STRATEGIC PLAN FOR CELLS: 2010-2014

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1 SUMMARY

The Consortium for the Construction, Equipping and Exploitation of the Synchrotron Light Source – CELLS - belongs with an equal share to the Catalan and the Spanish Administrations and it is the organization with the responsibility for the construction and future exploitation of the first ever Synchrotron Light (SL) facility built in Spain. The name given to this facility is ALBA.

ALBA is a 3rd generation SL source with a design that yields a similar performance in terms of electron energy and emittance/brilliance to that of the two most recent national light sources built in Europe, i.e. Soleil in France and Diamond in the UK. This is in spite of having significantly smaller dimensions. In other words, ALBA has the potential to be a world player among Synchrotron Light facilities.

Proposals for phase I beam-lines were assembled and channelled through the Spanish Association of Synchrotron Light Users after extensive consultations with the potential user community. The Scientific Advisory Committee of ALBA recommended to Management than seven beam-lines, with nine associated experimental stations, should be built in phase I of the beam-line program. Subsequently CELLS Council approved this recommendation and CELLS is currently in the process of constructing these beam-lines.

The completion of the Capital Project involving the construction of ALBA's facility consisting of: Complex of Buildings; Complex of Accelerators, and; seven beam-lines, with nine associated experimental stations, is expected towards the end of 2010.

This strategic plan addresses the transition that starts with the end of construction - year 2010 -, followed by commissioning and optimization – years 2010 and 2011 - and then move into routine operation – year 2011 onwards -. In addition to these activities, the main aims that are contemplated here are to:

i) Ramp up the number of operating hours/year until 6000 hours/year are reached by 2014. This is important in order to achieve best value for money in terms of the initial capital investment;

ii) Initiate a new beam-lines program with a construction rhythm of three new beam-lines every two years so that by the year 2030 the facility is operating at full capacity, This is important in order to have a reasonable number of years for the exploitation of the last set of beam-lines to be installed at ALBA, and finally;

iii) Deliver 25 SASE-3 undulators to the European X-ray Free Electron Laser (EXFEL). This arises because CELLS has applied to and has been accepted by the management of the EXFEL as an agency that will supply part of the in-kind payment that Spain will make as a partner country in the EXFEL project.

2. INTRODUCTION/BACKGROUND

2.1 Summary description of CELLS and of ALBA

The Consortium for the Construction, Equipping and Exploitation of the Synchrotron Light Source, hereinafter referred to as CELLS, is the organization that has been given the responsibility for the construction and future exploitation of the first ever Synchrotron Light (SL) facility built in Spain. ALBA is the name given to this facility.

ALBA is a third generation SL facility that is currently under construction in Cerdanyola del Vallés, Barcelona, Spain. The accelerator producing the SL is a storage ring with energy of 3 GeV and a design circulating current of 400 mA. The design criterion for this Storage Ring has been that it should deliver as high as possible photon flux densities on the samples. To this end the Storage Ring has been designed to have an electron beam emittance of ca. 4.5 nm.rad and, in spite of its relatively small perimeter - somewhat less than 270 m - the storage ring incorporates a significant number of straight sections in which to house Insertion Devices (IDs). The injector complex consists of a 100 MeV LINAC and a full energy, i.e. 3 GeV, Booster with a small emittance (ca. 9 nm.rad) to achieve efficient injection into the Storage Ring. This is because it is intended to operate the accelerator complex in a top-up mode from the very early stages of its operation. The project started in earnest in 2004 and its completion with seven beam-lines (BLs) in its initial phase, is expected by 2010, so that user operation can start in 2011.

CELLS is owned and jointly supported with an equal share by the Spanish and the autonomous Catalan administrations – see Chapter 4 for more details.

2.2 Background

In the early 1990s there emerged a number of proposals to construct a SR facility in Spain in response to the desire of the growing community of Spanish SL users that wished to have a source of their own. In the specific case of ALBA one can trace its origin to an initiative of the Catalan Autonomous Government, who in 1992 commissioned a feasibility study and in 1993 created a Commission to promote such a project and, simultaneously, initiated a program of personnel training. After consolidation of these first tentative steps, an agreement was reached between the Spanish State and the Catalan Autonomous governments to carry out a first detailed design study. The Consortium LLS (Laboratorio Luz Sincrotrón), belonging to the Autonomous University of Barcelona and the Generalitat, was charged with this study that was completed in 1998. After a significant period of reflection, in March 2002 an agreement between the Spanish State and the Catalan Autonomous Government to jointly fund a SR facility in Spain was announced.

3. LEGAL STATUS OF CELLS; GOVERNING AND MANAGEMENT BODIES; ADVISORY BODIES, AND; USERS' REPRESENTATION.

3.1 Legal status of CELLS and institutional commitment.

CELLS was constituted when a collaboration agreement was signed on the 14th March 2003 (BOE núm. 81, del 4 de abril. DOGC núm. 3858, del 4 de abril) between, at the time, *Ministerio de Ciencia y Tecnología* (Ministry of Science and Technology) - nowadays the *Ministerio de Ciencia e Innovación* (Ministry for Science and Innovation) - and the *Generalitat de Catalunya* (Autonomous Government of Catalonia) through its *Departament d'Universitats, Recerca i Societat de la Informació* (Department of Universities, Research and Information Society) – nowadays the *Departament d'Innovació, Universitats i Empresa* (Department of Innovation, Universities and Enterprises). Simultaneously the Statutes of the Consortium were published in the same issue of the BOE and DOGG and the Consortium CELLS was thus created.

The two institutions participating in CELLS committed to an equal share of the construction costs of the Synchrotron Light Source. The basis of this commitment is to be found in the Protocol of Intent signed between the administrations of the Spanish State and of the Catalan Autonomous Government on the 14th of March 2002. The 2nd clause of this Protocol of Intent establishes that both administrations will bear an equal share of the costs of the construction of a Synchrotron Light Source, and its 3rd clause states that "the concrete terms and conditions of such collaboration will be defined through a Collaboration Agreement". This was the culmination of a collaboration between both administrations that goes back to 1995 and that involved various projects related to the promotion and exploitation of Synchrotron Light Sources within Spain.

3.2 Governing and Management bodies: Rector Council; Executive Commission; Chairperson of the Executive Commission, and; Director.

The Statutes of the Consortium foresee two Governing Bodies with joint membership, namely: a Rector Council, that was constituted on the 12th of June 2003 and in which the two administrations that propelled the Project are represented, and; an Executive Commission that was constituted on the 25th of June 2003.

Membership of the Rector Council consists of a Chairperson, a vice-Chairperson, four delegates from the Spanish Ministry for Science and Innovation, four delegates from the Catalan Government, the Chairperson of the Executive Commission and a Secretary. The latter two with voice but without voting rights.

The Chair of the Rector Council rotates annually between the Minister of the Spanish Ministry for Science and Innovation and the "Conseller" of the Catalan Department of Innovation, Universities and Enterprises. Whoever of these two people does not occupy the Chair, automatically takes the vice-Chair position that, therefore, also rotates accordingly.

The Executive Commission consists of a Chairperson, two delegated members of the Rector Council from each one of the administrations there present (i.e. four delegates in total from the Rector Council), The Director of the Consortium and a Secretary. The latter two with voice but without voting rights.

The Chairperson of the Executive Commission is nominated by the Rector Council and has a - renewable - tenure of four years. The current Chairperson was appointed in the first meeting of the Rector Council on the 12th of June 2003 and was re-appointed for a further four years on the 2nd of July 2007.

The Rector Council upon a proposal by the Chairman of the Executive Commission appoints the Director of the Consortium. The appointment is of an indefinite nature.

The statutes confer all executive competences within CELLS to either the Rector Council or to the Chairman of the Executive Commission. The Director, upon taking the position, has whatever executive rights and duties these bodies delegate.

3.3 Advisory Bodies

The Statutes of CELLS contemplate two advisory bodies, namely the Scientific Advisory Committee (SAC) and the Machine Advisory Committee (MAC), whose appointment, function and composition will be agreed by the Rector Council upon a proposal by the Executive Commission.

SAC is the scientific consultative organ of the Consortium. It comprises a maximum of 10 and a minimum of 8 people with recognised international prestige in fields related to the activities and objectives of the Consortium. Members will be named, respecting parity, by the Rector Council from proposals by the Administrations in the Consortium. The Rector Council will also define the functions of SAC and the norms of internal behaviour. SAC meets on average twice a year and the Chairperson of the Spanish Association of Synchrotron Users (AUSE), the Chairperson of MAC and the Chairperson of the Executive Commission are invited to attend as Observers

The current role of SAC is, at the request of the Director, or on its own initiative to give its opinion or advice to the Director on any scientific/technical matter related to the scientific exploitation of the Photon Source. This includes the very important function to review proposals for beam-lines, to advice on their ranking and to follow through and advice during their construction and future exploitation.

MAC is the consultative organ of the Consortium in relation to the construction of the accelerators and to the production of SL. It comprises a maximum of 8 and a minimum of 6 people with recognised international prestige in fields related to the activities and objectives of the Consortium. MAC meets on average twice a year. Currently two Spanish people with experience on accelerator technology, the Chairperson of SAC and the Chairperson of the Executive Commission are invited to attend as Observers

The Statutes contemplate that the Director should chair both the SAC and the MAC meetings. However, it has become customary that the members of each committee elect a person from within their ranks to discharge this function.

3.4 User representation: the Spanish Association of Synchrotron Light Users.

In spite of the fact that there has never been a national Synchrotron Light Facility, Spain has a substantial number - in the several hundreds - of Synchrotron Light Users. These are organized within an association known as The Spanish Association of Synchrotron Light Users or AUSE. Although totally independent of ALBA, AUSE, among other things, channels and represents the interests and the objectives of the user community of ALBA. "De facto" AUSE has played a very important role as the institution through which the proposals emanating from the user community for the first set of beam-lines at ALBA were channelled. This proved a very effective way to converge to a set of beam-lines that overall represented best value for money at the time. Notwithstanding other possible ways to identify new beam lines for the future, we propose that AUSE will continue to be part of this process and its Chairperson will continue to be an Observer at the SAC meetings of ALBA. De facto, in the process of selection of phase II beam-lines currently in progress the same procedure has been approved by Council.

4. CELLS' VISION AND MISSION STATEMENT

4.1 Vision

To become a centre of excellence in Synchrotron Light Scientific and Industrial applications and to achieve the status of a recognised world leader in its field

4.2 Mission Statement

To research in, deliver and maintain methods and techniques with which to conduct cutting edge Synchrotron Light based research and development.

4.3 Guiding principles

To discharge its mission and achieve its vision, CELLS will be guided by the following creed so that it will strive to:

i) Enhance expertise and promote the utilization of Synchrotron Light by working with the Spanish and international scientific communities;
ii) Keep itself at the forefront of Synchrotron Light Science by conducting and enabling competitive research and providing the most advanced SL technologies;
iii) Provide a multidisciplinary environment that fosters innovation through scientific and technical collaboration;
iv) Foster industrial involvement and partnerships and thus promote commercial opportunities and economic development;

v) Contribute to the training of a highly skilled work force that will feed back into industry and society;
vi) Actively participate in the development of the public perception of Science, and;
vii) Collaborate across borders to promote the exchange of people and ideas.

5. OTHER COMMITMENTS OF CELLS

5.1 Activities in international and national projects, e.g. XFEL and CESLAB.

CELLS, in line with its guiding principles – see 4.3 –, must participate or be involved with projects that because of their nature are strategic and/or complementary to current or future scientific/technical objectives of ALBA. So, as part of its long term strategy CELLS will keep a keen eye to identify other national or international projects whose objectives are such that by being involved with them the outcome will be mutually beneficial and will have a long term strategic value. By way of illustration, we give here two current examples of this kind of activities. These examples are pertinent because the work involved will span right across the time period addressed in this strategic plan – see also Chapter 15.

5.2 The European X-ray Free Electron Laser

The European X-ray Free Electron Laser (EXFEL) is a new international infrastructure currently being built in the north west of Hamburg. Spain, through its Ministry of Science and Innovation, is a partner nation in the EXFEL project. It has been agreed that part of the financial contribution from partner nations can be made by delivering sub-systems needed by the project, i.e. a so called "in kind" contribution.

The purpose of the EXFEL is to generate extremely brilliant (10^{33} photons/s/mm^2/mrad^2/0.1% BW), ultra-short (≈ 100 fs) pulses of spatially coherent x-rays with wavelengths of 0.1 nm. The basic process adopted to generate the X-ray pulses is the Self-Amplified Spontaneous Emission (SASE) whereby electrons are generated in a high-brightness gun, brought to high energy (up to 20 GeV) in a superconducting linear accelerator and passed into long (up to 200 m) undulators where the X-rays are generated.

An X-ray source with the characteristics of the EXFEL has the potential to deliver revolutionary scientific results. For example, and among others, it might be possible to: determine the atomic/molecular structure of biological macromolecules from scattering/diffraction experiments using single molecules, thus bypassing the need of crystallisation; generate the conditions present in interstellar gases under laboratory conditions; provide movies of the atomic displacements and re-arrangements of chemical bonds during a chemical/biochemical reaction; image the nucleation of ordered phases at phase transitions, and; investigate many hitherto inaccessible states of matter. In addition to the scientific relevance of these potential scientific breakthroughs, the relevance of the

EXFEL extends beyond basic science and enters the realm of technologies of essential importance for Europe.

5.3 The importance for CELLS to participate in the EXFEL Project.

It is arguable that the scientific and technical objectives of the EXFEL project make it the most ground breaking and ambitious European accelerator based project undertaken for a long time. For this reason alone it would natural that an organization like CELLS that has a core interest in accelerator technologies would wish to be involved with such a project. However, the importance for CELLS to participate in the production of some of the accelerator sub-systems required by the EXFEL project goes beyond a simple vocational interest in accelerator based projects. ALBA is a third generation synchrotron light facility that today has a capacity for many new beam-lines using insertion devices as their photon sources. Therefore, to maintain and further develop know how in cutting edge undulator technology is going to be of crucial value for the future development of ALBA as a photon source. The EXFEL project provides a clear opportunity for CELLS to participate in the production, testing and commissioning of these technologies that will be essential for the development of ALBA throughout its expected lifetime (i.e. over the next 25 years or so).

5.4 The Central European Synchrotron Laboratory – CESLAB –

The Academy of Sciences of the Czech Republic – ASCR - has proposed the construction of a third generation SL source as one of the projects to be realized using Structural Funds of the EU. The construction of this facility - known as the Central European Synchrotron Laboratory, or CESLAB - will take place in the city of Brno in the Czech Republic.

CESLAB is planning to use ALBA as the reference design although, naturally, the objectives of the beam-lines may differ, as they have to cater for very different communities. As a result of CESLAB adopting the same design for their accelerator complex there has been a Memorandum of Understanding signed between CELLS and the ASCR whereby in return for know-how and support with their project, CESLAB places people at ALBA to help with the installation of the facility sub-systems. This kind of collaboration is mutually beneficial and adequately fulfills two of CELLS’ guiding principles, namely: to enhanced expertise and promote the utilization of Synchrotron Light by working with the Spanish and international scientific communities, and; to collaborate across borders to promote the exchange of people and ideas.

Note that even though the MOU states that contributions to the CESLAB project will be at neutral cost to ALBA, there are already significant mutual benefits in terms of synergies, development of human resources and, in the case of ALBA, substantial manpower savings.

6. CELLS' CURRENT HUMAN AND CAPITAL RESOURCES

6.1 Current human resources and organizational structure.

The Executive Commission on its meeting of the 25th of June 2003 agreed to a personnel structure appropriate to the construction of a SL facility. To this end five Divisions were created and were charged with the management and implementation of the various technical and administrative requirements. These Divisions are the:

- Accelerators Division that has the responsibility for the design, construction and eventual commissioning of the complex of accelerators of ALBA, i.e. its LINAC, Booster and Storage Ring, as well as the front ends of the beam-lines. Essentially the Accelerators Division has the responsibility for all sub-systems within the walls of the shielding tunnel and of its "through the wall" associated services.

- Experiments Division with the responsibility for the design, construction, commissioning, commissioning and eventual exploitation of the beam-lines and experimental stations of ALBA.

- Computing, Controls and Data Acquisition Systems - CC+DACQS - Division whose name practically explains its duties, i.e. the provision, development and management of all information services, controls of the accelerators, beam-lines, experimental stations and technical installations as well as the administrative information services.

- Engineering Division with the responsibility to provide engineering services and to manage the delivery of the Buildings and conventional services therein.

- Administration Division with responsibilities for the management of financial/personnel matters of the Consortium and to provide secretarial/administrative support to the other Divisions.

There is also the Director's office that includes the relatively small Radiological Protection group - two people - as well as two Project Coordinators whose function is to assist the Director and the Division Heads on the usage of human and capital resources.

Put in simple terms there are two Divisions that call on services, i.e. Accelerators and Experiments, and three support Divisions, i.e. CC+DACQS, Engineering and Administration, that provide them. A Division Head reporting to the Director leads each Division. The five Division Heads are members of ALBA's Management Board that is chaired by the Director.

Table 6.1.1 summarises the work years that could be supported within the existing personnel budget and how the staff are attributed to each of the 5 Divisions and to the Directors office.

Director's Office	5
Experiments Division	19
Accelerators' Division	20
CC+DACQ	41
Engineering	41
Administration	14
TOTAL	140

Table 6.1.1

The current staff numbers are somewhat below those in shown in Table 6.1.1 and come to a total of 132. This is due to the resignation of some staff and to recruitment difficulties in certain areas.

6.2 Summary of capital investments in the Capital Project.

When the declaration of intent to build the facility was made in 2002, the estimated capital project at the time contemplated the construction of the buildings, the accelerators' complex and five experimental stations and a time-table that covered from the year 2002 up to year 2008. However, as mentioned above the constitution CELLS was only formalised on the 14th of March 2003 and for a variety of reasons the appointment of its Director only occurred in September 2003. The consequence of this was that the project could only start in earnest in 2004 when it was possible to have some critical staff in place (e.g. Division Heads, section leaders, etc.).

In early 2004 the Spanish SR user community was invited to submit through its user association (AUSE) bids for the initial set of beam-lines at ALBA. Although capable of housing at least 33 beam-lines, as mentioned above the original capital costs for ALBA only contemplated an initial set of five BLs. The SR community submitted proposals for 13 beam-lines and associated experimental stations that were evaluated by ALBA´s SAC. SAC recommended that seven beam-lines, rather than five as planned, should be built in the first phase. Management submitted this recommendation to the Council of Alba who on their meeting on the 30th of June 2005 gave its approval. At this point the budget for the capital project of ALBA was redefined to take into account the fact that the construction project had been refined and therefore a more realistic costs estimate was available, that the project had to be extended to include the year 2009 due to its delayed start and, also, to take into account that the number of beam-lines to be built had been increased from five to seven.

Table 6.2.1 provides a summary of the commit profile of capital resources and running cost allocated to the construction Project of ALBA with an initial portfolio of seven beam-lines.

	2003	2004	2005	2006	2007	2008	2009	TOTAL
Personnel	495,1	1.293,3	2.844,2	4.470,4	5.985,9	7.272,1	7.490,3	**29.851,5**
Running costs	39,5	647,5	2.046,5	1.309,7	1.915,3	3.353,1	5.384,6	**14.696,2**
Site	0	0	13,209,3	0	0	0	0	**13.209,3**
Investments	298,6	4.922,4	12.295,0	31.669,4	50.183,8	33.250,0	11.020,0	**143.639,3**
TOTAL	**833,3**	**6.863,2**	**30.395,0**	**37.449,6**	**58.085,1**	**43.875,2**	**23.894,9**	**201.396,3**

(in k€)

Table 6.2.1

Whilst Table 6.2.2 shows a breakdown how the capital investment resources are distributed between the major construction blocks of the facility.

Accelerators' complex	42.813,440
Beam-lines	24.796,579
Buildings	45.740,681
CC+DACQ infrastructure	11.046,974
Conventional facilities	10.045,775
Other capital items	5.713,151
Cost Revisions	3.482,740
TOTAL	**143.639,340**

(in k€)

Table 6.2.2

Given the situation at the moment of writing this document it can be stated that it is almost certain that by the end of 2009 all the capital resources available for the capital project of ALBA will have been committed and spent. In other words, it appears that the commitment profile shown in Table 6.2.1 will be accomplished.

7. ALBA'S STRENGTHS, WEAKNESSES, OPPORTUNITIES AND THREATS. COMPARISON TO OTHER SL SOURCES – RELATIONAL ANALYSIS -

7.1 Strengths

The combination of low emittance – i.e. high brilliance - and relatively high energy – i.e. range of utilization – together with a large number of available straight sections for IDs places ALBA among the most competitive 3rd Generation SL sources in the world.

ALBA still has a huge potential for expansion in terms of new beam-lines and instrumentation with which to exploit the photon range and/or the brilliance of the source and, thus, the possibility to adapt to emerging scientific challenges, e.g. coherent imaging.

CELLS is a consortium jointly owned by the Spanish Administration and by the Administration of the Autonomous Government of Catalonia. This joint ownership is a double protection in situations of crisis.

CELLS can flexibly recruit and – if necessary dismiss - people as the personnel is contracted via labour contracts. This confers to CELLS an unusual flexibility compared to other research organisations in the country.

CELLS is a young institution, therefore carries no inherited ballast and it is free of long-established bad habits. The staff - that is on average young and mostly motivated - and the structure of CELLS are adaptable to new requirements

CELLS is the only organization within Spain with broad based know-how in accelerator technology and the first facility of its kind and size in the country. Also, it is the reference within Spain for the production of Synchrotron Light.

CELLS because of its relatively small staff numbers has found it necessary to develop good relationships with industry and to foster an international collaborative environment.

CELLS has a multicultural/international identity, with a large number of repatriated Spanish nationals as well as a very substantial fraction of non-Spanish nationals. These staff bring with them valuable experiences and know-how. Moreover, it facilitates international contacts.

CELLS has acquired and developed important know-how in the management of large scientific projects and follows best practices (e.g. ITIL and PRINCE2). For example, CELLS financial/accountancy software has become a desirable object for other Spanish organizations.

CELLS has the capability to integrate/develop new instrumentation/equipment into a complex facility.

CELLS has effectively networked itself with other national and international facilities through a series of bilateral agreements.

CELLS has a model of personnel management that includes regular evaluation of personnel performance and a recognition of this performance through a productivity bonus.

7.2 Weaknesses

There is limited tradition in the owner administrations on how to manage and develop multidisciplinary scientific facilities or on how to plan for their sustained funding. This carries the threat of stagnation and may put ALBA at a disadvantage relative to competing SL sources, e.g. Soleil, Diamond, SLS, etc.

CELLS is a relatively young organisation without a consolidated internal culture.

The transition from construction to exploitation could deprive ALBA of some of its best R&D people.

Mechanisms to ensure knowledge transfer from particularly skilled staff to the collective are not yet fully developed.

CELLS' personnel still lack competence in many fields. For example, very few, if any, junior individuals have any personal experience with the running of a facility.

Some groups are below critical mass.

ALBA does not have a consolidated R&D program in strategically important areas of instrumentation such as detectors, optics and insertion devices. This could be very damaging in the long term.

CELLS does not yet have any kind of applied/industrial outreach.

The work force consists of a core of highly experienced people that have been recruited from abroad – including Spanish nationals and nationals from other countries – and a majority of very inexperienced people with a somewhat inadequate educational background (e.g. limited skills in English and little relevant practical knowledge).

The personnel numbers in CELLS does not allow for redundancy of functions. This is threatening in the event of an unexpected departure of some key people.

ALBA has not yet identified a unique niche in SL applications. So far, the Science program is not qualitatively better than what is done elsewhere.

The site of CELLS has probably reached the maximum expansion imaginable. This may become a serious handicap for its future expansion.

7.3 Opportunities

The geographical location of ALBA makes it the only SL source in the whole of the South West of Europe. There is a large catchment area available to CELLS, both from the point of view of academic and industrial applications. The catchment may extend to Northern Africa and Latin America because of geographical and cultural reasons, respectively.

Bio-Cat – Bio-Regió de Catalunya - is the bio-cluster organization that promotes biotechnology and bio-medicine. The objectives of Bio-Cat and its geographical proximity provide an excellent opportunity for the development of ALBA's potential in the Life Sciences.

CELLS is placed next door to the so-called ALBA's Science Park. This offers clear opportunities for R&D applications with the private sector.

The facility is located in a region with many research institutes and Universities.

CELLS is located in the vicinity of a major university, thus allowing synergies and to establish strong links with academic groups.

CELLS is in the immediate vicinity of a city that is attractive to potential young staff members.

Given its core know how, CELLS is in a good position to act as agent for Spanish involvement in international facilities requiring accelerator know-how

CELLS does have the potential to generate many bi-products of either commercial or strategic value.

CELLS could place itself as a motor of Spanish technological applications by establishing close links with industrial institutions.

CELLS is in a good position to train university graduates/post-graduates in accelerator technology, instrumentation and in the applications of SL.

7.4 Threats

The competition for human resources comes from other national and international facilities whose salary scales are significantly higher than those of ALBA. In addition, living costs in the area of Barcelona are very high. This is not conducive to attracting highly qualified technical staff and/or senior scientific staff. Moreover, there is already accumulated evidence that other competing laboratories are successfully poaching ALBA's staff.

Attracting highly qualified foreign staff is often difficult because the job market available to their partners is twice as complicated as it is elsewhere. This is because of the required simultaneous proficiency in what to them are two alien languages: Spanish and Catalan.
The residential infrastructure and amenities in the immediate vicinity of the facility are somewhat limited and not sufficient to cater for a large user community.

There is a much larger number of beam-lines, therefore a much broader scope of experimental possibilities, in other 3rd generation SL facilities, e.g. Soleil, Diamond, SLS, etc. This might handicap ALBA in terms of attracting a broad range of talented users.

There is little local industry with expertise in the maintenance and R&D of the type of sub-systems that are/will be needed at ALBA.

CELLS might have to rely too heavily on the foreign market for the development of products with high added value and with an innovative technological aspect. This may affect the agility in the response time to emerging new requirements.

7.5 Relational analysis

Today there are 49 SL facilities in the world against which ALBA can be compared. Geographically they are distributed as follows:

Australia:	1
North America:	9
South America:	1
East Asia:	19
West Asia:	3
Europe:	16

It is clear that, with the exception of Central America and Africa, SL facilities are fairly ubiquitous. This ubiquity is unsurprising if the crucial role played by SL in fundamental and applied research is taken into consideration.

For practical reasons we will restrict our comparison to 3rd generation sources as ALBA is the last 3rd generation SL source in Europe that it is still under construction. It is indeed part of the analysis of the strengths and weaknesses of ALBA to compare its expected performance with that of other SL facilities of relatively recent construction.

Notwithstanding the above, we point out that there are other European proposals for new SL sources such as MAX-IV in Sweden - a 3 GeV source with an essentially diffraction limited vertical emittance -, CESLAB in the Czech Republic - basically a duplicate of ALBA -, a 3 GeV source at the Polish National Centre of Synchrotron Radiation - with a detailed design still under development - and Candle in Armenia – a 3 GeV source with an emittance of 8.4 nm rad. These projects have not yet been funded and, therefore, it is unlikely that they will come into operation in the immediate future. In addition, and outside Europe, the construction of NSLS-II in the USA – a 3 GeV source with a diffraction limited vertical emittance – has recently started.

There are many parameters that determine the quality of a SL facility such as the achievements of its Science program, the quality of its R&D, the efficiency of operations, etc. (see Chapter 16 for a number of performance indicators). However, as ALBA is still under construction these performance indicators will not be available until the operational phase and, therefore, we will restrict the comparison to the potential of ALBA as a light source. To this end one has to consider the source parameters that are crucial in determining the potential of the light source, i.e. Photon Spectral Range of utilization and the Brilliance of the source. The former gives the potential for different applications and different fields of research whilst the latter, as unambiguously predetermined by Liouville’s principle, determines the ultimate quality of the data.

The Spectral Range of the emitted photons increases with the square of the electron energy – i.e. ≈ E_e^2, as this is indeed the main factor defining the critical energy – i.e. the photon energy that corresponds to the median of the emitted photon power - whilst the Brilliance of the emitted radiation is approximately given by $I / \varepsilon^{1.5}$, where I is the electron circulating current and ε is the emittance of the electron beam. Naturally, there are other parameters that come into the equation such as the space available for IDs and the stability of the beam. The latter depends on the mechanical stability of the building, the electricity supply, the RF system, the vacuum-system, the feedback system, the optics system, etc. At this stage ALBA can only base its performance on its design parameters as installation of most of the facility components, never mind their commissioning and optimization, has yet to take place - see Chapters 8 and 9.

In order to compare ALBA with other SL sources one must make the distinction between medium energy SL facilities, typical of national installations like ALBA, and high energy facilities such as the ESRF, Spring-8 or the APS that are international or continental facilities meant to complement national/medium energy facilities. Among those there is a somewhat anomalous SL source, Petra-III that has originated from recycling an accelerator initially meant for high-energy physics. Today Petra III is the high-energy SL source with the best performance parameters (i.e. has the largest useful photon energy range with the lowest emittance). Regardless of these considerations and as shown in Table 7.5.1, ALBA compares very favourably with the ESRF, Spring-8 and the APS in terms of emittance, although Petra III is well ahead. Obviously, given its energy, ALBA cannot pretend to compete, nor it is meant to do so, with the photon energy range potentially available at these complementary facilities.

So, where is ALBA in relation to other national/medium energy SL sources? Table 7.5.1 compares operating facilities with a mission similar to ALBA. Note that the emittance of ALBA (3.8 nm rad of error free emittance) is only slightly bettered by that of Soleil (3.72 nm rad) and Diamond (2.75 nm rad), whilst its energy (3 GeV) is identical to that of Diamond and somewhat higher than Soleil’s (2.75 GeV). In other words in terms of Photon Spectral Range of utilization, i.e. dependent on electron energy, and source quality, i.e. dependent on Brilliance ≈ $I / \varepsilon^{3/2}$, ALBA has the potential to be with the top performers among the medium energy SL facilities. This is illustrated in Fig. 7.5.1 where the value of $I / \varepsilon^{3/2}$ for the various 3rd generation SL sources, normalised to that of ALBA, is shown against the electron energy of these sources.

		ENERGY	EMITTANCE	CURRENT	PERIMETER
		E	ε	I	P
SOURCES IN OPERATION	LOCATION, COUNTRY	(GeV)	(nm rad)	(mA)	(m)
ANKA	KARLSRUHE, GERMANY	2,50	41,00	200	240,0
PLS	POHANG, KOREA	2,50	12,00	174	281,0
CLS	SASKATOON, CANADA	2,90	17,70	170	178,0
NSRRC	TAIWAN	1,50	25,00	200	120,0
SPEAR-3	STANFORD, USA	3,00	18,00	500	234,0
ASP	MELBOURNE, AUSTRALIA	3,00	7,70	200	216,0

ELETTRA	TRIESTRE, ITALY	2,40	7,00	300	259,0
BESSY	BERLIN, GERMANY	1,90	5,20	220	240,0
MAX-II	LUND, SWEDEN	1,50	9,00	200	90,0
ALS	BERKELEY, USA	1,90	6,80	400	197,0
DIAMOND	CHILTON, UK	3,00	2,75	300	561,6
SLS	VILLIGEN, SWITZERLAND	2,40	5,00	400	288,0
SOLEIL	PARIS, FRANCE	2,75	3,72	400	354,0
NEW SOURCES IN CONSTRUCTION					
ALBA	CERDANYOLA DEL VALLES, SPAIN	3,00	3,80	400	267,0
NSLS II	BROOKHAVEN, USA	3,00	1,50	500	791,5
SESAME	AMMAN, JORDAN	2,50	26,20	400	124,8
SSRF	SHANGAI, CHINA	3,50	4,80	250	432,0
PROPOSED NEW SOURCES					
CANDLE	ARMENIA, YEREVAN	3,00	8,30	350	216,0
TPS	TAIWAN	3,00	1,70	400	518,4
MAX-IV	LUND, SWEDEN	3,00	1,20	500	285,0
CESLAB	BRNO, CZECH REPUBLIC	3,00	3,80	400	267,0
HIGH ENERGY SOURCES					
SPRING-8	HIMEJI, JAPAN	8,00	5,90	200	1432,0
APS	CHICAGO, USA	7,00	3,70	200	1104,0
ESRF	GRENOBLE, FRANCE	6,00	3,70	200	838,0
PETRA III	HAMBURG, GERMANY	6,00	1,00	100	2300,0

Table 7.5.1

For the purpose of comparison Fig. 7.5.1 also includes the normalized value of $I / \varepsilon^{1.5}$ for the ESRF, APS and Spring-8.

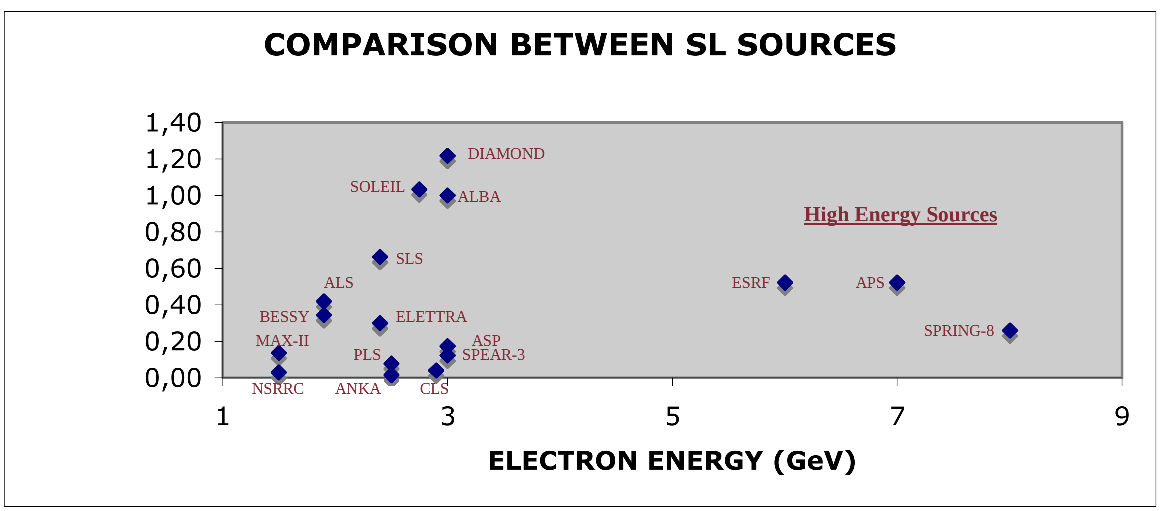

Fig. 7.5.1

Finally, we point out that the emittance of a SL facility is inversely proportional to the cube of the number of bending magnets in the lattice, which in turn is limited by the perimeter of the ring or, more prosaically, by the money available for the project as the accelerator costs scale proportionally with the radius of the ring, i.e. its perimeter, whilst the cost for the building scale with the square of this radius, i.e. with the area. Table 7.5.1 shows that the perimeter of ALBA is significantly smaller than that of Soleil and less than half of Diamond's. So, ALBA has a cost effective design.

8. PROJECT CHARACTERISTICS

8.1 Buildings and conventional services therein

ALBA is sited on a plot of land of about 60000 m^2. This site has undergone extensive geological studies since the middle of 2004, including detailed identification of sub-soil composition, long-term stability, vibration levels, etc. There is now reasonable confidence in the suitability of the site in terms of long-term soil stability and vibrations levels sufficient to ensure the necessary mechanical stability of the critical floor area (CFA), i.e. the area on which the complex of accelerators and the beam-lines are/will be placed.

The stringent mechanical stability performance demanded from the CFA is summarized in Table 8.1.1.

Dimensions of the corona in the critical floor area (CFA) within which stability requirements apply	
Inner diameter	ca. 60 m
Outer diameter	ca. 120 m

Estimate of loads on the CFA corona	
Total static charge	10.000 Tm
Distributed static charge	1,5 Tm / m^2
Maximum charge on a point	5 Tm / m^2
Dynamic charge	2 Tm

Floor differential displacements	
Slow relative displacements	< 0.25 mm/10 m/ year
	< 0.05 mm/10 m/month
	< 10 µm/10 m/ day
	< 1 µm/10 m/ hour
Maximum differential displacement over the whole perimeter	< 2.5 mm/ year

Floor deformability because of charges	**On the application point**	**At 2 m**
Static charge of 500 kg	6 µm	1 µm
Dynamic charge of 100 kg	-	1 µm

Vibrations		
Vertical amplitudes	< 4 µm	From 0.05 – 1 Hz
	< 0.4 µm	From 1 – 100 Hz
Horizontal amplitudes	2 µm	

Table 8.1.1

The solution adopted for the base of the CFA consists of a 1m thick concrete slab, constructed from 20 segments. The segments were produced one at a time and subsequently joined by shuttering boards and with longitudinal re-enforcing bars going through the shuttering. The area below the slab had been previously treated with a ca. 2 m thick refill of selected gravel, homogenously and suitably compacted for additional stability, and sandwiched between two layers of poor concrete for protection.

The architectural complex consists of three main areas/buildings: technical buildings - of ca. 7500 m^2 -, the main Hall – of ca. 18500 m^2 - placed over the slab but with decoupled foundations, and the office/personnel wing – with ca. 4000 m^2 -. The main Hall and the office/personnel wing share a common roof with metal cladding that allows the indirect entrance of natural light, but avoids temperature variations inside the building. It should be noted that in addition to the mechanical stability requirements demanded from the CFA, there also are the equally critical requirements on thermal and electrical stability. The total electrical power installed will be 12 MW. Tables 8.1.2 and 8.1.3 summarize the required specifications for thermal and electrical stability, respectively.

Thermal Stability	
Within the Ring Tunnel	23 ± 0.1º
In the Experimental Hall	23 ± 1º

Table 8.1.2

Electrical Stability	
Long power cuts (t > 0.6s)	< 1 per year
Medium duration power cuts (0.4s < t < 0.6s) and ΔV > 12% in 2 phases	< 3 per year
Short duration power cuts (t < 0.4s) and ΔV > 8% in 3 phases	< 3 per year

Other Electrical data	
Voltage Supply	25 kV
Expected power Consumption	9 MW

Table 8.1.2

The mechanical installations, comprising air conditioning, cooling, treatment and distribution of water arriving from the mains network, and fluids (i.e. natural gas, diesel, compressed air and technical fluids) are included as part of the Buildings' Project. The combination of the roof design and the internal air conditioning and temperature regulation equipment will ensure that below a height of 4m in the Experimental Hall and inside the tunnel the ambient temperature will be maintained within specifications.

Cold and hot energy production is carried out centrally and respectively obtained from water condensation in a cooling tower and by means of a condensation tank and a vapor tank. These plants are placed in the Technical Building. Distribution of hot and cold water is achieved via pumps also installed in the Technical Building. Distribution of chilled and de-ionized water is carried out via 4 circuits to the: service area and LINAC; Booster; Storage Ring, and; beam-lines. Water is treated with ion exchange and reverse osmosis units. The various gases and fluids are stored and/or delivered from source (e.g. natural gas) at the Technical Building and distributed to the rest of the facility thereafter.

Regarding electrical installations, earth connection of < 0.2 ohm is achieved via a 1mx1m reticule made of naked, buried copper wire of 50 mm^2 cross section. The reticule is re-enforced with copper-steel spokes and joined to an equipotential net of galvanized steel that is imbedded in the floor of the Hall. This net is also joined to a perimeter ring of naked copper, again with a cross-section of 50 mm^2. All earth networks are joined together into a single equipotential net. Two emergency diesel generators (720kW each) are installed in the Technical Building to back up static un-interruptible Power Supply units, UPS, in case of failure of the external supplies. Dynamic UPS, i.e. flywheels, are available as filters for short-lived dips in the mains with autonomy of 12 seconds which gives enough time to allow the mains to re-stabilize.

8.2 Sub-station and cogeneration plant.

ALBA has to operate so that the possibility of an uncontrolled shutdown due to power supply failure is minimal. Therefore, apart from the question of stability that is handled internally with the various technical appliances referred to above, there must be a redundancy in the external sources of the energy. Redundancy has been achieved as follows: ALBA can get energy either from a sub-station - named Codonyers - sited nearby and/or from a co-generation plant – named ST4 – also sited in the immediate vicinity of CELLS. CELLS is a minor partner in the society that will operate the ST4 plant.

ALBA is connected to Codonyers via a double dedicated electrical line. The 220 kV to 25 kV transformer as well as the high voltage positions are exclusively dedicated to ALBA's use. In this way ALBA receives the benefit of the higher rigidity to earth of the 220 kV bar. In addition, ALBA is connected to the cogeneration plant ST4 that can also provide CELLS with electrical power as well as warm and chilled water. So, with this scheme ALBA's energy requirements can be obtained from either the public electrical network at transport voltage or from the co-generation plant.

8.3 Design criteria for the complex of accelerators

The following objectives/design criteria were applied during the conception of ALBA:

- i) The energy should be 3 GeV;
- ii) Perimeter of the storage ring < 270 m;
- iii) Natural emittance < 5 nm rad;
- iv) Optimize the lattice for high photon flux density;
- v) Top-up operation;
- vi) Energy acceptance > 3%, and;
- vii) Sub-micron stability for the stored electron beam.

The reasons for these self-imposed objectives are various: the energy of 3 GeV was chosen to have a broad range of useful photon energies and, in particular, so that X-rays of 15 to 20 keV could be generated with in-vacuum undulators of realistic gaps; the perimeter of < 270 m was imposed by the size of the available plot of land and, more to the point, to keep the cost of the facility within budget; the emittance of < 5 nm rad was due to the intention to have a SL source that in spite of its relatively small perimeter could compete in brilliance with the newer, and much larger, 3rd generation SL facilities such as Soleil and Diamond; the optimization of the lattice for photon flux density, i.e. a small as possible source size, was due to the perception that spatially resolved spectroscopy or diffraction, as well as experiments using transversely coherent X-rays, is a strength for future applications; top-up operation was a requirement based on the obvious point that a constant thermal load on optical elements is an important requisite for their stability; energy acceptance of > 3% arises because it is necessary in order to have lifetimes in excess of 15 hours so that radiation levels in the experimental Hall can be kept well within bounds; sub-micron stability is needed if one wants to exploit a source with a high photon flux density to the full. The implication of this is that active feed-back systems are an essential requirement of the design. In addition, the option of future single bunch operation has been left open.

The design that was arrived at, and that fulfills the above listed criteria, is a complex of accelerators: Linear accelerator or LINAC, Booster and Storage Ring distributed in a highly compact arrangement as shown in Fig. 8.3.1. The 3 GeV Booster and the 3 GeV Storage Ring, with perimeters of 249.6 and 268.8 m, respectively, share the same tunnel. The tunnel is the area within the ratchet making the external shield wall and the internal, near circular, one. Both shield walls are shown by the blue contours in Fig. 8.3.1. This arrangement reproduces the Swiss Light Source concept and it minimizes the angle of deflection of the electron's trajectory in the Booster to Storage Ring transfer line – BTS. The 100 MeV LINAC is housed in its own bunker tucked away against the inner shield wall. The 100 MeV electrons generated in the LINAC are injected into the Booster via the LINAC to Booster transfer line. The Booster components are fixed on girders/supports attached to the inner shield wall, whilst their own high precision girders support the elements of the Storage Ring. Adjacent to the booster wall is the so-called service area that houses all the components required for the operation of the three accelerators and the two transfer lines - i.e. power supplies, RF power systems and waveguides, air conditioning units, etc. -

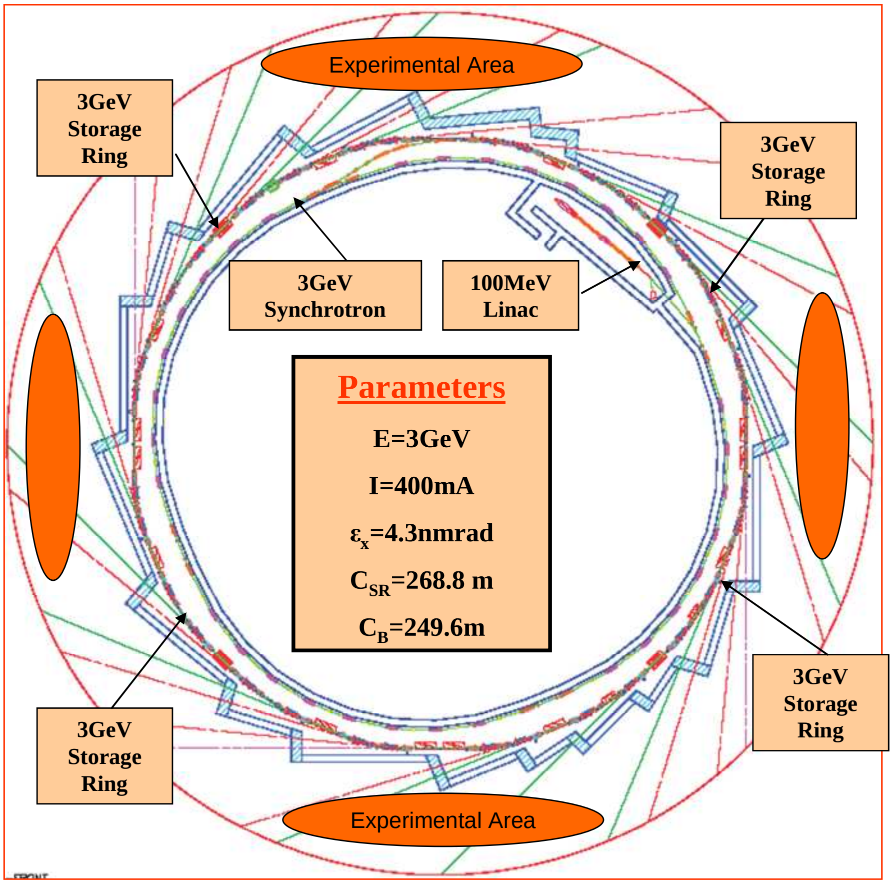

Fig. 8.3.1

8.4 LINAC

The LINAC - with a nominal energy of 100 MeV - is a turnkey device meant to operate both in single and multi-bunch mode. The LINAC is made up of a 90 kV thermo-ionic gun, a 500 MHz sub-harmonic pre-buncher, a 3 GHz pre-buncher, a 3 GHz/22-cells standing wave buncher and two traveling wave accelerating sections with constant gradient. Two pulsed klystrons feed the accelerating sections and the 3 GHz buncher, whilst the sub-harmonic pre-buncher and the buncher are fed from an independent RF amplifier. Beam focusing is ensured by solenoids up to the bunching section, and by a triplet of quadrupoles in between the two accelerating sections. The device with an 80% transmission efficiency from gun to exit has been delivered, installed, and its commissioning is completed.

8.5 Booster

The injection of electron bunches from the LINAC to Booster, i.e. LTB transfer line, is given by two bending magnets and 3 quadrupole triplets. The latter are located immediately after the LINAC, between a first bending magnet and the shield wall of the LINAC bunker and before the injection septum on the other side of the wall. The bending magnet is used to deflect the beam into a Faraday cup – used for diagnosis.

The Booster is a modified FODO lattice with 4-fold symmetry. Each quadrant has 10 cells, of which 8 are regular FODO cells and 2 act as matching cells. The four quadrants connect via four 2.46 m long straight sections. These will be used for injection, for installation of the RF system and for diagnostic components. All together the Booster has 40 bending magnets with combined function (these also provide the vertical focusing), 60 quadrupoles (horizontal focusing), 16 sextupoles and 72 steering magnets. The RF system is based on a 5-cell Petra type cavity, fed with 43 kW to deliver 1 MV at 500 MHz and 5 mA (i.e. the maximum that the LINAC can supply) current. The 43 kW are provided by an 80 kW Inductive Output Tubes – IOT -, that is identical to those in the Storage Ring, thus ensuring ample spare power as well as a facility wide standard. The Booster lattice delivers an emittance of ca. 9 nm rad that is currently the smallest of all the Booster synchrotrons in the world and that leads to a beam cross-section at injection < 1 mm. This is small enough to ensure very high injection efficiency for top-up operation. The main parameters of ALBA's Booster lattice are summarized in Table 8.5.1.

Energy	3	GeV
Natural emittance	9.0	nm rad
Tunes (Qx / Qy)	12.42 / 7.38	
Natural Chromaticity (ξ_x / ξ_y)	-17.0 / -9.6	
Momentum Compaction Factor (α1)	3.6 ×10-3	
Energy Spread (δE/E)	9.6×10-4	
Revolution frequency	1.202	MHz
Damping Times ($\tau_x/\tau_y/\tau_s$)	4.6/8.0/6.4	ms
Partition Numbers (J_x/ J_y/J_s)	1.75/1.0/1.25	
Energy Loss per turn (U_0)	625	keV
Harmonic Number (h)	416	

Table 8.5.1.

Fig. 8.5.1 shows the lattice functions within one quadrant of the Booster synchrotron. The figure shows the placing of the matching cells, consisting of one bending magnet and three quadrupoles, at the end of the quadrant. The 8 unit cells in the middle of the quadrant, with a combined magnet in the middle of each cell and a quadrupole at both ends, lead to the smallest emittance. Using the three quadrupoles in the matching section and the one in the unit cells one can change the working point. In order to ensure no dispersion at the injection straight, the deflection angle of the bending magnet in the matching cells is half that within one unit cell. Also, in order to make the Booster compact and more inexpensive, sextupole components for chromaticity compensation are introduced both in the bending magnets and in the quadrupoles of the unit cells.

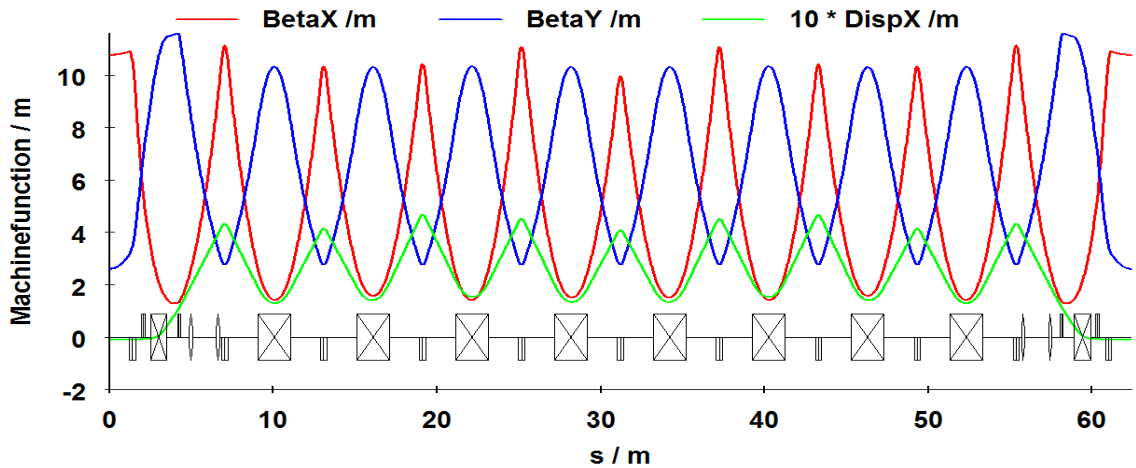

Fig. 8.5.1

8.6 Storage Ring

After a number of design iterations with the aim of: achieving the highest possible flux density on the samples; providing stable photon beams; maximizing the number of straight sections where to house insertion devices, and; not exceeding a perimeter of 270m, the final chosen design of ALBA is an expanded DBA lattice, with finite dispersion in the straight sections, and with 4 super-periods/quadrants. This results in 4 straight sections of ca. 8 m long each. Within each super-period, there are 3 straight sections with a length of ca. 4.2m length and 2 straight sections with a length of ca. 2.6m. Therefore, the total number of straight sections is: 8 of ca. 2.6m, 12 of ca. 4.2m, and 4 of ca. 8m length, of which there are 3 of ca. 8m, 12 of ca. 4.2m and 2 of ca. 2.6m available for the eventual installation of IDs. The others are used for injection, installation of RF cavities and plants, accelerator diagnosis and other components. The Storage Ring has a total of 32 bending magnets with a dipolar component of 1.42T and a gradient of 5.65 T/m each, 112 quadrupoles and 120 sextupoles. The chosen lattice frees a significant amount of space for IDs.

For the design current of 400 mA, the RF system has to provide an accelerating voltage of 3.6 MV and 520 kW of beam power. To this end, the RF system consists of six independent RF units (installed in the 2.6 m long straight sections), where in each one there is a Higher Order Mode (HOM) damped cavity, two 80 kW IOTs, whose power is combined in a Cavity Combiner and applied through a transmission line to the cavity.

To keep the perimeter of the ring within bounds, a number of compromises have been made, for example: the use of a relatively high gradient in the bending magnets that does most of the beam vertical focusing, and thus reduces the number of quadrupoles required; to allow some dispersion to occur in the straight sections; to place only doublets of quadrupoles in most straight sections, and; to integrate the corrector magnets in the sextupoles. Nonetheless, the lattice delivers low enough chromaticity so that with the use of nine families of sextupoles it provides a large dynamic aperture, good energy acceptance even after considering coupling errors and realistic physical apertures, and more than 40 hours Touschek lifetime. Moreover: there is sufficient flexibility in the configuration to allow change in the working point if/when needed; negative effects due to multipolar components are within bounds, and; the corrector strengths needed to achieve close orbit are well within acceptable tolerances and allow to reach sub-mm stability. Table 8.6.1 summarizes the main lattice parameters of the Storage Ring of ALBA, whilst Fig. 8.6.1 shows the lattice functions within one super-period/quadrant. As summarized in Table 8.6.2, this arrangement reduces the beam sizes at the source points – i.e. maximizes photon flux density – whilst keeping good collimation for the emitted beams.

Energy	3	GeV
Natural emittance	4.3	nm rad
Tunes (Qx/Qy)	18.179/8.372	
Natural Chromaticity (ξ_x / ξ_y)	-40.0/-25.6	
Momentum Compaction Factor (α1)	8.8×10^{-4}	
Energy Spread (δE/E)	1.05×10^{-3}	
Revolution frequency	1.1161	MHz
Damping Times ($\tau_x/\tau_y/\tau_s$)	4.6/8.0/6.4	ms
Partition Numbers ($J_x/J_y/J_s$)	1.3/1.0/1.7	
Energy Loss per turn (U_0)	1.017	MeV
Harmonic Number (h)	448	

Table 8.6.1

Source	Length (m)	σ_x (μm)	σ'_x (μrad)	σ_y (μm)	σ'_y (μrad)
Long S.	7.97	271.0	21	16.2	3
Med S.	4.19	131.0	47	7.6	6
Short S.	2.6	315.0	23	15.1	3
Bending M.		44.0	116	32.0	2

Table 8.6.2

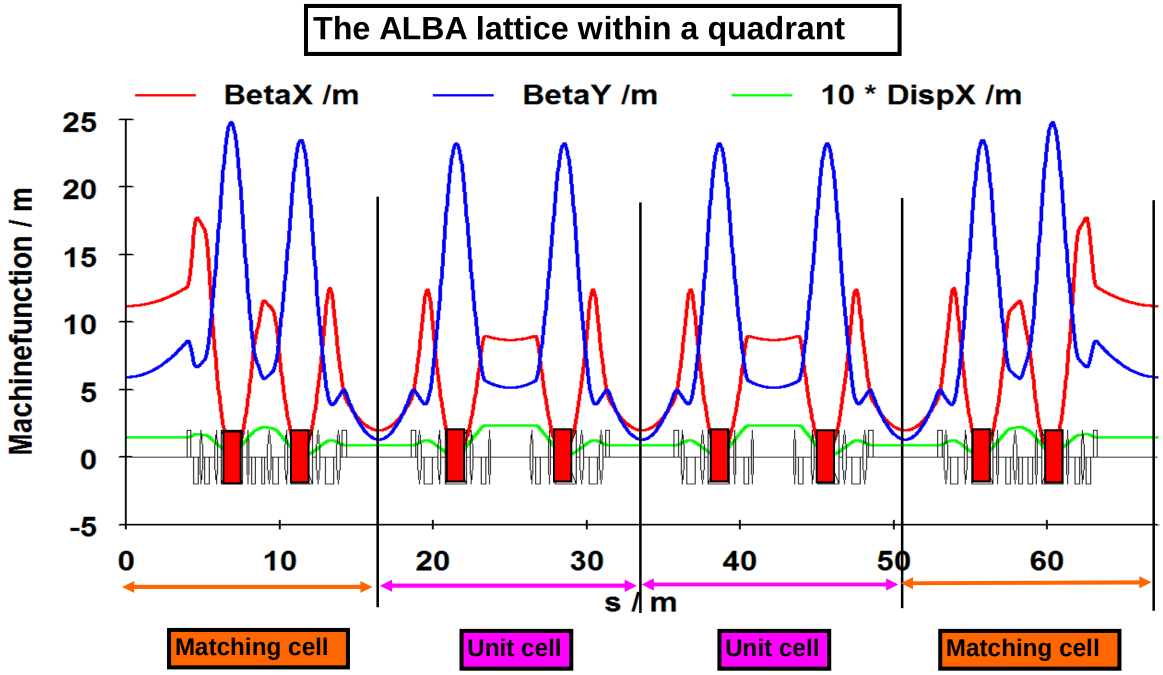

Fig. 8.6.1

8.7 Beam-lines

The original capital project contemplated the construction of the facility with only 5 beam-lines and associated experimental stations. In early 2004, and after a number of preparatory workshops and meetings, the Spanish scientific community was invited to submit bids through AUSE, i.e. its user association, for the initial set of beam-lines at ALBA. Proposals for thirteen beam-lines were submitted to ALBA. ALBA´s Science Advisory Committee (SAC) following a procedure along the lines described in 13.3 evaluated these proposals. In all cases, and in addition to its own judgment, SAC invited external experts to comment on the proposals. At the end of the review process SAC ranked the proposals according to the strengths of the scientific case, the weight and quality of the future user community, technical feasibility and quality. SAC identified 7 beam-lines – rather than the 5 planned - that given the size and strength of the user community should be available as soon as possible and recommended to the Management of ALBA that they should be built in the first phase. Subsequently the Council of ALBA approved this recommendation.

These beam-lines are currently under construction and they address technical and scientific objectives primarily in the areas of Materials Science, Physics, Chemistry and Biology. These are summarized in Table 8.4.1.

Port	Beam-line	Experimental techniques	Scientific applications
4	MSPD	High resolution powder diffraction High pressure diffraction	Structure of Materials, Time resolved diffraction
9	MISTRAL	Soft X-ray full field transmission X-ray microscope. Optimized on the water window	Cryogenic tomography of biological objects. Spatially resolved spectroscopy
11	NCD	High Resolution Small and High Angle X-ray Scattering/Diffraction	Structure and phase transformations of biological fibers, polymers, solutions. Time resolved X-ray studies
13	XALOC	X-ray diffraction from crystals of biological macromolecules	Protein crystallography, with particular emphasis on large unit cell crystals
22	XAS	EXAFS, XANES, Quick-EXAFS	Material Science, Chemistry, Time resolved studies.
24	CIRCE	Photoemission microscopy (PEEM) Near atmospheric pressure photo-emission (NAPP)	Nano-science and magnetic domain imaging (PEEM). Surface chemistry (NAPP)
29	XMCD	Circular Magnetic Dichroism Resonant Magnetic Diffraction	Magnetism, surface magnetism and magnetic structure

Table 8.4.1

Note that with the exception of MISTRAL that uses radiation from a bending magnet all the other beam-lines will be equipped with an insertion device tailored to their specific objectives. These 6 IDs are: one APPLE-II type undulators for CIRCE and another for the XMCD beam-line, respectively; one in-vacuum undulator for XALOC and another for the NCD beam-line, respectively; one low deflection, i.e. low K, superconducting multipole wiggler for the MSPD beam-lines, and finally; one conventional multipole wiggler for the XAS beam-line. Note also, that both CIRCE and XMCD have two end stations each. An X-ray magnetic circular dichroism station and a resonant magnetic scattering/diffraction station will take beam from the XMCD beam-line, whilst a photo-emission electron microscopy (PEEM) station and a station to carry out a photo-emission experiments at moderately high pressure, i.e. so that sample can be considered a “real” surface, will be taking beam from CIRCE.

9. TIME TABLE FOR CONSTRUCTION AND COMMISSIONING

9.1 Buildings and conventional services

The status of the civil works on the complex of buildings is that very few works are needed before completion. There are still some activities - e.g. preparatory works for final urbanization, internal partition walls, false roofs, painting and architectural details that are pending, but with the exception of gardening and landscaping all civil works should be completed before the end of 2008. Completion for gardening and landscaping is expected by April 2009.

Regarding building installations and services: about 2/3 of cooling water systems and HVAC are completed. Still pending are the accelerator and beam-lines cooling circuits, e.g. stainless steel pipes for the cooled/de-ionized water supply, and the chilled water production plant. Expected date of completion is March 2009

The electrical distribution is ¾ finished. There still remains the installation of some electrical cabinets, voice and data cabling networks. Complete installation of electrical cabinets is expected before the end of 2008, whilst voice and data cabling should be finished by February 2009

9.2 Sub-station and co-generation plant

With regards to the external energy supply, i.e. sub-station and co-generation plant, the current expectation is that the electrical substation is to be operative by December 2009, whilst the co-generation plant could be ready for commissioning by March 2009, even though regular operation of the co-generation plant can only occur when the electrical sub-station will be fully operative. So, CELLS will not have access to its high quality energy supply until December 2009. In order to proceed with accelerators and beam-line installation, as well as setting up the necessary infrastructure CELLS has pursued and succeeded to obtain up to 6 MW of electrical power from a provisional 25 kV line. This line is already operative and will be available for the installation and pre-commissioning of the sub-systems of ALBA. Note that the quality of this supply is inadequate for routine operation as it is unlikely that it will have the required stability and there is no redundancy to cope with power failures.

9.3 LINAC

The LINAC was installed and commissioned during 2008. A temporary enclosure and provisional services - power and fluids - were used for the purpose. The device performed well within design specifications.

9.4 Booster

Practically all the Booster sub-systems are available and stored in CELLS' warehouse. The start of the Booster installation has been handicapped by civil work and the installation of conventional services within the shield tunnel – lighting, piping, etc. - that did not allow neither the level of cleanliness necessary for the installation of sensitive sub-systems of the Booster nor the necessary accessibility. However, it has been possible to progress the pre-installation of all the racks that it is now completed. The mechanical installation of the Booster has already started with the mounting of components such as girder and alignment tables. The end of the installation of the mechanical components of the Booster ring (magnets, vacuum, pumps, etc..) will continue until mid-April 2009 when its completion is expected. Overlapping somewhat with this activity there is the installation of Booster controls and finishes. These are expected to end by the beginning of August 2009 when some pre-commissioning of some of the Booster sub-systems will take place. In summary the plan is that by the end of August 2009 the Booster will have been installed and the pre-commissioning of its main sub-systems carried far enough to detect any possible difficulties so that, if necessary corrective action may be taken.

9.5 Storage Ring

Even though most of the Storage Ring components have been delivered and are either stored in the warehouse or undergoing tests - e.g. vacuum vessels, dipole, quadrupoles, sextupoles, girders, BPM electronics, RF systems, etc. - the assembly of the SR components will only start in April 2009. This is due to access constraints and the plan is to start the assembly of the mechanical components of the Storage Ring after Booster finishes and controls installation are finished over large enough sections of the tunnel. The Storage Ring girders with all their magnets in place will be brought through the tunnel roof with the overhead cranes. Once in place the magnets will be opened and long pre-assembled section of the vacuum pipes with their respective pumps will also be brought through the roof and mounted on the magnets. The intention behind this procedure is to reduce the installation time to a minimum. These operations will continue until December 2009 when it is expected that the Storage Ring installation will be completed. With ca. 1.5 months stagger, i.e. by mid-May 2009, works with finishes of Storage Ring components and installation of the controls will start. These activities are expected to end by end of April 2010, when a 3 months period of Booster and Storage Ring commissioning has been scheduled. Previously, and in parallel with the Storage Ring installation, the ex-vacuum IDs will have been installed. However, installation of the in-vacuum IDs will only be possible after the end of Booster and Storage Ring commissioning, due by the end of July 2010. After about one month of in-vacuum ID installation commissioning of IDs will take place - note that this is also Booster and Storage Ring commissioning-. This is expected to last another three months so that by November 2010 facility will be able to store beam. In this plan it is expected to have some beam, albeit with relatively low quality but sufficient for beam-line alignment checks and testing with beam, as from the summer of 2010.

9.6 Beam-lines

The design of all experimental stations has been completed and all optical systems are ordered. All the associated infrastructures, e.g. power, fluids, etc., has been defined and in the process of being ordered. It is the intention that the installation and commissioning of the beam-lines without beam will proceed in parallel with the installation of the sub-systems making up the complex of accelerators. At the end of

2008 some of the hutches are either already installed, e.g. NCD, or in the process of installation, e.g. XALOC and CIRCE. The installation of the remaining hutches is expected to end by the beginning of the 3rd quarter of 2009. The installation of beam-line infrastructures - e.g. remaining optics and experimental hutches, services such as power, fluids, personnel safety systems, etc. – is expected to continue until the beginning of the 4th quarter of 2009. Assembly of beam-line optics, experimental station instrumentation and commissioning without beam is expected to start in the 1st quarter of 2009 and continue until the beginning of the 3rd quarter of 2010. Some commissioning with beam may be possible as from the middle of the 2nd quarter of 2010. The last beam-lines to come into operation with beam are those taking light from the in-vacuum undulators, as those will not be available until well into the 4th quarter of 2010. It is expected that some benchmarking measurements, possibly involving invited users, will be carried out towards the end of 2010 – section 10.2 -. However, first experiments with users are only expected to occur in 2011.

9.7 CSN operating Licenses

The CSN (*Consejo de Seguridad Nuclear*), or Nuclear Safety Council, is the Spanish regulating agency for radiological installations (e.g. hospitals) and radioactive installations (e.g. power plants using nuclear reactors). The CSN has a delegation within Catalonia – named SCAR, or *Servei de Coordinació d'Activitats Radiológicas* - with responsibility for radiological safety where it acts as a controller of activities.

In December 2007 the CSN issued a document establishing the procedure to grant authorization to ALBA as a radioactive installation of category I - i.e. a radioactive installation with scientific ends and without a nuclear combustion cycle – and determined that the licensing for the operations of ALBA would take place in 4 steps leading to the issuing of the operating license for: 1) a RF plant; 2) the LINAC; 3) the Booster accelerator, and; 4) the overall operation of ALBA.

The license to operate a RF plant needed to commission with power the RF cavities for the Booster and the Storage Ring was supervised by SCAR and granted quite some time ago. The license for the commissioning of the LINAC has also been awarded since March 2008 under the supervision of SCAR. This was done during the commissioning of the LINAC. CELLS is currently in the process of securing - this time via CSN – the operating license for the Booster accelerator. This is expected before the beginning of the 2nd quarter of 2009 in time for the pre-commissioning of some of the Booster subsystems. Finally, the overall operating license for ALBA is expected to be necessary by the beginning of the 2nd quarter of 2010 when commissioning of Booster and Storage Ring are due to start. It is intended that all necessary steps needed to secure the Overall Operating license for ALBA should be completed before that date. In parallel with all the above licensing activities, CELLS is expecting to have its Radiological Protection Service officially recognized by the CSN during the course of 2009.

9.8 Summary of installation and commissioning plans

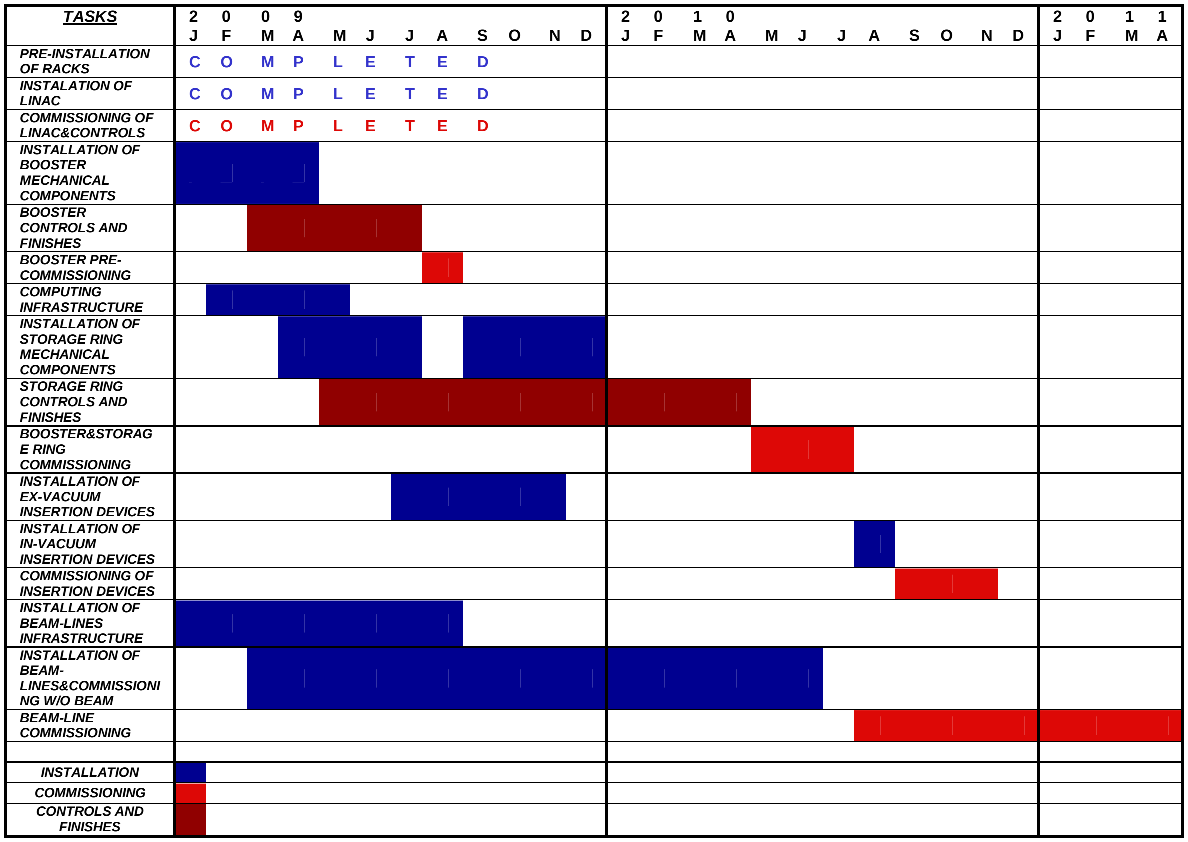

Table 9.8.1

Table 9.8.1 provides a summary of the installation plan for the Booster, Storage Ring and beam-lines. Blue color is used for activities associated with installation, red is to do with commissioning, whilst dark brown is used for work with finishes and controls

10. PLANS FOR THE TRANSITION TO ROUTINE OPERATIONS

10.1 Operational hours/year. Allocation to: accelerator physics; beam-line maintenance and development; in house research, and; users

The primary objective of any SL facility is to deliver first class photon beams to the users of the facility. To this end, in addition to the hours scheduled for users SL Facilities need to operate a certain number of hours for the purpose of facility maintenance and development. Critical parts of the facility are not accessible during operations because of the requirements of radiological protection therefore there must be scheduled shutdowns for the purpose of maintenance, refurbishment and development. Typically a one-day shutdown/week and two longish (ca. 5-6 weeks each) shutdowns a year are needed. The former are required for routine inspection and minor maintenance of subsystems, whilst the latter are needed for major refurbishment of components as well as replacement/installation of new components (e.g. new front end installation, removal of IDs for servicing, global surveys, etc..). The consequence of these requirements is that out of the 8760 hours (365 days) in a year only ca. 6000 hours are left for operations (i.e. 250 days, spread over ca. 42 weeks because of the need to stop operations once per week). During this time one can operate around the clock and use all 3 eight hour shifts available in a day.

Of the 250 days available for operations ca. 10% have to be devoted to accelerator physics, ca. 10% to beam-line maintenance and development with beam and ca. 10% for in-house research. The accelerator physics and beam-line maintenance and development allocations are necessary to maintain the facility competitive, whilst the allocation to in-house research is essential not only to maintain the facility competitive but also to attract the best possible scientists and technologists whose main motivation is to carry out leading R&D. Therefore, in the steady state of routine operations we propose a target in which ca. 175 days/year (i.e. 4200 hours/year) will be dedicated to operations for external users and 25 days/year to accelerator physics, beam-line maintenance/development with beam, and in-house research, respectively. This is to say a total of 250 days of operations around the clock, i.e. 3 shifts/day (see Table 10.2.1).

10.2 Proposed run-up to routine operations

For a facility like ALBA, the run-up to full routine operations will take sometime after the end of its construction. Therefore, it makes sense to define a target within which the run-up to consolidated routine operations should take place. Even though as a capital project the construction budget will be fully committed and largely spent, in the year 2010 there will still be a substantial fraction of installation work going on. Whilst it is the intention to invite experienced users to participate in some experiments, it is almost certain that the main aim of this period will be the commissioning and benchmarking of the facility. Given the current time scale for the end of the construction, it is expected that the facility in 2010 will operate for about 60 days, with about 12 operating hours/day (i.e. 1+1/2 shifts/day), primarily for commissioning purposes. The objective is to reach a stored current of 50 mA.

The target for 2011 is to reach 200 mA stored current and at least 10 hours lifetime. At this time the facility should be better understood and the first tests for top-up operation and fast orbit feedback will be done. We intend to achieve about 120 days of scheduled beam, with at least 60 days for external users, and run for 1+1/2 shifts/day. Naturally, all critical sub-systems will be kept in “warm” conditions during operational runs. In 2012 we propose to ramp this up to 200 days (140 days for external users) with 2 shifts/day and operate in top-up mode and to have the fast orbit feedback fully implemented. Target is to achieve currents of 300 mA. In 2013, the plan is to increase operations by running 208 days/year (with 145 days for external users) and running around the clock, i.e. with 3 shifts/day, whilst in 2014 the objective will be to run 250 days (with 175 days for external users) with 3 shifts/day. The design current of 400 mA is the target for 2014 and thereafter. Our target is to operate with at least 90% reliability. Naturally, our future target is to exceed this percentage once the facility has been understood and thoroughly debugged.

Fig. 10.2.1 shows how the number of total scheduled hours, external user hours and in-house hours of usage will ramp up with time and Table 10.2.1 provides a summary of the operational targets.

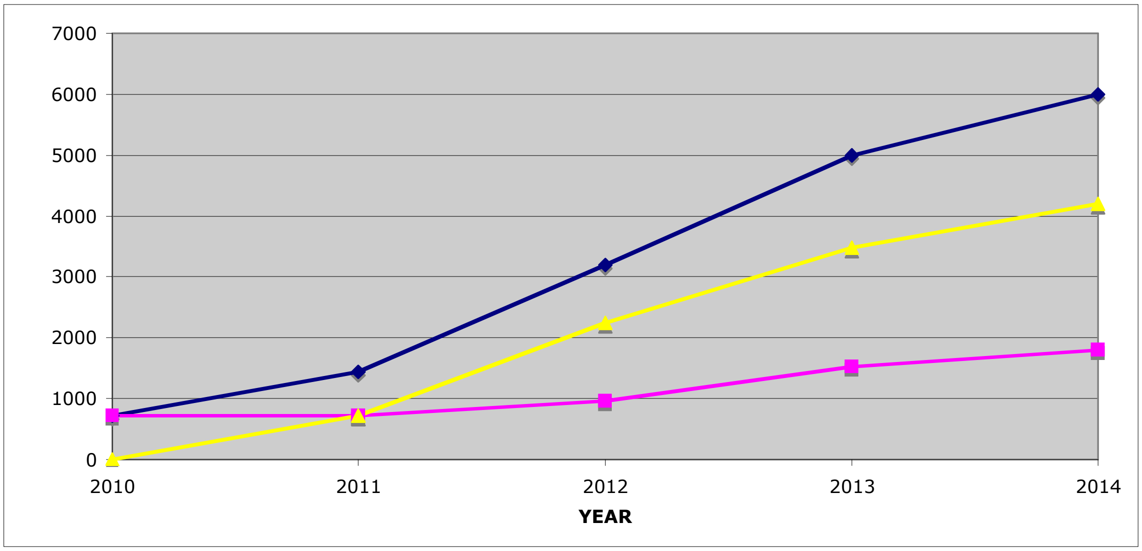

Fig. 10.2.1 Target ramp-up in operational hours/year. Blue is total/hours/year, yellow is scheduled user beam and pink is total allocation to accelerator physics, beam-line maintenance with beam and in-house research.

YEAR	Operational days/year	Operational shifts/day	Internal use hours/year	User's hours/year	Total hours/year
2010	60	1.5	720	0	720
2011	120	1.5	720	720	1440
2012	200	2.0	960	2240	3200
2013	208	3.0	1520	3480	5000
2014	250	3.0	1800	4200	6000

Table 10.2.1

Yearly targets for operational hours/year and its distribution in operational days, shifts, and activity (i.e. users and in-house activities: accelerator physics; beam-line and accelerator maintenance, and; R&D).

10.3 Mission, structure and operation of Advisory Bodies: New SAC + peer-review committees.

It has been explained in section 2 that the current statutes of CELLS contemplate that ALBA has two advisory bodies: the Scientific Advisory Committee (SAC) and the Machine Advisory Committee (MAC).

The role of MAC is primarily to advise on the construction of the accelerator complex that has a clearly defined end date. As it has been the case elsewhere, the role of MAC ceases when the commissioning of the accelerator complex is complete. Therefore, we propose that MAC should cease its function as an advisory body by the middle of 2011.

The current role of SAC is to advise the Director and, therefore, also the Management on any scientific/technical matter related to the scientific exploitation of the photon source. Within this remit SAC has played and will continue to play a very active role in the definition of new beam-lines. This role of SAC will continue for the foreseeable lifetime of the facility that if it is properly maintained and refurbished should remain serviceable for at least 25-30 years. This has been repeatedly demonstrated at similar installations. However, some of the current functions of MAC will also be necessary and upon the cessation of MAC's activities, we propose that the role of SAC should be enlarged to encompass the following mission:

"SAC, at the request of the Director of ALBA, or on its own initiative, gives its opinion or advice on any scientific/technical matter related to the scientific exploitation of the photon source as well as on the opportunity of new beam-lines, and of developments or upgrades in either the complex of accelerators or in the beam-lines"

Enlarging the role of SAC to cover the desirability of new developments or upgrades in the complex of accelerators (e.g. new ID's, feed-back systems, short bunches, etc.) means that knowledge of accelerator physics and its implication for the production of high quality photon beams must be incorporated into the SAC membership and thus complement the scientific and technical expertise needed to advise on the best possible scientific exploitation of ALBA. In other words, after the cessation of MAC's activities, it is proposed that the new SAC will incorporate some of the know-how currently resident in MAC. To this end, it is proposed that 2 out of the 8 members of SAC should have considerable expertise in accelerator physics. This SAC should start its expanded duties in the middle of 2011. The normal term of service of a SAC member should be three years.

Also, as from 2011 the use of the experimental facilities offered by ALBA to researchers carrying out publicly funded research, i.e. non-proprietary, should be regulated via peer review. To this end, it is proposed to create at least two peer review bodies, reporting to the Management of ALBA, to respectively cover the hard X-rays and the VUV/soft X-ray beam-lines at ALBA. These two review bodies should have at least one knowledgeable member per science discipline. So, both bodies should have expertise in physics, chemistry, materials science, surface science, magnetism and biology and, in addition, they should have significant expertise in the possibilities offered by the beam-lines of ALBA to their respective areas of scientific expertise. The membership in each review body should consist of a least 6 people. Membership will be for a period of 2 years, even though initially 3 people will be asked to serve for 3 years so that there always will be continuity/overlap between new members and retiring ones. This is essential to keep the collective memory of the peer-review bodies.

With regards to the question as to how should the members of the peer-review bodies be identified and appointed? It seems reasonable that Management should ask SAC and the

Spanish Association of Synchrotron Light Users (AUSE) to name people that they regard as qualified to discharge these jobs. For each one of the two peer review bodies, Management should propose to Council the name of six people. Of these Management choose the name of two people from those proposed by SAC, another two from those proposed by AUSE and, finally, should propose independently the names of the remaining two members in each peer-review body. In this way, one will ensure that fair play is guaranteed and that all parties involved have a voice in the matter.

In order to ensure an effective flow of communications, we propose that at least one SAC member should be a delegate in each of the peer-review committees, as well as a spokesperson and reporter for it to the rest of SAC. This should help SAC and Management to identify program malfunctions and allow the taking of early corrective action. One should note that in due course the number of beam-lines at ALBA may increase substantially and at this point it will be necessary to either enlarge the number of review bodies and/or the number of members in any given review body.

It is proposed to schedule operations on a six monthly basis. Therefore, the beam-line peer review committees should meet twice a year and at least a few months before the start of the allocation periods so that the ranking of applications can be done with sufficient time to comfortably prepare and publish the beam time schedule for users. It is important to note that the role of ALBA in the ranking of applications will be limited to provide technical advice and administrative support to the peer-review bodies.

In any given allocation period the schedule should not allocate all the shifts available. We propose to reserve two periods, one at the middle and another at the end of any allocation period to compensate users for losses of beam time due to beam-line and/or accelerator failure. In the event of the reserve not being needed as compensation for loss of beam time, then it will be used for allocating beam time to those proposals whose ranking has just fallen below the cut-off line, or as Management reserve for urgent applications, e.g. industrial users or other applications that require a fast response.

10.4 Modes of access by the entitled, non-entitled and international scientific community.

ALBA is a facility built with resources from the Spanish State and from the Autonomous Catalan administrations that are their Owners and, at least to start with, ALBA will operate exclusively with resources from the same agencies. This begs the question as to what distinction will be made in the mode of access of researchers funded by the Owners, i.e. entitled users, and those funded by some other national and/or international funding agency, i.e. not entitled user.

ALBA has the vocation to broaden and internationalize its user community as much as possible by attracting the best scientific proposals and programs regardless of where they come from. Therefore, we propose to schedule and rank proposals from researchers who are not funded by the Owners on an equal basis to those that are so funded. In other words: the ranking for access will be done taking into account only the scientific and/or technical merit of the proposal. The rationality of this approach has been amply demonstrated in other Large Scale Installations where whenever the overriding policy for access to the installation has been only the excellence of the scientific proposals, the returns have always led to important developments in know-how and knowledge that have enriched the facility and its broader user community at large. In general, we do not propose to cover travel, subsistence and accommodation expenses to these non-entitled users from ALBA's budget. However, as soon as ALBA becomes eligible, i.e. from the beginning of operations, we undertake to raise external resources with which to cover access costs of these non-entitled users by approaching other funding agencies (e.g. the EU funds for access to large scale scientific facilities).

10.5 User office and users' travel and subsistence (T&S).

The tried and very successful method of continual facility review provided by a SAC as well as regular peer-review of user proposals requires some significant full time management. This is necessary in order to organize the calls for proposals, collect them, distribute them to the reviewers, provide secretarial assistance to the reviewers, collect the information, provide feed-back to the authors' of the proposal about the outcome, organize the schedule, organize the safety training and reception of visiting users, etc.. In addition, there is a need to administer the travel and accommodation requirements of SAC, review panels and visiting users. Also, significant administration is needed to keep an updated information service, with records of users, successes and failures, user feed-back comments, publication records, etc.. To take care of these aspects we propose to set up a User's office consisting of at least 3 people: a person responsible, plus technical and administrative/secretarial help. Technical and scientific expertise from the Computing and Experiments Divisions will be co-opted to this activity whenever their expertise will be needed.

10.6 Policy on proprietary research: ALBA's Liaison Office for Proprietary Research and Public Relations.

Most of the users of ALBA will be involved in research that upon completion will be published in the public domain, i.e. non-proprietary research. However, ALBA, like any other modern SL facility, has significant potential for R&D in the proprietary domain, i.e. research leading to commercial benefits.

The cost of producing SL is not insignificant and this can be illustrated with the following: excluding amortization of ALBA's capital costs and considering only operational costs of ca. 23,70 M€/year to deliver 4200 hours of user operation/year (see table 12.1.1) it follows that the marginal costs, i.e. with not profit whatsoever, for use of one of the 7 beam-lines of ALBA amounts to ca. 6450 €/shift. Naturally, the marginal costs per shift would go down if all the potential beam-lines at ALBA were funded. In due course and upon a proposal from the Management of ALBA the owners of ALBA will have to agree to a pricing policy for proprietary research. This should contemplate not only the cost/shift of user beam but also other support that may be provided and that runs from collection of experimental data for the customer, to data interpretation and report writing of the results.

However, regardless of the pricing policy and even if proprietary research becomes “de facto” partially subsidized, it is clear from the above calculation that the costs are sufficiently high to make it necessary to demonstrate to potential customers the usefulness of SL applications if a reasonable number of industrial concerns are to become regular customers of ALBA. The importance of establishing communications with potential proprietary users arises not only because companies in general are not aware of the potential of SL applications and, therefore, without a significant effort in proselytism it is very unlikely that this potential will be realized, but also because most scientists involved with SL applications do not understand the requirements of proprietary researchers. It has been demonstrated elsewhere (e.g. SRS in the UK or the CLS in Canada) that to establish this two-way communication is absolutely necessary to attract industrial customers, but it is a slow process that requires the full time commitment of dedicated staff. So, as a pump-priming initiative, we propose to set-up a Liaison Office for Proprietary Research. The main objective of this office will be to promote industrial usage of SL technologies and to attract this kind of customers to ALBA. This office should include 3 people with industrial research experience and with responsibilities for public relations. Expertise from ALBA’s scientists and technologists will be co-opted whenever necessary. This office should be fully functional when ALBA has moved into a consolidated state of operations, therefore its activities should start not later than 2013 and the objective must be that in five years it should be at least self funding from customers revenue. This office should also double as the public relations office for ALBA. In addition, this office should take responsibility for the assembly of material for the annual report of ALBA and organizing promotions such as open days for schools and public.

10.7 Human resources during operations

As mentioned above ALBA as a capital project will be fully committed and largely spent in the year 2010. Even so, there will be still a substantial amount of installation work co-existing with work on the commissioning/optimization of accelerator systems and beam-lines. 2010 will be the year when the awkward transition from a personnel structure adequate for construction into one appropriate to operations/exploitation will have to be made. As also mentioned, the personnel structure of CELLS consists of a Director’s office and 5 Divisions. The Divisions are organized according to the functions required by the construction of a SL facility such as ALBA, i.e.: Administration; Engineering; Computer, Controls and Data Acquisition Systems; Accelerators, and; Experiments. Within this structure there are primarily two “client” Divisions, i.e. Accelerators and Experiments, and the remainder are Support Divisions. Once the exploitation phase of ALBA is consolidated the principal activities will be: Experimental Operations; Accelerator Operations; Accelerator Physics; Operations in Infrastructure, Maintenance and Support, and; Administration. Naturally, there will be activities that are small in personnel numbers but necessary such as: Management and Coordination (part of the Director’s Office), as well as the Radiological Safety (usually reporting directly to the

Director), the Users Office (usually associated to the Director's office or to Administration) and the Liaison Office for Proprietary Research (associated to the Director's Office).

Table 10.7.1 illustrates how the human resources for operations will originate from the various Divisions. It also shows where the additional human resources recruited to cover 3 shift operations will be allocated. This additional personnel totals 18 staff. Of these 18 staff, 2 are attributed to administration in order to cover the increased load due to the more operational hours/year and to larger personnel numbers, 4 are necessary to operate the electrical power plants (i.e. the co-generation plant and ALBA's electrical regulation systems) whilst the remaining 12 are allocated to "hands-on" work in Experiments and Accelerators Operations. In other words, a total of 69 staff will be devoted to the objective of running 3 shifts/day and to deliver 6000 operational hours/year. Of these 65 are direct "hands on" people.

The reason for the allocation of 65 staff to Experiments and Accelerators Operations is straightforward. The routine operation of the accelerator requires the presence of a crew of 4 people in the main control room and each beam-line needs the availability of at least one support scientist and one technician at any one time. Therefore, and on the basis of 7 beam-lines in operation, a total of 18 people are to be available at any one time for the operation of the facility and consequently, on the basis of 3 shifts/day, one can conclude that 54 people will be needed on a daily basis for the purpose of operations. Considering that redundancy in human resources is needed for the purpose of covering holidays, illness, etc., and that the number of working 8 hour days/year is 220 (whilst 250 days 8 hour days are needed to deliver 6000 hours of beam/year), it follows that in a consolidated state of operation (i.e. from 2014) ca. 65 staff/year will be needed exclusively for Experiments and Accelerator operations. As shown in Table 10.7.1, these 65 staff will be made up from the re-allocation of 52 existing staff to Experiments (36) and Accelerators (17) operations plus the 12 staff recruited for the purpose of running 3 shifts/day.

	DIRECTOR'S OFFICE	EXPERIMENTS DIVISION	ACCELERATORS DIVISION	CC+DACQ DIVISION	ENGINEERING DIVISION	ADMINISTRATION DIVISION	TOTAL
MANAGEMENT	**1**	**1**	1	**1**	**1**	**1**	6
COORDINATION	2	1	-	-	-	-	3
EXP. OPERATIONS	-	**14**	-	11	11	-	36
ACC. OPERATIONS	-	-	5	6	**6**	-	17
RADIOLOGICAL SAFETY	**2**	-	-	-	-	-	2
ACCELERATOR PHYSICS/IDs/ MAGNETS/RF/DIAGNOSTICS	-	-	14	-	-	-	14
OPERATIONS IN INFRASTRUCTURE/ MAINTENANCE/SUPPORT	-	**3**	-	23	**23**	-	49
ADMINISTRATION (SECRETARIAL/RECEPTION/ PERSONNEL/ACCOUNTANCY)	-	-	-	-	-	**13**	13
OPERATORS FOR ELECTRICAL POWER STATION&CO-GENERATION PLANT	-	-	-	-	4	-	4
INCREASE DUE TO SHIFT WORK	-	**7**	**1**	4	**0**	**2**	14
USERS' OFFICE	-	-	-	-	-	**3**	3
LIAISON OFFICE FOR PROP. RESEARCH	**3**	-	-	-	-	-	3
2014	**8**	**26**	**21**	**45**	**45**	**19**	**164**
2010	5	19	20	41	41	14	**140**

Table 10.7.1

10.8 User's meetings and Facility Promotion

A significant factor in the success of a facility like ALBA relies on establishing communications channels with its user community, as well as maintaining a continuous promotion for and search of prospective users. This is the reason why almost every SL facility periodically organizes User's meetings. In most SL facilities this is done once a year, but occasionally this might happen every six months.

We propose to have an annual User's meeting in our site, where: selected users will be invited to communicate their scientific/technical advances; ALBA will seek the user's opinion about the quality of the support provided; users will be encouraged to voice their future requirements; etc. The User's meeting is essential as part of a feed-back loop that is necessary for the early identification of problems or opportunities.

In addition to the yearly User's meeting, ALBA will need to be pro-active in Facility Promotion by establishing links and having structured meetings/workshops with other SL facilities or appropriate research establishments. This is needed to foster specific collaborations for joint projects, funded via contracts or agreements (e.g. CELLS's potential contribution to the European X-ray Free Electron Laser), or with European funding (e.g. the European ELISA program that funds access to SL facilities and of which ALBA is currently a member, albeit a minor one because it has not yet reached the operational phase). Similarly, ALBA should promote itself in the private sector and some workshops/meetings should be organized under the auspices of ALBA's Liaison Office for Proprietary Research. Also, and probably very important, ALBA should host at least one Open Day a year for the general public and a visits program.

In summary, we propose that ALBA should host meetings/workshops not only with its main user base (i.e. the academic and the peer community), but also with the private sector and the public at large so that its added value and contribution to the fabric of society is made clear from the very beginning of its operations.

11. IN-HOUSE R&D AND DEVELOPMENT OF HUMAN RESOURCES

11.1 In-house research: Independent and collaborative

The mission of ALBA is to research in, deliver and maintain methods and techniques with which to conduct cutting edge synchrotron based research and development. In order to discharge this mission it is essential that in addition to providing excellent support to their user community – this is indeed an essential justification for the funding of the facility- ALBA's scientific staff must engage in, and lead, their own research programs. This research may be either independent or collaborative with outside groups.

It is important that some facility staff is involved with research that it is driven by the desire to understand a system - i.e. a more academic type of research - by using the experimental stations available at the facility. This could be done either independently or in collaboration with some external group or institution. However, in general a collaborative approach should be the preferred option for this type of research. In this way there is no need to duplicate infrastructures that might be necessary for the preparation of samples and their appropriate characterization that are already available in some external institutions. The funding for this type of research should be secured by competitively applying to the same funding agencies other researchers apply to. In this way the peer-review system will ensure that the research objectives are desirable and worthy of support. In addition to its scientific value this type of research is needed because it provides the motivation for the scientific staff at the facility to keep at the peak of their performance the instruments they are responsible for and that they need to use to ensure the success of their own research. Moreover, this approach generates important synergies between the external scientific community and CELLS' staff.

There is another type on in-house research that arguably is even more important for the long-term scientific competitiveness of the facility. This is the research that starts by identifying an important scientific question or program that can only be addressed by a sustained effort in the development of new methods, instrumentation or technologies. In fact, a cursory study of the history of Synchrotron Radiation shows that this kind of research has led to the development of most of today's techniques that are available to external users at existing SL facilities. This kind of research is normally - but not necessarily exclusively - carried out by independent in-house research. It is very unlikely that the visiting users will have either the technical expertise, or the infrastructure, or the know-how, or the time to develop instrumentation and techniques in response to emerging scientific challenges. In general this is the role of the scientific personnel in the facility and in order to discharge this responsibility it is essential that they have an R&D program of their own. We propose that - as it is practically the case everywhere else - this kind of research should be funded directly from the budget of the facility (see Chapter 12). To ensure that appropriate review of the programs and subsequent follow up is carried out, and considering that it is part of the facility development, it seems appropriate that before attributing resources to this kind of research, Management invites SAC to review these in-house proposals and takes the views of SAC into consideration before attributing resources to it.

Management should ensure that the balance between these two types of in-house research is right. Too much of the former and the facility becomes stagnant and, at best, can only progress by copying what it is being done elsewhere. Too much of the latter and essential resources needed to support the daily users' needs are diverted away. Once again, the expertise of SAC is needed to advise Management on this balance.

Finally, one should not forget that providing means to the scientific staff of ALBA to carry out cutting edge research is the most important step that must be taken in order to keep and attract internationally recognized scientific/technical staff.

11.2 Human resources for in-house research: Studentships and postdoctoral positions

Perhaps the most important element for an in-house research program is the availability of individuals able to devote most of their energies to this activity. It is obvious that a facility like ALBA can only avoid stagnation by having a viable in-house research program. That this is essential is adequately demonstrated by experience elsewhere that shows that whenever a facility has not succeeded in having a successful R&D program of its own the certain consequence has been stagnation, followed by irrelevance, and eventually by the disappearance from the scientific scene.

The staff scientists at ALBA must have the obligation to carry out research. However, they will have also many other duties that make it difficult to find the necessary time to develop their research programs without additional human resources. On the other hand, if they can count with junior colleagues to collaborate with and guide their research, i.e. Ph. D. students and postdoctoral appointees, not only will they have the possibility to be involved in viable/competitive research but also they will be able to transmit their know-how to another generation. The resources that we proposed to allocate to this aspect of the facility's function are detailed in section 12.6 below.

11.3 Development of contacts with universities and research institutions: Joint Appointments

ALBA is not an academic organization. In order to house PhD students it will be necessary that agreements with entitled University staff are established so that, for example, an academic accepts a Thesis project and therefore there is the possibility to offer the prospect of a degree to the candidates of the studentships. This is a standard procedure at all SL facilities and has the obvious advantage of establishing links with academic institutions and of fostering the development of future scientists. This approach should be applied not only to purely academic subjects, but also to more applied/technological disciplines by extending the links to technical and/or engineering departments. The input of "fresh blood" to industrial R&D is of obvious importance to any knowledge based economy.

In addition CELLS should explore with a number of educational institutions the possibility to have the so-called Joint Appointments. These are people who have part time educational or institutional duties with an educational institution but conduct their research and work exclusively at the facility. The obvious advantage to, for example, a University department is that they have a continuous presence at the facility and, therefore, a deeper familiarity with the potentials offered as well as the access to facilities with the same rights – and obligations – as all of CELLS staff. On the other hand this approach allows the facility to count on staff that can officially act as academic supervisors.

12 COSTS OF FACILITY OPERATIONS

12.1 General budgetary considerations

In order to understand the use of resources at a SL facility, it is convenient to separate the budget in 5 large concepts: Salaries and Overheads; Fixed Operational Expenses; Variable Operational Expenses; Operational Investments, and; In-house Research and Development. Table 12.1.1 illustrates the yearly ramp-up in each of these blocks as derived from the model of operations described above. The origin of these expenses is shown with considerably more detail in Tables 12.2.1, 12.3.1, 12.4.1, 12.5.1 and 12.6.1. The data in these tables has been calculated using 2008 costs and quantities of monies are given in k€ throughout.

The concept of Fixed Operational Expenses includes all costs needed to simply be ready to operate. The costs included in Fixed Operational Expenses and in Salaries and Overheads, that "the facto" is a fixed operational expense, can only be effectively reduced by permanently closing down either some part of the facility (e.g. a beam-line, although in this case the savings are proportionally very un-important) or the facility in its totality. The Variable Operational Expenses are those that to a first approximation are dependent on the number of scheduled operational hours/year.

YEAR	SALARIES & OVERHEADS	FIXED OPERATIONAL EXPENSES	VARIABLE OPERATIONAL EXPENSES	OPERATIONAL INVESTMENTS	IN-HOUSE R&D	GRAND TOTAL
2010	7377,58	3186,00	3097,11	720,00	300,00	14680,69
2011	7588,37	3186,00	3245,64	720,00	300,00	15040,01
2012	7641,07	3186,00	4950,78	1600,00	730,00	18107,84
2013	8062,64	3186,00	6602,60	2500,00	1110,00	21461,24
2014	8642,31	3186,00	7540,23	3000,00	1300,00	23668,54

Table 12.1.1
(all costs in k€)

Another type of variable expense to consider is what we call here Operational Investments that should not to be confused with New Investments (see Chapter 13), e.g. additional beam-lines or ID's. The purpose of this budget line is to keep the facility always abreast of time and replace obsolete equipment. Finally, there is the budget line entitled In-house Research and Development. This is another form of investment that is also a variable expense. In-house R&D usually includes a significant fraction of development in human resources, both in scientific and technical activities.

12.2 Personnel costs due to operations and maintenance of the facility.

The estimate of personnel costs during this 5 year period has been done using the 2008 average salary & overhead cost at ALBA (52,697 k€/person/year). It has been assumed that escalation from personnel numbers during construction (140 staff in 2010) to those required for consolidated operations in 2014 (164 staff, see Table 10.7.1) will follow the pattern described in Table 12.2.1. Note that in the proposed model, the Users Office and the Liaison Office for Proprietary Research start operations, as they must, in 2011 and they come into full strength in 2013 when 3 shifts/day operations start. The additional people needed for shift work increases proportionally to the increase in the number of unsociable work hours. Note also, that the transfer of personnel from installation/commissioning to operations is to be completed by the end of 2012. During 2012 there is only a residual component of ca. 10 work years of commissioning work left.

SALARY&OVERHEADS/PERSON (2008 COSTS)	2010	2011	2012	2013	2014
52,70					
0.- SALARIES&OVERHEADS	7377,58	7588,37	7641,07	8062,64	8642,31
OPERATIONAL HOURS/YEAR	720	1440	3200	5000	6000
SHIFTS/OPERATIONAL DAY	1,5	1,5	2,0	3	3
0.1.- TOTAL STAFF	140	144	145	153	164
MANAGEMENT/COORDINATION	9	9	9	9	9
0.1.1. - MANAGEMENT	6	6	6	6	6
0.1.2. - COORDINATION	3	3	3	3	3
OPERATIONS	61	88	126	144	155
0.1.3. - EXPS. OPERATIONS	6	10	20	30	36
0.1.4. - ACCS. OPERATIONS	4	4	15	15	17
0.1.5. - SAFETY	2	2	2	2	2
0.1.6. - ACC. PHYS.: /IDs/MAGNETS/RF/DIAGNOSTICS	14	14	14	14	14
0.1.7. - OPERATIONS IN INFRASTRUCTURE/MAINTENANCE/SUPPORT	22	40	50	50	49
0.1.8. - ADMIN (SECRETARIAL/RECEPTION/PERSONNEL/ACCOUNTANCY)	13	13	13	13	13
0.1.9. - OPERATORS FOR ELECTRICAL STATIONS&COGEN. PLANT	0	2	4	4	4
0.1.10. - USERS' OFFICE	0	2	2	3	3
0.1.11. - LIAISON OFFICE FOR PROPRIETORY RESEARCH	0	1	2	3	3
0.1.12. - INCREASE DUE TO SHIFT WORK	0	0	8	14	14
INSTALLATION/COMMISSIONING	70	47	10	0	0
0.1.11. - INSTALLATION	60	5	0	0	0
0.1.12. - COMMISSIONING	10	42	10	0	0

Table 12.2.1
(all costs in k€)

12.3 Fixed Operational Expenses

The Fixed Operational Expenses at 2008 costs are shown in Table 12.3.1. These cover the costs associated with all the Services & Supplies needed by an installation like ALBA, as well as the costs associated with Outreach, Promotions, Entertainment and T&S and Transversal Infrastructure & Activities. Table 12.3.1 details what is included in these fixed operational expenses. The costs in Table 12.3.1 have been arrived at by extrapolation of current experience at ALBA. The two largest items are those in the Software and Computing Services, i.e. the central service for in-house and visiting users alike, and the costs of keeping the facility clean. The concept of Security includes the manning of the lodge around the clock for 365 days/year. The main cost in Transversal Infrastructure & Activities is in Health & Safety (line 1.3.1) and it is to maintain/upgrade the radiological safety protection system, the personnel safety system and the personnel dosimeters.

1. - FIXED OPERATIONAL EXPENSES	**3186,00**
1.1.- SERVICES&SUPPLIES	**2841,00**
1.1.1.- Phone charges	**45,00**
1.1.2.- Courier, delivery, duty, brokerage, transport, advertising	**25,00**
1.1.3.- Consulting Services	**100,00**
1.1.4.- Insurance	**80,00**
1.1.5.- Cleaning	**786,00**
1.1.6.- Security	**350,00**
1.1.8.- Taxes, Licenses & professional fees	**100,00**
1.1.8.- Library, publications, electronic subscriptions	**18,00**
1.1.9.- Software and Computing services	**1000,00**
1.1.10.- Office supplies and printing services	**72,00**
1.1.11.- Travel and subsistence	**190,00**
1.1.12.- Translations	**25,00**
1.1.13.- Other (jurists, AUSE, vehicles, renting, fuel, work clothes…)	**50,00**
1.2.- OUTREACH, PROMOTIONS, ENTERTAINMENT AND T&S	**125,00**
1.2.1.- Business lunches and entertainment	**20,00**
1.2.2.- Conference, Meetings and Workshops	**40,00**
1.2.3.- Professional development (training courses…)	**40,00**
1.2.4.- Other (small office works, adaptation, unforeseen…)	**25,00**
1.3.- TRANSVERSAL INFRASTRUCTURE & ACTIVITIES	**220,00**
1.3.1.- Health & Safety	**70,00**
1.3.2.- Visitors & Advisors	**40,00**
1.3.3.- Project coordination	**10,00**
1.3.4.- Administrative Services: Personnel, Legal, Accountancy & Secretarial	**100,00**

Table 12.3.1
(all costs in k€)

12.4 Variable Operational Expenses

Variable Operational Expenses are those that, at least to a first approximation, depend on the number of operational hours delivered/year. The details of the concepts within this chapter are given in Table 12.4.1. These include all the necessary Laboratory supplies needed to operate the beam lines for users, Energy and Utilities, Users Operations and Maintenance and Spares. These costs are calculated on the basis of commercial prices.

As shown in Table 12.4.1 the largest Variable Operational Expense is the bill for energy and utilities (primarily electrical power and water, but also included is a smaller component of natural gas and diesel fuel) and the maintenance, spares and repairs for the various buildings, accelerators and beam-lines services and sub-systems. Note that even though there will be fewer operational hours in 2010 the water bill is significantly higher than in 2011. This is because for 2010 the water connection bill (a one off payment!) has been included in this budget line.

YEAR	2010	2011	2012	2013	2014
2. - VARIABLE OPERATIONAL EXPENSES	3097,11	3245,64	4950,78	6602,60	7540,23
2.1.- LAB SUPPLIES	106,81	213,62	474,72	741,75	890,10
2.1.1.- Cryogenic consumables	26,04	52,08	115,73	180,83	217,00
2.1.2.- Laboratory & operating supplies (gases: N2, He, O2)	10,20	20,40	45,33	70,83	85,00
2.1.3.- Consumables	57,37	114,74	254,99	398,42	478,10
2.1.4.- Other	13,20	26,40	58,67	91,67	110,00
2.2.- ENERGY AND UTILITIES	2230,30	1956,02	2803,06	3669,35	4150,63
2.2.1.- Energy	1211,53	1475,77	2121,67	2782,26	3149,25
2.2.2.- Water	1018,77	480,25	681,39	887,09	1001,38
2.3.- USERS OPERATIONS	50,00	291,00	647,00	891,50	1049,50
2.3.1.- Shift Work	30,00	53,00	103,00	254,00	307,00
2.3.2.- User costs (T&S)	0,00	168,00	434,00	507,50	612,50
2.3.4.- Evaluation committees	20,00	40,00	40,00	40,00	40,00
2.3.5.- User's Meeting	0,00	20,00	40,00	40,00	40,00
2.3.5.- Liaison Office for Proprietary Research	0,00	10,00	30,00	50,00	50,00
2.4- MAINTENANCE AND SPARES	710,00	785,00	1026,00	1300,00	1450,00
2.4.1.- Maintenance	550,00	550,00	550,00	550,00	550,00
2.4.2.- Spare parts	75,00	150,00	300,00	475,00	570,00
2.4.3.- Repairs	70,00	70,00	144,00	225,00	270,00
2.4.4.- Other	15,00	15,00	32,00	50,00	60,00

Table 12.4.1
(all costs in k€)

The work during unsociable hours results in a salary supplement to pay for shift work. This is because in order to deliver 6000 hours of beam time/year, some of the staff at ALBA will have to work a significant amount of unsociable hours (one should recall here that the "normal" working hours/year is ca. 1760 or 220 working days of 8 hours). Therefore, in addition to salaries and overheads cost, ALBA will incur additional staff cost in the shape of compensation for unsociable hours due to shift work (that should not be confused with overtime work that may be necessary for other activities). In fact, and in so far as it is possible, no overtime work should be used in the operations of ALBA as the use of overtime should be kept for emergencies or for unexpected situations.

The Spanish legislation establishes the period of unsociable hours to run from 22:00 to 06:00 hours and any hours worked during the days of leisure. In the case of ALBA there will be some staff that will have to operate during hours that are "doubly unsociable", i.e. those between 22:00 to 06:00 during days of leisure. Eventually, the exact cost will be a matter of negotiations between the staff association and ALBA's management, but to illustrate how this additional cost may have to be budgeted for we show in Table 12.4.1, line 2.3.1, how the costs of unsociable hours escalate up to 307,0 k€/year during consolidated routine operation. These have been derived from assuming a 30% increase in the cost per unsociable hour or per hour of work during leisure days over normal hourly costs, and a 60% increase for unsociable hours during leisure days for the 10 people whose presence is required (i.e. 4 people in the accelerator crew, the power plant operator and 5 floor managers), plus the retainers for the experts (i.e. beam line scientists and technicians) that have to be on call. It is assumed that on average each expert will have to come in once a week to work during an unsociable shift. The important point here is that the costs associated with running shifts are < 6% the total salary bill for the facility, but shift work results in having a beam time output that is 3 times what could be achieved without shift work. In fact, this is one of the major reasons why the majority of SL facilities operate around the clock during schedule beam time periods.

Regarding the costs associated with the operation of the User's Office, we propose that as commonly done everywhere the travel and subsistence costs will be covered centrally for practical and economical reasons, i.e. ALBA's User Office will manage the travel and subsistence of users. The costs associated with this will depend very much on how many users/year one expects to house, how many users/experiment will be supported and what is the duration/experiment expected. Obviously, all of these depend on how many user hours/year ALBA will operate and on how many beam lines will be available to users. Assuming that: i) the ramp-up in user operations is as proposed in Chapter 10; ii) that 7 beam-lines will be operational for users, and; iii) that at the beginning the number of days/experimental session on average will be 10 in 2011 and will progressively decrease to 5 in 2014 (as expected when the number of shifts/day progressively increases and the efficiency of the facility matures). We also assume that: i) travel will cost on average 250 €/experimental session/person (we propose to cap this cost to a maximum of 400 €/experimental session/person); ii) that a subsistence allowance of 75 €/person/day will be paid (of these 60 € will correspond to accommodation and subsistence and 15 € to incidental expenses) and; iii) on average the costs of 4 users/experiment will be covered (this to be capped to a maximum of 5 users for experiments requiring a lot of manpower). With these assumptions the User Costs grow in time as the number of users resulting from the increase in the number of user hours delivered increases. This is shown in line 2.3.2 of Table 12.4.1.

Note that the costs associated with ALBA's Liaison Office for Proprietary Research (line 2.3.5 in Table 12.4.1) are included under Users Operations. In the long term this concept should not appear as a cost but, hopefully, as an income. The costs under this concept are those derived from the production of literature and glossy annual reports, business PR, out-reach, promotions, entertainment, etc. within the remit of the Liaison Office for Proprietary Research.

12.5 Operational Investments

Operational Investments includes the costs to: upgrade existing facilities with better, more advance, technology so that the equipment remains competitive (e.g. detectors, optics, IDs, etc.); replace ageing/obsolete components (e.g. vacuum pumps, electronic modules, X-ray mirrors, etc…). The estimates here (see Table 12.5.1) are made by assuming that over a period of 10 years all beam-line components will be obsolete and, therefore, 1/10 of the capital costs for the beam-lines should be spent per year. This very simple rule has been shown elsewhere to be of practical value. These Operational Investments exclude the amortization of the complex of accelerators as with a reasonable maintenance budget (see 2.4 in Table 12.4.1) the complex of accelerators can be kept going indefinitely until new technologies render the accelerators obsolete. In retrospect, this has happened every 25-30 years. The ramp up from 2011 to 2014 is calculated proportionally to the number of operational hours/year.

YEAR	2010	2011	2012	2013	2014
3- OPERATIONAL INVESTMENTS	720,00	720,00	1600,00	2500,00	3000,00
3.1.1.- Facility Development	240,00	240,00	533,33	833,33	1000,00
3.1.2.- Equipment improvement/replacement	480,00	480,00	1066,67	1666,67	2000,00

Table 12.5.1
(all costs in k€)

12.6 In-house R&D and development of human resources

In section 11.1 the importance of an in-house research program has been addressed. We recall here that an internationally competitive in-house research program is, arguably, the most important investment with which to guarantee the future competitiveness, both for the Facility and for its user community alike. Therefore, ALBA, like any other such facility, must ensure its future by having a powerful in-house R&D program, both in system driven and in methodology/instrumentation development driven research.

Also, and as argued in 11.2, the in-house R&D budget line must also include resources for the fostering and development of “new blood”. This is achieved by having a number of young scientist and technologists (PhD students and Post-doctoral fellows) that are incorporated into the in-house R&D. Whilst the more senior researchers at ALBA will have other duties (e.g. management and administration of their areas of responsibility, user support, etc.), the only function of these positions should be to strive for scientific and technical excellence in their chosen field of SL applications. These people will in due course find employment in, and therefore feed their skills into, academia, the private sector or the facility itself.

Table 12.6.1 gives an estimate of the pump priming resources we propose to devote to the in-house R&D program in instrumentation/facility development. In the steady state, these correspond to < 3,5 % of the total operating costs. Naturally, the in-house scientists are expected to supplement these resources with others from existing funding agencies to which they will competitively apply in order to have a viable system driven research program.

YEAR	2010	2011	2012	2013	2014
4- IN-HOUSE RESEARCH & DEVELOPMENT	300,00	300,00	730,00	1110,00	1300,00
4.1.1.- In-house R&D(Capital)	150,00	150,00	430,00	660,00	800,00
4.1.2.- In-house R&D (PhD Students + Post-Docs)	150,00	150,00	300,00	450,00	500,00

Table 12.6.1
(all costs in k€)

12.7 The consequences of capping the operational budget

Having considered the origin of the various sums - given in Table 12.1.1 – that would make up the operational budget in a steady state situation, i.e. that in 2014, it is interesting to look into the consequences of capping this budget. In other words what can be delivered from a budget capped at a given value? Clearly, how much operations can be stretched will depend on the capping of the overall budget. For the purpose of illustration an estimate of the overall running costs versus the total number of operational hours/year is given in Fig. 12.1.1. The reason for the sharp increase in going from 0 to a small number of operating hours is due to the fact that even in the variable expenses there is a minimal amount of start up resources that are needed just to switch on, e.g. gases, consumables, energy, water, etc. One can see, for example, that on the basis of running a number of hours equivalent to the number of working hours/year, i.e. 1760 hours in the case of CELLS, one would require an overall budget of ca. 15,6 M€/year.

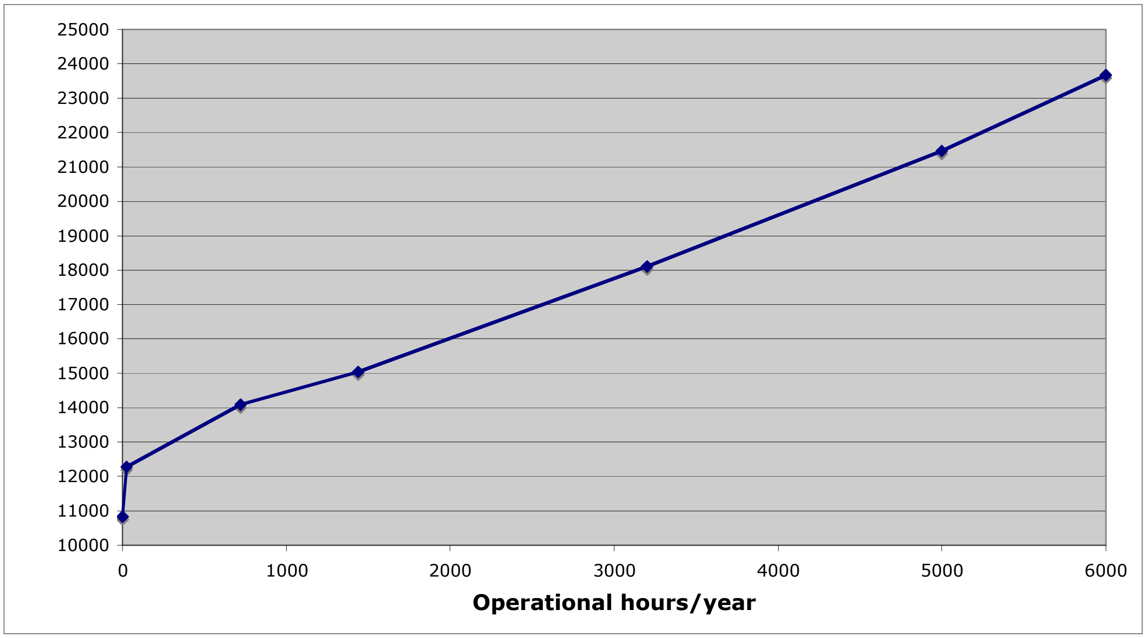

Fig.12.7.1

It is clear from Fig. 12.7.1 that more than half of the total costs of the facility are needed in order to be ready to run. Consequently, from the point of view of value for money - which in this case means costs effectiveness in scientific and, possibly, industrial returns - it is sensible to operate the maximum possible number of hours/year.

13. NEW INVESTMENTS, I.E. NEW BEAM-LINES AND EXPERIMENTAL STATIONS

13.1 Time line for construction of new beam-lines and experimental stations.

This strategic plan covers from years 2010 and 2014, both inclusive. However, in order to reach some sensible conclusion regarding investment on new beam-lines and associated experimental stations it is necessary to consider the whole lifetime of the facility.

Taking for granted that an adequate program of maintenance and refurbishment of the complex of accelerators will occur it can be safely assumed that the competitive lifetime of ALBA as a light source will be ca. 25 years from the moment of opening it to user operations, i.e. 2011. It should be noted that 25 years is an average lifetime that has been achieved by second-generation SL facilities, e.g. the British SRS, the NSLS in Brookhaven, etc., and by the early third generation ones (e.g. the ESRF has just celebrated its 20th anniversary. So, we assume that ALBA will operate until at least the year 2035.

It should be noted also that a minimum period of 5-6 years of exploitation is necessary to justify the investment on new beam-lines, as a shorter period does not permit to gather enough scientific returns. The implication of the above considerations is that during the period of time covering the years 2011-2030 all the possible 27 new beam-lines that ALBA can accommodate should be built, commissioned and brought into operation. Naturally, and if at all possible, this span of time should be shortened to give a longer period of exploitation and, therefore, more returns.

Another consideration to be brought into defining a time line for the construction of new beam-lines for ALBA is the knowledge that if adequate human and capital resources are available then the average time needed to bring a beam-line from conception to operation is ca. 4 years. So, in order to have all beam-lines on the floor operating by the year 2030 it means that the construction of the last batch of beam-lines at ALBA should not start later than 2026. As there are another 27 potential beam-lines at ALBA, it follows that on average there should be 3 more beam-lines and associated experimental stations approved every 2 years starting from 2010. This means that the first set of 3 beam-lines approved in 2010 should come into user operation in 2014, whilst another three approved in 2012 will still be under construction by the end of the time span of this strategic plan.

Fig. 13.1.1 shows how the number of approved new beam-lines increases with time - blue line - and when these new beam-lines come into user operation –pink line. Note that with this model it is still possible to have 6 years of exploitation for the last 3 beam-lines before ALBA is phased out after 25 years of service. Naturally, it is impossible to predict whether a revolutionary technical development like the one that has occurred with undulators and has been the main reason for pensioning off the second generation SL sources – that with adequate maintenance could have been made to last for ever - will occur or not and, consequently, it is imaginable that in practice the life span of ALBA may be longer or shorter than 25 years.

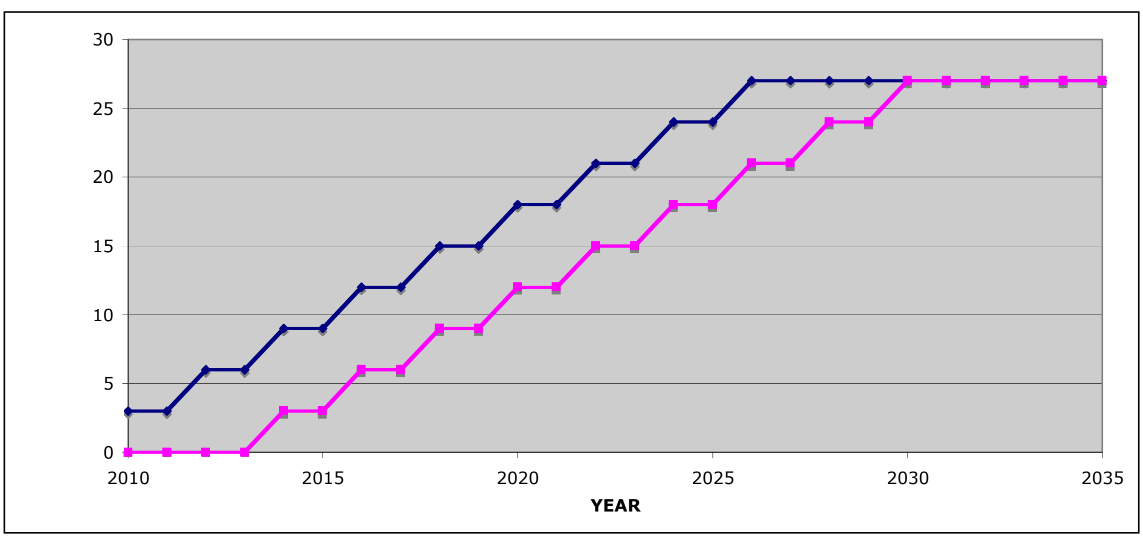

Fig. 13.1.1

13.2 Human resources requirements

The human resources needed to implement the model shown in Fig. 13.1.1 can be estimated on the basis that 5 more work-years/year of effort are needed when each new beam line is brought into operations, i.e. 3 beam-line scientists plus 2 work years of engineering/electronics/computing technical support. In addition, for every new 15 people, it is necessary to increase the administrative support by 1 work-year/year of effort. On this basis it is straightforward to work out that a yearly average of 6.85 work-years/year of additional effort should be brought into the personnel of ALBA as from the year 2010 and up to the year 2030. The consequence of this is that by the year 2030 ALBA should have another ca. 144 staff in post if an additional portfolio of 27 new beam-lines has to be operated for users.

How the additional staff numbers needed for the construction and subsequent operation of the full portfolio of possible beam-lines at ALBA should increase during the lifetime of the facility is shown in Fig. 13.2.1. It is instructive to note that this new staff added to those needed for the operation of the facility with the initial 7 beam-lines (see Chapter 10 and 12) makes a total of 308 staff. This number is very similar to the total personnel number in new facilities like Soleil and Diamond that because of their much more mature and numerous user community have to fill up to a full complement of new beam-lines as early as possible. In some respects it is a strength of ALBA that because the Spanish user community is not as large as that of countries like France or Great Britain - i.e. Spain has no previous history, therefore no ballast to carry, in national SL facilities - it is possible to reserve potential new beam-lines to take on emerging scientific challenges.

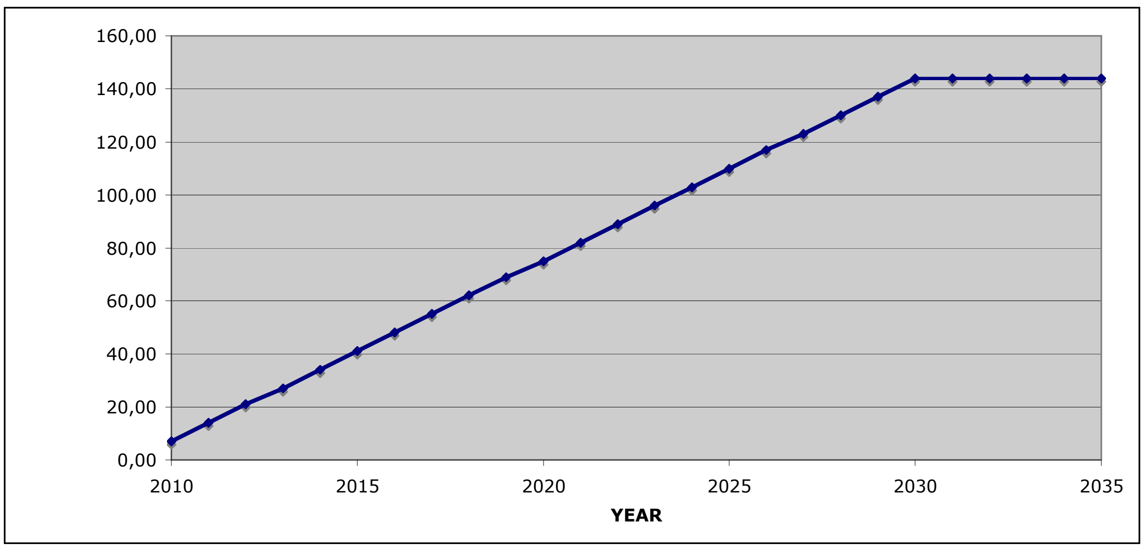

Fig. 13.2.1

Table 13.2.1 shows the additional staff that should take post during the time span comprised between years 2010 and 2014 in order to reach, in a linear manner, full beam line capacity by the year 2030 – i.e. as per model shown in Fig. 13.1.1. Note that during this period the construction of 3 new beam-lines starts in 2010 and will come into user operation by 2014, the construction of 3 more beam-lines would start in 2012 and the next 3 would be due to start in 2014. The Table also shows how many additional beam-lines will be under construction and/or operation during this time span. Note that as from the year 2012 and at any one time during the next 20 years CELLS will have to be in the process of building 6 new beam-lines in which 3 of them are staggered by being 2 years ahead in their construction. Note also that as from the year 2014 CELLS would be putting 3 more beam lines into user operations every 2 years (see Fig. 13.1.1).

YEAR	NEW STAFF IN POST	NEW BEAM-LINES UNDER CONSTRUCTION	NEW BEAM-LINES IN OPERATION
2010	7	3	0
2011	14 (7+7)	3	0
2012	21 (14+7)	6 (3+3)	0
2013	27 (21+6)	6 (3+3)	0
2014	34 (27+7)	6 (3+3)	3

Table 13.2.1

13.3 Methodology for the selection of new beam-lines.

Regardless of where the initiative for proposing the construction of a new beam-line at one of the SL sources of ALBA – i.e. ID or bending magnet – originates, it is proposed here that the procedure that has emerged from extensive interactions between CELLS' management, CELLS' SAC and CELLS' Executive Commission will systematically apply. The proposed procedure is very similar to that used to define the 7 initial beam-lines currently being built at ALBA and it is very similar to that generally used at SL facilities elsewhere. It should be emphasized that it has been shown in practice to have a high probability of delivering objective/impartial results, transparency and scientifically correct outcome.

The proposed procedure should incorporate the following:

- CELLS will publicize an announcement calling for the preparation of scientific/technical proposals for new beam-lines.

- The announcements take place at intervals of 2 years to fit in with the time-table shown in Fig. 13.1.1. In other words, the next announcement of calls for new beam-lines should be in 2010 and thereafter after an interval of every two years.

- The procedure is published so that maximum reach of the potential scientific community is achieved. It is important that complete transparency is achieved.

- A time period of one year is given for the preparation of the scientific/technical proposals. CELLS will assist, if so required, with technical issues.

- CELLS staff may also lead the case for a new beam-line.

- Technical proposals should include an estimate of costs

- There will be scientific/technical meetings to define/refine proposals

- Each proposal will have a spokesperson(s) that will coordinate the community

- The proposals will be channelled through AUSE

- The spokesperson(s) will submit proposals to CELLS' SAC who will begin evaluation of submitted proposals

- SAC will call upon external expertise whenever necessary

- SAC will rank proposals with consideration to the following criteria:

  a) Scientific excellence
  b) Technical feasibility
  c) Actual and potential size of the user community
  d) Strategic importance, uniqueness, etc.
  e) Complementary to/duplication of already existing beam-lines
  f) Volume of access by right to equivalent facilities elsewhere (i.e. the ESRF)

- CELLS will elaborate a final cost estimate of the proposals. CELLS Management will present SAC's ranking and its own views to Council so that it gives its approval or otherwise.

- CELLS will initiate selection procedure of personnel needed to implement the new beam-lines

- CELLS will proceed thereafter with detailed design, construction and commissioning.

13.4 Possibility of new beam-lines from foreign/external resources

It is a fact that ALBA is the only national SL source sited within the southwest of a line joining Paris with Triestre. It is also a fact that Spain has strong cultural connections with Latin America and that there are expanding economies in Northern Africa with a significant pool of people that wish to avail themselves with access to SL facilities (e.g. Morocco). The potential of Portugal as a partner in the exploitation of ALBA cannot be dismissed. Finally, there is the possibility of beam-lines and/or Science programs being funded through European consortia via EU funding. The combination of these factors means that there is a possibility to attract resources from external/foreign agencies by offering them the option to install their beam-lines on ALBA. CELLS, with the help of the Administrations that own it, should be pro-active in this front. There are nonetheless several criteria that should be respected:

- Any beam-line built by/for a foreign/external organization must fulfil the criteria of excellence, opportunity, strategic importance, etc. Therefore, any initiative should be scrutinised and supported by SAC.
- The people designing, constructing, installing, commissioning and exploiting this kind of beam-line must do so whilst respecting the standards and the discipline of CELLS. From this point of view they should have the same obligations - and rights – as CELLS' employees.
- In compensation for the fact that the foreign/external organization has not contributed to the initial capital investment of ALBA, putting a fraction of the total beam-time at the disposal of ALBA's users should make a payment in-kind. This fraction could be negotiable but it should be comparable to that applied elsewhere (e.g. 1/3 of the total beam time is the criteria applied at the ESRF for this kind of beam-line).

14. COST ESTIMATES FOR NEW INVESTMENTS

14.1 Estimate of the total capital investment and operational costs needed to bring the full complement of beam-lines into operation by the year 2030.

Here and below cost at 2008 prices will be used throughout. The average price of a new beam-line and associated experimental stations is between 4.5 and 5.5 M€ depending on whether the beam-line takes beam from a very sophisticated ID and/or uses a very complex instrumentation or whether it is a relatively straightforward stations and takes beam from a bending magnet. Roughly half of the remaining beam-lines at ALBA could take light from an ID, whilst the rest would be using bending magnets. Therefore, we assume that the average capital cost of each new beam-line will be 5.0 M€. In order to operate a beam line in a 3 shift scenario as proposed (see Table 10.2.1) each new beam line should have 5 full time people dedicated to it (i.e. 3 station scientists plus 2 work-years/year of technical support). In addition, for every new ca. 15 people it is important to have an additional person in administrative support. Also, once a beam-line moves into operation the required additional variable operational expenses, R&D resources and operational investments (see sections 12.4, 12.5 and 12.6 as well as Tables 12.4.1, 12.5.1 and 12.6.1) must be incorporated into ALBA's running budget.

On the basis of the above considerations the total capital costs for the remaining possible new beam-lines at ALBA amounts to 5.0 M€ * 27 beam-lines = 135 M€ in total. To have all of these beam-lines operating by the year 2030, it will be necessary to commit 6.750 M€/year over 20 years - i.e. from 2010 until 2029, both inclusive. It follows from the model proposed in Chapter 13 that as from 2014 every two years ALBA would bring into operations 3 more beam-lines.

With the criterion used in section 12.5 that 1/10 of the capital costs for the beam-lines should be spent per year in order to keep them competitive, it follows that an additional 1.5 M€/year should be found to cover the Operational Investments for each batch of 3 new beam-lines that are brought into operation. In addition, 0.557 M€/year will be needed as additional R&D resources as well as 0.850 M€/year of additional variable operational costs. These last two figures are calculated assuming that the required R&D resources and variable operational costs scale linearly with the number of beam lines once the costs attributable to the complex of accelerators are subtracted. It is assumed throughout that ALBA will operate 6000 hours/year.

On the basis of the above numbers it can be deduced that if CELLS succeeds to implement the growth plan described above that, incidentally, parallels what historically has happened with 2nd generation light sources - e.g. the British SRS or the American NSLS, that have by now come to the end of their useful lifetime - then, by the year 2030, the operation, maintenance and development of ALBA's complex of accelerators as well as the possible 34 beam-lines and associated experimental stations will require 308 work-years/year of effort and a total budget, including salaries and overheads, of ca. 57.5 M€/year of which 16.5 M€/year will be salaries and overheads costs and the rest – i.e. 42 M€/year – will be operational, maintenance and development expenses.

Naturally the above scenario will only materialise if there is significant growth in quality and quantity among the SL practitioners in Spain and the Management and Owners of ALBA are up to the formidable task to make the scientific base of SL users comparable to that existing in other more scientifically mature societies that have had their own national SL facilities for many years now (e.g. Great Britain, France, Germany, USA, Japan, Russia, etc.).

14.2 New capital investment and additional operational costs for the time span between year 2010 and 2014

Neglecting for now the enormous challenge associated with setting up the management structures and budgetary commitment required to achieve a full and efficient exploitation of a SL source with the competitive edge that ALBA has, and restricting the objectives within the time horizon going from year 2010 to 2014, it follows that in order to keep on track a development program as outlined above, the required investments in new beam-lines and experimental stations is that shown in Table 14.2.1. We propose that the objectives of CELLS regarding new investments during the period 2010-2014 should be those commensurate with the budget shown in Table 14.2.1 and carried out as detailed above.

YEAR	2010	2011	2012	2013	2014	TOTAL
ADDITIONAL CAPITAL INVESTMENT	6750,00	6750,00	6750,00	6750,00	6750,00	33750,00
ADDITIONAL NUMBER OF STAFF REQUIRED	7	14	21	27	34	
ADDITIONAL SALARIES&OVERHEADS	368,88	737,76	1106,64	1422,82	1791,70	5427,79
ADDITIONAL VARIABLE OPERATIONAL EXPENSES	0,00	0,00	0,00	0,00	850,19	850,19
ADDITIONAL OPERATIONAL INVESTMENTS	0,00	0,00	0,00	0,00	1500,00	1500,00
ADDITIONAL R&D RESOURCES	0,00	0,00	0,00	0,00	557,00	557,00
TOTAL	7118,88	7487,76	7856,64	8172,82	11448,89	42084,98

(ALL AT 2008 COSTS in k€)

Table 14.2.1.

15. CONTRIBUTION TO INTERNATIONAL PROJECTS: THE EUROPEAN X-RAY FREE ELECTRON LASER FACILITY

15.1 Background

Given its strategic value – see Chapter 5- CELLS has presented its candidature to the EXFEL management to produce, measure and install one of the SASE undulators (known as SASE3), made of 21 segments of undulators of 5 meters each. This proposal has already been accepted by the "in-kind" Review Committee of the EXFEL and by the EXFEL management. In parallel, CELLS has presented this candidature to the Spanish Ministry of Science and Innovation soliciting the resources needed by CELLS in order to deliver the SASE3 undulator segments to the EXFEL project and, in this way, CELLS de facto becomes the Ministry's agent for providing part of its "in kind" contribution to the EXFEL project. Even though no formal contractual arrangement have been signed so far (i.e. between the Spanish Ministry of Science and Innovation, the EXFEL and CELLS) all seems to indicate that this will be a major activity for CELLS in the next few years.

15.2 Tasks and timetable

The agreement reached between EXFEL management and CELLS contemplates the following scenario: CELLS will manage the contracts and follow up production of 21 undulators for SASE3. Undulator parts will be delivered at the EXFEL facility in Hamburg where CELLS staff will carry out their assembly and alignment as well as the subsequent magnetic measurements and undulator tuning. EXFEL personnel will install the undulators in the EXFEL tunnel. There is a preliminary phase (already started) in which a prototype will be designed, constructed and tested by DESY staff. CELLS will participate in order to secure the required familiarity with this type of undulators.

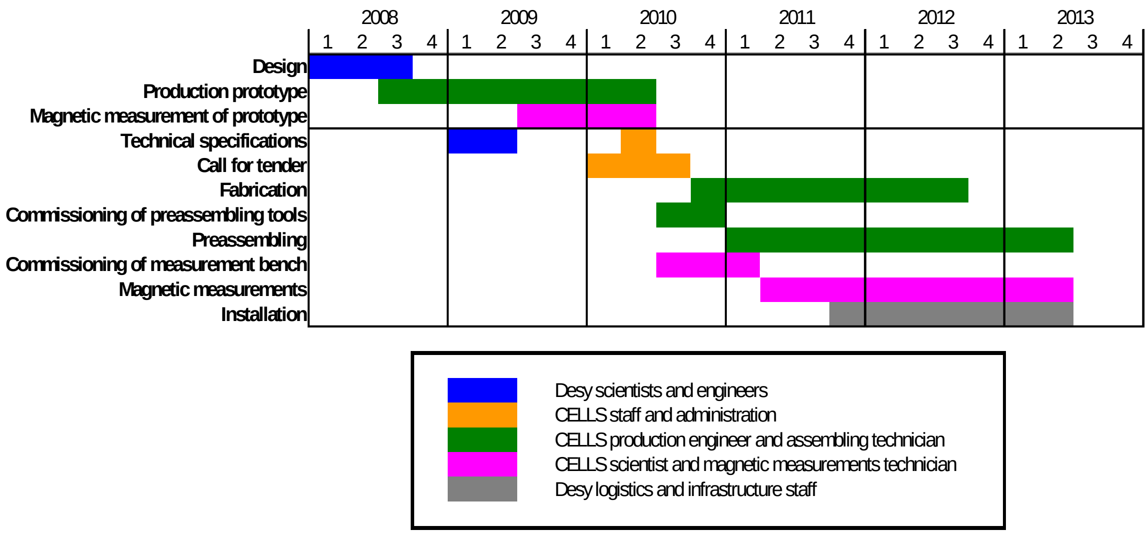

Fig. 15.2.1

Fig. 15.2.1 shows the agreed timetable for this project. Note from this timetable that the major tasks of the series production falls within the period of time pertinent to this strategic plan.

15.3 HUMAN RESOURCES; CAPITAL RESOURCES, AND; SPEND PROFILE

Table 15.3.1 shows the human resources needed to carry out the required tasks. A total of 15.5 work years (or full time equivalent years) will be needed. The average level of skill needed for this project is very high. This together with the fact that these staff will have to be provided with a foreign allowance to cover their costs whilst resident in Hamburg results in an estimate of ca. 1.24 M€ for the total manpower costs associated with this project (i.e. salaries, foreign allowance and overheads). Regarding capital costs required to deliver the agreed package, CELLS has asked for costs estimates from possible suppliers with the results shown in Table 15.3.2. Table 15.3.3 shows how expenditure will spread over the coming years.

N.	POSITION	TASKS	FTE
1	Scientist (100%)	Participation in magnetic measurements of the prototype(s)	1
1	Production engineer (100%)	Follow up of the fabrication of the prototype(s), training on its assembly and acceptance tests. Participation in preparing the technical specifications	2
1	Administration (66%)	Call for tender process	0.5
1	Scientist (100%)	Lead the assembly and tuning. Magnetic measurements	3
1	Production engineer (100%)	Follow up of the fabrication of the devices, assembly and acceptance tests.	3
1	Technician (100%)	Assembling of the frames with the magnet segments	3
1	Technician (100%)	Tuning the devices.	3

Table 15.3.1

CONCEPTS	COST (M€) (with VAT)	COSTS (M€) (without VAT)
Undulators SASE3 (21 segments at 465 k€ each. Cost calculated with 2008 prices corrected with a yearly inflation of 3%)	12.472	10.752
Staff	1.240	1.240
Magnetic measurements facility	1.160	1.000
Miscellaneous (accommodation, tools, travels, etc < 10%)	1.160	1.000
TOTAL	**16.032**	**13.992**

Table 15.3.2

CONCEPT	2008	2009	2010	2011	2012	2013	TOTAL
Undulator SASE3 (21 in total)			1.499	6.189	4.784		12.472
Staff	0.023	0.147	0.202	0.307	0.316	0.245	1.240
Facilities for magnetic measurements		1.160					1.160
Miscellaneous (acc., tools, etc)	0.021	0.138	0.189	0.288	0.296	0.228	1.160
TOTAL (with VAT)	**0.044**	**1.455**	**1.890**	**6.784**	**5.396**	**0.473**	**16.032**

Table 15.3.3

16 MEASUREMENTS OF EFFICIENCY

1.61 Criteria for evaluating the performance and results of the installation: Performance Indicators

The performance indicators that we propose to use are the following:

a) Total number of delivered shifts/year versus the number of scheduled ones.
b) Number of delivered user shifts/year versus the number of scheduled ones
c) Hours of user beam, i.e. the sum of delivered station hours to users
d) Accelerators' efficiency, i.e. hours delivered versus hours scheduled
e) Number of accelerator failures and reasons
f) Mean failure duration for accelerators
g) Mean time between failures for accelerators
h) Efficiency per station, i.e. hours delivered versus hours scheduled
i) Number of failures per station and reasons
j) Mean failure duration per station
k) Mean time between failures per station
l) Number of user groups/year
m) Number of user visitors/year, i.e. mean size of user group
n) Station shifts requested versus station shifts allocated (per station)
o) Publications/station/year
p) Ph D degrees awarded from work carried out at the facility
q) Number of foreign visiting scientists/per year
r) Station shifts for proprietary work
s) Patents and industrial outcomes

16.2 Registry of Actions of the facility

The facility will keep a registry of the above defined performance indicators for every beam time allocation period, i.e. on a six monthly basis. Experience elsewhere has shown that information on the publication record of users resulting from work carried out at the facility is hard to come by. This information will be required as part of the six monthly round of proposals for beam time.

16.3 Planning for evaluations

We propose that the Council of ALBA should set up a regular review of the facility and commit to the outcome of the review. This should occur once every four years and the outcome of the review should form the basis for defining/reviewing the financial Forward Look. The review body should include knowledgeable, internationally recognised, experts on SL production and applications. Management plans to propose this strategy to the Council of CELLS.

17. SUMMARY OF ACTIVITIES AND RESOURCE REQUIREMENTS

The principal activities during the period 2010-2014 will be to:

iv) Finalize the commissioning of the facility and move over to routine operations for the existing program, i.e. the complex of accelerators and 7 beam-lines.
v) Ramp up the number of operating hours/year until the maximum of 6000 hours is reached by 2014.
vi) Initiate a new beam-lines program with the construction at a rhythm of three beam-lines every two years, with a construction/commissioning time of four years per beam-line, so that by the year 2030 the facility is operating at full capacity.
vii) Deliver the SASE-3 undulators to the European X-ray Free Electron Laser.

The summary of total capital and human resources required to carry out the full program of activities addressed in this Strategic Plan is shown in Table 17.1

YEAR	2010	2011	2012	2013	2014
EXISTING PROGRAM					
STAFF FOR OPERATIONS OF EXISTING PROGRAM (SEE CHAPTER 10)	140	144	145	153	164
SALARIES&OVERHEADS FOR OPERATIONS OF EXISTING PROGRAM	7377,58	7588,37	7641,07	8062,64	8642,31
OPERATIONAL EXPENSES FOR EXISTING PROGRAM	7303,11	7451,64	10466,78	13398,60	15026,23
TOTAL EXISTING PROGRAM	14680,69	15040,01	18107,84	21461,24	23668,54
NEW BEAM-LINES PROGRAM					
STAFF FOR NEW BEAM-LINES PROGRAM (SEE CHAPTER 13)	7	14	21	27	34
SALARIES&OVERHEADS FOR NEW BEAM-LINES PROGRAM	368,88	737,76	1106,64	1422,82	1791,70
CAPITAL&OPERATIONAL EXPENSES FOR NEW BEAM-LINES PROGRAM	6750,00	6750,00	6750,00	6750,00	9657,19
TOTAL NEW PROGRAM	7118,88	7487,76	7856,64	8172,82	11448,89
CONTRIBUTION TO THE EXFEL PROGRAM					
STAFF COST OF EXFEL PROGRAM (SEE CHAPTER 13)	202,00	307,00	316,00	245,00	0,00
CAPITAL EXPENSES OF EXFEL PROGRAM	1688,00	6477,00	5080,00	228,00	0,00
TOTAL EXFEL PROGRAM	1890,00	6784,00	5396,00	473,00	0,00
FULL PROGRAM					
TOTAL STAFF FOR THE FULL PROGRAM	147	158	166	180	198
SALARIES AND OVERHEADS FULL PROGRAM	7948,46	8633,13	9063,70	9730,46	10434,01
CAPITAL&OPERATIONAL EXPENSES FOR FULL PROGRAM	15741,11	20678,64	22296,78	20376,60	24683,42
GRAND TOTAL FOR FULL PROGRAM	23689,57	29311,77	31360,48	30107,06	35117,42

Table 17.1