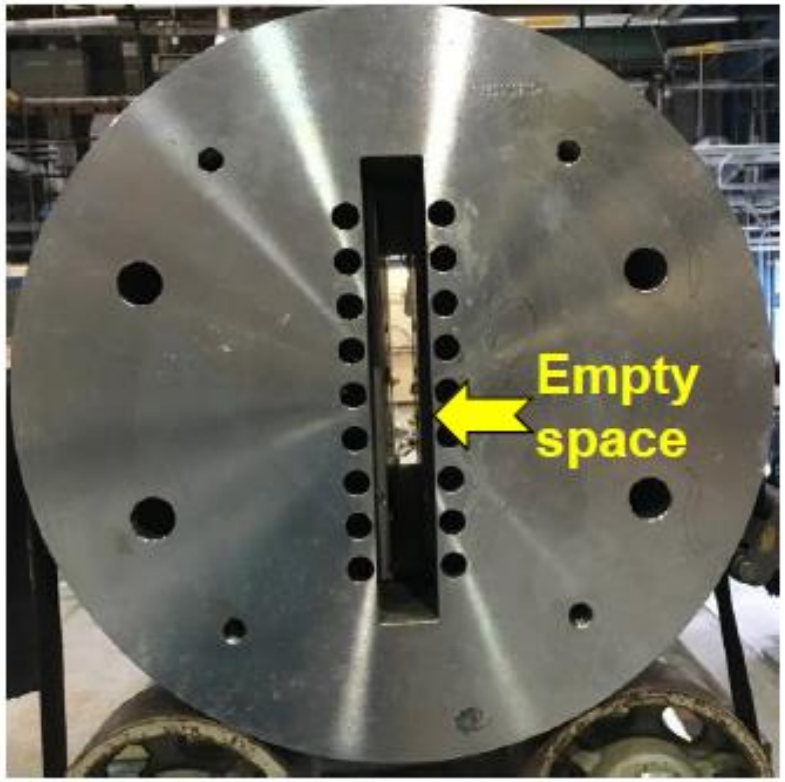
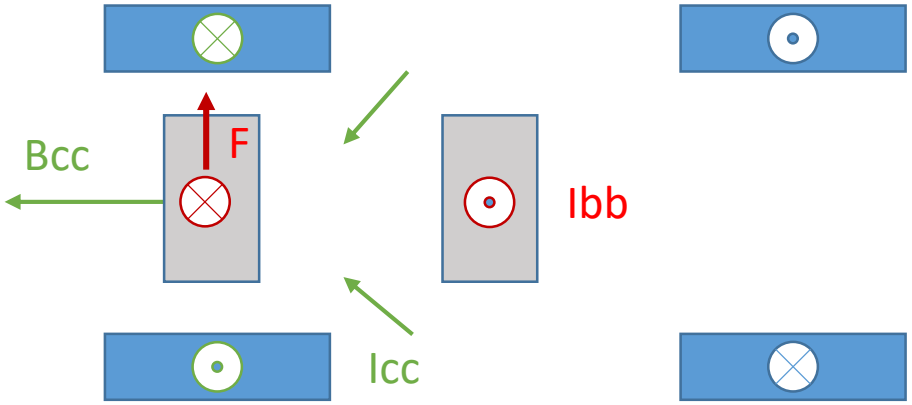
BNL/MDP – PSI Collaboration DCC017

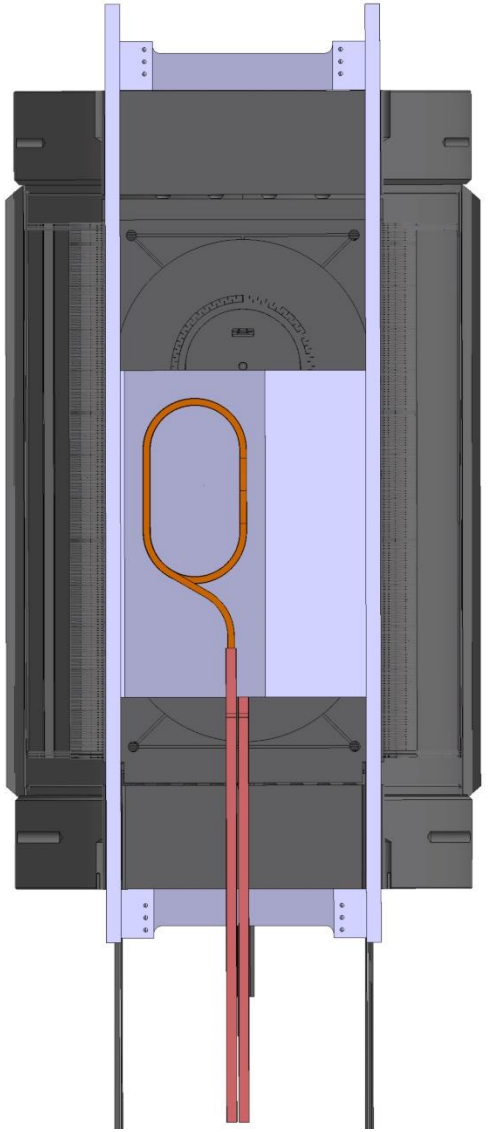
- Common coil dipole
- Free aperture of 30 x 335 mm
- Background field of 9 T
- Rapid-turn around



Goals and the role of DCC017 magnet

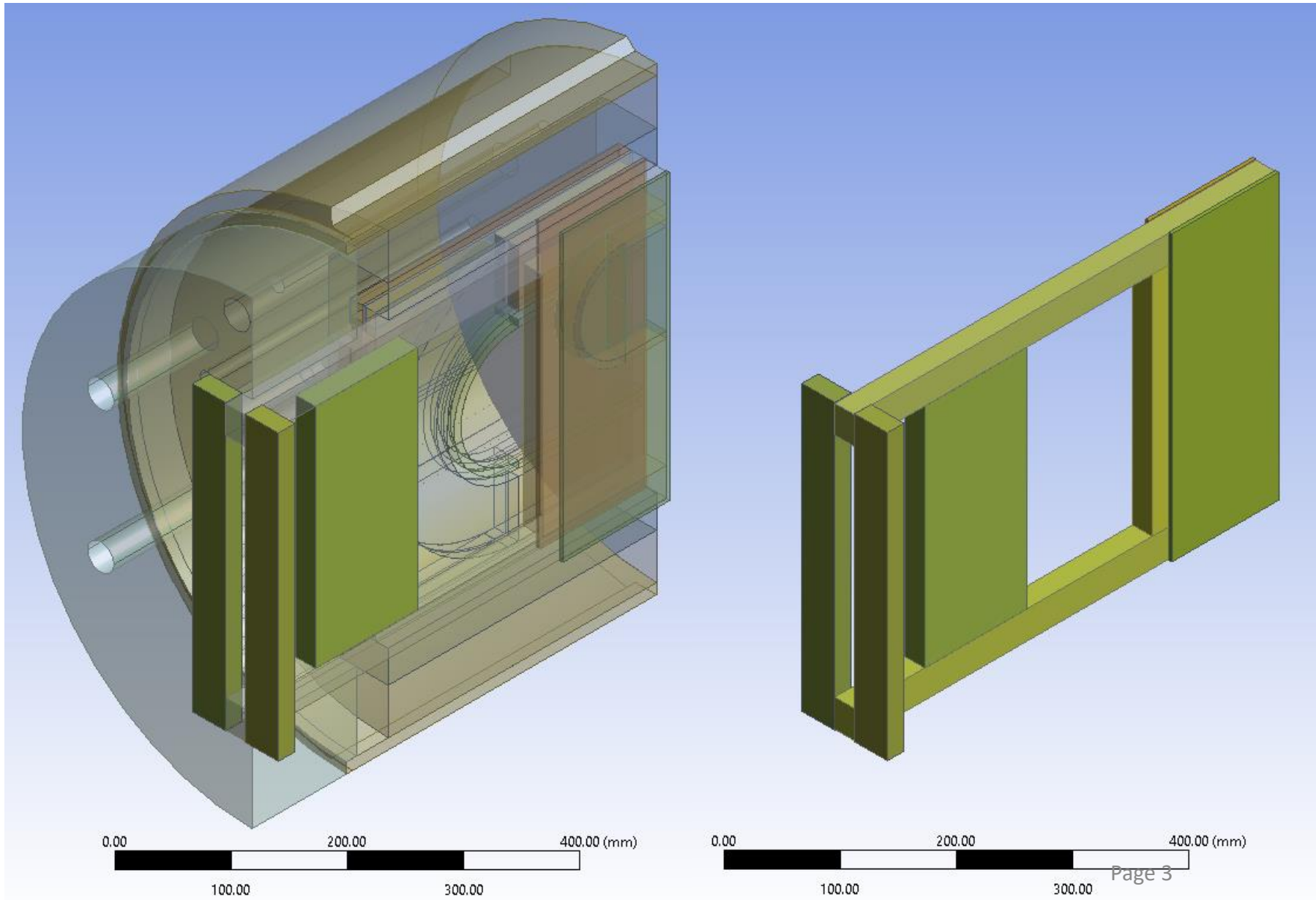
- Assessing coil performance
  - SC margin
  - conductor transversal pressure
  - training
- … and validating new technologies
  - load free magnet
  - Interface conditions
  - Wax impregnated coil performance
  - Stress-managed structure Insulation





Mechanical Coupling – Geometry

- **BigBOX Structure**
- **Coil**
- **Poles**
- **Box**
- **Covers**
- **Bars**
- **Connection**



Cable and strand parameters

- **Coil and background parameters**
  - number of turns: 13
  - cable bare width: 7.79 mm
  - cable bare thickness: 1.28 mm
  - insulation thickness: 155.0 µm
  - **electrical current: 20 kA (after upgrade)**
  - **background field of 9 T on the x direction**

- **Strand parameters**
  - strand diameter: 0.7 mm
  - operational temperature: 4.2 K
  - cabling degradation: 5%

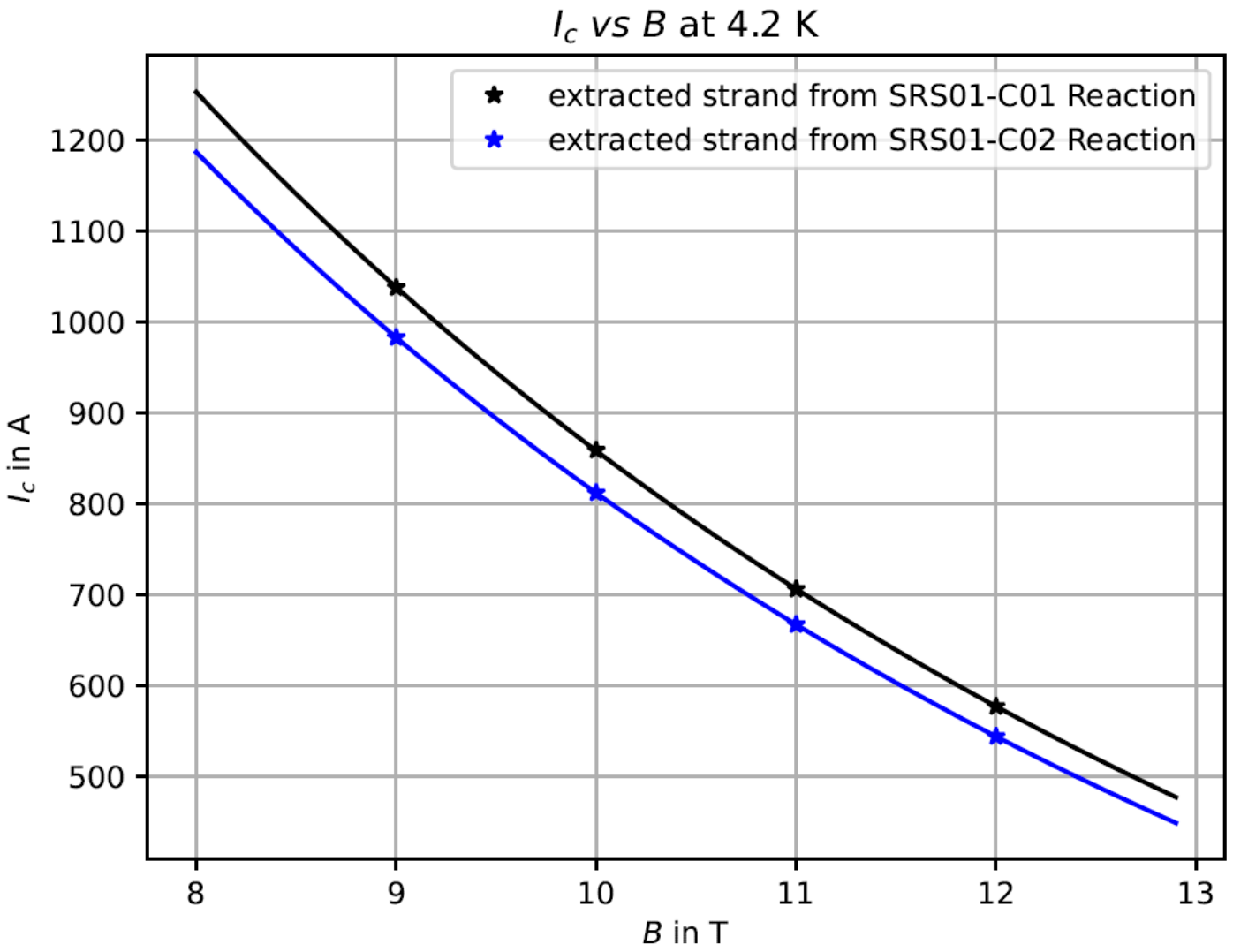
Cable provided by BNL

Thanks to LBNL for providing information on the HT cycle

Jc curve fitting

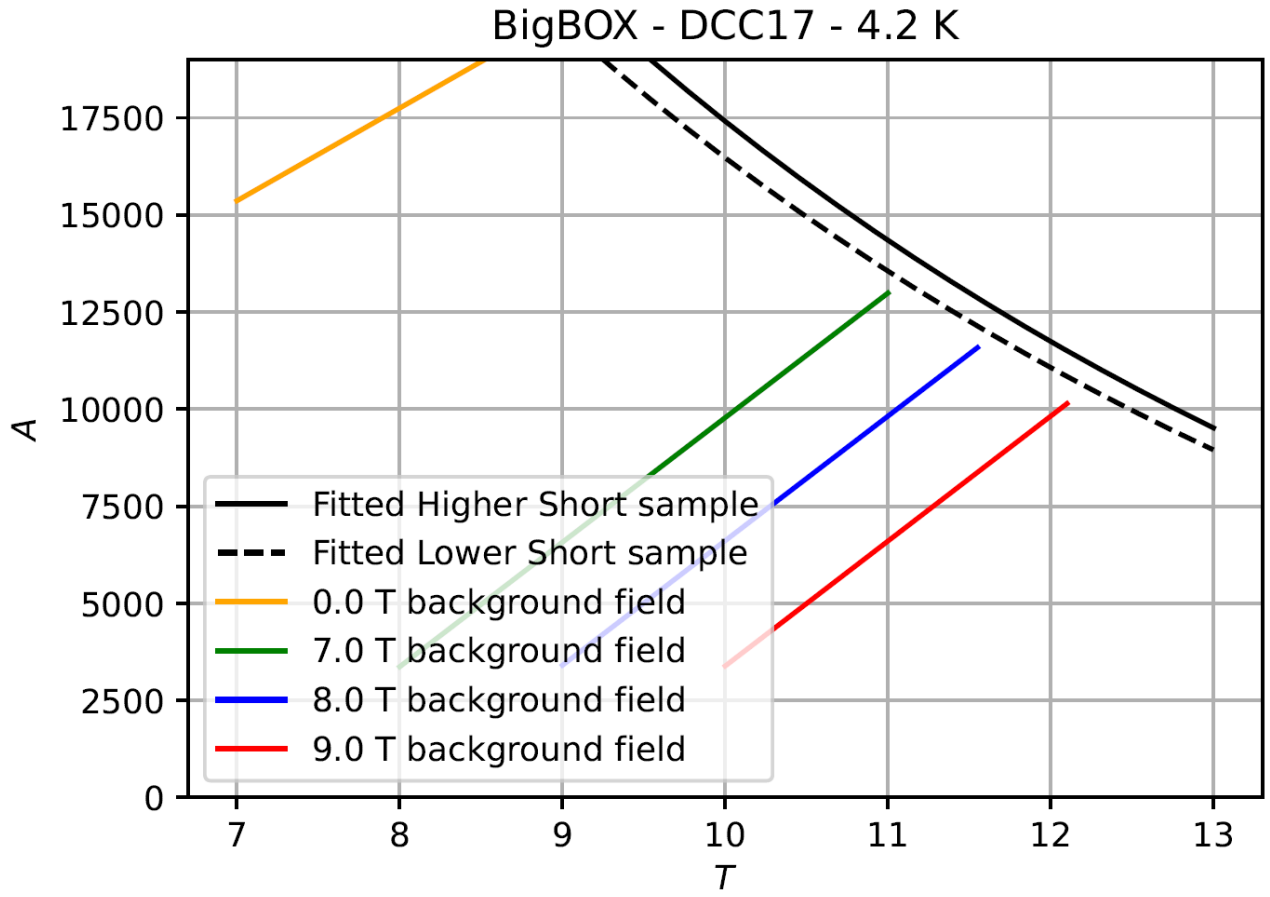
- Data From E. Barzi Paper*
  - Extracted strands
  - No self-field correction
  - Higher Jc
    - SRS01-C01 (Extr. 935R, BNL)
  - Lower Jc
    - SRS01-C02(Extr. 935R, BNL)

E. Barzi *et al.*, “RRP Nb3Sn strand studies for LARP,” *Applied Superconductivity, IEEE Transactions on*, vol. 17, pp. 2607–2610, Jul. 2007, doi: 10.1109/TASC.2007.899579.



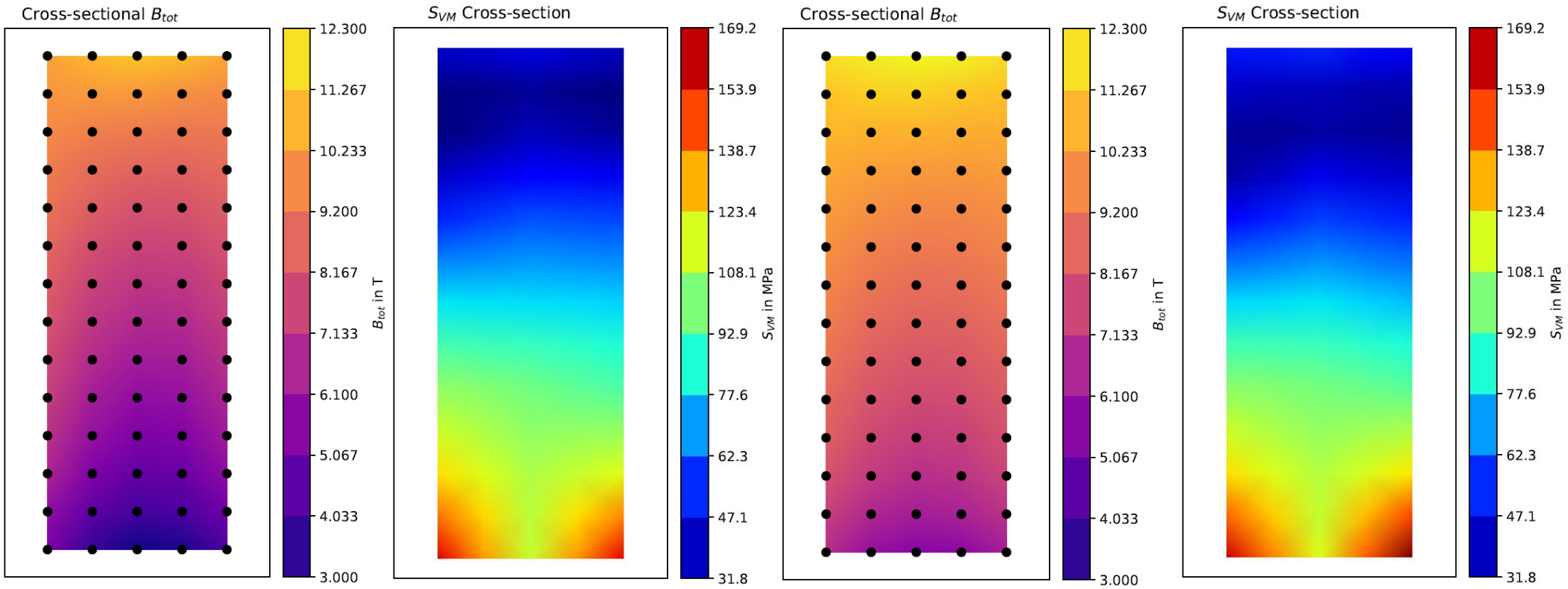
Changing Background field

- BigBOX load lines under different background fields



- By changing DCC17 background field the BigBOX load line changes.
- This allow us to change BigBOX stress level in respect to the load line position.

Stress and Field distribution (cross-section from 3D)

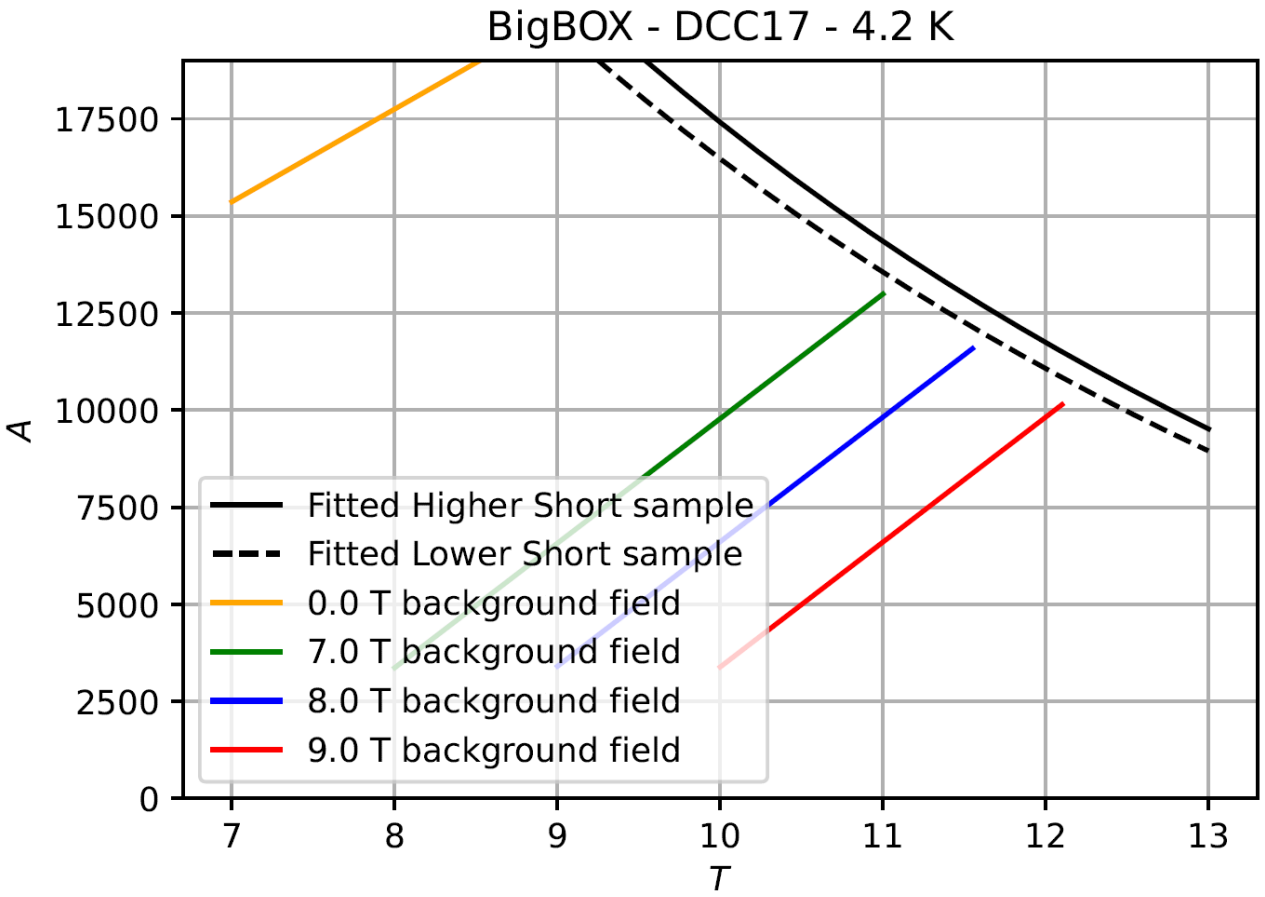


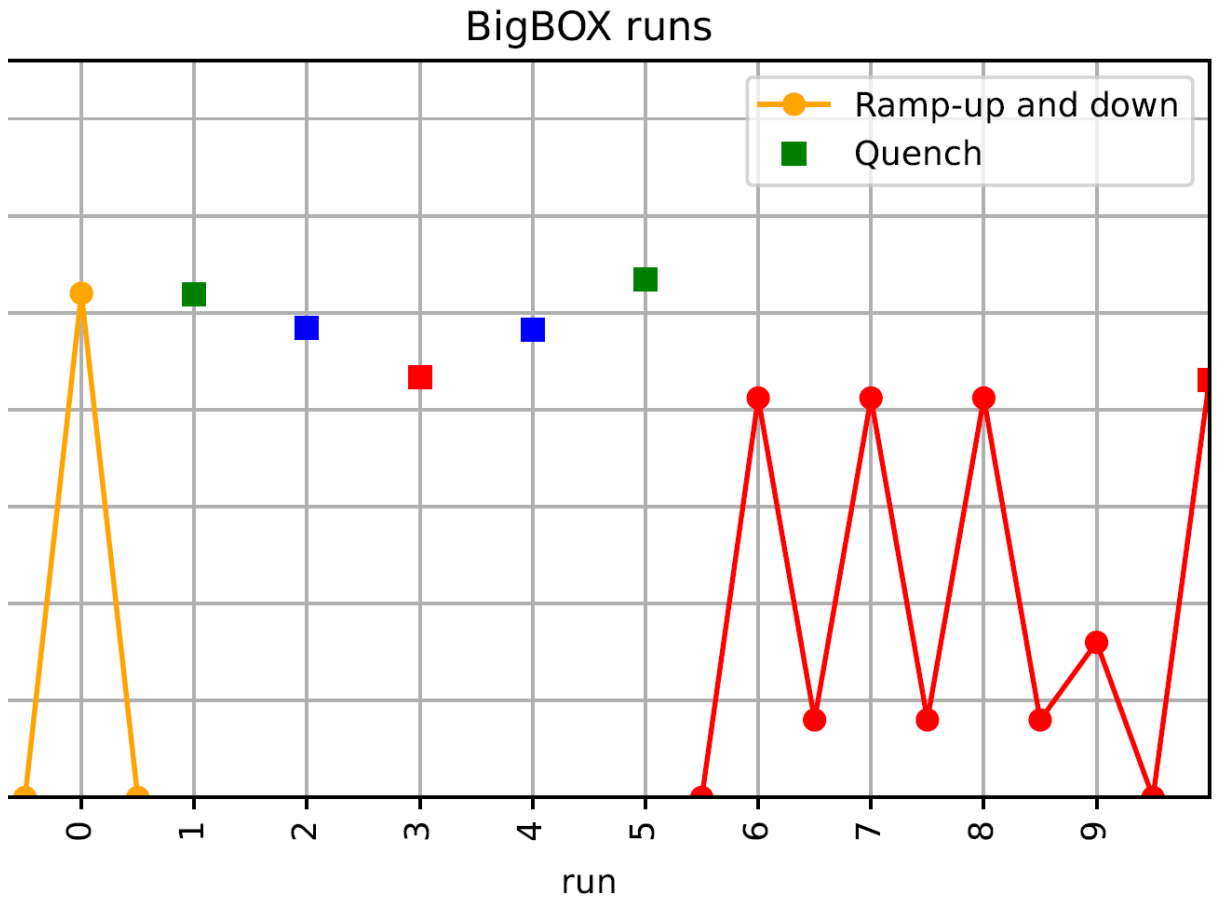
7 T background field

9 T background field

By increasing DCC17 background field BigBOX stress increases and margin decreases.

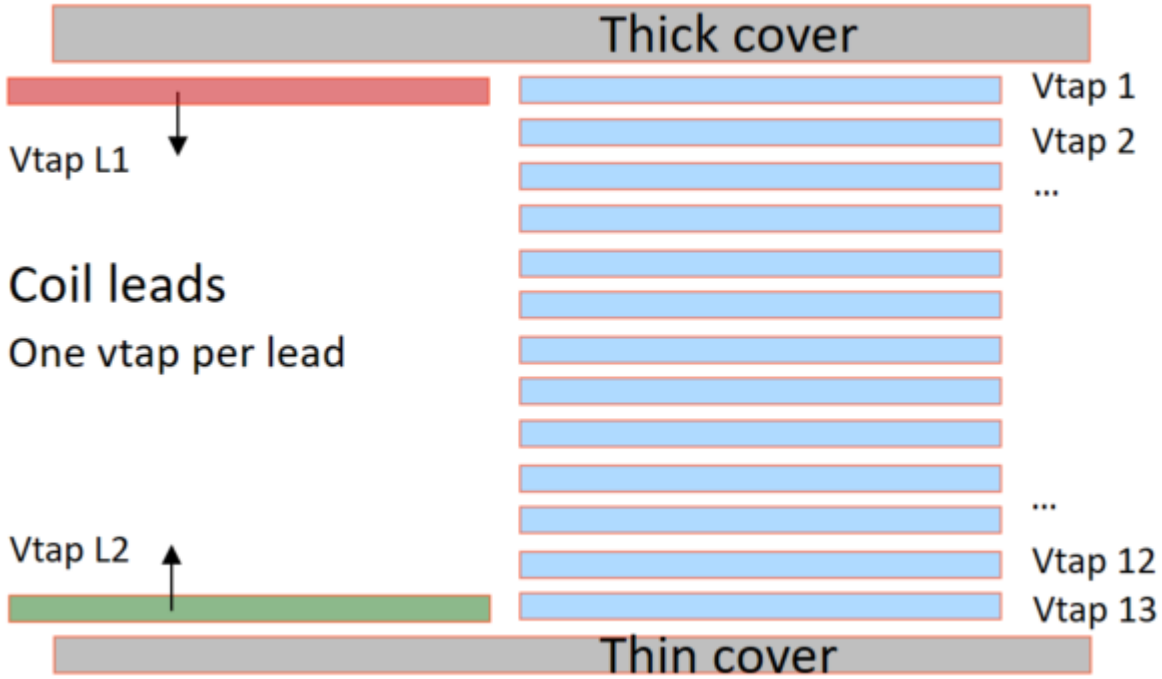
Results: Load line and Runs





Reminder on Instrumentation and Field / Stress Regions

Vtap 1 is the closest to the thick cover



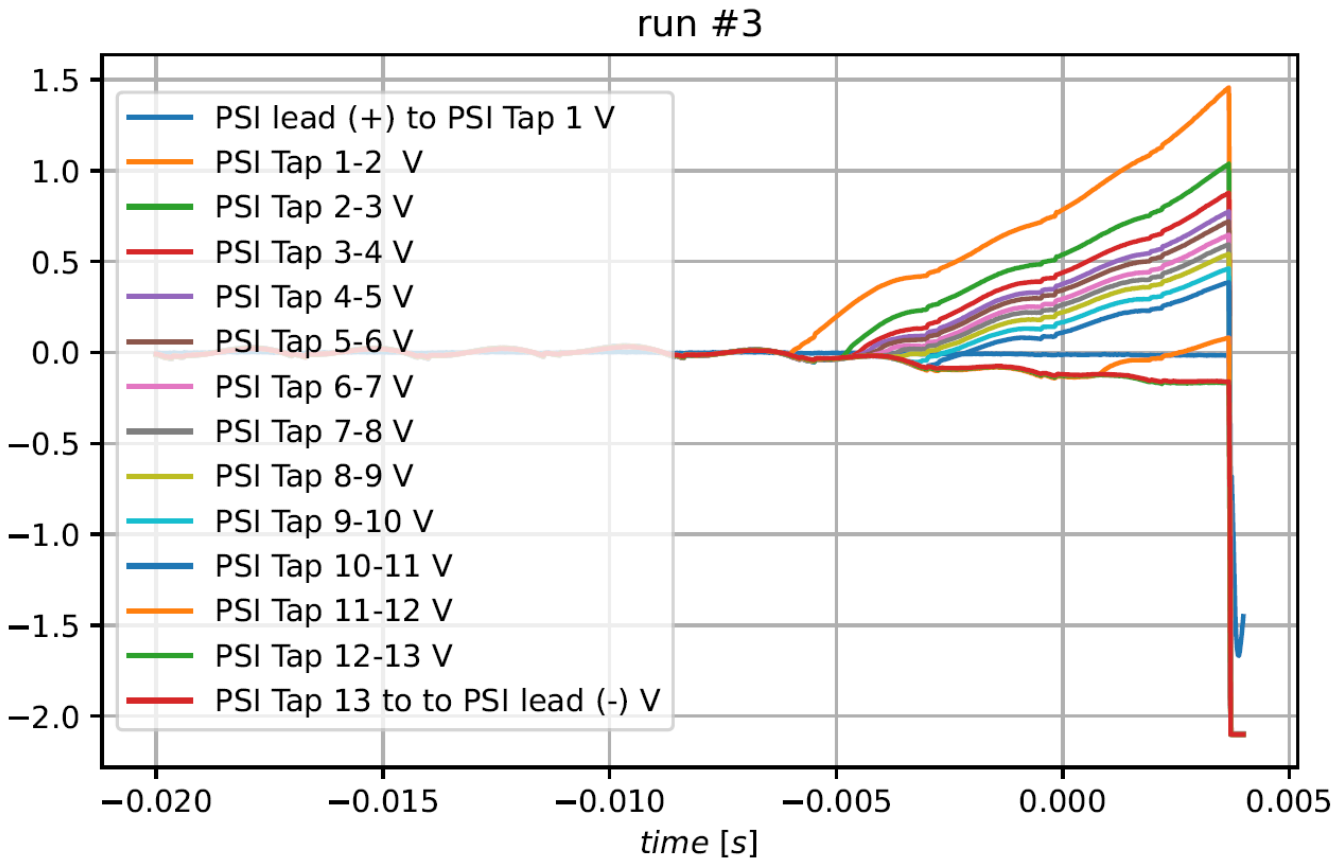
- The current was inverted during the test

High Stress & Low field region

High Stress & Low field region

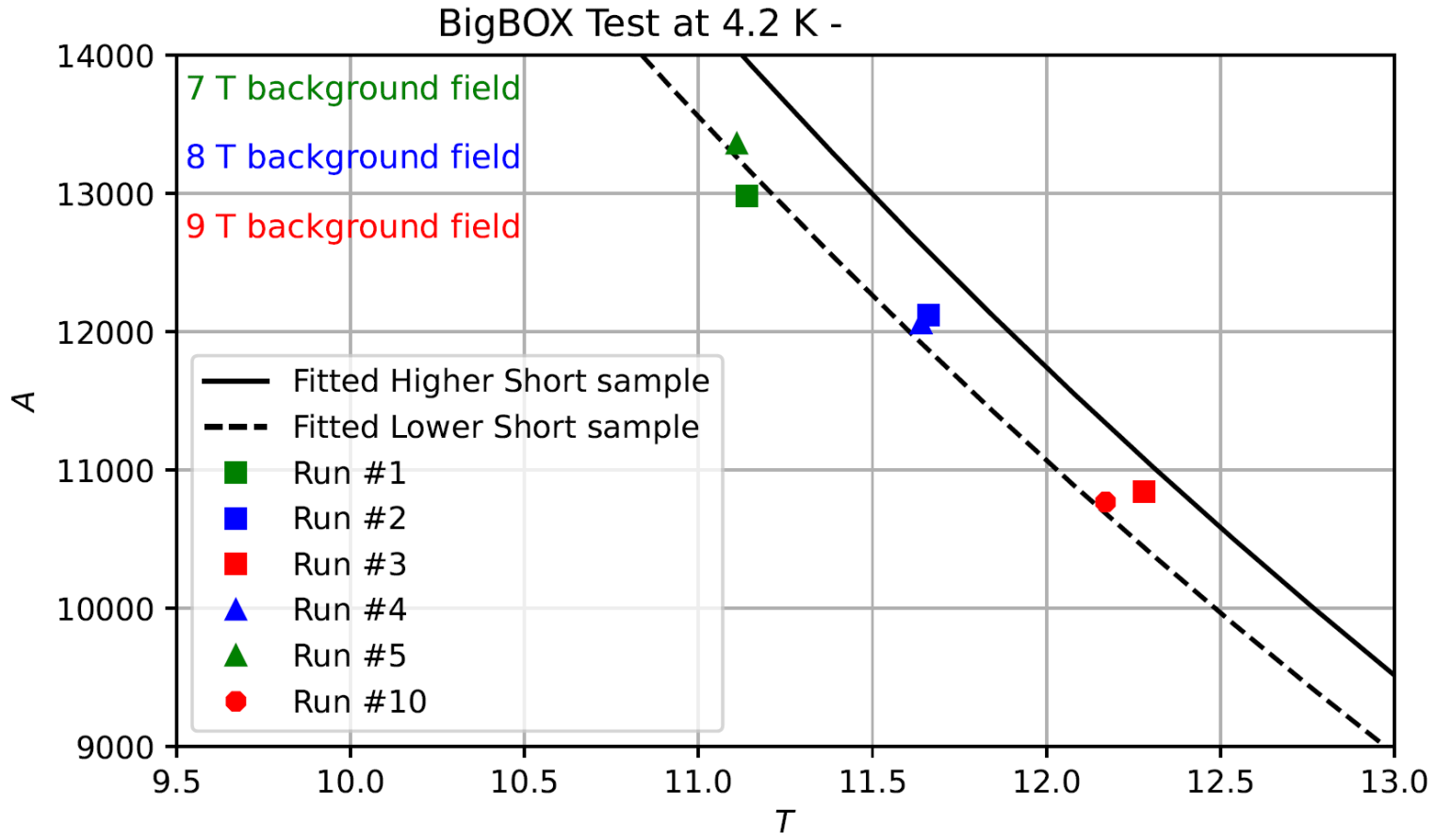
Quench Detection: Run #3

- Quench started on Vtap 1-2

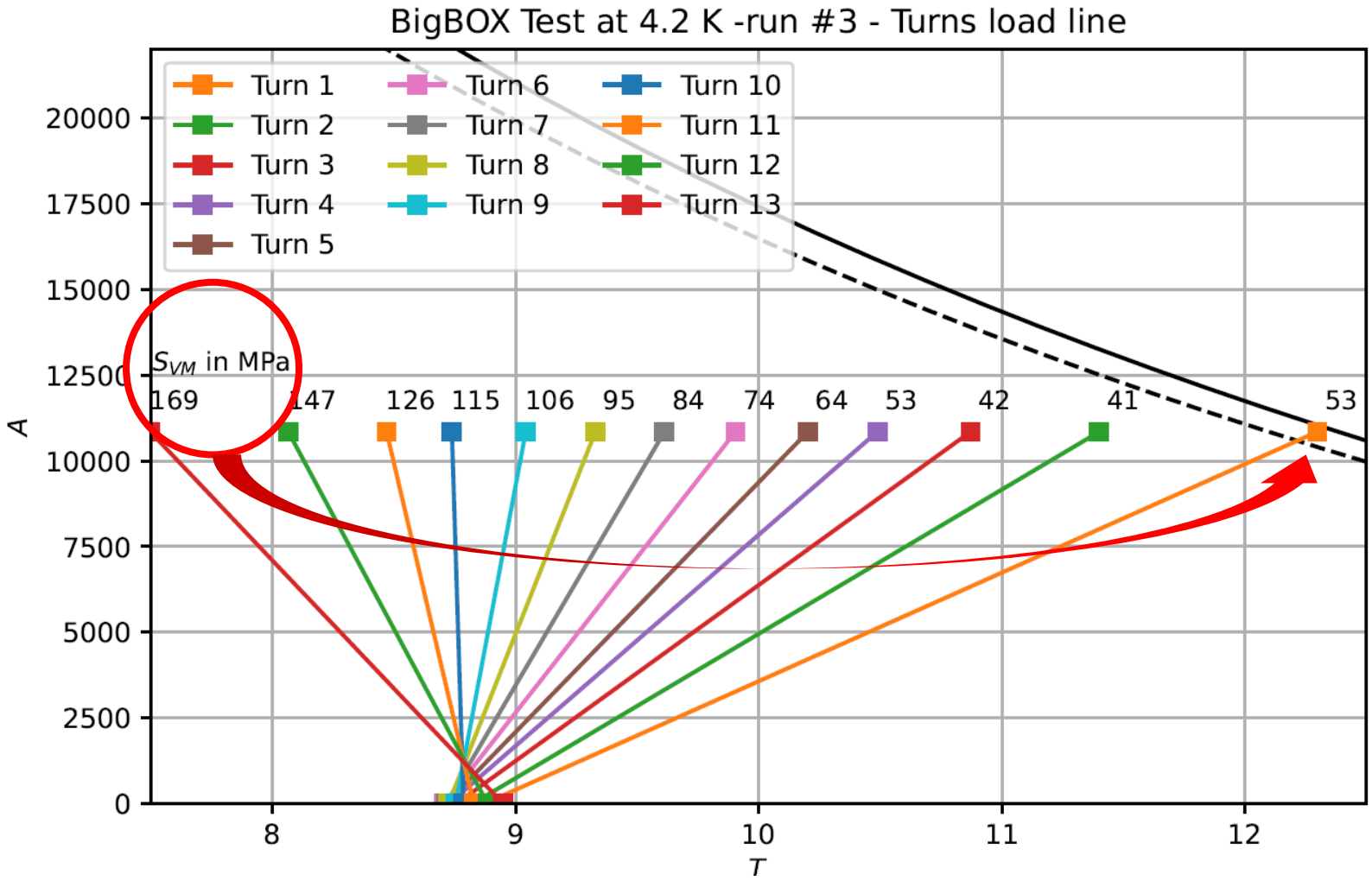


Placing the quenches on the Jc curve

- With the first turn computed magnetic field and BigBOX



Placing the quenches on the Jc curve

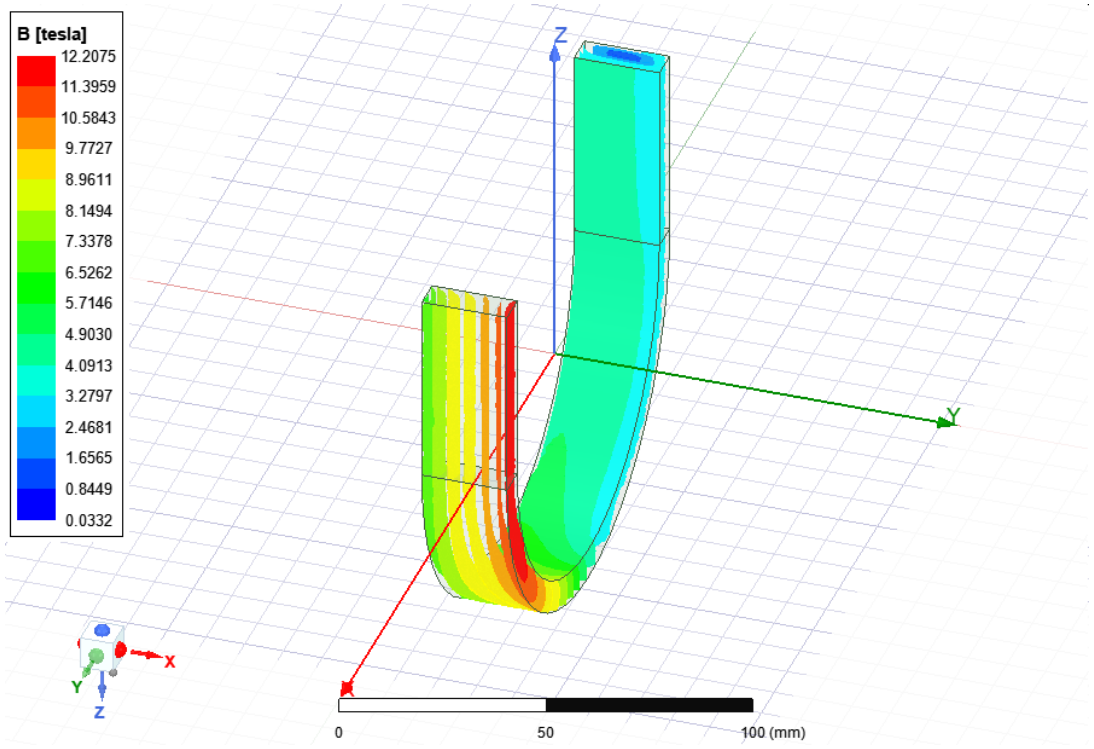


- BigBOX can be used as a means to study the permanent degradation of conductors
- Reversing the current would place the turn with a history of high stress in the high magnetic field region.

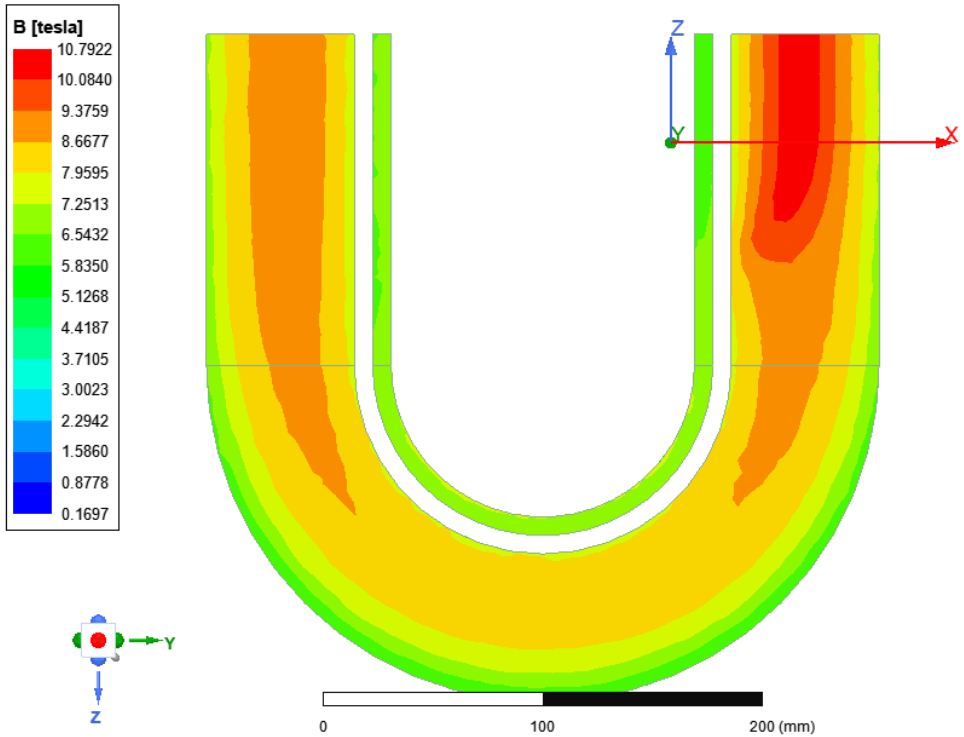
Run 10

3D magnetic and mechanical analysis

3D Magnetic Analysis

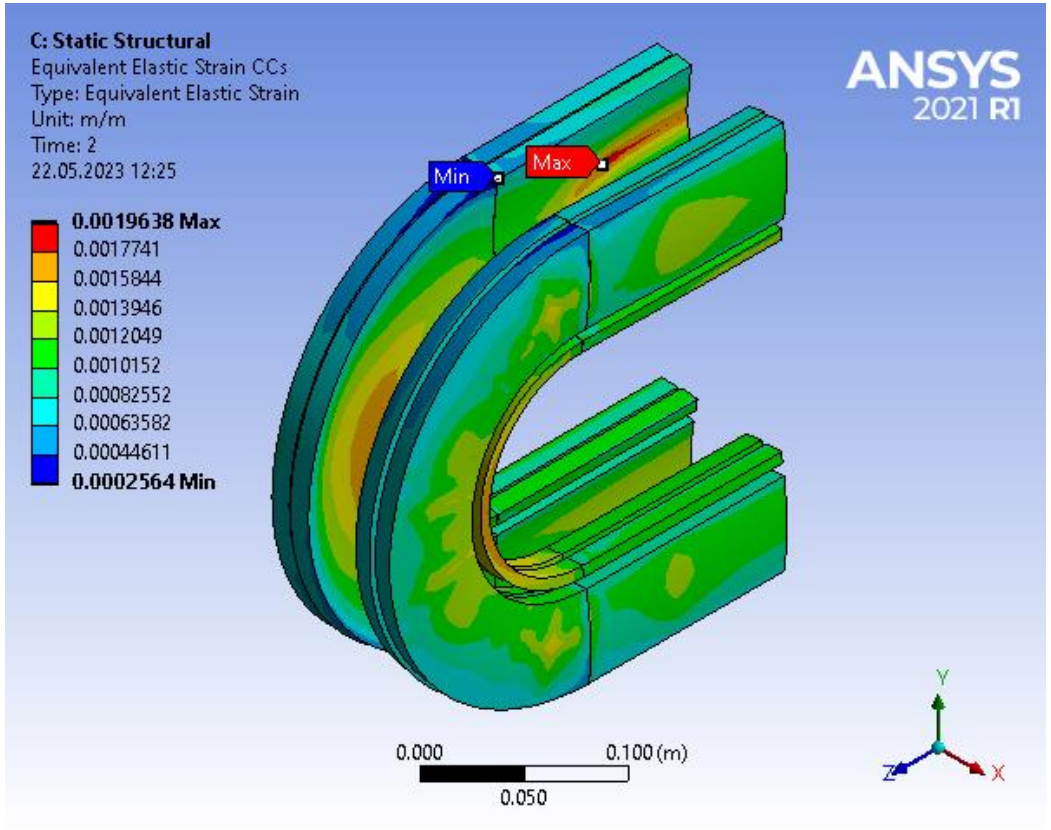


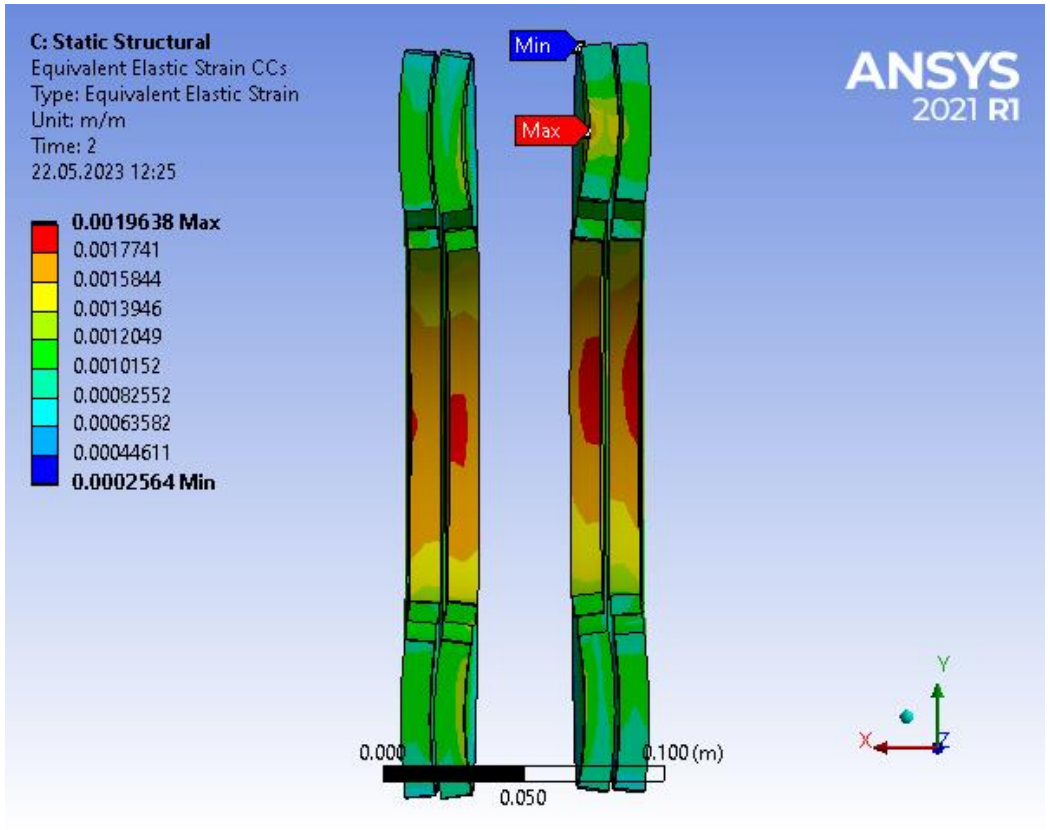
B_{peak} on BigBOX = 12.21 T
BigBOX I_{run10} = 10.77 kA



B_{peak} on DCC17 = 10.79 T
DCC17 I_{run10} = 9.04 kA

3D Mechanical Analysis: DCC17 LTS Coils

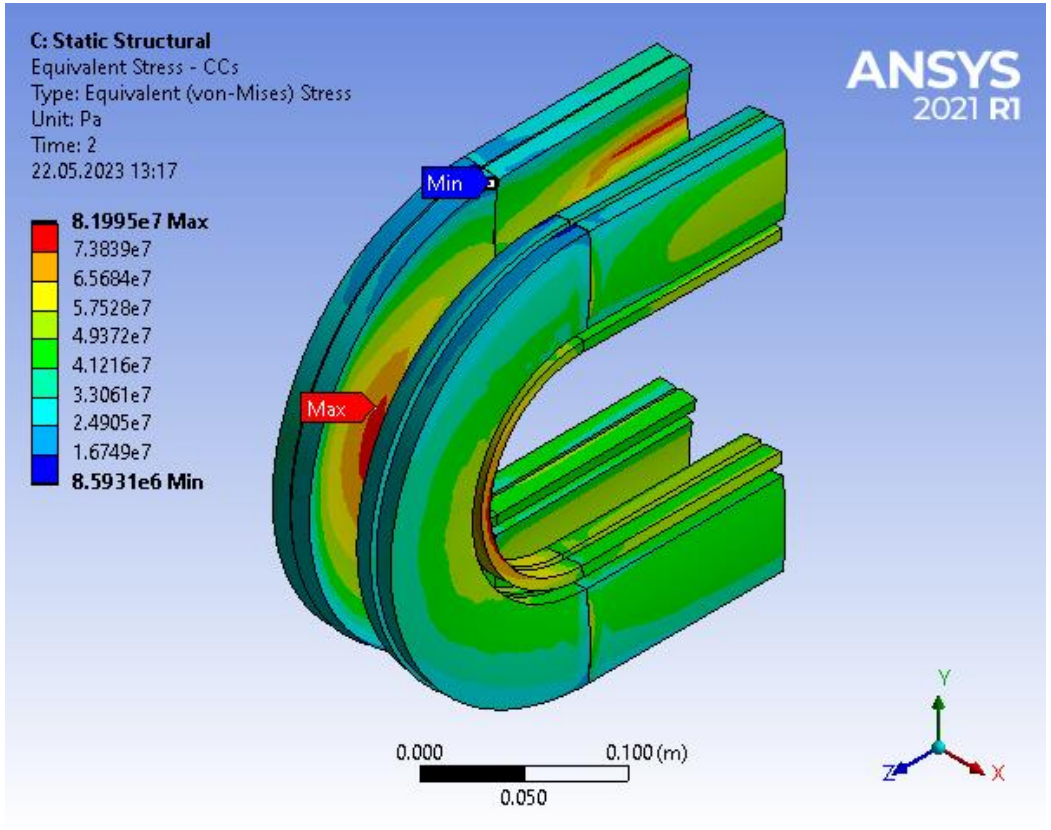


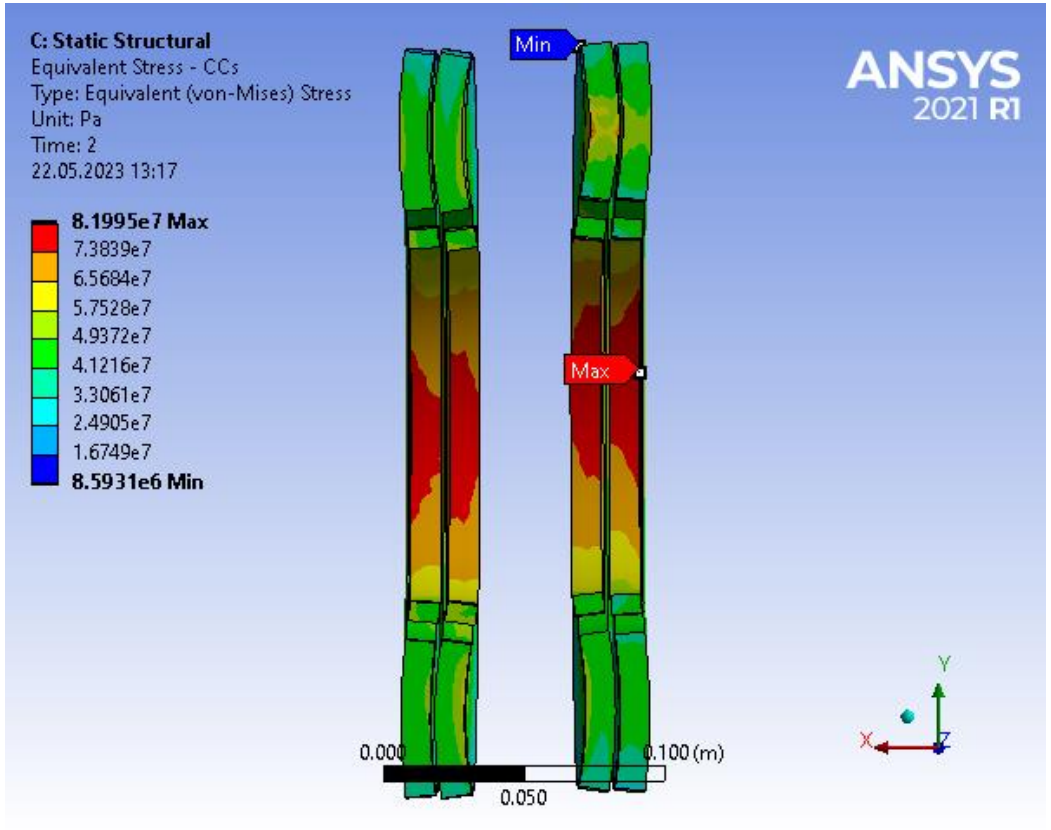


ε_{peak} on DCC17 = 0.00196
Due to BigBOX forces

This peak of strain has a value close to the on DCC17 coil ends

3D Mechanical Analysis: DCC17 LTS Coils

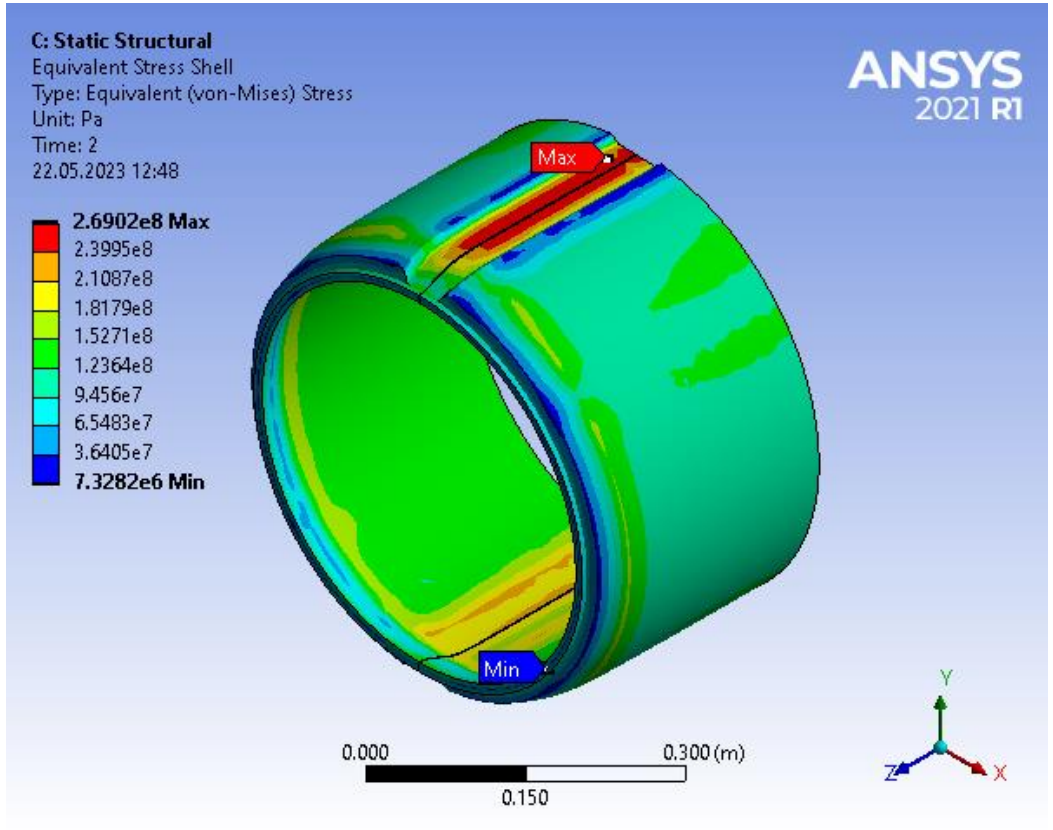


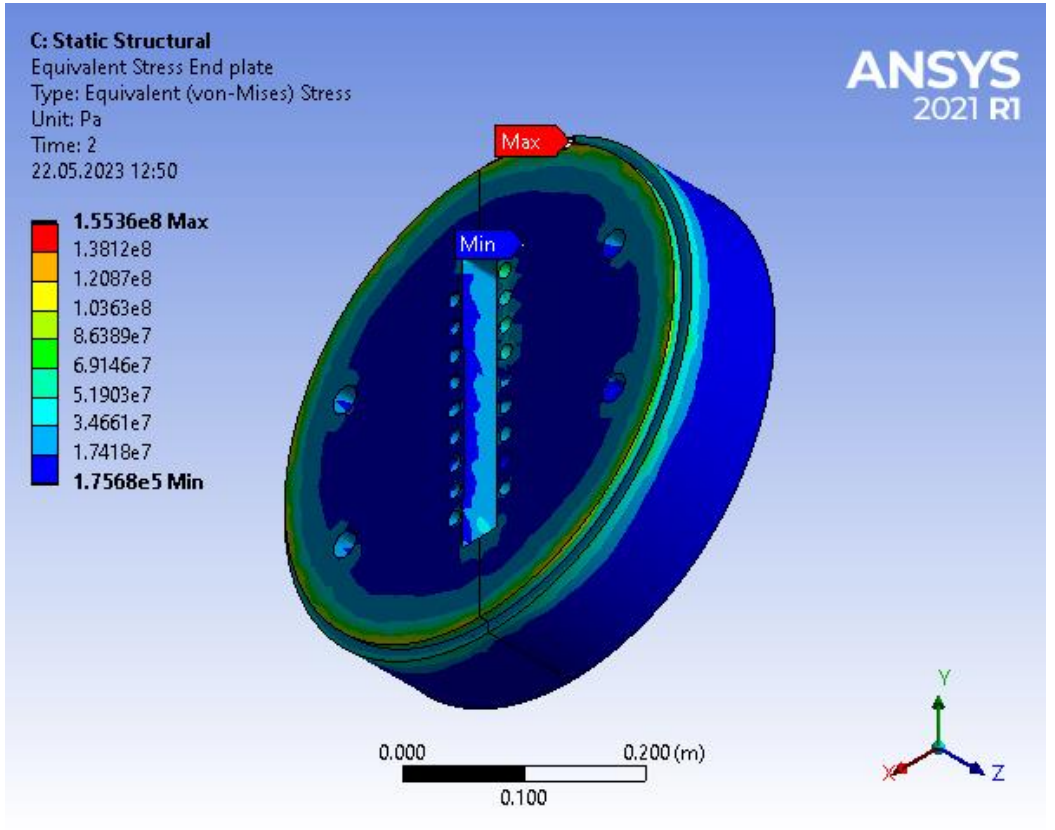


Max S_{VM} = 82 MPa
On the ends

Similar peak of VM stress on the ends and BigBOX region

3D Mechanical Analysis: DCC17 Shell and End-plate (both made of stainless steel)

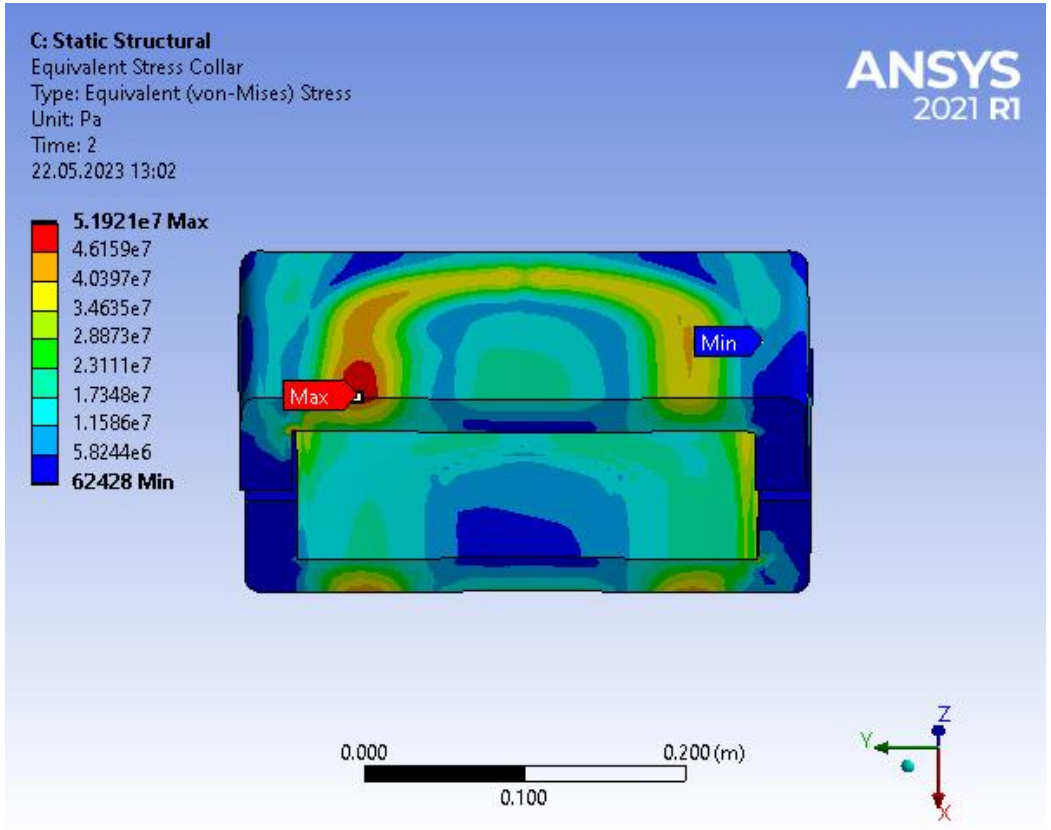


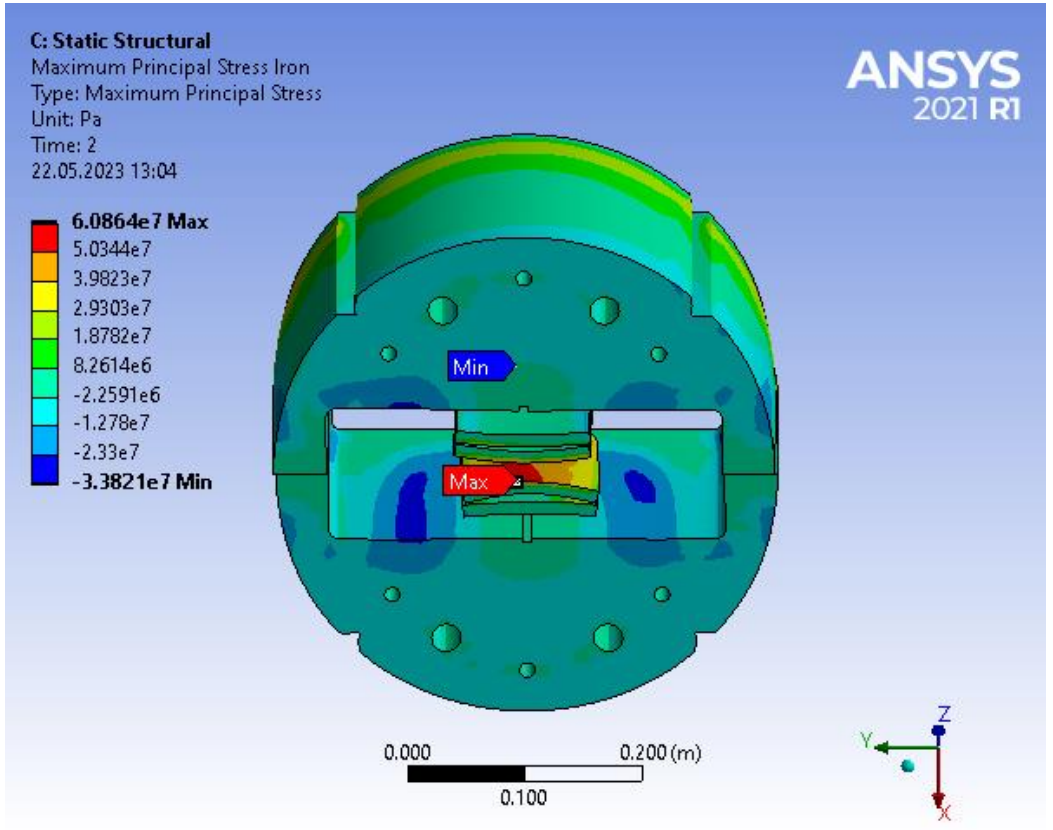


Max S_{eqv} on DCC17 Shell = 269 MPa

Max S_{eqv} on DCC17 End-plate = 155 MPa

3D Mechanical Analysis: DCC17 Collar (stainless steel) and Iron

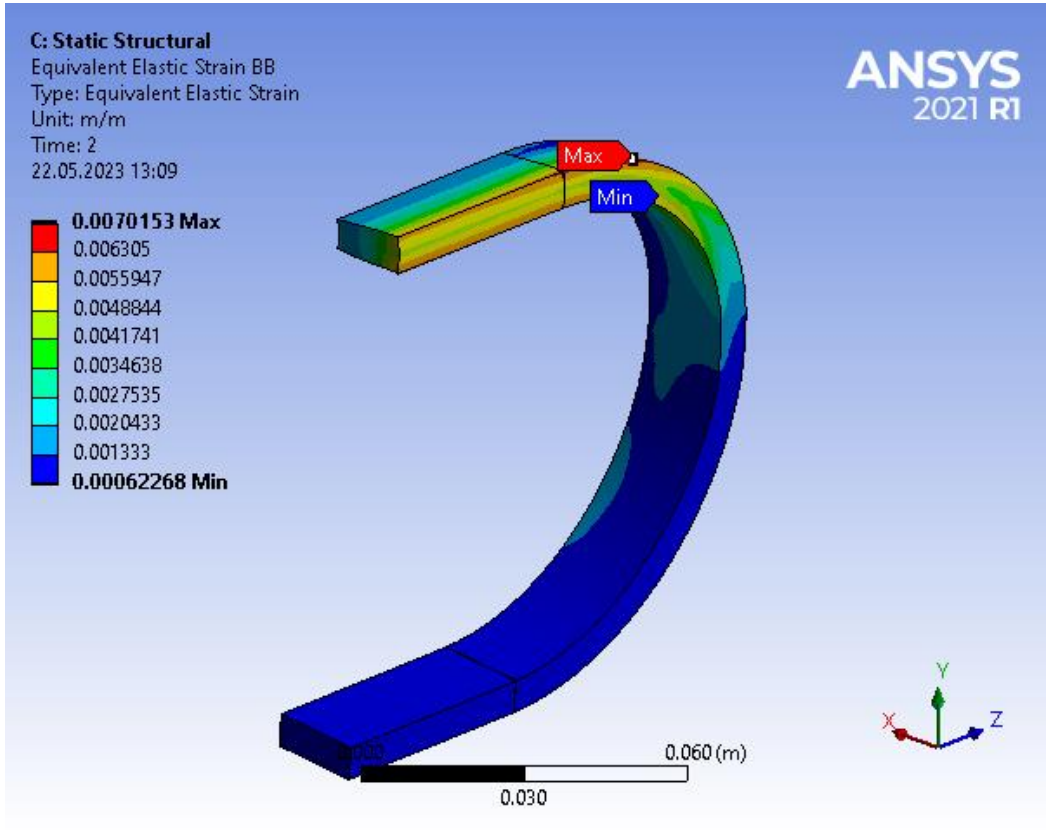




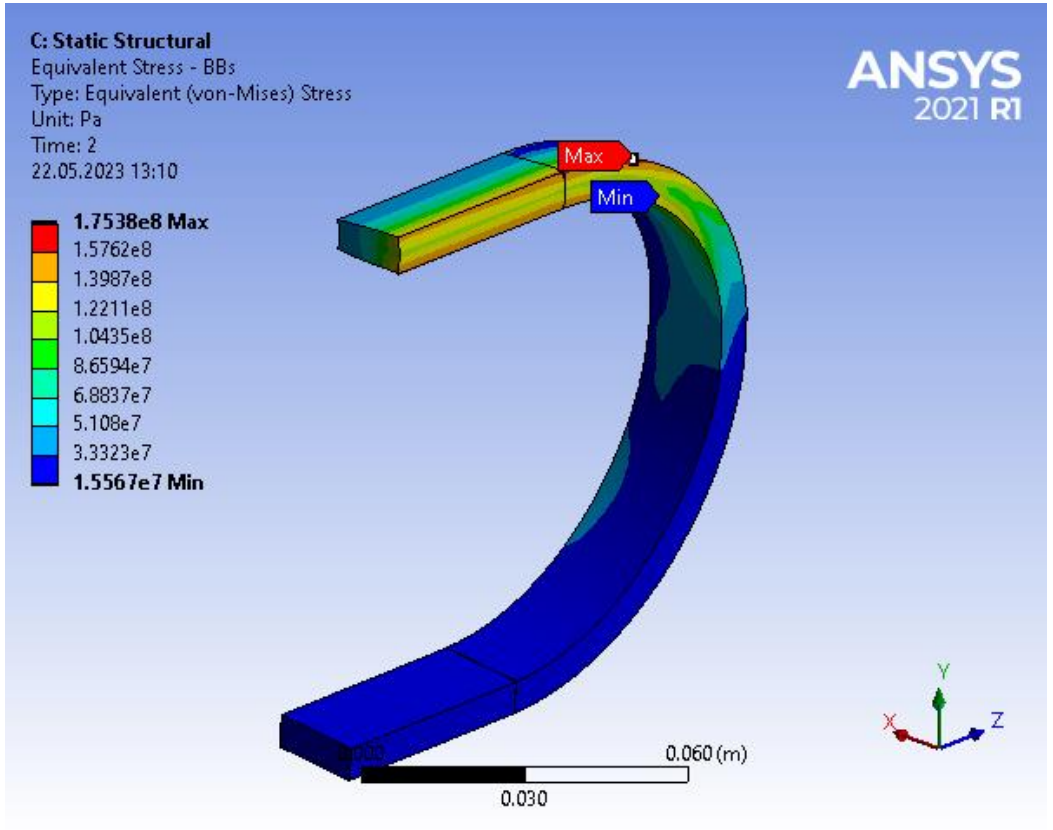
Max S_{eqv} on DCC17 Collar = 52 MPa

Max S_{MPS} on DCC17 Iron = 61 MPa

3D Mechanical Analysis: BigBOX LTS Coil

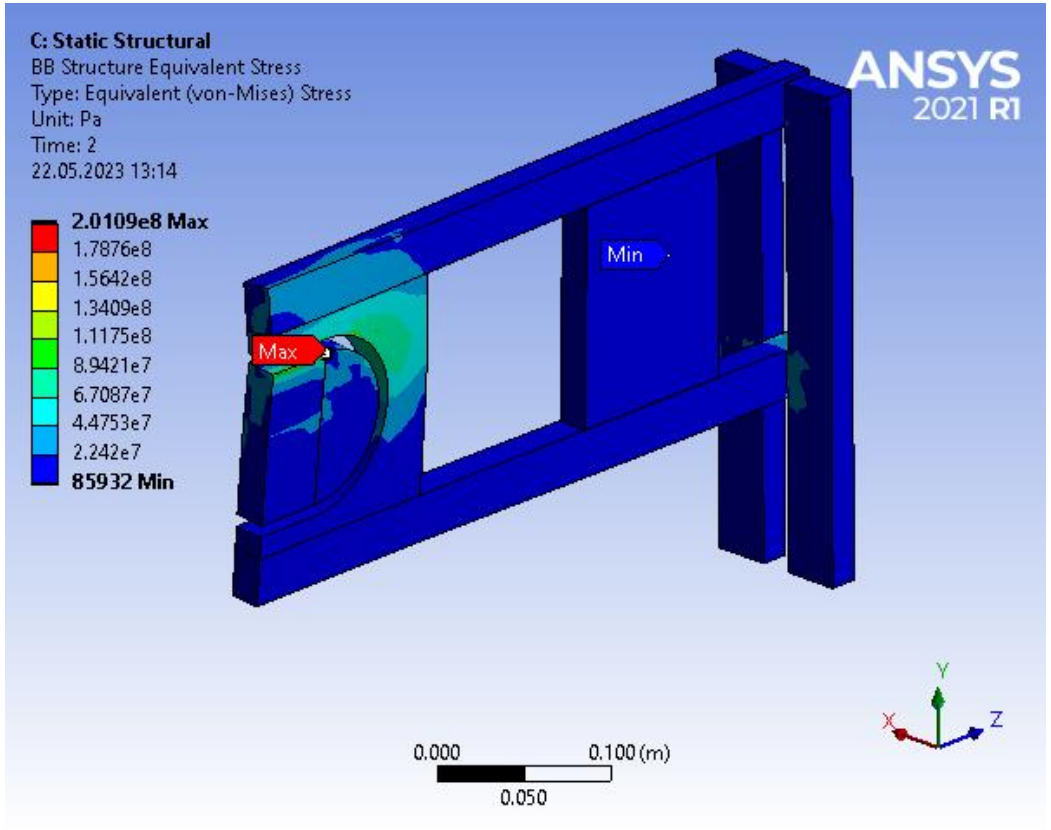


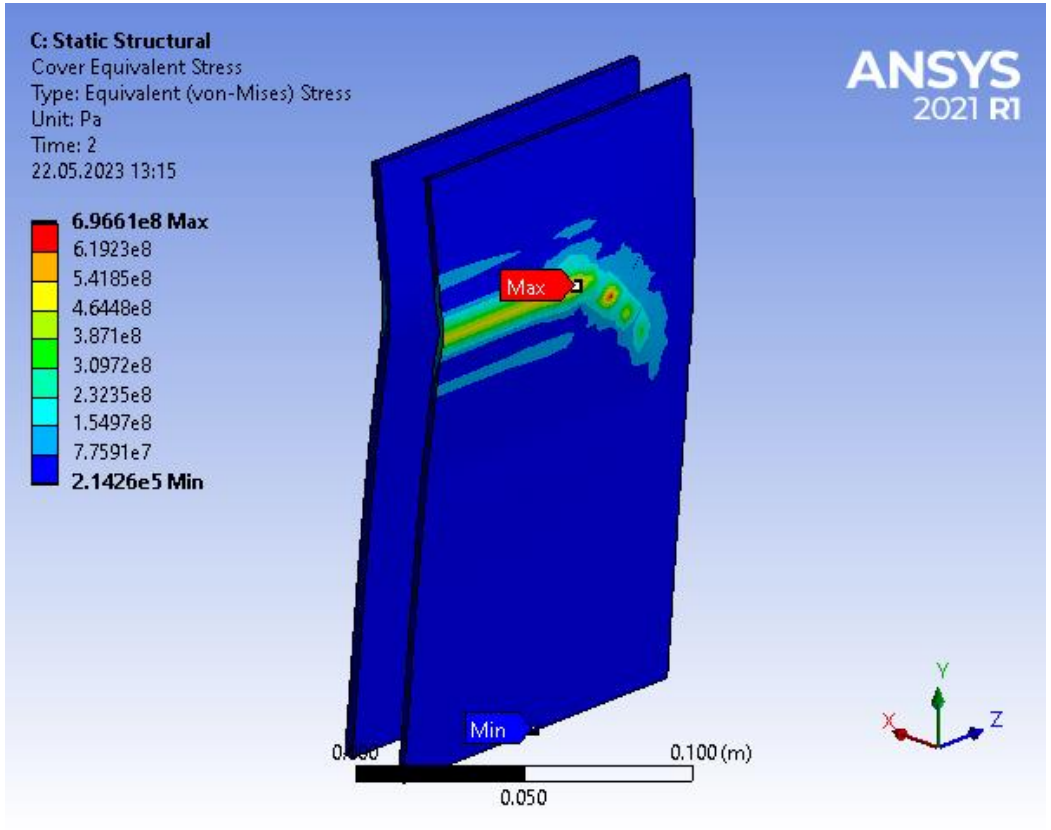
ε_{peak} on BigBOX = 0.007



Max S_{VM} = 175 MPa

3D Mechanical Analysis: BigBOX Structure and Covers





Max S_{eqv} on BigBOX structure = 201 MPa

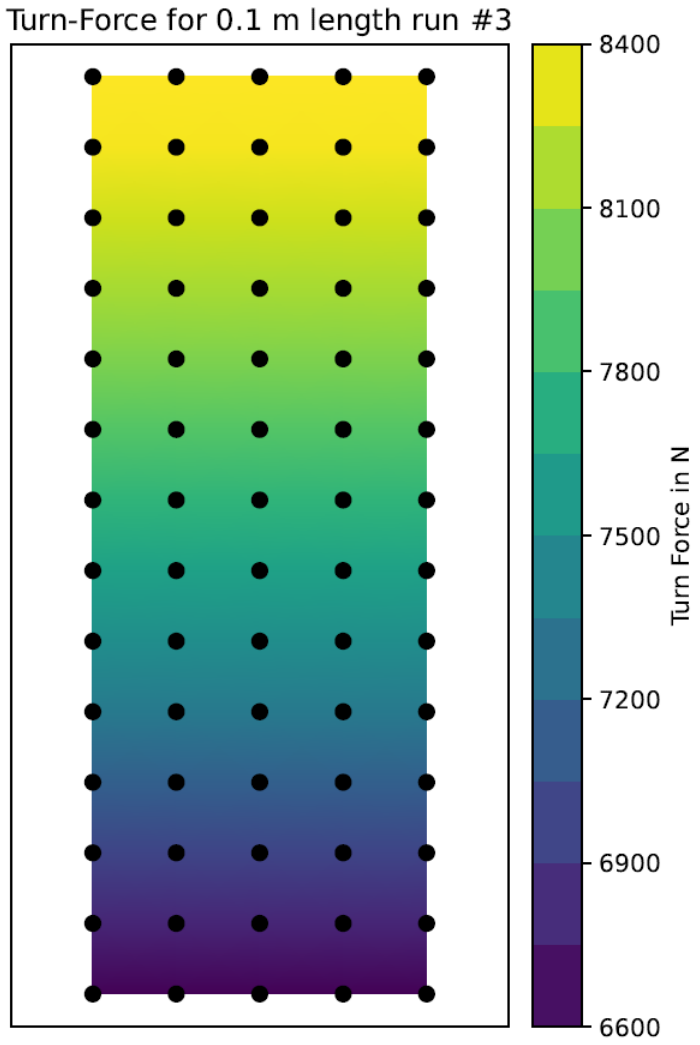
Max S_{eqv} on Covers = 697 MPa

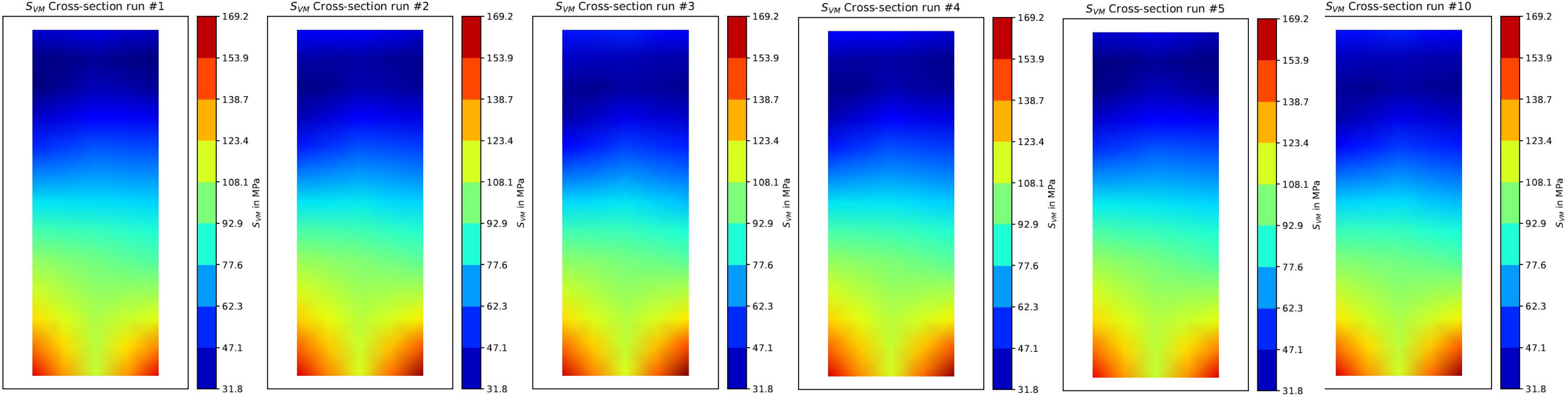
Due to the inverted current

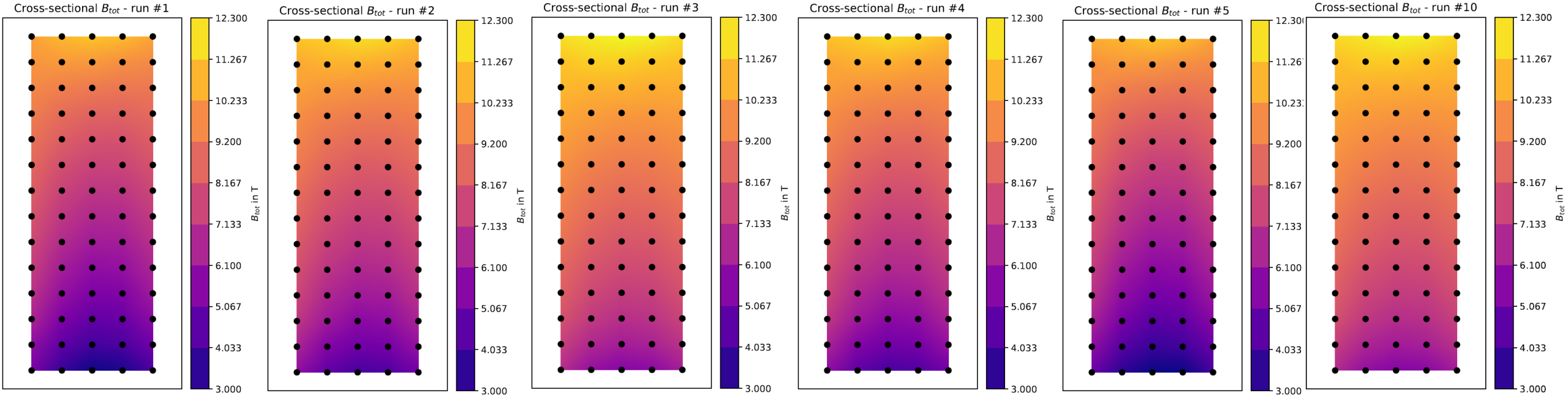
Backup slides

Force transferred to DCC17 coils on BigBOX Straight - Section

- Straight Section length of 100 mm
- Insulated cable width of 8 mm
- Force integrated from the cross-section: 98.563 kN
- Average Stress on the last turn of 123 MPa

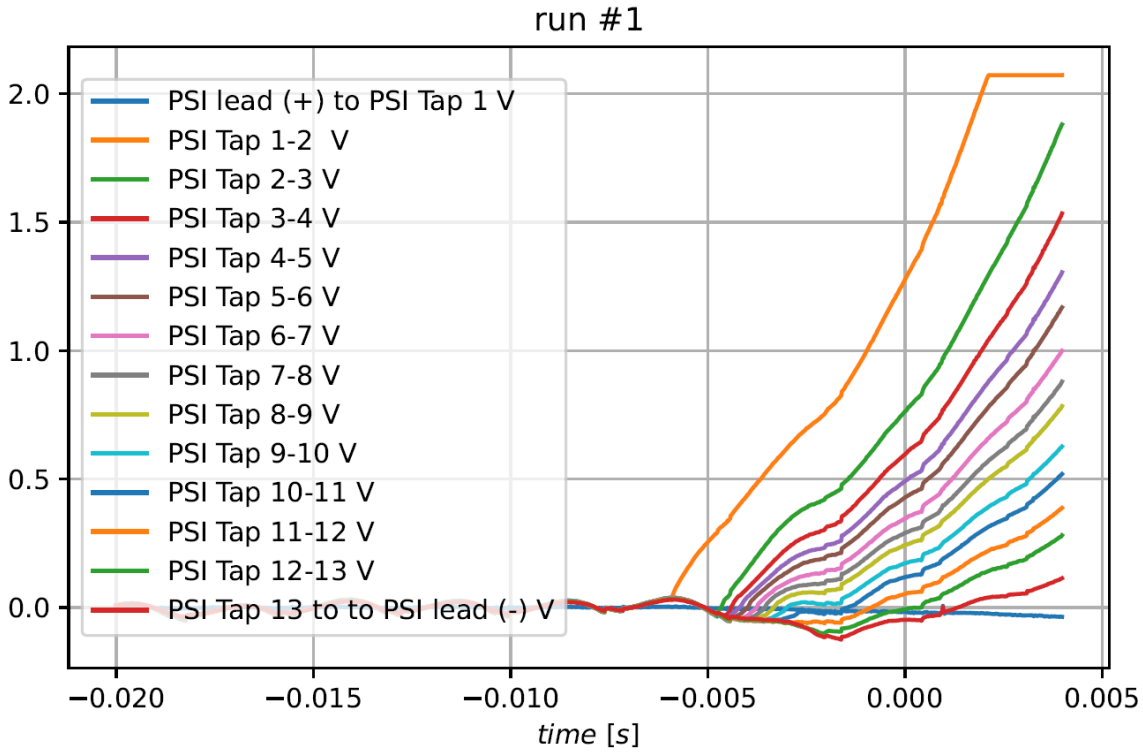


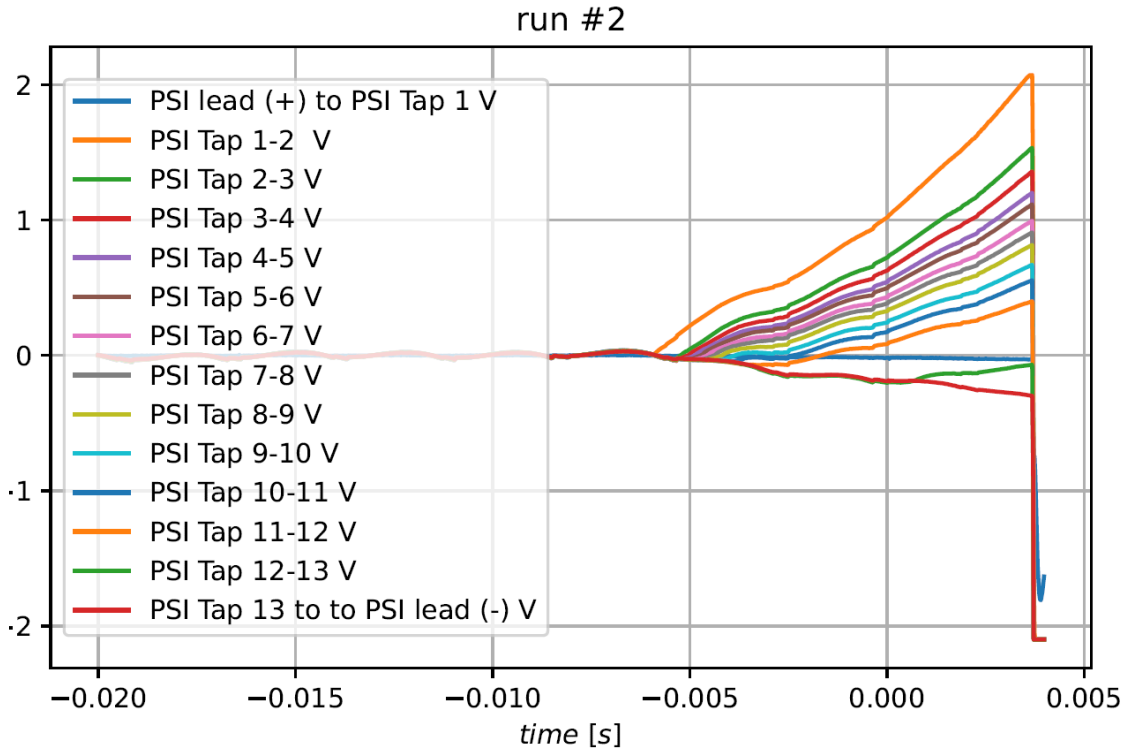

S_{VM} Cross-section run #1
S_{VM} Cross-section run #2
S_{VM} Cross-section run #3
S_{VM} Cross-section run #4
S_{VM} Cross-section run #5
S_{VM} Cross-section run #10
169.2
153.9
138.7
123.4
108.1
92.9
77.6
62.3
47.1
31.8
S_{VM} in MPa


Cross-sectional B_{tot} - run #1
Cross-sectional B_{tot} - run #2
Cross-sectional B_{tot} - run #3
Cross-sectional B_{tot} - run #4
Cross-sectional B_{tot} - run #5
Cross-sectional B_{tot} - run #10
12.300
11.267
10.233
9.200
8.167
7.133
6.100
5.067
4.033
3.000
B_{tot} in T

Quench Detection: Run #1 and #2

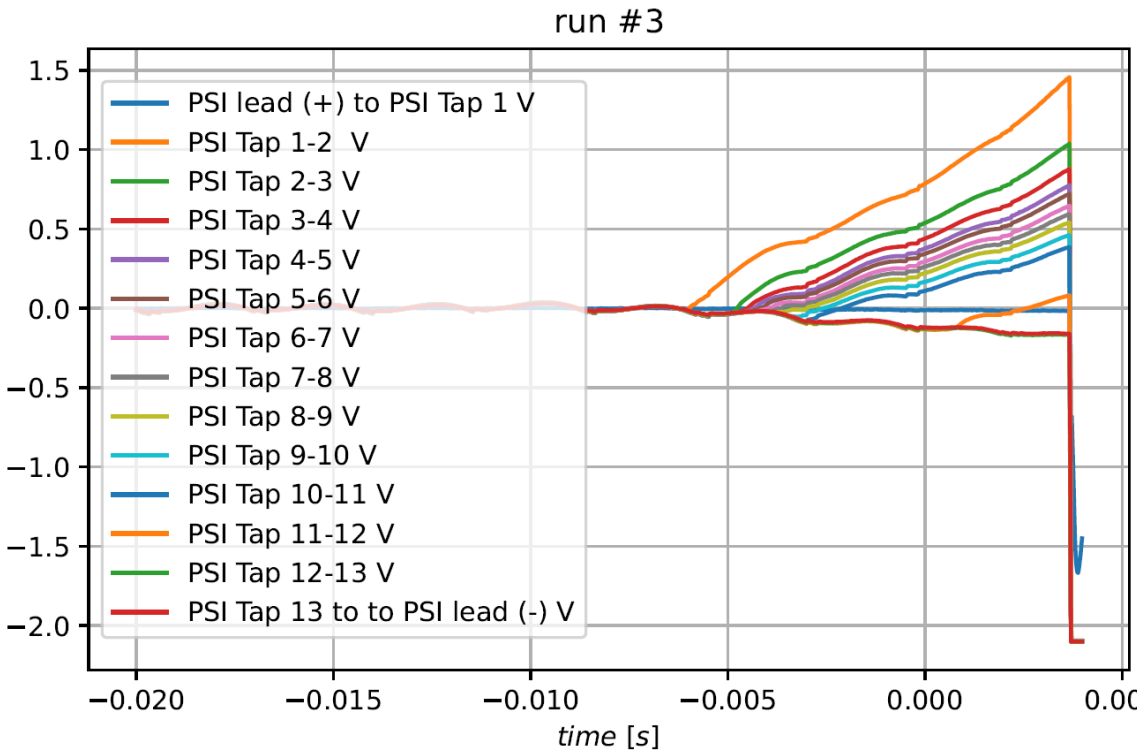
- Quench started on Vtap 1-2

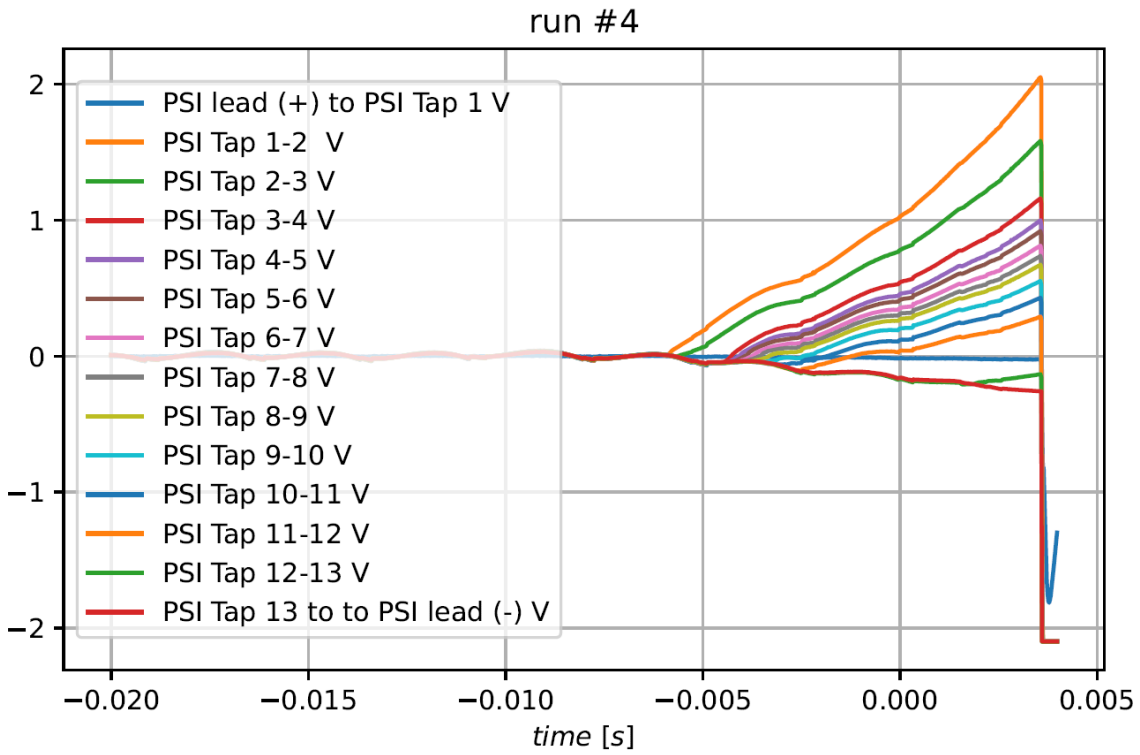




Quench Detection: Run #3 and #4

- Quench started on Vtap 1-2





Quench Detection: Run #5 and #6/10

- Quench started on Vtap 1-2