A COMPACT CLOSED LOOP 2K He^3 REFRIGERATOR AND ZERO-BOIL-OFF CRYOSTAT DESIGN FOR THE JAERI SUPERCONDUCTING RF LINAC-BASED FEL

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Since an invention of a superconducting rf linac in 1965, a less-efficient, complex, expensive and huge cryogenic system circulating liquid He and N_2 coolant media must be used to cool down cavities and heat shields of the linac. We also need a lot of specially-trained engineers and technicians for a domestic pressurized vessel code-regulated devices like the linac in every country to run it safely and continuously except for the power failure, repairs and maintenance.

We have newly developed a zero-boil off multi-refrigerators system integrated into the superconducting accelerator module cryostats to realize a highly-efficient system without any liquid coolant and any maintenance crew. A prototype of the system had a lot of troubles related to the He gas compressor's heat exchanger and related parts in the beginning phase. After the modification related to the troubles in the beginning of October1995, we can run all of the modules successfully for about 11 months without any trouble. Each cryostat of the new system has two independent refrigerators, each one is designed to be independently structured, and powered. A 4K closed-cycle He gas refrigerator mounted just above a liquid-He supply tower of the module was adopted to cool down and to recondense cold vapor of liquid He around a heat exchanger in the liquid He container. A 40K/80K two-stage closed-cycle He gas refrigerator, which was mounted in a vacuum vessel of the module was adopted to cool down the 40K and 80K heat shields and other major components of the cryostats. The 40K and 80K heat shields are used to prevent heat invasion from outside into the liquid He container. In order to minimize heat loads to the container, the heat shields work as a thermal anchor, and make the return route having a temperature higher than the liquid He temperature for all heat bridges from the outside.

In the conference, we will also discuss about a new cryogenic design for the 2K cryostats and refrigerator system of the superconducting rf linac with higher accelerating field and frequency than 5MV/m and 500MHz, respectively. Up to now, no 2K recondenser refrigerator has been available for the rf linac because of many technological difficulties related with a superfluidity of ^4He. According to the BCS theory, because surface resistance of the cavities is nearly proportional to square of frequency and exponential function of working temperature, we have to reduce the resistance in the higher frequency by lowering the cavity temperature down to around 2K or even lower. Here, we will report preliminary results of the 2K ^3He gas refrigerator and cryogenic measurements. The measurement set-up is shown in figs. 1,and 2. In the set-up, cooling power was measured to be about 1W at 2.17K and He^3 gas flow rate of 2.75Nm^3/h.

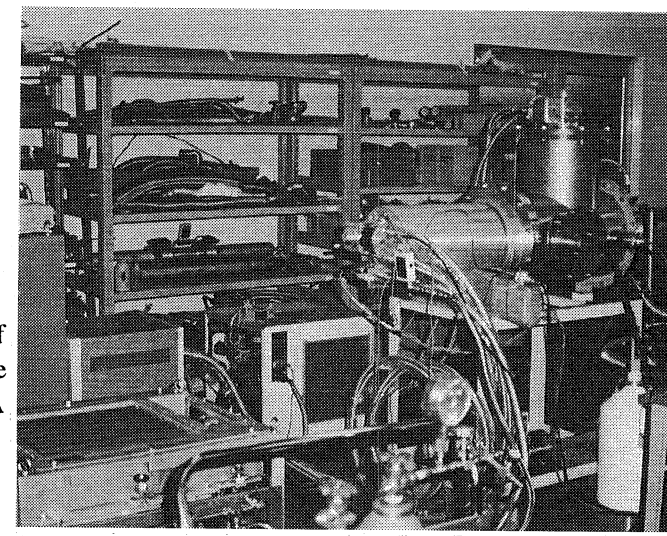

Fig.1, Photograph of the measurement set-up. 2K test cryostat and 2 compressors and 2 He^3 gas bottles

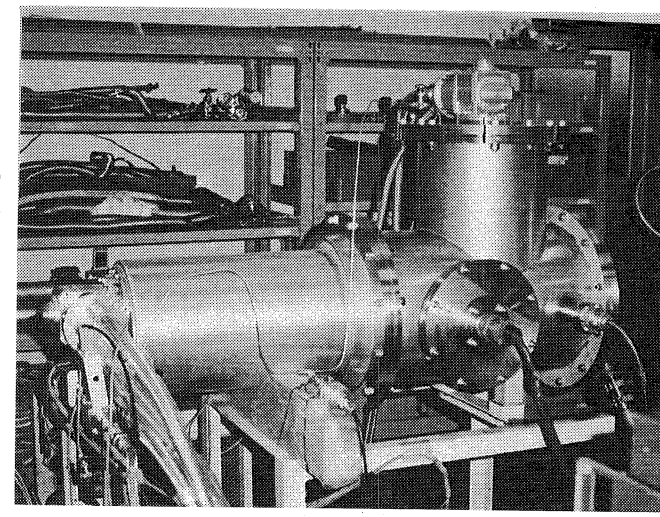

Fig.2, Photograph of the 2K test cryostat. A 20K/80K test cryostat heat shield cooler, feedthroughs and 2K He^3 refrigerator .