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The pathways from experiments to innovation impacts: evidence from ALBA Synchrotron Light Facility

RI PATHS
Research Infrastructure
imPact Assessment paTHwayS

Deliverables leader:	**ALBA-CSIL**
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Abstract: This deliverable is part of a project that has received funding from the European Union's Horizon 2020 under the grant agreement No. 777563. Specifically, it summarises the outcomes of a pilot exercise addressed to describe and trace the innovation impacts arising from experiments carried out at the ALBA Synchrotron Light facility as well as the pathways according to which these impacts materialise.

EFIS european future innovation system centre
Csil CENTRE FOR INDUSTRIAL STUDIES
EUROPEAN SCIENCE FOUNDATION
Fraunhofer ISI
EMBL
CERN
ALBA
DESY

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List of Figures

List of Tables

List of acronyms/abbreviations used in this document

Abbreviation	Meaning
CELLS	Consortium for the Construction, Equipping and Exploitation of the Synchrotron Light Source
CSIL	Centre for Industrial Studies
DOI	Digital object identifier
IA	Impact Assessment
ICTS	Infraestructura Cientifico Tecnica Singular
LEAPS	League of European Accelerator Based-Photon Sources
KPI	Key performance indicators
OPI	Organismo publico de investigacion (public research institution)
RI	Research Infrastructure
RIPATHS	Charting Impact Pathways of Investment in Research Infrastructures
WP5	Work Package 5

1 Introduction

This deliverable has been produced in the frame of the research project '*Charting Impact Pathways of Investment in Research Infrastructures*' (hereafter RIPATHS) co-financed by the European Union's Horizon 2020 research and innovation programme under the grant agreement No 777563 and addressed to develop a framework describing the socio-economic impact of Research Infrastructures (RIs) impacts[1].

Specifically, it **summarises the outcomes of a pilot exercise** carried out by the Centre for Industrial Studies (hereafter CSIL) and ALBA synchrotron light source (hereafter ALBA), the single-sited research infrastructure located in Cerdanyola del Vallès (Barcelona). The objective of ALBA-CSIL pilot exercise was to explore the operationalisation of the Impact Assessment (IA) framework arising from the RIPATHS' activities and specifically to **trace and describe the pathways according to which innovation impacts materialise starting from experiments carried out at ALBA by its users.**

Eight experimental beamlines are available at ALBA synchrotron which allow for investigations in different scientific fields (e.g. chemistry, pharmaceutical, automotive, aerospace, health, etc.). Every year hundreds of experiments are carried out by the scientific community – including academics and researchers - as well as (although for a minor share) by private companies. Results from these experiments often may translate in different outcomes, often into publications which are routinely tracked by ALBA as part of their Key Performance Indicators (KPI) monitoring system. However, little is known about the potential further application of this knowledge outcome in different sectors, in particular in terms of innovation developments (e.g. patents, new technologies, new products, etc.) both directly and indirectly to the industrial community. The aim of this pilot exercise is to shed some light on the duration and nature of the pathway leading from knowledge creation to knowledge exploitation for innovation.

ALBA-CSIL pilot exercise built explicitly on the evidence collected through two online surveys - targeting both direct and indirect users of ALBA experiments - as well as an **analysis of patents' citations** – addressed to trace the contribution of ALBA publications to the development of innovation outputs. This methodological approach was developed building on the evaluation strategy proposed by Florio (2019)[2] for assessing the innovation impacts generated by ALBA.

Results are presented in this report, which is structured as follows: Chapter 2 briefly describes ALBA research activities and provides statistics on the use of the different beamlines; Chapter 3 explains the methodological approach adopted for the performance of this exercise as well as the main challenges faced and solutions adopted; Chapter 4 presents the survey results while Chapter 5 concludes and provides lessons learnt as well as recommendations for monitoring these impacts in the future.

[1] Further details on this research project can be found at: https://ri-paths.eu/

[2] For more details see Chapter 7 of Florio, M. (2019). Investing in Science: Social Cost-Benefit Analysis of Research Infrastructures. MIT Press.

2 Presenting ALBA Synchrotron

2.1 A brief overview

ALBA is a 3rd generation Synchrotron Light facility located in Cerdanyola del Vallès (Barcelona), funded in equal parts by the Spanish and Catalan governments and managed by CELLS – the Consortium for the Construction, Equipping and Exploitation of the Synchrotron Light Source. The construction of ALBA began in 2006; the building was ready by 2009 while the accelerator in 2011; the first seven beamlines were commissioned by 2011-2012; ***first users were hosted in 2012***.

The facility consists of the *accelerator system* providing 3 GeV electron beam energy and currently *eight experimental beamlines*. ALBA can potentially host more beamlines (around 12 beamlines more). Indeed, four new beamlines are under construction, an additional one is under design, and further beamlines are expected to be approved during the following years[3].

- The ***accelerator system*** is a combination of a linear accelerator of electrons (Linac), a full-energy booster and the storage ring. The booster (250 m of circumference) and the storage ring (269 m of circumference) are both hosted in the same tunnel. The x-rays emitted by the 3 GeV electron beam allow to study the atomic structure of matter mainly for biosciences, condensed matter, materials science research.

- The ***eight beamlines*** (see Table below for details) allow to carry out experiments in the following scientific fields: *chemistry* (e.g., electronic structure characterization of solid samples at the atomic level); *advanced materials* (e.g., metals, ceramics, superconductors, etc.); *nanotechnology* (e.g., structure, characterization etc.); *pharmaceutical* (*inter alia*, structural biology, the interaction between drugs and therapeutic target at the atomic level, detection of impurities, 3D reconstruction of cells); *health products* (including cosmetics and personal care); food and agriculture (e.g., toxicity, fertilizers, etc.); environment (e.g., analysis of polluted water, air, and soil); *automotive and aerospace* (including catalysts for reducing emissions, oils and lubricants, etc.), *energy* (batteries, solar cells, etc.); and *cultural heritage* (ancient materials, paintings, etc.). Each beamline is, in fact, experimental equipment with different characteristics, tailored to the needs of different communities of users. The techniques, according to the existing beamlines, include X-ray powder (micro)diffraction, X-ray scattering, X-ray absorption and emission spectroscopy, infrared microspectroscopy, photoemission, macromolecular crystallography (particularly proteins), magnetic dichroism, soft X-ray microscopy, magnetic reflectivity, and resonant scattering.

A fraction of beam time is booked for internal ALBA researchers for their own studies (around 13%); 20% is reserved for testing and buffering (including reserve beamtime for proprietary access), while all the remaining beam time, over two thirds, is for external users from academia field (meaning peer review access)[4].

[3] Source : ALBA Activity Report, 2017

[4] Source: ALBA.

Table 1 ALBA Beamline and their scientific applications

BEAMLINE	EXPERIMENTAL TECHNIQUES	SCIENTIFIC APPLICATIONS	Start of operation
BL01-MIRAS	Infrared microspectroscopy	Life sciences, food sciences, materials science, cultural heritage	2016
BL04-MSPD	High-resolution powder diffraction Microdiffraction including high pressure	Structure of materials Time-resolved diffraction Quantitative phase analysis	2012
BL09-MISTRAL	Soft X-ray full-field transmission X-ray microscope. Optimized on the 'water window'.	Cryogenic tomography of biological objects. Spatially resolved spectroscopy	2012
BL011-NCD-SWEET	High-resolution small and high-angle X-ray scattering/diffraction	Structure and phase transformations of biological fibres, polymers, solutions Time-resolved X-ray studies	2012
BL13-XALOC	X-ray diffraction from crystals of biological macromolecules	Macromolecular crystallography, with particular emphasis on a large unit cell crystals	2012
BL22-CLAESS	EXAFS, XANES, Quick-EXAFS, XES	Materials science, catalysis, environmental sciences, electronic structures	2012
BL24-CIRCE	Photoemission microscopy (PEEM) Near-atmospheric-pressure photoemission (NAPP)	Nano-science and magnetic domain imaging (PEEM). Surface chemistry (NAPP)	2012
BL29-BOREAS	Circular magnetic dichroism Resonant magnetic diffraction	Magnetism, surface magnetism and magnetic structures	2012

Source: *ALBA Activity Report, 2017*

2.2 Users and use of ALBA beamlines

Overall, from 2012 until now ***4,793 users have benefitted from the use of beam time at ALBA***[5], coming from 821 different institutions[6]. It is worth clarifying that this number includes all the users which have been involved in experiments at ALBA which means not only the principal investigators but also other members of the team who physically accessed the facility for carrying out the experiment. Some of them may have worked/collaborated on several experiments. It may happen that these users apply for beamtime in the framework of more than one experiment, e.g. by submitting a proposal every year for a different experiment, as well as accessing ALBA for the same experiment several times.

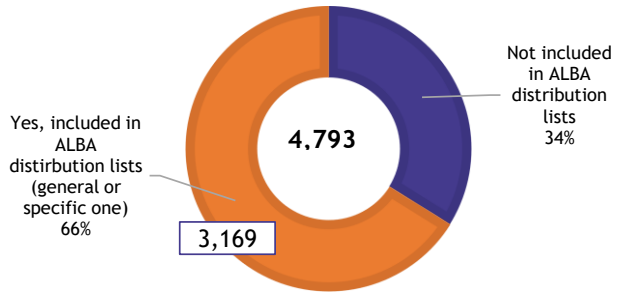
Out of the total number of users, 3,116 (65%) have agreed to belong to ALBA general distribution list, thus meaning that they have accepted to receive general information/e-mail from ALBA, 53 have agreed to be included only in the distribution list of specific beamline(s) while 1,624 asked for not being included in any of ALBA distribution lists. This information was relevant for the purpose of our piloting exercise since as better discussed in the following Section the survey was addressed to those users which have accepted to be included in the distribution lists (general or specific ones) of ALBA, which means a total of **3,169 users** (see Figure 1.a below).

[5] Data provided by ALBA on July, 12th 2019

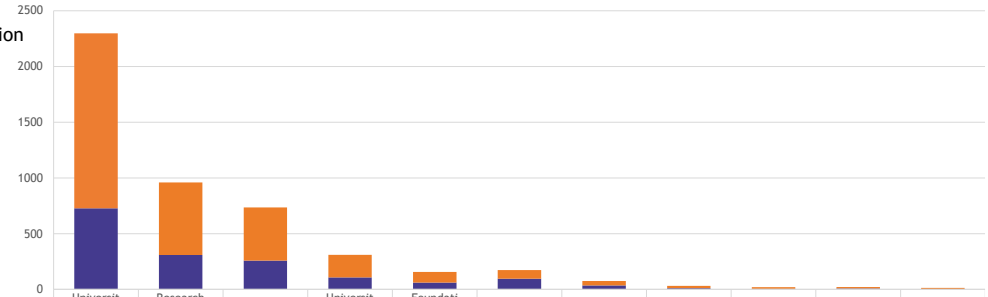
[6] The highest number of users (more than 580) comes from Consejo Superior de Investigaciones Científicas. A significant number comes from the universities located in the Barcelona metropolitan area (more than 300), from Universities of Valencia (including Politecnico Insititute, around 140) and from ALBA itself (more than 130).

Figure 1 ALBA users profile

a) ALBA distribution list: share of users

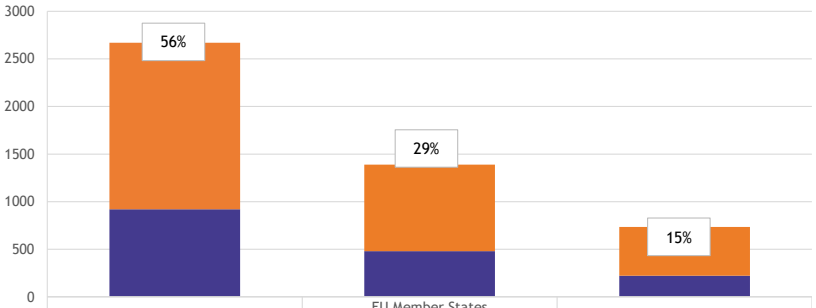


b) ALBA users by type of affiliation



	University	Research Institute	Agency	University/Agency	Foundation	ICTS	Industry*	Hospital	Private*	Others	OPI
Yes, included in ALBA distirbution lists (general or specific one)	1570	650	476	202	95	77	40	20	16	12	11
Not included in ALBA distribution lists	728	309	259	108	61	96	36	11	4	9	3

c) ALBA users by countries



	SPAIN	EU Member States (excluding Spain)	Other countries
Yes, included in ALBA distirbution lists (general or specific one)	1750	908	511
Not included in ALBA distribution lists	920	481	223

Source: *CSIL processing of ALBA data provided on July 12nd, 2019.* **Note:** **private; Others include mostly public institutes such as the museum, ministries, schools, etc. ICTS means Infraestructura Cientifico Tecnica Singular[7]. OPI stands for 'organismo publico de investigacion' (public research institution) focused on Aerospace, Health, Technology, etc.*

The vast majority of users (around 94%) of ALBA beamtime are researchers from public institutions, including university, research institutes, hospitals, etc. (see Figure 1.b above). These non-profit users are granted ***free beam time*** if their research project has a proven scientific validity[8]. A minor share of beam time (around 6%) is given to business (e.g. industry, and private companies) for proprietary R&D. These users pay EUR 573.68 per hour[9]. ***56% of all users are from Spain***. *The remaining 44% are users from abroad, and specifically 29% from other EU Member States[10], 15% from other countries[11].*

[7] It is a public research center like Alba or the Astronomic Observatory in Canary Island; it usually goes through the academic peer review access not the proprietary access

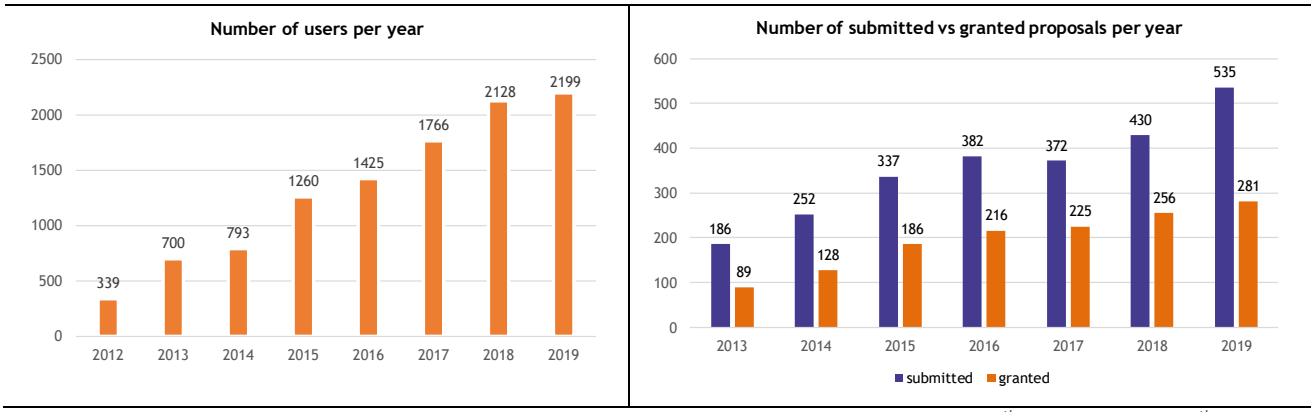
[8] Although some beamtime is reserved to ALBA scientists for their use and purposes, it is worth pointing out that they are also allowed to enter the open competition for peer-reviewed and ask for additional beamtime. This occurs frequently and with success.

[9] Source : https://www.cells.es/en/about/2019-rates-of-utilization

[10] Austria, Belgium, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Luxembourg, Netherlands, Poland, Portugal, Slovakia, Slovenia, Sweden.

The number of users has increased over the years. As showed by the Figure below, 2,199 users accessed ALBA in 2019 which represents a significant increase compared to 2012 (339 users). Also, the number of proposals submitted has increased, exceeding 500 in 2019 (see Figure below).

Figure 2. The use of ALBA beamlines over the years: number of users and submitted/granted proposals



Source: *CSIL processing of data provided by ALBA (January 27th, 2020 and April 30th, 2020)).*

ALBA organises - twice a year - calls for proposal to grant the use of beamlines. Each proposal is reviewed by a team of international experts who assess their merit, also considering technical and safety aspects[12]. Overall, 1,381 proposals have been granted between 2013 and 2019 out of 2,494 submitted (see Figure 2 above). Only half of the applications per year are accepted on average, but with wide differences across beamlines, as shown by the figure below.

Each proposal includes the request for spending a certain number of hours at a beamline (or more than one beamline). In order to estimate the extent to which the different beamlines are requested, granted and actually used by ALBA users, the number of 'shifts' should be considered[13]. **ONE SHIFT IS EQUAL TO 8 HOURS OF EXPERIMENTS.**

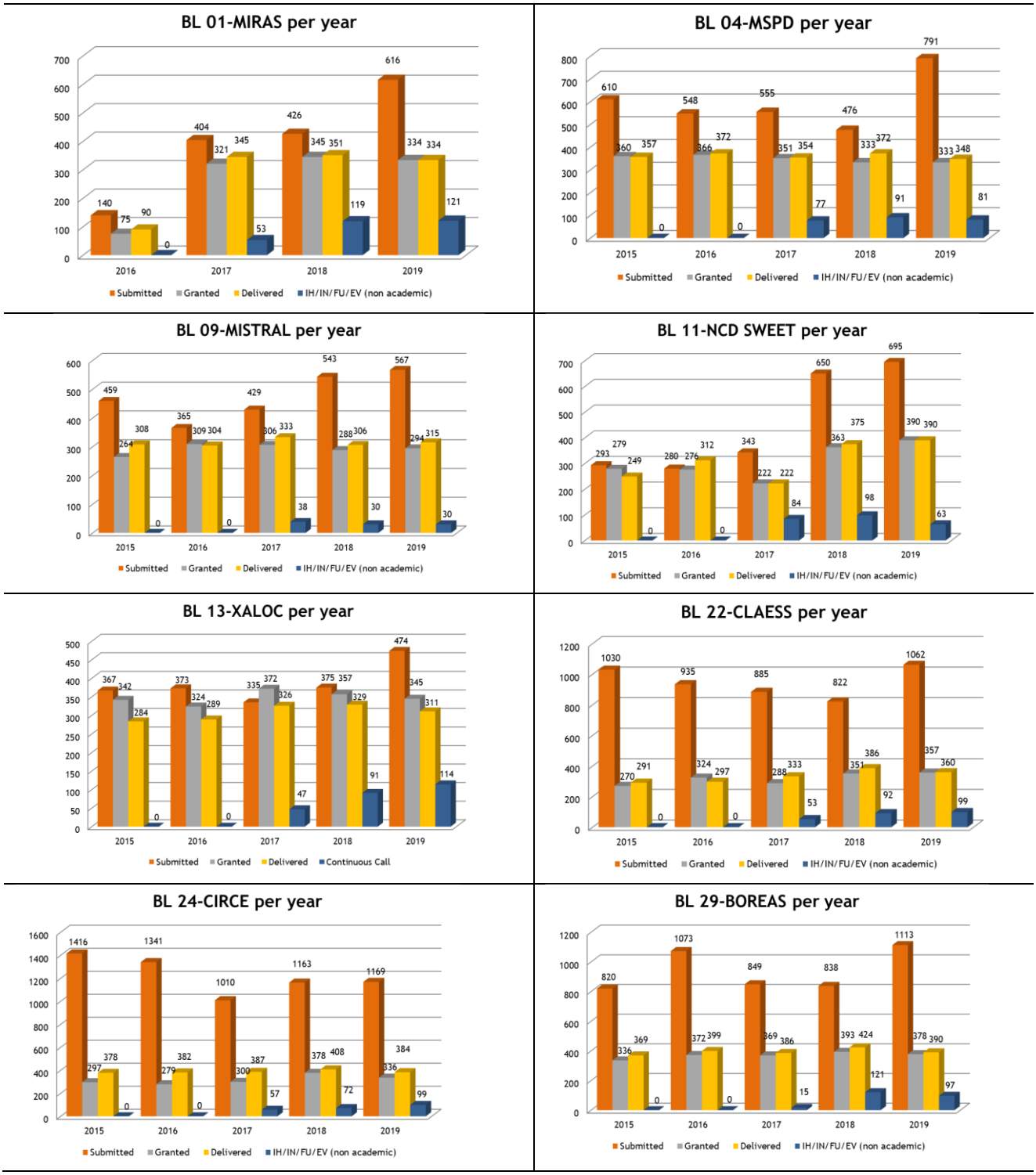
The Figures below provide an overview of the number of submitted, granted and delivered shifts. Amongst the beamlines, ***CIRCE - the photoemission spectroscopy and microscopy beamline with scientific applications in the field of nano-science and surface chemistry*** - is the highest demanded: 1,163 shifts requested in 2018 and 1,169 in 2019, amounting to 9,304 and 9,352 hours respectively.

[11] Argentina, Australia, Bosnia And Herzegovina, Brazil, Canada, Chile, China, Colombia, Egypt, India, Iran (Islamic Republic Of), Israel, Japan, Jordan, Korea, Republic of Mexico, Norway, Oman, Pakistan, Russian Federation, Saudi Arabia, Serbia, Singapore Switzerland, Taiwan, Turkey, Ukraine, United Kingdom, United States, Uruguay and Venezuela.

[12] https://www.cells.es/en/users/applying-for-beam-time

[13] It is worth noting that ALBA does not have 'automatic' statistics about the number of users by beamlines since some users can participate in various experiments in the same beamline or even different beamlines. Some experiments can have 10 users, and some experiments only one. Also, it is likely that the same experiment may be performed through different visits and the users of each visit can be different (e.g. a PhD the first visit and senior researcher for the second visit). This number can be of course estimated with some in-depth research by ALBA staff, if needed. However, the most relevant information - which also provide an indication about the extent to which each beamline is used - is the number of experiments and shifts (or number of hours) granted to users and actually delivered.

Figure 3. Overview of beamlines' use at ALBA



Source: Figure provided by ALBA (January 28th, 2020).

Note: *Submitted* means the number of shifts resulting from the applications received, *granted* are the number of shifts that ALBA accepted and planned to deliver while *delivered* are the number of shifts which have actually been performed.

These shifts all refer to academic proposals such as the ones which are requested to undergo a peer-review process (trough call for applications). The non-academic shifts – showed in blue in the figures below – instead refer to those shifts which are performed by ALBA staff (in-house), industrial access (paying a fee for using beamline) or by those users which have agreements with ALBA.

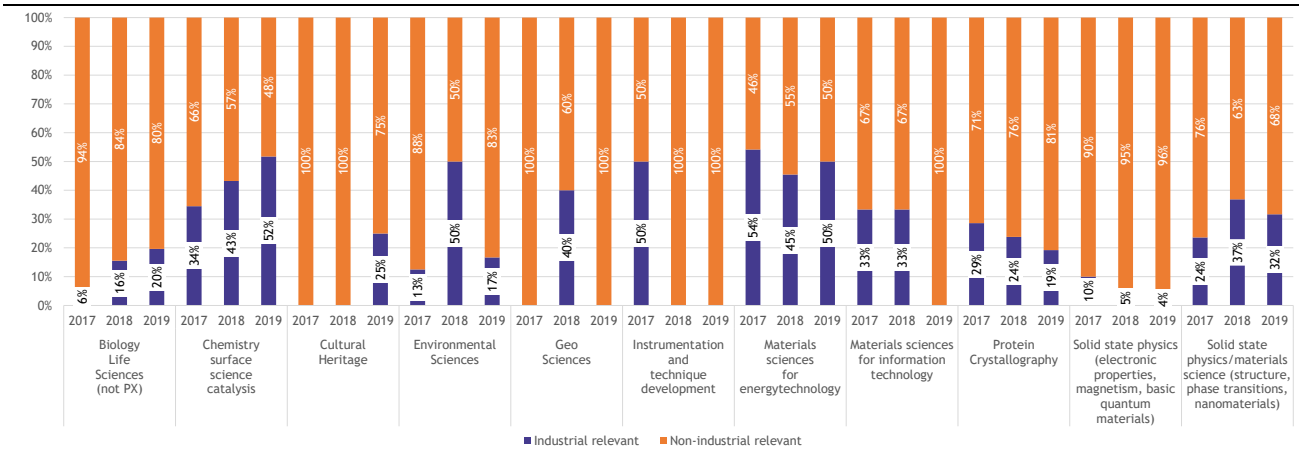
The number of delivered shifts (actually performed) may be higher than the ones granted (originally accepted by ALBA). See for instance MIRAS beamline in the figure (2017-2018). This means that additional proposals have been reviewed and accepted at a later stage by ALBA from the waiting list.

ALBA tracks the relationship between proposals and industry by asking the following questions at the time of the application process:

- Is this proposal industrial relevant?
- Is this proposal in collaboration with an industrial group?
- Does this proposal have any industrial involvement or sponsorship?

Around 10%[14] of the applicants declared in the online application form that they were already aware of the possible interest of the industry for the results of the experiment. This awareness - although declared at a very early stage of the process – revealed that some academic teams have likely already established some linkages with corporate R&D at the time of the application or will create such linkages with industry soon after the experimental data are available, or after the publication of the results. The figure below provides an overview of the industrial relationship for the ***'granted proposals'*** by fields of research as declared by the applicants at the time of the submission. Data provided by ALBA refer to 2017, 2018 and 2019 years since this question was not asked before. This information should, however, be taken with caution since it only reflects the perceptions of applicants while submitting the proposal. Also, it is worth pointing out that differences amongst research fields may be due to the fact that in some areas the number of proposals is relatively lower.

Figure 4 Industrial relationship of granted proposals by field of research (2017, 2018 and 2019)



Source: *ALBA provided on April 27th, 2019*

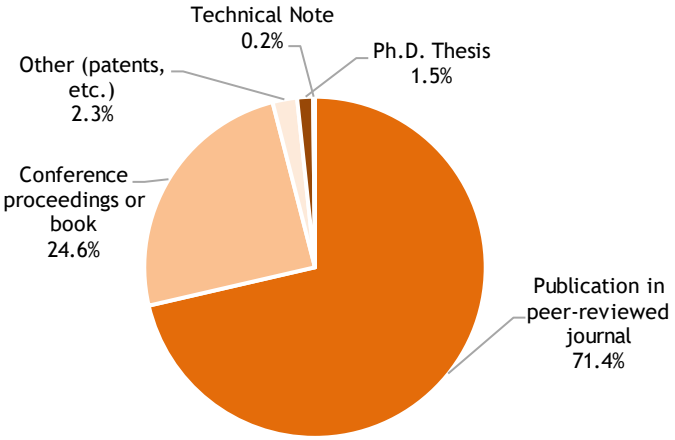
2.3 ALBA publications

Over the years, several hundreds of articles have been published basing on the scientific services provided by ALBA. Overall, at the time of drafting this note, ALBA database includes a total of **1,723 publications**[15] of which 96% have been already published while 4% have been accepted for publication. The largest share (71%, see Figure below) are published (or accepted for publication) in peer-reviewed journals or represents conference proceedings and book chapters (25%) while a very small percentage (4%) consists of a PhD thesis, technical notes or other (including patents).

[14] Source: ALBA

[15] Source: Data provided by ALBA on March 19, 2020. Publications included in the database have been mostly published from 2000 onwards. Only 10 publications have been published in 1990s (specifically 1 in 1992, 7 in 1996 and 2 in 1998)

Figure 5 Publications at ALBA by typologies, 1992-2020

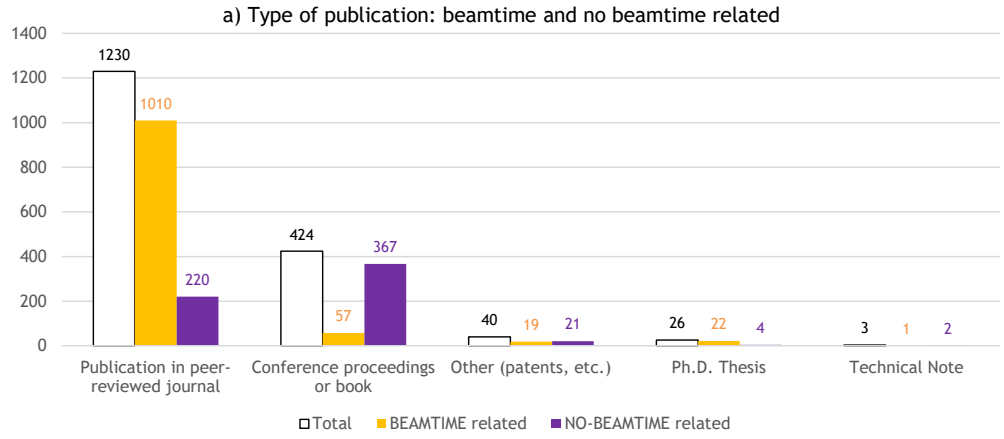


Source: *CSIL processing of data provided by ALBA on March 19th, 2020*

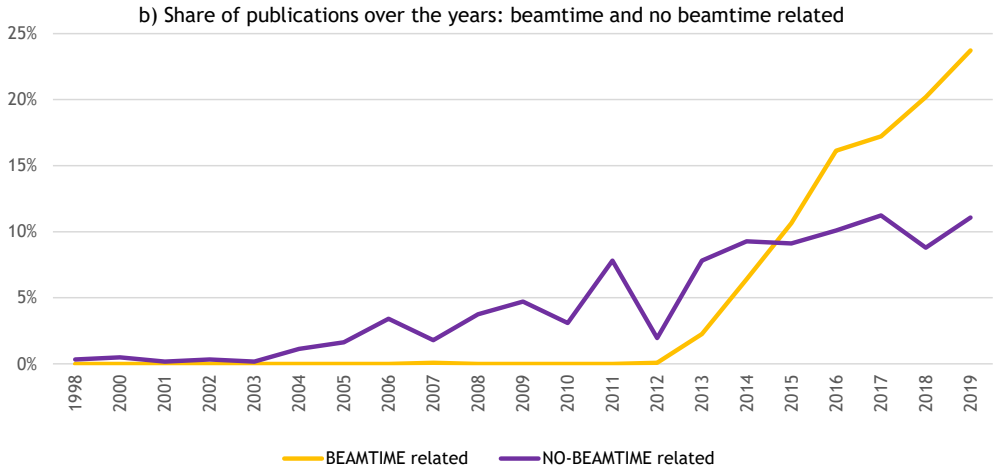
It is worth noting that out of 1,723, **1,109 publications** (64%) **are actually related to the use of beamline at ALBA**, while 614 (36%) are no beamtime related (which means that they do not rely on experiments carried out at ALBA beamlines). Depending on the experiments, these beamline related publications distinguish as follows: *84% are academic, 13% in-house, 2% by expert users*[16] *and 1% industrial*.

The list of ALBA publications dates back to 1992 and also includes publications related to the pre-construction phase of the synchrotron (before it was approved by the government). Most of these publications – especially the beamtime related - has been published from 2015 to 2019. Figure 6.b below provides an overview of the share of publications over the years by distinguishing between beamtime and no-beamtime related.

Figure 6 An overview of publications at ALBA (beamtime and no beamtime related)



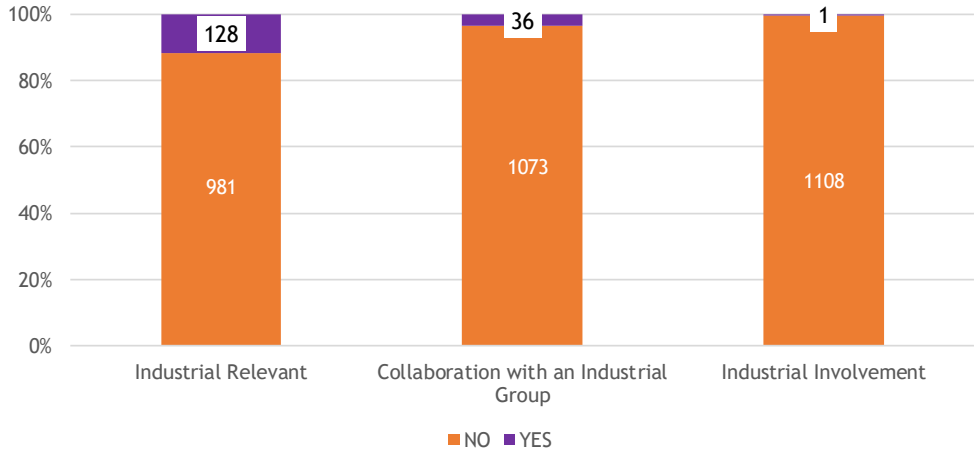
[16] In the synchrotron field as well as at ALBA, this term means that the experiment is carried out by an expert group which is automatically invited by the synchrotron facility (without passing through the peer-review process) because it is expected to help to evaluate how a new beamline is performing.



Source: *CSIL processing of data provided by ALBA on March 19th, 2020*

The Figure below focuses on beamtime related publications (1,109). It shows that 3% of these (36) comes from experiments – for which at the time of the submission of the proposal – it was declared to entail a collaboration with industrial groups while 12% (128) was expected to be relevant from the industrial perspective. No industrial involvement is recorded for any of these publications. All no-beamtime related publications (614) declared no industrial relevance.

Figure 7 Beamtime related publications and their relation with Industry



Source: *CSIL processing of data provided by ALBA on March 19th, 2020*

For the purpose of our analysis, it is worth pointing out that ALBA counts publications for each academic proposal passing peer review. In general, authors of publications are the '*principal investigator*' submitting the proposal while co-authors are the users physically joining the experiment at the beamline. However, in some cases, people from the group not coming physically to ALBA also contribute to the analysis of results.

3 Methodology

3.1 Objective of ALBA-CSIL pilot exercise

As showed in the previous section, every year hundreds of experiments are carried out at ALBA beamlines by the scientific community – including academics and researchers - as well as by private companies (although for a minor share of the beamtime) for different purposes and covering different fields of research. Results from **these experiments may have innovation impacts both directly and indirectly on the industrial community**. On the one hand, experiments can be part of a broader research study carried out by ALBA users (both industrial and academics) specifically addressed to develop a new device/treatment or improve an existing one. On the other hand, experiments carried out by academic and researchers – even if they do not involve the industrial sector directly - can indirectly have an impact on the industry. The outcomes of their experiments – often translated in publications in a peer-reviewed journal - can be of interest for companies or applied researchers and can find applications in a wide and diverse range of fields, such as -to cite some examples- polymers (e.g. packaging), automotive, food, geo-science, etc. In this case, the industrial community represents indeed the indirect users of the services provided by ALBA. This is confirmed by the declarations of around 10% of academic and researchers applying for beamtime at ALBA which - during the application process – report about expected linkages between results of their experiments and industry.

However, the pathways according to which these innovation impacts materialise may vary in terms of duration and nature (activities needed to achieve the innovation outputs). Indeed, experiments carried out at synchrotron beamlines might not have an immediate application in industry. Further steps are needed to get the innovation output. Even when the user is a private company, the latter can act as a research service provider for third parties interested in developing an innovation output (e.g. an innovative device/treatment) based on experiments carried out on the beamlines.

The objective of our pilot exercise was indeed to trace and describe these pathways and specifically to provide an answer to the following research questions:

1) How to measure outputs arising from accelerator-based photon source facilities, taking ALBA as an example of this type of research infrastructures?
2) In which fields and through which pathways innovations stemming from ALBA experiments are likely to materialise?
3) What is/are the *gestation lag(s) of innovation* at ALBA, such as the time lag that separates the experiment and the development of an innovation output with economic or practical significance?
4) What is/are the *research gap(s) of innovation at ALBA,* such as the additional research activities needed to develop an innovation output with economic or practical significance?

The pilot exercise built on the evidence collected through two surveys targeting direct and indirect users of ALBA experiments and on the analysis of patents' citations. More details on the methodological approach adopted as well as challenges faced are provided in what follows.

3.2 Methodological approach

With a view to tracing the pathways from the design of the experiments to the innovation outputs, we performed **two surveys**, one directed to ALBA beamline users and the other one to ALBA indirect users. The surveys were complemented by an **analysis of patent citations.** The two methods are presented in what follows.

3.2.1 Online surveys to ALBA direct and indirect users

Two online surveys were designed:

1. The **first survey** *(hereafter Survey N°1)* **targeted ALBA beamline direct users** who accessed ALBA physically to run the experiment and accepted to receive information from ALBA - being included in the general or specific beamline distribution lists of ALBA (see the previous section for details). These amount to **3,249 users**.

   This survey represents a step forward the questionnaire addressed by ALBA to its users at the time of application, which - as mentioned above – only asks whether the experiment they are applying for has/is expected to have a connection with industry. Indeed, it was addressed to gather information on the pathways allowing to the generation of innovation impacts on the industry (if any), as per users' knowledge (e.g. by asking the type of innovation outputs arising from their experiments, the potential field of application, the time, the activities and resources needed for getting an innovation output stemming from results of experiments, etc.).

   Two different questionnaires (see Sections 6.2 and 6.3) were drafted for the Survey N°1 in order to take into account ALBA users from the scientific community (e.g. academic/researchers) and users from private companies. These questionnaires were fine-tuned through scoping interviews with five selected users. The final versions were then uploaded on a web platform managed by CSIL while invitations and reminders (by e-mail and phone) to the survey were carried out by ALBA staff.

2. The **second survey** *(hereafter Survey N°2)* **targeted ALBA indirect users** that are third parties (academics, companies, researchers, etc.) which have benefitted from results of the experiments carried out at ALBA by getting in contact with ALBA direct users or simply relying on their publications, but without accessing ALBA directly.

   The questionnaire of Survey N°2 was designed to gather a more in-depth understanding of the innovation processes triggered by the experiments held at ALBA on third parties (see questionnaire enclosed in see Section 6.4). Specifically, it investigated the innovation (e.g. of products, process, etc.) generated by these experiments, additional cost needed to achieve an innovation output by third parties, as well as potential economic impacts arisen (e.g. increase of turnover, entering in new markets, etc.).

Both surveys were launched on December 2nd, 2019 and run until March 30th, 2020.

Overall, 369 questionnaires were collected from the Survey N°1 to direct users, and specifically 351 from the scientific community and **18 from the private sector**. These two samples of respondents are statistically representative of ALBA granted proposals, as described in section 4.1 below.

Some challenges were indeed faced while preparing and running the **Survey N°2**, which were tackled by appropriate mitigation measures, namely:

1. There is no tracking of the use of ALBA experiments' results by third parties. Therefore, **the first challenge was gathering contacts for the purpose of this survey**. In order to address this challenge, two different solutions were designed: i) relying on the support of ALBA direct users by asking them to suggest contacts of third parties interested in the results of their experiments or forward the link to the Survey N°2 directly; ii) gathering contacts by identifying the authors of patents citing ALBA publications and thus indirectly benefitting from experiments carried out on beamlines (see the following section).

2. **Ensuring a high response rate from indirect users of ALBA beamlines** was also found to be challenging. A management survey plan was adopted to solicit answers. Accordingly, reminders were periodically sent by email and phone recalls carried out by ALBA staff.

3. The evidence collected through the survey was then **complemented with in-depth interviews**[17].

Evidence collected from indirect users (overall 15) is used through the text to explain how results from experiments carried out at ALBA are used from third parties.

3.2.2 Analysis of ALBA publications and patent citations

With a view to grasping the full picture of ALBA's innovation pathways, **an analysis on patents' citations was also performed** in addition to the two surveys mentioned above. Patent citation analysis is a recent development which uses bibliometric techniques to examine the wealth of patent citation information. Many studies have been relying on this analysis[18] to assess the link between science and technology.

The analysis was specifically addressed to assess the extent to which innovations have been triggered by the knowledge produced by ALBA through publications. In other words, we looked at the extent to which ALBA publications are cited in patent's documents and therefore contributed to the development of innovation outputs. For the purpose of this analysis, we considered the knowledge, directly and indirectly, generated by ALBA - such as publications directly produced by ALBA users – labelled as level 0 publications (P_0) - and publications citing ALBA users publications – labelled as level 1 publications (P_1).

This analysis required the following actions:

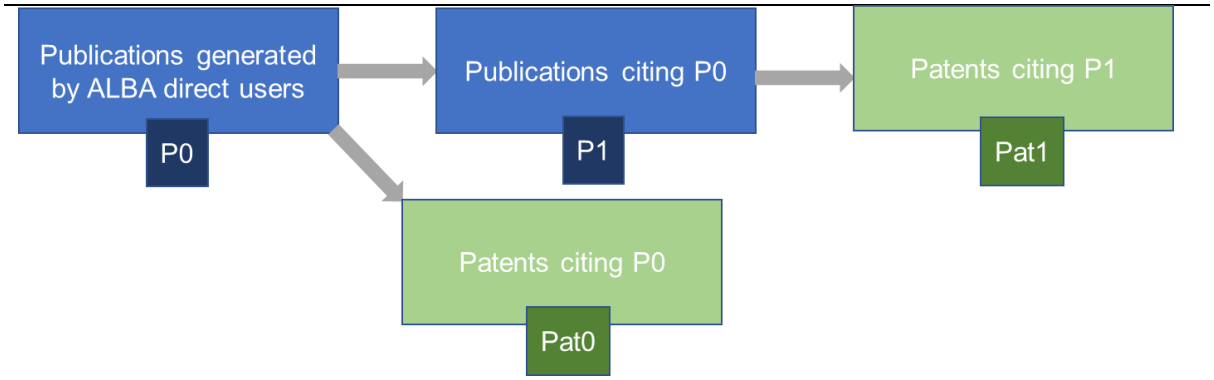
a. Analysis of ALBA publications database (described under Section 2.3), namely (P_0) publications;
b. Extraction of scientific publications which cite ALBA publications, namely (P_1) publications, from relevant publicly available repositories of scientific publications;

[17] Overall 15 indirect users were interviewed through Survey N°2 and in-depth interviews.
[18] See for instance: Yamashita, Y. (2018). Fukuzawa, N., & Ida, T. (2016). Branstetter, L., & Ogura, Y. (2005).

c. Creation of an ad-hoc database including bibliographic data - *such as titles, authors, co-authors, affiliations and country, abstracts, doi, year of publication, journal of publications, etc.* - of (P_0) and (P_1) publications.
d. Identification of patents (Pat_0) citing ALBA publications (P_0) as well as those patents (Pat_1) citing publications (P_1) which in turn cite ALBA publications(P_0).

The Figure below illustrates the relationship between publications and citing patents.

Figure 8 Patents' citation process in a nutshell



Source: *CSIL*

More details on the process which allowed us to track the innovation outputs stemming from ALBA publications along with results achieved with this analysis are described in Section 4.2 below.

It is worth pointing out that this analysis goes beyond the monitoring activity currently performed by ALBA, which is limited to track the publications arising from experiments. Indeed, it allowed us to:

- Getting the number of patents which have been developed starting from ALBA's (P_0) and (P_1) publications;
- Mapping the field/sector of applications in which these innovations have been developed;
- Identifying publications with technological importance and information on their topic, authors, co-authors involved.
- Describing the time gestation lag of these innovations, such as the time lag that separates the year of the publication and the year of patent's registration.

Amongst others, it also allowed us to identify authors of patents citing ALBA publications which were invited to participate in the Survey N°2 mentioned above since potentially being indirect users of the results stemming from ALBA experiments.

4 RESULTS

4.1 From experiments to innovation outputs: evidence from survey to ALBA direct users

4.1.1 Brief description of the sample

Sample from the scientific community (academics/researchers)

(1) 351 users from the scientific community answered the survey. **While accounting for 12% of the targeted users (2,947)[19], these users represent 63% of the proposals granted by ALBA from 2015 to 2019 (730 out of 1,164 proposals, *Figure 9.a*).** This response rate suggests that this sample of respondents provides a good representation of the research activity carried out at ALBA during this period. Each respondent (either in the position of the main proposer, co-proposer or member of the team) has been involved in at least two granted proposals (the proportion between users and proposals presented is 2.08) and represents for each proposal a user team usually made up of 4-8 people.

(2) This sample is also representative of the geographical origin of ALBA users coming from the scientific community *(Figure 9.b)*, the research fields covered by the proposals granted to them (*Figure 9.c*) as well as their use of beamlines (*Figure 9.d*). Indeed, respondents mostly come from Spain (54%) and the proposals - in which they have been involved - mostly cover the following research fields: solid-state physics/materials science, chemistry-surface science-catalysis, materials sciences for energy technology, solid-state physics, biology-life sciences and protein crystallography. For their experiments, these users have mostly relied on BL04-MSPD beamline (in 167 out of 730 proposals represented by this sample) followed by BL011-NCD-SWEET and BL13-XALOC (respectively in 108 and 100 proposals represented by this sample). It is worth noting that these beamlines are also the most 'granted' beamlines to users from the scientific community since enabling faster and more frequent experiments as compared, for instance, to the beamline BL09-MISTRAL.

(3) The majority of respondents are male (64%) and full/associate professor (40%) or fellow/associate (26%)[20]. Most of the respondents carry out applied research (54%) or pure basic research (42%) while only a few (4%) carries out industrially relevant research (*Figure 9.e*). According to respondents' declarations (*Figure 9.f*), their research is likely to contribute most to the following **areas of application**: energy (secure, clean and efficient), health, advances in other enabling technologies, climate resources (efficiency and raw materials).

(4) Almost one-third of the respondents are frequent users of ALBA which means that they have been granted the use of beamlines five or more times. The sample mostly includes occasional users (41%) – having been granted the use of beamlines more than once but less than five times - or infrequent users (32%) – having been awarded the use of beamlines once (*Figure 9.g*). Infrequent users of ALBA are mostly coming from other EU countries and who have experience of other synchrotron light sources (*Figures 9.g and 9.h*).

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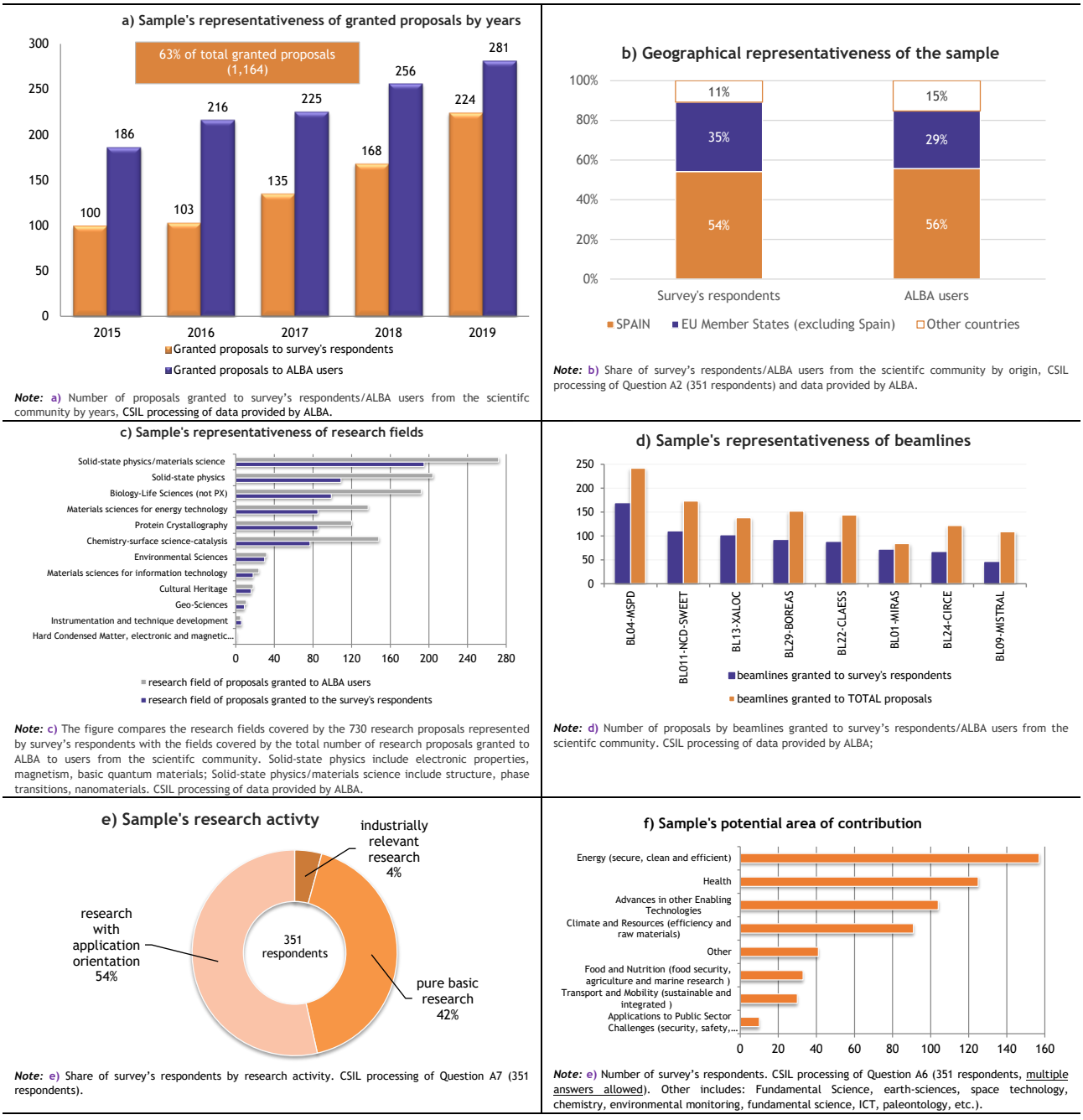
19 Overall, 3,210 invitations were sent to users from the scientific community, of which 2,947 were successfully delivered while 263 resulted to be no longer operative.

20 The remaining percentage is splitted amongst the following categories: PhD student (13%), Post-Doc (13%), Director/Senior Manager (3%), Master student (1%) and Other (4% including engineers, senior scientists, technician, facility managers, etc.).

(5) At the survey time, the majority of respondents (84%) used other synchrotron light sources beyond ALBA one, while only 16% of respondents used ALBA synchrotron light source only (*Figure 9.h*). Basing on this finding, it is reasonable considering results from this survey – involving ALBA users – as a good representation of the huge community of photon-source users in Europe and more specifically of the League of European Accelerator Based-Photon Sources (LEAPS)[21]. Amongst the most mentioned synchrotron light sources mentioned by respondents (*Figure 9.i*), which are also part of LEAPS, there are the European Synchrotron Radiation Facility (ESRF, in France), Diamond (in the UK), Soleil (in France), Desy (in Germany) and Elettra (in Italy).

Figure 9 Overview of the survey's respondents from the scientific community



Note: a) Number of proposals granted to survey's respondents/ALBA users from the scientifc community by years, CSIL processing of data provided by ALBA.

Note: b) Share of survey's respondents/ALBA users from the scientifc community by origin, CSIL processing of Question A2 (351 respondents) and data provided by ALBA.

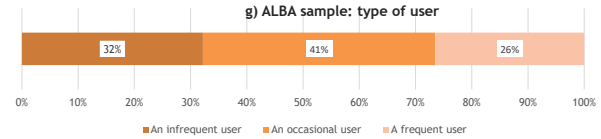
Note: c) The figure compares the research fields covered by the 730 research proposals represented by survey's respondents with the fields covered by the total number of research proposals granted to ALBA to users from the scientifc community. Solid-state physics include electronic properties, magnetism, basic quantum materials; Solid-state physics/materials science include structure, phase transitions, nanomaterials. CSIL processing of data provided by ALBA.

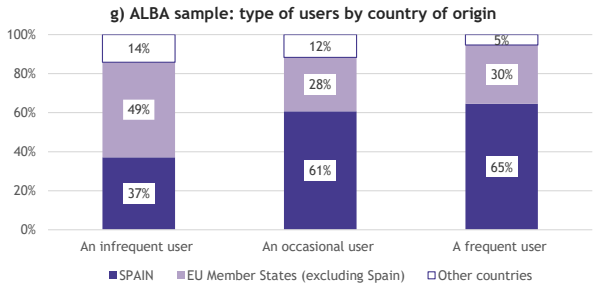
Note: d) Number of proposals by beamlines granted to survey's respondents/ALBA users from the scientifc community. CSIL processing of data provided by ALBA;

Note: e) Share of survey's respondents by research activity. CSIL processing of Question A7 (351 respondents).

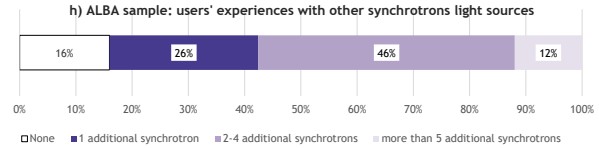
Note: e) Number of survey's respondents. CSIL processing of Question A6 (351 respondents, multiple answers allowed). Other includes: Fundamental Science, earth-sciences, space technology, chemistry, environmental monitoring, fundamental science, ICT, paleontology, etc.).

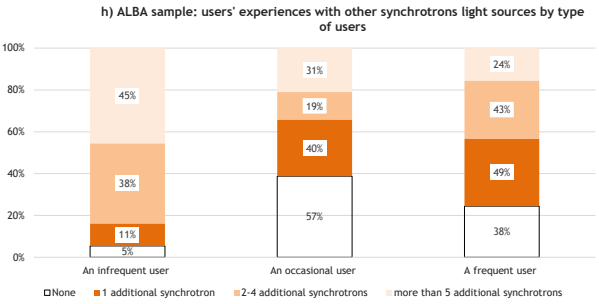
[21] LEAPS is a strategic consortium established on November 13th 2017 by the Directors of the Synchrotron Radiation (SR) and Free Electron Laser (FEL) user facilities in Europe. For details, see LEAPS webpage https://leaps-initiative.eu/ and the landscape analysis document available at https://leaps-initiative.eu/wp-content/uploads/2019/11/LEAPS_Landscape_Analysis_27March2019_final.pdf



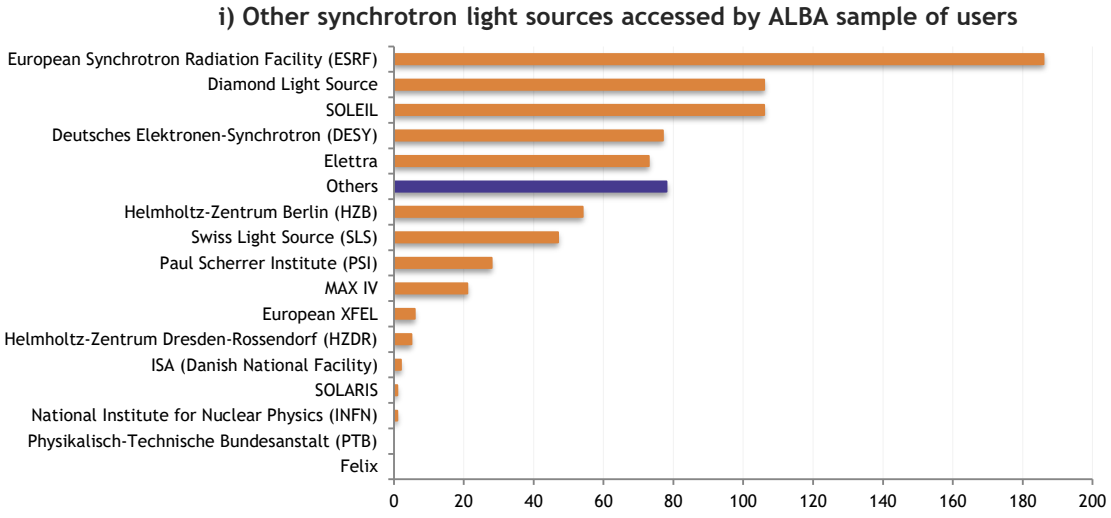


Note: g) Share of survey's respondents by type of users and country of origin. CSIL processing of Questions B.2 and A.2 (351 respondents).





Note: h) Share of survey's respondents CSIL processing of Questions B.6 and B.2 (351 respondents).



Note: i) Number of survey's respondents CSIL processing of Question B.6 (351 respondents, multiple answers allowed). Others include: APS, ALS, CCRLC (UK), SACLA, MAX II, BNL, OAK RIDGE, ASTRID2, NSLS-II, ANKA, BSRF, SPring8, Daresbury Labs, LURE, etc.

Source: *CSIL processing of survey to users from the scientific community (see Questionnaire in Annex 6.2) and data provided by ALBA*

Sample from the private sector

(6) 18 users from the private sector - involved in ALBA experiments carried out over the period 2013-2019 - answered the survey. This sample accounts for 46% of ALBA users from this field (in total 39).

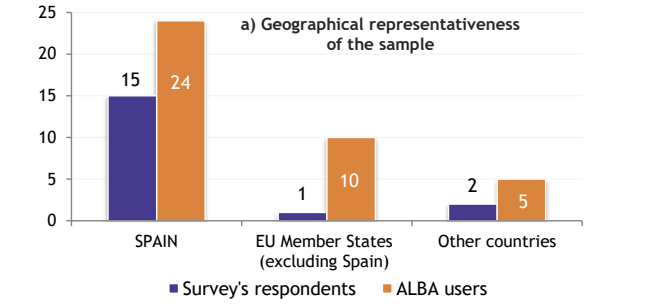
(7) The sample of respondents mirrors the size, the country of origin, the field of activities as well as the main beamlines used by private companies accessing ALBA. Indeed, respondents include a slight prevalence of large companies (*Figures 10.b and c)* and companies mostly located in Spain (*Figure 10.a*). The main field of activity is research and experimental development on chemicals and pharmaceuticals, followed by the manufacture of basic pharmaceutical products and manufacture of pharmaceutical preparations (*Figure 10.d*). The EU countries – as compared to Spain and other countries - are less represented by our sample. However, this shortcoming is adjusted by the representativeness of countries across the different fields of activities. Indeed, in the pharma sector there are usually many non-Spanish companies (other EU countries) while in the cement sector – which in comparison is less represented by our sample - there are more Spanish companies.

(8) For their experiments, these private sector respondents have mostly relied on BL04-MSPD, BL22-CLAESS, BL011-NCD-SWEET and BL13-XALOC (*Figure 10.e)*.

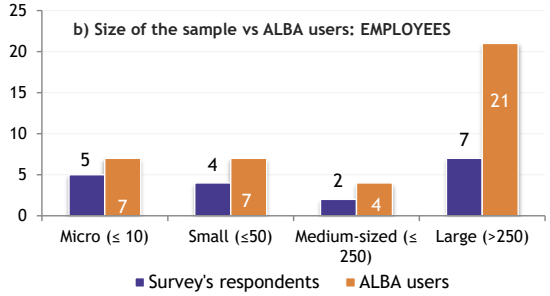
(9) The sample includes 8 frequent users, 7 infrequent users and 3 occasional users. While infrequent users (all from Spain) have accessed ALBA for the first time in recent years (2017, 2018, and 2019), there are frequent and occasional users (from Spain, EU and other countries) which have already accrued 4-5 years of experience with the use of ALBA beamlines (*Figure 10.f)*.

(10) Half of the respondents (9*)* has no other experiences of light sources in addition to ALBA. The remaining half has experienced at least another synchrotron (4 respondents) or more than one (4 respondents). Amongst the most mentioned ones (*Figure 10.g)*, there are the European Synchrotron Radiation Facility (ESRF, in France), Diamond (in the UK) and Swiss Light Source (in Switzerland).

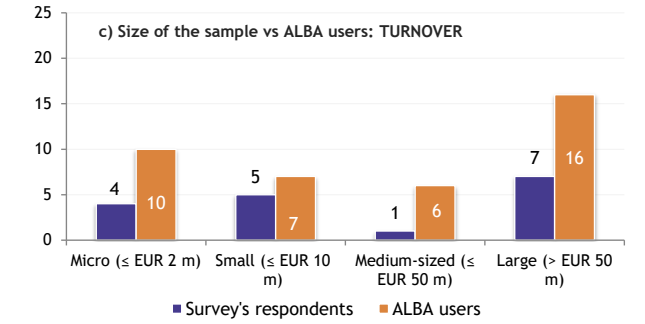
Figure 10 Overview of the survey's respondents from the private field



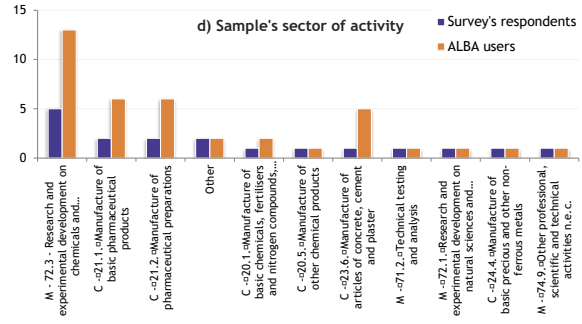
Note: a) Number of survey's respondents vs total users from private field. CSIL processing of Question A2 (18 respondents) and data provided by ALBA.



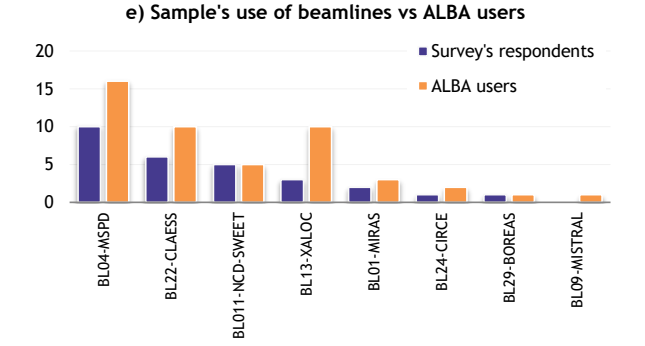
Note: b) Number of survey's respondents vs total users from private field. CSIL processing of Question A4 (18 respondents) and data provided by ALBA.



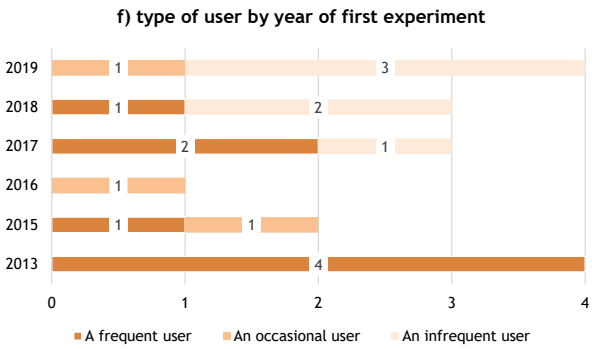
Note: c) Number of survey's respondents vs total users from private field. CSIL processing of Question A5 (18 respondents) and data provided by ALBA.



Note: d) Number of survey's respondents vs total users from private field. Other includes chemical companies working on adhesives, coatings and lubricants and companies working on cosmetics. CSIL processing of Question A3 (18 respondents) and data provided by ALBA.

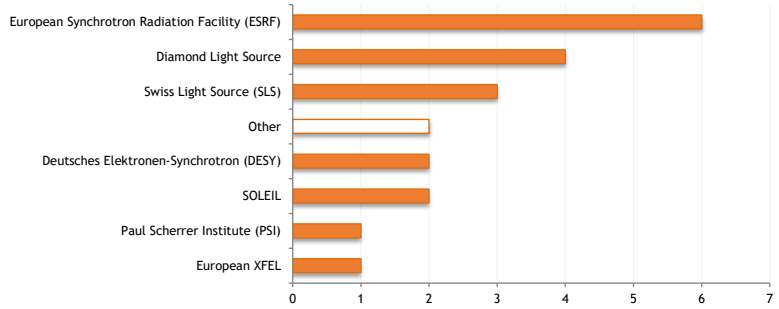


Note: e) Number of survey's respondents vs total users from private field. CSIL processing of Question B1 (18 respondents) and data provided by ALBA.



Note: f) Number of survey's respondents. CSIL processing of Questions B2 and B4 (18 respondents)

g) Other synchrotron light sources accessed by ALBA users



Note: g) Number of survey's respondents. CSIL processing of Questions B6 (18 respondents, multiple answers allowed)

Source: *CSIL processing of Survey to users from the private sector (see Questionnaire in Annex 6.3) and data provided by ALBA.*

4.1.1 From the design to the execution of experiments

The objective of this section is to describe the pathways leading to the design and the execution of experiments at ALBA beamlines, as reported by the survey's respondents.

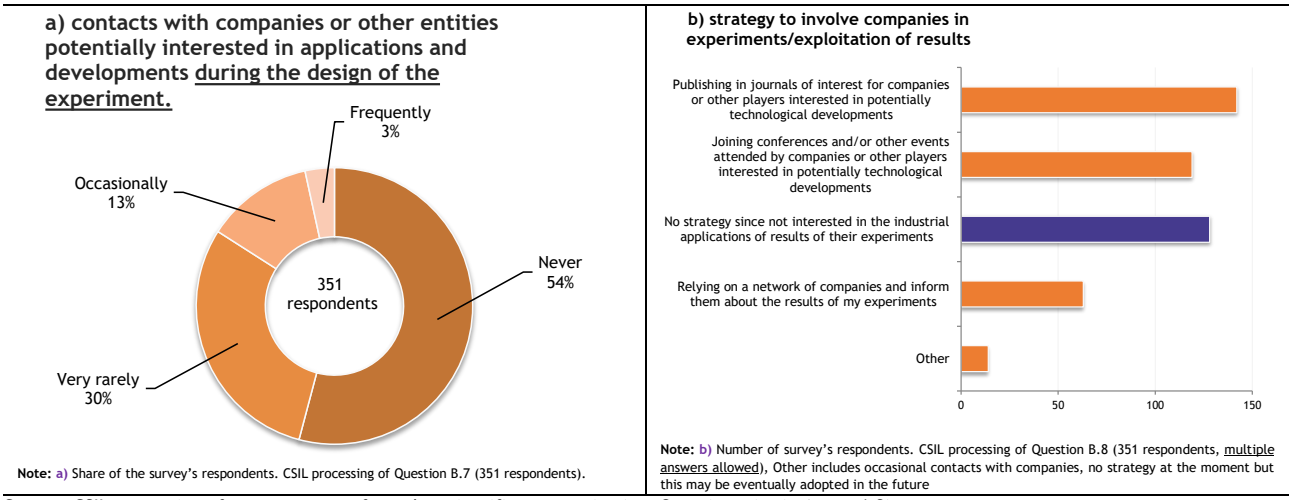
The scientific community

(10) When designing an experiment with synchrotron light sources (*Figure 11.a)*, respondents from the scientific community never (54%) or very rarely (30%) have contacts with companies or other entities potentially interested in applications and developments stemming from their experiments. Only a small percentage of respondents declared that this occasionally (13%) or frequently (3%) occurs.

(11) The most common approach (*Figure 11.b)* - to draw the attention from companies in their experiments/exploitation of their results - is to publish in journals of interest for companies or to join conferences or events attended by companies or players potentially interested in technological development. However, it also happens they have no strategy in this regard since they are not interested in the industrial applications of results when designing the experiment. This occurs especially in the case of basic research experiments. In a few cases, users rely on a network of companies and inform them about results (*Figure 11.b)*. Amongst these, there are - for instance - companies from the energy sector, dealing with conservation/restoration of stain glass or with x-ray detector development and synchrotron radiation.

(12) Respondents recognise that the experiments conducted at synchrotron light sources provide an opportunity for the industrial sector to improve the quality of a product (e.g. by understanding structure-property relationship on micro-scale level) or to contribute to the treatment of diseases (e.g. by studying and advancing in the treatment of Alzheimer disease). Some respondents also admitted that searching and contacting companies which could be interested in the technology and materials developed by their experiments is challenging especially for those covering the position of professors. These tasks are found to be easy when specifically supported by the technology transfer unit of their institution or where there is a spin-off of the university collaborating with them.

Figure 11 The use of synchrotron light sources from public users: the design phase



Note: a) Share of the survey's respondents. CSIL processing of Question B.7 (351 respondents).

Note: b) Number of survey's respondents. CSIL processing of Question B.8 (351 respondents, multiple answers allowed), Other includes occasional contacts with companies, no strategy at the moment but this may be eventually adopted in the future

Source: CSIL processing of survey to users from the scientific community (see Questionnaire in Annex 6.2)

(13) On average, 52% of experiments are designed and carried out by these users as part of a broader research design while 48% as a self-standing activity providing an answer to a specific research question or need from indirect users (***Figure 12.a***).

(14) A small percentage of experiments carried out by these respondents have been performed in collaboration with private companies (*Figure 12.b*); the majority has been carried out alone or in collaboration with other universities or research institutes. While carrying out their experiments, these respondents have mostly self-operated the beamlines or used them in collaboration with ALBA staff (*Figure 12.c*).

(15) The survey's responses confirmed that the use of ALBA beamlines is usually related to a specific type of research (*Figure 12.d*) and research fields (*Figure 12.e*).

- Beamlines such as BL013-XALOC and BL029-BOREAS are used mostly from users carrying out *pure basic research* and, respectively, in the framework of those proposals studying *protein crystallography* and *solid-state physics* (e.g. surface magnetism and magnetic structures).

- Other beamlines are mostly used by users carrying out *research with application orientation*, specifically BL04-MSPD, BL011-NCD-SWEET, BL021- MIRAS, BL022- CLAESS, BL09 MISTRAL.

- Amongst the eight beamlines, BL011-NCD-SWEET and BL24-CIRCE are those mostly used by users carrying out industrially relevant research, although this type of research is not predominant in none of the eight beamlines.

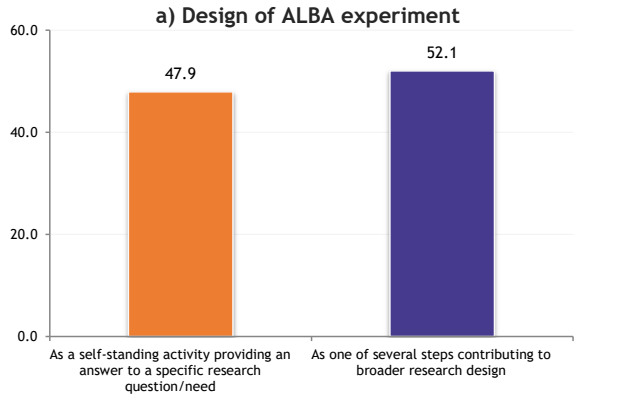
- BL04-MSPD and BL011-NCD-SWEET have been largely used for carrying out research in solid-state physics or material science (e.g. allowing to study the structure and phase transformations of biological fibres, polymers, solutions, etc.).

- BL022- CLAESS has been mostly used for researches on materials science for chemistry, surface science, catalysis, material sciences for energy technology, catalysis, environmental sciences.

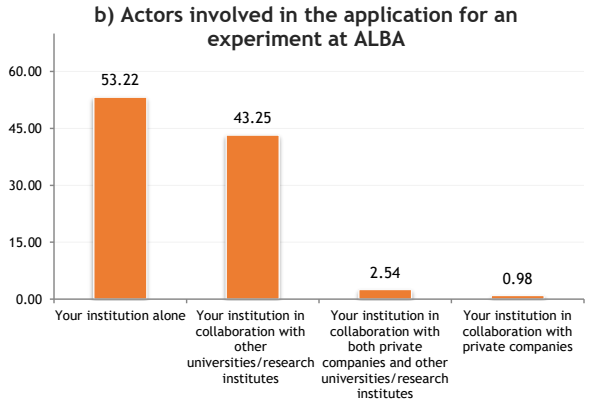
- Also, BL24-CIRCE has been mostly used for chemistry, surface and science catalysis as well as for more basic research on solid-state physics.

- BL021- MIRAS and BL09 MISTRAL have been largely used for researches in the field of biology and life science (e.g. food sciences and cryogenic tomography of biological objects) excluding protein crystallography (BL013-XALOC).

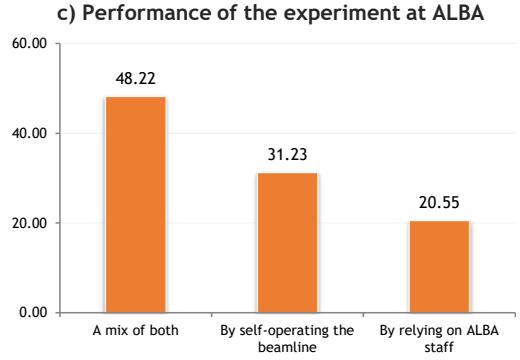
Figure 12 Experiments at ALBA beamlines from public users: from the design to the performance



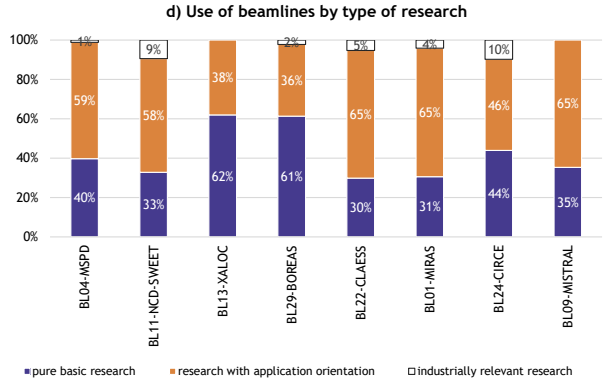
Note: a) Average share of experiments carried out by survey's respondents. CSIL processing of Question C2 'On the total of your experiments at ALBA, please indicate the share of those carried out' (351 respondents).



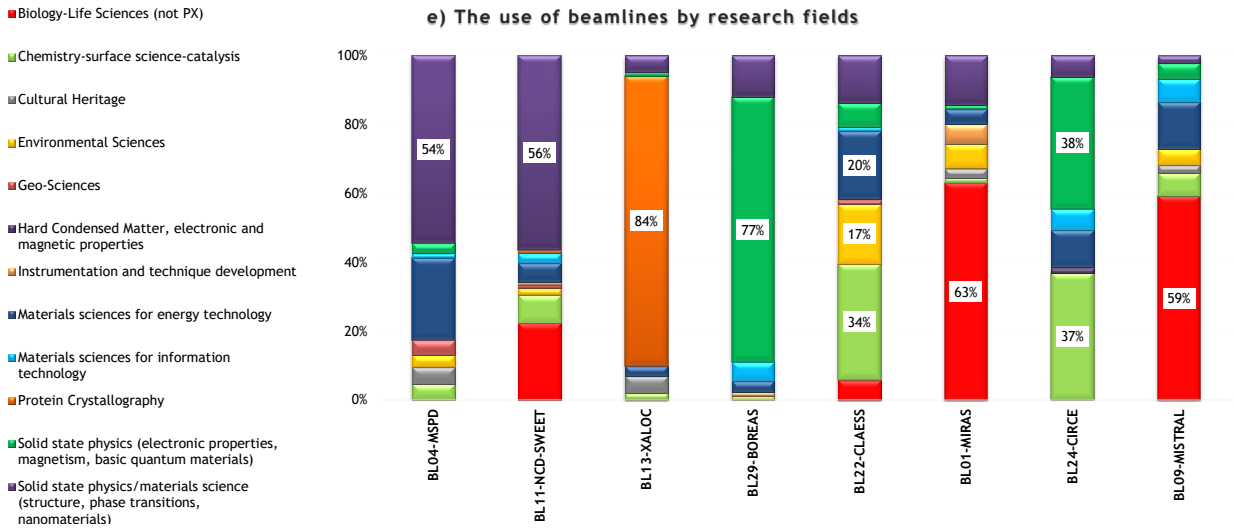
Note: b) Average share of experiments carried out by survey's respondents. CSIL processing of CSIL processing of Question B.3 'On the total of your experiments at ALBA, please indicate the share of those for which the application was submitted by' (351 respondents).



Note: c) Average share of experiments carried out by survey's respondents. CSIL processing of Question B4 'On the total of your experiments at ALBA, please indicate the share of those carried out' (351 respondents).



Note: d) Share of survey's respondents by beamlines and type of research carried out by the user. CSIL processing of Questions A7 and B1 (351 respondents).



Note: a) Share of proposals granted to survey's respondents. CSIL processing of data provided by ALBA on research fields and beamlines used in the framework of proposals granted to survey's respondents.

Source: CSIL processing of survey to users from the scientific community (see Questionnaire in Annex 6.2).

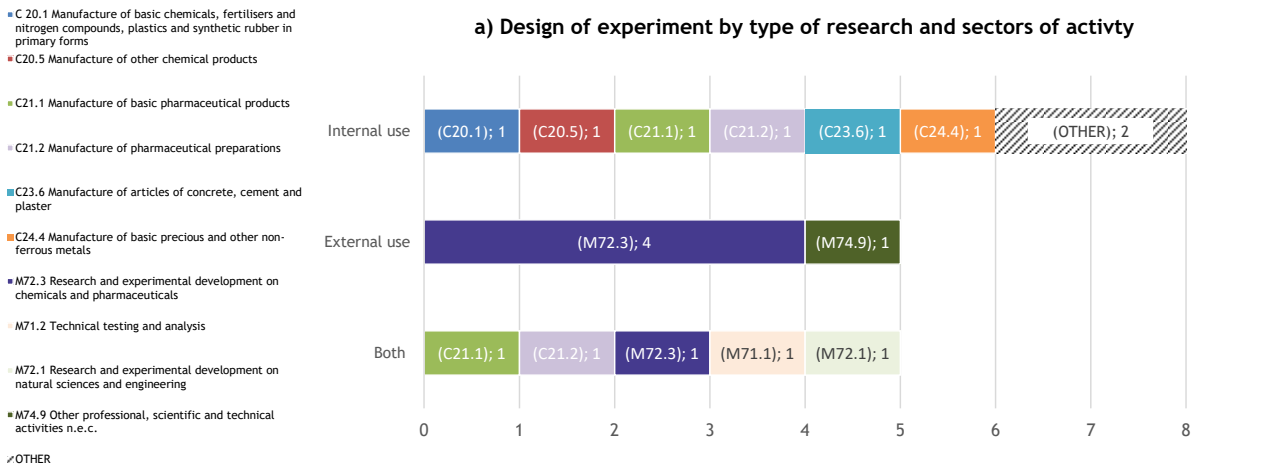
The private sector

(16) The majority of respondents (44%) from the private field carries out their experiments with the objective to use results internally (all manufacturers), 28% acts as intermediate service companies (companies dealing with research and experimental development on chemicals and pharmaceuticals or other professionals, scientific and technical activities) while the remaining 20% use the results either for an internal or external purpose (***Figure 13.a***).

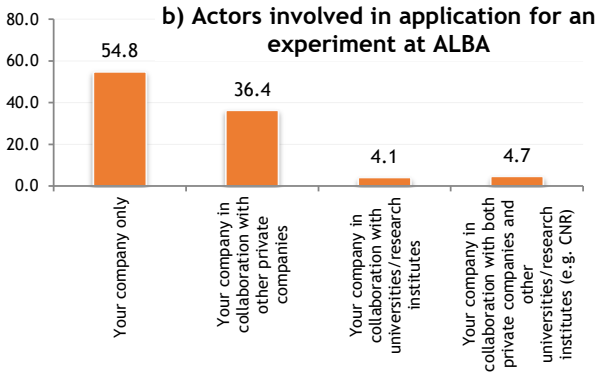
(17) A very small percentage (8.8%) of experiments carried out by these users involve universities or research institutes (*Figure 13.b*). Indeed, experiments are mostly carried out by the company only (54.8% of experiments) or in collaboration with other private companies (36.4%). Differently from users from the scientific community, while carrying out their experiments, these respondents have mostly relied on the support of ALBA staff (on average, 65.5% of experiments carried out, *Figure 13.c*).

(18) Some beamlines have been used to meet the needs of different sectors of activity while others are mostly demanded by specific sectors. BL22-CLAESS, BL011-NCD-SWEET and BL04-MSPD are versatile beamlines which are used by companies operating in different sectors. For instance, BL22-CLAESS has been used by companies dealing with the manufacture of basic chemicals, of basic precious and other non-ferrous metals as well as by those carrying out research and experimental development on chemicals and pharmaceuticals. Instead, beamlines such as BL13-XALOC are more sector-specific allowing to study biological molecules such as proteins, viruses and nucleic acids and therefore used by those companies dealing with research and experimental development on chemicals and pharmaceuticals, on natural sciences as well as technical testing and analysis (*Figure 13.d*).

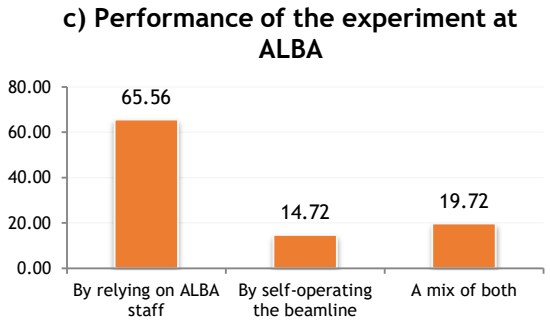
Figure 13 Experiments at ALBA beamlines from private sector users: from the design to the performance



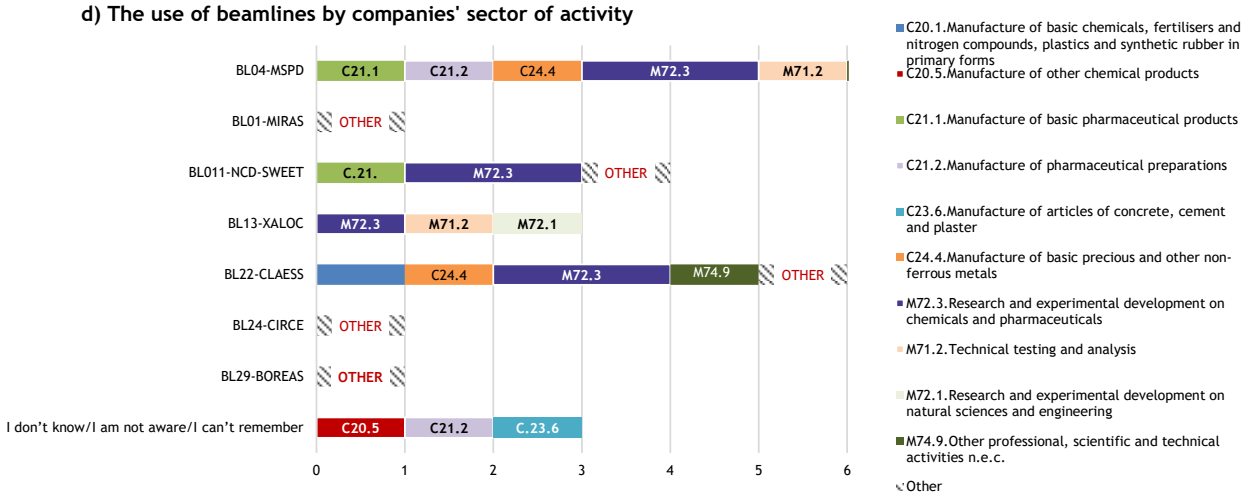
Note: a) Number of survey's respondents by use of results and sector of activity. CSIL processing of Questions A3 and C1 (18 respondents), Other includes manufacturers of cosmetics or chemical products.



Note: c) Average share of experiments carried out by survey's respondents. CSIL processing of Question B4 'On the total of experiments carried out at ALBA, please indicate the share of those for which the application was submitted by' (18 respondents).



Note: d) Average share of experiments carried out by survey's respondents. CSIL processing of Question B5 'On the total of your experiments at ALBA, please indicate the share of those carried out' (18 respondents).



Note: e) **Share of respondents by beamlines and sector of activity.** The beamline BL09-MISTRAL is missing since not used by this sample of respondents. CSIL processing of Questions A3 and B1 (18 respondents).

Source: *CSIL processing of Survey to users from the private sector (see Questionnaire in Annex 6.3)*

4.1.2 From the execution of the experiments to the innovation outputs

The objective of this section is to describe the pathways from the execution of the experiment to the development of an innovation output with economic or practical significance – such as a patent, a new product, improvement of an existing product/technology, etc. - by focusing on the time and activities (additional to the experiment carried out at ALBA) needed as reported by survey's respondents.

The scientific community

(19) 47% of respondents from the scientific community declares that they are not aware of the time needed to develop an innovation output - with economic or practical significance - starting from the results of their experiments at ALBA (***Figure 14.a***). 2% suggests that it may take less than 1 year while a significant share of respondents (about 35%) states that from 1 to 5 years are possibly needed. The remaining 16% suggests that more than 5 years may be needed.

(20) Only in a few cases, the results of an experiment can be immediately used for innovation purposes (***Figure 14.b***). Typically, other activities are needed to create an innovation output with economic or practical significance. According to respondents from the scientific community, most of the experiments (40%) need additional research activities carried out at their institutions, followed by a relatively low percentage of experiments which need additional

activities carried out by specialised companies (25%) or in other synchrotrons/research institutes (22%).

(21) Interestingly, different pathways can be observed depending on the type of research carried out (*Figures 14.c and d*), the research field (*Figures 14.e and f*) and the beamlines used (*Figures 14.g and h*).

- Not surprisingly, more uncertainty or a longer time span arise in the case of experiments entailing pure basic research while a shorter period is suggested for research with application orientation or industrially relevant research (*Figure 14.c*).

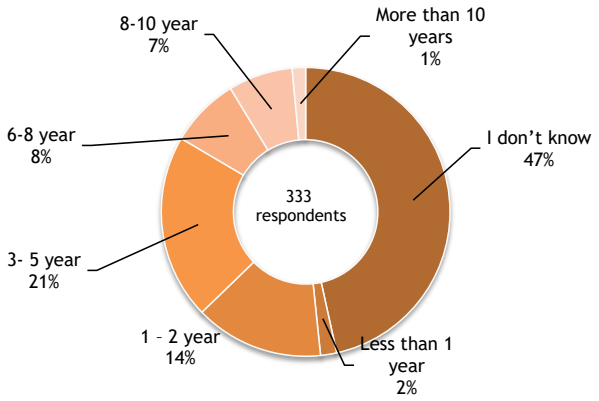
- Experiments entailing research with application orientation or industrially relevant research are mostly complemented with additional researches carried out internally. In comparison, experiments entailing pure basic research requires – on average - additional research activities carried out internally or in other research institutes and/or synchrotrons (*Figure 14.d*).

- More uncertainty or a longer time (mostly from 6 to more than 10 years) is suggested by respondents carrying out experiments in the field of solid-state physics and materials science concerning structure, phase transitions, nanomaterials as well as in the field of instrumentation and techniques development (*Figure 14.e*). These are also the research fields for which additional activities in other research institutes/synchrotrons as well as by specialised companies are mostly needed (*Figure 14.f*). A shorter period is indeed suggested for the experiments in the field of chemistry, material science for energy/information technology (the majority of respondents suggest less than 5 years), biology-life sciences and protein crystallography. In these research fields, experiments are mostly complemented with additional activities carried out internally (*Figures 14.e and f*).

- Being the use of beamlines mostly related to a specific type and field of research (as discussed above, Section 4.1.2), we identified some beamlines which are 'faster' to innovation, since providing results which need – in comparison – less time for being translated in innovation outputs and mostly activities carried out internally by the user groups. These include BL01-MSPD, BL22-CLAESS, BL13-XALOC, BL01-MIRAS and BL011-NCD-SWEET which are mostly used for research with an application or industrially relevant research in the field of energy, health, pharmaceutical, enabling technologies. On the other side, there are more basic research beamlines – such BL24-CIRCE, BL29-BOREAS and BL09-MISTRAL – which are 'slower' to innovation requiring a longer time to get into the market and generate an innovation output as well as additional activities carried out externally (e.g. in other synchrotrons or by specialised companies) (*Figures 14.g and h*).

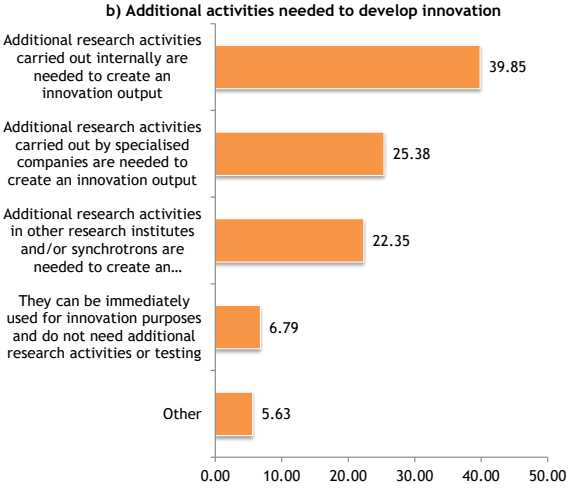
Figure 14 The pathways from experiments to innovation outputs: users from the scientific community

a) Additional time needed to develop innovation



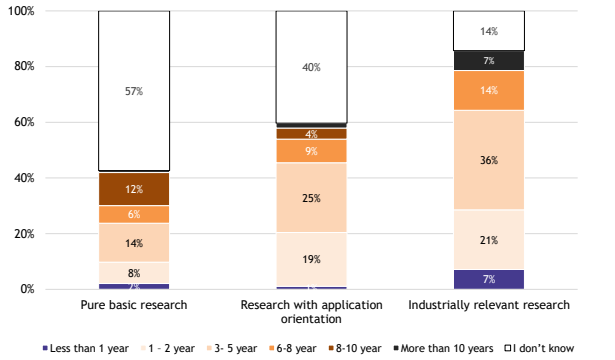
Note: a) Share of survey's respondents. CSIL processing of Question C4 (333 respondents).

b) Additional activities needed to develop innovation



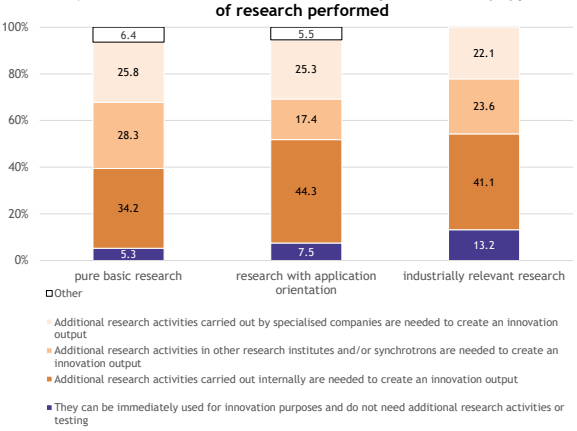
Note: b) Average share of experiments carried out by survey's respondents. CSIL processing of Question C5 'Considering the results of all your experiments at ALBA, please indicate the share of those for which the following steps/additional activities are usually needed to create an innovation output' (333 respondents). Other includes a combination of the above options or field trials to complete the experiments or 'I don't know' answers.

c) Additional time needed to develop innovation by type of research performed



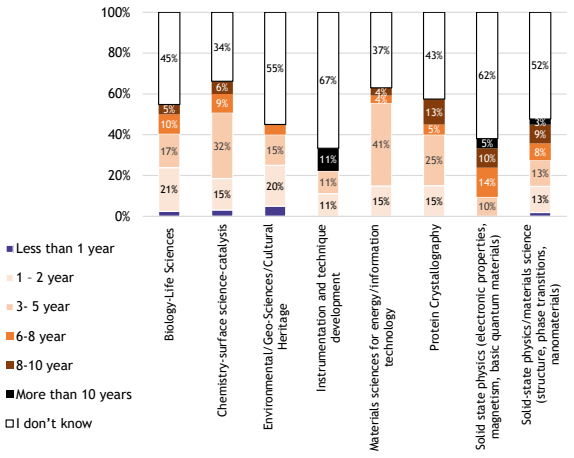
Note: c) Share of survey's respondents by type of research and years needed to create an innovation output. CSIL processing of Questions C3 and C4 (333 respondents).

d) Additional activities needed to develop innovation by type of research performed



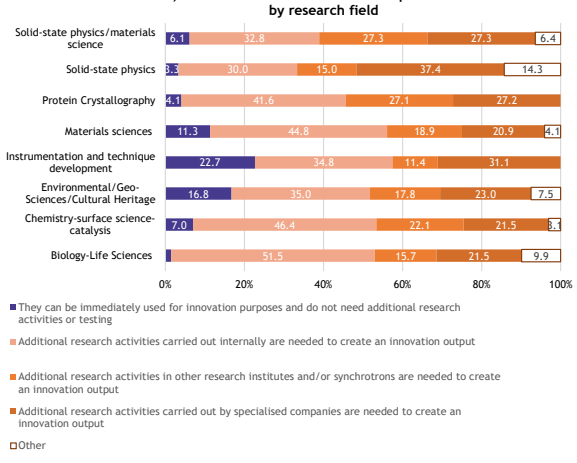
Note: d) Average share of experiments carried out by survey's respondents by type of research and activities needed to create an innovation output CSIL processing of Questions C3 and C5 (333 respondents)

e) Additional time needed to develop innovation by research field

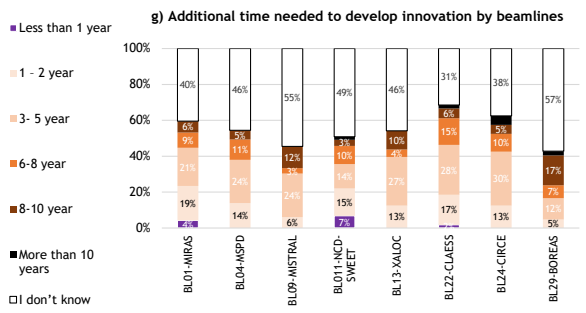


Note: e) Share of survey's respondents. CSIL processing of Questions A5 and C4 (333 respondents).

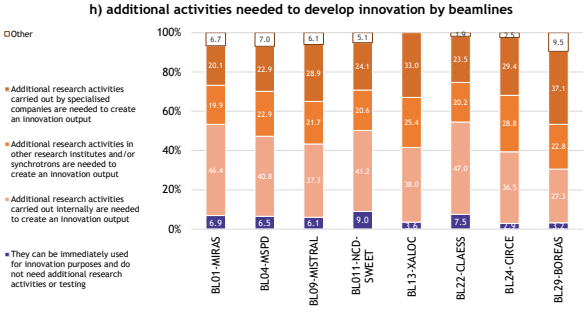
f) Additional time needed to develop innovation by research field



Note: e) Average share of experiments carried out by survey's respondents by research fields and activities needed to create an innovation output CSIL processing of Questions A5 and C5 (333 respondents)



Note: g) Share of survey's respondents. CSIL processing of Questions B1 and C4 (333 respondents).



Note: h) Average share of experiments carried out by survey's respondents. CSIL processing of Questions B1 and C5 (333 respondents).

Source: CSIL processing of Survey to users from the scientific community (see Questionnaire in Annex 6.2)

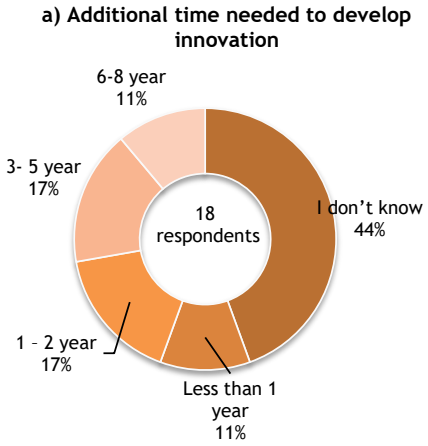
The private sector

(22) Similarly to users from the scientific community, there is a high share of respondents (44%) which is not aware of the time needed to develop an innovation output on the basis of their experiments at ALBA (***Figure 15.a***). 11% suggests that it may take less than 1 year while overall 34% suggests that the timing may range from 1 to 5 years. The remaining percentage (11%), suggests that from 6 to 8 years are possibly needed.

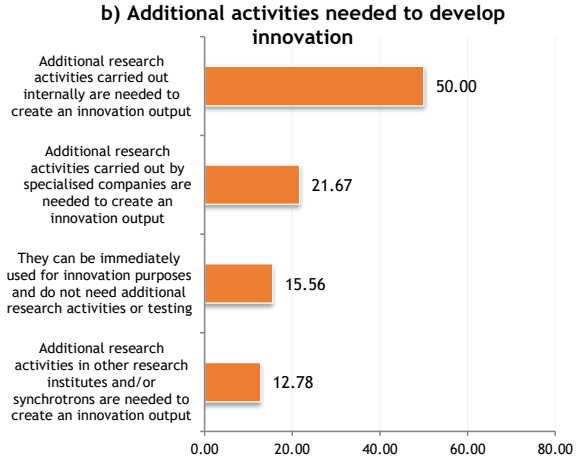
(23) In a few cases, results from experiments at ALBA can be immediately used to create an innovation output (on average 15.6% of experiments carried out by this sample). Additional activities carried out internally are mostly needed (50% of experiments) followed by those (on average, 21.7% of experiments carried out) which need additional activities carried out by specialised companies. Only for a few share (13%), additional researches in other research institutes or synchrotrons are needed (***Figure 15.b***).

(24) Overall, the majority of users from the private field (56%) estimates that they would need from EUR 500,000 to EUR 1,000,000 (including workforce and other costs) to create an innovation output on the basis of results of their experiments at ALBA (***Figure 15.c***). In terms of the workforce needed (***Figure 15.d***), the majority of respondents (50%) is not aware of the exact number of people needed, followed by 39% suggesting from 1 to 5 people and 11% from 6 to 10 people. In addition to the workforce, additional costs would be needed. Amongst the most mentioned ones (***Figure 15.e***), there is the purchase of raw materials or instruments to carry out additional research internally.

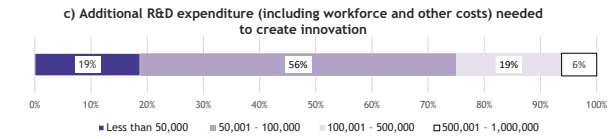
Figure 15 From experiments to innovation outputs: users from the private field



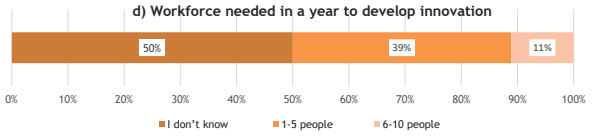
Note: a) Share of survey's respondents. CSIL processing of Question C3 (18 respondents).



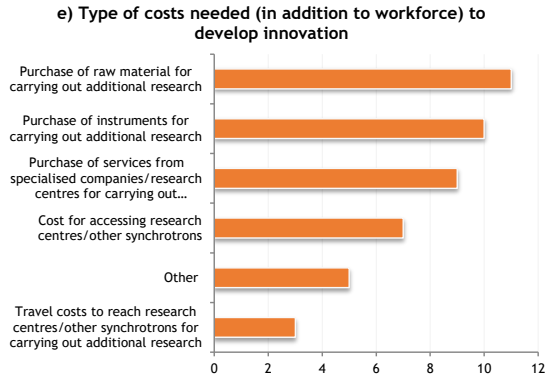
Note: b) Average share of experiments carried out by survey's respondents. CSIL processing of Question C2 'Considering the results of all your experiments at ALBA, please indicate the share of those for which the following steps/additional activities are usually needed to create an innovation output' (18 respondents).



Note: c) Share of survey's respondents. CSIL processing of Question C6 (17 respondents).



Note: d) Share of survey's respondents. CSIL processing of Question C4 (18 respondents).



Note: e) Number of survey's respondents. CSIL processing of Question C5, multiple asnwers allowed. (18 respondents).

Source: CSIL processing of Survey to users from the private sector (see Questionnaire in Annex 6.2)

(25) Different pathways can be observed depending on the purpose of the research carried out and the sector of activity.

- The majority (3 out of 5) of companies carrying out experiments for *external use* show uncertainty in terms of time needed to develop innovation (***Figure 16.a***). This is explained by the fact that all these users carry out research and experimental development on chemicals and pharmaceuticals. Results of their experiments are therefore provided to third companies (indirect users) – mostly manufacturers – which need additional time to develop new drugs and medicines; the time that third parties need may differ on whether they deal with basic products or pharmaceutical preparations. Users carrying out experiments for external use and suggesting from 1 to 5 years (2 out of 5) are companies dealing with research on natural sciences and engineering or other professionals, scientific and technical activities.

- Looking at users carrying out experiments for *internal use*, answers provided by respondents suggest that the time they need to develop innovation may be different (***Figure 16.a***). It is worth pointing out that all these users are manufacturers and the time they need may depend on the products they deal with. Users suggesting less than 1 year deal with pharmaceutical preparations or basic precious and other non-ferrous metals; users indicating from 1-2 years are users manufacturing articles of concrete, cement and plaster; users claiming from 3 to 5 years are those manufacturing basic chemicals, fertilisers and nitrogen compounds, plastics as well as synthetic rubber in primary forms; users answering 'I don't know' are those dealing with manufacture of chemical products or cosmetic.

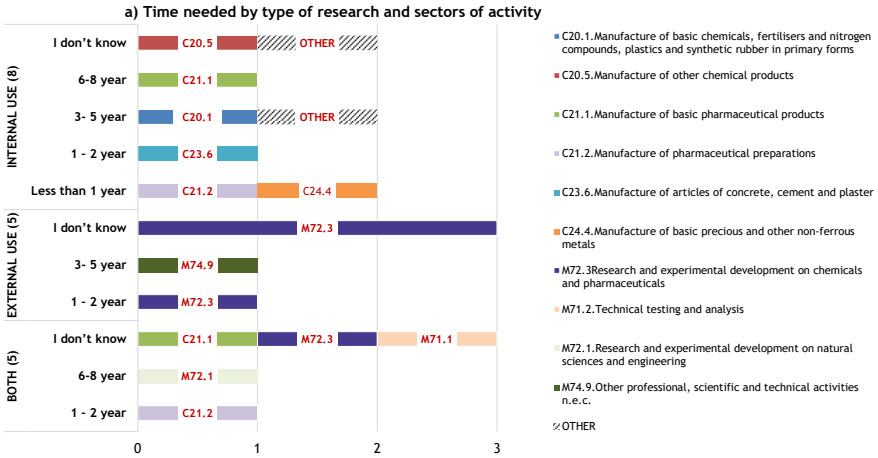
- Users carrying out experiments *both for internal and external use* also show more uncertainty on time needed to develop innovation. The majority (3 out of 5) of these users answered 'I don't know' (***Figure 16.a***). This can be explained by the fact that they deal with research and experimental development on chemicals and pharmaceuticals or testing and analysis for which it is more challenging to provide an estimation of the time. The remaining users providing an answer to this question are manufacturers. Specifically, users indicating from 1 to 2 years are those dealing with the manufacture of pharmaceutical preparations; those claiming from 6 to 8 years deal with research and experimental development on natural sciences and engineering, and therefore they expect that more time is needed to create an innovation.

- Overall, the time and the amount of additional resources (workforce and other costs) needed to develop innovation differ according to the sector of activity represented by the user (***Figures 16.b and c***).

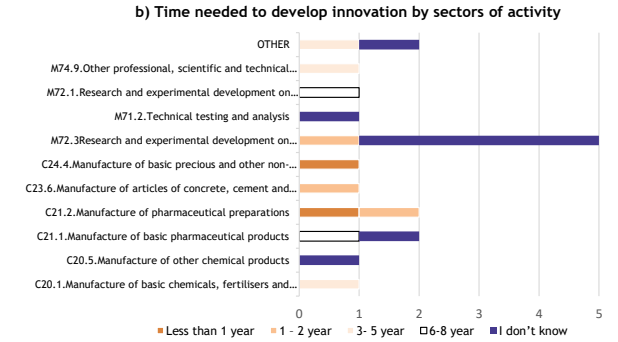
- There are some sectors for which there is more uncertainty – amongst users - about the time needed from experiments to innovation (***Figure 16.b***). These include companies dealing with research and experimental development on chemicals and pharmaceuticals, manufacture of chemical products or basic pharmaceutical product, technical testing and analysis. Looking more in details to the answers provided by these respondents, it arises that experiments carried out by these users may contribute to the initial phases of innovation development but, then, additional time is needed to carry out research mostly internally but also at other synchrotrons/research institutes or by specialised companies. In the field of basic pharmaceutical products, one user suggests that the development of innovation can also take from 6 to 8 years. Conversely, there are sectors in which innovation can be reached in a comparatively shorter time horizon (within 2 years). These include, for instance, manufacture of pharmaceutical preparations as well as of concrete, cement and plaster articles or basic precious and other non-ferrous metals.

- The amount of resources needed to develop innovation can vary a lot within the same sector (***Figure 16.c***). For instance, experiments from companies dealing with basic pharmaceutical products may require less than EUR 500,000 to develop an innovation - entailing the cost of 1-5 people and of accessing to additional synchrotrons - or also up to 1 billion – entailing the cost of 6-10 people, of instruments for carrying out additional research and of services by specialised companies (***Figures 16.d and e***).

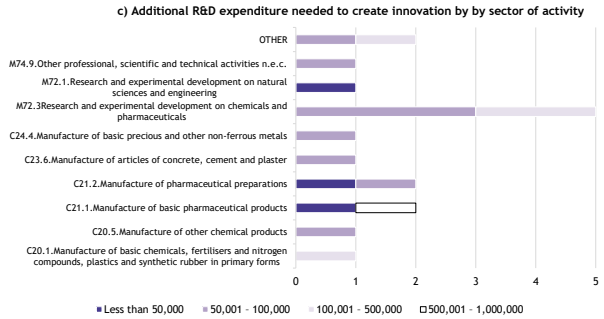
Figure 16 The pathways from the experiments to innovation: users from the private field



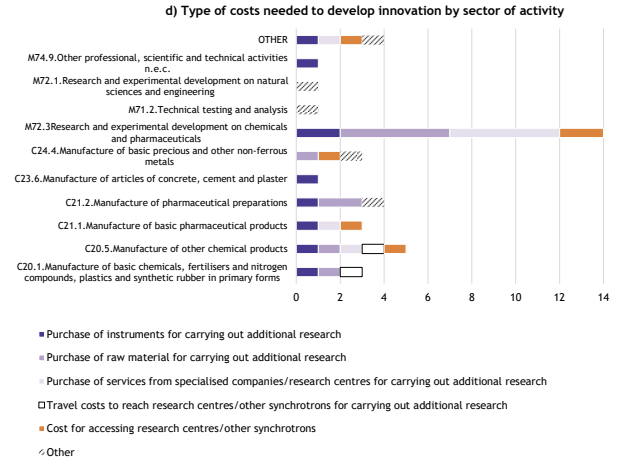
Note: a) Number of respondents by type of research, sectors of activity, years needed to develop innovation. CSIL processing of Questions A3, C1 and C3 (18 respondents).



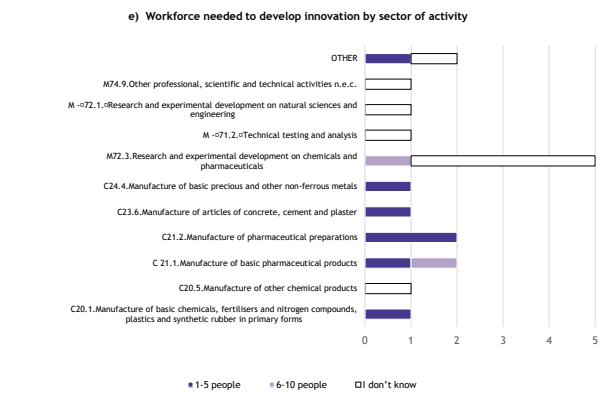
Note: b) Number of respondents. CSIL processing of Questions A3 and C3 (18 respondents).



Note: c) Number of respondents. CSIL processing of Questions A3 and C6 (17 respondents, missing answer from user representing the sector M - 71.2. Technical testing and analysis).



Note: d) Number of answers by sector of activity. CSIL processing of Questions A3 and C5 (18 respondents). Multiple answers allowed to Question C5.



Note: e) Number of respondents by sector of activity. CSIL processing of Questions A3 and C3 (18 respondents).

Source: CSIL processing of Survey to users from the private sector (see Questionnaire in Annex 6.3)

4.1.3 Outputs arising from experiments at ALBA

The objective of this section is to provide an overview of the type of outputs arising from experiments carried out at ALBA – through the processes described above - as reported by the survey's respondents.

The scientific community

(26) Publications in peer-reviewed journals are always (48% of respondents) or very often (39%) the outputs of experiments carried out at ALBA by users from the scientific community. Most common are also conference proceeding books or PhD thesis. Never or rarely, their experiments translate directly into patents or technical notes (***Figure 17.a***).

(27) Results stemming from the experiments carried out by these users are declared to be most relevant for basic research (***Figure 17.b***) and for academic/researchers (***Figure 17.c***). In very few cases, these results are stated to be immediately relevant to industries. Some differences have been noted across ALBA beamlines: experiments carried out on BL22-CLAESS and BL01-MIRAS allow to results which – as compared to other beamlines – are more useful for industrially relevant research (***Figure 17.d)***. On the other side, results from the use of BL13-XALOC and BL29-BOREAS are more relevant to fundamental research.

(28) Overall, 94% of respondents (***Figure 17.e***) recognise that as a result of the new knowledge generated by their experiments on ALBA beamline, companies and other players interested in technological developments *were able/could be able in the future* to achieve an innovation output. Amongst the most cited outputs, there are the development of new technologies and

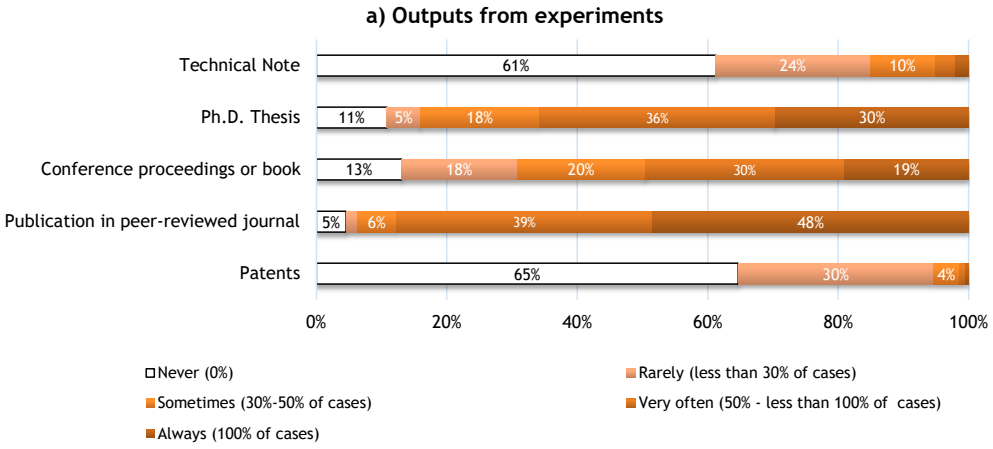
new products, improvement of technical know-how, R&D and innovation capabilities and quality of existing products. Interestingly, the development of new patents, copyrights, or other intellectual property rights ranks lower in their list (*Figure 17.f*).

(29) A very few percentages of respondents have declared that they have contributed in the past to the development of patents (4% of respondents) or that they are aware – mostly by word of mouth from other academic colleagues - of third parties (5% of respondents) which have filled in patents on the basis of their experiments (*Figure 17.g)*. When this occurred, the patent's sectors most cited by users are energy, chemistry, pharmaceutical and nanotechnologies (*Figure 17.h)*.

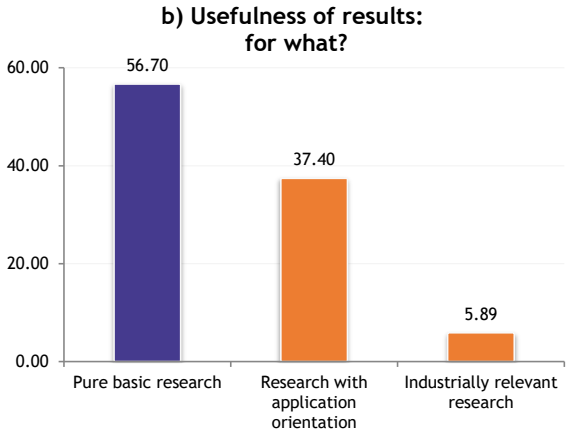
(30) Interestingly, the development of these patents – both directly or indirectly – are not related to a specific strategy adopted during the design of the experiment (e.g. involvement of a private company). They stem from experiments carried out by frequent and occasional users and mostly from those carrying out research with application orientation or pure basic research (only in one case the contribution to the development of patent comes from a user carrying out industrially relevant research) in the following research fields: chemistry, material science for energy/information technology, protein crystallography and solid-state physics/materials science (structure, phase transitions, nanomaterials).

(31) *Figure 17.i* below shows the beamlines which have been used by respondents who have directly or indirectly contributed to the development of a patent in a specific sector. It is worth noting that patents in the health and pharmaceutical sectors mostly come from those users who have carried out experiments on BL13-XALOC and BL22-CLAESS beamlines. Experiments on the beamline BL04-MSPD and BL22-CLAESS have directly or indirectly allowed to the development of patents across a wider range of fields.

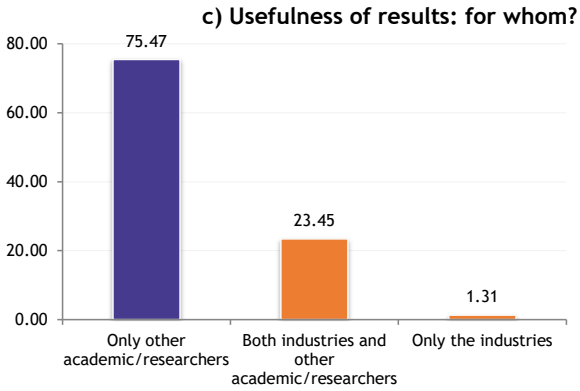
Figure 17 The use of ALBA beamlines: outputs arising from experiments carried out by users from the scientific community



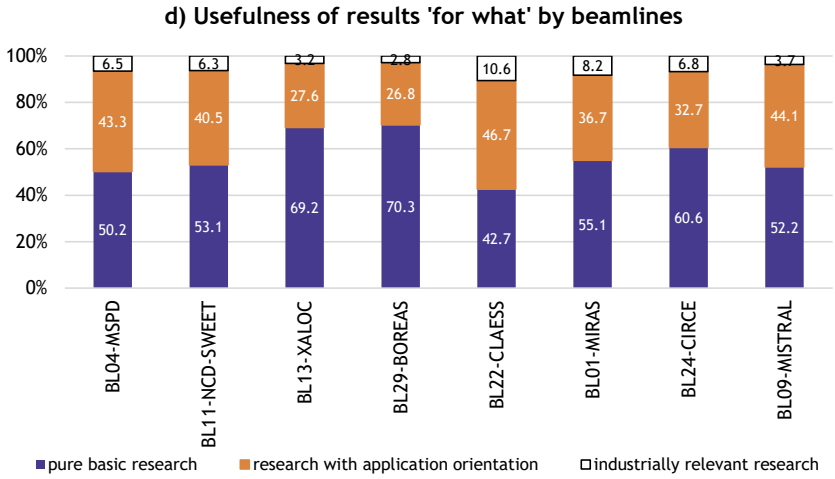
Note: a) Share of survey's respondents. CSIL processing of Question C.1 (351 respondents).



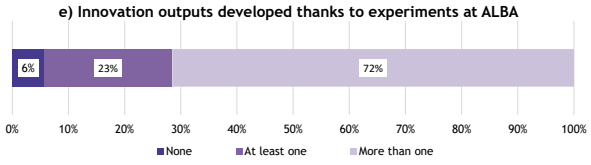
Note: b) Average share of experiments carried out by survey's respondents. CSIL processing of Question C.3 'On the total of your experiments at ALBA, please indicate the share of those whose results are useful for '(351 respondents).

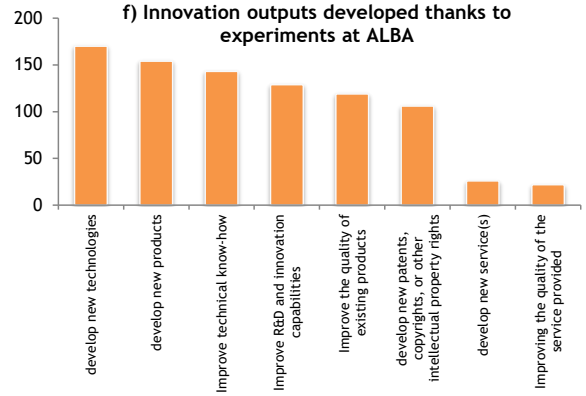


Note: c) Average share of experiments carried out by survey's respondents. CSIL processing of Question B.5 'On the total of your experiments at ALBA, please indicate the share of those whose results are relevant to' (351 respondents).

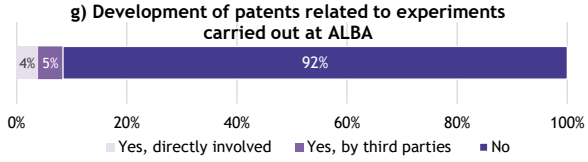


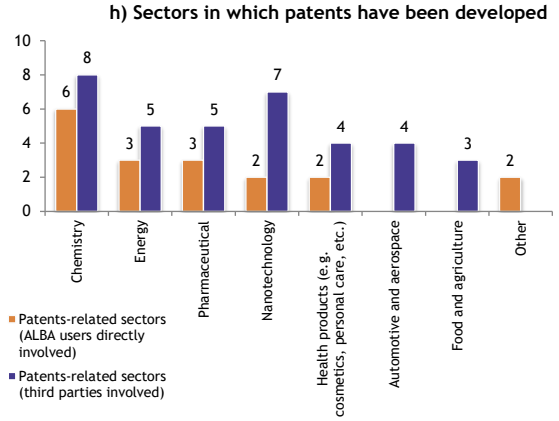
Note: d) Average share of experiments carried out by survey's respondents. CSIL processing of Questions C.3 and B.2 (351 respondents).



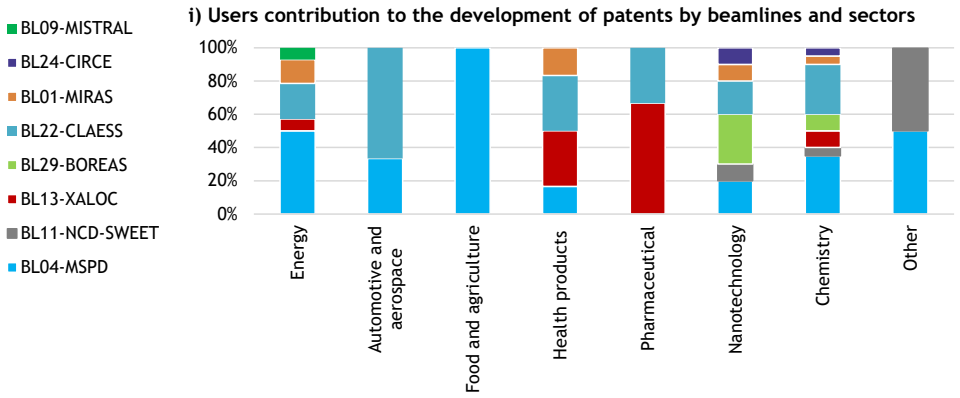


Note: e) Share of respondents. CSIL processing of Questions C.8 (351 respondents).
f) Number of respondents. CSIL processing of Questions C.8, multiple answers allowed (351 respondents).





Note: g) Share of respondents. CSIL processing of Questions C.6 and C7
h) Number of respondents. CSIL processing of Questions C.6.1 and C7.1 (333 respondents, multiple answers allowed), the figure shows the number of respondents indicating the sectors of patents they/third parties have contributed to. Other includes mechanical engineering and manufacturing.



Note: h) CSIL processing of Questions C.6.1, C7.1 and B1 (333 respondents).
Source: CSIL processing of Survey to users from the scientific community (see Questionnaire in Annex 6.2)

(32) As reported by respondents, several innovation outputs could be developed in the future based on their experiments at ALBA. Some interesting examples are provided in the Box below:

- Results can be used to develop drugs which prevent toxic protein aggregation (*user of BL01-MIRAS, pure basic research, health sector*).
- Ongoing experiments (carried out both at ALBA and Diamond light source) are focused on the characterization of two new models of Parkinson disease: one in mice and another in the rat. Once they are validated, they will be valuable to study new therapies to treat Parkinson (*user of BL09-MISTRAL and BL01-MIRAS, research with application orientation, health sector*).
- Experiments are addressed to improve the environmental resistance of anti-reflective coatings (ARC) based on texturized surfaces. ARC is generally employed to avoid glare and reflections of displays or improve the efficiency of solar cells (*user of BL011-NCD-SWEET, research with application orientation, energy sector*).
- Results of experiments would help to improve the diagnosis of harmful environmental conditions to plants. These techniques could help to increase crop production and food safety (*user of BL01-MIRAS, pure basic research, food and nutrition sector*).
- Experiment on metallic glasses may become quite important in structural applications and micromachinery (*user of BL22-CLAESS, BL04-MSPD, BL01-MIRAS, pure basic research, advances in other enabling technologies*)
- Metallic particles are analysed to be inserted in polymers for 3D printing (*user of BL04-MSPD, research with application orientation, applications to Public Sector Challenges such as security, safety, inclusiveness*).
- Although further experiments are needed, results are expected to end in patent applications for antivirals (*user of BL09-MISTRAL, research with application orientation, health sector*).
- New crops, more resistant to climate change, could be developed (*user of BL01-MIRAS, research with application orientation, environment sector*).
- Possible development of new or improved materials (or their patents) for spintronic and magnetoelectronic applications, such as telluride-based diluted magnetic semiconductors, thermoelectric materials or topological materials, with improved electronic and magnetic properties (*user of BL29-BOREAS, pure basic research, energy sector and advances in enabling technologies*)
- Studying scaling processes, especially studying the kinetics behind it (e.g. particle size, phase changes, etc.), is very useful for oil & gas industries (BaSO4) as well as drinking water industries (CaCO3) (*user of BL011-NCD-SWEET, industrially relevant research, Particle nucleation & growth*).
- Understanding the mechanisms on the aggregation of small molecules in aqueous media can contribute for designing new chemical agents with tailor-made properties regarding biological activity (*user of BL011-NCD-SWEET, pure basic research, health or advances in enabling technologies*).

Source: CSIL processing of Survey's results

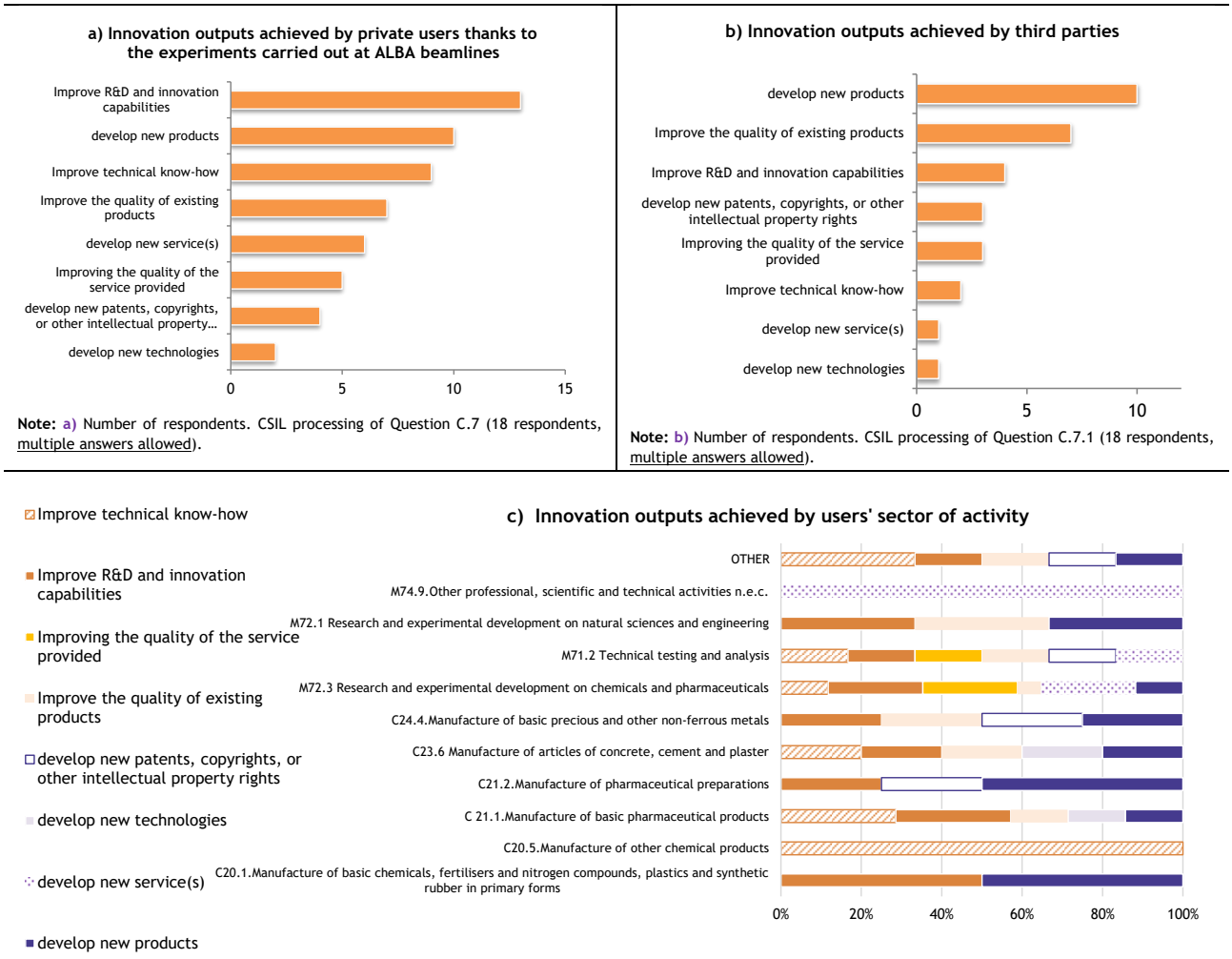
The private sector

(33) All respondents confirmed that an innovation output was achieved from their experiments at ALBA. Amongst the most cited outputs, there are 'improved R&D and innovation capabilities', 'development of new products', 'improved technical know-how and the quality of existing products'. The development of new patents or other forms of intellectual property ranks lower in this list (***Figure 18.a)***.

(34) It is worth pointing out that 'improved R&D and innovation capabilities' has been experienced by all the users regardless the sector in which they operate while some differences can be observed with regard to other innovation outputs (***Figure 18.c)***. Experiments performed by manufacturing companies or those carrying out research and development experiments have, in most sectors, allowed the development of a new product or improving an existing one. Companies which have experienced the development of new patents, copyrights, or other intellectual property rights operate in the following fields: manufacture of pharmaceutical preparations, manufacture of basic precious and other non-ferrous metals, technical testing and analysis and chemistry on adhesives, coatings and lubricants.

(35) The majority of respondents (14 out of 18) confirmed that innovation outputs were also experienced by third parties which have used results of their experiments. Specifically, these results have mostly contributed to the development of new products or improve the quality of existing ones (***Figure 18.b)***.

Figure 18 The use of ALBA beamlines: outputs arising from experiments carried out by users from private sector



Note: a) Number of respondents. CSIL processing of Question C.7 (18 respondents, multiple answers allowed).

Note: b) Number of respondents. CSIL processing of Question C.7.1 (18 respondents, multiple answers allowed).

Note: c) CSIL processing of Questions A3 and C.7 (18 respondents, multiple answers allowed), Other includes cosmetics and chemistry on adhesives, coatings and lubricants.

Source: CSIL processing of Survey to users from the private sector (see Questionnaire in Annex 6.3)

The use of results from ALBA experiments by indirect users

(36) Both users from public (50% of respondents) and private (39% of respondents) field admitted that they received an expression of interest for results arising from their experiments at ALBA by third parties. They reported that this interest came mostly from other researchers working in the academic field/in research centres and other private companies, respectively. Some respondents from public and private fields (overall 33) also suggested indirect users to be contacted for the purpose of this study.

(37) Indirect users interviewed in the framework of this study (overall 15) include a representative of the private sector (a spin-off working in the health sector) as well as professors/researchers covering the following research fields: Environmental Sciences, Biology-Life Sciences (not PX), Materials science for food-related applications, Food science and technology, Solid-state physics/materials science (structure, phase transitions, nanomaterials), Protein Crystallography and Cultural Heritage.

(38) The evidence collected suggests that indirect users of ALBA mostly divide in the following categories:

- those who have contributed to the design of the experiments - being part of the team submitting the proposals - but who have never accessed the synchrotron as a direct user;

- those who have specifically commissioned the experiment to ALBA direct user – both academics or companies – since they don't have the expertise and skills to operate the beamlines as well as to understand and explain the results;

- those who have known about results of experiments either through their network of researchers or companies they cooperate with or through publications or similar products (e.g. conference proceedings, PhD thesis, etc.) issued by ALBA users.

(39) In very few cases, results from experiments carried out at ALBA can be immediately used by indirect users. It is most frequent that – for the achievement of their objective – indirect users have to carry out, mostly internally, additional complementary research activities and testing. These results represent one of the several 'ingredients' to advance in their research which is mostly oriented to applications. Evidence collected suggests that these results have been used to contribute to different sectors, although the most cited ones are energy, food and nutrition, health, biodegradable packaging materials, climate and resources. To provide some examples, results have been used for improving the design of materials for food-related applications, for understanding the structure of polysaccharides (e.g. cellulose, agar, carrageenan, etc.) in biodegradable packaging materials or in gels developed for food ingredients, for advancing with the diagnosis of Parkison's Disease (e.g. by showing that the neuromelanin pigment generated in an experimental rodent model had the same properties as human neuromelanin), to understand active protein crystals grown in-situ within the hydrogel allowing to manufacture pharmaceutical compositions, etc.

(40) On the basis of results from ALBA experiments, indirect users mostly produce publications or conference proceedings/thesis which are expected to further contribute in the future to the development of new product or improving an existing one.

(41) Where patents are developed, these can be authored both by ALBA direct and indirect users or by indirect users only. The first example mostly occurs when indirect users are from the same university/department of ALBA direct users and have collaborated with them to the design of the experiments without accessing the synchrotron (e.g. because they don't have the skills or expertise to operate beamlines). The second example usually occurs when direct users act as 'service providers' such as they provide their expertise in the operation of beamlines and explanation of results to third parties who deal with the creation of the patent.

(42) The time needed to develop patents depends on several factors. Firstly, it depends on the nature of the results they rely on. The more results are related to basic research – such as focused on the structure of the materials - more time is needed to create the patent since additional activities are required to complement research results. Also, the time may be different according to the beamlines used, type of research and research field. On average, they entail 1-2 years – spent in additional research activities - to create the patent from the use of ALBA results. However, this time can be longer (e.g. up to 6-8 years) in the case of results from experiments related to basic research (e.g. on solid physics or, e.g. pure basic research on BL29-BOREAS). An additional aspect to consider is whether the registration of the patent occurs in the same country of the institution/company applying for it (as it frequently happens) – usually requiring 1 year for being accepted - or in a different country or systems (e.g. international or European system) which may require more time (additional 2-3 years).

(43) Results provided by ALBA experiments could have been achieved by using alternative tools (e.g. other synchrotrons, conventional X-rays techniques, etc.) but not for all the research fields. For instance, indirect users working with protein crystallization cannot understand the features of protein crystals without the use of specific beamlines.

(44) All the interviewees strongly agreed that the availability of results from ALBA experiments allowed them to increase productivity by saving time and costs in the advancement of their research. Amongst others, these results significantly helped them in getting a better understanding of their research area as well as improving the quality of their research.

4.1.4 Benefits gained by direct users from their use of ALBA

In addition to the wider impacts arising from ALBA experiments to the community - e.g. in terms of new knowledge created, improved technical know-how, new patents, etc. - experiments carried out at ALBA also generated some benefits on users themselves, as reported in what follows.

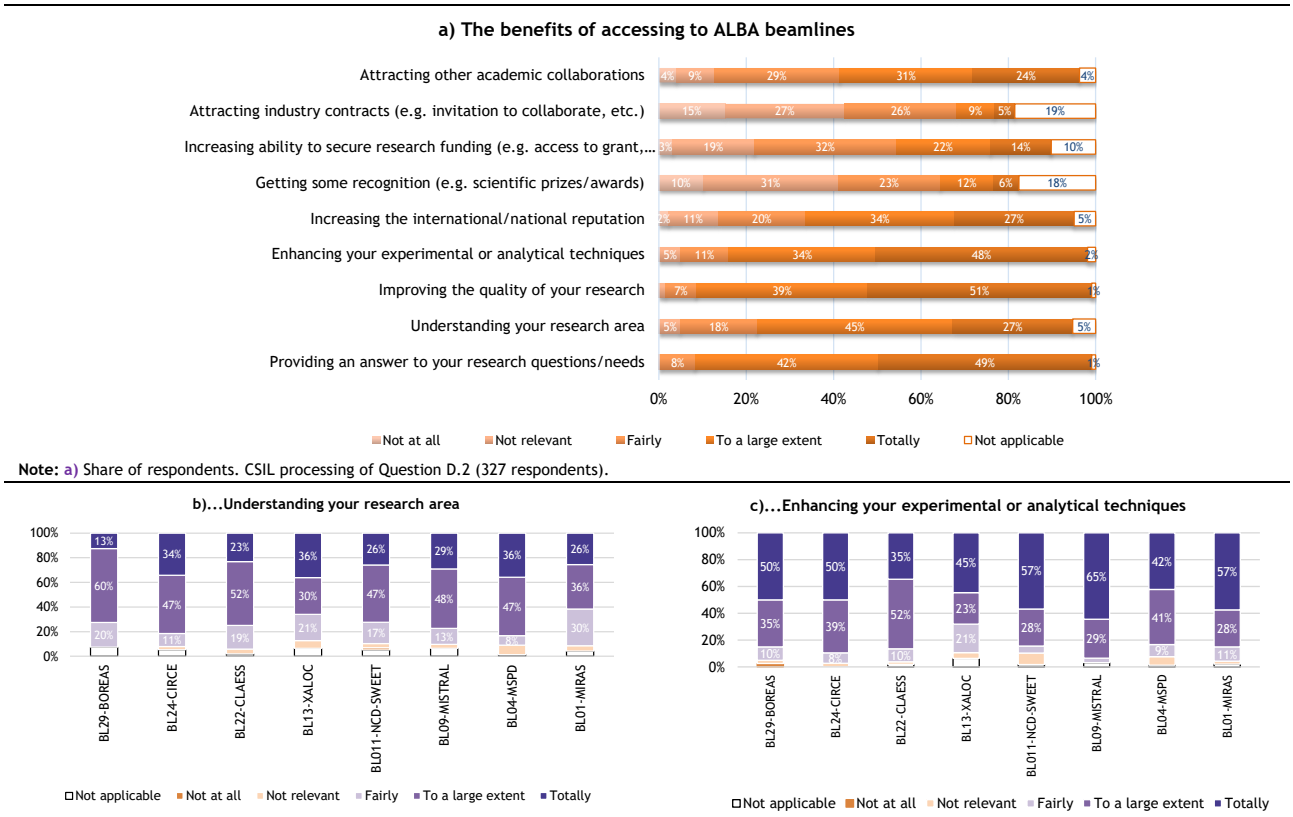
The scientific community

(45) According to respondents from the scientific community, accessing ALBA facilities helped to provide an answer to their research questions/needs, improve the quality of research, getting a better understanding of research areas, enhancing experimental or analytical techniques. In comparison, it was less relevant for getting international recognition or attracting industry contracts or academic collaborations (*Figure 19.a*). No significant differences were observed on the answers provided by frequent, infrequent or occasional users. Instead, some differences can be noted amongst respondents with respect to the beamlines they have been using, especially in

terms of 'understanding their research area' and 'enhancing experimental and/or analytical techniques (*Figures 19. b and c*).

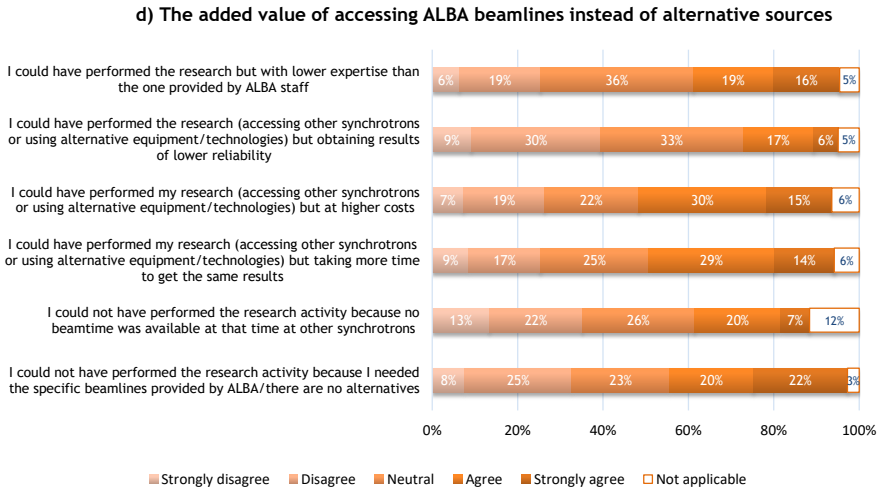
(46) Overall, a relatively high share of respondents agree or strongly agree with the fact that they could not have performed their research without the specific beamlines provided by ALBA (42%) and that using other alternatives (e.g. other synchrotrons or equipment/technologies) would have required longer time (43%) and entailed higher costs (45%), (*Figure 19.d*). Benefits in terms of time and costs are cited especially by respondents from Spain (*Figures 19.e and f*). As explained by some users, having ALBA close to their institution made much easier and cheaper the logistics of doing experiments. Also, having the possibility to access on a regular basis to the same beamline is critical where users have developed specific equipment to design the experiments and analyse data. Results also show that a relatively high share of respondents (42%) have applied to ALBA since they needed its specific beamlines, without which they could not have performed their research. In comparison, the decision to apply to ALBA is not related, for the majority of respondents, to the availability of beamlines at other synchrotrons or to have results of higher reliability (*Figure 19.d*).

Figure 19 Benefits gained by ALBA direct users from the scientific community

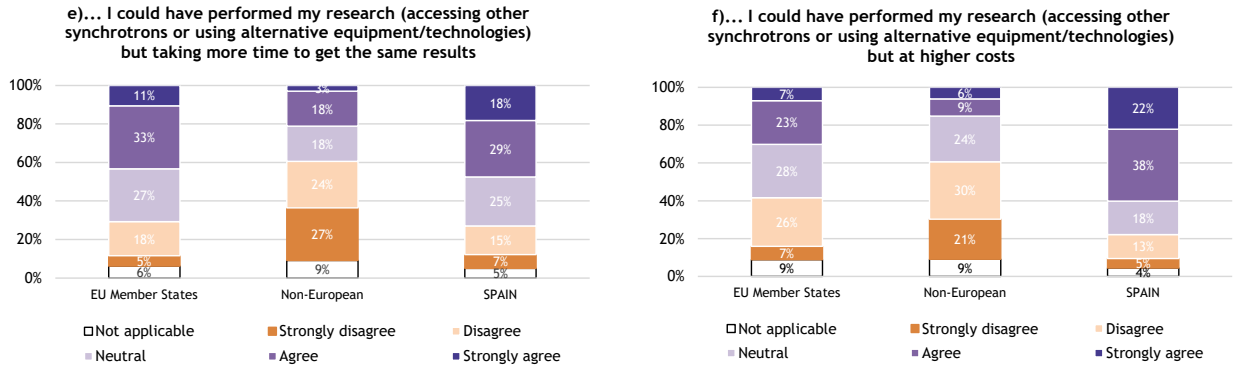


Note: a) Share of respondents. CSIL processing of Question D.2 (327 respondents).

Note: b) and c) Share of respondents. CSIL processing of Questions D.2 and B1 (327 respondents).



Note: d) Share of respondents. CSIL processing of Question D.1 (327 respondents).



Note: e) and f) Share of respondents. CSIL processing of Questions D.1 and country of respondents (A2) (327 respondents).

Source: CSIL processing of Survey to users from the scientific community (see Questionnaire in Annex 6.2)

The private sector

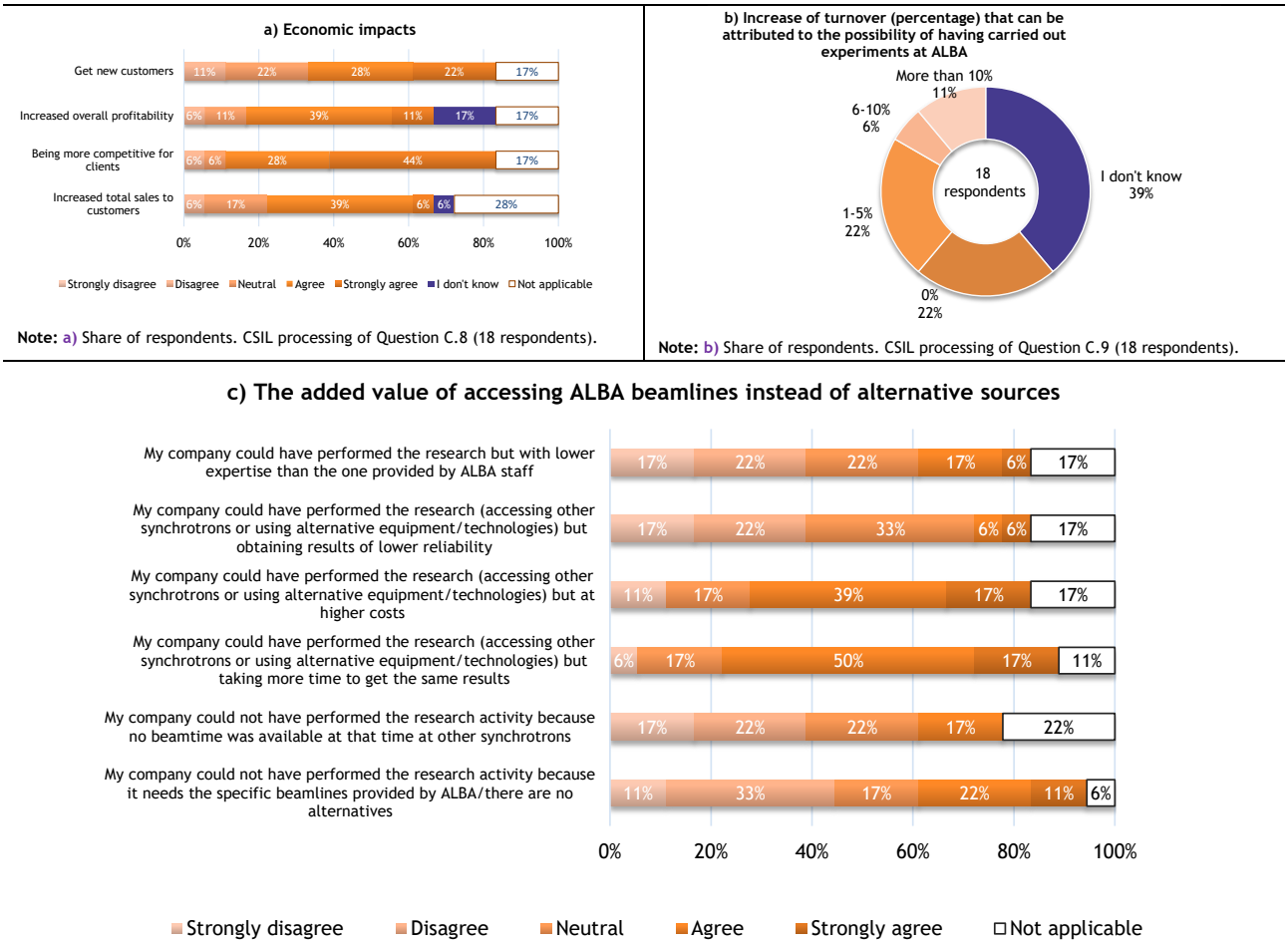
(47) As a result of the knowledge and improvements (e.g. to their product/services, etc.) gained with the experiments on ALBA beamline (*Figure 20.a*), there is a relatively high share of respondents which agreed or strongly agreed with the fact that they have become more competitive for clients (72% of respondents), increased total sales to customers (44%), increased overall profitability (50%) and got new customers (50%). Amongst these respondents, there are companies operating in the fields of manufacture of basic pharmaceutical products, manufacture of pharmaceutical preparations, manufacture of articles of concrete, cement and plaster, research and experimental development on chemicals and pharmaceuticals and technical testing and analysis.

(48) A high share of respondents (39%) is not able to quantify the increase of profitability related to the experiments carried out at ALBA (*Figure 20.b*). 22% declared that there was no increase while the other 22% that there was an increase between 1-5% of their turnover. A minor share of respondents (6%) recognised an increase between 6-10% while the remaining 11% experienced an increase of more than 10%.

(49) Similarly to users from the scientific community, there is a certain level of agreement amongst respondents from private field (*Figure 20.c*) about the fact that without accessing ALBA the company would have taken more time to get the same results (67% of respondents agreed or strongly agreed) as well as higher costs to perform the research (56% of respondents agreed or strongly agreed). This can be explained by the fact that the majority of ALBA private sector

users are from Spain and logistically it was more convenient for them accessing the synchrotron instead of looking for other alternatives.

Figure 20 Impacts on ALBA direct users from the private field



Note: a) Share of respondents. CSIL processing of Question C.8 (18 respondents).

Note: b) Share of respondents. CSIL processing of Question C.9 (18 respondents).

Note: e) Share of respondents. CSIL processing of Question C.10 (18 respondents).

Source: CSIL processing of Survey to users from the private sector (see Questionnaire in Annex 6.3)

4.2 From experiments to innovation outputs: evidence from patents' citation analysis

4.2.1 The process: from publications to patents

As mentioned in Section 3.2.2 above, tracking innovation outputs triggered by ALBA' scientific activities consisted of identifying patents generated by exploiting the knowledge generated by ALBA direct users' publications (first wave knowledge) as well as the knowledge encompassed in publications (second wave) citing articles written by ALBA direct users.

In the following, we define knowledge outputs generated by ALBA direct users as level 0 publications (P0) and knowledge outputs generated by those citing ALBA publications as level 1 publications (P1). Similarly, we defined patent documents citing level 0 publications as level 0 patents (Pat0) and patent documents citing level 1 publications as level 1 patents (Pat1).

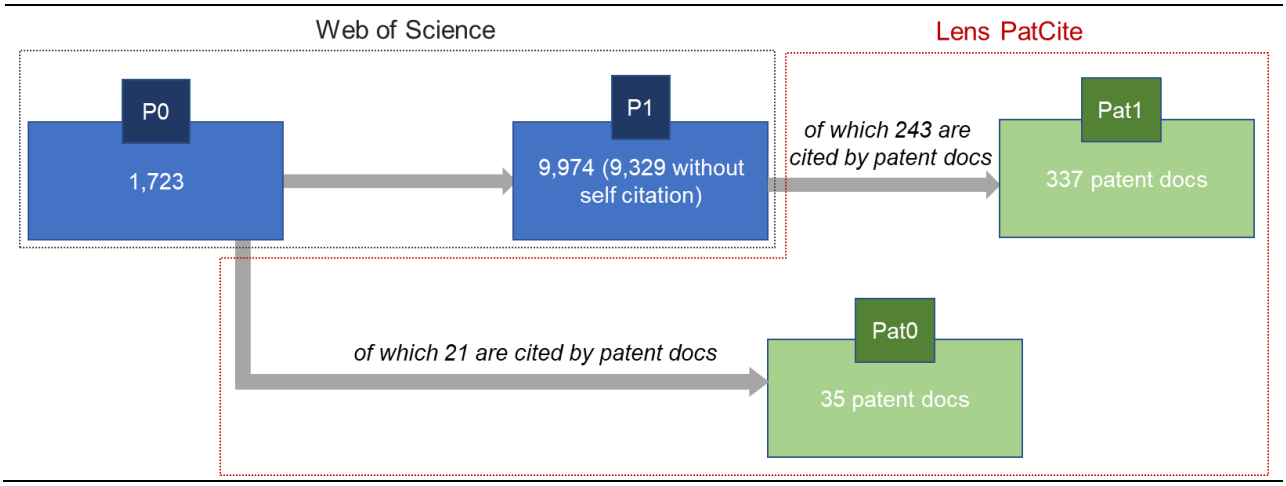
The bibliographic database used as a basis for the patent analysis was built into phases. For P0 publications, we relied on ALBA database which contains 1,723 references (see Section 2.3 above). The second wave publications were extracted directly from the Web of Science website by querying the public user interface. The collection of level 1 publications obtained by this

procedure allowed us to enlarge the database with 9,974 (9,329 without self-citation) additional references. The database was constructed during March 2019.

Next, we examined patents that cite scholarly articles. Starting from the publications' DOI[22], we built a database of patents that cite scientific publications of levels 0 and 1. To do so, we used Lens PatCite tool[23]. We found that that 21 out of 1,723 publications generated by ALBA users - (P0) publications - are cited by 35 patent documents of level 0 (Pat0). 243 out of 9,974 publications of level 1 are cited by 337 patent documents of level 1 (Pat1).

A graphical summary of such steps is shown in the Figure below.

Figure 21 Graphical representation of the analysis



Source: *CSIL*

4.2.2 Publications and patent documents of level 0

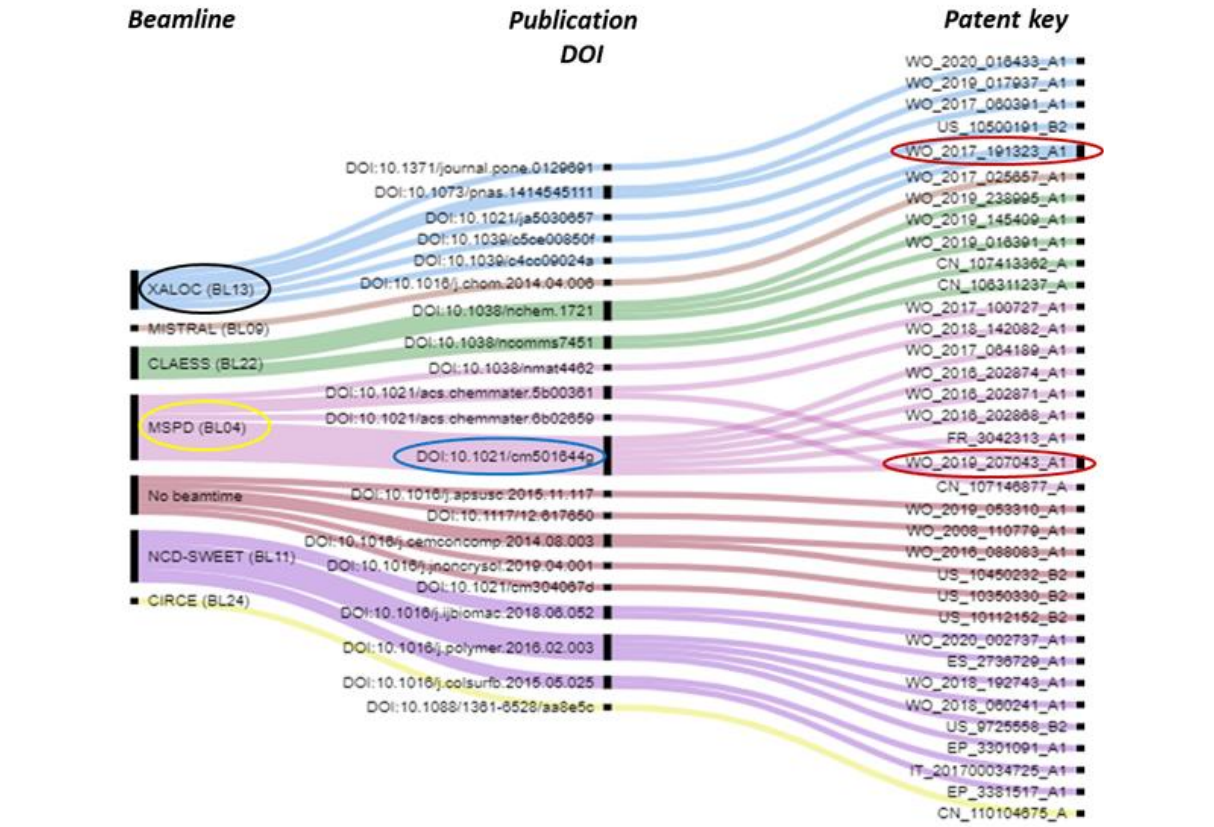
As said, 21 out of 1,723 publications generated by ALBA users were cited by 35 patents documents (corresponding to 31 patent families[24]). In particular, we found 5 granted patents and 30 patent applications of level 0. *Figure 22* shows the matches between the beamline used to carry out the experiment at ALBA, the publications (P0), and the patent documents (Pat0). The number of patent citations per article range from 1 to 6. The most cited article titled "Na3V2(PO4)2F3 Revisited: A High-Resolution Diffraction Study" (black circles) has been cited by 6 patent documents corresponding to 5 different patent families. Only in two cases (see blue circles), the same patent document cites more than one publication of level 0.

[22] The digital object identifier is a persistent identifier widely used to identify academic, professional, and government information, such as journal articles, research reports and data sets.

[23] https://www.lens.org/. Lens is the world's largest open and free data platform of the global patents and scholarly articles.

[24] A patent family is a collection of patent applications covering the same or similar technical content.

Figure 22 Matches between P0 (left-hand side) and Pat0 (right-hand side)



Note: Publications are identified with the DOI number, the patent documents with LensID
Source: *CSIL processing of Lens PatCite results*

The following table summarises the main features of the cited articles. All articles are in the field of chemistry, involve several authors (from a minimum of 3 up to 18) and were published in the period 2013-2019 with the exception of one article which dates back to 2005. 9 out of 21 articles (43%) were directly drafted by ALBA scientists. 16 out of 21 publications (76%) are actually related to the use of beamline at ALBA, while 5 (24%) are no beamtime related (which means that they do not rely on experiments carried out at ALBA beamlines). The beamline related publications (in total 16) distinguish as follows:

- In terms of the nature of experiments held on the beamlines: 13 are academic, 1 is in-house, 1 is industrial and 1 is from expert user.
- In terms of beamline: 5 used XALOC (BL13); 4 used MSPD (BL04); 3 used NCD-SWEET (BL11); 2 CLAESS (BL22); 1 used CIRCE (BL24), and 1 used MISTRAL (BL09). While most of P0 publications have been generated from experiments carried out at XALOC (BL13), MSPD (BL04) is the beamline associated to the higher number of patent documents (10, see yellow circle in *Figure 22* above).

Interestingly, at the time of the application process for ALBA beamtime, none of the articles was associated with industrial relevance/collaboration/involvement with the exception of one article for which collaboration with an industrial group was indicated. Nevertheless, 16 out of 35 patent documents (46%) which cite these articles are owned by a firm or by a firm in partnership with a university or a public research institute (see *Figure 22*). This fact reveals that such publications were to some extent of interest for the industry.

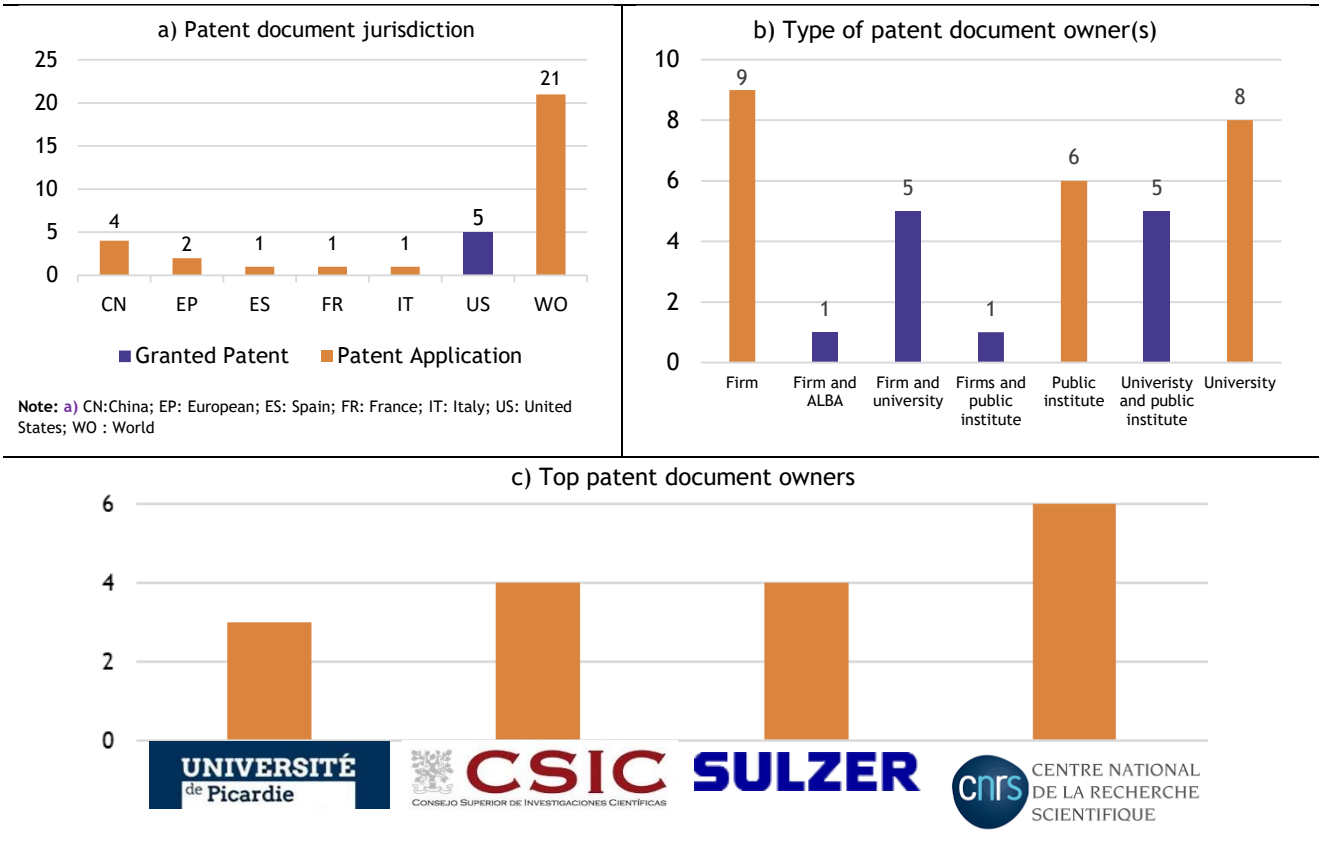
Table 2 The publication of level 0 cited by patent documents

YEAR	TITLE	N° OF AUTHORS	AUTHORS FROM ALBA	ALBA BEAM	TYPE OF RESEARCH	INDUSTRIAL RELEVANT	COLLABOR. WITH AN INDUSTRIAL GROUP	INDUSTRIAL INVOLVEMENT	CITING PATENTS (FAMILIES)
2014	Na3V2(PO4)2F3 Revisited: A High-Resolution Diffraction Study	8	Yes	MSPD (BL04)	In-house	No	No	No	6 (5)
2016	Poly (alkylene 2,5-furandicarboxylate)s (PEF and PBF) by ring opening polymerization	3	No	NCD-SWEET (BL11)	Academic	No	No	No	4 (4)
2013	Exceptional oxidation activity with size-controlled supported gold clusters of low atomicity	13	Yes	CLAESS (BL22)	Friendly	No	No	No	3 (3)
2015	Metal organic framework-mediated synthesis of highly active and stable Fischer-Tropsch catalysts	18	No	CLAESS (BL22)	Academic	No	No	No	2 (2)
2015	Faceted phospholipid vesicles tailored for the delivery of Santolina insularis essential oil to the skin	13	No	NCD-SWEET (BL11)	Academic	No	No	No	2 (1)
2018	Potential of lignocellulosic fractions from Posidonia oceanica to improve barrier and mechanical properties of bio-based packaging materials	3	No	NCD-SWEET (BL11)	Academic	No	No	No	2 (1)
2015	Effect of calcium sulfate source on the hydration of calcium sulfoaluminate eco-cement	6	No	No beamtime	No beamtime	No	No	No	2 (1)
2015	Comprehensive Investigation of the Na3V2(PO4)2F3–NaV2(PO4)2F3 System by Operando High Resolution Synchrotron X-ray Diffraction	7	Yes	MSPD (BL04)	Academic	No	No	No	2 (2)
2014	Structural insight into the molecular mechanism of allosteric activation of human cystathionine ß-synthase by S-adenosylmethionine	5	No	XALOC (BL13)	Academic	No	Yes	No	2 (2)
2017	Characterization of highly crystalline lead iodide nanosheets prepared by room-temperature solution processing	18	Yes	CIRCE (BL24)	Academic	No	No	No	1 (1)
2016	Strong impact of the oxygen content in Na3V2(PO4)2F3-yOy (0 £ y £ 0.5) on its structural and electrochemical properties	10	Yes	MSPD (BL04)	Academic	No	No	No	1 (1)
2016	Remote plasma cleaning of optical surfaces: Cleaning rates of different carbon allotropes as a function of RF powers and distances	7	Yes	No beamtime	No beamtime	No	No	No	1 (1)
2005	Operation of liquid-crystal displays for optical computing	6	Yes	No beamtime	No beamtime	No	No	No	1 (1)
2019	Evidence of the Coexistence of Multivalence Cerium Oxide Nano-Particles in a Sodium Borate Glass	8	Yes	No beamtime	No beamtime	No	No	No	1 (1)
2015	Protein crystallization in short-peptide supramolecular hydrogels: a versatile strategy towards biotechnological composite materials	5	No	XALOC (BL13)	Academic	No	No	No	1 (1)
2015	Influence of the chirality of short peptide supramolecular hydrogels in protein crystallogenesis	13	No	XALOC (BL13)	Academic	No	No	No	1 (1)
2014	T Cells Kill Bacteria Captured by Transinfection from Dendritic Cells and Confer Protection in Mice	16	Yes	MISTRAL (BL09)	Academic	No	No	No	1 (1)
2013	Structural and Conducting Features of Niobium-Doped Lanthanum Tungstate, La27(W1–xNbx)5O55.55–δ	7	No	No beamtime	No beamtime	No	No	No	1 (1)
2015	Crystal Structure of Hcp from Acinetobacter baumannii: A Component of the Type VI Secretion System	6	No	XALOC (BL13)	Academic	No	No	No	1 (1)
2015	Towards a calcium-based rechargeable battery	4	No	MSPD (BL04)	Industrial	No	No	No	1 (1)
2014	Disruption of Allosteric Response as an Unprecedented Mechanism of Resistance to Antibiotics	8	No	XALOC (BL13)	Academic	No	No	No	1 (1)

Source: *CSIL processing of Lens PatCite results*

Concerning patent documents, the following charts summarise their main features distinguishing between granted patents and patent applications (where relevant). The majority of patent documents (60%) were filled in using the international patent system but all the five granted patents have their jurisdiction in the United States (*Figure 23.a*). Most of the patent documents are owned by a sole entity (65%) either a firm (25%), a university (23%) or a public institute (17%). Only one patent application citing a publication of level 0 is owned by ALBA itself (*Figure 23.b*). With 6 patent documents, the top owner is the French National Centre for Scientific Research (Le Centre national de la recherche scientifique) which is followed by a private company (Sulzer Chemtech AG), the Spanish National Research Council, and a French university (University of Picardie Jules Verne) (*Figure 23.c*). 19 out of 35 patents documents report more than one technological area of application, including A - Human necessities; B - Performing operations transporting; C - Chemistry Metallurgy; F - Mechanical engineering lighting heating; G - Physics; H - Electricity.[25] 51% of patent documents pertain to some extent to the field of chemistry metallurgy[26]. However, the two technological areas most frequently reported in the documents are "H01 – Basic Electric Elements" and "A61 - Medical or Veterinary Science Hygiene" (*Figure 23.d*).

Figure 23 Patent documents of level 0

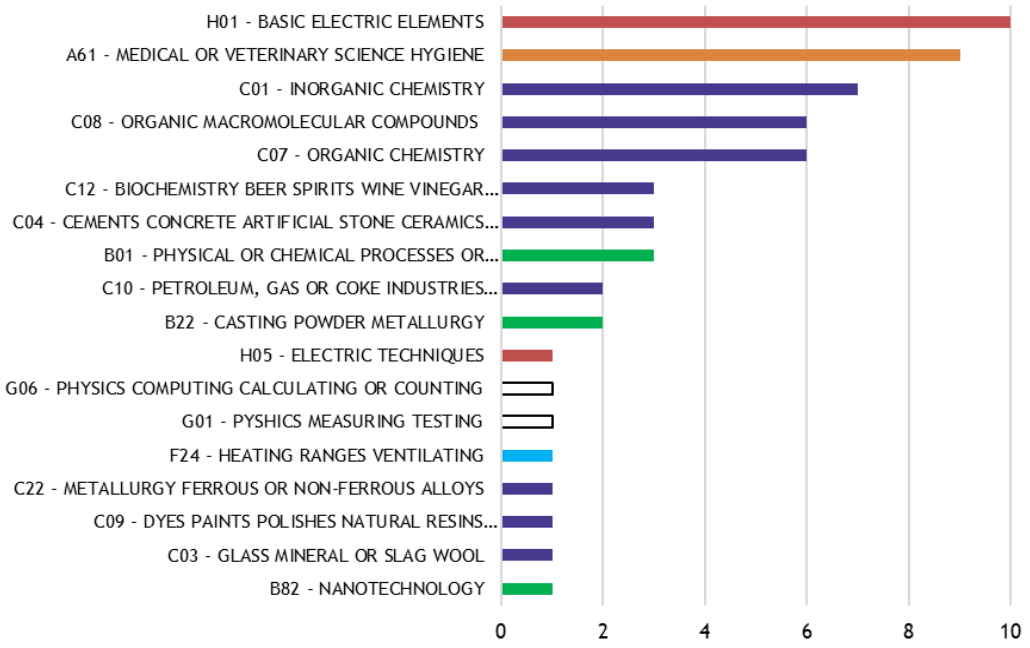


Note: a) CN:China; EP: European; ES: Spain; FR: France; IT: Italy; US: United States; WO : World

[25] According to International Patent Classification.

[26] Including : C01 - INORGANIC CHEMISTRY ; C03 - GLASS MINERAL OR SLAG WOOL ; C04 - CEMENTS CONCRETE ARTIFICIAL STONE CERAMICS REFRACTORIES ; C07 - ORGANIC CHEMISTRY ; C08 - ORGANIC MACROMOLECULAR COMPOUNDS ; C09 - DYES PAINTS POLISHES NATURAL RESINS ADHESIVES COMPOSITIONS ; C10 - PETROLEUM, GAS OR COKE INDUSTRIES TECHNICAL GASES ; C12 - BIOCHEMISTRY BEER SPIRITS WINE VINEGAR MICROBIOLOGY ENZYMOLOGY MUTATION OR GENETIC ENGINEERING ; C22 - METALLURGY FERROUS OR NON-FERROUS ALLOYS.

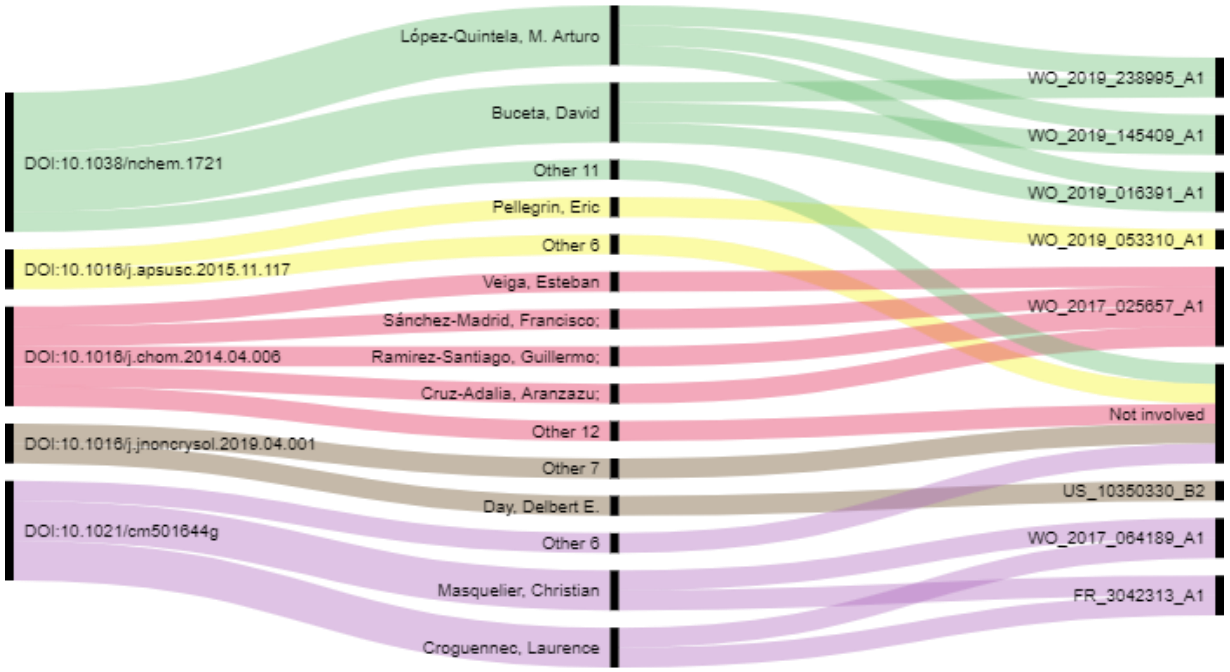
d) Fields of application



Source: *CSIL processing of Lens PatCite results*

The analysis of publications' and patent documents' authors pointed out that in 14 cases out of 35 at least an author of the publication was also listed among the inventors of the related patent document(s). In 5 cases, all the listed inventors were also among the authors of the related publication. 10 authors from ALBA are involved in 8 patent documents (see figure below). Typically, ALBA authors are supported by other inventors for developing the patent application. Only in 2 cases, they did it on their own.

Figure 24 Matches between ALBA's authors of P0 (left-hand side) and Pat0 (right-hand side)

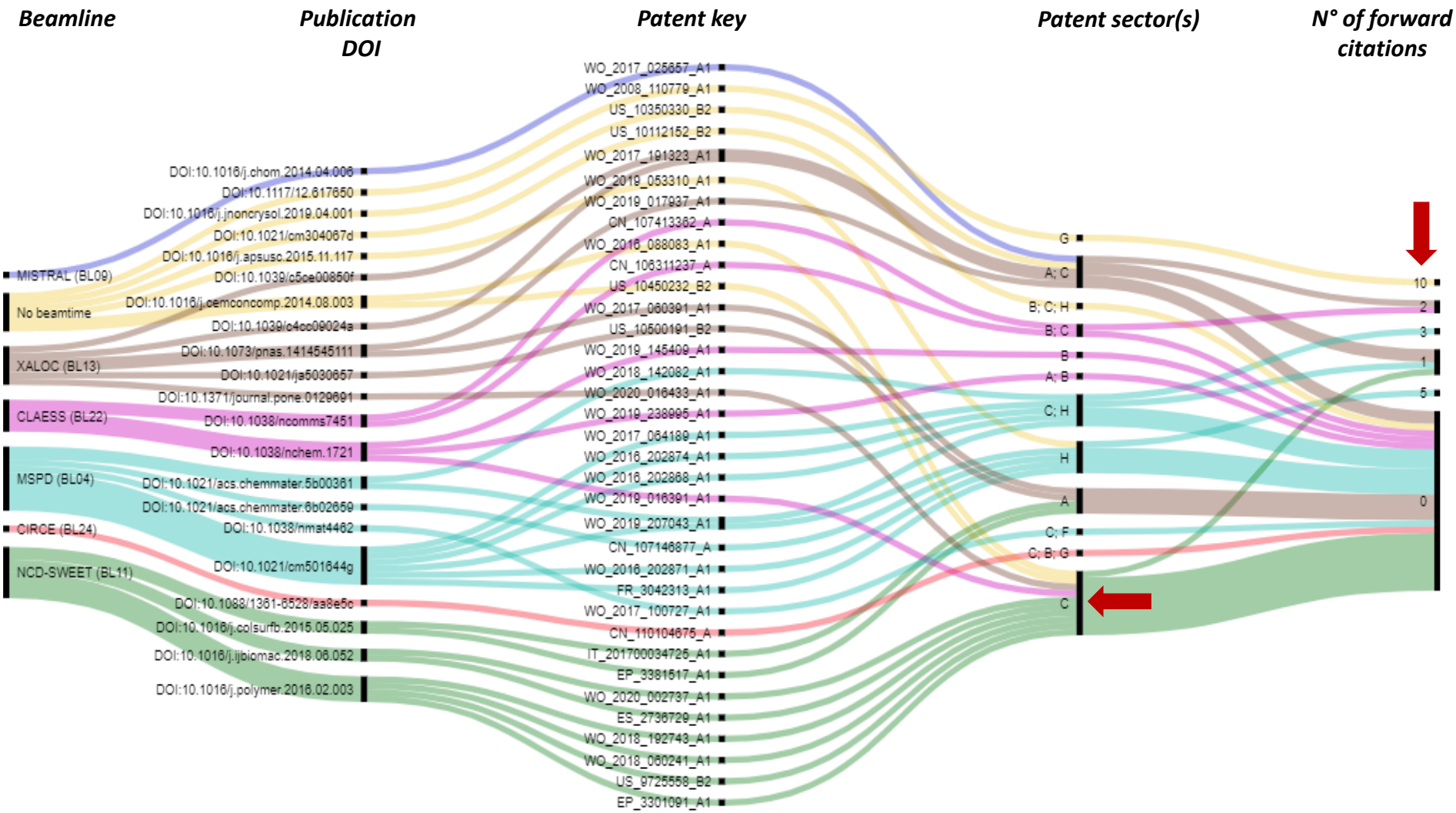


Note: Publications are identified with the DOI number, the patent documents with LensID
Source: *CSIL processing of Lens PatCite results*

Based on data extracted from Lens PatCite, 27 out of the 35 patent documents (i.e. 77%) have received zero forward citations[27], that are references to the given patent by another patent (see *Figure 24*). The other eight documents have received a number of citations which ranges from 1 to 10. With 10 forward citations, "Cement formulation based on aluminium sulphate with a specific proportion of Ye'elimite systems" is the most cited patent. This granted patent is owned by the University of Colombia and Cementos Argos S.A, and its area of application is C04 - Cements Concrete Artificial Stone Ceramics Refractories.

[27] Forward references are patents or applications that cite or reference the document in question.

Figure 25 Matches between beamline, publications, patent documents, patent sectors, and number of forward citations

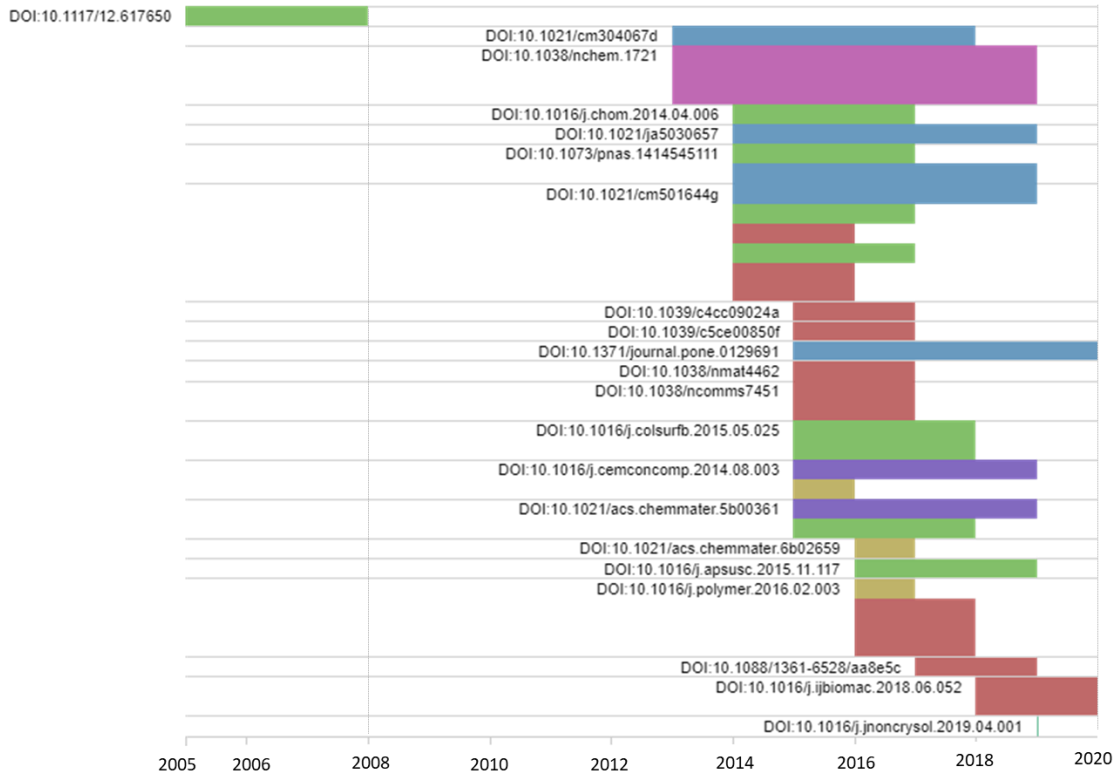


Note: *A - Human necessities; B - Performing operations transporting; C - Chemistry Metallurgy; F - Mechanical engineering lighting heating; G - Physics; H - Electricity*
Source: *CSIL processing of Lens PatCite results*

4.2.3 Time Lags between scientific publications and patents

The time-lapse between the publication year of an article and the year this article is cited in a patent may differ substantially between the various fields of technology (Finardi, 2011; Halevi and Moed, 2012). In the case of ALBA, we found that the time lag is between less than one year (DOI:10.1016/j.jnoncrysol.2019.04.001) and six years (DOI:10.1038/nchem.1721, fuchsia bars in the chart, see *Figure 26*).

Figure 26 Time Lags between publications and patents



Source: *CSIL processing of Lens PatCite results*

In this regard, it is worth noting two important time-related problems. First, publications can take months, if not years, to be published in scientific journals. Second, there are the delays between patent application and its publication[28] and the time lapse between the patent application publication and the granted patent (not every patent application results in an issued patent).

In the following table, we reconstructed the timeline of the five granted patents of level 0. As shown, the publication of patent applications may take from 6 to 26 months. Then, the patent publication takes at least other 16 months. Nevertheless, once the application is published, its content becomes prior art which the public can benefit even if the patent will never be granted.

[28] The patent application publication is not a granted patent. It is simply a published application.

Table 3 Timeline of the FIVE granted patents of level 0

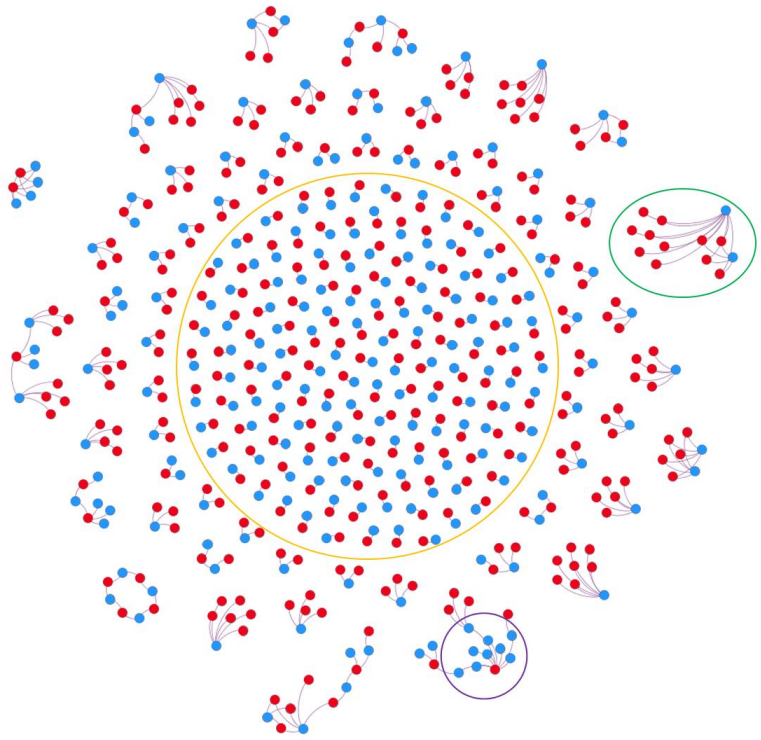
CODE	PATENT	PATENT EARLIEST PRIORITY DATE	PATENT FILING DATE	1st PATENT APPLICATION PUBLICATION	PATENT PUBLICATION
US_10112152_B2	Proton conducting ceramic membrane	23/05/13	23/05/2014 (+12 months)	07/04/2016 (+22 months)	30/10/2018 (+31 months)
US_10500191_B2	Compositions and methods of use of antibacterial drug combinations	09/07/15	08/07/2016 (+12 months)	19/07/2018 (+25 months)	10/12/2019 (+16 months)
US_10350330_B2	Method to produce inorganic nanomaterials and compositions thereof	09/09/14	09/09/2015 (+12 months)	17/03/2016 (+7 months)	16/07/2019 (+39 months)
US_10450232_B2	Cement formulation based on aluminium sulphate with a specific proportion of Ye'elimite systems	03/12/14	03/12/2015 (+12 months)	09/06/2016 (+6 months)	22/10/2019 (+40.5 months)
US_9725558_B2	Process to prepare a cyclic oligomer and a cyclic oligomer obtainable thereby	15/03/13	27/11/2013 (+12 months)	21/01/2016 (+26 months)	08/08/2017 (+18 months)

Source: *CSIL processing of Lens PatCite results*

4.2.4 Publications and patent documents of level 1

As said, 243 out of 9,974 publications of level 1 (i.e. articles citing P0) were cited by 337 patents documents. In particular, we found 107 granted patents and 214 patent applications of level 1.[29] *Figure 27* shows the matches between publications (P1, blue dots) and patent documents (Pat1, red dots). The number of patent citations per article range from 1 (see the yellow circle in *Figure 27*) to 11 (see green circle in *Figure 27*). In 42 cases, the same patent document cites more than one publication of level 1. The violet circle in *Figure 27* shows the patent which is linked to the highest number of publications (9).

Figure 27 Matches between P1 (blue dots) and Pat1 (red dots)



Source: *CSIL processing of Lens PatCite results with Gephi software*

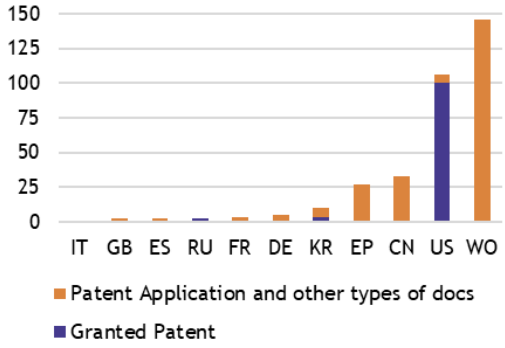
[29] The remaining documents were: design right (1); Search report (10); unclassified (5).

The following charts summarise the main features of patent documents of level 1, distinguishing between granted patents and patent applications (where relevant). The majority of patent documents (43%) were filled in using the international patent system but 93% of 107 granted patents have their jurisdiction in the United States (*Figure 28.a*). Most of the patent documents are owned by a sole entity (73%) either a firm (39%), a university (27%) or a public institute (7%) (*Figure 28.b*). With 17 patent documents, the top owner is the Spanish National Research Council, followed by the French National Centre for Scientific Research (Le Centre national de la recherche scientifique), co-owner of 15 patent documents.

Based on data extracted from Lens PatCite, 286 out of the 337 patent documents (i.e. 85%) have received zero forward citations (see *Figure 28.d*). The other documents have received a number of citations ranging from 1 to 14. With 14 forward citations, "Method for preparing the silicoaluminate form of the aei zeolite structure with high yields, and its application in catalysis" is the most cited patent. This patent application is owned by the Spanish National Research Council and the University of Valencia, and its areas of application are C01B - Non-metallic elements compounds thereof and B01J - Chemical or physical processes.

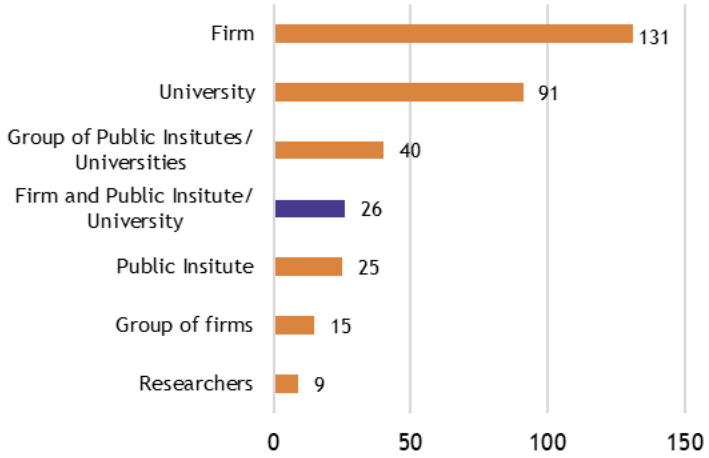
Figure 28 Patent documents of level 1

a) Patent document jurisdiction

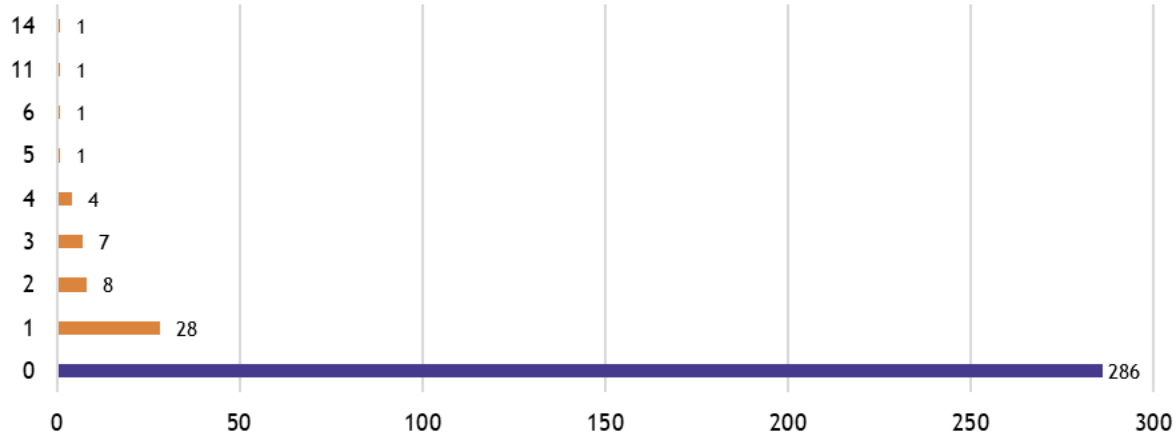


Note: a) IT: Italy; GB: United Kingdom ; ES: Spain; RU: Russia; FR: France; DE: Germany; KR: South Korea; EP: European; CN: China; US: United States; WO: World

b) Type of patent document owner(s)



c) Forward citations



Source: *CSIL processing of Lens PatCite results*

5 CONCLUSIONS

Research infrastructures are commonly used by scientific and industrial communities to conduct research and experiments which translate in the creation of new knowledge – taking on the form of different outcomes (e.g. publications, patents, etc.) - likely to find applications in different sectors and trigger innovation developments. Even when the experiment does not involve the industrial sectors directly, results can generate an impact on the industry after some time has elapsed and some additional research activities or other investments are carried out. However, the pathway from knowledge creation to innovation is complex: it is split among different players, from direct users of research facilities to industrial actors, and may take time and significant investments.

The objective of our pilot exercise was to trace and describe the pathways according to which innovation impacts may materialise by taking the example of ALBA Synchrotron Light source facility located in Barcelona and in operation since 2012. This synchrotron provides eight experimental beamlines allowing for investigations in different scientific fields (e.g. chemistry, pharmaceutical, health products, etc.). The majority of users are from the scientific community; only a minor share are private companies.

Our analysis built on the evidence collected through surveys to direct and indirect users of ALBA, in-depth interviews as well as an analysis of patents' citations. This methodological approach was developed starting from the evaluation strategy proposed by Florio (2019) for assessing the innovation impacts generated by ALBA. Specifically, our analysis looked at the pathways materialising from the design to the performance of the experiment as well as to generation of the innovation output and its impacts. In what follows, the main findings and lessons learnt are summarised.

Main findings

- Experiments carried out at ALBA synchrotron are rarely designed by scientific and industrial communities jointly. Users from the scientific community usually carry out their experiment alone or mostly in collaboration with other universities/research centres. Similarly, private companies usually perform their experiment alone or in collaboration with other private companies.

- Although recognising that results from their experiments may have a potential application for industry, users from the scientific community limit their strategy to publishing in peer-reviewed journals or attending conferences. This is in most cases explained by the fact that their research is found to be still far away from an immediate industrial application and therefore less attractive for industrial partnership. Where some strategy of networking with private companies is undertaken, some interviews suggest that this is found to work well if properly supported by technology transfer units within the users' affiliations.

- The performance of the experiments requires skills and expertise to operate the beamlines as well as to interpret and understand the results. Users from the scientific

community are usually experts who boast these skills and self-operate the beamlines themselves or in collaboration with ALBA staff while users from the private sector mostly rely on ALBA support. However, both users from the scientific community and private sector may act as 'intermediary' performing the experiment on behalf of third parties which specifically need the experiment for the purpose of their research.

- Once the experiment is completed, it is infrequent that the results can be immediately used. In most cases, the experiment represents a step contributing to broader research, and therefore, it requires additional time and complementary research activities to create innovation with economic relevance. The time and activities needed vary depending on the type of research carried out, the research field/sector of activity of the user as well as the beamlines used.

- The pathways to innovations are faster in the case of research with application orientation or industrially relevant research in the field of chemistry, material science for energy/information technology, biology-life sciences and protein crystallography (from 1 to 5 years). A longer time may be required for experiments in the field of solid-state physics and materials science concerning structure, phase transitions, nanomaterials as well as in the field of instrumentation and techniques development (see Figure 29 below).

- Even when the user is from the private field, results from experiments can not be immediately used. Additional activities are needed, and these are mostly carried out internally (especially if the experiment is performed for internal use). The time to create the innovation also depends on the sector of activity of the user. If the experiments are carried out by a manufacturer, 1-2 years may be needed to develop a new product or to improve an existing one. Instead, a longer time is required where the experiment is carried out by companies carrying out research which most likely operate on behalf of indirect users (see Figure 30 below).

- As from users' knowledge, experiments carried out at ALBA mostly translate in publications and very rarely in patents or other intellectual property. Where developed, patents have concerned the following sectors: chemistry, nanotechnology, energy and pharmaceutical. However, the analysis on patent's citations showed that 21 out of 1,723 publications generated by ALBA users (P0 publications) had been cited for developing 35 patents in the following field: including A - Human necessities; B - Performing operations transporting; C - Chemistry Metallurgy; F - Mechanical engineering lighting heating; G - Physics; H - Electricity. Typically, these patents are developed by the authors of ALBA publications with the support of other inventors.

- More indirectly, 243 out of 9,974 publications citing ALBA publication (P1 publications) have contributed to developing 337 patent documents.

- The survey showed that there are some beamlines – such as L01-MSPD, BL22-CLAESS, BL13-XALOC, BL01-MIRAS and BL011-NCD-SWEET - which are '*faster*' to innovation since related mostly to a type of research-oriented to application and covering specific research fields. The analysis of patent's citation found that patents citing ALBA publications specifically stem from experiments carried out on these beamlines.

- **Overall, it is worth pointing out that the above-described impacts are probably underestimated since ALBA is a young facility which started its operation in 2012, experiments and publications have significantly increased over the recent years and - considering the time lag described above - their effects are expected to materialise and be higher in the next years.**

Figures 29 and 30 below provides an overview of the main pathways identified in the framework of this pilot both for the scientific community and the private sector.

Lessons learnt

Some lessons learnt were drawn by this pilot exercise in view of monitoring and assessing innovation impacts at ALBA as well as in other research infrastructures. Specifically:

In terms of methodology, the following lessons were drawn:

- **Perceptions and opinions of the users are extremely important to trace long impact pathways**. They help to get a complete understanding of how experiments carried out at a research infrastructure can actually contribute to the development of innovations, by scrutinising on how much time is needed, which additionally activities they require, which stakeholders are involved (e.g. specialised companies, etc). These impact pathways cannot be identified by only looking at the number of publications or the number of patents developed by a research infrastructure.

- **Systematic users' surveys** after some time from the access to the research infrastructure and beyond the routinely performed follow-up questionnaire – required just after the access - should be encouraged. This would help to keep tracking of the impact pathways.

- The **analysis of patents' citations** is a useful and relatively simple way to trace in an objective way the influence of the knowledge produced by experiments on downstream research and innovation activities.

From ALBA perspective, the following lessons were drawn:

- This is the first ALBA user' survey focused on industry and innovation impact of the research infrastructure activities. The results are very helpful as they provide very relevant information about the ALBA impact on innovation, including valuable details on how the knowledge generated in the different experiments and techniques are contributing to innovation.

- The patent study provided outstanding and direct information about the innovation impact stemming from the knowledge generated by ALBA.

- Both user' survey and the patent study have proven to be effective techniques to obtain relevant information about the ALBA's capabilities for innovation and individual pathways for innovation.

- Periodical user' survey and patent study would allow a dynamic follow-up of the innovation contribution as ALBA evolves and develops future plans, particularly taking into account the lag-effect and the fact that ALBA is a relatively young facility.

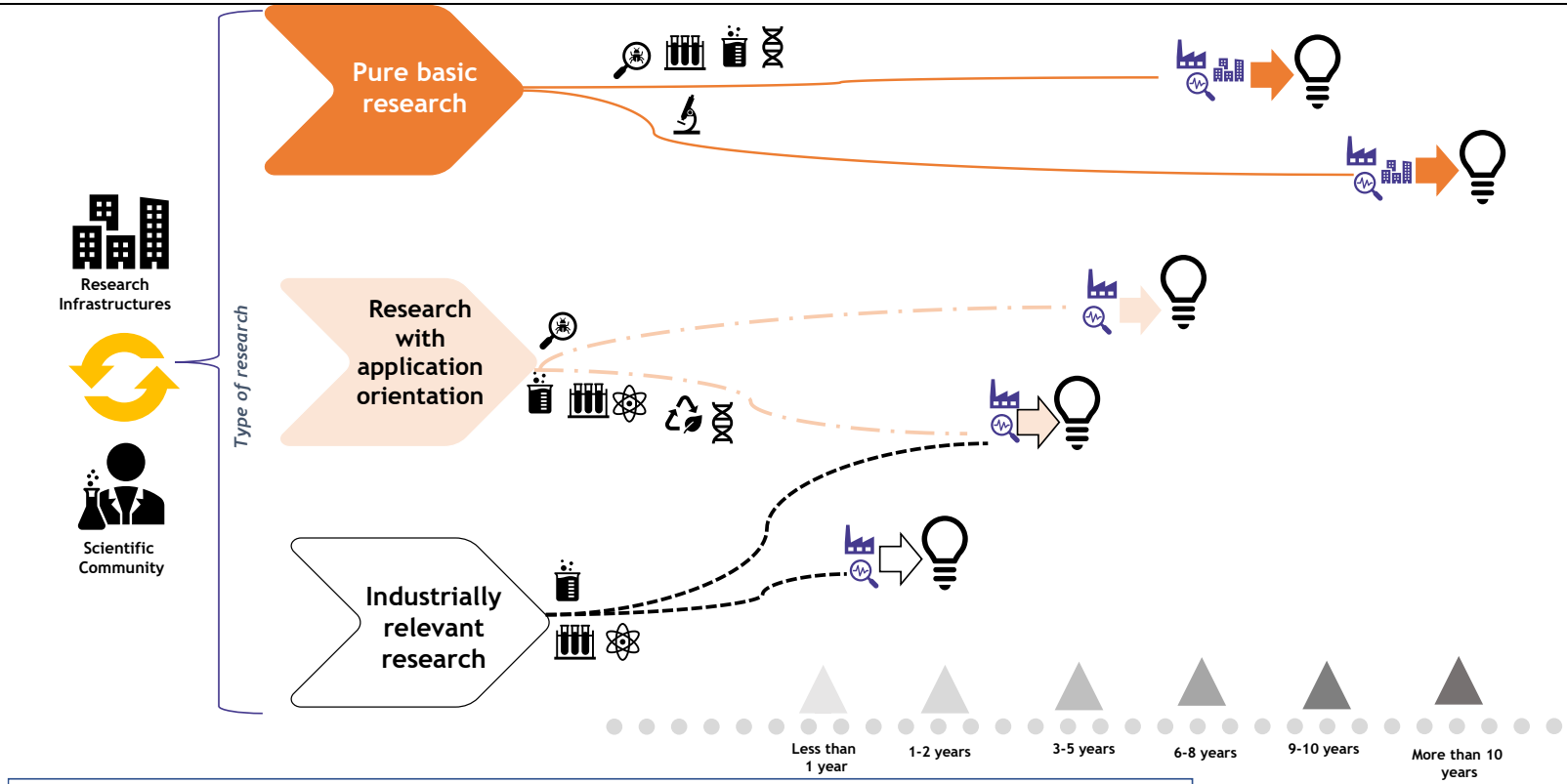
- The results of the user' survey and the patent study are relevant enough to be taken into account for the future strategic plans together with other important inputs.

- The results obtained in these user' survey and the patent study are likely to be relevant for other similar research facilities similar to ALBA and may be useful in collaborative frameworks as LEAPS (www.leaps-initiative.eu)

***

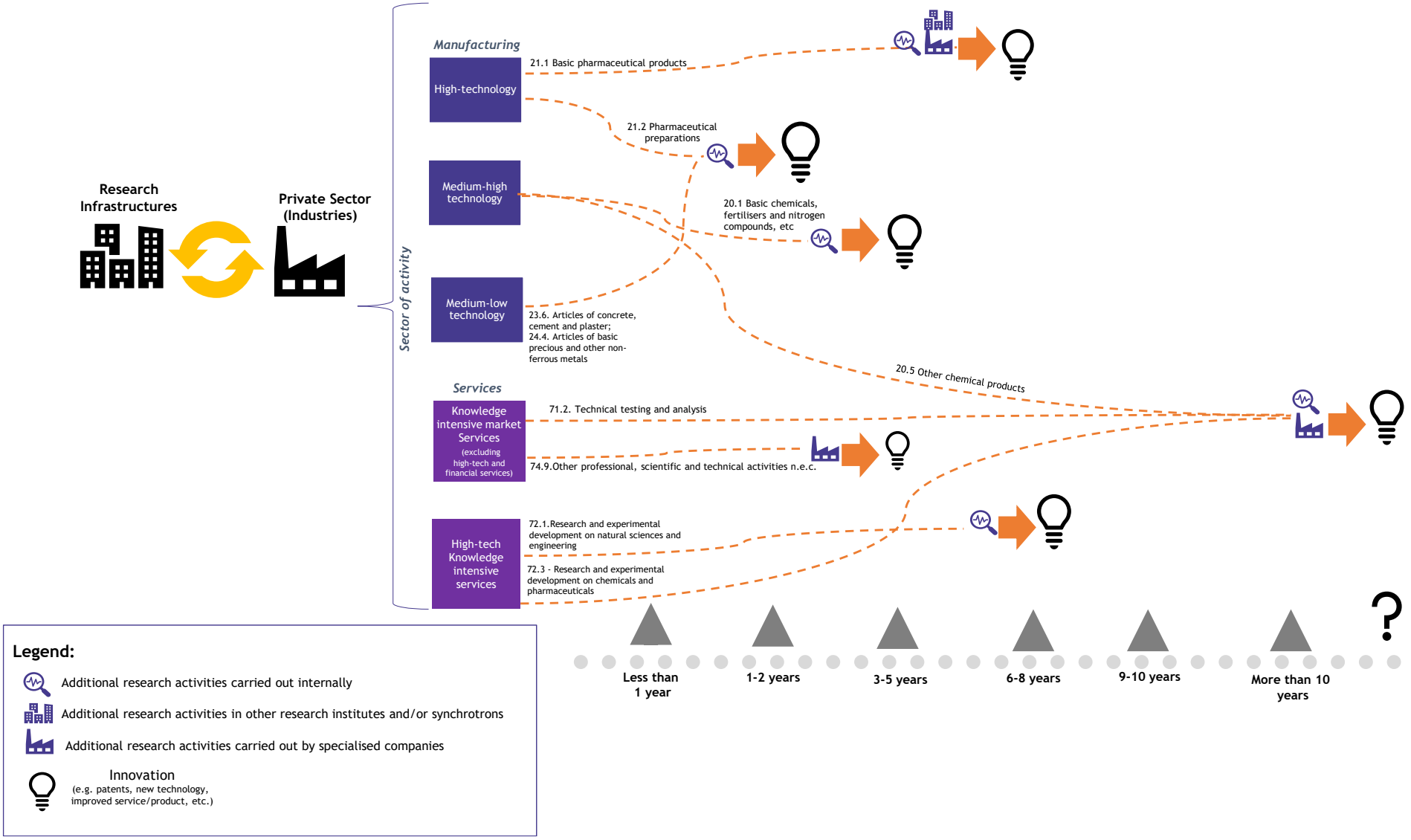
Overall, this study suggests a possible further empirical research on the economic impact of a synchrotron light source: while not all innovations are embodied in a patent, and not all patents have economic value, there is consistent evidence that the "statistical patent" has both private and social value. The latter arises from the knowledge that spills over to other patents or other innovations. The former from the expected market value of the innovations. Experiments at synchrotron light sources usually do not directly generate such innovations, but create knowledge embodied in scientific papers which in turn are cited by other papers and by patents. We have studied the initial linkages in this chain of cumulative effects, and discovered that while Alba operates only since 8 years, and is not yet working with its maximum number of beamlines (it may potentially host around 12 beamlines more), it clearly has the potential to create socio-economic value through some direct applications but mostly through the mediation of scientific papers that in turn enter in the process of knowledge creation. In a socio-economic impact assessment perspective, including possibly a social cost-benefit analysis, the current study paves the way to further empirical research on the value created for society by experiments at synchrotron light sources.

Figure 29 From the experiment to innovation: a description of pathways arising from the use of beamlines by the scientific community



Source: *CSIL*

Figure 30 From the experiment to innovation: a description of pathways arising from the use of beamlines by the private sector



Source: CSIL Note: High-tech aggregation by NACE based on https://ec.europa.eu/eurostat/cache/metadata/Annexes/htec_esms_an3.pdf

6 ANNEXES

6.1 References

- Branstetter, L., & Ogura, Y. (2005). *Is academic science driving a surge in industrial innovation? Evidence from patent citations (No. w11561)*, National Bureau of Economic Research.
- Callaert, Julie, Van Looy, B., Verbeek, A., Debackere, K., & Thijs, B. (2006). *Traces of prior art: An analysis of non-patent references found in patent documents*. Scientometrics, 69(1), 3-20.
- Finardi, U. (2011). Time relations between scientific production and patenting of knowledge: The case of nanotechnologies. Scientometrics, 89(1), 37–50.
- Florio, M. (2019). *Investing in Science: Social Cost-Benefit Analysis of Research Infrastructures*. MIT Press.
- Fukuzawa, N., & Ida, T. (2016). *Science linkages between scientific articles and patents for leading scientists in the life and medical sciences field: The case of Japan*. Scientometrics, 106(2), 629-644.
- Gittelman, M. and Bruce K. (2003). *Does good science lead to valuable knowledge? Biotechnology firms and the evolutionary logic of citation patterns*. Management Science 49.4: 366-382
- Halevi, G., & Moed, H.F. (2012). The technological impact of library science research: A patent analysis. In E. Archambault, Y. Gingras, & V. Larivière (Eds.), Proceedings of 17th International Conference on Science and Technology Indicators (Vol.1, pp. 371–380), Montréal: Science-Metrix and OST.
- Jaffe Adam B, Trajtenberg M, M.S. Fogarty (2000). *Knowledge Spillovers and Patent Citations: Evidence from a Survey of Inventors*, The American Economic Review, 90 (2000) 215-218.
- McMillan, G. Steven, Francis Narin, and David L. Deeds (2000). *An analysis of the critical role of public science in innovation: the case of biotechnology*. Research Policy 29.1: 1-8
- OECD (2009). *OECD Patent Statistics Manual* https://www.oecdilibraryorg/science-and-technology/oecd-patent-statistics-manual/the-use-andanalysis-of-citations-in-patents_9789264056442-7-en
- OECD (2013). *Turning Science into Business: Patenting and Licensing at Public Research Organisations*, OECD https://read.oecd-ilibrary.org/scienceand-technology/turning-science-into-business_9789264100244-en#page2
- Simmonds, P., Kraemer-Mbula, E., Horvath, A., Stroyan, J., & Zuijdam, F (2013). '*Big Science and Innovation*'. Technopolis Group.
- Yamashita, Y. (2018). *Exploring Characteristics of Patent-Paper Citations and Development of New Indicators*. Scientometrics, 151.

6.2 Questionnaire for ALBA users (type 1)[30]

Invitation Letter

Dear Madam/Sir,

The European Commission is interested in developing a framework describing the socio-economic impact of Research Infrastructures (RIs) and their related financial investments.

The RIPATHS project - funded by the European Union Horizon 2020 programme under grant agreement 777563 – is specifically focusing on this objective by exploring the wide range of impacts generated by the RIs and the different metrics for assessing them.

ALBA is a partner of this project and in collaboration with **CSIL - Centre for Industrial Studies** (Italy) – is interested in tracing and describing the **innovation impacts arising on the industry from results of experiments carried out by its users on beamlines as well as the pathways allowing to the generation of these impacts**.

In the framework of this project, we would like to cordially invite you to our survey in the spirit of close cooperation and the development of future activities. Please provide the information via a short online questionnaire, available in what follows.

CLICK HERE TO PARTICIPATE

All the information provided will be anonymised for analysis and will be treated confidentially.

Mr. **Alejandro Sánchez Grueso is available as your direct contact point for any specific questions** (asanchez@cells.es).

Deadline for completing the survey is March 30th 2020.

Upon completion of the survey, we will send you a report summarising findings and conclusions.

I thank you in advance for your valuable support and collaboration.

Your sincerely
Alejandro Sánchez Grueso (*ALBA Associate Director*)

[30] Academics, researchers and users from public institutions (e.g. hospitals, foundations, agencies, etc.)

WELCOME PAGE

Welcome to the online survey **on the impacts of your experiments at ALBA beamlines.**

The survey is managed by ALBA in collaboration with CSIL - Centre for Industrial Studies. For any questions or technical problems, please contact **Mr Alejandro Sánchez Grueso** via e-mail [asanchez@cells.es].

If you are not in the position to answer this survey, we would kindly ask you to forward this invitation to the appropriate person at your organisation.

The estimated time for completing this survey is 20 minutes. Please note that until you complete the survey, you may change any answers on previous survey pages.

Deadline for completing the survey is **March 30th 2020**.

Our most sincere thanks for your valuable cooperation!
ALBA and CSIL team

Privacy consent

You are receiving this survey since you are enrolled in the ALBA distribution list. Both ALBA and CSIL - which is contributing to the running of this survey - handle personal information according to the data protection regulations, including the GDPR.

Please, note that information collected through this survey will be kept anonymous and will be aggregated before being shared with the European Commission. **Personal data of the respondents will be shared with ALBA only**, but they will not be disclosed or communicated to third parties. Please, accept this clause to go to the questionnaire.

☐ I accept data share modalities

PART A: General information	
A.1 Your name	
A.2 Your affiliation	*Dropdown menu (including other, please specify)*
A.3 Gender	☐ Male ☐ Female
A.4 Your role within your affiliation	☐ Director/Senior manager ☐ Full Professor/Associate professor ☐ Research Fellow/Research Associate ☐ Postdoc ☐ PhD student ☐ Masters' student ☐ Other, please specify_____
A.5 Your discipline/research field	☐ AMO physics *(Atomic and Molecular Physics)* ☐ Biology-Life Sciences (not PX) ☐ Chemistry-surface science-catalysis ☐ Cultural Heritage ☐ Environmental Sciences ☐ Geo-Sciences ☐ Instrumentation and technique development ☐ Materials sciences for energy technology ☐ Materials sciences for information technology ☐ Metrology ☐ Protein Crystallography ☐ Solid-state physics *(electronic properties, magnetism, basic quantum materials)* ☐ Solid-state physics/materials science *(structure, phase transitions, nanomaterials)* ☐ Other, please specify_____
A.6 In which potential area of application may your research eventually contribute? *(more than an answer is possible)*	☐ Health ☐ Food and Nutrition (food security, agriculture and marine research) ☐ Energy (secure, clean and efficient) ☐ Transport and Mobility (sustainable and integrated) ☐ Climate and Resources (efficiency and raw materials) ☐ Applications to Public Sector Challenges (security, safety, inclusiveness) ☐ Advances in other Enabling Technologies ☐ Other, please specify/None of the above, please specify why: _____
A.7 Your research activity is *(Please indicate the one which mostly applies)*	☐ pure basic research ☐ research with application orientation ☐ industrially relevant research
PART B: Your experience with the use of ALBA beamlines and other synchrotrons	

B.1 In which of the following ALBA beamlines experiment(s) have you been involved? *(more than an answer is allowed)*	☐ BL01-MIRAS ☐ BL04-MSPD ☐ BL09-MISTRAL ☐ BL011-NCD-SWEET ☐ BL13-XALOC ☐ BL22-CLAESS ☐ BL24-CIRCE ☐ BL29-BOREAS ☐ I don't know/I am not aware/I can't remember
B.2 Please indicate if you are:	☐ An infrequent user = you have been granted* the use of beamlines once ☐ An occasional user = you have been granted* the use of beamlines more than once but less than five times ☐ A frequent user = you have been granted* the use of beamlines five or more times **Please note that granted means that you have submitted a proposal for the use of ALBA beamline(s) and this has been accepted.*
B.3 On the total of your experiments at ALBA, please indicate the share of those for which the application was submitted by:	Your institution alone: _____ Your institution in collaboration with private companies: _____ Your institution in collaboration with other universities/research institutes (e.g. CNR): _____ Your institution in collaboration with both private companies and other universities/research institutes (e.g. CNR): _____ *The sum of your answers should be equal to 100%*
B.4 On the total of your experiments at ALBA, please indicate the share of those carried out:	By self-operating the beamline: _____ By relying on ALBA staff: _____ A mix of both: _____ *The sum of your answers should be equal to 100%*
B.5 On the total of your experiments at ALBA, please indicate the share of those whose results are relevant to:	Only other academic/researchers: _____ Only the industries: _____ Both industries and other academic/researchers: _____ *The sum of your answers should be equal to 100%*
B.6 In addition to ALBA, which of the following synchrotron light sources have you been involved in for experiment(s), including e.g. data elaboration and related activities? *(more than an answer is allowed)*	☐ Deutsches Elektronen-Synchrotron (DESY) ☐ Diamond Light Source ☐ Elettra ☐ European Synchrotron Radiation Facility (ESRF) ☐ European XFEL ☐ Felix ☐ Helmholtz-Zentrum Berlin (HZB) ☐ Helmholtz-Zentrum Dresden-Rossendorf (HZDR) ☐ National Institute for Nuclear Physics (INFN) ☐ ISA (Danish National Facility) ☐ MAX IV ☐ Paul Scherrer Institute (PSI)

	☐ Physikalisch-Technische Bundesanstalt (PTB) ☐ SOLARIS ☐ SOLEIL ☐ Swiss Light Source (SLS) ☐ Other, please specify: _____
B.7 When <u>designing</u> an experiment with synchrotron light sources, do you have contacts with companies or other entities potentially interested in applications and developments?	☐ Never ☐ Very rarely ☐ Occasionally ☐ Frequently
B.8 What is your strategy (if any) to involve companies in your experiments/exploitation of results of your experiments at synchrotron light sources? *(more than an answer is allowed)*	☐ I usually join conferences and/or other events attended by companies or other players interested in potentially technological developments ☐ I usually attempt to publish in journals which might be of interest for companies or other players interested in potentially technological developments ☐ I have a network of companies I usually work with and I inform them about the results of my experiments ☐ I have no strategy since I am not interested in the industrial applications of results of my experiments ☐ Oher, please specify: _____
B.9 Please add any relevant comment to the above questions to further explain your answers:	

PART C: Innovation pathways: from your experiments at <u>ALBA beamlines</u> to the innovation output: *The objective of this section is to know more about the innovation results (e.g. concerning products, production process, etc.) achieved thanks to the results of your experiments at ALBA as well as the PATHWAYS which have allowed to this innovation.*

C.1 How frequently did results of your experiments translate into:

	Never *(0%)*	Rarely *(less than 30% of cases)*	Sometimes *(30%-50% of cases)*	Very often *(50% - less than 100% of cases)*	Always *(100% of cases)*
Patents:					
Publication in peer-reviewed journal:					
Conference proceedings or book:					
Ph.D. Thesis:					
Technical Note:					

Other, please specify_____

C.2 On the total of your experiments at ALBA, please	As a self-standing activity providing an answer to a specific research question/need: _____

indicate the share of those carried out:	As one of several steps contributing to broader research design: _____ *The sum of your answers should be equal to 100%*
C.3 On the total of your experiments at ALBA, please indicate the share of those whose results are useful for:	pure basic research _____ research with application orientation _____ industrially relevant research _____ *The sum of your answers should be equal to 100%*
C.4 On average, stemming from the results of your experiments at ALBA how much additional time it would take to develop innovation with economic or practical significance?	☐ I don't know ☐ Less than 1 year ☐ 1 – 2 year ☐ 3- 5 year ☐ 6-8 year ☐ 8-10 year ☐ More than 10 years, please specify: _____
C.5 Considering the results of all your experiments at ALBA, please indicate the share of those for which the following steps/additional activities are usually needed to create an innovation output:	They can be immediately used for innovation purposes and do not need additional research activities or testing: _____ Additional research activities carried out internally are needed to create an innovation output: _____ Additional research activities in other research institutes and/or synchrotrons are needed to create an innovation output: _____ Additional research activities carried out by specialised companies are needed to create an innovation output: _____ Other, please specify: _____ *The sum of your answers should be equal to 100%*
C.6 Did you ever file for patents related to your experiment(s) carried out at ALBA?	☐ YES **[GO to question C.6.1]** ☐ NO **[GO to question C.7]**
C.6.1 If yes, please could you indicate in which fields?	*Dropdown menu* ☐ Chemistry ☐ Nanotechnology ☐ Pharmaceutical ☐ Health products (e.g. cosmetics, personal care, etc.) ☐ Food and agriculture ☐ Automotive and aerospace ☐ Energy ☐ Other, please specify_____
C.7 Are you aware of third parties which have filed patents based on the results of your experiment(s) carried out at ALBA?	☐ YES **[GO to question C.7.1]** ☐ NO **[GO to question C.8]**
C.7.1 If yes, please could you indicate in which fields?	*Dropdown menu* ☐ Chemistry ☐ Nanotechnology

	☐ Pharmaceutical ☐ Health products (e.g. cosmetics, personal care, etc.) ☐ Food and agriculture ☐ Automotive and aerospace ☐ Energy ☐ Other, please specify_____
C.7.2 How do you know about patents/ potential applications of the results of your experiment(s) by third parties? *(more than an answer is allowed)*	☐ I read it from professional journals ☐ I am in contact with colleagues from companies' R&D departments ☐ Word of mouth from other academic colleagues ☐ Other, please specify: _____

C.8 From your knowledge, what is (or could be in the future) the innovation output achieved thanks to the experiments carried out at ALBA beamlines:

***As a result of the new knowledge acquired through results of my experiments on ALBA beamline*, companies and other players interested in technological developments were able/could be able to…**

(more than one answer is allowed)

- ☐ develop new products
- ☐ develop new service(s)
- ☐ develop new technologies
- ☐ develop new patents, copyrights, or other intellectual property rights
- ☐ Improve the quality of existing products
- ☐ Improving the quality of the service provided
- ☐ Improve R&D and innovation capabilities
- ☐ Improve technical know-how
- ☐ Other, please specify: _____

C.8.1 Please, feel free to add your comments to improve our understanding of the potential relationship between your research activity at ALBA and possible developments in the industry or elsewhere :

PART D: The impacts of your experience with ALBA beamlines <u>on your research activity</u>

We are interested to know possible benefits arising from the use of this facility for your research activity.

D.1 Please, indicate your level of agreement with the following statements about the added value of accessing ALBA beamlines instead of alternative sources (e.g. other synchrotrons/research institutes, etc.):

Without accessing ALBA…

	Strongly disagree	*Disagree*	*Neutral*	*Agree*	*Strongly agree*	*Not applicable*
I could not have performed the research activity <u>because I needed the specific beamlines provided by ALBA/there are no alternatives</u>						
I could not have						

performed the research activity <u>because no beamtime was available at that time at other synchrotrons</u>						
I could have performed my research *(accessing other synchrotrons or using alternative equipment/technologies)* <u>but taking more time to get the same results</u>						
I could have performed my research *(accessing other synchrotrons or using alternative equipment/technologies)* <u>but at higher costs</u>						
I could have performed the research *(accessing other synchrotrons or using alternative equipment/technologies)* <u>but obtaining results of lower reliability</u>						
I could have performed the research <u>but with lower expertise than the one provided by ALBA staff</u>						
Other, please specify:						

D.2 Please, indicate your level of agreement with the following statements about the **benefits** of accessing to ALBA beamlines:
The access to ALBA beamlines has been beneficial for…

	Not at all	*Not relevant*	*Fairly*	*To a large extent*	*Totally*	*Not applicable*
Providing an answer to your research questions/needs						
Understanding your research area						
Improving the quality of your research						
Enhancing your experimental or analytical techniques						
Increasing the international/national reputation						

Getting some recognition (e.g. scientific prizes/awards)						
Increasing ability to secure research funding (e.g. access to grant, etc.)						
Attracting industry contracts (e.g. invitation to collaborate, etc.)						
Attracting other academic collaborations						

Other, please specify:

PART E. Supporting the dissemination of our survey

We would kindly ask your help in tracking the innovation generated after your experiments at ALBA. We have prepared a **survey addressed to third parties which may have relied on results of your experiments**. To this end, we would need to identify the companies or other players which have expressed interests for the results arising from your experiment(s).

E.1 Have you received any expression of interest for the results arising from your experiment(s)?

(more than one answer is allowed)

- ☐ Yes, from researchers working in the academic field/in research centres **[GO to question E.2]**
- ☐ Yes, from industrial companies **[GO to question E.2]**
- ☐ No **[GO to the end of the questionnaire]**

E.2 If YES, would it be possible to provide us with their contact details (e-mail address):

Please, remind that information provided during this survey will be treated according to the privacy consent signed above (kept anonymous and not disclosed or communicated to third parties)

- ☐ YES **[GO to question E.2.1]**
- ☐ NO **[GO to question E.2.2]**

E.2.1 Please, provide the following details:

Name of the company/institute/university: _____
Contact person: _____
Email address: _____

Name of the company/institute/university: _____
Contact person: _____
Email address: _____

E.2.2 If you cannot provide us with their contact details, we kindly ask you to directly forward the message and link to the questionnaire which is suggested below to third parties which have expressed interest in the results of your experiments.

Dear Madam/Sir,

I would kindly ask you to contribute to a survey carried out by ALBA in collaboration with CSIL - Centre for Industrial Studies (Italy). The survey is carried out in the framework of an H2020 project - RIPATHS project (funded by the European Union under grant agreement 777563) and is addressed to trace and describe the innovation impacts arising on the industry from results of experiments carried out by ALBA users on beamlines. Since you might have used the results of these experiments, your contribution to this survey is extremely relevant to understand the pathways allowing the generation of these impacts.

All the information provided will be anonymised for analysis and will be treated confidentially.

Deadline for completing the survey is January 24th 2020.

https://www.surveymonkey.com/r/ALBAsurvey_thirdparties

I thank you in advance for your valuable support and collaboration.

END OF THE QUESTIONNAIRE

Your e-mail address:

If you are interested in receiving a summary of the results of this survey, please provide us with your e-mail address.

6.3 Questionnaire for ALBA users (type 2)[31]

Invitation Letter

Dear Madam/Sir,

The European Commission is interested in developing a framework describing the socio-economic impact of Research Infrastructures (RIs) and their related financial investments.

The RIPATHS project - funded by the European Union Horizon 2020 programme under grant agreement 777563 – is specifically focusing on this objective by exploring the wide range of impacts generated by the RIs and the different metrics for assessing them.

ALBA is a partner of this project and in collaboration with **CSIL - Centre for Industrial Studies** (Italy – is interested in tracing and describing the **innovation impacts arising on the industry from results of experiments carried out by its users on beamlines as well as the pathways allowing to the generation of these impacts**.

In the framework of this project, we would like to cordially invite you to our survey in the spirit of close cooperation and the development of future activities. Please provide the information via a short online questionnaire, available in what follows.

CLICK HERE TO PARTICIPATE

All the information provided will be anonymised for analysis and will be treated confidentially.

Mr. **Alejandro Sánchez Grueso is available as your direct contact point for any specific questions** (asanchez@cells.es).

Deadline for completing the survey is March 30th 2020.

Upon completion of the survey, we will send you a report summarising findings and conclusions.

I thank you in advance for your valuable support and collaboration.

Your sincerely
Alejandro Sánchez Grueso (*ALBA Associate Director*)

[31] Companies, users from private sector

WELCOME PAGE

Welcome to the online survey **on the impacts of your experiments at ALBA beamlines.**

The survey is managed by ALBA in collaboration with CSIL - Centre for Industrial Studies. For any questions or technical problems, please contact **Mr Alejandro Sánchez Grueso** via e-mail [asanchez@cells.es].

If you are not in the position to answer this survey, we would kindly ask you to forward this invitation to the appropriate person at your organisation or company.

The estimated time for completing this survey is 15 minutes. Please note that until you complete the survey, you may change any answers on previous survey pages.

Deadline for completing the survey is **March 30th 2020**.

Our most sincere thanks for your valuable cooperation!
ALBA and CSIL team

Privacy consent

You are receiving this survey since you are enrolled in the ALBA distribution list. ALBA and CSIL which is contributing to the running of this survey handle personal information according to the data protection regulations, including the GDPR.

Please, note that information collected through this survey will be kept anonymous and will be aggregated before being shared with the European Commission. **Personal data of the respondents will be shared with ALBA only**, but they will not be disclosed or communicated to third parties. Please, accept this clause to go to the questionnaire.

☐ I accept data share modalities

PART A: General information	
A.1 Name of the company	
A.2 Country	*Dropdown menu*
A.3 Sector of activity	*Dropdown menu (NACE codes, two digits)*
A.4. Size - *Employees*	☐ Micro (≤ 10) ☐ Small (≤50) ☐ Medium-sized (≤ 250) ☐ Large (>250)
A.5 Size – *Turnover*	☐ Micro (≤ EUR 2 m) ☐ Small (≤ EUR 10 m) ☐ Medium-sized (≤ EUR 50 m) ☐ Large (> EUR 50 m)
A.6 Name of the person filling the questionnaire	
A.7 Position of the respondent within the company	
PART B: Your experience with the use of ALBA beamlines and other synchrotrons	
B.1 In which of the following ALBA beamlines experiments has your company been involved? *(more than an answer is allowed)*	☐ BL01-MIRAS ☐ BL04-MSPD ☐ BL09-MISTRAL ☐ BL011-NCD-SWEET ☐ BL13-XALOC ☐ BL22-CLAESS ☐ BL24-CIRCE ☐ BL29-BOREAS ☐ I don't know/I am not aware/I can't remember
B.2 Please indicate if your company is:	☐ An infrequent user = it has been granted* the use of beamlines only once ☐ An occasional user = it has been granted* the use of beamlines more than 1 time but less than 5 times ☐ A frequent user = it has been granted* the use of beamlines 5 or more times **Please note that granted means that your company has submitted a proposal for the use of ALBA beamline(s) and this has been accepted.*
B.3 In which year was your company involved in experiments at ALBA beamline for the first time?	☐ 2012 ☐ 2013 ☐ 2014 ☐ 2015 ☐ 2016 ☐ 2017

	☐ 2018 ☐ 2019 ☐ I don't know/I am not aware/I can't remember
B.4 On the total of experiments carried out at ALBA, please indicate the share of those for which the application was submitted by:	Your company only Your company in collaboration with other private companies: _____ Your company in collaboration with universities/research institutes: _____ Your company in collaboration with both private companies and universities/research institutes (e.g. CNR): _____ *The sum of your answers should be equal to 100%*
B.5 On the total of experiments carried out at ALBA, please indicate the share of those carried out:	By self-operating the beamline: _____ By relying on ALBA staff: _____ A mix of both: _____ *The sum of your answers should be equal to 100%*
B.6 In addition to ALBA beamlines, which of the following synchrotron light sources have you used? *(more than an answer is allowed)*	☐ Deutsches Elektronen-Synchrotron (DESY) ☐ Diamond Light Source ☐ Elettra ☐ European Synchrotron Radiation Facility (ESRF) ☐ European XFEL ☐ Felix ☐ Helmholtz-Zentrum Berlin (HZB) ☐ Helmholtz-Zentrum Dresden-Rossendorf (HZDR) ☐ ISA (Danish National Facility) ☐ MAX IV ☐ National Institute for Nuclear Physics (INFN) ☐ Paul Scherrer Institute (PSI) ☐ Physikalisch-Technische Bundesanstalt (PTB) ☐ SOLARIS ☐ SOLEIL ☐ Swiss Light Source (SLS) ☐ Other, please specify: _____
B.7 Please add any relevant comment to the above questions to further explain your answers:	
PART C: Innovation pathways: from your experiments at ALBA beamlines to the innovation	

output: *The objective of this section is to know more about the innovation results (e.g. concerning products, production process, etc.) achieved thanks to the use of ALBA beamtime as well as the PATHWAYS which have allowed to this innovation.*	
C.1 For which purpose(s), are the results - obtained from experiments at ALBA - used for *(more than an answer is allowed):*	☐ **Internal use**: we use these results for the purpose of internal research, e.g. to develop/update our products/service, develop new patents, etc.) ☐ **External use**: we are an intermediate service company and we provide them to third parties for further development ☐ Other, please specify: _____
C.2 Considering all the results of experiments carried out at ALBA, please indicate the share of those for which the following steps/additional activities are usually needed to create an innovation output:	They can be immediately used for innovation purposes and do not need additional research activities or testing: _____ **[if they answer 100% to this option, go to C7)** Additional research activities carried out internally are needed to create an innovation output: _____ Additional research activities in other research institutes and/or synchrotrons are needed to create an innovation output: _____ Additional research activities carried out by specialised companies are needed to create an innovation output: _____ Other, please specify: _____ *The sum of your answers should be equal to 100%*
C.3 On average, how much time it would take to create an innovation - related to the results of experiments at ALBA – with economic or practical significance?	☐ I don't know ☐ Less than 1 year ☐ 1 – 2 year ☐ 3- 5 year ☐ 6-8 year ☐ 8-10 year ☐ More 10 years, please specify: _____
C4 Please, indicate how much workforce would be needed on average in a year to create an innovation output starting from results of experiments at ALBA:	☐ I don't know ☐ 1-5 people ☐ 6-10 people ☐ More than 10 people, please specify: _____
C5 Please, indicate which type of costs additional to	☐ Purchase of instruments for carrying out additional research ☐ Purchase of raw material for carrying out additional research ☐ Purchase of services from specialised companies/research centres

the workforce would be needed to create an innovation output starting from results of experiments at ALBA: *(more than an answer is allowed):*	for carrying out additional research ☐ Travel costs to reach research centres/other synchrotrons for carrying out additional research ☐ Cost for accessing research centres/other synchrotrons ☐ Other, please specify: _____
C6 By considering your answers to questions C4 and C5 above, please provide a rough estimation of additional R&D expenditure (including workforce and other costs) needed **-** on average - to create an innovation output starting from results of experiments at ALBA: *(optional)*	**EUR** ☐ Less than 50,000 ☐ 50,001 – 100,000 ☐ 100,001 – 500,000 ☐ 500,001 – 1,000,000 ☐ More than 1,000,000

C.6.1 Please provide any additional details to complement your answers to the above questions in order to help us to understand the amount of resources and efforts needed to create an innovation output starting from the results of your experiments *(optional)*:

C.7 Please, indicate the innovation output achieved thanks to the experiments carried out at ALBA beamlines:

As a result of the new knowledge acquired through the experiments on ALBA beamline, my company was able to... *(more than an answer is allowed)*

- ☐ develop new products
- ☐ develop new service(s)
- ☐ develop new technologies
- ☐ develop new patents, copyrights, or other intellectual property rights
- ☐ Improve the quality of existing products
- ☐ Improving the quality of the service provided
- ☐ Improve R&D and innovation capabilities
- ☐ Improve technical know-how
- ☐ Other, please specify: _____

Please, answer the following question only if results of your experiments are also used externally

As a result of the new knowledge acquired through the experiments on ALBA beamline, third parties were able to... *(more than an answer is allowed)*

- ☐ develop new products
- ☐ develop new service(s)

- ☐ develop new technologies
- ☐ develop new patents, copyrights, or other intellectual property rights
- ☐ Improve the quality of existing products
- ☐ Improving the quality of the service provided
- ☐ Improve R&D and innovation capabilities
- ☐ Improve technical know-how
- ☐ Other, please specify: _____

C.7.1 Please, feel free to add any details to improve our understanding of the innovation generated from your experiments at ALBA:

C.8 Please, indicate your level of agreement with the following statements:

As a result of the knowledge and improvements (e.g. to our product/services, etc.) gained with the experiments on ALBA beamline, we experienced the following economic impact

	Strongly disagree	*Disagree*	*Neutral*	*Agree*	*Strongly agree*	*I don't know*	*Not applicable*
Increased total sales to customers							
Being more competitive for clients							
Increased overall profitability							
Get new customers							

Other, please specify:

C.9 Considering the average annual turnover from the year your company have used ALBA beamlines (the first time) until 2019 is equal to 100%, what is the percentage that can be attributed to the possibility of having carried out experiments at ALBA?

- ☐ I don't know
- ☐ 0%
- ☐ 1-5%
- ☐ 6-10%
- ☐ More than 10%, please specify: _____

C.10 Please, indicate your level of agreement with the following statements about the added value of accessing ALBA beamlines instead of alternative sources (e.g. other synchrotrons/research institutes, etc.):

WITHOUT ACCESSING ALBA…

	Strongly disagree	*Disagree*	*Neutral*	*Agree*	*Strongly agree*	*Not applicable*
My company could not have performed the research activity because it needs the specific beamlines provided by ALBA/there are no alternatives						
My company could not have performed the research activity because no beamtime was available at that time at other synchrotrons						
My company could have performed the research *(accessing other synchrotrons or using alternative equipment/technologies)* but taking more time to get the same results						
My company could have performed the research *(accessing other synchrotrons or using alternative equipment/technologies)* but at higher costs						
My company could have performed the research *(accessing other synchrotrons or using alternative equipment/technologies)* but obtaining results of lower reliability						
My company could have performed the research but with lower expertise than the one provided by ALBA staff						
Other, please specify:						

PART D. Supporting the dissemination of our survey

We would kindly ask your help in tracking the innovation generated after your experiments at ALBA. We have prepared a **survey addressed to third parties** which have relied on results of your experiments. To this end, we would need to identify the companies or other players which have expressed interests for the results arising from your experiment(s).

D.1 Have you received any expression of interest for the results arising from your experiment(s)? *(more than one answer is allowed)*

- ☐ Yes, from researchers working in the academic field/in research centres **[GO to question D.2]**
- ☐ Yes, from industrial companies **[GO to question D.2]**
- ☐ No **[GO to the end of the questionnaire]**

D.2 If YES, would it be possible to provide us with their contact details (e-mail address):

Please, remind that information provided during this survey will be treated according to the privacy consent signed above (kept anonymous and not disclosed or communicated to third parties)

- ☐ YES **[GO to question D.2.1]**
- ☐ NO **[GO to question D.2.2]**

D.2.1 Please, provide the following details:

Name of the company/institute/university: _____
Contact person: _____
Email address: _____

Name of the company/institute/university: _____
Contact person: _____
Email address: _____

D.2.2 If you cannot provide us with their contact details, we kindly ask you to directly forward the message and link to the questionnaire which is suggested below to third parties which have expressed interest in the results of your experiments.

Dear Madam/Sir,

I would kindly ask you to contribute to a survey carried out by ALBA in collaboration with CSIL - Centre for Industrial Studies (Italy). The survey is carried out in the framework of an H2020 project - RIPATHS project (funded by the European Union under grant agreement 777563) and is addressed to trace and describe the innovation impacts arising on the industry from results of experiments carried out by ALBA users on beamlines. Since you might have used the results of these experiments, your contribution to this survey is extremely relevant to understand the pathways allowing the generation of these impacts.

All the information provided will be anonymised for analysis and will be treated confidentially.

Deadline for completing the survey is January 24th 2020.

https://www.surveymonkey.com/r/ALBAsurvey_thirdparties

I thank you in advance for your valuable support and collaboration.

END OF THE QUESTIONNAIRE

Your e-mail address:

If you are interested in receiving a summary of the results of this survey, please provide us with your e-mail address.

6.4 Questionnaire for ALBA indirect users

Invitation Letter[32]

Dear Madam/Sir,

We are contacting you in the framework of an H2020 project - RIPATHS project (funded by the European Union under grant agreement 777563) addressed to explore the wide range of impacts generated by Research Infrastructures and the different metrics for assessing them.

ALBA is a partner of this project and in collaboration with **CSIL - Centre for Industrial Studies** (Italy) – is interested in tracing and describing the **innovation impacts arising on the industry from results of experiments carried out by its users on beamlines as well as the pathways allowing to the generation of these impacts**.

Your contact was kindly suggested by a user of ALBA we have recently interviewed. We know that you might have used results of experiments carried out at ALBA and this email is to kindly invite you to our survey exploring the impacts generated by using these results.

Please provide your contribution to this study via a short, on-line questionnaire, available in what follows.

CLICK HERE TO PARTICIPATE

All the information provided will be anonymised for analysis and will be treated confidentially.

Mr. **Alejandro Sánchez Grueso is available as your direct contact point for any specific questions** (asanchez@cells.es).

Deadline for completing the survey is 30th March 2020.

I thank you in advance for your valuable support and collaboration.

Your sincerely
Alejandro Sánchez Grueso (*ALBA Associate Director*)

[32] This letter will be used by ALBA to invite those contacts suggested by respondents to the first survey.

WELCOME PAGE

This survey is carried out within the framework of the RIPATHS project funded by the Horizon 2020 programme under grant agreement 777563.

The survey is managed by ALBA in collaboration with CSIL - Centre for Industrial Studies. For any questions or technical problems, please contact **Mr Alejandro Sánchez Grueso** via email [asanchez@cells.es].

If you are not in the position to answer this survey, we would kindly ask you to forward this invitation to the appropriate person at your organisation or company.

The estimated time for completing this survey is 15 minutes. Please note that until you complete the survey, you may change any answers on previous survey pages.

Deadline for completing the survey is **30th March 2020**.

Our most sincere thanks for your valuable cooperation!
ALBA and CSIL team

Privacy consent

ALBA and CSIL which is contributing to the running of this survey handle personal information according to the data protection regulations, including the GDPR.
Please, note that information collected through this survey will be kept anonymous and will be aggregated before being shared with the European Commission. **Personal data of the respondents will be shared with ALBA only**, but they will not be disclosed or communicated to third parties. Please, accept this clause to go to the questionnaire.

☐ I accept data share modalities

PLEASE INDICATE THE TYPE OF INSTITUTION YOU WORK FOR:

- ☐ Universities/research centres **[GO to question PART A]**
- ☐ Private company **[GO to question PART A_bis]**

PART A: General information	
A.1 Your name *optional*	
A.2 Your affiliation *If you have more than one affiliation, please indicate the main one*	*Free Text*
A.3 Gender	☐ Male ☐ Female
A.4 Your role within your affiliation	☐ Director/Senior management ☐ Full Professor/Associate professor ☐ Research Fellow/Research Associate ☐ Postdoc ☐ PhD student ☐ Masters' student Other, please specify_____
A.5 Your discipline/research field	☐ AMO physics *(Atomic and Molecular Physics)* ☐ Biology-Life Sciences (not PX) ☐ Chemistry-surface science-catalysis ☐ Cultural Heritage ☐ Environmental Sciences ☐ Geo-Sciences ☐ Instrumentation and technique development ☐ Materials sciences for energy technology ☐ Materials sciences for information technology ☐ Metrology ☐ Protein Crystallography ☐ Solid-state physics *(electronic properties, magnetism, basic quantum materials)* ☐ Solid-state physics/materials science *(structure, phase transitions, nanomaterials)* ☐ Other, please specify_____

A.6 In which potential area of application may your research eventually contribute? *(more than an answer is possible)*	☐ Health ☐ Food and Nutrition (food security, agriculture and marine research) ☐ Energy (secure, clean and efficient) ☐ Transport and Mobility (sustainable and integrated) ☐ Climate and Resources (efficiency and raw materials) ☐ Applications to Public Sector Challenges (security, safety, inclusiveness) ☐ Advances in other Enabling Technologies Other, please specify/None of the above, please specify why: _____
A.7 Your research activity is *(Please indicate the one which mostly applies)*	☐ pure basic research ☐ research with application orientation ☐ industrially relevant research
PART B: Your use of results of experiments carried out at ALBA	
B.1 How frequently have you used results of experiments carried out at ALBA?	☐ Once ☐ Two-three times ☐ More than three times, please specify
B.2 How did you know about the availability of these results? *(more than an answer is allowed)*	☐ During conferences and/or other events attended by researchers/companies which have performed experiments at ALBA ☐ From publications in professional journals ☐ From a network of researchers/companies, I usually work with ☐ Word of mouth from other colleagues ☐ Oher, please specify: _____
B.3 For which purpose did you use the results of experiments at ALBA? *(more than an answer is allowed)*	☐ pure basic research ☐ industrially relevant research ☐ research with application orientation ☐ Other, please, specify
B.3.1 Please could you add some details on the objectives for which these results were used? *optional*	
B.4 Were these results immediately useful to achieve your objective(s)?	☐ Yes, I could immediately use it for your my purposes without carrying out additional activities or testing **[GO to question Q.B5]** ☐ No, I needed to carry out additional research activities **[GO to question Q.B.4.1]**
B.4.1 Which of the following steps/additional activities were needed in order to make these results useful to	☐ I had to carry out additional research activities internally ☐ I had to carry out additional research activities in other

achieve your objective? *(more than an answer is allowed)*	research institutes and/or synchrotrons ☐ I had to carry out additional research activities with the support of specialised companies ☐ Other, please specify: _____
B5 How much time did you take to make these results useful for achieving your objective?	☐ I can't remember ☐ Less than 1 year ☐ 1 – 2 year ☐ 3- 5 year ☐ More than 5 years, please specify: _____
B.6 Did you file for patents on the basis of results of ALBA experiments and your additional research activities (if any)?	☐ YES **[GO to question B.6.1]** ☐ NO **[GO to question B.7]**
B.6.1 If yes, please could you indicate in which fields?	*Dropdown menu* ☐ Chemistry ☐ Nanotechnology ☐ Pharmaceutical ☐ Health products (e.g. cosmetics, personal care, etc.) ☐ Food and agriculture ☐ Automotive and aerospace ☐ Energy Other, please specify_____
B.7 Based on results of ALBA experiments and your additional research activities (if any) which of the following outputs have you produced? *(more than an answer is allowed)*	☐ Publication in a peer-reviewed journal ☐ Conference proceedings or book ☐ PhD Thesis ☐ Technical Note ☐ None of these outputs Other, please specify_____
B.8 Based on results of ALBA experiments and your additional research activities (if any), please could you estimate how much time it would take to create innovation with economic or practical significance?	☐ I don't know ☐ Less than one year ☐ 1 – 2 year ☐ 3- 5 year ☐ 6-8 year ☐ 8-10 year ☐ More 10 years, please specify: _____
B.9 Please indicate which of the following steps/additional activities are needed to create an innovation output starting from results of ALBA experiments and your additional research activities (if any) *(more than an answer is allowed)*	☐ Results from experiments from ALBA completed with my additional research can be immediately used for innovation purposes and do not need additional research activities or testing ☐ Additional research activities carried out internally are needed to create an innovation output ☐ Additional research activities in other research institutes and/or synchrotrons are needed to create an innovation output ☐ Additional research activities carried out by specialised companies are needed to create an innovation output ☐ Other, please specify: _____
B.10 Have you received any expression of interest by third parties for your research output(s) created on the basis	☐ YES **[GO to question B.10.1]** ☐ NO **[GO to question B.11]**

of results of experiments carried out at ALBA?	
B.10.1 If yes, please could you indicate from which fields?	*Dropdown menu* ☐ Chemistry ☐ Nanotechnology ☐ Pharmaceutical ☐ Health products (e.g. cosmetics, personal care, etc.) ☐ Food and agriculture ☐ Automotive and aerospace ☐ Energy ☐ Other, please specify_____
B.11 From your knowledge, on the basis of results of ALBA experiments and your additional research activities (if any) which of the following innovation outputs companies or third parties interested in technological developments were able/could be able to achieve in the future?	*(more than one answer is allowed)* ☐ develop new products ☐ develop new service(s) ☐ develop new technologies ☐ develop new patents, copyrights, or other intellectual property rights ☐ Improve the quality of existing products ☐ Improving the quality of the service provided ☐ Improve R&D and innovation capabilities ☐ Improve technical know-how ☐ I don't know ☐ Other, please specify: _____
B.12 In addition to ALBA, have you used results of experiments and/or been directly involved in experiments at other synchrotron light sources?	☐ YES **[GO to Question B.12.1]** ☐ NO **[GO to Question B.13]**
B.12.1 Please, specify which of the following synchrotron light sources have you been involved for experiment(s) or used results of experiments carried out by others: *(more than an answer is allowed)*	☐ Deutsches Elektronen-Synchrotron (DESY) ☐ Diamond Light Source ☐ Elettra ☐ European Synchrotron Radiation Facility (ESRF) ☐ European XFEL ☐ Felix ☐ Helmholtz-Zentrum Berlin (HZB) ☐ Helmholtz-Zentrum Dresden-Rossendorf (HZDR) ☐ National Institute for Nuclear Physics (INFN) ☐ ISA (Danish National Facility) ☐ MAX IV ☐ Paul Scherrer Institute (PSI) ☐ Physikalisch-Technische Bundesanstalt (PTB) ☐ SOLARIS ☐ SOLEIL ☐ Swiss Light Source (SLS) Other, please specify: _____
B.13 Please add any relevant comment to the above questions to further explain your answers:	

PART C The impacts of using results of experiments carried out at ALBA <u>on your research activity</u>

C.1 Please, indicate your level of agreement with the following statements about the added value of relying on results of experiments carried out at ALBA instead of alternative sources (e.g. other synchrotrons/research institutes, etc.):

Without using results of experiments carried out at ALBA…

	Strongly disagree	*Disagree*	*Neutral*	*Agree*	*Strongly agree*	*Not applicable*
I could not achieve my objectives <u>because I needed these specific results/there were no alternatives</u>						
I could achieve my objectives *(relying on results from other synchrotrons or using alternative equipment/technologies)* <u>but taking more time</u>						
I could achieve my objectives *(relying on results from other synchrotrons or using alternative equipment/technologies)* <u>but at higher costs</u>						
I could achieve my objectives *(relying on results from other synchrotrons or using alternative equipment/technologies)* <u>but relying on results of lower reliability</u>						
Other, please specify:						

C.2 To what extent, the use of results from experiments carried out at ALBA has contributed to:

	Not at all	*Small improvement*	*Moderate improvement*	*Significant Improvement*	*Not applicable*
Providing an answer to your research questions/needs					
Understanding your research area					

Improving the quality of your research					
END OF THE QUESTIONNAIRE					

PART A_bis: General information	
A.1 Name of the company	
A.2 Country	*Dropdown menu*
A.3 Sector of activity	*Dropdown menu (NACE codes, two digits)*
A.4. Size - *Employees*	☐ Micro (≤ 10) ☐ Small (≤50) ☐ Medium-sized (≤ 250) ☐ Large (>250)
A.5 Size – *Turnover*	☐ Micro (≤ EUR 2 m) ☐ Small (≤ EUR 10 m) ☐ Medium-sized (≤ EUR 50 m) ☐ Large (> EUR 50 m)
A.6 Name of the person filling the questionnaire *(optional)*	
A.7 Position of the respondent within the company *(optional)*	
PART B_bis: Your use of results of experiments carried out at ALBA	
B.1 How frequently have you used results of experiments carried out at ALBA?	☐ Once ☐ Two-three times ☐ More than three times, please specify
B.2 How did you know about the availability of these results? *(more than an answer is allowed)*	☐ We commissioned these experiments at ALBA ☐ During conferences and/or other events attended by researchers/companies which have performed experiments at ALBA ☐ From publications in professional journals ☐ From a network of researchers/companies I usually work with ☐ Word of mouth ☐ Oher, please specify: _____
B.3 In which year did your company use results of experiments carried out at ALBA for the first time?	☐ 2012 ☐ 2013 ☐ 2014 ☐ 2015 ☐ 2016 ☐ 2017 ☐ 2018 ☐ 2019 ☐ I don't know/I am not aware/I can't remember
B4 In addition to ALBA, have you used	☐ YES **[GO to Question B.4.1]**

results of experiments and/or been directly involved in experiments at other synchrotron light sources?	☐ NO **[GO to Question B.5]**
B.4.1 Please, specify which of the following synchrotron light sources have you been involved for experiment(s) or used results of experiments carried out by others: *(more than an answer is allowed)*	☐ Deutsches Elektronen-Synchrotron (DESY) ☐ Diamond Light Source ☐ Elettra ☐ European Synchrotron Radiation Facility (ESRF) ☐ European XFEL ☐ Felix ☐ Helmholtz-Zentrum Berlin (HZB) ☐ Helmholtz-Zentrum Dresden-Rossendorf (HZDR) ☐ National Institute for Nuclear Physics (INFN) ☐ ISA (Danish National Facility) ☐ MAX IV ☐ Paul Scherrer Institute (PSI) ☐ Physikalisch-Technische Bundesanstalt (PTB) ☐ SOLARIS ☐ SOLEIL ☐ Swiss Light Source (SLS) ☐ Other, please specify: _____
B.5 Please add any relevant comment to the above questions to further explain your answers:	
PART C_bis: Innovation pathways: from the use of results of experiments at <u>ALBA beamlines</u> to the innovation output: *The objective of this section is to know more about the innovation results (e.g. concerning products, production process, etc.) achieved thanks to the use of ALBA beamtime as well as the PATHWAYS which have allowed to this innovation.*	
C.1 Were these results immediately useful to achieve your objective(s)?	☐ Yes, my company could immediately use it without carrying out additional activities or testing **[GO to question C.2]** ☐ No, my company needed to carry out additional research activities **[GO to question Q C.1.1]**
C.1.1 Which of the following steps/additional activities were needed in order to make these results useful to achieve your objective? *(more than an answer is allowed)*	☐ My company had to carry out additional research activities internally ☐ My company had to carry out additional research activities in other research institutes and/or synchrotrons ☐ My company had to carry out additional research activities with the support of specialised companies Other, please specify: _____

C.2 Please, indicate which of the following output(s) was achieved thanks to the use of results of experiments carried out at ALBA beamlines:

By using these results, <u>my company</u> was able to... *(more than an answer is allowed)*

- ☐ develop new products
- ☐ develop new service(s)
- ☐ develop new technologies
- ☐ develop new patents, copyrights, or other intellectual property rights

- ☐ Improve the quality of existing products
- ☐ Improving the quality of the service provided
- ☐ Improve R&D and innovation capabilities
- ☐ Improve technical know-how
- ☐ Other, please specify: _____

C.2.1 Please, feel free to add any details to improve our understanding of the innovation output generated from using results of experiments carried out at ALBA:

C.3 On average, how <u>much time</u> did you take to create the innovation output(s) mentioned in question C.2?	☐ I don't know ☐ Less than 1 year ☐ 1 – 2 year ☐ 3- 5 year ☐ More 5 years, please specify: _____
C4 Please, provide an indication of <u>how much manpower</u> did you need to create the innovation output(s) mentioned in question C.2?	☐ I don't know ☐ 1-5 people ☐ 6-10 people ☐ More than 10 people, please specify: _____
C5 Please, indicate which type of <u>additional costs</u> did you need to create the innovation output(s) mentioned in question C.2? *(more than an answer is allowed):*	☐ Purchase of instruments for carrying out additional research ☐ Purchase of raw material for carrying out additional research ☐ Purchase of services from specialised companies/research centres for carrying out additional research ☐ Travel costs to reach research centres/other synchrotrons for carrying out additional research ☐ Cost for accessing to research centres/other synchrotrons ☐ Other, please specify: _____
C6 By considering your answers to questions C4 and C5 above, please provide an <u>estimation of additional R&D expenditure</u> (including manpower and other costs) you needed - on average - to create the innovation output(s) mentioned in question C.2? *(optional)*	**<u>EUR</u>** ☐ Less than 50,000 ☐ 50,001 – 100,000 ☐ 100,001 – 500,000 ☐ 500,001 – 1,000,000 ☐ More than 1,000,000

C.6.1 Please provide any additional details to complement your answers to the above questions in order to help us to understand the amount of resources and efforts needed to create an innovation output starting from the results of experiments carried out at ALBA *(optional)*:

C.7 Please, indicate your level of agreement with the following statements:

As a result of the knowledge and improvements (e.g. to our product/services, etc.) gained thanks to the use of results of experiments on ALBA beamline, we experienced the following economic impact

	Strongly disagree	*Disagree*	*Neutral*	*Agree*	*Strongly agree*	*I don't know*	*Not applicable*
Increased total sales to customers							
Being more competitive for clients							
Increased overall profitability							
Get new customers							

Other, please specify:

C.8 Considering the **average annual turnover** from the year your company have used results of experiments carried out at ALBA (the first time) until 2019 **is equal to 100%**, what is the percentage that can be attributed to the possibility of having used these results

- ☐ I don't know
- ☐ 0%
- ☐ 1-5%
- ☐ 6-10%
- ☐ More than 10%, please specify: _____

C.9 Please, indicate your level of agreement with the following statements about the added value of having used results from experiments at ALBA instead of alternative sources (e.g. other synchrotrons/research institutes, etc.):

Without using results of experiments carried out at ALBA…

	Strongly disagree	*Disagree*	*Neutral*	*Agree*	*Strongly agree*	*Not applicable*
My company could not achieve its objectives because it needed these specific results/there were no alternatives						
My company could have achieved its objectives *(accessing other synchrotrons or using alternative equipment/technologies)* but taking more time to get the same results						
My company could have achieved its objectives *(accessing other synchrotrons or using alternative equipment/technologies)* but at higher costs						
My company could have achieved its objectives *(accessing other synchrotrons or using alternative*						

equipment/technologies) but relying on results of lower reliability						
Other, please specify:						
END OF THE QUESTIONNAIRE						
Your e-mail address: *If you are interested in receiving a summary of the results of this survey, please provide us with your e-mail address.*						