

INITIAL OPERATION OF THE LOW-FLUX PROTON BEAMLINE AT THE KOMAC 100 MeV LINAC*

Sang-Pil Yun[†], Hyeok-Jung Kwon, Han-Sung Kim, Seok-Geun Lee, Chorong Kim, Young-Gi Song, Dae-Il Kim
 KOMAC, KAERI, Gyeongju, Republic of Korea

Abstract

Korea multi-purpose Accelerator Complex (KOMAC) has been operating 20 MeV and 100 MeV proton beam-lines to provide proton beams to users since 2013. The new beam line and target irradiation facility, which is proposed applicable to development of the detector and simulation of the space radiation, constructed for low-flux proton utilization at 2016.

The new beam lines have the 100 MeV of maximum beam energy and 10 nA of maximum beam current. The new beam line was designed to operate with maximum duty 8%, the flux density of proton beam can be reduced to the 1/10,000 by the graphite collimator. The extracted proton beam energy can be adjustable by the double wedge type energy degrader and also, the beam energy can be selected by dipole magnet. In addition to the two sets of the octupole magnets were prepared for uniform beam irradiation with the $\pm 5\%$ uniformity. In this paper, the initial operation results of the constructed new beam line will be described.

INTRODUCTION

A high power proton linac is under operation at Korea multi-purpose accelerator complex (KOMAC). Currently, three beam lines are available at KOMAC, one is for a 20-MeV beam and the other is for a 100-MeV beam. Both of them are used for general purpose [1]. The third beam line, which is for RI production, was obtained the permit and license for the operation at 2016. The main purpose of the new beam line is for the low flux application such as a simulation of the space radiation, a development of the radiation detector. The users in this field want a beam which has low flux but high duty factor because almost CW low flux beam is advantageous for such applications. Therefore the design characteristic of the beam line is to operate the beam in high duty factor with a peak current as low as possible. The beam transport system of the beam line is constructed in 2016 and the beam commissioning is on-going in this year.

DESIGN AND INSTALLATION

The design specifications of the low flux beam line are introduced in [2]. For low-flux proton beam, the flux density of 100 MeV proton beam reduced by the graphite collimator. The other main feature of the new beam line is the easy adjustable proton energy and the uniform irradiation.

The proton energy can be adjustable from 20 MeV to 100 MeV continuously by using the wedge type aluminium energy degrader. Two sets of octupole magnets allow supplying the spatially uniform proton beam to the target with the $\pm 5\%$ uniformity. The designed beam transport line is shown in Fig. 1

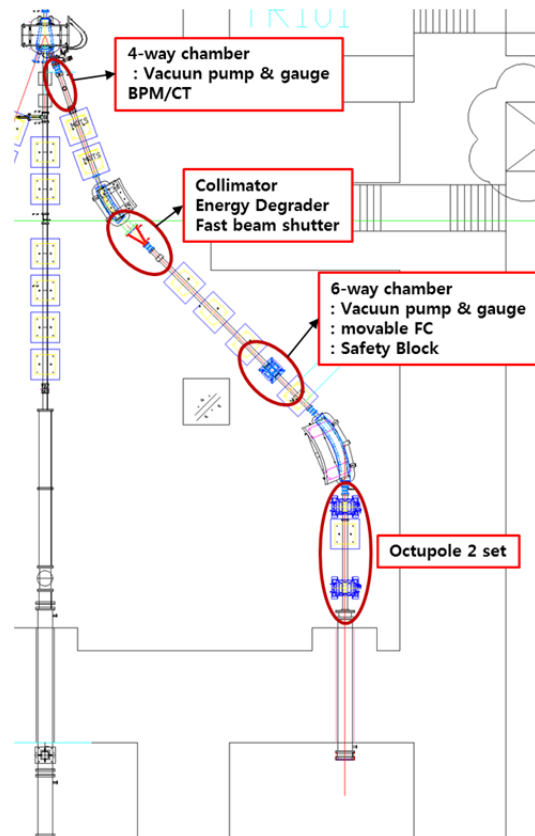


Figure 1: Layout of the Low Flux Beam Line.

Installation of the low flux beam line took place during the maintenance periods. Two sets of evacuation system are installed before and after the collimator, which consist of 300 l/s TMP and 180 l/s ion pump. This vacuum system allow to maintain the below $1.0E-7$ Torr of vacuum in the beam line. For the beam diagnostics, one stripline-type beam position monitor and ACCT are installed before collimator.

For low-current beam measurement, the movable Faraday-cup is installed after collimator. In addition to, the fast beam shutter and the beam stopper are installed to

* Work supported by Ministry of Science, ICT & Future Planning of the Korean Government.

[†] spyun@kaeri.re.kr

block the proton beam incidentally. Figure 2 and 3 shows the beam diagnostics and vacuum system in the beamline.

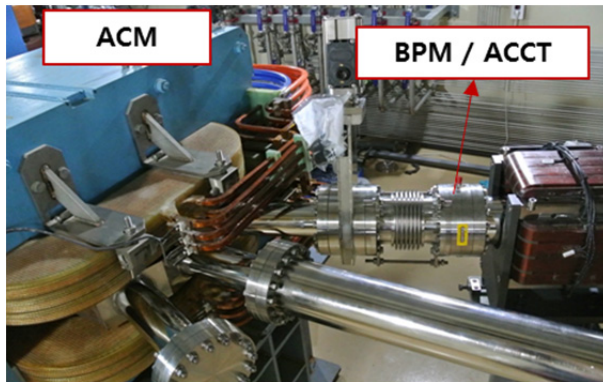


Figure 2: The Installation of the BPM and ACCT.

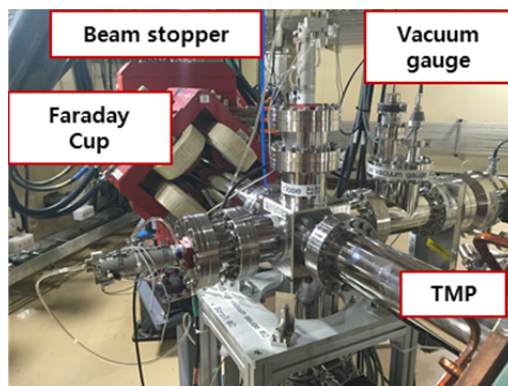


Figure 3: The Installation of vacuum system.

Collimator

A collimator is an essential part of the beam line which reduces the flux density of proton beam and dissipates maximum 0.8 kW beam power in average. A hole of 10 mm in diameter is located in the centre of the collimator and the beam is guided to the collimator in off axis direction. The beam absorber material was chosen with graphite which have low residual radio-activity. To remove the 0.8 kW of heat load efficiently, the graphite beam absorber is enclosed by the copper cooling jacket. To improve the thermal contact between the copper and graphite, the graphite are compressed to the copper cooling jacket by the bolt tightening as shown in Fig. 4. In addition to, the copper cooling jacket was brazed to the stainless steel enclosure.

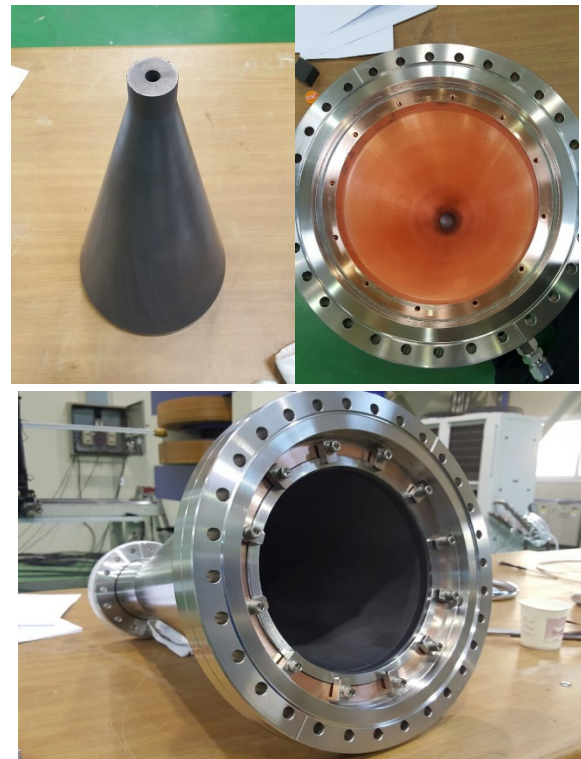


Figure 4: The fabrication of collimator.

Energy Degradar

The KOMAC Linac can supply the discrete energy of proton beam by adjusting the number of RF turn-on tank. To adjust the beam energy as continuous as possible, we installed two sets of wedge type energy degraders (Figure 5). The energy spread was estimated within 1% by using SRIM calculation. The degrader wedge made of aluminium due to the low residual radio-activity. The thickness of the aluminium wedge is from 0.5 mm to 8.5 mm, which can be adjusted by the motorized feedthrough remotely. Figure 6 shows the installation of energy degrader.

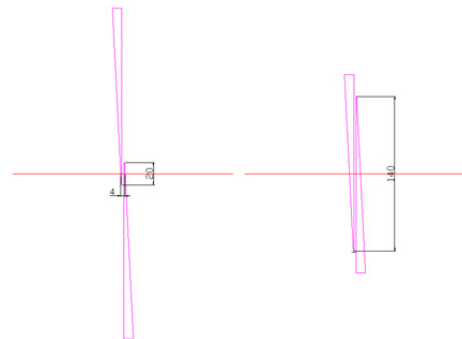


Figure 5: The design of the aluminium wedge.

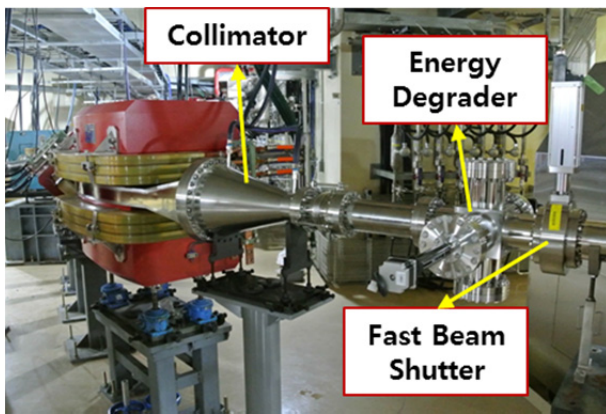


Figure 6: The installation of collimator and energy degrader.

Octupole Magnet

Two sets of octupole magnets are used to produce spatially uniform beam at the 100 mm × 100 mm target area. The uni-formity is within ± 5% inside the target area. The speci-fication of the octupole magnet is 200 mm in effeti-ve length and the maximum octupole strength is 500 T/m³. Figure 7 shows the installation status of the octu-pole magnets.

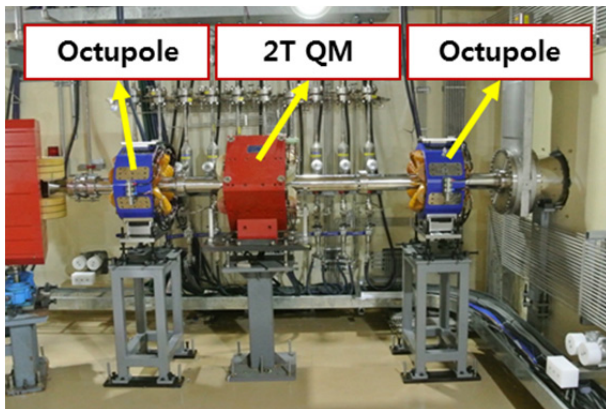


Figure 7: The octupole magnet system.

Beam Window

Figure 8 shows the installation of the beam window for the new beam line. The main role of a beam window is separating the beam line vacuum and the ambient air in the target room. An aluminium-beryllium alloy (AlBe-Met) is used as a beam window. The thickness of the beam window is 0.5 mm. The beam window is formed to concave shape to reduce the stress due to the pressure difference between atmosphere outside the beam line and vacuum inside the beam line. The diameter of the beam window is 300 mm and the curvature radius is 1 m. The energy loss in the beam window calculated as less than 1 % of 100-MeV proton beam by using the SRIM calculation. A helicoflex seal was used as a vacuum seal of the AlBeMet, on which KOMAC has an experience.



Figure 8: The AlBeMet Beam Window

PRELIMINARY BEAM TEST

We performed a preliminary beam test to check beam line components and beam transportation to target station. The 1 mA beam current of the transported 100-MeV proton was measured by the ACCT, which located after AC magnet. After collimator, the weak beam current measured by movable faraday cup as shown Fig. 9. And in the target room, low-flux density of proton beam identified by 2D array ion chamber detector as shown in Fig.10.

We can concluded the new beam line can be used for supplying the low flux proton beam.

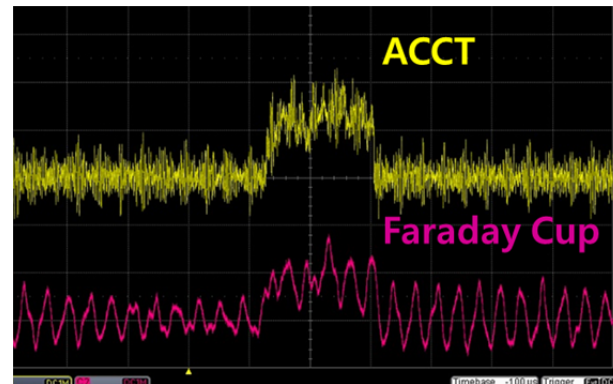


Figure 9: The beam current from ACCT and FC.

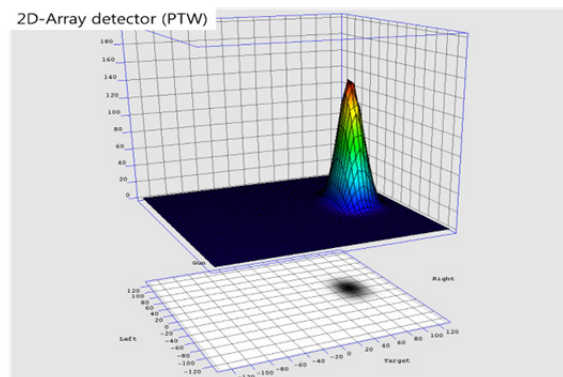


Figure 10: The Beam shape from the 2D array detector.

REFERENCES

- [1] Y. S. Cho, et al., “Beam Commissioning of 100-MeV KOMAC Linac”, in Proc. LINAC2014, Geneva, Switzerland, 2014, p. 413.
- [2] H. J. Kwon, et al., “Design of the 100-MeV Proton Beam line for the Low Flux Application”, in Proc. IPAC’16, Busan, Korea, 2016 p.938.