RF CHARACTERISTICS OF THE SDTL FOR THE J-PARC

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Abstract

For the J-PARC (Japan Proton Accelerator Research Complex) linac, an SDTL (Separated type Drift Tube Linac) is used to accelerate an H^- ion beam from 50MeV to 191MeV.

We have measured the RF characteristics of the SDTL tanks and adjusted the field distribution. The measured Q value was above 90% of an ideal SUPERFISH value. Furthremore the field distribution was adjusted within ±1% for all the tanks. In this paper, the results of RF measurements of the SDTL tanks are described.

INTRODUCTION

Japan Atomic Energy Agancy (JAEA) and High Energy Accelerator Research Organization (KEK) are jointly constructing the high intensity proton accelerator in Tokai site of JAEA [1-2]. The J-PARC accelerator consists of a 400MeV linac, a 3Gev rapid cycle synchrotron, and a 50GeV synchrotron. The linac is comprised of a negative hydrogen ion source, 3MeV RFQ (Radio Frequency Quadrupole) linac, a 50MeV DTL, 191MeV SDTL and a 400MeV ACS (Annular Coupled Structure) linac.

Figure 1 shows the schematic view of the SDTL. The Alvarez type SDTL accelerates the H- ion beam from 50MeV to 191MeV [3]. The focusing magnets are set between the tanks. The SDTL consists of 32 independent tanks. It has four drift tubes, two half drift tubes, two fixed tuners, one movable tuner and an RF input coupler. The inner diameter of the tanks is 520mm and the length of the tank is varied from 1.5m (SDTL1) to 2.5m (SDTL32). The resonant frequency of the tank is 324MHz. The main parameter of the SDTL is shown in table 1.

We measured the RF characteristics of the SDTL tanks at KEK where all the SDTL were assembled. In this paper, the rf measurement for the SDTL tanks are described.

Table 1: Main parameter of the SDTL

Number of tanks	32
Input Energy	50MeV
Output Energy	191MeV
Tank inner Diameter	520mm
Tank length	1.5m ~ 2.5m
Number of cells	5
Drift tube outer diameter	92mm
Drift tube inner diameter	36mm
Operating Frequency	324MHz

MEASUREMENT OF THE RF CHARACTERISTICS

Frequency Shift

The SDTL tanks have two fixed tuners (FT1 and FT2) and one movable tuner (AT). Figure 2 is an example of the frequency shift by the insertion length of the tuner for the SDTL 16th tank. The frequency sift is over 350kHz when the insertion length is 120mm. Since the resonant frequency of the tank is about 323.5MHz without all tuners, the maximum frequency shift by the tuner is sufficient to adjust the resonant frequency to 324MHz.

Field Distribution

In order to obtain the uniform electric field on the beam axis, the length of two fixed tuners was adjusted by using the movable model tuners instead of the real ones.

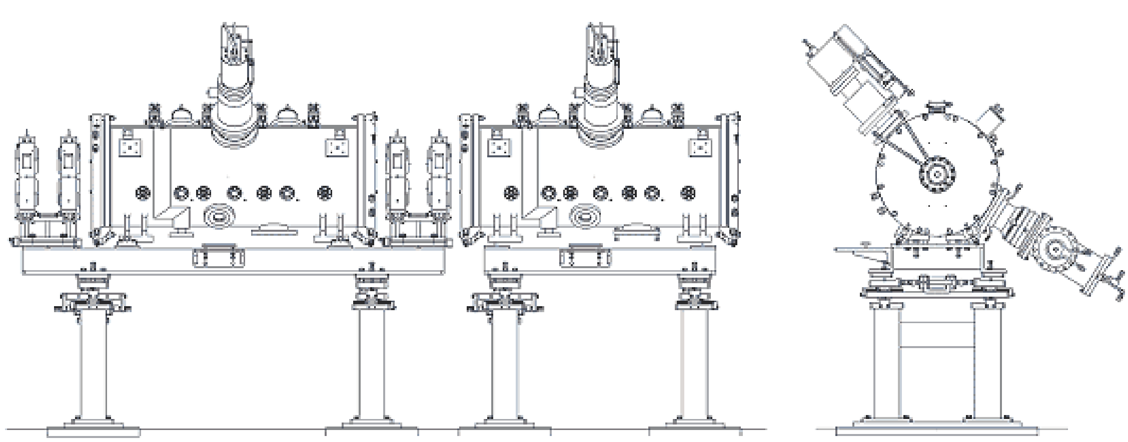

Figure 1: Schematic view of the SDTL.

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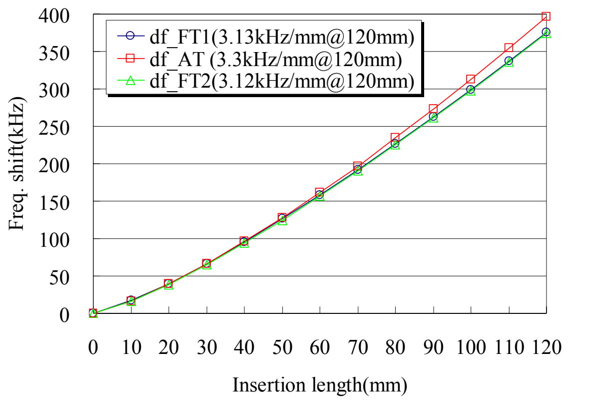

Figure 2: Insertion length of the tuner vs. Frequency shift.

Our target values for the rf properties are as follows: (1) the variation of the electric field distribution in a tank is within ±1%, (2) The resonant frequency is 324.016MHz (SDTL1&2) to 324.035MHz (for SDTL13-32)at 27 degrees (Celsius) at vacuum (The difference from the operating frequency is compensated by the deformation of the tank and the DT by the wall losses.)

Figure 3 is the raw data of the electric field distribution on the beam axis after the tuner adjustment for the SDTL 16th tank. The abscissa shows the point on the beam axis. The ordinate shows the frequency shift at each point. The insertion length of the tuners are 57mm (FT1: upstream), 31mm (FT2: downstream) and 67mm (AT) respectively. The measured resonant frequency is 323.95MHz at 23.6 degrees. At this tuner condition, the resonant frequency is about 324MHz under the actual operation of the tank.

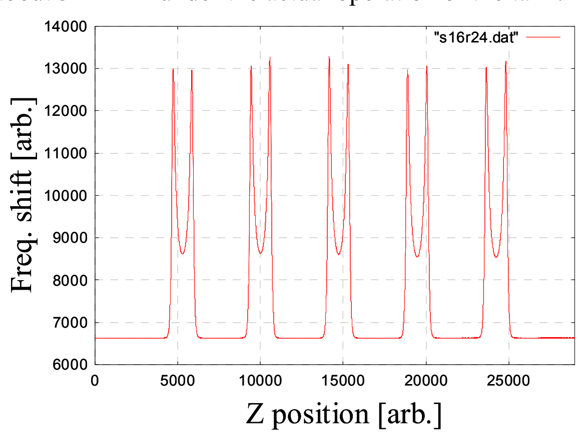

Figure 3: Electric field distribution on the beam axis.

The distribution of the average electric fields varies if the insertion length of movable tuner is changed. It is shown in figure 4. The abscissa is cell number and the ordinate is the calculated average field for each cell. The distribution at AT=67mm in the figure 4 has been chosen as the standard distribution. (Figure 3 corresponds to the raw data of the standard distribution for the SDTL 16th tank.)

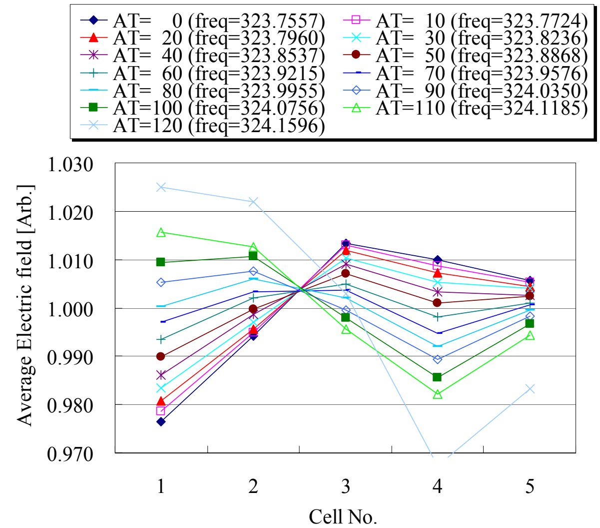

Figure 4: Average electric field at the various tuner length.

The distribution of the electric field is within ±1% when the insertion length of the movable tuner is from 50mm to 80mm. Then the span of the frequency is more than 100kHz. It is enough to adjust the frequency at full power operation.

We adjusted the field distribution within the ±1% for all SDTL tanks. Figure 5 is the result of the adjuted average field distribution of all SDTL. The horizontal axis is the number of the SDTL tank and 5 cell are included in the one division.The average field of the each tank is normalised to 1.0 in the figure for camparison of all data.

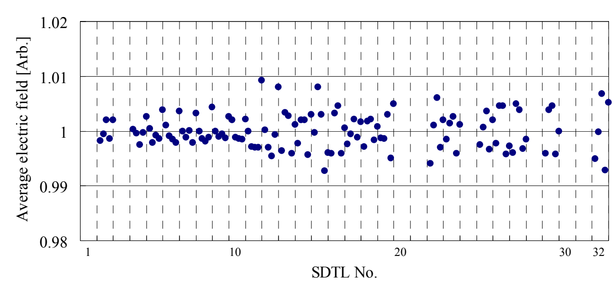

Figure 5: Adjusted electric field for all SDTL tanks.

Resonant Frequency and Q Value

We measured the Q value at the same time of the tuner adjustment. However all the SDTL tanks have to be transported from KEK to JAEA [4, 5]. The measured frequency and the Q value in JAEA are consistent with the results in KEK.

Table 2 shows the resonant frequency and the Q value before and after the transportation. The frequency in the table is corrected value for the effect of the atmosphere.

All the frequency of the tank is set to the values more than 324MHz in order to compensate the frequency shift induced by the deformation of the tank and the DT by the wall losses (10kHz ~ 40kHz). The fluctuation of the frequency is caused mainly by that the inaccuracy of the tuner position, and the difference of the RF coupler used at KEK (low-power model) from at JAEA (high-power model).

Both measured Q values at KEK and at JAEA were higher than expected value (~80%) than those of SUPERFISHby 90% of ideal SUPERFISH values. Consequently the required rf power for the tank is reduced.

Table 2: Resonant frequency and Q_0 value of the SDTL

Tank No.	Frequency [MHz]		Q_0 Value				
	KEK	JAEA	SUPER FISH	KEK	%	JAEA	%
1		324.0161	42464			41500	98
2	324.0096	324.0162	42456	41100	97	39900	94
3	324.0119	324.0137	42427	39300	93	41200	97
4	324.0180	324.0257	42401	42300	100	41000	97
5	324.0174	324.0214	42370	41200	97	40400	95
6	324.0225	324.2640	42329	41700	99	41800	99
7	324.0336	324.3990	42282	41000	97	41000	97
8	324.0369	324.4020	42228	39400	93	41300	98
9	324.0303	324.0365	42167	40700	97	41400	98
10	324.0272	324.0321	42101	40500	96	40900	97
11	324.0341	324.0375	42028	40600	97	41300	98
12	324.0283	324.0347	41950	39900	95	41300	98
13	324.0253	324.0345	41868	41200	98	42400	101
14	324.0238	324.0365	41789	40300	96	42000	101
15	324.0276	324.0300	41709	41100	99	42200	101
16	324.0345	324.0290	41629	40000	96	40500	97
17	324.0366	324.0306	41548	41600	100	41900	101
18	324.0226	324.0264	41470	40400	97	42300	102
19	324.0340	324.0382	41392	40900	99	41500	100
20	324.0344	324.0323	41316	40000	97	41400	100
21	324.0378	324.0469	41240	40300	98	41800	101
22	324.0301	324.0388	41167	40300	98	42000	102
23	324.0361	324.0418	41095	40000	97	41700	101
24	324.0268	324.0367	41025	40100	98	41200	100
25	324.0238	324.0367	40956	39900	97	41700	102
26	324.0233	324.0316	40890	41600	102	41000	100
27	324.0234	324.0320	40824	39900	98	40900	100
28	324.0275	324.0376	40761	41600	102	41500	102
29	324.0258	324.0344	40700	41600	102	40800	100
30	324.0205	324.0354	40640	39600	97	41300	102

CONCLUSION

- The field distribution was adjusted within ±1% for all the tanks at KEK.
- The measured Q value was above 90% of ideal SUPERFISH value.
- We confirmed that the resonant frequency and the Q value of the tank before and after transportation were not changed . As a result of this, we conclude that the RF characteristics of the SDTL at KEK and at JAEA was equivalent.

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