SOLEIL SYNCHROTRON

SOLEIL II

SCIENCE LIGHTS UP THE FUTURE

SOLEIL II AT THE HEART OF THE

Advanced materials

The growing need for computing performance and storage capacity required by Big data and artificial intelligence (AI) is extremely energy intensive: computers, data centers, networks, swallow up nearly 10% of the world's electricity consumption.

Quantum computing could multiply the computing power of computers while consuming less energy by a factor of 100 to 1000.

A key issue in many fields (aeronautics, transportation, security, energy, communication...) is the rapid development, integrating design and synthesis of advanced materials, with predefined characteristics and functionalities.

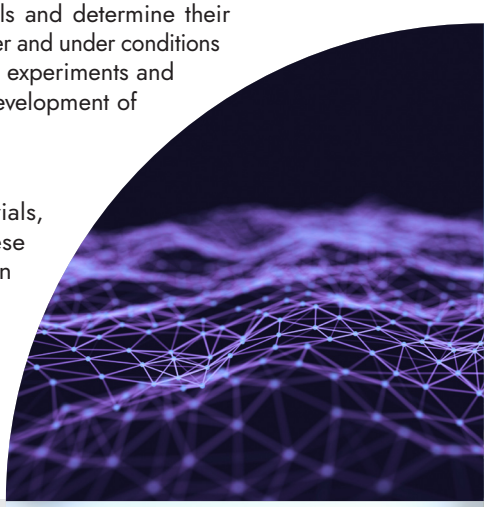
SOLEIL II BENEFITS

Materials engineering

Follow the synthesis of materials and determine their properties in an exhaustive manner and under conditions of use. Couple high-throughput experiments and AI methods to accelerate the development of materials and reduce their cost.

Information technologies

Develop new quantum materials, control the properties of these materials, whose composition is heterogeneous down to the nanometer scale on demand.



Health

Emerging infectious diseases are caused by pathogens (bacteria, viruses, fungi, parasites, prions) of very diverse origins. Treating these diseases is a major challenge, as their number is increasing and their impact is multiplied by the evolution of ecosystems linked to human activity.

The structural and cellular biology techniques developed thanks to SOLEIL II will enable to identify targets for new therapies and provide a rapid and appropriate response to these emerging diseases (vaccines, antibiotics).

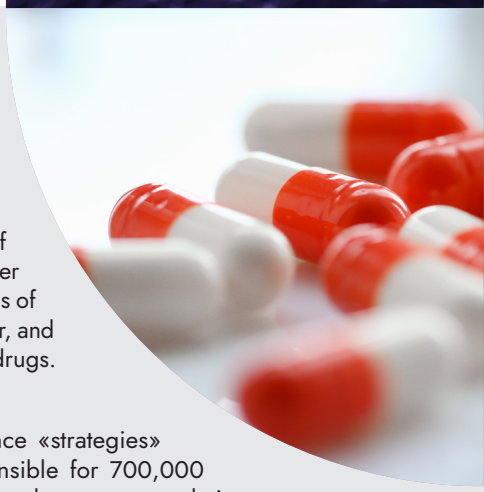
SOLEIL II BENEFITS

Cancer

Contribute to the development of cancer treatments through a better understanding of the mechanisms of cell dysfunction leading to cancer, and of the modes of action of new drugs.

Antibiotic resistance

To elucidate antibiotic resistance «strategies» developed by bacteria, responsible for 700,000 deaths worldwide per year, in order to counter their adaptation to existing treatments.



...THANKS TO A TECHNOLOGICAL LEAP AND A COMBINATION

UNIQUE LIGHT SOURCE,
FROM INFRARED TO HARD X-RAYS

UP TO 10,000 TIMES
FASTER EXPERIMENTS

UP TO 1000 TIMES
MORE SENSITIVE EXPERIMENTS

CHALLENGES OF TOMORROW

Energy and sustainable development

SOLEIL II BENEFITS

Batteries

Develop new materials for electrodes and electrolytes, using abundant chemical elements (Na, Mg, Fe), solid electrolyte technology... Optimize recycling processes.

Catalysis/green chemistry

Understand the processes of catalysis, from the atomic scale (identification of the active site) to the microscopic scale (evolution of the active site in the porous matrix).

Computers, smartphones, tablets, electric vehicles: they are ubiquitous in our daily lives, and operate thanks to the storage of electrochemical energy in batteries that we would like to be more compact, safer, faster recharging, longer lasting, more environment friendly...

In industry, 90% of reactions are catalytic, and frequently use rare resources (noble metals, rare earths, etc.). The development of new catalysts and the optimization of reactions could make it possible to reduce world energy consumption by 2050 by the equivalent of Germany's current annual energy consumption.

Environment

SOLEIL II BENEFITS

Impact of pollutants

Understand the capacity of nano-plastics to carry contaminants from the continents to the oceans, to assess their toxicological impact on ecosystems.

Global warming

Characterize the interaction and transformation processes of gases and nanoparticles in the atmosphere, whether natural or linked to human activity, in order to refine models and better predict the consequences of global warming.

By 2030, 50 million tons of plastic could reach aquatic ecosystems. Their alteration leads to the formation of micro- and then nano-particles of plastics that are very difficult to detect. More generally, the transfer of pollutants will grow with the increase in frequency and intensity of extreme climatic events (storms, floods) linked to global warming. Aerosols of natural (volcanoes, giant fires) or human (pollution) origin have a very strong impact on the climate.

OF EXPERIMENTAL DEVICES UNIQUE IN THE WORLD

NANOSCALE RESOLUTION

STUDY OF DEVICES IN REAL OPERATING CONDITIONS

COMPLEMENTARY BEAMLINES AND TECHNIQUES

SOLEIL II, AN AMBITIOUS AND

The most efficient particle accelerator in its class in the world

Based on a new arrangement of magnetic elements, the high-performance electron accelerator of SOLEIL II is designed to produce photon beams of unparalleled quality, which are essential for meeting the scientific challenges we face.

The new accelerator will be the world's most compact and highest-performance facility in the intermediate energy range (around 3 GeV), in terms of the size and divergence of the electron beams produced. It will strengthen France's strategic position in the production and use of synchrotron radiation.

This innovative and ambitious project aims to replace the current 354 m circumference accelerator while maintaining the existing infrastructure and beam extraction geometry of the beamlines, thus minimizing the project cost. The energy range of the photons produced covers ten orders of magnitude, from the far infrared to hard X-rays. SOLEIL's area of excellence (soft and tender X-rays) will remain the focus. Thanks to an electron beam 40 times smaller and circular (figure opposite), the photon beams will be at least 100 times brighter and more coherent in the X-ray range. The improved properties of the beams will make it possible to carry out experiments that were previously impossible or only possible with very long measurement times, while guaranteeing great stability of intensity, position and size. The upgrade of SOLEIL's accelerator is made possible, on the one hand, by the lifting of technological barriers, with the extreme miniaturization of the vacuum chambers where the electrons circulate and of the magnets that guide them, in order to obtain a very compact layout. On the other hand, by major innovations, with in particular a redesigned electron injection system, and brand new compact magnetic devices allowing the production and control of ever more intense photon beams. These innovative concepts are the subject of an intense prototyping phase and have already led to the filing of seven patents.

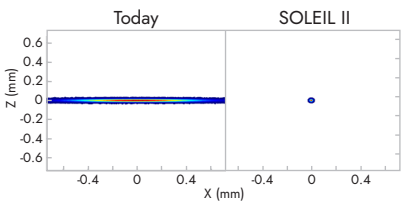


Image of the electron beam at the source point of a beamline, before and with SOLEIL II (simulation).

Prototype of the magnetic elements of the new storage ring lattice.

INNOVATIVE PROJECT TO MEET MAJOR TECHNOLOGICAL CHALLENGES

Beamlines and experimental stations at the cutting edge of innovation

All the beamlines will benefit from the unique properties of the new accelerator: measurements at the nanometer scale, study of ultrafast phenomena in real time, and considerably improved measurement sensitivity. These assets, combined with the unique variety of techniques available at SOLEIL over a wide range of energies, will provide the French and international scientific community with incomparable tools for exploring materials and living organisms to meet the challenges facing our society.

These properties will also open up entirely new experimental possibilities. In particular, techniques that could previously only be used with visible light could be transposed to X-rays, and considerably increase the precision of measurements. Spectacular progress is thus expected in the study of electronic, magnetic, chemical and structural properties. The ability to combine techniques over a wide range of wavelengths, unique to SOLEIL, will be further enhanced with SOLEIL II.

The integration of these new methods within innovative beamlines requires the design and realization of new generation optics, detectors and nanopositioning devices, developed within the framework of national and international academic and industrial partnerships.

Data at the heart of the project thanks to a global digital transformation

New digital services will fully exploit the potential of the new accelerator and beamlines.

Advanced computing techniques such as machine learning will be used to control the characteristics of the electron beam. Robotics will help to make the best use of the available beamtime, including remote experiments. In order to manage the deluge of data resulting from the increase in multi-technique experiments, the digital infrastructure will be modernized, supported by national computing and storage centers.

For the beamline Users, the added value of SOLEIL II will also reside in the visualization and analysis tools, data preservation, and associated access and data mining. Complying with the FAIR principles (Findable, Accessible, Interoperable, Reusable data), in line with the National Plan for Open Science, these services will maximize the impact of the experiments performed at SOLEIL. This transformation will be based on a modular architecture, to facilitate the integration of new services as well as the evolution of existing services and ensure their long-term adequacy with technical and scientific needs.

Improved reliability, through automation, of micro-pipetting operations on the SWING beamline.

OTHER DIMENSIONS

A reinforced impact on research, innovation and training

IMPACT ON RESEARCH AND INNOVATION

More than 14,000 users have already used SOLEIL and have come for nearly 53,000 visits. SOLEIL II will benefit 1000 laboratories and nearly 120 industrial companies annually, who will be able to take advantage of an unparalleled multidisciplinary tool. A bibliometric analysis shows that the projects carried out by SOLEIL users have a higher impact and a stronger innovative character than their other work.

SOLEIL has developed close and fruitful partnerships with many major academic and industrial players in the fields of energy, health and the environment who, by placing SOLEIL II at the heart of their strategic orientations, will be able to maximize the impact on their R&D.

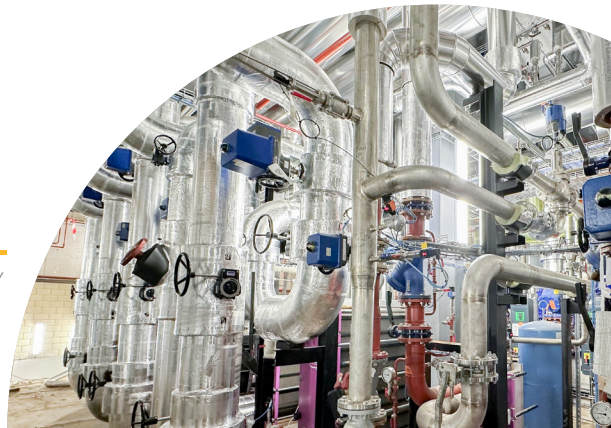
ECONOMIC IMPACT

A recent socio-economic impact study shows that one million euros spent by SOLEIL induces, on the one hand, another million euros of added value in the French economy and, on the other hand, supports over 12 jobs in France. Beyond this effect, SOLEIL II has a very strong potential for innovation with already about ten patents related to the project in preparation. From now on, French companies and associations of companies are involved in our approach in order to acquire the necessary know-how in high technology instrumentation, and to participate successfully in many similar projects in Europe and beyond.

SOCIETAL IMPACT AND TRAINING

A project as innovative as SOLEIL II offers countless opportunities for training in cutting-edge technologies. In particular, these opportunities can be realized through SOLEIL's dynamic apprenticeship policy, which trains between 20 and 30 apprentices per year.

In a completely different field, medical diagnostics, more than 20 French hospitals have already benefited from SOLEIL's unique equipment. This collaboration will be revolutionized by the development of high-throughput, high-resolution robotic analysis techniques.



Cooling circuits in the new, more reliable and environmentally-friendly chilled water production station (financed by the France Recovery Plan).

OF SOLEIL II

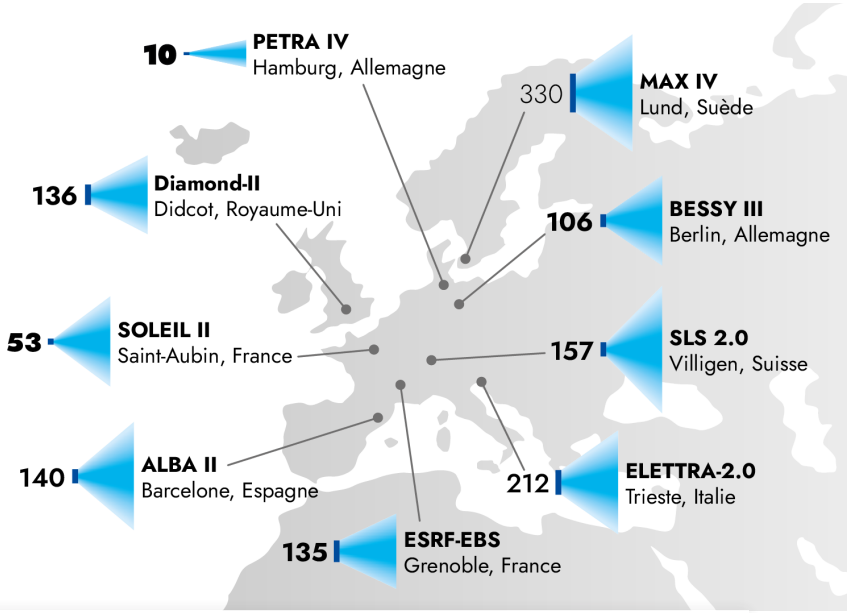
European ecosystem

SOLEIL II is positioned in a very dynamic European context where all synchrotrons are engaged in a similar process, initiated by the construction of the MAX IV synchrotron in Sweden, the first of this new generation (map). The first results obtained at MAX IV and at ESRF-EBS spectacularly demonstrate the potential of these extremely bright sources which are becoming the key element of the competitiveness of these facilities, and make SOLEIL II indispensable.

With its photon beams in the range from far infrared to X-rays, SOLEIL II will remain the indispensable complement to that of the ESRF, in Grenoble, which provides higher energy X-rays. French laboratories and industry will thus always have access to the full range of techniques covering all their needs. Since 2017, all European synchrotrons have been united in a community, LEAPS. SOLEIL is resolutely committed to this approach, in particular in all the innovative instrumentation development actions that will fully benefit SOLEIL II, accelerating developments and pooling their cost.

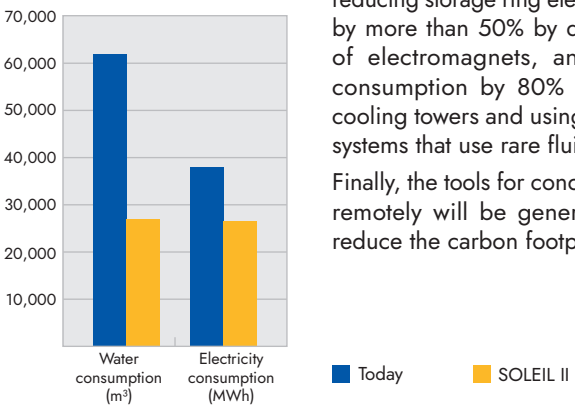
SOLEIL II, THE MOST AMBITIOUS PROJECT OF ITS KIND IN A RAPIDLY CHANGING ECOSYSTEM

Map of European next-generation synchrotrons.



A greener facility

Evolution of electrical and water consumption.



The accelerator will be built with the objective of a rational use of resources: reducing storage ring electricity consumption by more than 50% by diminishing the use of electromagnets, and drinking water consumption by 80% by upgrading the cooling towers and using closed circuits for systems that use rare fluids such as helium.

Finally, the tools for conducting experiments remotely will be generalized, which will reduce the carbon footprint of users.

SOLEIL II : TOWARDS THE WORLD'S MOST PERFORMING SYNCHROTRON IN ITS CATEGORY

- thanks to the upgrade of the accelerators and beamlines in two 5-year phases.
- meeting the challenges of tomorrow, essential to maintain the competitiveness of French research in Europe.
- complementary to the ESRF to offer French laboratories a set of synchrotron techniques that are unique in the world.
- saving resources with reduced operating costs.
- serving the competitiveness of companies.

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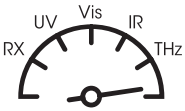

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FROM INFRARED TO HARD X-RAYS

COMPLEMENTARY
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