SiW ECAL *cooling*

(+HCAL cooling news)

JCL SACLAY November 28th 2013

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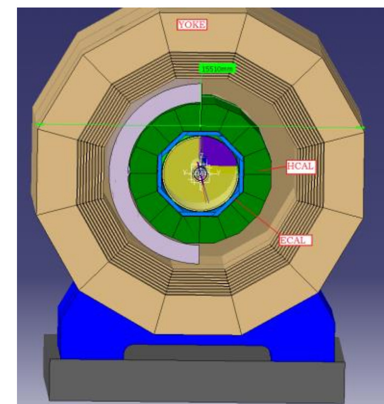
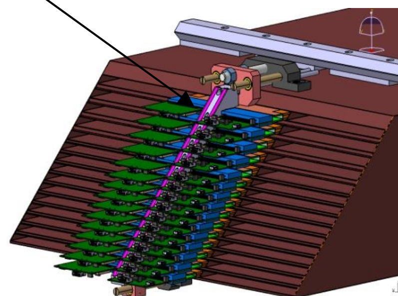
ECAL Cooling: the problem

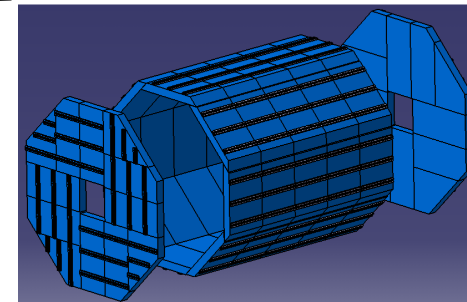
- ECAL detector is surrounded by detectors
  (detectors must be "thermal independents")
  (adjacent detector : thermalized at 20°c)



- Large exchange surface / low surface power (4500 W)

- Exchanger: location determined Cooling front–end
  25 mm free opening in DIF for extraction of cooling system





=>Needs:

- Thermalization @ ambiant temperature
- Low T° gradient accepted (20 °c)
- Variation of +/- 2.5°c

Conclusion
=>Choice: leakless water system

To be compared with a CO² diphasic system
- More difficult to implement
- More risky (leaks)
- And more expensive

Example of requirements for a CO² line

- Coaxial line
  - Sub-cooled liquid CO_2 at -40 ˚C in a 1.5mm OD pipe: no use here
  - 2-phase flow CO_2 (return line) at -40 ˚C in a 4 mm OD pipe
- The line needs to be flexible to be adapted to many turns and bends in situ
- Condensation on the surface has to be avoided
- Radiation hard materials

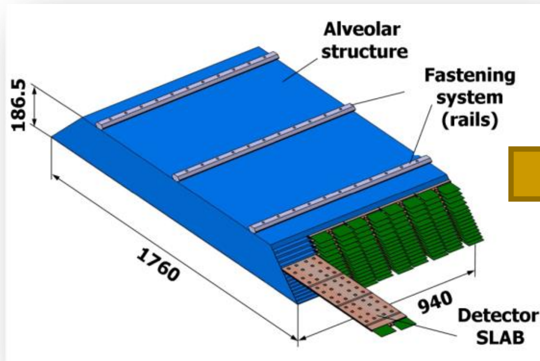
Design constraints

- Difficult to use foam insulation (Armaflex) due to space constraints:

Cooling: leakless water system

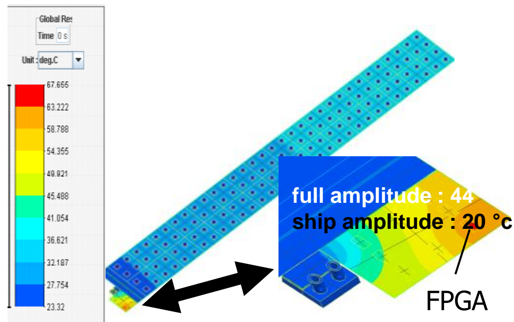
Calorimeter for ILC

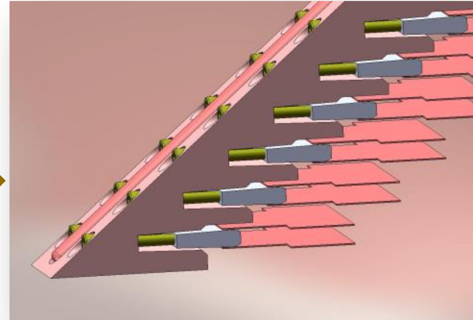
Study from the power source to the global cooling



SLAB

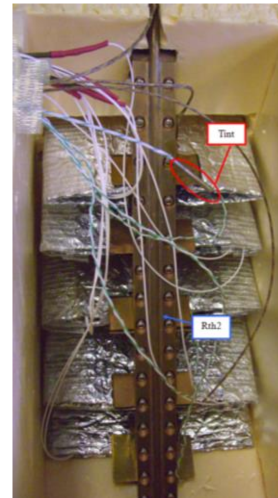
Thermal simulation and test on Slab

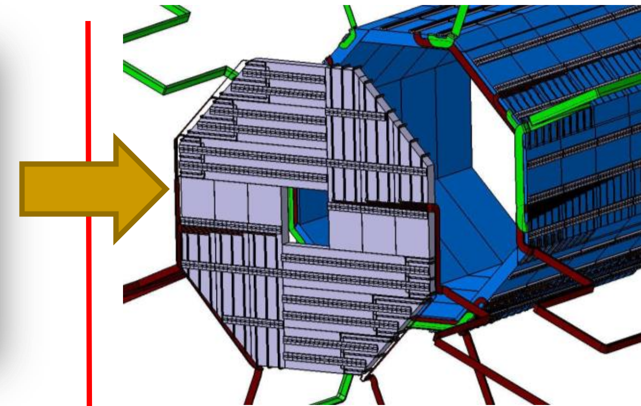




Heat exchanger

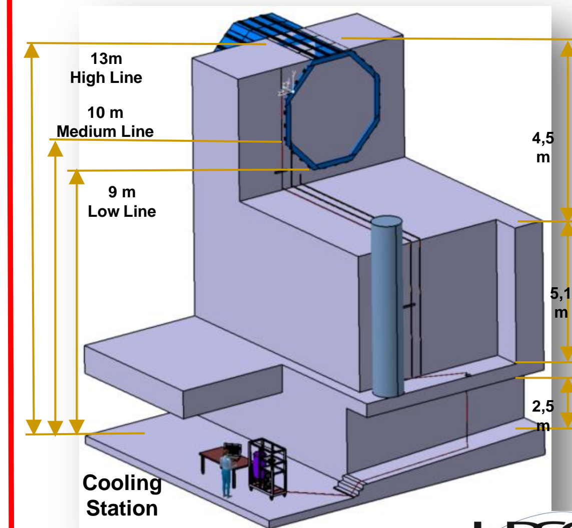
Simulation and test on different type of heat exchangers





Global cooling

True scale leak less loop
4500 W for whole detector



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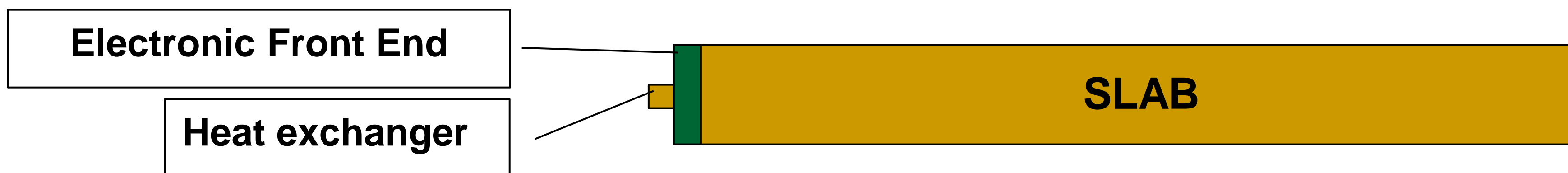
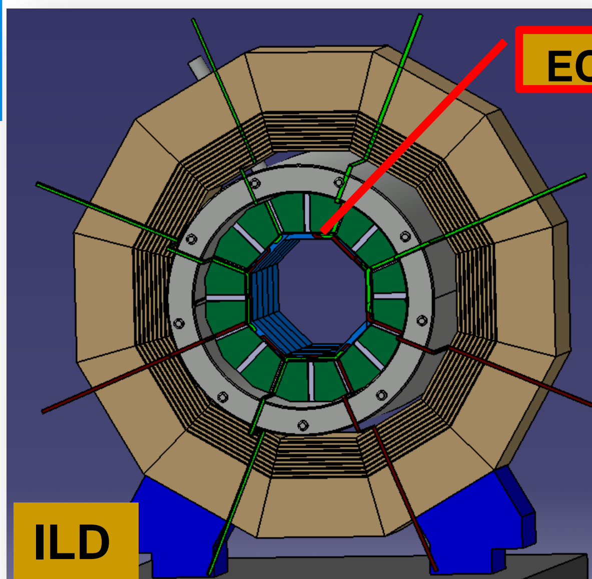
Cooling capabilities

/ Electronic consumption		Front electronic (W)	Wafer (W)	Total ECAL (W)	Temparature variation near the exchanger (°c) (Thermal contact resistance)	Temperature variation along the SLAB (°c)	Température at the end of the SLAB (°c) (water temp : 18°c)	Remark From 4,5 kW to…?
		1/2 SLAB						
Configuration 1	ECAL Goal	0.3	0.205	4500	0.5	2.2	20.7	Passive cooling : OK
Configuration 2	Front elec x 10	3	0.205	30 000	3.2	2.2	23.4	Front SLAB electronic close to the heat exchanger => low impact of the SLAB temperature
Configuration 3	Wafer x 10	3	2.05	45 000	5.1	24	47.1	Passive cooling may work
Configuration 4	Wafer x 100	3	20.5	205 000	24	250	292	Passive cooling will not work !! We need to work on active cooling in the SLAB

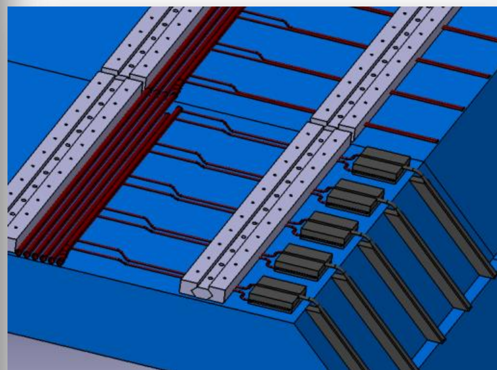


Cooling Integration

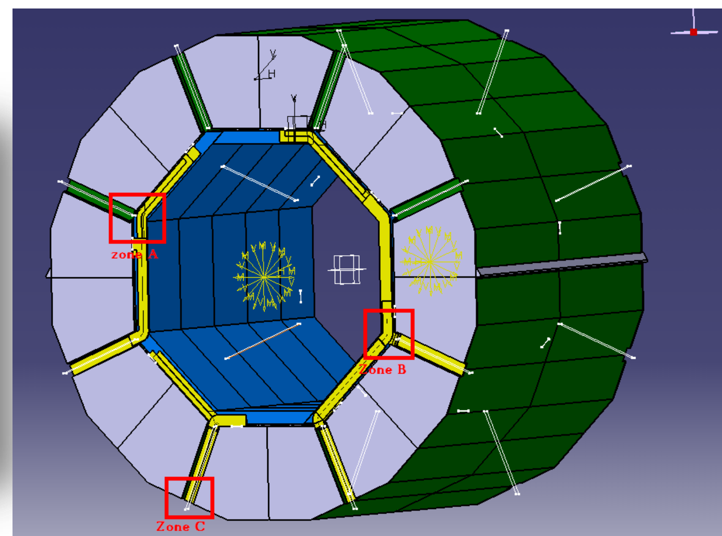
Calorimeter for ILC



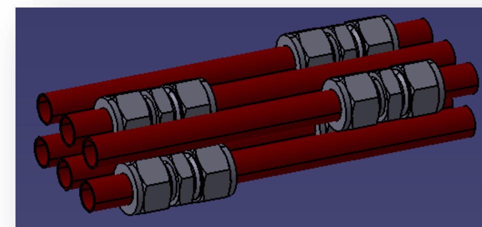
ECAL cooling lines crossing ILD



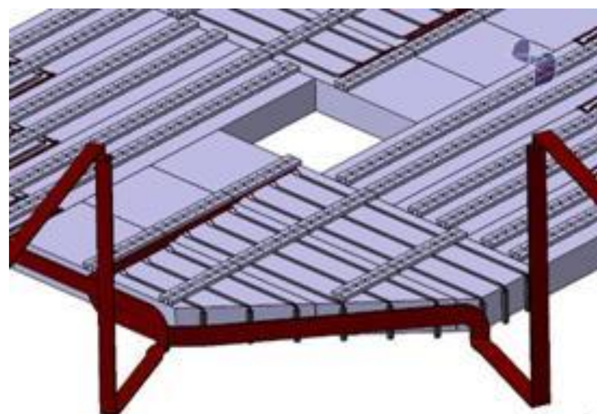
BAREL integration per module



Leak less => siphon not possible



Connection integration



ECAL End-Cap ~25,5 T
Intrados: integration with cooling lines

General distribution :
- **Water circulation under atmospheric pressure**
- **Water temperature input: 18°c**
- **Water temperature output: 23°c**
- **Maximal power per column: 150 W**
- **Pipes diameter : 13 mm**

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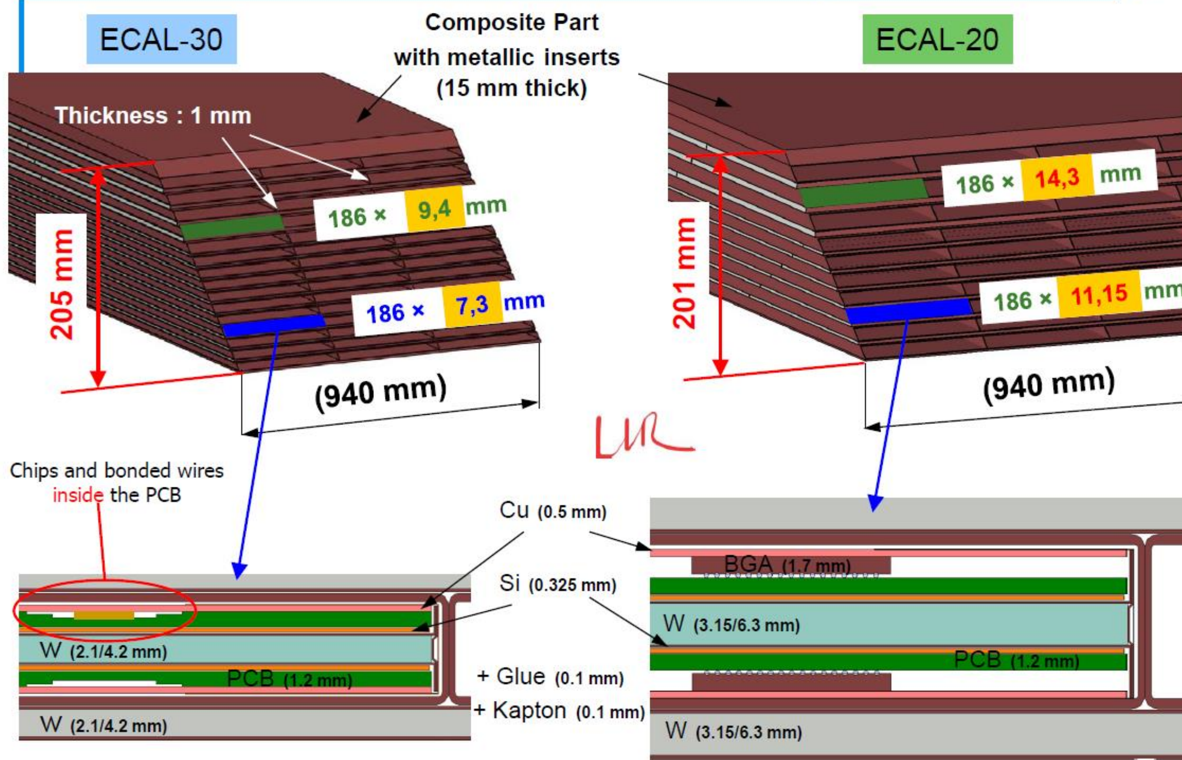
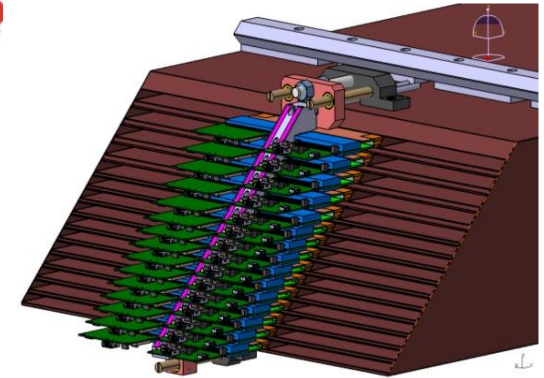
ECAL Cooling/ evolution

- This study is based on ILD target
- For the incoming "EUDET" prototype (<1 year), skiroc2 chips take about 1ms to stabilize, so it's 970µs more than expected and that <u>double or triple</u> the actual consumption
- For a ILD prototype (3 ans) it is hoped to have a skiroc3 which solves this pb & a new power-pulsed DIF (~100mW instead of 1W)





Update needed in thermal study:

- *Number of SLABs*
- *SLAB constitution (material distribution)*
- *Power variation*
- *Final geometry*
- *Power location (Front end or SLAB)*
- *Design: hydraulic safety, hardened components, cooling supervision of the representative process*

Barrel cooling

Cooling Options after local simulations

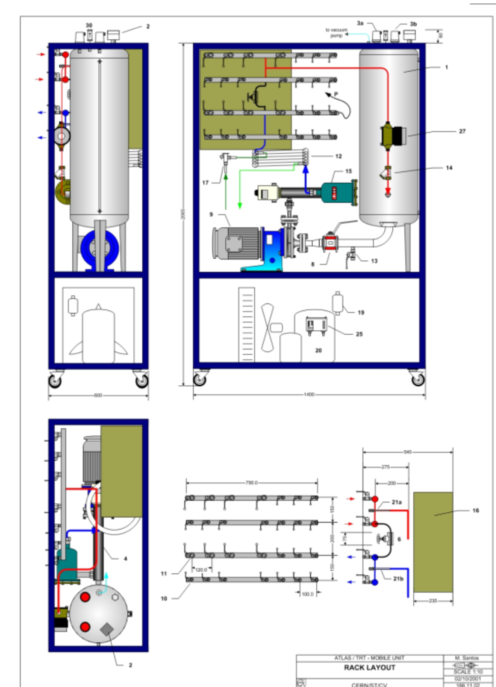
Low heat to extract

3 W/m² for GRPC *(total HCAL: 500 kW)*

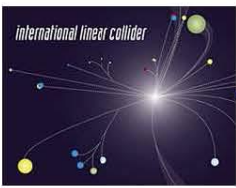
Big exchange surface

material with good conductivity

- **Leak-less water cooling** : no risk for electronic and other detectors, pressure between 0,8 and 1bar (cavitation), balanced network, pneumatic activators needed
- **Bi-phasic gas** like CO2 : High Pressure (100 bars), expensive connections (no leak), small diameter tubes, important exchange coefficient
- **Mono-phasic gas** like C6F14

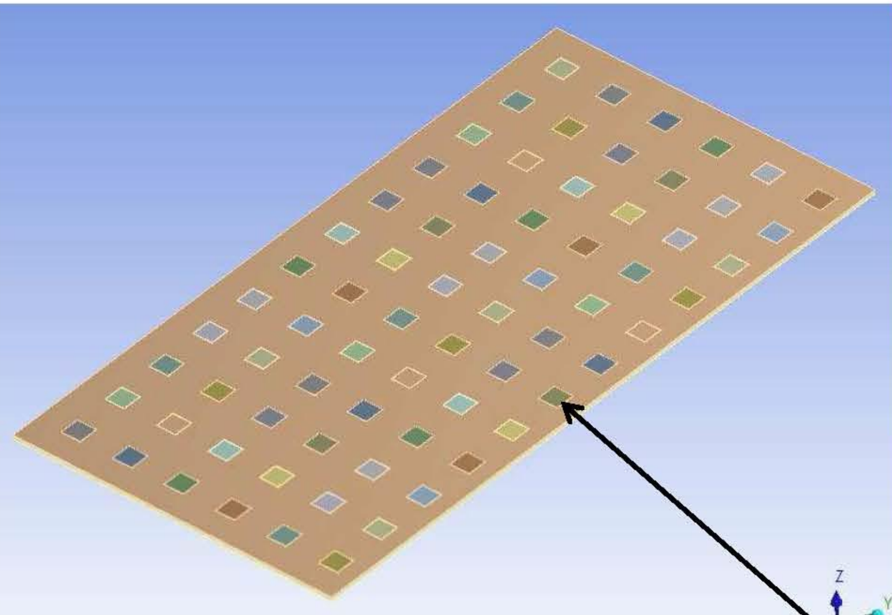


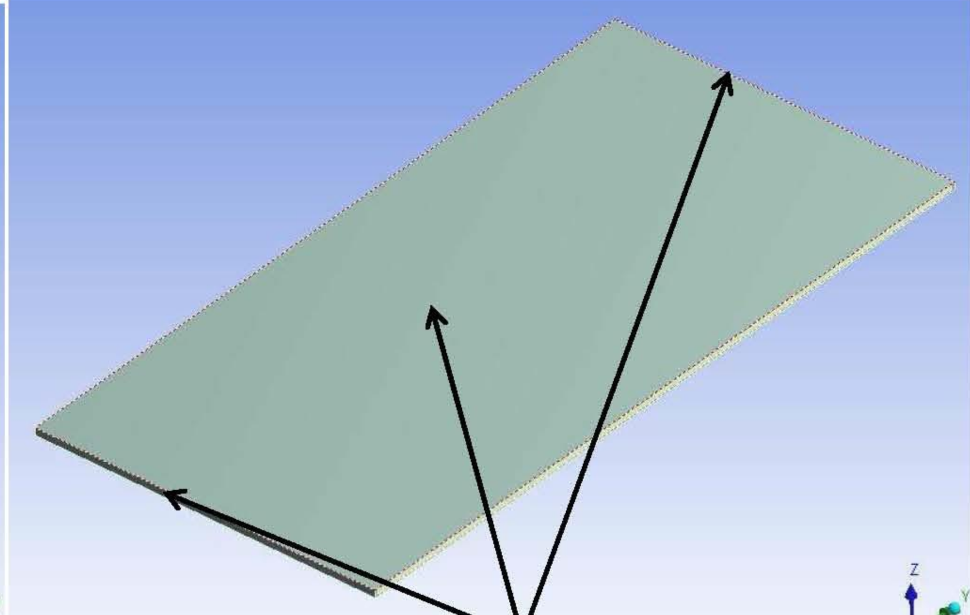
Atlas cooling plant



ILC M3 – *Thermal studies on GRPC*

12 x 6 chipsets modelisation = 1/2 detector



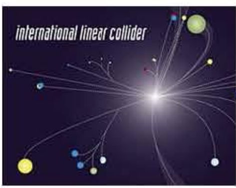


2 absorbers steel stainless 2.5 mm
72 chipsets 1.4 mm
1 pcb plate 1.4 mm
1 spacer polycarbonate 1.4 mm
1 glass 0.7 mm
1 frame pcb 1.2 mm
1 glass 1.1 mm

Heat exchange with air ambient 22°C on 2 faces and 3 sides

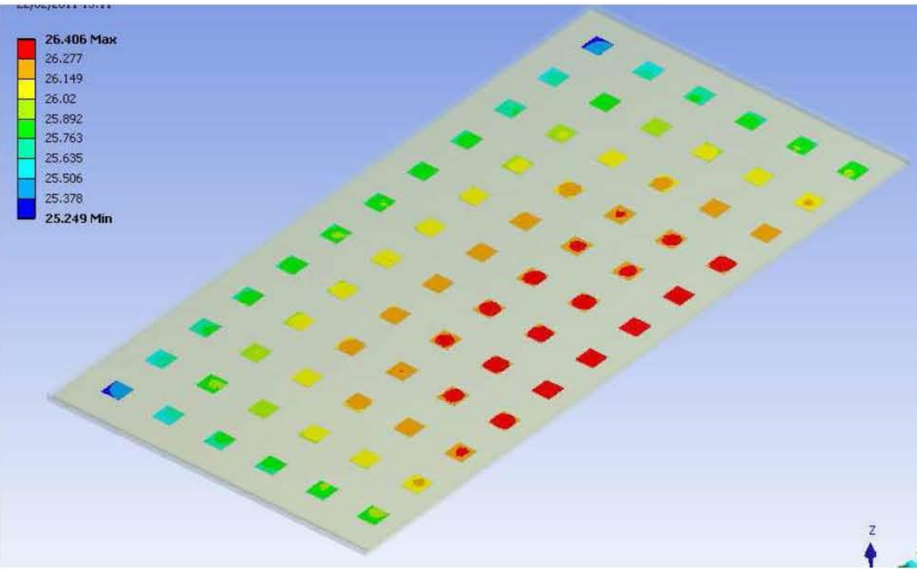
Heat flux on chipset = 0.133 W x 72 = 9.6 W

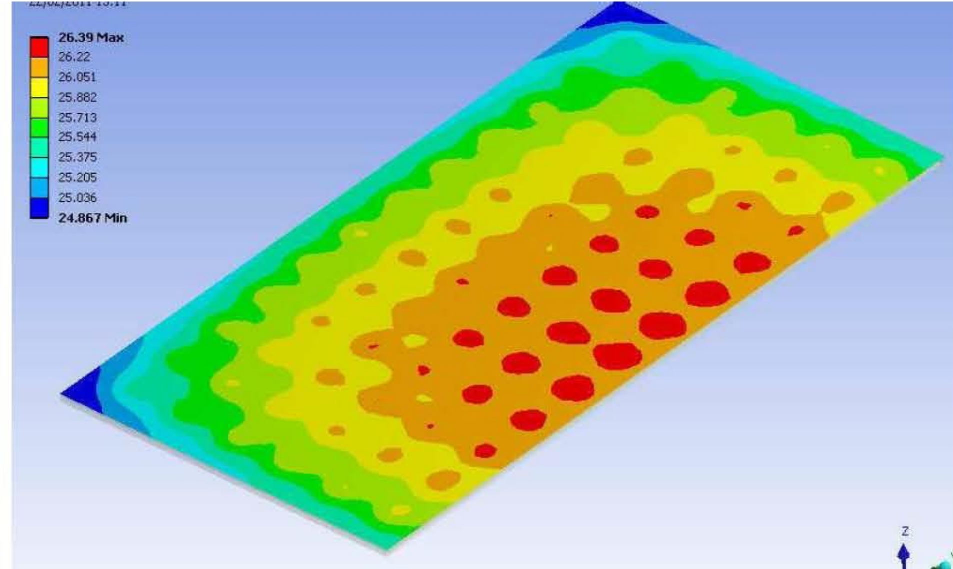
Laminar flow in gap of 2 mm between GRPC and absorbers



ILC M3 – *Thermal studies on GRPC*

Tmax = 26.4°C





Chipset

Absorber in contact with chipset

Heat extraction on 1 side absorbers for one detector = 9.6 w
Air ambient is OK for ILC M3
~~Water cooling~~ is needed for ILD Barrel – 0 W transmission

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