Electrical center measurement before and after the cavity tuning

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Abstract

We did “antenna measurement” of the prototype cavity BPMs fabricated in PAL. It is the measurement of the electrical center offset from the mechanical center by scanning the cavity with an antenna. The offset was measured to be smaller than 10 μm for all three models we tested, and no difference was observed after the cavity tuning. The outer surface of the BPM can be used as a good reference of the electrical center.

1 Introduction

The electrical center of the cavity BPM must be placed in the vicinity of the field center of quadrupole magnets. In the comissioning of ATF2 beam line, beam orbit will be adjusted so as to coincide with the field center of magnets. If the electrical center of the BPM has an offset with respect to the field center of the magnet, position signal remains even with the nominal orbit. The remained signal level must be well small compared with the saturation limit of the detection electronics otherwise it reduces the measurable range of the BPM.

When it is attached on the magnet in the construction period, we will use the outer surface of the BPM as a reference assuming that the mechanical center coincides with the electrical center. We should check this assumption beforehand.

The measurable range of the electronics is expected to be about ± 250 μm. Hopefully, the difference of the electrical center and the nominal orbit is better than 20% of the full range. The accuracy of the initial alignment in attaching the BPM on magnet is expected to be about ± 50 μm. The offset of the electrical center from the mechanical center should be better than this. Here we require it to be better than ± 20 μm.

It is not possible to directly measure the production model because it has a long beam pipe tube in the end, which makes it impossible to precisely scan the cavity with an antenna. We have to evaluate the possible amount of electric center shift from the experience of prototype models.

There are three prototype cavity BPMs in KEK at this moment. Although there is a minor difference in the three models, basically they were fabricated in the same way as the production model. The difference in the three models are in the dents placed on the cavity rim. We call them as; dents model (s/n=3), no dents model (s/n=4), and deep dents model (s/n=2). The cavity has tuners on the wall to tune xy-isolation and frequency. It should be checked if the electric center moves after the tuning.

2 Setup and Measurement

The device to measure the electrical center is shown in Figure 1 (The detail will be described in Y.Inoue's thesis). The BPM was mounted on a rotation mover in the base. An antenna was inserted in the cavity from the beam pipe. A network analyzer measured the transmittance of rf from the antenna to one of the ports of the BPM. The positions of the antenna and the cavity were monitored by laser displacement sensors. By scanning the antenna in transverse direction, we obtained the field map of the dipole mode, which told us the electrical center.

In order to extract the difference between the mechanical and electrical center without being affected by an angle error of the antenna, the measurement was repeated twice rotating the BPM in 180 degree using the rotation mover. A half of the difference of the electrical center position of the two measurements is the mechanical-electrical center offset.

It had been known that our device had some systematic error depending on the direction of the BPM mounting. To estimate/cancel the systematic effect, we tried flipped setup, mounting the BPM on the device in 180-degree rotated direction than the nominal setup.

The setups we measured in the experiment are illustrated in Figure 2. If we assume the measurements of port A,C or port B,D are the same, we did 4 measurements of the offset in one direction (changing port and setup). We did the measurement before and after the cavity tuning of each model.

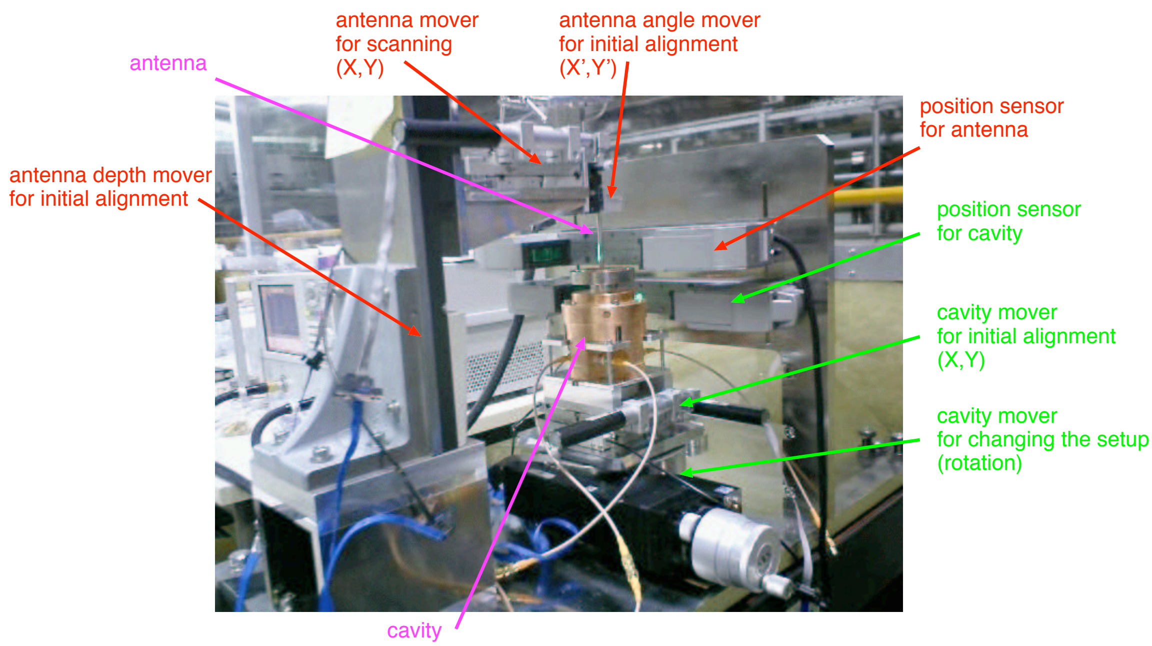

Figure 1: Antenna measurement device.

3 Result

The results of 4 measurements were averaged. The error in the measurements was estimated from the fluctuation of the results. Figure 3∼8 shows the results of 8 measurements (4 data each before and after the tuning) for the three models and two directions. The average and its error are also shown in the figures. Typical error in the average is about 4 μm, we can measure the offset in this accuracy.

All results sit within 10 μm, and no difference seen between before and after the tuning. The results are summarized in Table 1 with the results of frequency and xy-isolation. After the tuning, we succeeded in improving the xy-isolation to be better than -50 dB in all three models. The resonant frequency was not changed (less than 100 kHz) by the tuning.

4 Conclusion

The offset of the electrical center from the mechanical center was measured to be less than 10 μm for all three test models, which satisfies the requirement. It was not affected by the cavity tuning. We will be able to use the outer surface when attaching the BPM on magnets in the construction.

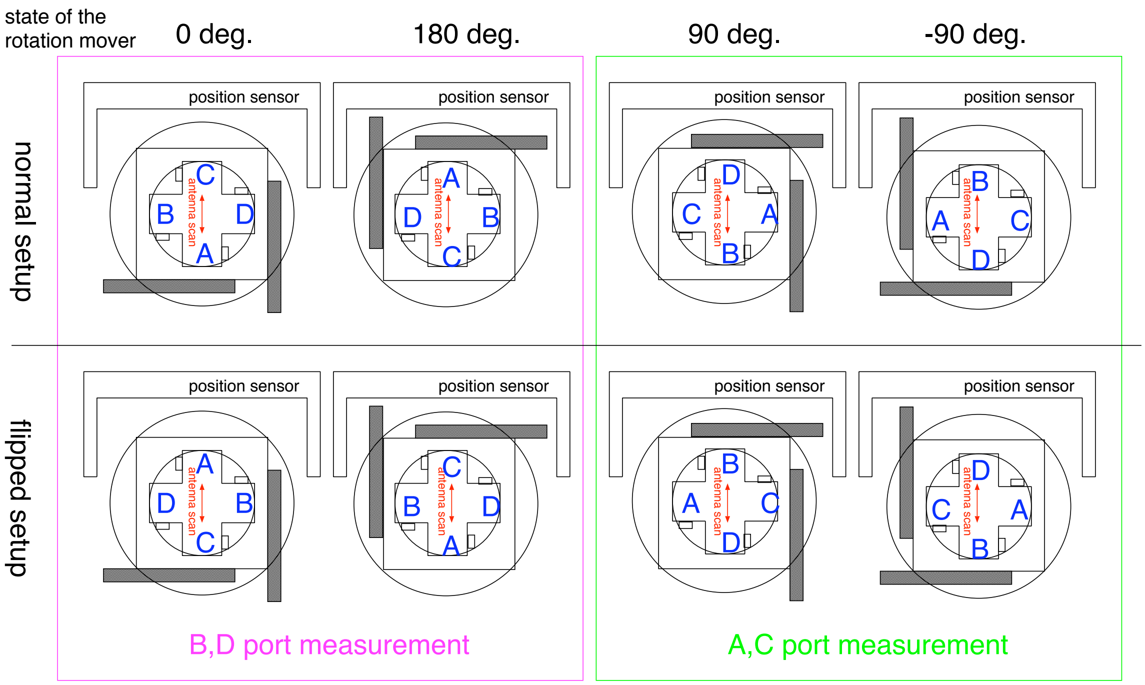

Figure 2: Setup of the cavity on the antenna measurement device.

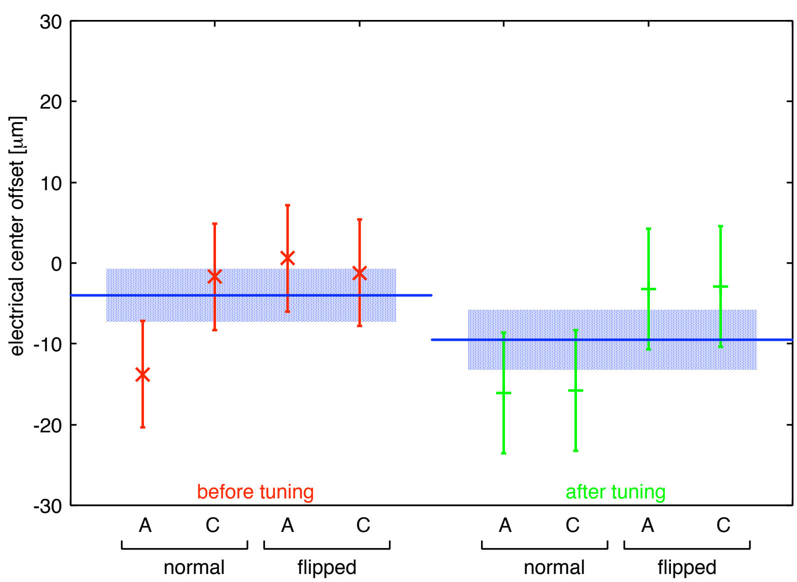

Figure 3: dents model (s/n=3), A and C port

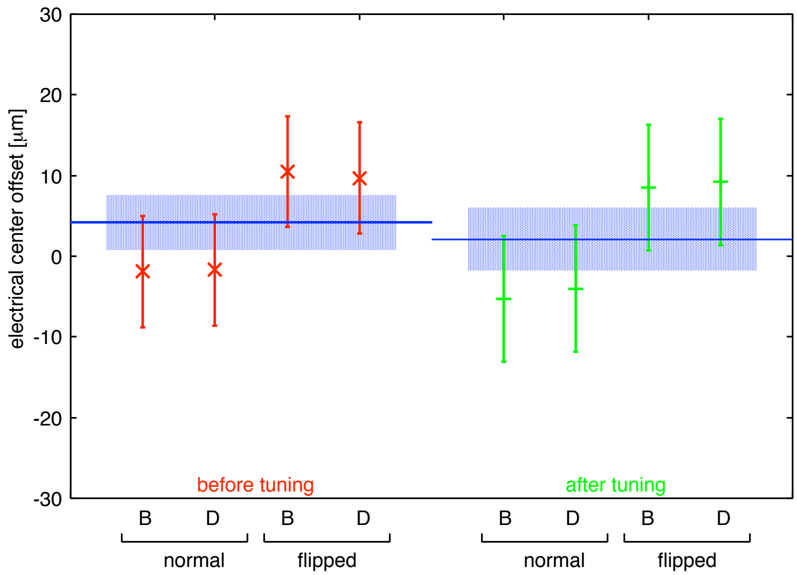

Figure 4: dents model (s/n=3), B and D port

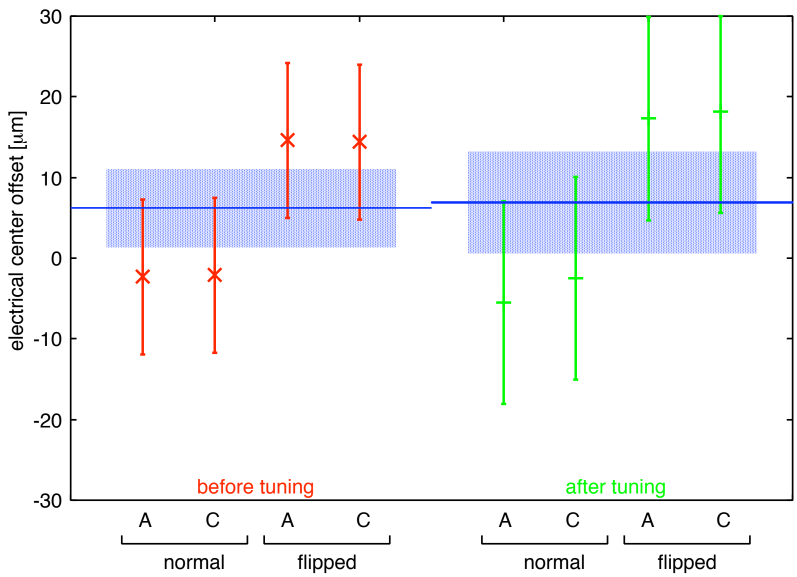

Figure 5: no dents model (s/n=4), A and C port

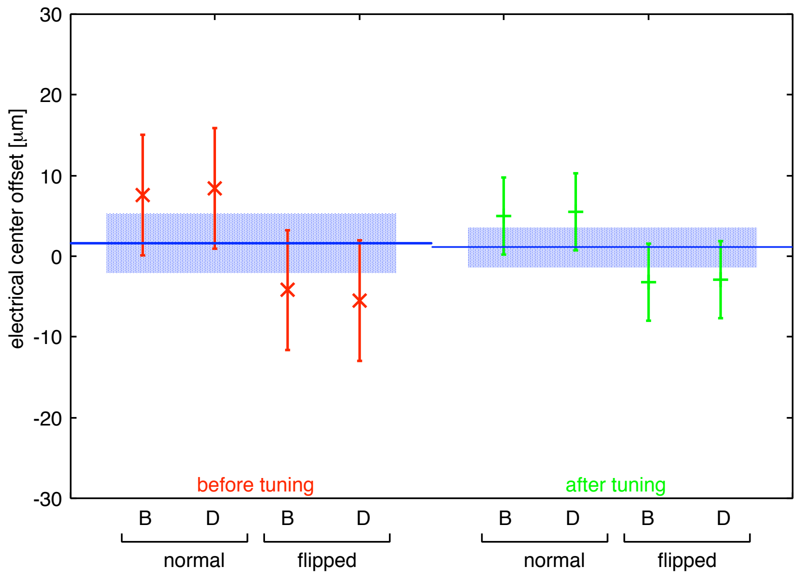

Figure 6: no dents model(s/n=4), B and D port

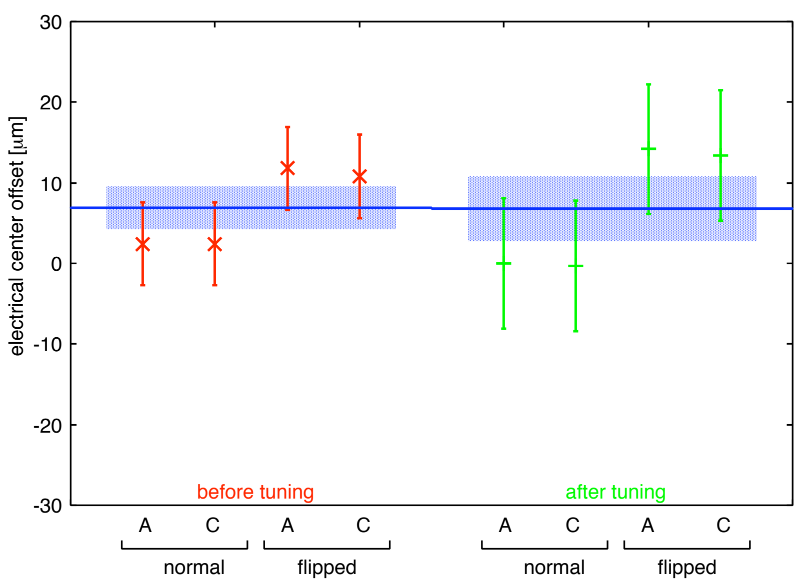

Figure 7: deep dents model(s/n=2), A and C port

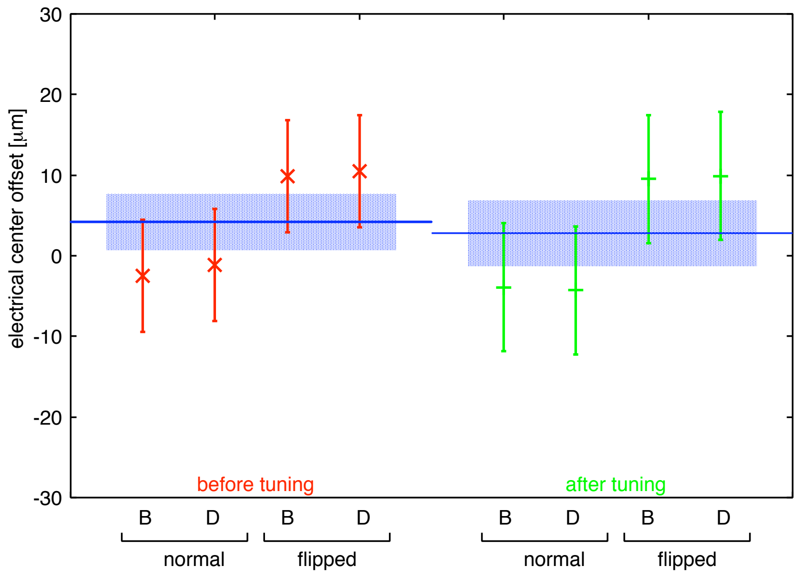

Figure 8: deep dents model (s/n=2), B and D port

Table 1: Summary of the result

s/n	prototype model		before brazing	after brazing	after tuning
3	dents (at PAL)	freq. A-C (GHz)	6.418	6.42051	
		freq. B-D (GHz)	6.417	6.41978	
		x-y isolation	-23 dB	-19.7 dB	
		e-center A,C (μm)			
		e-center B,D (μm)			
1	dents	freq. A-C (GHz)	6.41778	6.42024	6.42035
		freq. B-D (GHz)	6.41707	6.41952	6.41965
		x-y isolation	-46.1 dB	-21.3 dB	-50.8 dB
		e-center A,C (μm)		-4.0±3.3	-9.5±3.7
		e-center B,D (μm)		4.2±3.4	2.1±3.9
4	no dents	freq. A-C (GHz)	6.41771	6.42078	6.42067
		freq. B-D (GHz)	6.41766	6.42066	6.42058
		x-y isolation	-19.0 dB	-28.7 dB	-53.2 dB
		e-center A,C (μm)		6.2±4.8	6.9±6.3
		e-center B,D (μm)		1.6±3.7	1.1±2.4
2	deep dents	freq. A-C (GHz)	6.41720	6.41908	6.41915
		freq. B-D (GHz)	6.41430	6.41631	6.41630
		x-y isolation	-27.8 dB	-30.7 dB	-55.8 dB
		e-center A,C (μm)		6.9±2.6	6.8±4.0
		e-center B,D (μm)		4.2±3.5	2.8±4.0