

Development of 3-tesla HTS Magnet for MRI

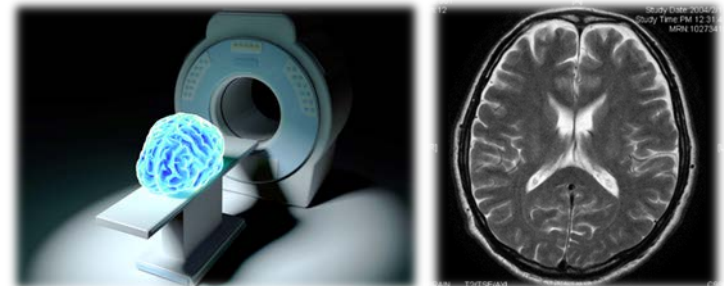
Date:
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Magnet Technology

Mitsubishi Electric Corporation

- previous study
- world first 3 T MR-imaging w/ 1/3-scale HTS magnet @2016
- what's next step?
- design & manufacture of **half-scale 3 T HTS magnet**
- conclusions

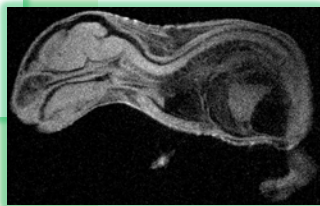
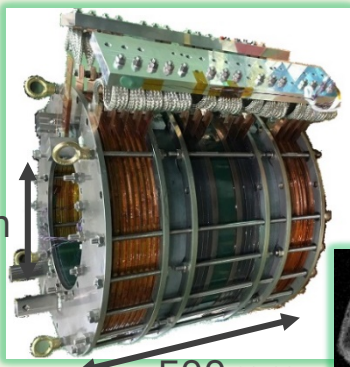




Mini coils

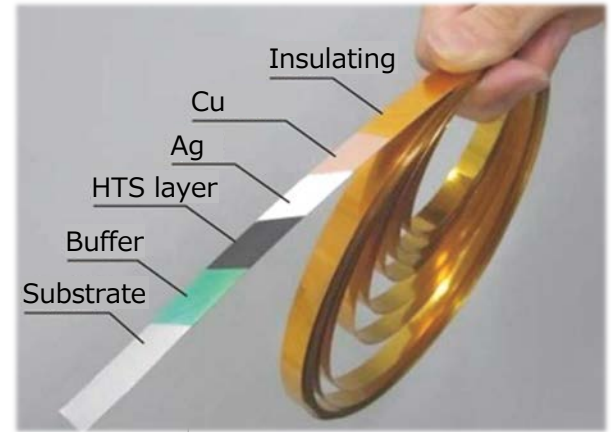
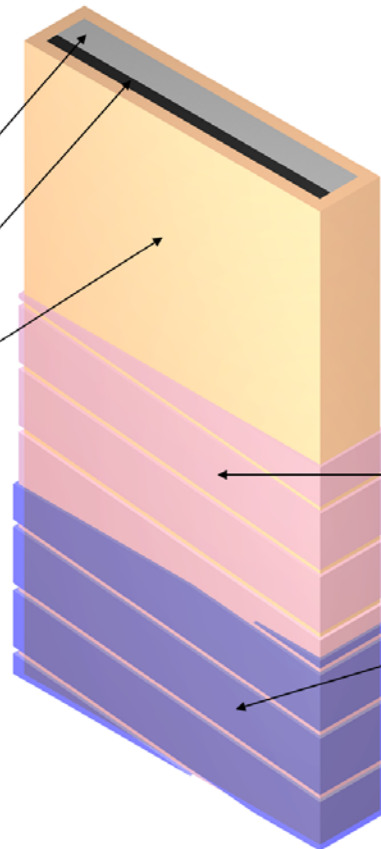


1/3 scale, 3T



1st Phase

Substrate
HTS layer
Cu plating



Inner Polyimide tape
(Fluorine coating)

Outer Polyimide tape
(No coating)

World's first 3T MR-Imaging w/ HTS magnet @2016

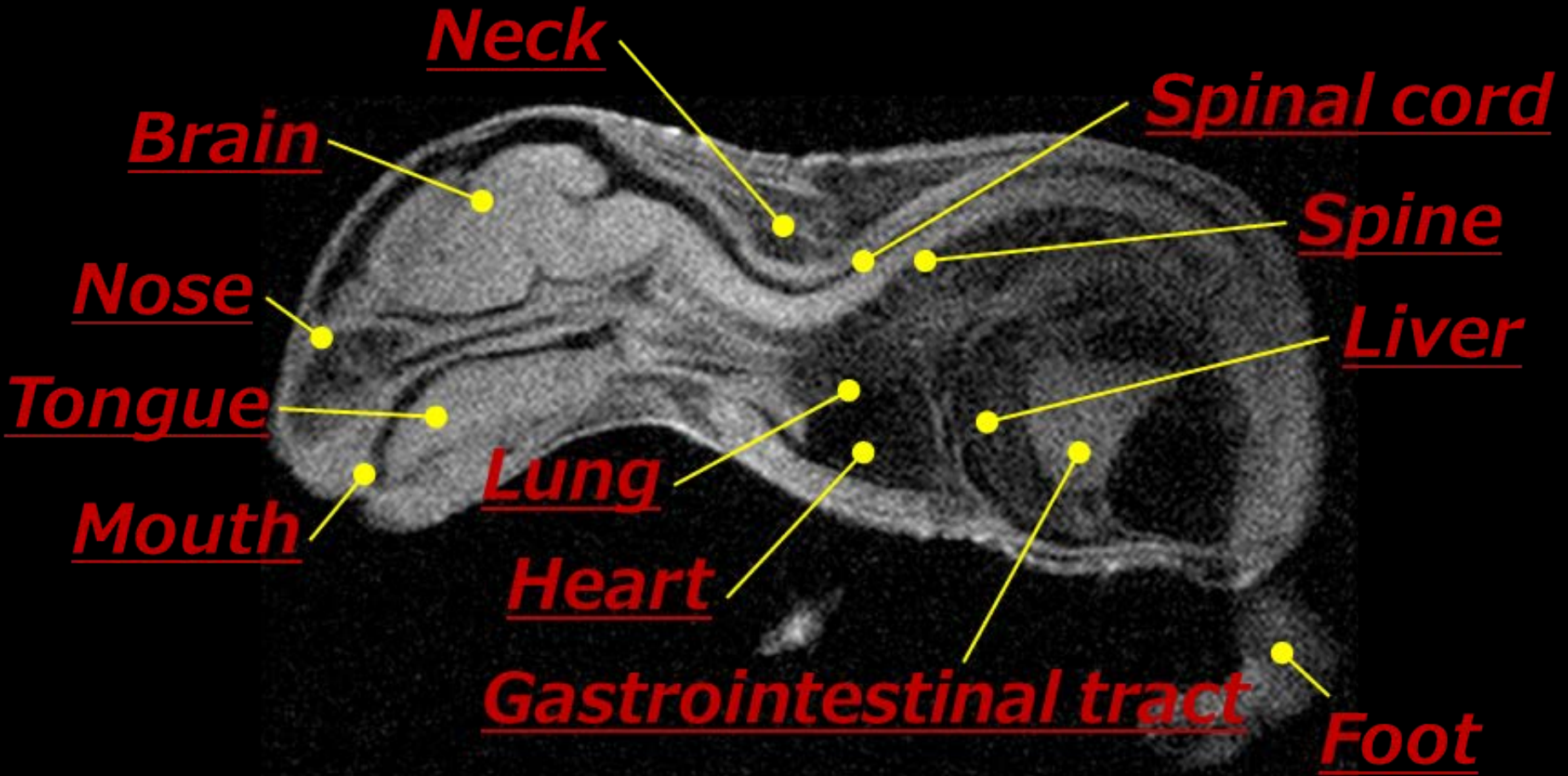
1/3 scale mini-model

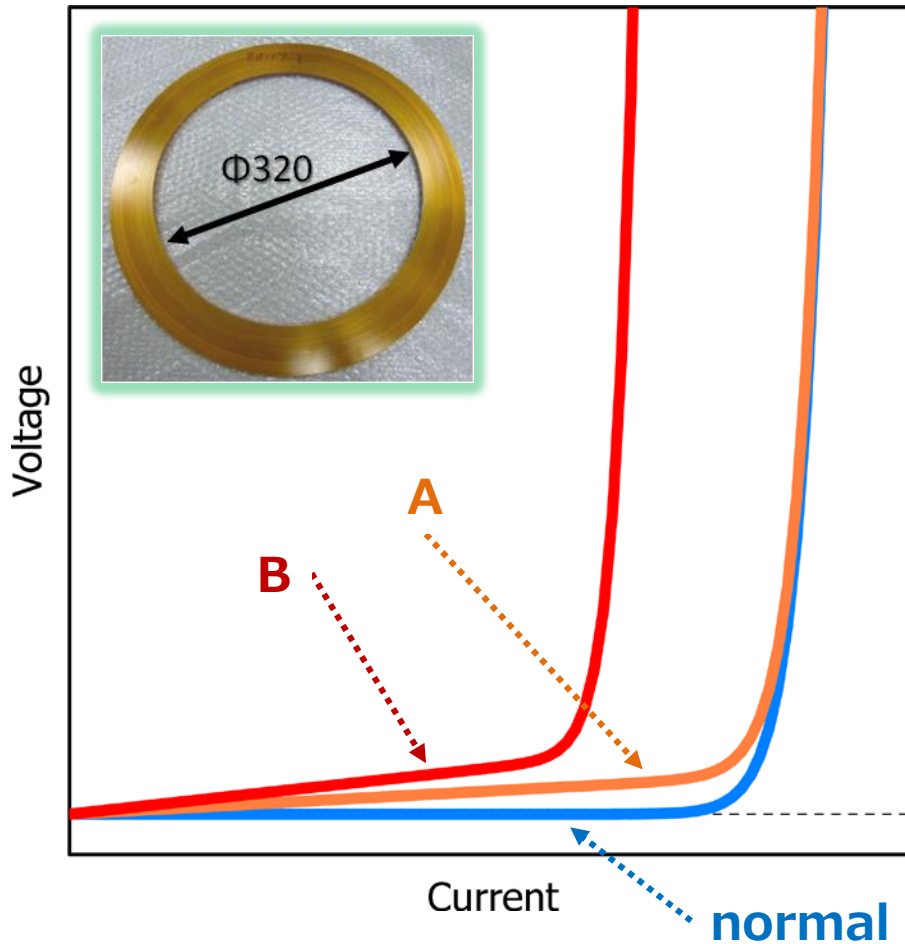


Bore diameter	300 mm
Outer diameter	470 mm
Length	500 mm
B @Center	2.9 T
B (maximum)	4.3 T
B (Uniformity)	1.7 ppm
Rated current	131 A
Current density	110 A/mm ²
Total wire length	16 km
Inductance	32 H
Maximum force	10 MPa

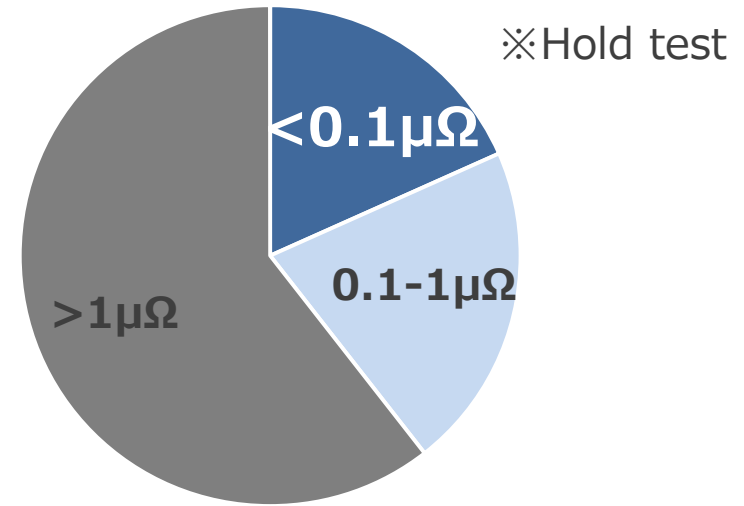
World's first 3T MR-Imaging w/ HTS magnet @2016

1/3 scale mini-model

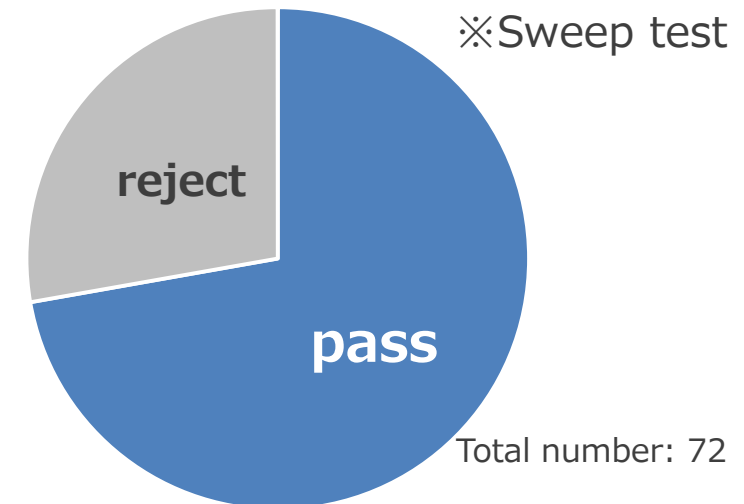




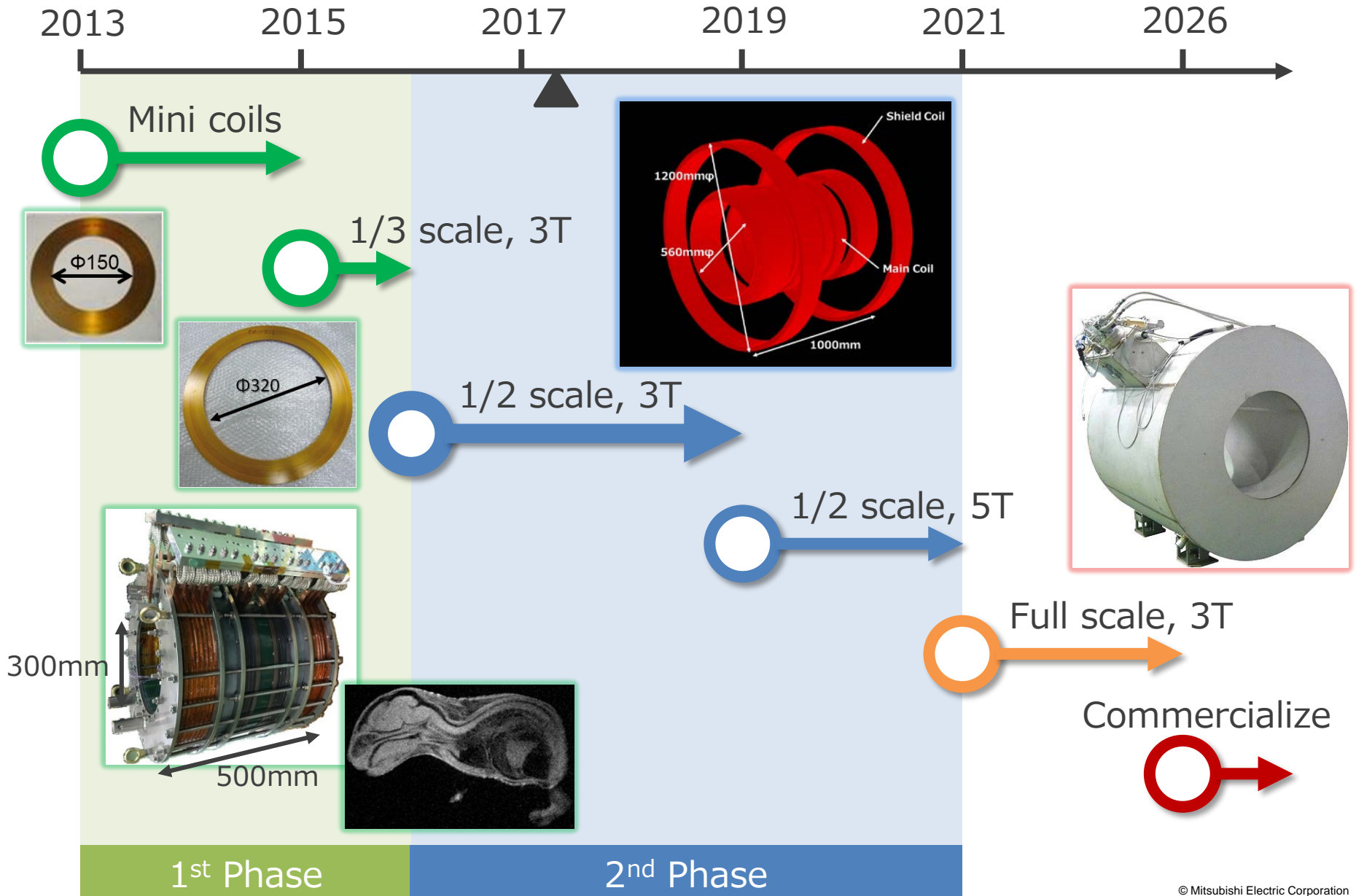
A : local degradation



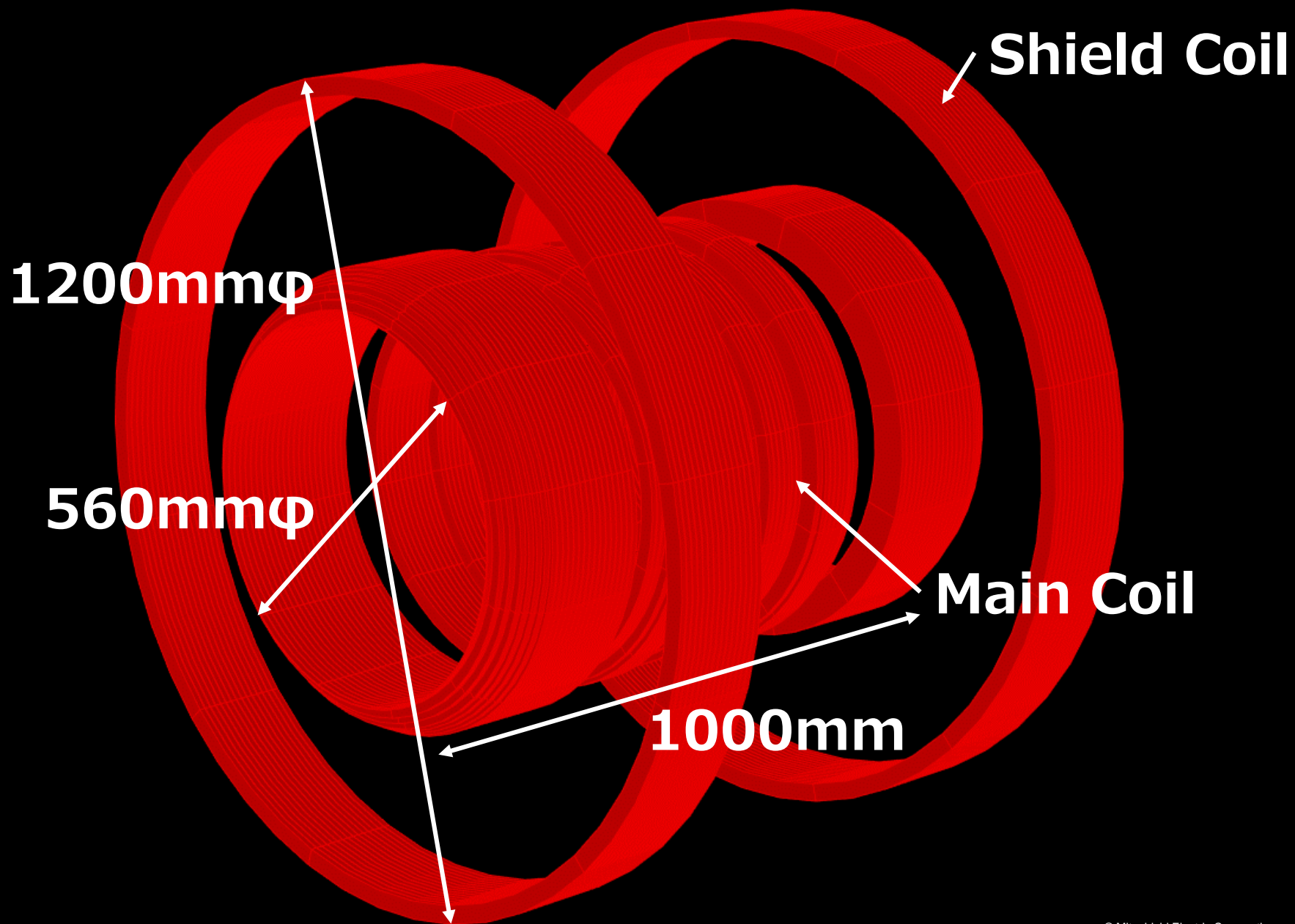
B : extensive degradation

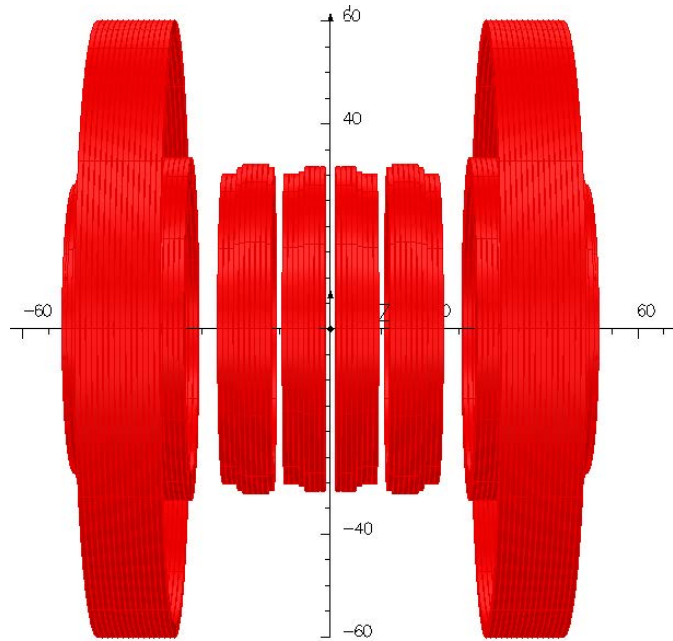
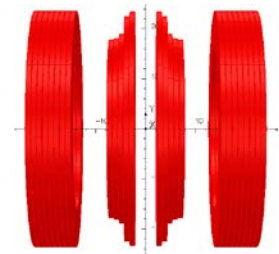


Local degradation has frequently occurred



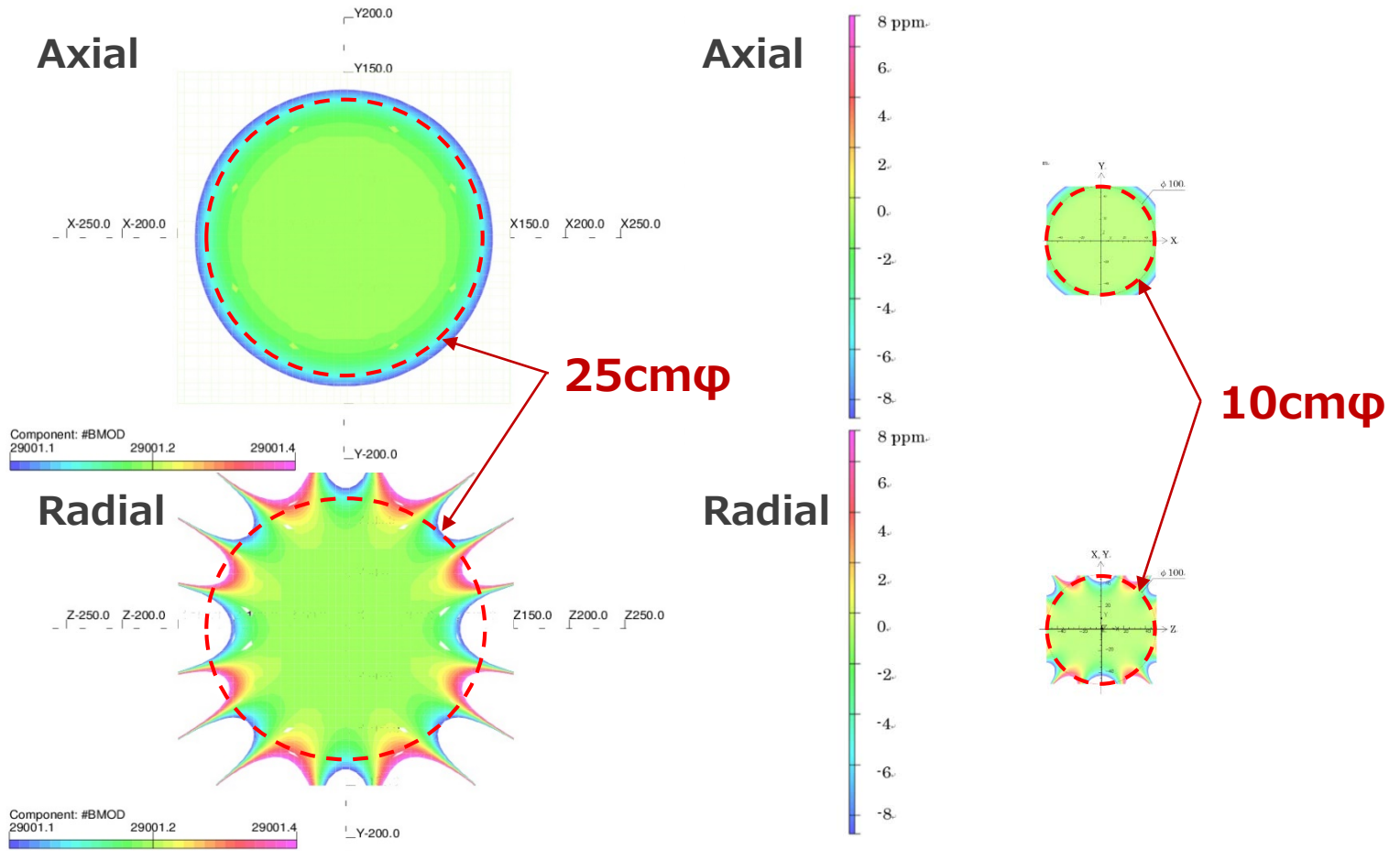
Half-scale HTS Magnet w/ active shield

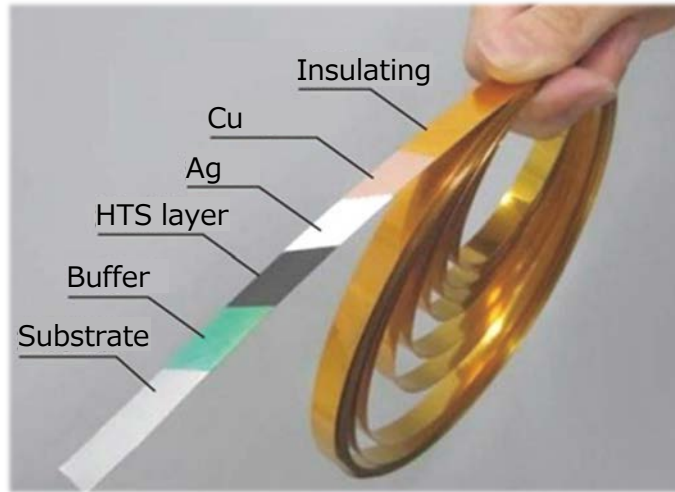


	1/2 scale	1/3 scale
Overview		
Coil number	220 SP coils	52 SP coils
Active shield	w/	w/o
Inner dia.	560 mm	320 mm
Inductance	145 H	32 H
Rated current	148 A (120 A/mm ²)	131 A (110 A/mm ²)
Bmax	4.2 T	4.3 T

	1/2 scale	1/3 scale
Target	< 10ppm (20cmDSV)	< 10ppm (10cmDSV)

Homogeneity





<http://www.fujikura.co.jp>

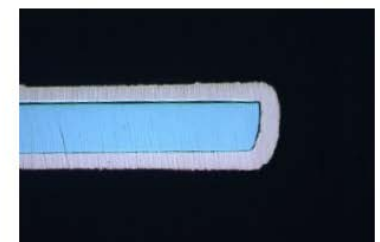
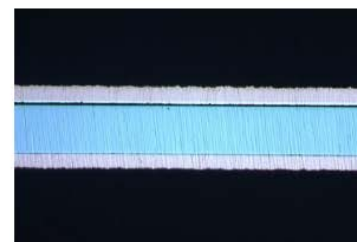
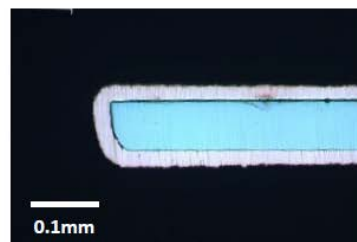
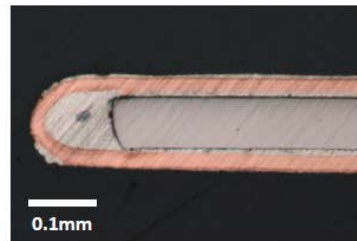
Specifications

item	value
Width	4 mm
Substrate	75 μm
Cu plating	20 μm
$I_c@77\text{K}, \text{s.f.}$	>165 A

1/3 scale
Cu forming wire

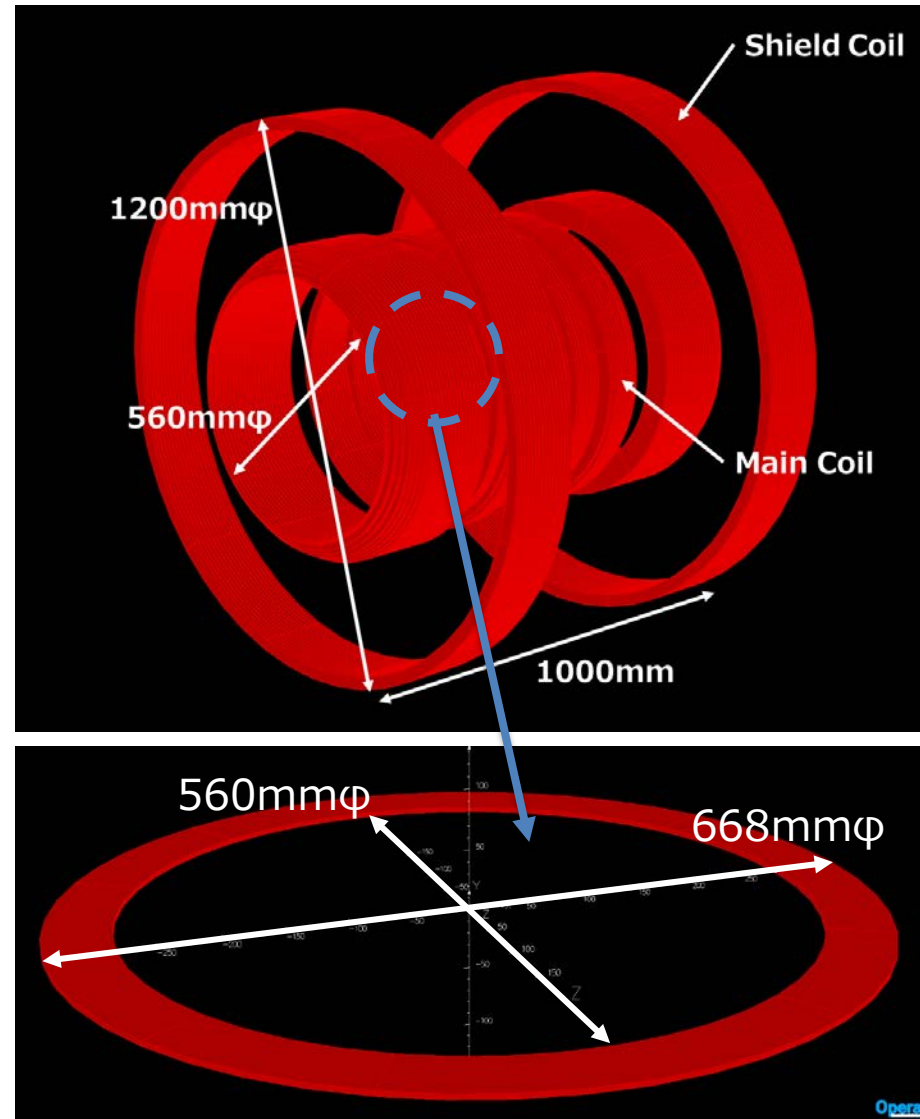


1/2 scale
Cu plating wire

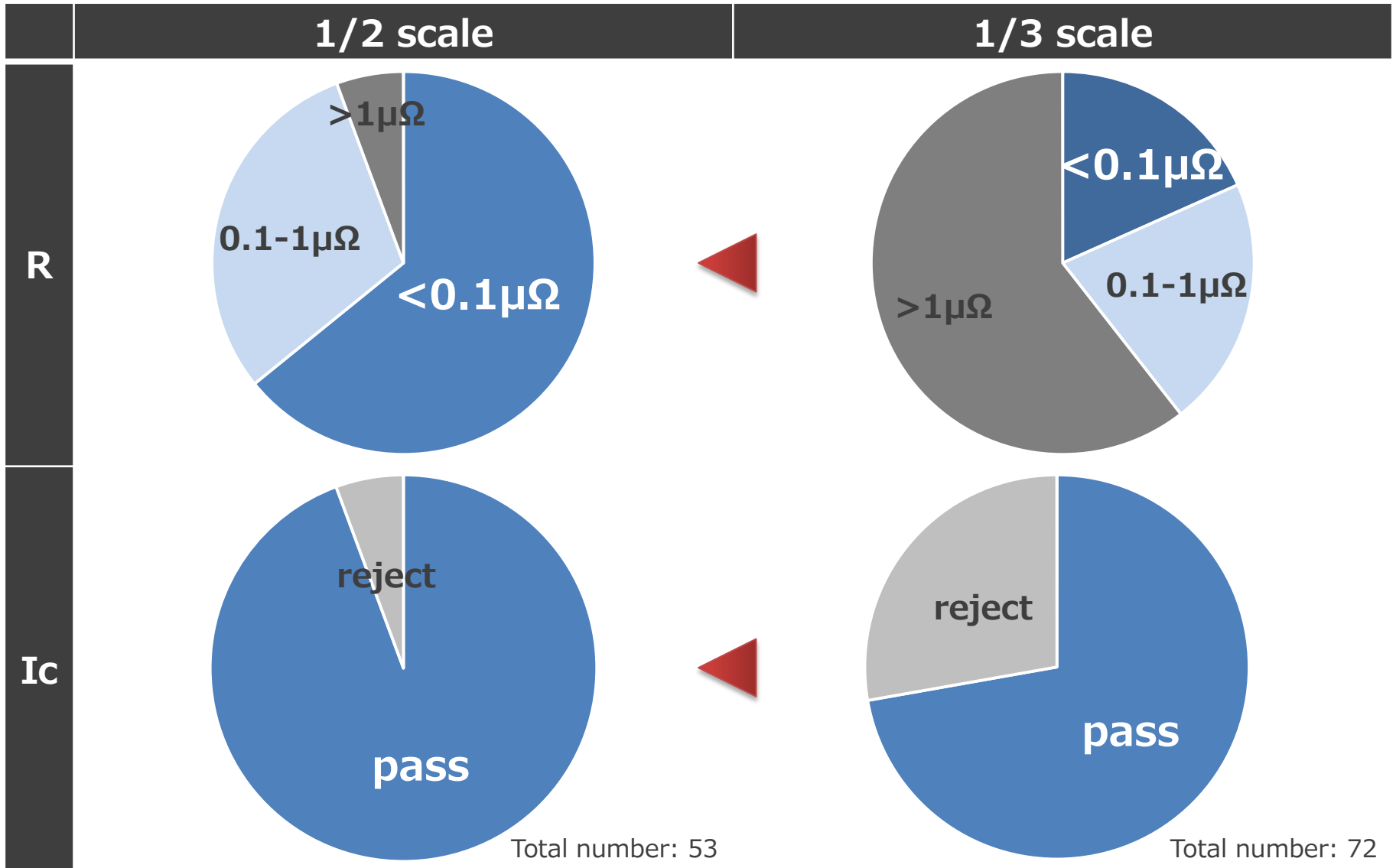


Specifications

Item	value
Inner dia.	560 mm
Outer dia.	670 mm
Height	54 mm
Turn number	200
Wire length	≒390 m



Fifty-three SP coils were manufactured

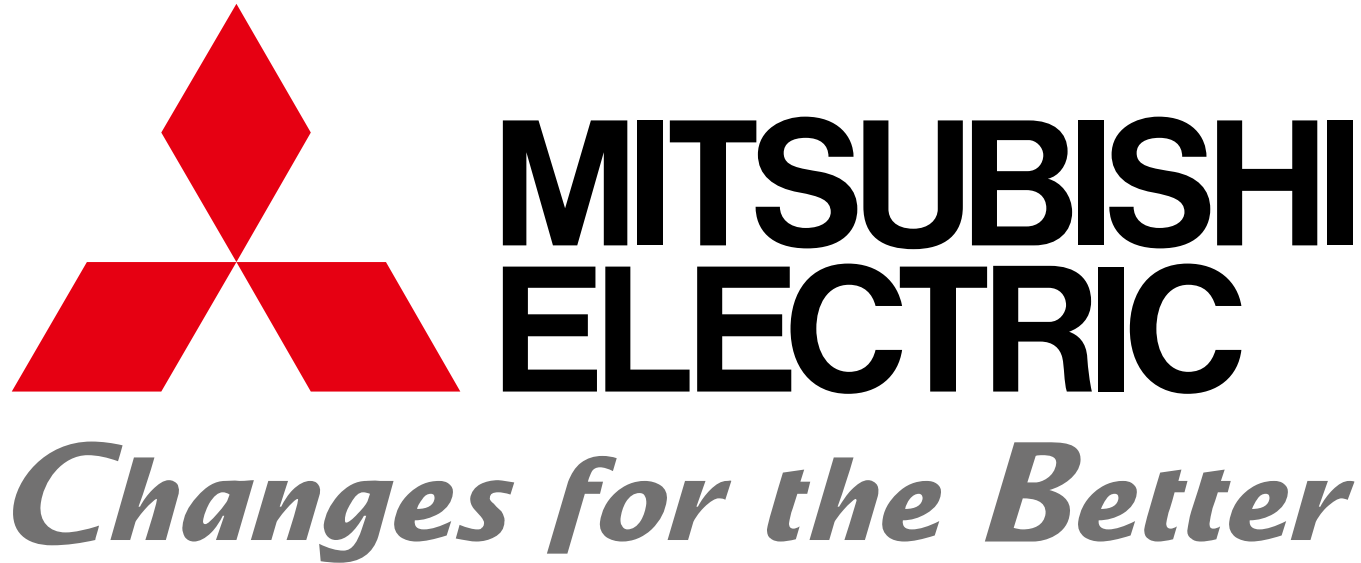


Yield rate has improved to 95%

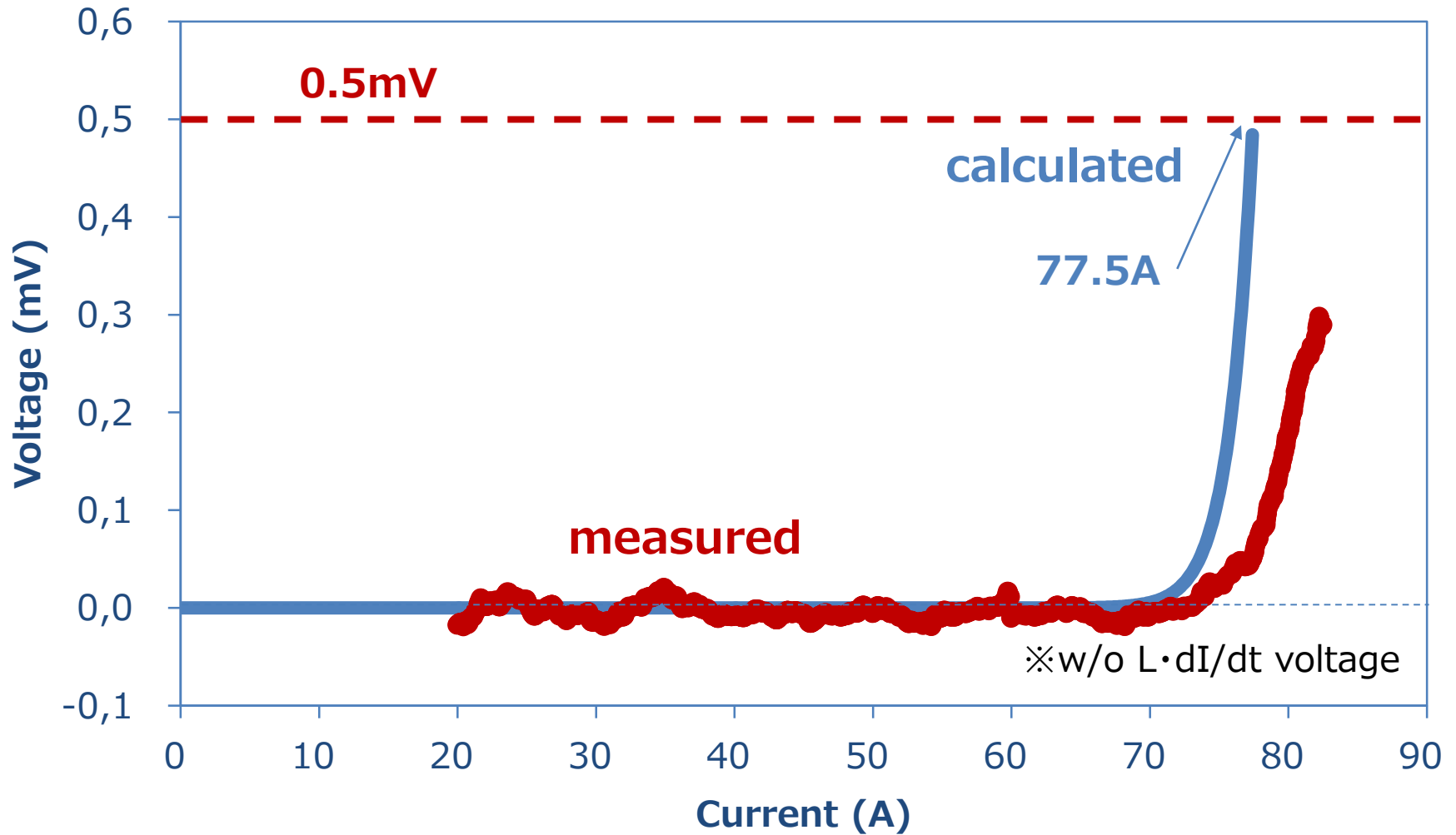
Half-scale 3-tesla HTS magnet with an active shield has been developed.

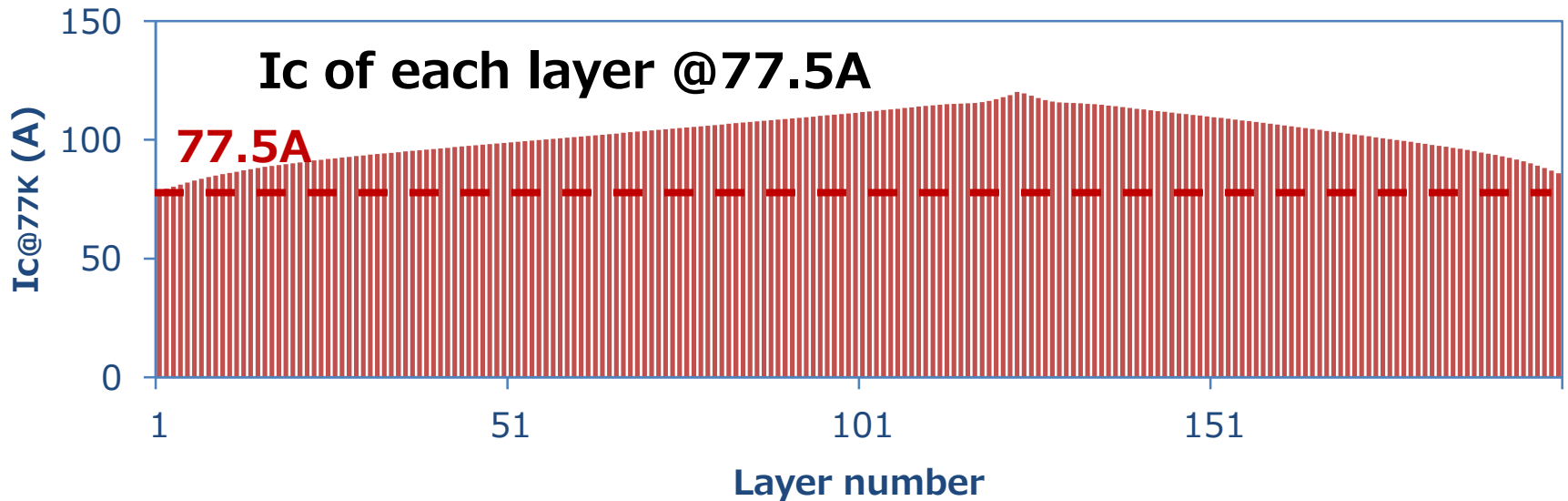
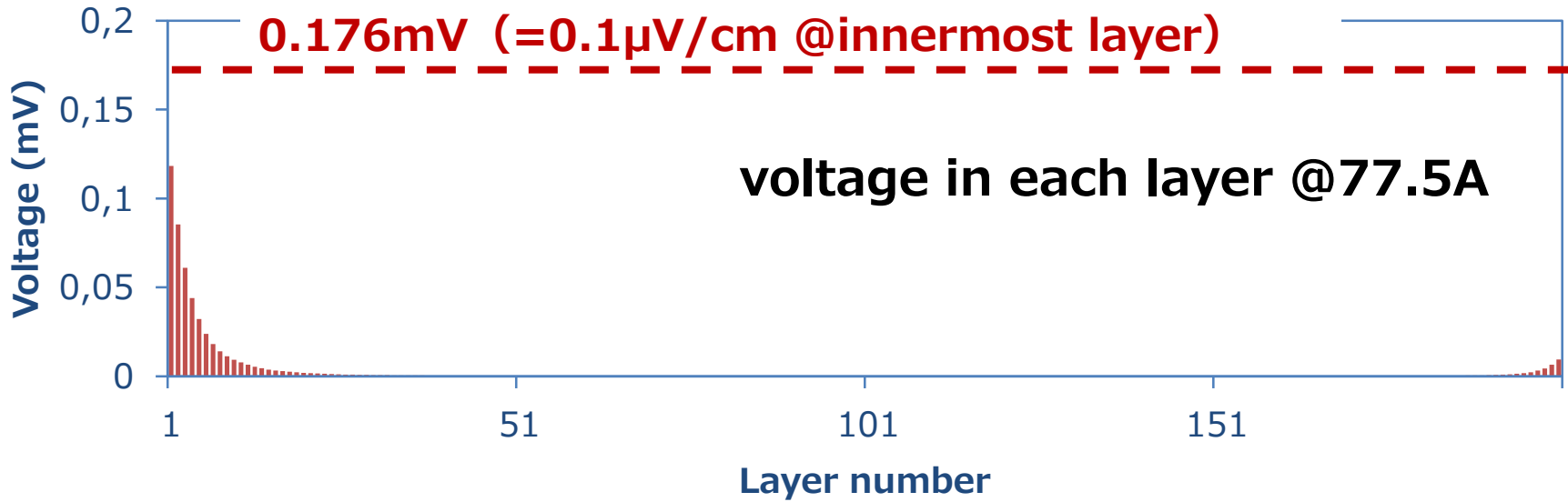
- **The coil design has been finished.** It consists of the 220 single-pancake coils with 72 km-long REBCO wire.
 - Inner diameter: 560 mm
 - Outer diameter: 1200 mm
 - Axial length: 1000 mm
 - Rated current: 148 A
 - Magnetic field homogeneity: 1.7 ppm @250 mmDSV.
- **53 single-pancake coils were manufactured in FY2016.** The electrical transport characteristics were investigated at 77.3 K, and the yield rate was about 95%.
- **The 3 T coil will be assembled and cooled in 2018,** and the MR imaging will be performed to evaluate the magnetic field uniformity and stability.

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	fruits	problems
Design	<ul style="list-style-type: none"> ● Coil design optimization ● Verification of screen current 	<ul style="list-style-type: none"> ● Design tech. for large coil ● Cooling tech. for large coil
Manufacture	<ul style="list-style-type: none"> ● Winding tech. for small coil ● Low resistance splice ● High accuracy winding 	<ul style="list-style-type: none"> ● Winding tech. for full-size coils ● Yield improvement
Protection	-	<ul style="list-style-type: none"> ● Burnout protection
Power supply	<ul style="list-style-type: none"> ● High stable power supply 	<ul style="list-style-type: none"> ● Low-cost practical system
Cost reduction	-	<ul style="list-style-type: none"> ● System cost reduction ● Optimization of temp. & current
Imaging	<ul style="list-style-type: none"> ● Small space 	<ul style="list-style-type: none"> ● Large space
High-stable field	<ul style="list-style-type: none"> ● < 1ppm/h (w/ overshoot method) 	<ul style="list-style-type: none"> ● < 0.1ppm/h ● Superconducting splice tech.





0.5mV@80A is defined as threshold