49.92 %				
max	864 ps	883 ps	662.8 mV	58.82 %				
sdev	52.99 ps	49.73 ps	1.945 mV	2.0916 %				
num	97.206e+3	106.520e+3	13.315e+3	89.694e+3				
status	✓	✓	✓	⚠				

C2 200 mV/div
-10.0 mV ofst
-116.3 mV
-326.5 mV

Timebase 0.0 ns Trigger C2
1.00 kS 10.0 ns/div Auto 48 mV
10 GS/s Edge Positive
X1= -100 ps ΔX= 12.5 ns
X2= 12.4 ns 1ΔX= 80.0 MHz
1/12/2011 2:37:38 PM

LeCroy

Dead pixels on OKF3



Thermal test bench



Thermal test bench



- Use of an **infra-red thermal camera FLIR T400**
precision $\pm 2^{\circ}\text{C}$ or $\pm 2\%$ of the measurement
- Measurements done at 27°C ambient temperature
- FH's simulation load input that we gave her **$\sim 730\text{ mW}$ per sensor**
(Analog :110mA/Digital 70-110mA per sensor \Rightarrow 180-220mA \Rightarrow 590-730 mW)
- Remark on the **current consumption** for the results comparison when **6 sensors are operating** :
What was measured on the flex :
All sensors ON at 50 % discri activation **920/640 mA**
 \Rightarrow **153mA/107mA per sensor** \Rightarrow $\sim 260\text{ mA}$ in total \Rightarrow 858mW (780mW @VddD=3V)
All sensors ON at 0% discri activation (Vref1=255) **940/430 mA**
 \Rightarrow **157 mA/72mA per sensor** \Rightarrow $\sim 217\text{ mA}$ in total \Rightarrow **727mW** (657mW @VddD=3V)
All sensors ON at 100% discri activation (Vref1=0) **910/600 mA**
 \Rightarrow **152 mA/100mA per sensor** \Rightarrow $\sim 252\text{ mA}$ in total \Rightarrow 832mW (756mW @VddD=3V)
- Remark on the **current consumption** for the results comparison when **only sensor 6 is operating** :
Chip6 ON at 50% discri activation others OFF (0% + ILVDSTx=ILVDS=0) **690/140 mA**
 \Rightarrow **115mA/140 mA per sensor** \Rightarrow 255mA in total \Rightarrow 842 mW (765mW @VddD=3V)
Chip6 ON at 0% discri activation others OFF (0% + ILVDSTx=ILVDS=0) **690/100 mA**
 \Rightarrow **115mA/100 mA per sensor** \Rightarrow 215mA in total \Rightarrow **710 mW** (645mW @VddD=3V)
Chip6 ON at 100% discri activation others OFF (0% + ILVDSTx=ILVDS=0) **690/130 mA**
 \Rightarrow **115mA/130 mA per sensor** \Rightarrow 245mA in total \Rightarrow 808 mW (735mW @VddD=3V)

**Hence, the corresponding configuration for my measurements in order to have the same dissipated power per sensor is with high thresholds.
In my measurements I take the case when sensors are set to a threshold $\sim 6\sigma$
(real BT conditions)**

6 sensors are operating (OKF3)



Configuration	pictures	Sensor1 °C	Sensor2 °C	Sensor3 °C	Sensor4 °C	Sensor5 °C	Sensor6 °C	Max Temp. °C (sensor Nb)
All 50%	611	81.8	89.2	97	97	92.1	86.1	97 (3+4)
All 50% [3V=VddD]	612	79	85.6	93	93	89.7	83.5	93 (3+4)
All 50%	621	83	90.6	98.6	98.6	93.9	85.4	98.6 (3+4)
All 50%	626	83.3	91.7	93.7	99.1	93.8	86.2	99.1 (3+74)
All ~6σ	629	76.6	80.8	89.4	89.8	85.1	78.2	89.8 (3+4)
All ~6σ	637	74.3	79.5	86.1	91.3	85	78.2	91.3 (4)
All ~6σ [3V]	630	72.9	78.1	86.7	86.7	80.9	74.7	86.7 (3+4)
All ~6σ [3V]	638	73.2	76.6	82.1	87	82.5	76.8	87 (4)
FH's sim. (12/10/2010)	FR4	67.7	65.7	90	90	65.8	63.2	90 (3+4)
FH's sim. (12/10/2010)	Polyamide (50μm)	63	60	91	91	60.8	60	91 (3+4)
Temp. Difference (green-blue)		12.5	20	-3	-0.6	25	18	-0.6

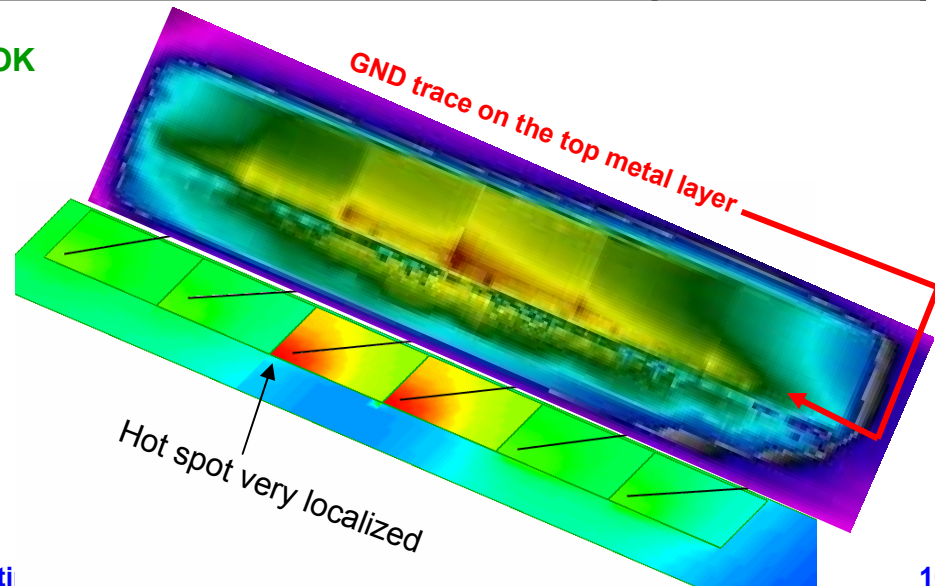
Global behaviour ~OK (middle sensors), max temperature OK

The simulation doesn't take into account :

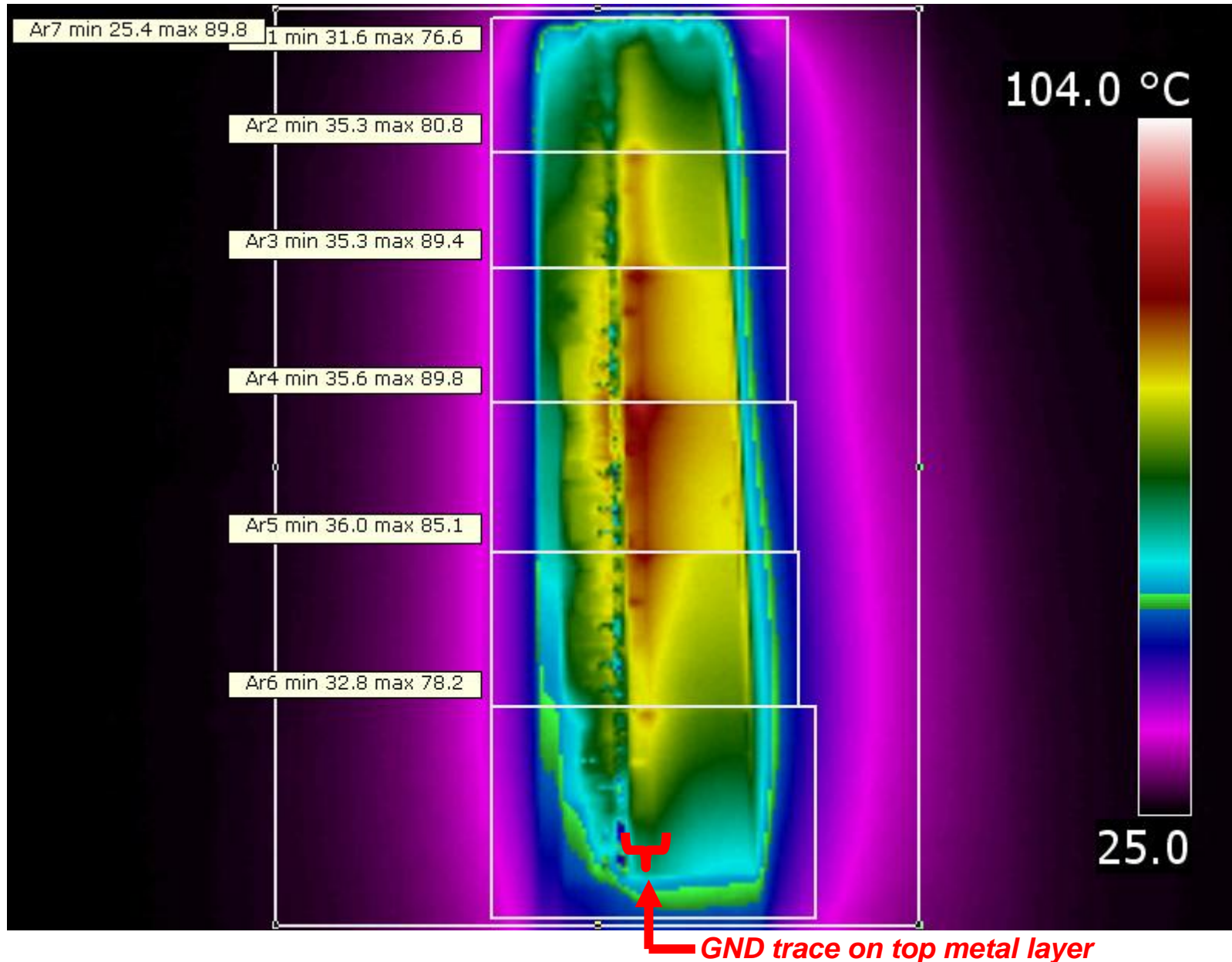
- GND trace on the top metal layer
- glue
- sole underneath the module which can act like a heater (residual heat between measurements)

The most important difference relies on the heat distribution/propagation which leads to the discrepancies when going to the extremities of the flex.

- GND trace on the top metal layer to be implemented
- hot spots to be redefined
- multiplier 4 ?



6 sensors are operating (OKF3)



Influence of the digital voltage on the temperature



Configuration	pictures	Sensor1 °C	Sensor2 °C	Sensor3 °C	Sensor4 °C	Sensor5 °C	Sensor6 °C	Max Temp. °C (sensor Nb)
All 50%	611	81.8	89.2	97	97	92.1	86.1	97 (3+4)
All 50% [3V]	612	79	85.6	93	93	89.7	83.5	93 (3+4)
All 50%	621	83	90.6	98.6	98.6	93.9	85.4	98.6 (3+4)
All 50%	626	83.3	91.7	93.7	99.1	93.8	86.2	99.1 (3+74)
All ~6σ	629	76.6	80.8	89.4	89.8	85.1	78.2	89.8 (3+4)
All ~6σ	637	74.3	79.5	86.1	91.3	85	78.2	91.3 (4)
All ~6σ [3V]	630	72.9	78.1	86.7	86.7	80.9	74.7	86.7 (3+4)
All ~6σ [3V]	638	73.2	76.6	82.1	87	82.5	76.8	87 (4)
Temp Difference (red,50%)		3.7	4.6	3.4	5	3.6	2.4	5
Temp. Difference (blue,~6σ)		2.4	2.8	3.3	3.7	3.3	2.4	3.7

- 6 sensors operating
 $50\% \text{ DeltaPower}[V_{ddD}, 3.3V-3V] = 858-780 = 78 \text{ mW}$
 $\sim 6\sigma \text{ DeltaPower}[V_{ddD}, 3.3V-3V] = 727-657 = 70 \text{ mW}$
- We see the effect on the temperature of reducing V_{ddD} to 3V between 2 and 5 °C according to the sensor localisation

Influence of the sensors activity on the sensors

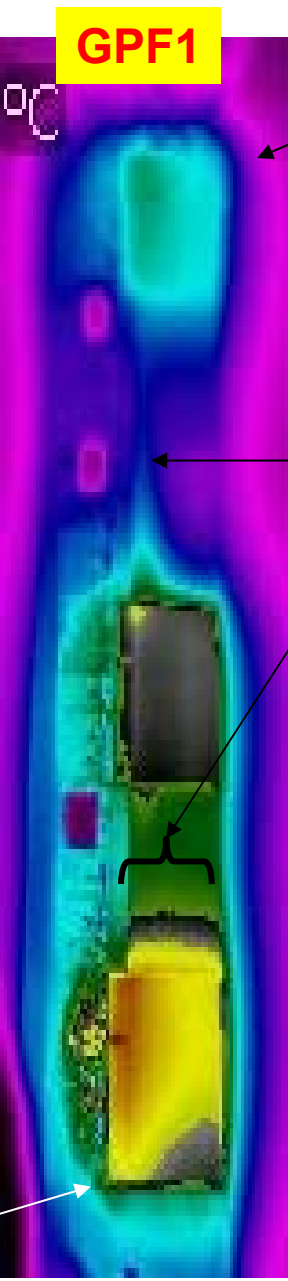
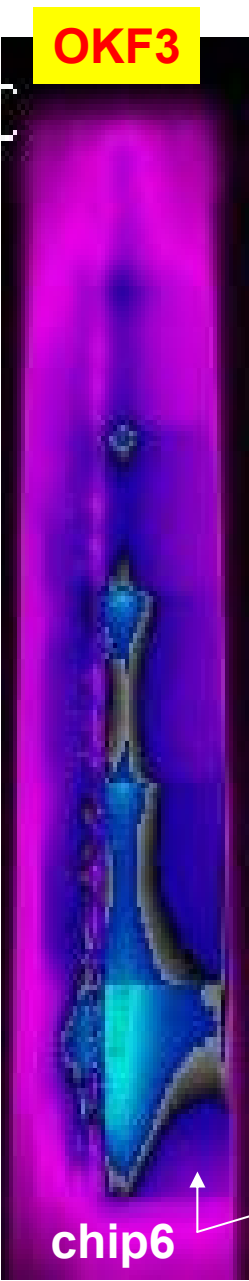


Configuration	pictures	Sensor1 °C	Sensor2 °C	Sensor3 °C	Sensor4 °C	Sensor5 °C	Sensor6 °C	Max Temp. °C (sensor Nb)
All 50%	611	81.8	89.2	97	97	92.1	86.1	97 (3+4)
All 50% [3V]	612	79	85.6	93	93	89.7	83.5	93 (3+4)
All 50%	621	83	90.6	98.6	98.6	93.9	85.4	98.6 (3+4)
All 50%	626	83.3	91.7	93.7	99.1	93.8	86.2	99.1 (3+74)
All ~6σ	629	76.6	80.8	89.4	89.8	85.1	78.2	89.8 (3+4)
All ~6σ	637	74.3	79.5	86.1	91.3	85	78.2	91.3 (4)
All ~6σ [3V]	630	72.9	78.1	86.7	86.7	80.9	74.7	86.7 (3+4)
All ~6σ [3V]	638	73.2	76.6	82.1	87	82.5	76.8	87 (4)
Temp.Difference (50% -6σ)		5.2	8.4	7.6	7.2	7	7.9	7.2
Temp.Difference(50% -6σ)3V		6.1	7.5	6.3	6.3	8.8	8.8	6.3

- We see the effect on the temperature by reducing the sensor activity
~5-8 °C (6-9°C @3V=VddD)

Only sensor 6 is operating (GPF1 & OKF3)

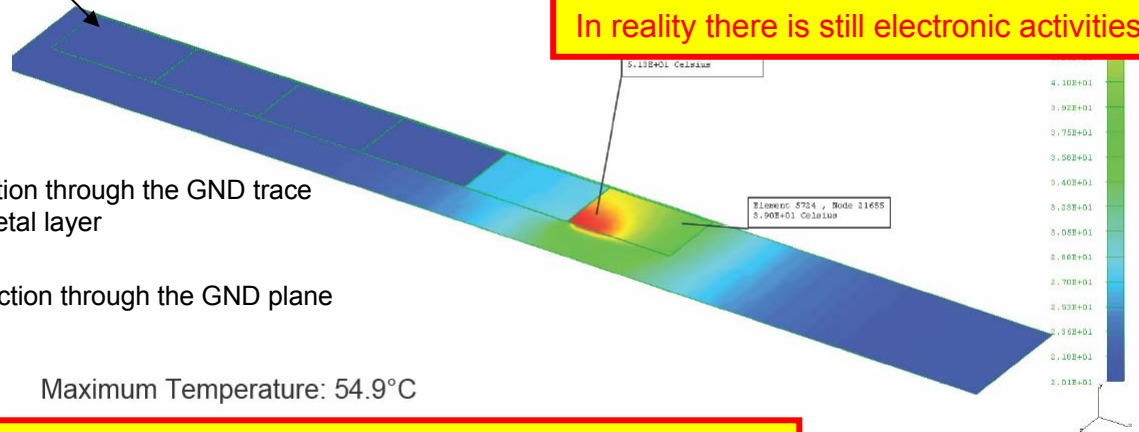
When considering only chip6 operating the other sensors are OFF ie (ILVDS=ILVDSTx=0) BUT we can see that their behaviour while they are power supplied but turned off is not modelised in the simulation
In reality there is still electronic activities



Polyamide – One Sensor O

```

February 1
07:10:10 - Multiplier 4
MODE VIEW
MODE TEMPERATURES
COMPRESSOR Shell: Uncovered Top shell
CNS: 2.01E+01 Celsius Max: 8.49E+01 Celsius
Face Coordinate System
    
```



Heat conduction through the GND trace on the top metal layer

Heat conduction through the GND plane

Maximum Temperature: 54.9°C

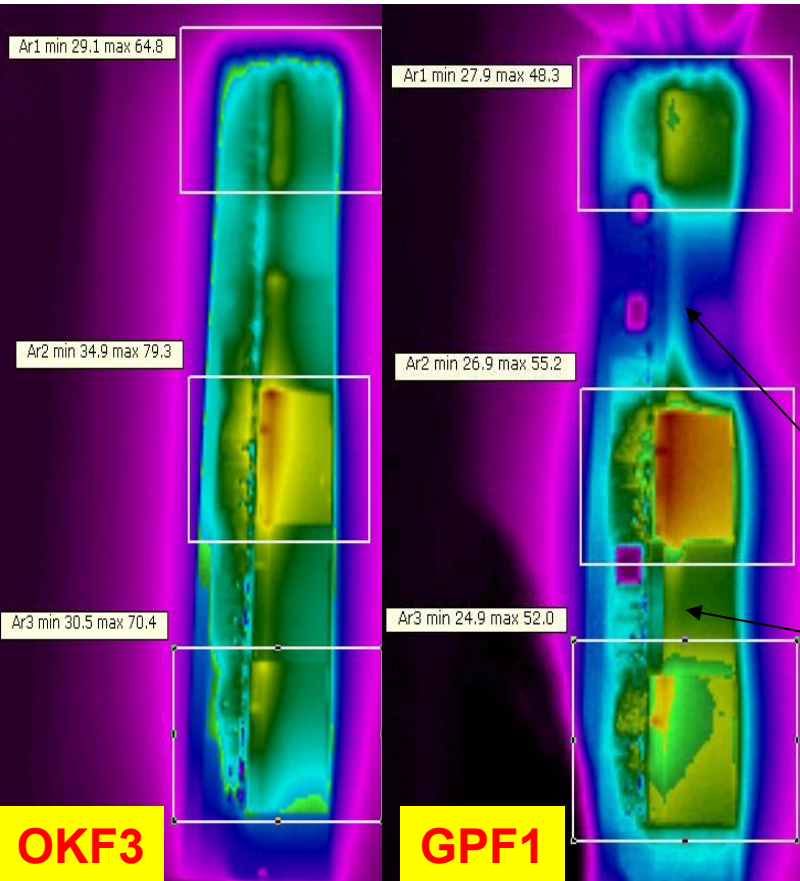
Nevertheless for GPF1, the max. temp. of chip6 is comparable to the one of the simulation eventhough the heat distribution on the overall flex is not correct. Probably because chip6 remains quite *isolated* from the heat generated by the other sensors.



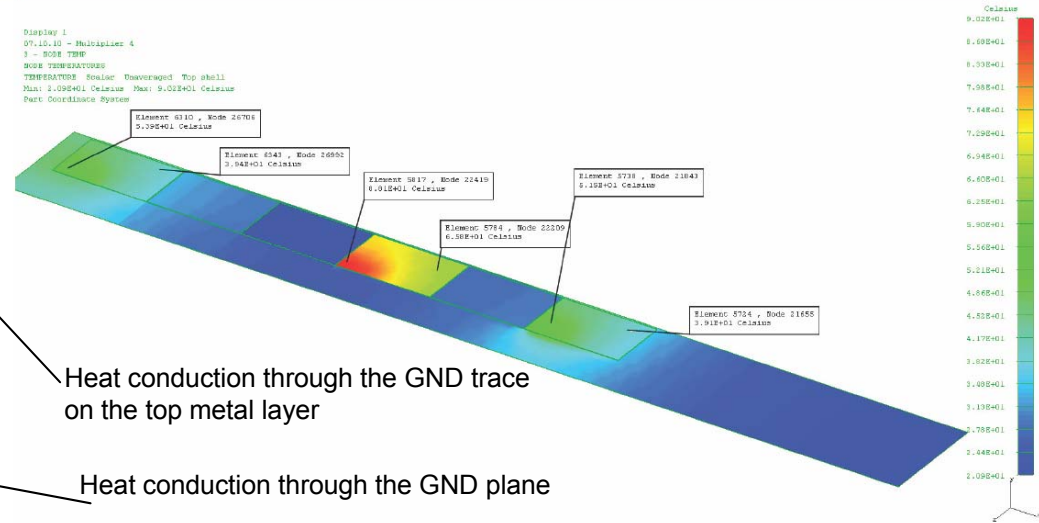
Config	pic	Sensor1 °C	Sensor2 °C	Sensor3 °C	Sensor4 °C	Sensor5 °C	Sensor6 °C
Chip6 50% OKF3	600	44.4	47.9	51.8	56.9	62.3	62.9
Chip6 50% GPF1	724	43.8	x	x	50.8	x	56.1
Chip6 ~6σ OKF3	590	51.5	55.4	58.9	63.2	62.8	68.5
Chip6 ~6σ GPF1	742	44.3	x	x	47.8	x	52.6
FH's simu FR4		x	x	x	x	x	54.3
Temp. Difference (50%/~6σ)		x	x	x	x	x	1.8/-1.7

* I didn't measure the current consumption for this configuration so I'm comparing both configurations

Sensors 6+4+1 operating (GPF1 & OKF3)



Polyamide – Three Sensor Operating



Maximum Temperature: 90.2°C

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- For OKF3 : the results are not comparable because of the presence of the other sensors also generating heat eventhough they are turned off.
- For GPF1 : the temperature measured are lower especially for sensor 4. The heat spreads more in reality (importance of the GND trace on the top metal layer and of the GND plane on the bottom metal layer) than in the simulations.

Config	pic	chip1 °C	chip2 °C	chip3 °C	chip4 °C	Chip5 °C	Chip6 °C
Chip6+4+1 50% OKF3	659	65	x	x	78.8	X	71.1
Chip6+4+1 50% GPF1	730	50.8	X	X	58.6	X	56
Chip6+4+1 ~6σ OKF3	696	64.8	X	X	79.3	X	70.4
Chip6+4+1 ~6σ GPF1	751	48.3	X	X	55.2	X	52
FH's simu (Polyam./FR4)		55.2/ 59.8	X	X	90.2/ 87	X	55.1/ 58.7

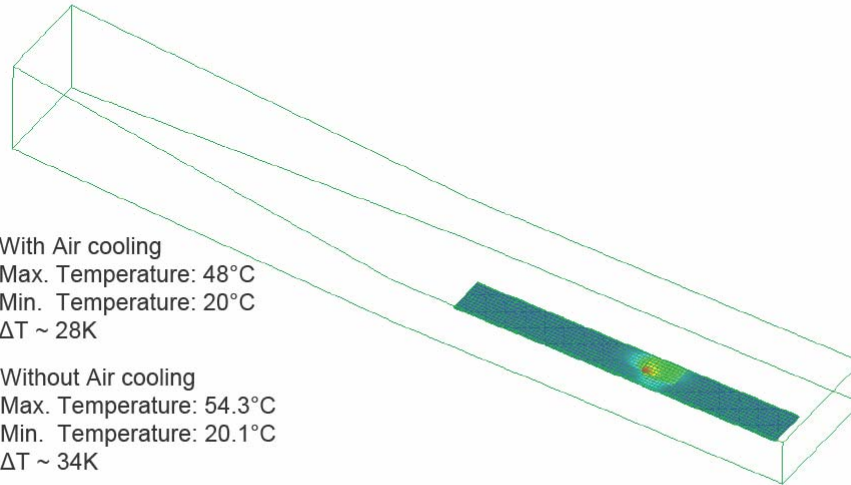
Air cooling : sensor 6 operating (GPF1)



- Measurements at $\sim 6\sigma$ thresholds
- I only consider measurements on GPF1 as it's the closer configuration to the simulation
- Not the same configuration as the simulation : big interface cable interacting (turbulence) with the cooled air, the fan is on the other side (near chip6)
- $T_{amb} = 27^\circ\text{C}$
- I don't have a precise anemometer therefore I didn't measure precisely the air speed and temperature but this could be done afterwards (calibration of the fan).
(average air speed ~ 1.5 m/s)
- The fan is at 14 cm of the chip6

Result with air-volume and a Fan of (60x60)mm²

```
Display 1
COPY_OF_Fen1
SOLID-TEMP ON NODES
SOLID-TEMP / ON NODES
TEMPERATURE Scalar Unaveraged Top shell
Min: 2.00E+01 Celsius Max: 4.80E+01 Celsius
Part Coordinate System
```



With Air cooling
 Max. Temperature: 48°C
 Min. Temperature: 20°C
 $\Delta T \sim 28\text{K}$

Without Air cooling
 Max. Temperature: 54.3°C
 Min. Temperature: 20.1°C
 $\Delta T \sim 34\text{K}$

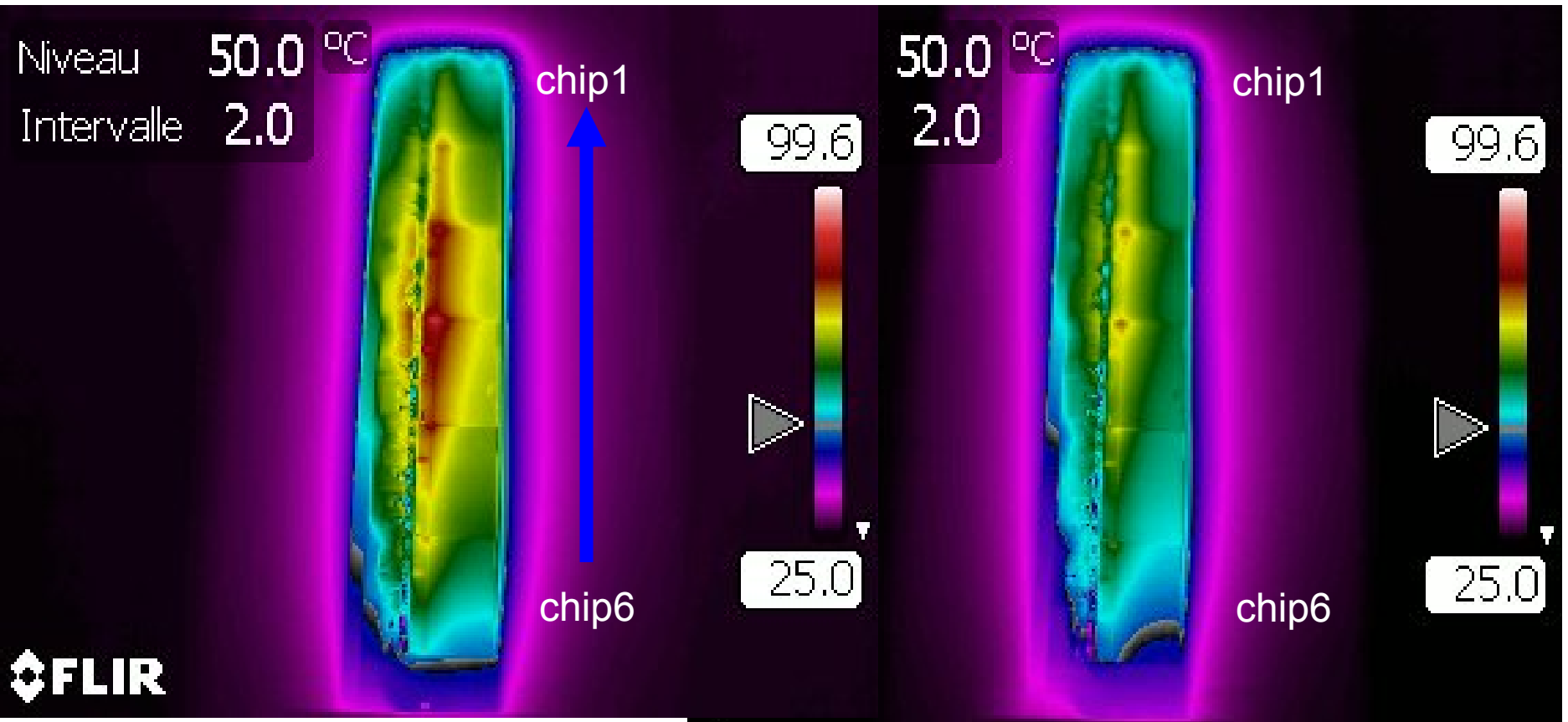
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	GPF1	Simu.
Without air cooling chip 6 is at a max. temp. (pic742) of :	$\sim 52.6^\circ\text{C}$	54.3°C
With air cooling chip 6 is a max. temp. (pic743) of :	$\sim 50.1^\circ\text{C}$	48.0°C (1m/s)

Just to give an idea ...

Air cooling : all sensors operating (OKF3)



Config	pic	chip1 °C	chip2 °C	chip3 °C	chip4 °C	Chip5 °C	Chip6 °C
all ~6σ OKF3	714	76.6	84.7	86.6	90.4	85.3	77.9
all ~6σ OKF3 + fan (~1.5m/s)	715	74.3	77.1	80.4	80.4	74.2	68.3
Temp. Diff		2.3	7.6	6.2	10	11.1	11.6



Air cooling direction
1.5m/s in average

Conclusion



- I can not check that there is no big difference between using an FR4 or a polyamide flex because I don't have a PCB flex equipped with 6 sensors.
 - Comparison with Franziska's simulations :
 - **all 6 sensors operating** : we find the same global behaviour (sensors 3+4 are the hottest : no cooper plane underneath). The heat distribution between the model and the reality could be improved by giving new inputs to Franziska
 - **sensor 6 only operating** : the behaviour of the bonded sensors turned off is not simulated but as chip6 is separated from the heat produced by the other sensors and as there is no silicon near chip1 to faster dissipate its heat, we find similar results (difference 2°C).
 - **air cooling** : sensor 6 operating
to compare the result is not relevant for the moment
no dynamical aspect
it seems difficult to cool the sensor : at ~1.5m/s we're still at 80°C (optimization of the set up)
- => Do we need to improve simulation by redefining more precisely the hot spots on the sensor ?**
- Other remarks :
 - Temperature variation according to the sensors activity from 50% to $\sim 6\sigma$ => ~5-8 °C less
 - Temperature variation according to the sensors digital voltage from 3.3V to 3V => ~2-5°C less
 - Thermal test bench in DESY ?
Glue for Lena
Do we need to go further on in Strasbourg ? Tasks sharing and plans ?

Next steps



- Redo measurements to check the offset shift on GPF1 (next week) and see if when there are less activity on the chips if this shift still exists
- Further tests on GPF1 ?
To measure the influence of the 10 μ F capacitors at the end of the flex on GPF1. Can we remove them (flex 2011 design optimization) ?
- OKF3 Calibration (discriminators scans)
no need to calibrate all the DAC ?
- OKF4 mounting with sensors + tests ...