A DIAGNOSTICS OF ION BEAM FROM 28GHz ELECTRON CYCLOTRON RESONANCE ION SOURCE

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Abstract

A neutron radiography facility utilizing a 28 GHz superconducting electron cyclotron resonance (ECR) ion source and a heavy ion accelerator is now under construction at Korea Basic Science Institute (KSBI). In order to generate a proper energy distribution of neutron, a lithium ion beam is considered. It will be accelerated up to the energy of 2.7 MeV/u by using a radio frequency quadrupole (RFQ) and drift tube linear (DTL) accelerator. The 28 GHz superconducting ECR ion source, which is the state of the art of an ion beam injector, has been built to produce the lithium ion beam. The ion beam of 12 keV/u would be extracted to low energy beam transport (LEBT) system, which is comprised of several types of electromagnets to focus and deliver the beam, effectively. After transporting an ion beam through LEBT, RFQ once accelerates the ion beam from 12 to 500 keV/u. Finally, we can achieve the final beam energy after accelerating at the DTL. Before the ion beam is delivered to accelerator, the requirements should be satisfied to confirm the status of beam. For this, we developed the instruments in the diagnostic chamber in the middle of LEBT system to observe the beam dynamics. An analyzing electromagnet, slits, wire scanners and faraday cup will be used to perform a diagnosis of ion beam characteristics. We will present and discuss the experimental results of ion beam profile and the current after selecting are required charge state.

INTRODUCTION

For the research facility based on accelerator technology at KBSI, a 28 GHz superconducting ECR ion source, a LEBT system, and linear accelerators are under development [1]. Recently, ECR plasma ignition was successfully implemented using 28 GHz superconducting ECR ion source [2]. Since then, a ion beam extraction from ECR ion source is scheduled to experiment. In the ion beam extraction test, the beam properties will be measured using various diagnostic technique. Figure 1 shows the layout of the KBSI Accelerator research facility. The first application to the KBSI accelerator research facility is neutron radiography. For the generation of neutron, the inverse kinematics technique is considered. In this method, a lithium beam accelerated up to 2.7 MeV/u will impact the hydrogen gas target, then the neutron will be generated. In order to accelerate lithium beam, radiofrequency quadrupole and drift tube linear accelerator will be used.

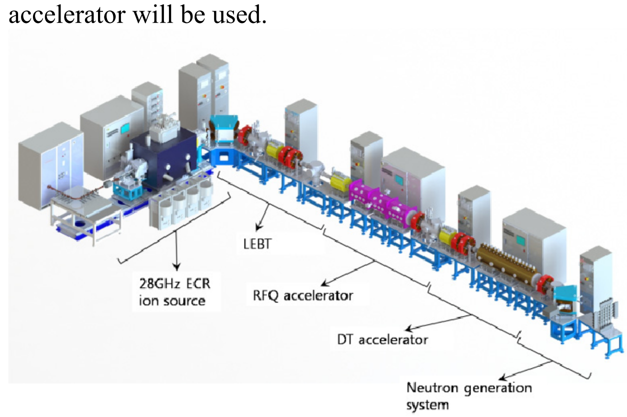

Figure 1: The layout of the KBSI accelerator research facility.

Also, for the beam transmission from ECR ion source to RFQ a LEBT system is designed. The schematic of LEBT system is showed in Figure 2.

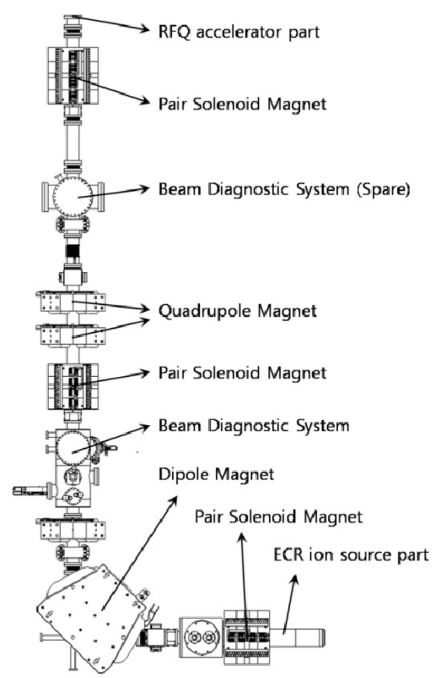

Figure 2: The schematic of LEBT system.

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The details of the LEBT system are presented next section.

LOW ENERGY BEAM TRANSMISSION SYSTEM

In order to satisfy the requirement for the input beam of RFQ, the LEBT system is designed. The whole LEBT system consists of a dipole magnet, three pair solenoids, three quadrupole magnets, four steering magnets, and two diagnostic chamber (1 spare). For the LEBT design, the TRANSPORT code is used[3]. The initial beam parameters are shown in table 1.The results of beam transport simulation are shown in the Figure 3. The abbreviation of Sol, D, BM, DG, QM is pair solenoid, drift tube, dipole magnet, diagnostic chamber, and quadrupole magnet, respectively. In Figure 3, the total length of the LEBT is 7 m and the calculated maximum beam size is around 4 cm. The elements of the LEBT are fabricated based on the results.

Table 1: The Initial Beam Parameters

Particle	**Lithium**
Mass	7
Charge	3
Energy	12 keV/u
Emittance	0.2 π mm mrad
Current	1.0 mA

The beam is extracted from 28 GHz superconducting ECR ion source, ate that time unwanted charge states particles and ions are included. A dipole magnet is used to separate these undesirable particles. After dipole magnet, beam devices in diagnostic system measure the beam profile, emittance and current. The description of the diagnostic system will be discussed in the next section.

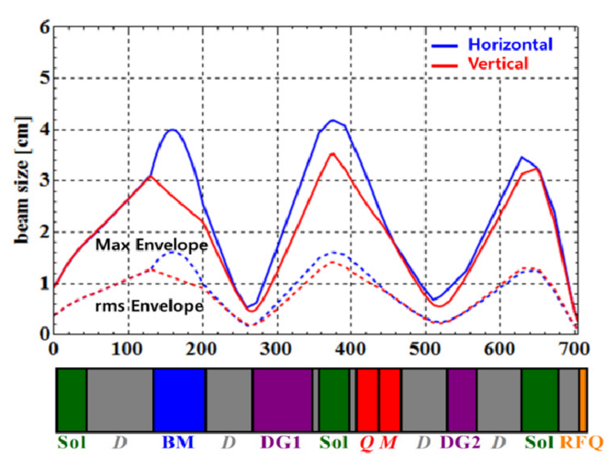

Figure 3: The beam optics simulation results using TRANSPORT code.

DIAGNOSTICS SYSTEMS

A various diagnostic devices are prepared in LEBT system. The whole name, the purpose of use and the number of devices are listed in table 2. The number of slit is two due to the horizontal and vertical position.

Table 2: List of Beam Diagnostic Equipments

Device		**#**
Slit	Beam separation	2
Screen	position and size	1
Wire scanner	Transverse emittance	1
Faraday cup	Current	1

The photo of equipments inserted into diagnostic chamber is shown in the Figure 4.

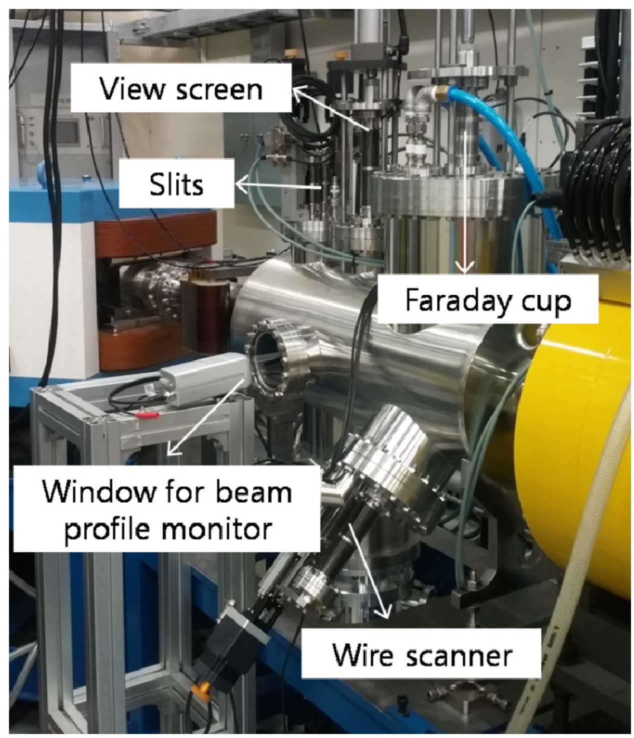

Figure 4: The photo of diagnostic chamber with measuring devices.

View Screen

In order to monitor the beam profile we have decided to use a view screen in the diagnostic chamber. The use of view screen is easy and simple method. The screen is comprised of stainless steel plate which tilts to 45° as compared with beam axis for beam profile observation. The stainless steel screen is designed with pin holes for calibration of beam position. The fabricated screen is shown in the Figure 5. Also, CCD camera for beam profile monitoring and a movable stage is installed as a part of view screen in the Figure 4.The Y_2O_2S is selected

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as a doping material, which has a high brightness in low beam energy regime and a short decay time.

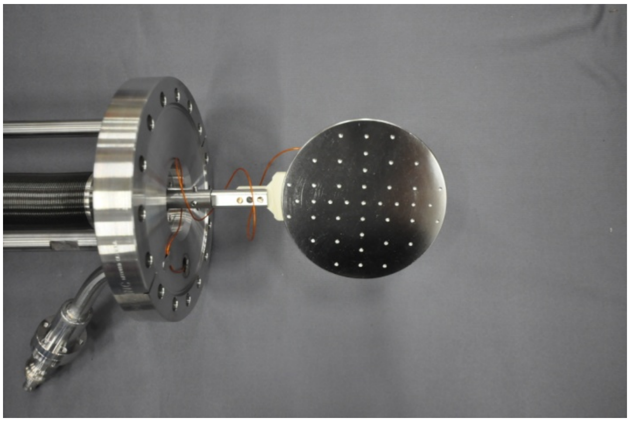

Figure 5: The photo of view screen with pin holes.

Faraday Cup

For the beam current monitoring, a faraday cup is designed. Faraday cup is inherently a destructive device and it measures beam intensity with collection of charge. Therefore, faraday cup has to absorb a full beam power and it can be used for beam dump. We multi-functionally choose both charge collection and beam dump in faraday cup design. The diameter of cup is also decided considering a beam size from LEBT simulation. In order to measure precisely beam intensity, a suppress electrode with voltage from -100 V to -500 V and a confinement of secondary electron emission from the inside of the cup is considered. A water cooling channel also is inserted in the body of faraday cup to take away a heat caused by an interaction between beam and cup. Figure 6 shows the results of faraday cup simulation.

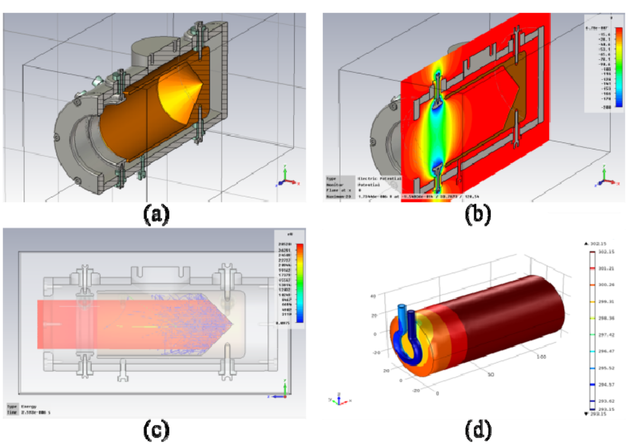

Figure 6: The simulation results of Faraday cup 3D model (a), potential distribution (b), secondary electron tracking (c), temperature distribution with cooling channel (d).

Based on the simulation results, the faraday cup is fabricated and it is shown in the Figure 7. In order to reduce a noise, de-ionised water is flowed for cooling and a electrically isolated ground is adopted. For a movement in the diagnostic chamber, movable stage also is inserted.

Figure 7: The photo of the fabricated faraday cup.

Wire Scanner

A wire scanner is used to measure a beam profile due to the it's silmple structure and high resolution. In order to measure beam profile, wire scanner sweaps a beam using a thin tungstenwire. A step moter and bellows are adopted for a wire movement of up and down. The wire has thickness of 0.1 and the minimum step of the step motor is 0.1 mm. These thin wire and small step garantee a high resolution when beam profile is measured. We use three wires for wire scanner. The three wires measurement provides projection signal as well as correlation, and twiss alpha information from a single measurement. The manufactured wire scanner with three wire is shown in th Figure 8.

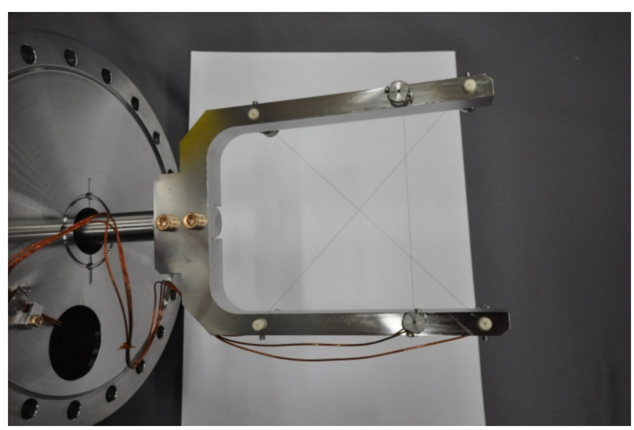

Figure 8: The photo of wire scanner with three wire.

For a verification of performance of the fabricated wire scanner and the measurement program, a pilot test is carried out at Research Center for Nuclear Physics (RCNP) in Japan [4] before operating our 28 GHz superconducting ECR ion source and LEBT system. The measured beam particle is $O^{7+}$with 30 eμA. The measured vertical and horizontal emittance using the fabricated slits and wire scanner is 137.1and 185.8 π mm mrad and previous emittance using RCNP's measurement system is 152.2 and 208.5 π mm mrad, respectively. The gap

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between the measured emittance values is come from the different data calibration method and the different measuring position between devices. However, the effect of the both factors on the results is small. Therefore, the measured emittance data from fabricated wire scanner is well matched up with a RCNP beam emittance data from existing measurement device in RCNP.

CONCLUSION

A 28 GHz ECR plasma is generated at KBSI and ion beam will be extracted soon. In order to measure ion beam properties extracted from 28 GHz superconducting ECR ion source, a beam diagnostic systemis prepared. Diagnostic devices consist of view screen, slits, faraday cup, and wire scanner. Each device is fabricated and installed in diagnostic chamber in LEBT. A pilot test of wire scanner is carried out at RCNP in Japan and the results are well matched with RCNP's emittance measurement data. After beam extraction from KBSI 28 GHz ECR ion source, the diagnostic system will be applied to analyse the ion beams.

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