

LAYOUT OF ALBA II ACCELERATOR

L. Ribó*, N. González, F. Fernández, J. C. Giraldo, P. Salmerón, J. Boyer, R. Parise, F. Pérez
ALBA Synchrotron Light Source, Cerdanyola del Vallès, Spain

Abstract

ALBA Synchrotron Light Source will be upgraded into a diffraction limited machine by the replacement of the storage ring, which implies the reduction of the emittance by at least a factor of twenty. Compactness ratio of the magnetic elements has increased by a factor of 2. The new lattice has been designed with two big constrains. Firstly, keeping the same orbit length allows us to preserve the actual injector. Secondly, the medium and short straights will be collinear with respect to ALBA current layout to avoid moving the present Insertion Devices Beamlines. The bending magnet beamlines must be repositioned on the new machine. Magnetic array, vacuum chambers and girders are positioned with respect to the main orbit under tight clearances, that's why envelope studies of those clearances will have to be performed for the 3 subsystems. Easiness of assembling and installation of the different subsystems of the machine has to be considered also as a design requirement, in order to minimize the installation time. A mock-up of one sector is being prepared for this reason. The upgrade will be executed before the end of the decade and will be profiting at maximum all existing ALBA infrastructures, in particular the building.

INTRODUCTION AND GEOMETRICAL CONSTRAINTS

Low Emittance Alba II storage ring is composed by about 720 magnets distributed in 16 arcs. As a first constraint, it is requested the orbit length to be the same as it is in the actual ALBA machine [1], this means 268.800 mm. Apart from that, the straight sections between the arcs where the insertion device (ID) beamlines are already located have to be collinear with the actual orbit, in order to keep these beamlines position as they are now. With respect to the accelerator, linac and booster are not upgraded, but the booster to storage ring transfer line will be redefined.

Another geometrical constraint for fitting the new storage ring is the existing infrastructure. Tunnel walls, roof and the primary cooling circuits will be the same.

The position of the ID front ends centrelines is kept but for two bending magnet actual beamlines a new optimal extraction point has to be found in a way that the optical layout of the beamlines changes minimally.

The full storage ring is composed by 4 quarters, each quarter composed by 4 arcs, and 5 straights, two long, two short and one medium. Medium and short straights are collinear with the ALBA storage ring, not as the long straight which will offset radially with respect the actual beam path.

LATTICE CELL

The lattice cell is under optimization. At the moment, is composed by 3 dipoles, 2 permanent magnet dipoles. 8 anti-bending quadrupoles, 6 pure quadrupoles, 11 sextupoles, 11 octupoles and 4 correctors fitted in an arc length of 12.800 mm. Additionally, each arc will have 8 to 10 beam position monitors. The tolerances for positioning the magnets and the girder will need to be tighter corresponding to a low emittance new machine, where the emittance is reduced by a factor of 20 [2]. The arc is represented in the next picture (Fig. 1) as a simplified scheme, where the dipoles and the 8 anti-bending quadrupoles are represented. The sextupoles, pure quadrupoles, octupoles and correctors are not represented on the figure but they are distributed evenly between the magnets.

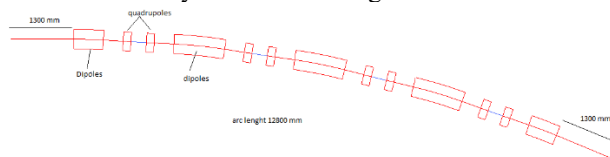


Figure 1: Schematic representation of the lattice arc.

MECHANICAL DESIGN OF THE CELL

Optimization of the lattice is being nowadays a continuous task, that is already converging into the most optimal solution in terms of emittance and beam life time. Due to the project planning, mechanical design cannot wait until the lattice distribution is frozen, that's why an updateable 3D model has been created to implement all the modifications in the most optimal way. Basically, the storage ring arcs are modeled in 4 subassemblies, where magnetic array, vacuum system, girders, Insertion devices, diagnostics and RF systems as others are restricted with respect to a fixed wireframe that follows the beam. This beam wireframe is the master reference for the remaining components of the storage ring, and it is built having the lattice geometrical model as an input. In this way, each time there is a lattice upgrade, the wireframe can be updated and all the components are automatically repositioned

Figure 2 shows an example of the wireframe beam path where all the coordinate axis are located to be the reference when positioning the magnets. After that, the girders and vacuum system are added, as can be seen in Fig. 3, where the compactness of the system can be appreciated

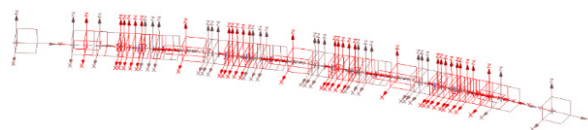


Figure 2: Wireframe beam path with magnets references.

* lribo@cells.es

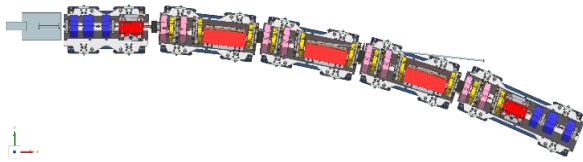


Figure 3: 3D model top view of a complete arc.

In the current design, each arc is divided in 5 girders, of about 3000 mm length. each girder is supporting one dipole and a stripe of quadrupoles and sextupoles. The most optimal girder split has been found where the vacuum pumping units are. With this configuration, the footprints of all BPM's are located on top of girder surface. Each magnet can be positioned with respect to the girder surface by means of precision wedges and fine threaded screws [3].

The vacuum chambers have a rhombic cross-section with 22mm horizontal aperture with a minimum wall thickness of 1.25 mm. Clearances of up to 1 mm from magnet poles, as it can be seen in Fig. 4.

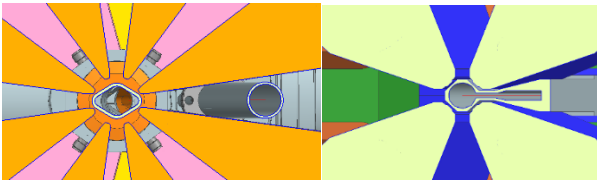


Figure 4: Example of the vacuum chamber profiles embedded into magnets.

Due to the low conductivity in such small chambers, the entire ring will be NEG coated to accelerate vacuum conditioning and achieve the required ultimate pressure. Most of the vacuum will be made of oxygen free cooper or Cu-CrZr to dissipate synchrotron radiation and reduce resistive wall impedance [4].

Space left for absorbers or flange tightening screws is very tight as it can be seen in following picture Fig. 5. Precise positioning systems for the vacuum system with respect to the magnets and a stable flat reference on top surface of the girder are a must in order to mount the systems respecting those clearances.

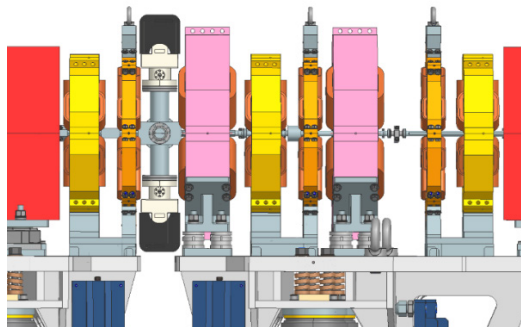


Figure 5: Example of the magnetic array between two dipoles. Girder partition is where the pumping units are.

THE STRAIGHT SECTIONS

Each storage ring quarter has one medium straight and two sort straight sections. The length of the straights is

3.444,3 mm for the short straight and 4.350,69 mm for the medium straight, that defines a symmetry on the quarter. Those are colinear with the original ALBA orbit. The length of the short straight has been adjusted for a full orbit length of the 268.800 mm. Having those constraints applied, the four long straights partitioned in two halves for each quarter, are 4.760,71 mm and offset radially with respect the actual beam.

The insertion devices are actually distributed in the medium and short straights, being actual position of ALBA when they are in the middle straight, or can displaced about 420 mm upstream or downstream, but in the same centre-line in the case of the short straights. For the short straights, the space is tight because not only the ID has to be located, also the transition chambers with an optimal taper of 1:10 when is possible.

A modification of the entrance and exit profiles of the in-vacuum ID's is being considered, to smoothen the profile change to the cell vacuum system. At Fig. 6 can be seen one of the ID's fitted in a short straight section, and the space left for the transition chambers.

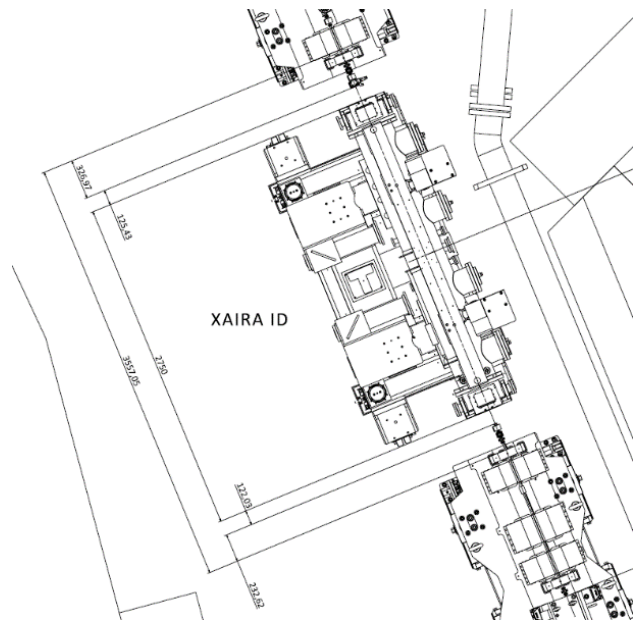


Figure 6: 2D top view of a short straight section with an in vacuum undulator.

The RF systems are located on two of the long straight sections, and the injection will be located on a dedicated long straight section.

All the diagnostics are distributed in the different straight sections, where the space permits or where the location is considered to be the most optimal in terms of performance. It is considered a total length of 1.796,5 mm for diagnostics, to be distributed on all the storage ring.

POSITION OF BENDING MAGNETS BEAMLINES

The actual bending magnet beamlines of ALBA are re-positioned with respect to the new storage ring, but a compromise solution has to be found in order to minimize this

impact for two of the beamlines. In both cases, the end station centerline has been taken as a first geometrical constraint, and by moving the first optical element, a new extraction point tangent to the bending magnet beam path is given. Figure 7 represents one example of this geometrical optimization.

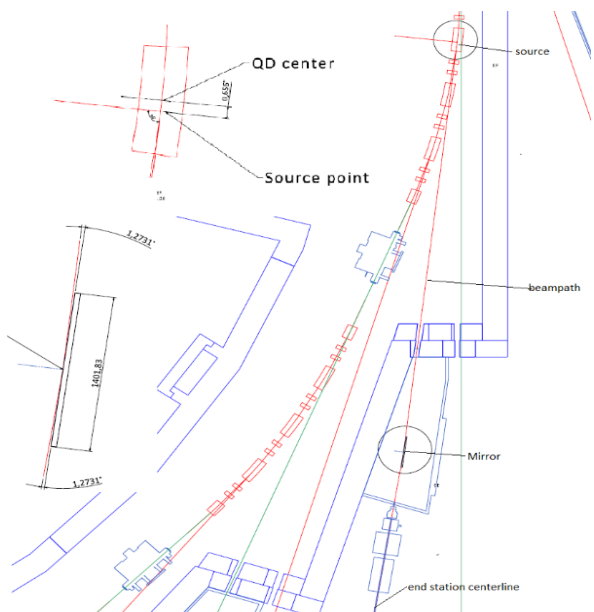


Figure 7: MISTRAL bending magnet beamline has been relocated by changing slightly the reflection angle of M2. The source point after the upgrade is not in the center of the bending magnet.

Other bending magnet beamline will be upgraded with a superbend, and the extraction line source will be on the center of the magnet.

PROTOTYPING PROJECT AND TESTING AREA

A specific project for prototyping critical equipment's for the new storage ring was awarded in 2022 for a duration of 3 years.

Prototypes for two girders are being manufactured to test stability and flatness of different frame and plinth architectures, as well as adjustment systems for alignment in XY plane.

Related to the vacuum system, few vacuum chambers of the arc are being fabricated where manufacturing technologies will be tested as well as important aspects of the vacuum conditioning.

Some electromagnets and a permanent magnet are being prototyped to test magnetic performance and their positioning systems.

All these prototypes will be validated individually, but the parts will be used to perform assembling exercises of the cell, assembling the modules composed by magnets, girders and vacuum system and evaluate the alignment strategy and test the overall stability of the system.

According to the planning of the upgrade project, the mentioned modules will be assembled before dismantling the storage ring, in 2030. The main components of those

modules will be assembled in ALBA warehouse after testing the received components. After that, the modules are going to be stored in a dedicated area. Transport of those girder and magnet assemblies will be done by means of specific tool. The previously assembled prototypes will be used to test as well any eventual dimensional drift on manipulation.

A testing mock-up (Fig. 8) is being furnished with the purpose of identifying difficulties or critical points when installing the girder modules with the magnets into the tunnel. Vacuum chamber arcs will be conditioned apart in the vacuum laboratory and installed when the girder modules are already in their definitive place. After that magnets have to be closed again. An alignment survey of the full arc will be done after that.

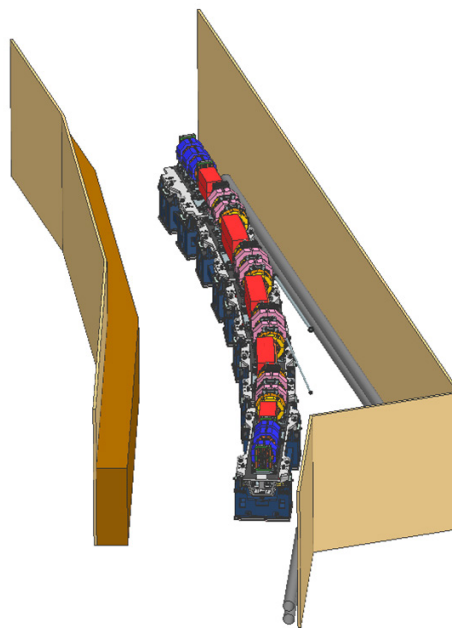


Figure 8: Sketch of the installation mock-up in the experimental area.

CONCLUSION

Storage ring lattice is still under optimization, but mechanical design work is being done for the components of the new storage ring.

Due to the high compactness of the storage ring magnetic elements and their required tight positioning tolerances, an effort to crosscheck all the integration of components has to be done continuously.

Purchasing for the prototyping project plan and results are expected for the first half of 2026. Prototyping tests have to include exercises on evaluating different positioning systems.

A compatible solution has been found for all the beamlines, where ID beamlines are kept in the same path, whereas bending magnet beamline will require minimal repositioning.

ALBA upgrade implementation will start on November 2029, and all the girder modules with magnets and vacuum system arcs should be ready for installation by then.

REFERENCES

- [1] G. Benedetti, M. Carlà, Z. Martí, F. Perez, and U. Iriso, “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](https://doi.org/10.18429/JACoW-IPAC2023-WEPL001)
- [2] F. Pérez *et al.*, “ALBA II accelerator upgrade project status”, in *Proc. IPAC’23*, Venice, Italy, May 2023, pp. 2582-2585.
[doi:10.18429/JACoW-IPAC2023-WE0GA1](https://doi.org/10.18429/JACoW-IPAC2023-WE0GA1)
- [3] J. Boyer *et al.*, “Design validation and alignment assesment of the girder prototypes for the ALBA II storage ring”, presented at the IPAC’26, Deauville, France, May 2026, paper MOP7189, this conference.
- [4] R. Parise *et al.*, “ALBAII vacuum system: design evolution and prototyping”, presented at IPAC’26, Deauville, France, May. 2026, paper MOP7096, this conference.