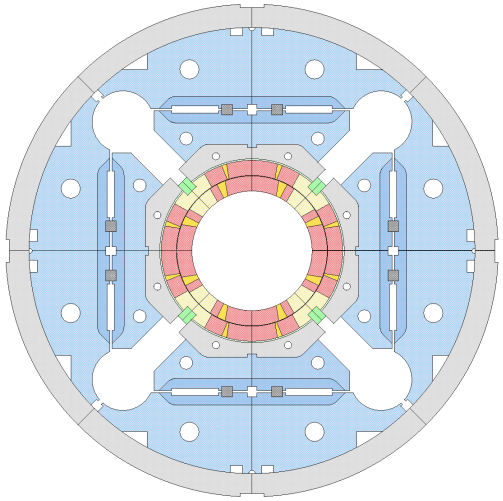


MQXFSD0 experience at CERN

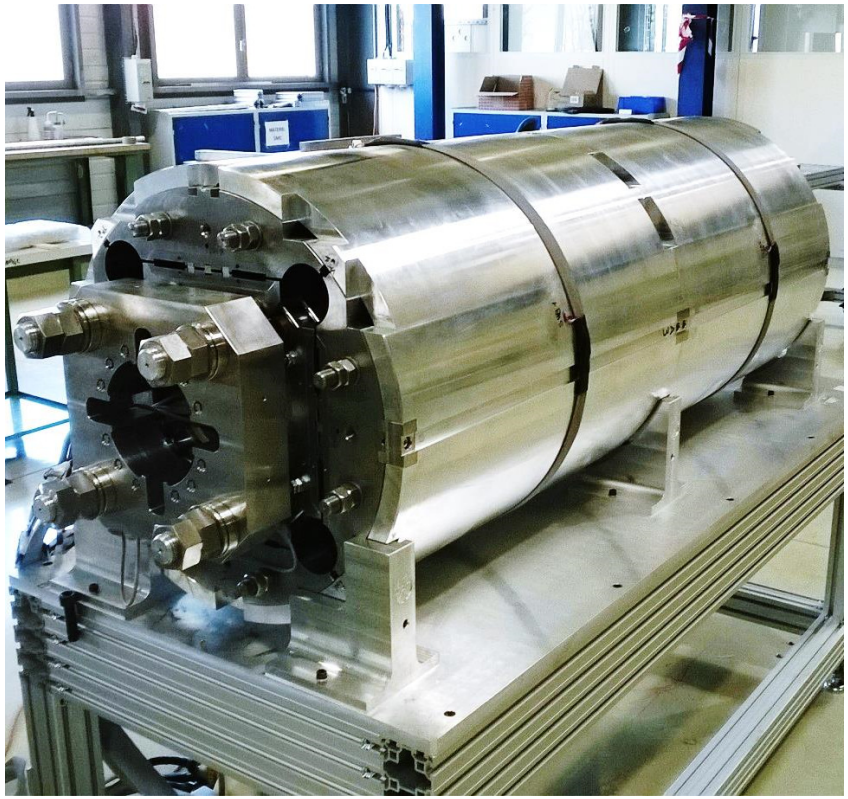
Mariusz Juchno, Hugo Bajas, Marta Bajko, Philippe Grosclaude, Michael Guinchard

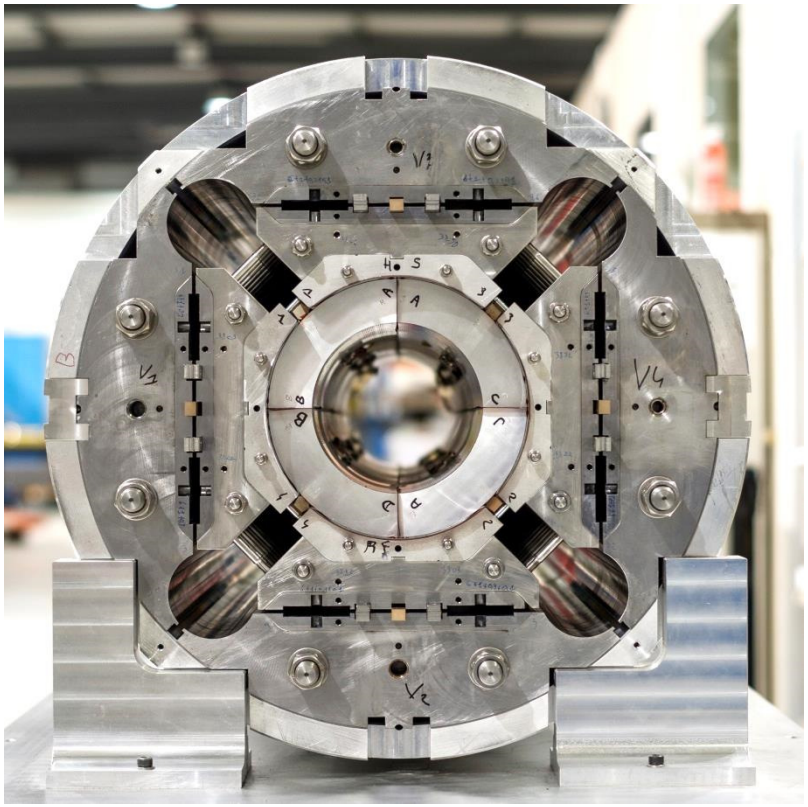
Outline

- Overview of the assembly and tests
- Coil-pack shims and dimensions
- Strain gauge location
- Details of the first RT assembly
- Details of the 77K tests
- Conclusions and next steps

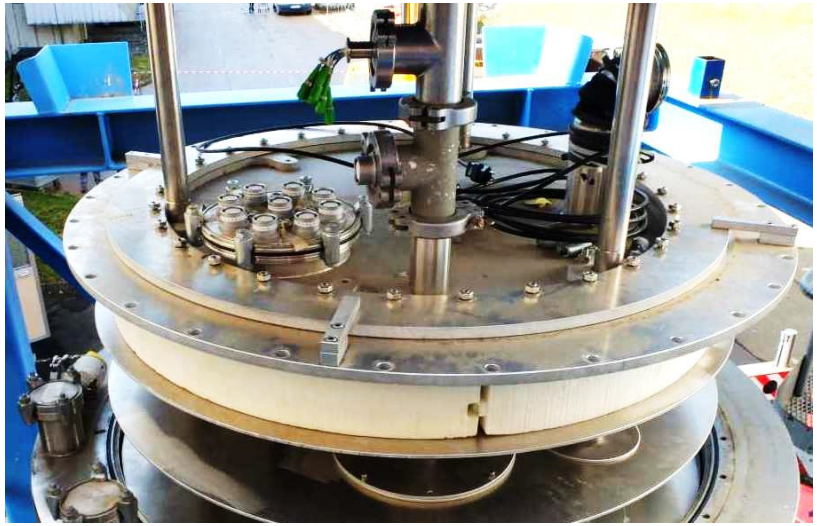
Assembled support structure with aluminium dummy coils

Two identical shell segments



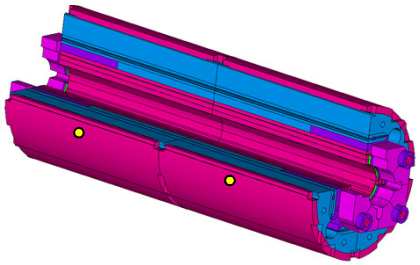


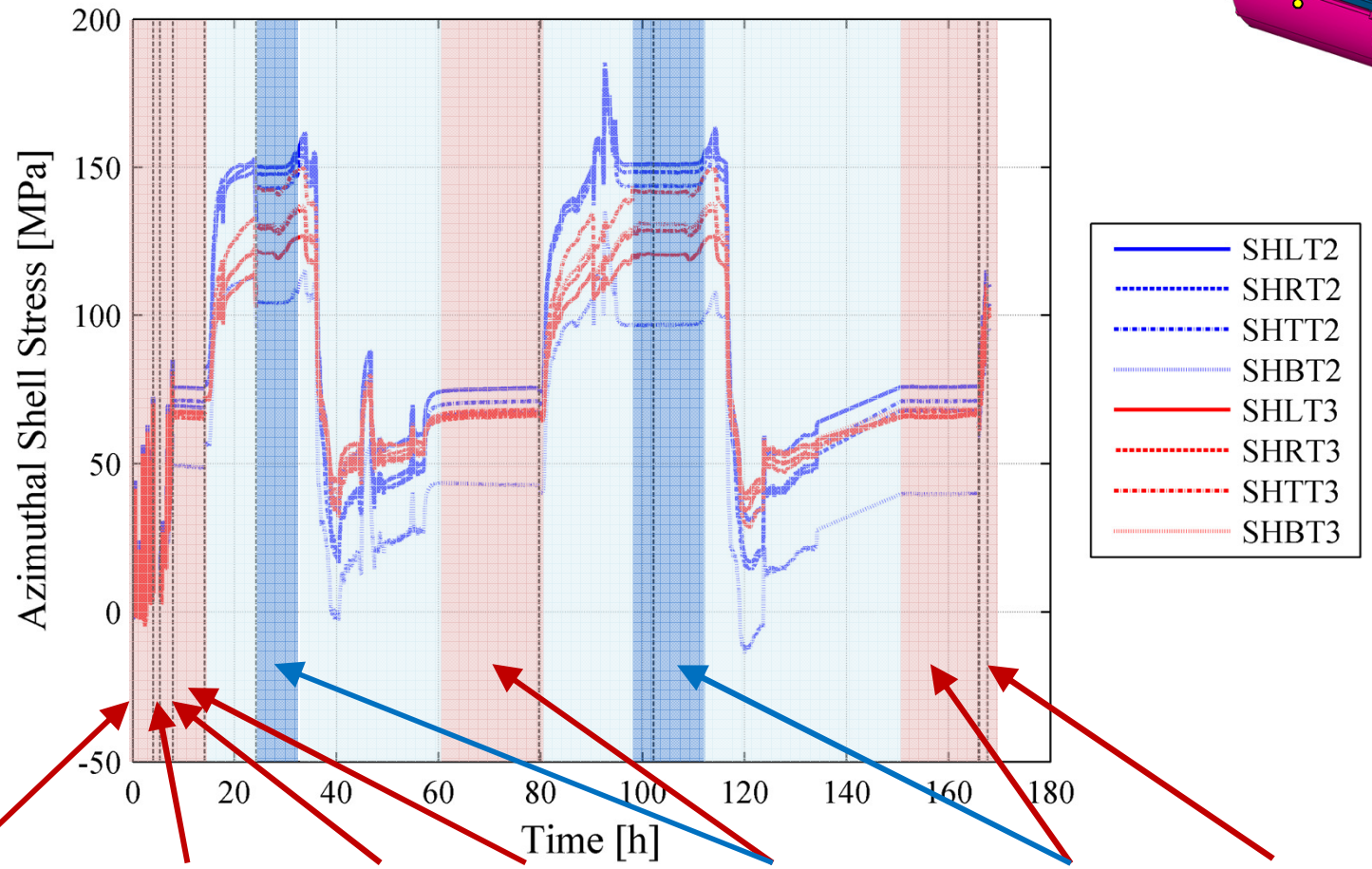
Structure transported and tested in SM18



Overview of the assembly and tests

Shell azimuthal stress

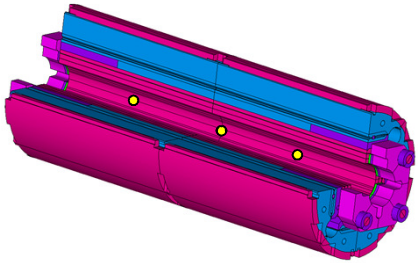


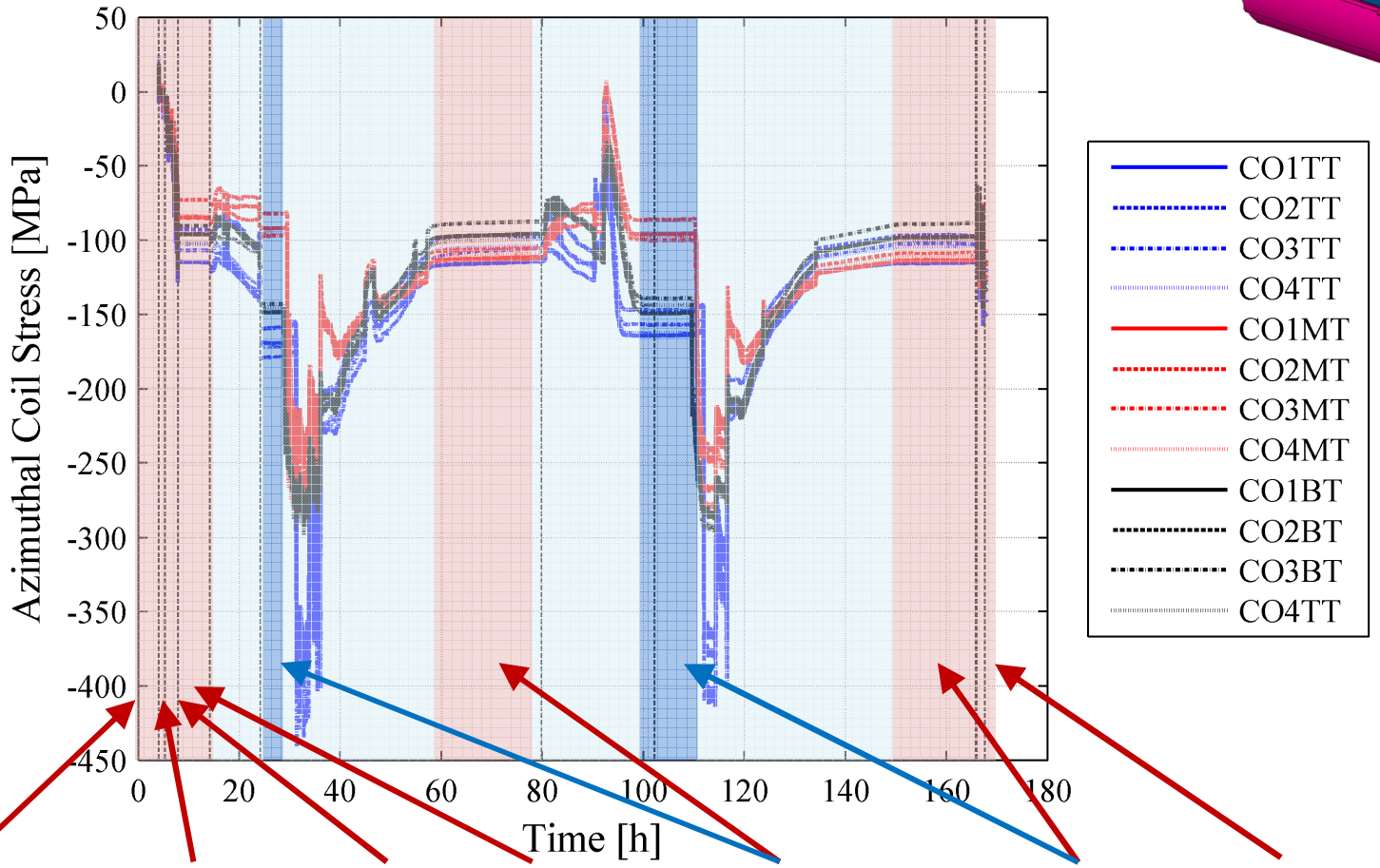


Shell sub-assembly Dec 2014 → Coil-pack assembly Jan 2015 → Azimuthal loading Jan 2015 → Axial loading Mar 2015 → First thermal cycle Mar 2015 → Second thermal cycle Mar 2015 → Second loading Apr 2015 → Third thermal cycle May 2015

Overview of the assembly and tests

Coil azimuthal stress

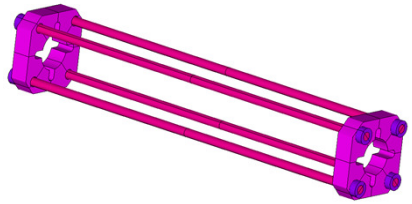


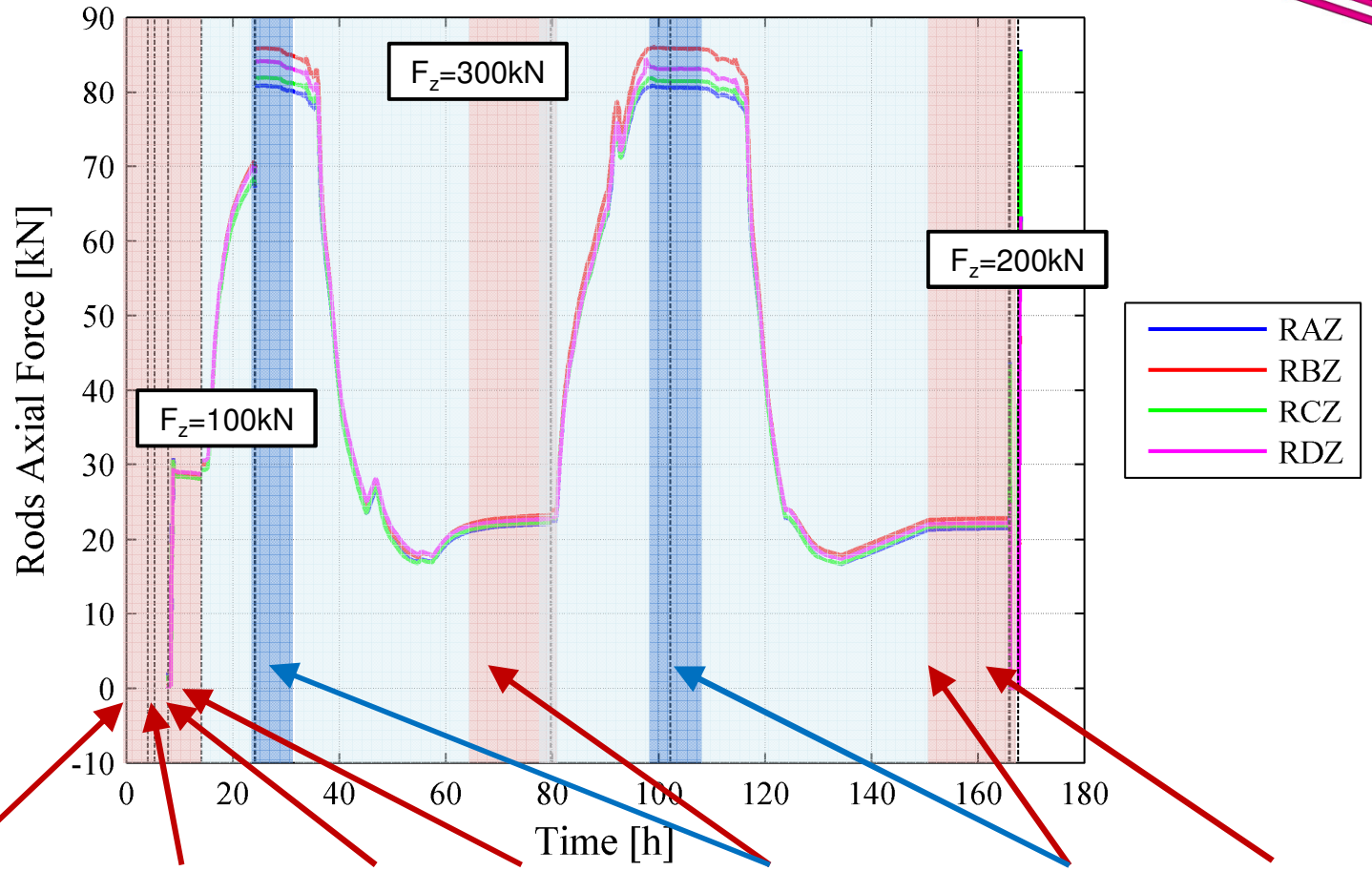


Shell sub-assembly Dec 2014 → Coil-pack assembly Jan 2015 → Azimuthal loading Jan 2015 → Axial loading Mar 2015 → First thermal cycle Mar 2015 → Second thermal cycle Mar 2015 → Second loading Apr 2015 → Third thermal cycle May 2015

Overview of the assembly and tests

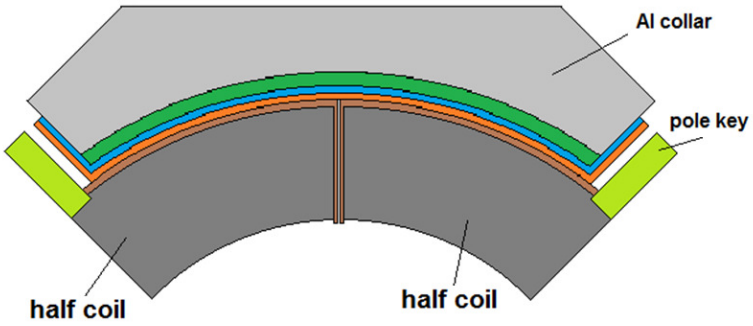
Rods axial force

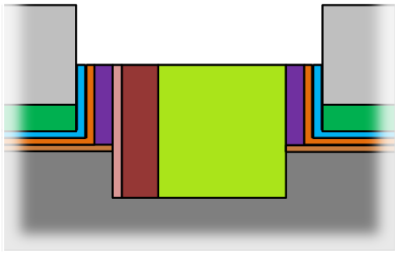




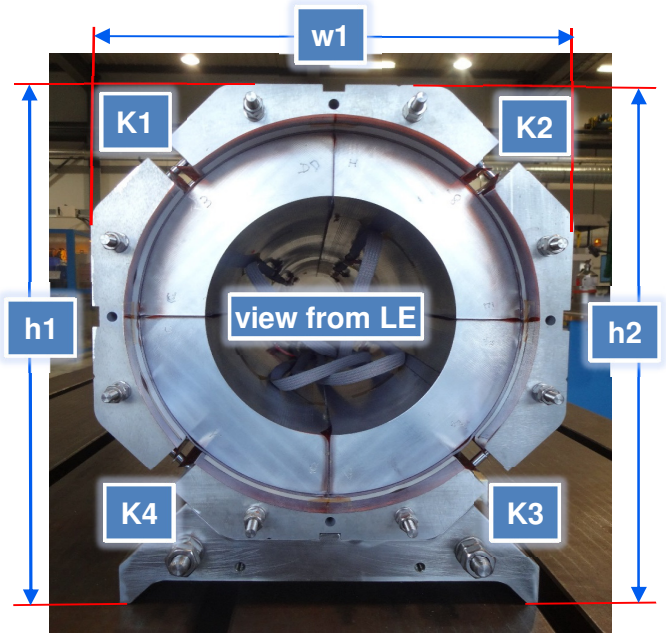
Shell sub-assembly Dec 2014 → Coil-pack assembly Jan 2015 → Azimuthal loading Jan 2015 → Axial loading Mar 2015 → First thermal cycle Mar 2015 → Second thermal cycle Mar 2015 → Second loading Apr 2015 → Third thermal cycle May 2015

Coil-pack shims and dimensions





G10 12.75 mm
Steel 1 mm
Steel 0.2 mm
Stainless 0.3 mm



Radial shims

- Nominal coil-collar distance 1.625 mm
- Inserted thk. 1.575 mm

Coil-pack

- Height within +/- 30 µm
- Width oversized by about 200 µm

Pole-key

- Nominal collar distance 15 mm
- Inserted PK stack thickness 14.95mm

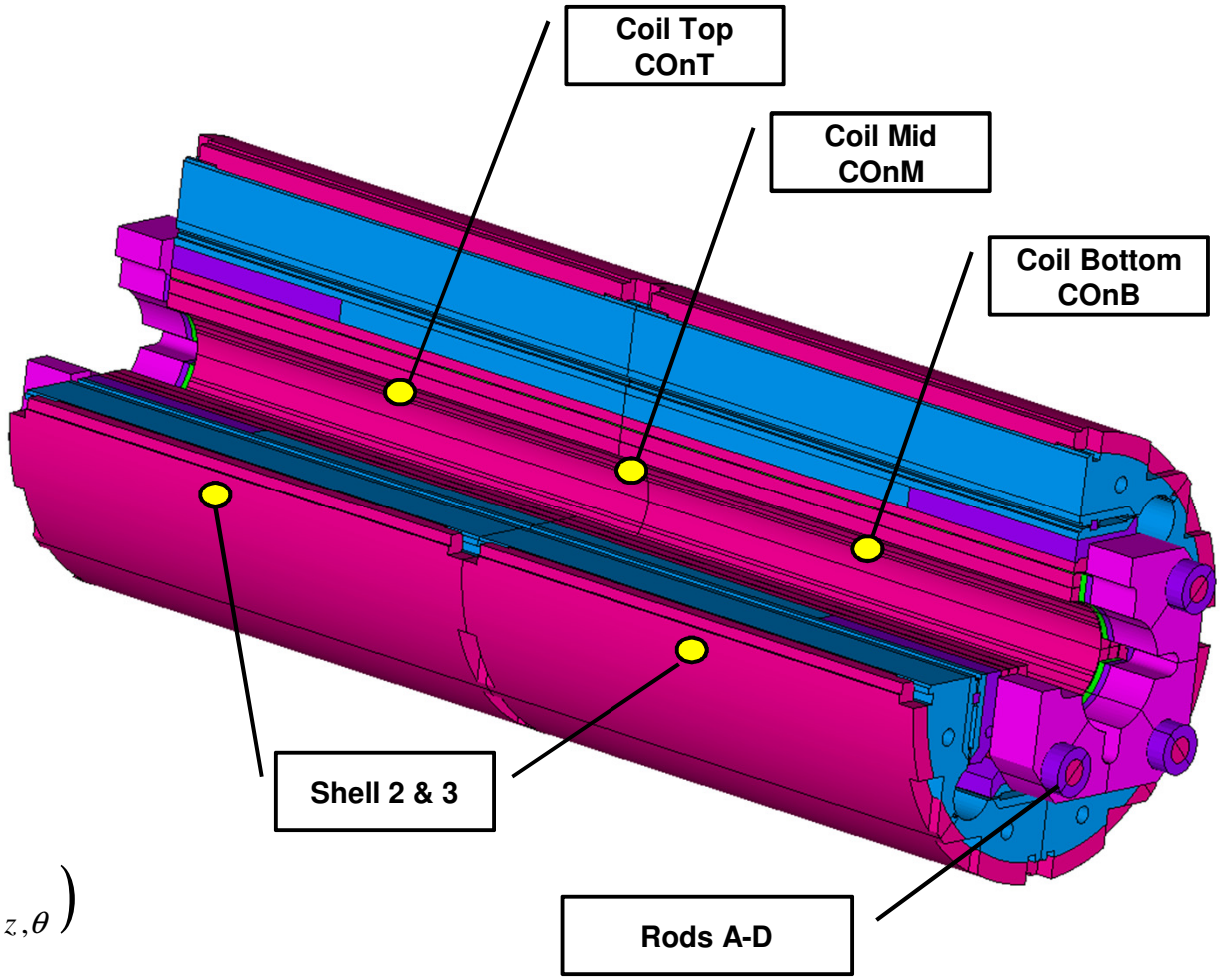
		x1	x2	x3	x4	x5	x6	x7	x8	Average	Nominal
LE	x (mm)	80	280	480	680	880	1080	1280	1480	-	-
	h1 (mm)	307.5	307.5	307.5	307.5	307.6	307.5	307.4	307.4	307.52	307.5
	h2 (mm)	307.5	307.5	307.5	307.4	307.5	307.4	307.4	307.4	307.47	307.5
	w1 (mm)	266.19	266.17	266.25	266.2	266.23	266.23	266.1	266.13	266.21	266

	AVG	STD
K1	14.95	0.022
K2	14.95	0.035
K3	15.01	0.036
K4	15.07	0.102
AVG	15.00	0.022

Coils & Shells SG locations

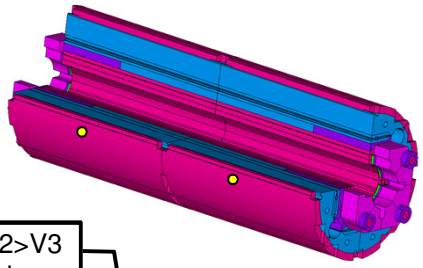
- 4 dummy coils
  - 3 stations on each (**T**op, **M**id, **B**ottom)
  - Azimuthal (T) and axial (Z) direction
- 2 shells
  - 4 stations on each (**L**eft, **R**ight, **T**op, **B**ottom)
  - Azimuthal (T) and axial (Z) direction
- 4 axial rods (**ABC&D**)
  - 1 station on each (full bridge)
  - Axial (Z) direction
- Stress estimation

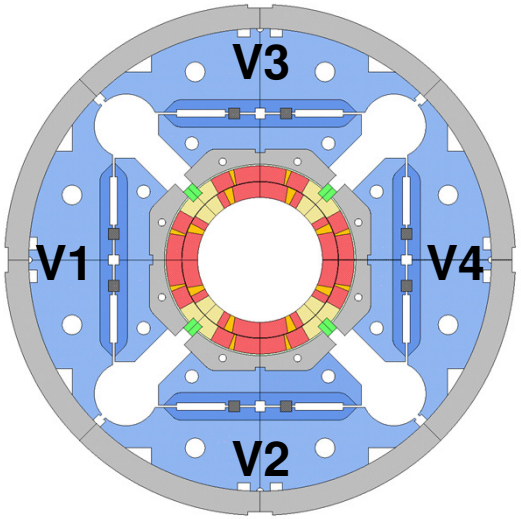
$$\sigma_{\theta,z} = \frac{E}{(1-\nu^2)}\left(\varepsilon_{\theta,z} + \nu\varepsilon_{z,\theta}\right)$$



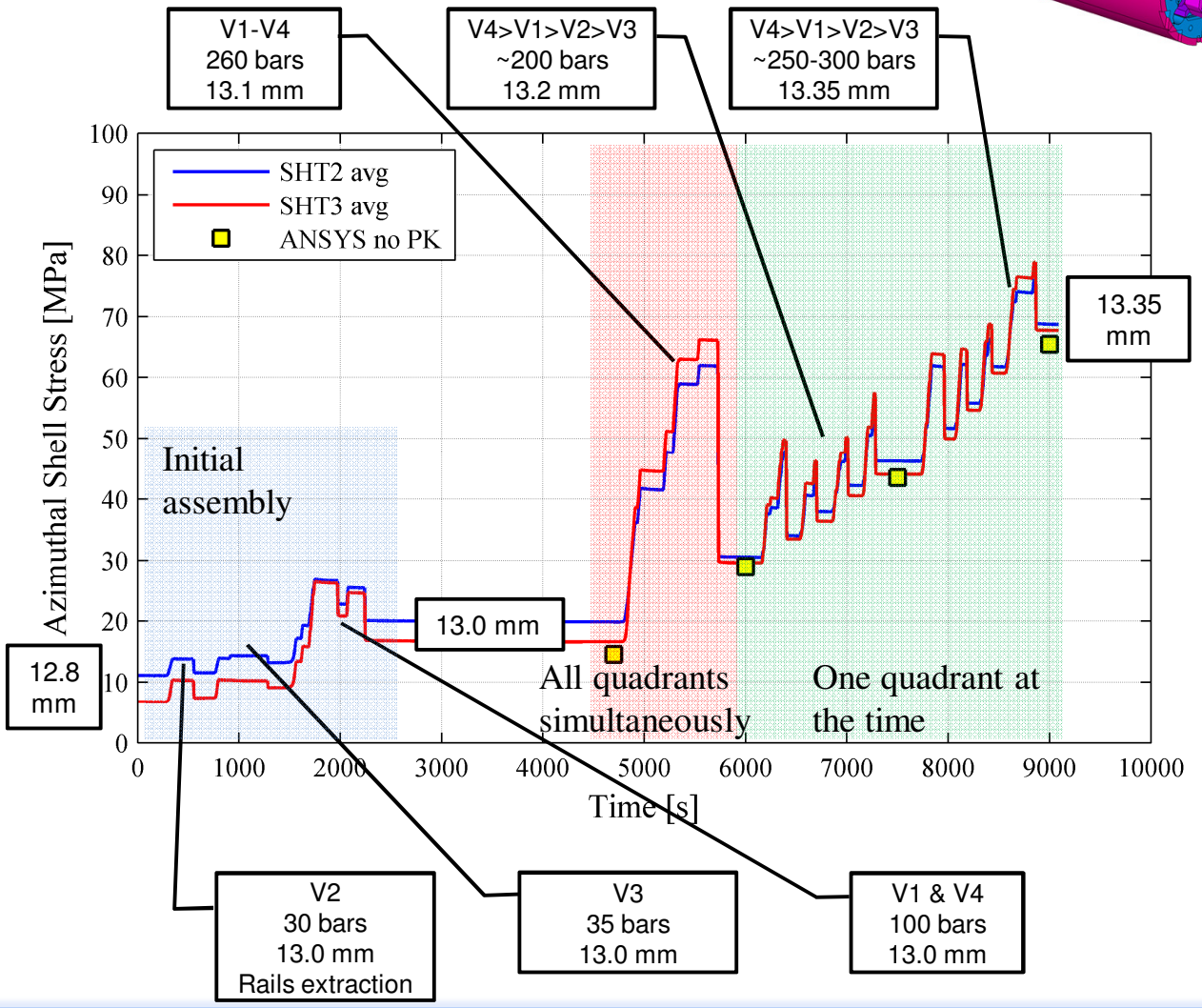
Details of the first loading

Shell azimuthal stress



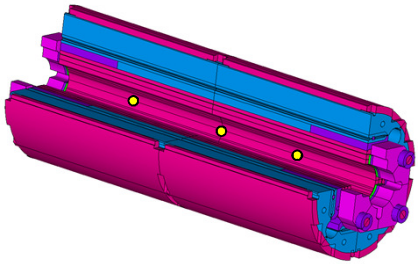


- Coil-pack oversized by about ~100µm per side
- Effective shim of 450 µm

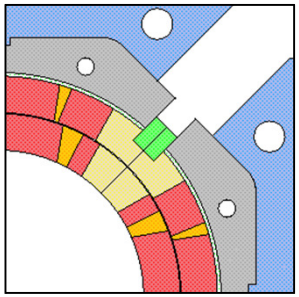


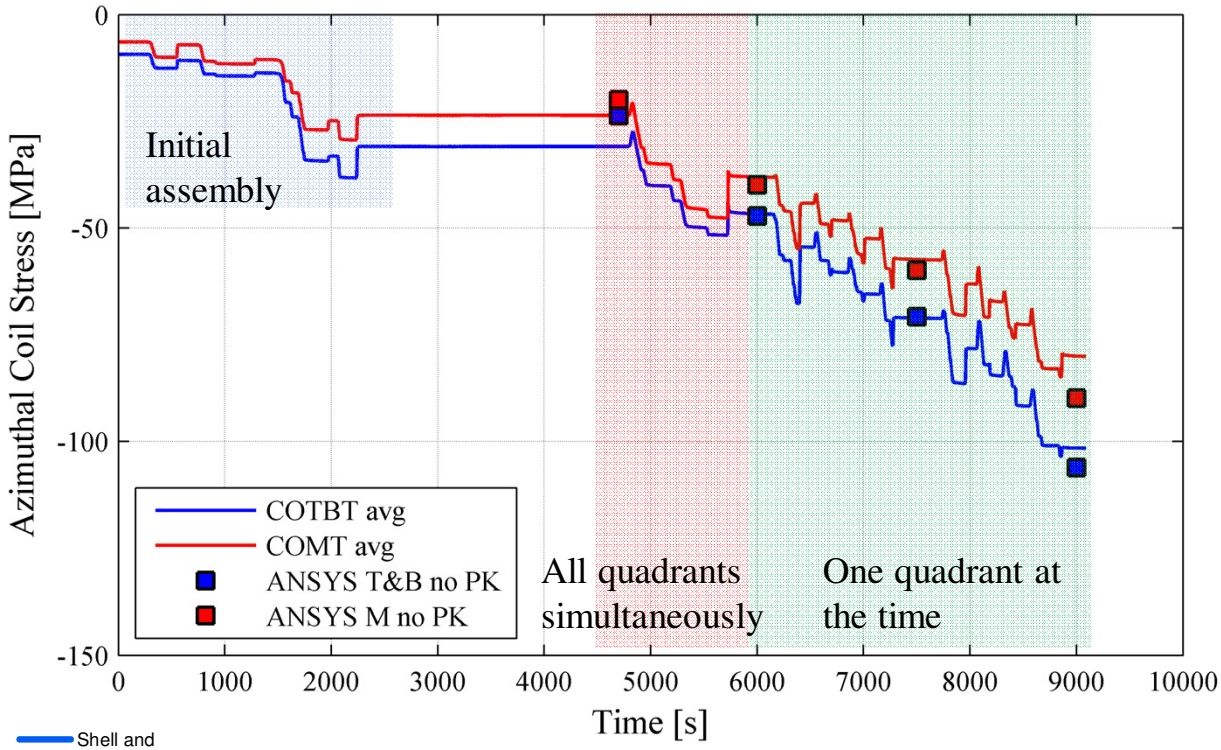
Details of the first loading

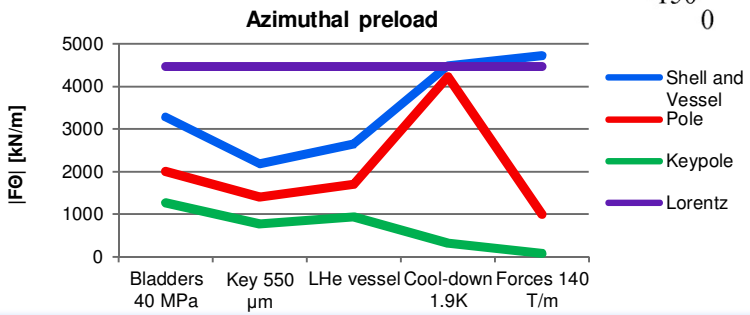
Coil azimuthal stress



- ANSYS simulation performed with and without the polekey
- Measurement indicate that the polekey does not intercept the force during assembly

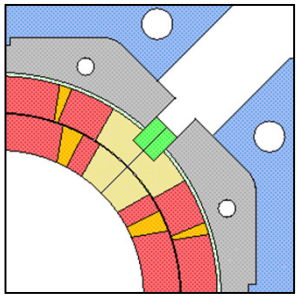


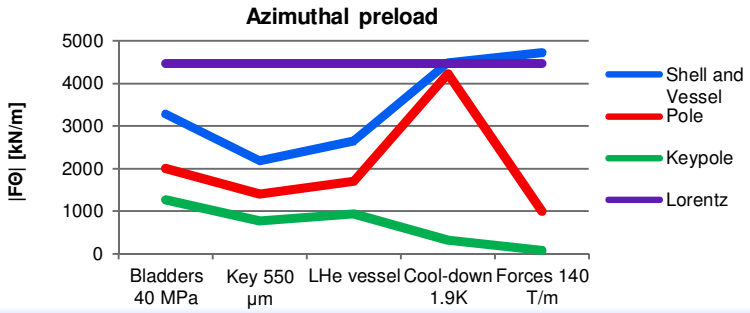


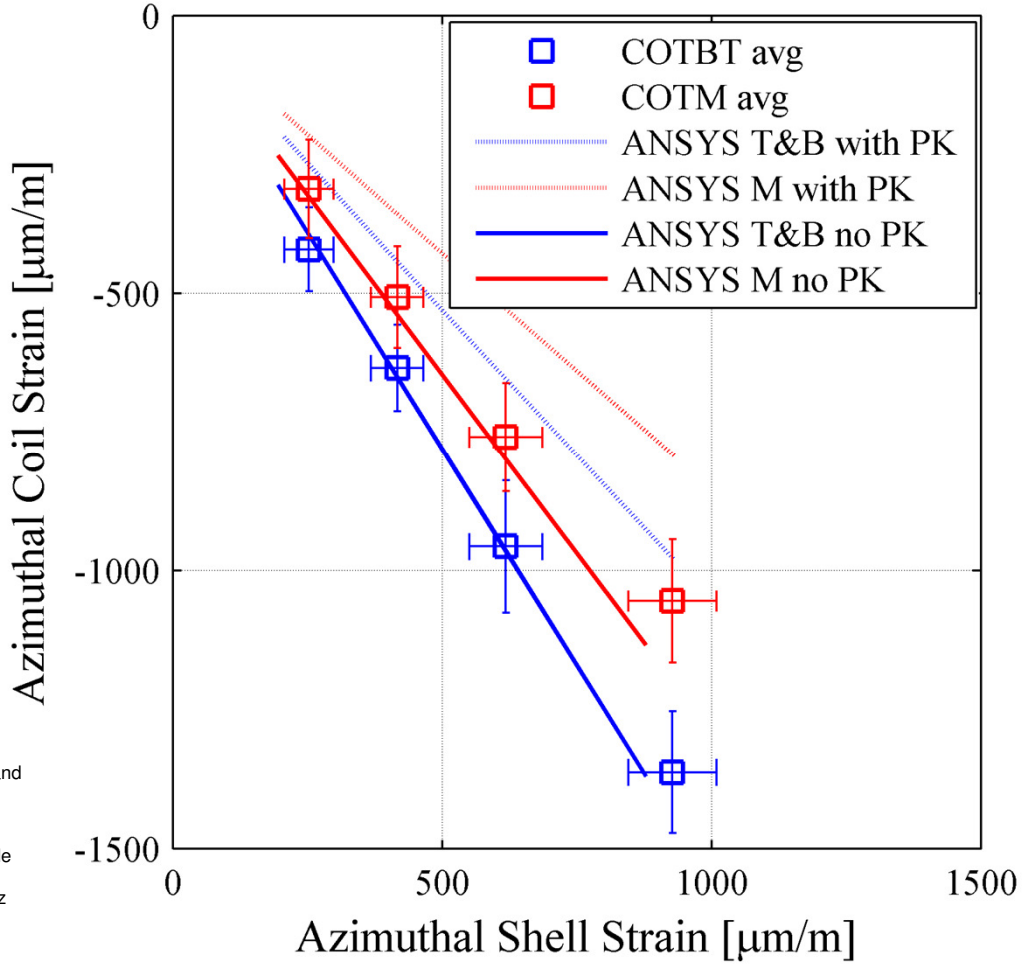


Shell vs Coil strain

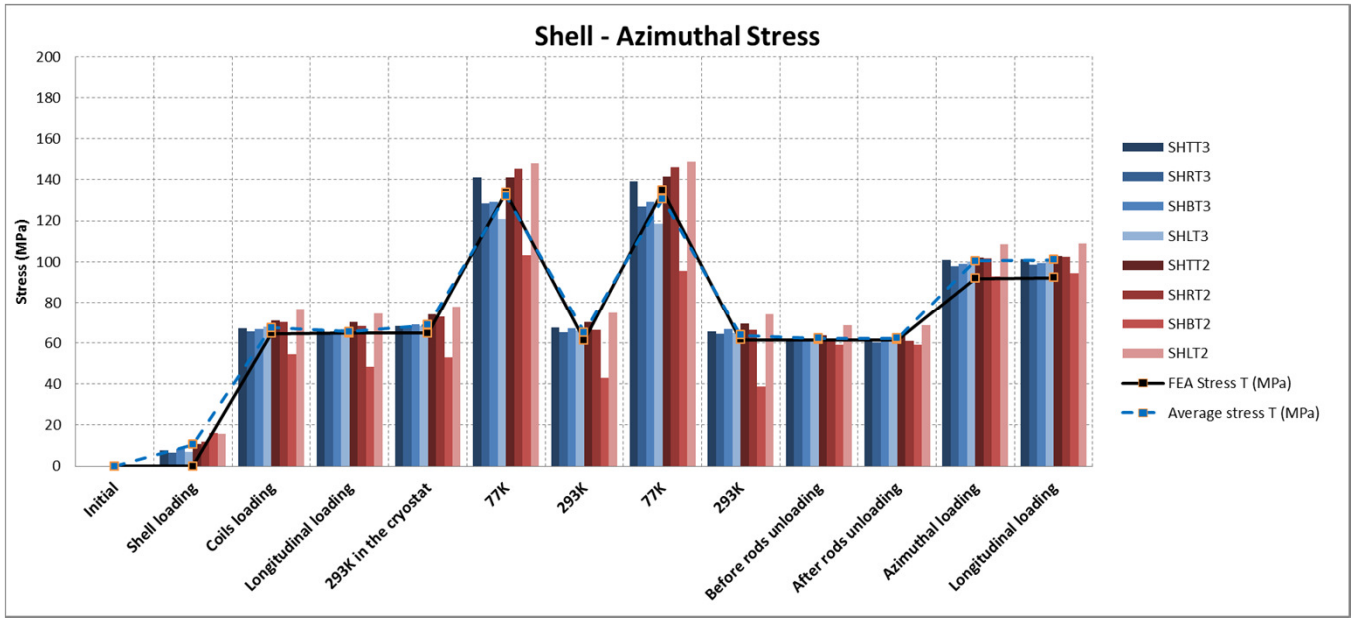
- ANSYS simulation performed with and without the polekey
- Measurement indicate that the polekey does not intercept the force during assembly

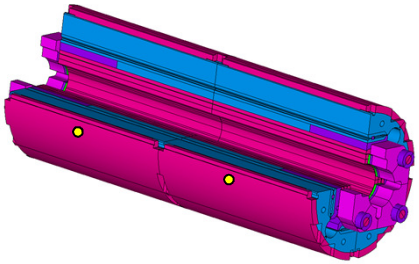






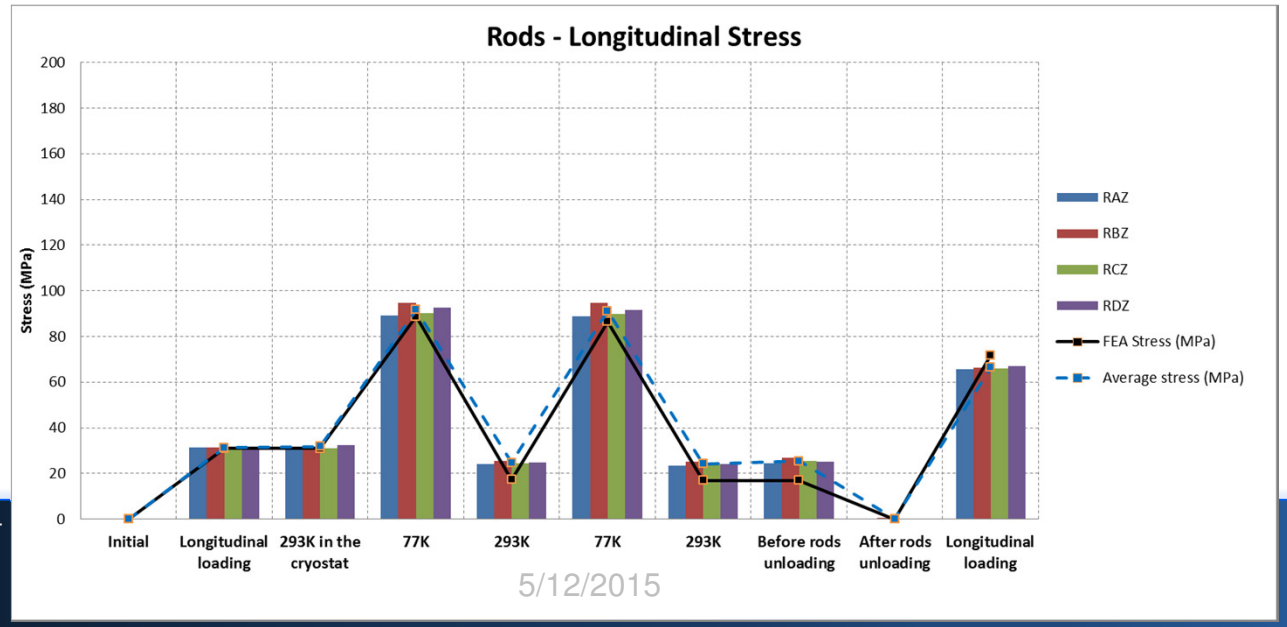
Stress in the shell and axial rods

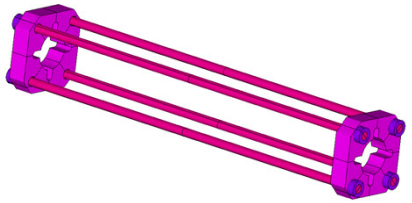




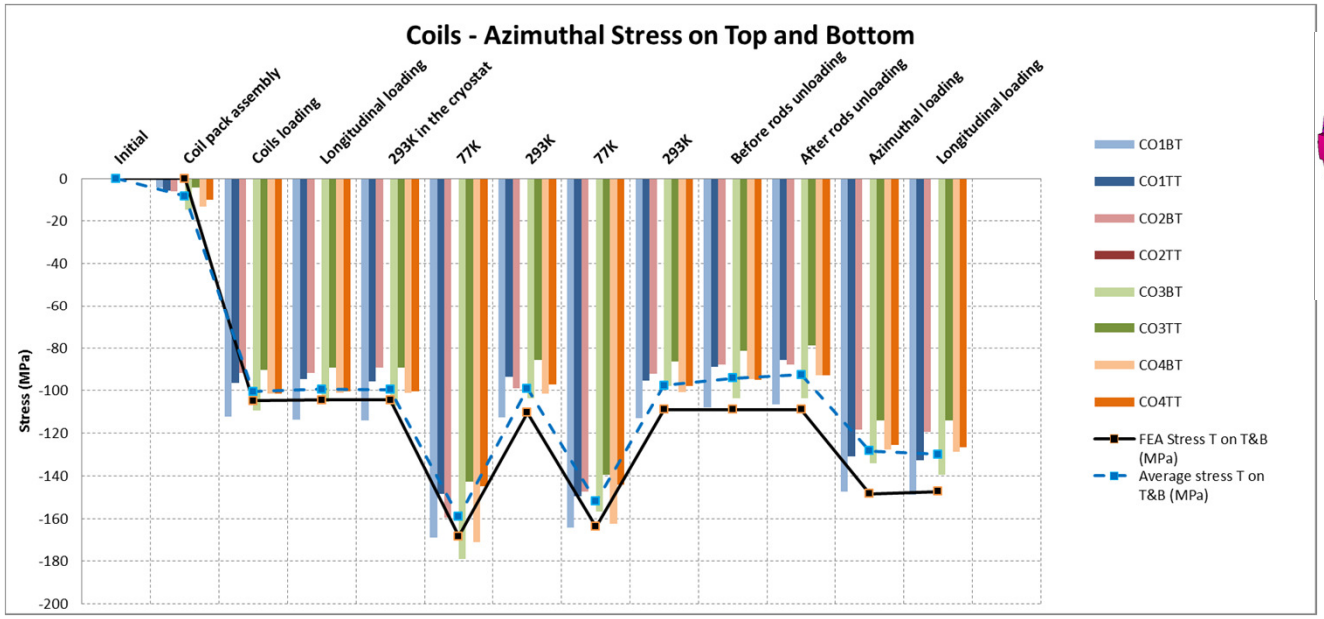
Mechanical elements providing the preload

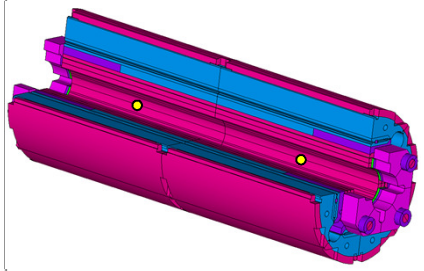
Good consistency between the model and the SG data





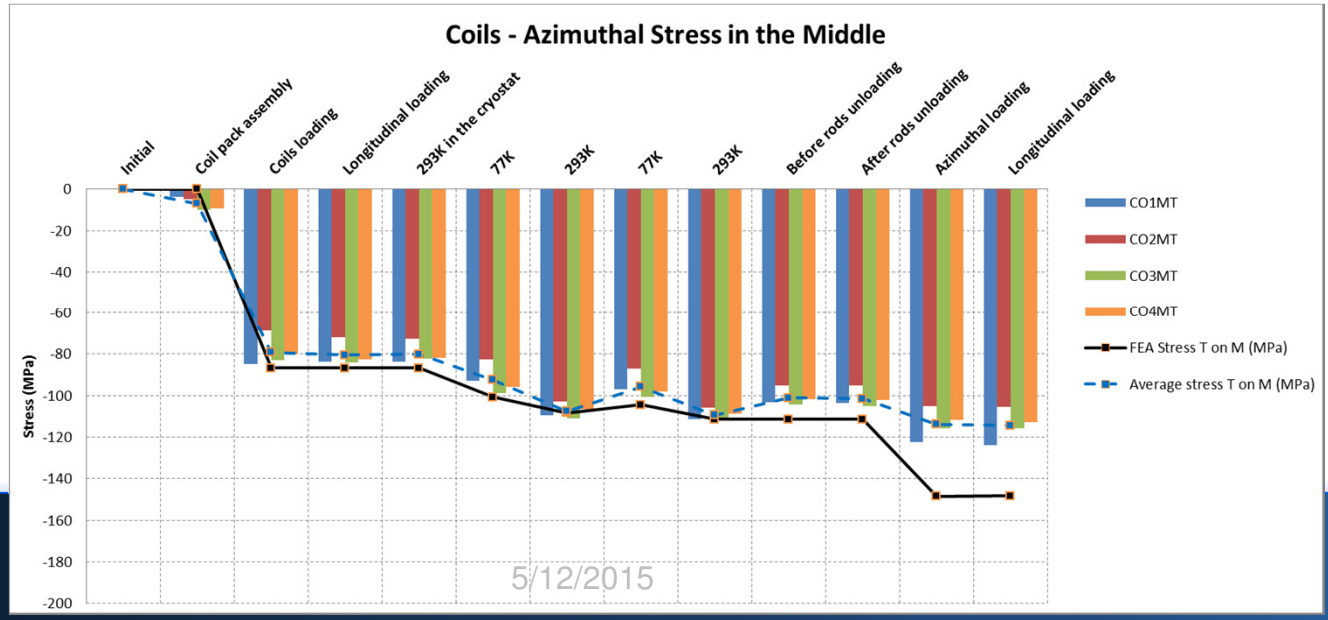
Azimuthal coil stress

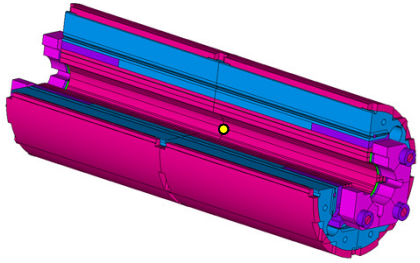




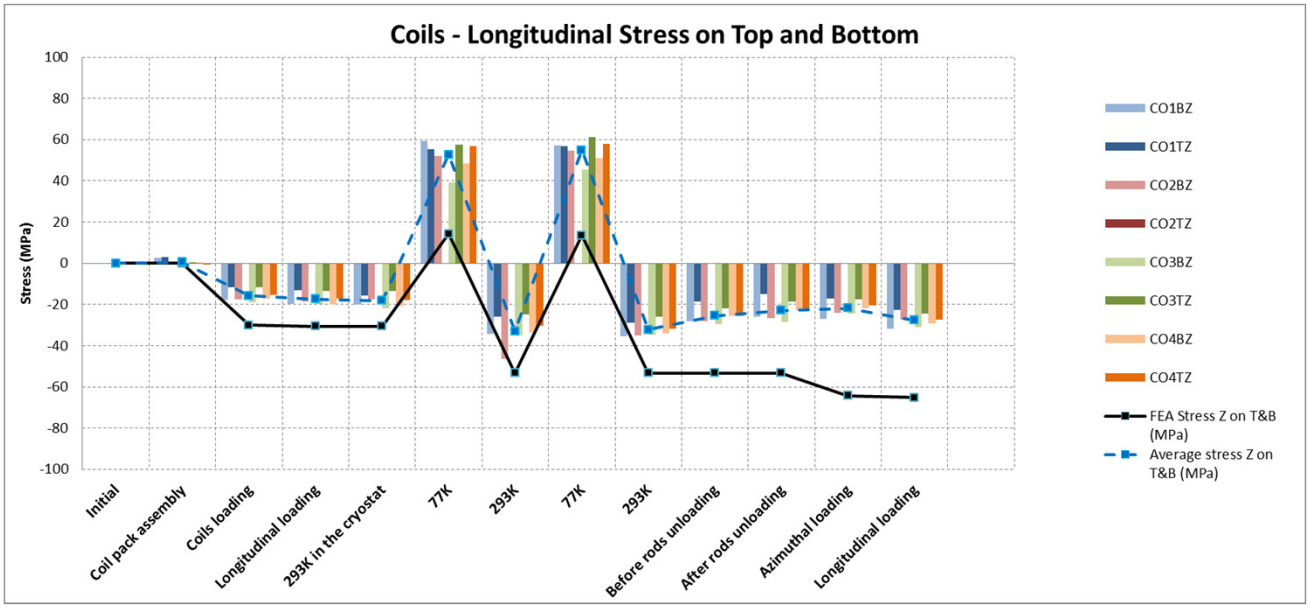
Good consistency for the T&B location

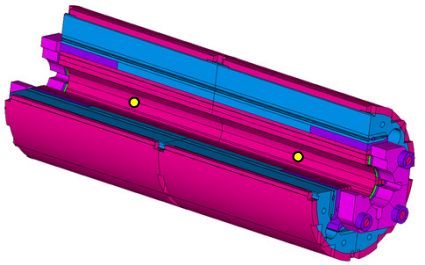
M location more difficult due to shells interface and friction (but overall well modelled)





Axial coil stress

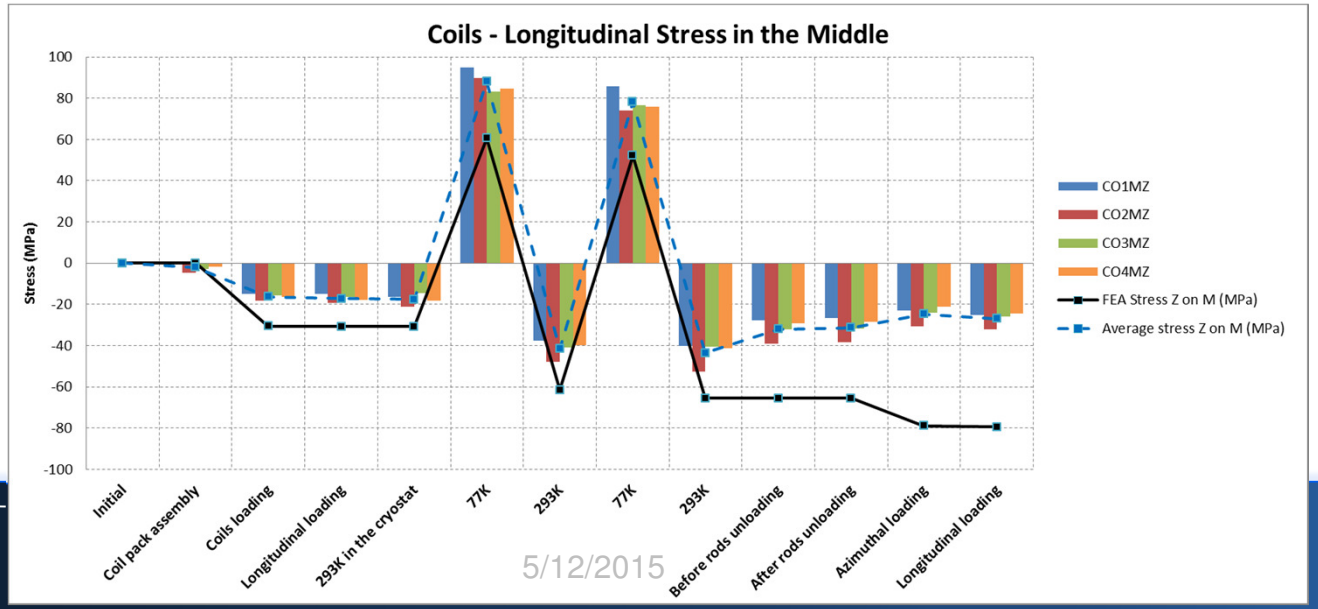


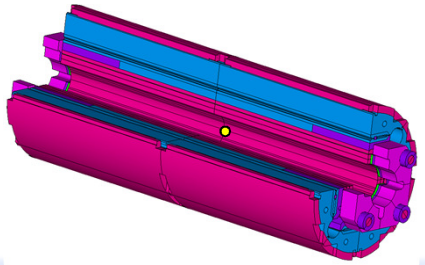


Axial direction generally more difficult due to friction

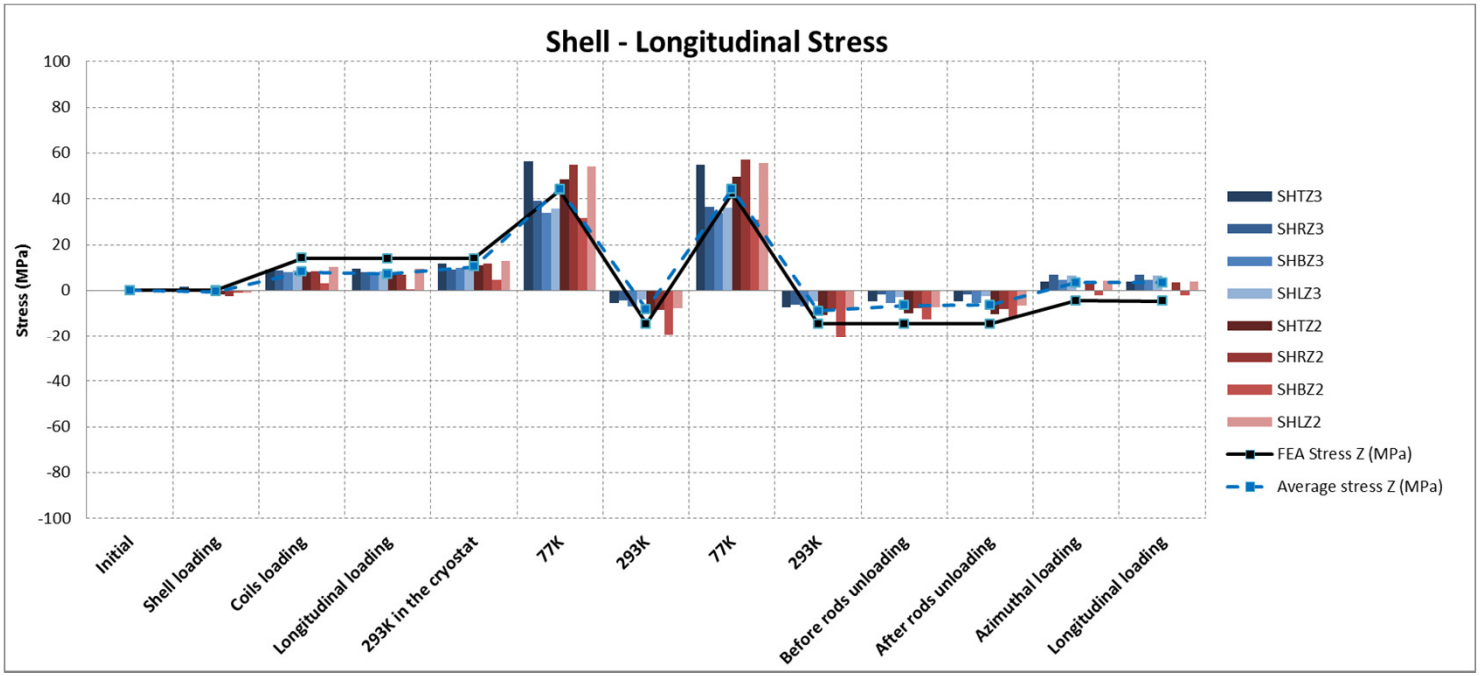
With f=0.3 the overall behavior is modelled properly

Friction effect still being investigated





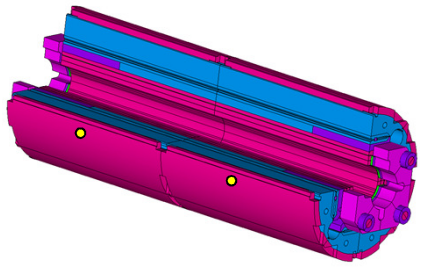
Axial shell stress



Path dependent effects introduced by friction

Numerical analysis performed with multiple sub-steps

Fine-tuning of the friction coefficient (from 0.2 to 0.3)



Conclusions

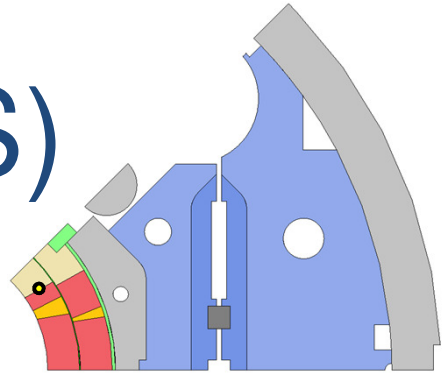
- Very good results which agree with the numerical prediction.
- Successful validation and fine-tuning of the numerical model of the structure

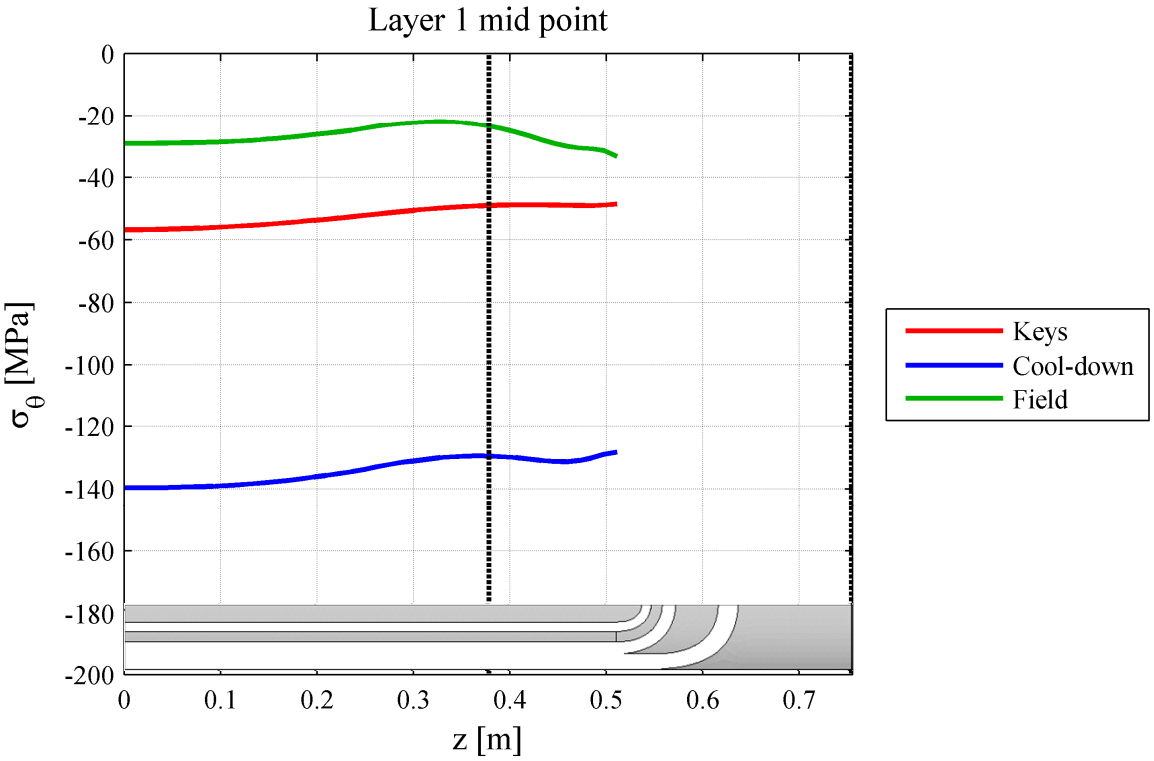
Next steps

- Third and fourth thermal cycle of the present model ongoing
- Disassembly and second assembly with dummy coils and the new set of shells
  (optimized design to decrease the stress variation along the coil and decrease the stress in the coil head)

Appendix

Stress variation (MQXFS)

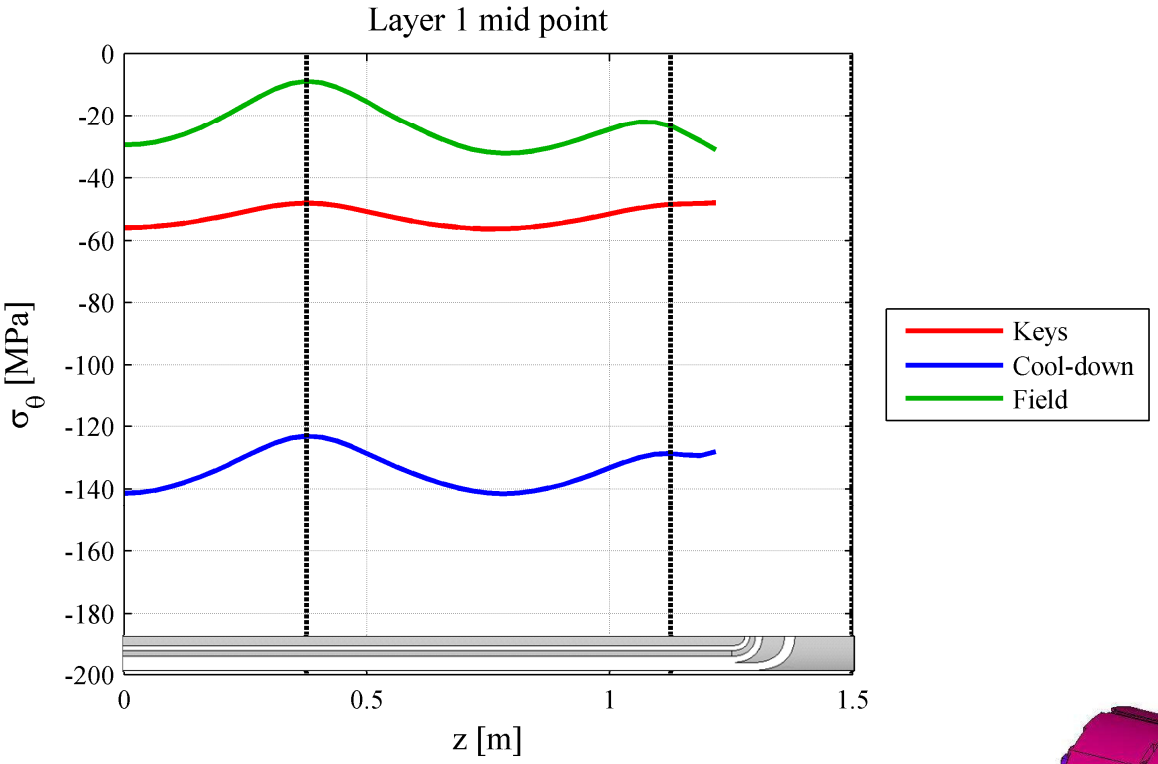


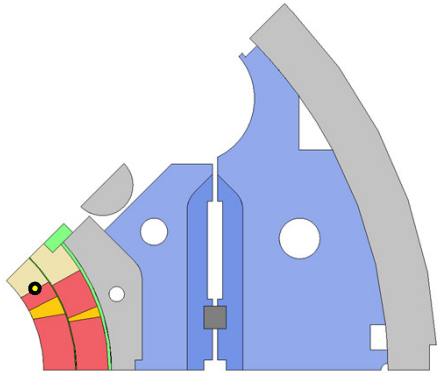


- Preload guaranteed at 140 T/m
- Stress variation under central segment **+/- 5 MPa** (affected by ends)
- Half-shells at the extremities decrease the stress variation

- **Optimised layout**
  - 1 normal shell (0.755m long)
  - 2 half-shells at extremities (0.377m)

Stress variation (3m)





- Stress variation under central segments **+/- 10 MPa**
- Half-shells at the extremities decrease the stress variation (affect adjoining long segments)

- **Optimised layout**
  - 3 normal shell (0.755m long)
  - 2 half-shells at extremities (0.377m)