Mechanical stability of Q-BPM

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Abstract

In order to test the mechanical/thermal stability of the BPM mounted on the magnet, we did a set of bench test with the prototype BPM. A mechanical stress was applied on the BPM chamber directly or through a bellows monitoring the position change of the BPM with respect to the magnet. The displacement was proved to be less than a few micron. The stability of xy-isolation of the BPM was also tested under the mechanical stress. No significant change was seen.

1 Introduction

The relative position beteen a BPM and the field center of the magnet on which the BPM is attached has to be stable enough during the beam operation. The required orbit accuracy to realize the goal of small spot size aimed at ATF2 is a few micron. The requirement on the stability of BPM should be better than this.

The BPM chamber will be connected to the chambers next to it with bellows chambers. One of the possible mechanical stress to move the BPM is the force throuth the bellows chamber. The Q-magnets will be moved during the beam tuning. It might change the position of the BPM if the bellows were not flexible enough.

The other concern on the stability of cavity BPM is the stability of the cavity. Although the cavity will be tuned before the installation (xy-isolation tuning), a stress on the cavity after the installation might worsen the xy-coupling. Mechanical stress on the chamber or a temperature variation on the surface of the magnet might cause a problem.

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2 Setup and Measurements

2.1 BPM test stand

We made a test stand to simulate the situation that the BPM was mounted on a Q-magnet (Figure 1). The plate on which BPM is mouted is made of steel. It has eight M5 screw holes to mount the BPM at the same positions as the actual ATF2 magnets. Since we used the prototype BPM which had ICF70 flange at the end, the aperture of the plate was enlarged than the actual aperture of the magnet to accept the flange. First, the adapter (aluminium) is attached on the plate using the screw holes. The adapter consists of two half-moon pieces. The alignment of the adapter will be done with respect to the pole tips of the magnet. A special jig will be used for this purpose. The BPM is attached on the adapter using four M5 bolts. The adapter is expected to determine the position of the BPM in 50 μm precision (need be tested later).

2.2 Mechanical stability test (bellows motion)

To test the isolation of the stress by a welding bellows, we connected a bellows chamber to the BPM as shown in Figure 2. The effective length of the bellows was 30 mm. The other end of the bellows chamber was fixed on a mover stage. The position of the BPM with respect to the table (it should be identical with the test stand) was monitored by a laser displacement sensor. The

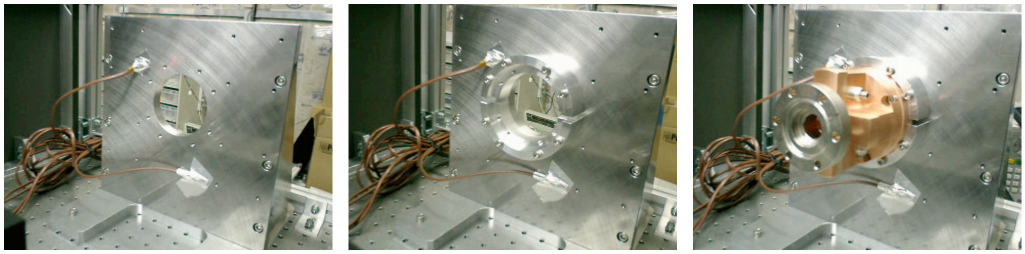

Figure 1: BPM mount system. left: The test stand simulating the magnet's surface, which is made of steel. center: The adapter which is made of aluminium. right: BPM mounted on the test stand.

resolution of the sensor was 200 nm. The position of the mover stage was also monitored by the same kind of sensor. The result of the mover stage position v.s. the BPM block displacement is shown in Figure 3. The movement of BPM block was proved to be less than a few micron even with a few mm lateral displacement of the bellows.

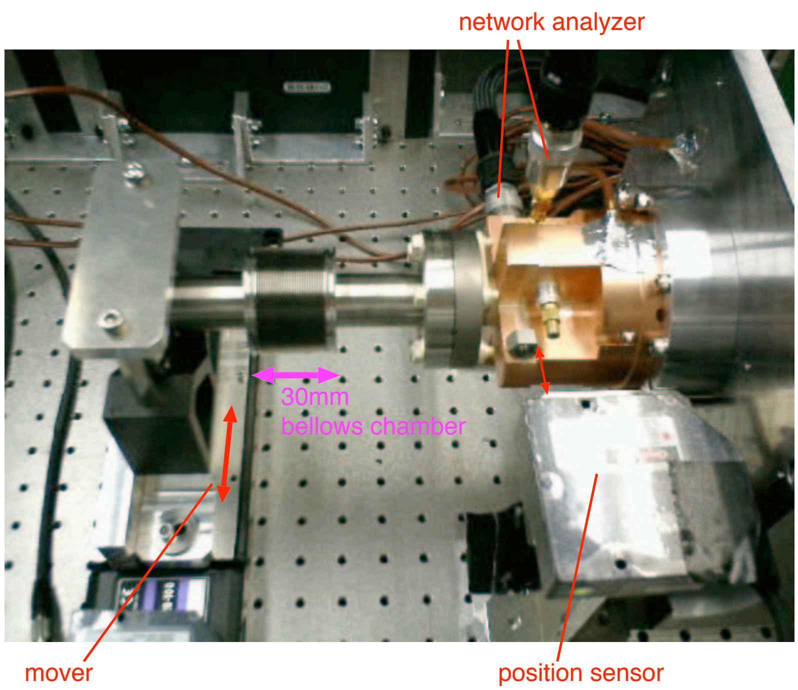

Figure 2: Setup for testing BPM displacement caused by the displacement of the bellows chamber.

2.3 Mechanical stability test (stress on the chamber)

Stiffness of the BPM chamber was also tested. The setup of the experiment is shown in Figure 4. A mechanical stress was applied on the vicinity of the flange while monitoring the position of the BPM by the laser displacement sensor. The stress was applied through a weight meter so that we could control the strength of the force. We did the experiment for two setups, force on the BPM side and the other side. The other side was extended with a 180 mm length beam pipe chamber as shown in the picture. The result is shown in Figure 5. The displacement of the BPM was less than a few micron with ± 6 kg·f force at the flanges.

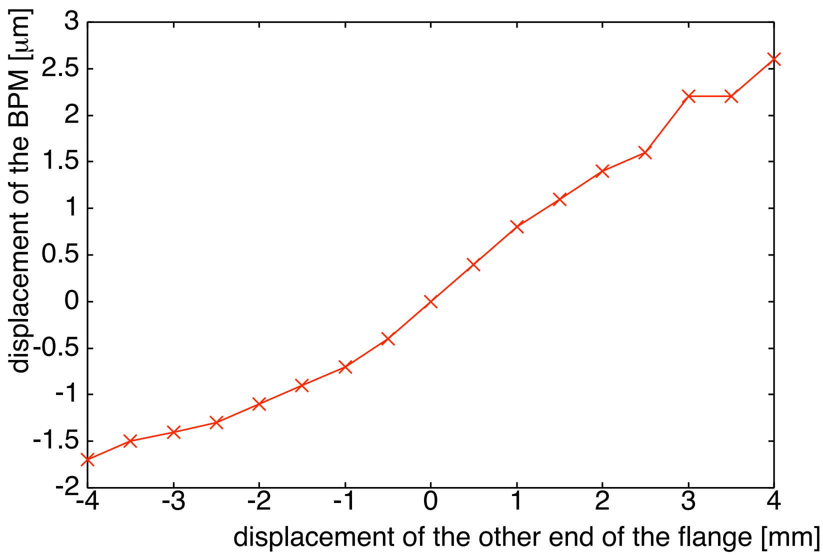

Figure 3: Result of the bellow stress test.

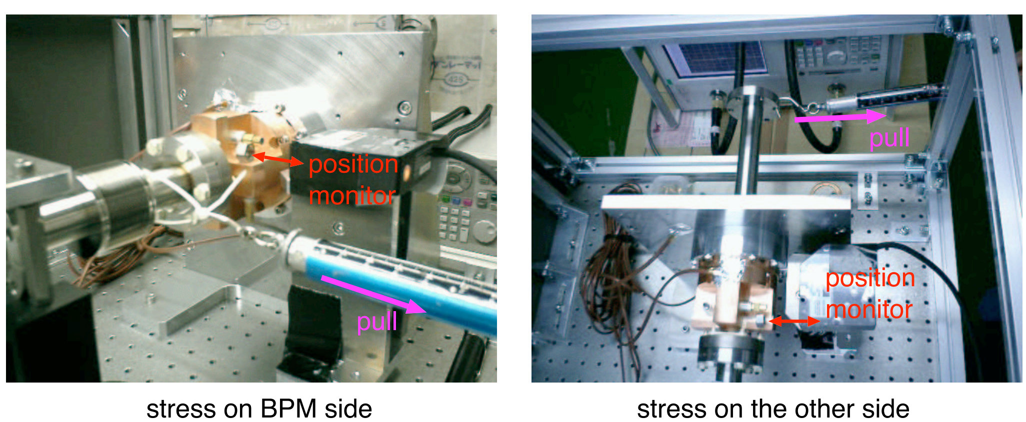

Figure 4: Setup for testing stiffness of the BPM chamber.

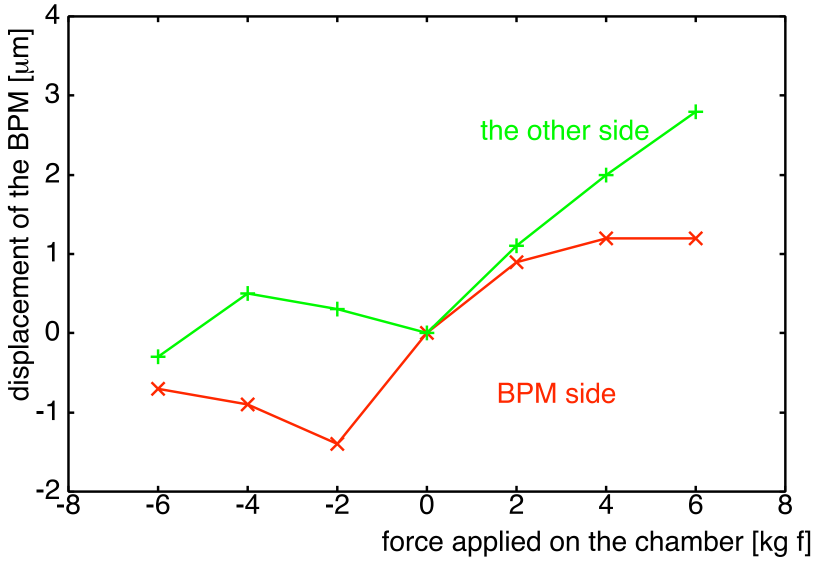

Figure 5: Stress on the chamber v.s. BPM displacement.

2.4 X-Y isolation (stress on the chamber)

There has been a concern about worsening xy-isolation due to a mechanical/thermal stress on the cavity. To test this, we measured xy-isolation while applying a stress on the beam pipe. Figure 6 shows the setup for this test. Transmission between the transverse ports was measured using a network analyzer. It was measured to be -59.9 dB without stress. The end of the beam pipe was pulled toward various direction. The strength of the force was controled to be 6 kg·f. Results under the force is summarized in Table 1. No significant change was seen.

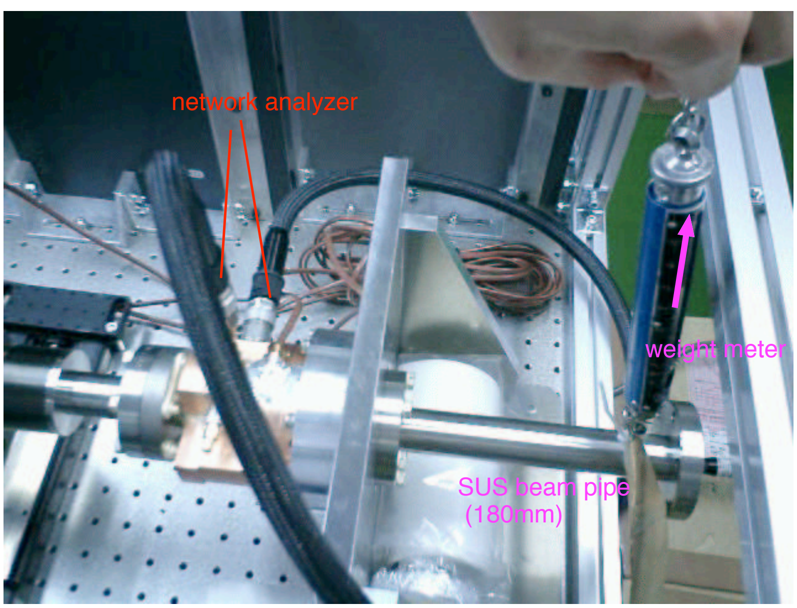

Figure 6: Setup for testing xy-isolation while applying a force on the chamber.

Effect of bellows motion on xy-isolation was also tested with the same setup as Section 2.2. The transmission between the transverse ports was measured while changing the displacement of the mover stage. The result is shown in Figure 7. No significant change was seen.

Table 1: XY isolation v.s. stress on the beam pipe

port	up	up-right	right	down-right	down	down-left	left	up-left
C to D	-59.4 dB	-57.9 dB	-55.0 dB	-57.3 dB	-59.4 dB	-61.3 dB	-62.4 dB	-61.8 dB

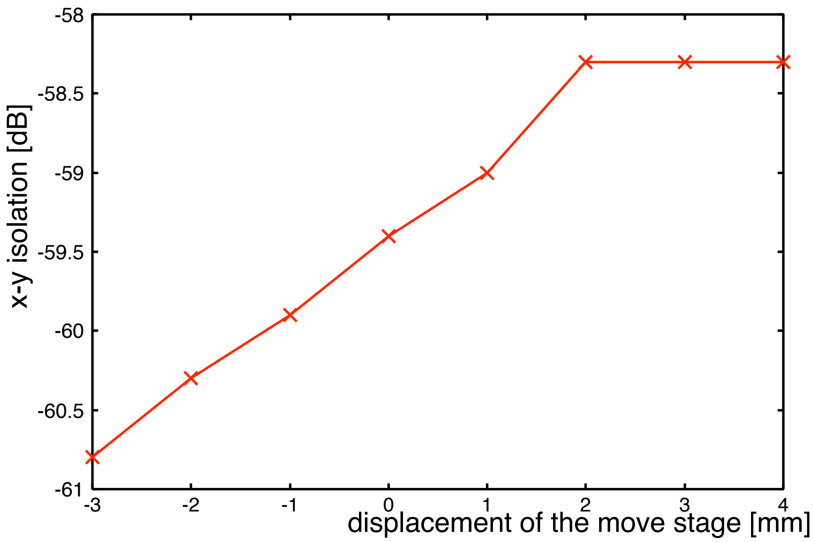

Figure 7: xy-isolation v.s. displacement of the bellows chamber.

2.5 X-Y isolation (thermal stress)

Mechanical stress produced by the temperature variation may worsen the xy-isolation. To test this effect, the plate was heated locally with a heat gun. As shown in Figure 8, three temperature sensors were installed in the setup; on the steel plate near the heated position (A), on the steel plate at the diagonal position (B) and on the BPM (C).

After heated up for a few minutes, the heater was stopped and the system started to cool down. XY-isolation was measured by a network analyzer during the system was cooling down. The result is summarized in Figure 9. No significant change was seen even with about 10 degree of temperature variation.

3 Conclusion

The BPM was mechanically stable within a few micron. XY isolation of the BPM does not change significantly with mechanical/thermal stress.

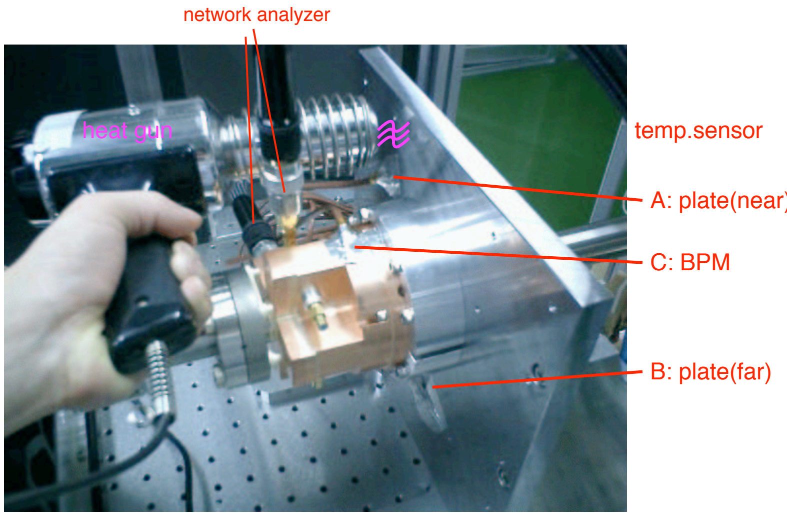

Figure 8: Setup for testing thermal stress effect on xy-isolation.

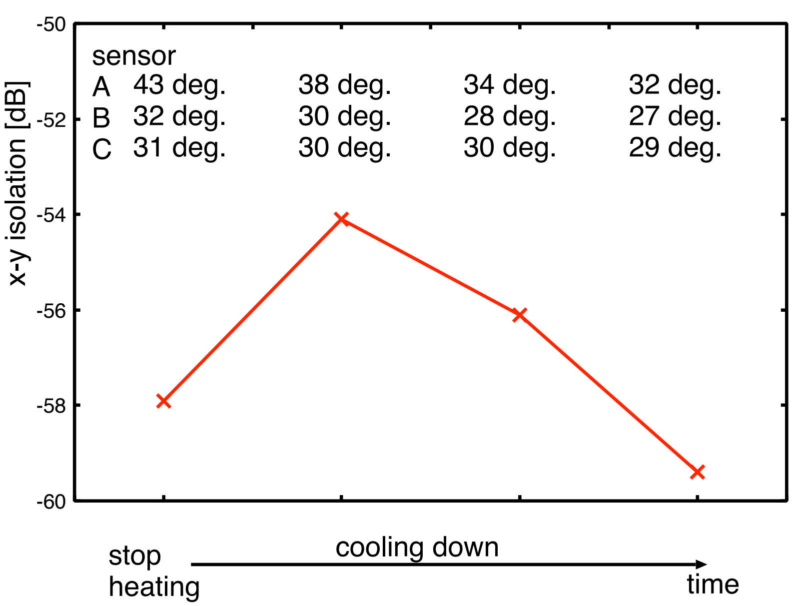

Figure 9: xy-isolation under the thermal stress.