Korea Atomic Energy Research Institute Heavy Ion Irradiation Facility: Status and Improvement Plans

Dae-Sik Chang [a*], Sung-Ryul Huh [a], Yong-Sub Cho [a], Seok-Kwan Lee [b], Hyung Gon Jin [a], Jeong-Tae Jin [a], Byung-Hoon Oh [a], Suk-Kwon Kim [a], Dong Won Lee [a]
[a]*Korea Atomic Energy Research Institute, 111 Daedeok-daero 989beon-gil, Yuseong-gu, Daejeon, South Korea*
[b]*Joong-Ang Vacuum Co., Ltd., 13 Daejeon-ro 1395beon-gil, Daedeok-gu, Daejeon, South Korea*
[*]*Corresponding author: dschang@kaeri.re.kr*

1. Introduction

For the purpose of supporting nuclear/fusion materials research and development, a heavy ion beam irradiation facility named Korea Atomic Energy Research Institute Heavy Ion Irradiation Facility (KAHIF) has been constructed at Korea Atomic Energy Research Institute (KAERI), Daejeon, Korea [1]. This facility is based on linear accelerators (linacs) of the Tokai Radioactive Ion Accelerator Complex (TRIAC) given from the high energy accelerator research organization (KEK), Japan [2–5]. The KAHIF produces heavy ion beams with energies up to about 1 MeV/nucleon for. In this article, present status and improvement plans of the KAHIF are presented and discussed.

2. Facility Description

An ion beamline of the KAHIF comprises an electron cyclotron resonance (ECR) ion source, a low energy beam transport (LEBT), a split-coaxial radio-frequency quadrupole (SCRFQ) linac, a rebuncher (RB), four interdigital H-type (IH) linacs, a high energy beam transport (HEBT), and a target chamber as shown in Fig. 1 (a) and (b).

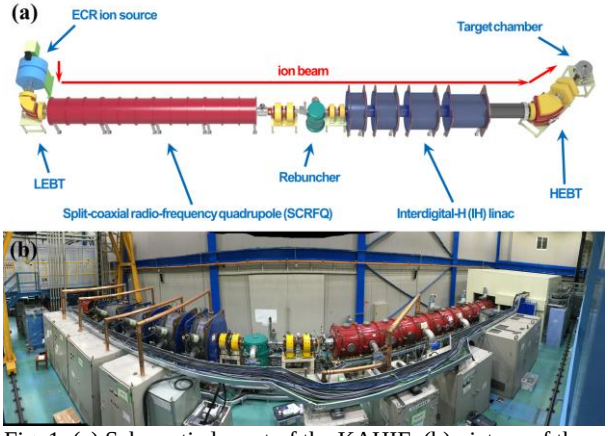

Fig. 1. (a) Schematic layout of the KAHIF, (b) picture of the beamline.

The KAHIF can only provide stable non-radioactive beams. The 18 GHz ECR ion source supplies linacs with ions heavier than protons through the LEBT. The 25.96 MHz SCRFQ linac accelerates the heavy ions up to 178 keV/ nucleon. Then, the accelerated ions reach to the 51.92 MHz IH linacs via a transport system composed of an RB and two sets of quadrupole doublet. Finally, the IH linacs can reaccelerate the ions up with energies up to 1.09 MeV/nucleon. The ions are delivered to the target chamber through the HEBT. The major specifications of the SCRFQ and IH linacs can be found in Table I [2]. Available beam energies can be selected by switching powers of the linacs (Table II).

Table I: Specifications of the KAHIF linacs

	SCRFQ	*IH*
Frequency	25.96 MHz	51.92 MHz
Charge-to-mass ratio	≥ 1/28	≥ 1/9
Input energy	2.07 keV/nucleon	178 keV/nucleon
Output energy	178 keV/nucleon	178–1090 keV/nucleon
Normalized emittance	0.6πmm·mrad	
Energy spread	1.03%	≤ 2.8%
Repetition rate	20–1000 Hz	
Total length	8.6 m	5.6 m

Table II: Beam energies of the KAHIF

Mode	*RFQ power*	*IH1 power*	*IH2 power*	*IH3 power*	*IH4 power*	*Beam energy (keV/nucleon)*
SCRFQ mode	on	off	off	off	off	172
IH1 mode	on	on	off	off	off	293
IH2 mode	on	on	on	off	off	476
IH3 mode	on	on	on	on	off	726
IH4 mode	on	on	on	on	on	1090

Most of control system has been implemented using the EPICS framework. Detailed information on integrated operator interfaces and interface hardware of the KAHIF is given in Fig. 2 and Table III.

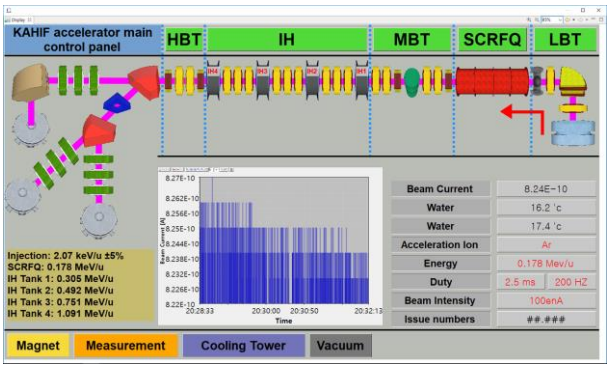

Fig. 2. KAHIF integrated operator interfaces.

Table III: Interface hardware of the KAHIF

function	*Interface hardware*
Beam monitor	NI PXI based
Einzel control	NI PXI based
Interlock	LS PLC based
cooling control	LS PLC based
Magnet control	NI GPIB / ENET-100
Ion Source control	Yokogawa PLC based
Vacuum monitor	Serial / Moxa server
LLRF	Analog circuit
RF feedback control	NI PCI based PC

3. Typical Performance

After acquisition of the radiation safety license, performance testing of the beamline components, and ion beam acceleration tests, the performance tests have been carried out. For the tests, He^{+} and Ar^{10+} ions were selected by adjusting magnetic field intensity of the LEBT bending electromagnets and accelerated in the IH4 mode. The results are summarized in Table IV.

Table IV: Results of the performance tests

	He^{+}	Ar^{10+}
Beam energy	4.2 MeV	42.3 MeV
Peak beam current	7.8 eμA (@ 4.2 MeV)	0.8 eμA (@ 42.3 MeV)
Duty cycle	28.8%	
Repetition frequency	120 Hz	
Pulse width	2.4 ms	
Beam flux	4.9×10^{17} #/m^2·s	5.1×10^{15} #/m^2·s
Beam irradiation condition	Horizontal / Vacuum	
Beam spot size	10×10 mm^2	

The beam currents were measured with a Faraday cup in the target chamber, and the measured values of He^{+} and Ar^{10+} beam currents were 7.8 and 0.8 eμA, respectively.

4. Improvement Plans

Heavy ion beams in the KAHIF now serve a vast range of scientific users in the fields of nuclear/fusion engineering. Especially, the facility can be used for simulating nuclear/fusion reactor environments. In the near future, improvements to achieve higher utilization will be started.

Together with fabrication of a new Fe ion source for supplying metal ion beams to the users, replacing the existing analogue low level RF (LLRF) systems with new digital LLRF will be one of the important improvements. The digital LLRF currently in preparation enables one to free from problems such as a number of inherent errors including DC-offsets, drifts and low accuracy. In this way, KAHIF can offer more stable beam with accurate beam control to users.

Presently, commissioning of the KAHIF accelerators for preparation of user service are in progress. More details of the status and improvement plans will be reported in the presentation.

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