ECAL END-CAP

Geometry, Fastening, Constraints

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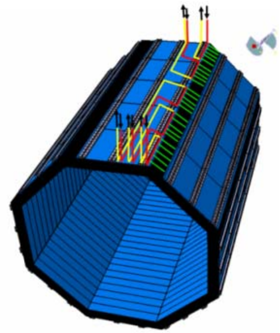
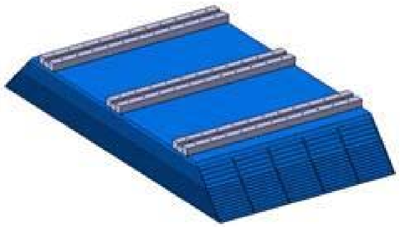
ILD Integration Meeting on calorimeters @ LAL / February 1st, 2012

Current structure of End-Caps

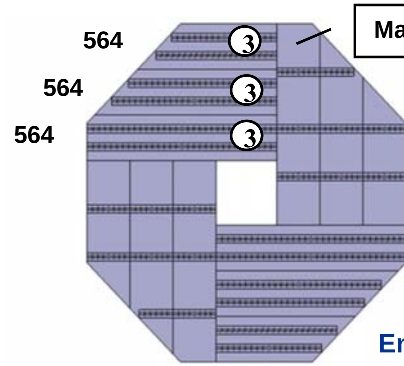
Modular structure	Barrel: 40 modules	End-Caps: 4 x 3 modules each



R_{barrel}=2028

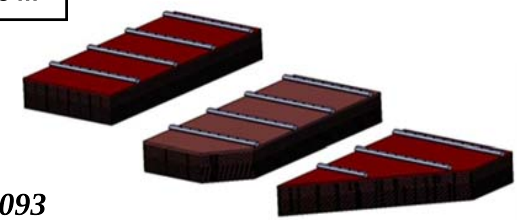


1 of the 40 « standard » module of the barrel



Max. Length. 2.5 m

R_{endcap}=2093



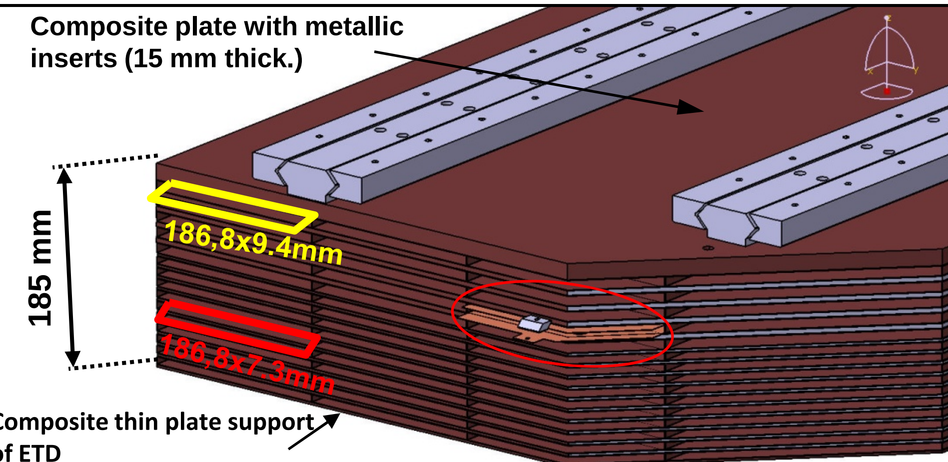
(2 orientations)

End-cap weight : ~ 17 T

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



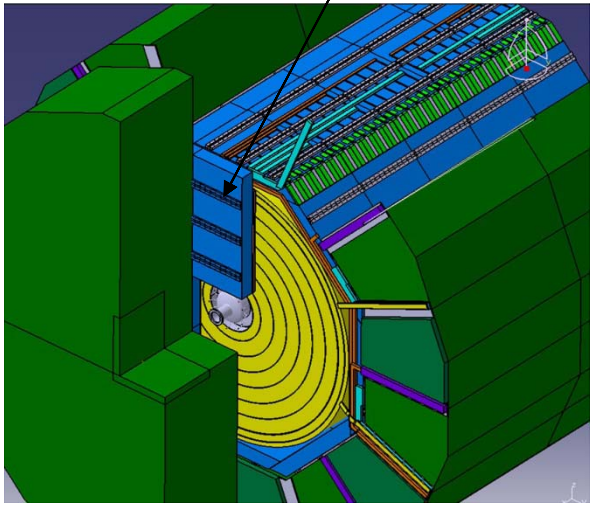
Module End-Cap n°2

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 (to be validated) & Cooling along 2,5m slab (back end T° of slabs)

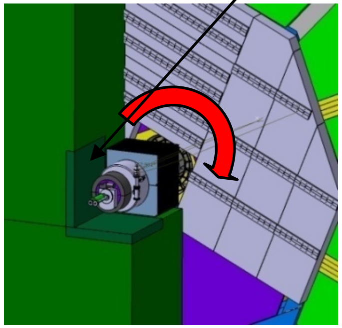
LPSC Grenoble

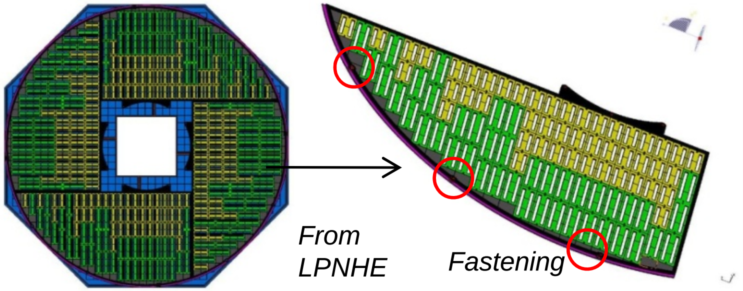
Tilt of 22°5 AHCAL: effects on End Caps

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



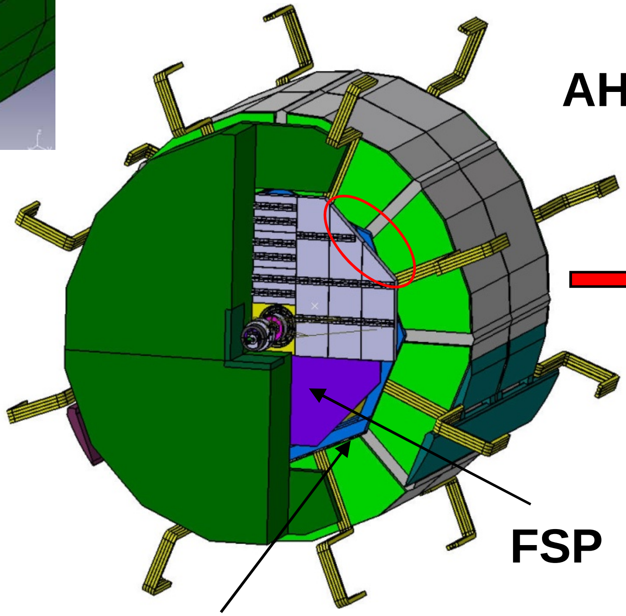
Square hole in HCAL end-caps remains in place…



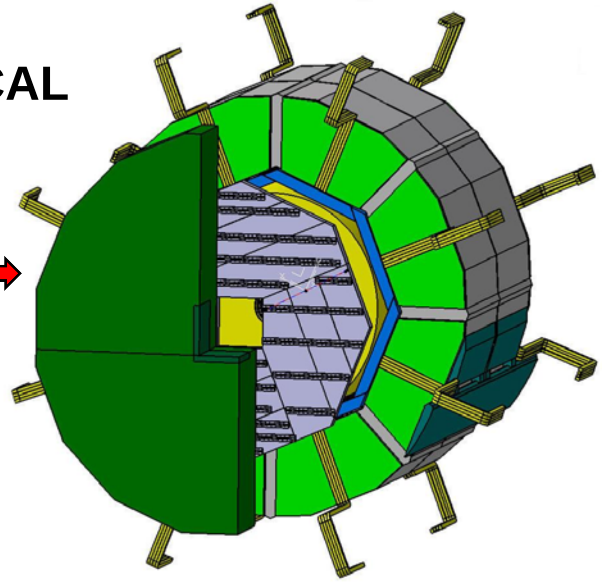


Seams not to be a problem for ETD **…**

AHCAL



The tilt of HCAL …then of ECAL barrel



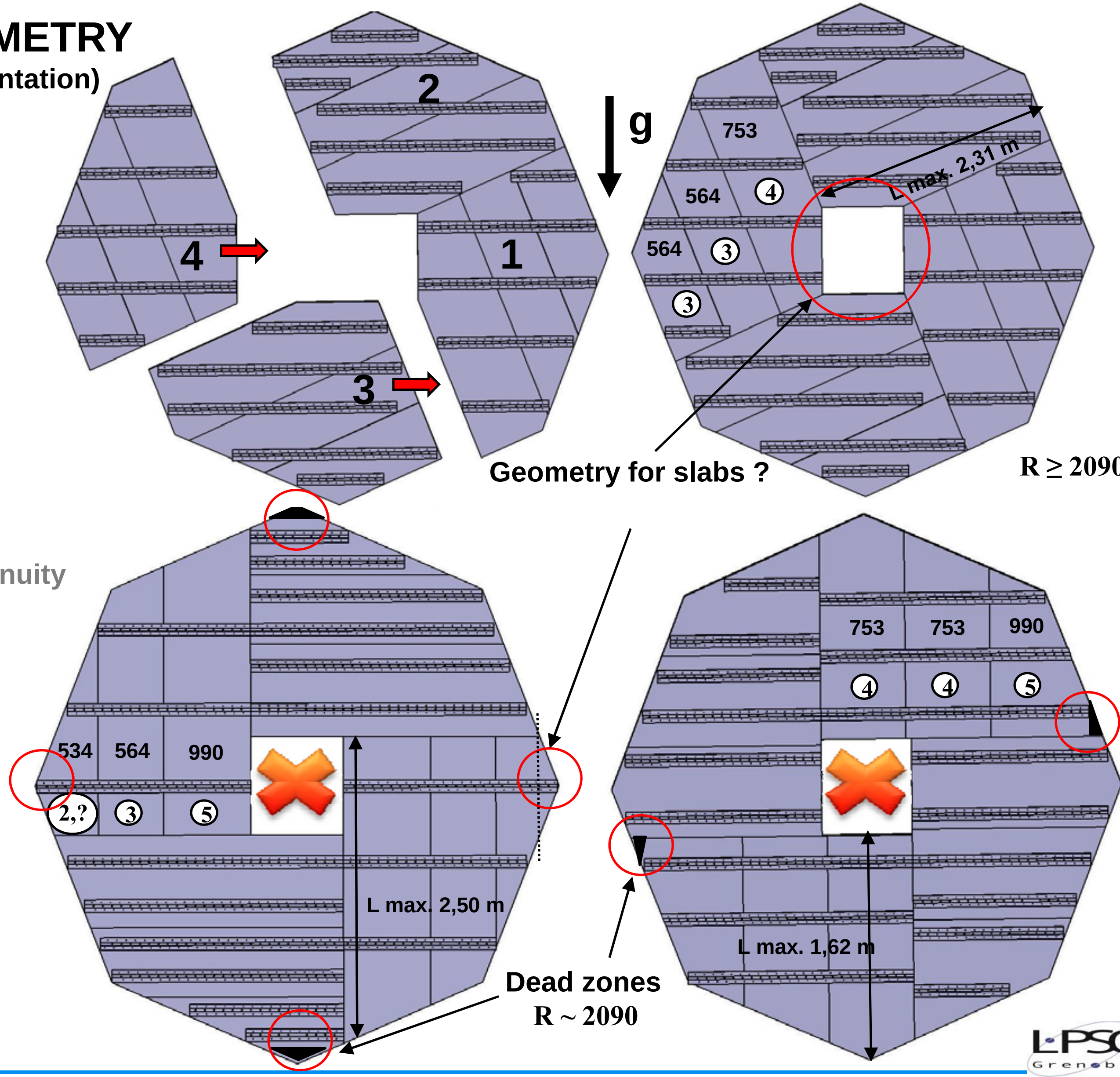
… So geometry of ECAL End-caps has to evolve

Tilt of 22°5 AHCAL: effects on End Caps

- **3 OPTIONS FOR GEOMETRY**
  with always 4x3 modules (Segmentation)

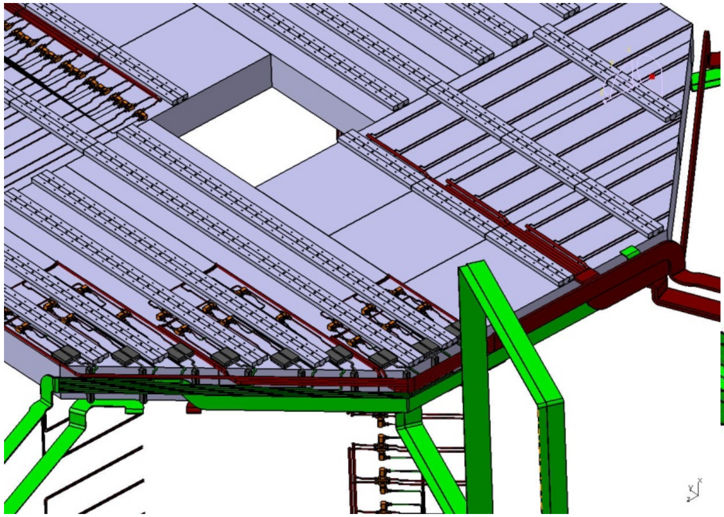
Mainly: drawbacks

- Dead zones due to the geometry (both structure and slabs)
- Modular structure: 2 or more orientations with problem of slab insertion
- Fastening : Nbr of rails and discontinuity for insertion / sector of 3 modules
- Deformation of End-Caps
- Fabrication of composite modules: cost of moulds...
- Constraints / free passage for cooling and services

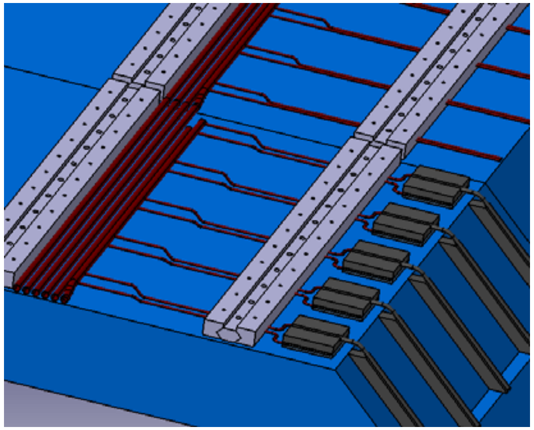


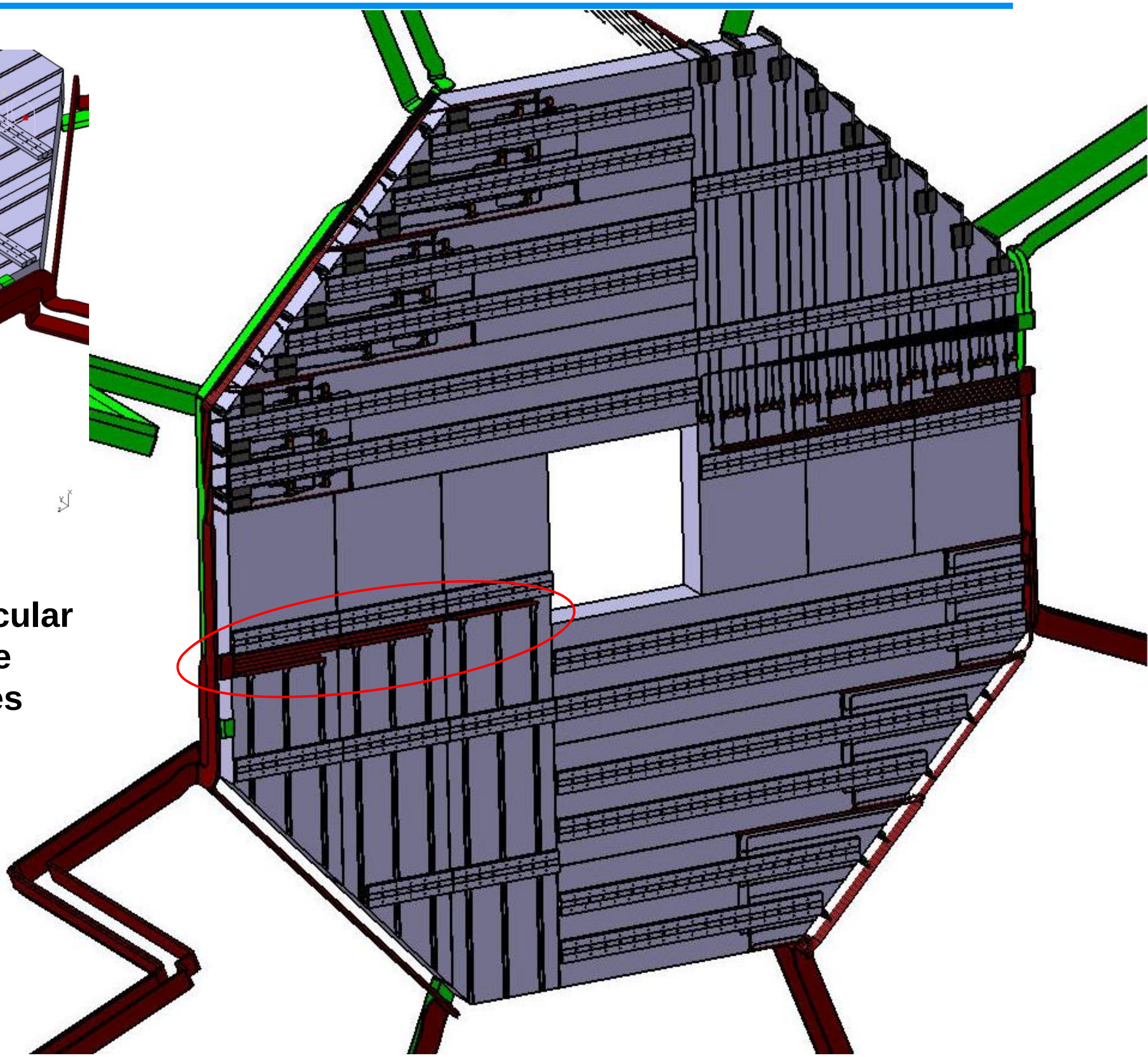
Tilt not convenient !

Passage of cooling pipes and services



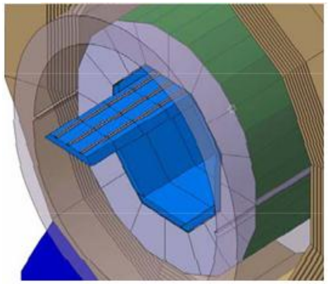
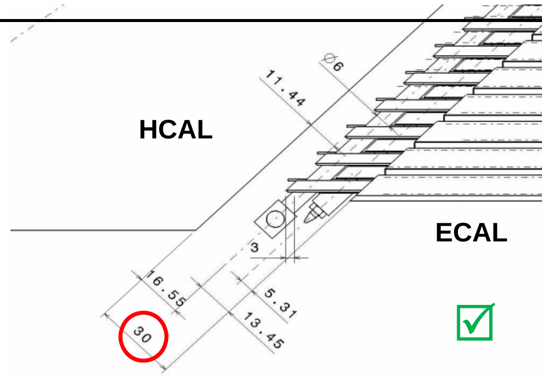
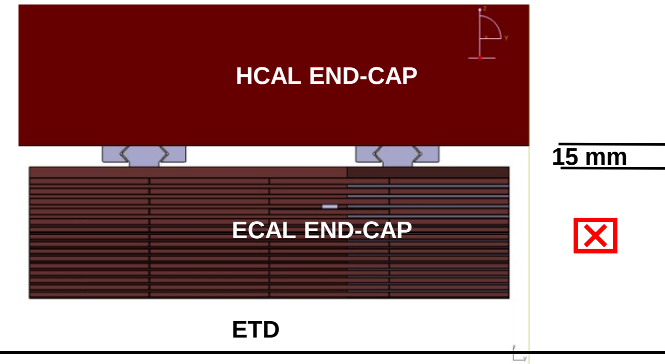
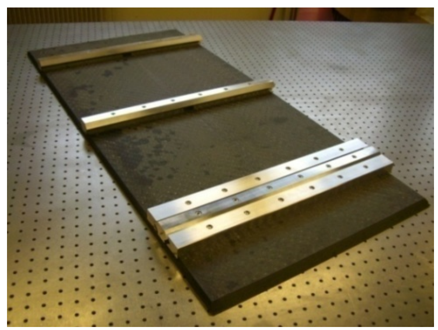
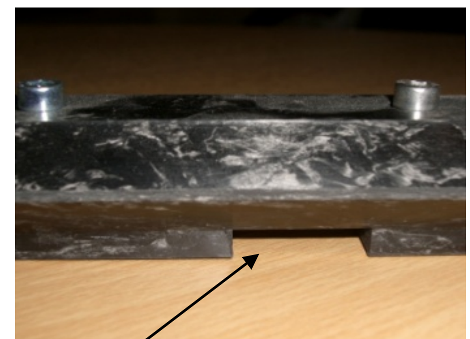
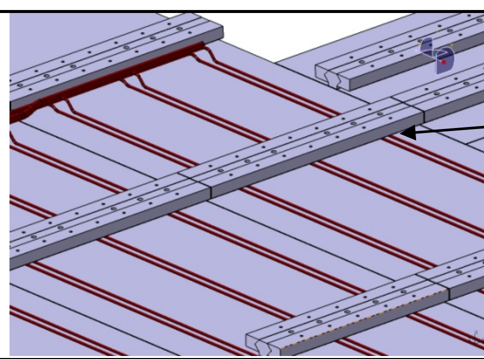
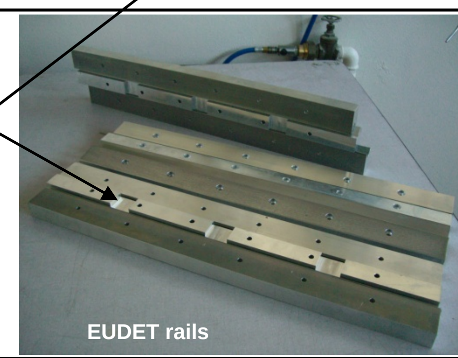
A solution with parallel or perpendicular rails / modules is better to allow free passage for cooling pipes & services





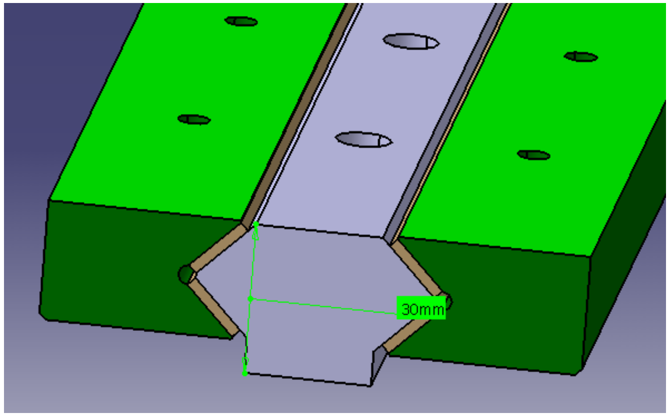
4 options of cooling services: in *red*, solution adopted (1 command per column)

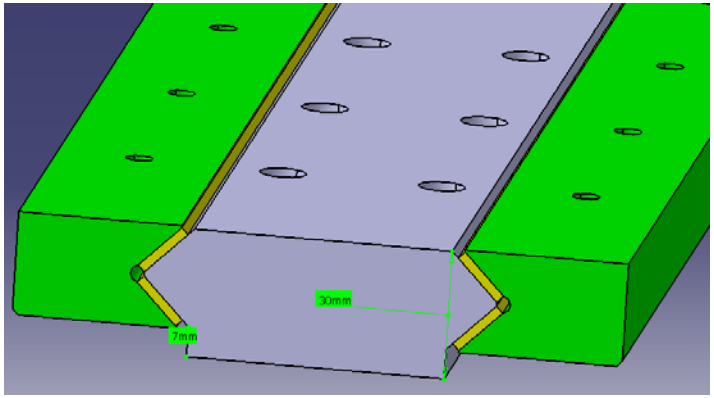
Fastening on HCAL

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 

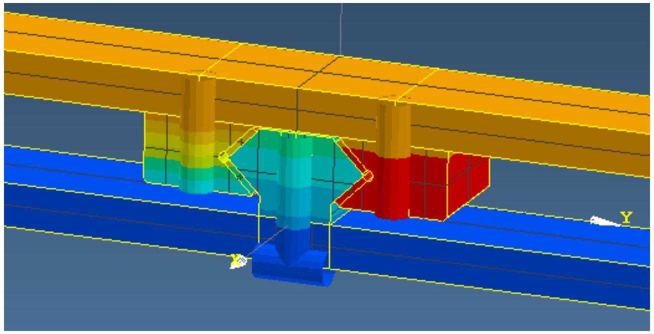
End Cap : Fastening system

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

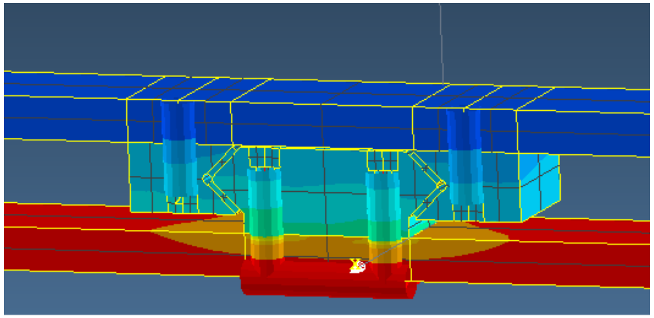




Finite element calculation to determine the stiffness of the rails : Wide / narrow



$a = 0{,}2\,mm$



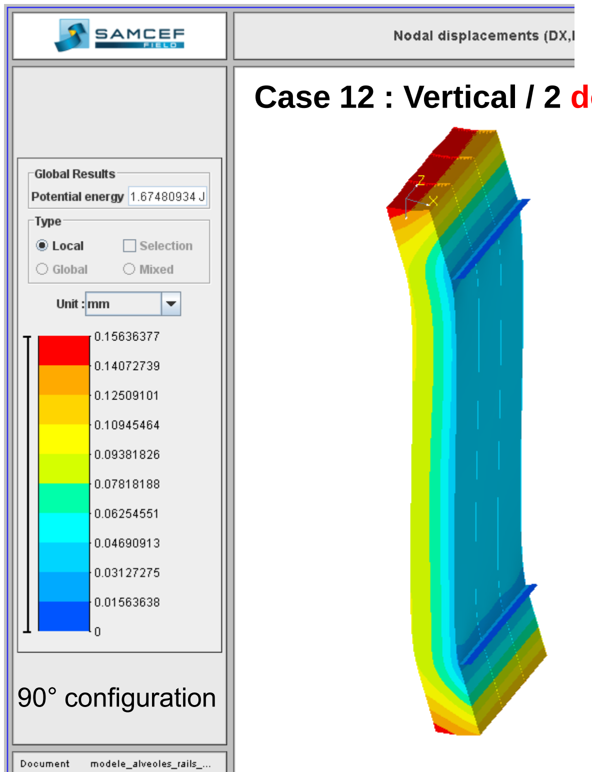
$a = 0{,}02\,mm$

End Cap : global simulation

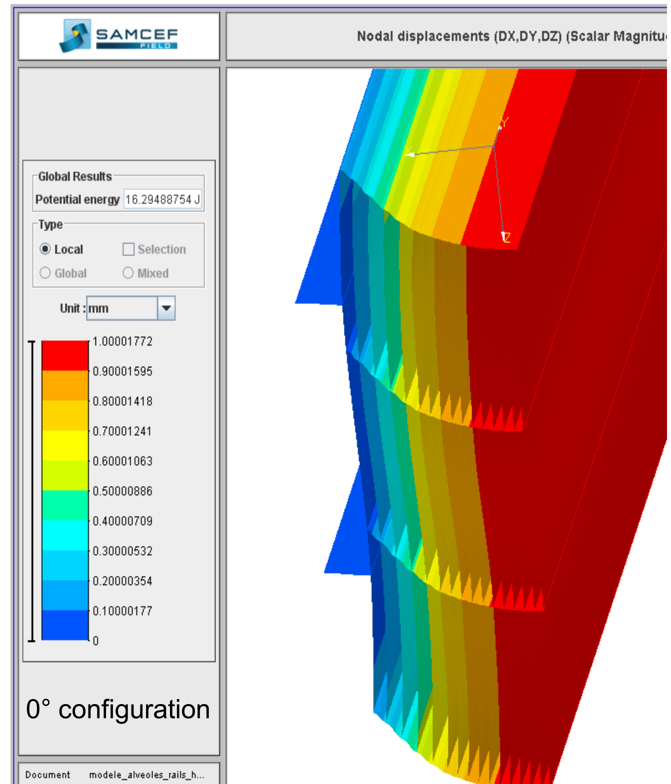
Finite element End Cap simulation : MODULE N°1

2.5 m long / 3 columns of 187 mm / position 0° and 90° / M = 2550 Kg

⇒ Goal of these simulations: Influence of the position / nbr of fastening systems on the mechanical behaviour (displacement / stress) …



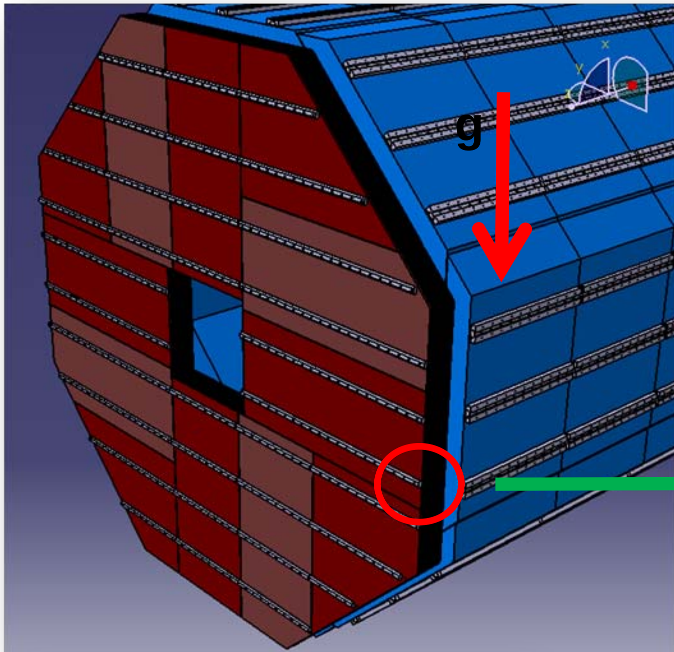
Type d'accrochage (vertical, horizontal)	Vertical
Nombre de rails	2
Type de rail (simple, bouble)	Double
Première contrainte principale (11411) (MPa)	8
Critères de TSAI Hill Version 1 (7621)	9.90E-03
Déplacement (mm)	0.16



Horizontal / 2 single rails

Type d'accrochage (vertical, horizontal)	Horizontal
Nombre de rails	2
Type de rail (simple, bouble)	Simple
Première contrainte principale (11411) (MPa)	108
Critères de TSAI Hill Version 1 (7621)	0.12
Déplacement (mm)	1

End Cap : global simulation



Fastening

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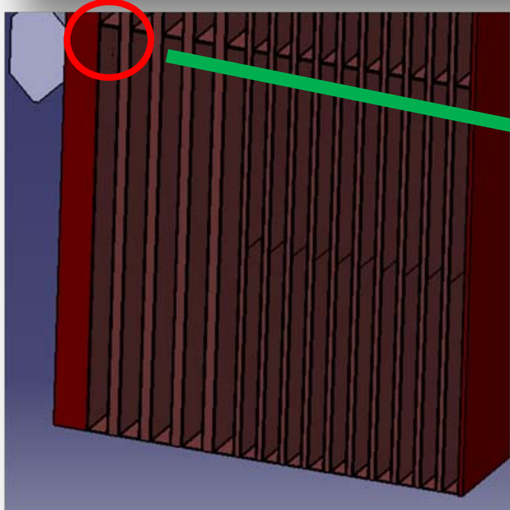
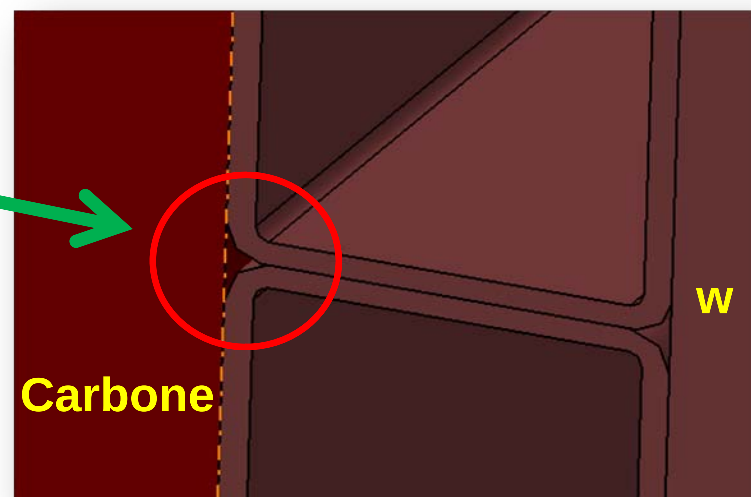
Bending stress of the skins



Detail



Fastening on HCAL

Conclusion

Even if module is fastened with 2 double rails instead of 3 simple rails, deflections are less important.
For now, double rails have been only simulated for vertical fastening with 2 rails.

FEM Model	*Deflection emax (mm)*	*TSAI-HILL (TS)*	*Margin of safety MoS (>1)*	*Von Mises stresses max (Mpa)*
ECAL-8-2	0,17	1,23E-02	2	7,23 (rails)
ECAL-8-3 *From LLR Barrel*	0,07	4,82E-03	3,8	3,06 (rails)
ECAL-12-3	0,15	3,59E-03	4,56	
ECAL-EC1-vertical-2-D	0.16	9,90E-03	2.35	8
ECAL-EC1-vertical-3-S	0.23	/		8
ECAL-EC1-horizontal-2-S	0.99	0.12	-0.04	108

With: $\text{MoS} = \frac{1}{K.\sqrt{TS}} - 1$; K= 3 (global safety factor)

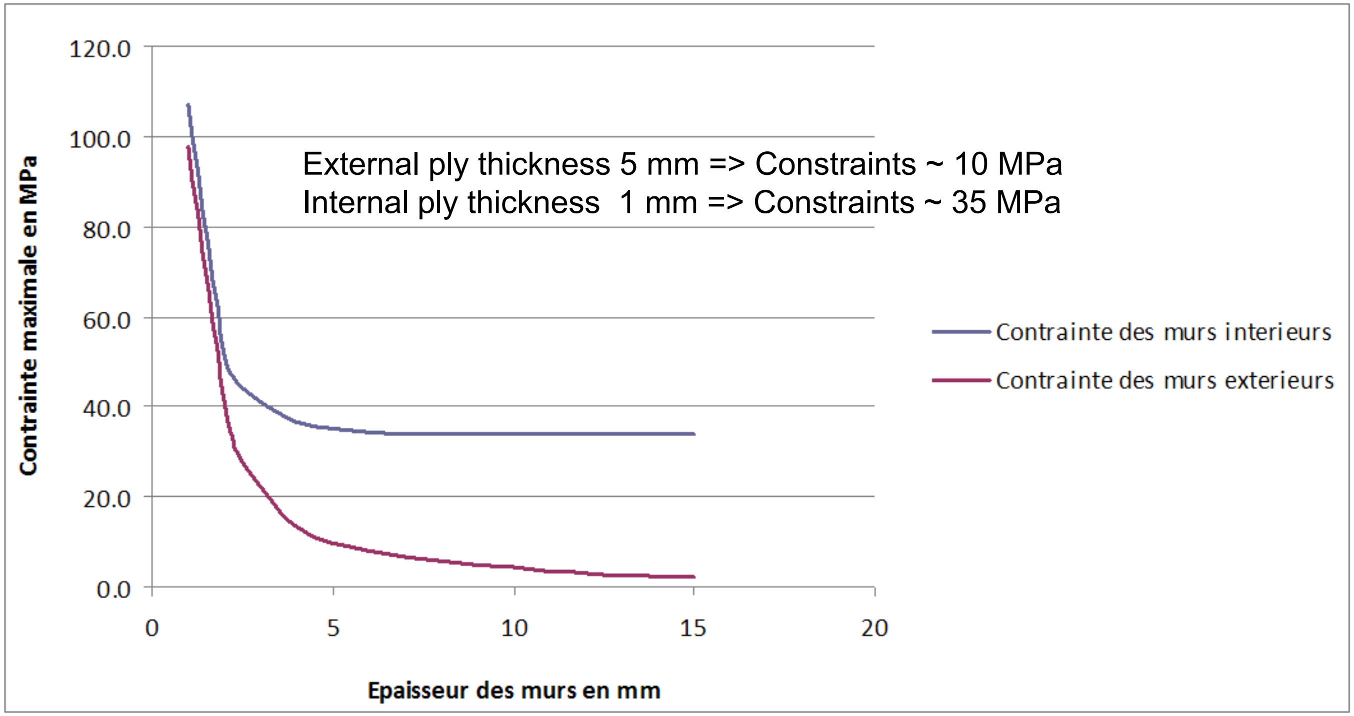
Optimization of deflection values / depending on the choice of safety factor & …

With a magnitude of maximal deflection of 1 mm, the maximal stress has a value greater than 13 Mpa (eligible tensile criteria)
The acceptable maximal stress with a safety factor, will be determined after destructive tests.
Then, It is necessary to perform tests with more carbon plies, or other material properties.

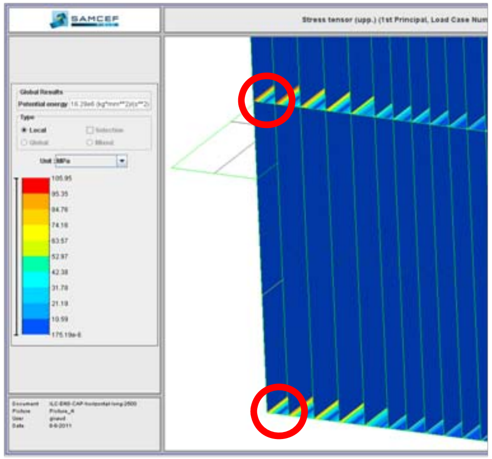
(When a ply is added to alveoli flanges, the constraint becomes two times lower – but not linear with more plies).

Results: evolution of skin thickness

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



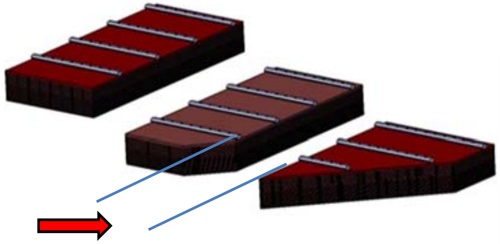
Problem of bending stress of alveoli skins



Alveoli wall : 4 x 0.25 mm

First main constraint: 106 Mpa (plate model)

- Constraints (1ère main) with 4 plies of 0.25 mm => ~ 90 MPa.
- 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...



Increase of external plies thickness => Problem = inter-modules dead zone

Tests on going in 2012…