Preliminary Design Report of PEFP MEBT System

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1. Introduction

One of main purposes of PEFP (Proton Engineering Frontier Project) is supplying 20MeV proton beam to the user group. However it gives some problem to the beam optics since the beam extraction system located after the 20MeV DTL implies a long drift space without focusing magnets. In order to focus the diverging beam in the transverse direction and to rebunch the beam in the longitudinal direction, MEBT (Medium Energy Beam Transport System) becomes an essential element in PEFP accelerating structure. The key role of MEBT is the matching of the 20MeV beam into the following DTL accelerator. The main elements are some quadrupole magnets to control the beam in the transverse direction and two bunching cavities to get the matched beam in the longitudinal direction.

2. MEBT Design and Result

In this section we describes the theoretical background of the beam matching and the simulation result using the TRACE3D code[1].

2.1 Matching Condition

In order to design the MEBT system, we needs the twiss parameters output beam of 20MeV DTL, matched input beam for the following DTL, and geometrical information of the beam extraction system. The transverse matching can be achieved by 4 quadrupole magnets which control the twiss parameters: α_x, β_x, α_y, β_y. Two buncher cavities can adjust the parameters α_z, β_z in the longitudinal direction.

2.2 Design Summary of PEFP DTL II

The DTL II which accelerate 20mA proton beam up to 55.1MeV has been designed [2]. It consist of 8 tanks where RF power is supplied by two 1MW klystron. The summary of the tanks is given in Table1. The total power of the first four tanks is 876.7 kW and it is 868.8kW for the second four tanks. The transverse and longitudinal emittances are 0.23 π mm-mrad and 0.15 deg-MeV respectively. The twiss parameters for the matched input beam is given in Table 2.

Table 1. Summary of the DTL II tanks

Tank	Cell number	Energy (MeV)	Length (cm)	Power (kW)	
				Total	Beam
1	26	24.6	476.6	220.2	92.4
2	24	29.2	481.6	221.0	91.7
3	22	33.6	475.6	216.7	88.8
4	21	38.1	483.3	218.8	88.5
5	20	42.4	486.1	218.8	87.3
6	19	46.7	484.4	216.8	85.4
7	18	50.8	478.6	213.0	82.3
8	18	55.1	497.1	220.2	84.5

Table 2. Matched input beam of the DTL II

	α	β
x	-2.70	1.04 (mm/mrad)
y	1.53	0.46 (mm/mrad)
z	-0.02	117.09 (deg/MeV)

2.3 Beam Extraction System

The beam extraction system is the most crucial element in the MEBT design process since it determines the drift space required to install the element. In the space, it's impossible to set some quadrupole magnets or buncher cavities and it will seriously destroy the beam properties. MEBT is responsible for the adjustment of the beam which becomes suitable for injecting into DTL II. Since the extraction system consists of quadrupole magnets and a bending magnet on the beam path between DTL I and DTL II, one way to improve the situation is using the quadrupole magnets as part of the MEBT.

Unfortunately, the design of the beam extraction system is not fixed and this work will be modified after finalizing the design. In this preliminary report, we have neglected the beam extraction system and designed the MEBT system with four quadrupole magnets and two buncher cavities.

2.4 20MeV Output beam of DTL I

The output beam of 20MeV DTL is given in Figure 1 and the Table 3 includes the twiss parameters of the beam.

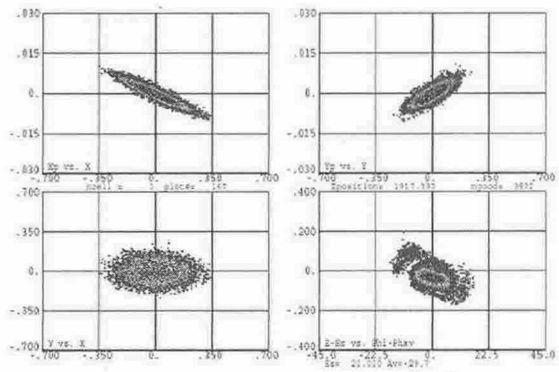

Figure 1. Output beam of 20MeV DTL in phase space.

Table 3. Output beam of 20MeV DTL

	α	β
x	-1.41	0.45 (mm/mrad)
y	2.74	1.03 (mm/mrad)
z	0.16	133.26 (deg/MeV)

2.5 TRACE3D Simulation Result

The quadrupole magnets in the MEBT system are separated by the distance of 1βλ, 17.4cm and their effective length is 6.5cm. The buncher cavities are located symmetrically, one between the first and second magnets and the other between the third and fourth ones.

Figure 2 shows the beam profiles in the MEBT consisting of four quadrupole magnets and two bucher cavities. The G in the figure represents the RF gap of the cavities. The field gradient of the magnets and the effective gap voltages of the bucher cavities are given in Table 4 and Table 5, respectively.

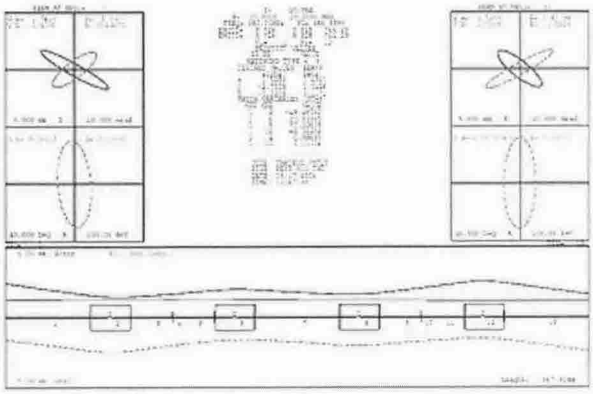

Figure 2. Beam profile obtained by TRACE3D

Table 4. Field gradients of the quadrupole magnets

Quadupole magnets	Field gradient (kG/cm)
Q1	-4.85
Q2	3.70
Q3	-3.71
Q4	4.83

Table 5. Effective gap voltage of the buncher cavities

Buncher cavity	Effective gap voltage (E_0TL, MV)
Cavity 1	0.99
Cavity 2	0.11

3. Conclusion

We have designed the MEBT for beam matching between DTL I and DTL II under the simple configuration with four quadrupole magnets and two buncher cavities. Since the MEBT design is seriously affected by the beam extraction system, it will be modified after finalizing the extraction system. The value of the effective gap voltage of the first cavity is somewhat larger and need to modify the design scheme. In near future, we have to study the cavity design using the 3-dimensional code such as MWS as well as the modification.

ACKNOWLEDGEMENT

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REFERENCES

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[2] J. H. Jang, Y. S. Cho, and H. J. Kwon, "Beam dynamics of the PEFP Accelerator", the 8th workshop on HPPA Development and Utilization, Daejeon, Korea.