

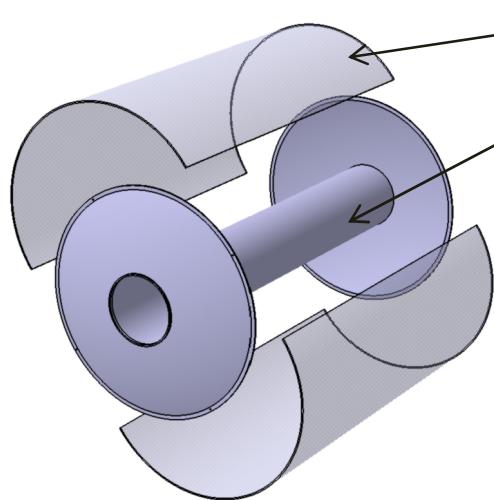
# Status of DCH Mechanical Structure

13 Dec 2011

# Summary

- Proposal for a mechanical structure of DCH
- Stringing strategy and analysis of deformations
- Buckling analysis on DCH

# Proposal of a mechanical structure: General layout



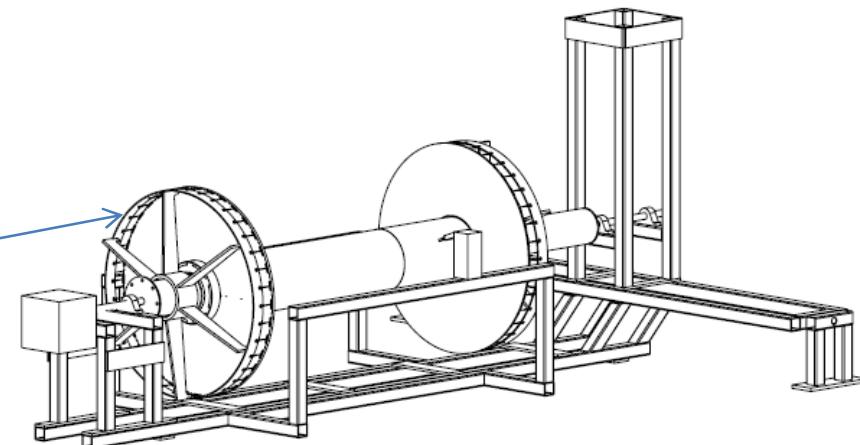
External load bearing structure

Thin inner cylinder

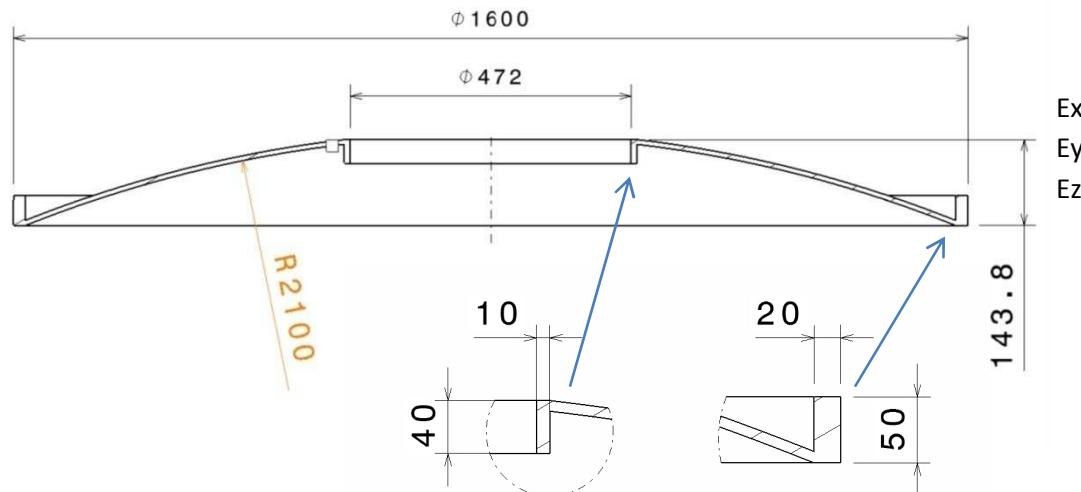
Homogeneous distribution of material in axial and angular direction

Two halves shell is a preferred solution with respect to a single cylindrical one. It is less expensive, uses less radial space and it is easier to build.

Endplates fixed only on outer rim  
Inner rim is free to move in axial direction



# Endplate: materials and geometry



$E_x = 130 \text{ GPa}$   
 $E_y = 4.6 \text{ GPa}$   
 $E_z = 4.6 \text{ GPa}$

$\nu_{xy} = 0.3$   
 $\nu_{xz} = 0.3$   
 $\nu_{zy} = 0.25$

$G_{xy} = 4.5 \text{ GPa}$   
 $G_{xz} = 4.5 \text{ GPa}$   
 $G_{zy} = 4.5 \text{ GPa}$

CF properties\*

8 x	Ply#	Lamina Type	Thickness(mm)	Angle (deg)
	1	Graphite/Epoxy	0.250	0
	2	Graphite/Epoxy	0.250	90
	3	Graphite/Epoxy	0.250	90
	4	Graphite/Epoxy	0.250	0

Endplates

10 x	Ply#	Lamina Type	Thickness(mm)	Angle (deg)
	1	Graphite/Epoxy	0.250	90
	2	Graphite/Epoxy	0.250	90
	3	Graphite/Epoxy	0.250	90
	4	Graphite/Epoxy	0.250	90

Inner stiffening ring

20 x	Ply#	Lamina Type	Thickness(mm)	Angle (deg)
	1	Graphite/Epoxy	0.250	90
	2	Graphite/Epoxy	0.250	90
	3	Graphite/Epoxy	0.250	90
	4	Graphite/Epoxy	0.250	90

Outer stiffening ring

To consider the holes effect, material properties are downgraded by a factor of 0.7

\*Taken from datasheets, may vary 10-20 %

# Wires: Materials and load

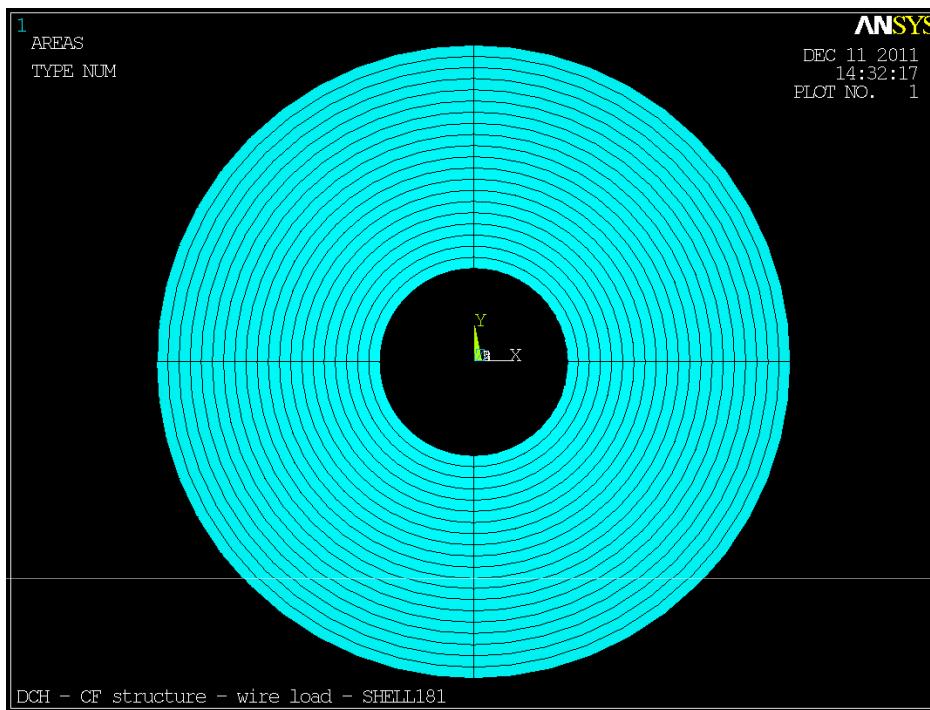
Wire type	Mat	r (mm)	N° Wires	Sag. (mm)
Field	Aluminium	0.04	24660	0.2
Sense	Molybdenum (AU coated)	0.0125	836	0.2
Guard	Aluminium	0.04	8056	0.2

Considering a maximum wire's length of 2700mm and endplate curvature the nominal load is 15677 N

Minor changes in wire layout, inner and outer diameter have not an important effect on results

Endplate curvature and thickness have a great influence on deformations

# FEM model for stringing process



Endplate is divided in 20 circular areas.

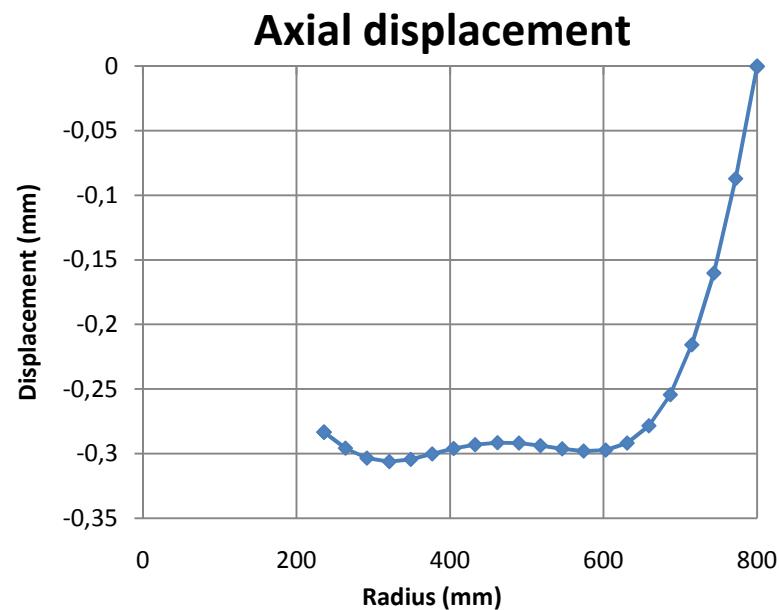
Total load is applied in 20 steps

For every step displacements are calculated

Every load is decreased according to material, length and deformation of every wire

	Initial Load (N)
Force 01	767
Force 02	699
Force 03	967
Force 04	820
Force 05	470
Force 06	467
Force 07	682
Force 08	659
Force 09	578
Force 10	790
Force 11	754
Force 12	878
Force 13	687
Force 14	866
Force 15	964
Force 16	755
Force 17	952
Force 18	1034
Force 19	826
Force 20	1052

# Final displacement



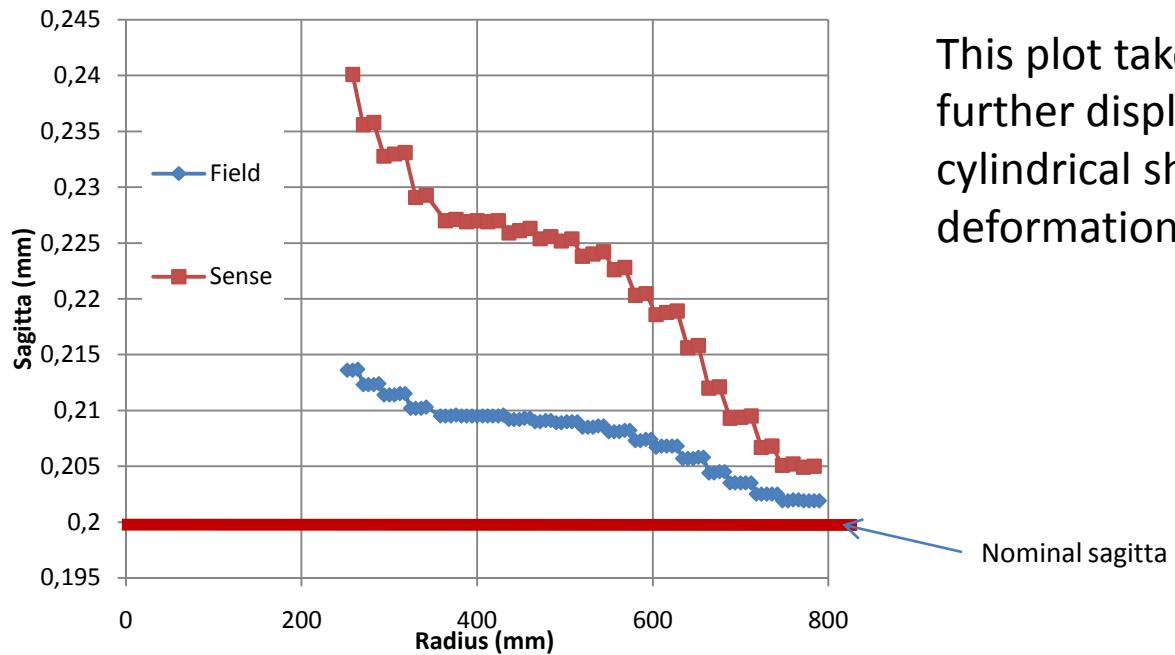
Max displacement: 0.31mm

Total nominal load: 15677 N

Total real load: 14711 N

	Initial Load (N)	Final Load (N)
Force 01	767	670
Force 02	699	619
Force 03	967	864
Force 04	820	743
Force 05	470	429
Force 06	467	427
Force 07	682	623
Force 08	659	604
Force 09	578	531
Force 10	790	727
Force 11	754	697
Force 12	878	817
Force 13	687	644
Force 14	866	818
Force 15	964	921
Force 16	755	732
Force 17	952	933
Force 18	1034	1026
Force 19	826	825
Force 20	1052	1052

# Stringing: Final sagitta

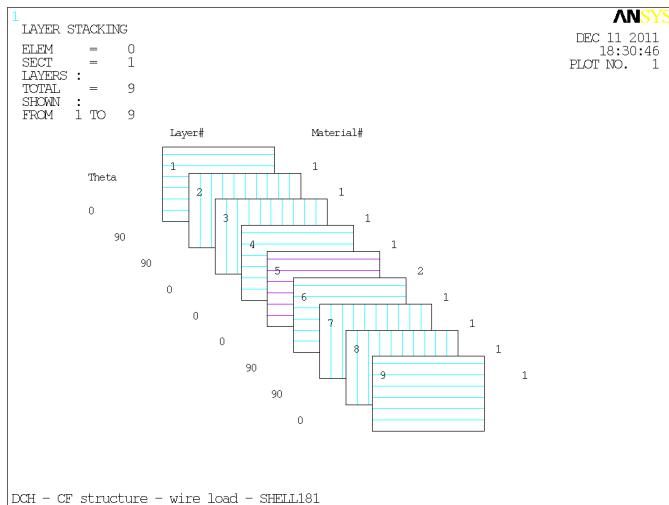


This plot takes into account a further displacement due to the cylindrical shell deformation, about 0.07mm

For a fixed displacement sense wires have a greater sagitta than field wires.  
Molybdenum is more rigid ( $E_{mo}=320 \text{ e}3 \text{ Mpa}$   $E_{al}=68.9 \text{ e}3 \text{ Mpa}$ )  
On the first layer act all the stringing process, so the difference is greater  
The first layers “feel” all the stringing process, so the difference in sagitta is larger

Max. Sagitta difference : 0.026mm

# Buckling: Shell material



Ply#	Lamina Type	Thickness(mm)	Angle (deg)
1	Graphite/Epoxy	0.250	0
2	Graphite/Epoxy	0.250	90
3	Graphite/Epoxy	0.250	90
4	Graphite/Epoxy	0.250	0
5	Honeycomb	6	0
6	Graphite/Epoxy	0.250	0
7	Graphite/Epoxy	0.250	90
8	Graphite/Epoxy	0.250	90
9	Graphite/Epoxy	0.250	0

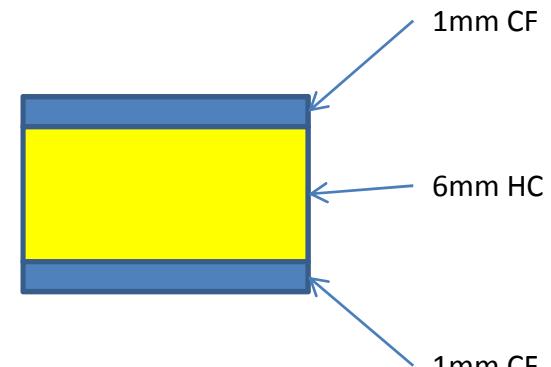
Cylindrical shell. Thickness 8mm

$$\begin{array}{lll} E_x = 130 \text{ GPa} & \nu_{xy} = 0.3 & G_{xy} = 4.5 \text{ GPa} \\ E_y = 4.6 \text{ GPa} & \nu_{xz} = 0.3 & G_{xz} = 4.5 \text{ GPa} \\ E_z = 4.6 \text{ GPa} & \nu_{zy} = 0.25 & G_{zy} = 4.5 \text{ GPa} \end{array}$$

CF properties

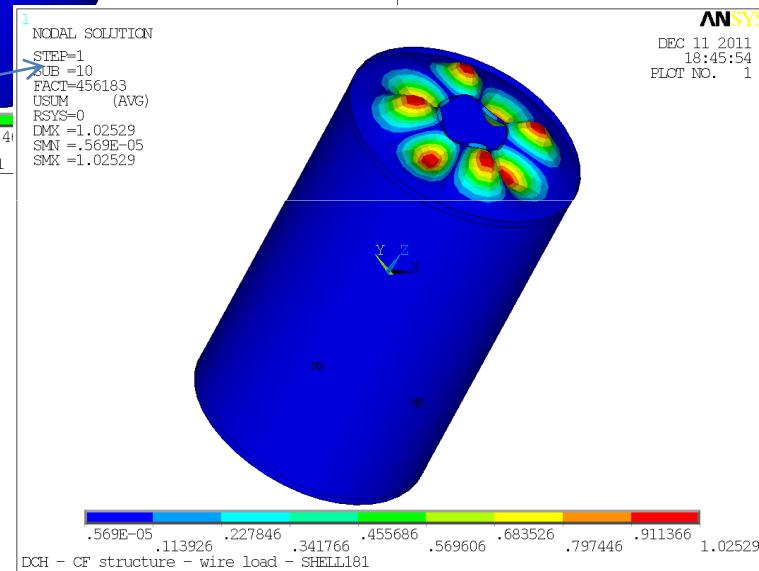
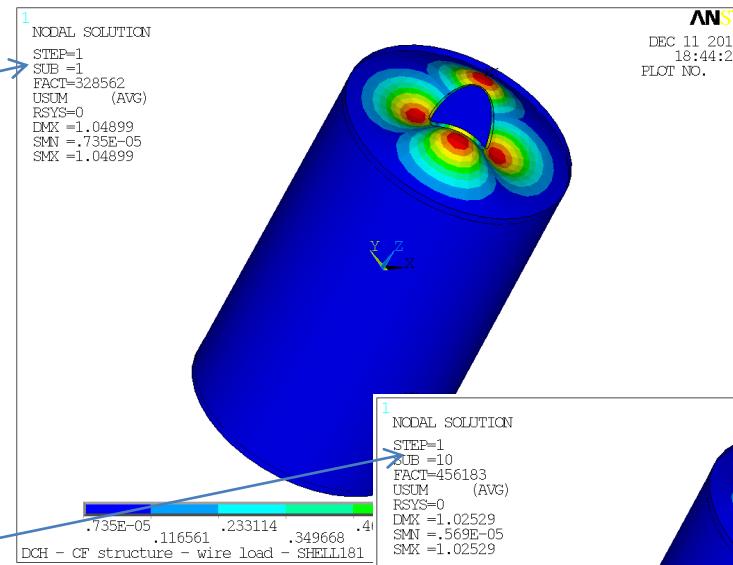
$$\begin{array}{lll} E_x = 138 \text{ MPa} & \nu_{xy} = 0.02 & G_{xy} = 1 \text{ MPa} \\ E_y = 3 \text{ MPa} & \nu_{xz} = 0.02 & G_{xz} = 45 \text{ MPa} \\ E_z = 3 \text{ MPa} & \nu_{zy} = 0.02 & G_{zy} = 24 \text{ MPa} \end{array}$$

Honeycomb properties



# Buckling: Analysis

Nº	Buckling Load (N)
1	0.32856E+06
2	0.32863E+06
3	0.32910E+06
4	0.36709E+06
5	0.40102E+06
6	0.40102E+06
7	0.40103E+06
8	0.40103E+06
9	0.45618E+06
10	0.45618E+06



Buckling occurs only on endplates.

Using HC allow to avoid instability problem on cylindrical shell and to use less material

First instability load: 328560 N

20 times higher than wire load

## Conclusions and plans

- Inner load bearing cylinder is not needed
- DCH can be strung without overtensioning wires
- CF laminates are optimized to reduce displacement
- The numbers used for the DCH inner radius, length and thickness of all elements are close to final, but we will check for updates. These updates are expected not to cause important changes on the conclusions
- Realize some test due to uncertainty on material properties
- Understand effect of feed-through holes with tests
- Understand how DCH is supported