OPERATION STATUS OF THE ALBA SYNCHROTRON LIGHT SOURCE

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Abstract

ALBA is a 3.0 GeV third generation synchrotron light source which has been commissioned during 2011. In October 2011, the seven beamlines of phase I started commissioning, 6 from insertion devices and 1 from a bending magnet. Since May 2012 the facility is open to external users. Beam current has been continuously increased and we reached 200 mA in a multi-bunch filling pattern. Orbit stability is kept at ±1 um with a slow orbit feedback running at 0.3 Hz.

The paper will review the operation and performance status of the different subsystems and review also the main objectives for 2012: delivery of 3000 hours of beam to beamlines, installation of a fast orbit feedback system and preparation for top-up operation.

STORAGE RING PERFORMANCE

The ALBA storage ring is running routinely at 100-150 mA with the filling pattern shown in Fig. 1 which consists of 8 trains, 112 ns long; on each train there are 45 buckets filled and a gap of 22 ns. This characteristic filling pattern was established on the early days of commissioning when no filling pattern control was available but it is also the pattern that provides the highest lifetime with a high onset current for transversal instabilities.

Lifetime is 15 hours for this filling pattern, 100 mA and 2.0 MV of RF voltage.

Figure 1: Filling pattern.

With 70 A.h accumulated dose until April 2012, the normalised average pressure is $2\cdot10^{-11}$ mbar in the storage ring. Figure 2 shows the evolution of the normalised average pressure as a function of the accumulated dose.

A slow orbit feedback (SOFB) is running at 0.3 Hz and keeping the orbit stable to within ±1 um. The RF frequency was recently added into the SOFB and it is corrected whenever the change is larger than 5 Hz [1]. The photon beam is as well stable in all the beamlines, except those coming from a bending magnet (MISTRAL and the diagnostic one) where we have seen in the past drifts of 10 um during one shift. Adding the RF frequency has helped to keep the photon beam more stable at these beamlines, but we are still working to further improve it.

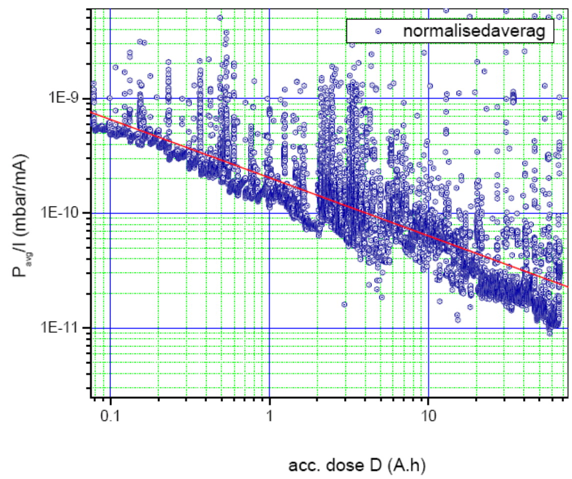

Figure 2: Normalised average pressure as a function of accumulated dose.

Table 1 shows the main parameters achieved on the storage ring.

Table 1: Main SR Parameters.

Parameter	Specified	Achieved
Energy [GeV]	3.0	3.0
Max. current [mA]	400.0	200.0
Tunes [Qx, Qy]	18.18, 8.37	18.15,8.37
Emittance [nm·rad]	4.3	4.67±0.30
Max. β_x, β_y	17.80, 24.54	17.89,24.93
Max. D_x	0.241	0.247
Energy spread	$1.05\cdot10^{-3}$	$0.89\cdot10^{-3}$
Coupling	< 1 %	0.5 %

INJECTOR PERFORMANCE

During the beamlines commissioning period, the ALBA linac has delivered bunch trains in multi-bunch mode of a length between 56 and 112 ns, 1 nC of charge, 110 MeV energy and energy spread below 0.4%. Since April 2012 the injector is running at the nominal frequency of 3.125 Hz.

On November 2011, the bidirectional coupler (bdc) placed on the waveguide after the klystron output was damaged. The internal 50 Ohm matching load of the bdc was burnt due to arcing in the waveguide system. After checking that the klystron was working properly it was found that two waveguide flanges did not make good contact and produced the arcs. The damaged waveguide

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pieces were reinstalled at different location. Since then the number of arcs has been strongly reduced. Arcing was not properly detected because it took place right after the klystron window output where no arc detection was provided. Nowadays a prototype accelerometer has been placed on the waveguide surface to detect the vibrations produced by the arcs.

The ALBA booster has been running in a reliable way. The only concern is that we missed one pulse every few seconds on a regular pattern. So far we have not been able to identify the source of this problem.

DIAGNOSTICS

The ALBA SR is equipped with 123 BPMs, one stripline, seven fluorescent screens, FCT and DCCT, 128 BLMs, and two front ends only used for electron beam diagnostics (pinhole and streak camera) [2]. The diagnostics components are operational since day-1, and have allowed an easy commissioning.

The emittance of ALBA, measured with a pinhole camera, has been found to be in excellent agreement with the model. The measured coupling, without any skew correction is 0.5 %. Currently the beam sizes are (58, 24) um in the horizontal and vertical plane respectively. See Fig. 3. These beam sizes provide emittance values of (4.67, 0.023) nm·rad, in both planes with a +/-7 % error bar mainly due to source point uncertainty.

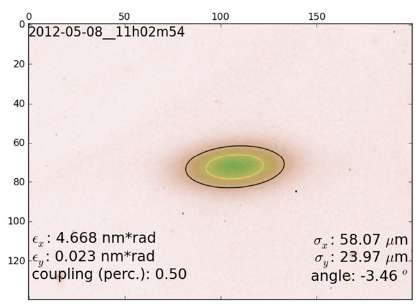

Figure 3: Emittance measurement.

On the contrary, the measurements with the streak camera show a discrepancy of 50% between the measurements and the nominal. Since all other storage ring parameters are closed to nominal values we are looking into the calibration of the camera.

We are working on the following new projects.

A Fast Gated Camera in collaboration with the CLIC-CERN project has been recently installed in order to determine the beam size variations inside the bunch train. The camera is looking at the visible part of the synchrotron light, and the image is currently dominated by the diffraction limit. Further developments are foreseen to avoid this limitation and obtain a reliable bunch by bunch transverse beam size measurement.

The hardware (stripline kickers) and electronics (Libera BbB) to set-up the bunch-by-bunch feedback system are already installed; first timing tests were successfully carried out and we plan to commission the system during this year.

The Fast Orbit Feedback system (FOFB) is based on 88 Beam Position Monitors (BPMs) and 88 power converters. The optical fiber intercommunication network and the timing distribution systems have been installed and are operational. Position data transfer from all BPM electronics to the FOFB processing nodes is accomplished by using the Diamond Communication Controller [3] and has been successfully tested using a so-called "sniffer board" borrowed from the ESRF [4]. Analysis of acquired data is shown on [1]. Data collecting and processing units are still under evaluation. A test bench in the lab is prepared to investigate the possible solutions.

RF SYSTEM

The RF system composed of six normal conducting HOM damped cavities, each one feed by combining two 80 kW IOTs [5], is fully operational since October 2011.

Two major problems have been found during the operation: vacuum leaks in the ceramic of the cavity's pick-up loops and poor reliability of the IOTs.

The first one has been solved by redesigning the pick-up loop and replacing the six of them by the new design. In Fig. 4 one can see the old design on the first two left pictures, with the ceramic dome that developed the leak and the new design on the right: an in vacuum loop with a standard N-connector vacuum feed-through.

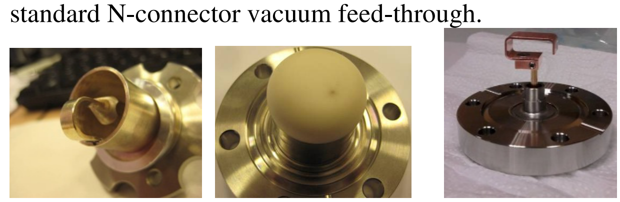

Figure 4: Cavity pick-up loops. The 2 pictures on the left correspond to the leaky old design. The picture on the right corresponds to the new in-vacuum design.

The second problem is more complex. It is related to the number of trips of the IOTs. Initially a wrong setting of the water configuration was causing an important number of interlocks, this was solved by readjusting flows, pressures and interlock settings. More recently, and due to a not proper start-up of the IOTs after a complete electrical and water shut down, a number of arcs inside the IOT is causing operational problems. This problem is not completely solved and we are now working in a proper procedure to maintain the vacuum quality inside the tubes more stable. Also, in one case, dust in the ceramic of the IOT was found to be the cause of problems.

INSERTION DEVICES

Six insertion devices were installed and commissioned already in 2011 [6].

The IVUs are running without any look-up table while the look-up tables for the APPLE-II devices have been refined with beam, complementing those coming from magnetic measurements. At present, the maximum orbit distortion is ±5 um. We expect that the FOFB will take care of this remaining distortion

Spectra measurements of emitted light taken from the IVUs have been used to check the performance of the devices as well as the Storage ring. [7]

For the multipole wiggler (MPW) we have added new correction coils, as those present initially had not the sufficient strength to correct for the observed orbit distortion, around ±100 um in the horizontal plane. A new look-up table for the correction coils has been calibrated, and now, with the slow orbit feedback running, the maximum closed orbit drift is ±5 um.

The superconducting wiggler (SCW) was installed in August. Cool down and commissioning was done in October 2011 and since then it is running regularly at 2.1 T. The l-He consumption has been null, because the cryostat operates below the l-He boiling temperature and also 0.5 bar below atmosphere pressure. Despite several quenches, correlated to electron beam losses, the boiling temperature and the internal pressure in the cool vessel never exceeded boiling temperature and atmospheric pressure, respectively, so no He losses have been produced. The SCW has a large influence on electron beam, inducing a closed orbit distortion of ±100 um in horizontal plane and ±50 um in vertical plane. Currently, correction coils are being built to compensate for these deviations.

PULSED ELEMENTS

It has been observed that the injection bump is not completely closed. Peak-to-peak deviations up to ±5 mm in the horizontal plane and ±250 um in the vertical plane have been measured at a given BPM. By changing the 4 kickers one at a time and measuring the kick produced on the orbit we have built a response matrix which has been used to adjust the kickers. A first iteration has shown that the deviations can be reduced down to ±120 um in the horizontal plane and to ±70 um in the vertical plane on the turns following the bump, as shown in Fig. 5. The study is to be continued in the future looking also the timing between the kickers and following the exchange of the present timing boards by new boards with 10 ps resolution.

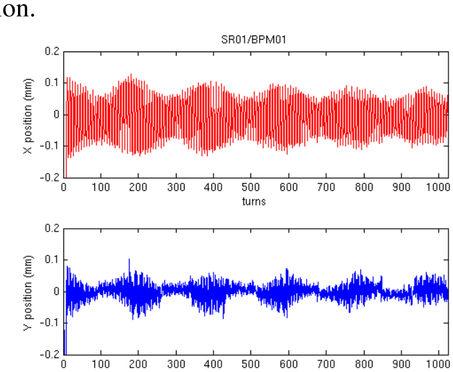

Figure 5: Residual orbit after adjustments.

Also, during the first shifts of commissioning we realised that the BO extraction septum and the SR injection septum were running at about 10% higher current than expected and that the SR injection septum had a non-negligible contribution to the stored beam orbit. The problem was addressed by breaking a ground loop which was established around the septa magnet by the wrong installation of a ceramic breaker. After the change has been implemented the septa are now running at nominal current and the orbit distortion has reduced to ±50 um in the horizontal plane and ±20 um in the vertical plane. Further effort to reduce this distortion is under way.

OPERATION

Starting in March 2011, the storage ring ran for 1320 h in 2011. Of this time, 75% was dedicated to storage ring commissioning and 25% to beamline commissioning.
For 2012 up to 4300 hours of operation have been scheduled. Of those, 3200 h will be devoted to users, the rest is shared between start-up periods and further machine commissioning and development. The storage ring runs for periods of 4 weeks on a 24h/7 days basis.

During the 4 first runs of operation of 2012, an average up time over 90% has been achieved. Issues with the RF, the pulsed elements and the BO as well as the SR power supplies have been responsible for most of the down time. Fig. 6 shows the beam availability since October 2011.

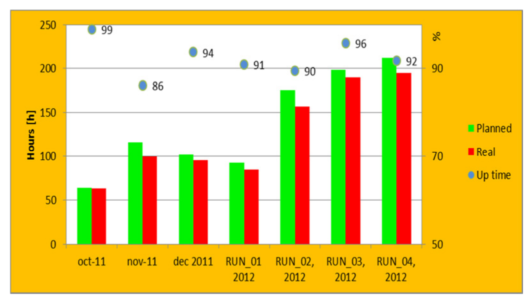

Figure 6: Beam availability since October 2011.

OBJECTIVES FOR 2012

The main objectives for 2012 are to implement the FOFB system and a transverse bunch by bunch feedback system. We are also doing the first simulations for top-up and some initial test to inject with the FE open have already taken place.

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