



ECAL

Cooling & mechanics status

at LPSC

CALICE Collaboration Meeting @ Casablanca

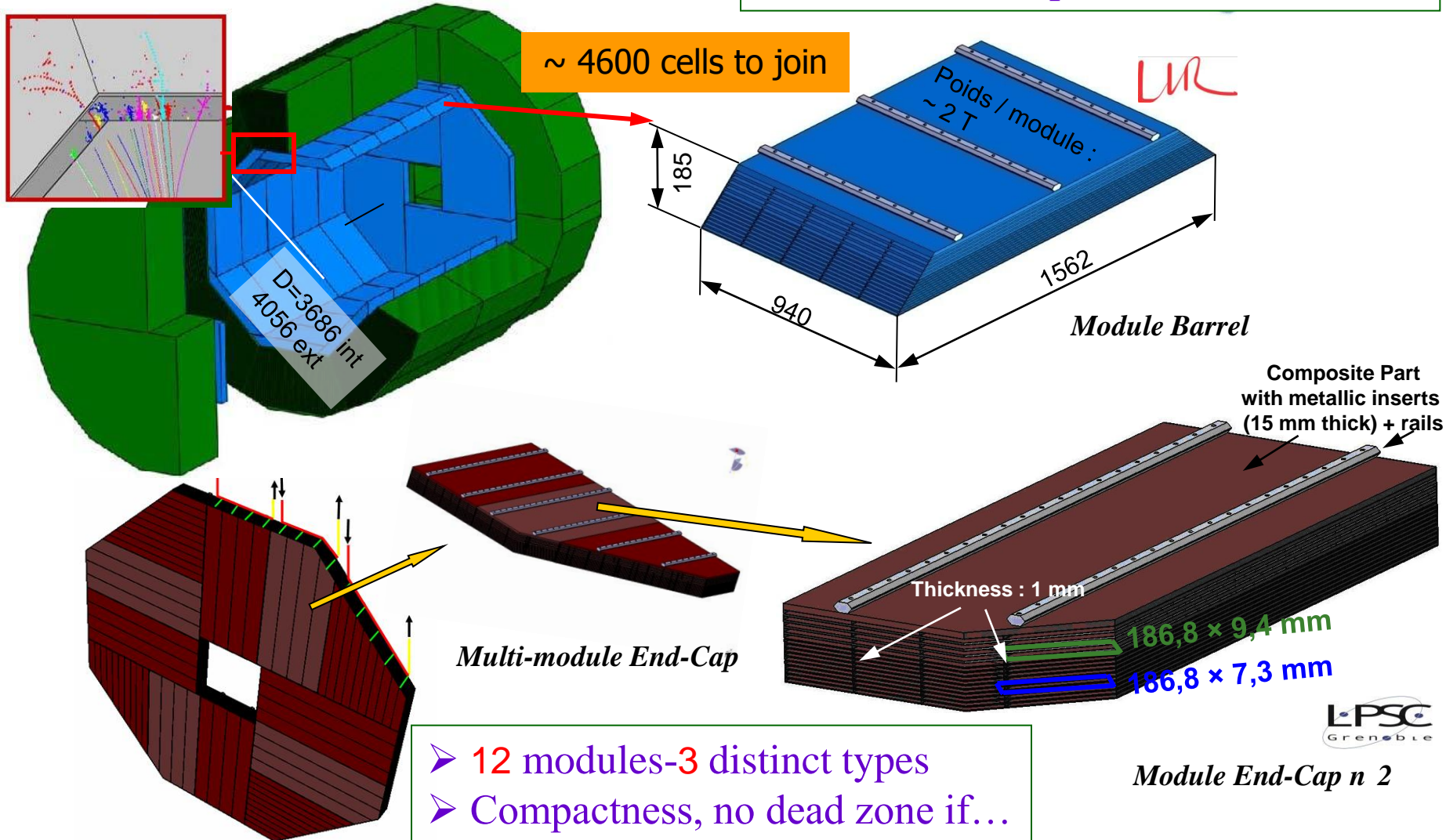


Denis Grondin – Sept.23TH, 2010

Si-W ECAL – Current baseline

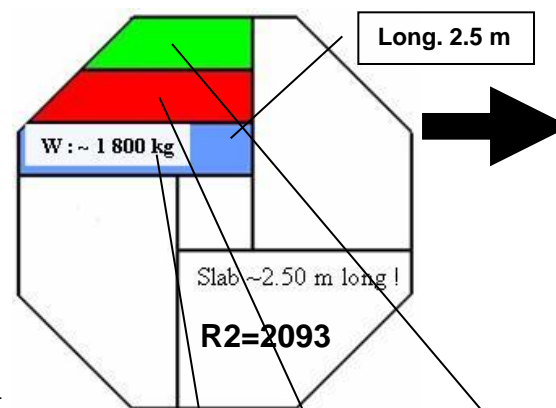
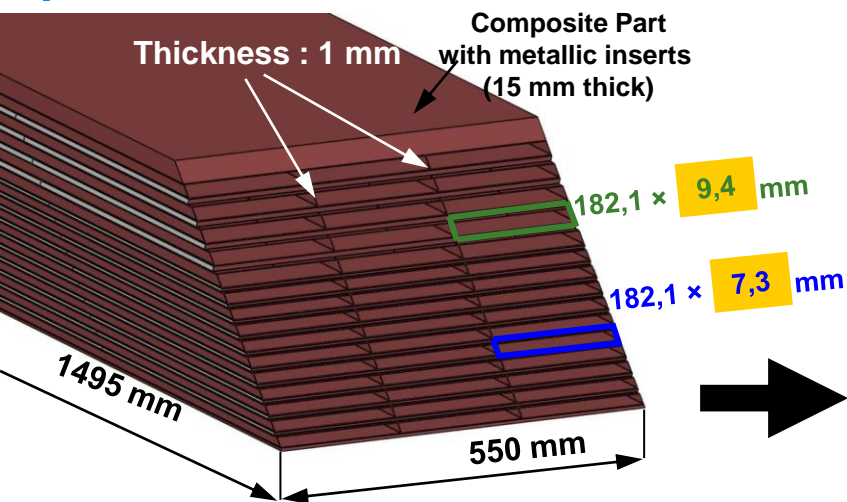
W/Si – ECAL weight:
~ 112 T (80 barrel+32 End-Cap)

- No dead zone, compactness
- 40 identical trapezoidal modules



End-Caps structure: baseline

- Today, with the barrel's demonstrator and EUDET, the process for composite structure is going to be validated, with a built layer module width based on 182.1 mm for EUDET, and 1,50 m long...

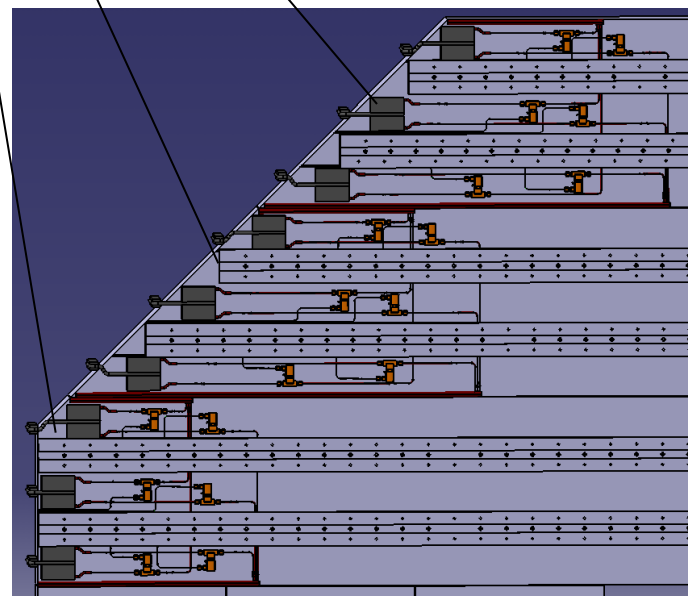


Construction of 2.5 m long composite alveoli : demonstrate whether or not the main process steps (similar to barrel ones) can be adapted

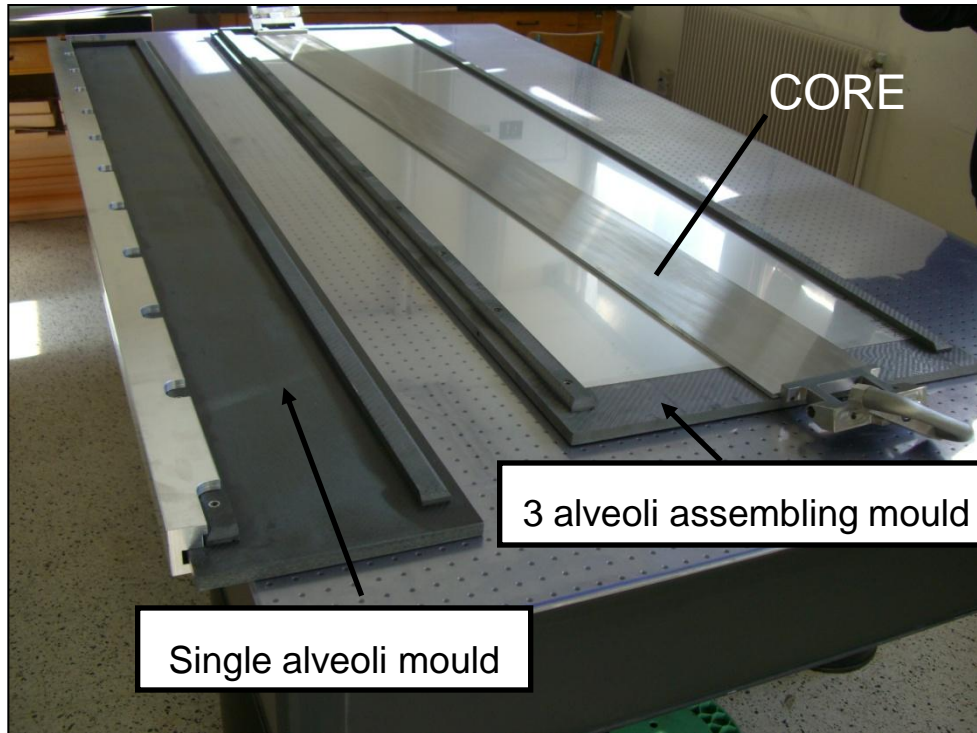
From Design of EUDET module → CALICE End-caps modules

End-cap structure : study and validation of most of technological solutions which could be used for the final detector taking into account industrialization aspect of process:

- Moulding process for long alveoli,
- Cooling system,
- Thick composite plates and stronger rails
- sizes of structures,...



End-Caps : long alveoli molding test



2.5 m alveoli molding

- The end-cap layer test consisted of
- **1 long alveolar cell**
(representative of the end-cap module longest layers)
- **Width of cell : 186.8 mm**
(Design2 - to fit LOI parameters (R~2090))
- **Thickness of cells : 6.5 mm - wall: 0.5 mm**
- **Length : 2.492 m**



Alveoli 2,50m: extraction of core

Pliers for extraction with good
adhesion on carbon plies



Friction
core/ 2,5 m carbon plies



First test:
negative

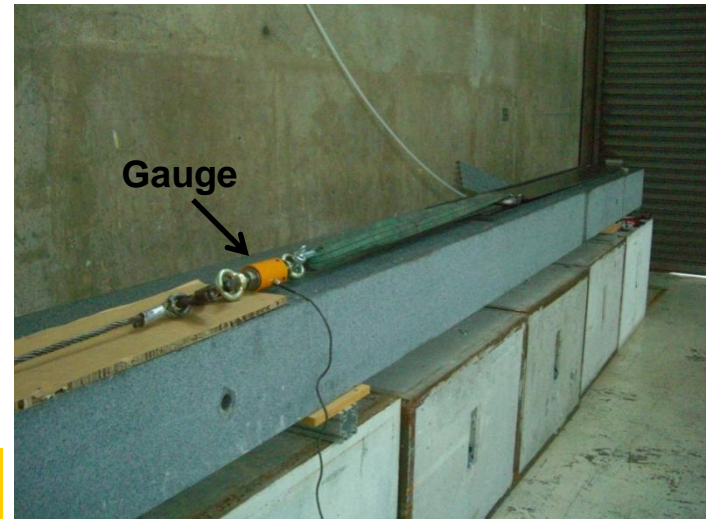


Adaptation on alveoli



Extraction : $>> 6000 \text{ N} !$

\Rightarrow To risky

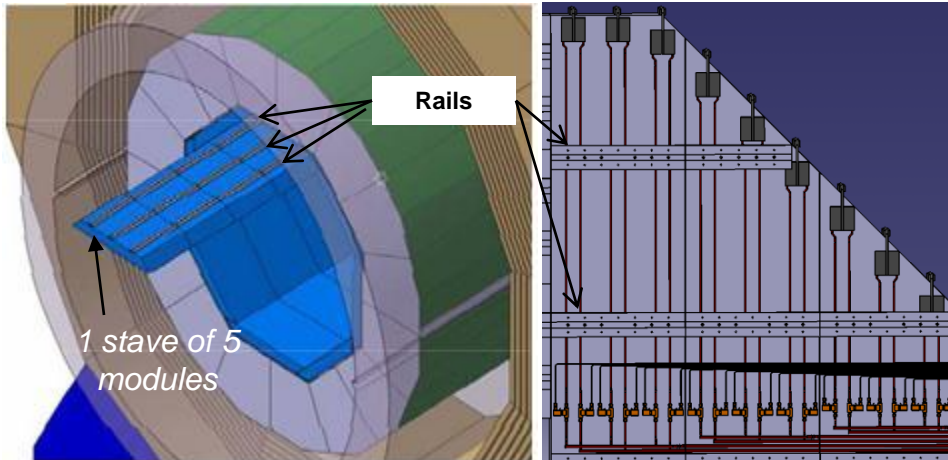


 New alveoli to mould with
aluminium core: *Fall 10*

Fastening ECAL/HCAL

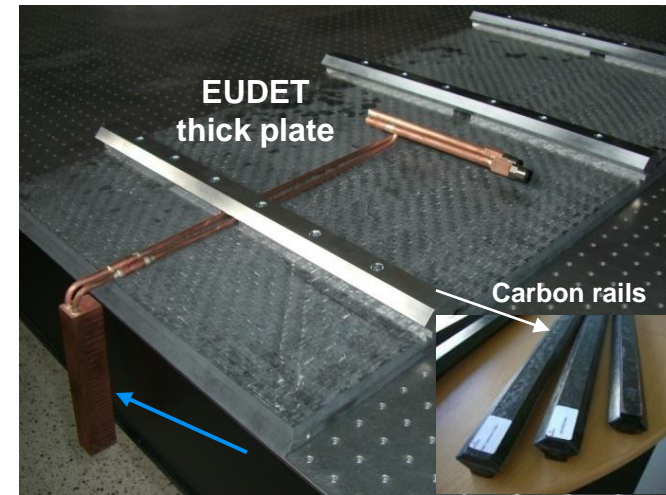
Constraints

- Fastening in a structure "wheel": bending constraints
- Carbon structure (thick plates and support...)
- Cooling pipes & cables (DAQ + HV + GND) integration



Barrel fastening

End-cap fastening



A column (cooling pipe), (25 mm wide minimum) to ensure quick thermal system's connection

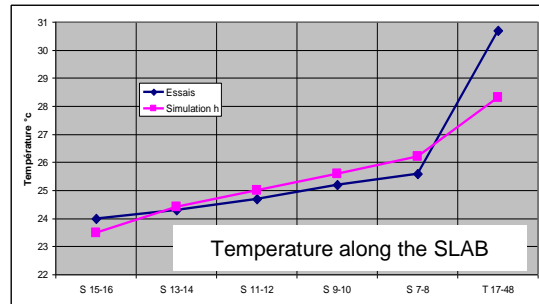
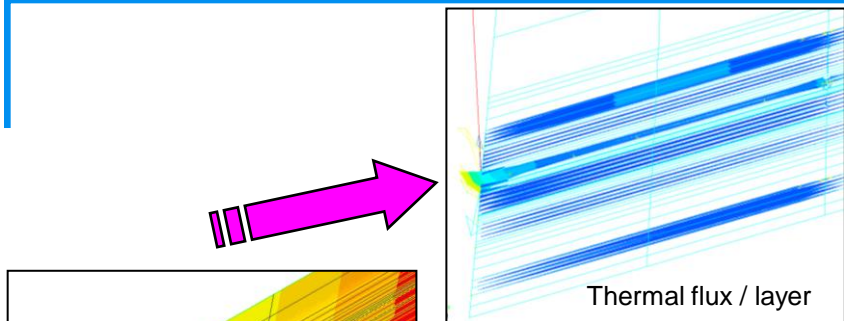
From metallic rails... to... composite structural system

- validation of technological solution
- industrialization aspect of process
- Alternative for fastening and positioning system: larger and thinner rails:

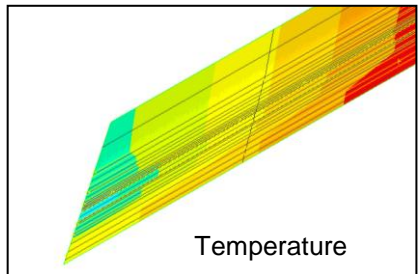


Mould for HexMC & SMC Carbon rails on a 80T heating press

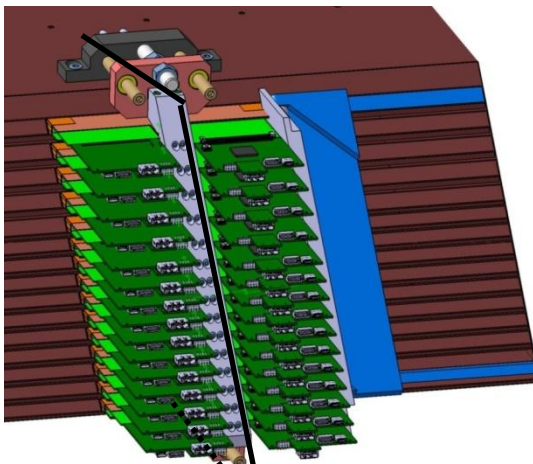
INTEGRATION COOLING ECAL



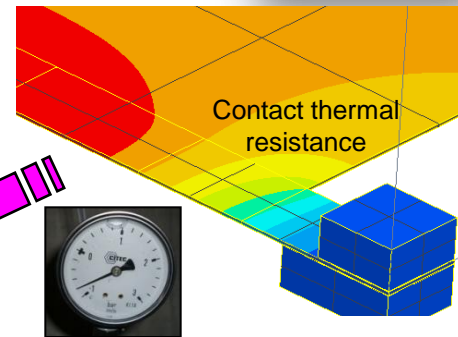
SLAB / Cooling connection



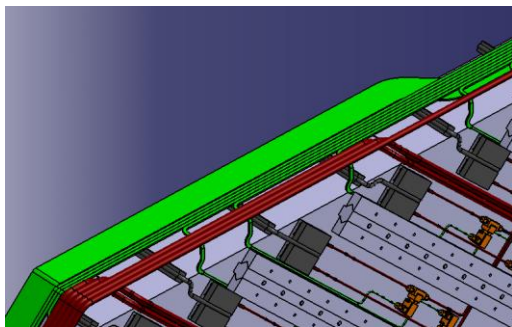
Module section thermal simulation



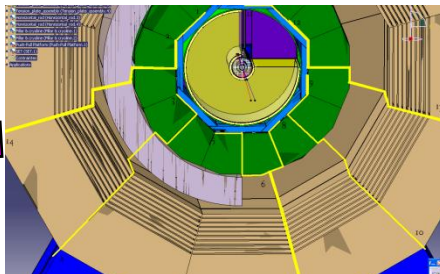
Test on demonstrator: correlation with simulation



Global cooling Leakless mode restriction (leakless zone is at the top of the loop)



Water circulation on module

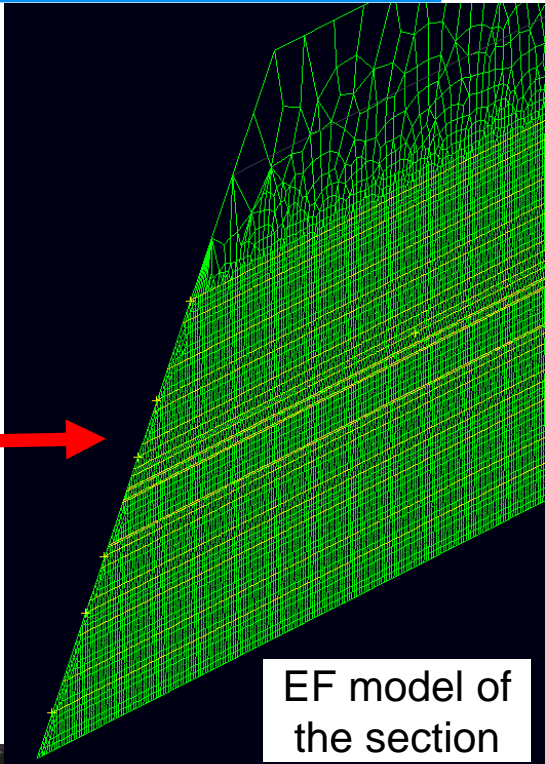
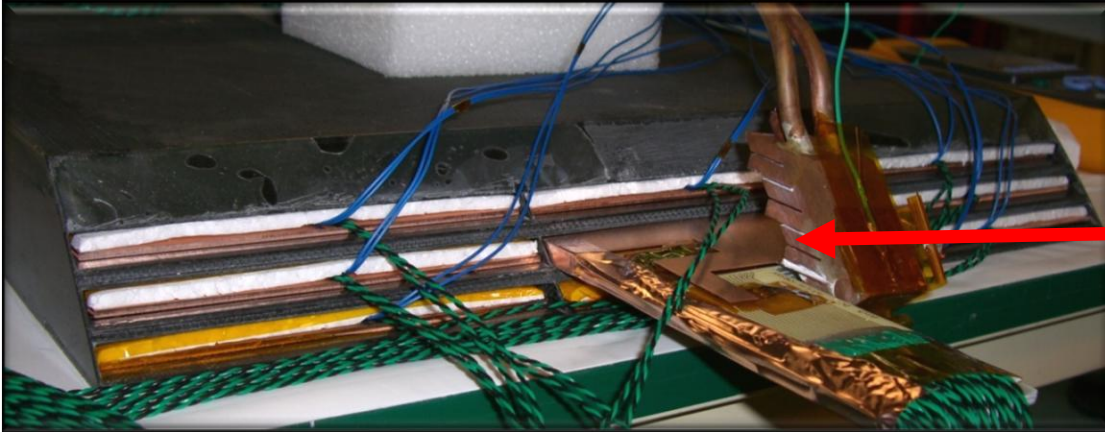


3D pipe modeling

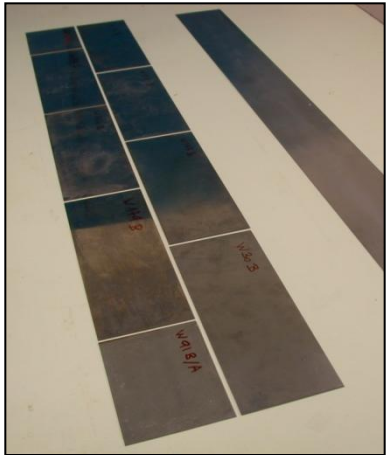
SLAB : thermal simulation

First step : Correlate test with simulation

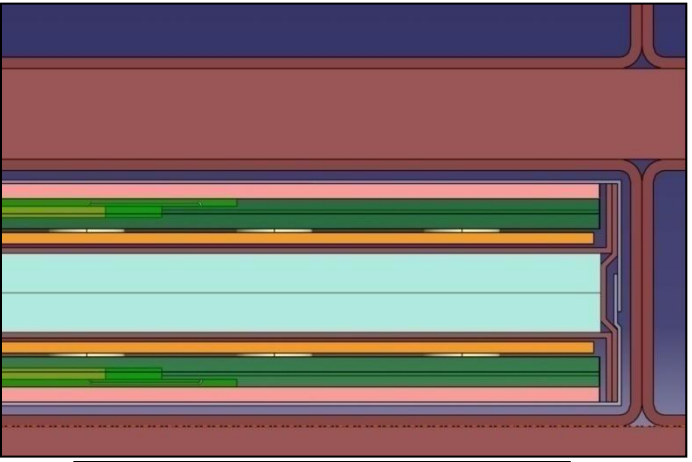
Thermal test with the first alveolar structure



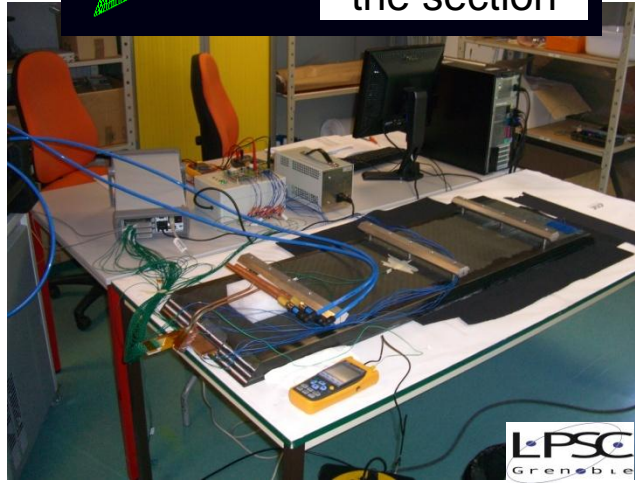
EF model of the section



Integrate W break



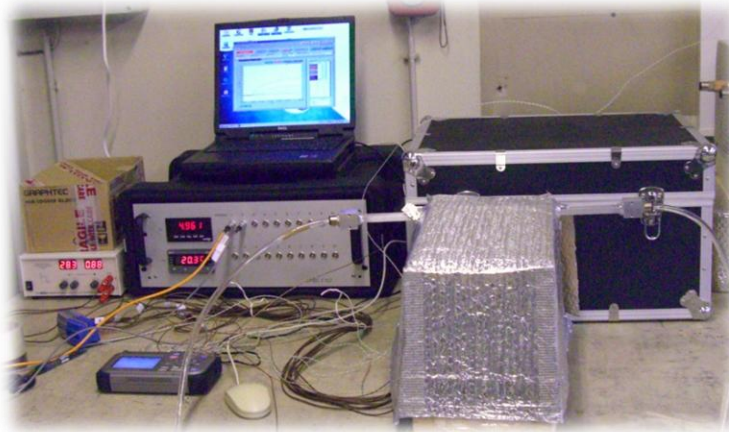
Integrate thermal contact resistance (air gap)



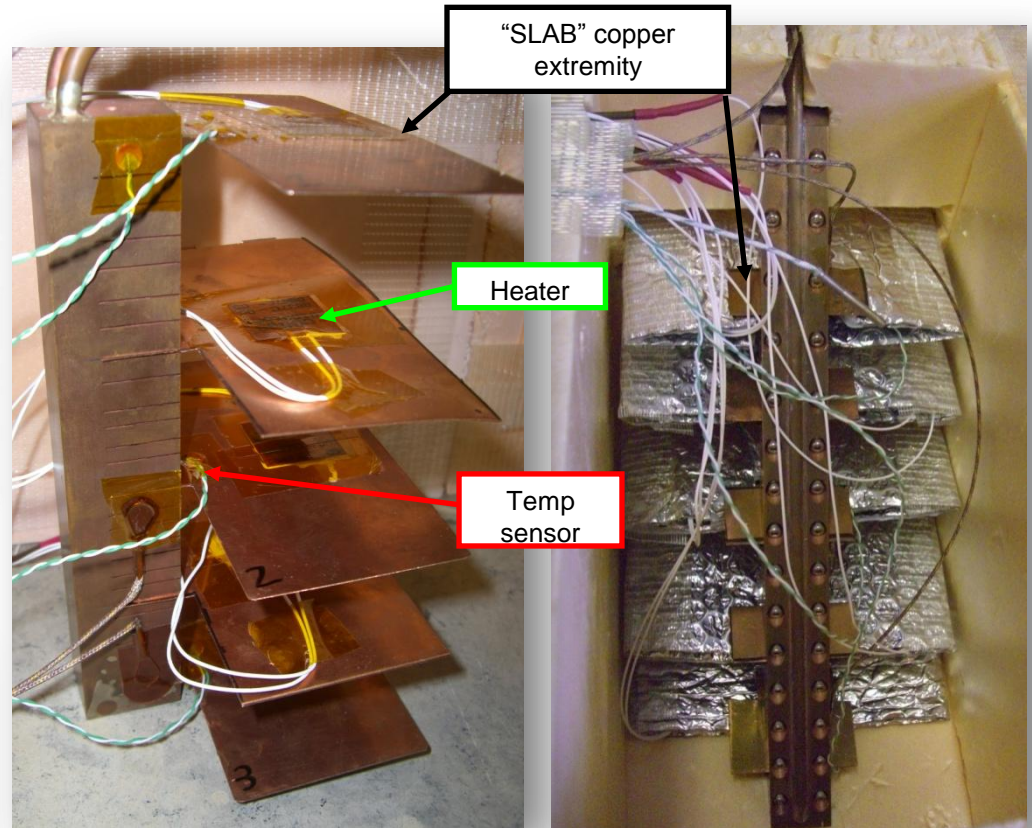
Front SLAB : thermal connection

Many thermal tests were done on heat pipe system and water system.

Goal => learn more about contact thermal resistance with the different configuration.



Test bench



Water
exchanger

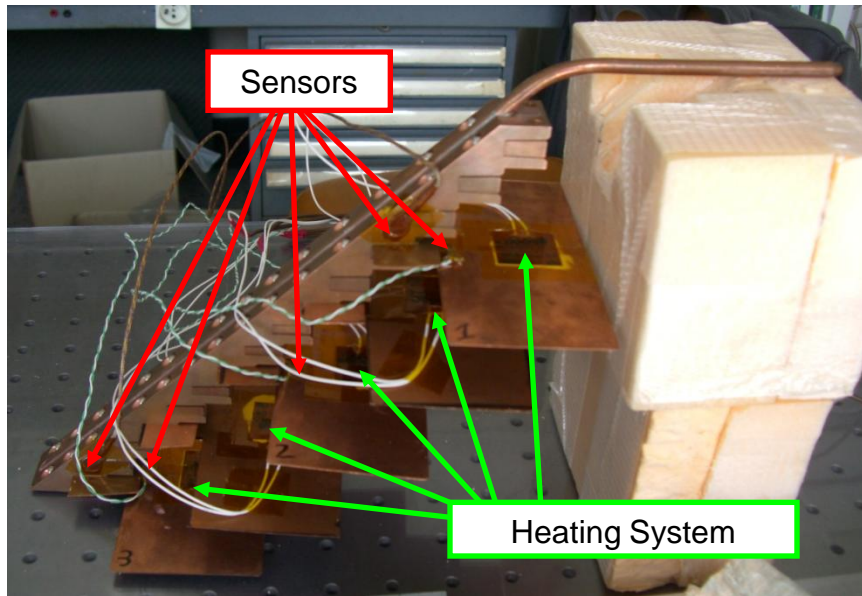
Heat pipe
exchanger



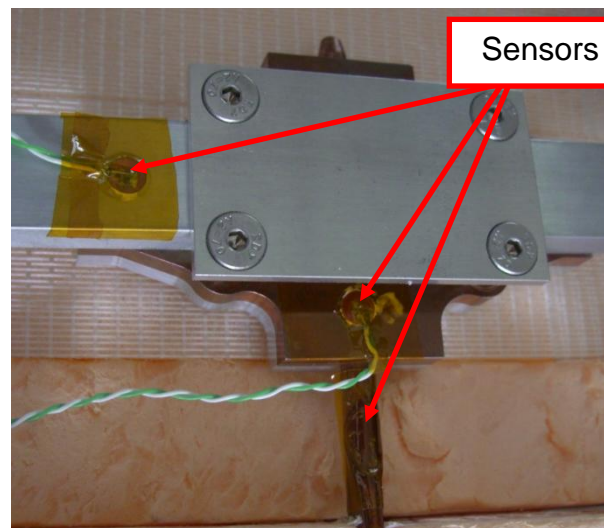
Connection Copper drain / exchanger

Cooling: heat pipe evolution

Tests on Heat-pipe

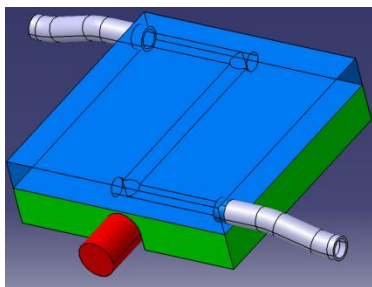


Evaporator

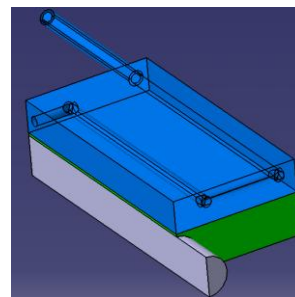
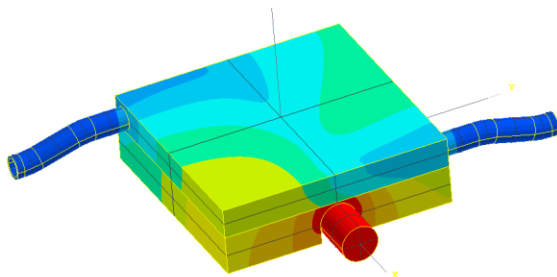


Condenser

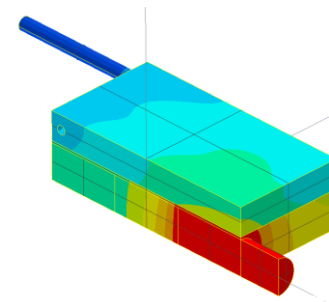
Heat-pipe optimizations



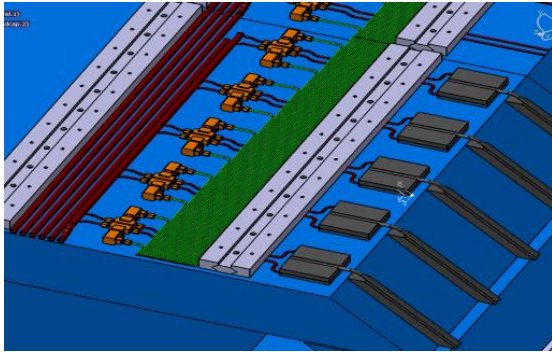
Temperature decrease / 28%



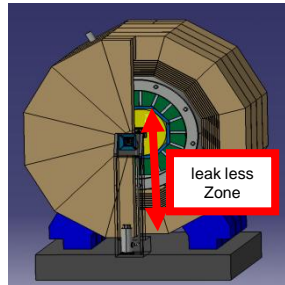
Temperature decrease / 29%
Independent cooling /column



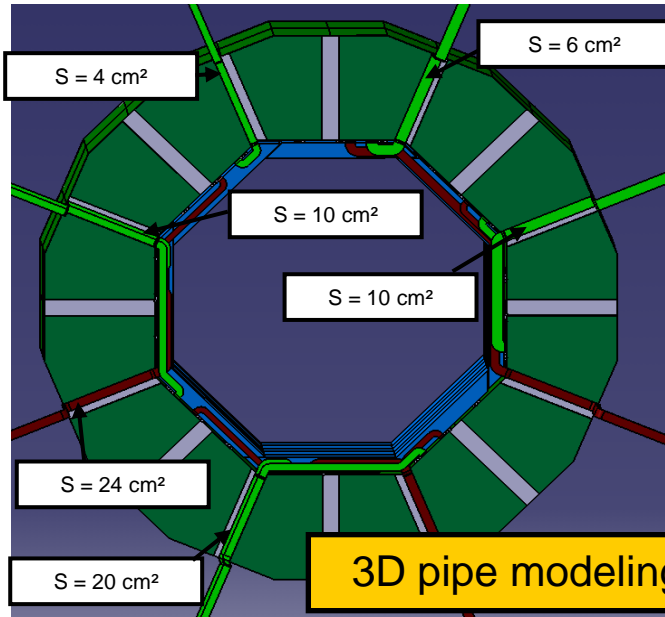
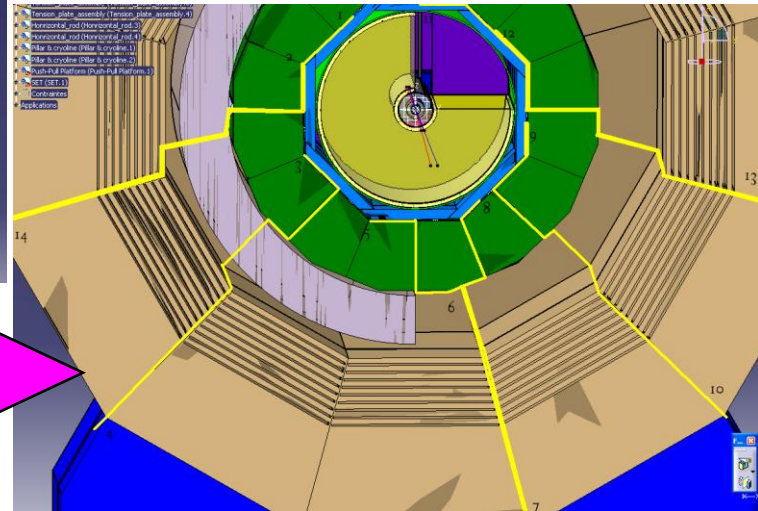
ECAL Cooling : 3D pipe modeling



Water circulation on module



leak less Zone



3D pipe modeling

Pathways of pipes through HCAL barrel

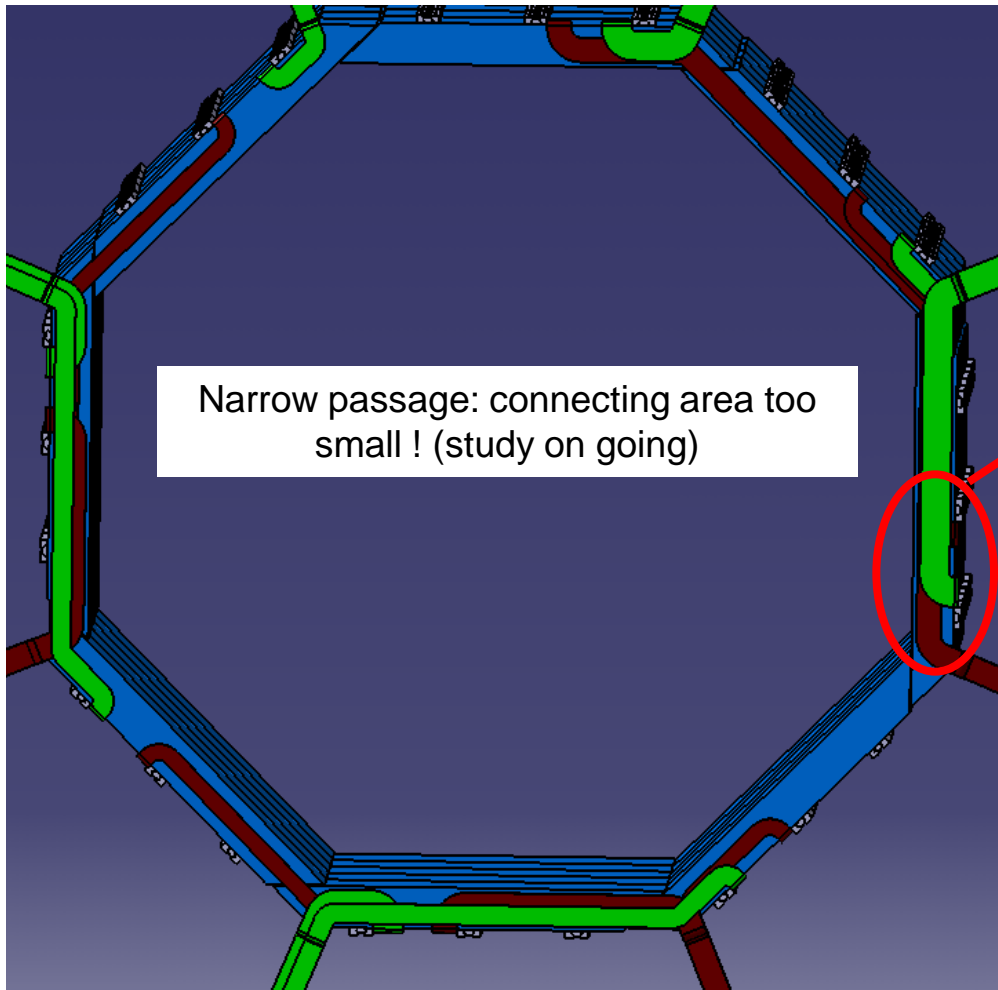
Leakless mode restriction
(leakless zone is at the top of the loop)

Global design

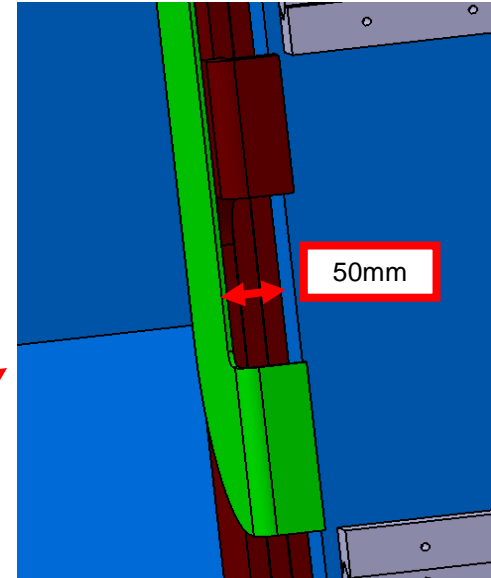
- Water cooling system
- Leakless zone over the entire height of the detector.
- One line / module.
- Inlet water temp: 18°C / Outlet water temp : 23°C
- Maximum power / column : 100 W.
- Pipe diameter : 13 mm.

Integration Cooling on ECAL

Pathways of pipes on ECAL barrel

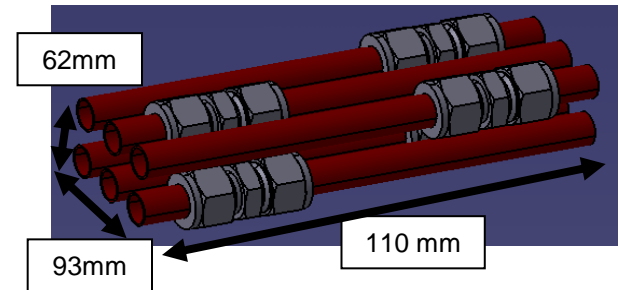


Narrow passage: connecting area too small ! (study on going)





Dimensions of connecting zones

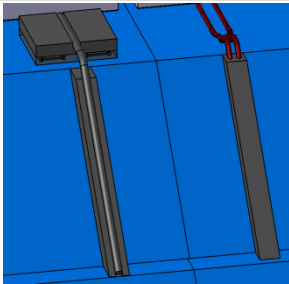
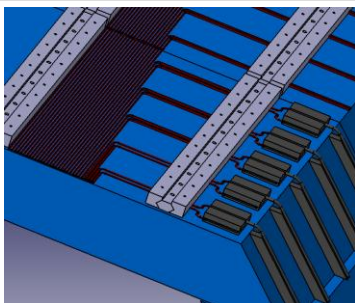
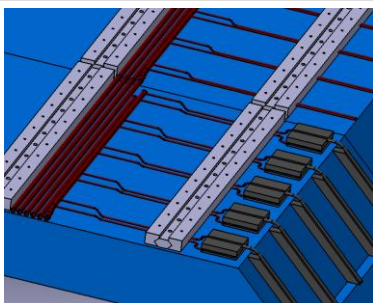
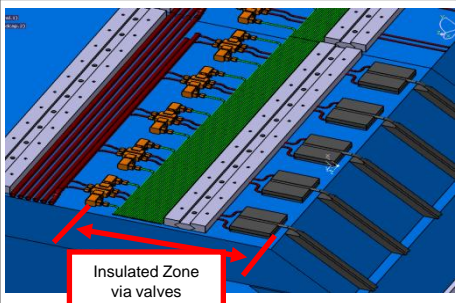
3 modules : $S = 58 \text{ cm}^2$



2 modules : $S = 20 \text{ cm}^2$

Air pipe : 
Water pipe : 

INTEGRATION COOLING ECAL

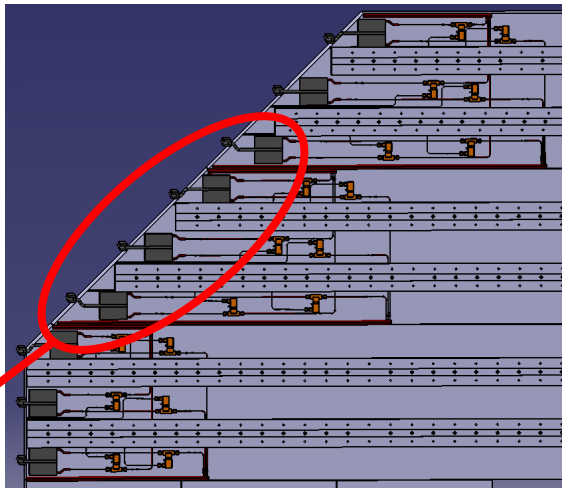
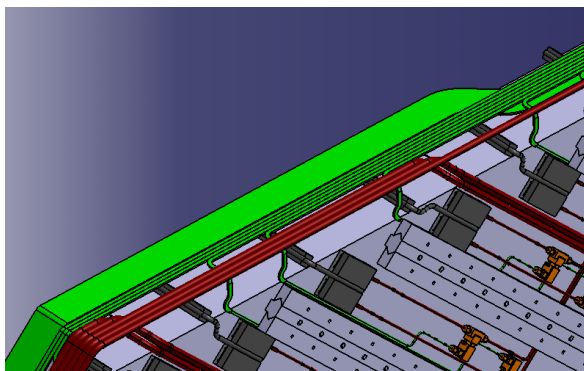
	Barrel solution 1 (1 line per column)	Barrel solution 2 (1 line per module)	Barrel solution 3 (1 line per module with valves)
 <p>Heat pipe or water</p>			 <p>Insulated Zone via valves</p>
Total amount of pipes <-> Pipe diameter	400 6mm	80 15mm	80 (water) + 400 (air) 15mm (water), 4mm (air)
Maxi. Power	15W	150W	150W
Flow section	14 cm ²	15 cm ²	15,5 cm ²
Advantages	<ul style="list-style-type: none"> - Command per column from exterior of detector 	<ul style="list-style-type: none"> - Less connexions to install - Important power range: 15/150W - Reduces volume (80 lines for barrel) 	<ul style="list-style-type: none"> - Command per column (on front-end circuit only) - Important power range: 15/150W
Disadvantages	<ul style="list-style-type: none"> - Power evacuated limited to 15W per column - Important Congestion - Flow management => a flowmeter /line=> important cost - Pressures management => 1 pressure gauge / line => important cost - High number of fitting may leak (400 lines for the barrel) 	<ul style="list-style-type: none"> - Command per module 	<ul style="list-style-type: none"> - More important congestion (water & air pipes + valves) - Connexions added near valves - Zone insulated per valves: restricted / to the addition of needed equipments - Valves management (distributor, command)

Solution 2 (one line per module): best technical compromise between reliability and congestion

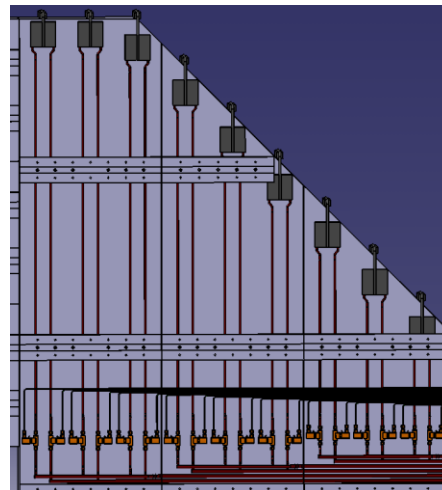
Endcap solution 1

This solution requires a 30mm gap between ECAL & HCAL Endcaps (15mm today)

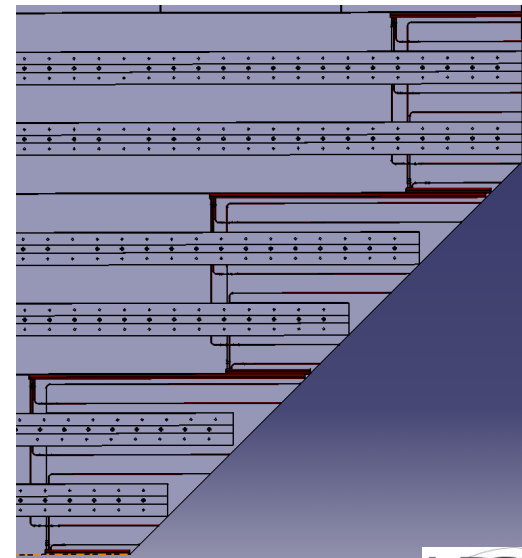
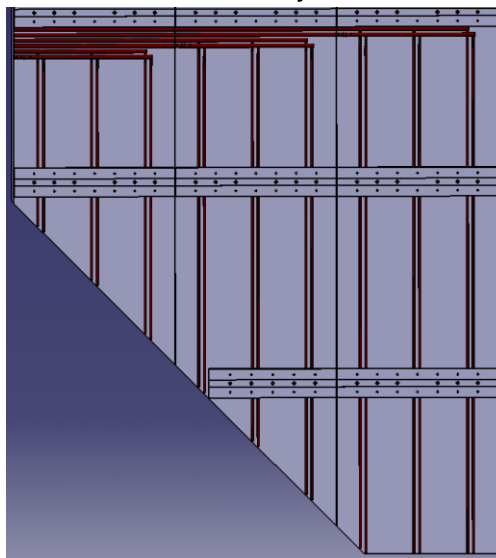
Pathways of pipes between HCAL & ECAL Endcaps



Control by column



Control by module



Endcap solution 2

This solution also requires a 30mm gap between ECAL & HCAL Endcaps

ECAL: Global COOLING

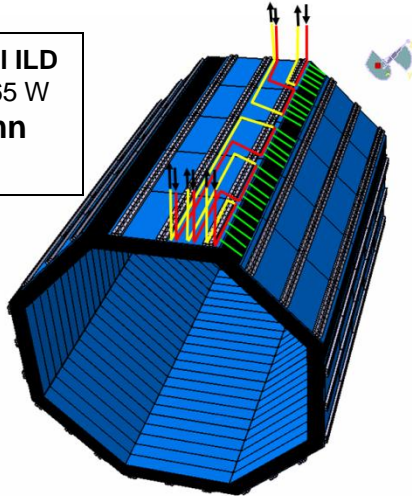
Study of the global cooling system for ECAL to continue:

- Design including safety systems
- Cost estimation (several solutions)

Leakless system :

- Low water speed
- Heat pipe termination
- Temperature and power range adapted

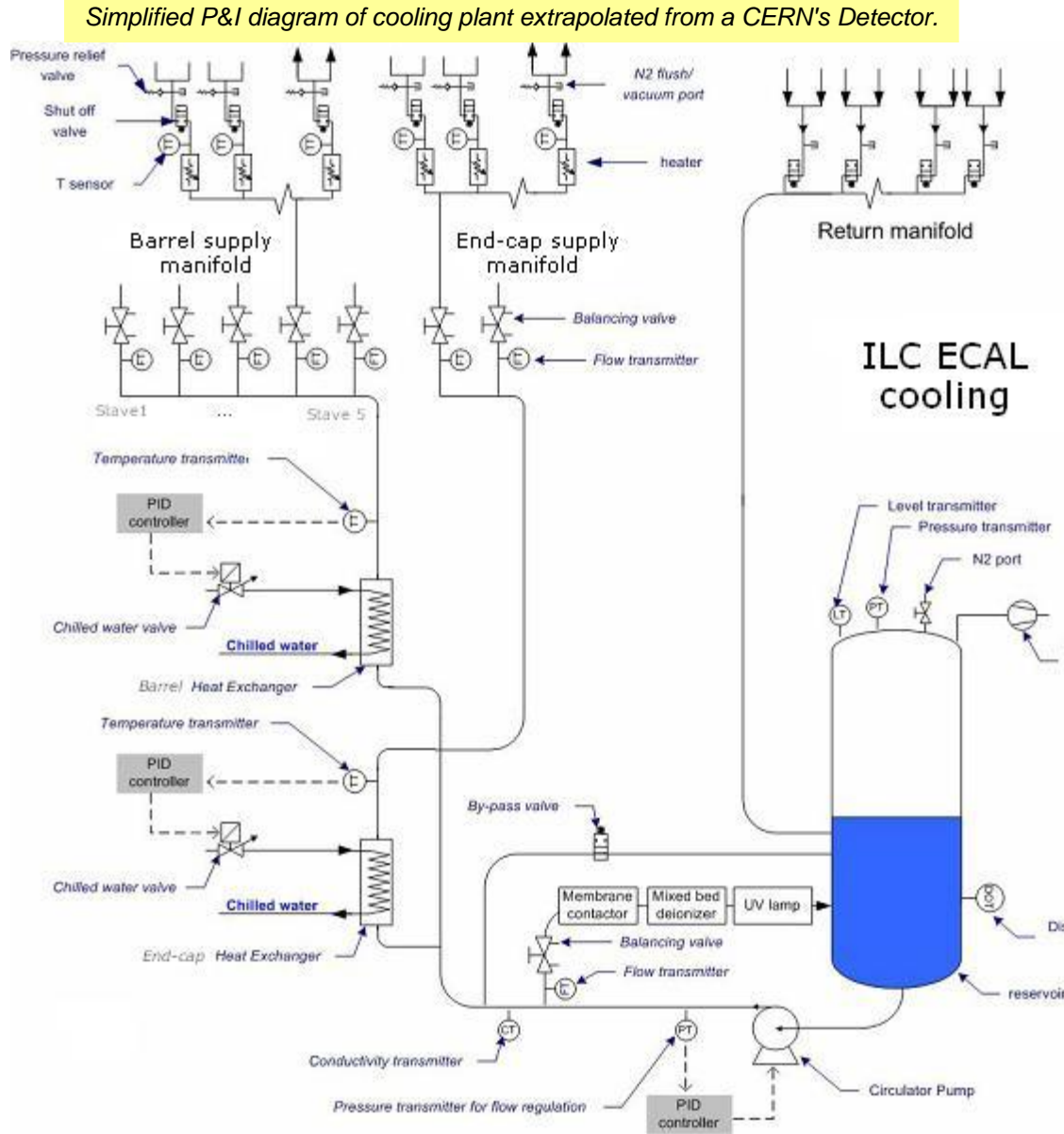
Power results / goal ILD
 Global Power : 4565 W
 $\cong 15 \text{ W / column}$
to dissipate



Leakless cooling system mock-up: 2010

True scale leakless cooling system test

- Base line : leakless system with representative systems to control
- the right components, sensors...
 - process, regulation
 - Interface and control



Conclusion :

Cooling

- Barrel / End cap global section simulation **June 2010**
- Slab / cooling system **connection** thermal **test** (transfer coeff., contacts...) **End 2010**
- **Cooling** systems for **EUDET** (heat pipe/water-143W) + portable cooling station **March 2011**
(final dimensions of the alveolar structure needed before November 2010)
- Module mockup: implementation & test of **connectors** for safe cooling **Spring 2011**
- Design & build a "true scale test **Leakless loop**" (<1atm) **Spring 2011**
- Design: hydraulic safety, hardened components, **cooling supervision** **Summer 2011**
- Alternative cooling studies: **μ -cooling devices** (with LEGI & CEA-LETI)... **2011...**

Fabrication – Long alveoli molding tests - characterization

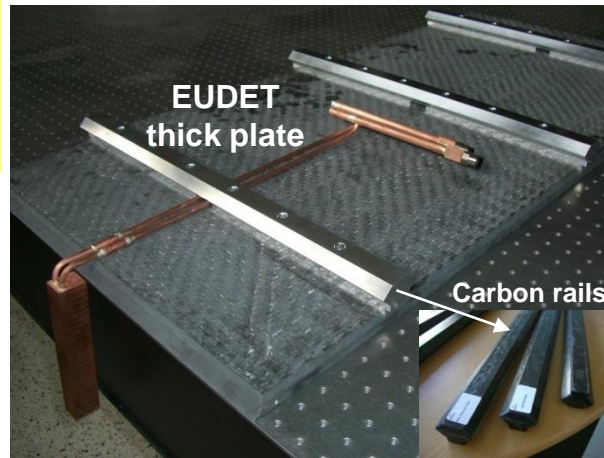
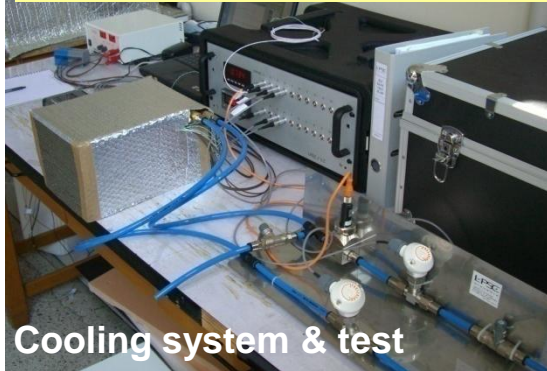
- End-cap: 2.5 m **alveoli** molding test **may 2010**
- End-cap: 2.5 m **alveoli** molding optimisation (core & wrapping) **fall 2010**
- Characterisation, tests & optimisation: composite elements and rails **Spring 2011**

Conception - Simulation

- End-cap **design**, mechanical & thermal simulations update **2011...**
- **Fastening system** ECAL/HCAL: alternatives for rails **Spring 2011**
- Handling and positioning tools for modules **Summer 2011**

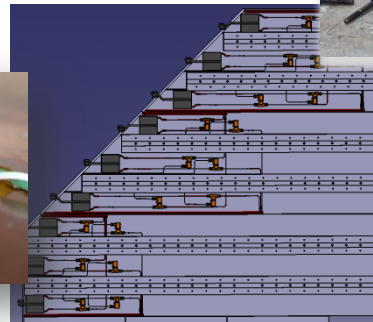
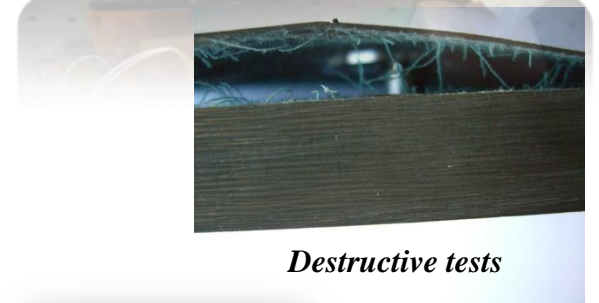
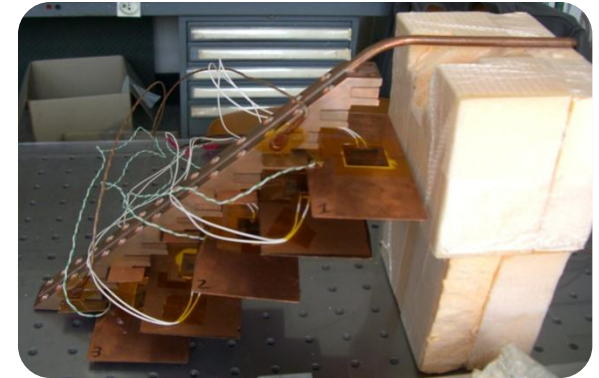
Thank you for your attention

Mechanical R&D on ECAL

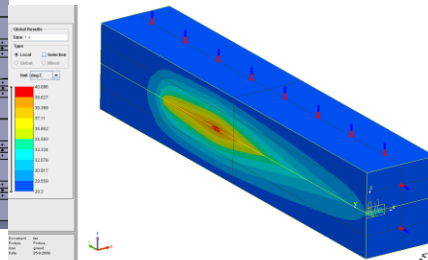


15mm thick plate with its rails; ready to be assembled with EUDET's layers

THERMAL tests



End-cap design



Fastening system integration

