

ALBA II ACCELERATOR UPGRADE PROJECT STATUS*

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Abstract

ALBA is working on the upgrade project that shall transform the actual storage ring, in operation since 2012, into a 4th generation light source, in which the soft X-rays part of the spectrum shall be diffraction limited. The project was launched in 2021 with an R&D budget to build prototypes of the more critical components. The storage ring upgrade is based on a MBA lattice which has to comply with several constraints imposed by the decision of maintaining the same circumference (269 m), the same number of cells (16), the same beam energy (3 GeV), and as many of the source points as possible unperturbed. At present, the lattice optimization, iterating with the technical constraints of space and performance, is ongoing. This paper presents the situation of the project, with the present proposed lattice and equipment design; the status of the prototyping of magnets, pulsed elements, vacuum chambers, buttons, BPMs, and girders; the proposed RF system with fundamental and harmonics cavities; and the general context of the upgrade.

INTRODUCTION

The main goal of the accelerator upgrade is the transformation of ALBA into a diffraction limited storage ring, which implies the reduction of the emittance by at least a factor of twenty. The upgrade has been conceived as a cost and time effective process, to be realized by the end of the decade and profiting at maximum from the existing infrastructures.

It has been decided that the storage ring (SR) upgrade shall be done without any major modification of the shielding tunnel, and that the Insertion Devices (IDs) will remain at their present position. The beamlines will be upgraded

to profit from the new lattice, though there will be minor changes on the ID light sources.

The beam energy will be maintained at 3 GeV, after having considered several factors, among them, that increasing the energy of the SR would require replacing the whole booster, increasing the cost of the project and lengthening its realization.

The circumference of the upgraded SR is constrained to be the same length as in the present SR in order to reuse the tunnel; and since we want to preserve also the IDs position, a sixteen-cell 4-fold symmetry, as the actual Storage Ring, is imposed, which implies a very compact cell. Details on the layout considerations can be found at [1].

Withing the program “Enabling Technologies for ALBA II”, the design and prototyping of the different components for ALBA II is under progress.

LATTICE

Since the last lattice proposal presented in 2025, where octupoles were introduced in the 5 BA cells, the work of the last year has been dedicated from one side to improve the lattice performances by refining the model and the optimization technique, and on the other side to develop a new optics of the injection section with asymmetric waist that allowed to recover a pseudo-16-fold symmetry with matched phase advances and chromatic function W_x in all the straight sections. In Fig. 1 is shown the 16-cells lattice, where the injection section is located in the middle.

The main benefit of this change in the lattice is its robustness to errors rendering 100% of injection efficiency for more than 90% of the simulated error seeds.

Detailed information about the new lattice can be found at [2].

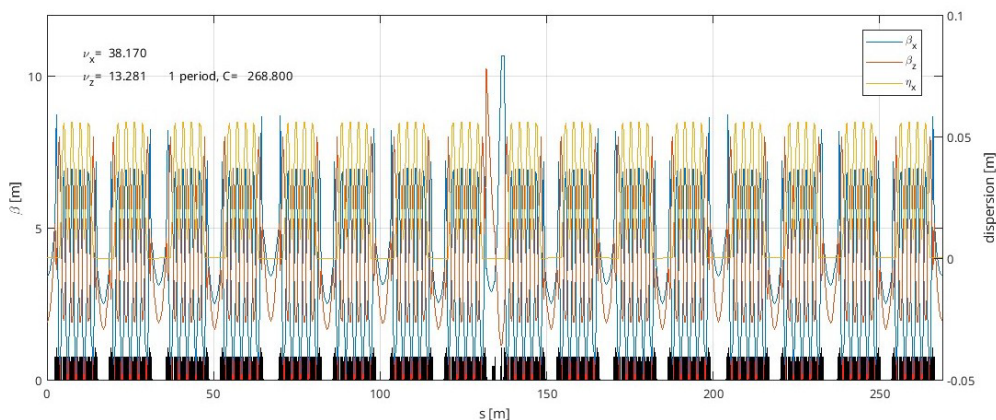


Figure 1: Optical functions of the pseudo-16-fold 5BA lattice proposed for ALBA II.

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MAGNETS

Due to the compactness of the lattice and the requirement for tunability, most of the magnets will be electromagnets, except the QDS, which are the first and last bendings of the cell, and the tunability will be done with the adjacent quadrupole and corrector.

Also, for specific beamlines, we will introduce a QD-Superbend, which will be a combined electro- and permanent magnet, producing the required dipolar and quadrupolar fields, with a 3.0 T peak at the center, see Fig. 2.

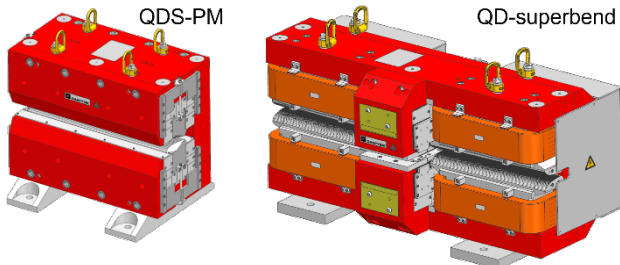


Figure 2: QDS Permanent Magnet; and QD-Superbend, a combined electro- and permanent magnet, with dipolar and quadrupolar tunability.

Apart of the design work, we have launched the prototype production of the different types of magnets. Most of the electromagnets' prototypes (Q3, QD, QDS, QFS, SH, SV and Correctors) are being produced by ANTEC [3]; the permanent magnets ones (QDS-PM and QD-Superbend) by Danfysik [4]; and the octupoles by Sigmaphi [5].

First prototypes have been delivered and are being tested, see Fig. 3.

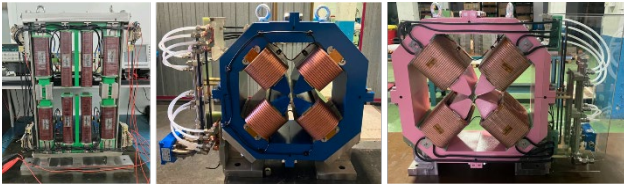


Figure 3: Corrector, and quadrupoles prototypes.

Detailed information about the magnets can be found at [6].

VACUUM

Aiming to achieve the best vacuum performance, and the lowest impedance effects, while keeping the overall project risk and maintainability under control, the vacuum system solution will be based on a hybrid configuration,

combining NEG-coated copper chambers with a conventional antechamber design for power management and localized pumping. Stainless-steel chambers will be used at the position of the correctors to increase the bandwidth of the orbit feedback.

In order to have enough horizontal aperture for the injected beam we have concluded that the inner shape of the vacuum chamber shall be rhombic. After several optimization process, including mechanical stability, manufacturability, and impedance consideration, the proposed dimensions are shown in Fig. 4.

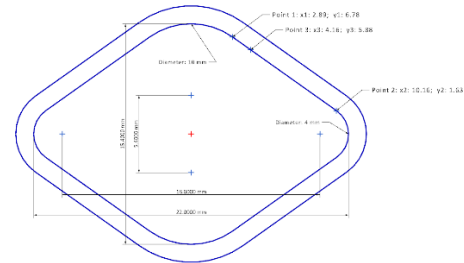


Figure 4: Dimensions of the vacuum chamber.

Also, several prototypes of vacuum chambers are being fabricated by FMB [7].

Detailed information about the vacuum systems can be found at [8].

GIRDER

The design of the girder has been driven by a main constrain, that the weight of the girder with all the magnets assembled should be less than 12 Tn - which is the capacity of our crane-, so that the full assembly can be installed directly on the tunnel with the crane, minimising the installation time.

Other constrains that we are taking into account are, as the interference with the existing main cooling distribution inside the tunnel, which will remain; and the easiness for installing the vacuum chamber.

Figure 5 shows the proposed solutions, with five girders per cell, the three centrals are identical, and the two at the extremes adapted to the space and weight.

Two girder prototypes have been manufactured by the company Nortemecanica [9], and have undergone several tests to assess the performance of the girders in comparison with the simulation results, see Fig. 6.

Detailed information of the prototype girders performance can be found at [10].

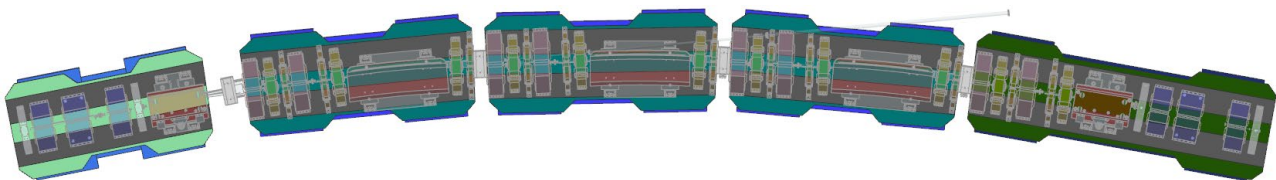


Figure 5: The five girders of one cell, with the magnets assembled.



Figure 6: Girders prototypes installed at the Experimental Hall of ALBA, being tested.

RF

The main 500 MHz RF system of ALBA will be re-used for ALBA II, since its operation parameters will be less demanding. In addition, for ALBA II the use of a 3rd harmonic system (3HC) is mandatory for increasing the bunch length, and so, the lifetime. So, ALBA II will have six cavities working at the fundamental frequency of 500 MHz, and four 3rd harmonic cavities at 1.5 GHz. Both will be active normal conducting HOM damped cavities. They will be installed in two straight sections. Figure 7 shows the foresee implementation of the cavities in one section.

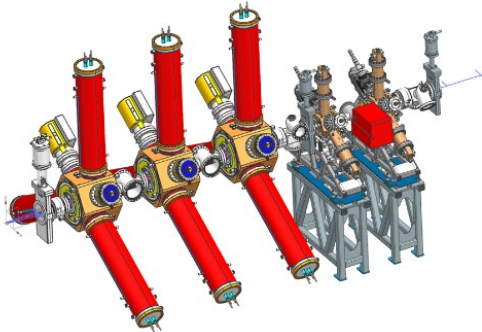


Figure 7: Three fundamental and two harmonic cavities in one section.

Four 3rd harmonic cavities will be installed at the present ALBA storage ring to have them operative before the upgrade. The series production of four 1.5 GHz RF systems is underway, including the cavities by RI [11], the solid-state amplifiers by BTESA [12], the waveguides by Spinner [13], and the LLRF system by SAFRAN [14, 15].

INJECTION

The existing ALBA booster, thanks to its large circumference, delivers a beam emittance already suitable for the injection into the upgraded storage ring. But the injection into the new storage ring will be more difficult due to the strong reduction of the horizontal dynamic aperture and the reduced injection straight length.

The proposed scheme that fulfils these conditions is to have two permanent dc magnet thick septa at the transfer line, which guides the injected beam to the thin pulsed septum, and a single fast pulsed multipole kicker magnet, the

ALBA designed Double Dipole Kicker (DDK), installed all in the injection straight section.

Two prototypes for the DDK have been manufactured, one by AVS [16] and another in collaboration with CNPEM [17]. The pulsed power supplies have been manufactured by RI [11].

The prototypes have been installed at ALBA for testing with beam, see Fig. 8. Results can be found at [18].

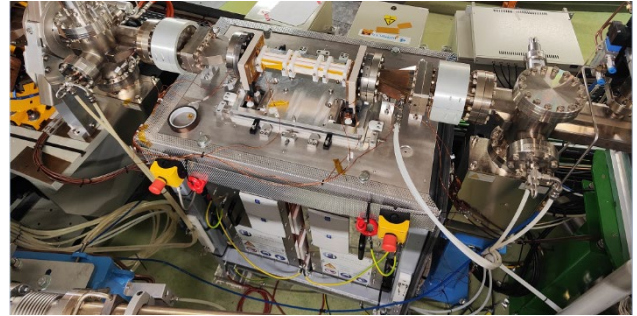


Figure 8: Prototype of the Doble Dipole Kicker (DDK), and its Pulsed PS, installed at ALBA for beam tests.

UPGRADE PROJECT

The upgrade ALBA II is a larger project [19] than only the accelerator replacement. It includes also the upgrade of the existing beamlines, and the expansion of the infrastructure towards an adjacent plot of land to allow for the construction of up to three new long beamlines, see Fig. 9.



Figure 9: Artistic view of future ALBA II facility.

The project is fully approved, and we are now working on establishing a detailed time schedule on the design, construction, assembly, installation and commissioning, in a coherent implementation program, see reference [20].

CONCLUSION

The project for upgrading ALBA to an ultra-low emittance, 4th generation, light source ALBA II is underway.

A series of prototypes for magnets, vacuum chambers, girders, and pulsed elements are being produced.

ACKNOWLEDGEMENTS

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