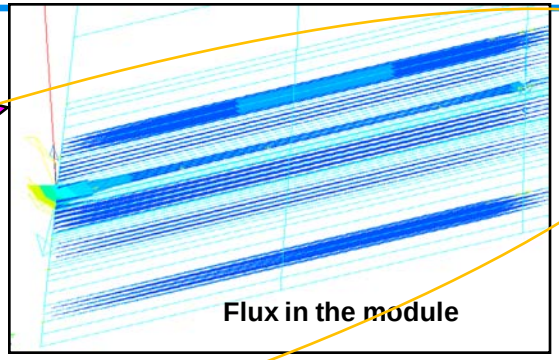
Si-W ECAL

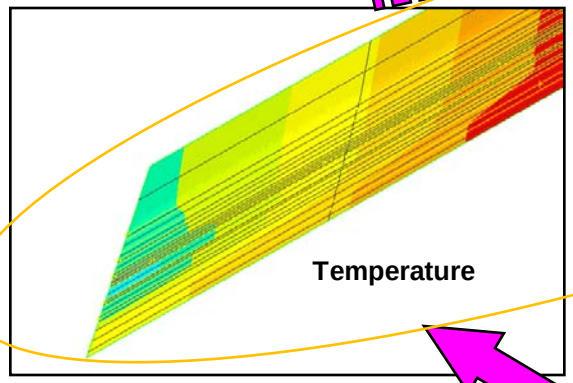
Mechanics/cooling

LLR / February 08th, 2011

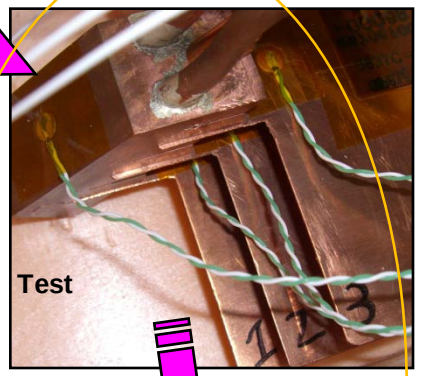
Julien GIRAUD
giraud@lpsc.in2p3.fr
04/76/28/41/13

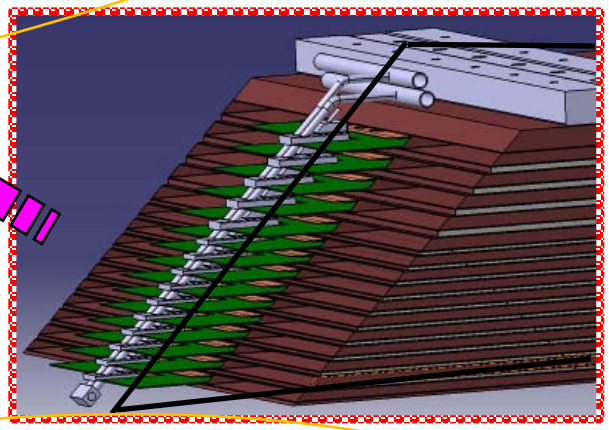
Work performed in cooling during 2010 and before



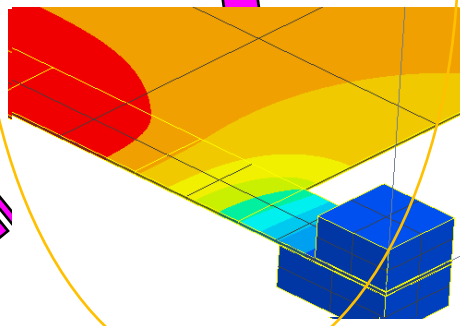


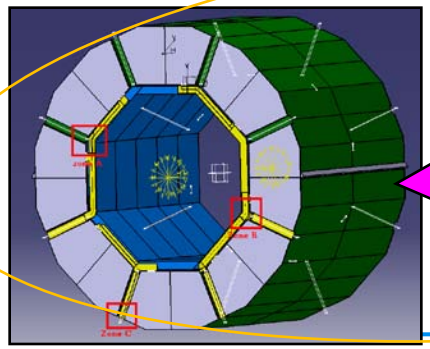
2 : Connection module / cooling

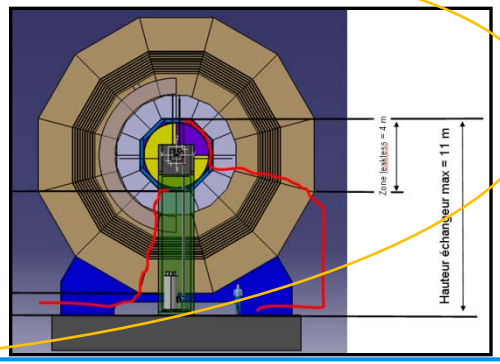




1 : Thermal transfert inside the module

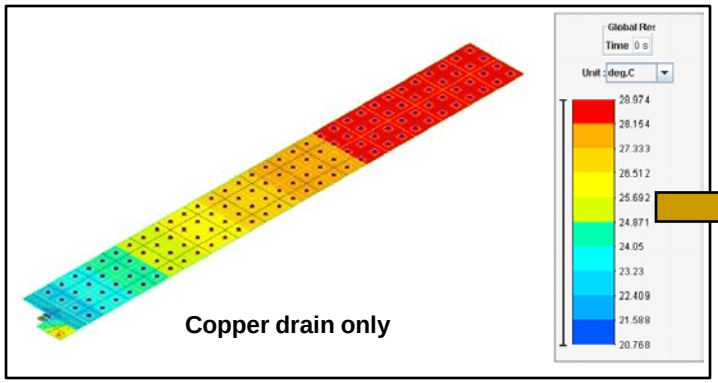


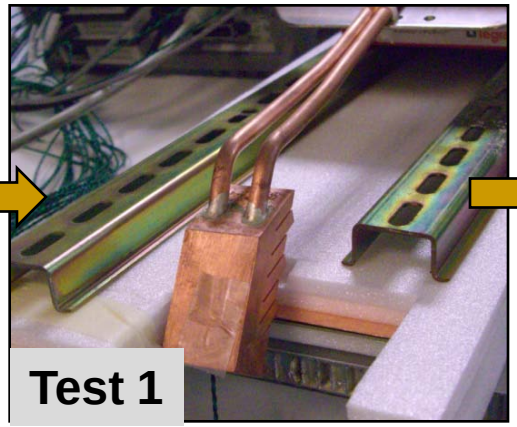


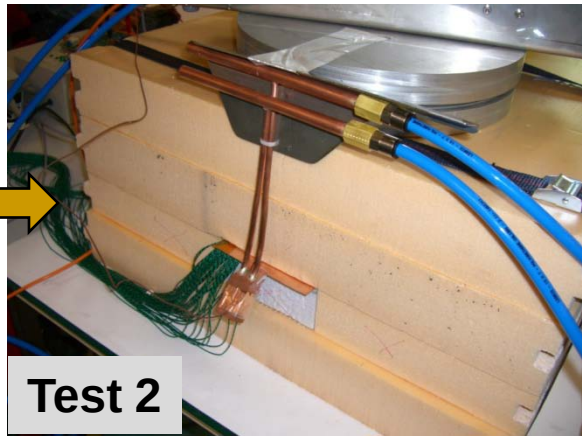


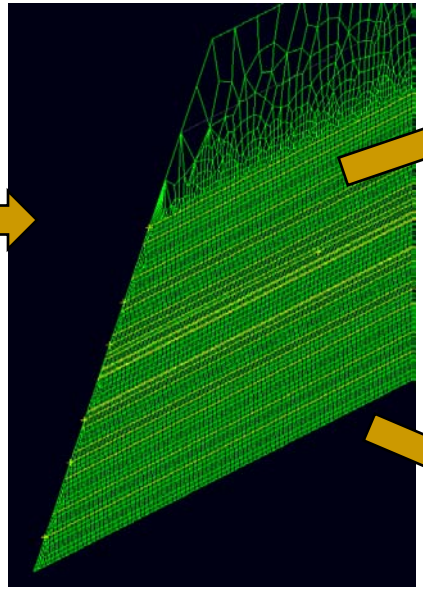
3 : Cooling global / Pipe integration

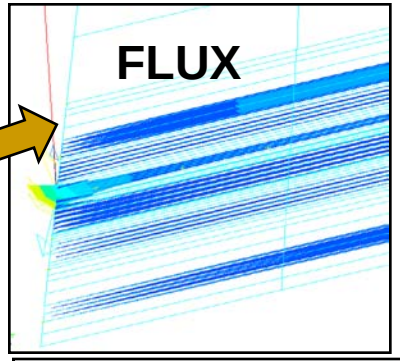
1°) Thermal flux inside the module

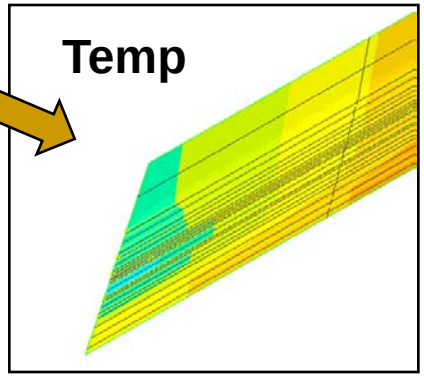










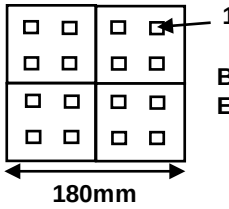


We need to simulate the whole SLAB to be representative of the reality

1°) Thermal flux inside the module

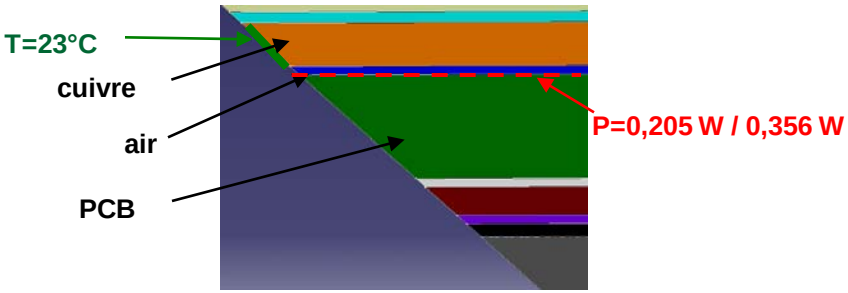
Inlet

Power on PCB = 0,205 W / 0,356 W



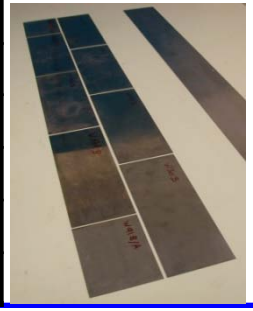
Barrel : (1,6.10-3*16)/180*1445=0,205 W
EndCap : (1,6.10-3*16)/180*2500=0,356W

Boundary condition T = 23 °C beginning of the copper plate
Air between copper plate and pcb is in the model



Discontinuity : Tungstène, PCB, Wafer

Conductivity W/m.K	Initiale	Equivalente	
		Barrel	EndCap
Tungstène Structure	177	97,3	99,6
Tungstène Slab	177	79,4	77,9
PCB	10	3,27	3,36
Wafer	148	2,38	2,39

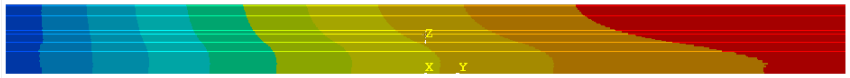


Results

Barrel : (1.5m)

ΔT = 2,2°C

End Cap : (2.5m)



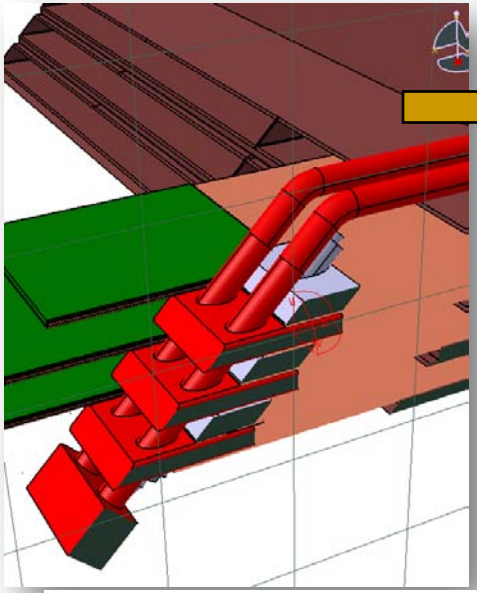
ΔT = 6°C

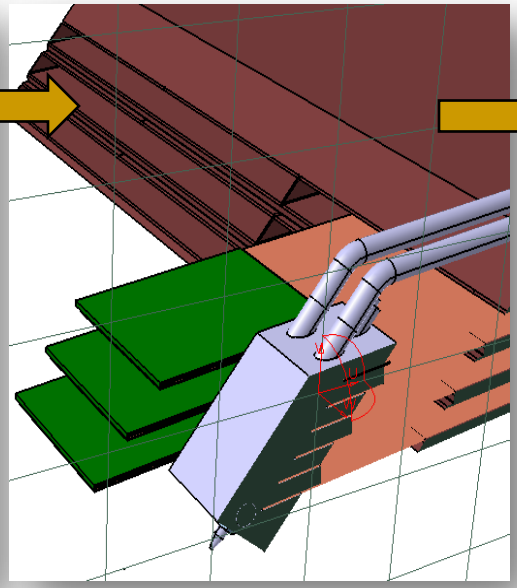
Conclusion

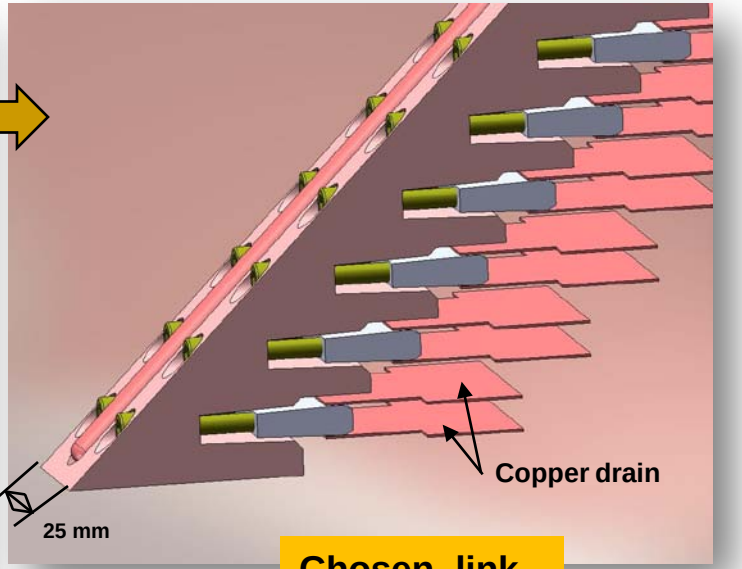
Low temperature gradient -> cooling system suitable

Cooling front –end (front of slab sufficient)

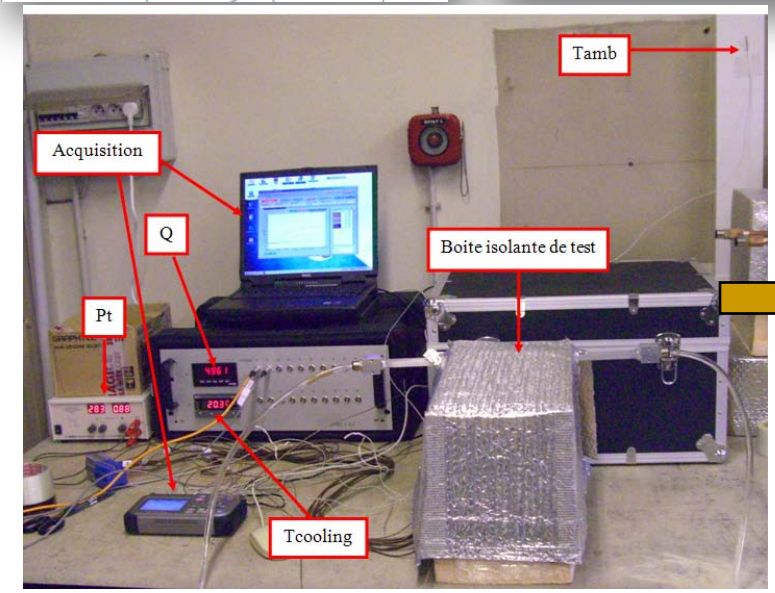
2°) Copper plate / heat exchanger link

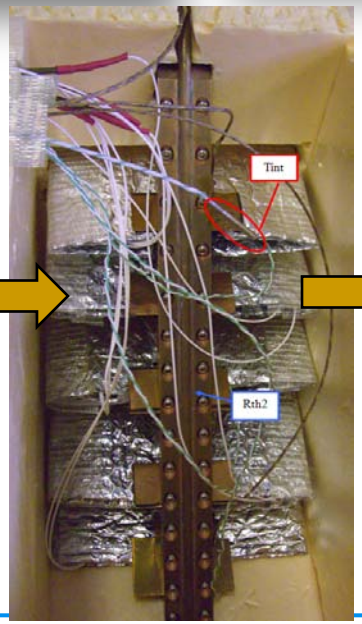




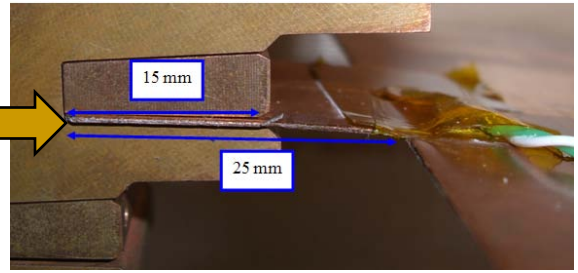


Chosen link





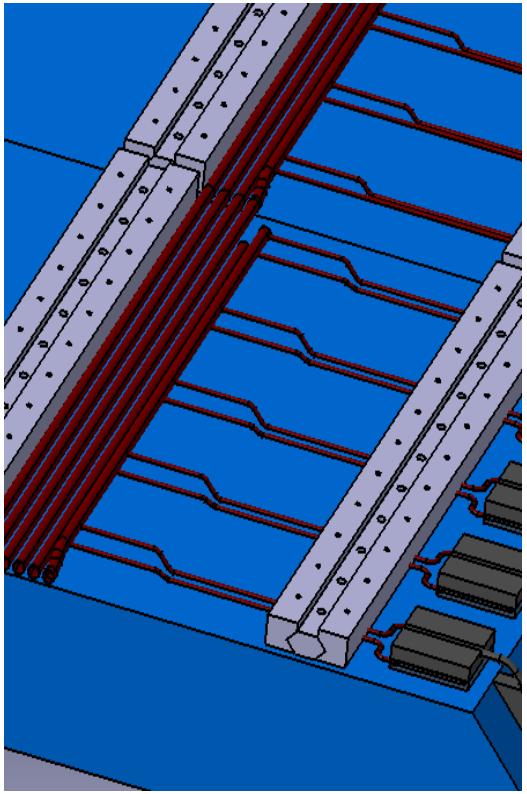
Confirmation: **25 mm** free opening in DIF for extraction of cooling system

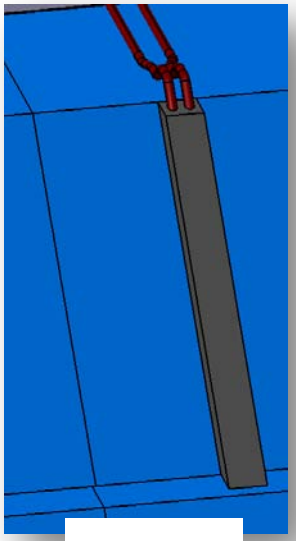


2°) Pipe distribution

-**Water heat exchanger chosen.**

- **One cooling loop for one module.**

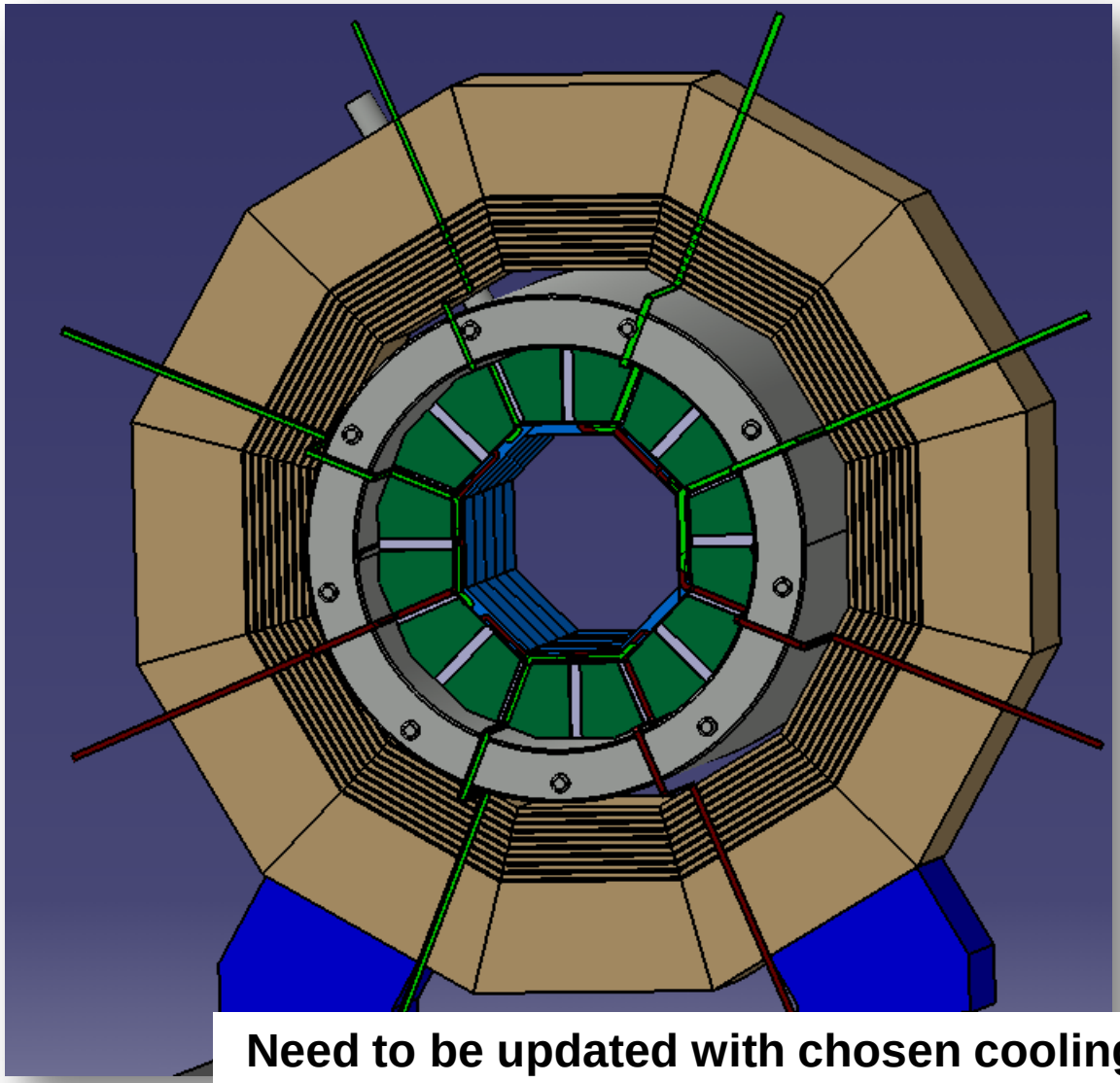


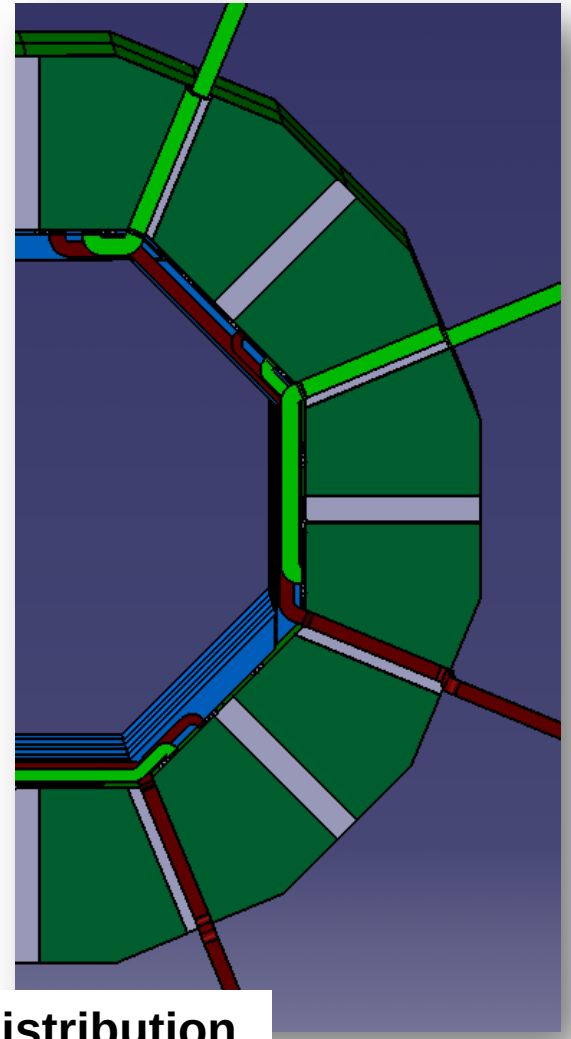


Water

	Power ASU (W)	Power DIFF (W)	T water (C)	T beginning slab (C)	T DIFF (C)	T end slab (C)
Barrel	0,205	0,3	18	20	27	22
EndCap	0,356	0,3	18	21	28	27

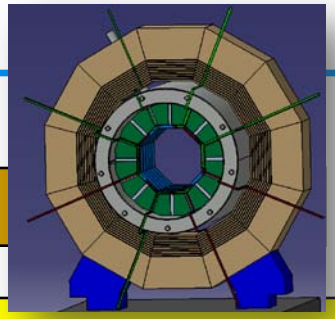
3°) Global cooling : Barrel





Need to be updated with chosen cooling distribution

Next : 2011 and beyond

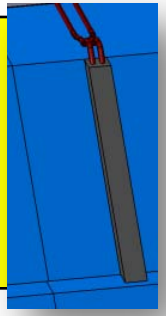


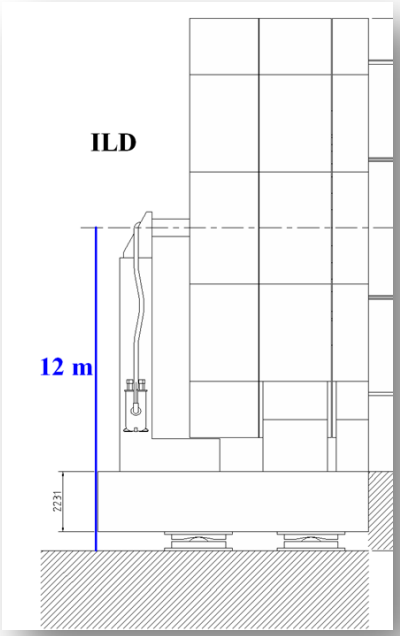
Integration : Update the 3D model

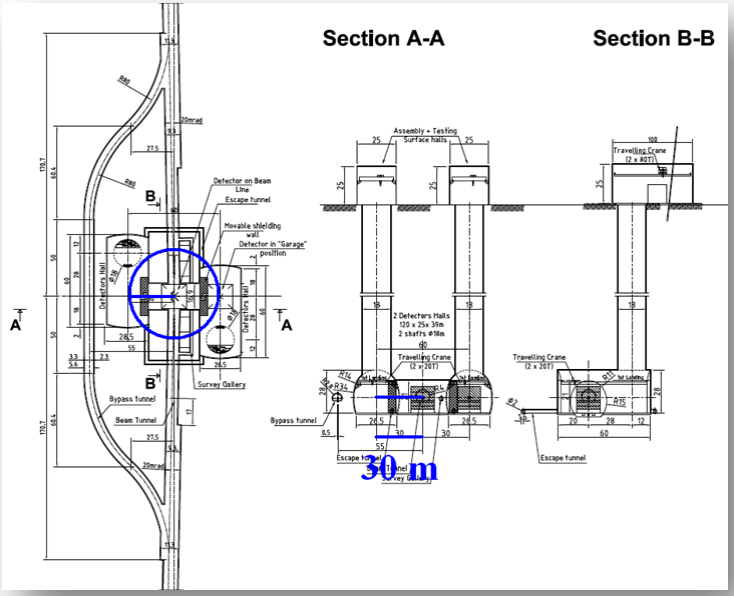
Cooling:

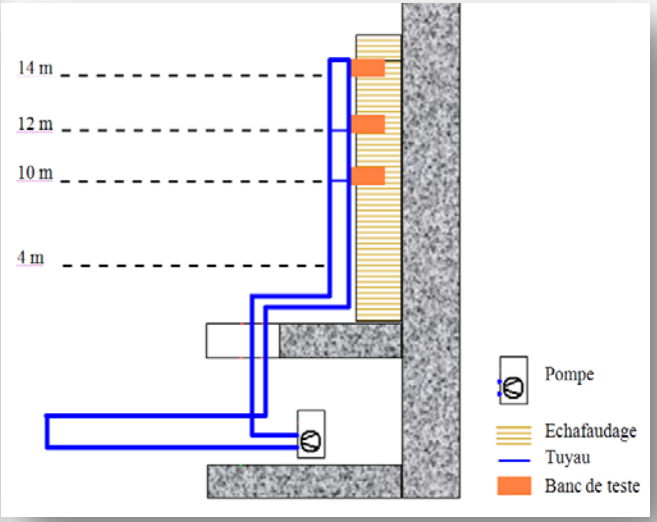
- Work on reliable connection between the cooling system and the water heat exchanger.

- Work on real scale leak less loop including different module altitude / electronic / sensor





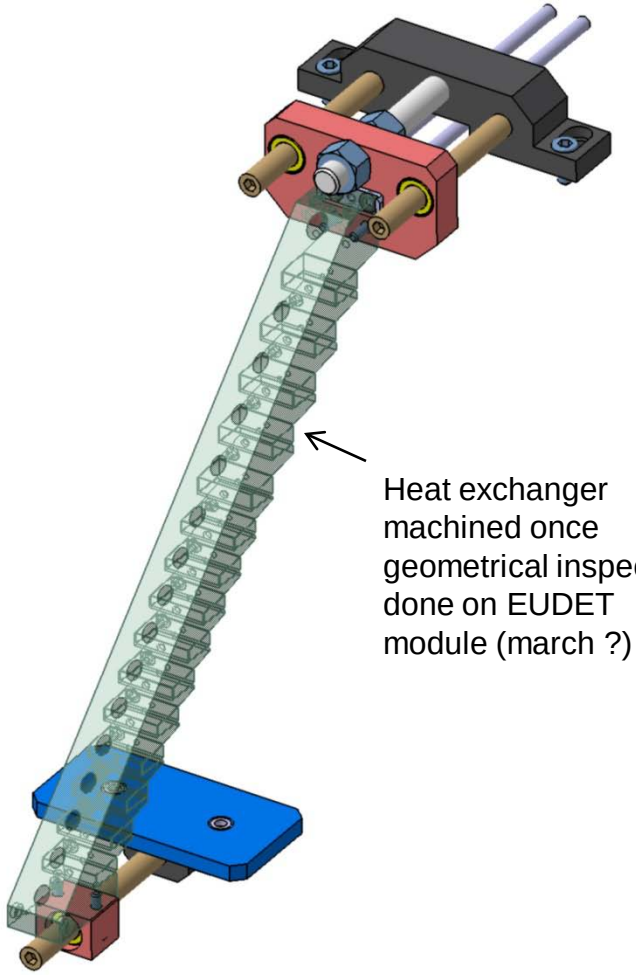




EUDET: to be delivered soon

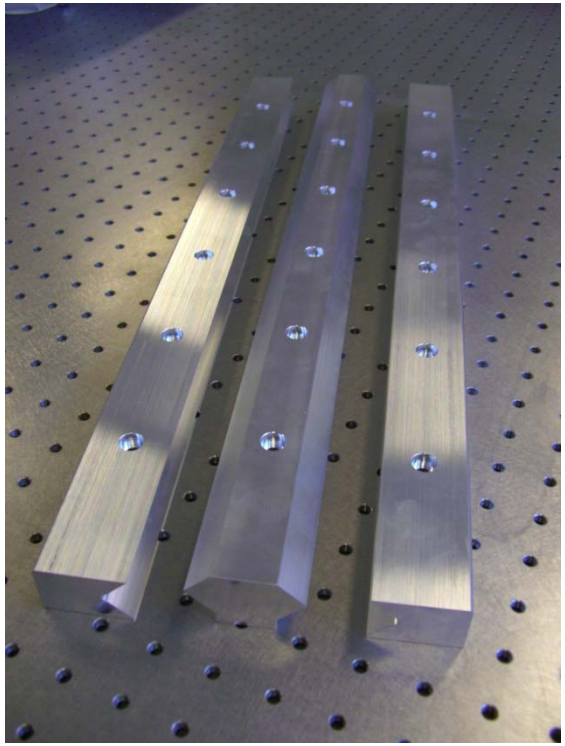
For end of february...

COOLING support



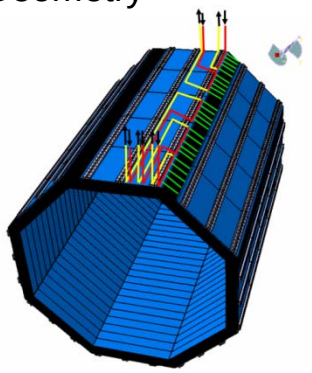
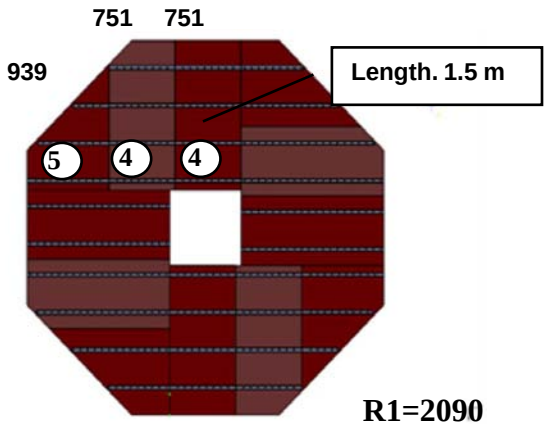
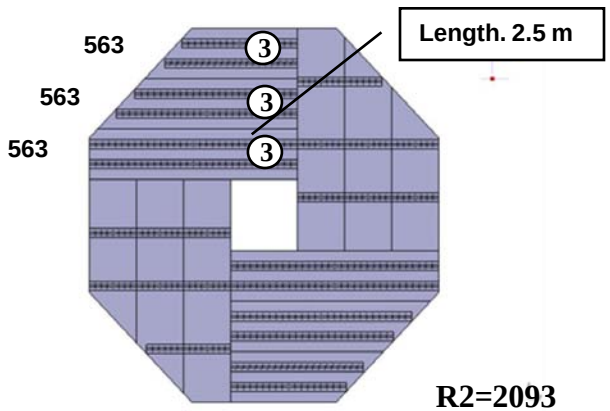
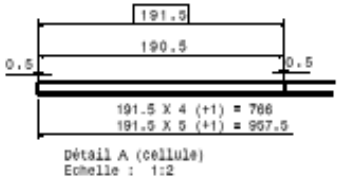
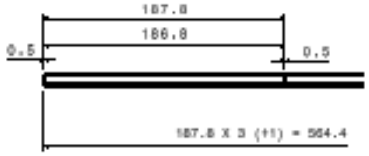
Heat exchanger machined once geometrical inspection done on EUDET module (march ?)

Rails: 3 sets



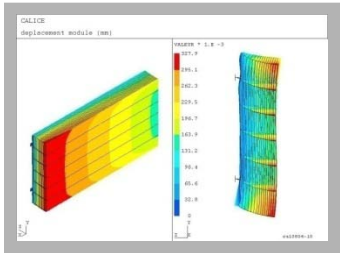
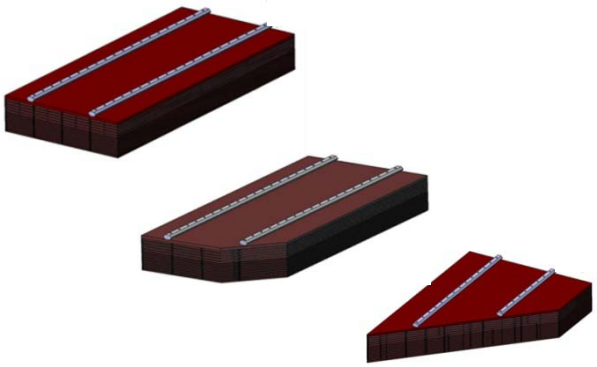
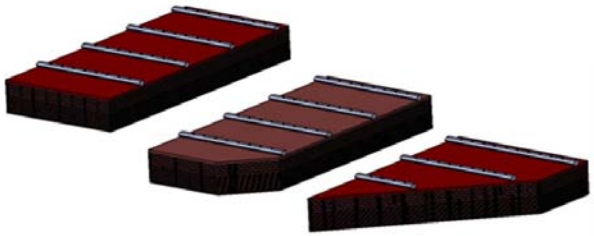
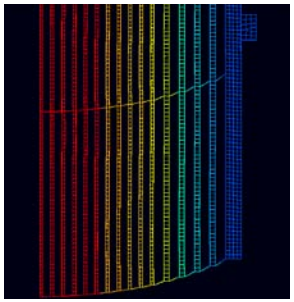
(3 inners with free ways for services + 6 externals)

End-Caps structure: baseline

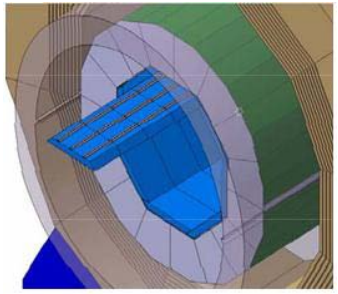
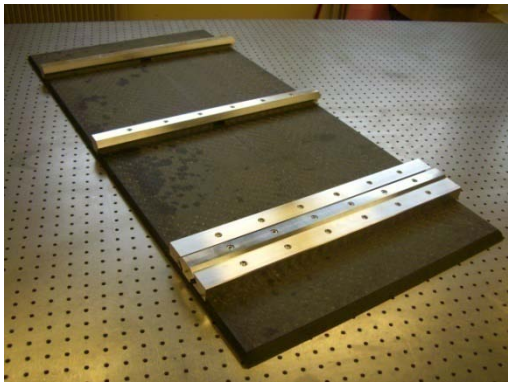
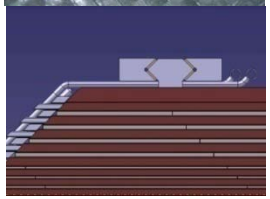
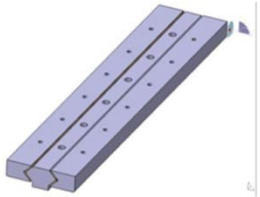
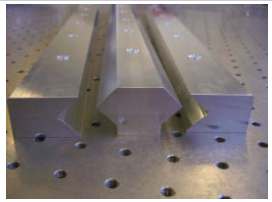
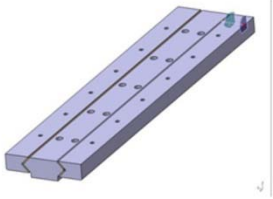
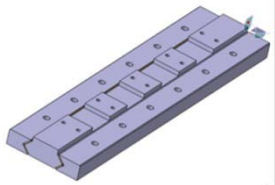
End-cap weight : ~ 17 T	**Design 1** **Alveoli width:191,5**	**Design 2** **(same alveoli width / barrel)**
Geometry  R_{barrel}=2028	 **R1=2090**	 **R2=2093**
Cell width **(182.1 mm for EUDET)**		
Number of cells	**780**	**540**
Advantages	-- = Dimensions LOI -- Construction of modules ~ similar to barrel	-- No crack / physics -- ~Dimensions of cells / barrel
Drawbacks	-- Possible cracks / physics (to be checked) -- different shapes of long slabs / barrel (DIF...): cost rising	-- Construction of alveoli up to 2.5 m (to be validated) -- Fastening to be reinforced (modules: heavy) -- Cooling along 2,5m slab (*back end T° of slabs)* -- Industrialization, tools : heavier

Solution 2 : best technical compromise between geometry and physics (still to be confirmed)

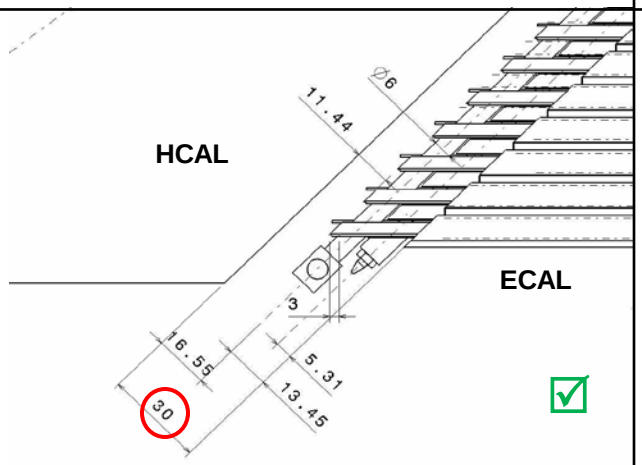
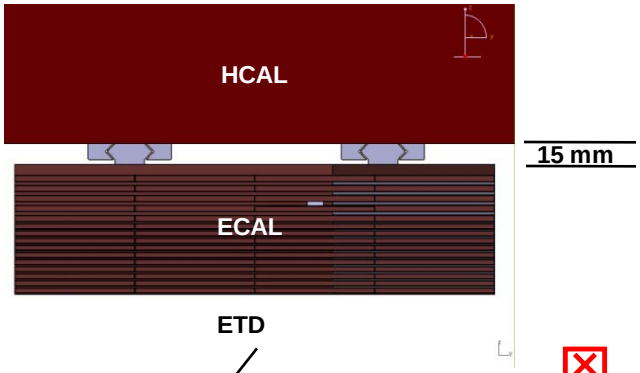
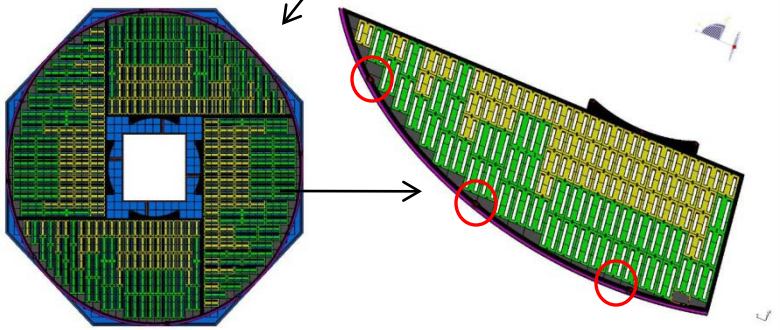
Structure of End-Caps

	2 x 3 modules	2 x 3 modules
Modular structure (2 orientations)  *Module End-Cap n 1*		
Alveolar structure ***Configuration 90°*** **FEA / deformations** 	Alveolar W-Carbon HR structure with: - Fastening system •Rails •Thick plate/ inserts (HCAL side) •Thin plate / inserts ? (ETD side) - Cooling system - Depending on the design: •From 3 to 5 columns of15 alveoli - Geometry: •Bevel impacting electronics •Free ways for services ≠ / design	**Composite plate with metallic inserts (15 mm thick.)** **186 mm** **186,8x9.4mm** **186,8x7.3mm** **Composite thin plate support of ETD** *Module End-Cap n 2*
Advantages	- Construction process of sets ~ similar to barrel	
Drawbacks	- Several variations of carbon parts (thick plates with orientation of inserts), mandatory ! - Design 2 : Guiding to be reinforced (modules heavier) - Alveoli width different / barrel → different slabs (wafers / DIF…) - Elec. Cost for End-Cap / geometry of extremities and slab's width	

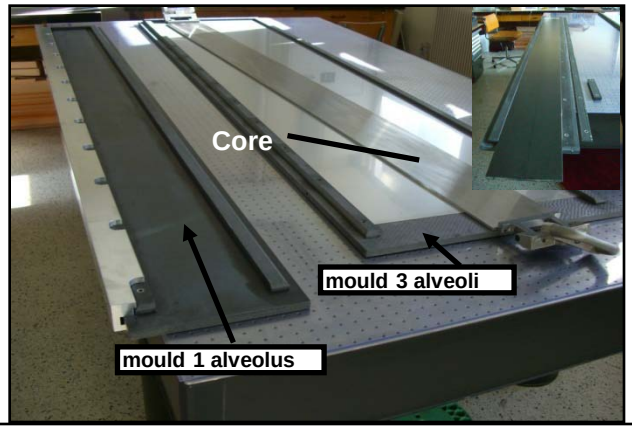
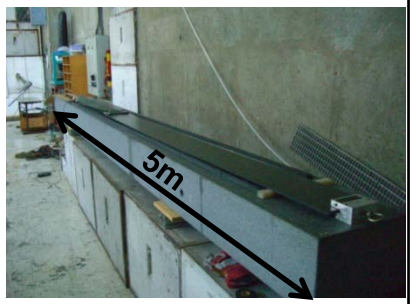
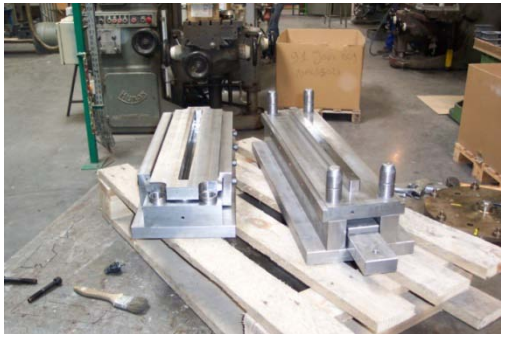
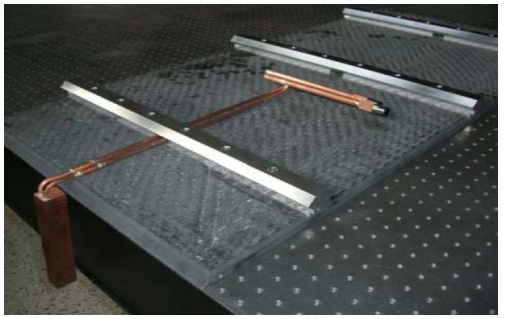
Fastening ECAL/HCAL/ETD

	Barrel and Design 1	Design 2
Rigidity of the supporting structure & transparency / φ 	 **Carbone HR plate 15 mm thick. With metallic inserts**	   **… or system rails (structural composite)**
Kind of rail	 	 
Space available	-Barrel: 3 cm ☑	End-Cap: 1,5 cm ☒ Insufficient / fixing of cooling
Advantages	- Construction of sets ~ similar to barrel - Realization mastered	- Minimization of dead matter - Minimization of nbr of rails (modules' deformation to be re-validated)
Drawbacks	- Dead matter - Nbr of rails (2 to 4 per module) - Free space under rail, passage & location for services	- Guiding & supporting to be reinforced (modules heavier) - Fastening system on HCAL / weight of module > 3T - Industrialization, tools: heavier
Design to be continued:	***- Alternative option for the guiding and fastening system : isostatic system***	***- Validation of "double rows" rails***

INTEGRATION of End-Cap

	Barrel	End-Cap
Free space	 ☑	 ☒
ETD Support	- (Last news from P.Ghislain from LPNHE january, 2011) – fastening locations - → thin plate (2mm) to redesign and test with special supporting systems	 LPNHE: SM4_PRD40800 (superposition dernière version) SM4_PRD40801 (superposition)
Comments	- Volume of dead matter depending of kind of cooling control : ok: One cooling loop for one module, to update. (Cooling pipes & cables (DAQ + HV + GND)) - Consideration of services from other detectors / volume - Positioning: coupling of modules together to be defined	

Réalisation des End-Caps

	Moulding	Finished part
Alveoli moulding 2,5 m • **Cell thickness: 6.5 mm** • **Wall: 0.5 mm** • **Length : 2.492 m**		***First test negative: friction core/ carbon plies*** ***Alveolus 2,50m: extraction of core >> 6000 N !***  **Adaptation of extraction clamp**  **Extraction of alveolus**
Machining or moulding of rails	 **Mould HP (80T) for heating press, for Carbone HR male rails**	  **Footprints in the rails 25 mm wide minimum, to enable the cooling system and cables to pass trough (1 per column)**
Comments Next : 2011 and beyond	***Specific heavy tools:*** ***• Handling cores & moulds (cumbersome)*** ***• Moulds*** ***• Area for preparation (room dust free)*** ***Conception to be continued:*** ***• Specifications of assembly mould M2*** ***• Realization: mould HP for external rails*** ***• Modification of mould HP rail male: larger*** ***• Mechanical simulations / design End-Cap***	***Tests to be continued:*** ***• Extraction of core after moulding: on aluminium core*** ***• Validation of a 2,5 m layer (spring 2011)*** ***• Conception of specific handling tools (may 2011)*** ***•Thinner Carbon plate (13mm) with inserts modified*** ***•Mechanical tests / rails (summer 2011)*** ***•Characterization, tests & optimization: elements & composite rails (spring 2011)***