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PROGRESS OF THE RAON HEAVY ION ACCELERATOR PROJECT*

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Abstract

Construction of the RAON heavy ion accelerator facility is progress in Korea with the In-flight Fragment (IF) and Isotope Separation On-Line (ISOL) facilities. Prototyping of major components and their tests are proceeding including the 28-GHz ECR ion source, RFQ, superconducting cavities, superconducting magnets and cryomodules. Superconducting magnets of the 28-GHz ECR ion source were fabricated and tested achieving 95% (80%) of design fields for the hexapole (solenoids) so far. Prototype superconducting cavities were fabricated through domestic vendors and delivered. Vertical tests showed good performance of the prototype cavities. Progress report of the RAON accelerator systems is presented.

INTRODUCTION

The RAON heavy ion accelerator facility is a unique facility that has the 400 kW In-flight Fragmentation (IF) facility and the 70 kW Isotope Separator On-Line (ISOL) facility providing wide range of rare isotope beams for users [1,2].

The driver accelerator for the IF facility is a superconducting linac (SCL) that can accelerate up to 200 MeV/u for the uranium beam delivering more than 400 kW of beam power to the IF target and various other targets. The driver for the ISOL facility is an H^- 70-MeV 1 mA cyclotron that delivers 70 kW beam power. The cyclotron has dual extraction ports with thin carbon foils for charge exchange extraction of H^- beam.

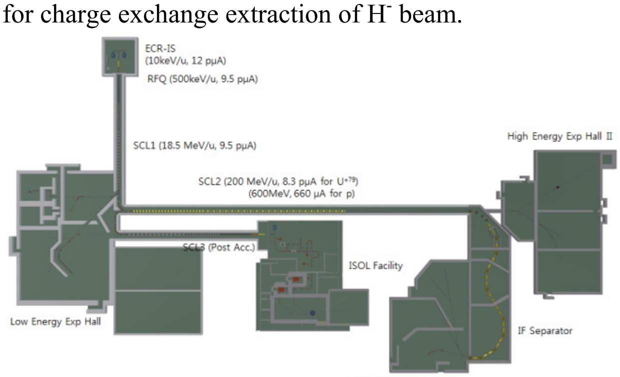

Figure 1: Plot of the RAON facility layout.

Rare isotope (RI) beams generated by the ISOL system is re-accelerated by a chain of post accelerators. The RI beams can be delivered to the low energy experimental hall or can be injected through P2DT to the SCL2 to accelerate to higher beam energy. The schematic layout of the facility is shown in Fig. 1.

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The accelerator systems design is optimized to provide various high intensity stable ion beams and radioactive isotope (RI) beams from proton to uranium, while avoiding potential issues related with performance and operation.

Construction of the RAON heavy ion accelerator facility has begun December 2011 to be completed by December 2021. Detailed design of the accelerator systems has completed, and prototyping and testing of critical components and systems have been performed. In this paper, the status of the RAON accelerator systems is presented along with prototyping progress.

DRIVER LINAC

The driver linac consists of an injector (28-GHz ECR ion source, 500-keV/u RFQ) and SCL1 (QWR, HWR type), CSS (Charge Stripper Section) and SCL2 (SSR1, SSR2 type) that can accelerate a uranium beam to 200 MeV/u, delivering 400-kW beam power to the target. The driver linac can accelerate beams from proton to uranium.

Injector

28-GHz ECR ion source for the driver linac was designed [3] and its superconducting magnet assembly for the 28-GHz ECR ion source (ECRIS) was fabricated through domestic vendors. It consists of a saddle-type hexapole and four solenoids made of NbTi wires. Figure 2 shows the plot of the superconducting magnet assembly, the plot of ECRIS cryostat and actual ECRIS cryostat.

The cryostat for the 28-GHz ECRIS was put together and superconducting magnet tests have been carried out, achieving 95% (80%) of the design goal for the hexapole (solenoid) in a combined operation. Further magnet training is in progress. In parallel, beam extraction test is being prepared for of the 28-GHz ECRIS with a partial LEBT installed along with it.

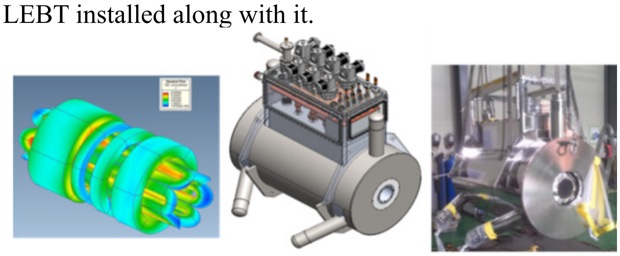

Figure 2: Plot of 28 GHz ECR ion source and its superconducting magnet assembly.

The 81.25-MHz RFQ is 5-meter long with a four-vane structure and its input and output beam energies are 10 keV/u and 500 keV/u respectively. RFQ prototype was successfully fabricated through a domestic vendor in September 2014, overcoming issues of the fabrication procedures and its photograph is shown in Fig. 3. The contract for the fabrication of the driver linac RFQ was

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awarded to a domestic vendor in April 2015 to be delivered by mid-2016.

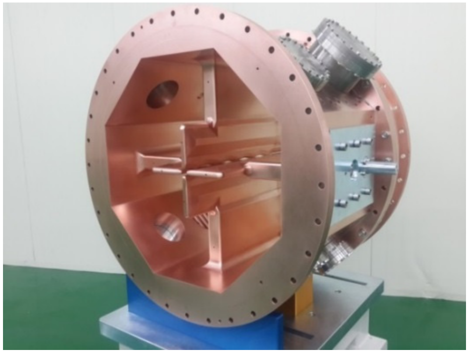

Figure 3: Photograph of 81.25MHz RFQ prototype.

Superconducting Cavities

All four types of the superconducting cavities (QWR, HWR, SSR1, SSR2) were designed by the IBS and their prototypes fabricated through the domestic vendors and delivered in 2014 to the IBS [4]. Their photographs are shown in Fig. 4. Lately vertical tests of the QWR and HWR cavities were carried out in collaboration with the TRIUMF using its SRF test facility.

Figure 4: Photographs of prototype superconducting cavities [QWR(top left), HWR(top right), SSR1(bottom right), SSR2(bottom left)].

Figures 5 and 6 show the vertical test results of the prototype QWR and HWR cavities. QWR prototype cavity showed very excellent results. These measurement data were limited only by cryogenic capacity of the facility. At 2K especially, the B_{peak} of the QWR prototype reached ~130 mT reaching 210% of the design field goal.

The HWR prototype showed some sign of field emission after the initial BCP and HPR. The RF field was not increased further as X rays are detected, achieving ~130% of the design field goal so far. Additional BCP is planned.

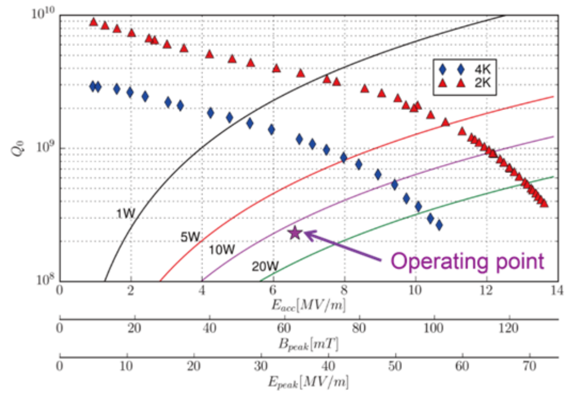

Figure 5: Plot of the vertical test results of the QWR prototype at 2K and 4K. For the 4K (2K) test, 160% (210%) of design field goal was achieved. Operating point for 4K is shown.

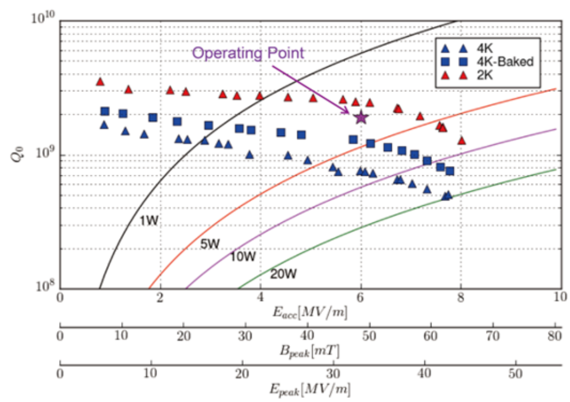

Figure 6: Plot of the vertical test results of the HWR prototype at 2K and 4K. For the 4K (2K) test, 130% (130%) of design field was achieved. Field emission took place and we did not increase the field further. Further processing will be tried. HF rinse needs to be done to increase the Q after the 120°C baking. Operating point for 2K is shown.

Couplers and Tuners

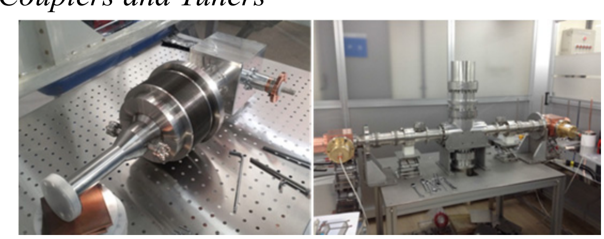

Figure 7: Photograph of the prototype HWR coupler (left) and prototype SSR couplers (right).

Prototyping of couplers (see Fig. 7) for the superconducting cavities (QWR, HWR, SSR1, SSR2) is carried out in collaboration with the IHEP, KEK etc. Lately prototype HWR couplers with 5-kW nominal RF power were fabricated and tested up to 15KW (5kW) in

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travelling (standing) wave mode in collaboration with the IHEP. Prototype SSR couplers with nominal RF power of 20kW were fabricated and under test now.

Prototyping of tuners is in progress. Figure 8 shows the prototype QWR tuner and SSR tuner. Prototype QWR tuner is being tested now.

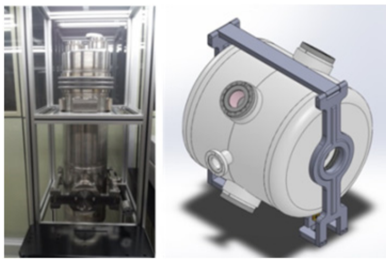

Figure 8: Plots of the prototype QWR and SSR tuners.

Cryomodules

Following the engineering design of each type of cryomodules, prototype cryomodules were fabricated through domestic vendors and basic tests were carried out such as vacuum tests and thermal load measurements. Figure 9 shows the photographs of cryomodule prototypes.

Table 1: Cryomodule Static Load Measurement

Cryomodule	Design Static Load	Measured Static Load
QWR Type	4.0 W	3.9 W
HWR Type	9.1 W	5.3 W

Table 1 lists the design and measured static loads of the cryomodule prototypes. The measurement confirms that the design meet the requirement.

Figure 9: Photos of prototype cryomodules fabricated through domestic vendors.

IF SYSTEM

The IF (In-flight Fragment) system consists of target, separator and beam dump (See Fig. 10). The in-flight isotope beam separator system can be largely divided into pre and main separators. The momentum acceptance of the separator has been designed to be ±3 %, while the angular acceptances will be ±40 mrad horizontally and ±50 mrad vertically. For the progress of the IF systems, please refer to [5-7] for more details.

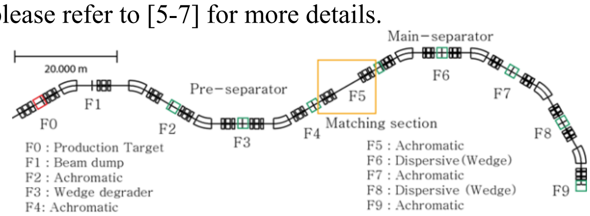

Figure 10: Schematic plot of the target and separator.

CONCLUSION

Prototyping reports of major subsystems such as 28-GHz ECR IS, RFQ, superconducting cavities, couplers, tuners, and cryomodules are presented. Prototypes of superconducting cavities show results surpassing the design requirements. 28-GHz ECR ion source SC magnets achieved 95% (80%) of design goals for the hexapole (solenoids).

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REFERENCES

[1] D. Jeon et al, “Design of the RAON accelerator systems”, J. Korean Phys. Soc. **65**, issue 7, 1010 (2014). DOI: 10.3938/jkps.65.1010.

[2] Dong-O Jeon and Hyung Jin Kim, “Status of the RAON heavy ion accelerator project”, Proc. of LINAC2014, p.775, Geneva, Switzerland (2014).

[3] S. Choi, Y. Kim, I.S. Hong, D. Jeon, Rev. of Sci. Instr. **85**, 02A906 (2014).

[4] H.J. Kim, H.J. Cha, M.O. Hyun, H.J. Jang, H.C. Jung, Y.K. Kim,M.K. Lee, G.-T. Park, Proc. of LINAC2014, p.245, Geneva, Switzerland (2014).

[5] J.Y. Kim, C.C. Yun, D.G. Kim, E.H. Kim, M.J. Kim, M. Kim, J.W. Kim, Proc. of PAC2013, p.454, Pasadena, USA (2013).

[6] C.C. Yun, Mi-Jung Kim, D.G. Kim, J.S. Song, Myeong-Jin Kim, J.W. Kim, J.R. Kim, W. Wan, Nucl. Instr. Meth. Phys. Res. B **317** (2013) 342.

[7] D.G. Kim, J.Y. Kim, J.W. Kim, M. Kim, C.C. Yun, A. Zaghloul, Proc. of PAC2013, p.3555, Pasadena, USA (2013).