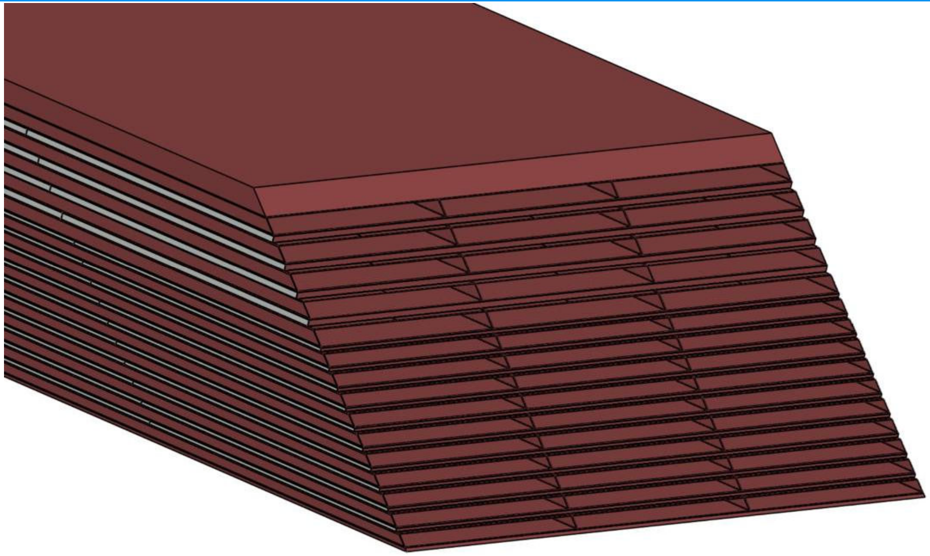
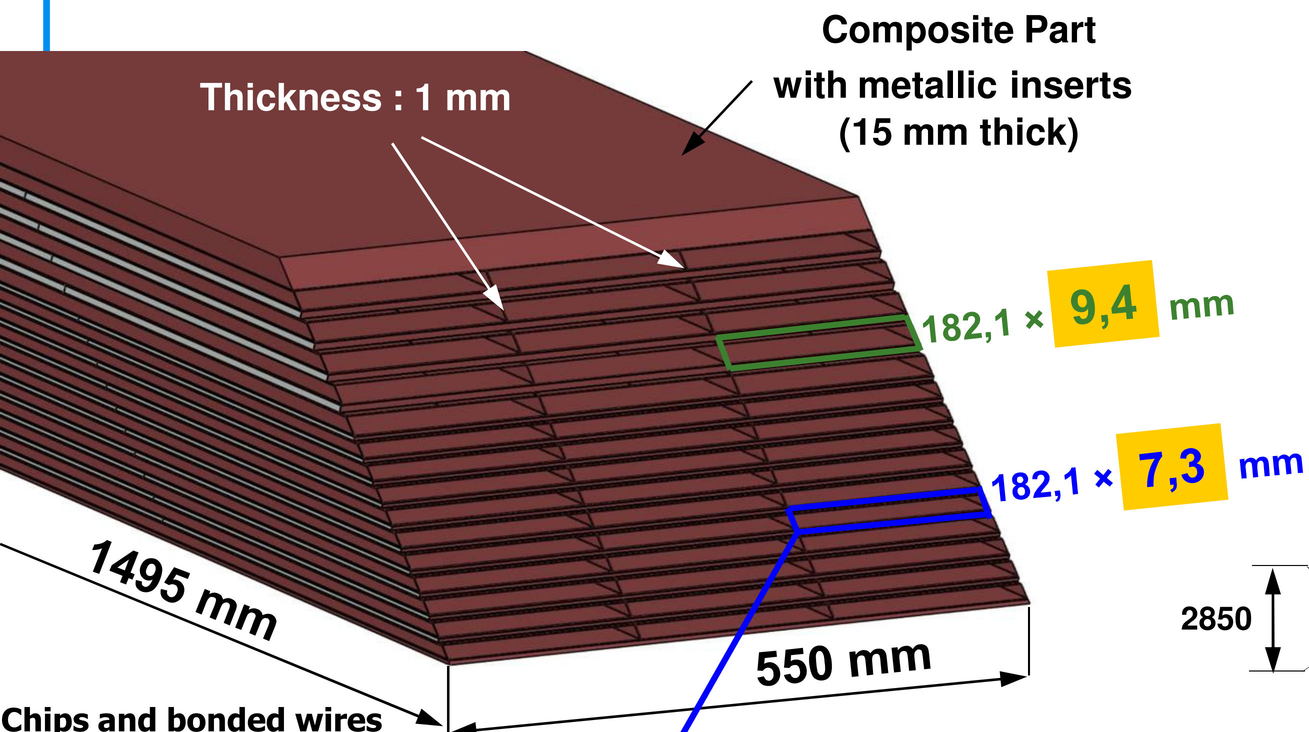
ECAL MACHANICAL R&D



CALICE meeting - Genève

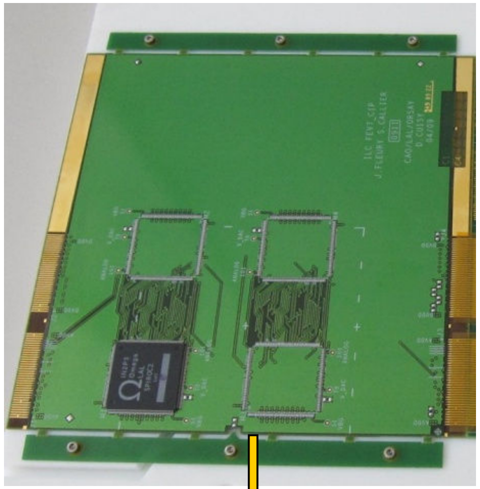
Mickael Frotin– 19/10/2009

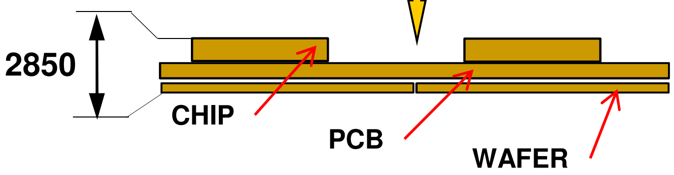
EUDET design

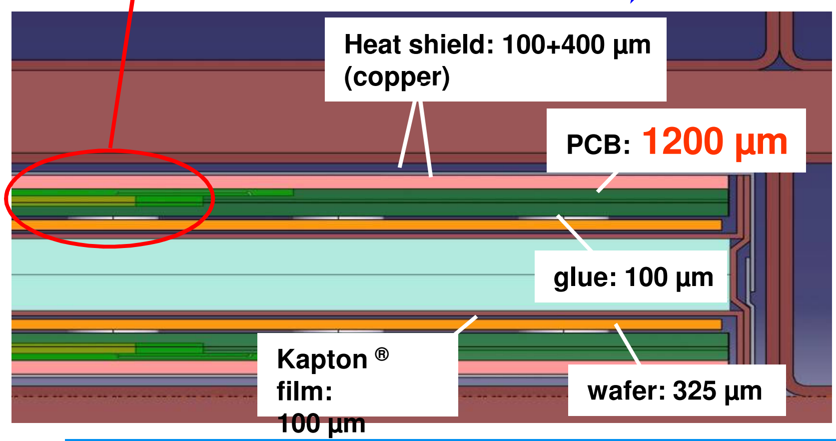


Chips and bonded wires **inside** the PCB

FEV7 CIP at the present time





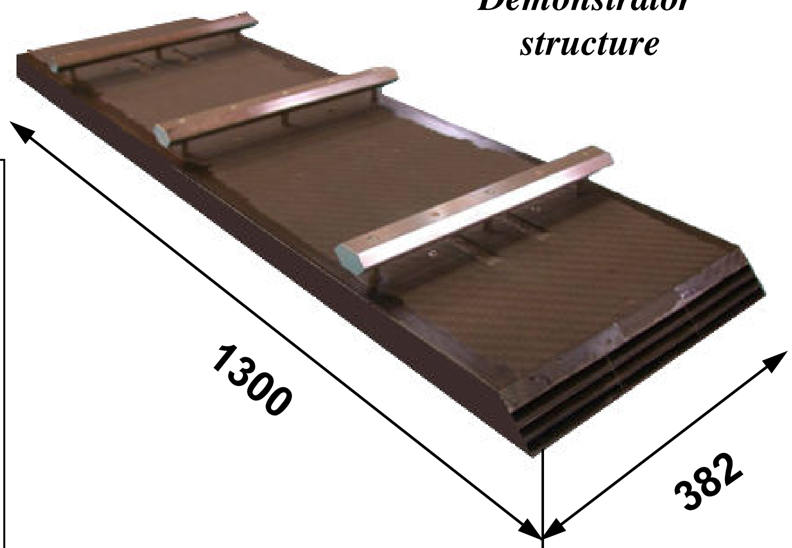


- ➩ **Clearance (slab integration) : 500 µm**
- ➩ **Heat shield : 500 µm → Thermal demonstrator**
- ➩ **PCB : 1200 µm → but 1100 µm used**
- ➩ **Thickness of glue : 100 µm**
- ➩ **Thickness of wafer : 325 µm**
- ➩ **Kapton® film HV : 100 µm ? → tests**
- ➩ **Thickness of W : 2100/4200 µm (± 80 µm)**

Demonstrator design

- 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 …)

Demonstrator structure



- **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**

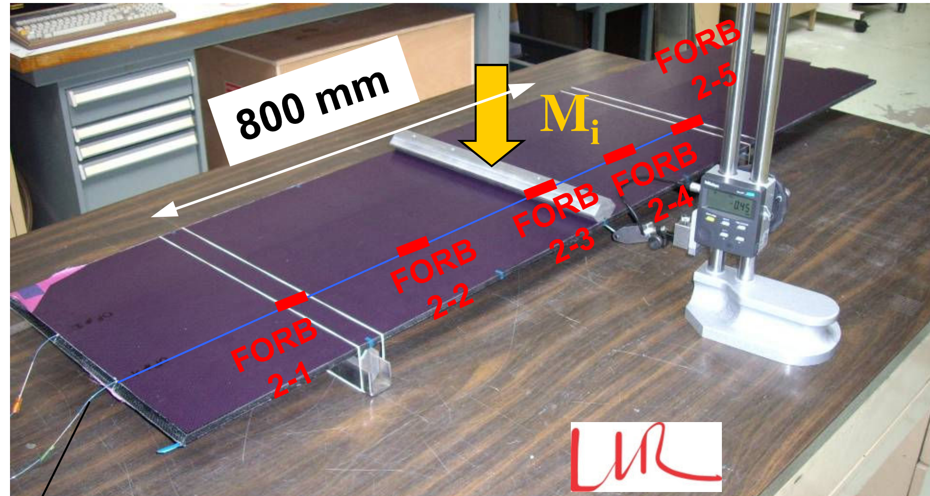
Demonstrator tests bragg grating

Embedded sensor:

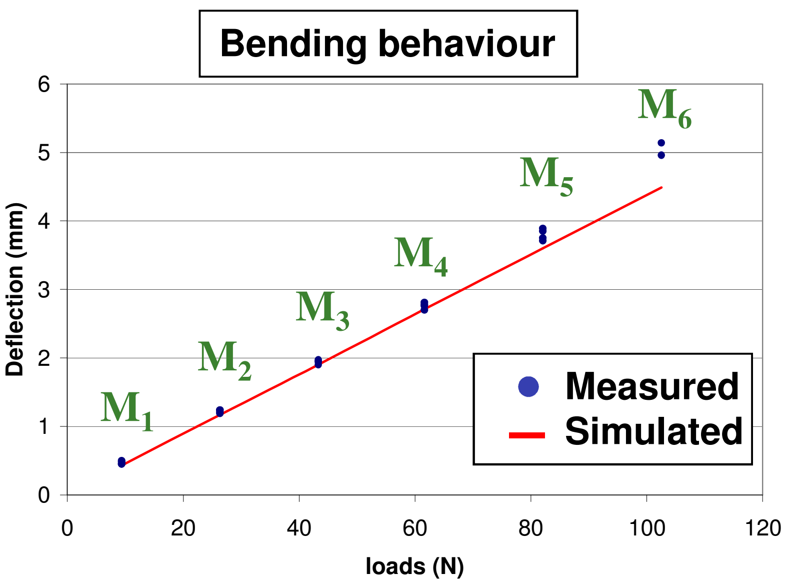
Improve the simulation about the mechanical behaviour

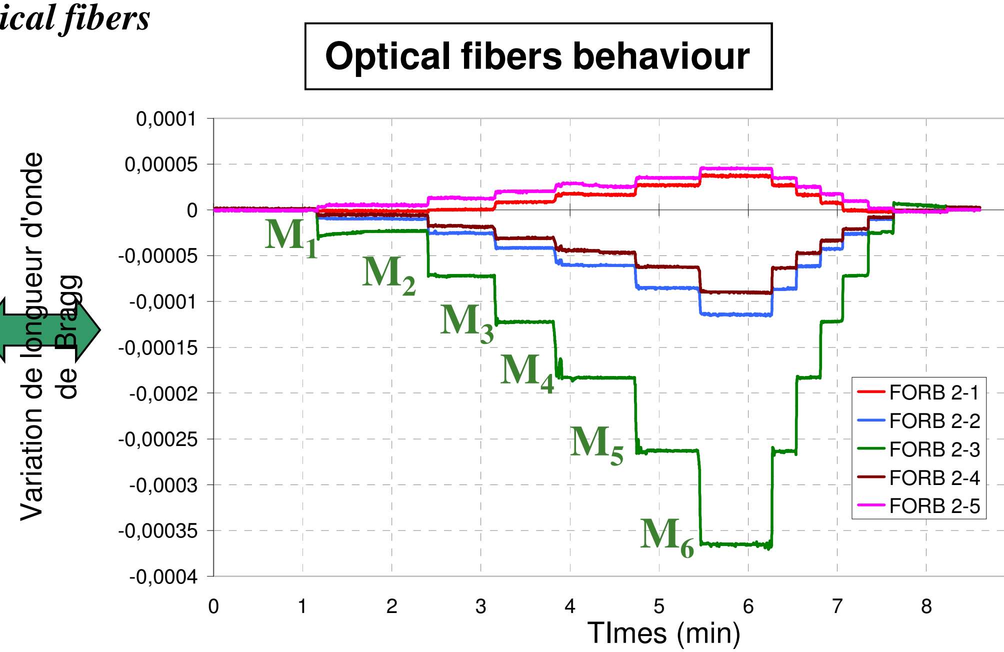
- Non-Destructive tests using optical fibers with 5 bragg gratings along the alveolar structure layer
- Bending tests (3 pts):

  6 different cases (Mi) compared with SAMCEF simulations



Optical fibers

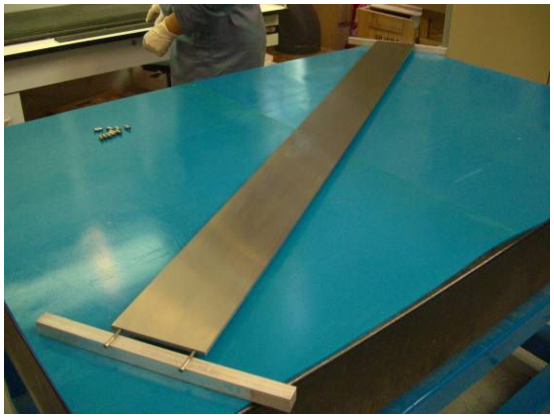




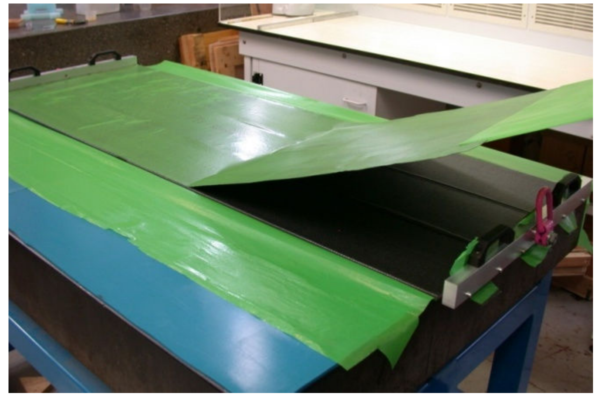
EUDET □ First layer (1/2)

<u>Main process steps :</u>

1 - mould release preparation

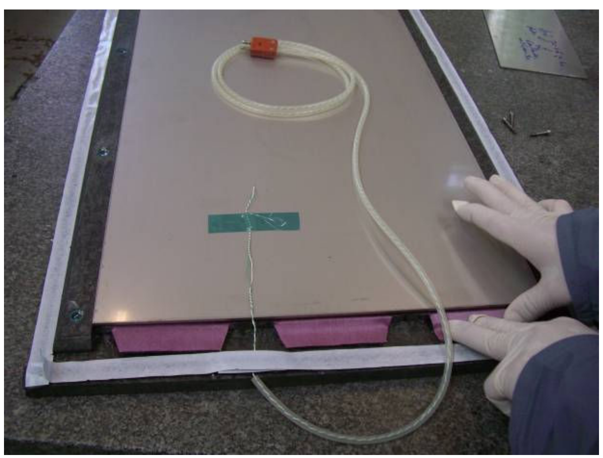


2 - Cores wrapped with prepreg

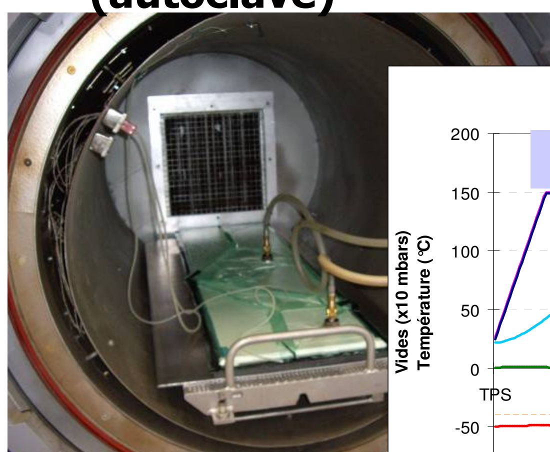


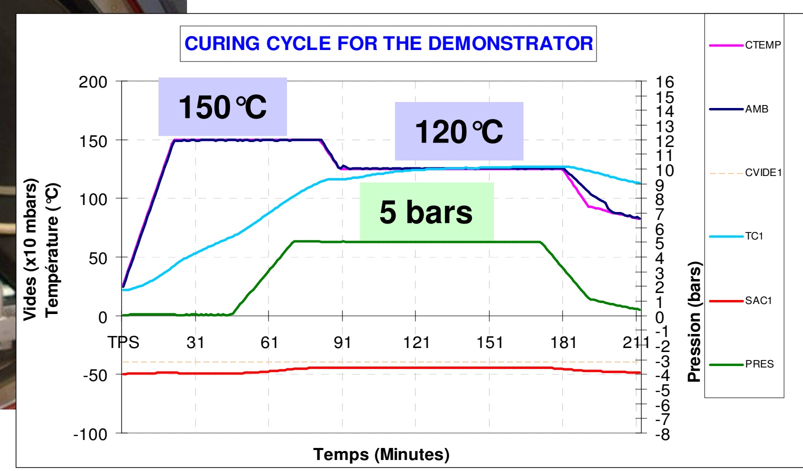
3 – Compression step

4 – Thermal sensor equipment



5 – Curing operation (autoclave)

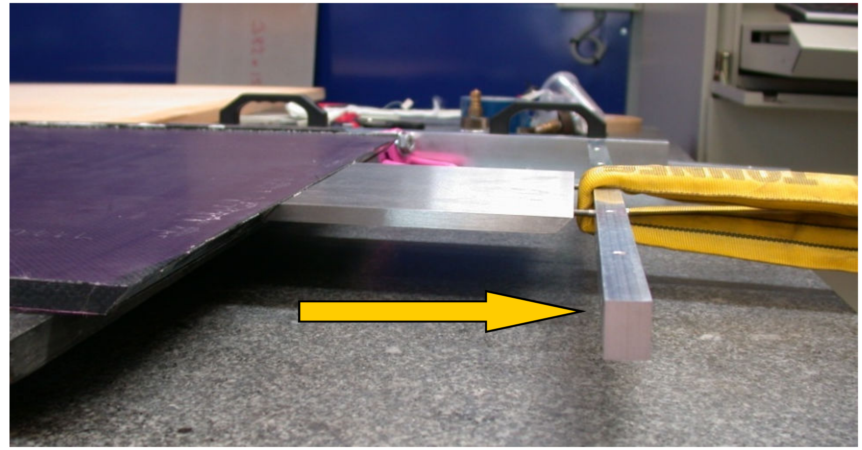


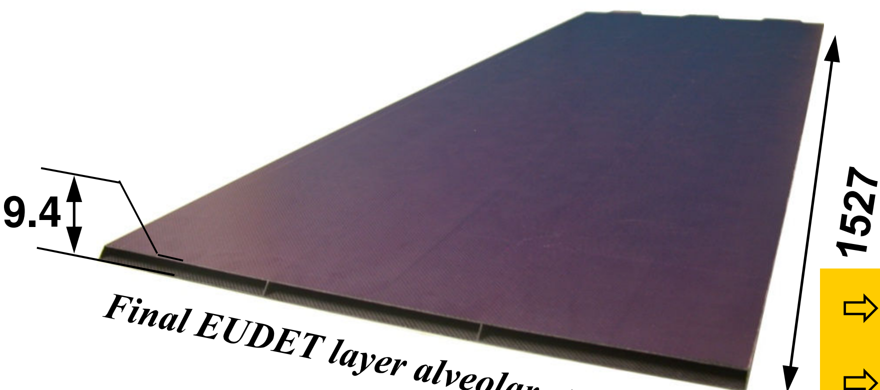


EUDET □ First layer (2/2)

6 – After curing step

7 – Main issue : 3000 Newtons of cores traction





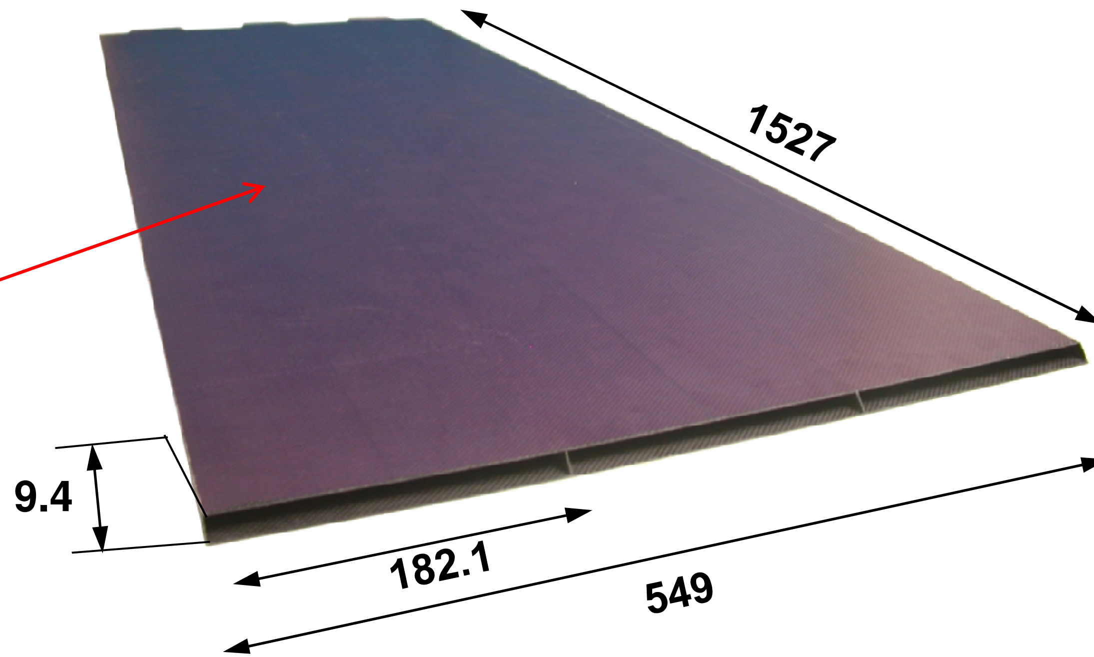
Final EUDET layer alveolar structure

- ⇨ Global design : ***OK***
- ⇨ 1/15 "Alveolar EUDET layer" structure : ***OK***
- ⇨ Cutting Layer operation: ***OK***
- ⇨ The supplier for cutting layer : ***OK***

EUDET design

- New built layer for the EUDET Module
- Cells width is based on 182.1 mm
- Used for BEAMTESTS.

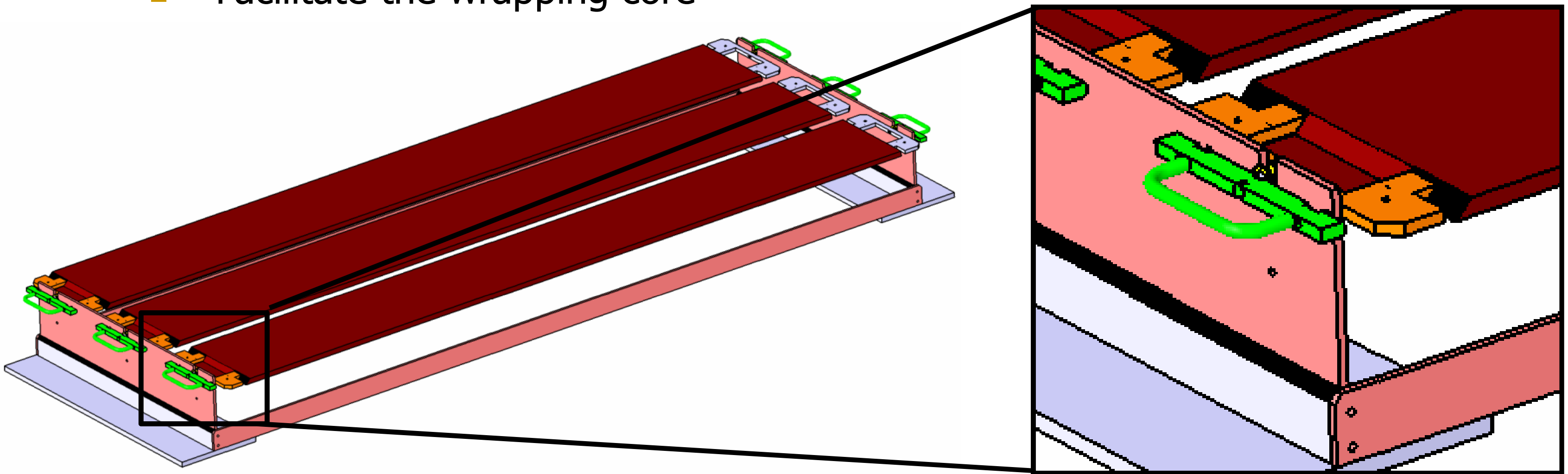
First EUDET layer alveolar structure



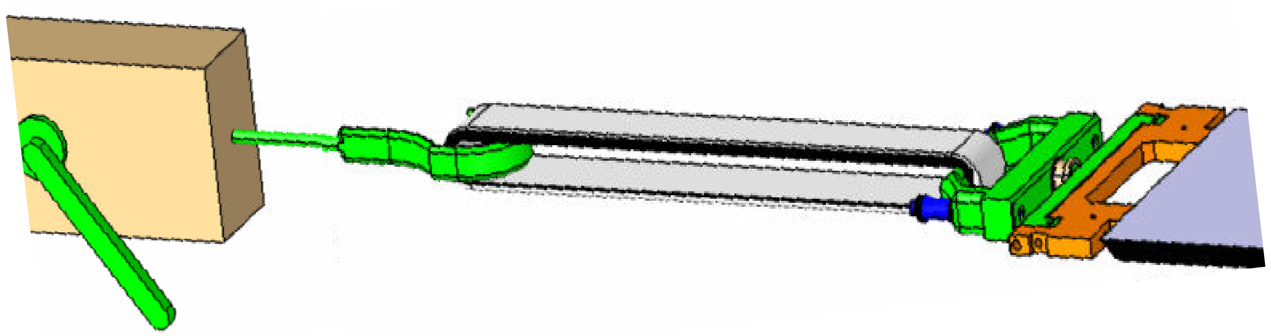
- **the assembly consisted of**
  - **15 alveolar layers + 14 Tungsten layers**
  - **3 columns of cells : representative cells in the middle of the structure**
- **Width of cells : 182.1 mm**
- **2 Thickness cells (7.3 mm and 9.4 mm)**
- **Identical global length : 1.495m**
- **Fastening system ECAL/HCAL**
- **Total weight : ~ 800 Kg**

EUDET TOOLS : Study and design

- EUDET handle core
  - Safety Transport
  - Facilitate the wrapping core

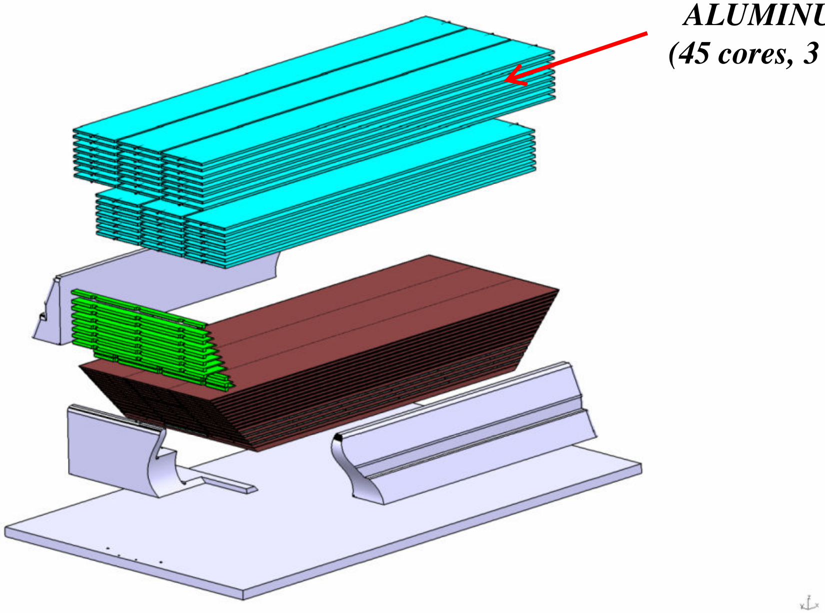


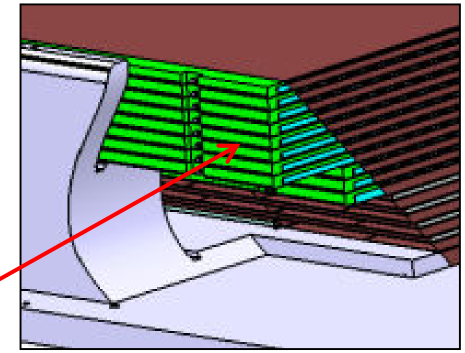
- Winch extraction core
  - Control the traction force (max 6000 N) and the speed extraction (0,5 m/min)

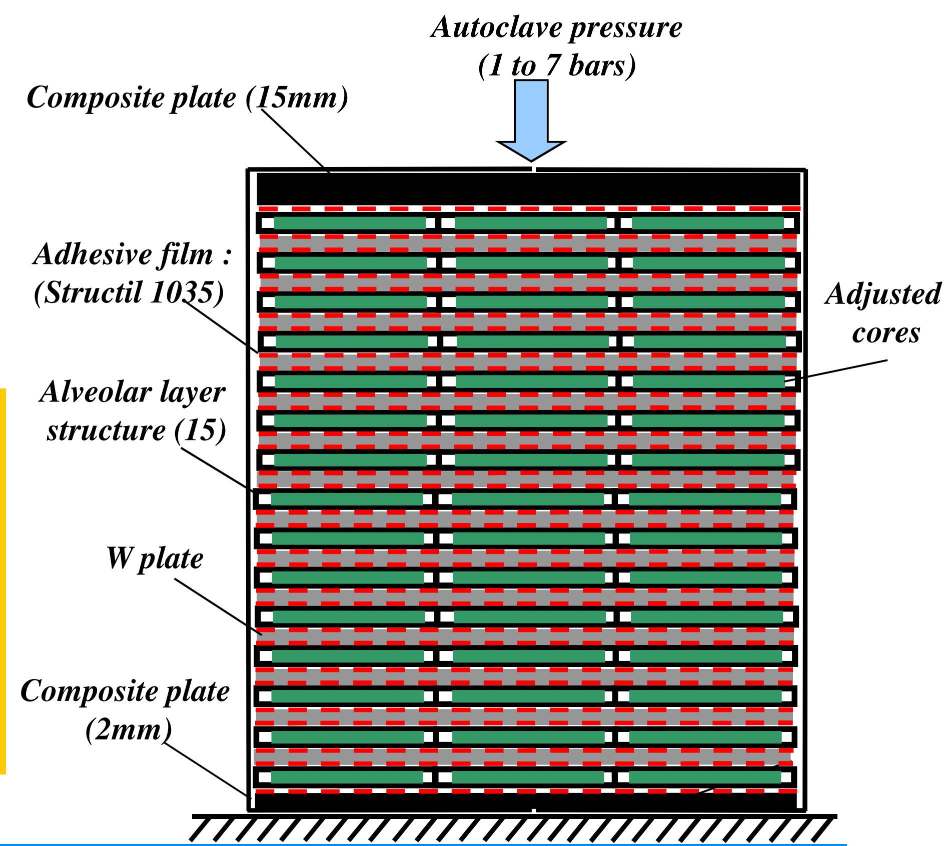


EUDET Assembly Mould

Now, here is the EUDET assembly mould :







- ⇨ Global design : ***OK***
- ⇨ W and Carbon Needs : ***OK***
- ⇨ Detailed design description : ***ON going***
- ⇨ Technical drawing : ***October 09***
- ⇨ Ordered : ***November 09***

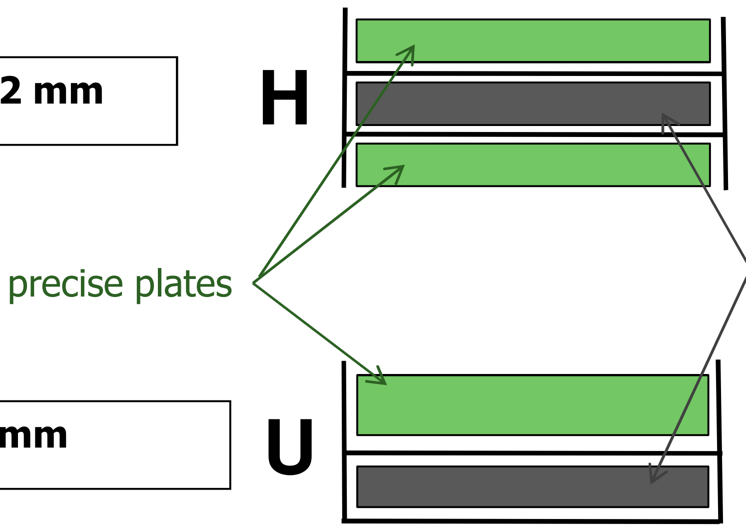
EUDET H or U SLAB

<u>Study of one mould for whole slab structures:</u>

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

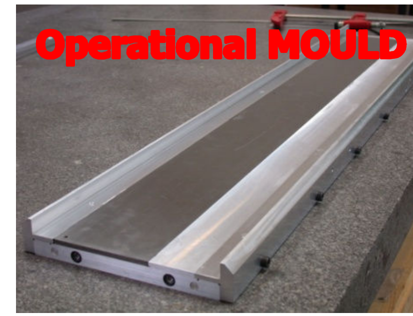
If PCB <= 1.2 mm

If > 1.2 mm



- 30 Silicium layers
- Chip on board

- 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: ***Decem 09***
⇨ EUDET short and long U SLAB: ***Fev 10***

Conclusion :

- We have realized a high step :
  - knowledge in the Carbon cells structures building.
  - the demonstrator assembly and mono- EUDET layer.
  - Global dimensions are correct to envisage the ILD assembly as planned.
  - Respect internal dimensions, no problem to insert the slab.
  - Start the Design and studies of the EUDET Assembly Mould.

- The next step :
  - Build 14 mono-EUDET layer.
  - Cutting layer operation.
  - Studies the thermal inerties parameters 1.7 T (W and mould)
  - Insertions slab tests
  - Characterize material Test
  - Continue the mechanical tests (with bragg grating) until destroy ?

Conclusion : schedule

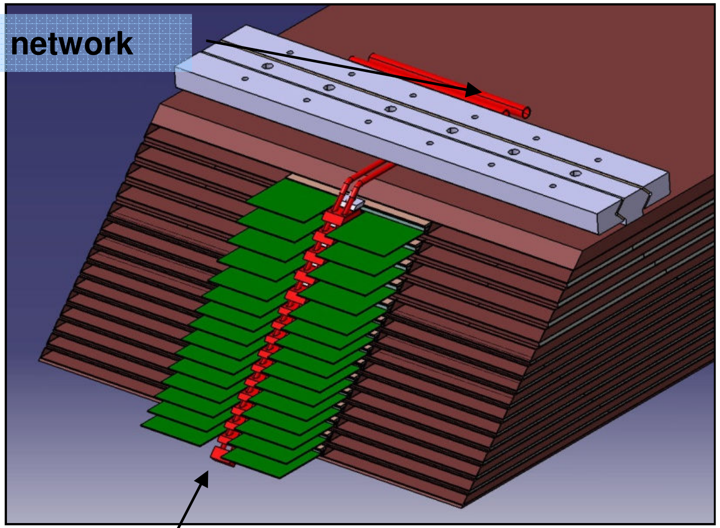
- For Eudet module :
  - Composite reception **realized in april (2008)**
  - "Alveolar layer" mould reception **realized in april (2008)**
  - Building one EUDET alveolar layer in **July (2009)**
  - We will plan:
    - "Assembly mould" design in **October (2009)**
    - 14 alveolar layers in **second half-year (2009)**
    - Eudet structure assembled in the **first 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)**

EUDET COOLING

Design

The purpose of cooling system is to maintain the electronics at an acceptable temperature (40°c maximum)

Cooling network



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

Cooling plan

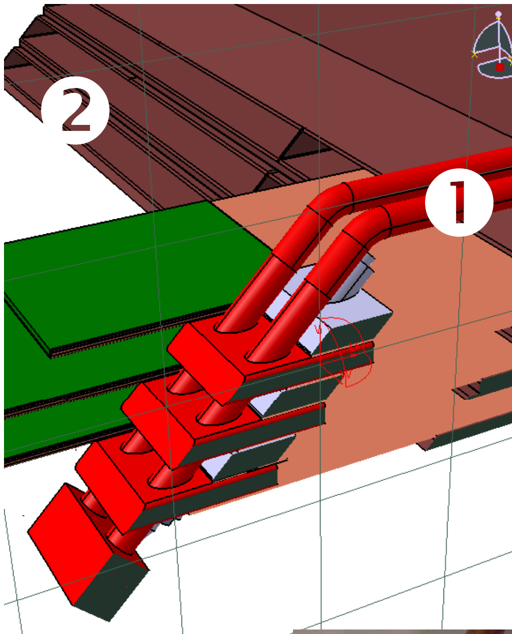
- Water cooling
- Sub atmospheric pressure at electronic level (Leakless system)
- Water cooling plus Heat pipe near Slabs
- Cooling temp : 20°c

Connection of the system : each cooling system is inserted and screwed to each column of slab with a thread rod or individual screwing on each slab and connected to the cooling network in a second step .

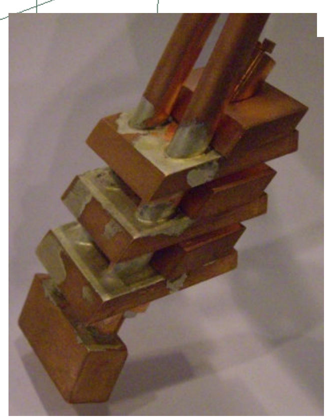
EUDET COOLING

Cold plate : 3 Solutions

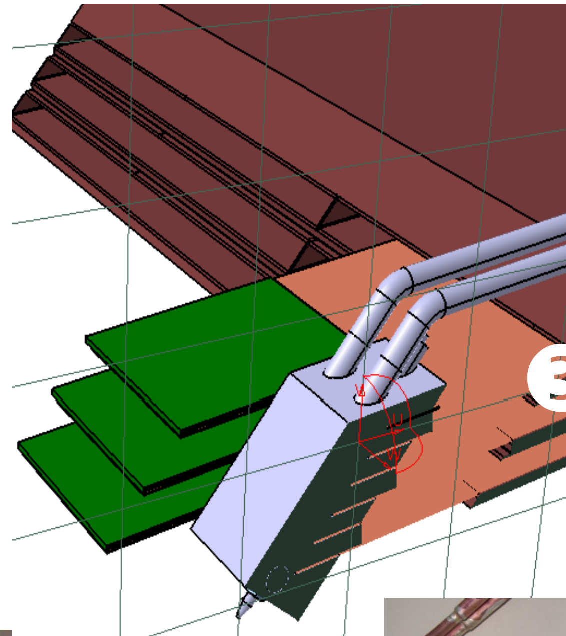
❶ Assembled solution



Water circulating into copper pipe (Internal diameter : 4 mm)

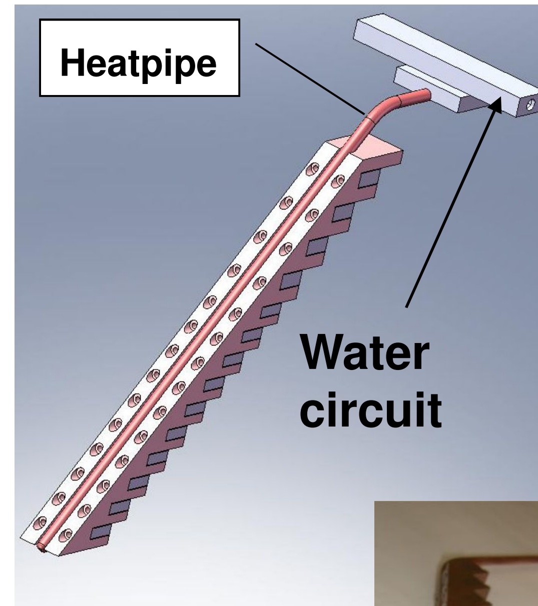


❷ Machining solution



-1 block with water circulating into copper pipe
-(Internal dia.: 4 mm)
- Easier to build

❸ Heatpipe



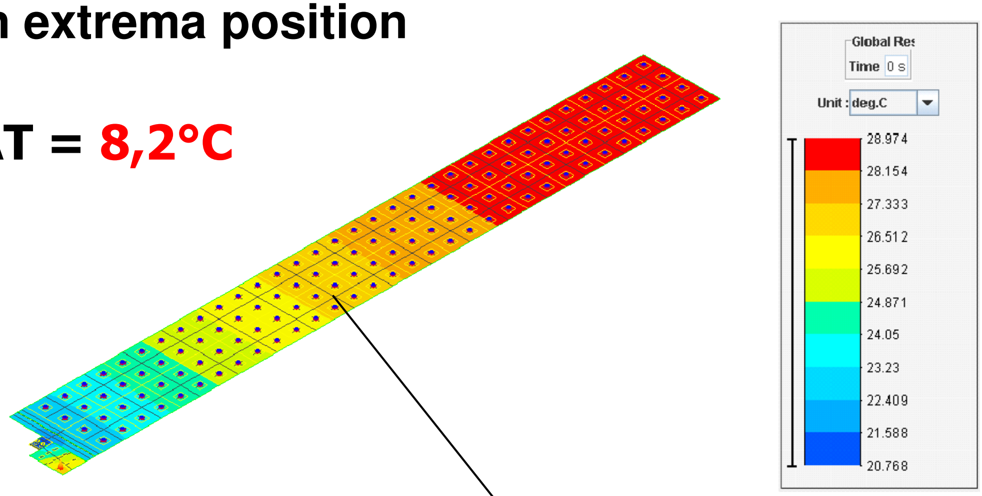
Main advantage : Connection between Heat pipe and water circuit => contact, far from front-end.
Easy to assemble and reduces leak risk

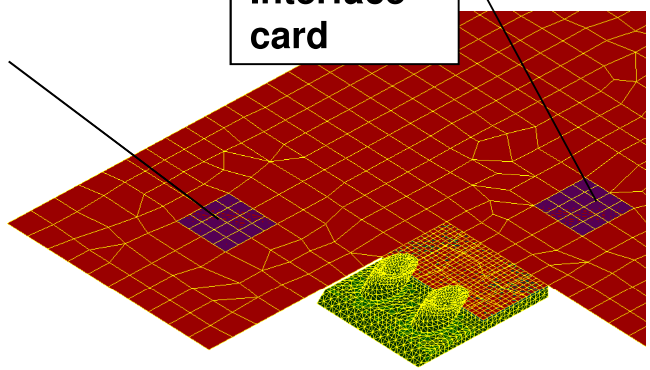
EUDET COOLING

Simulation of heat conduction just by the heat copper shield : Influence of FPGA dissipation (DIF) on current design of cooling system

Load case : FPGA power : 0,3 W distributed on 10 x 5 in extrema position

ΔT = 8,2°C

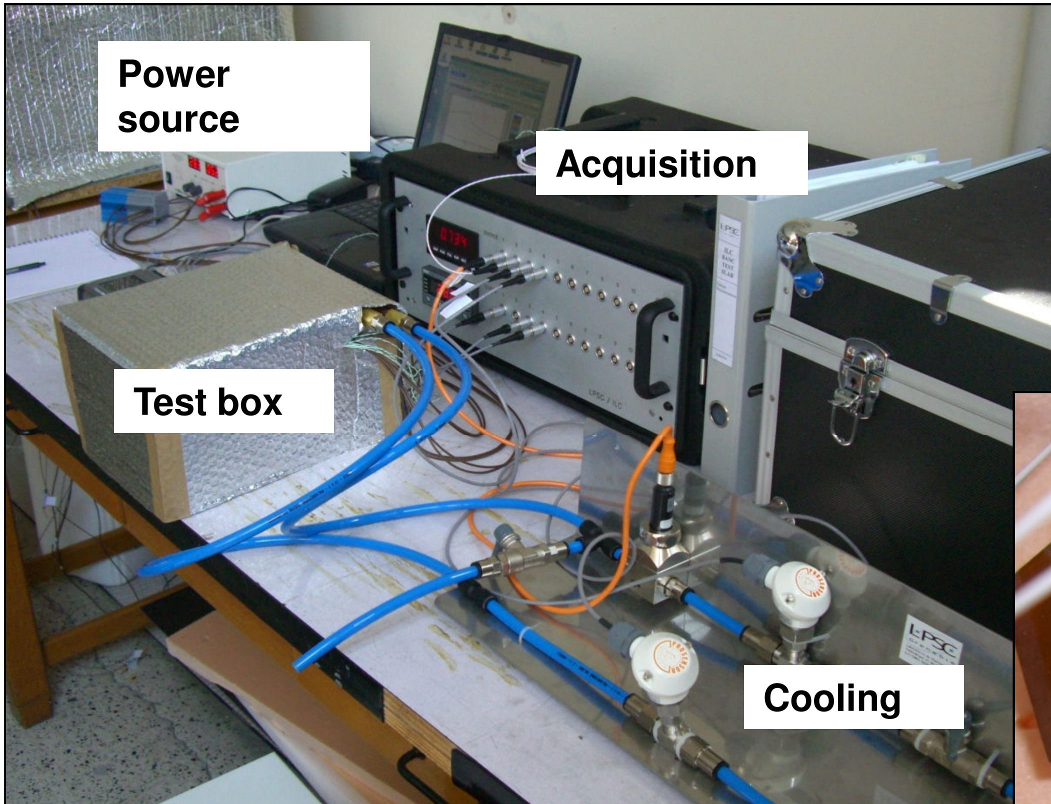




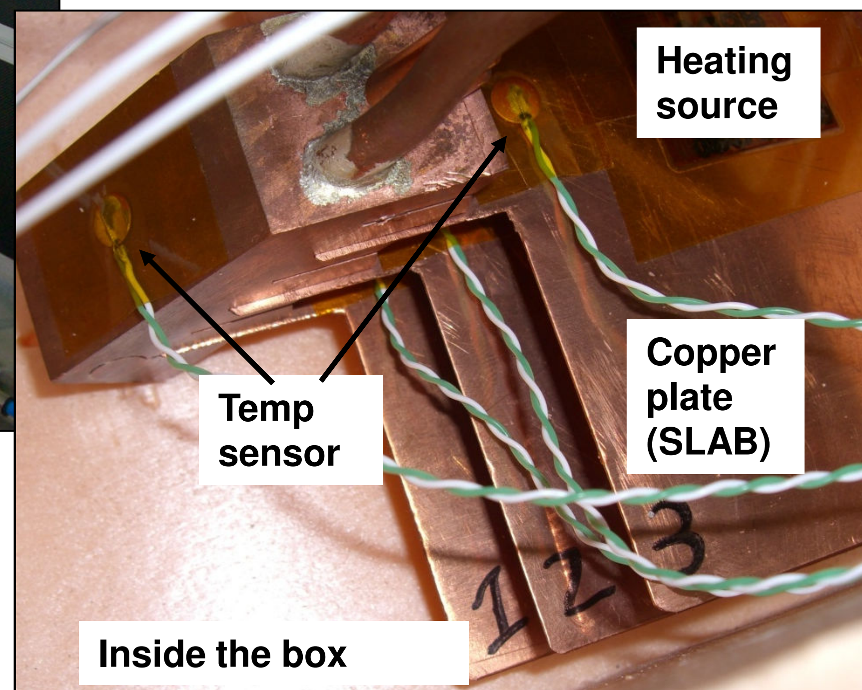
Model near cooling system connection

EUDET COOLING

Thermal contact resistance characterization



Global installation



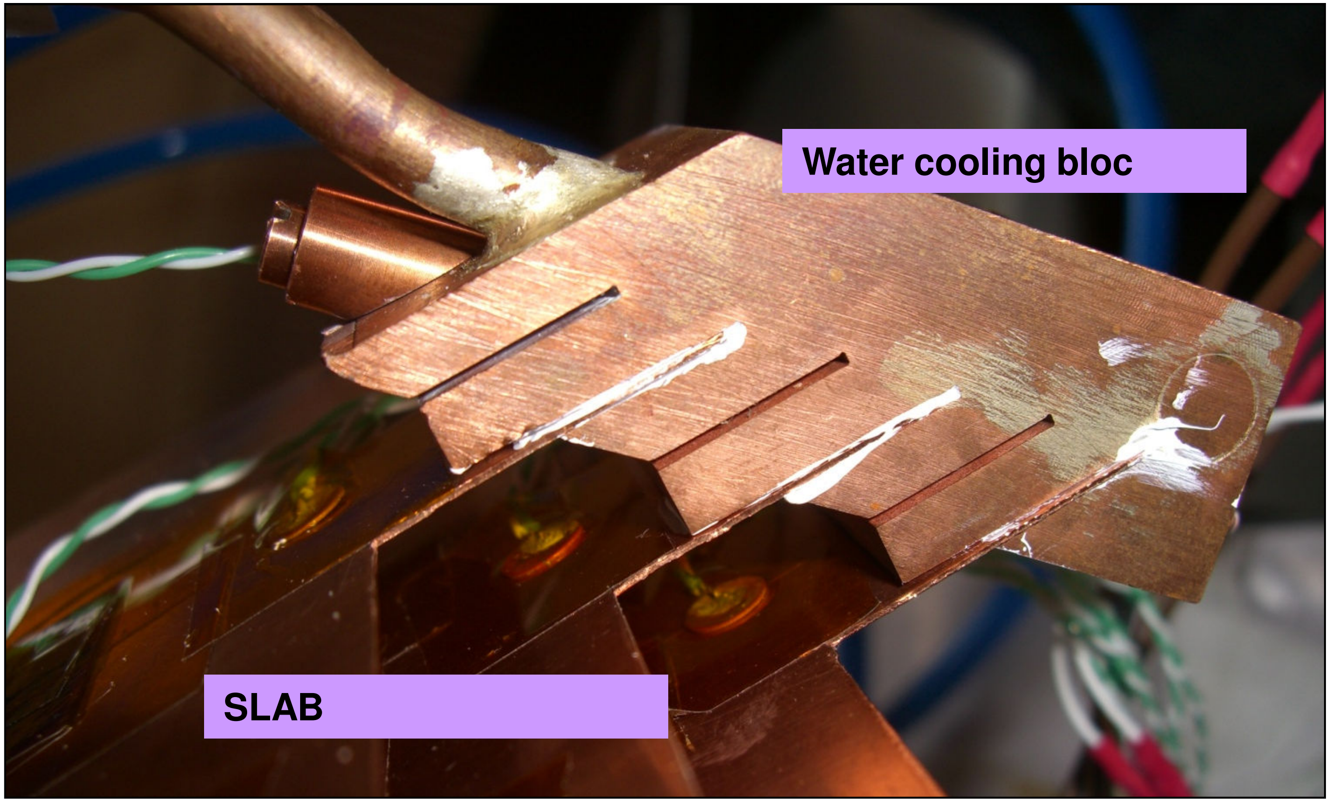
EUDET COOLING

Conclusion of the thermal contact resistance test :

Dry contact : 3.9 K / W

Contact with thermal paste (0.4 W/m/K) : 3.1 K / W

Thermal Paste => 20% gain



Ok if we have 0.5W / ½ slab => 1.55°… but ….. 3.5W / ½ slab => 11°c

EUDET COOLING

Next step: Thermal test in demonstrator at LAL : 26, 27 October

Heating test in the alveolar structure => closest to the real configuration
Test SLAB + heating system in the other alveoli => reproduce the symmetry of the heating source

Goal of the test : determine stabilization temperature system and to know more precisely the exchange with the upper and lower side of the demonstrator (to avoid thermalization of HCAL)