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TYL-FJPPL: A_RD_07

Suppression of magnetic flux trapping to achieve high-Q of SRF cavities

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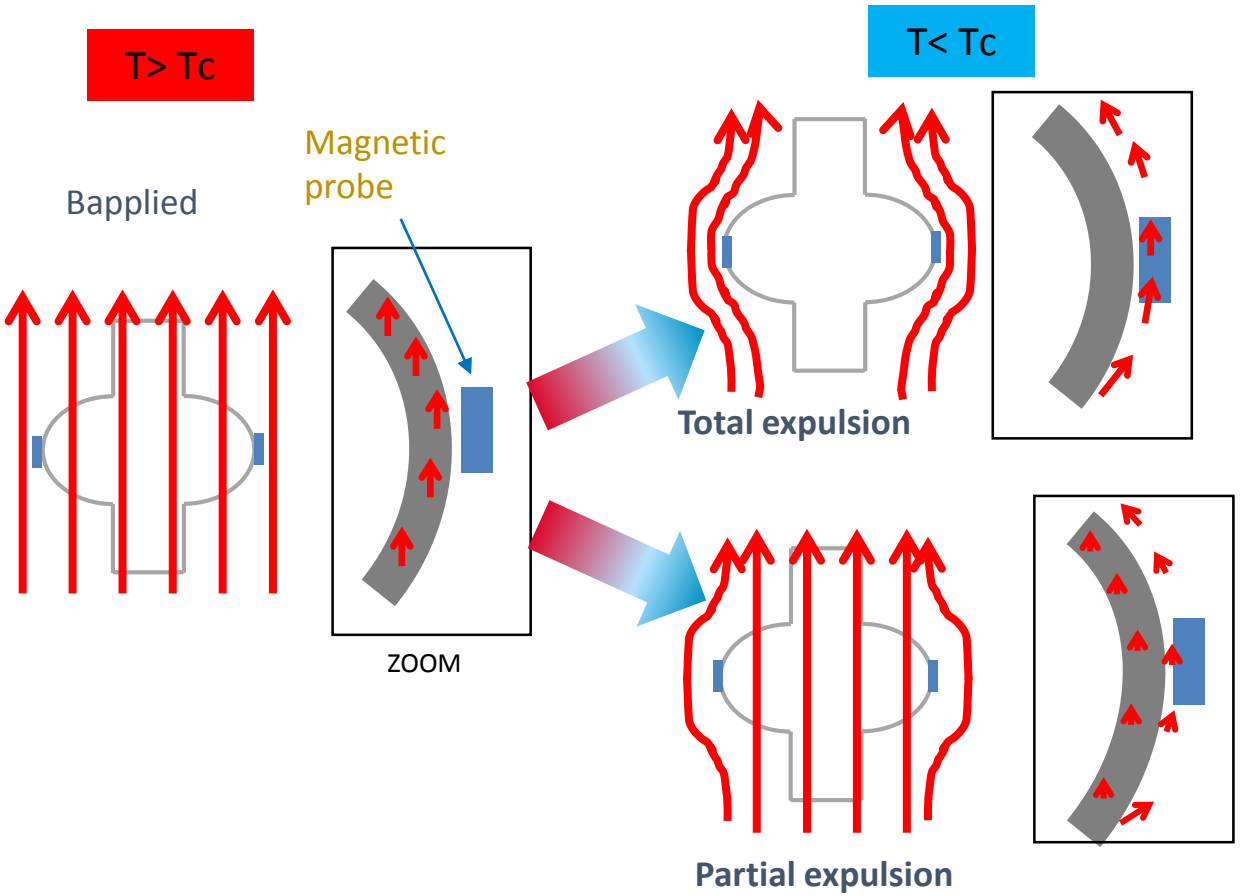
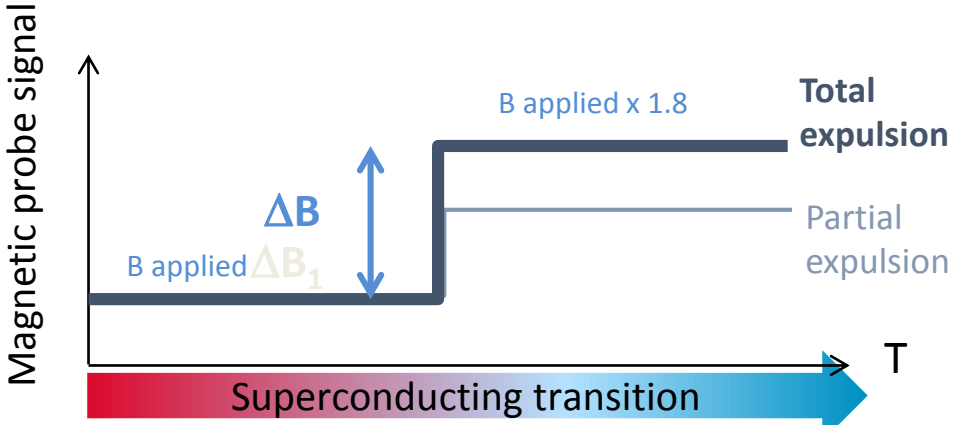
Flux trapping



During supraconducting transition of a niobium cavity, some of the ambient magnetic field is trapped

⇨ Surface resistance is improved ☹

⇨ degradation of the Q_0



Objective : limit flux trapping

- ✓ Reduce ambient field
- ✓ Improve flux expulsion during transition

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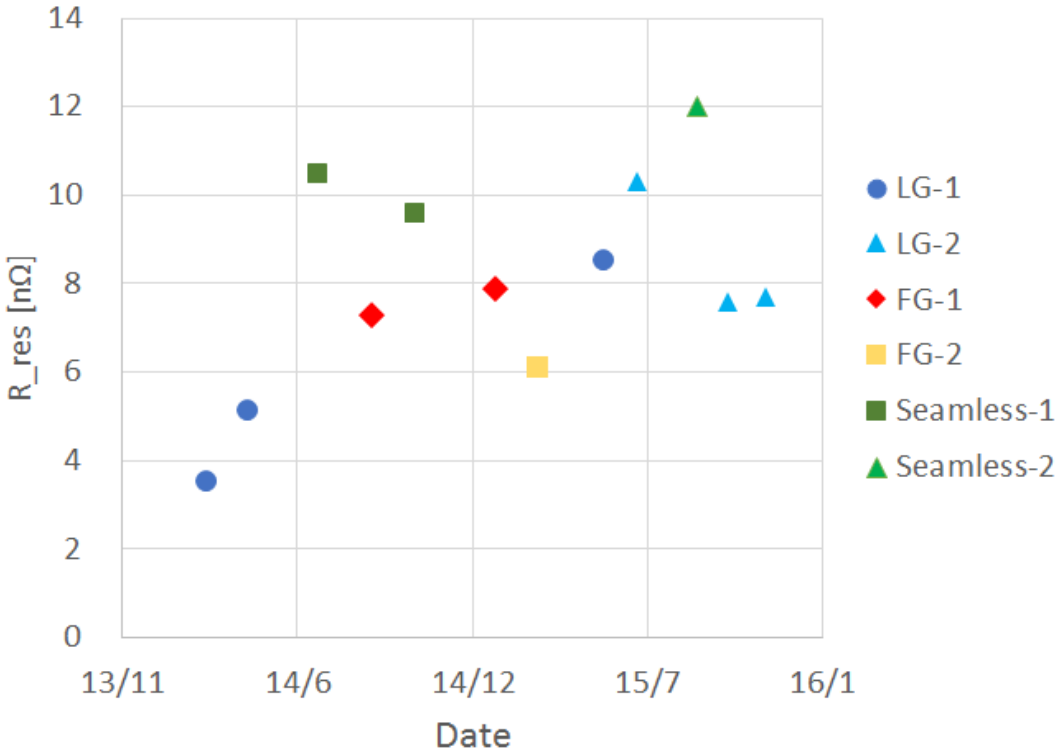
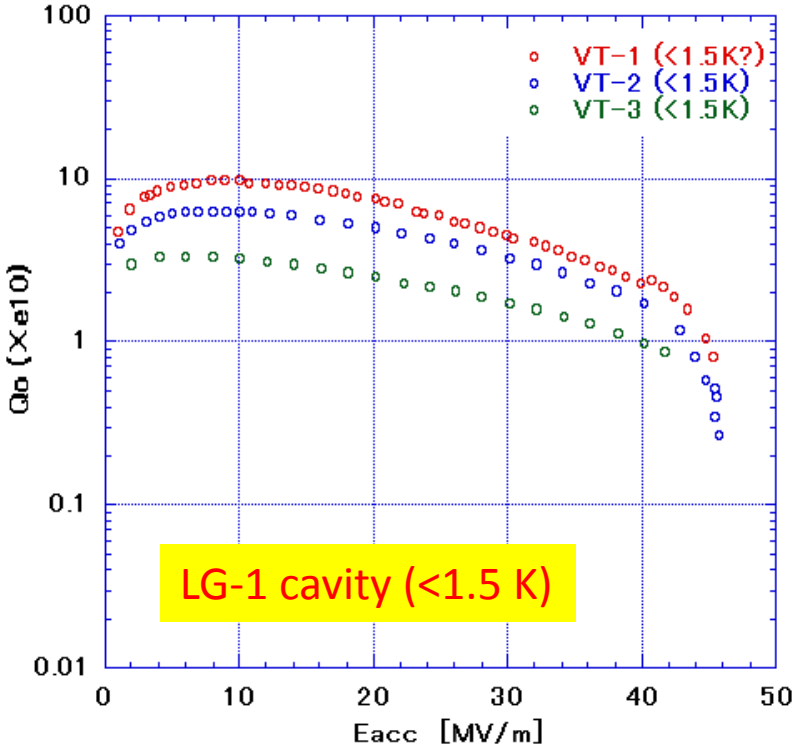
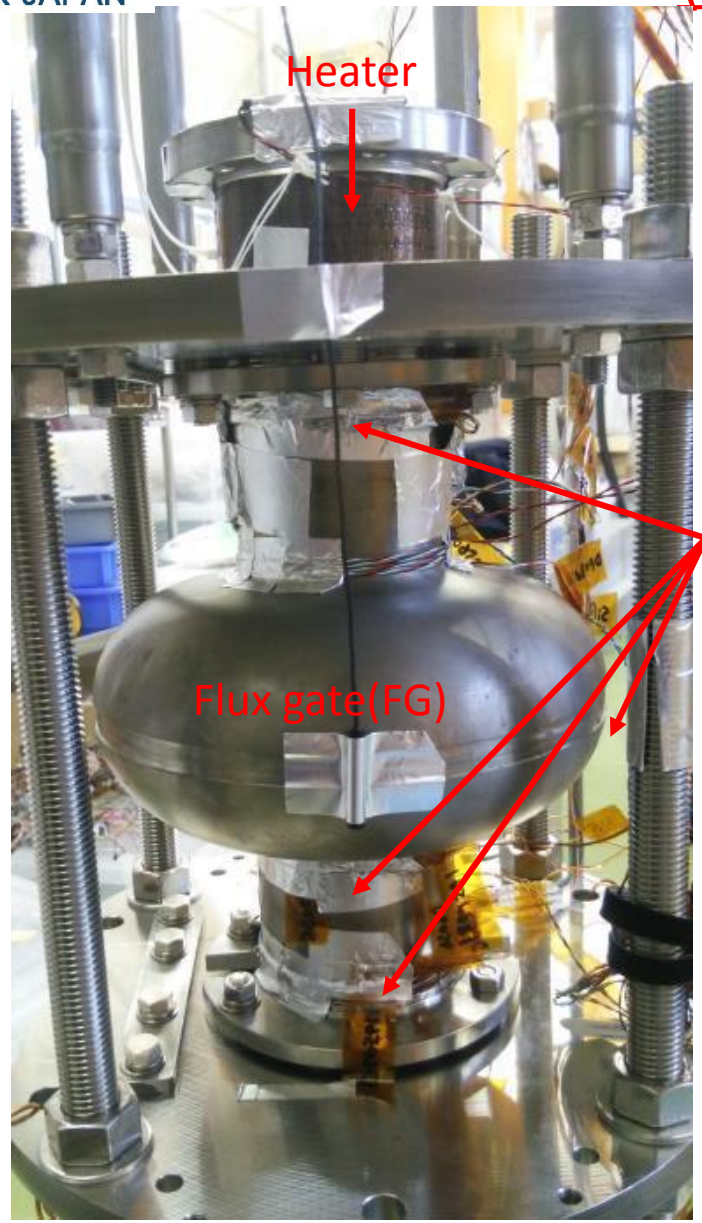
Residual resistance history of single-cell cavity vertical tests

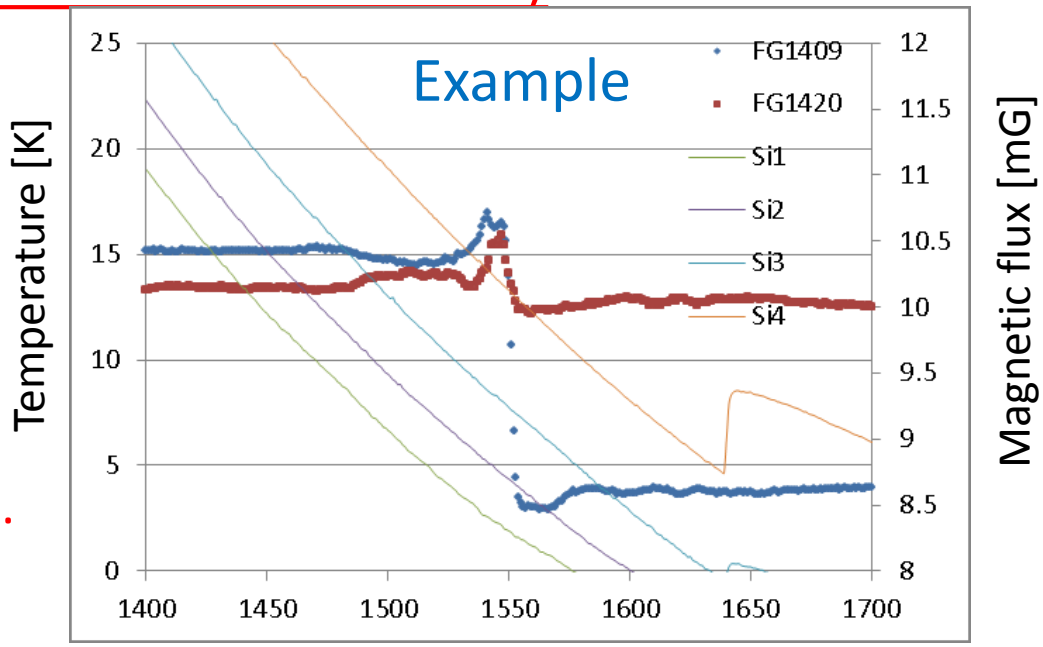




- R_res gradually increase?
- Q-values of large grain (LG) cavity were gradually decrease.

First stage of flux expulsion experiments at KEK-STF (2016/March ~ June)





- Some strange behaviors were observed during flux expulsion experiments.
  - Asymmetric magnetic field
  - Negative expulsion(?)
  - Significant horizontal magnetic field

E. Cenni & J. Plouin (CEA) participated to those tests in March 2017, in the frame of FJPPL

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Degradation of R_res?
Strange magnetic flux behavior?

Check magnetization for most of all the components of vertical test

Study on magnetized components (example)

No.	name	Magnetic field [mG]
14	Φ034 metal valve ①	430
15	Φ034 metal valve (which observed vacuum leak)	80
19	Φ034 metal valve ②	59
25	Volts and washers for support of input coupler shaft	140
28	Nuts and washers for hanging cavity	110
29	Stat-volts, nuts and washers for hanging cavity	300

Measure inside magnetic shield by using 3-axis flux gate sensor.

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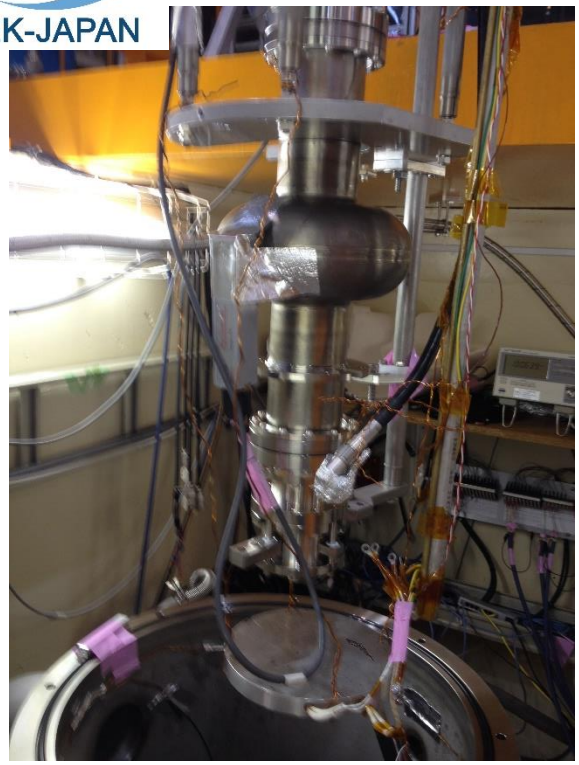
Effects of SUS shafts



SUS shafts for variable coupler were highly magnetized.
More than 1 G!!

Magnetic field with shafts inside vertical test dewar

Angle	Bx [mG]	By[mG]	Bz[mG]	B[mG]
0	-7	-11	-6	15
90	-6	2	-9	11
180	6	-11	-7	15
270	8	130	-49	139

If both shafts were removed
B ≦ 2mG for any positions.

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Then…

- Exchange SUS shafts to Ti
- Exchange or remove SUS components as much as possible
- Exchange metal valve to less magnetized one

And vertical tests were carried out.

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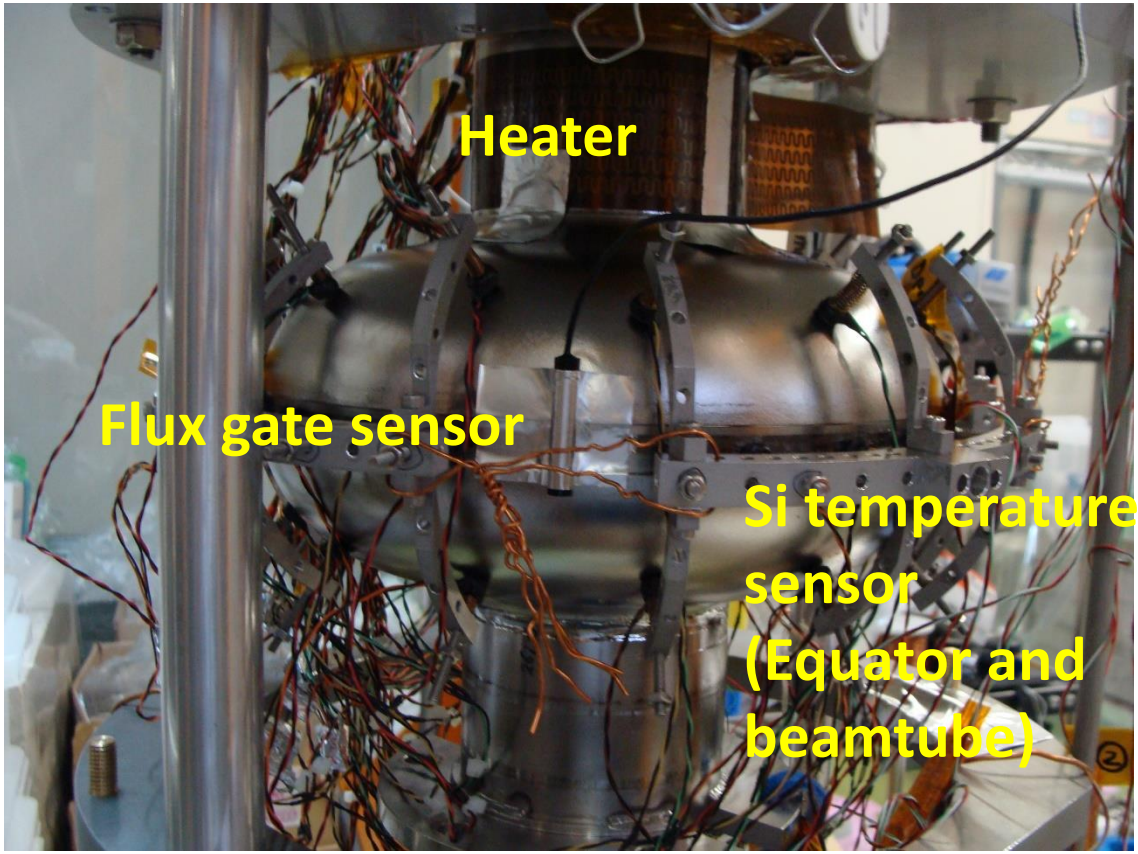
Vertical test setup



Flux gate sensor, Si temperature sensor, heater and solenoid coil were used.

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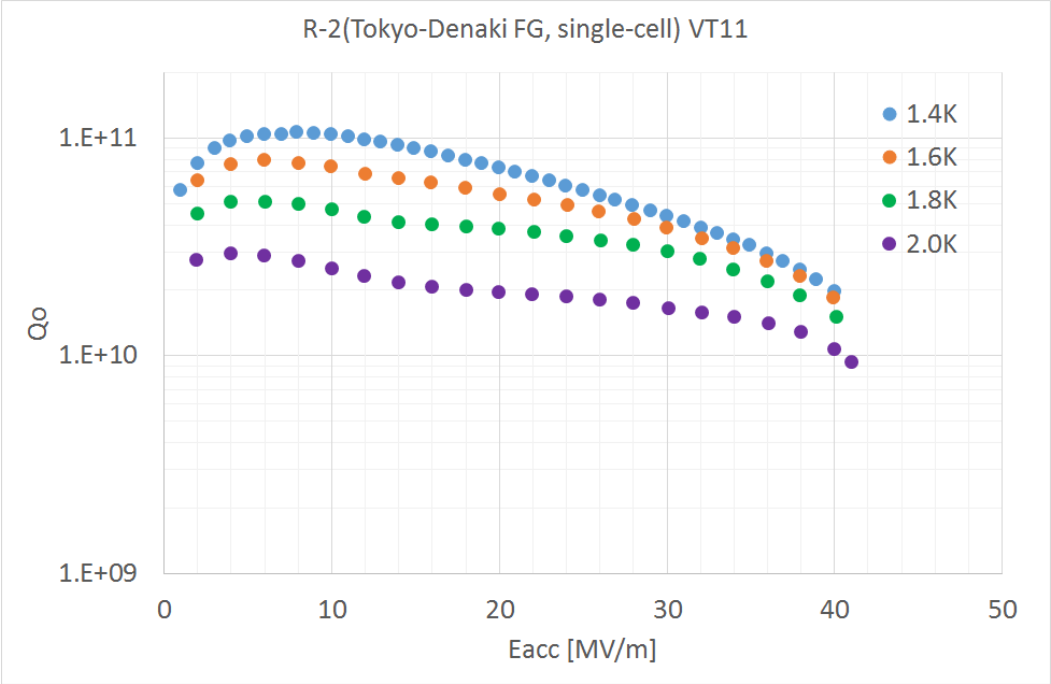
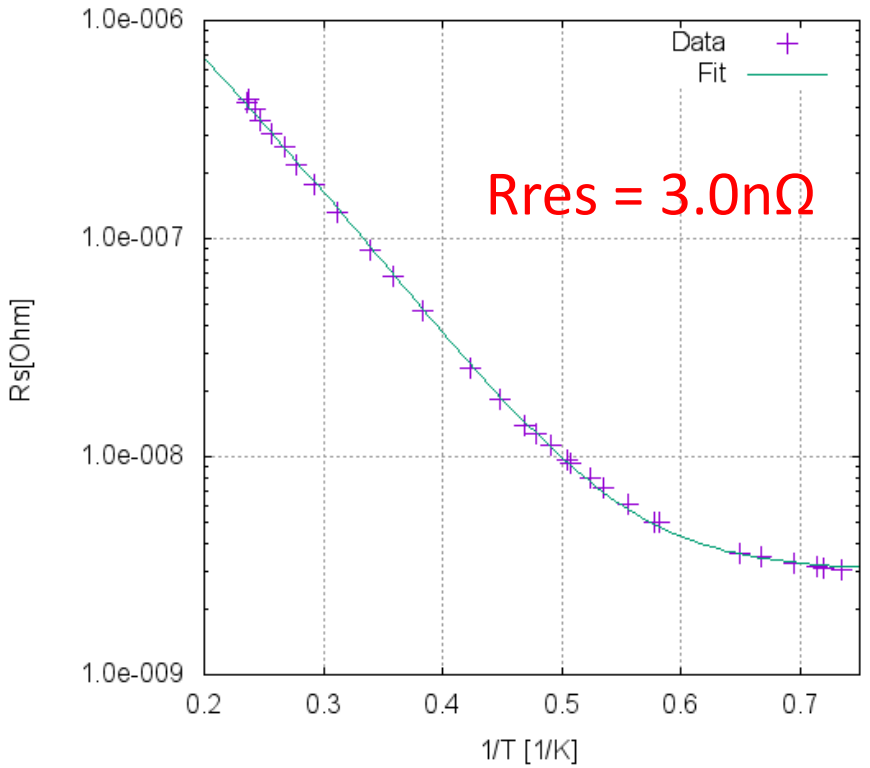
Vertical test results





- FG single-cell cavity (Tokyo-Denkai)
- Nominal recipe (Not N-doping)
- With cancelling coil
- With thermal gradient by heater

Very high-Q was observed after the effort for demagnetization

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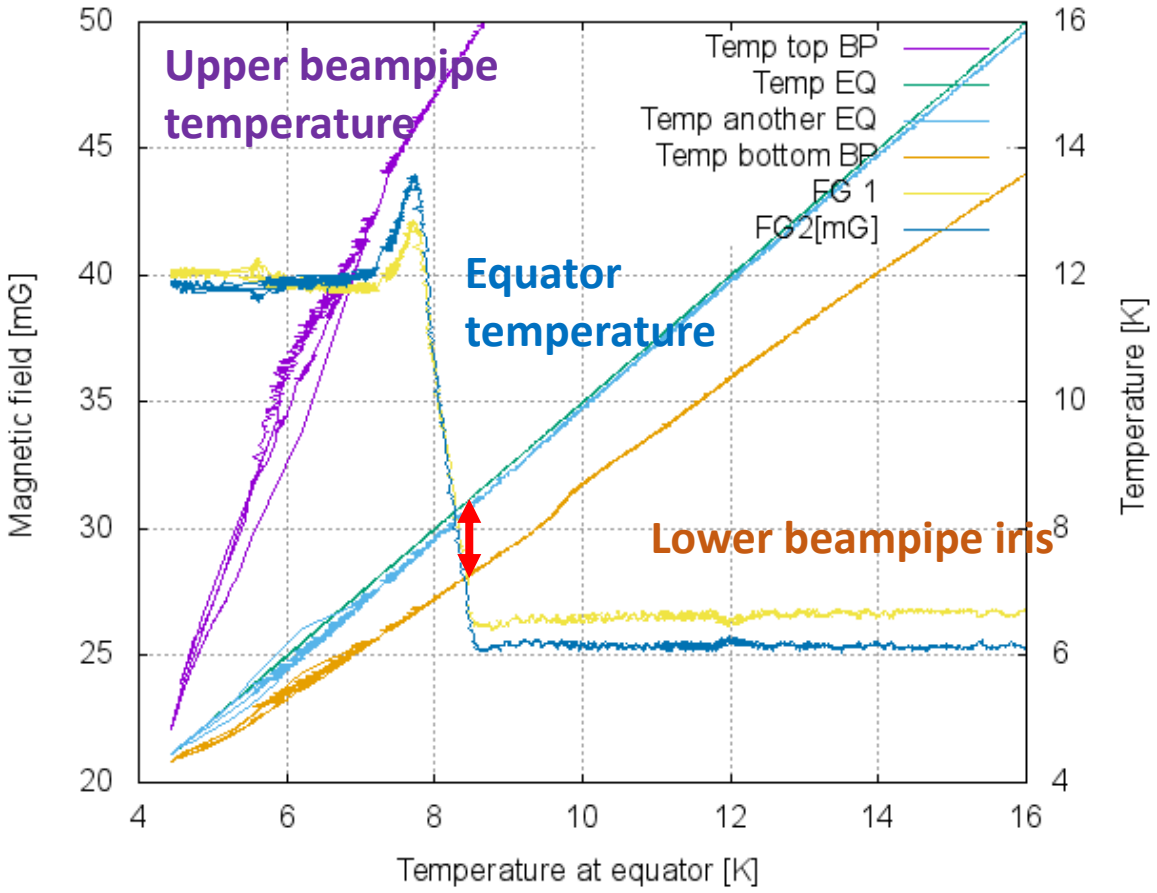
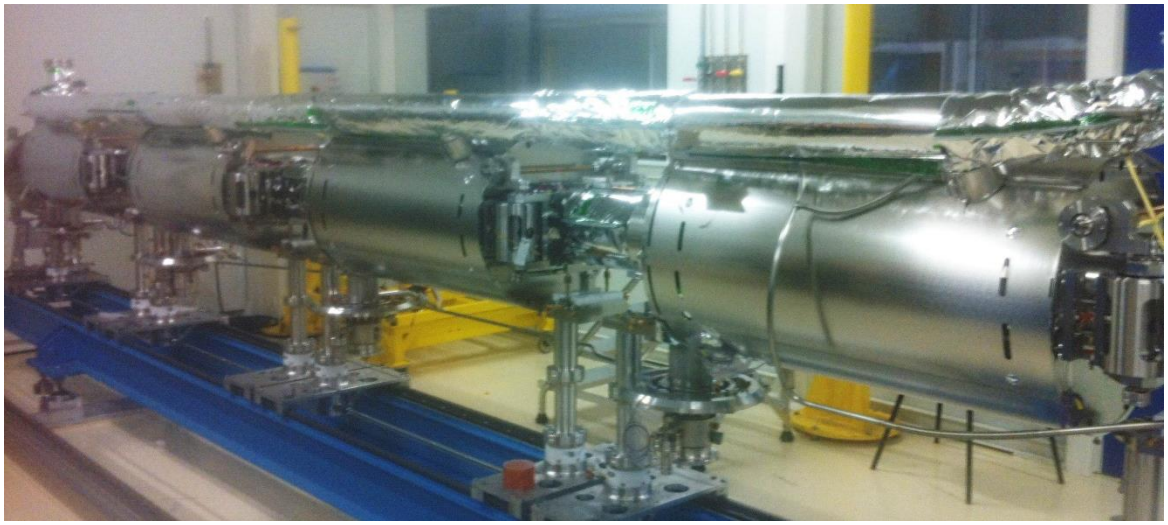
Flux expulsion during cool-down(add 16mG with coil)



- FG single-cell cavity (ULVAC)
- Nominal recipe (Not N-doping)
- 900 degree heat treatment applied
- Add +16mG with coil (Total 9 + 16 = 25mG)
- With thermal gradient by heater

- Clear flux expulsion(~90%) can be observed.
- Temperature gradient of more than 1 degree between equator and lower beampipe iris.

Magnetic shields characterization : ESS



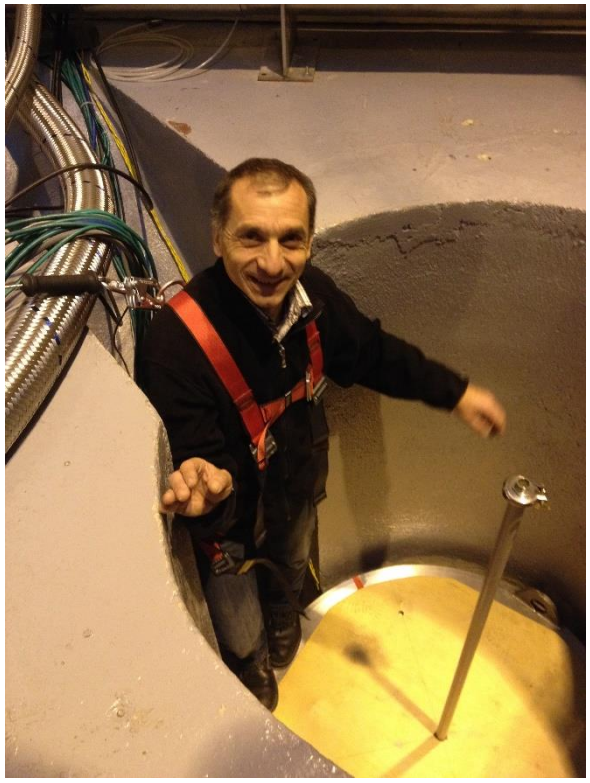
ESS magnetic shield
Cryophy, 2 mm
Diam 0,5 m, L = 1 m
B_{inside} < 0,5 µT
(meas. at room temperature,
meas. in LHe are foreseen)

Magnetic shields characterization : IFMIF

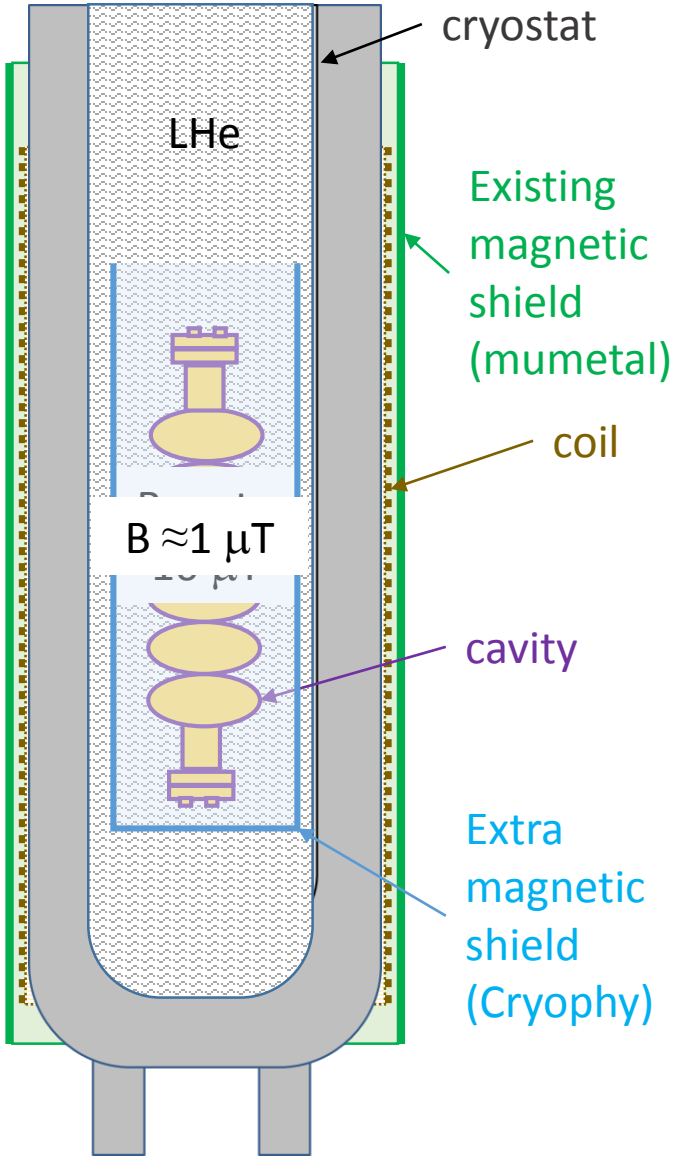
IFMIFmagnetic shield
mumetal, 2 mm
l~2 m, L = 6 m
Binside < 0,5 μT
(meas. at room temperature)

IFMIF samples
mumetal, 2 mm
Diam 0,15 m, L = 0,6 m
Binside < 0,05 μT

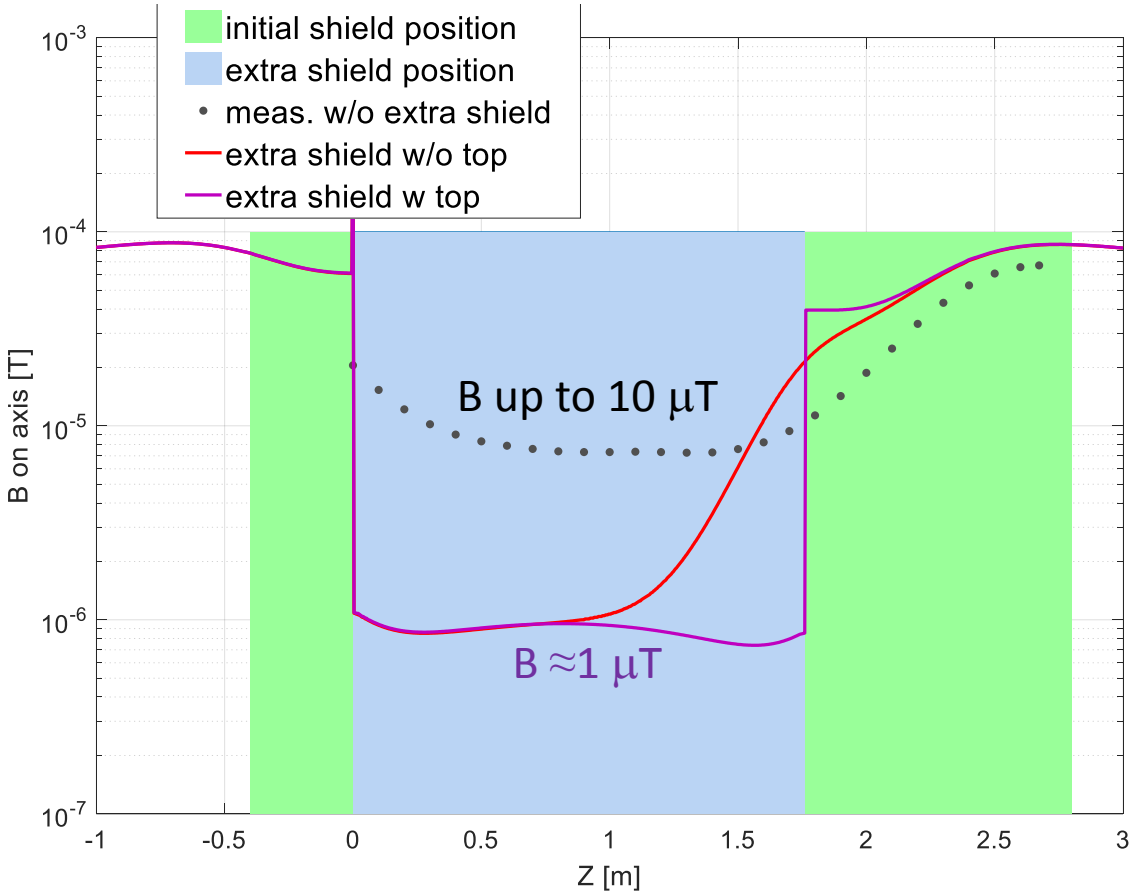
Improvement of the magnetic shield of Vertical Cryostat CV2

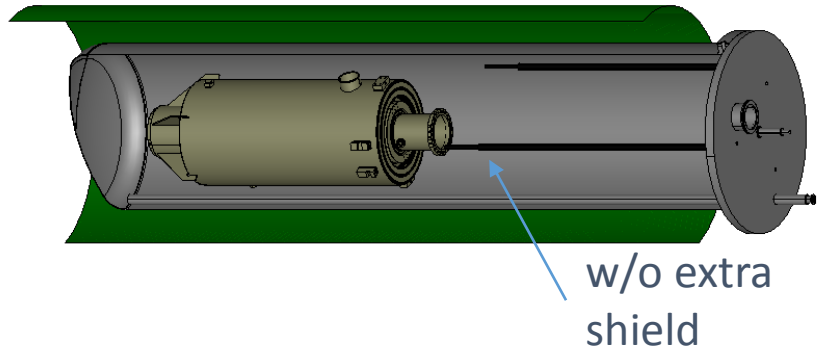


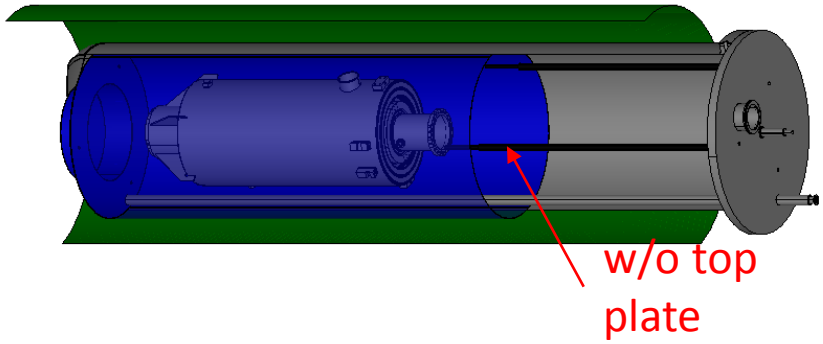
Measurement of B field inside the cryostat

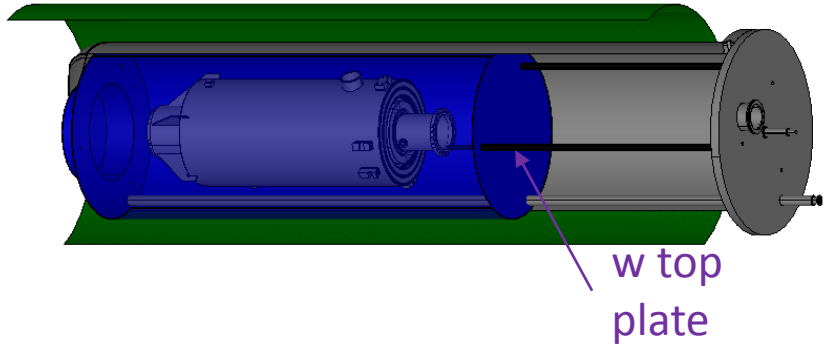


Design of the extra magnetic shield







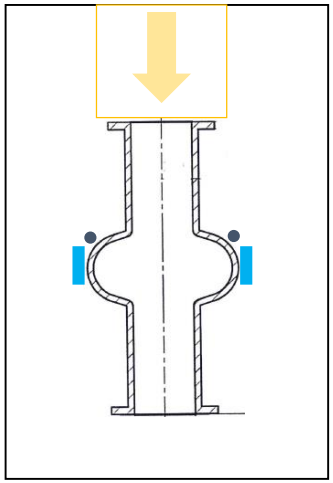


Fabrication of this new magnetic shield is planned during 2017

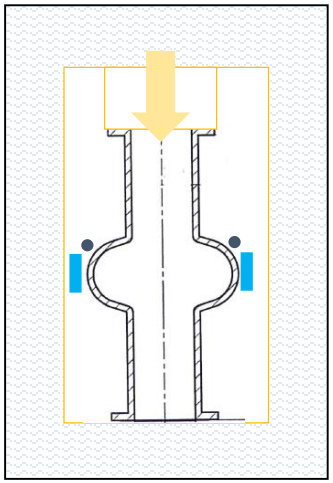
Flux expulsion during cool-down on 6 GHz cavity

Flux expulsion tests planned at Saclay

Monitoring of magnetic field and temperature



- cernox
- fluxgate

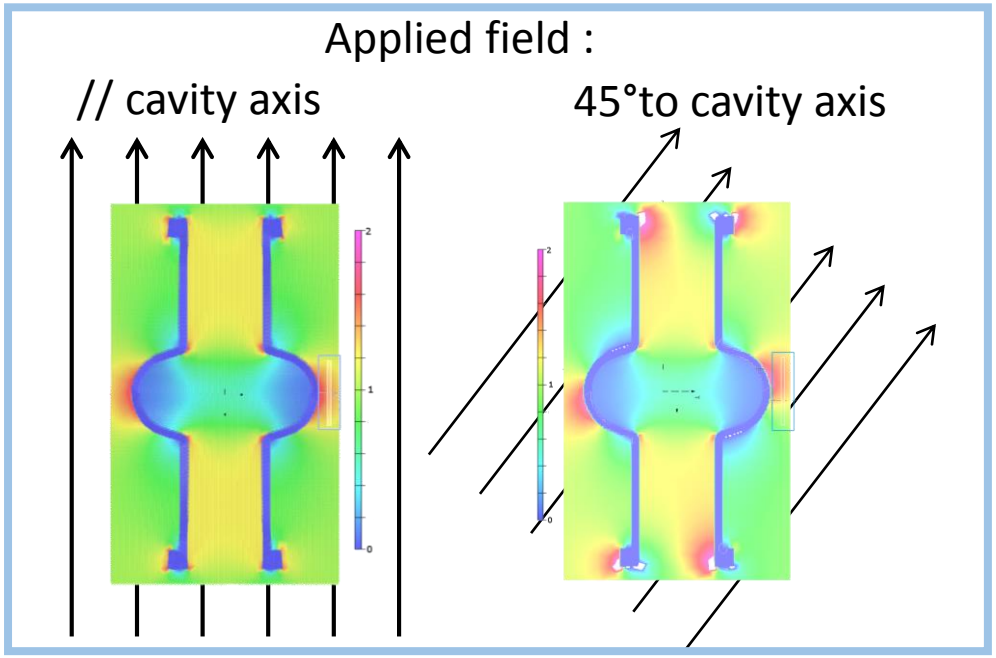


Cryocooler : better control of gradient and cooldown rate

Cryostat :cavity in a vacuum vessel placed in a cryostat

We have received a 6 GHz cavity (bulk Nb)

Flux expulsion calculation



Summary

At KEK

Effort has been achieved to eliminate magnetized elements in the vertical test cryostat

- ⇨ High Q could be measured on a cavity
- ⇨ Clear flux expulsion signal could be observed

At CEA

New magnetic shields have been designed, fabricated and tested

- ⇨ field around cavities < 0.5 μT

Improvement of the magnetic shield of the vertical test cryostat is planned

Flux expulsion on 6 GHz cavity is foreseen

KEK and CEA collaborate together within the international effort to high Q superconducting cavities