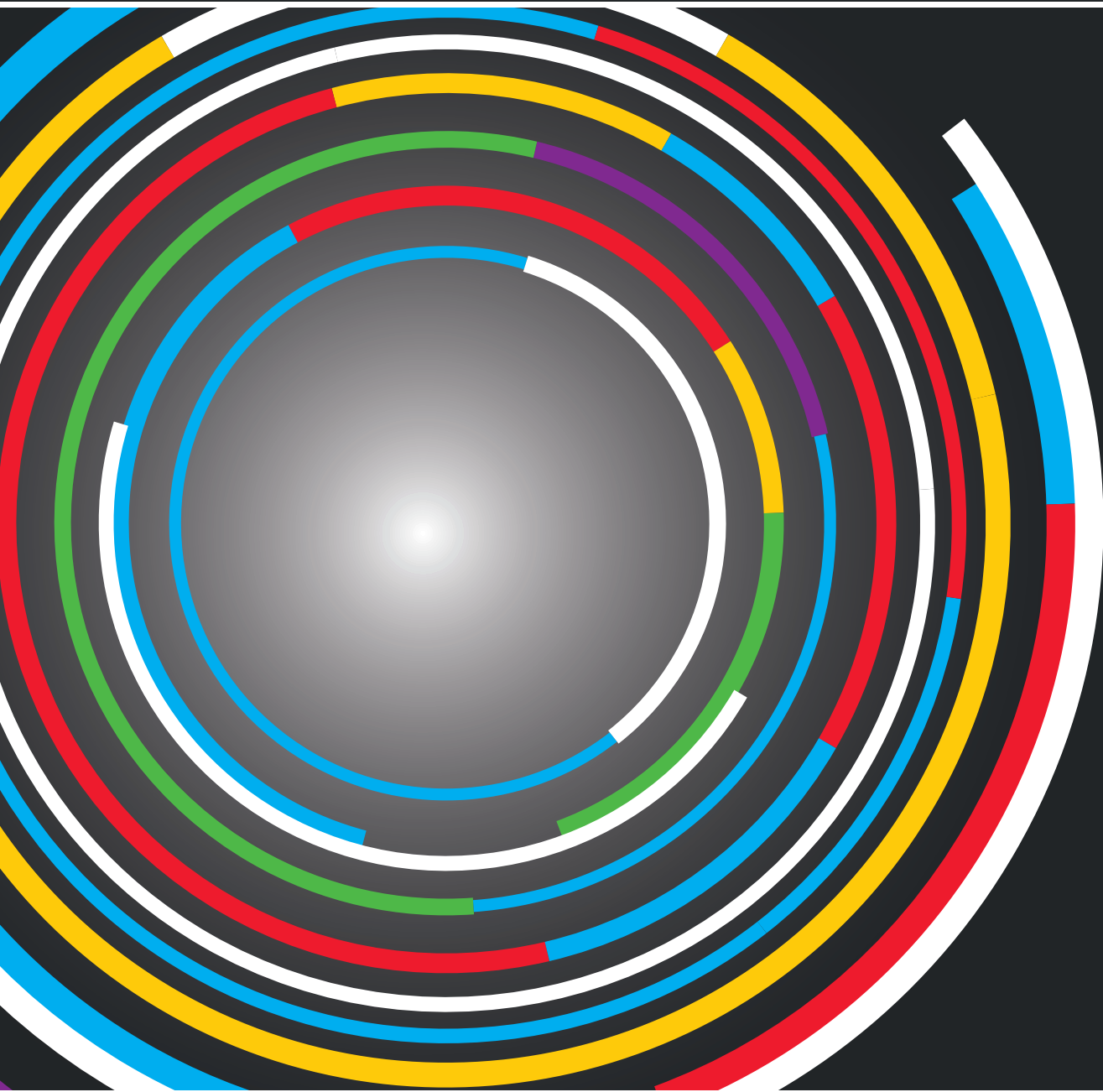


SOLARIS Centre



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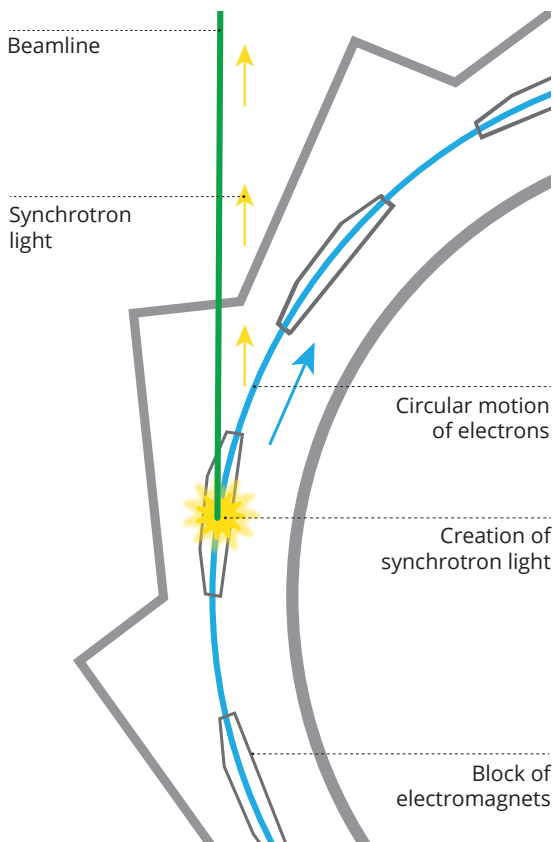
What is a synchrotron?

A **synchrotron is a cyclic accelerator**, a device that accelerates particles along a fixed, closed-loop path (in contrast to linear accelerators in which accelerated particles move in a straight line).

In the **SOLARIS synchrotron**, **electrons circulate**. They are emitted from in an electron gun and transferred to a linear accelerator, where they are accelerated to nearly the speed of light in a vacuum. These electrons are then injected into the synchrotron, where they complete over three

million laps in one second! As the electrons change direction at these curved sections, they emit electromagnetic radiation known as synchrotron light.

Synchrotron light extracted from the synchrotron is directed to the so-called *beamlines* and then guided to experimental stations, where it is used for scientific research.



A synchrotron is a device that produces synchrotron light used for scientific research.

Synchrotron light is remarkable for its extraordinary properties. It is immensely intense, millions of times brighter than sunlight reaching Earth. Moreover, synchrotron radiation spans a wide spectral range, from infrared and visible light to ultraviolet and X-rays. This enables scientists to study surfaces and interiors of various materials in numerous ways, uncovering their atomic structure, chemical composition, and electrical or magnetic properties. It also allows to study chemical reactions and transformations under diverse conditions, such as in the presence of magnetic or electric fields or at varying temperatures.

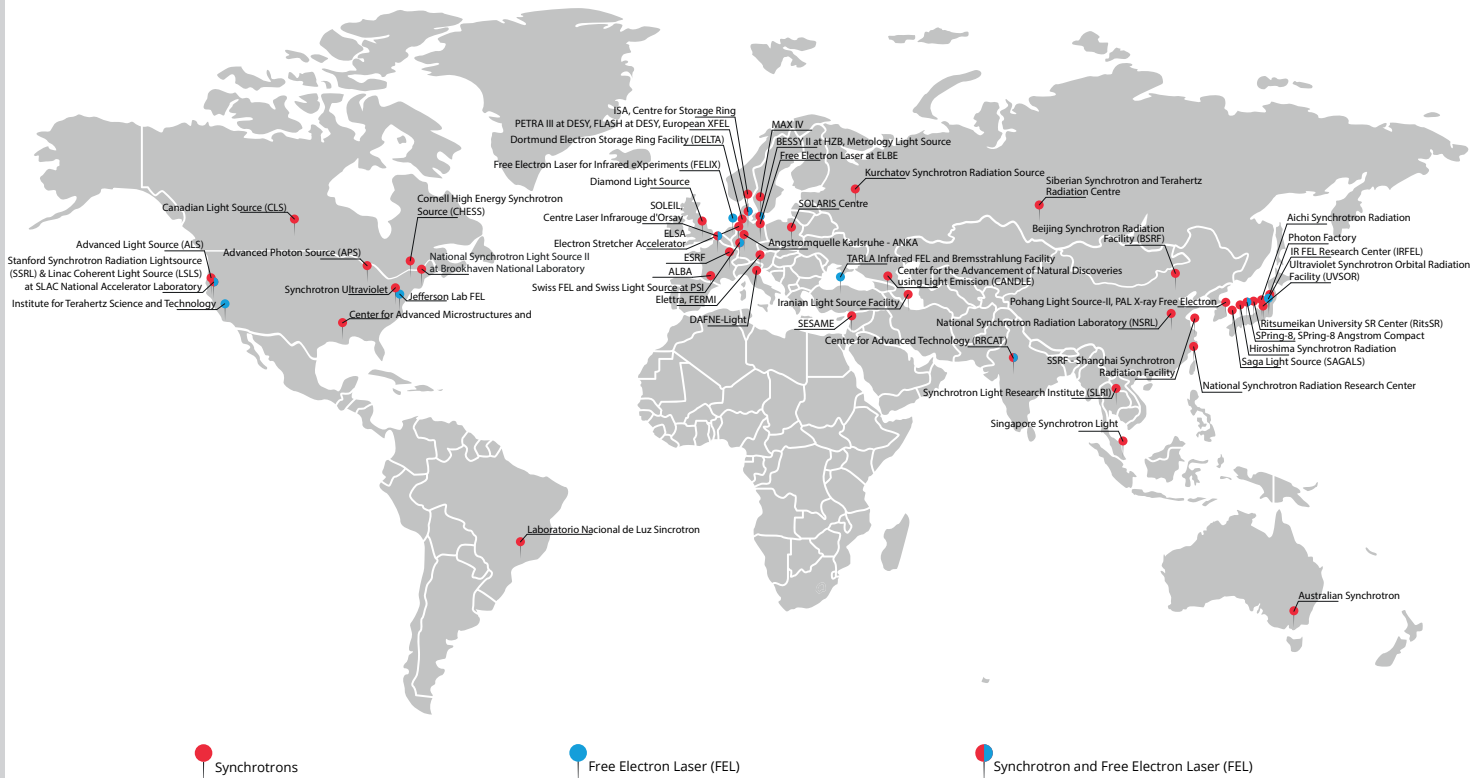
Synchrotrons in the world

Synchrotron light is widely used across various scientific disciplines, including biology, chemistry, physics, materials engineering, nanotechnology, medicine, pharmacology, geology, and crystallography.

Currently, approximately 30 synchrotron facilities operate worldwide, with most located in Europe, East Asia, and the United States - economically advanced regions where growth is driven by knowledge and innovation.

Many measurements can only be performed at synchrotron facilities. Synchrotrons allow researchers to obtain higher-quality data in significantly less time compared to traditional light sources. The unique properties of synchrotron radiation and the high demand from the scientific community ensure that **synchrotrons operate 24/7. Furthermore, researchers can conduct experiments simultaneously at multiple experimental stations within these facilities.**

Light sources in the world



Why do we need synchrotron research?

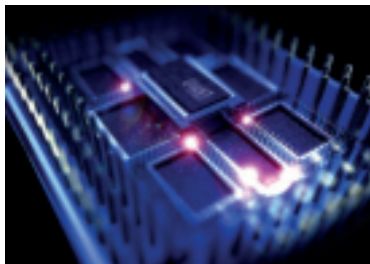
Most research conducted at synchrotrons focuses on fundamental studies, enabling scientists to delve deep into matter and perform precise electron, atomic, and structural analyses. **This foundational knowledge drives innovation and finds practical applications in everyday life.** For instance, fundamental research underpins the development of LED lighting, modern TV and mobile phone screens, and electric vehicles.

Synchrotron radiation also plays a key role in research vital for the modern economy, environmental sustainability, and for faster and more efficient methods of data storage. Synchrotron measurements support the discovery of new quantum materials, paving the way for faster and more efficient methods of data storage.

Thanks to synchrotrons, we learn that the microstructure of ice crystals and air bubbles affects the quality and sensory properties of ice cream. For

years, synchrotron studies have been improving the materials used in solar panels, enhancing their efficiency in converting sunlight into electricity. Investigating the magnetic properties of materials can advance the production of faster, higher-capacity data storage. Diffraction studies of protein structures and other biomolecules deepen our understanding of life process and contribute the development of new drugs. In summary, synchrotron facilities are at the forefront of research that is crucial for the modern economy, environmental sustainability, and the health of society.

**A synchrotron
is the accelerator
of an innovative
economy.**



About the SOLARIS synchrotron

The SOLARIS synchrotron is currently the largest open-access facility in Poland, supporting groundbreaking scientific research across diverse disciplines. It is also the first and only synchrotron light source in Central and Eastern Europe. The Polish synchrotron was constructed using state-of-the-art technologies and based on an innovative project designed by specialists from the Swedish MAX IV Laboratory. As a result, the electron beam has excellent parameters despite the relatively compact size of the device, **positioning the Kraków synchrotron among the world's leading facilities of its kind.** Ultimately, the experimental hall will house more than a dozen operational beamlines and approximately twenty end stations.

The SOLARIS Centre, a unit of the Jagiellonian University, is located on the Campus of the 600th Anniversary of the Jagiellonian University Revival. The SOLARIS building was constructed between 2011 and 2014. The investment was co-financed by the European Union with funds from the European Regional Development Fund, as part of the Innovative Economy Operational Programme for 2007–2013.

At the end of 2023, a new experimental hall was expanded at the SOLARIS Centre, paving the way for further advancements in the Centre's research infrastructure.

Currently, the SOLARIS Centre employs over 140 professionals. The core of the team are highly qualified scientists and engineers, many of whom are graduates of prestigious Polish universities (the Jagiellonian University, the AGH University of Science and Technology, the University of Silesia and Adam Mickiewicz University). Numerous SOLARIS staff members have earned scholarships at leading universities and research institutions in Europe and the United States. The Centre's operations are further supported by specialized administrative, project, and outreach teams responsible for promoting synchrotron research.

Selected parameters of the SOLARIS synchrotron



circumference	96 m
electron energy	1,5 GeV
maximum electron current	500 mA
natural emittance (bare lattice)	6 nm rad
electron lifetime	13 h

Available research techniques

Currently, researchers visiting the SOLARIS Centre can conduct studies on seven beamlines: URANOS, PIRX, DEMETER, PHELIX, ASTRA, CIRI, and POLYX. Additional beamlines are under construction - ARYA, SMAUG, Nano-X, and XAS&XRD - which are expected to be operational after 2027. Once these investments are completed, the experimental hall will accommodate multiple beamlines operating simultaneously, offering approximately twenty measurement stations.

Scientists conducting research at the SOLARIS Centre concentrate on addressing several key societal challenges, including generating energy from renewable sources, designing efficient energy storage systems, and improving the efficiency of chemical processes. To support such studies, they use the PIRX beamline, utilizing synchrotron radiation emitted by a bending magnet and dedicated to soft X-ray spectroscopy, and the ASTRA beamline, operating in the hard X-ray range.

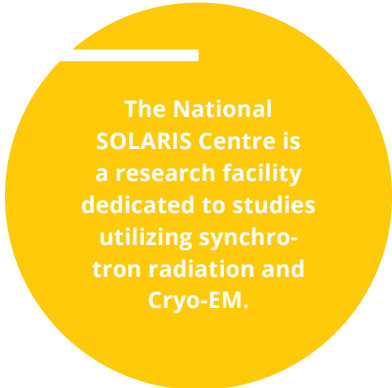
Another significant area of research involves zero-dimensional materials, topological materials, and nanostructures, which have the potential to revolutionize digital and computing technologies. In these studies, the advanced capabilities of the PHELIX and URANOS beamlines are utilized, offering techniques such as angle-resolved photo-electron spectroscopy (ARPES).

The beamlines operate under ultra-high vacuum conditions, enabling the use of synchrotron radiation in a range spanning from ultraviolet to soft X-rays. A crucial complement to these capabilities is research conducted using advanced X-ray microscopy techniques on beamlines such as DEMETER and POLYX. These beamlines offer complementary energy ranges and a diverse array of investigative methods.

A key area of research that benefits society is biomedical studies, particularly the development of innovative solutions for smart vaccines, new drugs, and advanced diagnostic therapies. The CIRI beamline is frequently employed in such studies, enabling, for example, the observation of intermolecular interactions.

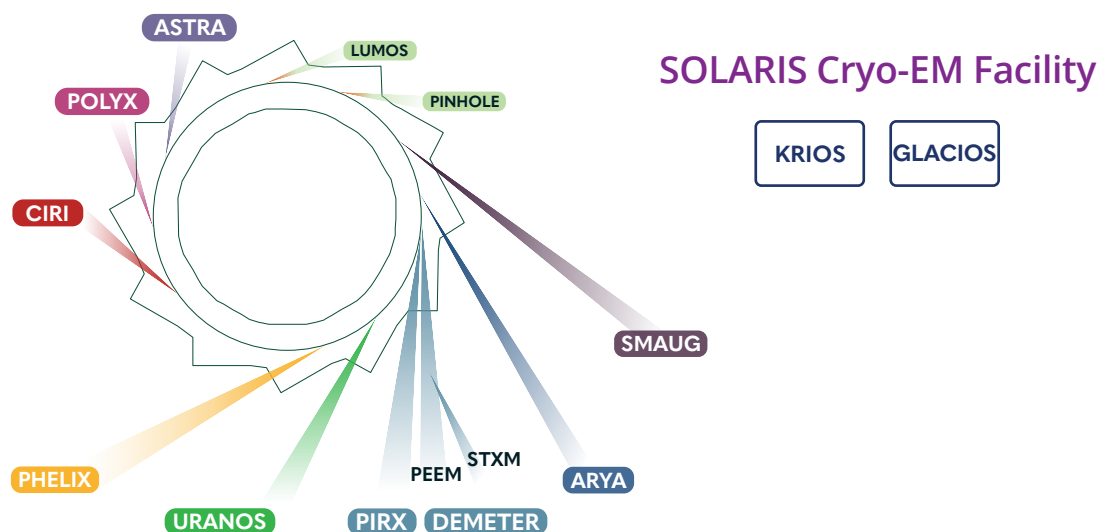
Current infrastructure investments focus on constructing new beamlines to broaden the range of structural methods (ARYA and SMAUG beamlines), microscopic techniques (Nano-X beamline), and applied spectroscopy and diffraction studies (XAS & XRD beamline).

However, the SOLARIS Centre is not solely focused on the synchrotron. **The facility also houses two state-of-the-art cryo-electron microscopes: Titan Krios and Glacios.** These instruments use Cryo-EM (cryogenic electron microscopy), a technique that relies on elastic scattering of electron beams passing through thin layers of materials or molecules being studied. This method offers a unique complement to the capabilities of the synchrotron beamlines.



The National SOLARIS Centre is a research facility dedicated to studies utilizing synchrotron radiation and Cryo-EM.

SOLARIS beamlines



Parameters of beamlines and cryomicroscopes

beamline name	source	photons/electrons energy range	research method	electromagnetic wave range
ASTRA	bending magnet	1 - 15 keV	absorption spectroscopy	soft and hard X-ray
POLYX	bending magnet	5 - 15 keV	absorption microspectroscopy, microimaging	hard X-ray
CIRI	bending magnet	12,5 - 500 meV	absorption spectroscopy	InfraRed - IR
PHELIX	undulator	50 - 2000 eV	absorption spectroscopy, photoelectron spectroscopy	soft X-ray
URANOS	undulator	8 - 150 eV	electron spectroscopy	soft X-ray and ultraviolet
PIRX	bending magnet	100 - 2000 eV	absorption spectroscopy	soft X-ray
DEMETER	undulator	100 - 2000 eV	absorption spectroscopy, photoelectron spectroscopy	soft X-ray
ARYA	wiggler 3T	5 - 15 keV	crystallography	hard X-ray
SMAUG	bending magnet	6 - 14 keV	dispersion small angle	hard X-ray
KRIOS	electron gun	300kV	single particle analysis (SPA), cryo-electron tomography (cET), electron diffraction on microcrystals (MicroED)	monochromatic waves of matter in the range of hard X-rays
GLACIOS		200kV		

ASTRA

Absorption Spectroscopy beamline for Tender energy Range and Above - operational beamline

The ASTRA beamline is used for fundamental and applied research. The beamline was especially designed for X-ray absorption spectroscopy measurements in the tender energy range, i.e., at the K absorption edges of important elements such as P, S, Si and other low-Z elements. What is more, ASTRA's energy range also includes K-edges of heavier elements up to Se, L-edges of elements up to Bi and some M-edges of elements including U, enabling the investigation of a variety of highly relevant materials. XANES and EXAFS data allow to investigate the atomic environment of selected chemical elements in solid materials (both crystalline and amorphous) or samples in liquid or gas phase. In the near future, XAS - Raman measurements will be available at the beamline, where XAS and Raman spectra will be collected simultaneously.

Types of research:

XANES spectra are highly sensitive to the coordination environment of the absorber atoms (e.g., oxidation state and coordination symmetry Td vs. Oh).

EXAFS data provides information about the average coordination number around the absorber atoms and bond distances.

Fields of science represented by users: physics, chemistry, materials science, energy, Earth and environmental sciences, biology, biomedicine, and agriculture.

Source: bending magnet

Photon energy range: 1–15 keV

Beam size at sample position (H × V): max 10 mm × 1 mm

Radiation polarisation: linear

Research techniques: X-ray absorption spectroscopy, XANES, EXAFS

Auxiliary Techniques: Raman spectroscopy (available in the near future)

Detection Modes: Transmission, Fluorescence, TEY (available in the near future)

Sample carrier: individual approach of each user

POLYX

X-ray microimaging and X-ray microspectroscopy - operational beamline

POLYX is a compact beamline for X-ray microimaging and microspectroscopy in energy range 5-15 keV. The name POLYX originates from polycapillary X-ray optics that is used for X-ray focusing and from the possibility of using polychromatic X-rays to increase the X-ray flux from SOLARIS bending magnet in the hard X-ray energy range. The beamline enables imaging of 2D and 3D structure, elemental distribution, and chemical phases in investigated samples.

The experimental geometry at POLYX can be easily reconfigured and the beamline features a dedicated area for user setups, facilitating non-standard experiments and tests.

Types of research:

imaging of 2D and 3D structure of objects, elemental distribution mapping, information about speciation and local atomic structure.

Fields of science represented by users: biomedical sciences, material science, physics, chemistry, earth science & environmental sciences, cultural heritage.

Source: bending magnet

Photon energy range: 5–15 keV

Beam size at sample (hor. X vert.):

unfocused beam (maximum beam size): 20mm × 4mm

focused beam: polycapillary optics 8µm - 200µm,

monocapillary <5µm

Radiation polarisation: linear

Beam type: white, monochromatic

Research techniques: µCT & radiography, multimodal X-ray imaging, µXRF, µXAS

Detectors in the experimental setup:

X-ray microscope Optique Peter with PCO Edge 5.5 SCMOS camera, 1M hybrid pixel detector (Dectris Eiger 2S 1M), two SDD detectors 80mm² Vortex (25µm Be i ML3.3 Extreme), ionization chambers, PIN diodes.

CIRI

Chemical InfraRed Imaging - operational beamline

The infrared beamline supports research, development, and applications across biomedicine, nanotechnology, archaeology, art conservation, and environmental science. The beamline enables chemical imaging from macro to nanoscale, offering detailed information about the composition and molecular structure of samples.

Types of research:

chemical composition analysis, macromolecular conformation and structure study, biomaterials research, nanomaterials research, chemical process investigation, industrial product quality control.

Fields of science represented by users: chemistry, life sciences and biotechnology, earth sciences and environment.

Source: bending magnet

Photon energy range: 12,5 meV – 500 meV

Beam size at sample (H x V): Spot size at the sample site: (diameter) approx. 10 μm (wavelength dependent)

Radiation polarization: linear, circular

Test stations: microscope-coupled FTIR spectrometer, s-SNOM/AFM-IR microscope, O-PTIR microscope

Research techniques: spectroscopy and IR imaging

Beam type: wide-range infrared (covering near, mid-infrared and far-infrared)

Detection Mode: FT-IR Station: Point Detector (MCT), Array Detector (FPA) O-PTIR Station: Probe beam S-SNOM/AFM-IR Station: Probe Tip/Point Detector (MCT)

End station parameters:

FT-IR station: resolution 4 – 12 μm

O-PTIR station: 50 – 800 nm

S-SNOM/AFM-IR Station: ~20 nm

Sample carrier:

FT-IR Station: BaF₂, CaF₂, Low-e, Any (ATR Mode)

O-PTIR Station: Microscope Slide, BaF₂, CaF₂

S-SNOM/AFM-IR Station: Silicon, Gold, Mica

PHELIX

PH - photoelectrons; *HELI* - possibility of light polarizations change; *X* - energy which is within the X-ray range - operational beamline

The PHELIX beamline is a complex infrastructure for photoemission and absorption spectroscopy studies. Very intense light in a soft X-ray energy range produced by undulator can be used for various research purposes like materials science, chemistry, physics, energy research, earth and environmental science, or archeology and cultural heritage.

Types of research:

Surface Composition Analysis, Semiconductor electronic structure measurements, Band structure characterization including Surface States studies of e.g. Topological Insulators or Transition Metal Dichalcogenides (TMDs), Surface characterization of catalysts e.g. metal oxides, perovskite or zeolites, Nanomaterials and nanostructure studies.

Fields of science represented by users: physics, chemistry, materials science, nanomaterials and catalysis.

Source: elliptically polarized APPLE II undulator

Photon energy range: 50–2000 eV

Beam size at sample (H x V): 150 μm x 70 μm

Radiation polarization: variable linear, circular and elliptical

Research techniques: photoemission spectroscopy PES and absorption spectroscopy XAS

Detection Mode: PES (XPS, SX-ARPES, SR-ARPES, CD-ARPES, ResPES, PEY), XAS (TFY, TEY)

End station parameters: 6-axis manipulator, LHe cooling, MBE chamber

Sample carrier: PREVAC PTS, OMICRON flag style holder

URANOS

Ultra Resolved Angular phOtoelectron Spectroscopy - operational beamline

The URANOS beamline provides photons in the vacuum ultraviolet range, enabling studies using the angle-resolved photoelectron spectroscopy technique (ARPES). This technique allows for rapid and precise analysis of the band structure in a four-dimensional space of quantum numbers (k_x , k_y , k_z , E). These investigations take into account interactions between electrons, electron-dopant interactions, and electron-phonon interactions. In other words, this technique enables the direct measurement of the real multidimensional dispersion relation $E(k)$ for electrons in solid-state materials. The beamline can be used in researching new materials in areas such as optics, spin, magnetism, electronics, nanostructures, superconductors, semiconductors, semimetals, and topological matter.

Types of research:

bulk and surface electronic structure measurements, chemical composition analysis.

Fields of science represented by users:

natural sciences, discipline: physical and chemical sciences, in particular the field of physics: solid state physics.

Source: elliptically polarizing undulator (EPU) type APPLE II, quasi-periodic

Photon energy range: 8–150 eV (ARPES), < 500 eV (XPS)

Beam size at sample (H x V): 60 μm x 150 μm

Radiation polarization: linear – vertical, horizontal, circular, elliptical, linear skewed

Measurements techniques: ARPES, spin-ARPES, CD-ARPES, RES-ARPES, XPS, Soft-XPS

Auxiliary techniques: LEED, RGA

Detection mode: angle and spin resolve detection of photoelectrons

End station parameters: Scienta DA30L analyser with deflectors, 3D VLEED, temperature range: 6.5 – 500 K

Sample carrier: Omicron style sample holders

PIRX

Premiere InstRument for Xas - operational beamline

The beamline is designed to investigate the chemical and electronic, structural and magnetic properties of samples using X-ray absorption spectroscopy (XAS) and variable polarization for XNLD, XMCD and, XMLD phenomena. The methods are suitable for probing element specific properties of bulk, surfaces, interfaces, thin films and nanomaterials. Three detection modes are available for X-ray absorption experiments: total electron yield (TEY), partial fluorescence yield (PEY) using an SDD detector and an intensity signal measured in transmission using an AXUV photodiode. Remote measurements are also supported.

Types of research:

research on materials used in conventional and renewable energy applications; surface chemical reactions; studies of model catalysts; surface magnetism, research on materials used in spintronics and magnetoelectronics; research on coatings and thin films; research on biomaterials.

Fields of science represented by users:

physics, chemistry, life sciences, biology, earth and environmental sciences, engineering and technology, and materials science.

Source: bending magnet

Photon energy range: 100–2000 eV

Beam size at sample (H x V): 250 μm x 40 μm

Radiation polarization: unpolarized, linear (horizontal) and elliptical

Research techniques: XAS, XMCD, XMLD, XNLD

Detection mode: sample current measurement (TEY), partial fluorescence detection (PFY), signal measurement in transmission

Parameters of the end station: measurement temperature range: 20–670 K, electromagnet 140 mT, 4-axis manipulator

Sample carrier: Omicron/flag style plates

DEMETER

Dual Microscopy and Electron spectroscopy beamline
- operational beamline

Microscopic beamline, equipped with two X-ray microscopes: **PEEM/LEEM** photoemission and low energy electron microscope and **STXM** scanning transmission X-ray microscope. The STXM microscope enables chemical analysis to be carried out at the nanoscale in a variable environment. The PEEM microscope enables imaging of chemical, electronic and magnetic properties of surfaces and nanostructures.

Types of research:

STXM: mapping of the sample elemental composition, analysis of the sample chemical state, magnetic state imaging of materials.

PEEM/LEEM: examination of the chemical composition, electronic and magnetic structure of materials, studying of the topography, morphology and crystallographic structure of surface nanostructures.

Fields of science represented by users: physics, chemistry, earth and environmental sciences, nanotechnology, biology and medicine, biomedical and materials engineering.

Source: undulator with the variable polarization

Photons energy range: 100 – 2000 eV

Radiation polarization: linear H,V; circular and/or elliptical

Beam size at the sample (H x V):

STXM: 30 nm – 300 nm (diameter); **PEEM:** 40 μm x 200 μm

Research techniques:

STXM, μXAS , NEXAFS, X-PEEM, XMCD/XMLD-PEEM, μXPS , $\mu\text{-XPD}$, MEM/LEEM, μLEED

Detection mode:

STXM: measurements in the transmission mode - photomultiplier (PMT) or avalanche photodiode (APD)

PEEM: detection of photoelectrons - multi-channel plate (MCP) + CCD camera

End station parameters:

STXM - pressure range: from $1\text{e-}7$ to 1100 mbar, in the atmosphere of He, Ar, O_2 , N_2 , CO_2 ; measurements at RT; scanning area (FoV): $50 \times 50 \mu\text{m}^2$; scanning resolution from 20 nm to 120 nm; required sample thickness: 50 – 1000 nm

PEEM: UHV conditions, max. pressure $1\text{e-}7$ mbar. Temperature range: 100 – 1200 K; field of view range (FoV): 5 - 100 μm ; spatial resolution in the X-PEEM mode: 50 nm, in the LEEM mode: 8 nm

Sample holder:

STXM: standard trapezoidal holder, for commercial TEM grids or membranes; **PEEM:** standard Elmitec holder

ARYA

macromolecular x-Ray crystallography - beamline
under construction

Macromolecular crystallography (MX) is a branch of science that uses X-ray crystallography to determine the three-dimensional structure of large biological molecules at atomic resolution. Research carried out at the beamline will contribute to biological sciences, medicine (drug design), chemistry, and material science. The end station will enable the analysis of the structure of proteins, viruses, nucleic acids, and polymers. These studies will offer insights into the molecular basis of living organisms and the architecture of macromolecules.

Types of research:

research on protein structure, research on the structure of nucleic acids, studies of protein/DNA/RNA complexes, Ligand screening, crystallographic fragment screening, research at cryogenic temperatures, pressure studies.

Fields of science represented by users:

biological sciences, medicine, chemistry and material science.

Source: wiggler 3T

Photon energy range: 5–15 keV

The transverse size of the radiation beam: 50 μm x 50 μm

End station: MX – macromolecular crystallography

Research techniques:

structural studies of biomacromolecules in a crystal (MX)

SMAUG

Small Angle X-ray Scattering - under construction

The SMAUG beamline will use the hard X-ray radiation from a bending magnet for structural studies of non-crystalline systems, in particular proteins and their complexes, nucleic acids, lipids, as well as polymers and copolymers, composite materials, various types of nanostructures, and a wide range of new materials.

Types of research:

studies of the low-resolution structure of proteins and nucleic acids in solutions, monitoring of conformational changes in protein molecules and the stability of proteins or complexes of proteins with nucleic acids at high pressures, analysis of the structure and stability of viruses in solution, structural studies of drug carriers composed of polymers, lipids or peptides and delivery systems of nucleic acids for gene therapy, the influence of chemical and physical parameters on the stability of protein complexes, analysis of polymer microstructure.

Fields of science represented by users: biology, chemistry, physics.

Source: bending magnet

Photon energy range: 6–14 keV

Beamline Energy Resolution $\Delta E/E$: $\sim 1.5 \times 10^{-4}$ (DCM)

Beam size at sample (H x V): 200 x 200 μm

Photon flux at sample: $5\text{--}6 \times 10^{10}$ ph/s (DCM), 1×10^{12} ph/s (DMM)

End station: SAXS

Research techniques: bioSAXS, SEC-SAXS, rheo-SAXS, GI-SAXS, static SAXS measurements (including experiments at low and high temperatures, magnetic or electric fields) and SAXS measurements of liquids at high pressures (up to 600 MPa).

SOLARIS Cryo-EM Facility

Provides access to two high-end transmission cryo-electron microscopes, Krios G3i and Glacios (both Thermo Fisher Scientific) specifically designed for measurements at cryogenic temperatures. The microscopes enable imaging of the sample structure with a near-atomic resolution.

Application Examples:

determination of the spatial structure of proteins, protein complexes, protein-ligand complexes, DNA, RNA and nanoparticles; imaging of cells and their fragments, viruses and bacteriophages, micelles and liposomes; characterization of polymers, fibers, nanomaterials and orientation and interaction of liquid crystal molecules.

Scientific fields most frequently represented by users: life sciences, biology, biotechnology, chemistry, materials science.

Experimental methods: single particle analysis (SPA), cryo-electron tomography (cryoET), and microcrystal electron diffraction (MicroED).

Electron source: X-FEG high-brightness field emission gun

KRIOS G3i Cryo-Electron Microscope:

accelerating voltage 300 kV, Direct Electron Detectors: Gatan K3 BioQuantum, TFS Falcon 3EC, Camera: TFS Ceta 16M, Energy Filter Gatan BioQuantum.

Cryo-Electron Microscope Glacios:

accelerating voltage 200 kV, Direct Electron Detector: TFS Falcon 4, Camera: TFS CetaD.

Example research

ASTRA beamline

A new generation of more environmentally friendly lithium batteries

This experiment, conducted by a research group from the University of Košice in Slovakia, focused on developing a new type of lithium battery that incorporates sulfur alongside lithium. This innovation aims to increase the battery's capacity by up to ten times compared to conventional lithium-ion batteries available on the market. Creating functional lithium-sulfur battery presents a significant challenge due to the dissolution of intermediate forms of lithium polysulfide in the electrolyte, leading to rapid loss of capacity. Despite these challenges, the research team developed an innovative solution to address this issue. Measurements at the ASTRA beamline provided valuable insights into the sulfur compounds formed in the battery during operation, the chemical processes involved, and how the battery components react with each

other. The quantification of polysulfides, sulfur and sulfates was important to this research. With this knowledge, scientists can more effectively select cathode elements and design batteries with increased efficiency.

materials
science, chemical
engineering,
energy storage
technology

CIRI beamline

What causes parrots to have colorful feathers?

An example of research conducted at the CIRI beamline is the analysis of pigments responsible for the color of parrot feathers by Dr. Peter Mojzeš from the Institute of Physics and Dr. Jindřich Brejcha from the Department of Philosophy and History of Science at Charles University in Prague. The research was conducted at the O-PTIR station, which allows for simultaneous measurements of samples using Raman spectroscopy (commonly used in this type of research) and photothermal infrared spectroscopy. This method maintains excellent sub-micron spatial resolution, and the infrared spectra provide complementary information to Raman spectroscopy. This enables the analysis of bands related to the vibrations of functional groups responsible for the color of parrot feathers, which are not visible in Raman spectra, while preserving high spatial resolution.

biological
and chemical
sciences

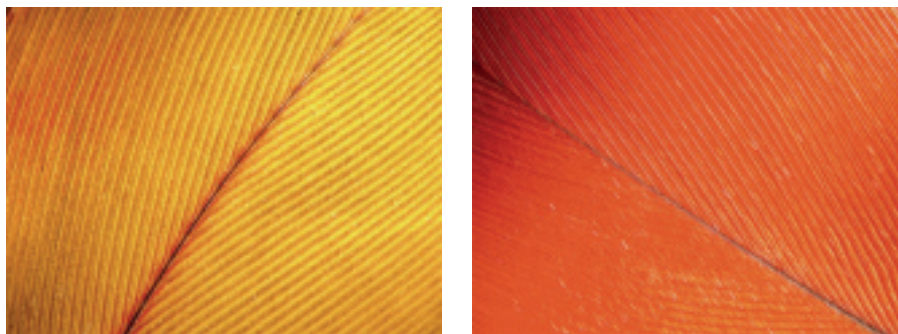


Fig. Detailed view of the feathers of a macaw parrot. Images by Dr. Jindřich. Brejcha.

Example research

PHELIX beamline

Advance in the solar perovskite cells

Perovskite solar cells (PSCs) are a modern type of cells that use perovskite as the photoactive material. Perovskites, with the general formula ABX_3 (where A and B are cations, with A typically being alkali or alkaline earth metals, B being, for example, manganese or titanium, and X being an anion—usually oxygen), exhibit high efficiency in converting absorbed sunlight into electrical energy. Over the past decade, significant progress has been made in improving PSC efficiency through, particularly by optimizing the quality of interfaces between the active and transport materials. Photoelectron spectroscopy and absorption spectroscopy enable the study of the chemical and electrical properties of these junctions. The PHELIX beamline allows for comprehensive studies of such materials, as demonstrated in, where the junction between a thin layer of perovskite and titanium oxide (TiO_2) was analyzed. The conducted experiment showed changes in the chemical and electrical properties depending on the thickness of the perovskite layer deposited on TiO_2 and determined the efficiency of such a cell at 18%.

advanced technologies, materials science

SOLARIS Cryo-EM Facility

The structure of the Elongator protein complex

After years of intensive research, scientists from Max Planck's group at the Malopolska Centre of Biotechnology at Jagiellonian University have resolved the structures of yeast and mouse Elongator. These

discoveries contribute to the broader context of nucleic acid research, opening new avenues for correcting proteome defects.

Elongator attaches a carboxymethyl group to wobble uridines in eukaryotic tRNA. This modification is crucial for proper protein synthesis, proteome fidelity, and it plays a role in preventing neurodegenerative diseases and cancer. Elongator is composed of two distinct units: (i) a larger catalytic subcomplex Elp123 and (ii) a smaller subcomplex Elp456, which assists in the release of modified tRNA. The obtained structures of Elongator reveal significant conformational changes during tRNA modification, show the high evolutionary conservation of Elongator's architecture from yeast to mammals, and have enabled the development of a reaction scheme. These results were made possible with the support of SOLARIS Cryo-Electron Microscopy. The study was published with distinction in the prestigious Oxford University Press journal *Nucleic Acids Research*.

biological sciences

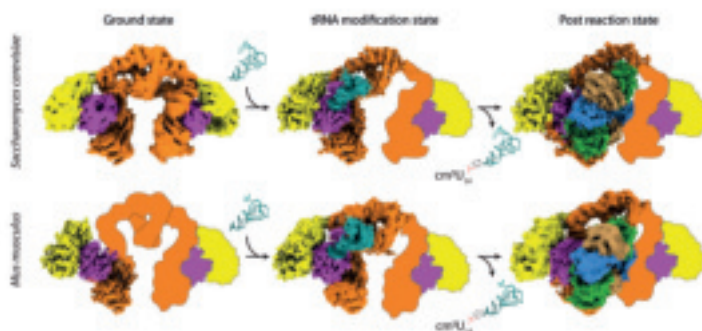


Fig. The Elp123 subcomplex of Elongator recognize, binds, and modifies substrates tRNA, while Elp456 assists in the release of the modified tRNA. A comparison of yeast and mouse Elongator reveals a high level of structure conservation among higher organisms.

Nucleic Acids Research, Volume 51, Issue 5, 21 March 2023, Pages 2011–2032.

How to use the SOLARIS research infrastructure?

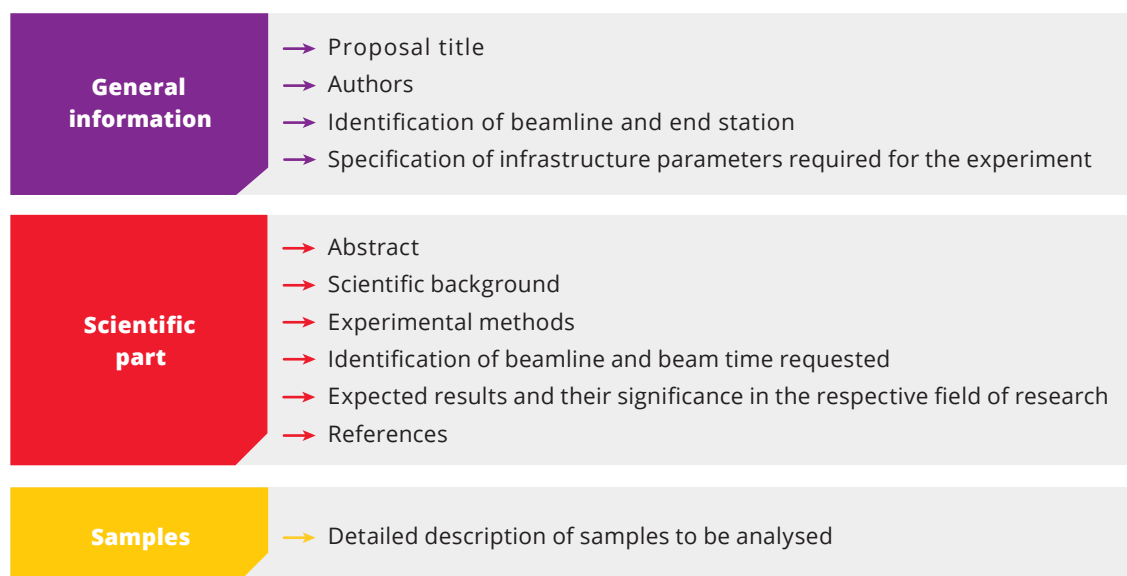
The use of SOLARIS research infrastructure is completely free of charge.

The SOLARIS synchrotron beamlines and the electron cryo-microscope are available to scientists worldwide, including those from Poland, provided their applications for beam time are approved by the international review panel. Even more importantly, **access to SOLARIS is free of charge for anyone who carries out non-commercial research.** Since the Centre first opened its doors to users in October 2018, nearly 1,700 scientists have visited the centre by the end of 2024. Between 2023 and 2024, this amounted to nearly 30,000 hours of beamtime. The activities of NSRC SOLARIS have contributed to 348 publications in prominent scientific journals such as *Nature* and *Nature Catalysis*.

The projects were submitted by scientists from 169 universities and research institutes, including 63 from Poland and 103 from other countries. The SOLARIS Centre supports research in fields such as physics, materials engineering, chemistry, and biology.

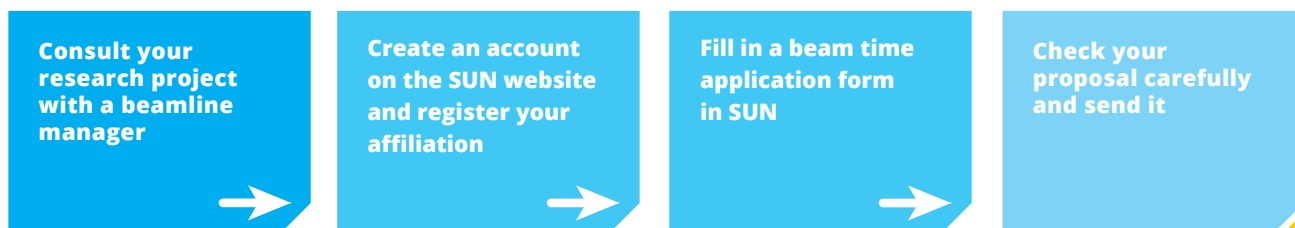
Calls for proposals are held biannually in spring and autumn. Experiments accepted during the spring call are carried out between September of the same year and February of the following year. Autumn experiments are conducted between March and August of the next year. Applications, which must be written in English, should be submitted through the **Solaris User Network (SUN)** website. Researchers can submit multiple proposals in each call.

SOLARIS proposal structure



How to submit a proposal?

Accessing SOLARIS in 4. steps:



Proposals are subject to:

- Technical evaluation, which determines whether the experiment can be conducted using the available research infrastructure
- (Sample) safety evaluation
- Substantive evaluation, focusing on the scientific value of the proposed experiment

Proposals that receive the highest ratings demonstrate a high level of innovation, well-defined scientific hypotheses, clearly defined methodology, and anticipated research outcomes. The applicant's prior scientific achievements are also considered.

Beamline managers and employees of the SOLARIS User Office provide assistance in preparing proposals.

We offer scientists the following support:

- Synchrotron radiation with unique properties and excellent parameters
- Expert technical and scientific assistance from beamline managers, from proposal preparation to result publication
- Professional IT support during measurements
- Assistance with travel arrangements to Krakow and accommodations during the measurement period

Solaris User Office

phone: + 48 571 445 045,
+ 48 12 664 41 85
e-mail: user.solaris@uj.edu.pl

Solaris User Network

www.sun.synchrotron.pl

SOLARIS International Projects

- RIANA



RIANA (Research Infrastructure Access in NANoscience & nanotechnology) is a Horizon Europe-funded project which supports both curiosity-driven research in nanoscience with open research questions with long-term impact, and challenge-driven research in nanotechnology with targeted research questions with short- and mid-term impact.

RIANA is coordinated by DESY, bringing together 7 European networks of top-tier research infrastructures (RIs) joins to cover the most advanced techniques relevant to nanofabrication, processing/synthesis, characterization, and analysis as well as simulation capacity. A highly customized and efficient access model connects users to 69 infrastructures (56 partners including SOLARIS) through a single-entry point, supported by a comprehensive scientific and innovation service delivered by senior scientists, facility experts, and highly trained junior scientists.

The core mission of RIANA is to attract new, inexperienced users, as well as experienced professionals from academia and industry, helping transform their promising ideas into successful projects and advancing them to higher Technology Readiness Levels (TRL).

The RIANA project offers:

- **TNAccess** (35 748 hours) to the most advanced RIs through the centralized user office (SOLARIS delivers 1200 hours of beamtime at all available beamlines).
- **Scientific Support Service** to maximize the effective use of RIs. This support is delivered by 21 junior scientists from RIANA (one of them hosted by SOLARIS), backed by senior scientists at each facility. The support includes:
 - Guidance in selecting techniques for optimum use offered by RIANA
 - Assistance with operating the experiments at RIANA facilities
 - Data analysis
 - Help in preparing reports and publications
- **Innovation Service** to unlock the potential of innovation from access to RIs. It supports industry-oriented RI access and develops the framework and the methodology to adapt access support, in particular for small and medium companies (SME). The aim is to mature their technology, to increase their corresponding TRL, and/or to upscale their production processes.

RIANA

www.riana-project.eu

e-mail: info@riana-project.eu



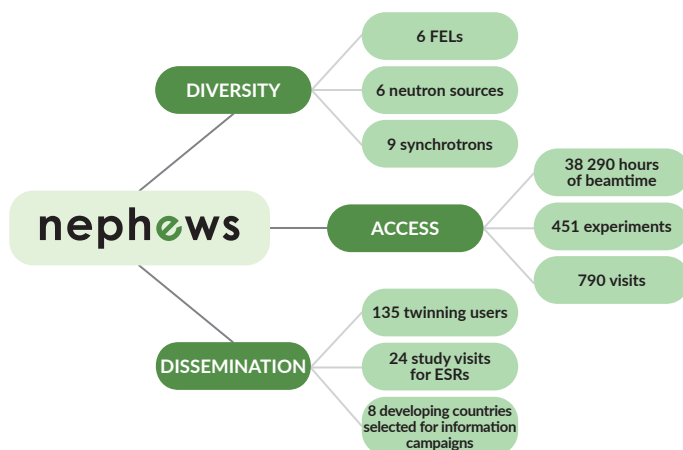
**Funded by
the European Union**

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SOLARIS International Projects - NEPHEWS

NEPHEWS (NEutrons and PHotons Elevating Worldwide Science), led by SOLARIS, is a project designed to provide scientists with access to world-class European research infrastructures.

NEPHEWS integrates two European Users Organisations: ESUO (European Synchrotron and Free Electron Laser User Organisation) and ENSA (European Neutron Scattering Association), with two largest and most advanced consortia, LEAPS (League of European Accelerator-based Photon Sources) and LENS (League of advanced European Neutron Sources). This initiative fosters a new model of cooperation, where neutron facilities work side by side with LEAPS Infrastructures. Additionally, NEPHEWS empowers users through an innovative User-to-User approach, giving ESUO and ENSA a central role in project development.



The NEPHEWS project offers:

- **Experienced Users:** 38,290 hours of beamtime for experiments (**TNA Programme**).
- **New Users:** Collaboration with experienced groups to enhance knowledge (**Twinning Programme**).
- **Young Scientists:** Week-long internships at partner research centres (**ESR Programme**).
- **Training Courses:** Focused on synchrotron, neutron, and FEL research, and beamtime application guidelines.
- **Training for African Scientists:** Specialized training and participation in the HERCULES school to deepen expertise.

The project also aims to establish collaboration with ministries and national funding agencies in developing countries. Its objectives include raising awareness about the importance of research funding and promoting cooperation with user communities.



**Co-funded by
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NEPHEWS

www.beamtime.eu

e-mail: nepheWS@uj.edu.pl

SOLARIS as part of international networks

SOLARIS National Synchrotron Radiation Centre has established multifaceted collaborations with many international entities, including consortia associating European synchrotron facilities (**LEAPS**), specialised laboratories (**CERIC**), as well as intercontinental web platforms (**LIGHTSOURCES.ORG** and **WAYFORLIGHT.EU**). The primary objective of these activities is to represent Polish science within the major research infrastructure organisations.

• **LEAPS - The League of European Accelerator-based Photon Sources**

It is a partnership of synchrotron centres and research facilities that use free-electron lasers. The consortium includes 16 European facilities, serving a very broad scientific community of over 30,000 researchers in Europe and attracting some of the brightest minds worldwide. These facilities span many countries, facilitate multinational collaborations, and support a spectrum of disciplines, including fundamental fundamental and applied sciences, as well as innovative industrial applications. They address key societal

challenges in areas such as health, the environment, and the energy. They educate the next generation of scientists, engineers, and facility managers and administrators, and significantly enhance the competitiveness of European industry, contributing to job creation.

LEAPS
www.leaps-initiative.eu

CERIC
www.ceric-eric.eu



LEAPS General Assembly has appointed the Director of the SOLARIS Center to serve on the Board of Directors from 2024 to 2026. Starting in 2025, Dr. Jakub Szlachetko will assume leadership of the LEAPS consortium.

• **CERIC-ERIC - The Central European Research Infrastructure Consortium**

The consortium consists of specialized laboratories and research facilities from Central Europe and Italy. At these free-of-charge facilities, research is conducted on various materials using photons, electrons, neutrons, and ions. Calls for proposals are held twice a year. Poland delegated SOLARIS to the consortium, and on 1 March 2016 the country became a full member of CERIC-ERIC, joining Austria, Croatia, the Czech Republic, Hungary, Italy, Romania, Serbia, and Slovenia. Each member country contributes one of its research facilities through a single open-access point. A peer review evaluation system guarantees access to nearly 50 multi-probe techniques utilizing, electrons, ions, neutrons and photons.

SOLARIS for industry

SOLARIS National Synchrotron Radiation Centre offers industrial partners a wide range of R&D services, utilizing synchrotron radiation-based methods, cryo-electron microscopy, and laboratory techniques.

Our team supports all stages of R&D projects, including problem analysis, scientific, technological and patent landscape research, experimental work, data analysis, and the formulation of final conclusions.

We ensure complete confidentiality of all information. Data security at our facility is guaranteed by ISO27001 certification. Various access modes are available, ranging from infrastructure access for external scientific teams to full project execution by our expert team.

SOLARIS Centre provides access to state-of-the-art, advanced characterization techniques, which exploit the unique properties of synchrotron radiation: a very wide spectral range, from infrared to hard X-ray, and exceptional brightness, orders of magnitude higher than standard laboratory sources.

Characterization methods available to the industry include: X-ray absorption spectroscopy (XAS), infrared nanospectroscopy (nanoIR), photoelectron spectroscopy in various modes (PS), scanning transmission X-ray microscopy (STXM), photoelectron emission microscopy (PEEM), magnetic dichroism, X-ray microtomography (μ CT), and cryo-electron microscopy (Cryo-EM).

Selected R&D areas:



Advanced materials and nanotechnology:

- Chemical composition of solids, liquids, and gases
- Sensitivity to chemical environment and local structure of materials
- Electron, magnetic, and spin structure

Biotechnology:

- Biomolecular structure determination without crystallization
- Chemical imaging of tissues
- Biochemical classification using machine learning methods

Chemistry and catalysis:

- Oxidation state determination
- *In-situ / operando* studies of chemical reactions
- Local structure of catalytic centers

Contact for industry

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+48 12 664 41 93

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Visiting SOLARIS and popular science activities

As the largest research facility in Poland, SOLARIS has significant potential to popularize science. With its advanced technology and research capabilities, the Center can attract public attention and present scientific discoveries in an engaging and accessible manner.

SOLARIS's strengths in popularizing science include:

- The opportunity to observe advanced experiments
- Demonstrating the practical applications of synchrotron research
- Engaging with scientists and exploring the results of their work
- Providing visual educational experiences

Organized groups of young people, students, and adults can visit SOLARIS Centre free-of-charge, throughout the year, with prior appointment required.

Academic visits reservation

phone: +48 12 664 41 85
e-mail: user.solaris@uj.edu.pl

School visits reservation

phone: +48 12 664 41 85
e-mail: zwiedzanie.solaris@uj.edu.pl

Follow us:



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@SOLARIS_science



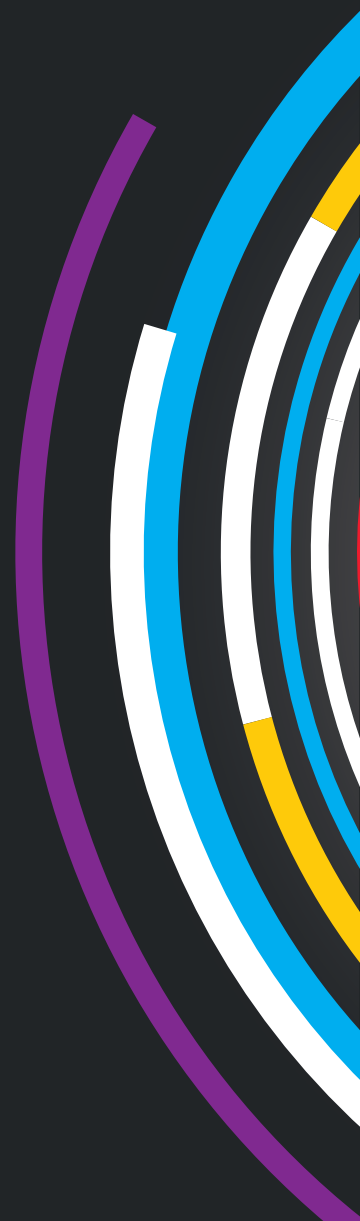
@synchrotronsolaris



Visitors exploring SOLARIS with the audio guide.
Photo by Joanna Kowalik.

The guided tour of SOLARIS follows a professional script, utilizing a variety of tools, including multimedia. It is an excellent form of popularizing various fields of science and complementing the educational process at all levels. The tour offers visitors access to advanced technologies, educates in science, inspires future and current scientists, bridges the gap between theoretical sciences and real-world applications, and ignites curiosity about scientific research. A visit to the Centre provides an opportunity to explore its core areas, understand key physical phenomena, and discover the most important research results. The goal is to unlock the potential of witnessing the country's largest research facility.

The SOLARIS Centre also welcomes individual guests during its annual open days, as well as regular Krakow's city events (e.g., Researchers Night). Participants can not only visit the SOLARIS synchrotron experimental hall but also take part in numerous special activities prepared by the SOLARIS team for this occasion. In previous years, these events have included workshops for children, science and technology family competitions, and film screenings.



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