1ST YEAR OPERATION OF THE ALBA SYNCHROTRON LIGHT SOURCE

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Abstract

ALBA is a 3 GeV, 3rd generation, synchrotron light source located in Cerdanyola del Vallès, near Barcelona (Spain), which started users operation in May 2012.

In this paper we will report about the transition from commissioning to operation, the main problems faced during this first year, the actual status of the accelerators and we will provide an outlook to the next steps.

STORAGE RING PERFORMANCE

Since the end of 2011 the storage ring has been routinely operating, initially for beam line commissioning and since May 2012 for users operation. The main parameters of the storage ring have been achieved [1].

The ALBA storage ring is, typically, running 120 mA in multibunch mode, with a filling pattern consisting of ten trains of 66 ns separated by 22 ns gaps. For this filling pattern and 2.4 MV of RF voltage, the product lifetime x current is around 2000 mA·h.

For users, the machine runs in "decay mode" with two injections per day, normally from Tuesday to Sunday, leaving Monday for small maintenance tasks and accelerators setups (see Fig. 1).

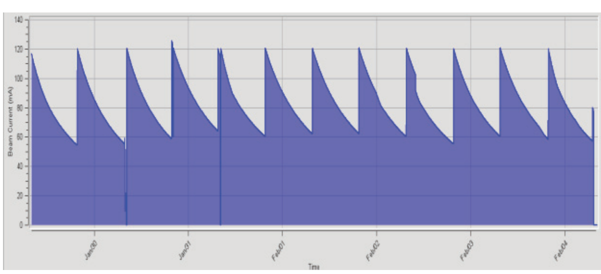

Figure 1: Beam current along a week period.

Orbit stability is maintained by the slow orbit feedback system (SOFB) below 1 um (rms) all around the storage ring, as measured by the eBPMs. In addition, the xBPM corresponding to the bending magnet beamline has been added to the SOFB in order to compensate for the thermal drift observed at this beamline. [2].

OPERATION

In 2012 around 4000 hours of operation were scheduled. Of those, 3000 h were devoted to users, with the rest shared between start-up periods and further machine commissioning and development.

The storage ring runs for periods of 4-5 weeks on a 24h/7 days basis. Eleven of these runs have been performed along the year, with one week maintenance in within runs and two long shut down periods in Christmas time and summer.

Figure 2 shows the availability along the eleven runs of 2012. The average beam availability has been 94 % without taking into account the run in November, when as a consequence of a large vacuum incident the operation was stopped for two weeks. The Mean Time Between Failures (MTBF) for 2012 has been 21 h.

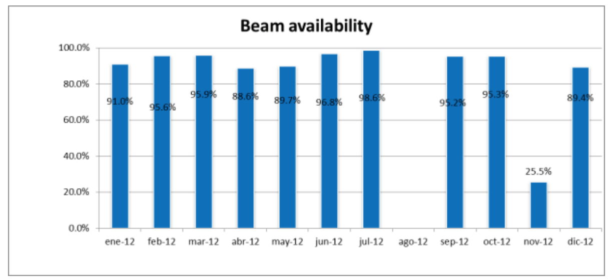

Figure 2: Beam availability per month along 2012.

Figure 3 shows the number of trips per main sub-system and figure 4 indicates the down time due to each sub-system excluding the vacuum incident, which as a single incident accounted for 57% of the total down time in 2012.

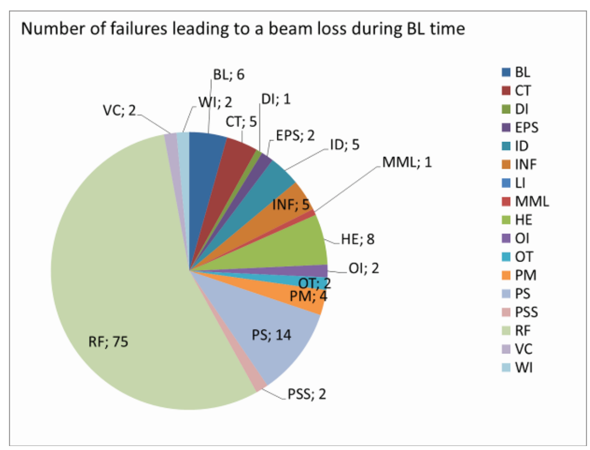

Figure 3: Number of trips per sub-system along 2012.

Analysis of figures 3 and 4 tells us that the main sub-systems causing problems are the RF and the power supplies (PS). The RF system has many failures with a short recovery time, while the power supplies have less failures but produce longer down times. This time has been reduced by improving the protocols dealing with power supplies replacement after a PS trip. The vacuum incident, the analysis of the RF failures and some additional problems faced during 2012 are described in the following paragraphs.

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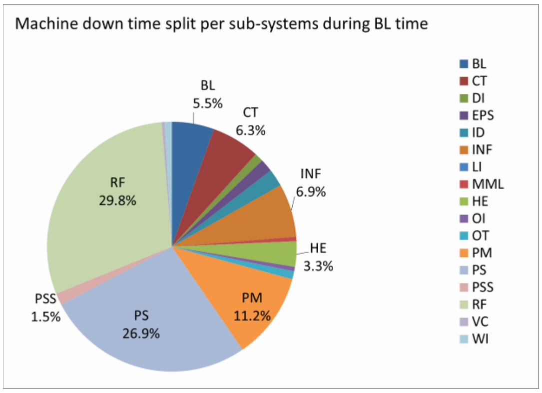

Figure 4: Down time for each sub-system, excluding the vacuum incident.

VACUUM INCIDENT

The vacuum incident took place on November 13th. The previous week had been a shut down week in which, among other maintenance tasks, there have been functional tests on the FOFB system and internal parameters on the SR corrector power supplies had been exchanged and unfortunately not replaced.

During the start-up phase the gain of the BPMs had to be adjusted and re-calibrated. The first part of this task is performed with the orbit interlock disabled so that any fake interlock generated by the electronics during the adjustment process does not kill the beam.

In parallel there is an attempt to bring the orbit to the um level. At this moment, 21 vertical correctors went off because the internal parameters were not correct. The orbit correction applied is removed because it is observed that the orbit has increased. Since there are 21 correctors off, the orbit does not return to the initial value but keeps getting away from the nominal.

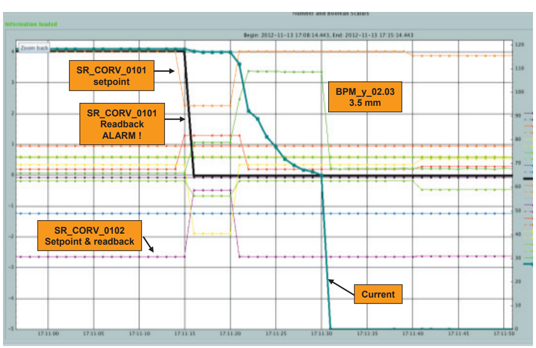

Figure 5: SR_CORV_0101 With the first change applied the corrector (setpoint=thin orange line) enters in alarm, and switches off (thick black line). The orbit (green line) moves to +1 mm, and when the correction is removed the orbit jumps to 3.5 mm on this specific BPM.

There are excursions up to ±10 mm in the vertical plane, the beam scrapes the vacuum chamber and immediately after five sectors in the SR indicate pressures in the 10^{-3} mbar range.

The day after systematic leak detection is performed around the SR. Leaks are "only" found in the VAT seal of the flange downstream of the dipoles. Having checked that there are enough spares, a systematic program to replace 13 damaged seals starts. One week later there is a first injection in the SR of 1 mA. It is confirmed that no further damage is present. After that an intensive schedule for vacuum cleaning is established, figure 7 shows the recovery of the product lifetime x current. Two weeks after the incident, 100 mA were provided to the BLs.

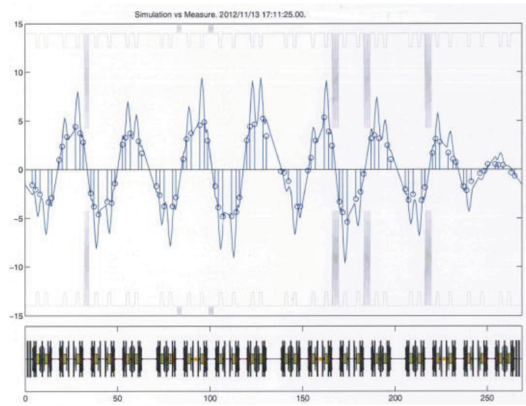

Figure 6: Maximum orbit distortion during the incident: Lines show the simulation and circles are the measurements at the BPMs. In grey the machine minimum vertical apertures are shown.

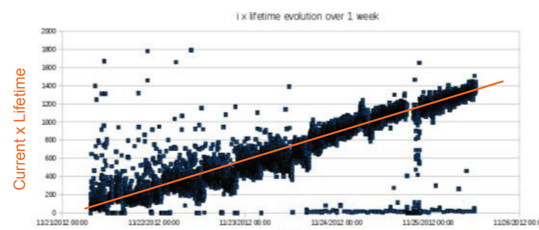

Figure 7: Recovery of the current x lifetime product after the vacuum incident.

RF SYSTEM

The RF system composed of six normal conducting HOM damped cavities, each one feed by combining two 80 kW IOTs [3], is fully operational since October 2011.

At present, there are several RF interlocks per week. The redundancy given by the six cavities makes possible the survival of the beam after one of these trips. Usually, less than 10% of RF interlocks leads to beam dumps.

One third of RF interlocks are due to water interlocks, another third are due to arcs inside the IOT tubes and the rest are due to arcs in other parts of the RF system, vacuum interlocks, reflected power and others.

To reduce the number of water interlocks, more diagnostics and air releasers have been installed in the cooling system of the IOTs. To reduce the number of arcs in the IOTs, the ion pumps of the tubes have been left always in operation even during shutdown periods and a new conditioning process for the tubes has been implemented after shutdown periods. This has proven to reduce the number of arcs in the IOTs.

During the last year and half, 5 IOTs broke down during operation. Two broke during SAT due to a mistake in the manufacturing process of the ceramic; one broke due to a water leak that flooded the ceramic while

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operating and the last two broke due to arcs inside the tube after 7000 hours of operation.

An autorecovery process has also been implemented in the digital LLRF system in order to recover, with a circulating beam, the faulty RF plant after a trip.

A Coaxial Stub system, CoStub [4], has been also installed in the RF plants. This system permits replacing one faulty IOT while keeping the other running, reducing the downtime of RF plants.

OTHER OPERATIONAL ISSUES

Linac Performance

Arcing problems in the waveguide system that occurred during last year, were solved by installing a new type of gaskets that improved the contact between flanges.

The linac beam energy oscillates around 0.4% between the morning and the evening injection. However, since the booster energy acceptance is higher than 1%, these energy variations have not disturbed the ALBA operation.

Radiation Damage on Injection Kicker

The thyristor driver board of kicker 02 of the storage ring had an erratic behaviour. It could start by presenting erratic drifts when switching on the kickers for injection, and showing a total failure after some weeks. The first times the board was simply replaced but a further analysis was required as the problem turned out to be recurrent. Having discarded a problem on the board itself, and any temperature related effect, shielding was locally applied to the KI pulser unit and since then the driver board has been running without any further trouble. Radiation measurements indicate the presence of high energy neutrons in the vicinity of this kicker. The component failing was identified as the MOSFET IXDN614 and IXDI614, which are the gate drivers used to switch the thyristors.

ID Operation Issues

IDs have been operated without relevant problems. Regarding the multipole wiggler MPW80, all optical limit switches have shown to be not resistant to radiation and have been replaced by mechanical limit switches. Also, correction coils have been installed in the superconducting wiggler SCW30 in order to control the horizontal field integral and complement the control of the vertical field integral through a feed-forward table.

The most severe incident with an ID happened in October 16th. The exit condenser bridge of one power supply of SCW30 was burned, leading to an increase of electrical output noise. This induced extra heating in the wiggler coils, through eddy currents, that the cryocoolers were not able to extract. Because of that, the SCW30 could only be operated during half a day, needing the next half day for cooling. This situation affected RUN #9 and lasted for two weeks. It was solved during the shutdown period right after the run, by replacing the burned condenser bridge.

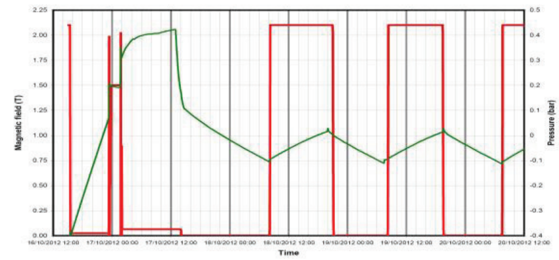

Figure 8: Evolution of internal pressure (green line) and magnetic field (red line) in the superconducting wiggler during the October incident showing the 12 h on/off sequence.

NEXT STEPS

ALBA will operate 5300 h this year 2013. The main objectives for 2013 include:

Implementation of the Top Up mode: The simulations for safe operation have been already performed [5] and the implementation of the safety interlocks and the control system is under way.

Implementation of the fast orbit feedback system. First tests with the hardware have been performed and full installation of devices is done. The chosen architecture of the FOFB system is based on 88 BPMs and 88 horizontal and vertical correctors [6]. Correction is distributed on 16 nodes, one per machine sector. Each node includes a sniffer board for BPMs data reception, a processing CPU for correction calculation and the corrector power supplies controllers. Current activities on the FOFB system are addressing the definition of the correction algorithm, its implementation and its tests.

Implementation of the transverse bunch by bunch feedback system. The stripline kickers and the Libera BbB front-end are already installed and first tests have been successfully carried out with beam. Regarding the feedback kickers, first tests demonstrated that the striplines provide the designed kick [7], while the tests using the electronics system were used to check the appropriate phases and delays of the system. The required software to control the whole system is planned to be developed during this year.

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