Beam test of prototype BPM after tuning

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Abstract

We did a beam test of the second model of ATF2 prototype cavity BPM. Before the installation, we did xy-isolation tuning of the cavity with tuners placed on the rim. The isolation of the two dipole modes was improved to be better than -50 dB, according to the network analyzer measurement. We checked sensitivity to the beam position (both 2-port and 1-port readout setups), and xy-isolation with a real beam. It was confirmed that xy-isolation was better than -40 dB.

1 Introduction

We have installed another type of ATF2 prototype cavity BPM, so-called "without-dents model", in the extraction line. This model does not have a designed frequency difference in the two dipole modes.

The cavity has tuners on the rim in order to adjust the frequency and the mode axis. Before the installation, we did tuning to improve x-y isolation (this time we did not try to adjust the resonant frequency). The tuners were pushed/pulled to minimize the transmission to transverse ports. According to the network analyzer measurement, we have succeeded in realizing -50dB x-y isolation.

We did some basic test with a simple detection electronics.

The goals of this beam test were;

- Sensitivity test. Check the output RF power v.s. beam position.
- Check the phase relation of two output ports. Does combiner gain the sensitivity?
- Check the x-y isolation by a beam. Set a large beam offset in one direction and check the leakage in the other direction port.

2 Setup

The detection electronics for the sensitivity test is shown in Figure 1. Signals of the opposite ports were combined with an anti-phase hybrid. The output of diodes were measured by an oscillo scope. The overall gain of the detection system was calibrated with a cw oscillator. Figure 2 is the calibration curve showing the diode's output voltage v.s. the actual power at the output of the cavity.

3 Result

3.1 Sensitivity and combiner test

The beam orbit was changed using a steering magnet in the extraction line, ZV7X for y-direction and ZH4X for x-direction. The beam orbit near the cavity BPM was monitored by the nearest strip-line BPMs, ML11X (upstream) and ML12X (downstream). The actual beam position at the cavity BPM was calculated by an interporation. The beam intensity was monitored by an ICT at the end of the beam line. The typical beam intensity in this measurement was 0.8×10^{10} e/bunch.

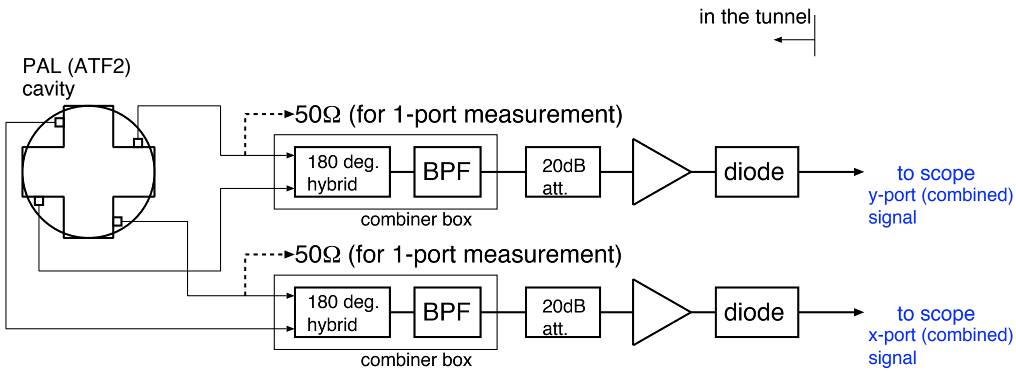

Figure 1: Detection electronics for the sensitivity measurement.

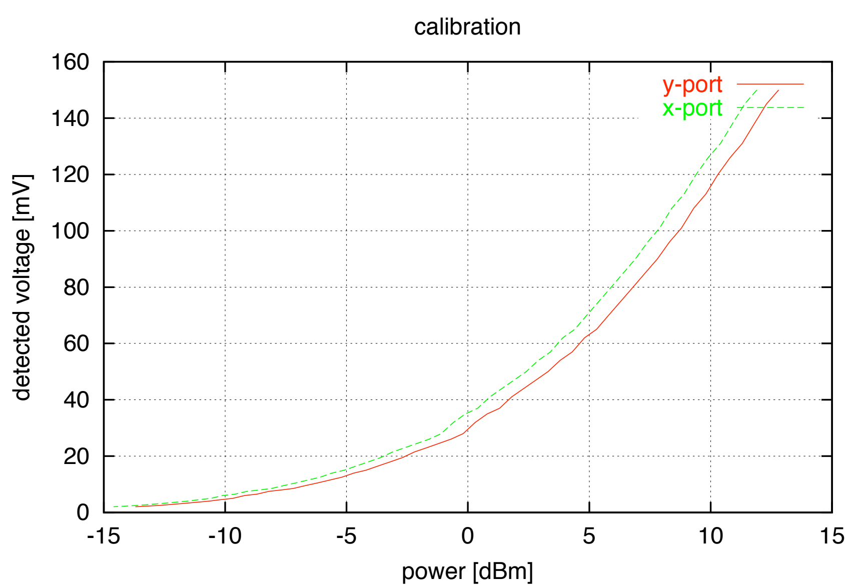

Figure 2: Calibration data for the detection electronics.

Before starting the scanning, beam position in the other direction was adjusted to the center of the cavity BPM by minimizing the output of the port. The peak voltage seen in the scope display was measured as a function of the beam position. The data was then converted to the actual voltage at the output of the BPM using the calibration curve given in Figure 2. After normalizing the data to the beam intensity of 10^{10} e/bunch case, we plot the output voltage v.s. beam position in Figure 3 and Figure 4.

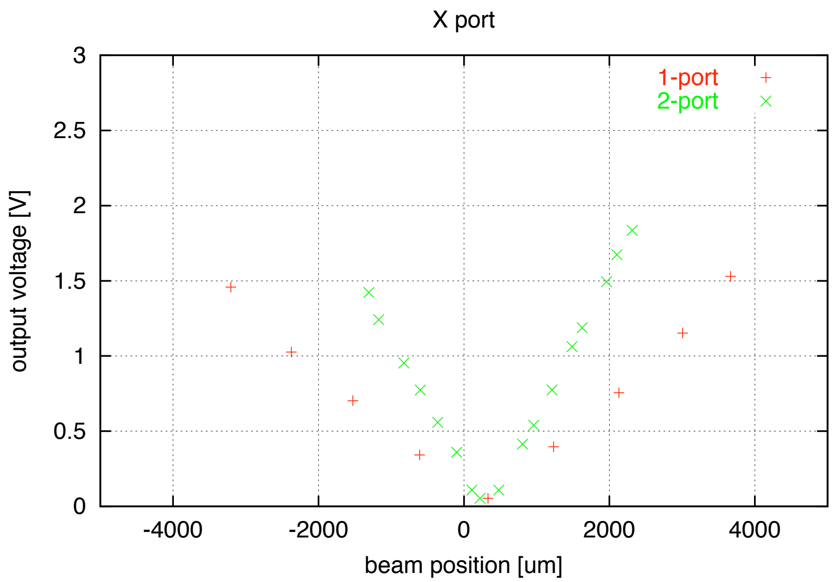

Figure 3: Sensitivity of the BPM (X-port)

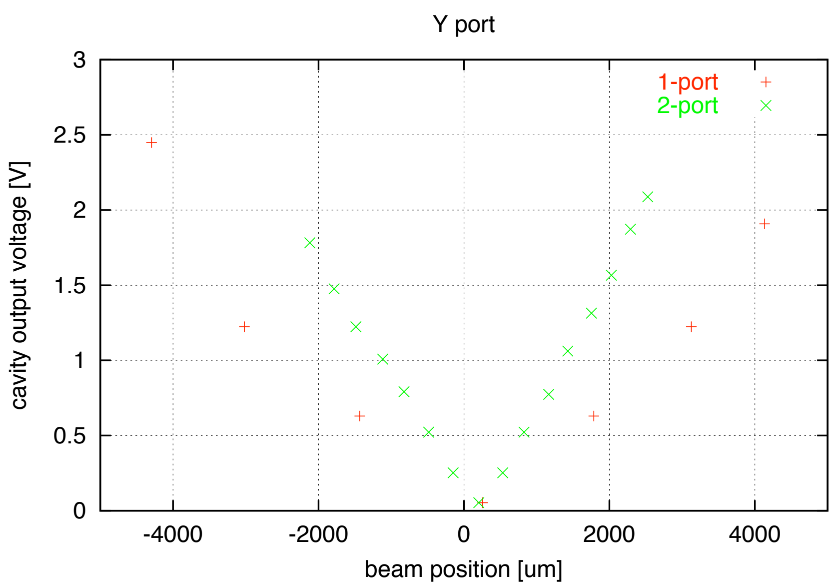

Figure 4: Sensitivity of the BPM (Y-port)

To check if the combiner gains the sensitivity, the measurement was repeated with 1-port readout scheme. In this case, one of the ports was disconnected from the hybrid and terminated by a 50Ω load. The results of 1-port readout case are also shown in Figure 3 and Figure 4.

The calculated sensitivity for 2-port case is 0.8 Volt/mm at 10^{10} e/bunch and with 8 mm bunch length. The experimental result seems consistent with this.

The signal sensitivity gained with the anti-phase combiner. It means that the phase relation between the opposite ports was anti-phase as expected.

3.2 X-Y cross talk measurement

In order to check the cross-talk between the dipole modes in the cavity, we observed y-port signal while setting a large beam offset in x-direction. To be able to see a small amount of leakage, the attenuator in the detection system of y-port was removed. X-port was set to be a 1-port readout scheme in this measurement. Overall, X-port was 23 dB less sensitive than Y-port. The setup of the electronics is shown in Figure 5.

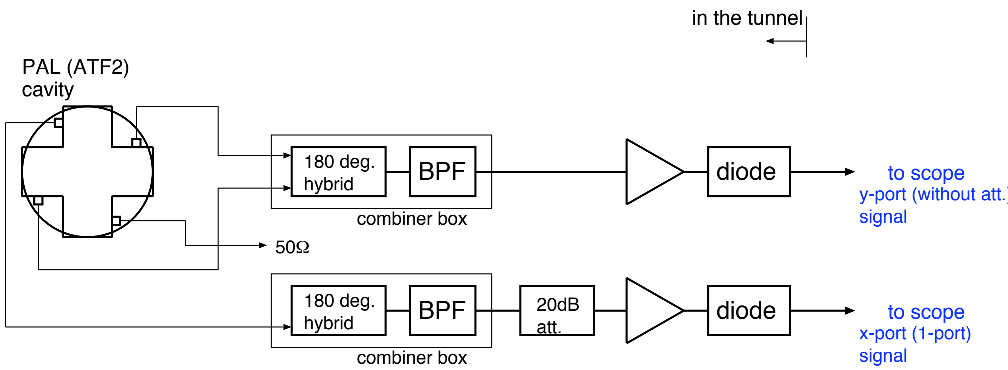

Figure 5: Setup for XY-isolation measurement

First, we did a sensitivity measurement of y-port with this electronics. Figure 6 shows output voltage on the scope v.s. beam position. Roughly speaking, 10 mV corresponds to 50μm beam offset signal.

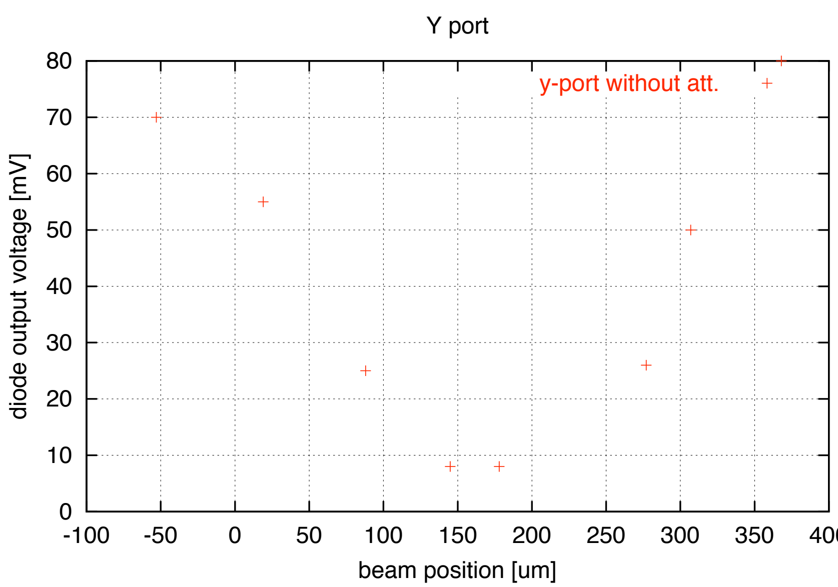

Figure 6: Sensitivity of the BPM (Y-port, without attenuator)

Then, we changed the beam orbit in x-direction in a large step (about in 2.5 mm steps). The behavior of the signal in the scan is shown in Figure 7. Note that X-port is 23 dB (factor 14) larger than it looks because of the electronics setup.

The signal in y-port was smaller than 10 mV, which corresponds to 50 μm, even in the case beam had 5 mm offset in x-direction. We can conclude that xy-isolation$< 20\log\frac{50\mu m}{5mm}$ = -40 dB.

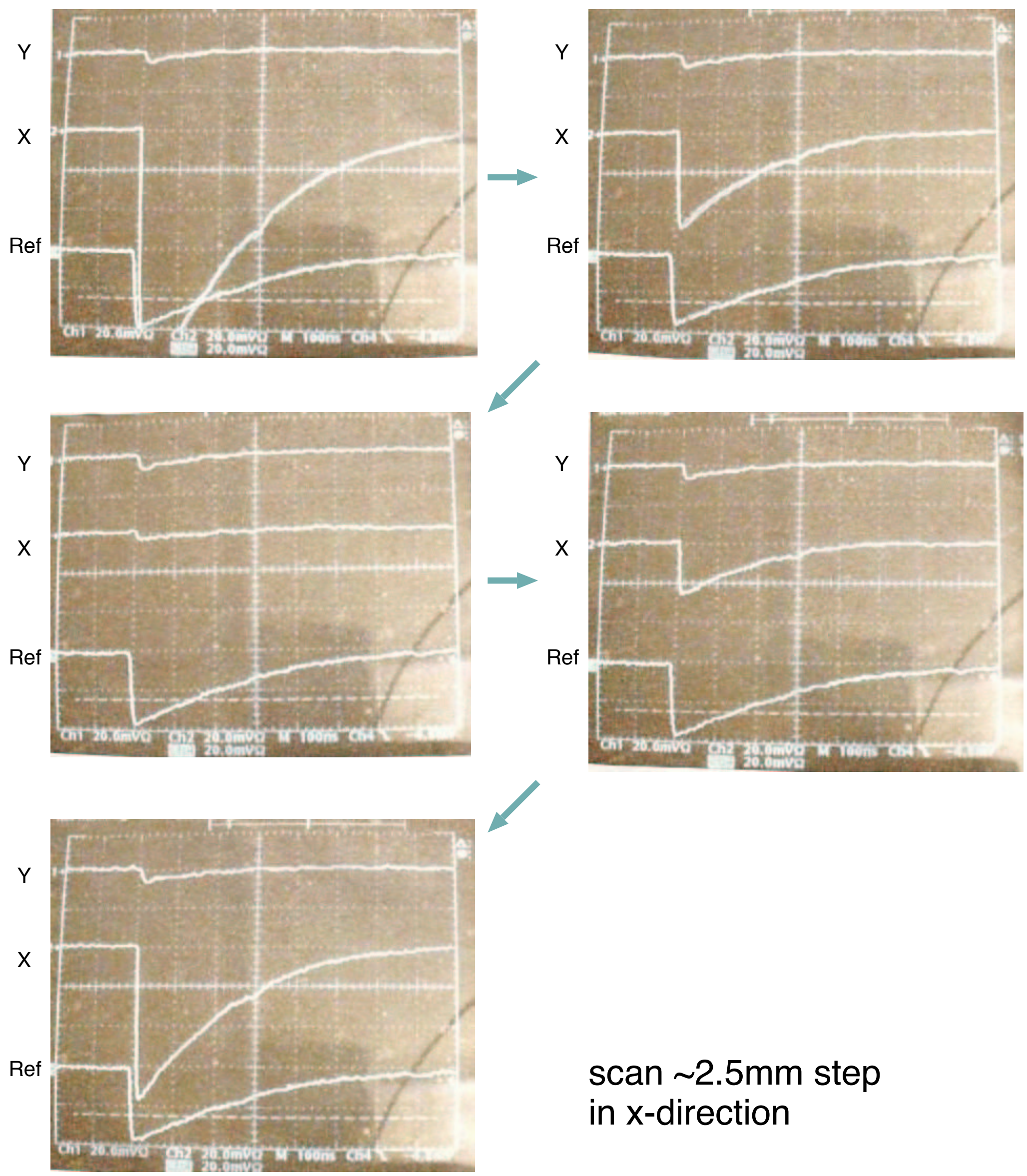

Figure 7: Result of XY-isolation measurement. Scan the beam in x-direction. X-port signal is 23dB attenuated compared with Y-port, because of the 20dB attenuator and 1-port readout.

4 Summary

Sensitivity of combined readout was measured to be consistent with the calculation. The signal of the opposite ports was anti-phase as expected. XY-isolation was proved to be better than -40 dB.