RILAC operation

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Originally, beam service was scheduled to start in January 2021. However, because of a failure owing to the aging of radio-frequency (RF) tanks of RILAC, repair of the breakdown and preventive measures were performed from January to March. In April, the external vacuum windows and the vacuum ports were added to the RF transmission line to energize the superconducting (SC) cavities, which were not used because of a vacuum leakage through the coupler ceramic windows. It operated well and ten SC-cavities became available. A user beam service started in May.

Some statistics regarding the RILAC operation from January 1 to December 31, 2021 are provided in Table 1.

Table 1. Statistics of RILAC operation from January 1 to December 31, 2021.

Operation time of RILAC	3294.0 h
Mechanical problems	185.4 h
Standalone RILAC	2141.5 h
Injection into RRC	0.0 h
Total beam service time of RILAC	2141.5 h

We performed the following maintenance works during the reporting period.

(1) Replacement of the leaky flowmeters for the cooling channels of the drift-tube quadrupole magnets in RILAC tanks and the quadrupole singlet magnets of the beam-transport-line.
(2) Rearrangement of the quadrupole magnets of the injection transport line to the tank #1 to enhance the transmission efficiency from the exit of the RFQ to the exit of tank #1.
(3) Renewal of the control and driving system of the coarse frequency tuners of RILAC tank #3 and tank #4.
(4) Removal of the fine frequency tuner of RILAC tank #2 because of the vacuum problem.
(5) Development of the beam interlock system (BIS) against the failure of the magnet power supplies.
(6) Construction of the quick BIS which instantly chops the beam when there is an error of the RF control system.
(7) Improvement of the rough evacuation ducts of the RILAC tanks by adding an automatic evacuation system.
(8) Introduction of automatic operation system of the cooling fans of the cooling towers for the ion source and the RFQ.
(9) Introduction of the automatic operation system of the cooling fans of the cooling towers for SRILAC and RILAC tanks with a function of alternating operation control.
(10) Renewal of the GPIB control system of the magnet power supplies.
(11) Feasibility test of the gyrotron for newly constructed SC-ECRIS (R28G-K).
(12) Installation of the external vacuum windows and the vacuum ports to the RF transmission lines of the SC-cavities.

We encountered several machine troubles during the reporting beam service period, which are listed as follows.

(1) Significant amount of coolant leakage from the drift-tubes of the RILAC tanks.
(2) RF power shortage of the RF power source for RILAC tank #1 due to the aging of a power tetrode.
(3) RF power shortage of the 1st-stage RF amplifier for the RILAC tank #6.
(4) Abnormal RF field error caused by the malfunctioning of the 1st-stage RF amplifier.
(5) Leakage of the cooling water from the final stage amplifier for RILAC tank #4.
(6) Burn out of the RF contacts for the shorting plate of the RFQ cavity due to a lack of cooling water.
(7) Leakage of the cooling water from the cooling pipe of the RFQ cavity.
(8) Leakage of the cooling water from the cooling pipe adopted to the end drift-tube of the tank A1.
(9) Malfunction of the power source for the solenoid coil (SoL11ab).
(10) Vacuum leakage from the bellows of the drive shaft of a mesh-beam-attenuator.
(11) Serious damage of the water pumps for the cooling system of the SRILAC RF amplifiers.

All the troubles were successfully fixed, and beam service was recovered instantly. The license of radiation safety to use heavy-ion beams with an intensity of 10 particle μA was updated after an inspection by the Secretariat of the Nuclear Regulation Authority.

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