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Design of the PEFP 20 MeV Proton Beamline

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1. Introduction

The Proton Engineering Frontier Project (PEFP) is aimed to build a 100 MeV proton linac and to provide its users with 20 MeV and 100 MeV proton beams [1]. Two separate beam extraction systems and beamlines are required to deliver the 20 MeV proton beams and 100 MeV proton beams to the experimental hall at which the proton beam is further split into several beamlines, upto five beamlines, with the various beam properties at each beam lines to meet the specific user's requirements.

The PEFP 20 MeV beamline consists of the beam extraction system, beam transport system, and beam distribution system, which was originally designed by Pohang Accelerator Laboratory [2]. However, there have been numerous modifications in the design of the PEFP 100 MeV linac, especially in the high energy accelerator part and its Medium Energy Beam Transport (MEBT), which is required to match the 20 MeV proton beam to the high energy part of the linac which has a higher accelerating field gradient [3]. The design of the accelerator tunnel and the experimental hall requires the distance between the accelerator and the wall to be less than two meters. These two major limitations were ignored in the original beamline design and should be considered in the new design.

The new design of the PEFP 20 MeV beamline is made to meet the limited space requirements while keeping its functionality to provide the users with the high quality proton beams for a wide range of beam conditions. We also performed the stability studies and error analyses of the new beam optics design. In the paper, we present the new design and the results of stability studies and error analyses.

2. Design of the Beamline

In this section we present the basic requirements of the PEFP 20 MeV beamline and beam optics design to meet the requirements.

2.1 The Layout of the beamline

The PEFP 20 MeV beamline should be able to deliver a wide range of proton beams because each user requires a unique beam conditions which are essential for the user to produce meaningful experimental results. To meet the widest possible user's requirements, the beamline should be operational with the beam conditions listed in Table 1. Furthermore, the beamline should be able to moderate the side effects due to the changes in beam properties, such as the beam centroid offset and the initial emmitances because these side effects may cause serious beam loss, worsen the beam conditions, or damage the beamline equipment.

Peak current (mA)	0.2 – 20.0
Pulse length (ms)	0.1 – 1.33
Repetition rate (Hz)	1, 5, 15, 30, 60

Table 1. Characteristics of the 20 MeV proton beam.

The implementation of the MEBT system limits the space between two bunchers, which is about 0.7 m span in which the 20 MeV proton beam extraction magnet should be installed. We has studied various dipole magnets with different bending angles and radii to fit into the limited space and found that a 90 degree bending magnet with the bending radius of about 0.6 m is the optimum solution, which is described in detail else where [4]. The dipole gap was determined to be 30 mm not to disturb the beamline aperture of the MEBT and the beamline in the higher energy part of the accelerator. In addition, the number of quadrupole magnets in the accelerator tunnel is required to be minimized because the space between the accelerator and the tunnel wall is should be less than 2 meters. With the limited space, we designed the beamline as schematically shown in Figure 1.

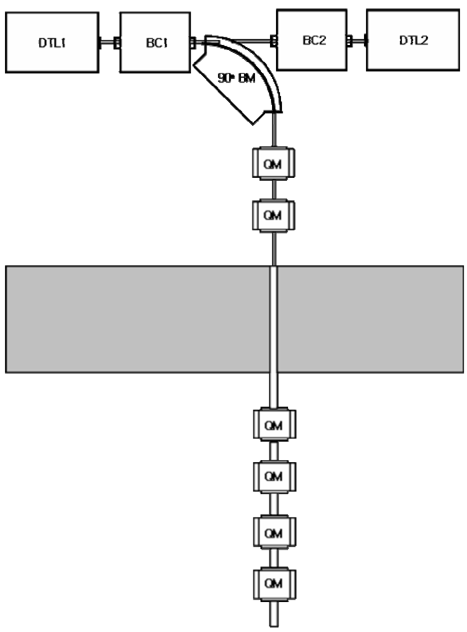

Figure 1. Schematic Layout of the PEFP 20 MeV Beamline.

2.2 Beam Optics of the beamline

We have simulated the beamline to determine the lattice arrangements and beam optocs by using the TRACE-3D code [5]. We have found the optimum solution of the PEFP beamline as shown in Figure 2, from which we found that a 20 MeV proton beam can be drifted through the 2 meter long wall between the accelerator tunnel and the user experimental hall without detectable beam loss, which makes the beamline design much simpler than the original design made by the PAL collaboration.

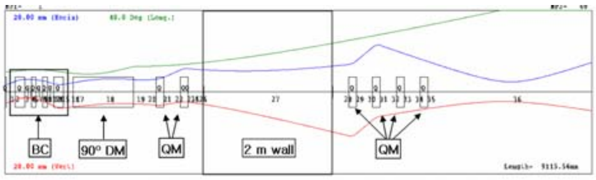

Figure 2. Beam Optics of the PEFP 20 MeV beamline with the TRACE-3D program.

The optimum parameters in the beamline design determined by the TRACE-3D calculation have been thoroughly checked if the beam dynamics is affected by changing the proton beam parameters, such as the beam current, the beam energy, the beam centroid offset, and the initial emmitance at the end of the 20 MeV linac. We found that the optimum parameters are stable for the varying beam current from 0.1 mA to 40 mA, the wide range of proton beam energy from 18.0 to 22.0 MeV. Furthermore, the optimized eamline optics can tolerate the beam centroid offset within ±50 μm and incident angle within 0.1 mrad in horizontal and vertical directions, which are within the designed mechanical error of the accelerator.

3. Results and Discussions

We have redesigned the PEFP 20 MeV beamline which consists of the beam extracting system and transport system to the user experimental hall. The new design is significantly simplified from the original design made by the PAL collaboration while demonstrating a better beam optics and control.

4. Acknowledgment

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