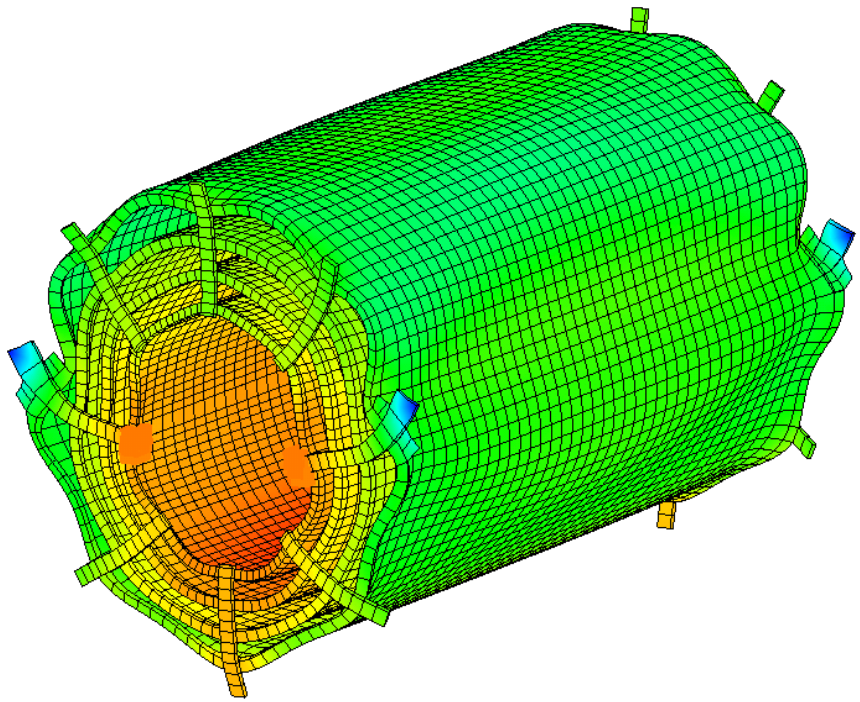
Finite Element Analysis of SCT Assembly



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Introduction

Main Objectives:

- Verify the design of the SCT Assembly
- Give information on required stiffness of Interlinks

Secondary Objectives:

- Understand the mechanical behavior of the SCT assembly
- Optimize and Compare the Assembly Stiffness with other designs
- Understand the boundary conditions effects between TRT / SCT / Pixel
- Better understanding of the materials

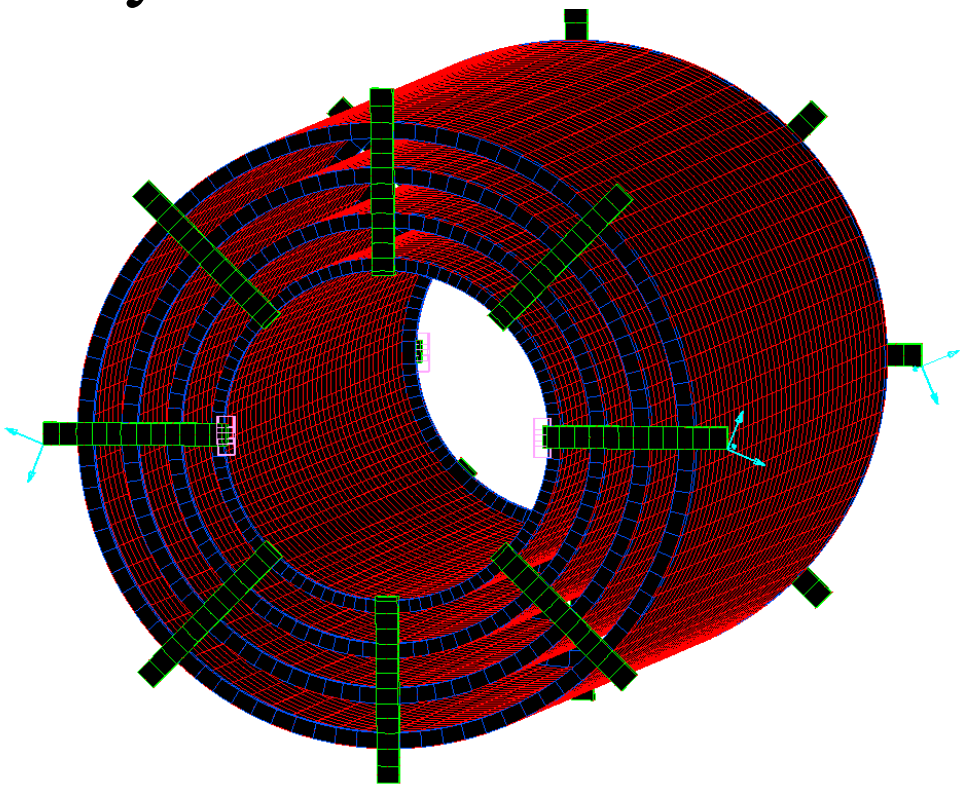
General Approach

General Approach:

- FE modeling of SCT Assembly
- Study of the Initial Design of Assembly
- Compare / Optimize various stiffening options
- Other Mechanical Studies (with Pixel)
- Design Validation / Recommendations

Finite Element Modelization

Cylinder Modelization:



- Laminate Material, equivalent stiffness compared to XN50RS3 Sandwich.
- Mindlin Shell elements with 8 nodes.
- Element size ~ 30 mm
- Mass: Self weight + Additional Surfacic mass for modules and services

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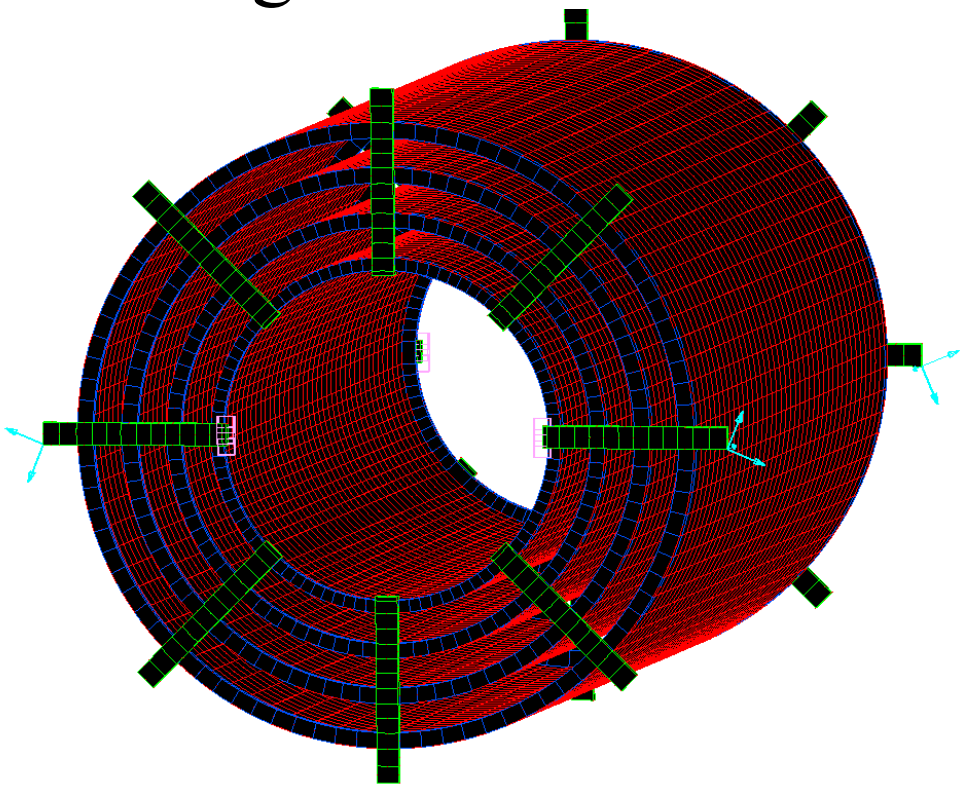
Finite Element Modelization

Flanges Modelization:



- Orthotropic Material , 1st orientation = circumferential
- Mindlin Shell elements with 8 nodes.
- Element size ~ 30 mm
- Mass: Self weight
- Perfectly bounded to Cylinders

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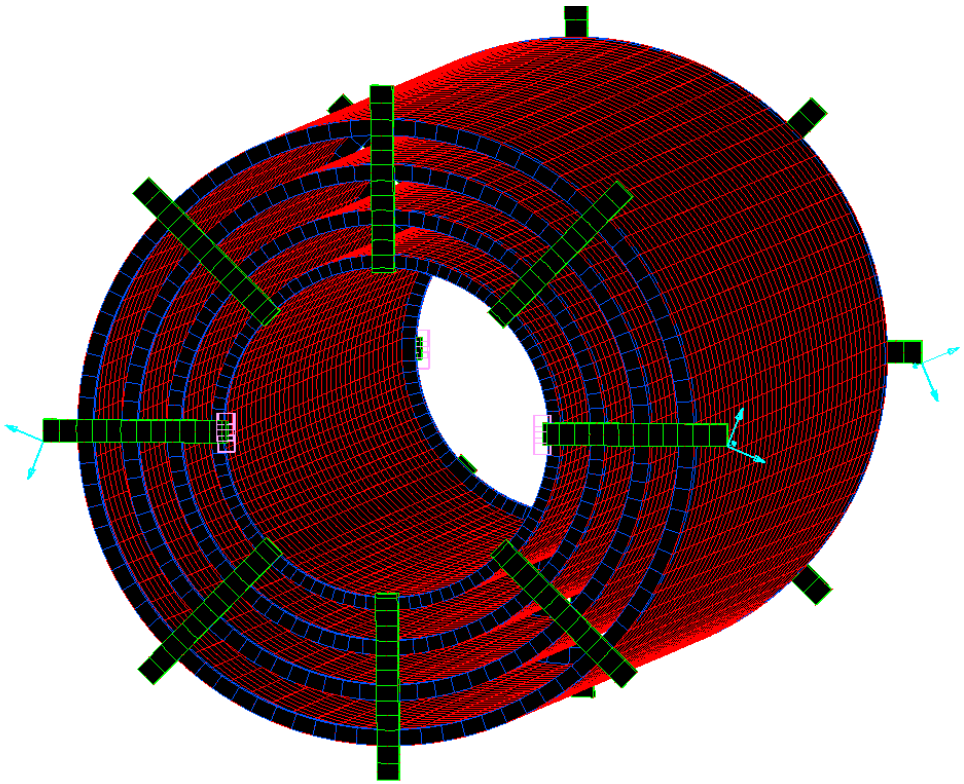
Finite Element Modelization

Interlinks Modelization:



- Isotropic material equ to aluminum (since it has not been defined yet)
- Quadratic Brick elements with 20 nodes.
- Element size ~ 30 mm
- Mass: Self weight + 1/4 of total Pixel mass at the end
- Perfectly bounded to flanges

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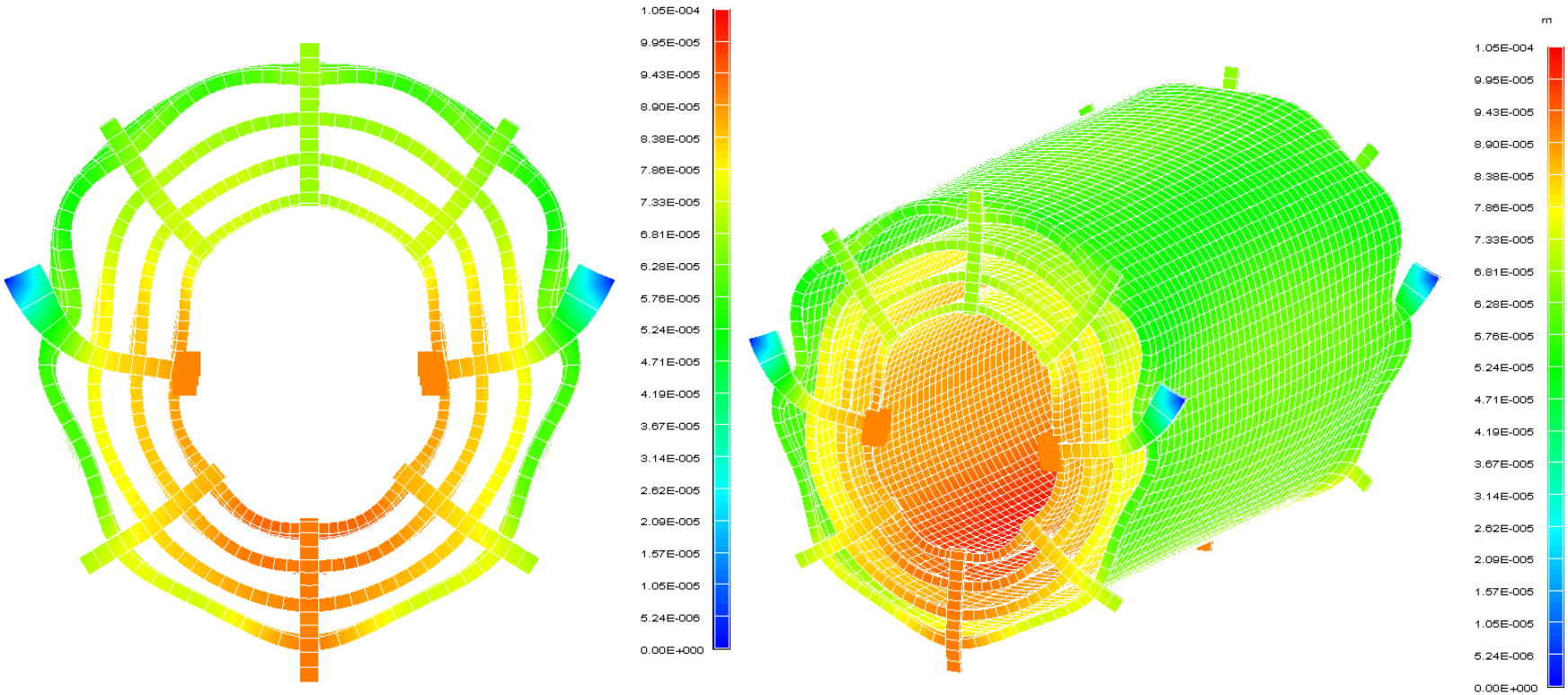
FEA of Initial Design

- **Loads**:
  - Gravity
- **Masses**:
  - Self Weight of Assembly (with additional mass for modules and services = 134 kg)
  - Total Pixel mass (75kg) distributed on the 4 Pixel-SCT support points
- **Supports**:
  - 4 simple supports (blocked displacements)

FEA of Initial Design

Results, Maximum Deflection :

- without pixel = 70 microns / with pixel = 105 microns



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FEA of Initial Design

1st Conclusions:

- Deformation mode is smooth & uniform
- Principal effect on deflection due to tilting of interlinks/flange in B6 region
- Relatively good stiffness and moderate deflection, but the design can be improved

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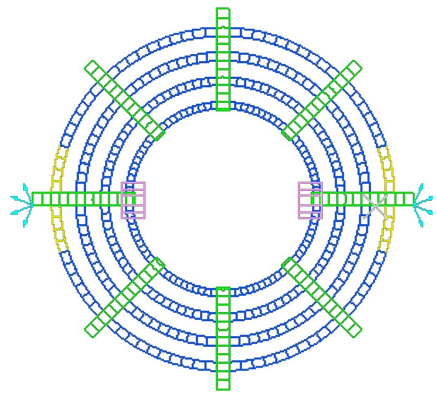
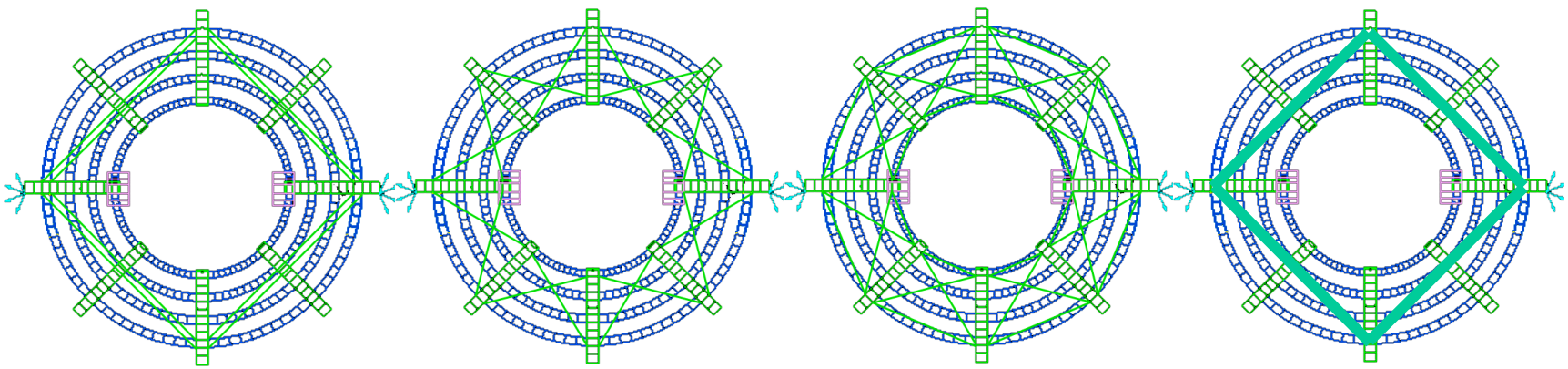
Assembly Stiffness Optimization

- Compare initial design with stiffened ones
- Different methods of stiffening
  - Infinitely Rigid Bar
  - External Beams
  - B6 Flange / Interlink reinforcements





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Assembly Stiffness Optimization

- Infinitely Rigid Beams:
  + Important gain in stiffness
  - Local Deformations
  - Not Feasible (geometry)
- External Beams
  + Interesting Gains in Stiffness / small local deformation
  - Geometric Constraints
- Flange reinforcements
  + Important Effects on Stiffness / small local deformation
  + Little Modification
  + Reinforcement Design uncoupled from Assembly Design

Stiffening technique	Max Displacement
Original Design	1.05E-01 mm
Flange Reinforcement	9.12E-02 mm
Flange + Interlinks Reinforc.	6.75E-02 mm
Rigid Stays on 4 points	4.49E-02 mm
Crossed Rigid Stays	4.92E-02 mm
Closed Loop Rigid Stay	3.00E-02 mm
Reinforcement Elastic Beams	6.50E-02 mm
B6-interlinks reinforcement part	6.99E-02 mm

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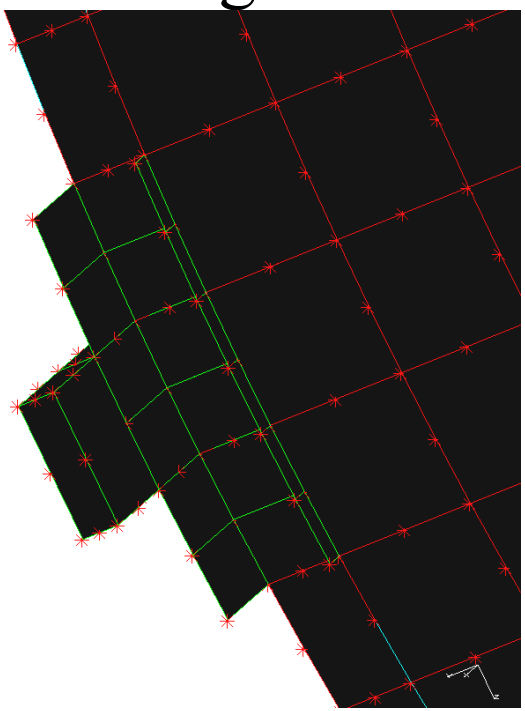
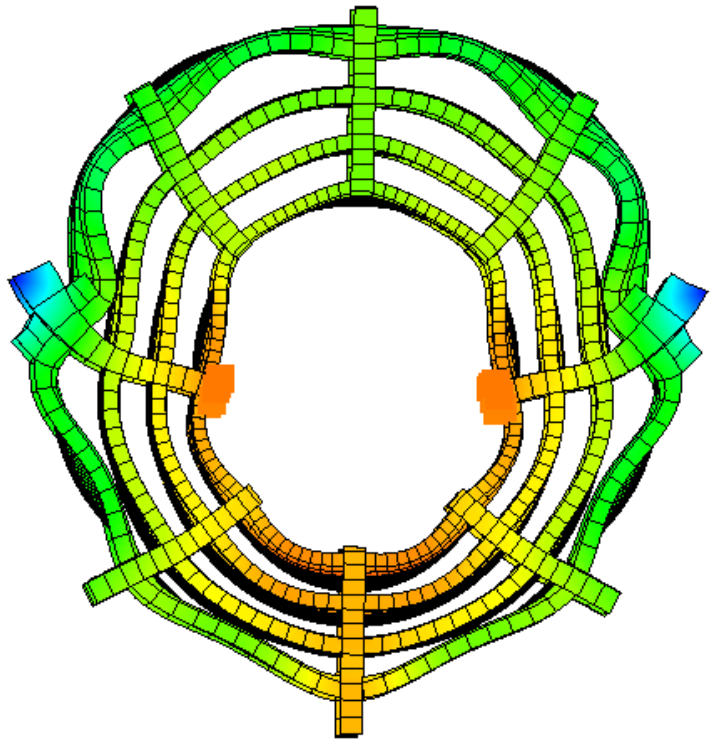
Assembly Stiffness Optimization

- Final Design:
  - B6 flange-interlink reinforcement part





- **Maximum deflection= 69 microns**
- **Max deformation in Sandwich =1/100 of ultimate deformation in bending**

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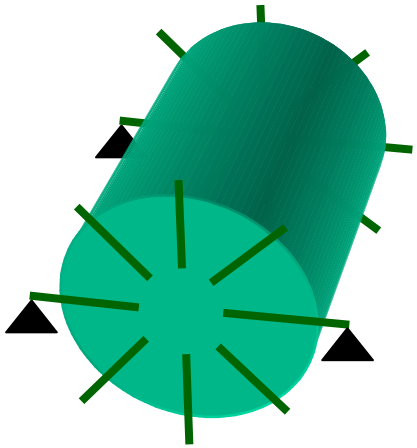
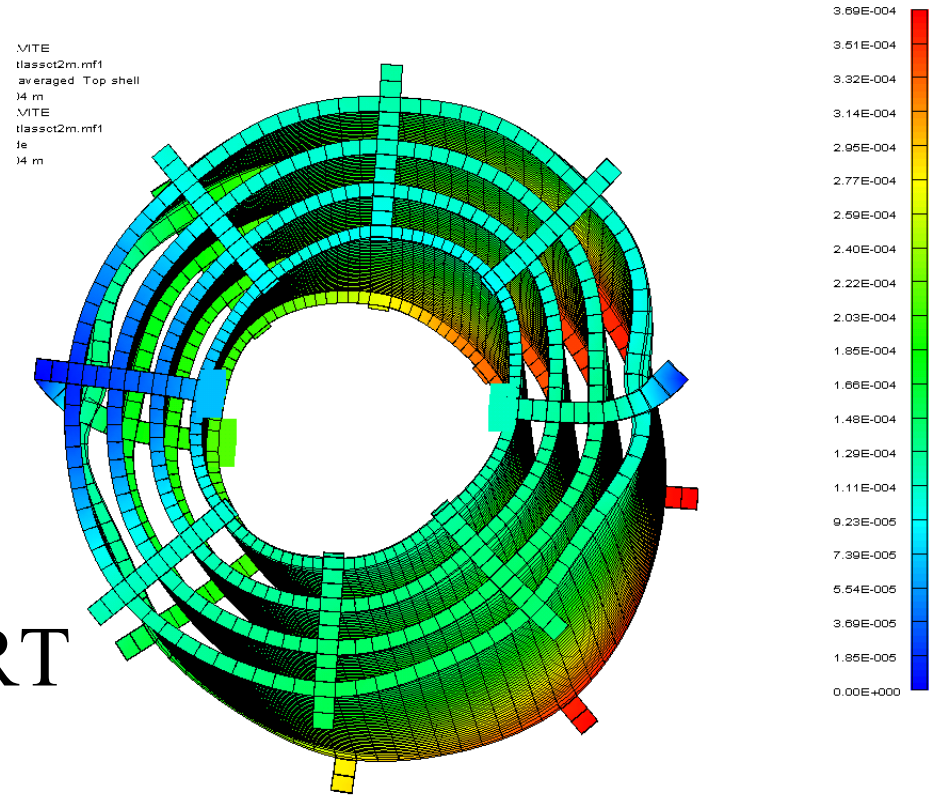
Other Studies: Torsional Behavior





- Simulate a loss of contact of SCT/TRT
- 3 Points support
  (equivalent to 2 points in diagonal)
- Maximum displacement = 369 microns

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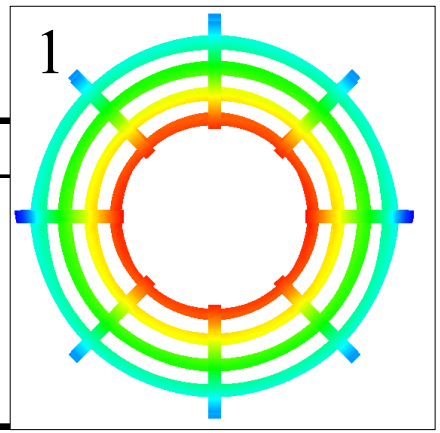
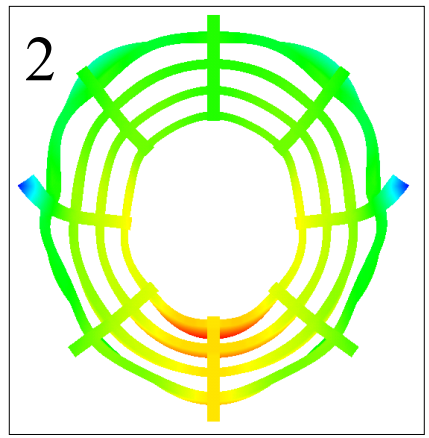
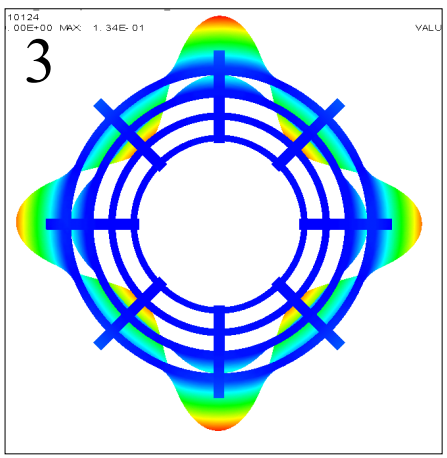
Other Studies:Eigenfrequencies

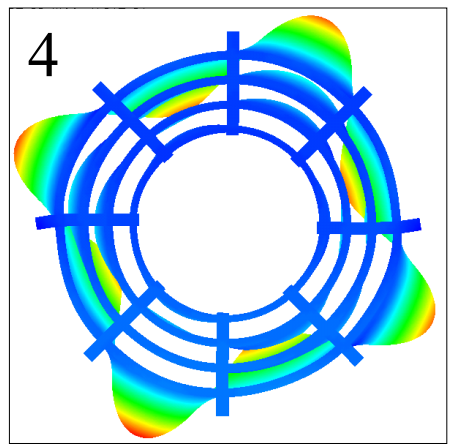
- Eigen Frequencies of SCT (with modules and services) + Pixel (pixel=75 kg)

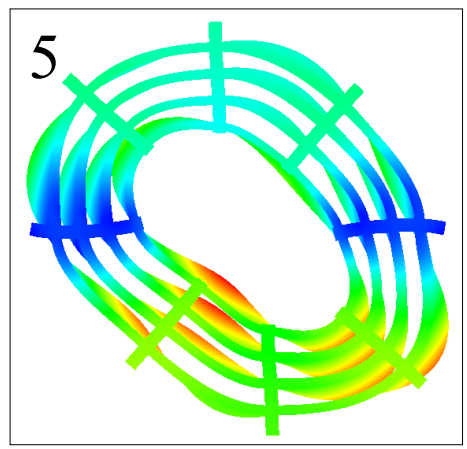
Mode	Eigen Frequencies
1	21.5 Hz
2	54.4 Hz
3	59.1 Hz
4	60.1 Hz
5	61.9 Hz











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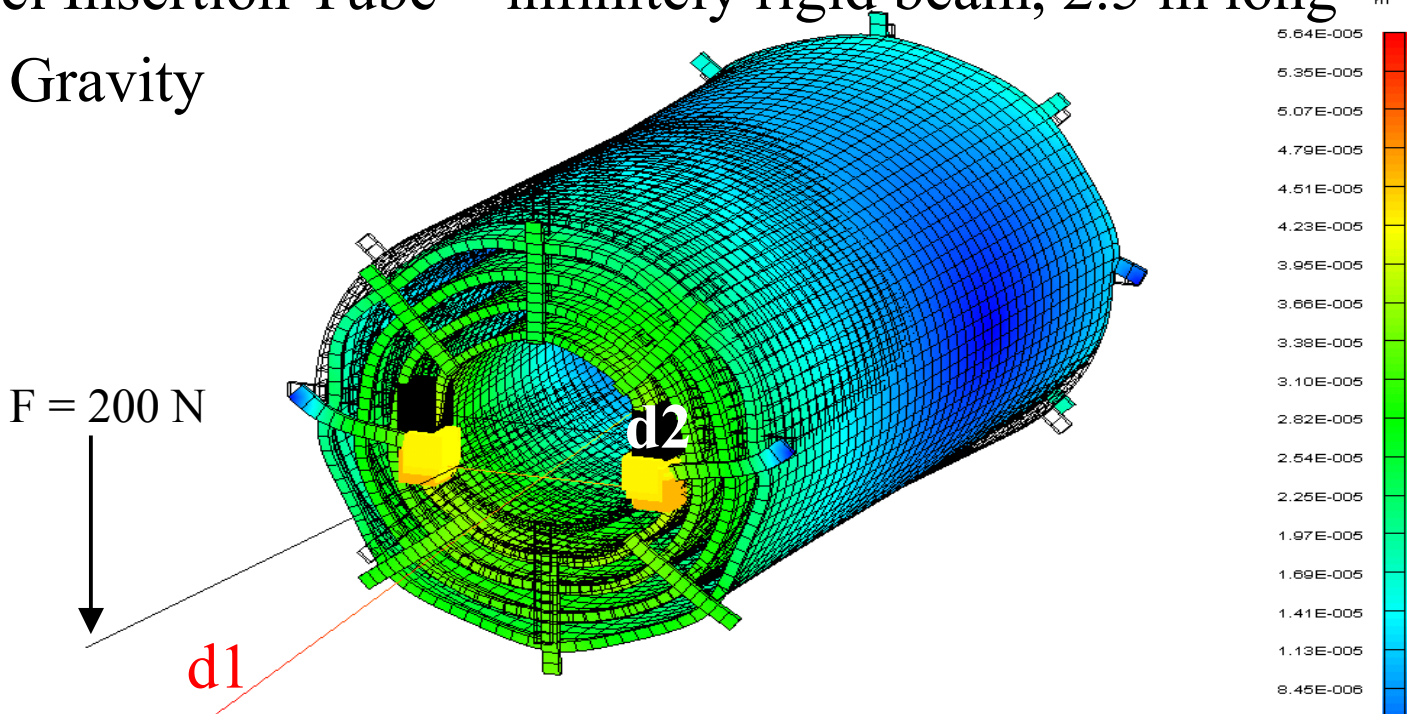
Other Studies: Pixel Tube Effects

- Evaluate the effects of Pixel Insertion **(no end support !!)**
- Pixel Insertion Tube = infinitely rigid beam, 2.5 m long
- No Gravity



- Max displacements:

Pixel = 141 microns (d1) / SCT = 48 microns (d2)

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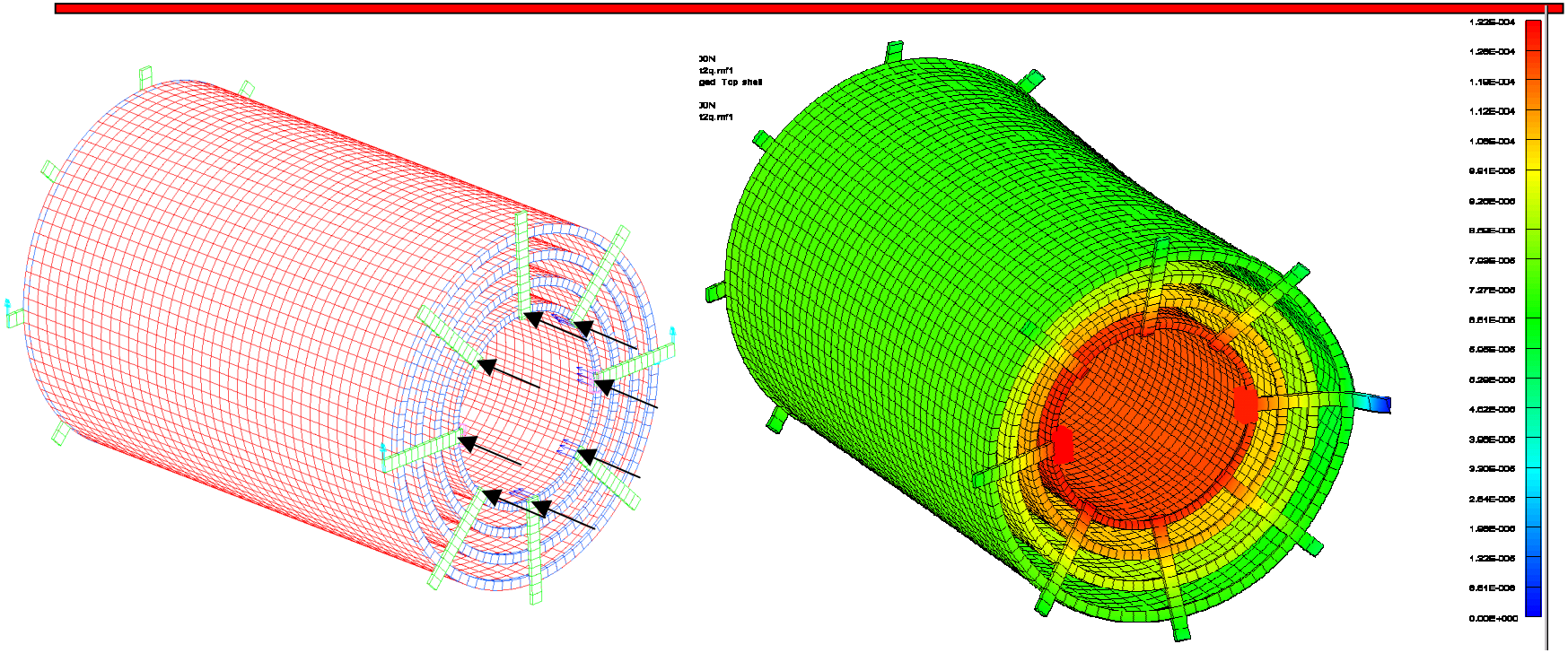
Other Studies: Z Stiffness



- Total Load = 200 N, distributed on 8 pts
- Max Displacement = 132 microns
- equivalent Z stiffness = 1.52E6 N/m

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Other Studies: Pixel-SCT interfaces

- In Progress:
  - Effects of thermal deformations btw Pixel / SCT
  - Stiffness coupling at the SCT / Pixel interface
  - Effects of the misalignment of Pixel Tube external supports on SCT

Conclusions

Final design :

- Optimal in the sense of maximum deflection / local deflections
- Sufficient Stiffness / Resistance
- Great potential improvements through the design of B6 Reinforcement Part => Guaranty to reach the specifications.
- ...

Conclusions

What we have learned:

- important effects of the B6 reinforcements on global stiffness
- more coupling => local deformation

What we recommend:

- Stress Analysis of the interface of Reinforcement Part / B6 flanges & cylinder

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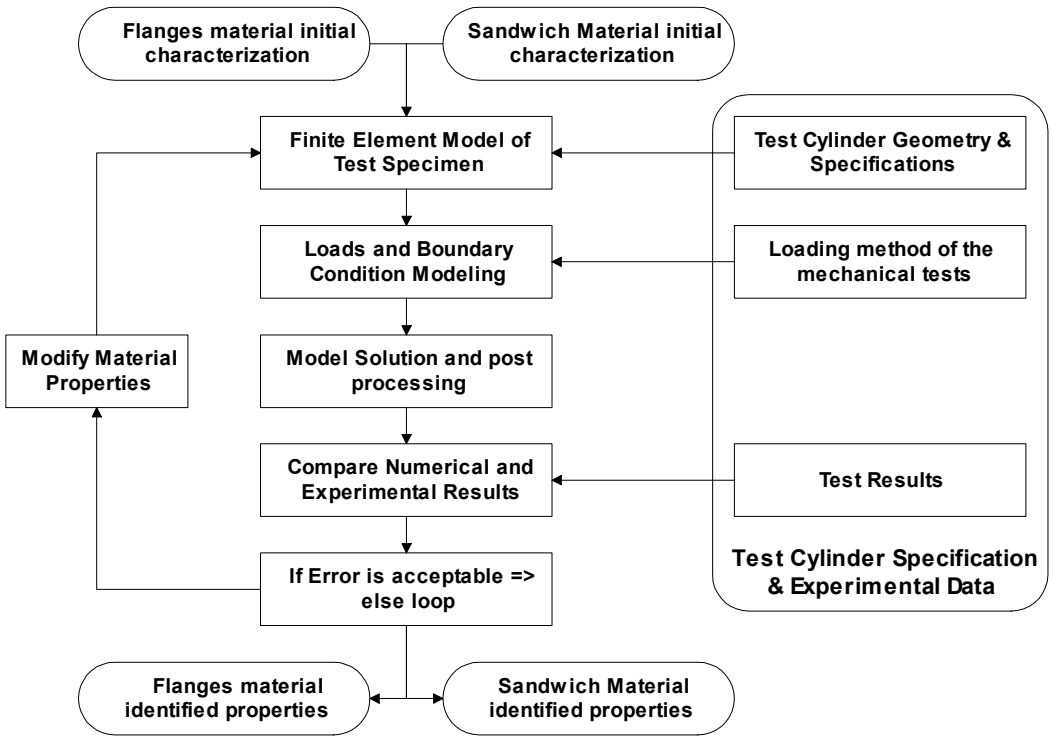
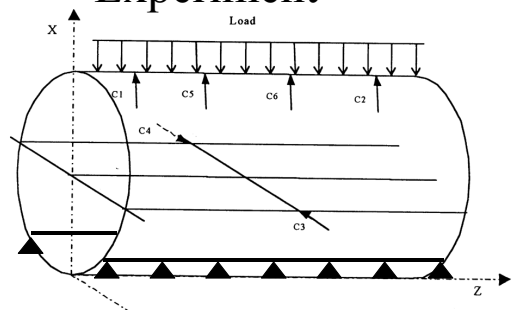
Material Characterization

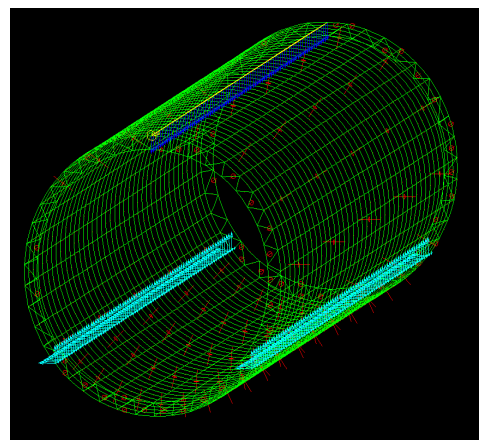
Mixed Numerical / Experimental Identification of Materials



Experiment



FE Simulation



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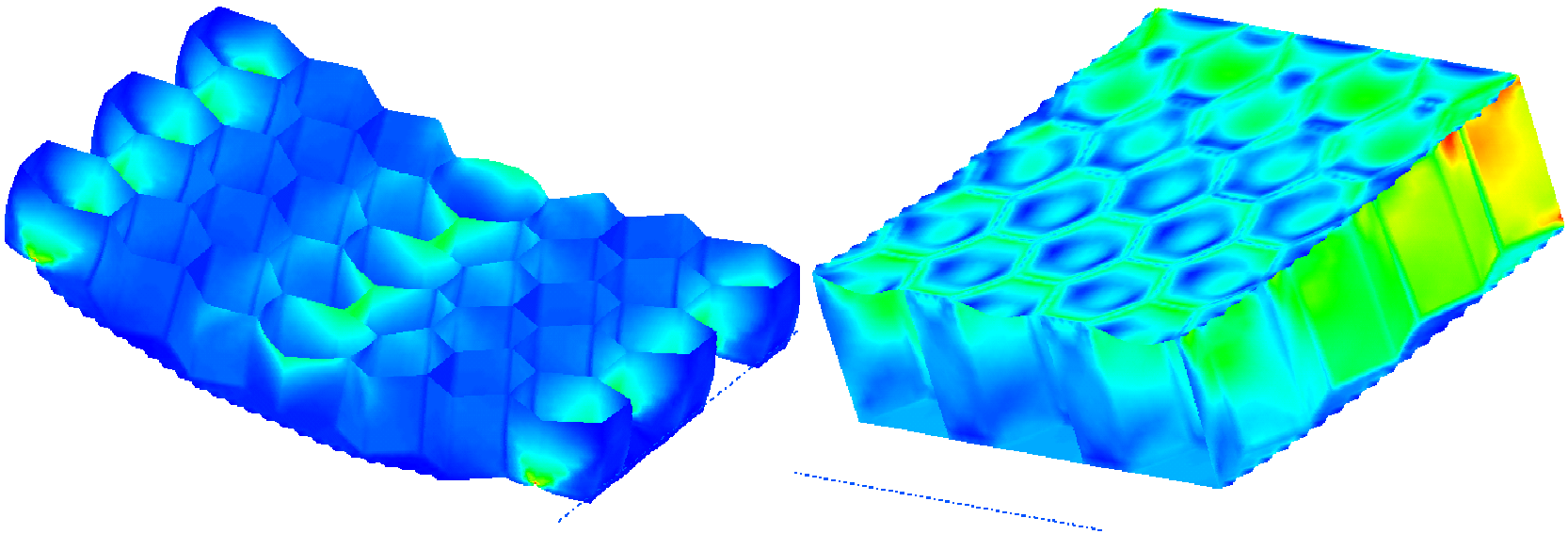
Material Characterization

- Sandwich properties verification using a refined FE model



- Good agreement btw num/exp identification and refined FE model of sandwich

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