Cooling down test of prototype accelerator system based on SC-QWR

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The construction of a prototype accelerator system based on the superconducting quarter-wavelength resonator (QWR)[1–3] was completed in March 2017. Subsequently, cooling down tests of the system and excitation tests of the QWR were conducted for a number of times. In this contribution, the results of the cooling down tests are reported.

Figure 1 shows an overview of the prototype accelerator system (cryomodule) seen from the beam axis. A thermal shield, which is made of aluminum and enfolded by super insulation, is installed just inside the vacuum vessel. The thermal shield is cooled down using a cryocooler, SHI CH-110L.[4] In order to cut off vibration of the cryocooler, the cryocooler and thermal shield had been connected using thermal contact wires that consist of oxygen-free copper braid wires. A medium such as Apiezon-N or indium had not been applied on the contact faces between the thermal contact wire and the cryocooler or thermal shield.

As a result of the test, liquid helium was filled up to a helium buffer tank, and the excitation of the QWR at a cryogenic temperature was successful. However, we faced a problem in that the temperature of the thermal shield was much higher than expected. While the cryocooler is cooled to below 30 K, the temperature of the bottom of the thermal shield, which was connected directly to the cryocooler via the thermal contact wires, was approximately 70 K. At the design phase of the cryomodule, we had assumed the temperature of the thermal shield to be 40 K. Possible causes for the much higher temperature of the thermal shield are as follows: the thermal contact resistance at the contact faces was too large, or the thermal conduction of the thermal contact wires was too small. At the design phase, these elements had not been estimated sufficiently. The thermal conduction between the cryocooler and the thermal shield must be improved.

In order to obtain information for the improvement, a cooling test of the thermal contact wire was performed. The setup of the test is shown in Fig. 2. An aluminum plate, which simulated the thermal shield, was connected to the cryocooler via a thermal contact wire. A heater was attached to the aluminum plate. By varying the heater power, temperatures at various points were measured with several conditions of the thermal contact faces: no medium, Apiezon-N, and indium.

The application of Apiezon-N showed the best thermal conduction, but it did not show a drastic improvement compared with no medium. More importantly, it was found that the temperature difference between the two ends of the thermal contact wire was very large. This fact suggests that the thermal conduction of the thermal contact wire itself is not good. Based on this result, a refinement of the structure and an increase of the number of thermal contact wires are being considered for better thermal conduction.

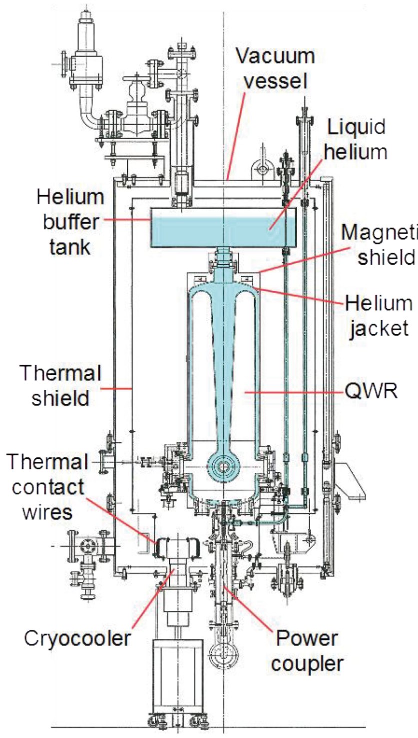

Fig. 1. Overview of the cryomodule.

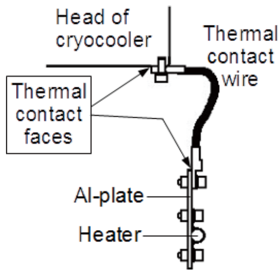

Fig. 2. Setup of the cooling test of the thermal contact wire. The entire system was installed in a vacuum chamber.

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References

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