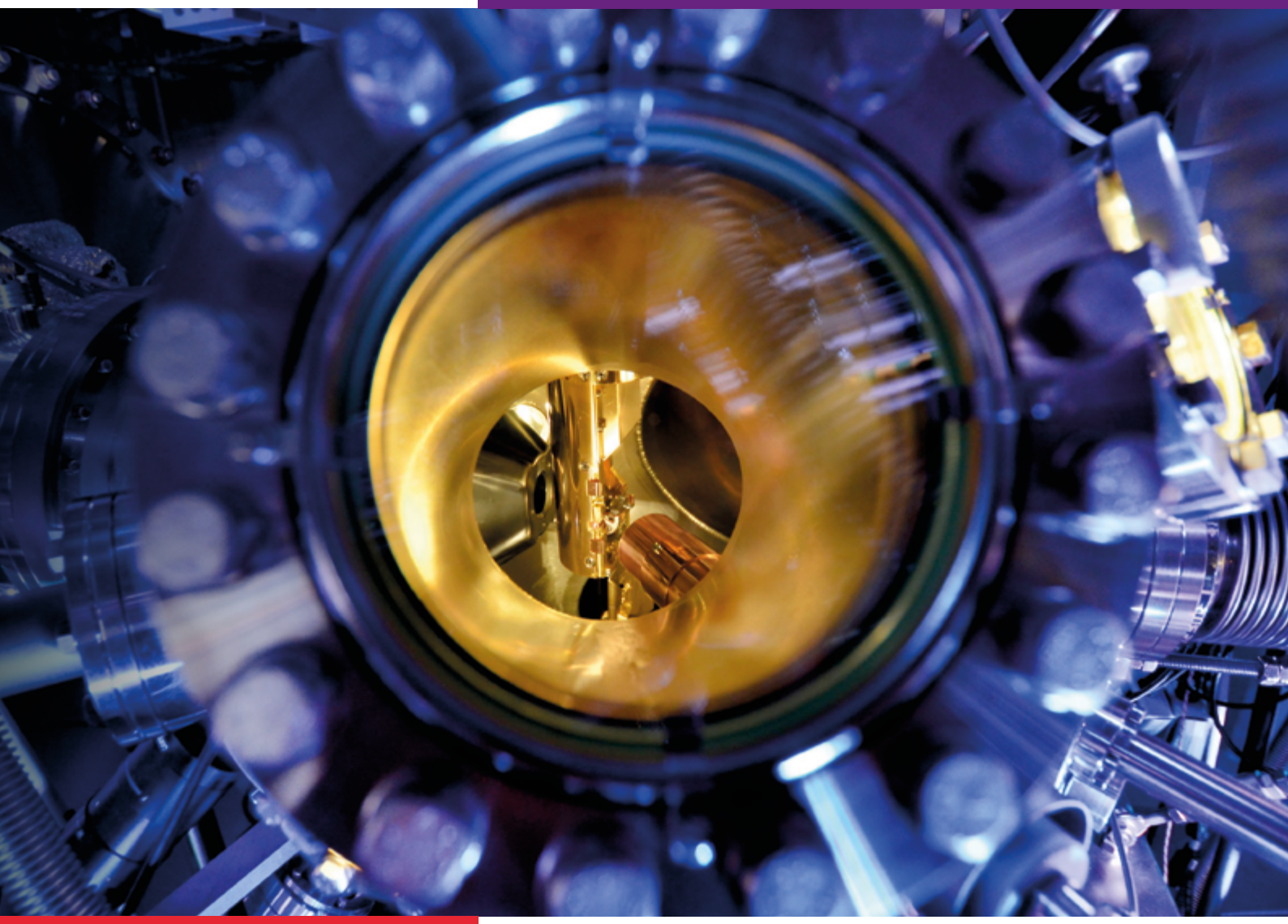

# Polish Roadmap for Research Infrastructures

Ministry of Science and Higher Education
Republic of Poland

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*Minister of Science*
*and Higher Education*

# Preface

Research plays a key role in the development of society and civilization. Through research we are able to effectively address new challenges such as quality of life, civilization diseases, demographic changes, sustainable development and environmental protection, as well as energy security. Without top-level research it is impossible not only to successfully face the above mentioned and other challenges but also to understand the dynamically changing world.

There are two elements of vital importance for research excellence – human capital and state-of-the-art research infrastructures. The latter is doubly important owing to its essential role in training future scientific and technical staff. Major strategic research infrastructures attract world-class scientists and innovative companies which enables economic growth as well as enhance social capital. Excellent laboratories applying the highest standards of research and education are therefore necessary for each country to develop.

The Polish Roadmap for Research Infrastructures is a tool created to facilitate the development of these laboratories. It comprises seventy of the most ambitious research infrastructure projects of great socio-economic significance, chosen through a transparent process carried out in accordance with international standards.

The Roadmap is to become the basis for the investment policy of the Ministry of Science and Higher Education in the coming years, however it is worth underlining that placing a research infrastructure project on the Roadmap does not automatically imply the financial commitment of the Ministry. The decision concerning the involvement of public funds within the current funding streams will be made on a case-by-case basis after a thorough analysis of the maturity level of the project, as well as of expected benefits for the economic and scientific communities. When supporting development of science, we have to ensure that public funds are spent properly.

# Contents:

# Selection process of research infrastructures included in the Polish Roadmap for Research Infrastructures

A call for proposals to include an infrastructure in the Polish Roadmap for Research Infrastructures was launched by the Ministry of Science and Higher Education in June 2019. Each of almost 150 applications was reviewed by members of the Advisory Panel on the Polish Roadmap for Research Infrastructures as well as by two external experts – a national one and a foreign one. Almost 160 reviewers were involved in the process of proposals assessment.

The following criteria (being differently weighted) were taken into consideration by the Advisory Panel and external experts when evaluating applications:

- The uniqueness of infrastructure in national and worldwide terms – 20%;
- Institutional and human resources capacity of the applicant – 18%;
- The extent to which infrastructure interests the national and international scientific and entrepreneurial community – 15%;
- The reasonableness of the costs related to infrastructure – 15%;
- Compatibility of the objectives and targets of infrastructure with national and international research, development and innovation policies – 12%;
- The potential for infrastructure development within the framework of international cooperation – 12%;
- The potential for infrastructure to be developed in the short and medium term – 8%.

The final assessment of each application was determined by adding 60% of weighted average of Advisory Panel and 40% of weighted average of external experts.

Having collected the final results of all proposals, the Advisory Panel submitted to the Minister of Science and Higher Education its recommendations regarding inclusion of 65 the best rated infrastructures in the Roadmap. The Minister responded favorably to these recommendations, at the same time deciding to additionally include in the Roadmap five European infrastructures where the Polish government had already declared its commitment. These infrastructures are as follows:

- CLARIN – Common Language Resources and Technology Infrastructure;
- Digital Research Infrastructures for the Arts and Humanities DARIAH-PL;
- FAIR – Facility for Antiproton and Ion Research;
- Biological and biomedical imaging infrastructure – Bio-Imaging Poland (BIPol);
- POL-OPENSCREEN – Polish Infrastructure of Open Screening Platforms for Chemical Biology.

Published in January 2020, the Roadmap includes 70 strategic research infrastructures, divided into six scientific areas, following the European Strategy Forum on Research Infrastructures classification: Physical sciences & engineering (23 projects); Social sciences & humanities (6); Technical sciences & energy (14); Earth & environmental sciences (5); Medical, biological & agricultural sciences (16); Digital infrastructures (6).

40 out of 70 infrastructures included in the Polish Roadmap for Research Infrastructures are nationally-based, while 30 have an international dimension.

[1] *The Advisory Panel on the Polish Roadmap for Research Infrastructures was composed of 17 experts representing eight scientific areas, particularly relevant to the character of the assessed research infrastructure projects. The full list of members can be found on page 160.*

# Selection process of the research infrastructures included in the Polish Roadmap for Research Infrastructures – the Advisory Panel's perspective

**prof. Agnieszka Zalewska**

*Chair of the Advisory Panel on the Polish Roadmap for Research Infrastructures*

The Advisory Panel on the Polish Roadmap for Research Infrastructures has recommended 65 projects to be put on the Polish Roadmap from among 146 evaluated proposals. This work took six months and was completed at the beginning of January 2020. The Panel developed its recommendations based on reviews prepared by its members and by external experts. There were several face-to-face Panel meetings complemented by a few teleconferences and e-mail exchanges.

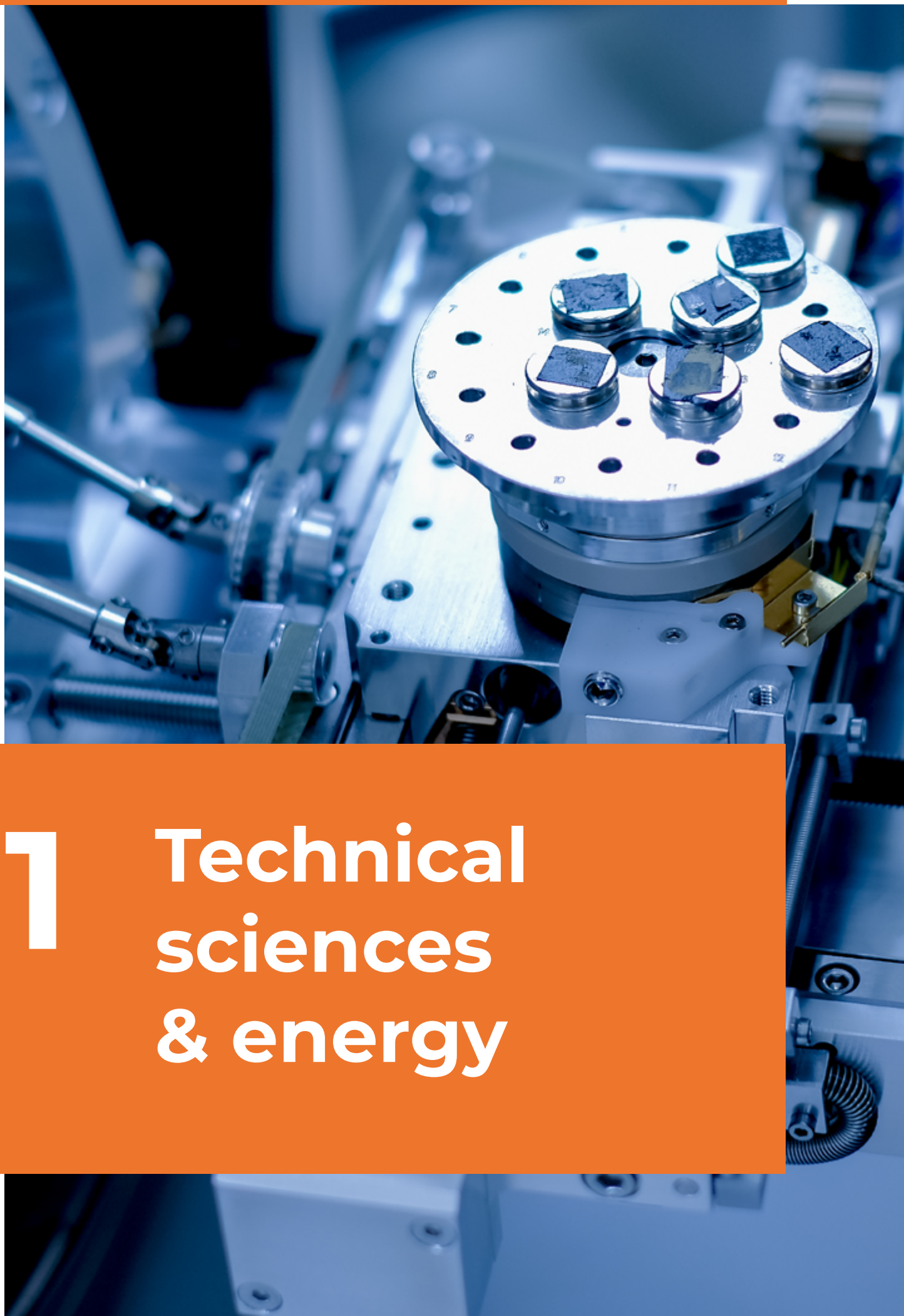
The work began by agreeing on principles of proposals' evaluation by experts and by the Panel, which gave a uniform way of applying the formal assessment criteria to all the proposals. Following the criteria, the Panel concentrated its efforts on the assessment of scientific excellence of the projects. In order to ensure the same approach to all the proposals, the Panel chose as the base of its work the definition of a research infrastructure used by ESFRI and the ERIC Forum.

The assignment of the proposals to the Panel members for evaluation was done at a plenary meeting after agreeing on principles and following the preliminary analysis of the proposals. This allowed for the optimal use of the competences of the Panel members and helped to avoid any conflict of interests.

There was a two-step process for the conversion from individual reviews of the Panel members to the reviews of the Panel as a whole. First, the individual reviews were discussed in the following five thematic subpanels: social sciences and humanities, technology, exact sciences and informatics, life sciences as well as Earth and environmental sciences. This resulted in the preparation of a set of agreed and harmonised evaluation reports by each subpanel. Then, at two plenary meetings in November and December 2019, a common position of the Panel on the vast majority of proposals was adopted. At this stage, most of the reviews from external experts were already available, so they could have been discussed and the final grades, which for each proposal were weighed averages from the results of three reviews, could have been produced. This process was concluded only in the last days of 2019, when the last external expert reviews reached the Ministry.

The final selection of the research infrastructures for the Roadmap was based on the distribution of the final grades. In its recommendation, the Panel aimed at including as many projects as possible, keeping in mind, however, the strategic character of the Roadmap as a supporting document for the implementation of the national science policy. 65 projects received the highest grades. Some of them are from smaller scientific centres in Poland, which should foster a more rapid development of these centres.

The last meeting of the Panel was held in January 2020, after the publication of the Roadmap by the Ministry of Science and Higher Education. At this meeting, the work performed on the Roadmap was summarised and the activities concerning the preparation of the present brochure and organization of a scientific seminar devoted to the Roadmap were discussed. Moreover, the Panel decided that, based on the experience gained, it will provide its comments to the Minister of Science and Higher Education on possible improvements in the procedures regarding the Roadmap's update, as well as some more strategic considerations concerning the better use and the development of research infrastructures at national level.



# 1 Technical sciences & energy

# Infrastructures in this area:

1. Centre of Advanced Materials and Manufacturing Process Engineering (CZMIPW)
2. Centre of Hybrid Additive Technologies, Non-Destructive Testing and Smart Materials – Experimental Factory NDTAM
3. Centre of Pro-Ecological Energy Technologies (CePTE)
4. Clean Coal Technologies Centre (CCTW+)
5. EUHTER
6. High-Pressure Hydrogen Research Station
7. Innovation Support Centre for Materials Engineering and Nanotechnology: Hybrid Nanomaterials for Special Applications
8. National Centre for Geothermal Energy and Heat Pumps
9. National Laboratory of Photovoltaics (NLF)
10. NOMATEN CoRE
11. NSMET – National Network of Coordinate Metrology
12. Polish EMC Laboratories Network (EMC-LabNet)
13. Research Centre for Pro-Environmental Energy-Efficient Materials and Technologies
14. WCAT 2.0 – Additive Technologies and Biomedical Engineering Centre.

# Centre of Advanced Materials and Manufacturing Process Engineering (CZMIPW)

**Entities involved:**

1. *West Pomeranian University of Technology in Szczecin*

## DESCRIPTION

The Centre will constitute a research infrastructure offering open access to microscopic, spectroscopic and analytical techniques in the field of scientific research and R&D&I works related to engineering and technical sciences, in particular materials science and chemical engineering. Based on existing scientific resources, the Centre's infrastructure will serve not only the scientists but also external entities, including industrial organizations, to achieve excellence in research and innovation in the area of advanced materials (nanomaterials, biomaterials, nanocomposites, hybrid structures, innovative functional materials) and in new technologies for their production. The location of CZMIPW's infrastructure in the heart of three regions of north-west Poland, including border areas, will constitute an important element of expanding its activities to an international level in the future.

## SERVICES

The infrastructure of CZMIPW will operate with respect for the principles of open access in order to conduct scientific research as well as development and innovative activities through the development of advanced materials and modern technologies. The Centre will undertake initiatives in the field of knowledge transfer as part of the process and product innovation, and will be a research base for enterprises in which R&D units have not been developed. A commercial offer for entrepreneurs is planned, including a comprehensive set of modern research services tailored to their needs. The centre will operate according to open innovation philosophy that will help build a competitive advantage for enterprises, in particular in the area of commercialization of research results. The infrastructure of CZMIPW, based

on the existing resources of the Nanotechnology Didactic and Research Centre and expanded to include specialized laboratories for Mass Spectrometry, Nuclear Magnetic Resonance, Spectroscopy, Microscopy, X-ray Techniques, Nanobioengineering, Engineering Materials Research and Analytical Techniques, will enable the development of top-level scientific research and innovative activities with commercial potential. The Centre will offer the possibility of performing a qualitative and quantitative analysis of materials, analysing the structure and changes occurring in them, as well as analysing the composition of process streams. The key element of the offer will be the ability to design materials and develop technologies along with the search for the optimal process solution, ensuring a dynamic transition from the laboratory phase to the production process.

## IMPACT

The Centre's strategy is based on the so-called "knowledge triangle" that highlights the need for an integrated approach to research, innovation and teaching. Its purpose is to support the development of the socio-economic environment and technology transfer. The idea of the Centre will also be based on levelling the so-called "innovation paradox" that can be observed in scientific units in north-western Poland. The Centre will conduct international cooperation and enable the creation of new partnerships to enrich the offer of initiatives that are part of ESFRI, which will translate into increased European integration and access to the research infrastructure.

The concept of the Centre is based on increasing scientific excellence in research conducted in the field of engineering and technical sciences, especially material engineering and chemical engineering. Open access to the infrastructure will enable the creation of new research teams, the activities of which will translate into effective dissemination of research results by implementing them into the socio-economic environment. The Centre will provide the opportunity for young researchers to carry out research work, including that under the "Industrial Doctorate" program. This will translate into raising the qualifications of future R&D&I staff. The Centre is to provide R&D auxiliary service for companies seeking innovative solutions and support in research conducted as part of programs offered by research agencies. Cooperation with National Key Clusters is also planned in order to encourage the enterprise sector to undertake joint activities in the area of technology development and transfer.

# Centre of Hybrid Additive Technologies, Non-Destructive Testing and Smart Materials – Experimental Factory NDTAM

**Entities involved:**

1. *Wroclaw University of Science and Technology – Applicant*
2. *University of Wroclaw*
3. *Wroclaw University of Environmental and Life Sciences*
4. *Regional Specialist Hospital in Wroclaw, Research and Development Centre*

## DESCRIPTION

NDTAM will rely on the creation of a professional research and technology experimental factory offering R&D services in the field of innovative technologies to research teams and production companies. Specifically, in the areas of additive manufacturing technologies, new materials, composites, manufacturing and inspection of market products, advanced technical and technological research, as well as modelling, simulation and product design. The essence of the project is the creation of a research, prototype, technological and clinical infrastructure (the first "Experimental Factory" in Poland) which will implement goals focused on the needs of the national and European economies. The concept of the planned research infrastructure development consists of the creation of a main technology and research HUB centre (a Core Facility: a non-destructive testing centre, NDT, with particular emphasis on 3D imaging of products from nano- to macro-scale) and 8 local HUBs, based on the needs and competences of 5 faculties of the entities involved in the project.

Research potential will be focused on medical and industrial applications, mainly aerospace, automotive, construction, energy and medical applications throughout the entire product development cycle.

## SERVICES

The goal of NDTAM is to integrate research-scientific-implementation activities in strong cooperation between scientific units and the economy, in close cooperation with the world's largest Scientific Centres, such as Poland's first experimental factory. The synergy of entities participating in NDTAM will allow to meet the research challenges and development, particularly in the field of:

- hybrid 3D imaging methods and AM process quality monitoring with the use of NDT, with particular emphasis on X-ray methods (unique in the country);
- innovative manufacturing technologies for components (AM ”3D” and ”4D”), especially for the most demanding applications in medical and aerospace industries;
- complete technology for the production of personalized new generation implants and the implementation of personalized therapeutic therapies based on additive technologies;
- comprehensive methodology and procedures for performing experimental surgical procedures;
- industrial laser and electron technology allowing for micro and nano processing and processing of difficult-to-cut materials;
- materials with assumed properties (e.g., carbon fiber monoliths manufactured with AM together with the construction of the installation for testing their physicochemical properties);
- methods of recycling and recycling of materials in AM processes.

## IMPACT

The implementation of the NDTAM investment will achieve a significant improvement in research competences in Poland and will bring new opportunities to the development of scientific research, increasing their commercial value as well as the competitiveness of Polish research ventures, also on the basis of international experience. This common technology platform, which will eventually become NDTAM, will be anchored in the European Research Area (ERA). This concept will increase the potential of using many research centres in international projects that will be noticeable not only in Europe. The concept of the ”Experimental Factory” will increase the capacity to conduct not only interdisciplinary scientific research, but also pre-implementation works enabling the production of new products on the scale of functional prototypes and short production series. The main challenge in the integration of new technologies with existing manufacturing environments is the possibility of moving from the stage of development and demonstration of technology to the possibility of its adaptation in production conditions. Breaking this barrier is possible thanks to the adopted concept of the experimental factory that allows the introduction of technology in the pilot production stage for short production runs with full validation of the production process.

# Centre of Pro-Ecological Energy Technologies (CePTE)

**Entities involved:**

1. *Cracow University of Technology*

## DESCRIPTION

The current legal regulations at the European Union level force a profound transformation of the Polish energy sector towards pro-ecological solutions.

To meet the expectations of the changing national energy sector, the Cracow University of Technology is taking the initiative to establish a Centre for Pro-ecological Energy Technologies (CePTE).

The mission of CePTE is to investigate and develop technology in the field of high-performance, low-emission and environmentally friendly energy generation, storage, and transmission technologies.

CePTE will focus its activities on the following areas:

- renewable energy technologies (RES);
- advanced energy storage including hydrogen production and utilization for electromobility;
- efficient heat and electricity transmission, with a focus on the district heating networks and power output from the off-shore wind farms;
- the development of intelligent energy solutions for buildings as a way to reduce low emissions and air pollution;
- increase of the flexibility of steam and gas-steam power units to handle the increasing share of RES in the Polish energy system;
- increase of the operational safety of nuclear power plants as an alternative to coal-fired units.

## SERVICES

The staff of CePTE gained experience in cooperation with the national energy industry, allowing it to offer specific solutions to the energy sector to improve the efficiency of power units, including the acceleration of boilers' start-ups, which with a large

share of coal-fired power units significantly reduce the environmental impact of power generation. The CePTE proposes systems for monitoring of power unit operation in terms of efficiency improvement and thermal stresses in critical, thick-walled, pressure components of boilers and turbines. The solutions offered are related to the improvement of the safety of power unit operation, not only in conventional power plants but also in nuclear power plants.

Moreover, the CePTE will address its offer to the SME sector, i.e., system components manufacturers and integrators. The CePTE is going to actively support the development of hybrid solutions utilizing RES for cogeneration and trigeneration. The objective of the CeTPE is to design and develop a self-sufficient and zero-emission hybrid energy system, capable of fully covering the heating, cooling and electrical energy demand for facilities of various destinations, i.e., single-family houses, large buildings or production halls.

## IMPACT

The CePTE's activity in the field of improving the flexibility of power units will allow the verification of modern solutions for monitoring critical loads of boiler and turbine components. This will contribute to improving the flexibility of coal-fired units operation adjusted to variable loads generated by less stable RES, mainly wind farms. Interdisciplinarity of the research conducted, as well as combining specialists in the field of thermal engineering, material science and IT, will ensure proper scientific development of new staff. Moreover, the innovative solutions offered, combining economics, environmental protection and safety, are for the professional energy industry as well as nuclear power plants.

The laboratory of hybrid systems will be used to study the interaction of RES based solutions within an autonomous, self-sufficient and zero-emission energy generation system. The idea of the project is to study the operation of the hybrid system with any choice of its components, i.e., solar collectors, photovoltaics, wind turbines, heat pumps, biomass boilers, fuel cells and hydrogen boilers, energy accumulation in the ground, with the use of phase change materials or in gas-liquid systems, i.e., GLES (Gas-Liquid Energy Storage). Equipment or systems provided by the stakeholders will also be tested within the system. The research will be in line with the trend of Poland's promotion of pro-ecological solutions that have a positive impact on air quality.

The critical aspect of the CePTE's operations will be the development of technologies for obtaining hydrogen using RES. The research aims to develop systems of renewable energy storage in the form of hydrogen and its utilization as fuel, providing electricity and/or heat for the residential sector and the electromobility sector, i.e., urban transport.

# Clean Coal Technologies Centre (CCTW+)

**Entities involved:**

1. *Central Mining Institute – Applicant*
2. *Institute for Chemical Processing of Coal*

## DESCRIPTION

The Clean Coal Technology Centre, CCTW+ (http://www.cctw.gig.eu), is a large, national research infrastructure with a distributed and stationary operational structure. It is located in the Silesian Voivodeship in Poland, spanning across three cities: Katowice, Mikołów (Central Mining Institute) and Zabrze (Institute for Chemical Processing of Coal). CCTW+ consists of modern laboratory units and unique research and development facilities of various scales, ranging from regular and large-scale laboratories to pilot installations.

The purpose behind the establishment of CCTW+ is to conduct complementary and focused analytical and research work which has huge potential for its implementation in what is known as “clean coal technologies”. This term encompasses multiple processes concerning the extracting of primary energy resources, their effective use, as well as managing by-products and waste while minimising the environmental impacts of commercial activities and the emissions of greenhouse gases. The use of CCTW+ research facilities makes it possible to improve complex solutions, such as: process design, technical documentation, technological solutions and know-how.

The scientific potential found in CCTW+ provides the conditions necessary to develop cooperation with commercial units, increasing the business sector’s innovation potential. A significant advantage of this piece of infrastructure is its ability to carry out complex and interdisciplinary research conducted using a PDU (Process Development Unit) scale, which determines the development and effective implementation of new technologies. In particular, facilities at this scale make it possible to correct the deficiencies in terms of scale-up with regard to

the results of scientific research and to accelerate the process through which a technology becomes ready for demonstration and implementation.

## SERVICES

The CCTW+ offer is addressed to the national and international scientific community, as well as to entrepreneurs. CCTW+ makes it possible to conduct a range of different types of research, from fundamental research to industrial research and experimental development within various disciplines. It is available to all users who are interested, with an equal access policy.

CCTW+ can be used for work concerning the following topics:

- developing and improving the efficiency of processes for the transformation of fossil fuel chemical energy into final energy commodities and chemicals;
- hydrogen economy;
- identification and minimisation of the influence exerted by current and discontinued industrial activity on individual components of the environment; reclamation of post-industrial land;
- low emission and resource efficient economy;
- decarbonised economy and climate protection;
- improving energy efficiency;
- raising competence in terms of environmental engineering and material engineering – stocks and materials for modern power engineering and electric vehicle use;
- waste and by-product use (circular economy);
- energy storage (including renewable energy), e.g., with the use of chemical synthesis processes.

CCTW+ equipment and offer undergo continuous verification and expansion, while retaining the infrastructure's uniqueness.

## IMPACT

The research that CCTW+ is aimed at involves numerous unit processes with wide application in both prominent and niche sectors of the economy. CCTW+ is unique in terms of its scope and purpose, incorporating complementary and multidisciplinary research services. Thanks to the constant expansion of CCTW+, it can be used to conduct research and development work and provide research services which are adapted to acknowledge development trends and market challenges, including: effective resource use, sustainable development, circular economy and climate protection.

There are ongoing efforts to connect CCTW+ with pan-European Research Infrastructures. This includes membership in the ECCSEL ERIC Scientific Advisory Board, which was awarded in recognition of the competence of CCTW+ personnel as well as of its existing research apparatus for carbon capture and storage (CCS). The individual elements of CCTW+ (the research apparatus and facilities) undergo use and expansion as part of the accomplishment of numerous projects, including international ones, with the participation of Central Mining Institute and Institute for Chemical Processing of Coal research teams.

# EUHTER

**Entities involved:**

1. *National Centre for Nuclear Research – Applicant*
2. *Institute of Nuclear Chemistry and Technology*

## DESCRIPTION

EUHTER is an experimental high-temperature nuclear reactor with helium gas cooling and 10MW of thermal power capacity. This research infrastructure will be crucial for the HTGR (High Temperature Gas-cooled Reactor) implementation program.

The purpose of building such an experimental reactor is to conduct scientific research and technical needs arising from the design and process of licensing, as well as to build competences and know-how necessary for the implementation of future industrial applications. An experimental reactor with 10 MWth capacity would enable the building up of safety analyses for commercial HTGR by direct measurements and simulations validated on a small reactor. Working on the experimental reactor will also be an excellent means for preparing personnel and defining the supply chain for industrial HTGR reactors. The basic task of the research infrastructure will be to conduct research in such areas as material, reactor safety analysis and technological innovations. The construction of a low-power experimental reactor in HTGR technology in Poland is the basis for gaining relevant experience and creating a research base that will facilitate the implementation of commercial HTGR reactors.

## SERVICES

The construction of the experimental EUHTER reactor will launch a research program on an international scale, both in terms of research and collaboration with industry. The reactor's long-term research program would include the following areas:

- materials: ageing test materials subjected to radiation, high temperature and high flow rate of helium;
- modelling: experimental support for the development of software for the calcu-

lation and simulation of HTGR reactors. Reactor safety analysis and experimental validation of computational tools for the purposes of commercial reactor, with the ability to compare measurements with calculations;

– technological innovations: tests of new technological solutions, in particular new types of fuel. An example of this is the development of various sensors that must work reliably in extreme conditions. Currently, most experience has been gathered about TRISO fuel based on UO2. However, the use of UCO seems more promising. Testing a new type of fuel requires its use in a working reactor, in conditions very close to the target.

Cooperation in each of the above areas will be possible.

## IMPACT

There are currently two HTGR research reactors in the world: in China and in Japan. However, the Chinese reactor is a different kind of technology than what is planned for Poland, while the reactor in Japan was stopped after the 2011 earthquake. The Polish experimental reactor will not only be a significant European infrastructure, but also global.

The design of the EUHTER experimental reactor, as the first step for implementing HTGR reactors for industry, is characterized by combining a high degree of innovation with enormous economic potential. Polish nuclear institutes and faculties of universities conducting research in this field would be involved in the works related to the design, licensing, construction and use of EUHTER. Industrial enterprises in Poland have also expressed interest in using the technology and participating in its implementation. The construction of the EUHTER experimental reactor will be a milestone in the implementation of high-temperature industrial reactors. This project will enable scientific development, staff education (including operators of future high-temperature industrial reactors), strengthening international cooperation, and in perspective, by replacing industrial coal boilers with HTGR reactors, reducing greenhouse gas emissions and other pollutants.

# High-Pressure Hydrogen Research Station

**Entities involved:**

1. *Oil and Gas Institute – National Research Institute*

## DESCRIPTION

The main purpose of building a high-pressure hydrogen test stand is to enable research on the impact of the mixture of natural gas and hydrogen on measuring devices, fittings, pipes and other elements for the construction of gas networks. It is expected that the position will also enable the use of other renewable flammable gases in the research installation, such as biogas or synthetis gas (syngas), and non-flammable gases (e.g. nitrogen). The combination of the position applied for with the remaining equipment concentrated in this location will create the only research centre in Poland providing a comprehensive base for the current needs in terms of research, innovation and development of Polish and international gas companies, and for the implementation of projects financed from national and EU funds.

The station will allow for further research on the introduction of hydrogen into gas networks, and the results of research will allow, i.e., to fill the gaps in legal regulations (laws, regulations) that would clearly define the rules for the introduction of hydrogen into the NG network. The possibility of working within a wide range of working pressures and creating gas mixtures of different compositions, including alternative fuels or those originating from renewable sources (RES), will make way for conducting necessary research to create solutions to priority issues in the assumptions of EU research programmes. The stand will enable the implementation of interdisciplinary work in the form of research on pipe systems, gas fittings, measuring devices, as well as research on NG and hydrogen mixtures and other components.

## SERVICES

It is intended to expand cooperation with universities and schools in order to educate young personnel, through the organisation of free apprenticeships for students of technical schools, participation in the education of students of technical and energy faculties, acting as promoters of diploma and master's theses, making research equipment available for the purposes of carrying out master's and doctoral theses, student internships, and conducting free internships for young scientists.

The Institute, once the investment is completed, could become an important partner in networks/groups that cooperate with the European energy community to develop innovative solutions, trying to meet the challenges of transforming energy systems into low-carbon ones. The Institute intends to cooperate with international organizations such as The European Gas Research Group (GERG) and the Technical Association of the European Natural Gas Industry (Marcogaz), European Energy Research Alliance (EERA), Gas Technology Institute (GTI USA), European Committee for Standardization (CEN). The proposed research site will allow it to be integrated into international structures in the field of energy research, including technical aspects of integration of energy systems, storage of energy on various scales and energy from RES. The proposed infrastructure will also allow for closer cooperation with the gas industry in Poland, and manufacturers of gas equipment and technologies by carrying out works at the request of the industry.

## IMPACT

The implementation of this investment fits into strategies set out by national and EU legal acts and governmental strategic documents which aim at limiting the negative impact of humans on the natural environment and implementing elements of sustainable development principles on a local, national and global scale. The construction and use of the stand will ensure state energy safety, while at the same time achieve the objective of increasing the share of energy from RES in the final gross energy consumption as well as reducing greenhouse gas emissions and mitigating the effects of climate change. The uniqueness of the planned infrastructure lies in the fact that, for the Polish and European gas market, it enables testing of gas network elements in terms of resistance not only to hydrogen but also to other gases, mainly from RES (i.e. biogas, biomethane), synthesis gas and other flammable and non-flammable gases under high pressure, in dynamic (with flow) and static conditions, along with the possibility of testing the durability of gas mixtures on a single test stand. In cooperation with universities, the station will also be used in the process of educating new staff for the economy.

# Innovation Support Centre for Materials Engineering and Nanotechnology: Hybrid Nanomaterials for Special Applications

**Entities involved:**

1. *AGH University of Science and Technology*

## DESCRIPTION

Innovation Support Centre for Materials Engineering and Nanotechnology: Hybrid Nanomaterials for Special Applications is the research infrastructure of the AGH University of Science and Technology in Cracow, focused at the Academic Centre of Materials and Nanotechnology (ACMiN). The Centre's goals are:

- enabling basic and applied research in the field of modern materials science and nanotechnology;
- creating and providing access to a modern research laboratory for material nanoengineering to scientists from national and European research centres;
- creating a leading research unit working for the development of several scientific disciplines: physics, chemistry and materials science.

A strategic objective of this project is maintaining and expanding the advanced equipment base with unique devices, offering the possibility of comprehensive research of materials used in nanotechnology. The basic scientific and research goal is to design, manufacture and test innovative materials for applications in the active elements of optical, electronic and mechanical micro-devices and for use in further miniaturisation of nanoelectronics. In particular, the goal is to develop scalable technologies for obtaining hybrid materials with excellent repeatability, low complexity, high efficiency and which are environmentally friendly.

## SERVICES

The Centre's equipment includes apparatus with a total value exceeding 55 million PLN for the preparation and characterization of condensed and soft matter as well as nanocomposites. The infrastructure offers research staff, equipment and research facil-

ities at the local and regional level (Cracow's academic environment).
Available research infrastructure:

Technologies for producing nanomaterials, i.e.:
- magnetron sputtering;
- molecular beam epitaxy (MBE);
- pulsed laser deposition (PLD);
- physical vapor deposition (PVD);
- inert gas condensation (IGC).

Experimental techniques for characterization of nanomaterials and nanodevices, i.e.:
- scanning tunneling microscope (STM);
- transmission electron microscope (TEM);
- scanning electron microscope with focused ion beam (SEM, SEM + FIB);
- atomic force microscope equipped with nanoindenter (AFM);
- X-ray powder diffraction (XRD);
- X-ray photoelectron spectroscopy (XPS);
- vibrating-sample magnetometer (VSM);
- Mössbauer spectroscopy;
- photoemission electron microscopy / X-ray absorption spectroscopy (PEEM / XAS) available in cooperation with the SOLARIS National Synchrotron Radiation Centre.

Equipment for tests in special conditions:
- 3He/4He dilution refrigerator with integrated superconducting magnet;
- clean-room with optical, laser and electron lithography.

The purchase of the following apparatus is planned in the nearest future:
- atom probe tomography (APT) instrument for structure and chemical composition analysis of solids;
- small/wide angle X-ray scattering (SAXS/WAXS) instrument for nanocomposites and nanoparticle solutions.

## IMPACT

The Centre's strategy, as a leading infrastructure in the field of nanotechnology, includes continuous expansion of the advanced and unique equipment base, opening the possibility of comprehensive, modern, large-scale research. Scientific discoveries, which will undoubtedly be the result of creating and granting access to a modern laboratory, will allow the high impact factor publication of results and the use of new solutions and materials for application developments, improving the innovation of the Polish industry. The infrastructure research goals are in line with national and global sustainable development goals. The created hybrid nanomaterials laboratory will therefore become an important place on the scientific map of Poland, attracting highly qualified scientific staff, both domestic and foreign, who will skilfully use many modern technologies and experimental techniques concentrated in one place. Modern research infrastructure is also a key competitive factor in terms of the quality of education of undergraduate and postgraduate students. The interdisciplinary nature of the infrastructure, on the border between physics, chemistry and materials engineering, with particular emphasis on nanotechnology, will stimulate cooperation within and between scientific disciplines. Finally, one can expect greater involvement of the Centre's employees in international research cooperation and participation in international research projects that will address emerging technological challenges.

# National Centre for Geothermal Energy and Heat Pumps

**Entities involved:**

1. *Mineral and Energy Economy Research Institute of the Polish Academy of Sciences – Applicant*
2. *AGH University of Science and Technology*

## DESCRIPTION

The main purpose of the research infrastructure project "National Centre for Geothermal Energy and Heat Pumps" is the increase of research potential of the two already existing, leading in the country laboratory units conducting research on use of Earth heat: the Geothermal Laboratory of Mineral and Energy Economy Research Institute of the Polish Academy of Sciences placed in Banska Nizna, and Laboratory of Renewable Sources and Energy Efficiency of FGGEP AGH-UST in Miekinia near Krzeszowice. Further development of both existing units will enable the development of applied researches as well as R&D activities of use of geothermal energy and heat pumps which are energetically and financially effective, environmentally friendly and socially neutral.

The planned increase in scientific and R&D potential of both laboratories will be obtained by means of purchasing new equipment, creating new measurement and research workstations, modernising existing research infrastructure and implementing innovative technological solutions (at least at the domestic level). Putting all this into action will lead to a significant increase in innovative research and development work. This would encompass, among others, creating innovative solutions in the field of exploitation and use of high, medium and low temperature geothermal energy, underground thermal energy storage, desalination of thermal waters, and comprehensive use of thermal waters for non-energy purposes (e.g., drinking water production).

## SERVICES

Planned investment in the strategic research infrastructure will be dispersed. It is going to be realised in the following four locations:

- Geothermal Laboratory of Mineral and Energy Economy Research Institute of the Polish Academy of Sciences in Banska Nizna near Nowy Targ, focused primarily on deep geothermal resources utilisation;
- Division of Renewable Energy Sources of Mineral and Energy Economy Research Institute of the Polish Academy of Sciences, Wybickiego 7A, Cracow, focusing on R&D activities in the field of modeling geothermal processes and analysis of heating systems;
- Laboratory of Renewable Sources and Energy Efficiency of FGGEP AGH-UST in Miękinia near Krzeszowice, excelling in shallow geothermal resources, especially heat pump development and optimisation;
- Laboratories belonging to FGGEP AGH-UST, on the AGH campus in Cracow, used for R&D activities in shallow geothermal energy and hydrogeochemical analyses.

The modernization of the research infrastructure will allow for the conducting of nationwide innovative research on:

- the use of geothermal heat in cascade systems;
- geothermal power generation;
- the designing of borehole heat exchangers;
- the designing of heat pump components and their optimisation;
- the designing of heat pump prototypes using low GWP working fluids;
- the certification of heat pumps;
- the development of hybrid cogeneration installations for distributed energy systems;
- the designing and monitoring of borehole thermal energy storage (BTES) systems;
- the desalination and thermal concentrating of geothermal waters.

The research infrastructure will be available to both the scientific community (Polish and international) and to the business community – on the terms specified in the agreement of cooperation or use of the research infrastructure.

## IMPACT

The creation of the ”National Centre for Geothermal Energy and Heat Pumps” will allow, among others, for the construction of a research infrastructure not yet available in the country, such as the construction of a borehole thermal energy storage (BTES) system, the construction of a desalination and thermal concentration plant of thermal waters, or the second installation in the country for generating electricity from geothermal waters (ORC technology). Undoubtedly, the research offer related to the use, optimization and certification of heat pumps will be of great interest. At present there is no institution in Poland which has the certification rights for heat pumps; the nearest centres are in the Czech Republic and Germany.

The construction of a modern research infrastructure and modernisation of the existing one will create opportunities for extensive cooperation between Polish and foreign research entities, both in the context of bilateral cooperation agreements, as well as for the implementation of joint research projects financed from both national and EU funds.

The Centre will also serve educational purposes – from bachelor to PhD students. Modernising the infrastructure will allow for the conducting of educational classes for high school students, specialist trainings as well as scientific workshops and seminars.

# National Laboratory of Photovoltaics (NLF)

**Entities involved:**

1. *University of Warsaw – Applicant*
2. *Warsaw University of Technology*
3. *Wroclaw University of Science and Technology*
4. *University of Lodz*
5. *Lodz University of Technology*
6. *University of Silesia in Katowice*
7. *Silesian University of Technology*
8. *Institute of Physics of the Polish Academy of Sciences*
9. *Łukasiewicz Research Network – Institute of Electronic Materials Technology*
10. *Łukasiewicz Research Network – Institute of Electron Technology*
11. *Military Institute of Technical Engineering*

## DESCRIPTION

The National Photovoltaic Laboratory (NLF) is a consortium composed of leading Polish scientific institutions conducting research and development in the field of using solar energy for electricity production and energy storage. It consists of 16 research groups – 6 from units of category A+ and 10 from A.

The goal of NLF is to integrate the scientific community involved in research on the use of solar energy for clean energy production, and by developing human potential and equipment facilities to stimulate joint research and development on a global scale.

NLF seeks funds for its research (by supporting grant applications, establishing contacts with industry, and proposals of research topics for funding agencies) and popularizes renewable energy issues. The dispersed structure of NLF corresponds to the basic idea of the Strategy for Responsible Development, concerning territorially sustainable development – NLF units cover a significant part of Poland, and the openness policy, which is an important element of the NLF strategy, will allow other groups to join.

## SERVICES

NLF, its infrastructure, broad research profile, outreach activities and specialized staff are attractive for domestic and foreign scientific communities, as well as for the growing domestic photovoltaic industry. NLF experts can help Polish politicians involved in the implementation of the European Green Deal, or regional authorities in activities aimed at a sustainable green transformation of Europe.

The NLF consortium has a large stock of scientific equipment purchased after Poland's accession to the European Union, with an estimated total book value of over EUR 25 million.

Technological lines with ALD reactors and cost-efficient technology for photovoltaic cells, as well as a laboratory for assembling lithium-ion batteries and rechargeable batteries, have a unique value in Poland. The research equipment gathered mainly at universities consists of evaporators, high-resolution electron or scanning probe microscopes, as well as multi-chamber ultra-high vacuum systems connected by vacuum cases for sample preparation and analysis. The measuring apparatus consists of X-ray and electron diffraction spectrometers, Auger, Raman ESR and NMR spectrometers, XPS, UPS and angular-resolved ARPES photoelectron spectroscopy, optical measurement systems, as well as time-resolved, and a mobile 8-channel aerosol lidar.

The scientific community may have access to this equipment after covering operating costs, whereas to the photovoltaic industry based on the terms of cooperation or commercial conditions.

## IMPACT

NLF is involved in the rapidly developing in Poland field of research on the use of solar energy. The motivation is the existential threat to life on Earth as a result of climate change caused largely by the use of fossil fuels, while the application of hydropower in Poland, which is mostly plains, is very limited.

NLF's scientific and infrastructural potential will support scientific development in the field of photovoltaics and energy storage, taking advantage of the cooperation of its members and openness to external cooperation with both scientific institutions and industry. NLF depends on the development of close collaboration with companies. A number of NFL members already conduct such cooperation realizing joint projects or industrial orders. Of high importance is, among others, cooperation with ML System S.A., a maker and distributor of photovoltaic panels, which, as the only company in Poland, has a research centre, ensuring modernity and innovation of the proposed solutions. Cooperation with industry will be strengthened by NLF's contacts with the Polish Chamber of Commerce for Electronics and Telecommunications, an organization of Polish business active in the field of renewable energy sources.

Cooperation with industrial partners and understanding their needs will translate into a modification of education in NLF's institutions, which will influence the development of current and education of future R&D staff.

# NOMATEN CoRE

**Entities involved:**

1. *National Centre for Nuclear Research*

## DESCRIPTION

The NOMATEN Centre of Excellence, devoted to the design, development and assessment of innovative multifunctional materials for industrial and medical applications is one of just three Polish projects which have received prestigious, long term grants under the European Commission programme Teaming for Excellence. NOMATEN operates on the basis of close cooperation between National Centre for Nuclear Research, Commissariat à l'Énergie Atomique et aux Énergies Alternatives, France (CEA) and Teknologian Tutkimuskeskus VTT Oy, Finland (VTT). The mission of the NOMATEN Centre is to serve the imperative needs of the Polish and European economies, and society in general, via the generation, application and dissemination of breakthrough research and innovation outputs as well as training the next generation of experts in the field. To understand and create new multifunctional materials, we must span the range from nanometers and picoseconds to meters and years. NOMATEN will use a holistic approach, combining theoretical concepts, computer modeling on various scales and their validation using a variety of experimental techniques.
The Teaming grant, together with the complementary funding provided by the Foundation for Polish Science and the Ministry of Science and Higher Educations, supports the organization and research staff of the NOMATEN CoE. The NOMATEN Centre partners are committed to long term support of the Centre, including access to their existing research facilities (most notably the MARIA research reactor at National Centre for Nuclear Research). The NOMATEN CoRE proposal complements the existing infrastructure, allowing the creation of a facility providing an environment unique on the European scale.

## SERVICES

The new equipment envisaged in the NOMATEN CoRE proposal will cover a broad range of research services, attractive not only to the Nomaten teams but also to other research groups, strengthening international scientific cooperation. The key component of the NOMATEN infrastructure is a tandem accelerator with an energy of 3 MV, with equipment allowing RBS, RBS/C, HR RBS, NRA and ERDA measurements. This accelerator will serve not only as a tool for materials analyses, but also to create materials modified via ion implantation and defect creation. Another important part of NOMATEN CoRE is a high resolution transmission electron microscope, equipped with FIB, EDS, EBSD and SIMS components. For advanced materials synthesis, such as high entropy alloys (HEA), oxide dispersion steels (ODS) or metal-ceramic composites the Centre would use dedicated tools. We will combine already existing infrastructure for material creation and modification, such as magnetrons, MEVVA implantators, plasma pulse guns and a SLM 3D metal printer with new Spark Plasma Synthesis and Hot Isostatic Press (HIP) equipment, allowing the creation of advanced materials from powders. NOMATEN will provide access to infrastructure research institutions and commercial companies, combining open access principles and legal requirements.

## IMPACT

Both the NOMATEN Centre of Excellence and the associated strategic infrastructure covered by the NOMATEN CoRE proposal will serve to improve the scientific capabilities and possibilities for seeking competitive funding of the Polish Research community, thanks to boosting its human and infrastructure capacity in conjunction with nurturing mutually beneficial partnerships. This will lead to an improvement of the research and innovation culture in Poland, thanks to the truly international nature of the Centre and the transfer of best practices from the Advanced Partner organizations. Moreover, NOMATEN will create long-term opportunities for economic development in Poland and the EU via effective translation of novel research results into relevant industries with large economic footprints.

The sectors where multifunctional materials resistant to harsh environments are critically needed – chemical, energy, and pharmaceutical industries and nuclear medicine – are of key importance for the European and Polish economies. These sectors will be the first to adopt the NOMATEN research services and innovation outputs resulting from the NOMATEN CoRE infrastructure. However, there are solid prospects for NOMATEN research to find uses and exploitation in other industrial sectors like metal processing, plastics production, cement and concrete, transportation, etc.

# NSMET – National Network of Coordinate Metrology

**Entities involved:**

1. *Cracow University of Technology – Applicant*
2. *Warsaw University of Technology*
3. *Poznan University of Technology*
4. *Kielce University of Technology*

## DESCRIPTION

Measurements and imaging of spatial objects, including their geometrical quantities (e.g., distances, dimensions, shapes, geometric relations such as perpendicularity, parallelism, angles, etc.) are of key importance in many fields of science and especially in numerous industries, including the automotive, aviation, energy, machinery, household appliances, medicine, photovoltaics, fiber optics, optoelectronics, bioengineering, in the production of composite materials and nanomaterials, etc. Without accurate measurements of parts of vehicles, machines, devices that give answer to the question whether components of complex mechanisms have been manufactured and assembled in a way that was assumed at the design stage, neither the functioning of these mechanisms, nor the progress associated with their continuous improvement would be possible. For this reason, the primary goal of NSMET was to shift the boundaries of knowledge by providing the highest accuracy of measurements of internal and external geometric structures of measured objects, on scales from nano to large-size measurements (which corresponds to the range from 10-9 m to 102 m) by developing their concept, ensuring an appropriate equipment base and developing new error correction methods, assessing measurement uncertainty, and calibrating/verifying both measurement systems and standards.

## SERVICES

It is impossible to present NSMET's entire rich offer in such a short description. In general, it is addressed to entities from the scientific community and enterprises and includes:

– coordinate industrial measurements from micro and nano to macro dimen-

sions, including measurements of internal structures (using X-ray computed tomography, optical diffraction tomography, terahertz tomography and magnetic resonance imaging, including hierarchical and multispectral measurements for complex objects – various materials with their volumetric texture and biological materials) and surface topography parameters;
- calibration of machines and coordinate systems as well as material standards for world-class national research and industrial laboratories;
- developing methods of error correction and improving the accuracy of coordinate measurements;
- developing new calibration methods – determining the structures of spatial (3D) and volumetric standards;
- constant supervision over the accuracy of measuring systems in order to maintain stable production and testing quality;
- measurement and analysis of machining tools – post-manufacturing tools control as well as assessment of their wear during operation.

## IMPACT

The functioning of NSMET will have an impact on the development of scientific and application research in many areas of science and industry. The forecasted impact of NSMET on several strategic development directions is described below:
- automation and robotization of technological processes – advanced coordinate measuring systems, whose development and better understanding can be considered as the goal of the described infrastructure, are widely used in the design, optimization as well as automation and robotization of manufacturing processes, including the implementation of the idea of Industry 4.0;
- m and bioengineering – through the use of modern coordinate measurement techniques supporting the development, design, implementation and production of innovative devices, instruments and medical devices (including materials that will be intended for manufacturing of implants) used to guide and support medical therapy or diagnostics;
- power engineering – through the possibility of performing accurate measurements of large-size elements of wind and water turbines enabling, for example, optimal selection of the shape of these elements;
- photonics, optoelectronics, manufacturing of nanoproducts – by improving the accuracy of measuring systems that are the basic systems used to assess the quality of materials (including nanomaterials and nanocomposites) and devices used in photonics and optoelectronics.

The experience gained during the functioning of NSMET will be transferred by its employees to the university lecture halls and laboratories, thanks to which students will be in contact with modern measuring equipment. It is also planned to build a national research base for the development of coordinate metrology by creating conditions for undertaking research by young employees (system of R&D staff recruitment) and internships for doctoral students.

# Polish EMC Laboratories Network (EMC-LabNet)

**Entities involved:**

1. *Wroclaw University of Science and Technology – Applicant*
2. *R&D Marine Technology Centre*
3. *Bialystok University of Technology*
4. *Ignacy Łukasiewicz Rzeszow University of Technology*
5. *Military University of Technology*

## DESCRIPTION

EMC-LabNet is a unique joint venture of five Polish scientific and research entities from different regions of the country which have both research experience as well as modern and specialized electromagnetic compatibility (EMC) laboratories equipped with advanced apparatus for generating electromagnetic disturbances, including high-energy pulses, and testing various devices to assess compliance with technical requirements in the field of electromagnetic compatibility, including immunity to electromagnetic disturbances as well as levels of unintended signals and electromagnetic fields, generated by these devices. The main goal of EMC-LabNet is to create a consolidated technical facility as a network of EMC laboratories as well as upgrade and develop the laboratories' research infrastructure to increase their research capacity and expand research services. The implementation of this goal will include the construction and development of laboratory facilities and innovative research setups which will enable, independently or with partners, the conducting of advanced experimental scientific research and developmental works, as well as providing comprehensive research and development services for external scientific and business entities in the field of electromagnetic compatibility and generation of high-energy surges (i.e., lightning currents, HPM, etc.).

## SERVICES

The EMC-LabNet research infrastructure provides the implementation of full electromagnetic compatibility tests in the extended frequency range from a few Hz up to 40 GHz, including those conducted in anechoic chambers, that are electromagnetically

isolated from the external environment. The infrastructure enables the following tests:

- measurement of conducted and radiated disturbance levels for various devices (e.g. household appliances, medical, ICT, radio, IoT, automotive, aviation, military, marine etc.);
- testing devices' immunity to electromagnetic disturbances, including continuous, pulse as well as low and high power disturbances;
- assessment of the protection efficiency of the developed safeguards to protect devices and systems against various electromagnetic phenomena, in particular those generated intentionally;
- measurements of radio device parameters (e.g. 5G), measurements of antennas (for wireless communication and installed in aircraft);
- measurements of the electromagnetic properties of innovative materials, e.g., shielding effectiveness;
- experimental strength tests of the protection systems and devices conducted in the laboratory and installation site of the tested element (building or aircraft) to direct (up to 100 kA, 10/350 μs) and indirect lightning discharges;
- testing of power supply fluctuations, including simultaneous voltage and frequency changes;
- measuring magnetostatic fields of large-size vessels and mechanisms.

EMC-LabNet also provides support for comprehensive and accredited testing of specialized and innovative electronic devices at the development stage of models, demonstrators and prototypes, as well as for assessing compliance with EMC requirements (e.g. European Union Directives) or certification.

## IMPACT

The EMC-LabNet project is the result of the reported needs of scientific entities and industry, thus the new infrastructure will provide a wider range of EMC tests, in particular for new and innovative devices and systems. As a result of the complete and developed infrastructure of scientists and engineers in many different fields (e.g. communication and information technology, military, aerospace, marine, automotive, space technology, etc.), they will gain access to comprehensive EMC tests for their innovative devices and the ability to test the immunity of applied protections (e.g. lightning surges or other electromagnetic disturbances). The extended availability and wider service of the EMC tests will contribute to the reduction of development and testing time of new devices. The availability of the EMC infrastructure in the country and the possibility of performing specialized tests will improve the quality of life of the society, e.g. by improving the quality and safety of used devices, lower electromagnetic emissions (so-called electromagnetic smog), and increasing the availability of new devices and systems supporting humans in everyday life (e-health, monitoring environmental pollution, intelligent solutions, IoT, etc.). The infrastructure as well as testing and research services can be used by anyone interested in EMC research.

# Research Centre for Pro-Environmental Energy-Efficient Materials and Technologies

**Entities involved:**

1. *Lublin University of Technology*

## DESCRIPTION

The Research Centre for Pro-Environmental Energy-Efficient Materials and Technologies (CeBMaT – acronym in Polish, henceforth referred to as the Centre) is concerned with the fields of knowledge pertaining to the energy industry, environmental and material engineering as well as opto- and mechatronic systems necessary to control technological processes.

The Centre will be involved in experimental and theoretical research which will enable the gathering of new knowledge on the production of materials with specific structural parameters and properties (implants, composites, laminates, sorbents). A significant challenge for the research works performed in the Centre will be the identification of the nature of phenomena connected with, i.e., energy acquisition, functional material production, recycling of waste materials and analysis of their course by means of advanced computer systems and deep learning algorithms.

The capacity to conduct advanced, highly-innovative research, especially aimed at developing the regional industry will be possible due to the unique equipment owned by the Centre. It will have a positive effect on improving the collaboration between the research teams of Lublin University of Technology (LUT) and national as well as international entrepreneurs.

The projected scope of the Centre‘s activity will significantly strengthen the synergy effect between interdisciplinary LUT research teams as well as between industrial partners, international scientific units and LUT.

## SERVICES

The current, so-called large research infrastructure of LUT comprises about 50 items, including: an X-ray micro-tomography sys-

tem, a scanning electron microscope, an X-ray fluorescence microscope, an X-ray diffractometer and a liquid chromatograph coupled with mass spectrometer.

In order to conduct research activities, it is necessary to purchase cutting-edge equipment for the Centre, including:

- S/TEM microscope enabling the preparation of TEM samples;
- multiresolution X-ray nanotomography system;
- universal thermomechanical simulator;
- system for measuring the composition of gases and exhaust gases in a combustion chamber;
- set for the investigation of intelligent sensors and algorithms with a highly-efficient system for parallel calculations;
- setup for studying the intensification of biogas production using advanced pre-processing and biomass analysis methods;
- spectrometer for investigating solid and liquid samples.

The infrastructure will be located at the Centre for Innovation and Advanced Technologies of Lublin University of Technology, which comprises 34 laboratories dedicated to the employees of Faculty of Mechanical Engineering, Faculty of Electrical Engineering and Computer Science, Faculty of Civil Engineering and Architecture and Faculty of Environmental Engineering.

Such allocation of the research equipment will open up its availability to scientists from the country as well as abroad. Additionally, the infrastructure will be made available to external entities (on condition of payment) interested in the implementation of cutting-edge research, development and innovation technologies in their business practice.

## IMPACT

The infrastructure of the Centre will contribute to the development of the areas of economy focused around entrepreneurs who consider scientific research on new materials and technologies relevant. The conducted research will involve:

- hybrid composite laminates as well as fiber metal laminates for use in aviation, transport and medicine;
- new types of waste-derived structural sorbents and catalysts used in the environmental engineering technologies;
- new generation of mineral and mineral-organic additives used in energy-efficient technologies for the manufacturing of construction materials;
- innovative technologies of shaping products using forming processes;
- influence of waste material and biomass gasification process conditions on the emission of pollutants;
- application of optical/fiber optic sensors with appropriate algorithms for the diagnostics of the gasification and combustion processes;
- materials for regenerative medicine and implantology.

Research at the Centre will be conducted with active participation of established national and international teams involving the LUT Doctoral School course participants and young employees of the R&D&I sector.

# WCAT 2.0 – Additive Technologies and Biomedical Engineering Centre

**Entities involved:**

1. *Adam Mickiewicz University in Poznan – Applicant*
2. *Poznan University of Technology*
3. *Poznan University of Medical Sciences*
4. *Poznan University of Life Sciences*
5. *Poznan University of Economics and Business*
6. *Institute of Bioorganic Chemistry Polish Academy of Sciences*
7. *Institute of Molecular Physics Polish Academy of Sciences*
8. *Institute of Plant Genetics Polish Academy of Science*
9. *Institute of Human Genetics Polish Academy of Sciences*
10. *Institute of Natural Fibres and Medicinal Plants*
11. *Poznan Science and Technology Park*
12. *City of Poznan – supporting partner*

## DESCRIPTION

The Adam Mickiewicz University Centre for Advanced Technology in Poznan (AMU CAT) is a unique research unit on a national scale owing to its multidisciplinary structure. The Centre brings together leading specialists in exact and natural sciences and engineering. It is focused on the design and characterization of new materials and biomaterials for multiple applications. It is one of the few units in Poland that, thanks to the use of its analytical and technological equipment, in addition to conducting research, provides services in the field of chemical analysis as well as optimization and technological consulting for the SME sector.

The Centre was built from European Structural Funds as part of a project co-financed by the ERDF under the Operational Programme Innovative Economy (EUR 63 million – buildings and research infrastructure) entitled Wielkopolska Centre for Advanced Technologies (WCAT), to serve the entire region. Its main goal is the implementation of R&D projects and the development of research programs in cooperation with companies and other research institutions, as well as providing specialized research services.

With the Centre's active participation, the University is also a partner in the EPICUR consortium (European Partnership for an Innovative Campus Unifying Regions) and has the status of a research university, and thus may set up collaborative teams of scientists from various scientific disciplines, mainly in the areas of "applied chemicals and biochemical" in the Centre.

## SERVICES

The AMU CAT focuses on the synthesis, structure and applications of materials with specific, industry-desired properties. This com-

bination of laboratory tests with the ability to scale up individual processes allows companies to test technologies developed at the Centre in a real process environment. Analytical laboratories provide research services based on the latest equipment, which covers a broad spectrum of parameters for the purposes of individual technologies, laboratories and research units. Advanced equipment located on the AMU Morasko campus in Poznan is available to both the scientific community and SME partners.

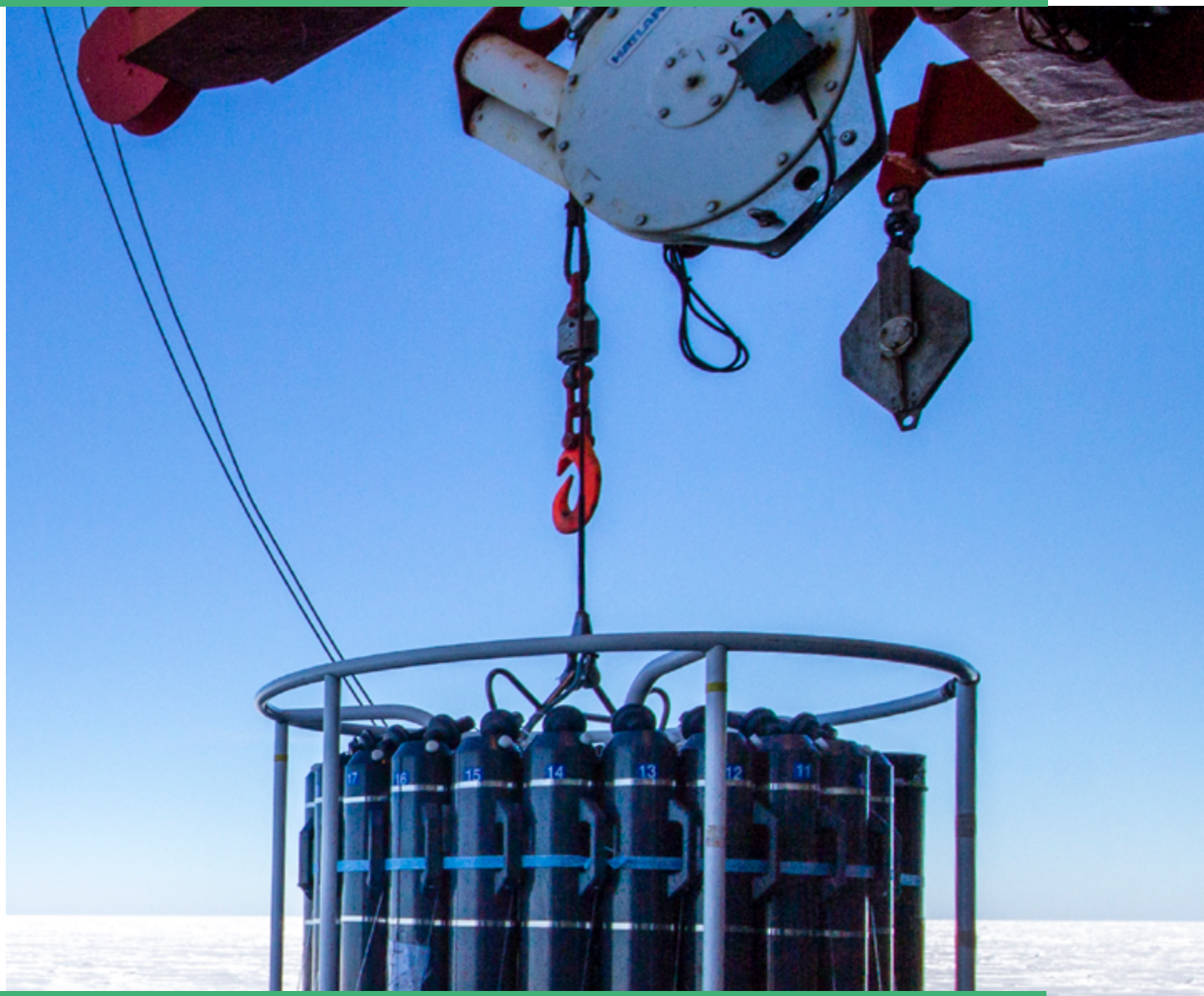
The infrastructure of AMU CAT includes: chemical laboratories for synthesis of precursors of novel materials, facilities for processing and testing the additives and materials, core facility labs characterizing the physico-chemical properties of novel chemicals and materials, and biotechnology laboratories crucial for biomaterial engineering and 3D bio-printing. One of the most modern animal houses in Poland allows the keeping of animals in accordance with the SPF (Specific Pathogen Free) standard and is adapted for breeding small animals (mice, rats, rabbits).

## IMPACT

The Centre, as a multidisciplinary research, development and innovation (R&D&I) infrastructure, is an important link between fundamental and applied research focusing on the implementation of newly developed solutions. Currently, a number of programs implemented by the Centre are based on cooperation with industry and aim to solve specific problems defined by companies, as well as develop new technologies and high-tech materials.

The Centre, as a research partner of innovation business, is currently developing the R&D&I infrastructure to full functionality in the area of support and development of material technologies focused on additive technologies and biomedical engineering. Additive technologies enable the processing of materials obtained by chemists, biologists and biotechnologists for the needs of medicine, robotics, mechatronics, engineering, prototyping and the space industry. Thus they form an interdisciplinary bridge which enables semi-industrial scaling in the field of materials science for 3D printing, composites, fillers and processing of polymers. For example, the animal testing facility studies the suitability of incrementally developed biomaterials, including bone, cartilage and joint structures for implants, and eventually 3D printing of body parts.

The role of the Centre is to provide support in the development of technology up to level 7 of technological readiness (7 TRL), while maintaining a high level of fundamental research. Cooperation in these areas will make it possible to achieve new breakthrough competitive advantages, as incremental innovation is a field which is in an early development phase, thus offering opportunities for Polish R&D centres to become leaders on a national and international scale.



# 2 Earth & environmental sciences

## Infrastructures in this area:

1. ACTRIS – Aerosols Clouds and Trace Gases Research Infrastructure
2. EPOS – European Plate Observing System
3. EURO-ARGO – Global Ocean Observation System
4. Integrated Carbon Observation System – ICOS PL
5. The Polish Multidisciplinary Laboratory for Polar Research (PolarPOL).

# ACTRIS – Aerosols Clouds and Trace Gases Research Infrastructure

**Entities involved:**

1. *Institute of Geophysics Polish Academy of Sciences – Applicant*
2. *University of Warsaw*
3. *University of Silesia in Katowice*
4. *University of Wroclaw*
5. *Poznan University of Life Sciences*
6. *Institute of Environmental Engineering Polish Academy of Sciences*
7. *Institute of Meteorology and Water Management – National Research Institute*

## DESCRIPTION

Knowledge of the atmosphere's composition and the processes taking place within it is key for studies of natural environment, spreading of pollutants and climate change. Moreover, these elements affect quality of life and human health. ACTRIS (Aerosols, Clouds and Trace gases Research Infrastructure, www.actris.eu) is a pan-European initiative consolidating observations in distributed observatories available to a wide range of users. Its goal is a better understanding of atmospheric processes based on high quality data. Specialized thematic centres provide training, calibration services and support in conducting measurements. ACTRIS allows for the exchange of experience between leading academic centres and industrial partners and enables the mobility of scientists between the partners.

In Poland, ACTRIS shall consist of a network of observatories focused on remote sensing and in-situ measurements of aerosols and remote sensing of clouds. The institutions involved include four universities as well as two institutes of the Polish Academy of Sciences and IMGW PiB. The infrastructure base consists of the partners' observatories in Belsk (Institute of Geophysics Polish Academy of Sciences), Warsaw (University of Warsaw), Raciborz (Institute of Environmental Engineering Polish Academy of Sciences), and Rzecin (PULS). In addition, joint mobile observatory and a new observatory in collocation with ICOS are foreseen. A possibility of further expansion with sites at University of Wroclaw and University of Silesia in Katowice is under consideration.

## SERVICES

One of the aims of ACTRIS is to provide easy and open access to a wide range of high quality services within the field of

atmospheric research. ACTRIS services for users comprise the following:

- data services – access to ACTRIS data and digital tools such as tailored codes and software for data processing and visualization, archiving of data from campaigns, research projects and initiatives;
- research services – access to instrumented observational and exploratory platforms for the realization of scientific experiments under ambient or controlled conditions;
- technical services – access to ACTRIS technology for instrument calibration, testing and comparisons, and the provision of quality assurance;
- innovation services – access to technological developments and new measurement techniques and methodologies, also for the private sector;
- training services – access for instrument operators, users from new regions worldwide and young scientists to ACTRIS facilities for best practice, knowledge sharing and transfer.

Access to services will be provided through a centralized access point to ensure equality and clearly defined access criteria, with free data access for researchers and the public sector from ACTRIS member and observer states. Fees can be charged for applications from countries that do not support ACTRIS membership or for services requested by the private sector requiring significant modifications of instruments.

## IMPACT

By providing access to measurement data and leading observatories, ACTRIS supports scientific developments while helping to disseminate knowledge and support technological developments. It provides data for numerical weather forecasts and pollution forecasts, enabling the forecasting of future states of the atmosphere (on a scale from hours to decades). This gives rise to a number of social and economic benefits. In particular, when forecasting short-term episodes of exposure to harmful agents in the air, testing long-term effects such as climate change and testing policies for pollution reduction.

Data and services provided by ACTRIS are important in answering the following questions: How do aerosols and trace gases affect the Earth's radiation budget? What is the response of clouds to global warming? What are the uncertainties associated with the complexity of the cloud system and its interaction with aerosols? What is the spatial variability of aerosol and trace gasses concentrations (including vertical profile)?

By opening access to research facilities, free access to data, support for measurements, development and calibration of measuring instruments and user training, the pan-European ACTRIS Research Infrastructure will contribute to strengthening the atmospheric sciences, dissemination of scientific research results, stimulating technological development and creating human capital and new workplaces.

# EPOS – European Plate Observing System

**Entities involved:**

1. *Institute of Geophysics Polish Academy of Sciences – Applicant*
2. *AGH University of Science and Technology*
3. *Central Mining Institute*
4. *Institute of Geodesy and Cartography*
5. *Institute of Geological Sciences Polish Academy of Sciences*
6. *Wroclaw University of Environmental and Life Sciences*
7. *Military University of Technology*
8. *Space Research Centre Polish Academy of Sciences*
9. *Warsaw University of Technology*
10. *Institute of Environmental Engineering Polish Academy of Sciences*
11. *Polish Mining Group*

## DESCRIPTION

EPOS is a long-term programme for the integration of open access to distributed research infrastructures in the field of Earth sciences, such as networks and measuring instruments, computing centres, online data servers, documentation, specialist software and other materials. 25 European countries are included in the programme. On October 30th, 2018, the European Commission granted the legal status of the European Research Infrastructure Consortium (ERIC) to EPOS. The ERIC legal framework provides EPOS with legal personality and capacity recognised in the whole European Union.

The mission of EPOS is the integration of the diverse and advanced research infrastructures of European Earth sciences. EPOS will contribute to the development of global interoperability in Earth sciences and increase access to multidisciplinary data and software. The new research model, based on international cooperation, will provide a framework for the success of research on a global scale and increase the ability to take on challenges facing society, such as natural and anthropogenic threats, and in particular, energy production in a changing climate.

In Poland, the integration of National Research Infrastructures is carried out in the following fields: Induced Seismicity, Geomagnetic and Magnetotelluric Observations, Analytical Laboratories, GNSS and Radiometric Data, Gravimetric Observations, Seismic Lithospheric Research, and Satellite Data.

Poland manages the Thematic Core Service – Anthropogenic Hazards, TCS-AH, by integrating European research infrastructures in this field and building the IS-EPOS platform https://tcs.ah-epos.eu/. The second key aspect of Poland's activities is related to the transfer of broadly understood IT solutions.

## SERVICES

EPOS aims to address the needs of the scientific community, businesses and society, for open access to existing and newly emerging integrated RI's in the field of solid Earth sciences, combined with a wide range of data, modelling tools and analytical services. This access is provided via the IT environment https://www.ics-c.epos-eu.org/. Using the EPOS, it will be possible to perform measurements/observations, elaborate expert opinions or analyses related to anthropogenic impact (economic activities, urbanisation and land use) on the natural environment. The offer may refer to a single area in the field of monitoring, expertise or analyses. At the same time, the offer may relate to a comprehensive service, an example of which the building of measurement polygons for the integrated observation of geodynamic processes in mining and post-mining areas in the Upper Silesian Coal Basin and Geophysical Safety System for Mining Protective Pillars in cooperation with the Industrial Partner Polska Grupa Górnicza S.A. [Polish Mining Group].

At the current implementation stage of the EPOS programme, the element of the developed research infrastructure implemented for use is the IS-EPOS platform – the main service of the Thematic Core Service – Anthropogenic Hazards TCS-AH, https://tcs.ah-epos.eu/. This platform provides access to integrated episodes (a data set), analytical applications, document repository and workspace for users.

## IMPACT

EPOS is an international programme for the construction of research infrastructure, enabling the study of complex processes occurring in the Earth's crust. The multidisciplinary nature of these studies, and their complexity, requires combining a number of research infrastructures into one ecosystem. This will lead to the consolidation of research, which so far is carried out independently, and, as a result, will allow for gaining a better understanding of the processes occurring inside and on the surface of the Earth, including the impact of natural resources exploitation and other technological human activity on the state of the environment. Additionally, due to close cooperation with Industrial Partners (e.g., PGG SA), this project will contribute to the strengthening of the partnership with the industry and building a permanent process of technology transfer between them.

The use of modern IT technologies allows for broad cooperation. This cooperation includes, among others, the joint performance of research, sharing data, analytical tools and achieved results. At the same time, it contributes to the development of broadly understood IT technology.

Appropriate legal solutions to manage dispersed pan-European RI's, ensuring a common policy on data sharing, open access and transparent use of data while fully respecting intellectual property rights have already been adopted.

# EURO-ARGO – Global Ocean Observation System

**Entities involved:**

1. *Institute of Oceanology Polish Academy of Sciences – Applicant*
2. *Space Research Centre Polish Academy of Sciences*
3. *Institute of Geophysics Polish Academy of Sciences*
4. *Institute of Geological Sciences Polish Academy of Sciences*
5. *Nicolaus Copernicus Astronomical Centre Polish Academy of Sciences*
6. *University of Gdansk*
7. *University of Szczecin*
8. *Pomeranian University in Slupsk*
9. *Polish Naval Academy of the Heroes of Westerplatte*
10. *Research and Production Enterprise FORKOS Ltd.*
11. *Jakub Zdroik SEARIS TECHNOLOGIES*

## DESCRIPTION

The Polish research infrastructure EURO-ARGO is part of the ARGO Global Ocean Observation System. By belonging to European Research Infrastructure Consortium Euro-Argo ERIC, Polish EURO-ARGO (also called Argo-Poland) performs important tasks in the creation and maintenance of the global ocean observation network. The global network consists of over 3500 autonomous ARGO floats profiling to a depth of 2000 m. Through satellite links, floats provide real-time data on the ocean's physical and biogeochemical properties. Euro-Argo ERIC was established in 2014. Poland is one of the twelve initiators of this research infrastructure, which is on the ESFRI international road map list. The goal of Euro-Argo is to provide optimised and sustained European contribution to the global observation network by maintaining 800 floats in stable operation. It requires deployment of 250 floats a year. The goal of Argo-Poland is to buy, deploy and service 3-4 floats a year. Polish EURO-ARGO has been launching floats in the European Arctic since 2009, and had successful launchings in the Baltic Sea the last three years. The goals of Argo-Poland are: independent final processing of data in delayed mode (DQMC), use of ARGO data for scientific studies, and research and development works.

## SERVICES

The Institute of Oceanology of the Polish Academy of Sciences (IO PAN) in Sopot is the only Polish scientific centre conducting systematic oceanographic research of the deep ocean. That is why IO PAN is the leader of the Polish EURO-ARGO program. Argo-Poland works with scientific organizations and programs, universities and R&D companies. The offer is directed mainly to the marine re-

search community. All ARGO data are widely available and used in operational oceanography, meteorology, climatology and basic research.

Two global centres deal with the collection and distribution of ARGO data. In Europe, GDAC Coriolis in France handles the collection, processing, storage and distribution of data. The data is available on FTP servers and websites.

Data from Polish ARGO profilers were used in PhDs written in IO PAN and scientific papers. The achievements are presented at national and international conferences. Data from the Baltic floats are provided by IO PAN to the SatBałtyk consortium, where they are used to supply and validate the numerical model. We also conduct research and development in cooperation with SMEs and the Naval Academy in Gdynia (AMW).

For better information, the Argo-Poland website is available in Polish and English: https://www.iopan.pl/hydrodynamics/po/Argo/argo.html.

## IMPACT

ARGO is the first global in-situ ocean observation system. It allows observation, understanding and prediction of the ocean, especially its role in shaping the Earth's climate. ARGO is also a well-organized network for receiving, processing and distributing data, as well as modern and evolving technology.

Argo-Poland has been financed by the Ministry of Science and Higher Education since 2016. As a result, Poland has joined this unique system, buys and launches floats, conducts R&D activity, educates staff and conducts scientific research. Data from ARGOs launched in the Arctic are a significant complement to the observations carried out each year by the IO PAN research vessel r/v Oceania under the long-term AREX program. The pioneering launch of ARGO in the Baltic Sea has proved the usefulness of this system in shallow shelf seas. Floats launched by IO PAN provide information on hydrography and oxygen conditions in the South Baltic. Argo-Poland is at the stage of building a monitoring system based on data from cruises, measurement buoys and ARGO floats. In cooperation with small and medium-sized R&D companies, Polish EURO-ARGO is working on the use of modern technologies to increase the scope of oceanographic observations. Together with AMW, Argo-Poland is working on a system for finding and catching inactive ARGO floats in the Baltic Sea.

Argo-Poland, in cooperation with Euro-Argo ERIC, trains its own specialists to handle floats and DMQC data. By participating in European scientific and infrastructure programs, Argo-Poland is working on technological development and increasing the range of the global ARGO network. Together with all partners, Polish EURO-ARGO plans to deploy a new generation of biogeochemical float (BGC) in the Baltic Sea.

# Integrated Carbon Observation System – ICOS PL

**Entities involved:**

1. *Institute of Environmental Protection – National Research Institute – Applicant*
2. *Poznan University of Life Sciences*
3. *University of Lodz*
4. *Institute of Agrophysics Polish Academy of Sciences*
5. *Institute of Oceanology Polish Academy of Sciences*
6. *AGH University of Science and Technology*

## DESCRIPTION

The Integrated Carbon Observation System (ICOS) is a distributed research infrastructure operating standardized, long-term observations, facilitating the acquisition of high-precision data on concentration and fluxes of greenhouse gases (GHG) exchanged between the atmosphere, land surface and oceans. ICOS-based knowledge supports decision-making to combat climate change and its impacts, while promoting technological developments by linking research, education and innovation. The recent so-called Green $CO_2$ Report considers ICOS as the backbone of the future operational $CO_2$ Emissions Monitoring & Verification Capacity in which the European Commission will invest substantial resources.

ICOS currently covers 12 European countries with a network of more than 130 measurement stations using state-of-the-art technologies. The strength of ICOS relies on several pillars: robust national networks, central facilities providing services and data integration for the whole infrastructure and highly-standardized data production. The open and free data is available at the Carbon Portal and is compliant with FAIR (Findable, Accessible, Interoperable, Reusable) principles.

## SERVICES

If the main product of ICOS is data, the Carbon Portal also develops elaborated services for different users. The advanced “visualisations” (flux maps) of certain GHGs in time and space, long-time records, estimation of anthropogenic emissions are constantly co-developed with the users.

For countries joining ICOS, the process of site labelling makes all stations interoperable and raise them to the highest global standards. The central facilities of ICOS (thematic centres and calibration laboratories) act

as internal service providers to help the local scientific teams implement ICOS protocols and upgrade the instrumentation. They also account for quality control and assurance of data.

The ICOS Community, with more than 500 scientists and 80 high-profile research institutions in Europe, ensures a strong link to the global community, which allows for experience exchange and training.

## IMPACT

As the forerunner among the infrastructures of the ESFRI roadmap, ICOS performed an impact assessment of its activities in 2018, making visible the positive effects of infrastructures over uncoordinated networks in Europe.

The contribution of ICOS to the latest advances of cutting-edge measurement techniques and standardized processing routines offers a fertile ground for innovation and implementation in various fields of science and practice.

The success of ICOS, on the ESFRI Roadmap since 2006 and as a Landmark since 2016, makes it a desired RI which attracts partners and makes it possible to elaborate successful research proposals (e.g. H2020 projects).

ICOS fosters cooperation with other European RIs and contributes to elaborate common positions towards European institutions like ESFRI or the Commission.

The ICOS-PL project will bring to the research infrastructure: four ecosystem stations (forest, wetland, agricultural area, city), two high towers for atmospheric research and a marine research vessel. All research stations are located in Poland and may also serve as contribution to other infrastructures (e.g. ACTRIS).

Poland's accession to ICOS will bring benefits for the country in 3 groups:

- scientific: improved assessment of GHG fluxes on Polish territory, efficient integration of scientific communities in Poland and Europe, development of modern technologies and research methods;
- educational: contribution to ecological education on the impact of human activities on the natural environment and atmosphere;
- political and economic: free access to data for all countries members of ICOS, which will be the basis for estimating and verifying the $CO_2$ balance for countries under EC policy, legitimizing positive effects of Poland's climate policy including reducing $CO_2$ emissions and increasing absorption by terrestrial ecosystems.

# The Polish Multidisciplinary Laboratory for Polar Research (PolarPOL)

**Entities involved:**

1. *Institute of Biochemistry and Biophysics Polish Academy of Sciences – Applicant*
2. *Institute of Geophysics Polish Academy of Sciences*
3. *Institute of Oceanology Polish Academy of Sciences*
4. *Adam Mickiewicz University in Poznan*
5. *University of Silesia in Katowice*

## DESCRIPTION

The Polish Multidisciplinary Laboratory for Polar Research (PolarPOL) constitutes a dispersed research infrastructure, the extension of which gives a chance to develop already existing, as well as obtain completely new possibilities, in the field of multi- and cross-disciplinary scientific research conducted in polar regions. PolarPOL was created as a strategic research infrastructure in response to the need to realise the ‚Strategies for Polish Polar Research' developed by the community of Polish polar researchers experienced in polar areas along with the acceptance and support of the Ministry of Science and Higher Education as well as the Ministry of Foreign Affairs. Taking into consideration its educational and cognitive meaning, as well as social and economic usefulness, it provides an answer to the need to implement the main directions of polar research progress in Poland.

## SERVICES

The Polish Multidisciplinary Laboratory for Polar Research (PolarPOL) is based on an existing distributed multimillion infrastructure, that is:

- Arctowski Polish Antarctic Station together with the Arctowski Unique Field Laboratory (the investment completed in 2019, PolarPOL stage II), managed by the Institute of Biochemistry and Biophysics Polish Academy of Sciences;
- Stanisław Siedlecki Polish Polar Station in Hornsund Unique Field Laboratory (the investment completed in 2017, PolarPOL stage I), managed by the Institute of Geophysics Polish Academy of Sciences;
- Research vessel Oceania, managed by the Institute of Oceanology Polish Academy of Sciences;

- Adam Mickiewicz University Polar Station ‚Petuniabukta';
- Antoni Bolesław Dobrowolski Antarctic Station managed by the Institute of Geophysics Polish Academy of Sciences;
- University of Silesia Polar Laboratory.

The availability of the above-mentioned infrastructure is regulated by the internal regulations of the Institutions that manage it.

## IMPACT

The main goals of PolarPOL, as well as polar researchers, is to enhance active and significant Polish scientific presence in polar regions. Over 60 years of experience in conducting scientific research within the Arctic and Antarctic, involvement in activities for the benefit of industry, development of innovations, as well as contribution to the international politics through the broad sense of scientific diplomacy reflect its importance. The improvement of logistic efforts in polar regions or molding the new generation of polar researchers and active participation in activities, which enhance civic involvement through educational activities as well as public outreach, is possible due to the development of polar research synergy. Considering that the realisation of the above-mentioned goals results from the quality of suggested research, as well as high-tech strategic research infrastructure, we apply for inclusion of the Polish Multidisciplinary Laboratory for Polar Research (PolarPOL) in the Polish Roadmap for Research Infrastructures. Establishing the Polar Research Laboratory as the decisive entity in case of fundamental needs enables the analysis of crucial and urgent tasks, as well as develops an optimal schedule of operations.

# 3 Medical, biological & agricultural sciences

# Infrastructures in this area:

1. Biological and Biomedical Imaging Infrastructure – Bio-Imaging Poland (BIPol)
2. Biomedical Multiscale Imaging Centre for Translational Research (MultIMA)
3. Centre for Advanced Organic Synthesis and Transformative Materials
4. Centre for Innovative and Sustainable Horticultural Technologies
5. Centre for New Pharmacotherapies of the Central Nervous System Diseases – Cephares
6. Centre for the Development of Therapies for Civilization and Age-Related Diseases
7. Cryo-Imaging Centre
8. ELIXIR.PL
9. European Centre for Bioinformatics and Genomics (ECBG)
10. National Biodiversity Collection of Recent and Fossil Organisms at W. Szafer Institute of Botany, Polish Academy of Sciences (NBC IB PAS)
11. Nuclear Magnetic Resonance – Interdisciplinary Platform for Physico-Chemical Studies. MAGREZ
12. Polish Biobanking Network BBMRI.pl
13. POL-OPENSCREEN – Polish Infrastructure of Open Screening Platforms for Chemical Biology
14. RAPID Centre of Radiation Research and Technology
15. Research Infrastructure of Molecules and Cells (IN-MOL-CELL)
16. Tech-Safe-Bio – Work Safety&Health Research Centre.

# Biological and Biomedical Imaging Infrastructure – Bio-Imaging Poland (BIPol)

**Entities involved:**

1. *Nencki Institute of Experimental Biology Polish Academy of Sciences – Applicant*
2. *Mossakowski Medical Research Centre Polish Academy of Sciences*
3. *Jagiellonian University in Cracow*

## DESCRIPTION

BIPol (Bio-Imaging Poland) – National Imaging Centre for Biological and Biomedical Sciences, is a Polish research initiative, which is part of the international project Euro-Bio-Imaging – European Research Infrastructure for Imaging Technology in Biological and Biomedical Sciences (EuBI), from the ESFRI Roadmap.

The aim of BIPol, coordinated by the Nencki Institute, is to create a state-of-the-art, unique research infrastructure for biological imaging. Environmental laboratories operating within BIPol are already made available to the scientific community by the three partners of this consortium: the Nencki Institute, the Jagiellonian University, and the Mossakowski Medical Research Centre. The main purpose of BIPol is to provide broad access to a range of modern biological and biomedical imaging techniques, to solve both basic and translational research problems. The task of the consortium is to implement imaging technology in order to develop new techniques for the detection of pathological changes. The BIPol project puts special emphasis on the diagnosis and therapy of civilization diseases such as: cancer, cardiovascular diseases, neurodegenerative diseases, diabetes and strokes.

## SERVICES

The BIPol project aims to develope and enrich the Polish research infrastructure with the latest achievements of imaging technology, which will allow to create a competitive, innovative infrastructure and conduct advanced research at the highest level.

The existing facilities of BIPol are already being made available to researchers from partner institutions as well as to external users, offering unique equipment and expertise. We provide a wide range of brain imaging

services using magnetic resonance imaging for neuropsychological, clinical and pharmacological research. We also offer a wide range of studies on the structure and function of biological samples at different levels of organization, using both optical and electron microscopes, and implementing various high-resolution imaging methods.
All labs that are part of BIPol operate according to the same sharing procedure, available on the websites of individual units. The process of applying for access to specialized equipment is carried out in accordance with the solutions adopted in the EuBI: on the basis of the research project, the user selects the appropriate technique, and sends the application through the website: https://www.eurobioimaging.eu/about-us/how-to-access. The consortium also organizes workshops and training for internal and external users, to make their offer as widely available as possible.

## IMPACT

The enormous progress in bioimaging techniques within recent years has opened new opportunities for biological imaging, and enabled new research challenges to be taken up. Consolidation of the national research infrastructure will allow to increase the effectiveness of the solutions used, to support international scientific cooperation, and to strengthen cooperation with the business sector. The BIPol project will help raise the prestige of Polish scientific entities, and will have a significant impact on the implementation of biological and medical imaging technologies in the diagnosis and therapy of civilization diseases. It provides a strong foundation for establishing and further developing long standing cooperation with leading research centres in Europe.

The project enables a wide range of users to consult and implement new research methods and technologies in their parent institutions, as well as ensuring knowledge transfer between EuBI users. Moreover, the task of BIPol is to create an optimal scientific environment for the existing ones, as well as to create new international research teams, and provide them with the most modern research infrastructure.
The project will significantly contribute to the intensification of R&D activities, leading to increased competitiveness and innovation of the Polish economy. The presence of BIPol on the Polish Roadmap for Research Infrastructures will strengthen the participation of the Polish scientific community in the implementation of the ESFRI Roadmap.

# Biomedical Multiscale Imaging Centre for Translational Research (MultIMA)

**Entities involved:**

1. *Jagiellonian University in Cracow*

## DESCRIPTION

The goal of the project implemented by the Faculty of Biochemistry, Biophysics and Biotechnology of the Jagiellonian University (FBBB), in cooperation with the Jagiellonian Centre of Innovation (JCI), is to establish the Biomedical Multiscale Imaging Centre (MultIMA).

The Centre will include four complementary research cores to focus on the interdependence of molecular, cellular and systemic processes, and offer services both for basic and translational research.

Four research cores will be developed and integrated within the FBBB:

- Core I: Molecule Imaging, aimed at solving the structures and dynamics of complex biomolecules;
- Core II: Cell Imaging, enabling the visualization of biological structures at the cellular, subcellular and molecular levels;
- Core III: Tissue Imaging, within which cell phenotypes will be studied in the context of their spatial location in the tissue, tissue microenvironment and processes occurring at the level of cells, tissues and organs;
- Core IV: Organism Imaging, enabling high-resolution anatomical, functional and molecular imaging.

## SERVICES

Research groups from the FBBB currently cooperate with several companies, working mainly on the evaluation of potential anticancer or anti-inflammatory drugs. These include Adamed Ltd. (Pienkow), Biovico Ltd. (Gdynia), Celon Pharma S.A. (Kielpin), Orion Biotechnology (Ottawa), Pharmena S.A. (Lodz), Selvita S.A. (Cracow), and WPD Pharmaceuticals (Warsaw).

After the establishment of the MultIMA research centre, the services will become

much more comprehensive, and frames of cooperation will move from research contracts to joint long-term projects. At the moment there are three companies interested in collaboration on an in-depth investigation of potential anticancer targets: Adamed Ltd. (Pienkow), Celon Pharma S.A. (Kielpin), and Ryvu (previously named Selvita, Cracow).

The JCI is already known in Poland as an institution that supports cooperation between science and business. Business contacts created as part of the JCI Life Science Park, and the Life Science Cluster will help in expanding the MultIMA infrastructure user base. Moreover, the Centre for Technology Transfer CITTRU, an institution established within the framework of the Jagiellonian University, which coordinates cooperation with pharmaceutical and biotechnological companies, will be actively involved in the identification of inventions, legal protection of intellectual property, coordination of research contracts, creation of research contract offers, their promotion among potential buyers and the negotiation of agreements.

## IMPACT

The project is of great strategic importance. First of all, it will contribute to the integration of different research teams at the FBBB, who have so far worked separately, and the creation of multiscale synergistic research labs with a long-standing and extensive expertise, covering the entire range of organisational levels, from molecules to organisms. Moreover, each lab will make use of the state-of-the-art infrastructure already present at the Faculty, as well as unique instruments, which involve cutting-edge technologies that are not currently available in our region or even Europe. The FBBB already has a fruitful, long-term cooperation with numerous national and foreign research units, as well as national pharmaceutical companies. The implementation of this venture will elevate the JU Faculty of Biochemistry, Biophysics and Biotechnology to a new level of competitiveness and will establish cooperation with top research centres and international companies. The new research infrastructure, its integration with the existing equipment within the research labs and revision of the equipment use policy will allow the FBBB to maximise infrastructure effectiveness and achieve a world-class level of research quality.

The long-term aim of the project is to create a multiscale imaging centre which will contribute to making the FBBB:

- unique on the European scale;
- open for collaboration with the best academic and commercial laboratories;
- ready to undertake and manage research of the highest standard, which will allow retaining and recruiting highly knowledgeable and visionary personnel, a condition sine qua non for further development.

The short-term goal is to improve the accessibility of the research infrastructure and maximise its economical effectiveness.

# Centre for Advanced Organic Synthesis and Transformative Materials

**Entities involved:**

1. *Institute of Organic Chemistry Polish Academy of Sciences*

## DESCRIPTION

At present, the research projects carried out in the Institute of Organic Chemistry of the Polish Academy of Sciences concern the most important topics and issues of contemporary organic synthesis, catalysis and search for new materials. The achievements of engaged scientists are highly appreciated by both domestic and international scientific communities (three laureates of FNP Prizes, laureates of TEAM and MAESTRO grants, numerous papers in influential journals with high IF and 200 points at the Ministry of Science and Higher Education list). The construction of the modern laboratory building for the Institute shall significantly improve the quality of research and enable effective competition with the best research institutions in the world.

The building planned for construction shall comprise modern laboratories and offices for ca. 200 scientists and state-of-the-art research equipment. The main aims of CASIM's activity will be pioneering multi-disciplinary scientific research integrated in areas related to C-H functionalisation, design of modern catalysts, functionalisation of complex molecules, design of modern drugs and fluorescent dyes, molecular recognition, photoredox catalysis, computational chemistry and photophysics.

The CASIM Centre is to be a modern scientific and research institution bringing together leading chemists, photophysicists, molecular biologists and computational chemists – working together on key problems of significant importance for science and the economy.

## SERVICES

The Institute of Organic Chemistry Polish Academy of Sciences, in addition to conducting innovative basic research, cooper-

ates scientifically with entities in the country and abroad, both at scientific level and in conducting research services for business partners.

The CASIM investment being on the Polish Roadmap will undoubtedly support the faster adaptation of the latest technological solutions by the Polish economy and society, which will increase the integration of the scientific and economic sectors. It will become possible to develop novel processes and methods for designing new materials and innovative technologies. The resulting know-how will be transferred to chemical, pharmaceutical and cosmetic industries.

Currently, there are five analytical laboratories at the Institute, grouped into one Laboratory of Bioactive Compounds Analysis (LASB). Equipment expansion and modernisation is also planned in the application. The centre will be open to scientific cooperation with research centres and commercial enterprises. Each time, the principles of cooperation will be specified in agreements with interested parties. In the area of cooperation with academic centres, free access to the research infrastructure will be possible. The private business for which the research offered by CASIM/LASB are necessary to develop new technologies for the synthesis of chemical compounds, modern production methods and methodologies for testing innovative materials for applications in the high-tech industry will also be recipient of analytical results.

## IMPACT

Construction of a modern centre for organic chemistry research, equipped with cutting-edge scientific equipment, capable of undertaking the most ambitious research and development tasks, will enable the conducting of research at the highest level as well as the training of scientific staff for the economy, science and education at a level fulfilling international standards. It will also contribute to the faster adaptation of the latest technological solutions by the Polish economy and society. As a result of project implementation, infrastructure, equipment and housing conditions will be created to conduct modern scientific research, which will allow for the development of new innovative technologies and the transfer of knowledge (know-how) to the economy. This will undoubtedly contribute to the increase of the scientific, industrial and economic potential of the region and Poland, contributing to the development of numerous fields of science, which will translate into an improvement of the health and quality of life of Polish society. Such a ground-breaking transformation cannot be achieved without the education of a new generation of creative and entrepreneurial chemists capable of commercialising their research results.

# Centre for Innovative and Sustainable Horticultural Technologies

**Entities involved:**

1. *Research Institute of Horticulture*

## DESCRIPTION

The infrastructure of the Centre for Innovative and Sustainable Horticultural Technologies (CIiZTO) has been planned in the structure of the Institute of Horticulture (RIH) as a place of functioning of interdisciplinary scientific teams working to solve the most important problems of horticultural production, with particular emphasis on contemporary threats – hydrological drought, progressive climate change, protection and rational use of bio-resources. The objective of the investment is to build a new laboratory complex that will provide appropriate conditions for research carried out by teams appointed to solve current horticulture problems, using the scientific potential of the RIH. The key element of the planned activity will be cooperation with external partners - both with horticultural producers and enterprises working for the horticulture or using horticultural raw materials.

The infrastructure of the Centre will be organized as a ”living lab” – a laboratory where the research space will be easy to adapt according to the changing needs of both new projects and commercial services. The laboratory created in the ”living lab” formula will be a place where final stakeholders will be able to cooperate with the Institute’s research teams, which will increase the potential for new implementation initiatives. It will also increase the potential to create innovative technologies that respond to market demand, and in which the results of research will be tested on experimental fields or in the production environment, on the premises of enterprises and farms.

## SERVICES

The CiiZTO offer will be focused on effective cooperation with external business and technology environments. The performed tasks

will support the needs of entrepreneurs and farmers in the search for the best possible solutions for current and rising problems in the field of horticulture and apiculture. Research teams will be competent to undertake developmental and implementation research in the fields of:

- optimization of methods of breeding and cultivation of plants of great importance for the economy, based on natural defence mechanisms;
- ways to counteract adverse soil phenomena arising as a result of pollution of agrocenoses with an excessive chemisation;
- ways to counteract adverse hydrological phenomena, especially by optimizing the use of water in horticultural production and implementing technologies that increase water retention in a production environment;
- development of new methods of soil resource management by growing plants with better genetic potential for adaptation to the climate and soil conditions, especially for drought stress;
- creating and implementing innovative management methods in plant cultivation allowing better use of natural adaptive mechanisms of plants;
- the use of soil and endophytic microorganisms to increase the productivity and adaptation potential of plants;
- support for the horticultural industry in efficient and high-yielding technologies of plants cultivation, taking into account sustainable use of natural resources.

## IMPACT

The benefits of establishing CIiZTO can be grouped into the following general areas:

1. Research and development aspect (laboratory and field research)
   - consolidation of human and equipment resources of the RIH in one place will lead to an increase in the efficiency of the use of research capacity;
   - this modern research environment will enable studies in the field of genomics, cytogenetics, metabolomics and development of innovative technologies in collaboration with external entities;
   - this modern research centre will be capable of obtaining scientific results that will be the basis for implementation;
   - the Centre will increase competitiveness in applying for national and European grants.
2. Discussion and training aspect
   - the Centre will enable the organization of scientific discussions, seminars and debates with the participation of regional administration decision makers, entrepreneurs and consumers;
   - quick transfer of horticultural knowledge will allow an increase in the qualifications of horticultural producers and enterprises in the field of modern technologies saving the agrocenoses and will accelerate their practical application;
   - research and implementation conducted in CIiZTO will increase the level of innovativeness and competitiveness of the horticultural production sector within the country as well as abroad.

# Centre for New Pharmacotherapies of the Central Nervous System Diseases – Cephares

**Entities involved:**

1. *Maj Institute of Pharmacology Polish Academy of Sciences*

## DESCRIPTION

A national centre (under the name Cephares) will be established at the May Institute of Pharmacology Polish Academy of Sciences (IP PAS) for research in the field of neuropsychopharmacology combined with the development of new bioactive compounds as innovative candidate drugs for treating CNS disorders. The concept of Cephares is based on: expansion (building new laboratories of approx. 1500 m2) and modernisation (with highly specialised automated research apparatuses) of existing research infrastructure at the IP PAS and development of the research capabilities of an existing Academia-based Platform (http://www.cns-platform.eu, http://platformex.eu) to expand the scope of research on affective disorders, neurodegenerative disease, cognitive disorders, drug addiction, and chronic pain. Switching to high throughput screening and high content screening methodologies for monitoring cellular processes and implementation of state of the art translational pharmacology methods will enable the realisation of comprehensive drug development programmes and thus obtaining authorisation to commence clinical trials. Moreover, the research infrastructure of Cephares will be used in: advanced genetic, biochemical, electrophysiological and pharmacological studies on the molecular mechanisms underlying development of CNS disorders, designing new in vivo models of diseases, optimising and applying state of the art translational methods to assess the therapeutic potential of drug candidates; as well as a space for the implementation of ERC grants and integrated R&D projects in cooperation with pharmaceutical industry and in the provision of commercial services covering particular research methods.

## SERVICES

Establishing the Centre addresses both the needs of the scientific environment, by enabling the conducting of research at a world-class level and publishing results in the most prestigious scientific journals, as well as the pharmaceutical industry within the scope of research into CNS drug development.

The use of the Cephares infrastructure for research purposes includes internal research programs and cooperation with many domestic and foreign research institutes as support for joint projects related to CNS research. Commercial entities that are interested in gaining access to the Cephares infrastructure with which IP PAS and has already established cooperation include national (Selvita and Celon Pharma) and international big pharmaceutical companies (e.g. Gedeon Richter, Orion Pharma, Lundbeck, Novartis, Janssen, Eli Lilly, Mitsubishi Pharmaceuticals, Abbott). In addition, available analytical documents (Map of Development of Polish Pharmaceutical Sector) and market research (reports: https://www.grandviewresearch.com/press-release/global-central-nervous-system-cns-therapeutic-market) indicate other entities interested in gaining access to the Cephares infrastructure: e.g. Adamed, Polpharma, BIOFARM, BIOTON, BLIRT and biotechnology companies and start-ups that specialise in early stages of compound development which, due to lack of own research facilities, are looking for solutions related to prototype drug testing.

## IMPACT

As an academic institution exploiting the potential of psychopharmacology, neurobiology and medicinal chemistry, Cephares will be unique in Europe. It will be equipped with cutting-edge research tools, thus enabling the conducting of comprehensive research meeting requirements for admitting prototype CNS drugs to clinical trials. Research work undertaken by the Centre will contribute to developing new innovative drugs focused mainly on alternative mechanisms of action (such as allosteric modulation) for CNS targets. As a country-wide project, Cephares will increase the chances of discovering the first Polish drug effective in therapies for particularly severe mental, neurodegenerative and addictive disorders, that, as civilisation diseases, have been recognized as a global threat to the 21st-century society. Establishment of the Centre will contribute to enhancing a competitive advantage and increasing the level of innovation in the Polish economy through providing technology for the development of initiatives, such as start-up/spin-off, focused on, by way of open access, the commercialisation of the results obtained by research units and reinforcing links between innovation, research and education, which, among others, will support the implementation of doctorates realised in collaboration with pharmaceutical companies.

# Centre for the Development of Therapies for Civilization and Age-Related Diseases

**Entities involved:**

1. *Jagiellonian University in Cracow*

## DESCRIPTION

The objective of the Centre for the Development of Therapies for Civilization and Age-Related Diseases (CDT-CARD) is to establish an interdisciplinary and innovative research centre specialising in designing and testing new treatments for civilization and age-related disease, with the purpose of performing preclinical trials. The research infrastructure as an integrated network of central laboratories shall constitute a key element of the Centre. It will enable preliminary evaluation of developed solutions and open up opportunities to establish more efficient collaboration with pharmaceutical and biotech industries. Comprehensive analysis of the actual health needs of societies, based on, among others, epidemiological and population-based studies conducted within CDT-CARD, will provide a starting point for the realisation of the research infrastructure. Taking into account the challenges of the contemporary world, including demographic trends, activities undertaken by the Centre will be focused on civilization and age-related diseases that are inefficiently treated and/or prevented. Concomitant demographic changes, the progressive decrease of professional activity and social participation, increasing treatment and hospitalization costs as well as lack of efficient pharmacological therapies make it necessary to seek more efficient solutions in the field of preventive medicine and available treatment. Technological advancements and detailed knowledge of the mechanisms underlying the development of diseases and age-related changes enable devising treatment strategies customized specifically to the needs of a particular patient (precision medicine).

## SERVICES

The Centre, fitted with modern equipment, will enable top-level research into innovative therapies for civilization and age-related diseases. The Centre will operate as a core facility open to internal and external users. The idea of open core facility is based on the principle of making unique equipment and know-how available to researchers from national and foreign research units. The proximity of university hospitals will encourage research collaboration with interdisciplinary research teams making use of patients' clinical material. Such research has already resulted in developing new diagnostic methods and soon it may turn out indispensable in routine clinical practice, especially when it comes to precision medicine.

It is assumed that the research infrastructure will be used by many R&D centres and national business partners, mainly by running collaborative research projects and performing commissioned services.

The Centre will operate on the basis of a simplified and open application to use infrastructure and know-how by researchers. Applications will be subject to evaluation by the Scientific Council established at the Centre in cooperation with the International Advisory Board – in terms of scientific quality, profitability, using financing and potential for project implementation.

## IMPACT

The unique nature of the proposed research infrastructure is characterized by:

- setting up new laboratories provided with the state-of-the-art equipment which specialise in developing and evaluating new therapeutic methods;
- grouping different research laboratories in one interdisciplinary Centre. The cooperation between physicians and researchers specialising in basic sciences and preclinical studies as well as experts on epidemiology of civilization and age-related diseases will enable the creation of interdisciplinary teams that will be capable of finding comprehensive solutions to research problems.

The Centre will ensure:

- access to individual stages of new drug development: designing and synthesising new ligands, evaluation of affinity for a wide range of biologic targets, functional tests determining impact on intracellular signal transduction, full bioavailability ADMET, pharmacokinetic parameters and animal models of civilization diseases;
- the development of one of the most advanced centres for conducting comprehensive preclinical trials in the country. At present, Poland lacks institutes and researchers specialising in designing phase I clinical trials for candidate drugs, selecting drug dosage and a range of tests to be performed. The unique character of the project in terms of its national and international significance also results from involvement in conducting non-commercial clinical trials.

# Cryo-Imaging Centre

**Entities involved:**

1. *Adam Mickiewicz University in Poznan*

## DESCRIPTION

The main objective of the project is to create a Centre which will provide a comprehensive solution for microscopic imaging based on cryo-techniques. The research infrastructure of the Centre will be based on various types of cryomicroscopes, both optic and electron. Other important elements will be unique devices for freezing samples and their cryo-transfer between devices (within the Centre, and as part of sample exchanges with other research units).

The implementation of these modern freezing techniques in the Cryo-Imaging Centre is aimed not only at improving the quality of microscopic imaging, but, above all, at creating completely new research opportunities. One example would be research into protein structure. Only since the application of low temperatures in electron microscopes has it been possible for scientists to analyse the structure of proteins for the first time, in a nearly atomic resolution, in a state closest to natural. Freezing techniques also make it possible to preserve the immunogenic properties of biomedical materials, which is important e.g. in the diagnosis of diseases and the actual chemical composition of microscopic samples (necessary in the microscopic analyses of elemental composition).

Another innovative solution within the Centre will be the possibility of examining the same sample using different types of microscopes, so-called correlative microscopy. This allows for complementary analysis of the examined material at different levels of its organization, which is a unique source of information about the examined objects.

## SERVICES

The idea of creating a Cryo-Imaging Centre meets the requirements and needs of modern science. Although cryo-imaging tech-

niques play an important role in the analysis of biomedical samples, they are also successfully applied to other types of materials, which gives these techniques their universal character. An additional advantage of the planned Centre is the concentration, in one place, of different types of cryomicroscopes which will be compatible due to correlation techniques. Thus, the infrastructure of the Centre is intended to create many possibilities for research while at the same time providing an excellent place for interdisciplinary activities. This will also be fostered by the open nature of the Centre's activities. The Centre will operate using open-access procedures based on the criterion of scientific excellence, developed and adopted earlier at the Faculty of Biology of the Adam Mickiewicz University, within the framework of the general units.

Within the framework of the Centre's activity, various forms of research and teaching projects as well as development work will be conducted, which will enable the use of the Centre's infrastructure by representatives of, among others, the scientific, pharmaceutical, economic, agricultural and nature protection communities. This will be done with the professional support of the Centre's qualified staff.

## IMPACT

The main result of the activities of the Cryo-Imaging Centre is predicted to be its scientific effects. However, in many cases, they will not only be cognitive, but also application-oriented. Often the aim of this type of work is to use the results obtained in the areas of human health (e.g. research on the development of new therapies), sustainable agriculture (e.g. development of methods for crop protection), environmental protection and preservation of biodiversity (e.g. increasing the phytoremediation efficiency, development of cryogenic methods to preserve gene resources of endangered and economically important species), safe and effective energy and modern material technologies (like research on the structural and functional features of materials in low-temperature conditions) and societal security (e.g. research on threats resulting from the use of new substances).

The above examples indicate that the Centre will also be important for development and implementation research in cooperation between science and industry. The Cryo-Imaging Centre is also intended to serve as a platform for an exchange of experiences in the field of cryotechniques used in microscopy. This will be implemented by, among other ways, organizing conferences, workshops, training sessions and scientific exchanges. An important goal of the creation of the Centre is also the widely understood educational activity. It will include the training of scientific staff and also the popularization of knowledge in the social environment.

# ELIXIR.PL

**Entities involved:**

1. *Adam Mickiewicz University in Poznan – Applicant*
2. *Institute of Biochemistry and Biophysics Polish Academy of Sciences*
3. *University of Warsaw*
4. *International Institute of Molecular and Cell Biology in Warsaw*
5. *Poznan University of Technology*

## DESCRIPTION

The ELIXIR.PL infrastructure was initiated by leading bioinformatics centres in Poland taking into account that the data stream dynamics provided by high-throughput experimentation in biology (-omics) significantly exceeds the dynamic growth of computer processing power, as well as the capacity for secure data storage by one centre, even if its well-equipped. Research addressing the major challenges facing our society – such as food security, changing ecosystems and provision of sustainable health care – rests on our ability to connect and compare data from many countries, disciplines and experiments. On the other hand, the common whole genome sequencing and other high-throughput methods generate a gigantic flow of data every day. Analysis of these data leads to the understanding of the functions of living organisms and new solutions in biotechnology and medicine, including personalised medicine. The ELIXIR project, a unique intergovernmental organization combining the resources of life sciences from all over Europe, responds to the challenge of secure storage and effective analysis of these data, through a dispersed pan-European structure based on national hubs grouping leading bioinformatics centres. The project plays a key role in contemporary biology and its application in biotechnology and medicine. The members of the consortium are going to take part in this European endeavour.

## SERVICES

Creating a dispersed infrastructure consisting of the national hub (Adam Mickiewicz University in Poznań) cooperating with the European hub (European Bioinformatics Institute), as well as specialized nodes, will significantly enhance the level of bioinfor-

matic support in Poland. This is extremely important considering the dynamics of high-throughput methods development in life sciences. Membership to the infrastructure is not meant to be just passive support of EBI in the distribution of European bioinformatics resources. Besides building a national infrastructure, the consortium would like to actively participate in pan-European activities focused on the development of tools and analytical pipelines, building databases, distribution of resources, training, standardization and, what is especially important, introducing FAIR principles (Findable, Accessible, Interoperable, and Reusable). The project will result in new bioinformatics services, better access to tools and computing resources located across Europe, including access to anonymised sensitive human data gathered in other member states. It is also envisioned to work together with other ESFRI infrastructures in Poland in order to identify overlapping challenges and needs to minimise duplication of efforts.

## IMPACT

The project has a direct connection with many societal challenges, particularly food security, sustainable agriculture and forestry, marine and inland water research, as well as bioeconomy. It is also strongly connected with health care challenges, especially those related to the diagnostics and treatment of rare diseases as well as diseases of affluence. Considering the growth of genomics and common utilization of big data and machine learning methods in biomedical studies, the project is of great importance for the development of personalized medicine. Hence, it facilitates interdisciplinary research, so that new solutions in the fields above can be found. The project will contribute to progress in Polish science by standardisation of the nomenclature and tools descriptors and by integration of tools and databases developed in Poland into the pan-European collection of specialised resources. Especially important will be the integration of molecular data with resources developed for medical studies, agriculture and marine bioindustry. Thanks to the intensive and coordinated training activities, the project will contribute to an increase in competence of users. In addition, it will strengthen the links with industry and improve transfer of knowledge to various sectors of bioindustry. Last but not least, an integrated infrastructure will undoubtedly have an educational value in transferring better knowledge of modern biomedical research to non-professionals.

# European Centre for Bioinformatics and Genomics (ECBG)

**Entities involved:**

1. *Institute of Bioorganic Chemistry Polish Academy of Sciences – Applicant*
2. *Poznan University of Technology*

## DESCRIPTION

The European Centre for Bioinformatics and Genomics (ECBG) has been in operation since 2007, pursuant to the agreement between the Institute of Bioorganic Chemistry Polish Academy of Sciences (IBCH PAS) and Poznan University of Technology. In 2014, this multi-disciplinary centre, destined for multi-scale and multi-level studies of biological systems, was listed for the first time on the Polish Roadmap for Research Infrastructures. Currently at ECBG, there are over 60 top-class experts in informatics, biology and chemistry. The long-term goal of the Centre is the development and practical application of advanced systems approaches in biological sciences and medicine. The reason is that there is a lot of evidence showing that it is not possible to explore complexed biological processes and mechanisms with the use of, until recently, common reductive approaches, and concentrated around the analysis of single, isolated molecules. It is necessary to create techniques allowing the study of whole genomes, transcriptomes, proteomes or metabolomes, and in further stages – cells, tissues and organisms. The activity of ECBG is based on three main pillars. The first one is laboratories devoted to structural genomics, the second is those dealing with functional genomics, and the third is those operating within the areas of bioinformatics and informatics. Within the framework of the Centre, IBCH PAS is in charge of research conducted in the field of structural and functional genomics, while the Institute of Informatics, Poznan University of Technology is responsible for the field of bioinformatics and informatics.

## SERVICES

ECBG offers access to a remarkably wide spectrum of specialized research equip-

ment and bioinformatics tools destined for: high-resolution structural studies of nucleic acids and proteins in the solid state (bio-crystallography), liquid state (NMR) and in silico; imaging of cellular and sub-cellular structures (ultra-resolution and confocal microscopy); analysis of genomes, transcriptomes, proteomes and metabolomes (micro-arrays, NGS sequencing, mass spectrometry); and integration, analysis, processing and storage of large data sets (Big Data). An important and unique element of ECBG is Poland's first platform allowing to conduct comprehensive archaeogenomic research. In addition, the establishment of two laboratories coupled with each other has recently been initiated. The first one shall deal with mass, parallel, multiomics analyses of single cells, and in the second one, the obtained data shall be analysed with the use of artificial intelligence and machine learning. The studies conducted at ECBG are of a horizontal character, which means that they concern all sorts of living systems, from viruses, bacteria and model plants through cell lines, organoids, to model animals and humans.

## IMPACT

ECBG supports the development of multiple research fields and notions, considered preferential in the state's scientific policy and included in the strategic field of priority directions for the National Research Program (KPB) and Framework Programs of the European Union. Among the seven strategic, interdisciplinary directions of research and developmental work, designated by KPB, at least four are being developed within the framework of research projects implemented at or in cooperation with ECBG. They are as follows:

- diseases of civilization, new drugs and regenerative medicine;
- applied information technologies;
- modern materials technologies;
- natural environment, agriculture and forestry.

Currently, the flagship initiative of ECBG is a project aimed at creating a Genomic Map of Poland. The basic goal of the project is to generate a referential genome, and subsequently a map describing genetic variability of the inhabitants of Poland, including members of ethnic minorities. In addition, it is planned to produce bioinformatics tools and databases identifying connections between the genotype and the phenotype. The infrastructure created within this project shall constitute a proper foundation for further development of genomic studies in our country. ECBG also takes many actions promoting science, ensuring the transfer of knowledge to new generations of specialists in bioinformatics, broadly understood genomics, biomedicine and systems biology. Both IBCH PAS and the Lecture Centre at the Poznan University of Technology are open to students and doctoral candidates willing to explore these fields, and thereby develop their future research careers.

# National Biodiversity Collection of Recent and Fossil Organisms at W. Szafer Institute of Botany, Polish Academy of Sciences (NBC IB PAS)

**Entities involved:**

1. *W. Szafer Institute of Botany Polish Academy of Sciences*

## DESCRIPTION

The research infrastructure of the National Biodiversity Collection of Recent and Fossil Organisms at W. Szafer Institute of Botany, Polish Academy of Sciences (NBC IB PAS) is based on unique in the country's scale and known in the world collections of contemporary and fossil organisms from various systematic groups, collected and studied at the W. Szafer Institute of Botany, Polish Academy of Sciences (IB PAS) for 65 years. These collections, with a total number of specimens of approximately 1.5 million, include paleobotanical objects, vascular plants, bryophytes, fungi, lichen, algae and slime molds from all continents. As part of the NBC IB PAS, new biological data sets have been also created (in the form of a bank of DNA isolates and living organisms' cultures), whose goal is to create a world-wide basis for studying the diversity of organisms. Traditionally, IB PAS collections have been documentation of research and source of reference material in studies on biodiversity and systematics. In connection with the development of modern research methods, incl. genetics, bioinformatics, museum and environmental genomics as well as isotope techniques, it is possible to use these traditional collections in problem-oriented research. They may concern, among others, evolution, molecular biogeography (like analysis of migration pathways of the invasive plants threatening natural biota), biodiversity in the aspect of monitoring climate change as well as ecology and nature protection.

## SERVICES

The NBC IB PAS global collections are both the basic reference point and a source of data for all kinds of the currently conducted research in the field of evolution and biogeography as well as environmental comparative

studies of various habitats, biosystems and continents for both domestic and foreign scientific centres. Open access to scientific resources accumulated in NBC IB PAS provides a broad scientific environment with a source of data for research using the latest techniques in the field of genetics, genomics, chemotaxonomy and metabolomics of organisms. Materials preserved in various forms (dry and wet collections, seed and tissue culture banks, DNA isolates, live cultures) constitute a specific gene bank. The development of research in the field of museum and environmental genomics still requires modernization and expansion of the research infrastructure existing around NBC IB PAS, e.g., by creating a fungi cultures laboratory and a genomics laboratory. The modernization of infrastructure in this direction will provide a great potential for cooperation with both scientific and economic sector. NBC IB PAS resources are currently in traditional open access for all interested parties. Currently, IB PAS aims to provide parallel open electronic access to its collections. The digitization of collections is done by creating digital metadata databases and digital images of objects. In this way, IB PAS is expanding its e-infrastructure to make it available in the digital European research space.

## IMPACT

The creation of NBC IB PAS as a separate structural unit containing all scientific collections (herbarium collections, fungi collections, paleobotanical collections, DNA isolate collections and relevant databases, fungi and algae cultures bank) is part of the latest trends in creating and managing research facilities. The scientific and laboratory infrastructure accompanying NBC IB PAS will allow for effective stimulation of research topics in the field of: analysis of vascular plant and cryptogam genomes, determination of the origin of species, study of evolutionary lines of plants and determination of directions of changes in ecosystem elements, which may help in turn in the restoration of entire ecosystems and the comprehensive use of research results for the environment and the economy. This collection is an important element in diagnosing the causes of global climate and environmental changes and in forecasting their further effects, based on real data. The research infrastructure of the NBC IB PAS will contribute to the dissemination of knowledge about the resources and potential of scientific collections, enrich educational opportunities at various levels of education (in particular doctoral schools) and allow the development of the current and education of the future staff.

# Nuclear Magnetic Resonance – Interdisciplinary Platform for Physico-Chemical Studies. MAGREZ

**Entities involved:**

1. *Centre of Molecular and Macromolecular Studies Polish Academy of Sciences – Applicant*
2. *University of Warmia and Mazury in Olsztyn*
3. *University of Warsaw*
4. *Institute of Molecular Physics Polish Academy of Sciences*
5. *Jerzy Haber Institute of Catalysis and Surface Chemistry Polish Academy of Sciences*
6. *Silesian Centre for Education and Interdisciplinary Research*

## DESCRIPTION

Experimental methods based on Nuclear Magnetic Resonance (spectroscopy, relaxometry and difusometry) hold a leading position among experimental techniques used in chemical, physicochemical and biological laboratories. Recently, medicine has become a field where significant achievements in methods utilizing localised NMR spectroscopy has been made, in addition to the traditional use of Magnetic Resonance Imaging for diagnostic and imaging of soft tissues.

One of the problems of NMR spectroscopy is the low sensitivity of conventional measurements. The solution to that problem is to use the recently developed Dynamic Nuclear Polarization technique. DNP enables signal amplification up to several hundred times by virtue of microwave radiation transferring polarization from unpaired electrons to nuclear spins. This results in a tremendous reduction of time measurements.

Furthermore, it is possible to perform measurements of quadruple nuclei (important in MRI reagents) or 2D $^{13}C$-$^{13}C$ or $^{13}C$-$^{15}N$ correlation spectra with natural isotopic content, which are basically impossible to obtain with classical NMR. This tool is fantastic in the study of catalysis and surface phenomena, where often the key component is in the trace amount. DNP NMR is important in pharmaceutical and material chemistry.

The consortium plans to purchase a DNP SS NMR system. As such systems are currently available only in a few of the best-equipped laboratories in the world, access to this unique technique is still very limited. Investment in such unique equipment in Poland would undoubtedly be an unprecedented event and would increase the attractiveness of domestic and international cooperation.

The aim of the project is to create the most

modern platform in the field of interdisciplinary physical and chemical research supporting the development of innovative methods used in nanotechnology, medicine, pharmacy, biophysical and biochemical sciences.

## SERVICES

The infrastructure created within this project will primarily serve the scientific community located in the field of basic research. It is assumed that the development of the research infrastructure will result in an increase in the quality level of scientific research conducted by Polish scientists, increasing their competitiveness on a global scale. This will be achieved by strengthening their innovative capabilities within already existing research potential and intensifying scientific cooperation between research centres of the Consortium, as well as between other units in Poland or abroad.

The structure and diversity of scientific projects of the participants require the strong cooperation and action in the system of open access.

The offer will meet the interest of commercial entities – pharmaceutical, food and processing industries are keen to reach for such a specialized analytical tool as NMR spectroscopy or relaxometry.

It should be pointed out that access to the project infrastructure will be equal and based on access regulations.

## IMPACT

The MAGREZ platform equipped with the unique DNP SS NMR system will be the one and only such system in Poland. This will result in new interdisciplinary activities in the field of nanotechnology, medicine, pharmacy and energy. These are priority scientific areas at the national and international level. It also fulfils key research/educational objectives and areas indicated in the strategic interdisciplinary directions of research and development work.

The effects of project implementation include scientific, economic, cultural and social aspects:

- significant increase in research activity and increase of the scale of commercialization of research by scientific institutions with direct or indirect participation of industry;
- the obtaining of novel process and product innovations in the area of innovative technologies that have significant capacity for commercialization;
- support for scientists in the implementation of cutting-edge pioneering research;
- an increase in the level of expertise in areas crucial for the development of Polish and international science, which will have a significant impact on the economy.

# Polish Biobanking Network BBMRI.pl

**Entities involved:**

1. *Medical University of Gdansk – Applicant*
2. *Łukasiewicz Research Network – PORT Polish Centre for Technology Development*
3. *Medical University of Warsaw*
4. *Wroclaw Medical University*
5. *Medical University of Lublin*
6. *University of Lodz*
7. *The Regional Science and Technology Centre, Podzamcze*

## DESCRIPTION

The Polish Biobanking Network BBMRI.pl (PBN-BBMRI.pl) is a unique research infrastructure in Poland whose main goal is to harmonise biobanking units and biomolecular resources throughout the country. Poland has been a member of the European BBMRI-ERIC Infrastructure since 2016. The Consortium was created by seven scientific partners. 43 biobanking units for biological material have joined the Network (26 Members and 17 Observers). The main goals and basic tasks of this infrastructure relate to:

- identifying and characterizing the entities interested in entering PBN-BBMRI.pl;
- developing consistent IT solutions for Polish biobanking facilities;
- determining the standards of biobanking biological materials for scientific purposes, implementing common solutions;
- establishing a Leading National Research Centre in the scope of biobanking, keeping the collection of biological material and supervising the implementation of the BBMRI.pl project;
- introducing a uniform quality control system for all stages of functioning of domestic biobanks;
- analysing ethical, legal and social aspects of biobanking human biological material in Poland.

## SERVICES

The creation of PBN-BBMRI.pl, as well as the identification and publication of catalogues of biological samples at the international level, serve to establish multi-centre cooperation between research teams from all over Europe. The BBMRI.pl Consortium provides substantive and technical support for all units and scientists interested in the development of biobanks and biorepositories, both for individual centres and the

entire Biobanking Network in Poland. The project involves the creation of tools that combine biobanks into one efficient infrastructure (coherent IT solutions, introduction of a uniform biobanking quality control system, common ethical, legal and social aspects that are available in the open system). The main goal is to make resources public and increase the possibilities of sharing material for further scientific research (Open Science/Open Data). The goal of these activities is well-developed scientific cooperation between Polish and European biobanks and strengthening of the scientific potential of Polish biobanking units on the international arena. Open access to the resources of Polish biobanks, research results and biomedical data enables cooperation between biobanks, scientific/research institutions and companies from the biotechnology, diagnostic and pharmaceutical sectors.

## IMPACT

Activities conducted by PBN-BBMRI.pl play an important role for the development of scientific and application research in strategic areas:

- cooperation between biobanks, scientific/research institutions and biopharmaceutical and bioinformatics companies contributes to the development of innovative entities that need samples and data collected in biorepositories to conduct preclinical and clinical trials, validate new therapeutic goals and develop diagnostic tools;
- the entities gathered in PBN-BBMRI.pl conduct numerous preventive programs. Based on the collected samples of donors' biological material, it is possible to diagnose their condition and take preventive actions, and the material taken from the sick individuals will be used for preparing improved diagnostic and treatment methods. The implementation of protocols based on ethical recommendations and the creation of social awareness will contribute to increased social trust and the degree of participation of citizens in scientific and research projects in biomedicine;
- the creation of a number of digital solutions enables data exchange and communication between biobanks on domestic and European levels, combining scientific and clinical databases for a better use of collective knowledge, digitisation of data in the form of images allowing for more efficient planning of scientific projects in silico. Such solutions and technological capabilities constitute a natural environment for creating new biotechnical concepts in Poland and encourage already existing entities specialising in biotechnology and pharmacy.

# POL-OPENSCREEN – Polish Infrastructure of Open Screening Platforms for Chemical Biology

**Entities involved:**

1. *Institute of Medical Biology Polish Academy of Sciences – Applicant*
2. *Institute of Biochemistry and Biophysics Polish Academy of Sciences*
3. *Institute of Bioorganic Chemistry Polish Academy of Sciences*
4. *Centre of Molecular and Macromolecular Studies Polish Academy of Sciences*
5. *Institute of Biotechnology and Antibiotics*
6. *Pharmaceutical Research Institute*
7. *Maj Institute of Pharmacology Polish Academy of Sciences*
8. *Institute of Human Genetics Polish Academy of Sciences*

## DESCRIPTION

The POL-OPENSCREEN project, a joint venture of a Polish consortium of the same name, is a part of the European consortium EU-OPENSCREEN ERIC (www.eu-openscreen.eu). The aim of the project, both at the national and European level, is to identify and develop compounds with biological activity for application in science, medicine, biotechnology and other industries. It does so by providing access to the collection of 140.000 small molecules and enabling their evaluation through high-throughput screening, computer optimisation of selected compounds and their chemical follow-up. On the national level, two complementary objectives are pursued:

– creation of the country's first National Library of Chemical Compounds (NLCC) at Institute of Medical Biology Polish Academy of Science by collecting compounds synthesised in national research laboratories and making them available for screening;
– consolidation and strengthening of existing national research infrastructure in order to intensify the screening of chemical compounds.

The Screening Laboratory of Bacteriology-Virology at Institute of Medical Biology Polish Academy of Sciences, the first Polish academic Centre for High-Throughput Screening Studies AGAMEDE at Institute of Bioorganic Chemistry Polish Academy of Sciences in Poznan and a platform for optimisation of compounds at Institute of Biochemistry and Biophysics Polish Academy of Sciences in Warsaw will support the Polish and European scientific community and industry in identification and development of biologically active chemical substances and candidates for commercialisation.

## SERVICES

Chemistry in Poland is one of the fields which has an enormous potential to generate significant innovations in life sciences. While many new chemicals are synthesised in national laboratories every year, only in very few cases systematic tests of their biological activities are carried out. As a result, the application potential of most synthesised compounds remains unnoticed.

In order to address this problem, POL-OPEN-SCREEN is offering competitive, open access tools, know-how and infrastructures:

- NLCC for depositing compounds synthesised at academic centres (Institute of Medical Biology Polish Academy of Sciences). In the first stage, NLCC plans to collect about 10,000 compounds and make them available for testing (2021). Data collected in the database will be accessible to all interested scientific institutions and industry with flexible IP policies to secure interest of all parties;
- fully automated high-throughput laboratory for screening and validation (AGAMEDE-Institute of Bioorganic Chemistry Polish Academy of Sciences) for testing activity of up to hundreds of thousands of compounds. Advanced detection technologies are used to assess biological activity on a single cell level while coupling to Artificial Intelligence improves data analysis and efficiency of identification of bioactives. An additional validation platform will be developed to aid elucidation of mechanism of action to improve translation of initially identified bioactives to practical applications;
- expertise and services in the area of chemoinformatics, modelling and virtual screening for optimisation of active compounds. This can aid screen design for better outcomes and optimisation resulting in bioactive candidates having improved performance in practical applications.

## IMPACT

Small molecule screening is a starting point for the identification of bioactive molecules that can be used for various applications. It can help investigating the molecular basis of biological processes and pathologies and act as an entry point to finding new medicine or active agents suitable for agriculture, cosmetology or environmental applications.

The implementation of the POL-OPEN-SCREEN project, including the creation of NLCC, as well as the screening and validation infrastructure, provides a unique opportunity for the Polish scientific community and allows for better use of research capabilities. In particular, it will be a source of new bioactive molecules, increase the impact of work in synthetic chemistry by exposing compounds to biological screens and maximise probability and efficiency of finding bioactive molecules, including those of commercial utility with Polish-based intellectual property. These will bring advancement in life sciences and create added value for society in the form of new therapies and improvements of other aspects of human life.

In addition, this project already enables participation in the European screening network, allowing for effective know-how transfer, development of personnel in R&D and bringing Polish chemical biology to the forefront of basic and applied research.

# RAPID Centre of Radiation Research and Technology

**Entities involved:**

1. *Institute of Nuclear Chemistry and Technology – Applicant*
2. *National Centre for Nuclear Research*
3. *Central Laboratory for Radiological Protection*
4. *Military Institute of Armament Technology*
5. *Lodz University of Technology*
6. *Warsaw University of Technology*
7. *University of Warsaw*
8. *Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences*

## DESCRIPTION

The RAPID Centre for Research and Radiation Technology of the Institute of Nuclear Chemistry and Technology (IChTJ) is an important research platform for conducting R&D for domestic and foreign scientific institutions, as well as small and medium enterprises in the field of work involving chemistry and radiation technology, carried out using electron beams, accelerated in accelerators with various parameters, covering energy range from 0.2 to 10 MeV and beam power up to 20 kW. The area of activity of the RAPID Centre is the initiation and conduct of scientific research using unique research equipment such as pulse nanosecond radiolysis, used in interdisciplinary research in various fields of natural sciences due to its unique equipment and research capabilities. Application and implementation activities include the possibility of running processes in a continuous mass scale using technological lines including, among others, radiation sterilization and radiation modification of polymers (electric wires, foams, heat-shrinkable products), as well as the possibility of using a pilot installation, particularly useful for assessing the possibility of industrial implementation of individual technological processes, and technologies related to environmental protection such as removal of impurities from the gas phase, sludge sanitation municipal, or sanitation of ocean ship ballast water.

## SERVICES

– open access for domestic and foreign scientific communities to study mechanisms of radical processes using nanosecond impulse radiolysis, characterization of radiation modified natural and synthetic polymer materials, compounds of biological importance, nanomaterials and semiconductors;

- the RAPID Centre has an installation equipped with an electron accelerator (10 MeV, 15 kW) for mass sterilization of a wide range of disposable medical devices as well as implants and transplants. Comfortable, fast, efficient and safe radiation sterilization is carried out based on the Quality Management System in accordance with the PN-EN ISO 13485 standard and GMP requirements, and according to the procedures of the PN-EN ISO 11137 standard (sterilization of materials in unit and collective packaging, short time sterilization, no toxic residue);
- the use of technological lines to guide, among others, a continuous process of radiation modification of semiconductors, electrical wires as well as heat shrink tubes and tapes in order to radically improve their functional properties;
- the possibility of conducting application work prior to industrial implementations using a universal pilot installation equipped with an electron accelerator (0.2–2 MeV, 20 kW), also useful in the implementation of technologies related to environmental protection such as removal of pollutants from the gas phase, sanitation of municipal sediments and ocean ship ballast water.

## IMPACT

Particularly important for scientific research, R&D and implementation works carried out at the RAPID Centre is the possibility of conducting intensive domestic and foreign scientific exchange and the provision of unique services in the field of radiation technology for small and medium enterprises. It is determined by:

- unique apparatus for conducting nanosecond impulse radiolysis, which few scientific laboratories have on a global scale;
- modern scientific apparatus, among others for paramagnetic resonance (EPR), apparatus designed for the characterisation of polymeric materials, three laboratory gamma radiation sources;
- an experienced team in the field of conducting works including R&D, implementation and technology transfer on a national, European and global scale;
- long-term cooperation with the IAEA and international exchange based on joint projects implemented under the status of the RAPID Centre as the ”IAEA Collaborating Centre”;
- conducting an international doctoral study;
- accelerator base enabling the implementation of advanced technological processes into industrial practice. The RAPID Centre has the only accelerator installation in the country for mass radiation sterilization of a wide range of disposable medical devices as well as implants and transplants;
- constant cooperation with the industry in the implementation of a number of joint projects;
- RAPID Centre activities for the transfer of technology, including the organization of training and seminars in the field of radiation technology for domestic and foreign participants.

# Research Infrastructure of Molecules and Cells (IN-MOL-CELL)

**Entities involved:**

1. *International Institute of Molecular and Cell Biology in Warsaw*

## DESCRIPTION

Research Infrastructure of Molecules and Cells (IN-MOL-CELL) will be created within the structure of the International Institute of Molecular and Cell Biology in Warsaw (IIMCB), through the establishment of seven core facilities offering state-of-the-art research methods and technologies together with professional expertise in the field of:

- Structural Biology and Cryo-EM;
- Proteomics, Protein Isolation and Analysis;
- Cellular Models, Organoids and Cell Banking;
- Animal Models (breeding and generating new strains of fish and rodents);
- Genomics and Single-Cell Sequencing;
- Bioimaging and High-Throughput Screening;
- Bioinformatics and Computational Biology.

Integration of these various resources will provide scientists and entrepreneurs from the R&D&I sector with access to comprehensive research services including the use of modern equipment, application of standardised procedures and proven materials as well as consultations with experts.

One of the most important objectives of IN-MOL-CELL is participation in pan-European research infrastructures within the framework of the ESFRI (the European Strategy Forum on Research Infrastructures) Roadmap, in particular in the ELIXIR project: European Life Sciences Infrastructure for Biological Information.

The international character of IN-MOL-CELL is also ensured by IIMCB membership in the EU-LIFE network, an alliance of 14 leading research centres in the field of life sciences, established to support and strengthen excellence in European research.

## SERVICES

IIMCB, having at its disposal the most modern research equipment, and to make full use of its resources, pursues a policy of making its infrastructure and unique expertise widely available to other entities, both scientific and R&D institutions, as well as to entrepreneurs. This approach will also be applied to the provision of IN-MOL-CELL services through:

- sharing of equipment with external users, where they reimburse the cost of materials used. In this model, an external user performs experiments independently or the IN-MOL-CELL specialists conduct them within the framework of scientific collaboration;
- paid research services performed by IN-MOL-CELL staff on request of external users. This model covers individual experiments and larger projects based on bilateral agreements with commercial prices including the costs of consumables, equipment maintenance and repair, and personnel. In case of orders for multi-stage and complex research (e.g. engaging several core facilities), prices of such services will be determined individually. Upon request, confidentiality agreements will be signed and full intellectual property will be transferred to the customer.

Potential users will be offered free-of-charge consultations by IN-MOL-CELL experts before they decide to use the services. Due to the international character of IIMCB and extensive cross-border scientific collaborations, the equipment is made available to foreign institutions on similar terms as to local partners.

## IMPACT

Basic research carried out at the highest professional level, using the Research Infrastructure of Molecules and Cells, will be oriented towards socially important biomedical problems so that ultimately it will be possible to create new therapeutic and diagnostic methods on their basis. One of the priorities of this project is a collaboration with industry and strengthening the potential of Polish companies by sharing IN-MOL-CELL resources and expertise. The offer will be particularly valuable for start-ups, providing access to an integrated platform of research services and excellent professional support. The scientific excellence of the Institute, in connection with cutting edge IN-MOL-CELL equipment and expertise, will raise the quality of research to an even higher level, and the resulting modern research centre will constitute a reference point for biomedical research in Poland. IN-MOL-CELL users will have an opportunity to expand their research interests by those currently poorly represented in our country, such as imaging of the physiology and pathology of tissues, systems and organisms at cellular resolution, studying physiological consequences of epigenetic changes, spatial structure of the genome, dynamics of single-cell interactions with the environment of an organism during the formation and functioning of systems of different levels of complexity (tissues, organs and entire organisms).

# Tech-Safe-Bio – Work Safety & Health Research Centre

**Entities involved:**

1. *Central Institute for Labour Protection – National Research Institute*

## DESCRIPTION

The objective of the Centre is to develop interdisciplinary research to ensure safe and ergonomic working conditions in Poland. The scientific and technical concept of the Centre responds to the challenges related to the transformation of the world of work in a modern economy and aims to support employers and employees in the area of occupational health, safety and ergonomics by transferring R&D results into social and economic practice.

The Centre is expected to strengthen the competitiveness of Polish enterprises and support their transformation towards Industry 4.0. and sharing economy (by implementing R&D results as product, process and management innovations). The Centre will contribute to reducing economic and social losses in Poland resulting from the consequences of improper working conditions estimated at PLN 25 billion per year, according to the ILO methodology.

The Centre is meant not only to support improvement in working conditions, i.e., health and safety conditions and employee protection, but also the social and labour market inclusion, especially of disabled and elderly people.

## SERVICES

The infrastructure may be used and research may be conducted in the following areas:

- development and certification of personal and collective protective equipment using phantoms of human body parts;
- vibroacoustics (impact of vibrations using a high speed camera, research and testing of elements, hearing perception and directionality directivity of hearing of signals as well as sound sources with the use of acoustic cameras);

- electromagnetic field interactions (in case of humans, e.g., research and testing using numerical dosimetry by means of virtual phantoms of the human body, and in case of material objects, e.g., testing of barrier materials parameters and metrological equipment);
- chemical, aerosol and biological hazards (e.g. research using cell culture monitoring and holotomographic microscopy, microbiological research, exposure assessment to harmful biological, chemical and aerosol agents, determination of ultrafine particles in the air, studies of morphology and topography of materials using scanning electron microscopy and energy dispersion spectrometry, research on flame retardancy of polymer materials);
- ergonomics (i.e. assessment of fitness for work, physical and psychosocial aspects of work, assessment of employee ability to perform work and of workstations in terms of ergonomics, thermal load research on a thermal manikins);
- safety of machinery and virtual reality technology (e.g. simulation of surroundings with the use of SEMI-CAVE virtual environment, development of applications and use of VR simulators, i.e., tower crane, gantry crane, passenger car – for training and rehabilitation support, research with the use of motion capture system in a room with a cubic capacity of 770 m3, research on safety of machinery and protective devices, research of functional parameters of new categories of protective systems.

## IMPACT

The Centre's R&D programme includes designing and developing innovative solutions aimed at reducing adverse effects of chemical, physical, biological and psycho-social hazards on humans in the working environment, in order to improve occupational safety in various sectors of the national economy (mainly in the machinery, chemical, construction, electric power, iron and steel as well as telecommunications industry, forestry, agriculture and health care).

Improved labour conditions and improved quality of life in Poland as a consequence of the Centre's activities will have a beneficial impact on the health status of workers. At the same time, the Centre responds to the challenges identified in the country's public policies and development strategies (like re-industrialisation, development of entrepreneurship, social cohesion, demographic changes), including the Strategy for Responsible Development listing "improvement of work safety" as one of the expected effects of innovation growth triggered by re-industrialisation.

Moreover, the research conducted in the Centre will contribute to the knowledge growth in the field of environmental engineering as well as the development of scientific personnel. It will also positively affect specialist services to be provided by accredited laboratories to enterprises and institutions, key to the creation of safe working conditions in the era of dynamic technological and labour changes.

# 4 Physical sciences & engineering

# Infrastructures in this area:

1. ATOMIN 2.0 – Material Testing Centre on an ATOM Scale for an INnovative Economy
2. Centre of Engineering of Cryogenic Materials and Research Equipment
3. Cherenkov Telescope Array (CTA)
4. Cyclotron Centre Bronowice, CCB
5. ELI – Extreme Light Infrastructure
6. ESS – European Spallation Source
7. European Magnetic Field Laboratory+
8. European Synchrotron Radiation Facility
9. E-XFEL – Free Electron Laser
10. FAIR – Facility for Antiproton and Ion Research
11. Hyper-Kamiokande
12. Laboratory of High-Pressure Research and Functionalization on Soft matter and Amorphous Solids: X-PressMatter
13. MNL Maria Neutron Laboratory
14. Nitride Semiconductors Physics and Technology Centre ”GaN-Unipress”
15. Particle Physics Research with the CERN Infrastructure
16. PolFEL – Polish Free Electron Laser
17. Polish LOFAR – a Low Frequency Radio Interferometer. System Development: LOFAR 2.0
18. Polish UV Satellite System – UVSat
19. SOLARIS National Synchrotron Radiation Centre
20. SPIRAL2
21. Vera C. Rubin Observatory (formerly The Large Synoptic Survey Telescope)
22. Very Long Baseline Interferometry (VLBI) Station at N. Copernicus University in Torun
23. Virgo – Gravitational-Wave Observatory.

# ATOMIN 2.0 – Material Testing Centre on an ATOM Scale for an INnovative Economy

**Entities involved:**

1. *Jagiellonian University in Cracow*

## DESCRIPTION

The ATOMIN 2.0 project aims at reinforcing the potential of the existing equipment park of the combined group of laboratories of the Faculty of Chemistry, as well as the Faculty of Physics, Astronomy and Applied Computer Science of the Jagiellonian University, for implementing breakthrough research programmes in the field of advanced material design. These materials are expected to have specific properties allowing their application in key areas of life defined by major societal challenges. The reinforcement will be done in two ways: through purchasing unique new research equipment, and equipping existing devices obtained during the ATOMIN project, which was the starting point for 2.0, where the latest modules will enhance their analytical possibilities.

Carrying out the ATOMIN 2.0 project will make it possible to take another step forward in the development of innovative applied research. This means to move the emphasis onto material research in a quest for new advanced materials necessary for meeting challenges emerging in such economy sectors as telecommunication, energy production, medicine, or environmental protection.

## SERVICES

ATOMIN 2.0 will be carried out in a unique environment. The national and European uniqueness originates from the fact that ATOMIN 2.0 facilities are situated on the modern campus renovated for the 600th Anniversary of the Jagiellonian University, next to strategic national scientific centres (including the SOLARIS synchrotron), and the Cracow Technology Park. The implementation of a number of specific research projects within four areas perfectly fits into three out of seven main societal challenges defined in “Horizon 2020”: Health; Secure,

clean and efficient energy; and Climate action, environment, resource efficiency and raw materials; as well as contributing to some other areas.

The ATOMIN 2.0 project will, on a regional scale, act as a spur for development in the sectors identified as National Smart Specialisations (NSS): Healthy society; Biotechnological and chemical processes, bio-products and products of specialised chemistry and environmental engineering; High efficiency, low-emission and integrated manufacturing, storage, transmission and distribution of energy systems; Multifunctional materials and composites with advanced properties, including nano-processes and nano-products; Sensors (including biosensors) and smart sensor networks; Printed, organic and flexible electronics and Photonics. The focus on the above-mentioned areas does not exclude potential influence on the growth of competitiveness and innovativeness within other branches of the NSS.

## IMPACT

Within the framework of the ATOMIN 2.0 project, consisting of 24 laboratories, novel interdisciplinary research supported by computer modelling has been conducted in the following areas: TECHNO – new materials and technologies, BIO – biotechnology, nano-biotechnology, bioengineering, medical diagnostic techniques, biomaterials and pharmaceuticals, and INFO – information technologies and computational sciences. The research infrastructure built within the framework of the ATOMIN project has enabled cooperation with leading research centres in Europe. It has also allowed scientists to successfully obtain research grants and orders in the research and development sector and effectively compete for industrial contracts and projects. The potential of the research equipment has allowed researchers to conduct investigations aimed at solving complex scientific problems. The wide range of research equipment available in the laboratories meets the needs of the local research community.

The research infrastructure has been put at the disposal of research groups from various local, regional and national institutions. Moreover, close cooperation with numerous European partners has been established. On this basis, the implementation of the ATOMIN 2.0 project will allow the Jagiellonian University to improve its competitiveness on the European level as well as increase its global recognition and ability to successfully obtain EU grants. It will also attract foreign researchers, making them more willing to establish their own research teams in Cracow.

# Centre of Engineering of Cryogenic Materials and Research Equipment

**Entities involved:**

1. *Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences – Applicant*
2. *AGH University of Science and Technology*
3. *Cracow University of Technology*

## DESCRIPTION

The Centre of Engineering of Cryogenic Materials and Research Equipment (CIKMUB) is a research infrastructure consisting of the Division of Scientific Equipment and Infrastructure Construction at the Henryk Niewodniczanski Institute of Nuclear Physics at the Polish Academy of Sciences, the Academic Centre for Materials and Nanotechnology at the AGH University of Science and Technology and the Laboratory of Extreme Low Temperatures at the Faculty of Mechanical Engineering at the campus ”Czyżyny” of the Cracow University of Technology. CIKMUB is a consolidation of a unique distributed infrastructure for research of this kind in Poland. The research program applies to materials and structures operating at low and extremely low temperatures. In equipment working at temperatures close to absolute zero (f.ex. superconducting magnets), construction materials, such as austenitic steels, copper, aluminium are used, as well as composite structure materials, such as multifilament superconductors NbTi, Nb3Sn or MgB2 in a copper matrix, high-temperature superconductors: YBCO, BSCCO and FeSC sputtered on metal tapes. Different phenomena can be observed in these materials when working in extremely low temperatures: the phenomenon of discontinuous plastic flow or the phenomenon of evolution of micro-damages, which may lead to rapid destruction of the structure. The design and building of working structures at combined loads in extremely low temperatures, is, among others, foreseen in this research program.

## SERVICES

CIKMUB offers the possibility of comprehensive research, including:

- basic research in the field of unconventional superconductivity in thin metallic layers, heavy fermion superconductors, magneto-transport in monocrystalline topological insulators;
- the study of mechanical properties of materials used at low temperatures, such as performing static stretching expansion/compression in testing machine in temperatures ranging from room temperature to the temperature of liquid nitrogen (77K), performing stress tests at temperatures close to absolute zero (4.2K), performing recurring loads in cryogenic temperature range (4.2K–77 K);
- strength analysis and structural materials used at extremely low temperatures as well as physical phenomena occurring in these materials;
- applied research of materials and equipment built with the use of these materials and operating at cryogenic temperatures;
- design of constructions working in cryogenic conditions such as:
  - low temperature compensating systems based on bellows;
  - curled thermal screens in cryogenic technology;
  - heat exchangers operating in liquid and superfluid helium;
  - superconducting magnets;
  - superconducting power transmission lines;
  - magnetic lenses in systems generating neutrino beams.

## IMPACT

The consolidation and the development of the distributed research infrastructure within CIKMUB provides the possibility to implement from a rich research program, including the design, modelling, and testing of materials and design, and construction and testing equipment at temperatures close to absolute zero. CIKMUB, as a consolidated research infrastructure, will allow to develop a unique complex of research laboratories in Poland and to integrate the research equipment for analysis, modelling and testing of materials and devices at cryogenic temperatures. Modern laboratory facilities will allow CIKMUB for even more complete participation in future international projects, related to the design of particle accelerators, the construction of the lossless superconducting power transmission network or improving devices for magnetic resonance imaging, using superconducting magnets operating at a temperature of liquid helium. CIKMUB will allow for the implementation of projects in response to major societal challenges defined in the EU framework program for research and innovation ”Horizon 2020”, particularly in terms of secure, clean and efficient energy. Basic and applied research of materials and equipment at cryogenic temperatures will be a significant step in the development of e.g.: innovative technology of transmission and storage of power, superconducting electronics or space technologies which are consistent with the Strategy for Responsible Development.

# Cherenkov Telescope Array (CTA)

**Entities involved:**

1. *Jagiellonian University in Cracow – Applicant*
2. *Nicolaus Copernicus Astronomical Centre Polish Academy of Sciences*
3. *Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences*
4. *Space Research Centre Polish Academy of Sciences*
5. *University of Warsaw*
6. *University of Lodz*
7. *AGH University of Science and Technology*
8. *Nicolaus Copernicus University in Torun*
9. *University of Zielona Gora*
10. *National Centre for Nuclear Research*
11. *Warsaw University of Technology*
12. *University of Bialystok*

## DESCRIPTION

The Cherenkov Telescope Array (CTA) is a large international research project in the field of high energy astrophysics, which, partially thanks to a Polish effort, became part of the ESFRI Roadmap.

Based on experiences with currently operating observatories H.E.S.S., MAGIC and VERITAS, a novel design for CTA has been implemented, allowing a substantial sensitivity increase by an order of magnitude in an unprecedentedly wide energy range, extending from 20 gigaelectronvolts up to 300 teraelectronvolts.

CTA measurements are based on the registration of Cherenkov radiation from atmospheric particle cascades generated by gamma-ray photons reaching Earth from space. These emissions are registered with arrays of specialised optical telescopes involving three telescope sizes, a ”small-sized telescope” with a 4 m mirror dish, a ”medium-sized” with a 12 m mirror dish, and a ”large-sized telescope” with a 23 m mirror dish diameter. The Cherenkov Telescope Array Observatory (CTAO) infrastructure will include two observatories, one for each hemisphere, allowing researchers to study gamma-ray sources over the full sky. The southern observatory will be located at an ESO site in Chile, and the northern one will be erected on La Palma island in Spain, while CTAO will have its headquarter in Bologna and data storage and analysis centre in DESY Zeuten near Berlin.

Though the CTA collaboration involves groups of scientists and engineers from more than 30 countries on five continents, the leading role is played by European countries. In Poland 13 scientific institutions are involved in the project, collaborating within the Polish Consortium of the Cherenkov Telescope Array Project.

## SERVICES

The conditions for future use of the infrastructure are being negotiated as part of the ERIC agreement, which will be the basis for CTAO construction and operation. It is expected that the observatory will be available for scientists in two ways. First, the researchers who are members of the international CTA Collaboration will use a significant part of the observational time to carry out studies of "key science projects" that include some of the most important research topics. Second, the remaining part of the observational time will be distributed in the form of competitions between applications made by individuals or groups of researchers, also from outside the CTA Collaboration. After a certain period of time, all CTA data will become public, free for use by all scientists.

The CTA is intended for purely research purposes; there are no plans to use it for industry or economy. However, it is expected that a number of novel technical designs and technologies developed in CTA institutions will prove to be useful and finally applied in several other research projects as well as in parts of the economy promoting novel technologies.

## IMPACT

CTAO operation will allow researchers to significantly extend the scope of studies in astrophysics, cosmology and fundamental physics. The research topics include cosmic particle accelerators: sources of cosmic rays. Many different types of astronomical objects will also be investigated, such as active galactic nuclei with their central supermassive black holes, relativistic jets and extended radio structures, gamma-ray bursts originating from distant regions of the observable universe, or very weak magnetic fields in intergalactic voids. The CTA will also enable studies closer to our Solar System such as, for instance, powerful supernova explosions and processes in their remnants or stellar mass black holes and neutron stars in such objects as microquasars and pulsars with their nebulae. In all these studies, the CTA will provide an important complementary channel in current multiwavelength and multimessenger studies, which also involve cosmic neutrinos, gravitational waves and ultra-high energy cosmic rays. A particularly important research goal for CTA is the search for dark matter particles. Equally important is revealing the quantum characteristics of space-time, possibly coded in gamma-ray photons that are registered.

This exceptionally wide range of planned studies will be an important element in the development of modern astronomy and physics, both in their theoretical and experimental aspects. During the construction of the observatory as well as during its operation, scientists and engineers will also develop innovative technical and computer science solutions with a broader, non-scientific scope of application.

# Cyclotron Centre Bronowice, CCB

**Entities involved:**

1. *Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences*

## DESCRIPTION

The Cyclotron Centre Bronowice (CCB) is a part of the Institute of Nuclear Physics of the Polish Academy of Sciences (IFJ PAN). The facility is based on the C-235 Proteus cyclotron and is designed for advanced proton radiotherapy and experimental research. The cyclotron accelerates protons to the energy of 230 MeV, which enables proton radiotherapy to be applied at all locations in the patient. The beam is brought to an experimental hall of 100 m2 floor area and 5.5 m height, dedicated to research, mainly in nuclear physics. Currently, the following nuclear research detector systems are in operation: the PARIS gamma calorimeter, large volume LaBr3 scintillators, the BINA (Big Instrument for Nuclear reaction Analysis), HECTOR (High Energy gamma-ray detector) and KRATTA (KRAkow Triple Telescope Array).

The medical part of CCB consists of three treatment rooms: one with a horizontal 70 MeV proton beam line for ocular radiotherapy, and two rooms equipped with rotating gantries, which allow the patient to be irradiated from any direction (00–3600). Both gantries are equipped with dedicated IBA nozzles, allowing irradiation fields of up to 30x40 cm to be applied, using proton Pencil Beam Scanning (PBS) technology. The position of the patient is maintained using a robotic positioning system, X-ray imaging and optical verification systems. For treatment of paediatric patients, anaesthetic columns and units are available. Dedicated dosimetry equipment is available for clinical dosimetry and quality control of the therapeutic beams.

It is planned to further extend the CCB facility by adding another, larger experimental hall, modern calibration laboratories with Co-60 and MV X-rays beams and dedicated PET and MRI scanners.

## SERVICES

CCB offers Trans National Access to experimental facilities for foreign scientists within two Horizon 2020 projects: ENSAR2 and INSPIRE https://inspire.ifj.edu.pl/. Free-of-charge access to these facilities is available to those who enter bilateral cooperation agreements. Together with external organizations, CCB will host experiments within projects jointly approved.

Radiotherapy

Proton radiotherapy has been performed at the facility since 2016, under contracts between several medical institutions and IFJ. Patient treatment is performed by these institutions and the operation of the CCB facility, including dosimetry, while partial patient treatment planning and patient irradiation are performed by state-certified IFJ PAN medical physicists and nuclear engineers. More information is available at https://ccb.ifj.edu.pl/en.home.html.

Nuclear Physics

On a yearly basis, an International Advisory Committee reviews and accepts submitted proposals for new experiments in nuclear physics. In beam time allocation, proton therapy has priority, so nuclear physics experiments are usually scheduled over nights and weekends. More information is available at https://experimentsccb.ifj.edu.pl/

Radiobiology

CCB hosts radiobiology experiments using cellular and animal systems. Two dedicated radiobiology rooms are equipped with basic tools for biology experiments (microscopes, freezers, cold room, centrifuges, etc.). An animal farm-house is available at IFJ PAN for handling experiments with small animals (rodents).

Medical Physics

Modern dosimetry and beam measurement equipment, dedicated to proton therapy, (ionization chambers, planar detectors, 2D scintillation, diamond detectors, thermoluminescence and alanine detectors) are available for measurements and experiments in medical physics and clinical dosimetry.

## IMPACT

CCB is the only proton therapy centre and the only accelerator centre in Poland to provide energetic proton beams for research and radiotherapy. Therefore, CCB offers unique opportunities for training PhD students, young scientists and engineers to use ultra-modern research equipment at research institutions in Poland and in Europe. Moreover, CCB offers hands-on and theoretical training for medical physicists in clinical dosimetry, quality control and treatment planning. An important part of the CCB mission is research in the field of radiobiology, including current hot-topics, such as FLASH therapy, interaction of protons with chemotherapy agents and nanoparticles in medical research. Access to this modern facility stimulates research and development in the bioengineering fields of detector development, radiation dosimetry, accelerator engineering and beam control.

# ELI – Extreme Light Infrastructure

**Entities involved:**

1. *Military University of Technology – Applicant*
2. *AGH University of Science and Technology*
3. *Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences*
4. *Institute of Plasma Physics and Laser Microfusion*
5. *Institute of Physics of the Polish Academy of Sciences*
6. *National Centre for Nuclear Research*
7. *Warsaw University of Technology*
8. *Wroclaw University of Science and Technology*
9. *University of Bialystok*
10. *Jan Kochanowski University in Kielce*
11. *University of Warsaw*

## DESCRIPTION

The interaction of laser radiation pulses with matter at radiation intensity above $10^{23}$ $Wcm^{-2}$ is the main subject of research planned for ELI – Extreme Light Infrastructure. Such high radiation intensity will be obtained by producing laser pulses with a duration below 10 fs, with energy in the pulse above 10 kJ. This will allow the study of matter exposed to very strong fields and measurements of the dynamics of processes occurring in the femto- and attosecond time scale (1 as = $10^{-18}$ s). The ELI research infrastructure consists of three infrastructures, located in Czechia (ELI-Beamlines), Hungary (ELI-ALPS) and Romania (ELI-NP). Research objectives and programs are different for individual constituent infrastructures. The ELI-Beamlines infrastructure program deals with laser-driven production of X-ray and ultraviolet pulses as well as high-energy particle beams. The goal of the program is to develop new X-ray sources and particle accelerators, and their applications in various fields of science and modern technology. The research program for the ELI-ALPS infrastructure concerns the generation of ultra-short radiation pulses in the attosecond range. The goal of the program is to develop sources of such pulses and their application in investigating the dynamics of ultrafast processes. The research program for the ELI-NP infrastructure concerns the use of high-power pulsed lasers in nuclear physics. The main goal of the program is to develop a new type of pulsed γ radiation source based on Compton scattering of the laser beam on high-energy electrons.

## SERVICES

The ELI infrastructure offers unique, high-power pulsed laser systems that will enable pioneer research in various fields of

science and technology. The ELI-Beamlines infrastructure will be equipped with three laser systems generating pulses of 203- fs duration, pulsed power from 5 TW to 1 PW and repetition rate from 1 kHz to 10 Hz, respectively. In addition, the infrastructure will have a system generating laser pulses with a duration of 150 fs and a pulsed-power of up to 10 PW with a repetition rate of 1 min. These systems will enable the research of new laser technologies, X-ray generation and particle acceleration as well as strong interactions. The ELI-ALPS infrastructure will be equipped with a variety of sources of ultra-short pulses of electromagnetic radiation in a wide spectral range, used to study ultrafast physical processes in the femto- and attosecond ranges. The pulses will be produced using several laser systems based on the parametric amplification of ultra-short laser pulses (OPCPA), which will allow the generation of laser pulses with a duration less than 5 fs with a repetition rate of 150 kHz. The ELI-NP infrastructure will offer two unique research devices: a two-beam laser system generating pulses with a duration of several dozen fs and pulsed power of up to 10 PW in each beam, and a source of γ radiation pulses.

## IMPACT

The ELI infrastructure is unique on a global scale. Its importance for modern science lies in the fact that the infrastructure includes the world's largest, so far non-existent, high-power pulsed laser systems that will allow for conducting experimental research which were previously impossible to perform, for example in the field of relativistic quantum electrodynamics. In addition to the main area of research, which is the interaction of laser pulses with matter at extremely high radiation intensities, the ELI infrastructure will also be widely used in many other areas of modern science and technology. This is due to, by the use of high-intensity and ultra-short laser pulses, the possibility of producing high power beams of electromagnetic radiation in a wide range of photon energy (or wavelength), from γ radiation and X-rays to long-wave radiation in the terahertz (THz) range and intensive streams of charged particles accelerated to very high energy. The parameters of the generated radiation and the accelerated streams of charged particles and electromagnetic radiation beams, will far exceed the parameters of radiation generated by traditional methods.

# ESS – European Spallation Source

**Entities involved:**

1. *Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences – Applicant*
2. *National Centre for Nuclear Research*
3. *Wroclaw University of Science and Technology*
4. *Lodz University of Technology*
5. *Warsaw University of Technology*

## DESCRIPTION

The European Spallation Source, ESS, is a large-scale multidisciplinary European research facility and a major technical undertaking, covering the construction and operation of the world's strongest pulsed neutron source. The neutrons are released as a result of nuclear spallation processes that occur in a tungsten target bombarded with the proton pulses from a linear accelerator. After moderation, the neutrons are directed to a number of unique scattering instruments (diffractometers, spectrometers, reflectometers), allowing the advanced experiments to be performed in the fields of physics, chemistry, material and engineering sciences, medicine, biology and earth sciences. The research using neutrons offer complementary methods to, for example, synchrotron radiation techniques. The demand for access to neutron scattering instruments by far exceeds their availability in the now-operating facilities. Very intense neutron beams are needed to study very small samples, or phenomena, as they occur in real time, or to carry out the most ambitious experiments such as with polarized beams. Since 15/08/2015 ESS has the status of an ERIC (European Research Infrastructure Consortium). Poland is one of its 15 founding members.

## SERVICES

Access to the infrastructure will be given to scientists from the countries participating in the operational costs, based on a competition of experimental proposals.
The following research instruments were approved for implementation:

1. Diffractometers:
   - DREAM – a powder variable resolution diffractometer for materials research;

- HEIMDAL – a hybrid diffractometer for materials research in a wide range of scattering vector;
- MAGIC – a diffractometer for studies of magnetism in single crystals;
- NMX – for soft and molecular matter.

2. Spectrometers
   - CSPEC – a high performance direct geometry spectrometer. For chemistry, functional materials, life sciences;
   - T-REX – a spectrometer capable of working with polarized neutrons. Excitations in small single crystals and quantum and molecular magnets;
   - BIFROST – an extreme conditions spectrometer. Magnetism and superconductivity, as well as earth sciences, functional materials;
   - VESPA – a spectrometer with universal application;
   - MIRACLES – a backscattering spectrometer.
3. Large scale structures:
   - LoKI – a high-performance broadband small angle scattering (SANS) instrument;
   - SKADI – a high resolution SANS instrument;
   - ESTIA – a focusing horizontal reflectometer. Research on interfaces, layers and boundaries, including their magnetic properties;
   - FREIA – a horizontal reflectometer for layers and interfaces in liquid samples, including deep layers.
4. Engineering and neutron imaging
   - ODIN – a multi-task instrument for neutron imaging;
   - BEER – a diffractometer for engineering applications.

## IMPACT

At the stage of construction and commissioning, the extensive ESS infrastructure ensures the involvement of very highly qualified engineering and technical staff, enabling them to participate in the most technologically advanced undertaking and thus associating it with national employment centres, but also ensuring the flow of technical thought (know-how) and the latest technologies, with great benefit for innovation in future development.

During steady-state operation, together with continuous engineering support, a new impact factor comes into play, e.g. those concerning research staff. Participation in the ESS gives the opportunity to engage in scientific research at the world's highest level, carried out using top-class scientific instruments, as well as to maintain creative contacts with the European and global research community. This applies especially to the most talented and most creative young researchers.

In many research areas neutron scattering methods are routinely used with great success. A few examples are for: the investigation of new energy sources, research on materials for energy storage, testing residual stress in machine elements, the study of supported catalysts, research on new drug carriers in targeted therapy, research on the interaction of nanoparticles with biological membranes, and non-invasive studies of works of art and monuments of antiquity.

Research which may be conducted at ESS directly refers to the specific Objective of the Responsible Development Strategy, which reads: Sustainable economic growth increasingly driven by knowledge, data and organizational excellence.

# European Magnetic Field Laboratory+

**Entities involved:**

1. *University of Warsaw – Applicant*
2. *Institute of Physics of the Polish Academy of Sciences*
3. *Institute of High Pressure Physics of the Polish Academy of Sciences*
4. *Łukasiewicz Research Network – Institute of Electron Technology*
5. *Łukasiewicz Research Network – Institute of Electronic Materials Technology*
6. *Institute of Molecular Physics Polish Academy of Sciences*
7. *Wroclaw University of Science and Technology*
8. *Nencki Institute of Experimental Biology Polish Academy of Sciences*
9. *Institute of Low Temperature and Structure Research Polish Academy of Sciences*

## DESCRIPTION

The European Magnetic Field Laboratory+ (EMFL+) supports Polish participation in the European Magnetic Field Laboratory (EMFL). The EMFL was created as an answer to fragmentation of infrastructure, duplication of R&I efforts in many centres and a lack of coordination at the regional, national and international levels. EMFL is an international structure comprising three host members: High Magnetic Field Laboratories in France, (Grenoble, Toulouse), in Germany (Dresden), and the Netherlands (Nijmegen) as well as the University of Nottingham, the United Kingdom, the University of Warsaw, Poland, and the CEA Institute of Research into the Fundamental Laws of the Universe, France. The EMFL is an ESFRI Landmark. Its mission is to promote scientific research in high magnetic fields specifically by:

- providing access to the high field infrastructures in the hosts;
- the coordination of activities aimed at strengthening the potential of research in high fields;
- the stimulation of international cooperation in the area of the high-field research.

## SERVICES

The mission of the EMFL+ is to support the execution of research projects in the existing EMFL infrastructure, to broaden the community of researchers interested in using high magnetic fields as a tool in their studies, and to stimulate interactions between the research groups in Poland already involved in such studies.

The project also comprises the implementation of Regional Magnetic Field Laboratories, which have unique capabilities that would be complementary to those existing in EMFL. They will offer specific experimental possibilities in intermediate magnetic

fields. Although the experimental techniques which will be provided are present in facilities across the country, the added value of this project results from their combination with conditions of intermediate magnetic fields. Those techniques are e.g. ultrafast optical spectroscopy, also in terahertz regime, scanning tunneling microscopy or angle-resolved photoelectron spectroscopy (ARPES) with a UV laser.

The main areas of interest for Polish researchers are:

- new materials and functional systems including semiconductor and magnetic semiconductor nanostructures, two-dimensional materials and perovskites;
- transition metal and rare earth ions in inorganic and organic compounds, of prime importance for applications such as: phosphors for white light emission, scintillators for medical applications, and in nuclear radiation dosimetry;
- research on metallic structures by means of magnetic, electric and X-ray methods including strongly correlated fermions, systems with metamagnetic transitions, with spin ice phases and others.

## IMPACT

High magnetic fields enable to study, modify, and control matter in several areas of science from physics and materials engineering to chemistry and life sciences. Technological applications include the characterization of superconducting materials and new low-dimensional materials. In the past, the employment of high magnetic fields enabled the discovery of several fascinating properties of two-dimensional systems and thus led to the discovery of the quantum Hall effect, the fractional quantum Hall effect, and the fascinating electric properties of graphene. The discoveries have been awarded with Nobel Prizes.

The potential of research in magnetic fields also covers other areas, which until now have not been the main focus of Polish researchers. Magnetic fields can be applied in metallurgy to study microstructure solidification processes and to study the thermo-physical properties of high-reactive materials such as titanium alloys for aerospace applications, zirconium compounds in nuclear applications or lithium in nuclear fusion.

The Laboratories will respond to the needs of the developing and diverse research community of Polish users and will allow the testing of new ideas and techniques as well as training new generations of researchers.

# European Synchrotron Radiation Facility

**Entities involved:**

1. *Institute of Physics of the Polish Academy of Sciences – Applicant*
2. *University of Silesia in Katowice*
3. *Institute of Physical Chemistry Polish Academy of Sciences*
4. *AGH University of Science and Technology*
5. *University of Warsaw*
6. *Institute of Paleobiology Polish Academy of Sciences*
7. *Gdansk University of Technology*
8. *University of Bialystok*
9. *Warsaw University of Technology*
10. *Silesian University of Technology*
11. *Military University of Technology*
12. *Institute of Metallurgy and Materials Science Polish Academy of Sciences*
13. *Adam Mickiewicz University in Poznan*
14. *Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences*
15. *Jan Kochanowski University in Kielce*
16. *Institute of Nuclear Chemistry and Technology*
17. *Institute of High Pressure Physics of the Polish Academy of Sciences*

## DESCRIPTION

The European Synchrotron Radiation Facility (ESRF) in Grenoble is an international scientific institute. The ESRF generates and delivers synchrotron radiation to 44 research stations (beamlines). They are available to scientists from countries that are part of the ESRF Consortium and contribute financially to the budget. France, Germany, Italy, United Kingdom, Spain, Switzerland, Russia, the BENESYNC Consortium consisting of Belgium and the Netherlands, the NORDSYNC Consortium consisting of Denmark, Finland, Norway and Sweden have a full membership, with a contribution at least of 4% of the infrastructure budget. Poland is an associated member with a 1% contribution.

In the ESRF, basic and applied research in physics, chemistry, molecular biology and material science are carried out. Synchrotron radiation is indispensable in the study of materials and proteins for modern technology, medicine, pharmacology, biology, chemistry and even in research on cultural heritage.

Currently, the ESRF is at the final stage of ring modernization. After that it will become the most modern radiation source with wide energy range and extreme brilliance and stability of the beam (EBS – Extremely Bright Source). There are 4 new beamlines at the implementation stage (flagships beamlines) which will take full advantage of the properties of new EBS. In March 2020, the first call for beamtime has been carried out on a new modernized source. The first experiments were planned for August 2020.

## SERVICES

The construction and operation of the largest and most modern synchrotron radiation source in Europe, which is the ESRF, enable faster progress in basic science, in solid state

physics (including investigations of materials used in electronics, studies under extreme condition i.e. under high pressure, high temperature and high magnetic field), in surface physics, physics and chemistry of polymers, chemistry, ecology, geology, molecular biology, medicine and also at the border of these disciplines.

The ESRF scientific program is formed by ranking the submitted proposals done by the International Peer Review Committee. The Committee consists of Specialized Teams of outstanding international experts in given fields. The main criterion for obtaining beamtime is the scientific quality of the proposal. Access to the beam is free for researchers from the countries that are part of the ESRF Consortium. The main condition is that the results should be published in scientific journals. The management of the ESRF ensures that the beamtime of researchers from a given country corresponds with the contribution made by that country. The ESRF also offers scientific expertise for a given industry, on commercial terms. Trainings and open days for companies are being organized. In addition, many European companies cooperate with research centres as part of R&D and perform joint research also using synchrotron radiation. The criterion that determines the payment for the research is the possibility of publishing the obtained results.

## IMPACT

The ESRF provides access to sophisticated instruments and enables research at the highest level globally. Beamlines are equipped with the most modern equipment which is constantly being improved. The source's needs stimulate progress in high vacuum technology, X-ray optics as well as in methods of detection, registration, data analysis and storage. Thanks to this, scientists have the opportunity to perform innovative experiments which cannot be carried out outside the ESRF.

Access to the most modern research infrastructure facilitates work on expanding knowledge and technology and contributes to the development of innovation. The examples of the research are studies related to new, more effective, less toxic remedies and diagnostic techniques. They have a significant impact on the social challenges related to Health and Food Security, along with the studies on marine and inland water pollution and the bio-economy. The research on new energy sources and materials for the construction of more efficient batteries and accumulators as well as energy-saving devices are directly related to renewable, Secure, Clean and Efficient Energy. The subjects of research carried out in the ESRF are wide, as evidenced by the number of publications, which is on average around 1800 per year.

# E-XFEL – Free Electron Laser

**Entities involved:**

1. *National Centre for Nuclear Research – Applicant*
2. *Institute of Physics of the Polish Academy of Sciences*
3. *Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences*
4. *Institute of Plasma Physics and Laser Microfusion*
5. *Institute of High Pressure Physics of the Polish Academy of Sciences*
6. *Wroclaw University of Science and Technology*
7. *Wroclaw Technology Park*
8. *Warsaw University of Technology*
9. *Łukasiewicz Research Network – Tele and Radio Research Institute*
10. *Łukasiewicz Research Network – Institute of Electronic Materials Technology*
11. *Lodz University of Technology*
12. *Military University of Technology*
13. *University of Warsaw*
14. *AGH University of Science and Technology*
15. *West Pomeranian University of Technology in Szczecin*
16. *Prevac*
17. *Łukasiewicz Research Network – Institute of Electron Technology*
18. *Cracow University of Technology*
19. *Jan Kochanowski University in Kielce*
20. *University of Bialystok*
21. *Adam Mickiewicz University in Poznan*
22. *Institute of Paleobiology Polish Academy of Sciences*
23. *Warsaw University of Life Sciences*
24. *Poznan University of Medical Sciences*
25. *Institute of Biochemistry and Biophysics Polish Academy of Sciences*
26. *International Institute of Molecular and Cell Biology in Warsaw*

## DESCRIPTION

The European, the world's largest X-ray free-electron laser generates ultrashort laser X-ray light flashes and with a brilliance that is a billion times higher than the best conventional X-ray radiation sources. To construct and operate the European XFEL, international partners agreed on the foundation of an independent research organization – the European XFEL GmbH, a non-profit limited liability company under German law. The company employs more than 400 people. At present, 12 countries are participating in the project: Denmark, France, Germany, Hungary, Italy, Poland, Russia, Slovakia, Spain, Sweden, Switzerland, and the United Kingdom. As it has been realized as a joint effort of many partners, the European XFEL GmbH cooperates closely with the research centre DESY and with other organizations worldwide. It's construction started in early 2009 and the costs amount to 1.54 billion euro (price levels of 2018). User operation began in September 2017. The world's largest X-ray laser is opening up completely new research opportunities for scientists and industrial users including new areas of research that were previously inaccessible. At the European XFEL, international research groups can use complex experiment stations to perform their experiments for a few days or weeks.

## SERVICES

The European XFEL generates X-ray radiation with properties similar to those of laser light. The X-ray flashes of the European XFEL enable a large variety of very different experiments at several different experiment stations. The experiments are similar in their basic setup. Depending on the experimental requirements, the X-ray flashes can be widened, focused, filtered, or weakened using optical elements such as mirrors, gratings, slits, or crystals. The samples are provided in the experiment station, where they interact with the X-ray flashes. The results of these interactions are measured using special detectors. The data is recorded and processed for analysis. The European XFEL is a research facility open to scientists worldwide. Beamtime is free of charge, but experiment proposals must go through a peer-review process. Proposals must be submitted through a User Portal in the frame of specific calls for proposals and will be chosen depending and their scientific excellence.

In addition, the Industrial Liaison Office (ILO) serves as a bridge between the publicly funded research and development at European XFEL and private industry. It attracts the engagement of industry in the Big Science market for the supply of cutting-edge components and engages industry in using the full potential of the European XFEL.

## IMPACT

With its special characteristics of ultrashort pulses and ultrahigh brilliance, the European XFEL will create new opportunities in many areas of research. Using the European XFEL, scientists are able to map the atomic details of viruses and cells, take three-dimensional pictures of the nanocosmos, film chemical reactions, and study processes similar to those occurring deep inside planets.

The wavelengths of the X-ray flashes are so small that it is possible to research the composition and structure of complex biomolecules and materials on the atomic scale. Research at European XFEL helps to gain a better insight into the structure of biological cells and develop new materials with optimized properties. In addition, the X-ray flashes are so short that scientists are able to use them to film ultrafast phenomena such as the formation or breakup of chemical bonds. Research at the European XFEL enables scientists to better understand chemical processes, with the possibility of developing more efficient industrial production methods, for instance. These studies can provide a basis for the development of new medicines. The X-ray laser flashes can also be used to study matter under extreme conditions of temperature and pressure, such as occurring in the interior of planets, and at extreme electric or magnetic field strengths. This will reveal new knowledge about the properties of materials under such conditions. Other studies with small objects, single molecules, or atoms in extreme X-ray fields will pave the way for new X-ray methods.

# FAIR – Facility for Antiproton and Ion Research

**Entities involved:**

1. *Jagiellonian University in Cracow – Applicant*
2. *University of Lodz*
3. *University of Silesia in Katowice*
4. *University of Warsaw*
5. *Gdansk University of Technology*
6. *Cracow University of Technology*
7. *Warsaw University of Technology*
8. *Wroclaw University of Science and Technology*
9. *Jan Kochanowski University in Kielce*
10. *AGH University of Science and Technology*
11. *Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences*
12. *National Centre for Nuclear Research*

## DESCRIPTION

The international accelerator facility FAIR, one of the largest research projects worldwide, is being built in Darmstadt, Germany by scientific and technical institutes from 9 countries of the FAIR GmbH shareholders (Finland, France, Germany, India, Poland, Romania, Russia, Slovenia, and Sweden) as well as by many more partner countries. The FAIR particle accelerator facility for international cutting-edge research is being created on a site of approximately 20 hectares, where unique buildings are constructed in order to house and operate the highly complex state-of-the-art research equipment. The FAIR particle accelerators will deliver the highest particle intensity beams of the highest precision, highest diversity of accelerated ions, high particle energies (up to 99 percent of the speed of light) and will allow up to four experiments to be carried out at the same time.

Research at the FAIR will provide new insights into the structure of matter and the evolution of the universe from the Big Bang until today ("the universe in the laboratory"). Here, it will also be possible to conduct research in materials science, radiation biology and cancer therapy with ion beams.

The scientific user community of the FAIR is organised in a set of experimental collaborations, which in itself are grouped into four scientific pillars of the FAIR research. Currently the number of scientific users of the facility involved in the preparation of planned research exceeds 3,000 researchers from 50 countries. The commissioning of the FAIR facility is planned for 2025.

## SERVICES

The cutting edge research programme of the FAIR project, as well as the design of the research infrastructure necessary for

its implementation, were prepared by an international team of 2,400 scientists, including 81 scientists from Poland. This unique research infrastructure of the FAIR facility will allow both basic research and its use for the benefit of society. The four pillars of research being prepared at the FAIR facility, named with the acronyms APPA, CBM, NuSTAR and PANDA, concern the following issues:

- APPA – atomic physics and fundamental symmetries, plasma physics, materials research, radiation biology, cancer therapy with ion beams;
- CBM – dense and hot nuclear matter;
- NuSTAR – nuclear structure and reaction studies with nuclei far off stability, physics of nucleosynthesis;
- PANDA – hadron structure and dynamics with cooled antiproton beams.

About 100 Polish scientists from academic and research institutions participate in the creation of experimental infrastructure for future research at the FAIR facility. The new generation of scientists, who are replacing the initiators of the FAIR project, already takes part in the so-called zero phase of research, testing individual elements of prepared experimental apparatus. The lectures of senior scientists and meetings of the FAIR Managing Director with the Polish scientists result in the young scientists' growing interest in future research at the FAIR facility.

Engineers and technicians from Polish academic institutions participate in the construction of the FAIR accelerator infrastructure as part of the declared Polish contribution to the construction of the FAIR facility. The original technical solutions of cryogenic devices for the FAIR accelerator infrastructure developed in Poland are implemented in the Polish industry. The fulfilment of particular tasks related to the construction of devices for the FAIR accelerator and experimental infrastructure are in the negotiation phase.

## IMPACT

The FAIR particle accelerator facility is primarily dedicated for cutting-edge basic research, the results of which are an inspiration for innovative solutions in industry and technology. The participation of Polish scientists in these fundamental studies has a huge impact on the position of Polish science in global competition. The FAIR will also carry out research directly related to its use for the benefit of the society (biology, medicine, space travel).

Polish scientists and technicians have been present in the FAIR project since late 1990s when preparations for the construction of a new international research facility were initiated. The strong involvement of the Polish scientific community in the FAIR project has resulted in the initiation of new directions of basic research in Poland as well as in the creation of conditions for the development of new technologies.

# Hyper-Kamiokande

**Entities involved:**

1. *National Centre for Nuclear Research – Applicant*
2. *AGH University of Science and Technology*
3. *Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences*
4. *Warsaw University of Technology*
5. *Jagiellonian University in Cracow*
6. *University of Silesia in Katowice*
7. *University of Warsaw*
8. *University of Wroclaw*

## DESCRIPTION

Hyper-Kamiokande will be an underground water detector utilizing Cherenkov radiation. Cherenkov light, generated by neutrino interactions, will be registered using photomultipliers as well as information such as the quantity of light and ring shape, which will allow energy and the point of interaction to be determined.

The detector will be almost 10 times larger than the currently operating Super-Kamiokande experiment. A huge water tank – height 60 m and diameter 74 m – will contain about 258 thousand tons of ultrapure water and allow measurements with unprecedented sensitivity. Its characteristic feature is the simple principle of operation, based on registration of the light produced (in clean water) by over 20 thousand large photomultipliers and about 5 thousand units composed of several small photomultipliers installed on the walls of the tank.

The Hyper-K detector will be built in the Tochibora mine, near Kamioka, Japan, about 300 km from the J-PARC research complex in Tokai, where a proton accelerator is used to produce a neutrino beam. The detector will be located underground at the depth of 650 m for protection against cosmic rays. Its location, combined with its size, is a challenge for physicists and engineers.

The experiment will also use a set of two detectors nearby whose purpose is to measure the energy spectrum, flux and flavour content of the neutrino beam close to its production point. The current near detector will be modernized and a new water Cherenkov detector will be built. The start of the Hyper-Kamiokande operation is planned for the second half of this decade.

## SERVICES

The new Hyper-Kamiokande infrastructure, currently being developed by an international collaboration of physicists and engineers, will be based on the experience gained with, and improvements of, the existing Super-Kamiokande detector and neutrino experiment with a long baseline - T2K (Tokai to Kamioka). However, it will provide much better sensitivity thanks to many innovative solutions. The aim of this work is to prepare a broad, ground-breaking program of physical research, planned for many years and dedicated to the search for new effects and studies of already known phenomena with precision unattainable by currently existing experiments.

The international community of physicists will gain access to research using a new generation of the Cherenkov water detector, the largest underground detector of this kind in the world. Furthermore, research using accelerator neutrinos will only be possible in two places in the world. The accelerator at J-PARC is currently the source of a high-power proton beam used to produce a high-intensity neutrino beam, and in the future it is planned to double its power (up to 1 MW). The plan is also to study neutrinos from natural sources such as the sun, supernova explosions or those produced in the Earth's atmosphere.

The planned facility will address the most interesting and fundamental questions in modern particle physics.

## IMPACT

The Hyper-Kamiokande detector will allow the study of the interactions of neutrinos from cosmic sources (the sun, cosmic radiation, supernova explosions, other astronomical sources), providing unique information about the astrophysical mechanisms of neutrino production and the properties of the universe. In addition, the planned detector will be used as the so-called far detector for neutrino beams produced in the J-PARC laboratory (T2HK experiment – Tokai to Hyper-Kamiokande). The purpose of these measurements will be to search for CP symmetry violation in the lepton sector, which could explain the predominance of matter over antimatter in the universe. The CP symmetry violation has so far only been observed for quarks.

In addition to the study of neutrinos, Hyper-Kamiokande will look for proton decay, which is of great importance for grand unification theories. To date, this decay has not been observed, and the established proton lifetime limits (mainly from Super-Kamiokande) have already ruled out numerous theories. The sensitivity of Hyper-Kamiokande will by far exceed that of currently running experiments.

The design and construction of the infrastructure will also contribute to the improvement of light sensor technology, information technology for sending and analysing large data sets, strengthening international cooperation and further developing the competence of teams of physicists and engineers.

# Laboratory of High-Pressure Research and Functionalization on Soft Matter and Amorphous Solids: X-PressMatter

**Entities involved:**

1. *Institute of High Pressure Physics of the Polish Academy of Sciences*

## DESCRIPTION

The X-PressMatter laboratory is a unique concept, even on a global scale, based in the Innovation Park of the Institute of High Pressure Physics at the Polish Academy of Sciences (IHPP PAS) "Unipress" in Celestynow, a borough located ca. 50 km east from Warsaw. The existing innovative research infrastructure for the characterisation and functionalisation was designed and built within IHPP PAS, which is the world-recognised producer of innovative high-pressure laboratory equipment. Set-ups in X-PressMatter are ready for in situ under pressure tests for a variety of Soft Matter systems: from model foods to liquid crystals, plastic crystals, polymers, resins, critical liquids, glasses, ceramics, supercooled liquids, including composites. A unique feature of the infrastructure is the ability to operate under high pressure in large volumes, even up to V ~ 50 L.

## SERVICES

The X-PressMatter laboratory offers basic and developmental research, and to some extent, industrial studies for the characterization of materials, electrical, thermodynamic and electro-optical properties of liquids and solids, primarily for Soft Matter (polymers, liquid crystals, model food, critical liquids). Thanks to the wide temperature range (from -160 °C to 1600 °C), high pressures (up to ~ 3 GPa = 30,000 atm) and simultaneous in situ monitoring under pressure for various properties, unique and in-deep characterizations are possible. The X-PressMatter laboratory has a broadband dielectric spectrometer (BDS) with a full range of equipment, a non-linear dielectric spectrometer (NDS), a system for testing the electro-optical Kerr effect (EKE, TEB), a polarizing microscope with a unique pressure cell, a microhardness system, an advanced tribology meter, and

a system for measuring the specific heat meter pressure and as a function of pressure. It is possible to implement fundamental research projects and industrial R&D orders/ actions in the area of foods, cosmetics and pharmaceuticals as well glasses and ceramics with tailored properties. All these include market pilot-series of products due to the High-Pressure Processing (HPP+) pilot line with a high-pressure chamber V = 50 litres volume. The laboratory also offers the design and functionalisation of glasses, ceramics and composites through the use of high pressures and temperatures, in many cases leading to extraordinary properties hardly or not at all available beyond the HP-HT functionalisation.

## IMPACT

The X-PressMatter laboratory is a unique high pressure (HP) and high temperature (HT) R&D centre. Only a few laboratories in the world have comparable equipment for similar HP or HT testing. However, X-PressMatter IHPP PAS combines these possibilities (HP-HT) with the unique ability to operate in large volumes. This is supported by the know-how, advanced analytical tools and highly qualified staff. The X-PressMatter laboratory cooperate with a wide range of national and international partners. In Poland, it is primarily the Warsaw University of Technology, the Rzeszow University of Technology, the University of Wroclaw and the Military University of Technology in Warsaw. Foreign cooperation includes the University of Maribor (Slovenia), the Jozef Stefan Institute (Slovenia), the Aalborg University (Denmark), the Odessa National Academy of Food Technologies, the Rensseller Polytechnic Institute (NY, USA), and Corning Glass Inc. (NY, USA). It is also a growing network of well-known Polish producers benefiting from support in developing new products and technologies using high pressures. X-PressMatter is important for the popularisation of science and the professional activation of local communities in Celestynów and Otwock Counties.

# MNL Maria Neutron Laboratory

**Entities involved:**

1. *National Centre for Nuclear Research*

## DESCRIPTION

The aim of the project is to create and operate a modern neutron laboratory, conducting research using neutrons with different energies produced by the MARIA nuclear research reactor. Planned operation time is about twenty years. The laboratory will use eight horizontal channels of the MARIA reactor and relevant in-core installations. One of the main pieces of equipment of the laboratory will be the thermal neutron diffractometers obtained from the Helmholtz Zentrum Berlin (HZB). The laboratory equipped with these diffractometers will be attractive to researchers from around the world. The long-term goal is to create a laboratory operating according to the "open access" formula, open to scientists from various countries and financially supported by the European Commission. The project also envisages the construction and commissioning of two stations for irradiating materials and biological samples with high intensity neutron beams, located at the H1 and H2 horizontal channels, among others for the needs of BNCT therapy.

The current agreements with HZB concern the transfer to National Centre for Nuclear Research of the E2, E3, E4, E5 and E6 diffractometers, including the internal stress measuring device (E3) and "flat cone" device (E2). Other devices are the E4 and E6 powder diffractometers as well as a 4-wheel diffractometer for single crystal measurements. These devices will allow the establishment of a world-class measurement laboratory, with a research program largely based on already existing projects mainly related to structural and magnetic studies of advanced materials.

## SERVICES

The MNL Laboratory, currently under construction at National Centre for Nuclear Research, will enable the testing of structural and magnetic properties of materials, neutron radiography, neutron activation analyses, material modification (e.g. neutron doping), production of isotopes for medical purposes and development of nuclear medicine methods based on the use of neutrons (e.g. the BNCT method). The laboratory will also provide services to industry, mainly using the E3 diffractometer, to measure internal and residual stresses. Access to research at MNL will be possible on the basis of project selection by the Scientific Committee and will be free of charge for researchers from Poland and abroad. In parallel, it will be possible for industrial companies, including companies currently using the diffractometers at HZB, to use the infrastructure on a commercial basis. It is worth emphasising that the agreement with HZB also includes access to lists of current users as well as current research programs that may be continued at National Centre for Nuclear Research. Therefore, even before its creation, the planned laboratory possesses lists of potential users with ongoing research programs, as well as names of companies interested in commercial use of the equipment. National Centre for Nuclear Research has extensive experience in implementing international research programs and supporting foreigners performing measurements in Poland.

## IMPACT

The implementation of the MNL project provides an answer to the challenges posed by growing research needs. In Europe and beyond, neutron beams are lacking, especially in the range of high intensity thermal and fast neutrons. Currently, devices designed to produce high intensity neutron beams are being designed or built, but their sources are accelerators rather than nuclear reactors. The launch of these installations is planned only after 2023 and 2029. The stations built at National Centre for Nuclear Research will be the only neutron lines operating in Poland, and among very few in Europe, enabling materials and biological research and the development of new boron carriers for boron neutron therapy. A unique feature of the emerging infrastructure will be a well-focused beam, with a diameter of about 10 cm. Intense neutron sources are very expensive to build, hence there are only a few such sources in Europe. Europe, which has played a leading role in neutron research over the past 40 years, may lose this position. It is thus particularly important to benefit from the leading role of the HZB centre and for National Centre for Nuclear Research and MNL to take over its position. The planned infrastructure will also be used for the needs of educating young researchers, including research leading to doctorates (as part of the National Centre for Nuclear Research/Institute of Nuclear Chemistry and Technology doctoral school) and obtaining higher academic degrees.

# Nitride semiconductors physics and technology centre GaN-Unipress

**Entities involved:**

1. *Institute of High Pressure Physics of the Polish Academy of Sciences*

## DESCRIPTION

The GaN-Unipress Centre belongs to the Institute of High Pressure Physics at the Polish Academy of Sciences (IHPP PAS), that is recognized for world-class research on the physics and technology of nitride semiconductors. GaN-Unipress enables access to the research infrastructure as well as to services in the area of semiconductor physics, crystallization, epitaxy and semiconductor device technologies. The infrastructure of the GaN-Unipress Centre is located in Warsaw and in Stanisławów Pierwszy. It consists of a unique combination of laboratories with broad research capabilities covering crystallization of bulk GaN and GaN substrates fabrication, epitaxy of quantum structures by MOVPE and MBE, optoelectronic and electronic device processing in cleanroom environment as well as characterization of crystals, quantum structures and devices. The aim of the Centre is to solve the problem of obtaining large GaN bulk crystals, which is fundamental for the entire nitride community. Efficient crystallization processes based on the most important methods and their combinations are being employed. The goal of the GaN-Unipress Centre is also to continue research of the physics of crystal lattice defects, their impact on recombination processes and quantum efficiency of light emitters, and solving challenges in the construction of semiconductor lasers and transistors. Quantum photonics, single and entangled photons emitters and detectors as well as high power vertical transistors are the new research directions at the GaN-Unipress Centre.

## SERVICES

The GaN-Unipress Centre comprises 4 laboratories: crystallization, epitaxy, processing and characterization. The knowledge and

experience of working scientists is unique on the international scale. The portfolio of available services is very broad and falls within the fields of physics, material engineering and fabrication and characterization of low-dimensional structures. The scope of services includes production of GaN substrates, high pressure annealing, epitaxy of layers and quantum structures as well as processing services, including photolithography, ion etching, and deposition of metallic layers. Structural and optical characterization is also available using X-ray diffraction, scanning and transmission electron microscopy, photoluminescence or Raman spectroscopy. Scientists from Poland and abroad can use the Centre's infrastructure on the basis of open access as part of scientific cooperation. Access to research using the GaN-Unipress infrastructure is realized according to internal regulations of the IHPP PAS and to the regulations of respective calls for scientific or research and development projects. PhD students and trainees from external entities use the infrastructure as part of research programs or internships under the supervision of scientists from the IHPP PAS. Interested entrepreneurs can also cooperate on a commercial basis. In the case of industrial partnerships, cooperation is preceded by the signature of confidentiality agreements (NDAs) as well as cooperation agreements specifying, in particular, the principles for the distribution and protection of intellectual property created as a result of cooperation. The main principle is that of open access, and the most important criterion used is that of scientific excellence.

## IMPACT

The GaN-Unipress Centre develops technologies for high quality GaN substrate crystals production, develops novel device constructions such as superluminescent diodes or tunnel junction devices using advanced epitaxy methods: MOVPE and PAMBE, and optoelectronic device processing. Thanks to the knowledge and experience of excellent scientists and PhD students working in the Centre's laboratories, and the unique equipment resources, also of own construction, both important basic research problems as well as key technological challenges of practical importance can be solved. Research on bulk GaN crystallization is carried out, strengthening Poland's leading world position in this area. New technologies in the field of optoelectronics and electronics of high power and high frequency are being developed. Projects aimed at the use of nitride laser diodes for medical purposes, oncology and dermatology are being implemented. The GaN-Unipress Centre is a place that consolidates scientific and technical potential in the strategic field of science and technology, which is the physics of nitride semiconductors.

# Particle Physics Research with the CERN Infrastructure

**Entities involved:**

1. *Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences – Applicant*
2. *AGH University of Science and Technology*
3. *University of Warsaw*
4. *National Centre for Nuclear Research*

## DESCRIPTION

The aim of the project is to perform fundamental studies of modern particle physics at CERN, complemented with the research and development of novel techniques for particle acceleration, particle detectors and global infrastructure of distributed computing. This research programme falls within the broader European Particle Physics Strategy (EPPS). The aim of the EPPS is to provide a prioritized list of projects to be carried out in order to advance particle physics science. The Strategy is documented in the ESFRI Roadmap.

CERN is an intergovernmental scientific organization of European states which includes Poland as a full member. Polish scientists are involved in flagship CERN projects using the available world-class infrastructure. These include four major Large Hadron Collider (LHC) experiments: ALICE, ATLAS, CMS and LHCb, which, after upgrading, will be used for the HL-LHC – an ESFRI landmark project. Polish physicists also participate in experiments (NA61/SHINE, COMPASS) using the SPS accelerator, projects (GBAR, ATRAP) at the AD complex, and they also utilize the CERN Neutrino Platform (the T2K experiment). Furthermore, Polish teams are involved in European and world-wide initiatives aiming to define scientific programmes and develop new particle detection and acceleration technologies: RD50, RD51, AIDA-2020, CLICdp, TIARA, FCC, ILC, all included in the EPPS strategy and planned to be carried out using the CERN infrastructure.

## SERVICES

CERN hosts the world's largest and most advanced scientific instruments, which are available for scientists to perform research. Among them are the currently operating accelerator complexes: LHC (Large Hadron Col-

lider) – the most powerful man-built particle accelerator; SPS (Super Proton Synchrotron); PS (Proton Synchrotron); ISOLDE (Isotope Separator On Line Device); nTOF (the neutron time-of-flight facility); AD (Antiproton Decelerator) – the only machine in the world producing low-energy antiprotons; and CERN Neutrino Platform. In addition, the following future infrastructures are being developed: HL-LHC (High-Luminosity Large Hadron Collider); CLIC (Compact Linear Collider); FCC (Future Circular Collider). At their disposal, researchers have access to a computing infrastructure (including distributed computing within the WLCG – Worldwide LHC Computing Grid) and a technical infrastructure to perform design and prototyping work as well as service work for specialized and complex scientific instruments. Poland, a legitimate member of CERN, enjoys full rights to perform scientific studies and carry out research and development activities using the CERN infrastructure. Polish teams are actively using and maintaining the existing infrastructures and taking part in the modernization and construction of new detector sub-systems. The construction of final sub-systems is usually awarded in the form of a production order to Polish industrial companies. In this way, not only are modern technology solutions transferred to the Polish industry, but also a significant amount of the ministerial budget funds return to the Polish economy.

## IMPACT

CERN is a world-class organisation and a leader in particle physics research. The scientific infrastructure of CERN allows the scientific community to pursue research with modern scientific instruments not accessible in other scientific centres. Prominent scientists of global recognition (experimentalists, theorists, engineers) are affiliated with CERN. Polish researchers and their studies profit not only from access to unique experimental facilities based on advanced technologies, but also from working together with elite scientists. All CERN projects are performed by large international collaborations. Over the years, Polish groups have established close connections and fruitful cooperation with foreign partners. Foreign scientists frequently visit domestic laboratories, taking part in workshops and conferences organised by them. CERN also offers attractive perspectives for Polish and foreign PhD students and postdocs, and many of them have already enrolled in CERN and Polish PhD studies, while others take postdoctoral positions at Polish institutes. Furthermore, Polish teachers, students and young scientists have the opportunity to participate in a variety of educational programmes organized by CERN.

# PolFEL – Polish Free Electron Laser

**Entities involved:**

1. *National Centre for Nuclear Research – Applicant*
2. *Military University of Technology*
3. *Warsaw University of Technology*
4. *Lodz University of Technology*
5. *Wroclaw University of Science and Technology*
6. *University of Zielona Gora*
7. *University of Bialystok*
8. *Jagiellonian University in Cracow*

## DESCRIPTION

PolFEL research infrastructure, currently under construction at the National Centre for Nuclear Research, will consist of a free electron laser with a collection of experimental stations and auxiliary laboratories. PolFEL will constitute a light source combining the advantages of conventional lasers (high power coherent ultra-short pulses) and synchrotrons (polarisation, tunability over a wide range of wavelengths). PolFEL will consist of an electron source, an accelerator providing a high quality e- beam and undulators in which the accelerated electrons will emit light pulses. The radiated light will be directed to experimental stations operating in the IR, THz and VUV wavelength ranges while the electron beam will be used to generate X rays with the use of inverse Compton scattering.

The unique properties of the radiation provided by PolFEL will turn it into a valuable research tool for many fields of science and technology. Coherent light of high intensity makes possible 3-D diffractive imaging of nanometric scale objects (e.g., surface structures or biomolecules) in a single laser shot. Generation of ultra-short laser pulses combined with a high repetition rate gives the possibility of time resolved measurements exploring the course of physical, chemical and biological processes on the femtosecond scale. The electronic properties of molecules and condensed matter can be studied in pump-probe experiments. High power pulses can create new states of matter like ultra-dense plasma. Further use of the electron beam will create research opportunities, for instance, in materials physics or nuclear physics.

## SERVICES

PolFEL will be a research infrastructure open to scientific users from Poland and other countries. Access to the radiation beamlines and experimental stations will be granted upon a transparent selection process based on the scientific value of the submitted proposals. The range of possible research fields includes, inter alia:

- research into electronic phenomena in a solid state, including high temperature superconductivity;
- research into and modification of electronic structures with single THz pulses;
- research on the interaction of electromagnetic radiation with tissues and biomolecules;
- time resolved research on the atomic and electronic structure of matter;
- research on chemical reaction dynamics;
- research in the field of high energy density physics;
- fundamental research on the properties of electromagnetic radiation and its interaction with matter;
- research on surface modification technology;
- research on particle acceleration techniques.

PolFEL will allow for industrial research to be conducted on a commercial basis and a part of the operational time will be reserved for that purpose. Proposals for commercial use of PolFEL will not be verified against their technical or scientific value. Research requirements of this kind which have been identified so far include not only the general subjects listed above but also materials research and tests of various detectors or control devices.

## IMPACT

PolFEL will be constructed in two stages, the first of which began in 2019. From the very beginning the infrastructure has relied on superconducting technology employed both for the accelerator as well as the electron source. Thanks to this, PolFEL will be able to work in continuous wave mode while preserving the possibility of operation in pulse mode. This innovation is of high importance for the development of free electron lasers and the research conducted with them.

Continuous wave mode operation allows the mean flux of photons detected in experiments to be increased by two orders of magnitude when compared with pulse mode. In turn, this allows experiments to be performed on low probability phenomenon and work with diluted samples. The continuous working of the light source makes it possible, by adapting the time structure of the pulses to the detector data collection speed, to tune the photon beam parameters to specific experimental needs and thus either to do research not possible with other methods or to use simpler detection systems. On the other hand, preserving the capability of pulse mode operation is important for achieving high power laser pulses and minimum possible wavelengths.

The second stage of PolFEL construction aims to extend the spectral range of the generated coherent radiation towards X rays. To that end, the development and implementation of plasma acceleration of the electron beam (with the PWA method) is foreseen.

# Polish LOFAR – a Low Frequency Radio Interferometer. System Development: LOFAR 2.0

**Entities involved:**

1. *University of Warmia and Mazury in Olsztyn – Applicant*
2. *Jagiellonian University in Cracow*
3. *Space Research Centre Polish Academy of Sciences*
4. *Institute of Bioorganic Chemistry Polish Academy of Sciences – Poznan Supercomputing and Networking Centre*
5. *University of Zielona Gora*
6. *Nicolaus Copernicus University in Torun*
7. *Nicolaus Copernicus Astronomical Centre Polish Academy of Sciences*
8. *University of Szczecin*
9. *Wroclaw University of Environmental and Life Sciences*

## DESCRIPTION

The subject of the project is the participation in the development and operation of the European LOw Frequency ARray (LOFAR) radio interferometer – an instrument operating in the 10 - 240 MHz frequency range, consisting of several dozen stations located in western and central Europe.

Currently, the system consists of 52 stations located in various places in Europe. 38 stations are located in the Netherlands, 6 in Germany, 3 in Poland, and 1 in Sweden, the United Kingdom, France, Ireland and Latvia each. Three members of the POLFARO consortium – University of Warmia and Mazury in Olsztyn, Jagiellonian University in Cracow and Space Research Centre Polish Academy of Sciences – established and currently manage the Polish LOFAR stations, in the vicinity of Olsztyn (Baldy), Cracow (Lazy), and Poznan (Borowiec), respectively. All European stations operate as one observational instrument forming the International LOFAR Telescope (ILT). LOFAR currently enables research to be carried out at very low frequencies, in the range of the electromagnetic spectrum that so far has been the least examined by radio astronomers.

In view of the research and organizational success of the LOFAR system, the European ILT consortium, of which Poland has been a member since 2015, is currently carrying out a programme of its further development – LOFAR 2.0. The main aim of the upgrade will be to maintain the top global position for the best multi-base low frequency array radio interferometer for the next decade. This development aims, above all, at increasing the observational capacity of the system, and significantly increasing the speed with which radio astronomical observations are processed and analysed.

## SERVICES

At the moment of completing the construction of three Polish stations and the inclusion of POLFARO into the ILT structure, Poland joined the group of countries hosting advanced radio astronomy instruments in their territory. Apart from the three above mentioned institutions that host the Polish LOFAR stations, a key role in this project is played by the Poznan Supercomputing and Networking Centre, which provides fast data transfer covering all of Europe, and the observations archive and analysis storage. From the start, the LOFAR project has been a result of European cooperation led by the Dutch institute – ASTRON, with the support of numerous institutions forming national consortia from the Netherlands, Germany, Poland, the United Kingdom, Sweden, France, Ireland, Latvia and Italy.

All national consortia that own LOFAR stations are members of, and operate under, the European research consortium – the ILT. The Polish national POLFARO consortium has a strong position in the ILT structures. Poland has been allocated more than 10% observational time of the entire ILT system. From 2015 to 2019 members of the POLFARO consortium already obtained dozens of grants for observation time in the ILT. This European instrument is dedicated for multiple studies, forming Key-Science Projects (KSPs), covering such issues as: evolution of active galaxies, magnetic fields in galaxies, galactic groups and clusters, pulsars and neutron stars, studies on the universe reionization era and solar physics and space weather.

## IMPACT

LOFAR is currently the world's largest radio telescope, working as a multipurpose sensor network, and the most sensitive interferometer operating in the low-frequency radio band. Numerous publications in prestigious journals: Nature 2019 or Astronomy and Astrophysics 2019, devoted to reviews of LOFAR, have proved that it brings excellent scientific results regarding both objects of the distant and close universe as well as the local surroundings of the Earth. The success of this project lies in the pioneer, modern, digital telescope design and close international scientific cooperation.

The ILT assumes that the LOFAR system will maintain its position as the globally strongest multi-base low frequency array radio interferometer until at least 2030-2035. An important element will be conversion of the present ILT consortium into the European Research Infrastructure Consortium – LOFAR-ERIC. Involvement in the development of the LOFAR 2.0 research infrastructure and the establishment of the LOFAR-ERIC consortium will, for the Polish research community, open a path for further cooperation within international research teams working on astronomical infrastructure, including the SKA telescope, for which the LOFAR 2.0 itself will provide a certain exploratory infrastructure.

# Polish UV satellite system – UVSat

**Entities involved:**

1. *Nicolaus Copernicus Astronomical Centre Polish Academy of Sciences – Applicant*
2. *Space Research Centre Polish Academy of Sciences*
3. *Creotech Instruments*
4. *University of Wroclaw*

## DESCRIPTION

The Polish UV Satellite System (UVSat) is a project that will enable the building of technologically advanced scientific research satellites through domestic effort. The primary objective of the project is to investigate the possibility of acquiring astronomical data in the ultraviolet (UV) range using both photometric and spectroscopic methods. Ultraviolet is a spectral range that covers the output of hot stars and compact stellar or galactic objects accreting matter. All these determine the chemical evolution of the Universe and constitute some of the most powerful sources of energy in the universe. Their UV radiation is significantly greater than that in the visible range, however, it can only be observed from space due to its absorption in the atmosphere. The primary practical objective of the project is to develop Polish expertise in space research based on Polish scientific and industrial capabilities in the area of e.g. satellite subsystems: power supply, thermal control, on-board computer, on-board memory, altitude and orbit control subsystems, instrumental optics, mechanical structure, mission control or a ground segment (Ground-Based Operations Centre).

## SERVICES

The research infrastructure to be developed will consist of a satellite system with 1 or more satellites in a low-Earth orbit (LEO) as well as a Ground-Based Operations Centre interfaced with geographically scattered researchers. This infrastructure will fill an important global niche for UV surveys, paving the way for new major discoveries. During the construction phase a well-balanced international cooperation on specific technical and technological tasks will be pursued, e.g. those related to:

- detectors and front-end electronics;
- optical systems;
- high-strength structure and materials. Given that foreign partners are to be included, it is planned to establish a Governing Board / a Board of Users that will make decisions on the assignment of observational time slots as well as technological and IT tests to be performed. The initial year-long phase of satellite use will only involve the implementation of key programs (100% of time slots) as defined by the major participants in the construction efforts. As far as the subsequent phase is concerned, it is expected that up to 50% of time slots will be assigned by the Board of Users based on open calls for observational projects. It will be possible to use the data reception and satellite control centre for receiving data from other missions, e.g. commercial or defence-related operations. It will also be necessary to establish a relevant infrastructure in the form of laboratories, specialised facilities and testing sites.

## IMPACT

The UVSat project is complementary to other existing and planned international UV satellite projects. At the same time it is unique in terms of its photometric component as none of the satellites that have been or are to be launched enable long-term observation of variabilities. In terms of the spectroscopic component, it will be the only UV satellite project that offers the capability of simultaneous spectroscopy and photometry in space.

Investments in the infrastructure will be used for other missions implemented by Polish and foreign organizations. The project involves the construction and fitting out of an assembly site for small satellites of weight up to about 300 kg, as well as a clean assembly area for telescopes and optical components, including a clean room, which can also be used for building optical instruments and telescopes designed for installation in other optoelectronic observational systems.

UV-oriented optical instruments and detectors can also be used for non-scientific purposes, e.g. for identification and tracking of missile launches and the type of fuel used in the missiles being launched (spectral analysis), both for research and military missions. When placed in the orbit, UVSat satellites can also be used for commercial testing of prototype subsystems and software designed for the space sector.

The existing GeoPlanet Doctoral School will enable the training of R&D&I specialists as part of doctoral studies. The School brings together seven institutes of the Polish Academy of Sciences that play a leading research role in the fields of astrophysics, physics, Earth, space and planetary sciences, and space engineering.

# SOLARIS National Synchrotron Radiation Centre

**Entities involved:**

1. *Jagiellonian University in Cracow – Applicant*
2. *Jerzy Haber Institute of Catalysis and Surface Chemistry Polish Academy of Sciences*
3. *AGH University of Science and Technology*
4. *Hochschule Niederrhein – University of Applied Science*
5. *Joint Institute for Nuclear Research*

## DESCRIPTION

The SOLARIS National Synchrotron Radiation Centre is the most modern and largest scientific multidisciplinary research infrastructure in Poland. Its key asset is the 1.5 GeV synchrotron. It is the only synchrotron light source in Central Europe. Moreover, during its construction, the innovative technology of integrated double-bend achromat cells was used for the first time. The synchrotron was built in 2010–2015.

Synchrotron radiation is extremely intense and contains electromagnetic waves from the infrared spectrum up to X-rays. These extraordinary properties allow the conducting of unique research that provides new knowledge about the structure of materials and their internal processes. This knowledge lays the foundation for new discoveries and finds practical application. Synchrotron radiation is used in many basic and applied branches of science such as biology, chemistry, physics, materials engineering, nanotechnology, medicine, pharmacology and geology.

The purpose of the Centre is to enable the Polish scientific community to conduct unique research, which until now could only be carried out abroad, in one of several dozen similar synchrotron centres in the world.

The main tasks of the SOLARIS team are to provide an outstanding, reliable research infrastructure and to secure substantive support to external research groups.

## SERVICES

The SOLARIS Centre provides open access to its research infrastructure and constantly expands the list of its measurement techniques. Calls for proposals are organised every six months. Applications are evaluated by an international review panel. Access to SOLARIS is free of charge for anyone who carries out non-commercial research. SO-

LARIS participation in the CERIC-ERIC consortium (https://www.ceric-eric.eu/) enables Polish scientists to use research infrastructures in eight CERIC-ERIC partner countries. SOLARIS holds great potential of development. There is capacity to install over a dozen beamlines around the synchrotron, offering many more research techniques. Construction of an ultra-short X-ray pulse facility for studying fast transient processes is also planned. It is worth noting that the development of SOLARIS is consulted with the scientific community and the international Scientific Advisory Committee.

Opportunities provided by SOLARIS cover unique commercial research opportunities for industries related to advanced materials (aerospace, automotive, chemical, electronic or petrochemical industries). Research techniques may be used in investigating metal alloys, thin metallic layers, magnetic nanostructures, magnetic layers, catalysts, topological insulators, semiconductors, superconductors, solar cells, and others. In addition, SOLARIS provides companies with a constantly expanding laboratory of cryo-electron microscopy, which is one of the key development techniques for the biotechnology industry. As a new infrastructure is being built, the offer for various industries is expanding.

## IMPACT

For the last forty years synchrotron light sources have been emerging in countries that invest in science and new technologies, opening up new research horizons. Synchrotron research is often ground-breaking and its results are published in prestigious scientific journals, becoming breakthroughs for further analyses and discoveries. Some research techniques are only available at synchrotron centres, such as in the case of protein crystallography, which helped determine the structures of human genome and is a key technique in the development of new drugs or in the early diagnosis of civilization diseases.

The results of synchrotron research are used in the development of new materials, for example for the energy industry. They also help in devising new data recording methods, in designing more efficient photovoltaic cells, as well as in making advances in electronics and spintronics by incorporating a new family of topological materials in these areas.

Synchrotrons foster exchange of the latest technical achievements, absorbing innovations in the field of accelerator technologies, vacuum technology, control systems or electromagnetic radiation optics.

Scientific papers cover not only the research results, but also the operation of accelerators and synchrotron control systems issues. Subsequently, findings and conclusions of these studies are directly used in industry.

# SPIRAL2

**Entities involved:**

1. *Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences – Applicant*
2. *Maria Curie Skłodowska University*
3. *University of Warsaw*
4. *Jagiellonian University in Cracow*
5. *Łukasiewicz Research Network – Institute of Electronic Materials Technology*
6. *National Centre for Nuclear Research*
7. *Warsaw University of Technology*
8. *University of Silesia in Katowice*
9. *University of Szczecin*
10. *University of Wroclaw*

## DESCRIPTION

The SPIRAL2 is a new ESFRI landmark infrastructure at the GANIL Laboratory in Caen (France), that will significantly extend the possibilities of Stable Heavy-Ion Beam and Radioactive Ion Beam (RIB) physics and related applications (https://www.ganil-spiral2.eu). The SPIRAL2 is based on a multi-beam driver allowing for both Isotope Separation On-Line (ISOL) and low-energy in-flight techniques to produce RIBs. SPIRAL2 comprises a linear accelerator (LINAC) and experimental areas for experiments with high flux of fast neutrons (Neutrons for Science, NFS); with very high intensity beams of heavy-ions (Super Separator Spectrometer, S3); and with low-energy exotic nuclei (DESIR) produced at S3 and the existing SPIRAL1 facility. The construction of a new injector of the SPIRAL2 Linear Accelerator is also planned in order to expand a range of available high-intensity heavy-ion beams up to Uranium.

In addition, a RIBs production building (Phase 2) is foreseen to deliver radioactive beams with an intensity that exceeds by 10 to 100 times what is available worldwide today.

Poland's participation in the construction and later in the operation of SPIRAL2 is coordinated by COPIN consortium – https://copin.ifj.edu.pl. This participation concerns both experimental fields (designing and building top-level research equipment), and theoretical approaches (developing advanced models of nuclear structure based on the theory of nuclear energy density functional and on the description nuclei as open quantum systems).

## SERVICES

The SPIRAL2 scientific program will be organized around three new experimental platforms:

- NFS for the delivery of a high-flux and well-collimated neutron beam in order to perform measurements with fast neutrons of energies up to 40 MeV. The broad program includes fundamental research, applications to nuclear reactors, medical diagnostics and therapy, fusion technology, and production of radioisotopes;
- S3, a new large-acceptance spectrometer and with high reaction channel selectivity for fundamental research in nuclear and atomic physics. S3 will allow to perform experiments with extremely low cross sections, taking advantage of the very high intensity stable beams of the SPIRAL2 LINAC. It will mainly use fusion-evaporation reactions to reach extreme regions of the nuclear chart opening new opportunities for super-heavy element studies and spectroscopy of nuclei near the limits of nuclear stability;
- DESIR, a new low-energy experimental hall to study mainly the ground state properties of exotic nuclei in unexplored regions of the nuclear chart. The physics program addresses, by means of complementary experimental techniques (decay spectroscopy, mass measurements, laser spectroscopy), a large number of important questions related to the structure of exotic nuclei, nucleosynthesis in the universe and fundamental interactions and symmetries.

In addition, innovative detection systems such as PARIS, AGATA, NEDA and FAZIA have been developed with large involvement of Polish scientists, offering an exclusive path to continue discovering new phenomena.

The infrastructure is of open access for the scientific projects recommended by the GANIL/SPIRAL2 PAC.

## IMPACT

The SPIRAL2 will offer unique opportunities to continue discovering new phenomena on the femtometer scale. By producing the most intense in the world ion and neutron beams, the SPIRAL2 will allow to carry on novel research in nuclear physics which address open questions such as the appearance of new shell closures (magic numbers) near and around the limits of nuclear stability, properties of nuclei relevant for astrophysics, existence and characteristics of very heavy elements, conducting research areas related to material sciences, radiobiology, hadron and isotope therapy, energy, environment, health, engineering and space.

The SPIRAL2 will also have enormous benefits for Polish science and the scientific community, as for example the training of PhD students, young scientists and engineers, access to unique research equipment and the possibility of using this equipment in Polish research institutions. There are also potential economic benefits, such as: a) contracts for Polish companies (cryogenics, mechanics, electronics) and their possible financing from GANIL / SPIRAL2 funds; and b) transfer of innovative technologies to Poland (superconducting accelerators and high-field magnets, robotics, high power lasers, high intensity ion sources and others).

# Vera C. Rubin Observatory (formerly Large Synoptic Survey Telescope)

**Entities involved:**

1. *National Centre for Nuclear Research*

## DESCRIPTION

The Vera C. Rubin Observatory (formerly the Large Synoptic Survey Telescope) project aims to build an 8.4 m telescope capable of producing deep wide synoptic surveys of the whole sky, in particular the Legacy Survey of Space and Time (LSST). Its first light is expected in 2021. The summit facility is located in Chile. LSST leverages innovative technology in all subsystems, in particular the camera and telescope, as well as data management.

The goal of the Rubin Observatory is to conduct a 10-year survey of the sky that will deliver a 200 petabyte set of images and data products related to 37 billion astronomical sources. They will allow some of the most pressing questions about the structure and evolution of the universe and the objects in it to be addressed. LSST will focus on four main science areas:

- the nature of Dark Matter and Dark Energy;
- hazardous asteroids and the remote Solar System;
- the transient optical sky;
- the formation and structure of the Milky Way.

The Rubin Observatory will conduct a deep survey over an unprecedentedly large area of sky – the main survey will cover 18 000 square degrees. Frequency of observations will enable images of every part of the visible sky to be obtained every few nights. The execution of this operation mode for at least ten years will allow the achievement of astronomical catalogues thousands of times larger than have ever previously been compiled. LSST is a project financed primarily by US agencies (National Science Foundation – NSF, the Department of Energy – DOE), and private funding, but with a long list of international contributors which includes Poland.

## SERVICES

The LSST data products are organized into three main categories.

Prompt data products are generated continuously every observing night. They include alerts to objects that have changed brightness or position, which are released with 60-second latency, source catalogues derived from difference images — including orbital parameters for solar system objects — and image data products that are released with 24-hour latency.

Data Release data products will be made available annually as the result of coherent processing of the entire science data set to date. These will include calibrated images; measurements of positions, fluxes and shapes; variability information; and an appropriate compact description of light curves. The Data Release data products will include a uniform reprocessing of the difference-imaging-based Prompt data products.

User Generated data products will originate from the community, including project teams. These will be created and stored using suitable Application Programming Interfaces (APIs) that will be provided by the LSST Data Management System.

Alert packets of transient data will be made public immediately and will become accessible through open access to the scientific community. All other data products will become public after a proprietary period of 2 years. During the proprietary period the data will be available to data right holders, among them international contributors, as regulated by individually negotiated agreements.

## IMPACT

The Rubin Observatory project is unique in its capability to combine very deep wide-angle observations of a large part of the sky with the ability to track the variability of objects at different time scales. It should be emphasized that none of the currently available or planned astronomical instruments provide either scientific or technological opportunities to carry out similar projects. Breakthrough results are expected in the fields of cosmology, stellar astrophysics and solar system research. At the same time, the data delivered will be a unique training field for the development of algorithms and methods for the analysis of large data sets in the field of Big Data, which in turn will contribute to the development of new IT technologies. An important aspect is the complementarity of the Rubin Observatory with other big observing facilities, which specialise in targeted observations or smaller and differently optimised surveys, among them the telescopes of the European Southern Observatory (ESO). LSST data will provide information that will then be confirmed, expanded and further analysed through follow-up observations by ESO telescopes.

# Very Long Baseline Interferometry (VLBI) station at Nicolaus Copernicus University in Torun

**Entities involved:**

1. *Nicolaus Copernicus University in Torun*

## DESCRIPTION

The European Very-Long Baseline Interferometry (VLBI) Network station at the Nicolaus Copernicus University in Torun (NCU) has a fully steerable radio telescope with a paraboloid mirror of a diameter of 32 metres. Its cryogenic, i.e. cooled down to temperatures of the order of several Kelvin degrees, and hence supersensitive, receiving systems operate at five frequency bands used in radio astronomy: 1.4, 5, 6, 12, and 22 GHz. It is one of the largest infrastructures to conduct fundamental research in Poland. Participation of the 32-metre radio telescope in the European VLBI Network (EVN) is a necessity resulting from a fundamental limitation of all radio telescopes. When working autonomously, they, unlike optical telescopes, are unable to provide sharp images of astronomical objects. It is a direct consequence of their low angular resolution that stems from the relatively low ratio of the mirror diameter of a typical radio telescope to the length of received waves. Typically, that ratio is of the order of about one thousand, whereas in case of the largest optical telescopes it reaches the order of a dozen of millions. However, this shortcoming of radio telescopes can be overcome by connecting them into a network in which pairs of its elements become interferometers – hence the name of the method. In this way, the angular resolution attained by the whole network may reach even thousandths of an arc-second. Such resolution is not available by any other observing technique in modern astronomy.

## SERVICES

The EVN is an infrastructure of distributed elements yet common technology and joint research programme, thus compliance with the VLBI standards is crucial here. To be ful-

ly compatible with other EVN stations, the NCU EVN station is equipped with all the necessary tools. Apart from the radio telescope with its receivers, it encompasses a hydrogen time-and-frequency standard and advanced IT infrastructure of high data transfer capacity. The latter is vital because simultaneous processing at one place, the so-called correlator, of an immense amount of data collected by radio telescopes located at various places in the world, is the essence of the VLBI. The volume of data transferred via optical fibre links is typically about 20 terabytes per station per day.

The EVN is open to the whole astronomical community. Access to the EVN is granted to the authors of observing proposals that are rated by an independent panel of reviewers, based solely on their scientific merit. Virtually all areas of astronomy from astrometry, then stars and interstellar matter in our Galaxy, to the most distant extragalactic objects, in particular, active galactic nuclei (AGN), are covered. EVN observations take place three times a year in the form of three- to four-week-long so-called observing sessions. Apart from that, one-day-long sessions are performed monthly.

## IMPACT

Since early experiments in 1967, observations using the VLBI have led to several crucial discoveries in astronomy. Recently, a momentous achievement was accomplished owing to the VLBI observations obtaining an image of a shadow of the supermassive black hole at the centre of the M87 galaxy. That discovery, announced on April 10th, 2019, confirmed the existence of such exotic objects in the universe.

A spectacular application of EVN was to localise the radio afterglow of the source of gravitational waves GW170817 triggered by the collision of two neutron stars. The observation was carried out on March 12th, 2018 with a network consisting of 33 radio telescopes worldwide including the 32-metre radio telescope of the NCU EVN station.

The NCU radio telescope is a unique research facility of this type, scale and technical parameters in our region of Europe. Given that the majority of European radio telescopes are in Western Europe, it is of great importance for the EVN that a large radio telescope is located in Poland. Therefore, the distances between western European instruments and the NCU radio telescope are among the longest. Its continued operation is of great benefit to the EVN because the longer those distances are, the finer the angular resolution of the whole network is.

# Virgo – gravitational-wave observatory

**Entities involved:**

1. *Institute of Mathematics Polish Academy of Sciences – Applicant*
2. *Nicolaus Copernicus Astronomical Centre Polish Academy of Sciences*
3. *National Centre for Nuclear Research*
4. *University of Bialystok*
5. *Jagiellonian University in Cracow*
6. *University of Warsaw*
7. *University of Zielona Gora*
8. *Paweł Chuchmała Smart Instruments, Wroclaw*

## DESCRIPTION

Virgo is a large-scale research infrastructure comprising a 3 km-long interferometric gravitational-wave detector built by the Centre National de la Recherche Scientifique (CNRS, France) and Istituto Nazionale di Fisica Nucleare (INFN, Italy). The detector is located near Pisa, Italy. The construction cost was around €150 million. Teams from other European countries, including Poland, joined the project and participate in the upgrading of the detector. Virgo is collaborating closely with the US LIGO project, which has two large 4 km-long gravitational-wave detectors. The members of the Polish Consortium of the Virgo Project have, therefore, full access to the global unique LIGO-Virgo infrastructure worth about $1 billion, which means, among other things, unlimited access to the data collected by the detectors. Currently, the Virgo project consists of 28 research groups composed of more than 500 scientists from around 100 institutes from Italy, France, the Netherlands, Poland, Hungary, Spain, Germany and Belgium.

## SERVICES

The discovery of gravitational waves has opened up completely new possibilities for astrophysical research: conducting precise tests of Einstein's theory of gravity and alternative theories, gaining data to better understand the laws governing very dense matter that makes neutron stars, and make independent measurements of cosmological parameters. Gravitational waves will allow one to study areas that are not accessible to electromagnetic waves. Gravitational-wave astronomy will answer basic questions of physics and astronomy: How do black holes form? Is Einstein's theory the correct theory of gravity? How does matter behave in the interiors of neutron stars and

during supernova explosions? Virgo-type laser interferometers are extremely sensitive (measure differences in detector arms length less than 1/10000 diameter of the proton). They use the most advanced laser and optical technology, precision mechanics, electronics and material physics. There are many examples of technology transfer from gravitational-wave interferometry to commercial applications in the industry. The Polish Consortium of the Virgo Project makes a significant contribution by identifying and reducing a certain type of noise resulting from changes in the gravitational field near the mirrors of the detector and measuring correlated noise from global electromagnetic fields. The Virgo project is open to new teams from all European countries. The data received as a result of the project are made public after 18 months. Methods of analysis employing machine learning and artificial intelligence methods, which were developed during the search for gravitational waves, have the potential to be applied in other fields of science and technology.

## IMPACT

Observations of gravitational waves provide extremely valuable information about our universe, its construction and evolution. This information is impossible to obtain by observing electromagnetic radiation. Gravitational-wave astronomy provides unique information on coalescences (as a result of gravitational radiation emissions) of binary systems composed of neutron stars or black holes, rotating single neutron stars, supernova explosions and gravitational background radiation, which is a remnant of processes taking place in the very early stages of universe evolution. Thanks to a Polish group of scientists' participation in the work of the Virgo gravitational-wave observatory, the recent scientific-critical discovery of gravitational waves is also a Polish discovery. Observations conducted jointly by LIGO and Virgo allowed the opening of a new window to the Universe by developing a new field of observational astronomy — gravitational-wave astronomy. Polish scientists make a significant contribution to the creation and development of this field. Participation in the Virgo project allows Polish doctoral students to participate in one of the most fascinating experiments of modern astrophysics. In addition, the planned Polish contribution to the construction of the Advanced Virgo detector, will lead to the development of high technologies in Poland.

# 5 Social sciences & humanities

## Infrastructures in this area:

1. CLARIN – Common Language Resources and Technology Infrastructure
2. Digital Research Infrastructures for the Arts and Humanities DARIAH-PL
3. European Interdisciplinary Centre for Research of Borderland Cultural Convergence
4. European Research Infrastructure Consortium for the European Social Survey Research Infrastructure (ESS ERIC)
5. Polish Research Infrastructure for Life Course Studies on Families, Generations, and Human Capital (PRILS-FGH)
6. Polish Research Infrastructure for Heritage Science – ERIHS.PL.

# CLARIN – Common Language Resources and Technology Infrastructure

**Entities involved:**

1. *Wroclaw University of Science and Technology – Applicant*
2. *Institute of Computer Science Polish Academy of Sciences*
3. *Institute of Slavic Studies Polish Academy of Sciences*
4. *Polish-Japanese Academy of Information Technology*
5. *University of Lodz*
6. *University of Wroclaw*

## DESCRIPTION

CLARIN-PL is a Polish research infrastructure that is part of the European Research Infrastructure CLARIN ERIC (Common Language Resources and Technology Infrastructure), included in the ESFRI Roadmap.

The strategic scientific objective of CLARIN ERIC and CLARIN-PL is to support research in the humanities and social sciences in a multicultural and multilingual Europe by developing tools which enable automated analysis of large collections of text documents, recordings of speech and multimedia resources which represent natural language communication, as well as providing distributed access to this data. The task of CLARIN-PL is to implement the strategy of CLARIN ERIC, focusing on the Polish language.

To achieve this goal, two CLARIN centres, both certified by independent international bodies, have been established: Language Technology Centre (which works with users and experts in the field of natural language processing and maintains a repository of tools and resources) and PolLinguaTec (which provides users with support and expertise in the application of technology for the Polish language in research).

## SERVICES

Access to CLARIN-PL infrastructure is open and free. In accordance with the current CLARIN ERIC policy, everybody can use the infrastructure, regardless of nationality or place from which research is conducted. Majority of CLARIN-PL tools and resources do not require the user to register or contact consortium employees. In case of difficulties, PolLinguaTec offers user support. Its service is particularly important for users without technical competence, who comprise the majority of CLARIN-PL customers, however,

the infrastructure's function extends further, as it provides support for sciences that use tools and resources of natural language processing in general.

CLARIN-PL offers its users the following tools and resources:

- D-Space repository and cloud repository CLARIN Cloud, adaptable to specific requirements and compatible with CLARIN ERIC (technologically up-to-date and certified on an ongoing basis);
- text corpora for Polish as well as multilingual corpora (annotated, parallel, text and speech) as well as applications for their editing and searching;
- lexical resource system for the Polish language, comprised of Polish-English Słowosieć (wordnet for Polish), linked with Linked Open Data and its global resources, as well as Walenty valence dictionary for Polish, along with editing tools for them;
- a set of language tools for Polish, operating at the basic pipeline processing level (morphology, syntax, lemmatisation, word sense disambiguation);
- basic tools and resources system for the analysis of speech;
- system of research applications which are based on language technology, allowing for multifaceted text analysis (so-called text mining).

## IMPACT

By developing large data resources available under open licences, filling gaps in the accessibility of tools for their processing, providing support and knowledge regarding their use in research and development on the basis of interdisciplinary data usage, CLARIN-PL sets out strategic goals nationwide, consisting in building an economy based on data and knowledge. The experience of the team has shown that the effects of the infrastructure are of particular importance in the following areas:

- education and self-education, including lifelong education;
- development of highly specialised staff in the fields of science, economy and administration;
- counteracting social exclusion by spreading access to knowledge and data;
- counteracting territorial inconsistency by providing access to tools and resources regardless of place of residence as well as supporting the coordination of distributed research and development centres (clusters) which utilise new NLP technologies;
- support for obtaining partners for R&D cooperation;
- providing social sciences and public institutions with tools for social diagnosis based on big data;
- innovation, interdisciplinarity and internationalisation of research;
- recognisability of the Polish language on the world map by supporting the tools for its development;
- cyberspace defence in terms of solutions used in tools for defining threats and their counteraction.

# Digital Research Infrastructures for the Arts and Humanities DARIAH-PL

**Entities involved:**

1. *University of Warsaw – Applicant*
2. *Academy of Fine Arts in Warsaw*
3. *National Library of Poland*
4. *Institute of Literary Research Polish Academy of Sciences*
5. *Institute of Bioorganic Chemistry Polish Academy of Sciences – Poznan Supercomputing and Networking Centre*
6. *Tadeusz Manteuffel Institute of History Polish Academy of Sciences*
7. *Institute of Polish Language Polish Academy of Sciences*
8. *Institute of Computer Science Polish Academy of Sciences*
9. *Institute of Slavic Studies Polish Academy of Sciences*
10. *Institute of Art Polish Academy of Sciences*
11. *Wroclaw University of Science and Technology*
12. *Adam Mickiewicz University in Poznan*
13. *Jagiellonian University in Cracow*
14. *Maria Curie Skłodowska University*
15. *Nicolaus Copernicus University in Torun*
16. *Pedagogical University of Cracow*
17. *University of Silesia in Katowice*
18. *University of Wroclaw*

## DESCRIPTION

DARIAH-PL (http://dariah.pl/en/) constitutes the Polish part of the European Research Infrastructure Consortium DARIAH. The aim of ARIAH ERIC is to comprehensively support research and teaching in the field of arts and humanities using digital tools, methods and technologies. Poland has been a member of DARIAH ERIC since 2015. The content-related background for this membership is provided by the DARIAH-PL Consortium.

## SERVICES

DARIAH-PL will be a dispersed infrastructure built on the basis of a combination of several specialised network research laboratories (real and virtual). DARIAH-PL will comprehensively support the production, analysis, processing, enrichment, storage, integration, retrieval and reuse of research data from arts and humanities. The infrastructure will make it possible to work with different types of data, including texts, images (two- and three-dimensional) and sound materials. The existing services, tools and resources of members of the DARIAH-PL Consortium will be integrated and supplemented with the missing elements in a way that allows their effective use by the entire Polish scientific community. Researchers will be able to use the system of services offered within the network research laboratories from the stage of formulating research problems, through collecting resources, managing research data, analysing and visualising these data, as well as formulating and publishing final results. The digital research infrastructure for arts and humanities (DARIAH-PL) will be fully compatible with the solutions developed within DARIAH ERIC, which will open new opportunities for international cooperation for Polish researchers.

## IMPACT

The use of digital tools, methods and technologies is crucial for further development of arts and humanities in Poland. Their integration and development within a system of network research laboratories will, on the one hand, provide individual researchers and research teams with easy access to the most advanced solutions, which are difficult to obtain within individual projects, and, on the other hand, significantly reduce the costs of digital infrastructure incurred for research. The implementation of appropriate standards, leading to interoperability of services and resources, will enable the scope of research to be extended, as well as facilitate the maintenance and reuse of the results. Modern digital solutions will help educate students and doctoral candidates. The development of the DARIAH-PL infrastructure, in close connection with DARIAH ERIC, will guarantee Polish scientists access to European services, tools and data, increase the visibility of their achievements in Europe and possibilities of international cooperation – including, in particular, more effective acquisition and implementation of nternational research projects – as well as contribute to the sustainability of the local infrastructure through its international use. Ensuring wide availability of digital resources of cultural heritage will open up new opportunities for use by creative industries.

# European Interdisciplinary Centre for Research of Borderland Cultural Convergence

**Entities involved:**

1. *University of Rzeszow – Applicant*
2. *Institute of Archaeology and Ethnology Polish Academy of Sciences*
3. *Adam Mickiewicz University in Poznan*
4. *Jagiellonian University in Cracow*
5. *Maria Curie Skłodowska University*
6. *University of Vienna*
7. *Leibniz Institute for the History and Culture of Eastern Europe*
8. *Ivan Franko National University of Lviv*
9. *Vasyl Stefanyk Precarpathian National University*
10. *University of Prešov*
11. *University of Oradea*
12. *Lviv Historical Museum*
13. *Museum in Vynnyky*
14. *Eastern Slovakia Museum*
15. *The National Heritage Board of Poland*
16. *National Institute for Museums and Public Collections*
17. *National reserve "Ancient Halych"*
18. *National Academy of Sciences of Ukraine, in particular – Institute of Ukrainian Studies, Institute of Archaeology and Rescue Archaeological Service research centre*
19. *Foundation of the Rzeszow Archaeological Centre*

## DESCRIPTION

The mission of the Infrastructure is to carry out research on cultural interactions that have occurred in the borderlands of modern Poland, Ukraine, and Slovakia; more broadly – the Carpathians. These territories have witnessed the intermingling of cultures since prehistory. The research is to be based on the already existing and also planned infrastructure. The goal of the research, which was initiated at the University of Rzeszow many years ago, is the multifaceted and all-encompassing protection of cultural heritage in the region between Cracow and Kiev. The research concerns archaeological heritage referring to prehistoric and medieval archaeological remains, coexistence of cultures, faiths and nations in modern times and the most recent times, and also current social processes taking place in territories being researched, with particular reference to convergence processes regarding cultures of the studied region. The research will be conducted in cooperation with research centres from Poland, Ukraine, Slovakia, Czechia, Hungary, Austria, Slovenia, Romania and Germany.

## SERVICES

The Infrastructure will be available in open access to researchers representing research teams from the University of Rzeszow as well as external research units. Additionally, it is envisaged that a portion of operating time of research equipment should be committed to activities in the interest of the economy. The University of Rzeszow cooperates with approx. 150 higher education institutions from all over the world. The University's partners include, i.a., Ukrainian, German, Slovak, Hungarian, Czech and Romanian institutions, which shows the international capability of the Infrastructure. For several

years now scientists from these centres have participated in conducting research on cultural relations in the borderlands, have taken part in research projects, have co-organised scientific conferences and have been co-authors of significant scientific publications. It is noteworthy that the Infrastructure has already been functioning, partly owing to international cooperation such as, for example, co-financing research and publications regarding the exploration of the region of Cherven Cities by the Leibniz-Institut für Geschichte und Kultur des östlichen Europa in Leipzig, organisational support provided by Ukrainian, Czech and Moldavian partners during the excavations conducted within their territories, as well as organising scientific conferences by partners of the University of Rzeszow. Moreover, the Infrastructure will play a key role in the construction of the scientific community as wide-reaching recruitment and permanent presence of foreign researchers are envisaged.

## IMPACT

The significance of the Infrastructure is determined by factors contributing to its unique position not only on the national scale but also in Europe. Those factors are as follows: the Infrastructure localisation; a long tradition of interdisciplinary studies dealing with issues connected with borderlands and points of contact between cultures; and the long-standing cooperation with research centres from Poland, countries and regions which border the Sub-Carpathian region as well as with partners from neighbouring countries. The Infrastructure will also be helpful in enabling the execution of ground-breaking research projects aimed at investigating intercultural relations as well as protecting cultural heritage. The development of the Infrastructure will contribute to a significant qualitative step forward for research organisation, proper storage of acquired cultural heritage objects, digitisation of results of carried-out projects and making them widely accessible, all to support the protection of centuries-old heritage connected with intercultural relations in borderlands. The fact that the Infrastructure will provide the ability to internationally conduct ground-breaking interdisciplinary research projects, to organise multidimensional presentation of gained results and activities leading to their dissemination as well as the establishment of a centre dealing with the protection of cultural heritage, proves the uniqueness of the Infrastructure and its huge research potential.

# European Research Infrastructure Consortium for the European Social Survey Research Infrastructure (ESS ERIC)

**Entities involved:**

1. *Institute of Philosophy and Sociology Polish Academy of Sciences – Applicant*
2. *Institute of Political Studies Polish Academy of Sciences*
3. *Collegium Civitas*
4. *University of Bialystok*

## DESCRIPTION

The ESS ERIC initiative is a response to the needs of the international communities of scholars, policymakers, public administration, journalists and others for reliable information concerning attitudes of European societies to key problems on our continent. The aim of the research, having been conducted every two years since 2002, is observation of trends concerning these issues. Thanks to the application of rigorous methodology at every stage of the research process, the project creates the possibility of observing not only changes occurring in particular countries but also of drawing warranted comparisons between countries.

The list of issues studied is updated with newly arising problems such as the inflow of immigrants, climate change, threats to democracy and the ageing of societies.

Development of research methodology, promotion of best practices and development of European research cooperation are also statutory aims of ESS ERIC. Depending on the research trial, from over twenty to over thirty countries, from both within the European Union and beyond, participate in the ESS.

## SERVICES

ESS data are available without any restriction or payment at the following address: http://www.europeansocialsurvey.org/data/. This is an integrated data set from all research trials for all countries participating in the project. The data set can be analysed using generally available statistical programs. With a view to enlarging the circle of ESS users beyond the academic community who often do not have access to statistical programs, an easy to use browser is available on the project webpage, enabling basic statistical analysis. Also available on the project web page are

the conceptual bases of all topics covered by the survey.

In order to promote modern principles of survey research based on the highest standards, the web page has detailed information about the methodology of every stage of the research (starting from translation of the questionnaire and selection of survey sample to preparation of data sets), mandatory ethical standards and those concerning GDPR, as well as a detailed description of the course of every research trial in individual countries. The ESS methodology is innovative in character and is constantly being improved: many solutions have been elaborated in connection with implementation of the project.

## IMPACT

ESS is one of the largest and most important European projects in social sciences. Its international character and the repetition of surveys allow observation and diagnosis of social changes not only from the perspective of particular countries, but also from that of our continent. The project has defined new standards for the preparation and conduct of surveys.

The ESS is carried out every two years, thus allowing access to up-to-date data concerning attitudes of European societies. They are put to broad use. In total, the number of users registered on the web page already exceeds 150 000 people in 219 countries, and each year the number of users grows by between ten and twenty thousand. The research data and descriptions of research standards on the ESS web page attract attention in, above all, the academic community: scholars, students and young researchers. They are used not only in preparing academic research, but also in the teaching process. In this way the highest standards are promoted, favouring the further improvement of surveys in Europe. Given the diversity of topics covered in the project, users of the data are not only sociologists but also political scientists, economists, psychologists and other social scientists.

In view of the above-mentioned methodological standards, ESS results also form a benchmark for the results of other surveys. Because the questions covered by the survey concern key European social problems, ESS data are also used outside academia. They are used by policymakers, state administration, NGOs private firms, journalists and private individuals.

# Polish Research Infrastructure for Life Course Studies on Families, Generations, and Human Capital (PRILS-FGH)

**Entities involved:**

1. *SGH Warsaw School of Economics*

## DESCRIPTION

The Polish Research Infrastructure for Life Course Studies on Families, Generations, and Human Capital (PRILS-FGH) will enable scholars in Poland to conduct comprehensive, advanced and innovative research on demographic and social developments that take place under ongoing transformations of European societies. It aims to systematically collect and distribute high-quality, cross-nationally comparable individual data to describe and explain how contemporary families and intergenerational relations are being changed in Poland. The data make it possible to run more in-depth studies on how these changes affect the formation and development of human capital, as well as people's well-being and quality of life.

PRILS-FGH, located at the Institute of Statistics and Demography at SGH, the Warsaw School of Economics, is built on two international panel studies:

- Survey for Health, Ageing and Retirement in Europe (SHARE, www.share-project.org) – a study on the living conditions and quality of life of people aged 50 or older. The study collects data on health, socio-economic status and social and family networks. So far, the survey has been conducted in 28 countries;
- Generations and Gender Survey (GGS, www.ggp-i.org) – a study on family related behaviours (unions' formation and dissolution, fertility) intergenerational relations and gender roles, that covers people aged 18–79. So far, the survey has been conducted in 20 countries.

Moreover, GGS is part of the Generations and Gender Programme (GGP), which also includes a Contextual Database – a unique set of economic, demographic and social indicators for 60 countries over the last 40 years.

## SERVICES

To date, six rounds of SHARE (the first one in 2006/2007, the last one in 2018/2019) and two rounds of GGS (2010/2011, 2014/2015) were conducted in Poland. Polish data are entered into international databases, available to the scientific community in the open access system.

The Polish Research Infrastructure for Life Course Studies on Families, Generations, and Human Capital will serve:

- to continue, along with SHARE and GGP standards, the systematic data collection on women and men from the age of 18 until very old ages. Data will cover their life course developments (education, work, family life, migration etc.), attitudes, plans and their realisation;
- to expand the scope and advance the life of research on societal transformations in Poland, referring also to an international comparative perspective;
- to facilitate a wider use of the unique longitudinal data among Polish scholars by providing on-line technical support and supporting materials, organisation of trainings, workshops and research seminars;
- to disseminate the research outcomes, especially outside academia (governmental institutions, non-governmental organisations, and media).

## IMPACT

The unique longitudinal data on key processes of societal transformations and analytical tools developed within the research infrastructure will contribute to progress in social sciences in Poland. They will enable advanced innovative research projects by interdisciplinary teams of scholars from various institutes, also in cooperation with researchers from other countries. Consequently, it would result in more developed international contacts of Polish researchers, their increased mobility and strengthening their presence in the European research area. Running the infrastructure will enrich Polish scholars with experience on survey-based and internationally comparable empirical research and facilitate research cooperation between academic institutions in Poland. It will strengthen the scientific potential of the Polish research community and improve its position in Europe, especially among the Central and Eastern European countries.

New research projects and high-quality scientific publications will be another important outcome of the research infrastructure. They will contribute to a better understanding of many key social problems regarding demographic changes and their multiple effects, especially in the context of growing socio-economic inequalities and threats to sustainable development. The transfer of this knowledge to a wider range of stakeholders will increase public awareness of social issues, related to demographic change in particular, and stimulate implementation of evidence-based development policies at the local, regional and national levels.

# Polish Research Infrastructure for Heritage Science – ERIHS.PL

**Entities involved:**

1. *Nicolaus Copernicus University in Torun – Applicant*
2. *Jan Matejko Academy of Fine Arts in Cracow*
3. *AGH University of Science and Technology*
4. *Institute of Nuclear Chemistry and Technology*
5. *Jerzy Haber Institute of Catalysis and Surface Chemistry Polish Academy of Sciences*
6. *The Szewalski Institute of Fluid-Flow Machinery Polish Academy of Sciences*
7. *National Museum in Cracow*
8. *National Centre for Nuclear Research*
9. *Warsaw University of Technology*
10. *Jagiellonian University in Cracow*
11. *Cracow University of Economics*
12. *University of Warsaw*
13. *University of Wroclaw*

## DESCRIPTION

The E-RIHS.pl [http://www.e-rihs.pl/index.php/english-info/] infrastructure was established for:

- development, coordination and implementation of an integrated system supporting access of art curators, restorers and other museum specialists to modern methods of physical and chemical tests and an exchange of information on the results of these tests and analyses;
- preparation of Poland's accession to and participation in the organized European infrastructure: E-RIHS ERIC [http://www.e-rihs.eu/]: European Research Infrastructure for Heritage Science;
- promotion of national and pan-European scientific cooperation in the field of physical and chemical research of cultural heritage monuments;
- supporting the exchange of experience and research results as well as strengthening the cooperation between consortium members by co-organizing scientific conferences and symposia;
- cooperation with scientific institutions, consortia, scientific networks, advanced technology centres and other centres integrating the scientific community in Poland and Europe.

The infrastructure operates in a distributed mode, based on current resources both in terms of equipment and necessary skills. The key aspect of its activity is close cooperation with art curators and restorers in the selection and implementation of physicochemical research procedures for understanding the structure, state of preservation, provenance and dating of tangible cultural heritage. The research projects implemented are comprehensive, combining the research resources of the partners in the infrastructure.

## SERVICES

The primary mode of operation of the infrastructure is the offer of free examinations [http://www.e-rihs.pl/index.php/english-info/#offer] to curators and restorers, thus enabling their access to high-class research procedures. The offer is organized into two platforms:

- MOLAB.PL: an examination carried out by a mobile research team that takes place in-situ (e.g., at a museum) – the offer includes 12 research procedures;
- FIXLAB.PL: testing which takes place in a specialized laboratory offering a given procedure and which utilises a non-mobile testing facility – 23 testing procedures are offered.

The offer is addressed to all institutions active in the area of cultural heritage research and protection and includes examination (in the presence of the object's curator) by qualified research staff of infrastructure partners, as well as analysis and interpretation of results prepared in close cooperation with the curator so that the results obtained are most useful to them. The research techniques offered include optical, spectroscopic, chromatographic, X-ray (tomographic and spectroscopic), laser, microbiological and radiation methods. Competitive selection of projects takes place once a year. So far (2020), four calls have been held, resulting in 33 projects accepted for implementation.

An integral part of the above offer is annual information workshops organized by the infrastructure to familiarize potential project authors with the methods offered, with particular stress on less well-known techniques. The emphasis is on presenting practical possibilities and limitations of the given methods.

## IMPACT

The E-RIHS.pl infrastructure brings benefits for both the development of scientific research in the field of cultural heritage science and, in a broader sense, for the preservation of a tangible cultural heritage. The development of new research methods, along with common standards for data analysis and storage, are conducive to combining multiple research techniques linking the humanities and the exact sciences. In addition, participation in the infrastructure involves an independent assessment (in the audit process by E-RIHS ERIC) of the scientific excellence of the national laboratories concerned. Furthermore, participation in joint E-RIHS ERIC projects will give researchers access to world-class heritage objects in European museums.

In turn, facilitating access to the highest quality research modalities for curators of these cultural heritage objects, thus expanding our knowledge about the objects and their condition, will create a strong drive for research in the fields of the humanities (history of art, archaeology, history, culture and religion) and of art itself (conservation of works of art). In addition, it will promote the development of cognitive tourism, stimulating economic growth and impacting society as a whole, contributing to reinforcing the identification of citizens with their heritage and intercultural understanding.

# 6 Digital infrastructures

## Infrastructures in this area:

1. National Cloud Infrastructure PLGrid for EOSC
2. National Data Storage. Universal Infrastructure for Data Storage and Access and Effective Processing of Large Data Volumes in HPC, BigData and Artificial Intelligence Computing Models
3. National Laboratory for Advanced 5G Research
4. National Supercomputing Infrastructure for EuroHPC
5. PIONIER-LAB – National Platform for Integrating Research Infrastructure with Ecosystems of Innovation
6. PRACE – Cooperation in Advanced Computing in Europe.

# National Cloud Infrastructure PLGrid for EOSC

**Entities involved:**

1. *AGH University of Science and Technology – Applicant*
2. *University of Warsaw*
3. *Institute of Bioorganic Chemistry Polish Academy of Sciences – Poznan Supercomputing and Networking Centre*
4. *Wroclaw University of Science and Technology*
5. *Gdansk University of Technology*
6. *National Centre for Nuclear Research*

## DESCRIPTION

The National Cloud Infrastructure PLGrid for EOSC is a program aiming to build a cloud infrastructure for research into solutions addressing the current and future needs of Polish society, scientific community and economy. The scope of these studies includes, among others, the issue of data itself, infrastructures and platforms for its processing, efficient algorithms and dedicated applications.

The program is based on the requirements of society, international scientific groups, ESFRI projects and entrepreneurs. Such groups require advanced environments of integration of distributed resources: software applications, infrastructures and specific services. These requirements can only be met by advanced IT technologies connected to computing, mass storage and data resources. The combination of all these elements in one flexible ecosystem is made possible through cloud technologies.

The National Cloud Infrastructure PLGrid for EOSC is a part of the European Open Science Cloud (EOSC, Declaration dated 26/10/2017) ecosystem. Poland develops two key components of this federated, globally open and multidisciplinary environment: Onedata – system of unified data management and provisioning and EOSC Portal. As a part of the European ecosystem, the National Cloud Infrastructure PLGrid for EOSC will offer a trusted and open environment for researchers of all scientific disciplines throughout the scientific data life cycle. This will allow for scientists, innovators, businesses, and the entire society to publish, search, use and reuse the collected data, tools, software, publications and other results of work for research, innovation and education.

## SERVICES

The proposed research plan will allow the development, validation and, in consequence, provision of services (general and dedicated) for the use of modern technologies and effective techniques for management, processing and reuse of data by the scientific environments, business entities and society. For this purpose, the Infrastructure will provide:

- the technologies for distributed environments including cloud computing, distributed service management, automation of complex processes, integration of platforms and infrastructures;
- secure data sharing and management based on national technology, interoperable with EOSC standards;
- research into specific user needs in the field of large-scale data processing in a distributed environment including: near-data processing, the use of the "Data Lakes" paradigm together with new analysis models, scalable resources in a distributed environment;
- a review of solutions for the needs of society, science and the economy in advanced applications;
- a catalogue of general services and cloud services for the economy, science and society resulting from research and development in cooperation with EOSC.
- The first stage of this work is currently carried out as part of the PLGrid e-Infrastructure (http://www.plgrid.pl/en).

## IMPACT

Modern scientific research as well as complex and multi-step production processes are characterised by a huge amount of data. Their analysis, due to the requirements or the need to control the production processes, must be carried out in a continuous mode by means of information technologies. Cloud technologies are now a proven and flexible tool that makes possible uploading, storing and analysing huge amounts of data, including those flowing continuously from the research equipment. The multitude of data, data formats and the need to ensure their mutual interoperability is a fundamental challenge for the National Cloud Infrastructure PLGrid for EOSC, as well as for the entire European Open Science Cloud initiative.

The Infrastructure will provide a set of general and advanced services with application programming interfaces. Introduction of the standards for data and catalogue of the general services will allow for their interoperability and thus better use in research and innovative applications.

In the science and economy sectors the proposed cloud-based research infrastructure means access to almost freely configurable environments dedicated to research problems. It creates also the opportunity of interdisciplinary cooperation between different groups of researchers on one scientific problem. For society it gives the possibility to take advantage of such dedicated services as personalized healthcare or space for digital gathering and access to digital cultural and heritage assets.

# National Data Storage. Universal Infrastructure for Data Storage and Access and Effective Processing of Large Data Volumes in HPC, BigData and Artificial Intelligence Computing Models

**Entities involved:**

1. *Institute of Bioorganic Chemistry Polish Academy of Sciences – Poznan Supercomputing and Networking Centre – Applicant*
2. *AGH University of Science and Technology*
3. *Bialystok University of Technology*
4. *Czestochowa University of Technology*
5. *Gdansk University of Technology*
6. *Lodz University of Technology*
7. *Kielce University of Technology*
8. *Wroclaw University of Science and Technology*
9. *University of Warsaw*
10. *National Centre for Nuclear Research*

## DESCRIPTION

The aim of the project is to deliver a production-level infrastructure for data storage, access and protection services as well as to integrate solutions for efficient analysis and processing of large and complex data sets based on the distributed ecosystem of HPC, BigData and AI platforms.

The infrastructure and services will enable integrated, professional, reliable and cost-efficient implementation of the fundamental tasks for data storage, management, processing and analysis. These processes are still performed independently by various academic and research organisations and companies. This leads to a redundancy of efforts, missed opportunities for data re-use and data-based collaboration, as well as increased overall costs.

Integration of the data analytics platforms (BigData) as well as artificial intelligence solutions (e.g. Machine Learning) in the data management infrastructure and tight integration with HPC and HTC systems at the academic computing centres will enable the efficient processing of large volumes of data and complex data sets.

## SERVICES

The proposed system will constitute a basis for implementing coordinated and integrated data management processes and plans for the purposes of the Polish academic and research environment as well as for public institutions, and society and industry, especially SMEs.

While the fundamental services enable to store and protect the data, including long-term storage, additional functionalities will include data access and presentation as well as tight integration with computing and data processing systems. This will enable the performing of advanced and efficient data

processing and analytics as well as implementation of the machine learning and artificial intelligence workloads based on large and complex data sets.

The system architecture of the data storage is designed into a fully open, modular and scalable data repository, equipped with a range of access protocols. The open architecture will enable extending the system with a range of data access and presentation services as well as other functionalities built on top of the basic storage layer. For instance converting the data object from raw storage format into presentation format will be integrated within data access and presentation services.

The storage system will implement the model and architecture of so-called Data Lake, adopted by many leading vendors in the IT industry, but also used by scientific institutions, including CERN. The second important feature of the architecture will follow open data access rules defined by the European Commission.

As noted above, the proposed system will support high-performance and cost-effective processing of high-volume and structurally complex datasets based on HPC, HTC, BigData and Machine Learning models.

## IMPACT

The proposed solution is unique, both nationally and on an international scale. The novelty lies in scalability, wide, universal and extendible usability and openness of the proposed solution. These features apply to architecture openness enabling technical implementation freedom, general architecture scalability and functional extendibility that allow for direct deployment of project results in many fields of economy and science.

The undertaking is implemented by 10 partners of the PIONIER consortium (HPC centres and academic networking operators), distributed across the country. Such distribution of partners and average low network latency to the closest partner, as well as wide bandwidth of the network connections, ensure the possibility of implementing the storage and data access services that can be accessed effectively from any point in Poland. The combination of server systems, disk and flash memories as well as networks with correspondingly high bandwidth links (local network 10 / 40 Gbit/s for servers, 40 / 100 Gbit/s for ToR switches and edgebanks, WAN network and backbone network even 100 GBit/s) determine the unique quality, performance and reliability of the system.

In addition, locating the largest data storage and sharing services points and infrastructure elements in HPC centres in Poznan, Warsaw, Swierk, Cracow, Wroclaw and Gdansk allows for tight integration of the data infrastructure with high-performance HPC computing systems and BigData platforms.

# National Laboratory for Advanced 5G Research

**Entities involved:**

1. *Warsaw University of Technology – Applicant*
2. *National Institute of Telecommunications – National Research Institute*
3. *Institute of Bioorganic Chemistry Polish Academy of Sciences – Poznan Supercomputing and Networking Centre*
4. *Gdansk University of Technology*
5. *Wroclaw University of Science and Technology*
6. *AGH University of Science and Technology*

## DESCRIPTION

The aim of the National Laboratory for Advanced 5G Research (PL-5G) is to build a nationally unique research infrastructure for performing experiments of new techniques and solutions in the area of 5G network and services. 5G networks are designed to support users and device mobility and, as a consequence, for assuring effective communication in society. The 5G network assumes a new multi-level architecture in which three basic levels stand out:

- the resource and functional level, which creates a network and computing infrastructure using virtualization techniques. The telecommunication networks traditionally consist of access networks and a wide area network, but compared to previous generations of the networks, the 5G network assumes the use of new, more efficient radio techniques, node virtualization and programmable network control. In turn, the organisation of computational resources assumes the use of cloud computing (also programmable) at the level of wide area network and edge computing at access networks;
- the network level, which creates a number of specialized networks (network slices), each using dedicated network and computing resources. These resources are provided by the network operating system. Examples of such networks are networks for Internet of Things applications, networks for Industry 4.0 or automotive networks;
- the service level, which performs orchestration of services offered in ”end-to-end” relation, in particular with respect to the following groups: eMBB (enhanced mobile broadband), URLLC (Ultra-Reliable Low-Latency Communication) and eMTC (enhanced Machine-Type Communication).

## SERVICES

The PL-5G infrastructure will allow running experiments in a dedicated 5G test environment. Access to the PL-5G network will be available to all stakeholders and will be defined on the basis of a reservation system created using dedicated access platform. The platform will support the management and monitoring of devices within the research infrastructure, as well as the management of a schedule for reservations of PL-5G resources for experiments. In addition, this platform will provide remote access to the research infrastructure, allowing users to launch experiments remotely. However, the use of PL-5G will require prior registration to get access to the platform. The registration process, as well as reservation of experimental resources, will be handled by a dedicated team elected among the members of the PL-5G Consortium. This team will make decisions taking into account justifiability of the planned experiment and the type of entity applying for access (e.g., scientific entity, company etc.) Also, the team will define the conditions of use of the PL-5G infrastructure for experiments carried out on a commercial basis.

## IMPACT

The developed infrastructure for 5G technology is unique on a national scale and will enable "the creation of new high-tech products and services, in particular in the area of ICT, as a basis for modernization and acceleration of growth of other industries". The infrastructure will contribute to the "growth of the industry's ability to meet global competition", enabling the testing of new solutions, services, and applications developed by domestic companies in an environment similar to the operating one. The above will contribute to "increasing the innovativeness of companies on domestic and foreign markets". The proposed research infrastructure will contribute directly to the "development of technical infrastructure and competences for Industry 4.0". It should be noted that one of the strategic activities is "to create an integrated digital network infrastructure that will enable the digitisation of the economy and the development of broadband Internet access (both fixed and mobile) for the Internet of Things, Physical Internet, RES, energy storage and electric cars after the year 2020." In addition, the use of the PL-5G laboratory to support professional courses (led by the consortium partners, especially by WUT, GUT, AGH UST and WUST) specialised on "vocational education for Industry 4.0, in response to the needs of a modern knowledge-based economy".

# National Supercomputing Infrastructure for EuroHPC

**Entities involved:**

1. *AGH University of Science and Technology – Applicant*
2. *University of Warsaw*
3. *National Centre for Nuclear Research*
4. *Institute of Bioorganic Chemistry Polish Academy of Sciences – Poznan Supercomputing and Networking Centre*
5. *Wroclaw University of Science and Technology*
6. *Gdansk University of Technology*

## DESCRIPTION

The goal of the National Supercomputing Infrastructure for EuroHPC is to build a computing infrastructure to meet the present and future requirements of Polish society, economy and science.

The Infrastructure provided by the project will include modern supercomputing systems, which enable both traditional simulation workloads and data analytics with the use of artificial intelligence. The production systems will be among the world's fastest supercomputers. Beside the computing infrastructure itself, the project will provide access to specialised training programmes and high-level technical support dedicated for science and industry, also handling resource allocation and reporting.

The project fits directly the scope of European High-Performance Computing Joint Undertaking, published in European Commission communication no. COM/2018/08 final – 2018/03 (NLE). EuroHPC is a venture with a goal to create a European system of High Performance Computers (exascale class), which are globally unique, based on technologies that are being developed in Europe. The project will be implemented by the PLGrid Consortium.

## SERVICES

As a result of the National Supercomputing Infrastructure for EuroHPC, a research infrastructure for scientific, industrial and social purposes will be established, which will take advantage of the newest HPC technologies, developed through the international cooperation of EuroHPC.

The infrastructure will offer many services including massively parallel simulations, high performance data analytics with use of artificial intelligence methods, high productivity software and tools including data

visualization, and user support and training. Beside the main computing systems, the infrastructure will contain smaller test and research machines which will be used to verify new processors, accelerators, memory technologies and high performance networks for the needs of construction of future production systems and also to conduct research and development in the field of efficient HPC infrastructures.

All services will be available through the PLGrid Infrastructure, which currently integrates most of HPC resources in Poland, what will ease the process of resource allocation and user support. The infrastructure will be integrated with European preexascale and petascale systems available through the EuroHPC programme, in particular with the supercomputer built by the LUMI consortium, of which Poland is a member.

## IMPACT

The computing power of supercomputers is a fundamental component necessary for conducting research in many fields, which greatly accelerates the research process, reducing cost at the same time. Many scientific problems require simulation exceeding the capabilities of workstations or small computing clusters, either due to the scale of the problem or the time required to perform such calculations. These types of needs must be satisfied by highly efficient computing systems i.e. supercomputers. Apart from typical users of such systems i.e. scientists, it has become more and more popular for companies that are doing simulations for their products in large scale, searching through a wide range of solutions looking of optimum configuration, performing large scale data analysis (Big Data) or using modern artificial intelligence methods e.g. machine learning. For strategic reasons it is important to locate the infrastructure in Poland and enable the use of high class components, including ones developed and manufactured in Europe.

Because of the above facts, it is critical to provide a long-term, sustainable plan to create and maintain a supercomputing infrastructure and to provide a sufficient level of support and knowledge transfer to the users – that is the Polish science and industry – and to integrate the infrastructure with the European one. These goals are addressed by the National Supercomputing Infrastructure for EuroHPC.

# PIONIER-LAB – National Platform for Integrating Research Infrastructure with Ecosystems of Innovation

**Entities involved:**

1. *Institute of Bioorganic Chemistry Polish Academy of Sciences – Poznan Supercomputing and Networking Centre – Applicant*
2. *AGH University of Science and Technology*
3. *Institute of Soil Science and Plant Cultivation – National Research Institute*
4. *NASK – National Research Institute*
5. *Bialystok University of Technology*
6. *Czestochowa University of Technology*
7. *Gdansk University of Technology*
8. *Koszalin University of Technology*
9. *Lodz University of Technology*
10. *Ignacy Łukasiewicz Rzeszow University of Technology*
11. *Kielce University of Technology*
12. *Wroclaw University of Science and Technology*
13. *Maria Curie Skłodowska University*
14. *Nicolaus Copernicus University in Torun*
15. *University of Opole*
16. *Kazimierz Pulaski University of Technology and Humanities in Radom*
17. *UTP University of Science and Technology in Bydgoszcz*
18. *University of Warmia and Mazury in Olsztyn*
19. *University of Warsaw*
20. *University of Zielona Gora*
21. *West Pomeranian University of Technology in Szczecin*

## DESCRIPTION

The main goal of the PIONIER-LAB project is to provide support in the field of ICT for users conducting research beyond the ICT domain, thus enabling interdisciplinary research in key research areas in the PIONIER-LAB ecosystem. In addition, the Project's goal is also to enable research in key areas in the field of new technologies related to social Internet, secure e-commerce and new generation networks.

Achieving the Project goals will be possible thanks to the building of an integrated ecosystem of advanced research infrastructures in the following domains:

- network security, including an infrastructure related to the protection of network and computing systems based on adaptive and intelligent systems for attack detection and data protection;
- distributed transactional systems, including a research infrastructure related to distributed registries for research on new technologies to ensure data integrity in peer-to-peer networks;
- artificial Intelligence, including intelligent decision support systems, automatic inference and autonomous decision-making based on learned patterns and their continuous improvement based on new data;

- Human-Centric Internet, including new technologies and solutions relevant to the individual needs of users and enabling the implementation of innovative and personalized information society services;
- multimedia technologies, including interactive systems, high-quality multimedia, VR and AR;
- network technologies, including modern transmission systems, both fiber optic and wireless, at the level of regional research centres.

## SERVICES

The construction of an ecosystem of connected services interacting with each other will allow the implementation of complex research scenarios in the following key areas:

- personalized internet services;
- secure e-commerce;
- new generation networks;
- new multimedia technologies in a network environment.

Users will have the opportunity to conduct research at the highest world level through access to one or many interconnected infrastructures.

The PIONIER-LAB research infrastructure will be made available on the basis of equal and non-discriminatory access.

Access to the research infrastructure will be remote, i.e. it will be possible to send input data and receive test results. In addition, the infrastructure will be available locally, i.e. it will allow the user's physical presence during the implementation of the research task.

## IMPACT

Implementation of the project will have a positive impact on the development of regions due to its dispersed nature and research and development character, thus causing potential socio-economic effects.

Benefits for enterprises

The results of research and development in the PIONIER-LAB infrastructure will stimulate the creation of new enterprises operating on the ICT market. The result will be the creation of new jobs with the demand for highly qualified employees and experts related to the new technology industry. Access to the PIONIER-LAB platform will stimulate the development and implementation of new products and services by domestic companies.

Benefits for scientists and students

Access to modern research equipment will result in stimulating research aimed at developing practical solutions. National research teams will be provided with infrastructure facilities to develop and test new technologies, becoming a desirable partner in international projects and initiatives. Access to advanced research tools will benefit young scientists participating in the implementation of the research.

Benefits for society

The development in the field of secure and reliable Internet technologies, or work on a collection of new personalized services for users will stimulate the development of e-services. Providing support for new social services may have an impact on areas such as Administration or Health. In addition, work taken up in matters of security and reliability of information transmission can be of great importance for Uniformed Services and the Army, and thus stimulate development in aspects of national security.

# PRACE – Cooperation in Advanced Computing in Europe

**Entities involved:**

1. *Institute of Bioorganic Chemistry Polish Academy of Sciences – Poznan Supercomputing and Networking Centre – Applicant*
2. *AGH University of Science and Technology*
3. *Gdansk University of Technology*
4. *Wroclaw University of Science and Technology*
5. *University of Warsaw*
6. *National Centre for Nuclear Research*

## DESCRIPTION

The initiative PRACE – Cooperation in Advanced Computing in Europe has continuously been on the Polish Roadmap for Research Infrastructures since its first edition (2011). This is a sign of strong interest in the subject of advanced computing (HPC, High Performance Computing), and at the same time the need to build and maintain an advanced research infrastructure in the form of supercomputers in Poland. It should also be noted that the need to use HPC technology has been noticed in new technological areas such as artificial intelligence (AI, Deep/Machine Learning), big data processing (Big Data), cyber security and Industry 4.0.

The mission of the Polish PRACE infrastructure is to enable advanced discoveries and engineering research in the field of science and industry, as well as development between fields in order to increase the competitiveness of Europe on global markets and to use computing for the needs of the ICT society.

The concept of creating the HPC computing environment is based on the harmonic development of computing potential in HPC centres in Poland, supporting key branches of science research. The planned infrastructure will consist of systems installed in Polish HPC centres supporting both local and international research groups of EuroHPC and PRACE initiatives.

## SERVICES

Cooperation with scientific entities and industry as well as public institutions will be implemented on several levels:

– providing resources and services as added value to the communication links within the PIONIER consortium;

- providing services developed in the project, such as HPC processing, cloud services, data storage to current HPC users;
- cooperation within the existing scientific and scientific-industrial centres;
- establishing cooperation within the framework of implemented national and international R&D projects;
- looking for new projects and forms of R&D cooperation;
- looking for new forms of cooperation in the economy during exhibitions, industry conferences and through direct contact with companies;
- creation of new centres of excellence for science and industry.

## IMPACT

The Polish PRACE infrastructure is correlated with the long-term development of HPC technology in Poland. The first stage of implementation was launched under the name PRACE-Lab (January 2019).

The second pillar of the initiative, apart from the main objective of supporting the Polish scientific community, is integration with the European research infrastructure ESFRI (PRACE) and EuroHPC.

The direct objective of the consortium is to build a widely accessible HPC computing infrastructure consisting of high-performance computing servers, specialized processing units and flexible data management systems, and to provide research units and enterprises based on this infrastructure with services for research and development and commercial activities, thus contributing to support their scientific potential and increasing their competitiveness in the national, European and global aspects.

The concerned PRACE Infrastructure, together with the necessary regional and national support network, will be created by 6 consortium members in connection with the existing scientific and research IT infrastructure in Poland, incl. the fibre academic network PIONIER. The infrastructure, created by the consortium members, will increase the efficiency of their computing infrastructure from 5 to 50 PFlops by the end of 2023. The long-term time schedule of HPC strategy in Poland (until 2030) will follow the national HPC strategy defined by the 6 partners of the HPC consortium.

# Members of the Advisory Panel on the Polish Roadmap for Research Infrastructures

**Chair of the Advisory Panel:**

**prof. Agnieszka Zalewska** – Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences in Cracow

**Members of the Advisory Panel:**

- **prof. Marek Biesiada** – National Centre for Nuclear Research in Otwock-Swierk;
- **prof. Tomasz Dietl** – Institute of Physics Polish Academy of Sciences in Warsaw;
- **prof. Józef Dulak** – Jagiellonian University in Cracow, Faculty of Biochemistry, Biophysics and Biotechnology;
- **prof. Mirosława El Fray** – West Pomeranian University of Technology in Szczecin, Faculty of Chemical Technology and Engineering;
- **prof. Jakub Fichna** – Medical University of Lodz, Faculty of Medicine;
- **prof. Andrzej Konon** – University of Warsaw, Faculty of Geology;
- **prof. Jarosław Koperski** – Jagiellonian University in Cracow, Faculty of Physics, Astronomy and Applied Computer Science;
- **prof. Jan Madey** – University of Warsaw, Faculty of Mathematics, Informatics and Mechanics;
- **prof. Andrzej Mizgajski** – Adam Mickiewicz University in Poznan, Faculty of Geographical and Geological Sciences;
- **prof. Lucjan Pawłowski** – Lublin University of Technology, Faculty of Environmental Engineering;
- **prof. Andrzej Seweryn** – Bialystok University of Technology, Faculty of Mechanical Engineering;
- **prof. Błażej Skoczeń** – Cracow University of Technology, Faculty of Mechanical Engineering;
- **prof. Wojciech Szeląg** – Poznan University of Technology, Faculty of Control, Robotics and Electrical Engineering;
- **prof. Tomasz Szlendak** – Nicolaus Copernicus University in Torun, Faculty of Philosophy and Social Sciences;
- **prof. Zofia Szweykowska-Kulińska** – Adam Mickiewicz University in Poznan, Faculty of Biology;
- **prof. Przemysław Urbańczyk** – Cardinal Stefan Wyszyński University in Warsaw, Faculty of Humanities.

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