Beampipe HOM absorber development for KEK-ERL main linac

2013/6/13

TTC topical meeting on CW SRF

KEK ERL main linac group

K. Umemori, K. Enami, T. Furuya, H. Sakai, M. Sato, K. Shinoe (KEK),

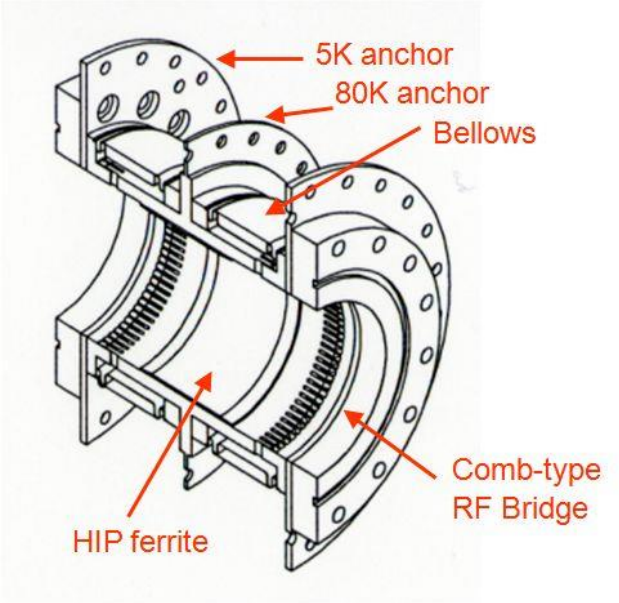
M. Sawamura (JAEA-ERL), E. Cenni (Sokendai)

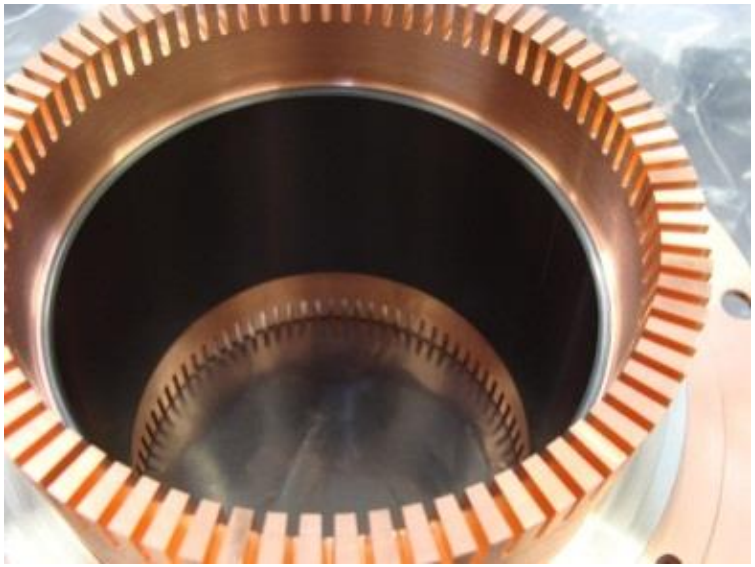
Contents

- Introduction
- Low temperature RF characteristics
- HIP condition
- Cooling test results
- Thermal cycle tests
- HOM measurement at RT
- HOM measurement at cryomodule
- Summary

HOM absorber

- HOM absorber located on 80K region
- Heat load of 150W/cavity is estimated for 100 + 100mA electron beam with 3ps bunch length
- New IB004 ferrite is HIP bonded on Cu pipe
  - Original IB004 is used for KEKB HOM absorber
- Outside: bellows, Inside: Comb-type RF bridge



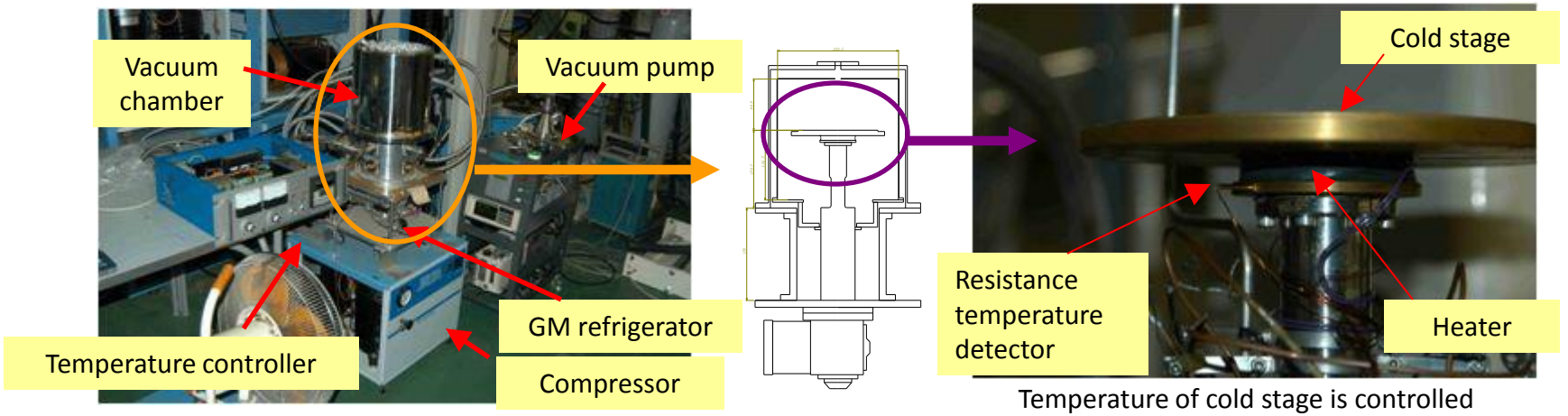


Low temperature RF characteristics of absorbers

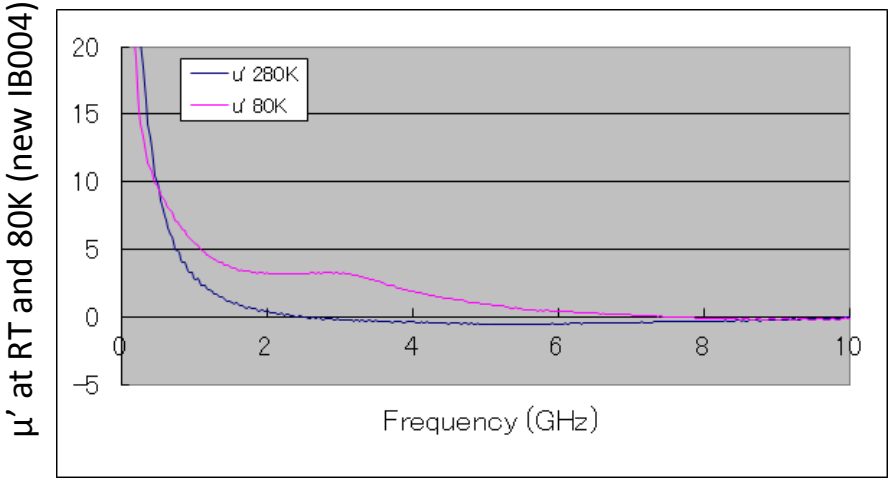
Low temperature measurement of RF absorber's characteristics

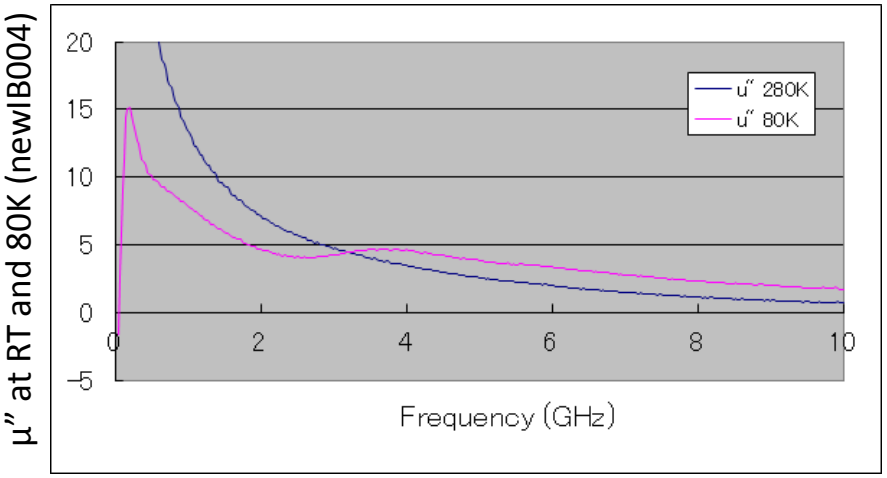
- RF absorber should work at 80K
- Temperature dependence was measured while cooling with refrigerator

Ferrite sample



Temperature of cold stage is controlled





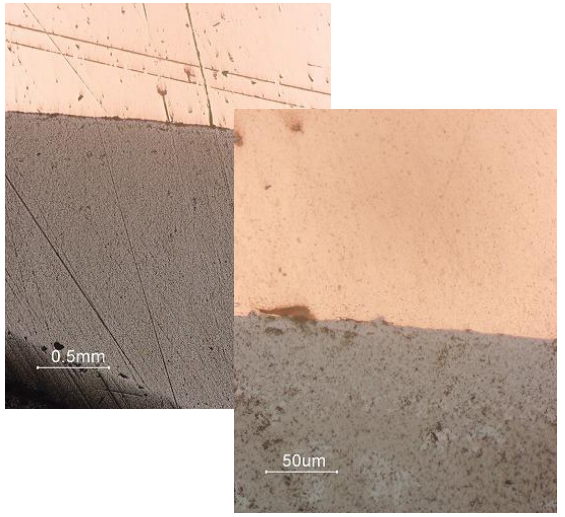
Good absorption at low temperature

Condition search of HIP process

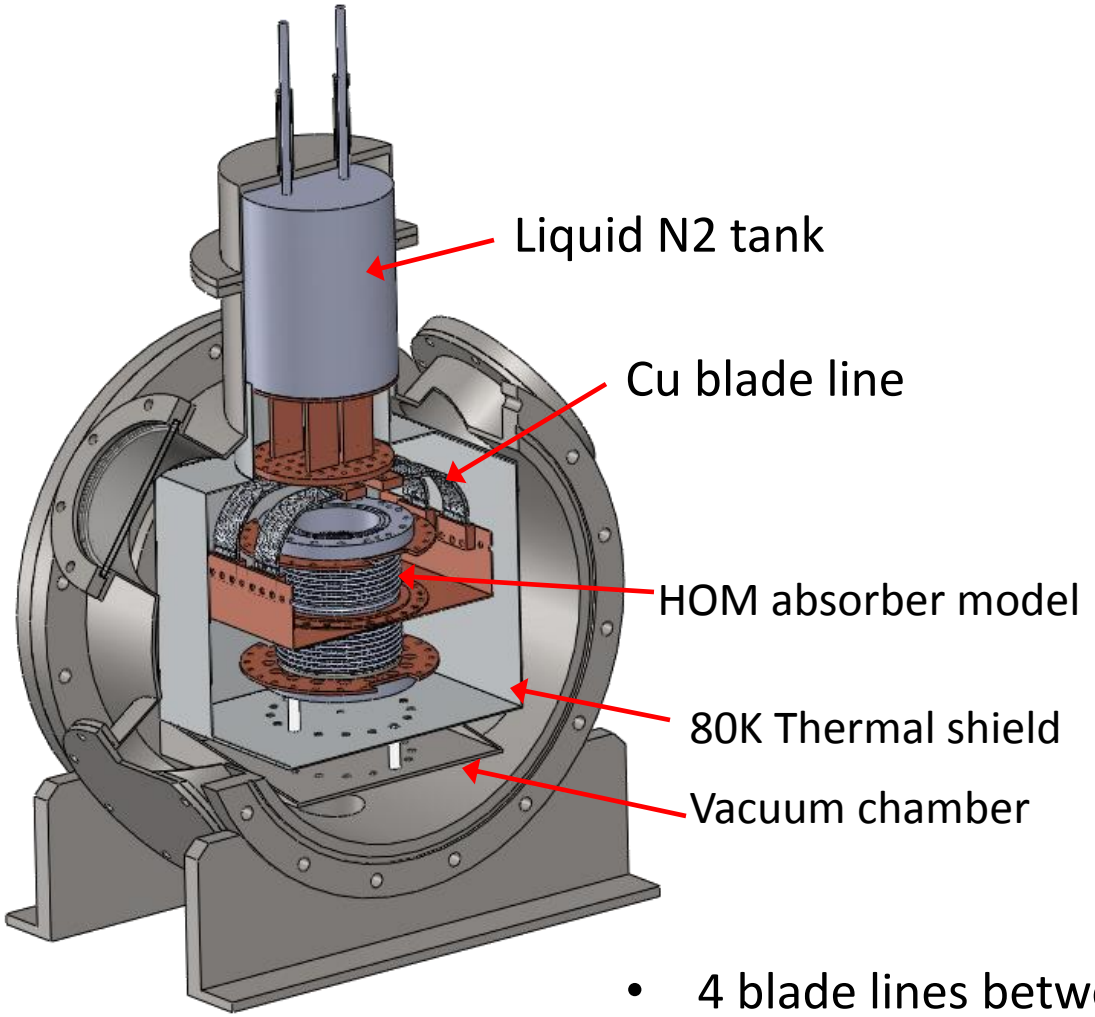
810℃ x 1500atm

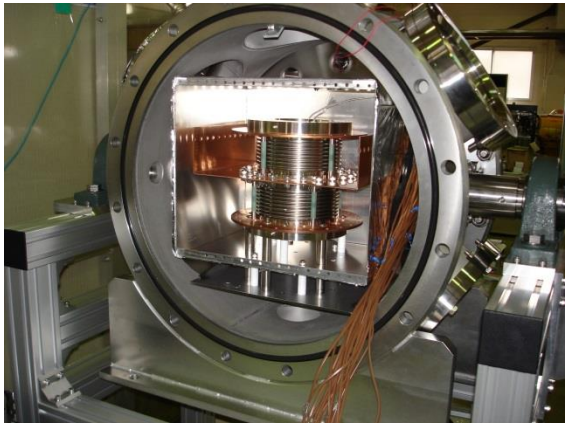
860℃ x 1500atm

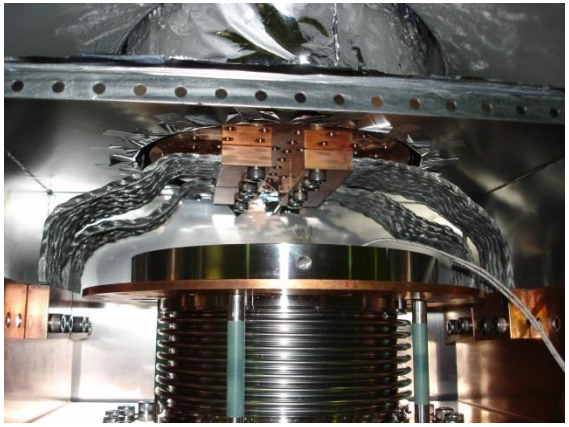
910℃ x 1500atm



Cooling test at vacuum chamber

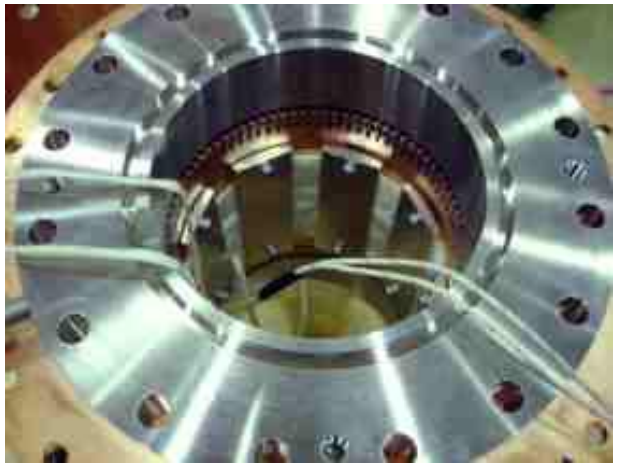






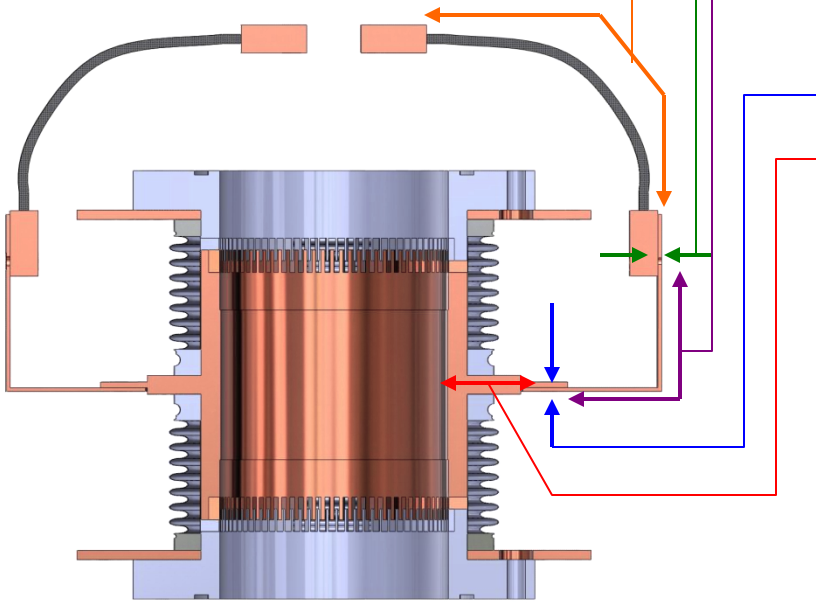
- 4 blade lines between liquid N2 tank and HOM absorber model
- Cross section 100mm^2 Length 200mm
- HOM absorber model is supported by Teflon bars

Heater test



Heater is placed on inside damper model, and simulate heat load

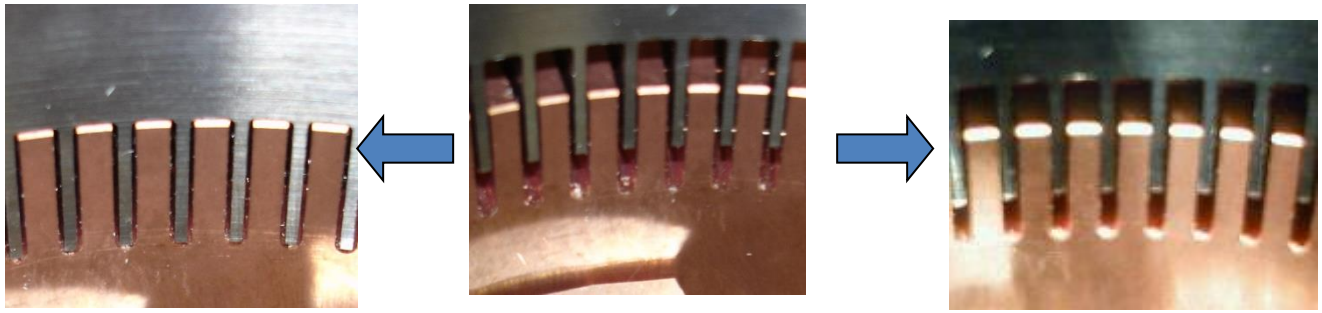
	0 W	38.5 W
Both end of blade line	2.4	40.8
Blade line and Cu plate	0.0	4.1
Both sides of Cu plate	0.1	8.1
Cu plate and 80K anchor	0.0	2.9
80K anchor and ferrite	0.6	0.9

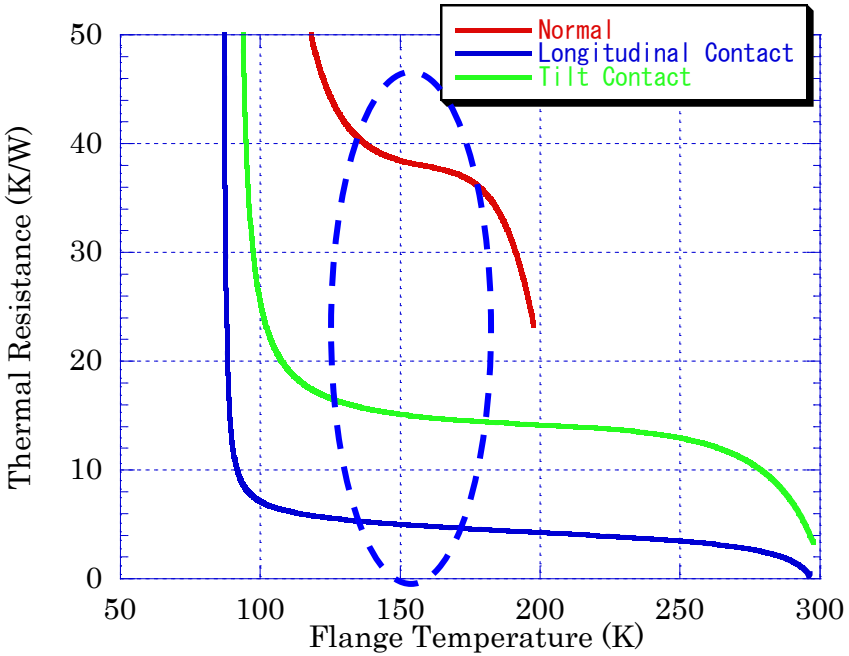


These measured data were used for thermal design of cERL cryomodule.

Effect of contact (Comb structure)

Longitudinal Contact: 15W **Normal: 2W** **Tilt contact: 5W**

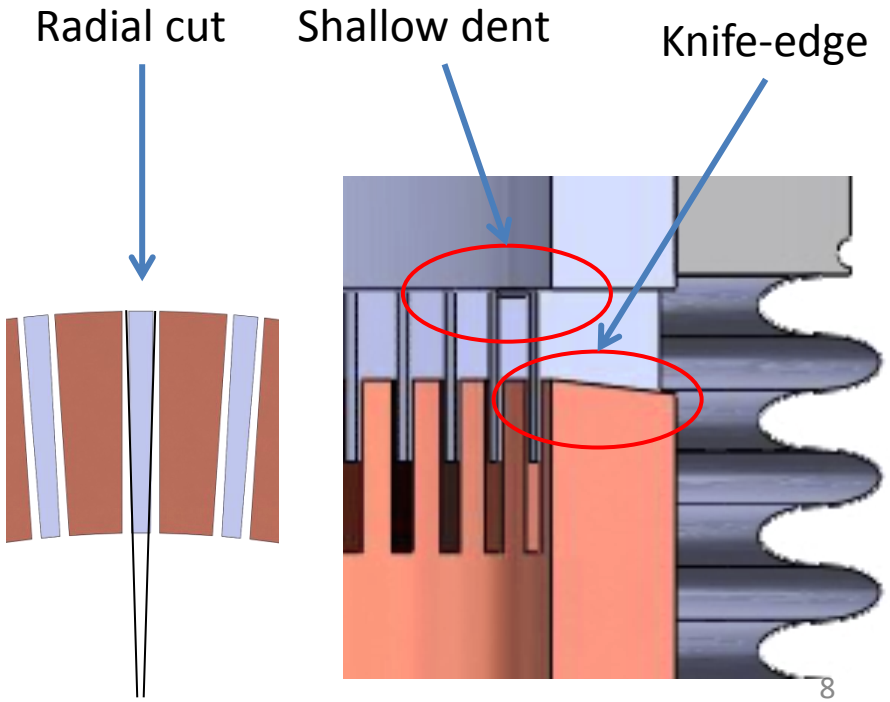




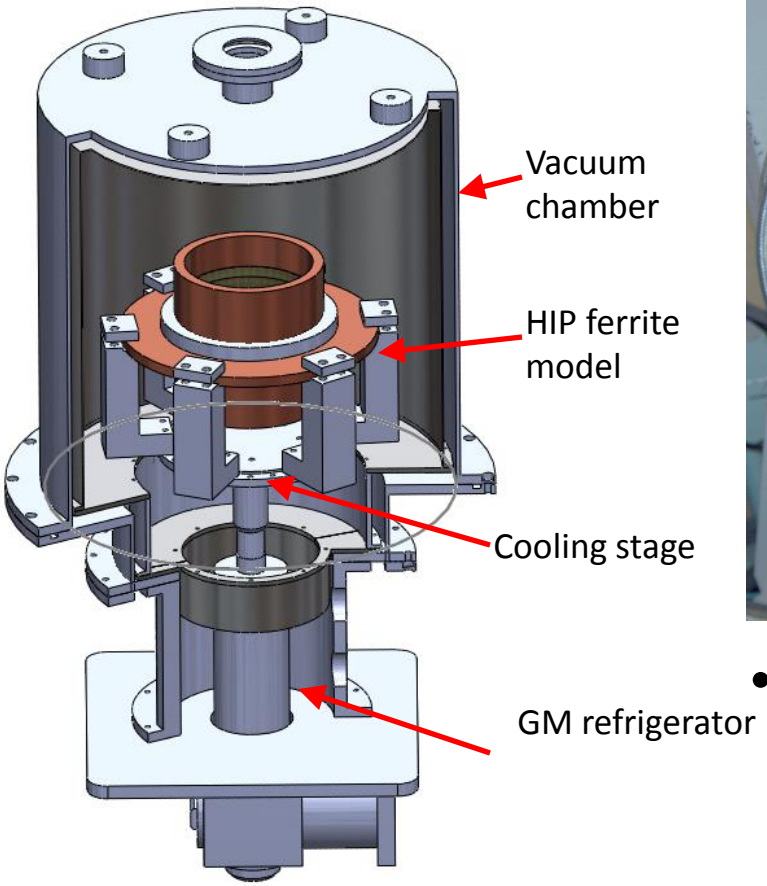
Relatively large heat input, when

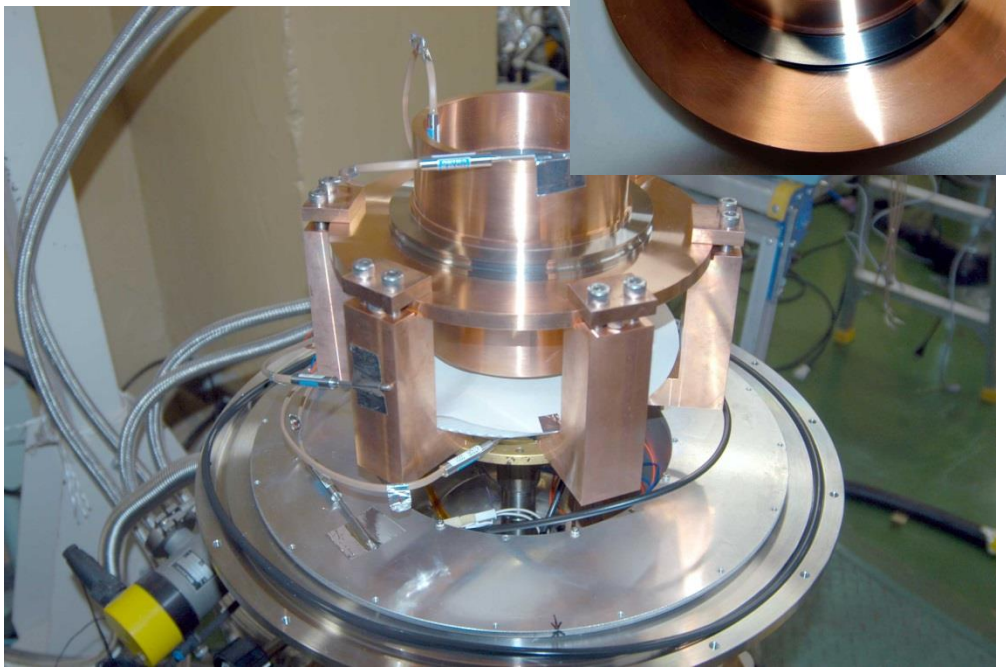
- contact longitudinally
- contact with tilt condition

Modify comb structure



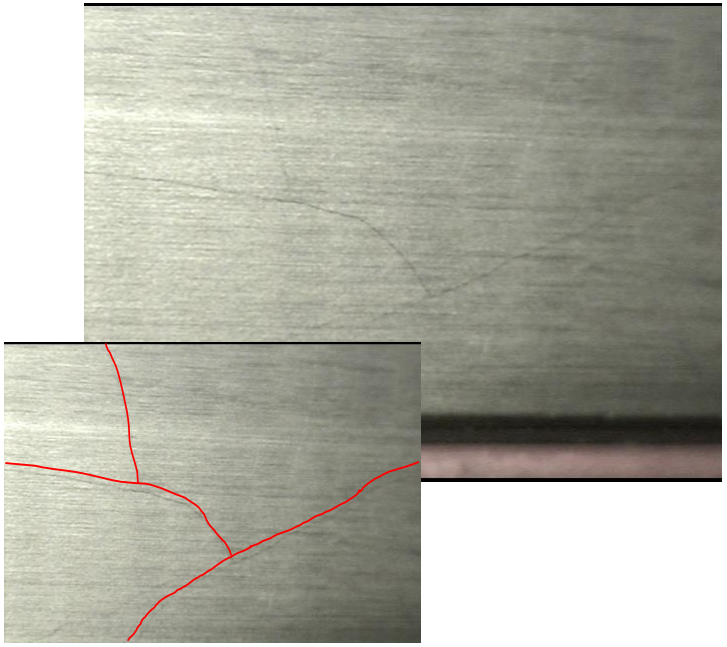
Thermal cycle test of HIP ferrite model

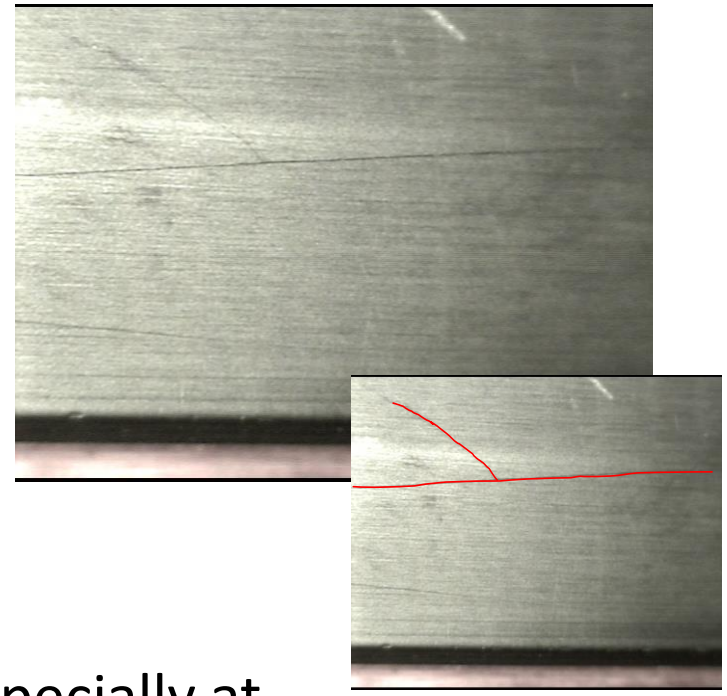




- Thermal cycle pattern
  - RT → 80K 3days (22min/K)
  - 80K keep 1days
  - 80K → RT 3days
- Observe ferrite surface

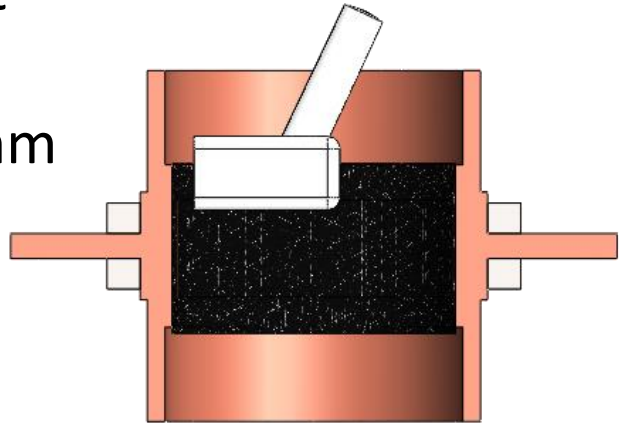
Observed cracks on ferrite surface



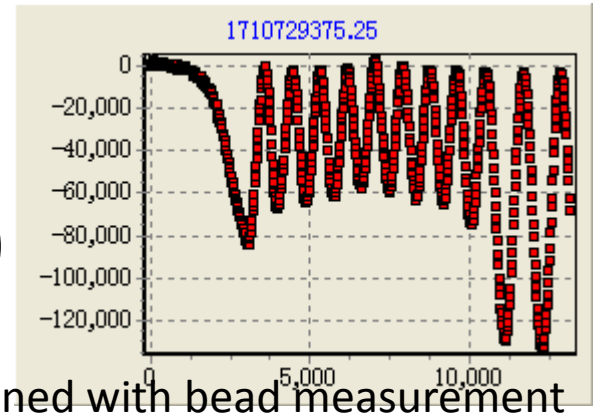


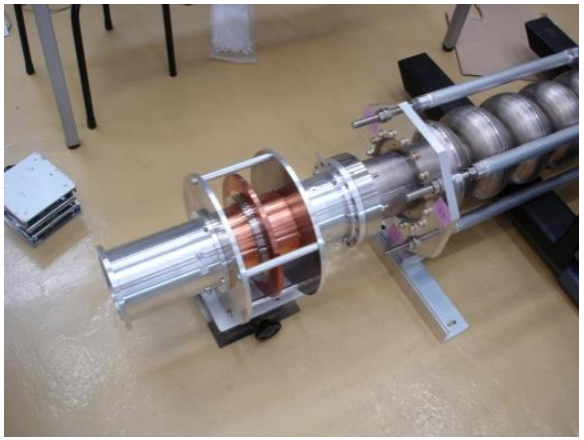
- Some cracks were observed, especially at taper part of ferrite
- Thickness of taper part changed from 1mm to 2mm.

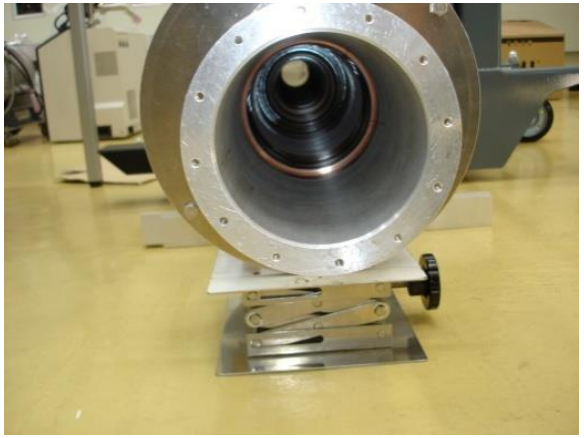
  → taper structure was changed
- Cracks appear at first or second cycles, seem not to grow much during further thermal cycles



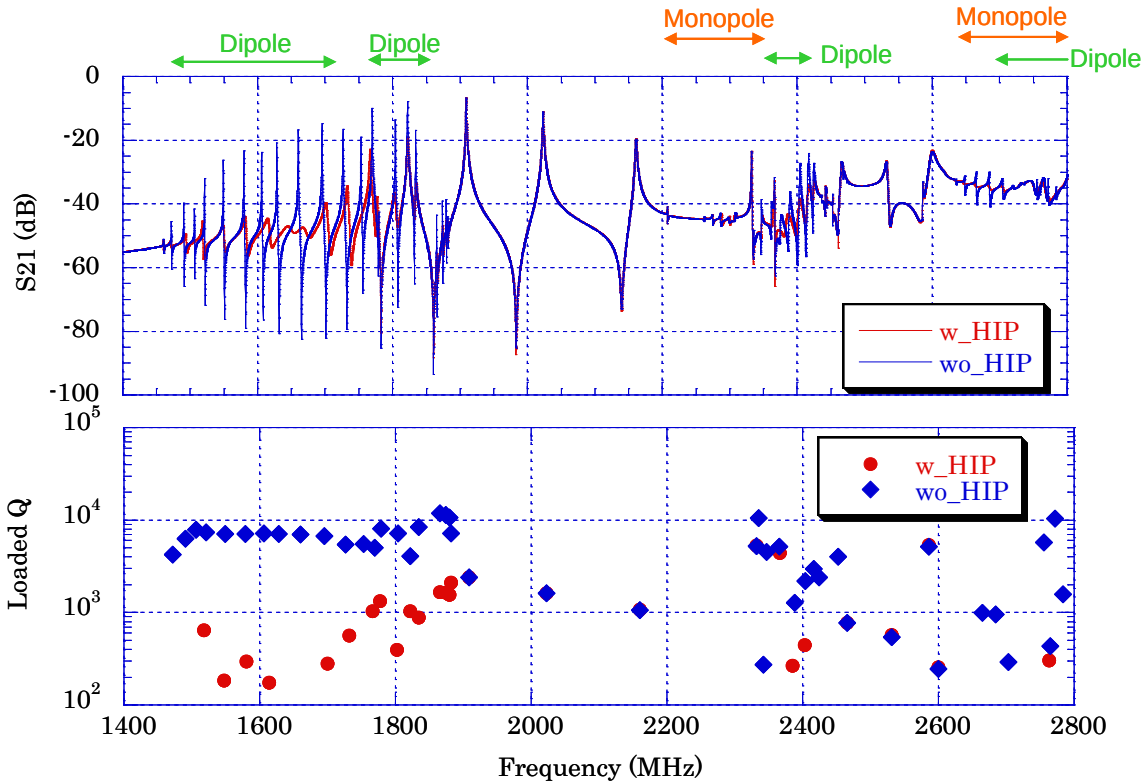
HOM measurement at RT
(using prototype with ferrite)





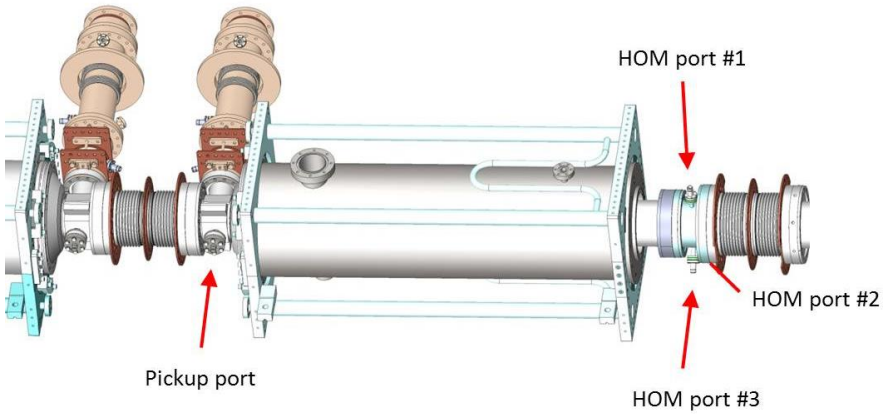


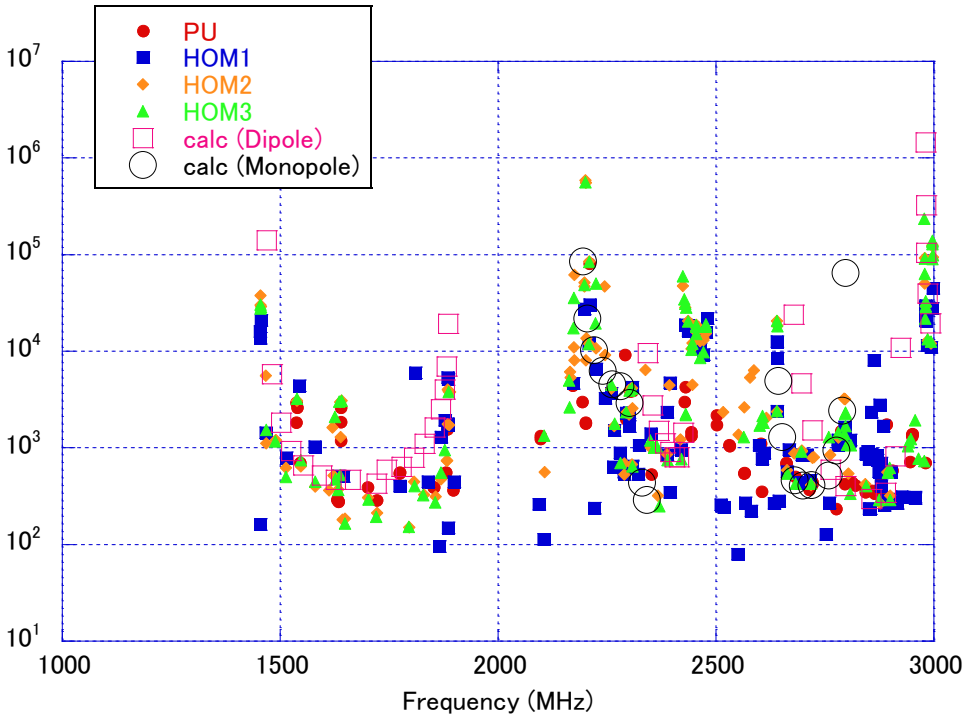
Mode assigned with bead measurement



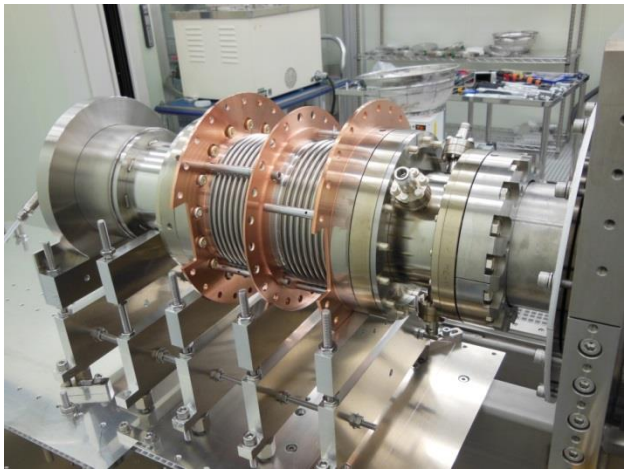
- Mounted on LBP side of #2 cavity, and measured at room temperature
- HOMs are sufficiently damped.

Cryomodule HOM measurement





- Using fundamental pickup port (PU) and HOM ports (HOM1, 2, 3), HOM characteristics were measured.
- Their behavior, frequency and loaded Q-values, were generally agreed with calculation results.



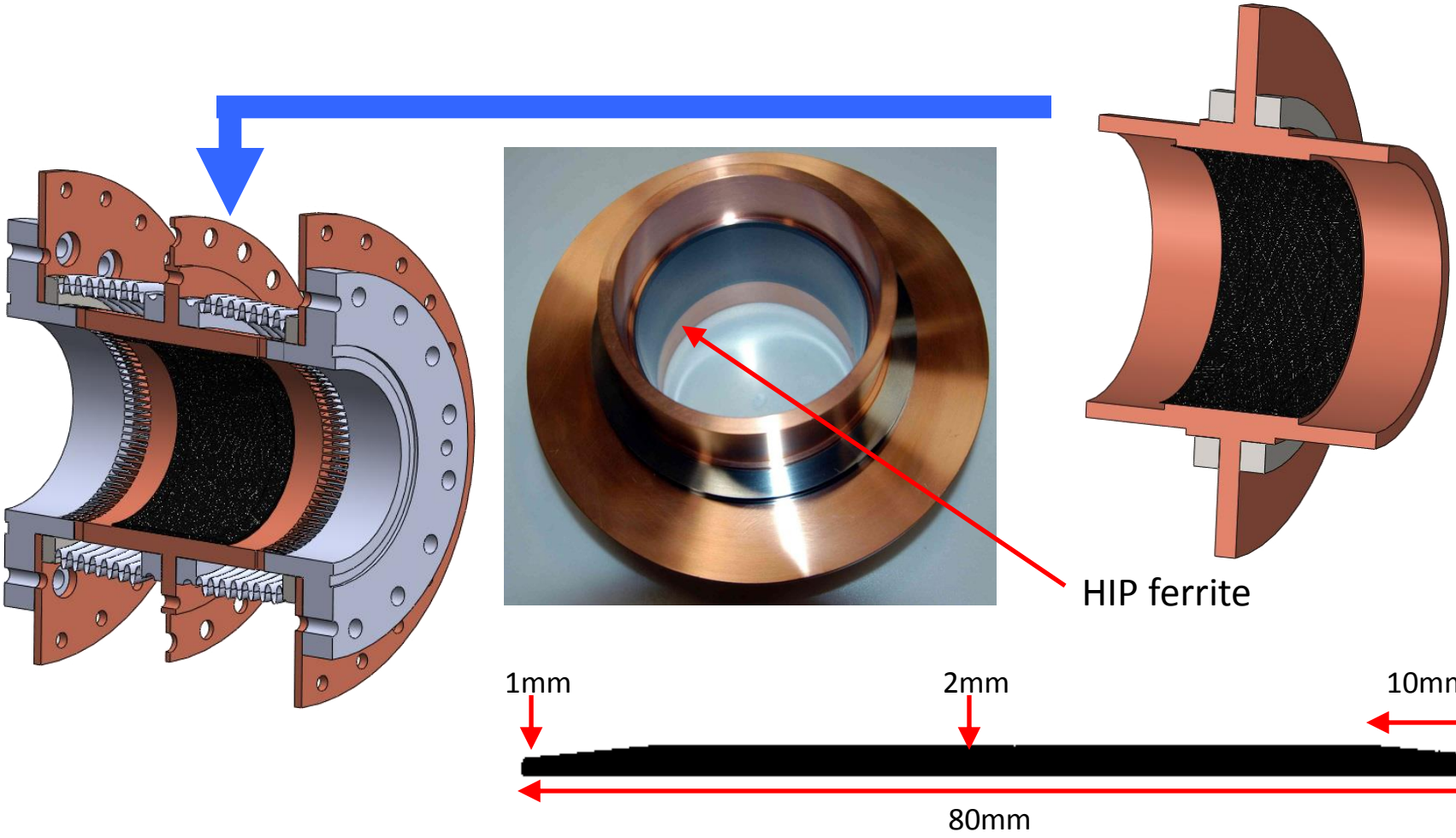
Summary

- Beampipe HOM absorbers have been developed for KEK-ERL
- Ferrite is HIPped on Cu beampipe
- Cooling tests were performed to understand thermal properties.
- Thermal cycle tests were performed. Some cracks were observed.
- HOM damping properties seem to be good.

Backup slide

HIP ferrite model

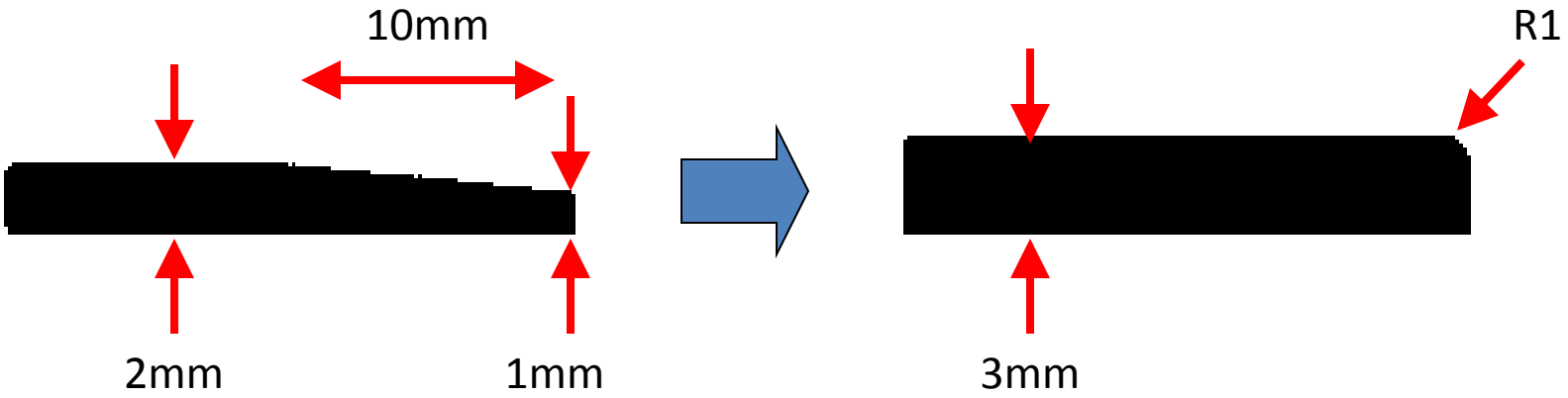
- Center part of HOM absorber before manufacturing Comb-type bridge and 80K anchor



Measure against cracks

- Change ferrite thickness
  - 2mm → 3mm

- Structure of ferrite end
  - Taper → Round shape



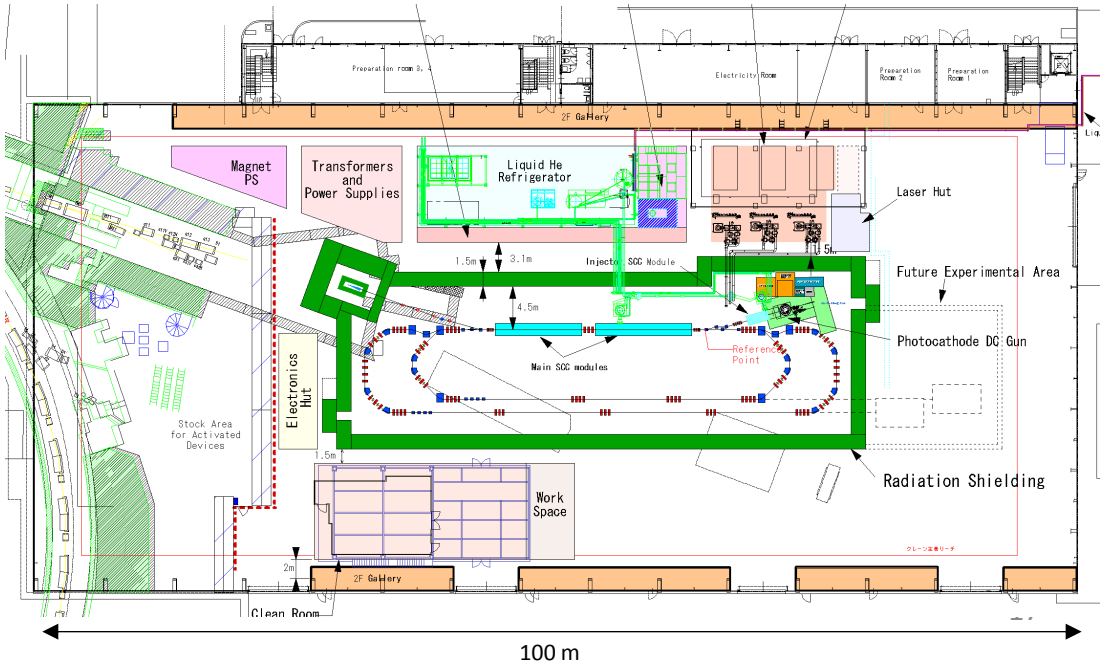
Compact ERL(cERL) project

Demonstrate the technologies needed for future multi-GeV class ERL, and show its beam performances

Parameters of the Compact ERL

	Parameters
Beam energy	35 - 200 MeV
Injection energy	5 MeV
Average current	10 - 100 mA
Acc. gradient (main linac)	15 MV/m
Normalized emittance	0.1 - 1 mm·mrad
Bunch length (rms)	1 - 3 ps (usual) ~ 100 fs (with B.C.)
RF frequency	1.3 GHz

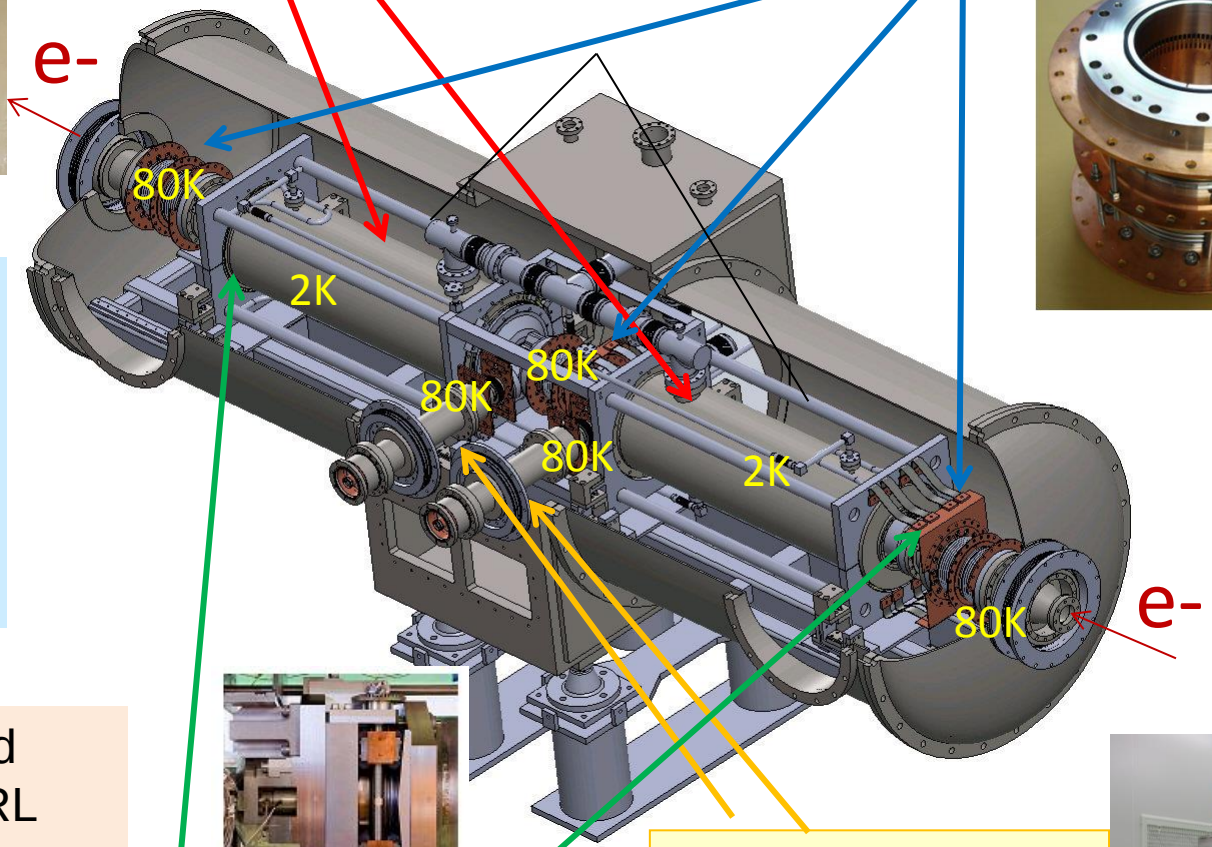
※ red numbers are parameters for initial stage



Compact ERL main linac cryomodule

9-cell SRF cavity
HOM damped cavity
Eacc = 15-20 MV/m
Q0 > 1*10^10 @15MV/m

HOM damper
- HIP ferrite on Cu beampipe
- Operation at 80K
- 150W HOM power handling



Requirement

Frequency : 1.3 GHz
Input power : 20kW CW (SW)
Gradient: 15-20MV/m
Q0: >1*10^10
Beam current : max 100mA
(HOM-BBU対策を施した空洞設計)

2-cavity cryomodule had been developed for cERL main linac

Frequency Tuner
Slide jack tuner
piezo tuner

Input coupler
- 20kW CW(total reflection)
- Cold and warm window
- HA997 ceramic is used
- QL=(1-4)*10^7(variable)