BOOSTER OF THE ALBA SYNCHROTRON LIGHT SOURCE: PRE-COMMISSIONING EXPERIENCES

M.Pont on behalf of the ALBA team, CELLS-ALBA, E-08290 Cerdanyola del Vallés, Spain

Abstract

ALBA is a 3 GeV third generation synchrotron light source being completed in Spain. The injection system is composed of a 100 MeV Linac as pre-injector followed by a full energy booster synchrotron which shares the same tunnel as the storage ring. With a circumference of 249.6 m and a magnetic lattice based on combined magnets an emittance of 9 nm.rad has been predicted for the Booster. After an intensive sub-system commissioning a two weeks run took place at the beginning of 2010. The main results during these two weeks are here summarised.

INTRODUCTION

The ALBA booster lattice has a four-fold symmetry, consisting of 4 arcs with 4 straight sections of 2.6 m each. The arc structure is made of 8 FODO cells, each with a defocusing gradient bending magnet and a focusing quadrupole [1]. At the end of each arc there is a matching cell with additional quadrupoles which lead to zero dispersion on the straight sections where the RF-cavity and the injection elements are installed. Extraction takes place on one arc. The gradient bending magnets and the quadrupole family of the unit cell have also a built-in sextupole component in the iron pole profile to correct the natural chromaticity to (+1,+1). The main parameters of the booster lattice are summarised in table 1. The booster RF consists of one 5-cell Petra type cavity feed with the same 80 kW IOT that is used for the SR RF system, although only about 45 kW of power are required for a 5 mA beam.

Table 1: Main parameters of the ALBA Booster

Injection energy	100	MeV
Extraction energy	3.0	GeV
Circumeference	249.6	m
Emittance at injection	150	mm.mrad
Emittance at 3 GeV	9	mm.mrad
Energy spread at injection	± 0.5 %	
Energy spread at 3 GeV	± 0.1 %	
Betatron tunes, Q_x / Q_y	12.42 / 7.38	
Maximum betas β_x / β_y	11.2 / 11.7	m
Maximum dispersion, D_x	0.47	m
Natural chromaticities, ξ_x / ξ_y	1.69	
Momentum compaction function	0.0036	
RF frequency	500	MHz
Harmonic number	416	
Damping times at 3 GeV τ_x / τ_y / τ_s	4.5/ 8.0 / 6.3	ms
Maximum repetition rate	3.125	Hz

COMMISSIONING

On December 21st 2009, the first beam at an energy of 105 MeV was injected into the booster. The next run took place during two weeks in January 2010. The Linac, which had been commissioned in Autumn 2008 [2], was providing a multibunch beam of 112 ns pulse length with a charge of 4 nC at a repetition rate of 1 Hz, although the repetition rate will be 3 Hz in normal operation.

On the 11th of January the beam made the first turn in the BO and two days later thousands of turns were already observed.

Figure 1: Three first turns in the booster

Figure 2: Many turns in the booster

The FFT of the turn-by-turn BPM position measurements yielded the following tunes: Qx=0.64 and Qy=0.43. The nominal tunes had been Qx=0.42 and Qy=0.38.

The RF was switched on with a power of 2 kW and an electron beam was immediately stored. The injection efficiency was very low, around 10-20%, with the losses taking place during the first turns.

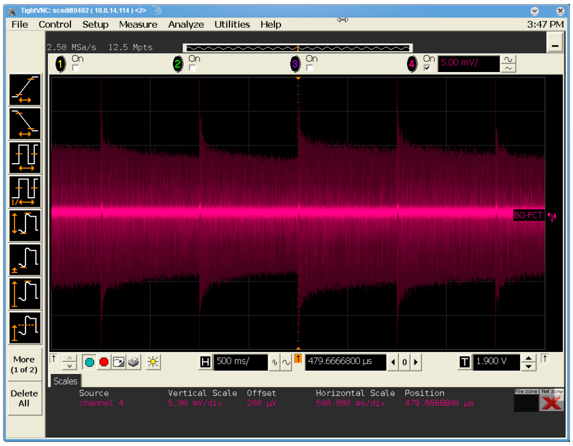

Figure 3: first stored beam in the booster. Several injections at 1 Hz are shown

After that we were ready to start ramping the beam. It had been decided to start ramping only up to 600 MeV to make sure all sub-systems were running properly. As a first step the power supplies generated a 3 Hz pure sinusoidal excitation of the magnets. A beam at 600 MeV was achieved on the 19th January 2010, and one day later the beam made it up to 2.7 GeV where it got lost while crossing a horizontal resonance. The main parameter for optimization during this period was the minimization of the losses during ramping, and no effort was made to keep the tunes constant. In addition the tune measurement application during ramping was not fully operational.

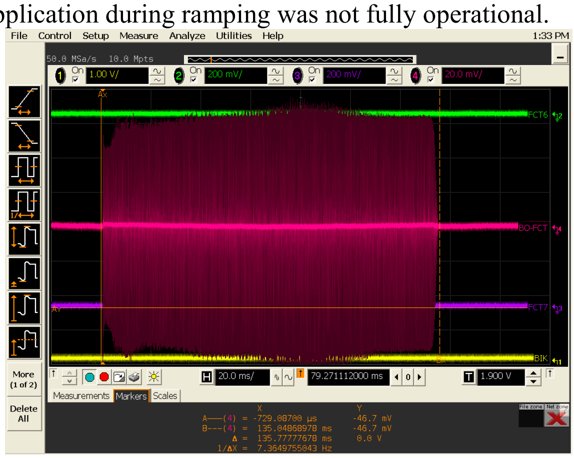

Figure 4: Ramped beam up to 2.7 GeV.

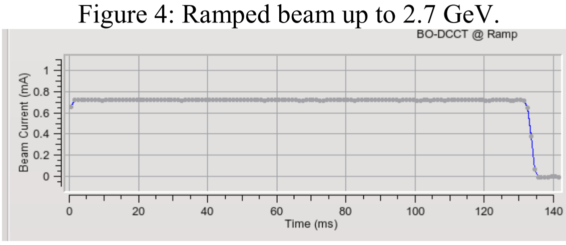

Figure 5: Current measured in the DCCT along the ramp showing no losses during ramping

Diagnostics

The diagnostics were available since day one of the booster run. As usual, beam is needed to commission the instrumentation and vice versa. More details about the diagnostics experience during this period are found in [3]. The performance was overall satisfactory.

Three screen monitors (FSOTR) in the LT and 4 in the BO were installed to ease the first commissioning goals (first injection, first quadrant, first turn). A detailed description of the FSOTR setup containing a Fluorescent Screen (YAG:Ce) and an Optical Transition Radiation plate is given in [4]. Furthermore, we could use the image of one (out of 3) Synchrotron Radiation Monitors (SRM) installed in the BO. Besides the desired image of the beam crossing the bending magnet, we also observed the parasitic image produced at a dipole upstream. Further studies are required to careful evaluate this effect.

Beam intensity measurements were done with two Bergoz components: the Fast Current Transformer (FCT) and DC Current Transformer (DCCT). No major problems were detected with any of them. The DCCT shows an offset drift of about 40uA (likely caused by a thermal effect, which is within the Bergoz specifications). A DCCT current measurement during a ramp is shown in Fig. 4.

Two striplines for tune measurements were installed. The first stripline excites the beam with a white noise signal around the tune frequencies, while the second one is devoted to precise beam position variations. In order to excite the beam with the *same intensity* all along the ramp, the excitation signal amplitude can be ramped in synchronism with the energy increase. The tune measurement can be done through two methods: the traditional FFT analysis from the turn-by-turn position measurements (using Matlab Middle Layer), and via the Real Time Spectrum Analyzer (RTSA). So far, only the MML could be set operational. More details about the tune measurement system are given in [5].

BPM's

The first closed orbit measured at 105 MeV was obtained with the use of few correctors and reached a maximum of ±8 mm in the horizontal plane and ±5 mm in the vertical plane, as shown in figure 6. These results are in agreement with the simulations performed assuming 0.2 mm rms for the horizontal and vertical displacement, and 0.1 mrad rms roll angle [1].

To correct the orbit a set of 44 horizontal correctors and 28 vertical correctors are available. The number of BPMs installed is 44, nevertheless based on previous simulations only 28 of them had been equipped with Libera electronic units. While this approach might be sufficient during normal operation, we found that the global correction would not reduce the orbit to better than ±2 mm, therefore the decision has been taken that for the next booster run all 44 BPM's will be equipped with Libera units

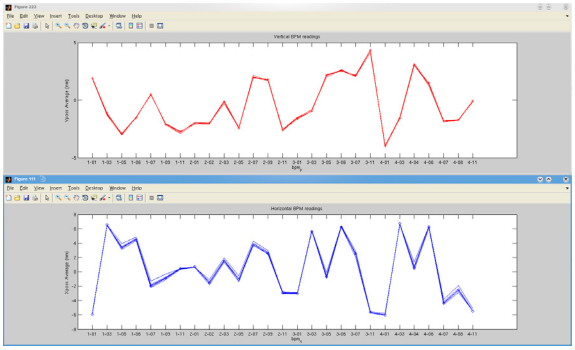

Figure 6: Natural orbits at injection

The Liberas, were typically used with the "*Data on Demand (DD) Mode*", which allows to obtain 200 ms of turn by turn data. We have been using this mode to monitor the orbit along the ramp and perform tune measurements.

Orbit correction was performed using the "*Slow Acquisition* (SA) *Mode*", which performs an average on a 10 Hz period. The accuracy for a 0.2 mA beam was ~4 µm on SA mode and 70 µm in DD mode, which agrees with the previous studies [6].

RF system

The RF System of the booster performed without major problems. Switching on the RF and store the beam (see figure 3) was achieved in around two hours.

Capture at injection was achieved by setting the cavity voltage to its minimum (100 W – 50 kV) and adjusting the RF frequency and phase.

A linear slope from 100 W to 35 kW was enough to ensure not losses of the beam energy ramping (see figure 5). Details can be found in ref. [7]

Power Supplies

The booster power supplies performed well during the first stages of the commissioning. Because of the sextupole component built-in in the combined function and the quadrupole magnets no sextupoles were used during this time. The corrector magnets were used only in dc mode, i.e. the orbit was only corrected at injection, and the combined function and quadrupole power supplies, described elsewhere in these proceedings [REF], were ramped using pure sinusoidal curves. Although the first intention had been to start the ramp at the injection energy due to a bug in the timing system it was later realised that we have already been injecting on the fly.

Vacuum pressure

At the start of the run the mean gauge pressure in the booster was 1-2x10^{-9} mbar, and the pressure was relatively uniform all along the booster. All the vacuum chamber, had been bake-out in sections prior to the assembly. A maximum pressure increase of 2 orders of magnitude was observed during the ramping trials at high energy, with a fast recovery to the values at injection when returning to low energy.

Radiation measurements

During the first days of commissioning the Experimental Hall and the Service Area were evacuated and as successive measurements did not show any radiation level above public dosage the access to these parts of the building was opened so that Storage Ring installation tasks could resume.

Beam dynamics

Measurements of the tune along the ramping, dispersion, and also a first attempt to run LOCO on the Booster are reported elsewhere on these Proceedings [8].

CONCLUSIONS

The goal for the two weeks Booster run in January 2010 had been to demonstrate that all sub-systems performed according to specifications. This objective has been greatly surpassed by being able to accelerate a beam close to the nominal energy of 3.0 GeV. The next commissioning run, in July of this year should allow us to reach the booster design values.

ACKNOWLEDGMENTS

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REFERENCES

[1] G.Benedetti, D.Einfeld, Z.Martí, M.Muñoz, and M.Pont, "Optics for the ALBA Booster Synchrotron", EPAC'08, Genoa (Italy), 2008

[2] A.S.Setty, D.Jousse, J.-L.Pastre, F.Rodrigues, G.Benedetti, D.Einfeld, A.Falone, U.Iriso, M.Muñoz, A.Olmos, F.Perez, M.Pont, F.Sanchez, and A.Sacharidis, "Commissioning of the 100 MeV Preinjector for the ALBA Synchrotron", PAC'09, Vancouver (Canada), 2009

[3] U.Iriso, M.Alvarez, R.Muñoz, A.Olmos, and F.Perez, "Diagnostics during the ALBA Booster Commissioning", Proc. of BIW'10, Santa Fe (USA), 2010

[4] U.Iriso, G.Benedetti, and F.Perez, "Experience with the YAG and OTR screens at ALBA" DIPAC'09, Basel (Switzerland), 2009

[5] U.Iriso, F.Perez, and A.Salom, "Tune measurement system at the ALBA Booster", Proc. of BIW'10, Santa Fe (USA), 2010

[6] A.Olmos, F.Perez and T.Günzel, "BPM design for the ALBA Synchrotron", EPAC06, Edinburgh, Scotland (2006)

[7] F.Perez, P.Sanchez and A.Salom, "RF System of the ALBA Booster: commissioning and operation", these proceedings.

[8] G.Benedetti, D.Einfeld, Z.Martí and M.Muñoz, "Beam optics measurements during the commissioning of the ALBA Booster", these proceedings.