Superconducting RF Activities at KEK

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[I] Operation of 32 superconducting cavities in TRISTAN.

In the summer of 1988, the first 16 (5-cell, 508MHz) superconduting cavities were installed in TRISTAN ring.The beam energy was increased from 28 GeV to 30 GeV. After one year operation, the last 16 superconducting cavities were installed in the summer shut-down of 1989. The refrigerator cooling power of 4.2 Kw at 4.2 K was also upgraded to 6.5 Kw by adding a turbine and compressor units. At this period all higher order mode(HOM) extraction cables were changed by the warter cooled cable to increase beam intensity, limited by temperature rise of type N connectors of the cables.

In the fall of 1989 the beam energy was increased to 32 Gev by using 200 MV superconducting cavity accelerating field. Figure 1 shows the cross section of the cryostat and Fig.2 shows a string of SC cavities in the TRISTAN tunnel. After the highest energy run, the beam energy was lowered to 29 GeV for high luminosity run. The beam current was limited to 13.5 mA due to the heating-up of the type N ceramic connectors used for extracting HOM power. At summer shut-down of 1990, all HOM extracting cables were changed to the new system shown in Fig.3.

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The measured accelerating fields after two year operation are shown in Fig.4. Almost all cavity performance did not degrade. The superconducting cavities was kept at cooled condition more than 5 months, the vacuum pressure increased from 10^{-10} Torr to 10^{-9} Torr by hydrogen gas. In worse vacuum condition and with beam some cavity frequently discharged and suffered break-down.[1)]

Like other high power RF systems, the high power ceramic window is the most critical component of the high power superconducting cavity system. The troubles of our input couplers are described in Table 1. The arcing detectors are very useful to avoid large ceramic breaking. In the case of minute pin-hole leaks, cavity performances were recovered by only the replacement of input couplers.[2)]

In the last operation period we experienced many breaking of the piezo-electric elements used for the frequency tuners. For radiation tightness, we changed binding bolts of piezo-electric elements from organic material to metalic one (SUS). After this replacement, 18 piezo-electric elements were broken by mechanical shock due to rapid increase of driving high voltage. We started re-using organic bolts and adding more lead radiation shield around piezo-elements.

〔II〕 Spare Cavities

Though almost all the cavities have shown no degradation of performance, some cavities had to be repaired and we must study the problems related to the difference of the performances between the laboratory tests (vertical tests) and the full-assembled tests (horizontal tests) for future higher gradient application.

For this purpose, spare cavities and off-line cavity cooling stands are demanded to store spare cavities under regulation. Four spare cavities have been made and two off-line cavity cooling stands were constructed at the klystron gallery above the tunnel. One cavity (18b) among these four, recorded the highest accelerating gradient (Eacc) of 15 MV/m at the vertical test as shown in Fig.5.[3)] Figure 6 shows distribution of accelerating field gradients of spare cavities.

〔Ⅲ〕 Thermal cycle tests

Recently, Q degradation of superconducting Nb cavities has been reported from several laboratories in the world.

For a single cell cavity and a 5-cell cavity, thermal cycle tests were performed. No degradation was observed for these cavities. As usual process of KEK surface treatment, these cavities were annealed at 700 ℃, 90 min. Large amount of hydrogen gas was desorbed during this process. This problem is reported in this workshop. [4)]

〔Ⅳ〕 Effort for TESLA

A research and development of L-band superconducting cavities started at KEK in 1989 for superconducting linear collider "TESLA". An optimized cell shape was studied and the single cells have been made. The vertical cryostat and He gas pumping station were constructed. In the initial test of the single cell L-Band cavities, the maximum accelerating field of 14 MV/m was achieved. Details of this R & D is reported in this workshop. [5)]

〔Ⅴ〕 B-Factory and synchrotron lightsource

After finishing high energy experiment at 29 GeV, TRISTAN ring will be used as synchrotron lightsource at 10 GeV with current of 100 mA. And two more rings will be constructed for the B-Factory in TRISTAN phaseⅢ.

For this purpose, we just started to design a superconducting cavity for B-Factory. We are studing a simple cavity shape with a round "flared" beam pipe. The model test will be down by modifying an existing single cell cavity which already reached 10 MV/m. The main RF parameters of B-Factory are shown in Table 2. Figure 8 shows conceptual design of superconducting cavity for TRISTAN B-Factory. In this design we planned to use coaxial input coupler which are now tested upto 200 KW.

The demanded refrigerator power and the number of cavities are shown in Fig.7. This curve indicates that the refrigerator of 6.5 KW now operating has enough power for B-Factory.

One of the most critical component in this system is the higher order mode damper at beam pipes. As an initial stage, we are now testing the ferrite 50 developed at Cornell University [6] and some of the ferrite tiles, used for microwave dark room. We now preparing model tests of HOM absorber. This HOM damping method could be applied to modify our existing 5-cell cavities for high current use as synchrotron lightsource in the future TRISTAN phase Ⅲ.

〔Ⅵ〕 Acknowledgements

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3) T.Tajima et al., "Spare Cavities for TRISTAN 508 MHz SC Cavities" this workshop.

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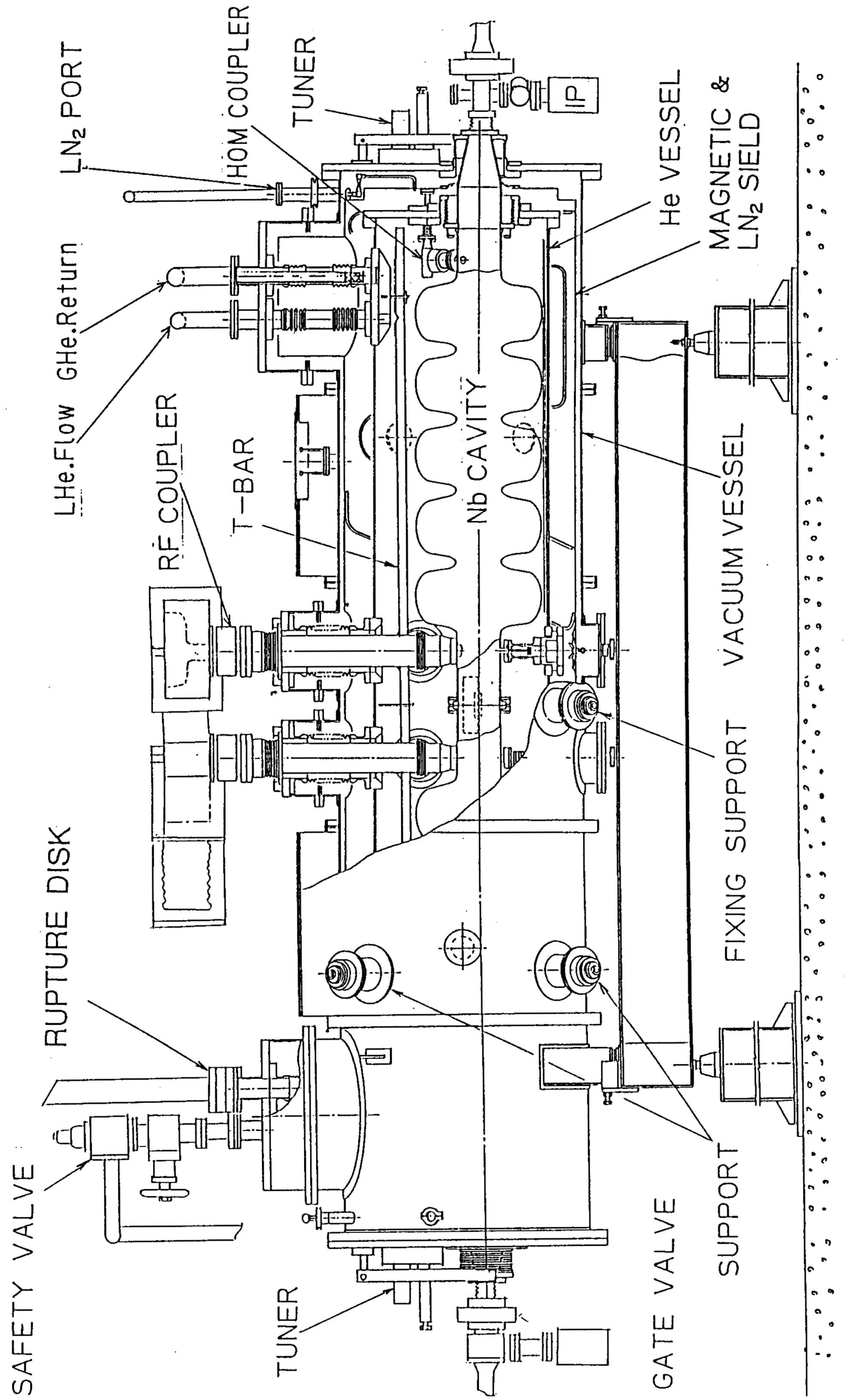


Fig.1 TRISTAN superconducting cavity

Fig.2 The string of SC cavities in the TRISTAN tunnel

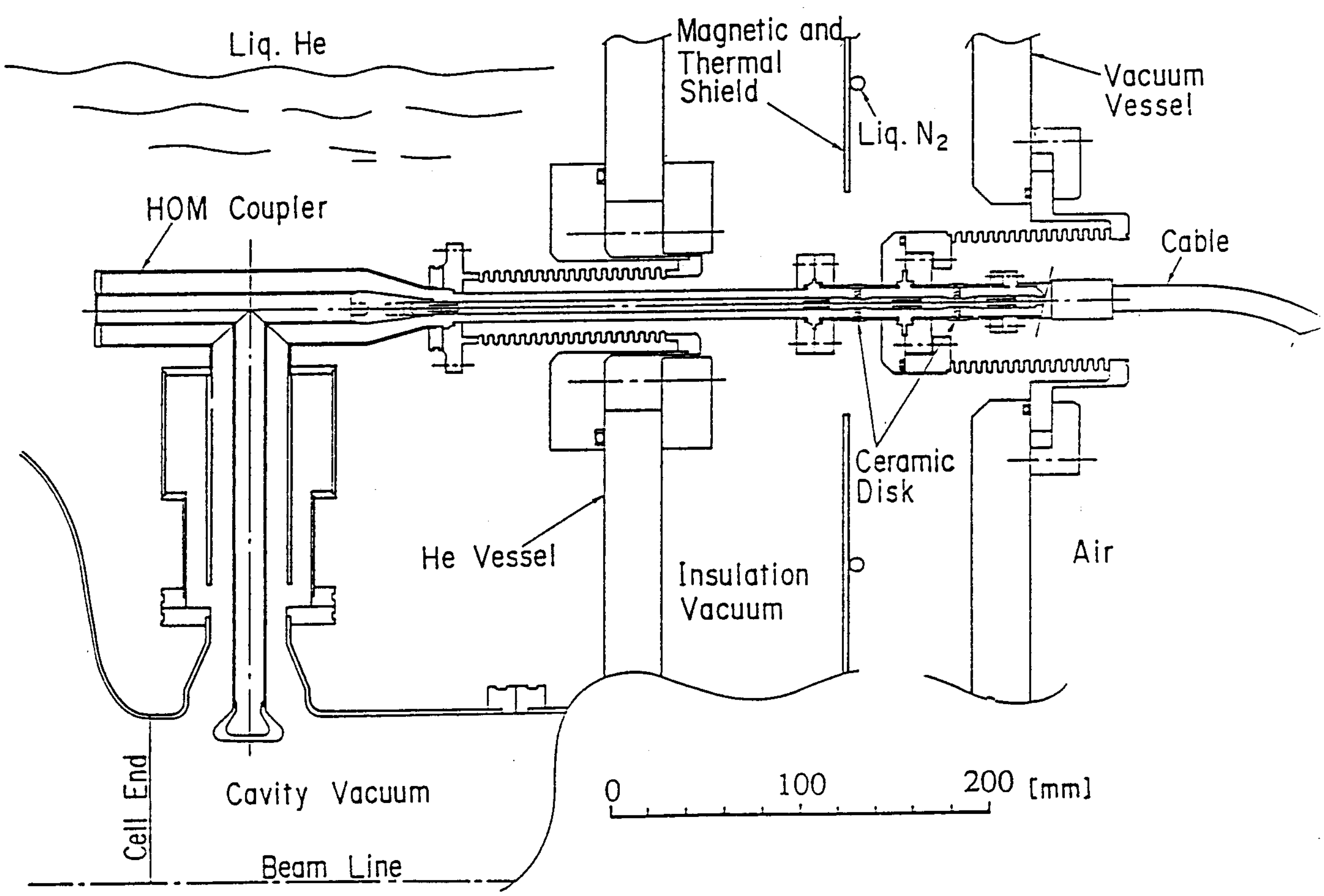


Fig.3 A new developed higher order mode extraction system

Table 1. Summary of ceramic window leak of input coupler.

Cavity;	Day;	Temp.;	Staus;	Damage of window
(1) 11B#3,	Jan.1989,	4.4K,	aging at beam-off,	crack.
----detuned because of low Eacc, max(OK in the vertical test after retreatment, but 3.0 MV/m in the horizontal rest).				
(2) 10B#1,	Feb.1989,	4.4K,	rf recovery with beam,	pin-hole,
----OK after replacement of input couper.				
(3) 10B#1,	Oct.1989,	300K,	shut-down,	pin-hole.
----OK after replacaement of input coupler.				
(4) 10D#2,	Jun.1990,	4.4K,	aging at beam-off,	burnt PE-disk.
----OK after replacement of input coupler.				
(5) 10C#3,	Jan.1991,	4.4K,	aging at beam-off,	crack.
----detuned because of a serious arcing of coaxial parts.				
(6) 10A#2,	Jul.1991,	4.4K →300k,	cooling warter (~30l) leaked into cavity.	
(7) 10B#1,	Jul.1991,	4.4K?		burnt TEFLON-disk

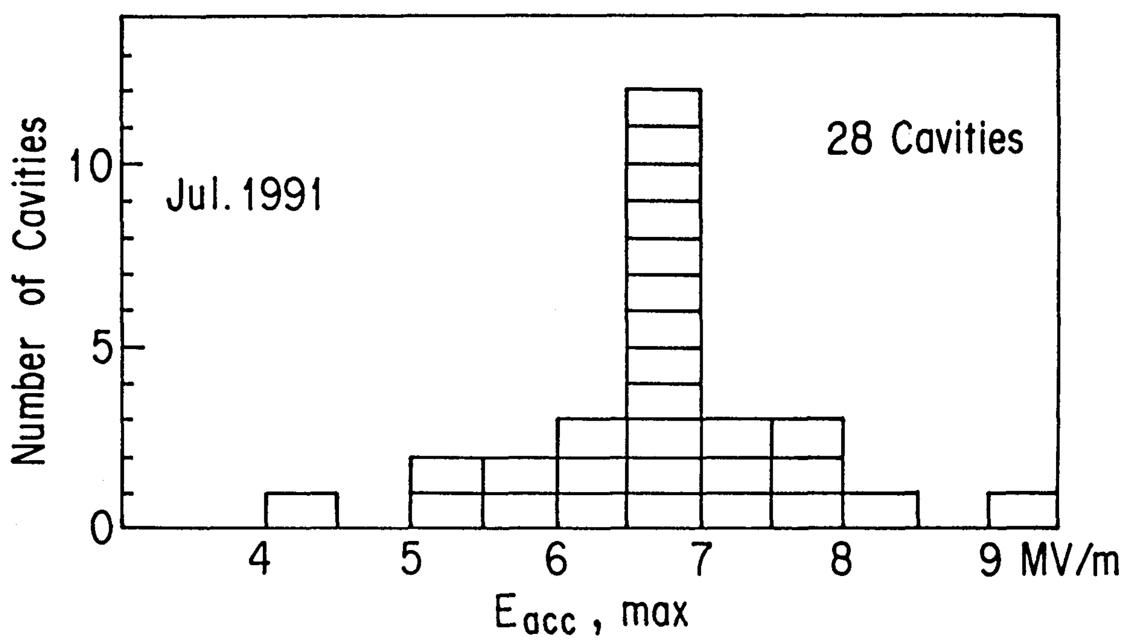


Fig.4 Distribution of accelerating field gradients of 28 5-cell cavities after two year operation. (2 cavities were not connected with RF system. Another 2 cavities off-lined due to leak)

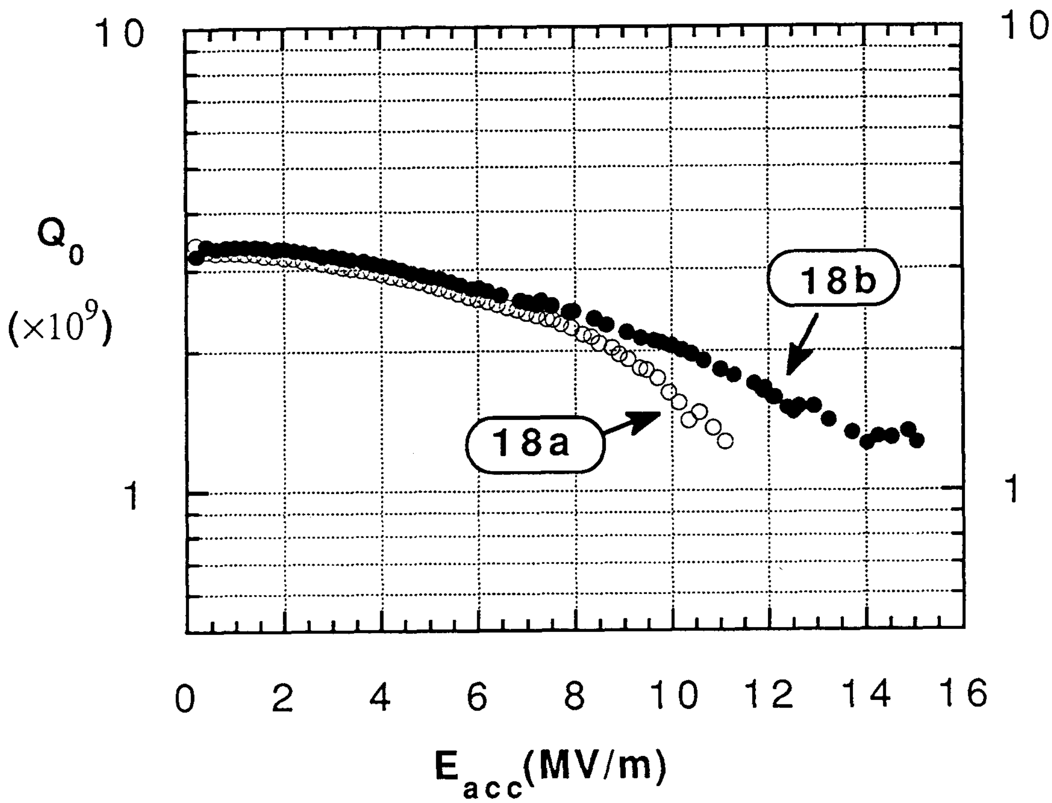


Fig.5 Qo-Eacc curve of the superconducting cavity

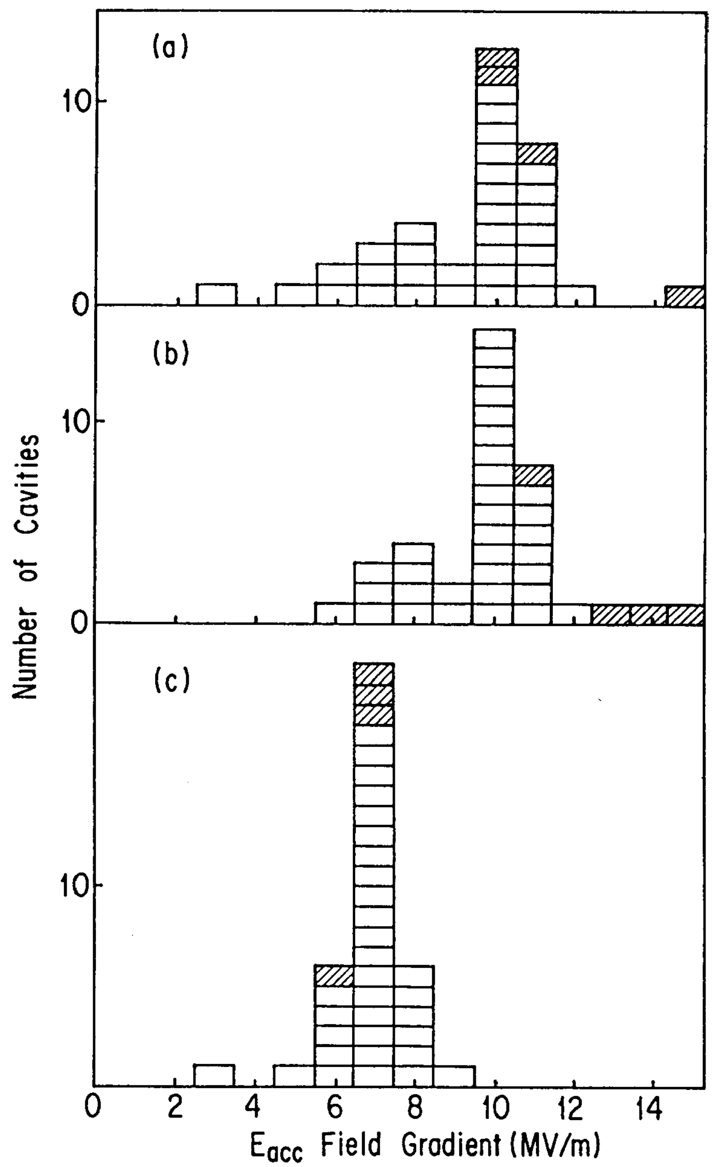


Fig.6 Distribution of accelerating field tradients of 32 TRISTAN cavities and spare cavities (hatched box)
(a) initial vertical test
(b) vertical test after retreatment
(c) after full assembly (horizontal test)

Table 2. Main RF Parameters of KEK B-Factory

	LER (e^+)	HER (e^-)
Beam Current	2.6 A	1.1 A
Energy Loss/turn	0.96 MV	4.2 MV
RF Voltage	22 MV	48 MV
COSθ	0.0436	0.0875
Q_L	$< 2.9 \times 10^5$	$< 3.7 \times 10^5$
Tuning Angle Δf	20 kHz	8 kHz

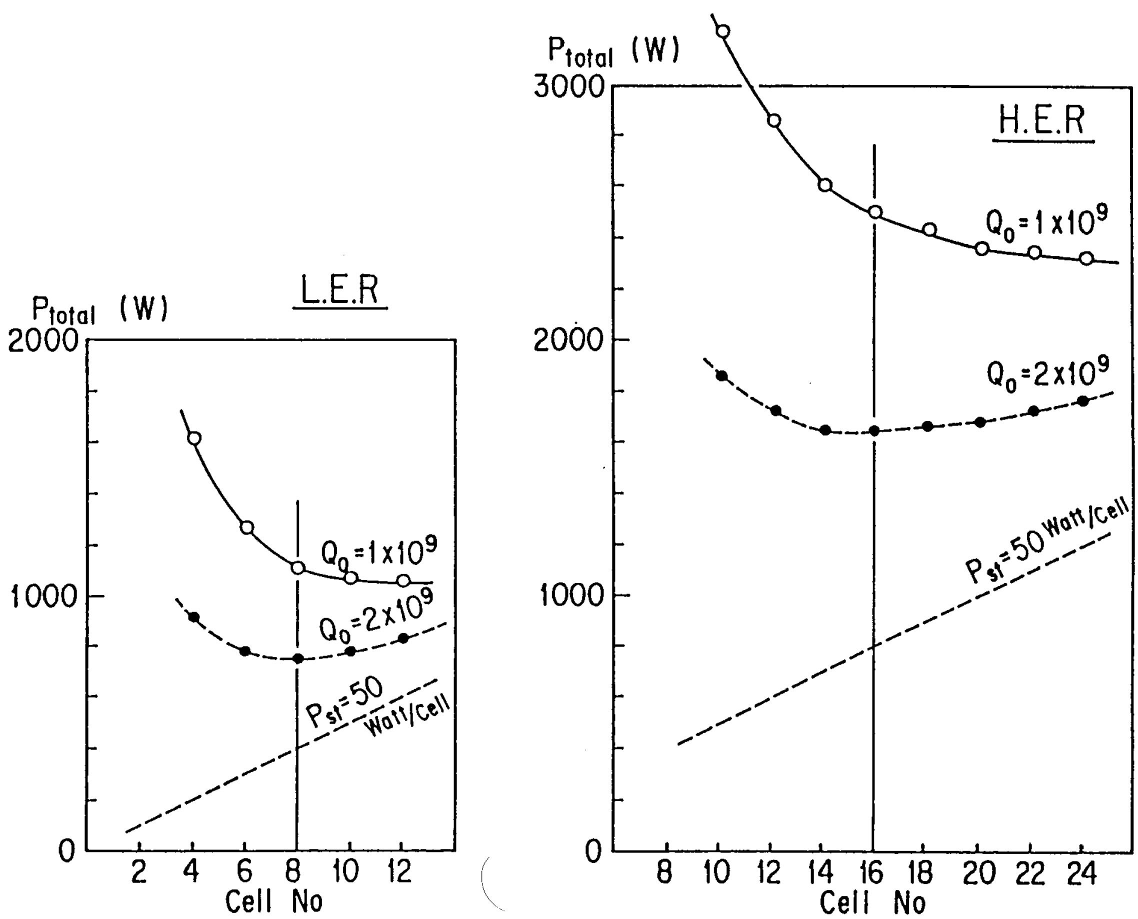
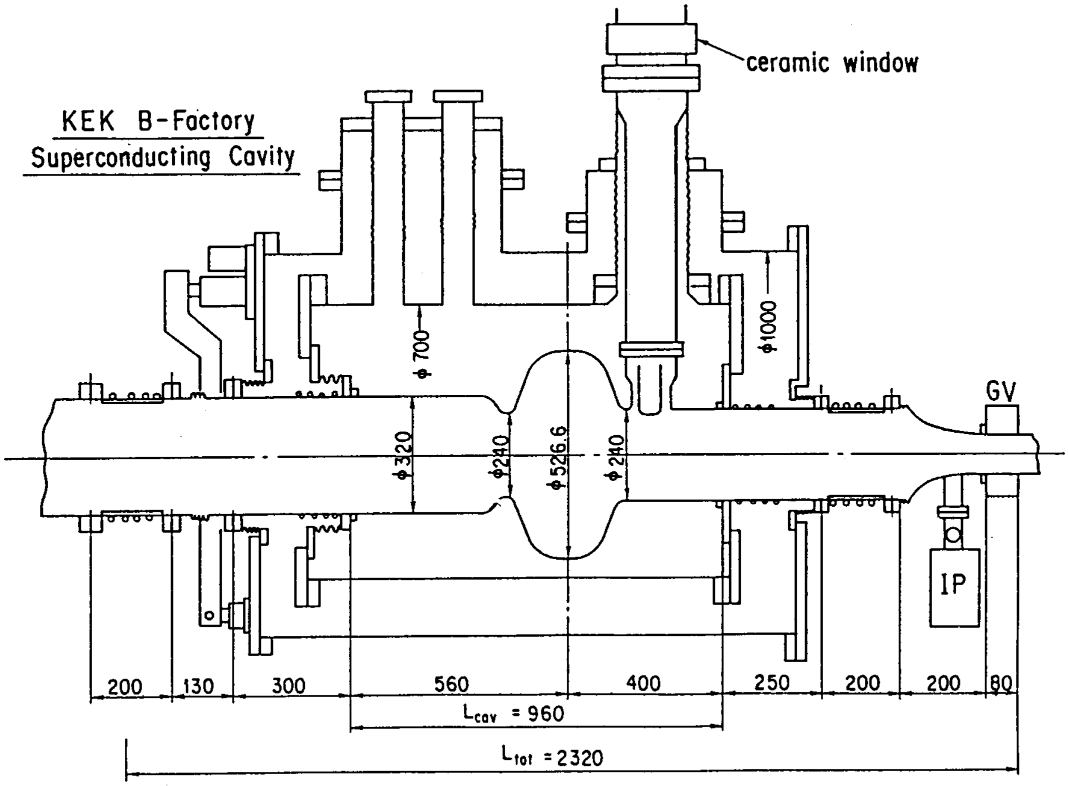
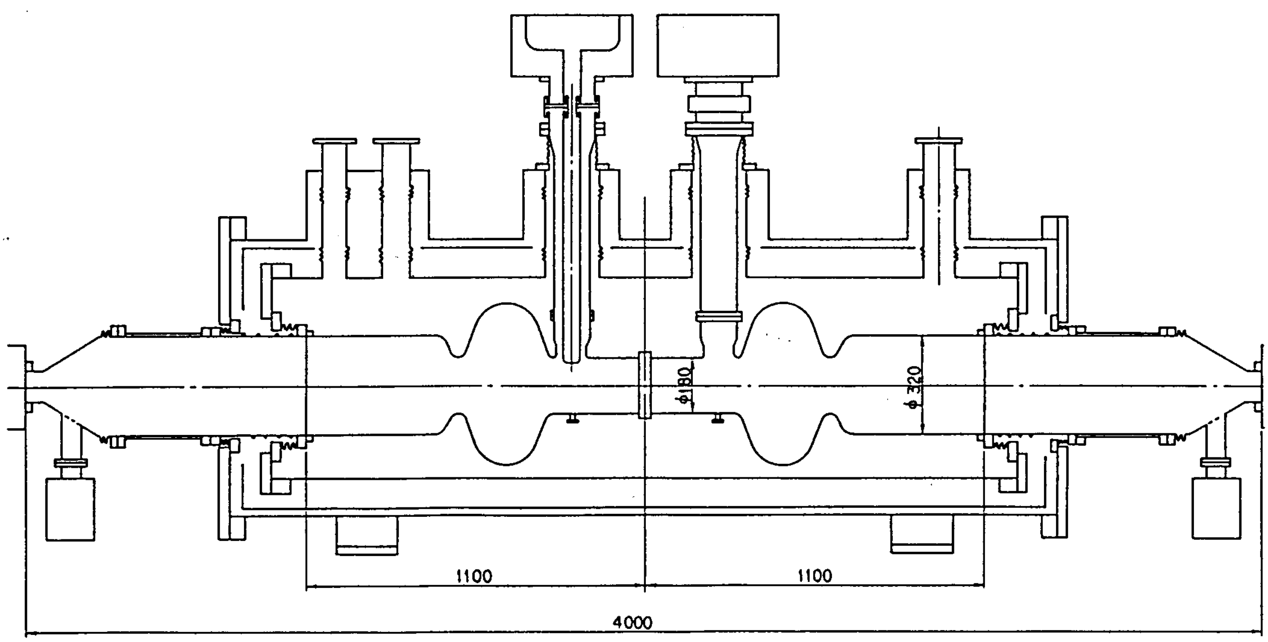


Fig. 7 Number of superconducting cavity cell and required refrigeration power for B-Factory





KEK B-Factory Superconducting Cavity
(High Energy Ring)

Fig.8 Conceptual design of superconducting cavity for TRISTAN B-Factory