

# E-FIELD MEASUREMENT OF 9.3 GHz RF CAVITY FOR 6 MeV LINAC

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## Abstract

In order to achieve performance close to the design value, fabricated cavity was tuned at Sungkyunkwan university. Tuning was done in two steps: each cell tuning and bead-pull system. Each cell tuning was used to determine the status of each cell and to remove the stop-band. Bead-pull system was used to measure the E-field distribution and obtain the required field flatness. This paper describes each cell measurement data and bead-pull measurement system and data.

## INTRODUCTION

A compact X-band 6 MeV electron linac is developed at Sungkyunkwan University [1]. Specification of the linac is shown in Table 1.

There must be a difference between design and fabrication. In order to reduce the difference, tuning is proceeding after fabrication.

In the case of a multi-cell cavity, the number of modes is derived from the number of cavity. In our case, there are 17 accelerating cells so 17 modes are derived. Each mode has different electromagnetic field. In order to measure the electromagnetic field profile for each mode, bead-pull perturbation method is necessary.

A bead-pull system has been constructed at Sungkyunkwan university for measuring each modes field profile.

The linac is operating  $\pi/2$  mode, and side-coupled type cavity. In this case, stop-band should be considered. The stop-band means that it has two different resonant frequencies in the same mode, which is caused by a structural difference between adjacent cells. In order to remove the stop-band, make adjacent cells have the same frequency in our case accelerating cells and side-coupled cells [2].

In this reason, additional each cavity cell measurement was proceeded.

Table 1: Specification of X-band Cavity

Parameters	Value
Operating Frequency	9.3 GHz
Output beam Energy	6 MeV
Operating Mode	Standing wave $\pi/2$ mode
Structure Type	Side-coupled cavity
Structure Aperture Radius	4 mm
Length of the Accelerating Structure	27 cm

## EACH CELL MEASUREMENT

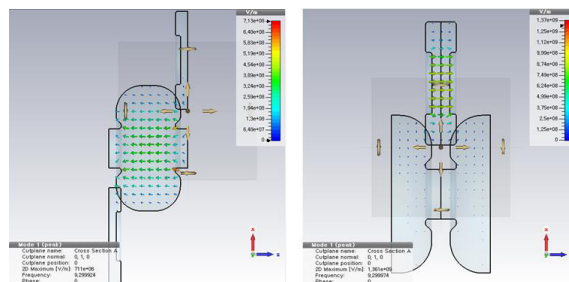


Figure 1: Designed X-band cavity cells (Accelerating Cell(AC) (left), Side-coupled Cell(SC)(right) have same frequency 9.2999 GHz).

Figure 1 shows design step for removing stop-band. The boundary conditions were selected so that the electromagnetic fields of  $\pi/2$  mode were generated in AC and SC.

In each cell tuning process, the parameters that can affect the measurement values such as temperature, probe position, surface roughness, and force to be assembled were considered to minimize measurement errors [3].

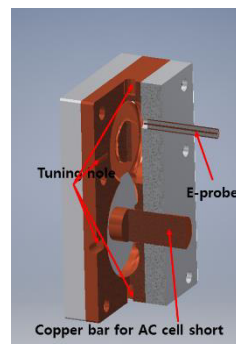


Figure 2: Device for measurement of each cell.

Figure 2 shows each cell measurement system in sungkyunkwan university. Tuning was carried out by putting a bead in the tuning hole and pushing a bead into cavity wall. The resonant frequency can be changed from 0 to 10 MHz in one hole.

There are 6 tuning hole of each cells (AC: 3, SC: 3) except coupler cell(AC:2,SC:3) because of coupling hole.

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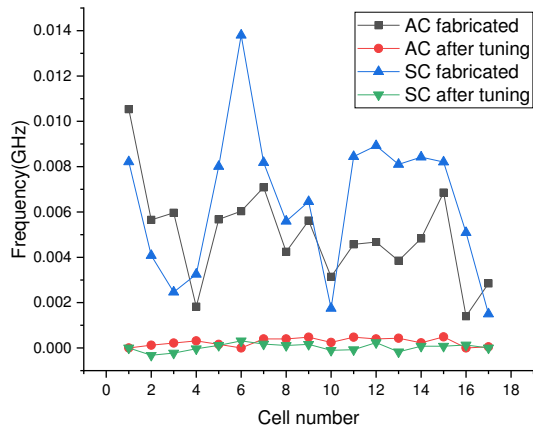


Figure 3: Resonant frequency before and after tuning.

Figure 3 shows the resonant frequency before and after tuning. Before the tuning, it has a difference of 0 ~ 15 MHz from the reference frequency. But after tuning, there are a difference of -0.5 ~ 0.5 MHz. It means that the resonance frequency of AC and SC are equal.

### BEAD-PULL MEASUREMENT

Bead-pull measurement technique is typically used to measure electromagnetic field profile in cavity. It was developed in 1951 by J.C Slater [4]. The bead-pull measurement system is based on the perturbation theory. If small electric bead or dielectric bead move through the longitudinal axis of the cavity, stored energy changes and this is connected to resonant frequency change. This relation is shown by Eq. 1.

$$\frac{\Delta\omega}{\omega_0} = \frac{\Delta U}{U} = -\frac{\pi r^3}{U} \left[ \epsilon_0 \left( \frac{\epsilon_r - 1}{\epsilon_r + 2} \right) E_0^2 + \mu_0 \left( \frac{\mu_r - 1}{\mu_r + 2} \right) H_0^2 \right] \quad (1)$$

Where  $\omega$  is resonant frequency,  $U$  is the energy stored in the cavity,  $\epsilon$  is the permittivity constant,  $\mu$  is permittivity constant,  $\pi^3$  is bead form factor,  $E$  is electric field,  $H$  is magnetic field.

In our cavity case, we can consider only  $E$  field because  $H$  field is zero on the axis of cavity where the small bead moving. It means that the change in resonant frequency can be seen as electric field change.

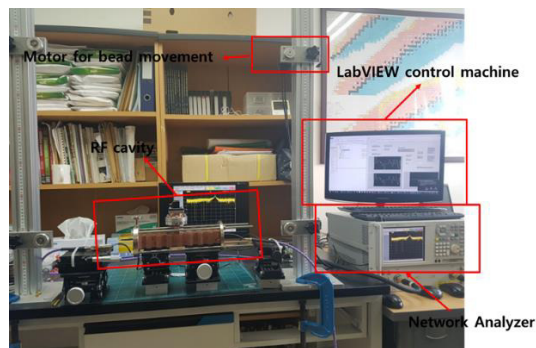


Figure 4: Bead-pull system.

The bead pull system installed at Sungkyunkwan university consists of software and hardware. In the case of software, LABVIEW code was used. The developed LABVIEW code consists of reading field map data, storing data, and processing data. In the case of hardware, supporters, motors, and fishing lines were used. Figure 4 shows our bead-pull system.

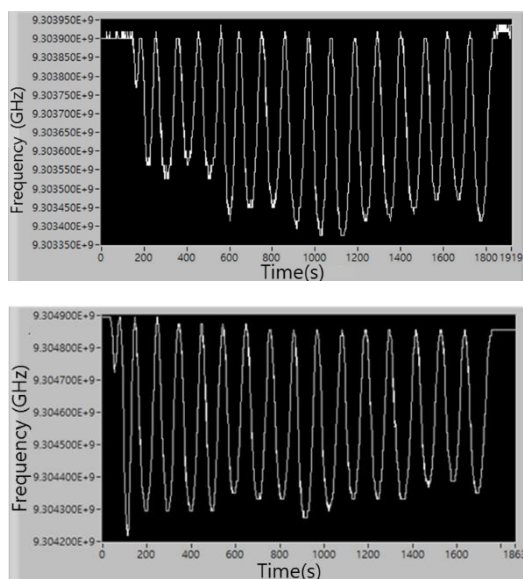


Figure 5: Electric Field Map in Cavities (Initial state(up-per), After Tuning(down))

Figure 5 shows the electric field distribution in cavity. In the initial state of cavity, the difference between the maximum peak and the minimum peak was more than 30%, but after the tuning using the bead pull system, it was less than 9%. Through the data obtained after tuning, we verified through ASTRA simulation code and confirmed that the beam accelerates to 6 MeV.

### CONCLUSION

In this study, electric field distribution measurement and tuning of the fabricated 6 MeV electron accelerator was verified. In each cell measurement and tuning process, various variables (temperature, e-probe depth, surface roughness and so on) were simulated by CST microwave studio

code before application. To measure the electric field distribution and obtain the required field flatness, bead-pull system based on perturbation theory was used.

## REFERENCE

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