ALBA news

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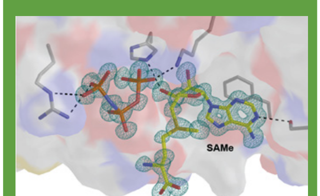

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Cover
Racks at the service area of the ALBA Synchrotron
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GOBIERNO DE ESPAÑA
MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD
Generalitat de Catalunya

Dear reader,

ALBA has celebrated the fifth year anniversary of the first synchrotron light at the synchrotron, what happened on 16 March 2011. Five years of hard activity devoted to move from the status of a young organization, pioneer in Spain as the biggest scientific infrastructure, to a consolidated user facility, providing beamtime to thousands of scientists from all over the world, producing high impact scientific results, few of them highlighted in this issue, and ready to further develop in terms of instruments and services.

One of these developments is MIRAS, the first Phase-II beamline, which in advance with respect to the original schedule is now accepting friendly users, and in few weeks will host the first official proposal.

While building the second Phase-II beamline, LOREA, dedicated to ARPES spectroscopy, this year has seen Phase-III birth, with the start of XAIRA construction, a microfocus beamline for macromolecular crystallography, specifically designed to deliver high flux X-rays with a beam size down to the micrometer size, fully tunable around all essential K and L edges.

A focus session is devoted to the control system, which can be thought as the nervous system of the whole installation, and which represents one of the fields in which ALBA is at the frontier with respect to similar facilities worldwide.

You will find also the description of the Open Day, when we stop every other activity to show to the general public what we do, why and how.

The early days of ALBA are remembered in the interview to Dieter Einfeld, one of the main artifices of our project. He is nowadays at ESRF contributing there to the machine upgrade, and looking towards the future.

Finally let me mention two of the recent initiatives which recognize the enormous contribution of Ramon Pascual to science in Spain and in particular to ALBA: the awarding of the *Encomienda de Alfonso X el Sabio* by the Spanish Government and the act of tribute recently held at the Parliament of the Generalitat in Barcelona, attended by more than one hundred people representing the academic and research world at the national level.

Enjoy the reading

Caterina Biscari
ALBA Director

ALBA initiates the construction of its 10th beamline

The new microfocus beamline for macromolecular crystallography will contribute to a better understanding of complex biological systems, with academic and industrial applications.

The microfocus beamline will deliver a small X-ray beam of the order of 1 micron at the sample position. The small beam size will allow tackling an increasing number of important projects that are limited by the size of the crystals or by the radiation damage effects. These projects include membrane proteins, protein complexes, DNA-protein complexes and radiation-sensitive proteins.

The budget for the construction of the new microfocus beamline for macromolecular crystallography is 7 million euros. The project will be co-funded by the European Regional Development Fund (ERDF) and the ALBA internal budget. The project was initiated in January 2016 with the appointment of the head of the beamline, Jordi Juanhuix, in order to start the design phase. The beamline is expected to be available for experiments in 2020.

Five years of synchrotron light in ALBA

On the 16th of March 2011, the electron accelerator of the ALBA Synchrotron emitted synchrotron light for the first time.

On the 16th of March of 2011, at 15:45, a group of scientists and technicians of the ALBA Synchrotron were toasting with cava. Eight years after the project's approval, it was possible to produce and see synchrotron light in the accelerators complex of the facility. That moment was the starting point of the ALBA Synchrotron, which, one year later, began hosting the first experiments.

In 2016 the ALBA Synchrotron is celebrating the fifth anniversary of the commissioning of the accelerator. "It was a very exciting moment because we were testing the work done in previous years and, if everything was right, we would be able to start the experiments very soon", says Francis Pérez, head of the Accelerators' division and former head of the Radiofrequency and Diagnostics section at that time.

For that reason, ALBA organised an event with all the staff, also including the presence of the former head of the Accelerators division, Dieter Einfeld. A commemorative video was released to explain the atmosphere of the moment and the anecdotes that took place. The event finished with a toast of all the attendees.

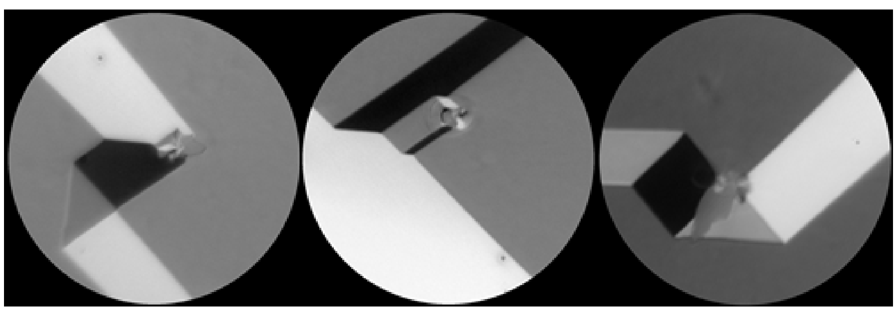
Nowadays, the accelerators' complex of ALBA works about 6,000 hours per year with an availability above 97%. New improvements have been made, such as the top-up working mode or a new fast-orbit feedback system, both of them in order to increase beam stability.

Images of the event celebrating the fifth anniversary of the commissioning of ALBA's Storage Ring. © ALBA Synchrotron

Five shades of gray...

At the CIRCE beamline.

During the magnetic reversal of an iron thin film, domains with magnetization pointing along the four crystalline easy axes are preferably formed close to defects like the round structures (medium gray) at the centre of the images (FOV 40 um). Under a suitable incidence angle, these domains are distinguishable by their gray scale intensity in the magnetic contrast XMCD-PEEM image: black, dark gray, light gray and white. Note how domain walls between reverse domains (black-white or gray-gray) are rotated by 45 deg with respect to domain walls between perpendicular domains.



Images courtesy of A. Brambilla, Politecnico de Milano.

The ALBA Control System

David Fernández, Guifré Cuní, Óscar Matilla
Computing & Control division, ALBA Synchrotron

A synchrotron light source is a particle accelerator and a number of beamlines with their experimental stations, with a large variety of instruments, mechanisms and detectors to observe how the light interacts with the matter in the samples. The ALBA Control System refers to the assembly of hardware and software devoted to the acquisition of signals and data, as well as the transmission of commands and values in order to supervise, regulate and operate the different machineries of the particle accelerators, beamlines and experimental stations. The Control System integrates automatic regulation and closed loops with open loops and operator interfaces and provides a large number of tools including alarm handlers, historical databases and complex sequences. They combine a large set of technologies to meet the particular requirements of the different types of experiments and subsystems[1].

The control and data acquisition systems at the core of the experiments

The Control systems have enormously progressed during the last decades. Commercial SCADAS (Supervisory Control and Data Acquisition software) have adapted well to industrial environments and are now at the core of industrial processes largely integrated with other applications such as financial, stock management, etc. Some specialized companies have identified and developed solutions for the scientific requirements of large research facilities. However, most scientific installations dedicate efforts and manpower to design and maintain their own solutions. This is expensive and time consuming, and budgets are limited, so the option of sharing code, efforts and experience has clear advantages. TANGO is a good example of a successful collaboration, where a growing number of laboratories around the world share efforts to write common software tools.

Synchrotrons, neutron sources and, more in particular, beamlines have very specific needs to perform experiments. They have diagnostics, detectors, diffractometers, sample environments and, above all, a large number of motors to be operated synchronously in any arbitrary combination. So, the hardware and the software must be flexible, in terms of configuration, such as what to acquire, what to plot or display and what to move and synchronize during an experiment. The SARDANA collaboration initiated at ALBA a few years ago offers a SCADA on top of TANGO, oriented to fulfill the requirements of the experiments in a beamline. SARDANA provides a macro environment to edit and run sequences and macros together with a hardware repository that configures the motors, detectors, counters, timers and synchronization elements controlled during data acquisition. The client-server architecture allows multiple command-line and graphical interfaces; whereas the completeness of the standard and purpose-specific macros adapt effectively to the different requirements of the experiments proposed by the scientists (users) who are typically granted access to a beamline for a few days or, in occasions, for only a few hours.

Definition and main purposes of the Control System at ALBA

The synchrotron is a set of particle accelerators (Linac, Booster and Storage Ring), installed in bunkers and enclosures (tunnels), that produce synchrotron light to serve the beamlines and experimental stations located in the periphery of the accelerators. The system is distributed so the Control System has to meet the requirements.

1. These technologies are both hardware and software. Hardware, such as Ethernet, Programmable Logic Controllers (PLCs), industrial PCs and comact PCI...etc. Software such as Linux, Python, C++, Qt, MySQL, etc.

The numerous pieces of electronic equipment and instrumentation are installed in racks distributed around the building and the software runs distributed in multiple microprocessors placed in these racks or in servers in the data center.

In an installation of this kind, the beams are steered in ultra-high vacuum chambers, with ion pumps, valves, gauges, temperature sensors, residual gas analyzers, etc. The electron beams are kept in orbit by the effect of magnets commanded by power supplies, and measured by a precise network of Beam Position Monitors and their electronics, which are part of the numerous diagnostic systems. The light for the beamlines is produced by the insertion devices which need motorized positioning systems, the Radio-Frequency plants recover the energy that the electrons lose due to the emission of synchrotron radiation and need specific control at low levels and interfaces with the generic Control systems. The whole installation, diagnostic elements and, in particular, the injection process, is synchronized by the timing system which gives a precision of up to a few picoseconds and the flexibility to configure arbitrary delays for the master signals at virtually any point in the accelerator and the beamlines. The Personnel Safety System (PSS) ensures that people do not get irradiated by both monitoring the radiation levels outside the enclosures and preventing unauthorized access to restricted areas during operation. The machine protection systems manage a set of conditions, permits and interlocks ensuring that the accelerators and beamline components and instrumentation do not get damaged during the operation.

Design choices and achievements

The Control System must fit its purpose, be reliable, maintainable and, above all, cost-effective in both design/installation/commissioning and operation phases. In order to do that, the Computing & Control engineers balanced risks and costs and made important standardization efforts, always keeping an open mind to exceptions when appropriate. This standardization effort is crucial to reduce the procurement and installation costs and the maintenance efforts or, in other words, the Total Cost of Ownership (TCO). Ethernet is the standard communication network and the standard fieldbus for most equipments, such as power supplies, motor controllers, diagnostics cameras, etc. So the system is distributed, based on a client server approach undertook by TANGO. Python is the most used programming language for both server and client applications, which widely use events as the default communication messages. The software is not real-time compliant, running mostly in Linux boxes, although there are some applications, like the fast electron orbit feedback which monitors positions and sets currents in 176 coils at a rate of 5 kHz, and therefore uses specific patches on Linux and specific quad-core CPUs. In the particular cases that require real-time or a deterministic behavior, an appropriate hardware is configured for these purposes.

In order to control the bunches of electrons traveling at almost the speed of light, the synchronization of the injection elements, diagnostics and experiments, requires a high accuracy and precision up-to few picoseconds range. Dedicated systems are built based on length-calibrated fiber optics to broadcast the synchronization signals from the generator to the receivers, and vice versa to propagate fast interlock signals from the machine protection system.

Other examples focus not on speed or precision, but on an enforced reliability on a large set of signals. The EPS (Equipment Protection System) is built on PLC (Programmable Logic Controller) technology and ensures that the machine and Beamlines do not get damaged during the operation managing in the order of eight thousand signals distributed and transmitted in a guaranteed time-window of 20 milliseconds.

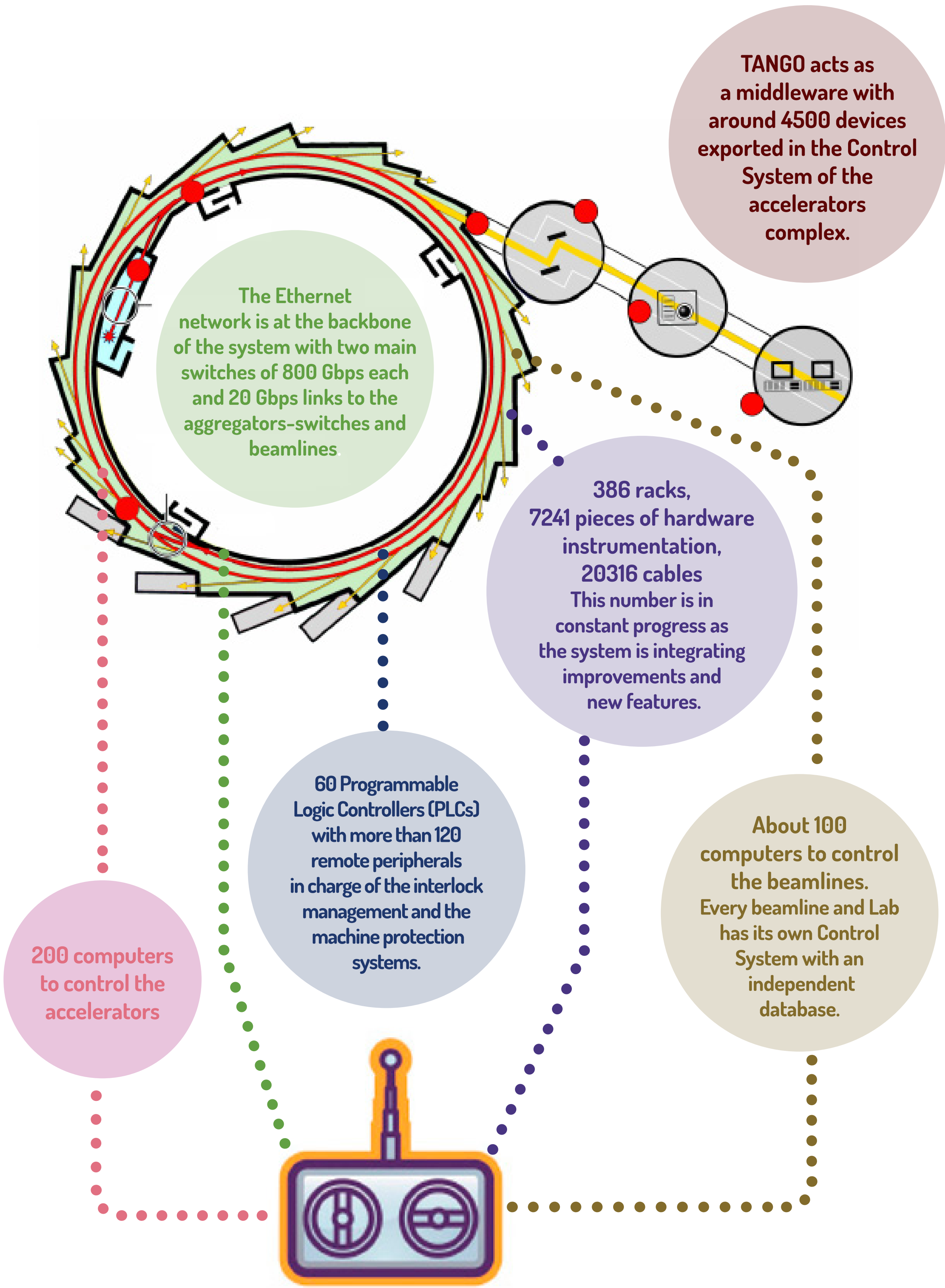
The standards must also consider exceptional restrictions like the PSS which needs to be installed independently, with special requirements of redundancy, diversity and certification of the hardware controllers, to comply with legal authorities and standards like SIL3 defined in the norm IEC 61508.

The Service

The synchrotron typically hosts experiments on a 24/6 basis, that is, 24 hours a day, 6 days a week, with one day per week for accelerators maintenance, the setup of the experiments at the beamlines and solving incidences in general. The Control System and the computing infrastructure work on a 24/7 basis, and has to be highly performing, robust, resilient and reliable. With 16 and 13 members respectively, the Control System and Electronics Sections in the Computing division ensure the support and maintenance of the software tools, the electronic equipment and the instrumentation. There is an on- call service in place with six persons per week to cover the different areas of the services, including the IT support.

More info at:
www.albasynchrotron.es
computing.cells.es
www.tango-controls.org
www.sardana-scada.org
www.taurus-scada.org

The ALBA Control System in numbers



INTERVIEW

Who are the 'Controllers'?

As mentioned previously, a group of 29 computing engineers, electronics engineers, physicists and technicians take part in the Controls and Electronics sections of the ALBA Synchrotron. We have talked to Óscar Matilla, Guifré Cuní, Zbigniew Reszela, Sergi Rubio and José Ávila to have a better idea of what their job is like and what their functions are in the difficult task of controlling a synchrotron facility.
Magnets, radio-frequency plants, diagnostics sensors, beam position monitors, beamline motors, data collection... There are many different components and devices involved for the right performance of a synchrotron facility. Without them, users wouldn't be able to run the experiment and thus bring interesting data home.

What do you think the main challenge is when controlling a synchrotron facility?

Sergi: Volume and scale. The number of devices that you have to control as well as the big number of interfaces. In our job, we need to integrate solutions from different companies and from different people.

Jose: It is also worth mentioning that the range of technical skills that you need to cover is very wide. When working on a private company, you rather focus on one specific issue (for example, power electronics). However, in a facility like ALBA, you are constantly facing different challenges (i.e. devices with very tiny currents but also digital processing,...).

Óscar: We need to know the whole spectrum and this is one of the most interesting aspects of our job.

So, I guess that you need to be learning new skills all the time.

Guifré: For sure! When you start working in a synchrotron facility Controls group, typically, you would need around 9-10 months to be completely adapted to the job position. There are many new procedures, concepts, protocols ... to be learnt.

Sergi: Besides, in a cutting-edge facility like ALBA, almost half of the technologies that we use are outdated in 4-5 years. So you must keep learning how to adapt a device when the provider does not exist anymore, for example. Here the instrumentation is quite unique. Perhaps only you and 4 or 5 other people in the world know how to control that specific device. So there is a lot of work investigating how to manipulate this device and obtain the best performance. In this sense, international collaboration with other facilities is needed in order to share knowledge and be more effective.

Zbigniew: When developing software, in private companies there are different roles: the business analyst, the software architect, the programmer and the tester. In our case, it's a bit different because each engineer covers the whole process. We work in agile self-organised teams which are responsible for providing the final product. This way of working allows you to learn a lot.

Which are the main benefits of having a reliable Control System for ALBA's users?

Guifré: One of the key factors is flexibility. Although each beamline has a common structure of experiment, the ALBA Control System is flexible enough to add new devices and measure specific signals.

Sergi: Another great advantage for users of having an in-house Controls & Electronics' group is the fast response. As most of the systems are standardized, we can provide maintenance and on-call assistance to solve problems very fast. We should not forget the capability of improvement of all the experimental stations and the accelerators. Beamlines are not static units; they do not have the same features as three years ago. The same happens to the accelerators. New upgrades have been progressively introduced.

How do you organize to deal with so many issues at the same time?

Óscar & Guifré: We are organized in two groups: Electronics and Controls. In the Controls group, part of us gives support to the accelerators, another to the beamlines – with specific profiles for each beamline, as they have different requirements -, others develop common software tools and solutions and, finally, there is a group for transversal services such as vacuum, archiving, etc. In the Electronics group, though we have different backgrounds, we can share projects with different degree of specialization.

Is it a very demanding job?

Óscar & Guifré: Yes, we do not do shifts but sometimes you have to work till late because the tunnel is open for few hours and that's the only moment to do maintenance. This happens frequently during shutdowns when there are tight schedules. Nevertheless, you also need to be prepared in advance. When doing an upgrade or a new installation, you need to previously define all the cables, the instruments, the database, the software... and have everything ready before the shutdown.

Guifré: When working with detectors, we also have very limited time as we need beamtime to test the detector but the beamline scientist also needs time for the beamline commissioning.

Sergi: In that sense, we could say that we have the same level of pressure as in a private company because we have to keep the accelerators and the beamlines running for users.

Do you develop in-house solutions?

Óscar & Jose: Our main goal is not to develop in-house devices. However, when there are no commercial solutions or the existing ones do not fulfill our requirements, we choose to develop our own projects with added value. For example, the development of an electrometer is one of our successful examples (which arose the interest of other facilities). But, in some other cases, we must also develop something for specific experiments like a magnetic pulse generator for the MISTRAL beamline.

Guifré & Sergi: In the case of software, we are strongly involved in the development of SARDANA and TAURUS. For instance, the SKA astronomy project – the multi radio telescope to be built in Australia and South Africa- is analysing part of the software developed in ALBA.

Is the ALBA Control System well recognized at an international level?

Óscar: The continuous learning process, from the designing of the facility until now that it is in full operation, has enabled us to create strong collaborations worldwide, so the ALBA Controls system is present and well-known in all scientific congresses. We can say that ALBA's contributions in this field are at the same level as that of other synchrotron facilities. And this is one of the reasons why ALBA is in charge of organizing the next edition of ICALEPCS in 2017, the International Conference on Accelerator and Large Experimental Physics Control Systems that gathers more than 700 attendees every two years.

ICALEPCS 2017 will be held in Barcelona, from 8 to 13 October 2017. Abstract submission begins in February 2017 and online registration will be available from April 2017. The event is hosted by the ALBA Synchrotron.

Adriana Rojas
CIC bioGUNE

High-resolution crystallographic structures provide a *movie* of SAMe synthesis.

Hepatocellular carcinoma (HCC) is the most common primary malignant tumour of the liver. Detection of HCC can be difficult, as most of the patients who develop this tumour have no symptoms other than those related to their longstanding liver disease. Consequently, there is an urgent need to understand the molecular mechanisms that are responsible for the development of this disease so that appropriate therapies can be designed. Liver is the main source of biosynthesis and consumption of the principal biological methyl donor, S-adenosylmethionine (SAMe). The synthesis of SAMe from methionine is catalyzed by the enzyme methionine adenosyltransferase (MAT).

Tight regulation of the levels of SAMe is essential for maintaining a healthy cell, However, in many diseases such as hepatocellular carcinoma and colon cancer, SAMe levels are dysregulated. These types of cancer are of significant social and clinical relevance as in 2012 alone, liver cancer was responsible for the second highest mortality rate worldwide, with colon cancer appearing third in the list.

The conservation across all kingdoms of these enzymes highlights their important role in the preservation of life. Mammals express three MAT genes, *MAT1A*, *MAT2A* and *MAT2B*; the former two encode for the catalytic subunits, MATα1 and MATα2, which share an 81% sequence homology whilst the third gene encodes for MATβ protein, a regulatory subunit which has low sequence homology to the catalytic subunits.

MAT enzymes display a tissue-specific expression pattern, whereas MATα2 is expressed during differentiation of foetal liver, MATα1 is exclusively detected in the adult liver. Conversely, a switch in MAT gene expression is observed during liver regeneration and hepatocarcinogenesis, which mimics the foetal expression pattern and causes reexpression of MATα2 in place of MATα1 (Fig1). Thus, increased MATα2 expression offers the liver cancer cells a growth advantage, indicating MATα2 as a possible therapeutic target.

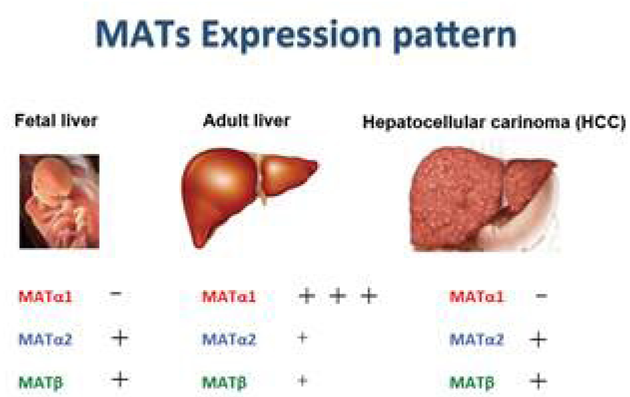


Figure 1. MAT enzymes expression in human liver.

By means of X-ray diffraction experiments, the structure of the ligand bound structures of human MATα2 at 1.1 Å, 1.45 Å and 1.8 Å were determined, giving insight into how SAMe is formed in Human MATα2. A detailed view of the triple phosphate group within the active site reveals not only its correct orientation (fig. 2) but also the coordination of surrounding ions. Each structure captured different conformational states of the reaction, and similar to the sequence of static images that give raise to a movie, these structures show the movement of the substrates during the catalysis. Remarkably, when the MATβ regulatory subunit is bound to MATα2 (PDB 4NDN) the residues at the active site remain in the same orientation suggesting that the binding of MATβ does not alter the overall reaction mechanism of SAMe production.

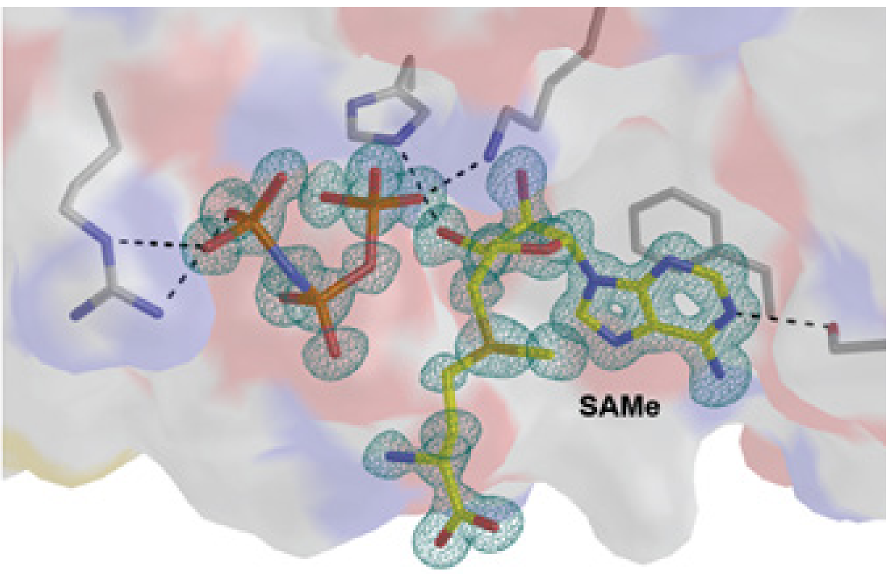


Figure 2. MATα2 active site.

The crystallographic 'movie' based on high-resolution structures shows for the first time a detailed mechanism of SAMe synthesis in humans including the initial position of the substrate methionine. Furthermore, the reported structures shed light on a long-standing debate about how the reaction product is released. According to these observations, we have proposed that the breakdown of the triple phosphate does not provide energy to release SAMe by causing movement in the 'gating loop', a loop which encloses the active site during synthesis.

The fact that we can see the crystallographic structure at 1.1 Å resolution provides us with information of an extremely precise nature for the next step: the development of anticancer drugs designed to block or reduce the activity of this protein.

The core of this study involved the use of X-ray crystallography at two synchrotron facilities, ALBA in Barcelona and DIAMOND in the UK, and is the result of an interdisciplinary collaboration between the Basque Centre for Cooperative Research in Biosciences CIC bioGUNE, Liverpool University and Cedars-Sinai Hospital in California.

References: B. Murray, S. V. Antonyuk, A. Marina, S. C. Lu, J. M. Mato, S. S. Hasnain & A. L. Rojas (2016). Crystallography captures catalytic steps in human methionine adenosyltransferase enzymes. *Proceedings of the National Academy of Sciences of the United States of America*, ***113*****(8)**, DOI: 10.1073/pnas.1510959113 2104–2109.

Storage Ring filling patterns for time-resolved experiments

The ALBA Synchrotron has developed an algorithm for controlling the amount and location of electrons at the Storage Ring. This new development will enable ALBA users to perform time-resolved experiments.

At the Storage Ring of ALBA, the accelerating voltage of the RF frequency compensates for the energy loss of the electrons due to the emission of synchrotron radiation. It also groups the electrons in bunches separated by 60 cm, which is the wavelength of the RF frequency (500 MHz), corresponding to a distance in time of 2 nanoseconds. The ALBA circumference is 268.8 m, so that there are 448 "spaces" that can be filled with electrons. The different filling of the bunches with electrons will generate different filling patterns. ALBA is usually filled with 320 bunches in 10 trains and with the same average current of 0.4 mA/bunch, as shown in figure 3.

In order to fulfil the demand of the scientists to perform time-resolved experiments, and simultaneously meet the needs of high brilliance experiments, the most commonly used filling pattern is the so-called hybrid mode, where there are a large number of contiguous bunches with a rather small current, followed by a gap in the middle of which a high intensity single bunch is located.

But in order to keep the bunches filled with different currents it has been necessary to develop a filling algorithm, called SBBS (single-bunch-bucket-selection), in which each bunch has a defined current that should be kept constant during the beamline run. An indication of the freedom existing now to create filling patterns is shown in figure 4 where the name "ALBA" and its mirror have been written with electrons.

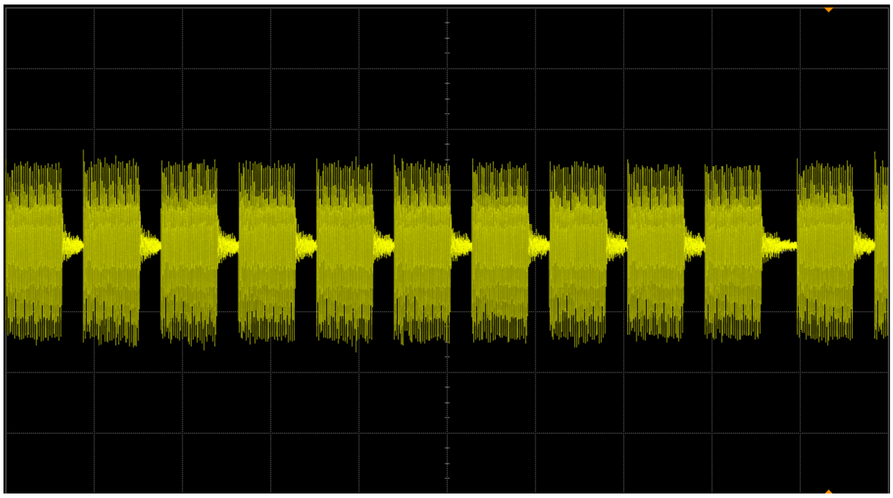


Figure 3: ALBA filling pattern with 320 bunches in 10 trains.

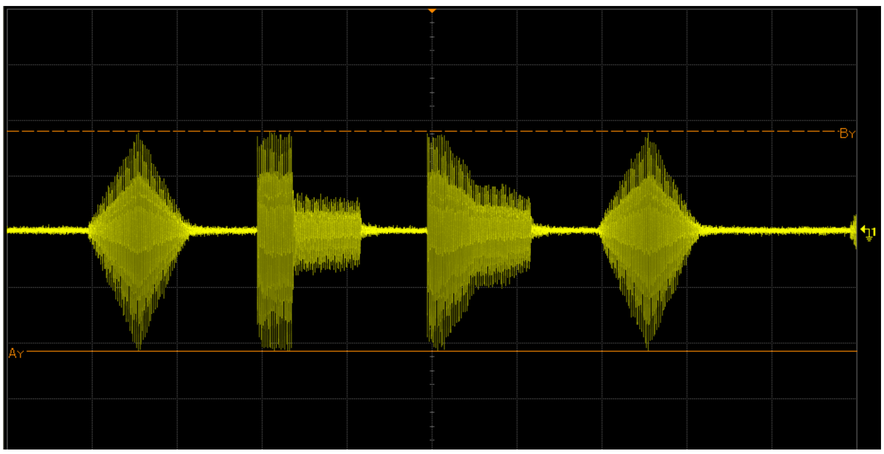


Figure 4: Experimental filling pattern where the word ALBA (and its mirror) has been formed by filling the bunches with different currents. If you wish to see the real time "writing" of the name ALBA with electrons, look at the video: https://youtu.be/vw_DdlCGzF4.

Active RF Trip Compensation

Here follows a description of the improvements made in the Radio Frequency systems of the ALBA Synchrotron. A Feed-Forward algorithm was implemented in order to minimize the beam oscillations due to RF interlocks and to prevent beam losses.

The main goal of the Radio Frequency (RF) systems of any accelerator is either to increase the energy of the electrons or to restore the energy lost by synchrotron radiation emission. This is accomplished by creating high electric fields in the path of the electrons. In the Storage Ring of ALBA, the electrons lose 1.1 MeV of energy per cycle. This implies that the minimum voltage to keep the electrons circulating in the Storage Ring should be 1.1 MV.

In the ALBA Storage Ring there are 6 normal conducting cavities capable of providing up to 3.6 MV RF voltage in overall (600 kV per cavity). This redundancy or over-voltage makes the RF system reliable enough to keep accelerating the stored beam even if one of the six cavities has an interlock and has stopped.

When this interlock happens, some longitudinal and transversal oscillations are created in the beam orbit that last around 3 ms (damping time). Depending on the available RF voltage and stored current, these oscillations may cause a beam dump (higher currents produce higher oscillations and more beam losses). In order to add more reliability to the accelerator operation, these oscillations were measured and characterized using the post-mortem analysis tools of the Low-Level RF System (LLRF). Then, a Feed-Forward algorithm was implemented in order to minimize the beam oscillations due to RF interlocks and to prevent beam losses.

Longitudinal Oscillations after RF Interlock

The current of the Storage Ring is not continuous, but distributed in bunches. The RF voltage is synchronized with these bunches to always provide a positive voltage in the presence of beam current. There is only one phase (or time instant) of the electrons with respect to the RF voltage where the beam receives exactly the same energy that it loses due to synchrotron radiation. This position or phase is called the "synchronous phase", as shown in Figure 5.

When one of the six Storage Ring cavities has an interlock, the available RF voltage of the Storage Ring is reduced and therefore the synchronous phase of the beam is also reduced. In order to achieve the new stable phase position the beam starts to oscillate longitudinally until it reaches the new equilibrium point. As a consequence of the longitudinal motion of the beam, the amplitude of the Storage Ring voltage also oscillates during a transient time of approximately 3 ms. If the overall voltage decreases below 1.1 MV due to these oscillations, the beam is lost.

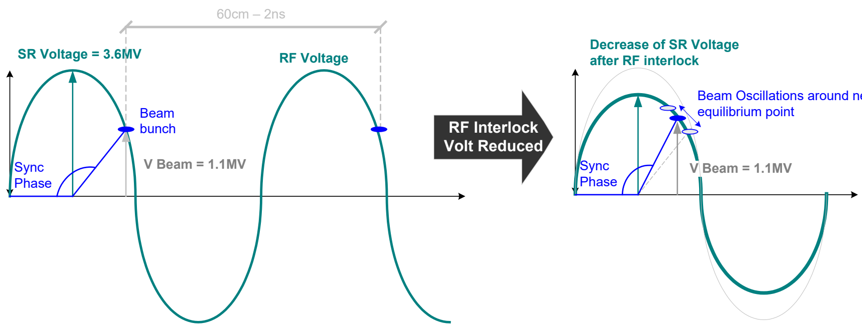


Figure 5: Beam Synchronous Phase and Phase Oscillations after RF interlocks.

Phase Modulation for RF Interlock Compensation

The LLRF post-mortem analysis tools allow us to measure the frequency of the oscillations induced in the RF voltage of the Storage Ring after a RF interlock, as well as their amplitude and decay time. With this data, we were able to implement a Feed-Forward loop to compensate these disturbances.

The compensation consists in applying a phase step in the RF voltage just after an interlock in order to anticipate the new phase that the beam is looking for. After this step, then the phase is modulated and moved in a direction opposite to the natural oscillations of the beam in order to damp the longitudinal motion of the beam as much as possible, and thus, minimize the oscillations induced in the cavity voltage.

Results of Phase Modulation for RF Trip Compensation

Figure 6 shows the evolution of the voltage of an active cavity after an interlock in another RF plant (Left plot: voltage Amplitude. Right plot: voltage Phase).

When there is no compensation (blue curve), the cavity trip generates large amplitude and phase distortion on the RF voltage and the beam is lost 1 ms after the interlock detection.

After properly adjusting the phase compensation parameters (black curve) the amplitude and phase oscillations are reduced, avoiding the initial large excursion in amplitude, and so the beam survives.

The active RF trip compensation has been active since January 2016. Although we cannot quantify how many beam losses due to RF have been prevented by using the RF trip compensation, what can be stated is that, in contrast with the 68 RF incidents occurred so far in 2016, only 4 of them have led to a lost beam, which is an improvement with respect to last year. This is the first time such a technique has been successfully implemented in an accelerator.

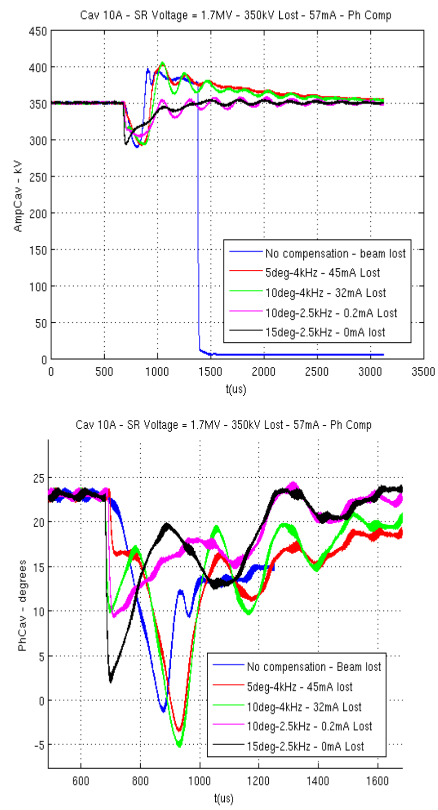


Figure 6: Voltage oscillations in an active cavity after RF interlock in another plant: Comparison of different compensation approaches.

MAGNETISM

Absence of magnetic proximity effects in magnetoresistive Pt/$CoFe_2O_4$ hybrid interfaces

BL29-BOREAS

Pure spin currents and spin accumulation and consequently magnetism can be induced in non-magnetic materials just by a flow on a non-spin-polarized charge current (Spin Hall effect). However, magnetism in some non-magnetic materials can also been induced by proximity effect by neighbouring magnetic layers. A group of researchers, led by Josep Fontcuberta from the ICMAB-CSIC, show that in Pt/$CoFe_2O_4$ hybrid systems, spin currents are generated in the absence of any proximity-induced magnetic moments in Platinum.

When an electric field is established within a metal sheet, electrons flow through it. In the presence of an applied magnetic field perpendicular to the current, a Lorentz force acts on the moving electrons deviating them transversally, so a local charge imbalance accumulates at either side of the sheet originating an equivalent *Hall voltage* (whose magnitude equilibrates the Lorentz force), which was early discovered by E. Hall in 1879. The so-called *Hall effect* has found application for example in magnetic field sensors such as the *Hall probes*. Moreover, in non-magnetic metals, even in the absence of any applied magnetic field and in the presence of a current flow, as electron scattering is spin dependent, spin-up and spin-down electrons suffer lateral forces of different sign that produce a spin accumulation (up and down) at opposite sides of the samples. This is a *pure spin current*, as not net flow of charge has occurred because the same amount of charge has been deflected at each side. Therefore magnetization of opposed sign is formed at sample edges and accumulates until the corresponding change of the electrochemical potential equals the magnetic force acting on the charge carriers. This is referred as *Spin Hall effect*. The same amount of charge is accumulated at each side, and thus no Hall voltage appears. As the amount of accumulated spins is the result of a spin equilibrium resulting from the charge flow, any perturbation on the spin accumulation should result in a modification of the charge flow (this is the so-called "*inverse Hall effect*") and thus the sample electric resistivity should vary. This is the so-called "*Spin Magnetoresistance*".

A convenient way to modify the spin accumulation is placing an adjacent insulating magnetic material. If its magnetization is perpendicular to the spin accumulation, then a torque among the magnetization and the accumulated spins should occur that will ultimately modify the magnetization distribution in both materials across the interface (a spin diffusion across will take place). Therefore a change of the resistivity of the metal will be produced. The simplest way to observe this effect is to magnetize the insulating ferromagnetic layers along two perpendicular directions and simultaneously measure the resistivity of the metallic layer. This opens opportunities for creating spin-induced voltages in metals. As spin currents do not dissipate heat, it is expected that pure spin currents could be the basis of a radically new family of spintronic materials, more energy friendly and faster.

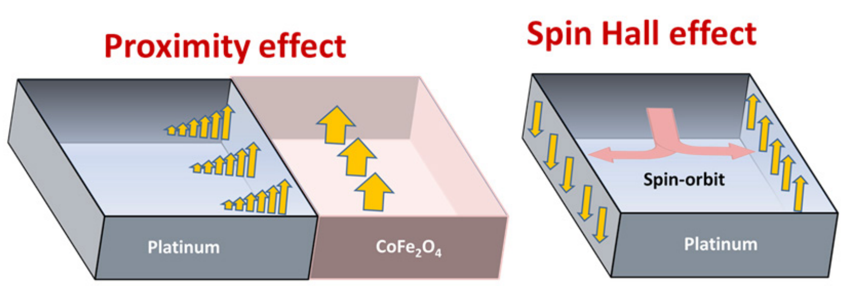


Figure 7: Schematics for the magnetic moments originated in Platinum on the case of a) proximity effects and b) spin accumulation due to Spin Hall effect.

In practice, however, when placing a non-magnetic material next to a magnetic material, a proximity-induced ferromagnetism may be induced in the former, which may give rise to a magnetoresistance analogous to that of conventional ferromagnets. Therefore, understanding and controlling pure-spin-current-based devices requires disentangling and excluding any proximity effect.

The goal of the study was to settle whether the observed magnetoresistance in Pt/$CoFe_2O_4$ hybrid systems is a signature of spin accumulation at the interface or could arise from a more conventional mechanism due to magnetic moment induced on the Pt metal layer by the proximity effect of the $CoFe_2O_4$ ferromagnetic layer. To this end, the authors performed XMCD measurements at the Pt-M3 and Pt-L2,3 edges of the BOREAS beamline at ALBA and the ID12 at ESRF, respectively probing element-specific Pt magnetism in Pt/$CoFe_2O_4$ (Pt/CFO) heterostructures. Results showed that the Pt magnetic moment is negligible, i.e. approximately below 0.001 Bohr magneton per atom averaged over the Pt layer, thus ruling out the occurrence of proximity effects in favour of the non-conventional spin-current origin for the observed transport effects.

The study therefore supports the occurrence of spin currents in this novel type of materials, providing a strong experimental evidence that it is possible to engineer spintronic materials and devices using spin current and spin accumulation effects, and in particular Pt and $CoFe_2O_4$ insulating ferromagnet interfaces, avoiding interfering proximity effects.

Reference: M. Valvidares, N. Dix, M. Isasa, K. Ollefs, F. Wilhelm, A. Rogalev, F. Sánchez, E. Pellegrin, A. Bedoya-Pinto, P. Gargiani, L. E. Hueso, F. Casanova and J. Fontcuberta, *Phys. Rev B* **93**, 214415 (2016). DOI: 10.1103/PhysRevB.93.214415

MAGNETISM

Surprisingly high temperature ferromagnetism in a $GdAg_2$ single-layer surface alloy

BL29-BOREAS

A group of researchers from the Basque Country University, led by Enrique Ortega, in collaboration with investigators from the Liège University and the Catalan Institute of Nanoscience and Nanotechnology (ICN2), has discovered a surprisingly high ferromagnetic transition temperature Tc in a $GdAg_2$ single-layer-alloy that may serve as a building block for future spintronic devices.

Ferromagnetism occurs when the magnetization of a material, the average orientation of its microscopic magnetic moments, is preserved along a specific direction without having to apply an external magnetic field. It is a common feature of permanent magnets and, for example, it is the way we use to preserve our data encoded in a spinning hard-disk. Conceiving a single atomic layer system that preserves a net magnetization at relatively high temperatures is a challenging result. Even more difficult is to realize a system formed by an alloy of magnetic and non-magnetic atoms, such as Gd and Ag, that show such property in monolayer thickness and that is also stable over structural and chemical disturbances.

Researchers have demonstrated that a single-layer $GdAg_2$ alloy has a remarkable high Curie temperature of 85K, is structurally stable and may offer a template for the ordered growth of other materials, such as organic molecules or metal clusters, without losing its magnetic properties. By using a combination of techniques, including ALBA's X rays, the researchers have been able to demonstrate the origin of the surprising phenomenon.

The researchers have examined their samples structure with scanning tunnelling microscopy and electron diffraction, finding that the $GdAg_2$ alloy at single layer coverage forms a structurally perfect atomic lattice modulated by a long-range "moiré", as shown in Fig. 8a. Then they replicated the preparation at the BOREAS beamline in order to investigate the magnetic properties of such $GdAg_2$ monolayer as a function of temperature with the XMCD technique (Fig 8b), obtaining a Curie temperature of about 75K, in agreement with magneto-optic Kerr effect experiments (85 K). Finally, they investigated the $GdAg_2$ valence band electronic structure close to the Fermi level, both experimentally, by means of angular-resolved photoemission (ARPES), and theoretically, with DFT calculations, and found that the Gd-Gd magnetic coupling in the alloy is mediated by hybrid Ag-Gd states as efficiently as in a pure metal ferromagnet.

Reference: M. Ormaza, L. Fernández, M. Ilyn, A. Magaña, B. Xu, M. J. Verstraete, M. Gastaldo, M. A. Valbuena, P. Gargiani, A. Mugarza, A. Ayuela, L. Vitali, M. Blanco-Rey, F. Schiller, and J. E. Ortega. High Temperature Ferromagnetism in a $GdAg_2$ monolayer. *Nanoletters*, June (2016). DOI: 10.1021/acs.nanolett.6b01197

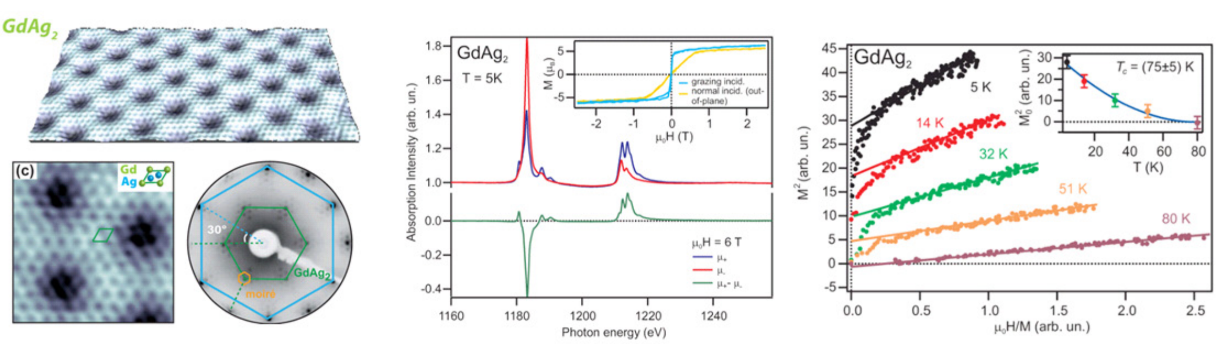


Figure 8: From left to right: the STM and electron diffraction (LEED) of the $GdAg_2$ monolayer showing the moiré modulation; at the centre, Gd XMCD spectra collected on a $GdAg_2$ monolayer at the BOREAS beamline at 5K of temperature and 6T of applied field; on the right, temperature-dependent magnetization curves (Arrot plot) collected at BOREAS showing (inset) the decreasing of the remanent magnetization as a function of temperature indicating a Curie temperature of 75K.

MAGNETISM

The hidden magnetism in high temperature superconductors

BL29-BOREAS

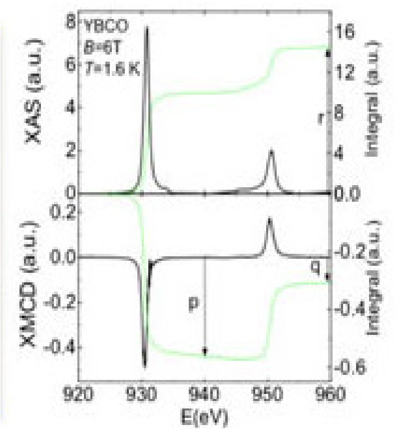
Researchers from the Institute of Materials Science of Barcelona (ICMAB-CSIC) and the ALBA Synchrotron have found a new magnetic mechanism in high temperature superconductor cuprates, proving the coexistence of magnetism and superconductivity. Results have been published in Advanced Science, including key measurements performed at the BOREAS beamline.

Superconductors are materials without electrical resistance. That means that they can conduct electricity without losing energy. However, they need to be cooled down to extremely low temperatures (near the absolute zero, -273°C) in order to show these properties. In 1986, a breakthrough took place with the discovery of the high temperature superconductors: the copper oxides, also known as cuprates, which can keep the superconducting state at higher temperatures (up to -135°C, compatible with liquid nitrogen). These materials have been one of the hottest research topics for the last 30 years but, still today, there are many aspects to discover about them. For instance, it was believed that superconductivity and magnetism were excluding phenomena.

A group of researchers from the Institute of Materials Science of Barcelona (ICMAB-CSIC), have reported the existence of a dilute ferromagnetic system in YBCO cuprates (YBa2Cu3O7−δ). This discovery not only allows a better understanding of these materials but also enhances their physical properties.

Using a combination of techniques, including ALBA's X rays, they have been able to identify a new magnetic behaviour within the superconductor and to correlate it to a network of copper and oxygen vacancy clusters. Therefore, contrary to what was previously suspected, these results show that ferromagnetic interactions do also happen in high temperature superconductors and offer new insights about the fundamental characteristics of these materials. To understand the complex nature of these materials, researchers have combined different techniques during the study. Scanning transmission electron microscopy (STEM) imaging and spectroscopy let scientists observe and characterize the defects clusters of the analysed materials. These results were also validated by density functional theory (DFT) calculations, showing that they present magnetic moments with ferromagnetic ordering. Finally, at the BOREAS beamline, X-ray magnetic circular dichroism (XMCD) spectroscopy was key to demonstrate the existence of copper magnetic moments and the presence of magnetic defects in these materials. This is a step forward in understanding magnetism at the atomic scale, contributing to a better knowledge and control of their properties. It may have a great impact on vortex pinning in high temperature superconductors, enabling their use in superconducting magnets for research, energy or transport, among others.

Reference: J. Gazquez, R. Guzman, R. Mishra, E. Bartolomé, J. Salafranca, C. Magén, M. Varela, M. Coll, A. Palau, S. M. Valvidares, P. Gargiani, E. Pellegrin, J. Herrero-Martin, S. J. Pennycook, S.T. Pantelides, T. Puig, X. Obradors. Emerging dilute ferromagnetism in high-Tc superconductors driven by point defect clusters. *Advanced Science* (2016). DOI: 10.1002/advs.201500295



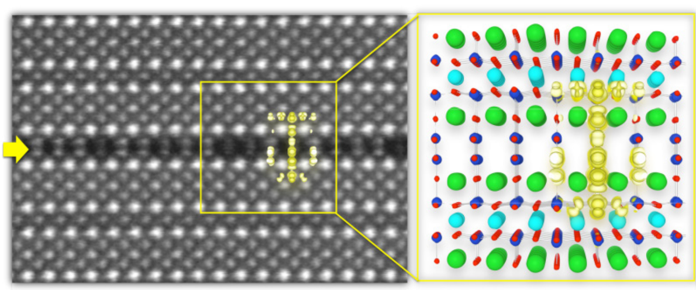


Figure 9: Right panel; atomic resolution image of the superconductor lattice showing the planar defect where the Cu and O vacancies are located (yellow arrow). The spots represent the atomic columns of YBCO. The dimmer contrast of the atomic columns, therefore, signals the presence of Cu vacancies. The inset shows, in yellow, the region where the vacancies surrounding Cu and O atoms show a ferromagnetic behaviour. Next panel; sketch of the superconductor structure with Cu and O atoms (in yellow) showing ferromagnetism. Top panel; Cu $L_{2,3}$ edge (top) background-subtracted XAS and (bottom) XMCD spectra measured at 6 T, 1.6 K in normal incidence for a YBCO thin-film.

BIOSCIENCES

A powerful drug has been described that will advance the fight against familial amyloidosis

BL13-XALOC

The research was led by Salvador Ventura, from the IBB-Department of Biochemistry at the UAB, and SOM Biotech, a biopharmaceutical company that discovered the use of tolcapone for treating ATTR and holds the patent on it. The crystal structure of TTR-tolcalpone was solved by the group of David Reverter, at the IBB-UAB, in collaboration with the XALOC beamline scientists.

ATTR is a rare degenerative disease that mainly affects the nervous system and heart muscle tissue (myocardium), and which is usually passed on from parents to children. It originates when the liver and other areas of the organism produce mutations of the protein transthyretin (TTR), which lose their functional structure. This causes toxic aggregates of amyloid fibres to build up, which, depending on the mutation involved, are deposited in different organs, such as the brain, the kidneys, the nerves, the eyes or the myocardium, causing them to malfunction and bringing on the various forms of the disease. To prevent the disease from progressing, a liver transplant or liver and heart transplant is needed.

Drug repositioning involves taking molecules that have already been approved for a specific therapeutic indication – as is the case with tolcapone for treating Parkinson's disease – and using them for a different disease, thus quickening their development and patients' access to new treatments.

This strategy also helps lower the cost of treatments, which, in the case of tolcapone, could facilitate its administration in countries like Brazil and Portugal, where the polyneuropathic variant is highly prevalent.

The drug has been designated an orphan drug for ATTR by the American Food and Drug Administration. This is important, as in the United States there is a large group of people suffering from the cardiomyopathic variant of ATTR.

In the study, the researchers conducted biophysical trials – in vitro in cell cultures and ex vivo in human plasma and in mouse models of the disease – to show that tolcapone is a powerful inhibitor of the aggregation of amyloid fibers by TTR, stabilizing the structure of the protein and thus slowing down the advance of the disease. This is a hitherto unknown property of the drug, which is used to treat Parkinson's disease. The compound turns out to be four times more effective than the only medicine currently available for treating the polyneuropathic variant of ATTR. The results were positive for all variants of the disease that were studied: familial amyloid polyneuropathy and cardiomyopathy (which affects the peripheral nerves and the myocardium, respectively) and senile systemic amyloidosis, a sporadic form that appears in a very high percentage of men over 60 years of age (and also affects the myocardium). In addition, the treatment was shown to cross the blood-brain barrier, making it the first to tackle the variants that affect the central nervous system. Tolcapone acts by imitating the process by which the thyroid hormone – T4 or thyroxine – binds to TTR in the bloodstream. Just like the hormone, the drug binds closely to the protein, tying together the four protein sub-units that form the protein's structure. This binding has been proven to stabilize the protein, preventing the sub-units from separating and then forming aggregates. The structural details of the interaction of tolcalpone with the transthyretin (TTR) tetramer, performed in collaboration with XALOC beamline scientists of the ALBA Synchrotron, revealed the molecular details of this strong drug-target interaction.

Tolcalpone has been described as a powerful drug to advance in the fight against familial amyloidosis. This molecule has proved in preclinical trials to be up to four times more effective than the only pharmacological treatment currently available for familial transthyretin amyloidosis, a rare degenerative disease, and has already been tested in a clinical trial with patients. It acts as a powerful inhibitor of the protein deposits that cause the disease, thus slowing its advance.

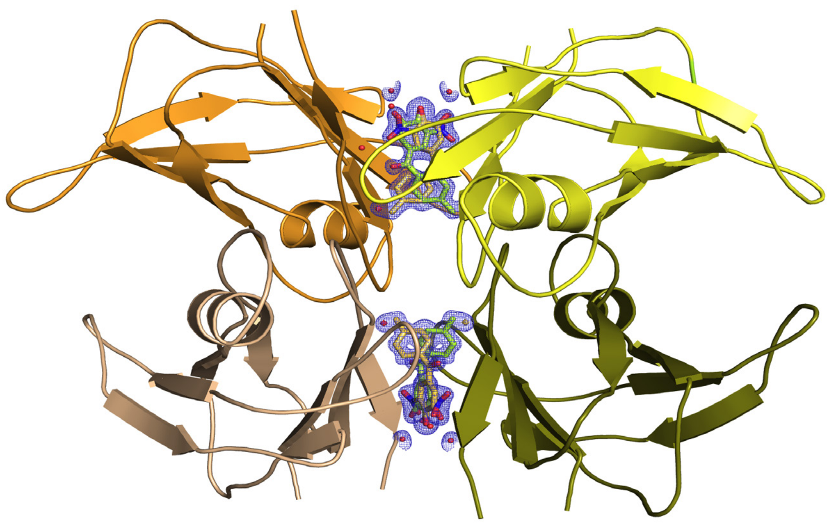


Figure 10: Drawing depicting the transthyretin tetramer (TTR) in complex with Tolcalpone (in stick representation with the electron density maps). Based on deposited structure with PDB code 4d7b.

Reference: R.Sant Anna, P.Gallego, L.Z.Robinson, A.Pereira- Henriques, N.Ferreira, F. Pinheiro, S.Esperante, I.Pallares, O.Huertas, M.R.Almeida, N.Reixachs, R.Insa, A.Velázquez-Campoy, D.Reverter, N. Reig and S. Ventura. Repositioning Tolcapone as a potent inhibitor of transthyretin amiloidogenesis and associated cellular toxicity. *Nature Communications*. DOI: 10.1038/NCOMMS10787.

BIOSCIENCES

Imaging intracellular calcium accumulation in calcifying marine algae using cryo-X-ray tomography

BL09-MISTRAL

A group of international researchers, led by the Max-Planck Institute of Molecular Plant Physiology (Potsdam, Germany), has provided the first insights on the spatial distribution of calcium in coccolithophores, widespread marine algae that may play an important role in the response of the oceanic ecosystem to predicted global climate change.

Coccolithophores are widespread marine algae that produce biogenic calcite in the form of minute calcitic scales, known as coccoliths. The coccolith is formed intracellularly, inside a membrane-bound compartment, and upon maturation it is extruded to the cell exterior where many coccoliths are covering the cell surface. This biomineralization process draws considerable attention since coccolithophores may play an important role in the response of the oceanic ecosystem to predicted global climate change, and because similar changes in the past were recorded in the chemical composition of coccoliths accumulated in ocean-floor sediments. Following dynamic cellular processes *in vivo*, such as coccolith synthesis, is extremely challenging. This is because of the experimental difficulties involved in following inorganic small molecules at the spatial and temporal resolution needed to trace intermediate and short-lived phases in the crystallization pathway. Therefore, the intracellular pathways responsible for the transport of the constituent ions from seawater to the growing coccolith are mostly unknown.

The authors used synchrotron soft-X-ray tomography at cryogenic conditions (MISTRAL beamline) in order to map the intracellular calcium in coccolith-producing cells of the model coccolithophore species *Emiliania huxleyi*. The cells were rapidly frozen and maintained at cryogenic conditions to preserve their intracellular organization. Single cells were imaged with the X-ray microscope at a resolution of 50 nm. Two types of data sets were acquired. The first is a tilt-series at the 'water window' energy range. At this X-ray energy the best contrast between carbon-rich intracellular membranes and the water-rich cytoplasm is achieved so the data can be used for 3D reconstruction of cells. The second data set was an energy scan around the Ca L-edge. A complete X-ray Absorption Near-Edge Spectroscopy (XANES) spectrum can be extracted from these data for each pixel in the image, providing information on the concentration of calcium inside intracellular organelles and spectroscopic information on the crystallinity of this Ca-rich phase. In the tomograms of cells all major organelles were visible, as well as intracellular membrane-bound coccoliths in *status nascendi*. Surprisingly, the cells contained distinct intracellular compartments packed with highly absorbing material, which the spectroscopic data showed to be rich in calcium. The XANES spectra collected from multiple Ca-rich compartments were clearly different from the spectra of coccolith calcite and exhibited characteristics of disordered local environment around the calcium atoms.

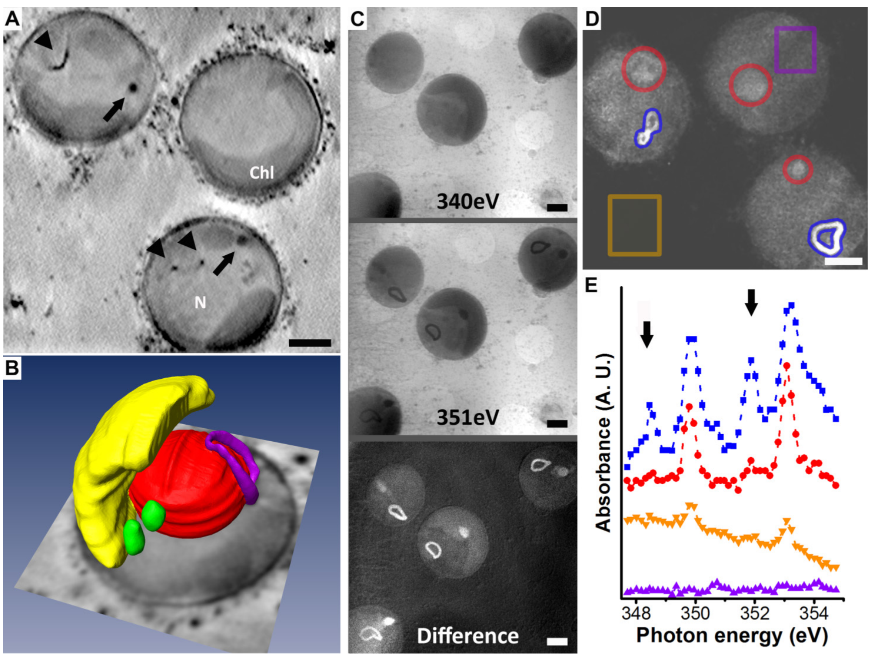


Figure 11: A) Virtual slice of the reconstructed tomogram showing 3 E. huxleyi cells. Immature coccoliths and calcium-rich bodies are marked by arrowheads and arrows, respectively. B) Segmented volume of a tomogram with the nucleus in red, the chloroplast in yellow, the intracellular coccolith in violet and the calcium-rich bodies in green. C) Soft X-ray projections recorded below the Ca L3 edge (top), at the edge (middle) and the absorption difference (bottom). D & E) XANES spectra at the Ca L3,2 edge of the different regions shown in D. Scale bars: 1 µm.

The authors discovered high amounts of calcium to be concentrated in membrane-bound compartments that are separate from the coccolith-producing compartment and they propose that this calcium pool is used for coccolith calcite formation. Inside the compartment calcium is stored as a disordered phase. This finding makes it tempting to speculate that a major fraction of the coccolith calcium is transported as intermediate calcium phase to the site of calcite formation. The exact chemical composition of these intermediate phases, and the way material is allocated in and out of the compartments are still elusive.

Reference: S. Sviben, A. Gal, M.H. Hood, L. Bertinetti, Y. Politi, M. Bennet, P. Krishnamoorthy, A. Schertel, R. Wirth, A. Sorrentino, E. Pereiro, D. Faivre & A. Scheffe, A vacuole-like compartment concentrates a disordered calcium phase in a key coccolithophorid alga. l, *Nature Communications* **7**: 11228 (2016). DOI: 10.1038/ncomms11228

X-Ray Emission Spectroscopy at CLÆSS beamline

BL22-CLÆSS

The CLEAR spectrometer of CLÆSS beamline has reached operating status and has been open to users in the last call for proposals.

Hard X-Ray spectroscopies, such as X-Ray emission (XES) or absorption (XAS) spectroscopy, are unique element-specific probes of the local electronic and atomic structure. XAS and XES are the two faces of the same phenomena. In XAS, the samples under study are illuminated with photons of selected energies that originate electronic transitions from occupied to empty levels or to the continuum and the evolution of the absorption coefficient as a function of energy gives access to the local electronic and structural properties. In XES, the samples under study are illuminated with photons of energy well above a selected absorption edge and the de-excitation process as the fluorescence signal following the creation of the core hole as a function of the emitted energy, allows to access complementary information on the local electronic, magnetic and structural properties. For example, an atom ionized at the K shell emits several fluorescence lines denoted $K\alpha$, $K\beta$, $L\alpha$, $L\beta$, etc.

In some cases, the energy-dependent photon absorption is monitored by measuring the fluorescence emitted by the excited atoms, arising from the refilling of the core hole by an electron on a higher shell. High resolution XAS can be collected by selecting a particular emission line if the emitted photons are discriminated with a sufficiently good energy resolution (in most cases an energy resolution around or below 1eV is needed).

At CLÆSS, the core level absorption and emission beamline of the ALBA synchrotron, the CLEAR emission spectrometer, conceived by the former ALBA scientist Konstantin Klementiev, has finally reached operating status. This has been the result of the collaborative effort of scientists, technicians, and engineers under the leadership of Laura Simonelli. The instrument, which has been engineered in-house and manufactured partially in-house and by local companies, allows to energy-analyze the emitted fluorescence and to resolve with good energy resolution (Fig. 12 right, bottom panel) the signals from the different de-excitation channels. Last but not least, thanks to the combined use of a Mythen unidimensional detector and a silicon diced analyzer, it permits the acquisition of the spectrum on a single-shot basis.

In practice this entails an enormous boost to the scientific possibilities of the beamlines since it will give access to all the complementary information obtainable by investigating the atomic emission lines, and the rather XAS featureless spectra, obtained with the conventional energy integrated mode, become spectra with fine structure containing key information on electronic levels and magnetic properties. Details on the instrument will be published soon.

We are confident that this instrument will generate a significant advancement in revealing the usually hidden details of the electronic structure of materials.

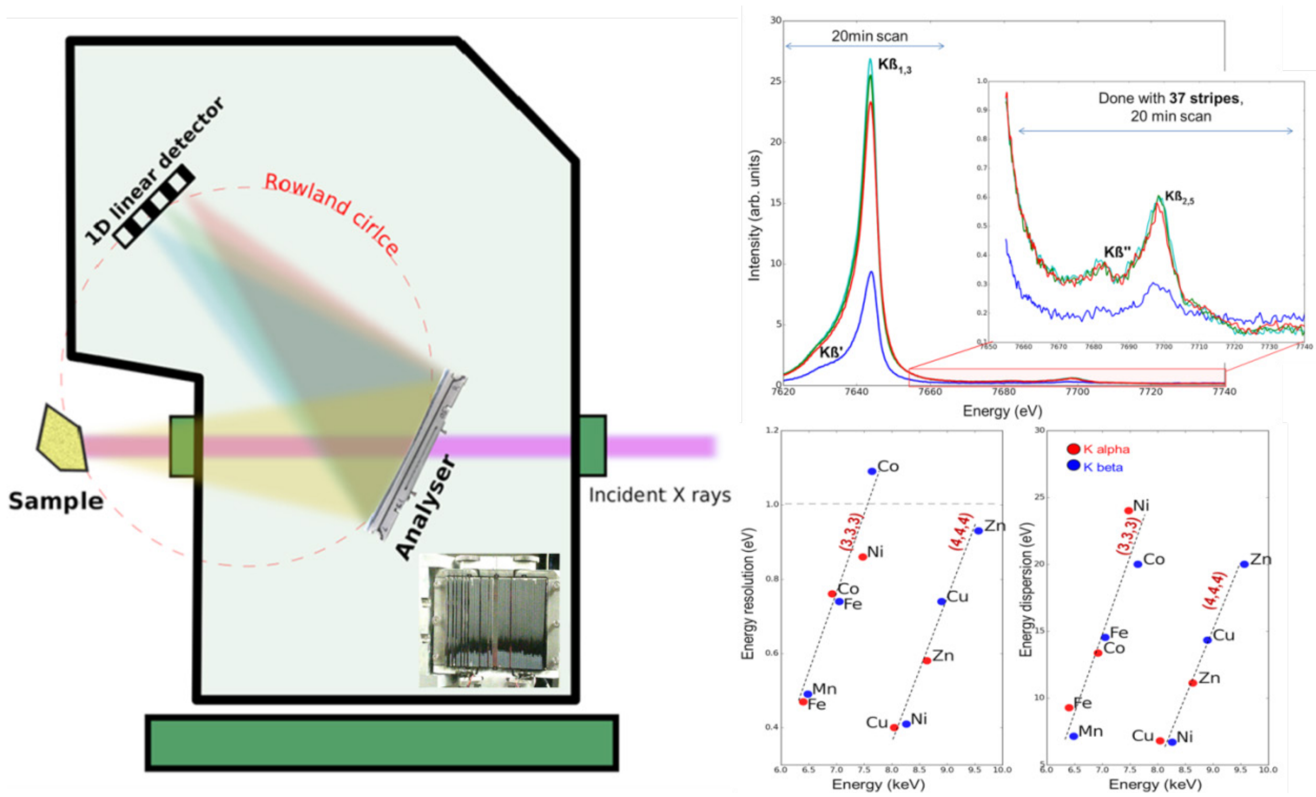


Figure 12: shows on the left a sketch of the CLEAR spectrometer with, at the bottom right, a picture of the presently operating Si(1,1,1) dynamically bent diced analyzer. This instrument is expected to work, like the other existing emission spectrometer, in Rowland circle geometry, but, unlike the others, it continuously covers a range between 2 and 22 keV by means of 4 analyzer crystal (with different crystals reflections) in fully back- of forward-scattering geometries, exploiting a working wide Bragg angular range (30°-80°). The energy resolution and photon intensity (focal properties) are ensured by the diced analyzer and the analyzer dynamical sagittal bending. While only the Si(1,1,1) analyzer reflection is available for the moment, other analyzers are underway starting with the Si(2,2,0) reflection.

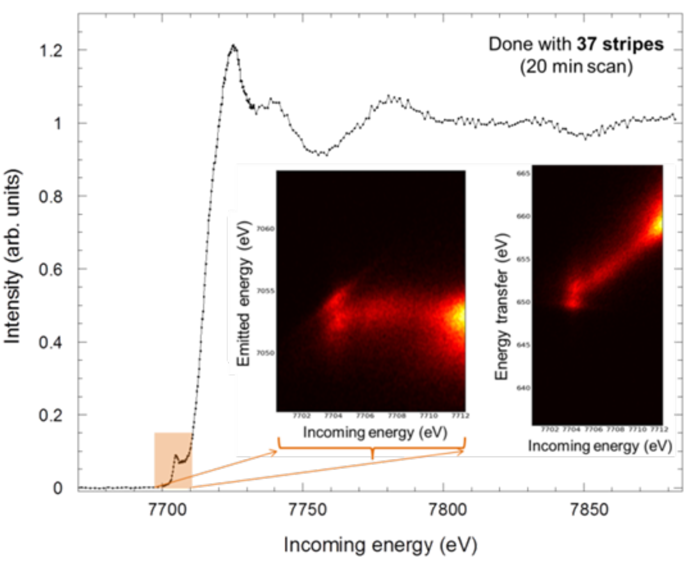


Figure 13: While figure 12 (right) reports an example of recently measured Co Kβ emission lines, Figure 13 shows an example of high resolution absorption spectra collected by selecting the Co Kβ1,3 emission energy and scanning the incoming energy across the Co K-edge. The combination of a unidimensional detector and a diced analyzer permitted the acquisition of the emission spectrum during the incoming energy scan on a single-shot basis (inset in Fig. 13: 2D plot representing the spectral intensity as a function of the emitted (or transferred) and incoming photon energy across the absorption pre-peak). The 2D plots reveal two different final states, not detectable by the classical XAS.

Friendly users at MIRAS

BL01-MIRAS

MIRAS, the 8th ALBA beamline – devoted to infrared microspectroscopy – is in commissioning with friendly users and soon it will enter in official operation.

MIRAS is dedicated to infrared microspectroscopy, covering far-IR and mid-IR regions, and is available for a wide range of scientific fields: surface and materials science, biochemistry, microanalysis, archaeology, geology, cell biology, biomedical diagnostics, environmental science, etc.

On 5th April 2016, MIRAS started commissioning with synchrotron light. That meant that in-tunnel transport mirrors were aligned until the first focus of synchrotron light was obtained outside the tunnel. This represented an important milestone in the construction of the beamline, which had been initiated in 2014, because all the in-tunnel installed components were validated. On May 2016, all the transport mirrors of the beamline have been aligned until the coupling of the synchrotron light with the beamline endstation. The first infrared spectrum was obtained, the full commissioning and performance tests were followed.

MIRAS is currently running with friendly users, three different groups working on (materials science, archeology and biomedicine) have performed successful measurements at MIRAS. The beamline will be open soon for official users on October 2016.

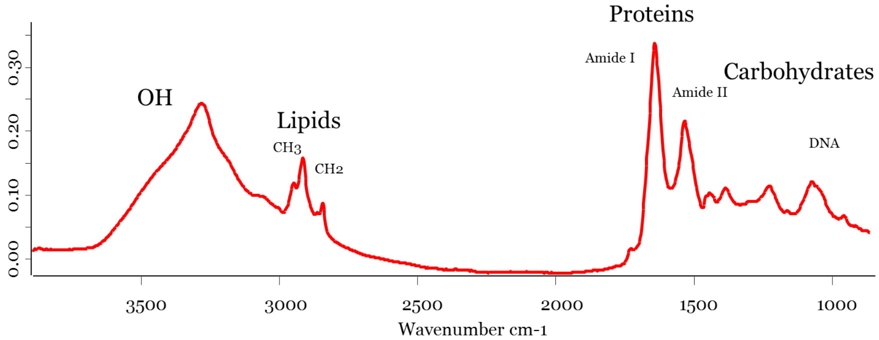


Figure 14: First measurement performed at MIRAS using synchrotron light: Glioma Cancer cell. MIRAS In-house Project. Aperture = 6x6µm2, 4cm-1 resolution. Synchrotron light, 256 scans = 40s. Courtesy of Immaculada Martinez-Rovira.

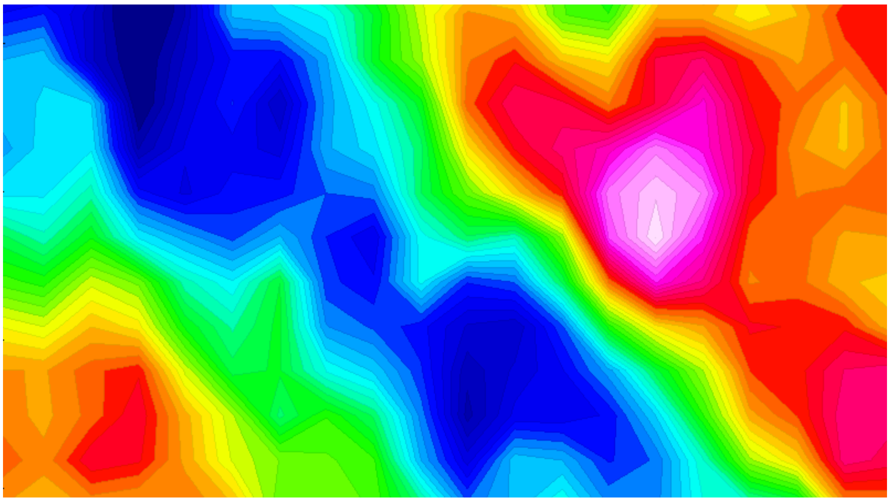


Figure 15: Chemical imaging on Epoxy blend nanocomposites using synchrotron infrared microspectroscopy at MIRAS beamline. Courtesy of Eduin González & Gary Ellis.

Artax Biopharma is using the XALOC beamline for drug design

Artax Biopharma (Cambridge, MA), has successfully solved the crystal structure of its target protein by using X-ray diffraction at the XALOC beamline of the ALBA Synchrotron.

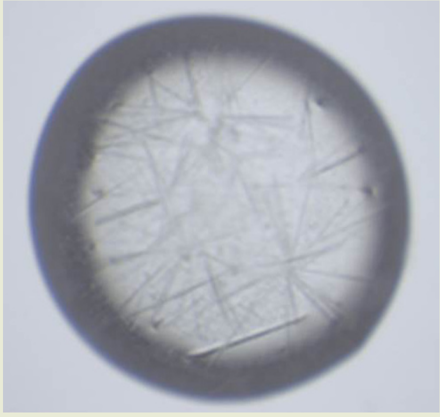
Artax, which has recently closed a series B round of financing led by Advent life science (UK) and former Genzyme CEO Henry Termeer, is developing a new generation of oral compounds against autoimmune diseases.

Autoimmune diseases cause the immune system to function abnormally, attacking body tissues and organs that it considers "foreign". Current treatments have two big pitfalls: their administration is mostly by intravenous route, they have low specificity and exert an immunosuppressant action. Hence, currently available treatments severely interfere with the immune system, decreasing their activity, which in turn reduces their effectiveness against infections by viruses and bacteria.

Instead, Artax compounds prevent T lymphocytes from responding against antigens but preserves their protective role against infection by pathogens. Such modulatory control of T cells allows the development of new treatments for a wide range of inflammatory and autoimmune diseases. Phase 1a and phase 1b have been completed with Artax most advanced compound and phase 2a will soon be initiated. The company also allocates part of its funds to develop a portfolio of new molecules.

A strategically important part of this effort is dedicated to a collaboration started in 2015 with the ALBA Synchrotron, in particular with the team of the Macromolecular Crystallography beamline XALOC. Different constructs of the Artax target protein, produced at the Biomolecular Screening & Protein Technologies Unit (CRG, Barcelona) directed by Carlo Carolis, were tested against several hundreds of crystallization conditions by ALBA personnel. The best crystals were diffracted with X-rays. In a few months, Fernando Gil and Roeland Boer, from the XALOC team, helped Artax to resolve the first ever structure of its target protein.

The success of the collaboration was due to the close and iterative interaction between the three parties, Artax, CRG and ALBA. Artax acknowledged the outstanding scientific level and commitment of ALBA scientists and the valuable help of the industrial liaison office. Crystals grown in ALBA diffracted to a resolution better than 2 Å, which will accelerate the identification of new candidates and support Artax discovery efforts.



Crystals obtained in crystallization plates by using the vapour diffusion method in sitting drops. © Artax Biopharma

Experimental hutch of XALOC beamline. © ALBA Synchrotron

What's on? Agenda of events

2016 NOVEMBER 7th - 9th	EuroCirCol H2020 Project Annual Meeting
2016 NOVEMBER 11th, 16th, 18th	Specialization course for high-school teachers
2016 NOVEMBER 17th - 18th	Meeting of the ALBA Scientific Advisory Committee
2017 OCTOBER 8th - 13th	ICALEPCS International Conference on Accelerator and Large Experimental Physics Control Systems
2017 OCTOBER 16th - 19th	Low Level RF Workshop, Barcelona

On the left, Ramon Pascual, the minister Baiget and Caterina Biscari, director of the ALBA Synchrotron, during the opening ceremony of the seminar. On the right, talk by Ricard March from Nubiola-Ferro. © ALBA Synchrotron - Teresa Llordés

Industrial workshop about cements, pigments, ceramics and glass

On Friday 6th May 2016, around 50 people attended the industrial workshop organized by the ALBA Synchrotron, where companies were able to know how to use synchrotron light for analyzing materials such as cements, pigments, ceramics and glasses. The event was officially opened by the Minister of Business and Knowledge of the Catalan Government, Jordi Baiget.

Materials such as cements or concretes, pigments, ceramics or glasses are fully integrated in our daily lives covering a double mission: structural and decorative. Science and construction materials seem to be faraway concepts. However, the knowledge and control of their physical and chemical properties together with their manufacturing processes can directly affect their performance.

The event was started by the Minister of Business and Knowledge of the Catalan Government, Jordi Baiget, who encouraged the participants to use ALBA's techniques, and by Caterina Biscari, director of the ALBA Synchrotron. During the event, the attendants were able to find out the main advantages of using synchrotron light for analyzing these materials: faster experiments, more flexibility in the experimental conditions, lower detection levels and higher resolution, among others. Several ALBA researchers explained the available techniques and the type of problems they can solve. For example, by using synchrotron light it is possible to discover the time needed for cement to cure or to understand its hydration processes. It was also mentioned that synchrotron light can help to better understand the degradation processes of materials by determining the oxidation state of their elements. Two industrial users from ALBA, Nubiola-Ferro Company, world-wide leader in the pigments sector, and X-Ray Data Services, spin-off company from the Malaga University specialized in the characterization of materials using X-ray diffraction with expertise analyzing cements with synchrotron light, also gave two talks commenting real examples and results and sharing their experiences with the audience. The event finished with a visit to the experimental hall and beamlines. But there were also different sessions for networking between ALBA researchers and attendees.

This seminar has been the third industrial seminar organized by the ALBA Industrial Liaison Office. Previous editions were devoted to the pharmaceutical sector in 2015 and the chemical industry in 2014, in both cases with the presence of more than 40 participants each.

Top, group photo of the IBIC delegates. Bottom, group photo of the MEDSI delegates. © ALBA Synchrotron

Top, the Drassanes Maritime Museum where conference dinners took place. Bottom, joint visit of MEDSI and IBIC delegates, inside the tunnel of the ALBA Synchrotron. © ALBA Synchrotron

ALBA welcomed more than 600 attendants at the IBIC and MEDSI conferences

From 11th to 16th September, more than 600 engineers and physicists from worldwide research centers attended the IBIC and MEDSI conferences, organized by the ALBA Synchrotron in Barcelona, Spain.

The 5th edition of the International Beam Instrumentation Conference (IBIC) and the 9th edition of the Mechanical Engineering Design of Synchrotron Radiation Equipment and Instrumentation (MEDSI) conference were a great success. 617 researchers and engineers, from all over the world, took part at the events, achieving new records of delegates, contributions and papers submitted as well as a high level of scientific discussion.

During the whole week, delegates were able to present the latest developments in the detection and measurement systems for particle accelerators, as well as the advances in the mechanical design of instrumentation and components, all of them key issues for achieving a good performance in the experiments and, also, of interest for technology transfer. The Faraday Cup was awarded at the IBIC conference to Brock Roberts from the University of New Mexico Department of Electrical and Computer Engineering. The MEDSI poster prizes were for Marlon Saveri Silva from the Brazilian Synchrotron Light Laboratory LNLS and for Mohammad Ali Al-Najdawi from SESAME.

Barcelona was the perfect venue for both conferences. IBIC 2016 was held at the World Trade Center, while MEDSI 2016 took place at the CosmoCaixa science museum, thanks to the collaboration of La Caixa Foundation. On Thursday 15 September all the delegates could visit the ALBA Synchrotron in organized guided tours.

The industrial participation at both events was very high, counting with the presence of more than 60 industrial exhibitors from companies specialized in scientific equipment and cutting-edge technology in areas such as cryogenics, vacuum, etc.

IBIC 2017 will be held at Grand Rapids, Michigan, hosted by the Michigan State University, while MEDSI 2018 be hosted by the Soleil Synchrotron in Paris.

The ALBA Open Day welcomes more than 2,100 people

The 5th edition of the ALBA Open Day took place on the 18th June, achieving a new record of participants: 2,130 people enjoyed a day of science with their families.

The event followed an itinerary composed of different areas of exhibition and demonstration. The participants were able to see the devices through which the electrons pass or those used for manipulating the synchrotron light, as well as to observe the interior of the accelerator's tunnel which was opened for the occasion. Fun demonstrations were organized to allow visitors to know more about concepts like vacuum or pressure, diffraction or spectroscopy. The kids enjoyed their own area where they could do a treasure hunt around the facility and a spectacular experiment with liquid nitrogen and balloons. At the end of the itinerary, the music band "Les Cateyes", made up of members of the ALBA staff, explained how a synchrotron works with their songs. Besides, four conferences were given about particle accelerators (by Caterina Biscari), applications of synchrotron light for studying cultural heritage (Glòria Molina, UPC researcher and ALBA user), synchrotron light sources (Pep Campmany, head of magnetic measurements) and applications of synchrotron light in medicine (Christina Kamma-Lorger, NCD beamline scientist). The participants also had the opportunity to use an audio guide which offered information about the different stops in the itinerary.

The ALBA Open Day was held thanks to the contribution of 82 volunteers from the ALBA Synchrotron who helped coordinating the event and also giving explanations and informing the visitors. It is also worth mentioning the support of Civil Protection, who generously offered their experience during the whole day.

Like in previous editions, the tickets for the ALBA Open Day ran out two weeks before the event. The access was free but required booking through the internet.

The ALBA Open Day was organized with the support of the Spanish Foundation for Science and Technology (FECYT) - Spanish Ministry of Economy and Competitiveness, La Caixa Foundation and the Catalan Government.

Selfie in front of the open tunnel.

The Kids Area full of activities and games. Below, a member of the Accelerators division explains how a radiofrequency cavity works. © ALBA Synchrotron - Pepo Segura.

Publication of the ALBA Activity Report 2015

The ALBA Synchrotron has published its annual report of the activities performed in 2015. This document includes scientific results, technology reviews and facts & figures of the facility.

The ALBA Activity Report is now available and includes the main activities of 2015. This document aims to give an overview of the scientific and technological developments at the ALBA Synchrotron.

This is the third edition of the ALBA Activity Report.

New members of the ALBA staff

From January to September 2016,, 10 new members have started working at the ALBA Synchrotron. Besides, two members of the ALBA staff have acquired new positions and 2 more have started a new professional period in our facility.

JOSE ANTONIO ALCOBENDAS
Radioprotection service
Director's Office

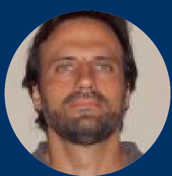
JOSE Mª ÁLVAREZ
Engineer for a 1.5 GHz 3rd harmonic cavity project of the ALBA/CERN-CLIC collaboration, Accelerators division

FEDERICO BISTI
Beamline scientist in LOREA, Experiments division

ROELAND BOER
Former beamline scientist in XALOC. Now beamline responsible of XALOC, Experiments division

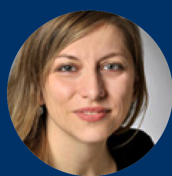
BÁRBARA CALISTO
Postdoc at XALOC, Experiments division

MICHELE CARLÀ
CLIC project (the Compact Linear Collider study), Accelerators division



XAVIER CARPENA
XALOC scientist Experiments division

ANA MARÍA CUESTA
Postdoc for the MINECO research project on cements, Experiments division



TANJA DUCIC
Former beamline scientist in MISTRAL. Now in MIRAS, Experiments division

JOSE RAMON GARCÍA
Mechanical engineer for the CLPU project, Engineering division

MARTIN KREUZER
Beamline scientist in MIRAS, Experiments division

NÚRIA MADRID
Part-time receptionist, Administration division

FRANCISCO MARTÍNEZ
Floor coordinator Experiments division

ALEKSANDR MISSIUL
Postdoc at MSPD beamline, Experiments division

NITYA RAMANAN
Postdoc at CLÆSS beamline, Experiments division

LAURA TORINO
Joint research project with the Istituto Nazionale di Fisica Nucleare (INFN), Accelerators division

Ramon Pascual awarded by the Spanish and Catalan governments

This 2016 the Spanish and Catalan governments have paid tribute to Ramon Pascual, president of the Executive Commission of the ALBA Synchrotron from 2003 to 2016.

On the 21st of January of 2016, Ramon Pascual was awarded the "Alfonso X El Sabio" in a ceremony with the participation of the acting president of Spain, Mariano Rajoy, with the aim of recognizing persons and institutions with merits in education, science, culture, teaching and research.

On the 13th of September 2016, about 100 people attended an event, organized by the Secretariat of Universities and Research of the Catalan government, also for paying tribute to Ramon Pascual. The event was chaired by the minister of Business and Knowledge of the Catalan government, the secretary of state for Research, Development and Innovation of the Spanish government, the director of ALBA, the former minister Andreu Mas-Colell, the general director for Research of the Catalan government and Anna Pascual, daughter of Ramon Pascual.

Ramon Pascual de Sans (Barcelona, 1942) studied Physics at the University of Barcelona, where he obtained his degree in 1963. In 1969 he obtained his PhD in the University of Valencia. Specialised in quantum mechanics and theory of elementary particles, he has been professor of Physics in the University of Zaragoza, the Autonomous University of Madrid and the Autonomous University of Barcelona, where he also was rector from 1986 to 1990. He has been honoured with different awards, such as the Narcís Monturiol award in 1991, the Creu de Sant Jordi in 2011 or the Encomienda de Alfonso X El Sabio in 2016. Nowadays, he continues working at the ALBA Synchrotron and the Institute of High Energy Physics (IFAE) at the Autonomous University of Barcelona, where he is emeritus professor, and he is also the president of the Royal Academy of Sciences and Arts of Barcelona (RACAB) since 2010.

Group photo at the stairs of the Palau de la Generalitat during the vent held the 13th of September 2016. © ALBA Synchrotron – Teresa Llordés

Dieter Einfeld, former head of the ALBA Accelerator division

During the celebration of the five years of synchrotron light in the ALBA Synchrotron, we were pleased to count on the presence of Dieter Einfeld, former head of the ALBA Accelerator division from 2004 till 2012. He is a physicist and engineer specialised in the design and building of particle accelerators with longstanding experience in many different projects: BESSY, ANKA, Maxlab, Elettra, Sesame, NSLSII, CLS, ALBA, TPS and ESRF-EBS. He was awarded the Narcís Monturiol medal by the Generalitat de Catalunya in 2012. We took advantage of the situation to discuss with him about the evolution of synchrotron light sources in the last 40 years.

• During your professional career, you have been involved in many particle accelerators projects. Is building a synchrotron something you can replicate in another facility? Or does each facility have its own specific characteristics?

Each facility has more or less its own specific characteristics and these are dictated by the budget which is available. The budget for the infrastructure, beam lines and the accelerator complex determines the circumference of the machine. The scientific case determined by the users has a big influence upon the energy of the machine is; for higher energies one needs a larger circumference. Each accelerator complex consisits of a linac and booster synchrotron and injector as well the storage ring for the production of the synchrotron radiation. This is the same for all synchrotron light sources.

The energy of the Linac is between 100 and 300 MeV; the final energy of the Booster will be the same as the Storage Ring. All facilities have the same components for the machine (magnets, power supplies, vacuum system, diagnostic, control system, etc.)

Each storage ring is made up of a number of cells, which are identical. The number of straight sections is fixed, according to the number of cells.. What differentiates the facilities is the lattice of the storage ring which determines the arrangement of magnets in a cell. The DBA- and TBA-lattices are very well-known. are. The DBA-lattice has 2 and the TBA 3 bending magnets in a cell. The arrangement and excitation of the other magnets (quadrupoles, sextupoles, correctors) around the bending magnet is different for all synchrotron light sources. All the parameters of these components are also different for all facilities in the world. Most of the 3rd generation light sources use the DBA – and TBA-lattice and this is replication to some extent.

For the 4th generation light sources there exists two types of lattice, the multi-bend- achromat (MBA) and the hybrid-multi-bend-achromat (HMBA). The MBA is used for MAV IV and the HMBA for the upgrade of the ESRF. Most of the facilities which are looking into upgrades use the HMBA-lattice. We can call this replication.

The replication of another facility has happened only once, the SOLARIS project in Krakow, Poland is identical to the 1.5 GeV facility at MAX IV. There exist a lot of similarities between synchrotron light sources, for example between DIAMOND in England, SSRF in China and TOS in Taiwan.

• You have been working in different countries. In a huge project like building a synchrotron facility, are the cultural differences important? How did you manage them?

When comparing countries such as Germany, Iran, Jordan and Spain, as an accelerator physicist working with the accelerator teams I didn't notice any cultural differences in particular. All the team members were very interested, all of them worked very hard, all the discussions were very fair. Cultural differences are usually seen outside the work context which did not concern me. During my time at ALBA I noticed a lot of similarities with living and working on projects in Germany.

• The world of synchrotron facilities has experienced enormous technological progress in the last years. In your opinion, which have been the main evolution in synchrotron light accelerators?

First, there are the superconducting cavities, with which a higher accelerating field can be produced and they are harmonic free, which means they don't excite instabilities and blowing up of the beam.Second, I would say the development of harmonic free normal conducting cavities.

Furthermore it is the NEG-Coating (Non-Evaporable-Getter thin film coating) which allows an ultra high vacuum without additional vacuum pumps. NEG thin-film coatings have been developed for the LHC project and have been already tested in a real machines such as the ESRF, Grenoble and MAX IV, Lund, Sweden.

Also to be mentioned is the progress in diagnostics with the measurement of the beam position. The position of the beam can be measured in the range of 100 to 200 nm. With a machine diameter of 300 m that makes an accuracy of 5*10-10 The magnets and the girders have to be machined with an accuracy for th 4th generation facilities of 20 µm. For MAX IV over a length of 5 m an accuracy of better than 10 µm was achieved.

• And what about the future? What can we expect from the next generation of synchrotron light sources?

What is the next generation? With MAX IV, Sirius, ESRF-EBS and other projects we are now building the 4th generation of Synchrotron Light Sources. These sources are coming up with emittances of 100 to 400 pm*rad, which are a factor of roughly 10 smaller than the 3rd generation. The users are looking for coherent light, but the 4th generation does not deliver coherent light for X-rays up to 5-10 keV. In order to reach this level, the emittance still has to be reduced by another factor of 10 and this would be the 5th generation. But this is only possible by increasing the circumference a lot, as for example PETRA IV which has a circumference of around 2.5 km.

• What do you consider is your best contribution to the world of particle accelerators? (i.e., the multi-bend achromat based lattice for synchrotron lights sources)? Which are the main advantages of this system?

Yes, it could be that my best contribution to the world of particle accelerators was the proposal for the multi-bend-achromat (MBA) lattice, showing that it should be possible to build a diffraction limited light source. Roughly 10 years after my proposal MAX-Lab in Lund, Sweden took it over for the design of MAX IV. Using this lattice the emittance will be decreased at least by a factor of 10 and the emitted radiation will be more coherent. This opens the door for new kinds of experiments.

Another contribution could be the change of the SESAME-design. When I started my engagement at SESAME a technical design report, written by machine experts and agreed by the future users, already existed. I myself was not convinced that the proposed layout was the right one for a future light source, hence I changed everything and it was not easy convincing all the different committees working on this project. Now, after 15 years, the commissioning of SESAME will start soon and it will be a very attractive light source for the Middle East Region. This was only possible because of the drastic changes I introduced at the beginning.

For sure one other contribution was to the construction of ALBA. ALBA is running very well and is a success. This is a big contribution the world of particle accelerators.

• As head of the ALBA Accelerator division, you lived for a long period in Spain. How can you evaluate the Spanish science ecosystem? Are we on the right track?

During my time in Spain I was concentrating on building ALBA, on building an synchrotron light source. I didn't have time to look at the science ecosystem in general. But from what I learnt, I would say Spain is on the right track.

Follow the ALBA Synchrotron in our social media channels