DIAGNOSTICS DURING THE ALBA STORAGE RING COMMISSIONING

U. Iriso*, M. Álvarez, F. Fernández, F. Pérez, A. Olmos
CELLS, Cerdanyola, Spain

Abstract

The ALBA Storage Ring is a 3 GeV 3rd Generation Synchrotron Light Source whose 1st phase commissioning took place in Spring 2011. The machine is equipped with 123 BPMs, one stripline, seven fluorescent screens, FCT and DCCT, 128 BLMs, and two front ends strictly used for electron beam diagnostics (pinhole and streak camera). This paper presents an overview of the Diagnostics elements installed in the machine and our experience during the commissioning.

INTRODUCTION

The ALBA Storage Ring is a 3 GeV Light Source of roughly 270 m circumference and small emittance (4.3 nm-rad). With an rf system of 500 MHz, it is designed to store up to 400 mA. The first phase (no operation of Insertion Devices) of the ALBA Storage Ring (SR) commissioning started in March 2011. In June 2011, we start insertion devices operation. Beamline commissioning is scheduled for Autumn 2011, and Users Operation is foreseen in Spring 2012.

Throughout the commissioning, the Diagnostics components are key elements to check SR performance. The electron beam is characterized by measuring its current, transverse and longitudinal shape, and transverse position inside the vacuum chamber. For these purposes, we installed 123 BPMs to monitor and correct the orbit, 128 pin diodes Bergoz BLMs to detect beam loss locations, one Fast Current Transformer (FCT) and one DC Current Transformer (DCCT) to check longitudinal beam structure and beam intensity, one stripline BPM for beam excitation during the tune measurements, and seven Fluorescent Screens (FS) to crosscheck beam size and position during early phases of SR commissioning. Two front ends are exclusively designed for beam diagnostics: an xray pinhole camera and a visible light beamline where the streak camera will be used.

A short straight section (2 m) is equipped with the main diagnostics components (see Fig. 1). This note presents an overview of the Diagnostics components in the SR and our experience with them.

FLUORESCENT SCREENS

We installed 5 in-air FS [1] which are moved in/out using a pneumatic piston. They were used to perform the 1st turn analysis. Furthermore, we installed two "horizontal" FS (FSH) whose motion is controlled by a motor. Located downstream the injection septum and downstream the first

* ubaldo.iriso@cells.es

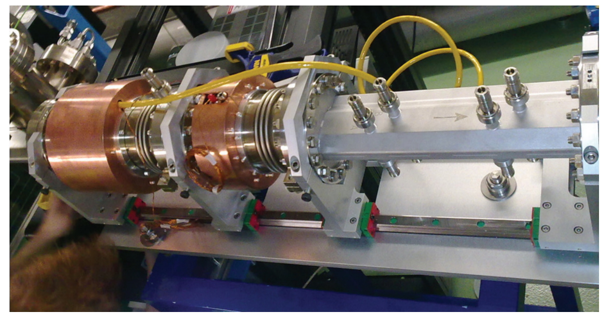

Figure 1: Beam diagnostics components in Sector 2. From left to right, the DCCT, AE, FCT, and a stripline BPM.

injector kicker, they were very useful to monitor the injection and kick angle through the beam centroid position. Figure 2 depicts the sketch with the FSH location (bottom), and three beam images (top) with the centroid position, from where the injected and kick angle are directly inferred.

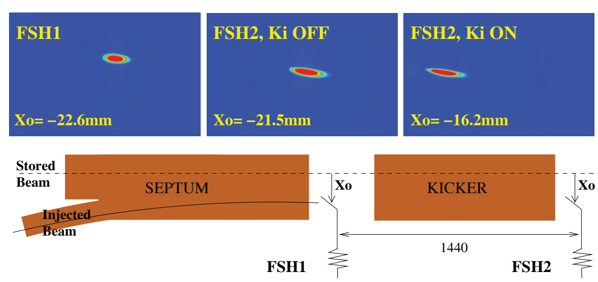

Figure 2: Sketch of the FSHs location at injection straight (bottom), and beam image at FSH1 (left), at FSH2 with kicker OFF (middle) and ON (right).

BEAM CURRENT MONITORS

In order to prevent high temperatures that could potentially damaged the coils, we installed a compressed air cooling circuit in both the FCT and DCCT (both of them are off-the-shelf Bergoz products). So far, injecting up to 100 mA did not produce any overheating in the FCT and DCCT coils. Figure 3 shows the injection of 75 mA in the machine (while monitoring beam size). The DCCT rms variation with no beam is ±2μA, which is taken as the DCCT resolution. However, we observe intensity oscillations in the order of 20μA when cycling the magnets and with temperature drifts.

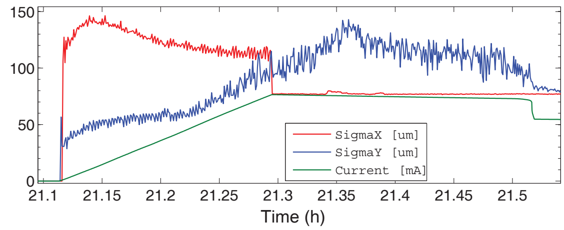

Figure 3: Injection of 80mA in the SR and beam size evolution. At 21h30, the beam is deliberately lost due to the insertion of the ver scraper.

The FCT and DCCT are continously used to check machine performance. It is also used to detect beam intensity assymetries. For example, a Fast Ion Instability which currently triggers at about 25 mA. Figure 4 shows the effect of closing the vertical scraper jaw from 10 to 0.25 mm: only the last bunches in the train are affected while the beam current is reduced from 75 to 55 mA.

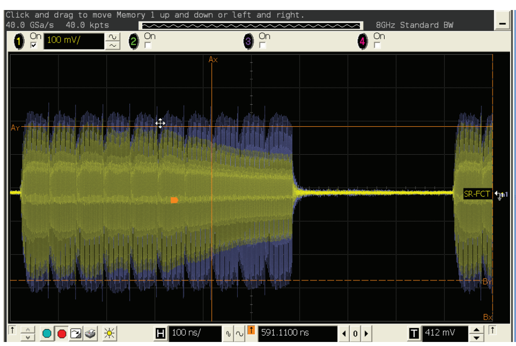

Figure 4: Bunch train before and after closing the vertical scraper gap in Fig. 3.

BEAM POSITION MONITORS

ALBA is equipped with 123 BPMs: two are reserved for future Bunch-by-Bunch feedback, one for diagnostics purposes (tune and beam dynamics measurements) and 120 for orbit control and interlock system. Beam signal is picked-up by 7 mm diameter feedthroughs [3] and brought to the Service Area by low-loss phase match RF cables of a wide variety of lenghts (12.5m-45m).

Figure 5 shows the slow acquisition rate (10 Hz) at one BPM during 40 min (beam intensity 20mA). Reading electronics (Libera Brilliance) were working on the basic mode, so no switching between input channels and no digital signal conditioning (DSC). The rms values (between 2 and 3µm) should improve with increasing current, using DSC and with better temperature stability in the tunnel and service area.

The orbit interlock system is already working and it dumps the beam whenever it is out of bounds (±3 mm hor, ±2 mm ver). Fine adjustments are still being carried out to avoid false trips during injection. Typically, the SR orbit after correction is kept below ±0.5 mm in both planes. The orbit should further improve when applying the BPM offsets obtained via Beam Based Alignment (currenly being applied), and the slow and fast orbit corrections (still to be implemented).

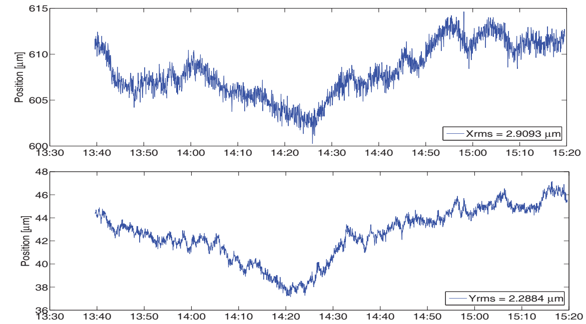

Figure 5: Beam stability during 40 min.

TUNE MEASUREMENT SYSTEM

The stripline BPM is composed of 4 electrodes matched to 50Ω, and is used for beam excitation during tune measurements. With the 50 W amplifier, the effective kick is $\Delta\theta = 0.15$ µrad [2]. Once the beam is accumulated, the excitation is carried out using a white noise function generator whose frequency and span is remotely controlled. Using a multiplexer, the stripline electrodes bias can be switch to produce either horizontal, vertical or diagonal excitation. Figure 6 shows the sketch of the tune excitation system.

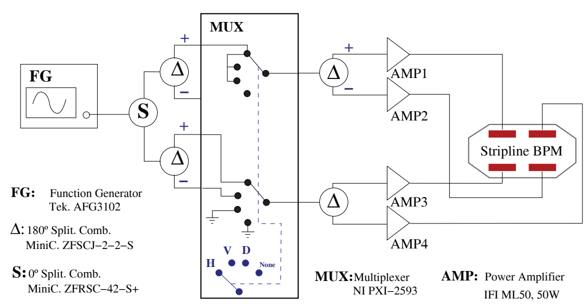

Figure 6: Sketch of the tune excitation system.

The FFT of the turn-by-turn data of any BPM then provides the fractional betatron tune. The result is that the tune (on both planes) can be monitored continuosly without problems of trigger or synchronization, allowing any tune required beam dynamics studies (as chromaticity measurements). Figure 7 shows an example of the tune measurement in the horizontal plane.

X-RAY PINHOLE CAMERA

Measurement of the transverse beam size is performed using a pinhole camera. To avoid the diffraction limit, this system analyzes the xray domain of the synchrotron radiation produced when the electron beam goes through a bending magnet.

A sketch of the pinhole camera is shown in Fig. 8, following the design in other machines [4]. The xray beam

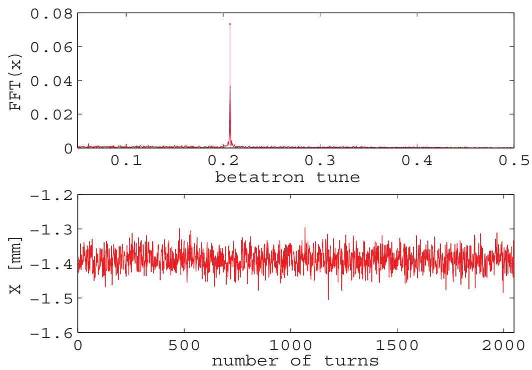

Figure 7: Example of a tune measurement in the hor plane.

goes through the 1mm Al window, which separates the vacuum from the in-air components and cuts out the radiation below 10keV. Later, a Cu block is gradually inserted in/out to chose the desired thickness that filters the remaining xray beam. We usually use about 0.2mm, which provides an xray beam of about 45keV. The pinhole is made using tungsten blocks of 3mm thick with slits of 100, 50, and 10µm. Placed vertical and horizontally, the slits form a grid in which we can chose either pinholes of 9 different sizes. Four motors allow us to move the pinhole block as desired. We typically use the smallest one (10x10µm). Downstream the pinhole (13.6m away), a YAG:Ce screen converts the xray into visible light and the image is captured by a CCD.

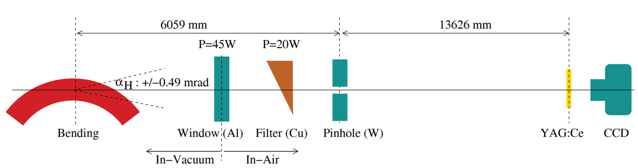

Figure 8: Schematic lay-out of the pinhole camera.

All in all, the pinhole system has been operational since first week of commissioning. This allowed us to detect hardware misfunctionings (a misconnected quadrupole power supply), determine the intensity thresholds and cures for the vertical instability, check beam size evolution with beam intensity, etc (see Figs. 3 and 9). Once dispersion and energy spread at the pinhole location were confidently measured, we also determined beam emittance. The smallest one we measured is ϵ_x = 4.4nm·rad with 2% coupling.

VISIBLE LIGHT MONITOR

Besides the pinhole camera, we also set-up a front end that uses the visible part of the synchrotron radiation to precisely analyze the longitudinal bunch structure (we followed the ESRF design [5]). The key system of this front end is a Cu mirror that is inserted vertically into the synchrotron radiation produced by a dipole. It is equipped with three thermocouples to avoid possible heat load damage in the mirror and control its vertical position.

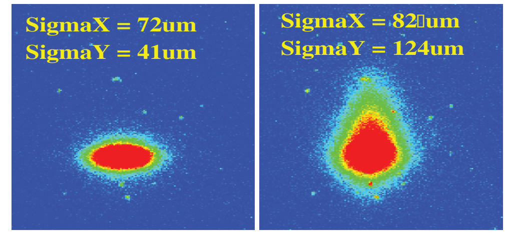

Figure 9: Beam pictures at 20 mA and 30 mA. In both cases, ξ_v=0.2.

The goal of this Front End is to reflect only the visible part of the spectrum. The light is directed to the Diagnostics Hutch through a hole in the shielding wall using conventional mirrors. The light is then analyzed by means of a streak camera, and once at the Diagnostics Hutch and using an optic splitter, we obtain a qualitative beam image (limited by diffraction effects). Although the light arrives at the Diagnostics Hutch, the streak camera has not been set operational.

CONCLUSIONS

The set of diagnostics described in this report performed satisfactorily and allowed a successful SR commissioning. All diagnostics devices perform with no problems and our task now is mainly to perform fine adjustments to increase their performance, set-up the streak camera, and prepare the slow and fast orbit correction.

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