TRANSVERSE BEAM JITTER PROPAGATION IN MULTI-BUNCH OPERATION AT ATF2

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Abstract

Pulse-to-pulse orbit jitter, if not controlled, can drastically degrade the luminosity in future linear colliders. The second goal of the ATF2 project at the KEK accelerator test facility is to stabilise the vertical beam position down to approximately 5% of the nominal rms vertical beam size at the virtual interaction point (IP). This will require control of the orbit to better than 1 micrometre at the entrance of the ATF2 final focus system. In this paper, by means of computer simulations, we study the vertical jitter propagation along the ATF2 from the start of the extraction line to the IP. For this study pulse-to-pulse vertical jitter measurements using three stripline beam position monitors are used as initial inputs. This study is performed for the case of a bunch-train with three bunches, but could easily be extended for a larger number of bunches. The cases with and without intra-train orbit feedback correction in the extraction line of ATF2 are compared.

Introduction

ATF2: Final focus test beam line facility at KEK

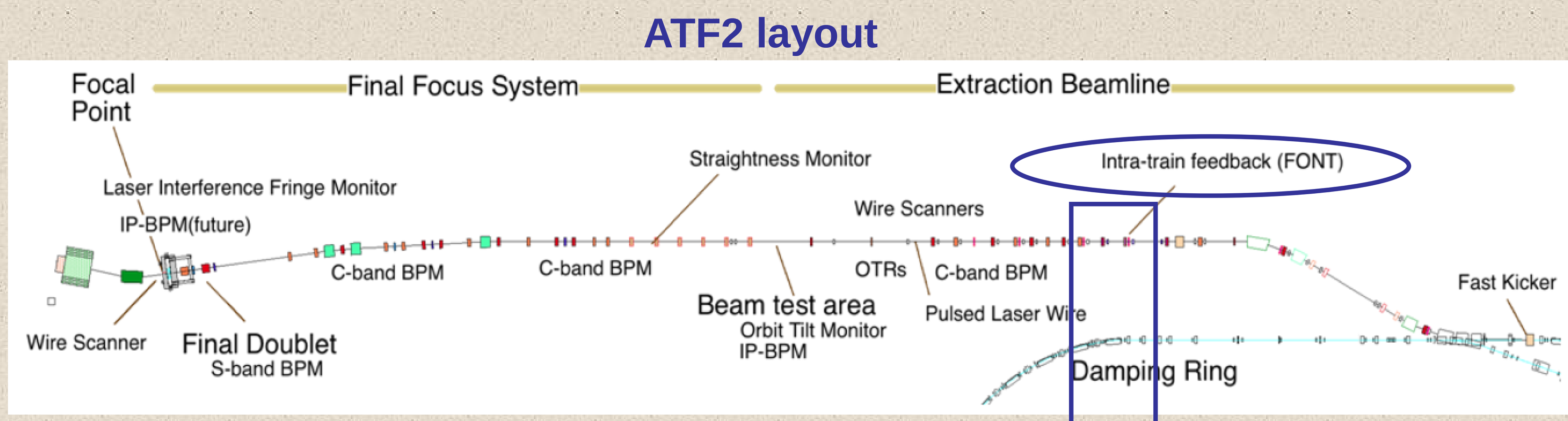
Two main goals of ATF2 :

- The achievement of transverse beam sizes of about 40 nm at the focal point. Currently progressing towards the achievement of this goal [1].
- Control of the beam position at the level of 5% of the rms beam size σ_y. R&D activities have already started to achieve this goal.

System to contribute to the second goal:

- Intra-train feedback (FB) system installed in the extraction line from the damping ring: **Feedback On Nano-second Timescales (FONT) [2,3].**

ATF2 layout



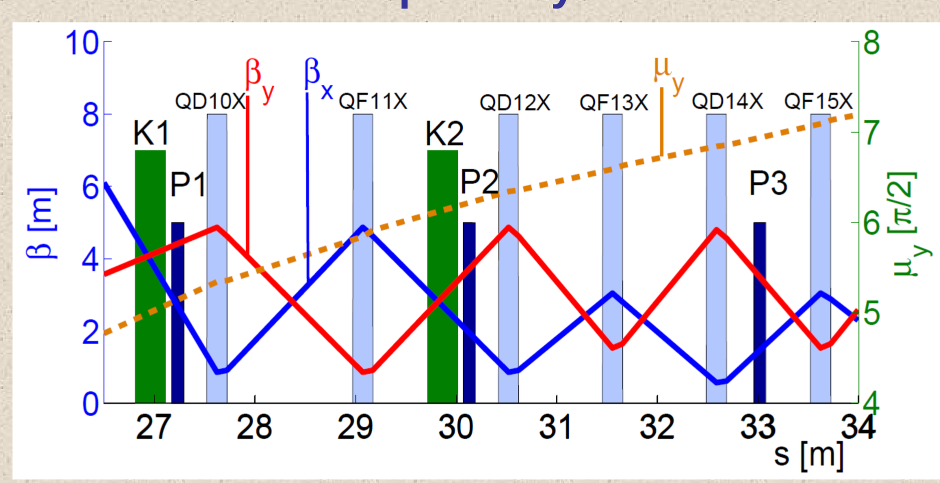
Intra-train Feedback System

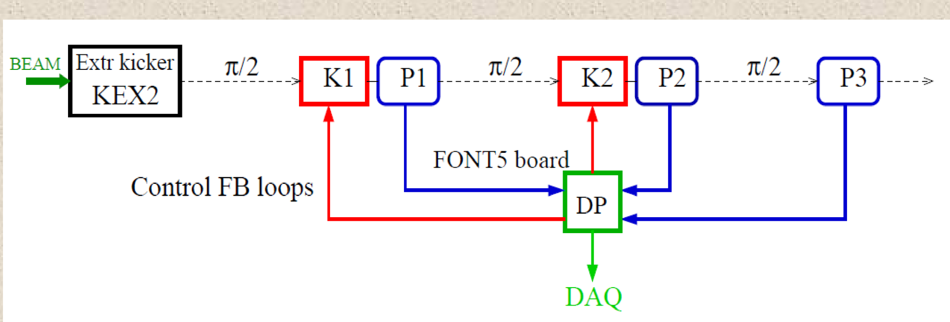
Optics layout

- ILC-like intra-train FB system prototype: **FONT5 [3]**

Key components:

- A pair of stripline kickers (K1 and K2)
- There stripline BPMs (P1, P2 and P3)
- Digital FB processor which allows the implementation of FB algorithms for simultaneous and coupled y and y' correction





Vertical Jitter Measurements

The FONT5 system was tested at ATF2 to correct incoming pulse-to-pulse jitter (jitter that is correlated between bunches) for **3-bunch trains**

Operation conditions:

- 1.3 GeV 3-bunch trains
- **154 ns bunch separation**

Intra-train FB system was operated in coupled FB mode in order to correct simultaneously y and y', Interleaving measurements with FB switched off and on

Table 1: Vertical beam jitter measurements by the FONT5 BPMs for each bunch in 3-bunch train operation. Data from 16th April 2010.

Bunch #	BPM P1 $\sigma_{(1)}$ [μm]	BPM P2 $\sigma_{(2)}$ [μm]	BPM P3 $\sigma_{(3)}$ [μm]
1 (FB OFF/ON)	3.3/3.4	2.4/2.2	3.4/3.2
2 (FB OFF/ON)	3.2/3.3	2.3/0.4	3.3/1.8
3 (FB OFF/ON)	3.3/3.5	2.5/1.1	3.3/1.6

Table 2: Vertical angle beam jitter at BPM P2. Data from 16th April 2010.

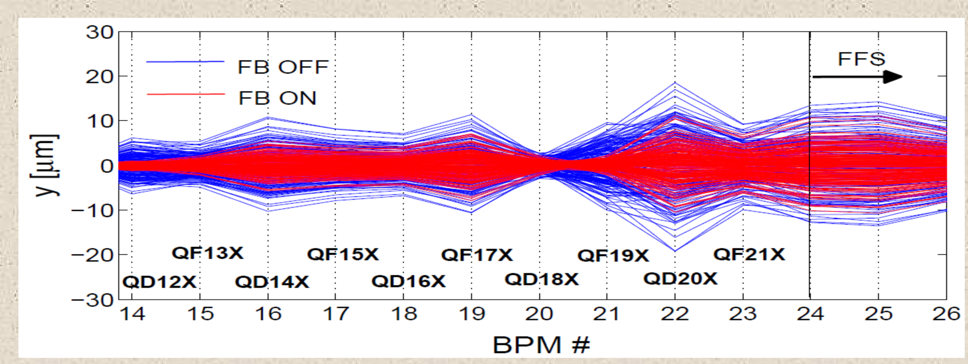
Bunch #	BPM P2 $\sigma'_{(2)}$ [μrad]
1 (FB OFF/ON)	1.9/1.7
2 (FB OFF/ON)	1.9/0.65
3 (FB OFF/ON)	1.9/0.72

Tracking Simulations and Jitter Prediction

Knowing the rms position and angle jitter at BPM P2, we can generate an initial bivariate normal distribution of y and y' offsets and perform tracking simulations in order to evaluate the vertical jitter at any other point of the lattice.

For this tracking study the code MAD [4] has been used. The simulation assumes no extra source of jitter downstream of the FB system.

Tracking from P2 to the entrance of the Final Focus System (FFS):



Vertical offset distribution at the entrance of the ATF2 FFS for bunch 2 and 3 for 1000 pulses:

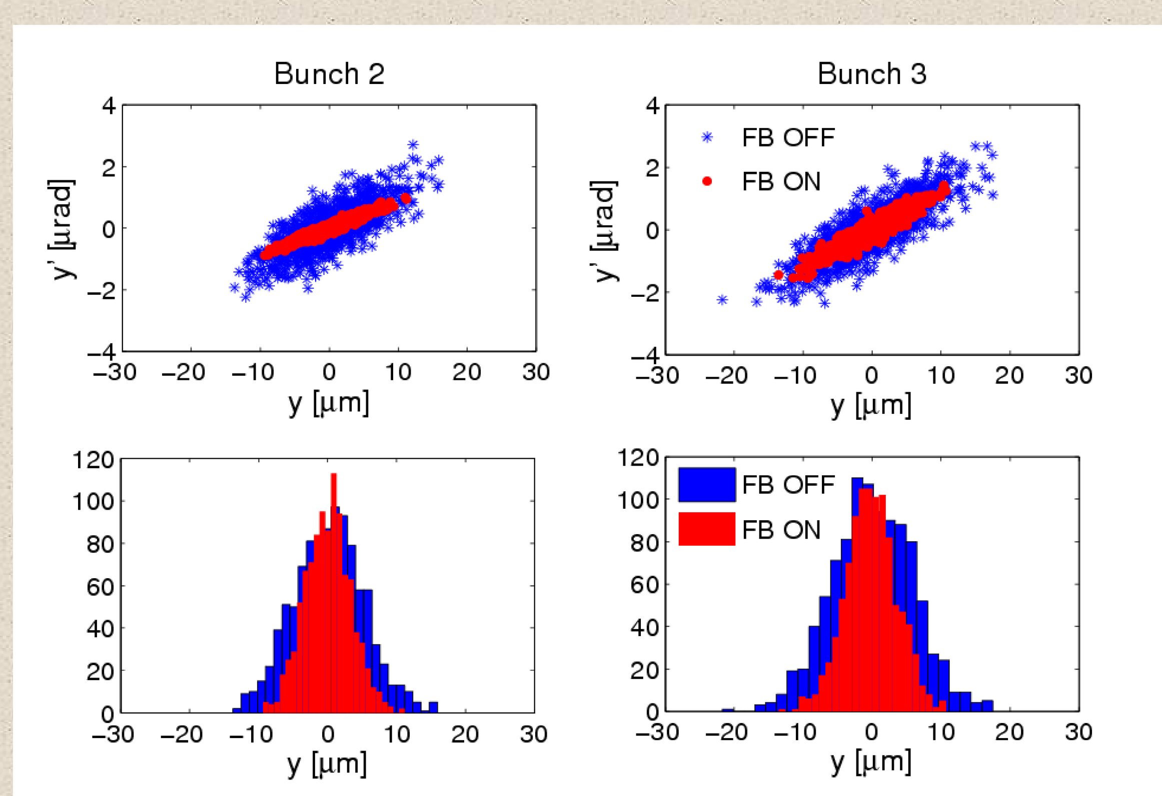
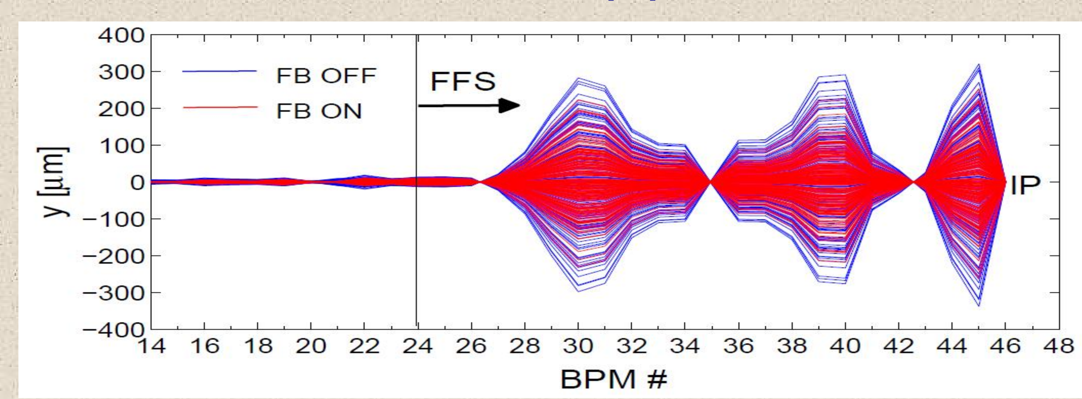


Table 3: Prediction of the vertical position and angular jitter at the FFS entrance.

Bunch #	$\sqrt{\langle y_{FFS}^2 \rangle}$ [μm]	$\sqrt{\langle y_{FFS}'^2 \rangle}$ [μrad]
2 (FB OFF/ON)	5.1/3.3	0.7/0.3
3 (FB OFF/ON)	5.9/3.7	0.9/0.5

Tracking from P2 to the ATF2 virtual Interaction Point (IP):



Vertical offset distribution at the IP for bunch 2 and 3 for 1000 pulses:

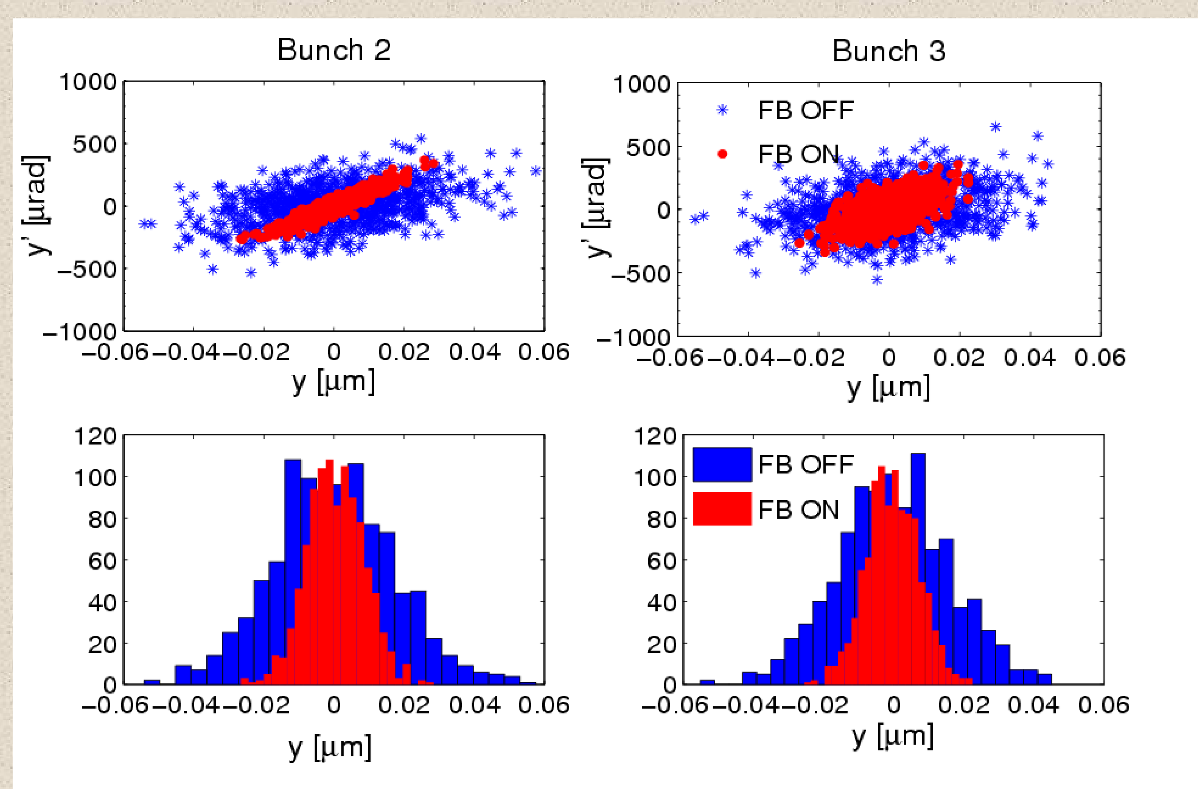


Table 4: Prediction of the vertical position and angular jitter at the IP.

Bunch #	$\sqrt{\langle y_{IP}^2 \rangle}$ [nm]	$\sqrt{\langle y_{IP}'^2 \rangle}$ [μrad]
2 (FB OFF/ON)	17.3/8.0	155.6/100.0
3 (FB OFF/ON)	16.0/7.5	173.7/110.5

FACTOR 2 POSITION JITTER REDUCTION AT IP !

FACTOR 1.6 ANGLE JITTER REDUCTION AT IP !

Conclusions

An intra-train FB system has been tested at the ATF2 beam test facility with short ILC-like trains in 3-bunch mode with 154 ns bunch separation. This FB system is placed in the ATF2 extraction line (upstream of the FFS) and corrects the incoming y and y' beam jitter. The FB system performs as expected, reaching a factor 5 position jitter reduction and a factor 3 angle jitter reduction at BPM P2. Simulation studies of jitter propagation have shown that the position and angle jitter are reduced downstream of the FB system. A FB OFF/ON correction ratio of 2 for position jitter and of 1.6 for angle jitter at the ATF2 virtual IP have been predicted by tracking simulations with the nominal ATF2 optics. Results show that the intra-train FB system in the extraction of ATF2 has the potential to stabilise the beam at the IP to below 10 nm. These results are very encouraging and provide an important step towards the achievement of the ATF2 second goal.

References

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[3] G. B. Christian et al., these proceedings, MOPO017
[4] H. Grote and F. C. Iselin, "The MAD Program, User's Reference Manual", CERN/SL/90-13 (AP) (1996)