

DE LA RECHERCHE À L'INDUSTRIE



Mechanical analysis on the ILD-TPC structure



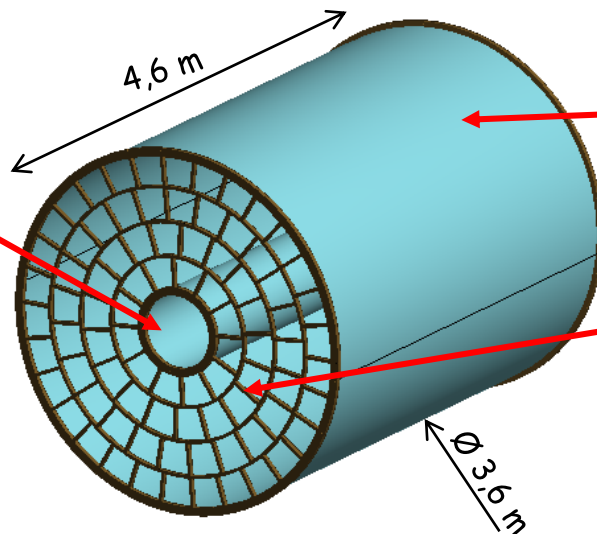
Julie Elman (CEA IRFU)

LCTPC Collaboration Meeting – DESY –
January 10, 2019

- Previous mechanical analysis made by M. Carty in 2009
 - Supports
 - Impact of pressure
- Purpose of this work : to improve the structural design in order to minimize the deformation by keeping the same mass budget by extensive FEA calculation using ANSYS software
- Contents :
 - Model presentation
 - 1st improvement : supports
 - 2nd improvement : layout of endplate
 - 3rd improvement : reinforcement of horizontal spokes
 - Open questions

INNER CAGE

- MATERIAL : Composite
- FEA ELEMENTS : shell
- THICKNESS : 25 mm



OUTER CAGE

- MATERIAL : Composite
- FEA ELEMENTS : shell
- THICKNESS : 60 mm

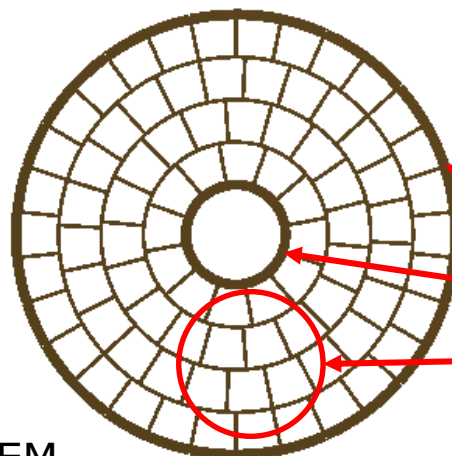
ENDPLATE

- MATERIAL : aluminum alloy
- FEA ELEMENTS : beam

Number of modules mounted on the 2 endplates (2 x 84 PCB) :

- PCB1 : 2 x 12
 - PCB2 : 2 x 18
 - PCB3 : 2 x 24
 - PCB4 : 2 x 30
- Size of the modules
≈ 300 x 330 mm

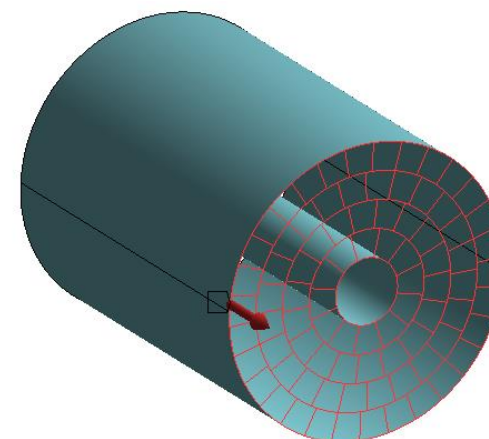
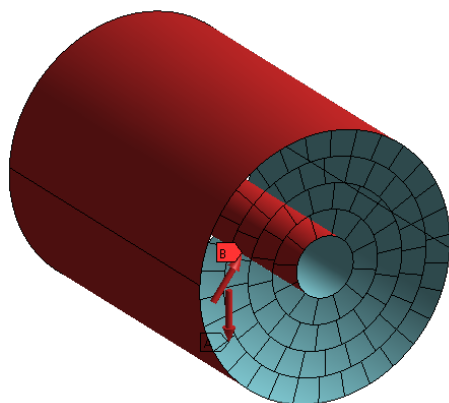
1 module = 1 MicroMegas or 4 GEM



Cross sections of the endplate components :

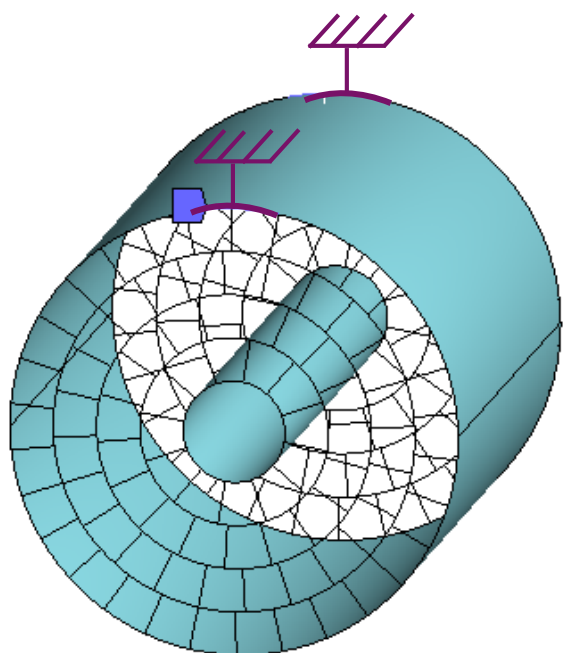
- 85 x 50 mm (outer ring)
- 82 x 50 mm (inner ring)
- 32 x 50 mm (intermediate rings and spokes)

- Gravitational loads
 - Self-weight of structure : 895 kg
 - Weight of the modules : 1176 kg (84 modules / endplate and 7 kg / modules)
- Total weight of 2 000 kg
- Overpressure of 3 mbar
 - Pressure applied on the cages
 - Forces applied on each endplate by taking into account the pressure on modules

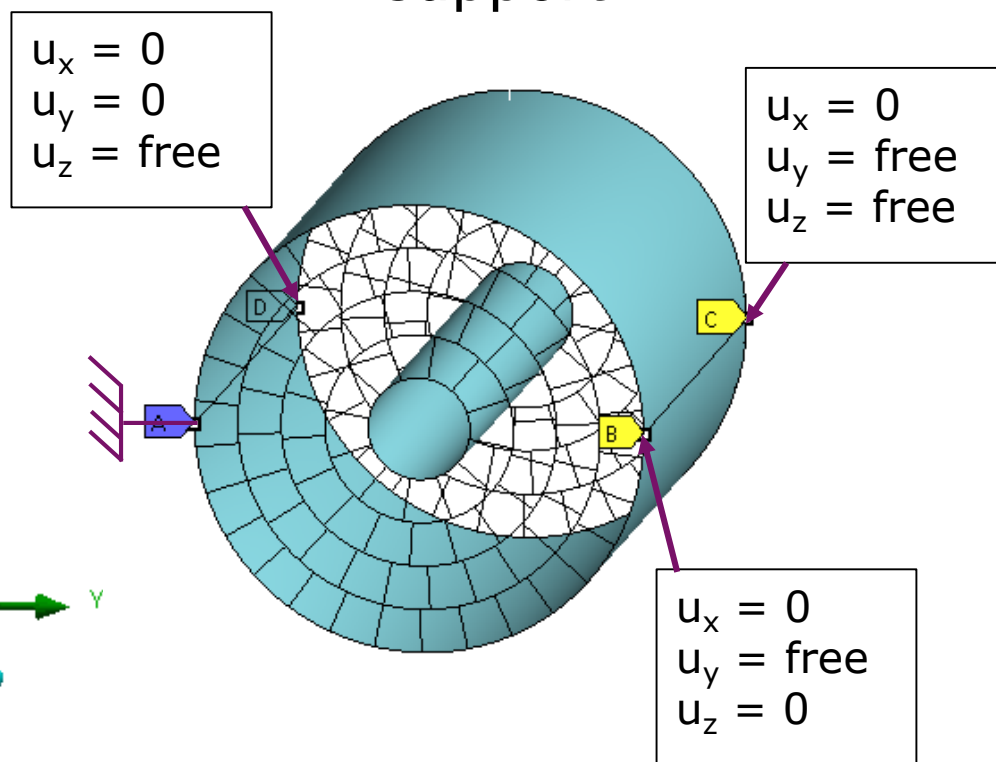


Exactly the same configuration but with 2 different boundaries conditions :

Top support

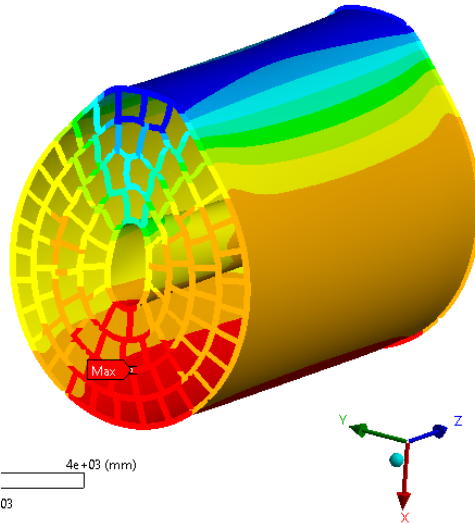
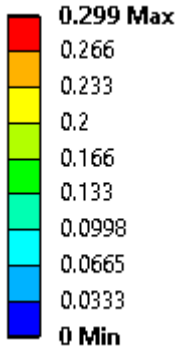


Isostatic median support



Top support

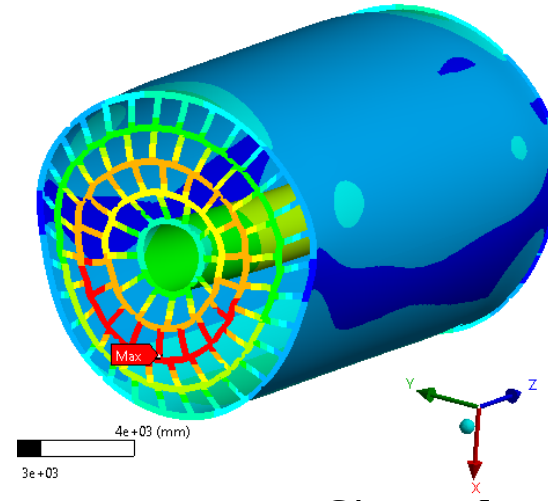
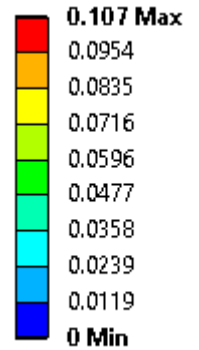
(mm)



Shape factor x1500

Isostatic median support

(mm)

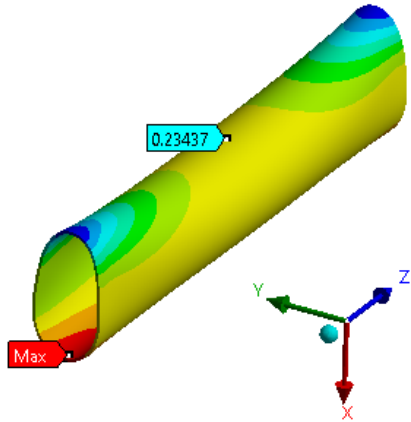
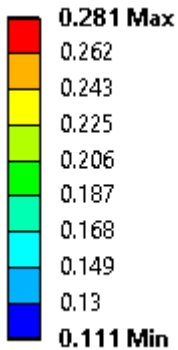


Shape factor x3000

Maximum deformation (μm)		Top support	Median support	Gain factor
Inner cage		234	68	3
Outer cage		298	39	7
Endplate displacements (μm)	X	290	44	7
	Y	110 / -99	23 / -21	5
	Z	91	93 / -98	1

Top support

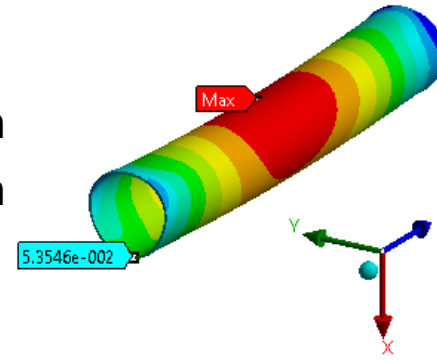
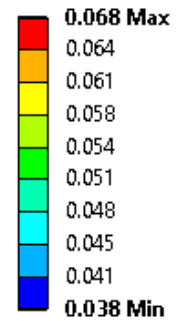
(mm)



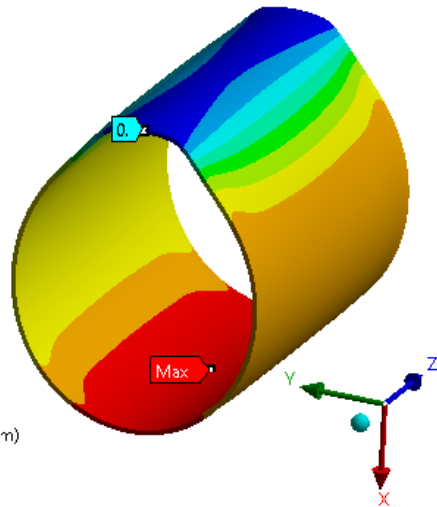
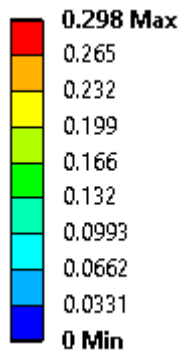
Inner cage
281 / 54 μm
234 / 68 μm

Isostatic median support

(mm)

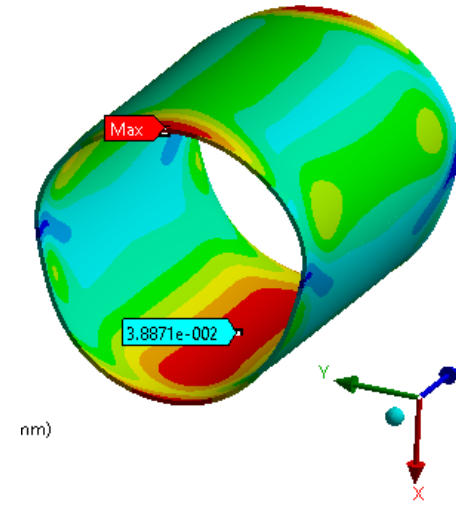
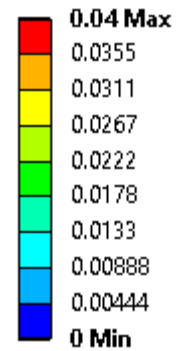


Shape factor x1500



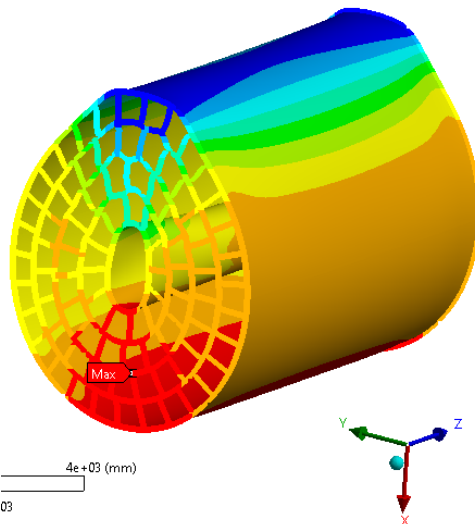
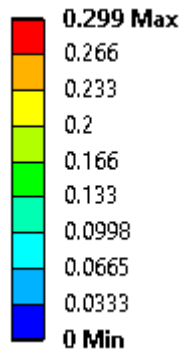
Outer cage
298 / 39 μm
0 / 40 μm

Shape factor x3000



Top support

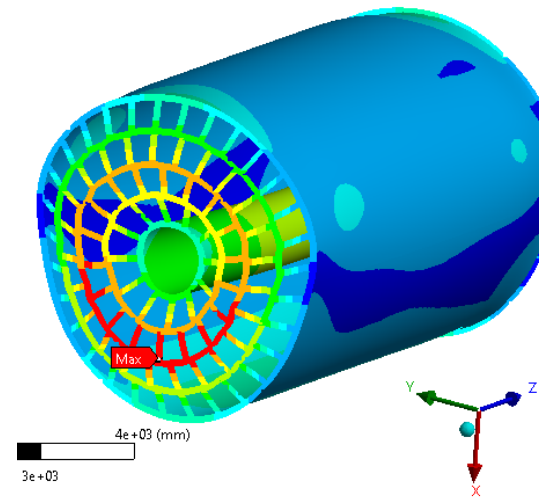
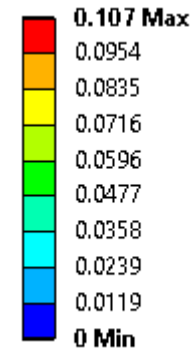
(mm)



Shape factor x1500

Isostatic median support

(mm)



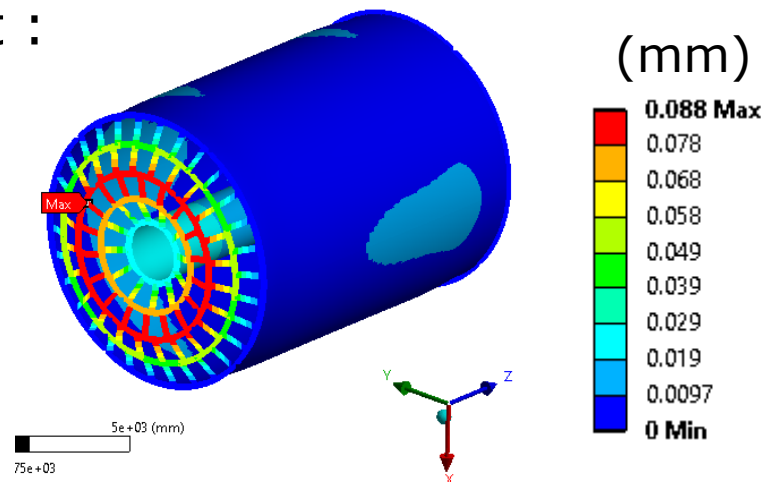
Shape factor x3000

Maximum deformation (μm)		Top support	Median support	Gain factor
Inner cage		234	68	3
Outer cage		298	39	7
Endplate displacements (μm)	X	290	44	7
	Y	110 / -99	23 / -21	5
	Z	91	93 / -98	1

→ The displacements have much lower values and are more homogeneous with the median support

- The pressure effect is only significant on the transversal displacement of the endplates
- Total displacement with only the overpressure at 3 mbar with a median support :

Shape factor x3000

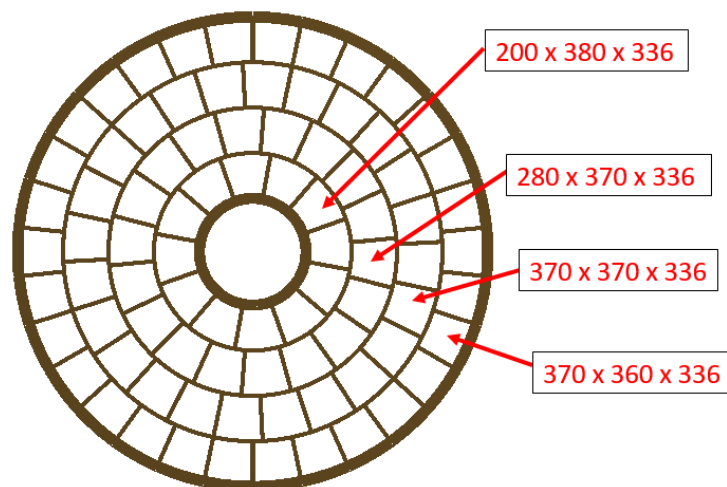


- Displacement of each component:

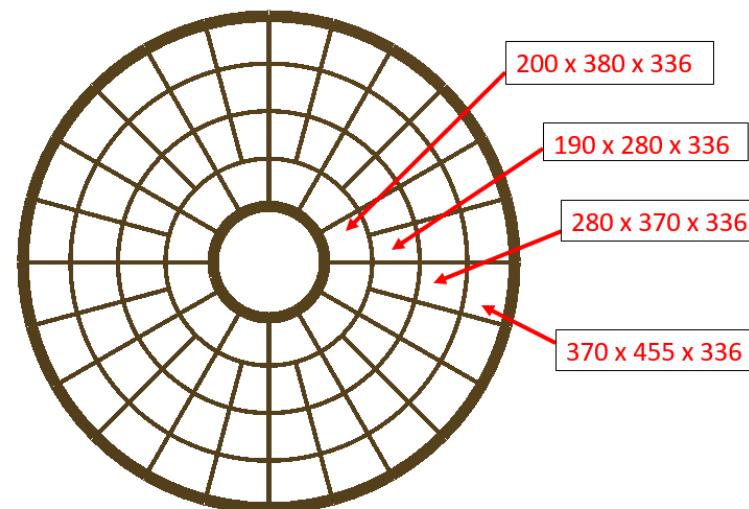
→ The calculations presented hereafter are all under the gravitational and pressure loads

Maximum deformation (μm)		P = 3 mbar
Inner cage		2
Outer cage		1
Endplate displacements (μm)	X	1
	Y	2
	Z	82 / - 88

Initial layout



Aligned layout

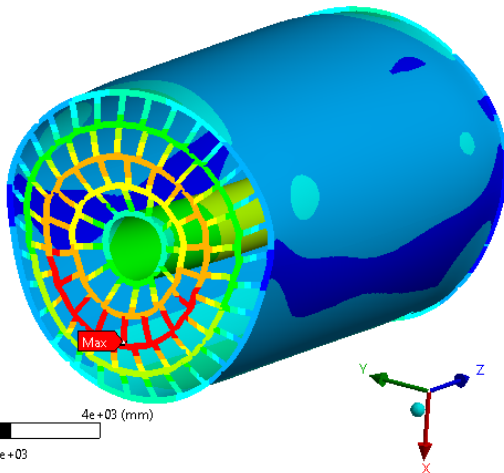
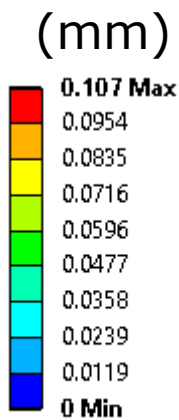


The indicated dimensions are : inner arc length x outer arc length x spoke length in mm

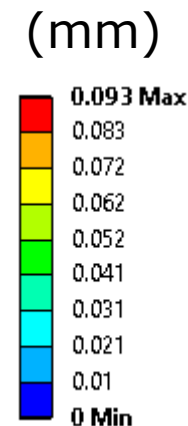
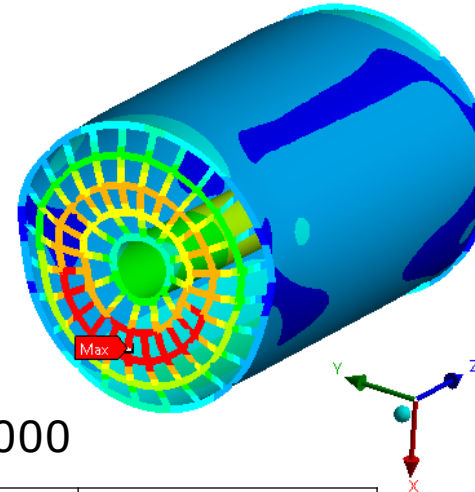
- Same number of modules : 84
- Same endplate weight
- Same weight per module : 7 kg
- Same cross sections of the beams
- Same boundaries conditions : median

Initial layout

Aligned layout



Shape factor x3000

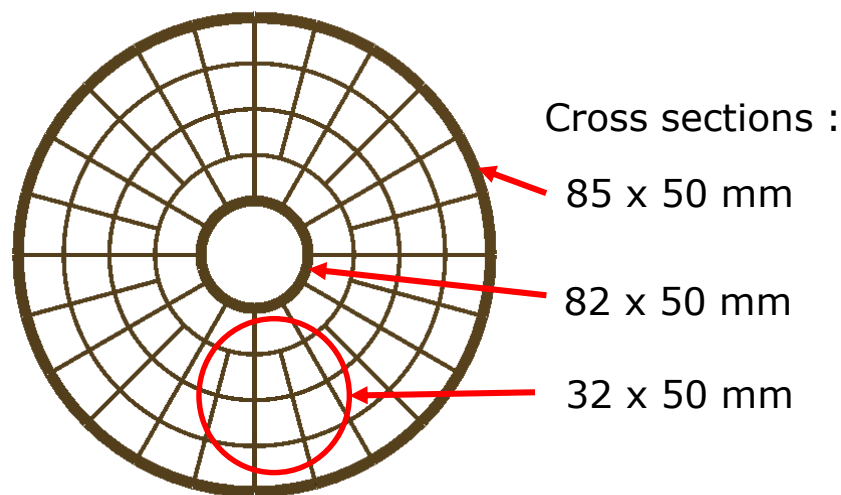


Maximum deformation (μm)		Initial layout	Aligned layout
Inner cage		68	58
Outer cage		39	33
Endplate displacements (μm)	X	44	35
	Y	23 / -21	17 / -16
	Z	93 / -98	80 / -87

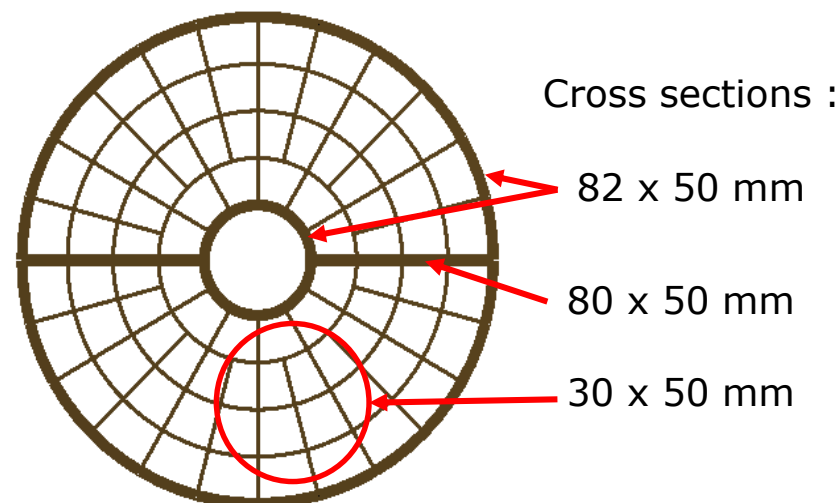
- Decrease of 10 μm of the maximum deformation on all components
- Much easier to produce, to assemble and to control on the geometry

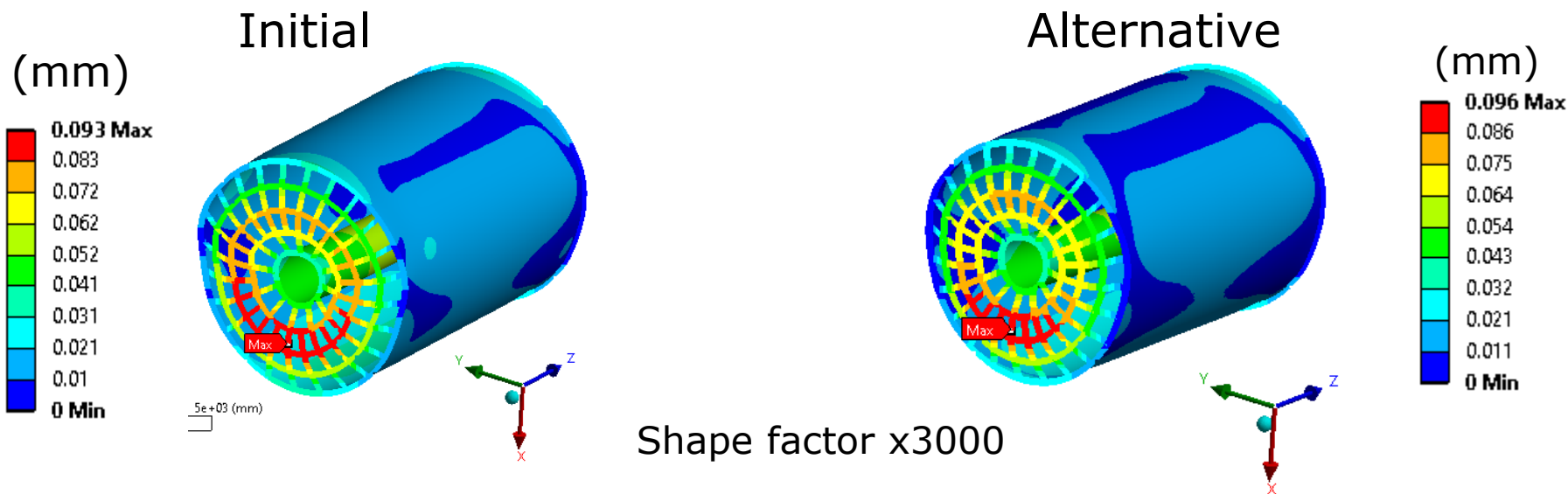
- An alternative has been studied to reinforce the horizontal spokes
- The other cross sections have been changed to keep the same weight

Initial



Alternative



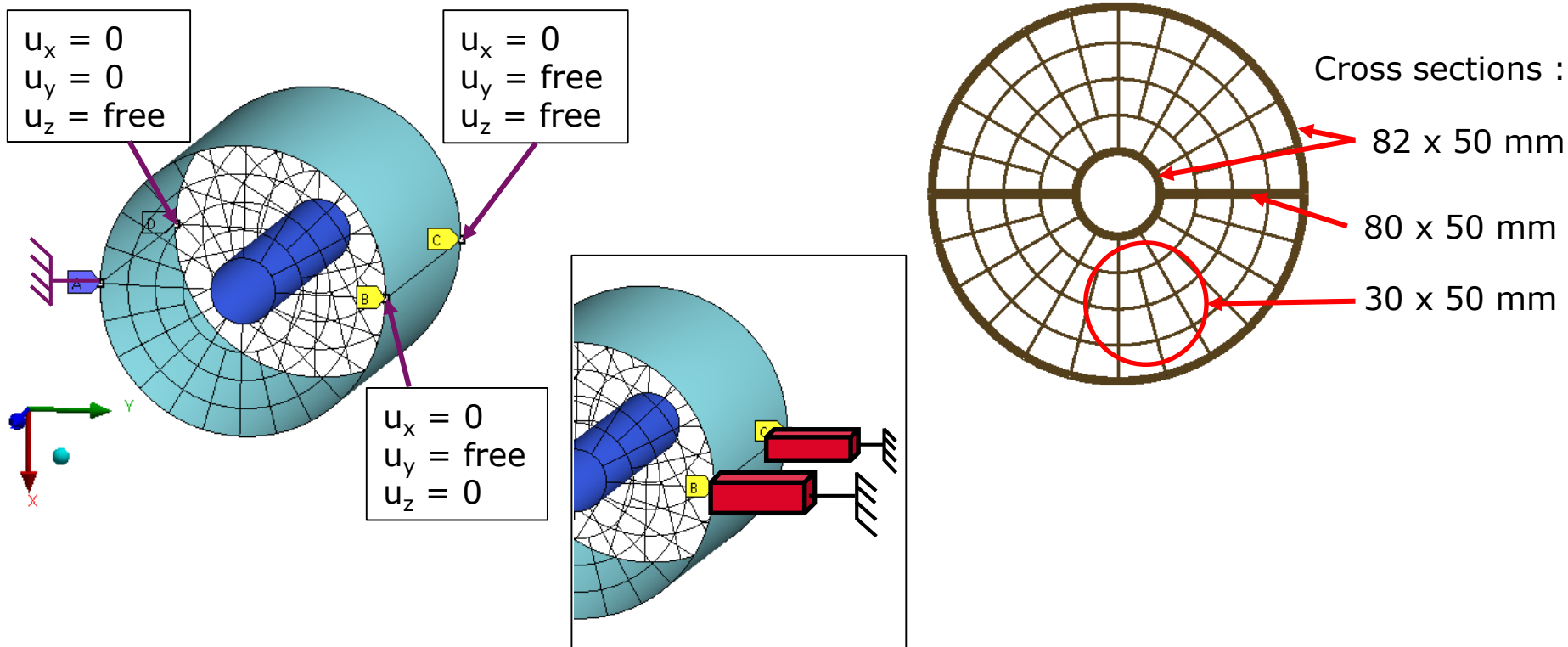


- No significant impact on the cages

Maximum displacements (μm)		Initial	Alternative
Endplate	X	35	32
	Y	17 / -16	12 / -11
	Z	80 / -87	81 / -91

- There are several micrometers less in all direction except in the transversal direction of the endplate
- The reduction of the deformation in the endplate plane is more important for the physics performance

- The best structure found so far has this characteristics :
 - Support in the median plane
 - Aligned spokes for an easier production and for lower deformation
 - Horizontal spokes reinforced for a gain of deformation, especially in the endplate planes

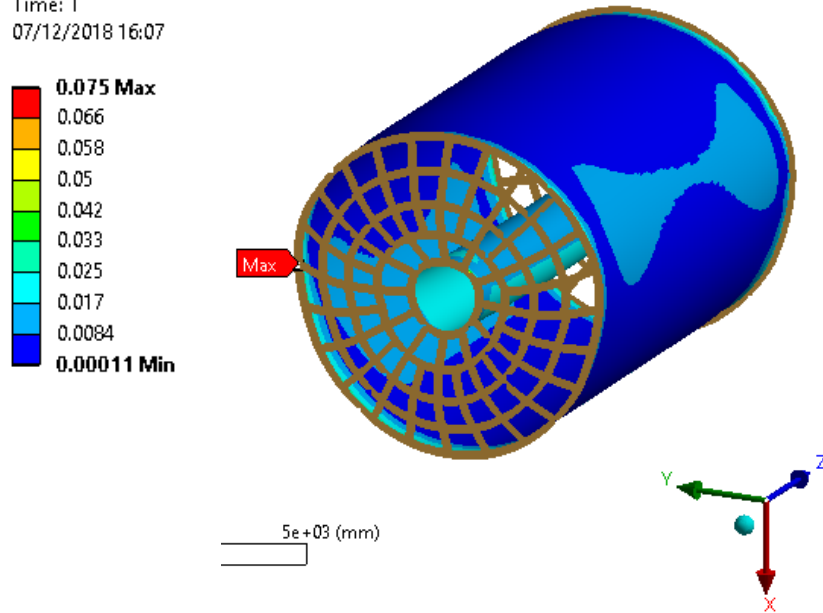


- Very small von Mises stress of the cages : < 1 MPa

- Axial forces in the beam elements : < 2500 N
- Higher stress near the supports

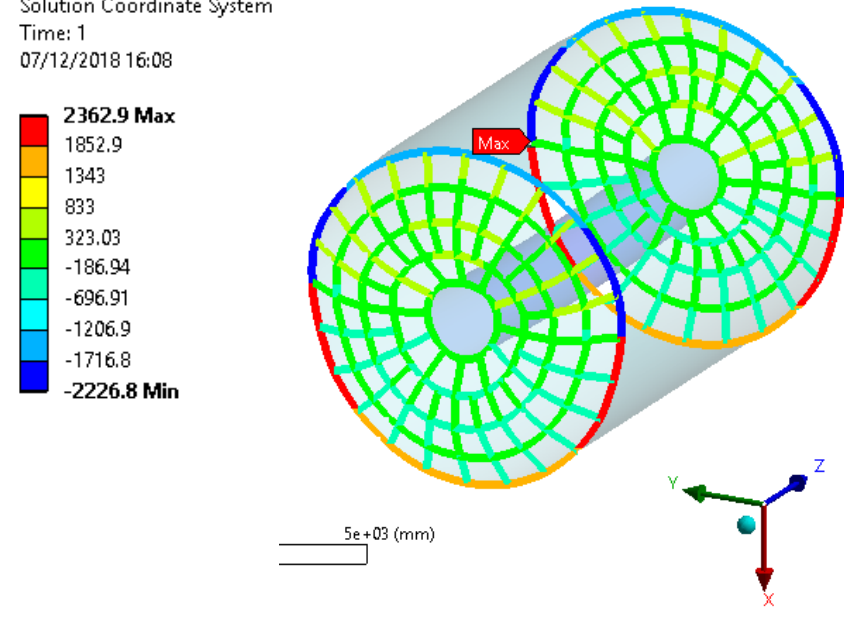
D: Static Structural

Equivalent Stress
Type: Equivalent (von-Mises) Stress - Top/Bottom
Unit: MPa
Time: 1
07/12/2018 16:07



D: Static Structural

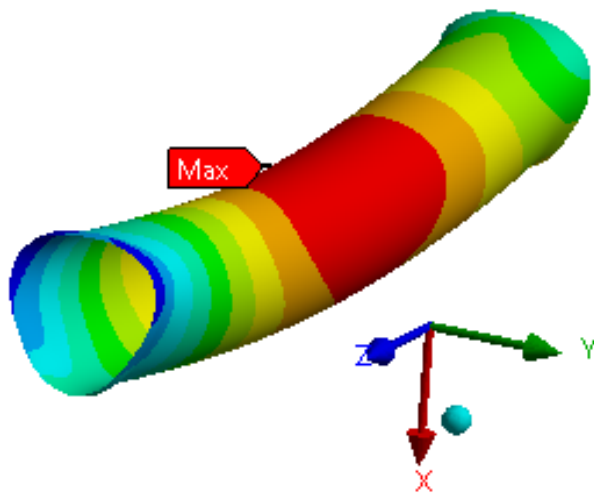
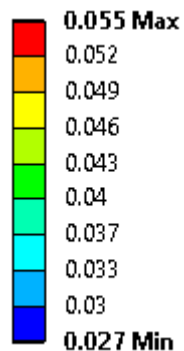
Axial Force
Type: Directional Axial Force(X Axis) (Unaveraged)
Unit: N
Solution Coordinate System
Time: 1
07/12/2018 16:08



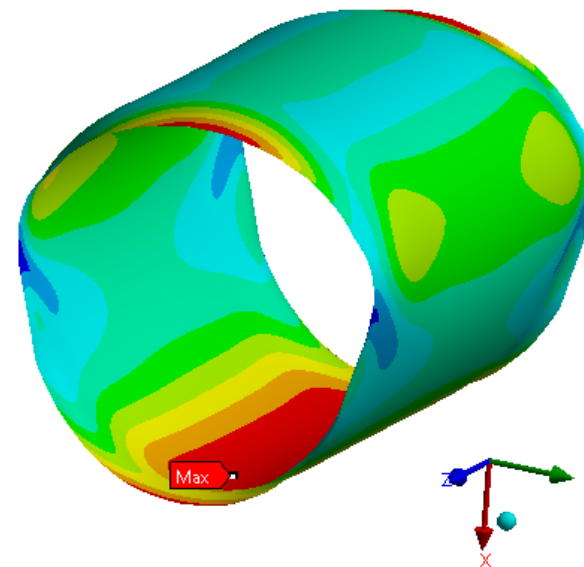
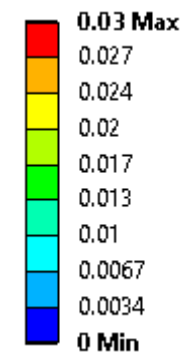
- Inner cage
< 60 μm

- Outer cage
< 30 μm

(mm)



(mm)



Shape factor x8000

- Open questions :
 - On the X-Y precision and stability, somewhat less than $50 \mu\text{m}$?
Displacement absolute or relative ? In each direction or in total ?
 - What are the other requirements for ensuring the physics performance ?

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