Ecal mechanics

Expert work presented by a layman

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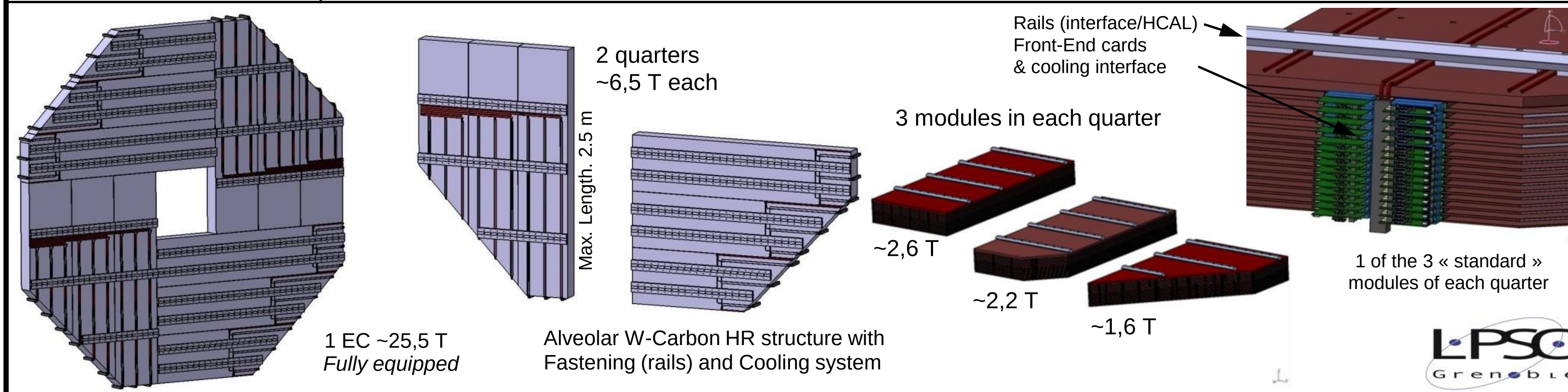
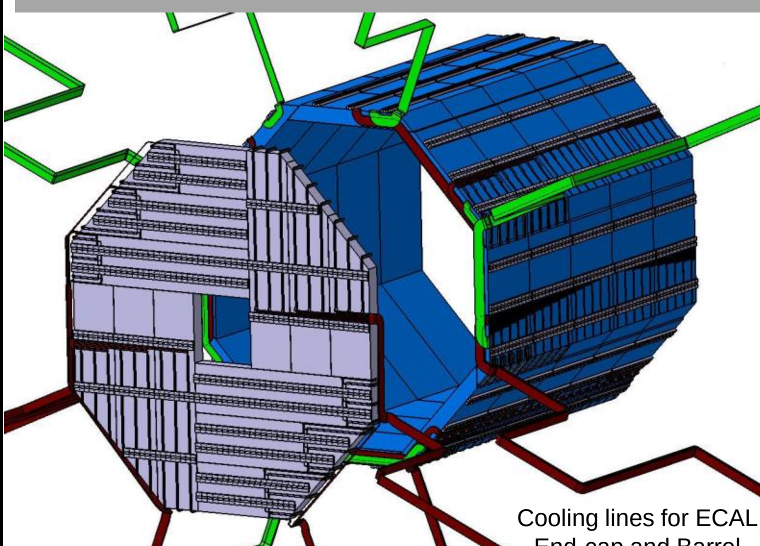
CALICE Collaboration Meeting Argonne/IL March 2014

Current structure of end caps

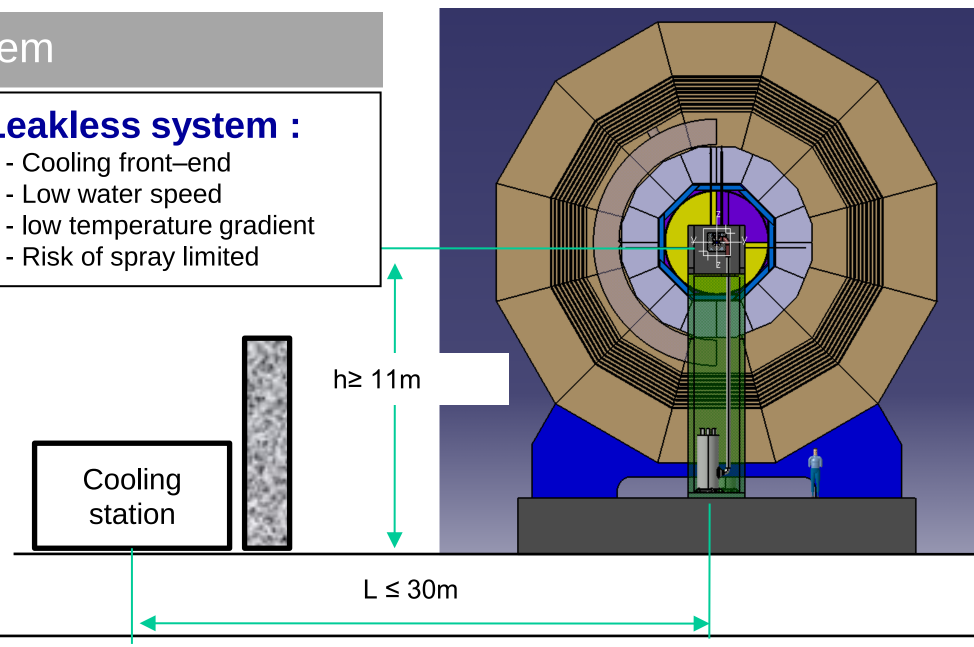
Modular structure	2 End-Caps Total of 2x12 modules = 2 x [4 quarters each]



ECAL Cooling Integration - Leakless system



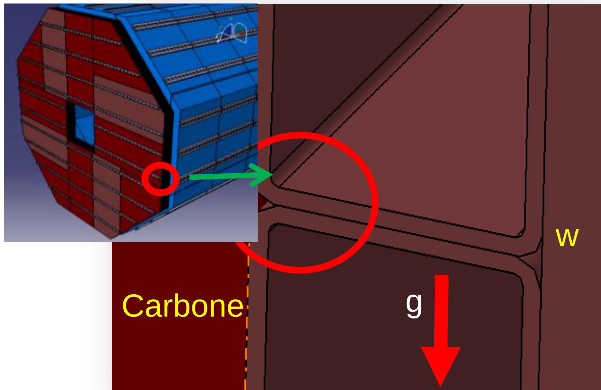
Leakless system :
- Cooling front–end
- Low water speed
- low temperature gradient
- Risk of spray limited

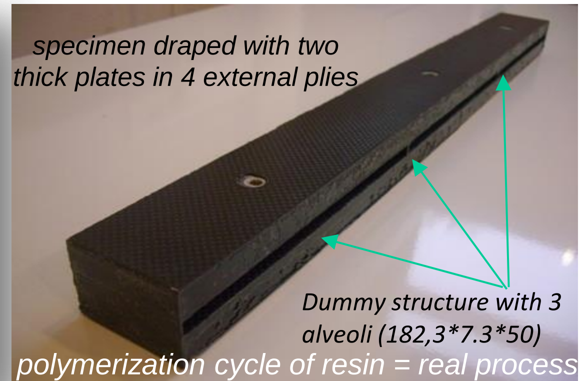


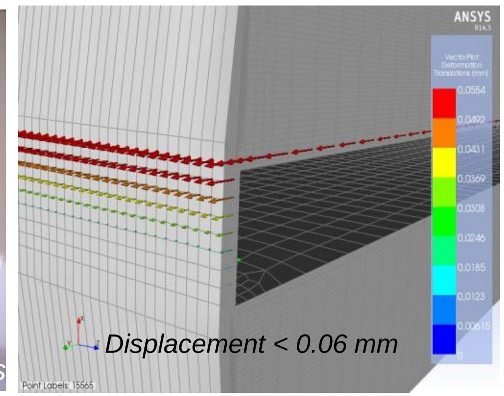
Evolution of skin thickness

Correlation of FEA simulations / shearing tests of representative structure

Problem of bending stress of alveoli skins / evolution of external plies







Influence of modification of external ply thickness on the first main constraint of external and internal walls

If external plies thickness increases => **Impact** on ECAL dead zone => Optimization of deflection values

Displacements	~0.1 mm vs 0.5mm for fatigue shearing tests ...
Main contraints	< 159 Mpa *both*
Shearing constraint	11.5 Mpa vs **6** (1,8/wall) Mpa for shearing tests ...

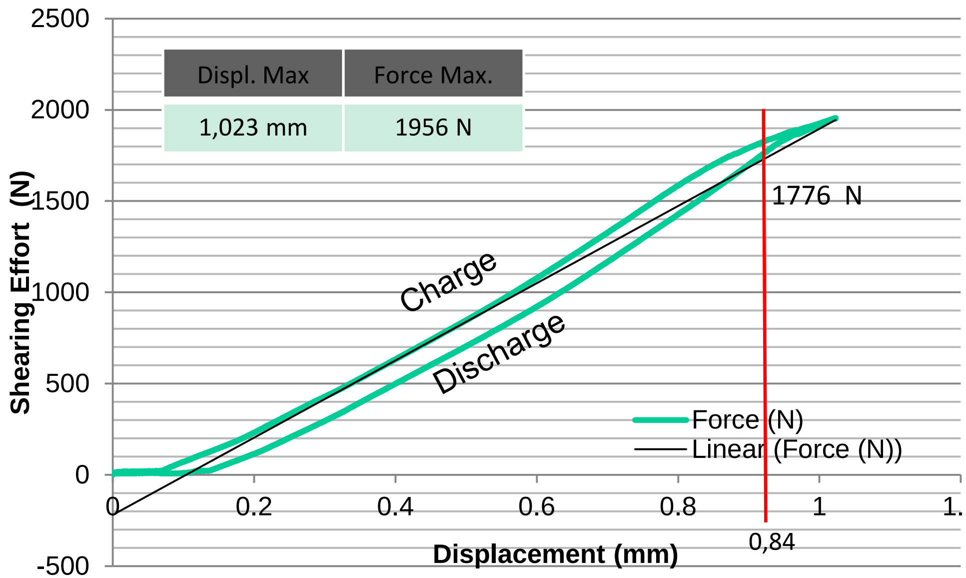
From simulations to shearing tests
(ANSYS APDL / SAMCEF / ANSYS ACP)

Tests & simulations to be performed

- Adapt FEA parameters to simulate the whole structure / shearing results
- Destructive test on a existing structure *(demonstrator -EUDET)* / verification of bonded structures
- Process: increase intercoat adhesion with structural adhesive film
- Process: obtaining reliable thicknesses of walls *(specific long moulds, tooling development)* / Draping optimization
- Reliability tests: good & uniform impregnation of parts, good compacting
- Resistance of End-Caps to earthquake
- "Mass" production conception *(ply book enhancement, tooling, process)*

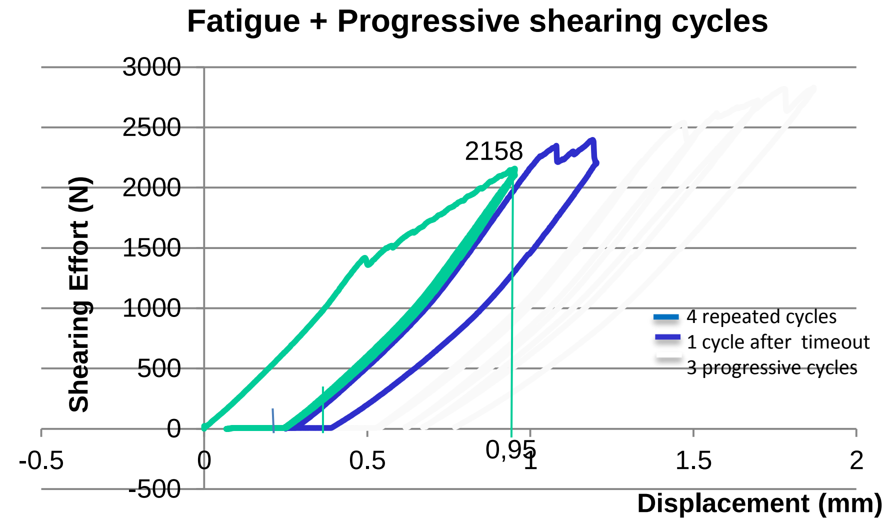
ECAL End-Caps: shearing tests

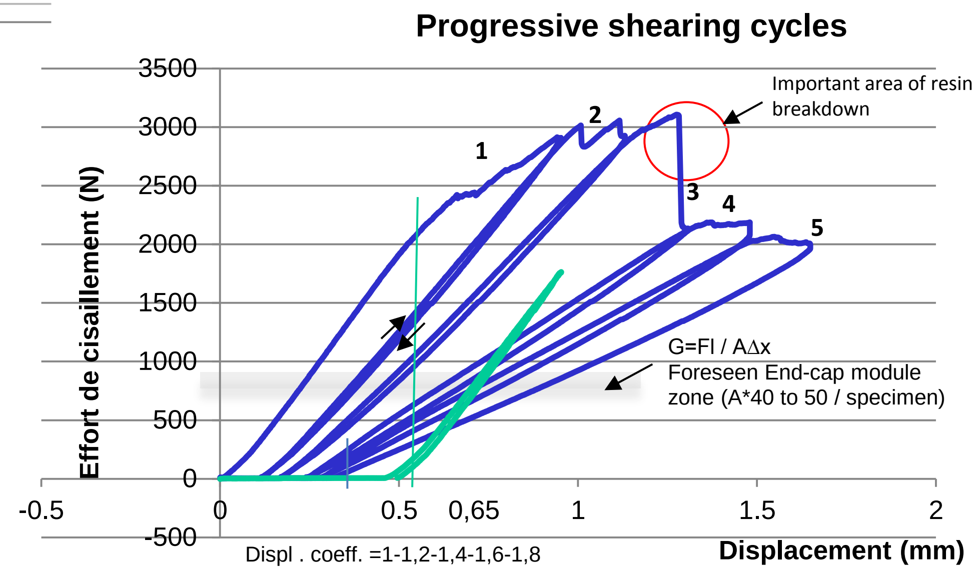
Monotonic shearing test



safety factor: s = 3.2 with respect to the stress induced / largest module (2,5m–25,5 kN) to be improved / "seismic issues" ILD'13 meeting in Cracow

Destructive tests with charge & discharge cycles / *hysteresis & weakening of the structures (resin) during repeated stresses*





Reduction in stiffness
predictable during integration
(G# 85 MPa to 74 Mpa)
Stay < Δx = 0.35 mm (mechanical limiters) or
Increase No. of envelope folds (/ seism)
Max. admissible flexion value of slabs to be confirmed

To be continued in 2014

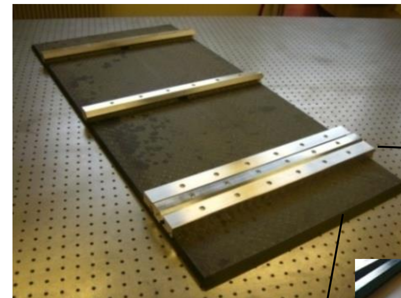
Structure of end caps

2.5 m alveoli layer molding

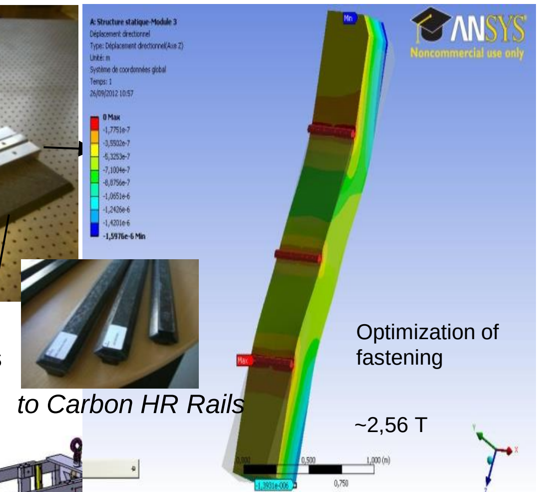
- **The end-cap layer test consisted of**
- **3 long alveoli** (representative of end-cap module longest layers)
- **Width of cell : 182,3 mm** like barrel's one (for electronic uniformity)
- **Thickness of cells : 7.3 mm - wall: 0.5 mm**
- **Length : 2.490 m**

long layer of 3 alveoli demolded nov.2013 with new system woven-resin (C202+ET445) .To be improved

Thick plates & fastening system



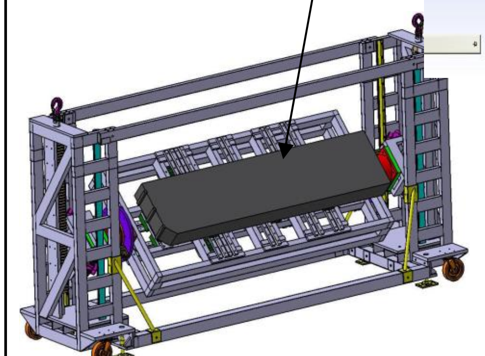
EUDET Carbon HR plate
13 mm with metallic inserts



to Carbon HR Rails

Optimization of fastening

~2,56 T



Building on going of transport and handling tools for integration & tests

Ongoing developments

- •Design of specific tools for long draping
- •Industrialisation study of process / long alveoli layers (~ 540 cells up to 2,50m)
- •Continuing the mounting of the handling tool of modules & design /quarters End-Cap
- •Thick composite plate for double low section rails: OK
- •Characterization, tests & optimization: positioning / bending of modules
- •Towards construction of a long EC module ?

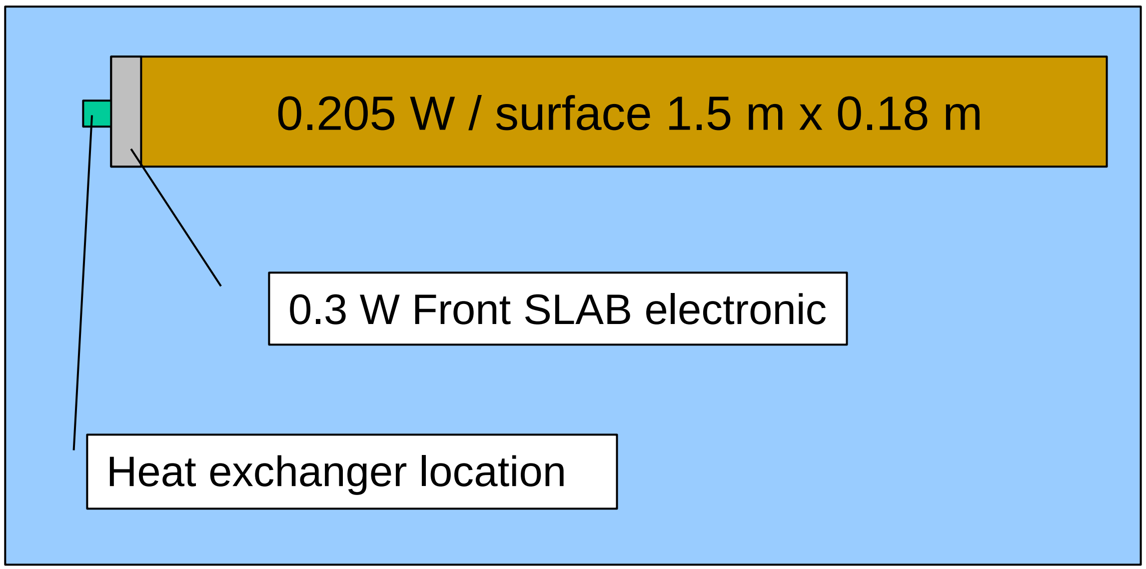
LPSC Grenoble

Cooling capacitites

Power dissipation : Final goal with power pulsing 1/100 s

For ½ SLAB from barrel
Wafers consumption : 0.205 W
Front SLAB electronic : 0.3 W

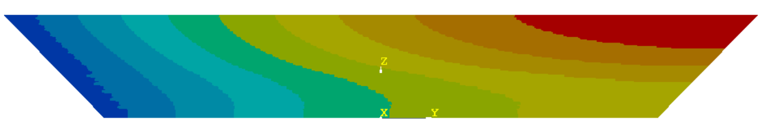
Ecal detector : 4.5 kW



Passive cooling : OK

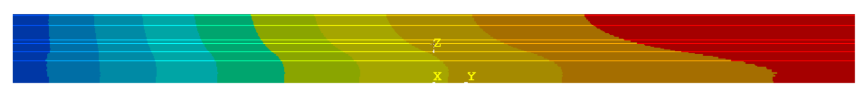
… support up to 10x bigger heat load (for details see backup)

Barrel : (1.5m)



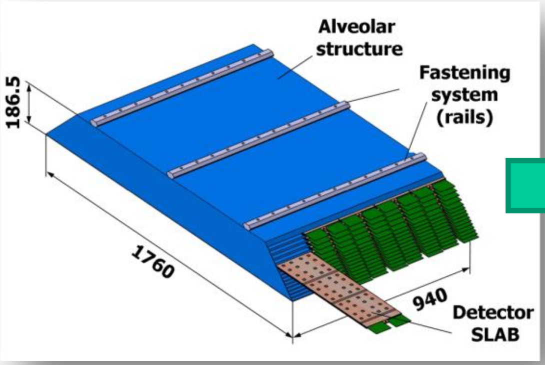
$\Delta T = 2{,}2^\circ$ C

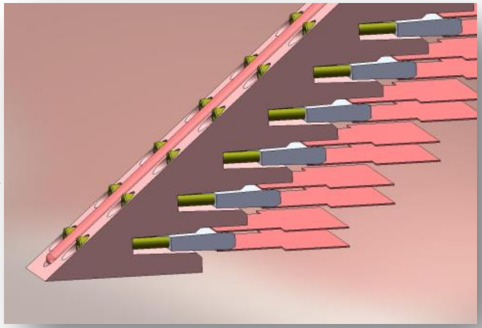
End Cap : (2.5m)

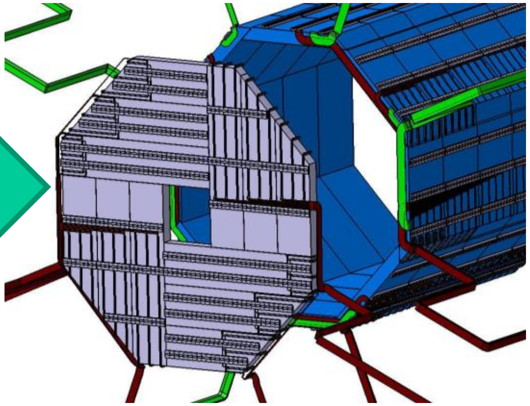


$\Delta T = 6^\circ$ C

Study from the power source to the global cooling

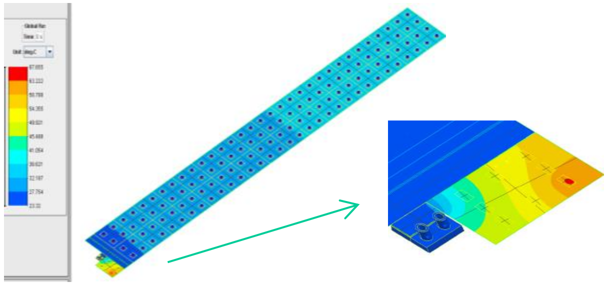






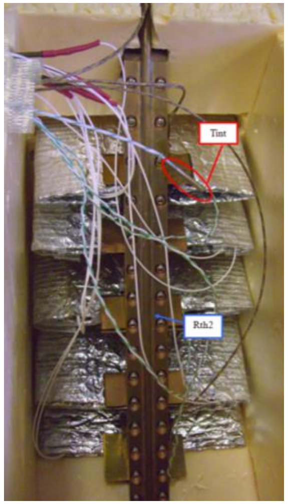
SLAB

Thermal simulation and test on Slab



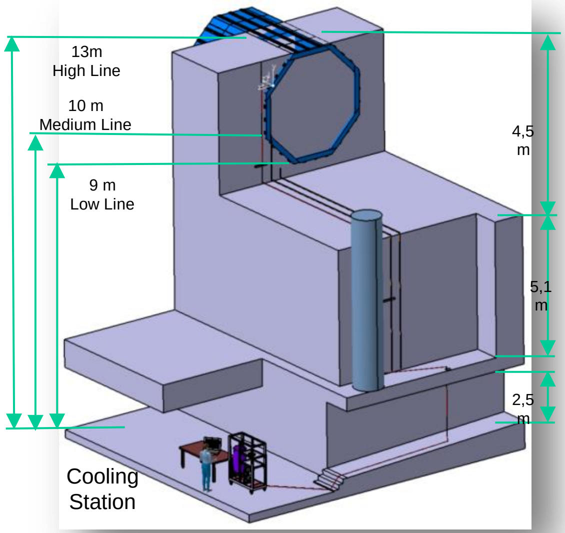
Heat exchanger

Simulation and test on different type of heat exchangers



Global cooling

True scale leak less loop

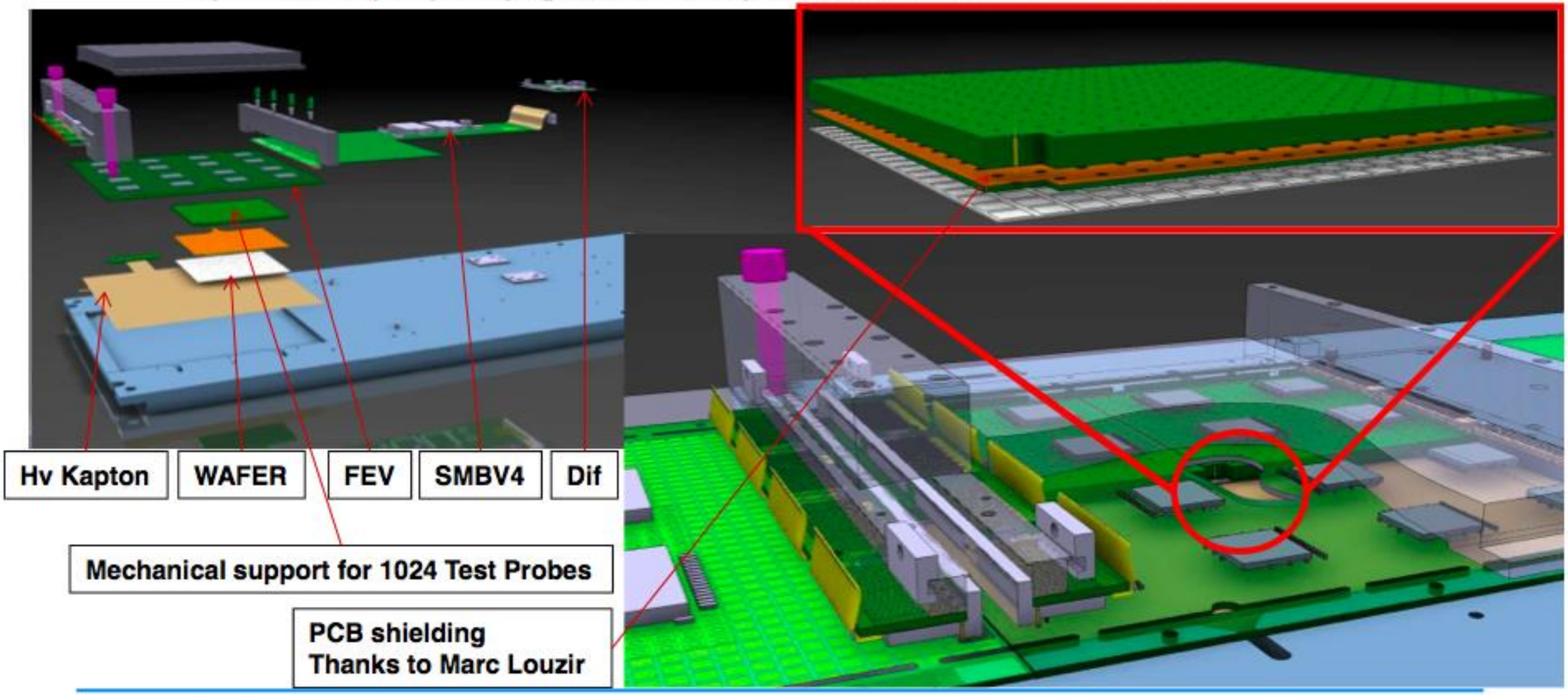


Flexible test bench

⇨ **The goal:**

2.0 – Setup option with support of test electric probes for connecting WAFER to FEV

- Realize an assembly with removable wafer in order to acquire cosmic data. This assembly will test the entire acquisition chain (Wafer-FEV-SMBV4-DIF-GDCC-CCC-PC-Software) before the wafer gluing operation. The first test was realized last week



Can be also used for reception tests for detector assembly

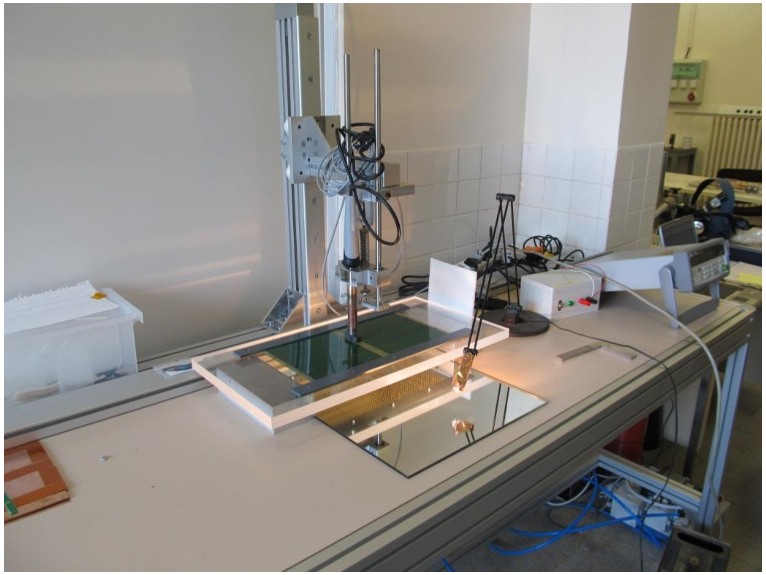
Towards assembly bench

- Development of a set of specifications to assure proper assembly of four wafer ASUs
  Tolerances of PCB, H or U board
  Example : Mechanical stress on wafers during interconnections
  First set end spring 2014

- Revision/Scrutinisation of assembly tools
  Development and validation of assembly bench, 'easy' reproducibilty
  Combination of ASU positioning and interconnection

Interconnection station

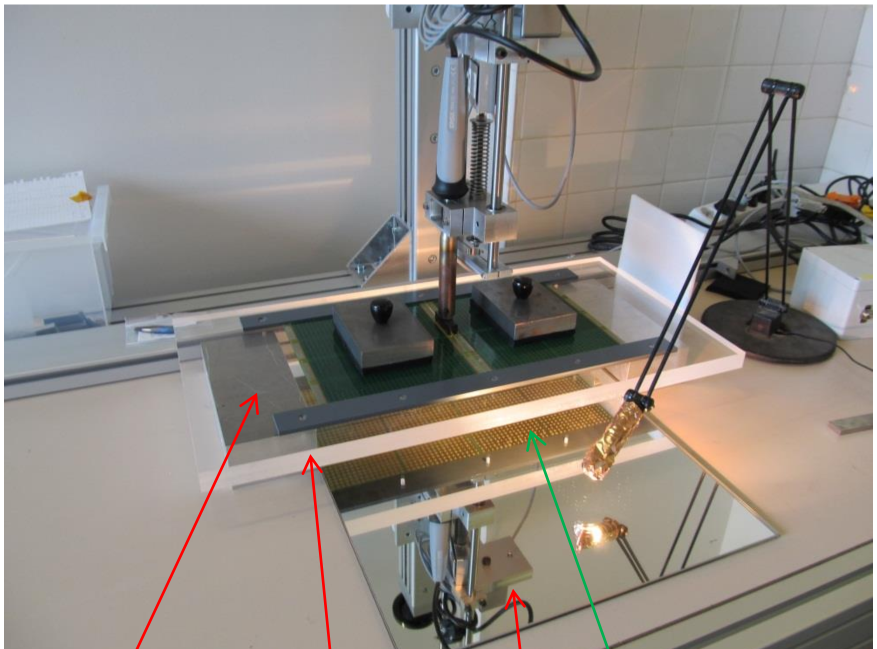
Assembly station

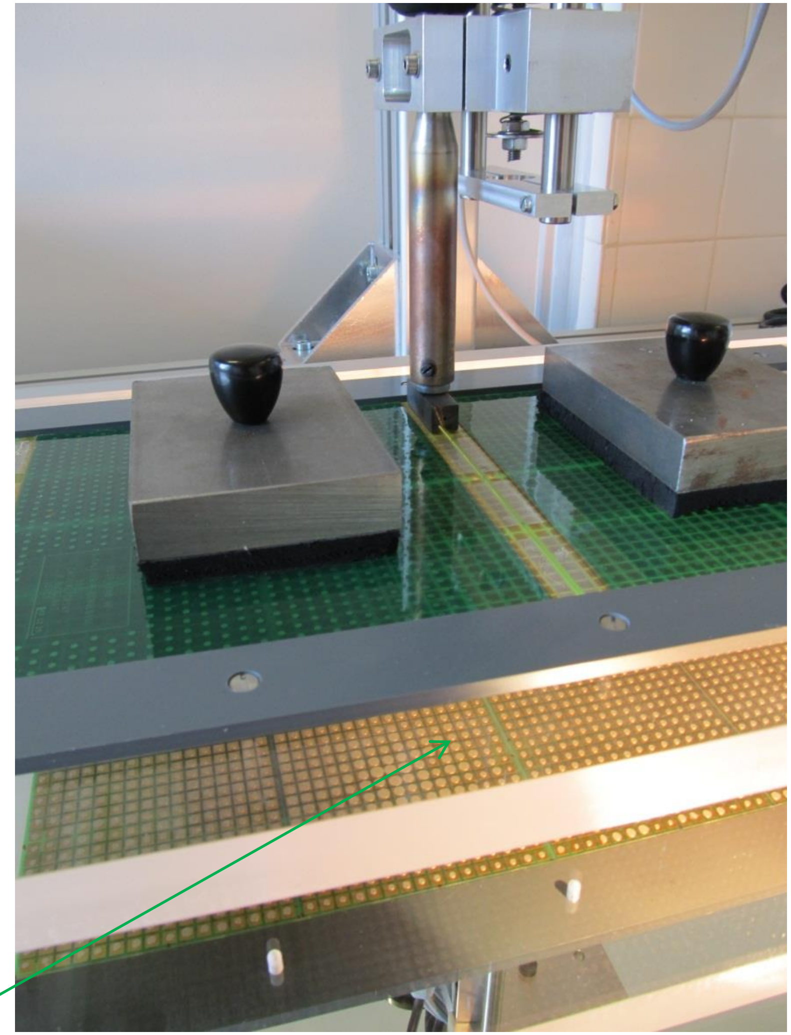


-Continous revision of process with aim to propose a procedure for LC Ecal in ~ 1 year
-(first version exists however)

Example for systematic studies

Pressure test on ASU (FEV8_Glass) with soldier iron for interconnection





Support of plate

Plexiglass plate

Mirror

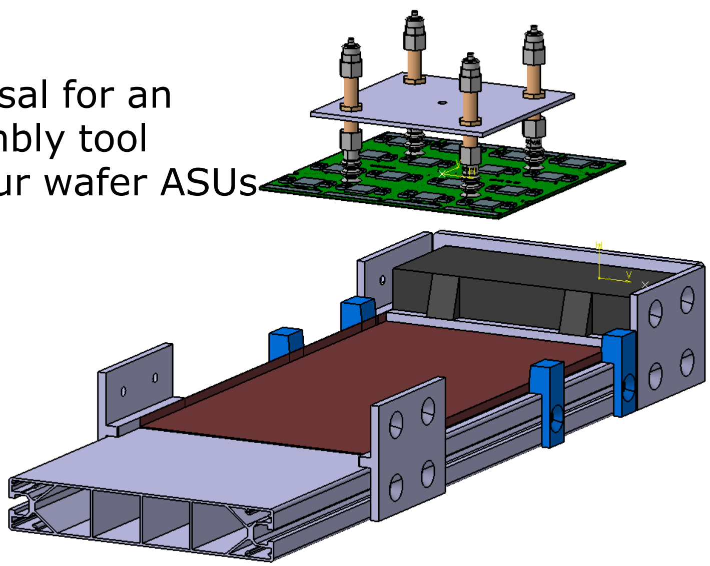
Mirrored image of lower ASU part

Tests will be repeated with ‘false’ wafers (contact with IEF Orsay)

Assembly bench – Tolerances and tools

Monitoring of mechanical forces during interconnection

Proposal for an assembly tool for four wafer ASUs



3D measurement of U board

Mitutoyo

RAPPORT DE CONTROLE

Nom utilisateur
Admin

DEMANDEUR :
JULIEN BONIS

11.03.2014 10:34

PROJET :

Nom et emplacement du programme
C:\Docs\Doc Contrôle\Cosmos 2011\prg cosmos\PVA0KE7M
Programme : PLAQUE FIBRE

ENSEMBLE :

PIECE :
PLAQUE FIBRE AVEC ALU

Nom du fichier pdf :
2014.03.11 10:34 PLAQUE FIBRE AVEC ALU

NUM PLAN :
****

No.	Line No	Element / Tolerance	Pnt. / Ref.	X-Coord. / X-Angle / Nominal	Y-Coord. / Y-Angle / Up/Lo	Z-Coord. / Z-Angle / Actual	Diameter / Dist./Ang. / Dev./Error	Variance
		COTE DE 180.5 A 5MM DE LA FACE						
2	90	DISTANCE 2 HAUT		180.500	0.100	180.611	0.111	0.011
		Distance XY			-0.100			-----+--->>
3	91	DISTANCE 3 HAUT		180.500	0.100	180.587	0.087	
		Distance XY			-0.100			-----*****-
4	92	DISTANCE 4 HAUT		180.500	0.100	180.739	0.239	0.139
		Distance XY			-0.100			-----+--->>
5	93	DISTANCE 5 HAUT		180.500	0.100	180.673	0.173	0.073
		Distance XY			-0.100			-----+--->>
		COTE DE 180.5 A 1MM DE LA FACE						
7	95	DISTANCE 2 BAS		180.500	0.100	180.747	0.247	0.147
		Distance XY			-0.100			-----+--->>
8	96	DISTANCE 3 BAS		180.500	0.100	180.741	0.241	0.141
		Distance XY			-0.100			-----+--->>
9	97	DISTANCE 4 BAS		180.500	0.100	180.760	0.260	0.160
		Distance XY			-0.100			-----+--->>
10	98	DISTANCE 5 BAS		180.500	0.100	180.740	0.240	0.140
		Distance XY			-0.100			-----+--->>
		PERPENDICULARITE COTE GAUCHE / BORD						
3	102	DROITE COTE GAUCHE			0.200		0.052	
		Perpendicularité						**----
		PERPENDICULARITE COTE DROIT / BORD						
4	104	DROITE COTE DROIT			0.200		0.155	
		Perpendicularité						*****-

GEOPAK Répétition MMT v3.2.R6 Edition 6 in MCOSMOS-2
- Page 1 -

Summary

- Studies for critical mechanical issues of end caps

  Examination of shear forces **(not only)** on end cap walls

  End cap demonstrator is part of AIDA2 proposal

- Continuous development of a cooling system

  Ready for tech. Prototype, studies for 'real' size detector

  Passive cooling seems to be feasible

- Towards assembly bench

  Flexible test beanch to assure tests before actual assembly

  Production of short layers with 4 wafers but development of methods applicable to long layers

  Definition of set of specifications to be respected for detector assembly

  'Where mechanics and electronics meet'

Aim is to present first proposal for mass production in ~ 1 year

Assembly bench is part of AIDA2 proposal

Ecal/End Cap studies

1. Design of the EM end-caps (alveolar structure)

- 2 End-Caps: modular structure of 2x12 modules - composite structure molding
2014… *Evolution of skin thickness* (optimization of deflection values)
Industrialization aspect of process / long modules (~ 540 cells up to 2,50m)
Improving of molds and parts for long module development

2. Cooling system (end-caps + barrel) - Leakless system

- Global Cooling / pipe Integration - design of cooling station + network
- Water heat exchanger design near detector

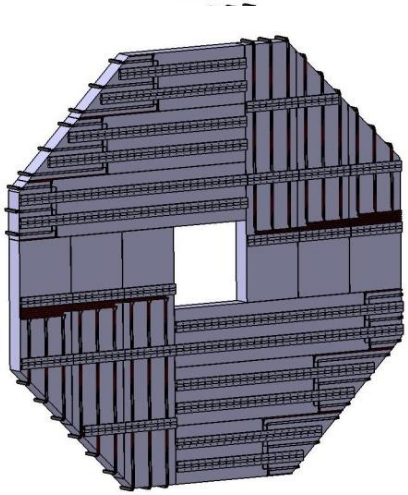
2014... Work on real scale *leakless loop* including *tests* on a real drop of 13m (<1atm)
Representative process to control/ electronic / sensors
Design: hydraulic safety, hardened components, *cooling supervision*

3. Assembly of the EM calorimeter (rails, guiding system ; ends-caps + barrel)

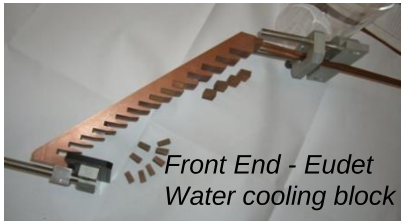
- 3D design & tests of fastening system => 30 mm thick & double row sized rails
2014... Tests & *optimization* / simulation of best *localisation* on modules
Validation of technological solutions (bending of modules)

4. Contribution to prototypes (demonstrator, EUDET module, AIDA, etc.)

- Thick composite plates with inserts and rails for Demonstrator, EUDET & EC module
- Heat exchanger of EUDET – Characterization of water cooling & heat pipe systems
- *Shearing tests to determine stress in the alveolar wall in a case of loading at 90°*
- *Improve the simulation about the global mechanical behavior of End-caps*
- *Conception of* transport and handling tools for integration…



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

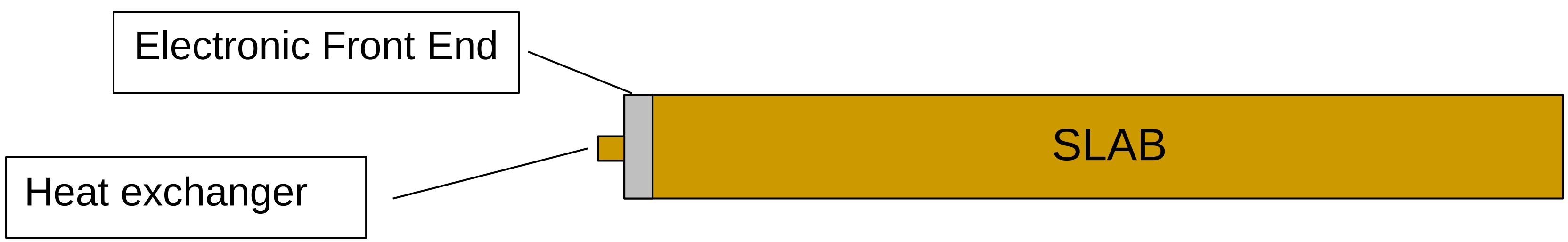


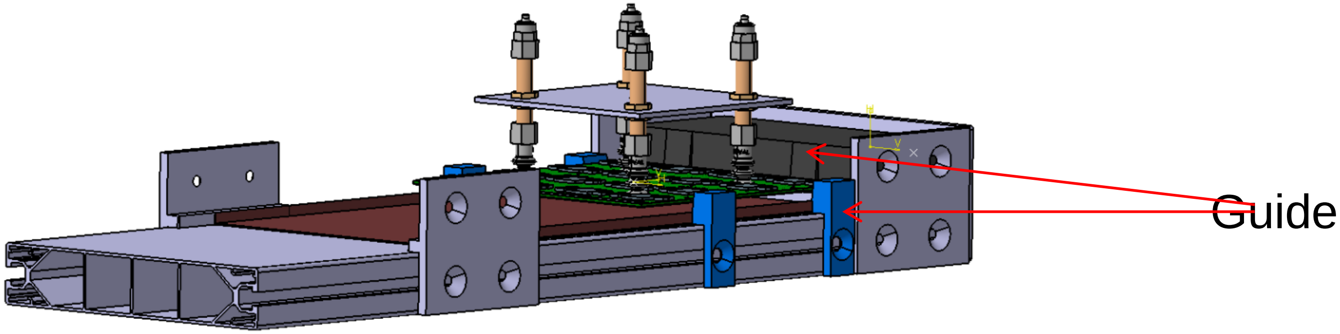
Front End - Eudet
Water cooling block

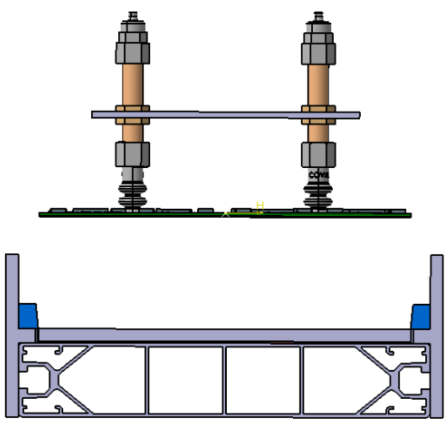
Long layer of 3 alveoli demolded
(186,8 x 6,5 mm x 2,5m – 0,5 mm thick)

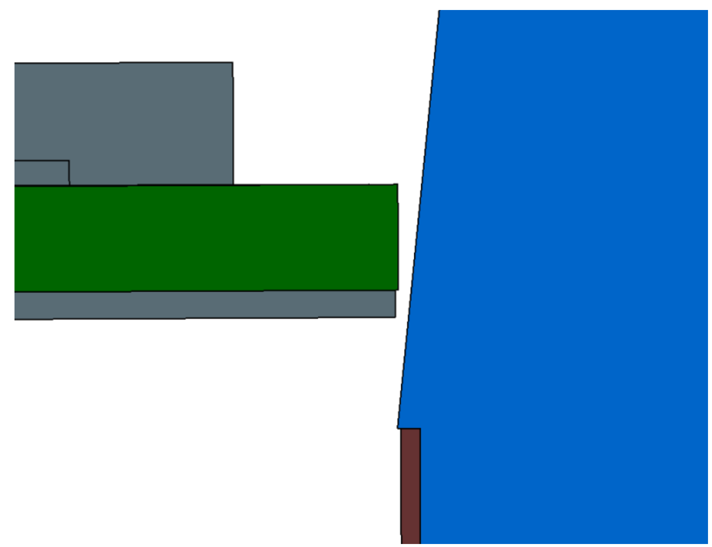
Cooling capacities II

		1/2 SLAB						
/ 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
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**

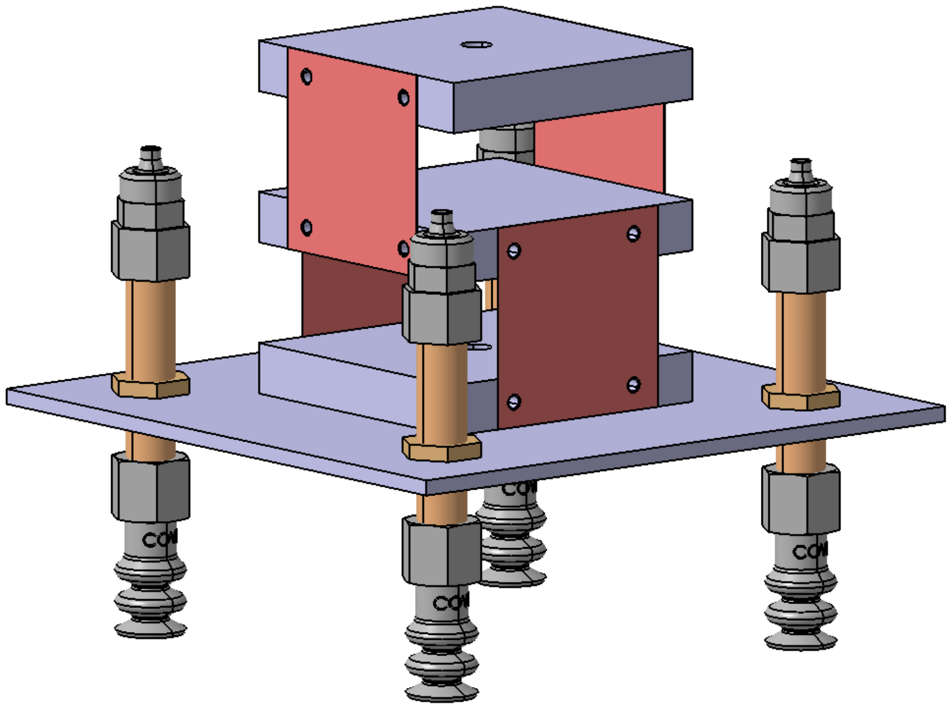








Le wafer n’entre pas en contact avec le guide



Préhenseur double flex