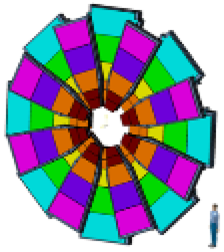
DE LA RECHERCHE À L'INDUSTRIE

ATLAS-NSW

SACLAY MMM WORKSHOP



SIMULATIONS OF THE MM WEDGES

WITH THE LAYOUT OPTION #3B

Patrick PONSOT & Patrick GRAFFIN for the CEA-Saclay-Irfu group:

F.Bauer, P.Daniel-Thomas, E.Ferrer-Ribas, J.Galan, W.Gamache, A.Giganon, P-F.Giraud, S.Hassani, S.Herlant, S.Hervé, F.Jeanneau, H.LeProvost, O.Meunier, A.Peyaud, Ph.Schune

18-19 of April 2013

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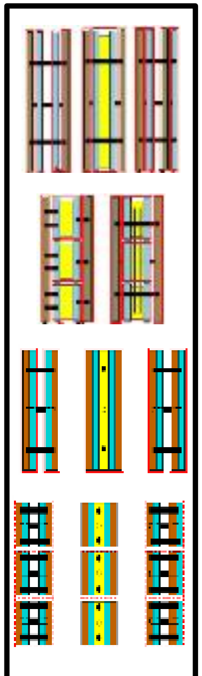
OUTLINE

- **Evolution of the layout**
  - From more than 10 configurations for a sector…
  - … to the open issue : Can we screwed the MM quadruplets on a spacer?
  - What are the MM layout options #3A and #3B
- **Thermo-mechanical simulations with screwing of the MM wedges (option #3B)**
  - Methodology: progressive approach
  - Exchange of materials for the structures (aluminum vs G10)
  - Comparison of the results
- **Conclusion**
  - Impact on the design of the quadruplets?

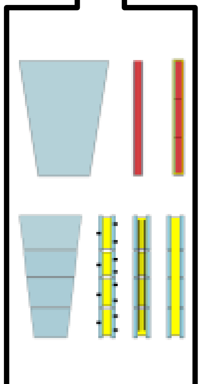
EVOLUTION OF THE LAYOUT

More than 10 configurations for a sector !

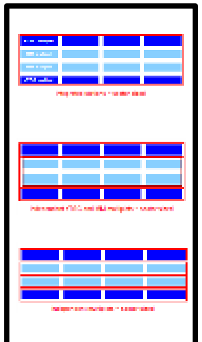


Agreement to build wedges for both sTGC & MM

2 options to build a MM wedge

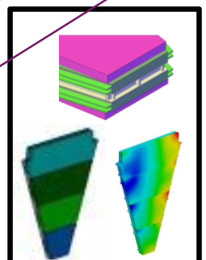


3 options to do the assembly of the 4 wedges !



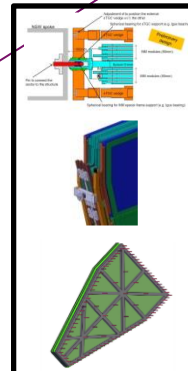
3 configurations are considered :

Option #1 – all is glued
Option #2 – external frame
Option #3 – central spacer



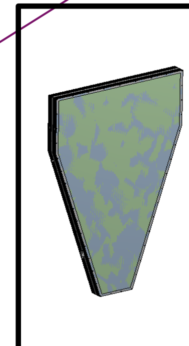
Simulations of the wedges made of 2x4 modules, fixed with kinematic supports on a spacer-frame

2 options to build the 2 MM wedges (modules vs full size wedges)



Option #3: Double kinematic supports to separate sTGC and MM wedges

Asking for simulation of the full size MM wedges by screwing them on a spacer



Results?

2012

ATLAS upgrade week
21th of Nov

1st MMM-Frascati
29-30th of Nov.

NSW milestones review
17th of Jan.

2013

2nd MMM-CERN
21-22nd of Feb.

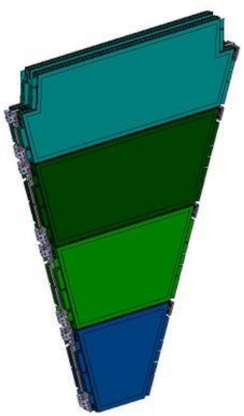
Special week #11 of Mar.
3 layout meetings

3rd MMM-Saclay
18-19th of Apr.

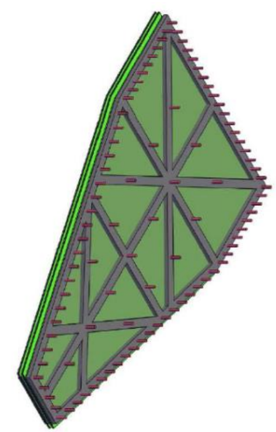
MM LAYOUT OPTIONS #3A AND #3B

- **Layout option #3A (Saclay proposal – Patrick P. and Patrick G.)**
  - The 2 MM wedges are made of 2x4 (or 2x3) modules
  - The modules are fixed on a spacer frame by using kinematic mounts
  - **Floating quadruplets,** no external constraints

- **Layout option #3B (CERN proposal – Joerg W. and Givi)**
  - Full size MM wedges, the 2 MM wedges are screwed on an aluminum spacer
  - **Screwed quadruplets**, external constraints must be taken in account (friction factor, tear forces of the screws)



Option #3A	Option #3B
At least 288+48 (2x3 modules per sector) adjustable kinematic supports (per NSW) are needed	Only 48 kinematic supports (per NSW) are needed
Access to the electronic is reduced by the part of the T profile which is needed to fix the kinematic supports	Access to the electronics is closed only in front of the 3 kinematic mounts of the sector
Radial overlaps are needed to limit the dead zones	No radial dead zones
Flatness at 50 microns seems feasible ($2m^2$)	Feasibility of the flatness at 50 microns should be demonstrate ($6m^2$)
No external constraints on the detectors (a lot of simulations have been done)	**The external constraints can deform or damage the detectors (it should be studied)**



- **Thermo-mechanical simulations with screwing of the MM wedges (option #3B)**

Preliminary remark, valid for all the talks done by the Saclay NSW team:

In all cases the thermo-mechanical simulations are made with simplified modelling*. The results must be considered as predictive tendencies and not as absolute values.

* The detailed design of the structures is not defined
* The tension of the mesh is not included (simulation in progress)

Methodology: Progressive approach

- Why? The final modelling should take in account the friction factors coupled with the tear force of the screws (FEA with contact elements). No-linear calculation induces very long time consuming. Today we need one night to do the computation with simplified model. (geometry, pre-processing, computation and post-processing → only 2 simulations per week)

- How? Instead of a lot of tests, we decided to use simplified modelling to reduce the number of simulations

- Plan ? for the thermo-mechanical simulations (weight + temperature gradient 2°C)
  - Step 1: The MM sector without the screws (all is glued, aluminum excepted for the skins)
  - Step 2: Full size wedges with aluminum, only screwed on the external frame of the spacer
  - Step 3: Full size wedges with G10, only screwed on the external frame of the spacer
  - Step 4 (a consequence of the result of step 3): 2x3 modules screwed on the external frame of the modules
  - Step 5: Introduction of the friction factors (no-linear calculation), but before this…maybe a step 4-Bis can be required

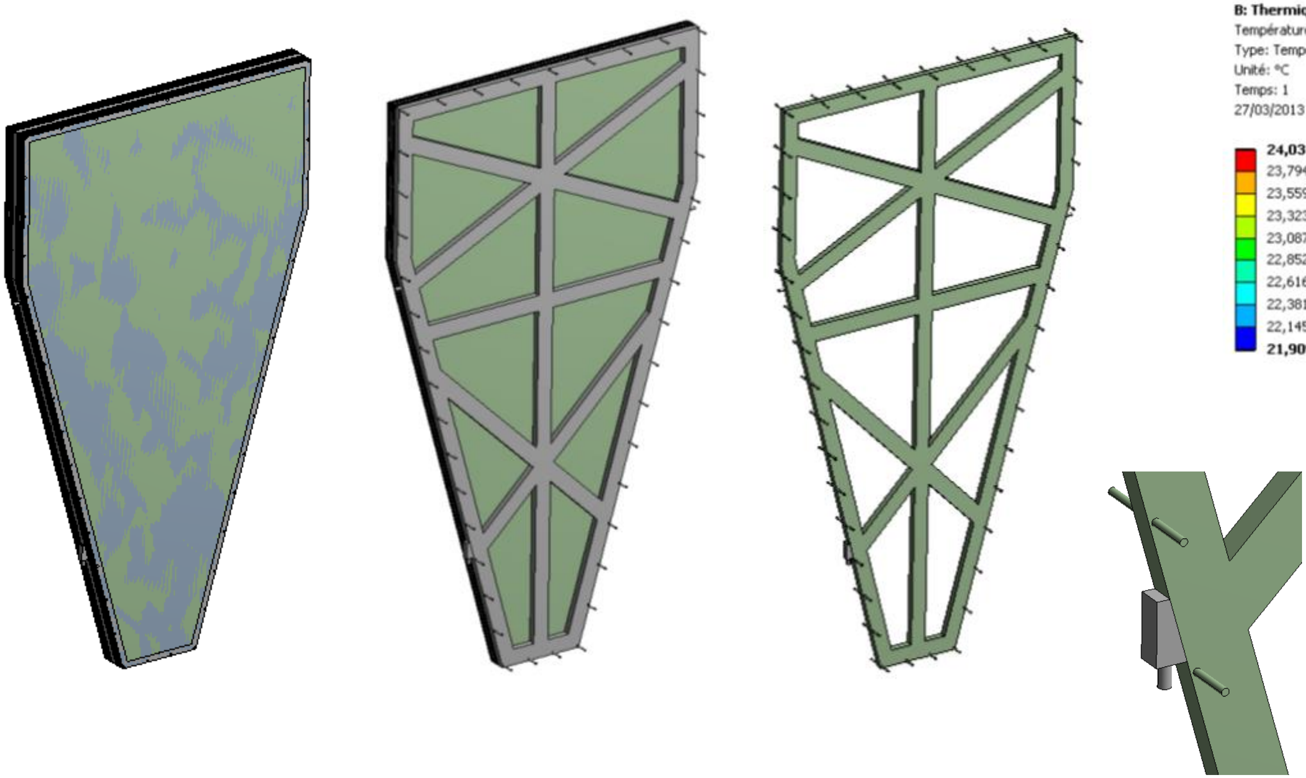
- **Screwing of the MM wedges (option #3B)**

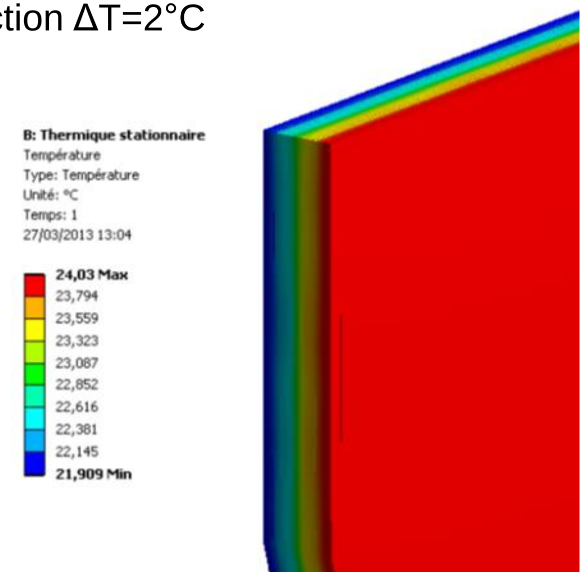
- **For the composite materials, the mechanical characteristics are fully dependent of their origin (datasheet is needed for all of them)**

- **Material used for the simulations:**

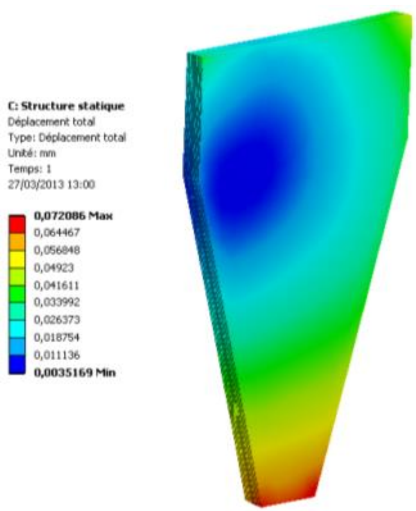
Component	PCB	Honeycomb		Structure	
Material	FR4	Aluminum 5056	Paper	G10	Aluminum
Density (Kg/m^3)	1950	129.7	48	1900	2770
Young modulus (MPa)	17000	2999	2800	24000	71000
Poisson’s ratio	0.37	0.3	0.24	0,3	0,3
Coefficient of thermal expansion α.K^{-1}	15x10^{-6}	23x10^{-6}	20x10^{-6}	13x10^{-6}	23x10^{-6}
Thermal conductivity (W.m^{-1}.K^{-1})	0,3	150	0.13	0,3	150

- **Step 1 to 3: Full size wedges (sector 5)**
- **Geometry, boundary and loading conditions**
  - Full size wedge + spacer
  - 3 kinematic mounts on the spacer
  - Self weight, Inclined at 0.704°, temperature gradient in Z direction ΔT=2°C

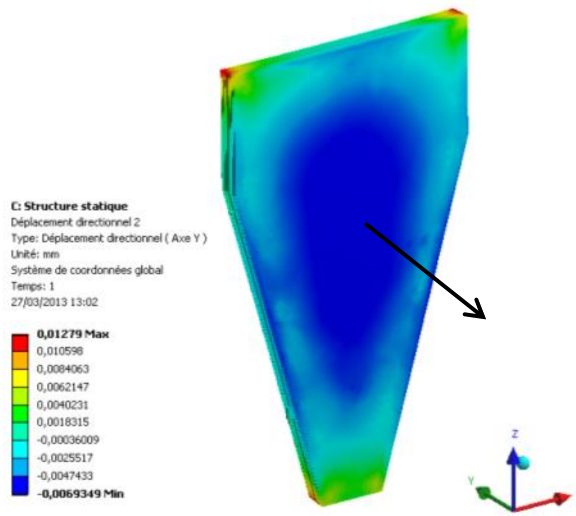




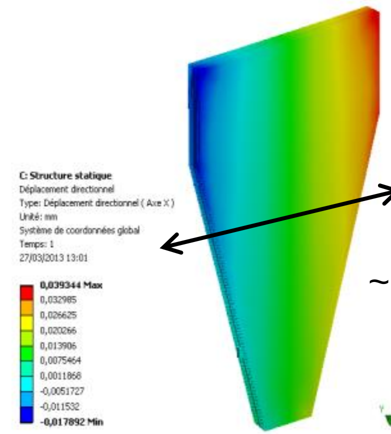
- **Step 1: The MM sector without the screws (all is glued, aluminum except for the skins)**
    - Displacement on IP side



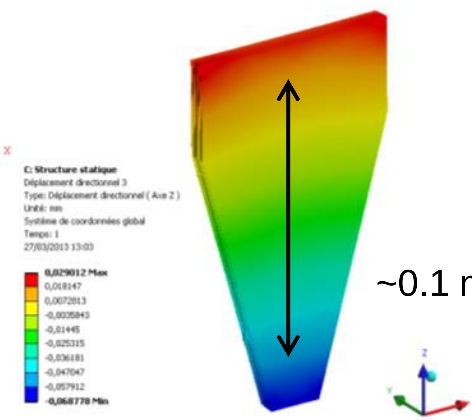
Global 3D
< 0.1 mm



~0.02 mm



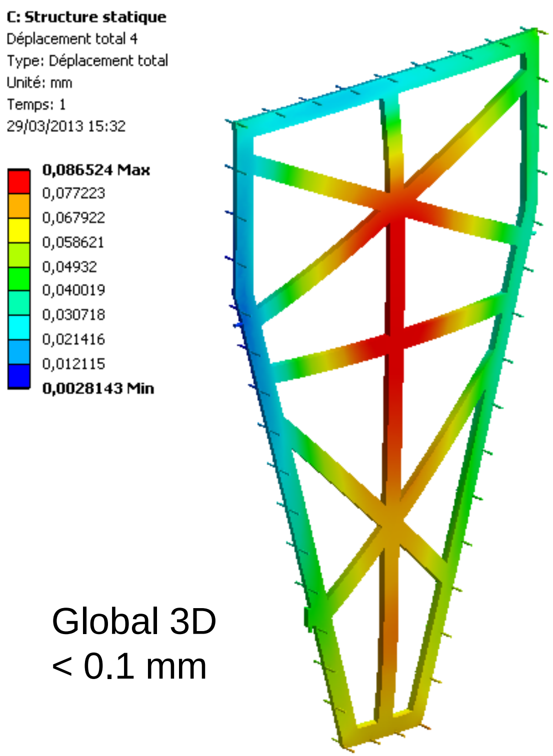
~0.05 mm



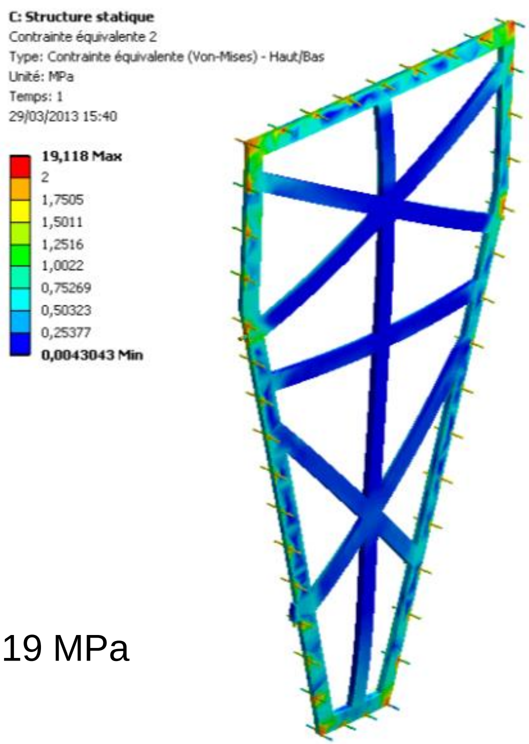
~0.1 mm

If all is glued, the displacements out of the plane are under 50 microns

- **Step 2: Full size wedges with aluminum, only screwed on the external frame of the spacer (no sliding for the screws)**
  - Displacement and stresses for the spacer



Global 3D
< 0.1 mm

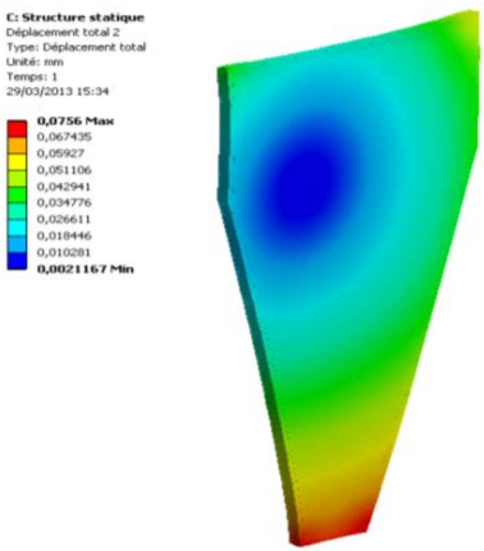


~19 MPa

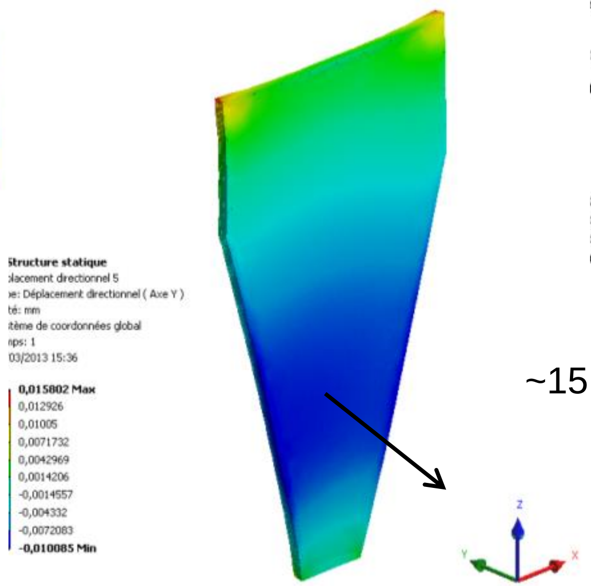
Displacements of the spacer are under 100 microns but the stresses are increased by a factor 10

THERMO-MECHANICAL SIMULATIONS

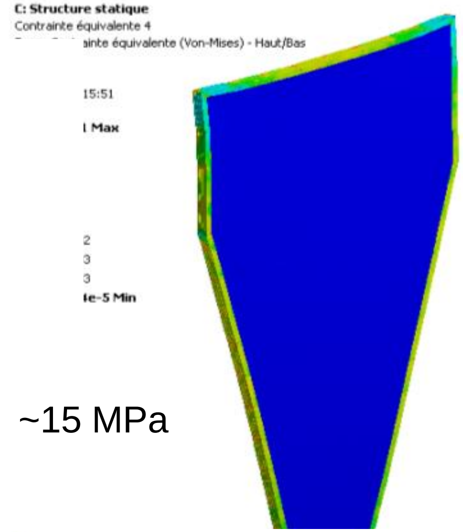
- **Step 2: Full size wedges with aluminum, only screwed on the external frame of the spacer (no sliding for the screws)**
  - Displacement on IP side and stresses for the wedge



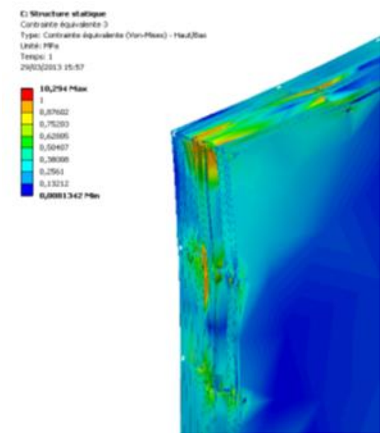
Global 3D
~0.08 mm

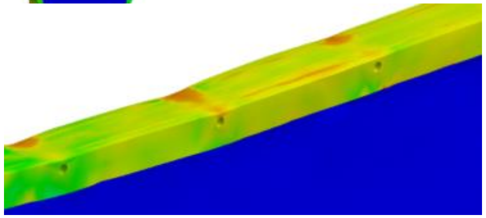


~0.03 mm ("without the effect of the displacement of the spacer", friction factor is not included)



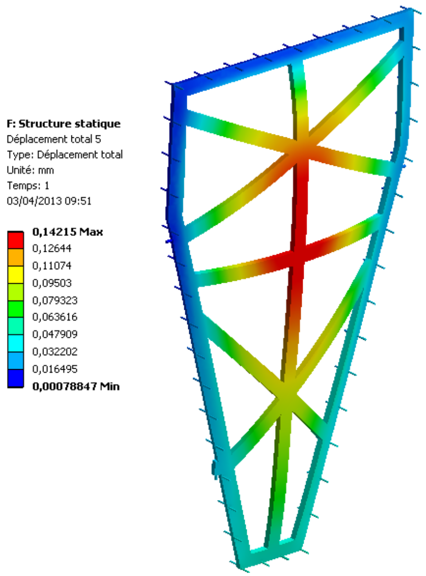
~15 MPa



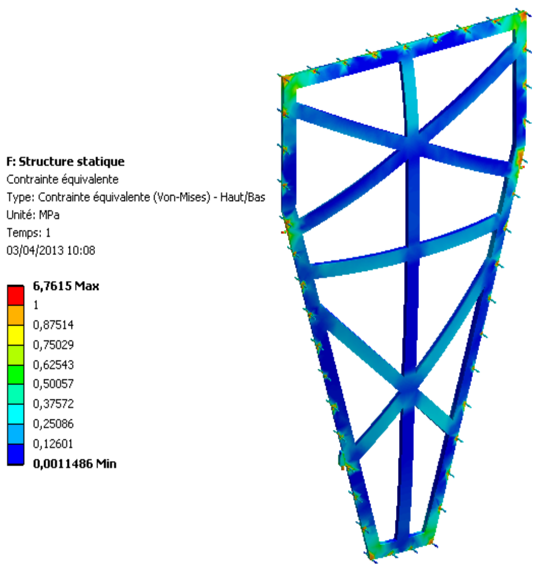


Displacements (due to thermal expansion) out of the plane are under 50 microns but the shear stresses are increased by a factor 10 :
The gluing of the skins can be broken !

- **Step 3: Full size wedges with G10 and paper honeycomb, only screwed on the external frame of the spacer (no sliding for the screws)**
  - Displacement and stresses for the spacer



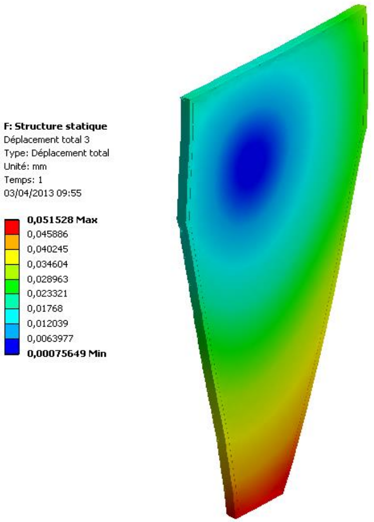
Global 3D
< 0.15 mm

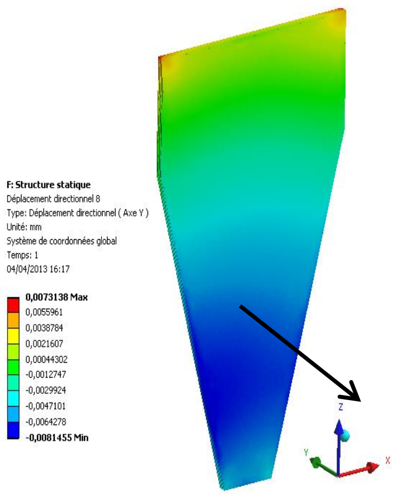


~7 MPa

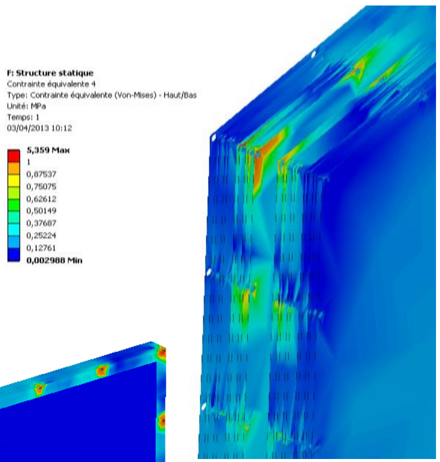
Displacements of the spacer are increased to 0.15mm and will deform the wedges out of the plane. The stresses are increased by a factor 5.

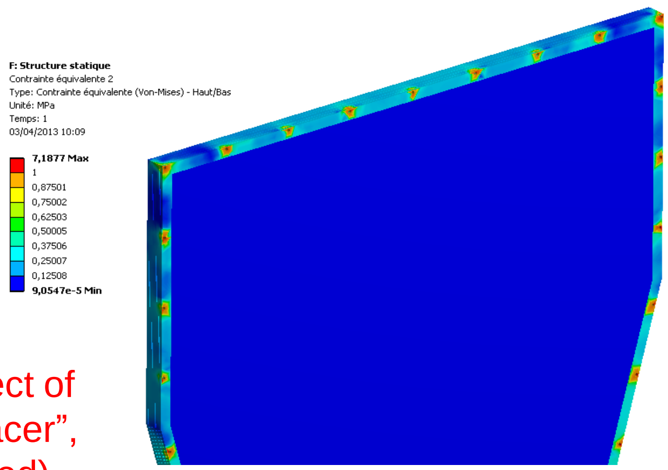
- **Step 3: Full size wedges with FR4 and paper honeycomb, only screwed on the external frame of the spacer (no sliding for the screws)**
  - Displacement on IP side and stresses for the wedge





~7 MPa



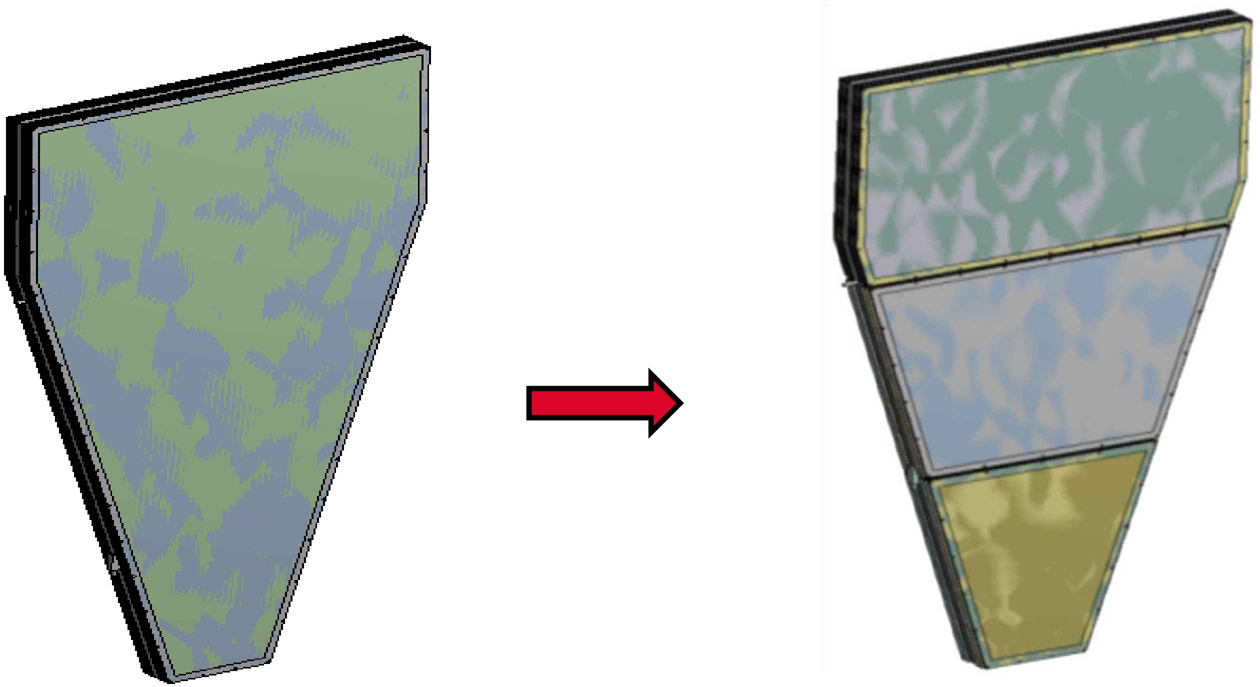


Global 3D
~0.05 mm

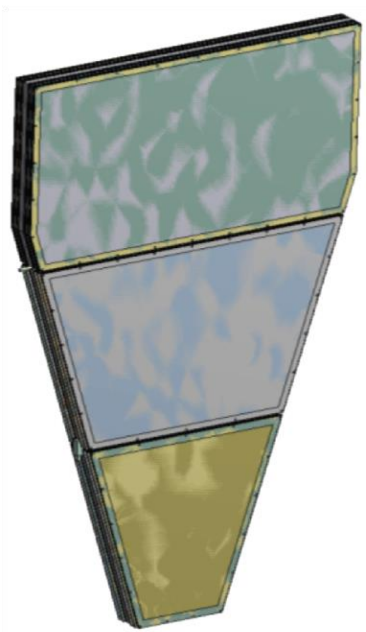
~0.02 mm ("without the effect of the displacement of the spacer", friction factor is not included)

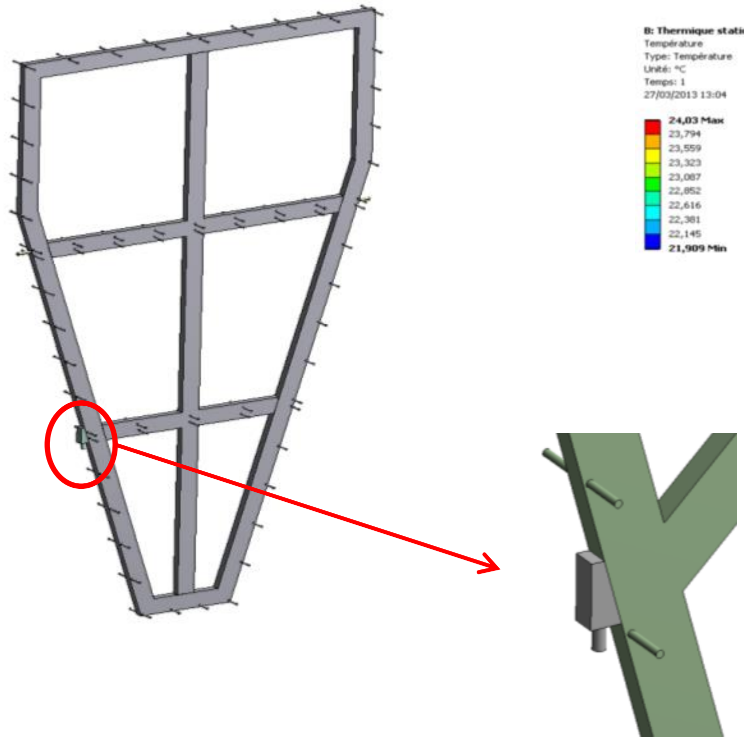
Displacements of the spacer are increased to 0.15mm and will deform the wedges out of the plane. The shear stresses are increased by a factor 5.

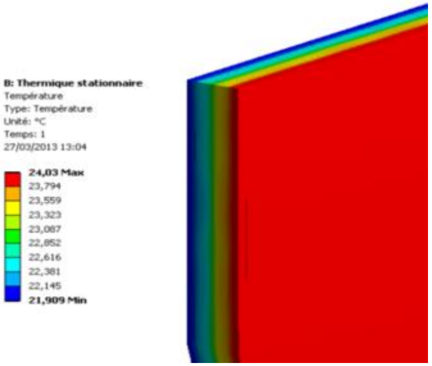
- **Due to the increasing of the shear stresses, it has been decided to study the effect of cutting the wedge (step 4)**



- **Step 4: Geometry, boundary and loading conditions (sector 5)**
  - 2x3 modules + spacer
  - 3 kinematic mounts on the spacer
  - Self weight + Inclined at 0.704° + temperature gradient in Z direction ΔT=2°C



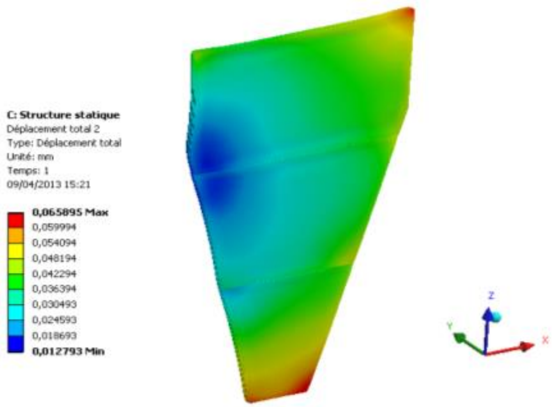


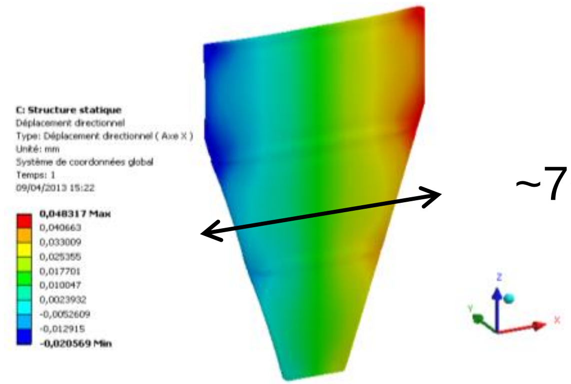


THERMO-MECHANICAL SIMULATIONS

- **Step 4: 2x3 modules with aluminum frames and aluminum honeycombs, only screwed on their external frame on an aluminum spacer (FR4 skins 0.5mm)**
  - Displacement for the modules on IP side

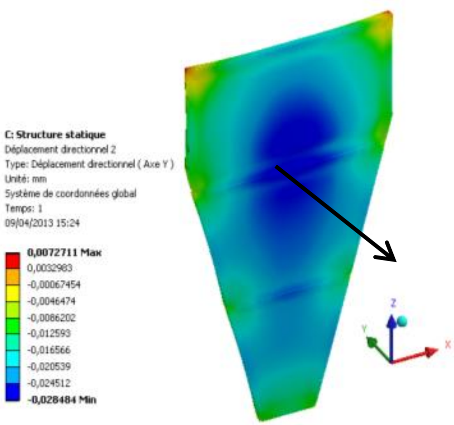
Global 3D

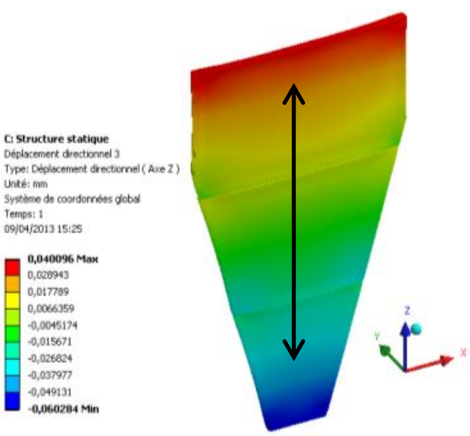




~70µm

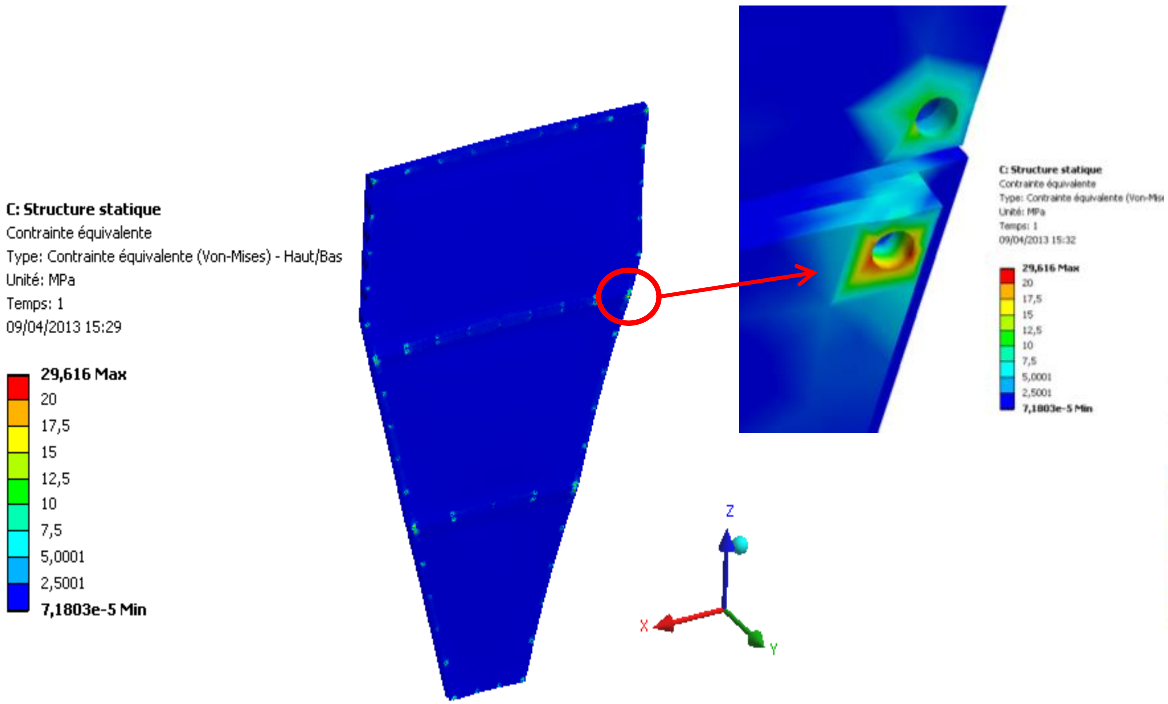
~35µm

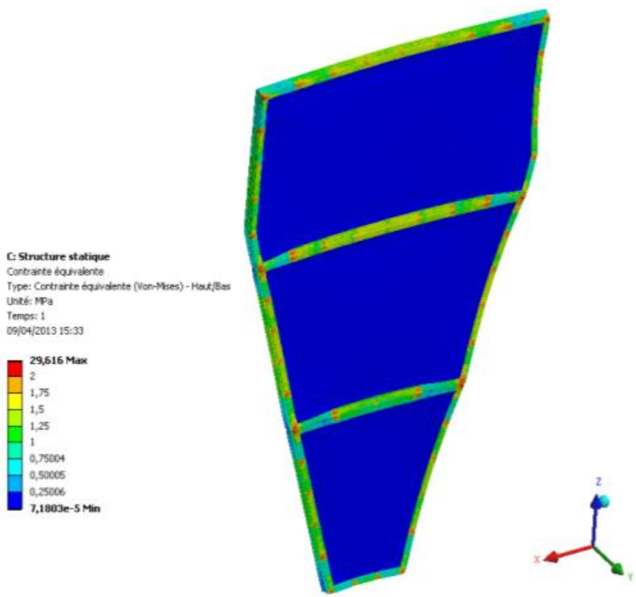




~100µm

- **Step 4: 2x3 modules with aluminum frames and aluminum honeycombs, only screwed on their external frame on an aluminum spacer (FR4 skins 0.5mm)**
  - Stresses for the modules on IP side



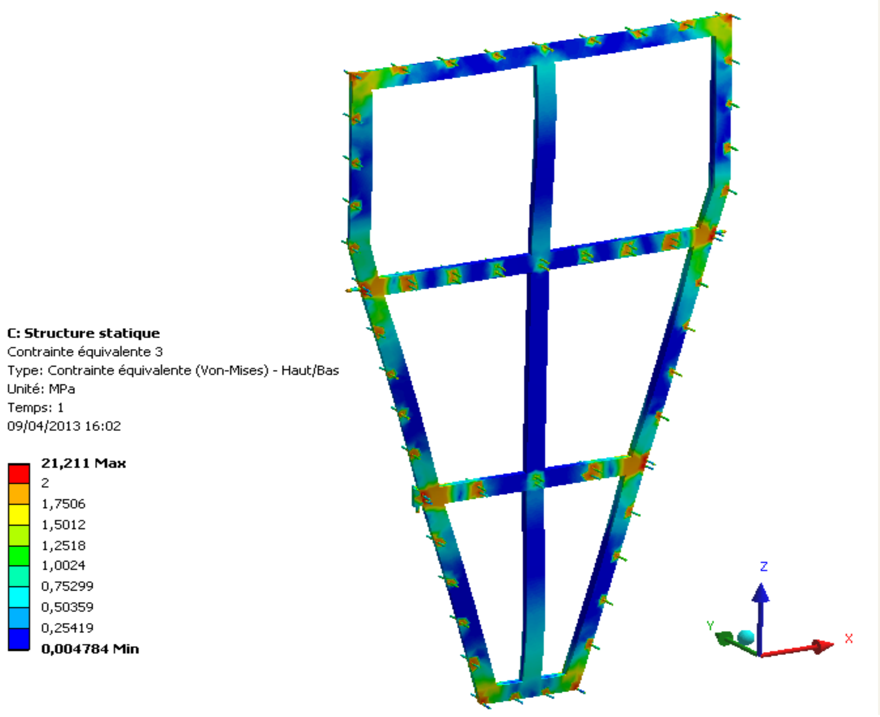


Up to ~29 MPa localized on the holes of the frames, but this is not a problem for aluminum material

~2 MPa

THERMO-MECHANICAL SIMULATIONS

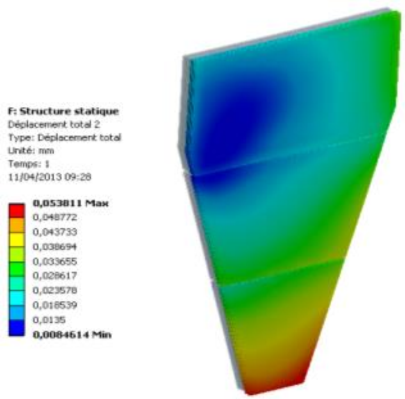
- **Step 4: 2x3 modules with aluminum frames and aluminum honeycombs, only screwed on their external frame on an aluminum spacer (FR4 skins 0.5mm)**
  - Stresses for the spacer

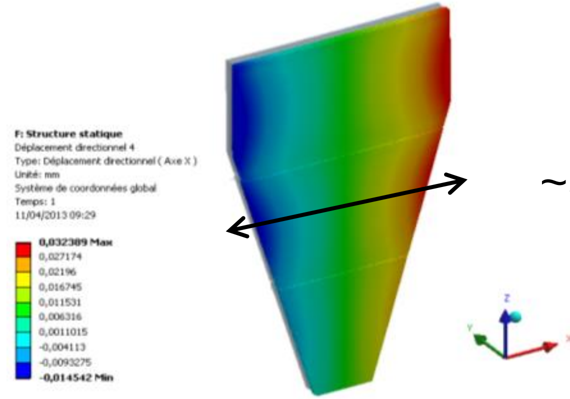


Up to ~21 MPa but this is not a problem for aluminum material

- **Step 4: 2x3 modules with G10 frames and paper honeycombs, only screwed on their external frame on a G10 spacer (FR4 skins 0.5mm)**
  - Displacement for the modules on IP side

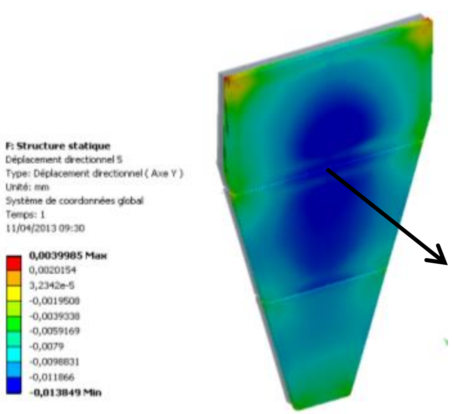
Global 3D

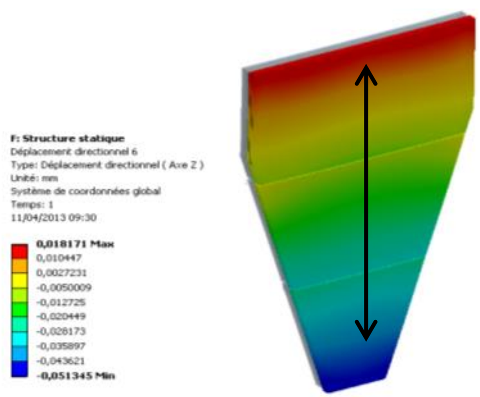




~50µm

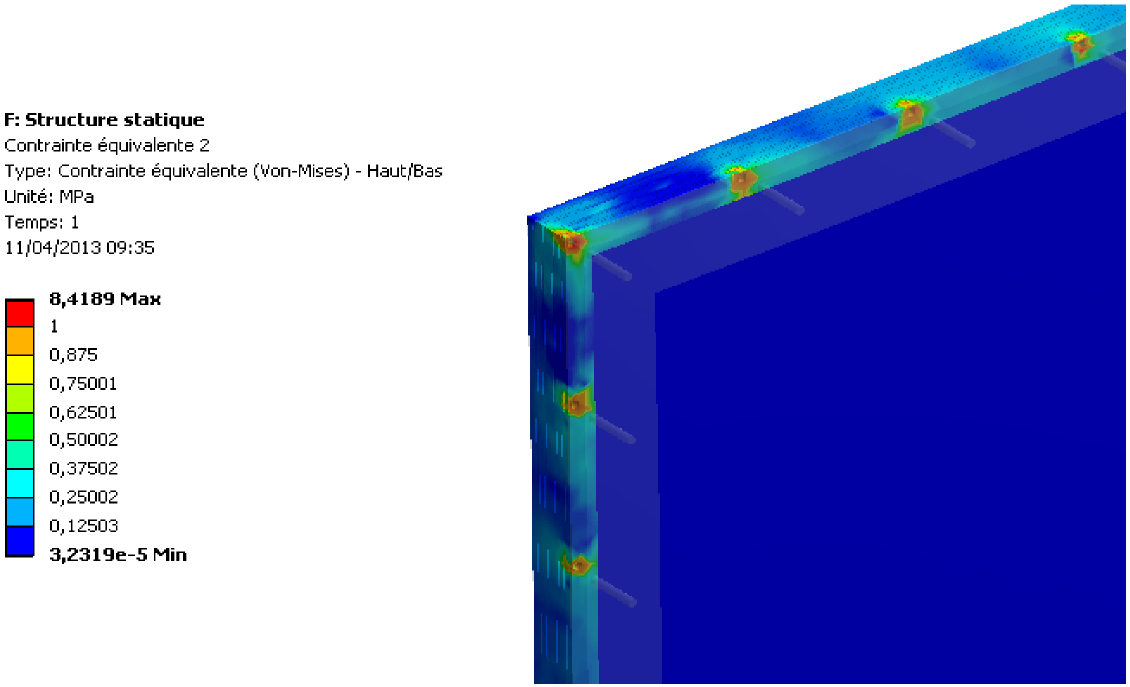
~18µm





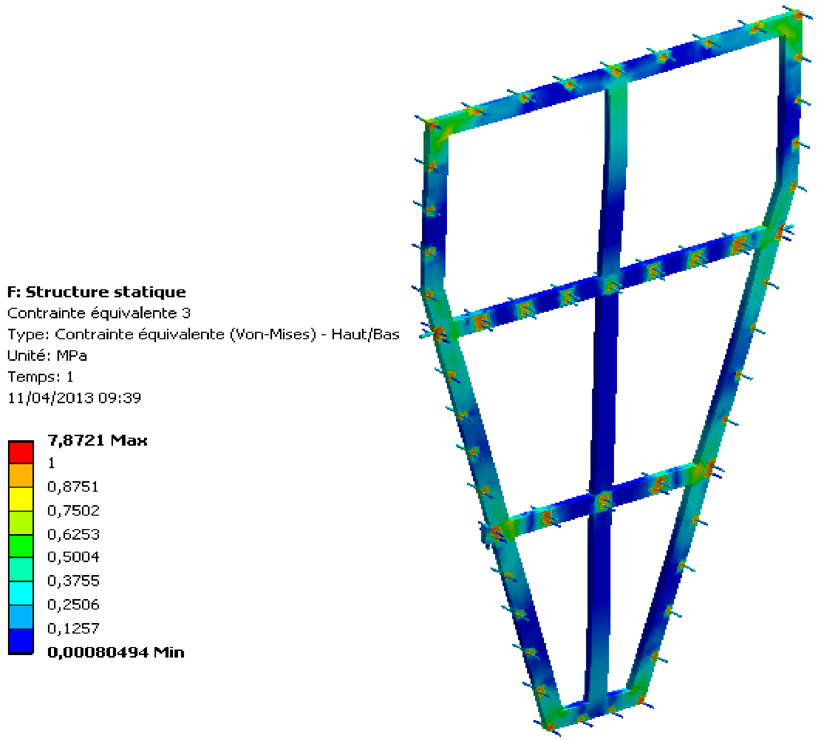
~70µm

- **Step 4: 2x3 modules with G10 frames and paper honeycombs, only screwed on their external frame on a G10 spacer (FR4 skins 0.5mm)**
    - Stresses for the modules on IP side



Up to ~9 MPa but localized around the holes
Less than ~2MPa for the skins

- **Step 4: 2x3 modules with G10 frames and paper honeycombs, only screwed on their external frame on a G10 spacer (FR4 skins 0.5mm)**
  - Stresses for the spacer



Up to ~8 MPa but this is not a problem for G10 material

- **Comparison of the results from step1 to step 4**

Options for the MM wedges (FR4 skins 0.5mm for all options)	Full size glued with aluminum	Full size screwed with aluminum	Full size screwed with G10	2x3 modules screwed with aluminum	2x3 modules screwed with G10
Displacement out of plane of the quadruplets (µm)	~20	~30	~100	~35	~18
Stresses for the skins (MPa)	~5	**> 15**	~7	~2	~9
Stresses for the the structure (MPa)	~10	~19	~7	~29	~8
Comments	**Assembly procedure to get a planar sector with a full size 6m² is not under control**	The increasing of the shear stresses can break the gluing of the skins. **Can we improve the design?**	The assembly is not so stiff, but we can have under control the displacement out of the plan Can we machine a very flat spacer made of G10 ?	**It should be investigated to take in account the detailed design of the modules**	Can we machine a very flat spacer made of G10 ?

Don’t forget that the tension of the mesh is not taken in account (new simulations in progress)

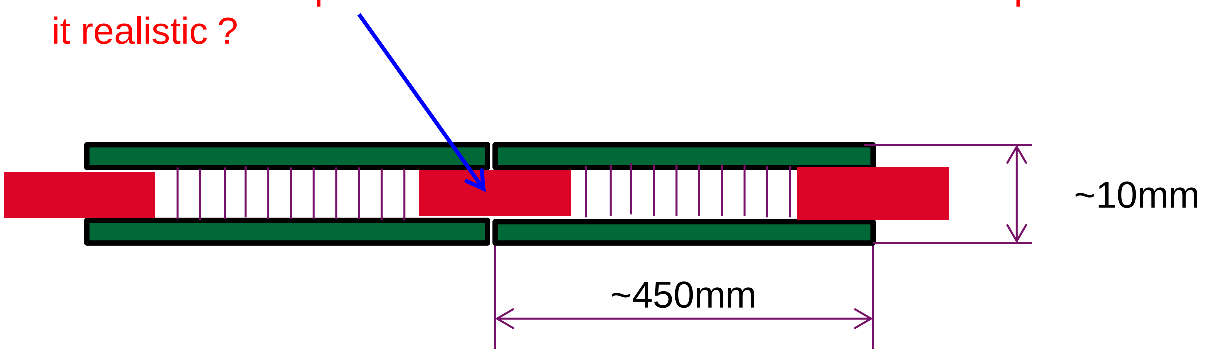
▪ Conclusion

- For the full size wedge, the main issue is the shear stresses induced in the glue film used to fix the skins (up to 15MPa)

- In theory, the problem can be solved by cutting the skins and addition of a expandable profile (few microns). A new simulation should be done to check this: Step 4-Bis

➡ If it is needed, can we design a full wedge with a segmentation w.r.t. the width of the PCBs (450mm)

➡ A radial flexible profile should be added between each couple of PCBs or skins, is it realistic ?



The bending of the quadruplets is the result of the thermal expansion. This deformation will be amplified, if we have not full contact with the spacer: **The flatness and the symmetry of the quadruplet, after construction and after assembly with the spacer are crucial.**

Thank you for your attention !

Commissariat à l’énergie atomique et aux énergies alternatives
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