18th International Conference on RF Superconductivity SRF2017, Lanzhou, China JACoW Publishing
ISBN: 978-3-95450-191-5 doi:10.18429/JACoW-SRF2017-MOYA03

PROGRESS OF THE RAON

D. Jeon†, H.C. Jung, H.M. Jang, Y.K. Kwon, S.C. Jeong, S.J. Choi, H.J. Jang, J.H. Jang, T.K. Ki, J.H. Kim, Y.K. Kim, S.I. Lee, B.S. Park, H.J. Cha, B.H. Choi, C.J. Choi, J.W. Choi, O.R. Choi, Y.J. Choi, I.W. Chun, I.S. Hong, M.O. Hyun, H.Y. Jeong, H.C. Jin, H.C. Jo, Y.B. Jo, Y.W. Jo, J.D. Joo, M.J. Joung, Y.C. Jung, I.I. Jung, J.S. Kang, D.G. Kim, D.M. Kim, H.J. Kim, H.T. Kim, J.W. Kim, W.K. Kim, Y.H. Kim, D.Y. Lee, J.W. Lee, K.W. Lee, M.K. Lee, S.B. Lee, S.H. Nam, M.J. Park, K.T. Seol, I.K. Shin, J.H. Shin, C.W. Son, H.J. Son, K.T. Son, K.S. Yang, S.W. Yoon, A. Zaghloul
Institute for Basic Science, Daejeon, Korea

Abstract

Construction of the RAON is under way in Korea building a heavy ion accelerator based on low beta superconducting cavities. The 81.25-MHz RFQ was fabricated and a beam test was conducted confirming beam acceleration. Major accelerator subsystems such as superconducting cavities are under development. QWR cryomodule test was conducted achieving the design field gradient and Q and HWR cryomodule test is planned shortly. SSR1 cavity is under development in collaboration with the TRIUMF. High Tc superconducting quadrupole prototype was successfully tested which is used in the IF separator.

INTRODUCTION

Construction of the RAON is in progress in Korea. The driver linac of the RAON is to accelerate uranium to proton beam up to 200 MeV/u and 600 MeV respectively, delivering 400-kW beam power to the target [1]. Site preparation is near completion. Figure 1 shows the bird's-eye view of the RAON facility.

Figure 1: Bird's-eye view of the RAON.

Prototyping and testing of subsystems are in progress. The injector consists of 28-GHz ECR ion source [2,3] and 81.25-MHz RFQ. The RAON superconducting linac (SCL) consists of SCL1, SCL2 and SCL3 and adopts a design that separates superconducting cavities and magnets. The lattice is robust and flexible in operation. The SCL consists of QWR (Quarter Wave Resonator), HWR (Half Wave Resonator) and SSR (Single Spoke Resonator). Superconducting cavities, couplers and tuners are fabricated and tested. High Tc superconducting quadrupole magnet prototype was fabricated in collaboration with domestic research institutes and successfully tested meeting the design requirement.

SRF Test Facility was constructed [4] and began operation from June 2016 and the SCL Demo facility is set-up.

DRIVER LINAC

The SCL Demo facility is set up to perform various tests which consists of the 28-GHz ECR ion source, LEBT, RFQ, MEBT and one QWR cryomodule. This facility is located in the SRF Test Facility at KAIST campus. At present the QWR cryomodule is being installed and the beam test is planned in September 2017.

The four-vane type 81.25 MHz RFQ was fabricated through a domestic vendor and accomplished successful beam acceleration in November 2016 accelerating the $^{16}O^{7+}$ beam from the 28-GHz ECR ion source to 0.516 MeV/u in the test facility [5].

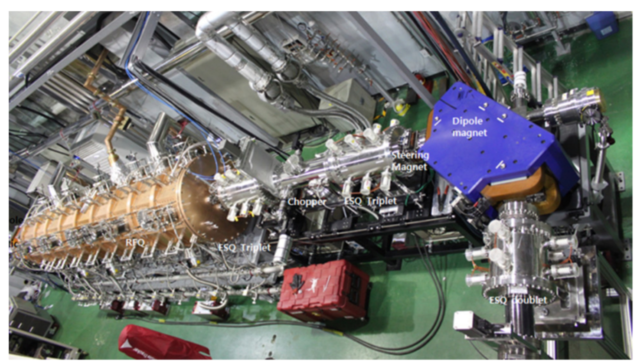

Figure 2: Photograph of the SCL Demo facility showing the RFQ installed.

Vertical test and horizontal test of QWR cavities and HWR cavities are in progress. Superconducting cavities are fabricated through domestic and international vendors. For the QWR cavities, following the vertical test of the bare cavity, vertical test of the jacketed test and an integrated test in a cryomodule were conducted. Figure 3 shows the Q vs E curves of the vertical test and horizontal test of a QWR in a cryomodule.

The total thermal load of the QWR cryomodule at the operating gradient was measured to be 9.9 W which is below 25 W of the design. The alignment was measured with

†jeond@ibs.re.kr

ISBN: 978-3-95450-191-5 doi:10.18429/JACoW-SRF2017-MOYA03

optical targets installed on the cavity. The misalignment was measured to be within ±1 mm after cool-down. This meets the beam dynamics requirement of the cavity misalignment. Figure 5 shows the photograph of the QWR cryomodule in a horizontal test bunker.

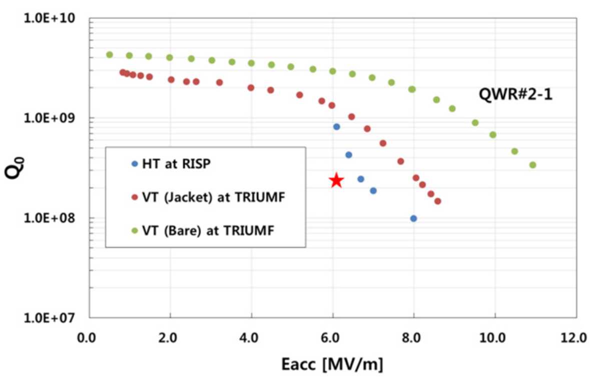

Figure 3: Q vs E curves of the QWR vertical test and horizontal test in a cryomodule. The red star represents the design goal.

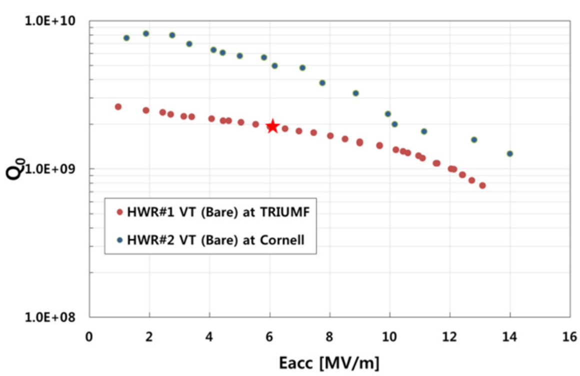

Figure 4: Q vs E curves of the HWR vertical test and horizontal test. The upper curve shows the Q vs E curve of the 2nd HWR prototype and the lower curve the 1st HWR prototype. Design modification improved the Q values. The red star represents the design goal.

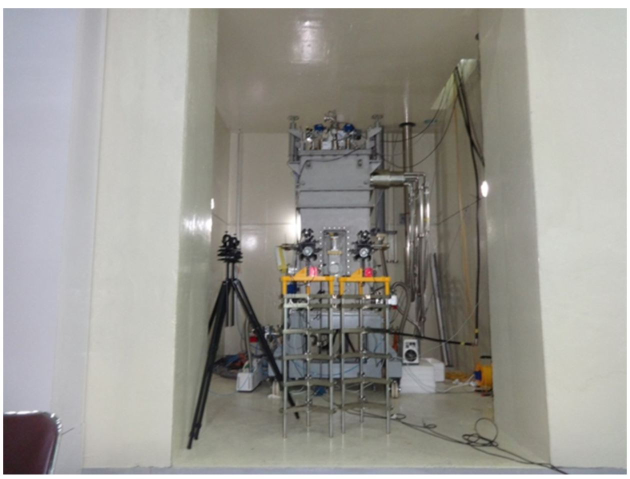

Figure 5: Photograph of the assembled QWR cryomodule in the horizontal test bunker.

The 1st HWR prototype was tested at TRIUMF in 2015 and some design change was made to improve the cavity performance. Some design change was made to improve the Q value and multipacting bands of the 1st cavity. The 2nd HWR prototype was tested at Cornell University with improved Q values as shown in Fig. 4.

Balloon type SSR1 is under development in collaboration with the TRIUMF as shown in Fig. 6 [6]. This type's merit lies in the reduced multipacting band of the cavity. Its vertical test is planned in August 2017.

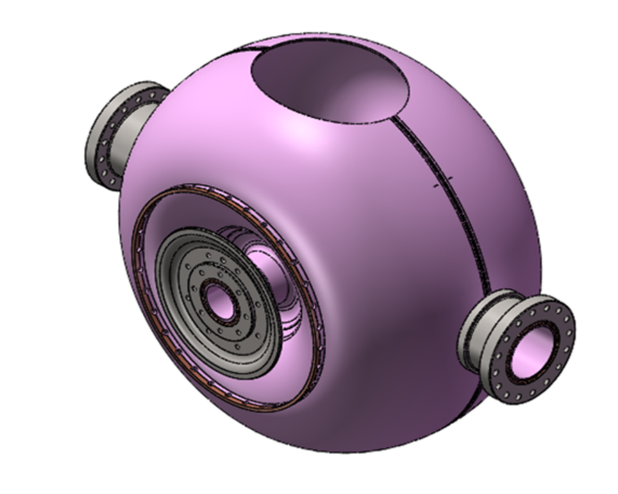

Figure 6: Plot of the balloon type SSR1 under development.

Prototyping efforts are taken for the couplers and tuners of the superconducting cavities. QWR couplers [7] are conditioned and integrated to the cavity in a cryomodule as shown in Fig. 5. Cavity test in Fig. 3 was conducted with the tuner. Couplers of slightly different design were fabricated and their test is planned. HWR couplers were designed and fabricated [8].

Tuners for the QWR and HWR cavities are designed and fabricated. QWR tuner was integrated in the cryomodule and tested as shown in Fig. 8. HWR tuners [9] are fabricated as shown in Fig. 9 and will be tested in a cryomodule late this year.

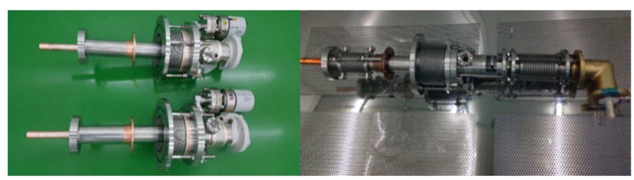

Figure 7: Photographs of the QWR couplers.

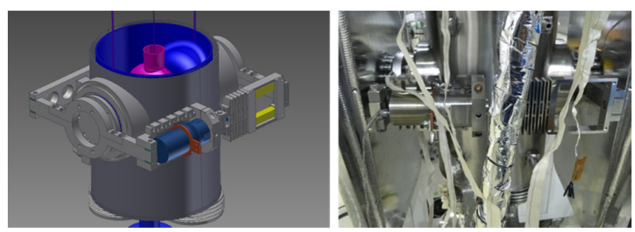

Figure 8: Photographs of the QWR tuners.

ISBN: 978-3-95450-191-5 doi:10.18429/JACoW-SRF2017-MOYA03

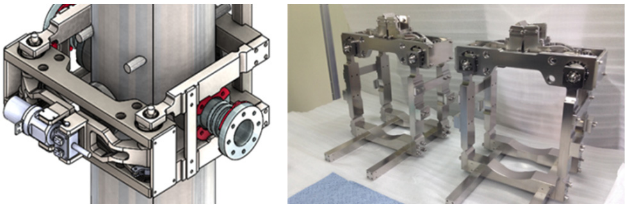

Figure 9: Photographs of the HWR tuners.

Another critical subsystem is the liquid lithium charge stripper to boost the charge state of the beam. At present the lithium stripper is designed and prototype is fabricated which consists of chamber, EM pump, purification system and e-gun system that measures the film thickness. Figure 10 shows the schematic plot of the charge stripper.

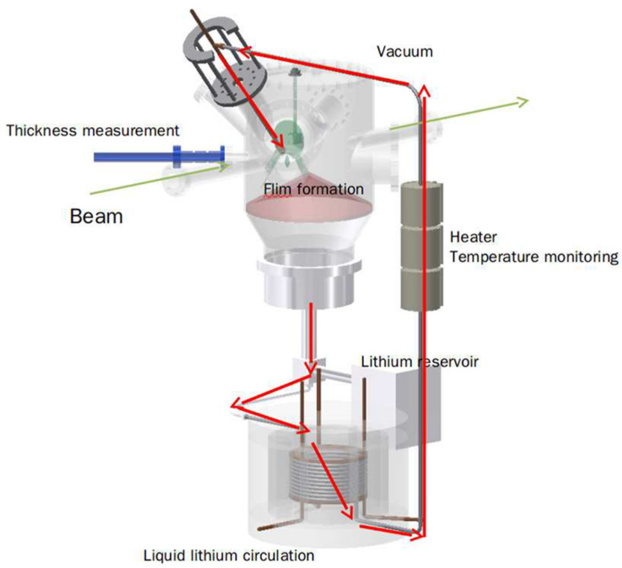

Figure 10: Schematic plot of the liquid lithium charge stripper under development.

IF SEPARATOR MEGNET

The IF separator is to separate the RI (Rare Isotope) beam of interest. Due to required aperture size, field gradient and radiation heat load, regular low Tc superconducting magnets are not suitable. This requires the high Tc superconducting (HTS) quadrupole.

Figure 11: Photograph of the High Tc superconducting quadrupole prototype.

The RAON has partnered with domestic research institutes to design the HTS quadrupole. The HTS quadrupole prototype was fabricated and tested successfully meeting the design requirement. Figure 11 shows the fabricated HTS quadrupole and Fig. 12 shows the plot of temperature change curves (color lines) and current (dotted line) of high Tc superconducting coils.

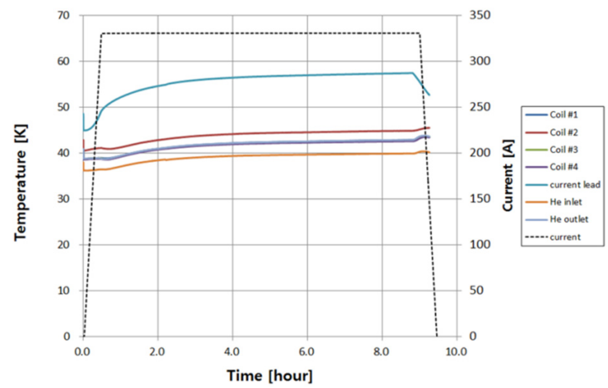

Figure 12: Plot of temperature change curves (colored real lines) and current (dotted line) of high Tc superconducting coils.

SUMMARY

Construction of the RAON is making a steady progress and critical subsystems are designed, tested and improved. Development of the low beta superconducting cavities and high Tc superconducting quadrupole contributes to the community.

ACKNOWLEDGEMENT

This work was supported by the Rare Isotope Science Project funded by the Ministry of Science, ICT and Future Planning (MSIP) and the National Research Foundation (NRF) of the Republic of Korea under Contract 2013M7A1A1075764.

REFERENCES

[1] D. Jeon *et al.*, “Design of the RAON accelerator systems”, *J. Korean Phys. Soc.,* vol. 65, pp. 1010-2014.

[2] I. S. Hong *et al.*, “Major components for the RISP injector”, *Nucl. Instr. Meth. B*, vol. 317, pp. 248-252, 2013.

[3] S. Choi *et al.*, “Superconducting magnets for the RAON electro cyclotron resonance ion source”, *Rev. Sci. Instr.*, vol. 85, no. 2, 2014.

[4] J. Joo *et al.*, in *Proc. LINAC’14*, Geneva, Switzerland, p. 619.

[5] Bumsik Park *et al.*, *Nucl. Instr. Meth. A*, unpublished.

[6] Z. Yao *et al.*, presented at SRF’17, Lanzhou, China, July 2017, paper THXA02, this conference.

[7] I. Shin *et al.*, in *Proc. SRF’15*, Whistler, BC, Canada, p. 1326.

[8] S. Lee *et al.*, in *Proc. IPAC’16*, Busan, Korea, p. 2208.

[9] M. Ge *et al.*, in *Proc. IPAC’17*, Copenhagen, Denmark, p. 1134.