N°24

LE RAYON DE SOLEIL

THE SYNCHROTRON MAGAZINE

SOLEIL, using light as an instrument

SOLEIL SYNCHROTRON

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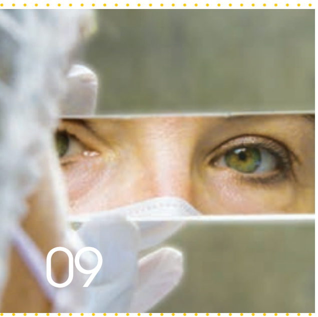
The magazine of the SOLEIL Synchrotron_N°24 December 2014



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Editorial

Jean Daillant
Director General

The UN proclaimed 2015 as the *International Year of Light and Light-based Technologies*, making it a very special year for all of the synchrotron community. Light-related topics are present everywhere in today's society, and of course at the core of SOLEIL through its various endeavors, from the Sources and Accelerators to every beamline. Among them, the ROCK beamline, devoted to the study of catalysis and batteries will welcome its first users in the Spring 2015. Besides, the two long, high resolution imaging ANATOMIX and NANOSCOPIUM beamlines are planned to open for operation in 2016. And finally, first photons were observed on the PUMA beamline in early November, increasing to 29 the number of beamlines in operation. These are the reasons why we see the coming year as the perfect opportunity to focus on the remarkable properties of the light used at SOLEIL, whether in terms of space, time or energy. Thanks to this light, we are constantly reducing the scale of our studies, observing shorter processes, and imaging smaller structures. SOLEIL's light was designed to continually allow for new experiments and uphold the synchrotron's tradition of scientific excellence, and with this in mind, 2015 will also provide you with a chance to rediscover SOLEIL's various experimental devices, either already available to its users or expected to open shortly. SOLEIL will also take part in various events celebrating 2015 as the Year of Light, and further cultivate its interactions with the general public. Through visits, conferences, educational videos, daylong scientific events and workshops designed specifically for children, we will be the ambassadors of the new and ongoing science.

INTERNATIONAL

New collaboration agreements

Khaled Toukan (right), Director General of SESAME, and Jean Daillant (left), Director General of SOLEIL, during the signature of the new collaboration agreement.

In 2014, SOLEIL reinforced its will to promote international scientific collaboration. A first agreement was signed on September 19th with SESAME, a 3rd generation synchrotron light source under construction in the Middle East. SOLEIL, which has been supporting the SESAME project from its very beginning, committed to conceive and build a high power radio-frequency Solid State Amplifier for its Middle-Eastern counterpart.

Moreover, a memorandum of understanding was signed on October 14th with the Indo-French Centre for the Promotion of Advanced Research (IFCPAR), in order to encourage Indian scientific projects led at SOLEIL.

FRANCE

Région Centre

Région Centre

The Région Centre wished to participate to the SOLEIL project early in its history, along with its funding members, CNRS and CEA, and with its territorial partners, the Région Ile-de-France and the Conseil Général de l'Essonne.

A convention was also signed after the synchrotron construction, thanks to which the Région Centre became an additional privileged partner, and was involved in the development of three of the beamlines.

Collaboration is going on, in particular through 8 scientific projects between SOLEIL and laboratories from the Région Centre (CBM, CEMHTI, CRMD, ISTO, I3MTO in Orléans and GREMAN in Tours), reflecting the multidisciplinarity and dynamism of the ongoing research.

IN BRIEF

ACCELERATORS

From 15th to 19th September 2014, SOLEIL and the International Atomic Energy Agency (IAEA) organized a week of reflection under the management of accelerators. The idea was to gather accelerators specialists (CERN, SOLEIL, ALBA, DESY...) and representatives from countries interested in these instruments (South Africa, Australia, Bulgaria, Hungary, Jordan, Poland, Turkey). The 49 participants will contribute to the writing of an accelerators management guide.

TOWARDS 500 mA OPERATION

Last September machine studies showed successfully that high reliable conditions are now met to deliver to the users 500 mA with a uniform filling pattern.
The operation mode is available each time high flux/brilliance experiences do not require an isolated bunch (hybrid mode). Such performance reinforces the front position of SOLEIL in the community of light sources.

UV MICROSCOPY

A better understanding of the tissue degeneration with ultraviolet light

one photon + one photon = one photon

Tissue degenerations appear at the early stages of many pathologies. Better appreciations allow earlier diagnostics. The repartition of the fibres in the tissues can be measured using state of the art optical photonic microscopy method. The first technique consists in combining fluorescence from two-photon excitation and second harmonic generation microscopy. When two photons are focused in a femto-volume for a time lower than a picosecond, non-linear phenomena show up: the two photons can be virtually added to be absorbed by a molecule usually excited by a single photon with a double energy. Moreover, a non-linear scattering with proper selection generates a second harmonic (SHG signal).
The second technique available takes profit of the deep ultraviolet range (DUV) emitted in the synchrotron radiation for fluorescence microscopy. Both techniques have been settled on the DISCO beamline at SOLEIL in order to compare the information obtained on several types of tissues.

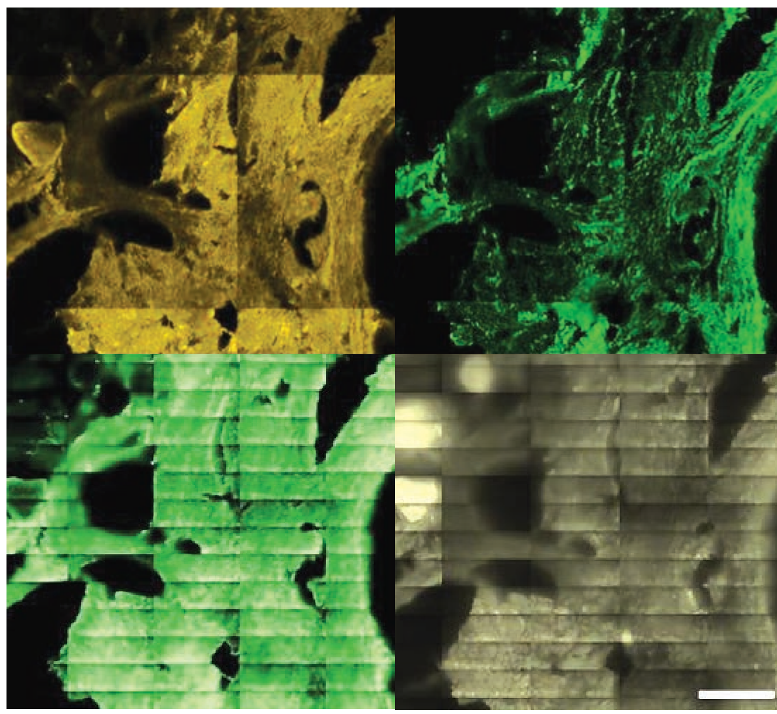

Figure 1. Tendon of a rat tail observed according several UV imaging techniques on DISCO (two-photon excitation for the upper cases, and single-photon excitation for the lower cases). Fibrillar collagen (up left), NADH and FAD (up right). Collagen, elastin and NADH (low left). Collagen and aromatic amino-acids (low right). The scale bar is 100µm.

Rat tail and mouse liver

The rat tail tendon, rich in collagen, is a perfect example for comparing the complementarity of information obtained with the two techniques. Figure 1 shows it is possible to quickly image the fibrillar collagen, the non fibrillar one, aromatic amino-acids and the NADH and FAD.

Once tested on this kind of model, it became interesting to try to adapt the method on a first pathology. The Hepatobiliary Center of APHP (Kremlin Bicêtre), the University Paris Sud and the INSERM have prepared a degeneration tissue model in mice with a gradation of the disease, starting with a simple steatosis and progressing in a non-alcoholic fatting liver disease (NAFD), then in a fibrosis, that may finally lead to a cirrhosis and hepatocarcinoma.

Techniques with complementary results

The complementarity of the two techniques become obvious on figure 2, where non fibrillar collagen supporting the erythrocytes in the veins is not visible using two-photon excitation. Thanks to this one last technique, it is possible to easily image type I and II of fibrillar

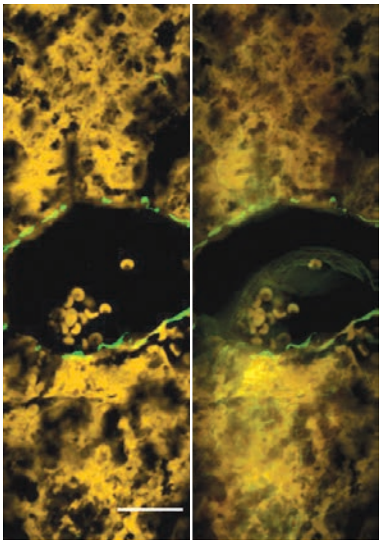

Figure 2. On the left, the UV obtained with two-photon excitation are only specific to the fibrillar collagen (in green) and do not detect the non-fibrillar observable collagen (on the right) in single-photon excitation (at the center in green).

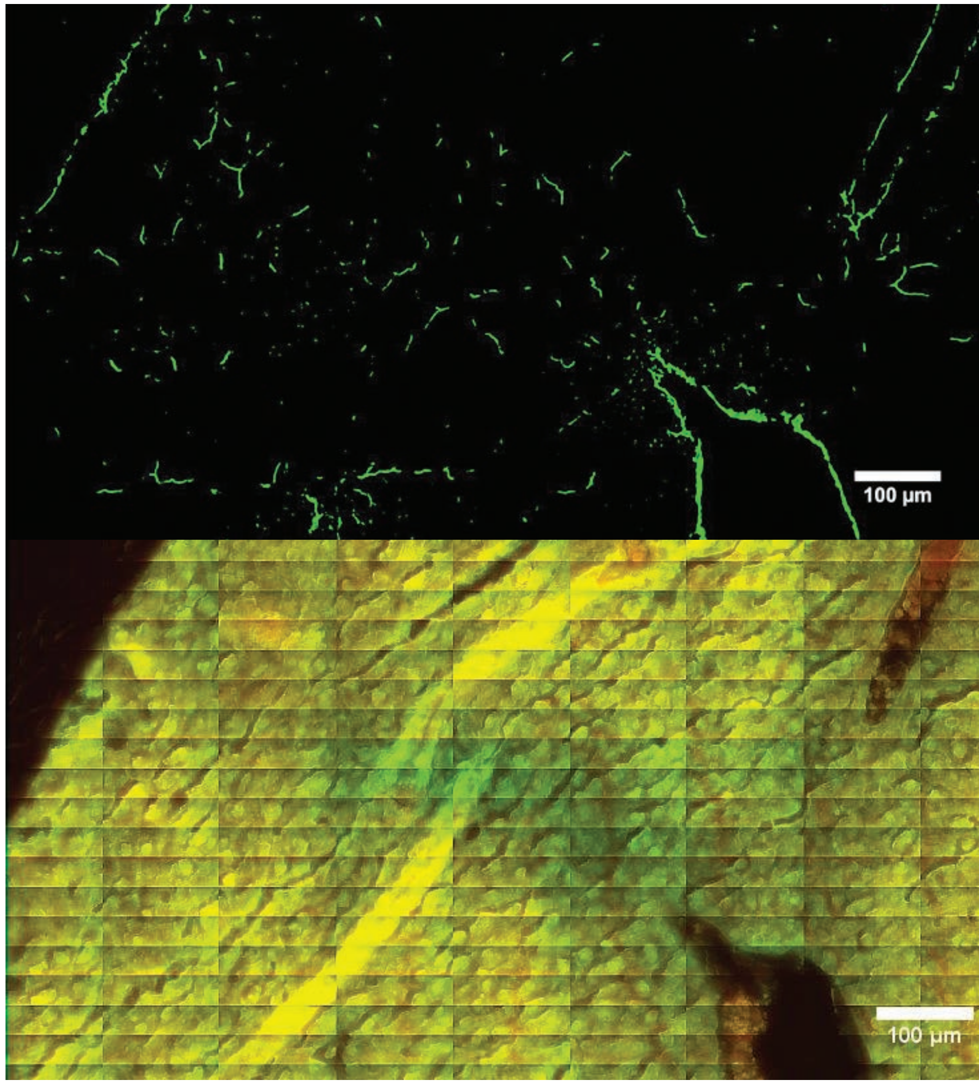

Figure 3. Mouse tissue, NASH in SHG excitation (up) and in ultraviolet single-photon excitation (low).

collagen without detecting the other types of collagen. The single-photon technique in deep UV reveals all type of collagen, without any discrimination. Combining these two microscopy techniques on a single tissue area offers a better overview of all the fibrillar collagens involved in pathologies.

Figure 3 confirms that the observable collagen with SHG excitation is mainly structuring, i.e. it mainly corresponds to the tissue limits and to the frame of the veins (up of the figure). However, the observable collagen with single photon excitation is not only structuring. The amount of collagen measured in each image can thus be linked to a disease stage. An increasing development of the total collagen has been observed for mice suffering from NASH.

The results show that some types of liver collagen can be quantified using second harmonic generation microscopy (SHG). DUV microscopy is less specific than SHG, but it allows detecting every protein and more types of collagen. It is worth noticing that according to scientists involved knowledge, this is the first use combining the three techniques for a liver histological analysis. Beyond the first results, the techniques combination may be easily used on other pathologies involving tissue degeneration.

→ Contact:
matthieu.refregiers@synchrotron-soleil.fr

Reference:
Zubkovs, V. et al.
Analyst, 139(11): 2663 (2014).

PSICHÉ

CAESAR data acquisition on the PSICHE beamline

X-ray diffraction at extreme conditions from large volumes cells

The name of PSICHE (in French), Pressure, Structure and Contrast Imaging at High Energy, sums up the thematics of the beamline: X-ray diffraction under extreme pressure conditions (whether or not coupled with temperature) and X-ray absorption wide-field tomography (3-D imaging). Here, we will focus on the first application.

Energy dispersive X-ray diffraction

The Bragg law describes the relationship between the distance between the crystallographic lattice planes, the diffraction angle and the wavelength of the diffracted photons.
$2d \sin\theta = \lambda$ which can be re-written introducing the energy E of photons (keV) **$d = 6.199/(E \sin\theta)$.**

We can see here that the energy and the sine of the diffraction angle play a similar role. Classical diffraction (angular dispersion) fixes the energy, and allows Θ to vary. In energy dispersive diffraction, the angle is fixed, and the energy allowed to vary. To achieve this, all energies must be present in the beam (as is the case for the PSICHE white beam), and the detector needs to be capable of analyzing the energy of the diffracted photons at a certain angle (it is the case for the Germanium (Ge) detector used on PSICHE which, coupled to a multi-channel analyzer, allows us to count the number of events at a given energy.

Figure 2 shows the energy dispersion diffraction display mounted on the CAESAR system. You can see the inlet and outlet slits which define the incident beam and the diffraction angle, the Paris-Edinburgh high-pressure cell and the Ge detector which analyzes the photon energies and counts them. The CAESAR system allows the diffraction angle to be varied between 0 and 30° with a circle of confusion inferior to 20 µm. By performing an energy dispersion acquisition for each angular step, we obtain a 3-dimension diagram, in which the axes are the diffraction angle, the energy of the photons and the diffracted intensity (figure 3 top). It can be read by extracting a profile at a given angle (energy dispersion), at a given energy (angular dispersion) or, by using the Bragg Law to transform the energy axis into d-spa-

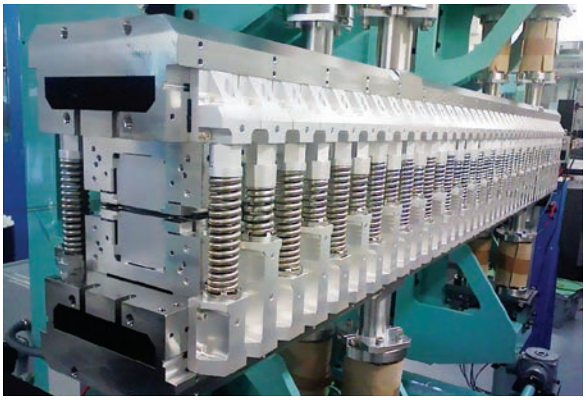

Figure 1. Multi-pole wiggler WS50.

The PSICHE beamline at SOLEIL is characterized by having as its source a multi-pole vacuum wiggler (on the left), designed by the Insertion group of the Source and Accelerator division[1]. The intrinsic properties of the wiggler as the insertion element offer the beamline particular characteristics in terms of bandwidth, flux and critical energy. In particular, the possibility of using a white beam with photons up to 80keV opens up perspectives unique in SOLEIL for X-ray diffraction as well as in tomography. Moreover, the beamline can also produce a monochromatic beam up to an energy of more than 50keV, which also offers the beamline specific possibilities.

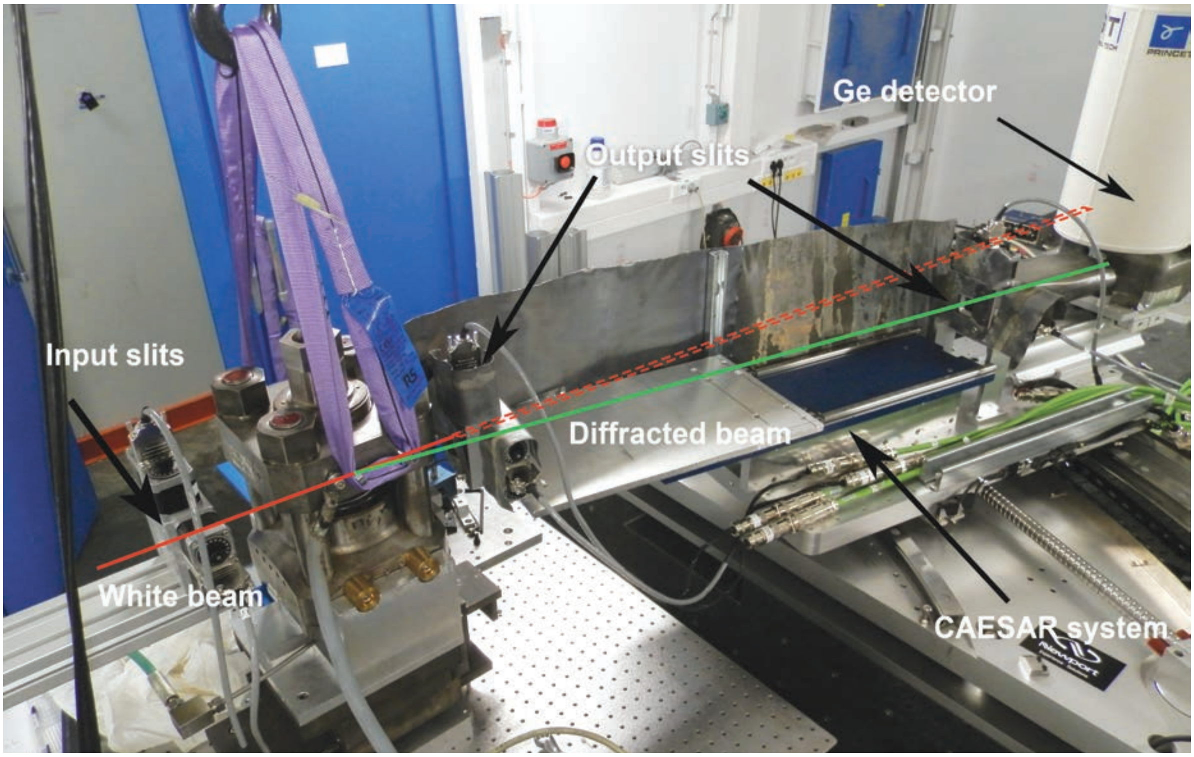

Figure 2. Energy dispersion diffraction display mounted on its CAESAR system.

cing (figure 3, middle, logarithmic coordinates). From this transformed data a classical diffraction spectrum is obtained, which intensity varies as a function of the interplanar distance; it gathers all of the data obtained at every angle and every energy (figure 3 bottom).

We see that it is possible to record spectra either by using the CAESAR system, or simply in energy dispersion. This last mode is much faster (a few seconds can suffice in some cases). When experimenting with pressure, energy dispersion spectra are enough to determine the evolution of the lattice parameters of the compressed material, because these depend only of the position of the diffraction peaks. On the other hand, if a new structure appears (modification of the diffraction peaks), then the energy dispersion is no longer ideal because the intensities of the diffraction peaks obtained are not suitable for use in a Rietveld refinement. In this case, as we will see later on, it is possible to use the CAESAR

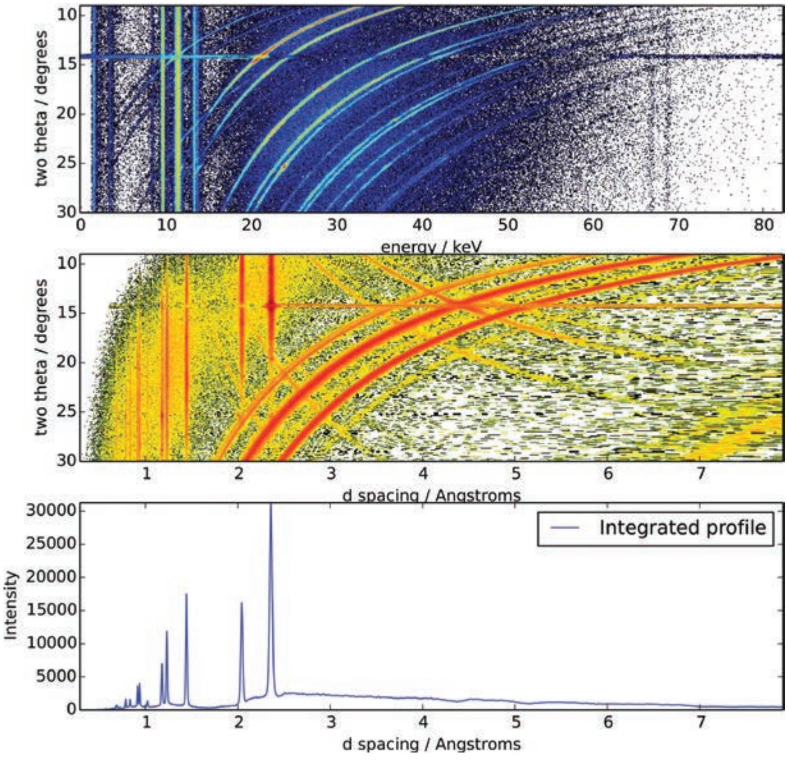

Figure 3. "CAESAR" acquisition of a gold leaf between 4° and 14°.

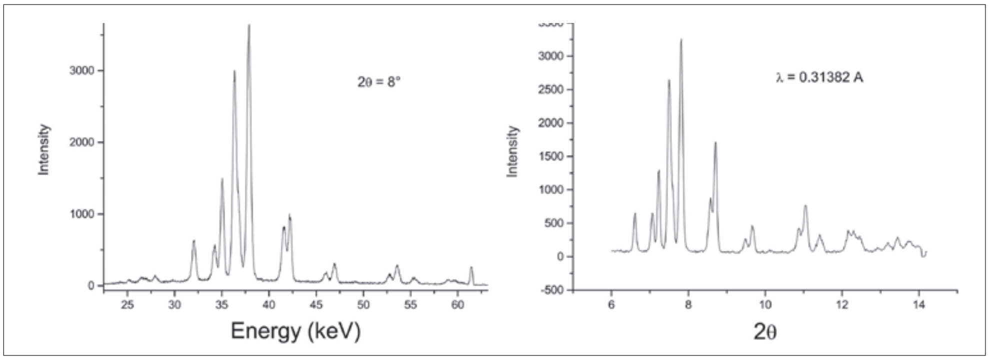

Figure 4. Energy dispersion and angular dispersion X-ray diffraction spectra, of a magnesium carbide sample under high pressure and high temperature (O. Kurakevych and Y. Le Godec).

system to obtain an angular dispersion spectrum and perform a Rietveld refinement to find the new structure. In addition, this angular dispersive spectrum can be obtained much faster than in a classical monochromatic experiment.

Synthesis of new magnesium carbide

Magnesium carbides are interesting components, both from the fundamental and applied point of view. From an advanced new materials research standpoint, the Mg-C system appears promising (polymerized carbon chains, magnesium-intercalated graphite, carbon clathrate…). However, at ambient pressure, reactions between carbon and magnesium are not favorable. That is why the IMPMC, UPMC team (O. Kurakevych, Y. Le Godec[2]), in collaboration with the PSICHE team, has developed high pressure magnesium carbide synthesis methods in a Paris-Edinburgh cell, by following in situ the reactions between materials with X-ray diffraction.

Figure 4 displays the same spectrum in both energy dispersion (for 2Θ=8°) and angular dispersion (for λ=0.313Å) of a sample synthesized under high pressure in a Paris-Edinburgh cell, measured with the CAESAR system on the PSICHE beamline. One can notice the similarity between spectra, but can also observe that the background is flat for the angular dispersion spectrum. The latter can be used to perform a Rietveld refinement, which has been done, revealing the existence of a new form of magnesium carbide (figure 5).

All this proves that CAESAR system is very well suited for following the structure modifications and new materials synthesis, *in situ*. The possibility to perform different pressure and temperature measurements is an essential step towards optimizing the most efficient thermodynamic path to the final product. The time-saving compared to a post-mortem analysis is huge, and allows the consideration of syntheses in which 3 parameters are altered: composition, temperature and pressure.

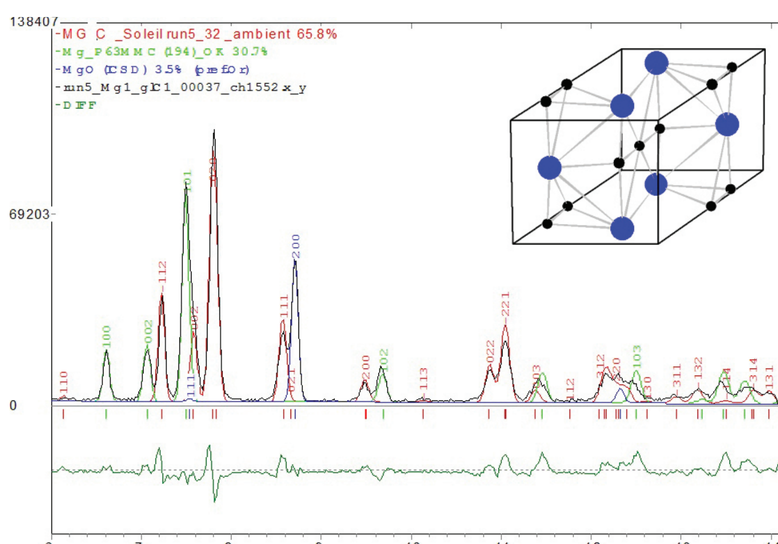

Figure 5. Rietveld refinement of the magnesium carbide monoclinic phase in the HP cell[2].

It is clear that the CAESAR acquisition system developed on the PSICHE beamline using a white beam is perfectly adapted to diffraction measurements at high pressure and high temperature in large-volume cells. It has been shown here with a Paris-Edinburg cell. Other experiments were conducted in a multi anvil cell, specially designed for the beamline, which allows performing higher pressure measurements. Recently, a team from the Magmas and Volcanoes Laboratory of the Clermont-Ferrand University has been able to achieve pressures of 25GPa à 2300°, and observe the melting of an Earth's mantle compound in these thermodynamic conditions.

→ **Contacts:**
jean-paul.itie@snchrotron-soleil.fr
nicolas.guignot@synchrotron-soleil.fr

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[1]**O. Marcouille et al.** Phys. Rev. ST Accel. Beams 16, art. 050702 (2013).
[2] **T.A. Strobel et al.** Inorg. Chem 53 (13), 7020 (2014).

FOCUS ON

When visible light
serves invisible light

The metrology laboratory in the optics group uses visible light to scrutinize the optics installed on the beamlines. In most cases, the focusing optics are mirrors used at grazing incidence; this is why they are very elongated in the propagation direction of the X-ray beam. The laboratory uses visible light to provide what can be seen as a «Google Maps» necessary to validate the optics before assembly, as the surface of these mirrors must be mapped on all scales ranging from a dozen centimeters to a nanometer. This process requires several measurement tools and is based on different methods of analysis.

The metrology laboratory is installed in a cleanroom, or in other words, a room where the dust and humidity levels, as well as the temperature, are controlled. What makes such close control necessary is that dust absorbs X-radiation, and changes in temperature and humidity disrupt the quality of the probing beams. The history of the laboratory starts with the LURE laboratory in 1996 with the development of the Long Trace Profiler (LTP) optical profilometer capable of characterizing the radii of curvature and large-scale defects (> 1 mm) which directly interfere with the geometry of the focused beam. Its resolution is about 2 nm. The LTP was transferred to SOLEIL at the end of 2005, along with other instruments completing the range of observable scales available in the laboratory. Since then, three phase scanning interferometers with complementary magnifications, a Shack-Hartmann type wave front sensor and atomic force microscope head have been installed in the laboratory. Some of these instruments have been entirely developed by the optics group while others are commercial instruments that have been significantly modified.
The lab team had to address a first challenge with the characterization of all 250 optics installed on the beamlines with uncertainty below 5 nm in height.

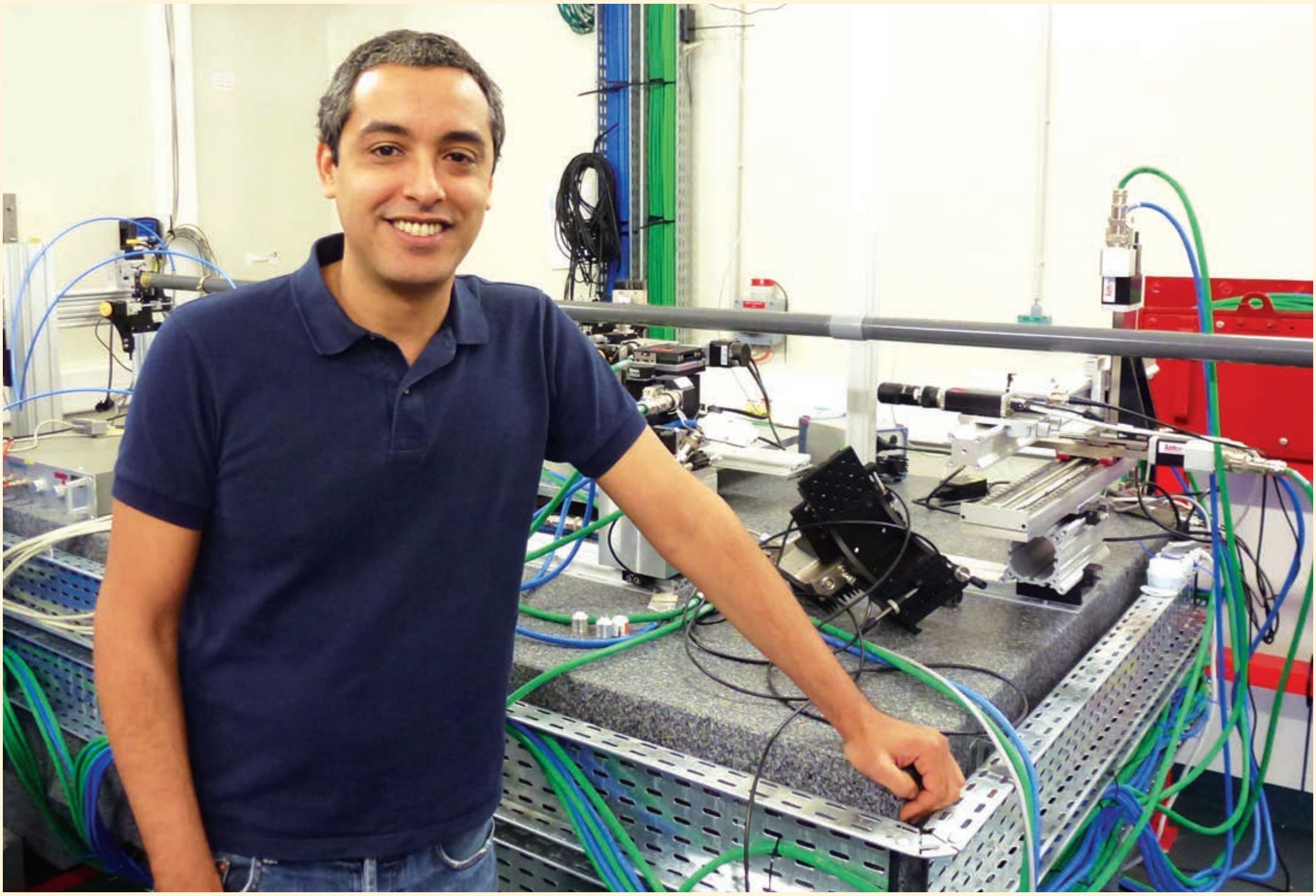
Now a new challenge has arisen with the development of sources producing diffraction-limited radiation, as the researchers have to make sure that SOLEIL's future optics do not alter the quality of the radiation. Uncertainty due to measurement errors should remain below 1 nm. That being said, recent developments in instrumentation and analytical methods have enabled the optics group to achieve uncertainty below 2 nm. The team is putting forth effort to reach that one last nanometer-a new goal that shall maintain the lab at the highest level internationally.

→ **Contacts:**
sylvain.brochet@synchrotron-soleil.fr
muriel.thomasset@synchrotron-soleil.fr
francois.polack@synchrotron-soleil.fr

EXPERT PORTRAIT

Kadda MEDJOUBI,

scientist on the NANOSCOPIUM beamline



Recruited at SOLEIL in the Detectors Group in 2004, Kadda Medjoubi –with a PhD in Physics in the field of X-rays imaging- has been scientist on the long beamline NANOSCOPIUM since 20012. An always high-speed path for a scientist who succeeded in keeping the chilling of his thesis, going from challenge to challenge.

What is your training path?

I completed all my studies at the University of Paris XI Orsay. Meanwhile, I had the chance of doing all my internships on projects of the LHC linked with detectors for High Energy Physics. This is about the time when I discovered a strong interest in the physic of interaction of particles with matter, in detectors and their modelling. I actually dived into this field, partially, when I started my thesis with a small team of 4 people led by Georges Charpak, in the Biospace startup company (EOS imaging today). Partially because I discovered another exciting field: X-ray Imaging. The (reached) purposed of my thesis was to develop a medical imaging system (still on the market today) allowing acquiring radiographic images within limiting the X-ray dose absorbed by the patient.

How did you end up at SOLEIL?

When I completed my PhD, I went to Grenoble for a post-doctoral position at the Laue-Langevin Institute, where I especially worked on the development of a large neutron detector for bio-crystallography. It was my first experience in a user-open facility. I was offered a permanent position, but in parallel an opportunity showed up in the Detector Group at SOLEIL. I was quickly interested in the synchrotron world, because it was a way to come back to X-rays, and to X imaging.

What was your job for 8 years?

As a physicist member of the Detector Group, I worked essentially on two-dimensional detectors for hard X-rays, in tight collaboration with my colleagues from the beamlines. Thanks to my thesis experience on contrast and noise transfer theory on imaging systems, I have been able to develop and settle methods – unusual in the synchrotron world- allowing optimizing the functioning of a large number of two-dimensional detectors used on the beamlines. I was also deeply involved in the XPAD3 adventure (Rayon de SOLEIL n°21 p20), a 2D detector of counting photons. It was an exciting R&D project, raising a wealth of new possibilities, realized in partnership with teams from the Center of Particle Physics in Marseille, with which I am still tightly in touch today. My knowledge of analytical modelling of X radiation interactions, combined with my experience in instrumentation, allowed me to develop and explore with this kind of detector new experimental methods such as color imaging for the Laue Diffraction in collaboration with PROXIMA 1, PSICHE and METROLOGIE[1]. Thanks to this multiple skill, I have also been strongly involved in the FLYSCAN project (Rayon de SOLEIL 22, p.9) developed with the NANOSCOPIUM beamline and the Electronics and Acquisition control Groups at SOLEIL. The FLYSCAN project led me to multi-technique scanning X microscopy experiments. It was an extremely ambitious project, a big challenge for SOLEIL and an opportunity for me to return to imaging itself. For "pleasure" (in addition to the tasks linked to my position in the Detectors Group), I realized algorithmic developments and the image treatment for 2D/3D multi-techniques experiments we had developed. All the projects would not have been successful without the strong motivation of many colleagues from SOLEIL.

Speaking about it, why did you decide to join a beamline?

Since the beginning I kept the deep willing of working on X imaging. To keep a tight link with this subject, I taught at the Paris XI University (MASTER 2 APIM, Particle Accelerators and Interaction with matter) and I'm still teaching today at Paris V (Master 2 PMV, Medical Physics and Living).

When a position opened on the NANOSCOPIUM beamline- which is an extremely ambitious project, with cutting edge instrumentation and unexplored imaging methodologies- I saw a true challenge I wanted to address.

Are you satisfied with this choice?

Totally, and I come into my new scientific career on the NANSOCOPIUM beamline with a lot of enthusiasm. I am now in charge of an experimental station dedicated to fast scanning and highly spatial resolved multimodal X imaging. My research subject is partially methodological and focuses on algorithm and the reconstruction and coupling of different modalities such as phase imaging, absorption, dark field and fluorescence. In another hand, the strong coherent properties of the beam specific to NANOSCOPIUM allow me turning towards new imaging methods.

The combination of these techniques has opened a very exciting and brand new way for 2D/3D quantitative imaging. It is actually in this working frame I am supervising a thesis in multi-disciplinary collaboration with the Curie Institute. My work relies on an application of the methods for biological research. So much motivating challenges remaining!

The unique possibilities of the methods have first been exploited in a partnership with the *Institut de Physique du Globe de Paris* in the field of paleobiology. For the first time, information has been obtained on the metal concentration and morphology of stromatolites samples (successive layers of sedimented bacterial lawn) more than 2.7 billion of years old[2]. This work shows the role of arsenic in the metabolism of the bacteria, and makes it a good bio-marker of primitive life on Earth.

Scientific possibilities of a beamline like NANOSCOPIUM are incredible. It makes the work of beamline scientist really intense, but I definitely think this is when I appreciate it the most!

→ **Contact:**
kadda.medjoubi@synchrotron-soleil.fr

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[2] **Sforna, M. C. et al.** Nature Geoscience, 7 (11): 811. (2014).

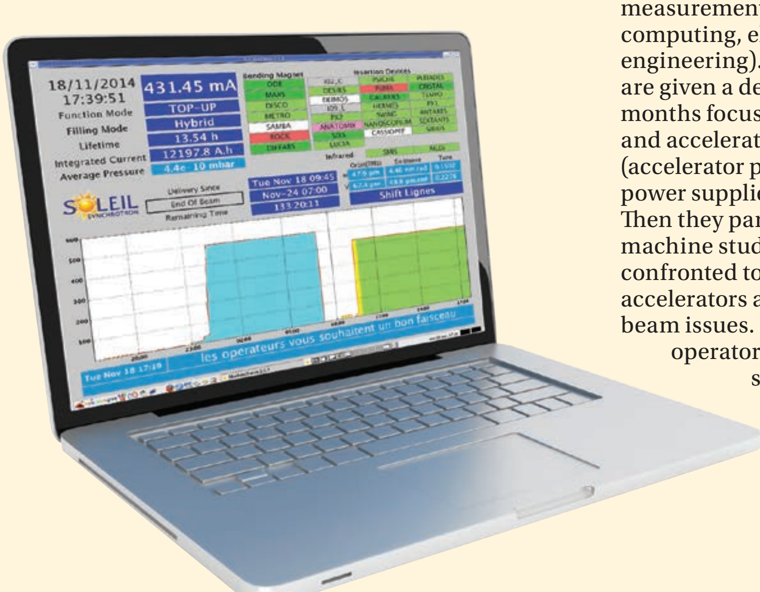
SPOTLIGHT ON

The Operation Group, a team at the ve

The operators control the day-to-day operation of the synchrotron. They operate several accelerators and monitor 24/7 all readings to ensure top quality of the beam parameters. They also develop related tools, equipment and software programs. To end they are the first contacts for any safety issue since the control room is a security PC.

At the center of the synchrotron building, in the control room, eight operators are taking turns day and night, seven days a week to ensure the optimum operation of the accelerators. They are managed by two engineers, and are part of the « Sources and Accelerators » Division of SOLEIL. During the machine-dedicated shifts, they give their support to the colleagues who are working with the accelerators. During the users' shifts, they work in pairs with a part-time operator who is a member from any SOLEIL division and participates to the whole operation. The operators ensure the set-up of the beams, and monitor all the parameters from the numerous devices located all around the accelerators: the LINAC, the Booster, the Storage Ring down to the beamline front-ends. They stand ready to respond to the slightest alert. The overall task is impressive according to the fact that almost 3 000 parameters are critical, i.e. are likely to cause a beam disturbance or even loss. If necessary, they can call on-duty SOLEIL experts who will come on-site and repair the malfunctioning equipment. Operators also play an important role in the delivered beam quality (position, dimension, intensity stability...), and in particular in the availability of the beam, which are essential parameters to ensure an efficient operation of a synchrotron light source.

This task of driving the accelerators at SOLEIL represents the largest part of their working time.



The Machine Status provides real-time information of the electron beam and beamline front-ends.

An in-house training to acquire a specific know-how

Operators are hired with various backgrounds (physics measurements, industrial computing, electronics or electrical engineering). At their arrival, they are given a dedicated training of 6 months focused on the equipment and accelerator operation (accelerator physics, magnets, power supplies, vacuum system...). Then they participate to some machine studies where they are confronted to real tunings of the accelerators and solving typical beam issues. The newly hired operator will then start sharing several shifts with a more experienced one before leading a shift by himself.

Facing an incident, analyzing, solving, anticipating

The beam in the storage ring is stable; no alert on the horizon. Suddenly, a crisis situation occurs. The beam is interrupted. To be solved, the origin of the problem must be first identified. The reaction speed is very crucial. If the incident is minor or its solution is already known, it will take only 20 minutes for the operator to deliver a new beam with the nominal characteristics. If the incident is more complex or of a new type, a precise analysis is performed, in particular on the 15 000 parameters stored today permanently in the

ry heart of the synchrotron performances

The entire Operation Group.

databases. Every fault is recorded and analyzed a posteriori. The overall goal is to identify the cause of any incident, and the actions to implement in order to avoid its reappearance in the future.

The operator also relies on procedures prepared and optimized together with all the technical groups, and on several applications available for postmortem diagnostics. In case it is necessary to enter into the accelerator tunnel to solve the problem, the operator is responsible for the control access entrance of the involved colleagues.

While solving the incident, the operator keep informed the experimental hall coordinators and updates the “Machine status” on the progress of the repair and the foreseen return time of the beam. The “Machine status” is a screen available in several places at SOLEIL and accessible from the SOLEIL webpage giving the status of the electron and photon beams in real time. The following-up of any shift is recorded in an electronic logbook filled in by the operators and available online for all SOLEIL staff.

Technical developments to improve the operation efficiency

The operators perform technical work of which first goal is to improve the accelerator operation. This work is performed either during the users’ shifts while they are monitoring the beam parameters in the control room or during the period of normal working hours in their offices. The operation group has developed about half of the applications used in the control room using several software packages (GlobalSCREEN, LabVIEW, Python…). These tools provide answers to operation needs and have various goals: continuous

In the control room, operators are monitoring thousands of parameters on dozens of control screens.

surveillance and control of equipment, automatic control of the Top-Up injection in the storage ring, operation statistics review... Operators are also in charge of the commissioning and maintenance of several technical devices such as: the temperature measurement system using PT100 probes, the water leakage detection system, the cameras and the video-distribution in the tunnels, the signal multiplexing of various screens...

During machine shutdown, operators supervise each intervention in the tunnels of the accelerators.

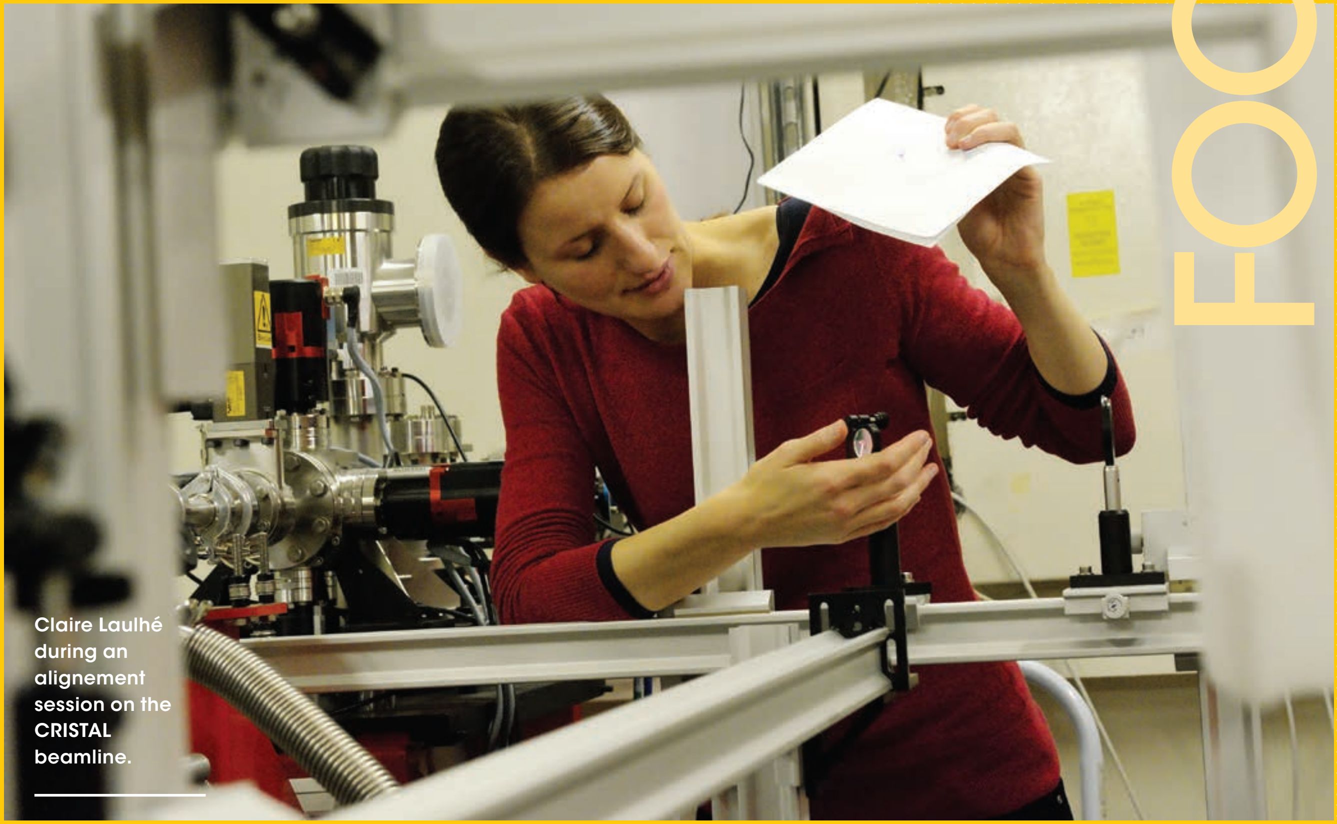
Always present, with or without beam!

The activity in the control room is remaining dense even during the shutdown of the accelerators. All the technical interventions are coordinated in the control room and follow a precise schedule established by the two engineers of the group. The operators are also daily responsible for the site safety (fire, first aid...), in close relation with the Safety Group of SOLEIL. At night especially, the operator in the control room must be able to face an emergency situation, whether it is a human or a material one. Operators are also the preferred contact point for comments or questions about the behavior of the photon beams of the beamlines (characteristics of the beam, stability, undulator control, front-end...). Finally, the operation group handles a broad variety of missions and needs to keep a constant vigilance to maintain SOLEIL performance at the highest level.

→ **Contact:**
jean-francois.lamarre@synchrotron-soleil.fr

FOCUS ON

SOLEIL, **using light as an instrument**



Claire Laulhé during an alignement session on the CRISTAL beamline.

2015 will be the International Year of Light, a topic at the core of the science carried out at SOLEIL, as in the synchrotron facility, light is produced, shaped, and used for all its various properties. Let's take a look at a few examples giving an overview of the research taking place at SOLEIL.

September 29th 2014, scientists are watching for the first time the interaction Terahertz signal of the Slicing project.

Synchrotron radiation begins to have quite a rather long history. It all started in the early 1960s, when it was used as part of the very first spectroscopic measurements, and it continued with a considerable contribution to structural matter determination and the use of light diffraction as a standard method to study ordered matter. Nowadays, synchrotron studies are once again becoming increasingly popular due to a growing need for coherence and temporal structure now available thanks to significant machine improvements on the one hand, and advances in beam control and optics performance on the other.

SOLEIL: a multipurpose light source

As we will be celebrating 2015 as the International Year of Light, it appeared interesting to show how SOLEIL already benefits from these advances within a few select areas such as direct and indirect imaging, ultra-high spectroscopy and time-resolved measurements. Let's start with machines: since it first started operating in 2006, SOLEIL's storage ring has undergone continual upgrades to meet the growing needs and challenges of each beamline. In this sense, SOLEIL can be seen as a multipurpose light source. Users can chose among several filling pattern options provided in Top-up injection,

To be continued on page 18...

NANOSCOPIUM

Nanofocusing at NANOSCOPIUM

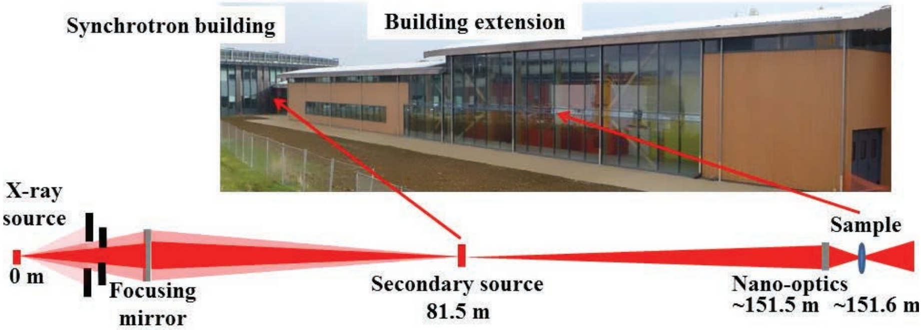


Figure 1. Optical scheme of nano-focalization at NANOSCOPIUM. The demagnification is determined by the ratio of the SS-nano-optic and nano-optic-sample distances.

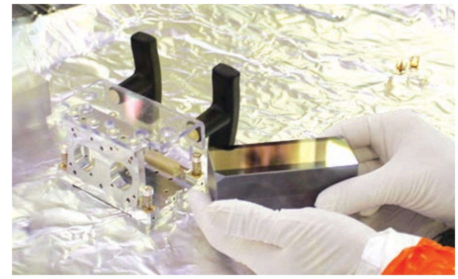


Figure 2a (top). Ultra-high quality nanofocusing (Kirkpatrick-Baez, KB) mirror. Figure 2b (low). Nanofocusing Fresnel Zone plate[2].

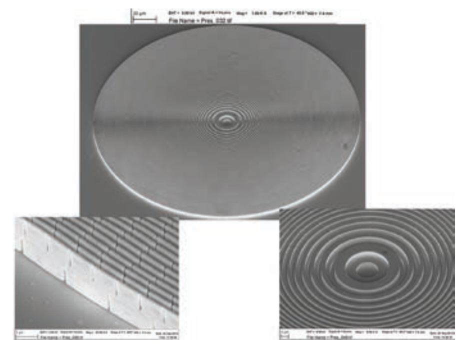
High societal impact research areas, such as biology, earth- and environmental sciences or bio-nanotechnology are seeking information down to nanometers scale on highly heterogeneous systems often in natural/in operando conditions. Scanning hard X-ray nano-imaging is getting increasing interest in such research providing morphological and elemental information together with high penetrating power particularly well suited for *in situ* studies. Recently X-ray microscopy witnessed tremendous development driven by this strong scientific interest.

In scanning X-ray imaging the sample is scanned in the intensive nano-beam created by a high quality X-ray optic. Next to the geometrical demagnification of the X-ray source, a physical limitation of beam focusing is due to the diffraction of X-rays. This "diffraction limited" beam-size, which is proportional to the X-ray wavelength, determines the ultimate spatial resolution of the optic. This is below of the diffraction limited resolution of visible light microscopes.

Fabrication of ultra-high quality optics is crucial for nano-focusing and comes with methodological and fabrication challenges. These are successfully tackled by latest nanofabrication technologies. Recent X-ray focusing devices, such as Fresnel Zone plates consisting of hundreds of concentric rings with decreases widths, or ultra-precisely figured elliptical mirror-pairs, or new class of x-ray optics as multilayer Laue lenses (MLL), provide near-diffraction-limited focusing. As such modern x-ray microscopy reaches a few tens of nanometers resolution and most recent results report even sub-10 nm focusing opening unprecedented research possibilities.

The NANOSCOPIUM[1] 155 m-long beamline is dedicated to 2D/3D scanning hard X-ray nano-imaging aiming to reach down to 30 nm spatial resolution. The large 60-70 m distance of the state of the art nano-focusing optics from the secondary source (SS) ensures high ~0.0015 demagnification (Fig. 1) necessary for obtaining nano-sized beams (i.e. 10 μm SS size is demagnified to 10 nm at the sample position).
The outstanding optical quality of the elliptically figured mirror-pair (Fig. 2a) (JTEC, Japan) is crucial for focusing down to 50-100 nm. The measured elliptical mirror shape agrees within ≤0.5 nm, almost atomic scale!, over the 100 mm mirror length with the theoretical shape. Beam-sizes down to 30 nm will be obtained by dedicated FZP's (Fig. 2b) developed by the group of C. David[2] (PSI, Villigen, Switzerland).

With these nano-optics NANOSCOPIUM will offer state of the art imaging with stable and high intensity nano-beams, which can be tailored in the 30-500 nm size-range according to the experimental needs. Moreover, fast continuous



scanning[3] makes multi-scale imaging and tomography feasible during a typical user experiment. This, together with the combination of complementary techniques (X-ray fluorescence, absorption, phase contrast and dark field) provides complete quantitative information about the sample structure, composition and chemistry for cutting edge sciences.

→ **Contact:**
andrea.somogyi@synchrotron-soleil.fr

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[2] **I. Mohacsi et al.**
Journal of Synchrotron Radiation, 21, 497–5 (2014).
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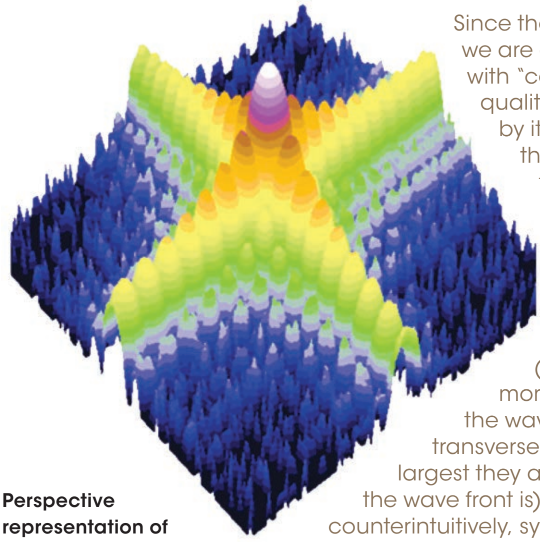
CRISTAL

Extreme coherence



Perspective representation of the X-ray coherent diffraction pattern obtained with 5x5 μm² slits at the CRISTAL beamline. Intensities are in log scale. The existence of fringes demonstrates the coherence of the beam.

Since the advent of the laser, we are accustomed to deal with "coherent light", a high quality light characterized by its spectral purity and the regularity of its wave front (planar or spherical). Physicists characterize these properties by two lengths, the longitudinal coherence length (the largest it is, the more "monochromatic" the wave is), and the two transverse coherence ones (the largest they are, the more perfect the wave front is). Rather counterintuitively, synchrotron light is not so coherent, especially in the X-ray range. Let's see why.

3rd generation sources are based on undulators, in which bunches of billions of electrons (a few cm long, *i.e.* a few tens of picosecond at the speed of light) undulate a hundred times. One electron of this bunch generates a nice plane wave of a hundred of oscillations (which is ~100 nm in the hard X-ray regime). Because each electron emits light **independently**, synchrotron light consists in a pulse of a few tens of picosecond, with a longitudinal coherence length of ~100 nm. The transverse lengths depend on the transverse sizes of the bunch: the smaller it is, the larger they are. In practical they are about a few tens of microns. Because the beam size is larger than that (~100 μm), the beam is **partially coherent**. So, how to use the coherence properties of such a beam?

The first trick is to use a monochromator, which increases the spectral quality of the beam, and thus the longitudinal coherence length, up to a micron. The second one is to place an aperture of about 10x10 μm² close to the sample in order to select the **coherent part** of the beam. This way a coherent beam is obtained, as shown by the diffraction pattern measured after the aperture, made of a pair of slits. Unfortunately, this is done at the expense of the intensity: a factor 10 000 is lost in this process. Still, it allows one to perform diffraction, that we call "coherent diffraction". On CRISTAL, we have developped coherent diffraction to study nanocrystals or multiphase compounds.

How to get more coherence? The first idea is to decrease the transverse size of the bunch by decreasing the so-called emittance of the electron beam till its minimum: the **diffraction limit**. This will be done in some synchrotron light centers, which will then become "Diffraction Limited Synchrotron Rings" (DLSR). The second way is to increase the size of the undulator in order to reach the self-amplified stimulated emission (SASE), in which the electrons of the bunch emit coherently! This is the principle of the **X-ray free electron lasers**, which have started to work ten years ago, but are not yet operating in these nominal conditions. Extreme coherence is knocking at the door!

→ **Contact:**
sylvain.ravy@synchrotron-soleil.fr

Reference:
V. Jacques et al.
Phys. Rev. B86, 144117 (2012).

... Continued from page 16

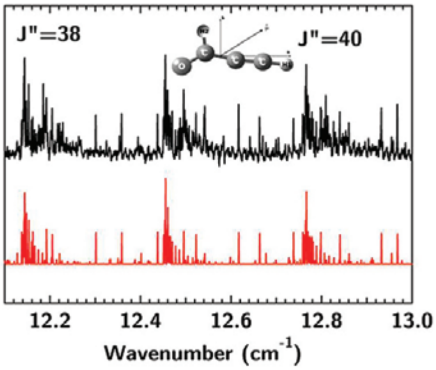
designed to meet their expectations in terms of high brilliance, time structure and short experiments. The beamline capacity has also increased by using canted undulators in single straight sections. Through the high reliability and stability of its photon beam, the SOLEIL synchrotron allows for versatile modes of operation that are tailored to meet the needs of each user. One of SOLEIL's unique features is also its ability to accept a multibunch current up to 500 mA and store more than 20 mA in a single bunch for time-resolved experiments. In addition to the mode where every single possible bunch (416 in total) is filled, the operating modes of SOLEIL's storage ring allow for a strong emphasis on the temporal structure exploitation. The hybrid mode consists of a series of 312 bunches of electrons with a total current reaching 425 mA over three quarters of the ring circumference, supplemented by an additional bunch with 5 mA in the middle of the last quarter. Two weeks per year are devoted to the so-called «eight-bunch mode» with a 90 mA total current, each separated by 148 ns and with a 25 ps RMS bunch length, while another two weeks are dedicated to the single-bunch mode with 16 mA current and 1.18 μs time interval.

AILES

High-resolution THz spectroscopy with coherent synchrotron radiation at SOLEIL

A new operation mode called Low-Alpha is now fully functional and available to SOLEIL's users. In this mode, the electrons emitting synchrotron radiation are densely packed in very short bunches, which allows for significant advances on beamlines performing time-resolved experiments on fast-changing phenomena. It has also been used by researchers from the AILES beamline to identify the spectral signatures of molecules in the area that lies between microwave and infrared radiation. In fact, when the wavelengths of the emitted light are similar to those of the bunches of electrons circulating in the synchrotron, this results in a significant increase in light flux. Basically, for «long» bunches in normal operating mode, each electron behaves as an independent light source and the light intensity is proportional to the number of electrons in each bunch. With short bunches, of the same order of magnitude as the emitted wavelengths, the electrons are very close to one another and their waves are in phase. In such a configuration, the light intensity of this so-called «coherent» emission is proportional to the square of the number of electrons in each bunch, resulting in a 10,000-fold gain in emission. Such phenomenon can occur for wavelengths from about 0.3 to 1 mm (250 to 750 GHz). What makes this energy range so special is that corresponds to the rotational energy levels of molecules in the gas phase, as surveyed by recent modern astronomy instruments such as Herschel and ALMA-recent projects that are seeking reference data issued by independent laboratories.

By juggling with the instruments' parameters, physicists at SOLEIL's Machine Group were able to improve the intrinsic instability of this functional mode, and through enhanced probing devices compensating for the source



Comparison of the pure rotational spectrum of the propynal molecule (top insert in black) as obtained in experiments, with the simulations based on these results (in red): the molecule's true «fingerprint» used for its identification in radio astronomy.

fluctuations, the researchers recorded the pure rotational spectrum of an organic molecule already detected in certain interstellar clouds, within a few hours of measurements over the entire range of interest. The analysis of such data provides improvements in the quantification of molecules found in very remote mediums, and this spectral range allows for the identification of many long-unsuspected organic molecules present in the interstellar medium. Each molecule has a spectral signature consisting of thousands of absorption lines, and even for molecules that have already been identified, it is still necessary to analyze their spectrum as such work could lead to the identification of new elements emerging in the middle of such a dense forest.

→ **Contacts:**
pascale.roy@synchrotron-soleil.fr
laurent.manceron@synchrotron-soleil.fr

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[1] **J. Barros et al.**
Rev. Sci. Inst.84, 033102, (2013).
[2] **J. Barros et al.**
J. Mol. Spectrosc. submitted (2014).

Promising imaging techniques

State-of-the-art optics on the NANOSCOPIUM beamline allow for 2D/3D nm imaging, with a significant impact expected in biology as well as in Earth and environmental sciences, a field overflowing with heterogeneous systems, the top candidates for this type of technique. Since January 2012, the storage ring has been operating with new optics including a quadrupole triplet that creates a double low vertical beta function in one of the long straight sections, and a four-magnet chicane to accommodate two canted in-vacuum undulators with a 6.5 mrad separation angle, producing two separate beams of light. The two 5.5 mm-gap undulators radiate independently hard X-rays in NANOSCOPIUM and ANATOMIX, the two long beamlines (180 m) to be used for contrast imaging and coherent diffraction.

As coherent diffraction is extensively used on the CRISTAL beamline, it is now possible to study nanocrystals and multiphase compounds (see page 18), while the ptychography technique allows users to probe larger samples. Bragg coherent diffraction patterns are expected to have a significant impact in the field of material science as it

To be continued on page 20...

Generating ultra-short X-ray pulses with femtosecond visible light pulses

On September 29, 2014 the first successful observation of femtosecond slicing of an electron bunch in the storage ring of SOLEIL was made. This opens up the door for studies of ultrafast structural and electronic phenomena at SOLEIL. The femtoslicing technique relies on the interaction between a femtosecond short infrared laser pulse and one of the electron bunches circulating in the storage ring*

*See also Rayon de SOLEIL 20, p11-12.

Figure 1. In the control room, Marie Labat and Marie-Agnès Tordeux are watching the interaction signal between the laser and the electron beam.

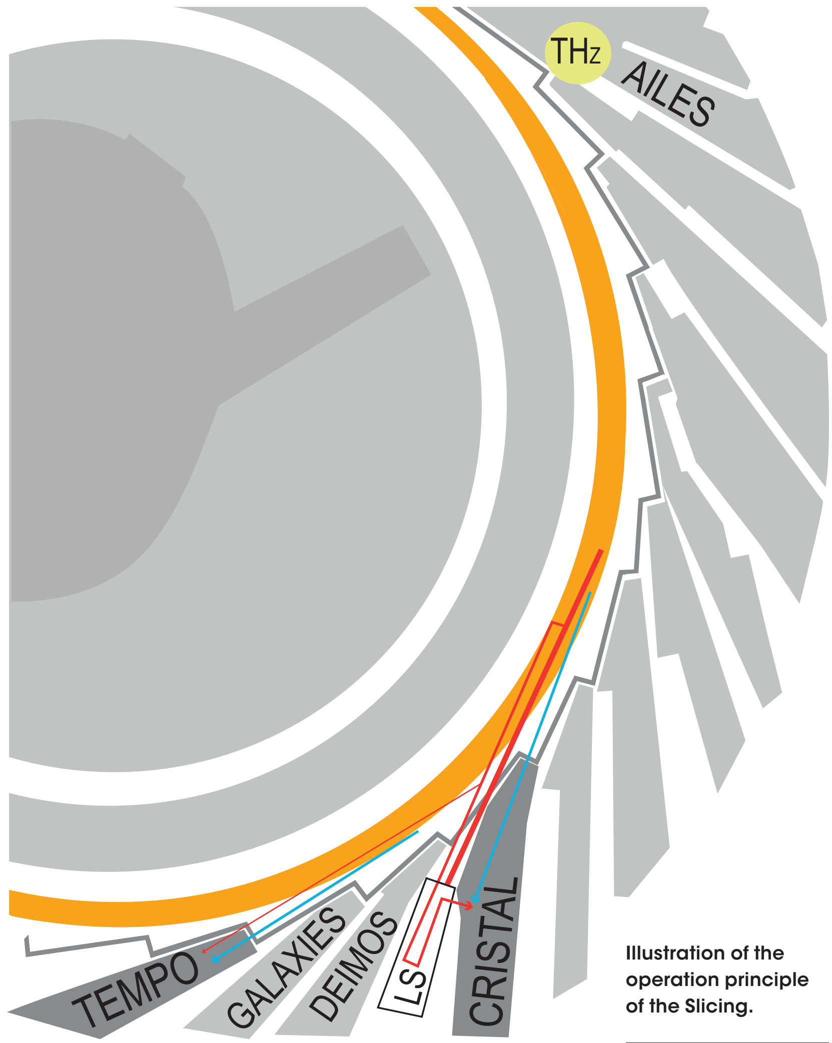

Illustration of the operation principle of the Slicing.

... Continued from page 19

allows for local constraint determination (stress, defaults etc.).

This coherence property is used quite differently on the AILES beamline, to achieve ultra-high resolution in the THz regime by means of CSR (coherent synchrotron emission) obtained when the electron beam size is of the same order of magnitude as the wavelength of the emitted photons. This has led to spectroscopic studies to obtain the spectral signature of molecules of astrophysical interest. These experiments on the AILES beamline are based on the so-called "low-alpha" mode that produces few-picosecond-long electron bunches and is also available two weeks per year (see page 19).

Probing ever-faster processes

The next new mode of operation developed at SOLEIL will be femto-slicing capabilities to several beamlines. X-ray pulses of a hundred femtoseconds will be rolled out first on the CRISTAL and TEMPO beamlines, possibly followed by DEIMOS and GALAXIES. Through these very short pulses, users will be able to probe ultra-fast dynamics (electronic and structural) processes induced in excited matter. Although the photon flux thus obtained

The femtoslicing facility at SOLEIL will be world-wide the first one providing femtosecond short X-ray pulses to several beamlines. The entire X-ray photon energy range will thus be covered at a single femtoslicing facility and femtosecond time resolution will be added to a variety of powerful X-ray techniques. Within the initial phase of the femtoslicing facility, experiments will take place at the CRISTAL and TEMPO beamlines (see figure 1). A future upgrade could provide femtosecond short X-ray pulses also at the DEIMOS and GALAXIES beamlines.

The requirement for spatial and temporal stability are stringent: scaling shows that it corresponds to pointing a laser from Paris at the Statue of Liberty in the harbour of New York – and keeping it there over the period of days, which is the typical duration of a femtoslicing experiment. To meet these requirements, significant contributions have been necessary from all of SOLEIL's divisions. To name a few of these, the laser itself had to be synchronized to SOLEIL's master RF clock; a vacuum compatible tubing had to be put in place along the transport path of the IR laser to avoid that air temperature variations or turbulences affect the laser pulse's pointing or arrival time; diagnostics had to be developed to characterize the IR beam's position, profile, energy, divergence and duration along the transport path…

All these efforts together have made it possible to reach the important milestone of observing for the first time the THz signal (see figure 1), which indicates that the electron beam and laser are spatially and temporally overlapping. Since then, a set of parameters has been optimized to further improve the overlap and to preserve it over an extended period.

The next step will be the detection of the femtosecond short X-ray pulses at the CRISTAL beamline. In preparation for the then to follow first femtoslicing experiments, scientists of the CRISTAL and TEMPO beamlines have already performed time resolved IR pump – X-ray probe experiments exploiting the currently available temporal resolution of 10 to a few tens of picoseconds. The stimulation of such out-of-equilibrium states by irradiation with ultra-short laser pulses induces electronic transitions on a timescale at which the lattice is considered to be frozen. Such excited states are inherently dynamic, involving changes over a wide range of length and time scales. Considering atomic structure, the fastest dynamics take the form of atomic vibrations with a period of the order of 100 fs. As an example figure 3 shows the time evolution of the intensity of a Bragg peak of 1T-TaS_2 during a laser driven phase transition. Femtosecond time resolution is clearly needed to get more information on the initial drop of intensity (green region).This phase transition of 1T-TaS_2 thus gives a good example why a femtosecond time resolution is needed.

Contacts:
philippe.hollander@synchrotron-soleil.fr
jan.luning@upmc.fr

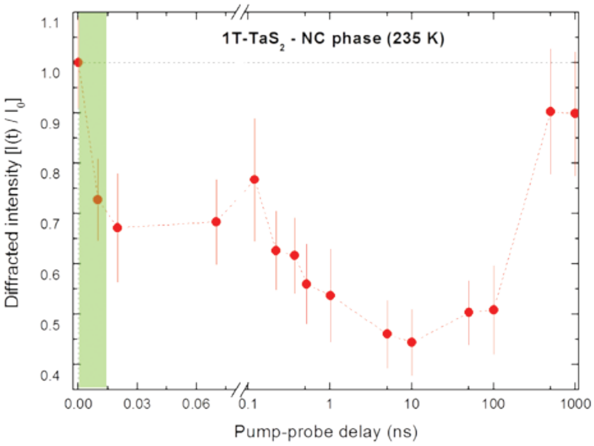

Figure 2. Intensity of a Bragg reflection as function of time after laser excitation. The intensity decrease is a direct signature of a structural transformation of the material. The first drop of intensity happens within 10 ps (region highlighted in green), which is the X-ray pulse length given temporal resolution of this measurement

does not allow for single-bunch experiments (as done on free electron lasers FEL), the unique stability of the beams is ideal for the study of reversible (repetitive) processes such as light-induced phase transition in solids and magnetization dynamics in magnetic compounds for enhanced data storage.

As is the case for other synchrotron research centers throughout the world, SOLEIL is considering upgrading to a Diffraction Limited Storage Ring (DLSR). Such an installation would include electron beam emittance near diffraction limit of the X-ray radiation, much larger coherent flux of photons and spectral brilliance 10 to 100 times greater than current third-generation synchrotron light sources. All things considered, synchrotron technology will indeed continue to serve increasingly demanding research for many years to come.

A Smart Building
demonstration project at SOLEIL

On October 2nd, 2014, SOLEIL hosted the inauguration of the Smart Building Paris IDF network demonstration project, bringing together 80 economic, scientific and institutional partners.

Created by the Essonne Chamber of Commerce and Industry in partnership with the Advancity cluster, the Paris IDF Smart Building network gathers **SMEs from the Paris area with a specific expertise in the field of smart building**, such as telemetry, flow control and monitoring, automation, and energy efficiency in buildings.
The network seeks to consolidate a more complete offer for owners of existing industrial and commercial buildings, encompassing technologies that, although often considered separate, are truly complementary.
SOLEIL was chosen as the Ile-de-France representative to host the technology demonstration project promoting offers designed under a common label and targeting the local, national and international markets.

SOLEIL: the perfect place to display the network's features

«SOLEIL is a very large facility with truly unique characteristics,» says Clément Guillon, Deputy CEO at Verteego, an SME providing cloud solutions for Sustainability Analytics, powered by Big Data. «It is open to research and technological projects, and the building itself is home to very complex facilities, with the synchrotron and its 29 beamlines, as well as offices, an 80-room accommodation building, and a company restaurant. Such a remarkable facility so close to Paris quickly emerged as the perfect place to demonstrate the high-quality solutions provided by our network members, their complementarity and interoperability.»
To meet its users' needs, the synchrotron building must also fulfill specific requirements, such as mechanical and thermal stability, machine performance and measurement reliability.
SOLEIL's staff includes infrastructure management teams that rely on a centralized technical management system. These teams recently worked in collaboration with 4 SMEs from the network-Energisme, Energiency, Vertical M2M and Verteego-for data collection and real-time flow processing.

Towards enhanced energy efficiency at SOLEIL

This project is part of SOLEIL's mission to support the competitiveness and innovation of SMEs, and in particular those from the Paris area (Ile-de-France). «The SMEs provide smart solutions for processing data collected via our current system, and these new solutions will give us a chance to raise awareness through real indicators, as well as to open up a discussion on the energy efficiency of our own buildings,» said Michel Bessière, Director of the Technical Supports and Business Development at SOLEIL.

→ **Contact:**
celine.lory@synchrotron-soleil.fr

IN BRIEF

SOLEIL AND THE RESEARCH TAX CREDIT

As a subsidiary of CNRS and CEA, two research institutions which are exempted from applying for a Research Tax Credit authorization by the French Ministry of Research, SOLEIL is also exempt from such an obligation.

This new status, which was confirmed by the Ministry of Research in the spring of 2014, enables companies collaborating with SOLEIL for R&D projects to declare the induced costs as their outsourced research expenses.

+ 5

SOLEIL has been home to 5 new inventions since October 2013, all based on research carried out by SOLEIL teams, either alone or with partners from the public and private sectors.
Four patents were filed in France with INPI (National Institute of Industrial Property), including one with a SME as co-owner, and one more should follow in the next few weeks. SOLEIL's patent portfolio is expected to reach over 15 patents, pending or issued, by the end of 2014.

International Year of Light, 2015 in the timelight

INTERNATIONAL YEAR OF LIGHT 2015

Light is omnipresent in our everyday life and will be even more so in 2015. All along the year events, conferences, symposiums, exhibitions and show will be organized around the light, aimed at all publics. Come and discover how light contributes to sciences, its industrial applications and its perspectives! All national actions will be listed on the website **lumiere2015.fr.**

A polished presentation via video

Three new pedagogical videos presenting SOLEIL were realized with an illustrator and a video team. Come and discover this fun and instructive media!

SOLEILsynchrotron

SynchrotronSOLEIL

A Science Break in SOLEIL

In 2014, SOLEIL associated with the Diagonale Paris-Saclay in order to offer the 2nd edition of this fun format of mini-conferences. On the agenda, 3 interventions of researchers around crystallography. After the hundred people who came and attended the event, you can watch the videos of Claire Laulhé and her passion for small cubes, Pierre Legrand and the magnetotactic bacteria, as well as Jean-Paul Itié and his experiment of ice crystal growth under pressure.

→ http://sciencebreak.ladiagonale-paris-saclay.fr/

“ One of my missions, of utmost importance: help our teams to put in place academic partnerships so that SOLEIL can remain at the best level of research. ”

Corinne Chabanne,
Scientific Partnership Officer

Various activities pursuing the mission of science **communication at SOLEIL**

Since it began in 2002, SOLEIL always placed an emphasis on the mission of spreading scientific and technical culture. As in many other lightsources in the world, SOLEIL furthers in day-to-day activities which reach an extremely large and various public. SOLEIL is the ideal location to discover science in the making, whatever the level of understanding of the visitor, because of the huge diversity of research that is achieved, but also because of the instrument itself. Very large instruments have been under the spotlight ever since the extraordinary scientific results that the Large Hadron Collider (LHC) has offered. Moreover, the local ground is extremely fertile since the Plateau de Saclay gathers a great number of research institutes, as well as the Paris-Saclay University project, which will have a global reach. On the occasion of the International Year of Light, our synchrotron will take advantage of the spotlight to reinforce our missions and our presence by the side of other local and national actors of the dissemination of knowledge. It will allow furthering the Science/Society debate which is necessary to understand a more and more specialized science, to such an extent that it can become difficult to access for uninitiated audience.

Visiting SOLEIL

Each year, SOLEIL welcomes several thousands of French and foreign visitors, who come to discover the synchrotron world. The program includes a visit adapted to different levels of understanding and a variety of audience: schools (high-schools), university students, institutions, associations and individuals, or professionals. In each case, the visit begins with a presentation of the main aspects of operations and applications of SOLEIL, through a very interactive seminar, followed by a visit of the facility which allows going much closer to the actors and the equipment of this big instrument. Contingent on the specialties of the public (particularly for professionals and master-degree students), beamlines scientists, accelerator physicists, engineers and technicians of the support groups play along and take the audience deeper into their work environment. The Communication team, recently backed-up by SOLEIL specially-trained PhD students, takes turns to let the public discover this very uncommon place where research is built, sample after sample.

François Bertran (CASSIOPEE beamline) explaining the functioning of SOLEIL in front of a packed-up mock-up during the 2014 Science Fair.

SOLEIL, an actor of scientific outreach events

Throughout the year, SOLEIL is always involved in unmissable dates with the public, which are very often held each year. Science Fair, operation "SOLEIL de Minuit" on the occasion of the Researchers' Night, "Bouge la Science" organized by Supélec, thematic days (such as the CristalÔ days organized in 2014 at the Musée des Arts et Métiers)… These events attended by several hundreds of people are a unique opportunity to talk about science through thematic and fun hands-on experiments, which accompany the richly informative speech of researchers and science explainers. On the occasion of the Year of Light, specific pedagogical workshops will be launched, in order to better understand this thematic.

These days are also gathering places for the national research community, they allow giving a true picture of its multiple actors.

In 2015, SOLEIL will also meet with students of primary schools, directly into their schools. The children will put themselves in the shoes of a researcher, and discover some of the light's properties in a playful way, thanks to a pedagogical project specially developed for this International Year by primary school teachers, assisted on the theoretical and experimental side by a professor of physics and chemistry seconded to SOLEIL by the Académie de Versailles… Tested in 2014 with its first audience, the reach set of hands-on experiments will be amplified with other young students, for the SOLEIL Communication team will train the teachers interested in this scientific approach.

Modernizing and adapting information vectors

The information supports evolve with society, whatever the audience. This is the time for social networks and video materials. SOLEIL thus decided to reinforce its action on these different tools. On the social networks, you can find the scientific news of the synchrotron, great collaborative projects in which it is involved, or even its different publications (quarterly newsletter).

On the video side, a very rewarding collaboration with a camera crew and an illustrator lead to the realization of a time-lapse drawing video, a short film presenting SOLEIL that has been drawn almost in real time, and voice commented so it is perfectly adapted to a large audience. At the same time and in order to ever better apprehend the research carried out on the beamlines, the list of educational short documentaries presenting an experiment conducted at SOLEIL will continue to grow. There will also be various seminars and conferences held at SOLEIL by scientists toward their peers or a wider public.

On the 4th of June, at SOLEIL, Sylvain Ravy (CRISTAL beamline) gave a lecture on the history of crystallography and the contribution of Joseph Fourier.

Christophe Sandt (SMIS beamline) introduces a teacher to the infrared microscopy during a training session organized with the Rectorat de Versailles.

The school audience is a priority target group for SOLEIL, and thereby the teachers associated to them. Teaching kits were designed to provide the teachers with the necessary tools to understand magnetism, vacuum, optics or even the different analyzing methods used in the synchrotron. In 2014, a synthesis kit regrouping all of these themes was realized; it is available in French, English, Spanish and German. Training sessions are also offered to teachers who wish to deepen their knowledge of the synchrotron and the research conducted in it, or even in spectroscopy techniques.

Science culture always was and remains a priority mission for SOLEIL. 2015 will create new opportunities to spread it ever wider.

→ **Contact:**
isabelle.quinkal@synchrotron-soleil.fr

6th SR2A international conference

SINCE ITS FIRST EDITION IN 2005 IN GRENOBLE, *the Synchrotron Radiation and Neutrons in Art and Archeology* conference has become increasingly popular. Its latest edition held at the musée du Louvre in Paris from September 9th to 12th, 2014. The Ile-de-France organizing team was coordinated by IPANEMA and its director Loïc Bertrand. The event gathered 300 participants from around the world, including scientists, museum professionals, and students, for three days of presentations on the latest scientific techniques used to analyze masterpieces, archaeological and paleontological materials. The synchrotron and neutron techniques do meet an increasing demand for the study of a variety of ancient materials, such as metals, ceramics, glass, textiles, stone artefacts, organic remains, and coloring agents. Seven laboratories from CNRS, the French Ministry of Culture and the National Museum of Natural History (IPANEMA, C2RMF, LAMS, the MNHN Department of Prehistory, LAPA, LRMH, CRCC) jointly organized this event with the Fondation des sciences du Patrimoine (FSP) and the musée du Louvre. With support from SOLEIL, the Ile-de-France regional authorities and the Royal Society of Chemistry, the conference addressed a set of themes including Conservation and Alteration, Processes and *Chaînes Opératoires*, New Methods and Analytical Processes, as well as Paleontology and Palaeo-environments.

The conference was a great opportunity for exchanges between scientists, curators as well as the general public through public sessions, and the event gained global media coverage, 23 countries being represented. The study visits hosted by curators and scientists in the musée du Louvre collections themselves were a highlight of the event. Until the next conference in 2016, contributions to the event will be published in a special issue of the international review *Journal of Analytical Atomic Spectrometry*. This joint publication reinforces the visibility of research in this area and will most likely lead the way to future applications of synchrotron radiation and neutron sources for art, archaeology and paleontology.

→ **Contact:**
loic.bertrand@synchrotron-soleil.fr

SOLEIL puts a spotlight on the environment

A WORKSHOP ON THE ENVIRONMENT TOOK PLACE ON MAY 13TH AND 14TH, 2014 AT SOLEIL, coordinated by chief scientist of LUCIA beamline Delphine Vantelon, and by chief scientist of SAMBA beamline Emiliano Fonda. The event sought to bring together members from the French and European environmental sciences community to give a comprehensive overview of the research conducted at SOLEIL. The workshop also identified the strengths and contributions of synchrotron radiation in this field, discussed the major results achieved in the past few years and conducted forward-looking reflection on the experimental means to be developed at SOLEIL to support emerging topics addressing the most critical environmental issues. The development of different types of spectroscopy and techniques that are specific to synchrotron radiation offer unrivalled, powerful analytical tools particularly suited to the complexity of the systems investigated in environmental sciences-XAFS and XRD over different time, energy and spatial scales, micro and nano imaging and tomography, NEXAFS, XES,

SUCCESS-2014
school at the Ecole de Physique des Houches

Over the past few years, strongly correlated systems-where the constituent particles interact strongly with each other-has been one of the favourite subjects of physicists. In the case of electrons in solids, the strong correlations give rise to remarkable physical properties with appealing possible applications, such as ferro- and antiferromagnetism, high-temperature superconductivity, and giant magnetoresistance.

Over the past few years, new analysis techniques to study these microscopic systems have emerged. This has created a perfect opportunity to provide graduate students and young researchers a theoretical and experimental overview of the current spectroscopy techniques that use UV or X-rays in this type of research. The event SUCCESS-2014, co-organized by Paris-Sud University, the SOLEIL synchrotron and the University of Würzburg in Germany, was held from September 1st to the 12th, 2014 at the Centre de Physique des Houches. The Center is located in the French Alps, in a scenic valley dominated by Mont Blanc. Founded in 1951, this internationally recognized institution has hosted many prestigious scientists among its teachers and students, such as Enrico Fermi, Wolfgang Pauli, Walter Kohn and Philippe Nozières.

In addition to general lectures on correlated electrons, materials, and models for many-body problems, the fifty participants were introduced to photoemission in all its variations (angle, time, and spin-resolved), elastic and inelastic X-ray scattering and absorption techniques, advanced instrumentation as well as new light sources, such as 3rd generation synchrotron, free-electron lasers, and high-harmonic generation UV and X-ray lasers.

The fifteen lecturers from French, German, and American universities were given a chance to share their experience as part of the program, which included numerous occasions for the scientists to discuss the challenges related to these promising areas of investigation. It once again highlighted the importance for future, young, and experienced researchers to share their perspectives and knowledge to continue designing new techniques and develop the innovations of tomorrow.

→ **Contacts:**
patrick.lefevre@synchrotron-soleil.fr
andres.santander@csnsm.in2p3.fr

STXM, UV and far and near IR spectroscopy and spectromicroscopy. The workshop gathered forty researchers to discuss the various synchrotron techniques for the study of soil condition, aquatic environments and the behavior of plants subjected to metals and nanoparticles. Eleven researchers from various institutes, including two invited speakers from ISTerre Grenoble and EAWAG Switzerland, presented the current status of these areas of investigation, and the participants addressed the prospects and future studies to be conducted in a round table. This successful first edition should lead to a new meeting by the end of 2015, declared the International Year of Light and the International Year of Soils by the United Nations.

→ **Contact:**
delphine.vantelon@synchrotron-soleil.fr

See also:
→ http://www.synchrotron-soleil.fr/Workshops/2014/ENVIES2014/

COSMETICS

SOLEIL engages in human beauty and well-being

Cream, shampoo, gel or lotion, these daily-used high-tech products incorporate the very last scientific advances in order to offer textures, shades, perfumes or new active principles. Quality and effectiveness control must be very rigorous, as well as their safety control.

Discussions in front of the screens of the SWING beamline.

Scientific and technological responses to these expectations require the cosmetic products characteristics (creams, emulsions, powders, gels, solutions...) and biological matrices (skin, hair, eyelash, eyebrow, nail, lips...) to be understood, and their interactions studied. Among the studies conducted at SOLEIL, one can cite skin moisture and skin dryness, the monitoring of penetration of active principles in the skin, anti-oxidation formulating tests on the skin, encapsulation and release of caffeine, which possesses lipid-reducing activity, in the skin, variation in chemical composition between hair from different geographical origins, hair bleaching, the effect of chemical treatment (coloring or bleaching, straightening or waving...) on the structure and chemical composition of hair, the structure of a dried lip gloss deposit... These examples are proof that cosmetics is at the fore-front of innovation in product.

The 3 keypoints

1 **SOLEIL established mid-2013 a privileged partnership** with the Bio-EC company, the Cergy-Pontoise University and Cosmetic Valley competitiveness Cluster, to study the quality and safety of cosmetic products in a pooled innovation platform called Cosmétomique.

2 **The SMIS, DISCO, SWING** and lastly **ANTARES** beamlines are involved in cosmetic studies.

3 **The NANOSCOPIUM and ANATOMIX** beamlines will soon make it possible to study nanometric (a millionth of a mm) elements such as nanoparticles.

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