# CAVITY DIAGNOSTIC SYSTEM FOR THE VERTICAL TEST OF THE STF BASELINE 9-CELL CAVITY AT KEK

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*Abstract*

The four 1.3GHz 9-cell superconducting cavities (BL1-4) were fabricated, surface-processed and measured for STF Phase-1.0 from 2005 to 2007. During these measurements, the simple T-mapping and x-ray monitor system were introduced and gradually improved. Eventually, all the cavities had the heating spot around the equator of the cell. It was successful to detect the heating using the system, although the number of the carbon resistor is only 44. It is conceivable that the quality of the electron beam welding was somewhat poor as the cause of the heating, when the dumbbells were connected.

The new vertical test facility is completed in KEK-STF in June/2008. The first measurement will be done at the beginning of July in 2008. The new T-mapping and DAQ system will be introduced for it instead of the previous one. The number of the carbon resistor will be increased to about several hundred channels in the future.

The new optical inspection system by Kyoto University/KEK was also introduced into STF. The new T-mapping system and the new optical inspection system will be the strong tools in the new vertical test facility.

## INTRODUCTION

Four 9-cell cavities for STF (Superconducting rf Test Facility) Phase-1.0 were designed and fabricated [1, 2] from 2005 to 2007 (Figure 1). During the vertical tests, the simple T-mapping and x-ray monitoring system were introduced to detect the heating spot around the equator of the cell and the field emission. It was successful to detect the heating for all the cavities using this system. This result was also consistent with that obtained by measuring the seven pass-band modes from 3π/9 to π mode. Although the only one cavity (BL2) achieved 29.4MV/m, the other cavities did around 20MV/m. From the results of the T-mapping data, it is conceivable that the quality of the electron beam welding was somewhat poor, when the dumbbells were connected. On the other hand, the PIN diodes on the beam axis were sensitive to the field emission.

The new optical inspection system [3] was recently introduced to search the cause of the heating in KEK-STF from Kyoto University. This is the very useful tool and it is crucial for the evaluation of the cavity performance to check the correlation between the heating spot and the doubtful location.

Using the optical inspection system, it takes about two days to survey every region of the cavity inside. It is necessary to shorten the survey time for a large number of the cavities. Typically, it takes only a few minutes to search a doubtful location in the region of 25mm x 25mm. Therefore, it is necessary to increase the number of the carbon resistor from 44 to several hundred. When the new vertical test facility is completed, the new T-mapping and x-ray monitoring system is also introduced.

The new two cavities (BL5&6) [4] were completed on April/2008 for STF Phase-1.5 or S1-Global, whose way of the electron beam welding was carefully chosen and greatly improved. AES#001 cavity was sent for the system check of the new EP facility and the new vertical test facility in STF from FNAL. The three ACCEL cavities (AC71, AC74, AC80) were sent for S0 plan related to ILC (International Linear Collider) from DESY. These cavities will be measured using the new T-mapping system and the new DAQ system. It is found that AES#001 cavity had the heating in one cell through a series of vertical tests in U.S. A few doubtful spots were found by the optical inspection system in Kyoto University. It is interesting to observe the heating or these spots through a few vertical tests and one EP treatment in KEK-STF.

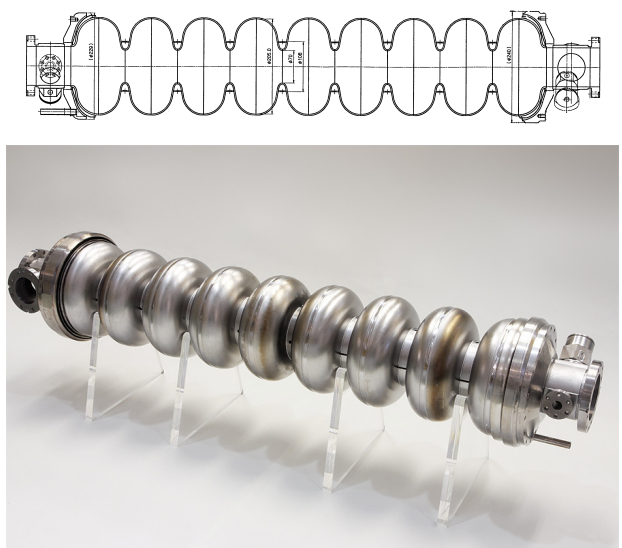

Figure 1: The STF Baseline 9-cell Cavity.

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## PREVIOUS SYSTEM & RESULTS

In the previous system, the four carbon resistors (Allen-Bradley, 51 Ω) and PIN diodes (HAMAMATSU, S1223-01) at each cell were attached every 90˚. An additional resistor was attached at cell #1, 2, 8 and 9 (cell #1 on the side of the input coupler). They were fixed at one point. The DAQ system is composed of the two PCs and two data loggers [5]. Although the sampling time was originally 200msec, it was changed to 100msec later. The faster sampling time is crucial to detect the heating spot, because the appearance of the heating spot on the equator was coincident with the quench of the cavity and disappeared within 1sec after the quench.

Figure 2 shows the examples of the results obtained by the previous system. The left figure shows the example of the heating data and the right one shows the x-ray emission. The blue line shows the accelerating field. Δ T means the temperature difference between the liquid helium and the heating spot. From the left figure, it is found that the heating and the cavity quench occurs at the same time. The green dotted plot in the right one shows the correlation between the accelerating field and the x-ray output level. The feature is the exponential growth characteristic of the field emission.

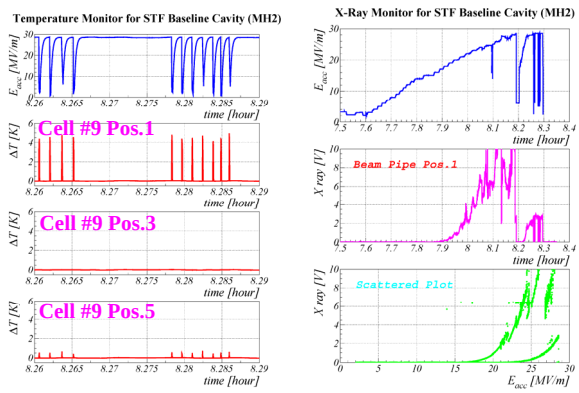


Figure 2: The example of the observation by the T-mapping and x-ray monitoring.

Not measured or Unknown

| Exp # | Year | Date | Cavity | $E^{\star}_{acc,max}$ [MV/m] | Limiting Cell | Radiation Level [mSv/h] † |
|---|---|---|---|---|---|---|
| 1 | 2006 | 25/Feb | BL1 | 19.1 | | >100 |
| 2 | | 26~27/Apr | BL2 | 14.2 | | 0 |
| 3 | | 25~26/May | BL1 | 19.3 | | 3 |
| 4 | | 8~9/Jun | BL3 | 20.3 | | 0.8 |
| 5 | | 22~23/Jun | BL2 | 21.5 | | 0.3 |
| 6 | | 6~7/Jul | BL1 | 19.3 | | >100 |
| 7 | | 24~25/Aug | BL4 | 17.1 | Cell #4 | 2.5 |
| 8 | | 21~22/Sep | BL3 | 20.5 | Cell #5 | 1.4 |
| 9 | | 12~13/Oct | BL2 | 19.3 | | 26 |
| 10 | | 7~8/Dec | BL4 | 17.1 | Cell #4 | 11 |
| 11 | | 21~22/Dec | BL1 | 20.8 | Cell #3 | >100 |
| 12 | 2007 | 18~19/Jan | BL2 | 20.6 | Cell #2 | 14 |
| 13 | | 31/Jan~1/Feb | BL4 | 20.2 | Cell #1 | 0.4 |
| 14 | | 22~23/Feb | BL2 | 29.4 | Cell #9 | 1.9 |

★ $E_{acc,max}$ is the value in the final state of the vertical test.
† The radiation level is measured on the top flange of the cryostat.

Figure 3: The summary of the previous measurements.

Figure 3 shows the summary of the results obtained by the previous system [6]. It was perfectly successful to detect the heating using it in the last five measurements, although the number of the carbon resistor is only 44.

## NEW VERTICAL TEST FACILITY & NEW T-MAPPING SYSTEM

The new vertical test facility for ILC and ERL (Energy Recovery Linac) was completed in KEK-STF on June/2008 (Figure 4). There are two holes for the two cryostats in the pit, the iron shield for the radiation which is automatically moved, the pumping system composed of 2 rotary pumps and 1 mechanical booster pump with the high exhaust velocity, the clean booth for the assembly of the T-mapping system, the control room and the four cavity stands. The 400W high-power amplifier is used for the RF measurement. The DAQ system for the RF measurement is based on the LabVIEW using GPIB network.

Figure 4: The new vertical test facility in STF.

The new T-mapping and x-ray monitor system is shown in Figure 5. It is called “Fish-Bone” structure [7]. Although the number of the carbon resistors is only 48 now, it will be attained several hundred channels in the future. The PIN diodes are attached to the top and bottom flanges for the observation of the field emission, and near the stiffening ring.

The new DAQ system for the new T-mapping is also introduced at the same time. The DAQ system is composed of PXI-4071 (Digital multiplexer), PXI-2501 for the T-mapping and PXI-6225 for the x-ray monitoring made by National Instruments. The sampling rate for PXI-2501 is about 10Hz, which is sufficiently fast to observe the heating during the RF measurement. On the other hand, that for PXI-6225 is several 10Hz, whose rate is faster. Therefore, the data averaging will be used in the future to lower the noise effect for the x-ray monitoring.

Because the DAQ program for the T-mapping and the x-ray monitoring is also based on LabVIEW, the RF measurement and the T-mapping system will be merged into the common program in the future. This new system was normally operated in the bench test.

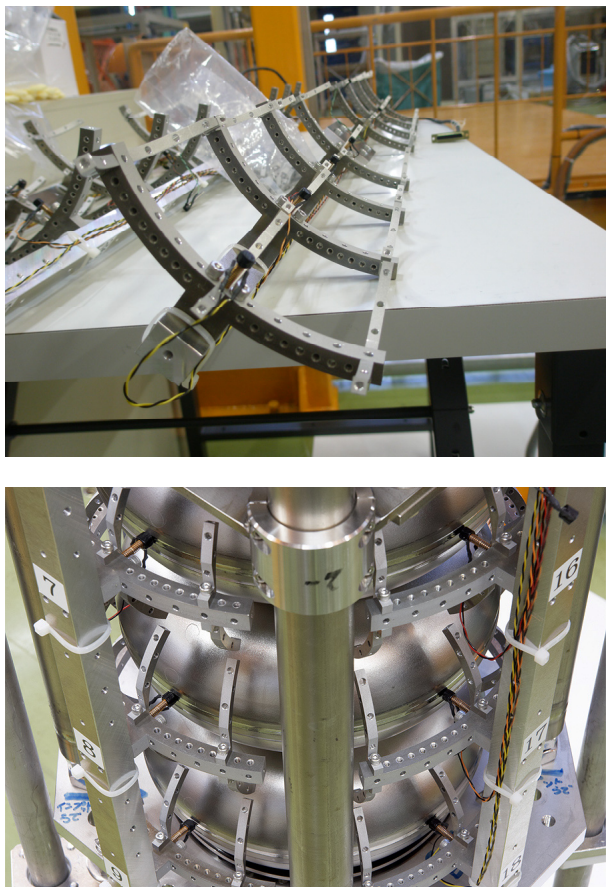

Figure 5: The new T-mapping and x-ray monitor system.

The first vertical test will be done at the beginning of July/2008 and the new T-mapping system with 48 carbon resistors will be used as the pilot measurement. It is necessary to carry out the system check including the helium transfer line, the pumping system, the RF measurement with the 400W high power amplifier, the DAQ system and etc in the first vertical test. After that, the system will be modified or improved, and the number of the carbon resistor will be gradually increased.

## SUMMARY & FUTURE PLAN

The previous T-mapping system worked very well during the vertical tests from 2006 to 2007. Although a small number of the carbon resistors are used, it was successful to observe the heating for every cavity.

The new vertical test facility is completed in STF and the new T-mapping system is also introduced. The first vertical test in STF will be done at the beginning of July/2008 to check the system control. It is necessary to investigate the inside of the cavity using the new optical inspection system, if the heating is detected.

The new T-mapping system and the new optical inspection system will become the standard and strong tools for S0 plan in KEK-STF. The sequential process including the cavity surface treatment, the optical inspection, and the vertical test will be completed within one year in KEK-STF.

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