A Study on the Longitudinal Matching Scheme in the PEFP MEBT

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1. Introduction

The Medium Energy Beam Transport (MEBT) system of the Proton Engineering Frontier Project (PEFP) linac will be used to match the 20MeV proton beam into the following 60MeV DTL passing through the beam extraction system. It consists of quadrupole magnets and buncher cavities for transverse and longitudinal matching, respectively. In this brief paper, we have studied the longitudinal matching scheme and physical properties of the beam going through system.

2. Matched input beam

First of all, we have studied the matched input beam for the 60MeV PEFP DTL under various situations. The matched beams are obtained by TRACE3D[1] and PARMILA[2] codes.

Figure 1 shows the matched input beam in the longitudinal trace space (ΔE-$\Delta\phi$ space). We have changed the face angle of the drift tubes in the DTL tanks from 10° to 40°.

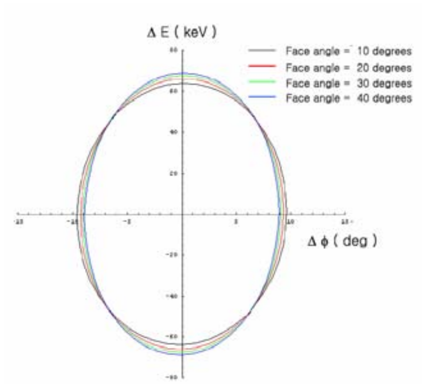

Figure 1. Matched input beam of the 60 MeV PEFP DTL with different face angles.

3. Longitudinal Matching Schemes

2.1 Transverse Matching

Before going into the longitudinal matching, we will briefly summarize the transverse matching for which 8 quadrupole magnet will be used. The initial 4 magnets before the bending magnet can control the transverse beam size in the beam extraction system and the remaining 4 quadrupoles are utilized to match the beam into the transverse focusing structure of the following DTL.

2.2 Two buncher Cavities

For the beam matching in the longitudinal direction, it needs at least 2 buncher cavities in order to control the beam shape in the longitudinal trace space. Figure 2 shows the MEBT scheme with 2 cavities. The effective voltages (E_0 T L) for the matching are given in Table 1.

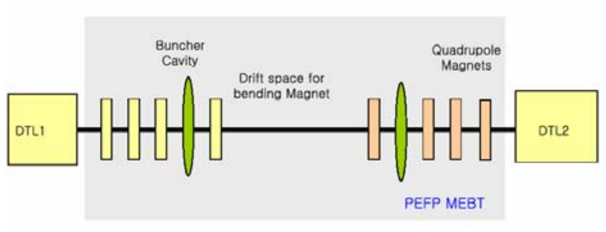

Figure 2. PEFP MEBT with two buncher cavities.

Table 1. Effective voltages of two buncher cavities for longitudinal matching under varying face angle of the drift tubes in the 60MeV DTL.

Face angle (degree)	Effective voltage (kV)	
	First cavity	Second cavity
10	605	400
20	620	413
30	631	423
40	639	431

The effective voltages for longitudinal matching are somewhat larger than the usual cavity values. It mainly comes from the fact that the proton energy is 20MeV in our case. For larger energy, it needs larger effective voltage for longitudinal matching as shown in Figure 3.

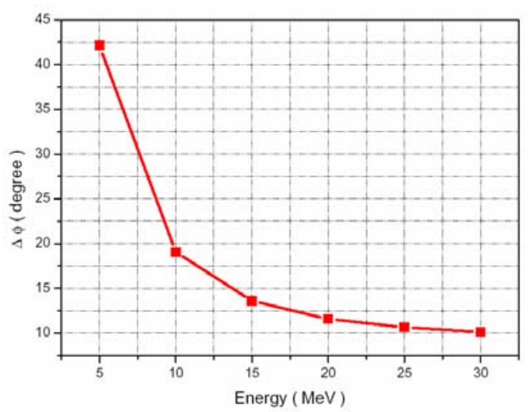

Figure 3. $\Delta\phi$ variation by a single buncher cavity with the effective voltage of 100kV. The result is obtained at the end of drift space of 1m after the cavity.

3. Matching with multiple cavities

Since the effective voltages obtained in the section 2 have larger values, we have studied how to reduce the voltage to the reasonable values below 200 kV. For this purpose, multiple-cavity schemes are used.

3.1 Effective voltage with multiple cavities

The simple extensions are adding the cavities into the spaces between quadrupole magnets in a symmetric way which give the 4-, 6-cavity schemes. Hence the matching method in the section 2 can be called the 2-cavity scheme. The other modification is doubling the cavity numbers which are called D2-, D4-, and D6-scheme. In these cases, we have tuned 2 cavities before and after the bending magnet under the fixed voltages of the other cavities. For example 6-cavity scheme is shown in Figure 4.

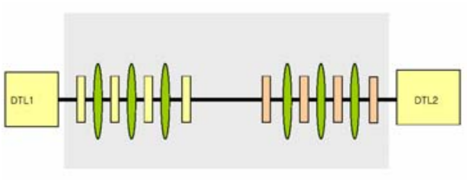

Figure 4. 6-cavity scheme for longitudinal matching.

The results of 4- and 6-cavity schemes are given in Figure 5 and 6. In the 4-cavity scheme, the effective voltages are still larger than the usual values. However the 6-cavity scheme gives the reduced effective voltages around 300 kV.

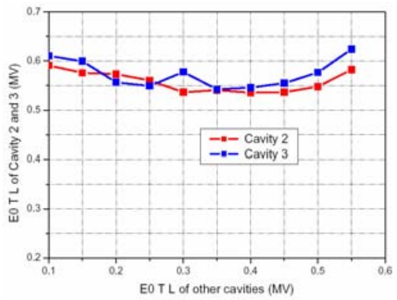

Figure 5. Effective voltages for longitudinal matching in the 4-cavity scheme.

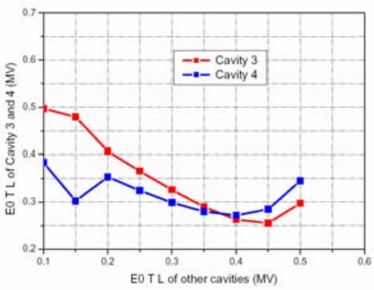

Figure 6. Effective voltages for longitudinal matching in the 6-cavity scheme.

Figure 7 and 8 show the results for D4- and D6-cavity schemes. The D4-cavity scheme is more efficient than the 4- and 6- cavity schemes. Especially, the voltages become smaller than 150kV for all cavities in the D6-scheme,.

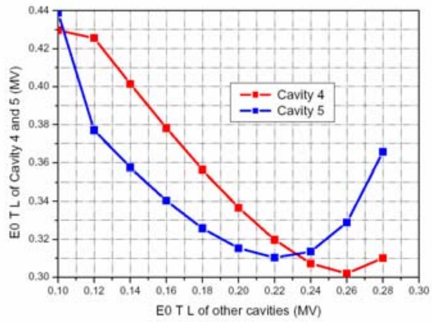

Figure 7. Effective voltages for longitudinal matching in the D4-cavity scheme.

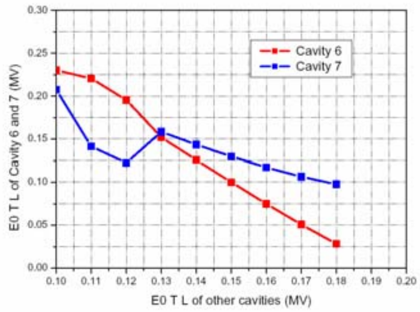

Figure 8. Effective voltages for longitudinal matching in the D6-cavity scheme.

3. Conclusion

We have studied the longitudinal matching scheme for the PEFP MEBT. In the simplest MEBT system with two buncher cavities, those effective voltages become somewhat larger than the usual values. In order to cure the situation, we have studied the multiple cavity scheme for the matching. Even though the cavity number becomes too large in order to give the reasonable voltage result, it should be an important information for the realistic MEBT design.

3. Acknowledgement

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REFERENCES

[1] K.R. Crandall and D.P. Rusthoi, "TRACE 3-D Documentation", LA-UR-97-886.
[2] H. Takeda and J.H. Billen. "Parmila", LA-UR-98-4478, Revised August 13, 2002.