ORBIT CONTROL AT ALBA

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Abstract

ALBA is a 3^{rd} generation light source in the final stage of the commissioning process, with the accelerator complex commissioning almost finished and the comissioning of the seven phase one beam lines also well advance, with user operation starting along the second quarter of 2012. In the last six month, a series of improvements have been implemented, in order to ensure the delivery of a stable photon beam to the beamlines: improved slow orbit feedback system (refined algorithm and inclusion of the RF frequency in the correction), improvements in the feed-forward scheme to compensate insertion devices effects, calibration of the X-BPMs in the front-ends and upgrades in the BPMs (activation of the digital signal conditioning). All this allows us to deliver a beam with stability at the micrometer level.

IMPROVEMENTS TO THE ORBIT CONTROL

Hardware Improvements

The two main changes to the hardware since the last report at IPAC 2011 [1] have been the use of the Digital Signal Conditioning mode of the Libera BPMs and the calibration of the photon BPMs of the beamline's frontend. The first change has reduced the noise level of the e-BPMs to values under 200 nm.

Slow Orbit Feedback System

The Slow orbit feedback (SOFB) at ALBA is based in the inversion of the response matrix using the SVD algorithm. Since the start of 2012, the control of the RF frequency is included in the algorithm, improving the long term orbit reproducibility and eliminating tune changes observed previously. This control is done by computing the equivalent RF change created by the horizontal correctors. Once this change reaches an absolute value of 5 Hz (equivalent to a displacement of 1 μm in the BPMs), this change is applied to the RF system and removed from the corrector strength.

By default the orbit is corrected each 3 seconds, to a golden orbit defined as the center of the BPMs respect the nearest quadrupole, according to the beam based callibration. A maximum value of 5 A of current in the correctors is allowed (50% of the maximum 10 A value). The SOFB uses only 88 out of the 104 BPMs available, and all the 88 correctors in each plane, in order to ensure a reproducible orbit. With this settings, the coupling is circa 0.5 % according to measures of the beam size.

Compensation of Insertion Devices Effects

A lot of effort has been devoted in order to compensate for the influence of the insertion devices in the orbit. At present, 4 kinds of insertion devices are present at ALBA [2]: one 2.1 T superconducting wiggle, 1 1.7 T multipole wiggler, 2 Apple-II elliptical undulators and 2 in-vacuum undulators. Of those, the one with the greater effect in the orbit is the superconducting wiggler. However, as the field is fixed, it can be easily compensated by the SOFB without any influence in the beamlines. The in-vacuum undulators have no influence in the orbit. To compensate the effect of the multipole wiggler and the Apple-II undulators, a combination of look-up table and SOFB is used. The look-up table are based in the measurement of the field of the IDs in the lab, and then they are refined using the influence of the ID on the stored beam, taking in account the delays in the writing of the settings of the correctors coils of the IDs. Figure 1 shows the reading of the BPMs (right Y axis) adjacent to the multipole wiggler when opening and closing the gap (blue line, left Y axis), with and without look-up tables and SOFB. Figure 2 shows the same for the case of one of the Apple-II undulators (including also the effect of the phase, green line). In both cases the effect is reduced to the micron level.

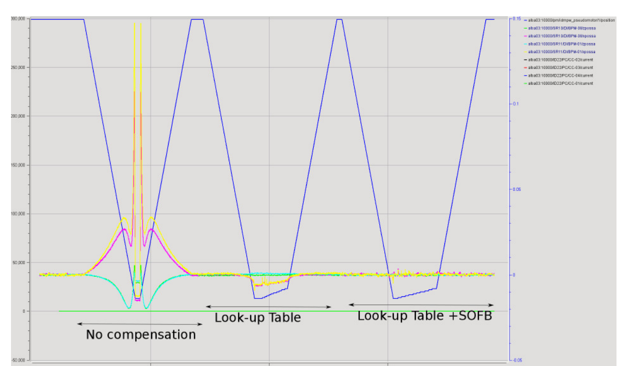

Figure 1: Compensation of the orbit effect of the multipole wiggler. The blue line shows the gap of the insertion device from fully open to the nominal one of 12.9 mm. The other four lines shows the reading of the upstream and downstream BPMs. Three cases are show: no compensation, with look-up table and with look-up table and SOFB. For the third case, the distortion is reduced from values 150 μm to under the μm level, except for brief spikes.

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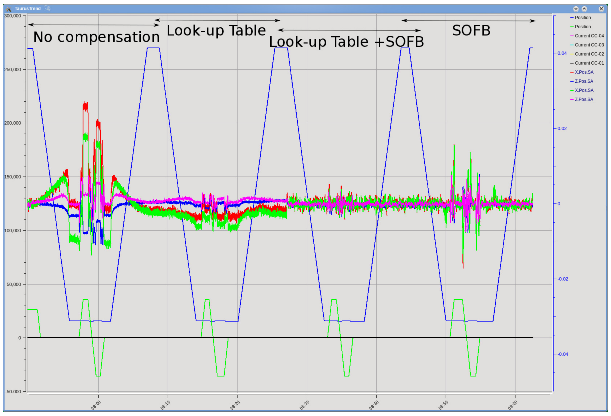

Figure 2: Compensation of the orbit effect of one of the Apple-II (EPU-71) multipole wiggler. The blue line shows the gap of the insertion device from fully open to the nominal one of 15 mm and the green line the phase. The other four lines shows the reading of the upstream and downstream BPMs. Four cases are show: no compensation, with look-up table, with look-up table and SOFB and with SOFB only. For the third case, the distortion is reduced from values 25 μm to under the μm level, except for brief spikes.

ORBIT STABILITY

Short Term

Figure 3 shows the reading of one BPM in one of the ID sections for a period of one a half day, with 3 injections. The orbit is controlled to rms values of $\sigma(x)$=0.6 μm and $\sigma(x)$=0.3 μm, well under the desired 10 % of the beam size at that point (150 μm and 6 μm). The same situation is reproduced in the other BPMs.

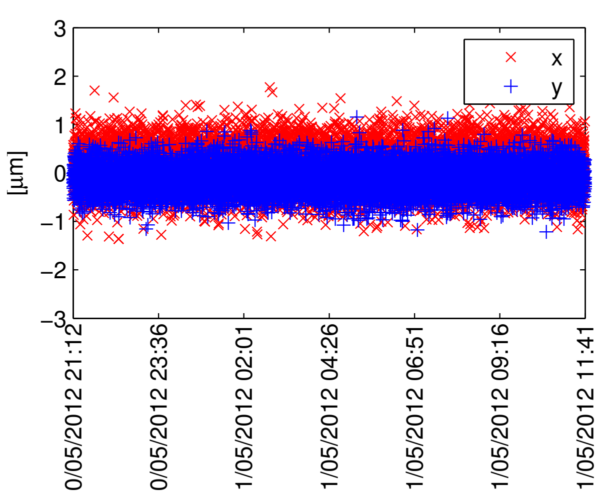

Figure 3: Orbit in BPM [2 1]. The orbit is controlled to rms values of $\sigma(x)$=0.6 μm and $\sigma(x)$=0.3 μm.

Figure 4 shows the changes of 16 correctors in both planes (the first one in each of the sectors of the machine) for the same period of Figure 3, and Figure 5 shows the change applied to the RF frequency. The same range of change is found in all the 88 correctors ($\pm$ 40 mA), with sudden changes after injection.

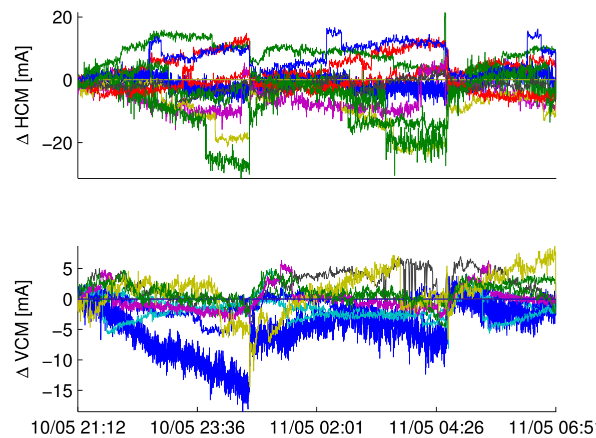

Figure 4: Change in the corrector strength for the first corrector in each sector. The upper figure shows the horizontal correctors and the lower the vertical ones. 20 mA of current correspond to a 2 μrad kick. The large changed observed for example in the blue line in the vertical correspond to the injection.

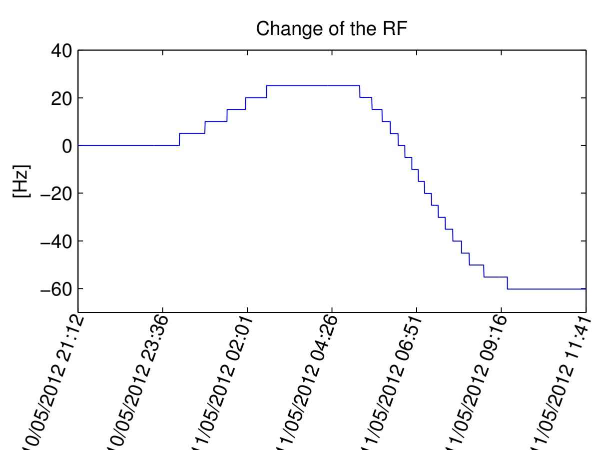

Figure 5: Changes applied to the RF frequency for the same period of Figures 3 and 4.

Medium Term

Figure 6 shows the position in the electron and photon BPMs for one week, projected to the same point, in one of the front-ends of the insertion devices. It can be seen that while the orbit stability according to the reading in the electron BPMs is under the μm level, large changes during the week can be observed in the X-BPMs. The same effect can be observed in the Mistral beamline, located in a bending magnet. The source of this drift still is to be determined.

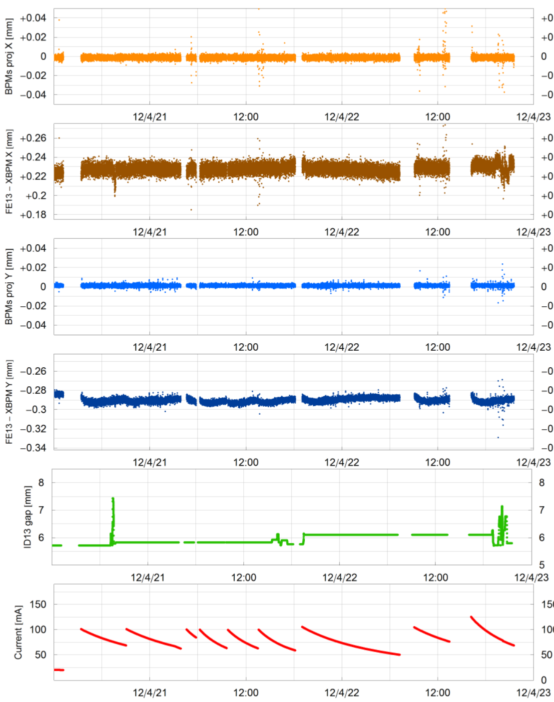

Figure 6: From top to bottom: (a) Horizontal projection of the electron beam down to the location of the Front End XBPM according to the readings of the two BPMs immediately before and after the photon beam source point; (b) Horizontal Front End XBPM reading; (c) Vertical projection of the electron beam down to the location of the Front End XBPM according to the readings of the two BPMs immediately before and after the photon beam source point; (d) Vertical Front End XBPM reading;(e) gap of the insertion device; (f) Storage Ring Current.

UPGRADES: FAST ORBIT FEEDBAK

Most of the hardware is already installed and operational (BPM electronics, Correctors power converters, optical fiber intercommunication network and timing distribution system). Position data transfer from all BPM electronics to the FOFB processing nodes is accomplished by using the Diamond Communication Controller and has been successfully tested using a so-called “sniffer board” borrowed from the ESRF. Analysis of acquired data is shown on Figure 7. Data collecting and processing units are still under evaluation. A laboratory testbench is prepared to investigate the possible solutions, with a working prototype installed in the storage ring at the start of 2013.

According to the data collected until now, the beam is very quiet, with the only frequencies visible are the 3.125 Hz of the booster (when is in operation), the 50 Hz of the mains, plus some small contribution of the eignfrequencies of the girders at 24 Hz and in the region between 57 and 70 Hz. In case of moving of insertion devices gaps, some frequencies in the range between 1 and 20 Hz are also excited. However, even in this case, the integrated motion in the vertical plane in the BPMs of the insertion devices straight between 0 and 100 Hz is under the 1 μm.

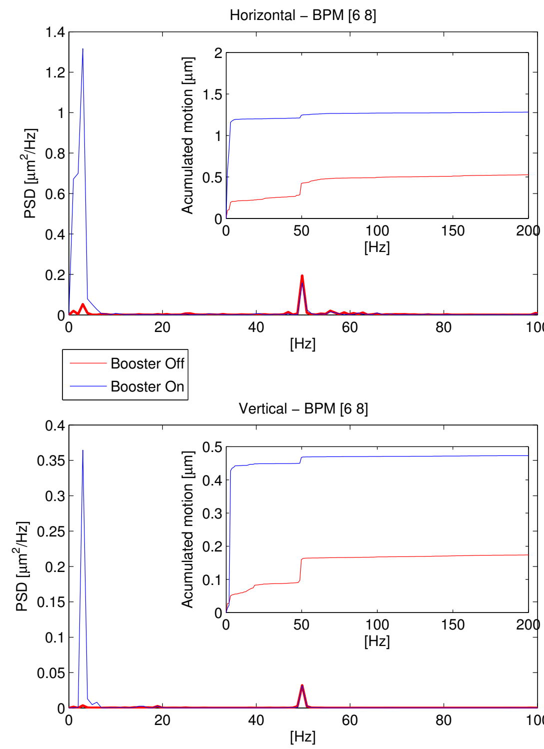

Figure 7: Power spectral density and accumulated motion for the 10 kHz sample data of the orbit, with the booster on and off. The large component at 3.125 Hz is the effect of the booster, but the accumulated motion is under the μm in the vertical and barely over it in the horizontal.

CONCLUSIONS

The correction system is working well, correcting the orbit under the micron level in both planes. The inclusion of the RF frequency in the SOFB loop has also reduced tune drift. Preliminary measurements of the 10 kHz sample rate of the orbit shows a very quiet beam. However, drift in the position of the beam in the X-BPMs, in particular in the case of the dipole beamline still need further investigation.

REFERENCES

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