CONCEPTUAL DESIGN OF BEAM TRANSPORT LINES FOR THE PEFP USER FACILITY*

Bum-Sik Park#, Yong-Sub Cho, Hyeok-Jung Kwon, Ji-Ho Jang, In-Seok Hong, Han-Sung Kim, Sang-Pil Yun, Hwa-Ryun Lee, Kye-Ryung Kim, Byung-Ho Choi,
Proton Engineering Frontier Project, Korea Atomic Energy Research Institute,
Daejeon 305-353, Korea

Abstract

PEFP(Proton Engineering Frontier Project) beamlines will be supplied either 20-MeV or 100-MeV proton beams from the 100-MeV proton linear accelerator for beam applications. Each proton beam will be transported to 2 beamlines for industrial purpose and 3 beamlines for various researches. Beam distribution to 3 research beam lines will be conducted sequentially by programmable AC magnet. To provide flexibility of the irradiation conditions, each beam line is designed to have specific beam parameters. We have designed the beamlines to the targets for wide or focused beams, external or in-vacuum beams, and horizontal or vertical beams. The detail design of each will be reported.

INTRODUCTION

It is the prominent concept of the PEFP user facility that the high current proton beam is supplied by a high power linear accelerator. Additionally, AC magnet is adopted to distribute proton beams to users as many as possible simultaneously.

Figure 1 shows the layout of the PEFP user facility and linear accelerator. There are two user facilities for the 20 MeV and 100 MeV proton beams.

Each user facilities are consisted with 5 beam lines respectively. There are two fixed beam lines and three beam lines operated simultaneously by a switching magnet.

BEAM LINE REQUIREMENTS

The surveys for proton beams demanded from many application fields, such as nano-technology (NT), bio-technology (BT), space technology (ST), and radio-isotope, had been done. From these activities, we had selected the common requirements for many applications and have summarized requirements for 10 beam lines of 100MeV and 20MeV. Table 1 and 2 shows summarized requirements for each target room. There are two fixed beam lines for industrial applications and three beam lines operated simultaneously by a switching magnet for a 20MeV and a 100MeV user facility respectively. Two fixed beam lines will be used for the radio isotope production and the power semiconductor production. To provide flexibilities of irradiation conditions for users from many application fields, we designed beam lines with wide or focused, external or in-vacuum, and horizontal or vertical beams[1].

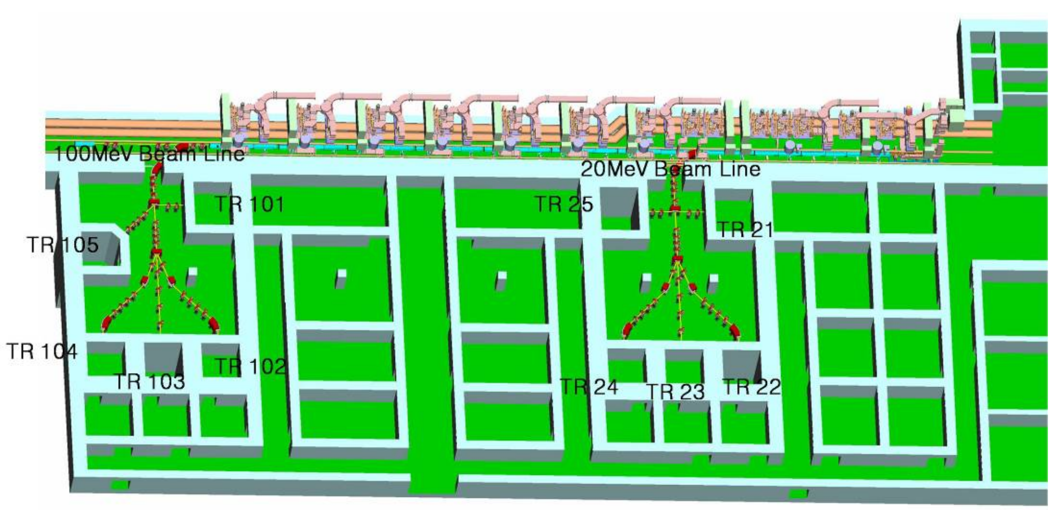

Figure 1: Layout of PEFP user facility.

*Work supported by the Ministry of Education, Science and Technology of the Korean Government
#bspark@kaeri.re.kr

Table 1: 100MeV target room requirements.

Target Room	Application Field	Rep. Rate (Hz)	Max. Avg. I(mA)	Irradi. Cond.	Max. Dia. (mm)
TR101	Isotope	60	0.6	Hor. Vac.	100
TR102	Medical(Proton Therapy Reseach)	7.5	0.01	Hor. Atm.	300
TR103	Materials/Energies and Environment	15	0.3	Hor. Atm.	300
TR104	Basic science(Physics, Chemistry), Aerospace	7.5	0.01	Hor. Atm.+Vac	100
TR105	Neutron Source/Irrdiation Trial	60	1.6	Ver. Atm.+Vac	100

Table 2: 20MeV target room requirements.

Target Room	Application Field	Rep. Rate (Hz)	Max. Avg. I(mA)	Irradi. Cond.	Max. Dia. (mm)
TR21	Semiconductor	60	0.6	Hor. Atm.	300
TR22	Biotech/Medical	15	0.06	Hor. Atm.	300
TR23	Materials/Energies and Environment	30	0.6	Hor. Atm.	300
TR24	Basic science(Physics, Chemistry)	15	0.06	Hor. Atm.+ Vac.	100
TR25	Isotope	60	1.2	Hor. Vac.	100

Table 3: Necessary magnets for transport lines.

Item	20MeV	100MeV	Total
AC magnet	1	1	2
Quadrupole (1T)	41	10	51
Quadrupole (2T)	6	40	46
45° dipole magnet	3	3	6
25° dipole magnet	2	2	4
90° dipole magnet	1	1	2
45° dipole magnet(MEBT)	1	-	1
Octupole magnet	2	2	4
Raster or wobbling magnet	5	5	10
Steerer magnet	10	10	20

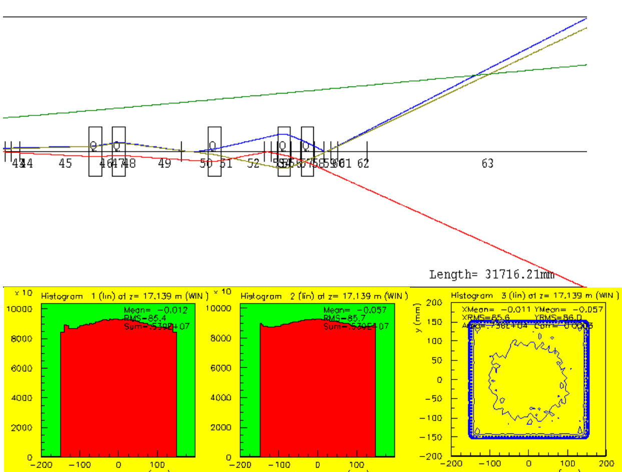

Figure 2: Beam optics of TR103 simulated with TRACE3D and TUTLE code.

To get the large irradiation area, we adopted several methods. Those are the spot-scanning method, the over-focusing method, and the nonlinear method using octupole magnets[2].

MAGNETS

On the basis of the beam optics calculation, we estimated the required magnets[3]. To save the cost and related efforts, all kinds of magnets were considered using the same design in 20MeV and 100MeV simultaneously. And we have been cooperated with IHEP(Institute of High Energy Physics Chinese Academy of Sciences) in design and fabrication of beam line magnets.

Table 3 shows the list of magnets for the 20MeV and 100MeV user beam lines. Among these magnets, quadrupole magnets and AC magnets were already manufactured and conducted the performance test. For the AC magnets, the DC mode test was only performed. AC mode test will be done with programmable current power supply under development. Additionally, some dipole magnets are under fabrication and design.

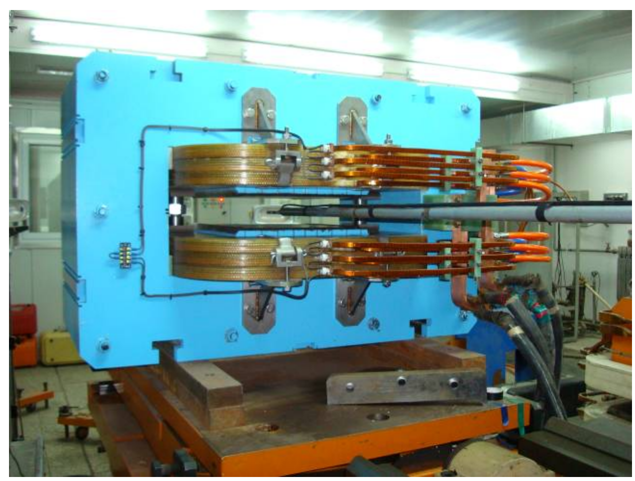

Figure 3: AC magnet for beam distribution.

Figure 4: 45° dipole magnet.

Figure 5: quadrupole magnets.

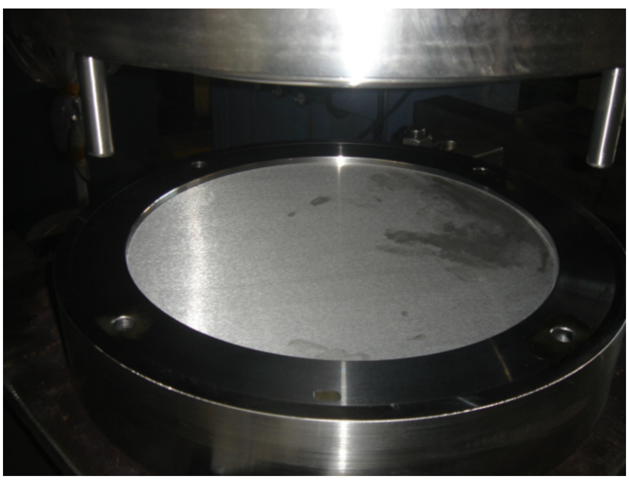

Figure 6: Large beam window for the external beam.

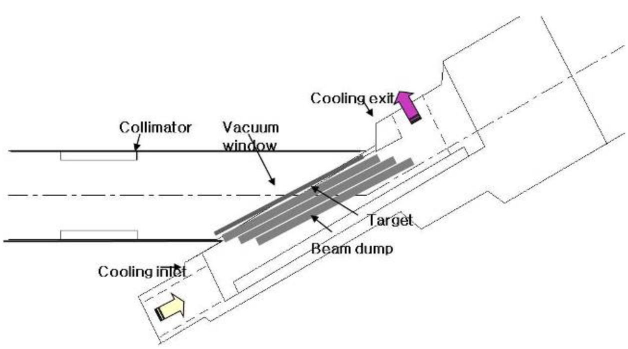

Figure 7: Targetry for the isotope production.

COMPONENT R&D

A distinctive feature of the beam lines is external beam. To extract the high current and large beam, we developed aluminium-beryllium alloy window with high mechanical strength at high temperature, low-Z for low beam loss, and good radiation resistivity.

We also will adopt a fast closing gate valve system to protect main facilities from the accident cause by the failure of the beam window.

SUMMARY

The 100MeV linear accelerator is being developed for the 20MeV and 100MeV user facilities of Proton Engineering Frontier Project (PEFP). 10 beam lines have been designed reflecting the various views of beam users. And the conceptual design of 10 target rooms including RI production facility is on-going. The R&D for beam line components, such as programmable current power supply, is also in progress. We will ground break in this July. The operation of this facility will start in 2011.

REFERENCES

[1] In-Seok Hong, *et al.*, “Conceptual Design of the PEFP Beam Line”, EPAC’08, Genoa, Italy, 2008

[2] B. Sherrill, *et al.*, “Use of Multipole Magnetic Fields for Making Uniform Irradiations”, Nuclear Instruments and Methods In Physics Research, B40/41, p.1004, 1989.

[3] J. H. Jang, *et al.*, “Beam optics of the PEFP Modified Beam Lines”, EPAC’08, Genoa, Italy, 2008