# HOM properties of main linac for cERL in Japan

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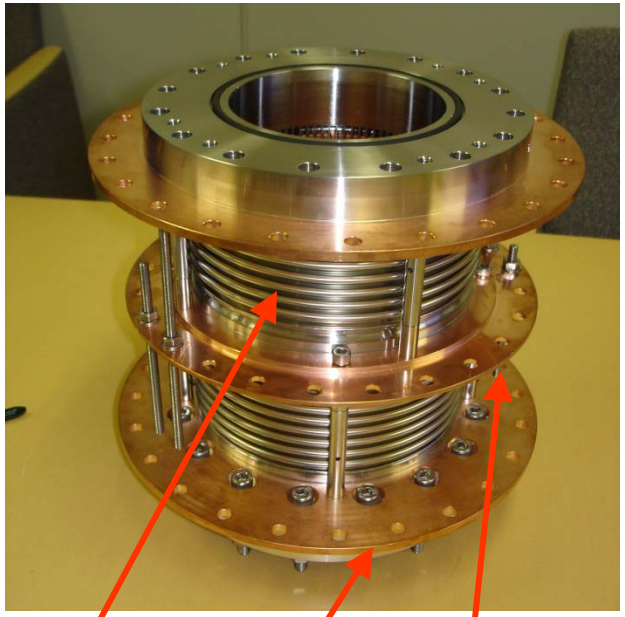
# About HOM absorber at ERL'09

- Measurement of RF absorber property
  - Frequency and temperature dependence of permittivity and permeability of ferrites and ceramics controlling temperature with GM refrigerator.
- Optimization of ferrite condition
  - Length, thickness and position were calculated to minimize Q-value
- HOM Q-value measurement
  - $Q_{load}$ and $Q_{ext}$ were measured with 9-cell model cavity by moving ferrite sheet along beam pipe
- HOM absorber model design
  - HIP ferrite of new-type IB004
  - Comb-type RF bridge
  - Two kinds of thermal anchor at 80K and 5K

# After ERL’09

- Fabrication of two HOM absorber models
  - HOM absorber model without ferrite
    - Measurement of thermal properties
    - Thermal conductance of bellows and comb-type RF contact
  - Center part with HIP ferrite
    - Check of cooling cycle tolerance of HIP ferrite
- Fabrication of two 9-cell cavities for cERL
    - Estimate HOM properties of 9-cell cavity at 4K and 2K

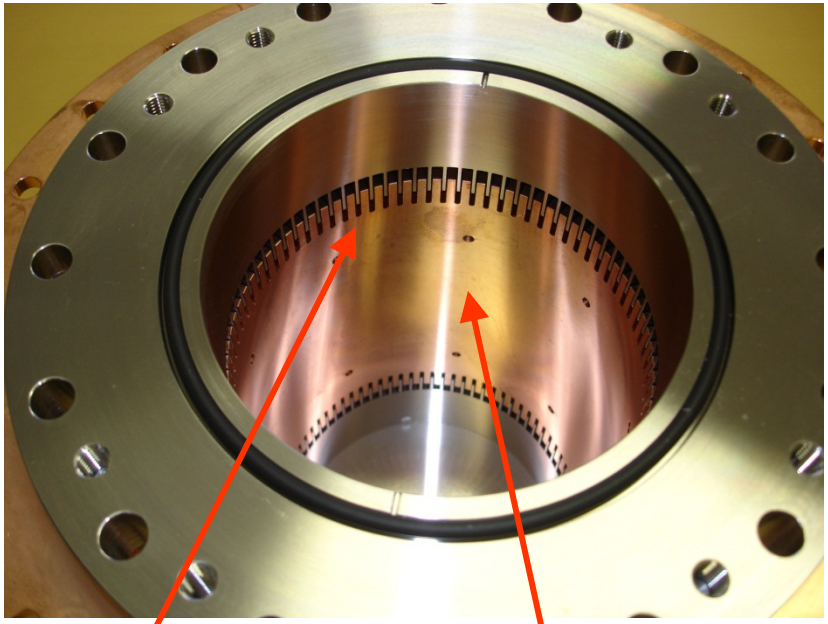
# HOM absorber Model without Ferrite



Bellows

5K Anchor

80K Anchor

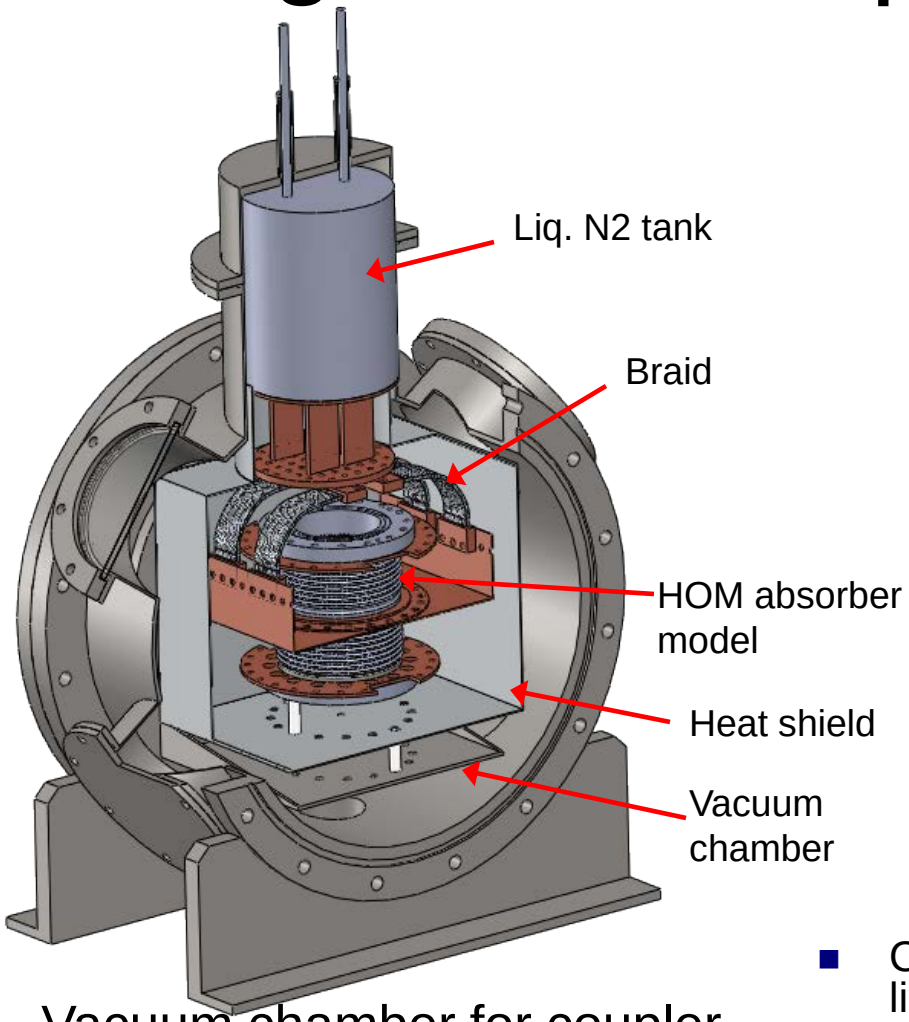


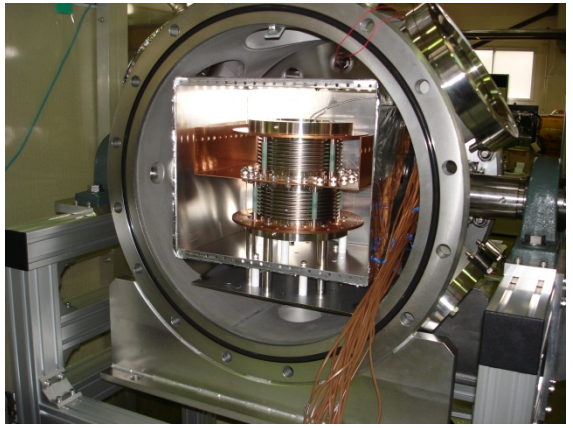
Comb-type RF Bridge

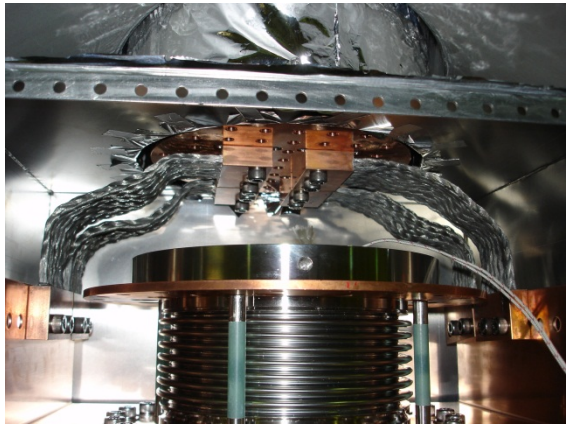
Ferrite to be HIPped

- Test for thermal conductance of bellows and comb-type RF bridge

# Cooling Test Setup



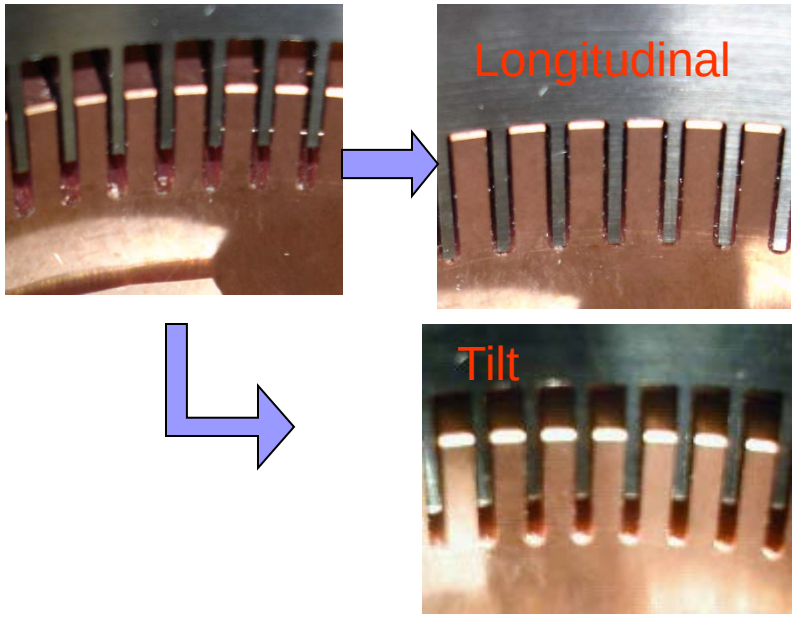



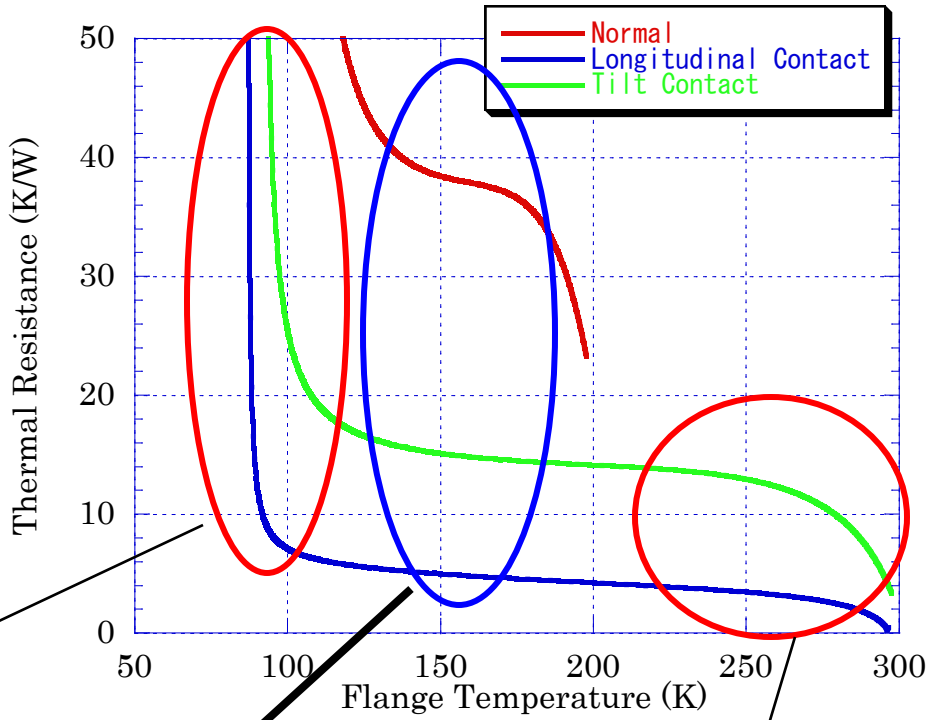


- Vacuum chamber for coupler power test was used

- Connected to Liq. $N_2$ tank with 4 braid lines of 100mm$^2$ cross-section and 200mm length
- HOM absorber model was supported by two Teflon rods

# Comparison with comb-type bridge contact




- Precious around here?
- Including heat transfer along support rods

Temperatures of flange and 80K anchor are different after long term of cooling

Apparent temperature difference and no heat transfer⇒high thermal resistance

Probably radiation heat

Exist other paths for cooling besides of bellows

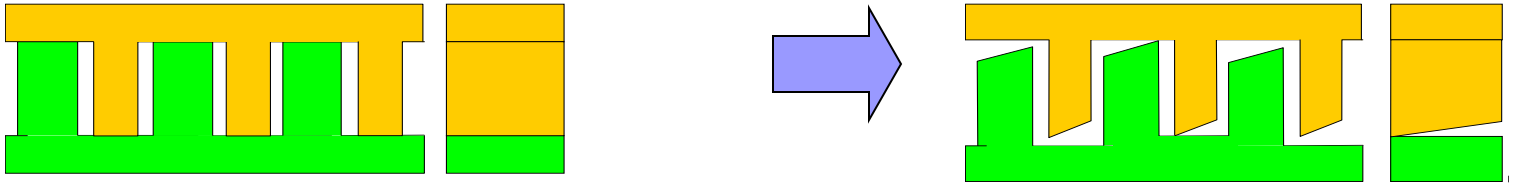
Apparently smaller thermal resistance

# Modify Comb Shape

- Power flow through comb-type RF bridge
  - Normal position (80K-5K)/ 37(K/W) = 2W
  - Longitudinal contact (80K-5K)/5(K/W) = 15W
- Reduce power flow through comb-type RF bridge
  - Point contact even if combs contact each other

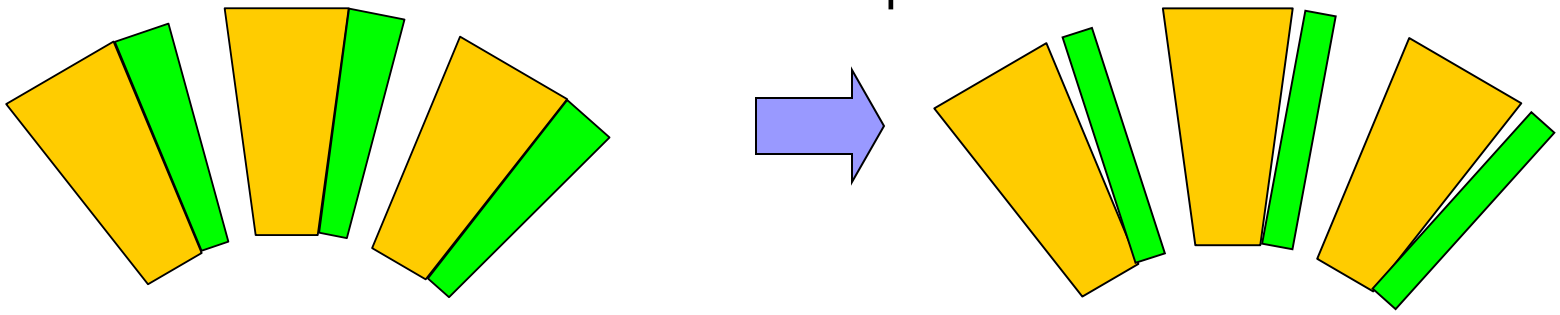
- Brick

knife-edge & different depth



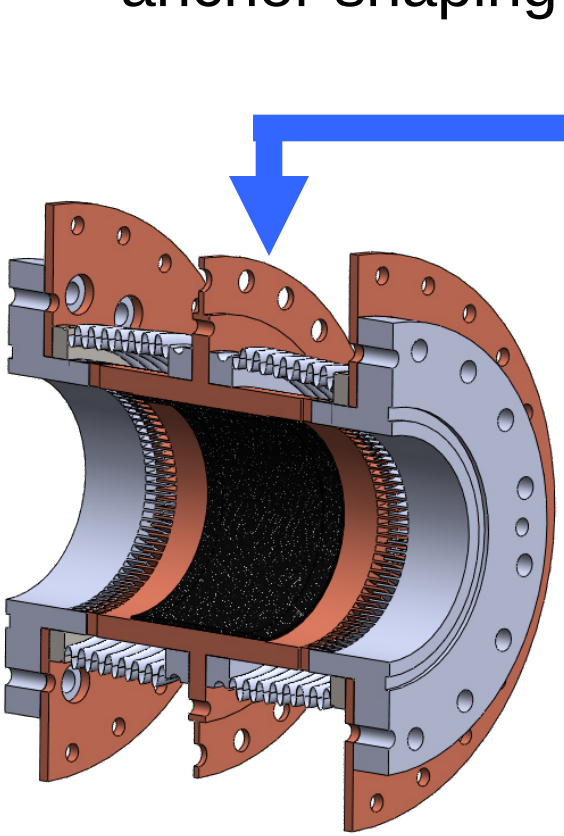
- Radial cut

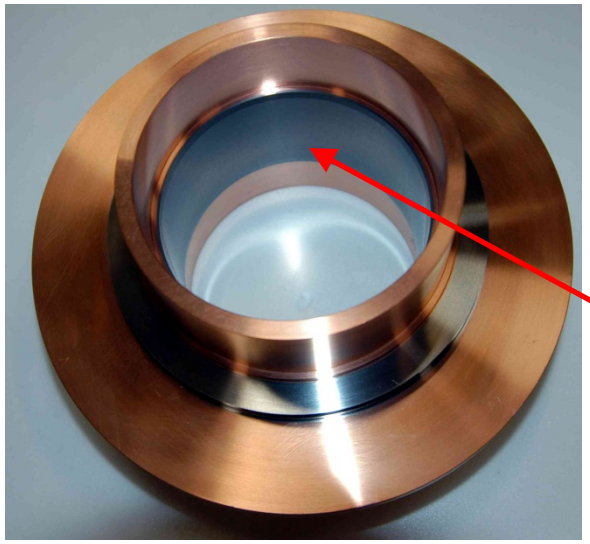
parallel cut

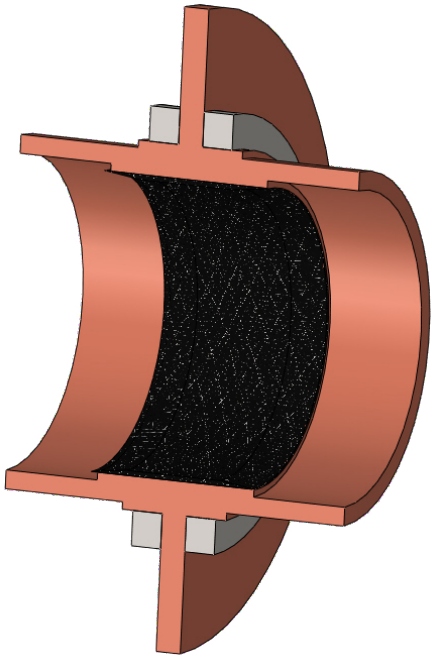


# HOM absorber Model with Ferrite

- Center part only before comb-type RF bridge and 80K anchor shaping



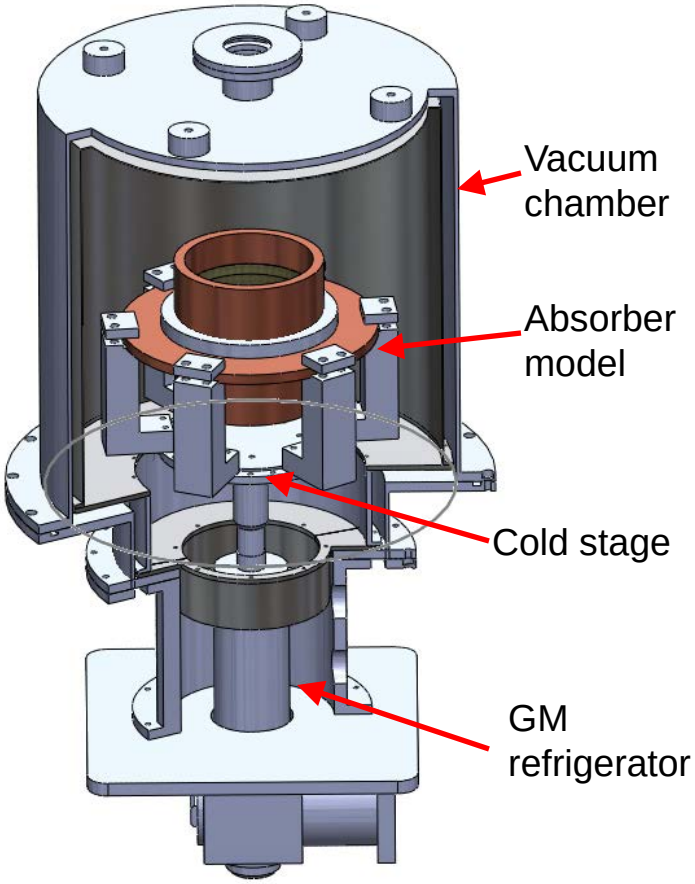


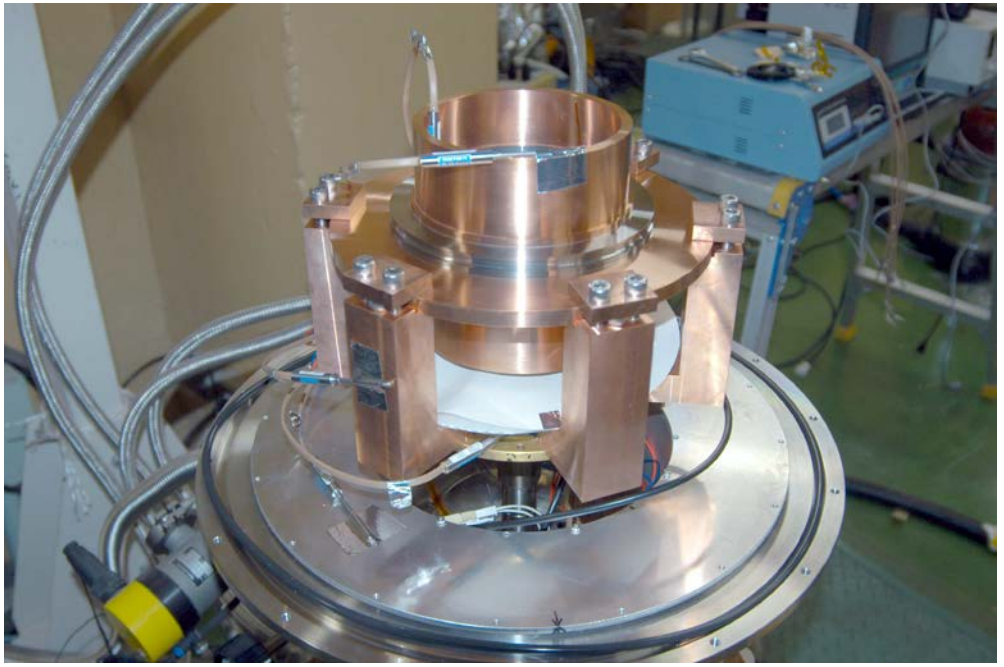


HIP Ferrite

- Test for cooling cycle tolerance

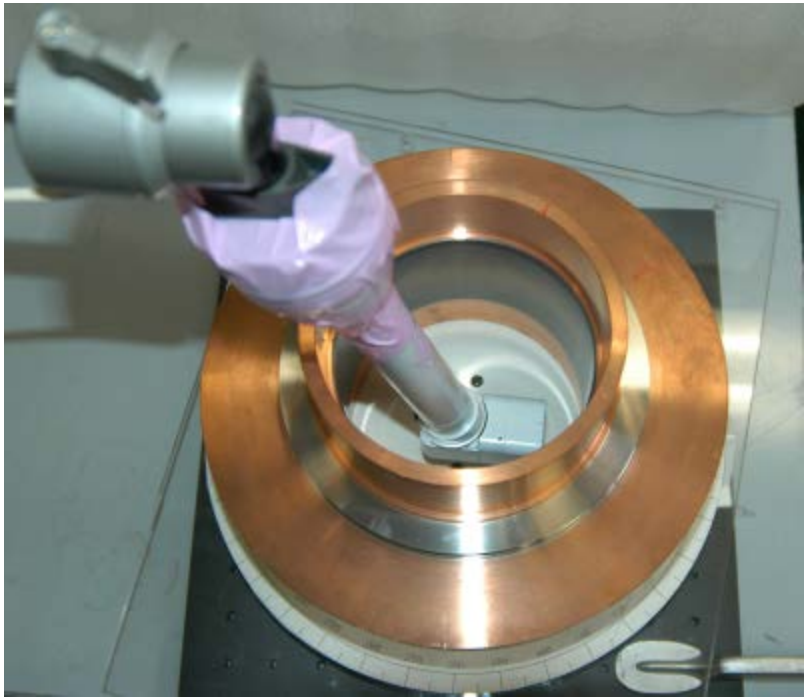
# Cooling cycle test setup



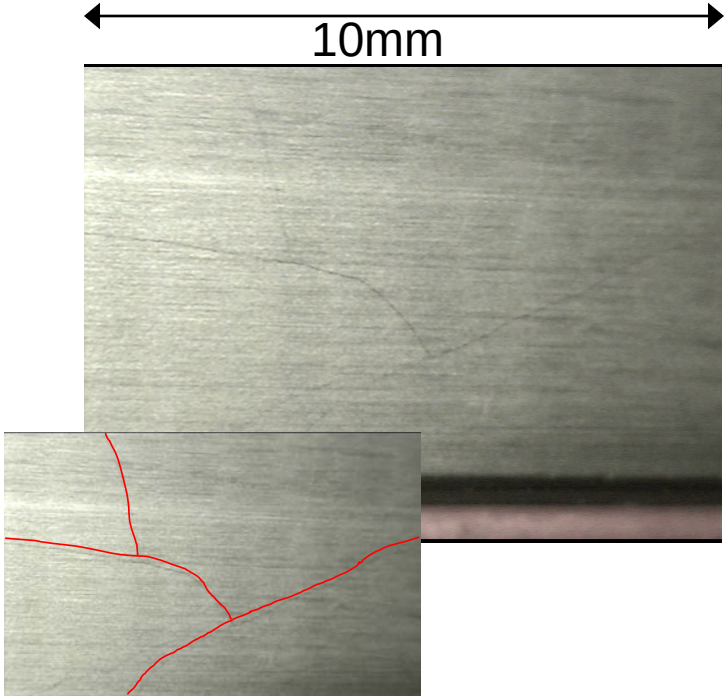
- Controlled temperature pattern
  - RT → 80K for 3 days (21.6min/K)
  - 80K keep for 1 day
  - 80K → RT 3 days
- Ferrite surface inspection

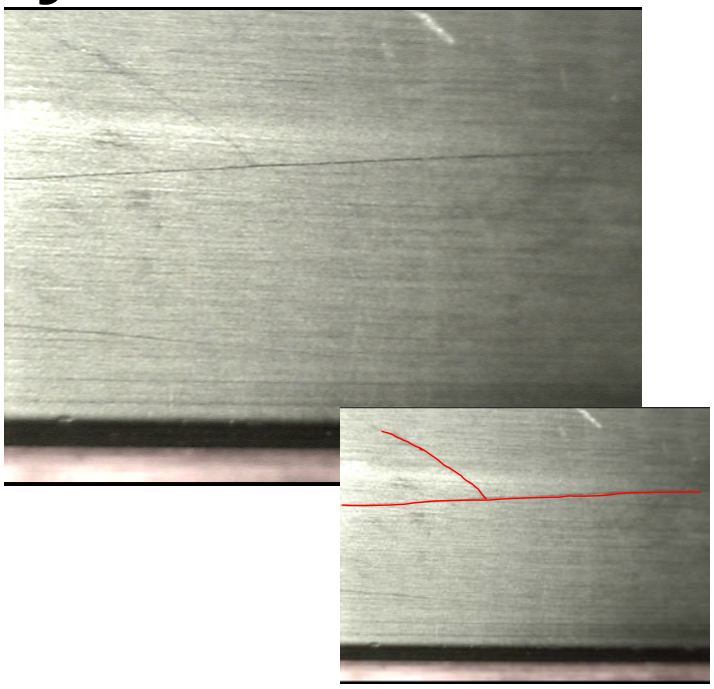
# Ferrite surface inspection



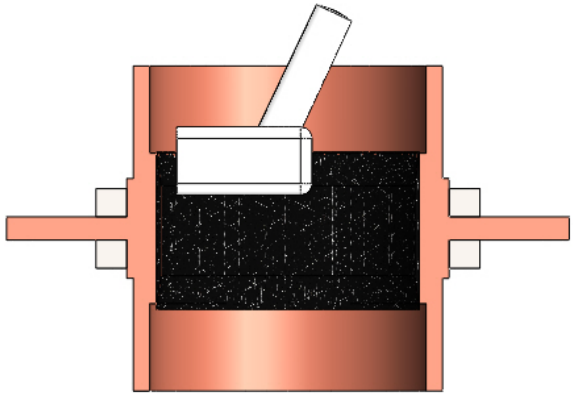
- Rotating ferrite on turn table and moving skin camera vertically

# Results of cooling cycle

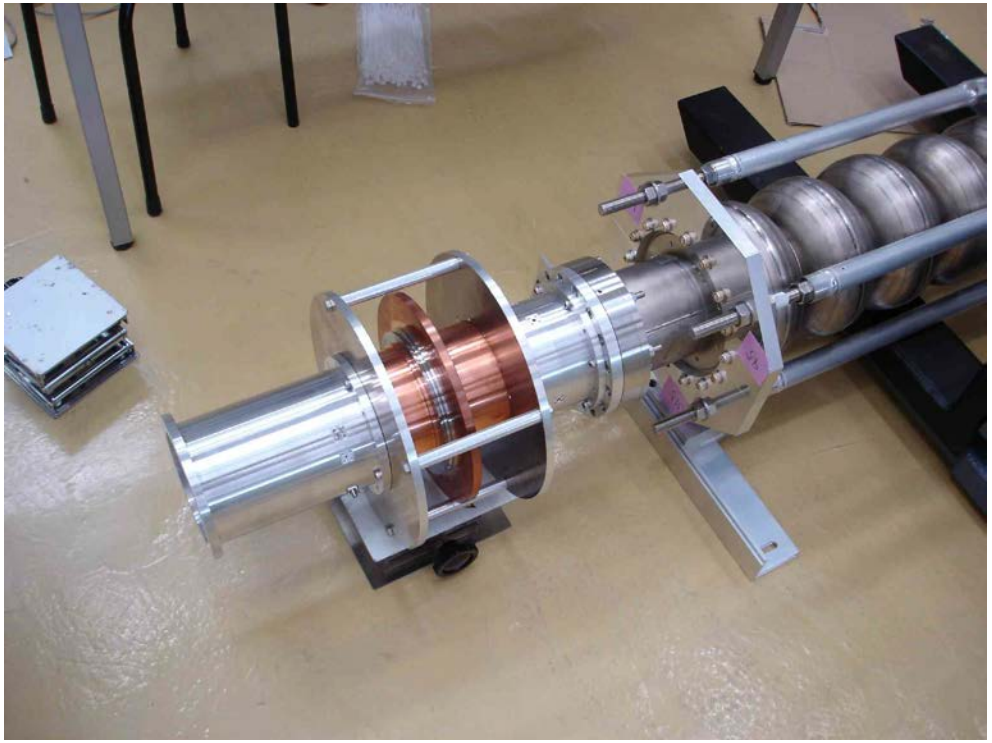


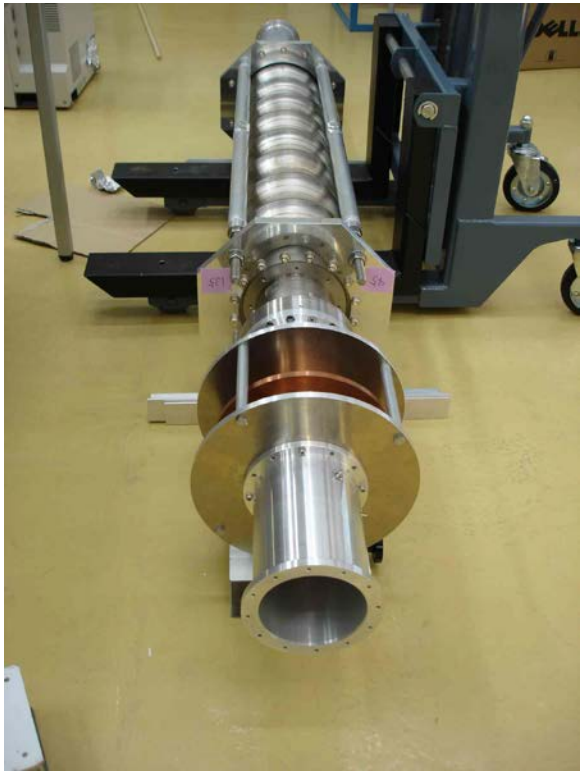



- Cracks occurred especially near taper
- More detail inspection with ultrasonic testing is in operation



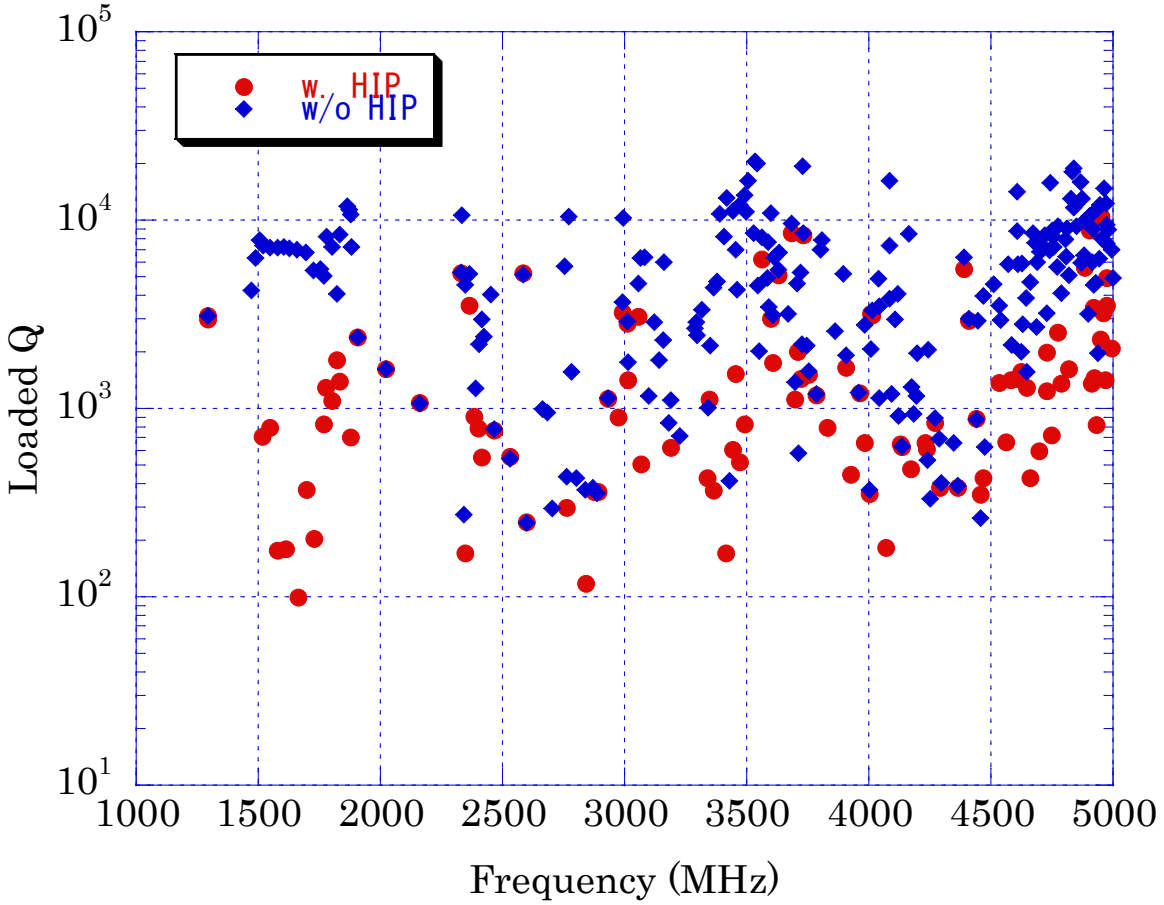
# HOM measurement with HIP ferrite at RT





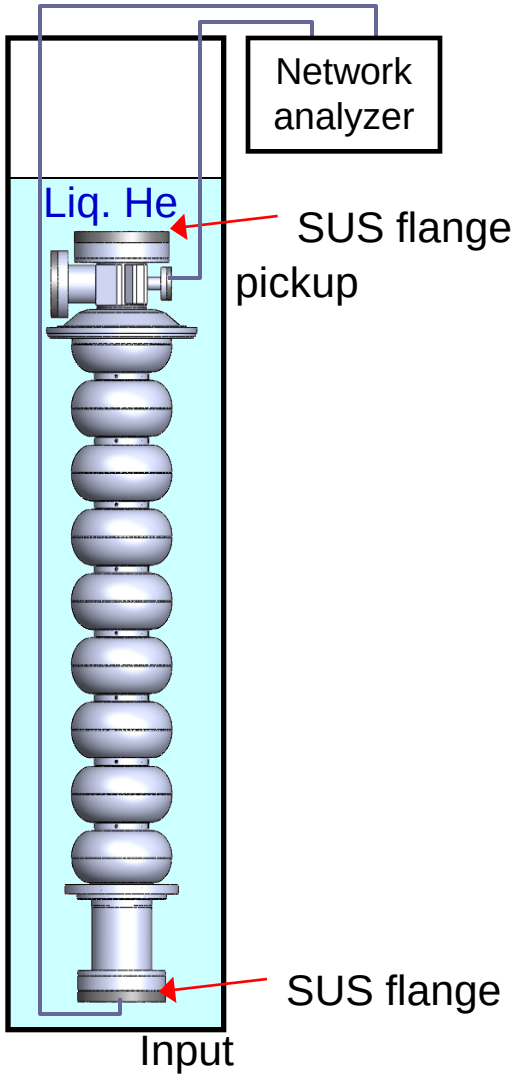
- Check position of HOM absorber
  - HOM absorber model with ferrite was attached to 9-cell cavity at the same position in a module
  - Measure loaded Q-value with and without ferrite

# Loaded Q-values at RT



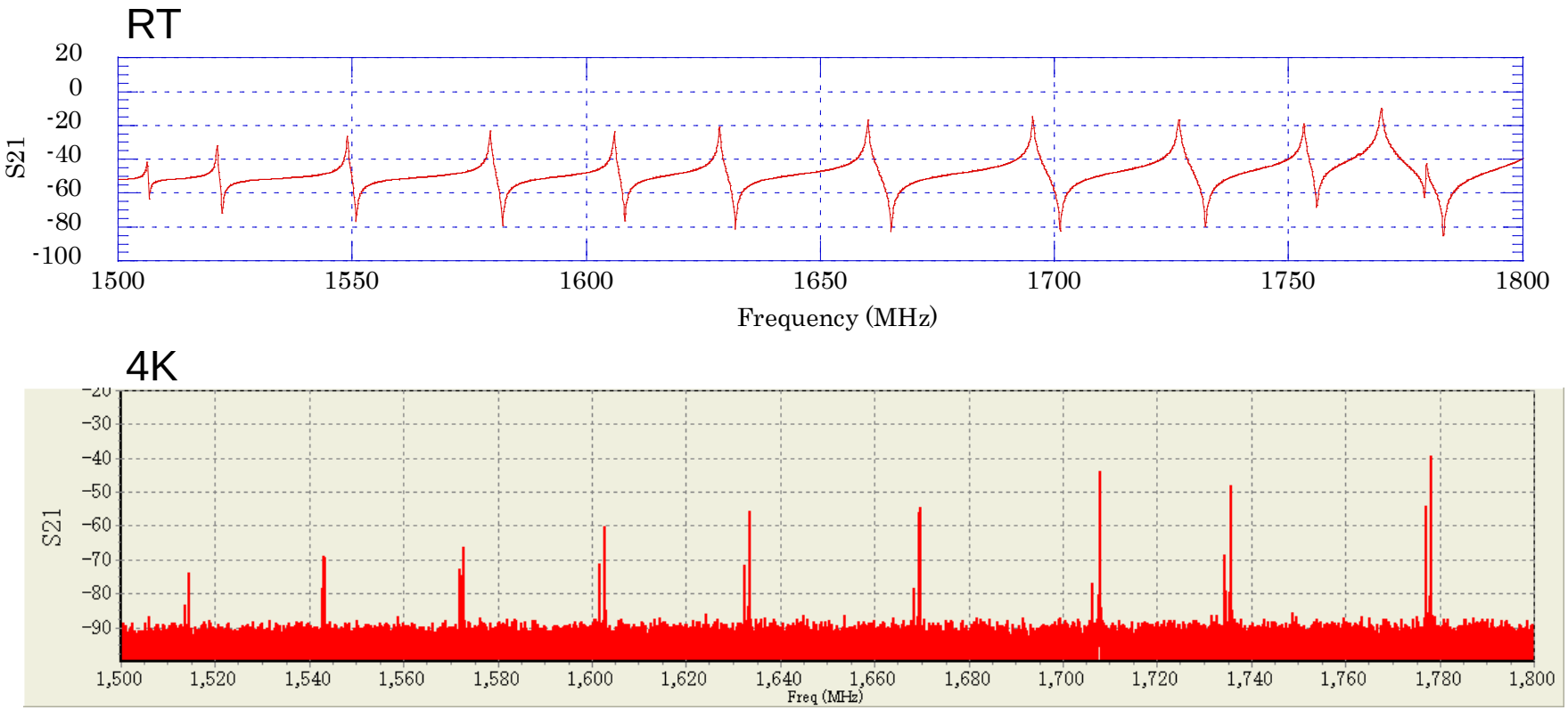

- HOM Q-values without ferrite were from $10^4$ to $10^3$
- HOM Q-values with ferrite decreased from $10^3$ to $10^2$

# HOM Measurement of Cavity at VT



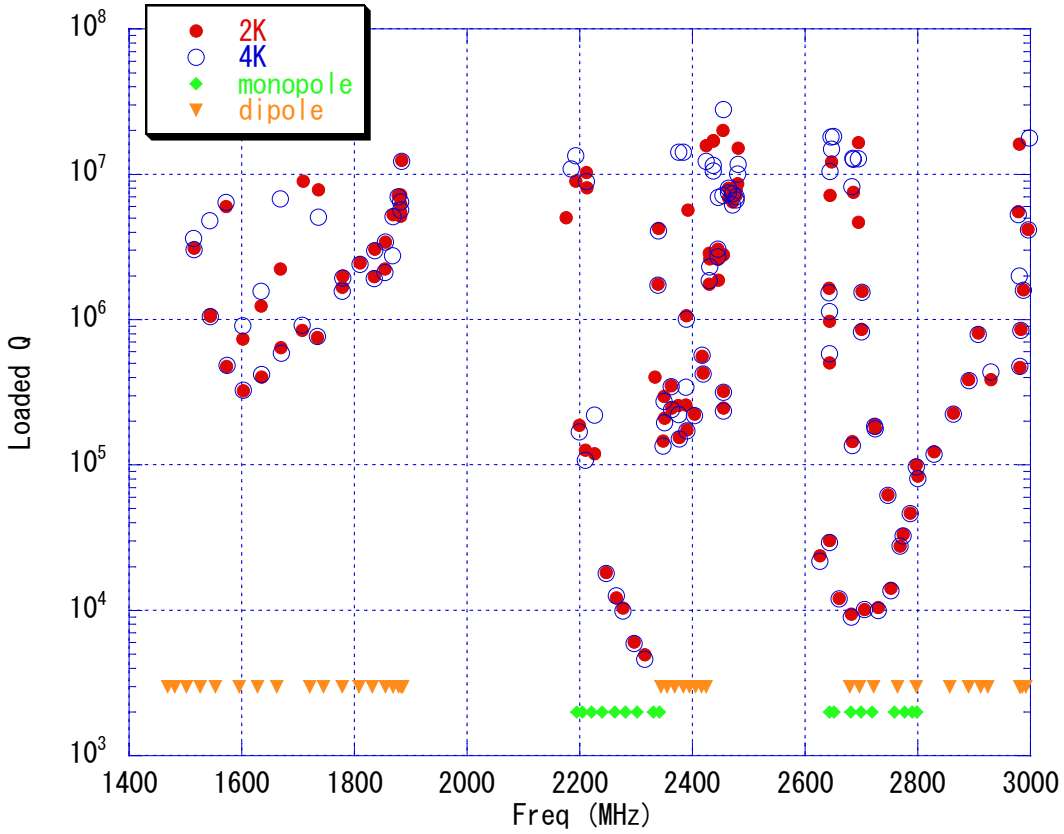

- Our vertical test setup
  - Beam pipe flanges are SUS
- HOM transported through beam pipe can be dissipated at SUS flanges
- HOM could be measured at VT with network analyzer

# HOM spectrum at RT & 4K



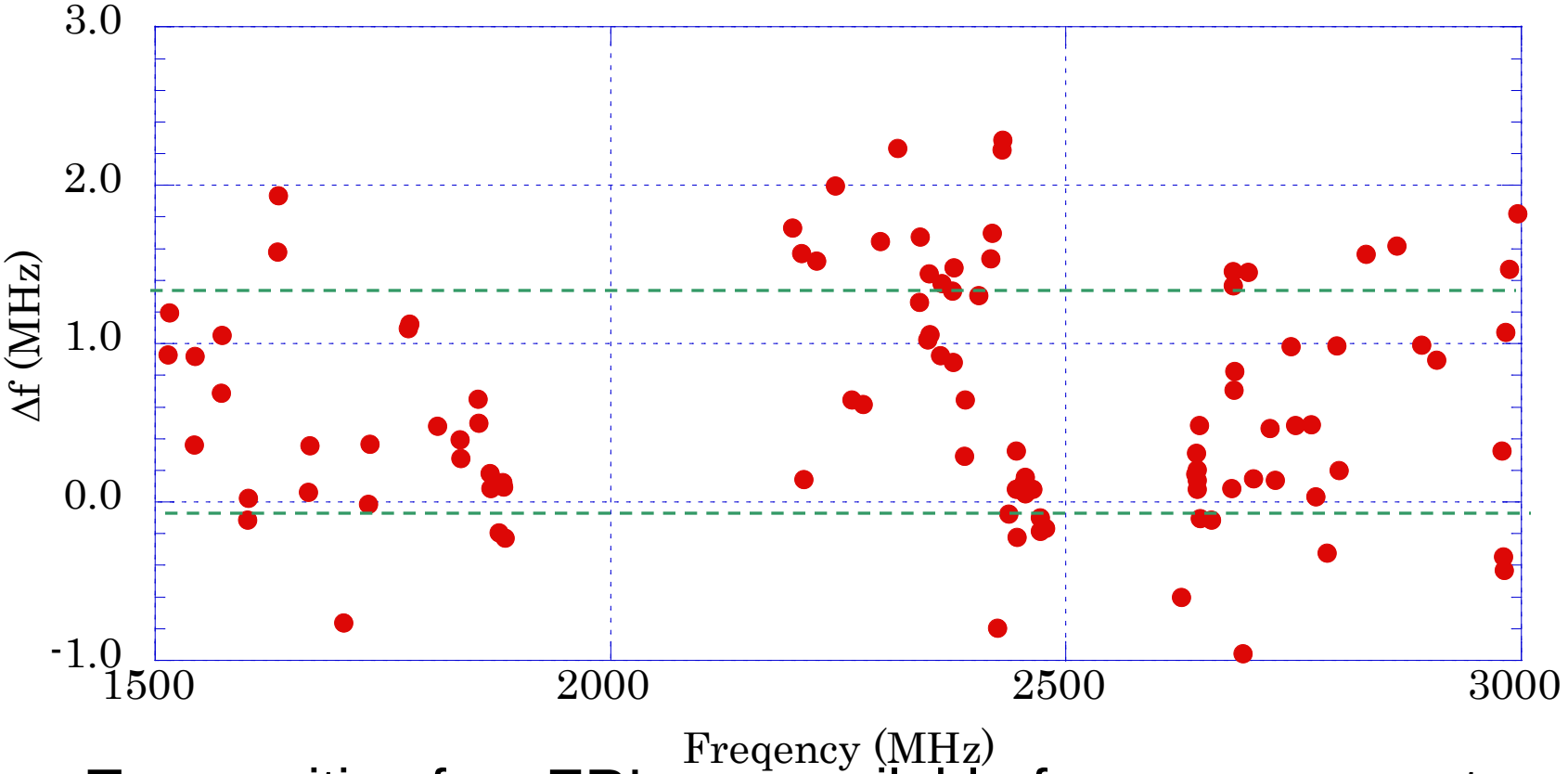

- HOM frequencies are different between RT and 4K
- Degenerate modes can be separated at 4K

# HOM Q-values at Liq. He



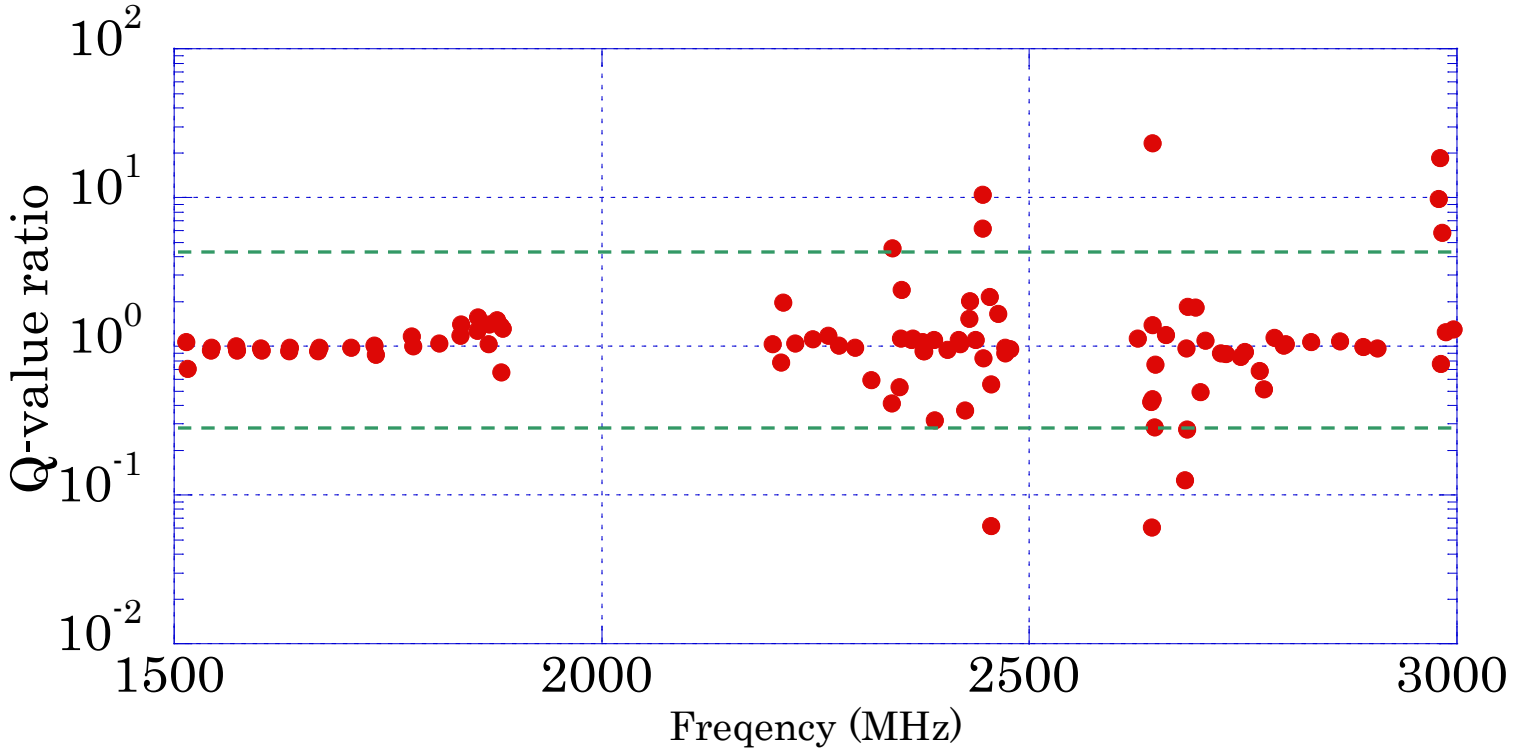

- Loaded Q-values were almost same between 4K and 2K
- $R_{BCS}(4K)/R_{BCS}(2K)$ ～40
- Main power loss was at SUS flange

# Frequency dispersion




- Two cavities for cERL are available for measurement
- Δf=±0.73MHz

# Q-value dispersion




- Many modes have almost same Q-values
- Dispersion within 3.8 times
- Several modes are different more than 10 times

# Summary

- HOM absorber model
  - Comb-type RF bridge may cause large heat transfer when combs contact
  - Modify comb-shape to reduce thermal conductance in case of comb contact
- HIP ferrite cooling cycle test
  - Cracks were observed especially near taper
  - Both end of ferrite will be machined not to taper but to round corner
- HOM spectrum in cavity
  - Frequency dispersion $\Delta f = \pm 0.73$MHz by two 9-cell cavities
  - Q-values vary almost within 3.8 times but several mode over 10 times
  - Frequency dispersion will increase threshold current, but Q-value dispersion may increase/decrease threshold current. Need BBU simulation with frequency and Q-value dispersion