LPSC Grenoble & LLR

CALICE Calorimeter for ILC

Next generation Si -W

ECAL Mechanics and thermal studies

LCWS 2010 @ Beijing

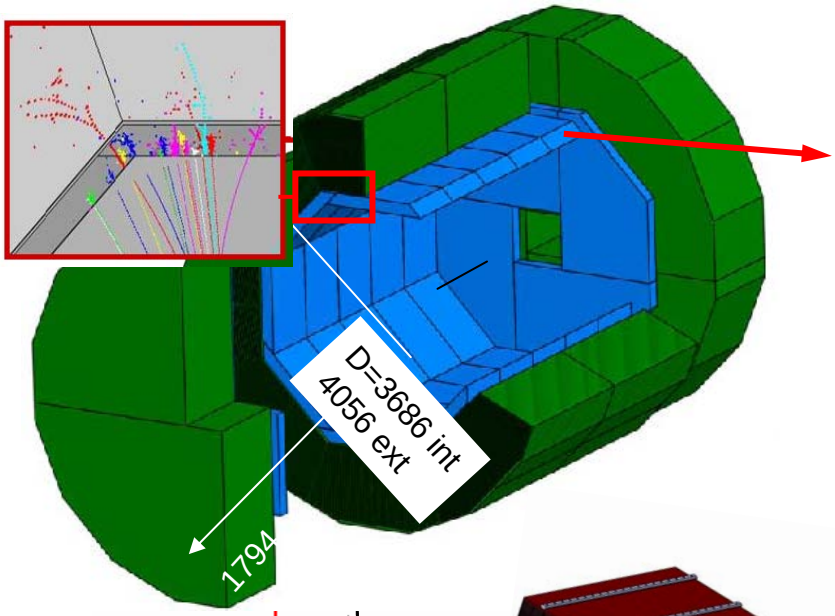
EUDET

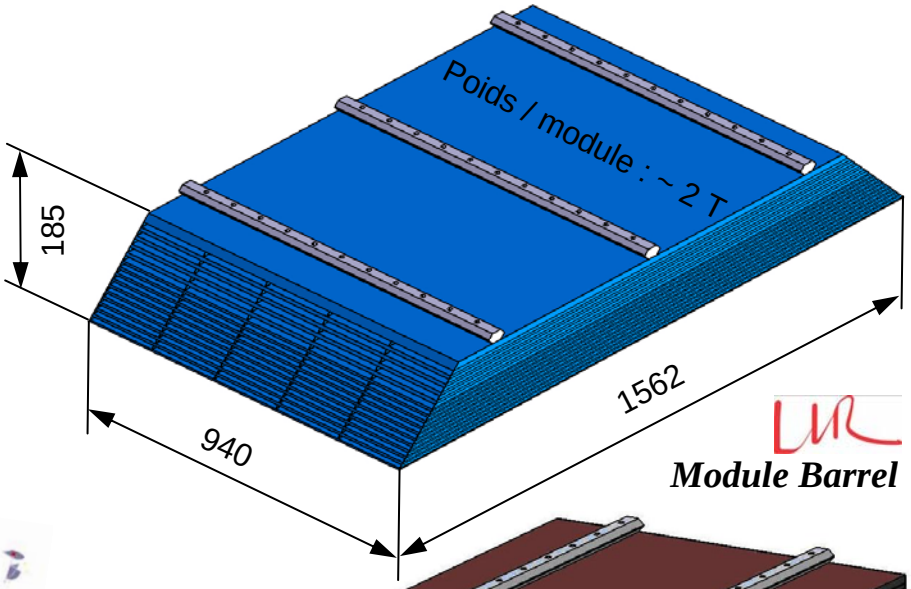
Denis Grondin – March 28th, 2010

Si-W ECAL – Current baseline

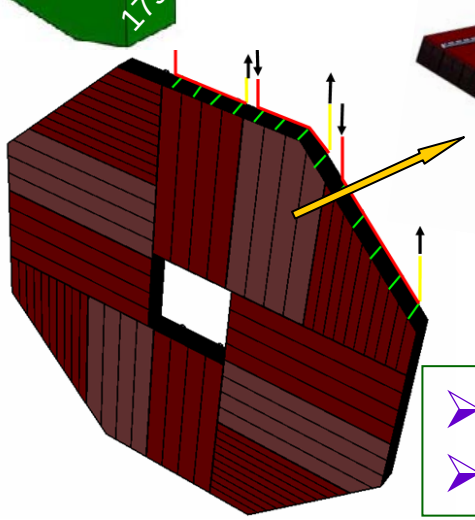
W/Si – ECAL weight:
~ 112 T (80 barrel+32 End-Cap)

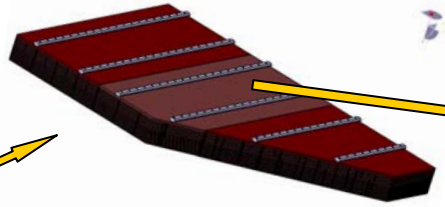
- No dead zone, compactness
- 40 identical trapezoidal modules



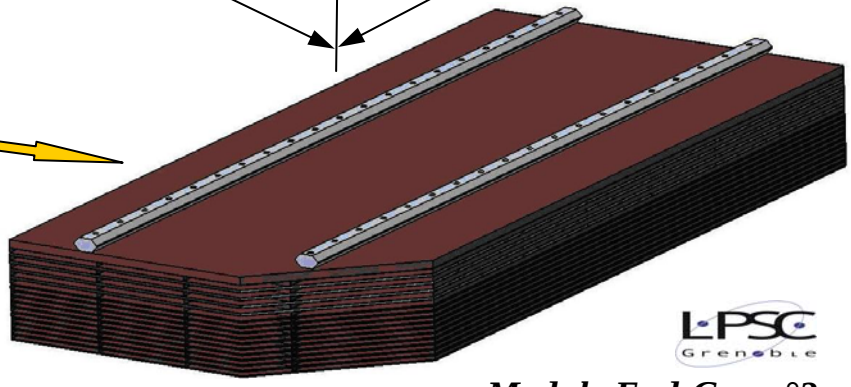


Module Barrel





Multi-module End-Cap

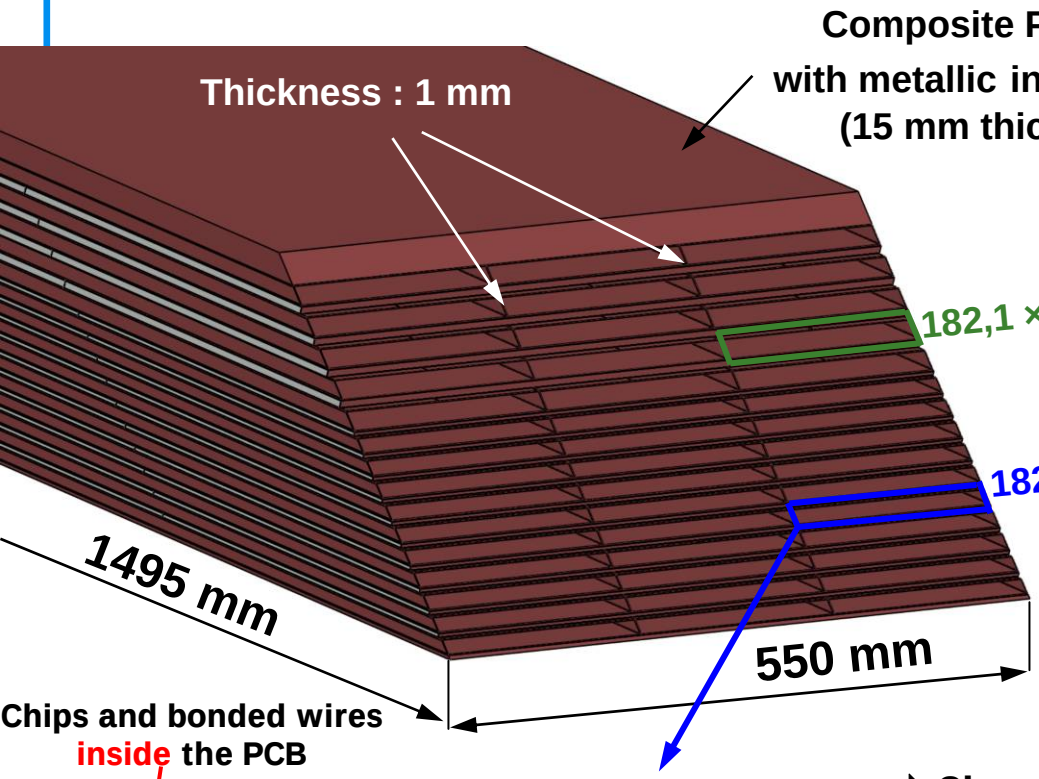


Module End-Cap n°2

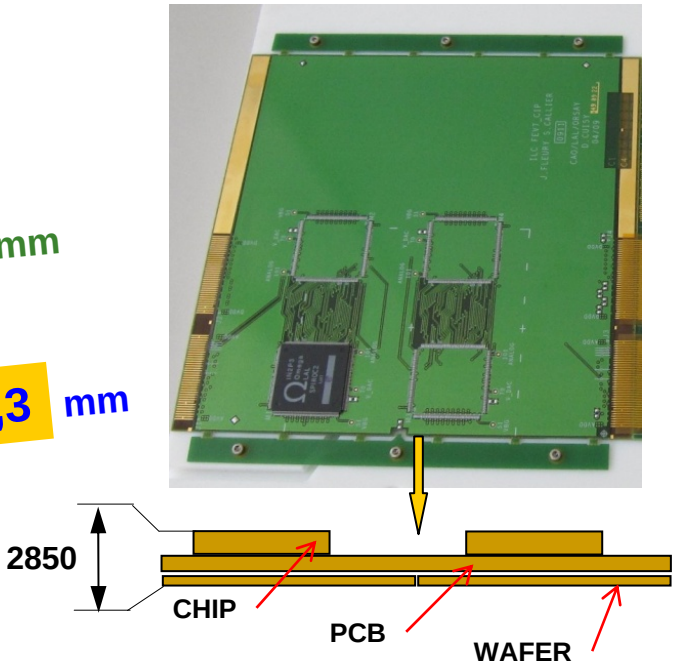
- 12 modules-3 distinct types
- Compactness, no dead zone if…

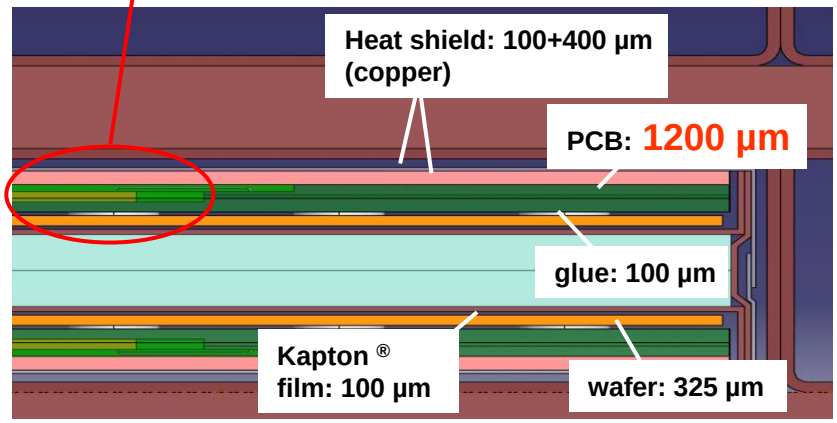
~ 4600 cells to join

EUDET design LLR



FEV7 CIP at the present time





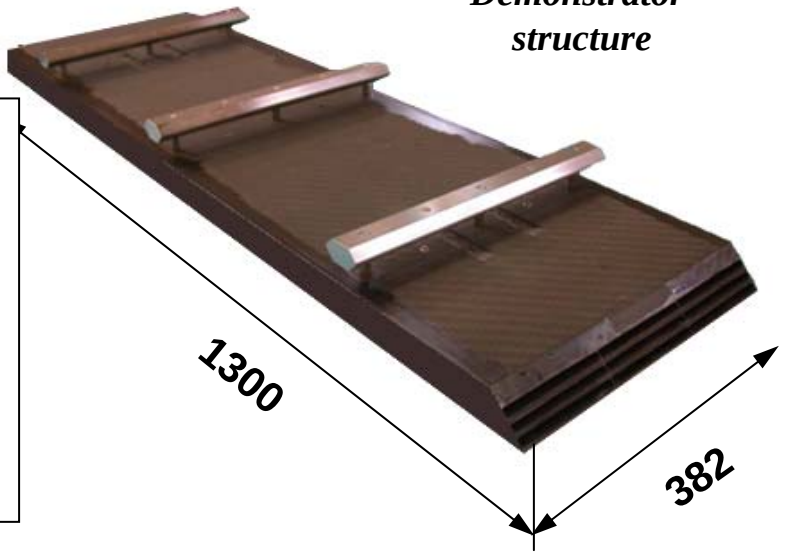
- ⇨ Clearance (slab integration) : 500 µm
- ⇨ Heat shield : 500 µm → Thermal demonstrator
- ⇨ PCB : 1200 µm → but 1100 µm used
- ⇨ Thickness of glue : 100 µm
- ⇨ Thickness of wafer : 325 µm
- ⇨ Kapton® film HV : 100 µm ? → tests
- ⇨ Thickness of W : 2100/4200 µm (± 80 µm)

Demonstrator design LLR

- Built a first demonstrator to understand all manufacturing processes
- Width is based on physics prototype (124 mm)
- Good precision (width, dead zone, cells thickness) (global tolerance +/- 0.01mm).
- Used for thermal PCB studies and cooling system analysis
- Used for the First test of slab integration (gluing, interconnection ...)

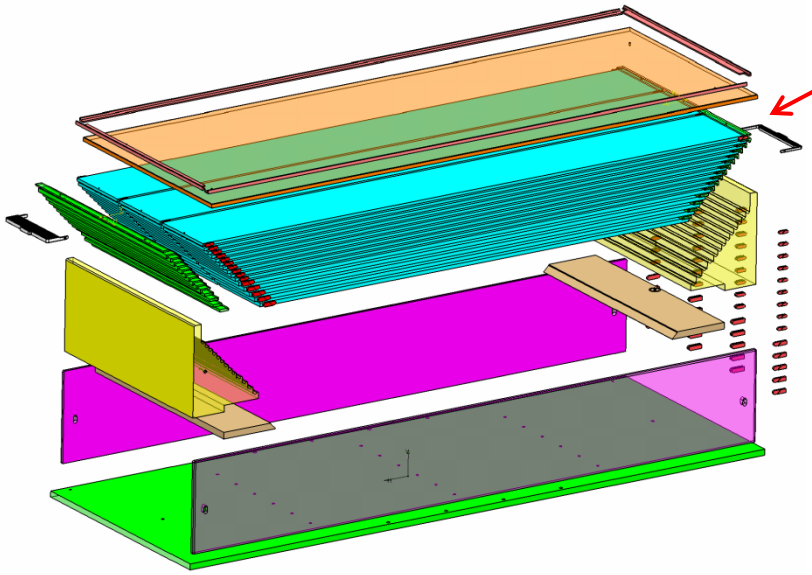
- **It's consisted of**
  - **3 alveolar layers + 2 Tungsten layers**
  - **3 columns of cells : representative cells in the middle of the structure**
- **Used for Thermal studies support**
- **Width of cells : 126 mm**
- **Identical global length : 1.3m and shape (trapezoidal)**
- **Fastening system ECAL/HCAL**
- **weight : ~ 60 Kg**

Demonstrator structure

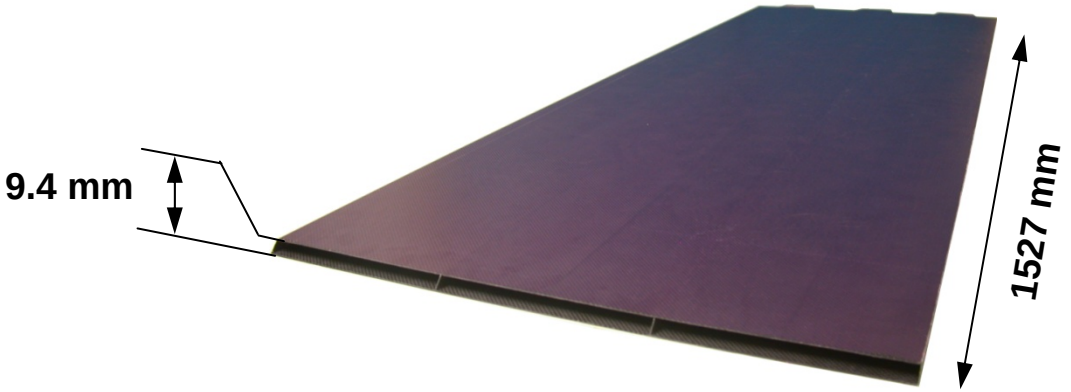


EUDET– Assembly Mould LLR

Now, here is the EUDET assembly mould With the first EUDET layer :



Assembly mould
(90 references, 500 Parts)



- ⇨ Global design : ***OK***
- ⇨ W and Carbon Needs : ***OK***
- ⇨ Detailed design description : ***OK***
- ⇨ Technical drawing : ***OK***
- ⇨ Ordered : ***MARS 10***

- ⇨ Global design : ***OK***
- ⇨ 1/15 “Alveolar EUDET layer” : ***OK***
- ⇨ Cutting Layer operation: ***OK***
- ⇨ The supplier for cutting layer : ***OK***
- ⇨ Layers Production : ***Mars 10***

EUDET H or U SLAB LLR

Study of one mould for whole slab structures:

- All slabs are made by several short but precise plates, assembled in 2 layers, in order to control the thickness and the flatness

If PCB <= 1.2 mm

H

- 30 Silicium layers
- Chip on board

precise plates

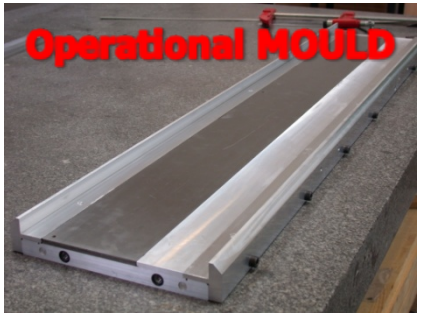
W plates

If > 1.2 mm

U

- 15 Silicium layer

- Chip on packaged



Building an other MOULD

- 2 months

- 3 k€

⇨ Design and Machining: ***OK***

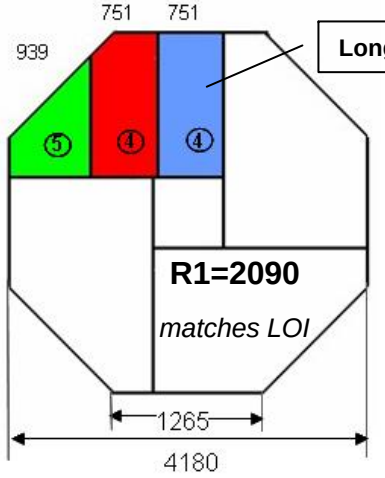
⇨ first H structure (1300×124): ***OK***

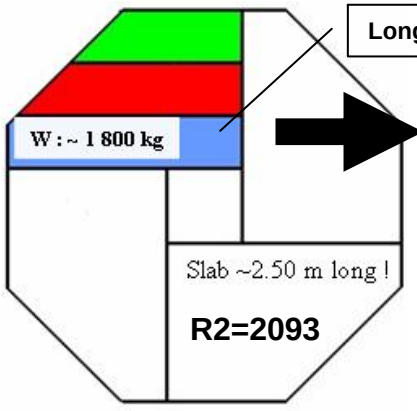
⇨ EUDET short and long H SLAB: ***second half-year 2010***

⇨ EUDET short and long U SLAB: ***second half-year 2010***

End-Caps structure: baseline - LPSC

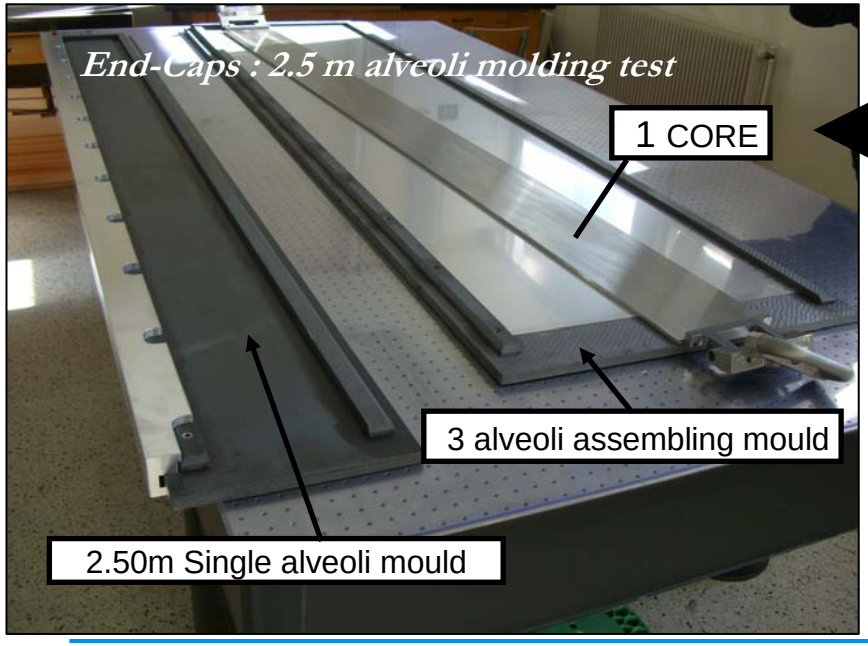
- Today, with the barrel's demonstrator and EUDET, the process for composite structure has been validated, with a built layer module width based on 182.1 mm for EUDET, and 1,50 m long…





(ok / cracks)

For End-caps, the goal is now to build 2,50 m long composite alveoli, and to demonstrate whether or not the main process steps (similar to barrel ones) can be adapted.



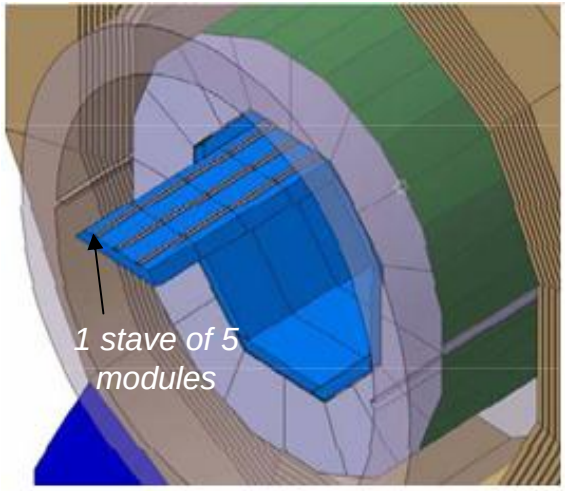
End-cap structure : study and validation of most of technological solutions which could be used for the final detector (moulding process, cooling system, sizes of structures,…) taking into account industrialization aspect of process

- **The end-cap layer test consisted of**
- **1 long alveolar layer of 3 cells**
  (representative of the end-cap module longest layers)
- **Width of cells : 186.8 mm**
  (Design2 - to fit LOI parameters (R~2090))
- **Thickness of cells : 6.5 mm - wall: 0.5 mm**
- **Length : 2.492 m**

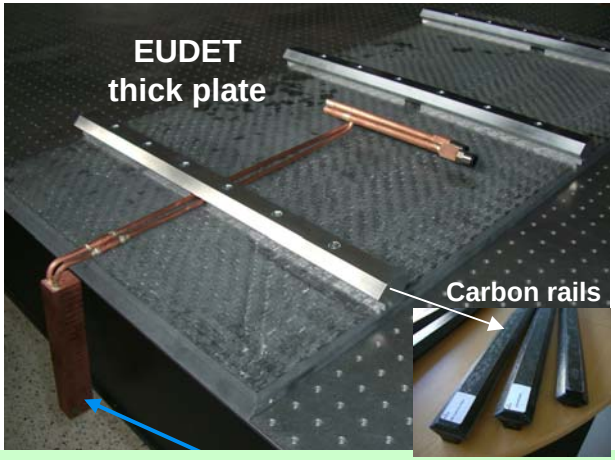
Fastening ECAL/HCAL - LPSC

Constraints

- Fastening in a structure “wheel”: bending constraints
- Carbon structure (thick plates and support…)
- Electronics: place for cabling : DAQ + HV + GND
- Cooling pipes integration



From metallic rails… to… composite structural system…



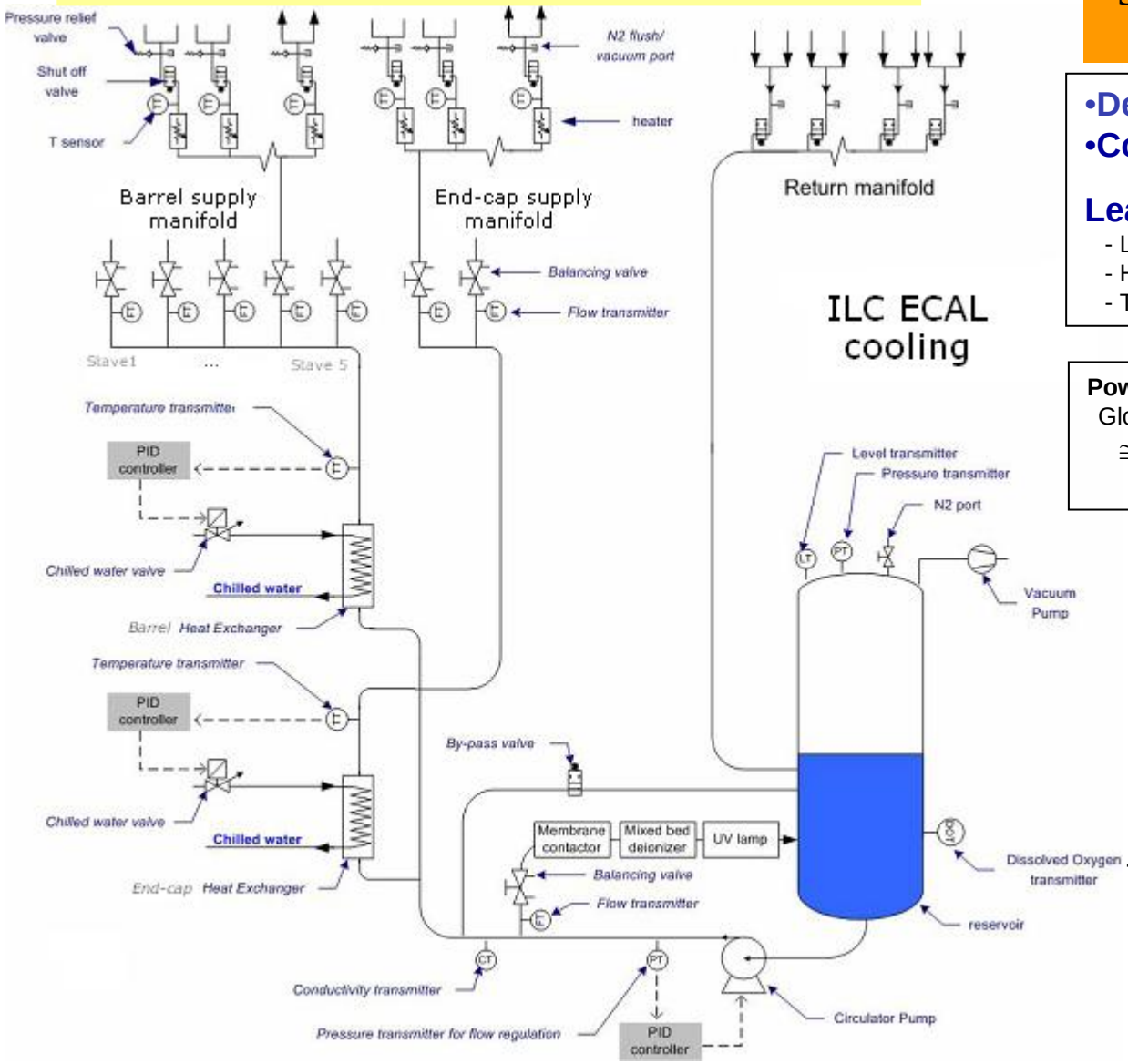
A column (cooling pipe), (25 mm wide minimum) to ensure quick thermal system’s connection

composite structural system
•validation of technological solution
•industrialization aspect of process

Mould delivered, ready to mould HexMC & SMC Carbon rails on a 80T heating press

ECAL: Global COOLING - LPSC

Simplified P&I diagram of cooling plant extrapolated from a CERN's Detector.



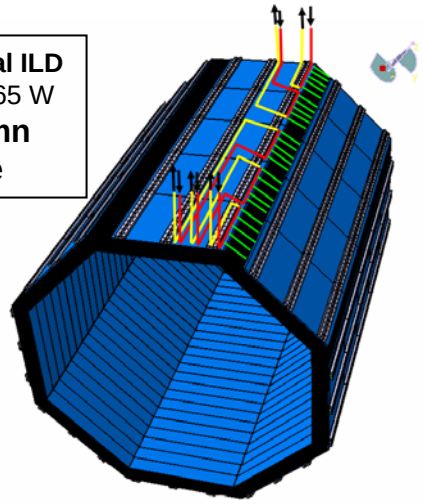
Study of the global cooling system for ECAL to continue:

- **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
≅15 W / column to dissipate

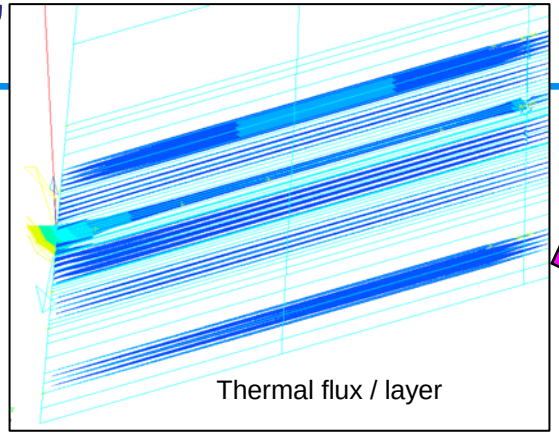


Leakless cooling system mock-up: **2010**

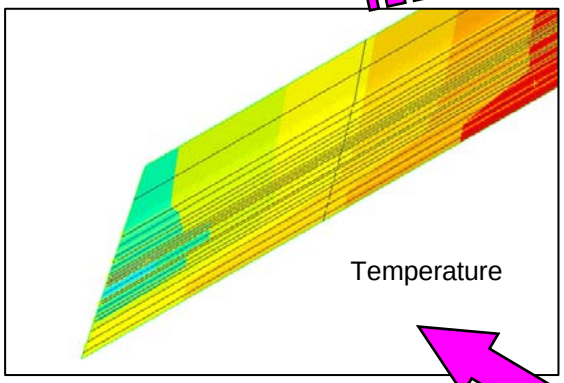
True scale leakless cooling system test
Base line : leakless system with representative systems to control

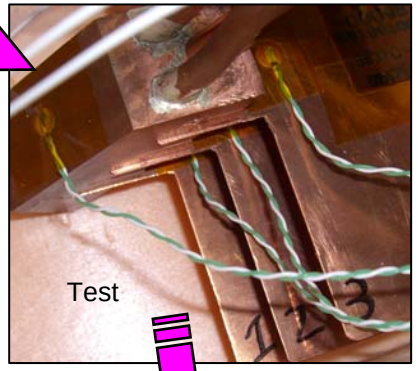
- the right components, sensors…
- process, regulation
- Interface and control

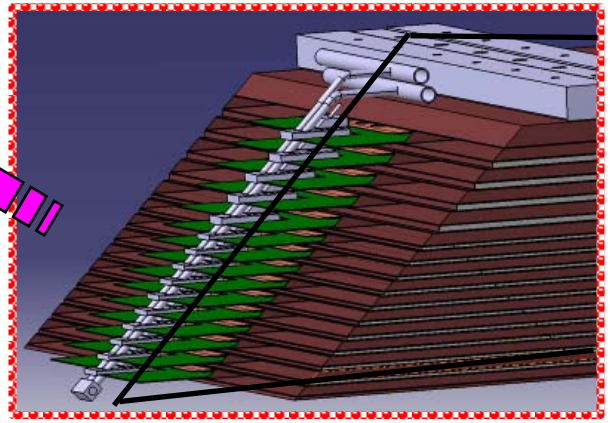
Cooling - LPSC



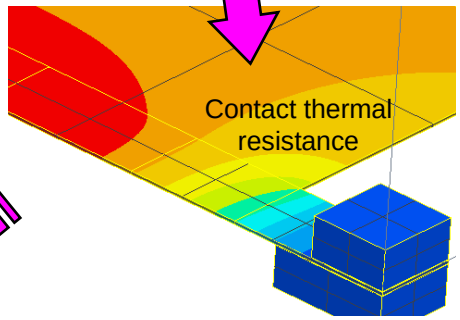
SLAB / Cooling connection

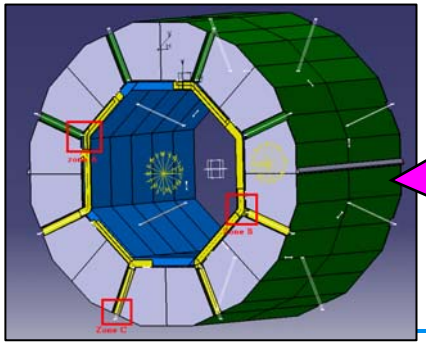


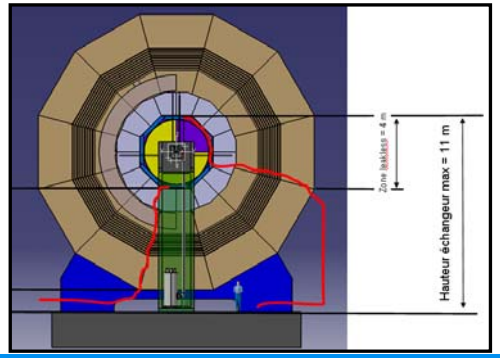




Module section thermal simulation







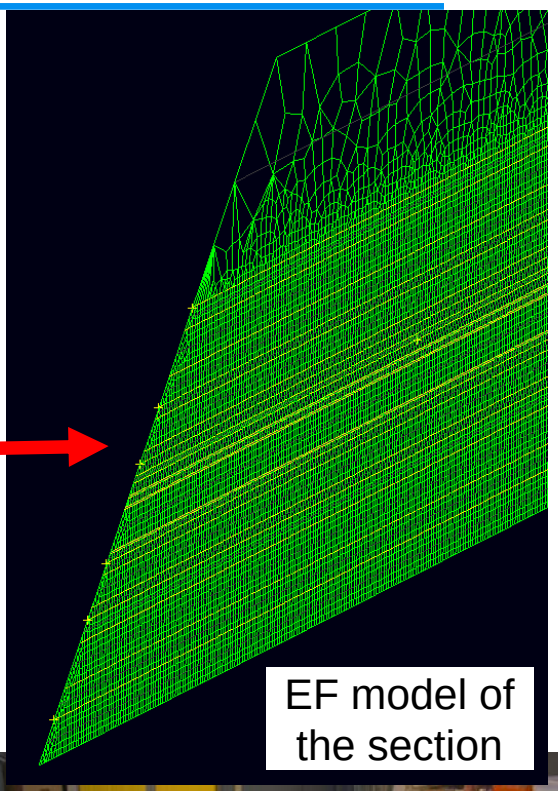
Global cooling

(leak less system)

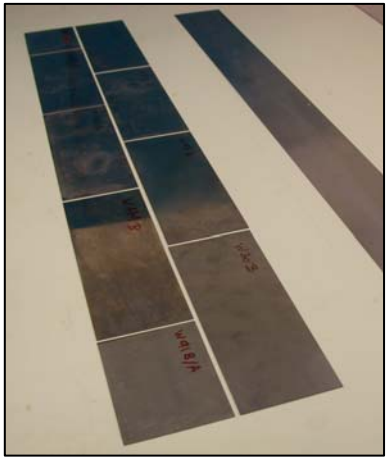
SLAB : thermal simulation - LPSC

First step : Correlate test with simulation

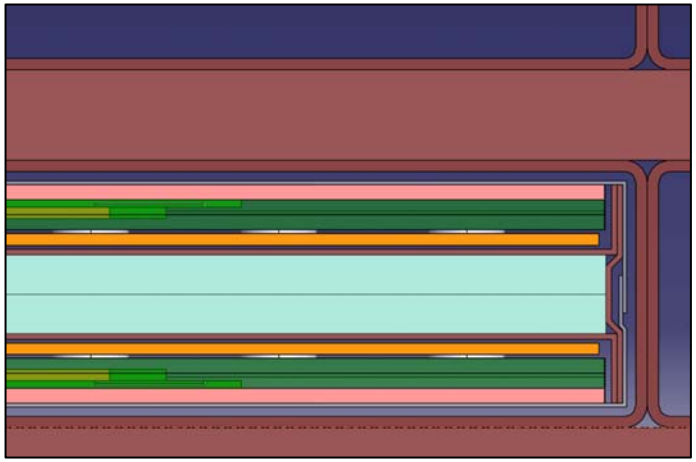
Autumn 2009 thermal test with the first alveolar structure



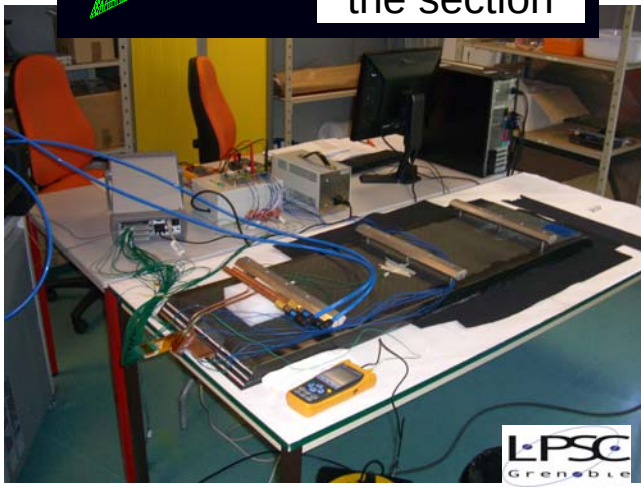
EF model of the section



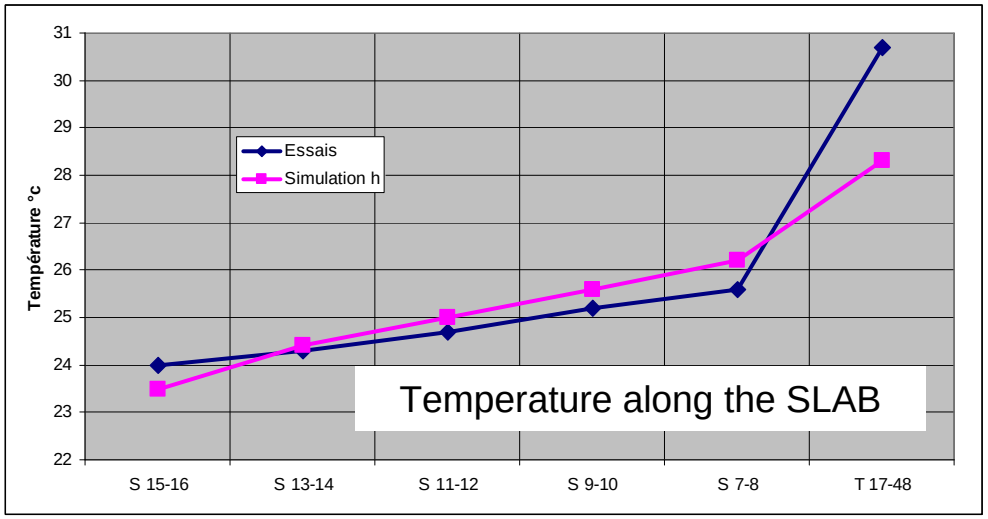
Integrate W break

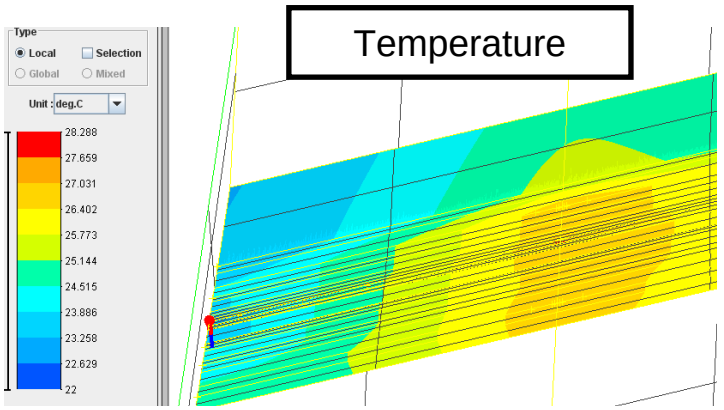


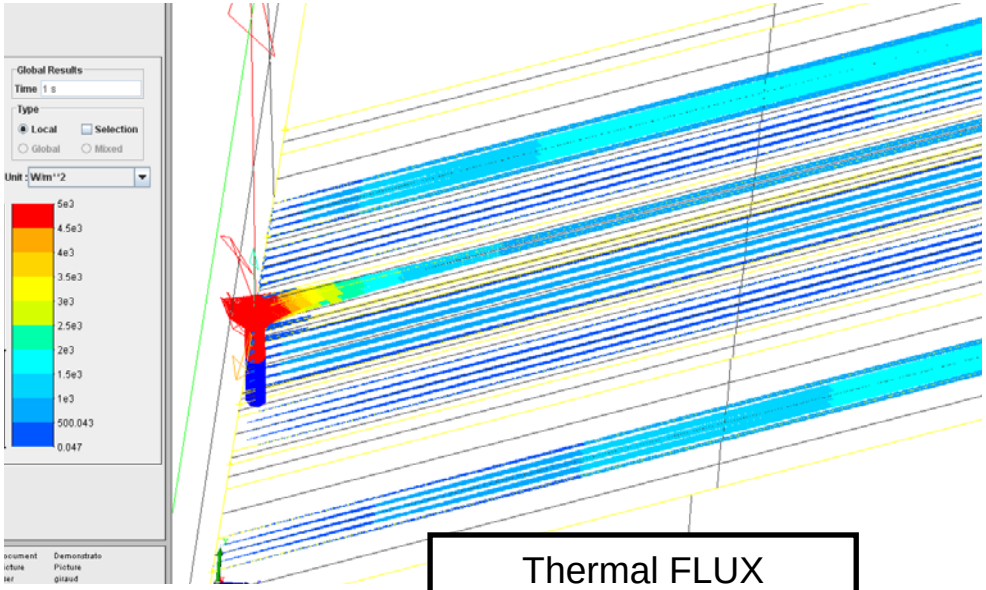
Integrate thermal contact resistance (air gap)



SLAB : thermal simulation - LPSC







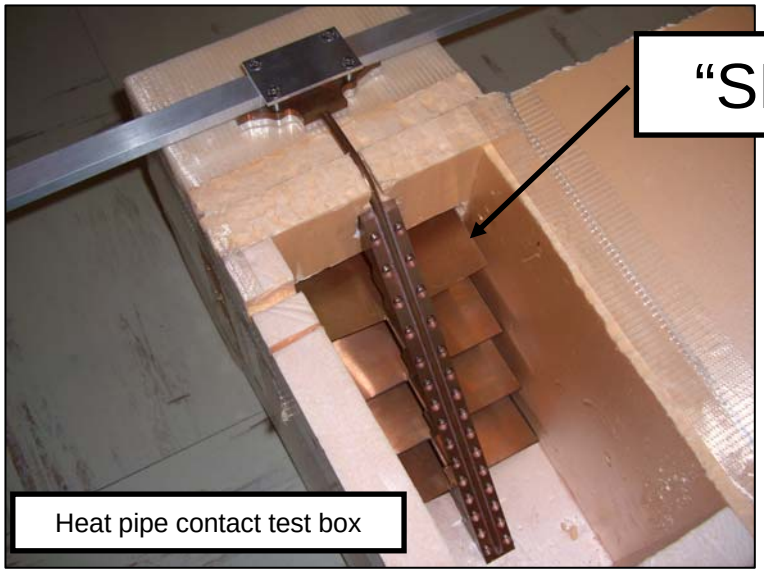
Simulation fit with test

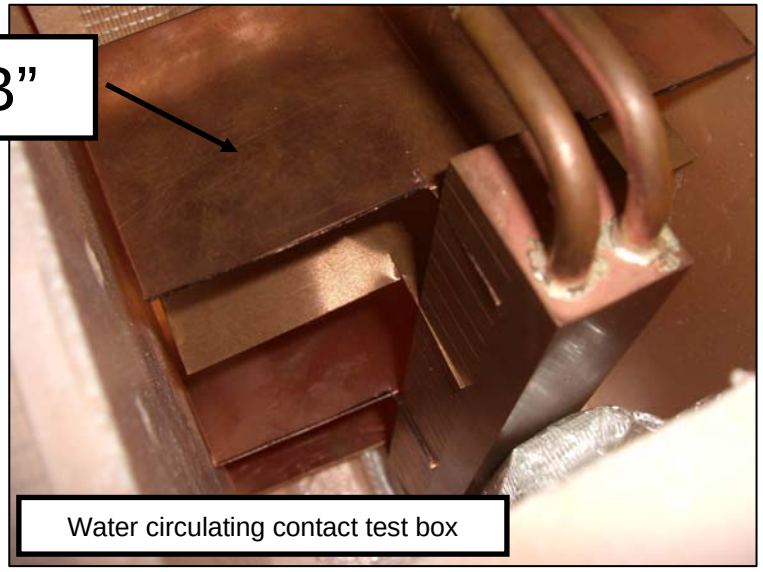
⇒Copper drain and tungsten are important for cooling

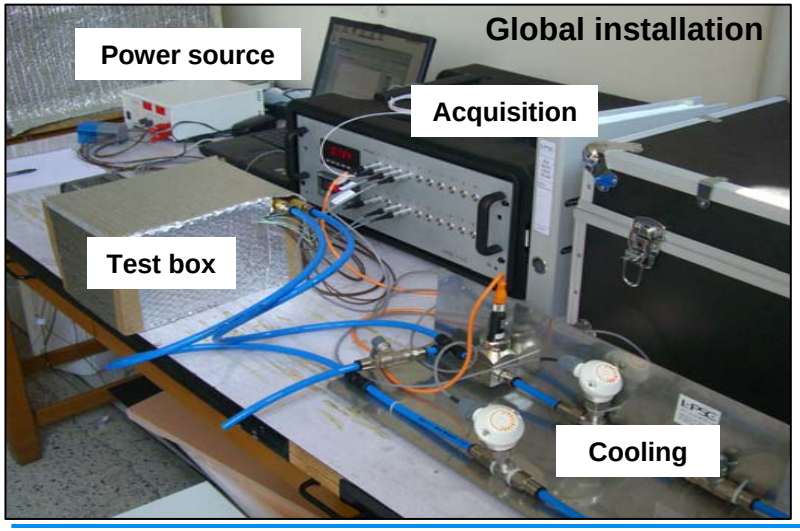
⇒ Next step Barrel and end cap global model

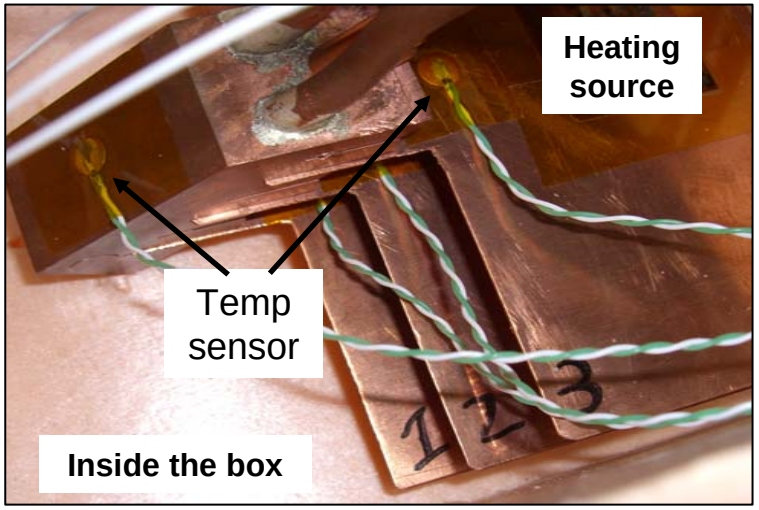
SLAB : thermal connection - LPSC

Beginning of connection test on EUDET type cooling

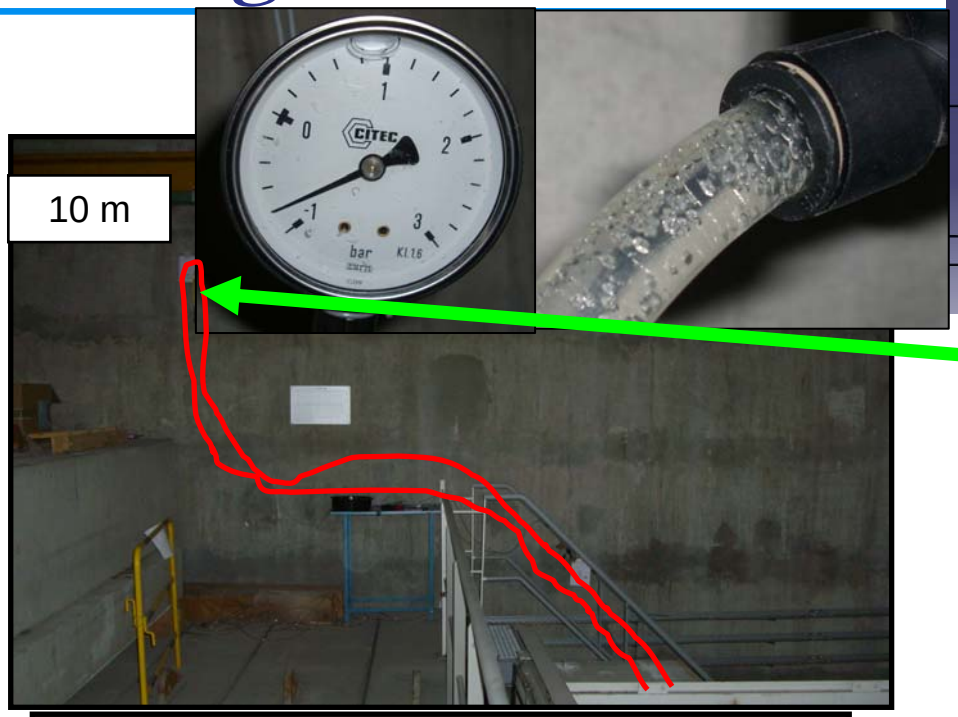


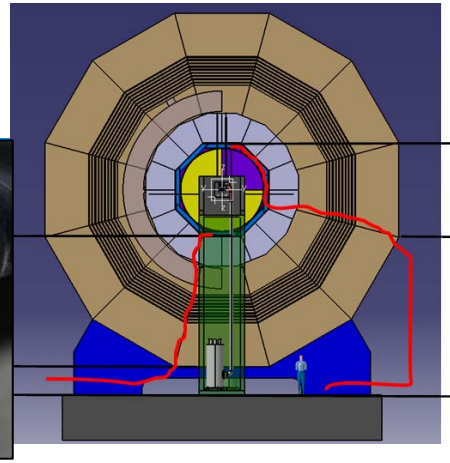


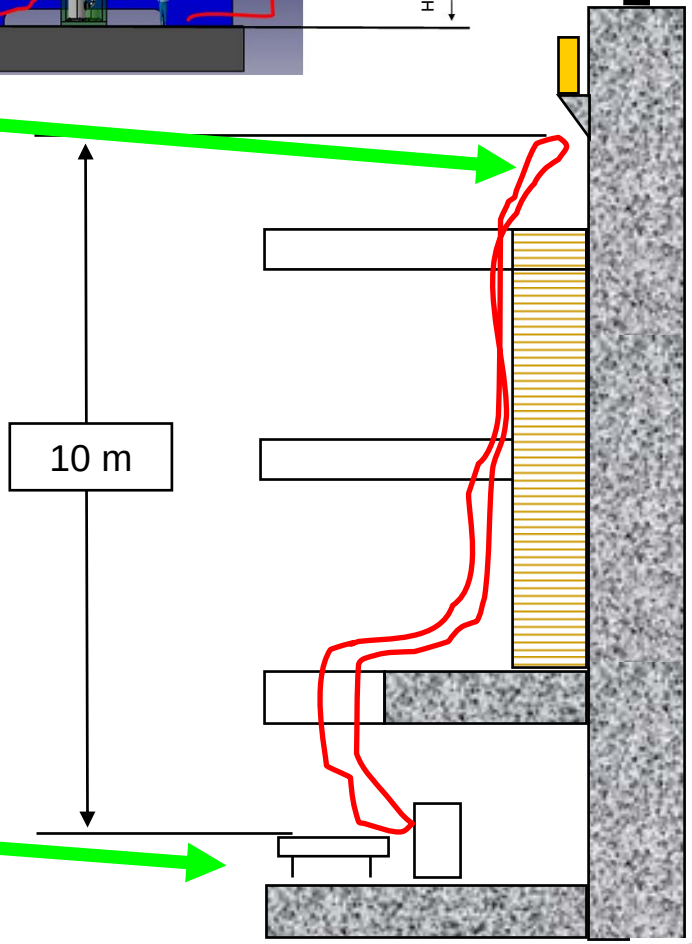




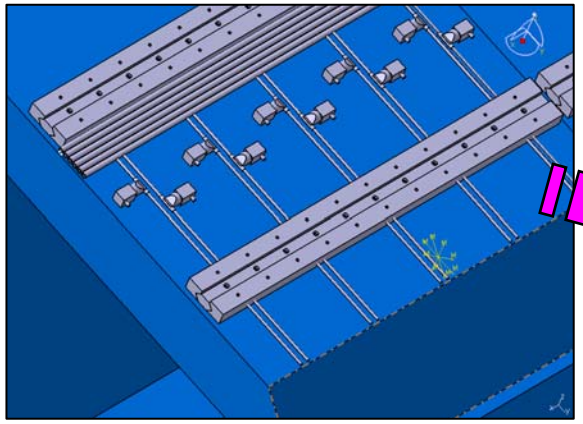
Cooling : Leakless test



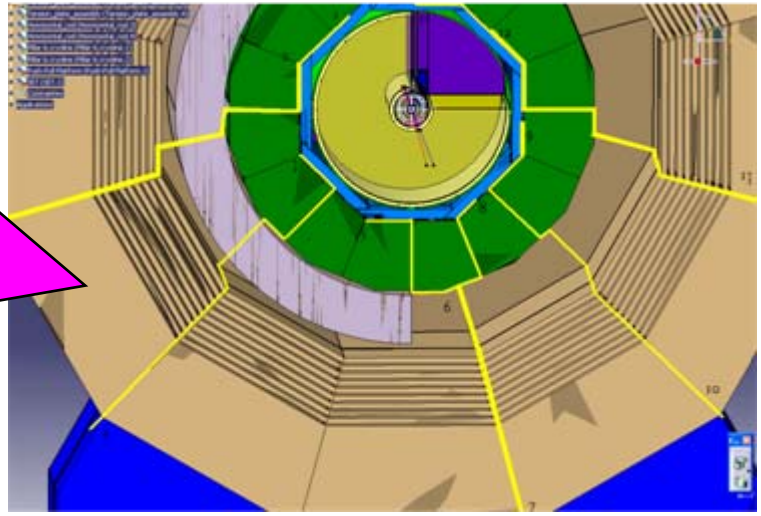




Cooling : 3D pipe modeling - LPSC

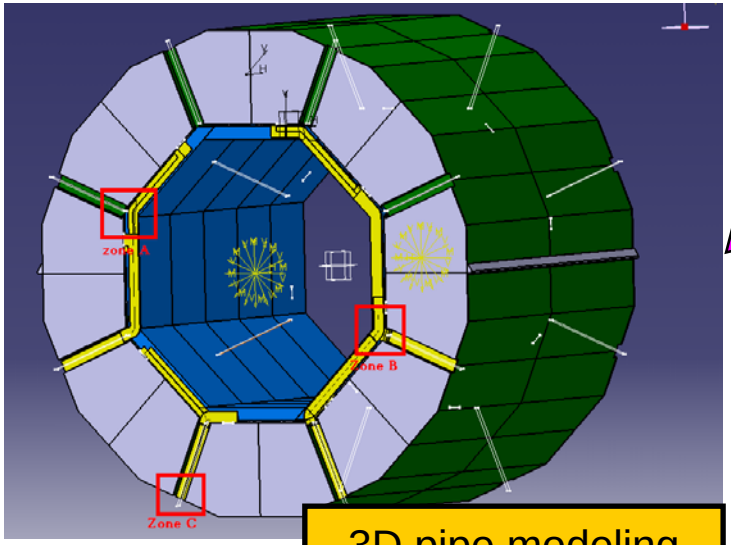


Water circulation on module

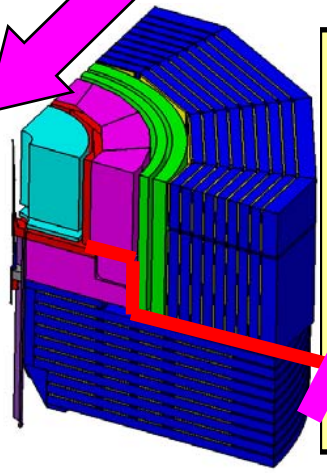


Leakless mode restriction

(leakless zone is at the top of the loop)



3D pipe modeling



Global design

- Leakless mode.
- One line / module.
- Inlet water temp: 18°c / Outlet water temp : 23°c
- Maximum power / column : 100 W (EUDET)
- Pipe diameter : 13 mm.

Conclusion : schedule

EUDET MODULE - LLR

"Alveolar layer" mould & composite reception	**realized in april (2008)**
Building one EUDET alveolar layer in	**July (2009)**
"Assembly mould" design in	**December (2009)**
14 alveolar layers in (3 done today)	**first half-year (2010)**
Eudet structure assembled in the	**Second half-year (2010)**
"14" H or U Short structure in	**second half-year (2010)**
"1" H or U long structure in	**second half-year (2010)**

COOLING - LPSC

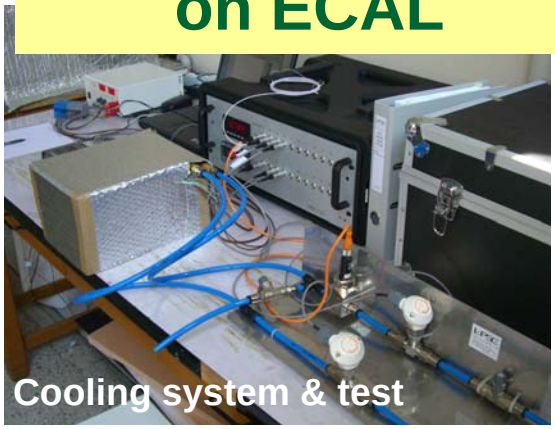
Barrel / End cap global section simulation	**Spring 2010**
Slab / cooling system connection thermal test (transfer coeff., contacts...)	**Spring 2010**
Specific cooling system for EUDET (portable)	**Sum 2010**
First Design: hydraulic safety, hardened components, cooling supervision...	**Fall 2010**
Design & build a "true scale test loop" : cooling system « Leakless » (<1atm)	**Fall 2010**

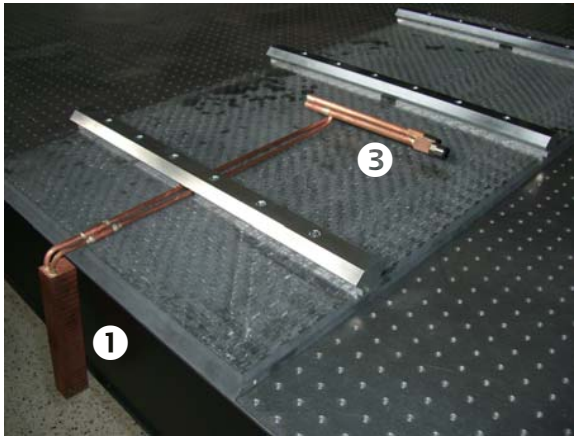
END-CAPS STRUCTURE - LPSC

End-cap: 2.5 m **alveoli** molding test	**Done in march 2010**
End-cap: 2.5 m **layer** molding test	**Sum 2010**
End-cap **design** & mechanical simulations, tests & optimisation composite	**Fall 2010**
Fastening system ECAL/HCAL: alternatives; modules' coupling.	**Sum 2010**

Thank you for your attention

Mechanical R&D on ECAL





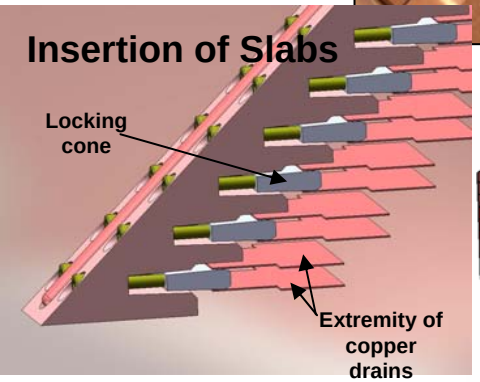
15mm thick plate with it's rails; ready to be assembled with EUDET's layers

Composite

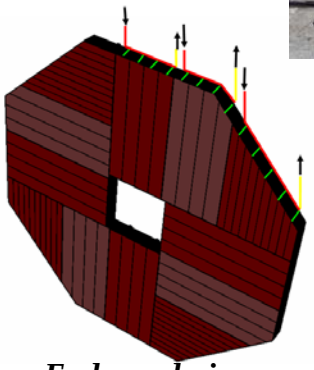
THERMAL tests

Mold for composite rails

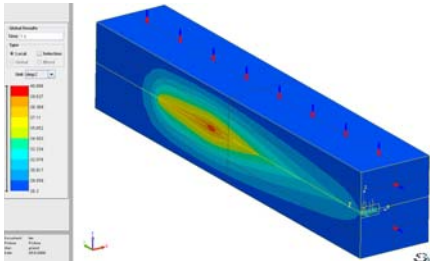
Destructive tests



Water cooling block



End-cap design



Fastening system