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STATUS AND INSTALLATION PLAN OF RISP RFQ AT PROJECT SITE *

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Abstract

The Rare Isotope Science Project (RISP) at Institute for Basic Science (IBS) has been developed a radio frequency quadrupole (RFQ) linear accelerator, which was fabricated and commissioned at the off-site test facility. An O^{+7} beam was accelerated from 10 keV/u to 507 keV/u as a preliminary beam test. For CW and high power operation, RF conditioning test was also conducted.

The RISP RFQ is 5 meters long, 1 meter in diameter and weighs about 18 tons. It will be disassembled and transported to the project site for installation as the injector system. The reinstallation commenced in October 2019 and the commissioning of the injector system is expected to begin in early 2020. In this paper, the development status and reinstallation plan were summarized.

INTRODUCTION

The Rare Isotope Science Project (RISP) is developing a superconducting linear accelerator to supply various stable ions and rare isotopes on the basis of user requirements. Figure 1 shows the layout of the RISP facilities. There are seven experimental systems for nuclear physics, nuclear astrophysics, and applications to material sciences, bio and medical sciences. The accelerator complex consists of two low energy superconducting accelerator (SCL1 and SCL3) and a high energy superconducting accelerator (SLC2) [1]. Recently, the SCL1 has been decided to be postponed due to the budget. However, the SCL3 is going to be taking a role of SCL1 in the early operation since the SCL3 is a duplicate of the SCL1.

The injector system is composed of two electron cyclotron resonance (ECR) ion sources, Low Energy Beam Transfer (LEBT), Radio Frequency Quadrupole (RFQ), and Medium Energy Beam Transfer (MEBT). To verify the performance of the components, the injector system has been installed and the performance test was conducted at the off-site test facility before the site construction was completed. Figure 2 shows the experimental set up on the off-site test facility. It is a layout that is not optimized and several components are omitted compared to the final layout.

The preliminary beam test for the RFQ was conducted and the oxygen 7+ was accelerated from 10 keV/u to 507 keV/u which was measured by using several methods. On the basis of the measured beam energy which is consisted with the PARMTEQ simulation result, the design, fabrication and the tuning procedures were verified [2].

Figure 1: Layout of the RISP facilities.

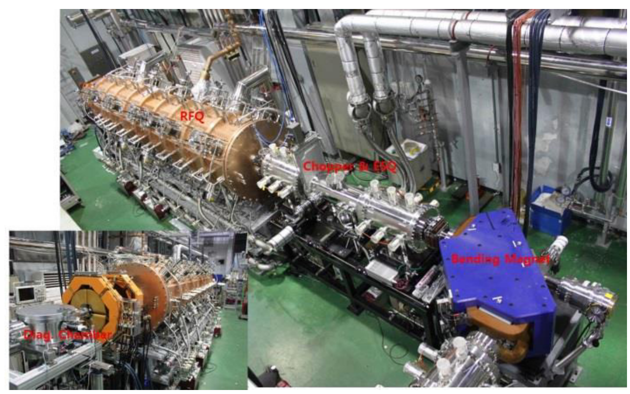

Figure 2: Experimental setup in the off-site test facility.

Table 1: Parameters of the RISP RFQ

Paramenters	Value
Frequency	81.25 MHz
Input Energy	10 keV/u
Output Energy	0.507 MeV/u
Duty Factor	100 %
Transmission	~98 %
Peak Surface Field	1.7 Kilpatrick

RISP RFQ

The RISP RFQ is a four-vane RFQ with a low operational frequency (< 200 MHz) and the cavity was fabricated by using brazing technology. The ramped inter-vane voltage profile was also adopted to reduce the cavity length. The basic parameters of the RISP RFQ were summarized in Table 1.

The RFQ cavity consists of nine longitudinal sections which are composed of the Oxygen Free Copper (OFC) as shown in Fig. 3. Each section was fabricated through 3

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steps of brazing, 2 steps of assembly and several steps of machining [3].

The field tuning was accomplished after the Resonance Control Cooling System (RCCS) was installed to control the resonance frequency by controlling the cavity wall temperature. Figure 3 shows the experimental setup to measure the field profile by using the bead-pull method. As a consequence, the ramped inter-vane voltage field profile and resonance frequency were tuned by using 20 movable slug tuners and the endplate geometry modification [4]. The reason why adopt a movable slug tuners are the cavity should be reinstalled in the project site after the completion of the construction.

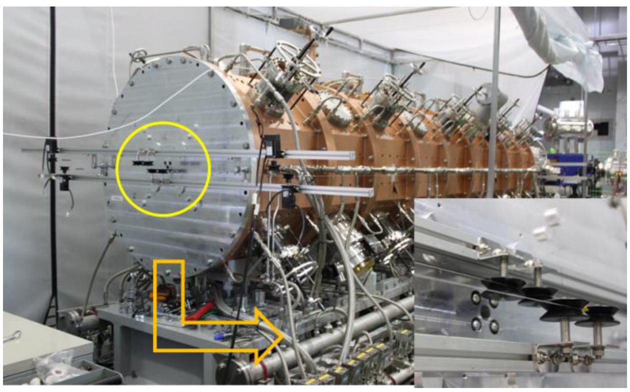

Figure 3: Experimental setup for the field tuning.

RF CONDITIONING

The RF conditioning of RISP RFQ started with a pulse mode and low duty. The repetition was increased from pulse mode to continuous-wave mode. To protect and check the characteristics of the cavity, the vacuum condition was monitored when the repetition was gradually increased. During the RF conditioning, the vacuum pressure was kept in the middle of 10^{-6} torr range to avoid sparking with the RF power in the cavity. The RF waveforms from the directional coupler and the pickup loop were used as a monitor of the multipactoring and sparking. Experimental results show that there is no significant mulipactoring range.

There are two power couplers for the cavity and the high power RF is provided by two 40 kW solid state amplifier (SSPA) systems as shown in Fig. 4. However, each coupler will be connected to the 80 kW SSPA with the 6-1/8 inch coaxial line in the project site. The phase difference between two couplers was compensated by the cable length of the low power lever and phase shifters as shown in Fig. 5.

RISP RFQ was installed and tested at the off-site test facility. However, the full RF power test can not be performed because of the limited cooling water capacity in the test facility. The operable condition is that the RF power of CW 60 kW can be operated through the operation of a set of 80 kW SSPA system. For the pulse mode, the RFQ has been conditioned to 70 kW without beam. The repetition rate was 20 Hz and the pulse width is 10 msec. For the cw mode, the cavity was conditioned to 30 kW. Figure 6 and 7 shows the conditioning results for the pulse mode and cw mode respectively [4]. The RF conditioning will continue with the optimization of the cooling water skid operation as RF power applied before the relocation .

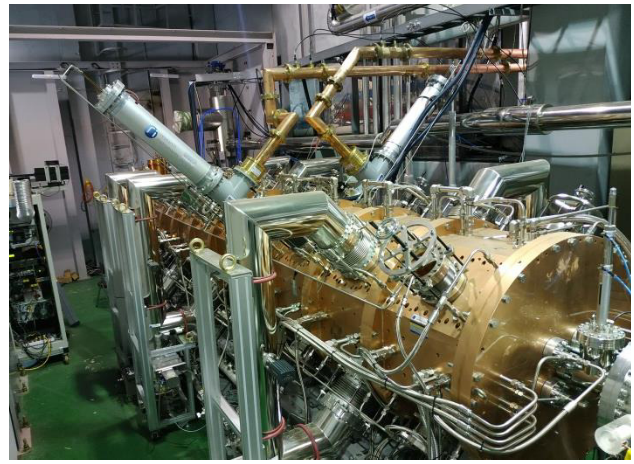

Figure 4: Two power couplers were installed and each will be connected to 80 kW SSPA systems.

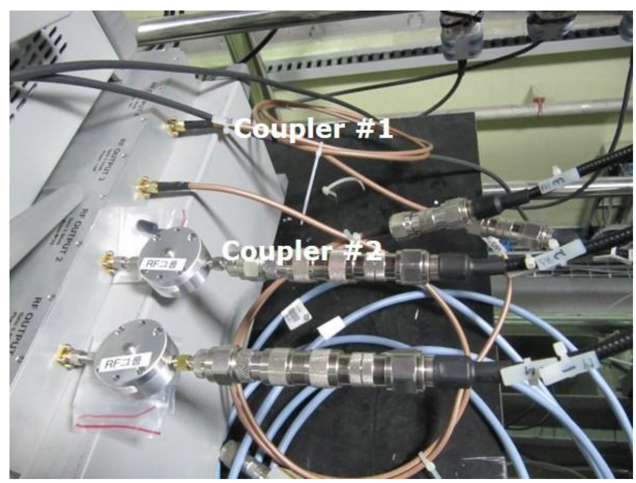

Figure 5: Phase difference between two power couplers was compensated by the cable length of the low power level and phase shifters.

REINSTALLATION

The RISP RFQ will be moved to the project site in October 2019, where the final commissioning will take place. The RFQ cavity which has 5 meters long and 1 meter in diameter will be disassembled and reinstalled until the end of 2019.

The weight of the RFQ cavity and the girder type support are 13 tons and 5 tons, respectively. Considering the gross weight of 18 tons and the access rout that the crane should be used, it was decided to move the cavity in disassembled form. The nine unit modules of the RISP RFQ

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will be installed and assembled according to the same procedures already performed in the off-site test facility.

Construction of the SCL3 area and the area connected to SCL2 has been completed as shown in Fig. 8. Moreover, the installation of the accelerator has been started and the utility will be supplied from early next year.

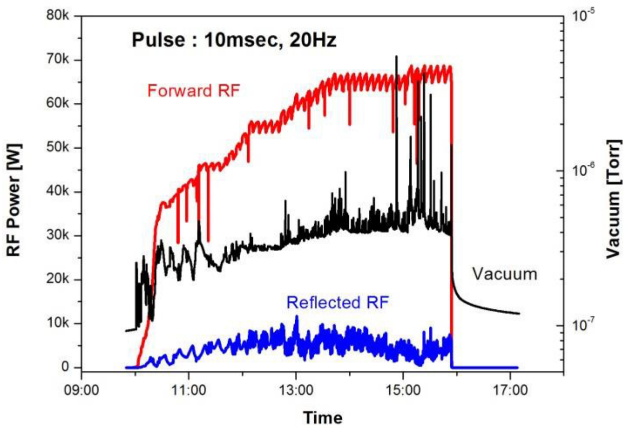

Figure 6: RF conditioning results for the pulse mode.

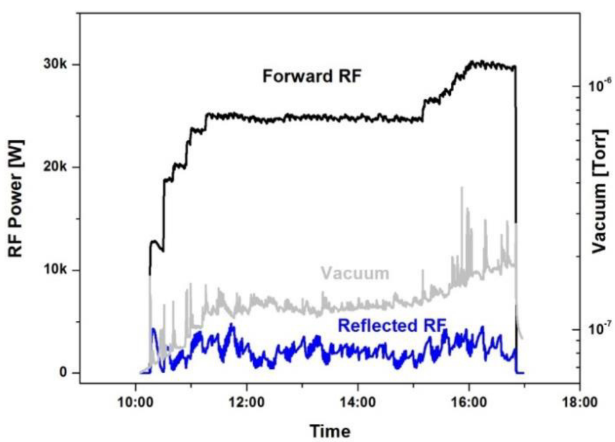

Figure 7: RF conditioning results for the cw mode.

Figure 8: Construction status for the tunnel and the injector hall.

CONCLUSION

RISP RFQ is under development to accelerate various heavy ions in the injector system of RAON facility. Before construction was completed, the RFQ was fabricated and installed to test the performance at the off-site test facility which is located at the Munji campus of KAIST. After the verification of the design, fabrication, and tuning results of the RFQ by the preliminary beam test, RF conditioning is underway. However, CW performance at maximum voltage will be performed not in the off-site test facility but in the project site due to insufficient cooling water availability.

The RFQ has been conditioned to 70 kW in pulse mode and 30 kW for cw mode without beam, which is sufficient to accelerate the key performance parameter beams, $^{40}Ar^{10+}$. In the end of 2020, a beam commissioning for the low energy superconducting linear accelerator (SCL3) will be performed.

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