Design of the PEFP Beam Line

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1. Introduction

The beam lines of the proton engineering frontier project (PEFP) are designed to supply 20/100 MeV proton beams into five target rooms for user group. For the 20 MeV beam line, the extracted proton beams are divided into a target room and an AC magnet through a 90-degree bending magnet . The AC magnet distributes the proton beams into three target rooms. A room is reserved for future extension. The similar scheme is used for the 100 MeV beam line. It is the modified scheme of the PEFP beam lines. This work summarizes the general description of the PEFP beam lines, a beam optics design and a magnet development for the beam lines.

2. PEFP Beam Line

This section describes the general scheme of the modified PEFP 20/100 MeV beam lines and the target rooms.

2.1 PEFP Beam Lines

The main change of the PEFP beam lines is the compact design compared with the pervious one [1] because the available space is largely reduced for the beam utilization building. The schematic plot of the PEFP beam lines is given in Fig. 1.

The 20 MeV proton beams are extracted by a 45-degree bending magnet (BM) in a medium energy beam transport [2] system and separated into BL21 and AC magnet. The magnet with ±20-degree bending capacity distributes proton beams into from BL22 to BL24. The BL25 is a reserved space for future extension. The 100MeV beam lines are designed under the same principle. The position of the reserved room BL105 is shifted for the experimental requirement as explained in the target room section. The length of the accelerator tunnel becomes so short that a 45-degree BM is located just downstream of the 100 MeV linac.

2.2 Target Room

Based on the user surveys for 20/100 proton beams, we determined the specification of the 10 target rooms as given in Table 1 and 2. The typical application areas of the 20 MeV proton beams are a radio-isotope production in BL21, a space technology in BL22, a nano-technology in BL23, a bio-technology in BL24, and a power-semiconductor production in BL25. For the 100 MeV target rooms, they are a radio-isotope production in BL101, a medical application in BL102, a nano-technology in BL103, a space technology in BL105, and a spallation neutron experiment in BL105. We considered the neutron guide lines when we choose the position of the target room for neutron production that is why BL105 is shifted compared with BL25. Fig. 2 shows schematic design of BL104 which is a vertical beam line.

Table 1. 20MeV target room (H:horizontal, V:vertical)

	repetition rate	average current	irradiation condition	beam diameter
BL21	60 Hz	2.4 mA	H, vacuum	100 mm
BL22	15 Hz	60 μA	V, air	300 mm
BL23	30 Hz	1.2 mA	H, vacuum	300 mm
BL24	15 Hz	0.6 mA	H, air	300 mm
BL25	60 Hz	0.6 mA	V, air	300 mm

Table 2. 100MeV target room (H:horizontal, V:vertical)

	repetition rate	average current	irradiation condition	beam diameter
BL101	60 Hz	1.6 mA	H, vacuum	100 mm
BL102	7.5 Hz	10 μA	H, air	300 mm
BL103	15 Hz	300 μA	H, air	300 mm
BL104	7.5 Hz	10 μA	V, air	300 mm
BL105	60 Hz	1.6 mA	V, vacuum	300 mm

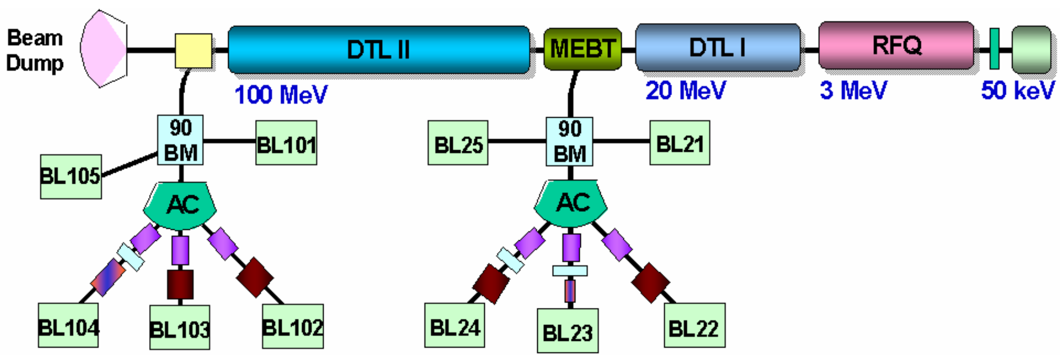

Fig. 1. Schematic plot of the PEFP beam lines.

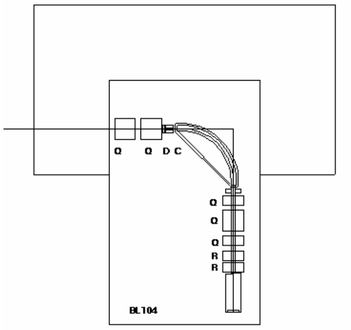

Fig 2. Schematic plot of BL104 vertical beam line.

2.3 Beam Optics

We studied the beam optics of the new beam lines in order to check the feasibility of beam transportation through the lattice structure. In the first step we found the dispersion free condition after two bending magnet pair and then we studied the matching conditions for each region to complete the beam optics calculation. Fig. 3 and 4 show the calculation results. We found that beam profile has reasonable size through beam lines. The dispersion values are not vanished after the last bending magnet because it is not paired by another bending magnet.

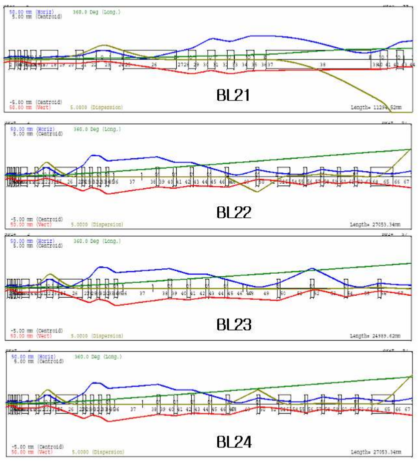

Fig. 3. Beam optics of PEFP 20MeV beam lines.

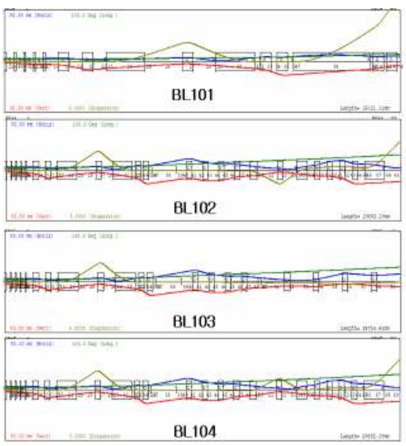

Fig. 4. Beam optics of PEFP 100MeV beam lines.

2.4 Magnets

The beam lines include a lot of magnets such as quadruople magnets for focusing, dipole magnets for bending of the proton beam and controlling the staggering phenomena of beam center which is generated by some imperfection of the magnets and their positioning errors, and AC magnets for beam distribution. The PEFP beam line uses two types of quadrupole magnets their effective lengths are 200 mm and 400 mm. The bending angles of the PEFP dipole magnets are 90, 45, 25 degrees. The bending angle of the AC magnets is 20 degrees. The field uniformity in the bending magnets is required to be less than 0.1% along the beam path. Fig. 5 shows a prototype of the quadrupole magnets which are made in IHEP, China.

Fig 5. Prototype of PEFP quadrupole magnet.

3. Conclusions

The PEFP beam lines were modified to be compact because the area of the beam utilization building is reduced. They were designed to supply 20/100 proton beams into 5 target rooms, respectively. We checked the beam optics in the new beam lines and found that the new beam lines transport proton beams into each target room without problems. The quadrupole magnets for the beam lines were designed and their fabrication is under progress.

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REFERENCES

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