ECAL Endcap and cooling studies

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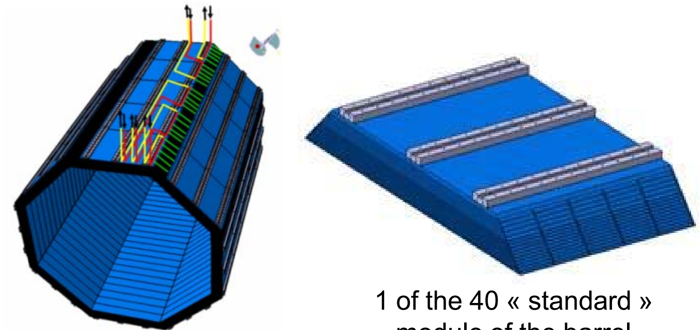
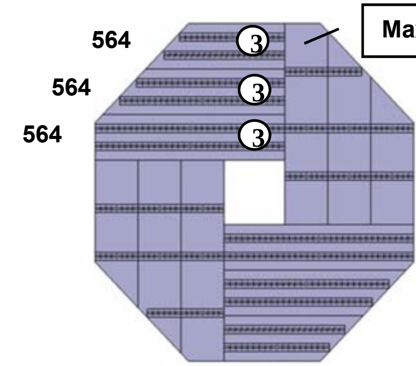
Current structure of End-Caps

Modular structure	Barrel: 40 modules	End-Caps: 4 x 3 modules each



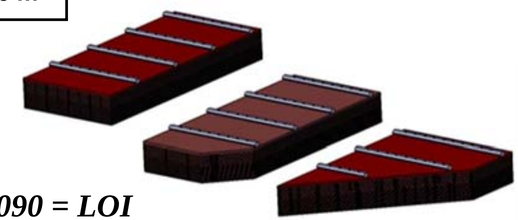
R_{barrel}=2028

1 of the 40 « standard » module of the barrel



Max. Length. 2.5 m

End-cap weight : ~ 17 T



(2 orientations)

R_{endcap}=2090 = LOI

Cell width: l=186,8

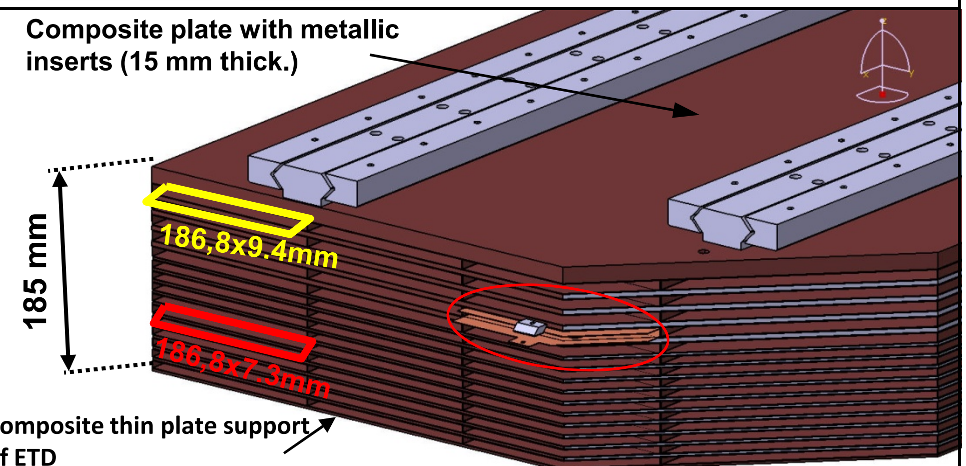
otherwise…

R=4120 with l=182,1 = Barrel geometry for slabs

Alveolar structure

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

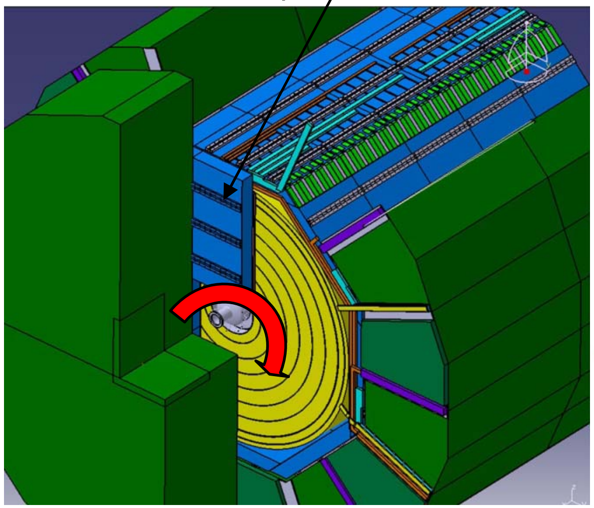


Module End-Cap n°2

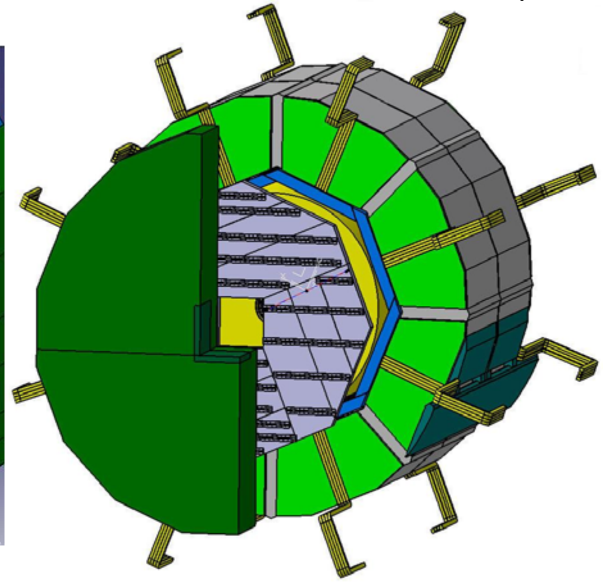
Advantages	- Construction process of sets ~ 540 cells similar to barrel BUT with different length (up to 2,50m) - No crack / physics
Drawbacks	- Several variations of carbon parts (thick plates with orientation of inserts), mandatory ! - Fastening system to be reinforced (modules heavier) - Alveoli width different / barrel → different slabs (wafers / DIF…) - Construction of alveoli up to 2.5 m & Cooling along 2,5m slab (back end T° of slabs)

Tilt of 22°5 AHCAL: effects on End Caps

Up to now, ECAL End-Cap is fastened on HCAL End-Cap inner face with rails



… rotation of ECAL End-caps…

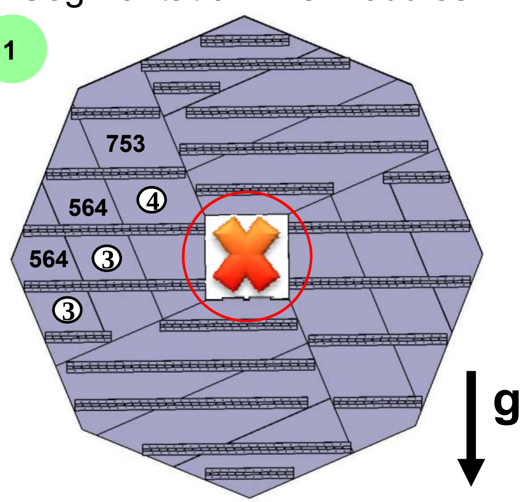


Mainly: drawbacks

- **Volume of detection lower**
- **Dead zones due to the geometry (both structure and slabs)**

3 OPTIONS FOR GEOMETRY
Segmentation 4x3 modules

1



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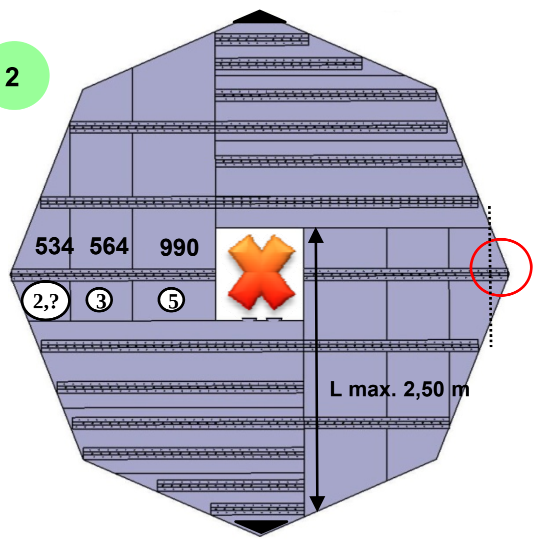

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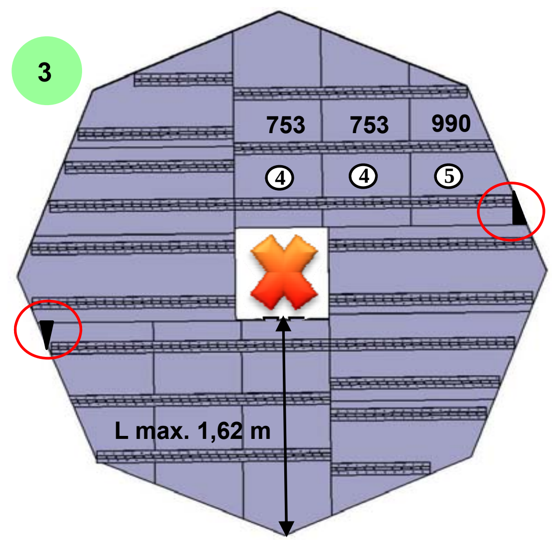
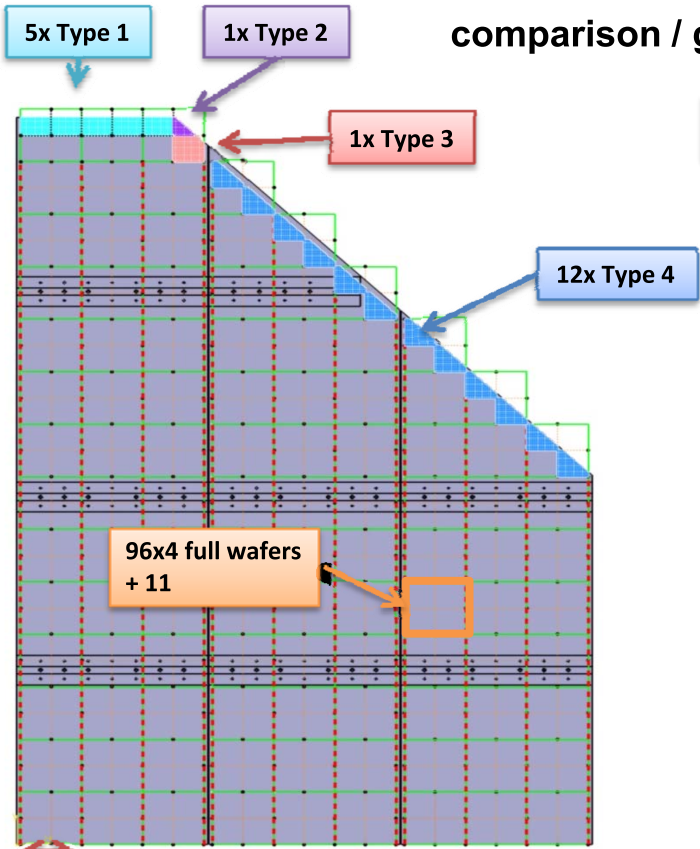


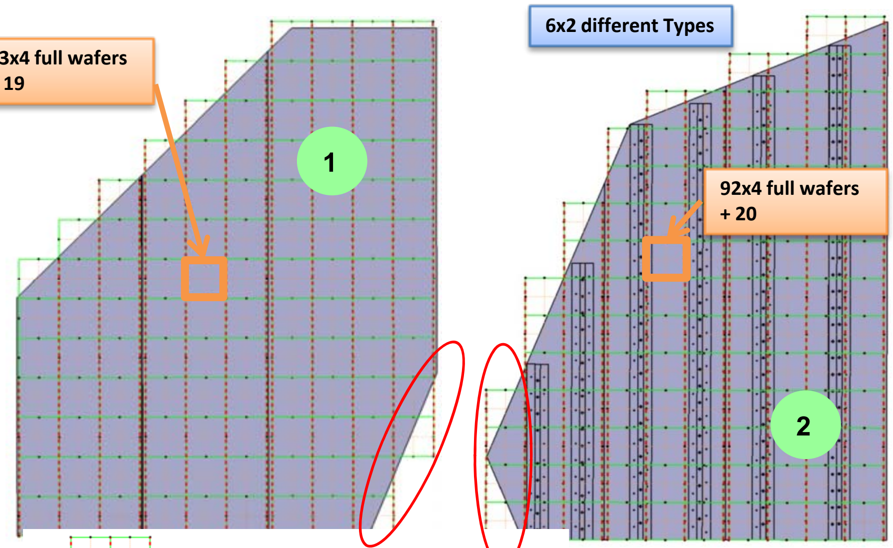
Tilt of 22°5 : volume of detection

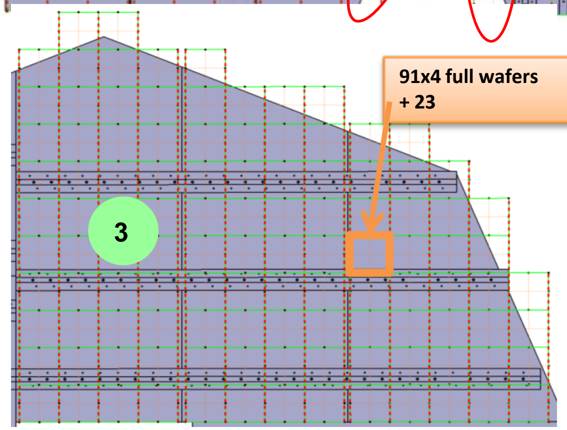
comparison / geometry



Slab = 180 (90 + 90)

Original shape: 4 types of different wafers for¼ End Cap



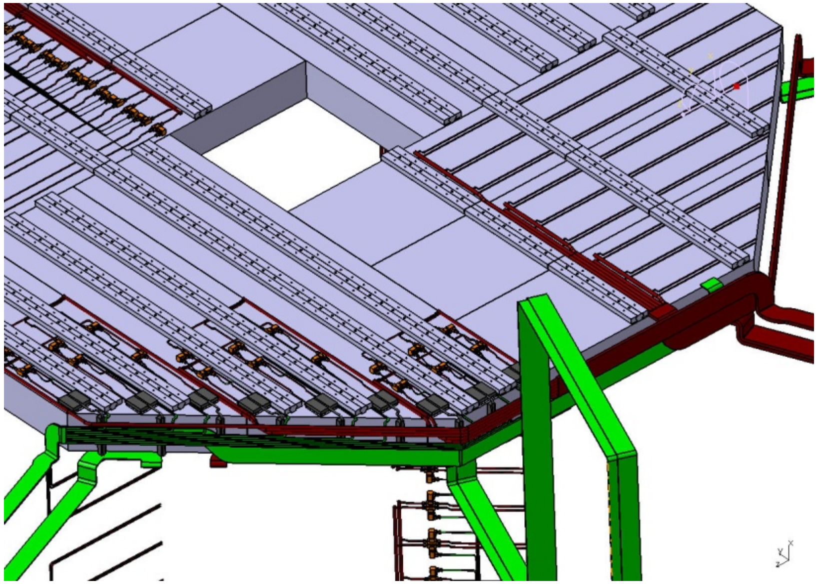


All "external" wafers are different
→ ≠ masks
Many lacks and/or small wafers

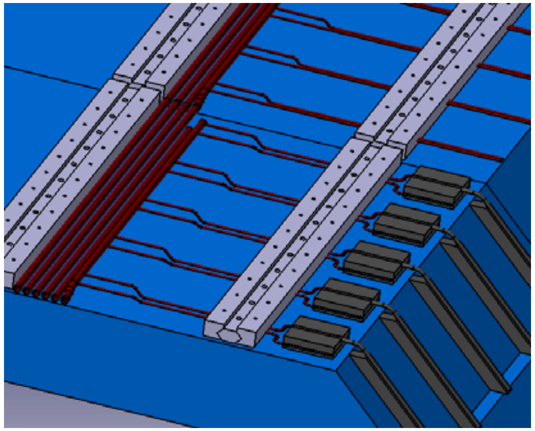
Tilt not convenient !

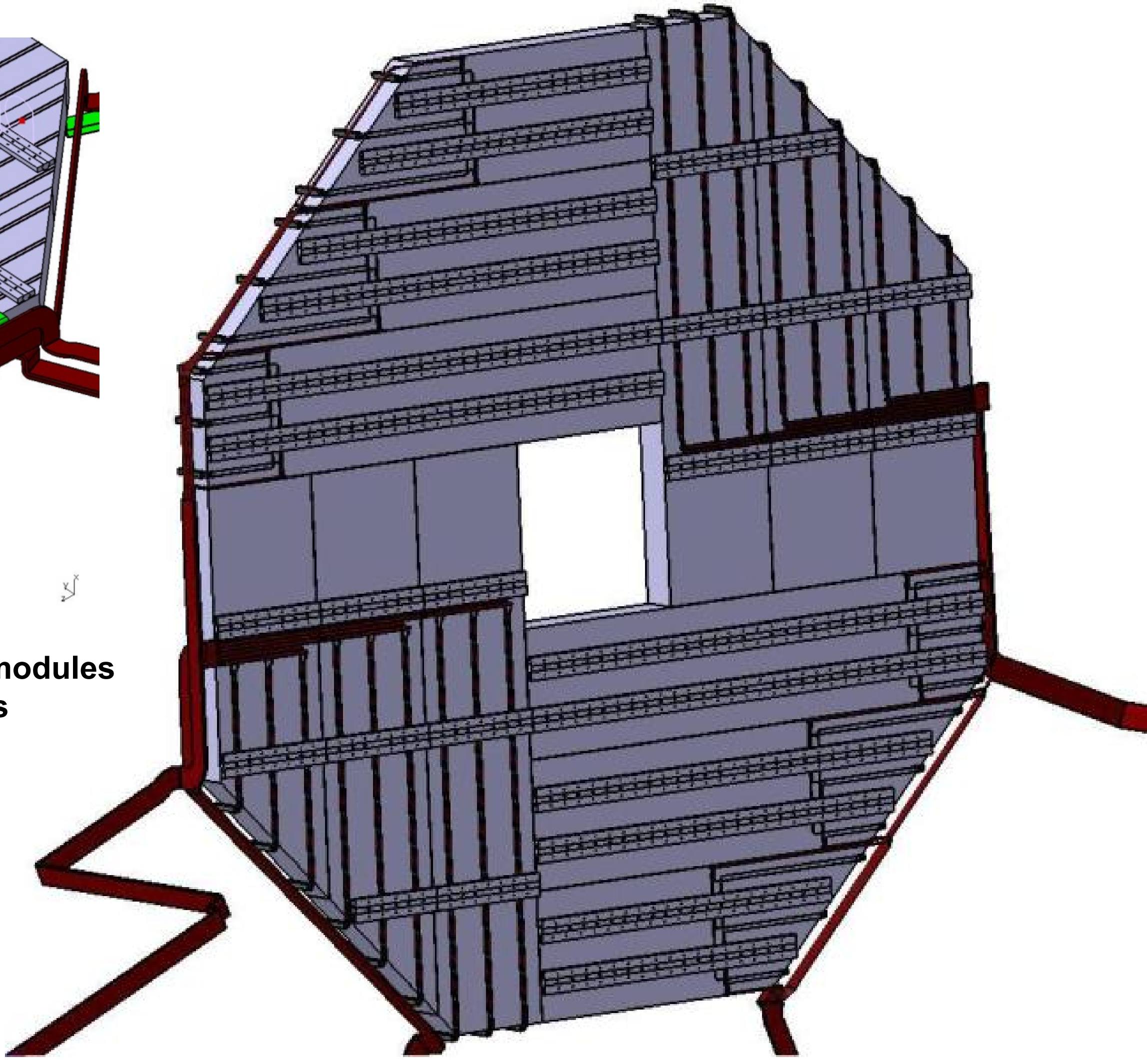
Similar layers→ minimum of
2 (endcaps)*30 (layers) *4 (1/4 endcap) = 240 of each sensor shape.
1 "mask" for fabrication ~ ± 15k Euro.
240 captors of 81cm² with a "final" price ± 6$ * 81 * 240 = ~120k$

Passage of cooling pipes and services



A solution with parallel or perpendicular rails / modules allows free passage for cooling pipes & services



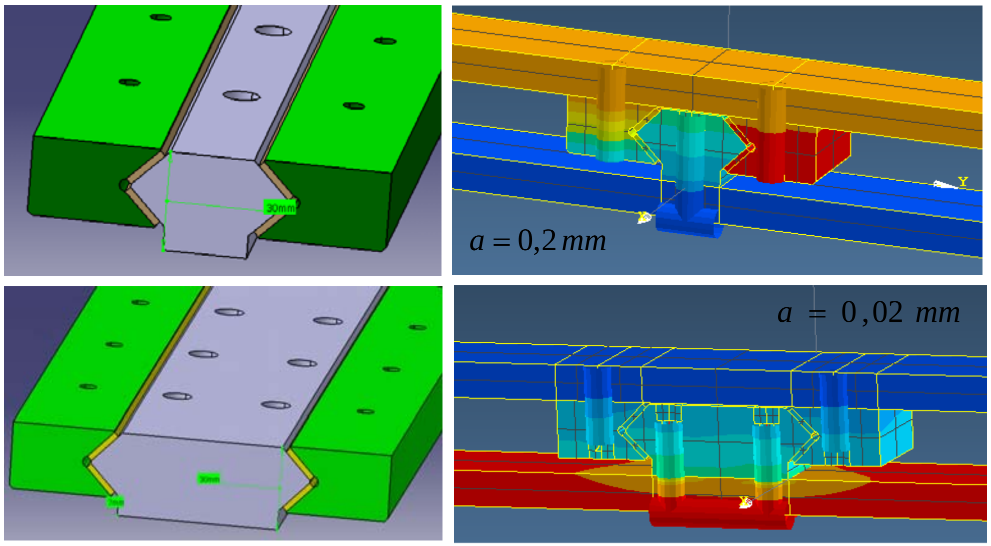


The option adopted for cooling services: 1 command per column in leak less mode (pipes incoming by lower side of End-cap)

- Next step: full Leak less loop (2012) after the real scale prototype realized in 2010

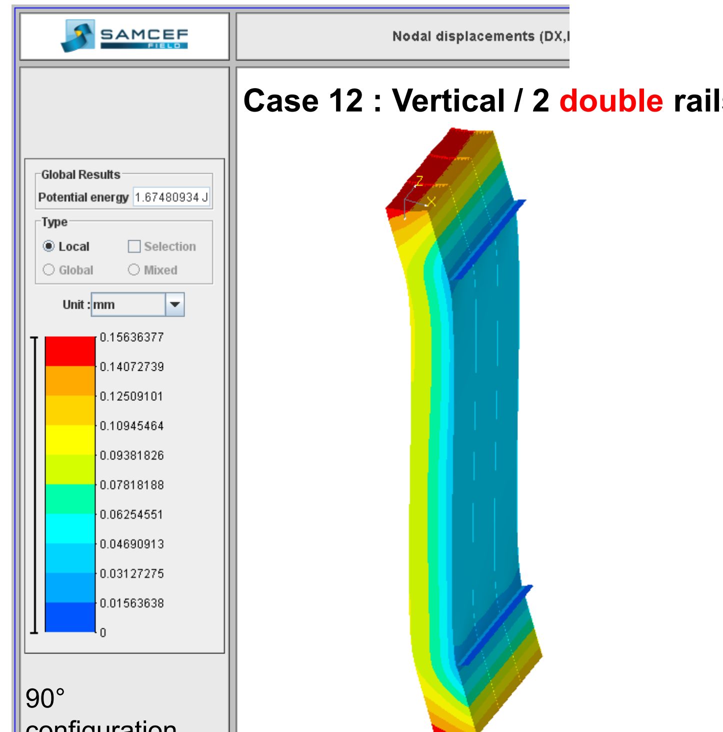
End Cap : Fastening system

3D design of different fastening system
⇒ Thickness 30 mm
⇒ Wide / narrow



Finite element calculation to determine the stiffness of the rails

Finite element End Cap simulation : MODULE N°1
2.5 m long / 3 columns of 187 mm / position 0° and 90° / M = 2550 Kg
⇒ Goal of these simulations: Influence of position / nbr of fastening systems on the mechanical behaviour (displacement / stress) …

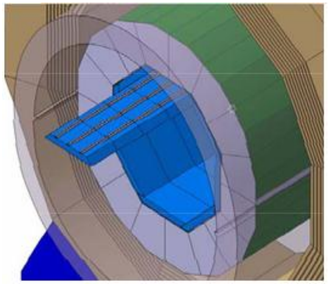
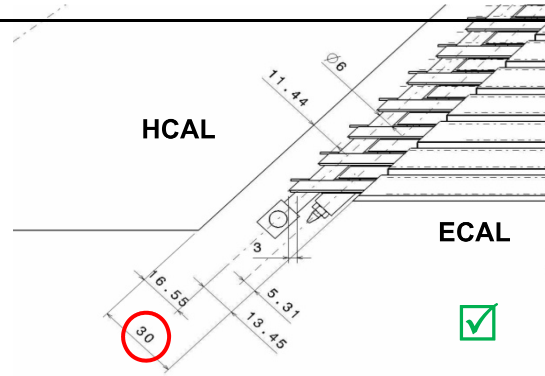
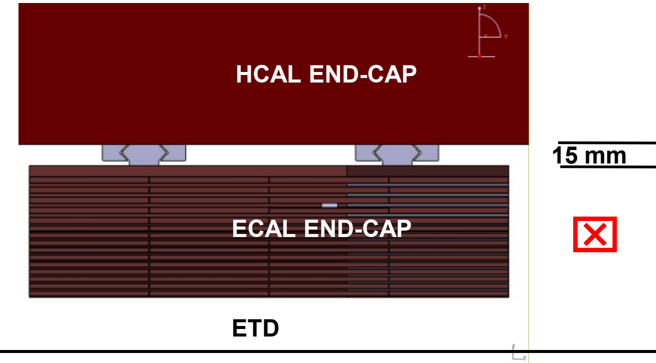
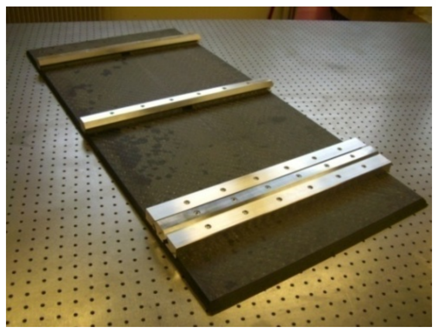
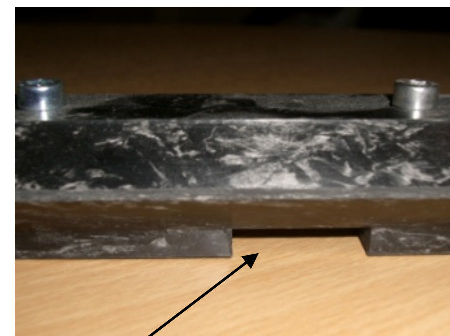
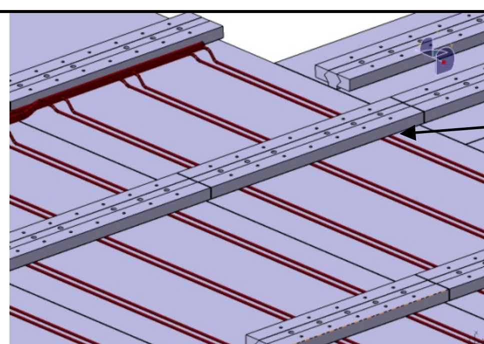
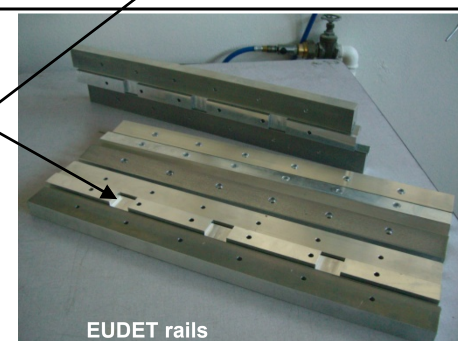


Type d'accrochage (vertical, horizontal)	Vertical
Nombre de rails	2
Type de rail (simple, bouble)	Double
Première contrainte principale (11411) (MPa)	8
Critères de TSAI Hill Version 1 (7621)	9.90E-03
Déplacement (mm)	0.16

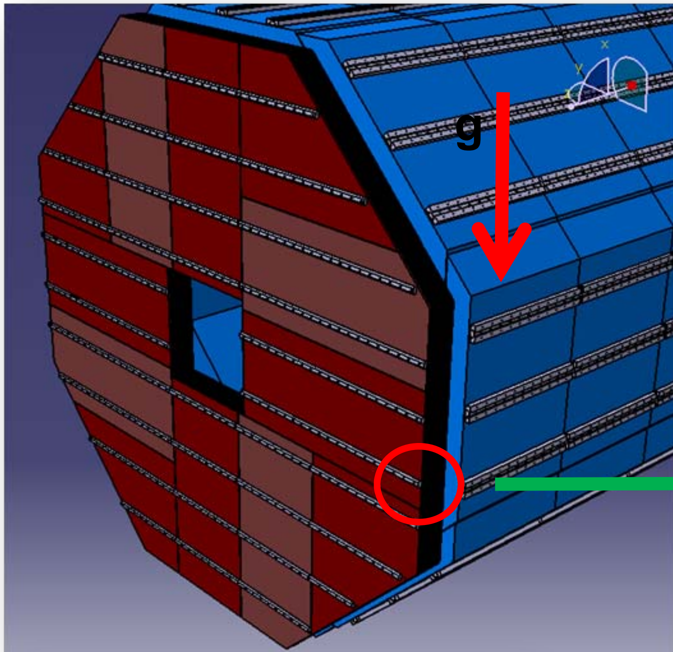
➢ Conclusion

Even if module is fastened with 2 double rails instead of 3 simple rails, deflections are less important.
➢ Next steps: simulation of double rails for all fastening positions and first prototypes.

Fastening on HCAL

Space available	Barrel: 3 cm ☑	End-Cap: 1,5 cm ☒ Insufficient / fixing of cooling
Fastening by rails 	 ☑	 ☒
Nature of rails… …Rigidity of the supporting structure & transparency / ϕ	 **Carbone HR plate 15 mm thick, with metallic inserts** ***Aluminium rails***	**or structural HR composite rails** 
Opening in rails… …for cooling and services		1 tunnel in rail ' base for each column 

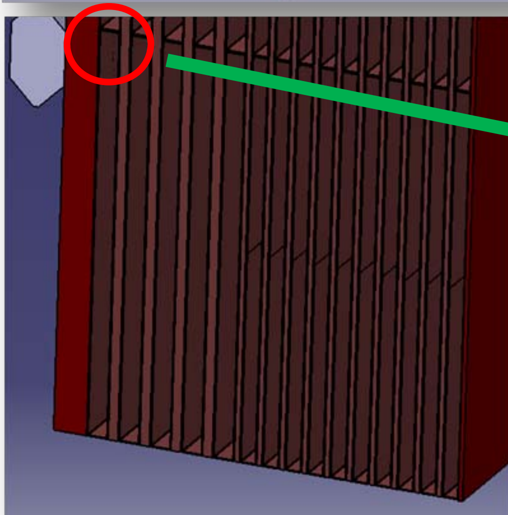
End Cap : global simulation



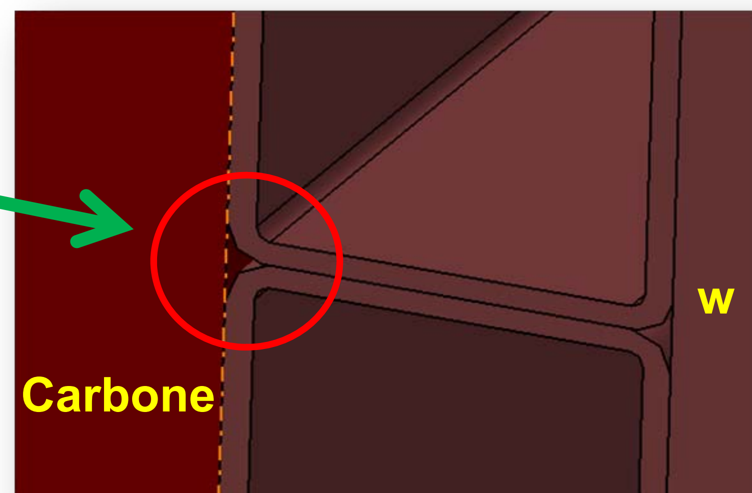
Fastening

g

Bending stress of the skins



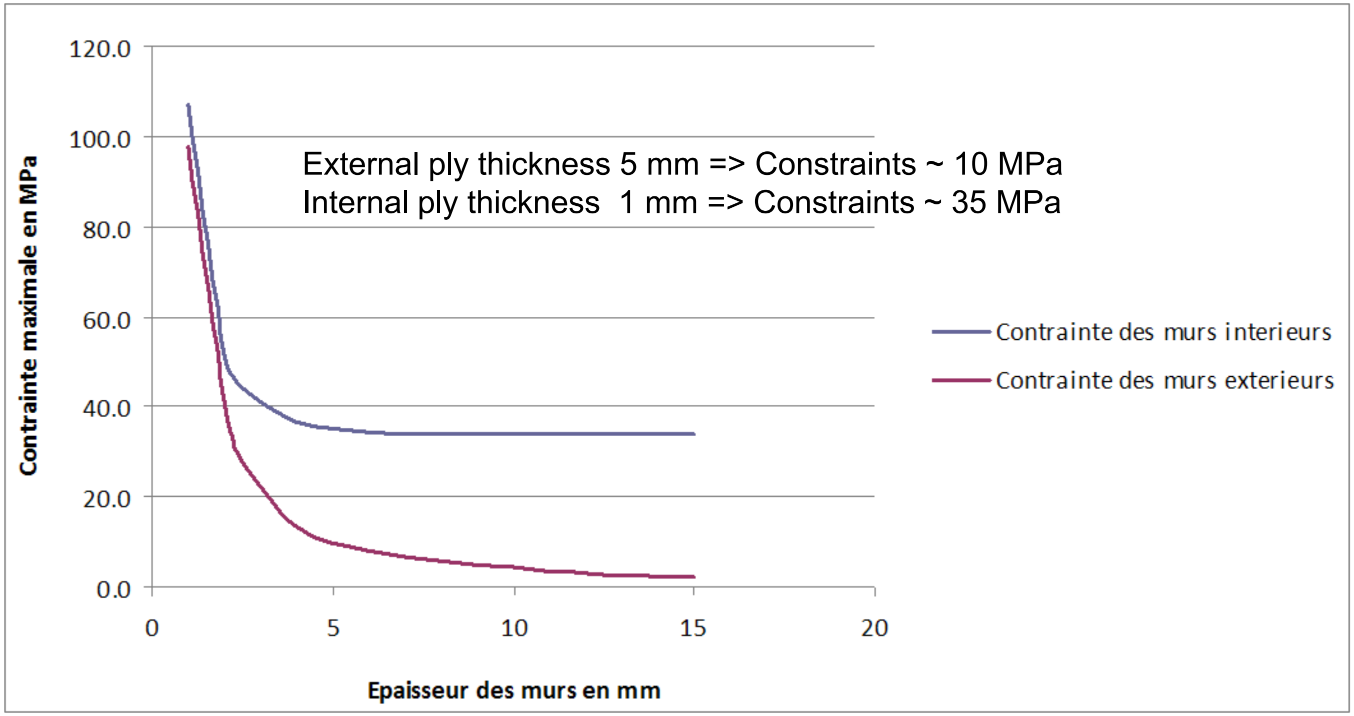
Detail

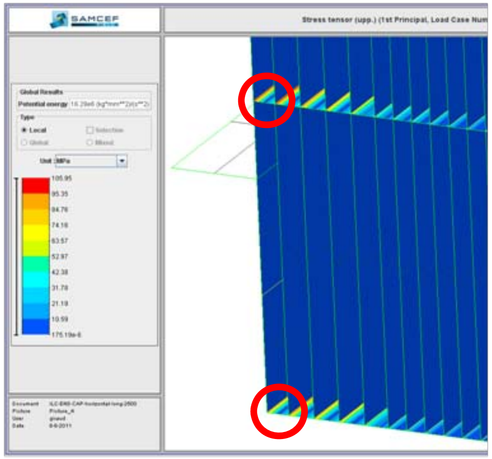


Results: evolution of skin thickness

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

Problem of bending stress of alveoli skins





Alveoli wall : 4 x 0.25 mm

First main constraint: 106 Mpa (plate model)

- Increase of thickness of external plies up to 5 mm in order to have a 10 MPa constraint (internal plies are 1 mm thick and we have a 35 MPa constraint) => too high...

Optimization of deflection values

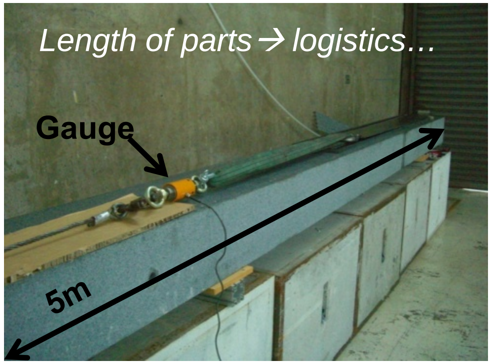
With a magnitude of maximal deflection of 1 mm, the maximal stress has a value greater than 13 Mpa (eligible tensile criteria)

➢ Next step: the acceptable maximal stress with a safety factor, will be determined after destructive tests (summer 2012)

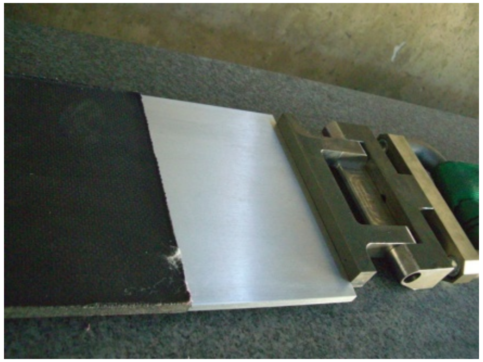
End-Caps : long alveoli molding test

2.5 m alveoli molding

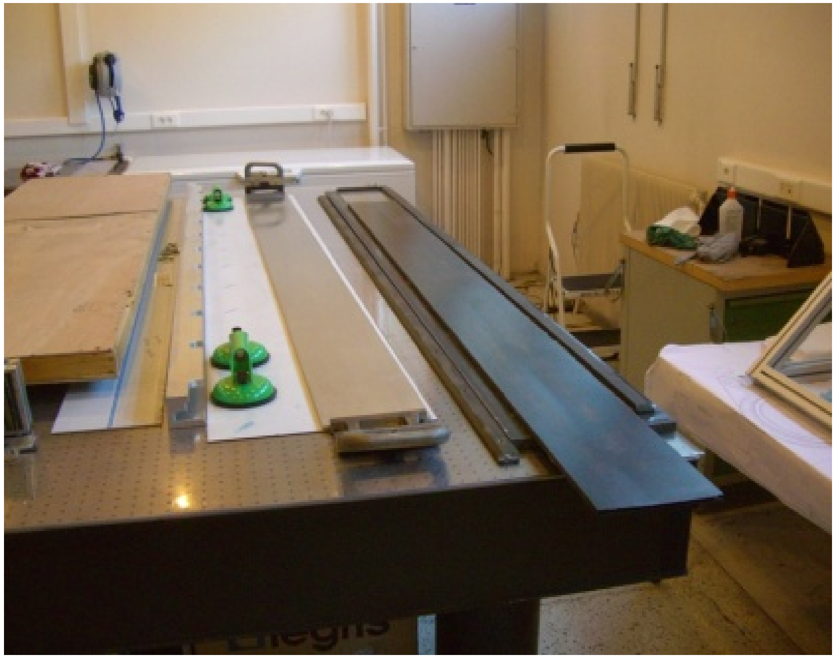
- <u>The end-cap layer test consisted of</u>
- 1 long alveolar
  (representative of the end-cap module longest layers)
- Width of cell : 186.8 mm
  (Design2 - to fit LOI parameters (R~2090))
- Thickness of cells : 6.5 mm - wall: 0.5 mm
- Length : 2.492 m



Measuring effort of friction core/ carbon plies



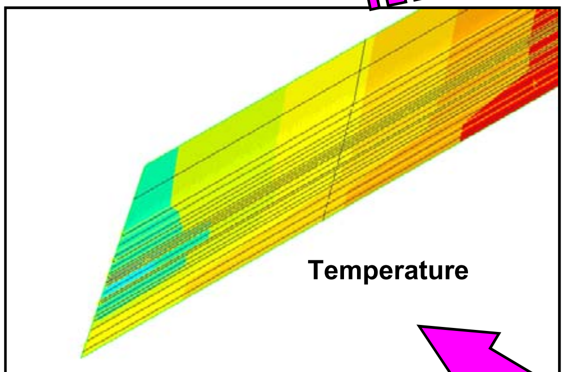
Extraction on going ~ 420 N : ok

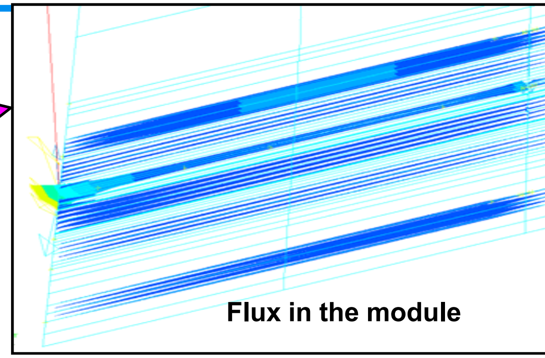


The 1st long alveolus

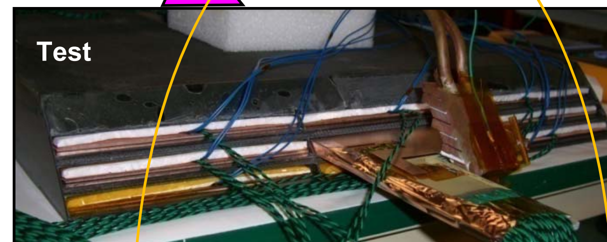
- **After first test negative with stainless steel core, long alveolus molded with aluminium core: *OK***
- **Next test: Long End-Cap alveolar layer** (summer 2012)

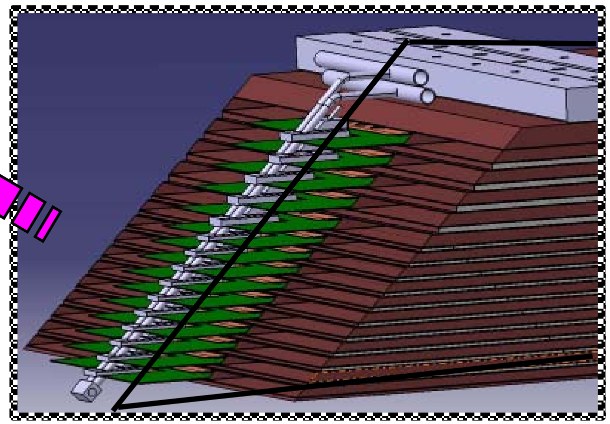
Cooling studies



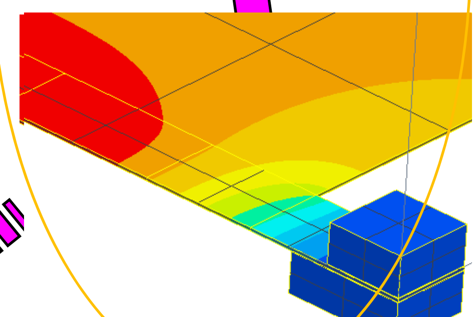


2 : Connection module / cooling

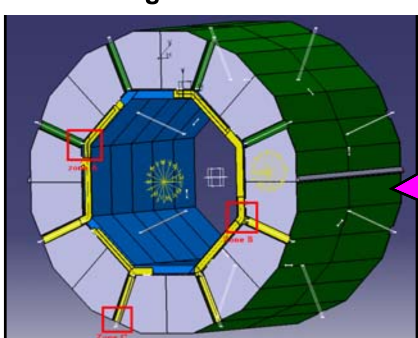


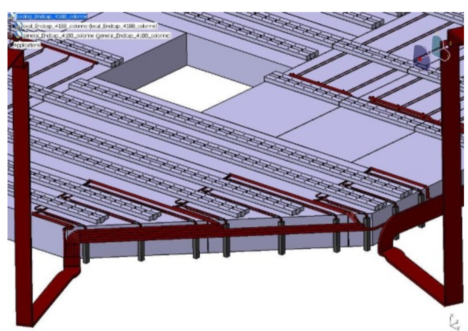


1 : Thermal transfert inside the module



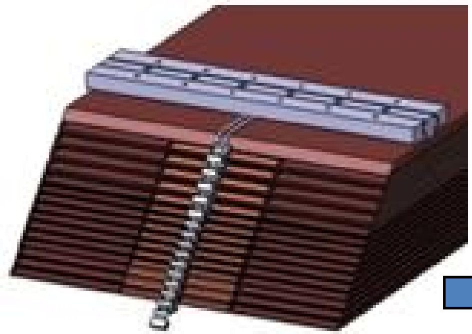
Cooling distribution



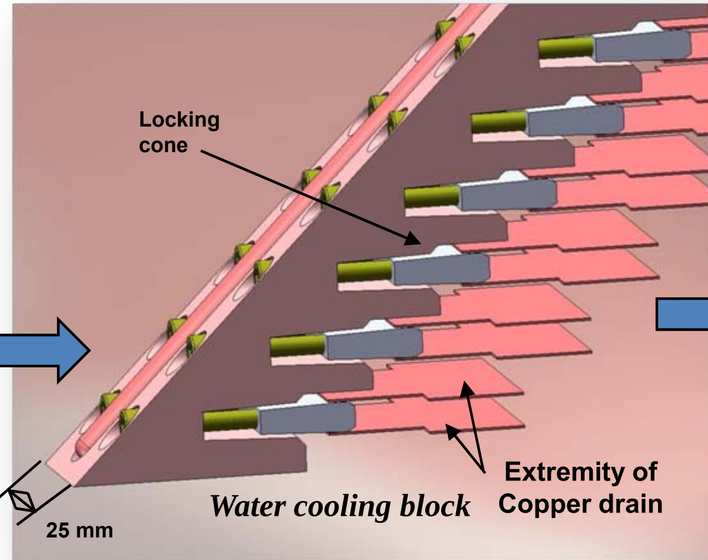


3 : Cooling global / Pipe integration

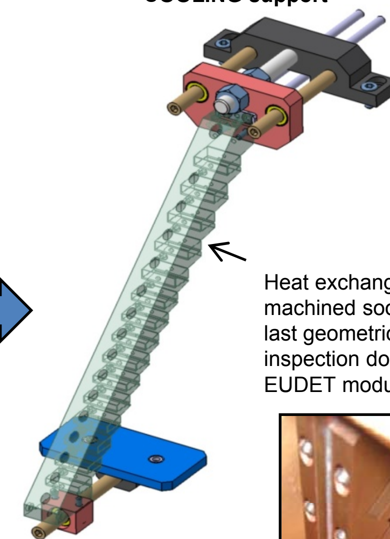
Cooling/ heat exchanger link



Heat exchanger on central column

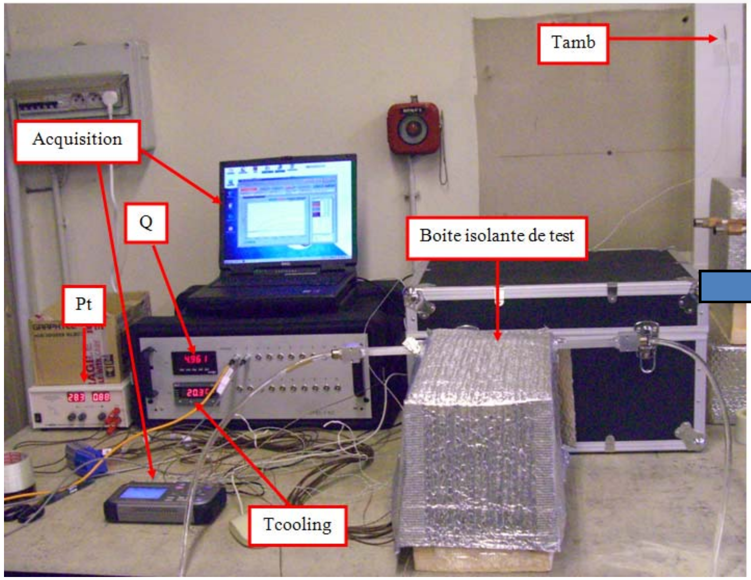


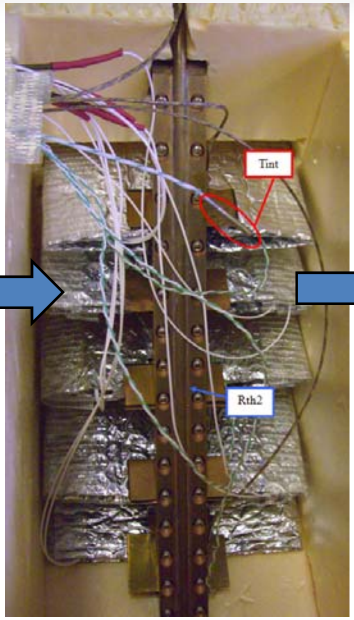
COOLING support

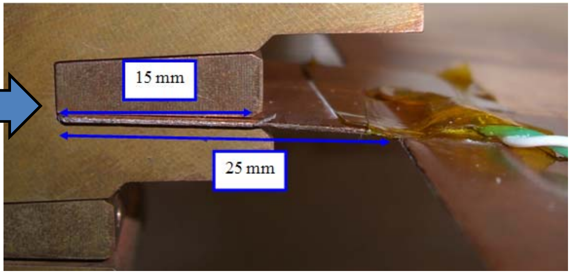


Heat exchanger machined soon with last geometrical inspection done on EUDET module

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







Next step: Heat exchanger of EUDET
Delivery: < summer 2012
Test of the full heating column