SCC

(Feb.25　16:30-16:50　T.Furuya)

Superconducting Cavity

~ R&D-target of SC for 4 A operation ~

Feb. 25, 2002
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- **From the latest parameter list of SuperKEKB:**

	KEKB	SuperKEKB
Beam intensity	1.1 A	4.1 A
Number of bunches	5000	5000
Bunch charge	2 nC/bunch	8 nC/bunch
Bunch length	4 mm	3 mm
Accelerating voltage	1.5 MV/cavity	1.3 MV/cavity
Number of SC cavities	8	12
RF power	250 kW/cavity	460 kW/cavity

- **Figures achieved in KEKB**

	design	usual operation
Beam intensity	1.1 A in 5000 bunches	0.88 A in 1225 bunches
Accelerating voltage	1.5 MV/cavity	1.1-1.4 MV/cavity
RF power	250 kW/cavity	250-300 kW/cavity
HOM power	5 kW/cavity	7 kW/cavity

- **For heavy beam loading**

We have to consider;

1) HOM power
2) Input coupler of 500kW.

➔ Traveling RF of 800kW was given to the coupler at a coupler test stand.

- **HOM power is the one that we have to concentrate.**
- **Source of HOM power**

1) Trapped HOM

$$\text{HOM power} = R/Q \cdot Q \cdot I_0^{\,2}$$

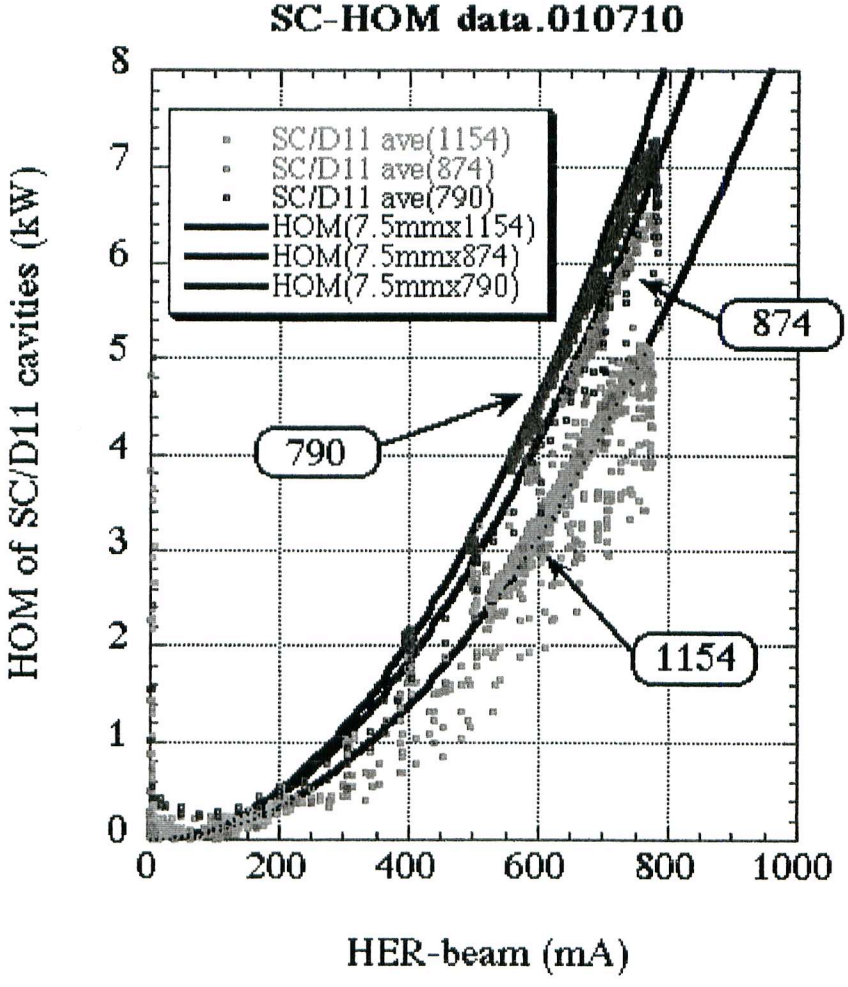
2) Wide range HOM, (loss factor k)

$$\text{HOM power} = k(\sigma_z) \cdot q \cdot I_0$$

$$= \frac{1}{f_{rev}} k(\sigma_z) I_0^{\,2} \frac{1}{N_b}$$

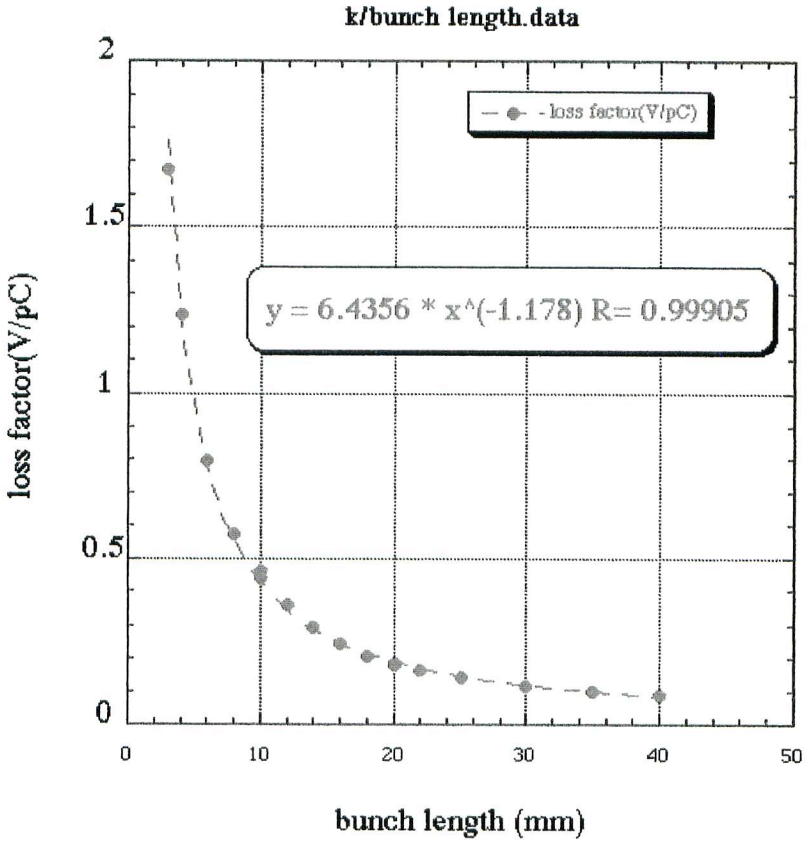
➔ Wide range HOM is dominant.

➔ Measured power is in agreement with the calculated one.



✓ **For existing cavities:**

❍ Loss factor k of 3mm bunch:



❍ HOM power of 80kW comes into a pair of ferrite dampers.

Power = 2.43(V/pC)*8e-9*4.1 = 80 kW

c.f. The k at 4mm is 1.8 V/pC.

➔ Estimated surface temperature of the ferrite reaches >250˚C!!!

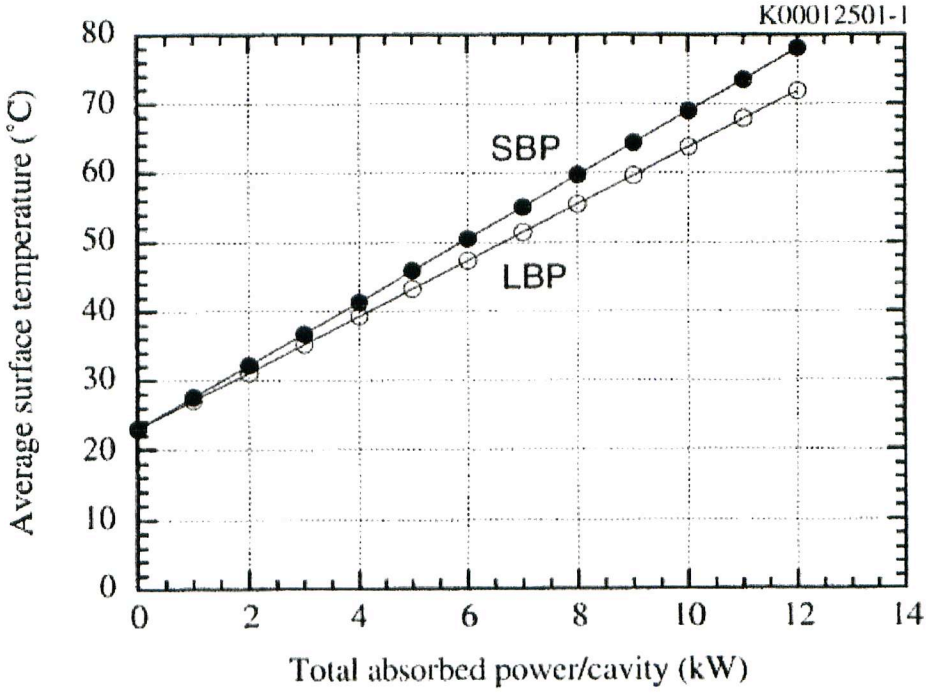
✓ **Power capacity of dampers**

➔ Out gas rate.

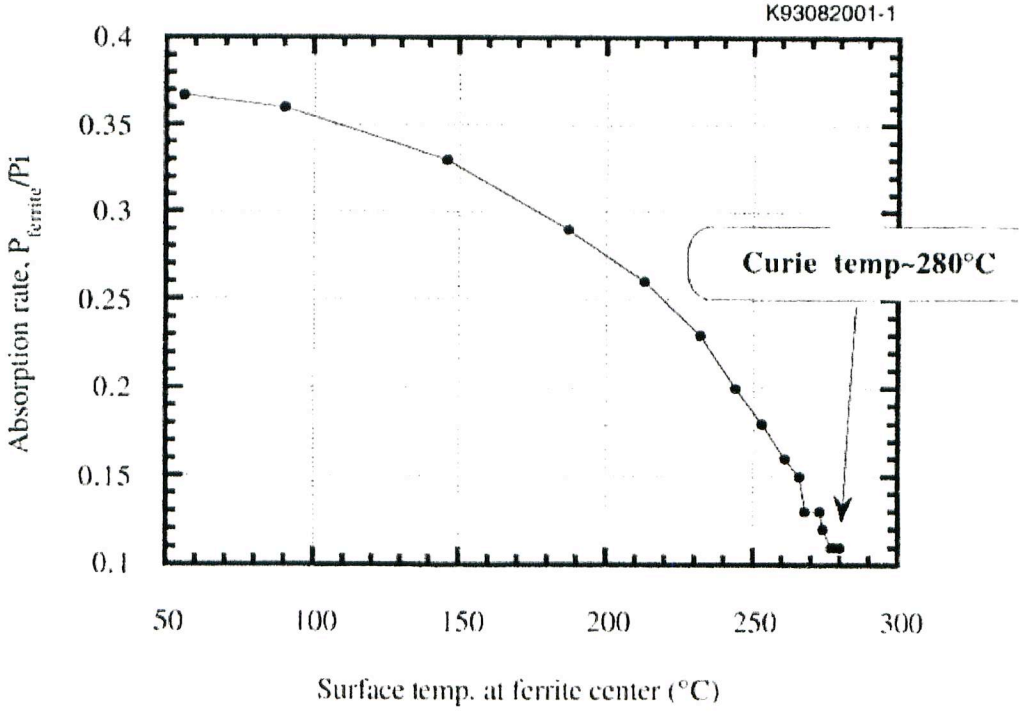
➔ Curie temperature of ferrite (280˚C).

➔ Reduce a loss factor without changing the cavity shape (inside of a cryostat).

1) HOM power vs estimated surface temperature.

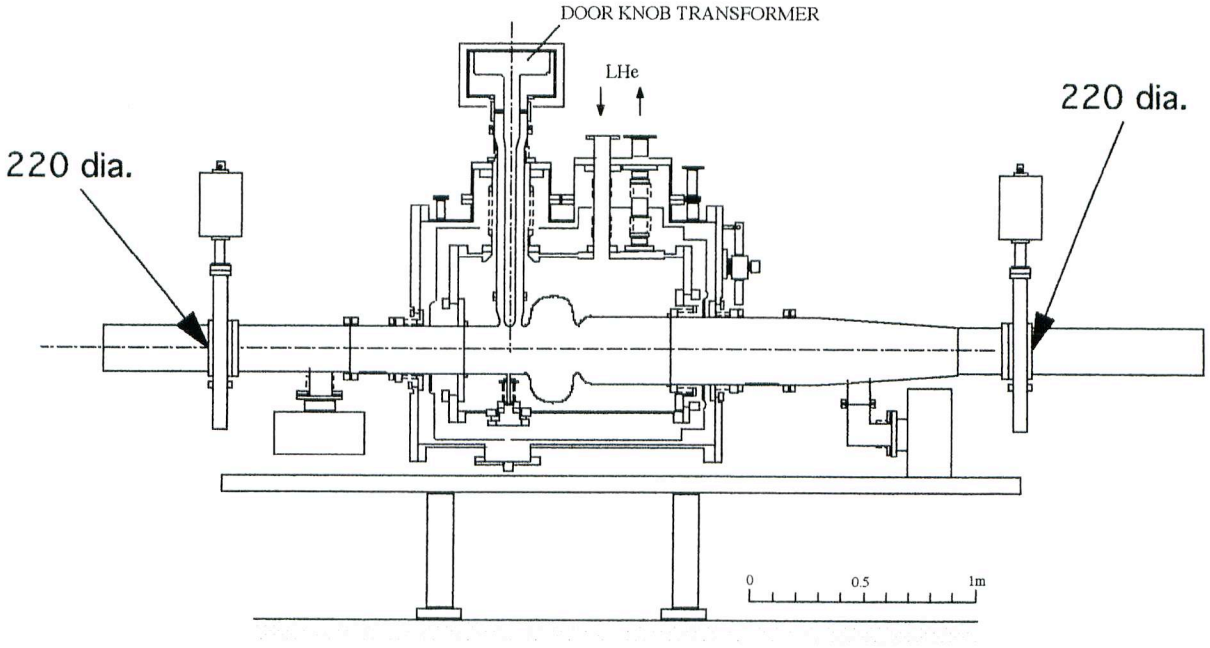


2) Power absorption vs temperature.

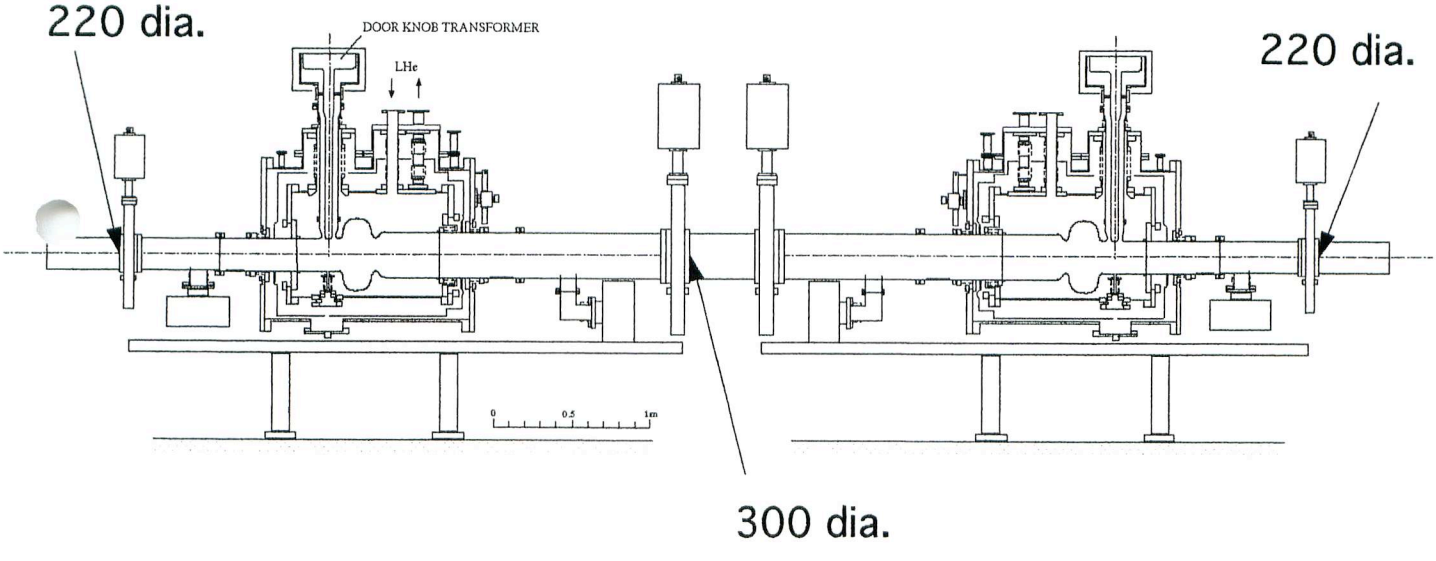


➢ Loss factor search

1) Size up of vacuum chamber from 150mm(dia.) to 220mm.



2) Connect 300mm(dia.) to 300mm.



➢ Loss factors in various cases

	k at 3mm		HOM/module at 4.1A x 5000	HOM/module at 4.1A x 5000 for 4mm bunch
1) existing	Taper-S Taper-L Cell Damper Total	0.264 0.709 0.856 0.6 2.43	80 kW	Total k = 1.83V/pC →59 kW
2) 220 duct	Taper-S Taper-L Cell Damper Total	0.0 0.204 0.856 0.6 1.66	55 kW	Total k = 1.37V/pC →45 kW
3) 300-300	Taper-S Taper-L Cell Damper Total	0.0 0.0 0.856 0.6 1.46	49 kW	Total k = 1.26V/pC →41 kW

- HOM power can be decreased to ~50 kW by changing tapers.
- Temperature rise at 50kW is still 120 – 140°C.
- The maximum power given to the dampers so far are;
  15 kW to LBP-damper,
  12 kW to SBP-damper,
  at a test stand.

➢ HOM damper for 50 kW/module

1) Reduce the ferrite thickness from 4mm to 2mm.

➔ Temperature-rise decreases to a half?

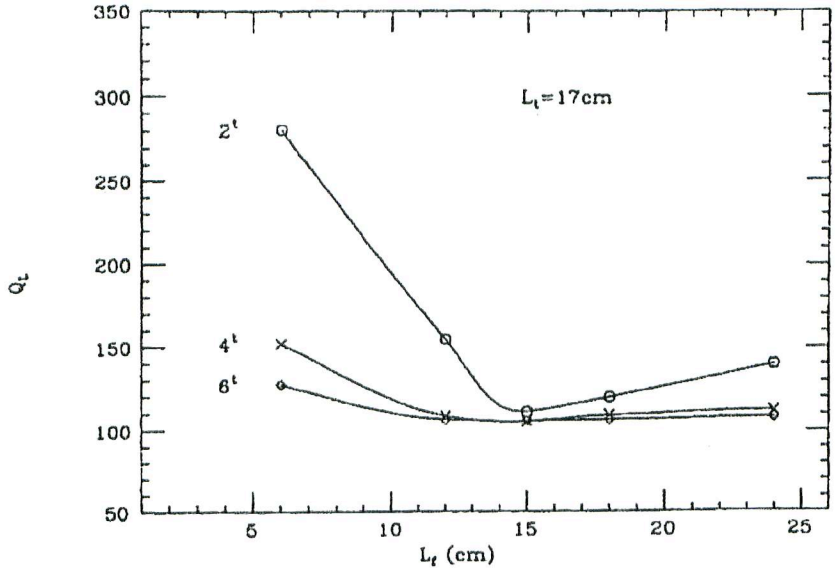
Assuming;

* thermal conductivity of ferrite of 7 W/mK,
* 30kW to LBP damper and 20kW to SBP damper.

Temperature rise is 60-70°C for both dampers.

➔ Need to check the Q of trapped-HOMs.

Simulation for the most dangerous mode (TM_{011}) shows a similar Q-value of around 150.



g. 6.2-3: Q as a function of ferrite length, L_f, when the distance from the taper is 17cm. Thickness was taken

➔ A test damper with 2mm ferrite is under fabrication.

2) Use a SiC damper because of its superior thermal conductivity?

➔ Thermal conductivity of ~150 W/mK.

➔ Need to optimize the damper shape and location.

➢ Summary

1) HOM power is a serious problem for the dampers under 4A operation.
2) Estimated HOM power at 4.1A reaches 80kW/cavity for existing cavities.
3) By changing the taper section, the loss factor can be reduced to 1.66 V/pC, which correspond to 50kW/cavity.
4) To reduce the surface temperature of ferrite at 50kW;
   - ✓ Reduction of ferrite thickness to 2mm,
   - ✓ Use of SiC damper.
5) R&D of HOM damper is essential for the SC of SuperKEKB.