Development of the Ion Beam Diagnostic System for BIBA Using 28 GHz ECRIS at KBSI

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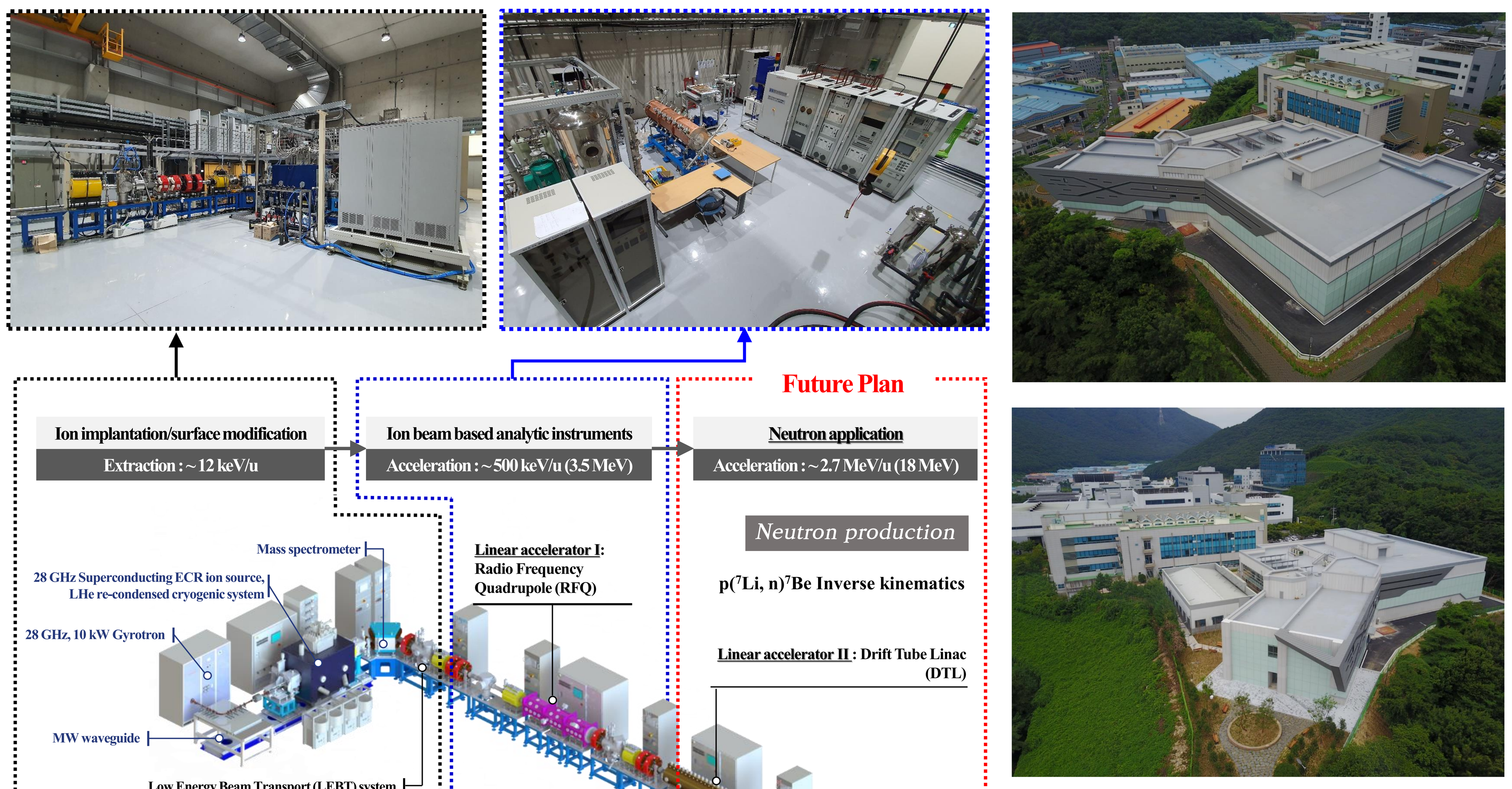
Introduction

- **BIBA (Busan Ion Beam Accelerator)** is a compact linear accelerator facility using the 28 GHz ECRIS (Electron Cyclotron Resonance Ion Source) at KBSI (Korea Basic Science Institute).
- **The practical purpose** of the BIBA is to produce **neutrons** and **multi-charged heavy ions.**
- In order to satisfy the requirements of beam selection, diagnosis of beam properties, application of ion beam implantation, and transport to the RFQ accelerator, including the fringe effect, a beam dynamics study of the LEBT was required for multi-purpose employment.



Constructed a new building in September of 2018.

Fig. 1. A brief schematic drawing of the BIBA and a new high-tech research facility.

Ion Beam Dynamics and Diagnostics System

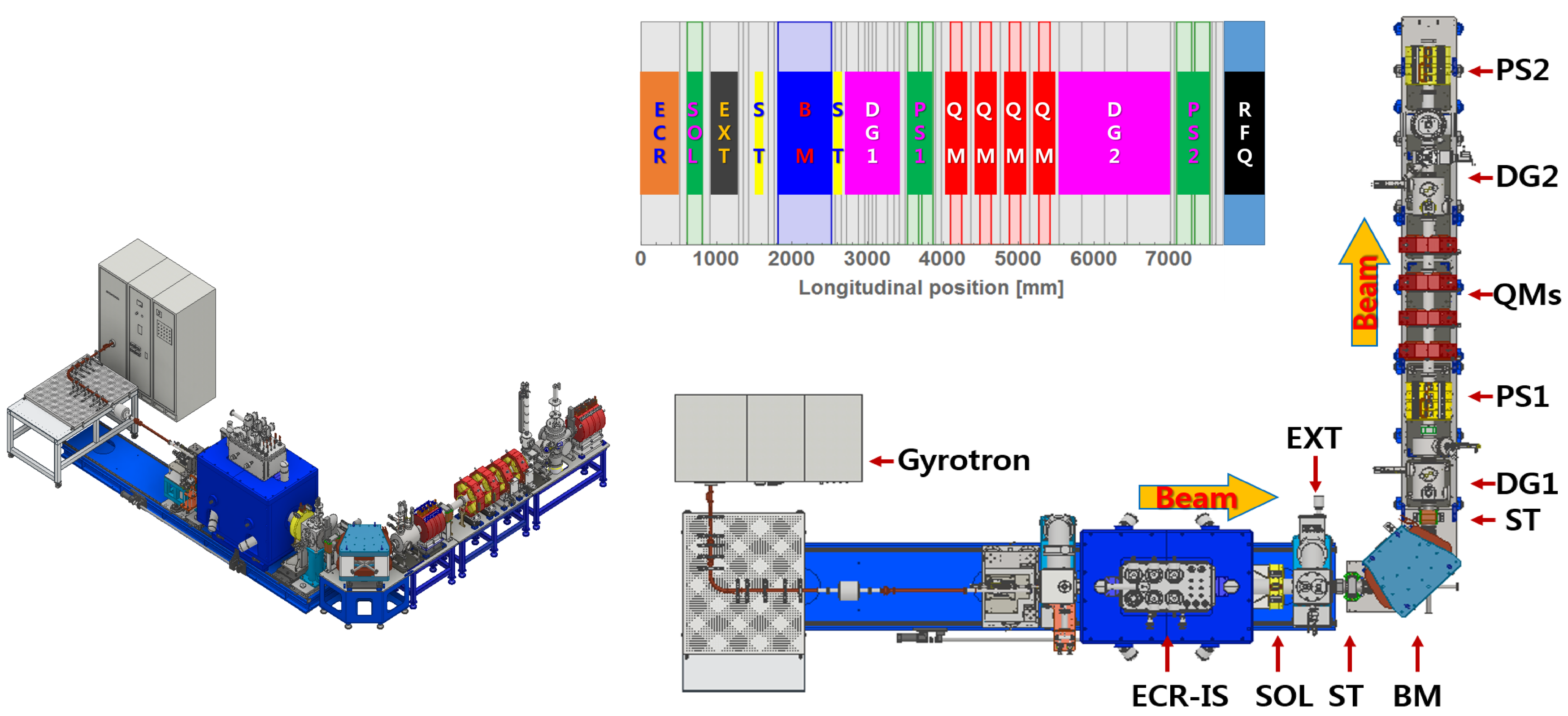


Fig. 2. A brief schematic drawing of the multi-purpose LEBT system.

- Recently, the low energy beam transport (LEBT) system for BIBA has been re-designed taking into account the fringe effect of magnet to match the ion beam for ion implantation as well as for input beam for the accelerator such as Radio-Frequency Quadrupole (RFQ).
- The LEBT system consists of a dipole magnet (BM), solenoid (SOL), quadrupole magnets (QM), steering magnet (ST) and a diagnostic system (DG1, DG2) as shown in fig. 2.
- In the first diagnostic system (DG1), horizontal and vertical slits and a wire scanner are positioned to separate ion beams and measure the beam profile and transverse emittance using the slit scan method. In addition, screen monitor, implantation chamber and Faraday Cup are installed in the second diagnostic system (DG2) to provide an ion implantation service and measure the beam intensity and transverse emittance for cross-check. Fig. 3 displays a brief schematic drawing of the diagnostic system, such as the slit, Faraday Cup, wire scanner and implantation chamber.

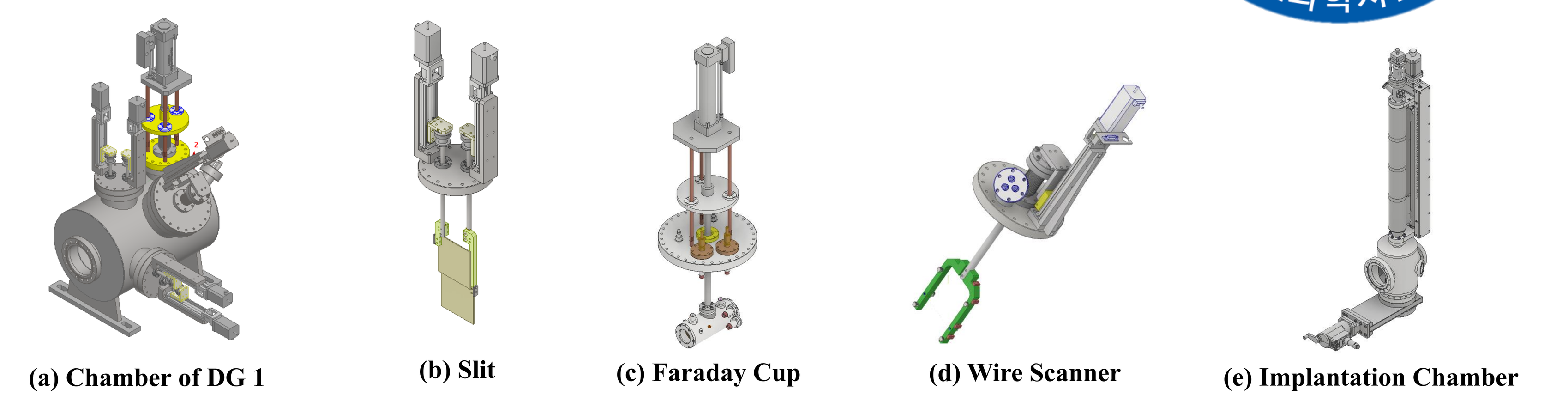


Fig. 3. A brief schematic drawing of Diagnostics System (DG 1, DG 2).

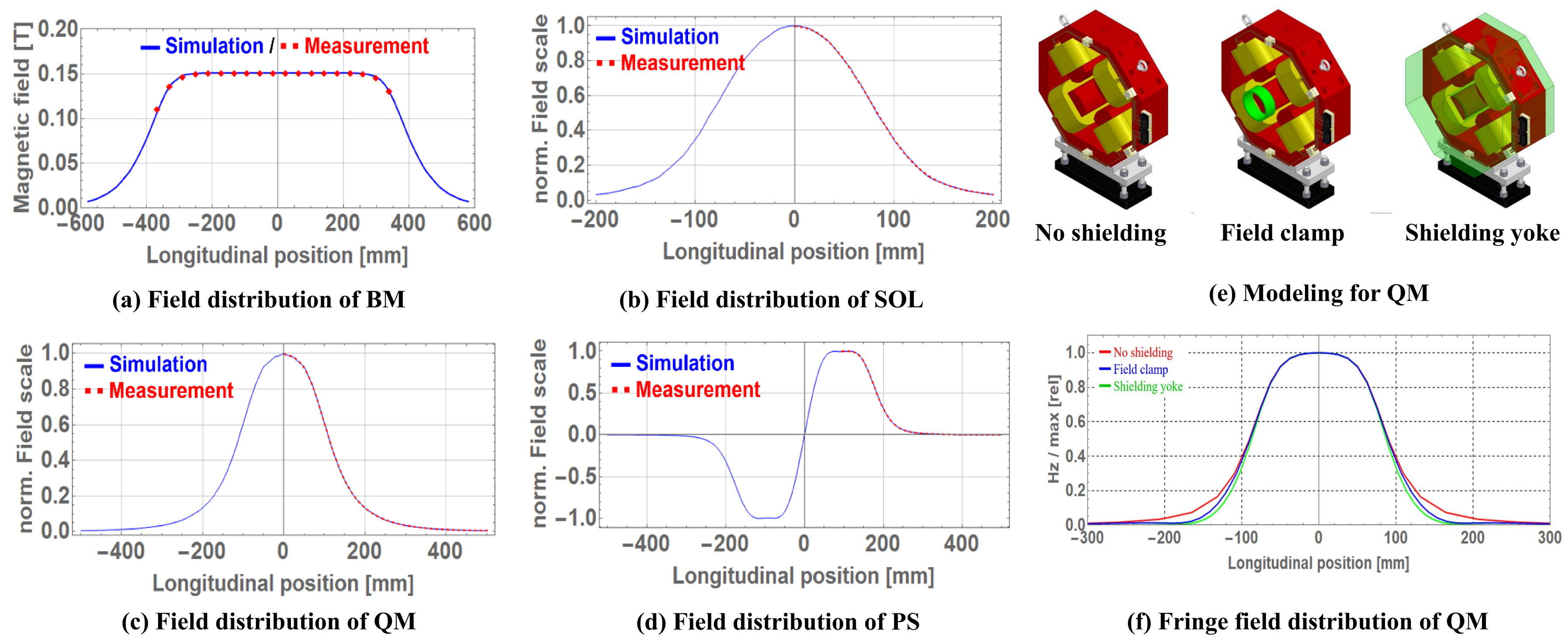


Fig. 4. Field distributions along the beam axis of the QM, SOL and BM magnets.

- Fig. 4 shows the magnetic field distribution in the longitudinal direction of all the constructed magnets in the LEBT, such as a single solenoid magnet, a pair of solenoid magnets, a quadrupole magnet and dipole magnets.
- Because the fringe field distribution is dependent on the aperture size of the magnets, the physical and effective length of the magnets and the space required for installation are considered to avoid magnetic field interference and damage in the beam dynamics study for the LEBT.
- The quadrupole magnet has a long fringe field distribution in the longitudinal direction, due to its coil shape and lack of magnetic field shielding. In order to reduce the fringe field distribution caused by magnets, magnetic field clamping or the use of a shielding block around the magnets are generally employed. Two cases of modeling, of a Shield yoke and a Field clamp, have been investigated to optimize the structure for the reduction of the fringe field distribution, as shown in Fig. 4 (e, f).

Component	Beam radius: 1.0 cm Strength [kG]	Beam radius: 1.5 cm Strength [kG]	Beam radius: 2.0 cm Strength [kG]
Sol	1.82	1.97	2.08
BM	0.77	0.77	0.77
PS1	1.43	1.41	1.39
QM1	0.11	0.13	0.09
QM2	-0.25	-0.19	-0.12
QM3	0.24	0.05	0.04
QM4	-0.11	0.04	0.01

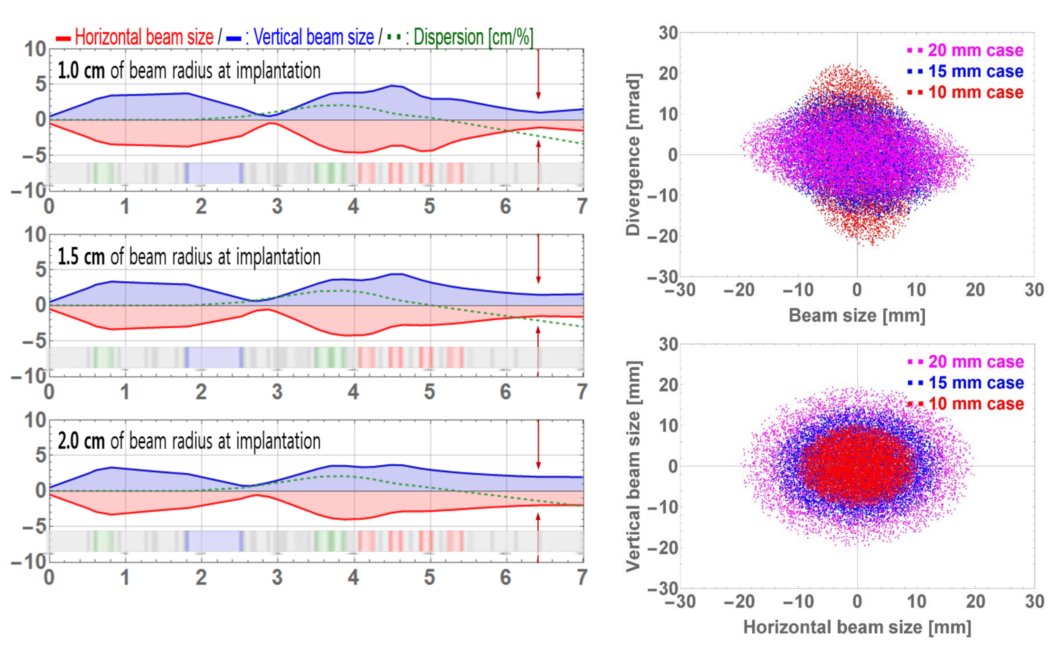


Fig. 5. Magnet strength of the LEBT magnet and Beam dynamics results and distributions of various A/q ion beams.

- As a results, Fig. 5 describes the magnetic strength of the LEBT magnets for the optimization of implantation. And, the beam envelopes and beam distribution at the sample are shown, respectively for various cases.

Conclusion

- We have studied various ion beam operation modes, such as ion beam implantation with magnetic field shielding to decrease the fringe field distribution, and optimization for ion beam transportation for various types of mass-to-charge ratios.
- In the future, a pepper-pot emittance meter is planned to be installed in the LEBT for a quick transverse emittance measurement, to verify the previous slit scanned emittance measurement.