BEAM TEST OF THE NEW BEAMLINE FOR RADIO-ISOTOPE PRODUCTION AT KOMAC

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Abstract

A high power proton linac is under operation at Korea multi-purpose accelerator complex (KOMAC). Currently, two beamlines are available and used to provide 20-MeV beam and 100-MeV beam to users from various fields. An additional 100-MeV beamline has been constructed mainly for production of radio-isotopes such as Sr-82 and Cu-67. Proton beam with the beam energy of 100 MeV and the average current of 0.6 mA is directed to the production target, which is located in a water-filled target chamber, through a beam window made of AlBeMet. The beam size at the target is designed to be about 100 mm in diameter. Installation of the beamline components including 1.5 T bending magnet and the beam diagnostic devices such as BPM and BCM is finished and beam commissioning is planned to start in early 2016. The details of newly-constructed beamline and the initial beam test results will be given in this paper.

INTRODUCTION

Since successful commissioning of a 100-MeV proton linac along with two beamlines in 2013, KOMAC has provided 20-MeV and 100-MeV beams to the users from various research and industrial fields such as bio and medical science, nuclear and radiation physics, and semiconductor and material etc. To expand the utilization of the linac, a new beamline for RI production is under development. Major facilities for RI production based on the high power linac include the BLIP (Brookhaven Linac Isotope Producer) at Brookhaven National Laboratory and the IPF (Isotope Production Facility) at Los Alamos National Laboratory.

KOMAC accelerator facility was originally designed to host up to ten beamlines; five for 20-MeV energy and the other five for 100-MeV beam utilization. Therefore, the space and target rooms for the beamlines other than the currently-operating ones are already prepared. The layout of the 100-MeV beamline switchyard is shown in Fig. 1. TR103 in Fig. 1 is under operation for user beam service and TR101 is dedicated for the RI production. The main parameters of the RI production beamline at KOMAC are summarized in Table 1 along with the two major RI production facilities, BLIP and IPF [1, 2].

Large variety of radio-isotopes can be produced by using the high power accelerator. Among them, Sr-82 and Cu-67 are under consideration. Sr-82 is used to monitor the blood flow in cardiac tissue and can be produced by using RbCl as a target. Cu-67 is used for cancer therapy and can be produced by using ZnO as a target.

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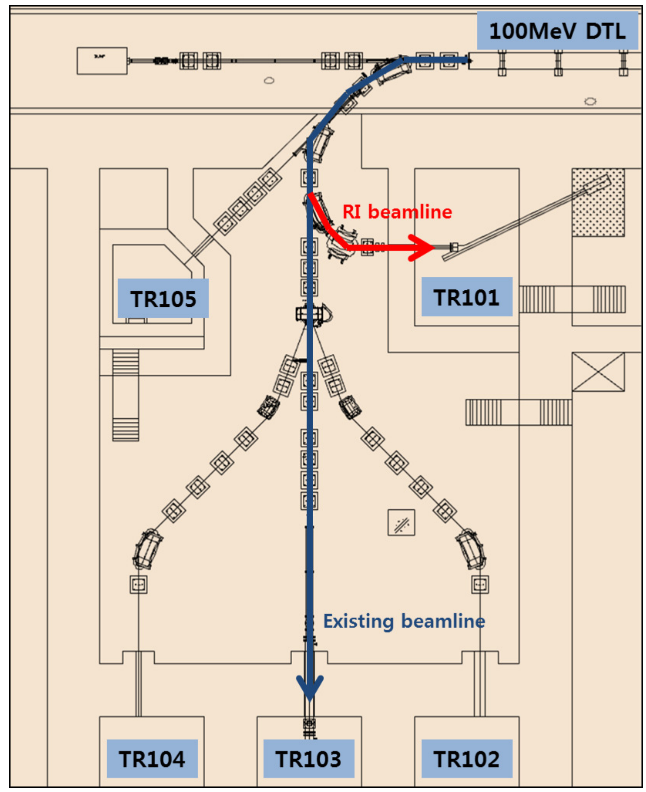

Figure 1: Layout of KOMAC 100-MeV beamline.

DESIGN OF BEAMLINE

Beam Dynamics

Beam optics design of the RI beamline was performed by using TraceWin code with the output beam parameter of 100-MeV DTL. From the DTL output to RI target, there are 5 quadrupoles for focusing and 4 bending magnets. The bending angle of 4 bending magnets is 45 degree, making 180 degree deflection as shown in Fig. 1. We aimed at making a round beam with 30 mm in diameter taking into consideration of the target size. The beam envelops and phase space distributions are shown in Fig. 2 and Fig. 3, respectively. The beam size in terms of the full width at half maximum (FWHM) at the target is 14.2 mm in the horizontal direction (x-direction) and 12.4 mm in vertical direction (y-direction).

1.5 T Bending Magnet

In the RI beamline, a relatively high field magnet was required due to the limited available space. We designed and fabricated a 1.5 T, 45-degree bending magnet. The bending radius is 1.0 m and the pole gap is 90 mm. We chose an H-type magnet with rectangular shape due to its simplicity and good field uniformity within the given

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space. We used POISSON code and EMStudio code to optimize the magnet and obtained good field region wider than 100 mm with uniformity better than 0.1% for a 310 mm pole width, which is enough considering the beam dynamics. Designed bending magnet is shown in Fig. 4.

Table 1: RI Production Facilities Based on the Linac

Parameter	KOMAC	BLIP	IPF
Energy [MeV]	100	202	100
Peak current [mA]	20	37	13.3
Pulse width [us]	500	425	625
Rep. rate [Hz]	60	6.67	30
Duty factor [%]	3.0	0.3	1.9
Ave. current [mA]	600	104	250
Peak power [MW]	2.0	7.5	1.3
Ave. power [kW]	60	21	25
E per pulse [J/pulse]	1000	3177	833
Target Dia. [mm]	100	75	50
Beam size FWHM [mm]	14.2*12.4	19*12.5	12.5
Scanning Method	Wobbling	No scan	Wobbling
Beam window	AlBeMat	Be / AlBe-Mat / STS	Inconel

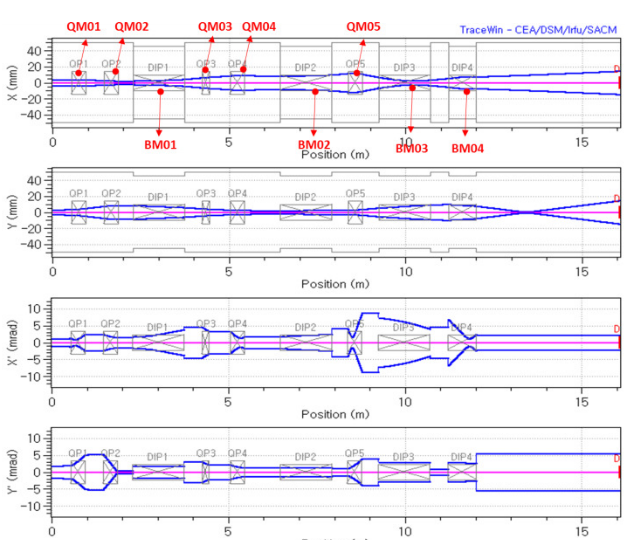

Figure 2: Beam envelops in the RI beamlines.

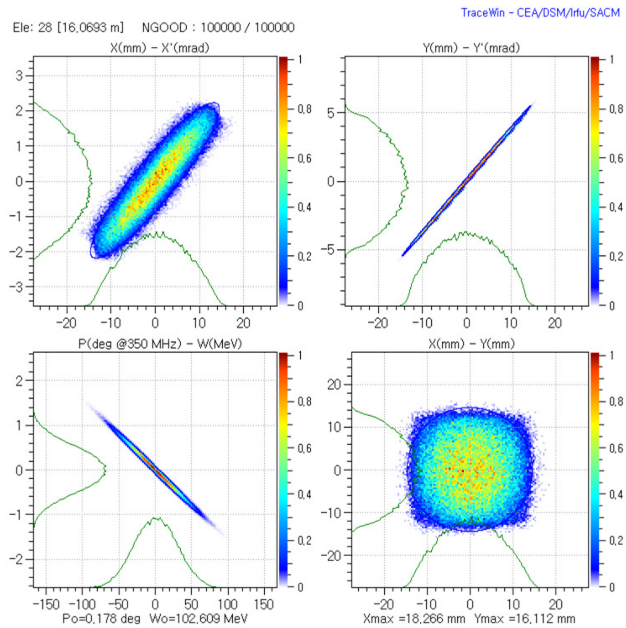

Figure 3: Beam distribution at RI production target.

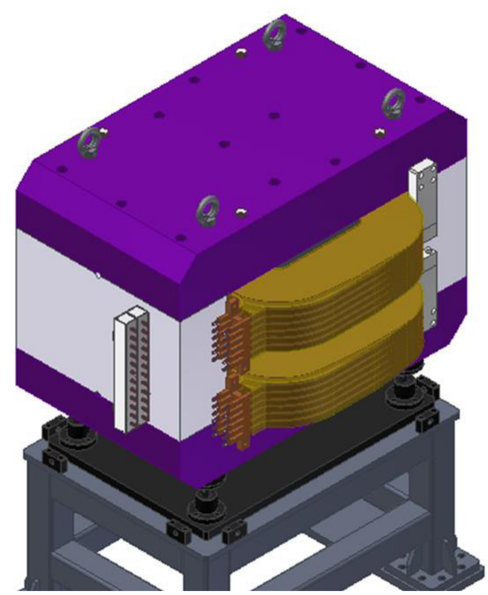

Figure 4: 1.5 T, 45 degree bending magnet.

Beam Window

The main role of a beam window is separating the beamline vacuum and the water-cooled target assembly. The beam window can be integrated into the target assembly to increase the cooling efficiency or separated from the target assembly to increase the mechanical reliability. We chose to separate the beam window from the target assembly to protect the beamline and the accelerator in the event of window rupture. In this design, we used AlBeMat as a beam window material and stainless steel as a target assembly window. The heat deposition in the beam window can be estimated by using SLIM code. When the thickness of the AlBeMat is 0.5 mm, the maximum heat deposition amounts to about 360 W, which can be cooled by using forced air convection.

INSTALLATION

Installation of the RI beamline took place during summer shutdown period in 2015. During installation, two 45-degree bending magnets and vacuum manifold and beam pipes were installed. In addition, some of beamline quadrupoles were relocated to make room for the new beamline components. The installed beamline components are shown in Fig. 5.

For the beam diagnostic devices, we installed two stripline-type beam position monitors and two ACCT type beam current monitors before and after the newly installed bending magnets. In addition, a Faraday cup is located in the vacuum manifold. To monitor the beam loss occurring near the bending magnet, we installed two proportional counter type beam loss monitors behind the bending magnet.

Vacuum system is separated from the other beamline and the accelerator. We used six-way tee to install the vacuum pumps and gauges as shown in Fig. 6. A 300 l/s TMP and a 180 l/s ion pump were used to evacuate the beamline. At the end of beamline, we installed an AlBeMat beam window as shown in Fig. 7. After 100-hours vacuum pumping, the pressure reached below 3.0E-8 torr.

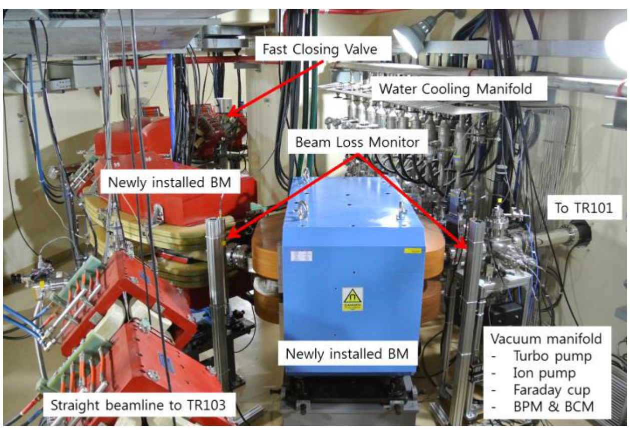

Figure 5: Newly installed RI beamline.

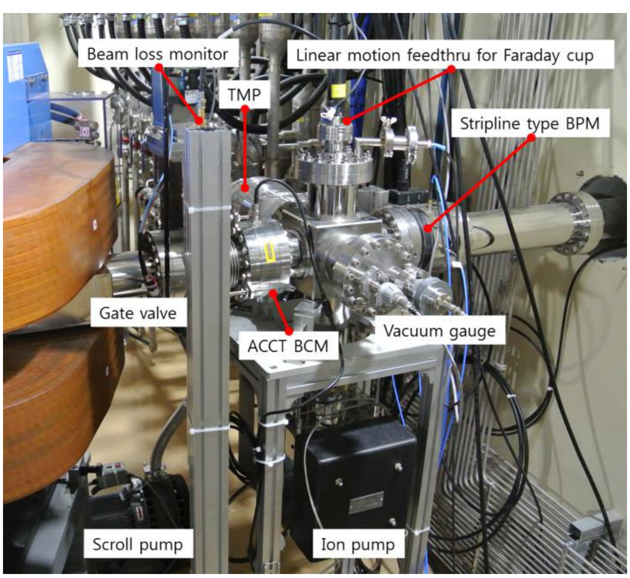

Figure 6: Vacuum manifold for the RI beamline.

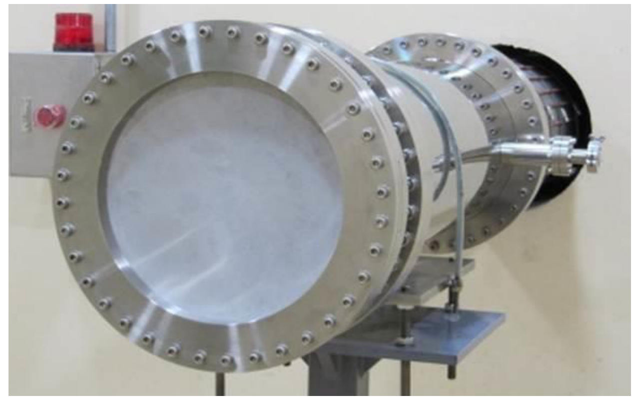

Figure 7: AlBeMat beam window at the end of beamline.

PRELIMINARY BEAM TEST

We performed a preliminary beam test to check beam line components and the radio-isotope production with low current operation. A 100-MeV beam was directed to zinc target to produce Cu-67. Peak current during the irradiation was 0.4 mA. Total 500 beam pulse was applied to the target. The radiation level right after the irradiation was about 5.5 uSv/hr at the target. We measured gamma-ray spectrum by using HPGe detector and found peaks around 91 keV, 93 keV and 184 keV, which are unique to Cu-67 as shown in Fig. 8. From the spectrum measurement, we can conclude that the new beamline can be used for RI production.

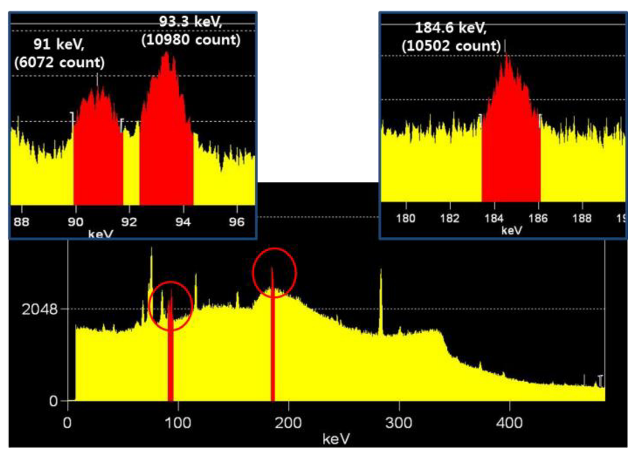

Figure 8: Gamma-ray spectrum from irradiated Zn target.

ACKNOWLEDGEMENT

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