Result of the beam test with a 13MHz cavity

Tu Anh Trinh [a,b*], Yong Sub Cho [a], Hyeok Jung Kwon [a], Han Sung Kim [a], Kyung Tae Seol [a],
[a] *Proton engineering Frontier Project, Korea Atomic Energy Research Institute, Daejeon 305-353*
[b] *University of Science and Technology, Daejeon 305-350*
[*] *Corresponding author: tuanh@kaeri.re.kr*

1. Introduction

A 13MHz rf cavity for an rf implanter with new concept has been developed at PEFP. Performance of this cavity is under investigation. Rf properties and high power tests showed that all designed values have been achieved [1]. As the last phase of development of the cavity, beam test was carried out. This paper addresses the experiment set up and result for beam test with this cavity

2. Methods and Results

2.1 Experiment set up

Experiment set up is shown in Fig.1. 30 keV 4He+ ions were generated from a duoplasmatron ion source. They were then focused by a compact triplet [2] whose focusing strength is 1.12T/m. The beam was accelerated by the cavity and bended by a bending magnet to diagnostic chamber. The radius and angle of the bending magnet are 40cm and 90 degrees, respectively. The diagnostic chamber was placed downstream of the linac and a Faraday cup was mounted 80cm far away from bending magnet

Fig. 1 Experiment set up

The power supplies have specifications of 60V, 50A with 0.05 % stability. Magnetic field of the bending magnet was measured by a Hall probe with the accuracy of 0.05%. Dependence of magnetic field on power supply current is shown in Fig.2. As can be seen, the magnetic field has a linear relation with power supply current in the investigated range.

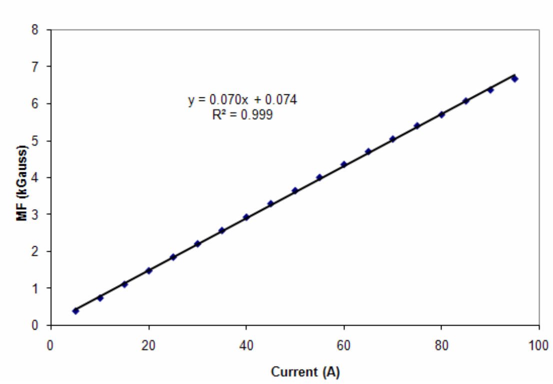

Fig. 2 Dependence of magnetic field on power supply current

2.2 Beam current and RF waveform

Following the RF conditioning, the beam acceleration experiments were carried out. To measure the beam current, a Faraday cup was installed about 80 cm away behind bending magnet. First, the beam current was measured without RF power applied. In this case, the transverse focusing power should be reduced because there was no RF defocusing force. The beam current was intentionally reduced by controlling the ion source to operate the machine within safety limit at the very beginning stage. When rf power was turned on, the current signal was amplified by the low noise current pre-amplifier (Stanford Research Systems, SR570) and recorded with the oscilloscope (Fig.3).

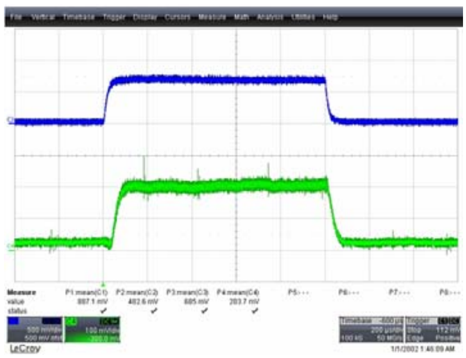

Fig. 3 Wave form of the forward power (C3) and beam current (C4)

Energy of the beam was roughly determined by changing the bending magnet power supply current (Fig. 4). The resolution of the magnet is 0.05%. At a fix driving frequency of 12.658MHz, rf power of 1.08kW and focusing magnet current of 20A, the maximum helium current of 2.2uA was achieved at a magnetic field of 0.24Tesla. With a bending radius of 40cm, it confirms that the magnetic rigidity is 0.1T-m. This means that the beam energy is 130keV. No peak can be found beside this magnetic field range.

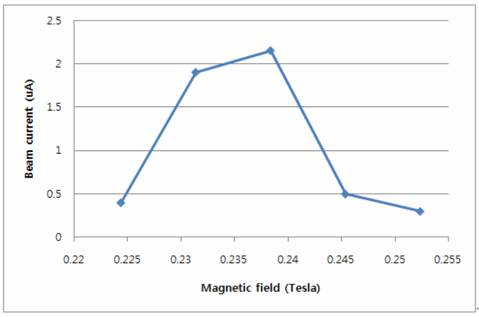

Fig. 4 Accelerated beam current depends on magnetic field (at fix driving frequency of 12.658MHz, rf power of 1.08kW and focusing magnet current of 20A)

The focusing magnet strength was then increased to focus the beam (Fig 5). A beam current of 5.5uA was obtained. However, we cannot increase the magnet current any more due to its affect to the cavity. Therefore, we limit the focusing magnet current at maximum value of 60A.

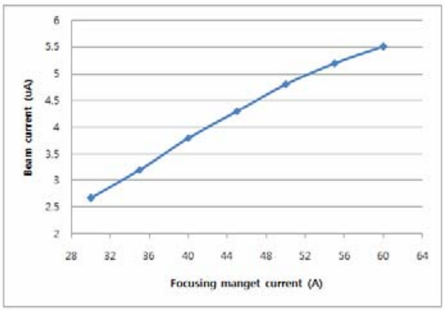

Fig. 5 Dependence of beam current of focusing magnet current.

The output energy was investigated in relation with rf power and driving frequency. The results are shown in Fig.6. The frequency shift step is 1kHz. When the driving frequency shifts from resonant frequency, the total accelerated voltage is slightly reduced. Start at rf power of 1kW, the energy gain slowly increases and achieves maximum value of 105keV at rf power of 1.08kW and then decreases to a saturated value.

Bunched beam signal in time domain is shown in Fig.7. The signal was then presented in frequency domain by Fourier transform. The frequency of bunched beam signal is 12.68MHz, which is slightly shifted from driving frequency. It can be explained due to the noise of the signal.

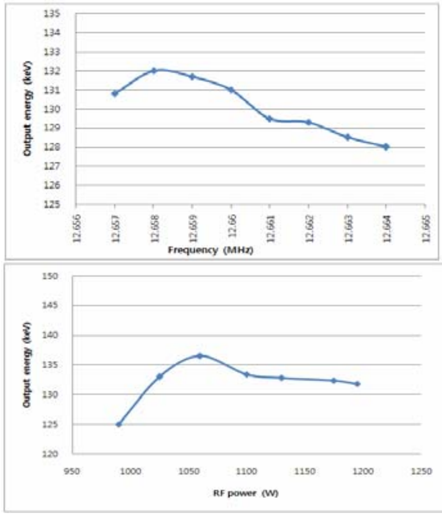

Fig. 6 Output energy versus driving frequency (top) and RF power (bottom)

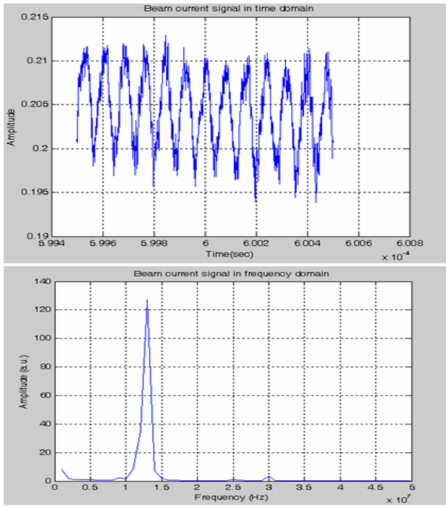

Fig.7 Beam current signal in time (top) and frequency (bottom) domain

3. Conclusions

Helium beam was successfully accelerated by a 13MHz cavity with beam current of 2uA at 1Hz of repetition rate and pulse width of 100us. Output energy was confirmed to be 130keV. Dependence of beam current and beam energy on experiment conditions were investigated. Beam energy spread will be measured in next experiment.

Acknowledgement
This work is supported by the MEST through Proton Engineering Frontier Project

REFERENCES

[1] T. A. Trinh, Y.S. Cho, H.J.Kwon, H.S.Kim, K.T.Seol, KPS Spring Meeting, 2011, Daejeon
[2] Y.S Cho, H.S Kim and H.J Kwon, Rev. Sci. Ins. 79, 02B715 (2008)