Superconducting Rf Activities at JAERI

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Abstract

The superconducting tandem booster and the free electron laser are under construction at JAERI. The tandem booster is in the final stage of its construction. The installation of all beam line components has been finished. The booster is just before beam acceleration. On the other hand, in the superconducting accelerator of the free electron laser, 4 acceleration modules have been installed. Refrigeration systems and the resonators have been tested and expected results have been obtained. The accelerator is under commissioning.

§1. Introduction

Two projects of superconducting accelerators have been proceeding at JAERI. One is the tandem superconducting heavy-ion booster linac and the other is superconducting free electron laser. Resonators and refrigeration systems in two accelerators have been tested. In this paper, the status of constructions and developments of the two projects are described.

§2 The tandem booster

2-1 The status of its construction

The tandem booster[1)] is in the final stage of its construction.

In 1992, the fabrication of the rest of 24 resonators and 16 cryostats was finished and they were delivered to JAERI. The new building was constructed and two refrigerators were installed. The performance tests of cryogenics were made and the refrigeration powers were confirmed. In this year, the surface treatments for 24 resonators have been finished and the resonators have been set in the cryostats. The installations of all beam line components have been finished in this summer(Fig.1).

A lay out of the building for the booster is shown in Fig.2. The 13 cryostats of the booster (buncher, sub-buncher, 10 cryostats of the linac and de-buncher) are set on the beam line. Each cryostat of the linac has four resonators in it. Beam diagnostics instruments are set on the beam line. For transverse beam diagnostics, beam profile monitors are installed between

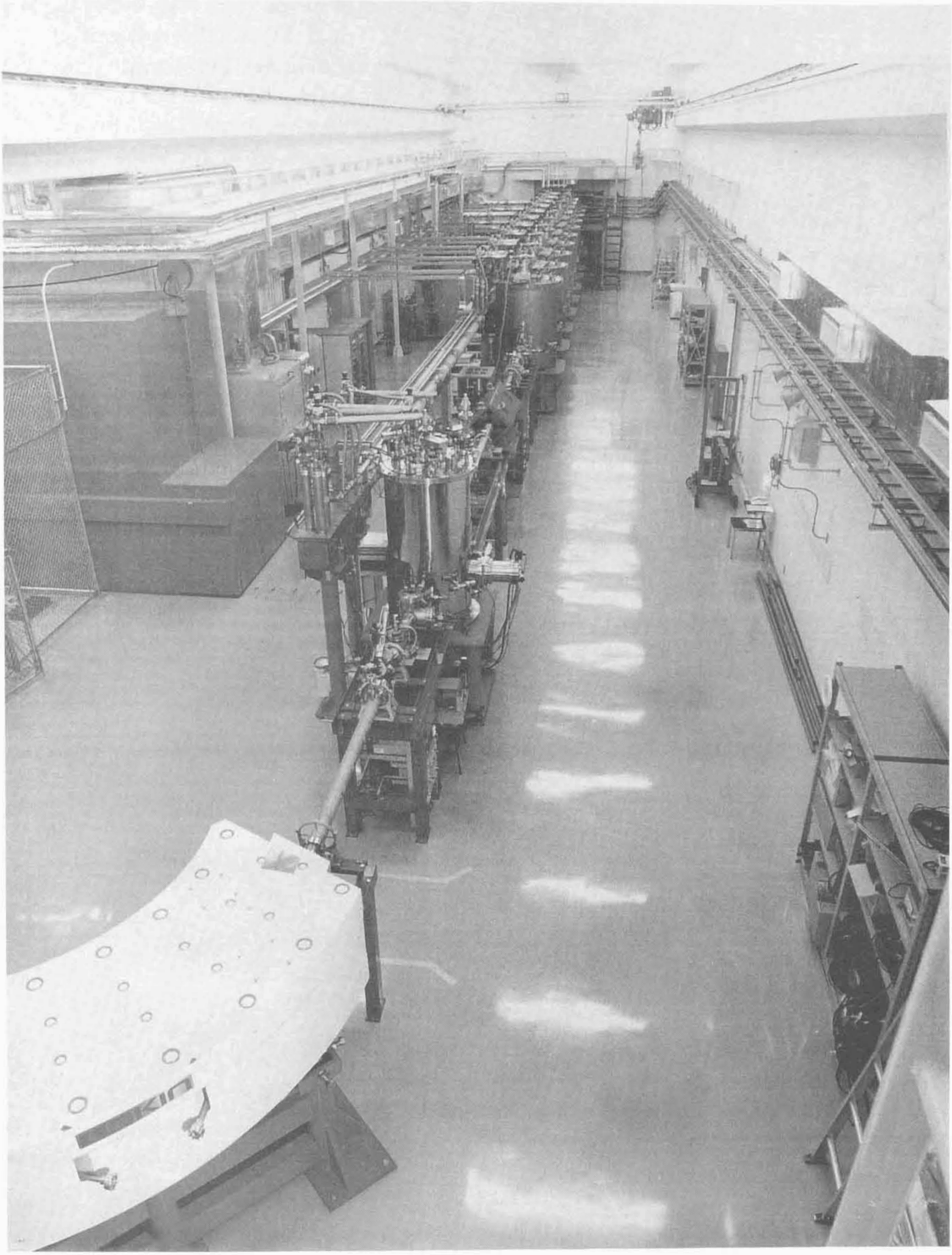


Fig.1 Over all view of the JAERI tandem booster.

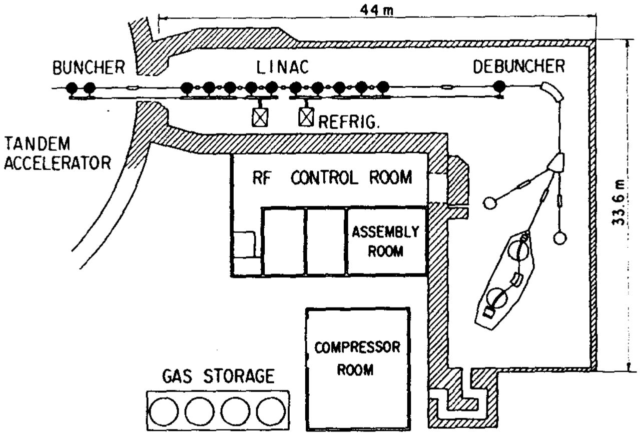


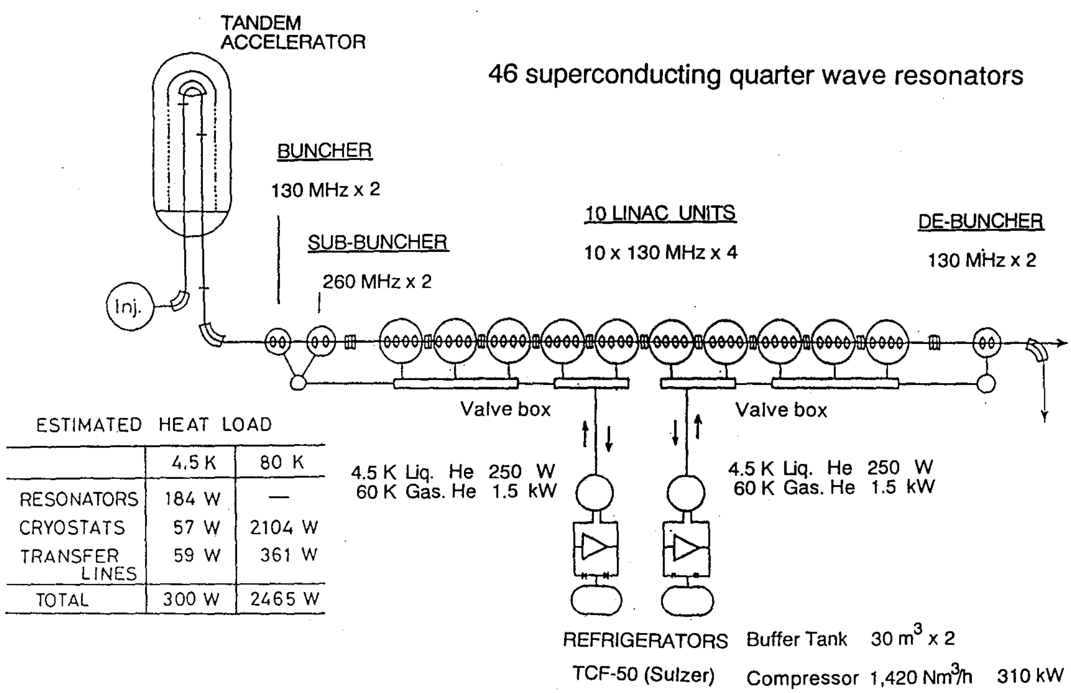
Fig.2 A lay out of the tandem booster.

buncher and sub-buncher, in front, middle and exit of the linac. For longitudinal beam diagnostics, energy-time detectors which are composed of Au target foils and silicon detectors are placed in front and at exit of the linac. The energy and time spectra are displayed two dimensionally on a CRT. Three beam bunch phase detectors are placed between no.3 and no.4 units, no.6 and no.7 units and exit of the linac.

In the rf control room, there are 46 rf power amplifiers, rf controllers provided by Applied Superconductivity Incorporation and some beam monitoring equipments. Rf powers are supplied to resonators from the rf control room.

2-2 Cryogenics

Two identical refrigerators(Sulzer's TCF-50) were equipped for the booster



	4.5 K	80 K
RESONATORS	184 W	—
CRYOSTATS	57 W	2104 W
TRANSFER LINES	59 W	361 W
TOTAL	300 W	2465 W

Fig.3 Schematic diagram of the refrigeration system for the tandem booster.

as shown in Fig.3. One is used for the buncher, sub-buncher and from no.1 to no.5 linac units. The other is used for from no.6 to no.10 linac units and de-buncher. The refrigerators are automatically operated by computers. Each refrigerator has a refrigeration power of 250 watts for 4.5 K liquid helium loop, 1,500 watts for 60 K gaseous helium loop. Each refrigerator has a screw compressor of 1,420 Nm^3/h (70 g/s) driven by motors with an output power of 310 kW and two buffer vessels of 30 m^3. The refrigerators do not use liquid nitrogen. The 60 K loops are used for radiation shielding for resonators and liquid helium transfer lines. The refrigerators do not have a liquid helium storage vessels outside the coldboxes or cryostats. Gaseous and liquid helium are branched in the valve boxes and supplied to cryostats in parallel. In the valve boxes, there are remote controlled helium distribution valves which are operated at the rf control room.

2–3 Resonator performances in off–line tests

The surface treatments by electro–chemical polishing were made for newly delivered 24 resonators and 8 of them were tested. In the off–line test, the resonators were put in the cryostat for the off–line test. They were precooled by liquid nitrogen and cooled down to 4.2 K one by one as fast as possible. A distribution of accelerating field gradient at an rf input power of 4 W for tested 28 resonators including previously reported 20 ones is shown in Fig.4. The averaged value of $E_{acc}(P_{in}=4W)$ was about 7 MV/m. (We report in detail in the other paper in this workshop[2)]).

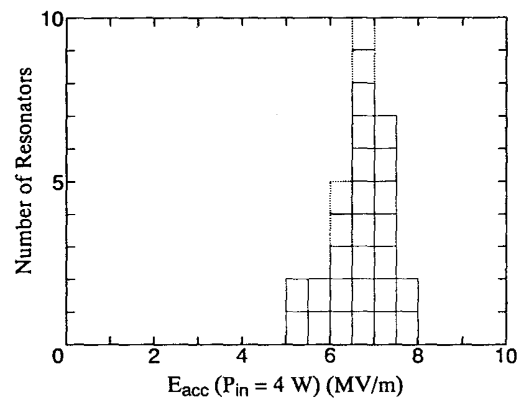


Fig.4 Rf performances of resonators.

2–4 Performance tests of the refrigerators and On–line tests for the resonators

The refrigerators are programmed as follows. At first, the radiation shields are precooled to 150 K, next the liquid helium vessel and the resonators are cooled down to 4.5 K. It took about 2.5 days to cool down the resonators as shown in Fig.5. It took about 4 hours for each resonator to across the dangerous temperature region of 130 K–90 K. Severe Q–degradations were observed in some resonators in the upper stream part and not observed in the down stream part.

We are going on cooling tests now. In this November, we will accelerate the first beam. In next year, the heavy–ion beams for experiments will be provided stably.

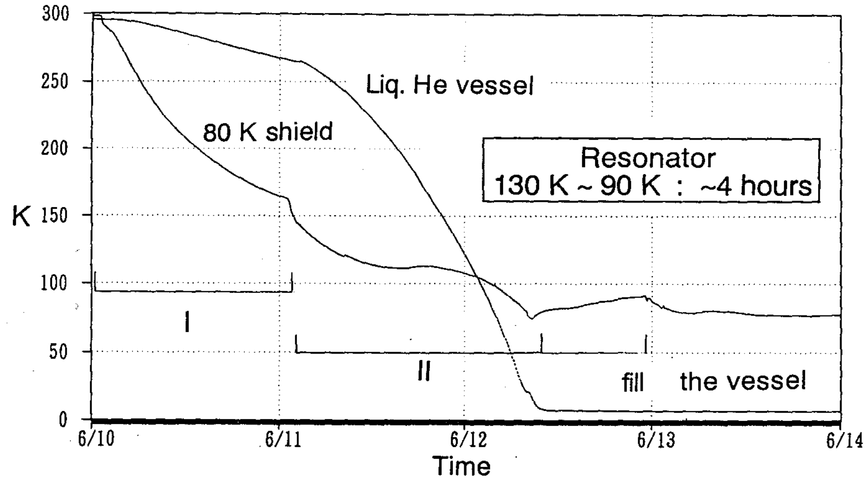


Fig.5 The cooling scheme of the radiation shield and the liquid helium vessel in the cryostat by the refrigerator.

§3 The free electron laser

A prototype for a quasi-cw, and high-averaged power free electron laser (FEL) have been developed. The FEL is driven by a 15 MeV superconducting rf linac. In 1992 Japanese fiscal year (April 1992~March 1993), Cryogenics and resonators in 4 modules were tested. Stand-by loss of cryogenics was less than 3.5 W at 4.5 K. The Q values and the maximum field gradients of resonators were about 2×10^9 and 7MV/m, respectively, without conditioning at JAERI.

A lay out of the free electron laser is shown in Fig.6. The superconducting linac consists of the electron-gun, bunching units, two pre-accelerator modules with a single cell cavity and two main accelerator modules with a 5-cell cavity. One of the pre-accelerator modules of superconducting accelerator is shown in Fig.7. It is composed of a 500 MHz Nb cavity, double heat shields, slow and fast tuner, 3 higher order mode couplers, an adjustable main coupler, a shield cooler, a compact 4 K He recondenser, their related peripherals and electronic instruments. The newly developed multi-refrigeration system is adopted. A 4 K closed-cycle helium refrigerator is adopted to cool down and to recondense cold vapor of liquid helium around a heat exchanger in the liquid helium containers. A 40K/80K two-stage refrigerator are adopted to cool down the 40 K and 80 K heat shields and other major components of the cryostat (Details are reported in the other paper in this meeting[3)]).

All of the 4 modules were already installed in the JAERI FEL vault in this January. The accelerator is under commissioning and is going to accelerate the first beam in near future.

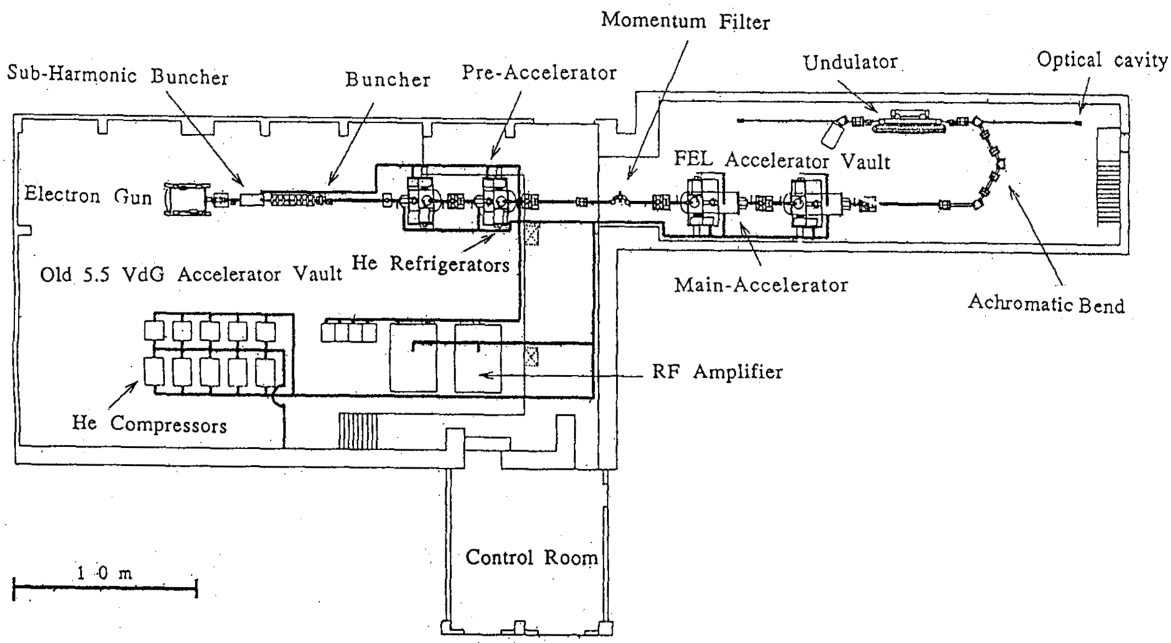


Fig.6 A lay out of the free electron laser.

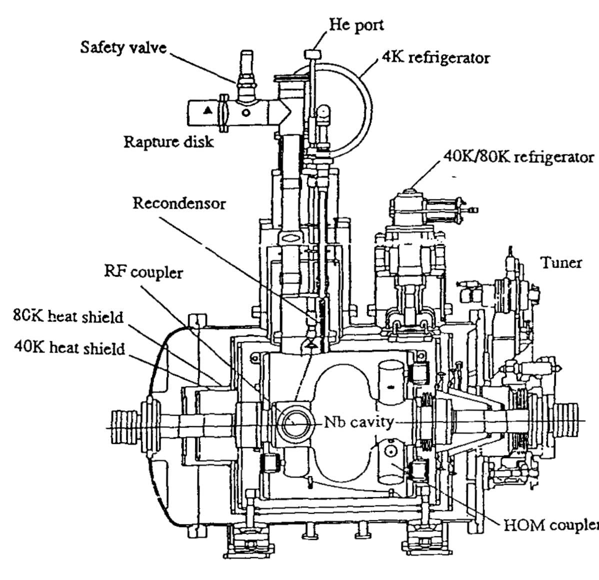


Fig.7 The superconducting accelerator module cryostat for free electron laser at JAERI.

References

1) S.Takeuchi. Proc. 5th workshop on RF superconductivity 1991, pp.76-83.
2) M.Shibata, S.Takeuchi, T.Ishii, S.Kanazawa, T.Yoshida and Y.Sugiyama. in the Proc. of this workshop.
3) E.J.Minehara et al. in the Proc. of this workshop.