15th International Particle Accelerator Conference,Nashville, TN JACoW Publishing
ISBN: 978-3-95450-247-9 ISSN: 2673-5490 doi: 10.18429/JACoW-IPAC2024-TUPG02

ALBA II ACCELERATOR UPGRADE PROJECT STATUS*

F. Pérez †, G. Benedetti, Z. Martí, M. Carlà, O. Blanco, J. Marcos, V. Massana, A. Fontanet
M. Ning, U. Iriso, T. Guenzel, L. Torino, R. Muñoz-Horta, F. Fernandez, J.C. Giraldo, P. Solans
I. Bellafont, J. Ocampo, C. Colldelram, L. Ribó, J. Boyer, R. Parise, P. Salmeron, J.M. Álvarez
N. González, M. Llonch and M. Pont, ALBA Synchrotron - CELLS, Barcelona, Spain

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 (269m), the same number of cells (16), the same beam energy (3GeV), 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 status of the project, with the present proposed lattice, the proposed design for magnets, vacuum chambers 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 geometry is imposed, which implies that a very compact cell is required.

Withing the program "Enabling Technologies for ALBA II" [1], the design and prototyping of the different components for ALBA II is under progress.

LATTICE

Since the last lattice proposal presented in 2023 [2], several iterations have been performed in order to deal with the dynamic aperture requirement for injection and lifetime, finding out that, given the limited available length for the arc, a 5BA lattice does have a better non-linear performance that the previously proposed 6BA, without a severe degradation of the emittance. As a conclusion, the present lattice proposal for ALBA II is a 5BA with an emittance of around 240 pmrad.

In addition, in order to maintain the same transversal position of the actual IDs of ALBA, the symmetry has to be a four-fold, with three different straight section lengths: 4.7, 4.3, and 3.7 m, and high horizontal beta sections, one of them to be used for injection.

Of the three other high horizontal beta sections, two will be used for the installation of the RF cavities, both fundamental at 500MHz, and 3rd harmonic at 1.5GHz.

The rest of the straight sections will be for IDs, maintaining the actual ones, and having space for three more new ones. Two of these will be used for long beam lines.

Figure 1 show the optics functions of the present design. The details of the current lattice are presented in [3].

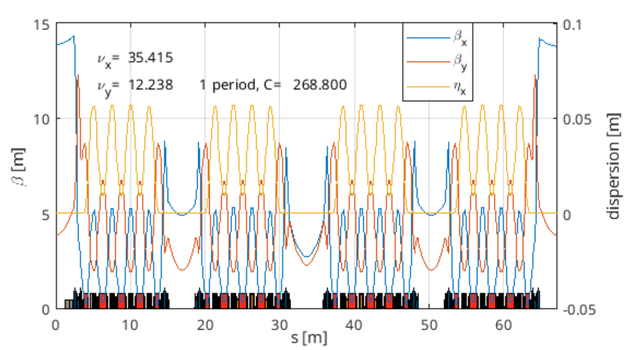

Figure 1: Optical functions of the 4-fold 5BA lattice proposed for ALBA II.

* Work supported by the Spanish and Catalan Governments, and co-funded by the European Union – NextGenerationEU project 28.50.460D.74903 from the Recovery and Resilience Mechanism.

† email address: francis@cells.es

ISBN: 978-3-95450-247-9 ISSN: 2673-5490 doi: 10.18429/JACoW-IPAC2024-TUPG02

MAGNETS

The base technology chosen is the standard electromagnets, and we have launched the prototype production of the different types required for ALBA II, as shown in Table 1.

Table 1: Electromagnets Protoypes

Magnet type	Field
Quadrupoles (Q3)	-95 T/m
Dipole-Quadrupole (QD)	1.25T ; -26.2 T/m
Dipole-Quadrupole (QDS)	1.16T ; -4.8 T/m
Reverse Bend (QFS)	-0.45T ; +70 T/m
Sextupoles (SH & SV)	5000 T/m^2
Corrector (COR)	0.05T

In addition, we are currently designing permanent magnet based versions for two of the magnets, one to replace the QDS, and another to replace some of the QD by a SuperBend with dipolar and quadrupolar tunability. This later is expected to deliver a field at the central pole of more than 3T, see Fig. 2.

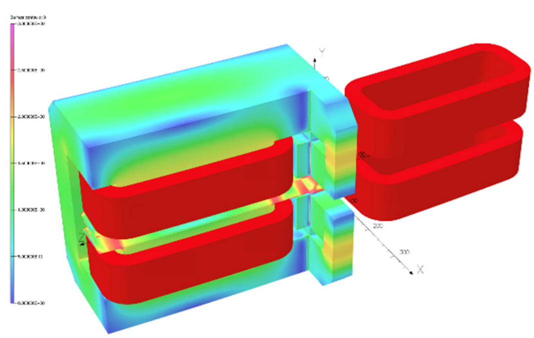

Figure 2: Design of a permanent magnet SuperBend with dipolar and quadrupolar tunability.

Details of the magnets designs and prototyping status are presented at [4].

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 that 12Tn -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. See reference [5] for removal and installation details.

With this constrain, we have concluded that five identical girders will be required for one cell, shown in Fig 3. Details of the design can be found at [6].

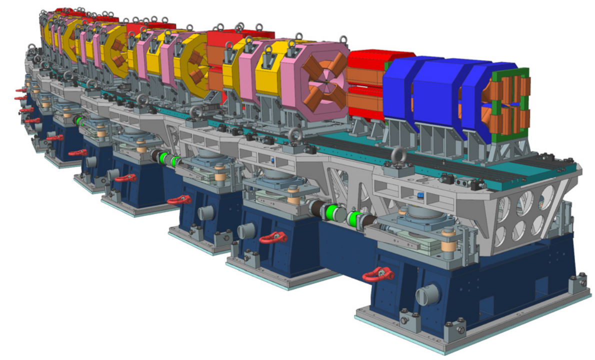

Figure 3: Girders with the magnets assembled.

Two different prototypes will be constructed in order to assess the optimum construction concept to ensure the best stability of the system.

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 16mm internal diameter NEG-coated copper round chambers with a conventional antechamber design for power management and localized pumping. Stainless-steel chambers will be used at the position of the correctors.

Synrad+ and Molflow+ [7] simulations have been performed, and indicate that the mean CO equivalent pressure after 100Ah beam dose will be around 2.10-10mbar.

To demonstrate the validity and manufacturability of the proposed solution, a number of vacuum chamber prototypes will be fabricated:

- Long dipole copper chamber, with antechamber and built-in integrated crotch absorber, as shown in Fig. 4.
- Short dipole copper chamber, featuring a conventional crotch absorber and the ID light extraction port.
- Fast corrector stainless steel chamber, with integrated BPM block and RF shielded bellows.

Due to the compactness of the lattice, the use of Matsumoto-Ohtsuka (MO) type flanges [8] is proposed.

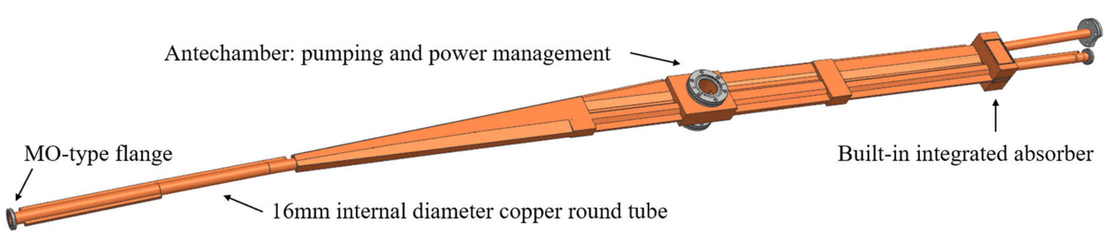

Figure 4: Long dipole copper chamber, with antechamber and built-in integrated crotch absorber.

ISBN: 978-3-95450-247-9 ISSN: 2673-5490 doi: 10.18429/JACoW-IPAC2024-TUPG02

RF

The main RF system of ALBA will be reused for ALBA II, since its operation parameters will be very similar and the nominal frequency will be kept at 500 MHz.

In addition to the main RF system, for ALBA II the use of a 3rd harmonic system (3HC) is mandatory for increasing the bunch length, and so, the lifetime. For this purpose, a complementary RF system operating at 1.5 GHz is foreseen.

In summary, 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 5 shows the foresee implementation of the cavities in one section.

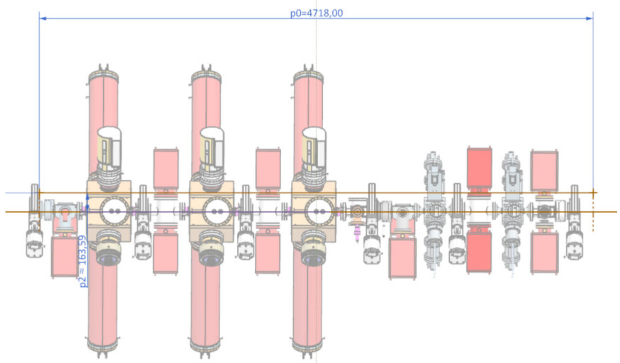

Figure 5: Three fundamental and two harmonic cavities in one section.

A prototype of the 3rd harmonic active cavity is being tested successfully in collaboration with DESY and HZB, both in single and multi-bunch mode, which has demonstrated the feasibility of such a system for ALBAII, PETRAIV and BESSYIII. See reference [9].

Having demonstrated its feasibility, the series production of four 1.5GHz RF systems is underway, including the cavities, the solid-state amplifiers, and the LLRF system [10]. Four cavities will be installed at the present ALBA storage ring to have them operatives before the upgrade.

INJECTION

The existing ALBA booster, thanks to its large circumference, delivers a beam emittance as small as 9 nmrad, already suitable for the injection into the upgraded storage ring. But the injection into the new storage ring will be more difficult compared to the existing ring, mainly due to the strong reduction of the horizontal dynamic aperture and the reduced injection straight length. The best scheme that fulfils these conditions is injecting with a single fast pulsed multipole kicker magnet installed in the same straight section as the septum magnet.

The multipole kicker under study for ALBA II is a novel design, called Double Dipole Kicker (DDK), where eight conductor rods are arranged in order to produce a sextupole-like behaviour around the center, resulting in zero field at the stored beam position and a field peak at the injected beam position [11]. The DDK will be powered by two pulsed power supplies for tuning the field profile. When switching off one of the power supplies the kicker can be used in dipolar mode, allowing on-axis injection, which can be very convenient during ALBA II commissioning.

In order to test the concept before the upgrade, a prototype specifically designed for ALBA is under production. It will be installed in the existing ALBA storage ring to test the injection stability with such a system. Figure 6 shows a picture of the design of the DDK prototype.

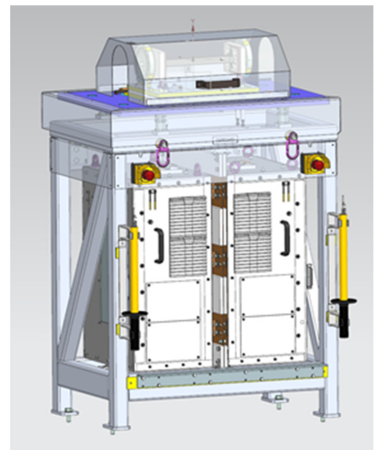

Figure 6: Double Dipole Kicker (DDK), with the two pulsed power supplies.

UPGRADE PROJECT

The upgrade ALBA II is a larger project 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 [12].

It will also serve as a synergy centre to create a scientific and technological pole in the area. Fig. 7 shows an artistic view of the future ALBA II infrastructure.

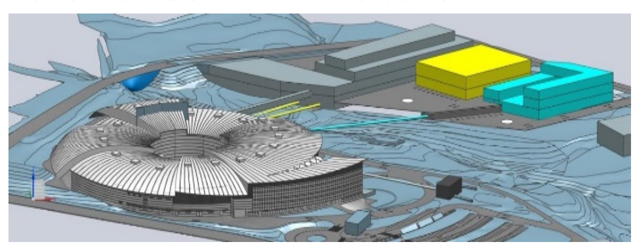

Figure 7: Artistic view of future ALBA II facility.

The project is not yet fully approved, but we are already operating with a budget for prototype construction, and the close-by land for the expansion has already been secured.

CONCLUSION

The project for upgrading ALBA to an ultra-low emittance, 4th generation, light source ALBA II is underway. Still under design, a series of prototypes for magnets, vacuum chambers, girders, and pulsed elements are foreseen to be produced by the end of 2025 [1].

ISBN: 978-3-95450-247-9 ISSN: 2673-5490 doi: 10.18429/JACoW-IPAC2024-TUPG02

REFERENCES

[1] Co-funded by the European Union – NextGenerationEU project 28.50.460D.74903 from the Recovery and Resilience Mechanism

[2] G. Benedetti, M. Carlà, U. Iriso, Z. Martí, and F. Perez, "Progress on the 6BA lattice for ALBA-II", in *Proc. IPAC'23*, Venice, Italy, May 2023, pp. 3098-3100. doi:10.18429/JACoW-IPAC2023-WEPL001

[3] M. Carlà, G. Benedetti, O. Blanco-García, and Z. Martí, "Status of the ALBA-II lattice studies", presented at the IPAC'24, Nashville, TN, USA, May 2024, paper THPC01, this conference.

[4] J. Marcos, V. Massana, M. Ning, and P. Salmeron, "Development of prototype magnets for the ultralow emittance storage ring ALBA II", presented at the IPAC'24, Nashville, TN, USA, May 2024, paper TUPR40, this conference.

[5] F. Fernandez, F. Perez, and M. Pont, "Dismantle, assembly and installation plans for the ALBA II upgrade", presented at the IPAC'24, Nashville, TN, USA, May 2024, paper TUPG01, this conference.

[6] L. Ribó, J. Boyer, N. Gonzalez, C. Colldelram, L. Nikitina and F. Perez, "The girder system prototype for ALBA II Storage Ring", in *Proc. MEDSI'23*, Beijing, China, November 2023, paper THPPP040.

[7] Synrad+ & Molflow+: https://molflow.docs.cern.ch/about/

[8] Y. Suetsugu, M. Ohtsuka, and M. Shirai, "Application of Stain-less Steel, Copper Alloy and Aluminum Alloy MO (Matsumoto-Ohtsuka)-type Flanges to Accelerator Beam Pipes", in *Proc. IPAC'10*, Kyoto, Japan, May 2010, paper THPEA080, pp. 3855-3857

[9] F. Perez *et al.*, "3rd harmonic active EU-HOM damped cavity commissioning results", presented at the IPAC'24, Nashville, TN, USA, May 2024, paper TUPG03, this conference.

[10] J. Fernández, A. M. Lopez Antequera, J. Benavides, and P. Gil, "Status of the development of the new digital LLRF for ALBA synchrotron light facility", presented at the IPAC'24, Nashville, TN, USA, May 2024, paper THPG74, this conference.

[11] G. Benedetti, M. Carlà, and M. Pont, "A Double Dipole Kicker for Off and On-Axis Injection for ALBA-II", in *Proc. IPAC'22,* Bangkok, Thailand, Jun. 2022, pp. 2701-2704. doi:10.18429/JACoW-IPAC2022-THPOPT047.

[12] ALBA II Upgrade: https://www.cells.es/en/science-at-alba/alba-ii-upgrade/alba-ii.