Development of the 1 MeV/n RFQ accelerator beam line at KOMAC

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1. Introduction

For the advantage of good beam quality that is essential for decreasing beam loss, Radio Frequency Quadrupole (RFQ) accelerator is the best accelerating structure for a low-energy beam with a strong space-charge effect. It provides a beam with both transverse focusing and longitudinal bunching, as well as acceleration [1]. Korea Multi-purpose Accelerator Complex (KOMAC) has been designing and developing the 1 MeV/n RFQ accelerator for several years. We could sketch the design like Figure 1. Considering optical simulation and engineering design. The four-vane type RFQ accelerates an ion beam from a 2.45 GHz microwave ion source of 25 keV/n to an energy 1 MeV/n. The main parameter of this accelerator is shown in the table 1. It can be application for test stand of 100 MeV proton linac accelerator and neutron production.

Table 1. The 1 MeV/n RFQ main parameter. [2]

Design particle	$^{4}He^{2+}$
Input beam Energy	**100 KeV**
Output beam Energy	**4 MeV**
Peak Current	**10 mA**
Structure Type	**Four vane**
RF frequency	**200 MHz**
RF power	**130 kW**
Length	**320 cm**
Transmission	**96.4 %**

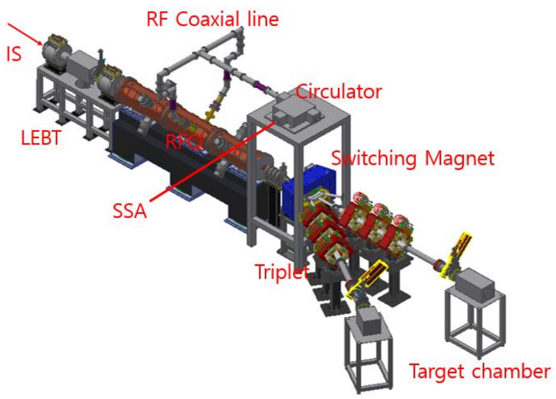


Figure 1. Sketch of the 1 MeV/n RFQ accelerator, KOMAC.

2. Design of the 1 MeV/n RFQ accelerator beam line

In this section, we will describe beam line starting at microwave ion source passing through low-energy beam-transport (LEBT) and RFQ. There are some components for an optimal beam, an E-trap, quadrupole magnets in a row, a switching magnet and the triplet can affect the beam quality and trajectory. Optical calculation is made with Trace Win before engineering design.

2.1 LEBT Beam line

The LEBT line for the accelerator is required to deliver effectively the beam produced by the microwave ion source. This LEBT was designed to transmit an ion beam with an energy of 25 keV/n at the entrance of the LEBT. This line consisted of vacuum beam pipe, a pair of solenoids and electron-trap (same as electron repeller) with an injection cone like Figure 2.

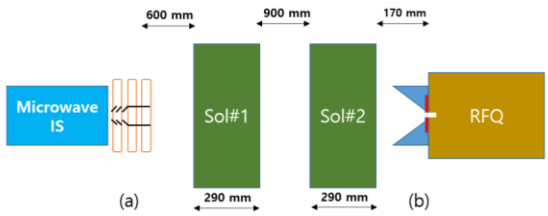


Figure 2. Scheme of LEBT. (a) : Microwave IS extraction system (b) : RFQ injection cone and injection port of RFQ

The LEBT consist of Microwave IS, injection parts, a pair of the solenoid and an input part of the RFQ in a raw. Based on these LEBT components. We calculated the beam optics and emittance using the Trace-Win code. The $4He^{2+}$ beam with 10 mA, 100 keV energy from ion source transport through the LEBT and RFQ injection aperture is shown on Fig. 3. The solenoid magnetic field values on axis are 0.227 T and 0.291 T.

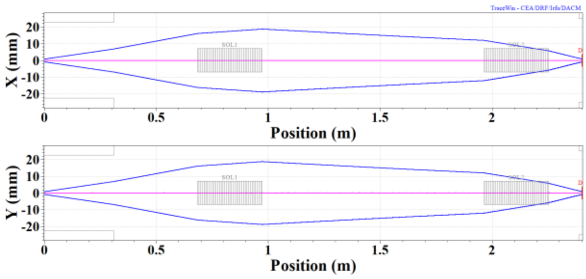


Figure 3. Beam transport throughout the LEBT with a pair of solenoid and electron-trap

The transmission of the RFQ up to 99.67% along the LEBT. At the RFQ entrance, the RMS emittance is 0.1194 π.mm. mrad and the Twiss parameters are α=1.5, β=0.051mm/ π. mrad(Figure 4 is the particle phase space distribution at the RFQ entrance).

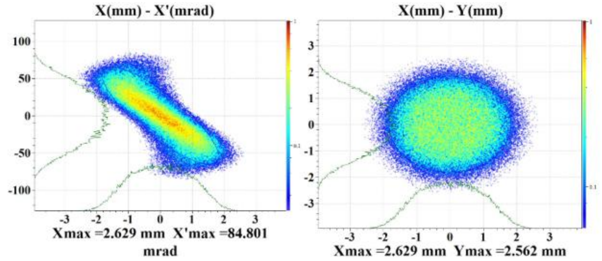
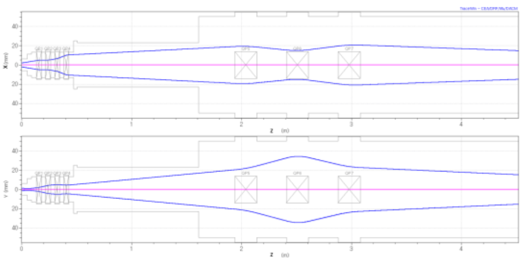


Figure 4. Particle phase space distribution (x, x') and (x, y) at RFQ entrance

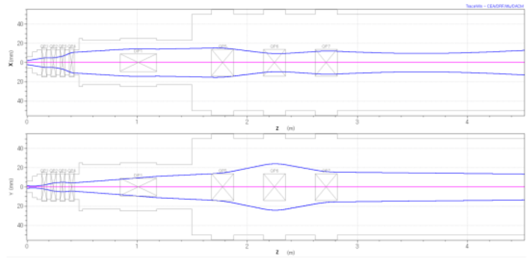
The Result of a calculation with Trace-Win code, we can define the size of the injection cone and e-trap for fabrication. In addition, the size of the injection aperture of RFQ had to be corrected.

2.2 Beam line from RFQ to Target chamber

After beam accelerated by RFQ transmit to the two direction of the beam line. The beam line consisted of the quadrupoles, the switching magnet and a pair of the triplets reached to the target chamber. Straight beam line is for using neutron production system. 30 degrees line is for using irradiation target [3]. As designing LEBT Beam line, first, define the optimal beam condition with Trace-Win code (Figure 5.). After then, we determined the dimension of the distance between components.



(a) Straight beam line



(b) 30 degrees beam line

Figure 5. Beam accelerated by RFQ passing through the switching magnet and quadrupole magnets to the target chamber

3. Conclusion and future work

Based on the calculation with code, we already fabricated all components of the beam line. We will install the beam line components and carry out beam line arrangement for decreasing beam loss or alignment. Figure 6 is the overview of the 1 MeV/n RFQ accelerator at KOMAC. Now, we are testing the conditioning for RF input to the RFQ. After then, we are going to test for improving beam emittance depending on the injecting gas species and reaching the beam to the target chamber. We expect the facility inspection will be conducted in this year.

Figure 6. Overview of the 1 MeV/n RFQ accelerator, KOMAC

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