Superconducting RILAC booster†

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The RIKEN Heavy-Ion Linac (RILAC) is undergoing an upgrade to enable it to further investigate superheavy elements and produce of radioactive isotopes for medical applications. In this project, a new superconducting (SC) electron cyclotron resonance ion source and SC booster linac (SRILAC) are being developed and constructed. The SRILAC consists of 10 TEM quarter-wavelength resonators that are operated at 73 MHz and contained in three cryomodules (CMs). The goals of the upgrade are listed in Table 1. It should be noted that the fundamental frequency of the reference radio frequency (RF) signal has been chosen as 36.5 MHz because it is the frequency for the RF system of the RIBF accelerators.

As shown in Fig. 1, the SRILAC consists of three CMs–CM1, CM2, and CM3–with a room-temperature medium-energy beam transport (MEBT) between them. The CMs do not contain superconducting magnets. The design of the CMs is a modification of a prototype CM developed at RIKEN.[1–3)]

The operational parameters of the CMs are listed in Table 2. The gap length of the cavity is optimized for $\beta = 0.08$ particles with a transit time factor (TTF) of 0.9. The gap voltage is 1.2 MV, which corresponds to an acceleration gradient E_{acc} of 6.8 MV/m with a synchronous phase of $-25°$. After the fabrication of the ten SC-cavities, all cavities were tested and passed the acceptance test.[5)]

The SC-cavities are cooled by 4-K liquid helium provided by a liquid helium cryogenic system using a HELIAL MF refrigerator (Air Liquide).

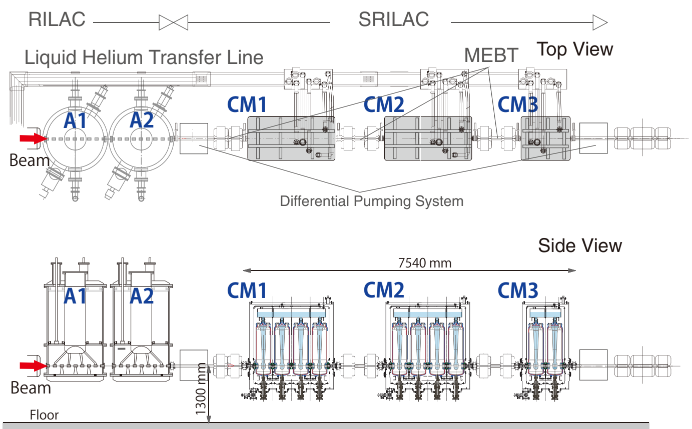

Fig. 1. Layout of the Superconducting RILAC (SRILAC).

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Table 1. Specifications of RILAC before and after upgrade.

Upgrade	Before	After
Number of tanks	12 DTLs	8 DTLs, 3 CMs
Frequency (MHz)	37.75/75.5	36.5/73.0
Total V_{acc} (MV)	25 ($A/q = 5$)	39 ($A/q = 6$)

Table 2. Operational parameters of the SRILAC.

Frequency (MHz)	73.0 (c. w.)
E_{inj} (MeV/nucleon)	3.6
E_{ext} (MeV/nucleon)	6.5 for $A/q = 6$
Number of cavities	10
Cavity type	TEM, $\lambda/4$
Max. gap voltage (MV)	1.2
Synchronous phase (°)	−25
Max. acc. gradient (MV/m)	6.8
Target Q_0 (at E_{acc} = 6.8 MV/m)	1 $\times 10^9$
Beam current (μA)	≤100
Q_{ext}	1–4.5 $\times 10^6$
Amplifier output (kW)	7.5

For the MEBT, a newly designed beam energy position monitor will be employed instead of the traditional wire scanners. Because beam measurement is non-destructive, ideally there is neither outgassing nor spattering to produce particulates in the high-vacuum sections.

Because the SRILAC will be installed in the existing facility, it is important to have an isolation system indicated as a differential pumping system in Fig. 1 to prevent contamination of the SC-cavities, which deteriorates the performance of the SC-cavities.

Full assembly of the CM will be finished in the first quarter of 2019 and its installation in the accelerator building is scheduled for March 2019. After installing the MEBT, including the differential pumping systems, cooling and RF testing will be performed during the second quarter of 2019 with the aim of full beam commissioning in the third quarter of 2019.

References

1) K. Ozeki *et al.*, *Cryomodule and power coupler for RIKEN Superconducting QWR*, LINAC2016, East Lansing, September 2016, TUPLR061, p. 598.
2) K. Yamada *et al.*, *First Vertical Test of Superconducting QWR Prototype at RIKEN*, LINAC2016, East Lansing, September 2016, THPLR040, p. 939.
3) N. Sakamoto *et al.*, SRF2017, WEYA01; K. Yamada *et al.*, PASJ 14th Annual Meeting, TUOL02.
4) http://www.jst.go.jp/impact/en/program/08.html
5) K. Yamada *et al.*, *Performance test of bulk-niobium cavities for new superconducting linear accelerator*, in these reports.