MDP - Common-Coils 20 T PSI Contribution to the magnet design and analysis

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March 12, 2024

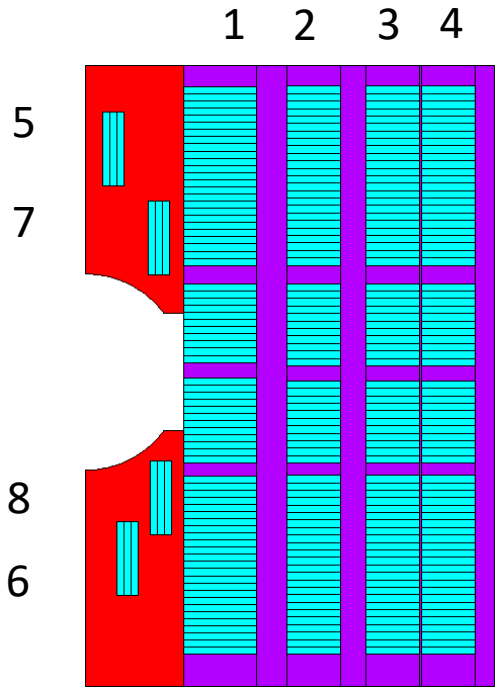
Cross-Section

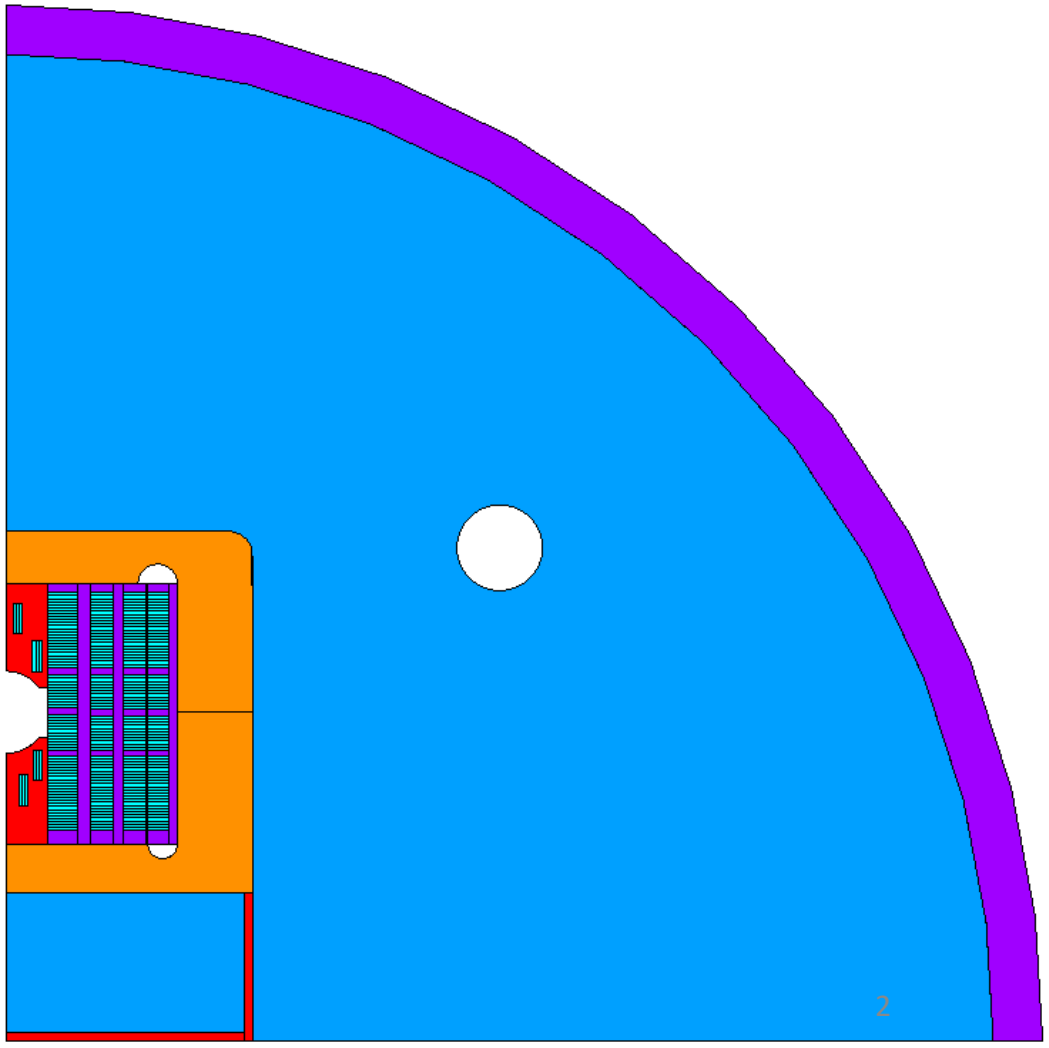
- Intra-beam distance of 400 mm
- Yoke diameter of 1.2 m
- Shell (stainless) thickness is 30 mm

- 4 common-coils

1 x HTS + 3 x Nb_3Sn

- 4 pole-coils (HTS)
- 50 mm clear bore
- Target Field is 20 T





Coil and Cable Parameters

Layer	Type	N turns
1	HTS	73
2	Nb_3Sn	73
3	Nb_3Sn	73
4	Nb_3Sn	73
5 .. 8	HTS	4 x 3

	Bi2212	Nb_3Sn
Height in mm	18.35	13.3
Width in mm	1.52	1.6
N strands	40	28
Strand Dia in mm	0.85	0.9
Cu/nCu	3	1

	Bi2212	Nb_3Sn 1	Nb_3Sn 2
Height in mm	18.35	19.0	17.1
Width in mm	1.52	1.6	1.6
N strands	40	40	36
Strand Dia in mm	0.85	0.9	0.9
Cu/nCu	3	1.8	2.5

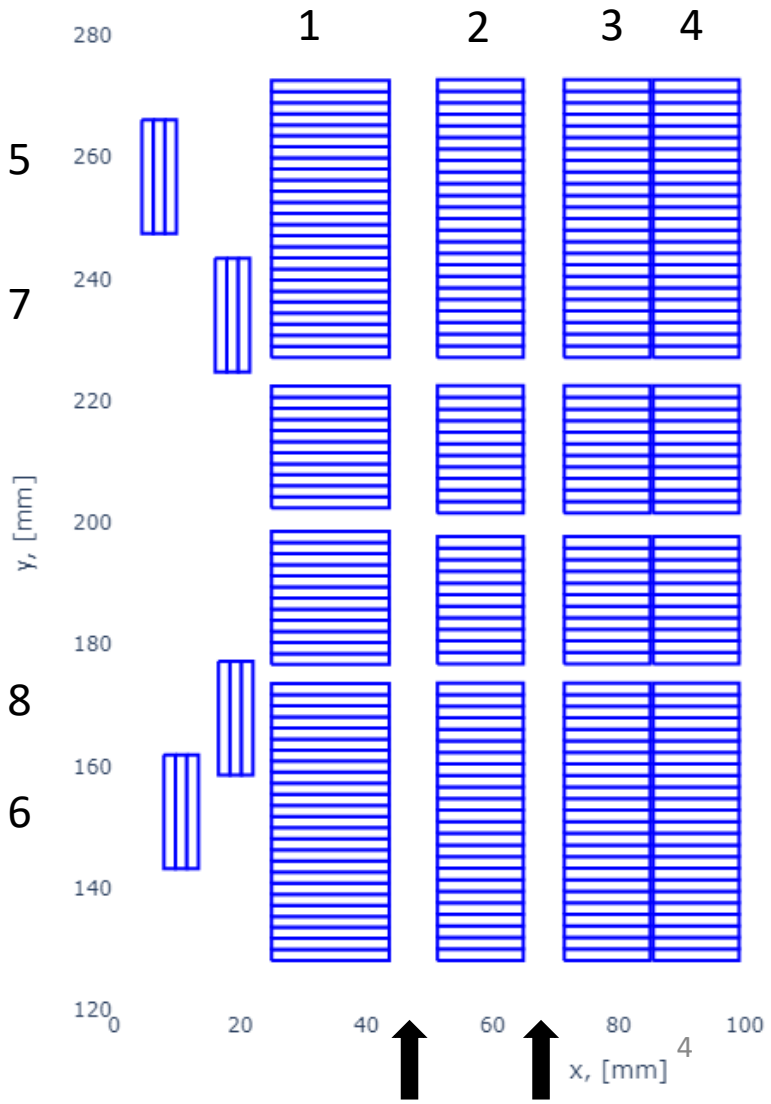
Insulation thickness of 0.15 mm

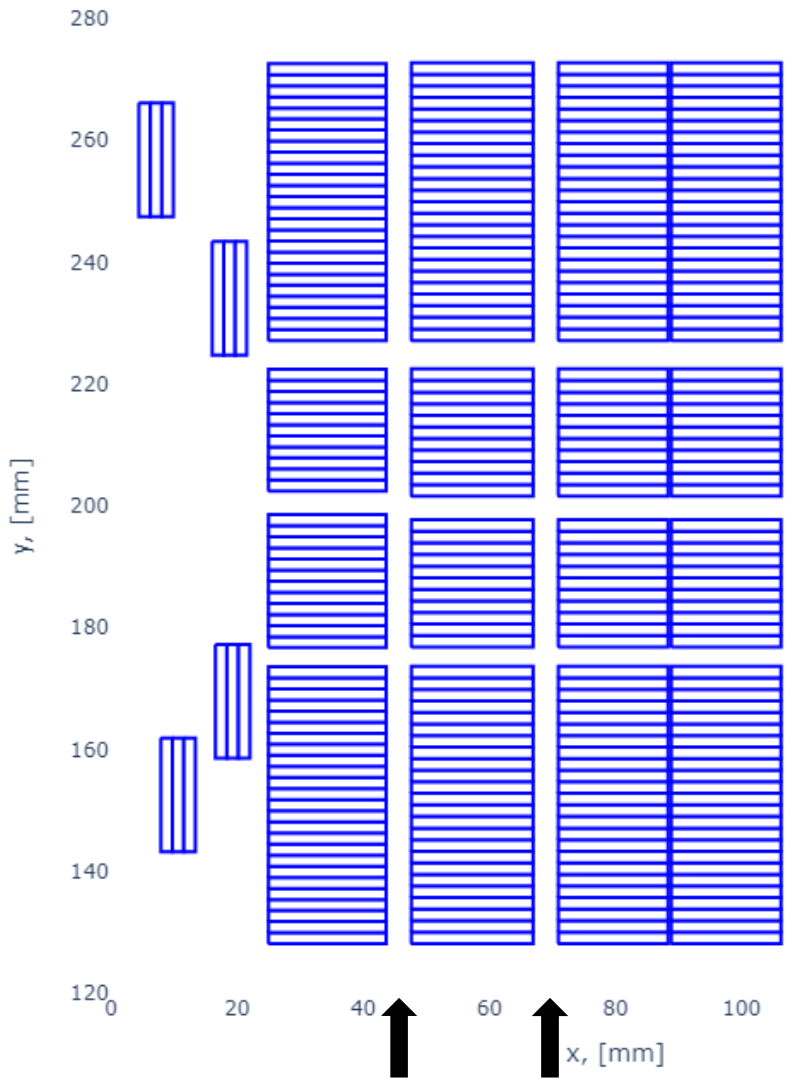
Models 1 & 2

Model 1

Model 2

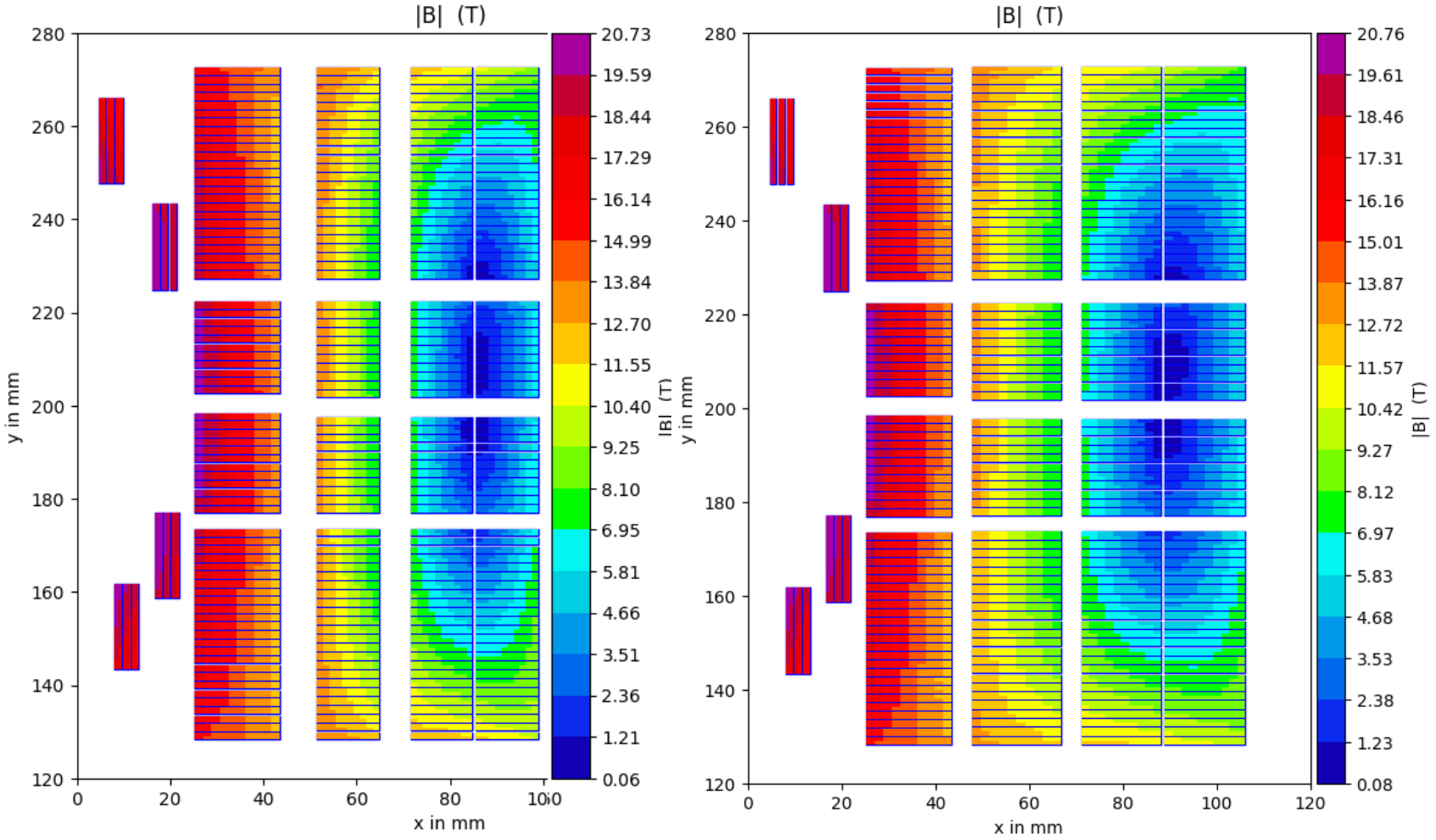
Models 1 & 2: Coil





Model	Intralayer 1-2	2-3
1	7.65	6.5
2	4.0	4.0

Models 1 & 2 Magnetic Analysis: B_0 19.98



With self-field contribution

layer	Max field in T | 1	2
1	20.22	20.22
2	13.85	13.27
3	12.38	11.8
4	11.66	10.98
5	19.75	19.79
6	20.27	20.3
7	20.73	20.76
8	20.63	20.65

Model	I_{op} in kA
1	13.63
2	13.75

Magnetic Analysis: Field quality and Margin

ax	Units
2	+ 0.22
4	- 0.03
6	- 0.27
8	+ 0.43

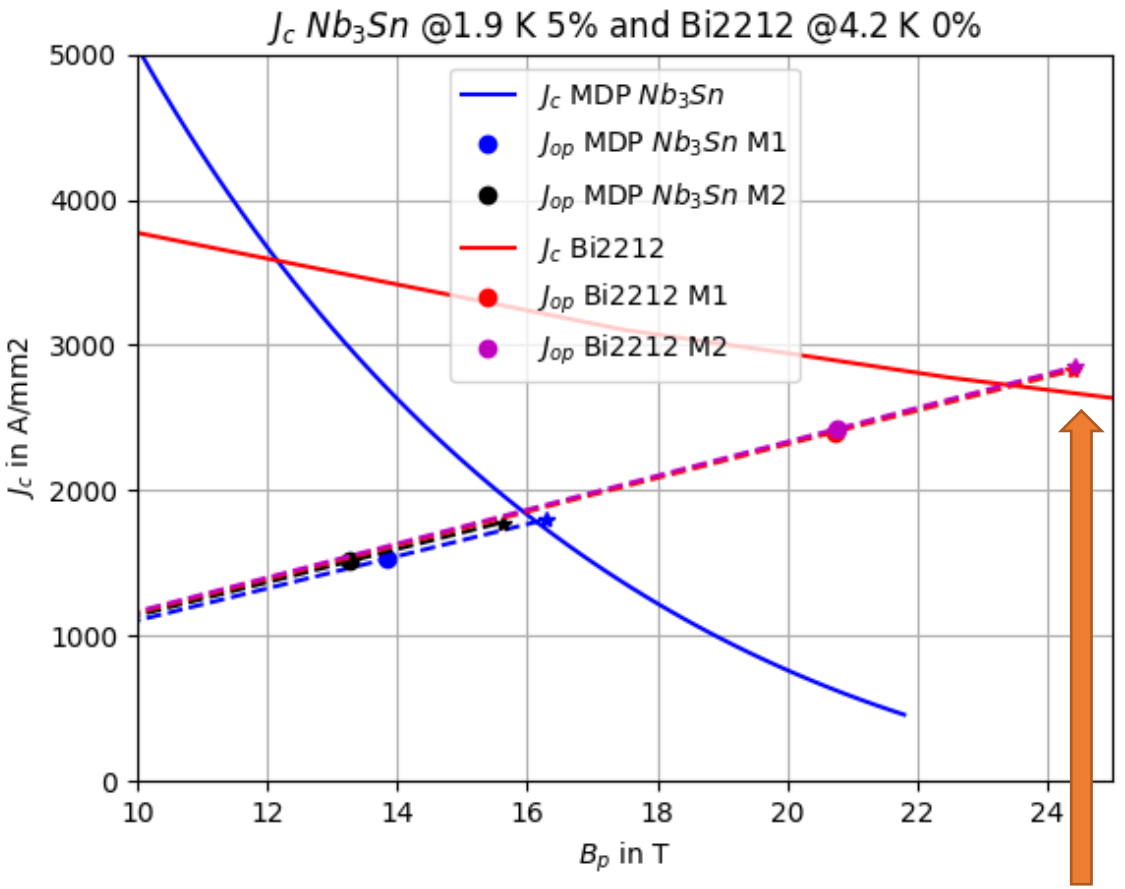
bx	Units
3	+ 0.06
5	+ 0.14
7	- 1.47
9	- 2.16

Model 1

ax	Units
2	+ 0.24
4	- 0.02
6	- 0.28
8	+ 0.44

bx	Units
3	- 2.18
5	+ 0.14
7	- 1.49
9	- 2.18

Model 2

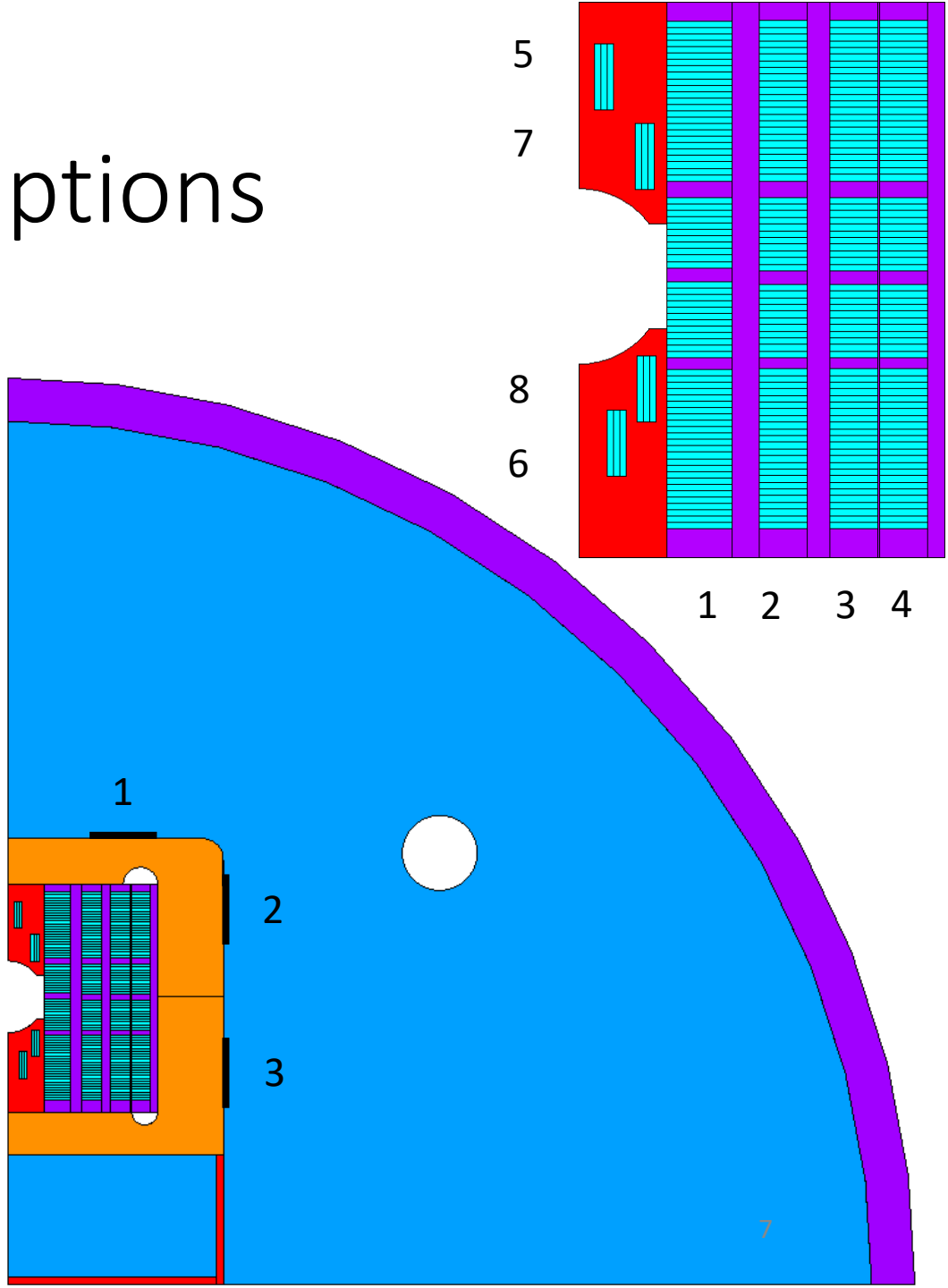


Bi2212 Margin < 15%

Mech Analysis: some assumptions

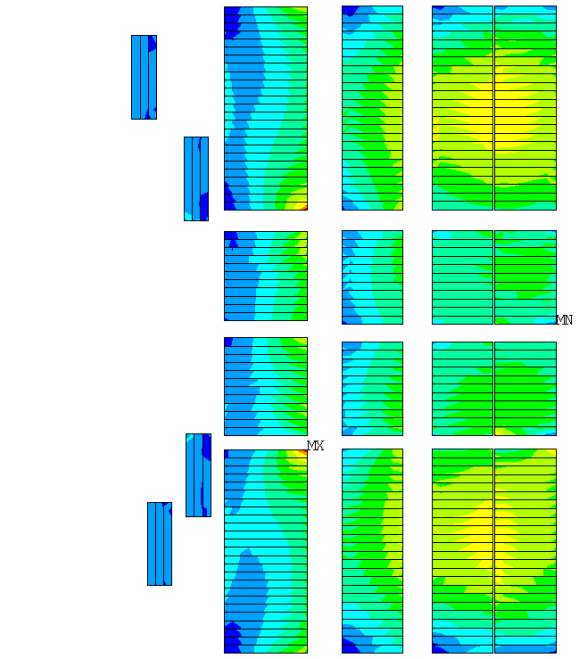
- Shell, pads/collars, common-coils formers and pole coils forms made of 314 L
- Turns belonging to the same block are bonded together
- Pads/collars pieces are bonded
- Layers can slide and detach from each other and from the surrounding pads/collars
- Pole formers are attached to the pad/collar
- Pre-load is applied with three keys (contacts)
- Keys are 40 mm long
- Many DoFs to be optimized

key	Interference in mm
1	0.1
2	0.8
3	0.8

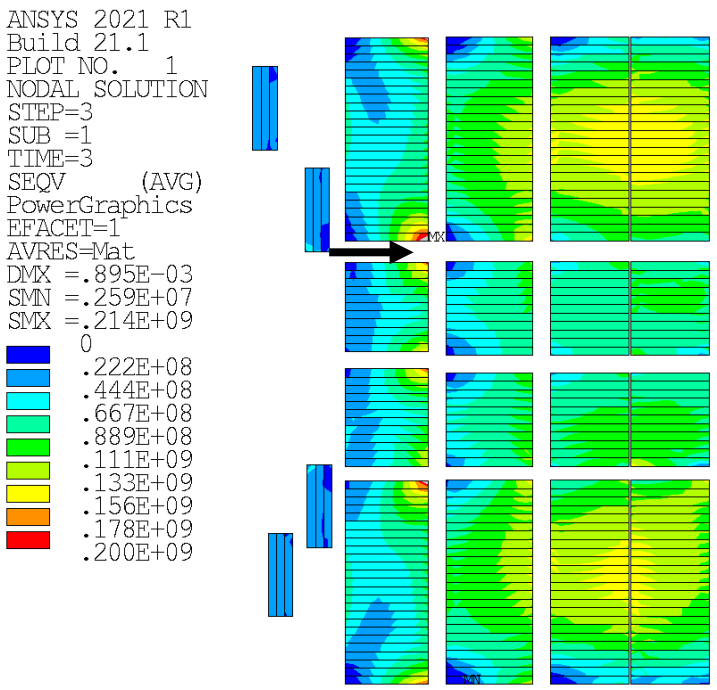


Mech Analysis Coils

- Model 2 higher stress due to the interlayer 1-2 overbend



Nominal field



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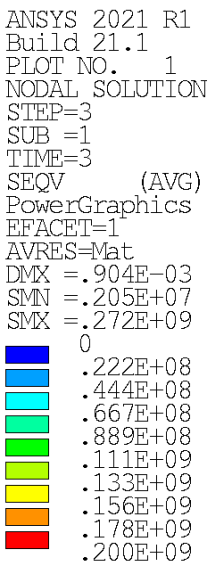

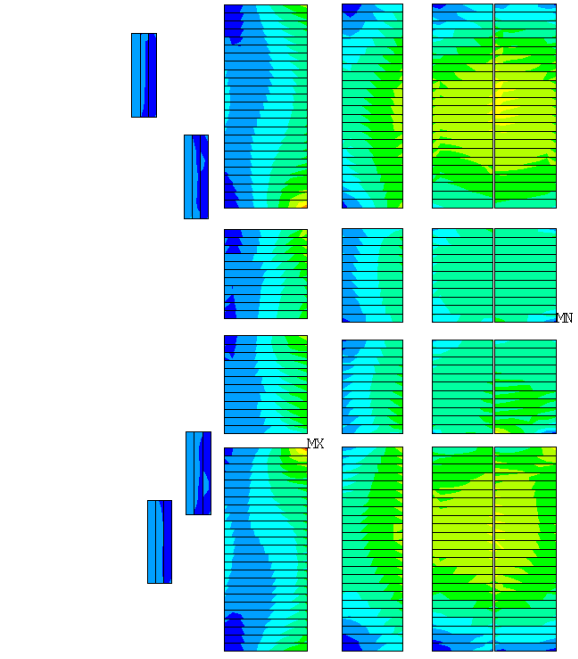

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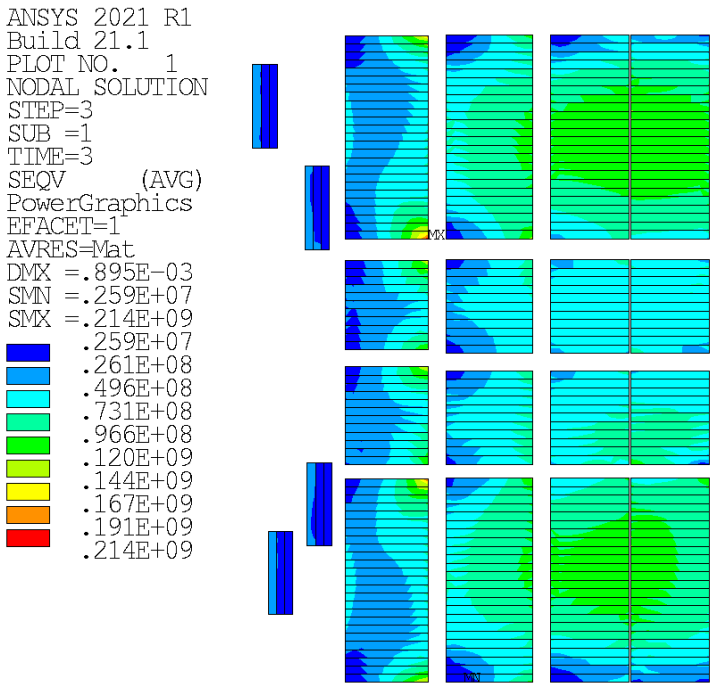

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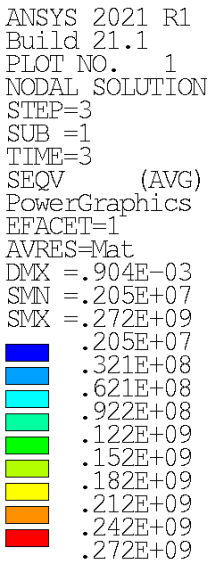
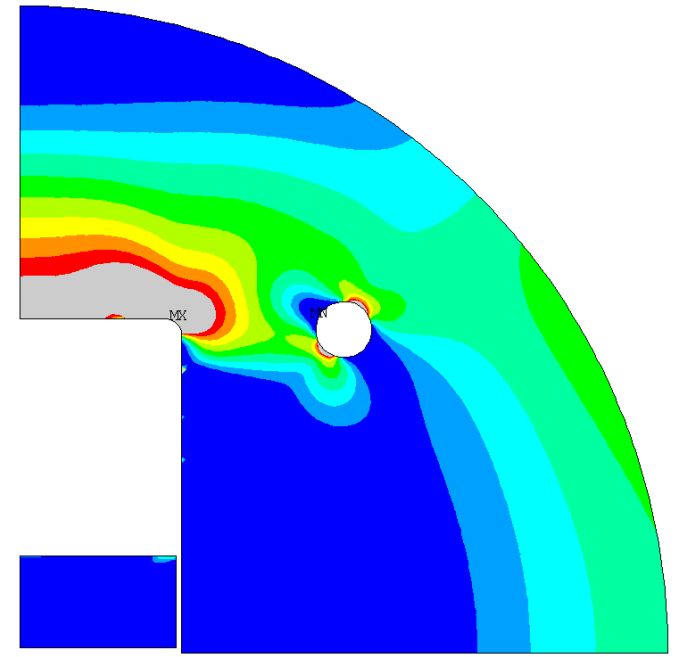


Mech Analysis Iron

- Increasing inner yoke radius



ANSYS 2021 R1
Build 21.1
PLOT NO. 1
NODAL SOLUTION
STEP=3
SUB =1
TIME=3
S1 (AVG)
PowerGraphics
EFACET=1
AVRES=Mat
DMX =.001456
SMX =.850E+09

0
.222E+08
.444E+08
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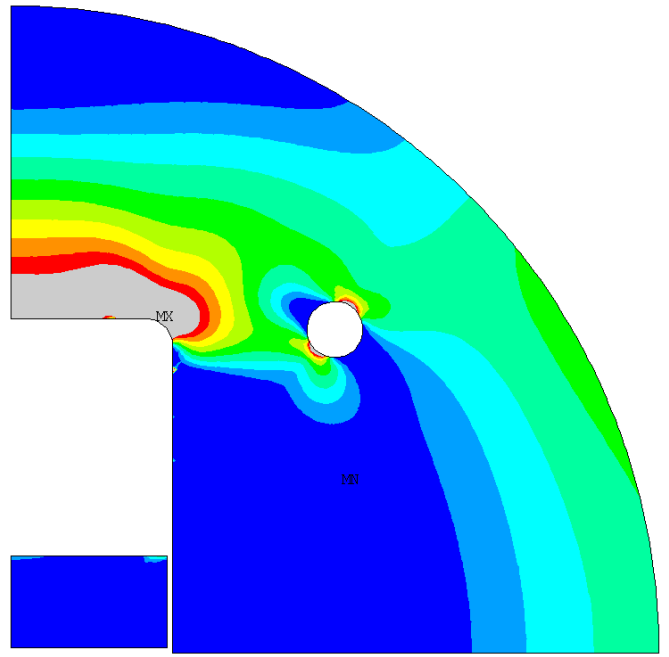
.889E+08
.111E+09
.133E+09
.156E+09
.178E+09
.200E+09

Nominal field



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0
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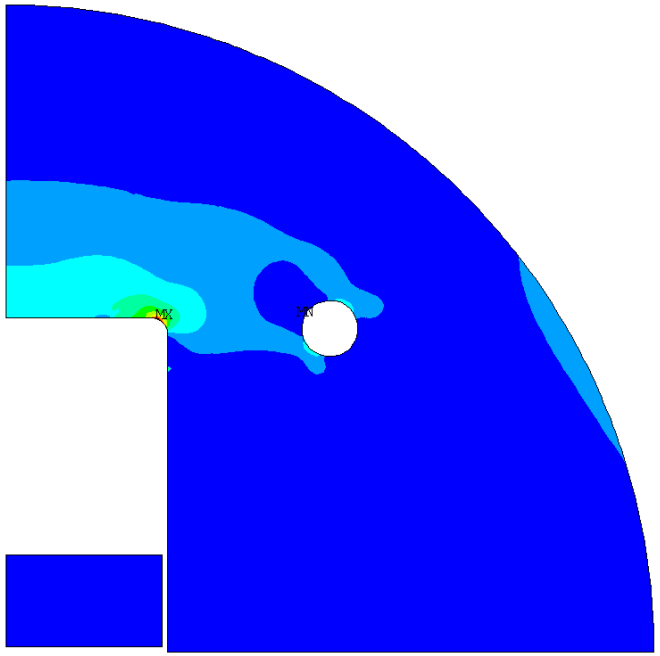
Nominal field



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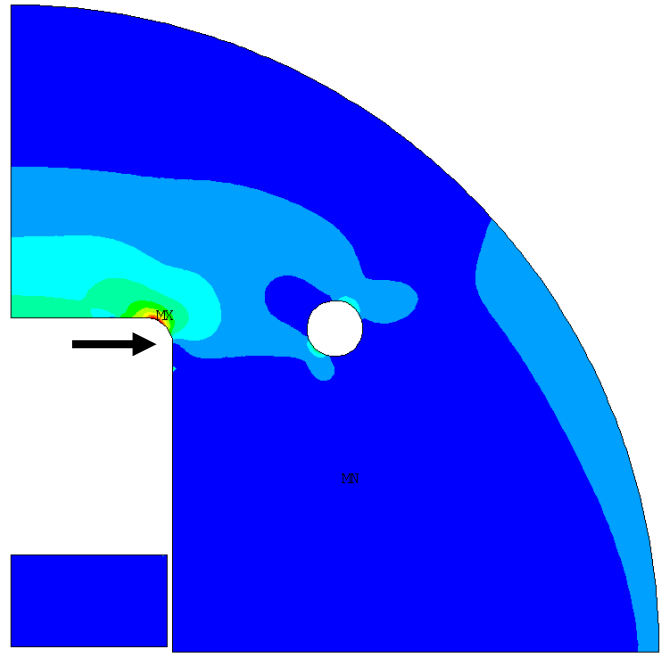
Nominal field



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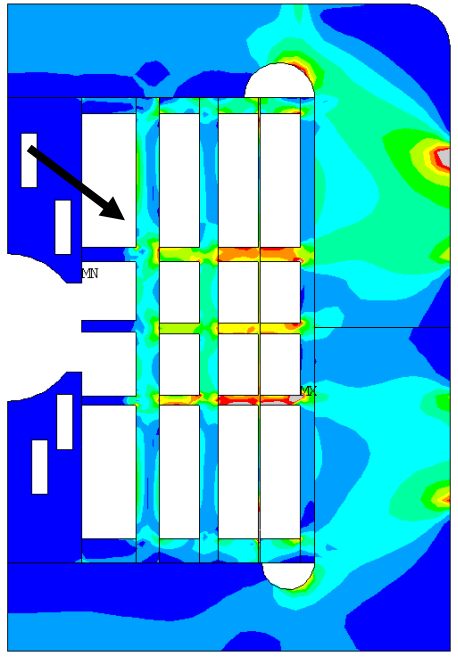
S1 (AVG)
PowerGraphics
EFACET=1
AVRES=Mat
DMX =.001462
SMX =.697E+09

0
.774E+08
.155E+09
.232E+09
.310E+09
.387E+09
.464E+09
.542E+09
.619E+09
.697E+09

Nominal field

Mech Analysis Formers and Pads

- interlayer 1-2 overbend



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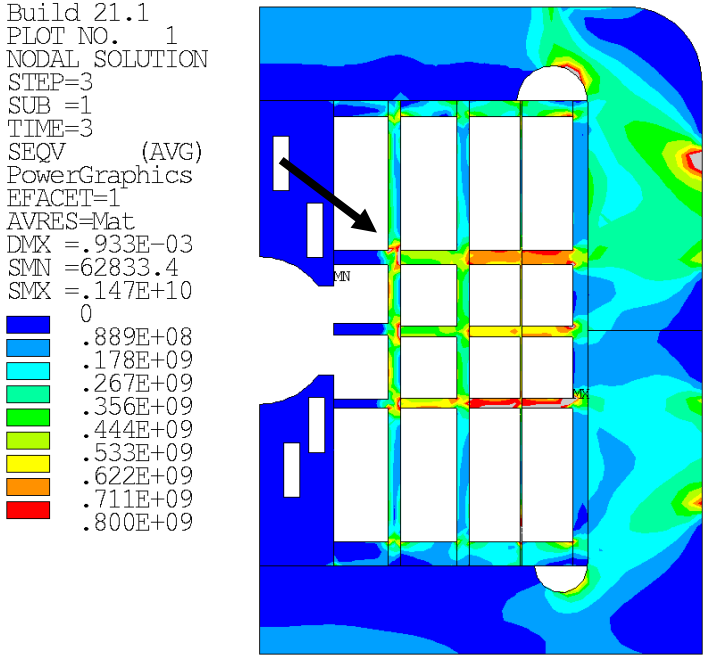

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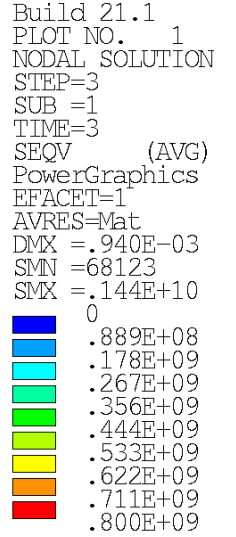

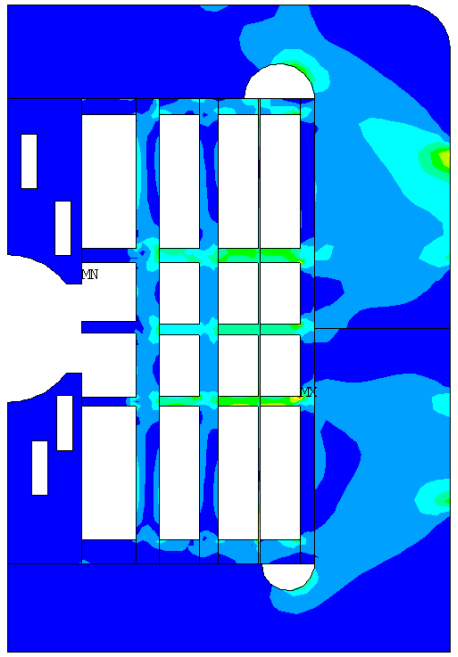

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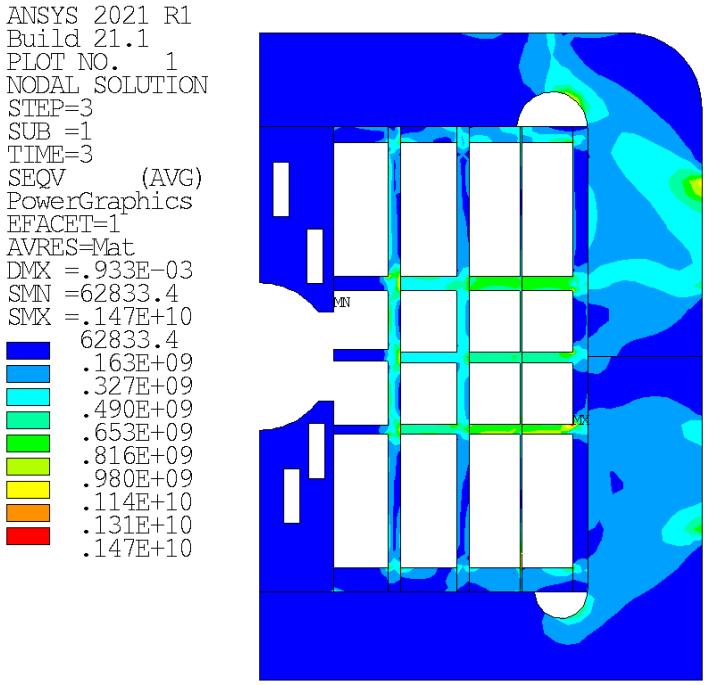

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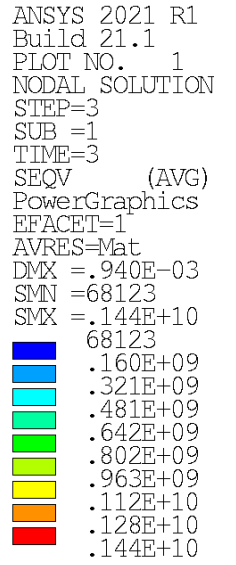
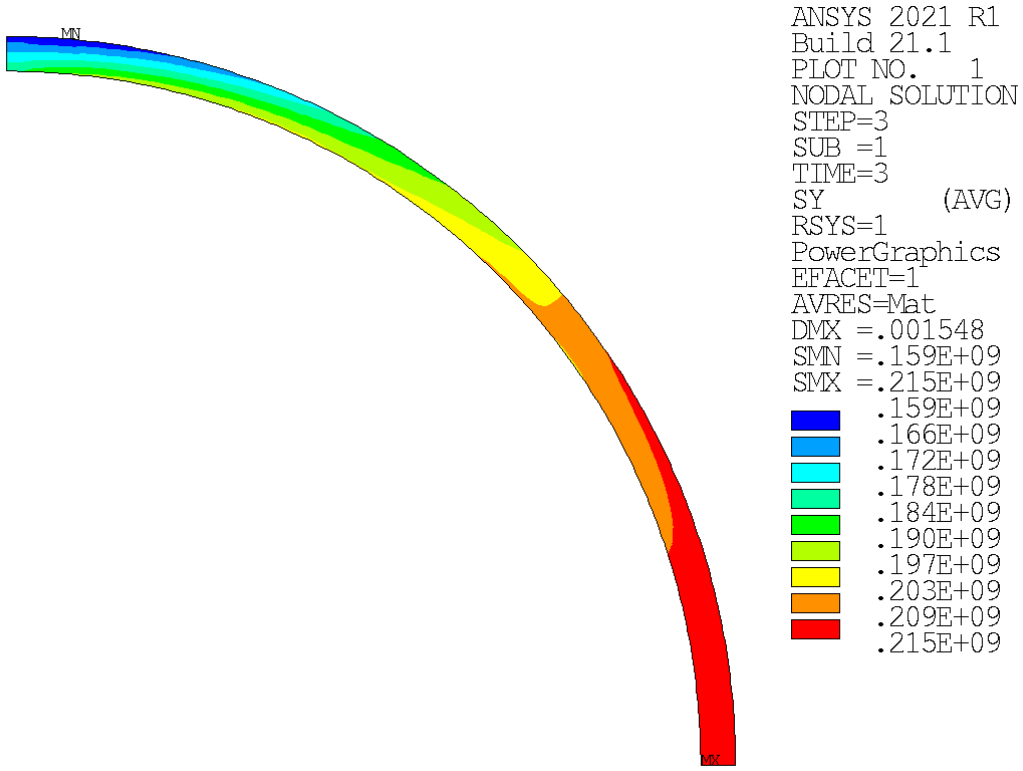


Mech Analysis Shell



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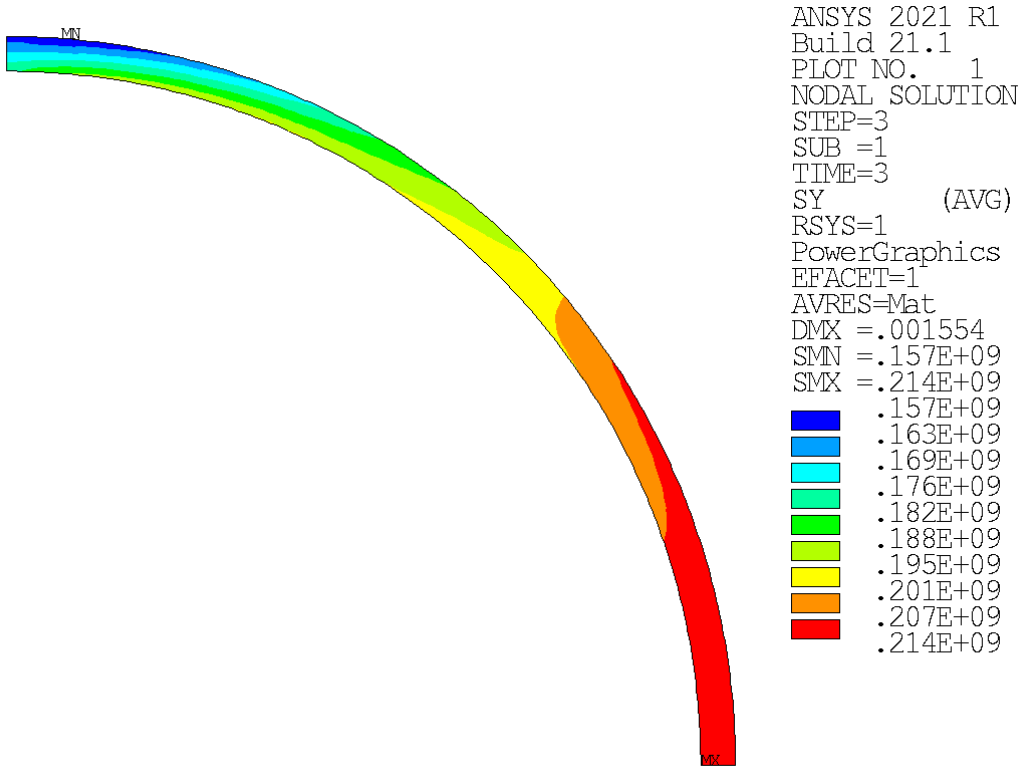

Nominal field

To be done

- Add strands on lay 1 to have 15% of margin
- Thicker intralayer 1-2
- Thicker rib between blocks on the bottom
- Match rib to pole coils former
- Re-optimize for field quality
- Check protection