Nb3Sn development at KEK

Nb3Sn Coating & Conduction cooling

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Nb3Sn coating research

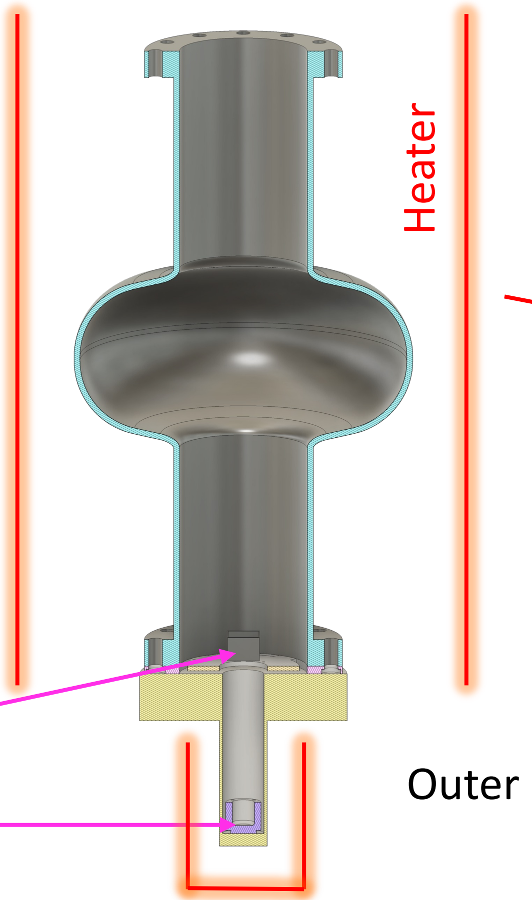
Overview

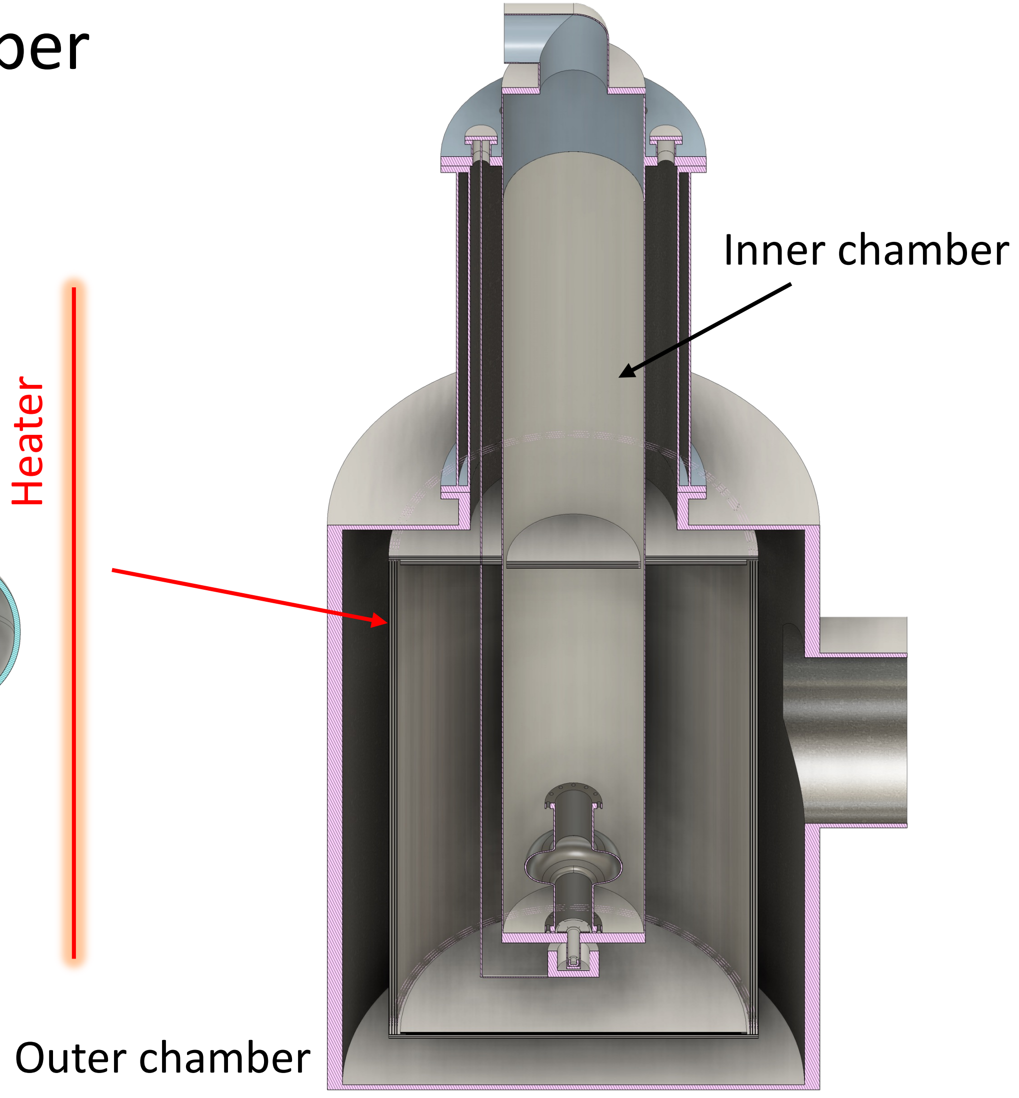
- Nb3Sn coating is regularly performed by vaper diffusion method in KEK.

- Several recent improvements and considerations:
  - ➢Clean booth at the coating area
  - ➢Coating temperature parameter
  - ➢Sn crucible shape
  - ➢Vaper pressure

- Target RF performance:

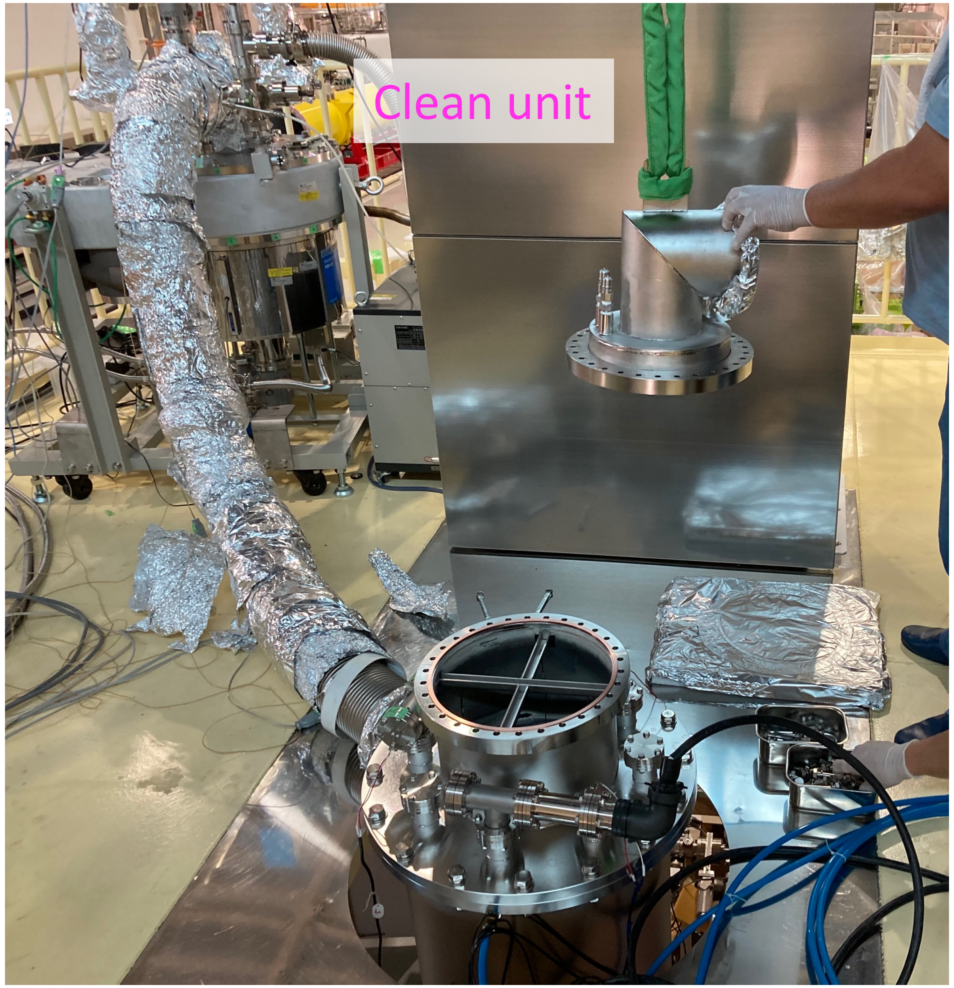
  10MV/m at 1E10 (1.3GHz)

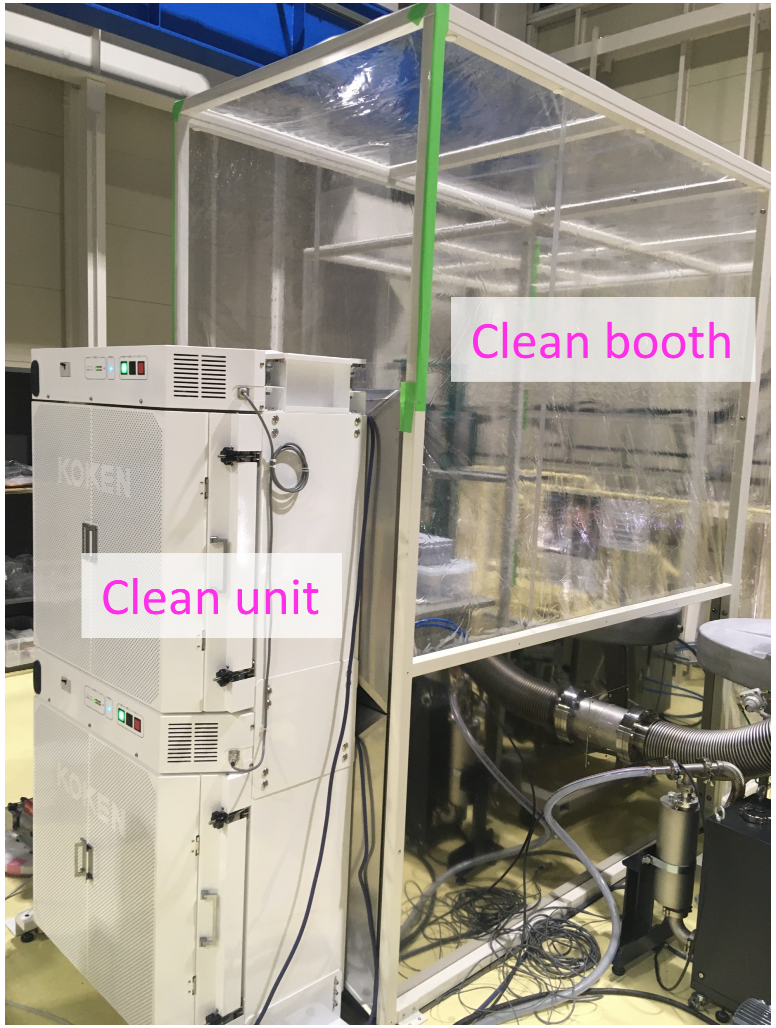




Nb_3Sn coating furnace

Clean booth



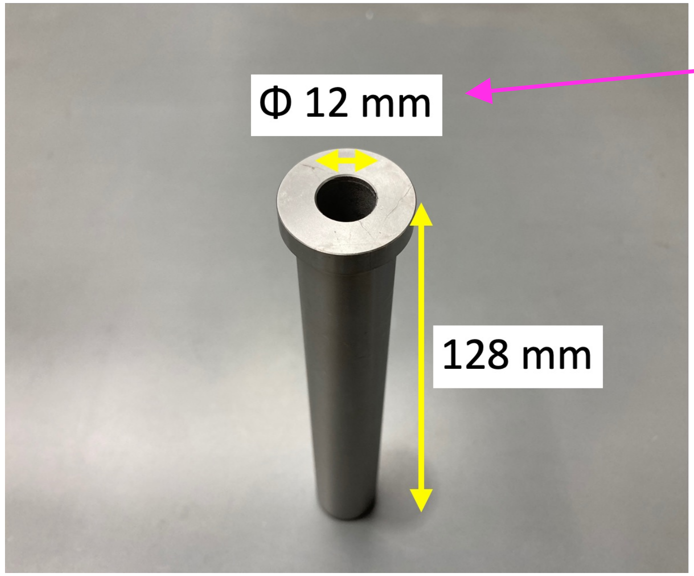


We added a clean booth in front of clean units.

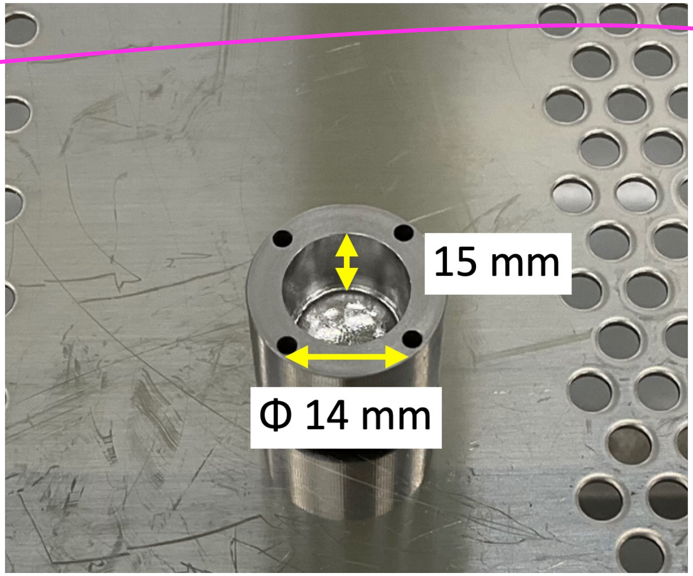
Sn crucible

- Since Sn evaporation was not sufficient in the crucible “ver1”, it was replaced with “ver2” with wider diameter and shorter height.

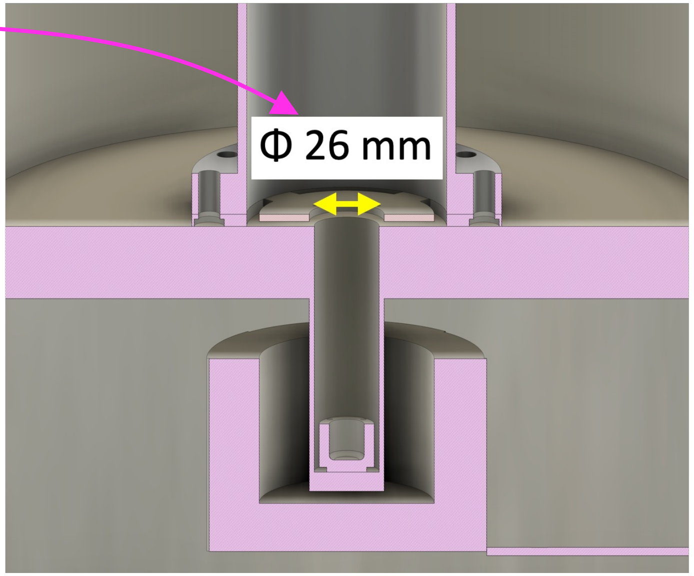
Sn crucible ver.1



Sn crucible ver.2



Effective aperture in Sn crucible ver.2



- “Ver2” has twice larger effective aperture than “ver.1”. (ϕ12 mm to ϕ26 mm)
- All Sn in the crucible can be evaporated using “ver2”. Now we can control the amount of Sn evaporation.

Vaper pressure

- Top flange was closed to increase Sn vaper pressure and prevent dusts.

1st cavity coating

2nd cavity coating

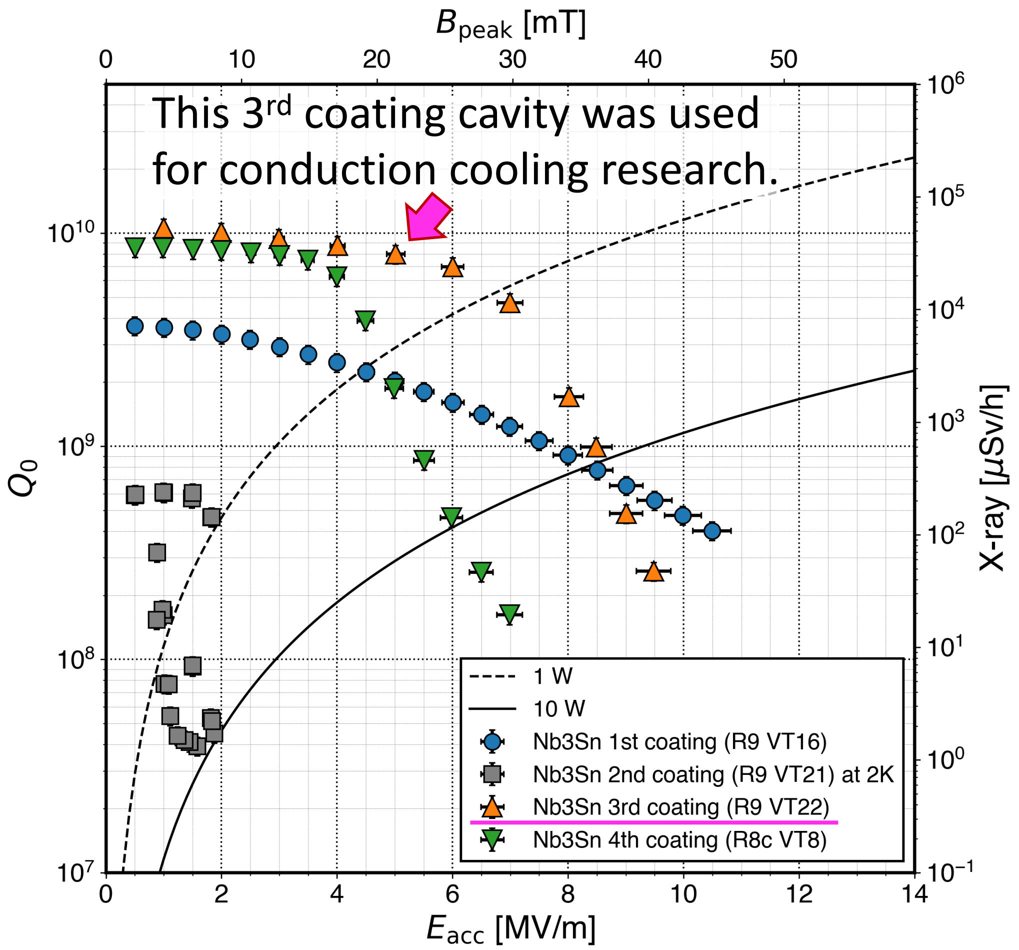
Nb foil

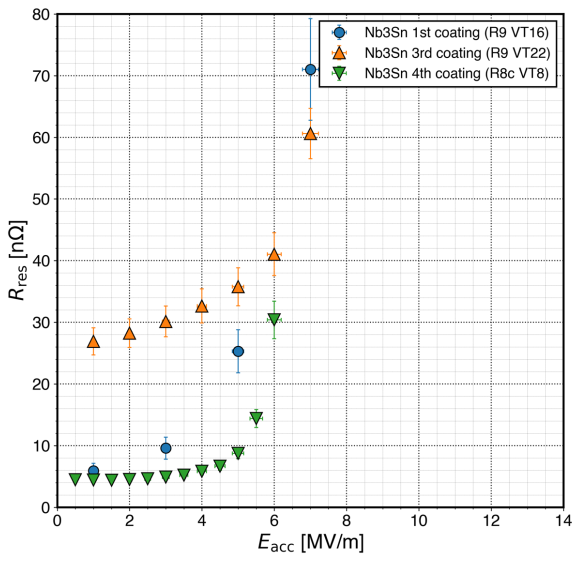
3rd cavity coating

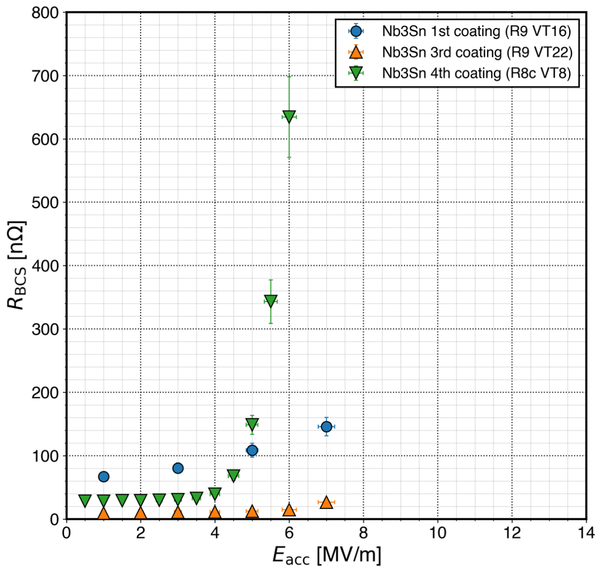
Mo plate

4th cavity coating

RF performance







In the 2nd coated cavity, the effect of the Sn droplets was so significant. 2 K measurement resulted in Q-values <10E9.

The 3rd coated cavity achieved a Q-value >1E10 at low field but the Q-value dropped strongly from 6 MV/m. In the 4th coated cavity, the behavior is similar to the 3rd coated cavity, but the Q-value dropped from 4 MV/m.

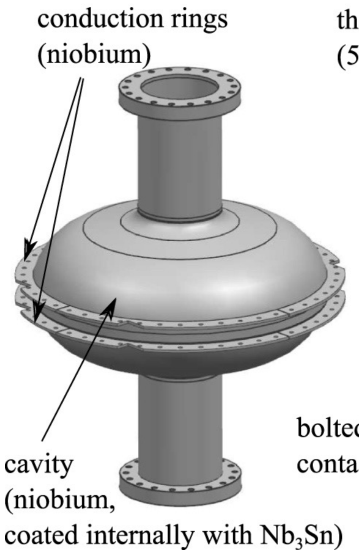
Conduction cooling research

Cavity conduction cooling strategy

- KEK method is the copper clamping surrounding cavity equator region.

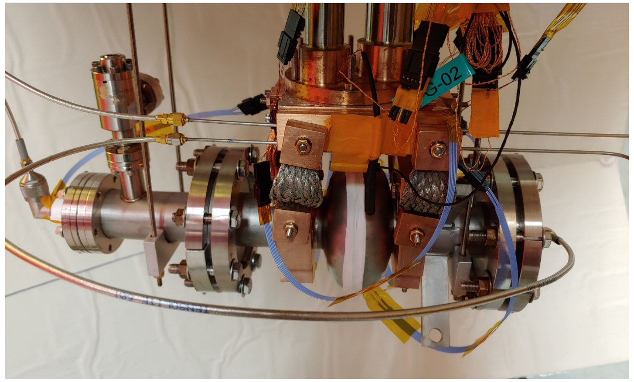
Reasons:

- Cooling wide area of equator outside
- Detachable system for Nb3Sn re-coating
- (Short time implementation because of GM-JT rental period)



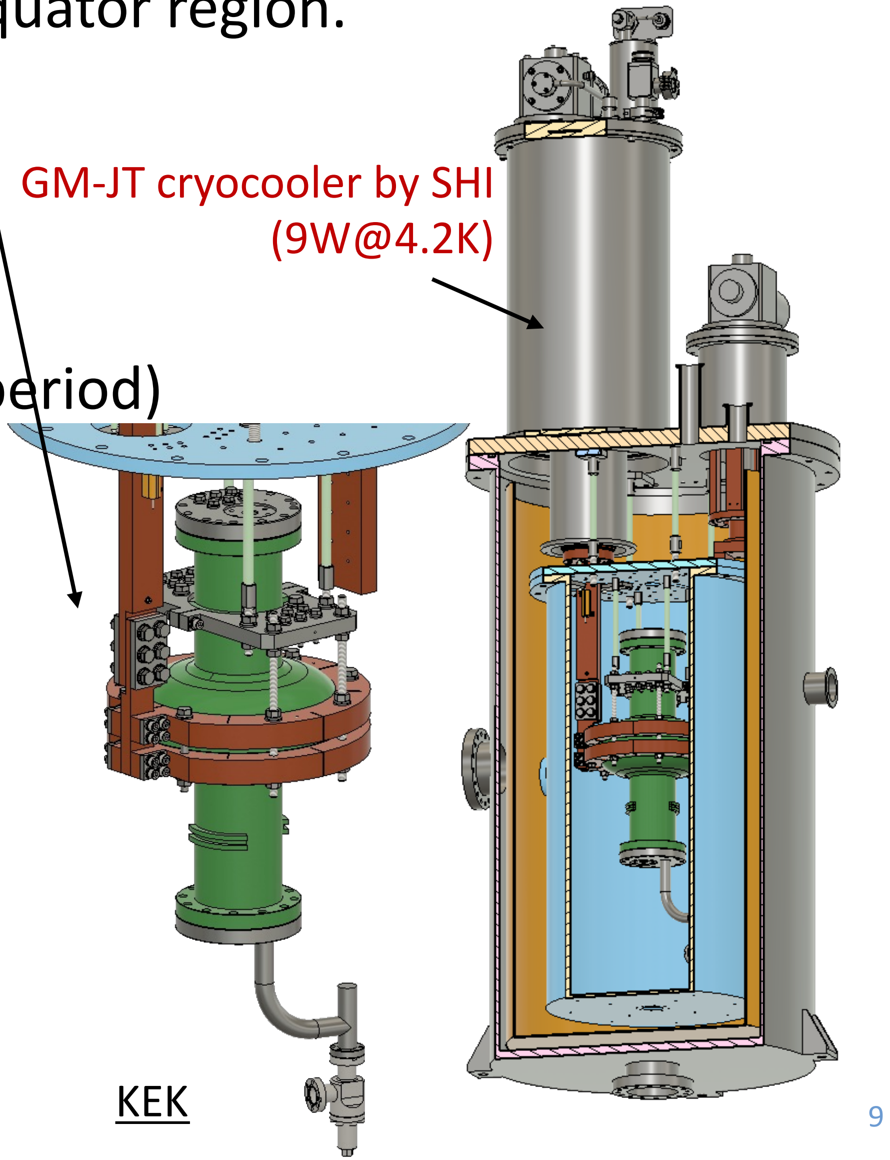
Fermi Lab

Jefferson Lab



Cornell Univ.

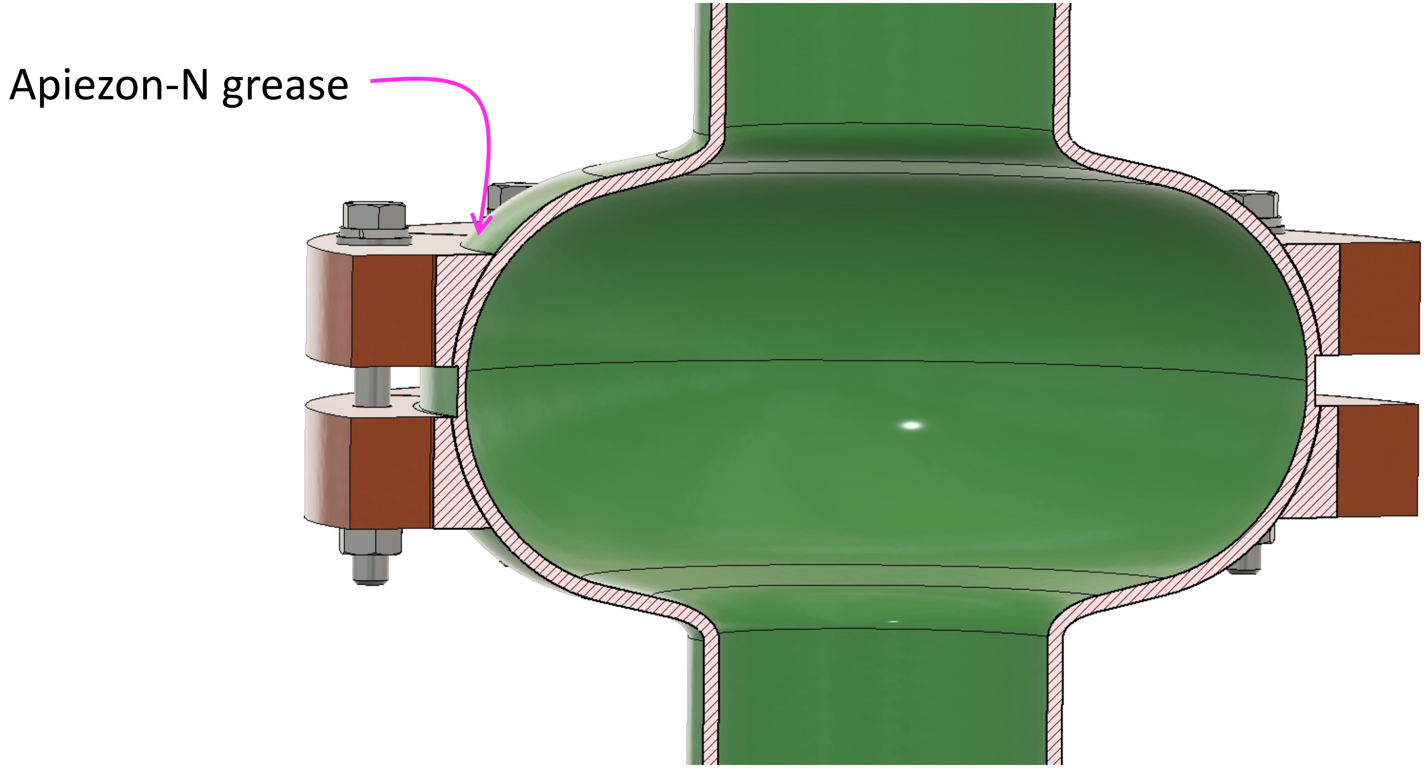
GM-JT cryocooler by SHI
(9W@4.2K)

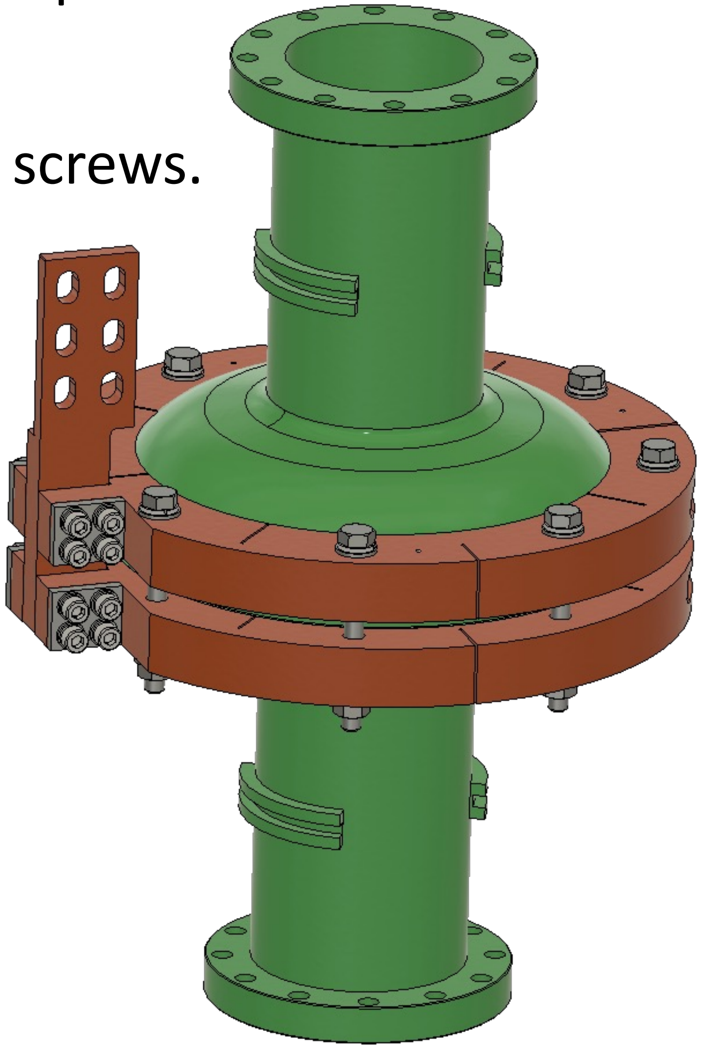


KEK

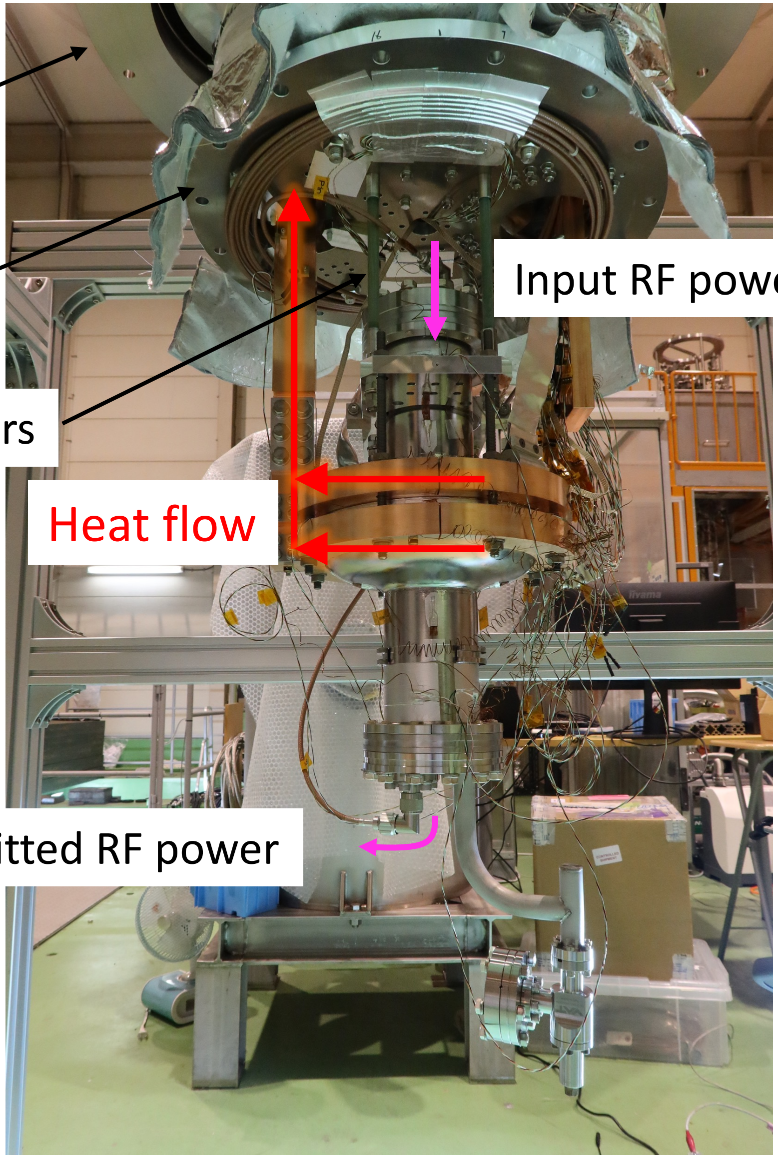
Copper jigs

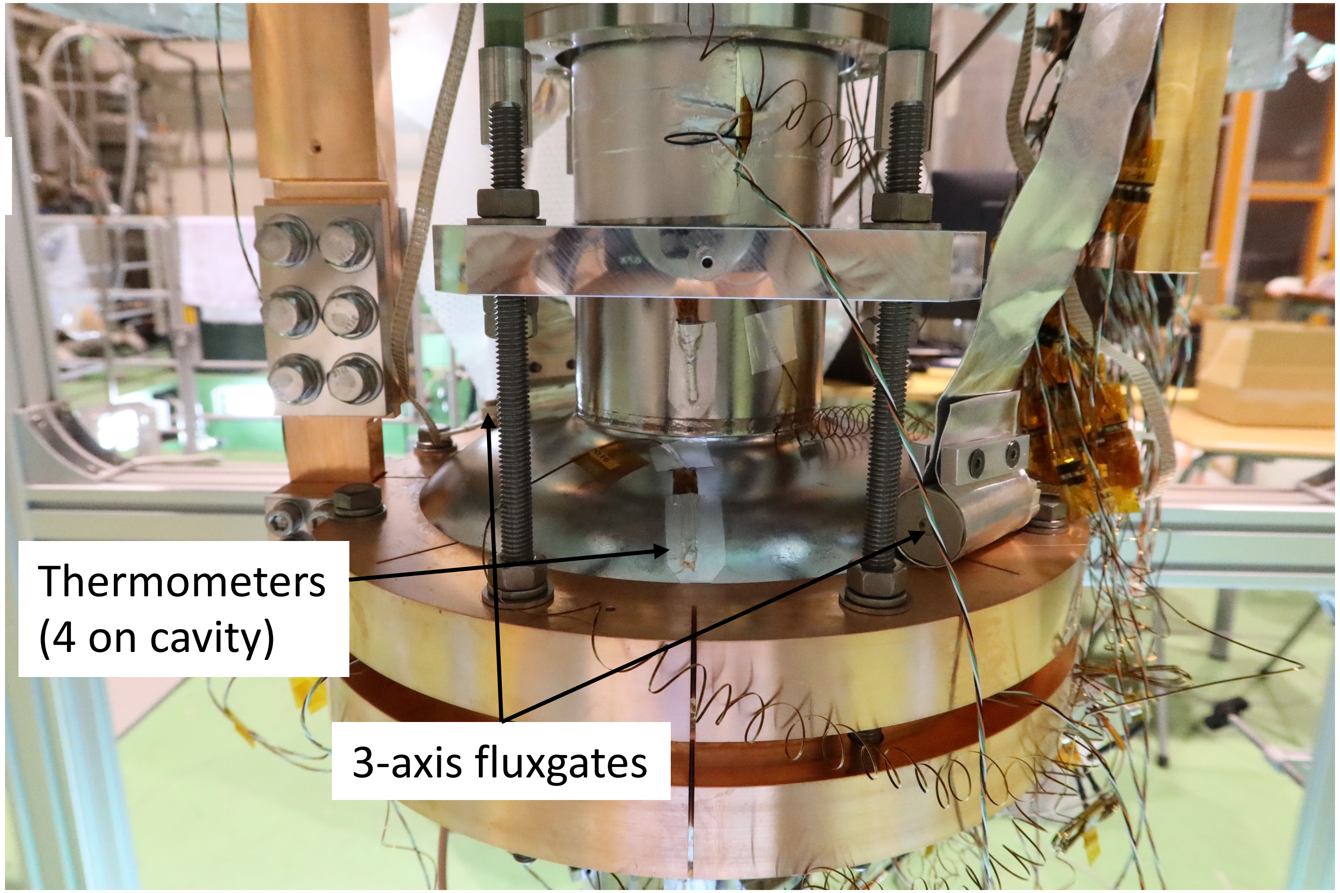
- A copper ring has an inner shape that follows the cavity outer shape.
- Slits were prepared to relax difference of thermal shrink.
- Four copper rings are connected by circumferential and vertical screws.





Conduction cooling and RF test

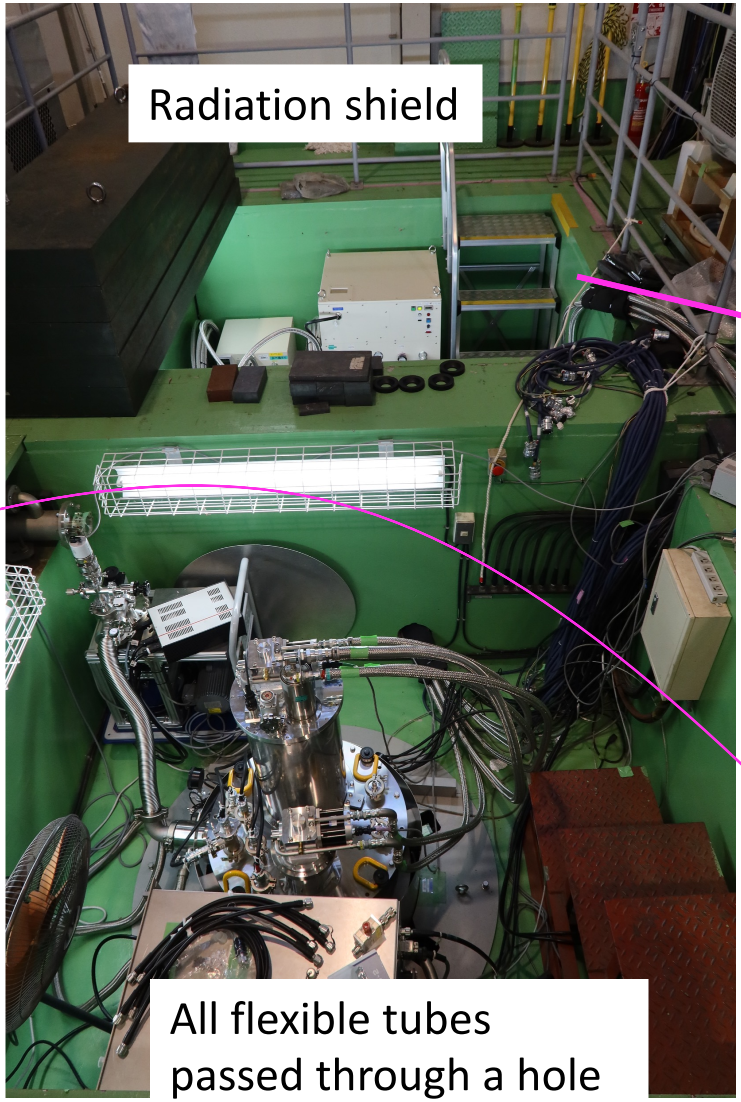




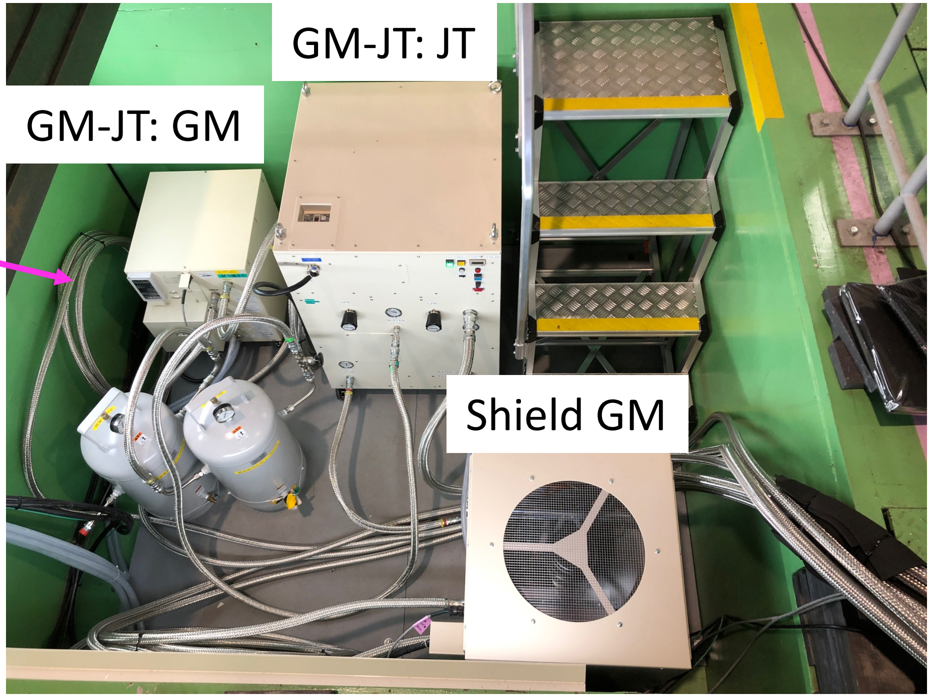
3rd Nb3Sn coating cavity

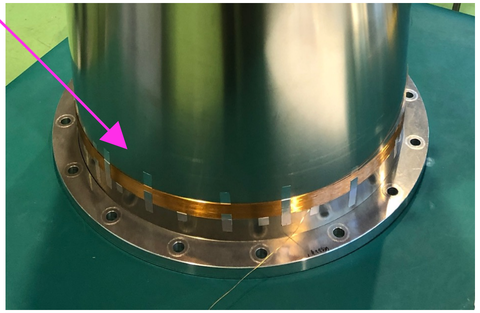
Experimental setup

Magnetic shield
(Room temp, Permalloy)



All flexible tubes passed through a hole on the side wall.



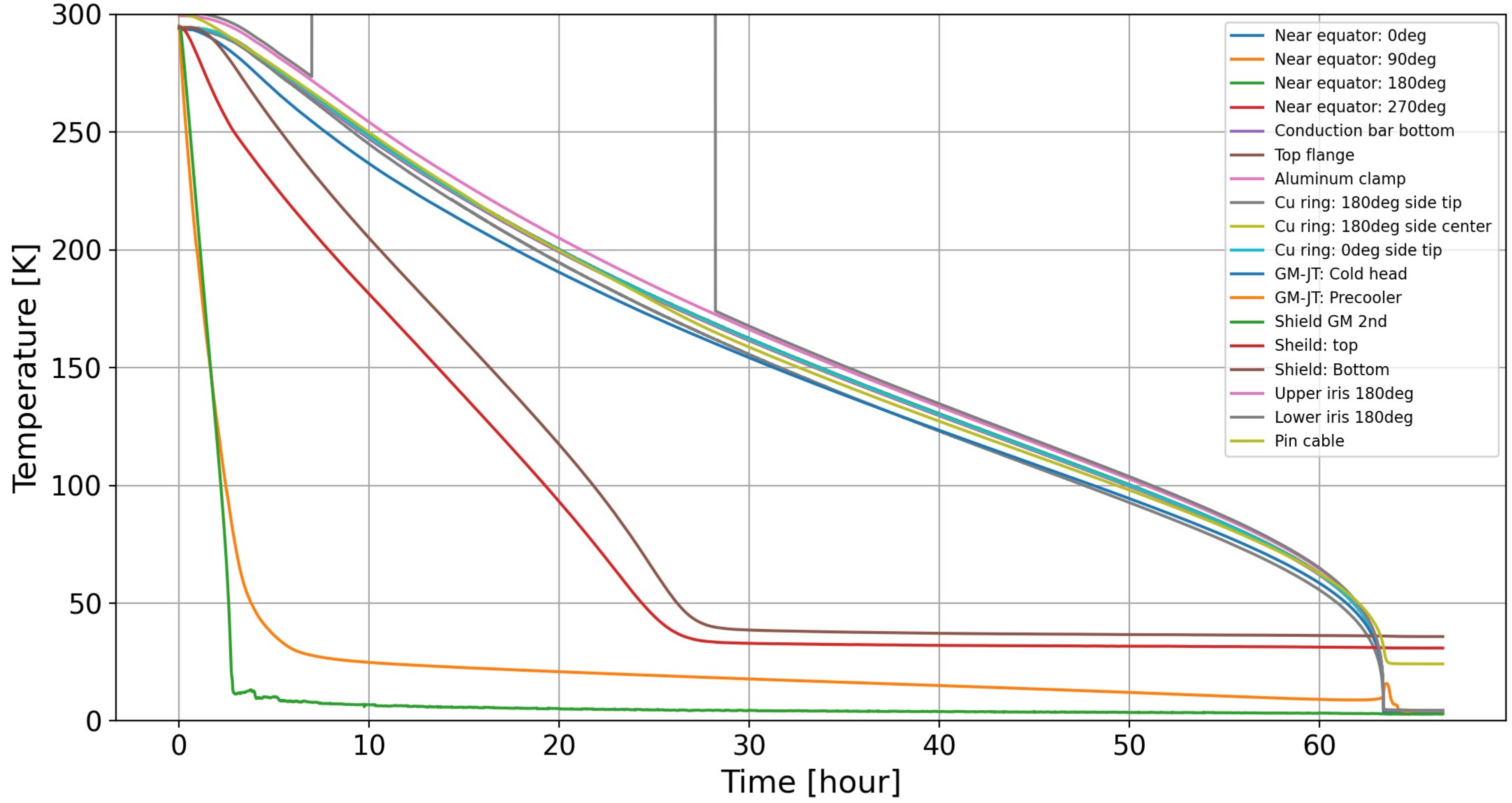


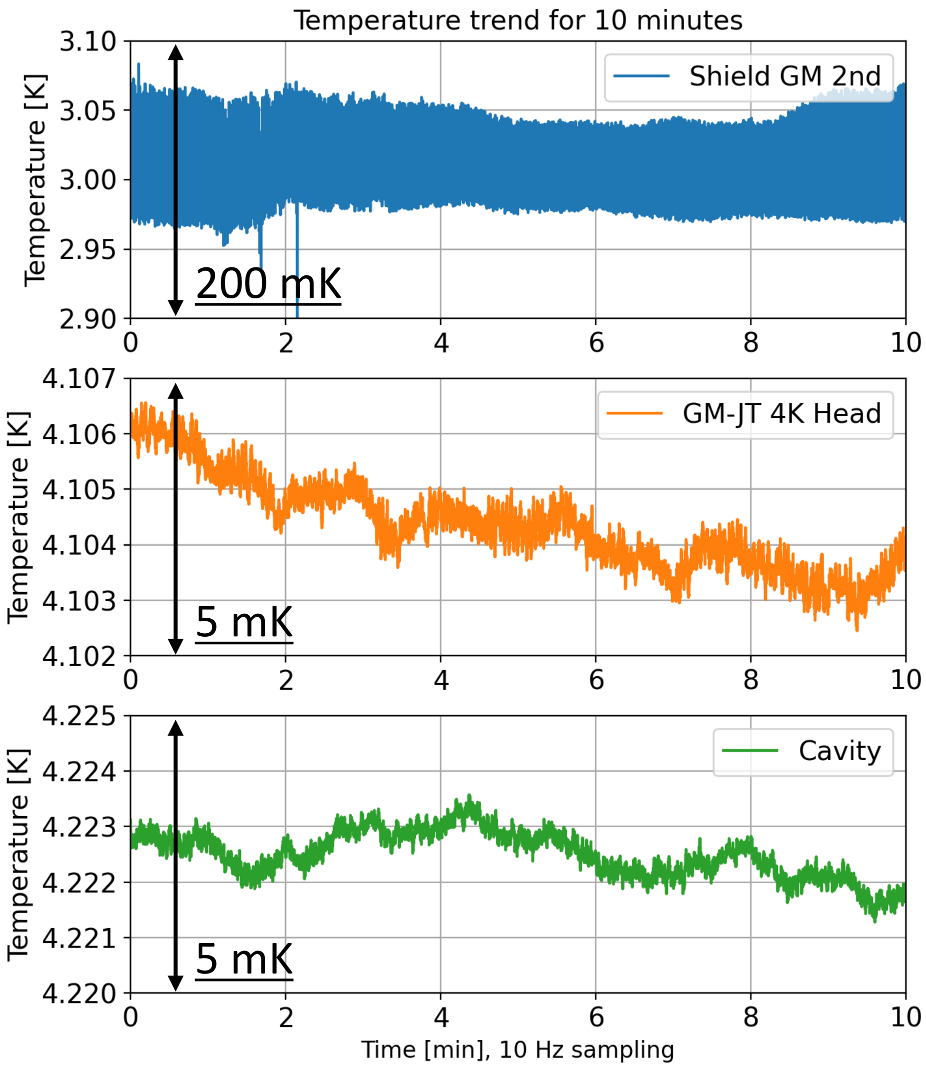
Magnetic field cancellation coil on the thermal shield inside magnetic shield

Cooling

This is due to GM-JT cryocooler. The usual GM can cool it down in 12 hours.

- The cavity was cooled down in 63 hours (~2.5 days).
- Temperature fluctuation in the GM-JT line was quite small like a few mK <-> nearly 100 mK in GM.



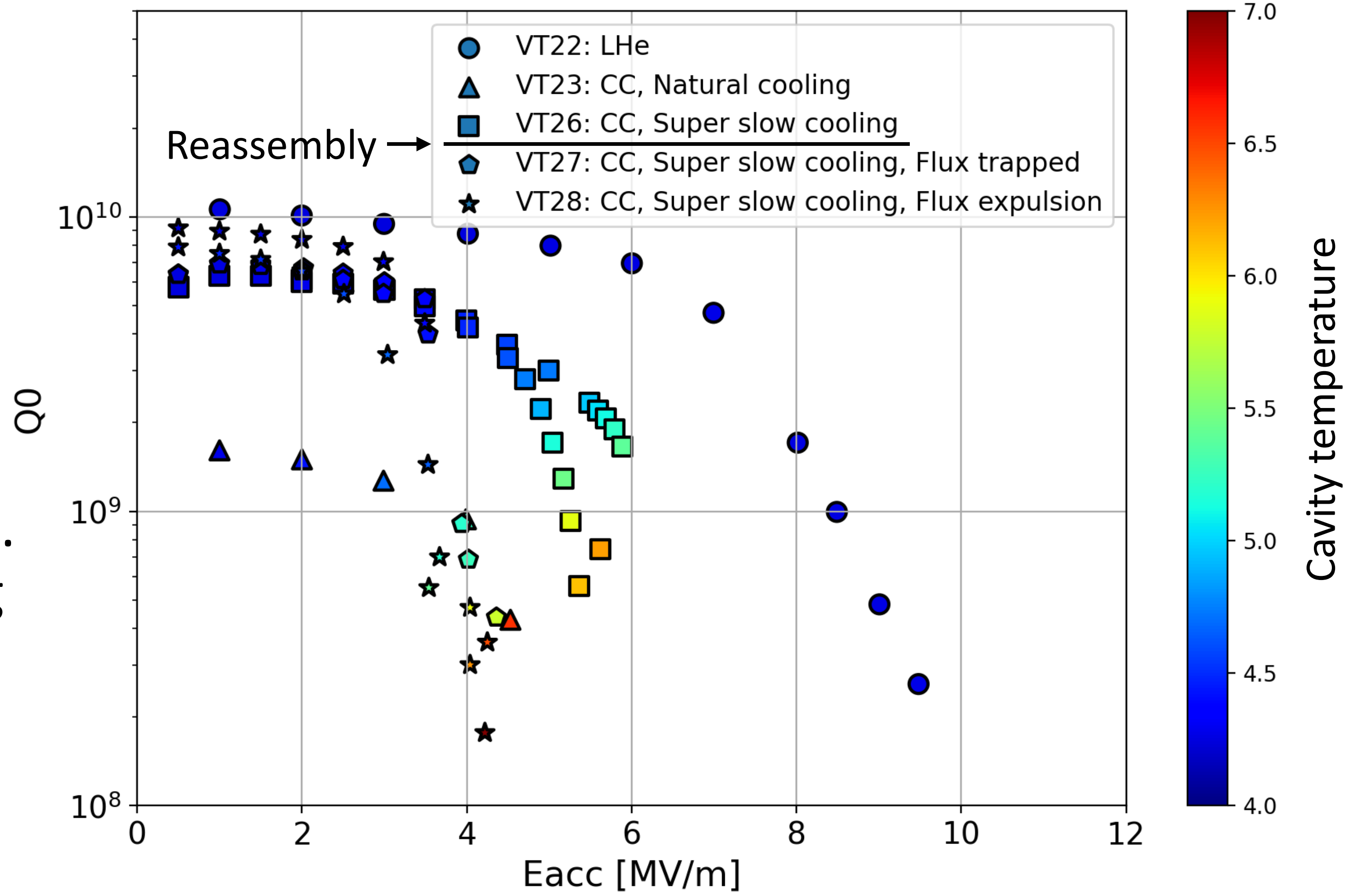


RF performance under conduction cooling

- 3rd Nb3Sn coating cavity was RF tested with several cooling and magnetic field conditions.

	Q at 1MV/m	Memo
VT22	1.1 E10	LHe
VT26	6.3 E9	Cryocooler
VT27	6.9 E9	Cryocooler
VT28	8.9 E9	Cryocooler

- Between VT26 and 27, the copper jigs are re-assembled.
- After VT27, Q dropped at 3.5MV/m. This is probably caused by breaking of Nb3Sn film due to excessive clamping force in the reassembly work for copper jigs.



Summary

- Nb3Sn coating and conduction cooling researches are parallelly carried out in KEK.
- Towards high quality Nb3Sn coating,
  - clean booth was prepared,
  - the Sn crucible was modified and vaper pressure increment was studied.
- Towards liquid helium free cryomodule,
  - the Nb3Sn coated cavity was RF tested for the first time in KEK,
  - we observed brittleness of Nb3Sn film.

<u>Researches for better Nb3Sn coating and better conduction cooling is being conducted steadily in KEK.</u>