Study on the Tuning of PEFP DTL

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1. Introduction

A conventional 20 MeV drift tube linac(DTL) for the Proton Engineering Frontier Project(PEFP) has been developed as a low energy section of 100 MeV accelerator. The DTL consists of four tanks with 152 cells supplied with 900 kW RF power from 350 MHz klystron through the ridge-loaded waveguide coupler.

After the fabrication and assembling of the DTL, it should be tuned to meet the requirement of the resonant frequency and field profile. The tuning goal of the resonant frequency is 350 MHz at 40 ℃ and that of the field flatness is ±1%. We performed the bead pull measurements under various combinations of slug tuners position and post couplers position. The final tuning can be obtained through several iterations of the tuner position adjustment and measurement.

The methods and the results of the DTL tuning will be given in this presentation.

2. Methods and Results

The DTL can be tuned to the correct resonant frequency and designed field profile through the adjustment of the slug tuner position and the post coupler position and rotation. The slug tuners and the post couplers installed in the PEFP DTL tank1 can be seen in figure 1.

To measure the field profile of the DTL, we performed the bead pull measurement, where the aluminum spherical hollow bead was sent through the beam axis and measured the phase shift caused by the bead perturbation, which is proportional to the square of the field intensity. For a spherical bead, the shift is given as a function of the unperturbed field amplitudes, which are assumed to be constant over the bead, by following equation.

$$\frac{\Delta\omega_0}{\omega_0} = -\frac{3\Delta V}{4U}\left(\frac{\varepsilon_r - 1}{\varepsilon_r + 2}\varepsilon_0 E^2 + \frac{\mu_r - 1}{\mu_r + 2}\mu_0 H^2\right)$$

For near the resonance, the frequency shift is proportional to the phase shift. The time required for the phase shift scan is far less than that for the frequency shift scan, so we adopted the phase shift scan method to reduce the error caused by the temperature drift during the measurement.

The vector network analyzer and LabVIEW program were used to measure the phase shift of S21 parameter. It takes about 3 minutes for the bead to go through the DTL tank1 and the total number of data points was 16001, which is amount to 0.28 mm spatial resolution. To keep the temperature constant during the measurement, the SCR power controlled heating cable with insulation layer was wrapped around the DTL.

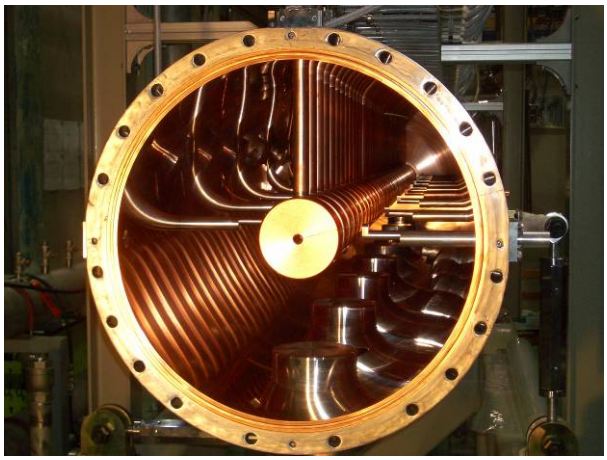

Figure 1. DTL tank1 with drift tubes and tuners

The basic tuning procedure is like followings.

1. With all the post couplers inserted maximally, the slug tuners position is adjusted for the correct resonant frequency and flat field profile.
2. The post couplers position is adjusted to correct the local field profile error.
3. The fine tuning is performed with the post coupler tab rotation.

The preliminary result before fine tuning can be seen in the figure 2. The field variation was about ±5%.

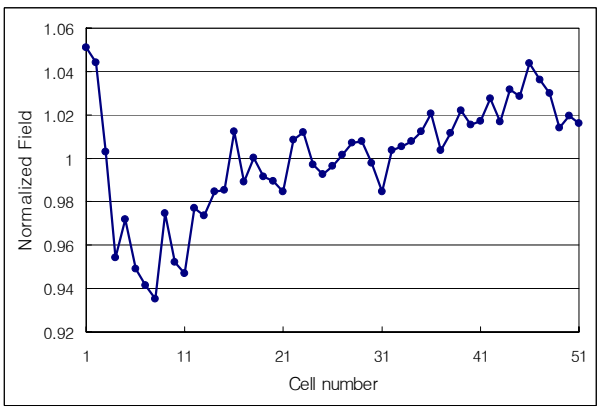

Figure 2. Normalized Field along the Beam Axis

In addition to the field profile, the dispersion relation of the DTL tank1 was also measured. When the tuning is correctly done, the TM accelerating mode and the PC post coupler mode show the confluence, which is typical for the resonant coupling mechanism. Figure 3 shows the measured the dispersion curve.

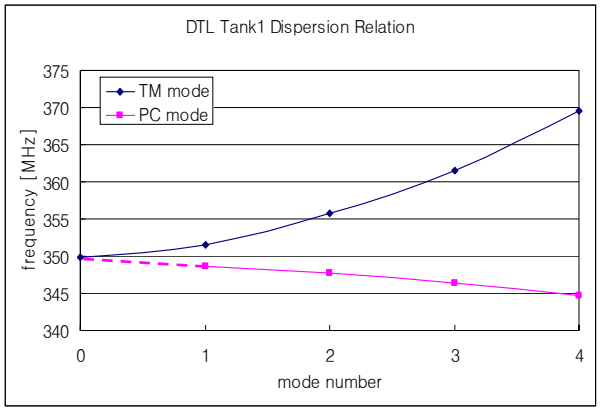

Figure 3. DTL tank1 dispersion relation

3. Conclusions and Future Works

The preliminary tuning of the PEFP DTL tank1 was performed with the bead pull perturbation method. The scheme and the procedure of the tuning were checked with no problem. The dispersion curve also measured and showed the typical confluence. The fine tuning to meet the tuning requirements will be performed and the RF power coupler also will be tuned, which complete the whole tuning process of the DTL and make DTL ready for beam test.

REFERENCES

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