BEAM LINE DESIGN FOR PEFP USER FACILITY*

Y.S. Cho#, B.C. Chung, K.Y. Kim, Y.H. Kim, K.R. Kim, Y.Y. Lee, B.H. Choi, Proton Engineering Frontier Project, Korea Atomic Energy Research Institute, Daejeon 305-353, Korea.

Abstract

In the Proton Engineering Frontier Project (PEFP), 20MeV and 100MeV proton beams from a 100MeV proton linear accelerator [1] will be supplied to users for beam applications. The basic lattice for beam transport line will be FODO from the linac to the targets. Dipole magnets exited with shaped AC currents will distribute the beam from the linac to five targets simultaneously. To provide flexibilities of irradiation conditions for users from many application fields, we design beam lines to the targets with wide or focused, external or in-vacuum, and horizontal or vertical beams. The details of the beam line design will be reported.

INTRODUCTION

The main concept of the PEFP proton beam facility is that a high power proton accelerator supplies proton beam to many users simultaneously. This concept can be compared with a facility with many low power proton accelerators for many users. Based on the user demand survey for proton beam applications, we have chosen a facility with a high power accelerator. There are many types of proton accelerator for proton beam applications, such as cyclotron, synchrotron, and linac. Because the capability of high beam power is the most important feature, we have decided to choose a linac for the main accelerator of the facility. Figure 1 shows the schematic diagram of the PEFP user beam line.

Proton beams of 100MeV and 20MeV will be extracted and distributed to maximum five users simultaneously by AC magnets with a programmable current power supply. We will control the beam energy stepwise with RF ON/OFF of each DTL tank. To control the beam energy continuously, we will put energy degraders and energy filters in the beam lines for special applications.

BEAM LINE REQURIEMENTS

The surveys for proton beam demand from many application fields, such as nano-technology (NT), bio-technology (BT), space technology (ST), and radio-isotope production, have been done through the homepage (http://www.komac.re.kr) and the user program from 2003 to 2006. From these activities, we have selected the common requirements for many applications and have summarized the beam line requirements for 10 beam lines of 100MeV and 20MeV, which are shown in Table 1 and 2. In the selection process, we have put more weighting to high beam power applications, which will be main applications in this facility.

Table 1: 100MeV beam line requirements

Beam Line No.	Energy	Avg. Current	Irradiation Condition	Max. Target Size
BL100	100MeV	~1.8mA	Horizontal Vacuum	Beam Dump
BL101	33,45,57, 69,80,92, 103MeV	30~ 300μA	Horizontal Vacuum	100mm
BL102	20~ 103MeV	~10μA (10nA)	Vertical External	300mm
BL103	20~ 103MeV	30~ 300μA	Horizontal External	300mm
BL104	20~ 103MeV	10nA ~10μA	Horizontal External	300mm
BL105	103MeV	30~ 300μA	Horizontal Vacuum	100mm

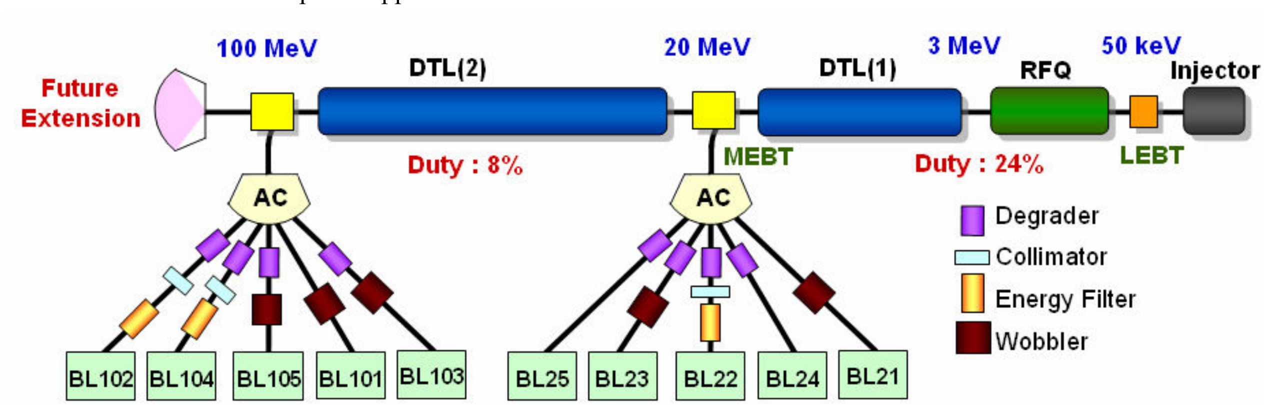

Figure 1: Schematic diagram of PEFP user beam line.

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#choys@kaeri.re.kr

Table 2: 20MeV Beam Line Requirements.

Beam Line No.	Energy	Avg. Current	Irradiation Condition	Max. Target Size
BL20	20MeV	~4.8mA	Horizontal Vacuum	-
BL21	20MeV	120μA ~1.2mA	Horizontal Vacuum	100mm
BL22	3~20MeV	10nA ~60μA	Vertical External	300mm
BL23	3~20MeV	60μA ~1.2mA	Horizontal External	300mm
BL24	20MeV	120μA ~1.2mA	Horizontal Vacuum	100mm
BL25	20MeV	120μA ~1.2mA	Horizontal Vacuum	300mm

BEAM LINES

Table 3 shows the beam parameters from the proton linac, which consists of a 50 keV proton injector, a 3 MeV RFQ, and a 20 MeV DTL [2], and a 100MeV DTL as shown in Figure 1. The average beam current is enough to supply the beams to 5 beam lines simultaneously.

Table 3: Beam Parameters.

Energy (MeV)	20	100
Energy spread (%)	< 1%	< 1%
Peak current (mA)	1~20	1~20
Max. beam duty (%)	24	8
Average beam current (mA)	0.1~4.8	0.1~1.6
Pulse width (ms)	0.1~2	0.1~1.33
Max. repetition rate (Hz)	120	60
Max. beam power (kW)	96	160

With the beam line requirements, we have arranged target rooms for beam applications on the experimental hall, which was be 50m wide and 150m long. Figure 2 shows the layout of 20MeV beam lines.

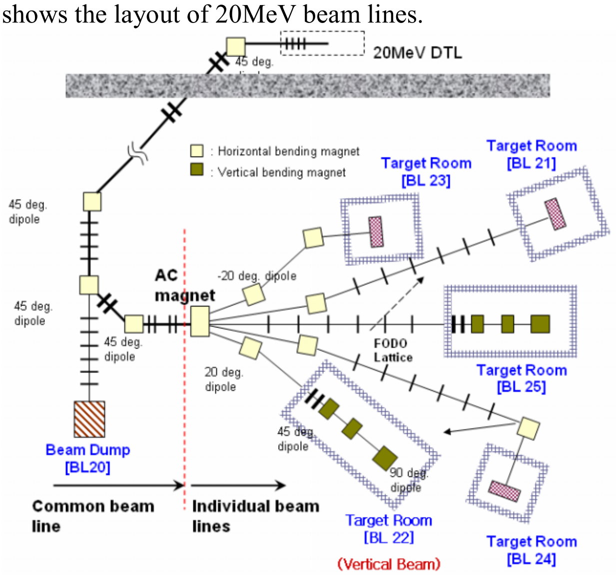

Figure 2: Layout of 20MeV Beam Lines.

A 20MeV proton beam from the Drift Tube Linac (DTL) is transported with bending magnets and quadrupole magnets from linac tunnel to experimental hall. The first bending magnet for the user beam line is located between two buncher cavities of medium energy beam transport (MEBT) [3] at the end of the 20MeV Linac. The basic lattice of the beam transport line is FODO, and the all bends are achromatic.

Figure 3 is an example of the beam optics calculation from the 20MeV Linac to target room #25 with TRACE-3D [4].

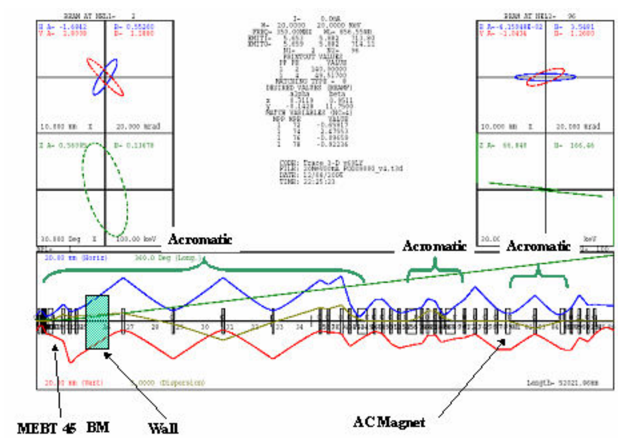

Figure 3: Beam Optics of BL25.

For 100MeV beam lines, the schematic layout is almost same with the 20MeV beam lines. A 100MeV beam is transported through long transport line with doublet lattice from the 100MeV DTL. Figure 4 shows the beam optics from the linac to the target room #102.

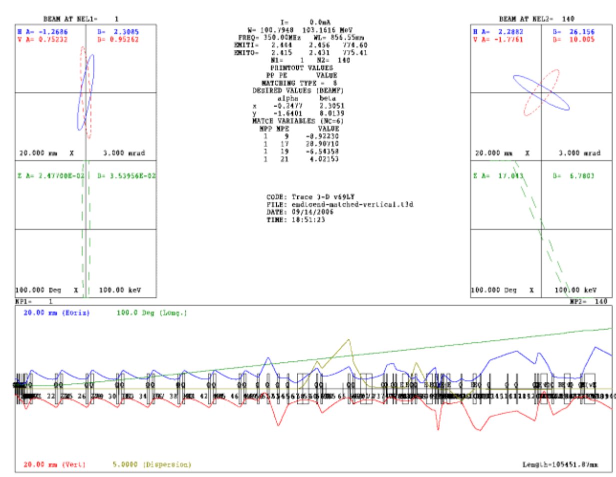

Figure 4: Beam Optics of BL102.

BEAM LINE COMPONENT R&D

In the concept of the user facility, AC magnets are important components. We are designing the AC magnet, as shown in Figure 5. The AC magnet will be excited with a programmable current power supply, which is synchronized with linac beam pulses.

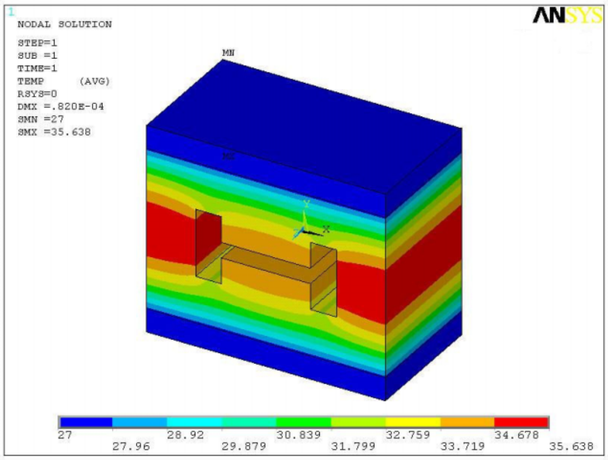

Figure 5: Thermal Analysis of AC Magnet.

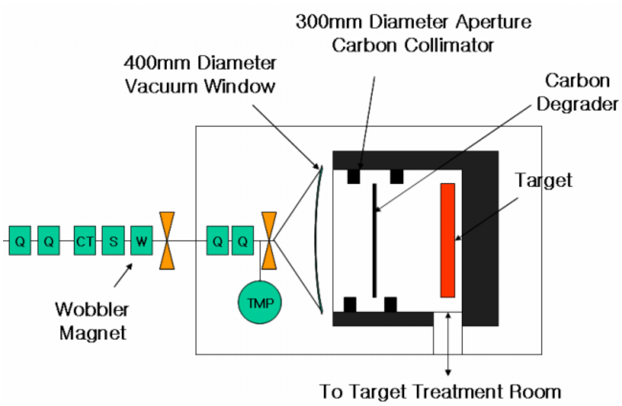

Figure 6: Target Room for external beam with large area

An important requirement in the beam lines is external beam, which requires beam windows. It is not easy to design high power beam window with large area because of thermal load for low energy and radiation damage for high energy. Magnets for beam irradiation, such as wobbler magnet, scanning magnet, and large aperture quadrupole magnet, are also important to utilize high current proton beam efficiently for applications, which require uniform irradiation on the target, as shown in Figure 6. The R&D for target rooms is started.

SUMMARY

20MeV and 100MeV proton beams from a 100MeV proton linear accelerator will be supplied to users for beam applications. From the results of user demand survey, beam line requirements have been prepared. With the requirements, the layout of the experimental hall was developed as shown in Figure 7. The R&D for beam line components, such as AC magnets, is on-going. The construction will start in 2007, and the operation will start in 2011.

REFERENCES

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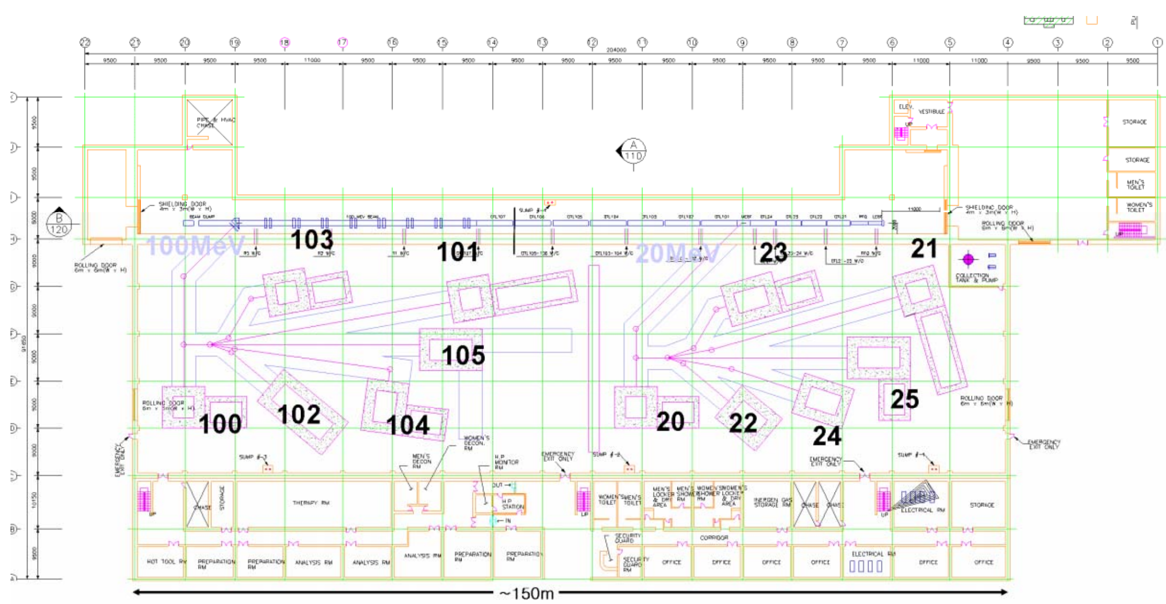

Figure 7: PEFP Experimental Hall with user beam lines.