STRATEGY PLAN 2021 -2024

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INTRODUCTION

Over the past decade, ALBA Synchrotron (1) has become an important pillar of the Spanish and European Research Area, providing extended research capabilities to academic and industrial users thanks to the excellence in the offer and operation of state-of-the-art instrumentation, and to the scientific and technological initiatives originating at the facility.

ALBA is managed by the Consortium for the Construction, Equipment and Exploitation of a Synchrotron Light Laboratory (CELLS) and is in exploitation since 2012. It is included in the *Spanish Map of Infraestructuras Científico Técnicas Singulares* (ICTS) (2), and is a public entity participated by the Spanish and Catalan Governments. The infrastructure contains the accelerator systems where the 3 GeV electron beam produces synchrotron radiation (SR), the beamlines (BLs) where the synchrotron light is exploited, and several laboratories.

It delivers to the Spanish research and policy community another gate to the larger European research network and infrastructures from its current chairing of LEAPS, the League of European Accelerator-based Photon Sources (3), its connection with all European Analytical Research Infrastructure (see ARIE (4)), its positioning in the now-starting Horizon Europe (5) programs of the European Commission. ALBA industrial program directly impacts the economic growth by showing industrial leaders of Spain new development opportunities and ultimately windows of innovation for their businesses.

Under last year COVID-19 pandemic conditions, ALBA, always privileging staff and visitor's safety, has maintained safe and high reliability operation, developing new tools for user services like mailing-in samples, remote access and remote control, opening quick access calls for COVID-19 related experiments, with the outstanding result of performing a total number of experiments equal to the originally scheduled.

ALBA plays an influential role in science tutoring and education, in the whole range from dual professional training to early-career researchers, preparing and enabling young scientist and engineers for their national and international career, and seeding the inquisitiveness for rational cognizance and the scientific perspective in the youngest generations.

ALBA is nowadays ready to start the program for the next upgrade, ALBA II, the evolution from the 3^{rd} to the 4^{th} generation light source, a conceptual and technological development which is opening new frontiers in the capacity of synchrotrons to probe details and properties of matter. This is a process of several years which will take ALBA to the next level of scientific excellence in a decade from now.

ALBA strategy for the present four-year period is therefore centered in starting the ALBA II project, while simultaneously maintaining the excellent operation and user services, and further developing the present instruments, in view of their long-term usage also at ALBA II. The proposal of expanding the synchrotron environment with the creation of a Science, Technology and Innovation Park (ALBA Science, Technology and Innovation Park, ASTIP) in collaboration with several academic and research institutions is emerging as a unique opportunity which will make ALBA II and its environment an essential asset in the Mediterranean Area at the service of our society.

Both ALBA II and ASTIP offer to the national industrial fabric an unparalleled chance of development and capacitation as providers for the scientific world, in addition to a host of opportunities for their analytical R&D requirements; will be motors of economic growth, training capacity, talent attraction, and educational impact on the society.

1. ANALYSIS OF COMPLIANCE WITH THE PREVIOUS STRATEGIC PLAN

ALBA has **fully fulfilled its mission** as stated in the 2017-2020 Strategy Plan, namely "contribute to the improvement of well-being and progress of society as a whole through provision of scientific instruments dedicated to solving societal challenges such as health, environment, energy and communication" and "be a center of excellence in synchrotron radiation science and technology at European level and consolidate the status of CELLS as a recognized world class facility in its field".

Annex A ("ANALYSIS OF COMPLIANCE WITH THE PREVIOUS STRATEGIC PLAN") contains a more detailed description of the activities of the facility during the last four years. In this document we briefly mention the most relevant details. ALBA has realized or is completing all the priority investments included in the ANNEX C of CAIS report for SP2017-20, except for one of the new BLs, for which the funding has not been received. Through the collaboration with the European Space Agency (ESA) another BL, not originally foreseen, is being constructed as a Partner BeamLine.

The period 2017-2019 has outperformed the expected achievements in the scientific production and the operation reliability. It has also seen the construction of new BLs, the attraction of new users, with a special increase in industrial ones, and great advancement in cooperation capacity. During 2020, the COVID-19 **pandemic** has challenged the normal development of the foreseen strategies, but has also opened the door to develop smarter operation modes and in addition has made clear to the whole world the necessity of strong research systems for solving societal challenges.

This year has also set the basis for the future of our ICTS. The official start-up of the upgrade towards the 4th generation (ALBA II) and the proposal of a collaborative initiative for developing the nearby environment of ALBA into a Science, Technology and Innovation Park (ASTIP) are pushing the facility into a higher class of capacity as a societal investment.

In other words, ALBA has proven to be a resilient essential part of the Spanish research landscape and ALBA staff has shown their social and innovation responsibility corroborating ALBA as an important asset in Spain.

1.1. Scientific Impact

While serving the user community in all fields of science, prioritization in specific areas has been guiding the BL development and the collaboration directions, in particular in Life Science (*Drug design and characterization and biological processes involving drugs*); Magnetic nanomaterials; Catalysis and environmental sciences; and Materials for Energy-Related applications. Some illustrative examples of the research can be found in ANNEX A.

The current COVID-19 crisis has put **life sciences** research at the center of the entire society. An integrated approach allowing the description of the specific morphologies of in vivo organisms ranging from micrometric dimensions down to atomic level is part of the strategy of ALBA. Examples are the localization of anticancer drugs into the cells, or the integrated approach correlating the changes at molecular level with their effects at a cellular level, key for therapeutic efficacy. The integrative approach strategy requires the use of many techniques, of which available at ALBA are in particular small-angle X-ray scattering, cryo X-ray tomography, Infrared Spectroscopy and Macromolecular Crystallography (MX), at the NCD-SWEET, MISTRAL, MIRAS and XALOC BLs respectively, able to reach near atomic level resolutions. The cryo super-resolution microscopy, currently being developed as a collaboration with several national institutions and to be installed at ALBA in 2022, will complement the instrumentation and will allow to study structures at a cellular level to higher resolution techniques.

In addition, data analysis and integrative modelling are also required and are being developed for serial MX and cryo-EM, together with the use of high-performance computing which enables the possibility of computational modelling further pushing the limits in spatial and temporal resolution of the techniques.

Academic and proprietary **COVID-19 related research** has been the subject of several priority experiments channeled through a special call, as the studies focused on complexes of SARS2-CoV-2 MPro protein with inhibitors or the antivirals interfering the microtubule structure of the infected cell to hamper virus replication (6).

Nanomagnetism is experiencing in the last years a large progress due to the discovery of new materials with *exotic* properties, and understanding their electronic and magnetic properties is of use for developing quantum computers and advanced electronic devices. Quantum materials, of which graphene is the most popular, bismuth antimonides, selenides and tellurides, topological insulators, or skyrmions, are some of the subject of studies conducted in several of the ALBA BLs, namely BOREAS, CIRCE and MISTRAL, producing great advances in these fields, like the study on a new material ideal for magnetic recording with a huge capacity of storage (7).

Research in **catalysis** has been and will continue to be a field of intense activity at ALBA in correspondence to the large community of researchers in catalysis in Spain, with BLs specialized like CLAESS, CIRCE and MISTRAL. Catalyst are in most cases ensembles of particles of metallic atoms sitting on non-metallic supports. Only the atoms at the surfaces of the particles can affect chemical reactions since they are in contact with the reactant gases. Commonly, the metallic atoms are expensive precious metals and to minimize the cost of the catalysts, researchers synthetize nanoparticles as small as possible, as for example using zeolites as support (8).

Environmental sciences are an emerging research area at Alba due to their uppermost importance for the future of our planet, and experiments are carried out in XALOC, MIRAS, CLAESS, MSPD, NCD-SWEET, MISTRAL. Examples are the monitoring of plastic contamination in water or studies for PET recycling (9).

Battery research is one of the most active fields in today scientific activity. Research aims to develop better anodes and cathodes with surface coatings and other strategies in order to move away from $LiCoO_2$ and to eliminate carbon emissions in their production. Basic research becomes essential for their development: moving beyond Li by developing Na, Mg, Ca anodes, (10), substituting liquid electrolytes by solid state electrolytes or ionic liquids, understanding and controlling the solid-electrolyte interfaces are some of the issues that come into play. At ALBA BLs CLAESS, MSPD, MISTRAL, CIRCE, MIRAS are used for characterizing battery electrodes either static or *operando*.

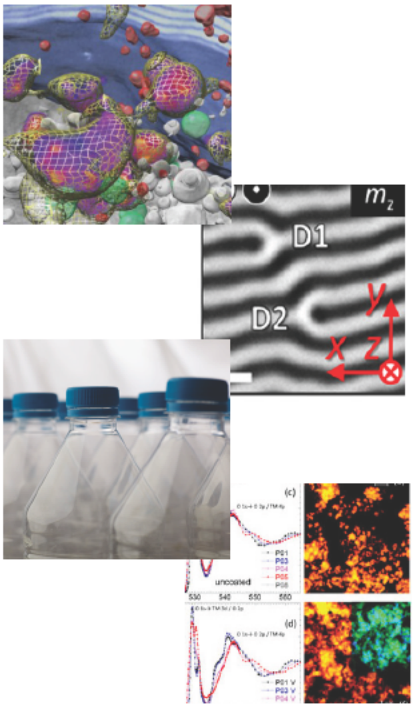


Figure 1 - Images corresponding to experiments performed at the ALBA Synchrotron (11), (12), (9) and (13).

1.2. User operation

The Spanish SR user community had only 200 researchers at the time of ALBA approval and today at ALBA User Database there are almost 3,000, plus more than 2,600 from outside Spain, numbers which continue to grow. This community has an ever-increasing demand of the access with an average Overbooking Factor of the order of 2. Users from all of Spain are using ALBA BLs, the most numerous from Catalunya, Madrid and Valencia. The request from international users is continuously increasing, passing from the initial 20% to more than 40% in the latest calls. More detailed statistics on the user access modes are in the document "Analysis of Competitive Access" and in ANNEX A.

> "In 2020,more than 95% of originally granted scheduled experiments were carried out"

The continuously on-going development of experimental methods, including on-line data analysis, speeds-up the experiment realization. As an example, remote access was introduced in 2017 at the XALOC BL, boosting its capacity to assist a large number of users, what has proven to be very important for the industrial sector and essential during the pandemic time: during 2020 90% of the users accessed this BL remotely.

During 2020, in spite of a 20% reduction of total beamtime due to the lockdown, more than 95% of the number of experiments originally scheduled in all BLs could be realized. Re-programming, allowing users to send samples, organizing online connection to handle the instruments and collecting data, relying on an extraordinary work done by the staff have been key for this great result. Furthermore, through the quick access COVID-19 call up to 6 experiments from both academic and industrial communities were performed. ALBA's effective answer to the singular situation is considered a great team success.

The **scientific productivity** is measured by Key Performance Indicators (KPIs). The number of peer reviewed publications based on beamtime is steadily increasing at the time of writing (Mar2021), the average number of papers per BL in 2020 is 35.5, and is outstanding when compared with other European synchrotron facilities. Another KPI is the Impact Factor (IF), and in the SR world the indicator is the average IF and the percentage of publications with IF>7. ALBA is among the best performing synchrotrons of Europe, having reached last year a percentage of 38%

(20% is considered a good result, 30% is excellence) and an average value of IF of 7.3 (5 is a good result, 6 is excellence).

ALBA **industrial users** belong mainly to the industrial sectors of pharmaceutical, nanotechnology, advanced materials and chemistry sector, lately complemented by the battery field, thanks to the strategic decisions of focusing in energy material research. All the BLs have been involved in industrial activities receiving industrial clients, and in the period 2017/2020 the number of delivered hours have doubled with respect to the previous 4-years period, maintaining a good rhythm even during the pandemic in spite of the lockdown effects also in companies.

The total portfolio of unique proprietary clients has increased up to 56 where 37% are small and medium enterprises (SME). 34 new clients have been attracted in the period 2017-2020. In 2020 pharmaceutical companies performing experiments for COVID-19 research were hosted. The active industrial outreach program has shown to be fundamental for enlarging the industrial portfolio, as well as the leadership role played by ALBA in the European H20202 CALIPSOplus project SME access program (ref. 730872).

Some of the industrial collaborations go beyond the use of beamtime, as for example the contribution to the funding of the construction of the FAXTOR BL by a private industry.

1.3. Operating the facility

All objectives on the **accelerator performance** of the previous Strategy Plan have been successfully accomplished. Reliability of the accelerator has been maintained at excellent levels, with an average availability of 98,2% over the four years, even in the challenging 2020 period during the pandemic, when the resources to quickly react to unexpected incidents have been fewer than normal, thanks to the continuous developments (ALBA32 and ALBA38 in SP17-20).

The beam current has been increased to the nominal value of 250 mA, maintaining the stability of the beam. This was accomplished after the successful intervention to repair the superconducting wiggler of the MSPD BL, which was overheating for stored currents over 150 mA due to broken screws in the inner beam liner, and it was not necessary to substitute the wiggler (ALBA31 in SP17-20).

One of the remaining issues is related with the reliability of the booster bending power supply, which has suffered recurrent breakdowns. Mitigation measures have been applied while a mayor upgrade is planned (ALBA 36 in SP17-20).

The new prototype developments, the 3rd harmonic radiofrequency (RF) cavity (ALBA24 in SP17-20) and the non-Linear Kicker for injection in the storage ring, are both under way. The IOT upgrade and the Solid-State Amplifier for the Booster are successfully installed and perfectly performing (ALBA26 in SP17-20).

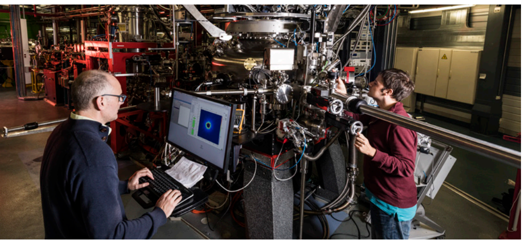
And finally, the hybrid operation of the storage has been successfully developed and tested, and it is nowadays available when required by the users.

Several upgrades were performed in the **complementary laboratories**. For example, the optics laboratory is now equipped with an interference microscope and a Fizeau interferometer and has become a trustworthy resource for several international instrumentation suppliers, which have used its metrology capabilities for numerous projects, for facilities around the world, like SwissFEL(14), MaxIV(15), ESRF(16), PETRA III(17), SSRF(18), APS(19) or the Australian Synchrotron(20). The magnetic measurements laboratory, upgraded with a hall-probe to measure close geometry magnetic structures up to 2m long, has directly benefitted Spanish industry by characterizing magnets for companies, like Elytt, and research institutes, like CIEMAT.

The maintenance of the conventional technical systems is the backbone of any research infrastructure. Special attention deserves the **de-ionized water-cooling system** responsible for the heat evacuation of the accelerators systems, which has been the subject of upgrade and on-going investigation of the water quality in order to ensure proper and long-term performance. Details are in ANNEX A. The completion of the HE liquefying plant has been so advanced that the plant is already in operation (ALBA27) and the 2nd half ring for Liquid Nitrogen around the experimental hall is on-going (ALBA45 and ALBA50 in SP17-20).

> “Average availability of accelerators has been over 98% along the four years”

1.4. Developing the facility



The BL performance optimization relies on continuous maintenance and upgrade of instruments. During the last four years almost all the **BLs** at ALBA have been **upgraded** and details can be found in ANNEX A. Let's mention just the upgrade of the **NCD-SWEET BL** (ALBA15 and ALBA16 in SP17-20), where the main detector has been substituted by a new one, the design of the experimental set up has been changed, the sample stage has been modified, a movable detector for wide angle scattering (WAXS) has been implemented, the beam optics has been redesigned by implementing X ray refracting lenses and an on-axis viewing system. The number of user proposals for the BL has doubled after the upgrade and the scientific productivity has strongly improved. At **BOREAS** a Silicon drift detector for partial fluorescence yield detection, and a radial distribution chamber with a connected STM and MBE chamber for sample treatments and preparation have been installed (ALBA21 in SP17-20). At **CLAESS** the fluorescence spectrometer has been equipped with a mosaic crystal analyzer and the monochromator has also been upgraded (ALBA19 in SP17-20). At **MISTRAL** a new grating with higher optical quality has been installed (ALBA13 in SP17-20) while phase-contrast imaging system (ALBA14 in SP17-20) is still pending.

Two new BLs have been opened to users for the first call for proposals of 2021: **LOREA** (ALBA01 in SP17-20) dedicated to angle-resolved photoemission spectroscopy (ARPES) and **NOTOS** (ALBA03 in SP17-20), devoted to X-ray Absorption Spectroscopy (XAS), X-Ray Diffraction (XRD) and instrumentation tests. Despite some delays caused by the coronavirus pandemics, both BLs have started the **commissioning** and are getting ready to receive users in the first half of 2021.

There have been advances also in the construction of **three additional BLs**, all of them to enter in operation before 2024: **XAIRA** (ALBA02 in SP17-20), a microfocus BL for macromolecular crystallography, **FAXTOR** (ALBA04 in SP17-20), a hard x-ray imaging BL for fast tomography, and **MINERVA**, a special collaboration with European Space Agency (ESA) which opens the use of the synchrotron to another field of science, with possible future applications with other space agencies. It is dedicated to metrology of x-ray optical components for astronomy elements to be installed in the Athena-X space telescope. MINERVA was not foreseen in the previous SP17-20 and ALBA has been able to secure the start-up of another BL, even if the funding for the foreseen BL, SUBmicro (ALBA05 in SP17-20), was not received. The concept of SUBmicro will be reviewed in view of the opportunities at ALBA II.

In this period, ALBA has taken decisive steps towards the adoption of the **FAIR principles**, taking part in the ExPaNDS project(39), within LEAPS. The final objective is to share efforts in the various developments necessary for the future European Open Science Cloud (EOSC (21)): the definition of a common Data Policy, the establishment of Data Catalogue and its tools, the implementation of a Data Portal or the architecture of future Data Analysis as a Service (DaaS) platform.

An important **renewal** of the **IT infrastructure** installed in 2010 took place from 2017 to 2020, increasing the capacity of storage systems for scientific and general data, and improving the High-Performance Cluster by multiplying the number of available nodes and adding new GPU-based servers. Most of the facility's switches, which were 10 years old and on the edge of their life cycle, were replaced by modern units (ALBA33 and ALBA37 in SP17-20).

The **possibility of upgrading the ALBA** storage ring towards a low emittance ring for transforming ALBA into a **4th generation** light source has been investigated and demonstrated under the hypothesis of maintaining the synchrotron layout and the existing ID BLs. BLs using dipoles as photon sources will need relocation whose characteristics are under study. Beam dynamics studies have been conducted, multiple contacts with other projects have been made, technologies assessment has been done, and a first design based on 7 MultiBend achromat has been proposed (22). All this preparatory work has been the basis for the obtention on December 2020 of the green light by CELLS Rector Council to officially start in 2021 the design stage of the **ALBA II project**.

The recent advances in electron microscopy based on new detectors and improved electron optics have revolutionized the field. The complementarity of their analytical capacities to synchrotron tools is the reason of many light sources incorporating electron microscopes in their facilities for both life and material sciences. The proposal of creating an **Advanced Microscope Platform** in the Barcelona area, with one of the pillars at ALBA, with the participation of several institutions as co-owners and main users was done years ago, and it is now an approved project.

The Platform has a pillar for material science with a 300-kV transmission electron microscope (TEM) with a double aberration correction system with monochromatic beam, and a pillar for life science with a mid-range 200 kV cryo-microscope with a top end detector, which will be used for both single particle imaging and sample screening and characterization. Both microscopes will be installed before summer 2022 in a specially adapted space, attached to the experimental hall of ALBA.

1.5. Bridging to the Spanish and European Research Area

The last four years have seen the bloom of ALBA links and collaborations with national and international Research Institutions and Research Infrastructures (RIs), driven by the simultaneous maturity of an operating facility and its remarkable development capacity.

The in-house research program of the BL scientific staff has developed towards solid collaborations with external entities and is the seed for the program development, and participation in competitive calls open to answer the societal challenges. This provides means to extend and guide the instrumentation capabilities beyond the basic funding from our stakeholders, to offer co-funded grants for PhD students and Post-Docs, and ultimately to develop and introduce new techniques, application areas, and methodologies.

> “The active role of ALBA in LEAPS has opened opportunities for advancements and developments to our users’ community”

The active participation in **LEAPS** from its inception in 2015 has opened opportunities for advancements and developments to the full ALBA community, including its users. ALBA has been acting as LEAPS vice-chair during 2018 and 2019, nominated chair for 2020, position which has been reconfirmed in 2021.

LEAPS-INNOV, the first LEAPS common proposal for an EC H2020 call, dedicated to key technological developments, in particular those related to the newest generation of light sources, was granted. It is an example on how the public-private partnership can advance in exploring new approaches, and preparing the industry for being more competitive (ALBA09 in SP17-20).

In 2020 a LEAPS initiative brought all European Analytical Facilities together, forming ARIE (Analytical Research Infrastructures of Europe) (4); ARIE builds on the complementarity of the different analytical tools and joints forces to develop a better environment for European citizens and the rest of the world by mitigating present and future threats.

On a more local scale the collaboration with Portugal has evolved, through an agreement signed in 2019 by ALBA and the Fundação para a Ciência e a Tecnologia (FCT (23)) giving rise to the start-up of an Iberian Project of Research and Innovation, focused on the four strategic scientific areas of ALBA.

The relevance of ALBA in the granted European projects has increased in the period 2017-2020 becoming an active player in several projects not only as participant but as task and work package leader. A total of 11 international and 19 Spanish national grants were active for ALBA in this period, details can be found in ANNEX A.

1.6. Serving the society

Innovation and knowledge transfer activities have been fostered resulting in collaboration agreements with companies and in a portfolio of 16 patents registered under ALBA, five of which were registered in the period 2017-2020.

An **innovation impact study** has been carried out within the framework of the H2020 RI-PATHS project (24) and based on the CSIL (25) methodology. The study analyzed the scientific impact and its spillovers into the society especially into the companies, unveiling that 372 patents worldwide cited ALBA publications in a direct or indirect way, covering a wide range of fields: Human necessities; Performing operations transporting; Chemistry and Metallurgy; Mechanical engineering lighting heating; Physics and Electricity. Given the fact that the average time span between publication and patent is six years, we are here seeing the impact of a small part of ALBA activity, corresponding to the first years of its operation, and we expect this innovation impact to be strongly amplified in the coming years.

H&S Group tasks during the period have been focused in maintaining safe operation in a mature user facility, focusing on all safety aspects of staff, users, contractors, and visitors; major achievement is developing and nurturing a safety culture, which is now fully part of ALBA's DNA.

The **Radiation Protection Group** has been an essential part in the construction of the new BLs of ALBA and provided external services to SESAME (26), taking care of all aspects related with radiation protection.

Countless are the actions of the **Conventional Safety Group**. The pandemic dominated its activity during 2020, with the Conventional Safety Group being key protagonist of procedures implemented in the facility for keeping staff, collaborators, contractors and visitors safe. During 2020 no tested positive cases were reported among all people at ALBA, even if few suspect cases were appearing during spring. To ensure fast and efficient communication and a wide consensus between all stakeholders within ALBA, an Emergency Committee with representation from management, H&S and Worker's Council was nominated by the director in February. A contingency plan based on three different scenarios, called containment, mitigation, and escalation, defines guidelines for all business aspects of the organization and provides a long-term planning security and effective management of the business units.

Selecting and retaining qualified staff is challenging under the present administrative and economic condition. Programs are developed aiming at widening the base of potential candidates and reinforcing the image and messages of ALBA as an attractive employer offering Equal opportunities, diversity and non-discrimination at the workplace. The student program is strengthened at all levels: vocational training, trainees, degree students. Additional Postdoc positions have been opened, funded by ALBA and/or partners. Actions to further improve working conditions and internal relationships and cohesion are taken.

Efforts to reduce the rate of temporal contracts for the structural positions are on-going, together with optimization of the implementations adjusted to national regulation for human resources management. At the same time, we try to influence a new national regulation for research institutions like ALBA in order to achieve the necessary improved boundary conditions for running the consortium in an important phase of growth.

General progress in these tasks is considerable positive. More tangible results should become visible in mid-term. As indicators for this may serve the fact that in the first 2 months of 2021 11 persons could be hired, 9 of them in the specially complicated target market of the Computing Division.

Unfortunately, not all actions were accompanied by corresponding public regulations. In such cases the impact of our actions was somehow limited. Also, priorities had to be given to the more urgent actions, achievable within the scope of resources available for the management of the HR programs. This explains why the initiative of obtaining the HRS4R label for ALBA was put on hold for the time being.

ALBA **communications and outreach** have evolved during this period, by consolidating specific communications activities and educational projects and finding new ways to transmit science. The team has been reinforced, having two permanent full-time persons dedicated. Presence of ALBA in media has been increased and a solid set of channels keeps the facility connected with its targets (users, scientific community, general public, media, students): annual activity report, newsletters, social media platforms, website, events' organization and news and highlights.

ALBA is an attraction hotspot for the general public and students, welcoming more than 22,000 visitors during the Open Days and the guided tours held during these years. The *Misión ALBA* born in 2018, dedicated to children has counted with more than 20,000 students and 500 teachers from all the regions of Spain.

1.7. Resources

The availability of sufficient and adequate personnel continues being critical key factor for ALBA strategic goals. We aim at contracting a mixture of experienced and expert people and young people to be trained on the job in all areas of operations and developments. Only very few clearly non-critical services are externalized.

Nevertheless, important risks and threats in the context of staff evolution of the still fast-growing RI need continuously to be overcome, as the high rotation in some sectors and disciplines, difficulties in hiring competent persons for some authorized positions in some sectors and disciplines, frequent deserted job offers, or positions with approved budgets which cannot be published due to delayed or missing formal authorization by Ministry of Finance.

We believe that the reasons for these difficulties mostly have their origin in public administrative constraints and difficult labor market conditions and that in general, public rules for hiring do not match the requirements of a growing research organization and do not coincide with the approval of budgets, strategies and programs.

ALBA Positions	2017	2018	2019	2020
# POSITIONS SP 17-20 (HP)	192	209	223	231
# POSITIONS IN YEARLY BUDGETS	188	198	221	231
# POSITIONS FINALLY AUTHORIZED	188	198	209	220
% OF TEMPORAL CONTRACTS	42%	43%	33%	35%
EXTERNAL FUNDING AND COLLABORATIONS	9	10	13	11

Table 1 – Evolution during the 2017-2020 period of staff numbers.

For the reporting period, the evolution of the staff is shown in Table 1. Gender proportion has slightly improved (from 25.4% in 2017 to 28.4% in 2020) and is balanced, considering the usual sectorial proportions.

Budgets could be adjusted to the High Priority objectives marked by the Strategic Plan 2017-2020. In all cases, we succeed in publishing all authorized positions and reissue quickly deserted job offers. However, in 2019 and 2020 formal authorization arrived very late in the year leading to important peaks of ongoing selection processes and the loss of important time in operative and development programs.

The proportion of temporal contracts is too high. In 2019 the applicable normative allowed the conversion of some long-term temporal contracts into permanent contracts (43% -> 33%) but this instrument was not continued afterwards, so the numbers have started to increase again due to rotation and growth of ALBA.

Despite the described difficulties ALBA has succeeded complying with most of its objectives 2017-2020. The efforts of the highly motivated staff were extraordinary. But the associated risks and threats will persist, while ALBA can mitigate or influence them only to a small portion. A strong support by public administrative rules to ambitious objectives is clearly needed.

ALBA economy up to 2020 has been based on the plurennial **budget** approved in 2008, covering operation of the infrastructure with Phase I BL and only 3000 hours of operation per year. Nevertheless, ALBA has over performed in number of BL and operation hours per year with respect to the provisions of the assigned budgets. European Regional Development Funds (ERDF) (16 M€), corresponding to the 2014-2020 period, were assigned to ALBA to be co-funded with the same amount to provide 32 M€ for new investments. These funds have started to be delivered in 2017 and up to now only 14,5 M€ have been formally granted. On top of that extra basic funding to cover the multiannual deficit has been provided by a total amount of 6,3 M€, with additional 8,9 M€ assigned to 2021 practically completing the 15.6 M€ requested for 2017-2020.

Table 2 shows the budget evolution during the period 2017-2020, together with what was requested in the 2017-20 SP. The funding gap (the difference between what was foreseen in the SP High Priority (HP) Objectives and the effective funding received) during this period amounts to 39,8 M€, of which 7,2 have been covered with income from industrial usage, collaborative projects and other minor sources.

SP 17-20 vs. funding received	2017	2018	2019	2020
SP 17-20 HP Budget	43.055	46.209	48.182	50.050
Total funding obtained	34.560	38.190	38.811	36.168
from basic funding (agreement)	30.870	31.444	32.035	32.645
from additional basic funding	0	0	3.600	2.662
from ERDF Operative Program 14-20	3.690	6.746	3.175	861
Funding Gap (related to SP17-20)	8.495	8.019	9.371	13.883
Accumulated funding gap (w/o Project & industry inc.)	8.495	16.514	25.885	39.768
Income from collaborative projects, industry & others	1.896	1.767	1.645	1.900

Table 2 - Requested Budget and Budget Gap evolution during the 2017-2020 period; 2020 are provisional numbers [figures in k€].

Table 3 shows the expenditure evolution and the investment balance for 2017-2020. As mentioned before, the available budget for personnel cost could not be spent as desired. In the chapters of current and financial expenditure, important savings could be achieved, mainly due to the reduction of energy cost (in our case based on the evolution of the market price for natural gas), careful and austere budget administration and the reduction of travel and congress cost during the pandemic in 2020.

Investments are lagging behind as they need to be adjusted to real budget and cash availability and to the staff available to actually work and integrate the items purchased. The "investment gap" (difference of HP investments of the SP17-20 and the executed investment budget) almost completely matches with the ERDF funds pending to be executed. In spite of the evidence that accomplishing what was described in the last SP ago has been out of reach, we can proudly show that a large part of the plan has been accomplished, new projects have been started, applying careful and effective management methodologies.

Expenditure	2017	2018	2019	2020
Total expenditure	39.542	40.000	36.819	36.968
Personnel	10.822	11.210	11.963	11.940
Current and financial	8.111	8.407	7.939	7.483
Investment	8.878	8.652	5.186	5.815
Loan return	11.731	11.731	11.731	11.731
SP 17-20 HP Investment Budget	8.885	11.015	9.430	10.268
Investment gap (ERDF programs ongoing)	7	2.363	4.244	4.452
Accum. Investment gap (ERDF programs ongoing)	7	2.370	6.614	11.067
Pending investments in ERDF programs (31/12/2020)				13.381
ERDF requested (pending)				1.528
Received funding pending to be applied to investments				1.609

Table 3 - Expenditure and pending investments; 2020 are provisional numbers [figures in k€] .

2. MISSION AND VISION

2.1. Mission

- Contribute to the improvement of well-being and progress of society as a whole through provision of scientific instruments dedicated to solving societal challenges such as health, environment, energy and communication.
- Act as a catalyst for regional and national collaborations addressing overarching societal challenges.

2.2. Vision

- Develop synchrotron radiation and accelerators technologies towards a fourth generation SR source at the end of the 20's.
- Provide access to state-of-the-art SR facilities and expertise to academic/ industrial communities.
- Constantly monitor the user needs and accordingly improve methods, instrumentation, and/or techniques.
- Expand the scope of provided services to electron microscopy and FAIR data handling.
- As the largest national scientific user facility of Spain, foster development and innovation of the Spanish scientific community and industry to strengthen its competitiveness in a rapidly evolving world.
- Collaborate with similar facilities in promoting the quality and impact of fundamental, applied and industrial research.
- Inspire a new generation of scientists, engineers and administrators and participate actively in the education of society in science and technology and in its public perception.
- Effectively operate the facility, protecting the environment, and ensuring safety and health .
- Offer to the international community those instruments which are unique or which complement other light sources capacities.
- Connect ALBA research capabilities to national and international research initiatives by developing collaboration agreements with individual institutions and consortia, specifically LEAPS and ARIE.
- Endorse, support, and develop complementary and synergetic research facilities mainly within the ASTIP project with the goal of increasing ALBA impact on research and innovation in Spain.
- Bridging scientific communities in developing countries to contribute in the advancement of opportunities worldwide, exchanging experiences and cultural richness.

3. SWOT ANALYSIS

3.1. Strengths

- Reference laboratory in Spain for Accelerator Science and Technology, for exploitation of SR methods, and reference institution at national level for conventional and radiological safety in research area.
- Exceptional track record for dissemination of scientific knowledge measured by scientific publications and the out-reach program.
- Leading member of LEAPS with key participation in European Commission projects.
- Driving force in Spain for academic, industrial applications and technological transfer.
- Optimized cutting-edge instrumentation infrastructure for dedicated focus research areas matched to the Spanish user community.
- Highly motivated, diverse, and multidisciplinary staff with national and international reputation.
- Mentoring, network fostering, and training initiatives for various education and career levels.
- Lean management structure with proven fast and effective problem-solving power.

3.3. Opportunities

- Developing synergies within program opportunity to complete BL portfolio, invest in support infrastructure and start updating program (ALBA-II) based on 10 years of operational experience.
- Clear funding agent support for the program, in conjunction with the renovation of the long-term funding period.
- New funding opportunities coming for RI: Next Generation Europe, Horizon Europe, new ERDF Operative Program (2021-2027).
- Developing additional user access modes fostering fast access and effective and tailored use of beamtime.
- Extending imaging and characterization capabilities to atomic resolution by implementing Electron Microscopy and upgrading ALBA to a 4th generation instrument.
- Extending services to big data community by Implementing FAIR data and optimized beamlines.
- With ASTIP or similar agreements, like the Advanced Microscopy Platform, providing extended research capabilities to full Spanish researcher community and strengthening collaborations.
- Adding capabilities using Partner BL, Partner Instrumentation and Association Agreements.
- Increased visibility and attractiveness of ALBA for collaborations, industrial cooperation and qualified staff thanks to the upcoming programs and initiatives.

3.2. Weaknesses

- Limited number of BLs and related SR techniques to fully exploit all scientific opportunities.
- Limited staff number making the facility vulnerable to staff fluctuations and work load spikes.
- High rotation rate of staff and some sectorial difficulties in hiring experienced personnel.
- Missing support from other institutions for users to enabling capabilities beyond core SR task, like sophisticated sample preparation, simulation, theory, and data analytics services.

3.4. Threats

- Legal framework and administrative regulations not well adapted to the projected growth.
- In EU comparison, weak involvement of national industries into R&D and high-risk products.
- Extraordinary competition for work-force in some critical sectors.
- Staff growth rate may lag behind facility growth rate.
- Enhanced project and process control to compensate low contingency in staff resources.
- Vulnerability of Spanish and EU economy due COVID crisis with reduced public R&D investment.

4. OBJECTIVES OF THE NEXT FOUR-YEAR PERIOD

Even if a four-year period in the life of a RI usually offers only a partial view on the range of activities, spanning through much longer periods, the current passage of ALBA between two strategic plans coincides with the transition between two major facility stages shaped by the upgrade from the 3rd generation ALBA to the 4th generation ALBA II. This process will be completed within almost one decade, requiring multiple distinct periods including an initialization and preparation phase. ALBA II details reported in this document are therefore to be considered preliminary.

We concentrate our objectives in launching the upgrade program while completing the ALBA developments of new instrumentation, and maintaining the highest standards of overall operation aspects. Building on the involvement of users and collaborators, we aim at developing the facility to a new level of scientific and technological excellence fully tuned to the future needs of the community.

4.1. Description of the objectives

4.1.1. ALBA II: Developing scientific, technological and innovation power of the facility

Significant progress in accelerator design, X-ray optics, detection technology, and Information Technology (IT) infrastructure drives worldwide the evolution of synchrotron light sources to the 4th generation, with cutting-edge research instruments opening new windows to the exploration of inner details of matter, devices, and their functionality. Photon brilliance (photons per unit time, per unit area, per unit solid angle and per unit spectral bandwidth) and the coherent fraction of the photon flux are increased by orders of magnitude, providing the ground for unmatched analytics tools, ultimately leading to develop new approaches and technologies for a sustainable, clean and smart economy and a more efficient health system. ALBA is ready to leap from the 3rd to the 4th generation and give birth to ALBA II, by combining the partial substitution of the accelerator with the upgrade of the existing instrumentation and the addition of new and fully optimized BLs, thus providing a crucial competitive advantage for the Spanish innovation ecosystem.

The ALBA II project will be carried out during the next decade while simultaneously operating ALBA and renovating the present BLs in view of the future source.

ALBA II will have a total capacity of 21 BLs, of which 13 receiving photons from IDs and up to 8 from fixed field dipolar systems, which will substitute the present dipolar sources (DSs).In fact, having not used the whole potential in terms of BL capacity (9 IDs + 4 DS nowadays) turns out to be an opportunity for ALBA II; ports free, still not occupied by a beamline, can be now used for fully making use of the more brilliant photon source using cutting-edge technologies and providing techniques fully exploiting a 4th generation source.

This Strategy Plan includes the construction of up to four new BLs to be started in the period 2021-2024, the first of them to be in operation before the upgrade of the source, the others to be ready for commissioning when the new accelerator will be providing its first photons. Advancement in technology, societal needs, evolution in the national scientific and industrial community will guide the choice of the BL definition, in this first period and in the successive ones for the completion of the whole fan of possibilities in ALBA II.

By substantially contributing to ALBA II construction, **the Spanish research instrumentation industry is provided with a unique opportunity to develop products and train their personnel in accelerator and X-ray technologies**, positioning them at the European and global level as high-tech suppliers, entering a global growth market which is characterized by the strag-

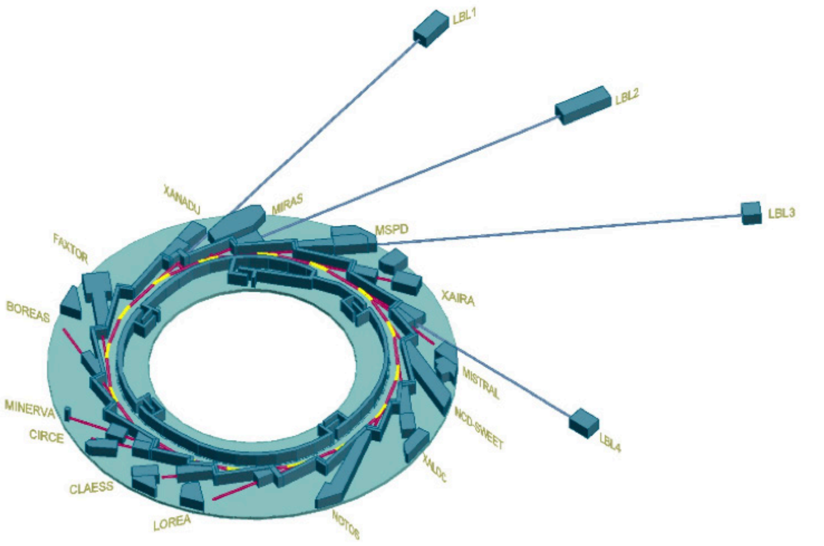


Figure 2 – ALBA and ALBA II BLs sketch.

gle of satisfying the increased request caused by many simultaneous upgrade projects worldwide.

The assessment of the **socio-economic impact of ALBA II** in the Spanish and local environment will be carried out, as it was done for the ALBA project, *ex-ante* in 2004 (27) just after the project approval and *ex-post* in 2010 (28), at the end of the construction.

4.1.2. Excellence in ALBA operation and services

A user facility is a combination of reliable, state-of-the-art, instruments within a dynamic scientific and technological environment where ideas and proposals are continuously arising for advancing knowledge and quality of provided services. Ensuring the reliability of all the systems which have been operative during one decade, is one of the priorities for the next period.

Accelerators operate nowadays with excellent performances, with an availability for the users over 98% that we aim at maintaining. Adequate maintenance and expert personnel to cope with the obsolescence of the equipment and with the unforeseen aspects of the day to day operation are needed.

Present **BL portfolio** is a mixture of operating, commissioning and in construction BLs. The day-one BLs need, as the accelerator, revision of some of the subsystems addressing possible obsolescence and maintaining their characteristics at the forefront of the newest technology. All updates from now on will be consistent with ALBA II photon beam characteristics, creating investments for the future. Another priority is completing the commissioning of two BLs (LOREA and NOTOS) in 2021 and finishing constructing three additional beamlines (XAIRA, FAXTOR and MINERVA) within 2023.

The facility will also continue to grow its capacity to expand the user services: new modes of access including remote access mail-in or the mixed remote access/ control, most of these modes started during the pandemic to enable basic operations, will be further developed and accompanied by instrumentation updates. Automatization, standardization, digitalization and optimized data management are going hand-in-hand by LEAPS initiatives, as described next in 4.1.3.

Industry, in the role of a user, can benefit from the unique ALBA synchrotron techniques to grasp deeper knowledge of their materials, products and manufacturing processes, helping to develop innovative solutions, and to gain competitiveness. A broad range of industrial sectors may be benefiting by the techniques offered at ALBA, including those focused-on energy storage, generation and transportation, environmental residues, new drugs development, biomedicine, agrofood and packaging, cosmetics and nanotechnology. ALBA is aiming at enhancing its service to industry as user by offering tailored and new characterization services building on the techniques offered at ALBA II and expanding the external collaborations with initiatives like ASTIP as detailed in 4.1.4.

4.1.3. Expanding the collaboration networks

ALBA will maintain chairing **LEAPS** (3) during 2021, and as such will continue having a strong voice inside the photon community and be one of the interlocutors of the Directorate General for Research and Innovation of the European Commission.

Reacting to the pandemic crisis has provoked to push both the scientific mission and the operation standards towards the green and digital transformation. The reconsideration of user operation including remote operation tools and artificial intelligence concepts, in the entire train of the experimental installations from the accelerator to big data handling, is the basis of the "Digital LEAPS" project currently being developed.

Active participation in Horizon Europe programs is expected, evolving towards a model of public-private collaboration, both within LEAPS and within ARIE, which has just submitted a proposal to a call of H2020, ARIE4GD, meant to create a new generation of guided and facilitated transnational access (TNA) services, which will make the best analytical research infrastructure facilities of Europe available to clean energy-storage technologies.

ALBA will continue maintaining and further developing the collaborations within Europe, like the Iberian Project with Portugal, and beyond Europe, for example with SESAME, the African Light Source(29) or the Mexican Synchrotron.

4.1.4. Evolution of ALBA Environment into a Science, Technology and Innovation Park

An extended and still growing collaborative network has developed around ALBA which is creating new opportunities for cooperation initiatives targeting the grand challenges of our present and involving the whole Spanish Research and Innovation system, with a very active role of the nearby institutions.

A proposal is being shaped together with several academic, research and innovation institutions for **a new scientific and technological center in the vicinity of ALBA,** grabbing the opportunity of combining the ALBA evolution into a 4th generation light source with the simultaneous construction of an advanced infrastructure fully optimized to profit of the capabilities of the new source.

ASTIP (ALBA Science, Technology and Innovation Park) purpose is the establishment of an ecosystem where scientific research, technology development and industrial innovation are integrated to create a resilient, resource-efficient and competitive environment focused on **green energy, digital transition and health**. ASTIP would nucleate around the ALBA Synchrotron and its upgrading to ALBA II, and enclose the key actors involved in the innovation value chain located in the Barcelona area, including several leading research institutions with a high representation of CSIC (30) and BIST (31), the Universitat Autònoma de Barcelona (UAB) (32), and the Eurecat technology center (33).

ASTIP is foreseen as an **interdisciplinary innovation hub** that blends a unique combination of imaging and characterization tools for complex materials and for biological systems, material growth and detector and device fabrication facilities, big-data and data-mining capabilities with innovation driving synergies.

ASTIP builds upon this successful mode of collaboration and is to be located in a new complex adjacent to the ALBA Synchrotron within the Parc de l'Alba (34). ASTIP is meant to be inclusive and open to more national and international institutes who can profit from the proximity of the research environment to a large research infrastructure.

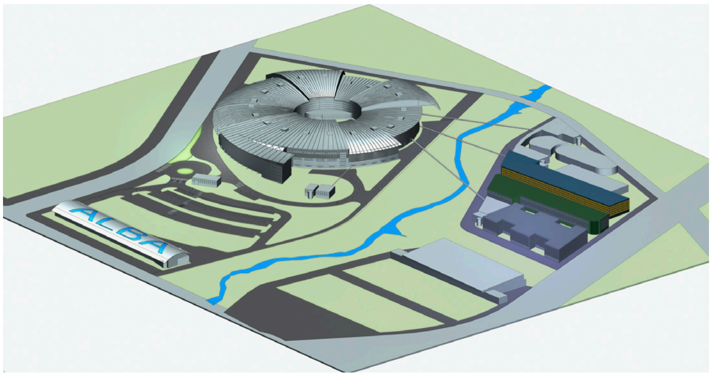


Figure 3 – ALBA and ASTIP layout.

4.1.5. Societal consciousness and services

As scientists we have the responsibility to contribute to the future generation education laying the foundation for a research driven society. With an ambitious outreach program, we will address not only those who will undertake scientific careers, but also the general public at large, among which there are future decision makers and important stakeholders interested in the welfare created by a knowledge based, resilient and in all sense's sustainable society.

A large facility like ALBA is an excellent instrument to complement the regular education at different levels, starting from schools, passing through universities, fostering the participation of girls in Science, Technology, Engineering, and Mathematics (STEM) carriers, and reaching the political elite and the general public. ALBA training on the job and career development opportunities at all levels and for the different professions contributes to the general leap of a knowledge-based society. It is important to point out that we are not only focusing on highly specialized scientist profiles but also foster the professional progress for an extremely wide rank of disciplines and profiles at all experience levels reducing societal disparities and decreasing the risk of social segregation.

Capabilities on training activities for technical schools, undergraduate and PhD students will be continuously pursued in collaboration with universities and external institutions.

4.2. STRATEGIES AND THEIR DEVELOPMENT TO ACHIEVE THE OBJECTIVES

The strategies and their development to achieve the objectives defined in 4.1 are described in ANNEX B ("STRATEGIES AND THEIR DEVELOPMENT TO ACHIEVE THE OBJECTIVES"). Here we briefly summarize all of them for reference.

4.2.1. ALBA II Scientific Strategy *(Objectives 4.1.1, 4.1.4, 4.1.3, 4.1.5)*

Most urgent challenges in the world are related to health, climate change, environment and energy. Solutions require the visualization of complex systems and understanding how subsystems work together on different length scales. Promoting ALBA to a 4th generation light source will enable imaging tools with enhanced resolution capacity and allow imaging techniques with near atomic resolution. It will also provide more powerful instruments to probe the structural and electronic changes under operando conditions with higher-energy X-rays. The combination of advanced data analysis algorithms with the increased volume of the data acquired meeting FAIR principles will reveal correlations between changes and functions, and will make our microscopic information available to the big-data world, closing the loop between the micro and macro scales.

4.2.2. ALBA II Accelerator development *(Objectives 4.1.1, 4.1.2, 4.1.3)*

The core of the upgrade of a light source from 3rd to 4th generation is the increase of brilliance and coherence fraction of the photon beam by minimizing the emittance of the electron beam in the storage ring, combined with the upgrade of BL optics and technologies and completed with new state-of-the-art BLs.

The low emittance is obtained with the so-called Multi-Bend Achromat (MBA) in the arcs of the storage ring, increasing the total number of dipoles. The design under study foresees an emittance decrease of about a factor of 20, based on novel magnet and vacuum technologies which will be prototyped in the next years. The design, the construction and part of the installation of ALBA II systems will be carried out while operating the facility with its present BLs during the next eight years (2021-28). Then, the facility will be shut down during one year for the installation of the new storage ring components and another year will be dedicated to commissioning of the accelerator and of the new BLs, in an extremely cost-effective intervention.

4.2.3. ALBA II Beamlines *(Objectives 4.1.1, 4.1.2, 4.1.4, 4.1.3, 4.1.5)*

ALBA II photon beam qualities will provide significant photon flux gain, a high coherent fraction of the beam over a wide energy range, and excellent experimental conditions in the full energy range up to 25keV.

The construction of new BLs for ALBA II will exploit these opportunities by providing two long and fully optimized ID instruments, with end-stations located in the plot next to the ALBA parcel. The instruments will be ready for commissioning together with the upgraded ring, employing techniques and probes either not possible at current ALBA or largely benefitting by the ring upgrade. In addition, we plan to build one short ID instrument, operational under ALBA conditions but fully benefitted by ALBA II and an additional bending magnet (BM) BL to consolidate and complement the existing portfolio of research tools to deliver the full service to the user community.

A decision process, supported by AUSE, based on the community needs, and reflecting the position of ALBA within the international competition, the success and short comes of the existing BL programs and a gap analysis, is now starting, geared to choose instruments with highest impact for the research community.

4.2.4. ALBA Accelerators Operation *(Objective 4.1.2)*

The ALBA accelerators are operating with excellent levels of reliability while, at the same time, improving and upgrading their performances. Maintaining these standards is obtained by modernizing components and optimizing the procedures to take full advantage of the available resources.

Our strategy is to renovate or even substitute the equipment according to the needs. The modernization of the equipment for ALBA will be done having in mind the requirements for ALBA II

Several systems have been identified as requiring modernization, and are here listed, such as the Digital Low-Level RF, the RF amplifiers, the Linac spare equipment, the SR cavity spares, the BPMs and FOFB Electronics, the Timing System, the Control System Hardware and the injector Power Supplies. And in addition, there are two on-going development projects to be continued, namely the 3rd Harmonic RF System and the Non-Linear Kicker.

National and international collaborations in development and research in accelerator technologies will continue.

4.2.5. ALBA Operation: Upgrade of operating Beamlines *(Objectives 4.1.2, 4.1.1, 4.1.3, 4.1.5)*

The BLs have been continuously upgraded in the last four years in order to keep the instrumentation up to date, and these activities will continue in the forthcoming years. A plan of technical review of the different BLs to be carried out during 2021 and 2022 aims at defining the major changes in the present instrumentation, all upgrades to be done considering their future in ALBA II.

Among the most urgent upgrades we foresee the need of updating sample environments in several BLs, the High-Pressure User Laboratory and the gas handling system.

Changing of operation modalities which were started during the pandemic in view of the unavailability of users on-site will be further expanded and optimized for increasing the productivity and reducing travels. Automatization of BL alignment, beam focusing, detector operation, data acquisition, visualization and on-line treatment will be implemented in all BLs and adapted for remote operation.

In the long term, there is the plan of adding variable micro focusing and a side branch with Photo Electron Emission Microscopy (PEEM) at LOREA, installing a new aberration corrected PEEM system and installing a P3 environment at MISTRAL.

4.2.6. ALBA Operation: Start and consolidate operation for BLs in construction *(Objectives 4.1.2, 4.1.5)*

During the period of this strategic plan five BLs will start to operate and receive users. LOREA and NOTOS have started commissioning already and will open to users in summer of 2021. XAIRA and MINERVA will have users in 2022, and FAXTOR will open in late 2023. With them, ALBA will increase the number of BLs receiving users from 8 to 13, and will add several experimental techniques to the portfolio of the facility. Since the number of simultaneous experiments being run at ALBA will increase by about a 63% with respect to ALBA current capacity, all transversal services and infrastructures of the facility will need to be updated, including data storage capacity and the network infrastructure, in order to consolidate the operation of the new BLs. All complementary services as for example user laboratories for sample preparation, and vacuum, electronics or the proximity workshop will require some degree of growth, and some of them will require specific investments, as detailed in ANNEX C.

4.2.7. ASTIP definition and start of construction *(Objective 4.1.1, 4.1.4, 4.1.3, 4.1.5)*

The integration of ALBA in the proposed ASTIP scientific hub would enhance the opportunities for collaboration with the participating institutes, streaming from the Advanced Microscope Platform now in construction at ALBA which hosts instrumentation owned by several research institutions. The hub should also host the data center PIC (*Port d'Informació Científica* (35)), a great opportunity for enlarging the data storage and on-line capacities of the ALBA IT infrastructure.

ASTIP proposal is based on three new centers and the new ALBA II BLs which enhance ASTIP scientific reach. The centers are the Complex Materials and Technologies Center (**COMTEC**), the Advanced Multiscale Bio Imaging Center (**AMBIC**), and the Innovation Hub (**SYNDUSTRY**, Synchrotron light- based R&D towards new industrial applications). Combining the optimization of already existing resources with state-of- the-art instrumentation fully profiting of the enhanced properties of the synchrotron, will make this center almost unique worldwide.

The center will exploit existing local and urban infrastructures and boost the research and training vocation of Cerdanyola del Vallès to a new level. It will include a large auditorium and a guest house.

ASTIP is one of the proposals presented to the Generalitat de Catalunya in the call for ideas for Next Generation EUrope. Its timely realization is of course strongly depending on the availability of these funds, but the concept will be in any case pursued in the future by the ensemble of involved institutions to ensure the development of such area as a powerful scientific, technological and innovative pole in the Mediterranean Area and as an added value to ALBA II which will enhance its potential.

4.2.8. Innovation and technology transfer *(Objectives 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.1.5)*

The tailored service provided to industry as a user will be enhanced by offering an increasing variety of characterization options to better satisfy the innovation needs in particular thanks to the new portfolio of BLs at ALBA and the future ALBA II instrumentation. The strengthened network of collaborations will make available all existing synchrotron techniques provided at ALBA to industry for its transformation into innovation solutions. Planned or current programs are represented by ASTIP, the ARIE4GD proposal and the relevant role to be played by ALBA in the SME access to the European synchrotron facilities within the LEAPS-INNOV project.

The construction of ALBA II is a unique opportunity for the industry as a supplier because it will imply design, development and manufacturing of new instrumentation for the new accelerator complex as well as for the new BLs. A proposal including most of these aspects was submitted in January 2021 to a call opened by the Spanish Ministry of Industry Commerce and Tourism (Mincotur) for the projects to be funded through the Next Generation Europe program. The proposal was presented by a consortium made of private companies, the Ineustar association (38) and ALBA. Participation in industrial related initiatives is key for the success of the ALBA II project and for the socio-economic impact of ALBA.

4.2.9. Data management evolution *(Objectives 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.1.5)*

Optimizing data management is key to the success of all scientific activities at ALBA. In recent years, as a result of different technical breakthrough developments, the increase in the volume and complexity of scientific data generated in synchrotrons is unprecedented. On the other hand, the increasing importance and demands of the big data community have resulted in systematic and massive re-analysis of datasets. Data Science is flourishing and envisaging a future which is fully shaped by clear guidelines of the European Commission (EC): the adoption of the Open Science principles and the creation of the European Open Science Cloud (21), to which ALBA has adhered, in conjunction with other research infrastructures. ALBA is an active participant in the ExPaNDS project (39) as part of the H2020 Research and Innovation program with common objectives towards the implementation of the EOSC in the Photon and Neutron sources research infrastructures.

Examples of the above-mentioned developments are used in the XAIRA and FAXTOR BLs, which will generate per year 30 times the volume currently produced in the eight operational BLs in 2020. A complete upgrade of the entire IT infrastructure to a High-Performance infrastructure will be required in the next three years allowing to store, process and archive these data.

4.2.10. Electronics and Detectors Developments *(Objectives 4.1.1, 4.1.4, 4.1.2, 4.1.3)*

The use of highly optimized instrumentation beyond off-the-shelf hardware is a must, and essential to provide enabling subsystems for accelerator and BLs.

Based on our long history of collaborations, our strategy to provide these solutions is fourfold: train experts and build solid expertise, team up with other facilities and industrial partners, fine tune existing solutions, and, if necessary, develop our own solution.

Field Programmable Gate Arrays (FPGA) are one of the selected key technologies, necessary to master fast nano- and micro- positioning with synchronized detection, feedback systems in general, but also online data reduction and pre-analysis, and compression. Mastering this technology will not only allow to participate at, and develop own projects but also optimize and modify commercial products. Our local collaboration partners like IFAE (36), CNM (35), or ICN2 (40) will play here an important role.

4.2.11. Complementary Laboratories Upgrades and Exploitation *(Objectives 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.1.5)*

Upgrading the complementary laboratories is mandatory for continuing to provide their invaluable service to the facility, the users, the collaborations both private and public.

The participation in LEAPS-INNOV allows for upgrading the Magnetic Measurements, the RF and the Optics and Metrology laboratories, all of them essential for the ALBA II developments.

Laboratories open to users (biology, chemistry, high pressure and material science) as well as those supporting the facility maintenance and development (He liquefaction plant, vacuum and cryogenics, survey and alignment, electronics, mechanics) will be kept updated and adjusted to the growing operations. Summed to ASTIP can become an outstanding interdisciplinary innovation hub with unique combinations of imaging and characterization tools for complex materials and for biological systems.

4.2.12. Excellence in personnel and budget management *(Objectives 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.1.5)*

ALBA will continue developing and training highly qualified personnel throughout all activities and functional areas. This will contribute to attract and retain qualified staff and to the overall socio-economic impact of ALBA when persons leave ALBA towards different destinations.

The components of the career development are centered in the continuation of the successful student program, including the present program of hosting PhD students in collaboration with other institutions, and of the present Post-Doc Researcher program adding to these positions in cofounding schemes through collaboration with and without competitive grants.

Develop more structured ALBA career path policies for technical and scientific staff, accompanied by effective internal and external training plans and in general, pursue to increase external funding schemes to further increase capacities and potential impact.

4.2.13. Communication and outreach *(Objectives 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.1.5)*

The communications and outreach plan will further develop the successful on-going programs, at all levels: internal, towards the scientific community and towards the general public and media, also taking the opportunity of disseminating the ALBA II project. These programs include internal and external publications, organization of scientific events, continuation of the *Misión ALBA* project, the yearly Open Days, guided tours, both virtual and face-to-face. A new ALBA Synchrotron website is foreseen for 2022.

4.2.14. Health and safety *(Objectives 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.1.5)*

The health and safety group is focused on guaranteeing a safe environment at ALBA for all staff, users, visitors, and contractors during the pandemic condition and beyond, by maintaining the priority of having each year zero accidents involving medical leave during work activity for the period 2021-24.

The contingency plan addressing COVID-19 conditions and approved last year will be updated as long as required to ensure its effectiveness in preserving health and safety of the ALBA community.

The conventional risk assessment and mitigation plan covers five specific areas, namely risk assessment of machinery and facilities, hygienic of working area, psychosocial aspect, ergonomics aspect and health surveillance.

For the period 2021-24, a major change of the Health and Safety Group's responsibilities is expected due to moving from an external preventive service (SPA) to an own preventive model (SPP). This action is driven by the expected growth of the facility and is a legal obligation for institutions with more than 250 employees. With a delayed start due to the pandemic, the implementation will be done progressively during the period 2022 to 2024, starting with the first two primary areas (risk assessment of machinery and facilities, hygienic of working area), and finishing in 2024 by providing all services by ALBA besides those for Health Surveillance.

We continue extending a solid preventive culture not only to all staff but also to users, trainees, external companies or collaborators, based on the message that safety is the job of everyone and working unsafe is not an option.

This requires keeping continuously updated the preventive system, which includes preventive plan, norms, procedures, etc., emergency tools, encoded in the existing self-protection plan, and all the risk assessments.

The radiation protection rules, procedures, practices and formal documents with the changes required by Consejo de Seguridad Nuclear for new BLs or other modifications in the facility will be kept updated.

4.2.15. Expanding the collaboration networks *(Objectives 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.1.5)*

ALBA policy of networking has been evolving at national and international directions, each fostering the other. The team which has gathered to present the ASTIP proposal for the future evolution of ALBA surroundings is already strengthening its ongoing collaboration and is generating ideas which nourish the research plans of the totality. We are attracting to the hub collaborators from research institutions from all Spain to further opening its horizons and actively involving companies to enhance its innovation power.

The position of ALBA inside LEAPS and ARIE is providing a huge number of opportunities for cooperation, common developments, participation to transversal platforms open to public and private researchers, capacity to be part of the entities defining scientific priorities and related technological developments for the future of our society.

The start-up of the Iberian project of collaboration with Portugal is setting the basis for fruitful build-up of research in the well-defined areas of ALBA strategic fields.

4.2.16. CELLS complementary developments *(Objectives 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.1.5)*

Several complementary developments are being discussed with the Spanish scientific community in order to enlarge the scientific instrumentation and capabilities of Spain.

One of them, being discussed by the High Energy Physics community, is to create an electron beamline at ALBA, **eALBA**, where experiment with electrons can be performed, for testing high energy and astrophysics detectors, for irradiation tests of material and electronics or to produce gamma photons.

Another one, being discussed with the **ultra-fast dynamics'** scientific community, is developing the technology for producing short electron bunches in order to obtain photon pulses of the order of 10s of femtoseconds. Some of the ideas are an Ultrafast Electron Diffraction, an Infrared Free Electron Laser, or a Compton backscattering energy tunable X-ray source.

In addition, being ALBA the reference center for accelerator technologies in Spain, we are prepared to collaborate and contribute to any other accelerator-based facilities that are envisaged in the next future.

4.3. Resources

Resources needed to accomplish the strategies above described are hereby summarized, detailing investments costs, staff resources, and corresponding staff costs. We include also a summary of the total operating budget, including the loan return. The details are specified in the ANNEX C.

4.3.1. Investment budget

We have grouped the investments under "programs", as explained in ANNEX C and listed in Table 4.

The investment profile during the period 2021-2024 is shown in Figure 4 left, detailing the three priority levels. We actually project figures until 2027, the end of the current Operational Program of the European Regional Development Funds (ERDF). Several investments started during the presented period shall continue after 2027 given the long-term cycles of our investment programs. In the next strategic plan 2025 to 2028, some programs may change priority and others may be added. Figure 4 shows the spending profile of the High Priority investments foreseen. The greater share for 2021-2024 corresponds to the necessary facility expansion to new terrains (Programs 02, 03), while ALBA-II Accelerator Complex developments and New BL shall ramp up from 2022 (Programs II-01, II-02). The BL Upgrade and transversal infrastructure programs shall start visibly from 2024 (programs II-02, II-03).

The TOTAL investments for 2021-2024 amount to about 131 M€, with 72M€ (55%) corresponding to high priority investments. Notable synergy effects, especially in the creation of new ALBA-II related experimental infrastructure, should arise from strategic collaborations and ASTIP.

All the details on each chapter and their relationship to the proposed strategies can be found in the annex on the Investment Plan.

Program	HIGH Priority	MEDIUM Priority	LOW Priority
01 ALBA operational reliability and competitiveness	23.968	13.763	5.765
02 Facility expansion (terrains)	9.985	0	3.935
03 Facility expansion	10.700	6.730	0
04 Strategic collaborations	2.000	12.500	15.500
II-01 ALBA-II Accelerator complex	14.350	0	0
II-02 ALBA-II New BL	10.100	406	500
II-03 ALBA-II transversal infrastructures	1.000	0	0
Grand Total	**72.103**	**33.399**	**25.700**

Table 4 - Investments organized according to priority levels.

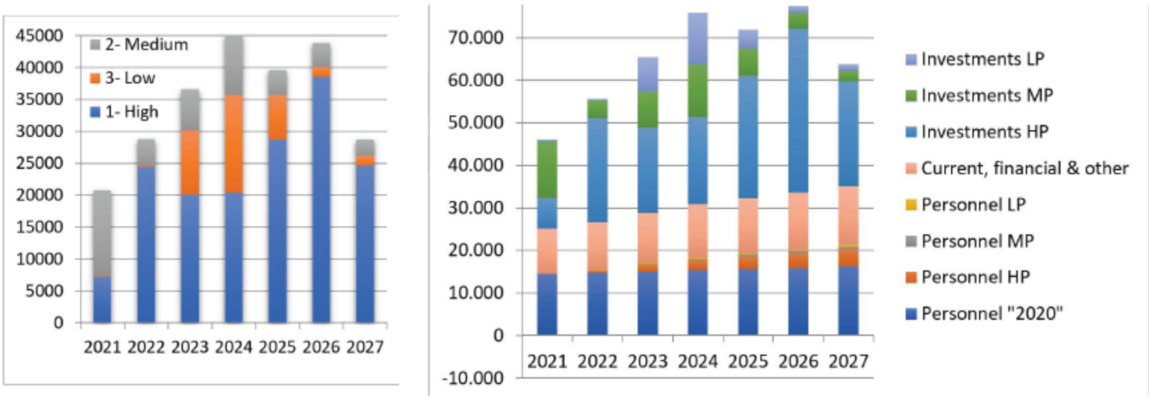


Figure 4 – Investment budget profile (left) and Investment budget profile detail for High Priority Programs (right) during the period 2021-2024 and continuation of the proposed items until 2027.

4.3.2. Staff resources

The staff needed for the implementation of this SP is detailed in the annex "Investment Plan", indicating for each investment the extra resources to be added to those already present. In that Annex the criteria of staffing for specific investments are also explained. The whole ALBA-II program will have additional requirements in terms of design, construction, operation and management.

For the strategic collaborations, notable synergies are expected, so only a very small specific team is projected (Program 07).

Table 5 shows the personnel linked to the investments specifying the priority.

We mention only the structural positions, with the hypothesis of maintaining an additional staff quota at the level of around 5 up to 10% through external projects and collaborations.

Personnel, priorities and investment chapters	2021	2022	2023	2024	2025	2026	2027
1: HP	**233**	**243**	**267**	**285**	**297**	**307**	**310**
ALBA_2020 base resources	231	231	231	231	231	231	231
ALBA01 Enabling advanced technologies for ALBA II	0	4	7	8	8	8	8
ALBA02 ALBA-II accelerator components	0	0	0	2	6	10	11
ALBA03 Construction of new Beamlines for ALBA II (long, hard)	0	0	2	6	7	9	9
ALBA04 Construction of new Beamlines for ALBA II (long, soft)	0	0	0	2	5	7	9
ALBA05 Construction of new Beamlines for ALBA II (short, ID)	0	2	5	7	7	8	8
ALBA07 Experimental prototyping towards ALBA II	0	1	5	7	8	8	8
ALBA10 Upgrade operational beamlines for ALBA II	0	0	0	2	2	2	2
ALBA21 Enhancing experimental capabilities	0	0	1	1	1	1	1
ALBA23 Consolidation of BLs under construction	0	2	6	6	6	6	6
ALBA26 IT Infrastucture to enhance Data management capabilities	0	0	1	1	1	1	1
ALBA28 Engineering Infrastructures update	0	1	2	2	2	3	3
ALL Transversal to ALBA 01-41	2	2	7	10	13	13	13
2: MP	**0**	**1**	**2**	**5**	**8**	**10**	**11**
ALBA06 Construction of new Beamlines for ALBA II (short, BM)	0	0	0	2	5	7	8
ALBA27 Complementary IT Infrastucture to enhance Data management capabilities	0	0	0	1	1	1	1
ALBA41 In-Caem proposal for microscopy	0	1	2	2	2	2	2
3: LP	**0**	**3**	**4**	**6**	**6**	**7**	**7**
ALBA09 Detector Laboratory	0	3	4	5	5	6	6
ALBA40 Additional microscopes for the Microscopy Center	0	0	0	1	1	1	1
Grand Total	**233**	**247**	**273**	**296**	**311**	**324**	**328**

Table 5 – Evolution of ALBA staff until 2027: priorities according to the corresponding investment chapters.

4.3.3. Total budget

As a general overview the total forecast of expenditure 2021-2027 including staff (excluding loan return) is shown for all priorities in Figure 5 as well as for the elements classified as High Priority only in Figure 6. The numbers take into account the operation of new BLs that scales up from 10 in 2021 to 13 in 2027, with others almost ready to receive users. The current cost items are scaled annually, according to their nature: either general price development (1,5% per year), or the number of staff (see 4.3.2), BLs in operation, or, finally, the estimated cost increase of energy supply. As many of these parameters can only be estimated and will depend on external factors, the number should be considered rough preliminary best guess and need to be reviewed on an annual basis.

The current funding framework signed in by the two funding administrations will finish by the end of 2022. A new framework is in preparation. This includes exploring the possibilities of a long-term loan agreement (until up to 2037) between CELLS and the Public Administrations for major part of the investment plan. By such a loan, budget peaks in the initial stage of the ALBA-II construction and update programs can be compensated by a smooth and uniform pluriannual funding scheme that includes basic funding for the loan return. Such an instrument was already used successfully in the initial construction stage of ALBA and is now running out in 2022.

We have evaluated the approximate cost of the ALBA II upgrade with respect to the cost of running the facility as it is, and increasing the number of BLs by 5. Summing up the new accelerator systems, including the prototyping phase; the building infrastructure including the addition of new plot lands; the difference in the cost of 5 beamlines which in the case of ALBA would be around 40 M€; the cost of updating the present BLs to the 4th generation; the cost of uninstalling and installing the accelerator systems and of the related temporal FTE; and finally the extra staff, about 30 people; we find out that the difference of budget 2021-2030 is of the order of 120 M€, which corresponds roughly to an increase of 30% of the budget during the next decade.

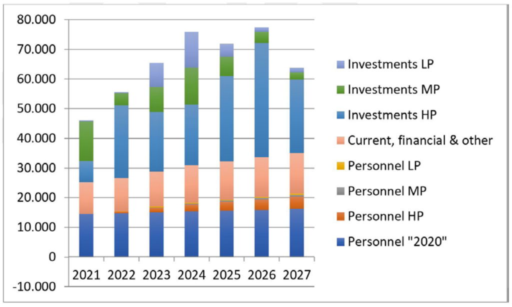


Figure 5 – Total budget of the facility (HP, MP, LP stays for High, Medium, Low priorities).

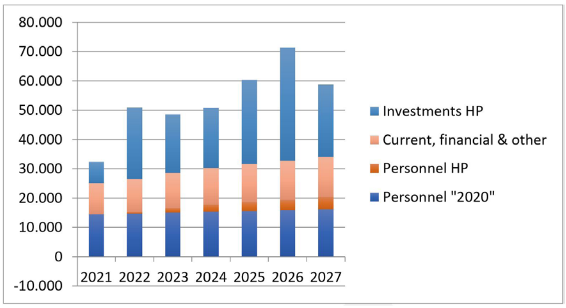


Figure 6 - Same as Figure 4 but only for HP elements.

5. SCHEDULE AND FOLLOW-UP

We briefly describe the expected timeline of the main actions presented in this SP.

5.1. Schedule

This chapter summarizes a simplified timeline in the perspective of more than three decades' period which covers from the moment of the project approval up to the operation of the upgraded facility. Details on timeline for specific investments are summarized in Annex C.

ALBA project was approved in 2003, the accelerators were commissioned in 2010, the seven Phase I BLs beamlines in 2011 and entered in operation in 2012. Discussions on the evolution were carried out in 2009, resulting in two BL projects (Phase II), whose construction suffered years of delay due to what we call 'the austerity period' in which no extra funding was obtained due to the economic crisis; period which, on the other hand, was fully profited for consolidating the facility operation at very high standards. Phase III BLs process in 2014 defined six projects, three of which have been progressively funded and realized and are entering in operation soon. In the meantime, another BL has been approved as a special collaboration with the ESA. The new step for ALBA is the preparation for the upgrade to ALBA II. Every new BL will be built to take full advantage of the new source, of which we are starting now the design.

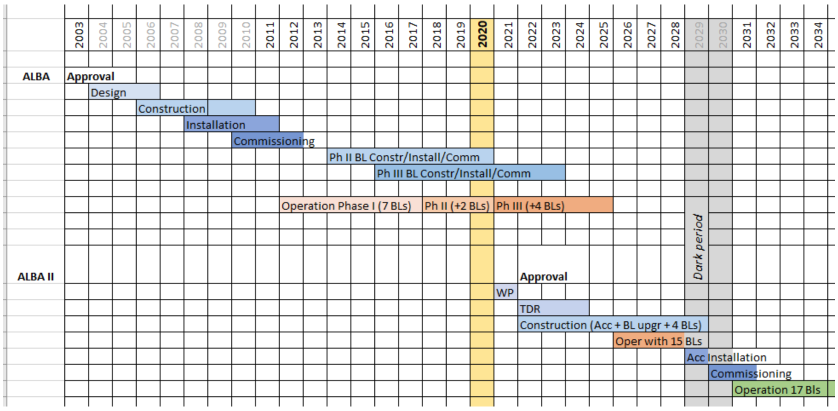


Figure 7 – Schematic Schedule of ALBA and ALBA II

5.2. Follow-up indicators

5.2.1. Measurements of efficiency

The performance indicators of the installation, of which the facility will keep a registry are the following:

a) Accelerator availability (delivered hours versus scheduled hours per year)
b) Mean time to repair for accelerators
c) Mean time between failures for accelerators
d) Number of delivered user shifts/year versus the number of scheduled ones
e) Hours of user beam, i.e. the sum of delivered station hours to users
f) Number of accelerator failures and reasons
g) Efficiency per station, i.e. hours delivered versus hours scheduled
h) Number of user groups/year
i) Number of user visitors/year, i.e. mean size of user group
j) Statistics on publications
k) Statistics on user nationality
l) Station shifts requested versus station shifts allocated (per station)
m) PhD degrees awarded from work carried out at the facility
n) PhD degrees awarded from work carried out using data taken at the facility
o) Station shifts for proprietary work
p) Number of proprietary users
q) Number of patents and licenses
r) Number of SAC and evaluation panels meetings
s) Number of competitive projects
t) Income from competitive projects
u) Income from proprietary usage of beamtime, labtime and others
v) Staff statistics, including gender, nationality, external contracts
w) Number of student training
x) Number of visits to the facility
y) Key steps in construction of BLs
z) Statistics on incidents/accidents

5.2.2. Risk Analysis

Risk analysis of this Strategy Plan including mitigation measures is performed and reported in Table 6 following the most serious risk being related to the non-availability of the appropriate resources, both in terms of budget and staffing.

Strategy	Risk	Monitoring	Mitigation or correction measures
ALBA II Scient fic Strategy – (Objective 4.1.1, 4.1.4, 4.1.3, 4.1.5)	Scient fic use cases change due to change of technology or societal needs.	Frequent review and update of science case in cooperation with Advisory Committees, User representatives, industry and ALBA/ CELLS Government organs.	Agile planning, design and implementation, maintain capacity to partial redesign at any time.
ALBA II Accelerator development – (Objective 4.1.1, 4.1.2, 4.1.3)	Ambitious development schedule, design requirements and parallel operations may provoke delays.	Coordination Team implements excellent project management schemes and checks progress against planning and operation needs.	Implementation of effective Coordination Team. Allocation of adequate resources and priorities (resource loaded planning). Management to pursue optimized administrative cond tions for resource availability (budgets, funding, hiring).
ALBA II Beamlines – (Objectives 4.1.1, 4.1.2, 4.1.4, 4.1.3, 4.1.5)	Same as the above.	Same as the above.	Same as the above.
General Investment Strategy	Overdemand of equipment in the Synchrotron markets may be cost driver of investments or may lead to deserted call for tenders.	Exchange with sister infrastructures. Own procurement parameters and outcome.	Coordinating project plan w th LEAPS facil ties, cultivate close supply chains, broaden awareness on outer-European regions.
ALBA Accelerators Operation (Objective 4.1.2)	ALBA-II and BL development may punctually compete for resources needed for operations and maintenance.	Same as the above.	Same as the above.
ALBA Operation: Upgrade of operating Beamlines (Objectives 4.1.2, 4.1.1, 4.1.3, 4.1.5)	Same as the above.	Same as the above.	Same as the above.
ASTIP definition and start of construction – (Objective 4.1.1, 4.1.4, 4.1.3, 4.1.5)	A though ASTIP is complementary to all of the above, d fferent timeline requirements and additional ASTIP collaborators' requirements may need to be matched into current ALBA operations and developments.Very significant additional funding management and coordination efforts needed.	Frequent exchange with ASTIP steering Comm ttees and funders on strategic and all technical levels.	ALBA to take lead role in the implementation of ASTIP. This requires the allocation of adequate project management and administration resources, besides the evident technical and scientific resources.
Data management evolution (Objectives 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.1.5)	Data handling evolution (Objectives 4.1.3, 4.1.1, 4.1.2, 4.1.5, 4.1.4)	Sustainability of the required IT infrastructure.	Periodic forecasts of the IT resources required by the different data services.
Data management evolution (Objectives 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.1.5)	FAIR policies implementation delays.	Degree of fulfillment of the FAIR metrics agreed in the EC.	Participation in the EOSC Association. Close collaboration w th other National RIs in the ExPaNDS project or under IT WG of LEAPS.
Electronics and Detectors Developments (objectives 4.1.1, 4.1.4, 4.1.2, 4.1.3)	The development of technological expertise is not fast enough.	To mon tor and foster these technological expertise, different pilot projects w th a maximum duration of one to two years will be launched.	Training. Creation of transversal specialized groups.
Complementary Laboratories Upgrades and Explo tation (Objectives 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.1.5)	Failure of aged instrumentation that has been working for about 10 years. Limit ALBA capac ty of performing state-of-the-art experiments due to lack of instrumentation for sample preparation and sample pre-characterization. Lose the ability to build and maintain the different components used in the accelerator and the BLs of ALBA and ALBA-II, due to lack of non-adequate test and control instrumentation.	Regular review of the service time of laboratory instrumentation. Regular review of users' needs, with the information collected by the User Office, and in BL Reviews. Keep track of add tional needs at the development labs (instrumentation, RF, IDs) required for the ALBA-II upgrade and similar projects worldwide.	Investments to service or upgrade laboratory instrumentation in order to meet the needs of the user program in terms of sample preparation and characterization as well as to guarantee the readiness of the development labs in front of the upcoming upgrades of at ALBA and similar projects worldwide. Keep an adequate staff number at the laboratories.
Innovation and technology transfer (Objectives 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.1.5)	Proprietary access to beamtime below expectations or in negative tendency.	Beamtime hours delivered. Bimonthly checking.	Strengthen outreach and dissemination activities targeting specific industries. Focused workshops, meetings and promotion material.
Excellence in personnel and budget management (Objectives 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.1.5)Communication and outreach (Objectives 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.1.5)Hea th and safety (Objectives 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.1.5)	These transversal strategies will not be effective policies if not fully integrated in the overall activ ties at all levels.	Frequent, structured exchange between the owner of these strategies (transversal offices and administration) and the different operative divisions, coordination teams and collaborators.	Management shall assure that all strategic components and actors therein shall network and exchange requirements efficiently.
CELLS complementary developments	Additional resources needed may compete with other operational and development strategies.	Coordination Team implements excellent project management schemes and checks progress against planning and operation needs. Frequent exchange with collaborators.	Management shall decide scope of complementary developments in function of available resources, potential synergies and strategic value for the ALBA-II mission. Establish collaborations for external funding schemes.

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