CONCPTUAL DESIGN OF THE PEFP BEAM LINE*

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Abstract

In the Proton Engineering Frontier Project (PEFP), 20MeV and 100MeV proton beams from a 100MeV proton liner accelerator will be supplied to users for proton beam applications. Switch magnets will share the beam to three direction, two fixed beam lines and one AC magnet. The two fixed beam lines will be used for isotope production and power semiconductor production. AC magnets will distribute the beams to three 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. As far as possible we design the simple beam lines to reduce the construction cost. We have considered and designed conceptually a beamline and target room for production of the radio isotope using 100MeV proton beam. The conceptual design of the whole beam lines and RI production room 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 using AC magnet at 20MeV and 100MeV proton beamline. This concept can be compared with a facility with many low power proton accelerators such as cyclotrons and high power proton linacs and synchrotrons such as a spallation neutron source. Based on the user demand survey for proton beam applications, we had chosen a multi-pupose facility using a high power accelerator. Because the capability of high beam power is the most important feature, we had decided to choose a linac for the main accelerator of the facility[1]. Proton beams of 100MeV and 20MeV will be extracted and distributed to maximum five users simultaneously using AC magnets with a programmable current power supply.

Figure 1 shows the layout of the PEFP user beam line and its target room. This design is some modified to save construction cost. The size of the beam line hall is compact with 2meter of the fixed shielding wall. Each target room which size is 2m x2m has a target treat room for preparing, post processing, and radioactive cooling of the samples.

BEAM LINE REQURIEMENTS

From a survey of the demand and activities of the users

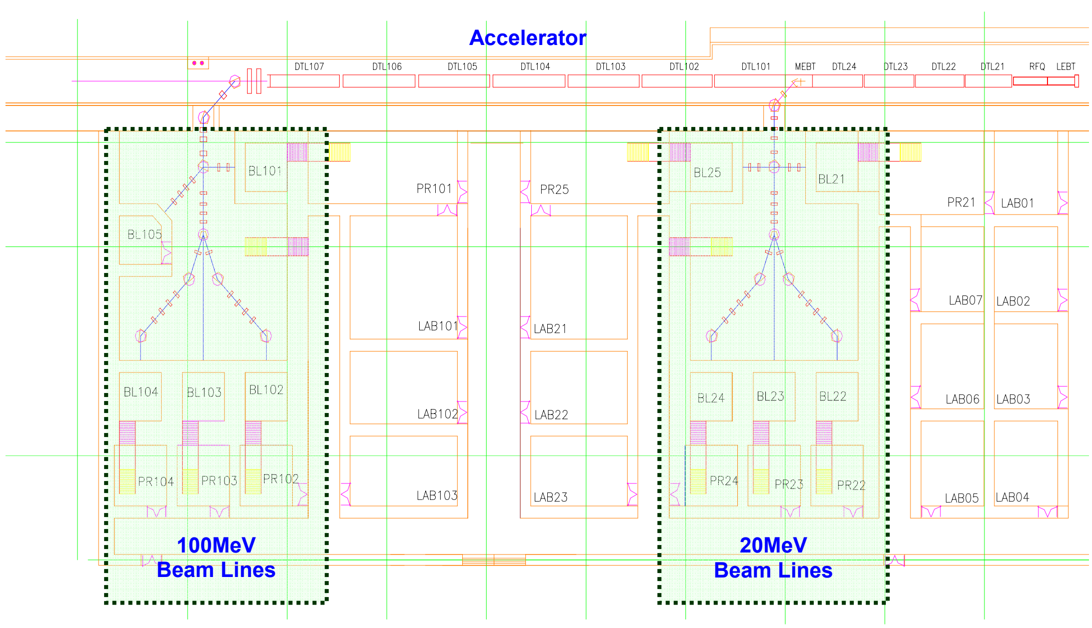

Figure 1: Layout of PEFP user beam line.

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program, we had 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.

Table 1: 100 MeV beam line requirements

Beam Line	Application Field	Rep. Rate	Max. Avg. Current	Irradiation Condition	Max. Area (Dia.)
BL101	RI	60Hz	0.6mA	Horizontal Vacuum	100mm
BL102	LEPT (Animal, Cell)	7.5Hz	10μA	Horizontal External	300mm
BL103	Fuel Cell Nano Particle	15Hz	0.3mA	Horizontal External	300mm
BL104	Detector, Space Rad.	7.5Hz	10μA	Vertical External	300mm
BL105	Neutron	60Hz	1.6mA	Vertical Vacuum	300mm

Table 2: 20 MeV Beam Line Requirements

Beam Line	Application Field	Rep. Rate	Max. Avg. Current	Irradiation Condition	Max. Area (Dia.)
BL21	RI (PET)	60Hz	2.4mA	Horizontal Vacuum	100mm
BL22	Detector Space Rad.	15Hz	60μA	Vertical External	300mm
BL23	Fuel Cell, Nano Particle	30Hz	1.2mA	Horizontal Vacuum	300mm
BL24	Bio. Sample (Cell, Plant)	15Hz	0.6mA	Horizontal External	300mm
BL25	Semi-conductor	60Hz	0.6mA	Vertical External	300mm

BEAM LINES

According to modifying the position of the target rooms and the length of the beamlines, we have modified array of beam transport elements and calculated the beam optics of these beamlines[2]. Figure 2and 3 show modified 100MeV and 20MeV proton beamline respectively. 90 degree bending is added in 20MeV and 100MeV beamline to deliver high current proton beams for right and left target rooms. AC magnet can cover 3 low current beamlines for the 100MeV and 20MeV beamline.

A 20MeV proton beam from the Drift Tube Linac (DTL) is transported with two sets of the 45 bending magnets and some 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) at the end of the 20MeV Linac. For 100MeV beam lines, the schematic layout is almost same with the 20MeV beam lines.

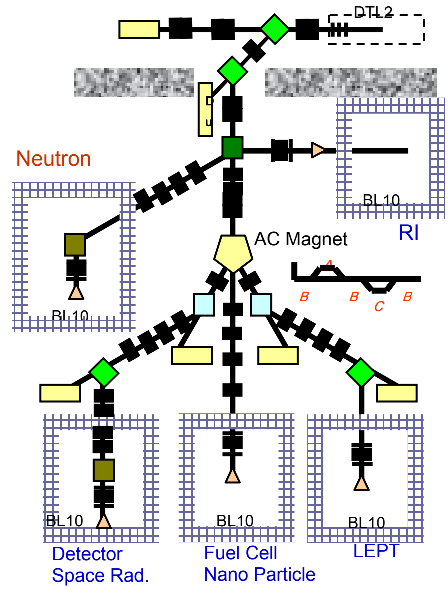


Figure 2: Layout of 100 MeV Beam Lines.

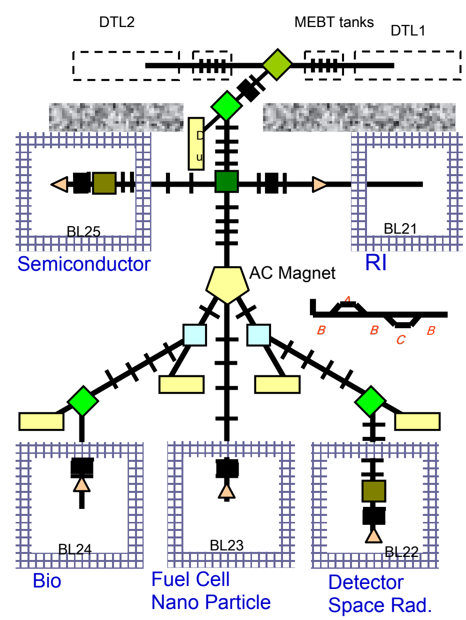


Figure 3: Layout of 20 MeV Beam Lines.

RI PRODUCTION FACILITIY USING 100 MeV PROTON BEAMS

The R&D for target rooms has been started from RI production facility. We have considered similar facility of the IPF at LANL[3] and BLIP at BNL[4]. User's facility for RI production using 100MeV exists in right side of 100MeV beam line as shown in figure 2. The internal size of the RI production room is 4m x 4m with 2meter thickness of the concrete wall for radiation shielding. Figure 4 shows Schematic diagram of 100MeV RI facility. Auxiliary iron shielding block can be installed in the room if necessary. Major components in the RI production room are vacuum pipe with a diameter of

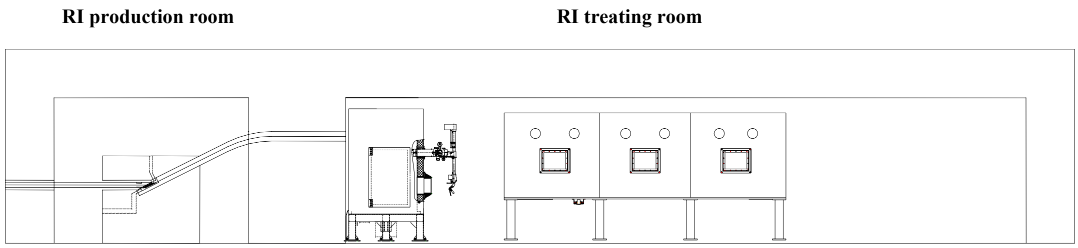


Figure 4: Schematic diagram of 100 MeV RI facility at PEFP.

100mm to deliver the proton beam and target station including its cooling and delivery system.

We considered slanted stacked targets to reduce heat load of the RI targets. 60kW of the proton beam is dumped to the target station with the angle of the 26.6 degree to reduce less than 1/2 heat load of the target by enlarging the effective irradiated area. Vacuum window to extract proton beam is Inconel plate with a thickness of 0.5mm. Target plates (5cm x 8cm) are embedded the cylinder target station. Cooling water flows between targets stacks as shown in figure 5. Targets stacks are composed of 3 layers with high energy, medium energy, and low energy. Each target shares heat load around 20kW of the beam power.

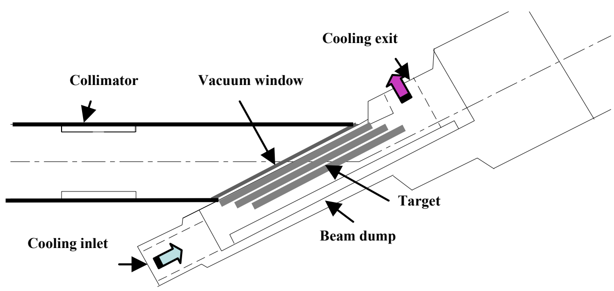
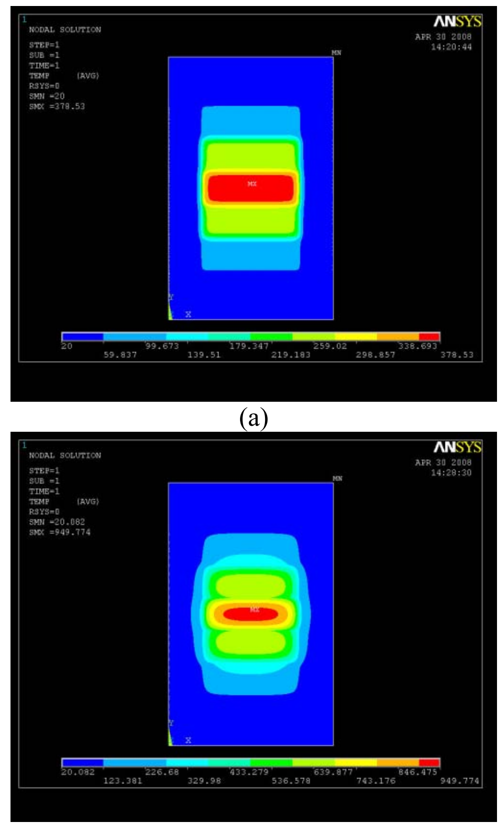


Figure 5: Slanted targetry of the 100 Mev RI production.

We considered niobium dummy targets before considering actual RI production. Thermal analysis in the vacuum window and the dummy targets are required since high thermal power density is dumped. Calculation of the thermal load of the vacuum window and the high energy target was performed using ANSYS[5]. The results of the thermal analysis of the vacuum window and the target can see at the figure 6. The highest temperature at the center of the window and target is sustained under their melting temperature.

SUMMARY

We have a plan to supply 20MeV and 100MeV proton beams to users for beam applications using a PEFP proton linear accelerator. Conceptual design of each beamline and its target room is started from RI production facility and R&D about components of the target room has been performed. The construction of the accelerator tunnel and experimental hall will start in 2008, and the operation will start in 2011.



(a)

(b)

Figure 6: Thermal analysis of the dummy target; (a) at window, (b) at niobium.

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