Summary of the first experimental tests of the cavity of the IP-BPM

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Abstract

The Cavity of the IP-BPM was installed at the LINAC end of the ATF facility. Two shifts were dedicated to IP-BPM. The first one allowed to compare the sensitivity of the cavity with the previous ATF2 cavity BPM (QBPM). The expected sensitivities for X and Y are respectively 2 times and 4 times larger than those of the ATF2 QBPM. The shift proved that the sensitivity in X was the same than the ATF2 QBPM and twice better in Y. The second shift was dedicated to see the presence of unwanted modes in the answer of the cavity. It showed a little presence of them but this was mainly removed by a bandpass filter (BPF) and a combiner.

1 Introduction

1.1 Presentation

The IP-BPM is a beam position monitor (BPM) intended to measure an electron beam's position with a nanometric precision. It consists of a rectangular cavity and low noise electronics. A first cavity has been built and tested at the ATF facility in KEK during two shifts. The first one was dedicated to a measurement of the sensitivity of the cavity and the second one consisted in a study of the pulse's shape. *Important note* : This article must be read with at least the figures of [1] and [2] which present in more details the setup and results of the two shifts.

1.2 Setup and Tuning

As one can see on the picture after, the IP-BPM was put inside a vacuum chamber. It was positionned at the end of the LINAC of the ATF facility. Then, the ATF was run in *LINAC mode* with an intensity of about 0.4×10^{10} electrons per bunch.

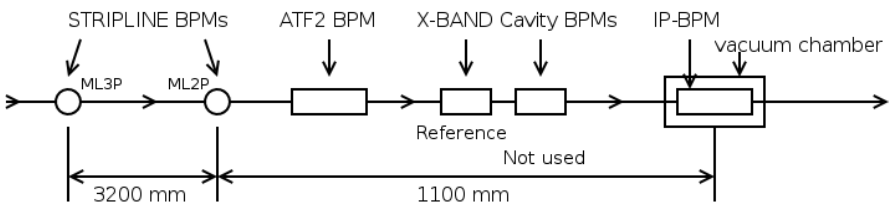


Figure 1: The setup of the LINAC end

At first, one has to do some RF gun tuning to obtain correct properties of the electron bunch especially the intensity. Then the beam must be found in the cavity : for that, the steering magnets ZH1P, ZV1P, ZH2P and ZV2P were used. They are located upstream of the ML3P stripline BPM. The intensity has been adjusted so that the beam passes through the cavity.
When the beam is found in the cavity (a signal appears), one must check the range in which the beam passes through the cavity. Thus, the magnets *ZV1P* and *ZH2P* were used but with a lower intensity step. The ranges can be defined as the limits where the beam hits the cavity without going out of it.
Note : It is important to begin with a large scan to be sure of these limits and then try to find the center of the cavity. Indeed, the signal is

low at the center of the cavity but also if the beam doesn't go through the cavity.

1.3 About the combiner

During the two shifts a combiner has been used. This combiner is an eletronic device inserted at the outputs of the cavity. The cavity of the IP-BPM has two outputs for each directions X and Y. Consequently, for a given direction, the two outputs have a 180 degrees phase difference. The purpose of the combiner is to add the two opposite signals, then to select the dipole modes with a BPF.
This is interesting if some signal coming from the common modes remains : the signal will be mainly suppressed by the combination since the common modes signal of the two outputs is the same and then reduced by the BPF.
The main interest of the second shift is to see if a lot of unexpected modes like common modes couple with the dipole modes in the cavity. Using the combiner or not will show the amount of signal comming from these modes.

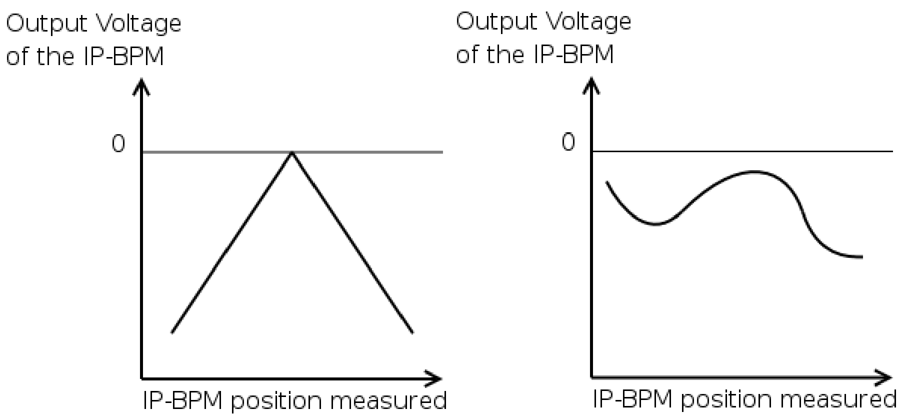
2 First shift : sensitivity of the cavity

After tuning the beam and defining the intensity range for the two steering magnets, the measurements can be done. Please read this part with [1].

2.1 First experiment : using IP-BPM cavity with 2-ports combiner

At first, horizontal and vertical position measurements were done. Changing the intensity of a given steering magnet bends the beam in a direction and the position of the beam in the IP-BPM can be deduced by reading the positions given by the stripline BPMs *ML3P* and *ML2P*. Then one can plot the output peak voltage as a function of the calculated position.
The expected graph is shown after. However, the plot obtained looks more like the second graph.

These first results seem very poor. But the explanation is certainly that on the borders of the observed window, the beam hits the beampipe's walls ; some energy is lost on the walls so that the cavity doesn't see all the beam's energy.



(a) Expected graph (b) Real graph

Figure 2: Response of the cavity versus offset

Furthermore, the combiner has been used with 2 ports for each direction. This is useful since it increases precision of the measurement and it has a bandpass filter that selects the dipole modes and rejects other modes. (This point has been checked during the second shift.)
However, the non linear results may be due to the fact that the combined outputs were not exactly dephased of Pi. This phase error may have come from different length in the cables connecting the cavity and the combiner. This part was adjusted for the second shift.

2.2 Second experiment : using ATF2 cavity and IP-BPM cavity with 1-port combiner

The same experiment was performed so that the results between the two cavities could be compared. Here, just one port of the combiner has been used.
The results can be seen on pages 6 and 7 of [1]. The ATF2 cavity proved its reliability since the results showed a very linear waveform and with a low offset level at the center. And the IP-BPM cavity also showed better results than the previous ones.
The sensitivity of the BPM is given by the slope of the linear part of the waveform. As shown on the graphs, the two BPMs have the *same sensitivity in X* and the IP-BPM has a *two times better sensitivity in Y*.
The offset voltage at the center is higher for the IP-BPM cavity than for the ATF2 cavity BPM.
Moreover, as it can be seen on the scopes, the X output is not really

regular : this strange shape is due to interferences of the X dipole mode with the mode of the correspondant waveguide whose frequencies are very close to each other. This problem will be corrected for the next version of the IP-BPM's cavity.

3 Second shift : presence of undesired modes

The shift was dedicated to study the shape of the pulses, especially to see if other modes were contaminating the dipole modes. Please refer to [2] while reading this part.

3.1 Response of the cavities with different output setups

Here, we are interested in the contamination of other modes different than the dipole modes that should only be observed. The combiner presented in the previous part was used here in different ways. One can see the different setup possibilities of the output of the cavity in [2] on page 2.
The IP-BPM cavity has been studied with 1 port combiner, 2 ports combiner and with just one 3 dB attenuator. The ATF2 cavity was tested with 1 port combiner and with a 3 dB attenuator.
The results show that the combiner has the expected effect on the voltage seen at the center of the cavity. Indeed, an offset due to another mode appears without the combiner and vanishes with at least 1 port setup. On the one hand, this means that the combiner plays effectively its role by removing the other modes. But on the other hand, it shows that there is still some coupling between with other modes in the cavity.

3.2 Effects of an offset on the output waveform

Using the same setups (2 port and 1 port combiner and with attenuator only), a qualitative study of the pulse shape has been done. The purpose was to see the evolution of the waveforms due to a little offset when the beam is at a given position. The following graphic explains where the initial position was : the beam was in the circles and the steering magnets were adjusted to move the beam more in the center or closer to the walls. The effects with different setups on different ports can be seen on pages 6 and 7 for the IP-BPM and 8 for the ATF2 BPM.
Finally, one can be interested in the effects of the beam jitter which

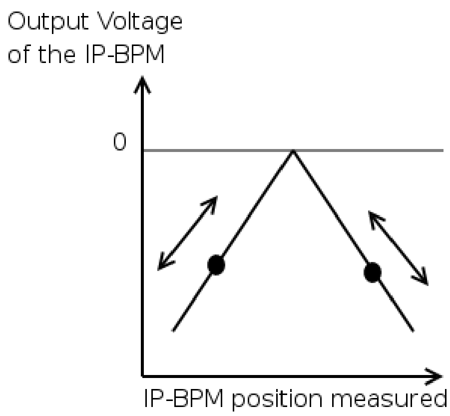


Figure 3: Basic scheme done to obtain the changes in the waveform

can be seen on page 5 : one can see the effects of the beam jittering on X and Y position with different setups. Besides, using the two ports of the combiner, the mean value is effectively 0, but with one port or just an attenuator, this value is not acchieved. Once more : the combiner is correctly suppressing the voltage comming from unwanted modes.

4 Conclusion

These two shifts allowed to make preliminary measurements of the off-set level at the center with and without combiner and the sensitivity of the IP-BPM's cavity. The cavity proved to work correctly and even if some unexpected modes were observed, their level is low and can be easily deleted with the combiner module.
However, a factor two more in the sensitivities in X and Y were expected. Many reasons can explain that since the cavity is still under development so the model used was only a *cold* model and the process of fabrication was not as precise as for a real one.
I would like to thank Honda-san, Inoue-san and Hino-san for their help during the two shifts and Tauchi-san for all his advice.

References

[1] Y.Honda *et al.*, Position Sensitivity test of IP-BPM, 2006/06/09

[2] Y.Honda *et al.*, Study on IP-BPM pulse shape, 2006/06/18