# COLD-MODEL TESTS AND FABRICATION STATUS FOR J-PARC ACS

H. Ao[#], H. Akikawa, A. Ueno, K. Hasegawa, Y. Yamazaki, JAERI, Tokai, Ibaraki, 319-1195, Japan

M. Ikegami, S. Noguchi KEK, Tsukuba, Ibaraki, 305-0801, Japan

N. Hayashizaki, TIT, Meguro, Tokyo, 152-8550, Japan

V. Paramonov, INR RAS, Russia

*Abstract*

The J-PARC (Japan Proton Accelerator Research Complex) LINAC will be commissioned with energy of 181-MeV using 50-keV ion source, 3-MeV RFQ, 50-MeV DTL and 181-MeV SDTL (Separated DTL) on September 2006. It is planed to be upgraded by using a 400-MeV ACS (Annular Coupled Structure), which is a high-beta structure most suitable for the J-PARC, in a few years from the commissioning. The first ACS type cavity, which will be used as the first buncher between the SDTL and the ACS, is under fabrication. Detailed design and tuning procedure of ACS cavities has been studied with RF simulation analysis and cold-model measurements. The results of cold-model measurements, fabrication status, and related development items are described in this paper.

## INTRODUCTION

An Annular Coupled Structure (ACS) has been developed for upgrade of a J-PARC linac from 180 MeV to 400 MeV. An operation frequency is 972 MHz.[1]

An ACS-type buncher cavity has been fabricated from Apr.2002. This cavity consists of two 5-cell ACS accelerating cavities and a bridge cavity, which will be installed to a matching section from the SDTL to the ACS as the first cavity of two buncher cavities. It is the first fabrication of an ACS-type cavity for the J-PARC linac. It will be finished at the end of FY2004.

For the study of tuning procedure and RF measurement, we machined some aluminium and OFC intermediate cells that were designed for a periodical symmetry part. RF measurement procedure, tools, and frequency tuning process have been improved with these test cells.

10-cell half-scale aluminum models (beta=0.7114) were also fabricated in FY2003. Intermediate cells and end-cells were tuned for an operating frequency, and then total properties and end-cell effects were measured with this model.

This paper reports a fabrication status and measurement results.

## BUNCHER CAVITY

### *Intermediate Cell*

Trial machining and RF measurement for the buncher cavity has been developed. [2,3,4,5]. The frequency has to be adjusted to an operating one by final machining with RF measurement. Because a cavity design based on a 2D and 3D electromagnetic analysis has some errors, and machining process also has certain errors.

In FY2004, we tried final frequency tuning process and measured a frequency correction factor (amount of cutting versus a frequency shift) for frequency tuning regions.

An accelerating mode and a coupling mode have to be considered for the ACS cavity. In the accelerating cell, outer diameter of the cell has a tuning margin, and in the coupling cell, a ledge part has a tuning margin. Figure 1 shows the tuning parts for each cell and the frequency correction factor.

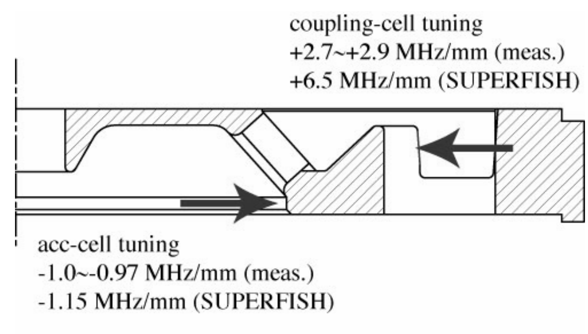


Figure 1: Tuning part and frequency shift.

About the accelerating cell, we consider that expanded volume of an electromagnetic field through a coupling slot makes the frequency shift of the accelerating cell smaller than the SUPERFISH analysis. About the coupling cell, eight vacuum ports cut the tuning ledge part, so that the frequency shift is smaller than the analysis. These results suggest the initial amount of cutting in frequency tuning procedure.

We also added a 5 mm vertical straight at bottom of the ledge part to make it easy for 3D profile measurement after machining.

The test brazing with these cells is planned to confirm a frequency shift before and after brazing.

The cell dimensions of the buncher cavity are almost fixed except for minor corrections required the mechanical restriction. Test cavities for an end-cell and bridge cavity were not fabricated, so that we design and correct dimensions based on a 2D and 3D electromagnetic analysis and the measurement of an half-scale aluminum model.

[#]aohi@linac.tokai.jaeri.go.jp

### *Module Design*

The bridge cavity was located above a drift space between two ACS cavities in a previous ACS module developed in KEK. A quadruple magnet, beam monitors and a vacuum valve are installed in this space of an accelerating ACS module. The bridge cavity of this buncher moved to under a drift space as same as an accelerating ACS module fabricated in the next fiscal year, because of easy access for a magnet, alignment and maintenances. For this change, three frequency tuners have to be installed under the bridge cavity. Detailed arrangement about a bridge cavity, a wave-guide, cooling pipes, vacuum ports and pumps is in progress.

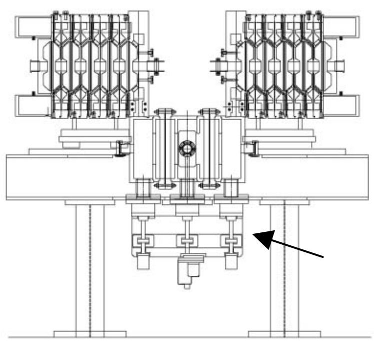

Figure 2: Buncher module (5+5-cell).

Alignment bases are attached on the upper side of ACS cavities. These bases have a common design for J-PARC accelerators; it is convenient to use and design an attachment for surveying instruments. These bases have to be mounted on the cavity after the final brazing, so that it is important to keep or confirm a relative position between the base and the beam-line of the cavity. This assembling procedure is considered with other module designs.

### *ICF Frange*

The two ACS cavities are connected to the bridge cavity with a double edges conflat flange (ICF356) at a coupling cell of the bridge cavity. An inner edge keeps RF-contact and it has four slits for evacuation. This flange made of stainless steel is brazed to a cupper cavity, so that it should be strong for a thermal process. A pair of these flanges was fabricated to test for vacuum leak after the thermal process.

This result showed no vacuum leak and reliable properties. In detail observation, the inner edge looked lean slightly at a slit region, therefore these slits were changed to evacuation holes drilled at inner part of a flange.

## TUNING OF ALUMINUM MODEL

### *High-Beta Aluminium Model*

From the last of FY2003, we fabricated the 10-cell aluminium model of the ACS cavity for a high-beta region (beta = 0.7114). This model is half scale of 972 MHz ACS cavities, thus an operating frequency is 1944 MHz. The purposes of this model are check of an RF design and confirmation of tuning procedure for the buncher fabrication. RF tuning, measurement and related equipment design are not easy on a paper simulation, so that we plan and improve these procedure based on these results.

### *Tuning of Intermediate Cells*

Accelerating and coupling mode frequencies of the intermediate cell are measured with short plates for each boundary condition. The coupling cell has second nearest coupling through vacuum ports, therefore the coupling mode frequency was measured in various cells from one to four. The frequency at infinity cell was estimated with the fitting curve of the measurement data.

The two accelerating cells (four half cells) were tuned, and then finial dimensions for other cells were fixed considering a correction based on 3D profile measurement results for a sensitive region such as a radius of nose cone and an accelerating gap length.

About a coupling cell, we planed that six cells (12 half cells) were tuned. Correction machining around an outer diameter in the coupling cell caused a slight deformation of an RF contact plane. Thus, the contact plane lost flatness. The measured frequency depends on a stacking torque strongly. As a result, repeatability of RF measurement could not be kept.

This deformation could be observed only scanning with a micron-order dial gauge on a NC lathe. At first, 3D profile measurement showed no deformations, because a probe could not pick up the small deformation. However, this problem solved with a careful check of a contact plane after machining and re-polish to keep flatness if needed.

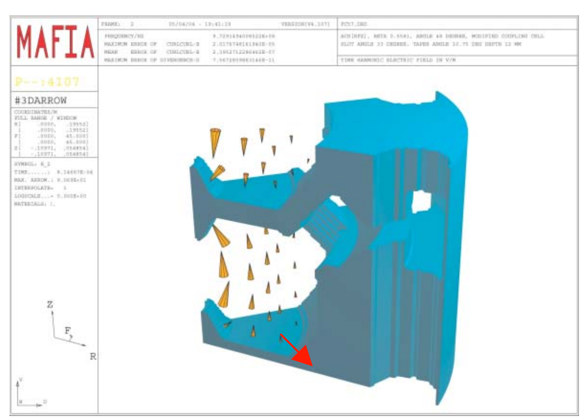


Figure 3: End cell tuning.

### *Tuning of End-Cells*

The frequency of an end accelerating cell is higher than intermediate one if it keeps the same dimensions of the intermediate cell, because the cell do not have a slot. Frequency was adjusted by extending a volume of an accelerating cell. The example of analysis by a MAFIA is shown in Fig. 3. The gap length and nose cone dimensions were not changed. In this analysis, only the frequency was tuned. A measurement of an electric field distribution with these models is prepared using these models.

### *Multi-Cell Measurement*

The dispersion curve of the accelerating cells and the coupling cells were measured up to 9-cell in a factory after frequency tuning. Figure 4 and 5 show the dispersion measurement result at a 9-cell and a 3-cell set up respectively.

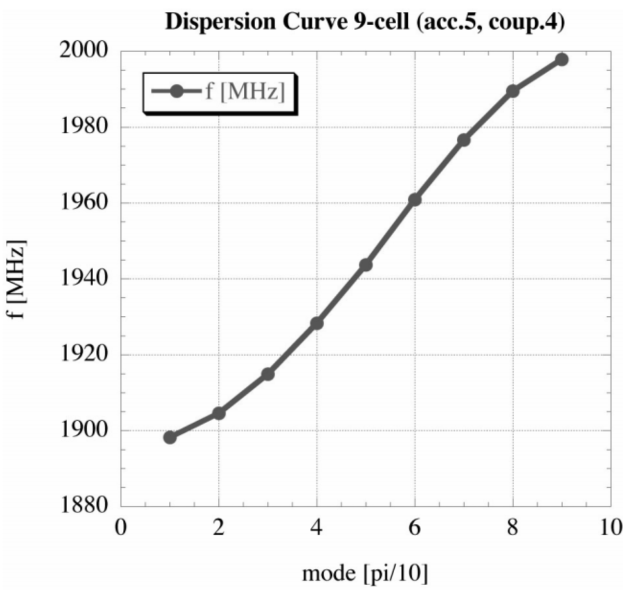


Figure 4: Dispersion curve of 9-cell.

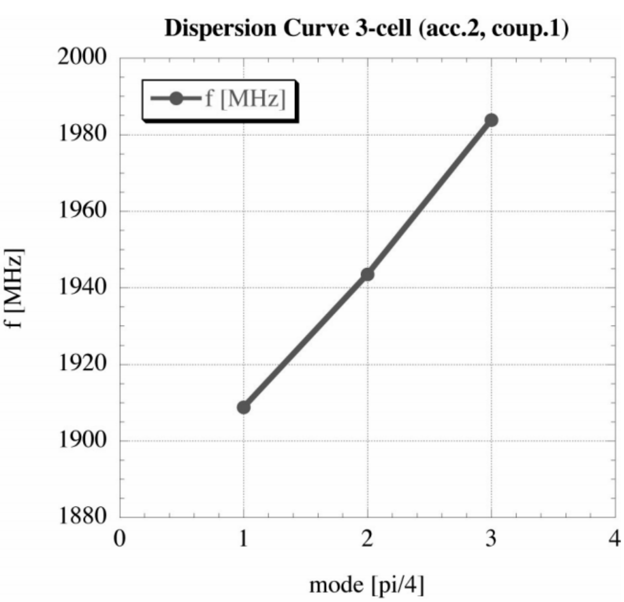


Figure 5: Dispersion curve of 3-cell.

The result of 3-cell measurement shows that the frequency of the coupling mode is slightly higher than accelerating one. This is because that a coupling cell has electric (short) conditions at both end sides in a 3-cell set up, and it was not equal to periodic (magnetic) boundary conditions. Only the both end coupling cell were not periodic conditions in 9-cell measurement. Although the frequency has been adjusted to the range of about 1944$\pm$1MHz as the intermediate cell, the boundary conditions of an end cell, which has an irregular boundary, has not been compensated correctly. Therefore, the coupling mode frequency of the 9-cell measurement is averaged as whole cells.

On the process of coupling cell tuning, the end cell of the coupling cell was not distinguished clearly and adjusted. We are going to correct the frequency of the end cell to optimize a total frequency. The effect of boundary conditions for the each end coupling cells will be tuned correctly for the buncher cavity.

## SUMMARY

The studies required for the fabrication of the buncher cavity, especially about the intermediate cell, have been performed for a long time. Consequently, the development of adjustment machining for the frequency tuning has been finished with the trial fabrication of real scale cells.

The end cell design and tuning process were confirmed based on measurement of the half scale aluminum model. These results will be reflected in the buncher design.

However, about the tuning procedure of the bridge cavity and vacuum properties are not discussed in this paper. Although these designs have been finished partly, we have still many items to be studied. These items have to be followed up in the process of buncher cavity fabrication. The high power test used this buncher module is planed for a next step.

## REFERENCES

[1] V. V. Paromonov, "The Annular Coupled Structure Optimization for JAERI/KEK Joint Project for High Intensity Proton Accelerators", KEK Report 2001-14(2001)

[2] H. Ao et al. "R&D Status of the Annular Coupled Structure Linac for the JAERI/KEK Joint Project", Proc. of the 2002 Linac Conf., August 2002

[3] N. Hayashizaki et al. "Power-Handring Capability of the Annuler Coupled Structure Linac for the JAERI/KEK Joint Project", Proc. of the 2002 Linac Conf., August 2002

[4] N. Hayashizaki et al. "Structure Design of the Annuler Coupled Structure Linac for the JAERI/KEK Joint Project", Proc. of the 2002 Linac Conf., August 2002

[5] H. Ao et al. "Cold-model Tests of an Annular Coupled Structure for upgrade of a J-PARC Linac", Proc. of the 2003 Particle Accelerator Conf., May 2003