Preliminary Design of the Straight Beam Transport System for Secondary Particle Production Based on the 100-MeV Proton Accelerator

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1. Introduction

A 100-MeV proton linear accelerator has been operating since 2013 at Korea Multi-purpose Accelerator Complex (KOMAC) [1]. The accumulated operation time reached 11,062 hours at the end of 2016. Until now, the users, who are from various fields such as nano/material/semiconductor science, bio/medical science, energy/nuclear/basic science, did the research by using the proton beam directly irradiated on the sample. To increase the application field of the 100-MeV proton accelerator, we consider the utilization of the secondary particle beam produced by the proton bombardment on the production target. At first stage, we consider Li-8 beam and pulse neutron as secondary particle. For pulse neutron production, we are going to install the production target at the end of the accelerator tunnel in order to prepare the room for pulsed neutron beam line installation and possible proton beam energy increase. A preliminary design study of the beam transport line was done based on the period focusing lattice. In this paper, the result of the design study is presented for the straight beam transport line from the end of the 100-MeV accelerator to the target located at the end of the secondary particle production target.

2. Straight Beam Transport Line

We have 40 m straight section after the 100-MeV linac, over which space the beam transport line should cover in order to deliver the 100-MeV proton beam to production target.

2.1 100-MeV Beam Parameters

The 100-MeV accelerator was designed and simulated based on the PARMILA code which is a multi-particle simulation code [2]. We used a TRACE-3D code, which is based on a beam envelope calculation, in order to design the straight beam transport line because it is much easier to use a beam envelop code to get a matched beam parameters of the lattice in addition to matching parameters between accelerator and beam transport line [3]. We converted the PARMILA results into TRACE-3D and got a beam envelop along the 100-MeV accelerator as shown in Fig. 1. During the beam envelope calculation, we used the output beam parameters from the radio frequency quadrupole (RFQ).

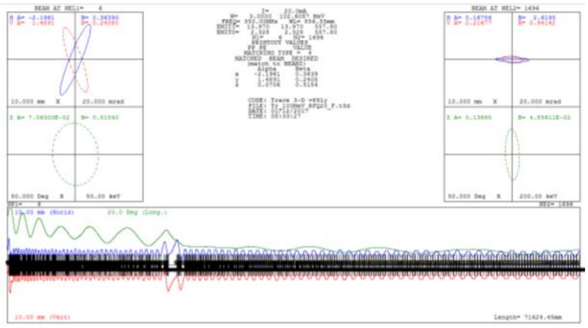

Fig. 1. Beam envelope along the 100-MeV linac.

2.2 Focusing Lattice

Two focusing lattices are considered, one is FODO and the other is doublet. The constraints on the design of the beam transport line are 1) The parameters of the quadrupole magnet are already fixed, maximum field gradient is 5 T/m, effective length is 200 mm with aperture diameter is 110 mm, because we are going to use the same quadrupole magnet used for the KOMAC beam line transport system. 2) The distance between magnets should accommodate the accelerator structure currently designed as a Half-Wave Resonator (HWR). With the above two constraints, the distance between magnets depending on the beam radius was calculated taking into account the optimum phase advance and the available maximum field gradient of the quadrupole. The results are shown in Fig. 2.

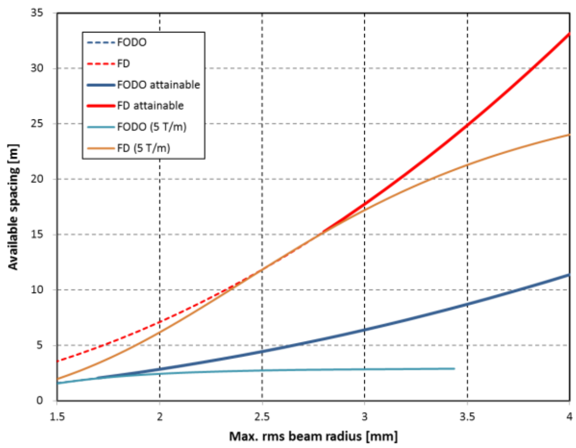

Fig. 2. Distance between magnets depending on beam radius for both FODO and doublet lattice.

2.3 Beam Transport along the Straight Section

For the preliminary estimation, the distance between magnets was decided to 4,300 mm which could accommodate the cryomodule for 4 sets of HWR cavities. The matched beam parameters for each lattice were calculated by using TRACE-3D matching algorithm. Four sets of quadrupole magnets were used to match the from the 100-MeV beam from the accelerator to the focusing lattice. In this case, we used different magnets which have the same field gradient but have twice longer effective length than the one considered in beam transport line. The results are shown in Fig. 3 for FODO lattice and Fig. 4 for doublet lattice respectively.

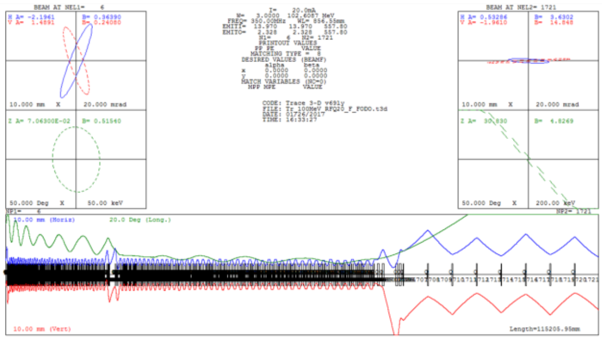

Fig. 3. Beam envelope along the straight beam transport line after 100-MeV accelerator in FODO lattice.

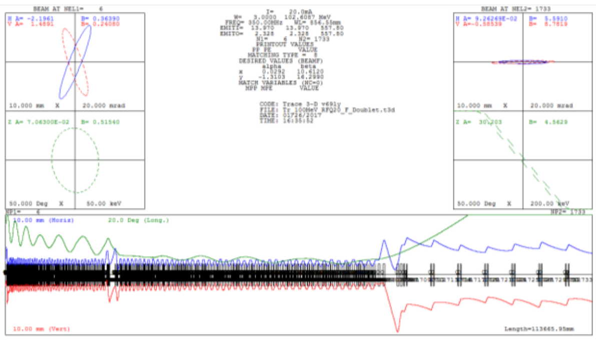

Fig. 4. Beam envelope along the straight beam transport line after 100-MeV accelerator in doublet lattice.

3. Conclusions

The straight beam transport line after the 100-MeV proton linear accelerator was preliminary designed in order to deliver the beam to the secondary particle production target which will be installed at the end of the accelerator tunnel. Two lattices, FODO lattice and doublet lattice, were considered based on the two constraints; one is to use existing quadrupole magnets and the other is the distance between magnets which can accommodate the HWR. The doublet is superior to FODO in the beam symmetry viewpoint whereas it needs more magnets. The beam transport system will include the HWR for further acceleration of the proton beam in next study.

ACKNOWLEDGEMENT

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