CONSTRUCTION OF THE JAERI FEL SUPERCONDUCTING LINEAR ACCELERATOR MODULE

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Abstract

Since the 1989 Japanese fiscal year, construction of the free electron laser(FEL) driven by a superconducting linear accelerator has been started at Tokai site of Japan atomic energy research institute(JAERI). A conceptual design of the JAERI FEL and some details of the accelerator was finished, especially about a multi-refrigerators system for a cryostat of the accelerator module with vibrational insulators, double heat shields, radio-frequency tuners and a variable main coupler, and turbomolecular and ion pump stations at JAERI Tokai in March 1991. The present status and schedule of the design and construction are reported.

1. Introduction

A developmental program[1] of the free electron laser system for far- infrared region from the wavelength of 10 m m to 50 m m has been under construction at Japan Atomic Energy Research Institute, Tokai. An outlook of the program is reported as another paper in the symposium in detail. Here, every component of a superconducting linear accelerator module as a key of the program is described, and discussed in the following. The present status and schedule of the design and construction are reported.
Thermal design[2] of the module contains a large amount of the calculational and experimental results, and therefore the explanation of the design needs another paper in the symposium.

2. Acccelerating Cavities

A resonant frequency of accelerating cavities is 499.8MHz which is exactly the same with a buncher, and the sixth harmonic of a subharmonic buncher in the bunching system of the injector[1]. As a capture section or a preaccelerator, 2 single-cell cavities are mounted in 2 independent cryostats. As a main accelerator, 2 five-cell cavities are also mounted in 2 independent cryostats. Each cavity is independently equipped with a set of RF couplers and tuners.

We decided to choose DESY concepts of the cavity geometry and fabrication technology refined by Siemens Energieerzeugung KWU for the JAERI FEL superconducting linear accelerator late September 1990. Design values of the accelerating field strength and Q-value for the cavities are 5MV/m, and 2 x 10^9, respectively.

3. RF couplers and tuner

As a main coupler was designed to have a variable coupling coefficient over 3 and half decades, we could inject not only low current electron beams but also high current ones into the accelerator module. Typical peak RF power for the coupler was measured up to the 50KW without trouble. The coupling coefficient was designed to adjust by inserting or removing a center conductor from the cavity, and by tuning stubs in the waveguide.

Three sets of the higher mode couplers have been under consideration to suppress unwanted and harmful TE and TM modes having a higher resonance frequency. Two monitor couplers was planed to use for monitoring and phase detection in the feedback loop of a fast tuner.

Three sets of slow and fast tuners were designed to tune a resonance frequency of the cavity in the module. The slow tuners consist of a stepping motor driver and an interface from the control system. The fast tuners consist of a piezo-electric element actuator, a high voltage power supply, a feedback loop, and an interface from the phase detector and the control system.

4. Cryostat and Refrigerators

We have newly developed a multi-refrigerators system integrated into the superconducting linear accelerator module cryostat to realize the highly-efficient system without any liquid coolant. A 4K closed-cycle He gas refrigerator mounted just above a chimney of the module was adopted to cool down and to recondense cold vapour of liquid He around a heat exchanger in the liquid He vessel. A 20K/80K two- stage closed-cycle He gas refrigerator, which mounted in a vacuum vessel of the module like a piggy back, was adopted to cool down 40K and 80K heat shields and other major components of the cryostat. These two kinds of the He-gas refrigerators have been available commercially in Japan. The 4K refrigerator suspended in a lifter-frame can be lifted up and down to remove the heat exchanger out of the liquid He vessel, and to insert the exchanger into the vessel. Cooling capacity of the refrigerator is 9.6W at 4.5K and 60Hz.

The 40K and 80K heat shields are used to prevent heat invasion from outside into the liquid He vessel. These heat shields make the return route with a temperature higher than 4K for all heat bridges from the outside to minimize heat loads to the vessel. These shields are cooled down to work as a thermal anchor by a closed cycle He gas refrigerator. The 20K/80K refrigerator used here provides two cooling stages with a typical pair of temperature of 40K and 80K and heat load capacities of 120W and 40W, respectively.

5.RF Power Supply

The merit of a superconducting accelerating cavity is low power loss and makes it possible to use a so-called all-solid-state RF power amplifier for all the accelerating cavities. Because of the lower control voltage of the all-solid-state amplifier than that of a klystron and a tetrode, more stable RF power is expected to realize. We chose two sets of the all-solid-state 50KW RF power amplifier as RF power supplies for the JAERI FEL main accelerator modules.

6.Pumping Station

A magnetically-suspended 1000 L/s turbomolecular pump is planed to use for a vacuum vessel of the cryostat, and a 500 L/s sputter ion pump for the single- cell or 5-cell cavity. The turbomolecular pumping station have a 8" diameter inlet of the pump and a 6" gate valve, and the ion pump the 6" inlet and 6" gate valve. A magnetically-suspended 200 L/s molecular drag pump as an auxiliary pumping station specially designed to prevent oil-contamination was planed to use in initial pumping the cavity.

7.Present Status and Schedule

A final design review for the JAERI superconducting accelerator module was done late August, 1991 to review and to summarize design activities over all components of the module, and to start their production in full scale. Cooling tests of the modules are planned to start around March, 1992. High power tests of the modules as a major acceptance test are planned to start around May, 1992. Two sets of the single-cell cavity module are planned to ship around July, 1992 and to deliver at Tokai site of JAERI around

August,1992.

Other components of the modules including the RF power supplies, pumping stations, and refrigerators are expected to ship, and to deliver at Tokai site around May 1992.

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References

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2) N.Kikuzawa et. al. presented in the symposium.