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Performance test of bulk-niobium cavities for new superconducting linear accelerators

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In order to upgrade the beam intensity and energy of the RIKEN Linear Accelerator (RILAC),[1)] an upgrade project of the RILAC is now ongoing. The beam intensity is increased by the newly built 28 GHz superconducting (SC) ECR ion source,[2)] and the beam energy is boosted over 6.5 MeV/nucleon for ions with mass to charge ratio of 6 by the new SC linear accelerator (SRILAC).[3)] The SRILAC consists of three cryomodules including ten SC quarter-wavelength resonators (QWRs) with a resonant frequency of 73 MHz. The SC-QWRs are made of bulk niobium and kept at 4.2 K by using a large liquid-helium refrigerator.

In order to test the performance of SC-QWRs in the SC state, a test stand was prepared at RIKEN based on the test stand at KEK.[4)] We drilled a hole in the floor and installed a cryostat with an inner diameter of 700 mm and a depth of 3240 mm. A magnetic shield was put into the cryostat to prevent the penetration of geomagnetism and achieved a value of less than 10 mGauss. The SC-QWR to be tested is suspended from a flange and stored in the cryostat as shown in Fig. 1. Liquid helium is poured into the cryostat until the cavity is submerged, and the SC-QWR is tested by applying RF power. X-rays may be generated at high voltage by factors such as field emission of electrons, and the test stand is structured to be covered with an iron shield. The validity of the new test stand was confirmed by comparing the test result of a 73 MHz prototype SC-QWR carried out in the RIKEN and the KEK.

The performance test of actual SC-QWRs took place from June 2018. When the assembly of an SC-QWR was completed, the performance test was carried out sequentially and it was confirmed whether or not acceptable performance was obtained. In the early days, there was a problem of vacuum leak of the SC-QWR, but it was stopped by tightening the flange bolts again. All the SC-QWRs were fabricated until November 2018 and tested immediately. The details of the test procedure are the same as that given in Ref. 4).

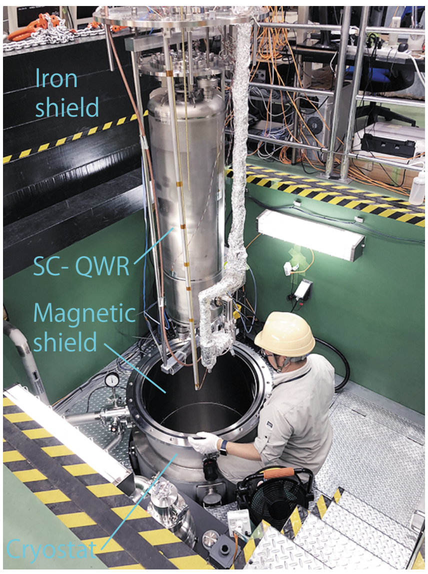

Fig. 1. Installation of a test assembly by suspending a SC-QWR into the cryostat.

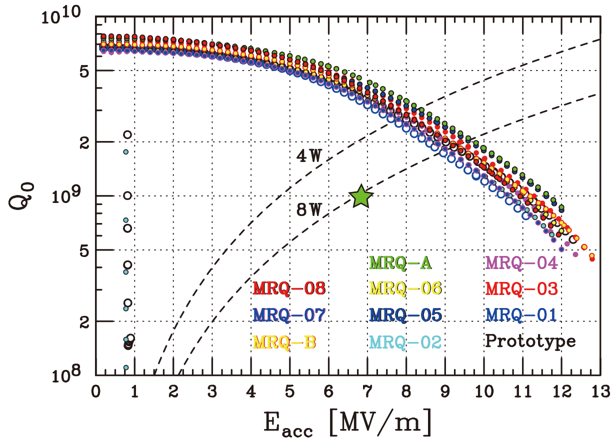

Fig. 2. Q_0 vs E_{acc} plot of the bulk SC-QWRs. The green star represents the criteria of the SRILAC.

Figure 2 shows the quarity factor Q_0 plotted against acceleration voltage E_{acc} for all SC-QWRs. Although multipacting was observed at 0.9 MV/m for each SC-QWR as indicated in the figure, it could be processed within a few hours. The test results indicate very high values of Q_0 and E_{acc} for all SC-QWRs; thus, all the SC-QWRs passed the acceptance test successfully. The maximum E_{acc} is significantly higher than the required value, and the exponential deterioration of Q_0 has not yet been observed for all SC-QWRs. Note that the resonant frequency of all SC-QWRs is in the range of the frequency tuner as expected.

The SC-QWR with which the performance was confirmed was slowly leaked in an ISO class 1 clean room immediately, the test coupler and vacuum exhaust pipe were removed, and blank flanges were attached to send back to the factory for the post-process of installing the titanium jacket. Currently the SC-QWRs are being installed in the SRILAC cryomodules. The three cryomodules will be completed and allocated in the beginning of March 2019.

References

1) M. Odera *et al.*, Nucl. Instrum. Methods Phys. Res. A **227**, 187 (1984).
2) T. Nagatomo *et al.*, in this report.
3) N. Sakamoto *et al.*, Proc. of LINAC18, WE2A03, 620 (2018).
4) K. Yamada *et al.*, Proc. of LINAC16, THPLR040, 939 (2016).

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