U.S. MAGNET DEVELOPMENT PROGRAM

BERKELEY LAB

Support structure optimization Testing CCT6 at LBNL

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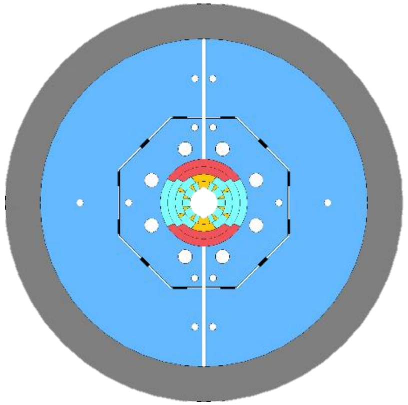
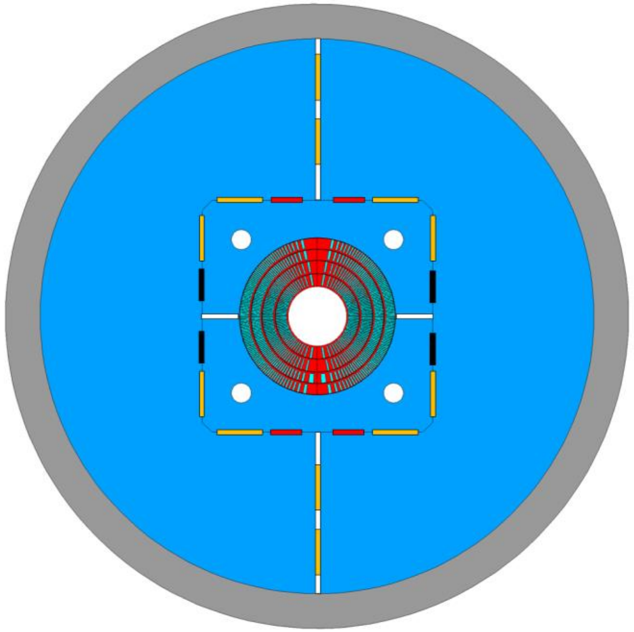
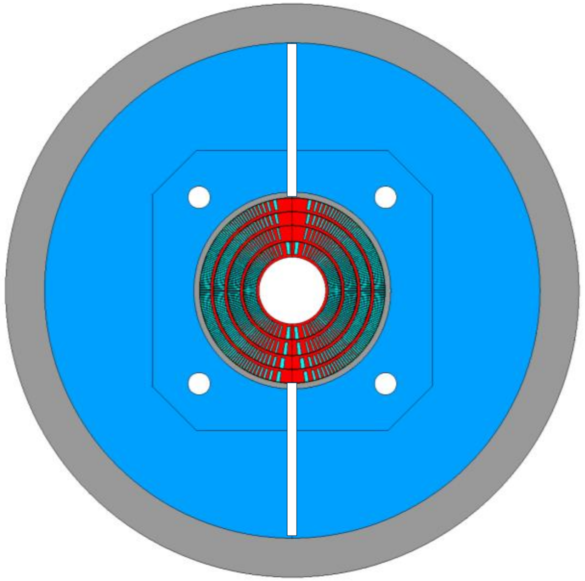
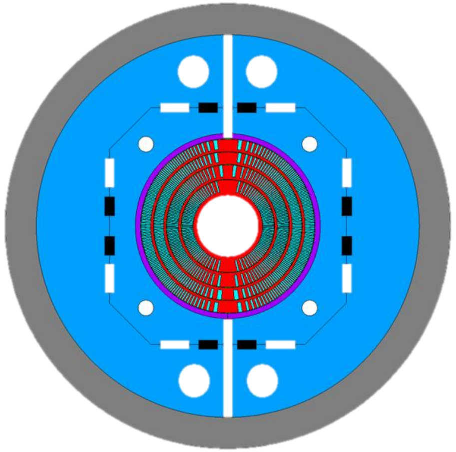
MDP structure design evolution for various goals/constraints







This presentation



750 mm OD

- CCT5/MDPCT
- Smaller FNAL cryostat (?)
- Octagonal pad due to limited space

1260 mm OD

- CCT6/SMCT/20T
- Existing LD1 shell
- Vertical split yoke, horizontal split pad due to high (fixed) cool-down pre-load

1030 mm OD

- CCT6/SMCT
- Current LBNL pit, new cryostat
- Vertical split yoke/pad thanks to smaller shell

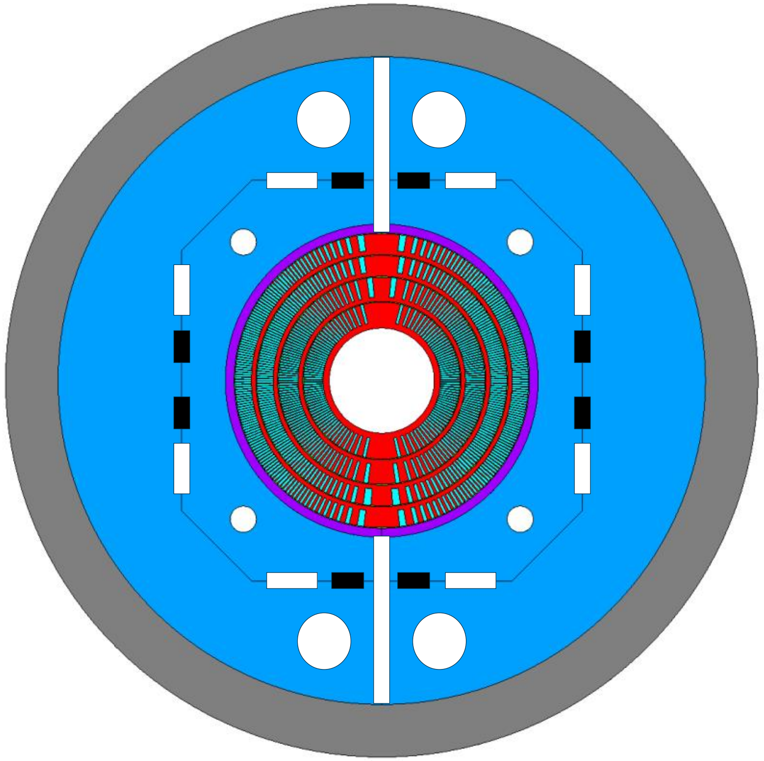
860 mm OD

- CCT6/SMCT
- Current LBNL cryostat
- Optimized spar thickness and new mandrel material

CCT6 structure for current cryostat

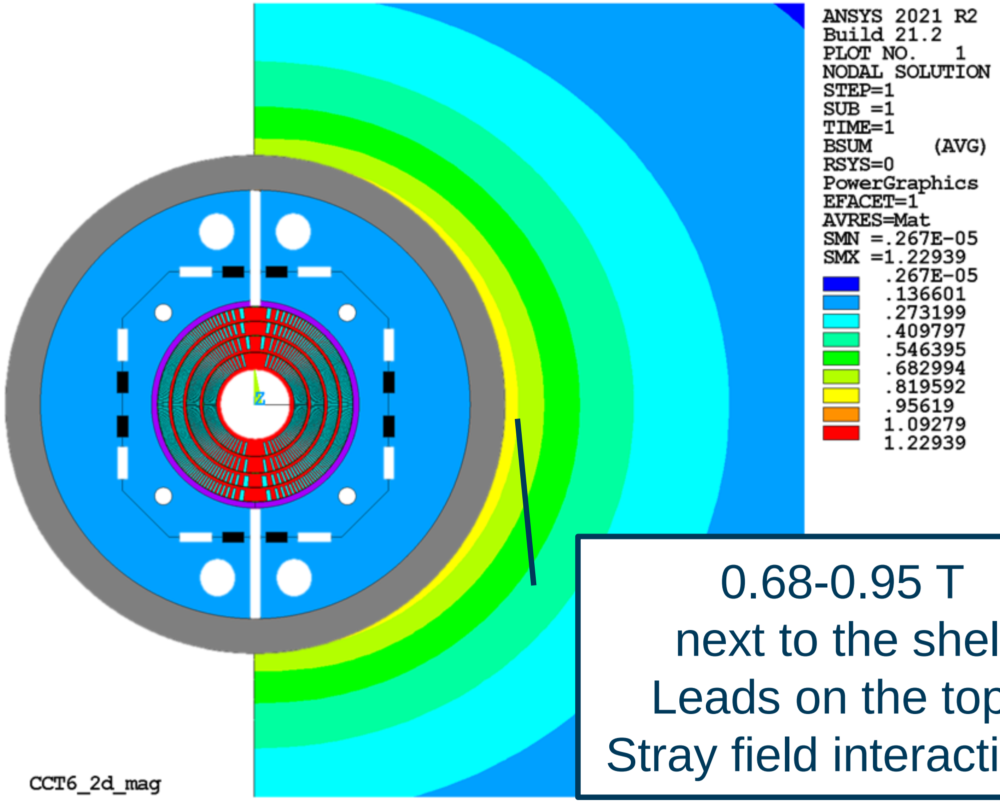
Structure designed around existing LD1 shell (already presented) shows satisfactory coil preload.

Smaller structure is being investigated to take advantage of existing 36” cryostat.



- Aluminum shell
  - OD 860 mm, TH 60 mm
- Iron yoke/pad
  - Vertical split
- Protective shell (split)
  - Stainless steel
- Aluminum bronze mandrel
  - Spar thickness 7-5-5-5 mm
  - C63000 instead of C94500
- Load keys
  - Horizontal 700um, Vertical 0um
- Bladder pressure
  - < 40MPa
- Magnet supported from the yoke
- Leads at the top

Impact of reduced yoke OD



0.68-0.95 T
next to the shell
Leads on the top?
Stray field interaction?

- Mechanical analysis at 13.2 T
  - Current for 1260 mm OD structure
    - 11.8 kA
  - Current for 860 mm OD structure
    - 12.58 kA
  - About 6.6% increase due to reduced iron OD
    - Impact on current margins (1-2 %? TBD)

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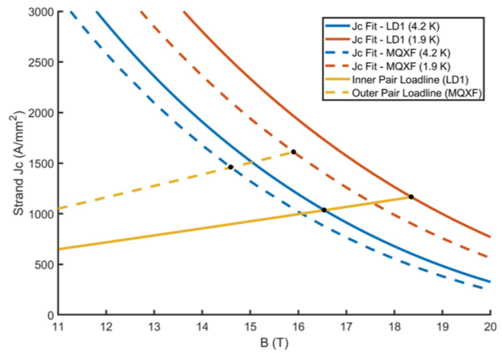
Short-sample current margin of 30+ % at target operating points

- 30+ % current margin at target fields of 12 T, 4.2 K and 13 T, 1.9 K
- only 1-2% rise of field at conductor in 3D

TABLE IV
SHORT-SAMPLE AND CURRENT MARGIN

operating point	current (kA)	energy (MJ)	layer pair	conductor field (T)	I_{ss} (kA)	current margin
12 T, 4.2 K	10.1	2.3	1,2	12.2	14.4	30%
			3,4	10.2	15.3	34%
13 T, 1.9 K	11.1	2.7	1,2	13.2	16.2	32%
			3,4	11.1	16.8	34%



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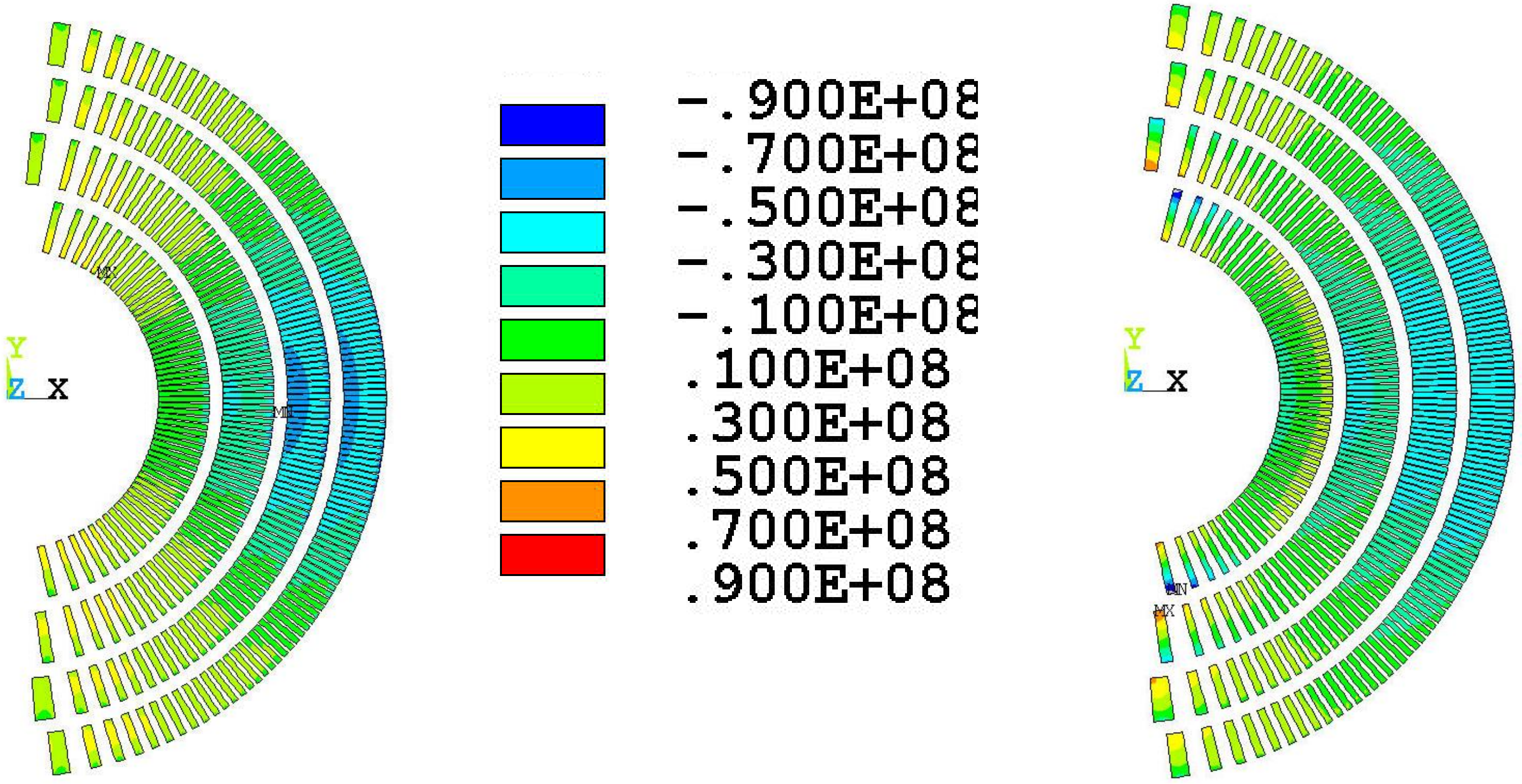
Conductor stress with magnetic forces at 13.2T (bonded)

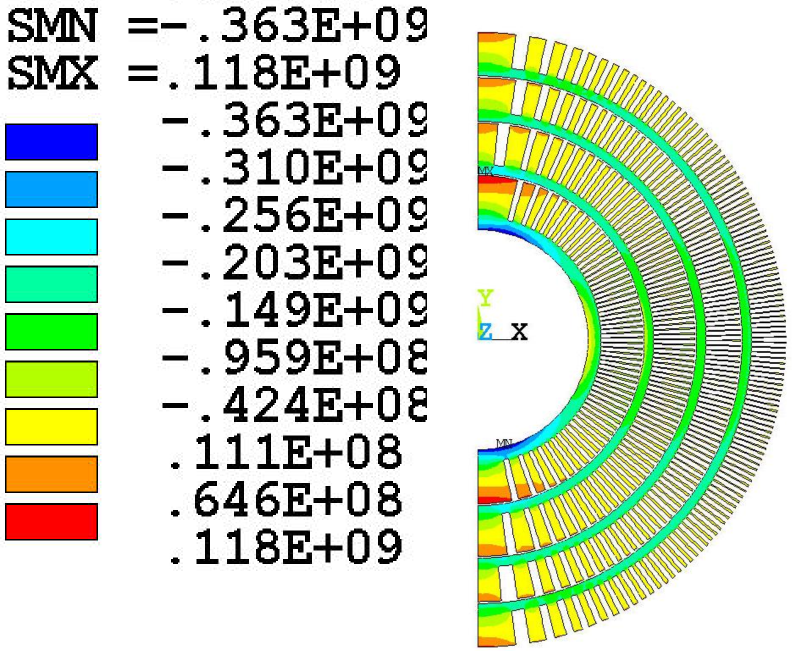
Radial stress <70 MPa

Azimuthal stress < 120 MPa



Mandrel Stress (azimuthal stress) <363MPa (C63000 Rp0.2 at 4.2K is 578.6 MPa)

Cool-down < 363 MPa



C63000

at RT as produced

Rm/Rp0,2/A: 857/612/12 MPa/MPa/%

at RT after a heat treatment at 670ºC for 48h.

Rm/**Rp0,2**/A: 739/**390**/23 MPa/MPa/%

at 4.2 K after a heat treatment at 670ºC for 48h.

Rm/**Rp0,2**/A: 918/**578**/6 MPa/MPa/% and an elastic modulus of 133 GPa

C94500

at RT as cast

Rm/Rp0,2/A: 515/205/12 MPa/MPa/%

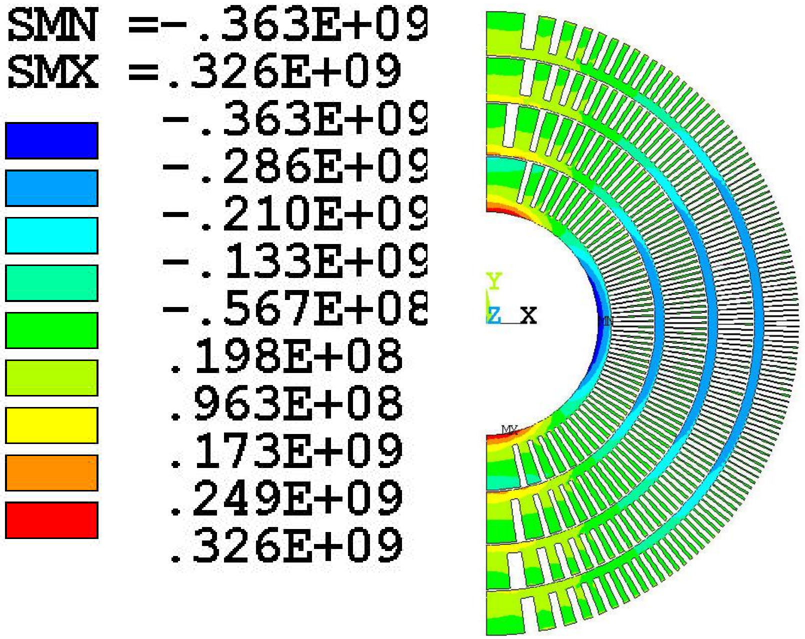
at RT after TQ50 temper

Rm/Rp0,2/A: 620/310/6 MPa/MPa/%

at 4.2 K after a heat treatment at 670ºC for 48h.

No data (plan to do the measurement)

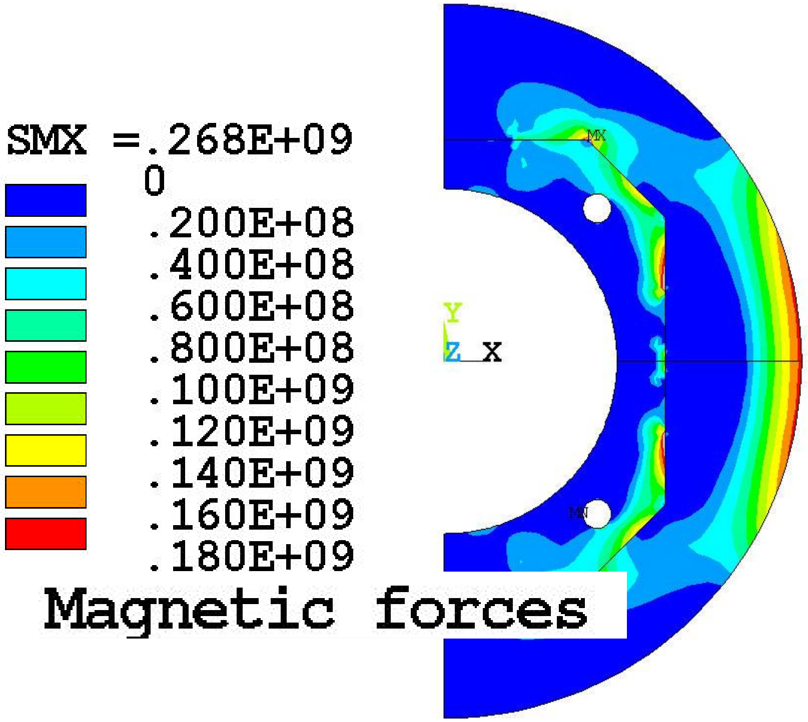
Magnetic forces < 363 MPa

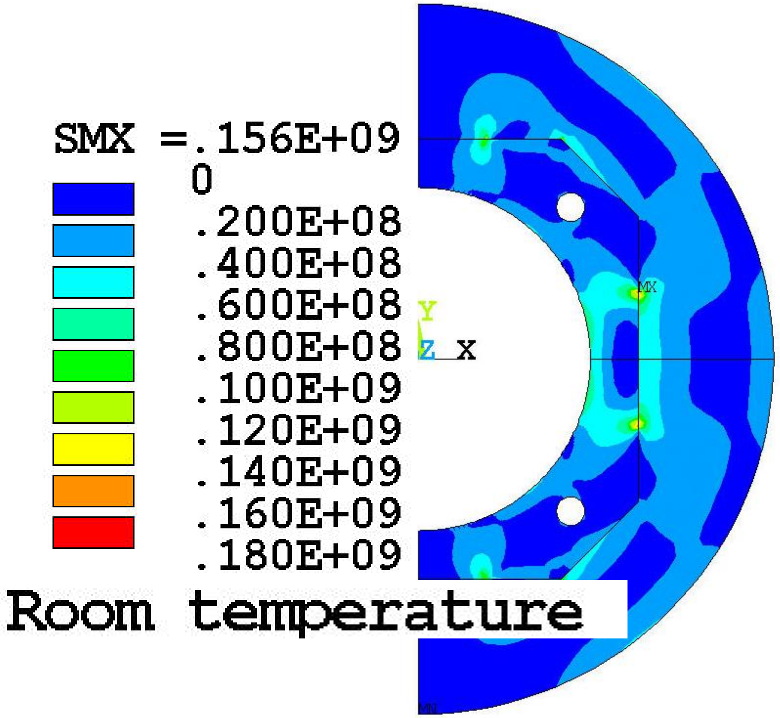


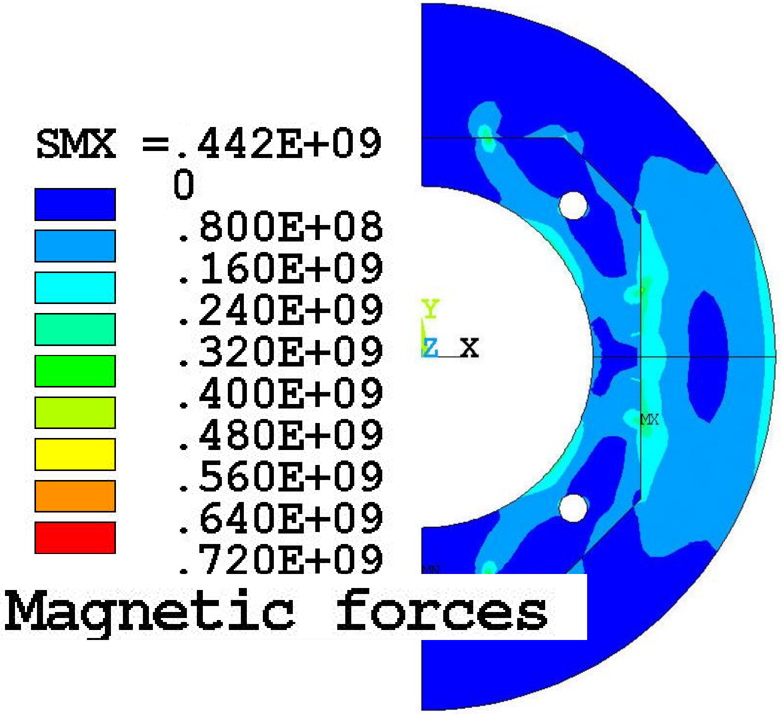
Iron yoke and pad

First principal stress

Von Mises stress

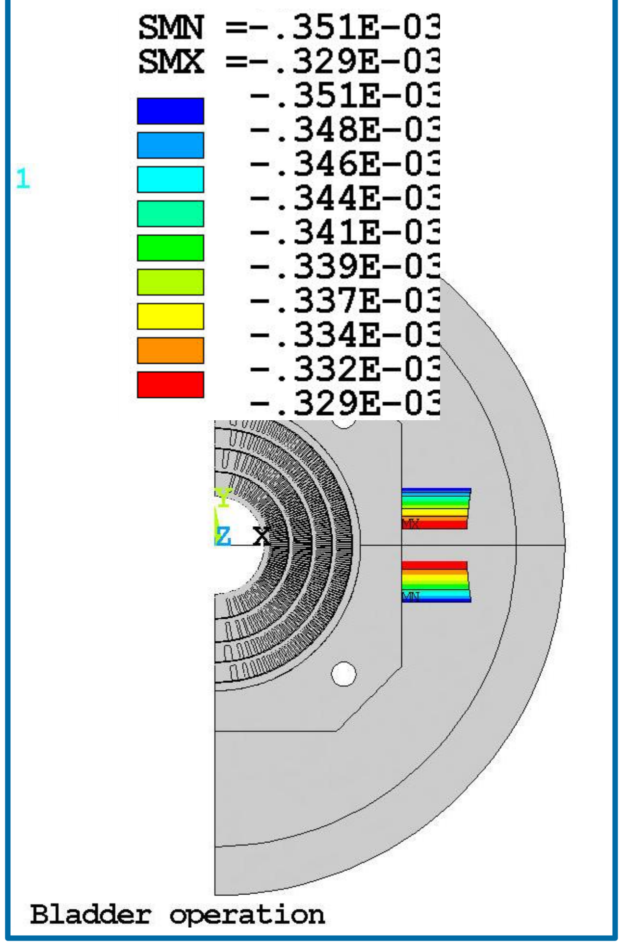


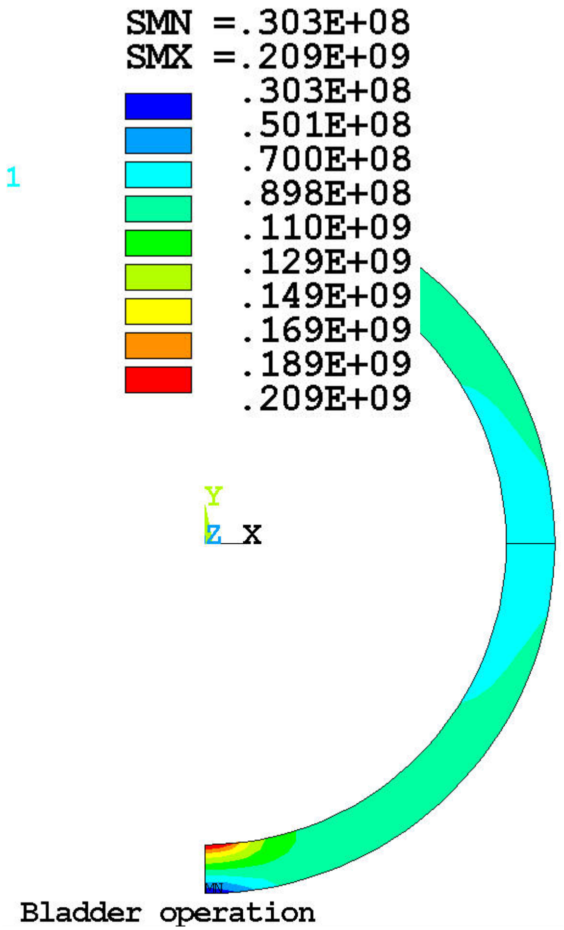


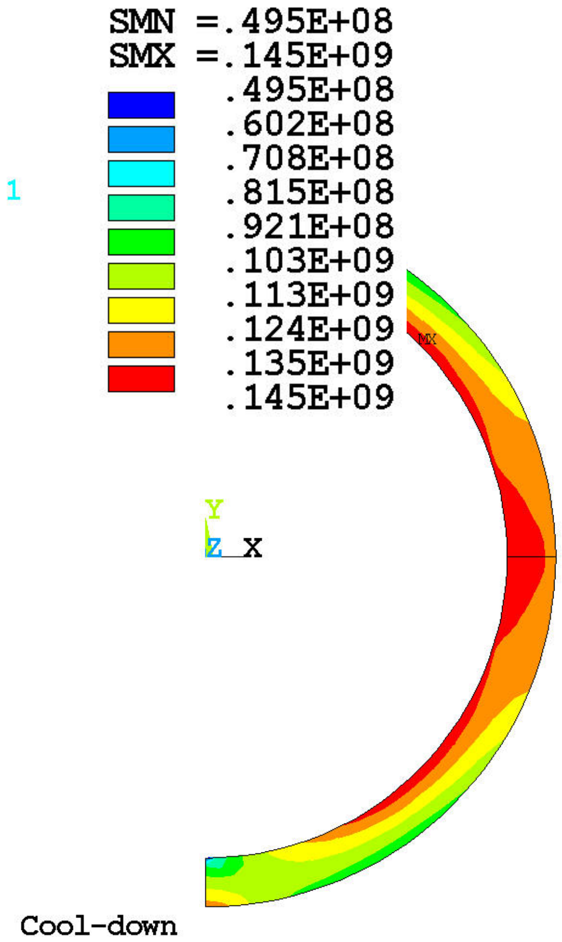


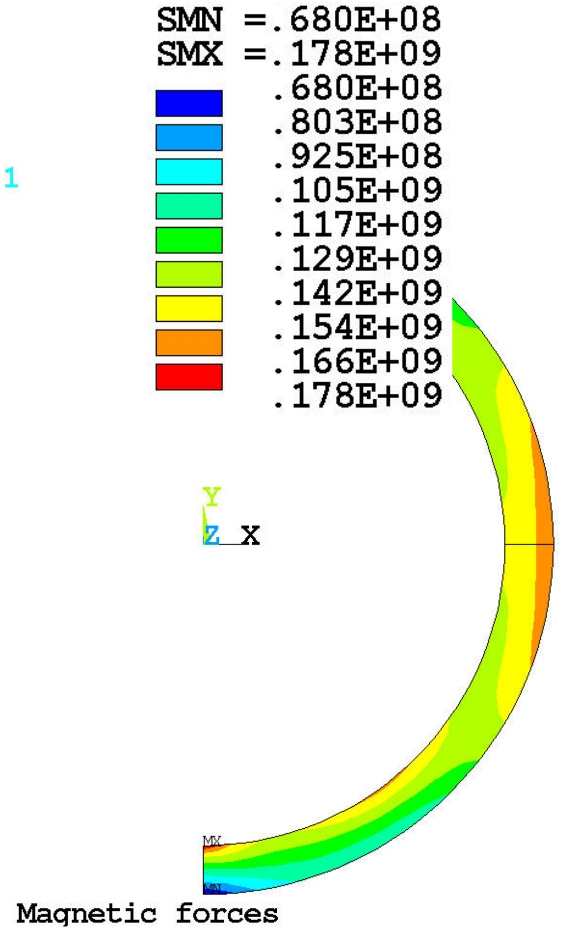
Azimuthal Shell Stress

Gap [m] at 40 MPa bladder pressure









Conclusions

- Design with reduced structure OD does not show any major limitations
  - Analysis is still ongoing
  - Optimized spar thickness and new mandrel material allow to mitigate mandrel deformation/damage risk
- Next steps
  - Investigation of testing CCT6+BiCCT1/2
  - Performing analysis with SMCT geometry (860 and 1260 mm OD shells)