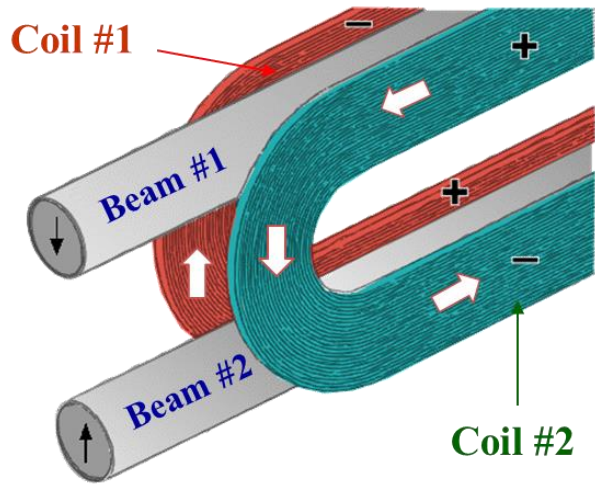


# Unique BNL Common Coil Dipole DCC017 for Cable and Coil Testing at High Fields

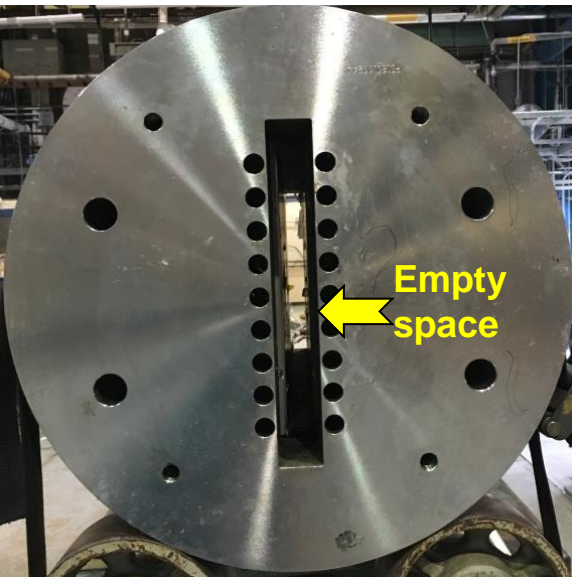


**Prepared by Ramesh Gupta for  
Superconducting Magnet Division @ BNL**

# A Unique Background-field Dipole



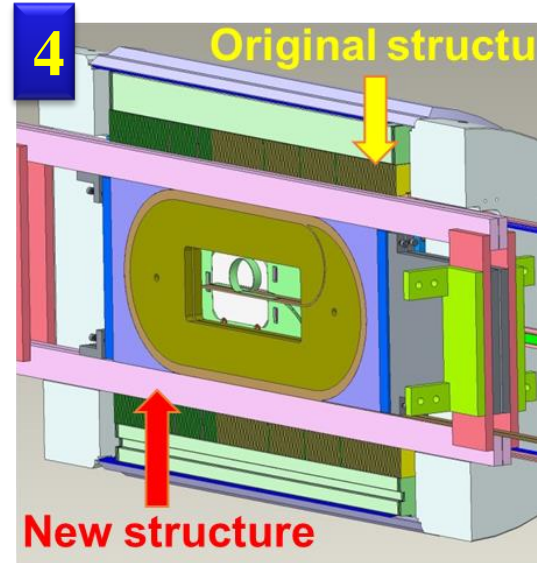
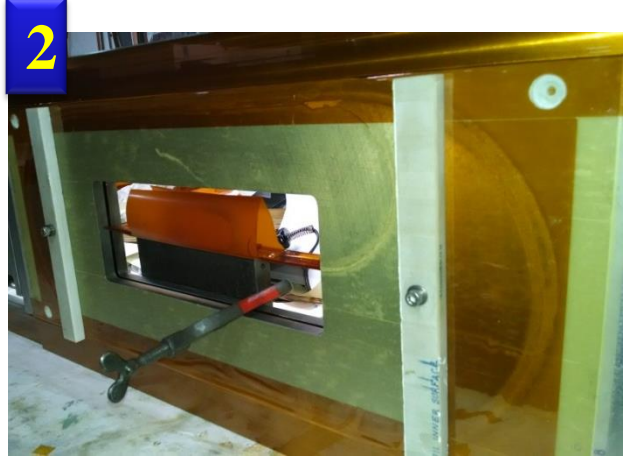
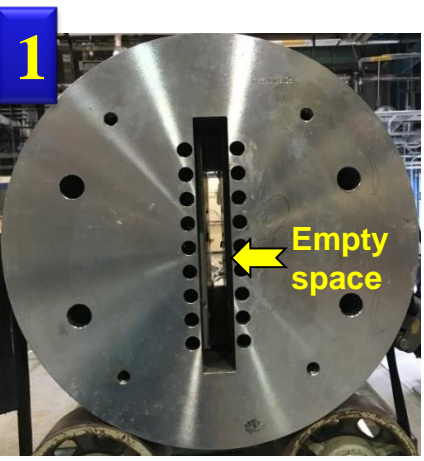
- **Nb<sub>3</sub>Sn, 2-in-1, common coil dipole**
- **Structure specifically designed to provide a large open space (31mm wide, 335mm high)**
- **New racetrack coils can be inserted here for testing them in a background field of ~10 T**
- **These new insert coils come in direct contact with the existing Nb<sub>3</sub>Sn coils and become an integral part of a potential ~16 T dipole**
- **A new coil test becomes a new magnet test**
- **Allows a rapid-turn around, low-cost test**
- **A unique facility for testing HTS cables also**



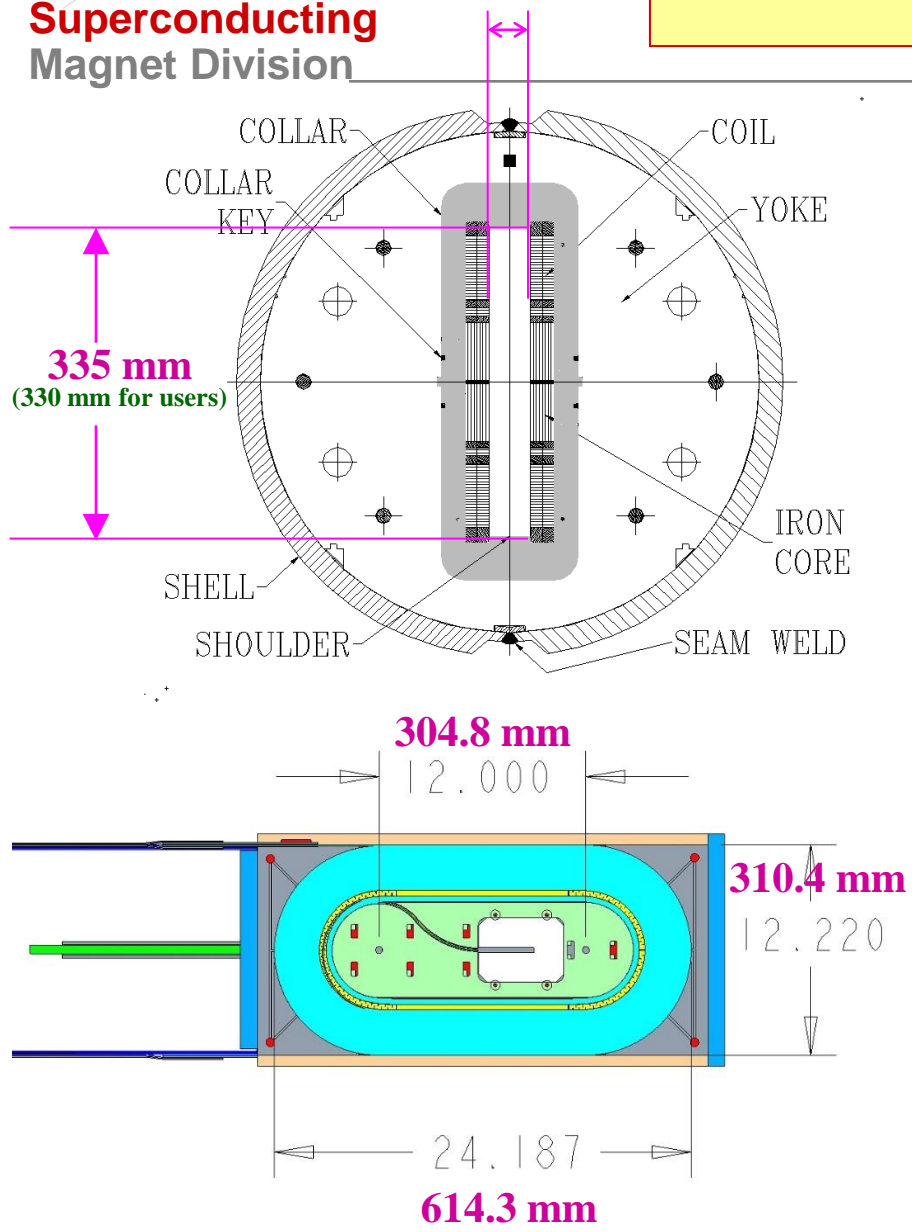
# Rapid turn-around, Low cost R&D Approach

## Five Simple Steps/Components

1. Magnet (dipole) with a large open space
2. Coil for high field testing
3. Slide coil in the magnet
4. Coils become an integral part of the magnet
5. Magnet with new coil(s) ready for testing



# Basic Parameters of Dipole DCC017



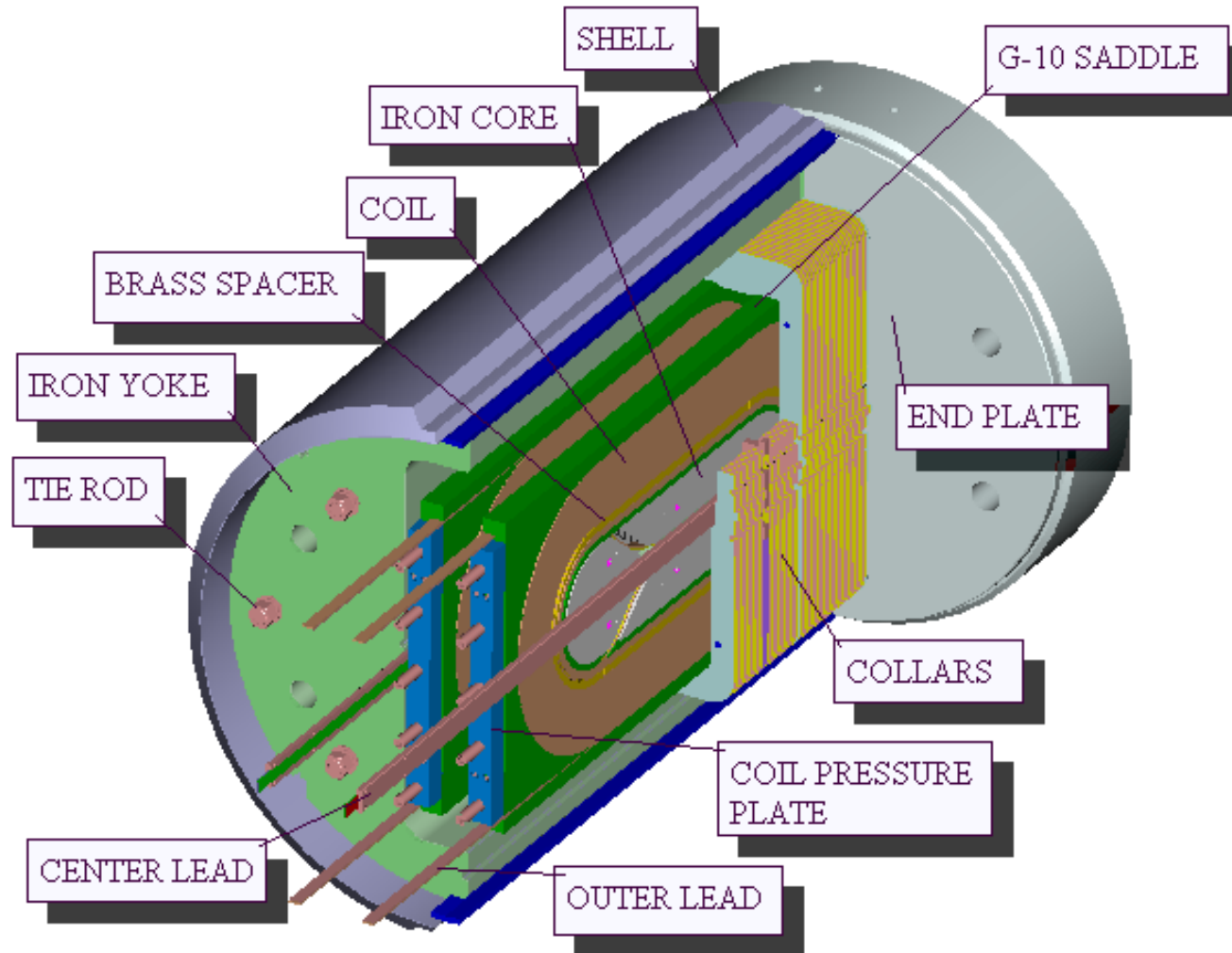
- Two layer, 2-in-1 common coil design
- 10.2 T bore field, 10.7 T peak field at 10.8 kA short sample current
- **31 mm (use 29 mm) horizontal aperture**
- **335 mm (use 330 mm) vertical aperture**
  - **A unique feature for testing insert coils or cables**
- **977 mm magnet length (overall)**
- **305 mm coil straight section**
- 0.8 mm, 30 strand Rutherford cable
- 70 mm minimum bend radius
- 85 mm coil height
- 614 mm coil length
- 653 mm yoke length One spacer in body and one in ends
- Iron bobbin
- Stored Energy@Quench ~0.2 MJ

# Detailed Design Parameters of DCC017

## Superconducting Magnet Division

### MAJOR PARAMETERS OF REACT & WIND COMMON COIL DIPOLE DCC017

|   |  |
|---|--|
| Magnet design   | 2-in-1 common coil dipole with racetrack coils |
| Conductor type  | Nb <sub>3</sub> Sn                             |
| Magnet technology   | React and wind                                 |
| Horizontal coil aperture (clear space)  | 31 mm  |
| Vertical coil aperture (clear space)  | 335 mm   |
| Separation between the magnetic center of the upper and lower aperture            | 236 mm   |
| Number of layers  | Two  |
| Number of turns per quadrant of single aperture (pole-to-pole)                    | 45 turns in each layer                         |
| Coil height (pole-to-pole)  | 85 mm  |
| Wedge(s) (size and number)  | 8.5 mm, one in each layer (inner & outer)      |
| End-spacer(s) (size and number)   | 8.5 mm, one in each layer (inner & outer)      |
| Wire non-Cu J <sub>sc</sub> (4.2 K, 12 T)   | 1900 A/mm <sup>2</sup>                         |
| Strand diameter   | 0.8 mm   |
| Number of strands in inner and outer cable  | 30   |
| Cable width (inner and outer layers)  | 13.13 mm                                       |
| Cu/Non-Cu ratio in the wire (same for both inner and outer cables)                | 1.53   |
| Computed quench current (limited by inner)  | 10.8 kA  |
| Computed quench field @4.2 K  | 10.2 T   |
| Peak field at quench in inner, outer Layer  | 10.7 T, 6.1 T                                  |
| Special electrical feature (not used)   | Shunt between layers                           |
| Computed stored energy at quench  | 0.2 MJ   |
| Computed inductance   | 4.9 mH   |
| Coil bobbin (core) material   | Carbon steel                                   |
| Coil length (overall)   | 614.3 mm                                       |
| Coil straight section length  | 304.8 mm                                       |
| Coil height (overall)   | 310.4 mm                                       |
| Coil inside radius in ends  | 70 mm  |
| Coil outside radius in ends   | 155 mm   |
| Coil curing preload - sides   | 0 N  |
| Coil curing preload - ends  | 0 N  |
| Insulation thickness between turns  | 180 μm thick Nomex®                            |
| Potting agent   | CTD-101K                                       |
| Thickness of the collar   | 26.6 mm  |
| Thickness of stainless-steel sheet between inner and outer layers                 | 1.65 mm  |
| Vertical pre-stress applied   | 17 MPa (low)                                   |
| Horizontal pre-stress applied   | Essentially none                               |
| Computed horizontal stress on structure   | 59 MPa at 10.2 T                               |
| Design maximum for horizontal stress  | 75 MPa   |
| Stainless steel shell thickness   | 25.4 mm  |
| Thickness of the end plates   | 127 mm   |
| Yoke outer radius   | 267 mm   |
| Yoke length   | 653 mm   |
| Quench protection strip heaters (no energy extraction available during the tests) | 25 μm X 38.1 mm, each quadrant, between layers |

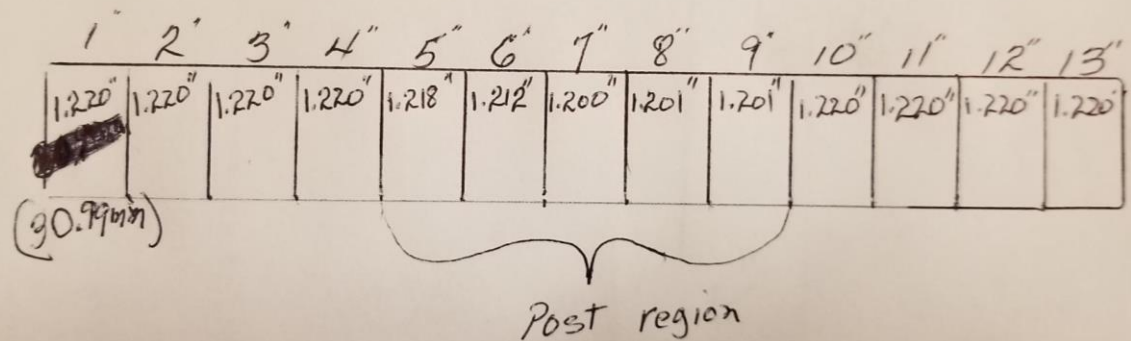


# Space Restrictions



10-18-2021

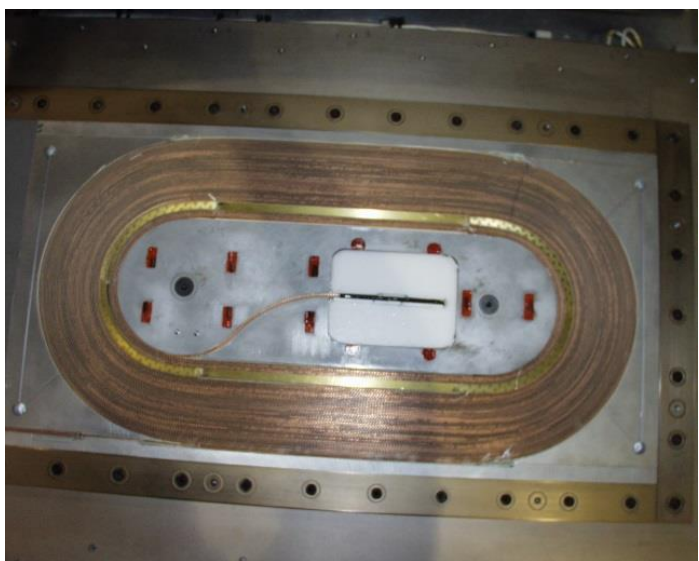
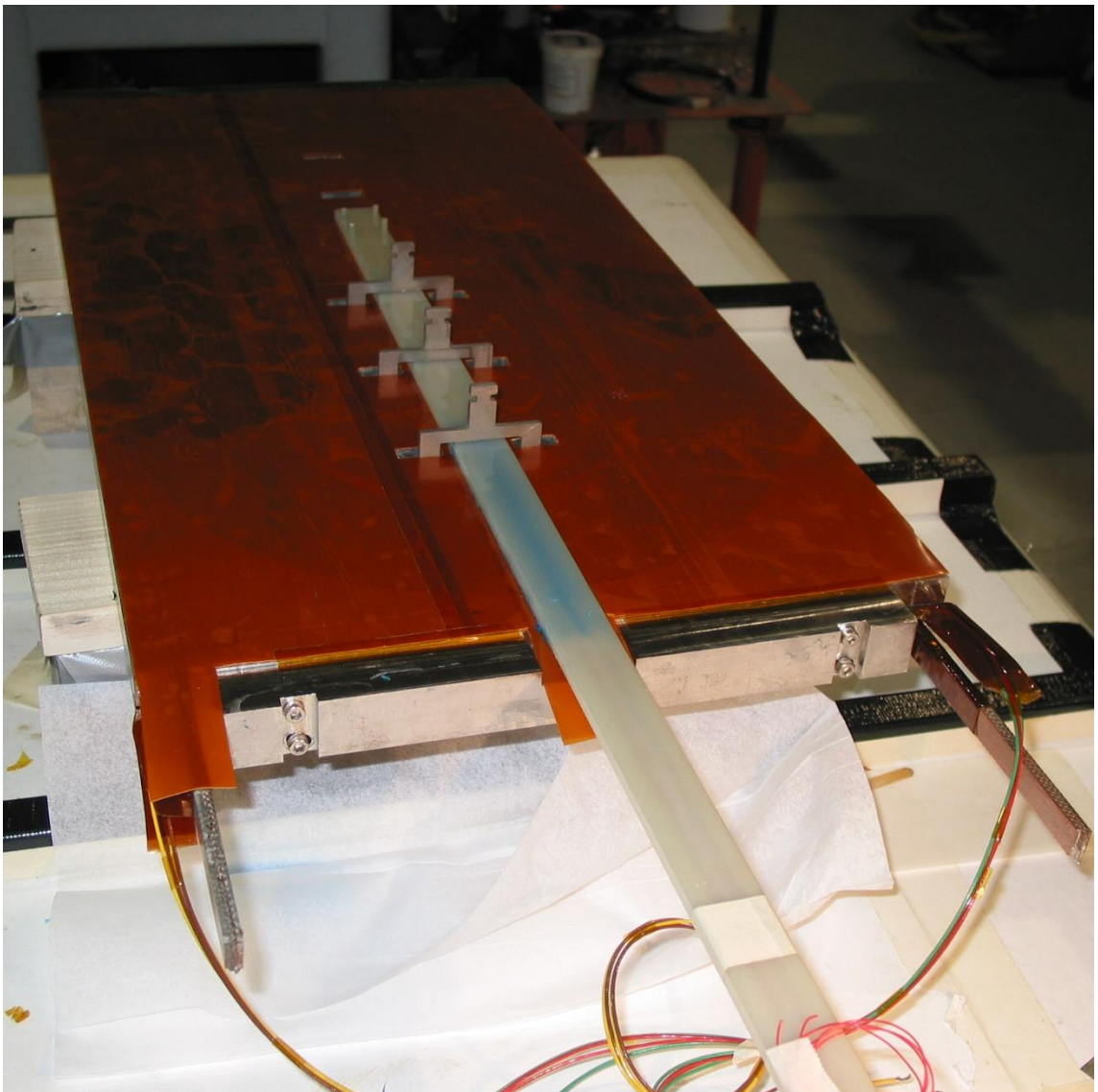
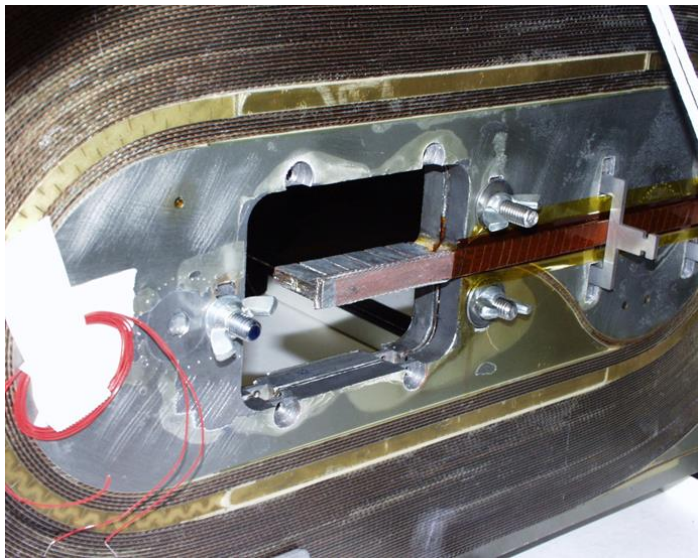
Common Coil Aperture Size



1" to 13" are only accessible from below.

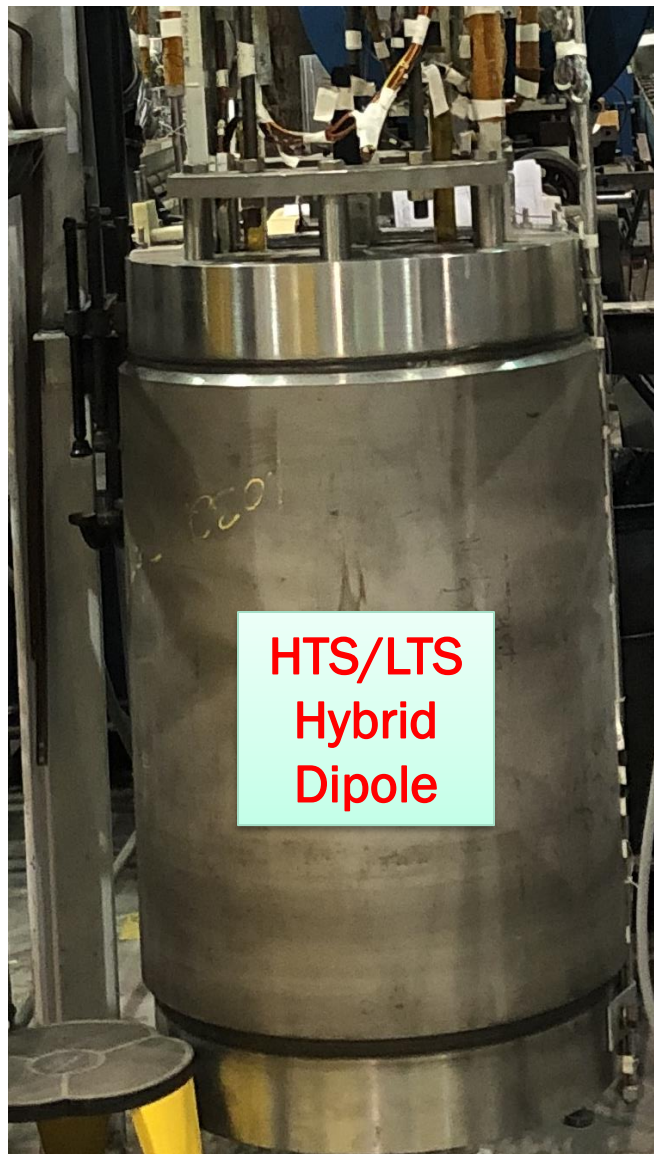


# Nb<sub>3</sub>Sn Coil Package of DCC017

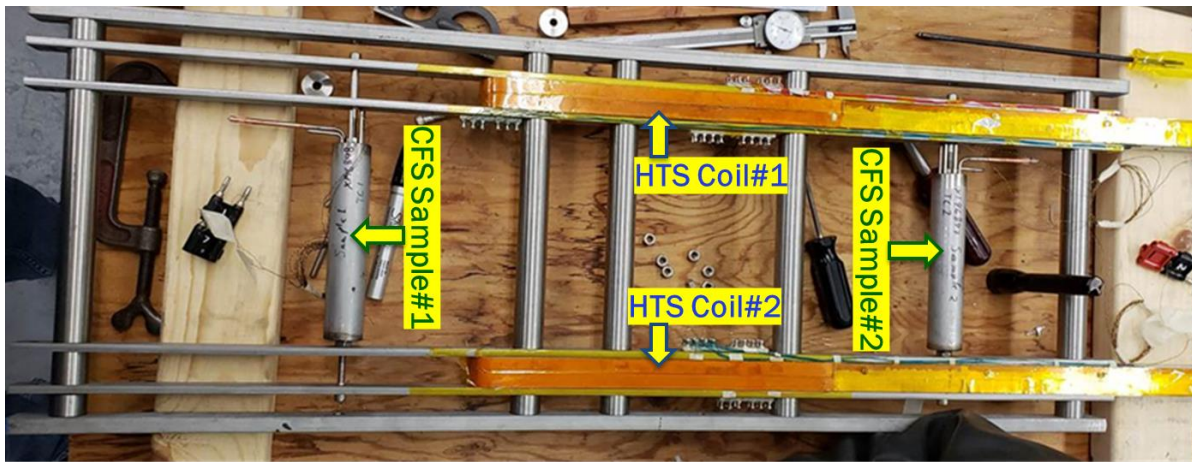
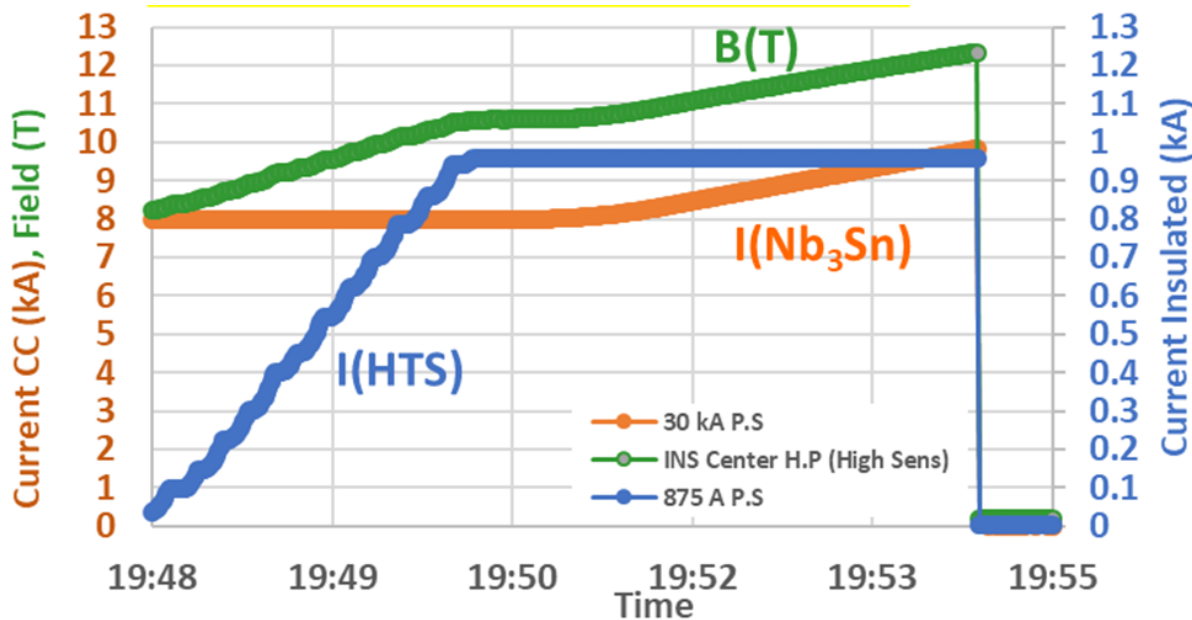




# HTS/LTS Hybrid Dipole & Cable Test (2019) (an example of four tests in one run)

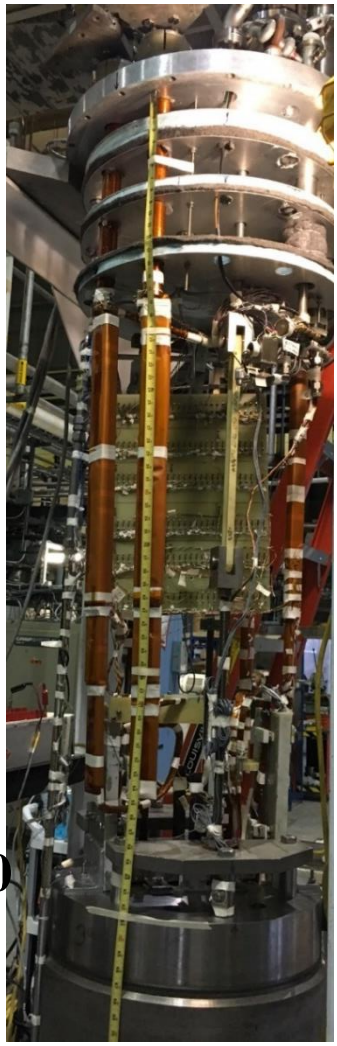
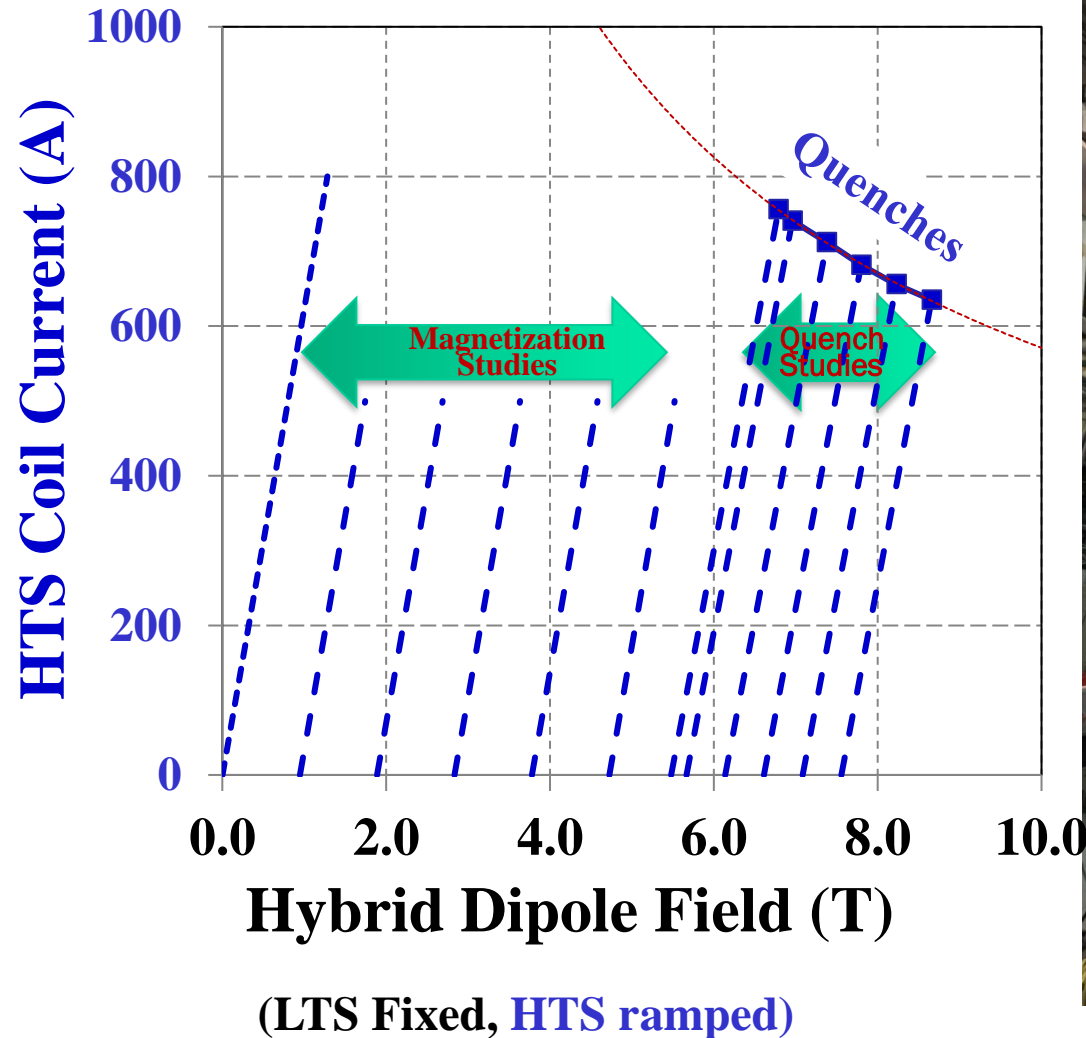


HTS/LTS  
Hybrid  
Dipole



# HTS/LTS Hybrid Dipole Test (2016)

(new HTS insert coils with existing Nb<sub>3</sub>Sn magnet coil)

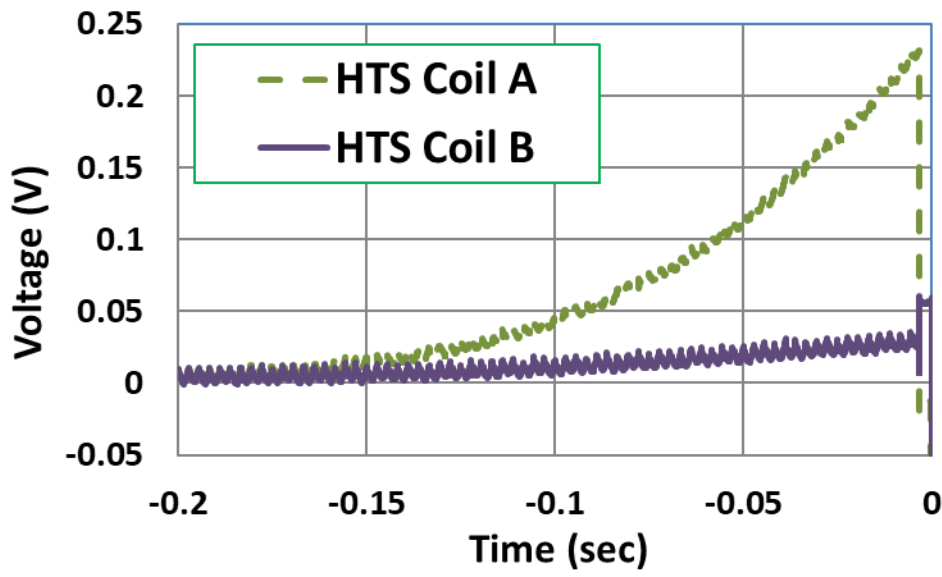


HTS coils were ramped to quench, just like LTS coils

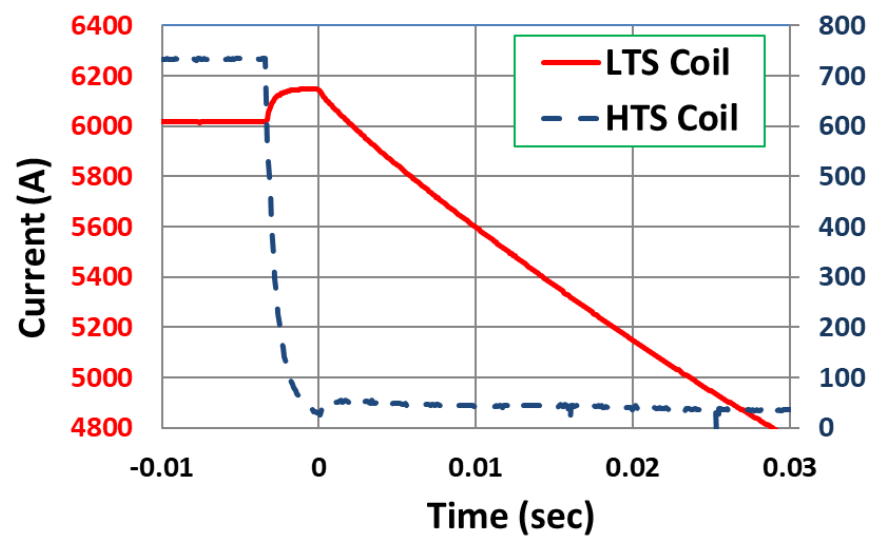
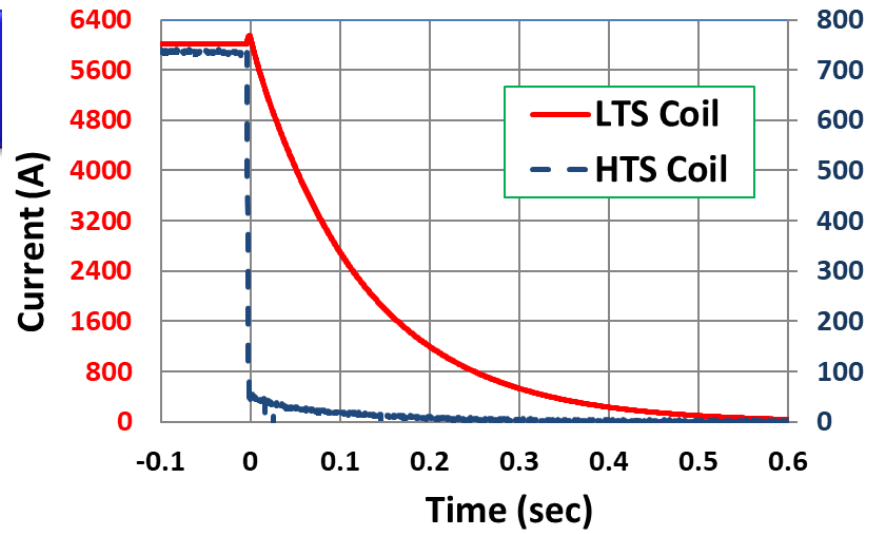
HTS coils exhibited NO training and NO degradation despite a number of quenches

# Quench Protection of HTS Coils in HTS/LTS Hybrid Magnet (2016)

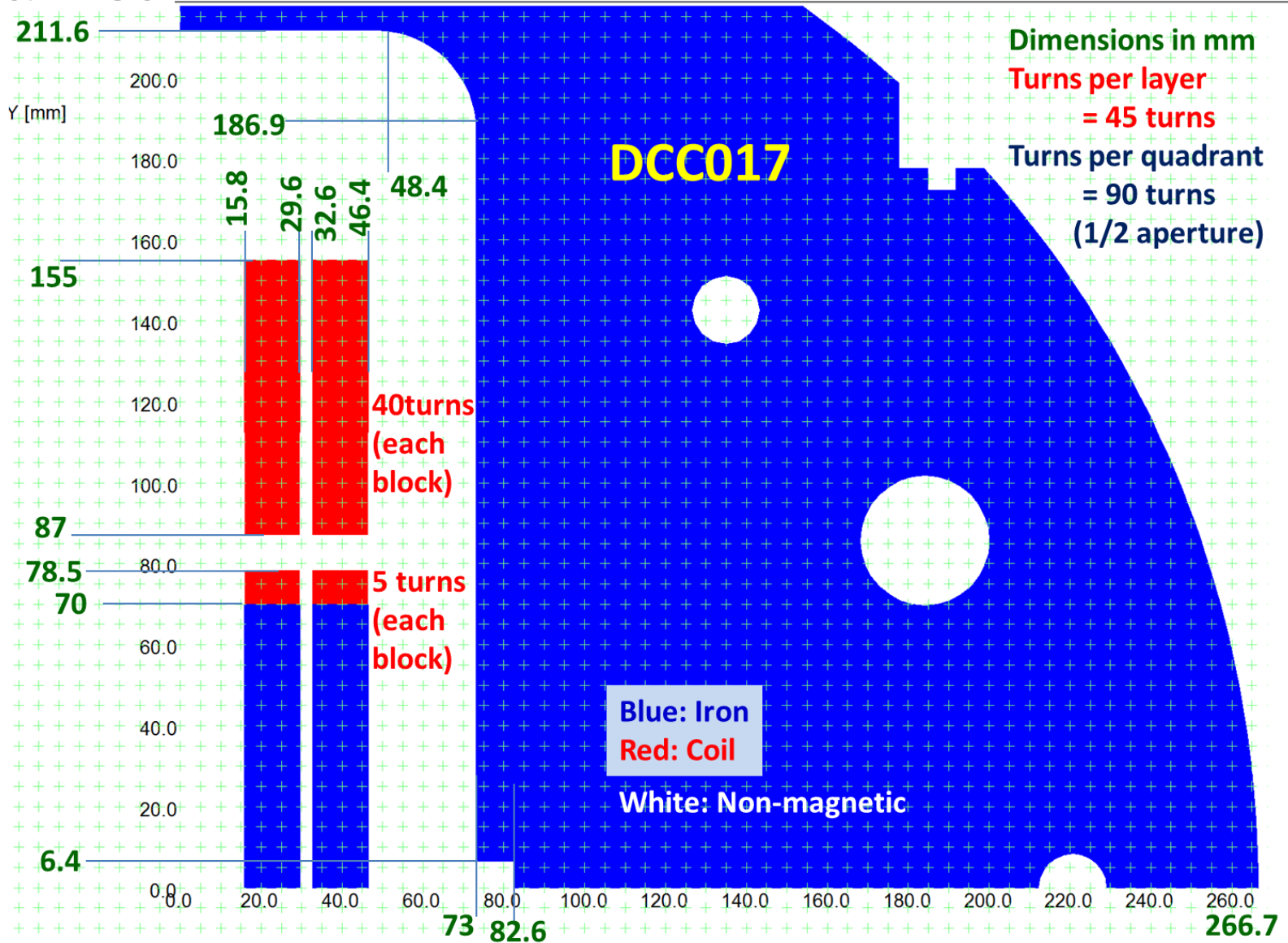
**HTS coils were operated like the LTS coils**  
(significant voltages allowed till quench even on the HTS coils)



**HTS and LTS coils were operated with different power supplies and had separate energy extraction under a common platform**

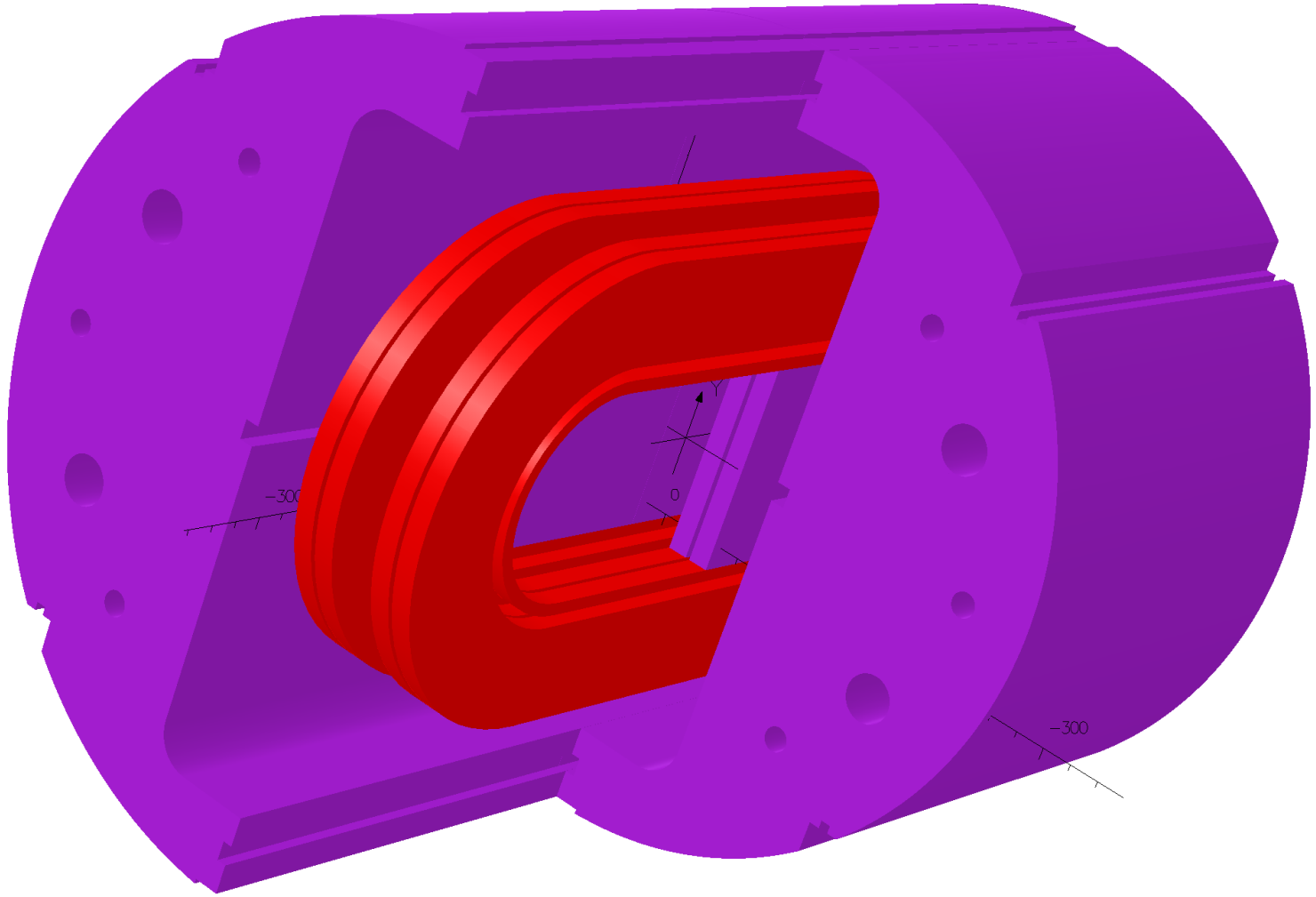


# 2-d Magnetic Model



# 3d-model and the Field Profile inside DCC017

# 3-d model of the coils with $\frac{3}{4}$ cut-out of the iron yoke



| UNITS             |                    |
|-------------------|--------------------|
| Length            | mm                 |
| Magn Flux Density | T                  |
| Magn Field        | A m <sup>-1</sup>  |
| Magn Scalar Pot   | A                  |
| Magn Vector Pot   | Wb m <sup>-1</sup> |
| Elec Flux Density | Cm <sup>-1</sup>   |
| Elec Field        | V m <sup>-1</sup>  |
| Conductivity      | S mm <sup>-1</sup> |
| Current Density   | A mm <sup>-2</sup> |
| Power             | W                  |
| Force             | N                  |
| Energy            | J                  |
| Mass              | kg                 |

| MODEL DATA                         |  |
|------------------------------------|--|
| dcc017-no-ifs-usmddp.op3           |  |
| TOSCA Magnetostatic                |  |
| Nonlinear materials                |  |
| Simulation No 1 of 1               |  |
| 47698232 elements                  |  |
| 9484251 nodes                      |  |
| 8 conductors                       |  |
| Nodally interpolated fields        |  |
| Activated in global coordinates    |  |
| Reflection in XZ plane (z field=0) |  |
| Reflection in YZ plane (x field=0) |  |

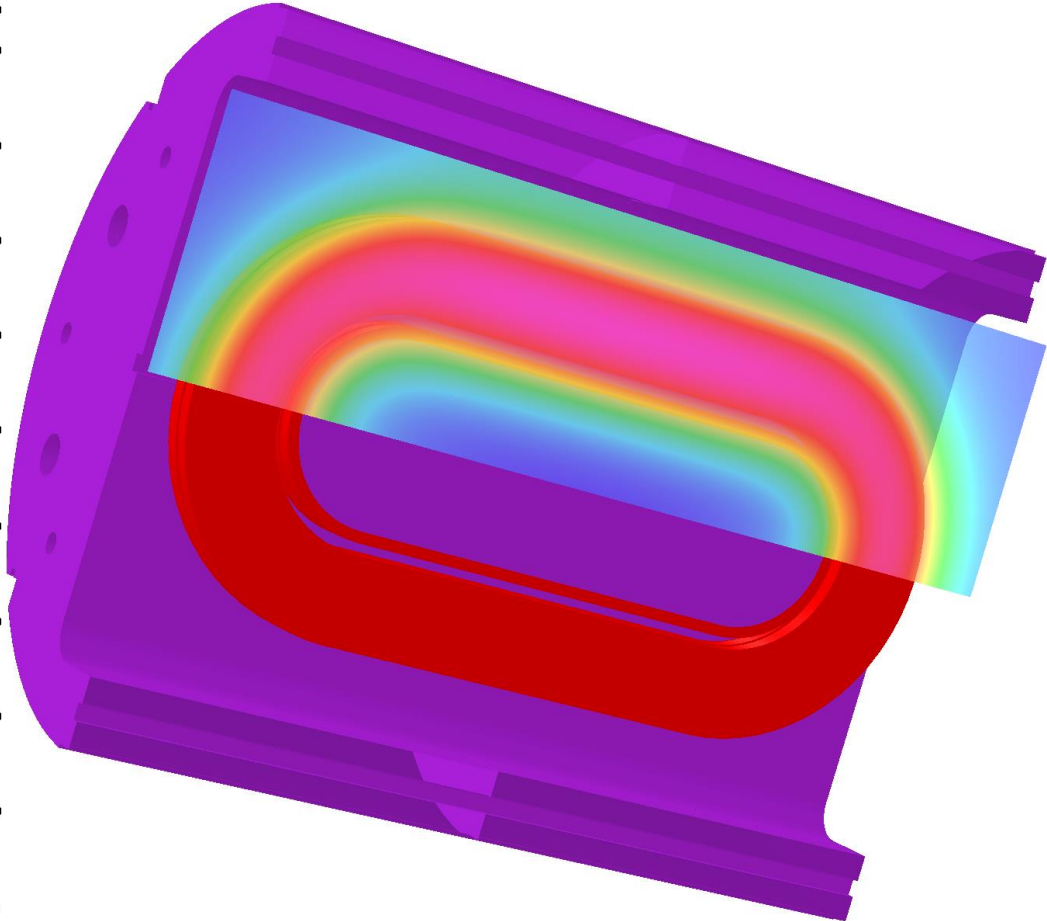
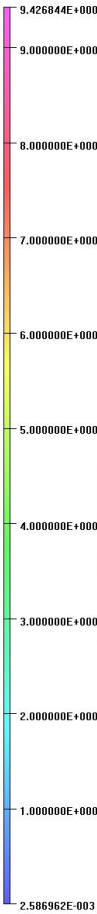
  

| Field Point Local Coordinates |          |
|-------------------------------|----------|
| Local                         | = global |

# Magnitude of the Field in DCC017 at $x=0$ ( $y-z$ plane)

13/Sep/2019 11:48:44

Map contours: B



Integral = 6.487019E+005

| UNITS             |                    |
|-------------------|--------------------|
| Length            | mm                 |
| Magn Flux Density | T                  |
| Magn Field        | A m <sup>-1</sup>  |
| Magn Scalar Pot   | A                  |
| Magn Vector Pot   | Wb m <sup>-1</sup> |
| Elec Flux Density | C m <sup>-2</sup>  |
| Elec Field        | V m <sup>-1</sup>  |
| Conductivity      | S mm <sup>-1</sup> |
| Current Density   | A mm <sup>-2</sup> |
| Power             | W                  |
| Force             | N                  |
| Energy            | J                  |
| Mass              | kg                 |

| MODEL DATA                         |  |
|------------------------------------|--|
| dcc017-no-ins-usmdp.op3            |  |
| TOSCA Magnetostatic                |  |
| Nonlinear materials                |  |
| Simulation No 1 of 1               |  |
| 47698232 elements                  |  |
| 9454231 nodes                      |  |
| 8 conductors                       |  |
| Nodally interpolated fields        |  |
| Activated in global coordinates    |  |
| Reflection in XY plane (Z field=0) |  |
| Reflection in YZ plane (X field=0) |  |

| Field Point Local Coordinates |  |
|-------------------------------|--|
| Local = Global                |  |

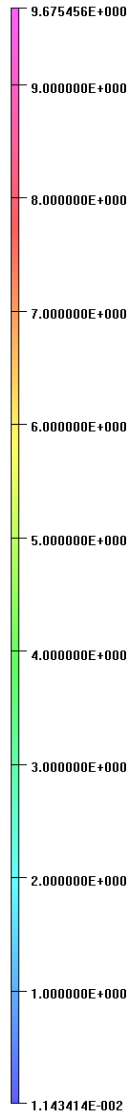
| FIELD EVALUATIONS           |                |                   |
|-----------------------------|----------------|-------------------|
| Cartesian CARTESIAN (nodal) | 100x100        | Cartesian         |
| x=0.0                       | y=0.0 to 200.0 | z=-350.0 to 350.0 |

**@10 kA**

Opera

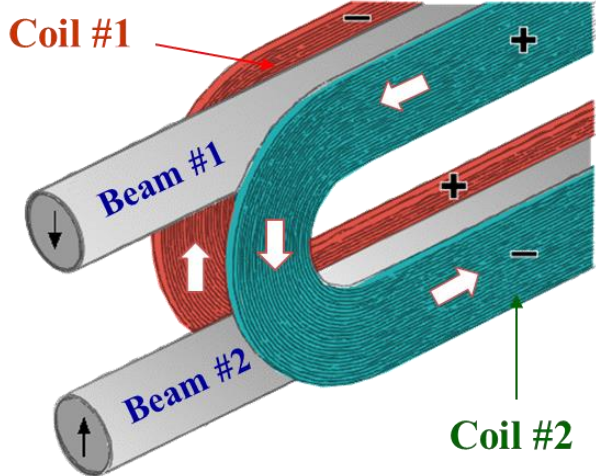
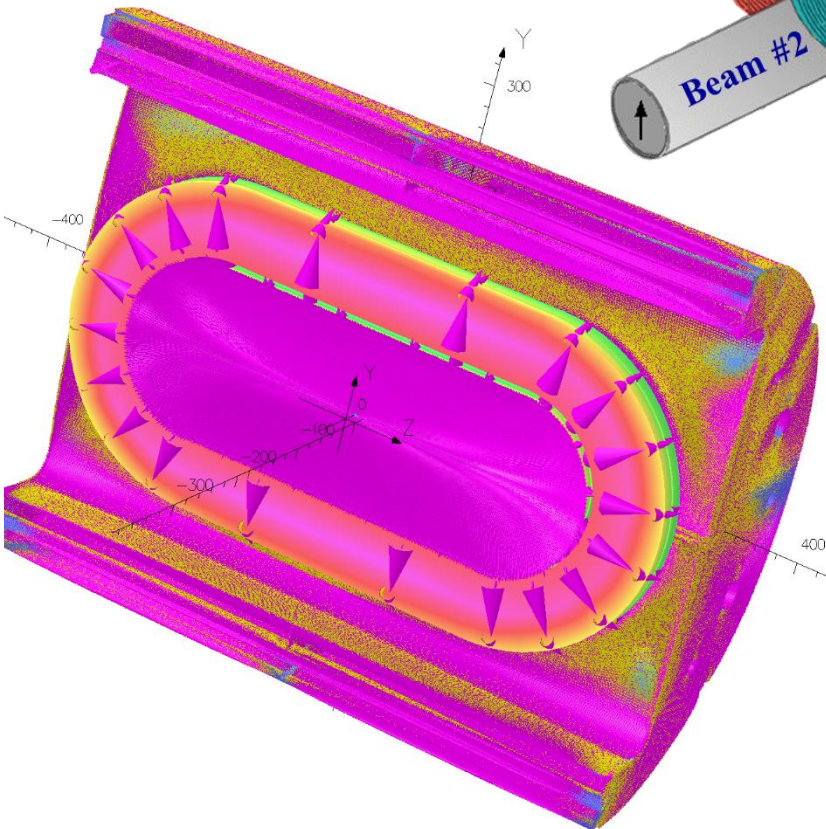
# Direction of the Field between the Coils in the Open Space of DCC017

Surface contours: B

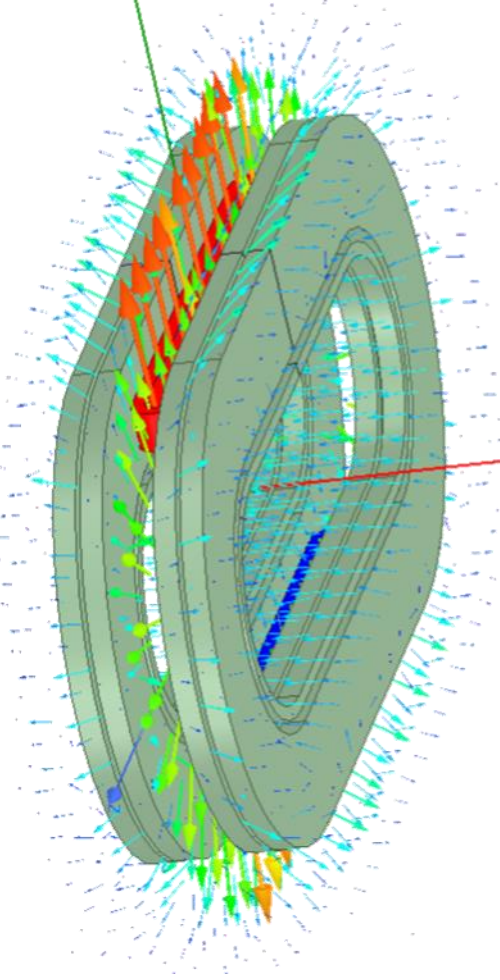


**DCC017**  
**(magnet only)**

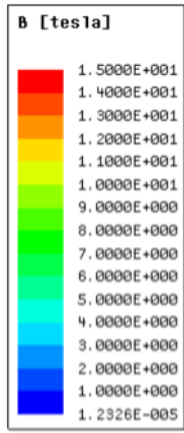
@ 10 kA



**DCC017**  
**(with an insert coil)**



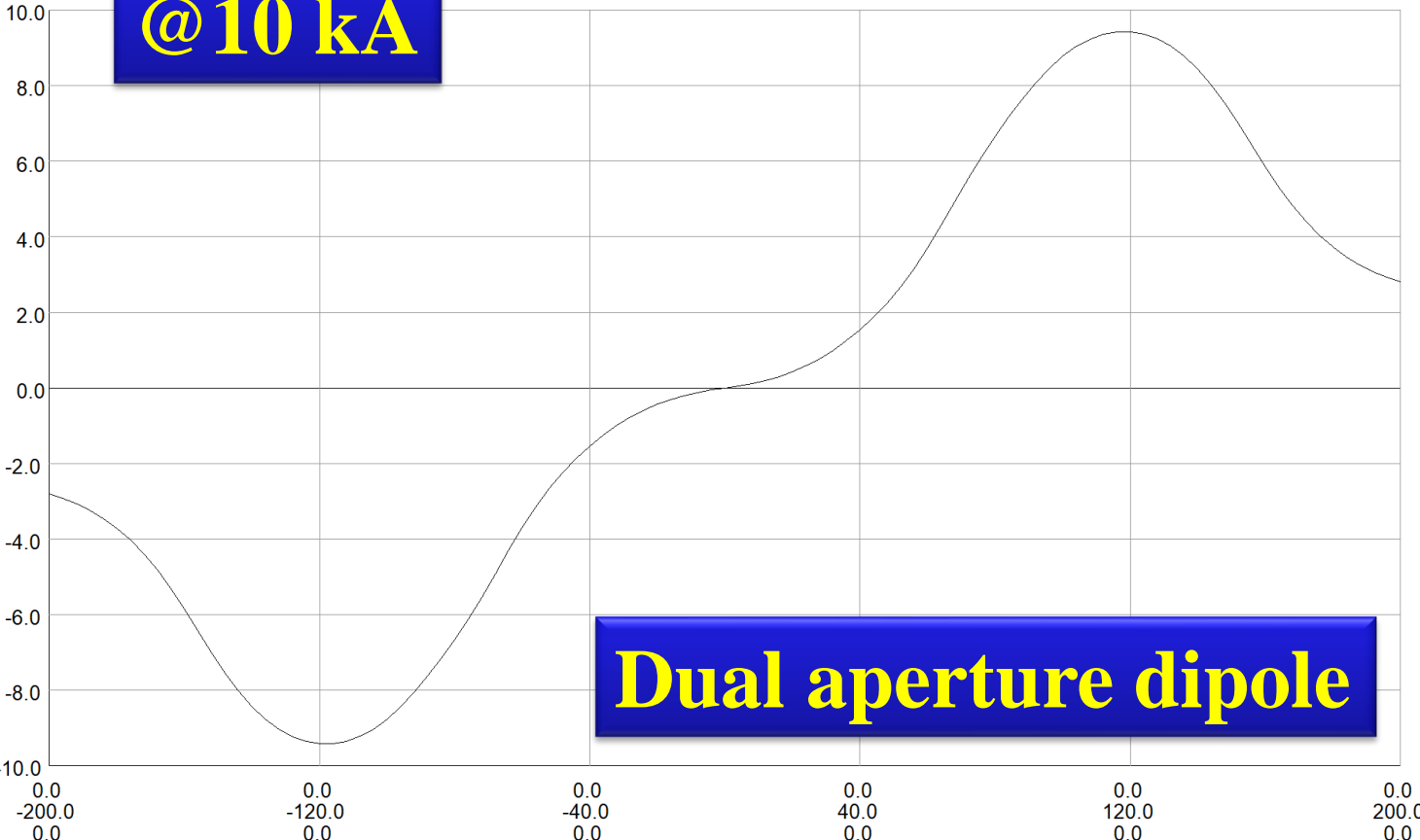
COMSOL





**$B_y$  along the Vertical-axis at  $x=0, z=0$**

**@10 kA**



**Dual aperture dipole**

Component: BY, from buffer: Line, Integral = 0.0208363806530265

| UNITS             |                    |
|-------------------|--------------------|
| Length            | mm                 |
| Magn Flux Density | T                  |
| Magn Field        | A m <sup>-1</sup>  |
| Magn Scalar Pot   | A                  |
| Magn Vector Pot   | Vb m <sup>-1</sup> |
| Elec Flux Density | C m <sup>-2</sup>  |
| Elec Field        | V m <sup>-1</sup>  |
| Conductivity      | S mm <sup>-1</sup> |
| Current Density   | A mm <sup>-2</sup> |
| Power             | W                  |
| Force             | N                  |
| Energy            | J                  |
| Mass              | kg                 |

| MODEL DATA                         |  |
|------------------------------------|--|
| dcc017-no-ins-usmdp.op3            |  |
| TOSCA Magnetostatic                |  |
| Nonlinear materials                |  |
| Simulation No 1 of 1               |  |
| 47698232 elements                  |  |
| 9454251 nodes                      |  |
| 8 conductors                       |  |
| Nodally interpolated fields        |  |
| Activated in global coordinates    |  |
| Reflection in XY plane (Z field=0) |  |
| Reflection in YZ plane (X field=0) |  |

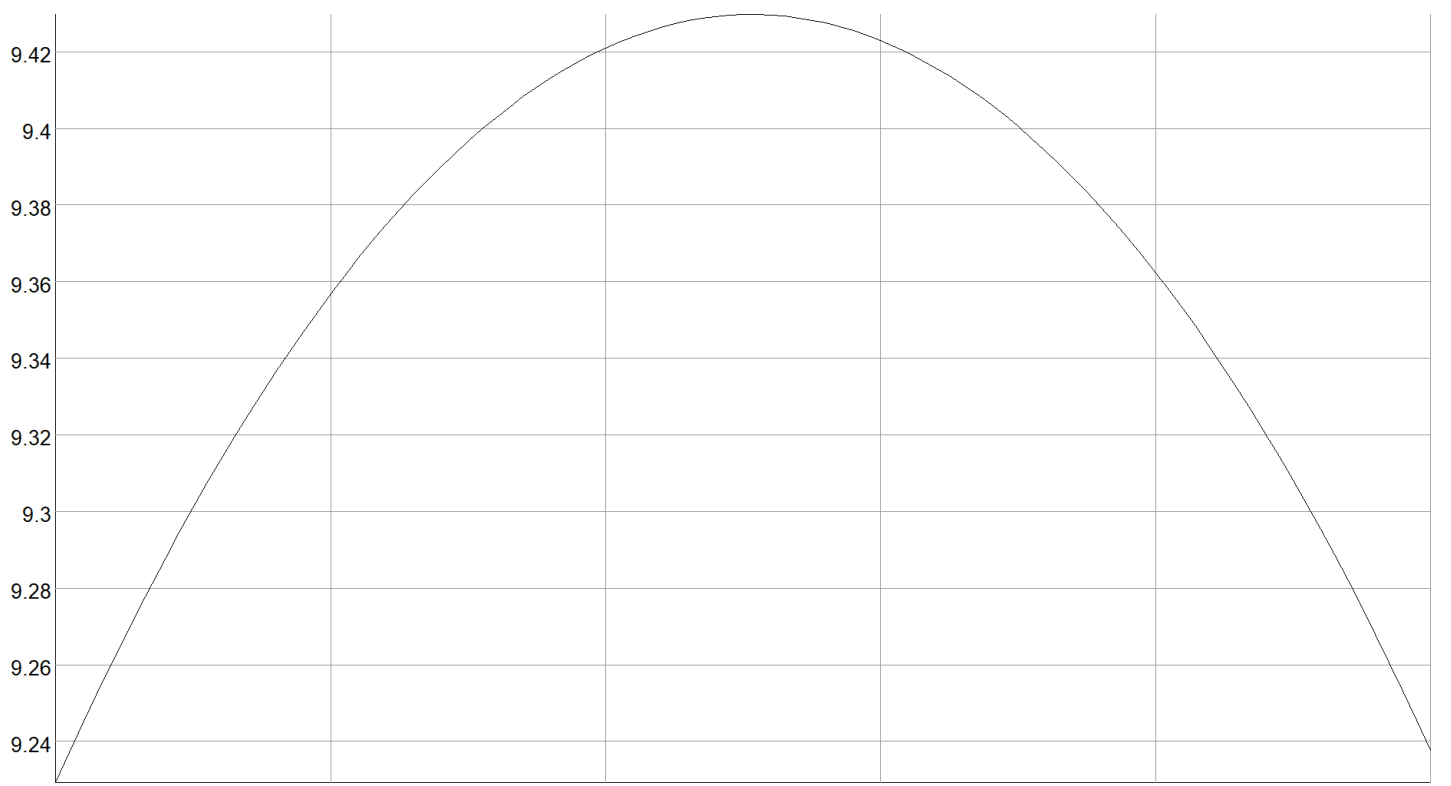
| Field Point Local Coordinates |  |
|-------------------------------|--|
| Local = Global                |  |

| FIELD EVALUATIONS     |                   |       |
|-----------------------|-------------------|-------|
| Line LINE (nodal) 101 | Cartesian         |       |
| x=0.0                 | y=-200.0 to 200.0 | z=0.0 |

**B along the y-axis at x=0, z=0 (upper bore)**

6/Aug/2019 10:23:23



|         |       |       |       |       |       |       |
|---------|-------|-------|-------|-------|-------|-------|
| X coord | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| Y coord | 108.0 | 112.0 | 116.0 | 120.0 | 124.0 | 128.0 |
| Z coord | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |

Component: B, from buffer: Line, Integral = 187.291536722363

**UNITS**  
 Length mm  
 Magn Flux Density T  
 Magn Field A m<sup>-1</sup>  
 Magn Scalar Pot A  
 Magn Vector Pot Wb m<sup>-1</sup>  
 Elec Flux Density C m<sup>-2</sup>  
 Elec Field V m<sup>-1</sup>  
 Conductivity S mm<sup>-1</sup>  
 Current Density A mm<sup>-2</sup>  
 Power W  
 Force N  
 Energy J  
 Mass kg

**MODEL DATA**  
 dcc017-no-ins-usmdp.op3  
 TOSCA Magnetostatic  
 Nonlinear materials  
 Simulation No 1 of 1  
 47698232 elements  
 9454251 nodes  
 8 conductors  
 Nodally interpolated fields  
 with B and H by integration  
 Activated in global coordinates  
 Reflection in XY plane (Z field=0)  
 Reflection in YZ plane (X field=0)

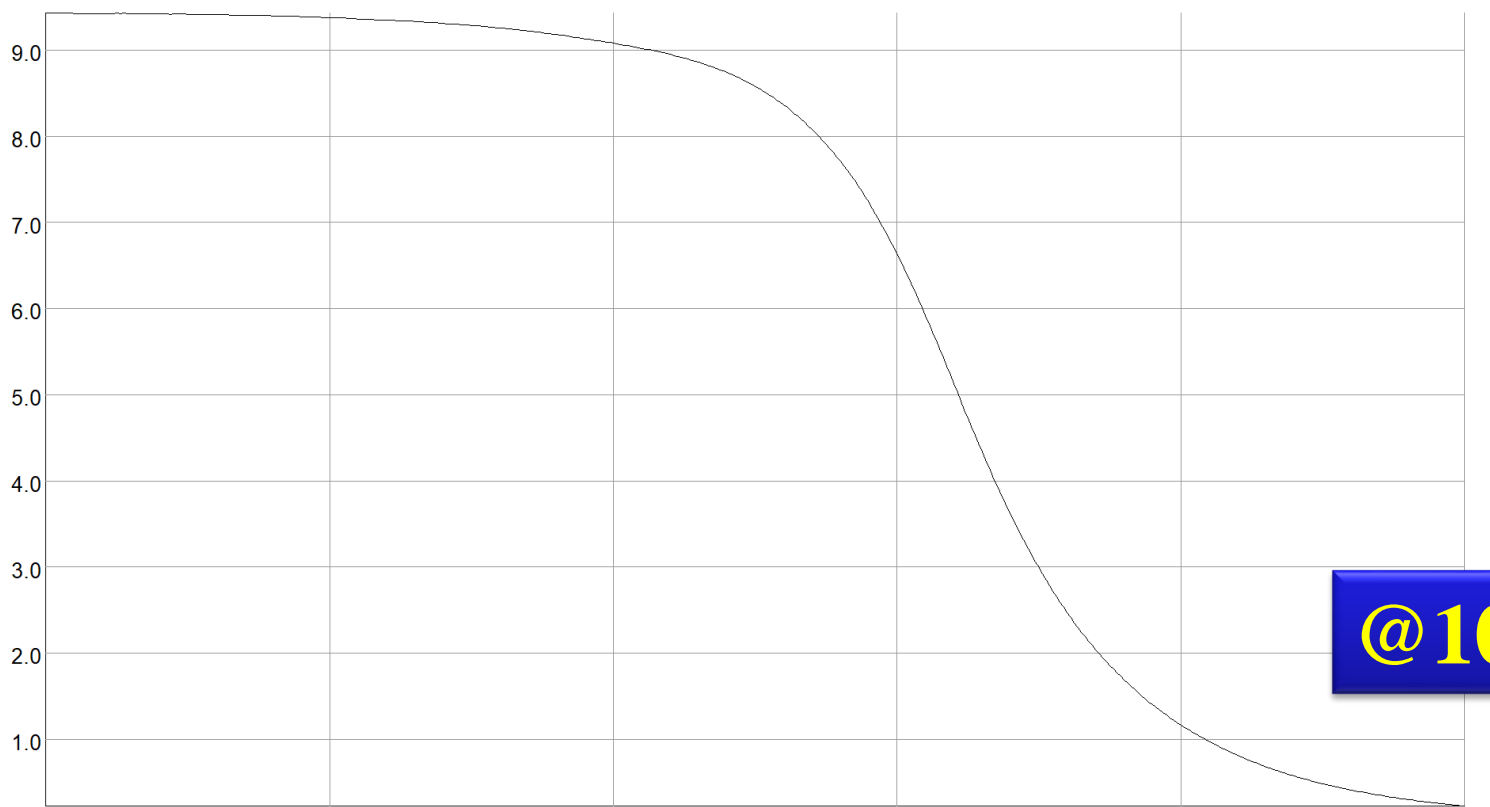
**Field Point Local Coordinates**  
 Local = Global

**FIELD EVALUATIONS**  
 Line L:HE (nodal+inte) 101 Cartesian  
 x=0.0 y=108.0 to 128.0 z=0.0

**@10 kA**

**Opera**

# B along the z-axis (center of upper bore)



|         |       |       |       |       |       |       |
|---------|-------|-------|-------|-------|-------|-------|
| X coord | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| Y coord | 118.0 | 118.0 | 118.0 | 118.0 | 118.0 | 118.0 |
| Z coord | 0.0   | 80.0  | 160.0 | 240.0 | 320.0 | 400.0 |

Component: B, from buffer: Line, Integral = 2473.79306925243

**@10 kA**

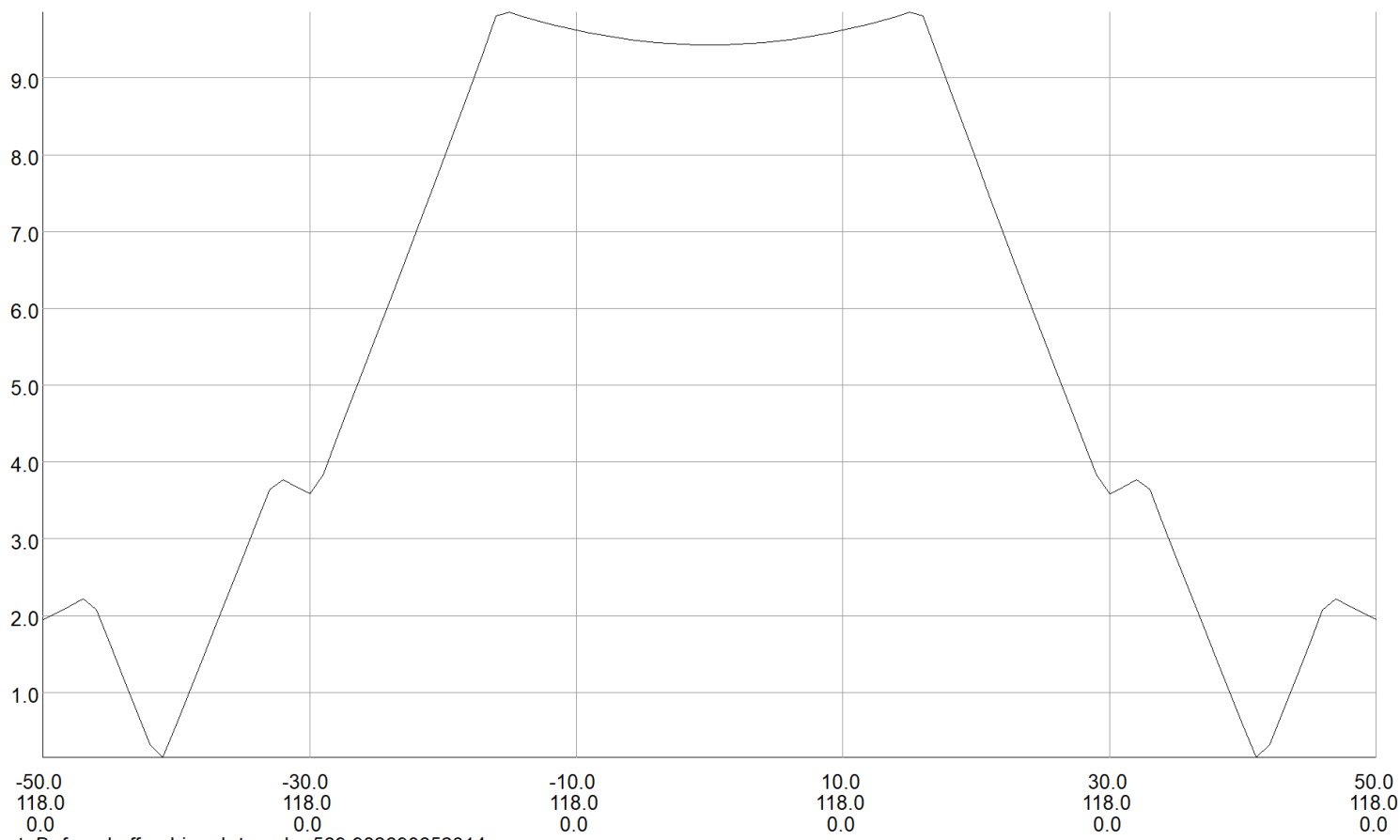
**UNITS**  
 Length mm  
 Magn Flux Density T  
 Magn Field A m<sup>-1</sup>  
 Magn Scalar Pot A  
 Magn Vector Pot Wb m<sup>-1</sup>  
 Elec Flux Density C m<sup>-1</sup>  
 Elec Field V m<sup>-1</sup>  
 Conductivity S mm<sup>-1</sup>  
 Current Density A mm<sup>-2</sup>  
 Power W  
 Force N  
 Energy J  
 Mass kg

**MODEL DATA**  
 dco017-no-rs-usmdp.op3  
 TOSCA Magnetostatic  
 Nonlinear materials  
 Simulation No 1 of 1  
 47698232 elements  
 9454251 nodes  
 8 conductors  
 Nodally interpolated fields  
 Activated in global coordinates  
 Reflection in XZ plane (Z field=0)  
 Reflection in YZ plane (X field=0)

**Field Point Local Coordinates**  
 Local = Global

**FIELD EVALUATIONS**  
 Line LINE (reda) 401 Cartesian  
 x=0.0 y=118.0 z=0.0 to 400.0

# B along the x-axis at z=0 (upper bore)



Component: B, from buffer: Line, Integral = 569.982690652314

**UNITS**  
 Length mm  
 Magn Flux Density T  
 Magn Field A m<sup>-1</sup>  
 Magn Scalar Pot A  
 Magn Vector Pot Wb m<sup>-1</sup>  
 Elec Flux Density C m<sup>-1</sup>  
 Elec Field V m<sup>-1</sup>  
 Conductivity S mm<sup>-1</sup>  
 Current Density A mm<sup>-2</sup>  
 Power W  
 Force N  
 Energy J  
 Mass kg

**MODEL DATA**  
 dcc017-no-ris-usmdp.op3  
 TOSCA Magnetostatic  
 Nonlinear materials  
 Simulation no 1 of 1  
 47698232 elements  
 9454251 nodes  
 8 conductors  
 Nodally interpolated fields  
 with B and H by integration  
 Activated in global coordinates  
 Reflection in XY plane (z field=0)  
 Reflection in YZ plane (x field=0)

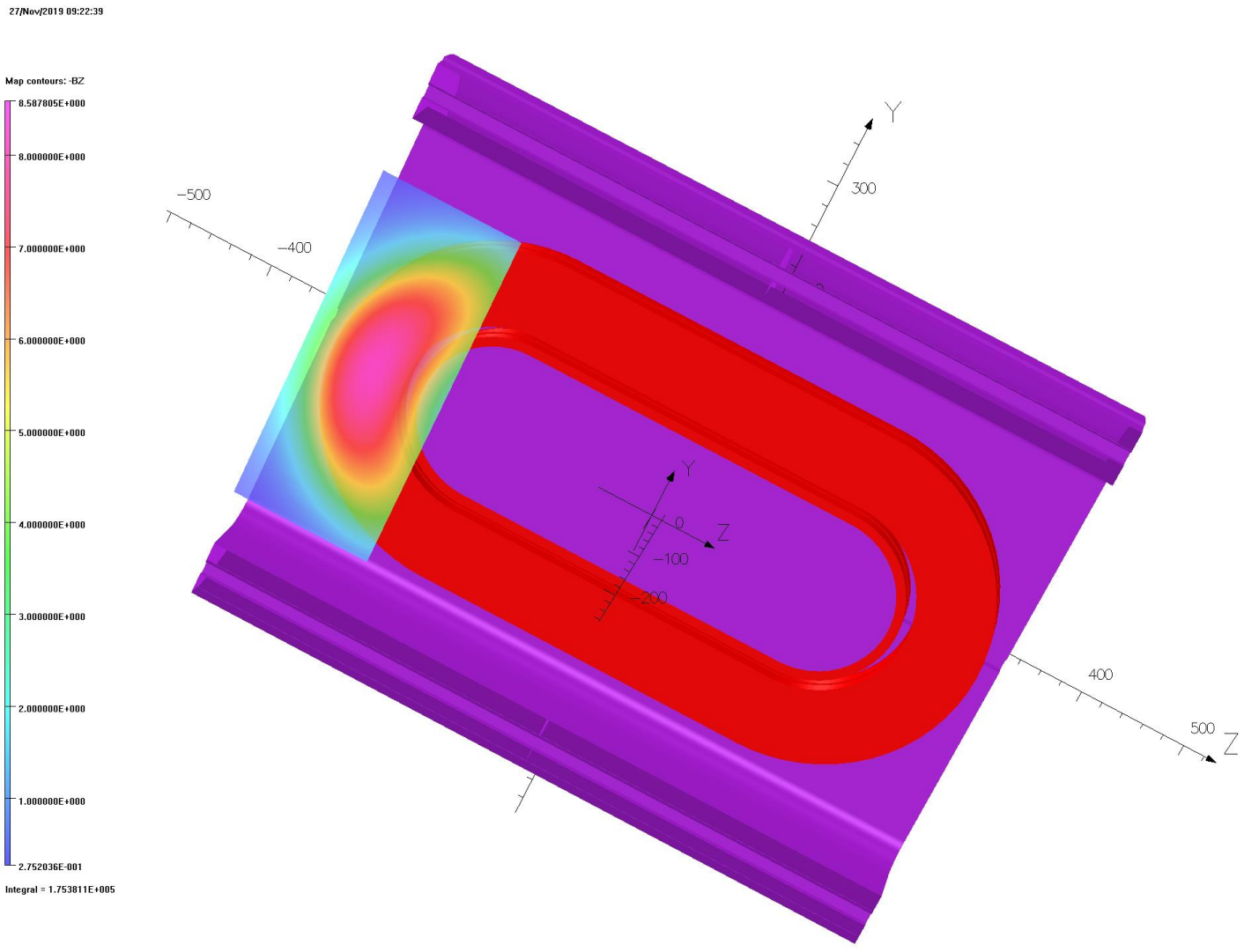
**Field Point Local Coordinates**  
 Local = Global

**FIELD EVALUATIONS**  
 Line LINE (nodal+int) 101 Cartesian  
 x=-50.0 to 50.0 y=118.0 z=0.0

**@10 kA**

Opera

# Magnitude of the Axial Field (Bz) Map in DCC017 in the End Region



**UNITS**

|                   |                                 |
|-------------------|---------------------------------|
| Length            | mm                              |
| Magn Flux Density | T                               |
| Magn Field        | A m <sup>-1</sup>               |
| Magn Scalar Pot   | A                               |
| Magn Vector Pot   | 10 <sup>6</sup> m <sup>-1</sup> |
| Elec Flux Density | C m <sup>-2</sup>               |
| Elec Field        | V m <sup>-1</sup>               |
| Conductivity      | S mm <sup>-1</sup>              |
| Current Density   | A mm <sup>-2</sup>              |
| Power             | W                               |
| Force             | N                               |
| Energy            | J                               |
| Mass              | kg                              |

**MODEL DATA**

dcc017-no-ins-usmb.op3  
 TOSCA Magnetostatic  
 Nonlinear materials  
 Simulation No. 1 of 1  
 47598232 elements  
 9454251 nodes  
 8 conductors  
 Nodally interpolated fields  
 Activated in global coordinates  
 Reflection in XY plane (Z field=0)  
 Reflection in YZ plane (X field=0)

**Field Point Local Coordinates**  
 Local = Global

**FIELD EVALUATIONS**

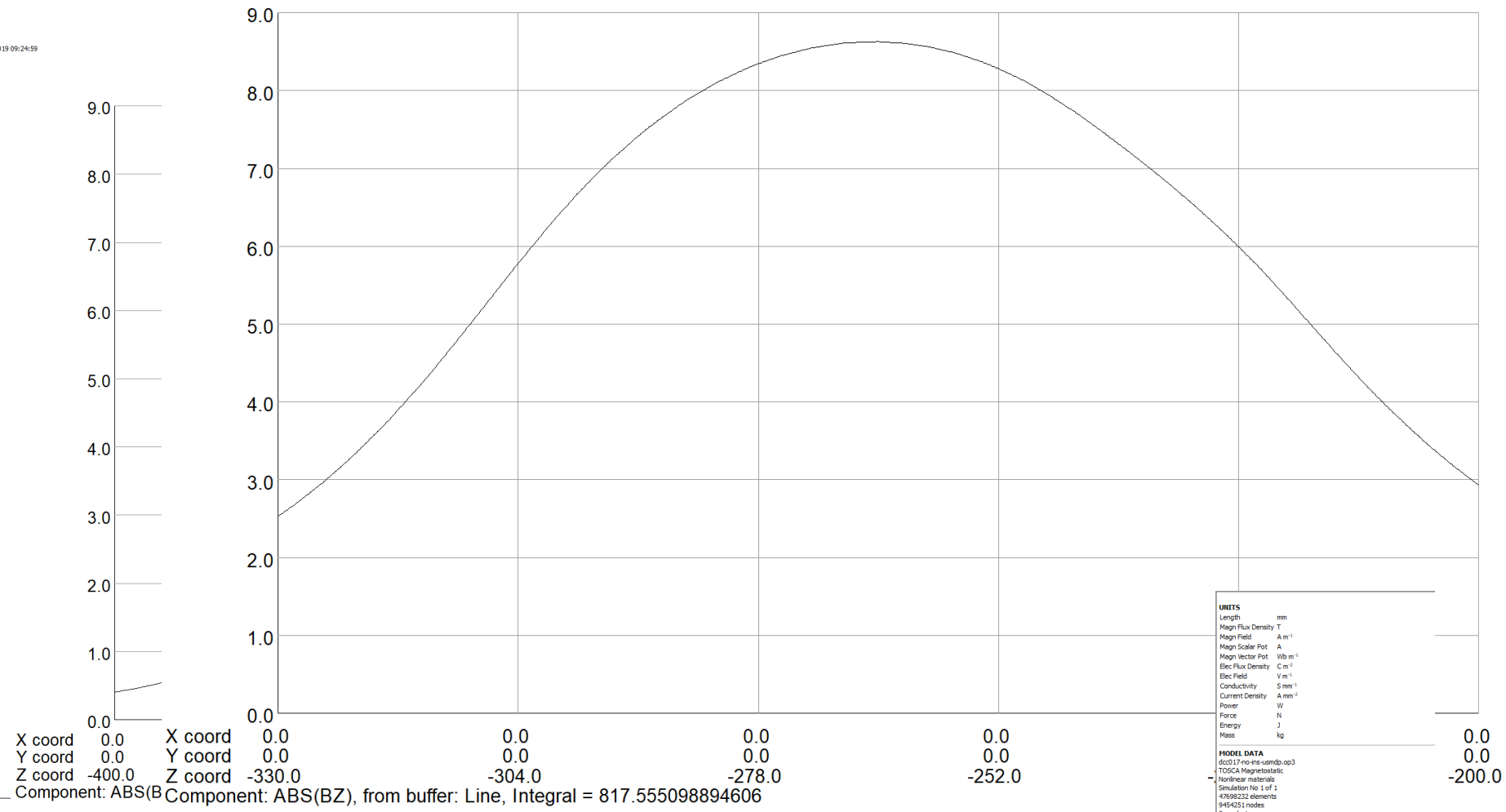
| Cartesian | CARTESIAN (nodal) | 20x20              | Cartesian |
|-----------|-------------------|--------------------|-----------|
| x=0.0     | y=-160.0 to 160.0 | z=-330.0 to -200.0 |           |

**@10 kA**

Opera

# Magnitude of the Axial Field (Bz) along the z-axis in DCC017 in the End Region

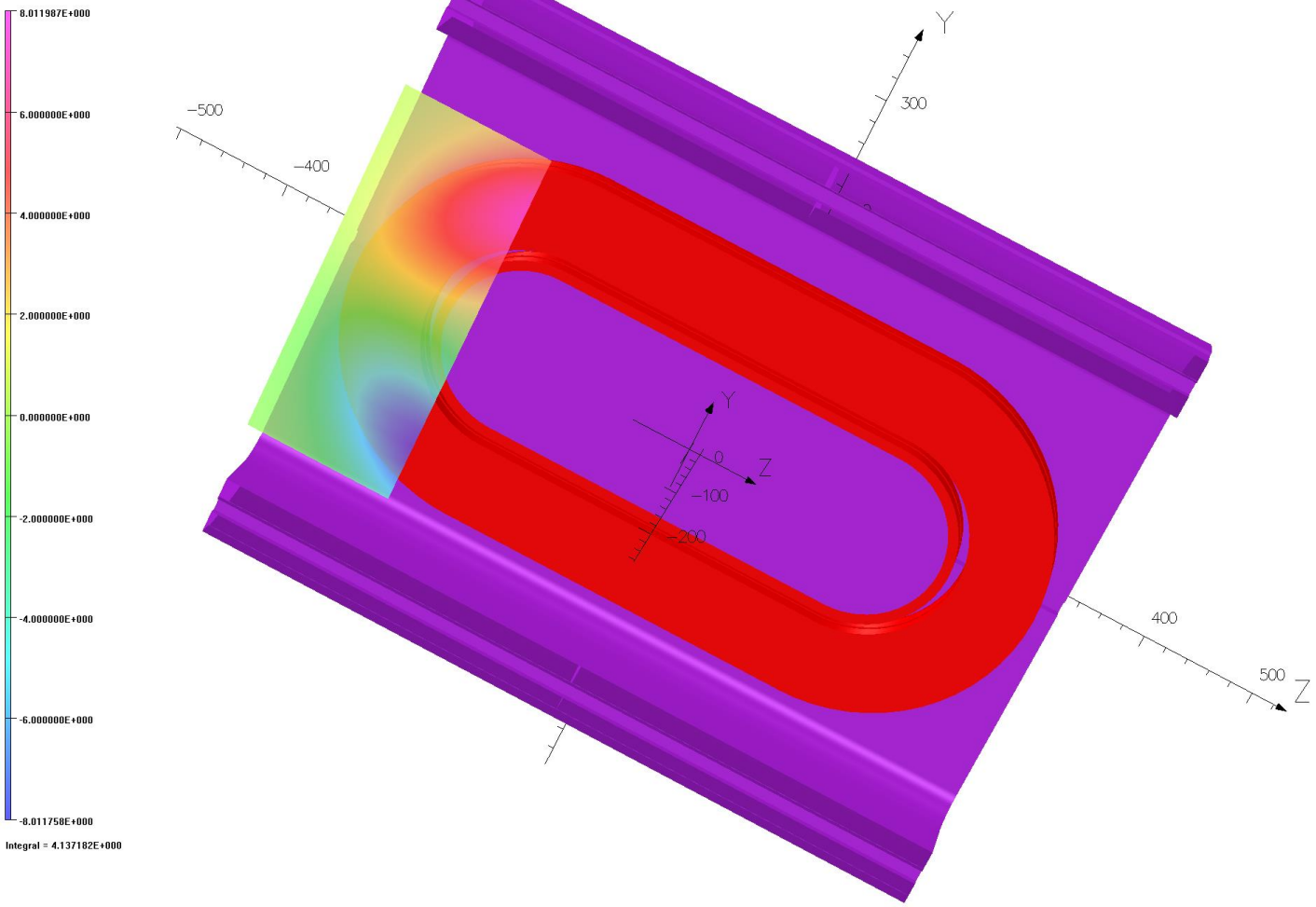
27Nov/2019 09:24:59



# Vertical Field (By) Map in DCC017 in the End Region

27/Nov/2019 09:21:05

Map contours: BY



| UNITS             |                    |
|-------------------|--------------------|
| Length            | mm                 |
| Magn Flux Density | T                  |
| Magn Field        | A m <sup>-1</sup>  |
| Magn Scaler Pot   | A                  |
| Magn Vector Pot   | Wb m <sup>-1</sup> |
| Elec Flux Density | C m <sup>-1</sup>  |
| Elec Field        | V m <sup>-1</sup>  |
| Conductivity      | S mm <sup>-1</sup> |
| Current Density   | A mm <sup>-2</sup> |
| Power             | W                  |
| Force             | N                  |
| Energy            | J                  |
| Mass              | kg                 |

| MODEL DATA                         |  |
|------------------------------------|--|
| dco17-no-ins-umdb.op3              |  |
| TOSCA Magnetostatic                |  |
| Nonlinear materials                |  |
| Simulation No. 1 of 1              |  |
| 47696232 elements                  |  |
| 9454251 nodes                      |  |
| 0 conductors                       |  |
| Nodally interpolated fields        |  |
| Activated in global coordinates    |  |
| Reflection in XY plane (Z field=0) |  |
| Reflection in YZ plane (X field=0) |  |

| Field Point Local Coordinates |  |
|-------------------------------|--|
| Local = Global                |  |

| FIELD EVALUATIONS                 |                   |                    |
|-----------------------------------|-------------------|--------------------|
| Cartesian CARTESIAN (nodal) 20x20 | Cartesian         |                    |
| x=0.0                             | y=-160.0 to 160.0 | z=-330.0 to -200.0 |

**@10 kA**

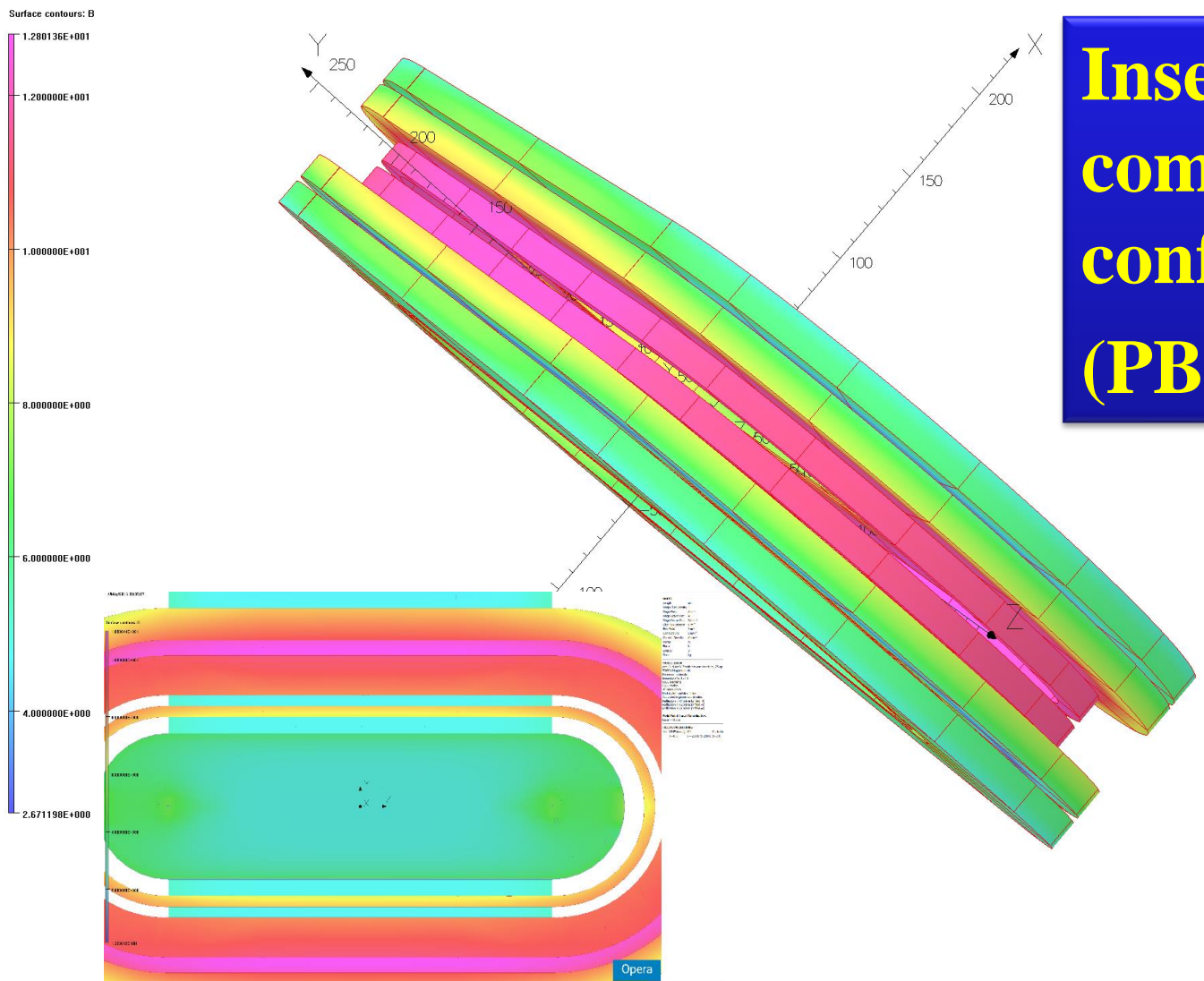
Opera

# Models of Insert Coil Testing in DCC017



# Insert Coil Test Configuration #1 (common coil insert)

UNITS  
Length mm  
Magn Flux Density T  
Magn Field A m<sup>-1</sup>  
Magn Scalar Pot A  
Magn Vector Pot Wb m<sup>-1</sup>



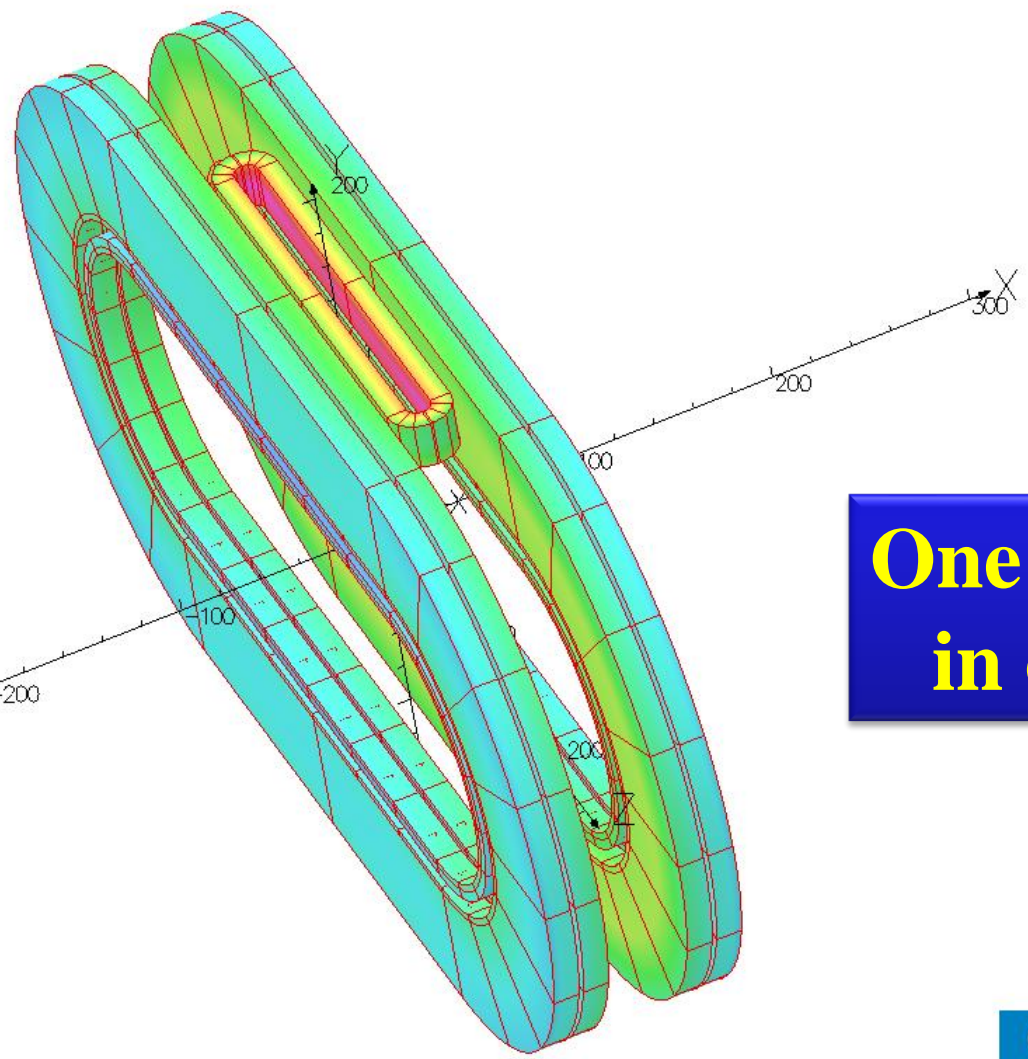
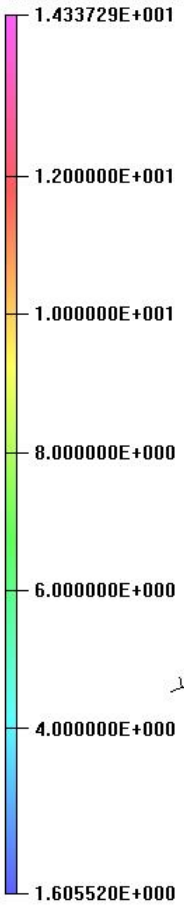
**Insert coils in  
common coil  
configuration  
(PBL/MT25)**

Opera

# Insert Coil Test Configuration #2 (one coil insert in one bore)

1/Nov/2014 16:42:51

Surface contours: BMOD\*.8



**UNITS**

|                   |                    |
|-------------------|--------------------|
| Length            | mm                 |
| Magn Flux Density | T                  |
| Magn Field        | A m <sup>-1</sup>  |
| Magn Scalar Pot   | A                  |
| Magn Vector Pot   | Wb m <sup>-1</sup> |
| Elec Flux Density | C m <sup>-2</sup>  |
| Elec Field        | V m <sup>-1</sup>  |
| Conductivity      | S m <sup>-1</sup>  |
| Current Density   | A mm <sup>-2</sup> |
| Power             | W                  |
| Force             | N                  |
| Energy            | J                  |
| Mass              | kg                 |

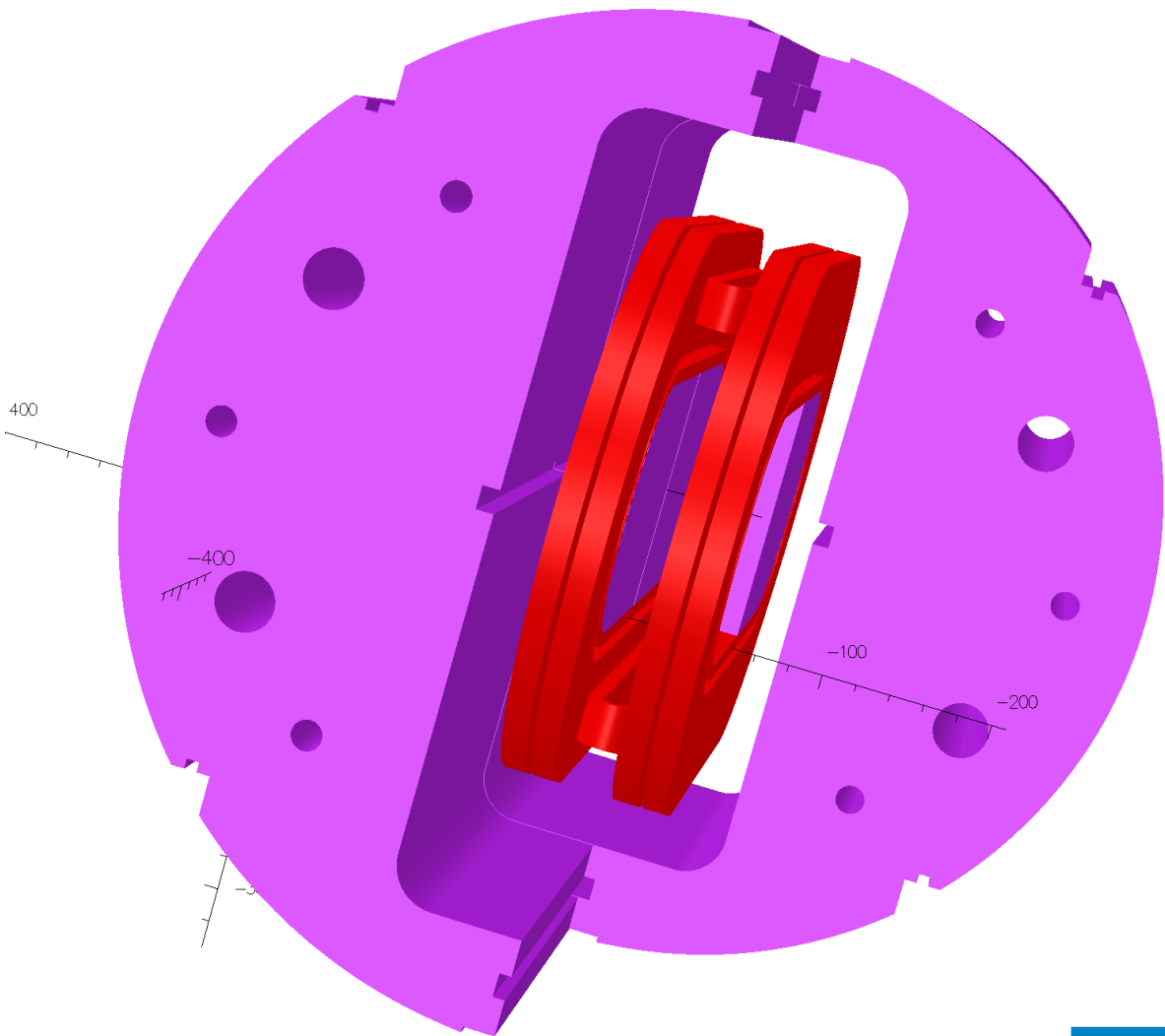
**MODEL DATA**  
17 conductors

**Field Point Local Coordinates**  
Local = Global

**One insert coil  
in one bore**

Opera

# Insert Coils Test Configuration #3 (two coils in two bores, parallel)



| UNITS             |                    |
|-------------------|--------------------|
| Length            | mm                 |
| Magn Flux Density | T                  |
| Magn Field        | A m <sup>-1</sup>  |
| Magn Scalar Pot   | A                  |
| Magn Vector Pot   | Wb m <sup>-1</sup> |
| Elec Flux Density | C m <sup>-2</sup>  |
| Elec Field        | V m <sup>-1</sup>  |
| Conductivity      | S mm <sup>-1</sup> |
| Current Density   | A mm <sup>-2</sup> |
| Power             | W                  |
| Force             | N                  |
| Energy            | J                  |
| Mass              | kg                 |

| MODEL DATA                                    |  |
|---|--|
| dco17-nl-nomex-hls-ins-both-usmdp.op3         |  |
| TOSCA Magnetostatic                           |  |
| Nonlinear materials                           |  |
| Simulation No. 1 of 1                         |  |
| 47698232 elements                             |  |
| 9454251 nodes                                 |  |
| 10 conductors                                 |  |
| Nodally interpolated fields                   |  |
| Activated in global coordinates               |  |
| Reflector in X <sup>1</sup> plane (Z field=0) |  |
| Reflector in YZ plane (X field=0)             |  |

| Field Point Local Coordinates |  |
|-------------------------------|--|
| Local = global                |  |

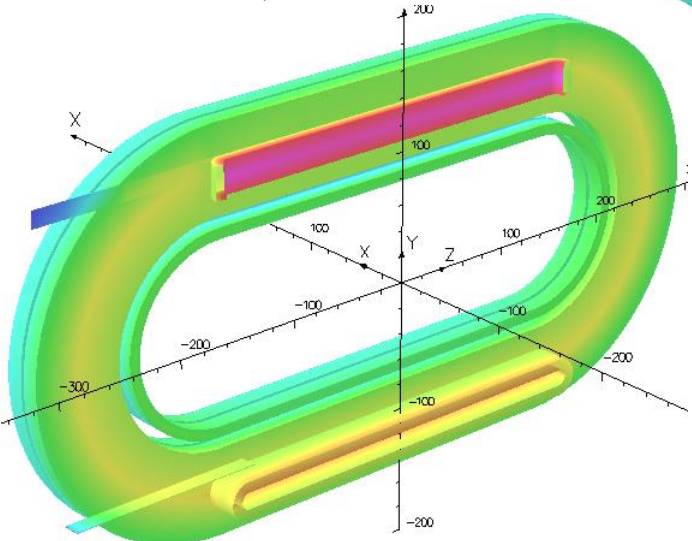
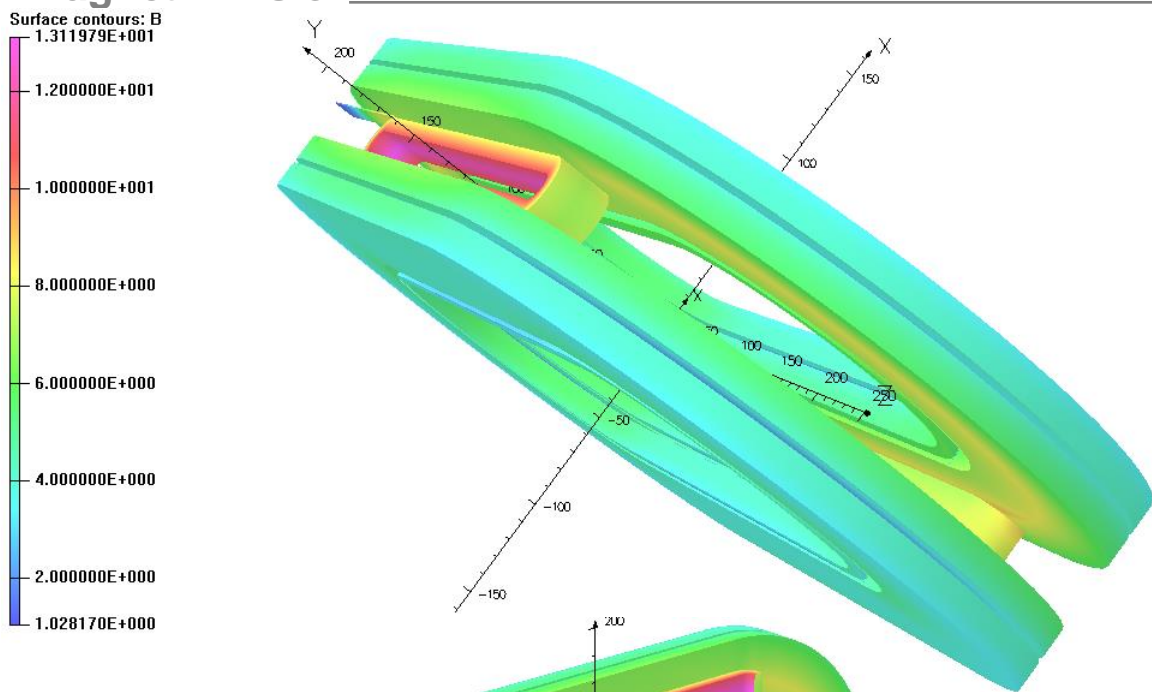
  

| FIELD EVALUATIONS  |                   |           |
|--------------------|-------------------|-----------|
| Line LINC (radial) | 101               | Cartesian |
| x=0.0              | y=-300.0 to 300.0 | z=0.0     |

**Two insert coils  
in two bores  
(Feb 2020 test)**

Opera

# Insert Coils Test Configuration#4 (two insert coils, parallel & perpendicular)



**Cut away view**

**Two HTS insert coils in two bores (apertures) of the common coil dipole**

**(a) Upper bore: Field primarily parallel**

**(b) Lower bore: Field primarily perpendicular**

# Insert Coil Test Configuration #5 (one coil insert, one side in bore)

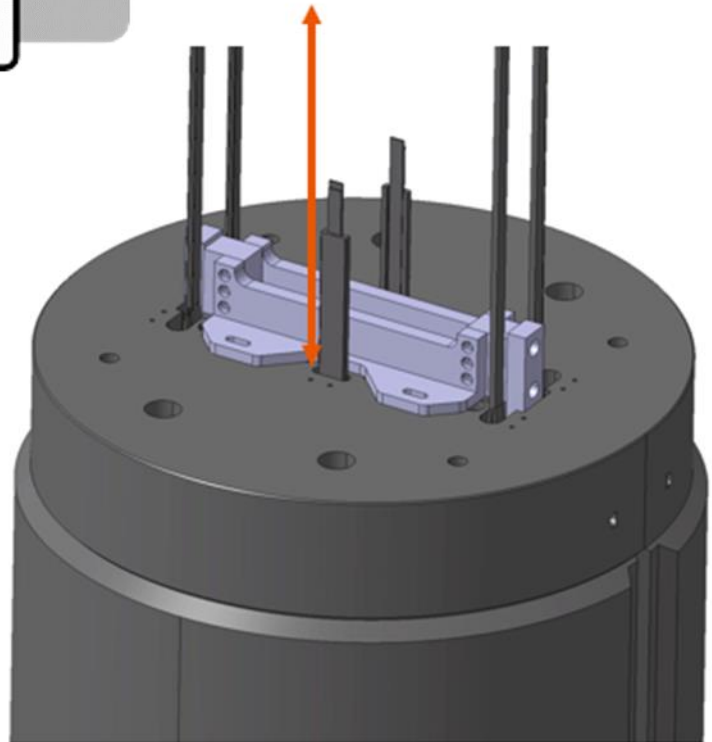
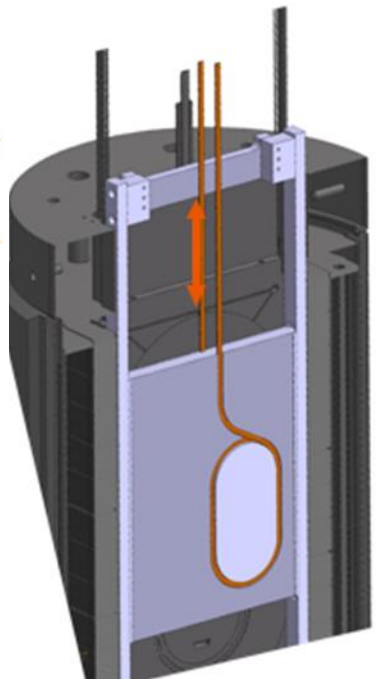
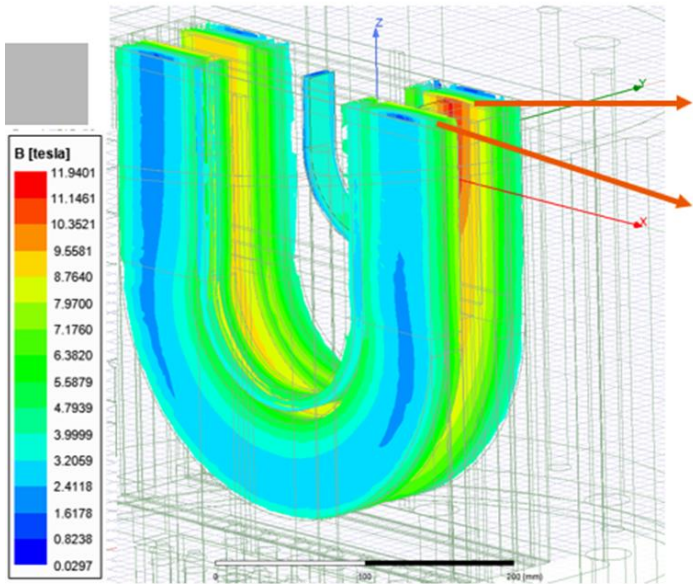


**Coil partially in field (one side of the coil in one bore)**

D. Martins Araujo :: on behalf of MagDev team :: Paul Scherrer Institute  
BigBOX  
modelling and engineering design progress  
PSI / BNL-MDP Collaboration meeting, February 2022

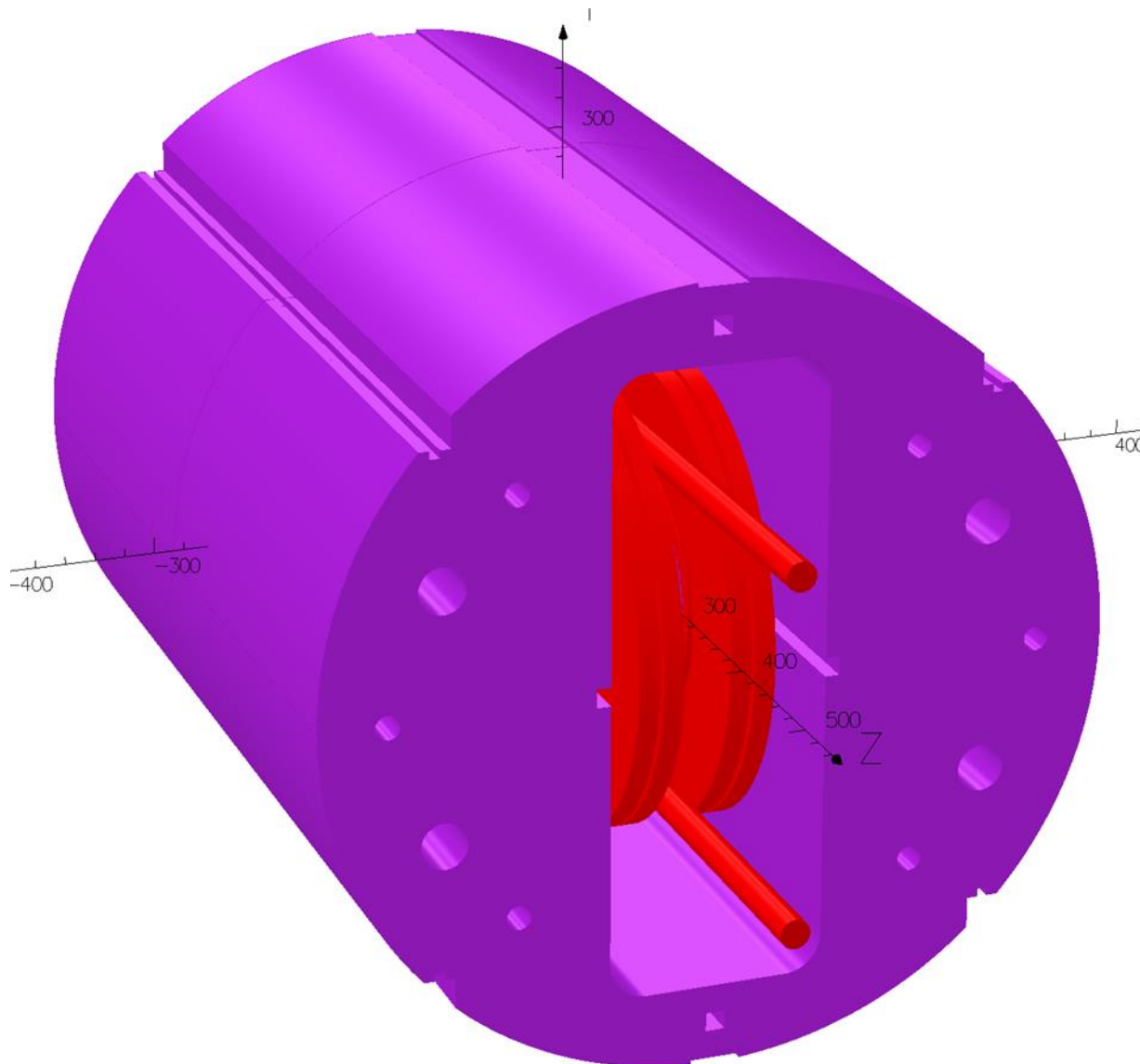


**Test planned in 2022**



# Models of Cable Testing in DCC017

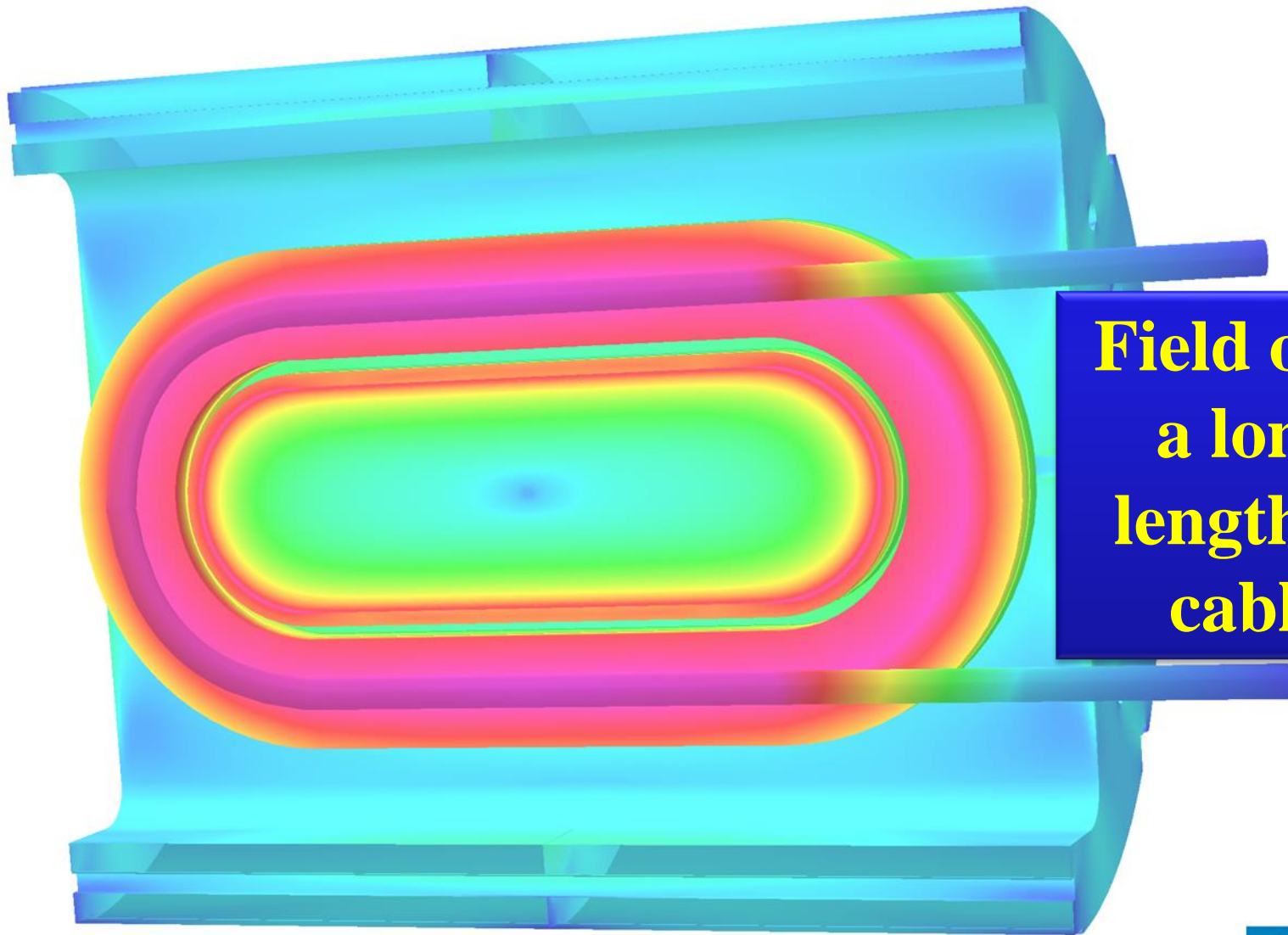
# Cable Testing Model - View 1



**Single  
turn  
cable test**

# Cable Testing Model - View 2

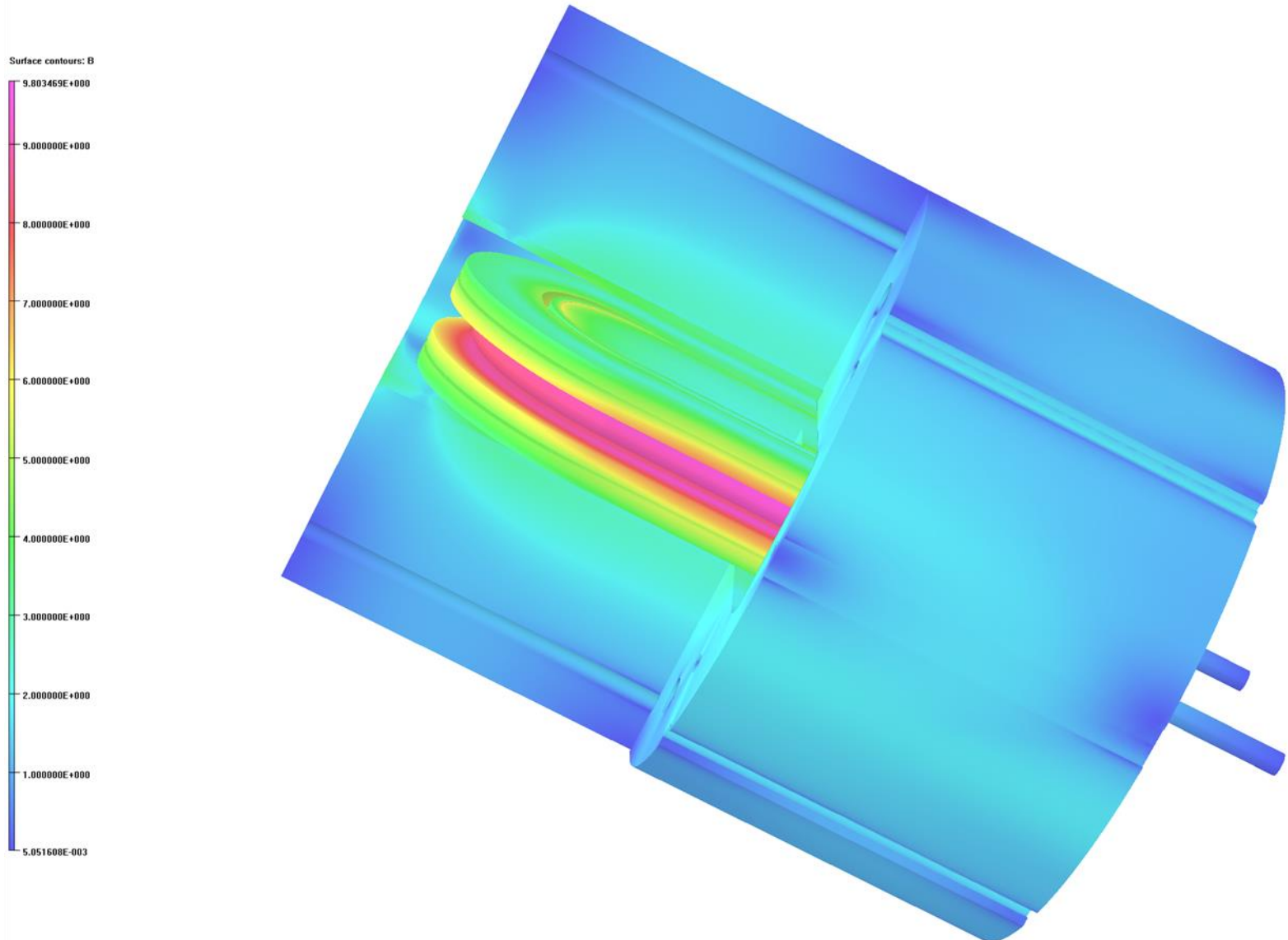
Surface contours: B



**Field over  
a long  
length of  
cable**

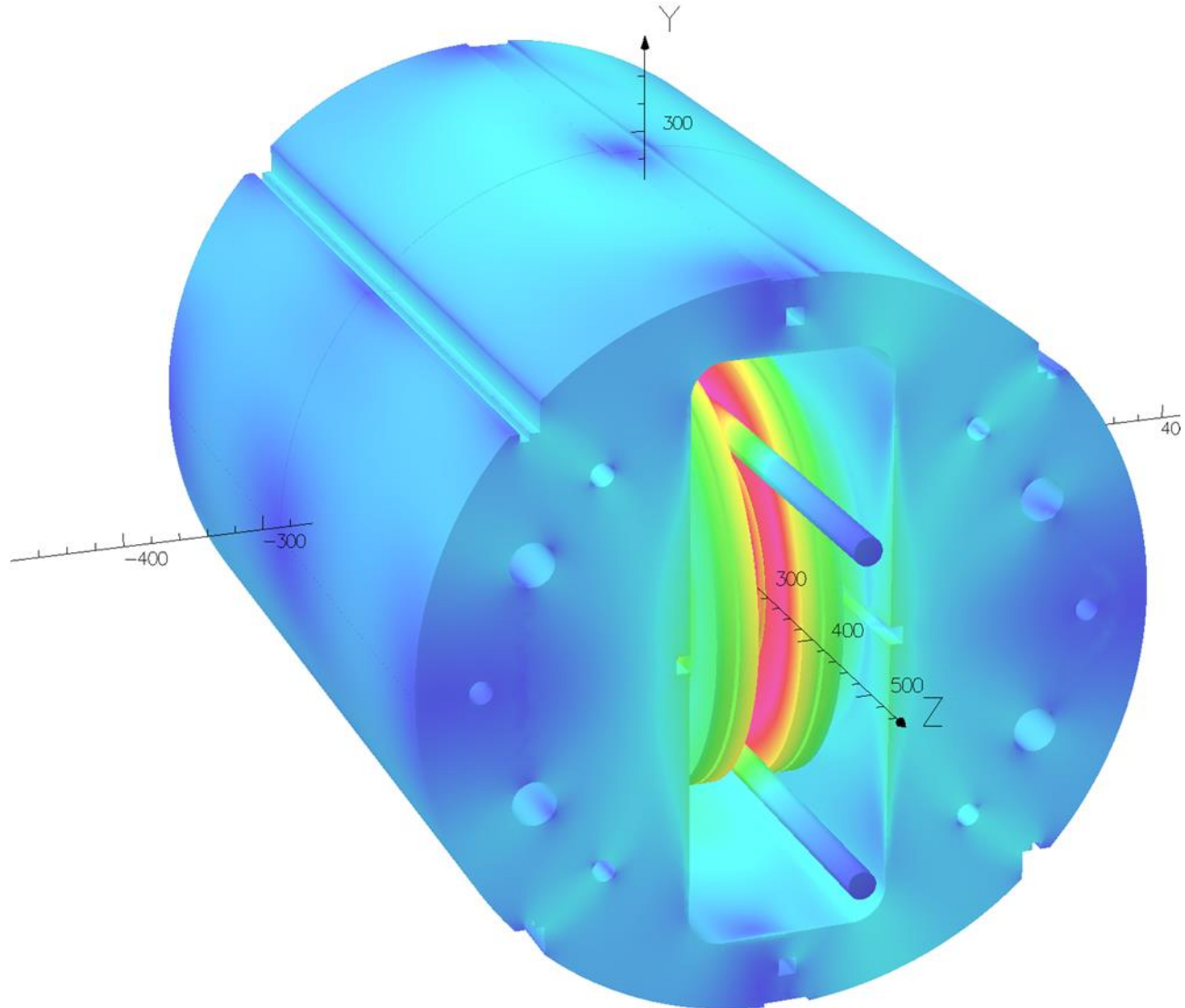
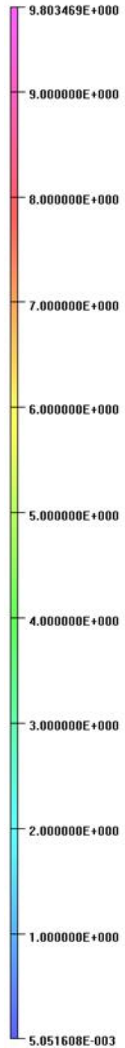


# Cable Testing Model - View 3

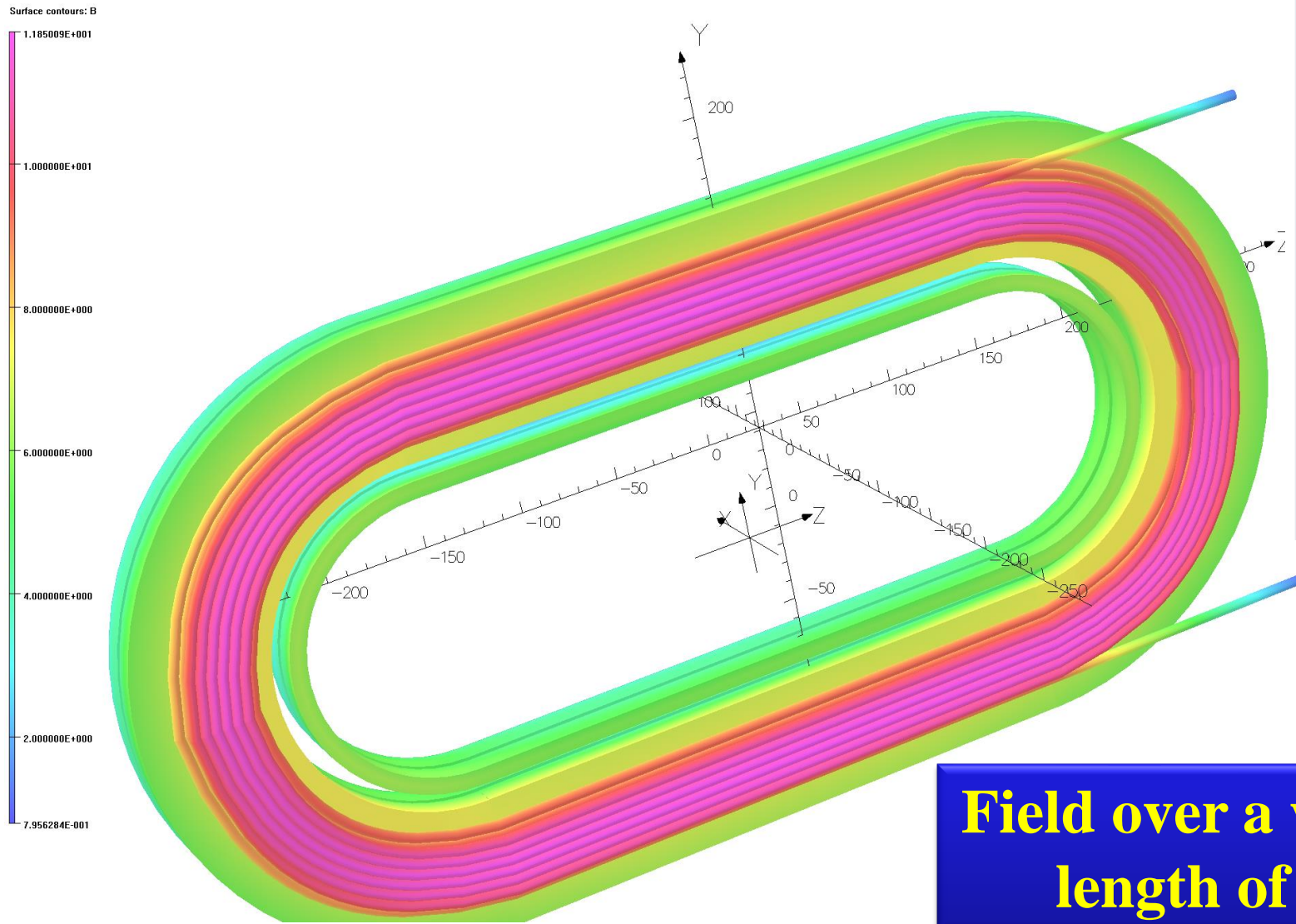


# Cable Testing Model - View 4

Surface contours: B



# Multi-turn Cable Test



| UNITS             |                    |
|-------------------|--------------------|
| Length            | mm                 |
| Magn Flux Density | T                  |
| Magn Field        | A m <sup>-1</sup>  |
| Magn Scalar Pot   | A                  |
| Magn Vector Pot   | Wb m <sup>-1</sup> |
| Elec Flux Density | C m <sup>-2</sup>  |
| Elec Field        | V m <sup>-1</sup>  |
| Conductivity      | S m <sup>-1</sup>  |
| Current Density   | A mm <sup>-2</sup> |
| Power             | W                  |
| Force             | N                  |
| Energy            | J                  |
| Mass              | kg                 |

---

| MODEL DATA    |  |
|---------------|--|
| 66 conductors |  |

---

**Field Point Local Coordinate**  
Local = Global

**Field over a very long length of cable**

## Upgrades Under Consideration

### Current setup is for

- Insert coil/cable up to 4.5 kA for any background field up to 10 T
- Insert coil/cable up 10 kA, if in series with common coil

### Future upgrades planned for

- Setup for 20 K testing of cables and insert coils
- Quench detection upgrades, including fiber optics and acoustics
- Insert coil/cable to 7.5 kA for any background field up to 10 T
- Insert coil/cable up to 15 kA, if in series with common coil with added shunt allowing variation in current in insert coil/cable
- Configuring existing power supplies at BNL for 30 kA insert coil or cable testing with upgrade to top-hat
- Transformer inside cryostat allowing up to 100 kA for cable test with any background up to 10 T