U.S. MAGNET DEVELOPMENT PROGRAM

20 T Common Coil Mechanical FEA

M. Anerella
for
John Cozzolino, Chris Runyan
and
Ramesh Gupta

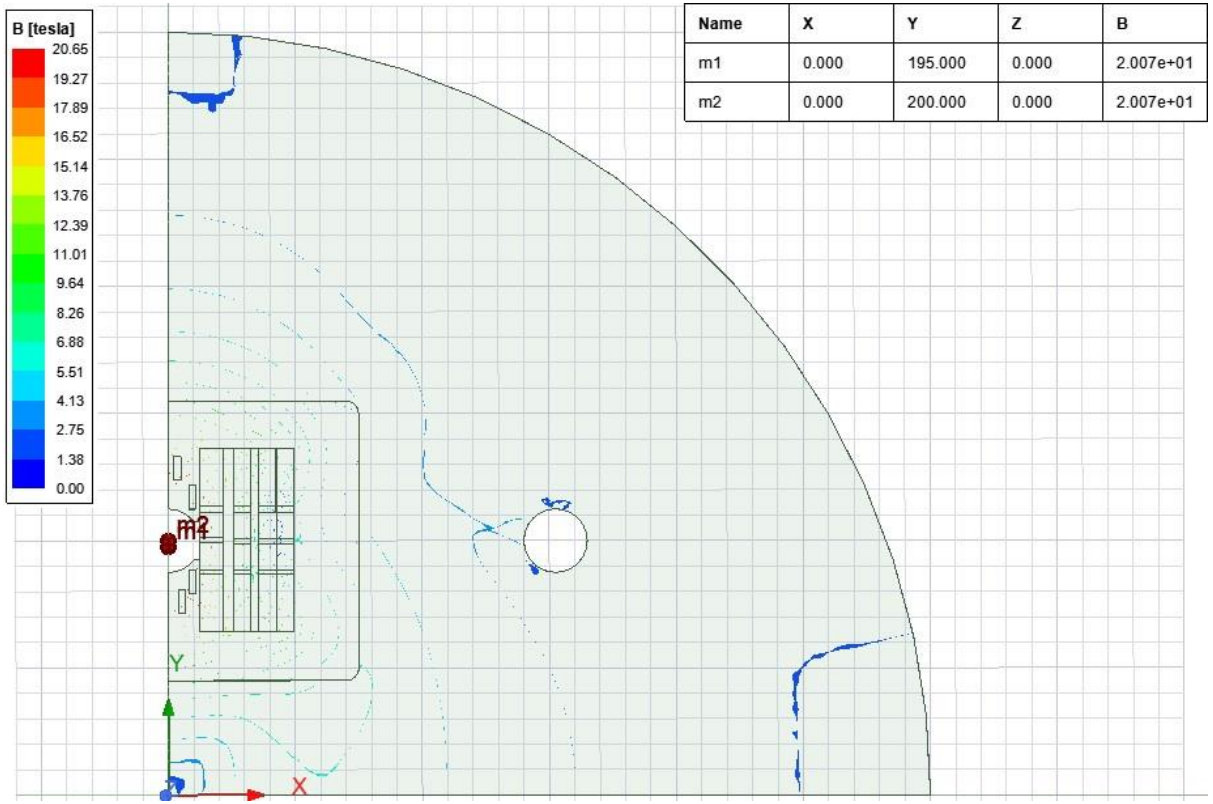
US Magnet Development Program Collaboration Meeting 2023

Hosted by Brookhaven National Laboratory
March 21–24, 2023

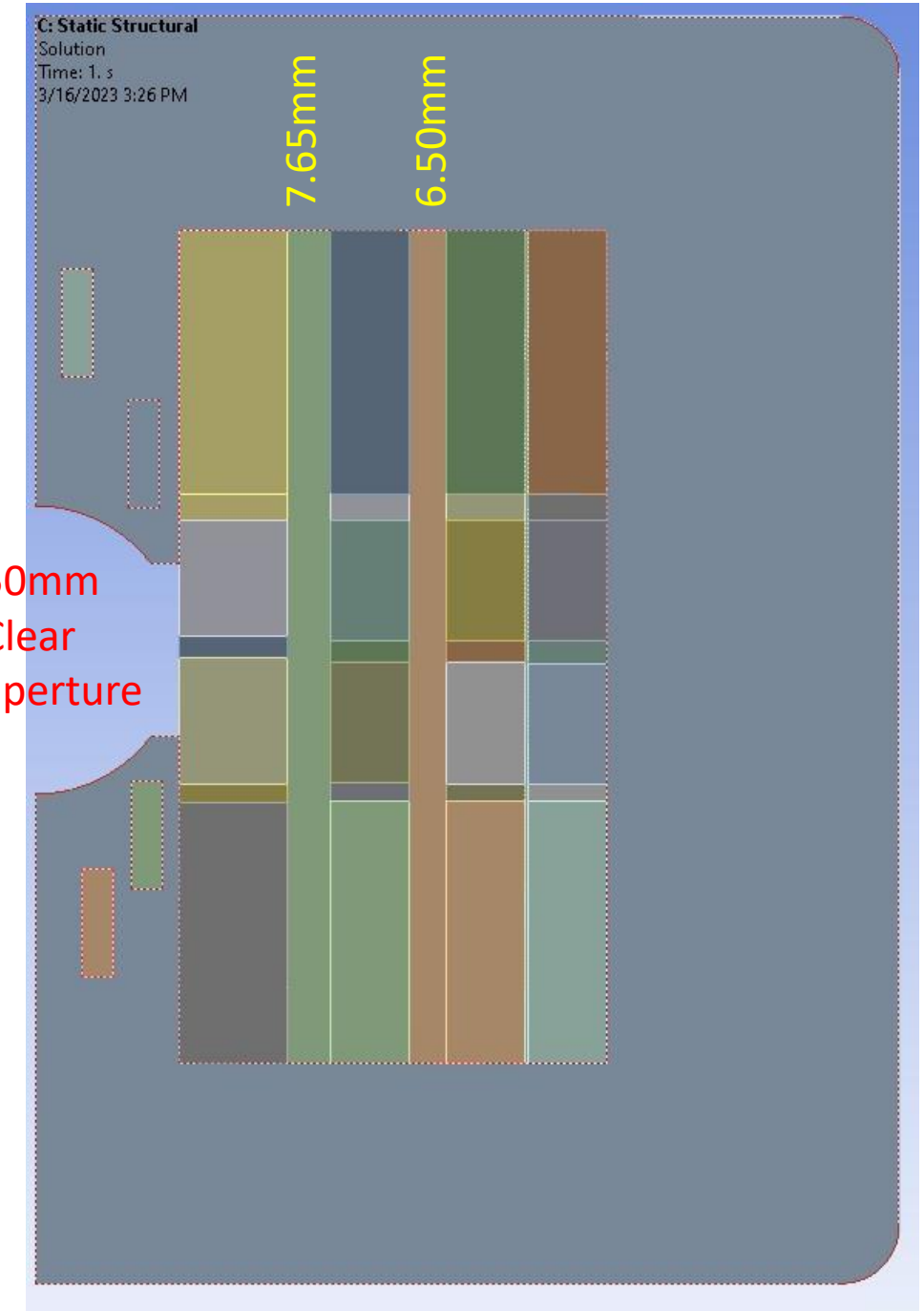
Model from previous review:

Initial Finite Element Model

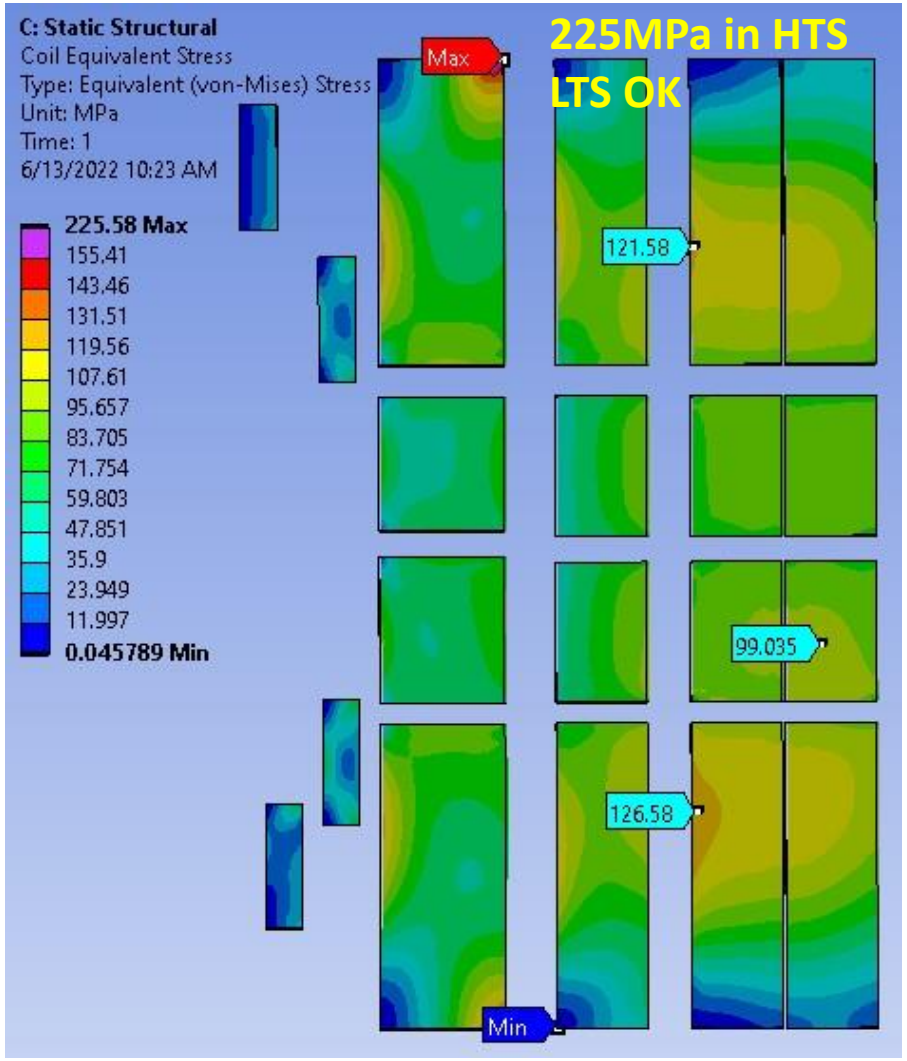
- Structure consists of a solid stainless-steel collar.
- Inner and outer coil vertical spacing of 7.65 and 6.50 mm respectively between coils



Name	X	Y	Z	B
m1	0.000	195.000	0.000	2.007e+01
m2	0.000	200.000	0.000	2.007e+01

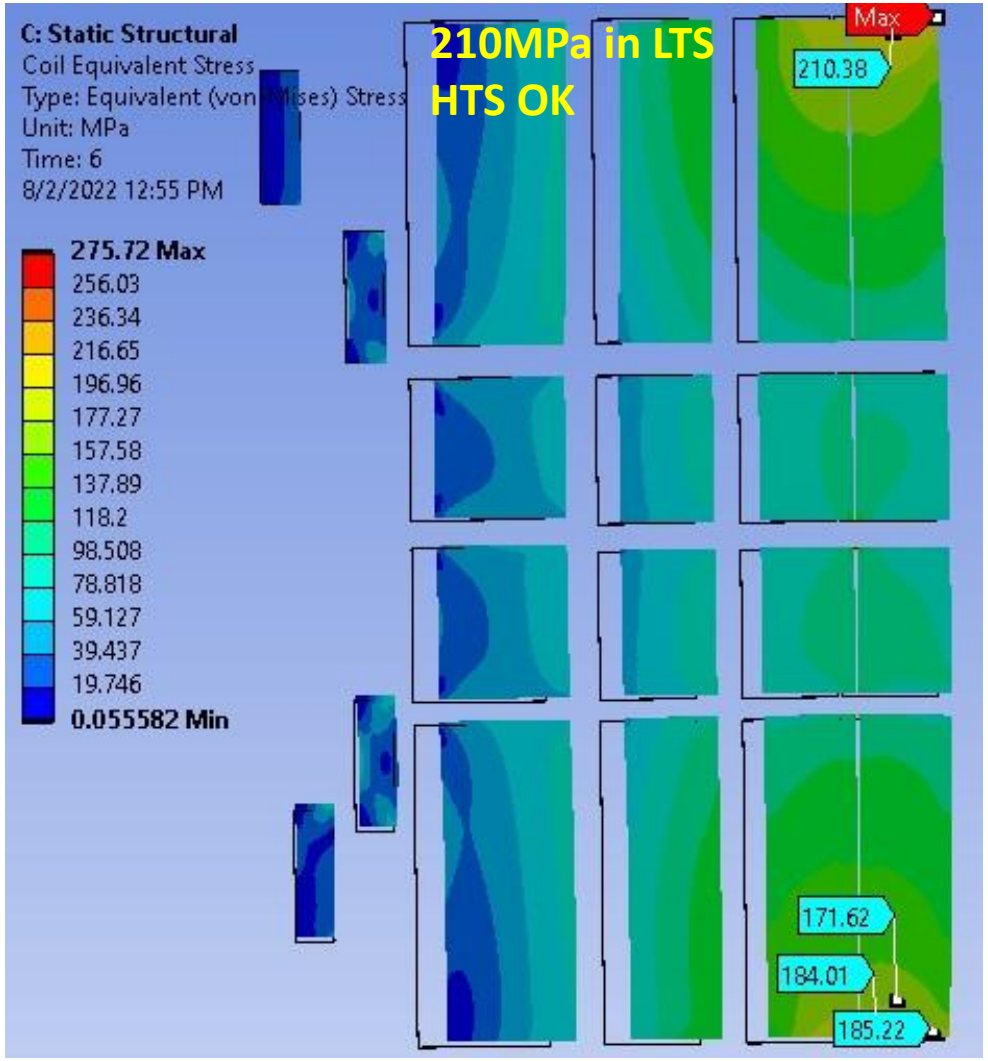


Results from previous review:



Coil Equivalent Stress – **Fixed Vertical Separators**

- Solid stainless steel one-piece collar
- Stainless steel horizontal stress supports



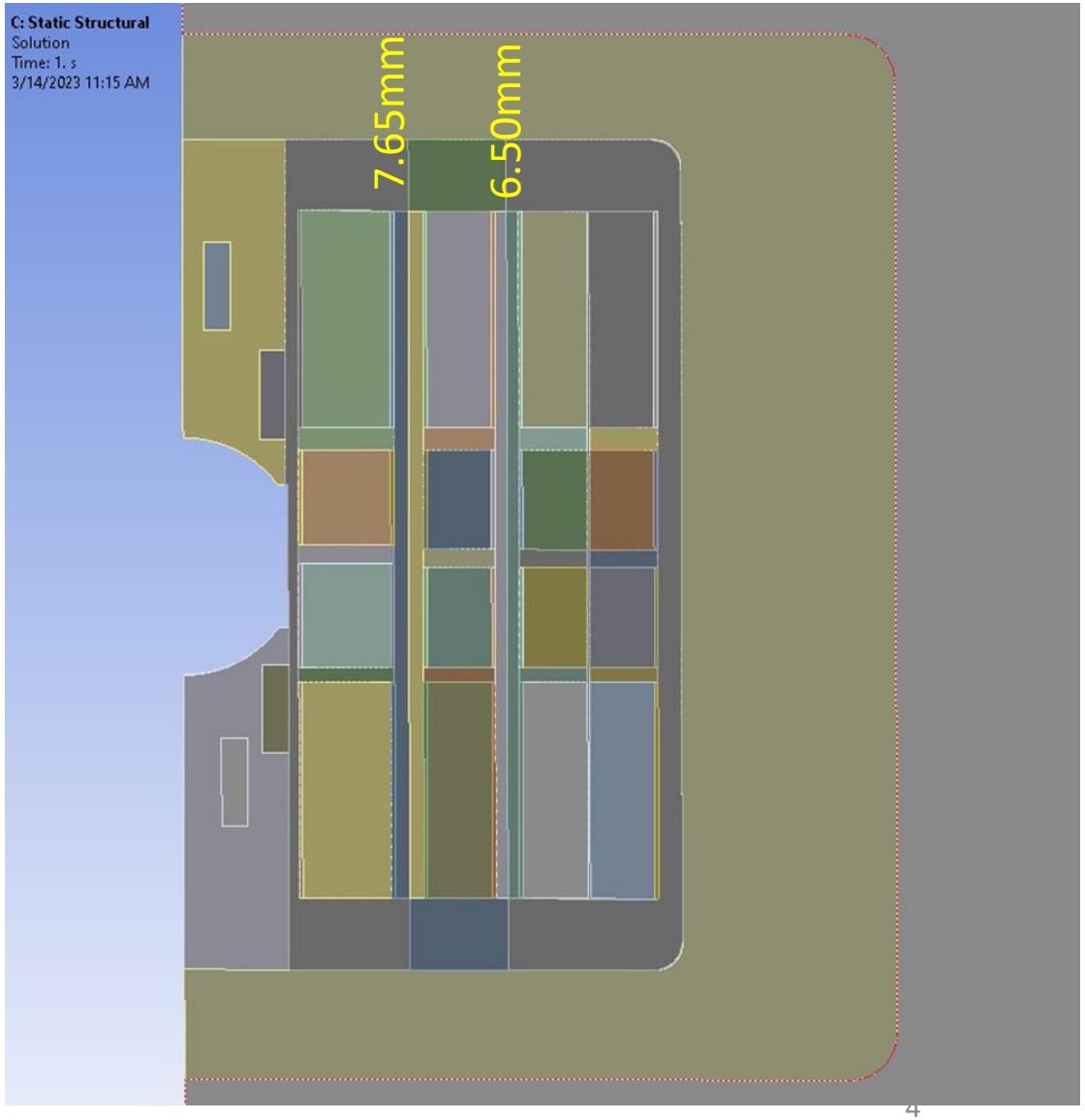
Coil Equivalent Stress – **Sliding Vertical Separators**

- Solid stainless steel one-piece collar
- Stainless steel horizontal stress supports

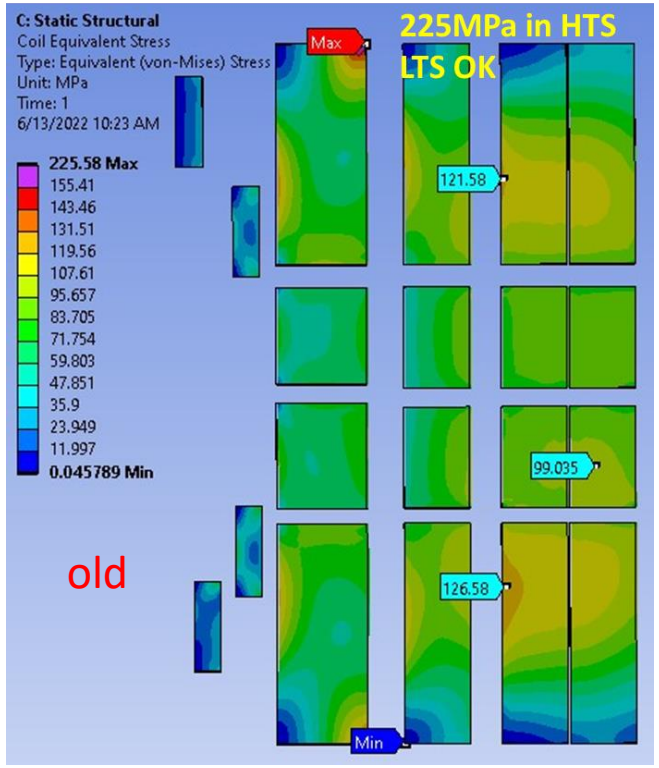
Goal of follow-on work: produce acceptable stresses in HTS & LTS together

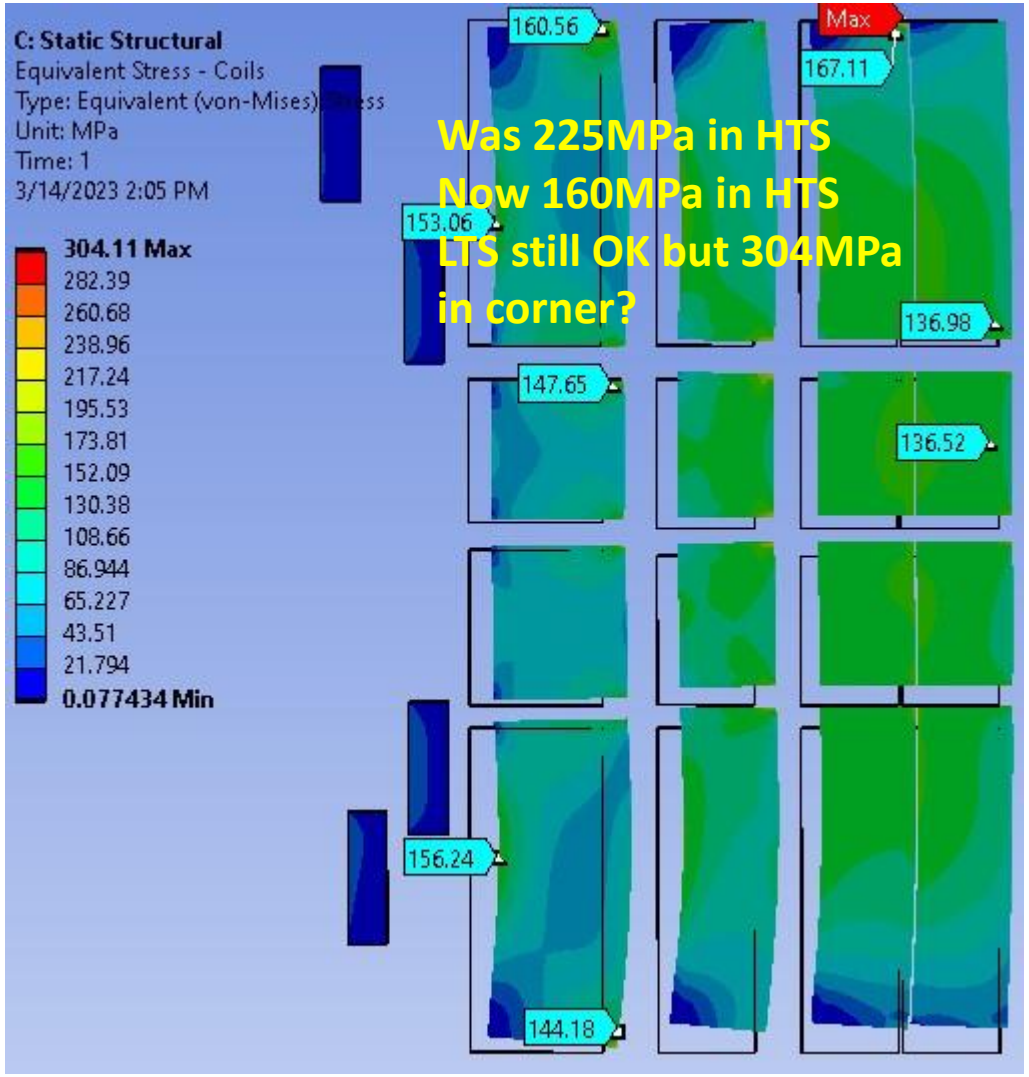
Initial Method: Revised Structural FE Model

- Uses original Maxwell model shown above because coil positions have not changed.
- Structure divided into:
  - individual collars inside an outer collar.
  - 0.76 mm “spacers” on both sides of coils (within original 7.65mm and 6.50mm vertical separations)
  - Provides option of experimenting with different softer materials to minimize peak stresses – *when not implemented, 0.76mm spacers are reverted to SST and bonded to original spacers*



Results of initial revised model: improvement, but not yet acceptable





Coil Equivalent Stress – Fixed Vertical Separators

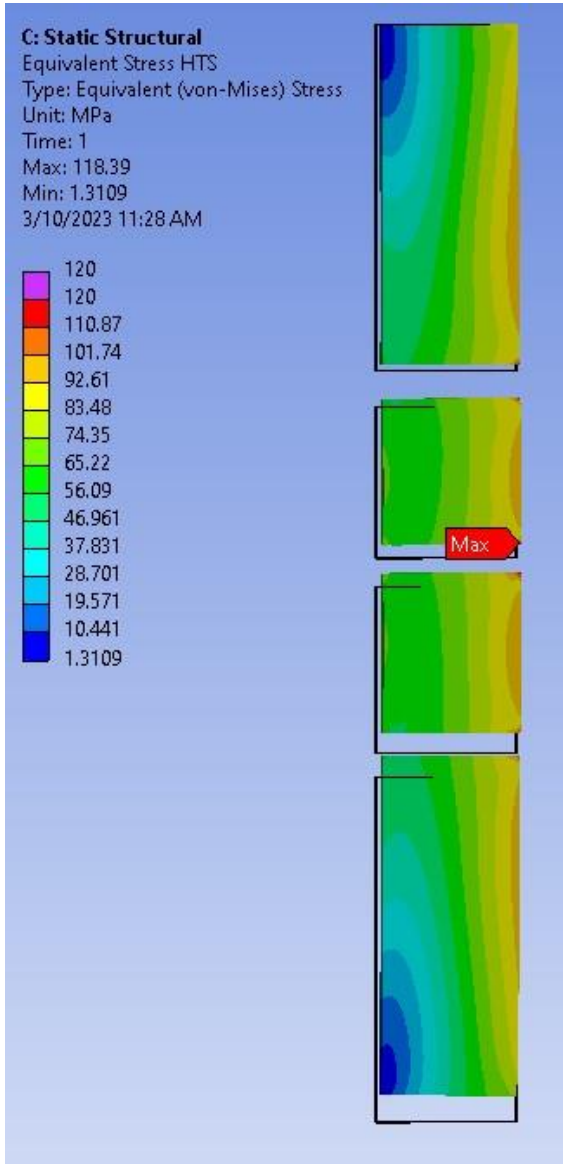
- SST structure is split into individual collars
- Frictionless contact between adjacent collars
- 0.76 mm Kapton padding on right side of all coils.

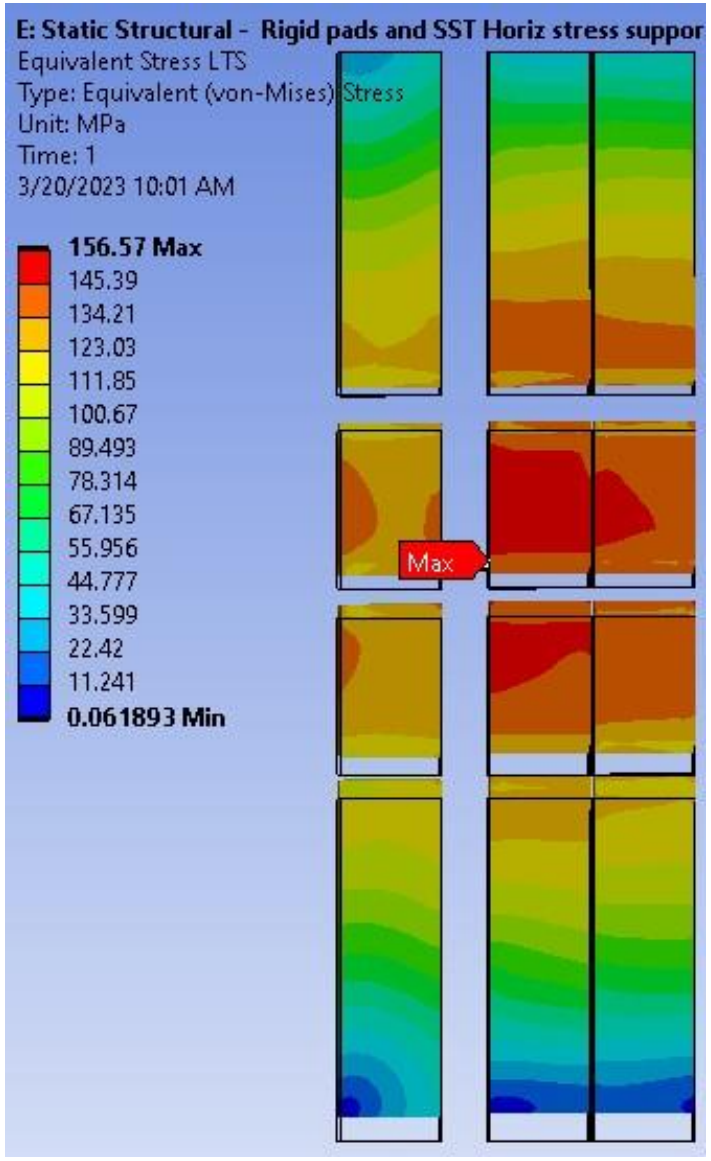
Test – determine effect of eliminating all bending within structure

Coil Equivalent Stress – Fixed Vertical Separators

- Rigid spacers & collars are fully bonded together
- Inner & outer coil vertical spacing is 7.65 and 6.50 mm respectively.
- No Kapton padding

→ HTS & LTS stresses are acceptable; need to reduce bending

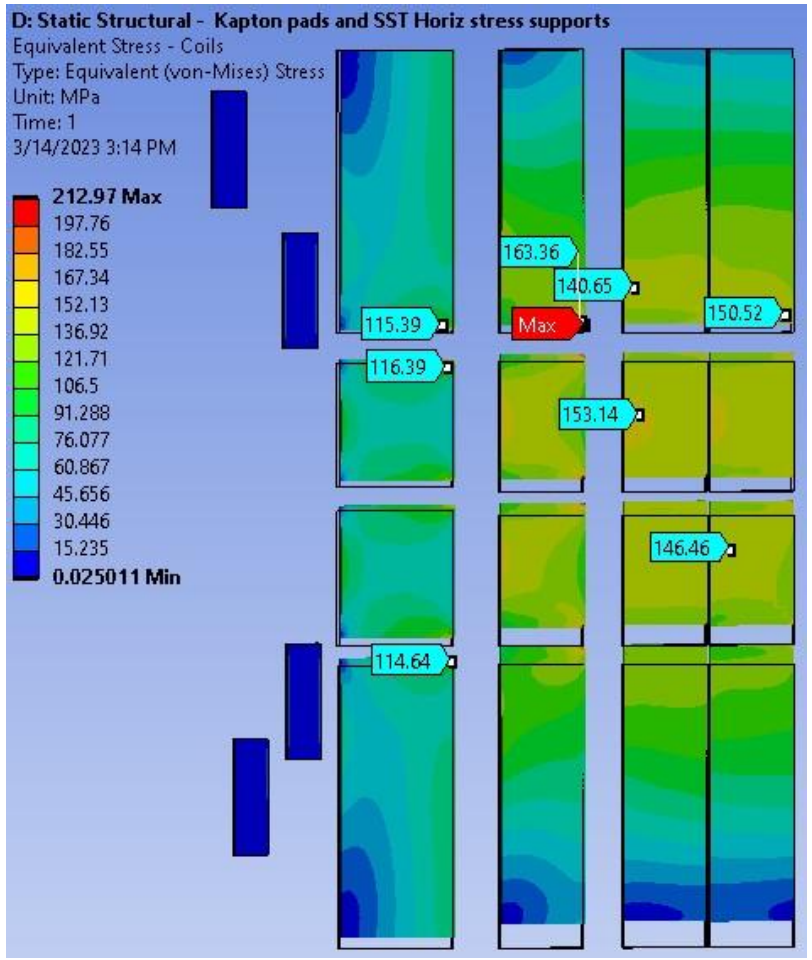




Test – determine added effect of zero bending plus soft material

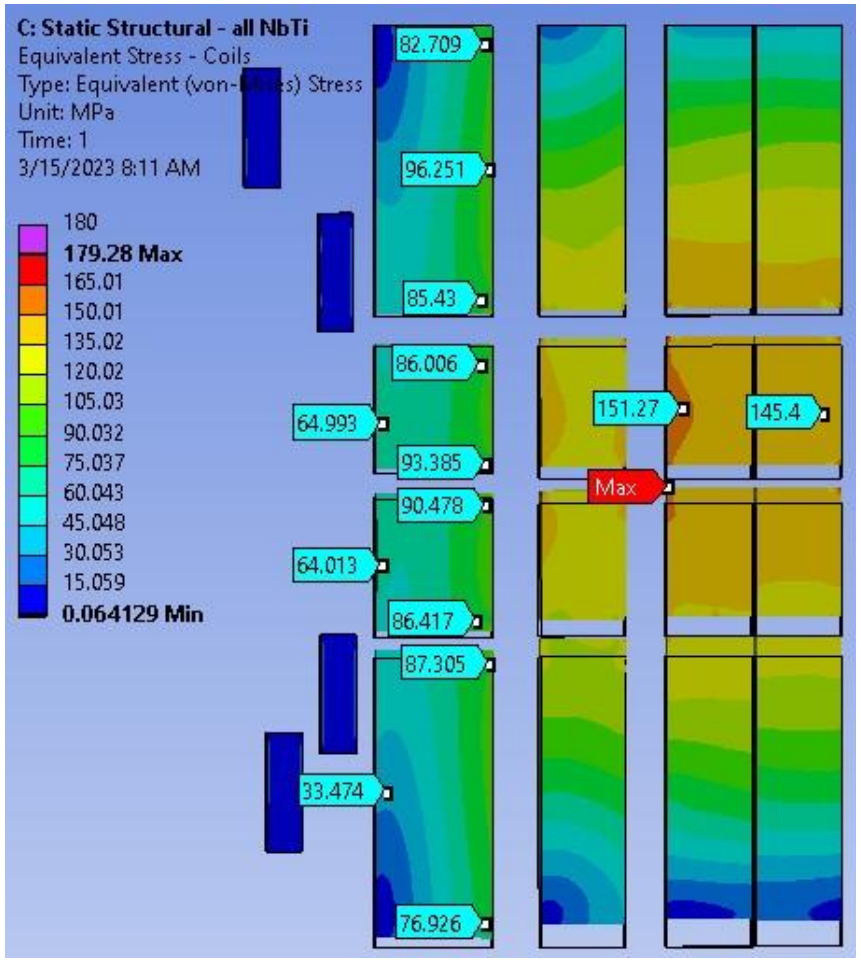
Coil Equivalent Stress – Fixed Vertical Separators

- Rigid spacers & collars are fully bonded together
- Inner & outer coil vertical spacing is 7.65 and 6.50 mm respectively.



- 0.76 mm Kapton padding on right side of all coils.

→ HTS stresses are ok, LTS 212MPa peak



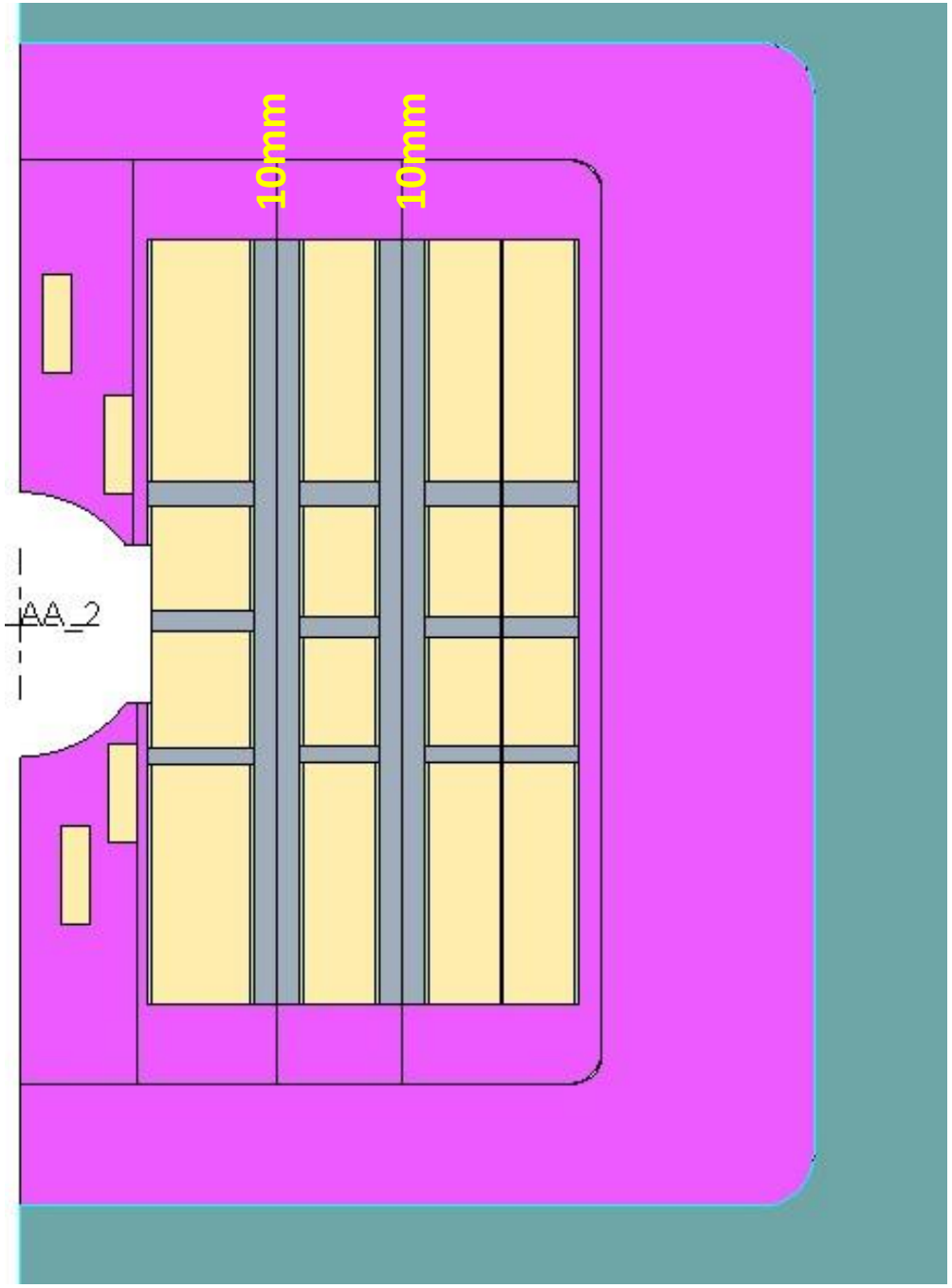
- Pads and horizontal stress supports all set to the modulus of Nb_3Sn.

→ HTS and LTS stresses are acceptable

Real model solution

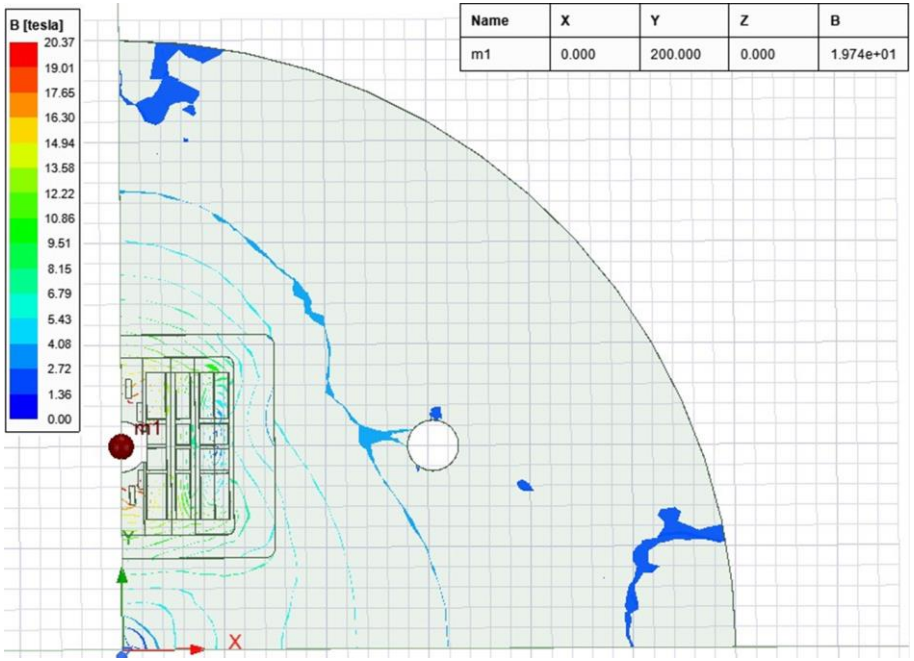
<u>Second Revised Structural FE Model</u>:

- Coil inner and outer vertical spacing increased both to 10 mm *to reduce bending*
- 50 mm aperture.
- Uses revised Maxwell model shown below because coil positions have changed.
- 0.76 mm thick “spacers” on both sides of coils (within 10mm)
  - Provides option of selectively adding different soft materials.
- *Collars, spacers – modulus restored to SST unless noted*



Revised Maxwell magnetic model

- Reflects inner and outer coil vertical spacing of 10 mm.
- Dipole central flux density dropped slightly to just under 20 T.



Real model solution (cont'd)

- Coil Equivalent Stress – Fixed Vertical Separators
- Stainless steel collars are fully bonded together.
- Right pads are Kapton on HTS only. All others are stainless steel
- Horizontal stress supports are stainless steel.

  ✓ 112MPa max in HTS
  ✓ ~180MPa max* in LTS

  * 184MPa in corner, to be corrected via mesh refinement…