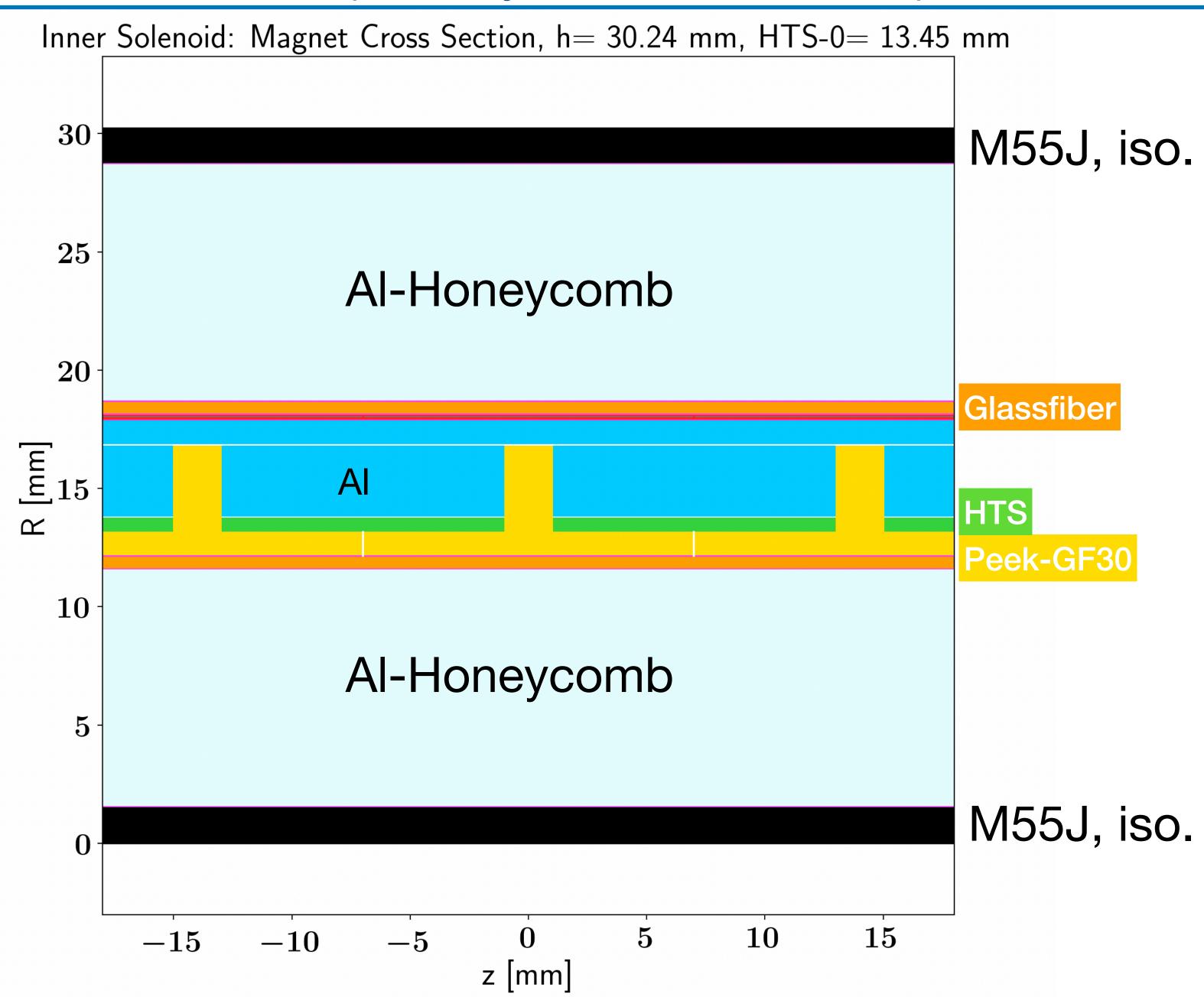
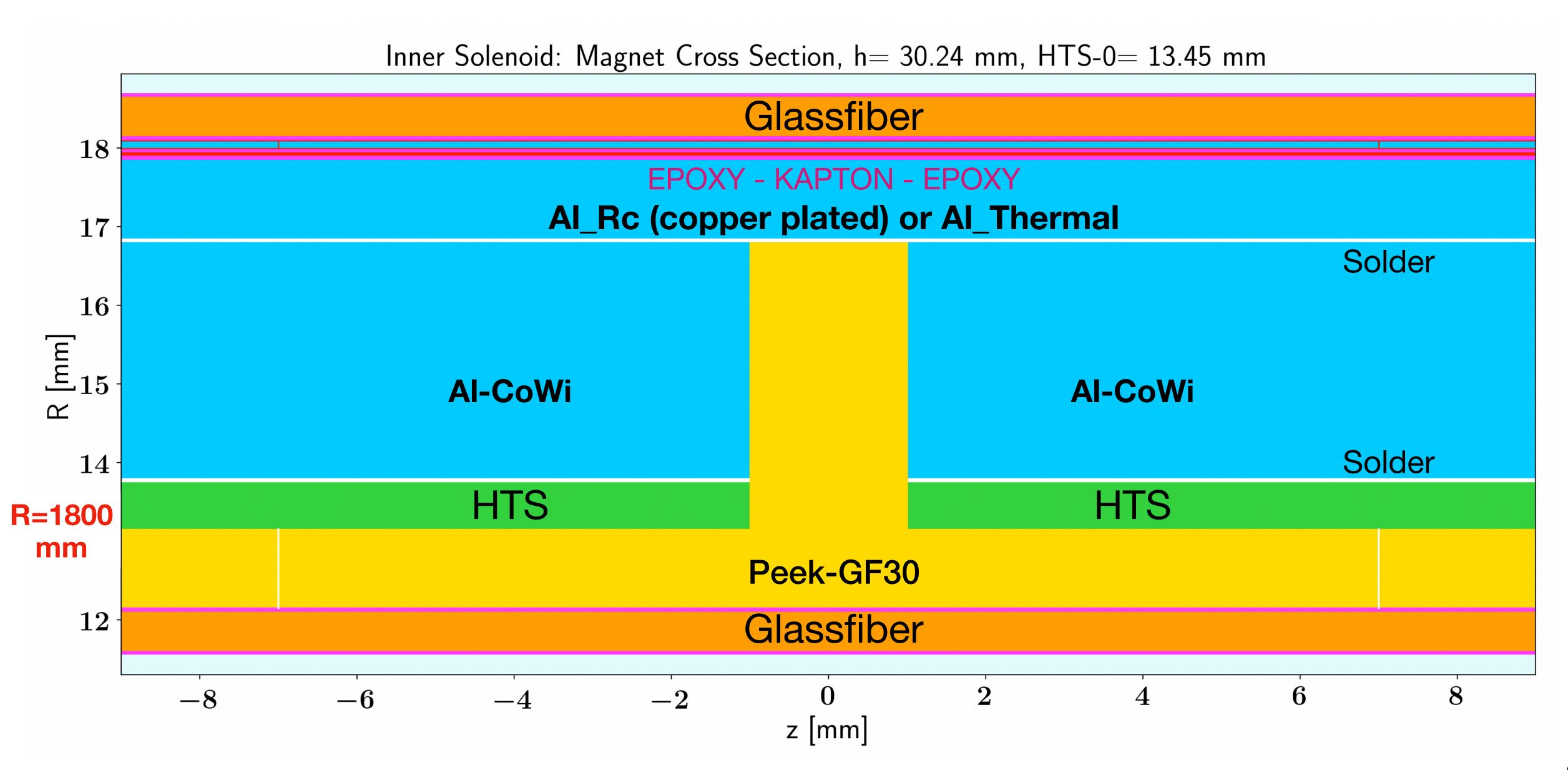
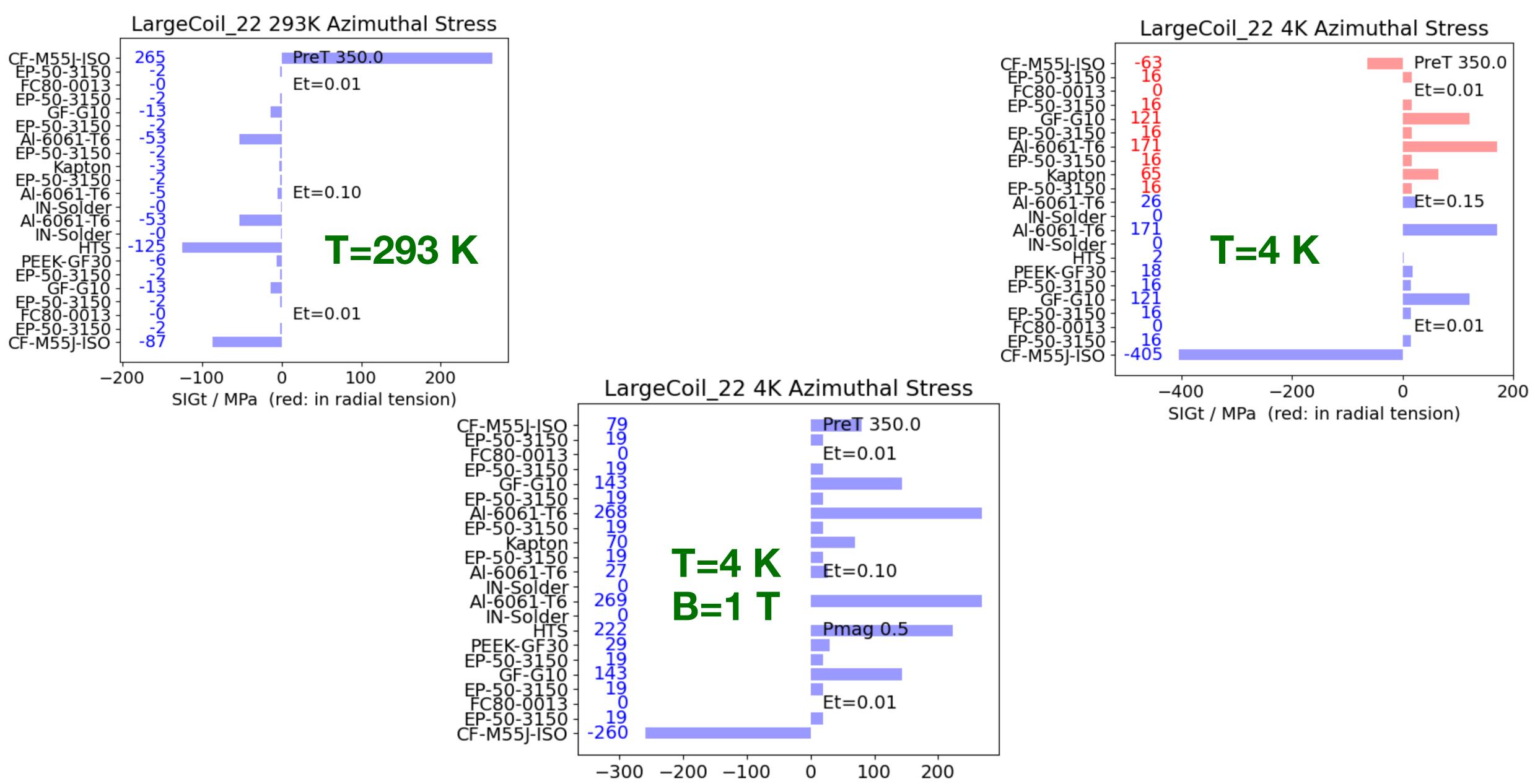
AMS-100 - (03. July 2020, Version 2.2)



AMS-100 - (03. July 2020, Version 2.2)



AMS-100 - (03. July 2020, Version 2.2): Pre-Tension Outer CFRP by 350 MPA



SIGt / MPa (red: in radial tension)

AMS-100 - (03. July 2020, Version 2.2)

```
Inner Solenoid
Z0= 0.00 m; CoilInnerRadius= 1.80 m; CoilThickness= 0.59 mm; nTapesPerStack= 22; Current=13200.0 A; LenZ= 5.40 m; nTurns= 386; nTurnsPerM=
                                                                                                                                               71 1/m; TapeLength= 96.058 km;
MagneticMoment= 51.86 MAm^2; TorqueSun= 0.24 Nm; Energy= 28.13 MJ; EnergyDensity=511.84 kPa <=> 5.1184E+00 bar; Weight=1635.6 kg; X0= 0.131;
B(r=0,z=0)= 0.99 T; B(r=Rin-epsilon,z=0)= 1.04 T; B(r=Rout+epsilon,z=0)= -0.14 T; Stress_R=-139.69 kPa; Stress_Theta=1291.5 MPa; Stress_Z=-647.7 MPa
           0 m**3; Volume_Rin=178.00 cm; Volume_Rout=182.00 cm; nJoints= 321; PowerLoss= 2.31 Watt; Inductance= 0.32 Henry; PowerLossStackToStack= 0.62 Watt;
Volume=
HoopForcePerTape= 1064.88 N; HoopStressPerTape= 3286.67 MPa; StrainPerTape= 1.57 % (Hastelloy Only)
QuenchDetectionCoil: Length= 4363 m, CrossSection= 1.40 mm2, Resistance= 62.33 Ohm
                    Length= 4363 m, CrossSection= 36.00 mm2, Resistance= 2.42 Ohm
Co-WindCoil:
                   : Length= 4366 m, CrossSection= 7.13 mm2, Resistance=753.44 Ohm
HTS-StackCoil
                       R_i [mm] | d [mm] | Density [kg/m^3] | Mass [kg] | X0 [%] | NIL [%] | E0 [MPa] |
                                                                                                            CTE [1/K] | Strain [%] | Stress [MPa]
                                                                  161.77 I
       CFRP-M55J_Out |
                        1815.59 | 1.500 |
                                                     1750.00 l
                                                                             0.62 l
                                                                                       0.34 l
                                                                                                 120000 l
                                                                                                             1.000E-06 |
                                                                                                                              -0.20 |
                                                                                                                                         -235.71
       Epoxy-50-3150 |
                        1815.54 l
                                                                    3.57 l
                                                                             0.01 |
                                                                                       0.01 I
                                                                                                   2100 |
                                                                                                             2.500E-05 |
                                                                                                                               0.50 |
                                                                                                                                           10.45
                                    0.050 l
                                                     1160.00 l
                                                       32.00
                                                                   19.66 I
                                                                                                                                            0.38
       Al-Honeycomb |
                        1805.54 | 10.000 |
                                                                             0.13 l
                                                                                       0.03 l
                                                                                                                               0.19 I
                                                                                                    200 I
                                                                                                            1.431E-05 |
       Epoxy-50-3150 |
                        1805.49 I
                                                     1160.00
                                                                    3.55 l
                                                                             0.01 I
                                                                                       0.01 I
                                                                                                             2.500E-05
                                                                                                                                           10.45
                                    0.050 l
                                                                                                   2100 |
                                                                                                                               0.50 l
          FiberGlass |
                                    0.500 l
                                                                   79.93 l
                                                                                       0.13 I
                                                                                                                                           48.76
                        1804.99 I
                                                     2610.00
                                                                             0.51 l
                                                                                                  19000 |
                                                                                                            1.667E-05 |
                                                                                                                               0.26 I
                                                                    3.55 l
                                                                                                                                           10.45
       Epoxy-50-3150
                        1804.94 l
                                    0.050 l
                                                     1160.00
                                                                             0.01 l
                                                                                       0.01
                                                                                                   2100 |
                                                                                                             2.500E-05 |
                                                                                                                               0.50 l
              Al_QDC
                        1804.84 I
                                    0.100 I
                                                     2700.00
                                                                   16.53 l
                                                                             0.11 |
                                                                                       0.03 I
                                                                                                  77749 I
                                                                                                             1.431E-05
                                                                                                                               0.19 I
                                                                                                                                          146.53
                        1804.79 I
                                     0.050 I
                                                     1160.00 I
                                                                             0.01 I
                                                                                       0.01 I
                                                                                                   2100 I
                                                                                                             2.500E-05 |
       Epoxy-50-3150
                                                                    3.55 |
                                                                                                                               0.50 l
                                                                                                                                           10.45
                                                     1420.00
                                                                    4.35 l
                                                                                       0.01 I
                                                                                                                                           43.73
                                                                             0.02 |
              Kapton
                        1804.74 l
                                    0.050 l
                                                                                                   3758 I
                                                                                                             4.804E-05 |
                                                                                                                               1.16
                                                     1160.00
                                                                    3.55 l
                                                                                                                                           10.45
       Epoxy-50-3150
                                    0.050 l
                                                                                                                               0.50 l
                        1804.69 I
                                                                             0.01 I
                                                                                       0.01
                                                                                                   2100 I
                                                                                                             2.500E-05
                        1803.69 I
                                                     2700.00
                                                                  165.28 I
                                                                                       0.25 I
               Al_Rc
                                    1.000 l
                                                                             1.12 I
                                                                                                  77749 |
                                                                                                             1.431E-05
                                                                                                                               0.19 I
                                                                                                                                          146.53
                                                                   22.37 |
           In-Solder
                        1803.64 l
                                    0.050 l
                                                     7310.00
                                                                             0.41 l
                                                                                       0.02 |
                                                                                                    100 |
                                                                                                             3.300E-05 |
                                                                                                                                            0.73
                                                                                                                               0.73 l
             Al_CoWi
                                                     2700.00
                         1800.64 I
                                     3.000 I
                                                                  495.28 I
                                                                             3.37 l
                                                                                       0.76 I
                                                                                                  77749 I
                                                                                                             1.431E-05
                                                                                                                                          146.53
                                                                                                                               0.19
                                                                                       0.02
                                                                                                                                            0.73
           In-Solder
                         1800.59 I
                                    0.050 l
                                                     7310.00
                                                                   22.33 l
                                                                             0.41 I
                                                                                                    100 l
                                                                                                             3.300E-05 |
                                                                                                                               0.73 l
                                                                                       0.37 I
                                                                                                                                           74.46
           HTS-Coil
                        1800.00 H
                                    0.594 l
                                                     9021.48
                                                                  280.77 I
                                                                             4.72 l
                                                                                                 177510 I
                                                                                                             9.244E-06
                                                                                                                               0.04 |
                                                                                                                                            6.75
       Peek-GF30_Gap
                                    1.000 l
                                                     1320.00
                                                                   80.59 I
                                                                             0.29 I
                                                                                       0.14
                        1799.00 l
                                                                                                   3760 l
                                                                                                             1.400E-05
                                                                                                                               0.18 l
                                                                    3.54 |
                                                                                                                                           10.45
       Epoxy-50-3150
                        1798.95 I
                                    0.050 l
                                                     1160.00
                                                                             0.01 I
                                                                                       0.01
                                                                                                   2100 |
                                                                                                             2.500E-05
                                                                                                                               0.50
                                                     2610.00
                                                                   79.64 l
                                                                             0.51 l
                                                                                       0.13 I
                                                                                                             1.667E-05 |
                                                                                                                                           48.76
          FiberGlass
                        1798.45 I
                                    0.500 I
                                                                                                  19000 |
                                                                                                                               0.26 l
       Epoxy-50-3150
                        1798.40 l
                                                                    3.54 |
                                                                                                   2100 I
                                                                                                             2.500E-05 |
                                    0.050 l
                                                     1160.00
                                                                             0.01 l
                                                                                       0.01 I
                                                                                                                               0.50 l
                                                                                                                                           10.45
        Al-Honeycomb
                                   10.000 l
                                                        32.00
                                                                   19.47 l
                                                                             0.13 l
                                                                                       0.03 l
                                                                                                                                            0.38
                                                                                                    200 I
                                                                                                             1.431E-05 |
                        1788.40 l
                                                                                                                               0.19 l
                                                                    3.52 l
                                                                             0.01 I
                                                                                       0.01
                                                                                                             2.500E-05
                                                                                                                               0.50 l
                                                                                                                                           10.45
       Epoxy-50-3150
                        1788.35 I
                                    0.050 l
                                                     1160.00
                                                                                                   2100 l
                                                     1750.00
                                                                             0.62
       CFRP-M55J_In
                        1786.85 I
                                    1.500 l
                                                                  159.21 I
                                                                                       0.34
                                                                                                 120000 I
                                                                                                             1.000E-06
                                                                                                                              -0.20 |
                                                                                                                                         -235.71
                                | 30.244 |
                                                      909.76 I
                                                                1635.57 | 13.09 |
                                                                                      2.67
                 sum
Total Al-Mass=676.18 kg; TfinalAfterQuench= 1.5421E+02 K
Weight = 1635.6 kg = Weight_Support= 1354.8 kg + Weight_Coil= 280.8 kg
```

 $+ X0_{\text{Coil}} = 0.0472 = X0_{\text{Cu}} = 0.0077 + X0_{\text{Hastelloy}} = 0.0344 + X0_{\text{Ag}} = 0.0052 + X0_{\text{Al}} = 0.0000$

+ NIL_Coil= 0.0037 = NIL_Cu= 0.0007 + NIL_Hastelloy= 0.0027 + NIL_Ag= 0.0003 + NIL_Al= 0.0000

 $= X0_Support = 0.0837$

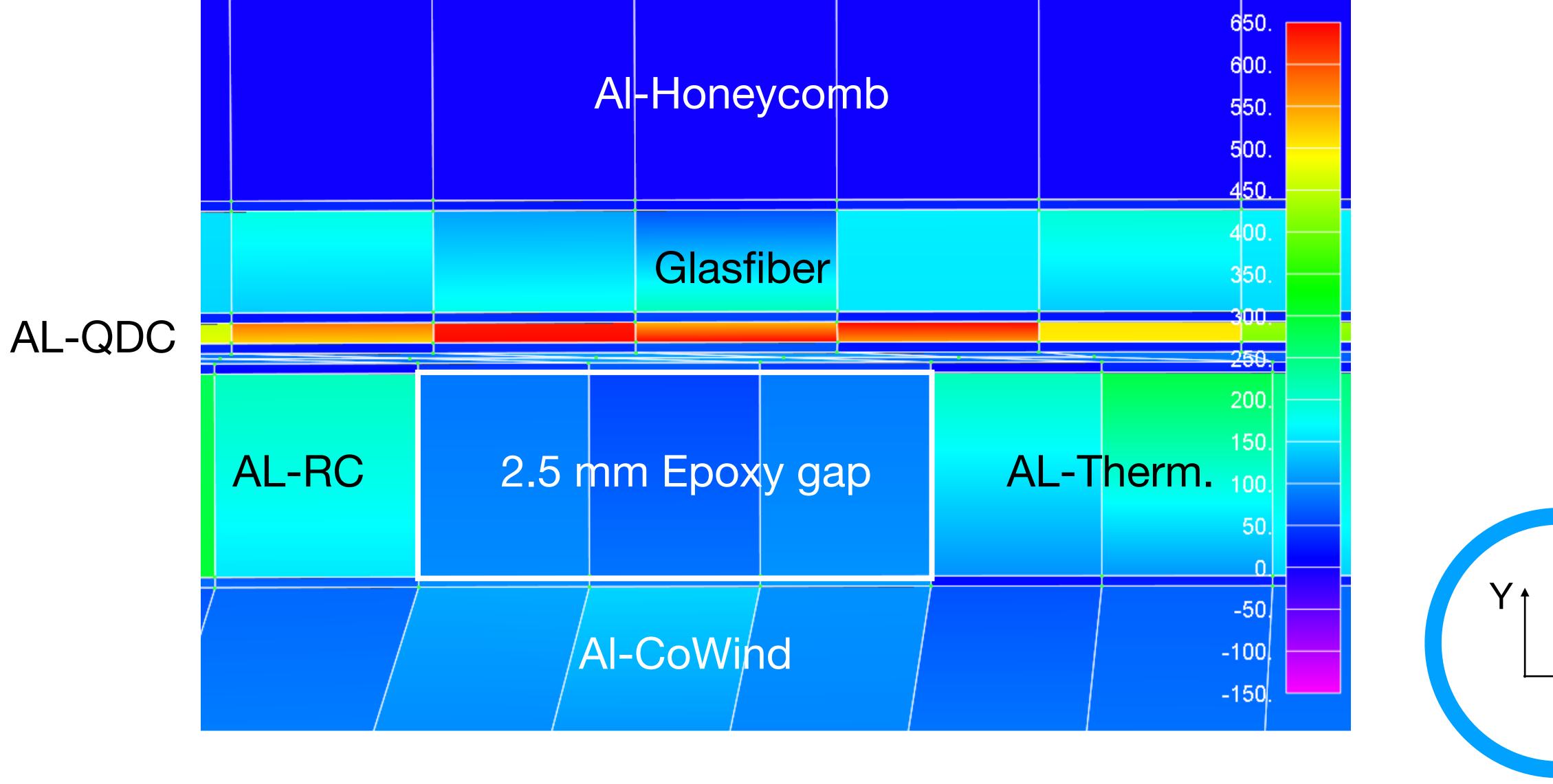
= NIL_Support= 0.0230

= 0.1309

= 0.0267

NIL

AMS-100 - (03. July 2020, Version 2.2): Cool-Down from 293 K to 4 K

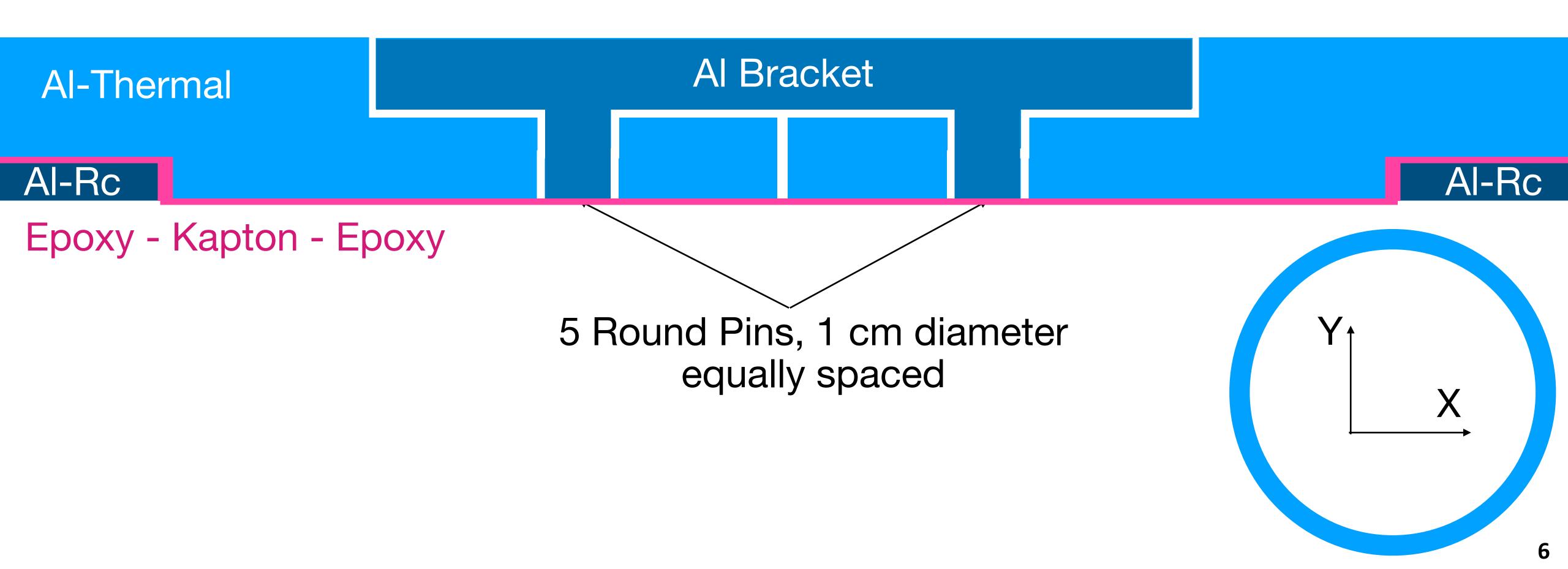


X

The local tension in the AL-QDC of 600 MPa is too high!

Create a "solid" cylinder for the thermal Aluminum

Connection of the four AL 1/4-Shells by using multiple ~20 cm long AL Brackets along the z-axis, machined to fit locally with precision



AMS-100 - (08. July 2020, Version 2.3)

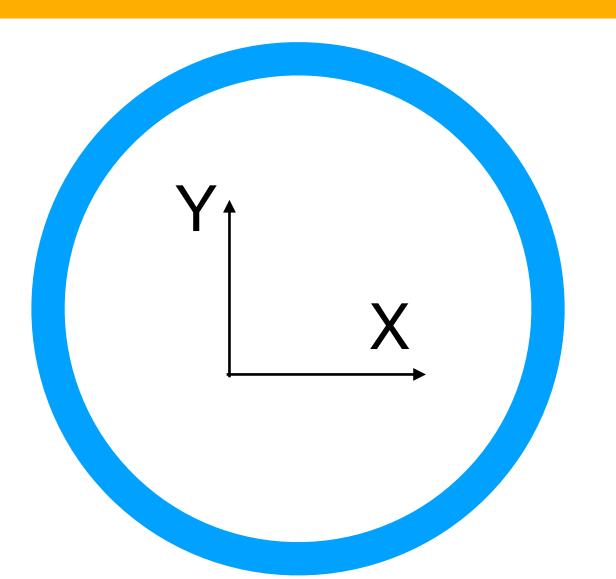
Al-Thermal

Al-Rc Al-Rc

Al-CoWind

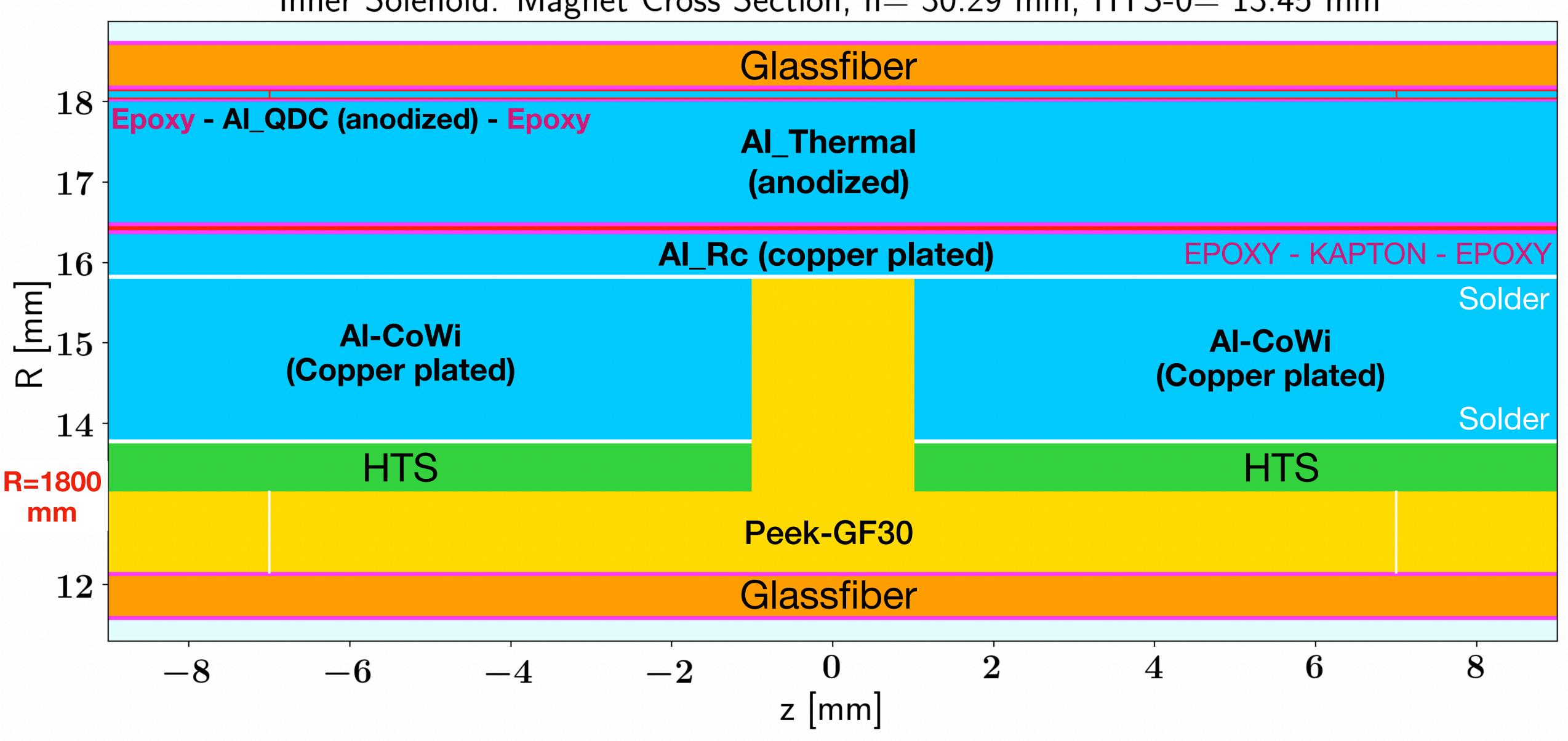
HTS

PEEK-GF30



AMS-100 - (08. July 2020, Version 2.3)

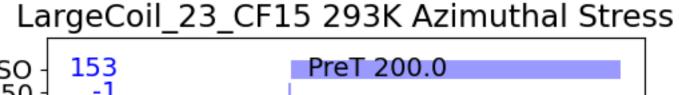
Inner Solenoid: Magnet Cross Section, h=30.29 mm, HTS-0=13.45 mm

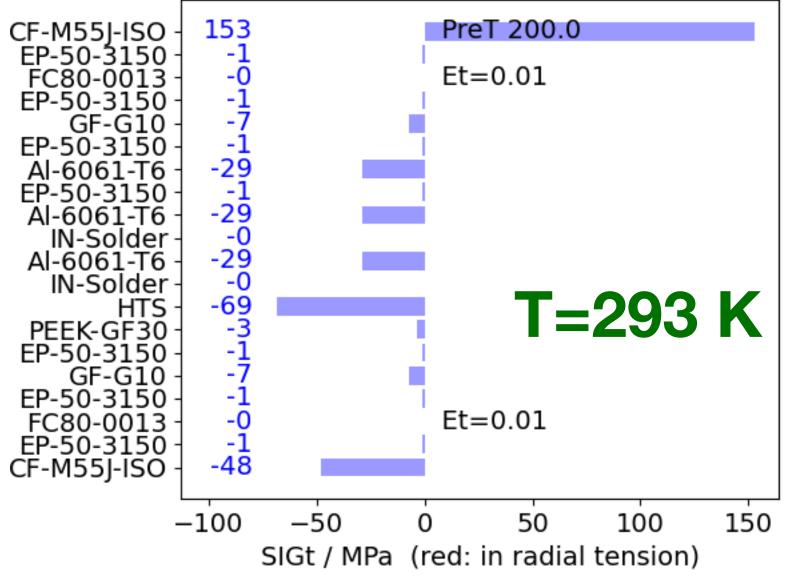


AMS-100 - (08. July 2020, Version 2.3)

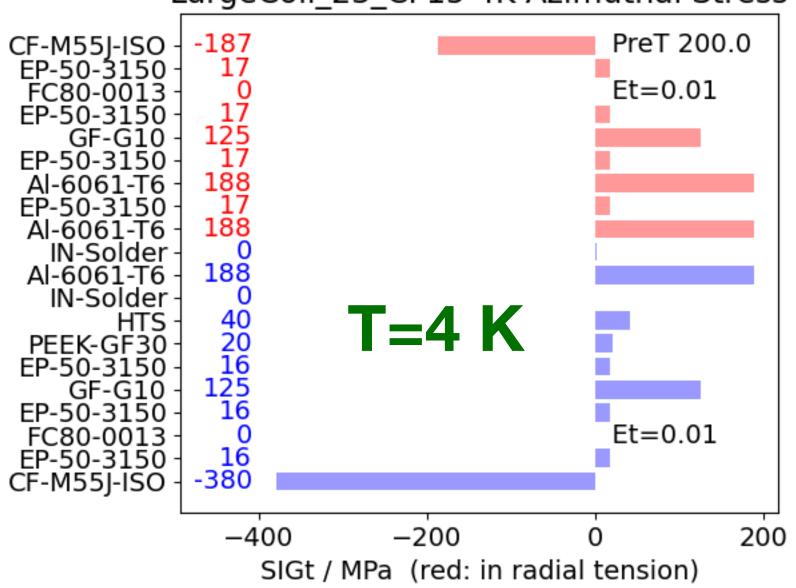
```
Inner Solenoid
Z0= 0.00 m; CoilInnerRadius= 1.80 m; CoilThickness= 0.59 mm; nTapesPerStack= 22; Current=13200.0 A; LenZ= 5.40 m; nTurns= 386; nTurnsPerM=
                                                                                                                                                 71 1/m; TapeLength= 96.058 km;
MagneticMoment= 51.86 MAm^2; TorqueSun= 0.24 Nm; Energy= 28.13 MJ; EnergyDensity=511.84 kPa <=> 5.1184E+00 bar; Weight=1639.1 kg; X0= 0.131;
B(r=0,z=0)= 0.99 T; B(r=Rin-epsilon,z=0)= 1.04 T; B(r=Rout+epsilon,z=0)= -0.14 T; Stress_R=-139.69 kPa; Stress_Theta=1291.5 MPa; Stress_Z=-647.7 MPa
           0 m**3; Volume_Rin=178.00 cm; Volume_Rout=182.00 cm; nJoints= 321; PowerLoss= 2.31 Watt; Inductance= 0.32 Henry; PowerLossStackToStack= 1.23 Watt;
HoopForcePerTape= 1064.88 N; HoopStressPerTape= 3286.67 MPa; StrainPerTape= 1.57 % (Hastelloy Only)
QuenchDetectionCoil: Length= 4363 m, CrossSection= 1.40 mm2, Resistance= 62.33 Ohm
                    Length= 4363 m, CrossSection= 24.00 mm2, Resistance= 3.64 Ohm
Co-WindCoil:
                  : Length= 4366 m, CrossSection= 7.13 mm2, Resistance=753.44 Ohm
HTS-StackCoil
                    | R_i [mm] | d [mm] | Density [kg/m^3] | Mass [kg] | X0 [%] | NIL [%] | E0 [MPa] |
                                                                                                             CTE [1/K] | Strain [%] | Stress [MPa]
       CFRP-M55J_Out | 1815.64 | 1.500 |
                                                                  161.78 | 0.62 |
                                                                                       0.34 |
                                                                                                 120000 l
                                                                                                             1.000E-06
                                                                                                                                         -235.79
                                                     1750.00 l
                                                                                                                              -0.20 l
                        1815.59 I
                                                                                                             2.500E-05
                                                                                                                               0.50 l
       Epoxy-50-3150 |
                                    0.050 l
                                                     1160.00 I
                                                                    3.57 l
                                                                             0.01 l
                                                                                       0.01 |
                                                                                                   2100 I
                                                                                                                                           10.45
                        1805.59 | 10.000 |
                                                                             0.13 l
                                                                                       0.03 l
                                                                                                    200 I
                                                                                                                                            0.38
       Al-Honeycomb |
                                                       32.00 l
                                                                   19.66 l
                                                                                                             1.431E-05
                                                                                                                               0.19 I
       Epoxy-50-3150 |
                        1805.54 l
                                    0.050 l
                                                     1160.00
                                                                    3.55 |
                                                                             0.01 l
                                                                                       0.01
                                                                                                             2.500E-05
                                                                                                                               0.50 I
                                                                                                                                           10.45
                                                                                                   2100 I
                                                                                                                                           48.75
          FiberGlass |
                        1805.04 l
                                    0.500 l
                                                     2610.00 I
                                                                   79.93 l
                                                                             0.51 l
                                                                                       0.13 |
                                                                                                  19000 l
                                                                                                             1.667E-05
                                                                                                                               0.26 l
                        1804.99 I
                                                                                                             2.500E-05
       Epoxy-50-3150 |
                                    0.050 l
                                                     1160.00
                                                                    3.55 l
                                                                             0.01 I
                                                                                       0.01
                                                                                                   2100 I
                                                                                                                               0.50 I
                                                                                                                                           10.45
                                                                             0.11 I
                        1804.89 l
                                    0.100 l
                                                     2700.00 l
                                                                   16.53 l
                                                                                       0.03
                                                                                                  77749 l
                                                                                                             1.431E-05
                                                                                                                               0.19 I
                                                                                                                                          146.48
             Al_QDC |
                                                                    3.55 l
                                                                             0.01 I
                                                                                       0.01
                                                                                                             2.500E-05
                                                                                                                               0.50 I
                                                                                                                                           10.45
       Epoxy-50-3150 |
                        1804.84 I
                                    0.050 l
                                                     1160.00
                                                                                                   2100 I
                                                                             1.69 l
            Al_Therm |
                        1803.34 l
                                    1.500 |
                                                                  247.91 I
                                                                                       0.38 l
                                                                                                  77749 l
                                                                                                             1.431E-05
                                                                                                                               0.19
                                                                                                                                          146.48
                                                     2700.00 l
       Epoxy-50-3150 |
                        1803.29 I
                                    0.050 l
                                                                    3.55 l
                                                                             0.01 l
                                                                                       0.01
                                                                                                   2100 I
                                                                                                             2.500E-05
                                                                                                                               0.50
                                                                                                                                           10.45
                                                     1160.00
                        1803.24 I
                                                                             0.02 |
                                                                                                   3758 I
                                                                                                                                           43.73
                                    0.050 l
                                                     1420.00 l
                                                                    4.34
                                                                                       0.01
                                                                                                             4.804E-05
                                                                                                                               1.16
              Kapton |
      Epoxy-50-3150 |
                        1803.19 I
                                    0.050 l
                                                     1160.00
                                                                    3.55 |
                                                                             0.01 l
                                                                                       0.01
                                                                                                   2100 l
                                                                                                             2.500E-05
                                                                                                                               0.50 I
                                                                                                                                           10.45
              Al_Rc |
                        1802.69 I
                                    0.500 l
                                                     2700.00 l
                                                                   82.58 I
                                                                             0.56 l
                                                                                       0.13
                                                                                                  77749 l
                                                                                                             1.431E-05
                                                                                                                               0.19
                                                                                                                                          146.48
          In-Solder |
                        1802.64 I
                                                                   22.36 I
                                                                             0.41 I
                                                                                       0.02
                                                                                                    100 l
                                                                                                             3.300E-05
                                                                                                                               0.73 I
                                                                                                                                            0.73
                                    0.050 l
                                                     7310.00
                                                                             2.25 |
            Al_CoWi |
                        1800.64 l
                                    2.000 |
                                                     2700.00
                                                                  330.09 |
                                                                                       0.50
                                                                                                  77749 l
                                                                                                             1.431E-05
                                                                                                                               0.19
                                                                                                                                          146.48
                                                                   22.33 l
                                                                             0.41 l
                                                                                                                                            0.73
          In-Solder |
                                                                                       0.02
                                                                                                             3.300E-05
                                                                                                                               0.73
                        1800.59 I
                                    0.050 l
                                                     7310.00
                                                                                                    100 l
           HTS-Coil |
                        1800.00 l
                                                                  280.77
                                                                             4.72 |
                                                                                       0.37
                                                                                                 177510 l
                                                                                                             9.244E-06
                                                                                                                               0.04
                                                                                                                                           74.35
                                    0.594 l
                                                     9021.48
       Peek-GF30_Gap |
                        1799.00 l
                                    1.000 |
                                                     1320.00
                                                                   80.59 I
                                                                             0.29 I
                                                                                       0.14
                                                                                                   3760 I
                                                                                                             1.400E-05
                                                                                                                                            6.75
                                                                                                                               0.18 |
      Epoxy-50-3150 |
                                                                             0.01 I
                                                                                                                               0.50 l
                                                                                                                                           10.45
                        1798.95 I
                                    0.050 l
                                                     1160.00 I
                                                                    3.54
                                                                                       0.01
                                                                                                   2100 I
                                                                                                             2.500E-05
          FiberGlass |
                                                                                                                                           48.75
                        1798.45 I
                                    0.500 l
                                                     2610.00
                                                                   79.64 l
                                                                             0.51 l
                                                                                       0.13
                                                                                                  19000 l
                                                                                                             1.667E-05
                                                                                                                               0.26 I
                                                                                                                                           10.45
       Epoxy-50-3150 |
                        1798.40
                                    0.050 l
                                                     1160.00
                                                                    3.54
                                                                             0.01 |
                                                                                       0.01
                                                                                                   2100 |
                                                                                                             2.500E-05
                                                                                                                               0.50 l
       Al-Honeycomb |
                        1788.40 l
                                   10.000 l
                                                       32.00
                                                                   19.47 l
                                                                             0.13 l
                                                                                       0.03 l
                                                                                                    200 l
                                                                                                             1.431E-05
                                                                                                                               0.19 I
                                                                                                                                            0.38
       Epoxy-50-3150 | 1788.35 |
                                    0.050 l
                                                     1160.00
                                                                    3.52 l
                                                                             0.01 l
                                                                                       0.01
                                                                                                   2100 |
                                                                                                             2.500E-05
                                                                                                                               0.50 l
                                                                                                                                           10.45
       CFRP-M55J_In | 1786.85 |
                                                     1750.00 I
                                                                                                 120000 I
                                   30.294 l
                                                      910.17 | 1639.13 | 13.11 | 2.68
                 sum |
Total Al-Mass=676.18 kg; TfinalAfterQuench= 1.5421E+02 K
Weight = 1639.1 kg = Weight_Support= 1358.4 kg + Weight_Coil= 280.8 kg
                  = X0_Support = 0.0838
                                              + X0_{\text{coil}} = 0.0472 = X0_{\text{cu}} = 0.0077 + X0_{\text{Hastelloy}} = 0.0344 + X0_{\text{Ag}} = 0.0052 + X0_{\text{Al}} = 0.0000
      = 0.1311
     = 0.0268
                  = NIL_Support= 0.0230
                                              + NIL_Coil= 0.0037 = NIL_Cu= 0.0007 + NIL_Hastelloy= 0.0027 + NIL_Ag= 0.0003 + NIL_Al= 0.0000
```

AMS-100 - (08. July 2020, Version 2.3): Pre-Tension Outer CFRP by 200 MPA

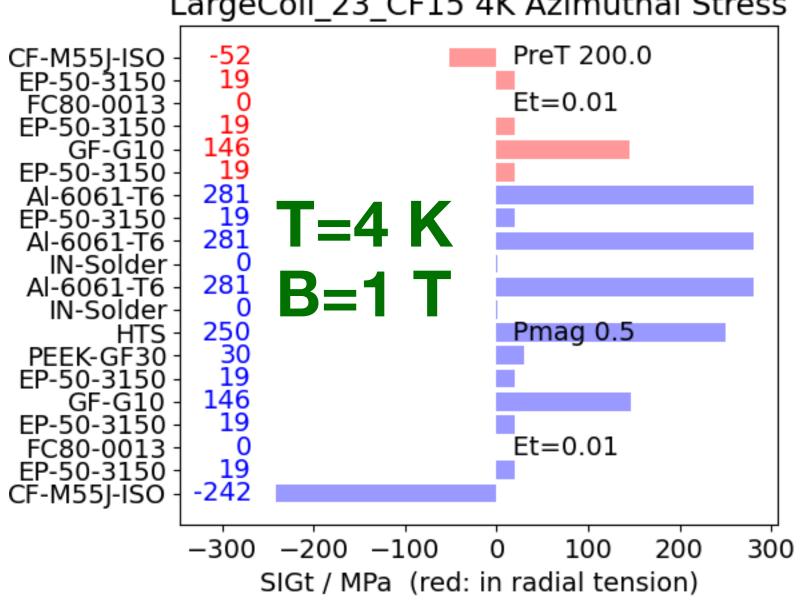




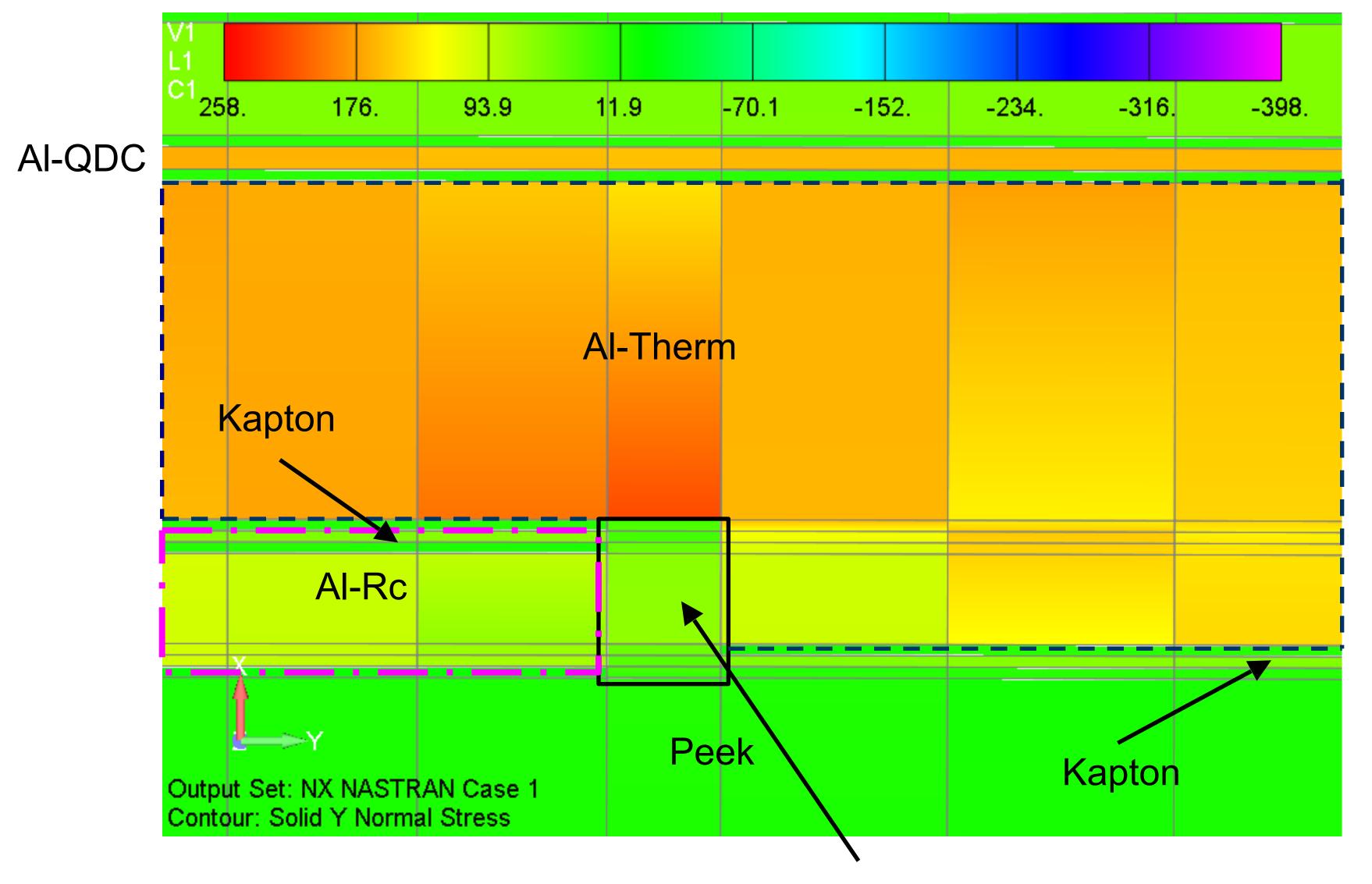
LargeCoil_23_CF15_4K Azimuthal Stress







AMS-100 - (08. July 2020, Version 2.3): Cool-Down from 293 K to 4 K



Epoxy filled gap between Al-Rc and Al-therm