COMMISSIONING OF THE RI PRODUCTION BEAM LINE OF KOMAC*

Hyeok-Jung Kwon†, Han-Sung Kim, Sang-Pil Yun, Young-Gi Song, Yong-Sub Cho
Korea Multi-purpose Accelerator Complex,
Korea Atomic Energy Research Institute, Gyeongju, South Korea

Abstract

A radioisotope (RI) production beam line has developed at Korea Multi-purpose Accelerator Complex (KOMAC) in 2015 and the commissioning started in 2016. The beam parameters of the beam line are 100 MeV beam energy with a maximum 30 kW beam power, which is driven by KOMAC 100 MeV proton linac. The main components of the beam line are a beam transport system, a target transport system, a cooling system for target and hot cell. KOMAC has a plan to commission the beam line and get an operation license in 2016 and start user service in 2017. In this paper, the development and initial commissioning results of the RI production beam line are presented.

INTRODUCTION

One of the utilization fields of the 100 MeV proton beam is the production of the radioisotopes. Major facilities for RI production based on the high power linac include the BLIP (Brookhaven Linac Isotope Producer) at Brookhaven Nation Laboratory and the IPF (Isotope Production Facility) at Los Alamos National Laboratory. [1, 2]

KOMAC started the beam service to users with 2 beam lines from 2013. To satisfy the user requirement, KOMAC developed a new beam line for RI production. In 2015, the construction of the RI production beam line was finished and the commissioning of the beam line is underway. The main components of the beam line are a beam transport system, a target transport system, a cooling system for target and hot cell. All of the components were installed and the test of each component was carried out including RI production test with low power proton beam.

Two RIs are considered to be produced at KOMAC in initial stage. One is a Sr-82 which is used for PET imaging and can be produced from RbCl. The other is Cu-67 which is used for cancer therapy and can be produced from Zn or ZnO. Both of them are efficiently produced through 100 MeV proton beam.

BEAM LINE DEVELOPMENTS

The specification of the RI production beam line is shown in Table 1 and the layout is shown in Fig. 1. [3]

Beam Transport System

The beam transport system consists of 2 sets of 45 degree bending magnets, vacuum box, beam diagnostics and beam window. 2 sets of wobbling magnets are not installed yet. They will be installed after initial operation test. 2 sets of 45 degree bending magnet are different from each other. The pole tip field of the 1st bending magnet is 0.8 T with C type yoke whereas that of 2nd magnet is 1.5 T by using H type yoke because the 1st bending magnet shares two beam lines whereas the 2nd one is only for RI production beam line in limited space. A strip-line type beam position monitor is installed after the 2nd bending magnet and a movable Faraday cup is installed in the vacuum box. Two sets of proportional counter were installed before and after the 2nd bending magnet as a beam loss monitor. A beam window is installed at the end of the beam transport line. The main role of a beam window is separating the beam line vacuum from the water cooling target assembly. The material of the beam window is AlBeMat with 0.5 mm thickness. Before the beam window, vacuum sensor for activating a fast closing valve was installed to protect the accelerator when there is a rupture of the beam window. The beam transport system after installation is shown in Fig. 2.

Table 1: Specification of the RI Production Beam Line

Parameter	Value
Energy [MeV]	100
Peak current [mA]	20
Pulse width [us]	500
Rep. rate [Hz]	30
Duty factor [%]	1.5
Ave. current [mA]	600
Peak power [MW]	2.0
Ave. power [kW]	30
E per pulse [J/pulse]	1000
Target Dia. [mm]	100
Beam size FWHM [mm]	14.2*12.4
Scanning Method	Wobbling
Beam window	AlBeMat

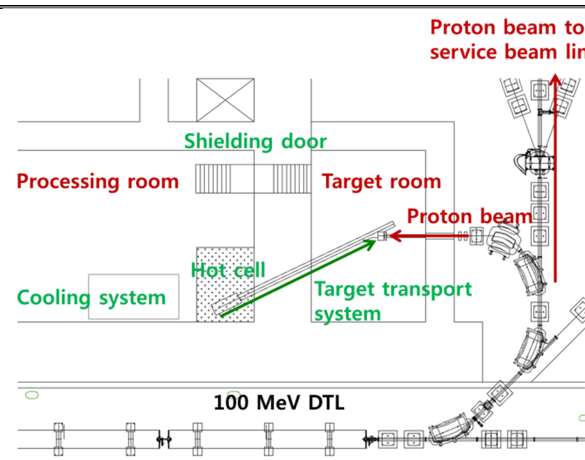

Figure 1: Layout of the RI production beam line.

* Work supported by Ministry of Science, ICT & Future Planning of the Korean Government.
† hjkwon@kaeri.re.kr

ISBN 978-3-95450-169-4

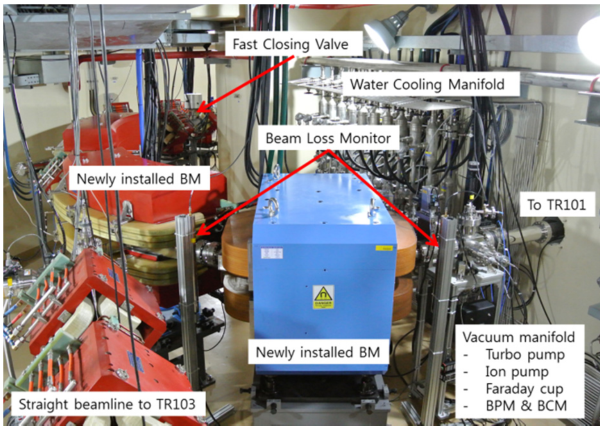

Figure 2: Beam transport system of the RI production beam line.

Target Transport System and Hot Cell

A target chamber is installed just after the beam window in the target room. A iron shielding for neutron is installed at the end of the target chamber in the target room too. The target room is shown in Fig. 3. A RI production target is installed in the target holder inside a hot cell, which is transported to the target chamber through target transport system. The target holder is driven by AC servo motor with chain and sprocket system through the guide rail inside the 200 mm diameter pipe of the target transport system. The inside of the pipe is filled with the circulating deionized water which is used for shielding of the prompt neutron. The water is also used for target cooling.

A hot cell consists of two cells, the one is used for target installation into or extraction from the target holder, the other is used for target handing to the chemical processing cell. A hot-cell is containing 15 cm of lead wall with 376 mm thick lead glass windows and two sets of master slave manipulators. The hot cell is shown behind the cooling system in Fig. 4.

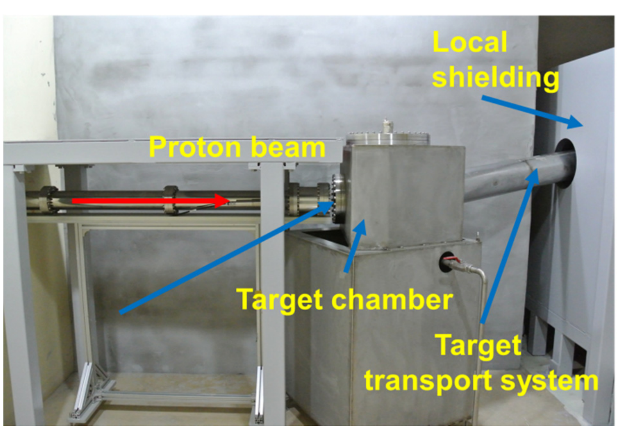

Figure 3: Beam transport system and target transport system in the target room.

Target Cooling System

The maximum heat from the target is 30 kW. To remove the heat from the target, a cooling system was installed. The cooling system was installed outside the target room. The cooling water is supplied to the target through the target transport system. The cooling system consists of air-cooled chiller, water purification filter and de-ionized water product apparatus and all components are integrated as a skid. The cooling system is closed loop without any interaction to other facility. When there is a leak of RI from the target, the contamination is confined inside the cooling skid. The radioactivity monitor and the conductivity meter were used to monitor the radioactivity of the water and the signals are used as a source for machine interlock. To shield the gamma from the radio-activated cooling water, 5 cm-thick lead shielding was used around the skid and along the cooling pipe. The target cooling systems can be remotely monitored and controlled by EPICS IOC. The cooling skid is shown in Fig. 4.

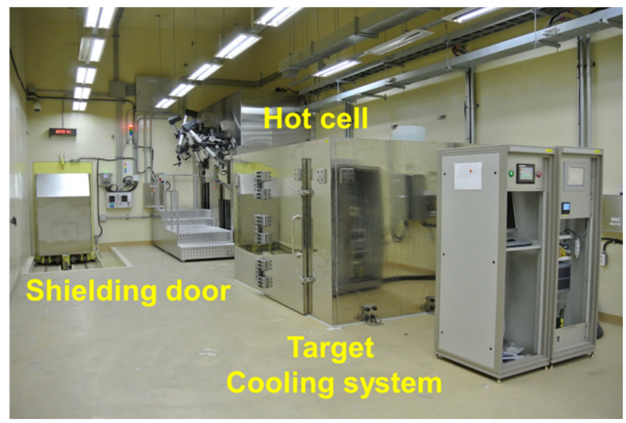

Figure 4: Target cooling system and hot cell.

Target Preparation

The thickness of the RI production targets were designed considering the beam energy loss by the beam window, cooling water and target claddings [4]. The RbCl pellet and Zn metal disc were prepared for the Sr-82 and Cu-67 production. Prepared pellet is encapsulated in stainless steel cladding with 60 mm in diameter with 0.3 mm window for the proton irradiation. The target cladding was laser welded to prevent the leakage of the radioactive species. The RI targets are mounted inside the target holder for transportation and cooling. The cooling water is supplied from the bottom side of target holder and returned out through the upper side. The RI production target and target holder is shown in Fig. 5.

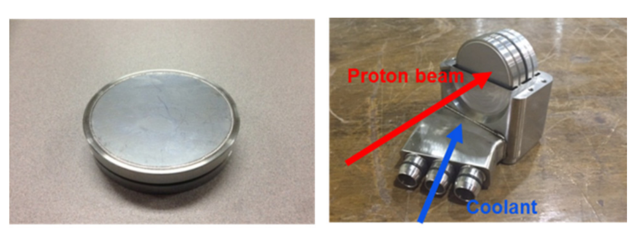

Figure 5: Prepared target (left) and target installed inside target holder.

Preliminary Irradiation Test

A preliminary beam test was done to check the soundness of the components. A beam test into the dummy aluminium target was done up to 30 Hz, 250 us. RI production test was done with extremely low beam power. The irradiation dose on the target was 2.5E10 during the test. The characteristic gamma emission spectrum was measured to identify the production of the Sr-82 and Cu-67 from RbCl and Zn target respectively. A HPGe (High Purity Germanium) detector was used to measure the spectrum. The target cladding was not separated during measurement because the RI separation and purification facility is not prepared yet.

The measured spectrums from RbCl and Zn targets are shown in Figs. 6 and 7. Peaks of 511 keV and 776.5 keV were measured, which are the typical gamma spectrum from Sr-82/Rb-82. Also peaks of 91 keV, 93.3 keV, 184.6 keV were measured, which are the typical gamma spectrum from Cu-67. In addition to the characteristic peaks, other peaks were measured, which are supposed to come from the cladding material.

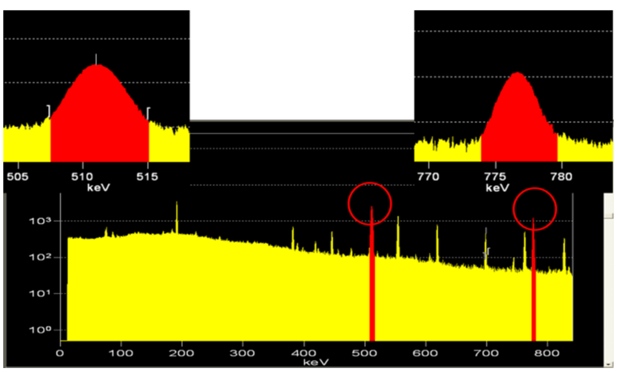

Figure 6: Gamma spectrum from RbCl target.

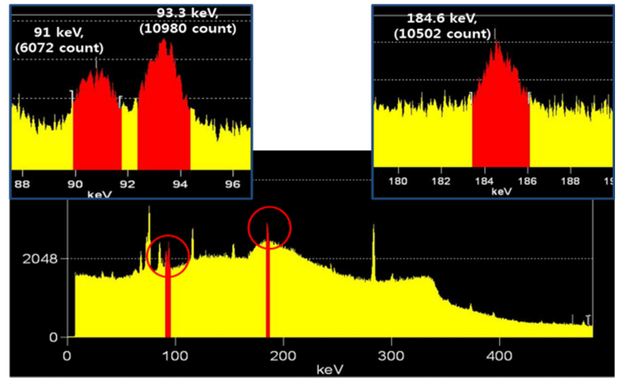

Figure 7: Gamma spectrum from Zn target.

CONCLUSION

The RI production beam line was developed at KOMAC. The main components are the beam transport system, target transport system, cooling system and hot cell. Each of the main components was tested. The beam test was done up to 30 Hz, 250 us. The RI production test was also done by using RbCl and Zn target, which showed the desired RIs were produced. The facility inspection is planned in October, 2016 by the Government. After getting the operation license through facility inspection, wer are going to increase the beam power on the target. And the production starts in 2017.

REFERENCES

[1] L. F. Mausner et al., “Target Design Considerations Isotope Production with High Intensity 200MeV Protons”, Nucl. Instrum. Metho. Phys. Res. A, vol. 397, p. 18, 1997.

[2] F. M. Nortier et al., “Large-Scale Isotope Production with an Intense 100MeV Proton Beam”, in Proc. 18th Int. Cyclotrons and their Applications Conf., Giardini Naxos, Italy, 2007, p. 257.

[3] Han-Sung Kim, et al., “Beam test of the new line for the radio-isotope production at KOMAC”, in Proc. of the 7th International Particle Accelerator Conference, Busan, South Korea, May 2016, p. 1349.

[4] Sang-Pil Yun, et al., “Solid targetry for the isotope production facility at the KOMAC 100 MeV linac”, Proc. of the 7th International Particle Accelerator Conference, Busan, South Korea, May 2016, p. 1384.

ISBN 978-3-95450-169-4