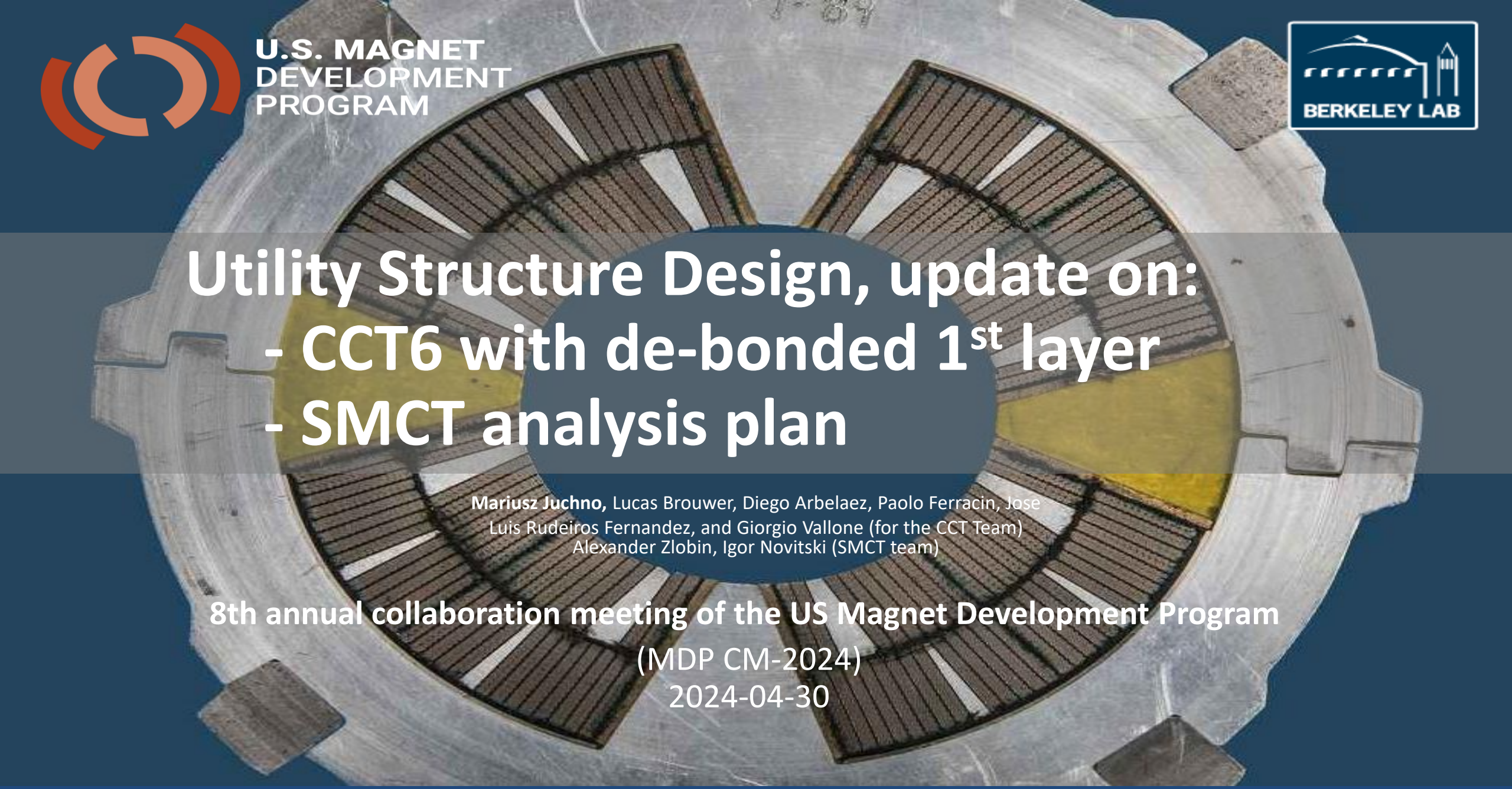


U.S. MAGNET DEVELOPMENT PROGRAM

BERKELEY LAB

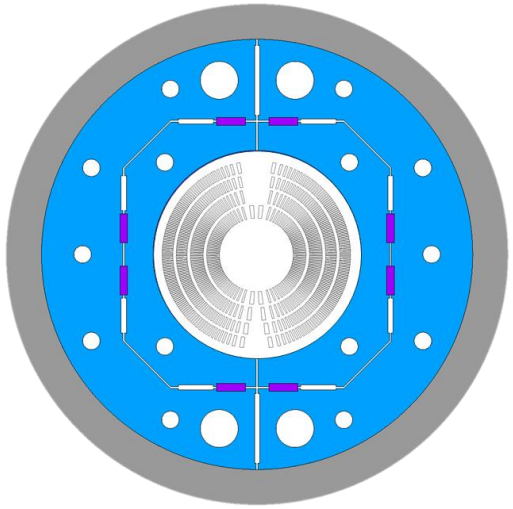
Utility Structure Design, update on:
- CCT6 with de-bonded 1st layer
- SMCT analysis plan

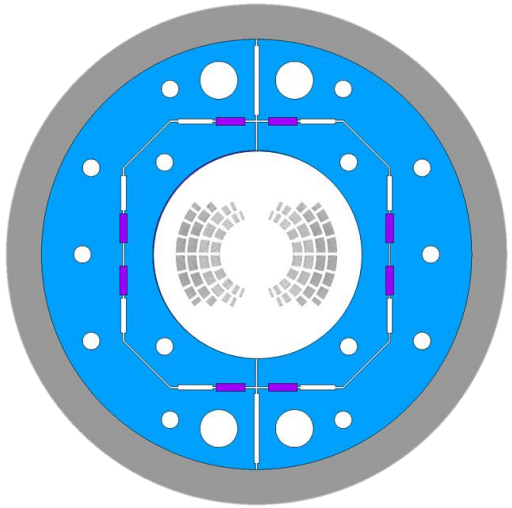
Mariusz Juchno, Lucas Brouwer, Diego Arbelaez, Paolo Ferracin, Jose Luis Rudeiros Fernandez, and Giorgio Vallone (for the CCT Team)
Alexander Zlobin, Igor Novitski (SMCT team)

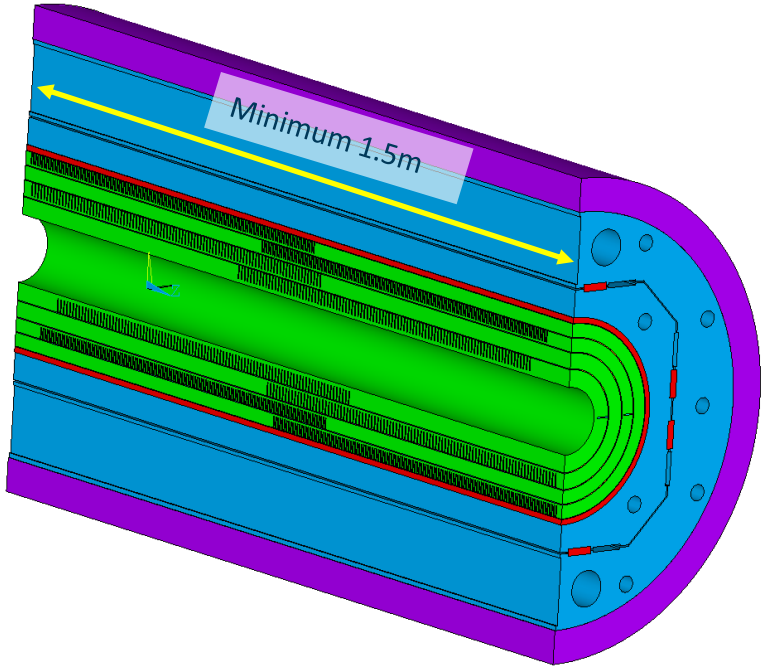
8th annual collaboration meeting of the US Magnet Development Program

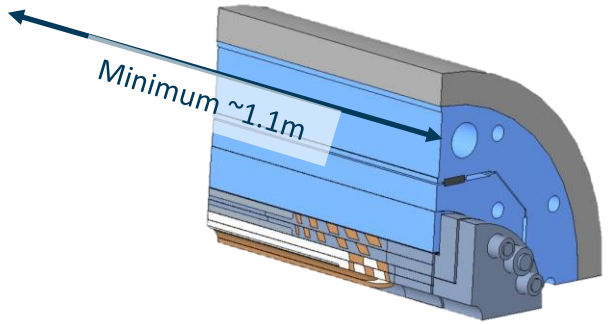
(MDP CM-2024)
2024-04-30

Compatibility with magnets and test facilities









Magnets

- CCT6
  - 2 layers with a spacer
  - 4 Layers with protective a (split) cylinder
- SMCT
  - 2 or 4 layers with a spacer
  - Axial preload?
- Hybrid configurations

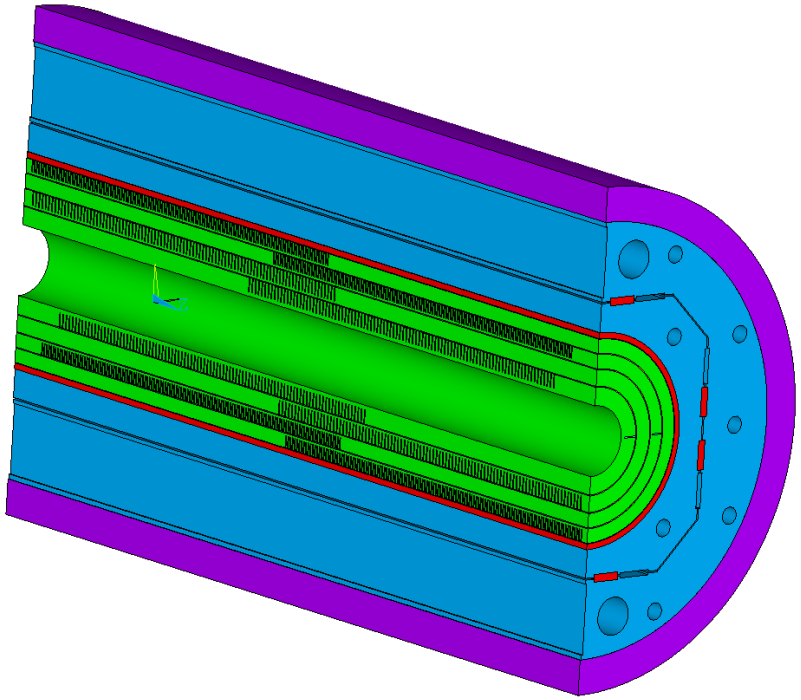
Facilities

- LBNL at 4.2K
  - 860 mm OD compatible with the current cryostat
- FERMILAB at 1.9K
  - 860 mm OD compatible with HFVMTF (additional magnetic shielding will be required)
  - Coldmass OD would be limited to ~750 mm by the current test facility

CCT6

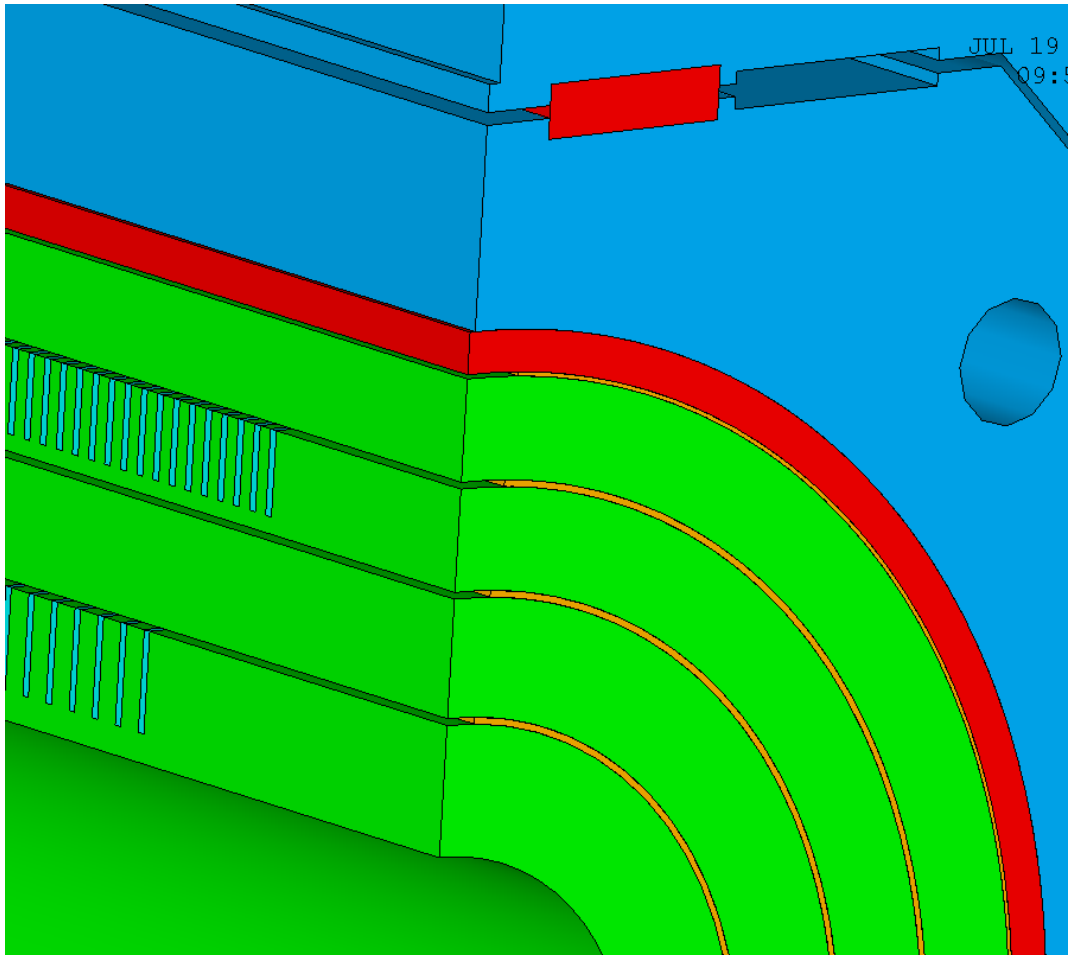
Conductor and mandrel stress in case of 1st layer conductor interface debonding

Mechanical model (LD1+MQXF cable)



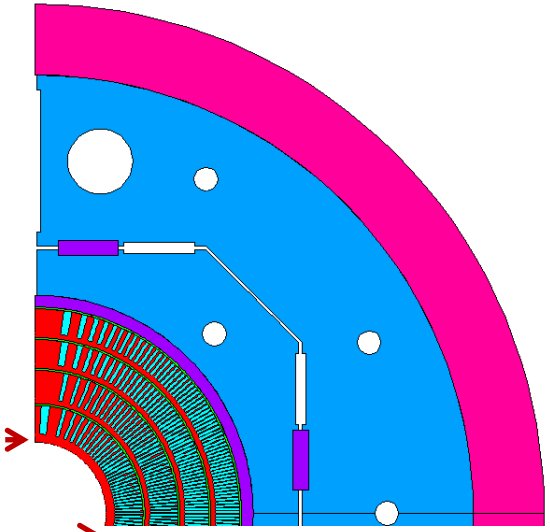
Shared nodes in layers 2-4

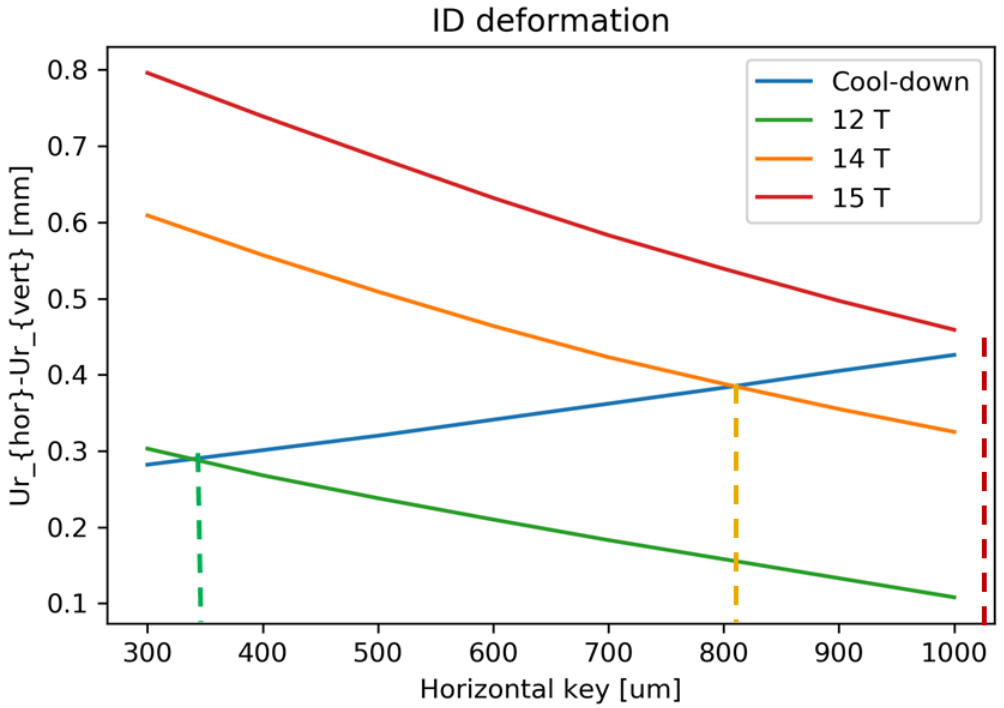
Contacts in 1st layer

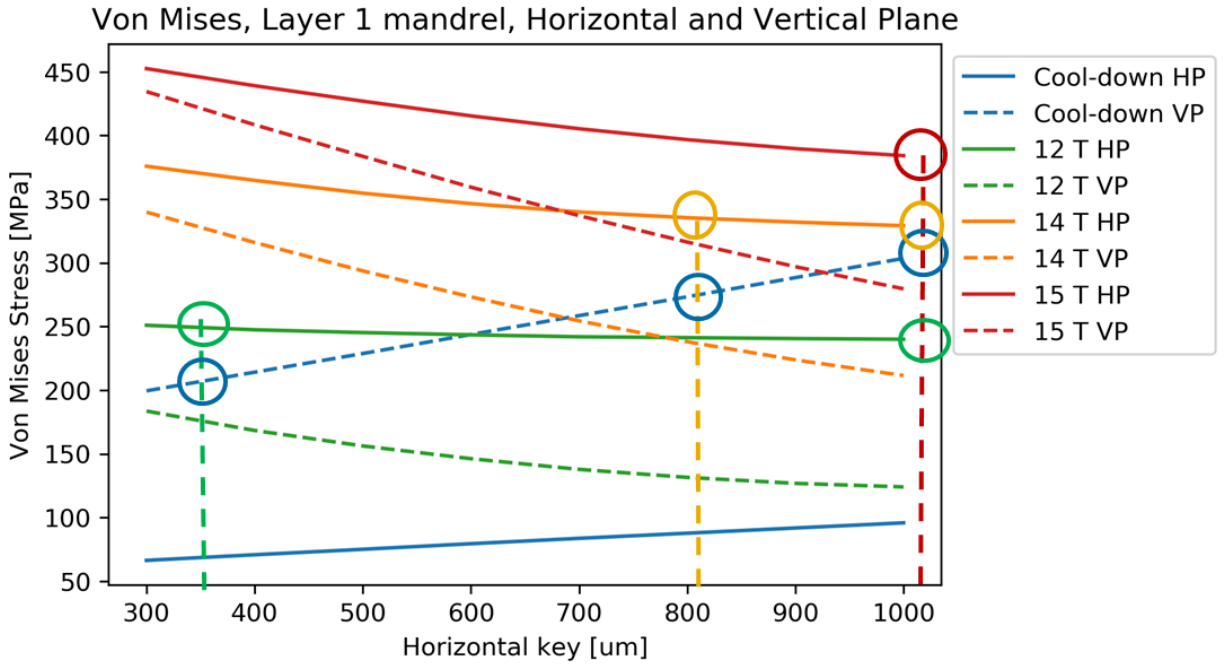


Comparison is made with a fully shared-nodes model

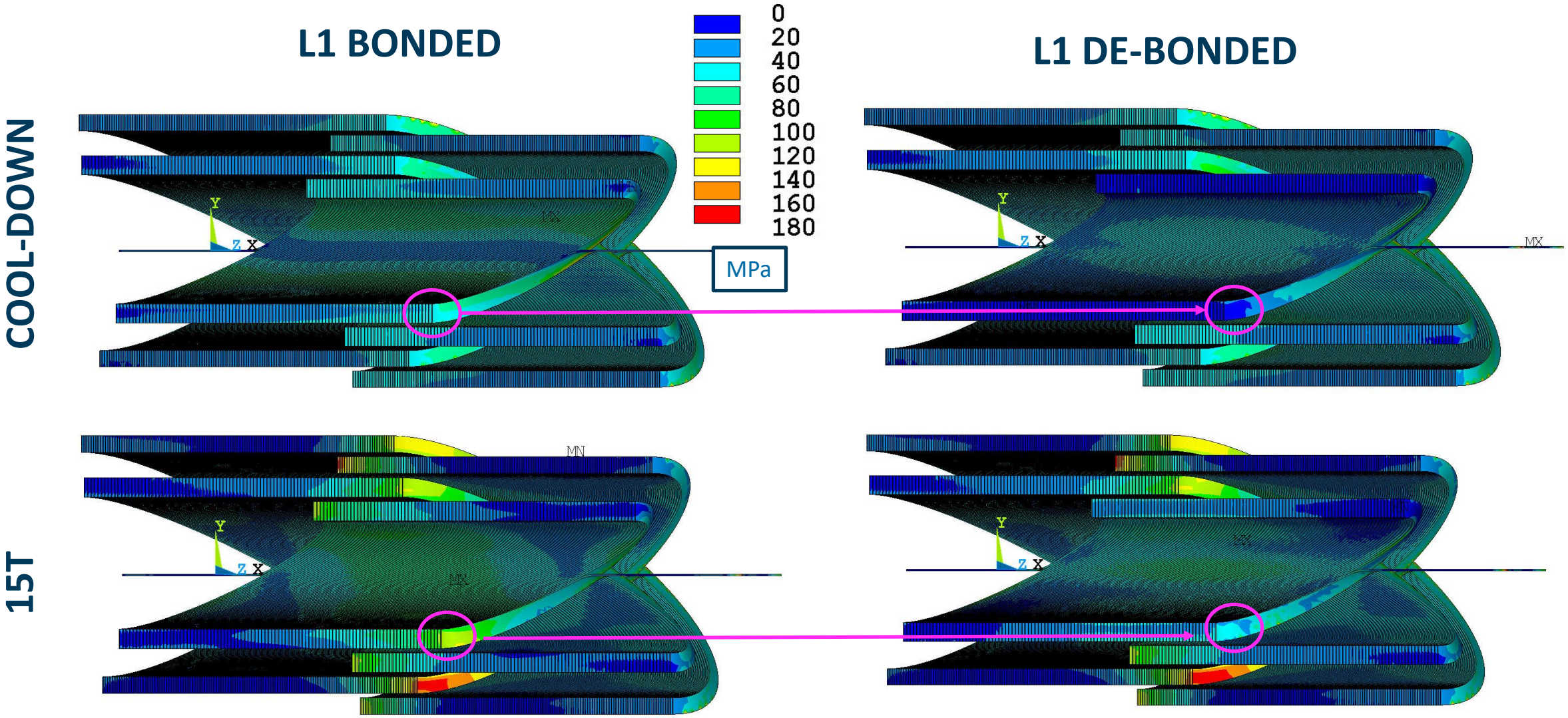
Key values to minimize the deformation
Von Mises stress in the mandrel in 1st layer





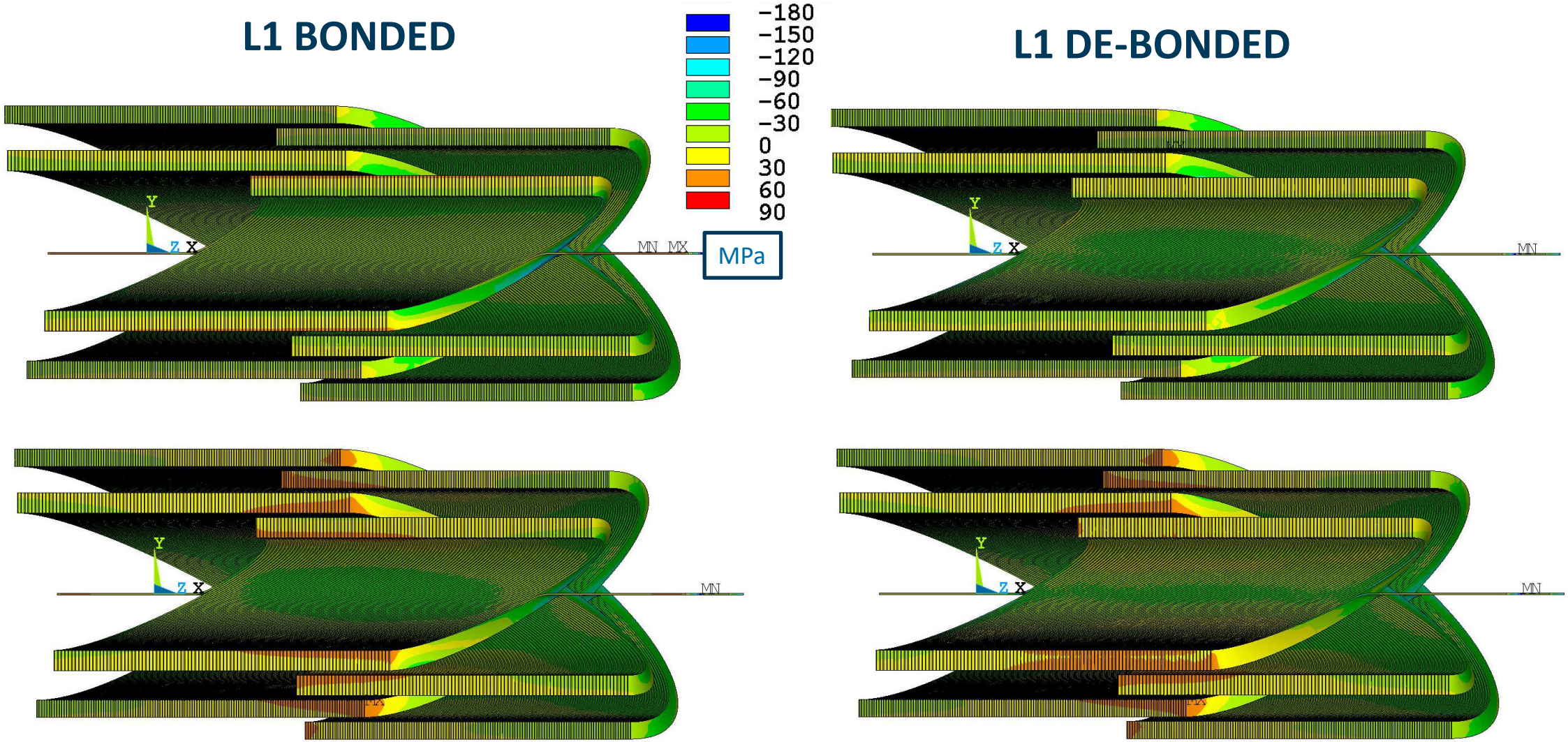


Stress in the coil (von Mises)



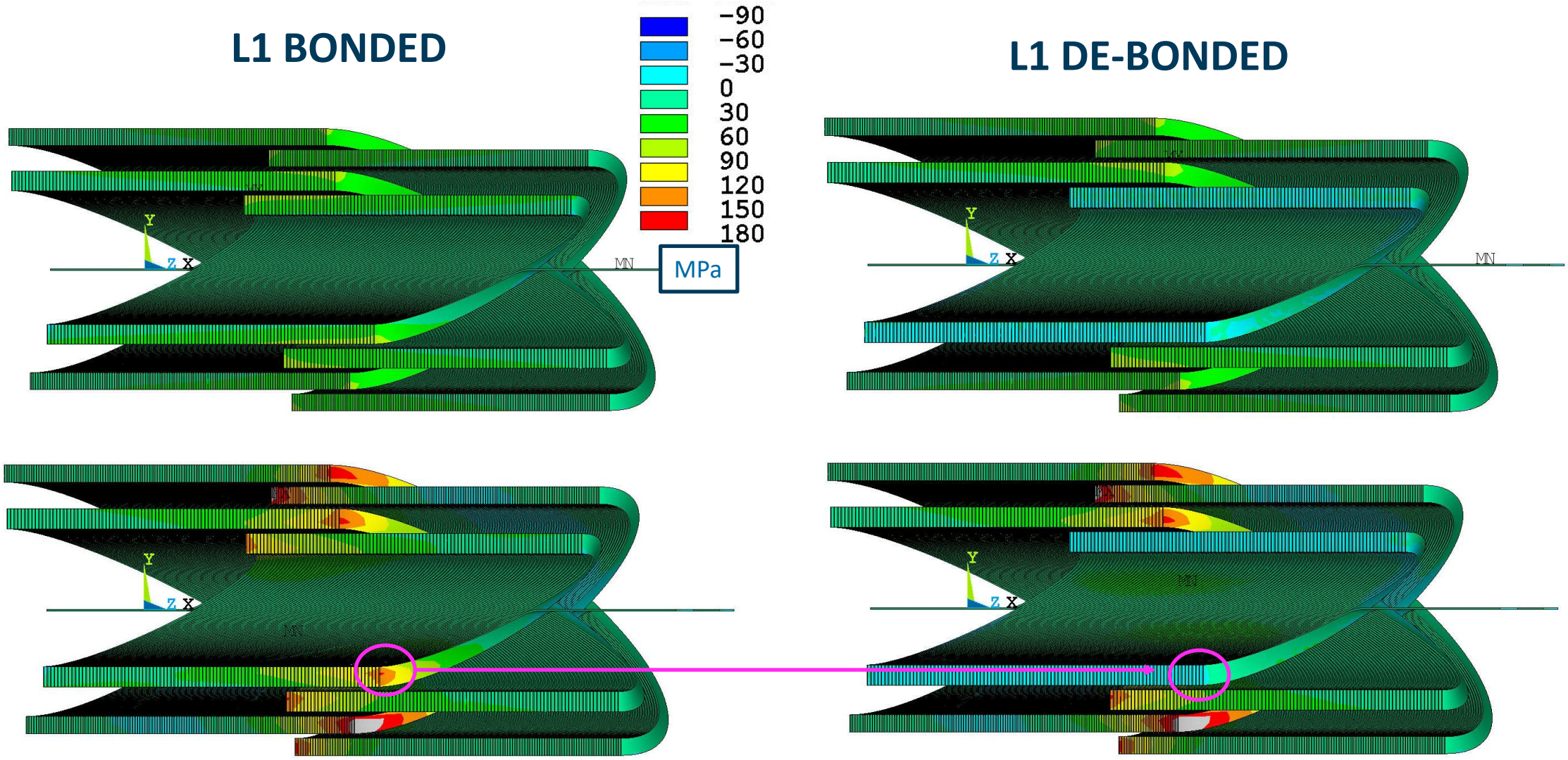
Overall reduction of stress in the de-bonded layer (~40MPa)

Stress in the coil (Azimuthal)



Azimuthal stress remain nearly the same

Stress in the coil (Axial)



Significant reduction of the axial stress after debonding

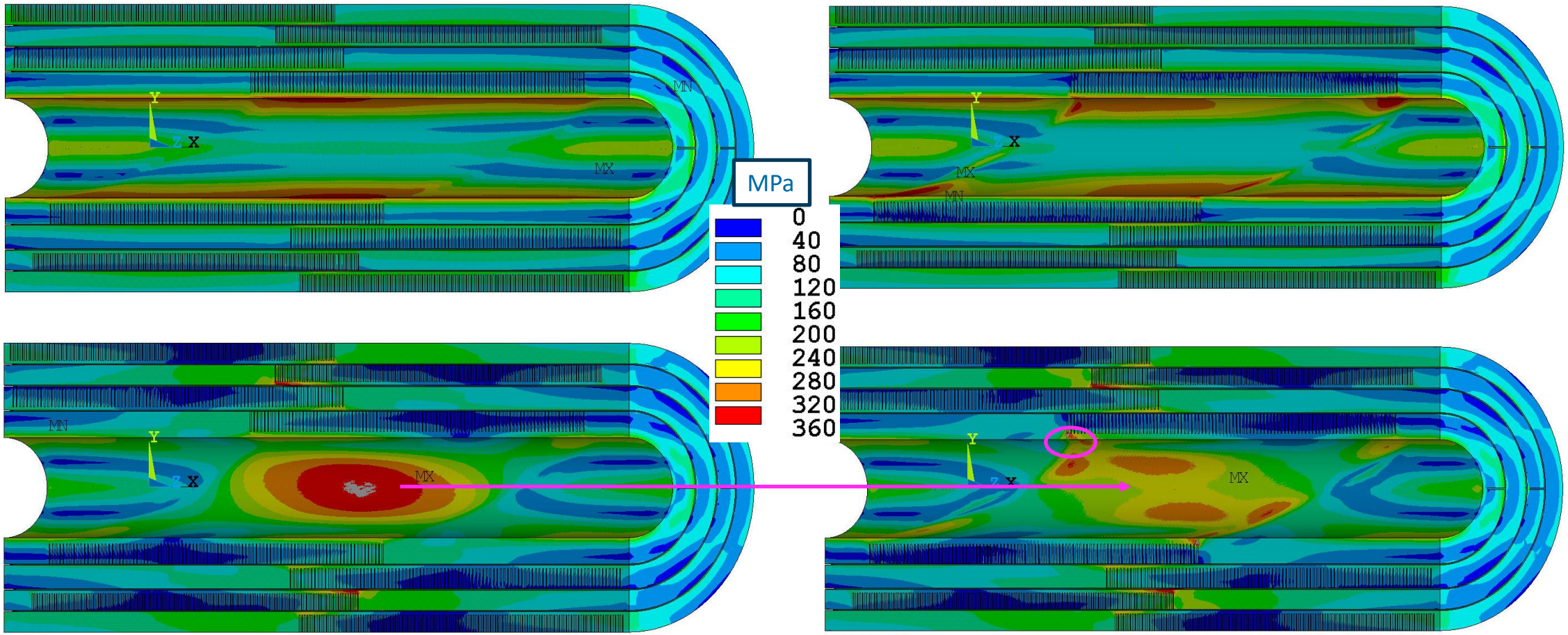
Stress in the mandrel (von Mises)

L1 BONDED

L1 DE-BONDED

COOL-DOWN

15T



Bending (and stress) in the center of the mandrel is reduced

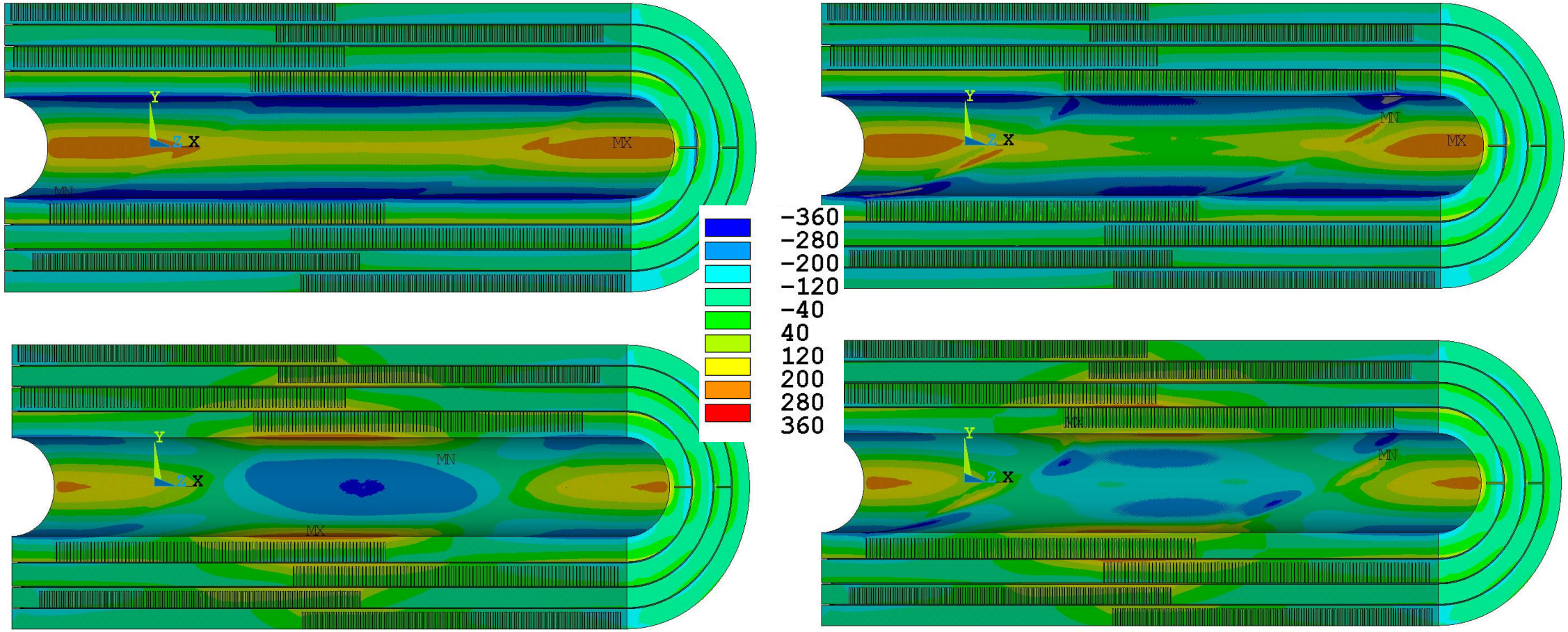
Stress in the mandrel (Azimuthal)

L1 BONDED

L1 DE-BONDED

COOL-DOWN

15T



Azimuthal stress in the center is reduced

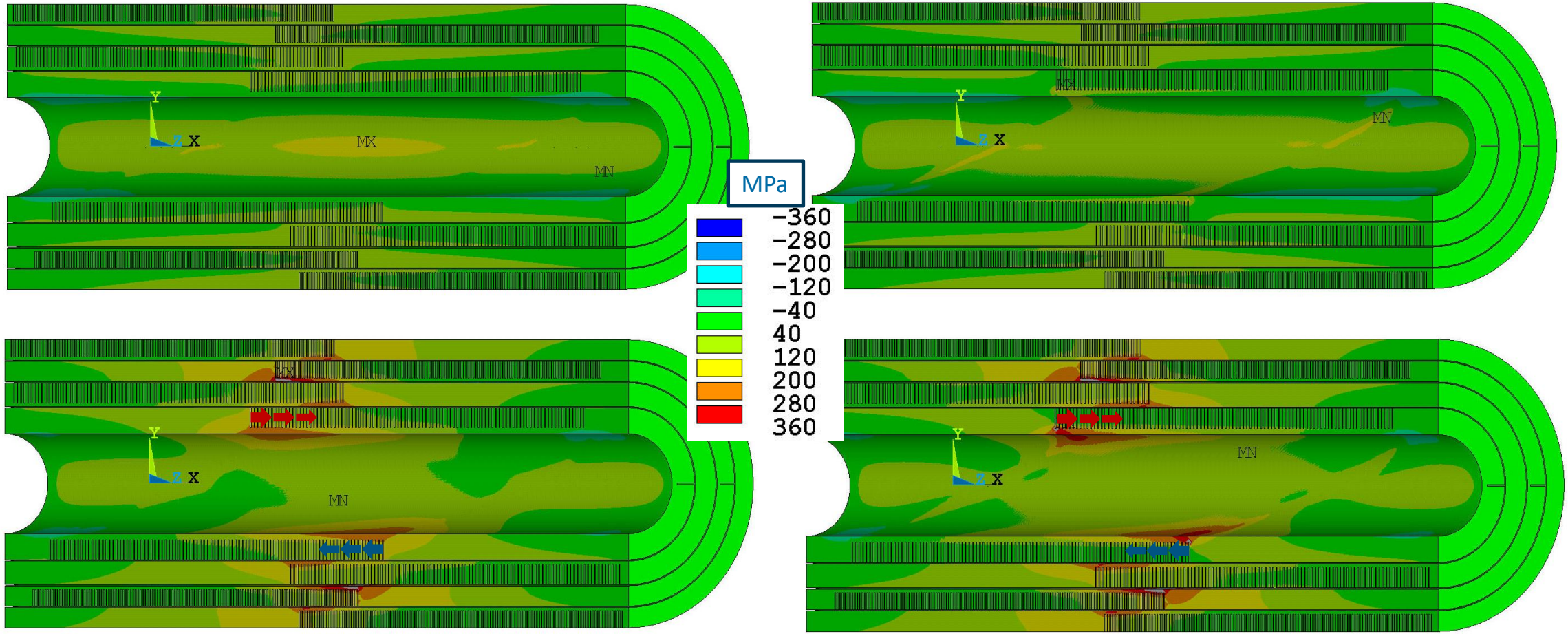
Stress in the mandrel (Axial)

L1 BONDED

L1 DE-BONDED

COOL-DOWN

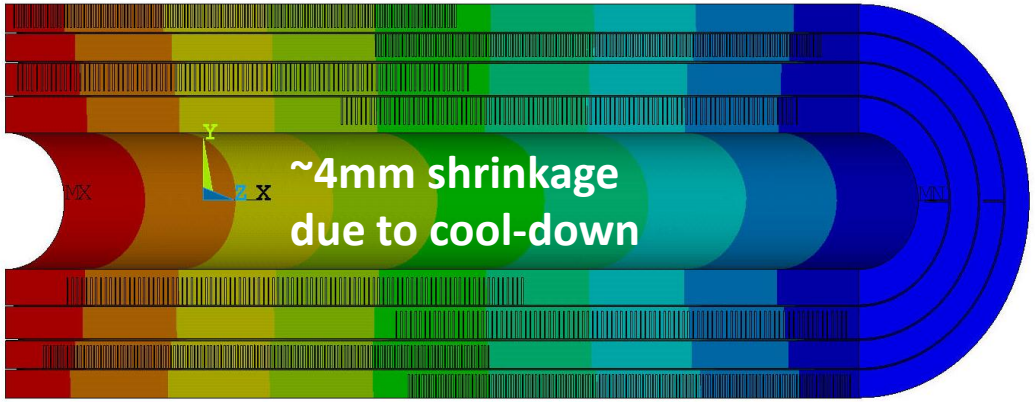
15T

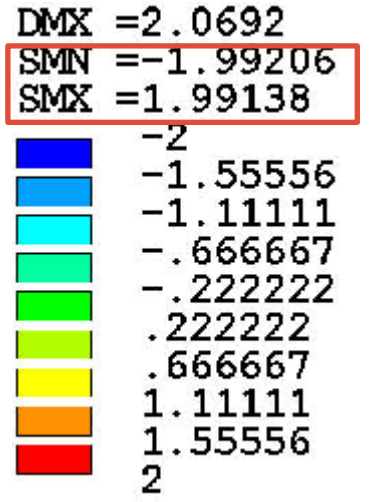


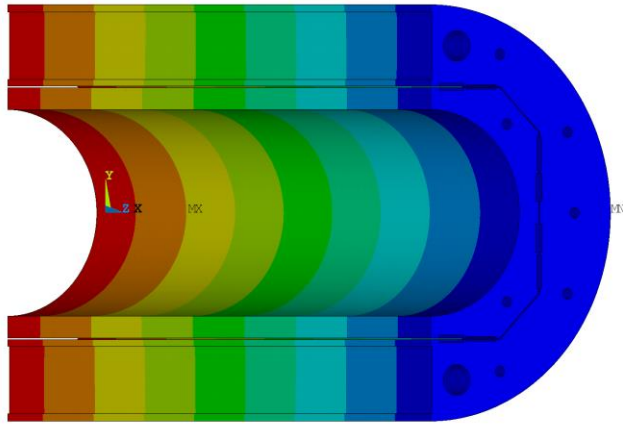
Local increase of the axial tension in the mandrel

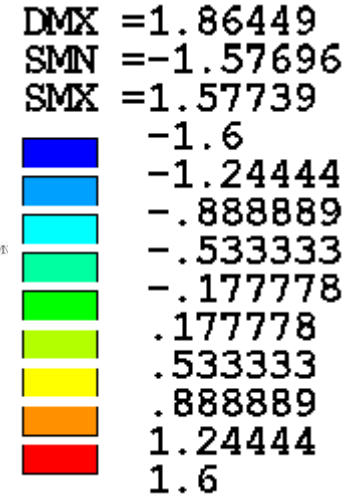
Mandrel vs yoke axial displacement (bonded case)

COOL-DOWN

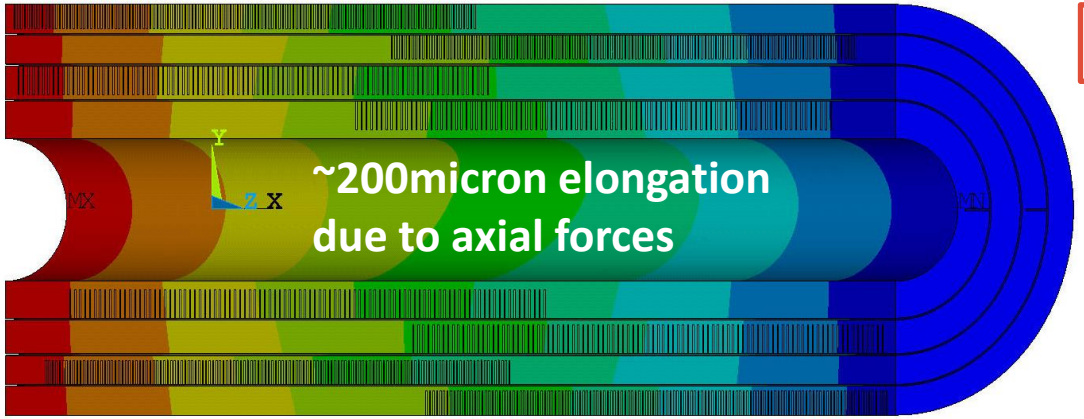


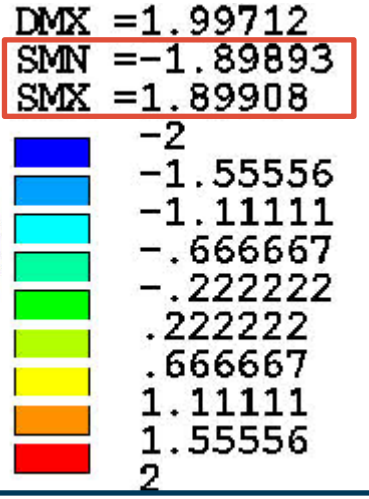


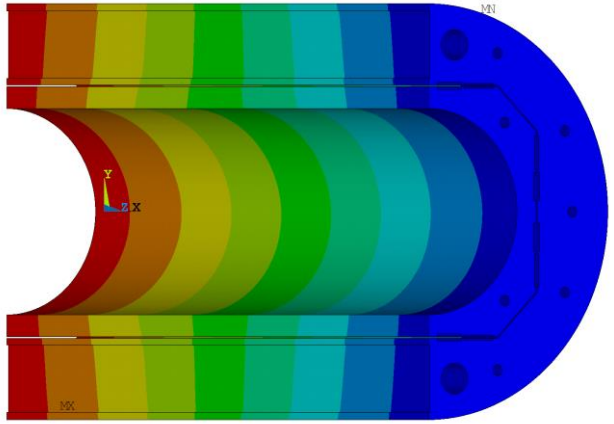


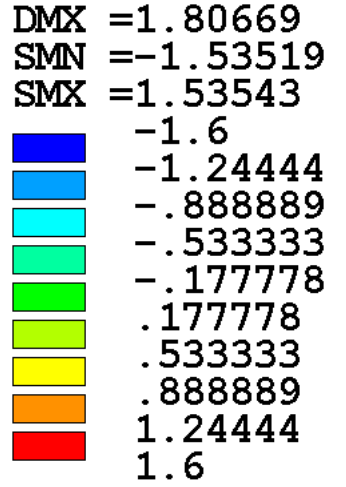


15T









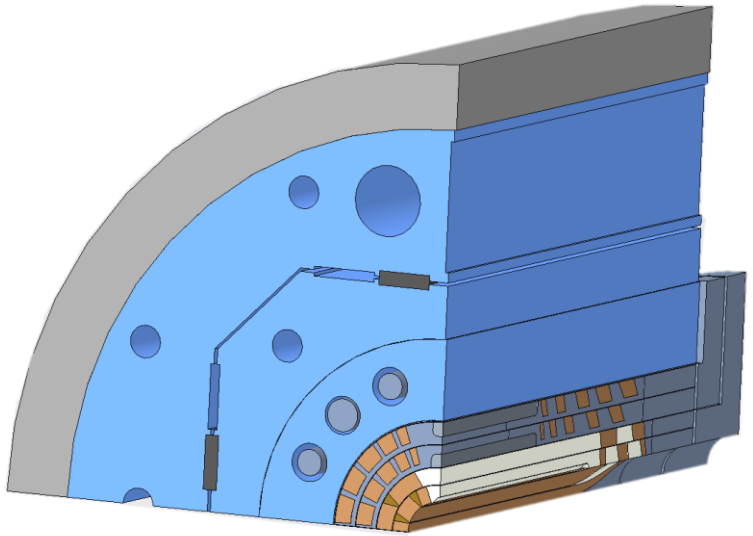
Highest axial forces are localized near the center of the magnet.
External axial system ineffective to provide compressin.

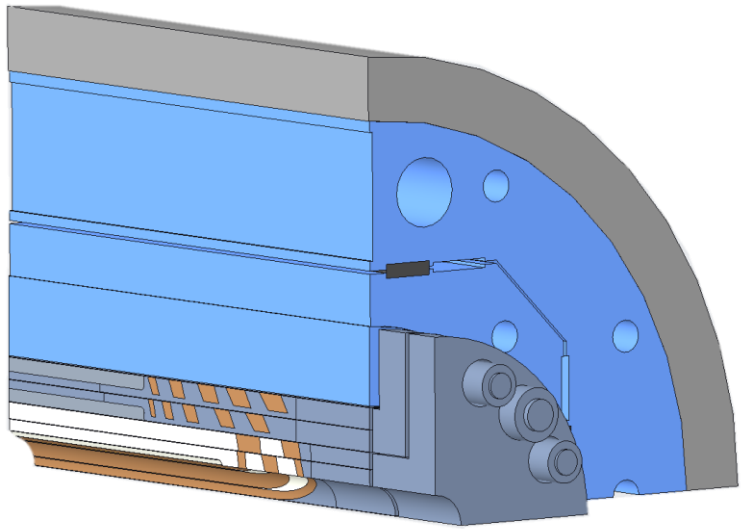
SMCT

Fist steps towards mechanical analysis with the Utility Structure

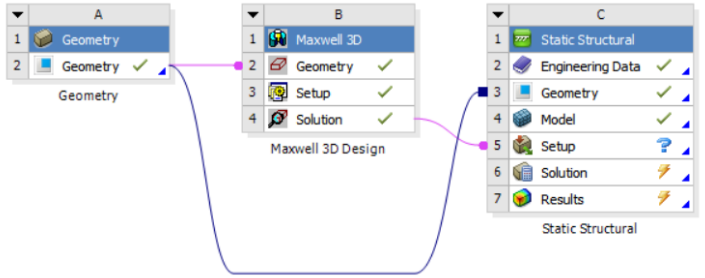
Setting up mechanical analysis of the SMCT in Utility Structure

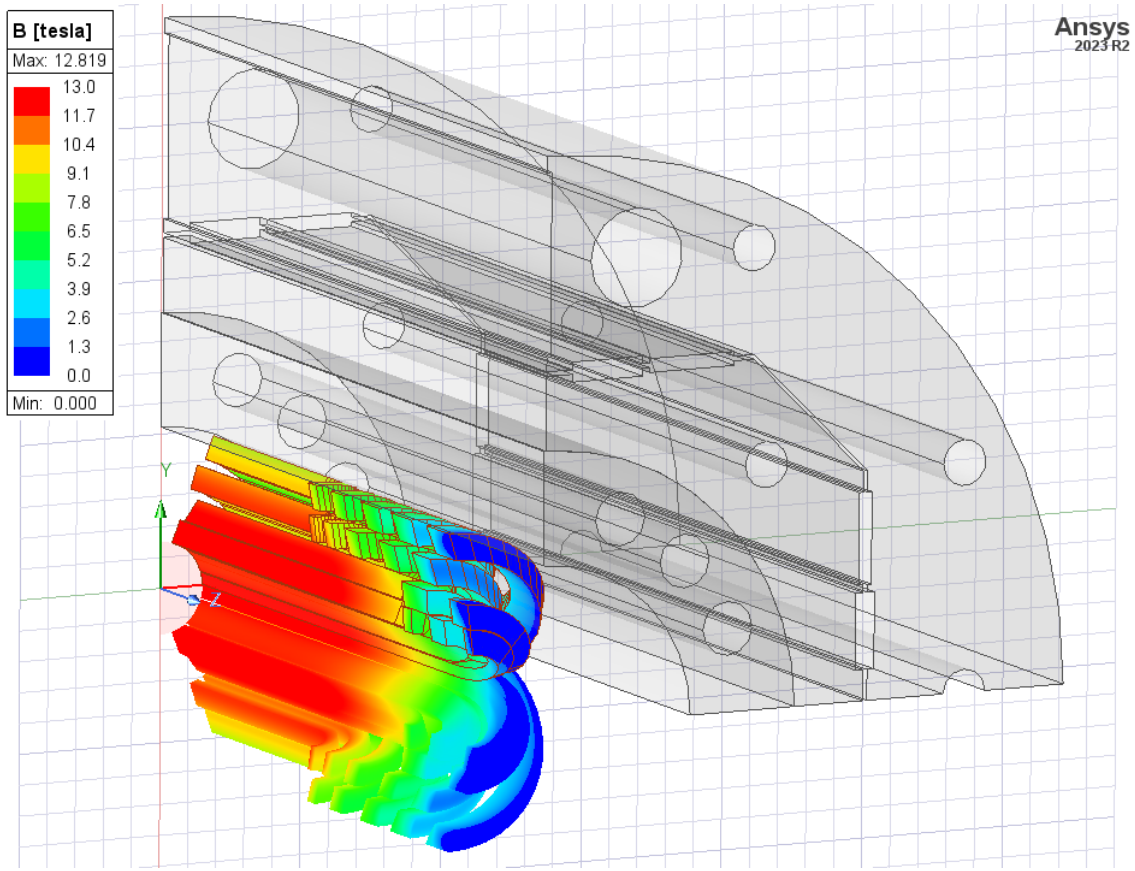
- Coil configuration
  - L1&2: Inner layers from 15T cos-theta coil
  - L3&4: Inner layers of SMCT
- Coil geometry not “as build” but “close enough” (some adjustments might be needed)
- Support structure – first approach
  - Support structure length reduced to 1.1 m
  - Pad inner diameter is the same as for CCT6
  - Iron filler placed between the coil and the pad
  - Axial support system resembles FNAL axial support but with full length axial rods
- Goal of the preliminary analysis – investigate SMCT preload needs without changing the established cross-section





Ansys Maxwell and Workbench



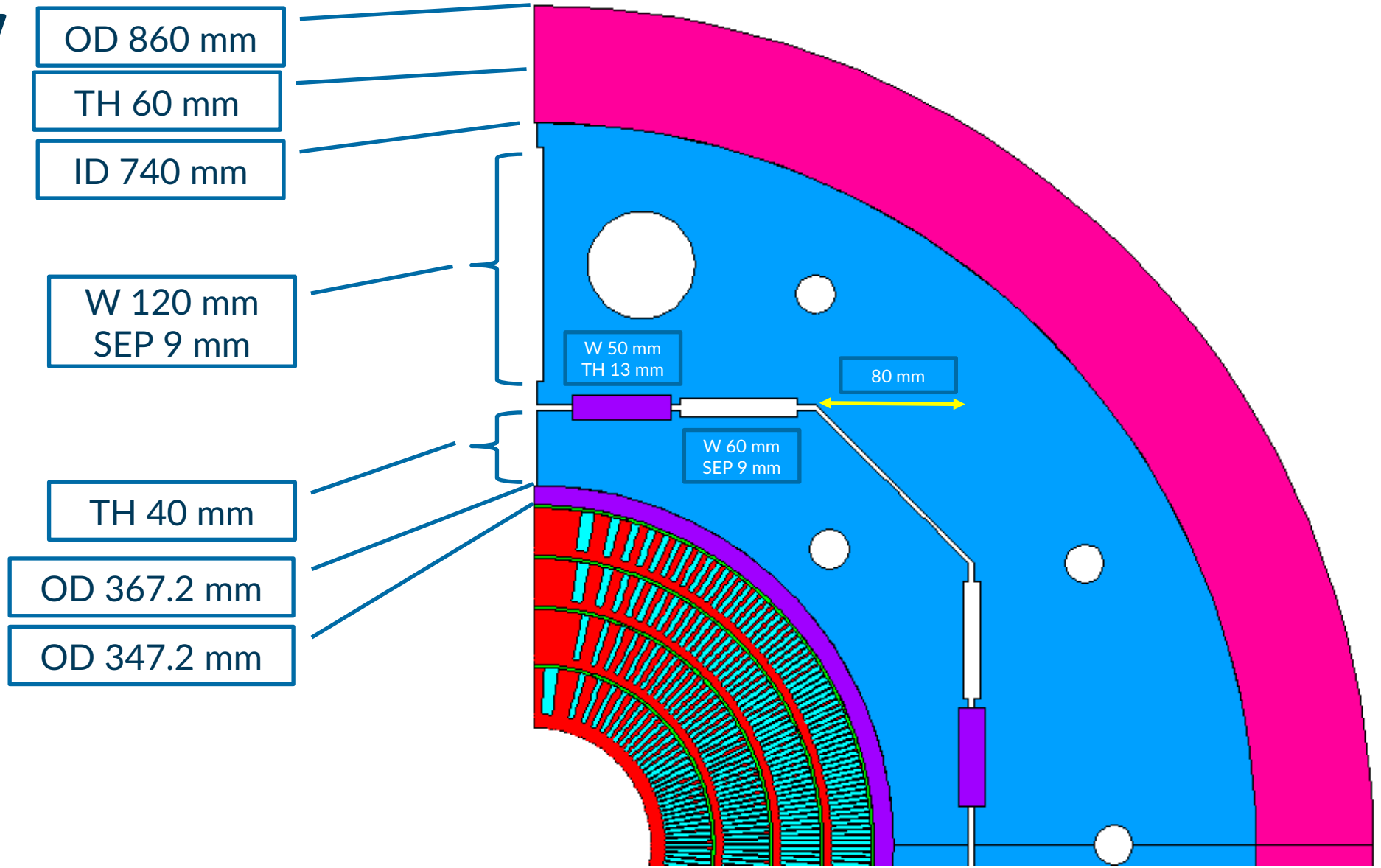


- Magnetic model in Maxwell is operational
  - First solution at 8kA and 13T has to be discussed with Sasha and Igor
- Next step is to set-up the mechanical analysis in Workbench
  - Similar setup and simulation steps as for CCT6 in ANSYS APDL
  - Magnetic forces imported from Maxwell

Thank you!

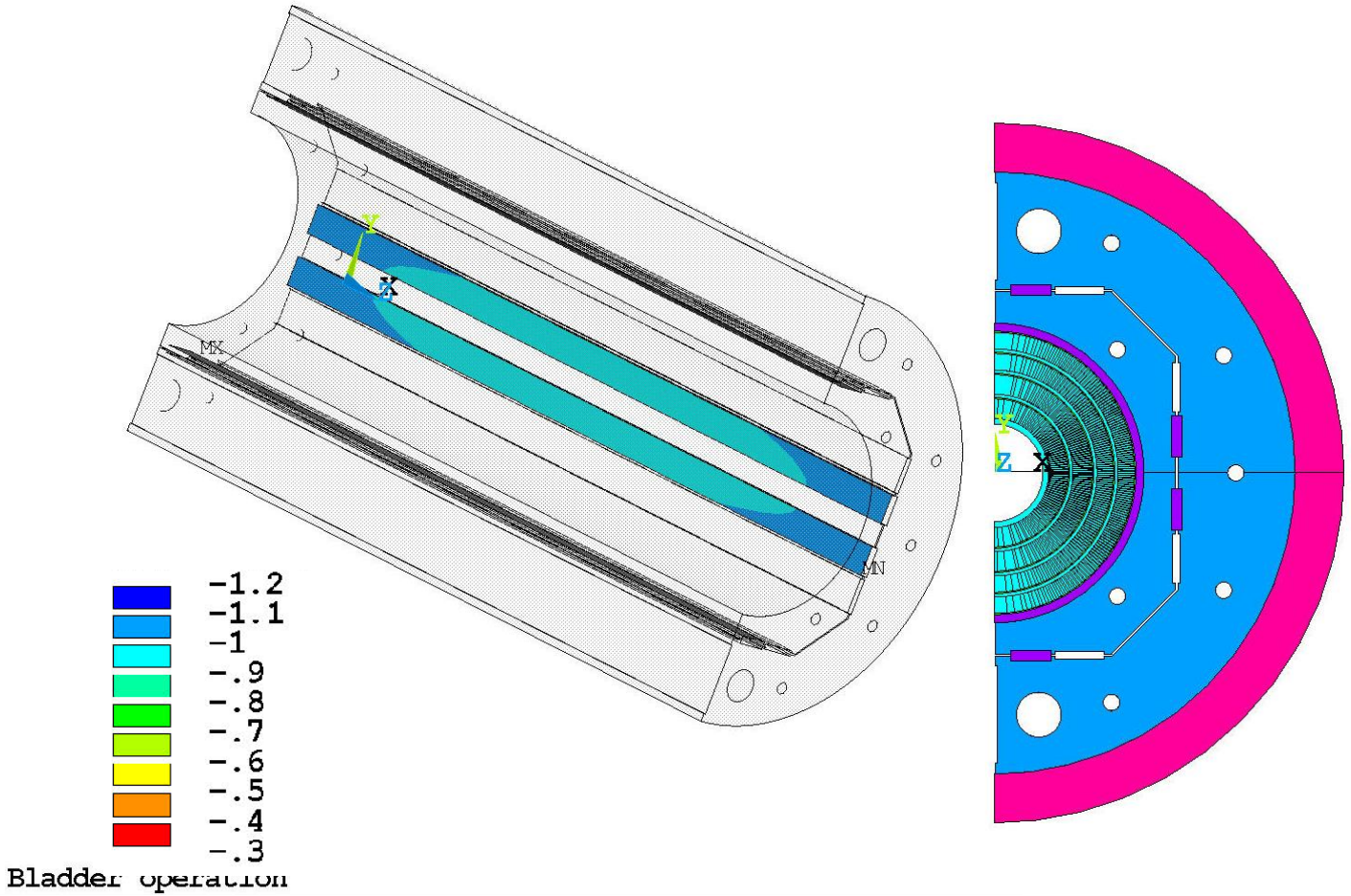
Backup

Geometry



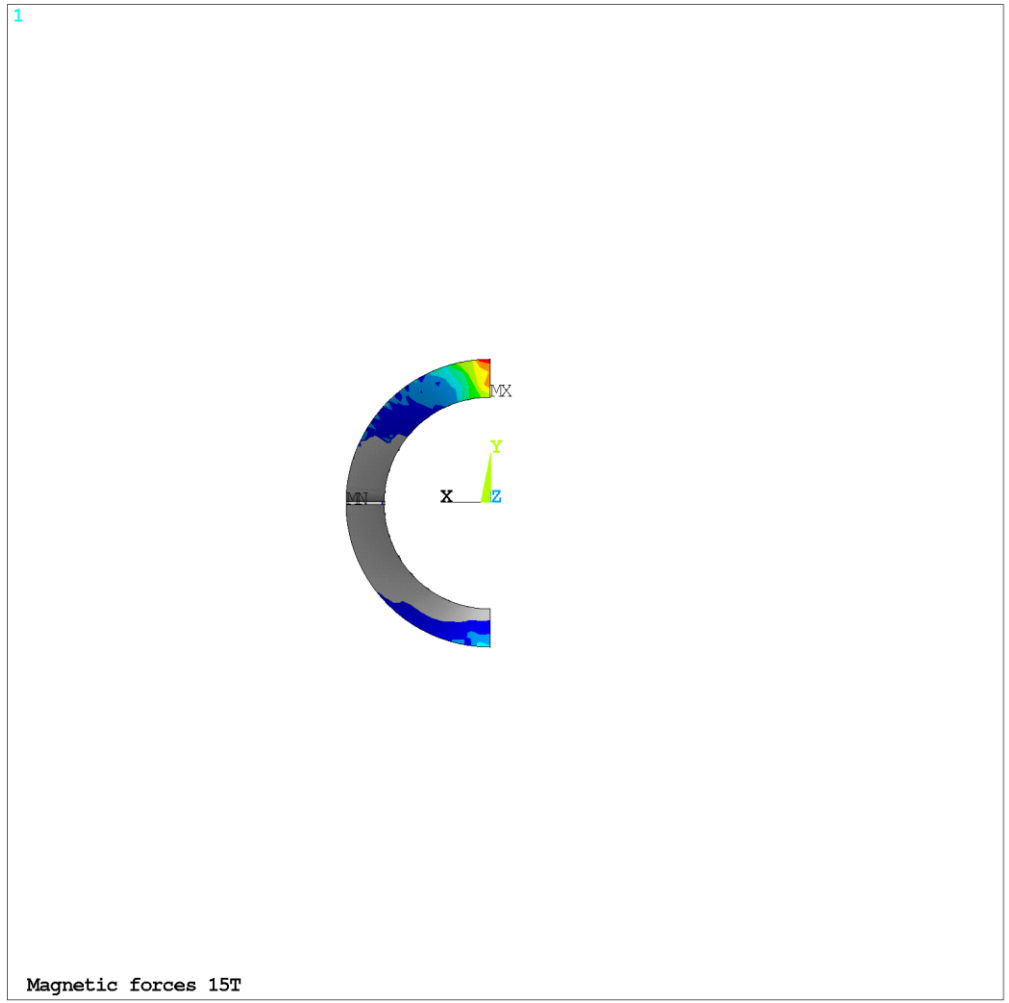
- Separation
  - Yoke to yoke 3 mm
  - Pad to pad 3 mm
  - Pad to yoke 3 mm

Bladder operation at 40 MPa



- 40 MPa allows to open the key slot to about 0.9-1.1 mm
- Enough for 800 um key
- There is no space for bigger bladders
- Bladders can withstand higher pressure

Distribution of azimuthal stress is symmetrical



ANSYS 2021 R2
Build 21.2
PLOT NO. 1
NODAL SOLUTION
STEP=5
SUB =1
TIME=5
SY (AVG)
RSYS=1
PowerGraphics
EFACET=1
AVRES=Mat
DMX =1.91575
SMN =-201.179
SMX =51.5165

0
5
10
15
20
25
30
35
40
45