

# THE LNLS EXPERIENCE WITH LIBERA BRILLIANCE

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## Abstract

The digital beam position monitors manufactured by the Slovenian company I-Tech have emerged as a rich tool for diagnostics, extending measurement capabilities and allowing routine execution of a wide variety of machine physics experiments. This paper reports on the LNLS experience with a Libera Brilliance unit through the realization of a set of experiments which allowed testing key features of the instrument, taking advantage mainly of its turn-by-turn and fast data capabilities. Moreover, the development of a Matlab control program and future plans regarding new applications and installation of a second unit are presented.

## INTRODUCTION

The LNLS storage ring is equipped with 24 MX-BPM electronics produced by Bergoz Instrumentation, which are able to generate position data at sub-micrometer level with reduced bandwidth or micrometric resolution at 1 kHz. These monitors are operated under the maximum effective sampling rate of 2 S/s after analog filtering (16 Hz), oversampling (620 SPS) and up to 255 averages, which is limited by the serial-based proprietary control system developed in the LNLS [1]. That system limits the performance of wide bandwidth measurements, for which purpose-specific instruments such as streak camera, pinholes or oscilloscopes are normally employed.

In this scenario the new digital beam position monitors I-Tech [2] have extensively delivered to the market seemed to be an interesting complementary option, taking also into account the features available for the implementation of fast feedback loops [3].

Many tests could be performed by using the turn-by-turn and fast data features of a unit installed at a high betatron location in parallel with a regular MX-BPM. This setup allowed the observation of damping times in different conditions, as well as *beam-based* characterization of new steering magnets current supplies, tracking of low frequencies coupling the beam and observation of the slow orbit feedback system asynchronous action over the beam.

## MATLAB GUI

A Matlab control program has been developed since the earlier tests with the equipment, considering the potential processing flexibility of this environment. The instrument communication layer uses a free Windows program called T4eRexec to remotely execute shell commands in the Libera embedded operational system. This communication scheme was chosen due to its simple implementation as compared to others available and it was shown to be effective.

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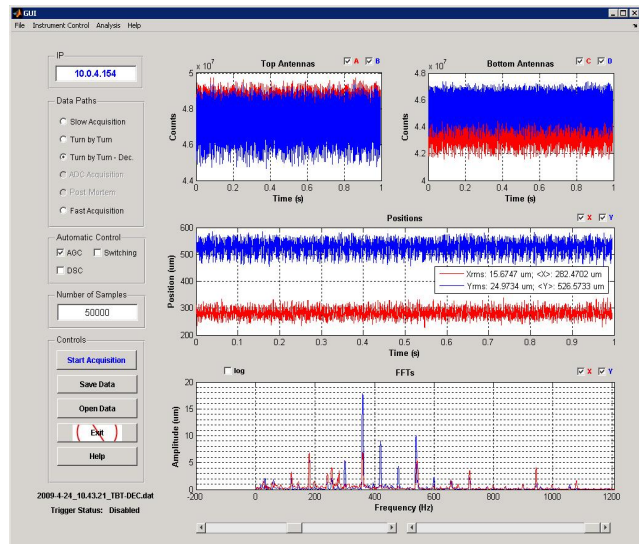


Figure 1: GUI developed for the Libera tests.

The user interface showed in Fig. 1 provides access to all the operational features of a general unit in addition to post-processing analysis tools which are gradually being added. It is possible to set and check environment variables, get data from all data paths and proceed with transversal and longitudinal data analysis which includes FFTs. Spectrograms and phase-space ellipse measurements are to be implemented in the next period with the installation of a second Libera unit.

## FAST DATA – ORBIT CORRECTIONS

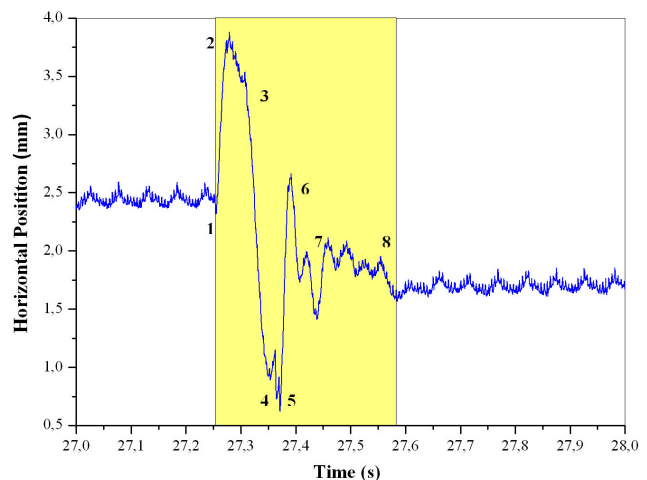


Figure 2: Asynchronous action of steering magnets during an orbit correction.

Figure 2 is an example of fast data acquisition (~10 kS/s) illustrating the asynchronous effect of the orbit correction system, in which at least 8 sequential kicks can

be noted, with the whole correction process lasting about 320 ms.

In the presented case this effect is harmful since it shows corrections during an energy ramp, when the beam position drifts are big and further deviations can exceed dynamic aperture and lead to beam losses. Corrections executed during ordinary user shifts are essentially imperceptible considering the orbit is already settled and the deviations between consecutive corrections are then negligible. The synchronization of the corrections will be possible after replacing the control system processing units to an ethernet-based version, where interruptions can be used easier to receive trigger signals, allowing all the power supplies to implement the calculated change at the same time. This improvement is being discussed along with the Control Group.

## DECIMATED TURN-BY-TURN

### Steering Magnets Power Supplies

In the last two years the LNLS started an effort to replace the steering magnets power supplies in order to improve several features of these devices, a replacement which shall be concluded by the end of this year. The previous version presented several problems due to aging, leading to frequent maintenance interventions. Taking advantage of this problem, many technological improvements could be added to the new design leading to faster rise time, lower ripple, power factor correction, long term stability, among others.

Figure 3 shows through decimated turn-by-turn data ( $\sim 50$  kS/s) the different step response of the two versions of power supplies (the new and the old one) directly coupled to the e-beam. As can be noted ACH07A power supply is far better than ACH08A, revealing a really short settling time  $\tau$  and no ringing, which confirm the effectiveness of the new design.

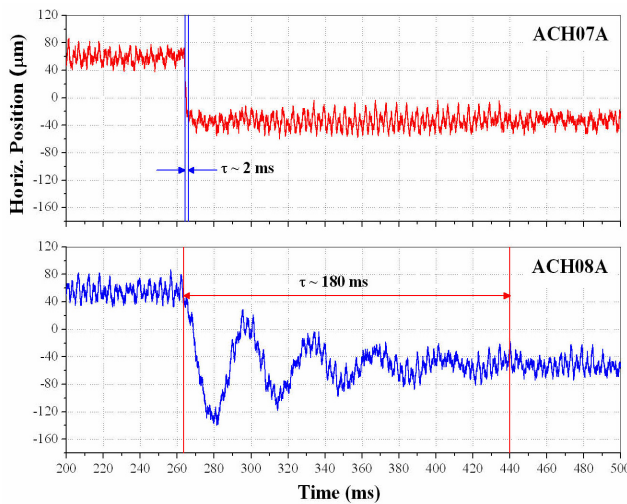


Figure 3: Steering magnets current supplies response.

### Coupled Vibration and Electrical Disturbances

Huge oscillations are also clearly observable in Fig. 3, reaching tens of  $\mu\text{m}$ , corresponding up to the 12<sup>th</sup> 60 Hz harmonic contamination in addition to low frequency vibration modes associated to girders and water pipes as can be seen in the Fig. 4, which shows the FFT of position data taken during an ordinary user shift. The peaks are associated to the high voltage power supplies polarizing the klystron tubes and ripple in the steering magnets current supplies. A strange blur that can be observed around 240 Hz in the horizontal direction is under investigation.

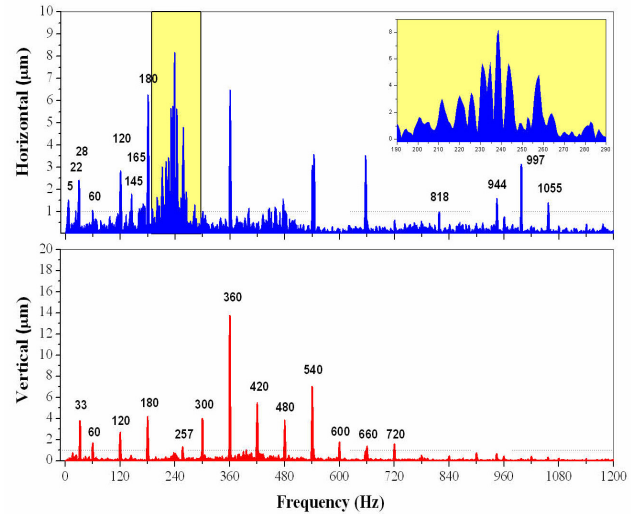


Figure 4: Low frequencies coupled to the e-beam.

## TURN-BY-TURN

Figure 5 shows different responses of a 4 mA single bunch bucket for a horizontal kick under different chromaticities. As pointed out in [4], damping time can not be uniquely explained by fitting just one exponential, even in the single bunch mode.

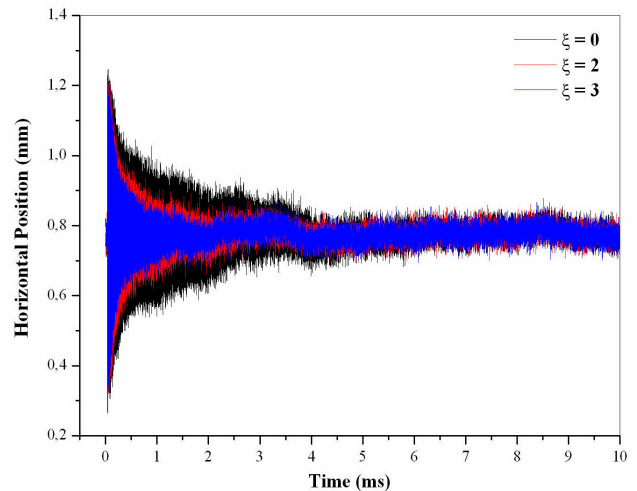


Figure 5: Damping time for different chromaticities in the single-bunch mode.

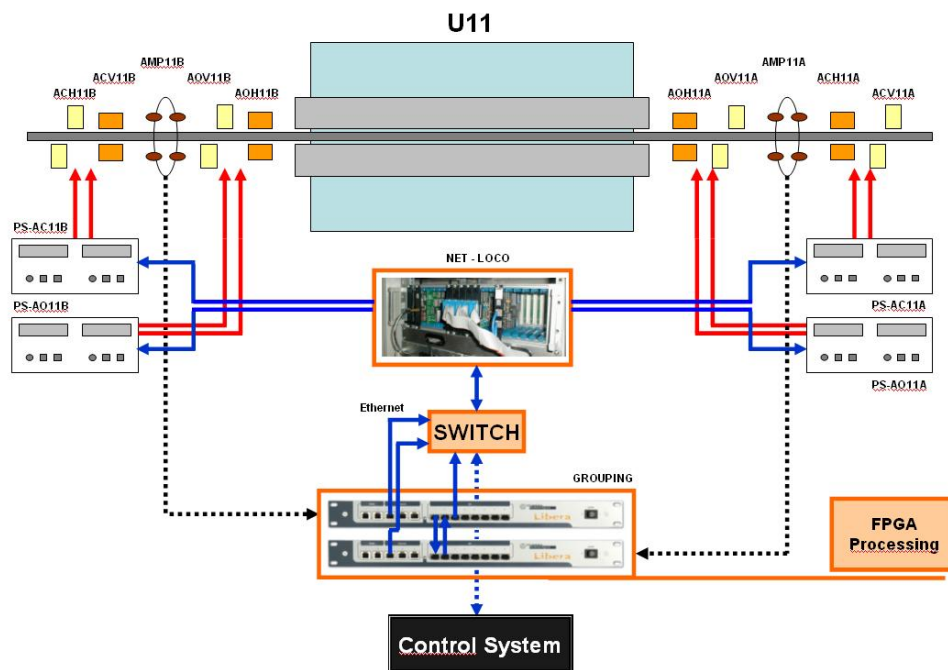


Figure 6: Schematic view of the planned fast feedback system for the LNLS elliptically polarized undulator (EPU).

As can be noted in Fig. 5, the initial 0.5 ms exhibits a faster damping time than what follows in the next milliseconds. A possible explanation for this behavior is the presence of more than one decoherence time for longitudinal e-beam islands of stability created by the RF phase modulation set in the ring to suppress coupled bunch modes driven by HOMs in the cavity [5]. Further experiments are necessary to better understand the terms which contribute to this behavior.

## PERSPECTIVES

A second Libera unit is going to be installed in the same straight section where the first one is (the last one without an insertion device), taking advantage of the high betatron function and the minor contribution of residual fields. That simplification may make the interpretation of phase-space measurements easier, allowing us to measure more accurately the twiss parameters. Turn-by-turn data display a very rich variety of phenomena that depend on beam parameters. In particular, it has been shown [6, 7] that turn-by-turn data has a tremendous potential for the study of nonlinear beam dynamics. Unfortunately the task of inferring beam parameters from data is not easy and we are currently pursuing it.

Additional plans for developing a fast local feedback system [8, 9] for the elliptically polarizing undulator, as depicted in Fig. 6, are in course. One of the objectives here is to get familiarized with Libera FPGA capabilities and fast feedback building blocks.

Measurements of the injection efficiency through the single-pass capabilities of the last Libera software release will also be possible by installing these two units along the booster to storage ring transfer line.

## SUMMARY

These first set of machine experiments revealed Libera Brilliance as a versatile equipment which can help the accelerator physics group to better understand the machine and to refine its model through several experiments, such as, among others, transverse phase-space measurements from which it is possible to get the characteristic parameters of the storage ring optics. In the next period the instrument FPGA programming capabilities are going to be explored by the implementation of a local fast feedback loop, part of the preparation for the LNLS-2 detailed project.

## REFERENCES

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