Linear Collider Final Doublet Considerations: ATF2 Vibration Measurements

B. Bolzon, N. Geffroy, A. Jérémie, M. Oroku, T. Yamanaka, Y. Kamiya, T. Kume

To cite this version:

B. Bolzon, N. Geffroy, A. Jérémie, M. Oroku, T. Yamanaka, et al.. Linear Collider Final Doublet Considerations: ATF2 Vibration Measurements. Particle Accelerator Conference (PAC09), May 2009, Vancouver, Canada. pp.TH5RFP087. in2p3-00590521

HAL Id: in2p3-00590521
https://hal.in2p3.fr/in2p3-00590521
Submitted on 6 May 2011

LINEAR COLLIDER FINAL DOUBLET CONSIDERATIONS: ATF2 VIBRATION MEASUREMENTS*

B. Bolzon[#], N. Geffroy, A. Jeremie, IN2P3-LAPP, Annecy-le-Vieux, France
M. Oroku, T. Yamanaka, The University of Tokyo, 7-3-1, Hongo, Bunkyo, Tokyo, 113-0033, Japan
Y. Kamiya, ICEPP The University of Tokyo, 7-3-1, Hongo, Bunkyo, Tokyo, 113-0033, Japan
T. Kume, KEK, 1-1 Oho, Tsukuba, Ibaraki, 305-0801, Japan

Abstract

At ATF2, to allow the Shintake Monitor located at the Interaction Point to measure the beam size with only 2% of error, vertical relative motion tolerance between SM (Shintake Monitor) and final doublet magnets (FD) is of 7nm for QD0 and 20nm for QF1 above 0.1Hz.

Vibration transfer function of FD and SM with their supports has been measured and show a good rigidity.

Vertical relative motion between the SM and QD0 (QF1) was thus measured to be only of 5.1nm (6.5nm) with high ground motion representative of a shift period. Same measurements done in horizontal directions showed that tolerances were also respected (much less strict). Moreover, relative motion tolerances should be released due to the good motion correlation measured between FD.

Thus the FD and SM supports have been validated on site at ATF2 to be within the vibration specifications.

INTRODUCTION

ATF2 project proposes a test facility with a projected beam of 37nm. To measure the beam size with only 2% of error, vertical relative jitter tolerance (above 0.1Hz) between the FD (QD0, SD0, QF1, SF1) and the SM is of the order of 7nm for QD0 and 20nm for QF1 [1].

Thanks to adequate instrumentation [2], investigations were done in the past to design supports for FD. Since ground motion measurements showed good coherence up to 4m [3], more than the distance between FD and SM, we chose a stiff support for FD fixed to the ground on its entire surface [4] [5] [6]. Thus, FD and SM should move in a coherent way. Measurements done at LAPP showed that FD and their supports were sufficiently rigid and flowing cooling water induced no or low vibrations so that tolerances would not be exceeded [7].

After installing FD at ATF2 [8], new measurements have been done to evaluate their relative motion to SM. We used GURALP CMG-40T geophones and MG-102S accelerometers to measure in the three axes low ([0.1;13]Hz) and medium ([13;100]Hz) frequency vibrations respectively and ENDEVCO accelerometers to measure medium frequency vibrations in vertical axis.

First, ground motion was measured for 72 hours to get a representative spectrum for relative motion calculation.

Then, transfer functions of FD and SM vibrations (with their supports) were measured to evaluate their rigidity.

The correlation of QD0 and QF1 motion has also been studied in order to know if tolerances can be released.

To finish, the vibratory behaviour between SM and FD has been measured to calculate their relative motion.

GROUND MOTION VERSUS TIME

Since relative motion depends on the amplitude of ground motion, a representative ground motion has been chosen for the calculation of relative motion.

For that, ground motion was measured near FD during three days including a day of shift (9h-17h) on December 2008 (up to 100Hz in vertical axis and up to 50Hz in horizontal axis). Figure 1 shows the integrated RMS of motion versus time above 0.2Hz (signal to noise ratio very low below) at left and above 1Hz at right.

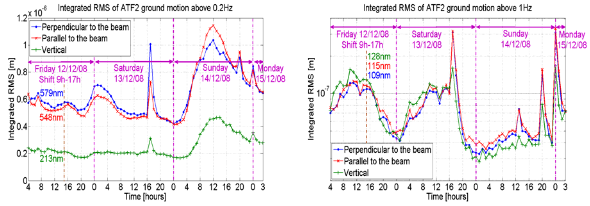

Figure 1: Integrated RMS of ATF2 ground motion versus time (at left: above 0.2Hz and at right: above 1Hz).

In order to take the worst case of vibrations during shift period, ground motion of the 12/12/08 at 3pm has been chosen due to its high amplitude above 1Hz, frequency from where coherence falls quickly with distance and resonances of mechanical structures appear. In horizontal directions, data were extrapolated up to 100Hz thanks to other measurements done during 20 minutes.

FINAL DOUBLETS

Vibration measurements have been done simultaneously on the top of FD and on the floor in order to evaluate their rigidity including their supports.

Figure 2 shows transfer function between QD0 and the floor (left) and between QF1 and the floor (right).

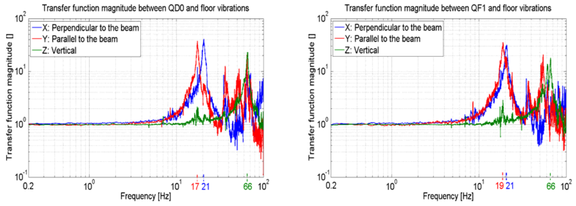

Figure 2: Vibration transfer function between QD0 and the floor (left) and between QF1 and the floor (right).

---

*Work supported by the Agence Nationale de la Recherche of the French Ministry of Research (Programme Blanc, Project ATF2-IN2P3-KEK, contract ANR-06-BLAN-0027)
#benoit.bolzon@lapp.in2p3.fr

The vibratory behaviour of QD0 and QF1 (with their supports) is almost the same.

Their transfer function is totally flat below 10Hz, frequency range where ground motion is the highest.

In the horizontal directions, their first resonance is at quite low frequency (around 20Hz).

But in the vertical direction where the tolerances are critical, there is only one resonance which is at a frequency where ground motion is low (66Hz).

QD0 AND QF1

Due to the defocusing and focusing effects, tolerances can be released if QD0 and QF1 move in phase.

From vibration measurements done simultaneously between the top of QD0 and QF1, the respective transfer function has been calculated to study coupling motion. Figure 3 shows its magnitude at left and phase at right.

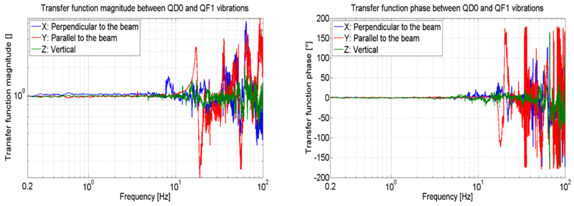

Figure 3: Magnitude (left) and phase (right) of vibration transfer function between the top of QD0 and QF1.

Below 10Hz, the magnitude is totally flat and the phase equals zero in the three directions.

In Y direction, the magnitude contains the first resonance of QD0 and QF1 since they are not exactly at the same frequency. The phase becomes thus high from this first resonance (above 10Hz).

However, in X and Z directions, the first resonance of the FD does not appear in the magnitude since they are exactly at the same frequency. Moreover, the phase is good up to the second resonance of FD (above 50Hz) in X direction and up to 60Hz in Z direction.

These results show that QDO and QF1 move in phase in Z and X directions. Tolerances can thus be released in these directions.

Note that QD0 feet had to be slightly shortened and have not the same height than the ones of QF1. If they had, FD would probably move in phase in Y axis also.

SHINTAKE MONITOR

Vibration measurements have been done between the top of SM vertical table and the floor to evaluate the rigidity of the supports. Their description can be found in [9]. The respective transfer function is shown in figure 4.

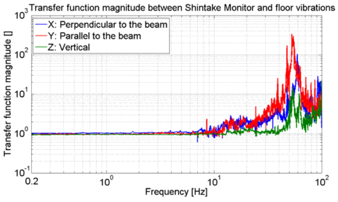

Figure 4:Transfer function between top of SM and floor.

In the three directions, the transfer function is totally flat below 10Hz and the first resonance appears only around 50Hz. Moreover, the transfer function is very flat up to 40Hz in vertical direction.

Note that coherence and relative motion can be found in [9] (calculated from the same measurements).

BSM AND FD

In order to evaluate relative motion between SM and FD, vibration measurements have been done between the top of the SM and the top of FD.

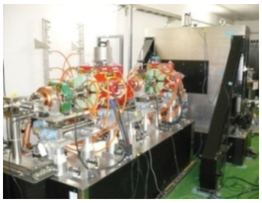

Figure 5: FD and SM with their supports at ATF2.

Transfer Function

Figure 6 shows transfer function magnitude between SM and QD0 (left) and between SM and QF1 (right)

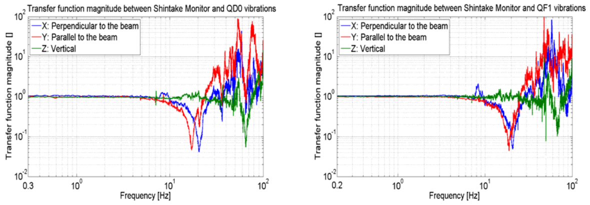

Figure 6: Transfer function magnitude between SM and QD0 (left) and between SM and QF1 (right).

The transfer function is almost the same between SM and QD0 and between SM and QF1.

It is totally flat below 10Hz in the three directions.

An anti-resonance is observed around 20Hz in horizontal directions and around 70Hz in vertical direction because of the final doublet resonance.

The resonance around 50Hz in the three directions comes from the one of the SM.

Above 70Hz, the amplifications (in all directions) come from both SM and FD.

Coherence

In order to see the influence of the distance between FD and SM, figure 7 shows the coherence between QD0 and SM (left) and between QF1 and SM (right).

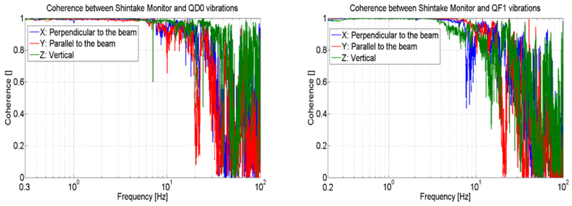

Figure 7: Vibration coherence between SM and QD0 (left) and between SM and QF1 (right).

Below 10Hz, coherence is at 1 in all directions for QD0 and in horizontal directions for QF1.

In Z direction, coherence decreases slightly above 10Hz for QD0 and above 4Hz for QF1. Coherence becomes bad only above 50Hz for QD0 (due to resonance) but above 10Hz for QF1. The difference is explained by the fact that QF1 is at 3m from SM while QD0 is only at 1m50.

Relative Motion

In order to know relative motion between SM and FD with the chosen ground motion, the integrated RMS of relative motion has been calculated by incorporating the measured complex transfer function between SM and FD and the PSD of FD motion. This last one has been calculated by multiplying the chosen ground motion PSD by the measured transfer function magnitude between FD and the floor. The formula can be found in [6].

In figure 8, results are shown between SM and QD0 (left) and between SM and QF1 (right).

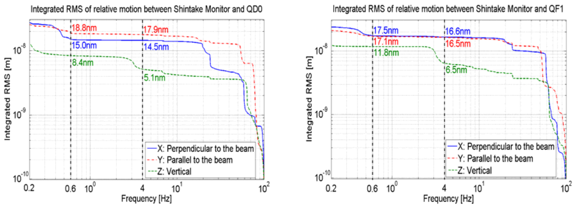

Figure 8: Integrated RMS of relative motion between SM and QD0 (left) and between SM and QF1 (right).

The increase of relative motion at 0.2-0.4Hz and at 3.5Hz is due to small error on transfer function measurements (around 1%) amplified by two huge peaks of floor motion [9] at these frequencies.

In fact, coherence and transfer function (in magnitude and phase) are very good up to 4Hz and ground motion should not increase relative motion below this frequency.

Relative motion of SM to QD0 and of SM to QF1 is almost the same in the three directions. It is just slightly worse in the vertical direction for QF1 due to the loss of coherence at lower frequencies.

The increase around 50Hz mainly comes from the SM while the increase around 20Hz comes from the FD. Above 70Hz, the increase comes from both SM and FD.

Achievement of Tolerances

In table 1, the measured relative motions are given with their tolerances in the three directions between QD0 and SM and between QF1 and SM. Also, the integrated RMS of the chosen ground motion is given above 0.2Hz.

Table 1: Relative Motion Tlerances and Measurements

	Tolerance (nm)	**Meas. QD0 (nm)**	**Meas. QF1 (nm)**	**Absolute (nm)**
X	~500	14.5	16.6	578.8
Y	~10000	17.9	16.5	548.5
Z	7 (QD0) 20 (QF1)	5.1	6.5	212.6

In the horizontal directions, relative motion is well below tolerances.

In vertical direction, tolerances are stricter but relative motion is still within tolerances while ground motion is very high. The damping factor of relative stabilization is of 42 for QD0 and of 33 for QF1.

CONCLUSION

Vibration measurements show that the supports of FD and of SM were well designed and very rigid.

In fact, their resonance is at high frequency and allows a relative motion of FD to SM within tolerances in the three directions when taking a high activity ground motion for the calculation.

Moreover, QD0 and QF1 move in phase thanks to their same rigid supports. Relative motion tolerances between FD and the SM should thus be released.

New measurements will be done on site with cooling water in order to confirm the results of measurements done at LAPP (no influence on FD jitter).

To finish, vertical relative motion between SM and FD will be measured over a long time to show its evolution.

ACKNOWLEDGMENTS

Authors thank Ryuhei Sugahara of KEK for providing MG102-S accelerometers with the associated amplifiers.

REFERENCES

[1] H. Braun et al., “ATF2 Proposal: V.1”, CERN-AB-2005-035, KEK-REPORT-2005-2

[2] B. Bolzon et al., “Study of vibrations and stabilization at the sub-nanometer scale for CLIC final doublets”, LAPP-TECH-2008-05, September 2008. Presented at the Nanobeam 08 workshop, Novosibirsk, Siberia

[3] R. Sugahara, “Floor Movement Measurement at ATF Ring”, presented at the 3rd ATF2 Project Meeting, KEK, 18-20 December 2006

[4] B. Bolzon, “CERN CLIC table performance - Pertinence in ATF2 context”, presented at the 3rd ATF2 Project Meeting, KEK, 18-20 December 2006

[5] B. Bolzon, “Efficiency of an active isolation of magnets from the ground for CLIC and ATF-2 project”, presented at the CLIC Stabilisation Meeting 2, CERN, 10 June 2008

[6] B. Bolzon et al., “Study of supports for the final doublets of ATF2”, LAPP-TECH-2008-04, also as ATF-08-11, September 2008. Presented at the Nanobeam 08 conference, Novosibirsk, Siberia

[7] B. Bolzon et al., “Impact of flowing cooling water on the ATF2 final doublets vibrations”, ATF-09-01, 15 April 2009

[8] A. Jeremie, “Installation of FD in September”, presented at the 7th ATF2 Project Meeting, 15-18 December 2008

[9] T. Kume et al., “Nanometer Order of Stabilization for Precision Beam Size monitor (Shintake monitor)”, Proc. PAC2009, Vancouver, Canada, 2009