ORBIT STUDIES DURING ALBA COMMISSIONING

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Abstract

The 3rd generation light source ALBA is in the commissioning stage [1]. This paper review the results of the commissioning concerning the transversal beam behavior, in particular the orbit correction system, results from the beam based alignment (BBA), and coupling. The orbit control system of ALBA consists of 88 horizontal and vertical correctors, mounted as extra coils in the sextupole magnets, up to 104 LIBERA BPMs (brilliance version). The correctors magnets would be used for both static orbit correction and for the fast orbit feedback mode, providing up to 1 mrad of correction in the static case. In phase one of the commissioning, the orbit has been corrected down to values of 50 μm rms, with an estimated emittance ratio in the order of 1% .

INTRODUCTION

The commissioning of the storage ring of the ALBA synchrotron started in February 2011, with the first stage (machine without any narrow gap insertion devices) finishing in June 2011. The lattice description can be found in [2]. The orbit correction system consists of 88 horizontal and vertical correctors, located as extra coils in the sextupoles magnets, and 104 BPMs, equipped with Libera Brilliance electronics. The 88 corrector magnets will used for the slow orbit correction as well as for the fast orbit feedback system.

During this stage of the commissioning all avalaible BPMs (in general 102 out of the 104) were used for correcting the orbit, with the target orbit being defined by the center of the quadrupoles. The RF frequency has not been included routinely in the correction, only adjusting it once in order to find the center frequency.

Algorithm and Software

The starting algorithm used for correcting the orbit is the well know inversion of the response matrix by means of the Singular Value Decomposition (SVD). The response matrix used have been the measured one, only using the theoretical one at the start. After inclusion of the Beam Based Alignment constants, it was possible to correct the orbit using up to 86 out of the 88 SVD eigenvalue in each plane. The software used is the `setorbitgui` routine of the Matlab MiddleLayer (MMA). The option to use Tikhonov regularization in place of the simpler truncated SVD technique for inverting the response matrix has been added to the GUI. When using this method, the orbit can be corrected using maximum corrector values a 30 % smaller thant when using the truncated SVD.

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BEAM BASED ALIGNMENT

The BBA constant of the BPMs respect the center of the nearest quadrupoles have been measured two times, with the second measure performed after taking in accoung the results for the first round. Figure 1 show the total BBA constant measured. The results are reproducible to values under 10 μm, consistent with the noise in the BPMs at this stage of the commissioning. Most offsets are of the order of the 100 μm, but some peaks up to the 1 mm are present. The possible source of this large deviations have not been identified.

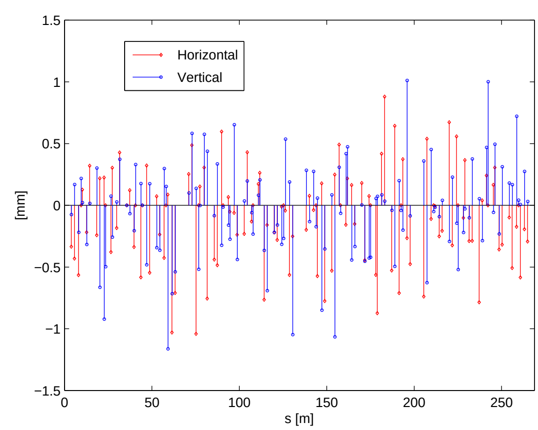

Figure 1: Offset from the electrical center of the BPMs to the magnetic center of the nearest quadrupoles (BBA offsets).

ORBIT EVOLUTION DURING COMMISSIONING

BPM Noise

In this stage of the commissioning, the switching mode of the BPM electronics was not activated, increasing the noise in the measurement of the orbit. Figure 2 shows the measured noise in the BPMs. The figure shows the change in the reading of the BPMs during a period of 180 seconds, with a new measure each second, respect the average value.

Bare Orbit

In the initial stage of the commissioning one corrector in each plane was needed for injection and accumulation

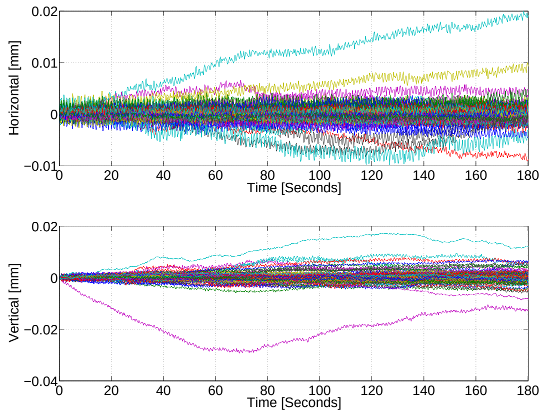

Figure 2: Signal in the 102 working BPMs, measured during 180 s, at 2 Hz. Some BPMs present a large drift of several 10s μm, but the noise is under the μm level.

but after reaching the right working point, and the injection parameters have been optimized, it was possible to inject and store the beam without any correctors. The bare orbit is small (3), a sign of a good alignment.

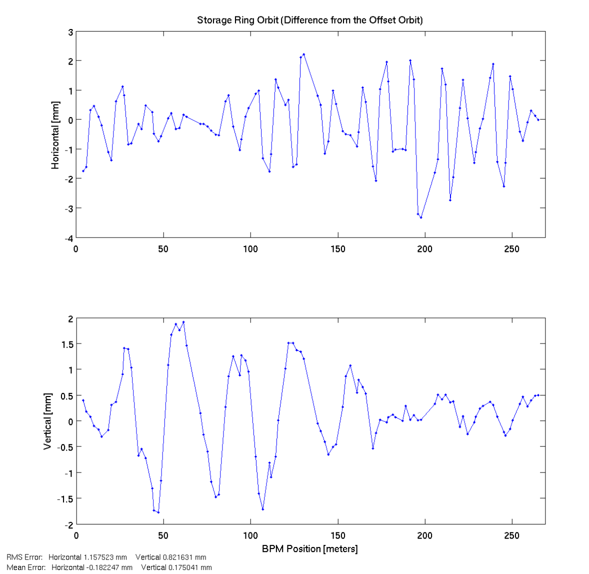

Figure 3: Measurement of the bare orbit.

Best Correction

Starting from the bare orbit, using a measured response matrix, and using the Tikhonov regularization method to invert it, the orbit has been corrected down to values circa 30 μm at all the BPMs, using a only 30 % of the avalaible corrector strength. Figures 4 and 5 show the results.

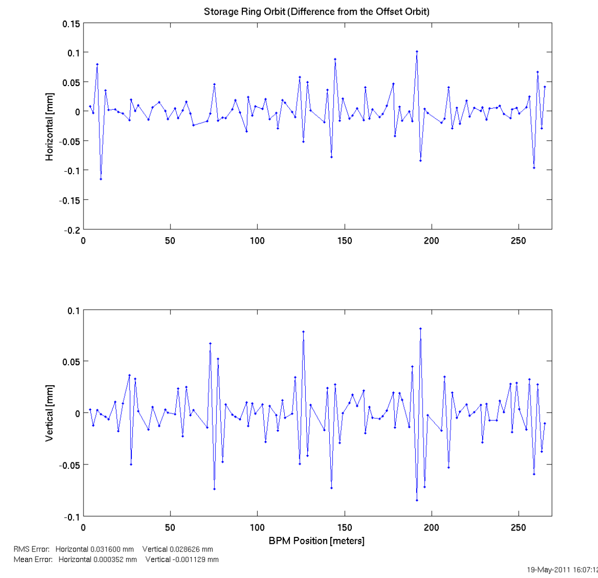

Figure 4: Optimal orbit correction. Orbit corrected at the 102 BPMs, using the Tikhonov regularization.

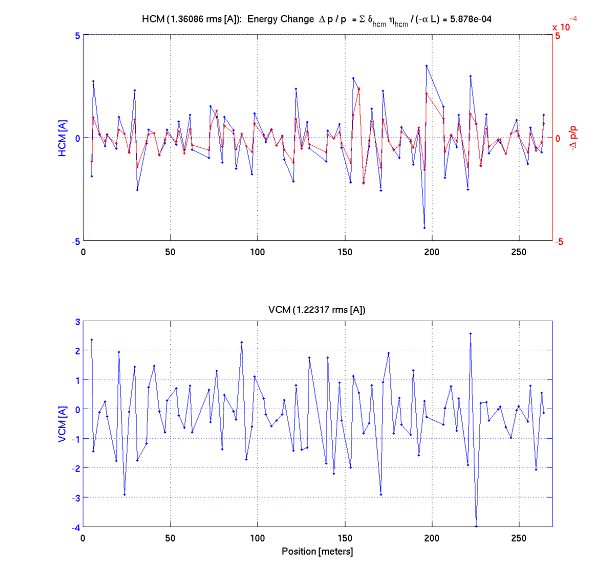

Figure 5: Optimal orbit correction. Current in the correctors. The correctors can reach up to 10 A, corresponding to 1 mrad of deflection.

Reproducibility

The orbit of the machine was very reproducible, with changes up to 100 μm between days or when changing the conditions of the machine (cycling of the magnets, changes of the chromaticity). Figures 6 and 7 show the change in the orbit and correctors along the commissioning. The large reductions in orbit and corrector strength corresponds to the setting of the right RF frequency (first large drop) and to the inclusion of the BBA offsets.

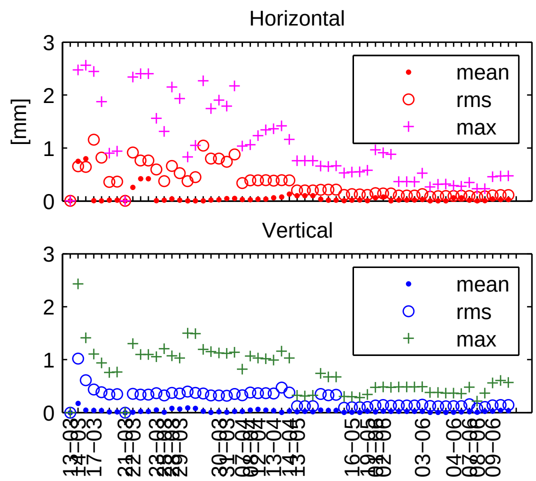

Figure 6: Orbit evolution. Measured corrected orbit during commissioning. The first large reduction corresponds to the fixing of the central frequency. The next one to the BBA offset inclusion in the correction.

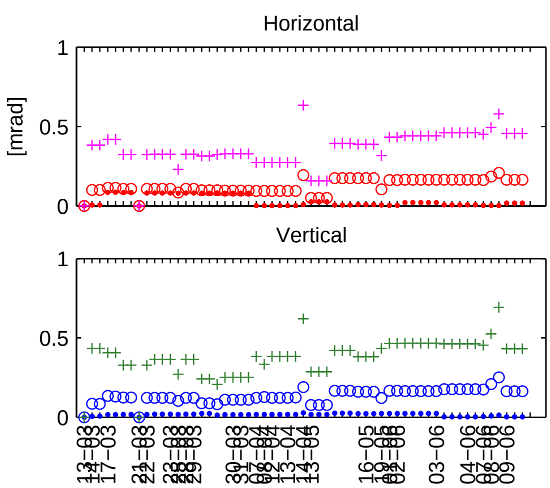

Figure 7: Orbit evolution: Corrector values corresponding to 6. Note that the mean value of the horizontal correctors goes to zero when the frequency is corrected.

COUPLING AND DISPERSION

The orbit correction system also compensate the coupling and the dispersion. Figure 8 shows a typical measurement of the horizontal and vertical dispersion after correcting the orbit. The vertical dispersion is under 10 mm. The measured coupling is between 0.5 % and 2 %. This value is consistent with measurements of the beam size and of the lifetime.

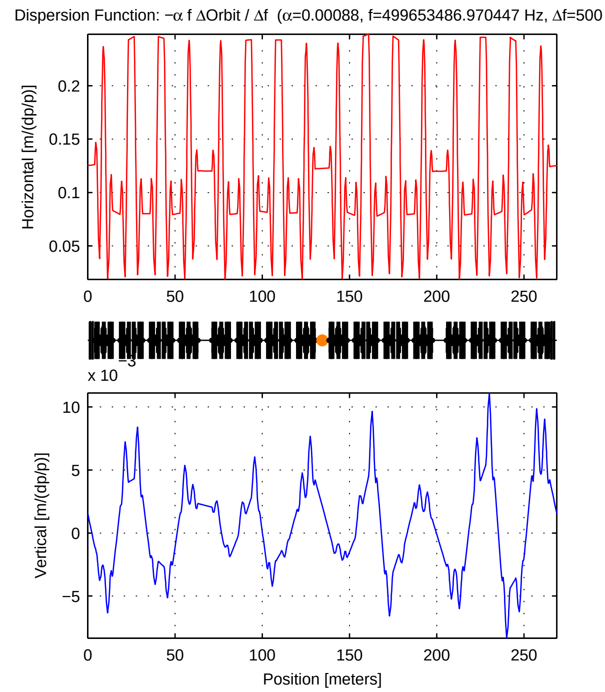

Figure 8: Measured Dispersion. The gain and coupling of the BPMs, calculated by LOCO, are taken in acccount.

NEXT STEPS

Definition of the Golden Orbit

In the next steps of the commissioning, synchrotron light would be delivered routinely to the beam lines for commissioning. A golden orbit in 88 BPMs would be defined, and the orbit will be corrected using only this BPMs, using the other 16 for monitoring. In the future, the 104 BPMs could be used for correction, including weights.

Feedback System

The Slow Orbit feedback has been already been tested, running as a Matlab application. The maximum rate of the present implementation is 0.5 Hz, and has proved capable of compensating the perturbation created by closing the gap of the multipole wiggler. The design of the Fast Orbit feedback is finished, with the implementation under way, and is expected to be commissioned before the end of 2012.

REFERENCES

[1] D. Einfeld, "Commissioning of ALBA" IPAC'11, September 2011, MOXAA01, This proceedings, `http://www.jacow.org`.

[2] M. Muñoz and D. Einfeld, "Lattice and beam dynamics of the ALBA storage ring",ICFA Beam Dyn. Newslett. 44, 2007.