UPDATE 2019

Roadmap of Large Research Infrastructures of the Czech Republic for the years 2016-2022

Ministry of Education, Youth and Sports

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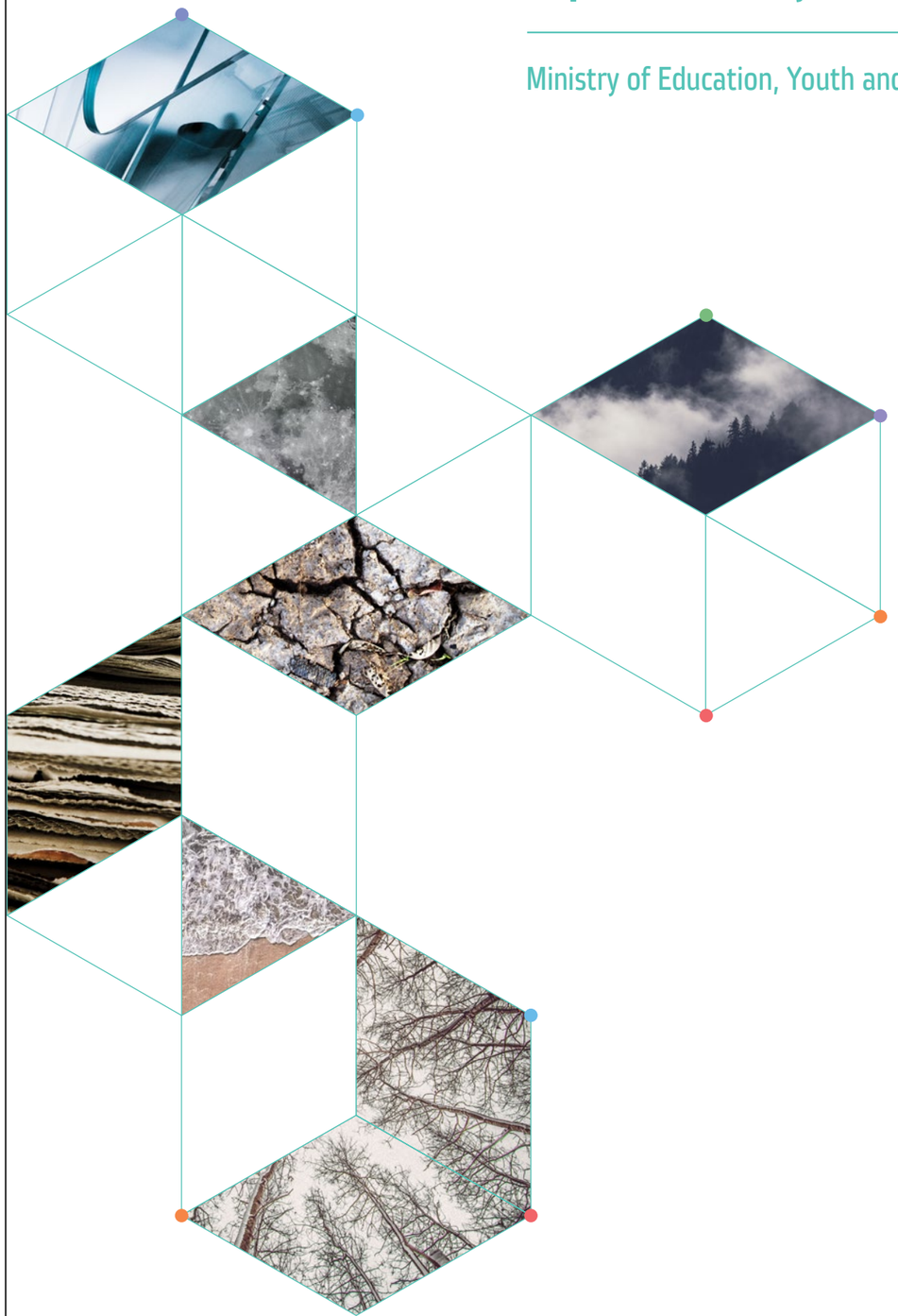

MINISTRY OF EDUCATION,
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Foreword

Research infrastructures are one of the key pillars of national research and innovation systems of the EU Member States, the European Research Area as a whole, and other formations of the macro-regional and global dimension and impact. They form the backbone network for excellent basic and applied research and they are a platform for the development of the most advanced technologies that are characterised by large knowledge-intensity and a potential to be applied in innovative goods and services with high added value.

Research infrastructures concentrate above-critical amount of material, human and financial resources in their capacities, which are necessary to obtain breakthrough knowledge and bring solutions to the socio-economic challenges that we are facing. Through their equipment, they provide unique opportunities to conduct exceptional scientific experiments and research. The users of the research infrastructures come from both the research community and the industrial (business) sector that can use the research infrastructures under commercial conditions.

Since research infrastructures significantly overlap with the educational and industrial areas, they represent the optimal environment to effectively connect the segments of the knowledge triangle, resulting in strong interactions between education, research and industry. Thanks to the research infrastructures, we have been able to push the boundaries of human knowledge towards unexplored horizons. The research infrastructures are also places providing excellent opportunities for the development of top-class professional careers for those who operate the research infrastructures and for those who use them, i.e. researchers and innovators.

The construction of research infrastructures, the development of their experimental facilities and the modernisation of their capacities also provides great opportunities for enterprises that participate in procurements to supply such facilities. The public contracts stimulate businesses to develop state-of-the-art technologies and to increase their innovation capabilities and skills. Businesses can then apply also the advanced know-how, which results from the research and development conducted in research infrastructures, as they can act as partners and participate in follow-up collaborative research and development projects of research infrastructures' users from the public research area, using knowledge that has been obtained by use of the research infrastructures.

International "single-sited" research infrastructures, research infrastructures of a distributed nature formed by national "nodes" of the Member States involved, and virtual e-infrastructures, all accessible to their user communities on the principle of open access policy, make it possible to address socio-economic challenges much more effectively. Sharing expertise in research infrastructures also helps prevent the fragmentation of investments and duplication of efforts by research, development and innovation funding providers and beneficiaries, i.e. research organisations.

Operating research infrastructures fully in compliance with the policy of open access to their capacities and within an integrated international environment enables their users to achieve results that

would be hard to otherwise be obtained by individual stakeholders exclusively using the capacities of their home institutions. From this perspective, research infrastructures – open to all their potential user communities – help increase the efficiency of expenditures invested in research, development and innovation.

Besides the benefits of new scientific findings and the development of new technologies that are applied in innovative products and services, investments in research infrastructures also significantly overlap with other socio-economic spheres. Research infrastructures contribute to the development of entire industries and, from the geographic perspective, of entire territorial units, as well as regional and macro-regional levels of both a national and international nature. Therefore, more and more stakeholders pay attention to research infrastructures.

The research community in the Czech Republic has a wide range of expertise that enables to operate a number of research infrastructures – in the Czech Republic, these are referred to as "large research infrastructures" – with significant international overlaps and also allows it to participate in the most important European and global research facilities that specialise in the physical sciences and engineering, energy, environmental sciences, biological and medical sciences, as well as health and food and social sciences and humanities. These large research infrastructures are complemented by the Czech e-infrastructure that provides appropriate ICT services to the large research infrastructures' operators and users, designed for their specific individual needs.

This trend requires that the Czech Republic continues fostering favourable legal and financial environment for the operation and further development of large research infrastructures of the Czech Republic. Only a strategic approach that provides a stable system of public funding will enable the sustainable development of large research infrastructures of the Czech Republic over the long term.

For that reason, the Ministry of Education, Youth and Sports, as the central body of the Czech Republic responsible for the large research infrastructures' policy-making, their support from the public funds of the Czech Republic, and international cooperation and internationalisation, will continue both with the trends that have been established and with the harmonisation of the Czech research infrastructures' policy in compliance with good practice examples provided by the European Strategy Forum on Research Infrastructures (ESFRI). The development of large research infrastructures of the Czech Republic will then enhance research, development and innovation, as well as the international competitiveness of both the Czech Republic and the entire EU.

Therefore, I am very pleased that I can introduce to you this update to the Roadmap of Large Research Infrastructures of the Czech Republic for the years 2016-2022, published in 2019, which shows how the Czech Republic is responding to the challenges and opportunities in the field of research infrastructures. The Roadmap includes 48 large research infrastructures of the Czech Republic operated in a wide range of scientific fields, including 12 projects through which the research community in the Czech Republic is participating in international research infrastructures outside the Czech Republic (beyond the Czech memberships in international R&D organisations established under international public law). All these large research infrastructures have been approved by the Government of the Czech Republic for public funding until 2022.

I truly appreciate the work of the International Assessment Committee, which in 2017 evaluated the large research infrastructures of the Czech Republic, the work of my colleagues from the Ministry of Education, Youth and Sports, who created appropriate conditions for the work of the Committee, and, last but not least, the enormous engagement of individual research infrastructure teams that have made it possible for this Roadmap to be introduced to both professionals and the general public in the Czech Republic, Europe and around the world.

Robert Plaga, Ph.D.
Minister of Education, Youth and Sports
of the Czech Republic

Contents

Research infrastructures in the European Research Area

The ever-growing importance of research infrastructures in relation to the enhancement of national research and innovation systems of the EU Member States, the **European Research Area** (hereinafter the "ERA") as a whole, and the international competitiveness of EU Member States and the European economy in the global context is reflected in a number of important measures that have been taken over the past period.

In 2002, following a decision taken by the EU Competitiveness Council formed by EU Member States' Ministers responsible for research, the **European Strategy Forum on Research Infrastructures** (hereinafter the "ESFRI") was established. The ESFRI gathers delegates from the EU Member States, the Directorate General for Research and Innovation of the European Commission, and Associated Countries under the EU Framework Programmes for research, development and innovation and facilitates their strategic debates regarding issues of policy-making for research infrastructures of European nature, importance and impact. In 2006, the ESFRI prepared the first **ESFRI Roadmap**, which was later updated in 2008, 2010, 2016 and 2018. The following update to the ESFRI Roadmap is planned for 2021. The ESFRI Roadmap includes research infrastructures of European importance, whose designs and concepts have been already successfully put into practice by their host countries (ESFRI Landmarks) or which are under preparation or in their construction phase (ESFRI Projects), and places them in the context of the European research infrastructure landscape in the form of an analytical study.

Parallel to the ESFRI, a specific expert forum was set in 2003 to focus on European research infrastructures that are specialised in ICT, the **e-IRG** (*e-Infrastructures Reflection Group*). The foundation of the e-IRG emphasized the particular role of the European e-infrastructure, which represents the backbone ICT environment, capacities and services for conducting research, development and innovation across all branches and fields of science.

◀ ELI Beamlines (*Extreme Light Infrastructure*)

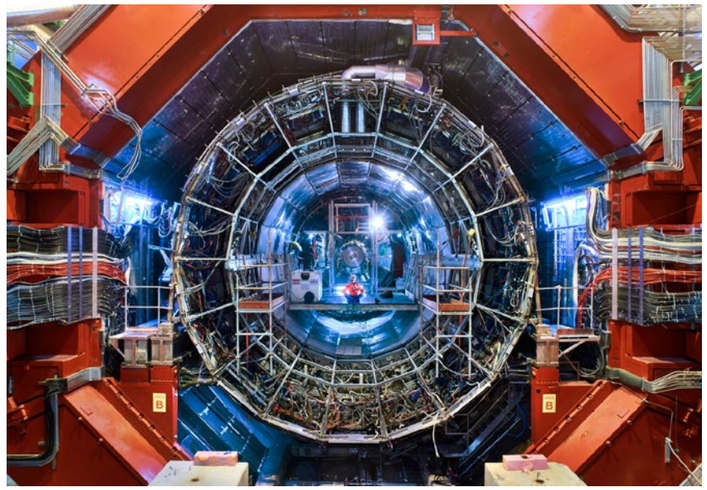
At the legislative level, the increased emphasis placed on research infrastructures of European relevance has brought a brand new EU legal framework which defines the principles for the governance of European research infrastructures jointly operated by at least three EU Member States. Since 2009, this brand new type of legal entity, a **European Research Infrastructure Consortium**[1] (hereinafter the "ERIC"), has made it possible to adopt fully flexible models for the management of research infrastructures of a European nature. The ERIC legal entities and the "representing entities" of ERIC Member States participating in the operation of European research infrastructures can also enjoy some advantages that are otherwise associated with the status of an international organisation established under the international public law, such as VAT or concise tax exemption and special rules for procurements.

Research infrastructures are also included in the **EU Framework Programmes for research, development and innovation as one of their priorities.** In this respect, their key importance, benefit and impact on a progressive ERA development is confirmed by their inclusion into the Excellent Science pillar of the Horizon 2020, the EU Framework Programme for Research and Innovation (2014-2020). Research infrastructures will also be included in the Open Science pillar of the Horizon Europe, the 9th EU Framework Programme for Research and Innovation (2021-2027). The budget resources of EU Framework Programmes for research, development and innovation are used for the preparatory phases of European research infrastructures and their internationally-integrating activities leading to the establishment of international consortia, especially ERIC legal entities, and a transnational access to their capacities.

In 2014, EU legal regulations setting the conditions for the provision of state aid for research, development and innovation from public funds, brought about a **legislative definition of a research infrastructure**, taking into consideration the specifics of its financing: *"Research infrastructure means facilities, resources and related services that are used by the scientific community to conduct research in their respective fields and covers scientific equipment or sets of instruments, knowledge-based resources such as collections, archives or structured scientific information, enabling information and communication technology-based infrastructures such as grid, computing, software and communication, or any other entity of a unique nature essential to conduct research. Such infrastructures may be 'single-sited' or 'distributed' (an organised network of resources) in accordance with Article 2(a) of Council Regulation (EC) No 723/2009 of 25 June 2009 on the Community legal framework for a European Research Infrastructure Consortium (ERIC)."*[2]

The growing demand for research infrastructures due to the increasing pressure on successful **addressing socio-economic challenges**, requiring knowledge-intensive and technologically most advanced solutions, also requires a specific approach to be taken towards the research infrastructures' public administration with respect to political, legal and financial coordination, including the ability to undertake long-term commitments at the national, European, macro-regional and global levels. Only favourable environment that provides a long-term stable and predictable system of research infrastructures' public funding enables research infrastructures and their users to achieve all their objectives.

Research infrastructures fundamentally help make the **support of research, development and innovation from public funds more efficient.** They are unique facilities at an exceptional level of knowledge and technology, and are hosted by their host institutions, ensuring their operation and further investment development, for the use by all their potential users from the research community and the industrial sector on the principle of open access policy. The concentration of knowledge and technology potential and required material, personnel and financial resources within research infrastructures eliminate the necessity to acquire facilities of the same cost at other research organisations specialising in similar research, development and innovation goals.



▲ CERN (*Conseil Européen pour la Recherche Nucléaire*) – ALICE Experiment

1/ Council Regulation (EC) No 723/2009 of 25 June 2009 on the Community legal framework for a European Research Infrastructure Consortium (ERIC) as amended by Council Regulation (EU) No 1261/2013 of 2 December 2013 amending Regulation (EC) No 723/2009 concerning the Community legal framework for a European Research Infrastructures Consortium (ERIC).

2/ Framework for State Aid for Research and Development and Innovation (2014/C 198/01) and the Commission Regulation (EU) No 651/2014 of 17 June 2014 declaring certain categories of aid compatible with the internal market in application of Articles 107 and 108 of the Treaty.

Large research infrastructures of the Czech Republic

Over the past few years, the Czech Republic has also responded to the increasing importance of research infrastructures and for the purpose of showing them as **one of the key elements of the national research and innovation system**, a number of measures towards creating a stable environment for research infrastructures' construction, operation and further investment development has been taken.

In 2009, a new legislative instrument[3] to support research infrastructures from the public funds of the Czech Republic was integrated into the legal regulations that stipulate the conditions for the provision of aid for research, development and innovation. The Ministry of Education, Youth and Sports (hereinafter the "MEYS") has become the central public administration body of the Czech Republic responsible for supporting **"large research infrastructures"** and in its role as the administrator of the international cooperation of the Czech Republic in research and development, it has started to promote the internationalisation and international cooperation of large research infrastructures of the Czech Republic and their membership in consortia, especially in ERIC legal entities.

Under the current legal regulations of the Czech Republic, the capacity of a large research infrastructures is **defined** as *"a research infrastructure[4] that is a research facility necessary for conducting comprehensive research and development with high financial and technology demands, approved by the Government and established to be also used by other research organisations."*

In 2010, the MEYS prepared the Roadmap of Large Research Infrastructures of the Czech Republic for the first time. Its structure and contents correspond to the ESFRI Roadmap. It was updated in 2011 and 2015 and the presented **Roadmap of Large Research Infrastructures of the Czech Republic for the years 2016-2022, updated in 2019**, provides the most current overview of the policy-making and public funding of large research infrastructures in the Czech Republic.

Since 2009, importance attributed to the large research infrastructures has been enhanced by the fact that proposals to finance large research infrastructures from the MEYS's budget are submitted to the Government of the Czech Republic for approval as the only individual research, development and innovation projects in the Czech Republic.

Stakeholders engaged in the support of large research infrastructures from the public funds of the Czech Republic are coordinated within two expert advisory and consulting bodies. The first of these coordination platforms is the **Council for Large Research Infrastructures**, an expert advisory body established by the Minister of Education, Youth and Sports. The Council joins the officially delegated representatives of the MEYS, the Council for Research, Development and Innovation, the Ministry of Industry and Trade, the Czech Academy of Sciences, the Czech Rectors Conference, the Council of Higher Education Institutions, and last but not least, the most important large research infrastructures of the Czech Republic operated in individual scientific fields. The Council also includes the Czech delegates to the ESFRI forum as well as representatives of the National Contact Point for the support of research infrastructures from EU Framework Programmes for research, development and innovation. The other coordination platform is the **Council for Research, Development and Innovation** in its role of an expert advisory and consulting body to the Government of the Czech Republic. The Council acts on the supreme level and gathers representatives of the most important research, development and innovation stakeholders in the Czech Republic that represent the public research sector and the industrial sphere.

A specialised **communication and marketing portal of the large research infrastructures of the Czech Republic** both for Czech and foreign users is the website https://www.vyzkumne-infrastruktury.cz/en/, operated by the CESNET e-infrastructure in cooperation with the MEYS and other partners.

3/ Act No 130/2002 Coll., on the Support of Research, Experimental Development and Innovation from Public Funds and on Amendments to Some Related Act (the Act on the Support of Research, Experimental Development and Innovation), as amended.

4/ Article 2(91) of Commission Regulation (EU) No 651/2014 of 17 June 2014 declaring certain categories of aid compatible with the internal market in application of Articles 107 and 108 of the Treaty.

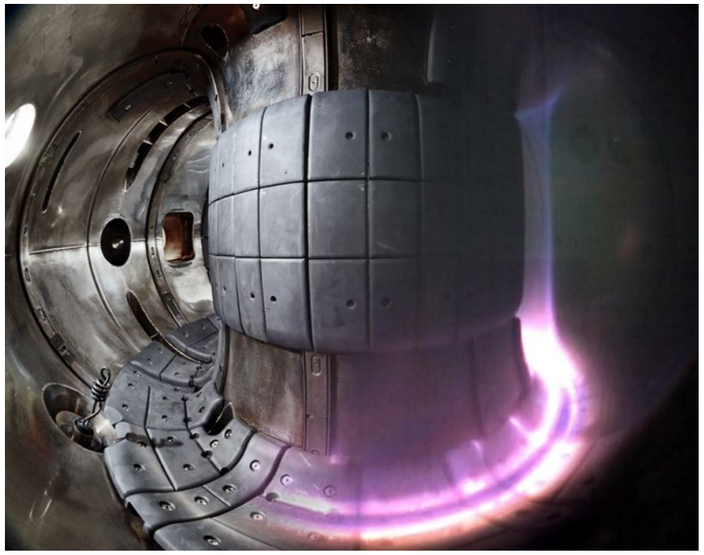
Investments made in large research infrastructures of the Czech Republic with the use of EU Cohesion Policy instruments

Complementarily to the state budget expenditures of the Czech Republic spent on research, development and innovation, that are used to cover the **operation costs** of large research infrastructures, **investment costs** to modernise the facilities, enabling to maintain the research infrastructures at an exceptional and internationally competitive level, are primarily covered with the use of EU Cohesion Policy instruments, i.e. the **European Structural and Investment Funds** (hereinafter the "ESIF").

Between **2007 and 2015**, the investments in large research infrastructures were made mainly under the **Operational Programme Research and Development for Innovation** (hereinafter the "OP RDI"). Investments of a smaller scale that were made in the region of the Capital City of Prague came from the **Operational Programme Prague – Competitiveness** (hereinafter the "OP PC"). In many cases, investments have helped to achieve breakthrough technology modernisation at already operating large research infrastructures or the development of brand new large research infrastructures that have proved not only their Czech nation-wide, but also European, macro-regional, and exceptionally also global dimensions, importance and impact (e.g. ELI Beamlines).

For the **2016 to 2022 period**, the Czech Republic followed up the model of complementary funding of operation and investment costs of large research infrastructures with the use of state budget expenditures on research, development and innovation and ESIF. The instrument used to cover the investment costs of large research infrastructures of the Czech Republic has been the **Operational Programme Research, Development and Education** (hereinafter the "OP RDE") under which a series of specific calls for the purpose of financing the investment costs of large research infrastructures of the Czech Republic was announced for the 2016 to 2019 and 2020 to 2022 periods.

Beyond the scope of financing the investment costs of large research infrastructures that are located in the Czech Republic, funds drawn from the EU Cohesion Policy instruments are used to cover the costs of **development and "in-kind" deliveries of technology equipment into European research infrastructures** in which the Czech Republic participates (e.g. European Spallation Source) and where the Czech Republic will be able to use experimental facilities once they have entered the user phase.



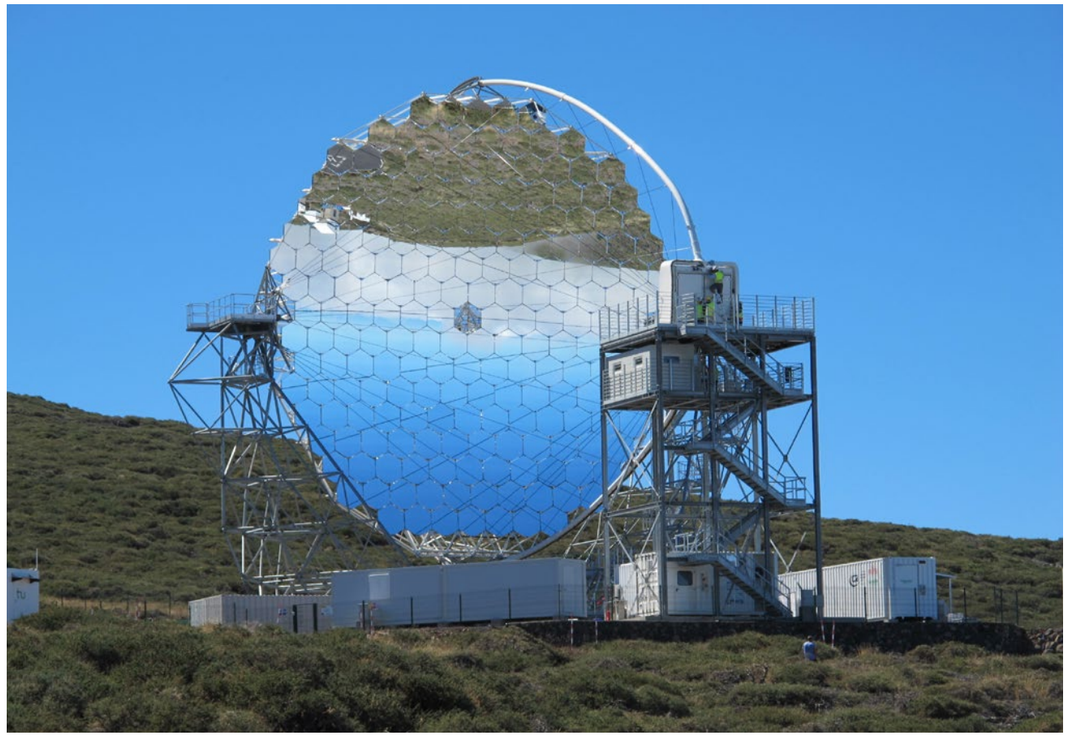
◀ COMPASS (*Tokamak for Thermonuclear Fusion Research*)

Typology of large research infrastructures of the Czech Republic

The basic typology of research infrastructures divides facilities into three groups: **single-sited** research infrastructures situated in one place, **distributed** research infrastructures including a larger number of capacities situated in different places, and **virtual** research infrastructures. From the perspective of life cycle stages, research infrastructures are classified into research infrastructures in the **preparatory phase, implementation / construction phase, operation phase and decommissioning phase.** All of the above types of research infrastructures – with the exception of decommissioned research infrastructures – can also be found in the research and innovation system of the Czech Republic.

One specific type of large research infrastructure project in the Czech Republic is the project implemented for the purpose of securing the Czech participation in an international research infrastructure located abroad. The purpose of such a large research infrastructure project is typically to **secure the Czech share in the construction and/or upgrade of technological equipment of an international research infrastructure in the form of development and "in-kind" deliveries of experimental equipment** (e.g. to CERN). If such an international research infrastructure is an international organisation founded under international public law and/or ERIC, any other obligations related to the Czech membership (i.e. typically the payment of mandatory membership fees) are fulfilled by the MEYS in its role as a public administration body of the Czech Republic exercising membership rights in such an international legal entity.

▼ CTA (*Cherenkov Telescope Array*)



Nevertheless, there are also international research infrastructures that have neither the ERIC legal form nor international public law based framework, but are established on the legal basis of their host countries (e.g. Jules Horowitz Reactor). In this case, the state does not act as a member of these legal entities and the state does not pay for mandatory membership duties with respect to the given legal entity (typically, these include mandatory membership fees or "in-kind" form of participation in the operations and/or further investment development of the international research infrastructure). In this case, a large research infrastructure can be seen as an **access point to an international research infrastructure** where the large research infrastructure project holder deals with requirements on behalf of the user community of the Czech Republic that for ERIC legal entities and/or international organisations founded under international public law are addressed directly by the MEYS on behalf of the Czech Republic as a Member State of such legal entities.

The following projects referred to with their acronyms represent the above categories of large research infrastructures included in the Roadmap of Large Research Infrastructures of the Czech Republic and are funded under the relevant grant (international research infrastructures that the Czech user community can access are provided in parentheses):

- **AUGER-CZ** (*Pierre Auger Observatory*);
- **BNL-CZ** (*Brookhaven National Laboratory*);
- **CERN-CZ** (*Conseil Européen pour la Recherche Nucléaire*);
- **CTA-CZ** (*Cherenkov Telescope Array*);
- **ESS Scandinavia-CZ** (*European Spallation Source*);
- **EST-CZ** (*European Solar Telescope*);
- **EU-ARC.CZ** (*Atacama Large Millimeter / Submillimeter Array*);
- **FAIR-CZ** (*Facility for Antiproton and Ion Research*);
- **Fermilab-CZ** (*Fermi National Accelerator Laboratory*);
- **JHR-CZ** (*Jules Horowitz Reactor*);
- **LSM-CZ** (*Laboratoire Souterrain de Modane*);
- **SPIRAL2-CZ** (*Système de Production d'Ions Radioactifs Accélérés en Ligne de 2ème génération*).

Beyond the scope of the above typology, there is a specific type of research infrastructure that is not funded from the grant for large research infrastructures, but that uses another legislative framework of funding (administered by the MEYS) and which brings the **Czech Republic's membership in international R&D organisations founded under international public law.** In this respect, the Czech Republic is a Member State in the following organisations:

- **CERN** (*Conseil Européen pour la Recherche Nucléaire*);
- **EMBC** (*European Molecular Biology Conference*);
- **EMBL** (*European Molecular Biology Laboratory, including* **ELIXIR**);
- **ESA** (*European Space Agency*);
- **ESO** (*European Southern Observatory, including* **ELT** *– Extremely Large Telescope*);
- **JINR** (*Joint Institute for Nuclear Research*).

Through its membership in NATO (*North Atlantic Treaty Organisation*), the Czech Republic has become a Member State of the international organisation **VKIFD** (*Von Karman Institute for Fluid Dynamics*). Through membership in EURATOM (European Atomic Energy Community), the Czech Republic has participated in the **ITER** (*International Thermonuclear Experimental Reactor*) project.

Last but not least, a specific form of the Czech Republic's involvement in international research infrastructures is the participation in the following international facilities: ESRF (*European Synchrotron Radiation Facility*) and ILL (*Institut Laue-Langevin*) in France and European XFEL (*European X-Ray Free Electron Laser Facility*) in Germany. Membership in the above organisations is not provided through large research infrastructure projects. Given the legal nature of these international entities that do not show signs of an international intergovernmental organisation founded under international public law or the ERIC legal framework, the membership duty of the Czech Republic does not exist at the level of a Government body of the Czech Republic. Therefore, the engagement of the Czech Republic in these facilities is provided through the research community itself. However, this does not diminish the importance of such engagement even though with respect to the source of funding, it is not supported from a grant for large research infrastructures and it cannot be included in the presented Roadmap in the form of partial large research infrastructure projects of the Czech Republic.

International cooperation and internationalisation of large research infrastructures of the Czech Republic

International cooperation of large research infrastructures of the Czech Republic is a crucial prerequisite for the establishment in the ERA and other macro-regional research infrastructure networks, including on the global level. At the same time, the internationalisation of large research infrastructures of the Czech Republic is also important to maximise the use of their potential, both in relation to the Czech domestic and foreign user communities.

In international research infrastructure networks that associate mainly **distributed research infrastructures** across the ERA (and very often adopt the ERIC legal form), the expertise and capacities of research infrastructures can be effectively shared and a much wider portfolio of experimental equipment, knowledge and services than the sole potential of their individual national nodes operated at the level of the host states would enable. Typically, the process of research infrastructure internationalisation is conducted at the international level, especially for research infrastructures specialising in biological and medical sciences (e.g. Instruct-ERIC and BBMRI-ERIC), social sciences and humanities (e.g. CESSDA ERIC and CLARIN ERIC) and environmental sciences (e.g. ICOS ERIC), but is not unusual for research infrastructures that area operated in the field of physical sciences and engineering (e.g. CERIC-ERIC). The basic pre-requisite for research infrastructure internationalisation is the international interoperability of e-infrastructure that provides them suitably dimensioned ICT services (e.g. PRACE).

For **single-sited international research infrastructures**, international cooperation is the very reason for the formation of such research infrastructures as their preparatory and construction phases are implemented through numerous international consortia that associate a large number of countries, and through their national research and industrial communities, also a wide range of specialised knowledge, technology expertise and personnel, material and financial resources. Typical examples of this type of international cooperation are mainly extensive research infrastructures operated in the field of physical sciences and engineering (e.g. CERN). It can be said that many single-sited international research infrastructures could never have been built without extensive international cooperation. Even in the most advanced countries, the range of knowledge and technology, and personnel, material and financial resources is not broad enough that they could build and operate such research infrastructures and fully use their user capacities at the national level.

▼ ELI Beamlines (*Extreme Light Infrastructure*)

Also for the above reasons, the MEYS supports intensive international cooperation of large research infrastructures of the Czech Republic and their integration within the ERA and enters into the legal entities that manage the work of research infrastructures at the international level in its role as the public administration body of the Czech Republic responsible for the given subject-matter. **The Czech Republic has become a Member State of 14 ERIC legal entities:**

- **BBMRI-ERIC** (*Biobanks and Biomolecular Resources Research Infrastructure Consortium*);
- **CERIC-ERIC** (*Central European Research Infrastructure Consortium*);
- **CESSDA ERIC** (*Consortium of European Social Science Data Archives*);
- **CLARIN ERIC** (*Common Language Resources and Technology Infrastructure*);
- **DARIAH ERIC** (*Digital Research Infrastructure for the Arts and Humanities*)
- **EATRIS ERIC** (*European Advanced Translational Research Infrastructure in Medicine*);
- **ECRIN-ERIC** (*European Clinical Research Infrastructure Network*);
- **ESS ERIC** (*European Social Survey*);
- **Euro-BioImaging ERIC** (*European Research Infrastructure for Imaging Technologies in Biological and Biomedical Sciences*);
- **European Spallation Source ERIC**;
- **EU-OPENSCREEN ERIC** (*European Infrastructure of Open Screening Platforms for Chemical Biology*);
- **ICOS ERIC** (*Integrated Carbon Observation System*);
- **Instruct-ERIC** (*Integrated Structural Biology European Research Infrastructure Consortium*);
- **SHARE-ERIC** (*Survey of Health, Ageing and Retirement in Europe*).

In 2020, the **ELI ERIC** legal entity will be established with the Czech Republic as a founding member. The legal entity will manage the operation phase of the large research infrastructure ELI Beamlines, the Czech pillar of the ELI (*Extreme Light Infrastructure*) European research infrastructure.

In the following period, the Czech Republic is expected to become one of the founding Member States of **ERIC legal entities** in whose establishment the MEYS and the research community in the Czech Republic has been intensively participating. They include the European research infrastructures:

- **ACTRIS** (*Aerosol, Clouds and Trace Gases Research Infrastructure*);
- **AnaEE** (*Infrastructure for Analysis and Experimentation on Ecosystems*);
- **CTA** (*Cherenkov Telescope Array*);
- **DANUBIUS-RI** (*International Centre for Advanced Studies on River-Sea Systems*);
- **INFRAFRONTIER** (*European Research Infrastructure for the Generation, Phenotyping, Archiving and Distribution of Model Mammalian Genomes*).

In addition, the Czech Republic is a Member State of international research infrastructures listed as **international organisations founded under international public law** and specified in Chapter 4 of the Roadmap, namely CERN, EMBC, EMBL, ESA, ESO and JINR.

Through its research community, the Czech Republic is also involved in other **European and global research infrastructures that do not have an international legal form**. Beyond the research infrastructures listed above in Chapter 4 of the Roadmap, they include research infrastructures such as PRACE, GÉANT, EGI or GLIF. The involvement of the Czech Republic in European infrastructures included in the most current version of the 2018 ESFRI Roadmap is covered in more detail in Chapter 8 of the Roadmap.

International evaluation of large research infrastructures of the Czech Republic

Since 2010, large research infrastructures of the Czech Republic have been financed from the public funds of the Czech Republic under a specific grant scheme, following the introduction of a relevant legislative instrument into the legal framework of the Czech Republic in 2009. **Since 2014, large research infrastructures of the Czech Republic have been subject to evaluations that are made periodically and are organised in the form of an international peer-review.**

The first of these international assessment processes was organised by the MEYS in 2014. It served as an instrument to obtain independent expert opinions for the purpose of taking evidence-based political decisions by the Government of the Czech Republic on the financing of large research infrastructures from the public funds of the Czech Republic for the 2016 to 2019 period. In addition to the decision on which large research infrastructures that were funded then would continue receiving support from the Government of the Czech Republic, the evaluation process also had an important structuring nature. As many investment projects financed between 2007 and 2015 by the use of ESIF were gradually completed, the purpose of the assessment was to evaluate the capacities that have been newly developed with the help of EU Cohesion Policy tools to operate them based on the open access large research infrastructure principle. Subsequently, **following the outcomes of international assessment conducted in 2014, the Government of the Czech Republic approved 58 large research infrastructures to be funded from public resources between 2016 and 2019.**

At the same time, the decision adopted by the Government of the Czech Republic provided that the continuation of funding of large research infrastructures between 2020 and 2022 would be conditioned on a positive outcome of their 2017 interim evaluation. Moreover, the Roadmap of Large Research Infrastructures of the Czech Republic for the years 2016-2022 stipulated that in 2017, a call will be announced for an ex-ante evaluation of brand new large research infrastructure project proposals. **Therefore, the second round of international evaluation of large research infrastructures was organised in 2017 under the auspices of the MEYS. The assessment included both large research infrastructures that had been funded, for which it was an interim evaluation, and large research infrastructure project proposals that have been developed in the Czech Republic since 2014 as brand new and for which it was an ex-ante evaluation.**

The international assessment of large research infrastructures followed the evaluation methodology that has been applied in the Czech Republic since 2014 and is inspired by ESFRI evaluation processes. Prior to the announcement of a call to submit documents for evaluation, the subject-matter methodical procedures were consulted and also approved in the platform of the Council for Large Research Infrastructures.

As far as **evaluation criteria** are concerned, the assessment of large research infrastructures and new designs thereof were focused on assessing the following aspects:

- **Expertise** – the knowledge and technology provided by a large research infrastructure to its user community based on the principle of open access to its capacities;
- **Management** – the governance structure and the procuring of HR resources to operate a large research infrastructure on the principle of open access to its capacities;
- **Importance and benefits** – the manner in which a large research infrastructure reflects on and addresses the needs of its user community from the research and industrial sphere and contributes to the development of scientific field of its specialisation;
- **Cooperation** – the cooperation of a large research infrastructure with other research infrastructures, research organisations and industrial partners in the Czech Republic, the ERA and all over the world;
- **Open access policy** – the manner of organising open access to the capacities that a large research infrastructure offers to its user community;
- **Use of capacities** – the analysis of structure and the number of users of a large research infrastructure in the Czech Republic and abroad and the intensity of use of its capacities that are made accessible in the open access regime;
- **Research results** – the quantity and quality of research, development and innovation results achieved by the users of a large research infrastructure by using its capacities available in the open access regime, including their benefits for the development of new technologies;
- **Strategy development** – the strategy of further investment development of a large research infrastructure over a short- and long-term horizon, including a feasibility strategy and a SWOT analysis;
- **Budget** – the operation and investment costs of a large research infrastructure over the period until 2022, including detailed specifications of individual budget items;
- **Progress over the past period** – the main milestones achieved by a large research infrastructure in the period from the last international evaluation in 2014 and the manner in which recommendations made by the International Assessment Committee have been reflected;
- **Communication and marketing strategy** – the communication of a large research infrastructure in relation to both experts and the general public, including the development of popularisation activities.

◀ CZ-OPENSCREEN (*National Infrastructure for Chemical Biology*)

The evaluation of large research infrastructures and new submitted proposals was made by the **International Assessment Committee** that included 6 scientific panels with 5 members, each of which 4 members always were from abroad, 1 member was from the Czech Republic and 1 was the Chair of the panel. The International Assessment Committee also had a Chair overseeing the evaluation work of the specialised panels so that each panel applied the evaluation criteria to the same extent and with the same relevance. The specialisation of panels on the International Assessment Committee corresponded to the classification of the Roadmap of Large Research Infrastructures of the Czech Republic for the years 2016-2022 and the ESFRI Roadmap. Their expertise included the following scientific domains:

- **Physical sciences and engineering;**
- **Energy;**
- **Environmental sciences;**
- **Health and food (≈ biological and medical sciences);**
- **Social sciences and humanities (≈ social and cultural innovation);**
- **e-Infrastructures (≈ data, computing and digital research infrastructures).**

Large research infrastructures and their new proposals were evaluated by the International Assessment Committee based on submitted documentation and with the help of outputs from an independent external international peer-review which involved **3 independent peer reviews** prepared for each large research infrastructure, or a proposal thereof. Another input to the evaluation were **personal interviews** organised between representatives of large research infrastructures or those who submitted new proposals and members of the panels of the International Assessment Committee. However, the summary decision on the outcome of each evaluation was the sole responsibility of the panels of the International Assessment Committee which prepared the final outcomes in the form of **consensus reports** of a pre-defined structure. In compliance with the evaluation methodology, large research infrastructures and new submitted proposals thereof were granted a score indicating their summary **qualitative level on a scale from 5 to 0 where 5** was the highest score and 1 was the lowest. Large research infrastructures that received 0 were found by the International Assessment Committee to be non-compliant with the basic qualitative criteria of large research infrastructures.

Based on the outcomes of the international evaluation that took place in 2017, the Government of the Czech Republic approved 48 large research infrastructures, including 7 new proposals, to be funded from the public funds of the Czech Republic in the period until 2022. Their list is provided in Annex 1.

Members of the International Assessment Committee of large research infrastructures of the Czech Republic and new proposals thereof from 2017 are listed in **Annex 2**.

Evaluation of benefits of Czech memberships in international R&D organisations founded under international public law

Analogically to the international evaluation of large research infrastructures that are funded in the Czech Republic through a particularly dedicated grant instrument of the MEYS, since 2016, the MEYS has also been **assessing the benefits of Czech memberships in international R&D organisations established under international public law**. Similarly to the evaluation of large research infrastructures, the evaluation process is fully based on the principles of international peer-review and the applied methodical approach can be seen as complementary to the methodical approach taken towards the assessment of large research infrastructures. The methodology for evaluating large research infrastructures and the methodology for assessing the benefits of Czech memberships in international R&D organisations jointly form a comprehensive methodical framework for evaluating large research infrastructures of both a national and international nature in whose construction, operations and further development the Czech Republic takes part.

The first cycle of assessment of benefits of Czech memberships in international R&D organisations established under international public law was organised by the MEYS in 2016. The evaluation focused on the benefits for the Czech Republic under its memberships in the international organisations CERN, EMBC, EMBL, ESA, ESO, JINR and VKIFD. The assessment was performed by the **International Assessment Committee** comprising 10 members, including Chair, and divided into 3 scientific panels evaluating international R&D organisations with a similar focus.

As far as **evaluation criteria** are concerned, the assessment focused on the following aspects:

- **Participation and engagement management** – the manner in which the Czech Republic engages in the managing bodies of an international R&D organisation, including the manner of coordinating the preparation of the Czech positions and statements and the manner in which the research and industrial communities receive information on the possible use of the potential that the Czech membership brings, especially with respect to projects of research, development and innovation, procurements for development and supplies of experimental facilities and selection procedures to staff open job positions;
- **Benefits in the field of research** – the structure and the number of members of the Czech research community that uses the capacities of an international R&D organisation and the intensity of use of capacities by the research community in the Czech Republic, including the quantity and quality of research results achieved with the help of an international R&D organisation's capacities;
- **Contributions in the field of technology development and innovation** – the transfer of knowledge obtained with the use of an international R&D organisation's capacities during the development of new technologies and innovative products and services and the intensity of engagement of industrial sector of the Czech Republic in the development and deliveries of technological equipment requested by an international R&D organisation;
- **Benefits in the field of HR development** – the manner in which the Czech Republic is represented in the management of an international R&D organisation at the level of managerial, administrative, research and/or technical positions and the manner in which the Czech Republic uses the potential offered by an international R&D organisation in the field of HR development with respect to training, research, development and innovation;
- **Communication strategy** – the manner in which the Czech membership in an international R&D organisation is publicly communicated both to experts and to the general public in the Czech Republic with respect to the dissemination of information on the success that the international R&D organisation has achieved with the Czech contribution and on the opportunities that the international R&D organisation offers to the research and industrial community in the Czech Republic.

An external input to the evaluation performed by the International Assessment Committee was the outcome of an international peer-review which always involved **2 peer-reviews** that the International Assessment Committee took into consideration in its summary evaluation, which was prepared in the form of **consensus reports**. The evaluation also involved **personal interviews** between the scientific panels of the International Assessment Committee and delegates from the Czech Republic (representing either the MEYS or the relevant research community) in the governing bodies of the relevant international organisation.

The evaluation of benefits of Czech memberships in international R&D organisations carried out in 2016 provided the MEYS independent expert opinions that are further used by the MEYS to adopt **measures leading to the maximisation of benefits** that the Czech memberships in the international R&D organisations potentially bring. **Another cycle focused, among other things, on an evaluation of the effectiveness and impact of measures that have been adopted will take place in 2021.**

The members of the 2016 International Assessment Committee that evaluated the benefits of Czech memberships in international R&D organisations founded under international public law are listed in **Annex 3**.

▼ ESO (*European Southern Observatory*) – ALMA (*Atacama Large Millimeter/Submillimeter Array*)

Alignment of periodic updates to the Roadmap of Large Research Infrastructures of the Czech Republic with the process of periodic updates to the ESFRI Roadmap

The Czech Republic has been a long-term and an active member of the ESFRI, both in terms of adopting ESFRI good practice examples in research infrastructures' policy-making, and in terms of engaging in the ESFRI working groups, including the supreme bodies. Between 2016 and 2018, the Czech delegate to the ESFRI, Dr Jan Hrušák, was a member of the ESFRI Executive Board and an ESFRI Vice-Chair. In 2018, he was also elected the ESFRI Chair beginning 1st January 2019. **Dr Jan Hrušák has been the first ESFRI Chair coming from the Central and Eastern European countries that joined the EU during the 2004 expansion.**

From the perspective of national roadmaps of research infrastructures of countries involved in the ESFRI, an important aspect of the **roadmapping** is the synchronisation of periodic updates to the roadmap with periodic updates to the ESFRI Roadmap. The **synchronisation** is also important because national entities that engage into new proposals of European research infrastructures that are submitted to be included into the ESFRI Roadmap updates ask for political support through their national ESFRI delegates. Political support means that a given ESFRI Member State can guarantee that the contribution of its national research community to the implementation of a new submitted project of a European research infrastructure is supported with a commitment to such engagement at the national level, or at least with the assumption that such commitment will be made in the near future.

The Czech Republic synchronises the processes of periodic updates to the Roadmap of Large Research Infrastructures with the processes of periodic updates to the ESFRI Roadmap so that the stakeholders participating in new submitted proposals of European research infrastructures can receive political support from the MEYS for their participation. In practice, this means that the MEYS organises international evaluations of large research infrastructures in the Czech Republic so that it precedes the evaluations of European research infrastructures that are submitted for ESFRI Roadmap updates. **Large research infrastructures that succeed in an evaluation organised in the Czech Republic, or those for which a political commitment has been adopted as far as their funding from the public funds of the Czech Republic is concerned, or for which such political commitment can be anticipated in the near future, can ask the MEYS for political support for their participation in European research infrastructure proposals applied to updates made to the ESFRI Roadmap.**

The political commitment of the Government of the Czech Republic regarding the financing of large research infrastructures from the public funds of the Czech Republic for the period ending in 2022 will guide the MEYS in its decision on providing political support to those proposals of European research infrastructures with the Czech participation that will apply for the ESFRI Project status in the 2021 ESFRI Roadmap update.

Currently, the Czech Republic is participating in 28 (out of a total 55) European research infrastructures listed in the most recent 2018 ESFRI Roadmap update. Out of those, 23 European research infrastructures have the status of an ESFRI Landmark (out of a total of 37) and 5 have the status of an ESFRI Project (out of a total of 18). An overview of the Czech engagement in European research infrastructures included in the 2018 ESFRI Roadmap is listed in **Annex 7**.

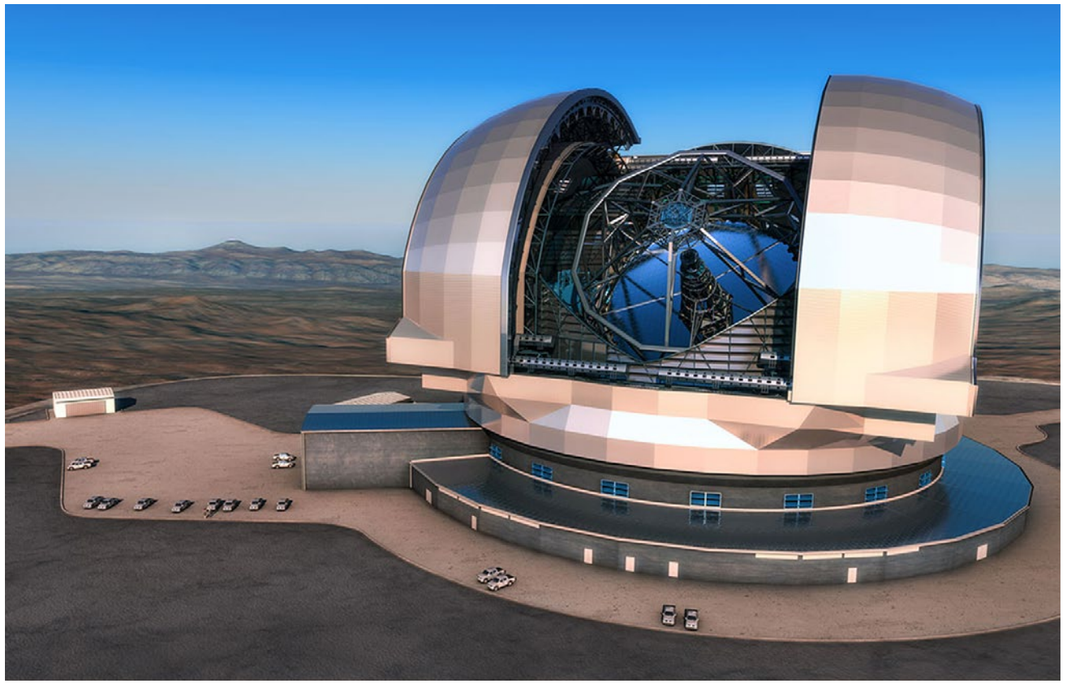
Summary and outlook for the period after 2022

Since 2002, the EU research infrastructures' policy-making has undergone unprecedented development and has registered **noticeable progress at all levels of political, legal and financial coordination.** The specific approach taken by the Czech Republic with respect to the issue of research infrastructures dates back to 2009 and has been adopted after a certain amount of delay. However, the **10th anniversary of the large research infrastructures of the Czech Republic, framed by the latest 2019 update to the Roadmap of Large Research Infrastructures of the Czech Republic for the years 2016-2022**, documents the successes achieved at the national level.

Enhancing the political, legal and financial coordination of EU Member States and Associated Countries is documented by the **successful ESFRI forum, the intensively used ERIC legal framework and the support of European research infrastructures from EU Framework Programmes for research, development and innovation, as well as from the ESIF**. The periodically updated ESFRI Roadmap jointly with national research infrastructure roadmaps of ESFRI Member States present **a vast landscape of research infrastructures that brings the most advanced knowledge and technology** to the research and industrial communities that are needed for excellent research, development and innovation.

Research infrastructures are facilities showing advanced knowledge and technology demands and their life cycle usually spans several decades. Therefore, it is necessary to pay attention to taking a strategic approach towards research infrastructures' policy-making that must also be reflected in **long-term political commitments in relation to research infrastructures' funding**. On the one hand, research infrastructures are the backbone network for excellent research, development and innovation with high knowledge and technology demands. On the other hand, there are 2 necessary preconditions for their construction, operation and long-term sustainable development: **budgetary stability and predictability of**

▼ ESO (*European Southern Observatory*) – ELT (*Extremely Large Telescope*)



public funding. Only a political and financial commitment of a long-term nature can make it possible for research infrastructures to adopt strategic decisions that necessarily exceed one decade and provide the ability to maintain or keep developing their high performance standards.

Therefore, the EU Competitiveness Council, comprising Ministers from EU Member States in charge of research, has repeatedly invited EU Member States to continue **increasing the level of public funding spent on research, development and innovation**. It has been proved that those EU Member States showing a higher intensity of research, development and innovation expenditures have greater innovation performance over the long term and do not feel the impact of potential financial crises so strongly; quite the contrary, they show higher resistance and economic competitiveness. Together with that, EU Member States have been invited to **give preference to investments made in research infrastructures** from their public funds spent on research, development and innovation which, due to their knowledge and technology expertise, provide opportunities to obtain breakthrough knowledge with the potential for their use in the development of goods and services of high added value.

Since research infrastructures are usually constructed and operated as a direct response to socio-economic challenges, it can be expected that in the years to come, new proposals of research infrastructures will continue emerging both in the Czech Republic and in the ERA in areas where a relevant socio-economic need is defined. For this reason, it is necessary to approach the issue of research infrastructures as being one that continuously organically develops and responds to **changing socio-economic needs redefined over time**. Top-class research, development and innovation have increasingly shifted to multidisciplinary platforms interconnecting and combining expertise from different scientific fields. Therefore, in the future we can expect an even more intensive **development of new research infrastructures with a multidisciplinary focus**.

In line with the ESFRI Roadmap periodic updates in the future (first follow-up update is planned for 2021), it is the Czech Republic's vision and political commitment to **periodically update the Roadmap of Large Research Infrastructures of the Czech Republic**. A pre-condition for this is having a continuous process of interim evaluations of large research infrastructures that have received public funds and evaluations of possible new large research infrastructure proposals whose concepts would reflect a newly defined socio-economic need. The upcoming cycle of **international evaluation of large research infrastructures of the Czech Republic and their new proposals will happen in 2021 and will serve as an instrument to obtain independent expert basis to help the Government of the Czech Republic make evidence-based political decisions on further support of large research infrastructures from the public funds of the Czech Republic between 2023 and 2029.**

For large research infrastructures approved by the Government of the Czech Republic for public funding until 2022, it will be an **interim evaluation** whose purpose should be to continue cultivating the operations and plans of their further investment development based on feedback received and recommendations made by independent internationally recognised evaluators. For newly submitted large research infrastructure proposals, it will be an **ex-ante evaluation**. Prior to the announcement of a call to submit proposals for new large research infrastructures, a **gap analysis** will be made at the national level of the Czech Republic with the aim of mapping the socio-economic demand for new large research infrastructures. The gap analysis made under the coordination auspices of the Council for Large Research Infrastructures will include the MEYS and other stakeholders in the Czech Republic, namely sectorial Ministries in charge of different sectorial policies of the Czech Republic. Based on the results of the gap analysis, fields should be defined through which the Czech Republic can identify demand for potential new large research infrastructures based on which new proposals of large research infrastructures can respond.

Following the above, in the period to come, crucial emphasis in the Czech Republic will be also placed on the creation of a framework to finance the operation and further investment development of large research infrastructures, predictable over a long term. It is anticipated that large research infrastructures will be funded from the public funds of the Czech Republic from 2023 on in periods of 7 years similarly to EU Framework Programmes for research, development and innovation and EU Cohesion Policy instruments that are implemented in 7-year intervals. More attention will also be paid to further cultivate a methodical environment for assessment of large research infrastructures. The methodical framework will reflect the **good practice examples of European research infrastructure evaluations performed by the ESFRI** and will also focus more on an analysis of the socio-economic benefits and impacts of large research infrastructures.

The success of research infrastructures policy – or large research infrastructures in the Czech Republic – primarily involves the ability to provide the user community with the most advanced experimental equipment, a wide portfolio of expertise and data and to offer them in the open access regime. Ideally, research, development and innovation performed with the help of research infrastructure capacities generate results that are highly beneficial for the research community, the industrial sphere, public administration bodies and the general public.

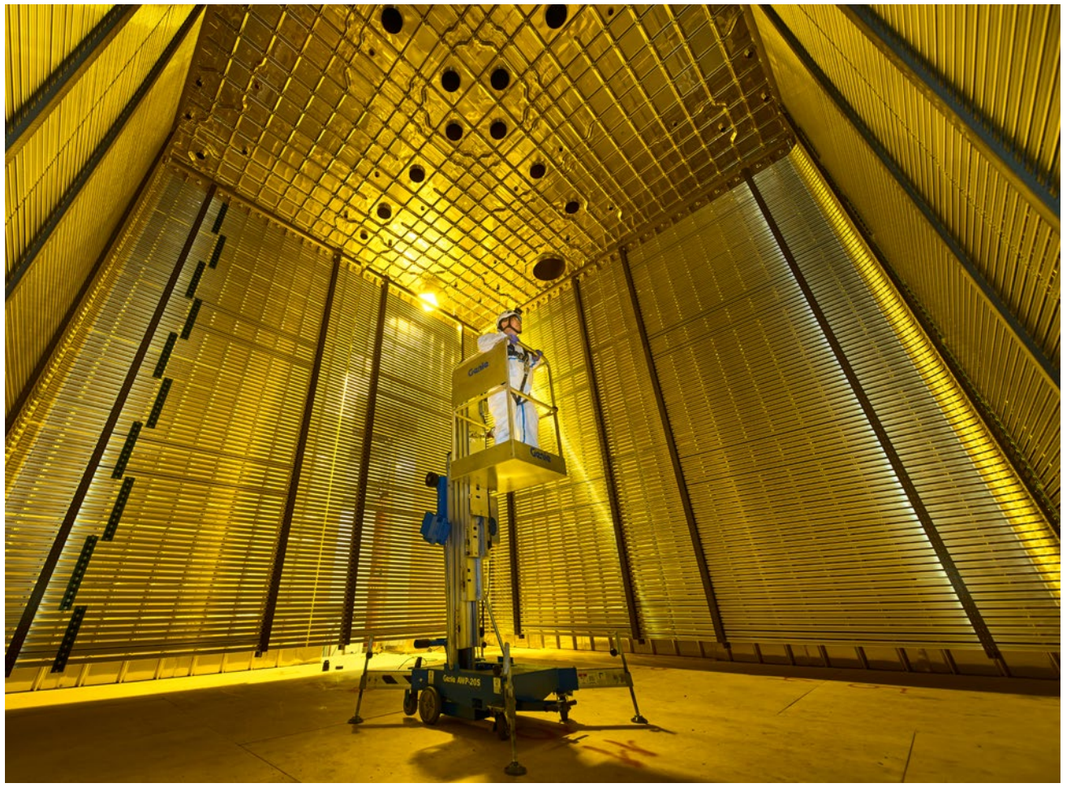
Structure

The presented update to the Roadmap of Large Research Infrastructures of the Czech Republic for the years 2016-2022, published in 2019, includes a **foreword** by the Minister of Education, Youth and Sports Mr Robert Plaga, Ph.D.; a **genesis and development of large research infrastructures**' policy-making in the Czech Republic from its inception in 2009 to date; and a **presentation of 48 large research infrastructures** approved by the Government of the Czech Republic for public funding for the period until 2022, including their incorporation into the landscape of **large research infrastructures** of the Czech Republic in the following 6 scientific fields:

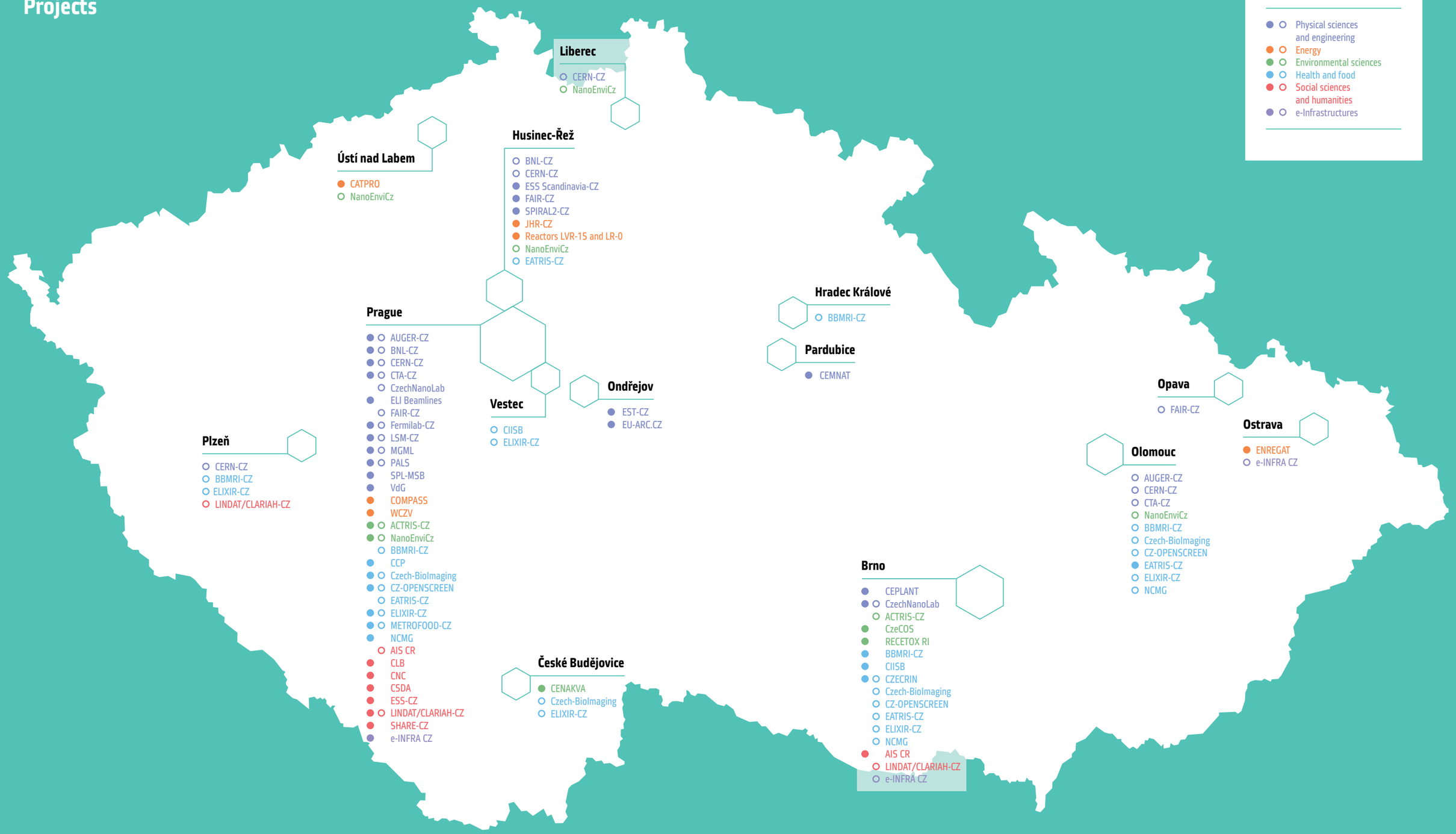
- **Physical sciences and engineering;**
- **Energy;**
- **Environmental sciences;**
- **Health and food;**
- **Social sciences and humanities;**
- **e-Infrastructures.**

Each of the following chapters of the Roadmap begins with a short landscape analysis setting individual large research infrastructures into the context of other capacities that specialise in the relevant scientific field. Each large research infrastructure included in the Roadmap is then described with respect to its expertise and technology specialisation, cooperation in the ERA and other macro-regional research infrastructure networks and its socio-economic benefits.

▼ Fermilab (*Fermi National Accelerator Laboratory*)



Host and Partner Institutions of Large Research Infrastructure Projects



Typology of Institutions

(according to the institution's statutory seat location)

- Hosting institution
- Partner institution

- Physical sciences and engineering
- Energy
- Environmental sciences
- Health and food
- Social sciences and humanities
- e-Infrastructures

International Research Infrastructures located abroad and participated by the Czech Republic

Batavia, Illinois / USA
Fermilab

Upton, New York / USA
BNL

Kourou / French Guiana
ESA

Atacama / Chile
ESO

Atacama / Chile
CTA

Malargüe / Argentina
Pierre Auger Observatory

Sint-Genesius-Rode / Belgium
VKIFD

Paris/ France
ESA

Caen / France
GANIL-SPIRAL2

Geneva / Switzerland / CERN

Modane / France / LSM

Cadarache / France
JHR
ITER

Canary Islands / Spain / CTA

Canary Islands / Spain / EST

Lund / Sweden
European Spallation Source

Heidelberg / Germany
EMBC
EMBL

Darmstadt / Germany / FAIR

Garching / Germany
ESO

Bologna / Italy
CTA

Dubna / Russia
JINR

* **ESA Sites in Europe**

Cologne / Germany / EAC
Didcot / United Kingdom / ECSAT
Villanueva de la Cañada / Spain / ESAC
Redu / Belgium / ESEC
Darmstadt / Germany / ESOC
Rome / Italy / ESRIN
Noordwijk / Netherlands / ESTEC

Physical sciences and engineering

10.1

page

Research, development and innovation in physics and technical sciences usually require large research infrastructures equipped with state-of-the-art technology. Such large research infrastructures provide the opportunity not only to keep pace with excellent research in particle and nuclear physics, but also to perform excellent research in material sciences and to develop instruments and structures used in further studies of the specific properties of materials using both macroscopic and microscopic methods.

The operation and further development of these unique large research infrastructures for physics is highly demanding from the financial point of view and it usually exceeds not only the capabilities of individual research organisations, but also those of regions and even states. One can achieve an effective use of resources only by integration at the international level within the framework of research infrastructures at the service of the wider scientific community.

The system of large research infrastructures listed in the Roadmap of the Czech Republic was designed for the 2016-2022 period and recently updated in 2019. These large research infrastructures operate in the Czech Republic and provide services for R&D in physics and technical sciences. They are further supplemented by numerous memberships of the Czech Republic in international research organisations in Europe and the USA.

10.1 | Roadmap of Large Research Infrastructures of the Czech Republic for the years 2016-2022
Physical sciences and engineering

Nuclear and particle physics

Research in the fields of nuclear and particle physics usually requires large research infrastructures and it is conducted in large international laboratories. Czech researchers have a good reputation in this regard, and they participate in the most important experiments in Europe and worldwide.

Since its establishment, the Czech Republic has been a Member State of the most famous laboratory for the research of fundamental properties of matter in the world – CERN (*Conseil Européen pour la Recherche Nucléaire*). The Czech Republic is active not only in the CERN scientific programme within experiments such as ATLAS and ALICE, but it is also involved in technology contracts and provides equipment to CERN. The **CERN-CZ** (*Research Infrastructure for Experiments at CERN*) large research infrastructure provides funds and organises Czech scientists to participate in CERN experiments and supports the development, construction and operation of certain equipment at CERN. In the Czech Republic, it supports the related research infrastructure necessary e.g. for the development and testing of detectors and IT research infrastructure.

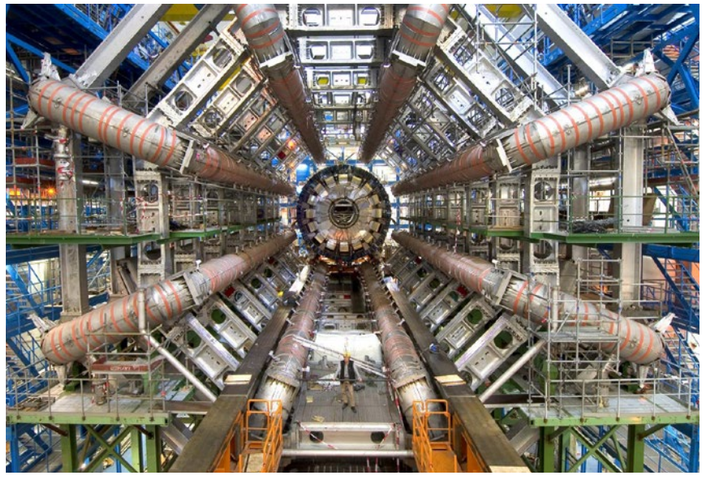
The Czech research community also participates in experiments performed at Fermilab (*Fermi National Accelerator Laboratory*) in the USA. After the termination of the Tevatron collider in 2011, the laboratory has been devoting its capacity to the preparation of a major neutrino physics experiment. The large research infrastructure in the Czech Republic related to Fermilab is **Fermilab-CZ** (*Research Infrastructure for Fermilab Experiments*), which is taking part in the NOvA experiment and it is participating in the construction of what is currently the largest neutrino experiment, DUNE. It also runs a detector laboratory contributing to the design and construction of detectors for Fermilab experiments and is developing methods of neutrino data processing based on artificial intelligence and neural networks.

To conduct experiments based on collisions of heavy ions at high energies, the Czech scientific community takes advantage of the possibility to work with the unique collider at BNL (*Brookhaven National Laboratory*) in the USA. Related to BNL, based on the same principle as in the former cases, the **BNL-CZ** (*Brookhaven National Laboratory – participation of the Czech Republic*) large research infrastructure supports the participation of Czech scientists in the construction and operation of the latest detection technologies used in BNL to study ultrarelativistic collisions of nuclei.

The LSM (*Laboratoire Souterrain de Modane*) underground research laboratory situated in France covers multidisciplinary fundamental research (e.g. dark matter searches, neutrino properties, radiobiology, etc.) and the related applied research (e.g. security in nuclear energetics, electronics, etc.) which requires an extremely low radiation background. The Czech Republic is taking part in the construction of new LSM equipment (e.g. in the field of the automated operation of detectors) and laboratory operations (e.g. a laboratory of ultra-sensitive detectors, anti-radon measures). Additionally, in this case, the Czech Republic's activities are supported by means of the **LSM-CZ** (*Laboratoire Souterrain de Modane – participation of the Czech Republic*) large research infrastructure project.

The main goal of the **AUGER-CZ** (*Pierre Auger Observatory – participation of the Czech Republic*) large research infrastructure is to contribute to the understanding of the nature, origin and propagation of ultra-high energy cosmic rays in the universe. This is being studied by the Pierre Auger Observatory, the largest detector of cosmic rays in the world, which was built in Argentina. Czech scientists participate in the development and construction of fluorescence telescopes, atmospheric monitoring and data analysis.

The **CTA-CZ** (*Cherenkov Telescope Array – participation of the Czech Republic*) large



▶ CERN (*Conseil Européen pour la Recherche Nucléaire*) – ATLAS Experiment

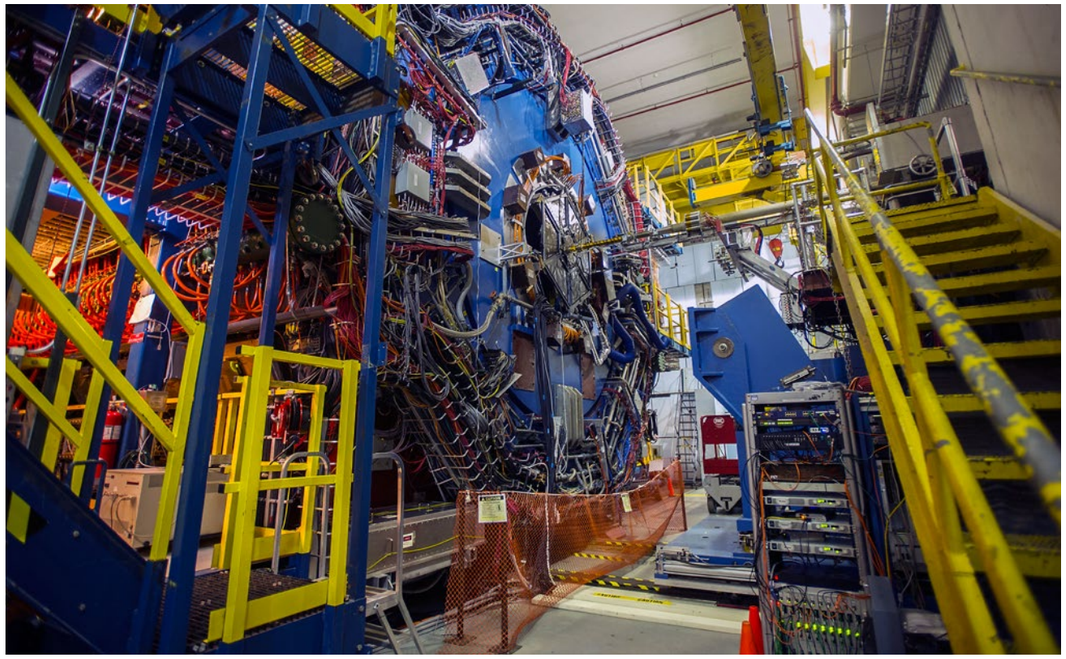
research infrastructure facilitates the participation of Czech teams in the construction and operation of the CTA experiment (*Cherenkov Telescope Array*), which is under construction in Chile and on the Canary Island of La Palma, Spain. The participation of the Czech Republic mainly consists of the development of mirrors for telescopes and the preparation of an atmospheric monitoring system. The involvement of the Czech scientific community at CTA will provide opportunities to take part in the discoveries of new gamma ray sources in the universe.

Last but not least, Czech scientists are involved in FAIR (*Facility for Antiproton and Ion Research in Europe*) in Germany by means of the **FAIR-CZ** (*Facility for Antiproton and Ion Research – participation of the Czech Republic*) large research infrastructure, which enables the participation of Czech scientists in experiments with antiprotons and heavy ion beams.

Beyond the above-mentioned large research infrastructure projects, the Czech Republic is also active in other international facilities. However, as the involvement in these facilities does not have the defining features of large research infrastructures and these facilities are, from the legal point of view, considered to be more national law-based rather than international organisations, the participation of the Czech Republic cannot be organised at the governmental level. Czech membership in such facilities is thus financed by means of other funds available directly to Czech scientists. However, such circumstances do not restrict the importance of the Czech involvement in the development and operation of the relevant facilities. The most important ones are ESRF (*European Synchrotron Radiation Facility*) and ILL (*Institut Laue-Langevin*) in France and XFEL (*X-ray Free Electron Laser*) in Germany.

To complete the list of the international research organisations in which the Czech Republic participates as a Member State, one has to mention JINR (*Joint Institute for Nuclear Research*). This membership also plays a role in the development of nuclear and particle physics in the Czech Republic and abroad.

A new trend among European research infrastructures in the field of physics and technical sciences is so called "clustering". Important initiatives started during the autumn of 2018 include the consortia LENS (*League of Advanced European Neutron Sources*) and LEAPS (*League of European Accelerator-based Photon Sources*). The goal of LENS is to improve the coordination, effectiveness of operation and long-term sustainability of neutron sources in Europe. LEAPS combines the majority of European synchrotrons and laser facilities aiming to improve and increase the efficiency of service provided to users, including industrial partners. Relevant large research infrastructures in the Czech Republic, namely those in laser physics, should embrace this trend and they should join the "clustering" effort of European research infrastructures.



▼ BNL (*Brookhaven National Laboratory*) – STAR Detector

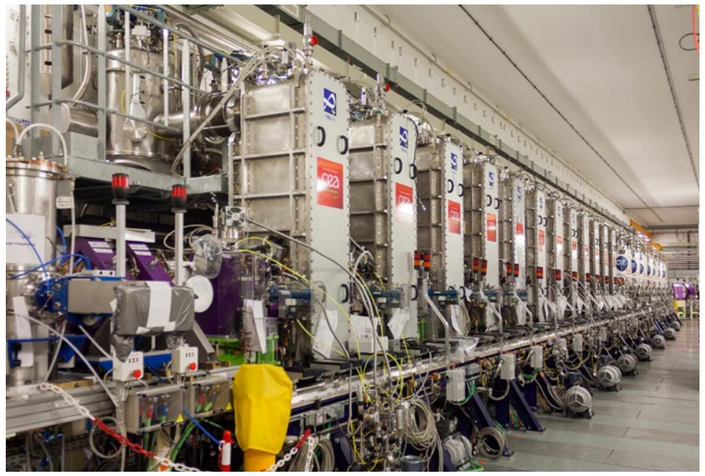
Radiation based physical sciences

The radiation of photons, neutrons and charged particles is among the key technologies in research, development and innovation in many areas, including materials research and biology. In the Czech Republic, there are several large research infrastructures using such methods. The Czech research community is currently also involved in many similar international laboratories abroad.

One of the most developed memberships of the Czech Republic in international research infrastructures is the **SPL-MSB** (*Surface Physics Laboratory – Materials Science Beamline*) large research infrastructure. SPL-MSB provides unique experimental equipment for photoemission spectroscopy, which forms a part of the CERIC-ERIC (*Central European Research Infrastructure Consortium*) European research infrastructure. SPL-MSB includes an Optical Beam Laboratory for materials research (MSB) placed at Elettra Sincrotrone Trieste in Italy and a Surface Physics Laboratory (SPL) operated at the Faculty of Mathematics and Physics, Charles University. It provides top-class conditions for materials research, surface physics and chemistry, catalysis and the study of organic molecules.

The **ESS Scandinavia-CZ** (*European Spallation Source – participation of the Czech Republic*) large research infrastructure focuses on the engineering design, development and construction of the BEER (Beamline for European Engineering Materials Research) diffractometer and other technological equipment which will be installed in the European Spallation Source ERIC European research infrastructure, the most intensive neutron pulsed source in the world, currently under construction in Lund, Sweden.

VdG (*Van de Graaff Accelerator – A Tunable Source of Mono-energetic Neutrons and Light Ions*) allows for the execution of important projects in the field of neutron physics. The support of ESA (European Space Agency) allowed for an upgrade and calibration of VdG neutron sources and the construction of a testing station for a source of gamma radiation with discrete energies. All this equipment provided by ESA was subsequently certified and it is used for testing and calibrating radiation-sensitive detectors for cosmic research.



▲ SPIRAL2 (*Système de Production d'Ions Radioactifs Accélérés en Ligne*)

The SPIRAL2 (*Système de Production d'Ions Radioactifs Accélérés en Ligne*) research infrastructure was built as an important expansion of the existing GANIL (*Grand Accélérateur National d'ions Lourds*) laboratory in Caen, France. The cooperation within this infrastructure is facilitated by means of the **SPIRAL2-CZ** (*Système de Production d'Ions Radioactifs Accélérés en Ligne – participation of the Czech Republic*) large research infrastructure. Participation in the operation of SPIRAL2 enables Czech researchers to study nuclear reactions that are important for the astrophysical models of nucleosynthesis in red giants, explosions in novae and changes in materials' properties in neutron fields.

Laser physics

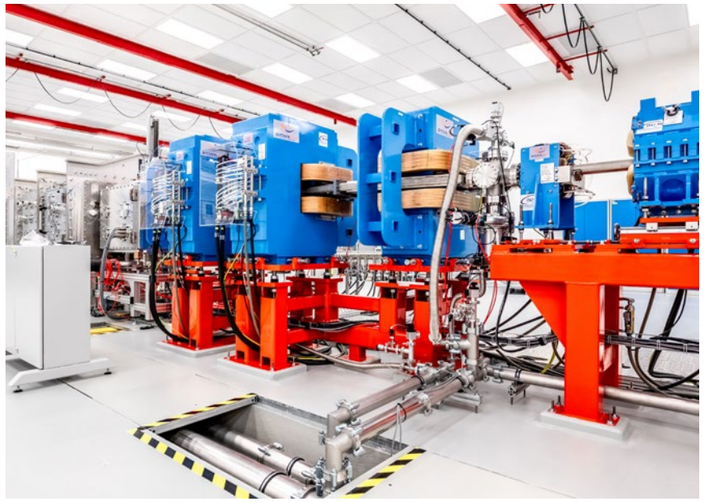
The operation and financing of the further development of laser facilities situated in the Czech Republic represent a major contribution to the Laserlab-Europe (*Integrated Initiative of European Laser Research Infrastructures*) union of European laser laboratories. The Czech Republic is an important player in the field of laser physics and contributes to the general progress in this field both in Europe and worldwide. The expertise gained by Czech scientists in this field led not only to the assignment of the PALS research infrastructure to the Czech Republic, but also subsequently to the decision to place the ELI Beamlines research infrastructure in the Czech Republic. ELI Beamlines is one of the pillars of the ELI international research infrastructure, the equipment with most intense lasers in the world.

The **PALS** (*Prague Asterix Laser System*) large research infrastructure is a first class research infrastructure designed to study laser induced plasma and its applications, as well as the interactions between radiation, in particular X-rays, with matter. PALS plays a decisive role in the development of laser sources of multiply charged ions with energies on the order of MeV/nucleon. PALS is also a facility where the properties of materials under extreme temperatures and pressures and surface modifications for various applications are studied. It has become the basis for the growth of laser physics in the Czech Republic, which led to the formation of ELI Beamlines and to the Czech assignment in ELI.

The **ELI Beamlines** (*Extreme Light Infrastructure – ELI Beamlines*) large research infrastructure is one of the three pillars of the ELI (*Extreme Light Infrastructure*) research infrastructure and it operates a world-class laser facility. ELI will provide a facility to carry out applied research experiments involving the interaction between light and matter at light intensities approximately ten times higher than the currently achieved values. The experimental equipment at ELI Beamlines will provide ultra-short laser pulses with a duration typically of only several femtoseconds and at a power up to 10 PW. This will open new insights with potential applications in medicine and diagnostics, the manufacture of instruments for the development and testing of new materials, and X-ray optics.

The decision to build one of the pillars of the most powerful laser equipment in the world, ELI, in the Czech Republic resulted from the wide recognition of the expertise of Czech laser physicists, confirmed by the successful transfer and operation of the PALS laser (former ASTERIX) and its further development and the introduction of new experiments. Thus, the Czech Republic gained good foundations to host excellent researchers and it has become a generally recognized centre of excellent laser science. The future development of laser research infrastructures situated in the Czech Republic will bring new challenges in the development and technology of sophisticated instruments necessary for upcoming new fields of research, development and innovation. This progress will also provide opportunities for facilities complementary to ELI (e.g. HiLASE – *New Lasers for Industry and Research*).

The significance of the ELI research infrastructure as a whole is symbolically emphasized by the fact that it is the very first and only research infrastructure from the ESFRI Roadmap which was built entirely in the so called "new EU Member States" (Czech Republic, Hungary and Romania). The success of operation of all the pillars of ELI depends on their integration within the framework of the legal entity ELI-ERIC and close cooperation with the states with the most important user communities. Wide involvement of the international community of laser physicists in the research and development programmes of ELI Beamlines, PALS and HiLASE is therefore a key prerequisite for the efficient use of these research infrastructures and the main condition for their further development, sustainable in the long term for what concerns research, innovative development and finance.



◀ ELI Beamlines (*Extreme Light Infrastructure*)

Materials physics

◀ CEPLANT (*R&D Centre for Low-Cost Plasma and Nanotechnology Surface Modifications*)

Progress in the research, development and innovations performed in the areas of the fabrication, characterisation and use of new materials, nanomaterials, functional materials and nanostructures in the Czech Republic is very intense. During the initial period of worldwide interest in new materials and advances in nanotechnologies, the Czech Republic was set back by its lack of laboratory equipment necessary for these new materials and nano-sciences. The first phase of construction of relevant research capacities financed from ESIF enabled Czech researchers to gain the best quality equipment. After finishing this phase, the above-mentioned deficit was eliminated. Nevertheless, the profile of the majority of individual large research infrastructures in the field of materials physics is relatively similar. It is therefore necessary for future development to achieve higher specialisation, narrower specification and cooperation based on complementarity and synergies. The following periods of advancement of newly constructed large research infrastructures in the Czech Republic will depend not only on sustainability, but also on the ability to react sufficiently fast to the new challenges in materials sciences and to the progress made in corresponding instrumentation.

The contribution of the Czech Republic to the pool of European research organisations acting in materials sciences is mainly through the **CzechNanoLab** (*CzechNanolab Research Infrastructure*) large research infrastructure, providing open access to technological equipment and services in the fields of nanotechnologies and materials sciences. CzechNanoLab consists of two laboratories – the CEITEC Nano laboratory in Brno and the Prague Laboratory of Nanostructures and Nanomaterials, LNSM. These two laboratories together provide open access to excellent instruments for the fabrication and analysis of nanostructures, nanomaterials and nanocomponents. This expertise is further complemented by the **CEMNAT** (*Center for Materials and Nanotechnologies*) large research infrastructure, which contributes to both fundamental and applied research, development and innovation in physics, chemistry and in the field of new materials synthesis and their characterization. **MGML** (*Materials Growth and Measurement Laboratory*) is a large research infrastructure which offers open access to equipment designed for the preparation and characterization of high-quality materials, mostly monocrystals. MGML also enables the taking of measurements of the physical properties of materials in a wide range of temperatures, magnetic and electrical fields and hydrostatic and monoaxial pressures. The portfolio of large research infrastructures operated in the realm of materials sciences is last but not least complemented by **CEPLANT** (*R&D Centre for Low-Cost Plasma and Nanotechnology Surface Modifications*), which aims to provide infrastructure services for the R&D of plasma technologies and nanotechnologies leading to the fabrication of unique advanced materials and the introduction of environmentally friendly manufacturing processes.

10.1 | Roadmap of Large Research Infrastructures of the Czech Republic for the years 2016-2022

Physical sciences and engineering

Astronomy, astrophysics and space activities

The engagement of Czech scientists in the Pierre Auger Observatory and the construction of CTA (*Cherenkov Telescope Array*), described above in the context of Czech large research infrastructures operated in the fields of nuclear and particle physics, are also highly relevant within the research being conducted in astrophysics.

The main partner of the Czech research in astronomy is the international organisation ESO (*European Organisation for Astronomic Research in the Southern Hemisphere*), in which the Czech Republic is a Member State. Membership in ESO guarantees Czech astronomers access to excellent instruments for making astronomical observations, including participation in the construction and operation of the largest ground based telescope – ELT (*Extremely Large Telescope*). ESO, in cooperation with American and East Asian partners, has built and operates the ALMA (*Atacama Large Millimeter / Submillimeter Array*) Interferometer. The access of users from the Czech Republic and Central Europe to ALMA is facilitated by means of the **EU-ARC.CZ** (*Atacama Large Millimeter / Submillimeter Array – participation of the Czech Republic*) large research infrastructure. Its goal is participation in the implementation and further development of the ALMA project.

The **EST-CZ** (*European Solar Telescope – participation of the Czech Republic*) large research infrastructure supports Czech involvement in the construction, design and operation of the EST (*European Solar Telescope*) apparatus, which will be built on one of the Canary Islands – Tenerife or La Palma, Spain. The Czech research community will thus be able to participate in the EST project and to gain access to the largest and most advanced telescope designed to observe the Sun, and to take part in the studies of basic interactions between plasma, magnetic fields and radiation.

The Czech Republic is also a Member State of the international organisation ESA (*European Space Agency*), which focuses on space research and the development of space technologies. Based on its membership, the Czech Republic can use the research, development and innovation capacities of ESA – EAC (*European Astronauts Centre*), ESAC (*European Space Astronomy Centre*), ESEC (*European Space Security and Education Centre*), ESOC (*European Space Operations Centre*), ESRIN (*European Space Research Institute*), ESTEC (*European Space Research and Technology Centre*), ECSAT (*European Centre for Space Applications and Telecommunications*) and also the European Space Centre at Kourou (*Centre Spatial Guyanais*) and the European module Columbus in the ISS (*International Space Station*).

The specific membership of the Czech Republic in international research organisations reaching a wide spectrum of science disciplines, including aeronautics, is seen the Czech participation in VKIFD (*Von Karman Institute for Fluid Dynamics*), which is oriented towards the study of fluid dynamics in all its aspects.

The key areas of research, development and innovation conducted in astronomy, astrophysics and in the space are fully international. This brings an obvious advantage to the smaller and middle-sized states with limited capacities, including the Czech Republic. Thanks to its participation in the international research infrastructures described above, Czech researchers can gain access to excellent facilities which substantially exceed the capabilities of the equipment in their home institutions. Also for this reason, the large research infrastructures of the Czech Republic operating in the fields of astronomy, astrophysics and space research and development, supported by the membership of the Czech Republic in international organisations such as ESO, ESA and VKIFD sufficiently cover the needs of research, development and innovation in given areas in the Czech Republic.

▶ ESO (*European Southern Observatory*) – VLT (*Very Large Telescope*)

Pierre Auger Observatory – participation of the Czech Republic

Acronym:
AUGER-CZ

Hosting institution:
Institute of Physics of the Czech Academy of Sciences

Partner institutions:
Charles University
Palacký University Olomouc

Phase: operational
Character: single-sited

Responsible person:
Prof Jan Řídký, Dr
ridky@fzu.cz

Website:
particle.cz/infrastructures/auger-cz/en

Year of inclusion on the Czech Roadmap: 2010

Motto:
An international infrastructure to study the most energetic particles in the Universe.

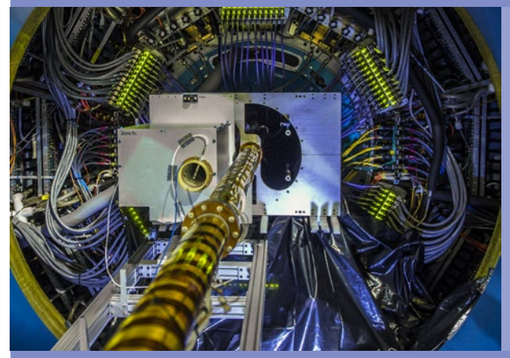
Characteristics

Already for more than a decade, the Czech Republic has been contributing to the construction, operation, maintenance and improvement of the equipment at the Pierre Auger Observatory, the largest detector of cosmic rays in the world, which covers more than 3,000 square kilometers of Argentinean pampa. The Observatory is an international research infrastructure with 17 participating countries and uses two techniques to detect cosmic rays – namely fluorescence telescopes and an array of surface detectors. Both systems are targeted towards the particles of the highest possible energies that arrive to Earth from space. The Czech research community, in collaboration with its international partners, contributes to a deeper understanding of the properties of the cosmic ray particles; its key role has been demonstrated by its taking leadership responsibility over for the operation of the fluorescence telescope system for many years. Overall, 15 out of 27 telescopes are equipped with glass mirrors of Czech provenience. Another unique contribution lies within the development and construction of devices for atmospheric monitoring. The Czech robotic telescope FRAM, which works fully autonomously, measures the aerosol content above the observatory and determines whether cosmic ray showers seen with an anomalous Profle through the fluorescence detectors are affected by the scattering of light in the presence of clouds. The all-sky cameras from Czech Republic measure the distribution of clouds above the observatory. One of the goals of AUGER-CZ is thus to continue the development of technological solutions of optical and other systems for detecting cosmic rays and for monitoring atmospheric conditions. Experts from the Czech Republic carry out tests of brand new techniques to study cosmic rays. Recently, the Czech Republic has been participating in the expansion of the Pierre Auger Observatory with an array of scintillator detectors placed above the existing surface detector stations. The successful activities of AUGER-CZ have also led to the current involvement of the Czech Republic within the planned CTA (*Cherenkov Telescope Array*) observatory. AUGER-CZ is actively involved in a number of European infrastructure networks, such as the AugerNext project, which studies the possibilities offered by new techniques of cosmic ray detection. AUGER-CZ is also participating on strategy building within APPEC (*Astroparticle Physics European Consortium*).

Socio-economic benefits

The construction and subsequent expansion of the Pierre Auger Observatory have demanded the development of technologies for the manufacturing of mirrors and their serial production, so that the robotization of devices may collect data in autonomous mode, for the detection of optical and radio-frequency radiation and for wireless communications. For the Czech companies that supply glass, optical and mechanical components, AUGER-CZ presents opportunities for collaboration within the world's largest experiment in the field and significantly increases their international name recognition, potential for innovation and competitiveness. Czech companies have become the suppliers of glass substrates for mirror manufacturing and astronomical CCD cameras for atmospheric monitoring devices at the Pierre Auger Observatory.

Brookhaven National Laboratory – participation of the Czech Republic



Acronym:
BNL-CZ

Hosting institution:
Czech Technical University in Prague

Partner institution:
Charles University
Nuclear Physics Institute of the Czech Academy of Sciences

Phase: operational
Character: single-sited

Responsible person:
Jaroslav Bielčík, Ph.D.
jaroslav.bielcik@fjfi.cvut.cz

Website:
bnl.casticova-fyzika.cz/home

Year of inclusion on the Czech Roadmap: 2015

Motto:
Unravelling the fundamental properties of nuclear matter and developing modern detection technologies for applications.

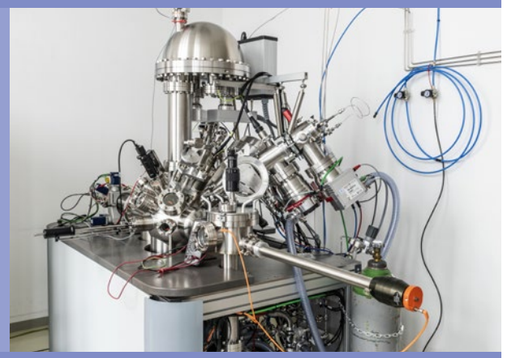
Characteristics

BNL-CZ facilitates access and supports the participation of Czech research teams in BNL (*Brookhaven National Laboratory*) in the USA. BNL is one of the largest multi-disciplinary laboratories in the world. High-energy heavy-ion collisions are an integral part of modern nuclear physics with importance for other fields, such as condensed matter physics, particle physics, astrophysics and cosmology. BNL-CZ provides access to several world unique scientific instruments, BNL's Relativistic Heavy Ion Collider (RHIC), National Synchrotron Light Source and Brookhaven Linac Isotope Producer. Czech researchers have made significant contributions to experiments at RHIC in the exploration of nuclear matter, proton spin structures and research and development of new detector technologies. Therefore, one of the main goals of BNL-CZ is to enable access to the experimental facilities at RHIC, allowing the continuation of Czech participation in the STAR, PHENIX and sPHENIX experiments, and taking part in the development, construction and operations of leading edge detectors. BNL-CZ also grants access to the RHIC Computing Facility – a large-scale computing centre used for analysing the data collected at RHIC. The local branch of BNL-CZ supports the development and maintenance of the computing cluster Sunrise at the Czech Technical University in Prague. The research program at BNL is fully complementary with the research carried out by CERN experiments. In the near future, the focus will be a detailed study of a nuclear matter phase diagram and the search for the critical point. In the long term, after completion of the heavy ion program, the construction of the new Electron Ion Collider will start in order to study the gluon structure of nuclear matter. BNL-CZ is also directly involved in broad international collaboration with the most prestigious laboratories, such as LBL (*Lawrence Berkeley National Laboratory*), LLNL (*Lawrence Livermore National Laboratory*) and ANL (*Argonne National Laboratory*). In the European area, Czech researchers are intensively working in the development and testing of new detector technologies with research infrastructures FAIR (*Facility for Antiproton and Ion Research*) in Germany and High-Luminosity LHC (*High-Luminosity Large Hadron Collider*) in CERN.

Socio-economic benefits

BNL-CZ performs research of nuclear matter and development of detector technologies that push the limits of human knowledge in material physics, astrophysics and medicine. BNL-CZ develops the most modern silicon pixel detectors needed for industry applications in medical diagnostics as well as radiotherapy, defectoscopy, material fatigue, environment monitoring and nuclear waste control. Collaboration in these applications increases the competitiveness of industry partners in the Czech Republic. BNL-CZ is an example of good practice of cooperation with the commercial sector to jointly develop technologies for silicon based semiconducting sensors for particle detection.

Centre of Materials and Nanotechnologies



Acronym:
CEMNAT

Hosting institution:
University Pardubice

Phase: operational
Character: single-sited

Responsible person:
Prof Miroslav Vlček, Dr
miroslav.vlcek@upce.cz

Website:
fcht.upce.cz/fcht/cemnat.html

Year of inclusion on the Czech Roadmap: 2015

Motto:
CEMNAT is a research infrastructure for basic and applied research with particular significance in the field of one- and two-dimensional nanomaterials and sets new trends in their synthesis and practical application.

Characteristics

CEMNAT is a research infrastructure for basic and applied research with particular significance in the field of chemistry and new materials' technologies. Within the Czech Republic, it contributes to fulfilling national priorities in terms of the sustainability of energetic and materials resources. CEMNAT research and development is focused on one-dimensional nanomaterials (e.g. nanotubes and nanofibers) and thin films, in particular, on thin functional layers, and it significantly moves forward the latest trends in their synthesis and practical application. CEMNAT owns a whole range of modern scientific instruments that are operated in the open access regime. Many of these are unique in the Czech Republic and are intensively being utilized by various user groups. Among these instruments, in particular, the tool for atomic layer deposition is very remarkable, as it enables users to deposit a whole range of functional material onto various substrates and hence it is a very attractive technique for various surface modifications. CEMNAT further operates a tool for fibre synthesis that enables its users to prepare high quality polymeric and inorganic fibres with diameters ranging from hundreds of nanometres up to units of micrometres. Also unique is the dual electron microscope, which can modify surfaces of various materials by focusing a beam of gallium ions and it can create targeted geometrical patterns, apart from classical visualization functions and elemental analyses. All prepared or modified materials have various uses. Using the CEMNAT equipment, its users are able to achieve excellent scientific results that overcome challenges in various fields (energy conversion and storage, optoelectronics, surface engineering). CEMNAT is a partner of numerous Czech nanotechnological companies that deal with research and development of various types of nanomaterials for various uses. CEMNAT is part of the NANOPROGRESS cluster, which connects various companies and research organisations that are active in the research and development and commercialization of nanomaterials. CEMNAT also cooperates with numerous research infrastructures in the Czech Republic and abroad that are very significant in materials research. This applies in particular for synchrotron units, Elettra Sincrotrone Trieste and ESRF (*European Synchrotron Radiation Facility*), and also for research infrastructures utilizing high energy lasers, ELI Beamlines (*Extreme Light Infrastructure*) and HiLASE (*High Average Power Pulsed Lasers*).

Socio-economic benefits

CEMNAT researchers prepare materials with high added value (pure amorphous or crystalline inorganic materials) that are key materials for innovative devices, such as solar cells, memory chips, batteries, and optoelectronics. Thanks to their excellent know-how and quality of equipment, CEMNAT has successfully developed collaboration with many companies that deal with nanomaterials. The most important collaboration include the development of technologies for the production of silica fibres, copper nanoparticles, various biopolymeric fibres for use in various fields (sorption, catalysis, electronics, and medicine). Based on these partnerships, new patents and verified technologies are being realized jointly, and this significantly strengthens the position of the involved parties on the market. The developed materials (and the technological fields behind them) are highly useful and reflect both the current as well as future needs of the Czech Republic and many other countries. CEMNAT contributes to the competitiveness of the Czech Republic also via the education of students and young researchers, who are able to work with excellent technologies.

R&D Centre for Low-Cost Plasma and Nanotechnology Surface Modifications

Acronym:
CEPLANT

Hosting institution:
Masaryk University

Phase: operational
Character: single-sited

Responsible person:
Prof Mirko Černák, Dr
cernak@physics.muni.cz

Website:
ceplant.cz

Year of inclusion on the Czech Roadmap: 2019

Motto:
Environmentally friendly plasma technologies.

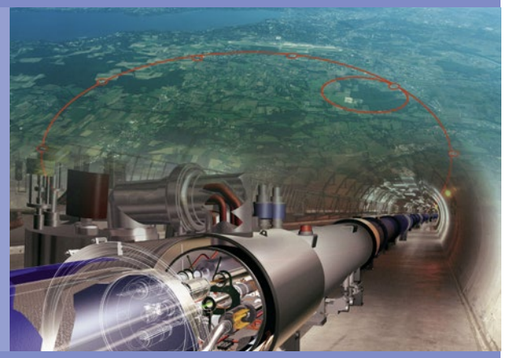
Characteristics

CEPLANT is based on the long-standing tradition of top basic and applied research in the field of thermally-disequilibrium plasma physics, which has already resulted in several industrial applications with eco-friendly and cost-effective solutions for preparing new advanced materials and the surface treatment of traditional materials. Research and development in this area, in collaboration with the community of users of CEPLANT large research infrastructure, will help to address current socio-economic challenges and environmental issues, such as environmental protection and the reduction of the use of chemicals. The uniqueness of CEPLANT lies in the broad focus of its scope. CEPLANT is active at all levels of research, development and innovation – its activities are successful in covering the entire process from basic research, through applied research with business institutions to the transfer of plasma technology for industrial applications. CEPLANT laboratories are equipped with modern scientific instruments which are commercially available, but there are some customized plasma technologies developed to test the different plasma surface treatment conditions of a material according to the user's specifications. The influence of plasma treatment on the properties of a surface material is subsequently being subjected to research in the Physical and Chemical Analysis Laboratory where complete information on the interested surface can be obtained. CEPLANT users are also able to carry out research and modelling of fundamental plasma processes and their advanced diagnostics at an international level. CEPLANT also participates in the teaching and conducting of bachelor's, master's and Ph.D. students and involves them in their research projects. CEPLANT is involved in international networks and associations of research organisations and innovative companies active in the field of plasma technology and cooperates, for example, with INPLAS (*Network of Competence Industrial Plasma Surface Technology*), CEST (*Competence Centre for Electrochemical Surface Technology*) and BalticNet-PlasmaTec.

Socio-economic benefits

The key feature of CEPLANT is to carry out research and development of unique advanced materials and environmental production processes in engineering, energy and sustainable agriculture, especially in the textile, food, glass, paper and wood industries. In cooperation with various companies, CEPLANT develops plasma technologies for the environmental cleaning of material surfaces, advanced materials for photovoltaics and printed electronics, plasma sources for biomedicine and agriculture, and the deposition of functional coatings for engineering. Long-term cooperation with business institutions has already resulted in the inclusion of CEPLANT in the European map of KET centres ("*Technology Centers in the field of Key Enabling Technologies*") that cooperate with SMEs across the EU. CEPLANT is implementing international projects with SMEs and, thanks to its close links to the business sector, can flexibly respond to the needs and requirements of industry.

Research Infrastructure for Experiments at CERN



Acronym:
CERN-CZ

Hosting institution:
Institute of Physics of the Czech Academy of Sciences

Partner institutions:
Czech Technical University in Prague / Technical University of Liberec / Charles University / Palacký University Olomouc / Nuclear Physics Institute of the Czech Academy of Sciences / University of West Bohemia

Phase: operational
Character: distributed

Responsible person:
Assoc. Prof Alexander Kupčo, Ph.D.
kupco@fzu.cz

Website:
particle.cz/infrastructures/CERN-CZ/en

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2018: landmark

Motto:
CERN-CZ enables Czech researchers to have access to the world's largest particle accelerator and unique discoveries, as well as the engagement of Czech firms in CERN technology development.

FZU Institute of Physics of the Czech Academy of Sciences

Characteristics

CERN-CZ organizes the participation of Czech universities and research institutions in the international particle physics laboratory CERN (*Conseil Européen pour la Recherche Nucléaire*) in Geneva, Switzerland. CERN operates the world's largest particle accelerator – Large Hadron Collider (LHC) – and hosts experiments which study particle collisions at the highest energies. It thus plays a world-leading role in the research of elementary particle physics and the properties of matter under extreme conditions. CERN coordinates and organizes European research in this field. The aim of CERN-CZ is to support the participation of the Czech Republic at CERN experiments, primarily in the area of the development, construction and operation of these research facilities. Because of this support, scientists from Czech research institutions have free access to CERN experimental data. The support also covers the operation of local Czech research infrastructure, which is substantial for detector production, as well as computing infrastructure for data processing. CERN-CZ develops new technologies for particle detectors, including their applications, primarily in the field of calorimetry and semiconductor tracking detectors. The technology scope of CERN-CZ covers issues in the development and construction of detectors, including radiation hardened semiconductor detectors, electronics, cryogenics, vacuum technologies, metrology, electronic and mechanical design, databases and the processing of extreme data volumes. In coordination with the Committee for Collaboration of the Czech Republic with CERN, which is an advisory body to the Ministry of Education, Youth and Sports, CERN-CZ also ensures the representation and exercise of rights in CERN's governing and advisory bodies and authorities of particular experiments. The unique experimental equipment at CERN, constructed and operated with the help of Czech research institutions, enables the research community of the Czech Republic to make important contributions to world-class results in nuclear and particle physics, which CERN regularly achieves. One example is the discovery of the Higgs boson in 2012.

Socio-economic benefits

The ambitious CERN research programme and access to the most progressive technologies increase the attractiveness of educational and research institutions for many experts and students, who subsequently use their acquired skills in commercial companies, increasing their innovative potential and competitiveness. Fulfilled contracts and the successful operation of many devices constructed in the Czech Republic for CERN represent prestigious and technologically demanding tasks for these companies, which stimulate their innovation abilities. On average, Czech firms obtain CERN contracts amounting to CZK 50 – 100 million per year. Czech companies have significantly contributed to the construction of CERN LHC experiments (silicon detectors, power sources, vacuum and optical components, steel) and the planned High-Luminosity LHC (*High-Luminosity Large Hadron Collider*) provides even further opportunities. Examples of the application of technologies in Czech industry include the TimePix silicone detectors with applications in the cosmic industry, education and medicine, and scintillation detectors employed in electron microscopy and tomography.

cta

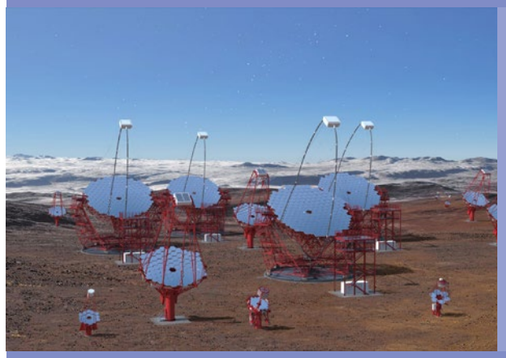
Characteristics

The CTA (*Cherenkov Telescope Array*) is a research infrastructure of international astroparticle physics, which will enable the discovery of a large number of new astrophysical sources of gamma radiation and the study of their properties. The scientific community of the Czech Republic is playing an important role in the preparation of the CTA, in particular through the development of mirrors for Cherenkov telescopes and the construction of devices for the characterization of atmospheric conditions. The optical laboratory of Palacký University Olomouc and the Institute of Physics of the Czech Academy of Sciences is where the manufacturing and prototype testing of mirrors and optical samples is taking place. Czech opticians are developing technologies for the production of mirrors for the SST (*Small Size Telescopes*). Throughout this process, they apply the experience they gained at the Pierre Auger Observatory. The manufacturing process includes newly developed technologies of gravitational bending of planar glass and the follow-up machining and quality control using CNC (*Computer Numerical Control*) machines. Regarding the monitoring of the atmosphere above the future observatory, the CTA-CZ has commissioned a complex of all-sky cameras used to determine the cloudiness of the sky in real time during observations. For a detailed analysis of atmospheric conditions, CTA-CZ has further developed the autonomous robotic FRAM telescopes. The uniqueness of the FRAM telescopes lies in their non-invasive measurement method without any interference from the observing conditions of the main telescopes during FRAM operation. One FRAM device is already in operation on the site of the future southern part of the CTA observatory in Chile close to the experimental apparatuses of the ESO (*European Organisation for Astronomic Research in the Southern Hemisphere*). A further FRAM device is installed at the site of the future northern part of CTA on La Palma Island within the Canary Islands archipelago. The third FRAM will be again deployed in Chile and is currently undergoing testing. The atmospheric monitoring activities are a continuation of the previous work regarding the search for the optimal locations of the CTA sites. CTA-CZ significantly contributed by the development of all-sky cameras and new methods for analysing satellite images. CTA is collaborating with other research infrastructures such as the SKA (*Square Kilometer Array*) and it is striving to establish a European Research Infrastructure Consortium (ERIC).

Socio-economic benefits

The Czech Republic is contributing to the construction of the CTA mainly through the development of optical systems for Cherenkov telescopes and atmospheric monitoring devices through the FRAM telescopes and all-sky cameras. Czech optical detectors are already being used in atmospheric monitoring devices and the development of further devices is underway. Participation in the CTA project is thus significant, specifically regarding the development of technologies and the manufacture of optical elements and light detectors. The CTA presents a unique opportunity for Czech industry to collaborate within a research infrastructure of worldwide importance on the development of optical technologies and the manufacturing of optical elements. The Czech companies that supply optical and mechanical components gain prestige from Czech participation on this largest international experiment in the field; their international name recognition is significantly increased, as is their competitiveness.

Cherenkov Telescope Array – participation of the Czech Republic



Acronym:
CTA-CZ

Hosting institution:
Institute of Physics of the Czech Academy of Sciences

Partner institutions:
Charles University
Palacký University Olomouc

Phase: construction
Character: single-sited

Responsible person:
Petr Trávníček, PhD.
petr.travnicek@fzu.cz

Website:
particle.cz/infrastructures/cta-cz/en

Year of inclusion on the Czech Roadmap: 2015
Status on the ESFRI Roadmap 2018: landmark

Motto:
A research infrastructure connected with astronomy for the use of high-energy photons as a probe into the extreme processes in the Universe.

CzechNanoLab Research Infrastructure

Acronym:
CzechNanoLab

Hosting institution:
Brno University of Technology

Partner institutions:
Institute of Physics of the Czech Academy of Sciences
Masaryk University

Phase: operational
Character: distributed

Responsible person:
Michal Urbánek, Ph.D.
michal.urbanek@ceitec.vutbr.cz

Website:
czechnanolab.cz

Year of inclusion on the Czech Roadmap: 2010

Motto:
CzechNanoLab provides comprehensive equipment, expertise and services for cutting-edge research in nanotechnology and advanced materials.

Characteristics

CzechNanoLab provides open access to equipment and services in nanotechnology and materials science. CzechNanoLab consists of two sites, CEITEC Nano located in Brno, and the Laboratory of Nanostructures and Nanomaterials LNSM, located in Prague. These two workplaces provide fast and easy access to cutting-edge equipment an expertise for the fabrication and analysis of nanostructures and nanomaterials. Researchers from both academic and industrial institutions from the Czech Republic and from abroad may access this large research infrastructure. Basic technologies and devices are available at both CzechNanoLab sites, and the sites complement each other in advanced and more demanding equipment. CzechNanoLab also provides its services and expertise to other research infrastructures in the Czech Republic and is involved in European and global networks such as EuroNanoLab, IUVSTA (*International Union for Vacuum Science, Technique and Applications*) or AVS (*American Vacuum Society*).

The CEITEC Nano Research Infrastructure consists of 4 laboratories – the Nanofabrication laboratory, the Nanocharacterization laboratory, the Laboratory of Structural analysis and the X-Ray computed tomography laboratory. CEITEC Nano offers complete processes for the fabrication and characterization of nano-objects to the sub-nanometre level in cleanroom environments. Research disciplines using CEITEC Nano include physics and chemistry of low-dimensional systems (nanoelectronics, nanophotonics), materials science, chemistry, surface engineering, biochemistry, bioengineering and biomedicine. The portfolio of services provided is focused on fabrication and analytical processes using excellent devices that provide detailed information on surfaces, interfaces, nanostructures and nanomaterials. CEITEC Nano enables the user to fabricate nanostructures, determine their shape and chemical composition and measure their often unique properties. CEITEC Nano also opens up ways to collaborate with nanobiology and nanomedicine research teams, for example in the area of biosensors and nanostructures for cell and tissue cultures.

The LNSM Research Infrastructure focuses on providing research and development services for a wide range of inorganic nanomaterials (semiconductors, metals and ceramics) and nanostructures (particles, wires, interfaces, monolayers, thin films and bulk nanostructured materials). LNSM topics include microelectronics, nanoelectronics and spintronics, photovoltaics, photonics, carbonaceous layers, and nanostructures and materials and their surface functionalization for medical applications (e.g. implants or sensors). LNSM mainly produces semiconductor and spintronic materials and nanostructures as well as composite materials. LNSM also includes support for theoretical groups that design new types of materials.

Socio-economic benefits

CzechNanoLab offers unique services and expertise in the Czech Republic that are used by a number of educational institutions, research organisations and high-tech companies. New materials and nanostructures developed in CzechNanoLab laboratories can lead, for example, to the development of faster and more economical recording media or to a timelier diagnosis of diseases. Unique within Central Europe, the open access to CzechNanoLab facilities enables researchers to use most of the technology independently in a so-called self-service regime. Thanks to these services, the exchange of know-how between CzechNanoLab users and staff is developing, allowing research groups to gain a high level of expertise. Another positive impact of CzechNanoLab is its contribution to the development of highly added value products in cooperation with high-tech companies.

Extreme Light Infrastructure – ELI Beamlines

Acronym:
ELI Beamlines

Hosting institution:
Institute of Physics of the Czech Academy of Sciences

Phase: operational
Character: single-sited

Responsible person:
Roman Hvězda
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Website:
eli-beams.eu

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2018: landmark

Motto:
The world's fastest and most intense advanced lasers to unravel the fundamental secrets of the Universe and materials.

Characteristics

ELI Beamlines is a unique international research infrastructure in its scientific measure, where a new generation of laser technologies are being developed, generating the most intense light pulses in the world. ELI Beamlines provides a facility to perform a large scale of scientific applications, both for basic and applied research, examining the interactions between light with matter using light beamlines intensities that previously never been reached. ELI Beamlines' mission is to develop and operate the most intense laser system in the world. Thanks to the combination of four high-repetition and high-performance laser systems of 10 PW output (petawatt = 10^{15} watt) and intensities of 10^{24}W/cm^2, the users will have the opportunity to employ unique X-ray laser-based sources, laser-driven particle acceleration beams (electron and ion acceleration), as well as a plasma physics research platform and the study of high-intensity gravitational fields. These so-called beamlines will enable pioneering research not only in the fields of physics and materials science, but also in biomedical and laboratory astrophysics and many other sciences. ELI Beamlines is one of the three pillars of ELI research infrastructure, which is located in the Czech Republic. ELI is a distributed research infrastructure comprising 3 laser centres: ELI Beamlines in Dolní Břežany, Czech Republic; ELI Attosecond in Szeged, Hungary; and ELI Nuclear Physics in Măgurele, Romania. ELI Beamlines' vision is to establish a unique excellent research facility for Czech and international users, which will provide a platform for a wide range of basic and applied research, inspired by other prosperous world impact research facilities, such as CERN (*Conseil Européen pour la Recherche Nucléaire*). In the near future (2020), a new legal entity, the European Research Infrastructure Consortium, ELI ERIC, will be established, with the main task of operating and maintaining the three ELI pillars. ELI ERIC will associate Member States representing the most significant experimental research user communities.

Socio-economic benefits

Apart from basic research and development in the field of laser science, ELI Beamlines' applied research covers domains such as oncological treatment, medical imagining techniques, fast electronics, and the study of materials ageing of a nuclear reactor and innovative new methods of nuclear waste handling. The Czech Republic, will, thanks to ELI, become a hosting country of top international research teams, which has the potential to attract new investments to highly developed technologies with high value added. ELI Beamlines will also attract companies, excellent scientific workers and technical personnel primarily involved in optics and laser sciences, material sciences, electronics and engineering. In addition, the Czech optics and photonics industry is expected to play a significant role in the development required for the construction of ELI Beamlines and the future maintenance and innovation of its facilities. ELI Beamlines will also serve as a platform for local and regional innovation initiatives.

European Spallation Source – participation of the Czech Republic

Acronym:
ESS Scandinavia-CZ

Hosting institution:
Nuclear Physics Institute of the Czech Academy of Sciences

Phase: construction
Character: single-sited

Responsible person:
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Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2018: landmark

Motto:
The ESS is constructed with the aim of providing the scientific community with the world's most powerful neutron source, enabling breakthrough studies in materials research, energy, medicine, environmental research, and other fields.

Characteristics

The ESS (*European Spallation Source*) is a project of a high-power pulsed neutron source, which is currently under construction in Lund, Sweden. The neutron beams from ESS will help to solve problems in many scientific fields, such as condensed matter physics (superconductivity and magnetic structures), chemistry (structures of surfactants), biology (effects of pharmaceuticals, structure, ordering and dynamics of DNA chains), material research (in-situ and in-operando studies of advanced materials, charge-discharge processes in batteries, hydrogen transport in fuel cells, phase transitions in new types of alloys with unique properties like high mechanical and thermal resistance and the shape memory effect) and cultural heritage (non-destructive imaging studies of historical artefacts). The in-kind contribution of the Czech Republic to the ESS's construction – the diffractometer BEER (*Beamline for European Engineering materials Research*) – is a scientific instrument on one of the ESS beams. It is specially designed to provide detailed non-destructive characterisation of engineering materials and technological components in-situ and in-operando in the course of thermo-mechanical loading, under conditions simulating real industrial processes during manufacturing, processing and operation. The delivery of systems – a helium cooling loop, target water cooling systems and HVAC (*Heating, Ventilation, Air Conditioning*) for the target station building – is another in-kind contribution of the Czech Republic to the ESS's construction. These contributions will provide researchers from the Czech Republic with 2% of the measuring capacities across the whole suite of ESS instruments. The Czech Republic became a Member State of the European Research Infrastructure Consortium ESS ERIC, and ESS Scandinavia-CZ will provide assistance to the Czech user community to access the ESS's instruments after becoming operational. European Spallation Source ERIC as a legal entity participates in international networks through the strategic consortium LENS (*League of Advanced European Neutron Sources*), which will bring together key European research infrastructures running neutron sources and ensure their optimal exploitation by users from both the academic and commercial spheres.

Socio-economic benefits

The ESS's construction involves a number of Czech innovative companies, particularly those active in the field of nuclear technologies. The Czech contributions by the delivery of cutting-edge technologies for the ESS target building and the BEER instrument are being realized by Czech companies that have thus entered the European market and are getting the opportunity to realize further follow-on deliveries for the ESS. The Czech membership in European Spallation Source ERIC and future access by scientific and industrial users to the unique ESS facilities will bring a number of technological innovations and applications in materials engineering, energy, information technology, chemistry, pharmacy and medicine and will help to address certain socio-economic challenges such as sustainable energy, the introduction of new technologies in industry, and environmentally friendly transport systems.

European Solar Telescope – participation of the Czech Republic

Acronym:
EST-CZ

Hosting institution:
Astronomical Institute of the Czech Academy of Sciences

Phase: preparatory
Character: single-sited

Responsible person:
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Year of inclusion on the Czech Roadmap: 2019
Status on the ESFRI Roadmap 2018: project

Motto:
The development and construction of a unique new-generation telescope to observe the Sun and its magnetic activity.

Characteristics

The goal of EST-CZ is to ensure the participation of the Czech Republic in the realisation and operation of the EST (*European Solar Telescope*). The EST will be a research infrastructure focused on making observations of the Sun, the only star that can be investigated in high resolution and on which life on Earth depends. This 4-meter aperture solar telescope will be one of the two largest solar instruments worldwide. It will be located on the Canary Islands, where the best observation conditions in Europe are available. The EST will provide the most advanced observations that will allow us to understand the complex mechanisms governing the magnetic activity of the Sun and to study fundamental interactions between plasma, magnetic fields, and radiation in the stellar atmosphere. These data will also enable us to understand in greater detail energetic events that take place in the solar atmosphere that influence space weather and thus affect human technologies. The EST is the only planned research infrastructure focused primarily on the field of solar physics and unites the interests of this research community within the European Research Area. The realisation of the EST project will provide the user community with access to the most advanced instruments designed to observe the Sun. The institutes involved in the EST project will have the preferential right to use most of the observation time, but at the same time, it is planned to provide all the observed and calibrated data in freely accessible databases after a proprietary period of time. It is assumed that the construction of the EST will start in 2021 and the device will become operational in 2027. The EST project cannot be realised by any single European country alone, therefore the EAST (*European Association for Solar Telescopes*) consortium was established to coordinate the development, construction, and the future operation of the EST. Currently, the European Research Infrastructure Consortium (ERIC) is being prepared to manage the EST project in the future. The EST will closely collaborate with the ESO ALMA observatory (*Atacama Large Millimeter / Submillimeter Array*), in which the Czech Republic is also involved.

Socio-economic benefits

New knowledge gained via the EST can be used to understand the principles of natural threats associated with solar activity and space weather (e.g. geomagnetic storms, power outages, disruptions of satellite communications and navigation, etc.). More than 15 private companies from all over Europe are participating in the preparation of the EST project. In the conceptual phase of the project, the Auxiliary Full Disc Telescope of the EST was designed in the Czech Republic in collaboration with the TOPTEC centre (Research Centre for Special Optics and Optoelectronic Systems) at the Institute of Plasma Physics of the Czech Academy of Sciences. During the construction of the EST, Czech companies will have the opportunity to compete in the selection process for the provision of individual technological systems for the EST, thus gaining the opportunity to strengthen their innovation capacity and increase their competitiveness on both the domestic and foreign markets.

Atacama Large Millimeter / Submillimeter Array – participation of the Czech Republic

Acronym:
EU-ARC.CZ

Hosting institution:
Astronomical Institute of the Czech Academy of Sciences

Phase: operational
Character: distributed

Responsible person:
Pavel Jáchym, Ph.D.
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Website:
asu.cas.cz/alma

Year of inclusion on the Czech Roadmap: 2015

Motto:
Unveiling hidden secrets of the Universe with the world's most powerful radio interferometer.

Characteristics

ALMA (*Atacama Large Millimeter / Submillimeter Array*) is an excellent astrophysical facility built and operated through worldwide collaboration in the Chilean Atacama desert, at an altitude of 5,000 meters, to observe the universe at (sub-)millimeter wavelengths. The main partners in the consortium are ESO (*European Organisation for Astronomical Research in the Southern Hemisphere*), NRAO (*National Radio Astronomical Observatory*) and NAOJ (*National Astronomical Observatory of Japan*). ALMA is the largest ground-based astronomical observatory in existence. It comprises 66 high-precision antennas (radio telescopes) that can be arranged in configurations with distances up to 16 km. ALMA operates as an interferometer, with its antennas interconnected and working together as if they were a single giant telescope. This results in unprecedented sensitivity and an angular resolution that exceeds that of the Hubble Space Telescope. ALMA opens up entirely new possibilities in the exploration of the universe, such as the imaging of proto-planetary disks, observations of the earliest stars and galaxies, providing direct views of the event horizon of black holes, and allowing for detailed studies of the Sun and the Solar System. EU-ARC.CZ provides support to ALMA users, in particular from the Czech Republic and Central Europe at all levels – from assistance with the preparation of observational projects (Phase I) and communication of technical details between the researchers and the observatory (Phase II), calibration and imaging of acquired data, to assistance with data analysis and the interpretation of results. EU-ARC.CZ is the only node of the European network that has expertise not only in solar research with ALMA, but also in galactic and extragalactic astrophysics, stellar physics and the physics of interstellar matter, and microwave laboratory spectroscopy. EU-ARC.CZ contributes to the further development of ALMA's capabilities – with its unique capability in Europe, it is participating in the development of the special solar observing mode and related software for processing specific solar data. Access to ALMA observations and to the services provided by EU-ARC.CZ is fully open to the scientific community, regardless of nationality, affiliation or professional background. EU-ARC.CZ is part of a network of 7 nodes of the European ALMA Regional Center (*ARC – ALMA Regional Centre*), coordinated by ESO from Garching near Munich. Thus, EU-ARC.CZ works closely with other nodes of the European ARC network, the ESO and other partners in the ALMA consortium.

Socio-economic benefits

Throughout its existence, ALMA has already brought about a number of breakthrough discoveries. EU-ARC.CZ has enabled the research community in the Czech Republic to access this state-of-the-art instrument and to use its capabilities to study the formation and evolution of planets and organic molecules necessary for the emergence of life in the Universe. Thanks to EU-ARC.CZ, the Czech Republic is the only country in Central and Eastern Europe directly participating in ALMA activities and providing support to its users. In the area of solar research with ALMA, EU-ARC.CZ plays a leading role across Europe. This increases the competitiveness of the Czech Republic in the field of astrophysical research and development. EU-ARC.CZ is actively involved in the further development of ALMA, in particular in the development of the special solar observing mode and related software. Within the framework of the membership of the Czech Republic in the international organisation ESO, Czech companies participated in the construction of the ALMA Observatory. And the activities of EU-ARC.CZ bring the potential for Czech companies to participate in further technological development of this revolutionary instrument.

Facility for Antiproton and Ion Research (FAIR) – participation of the Czech Republic

Acronym:
FAIR-CZ

Hosting institution:
Nuclear Physics Institute of the Czech Academy of Sciences

Partner institutions:
Czech Technical University in Prague / Charles University / Silesian University in Opava

Phase: construction
Character: single-sited

Responsible person:
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Website:
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Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2018: landmark

Motto:
Research infrastructure to study the Universe in a laboratory setting by exploiting beams of accelerated antiprotons and relativistic heavy ions.

Characteristics

FAIR (*Facility for Antiproton and Ion Research in Europe*) is a new European research infrastructure for nuclear and hadron physics currently under construction at Darmstadt in Germany as a part of the capacity of GSI (*Helmholtzzentrum für Schwerionenforschung*). The Czech participation in FAIR, organized within FAIR-CZ, is anticipated to cover not only research activities in hadron physics, nuclear physics and nuclear astrophysics in CBM (*Compressed Baryonic Matter*), PANDA (*Anti-Proton Annihilation at Darmstadt*) and NuSTAR (*Nuclear Structure, Astrophysics and Reactions*), which are research pillars of FAIR, but also activities in other fields of science, such as radiobiology and biophysics developed in FAIR-APPA (*Atomic, Plasma Physics and Applications*), another research pillar of FAIR. The multidisciplinary aspect of FAIR-CZ is one of its unique features, supported by portfolio of services, such as support and infrastructure for the development and production of complex scientific devices for conducting FAIR experiments in the Czech Republic, coordinating access to research at FAIR, as well as technologies developed in all four FAIR research pillars and the operation of a computer centre in the main FAIR hosting institution, which serves as the national Tier3 centre of the GRID computer network. After its completion, FAIR will be a leading worldwide facility for hadron and nuclear physics for the next several decades. FAIR will be unique in areas such as the production of highly compressed plasma exploiting intense heavy-ion beams, with an unparalleled research program focused on cooled antiproton beams and internal-target storage-ring capabilities for Quantum Chromodynamics studies. FAIR is expected, for example, to verify models of compressed matter, which is used to describe the fusion of neutron stars assumed to be the source of recently detected gravitational waves (Nobel Prize in 2017).

Socio-economic benefits

FAIR-CZ will contribute to new innovations in oncology by developing microdosimetry and by studying modifications in absorbed radiation dosages due to implants. In addition, it will contribute to the development of technologies and detectors used in medicine (PET cameras, diagnostics), the energy industry (new materials for fusion) and machinery. FAIR-CZ also educates students. Czech companies will benefit from the involvement of the Czech research community in FAIR by delivering sophisticated research instruments for FAIR, thus improving their technological expertise. Specific examples include the massive production of unique $PbWO_4$ scintillators for FAIR on an order of approximately € 20 million, and the development of new silicon sensors with high density pads and with a high tolerance to radiation, which can be used for PET cameras in the future.

Research Infrastructure for Fermilab Experiments

Acronym:
Fermilab-CZ

Hosting institution:
Institute of Physics of the Czech Academy of Sciences

Partner institutions:
Czech Technical University in Prague / Charles University / Institute of Computer Science of the Czech Academy of Sciences

Phase: operational
Character: single-sited

Responsible person:
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particle.cz/infrastructures/fermilab-cz/

Year of inclusion on the Czech Roadmap: 2010

Motto:
An integrated environment for efficient collaboration on experimental activities in Fermilab in all their phases, starting from the initial proposal, through construction and implementation, up to the final data analysis with the utilisation of the most recent artificial intelligence methods.

FERMILAB-CZ

Characteristics

The Fermilab-CZ is devoted to collaboration with the U.S. national laboratory Fermilab (*Fermi National Accelerator Laboratory*), the primary concern of which is the research of elementary particles. The core of the present Fermilab research programme is the neutrino experiments, including NOvA and DUNE experiments. European laboratories and universities actively participate in these neutrino experiments, including CERN (*Conseil Européen pour la Recherche Nucléaire*), participating through strategic cooperation. The main knowledge expertise of the Fermilab-CZ is represented by its detector laboratory, contributing to the design and construction of detectors, and by the mathematical expert group, involved in the development and application of statistical and non-statistical methods of artificial intelligence for data analysis. Fermilab-CZ also contributes to the research activities with its significant computational resources in the field of distributed processing of experimental data and simulations, and is contributing to software development for data acquisition, operation and control, using the most recent international standards. The Fermilab-CZ group of experts is part of a community of approximately 12,000 researchers, who are working together on the development of detectors, electronics and data analysis methods, all of which are used in wide areas of human activities. Because of its deep involvement in the construction and operation of the experiments, Fermilab-CZ allows the Czech research institutions to participate in unique physics research. Both Czech researchers and all individual members and research groups of the supported experiments gratuitously use and exploit all Fermilab-CZ services on an open access basis. In the field of data processing, Fermilab-CZ collaborates with the e-INFRA CZ e-infrastructure of the Czech Republic to provide a high speed and stable connection to international laboratories. Fermilab-CZ also appreciates its cooperation with the IT4Innovations e-infrastructure in order to take advantage of its capacity for data analysis.

Socio-economic benefits

Fermilab-CZ contributes to the development of excellent research, with the goal of understanding the basic laws of elementary particle interactions and their properties. High-end technologies are utilized within individual experiments, and often further developments and new technology advancements take place with a subsequent transfer to the industry. For example, during the construction of the Tevatron accelerator, a new technology for the production of reliable superconducting magnets was developed, which allowed for the efficient production of superconducting magnets used later in medical Magnetic Resonance Imaging (NMR) applications. The DUNE Detector will be the largest liquid Argon detector in the world, which may stimulate the progress, for example, in cryogenic technologies. The experiments are carried out with the significant participation of students in international expert teams. Thus, the students not only obtain knowledge of new technologies and scientific content of experiments, but they are also subject to the advanced management methods utilized within large experimental collaborations. Furthermore, they are exposed to the ethical issues of scientific research. The students then transfer such precious experience to their subsequent professional activities, not only in the field of research, but also in industry, governmental management, or state administration.

Laboratoire Souterrain de Modane – participation of the Czech Republic

Acronym:
LSM-CZ

Hosting institution:
Czech Technical University in Prague

Partner institution:
National Radiation Protection Institute

Phase: operational
Character: single-sited

Responsible person:
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Year of inclusion on the Czech Roadmap: 2010

Motto:
Unique multidisciplinary research infrastructure for conducting fundamental and applied research in a "radiation vacuum" environment.

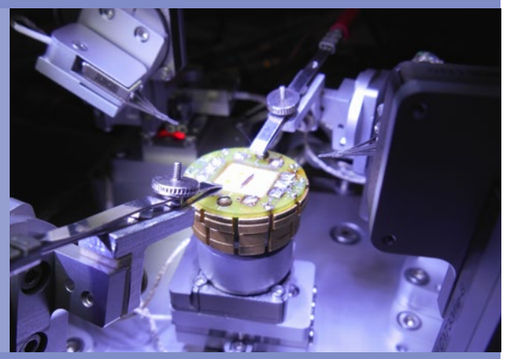
Characteristics

LSM-CZ organizes the participation of the Czech research community in the international underground laboratory LSM (*Laboratoire Souterrain de Modane*) and has a significant share in the construction of new facilities and operation. In LSM, multidisciplinary fundamental research in particle, astroparticle and nuclear physics (e.g. search for dark matter, studies of the properties of neutrinos) and a broad range of applications requiring extremely low radioactivity environments is performed. Examples of areas in which unique technologies developed in LSM are being applied includes the sensitive detection of radionuclides for safety and health protection, the ultra-sensitive monitoring of nuclear power plant outlets for the hidden leakage of radionuclides, microelectronics in the testing of chips for computer safety from the point of view of damage caused by radioactivity, radiobiology in the investigation of DNA and cells under conditions of extremely low levels of ionizing radiation, geoscience by geoneutrinos, and archeology in radionuclides dating and climatology. LSM provides unique technologies with significant application potential for industry, including an environment with ultra-low background conditions with the suppression of all types of radioactivity (cosmic rays, gammas, neutrons), a clean room with highly reduced radon concentration, a filtration anti-radon facility suppressing the content of radon by a factor 10000 and ultra-low background HPGe (*High Purity Germanium*) spectroscopy for the detection of radioactivity in the environment. LSM also offers conditions for researching trace amounts of radioactive contamination arising from Chernobyl contamination in the Czech Republic, for selecting radio-pure materials and for studying ultra-rare nuclear processes, automatic systems for HPGe detectors, BiPo detectors for taking thin foil radioactivity measurements at the level of just a few μBq/kg in ^{208}Tl and ^{214}Bi, an advanced radon emanation screening facility and improved innovative detector technologies (pixel detectors) for low background conditions. Similar conditions or such sensitive technologies are impossible to reach outside of the underground laboratories. The research being conducted at LSM may have significant application potential for the long-term storage of biological materials (e.g. umbilical cord blood, sperm, eggs) to reduce radiation damage by cosmic rays. LSM is involved in international cooperation with other deep underground laboratories in the United Kingdom (*Boulby Underground Laboratory*), Spain (*Canfranc Underground Laboratory*), Italy (*Laboratori Nazionali del Gran Sasso*), China (*Jinping Underground Laboratory*) and Canada (*SNOLAB*). In the EU, the establishment of a distributed platform for deep underground research laboratories as a European Research Infrastructure Consortium (ERIC) is under preparation.

Socio-economic benefits

The impact of LSM-CZ's activities is given by the creation and operation of a complementary national research infrastructure in the Czech Republic, the education of students and young experts in a broad range of R&D fields, attracting experts from abroad, and cooperation with innovative companies providing common research, increasing production, supporting exports and employment, and involvement in joint projects. Examples of cooperation with companies include patents that have resulted in the delivery of scintillationc detectors to LSM and a cosmic veto for the joint Fermilab (*Fermi National Accelerator Laboratory*) and CERN (*Conseil Européen pour la Recherche Nucléaire*) project, as well as the delivery of anti-radon devices. One recent example is the construction of a clean room with the suppression of radon resulting in a patent application. An international MEDEX conference focused on research related to LSM as a platform for exchanging knowledge and the further education of students is regularly organized in the Czech Republic.

Materials Growth and Measurement Laboratory



Acronym:
MGML

Hosting institution:
Charles University

Partner institution:
Institute of Physics of the Czech Academy of Sciences

Phase: operational
Character: single-sited

Responsible person:
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Website:
mgml.eu

Year of inclusion on the Czech Roadmap: 2010

Motto:
The synthesis of high-quality materials for modern research and applications and taking measurements of their physical properties under different external conditions (temperature, electric and magnetic fields and external pressure).

MGML
Materials Growth and Measurement Laboratory

Characteristics

MGML is a research infrastructure providing a laboratory base for advanced material research. Within its two closely co-operating units, the Material Growth and Characterization Laboratory (MGCL) and the Material Properties Measurement Laboratory (MPML), MGML offers open access for external users to utilize a vast experimental instrument suite as well as the high-level expertise of its scientists. MGCL has state-of-the-art facilities for metal refinement, the synthesis of new materials, and the preparation of high-quality single crystals using 5 different techniques. The unique combination of different crystal growth methods allows its users a great deal of flexibility and the ability to optimize the technology of producing entirely new materials. Modern X-ray diffraction and electron microscopy instruments allow for detailed structural and phase characterization of samples. MPML offers measurements of a wide portfolio of the physical (magnetic, transport, thermal, acoustic and elastic) properties of materials through several complementary experimental methods. The extensive range of MGML instruments makes it possible to carry out measurements in temperatures ranging from miliKelvins up to several hundred degrees Celsius, magnetic (up to 20 T) and electric (from -50V to + 50V) fields, hydrostatic and uniaxial pressures up to 15 GPa. Also important is the possibility to prepare, characterize and measure uranium materials, for which the host institution has the appropriate license. Interconnected with this wide range of experimental techniques for the preparation, characterization and measurement of physical properties makes MGML a unique large research infrastructure in the Czech Republic, fully comparable with the world's leading laboratories. MGML actively collaborates with major European research infrastructures such as HLD (*Dresden High Magnetic Field Laboratory*), ILL (*Institut Laue-Langevin*), ESRF (*European Synchrotron Radiation Facility*) or European Spallation Source ERIC. For these subjects, MGML acts as a supportive research infrastructure providing top-notch high-quality sample preparation and characterization as well as a broad spectrum of macroscopic experimental techniques.

Socio-economic benefits

MGML equipment contributes to the development of material research and physics, in particular in the search for functional materials and a greater understanding of the physical phenomena that may lead to the emergence of new technologies (e.g. spintronics and energy). The research of magnetocaloric materials, uranium alloys or radiation-modified superconductors intended for the construction of tokamaks contributes to solving the technological challenges currently being faced by the fields of energy while helping in the investigation of magnetic nanoparticles for hyperthermia, which is significant for medicine. Cooperation with suppliers in developing prototype equipment for the preparation of new materials and for measuring physical properties extends the spectrum of technologies offered to MGML users and increases the competitiveness of these suppliers on the world market with instrument techniques. The involvement of students and young researchers in MGML contributes to the education of the young generation in basic and applied research and development.

Prague Asterix Laser System

Acronym:
PALS

Hosting institution:
Institute of Plasma Physics of the Czech Academy of Sciences

Partner institution:
Institute of Physics of the Czech Academy of Sciences

Phase: operational

Character: single-sited

Responsible person:
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Website:
pals.cas.cz

Year of inclusion on the Czech Roadmap: 2010

Motto:
A unique pulsed iodine laser operated by the PALS is among the four largest EU laser systems. Its reliable operation and varied diagnostic equipment make it one of the most demanded user laser facilities in Europe.

Characteristics

For almost two decades, PALS has been among the world's leading laboratories in physics and has provided top-quality high-power lasers with focus on the interaction between laser radiation and matter. PALS operates a pulsed terawatt iodine laser, one of four of the largest lasers in the EU. This laser delivers on its target up to 1 kJ of energy in an infrared sub-nanosecond pulse. The intensity in the main beam, which can be focused into a pattern less than 50 μm, can exceed 30 PW/cm^2. Its high beam quality, ultra-narrow spectral line, versatile target chambers with varied diagnostic equipment and reliable operation make it one of the most demanded user laser facilities in Europe. The iodine laser can also be employed as a driver for a zinc x-ray laser emitting at a wavelength of 21.2 nm. The precise synchronization of the iodine laser with the ultrashort (femtosecond) Titanium:Sapphire laser is completely unique. Synchronized femtosecond pulses are primarily exploited for probing plasma generated by the iodine laser. Such synchronization of ultrashort (femtosecond) and high energetic short (sub-nanosecond) pulses is available in just a few laboratories around the world. The flexible laser systems at PALS are well suited for conducting experimental studies of dense plasma, laboratory astrophysics, inertial fusion, laser plasma-chemistry experiments, origin of life studies and for developing and testing sources generating photons with high-energy and charged particles. As one of the founding members of the Laserlab-Europe (*Integrated Initiative of European Laser Research Infrastructures*), PALS offers open access to its users, where selected European projects with the participation of overseas experts, mainly from the USA, Japan and South Korea, are carried out. PALS also serves as a training centre for students and young researchers from the Czech Republic and abroad, allowing them to obtain experience with cutting-edge technologies. Within the framework of its international activities, PALS participates in projects of pan-European research infrastructures such as ELI (*Extreme Light Infrastructure*) and HiPER (*High Power Laser Energy for Research*). As a partner of the EUROfusion consortium, it devotes a part of the beam-time to the investigation of energy production by means of inertial fusion and also collaborates with the FAIR (*Facility for Antiproton and Ion Research*) European research infrastructure. Within the Czech Republic, the PALS also collaborates closely with the laser research infrastructures ELI Beamlines (*Extreme Light Infrastructure – ELI Beamlines*) and HiLASE (*New Lasers for Industry and Research*).

Socio-economic benefits

The long-term existence of PALS, the first large-scale international laser research infrastructure in the Czech Republic, is a remarkable stabilizing factor of Czech laser research, making the Czech Republic ranked side by side with the field "established" countries like Great Britain, Germany, and France. Within the Czech Republic, it contributes to research and development in the fields of the use of energy, the structure of matter and the Universe. PALS is a partner to companies developing and delivering special optical materials for high-power lasers, fine quartz-glass tubes, non-linear optic crystals and vacuum components. In addition to its collaboration with the application sector, PALS contributes to the competitiveness of the Czech Republic by educating young researchers, allowing them to obtain experience with cutting-edge technologies in high-power photonics in connection with high-level vacuum, precise electronic driving systems, metrology and biomedicine and environmental technologies.

Système de Production d'Ions Radioactifs Accélérés en Ligne – participation of the Czech Republic

Acronym:
SPIRAL2-CZ

Hosting institution:
Nuclear Physics Institute of the Czech Academy of Sciences

Phase: construction
Character: single-sited

Responsible person:
Jaromír Mrázek, Ph.D.
mrazek@ujf.cas.cz

Website:
ujf.cas.cz/cs/vyzkum-a-vyvoj/velke-vyzkumne-infrastruktury-a-centra/spiral2-cz/

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2018: landmark

Motto:
A laboratory equipped with stable and radioactive ion beams and fast neutron fields for conducting research in nuclear physics and astrophysics, construction materials and radioisotopes for medicine.

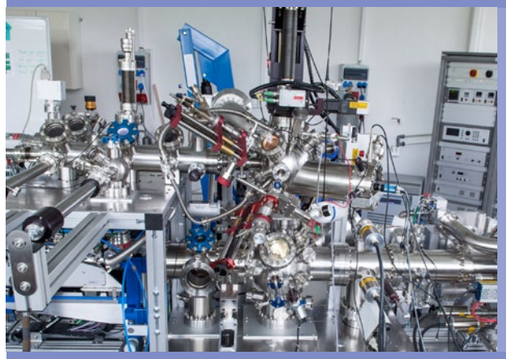
Characteristics

SPIRAL2-CZ secures the participation of the Czech Republic in the SPIRAL2 (*Système de Production d'Ions Radioactifs Accélérés en Ligne*) research infrastructure, which is being built as part of an important upgrade to the existing GANIL (*Grand Accélérateur National d'Ions Lourds*) facility in Caen, France. SPIRAL2 is being constructed for basic and interdisciplinary research and research linked to applications. Intense ion and neutron beams and related equipment will enable researchers to study nuclear physics topics including nucleosynthesis astrophysical scenarios ranging from Red Giants to explosive processes in novae, study the activation of construction and target materials by charged particles and explore changes in materials exposed to neutron fields (for nuclear and fusion facilities). Intense ion beams will be used for the investigation of radio-isotopes with medical potential, of the energy dependence of nuclear reactions and techniques for the production of new therapeutics and theranostics. In the first stage of the SPIRAL2 project, technologies for irradiation by intense ion beams and measurements taken of short-lived products will be available (vacuum/pneumatic system for activation, transport and measurement developed in the Czech Republic). The data are necessary for the modelling, design, and decommissioning of construction and target materials of future nuclear energy facilities. The emergence of changes and the degradation of the properties of these materials during their life cycle is a well-known problem. The technology and equipment at SPIRAL2 will allow for a higher level of these experimental tests. Thanks to the combination of stable, radioactive and neutron beams, GANIL/SPIRAL2 will continue to be among the most important laboratories in nuclear physics of low and middle energies in Europe.

Socio-economic benefits

New neutron generators and a new station for irradiation by charged particles are an important source of data in the field of energetics and materials engineering for new target technologies, material behaviour and material activation. In the field of radioisotopes for medicine, this equipment has great potential to push the current knowledge and technology towards new combined, safer and more effective radioisotopes for diagnostics and therapy. Within the framework of SPIRAL2-CZ, two target technologies are planned, while there are several companies in the Czech Republic that can participate in the construction of the facilities, as they are able to work with clean vacuum materials and vacuum technologies. Czech companies can participate in the project surrounding a 10kW rotating target to research radioisotopes with medical potential that is being planned after 2019. In the future, Czech companies may take part in the production of the 200kW power target of SPIRAL2, which is based on uranium carbide.

Surface Physics Laboratory – Materials Science Beamline



Acronym:
SPL-MSB

Hosting institution:
Charles University

Phase: operational
Character: distributed

Responsible person:
Prof Vladimír Matolín, Dr
matolin@mbox.troja.mff.cuni.cz

Website:
nano.mff.cuni.cz

Year of inclusion on the Czech Roadmap: 2010

Motto:
SPL-MSB – our goal is to offer advanced analytical techniques to scientists worldwide.

Characteristics

SPL-MSB is a union of the Czech Material Science Beamline Laboratory (MSB) in Trieste and its former operator, the Surface Physics Laboratory (SPL) of the Faculty of Mathematics and Physics of Charles University. SPL-MSB offers access to its research facilities through a single entry point of the CERIC-ERIC (*CentralEuropean Research Infrastructure Consortium*), which brings together 9 European countries and is open to researchers from around the world through periodic calls for proposals with independent peer review. The excellence of SPL-MSB is based on its expertise of SPL, the most comprehensive surface research laboratory in the Czech Republic, which has long been operating a number of facilities for materials research, physics and surface chemistry, catalysis and organic molecule studies. These facilities include a full range of photoelectron spectroscopies, particularly spectroscopy at MSB based on synchrotron radiation (e.g. resonance photoemissions and NEXAFS). SPL-MSB provides ion scattering spectroscopy, electron diffraction, scanning tunnelling microscopy, thermodesorption spectrometry, X-ray scanning electron microscopy and focussed ion beam lithography, and atomic force microscopy, which enables electrochemical analysis in liquids. SPL provides its users access to advanced surface research methods and expert support from their staff. The devices offered in open access mode to the Czech and international research community include NAPXPS (*Near Ambient Pressure Photoelectron Spectrometer*), angle resolved photoelectron spectroscopy and XPS / XPD diffraction, and an FESEM scanning electron microscope with a field emission cathode and synchrotron beamline for materials science at MSB Elettra Sincrotrone Trieste. The active involvement of the students of the Faculty of Mathematics and Physics of Charles University in SPL-MSB's activities plays a significant role in their Ph.D. and master's degree studies. Regular workshops attended by both Charles University and foreign partner institutions students are organised.

Socio-economic benefits

SPL-MSB has successfully participated, among other things, in research that led to the development of innovative nanocatalysts for fuel cell technologies. These are now protected by a total of 7 international patents, and SPL is preparing their entry into the technology transfer market. Within CERIC-ERIC, SPL-MSB contributes to the open access by research organisations to cutting-edge research infrastructure, technology transfer, and industrial relations. The results of the research on the fundamental characteristics of innovative nanocatalysts have been the basis of the applied development of fuel cell catalysts for the production of hydrogen energy storage cells and the promotion of a strategic European portfolio of sustainable energy.

Van de Graaff Accelerator – A Tunable Source of Mono-energetic Neutrons and Light Ions

Acronym:
VdG

Hosting institution:
Czech Technical University in Prague

Phase: operational
Character: single-sited

Responsible person:
Dr Jaroslav Smejkal
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Website:
aladdin.utef.cvut.cz/projekty/vdg

Year of inclusion on the Czech Roadmap: 2010

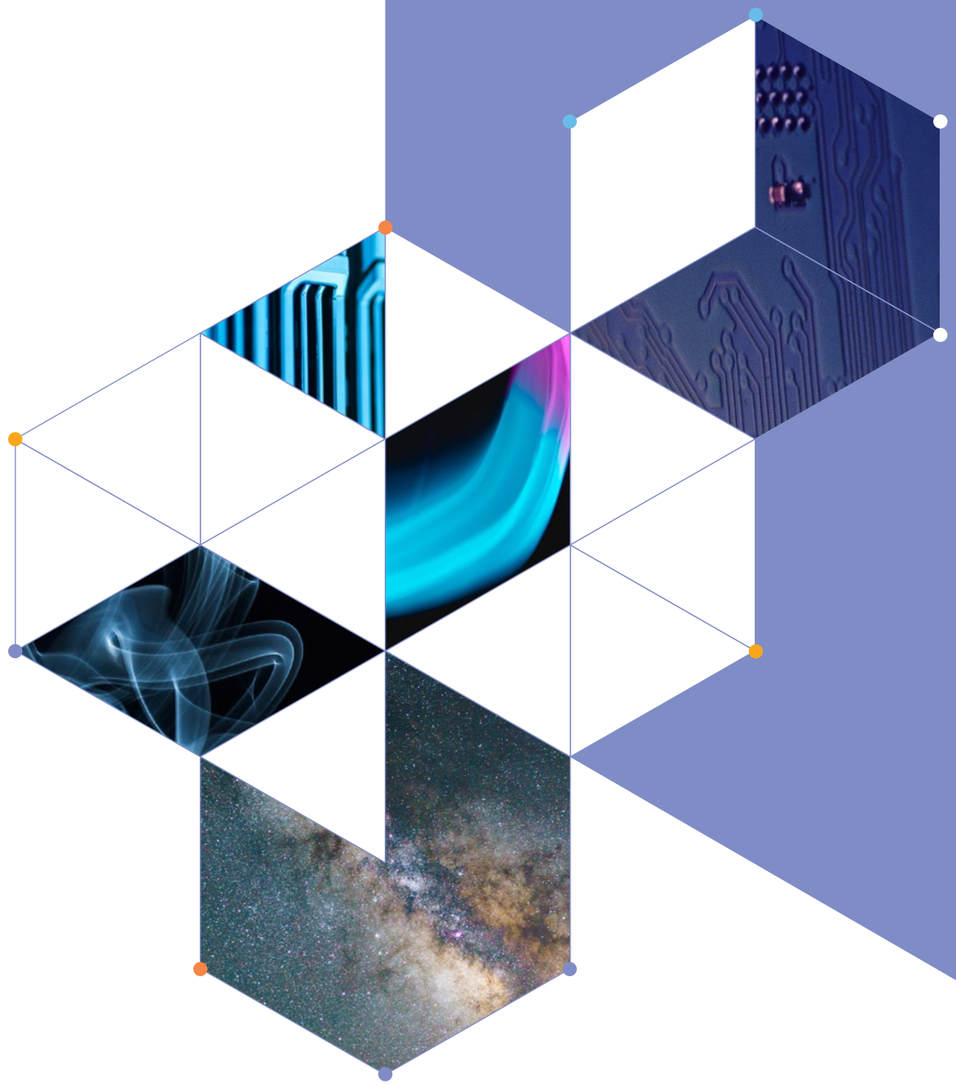
Motto:
A complex multipurpose laboratory for various types of ionizing radiation, which provides a wide spectrum of radionuclide sources and is equipped with a large range of detectors and detecting techniques.

Characteristics

The VdG acts as a complex multipurpose laboratory for various types of ionizing radiation, which is operated in open access mode. For its users, the VdG provides light ions and unique mono-energetic neutrons with tunable energy, which are used for conducting basic and widely focused applied research in subatomic physics, materials physics, detector technics, for researching electronic components' reliability (radiation damage), and for testing space technologies. Moreover, the VdG ensures education for students and professional training for young researchers. With the support of the ESA (*European Space Agency*), the VdG laboratory has modernized and calibrated its neutron sources and built a testing station for gamma rays of discrete energies. These facilities are ESA certified and serve to test and calibrate radiation sensitive detectors for space research. Additionally, also in collaboration with the ESA, a transportable gamma-ray station was constructed to be used for performing remote tests on devices which are designed for operating in space stations and satellites in orbit; currently, it is located in the IKI (*Space Research Institute*) in Moscow, where it is serving to calibrate detectors. The VdG laboratory is equipped with a broad spectrum of radionuclide sources – those of X-, alpha, gamma, and beta rays are available along with a compact neutron AmBe source, and by the end of 2018, a new deuterium-tritium neutron source will also be added. Thus, the VdG enables researchers to carry out physical research which involves polarization neutron experiment with polarized targets for spin physics and nuclear analytical methods using tagged neutron beams, as well as studying nuclear reactions for thermonuclear fusion and astrophysics. For measuring and evaluating their experimental results, the VdG's users may employ a large range of detectors and detection techniques which are accessible at the workplace. Widely targeted activities utilizing the VdG's capacities take place in close cooperation with both domestic and foreign research groups. The VdG actively collaborates with international research infrastructures; they are, in particular, ESA, CERN (*Conseil Européen pour la Recherche Nucléaire*), European Spallation Source ERIC, and JINR (*Joint Institute for Nuclear Research*) and above all are the University of Montreal's accelerator centre and Immanuel Kant Baltic Federal University in Kaliningrad.

Socio-economic benefits

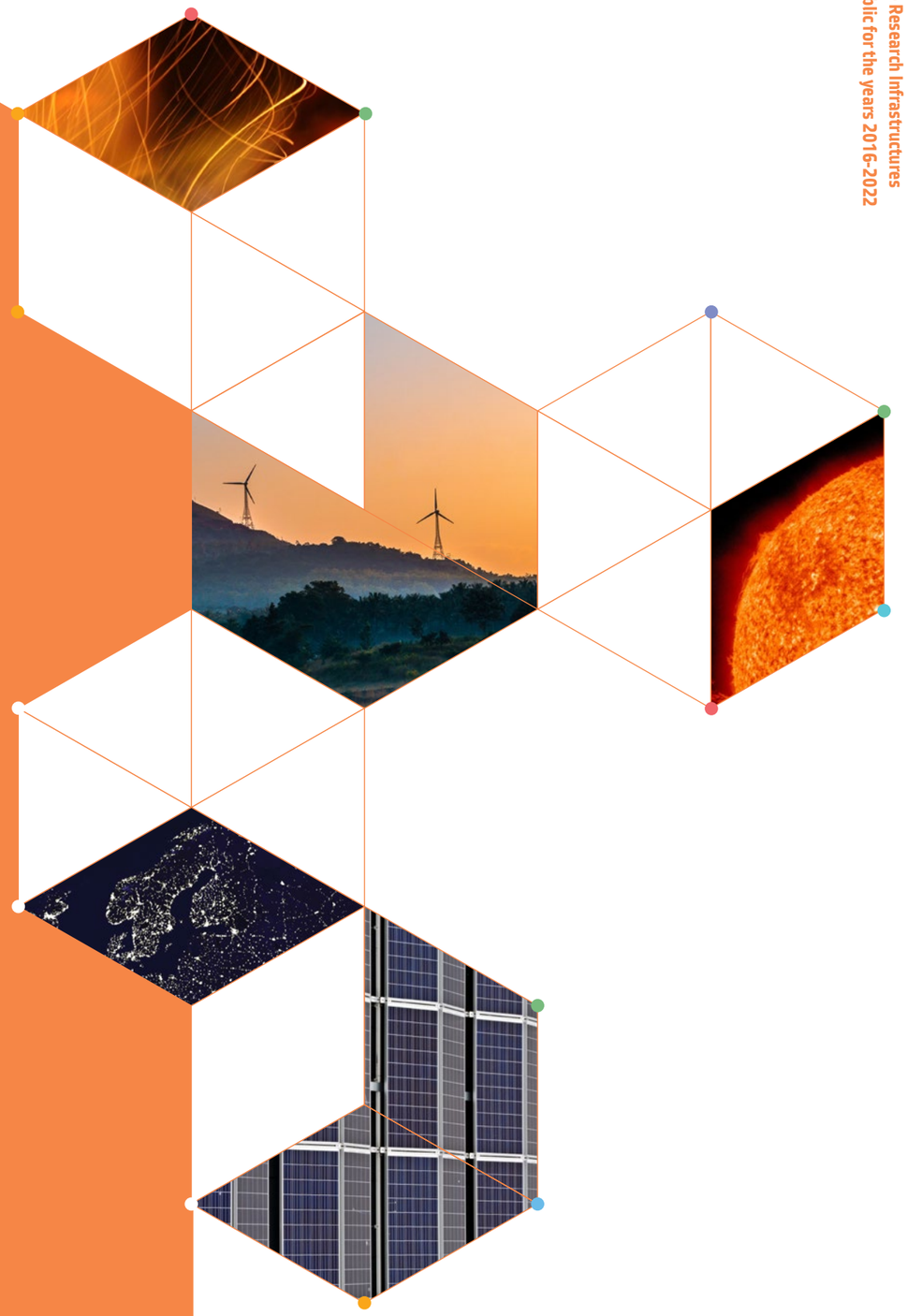
The VdG is utilized by high-tech enterprises which work in the fields of advanced detector and electronic instrumentation. The VdG's collaboration with the private sector is especially related to applied research and occurs, inter alia, through common projects which lead to the development of new technology products. The VdG possesses the sole particle accelerator situated in a Czech university and, in this way, it plays an indispensable role in the education of technical and natural science students. The VdG trains young experts for the industrial sphere and attracts highly qualified workers from abroad to the Czech Republic as well. The laboratory also serves for testing and calibrating experimental instrumentation and devices designed for other workplaces and larger international corporations.



Energy

10.2

page



Over the past 25 years, the energy sector has gone through significant technological transformations as a result of intensive research, development and innovation. Extensive investments in research, development and innovation in energy resources have been made in the USA, leading to increased oil and gas production from unconventional sources. Among other factors (such as the economic crisis, etc.), this increase in production led to a reduction in fossil fuel prices. Global efforts to reduce greenhouse gas emissions are a major driving force for innovations in the field of renewable energy, technologies for carbon capture and storage, and nuclear power generation. However, at the same time, some countries (e.g. Germany) have decided to move away from the use of nuclear energy, and, consequently, to shut down both their nuclear power plants and their research reactors.

10.2 | Roadmap of Large Research Infrastructures of the Czech Republic for the years 2016-2022

Energy

In 2007, the European Commission issued the "SET Plan" (*Strategic Energy Technology Plan*), which emphasizes the need for the development of energy technologies with clearly defined goals for 2020 – a 20% reduction in greenhouse gas emissions, a 20% share of renewable energy resources, and a 20% reduction in power consumption by increasing the efficiency of its uses. By 2050, the European Strategic Energy Technology Plan (SET Plan) will focus on reducing the rate of climate change (global warming below 2ºC), particularly by reducing greenhouse gas emissions by 80% to 95%. The SET Plan also aims at reducing the cost of low-carbon power generation, and at transforming the energy industry within the context of low-carbon energy technologies.

In 2014, a coordinated approach was proposed as part of the "Towards an Integrated Roadmap: Research and Innovation Challenges and Needs of the EU Energy System" by the European Commission, EU Member States and relevant EU stakeholders. The EU Council approved a goal of reducing greenhouse gas emissions by at least 40% by 2030 as compared to 1990, setting a target of producing at least 27% renewable energy as well as an indicative energy savings target for 2030. A review of these objectives is planned for 2020.

Research, development and innovation are the key pillars of the SET Plan implementation, whilst the EU Framework Programme for Research and Innovation Horizon 2020 (2014-2020), the European Atomic Energy Community Programme for Research and Training (2014-2018), extended until 2020, the EERA (*European Energy Research Alliance*), ERA-NET and ERA-NET Plus, Joint Technology Initiatives and national programmes for research, development and innovation, including Operational Programmes using ESIF resources, are the main financial instruments to achieve the above-mentioned objectives.

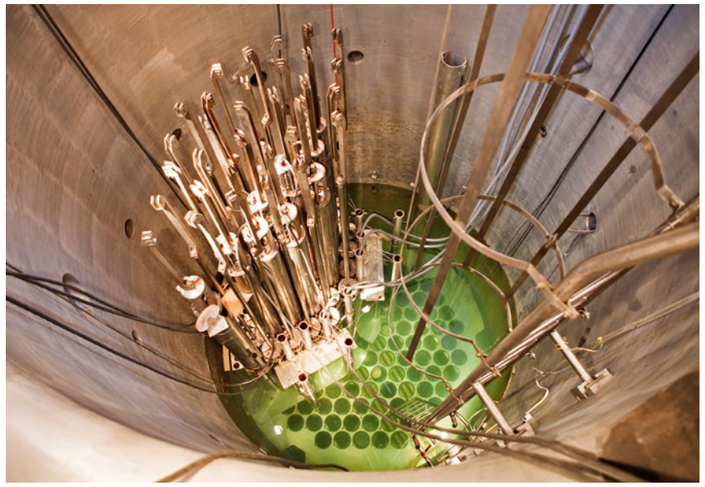
The main objective of the research, development and innovation implemented in the Czech Republic and Europe in the field of energy is to ensure sustainable, safe, competitive and affordable energy. The primary energy resource structure in the Czech Republic consists of 37.2% coal, 18.3% natural gas, 20.8% oil and petroleum products, 18.6% nuclear fuel, 8.7% renewable resources, 0.7% other fuels and a -4.3% electricity balance. The final energy consumption structure is based on the following: 7.7% on coal, 23.8% on natural gas, 29.7% on oil and petroleum products, 18.1% on electricity, 10.1% on heat and 10.6% on other fuels. Up to 50% of primary energy sources are used to generate electricity (49% from coal, 5% from natural gas, 34% from nuclear sources, 5% from biofuels, 3% from hydroelectric power, 1% from wind power, 2% from photovoltaic and 1% from other sources).

The SET Plan targets to be achieved by 2050 represent major challenges for the Czech Republic in terms of reducing its energy intensity and increasing the resilience of the electricity grid. Research, development and innovation using state-of-the-art research infrastructures should, therefore, focus on addressing these challenges.

The scope and focus of research, development and innovation programmes implemented at the EU level is very broad and reflects the diverse possibilities and orientations of the EU Member States, distinguishing them into the following areas: (1) renewables (photovoltaics, concentrated solar energy, geothermal energy, wind energy, ocean energy, hydropower, biofuels); (2) efficient energy transformation and its use in industry and transport (energy transmission and storage, fuel cells and hydrogen, smart cities and communities, intelligent energy networks); (3) carbon dioxide capture and storage technologies with the aim of reducing greenhouse gas emissions from fossil fuels and biofuels; (4) nuclear energy (nuclear fission and fusion); and (5) interdisciplinary energy technologies (simulations and modelling, monitoring and testing devices, advanced materials). Such a broad portfolio of research, development and innovation also raises the need for cooperation at the European level and between the EU Member States.

Some areas of research, development and innovation have relatively limited importance for the Czech Republic (such as energy conversion using tidal effects). On the other hand, due to its geographical position and especially the tradition in the Czech Republic, other areas of energy research, development and innovation deserve significantly higher attention – nuclear fission, nuclear fusion, the use of biomasses, fossil fuels (with limitations due to greenhouse gas emissions or gradual extraction of coal reserves), the storage and accumulation of energy, co-generation, the storage of heat, energy efficiency improvement and advanced materials.

With its 25% share in electricity generation, nuclear energy is currently a significant component of the so-called low carbon electricity in the EU. Within the energy plan for 2050



▶ Nuclear Research Reactors LVR-15 and LR-0

10.2 | Roadmap of Large Research Infrastructures of the Czech Republic for the years 2016-2022

Energy

– A Clean Planet for All: A European Strategic Long-Term Vision for a Prosperous, Modern, Competitive and Climate Neutral Economy – nuclear energy is expected to remain an important part of EU energy production for the near future. However, further significant investments are necessary to provide for both short and long-term safety and security, a more efficient operation of nuclear plants, the development of innovative nuclear reactor concepts, sustainable solutions for radioactive waste management and the decommissioning of nuclear reactors. Especially since the Fukushima nuclear accident in 2011, nuclear reactor technologies have been placing emphasis on their safety and security. Security studies are, therefore, included not only in nuclear-oriented research, development and innovation programmes, but also in multidisciplinary programmes such as the EURAMET (*European Association of National Metrology Institutes*), which aims to develop advanced detection technologies for the new generation of nuclear power plants.

Nuclear energy has played a key role in the Czech Republic's energy supply for many years. In order to provide the means for the research and development of advanced technologies for nuclear energy, it was necessary to construct appropriate large research infrastructures. The **LVR-15 and LR-0 Experimental Nuclear Reactors** are the basis for neutron physics applications in nuclear research, including the reactors of II, III, and IV generation and nuclear fusion. The international significance and impact of these research infrastructures are continually growing. This trend may be explained, possibly among other things, by the fact that the research infrastructures offer the potential to replace those research reactors that are being shut down across Europe. The significant potential of the LVR-15 and LR-0 Experimental Nuclear Reactors also lies in the future in materials research and, thus, in covering a wide spectrum of research, not only in the energy sector. The **JHR-CZ** (*Jules Horowitz Reactor – participation of the Czech Republic*) large research infrastructure represents the participation of the Czech Republic in the Jules Horowitz Reactor, which is the most advanced European test reactor (currently under construction in Cadarache, France) and which will provide an intense flux of fast neutrons 5x1014 cm2s-1 for conducting materials tests. The **WCZV** (*VR-1 – Training Reactor for Research Activities*) large research infrastructure provides access to a training reactor as an experimental facility for the education of Czech and foreign university students. The VR-1 reactor is also used for research, development and innovation in the areas of nuclear safety, reactor and neutron physics, nuclear fuel cycles and as a source of neutrons for experimental tests. The contribution of the Czech Republic to the development of thermonuclear fusion energy under the auspices of the ITER (*International Thermonuclear Experimental Reactor*) project consists in the **COMPASS** (*Tokamak for Thermonuclear Fusion Research*) large research infrastructure. This large research infrastructure, together with the JET (*Joint European Torus*) tokamak and the ASDEX-Upgrade tokamak, represent the key parts of European thermonuclear fusion efforts. The list of large research infrastructures in the Czech Republic in the energy sector is completed by **CATPRO** (*Efficient Use of Energy Resources Using Catalytic Processes*), focusing on the efficient use of energy resources, particularly on the basis of biomass for the production of liquid fuels and chemicals, and **ENREGAT** (*Energy Waste Recovery and Gas Treatment*), operating large research infrastructure capacities for waste treatment (e.g. the production of energy) and minimizing the emissions of gaseous pollutants, and enabling data transfer from the laboratory scale to the pilot scale.

This overview shows that large research infrastructures in the Czech Republic are focused on nuclear fission and nuclear fusion and the efficient use of energy and biofuels. On the other hand, some other important areas of energy research, development and innovation in the Czech Republic are insufficiently covered, especially in connection with the operation of large research infrastructures, in particular, renewable energy (photovoltaics, concentrated solar energy, wind power, hydropower) and efficient energy conversion and use (smart cities and communities, smart grids, energy storage, hydrogen and fuel cells, carbon capture and storage). Nonetheless, there are research and development centres in the Czech Republic which are focused on some of these areas of energy research, development and innovation. However, due to their present mode of operation, they are not included among the large research infrastructures of the Czech Republic.

One of the possible approaches to filling these "gaps" in the area of energy research, development and innovation in the Czech Republic could be closer cooperation of the Czech Republic with already existing, or newly planned, research infrastructures of European importance, such as ECCSEL (*European Carbon Dioxide Capture and Storage Laboratory Infrastructure*), EU-SOLARIS (*European Solar Thermal Research Infrastructure for Concentrated Solar Power*) and WindScanner, taking into account the key aspects of the state energy concepts of the Czech Republic.

Publicly funded research, development and innovation in the energy sector is characterized by the transfer of innovative technologies to the industrial sector. This gives considerable advantages to the industrial partners. Due to the fact that the construction and operation costs of large research infrastructures are sizeable, the industrial partners should be financially involved in future construction and modernisation.

Another characteristic feature of energy research, development and innovation in the Czech Republic is the fragmentation among research organisations, which are relatively small in comparison with their European counterparts. There is, therefore, the need to encourage closer cooperation among the existing research organisations and to concentrate their capacities and resources into larger units, which could also contribute to higher efficiency. The energy research, development and innovation sector should also attract larger numbers of foreign experts to the Czech Republic, with a deeper integration of the national large energy research infrastructures within the ERA. Positive examples in this context include the Czech participation in the Jules Horowitz Reactor project and the involvement of the Czech Republic in the EUROfusion consortium (*European Consortium for Development of Fusion Energy*).

VR-1 – Training Reactor for Research Activities

Efficient Use of Energy Resources Using Catalytic Processes

Acronym:
CATPRO

Hosting institution:
Unipetrol Centre for Research and Education, a.s.

Phase: operational
Character: single-sited

Responsible person:
Ing. Josef Šimek, Ph.D.
josef.simek@unicre.cz

Website:
www.unicre.cz/vyzkumna-infrastruktura-catpro

Year of inclusion on the Czech Roadmap: 2015

Motto:
Provide and support research, development and education in the field of catalytic processes, increase collaboration between research and industry and provide for young researchers in this field.

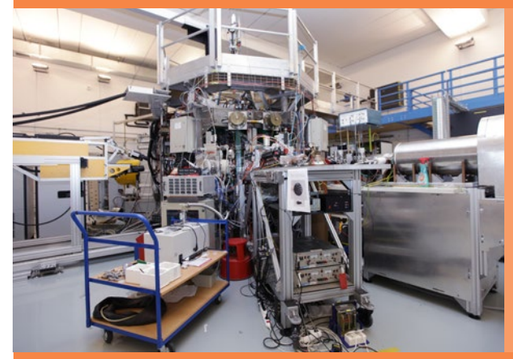
Characteristics

CATPRO focuses on the operation of research and development facilities related to the efficient use of carbonaceous raw materials through catalytic processes. One of the greatest challenges facing research and development in the field of transforming carbonaceous energy resources (including the use of biomass) for the production of advanced liquid fuels is that of transferring results achieved in the laboratory to the industrial sphere. CATPRO is proficient at enabling nearly all research and development activities necessary to overcome this barrier that is necessary for the development of heterogeneous catalysts and catalytic processes. CATPRO provides know-how and services that include catalytic synthesis, intensification of catalyst preparation, catalyst development, testing and development, pilot scale catalytic testing and analysis, and identification of complex mixtures of reaction products. CATPRO is unique in its concentration of research facilities for testing, synthesis and analytical characterization of catalysts, while testing devices are operated under realistic conditions and in continuous operation. CATPRO is also an open platform that enables intensive contact with the research community and industry and provides conditions for Ph.D. and master students to implement their research projects on top-of-the-line research infrastructure. Through its host institution UniCRE, CATPRO is involved in international projects in which it collaborates with European institutions such as VTT (*Technical Research Centre of Finland Ltd*), INERATEC (*Innovative Chemical Reactor Technologies*), GKN (*Sinter Metals Filters GmbH Radevormwald*), DLR (*German Aerospace Centre*), AF (ÅF-CONSULT Ltd), UNOTT (*University of Nottingham*), LNEG (*Laboratório Nacional de Energia* e *Geologia*) and CIEMAT (*Centro de Investigaciones Energéticas, Medioambientales* y *Tecnológicas*). In addition, UniCRE is a member of EUBIA (*European Biomass Industry Association*), RILEM (*Réunion Internationale des Laboratoires et Experts des Matériaux, systèmes de construction et ouvrages*) and DGMK (*Deutsche Wissenschaftliche Gesellschaft für Erdöl, Erdgas und Kohle*).

Socio-economic benefits

CATPRO significantly contributes to increasing the competitiveness of the Czech chemical industry as it strengthens the position of chemical research in the field of sustainable chemical technologies. It helps accelerate the transfer of knowledge into practice and introduce innovations to the chemical industry. CATPRO also cooperates with educational institutions to contribute to improving technical education in the Czech Republic and strengthening the links between academic and industry-oriented research. CATPRO supports the implementation of research projects developed in cooperation with the industrial sphere, in particular by providing its own equipment. The result of CATPRO's collaboration with the private sector is to increase the attractiveness of research for industry and potential investors and to apply research results to the market.

COMPASS – Tokamak for Thermonuclear Fusion Research



Acronym:
COMPASS

Hosting institution:
Institute of Plasma Physics of the Czech Academy of Sciences

Phase: operational
Character: single-sited

Responsible person:
Radomír Pánek, Ph.D.
panek@ipp.cas.cz

Website:
ipp.cas.cz/vedecka_struktura_ufp/tokamak/tokamak_compass

Year of inclusion on the Czech Roadmap: 2010

Motto:
Flexible research infrastructure for finding solutions to key challenges in the development of energy sources based on thermonuclear fusion.

Characteristics

The COMPASS research infrastructure consists of tokamak and its auxiliary systems. It represents one of the key facilities in the joint European effort to master thermonuclear fusion as an energy source within the EUROfusion consortium (*European Consortium for the Development of Fusion Energy*). COMPASS operates in a divertor plasma configuration with a plasma cross-section similar to the ITER tokamak (*International Thermonuclear Experimental Reactor*), which is currently under construction in France. Such a combination of features together with the relevant plasma parameters allows COMPASS to address the key challenges of ITER construction as well as its future exploitation, which are one of the key missions of the main EUROfusion consortium document – European Research Roadmap to the Realisation of Fusion Energy. COMPASS provides open access for a wide user community and enhances education in the field of hightemperature magnetized plasma physics. Furthermore, COMPASS provides expertise in the development of plasma control and data acquisition systems and the development of advanced diagnostics edge plasma physics, as well as in several aspects of tokamak construction. It has established extensive collaboration with Czech and world-leading research organisations and universities. On the European level, COMPASS is being used mainly within the EUROfusion consortium and the ITER Organisation.

Socio-economic benefits

Securing the worldwide increase of energy consumption without any negative effects is a key socio-economic challenge to which COMPASS is significantly contributing. The research being conducted brings about new results and knowledge in the field of magnetized plasma physics, which significantly overlaps into other fields such as nuclear physics, material research, etc. The diagnostic and operating systems of COMPASS represent cutting-edge technologies. The development and production of these systems in collaboration with research infrastructure therefore have a direct impact on new innovations and increased skills, increased technological levels and know-how of the participating companies. COMPASS also represents the ideal tool for training and educating the young generation of scientists, who will now be ready to address both present and future socio-economic challenges. In addition, by intensively participating in the research activities of the EUROfusion consortium as well as of the ITER Organisation, COMPASS contributes to the integration of Czech science in both the European and worldwide contexts.

Energy Waste Recovery and Gas Treatment

Acronym:
ENREGAT

Hosting institution:
VŠB – Technical University of Ostrava

Phase: operational

Character: single-sited

Responsible person:
Prof Lucie Obalová, Ph.D.
lucie.obalova@vsb.cz

Website:
iet.vsb.cz/en

Year of inclusion on the Czech Roadmap: 2019

Motto:
Research infrastructure for the material and energy recovery of waste and the minimization of emissions of gaseous pollutants, enabling data transfer from the laboratory to the pilot scale.

INSTITUTE OF ENVIRONMENTAL TECHNOLOGY

Characteristics

ENREGAT represents a unique base for the implementation of comprehensive research in the area of the material and energy recovery of waste by means of combustion, pyrolysis and anaerobic processes, as well as in the field of catalytic, sorption and photocatalytic cleaning of the resulting gases. In addition, ENREGAT also allows for research in related areas, for example the resistance of refractory materials used in waste incineration, material utilization of slag and fly ash, the possibilities of using pyrolysis products and analytical services. The large research infrastructure includes 3 pilot scale facilities with technologies for the energy recovery of waste and several specialized laboratories equipped with catalytic and photocatalytic units and modern analytical techniques. The uniqueness of ENREGAT lies in the ability to perform basic and applied research focused on several waste-to-energy technologies from the laboratory up to the pilot plant scale for a wide range of waste, and thus to assess the suitability of the technology for the selected type of waste. Additionally, it allows for research on a number of technologies for the abatement of different gaseous pollutants (e.g. nitrogen oxides, carbon dioxide, organic substances) through laboratory tests up to pilot scale verification for waste incineration, which is available here. The aim of ENREGAT is to provide services to the research community that in the open access mode supports the development of innovation through cooperation with industry. ENREGAT is already involved in a large number of national research projects and is collaborating with a number of foreign partners as well as with the private sector. On the national level, there is cooperation e.g. with suppliers and operators of biogas plants, as well as companies dealing with the development of mobile units for the thermal degradation of waste by incineration and torefaction, with research to increase the efficiency of catalytic technologies for NOx reduction and the degradation of organic matter, or the elimination of emissions from exhaust air resulting from photochemical oxidation. Jagiellonian University of Krakow (Poland), University of Oulu (Finland), National Taiwan University (Taiwan) and University of Crete (Crete) can be mentioned as foreign partners.

Socio-economic benefits:

ENREGAT allows for interdisciplinary research and the acquisition of new knowledge in the field of energy recovery of waste (mixed municipal and hazardous waste, biowaste, TAP) and helps to achieve the goals of the Czech Republic to significantly reduce the landfilling of mixed municipal and biodegradable waste. ENREGAT also allows for research to improve air quality by reducing emissions from energy sources in line with stricter emission limits under new EU legislation. Examples of the collaboration among ENREGAT users with the application sphere in collaborative and contract research include pilot incineration tests of solid alternative fuels and an evaluation of the resulting pollutant emissions, development of more efficient catalysts for the reduction of nitrogen oxides and pilot testing of new types of bioreactors. The use of ENREGAT by students increases the level of education in technical disciplines, where there is a constant shortage of highly qualified and trained professionals.

Jules Horowitz Reactor – participation of the Czech Republic

Acronym:
JHR-CZ

Hosting institution:
Research Centre Řež s.r.o.

Phase: construction
Character: single-sited

Responsible person:
Petr Březina
petr.brezina@cvrez.cz

Website:
jhr.cvrez.cz/en

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2018: landmark

Motto:
JHR is a material testing reactor for the R&D and qualification of materials and nuclear fuel. The related studies contribute to improving the safety of both existing and future nuclear reactors.

Centrum výzkumu Řež s.r.o.
Research Centre Řež

Characteristics

JHR-CZ is a research infrastructure that will allow for the participation of the Czech Republic in JHR (*Jules Horowitz Reactor*). JHR is a material testing reactor for the research and development and qualification of materials and nuclear fuel. The related studies contribute to improving the safety of both existing and future nuclear reactors. JHR will allow researchers to test materials under the conditions of power reactors, to speed up the modelling of the degradation of materials and to evaluate the end of life properties of components. Research results will be useful in both medicine and the energy industry. JHR will support a broad range of irradiation tests, such as fuel studies covering selection and characterisation, testing the behaviour of fuel subjected to power transients, the evaluation of fuel in normal and beyond-design and accidental conditions, materials studies consisting of, e.g., clad corrosion, high dose rate on cladding and structural materials. The portfolio of provided expertise and services also includes nuclear waste management and medical applications. JHR is provided by an international consortium of research and industrial organisations from Belgium, Czech Republic, Finland, France, India, Israel, Japan, Spain, Sweden and the United Kingdom. The European Commission is also a partner of the JHR project. JHR-CZ ensures the Czech Republic's involvement in JHR's construction and participates in its construction via the delivery of so-called hot cells. Thanks to the delivery of this component, the Czech Republic will have access to JHR's measuring capacity up to 3% after the start of the JHR operational phase. On the basis of an open access policy, JHR-CZ will subsequently provide the Czech Republic's research community with access to JHR's capabilities. At the same time, the research infrastructure will train a new generation of scientists and engineers who will also have access to JHR through the Czech Republic. As part of the preparatory experimental work of JHR, JHR-CZ is involved in, among other things, the FIJHOP (*Foundation for Future International Jules Horowitz Experimental Programs*).

Socio-economic benefits

Based on open access, JHR will link research results through knowledge transfer and technology transfer to industrial enterprises. The participation of the Czech Republic in the project will allow for the participation of Czech research organisations and industry in JHR experiments that will be conducted here, not only to strengthen the nuclear energy sector, but also to develop materials research, radiopharmaceuticals and nuclear waste processing. Industrial companies will also be able to include their demands if the full capacity of JHR is not being used by research organisations, under market conditions, to prevent unauthorized public support. Research Centre Řež has developed extensive cooperation with a large number of Czech research and development organisations in the field of nuclear technologies. The JHR project thus uses a number of industrial companies as technology suppliers.

Nuclear Research Reactors LVR-15 and LR-0

Acronym:
Reactors LVR-15 and LR-0

Hosting institution:
Research Center Řež s.r.o.

Phase: operational
Character: single-sited

Responsible person:
Vlastimil Juříček
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Website:
reaktory.cvrez.cz/en

Year of inclusion on the Czech Roadmap: 2010

Motto:
Research reactors are a basic tool for the development of ionizing radiation applications, conducting research on materials for nuclear technology, educating nuclear experts and the production of radionuclides.

Centrum výzkumu Řež s.r.o.
Research Centre Řež

Characteristics

The main purpose of the LVR-15 and LR-0 experimental nuclear reactors is to provide technological and experimental background for users in the field of research and development of nuclear technology of II, III/III+, IV generations and fusion, or in specific cases of conventional energy as well. The LVR-15 reactor is a multi-purpose research reactor producing 10MW of thermal power. The LVR-15 reactor provides a high-density neutron field comparable to energy reactors, suitable for example for researching neutron properties (on so-called horizontal neutron beams), for the production of radionuclides for medical purposes, and for the research of radiation resistance of construction materials in related experimental devices (so-called experimental loops and irradiation rigs) that simulate the operational conditions of different types of energy reactors. At the European level, with its parameters and experimental equipment, the LVR-15 research reactor is comparable to 5 other research reactors. Most of them, however, are approaching the end of their service life and the significance of LVR-15 continues to increase as it gradually takes over the research and irradiation activities of the other decommissioned research reactors. LR-0 is an experimental zero-power nuclear reactor that allows researchers to take very accurate measurements in the field of reactor physics to verify computational tools and nuclear data for their further use in research, development and safety assessments of nuclear technology. The high accuracy of LR-0's measurements is achieved by using unique measurement methods, which are often developed in collaboration with leading nuclear instrumentation suppliers directly inside the reactor. The construction of the LR-0 reactor was designed for the performance of full-scale experiments in the field of VVER energy reactor physics, however it also allows is users to simulate other reactor technologies, especially selected types of Gen IV reactors over the course of the last 10 years. The combination of experimental flexibility, as well as large field versatility, makes the LR-0 reactor unique in the world. The LVR-15 and LR-0 reactors are part of the regional network and global association of research reactor operators dealing with the operation, usage and safety of reactors, for example, EERRI (*Eastern European Research Reactor Initiative*), TWGRR (*Technical Working Group on Research Reactors*), RROG (*Research Reactor Operators Group*) and AIPES (*Association of Imaging Producers and Equipment Suppliers*). Cooperation with research reactors and institutions from around the world is developed within such international network.

Socio-economic benefits

The LVR-15 and LR-0 reactors play an irreplaceable role in enhancing the nuclear safety of energy reactors through their research in radiation resistance, the development of advanced computational methods, and the validation of nuclear data. Equally important is the research and development of new technologies, namely Gen IV reactors and nuclear fusion. Research reactors also produce radionuclides, which have an invaluable role in medicine and many industrial applications. It also performs non-economic tasks by educating university students and popularizing the nuclear field through Technical Tours and Open Door Days. Cutting-edge devices for conducting experiments are developed in cooperation with external partners. The knowledge acquired in this way is also used in nuclear power plants even outside the Czech Republic, e.g. highly reliable neutron detectors and radiation-resistant sensors. Industrial partners are working together on the development of new neutron devices, which can then be delivered abroad and the LVR-15 and LR-0 reactors serve as a reference.

CTU CZECH TECHNICAL UNIVERSITY IN PRAGUE

VR-1 – Training Reactor for Research Activities

Acronym:
WCZV

Hosting institution:
Czech Technical University in Prague

Phase: operational
Character: single-sited

Responsible person:
Assoc. Prof Ľubomír Sklenka, Ph.D.
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Website:
reaktor-vr1.cz/en

Year of inclusion on the Czech Roadmap: 2011

Motto:
Experimental instrumentation for providing education in nuclear engineering and neutron applications in bachelor, master and Ph.D. study programmes and for new technologies in respect of research and development applicable in nuclear technologies.

Characteristics

Training Reactor VR-1 is a state-of-the-art experimental instrument used for the education of bachelor, master and Ph.D. students in the field of nuclear engineering from both the Czech Republic and abroad. Research and development activities are mainly focused on current challenges in nuclear energy development; particularly, on the safe operation of nuclear installations, theoretical and experimental reactor physics, nuclear safety and nuclear fuel cycles. Research and development works at the reactor are focused on the development of new technologies which can be applied in various nuclear applications, such as research on pyroelectric neutron generators and the development of diamond detectors for monitoring the safe operation of nuclear reactors. The experimental instrumentation of the VR-1 reactor and its laboratories allows for industrial partners to develop of new instrumentation and devices or to innovate industrial processes. Studying the influence that radiation has on various materials or testing a new generation of neutron detectors can be mentioned as examples. Apart from traditional nuclear research, the VR-1 reactor also enables users to conduct various multidisciplinary research that combines nuclear technology and natural sciences, social sciences or humanities, such as the study of mammoth bone composition, the study of traditional Tibetan medicines or technology-policy research in nuclear safeguards and security. The reactor provides state-of-the-art experimental education in nuclear engineering and neutron applications, thus significantly increasing the quality of education at the bachelor, master and Ph.D. levels in the Czech Republic and abroad. Students often use the reactor within individual student research projects and bachelor, master, and Ph.D. theses in experimental research in the safe operation of nuclear reactors, reactor physics and neutron applications. The Faculty of Nuclear Sciences and Physical Engineering of Czech Technical University in Prague as the operational organisation of the VR-1 reactor is a member of various educational and research networks, e.g. EERRI (*Eastern European Research Reactors Initiative*), RROG (*Research Reactors Operators Group*) and ENEN (*European Nuclear Education Network*). The reactor's staff closely collaborates with IAEA (*International Atomic Energy Agency*) and through its several regional projects focused on Europe, Asia and Latin America, the reactor's staff collaborate with researchers at research reactors worldwide.

Socio-economic benefits

Research and development activities performed at the reactor allow for users to develop new technologies which can then be applied in various nuclear applications. In collaboration with industrial partners, the development of new instrumentation and devices, as well as the innovation of industrial processes which increase the competitiveness of the industrial partners is taking place. Apart from research and development, the reactor provides state-of-the-art experimental education in nuclear engineering and neutron applications. Thus, the reactor provides a unique chance for education for bachelor, master, and Ph.D. students from the Czech Republic and from abroad. The multidisciplinary research and development which is being carried out at the reactor brings about unique collaboration between nuclear technology and natural sciences, social sciences, and humanities.

Environmental sciences

10.3

page

The environmental sciences cover not only ecology, which assesses the relationships between the environment and living organisms, but also geosciences, which strive to understand the complex functions of energetic metabolism and the biogeochemical cycles on planet Earth. Environmental research is also focused on interactions between the environment, individual humans and society as a whole, including assessment of the regulation pathways. These aspects are crucially important since according to the "one-health" concept, the Earth's living environment determines the existence of life and the survival of humankind as such, its nutrition, health, and wellbeing. The environment provides the natural and ecosystem services that are necessary to support the existence of life and even though we tend to take these services for granted, human activities can seriously threaten their future availability.

10.3 | Roadmap of Large Research Infrastructures of the Czech Republic for the years 2016-2022
Environmental sciences

The fact that environmental processes take place at various temporal and spatial levels further complicates the already complex problems related to the individual environmental compartments described above. Many key environmental processes occur at the microscale, but their cumulative effects can be observed at the global level and the timescale of their impact can exceed one human lifetime. Global changes in climate and environment, e.g., the eutrophication of waters, are examples of such complex problems requiring complex solutions at various levels. Current sciences are pressing for a better understanding of such complex problems through the development of new methods for assessing the environmental processes at various temporal and spatial levels, including the large-scale approaches, long-term monitoring efforts, and new data mining methods. This introduces the urgent need for the development of systematic and harmonised approaches to data collection, development of standardised databases, and their horizontal alignment through the shared protocols and data management methods. Such an approach will allow for future complex data management, cumulative analyses of data, their assessment at various levels, and the testing of new hypotheses.

A number of research institutions are participating in environmental research in the Czech Republic. The structure of the large research infrastructures they are hosting adequately reflects the importance of the environmental challenges as well as current trends in each given research field. As to the geographic distribution, the majority of the large research infrastructures operated in the Czech Republic in the environmental context is focused on the European region and linked to the European networks reflecting the geopolitical position of the Czech Republic. The large research infrastructures listed below support a wide range of research, development and innovation activities of their users, provide them with a technology, expertise, and data that are hard to get elsewhere as well as with the opportunity to collaborate in data analysis and interpretation.

One of the major environmental challenges is global climate change, as can be seen in the increasing volume of research efforts in this field. The **ACTRIS-CZ** (*ACTRIS – participation of the Czech Republic*) large research infrastructure participating in the European ACTRIS (Aerosol, Clouds and Trace Gases Research Infrastructure) research infrastructure is focused on the long-term monitoring of air quality and research addressing interactions between aerosols, clouds and trace gases, and their impacts on biological processes, human activities and the population's health. ACTRIS-CZ contributes to improving the global and macro-regional atmospheric models needed for predicting and mitigating climate change and other environmental, societal, and health impact challenges related to air quality.

Global climate change is closely connected to biogeochemical cycles, especially the carbon cycle. A detailed assessment of the links

▼ ACTRIS-CZ (*ACTRIS – participation of the Czech Republic*)

between the climate and terrestrial ecosystems is necessary to improve our understanding of the mechanisms of climate change and at the same time to allow us to plan adaptations and mitigation activities. The **CzeCOS** large research infrastructure offers a unique platform supporting complex research of the global impacts of climate change on terrestrial ecosystems. CzeCOS also represents a Czech national hub of the AnaEE (*Analysis and Experimentations on Ecosystems*), DANUBIUS-RI (*International Centre for Advanced Studies on River-Sea Systems*), EUFAR (*European Facility for Airborne Research in Environmental and Geo-Sciences*) and ICOS ERIC (*Integrated Carbon Observation System*) research infrastructures. It provides its users with a unique set of equipment for long-term manipulated experiments addressing the impacts of environmental factors on ecosystems and plants, tools for making physiological field observations, technologies for the observation and quantification of greenhouse gases fluctuations in various ecosystems and the atmosphere, laboratories for metabolomics, stabile isotope analysis as well as Earth observation and remote sensing.

Toxic compounds in the environment and related environmental and human health risks are the areas of interest of the **RECETOX RI** (*RECETOX Research Infrastructure*) large research infrastructure. The existing and newly built core facilities of this large research infrastructure offer their users a range of expertise needed for making an assessment of the impacts of environmental exposures on humans and populations as well as open access to environmental monitoring networks, population studies, capacities of the chemical, toxicological and microbiological laboratories, and extensive databases. RECETOX RI closely collaborates with the European research infrastructures monitoring degradation of the natural environment and its impact on society (ACTRIS), as well as on those active in various fields of biology and health sciences, such as BBMRI-ERIC (*Biobanks and Biomolecular Resources Research Infrastructure Consortium*) and ELIXIR (*European Life-Science Infrastructure for Biological Information*). It builds interdisciplinary links between environmental monitoring and health research, existing population cohorts and cross-cutting studies supporting the development of new approaches of personalised medicine and prevention.

The development of new nanotechnologies has to be accompanied by an informed assessment of their advantages as well as their potential risks. The **NanoEnviCz** (*Nanomaterials and Nanotechnologies for Environment Protection and Sustainable Future*) large research infrastructure provides a platform for conducting research on nanomaterials and nanocomposites applicable in environmental protection and related fields such as chemical synthesis, chemical, structural and morphological characterisation, optimisation of nanomaterial functional properties, and the development of tools for assessing their application potential and potential harmful effects.

The research objective of the **CENAKVA** (*South Bohemian Research Centre of Aquaculture and Biodiversity of Hydrocenoses*) large research infrastructure is gaining a better understanding of the ongoing processes in freshwater ecosystems and their societal importance with respect to the conservation of biodiversity and the protection of water environments and water resources necessary for the sustainability of human life and activities. The unique aquaculture, experimental and research infrastructure of the centre allows for the planning and testing of future changes in the management of those freshwater ecosystems related to climate changes. Having more available information and improved data management allows for better strategic planning in the areas related to landscaping for water conservation, drinking water and waste water treatment, as well as aquaculture.

The large research infrastructures in the Czech Republic operating in the field of environmental sciences cover an extensive portfolio of current trends in the environmental sciences. They are primarily focused on global change with respect to the general meaning of the phrase (ACTRIS-CZ and CzeCOS), the challenges related to chemical pollution and degradation of the natural environment, and consecutive environmental and human health risks (CENAKVA, NanoEnviCz, and RECETOX RI). These large research infrastructures not only strive to explain the mechanisms driving the key environmental processes, but also develop new applications and technologies for mitigating the adverse impacts of human activities, such as decontamination technologies, tools for the adaptation and mitigation of climate changes, biodiversity conservation, and ecosystem restoration (CENAKVA, CzeCOS, NanoEnviCz and RECETOX RI). Future challenges include further integration of the large research infrastructures to support the development of the "one-health" concept, which embraces interactions between the individual environmental compartments and biological systems, including the human population, and the social aspects of such interactions.

Bridging the environmental large research infrastructures with those operating in the biological, health and social sciences, and humanities will be even more important in the future. It will allow for the characterization of human exposome, and for exploring new approaches to changing the behaviour of human society, the long-term sustainable exploitation of natural resources and preservation of the Earth's natural environment, health and wellbeing of the human population.

▶ CzeCOS

ACTRIS – participation of the Czech Republic

Acronym:
ACTRIS-CZ

Hosting institution:
Czech Hydrometeorological Institute

Partner institutions:
Masaryk University / Institute of Chemical Process Fundamentals of the Czech Academy of Sciences / Global Change Research Centre of the Czech Academy of Sciences

Phase: operational
Character: distributed

Responsible person:
Milan Váňa, Ph.D.
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Website:
actris-ri.cz/en/

Year of inclusion on the Czech Roadmap: 2015
Status on the ESFRI Roadmap 2018: project

Motto:
A unique platform focused on long-term background air quality monitoring and research closely connected to health, climatic and environmental impacts of changes in atmospheric composition.

Characteristics

ACTRIS-CZ provides expertise in the field of atmospheric sciences, especially the research of atmospheric aerosols and trace gases. The capacity of ACTRIS-CZ is provided by NAOK (*National Atmospheric Observatory Košetice*) and by research and operating support from partner institutions. Some measurements being taken at ACTRIS-CZ are unique in the Czech Republic, especially the on-line measurements of aerosol physical and chemical properties, volatile organic compounds, base cations in the air and meteorological parameters measured in a vertical gradient up to 250 m above ground. ACTRIS-CZ is also unique (not only nationally, but globally) by the scope of measurements focused on airborne persistent pollutants. The uniqueness of ACTRIS-CZ is exemplified by the close work of 4 strong research partners with complementary expertise collaborating in the development of a multidisciplinary research field, the interconnection of atmospheric research to other compartments of the environment within the framework of integrated monitoring, the availability of a 30-year-long homogeneous air quality data series, a newly built 250 m tall atmospheric tower serving primarily for scientific purposes and close links between the field measurements and the available capacities of accredited laboratories. ACTRIS-CZ provides access to the equipment employed at NAOK and upon request, access to data sets and other products (standard operational procedures, calibration results). Moreover, technicians specialized in the field of air quality monitoring and scientific staff experienced in the validation, evaluation and multidisciplinary interpretation of measured data is at the users' disposal. ACTRIS-CZ represents the Czech national node of the ACTRIS (*Aerosol, Clouds and Trace Gases Research Infrastructure*) European research infrastructure. The capacity of ACTRIS-CZ is also integrated into the ICOS ERIC (*Integrated Carbon Observation System*) European research infrastructure.

Socio-economic benefits

ACTRIS-CZ offers a unique combination of advanced equipment, services, workshops and education for students and scientists from the Czech Republic and abroad. The results of research obtained within ACTRIS-CZ are used in practical applications such as improving weather forecast models, especially in extreme events (floods, storms, etc.). ACTRIS-CZ outcomes are also contributing to preventing emergency situations. The data has been repeatedly used for the development of utility models for new sampling devices. The tall atmospheric tower is also suitable for the steel construction sector, especially in the area of dynamics and statics of tall slender constructions. The Aero-club of the Czech Republic installed equipment to register the movement of aircraft. The data are available on-line for small airplanes. New lidar acquisition will serve as the basis of a warning system for air traffic.

South Bohemian Research Centre of Aquaculture and Biodiversity of Hydrocenoses

Acronym:
CENAKVA

Hosting institution:
University of South Bohemia in České Budějovice

Phase: operational
Character: single-sited

Responsible person:
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Website:
www.frov.jcu.cz/en/cenakva

Year of inclusion on the Czech Roadmap: 2019

Motto:
Understanding changes in freshwater ecosystems and their societal importance in terms of preserving biodiversity, protecting the aquatic environment and water resources important to human life and activity.

Characteristics

CENAKVA serves a wide range of users in the Czech Republic and abroad, offering a flexible experimental background which is focused on biology and the quality production of freshwater fishes, including sturgeon aquaculture and conservation, long-term sustainable pond culture and intensive aquaculture, biology and the protection of crayfish and other invertebrates, and the management of water quality and aquatic environments; all of these are responsive to global environmental changes, and we are finally equipped to efficiently collect, analyse and manage experimental data. CENAKVA has unique European pond facilities located in Vodňany, which encompasses an area of 40 hectares. Furthermore, CENAKVA has a large number of closed recirculation and aquaponic systems with biological and hydroponic water purification systems which can be used for production, as well as for artificial propagation and breeding. CENAKVA has expertise in the managed reproduction and breeding of nearly 30 species of freshwater fish and crustaceans; the artificial propagation of carp, tench, and catfish is world renowned and CENAKVA manages the largest sturgeon gene bank in the world. The biological, chemical and toxicological laboratories have state-of-the-art equipment. CENAKVA is a unique large research infrastructure in the Czech Republic, dealing with global processes in freshwater ecosystems and the cycling of substances in water, including the monitoring of new environmental pollutants. The unique ponds, experimental facilities and scientific background of the scientists at CENAKVA maintain close ties with the aquaculture community in the Czech Republic, Europe and the world; these connections allow to plan and verify modifications to pond management within the context of climate change. CENAKVA also organizes professional conferences for scientists and lectures for the public. Within the framework of the open sharing of research in the European community, it is a member of the AQUAEXCEL2020 (*Aquaculture Infrastructures for Excellence in European Fish Research*) European research infrastructure. CENAKVA is participating in a consortium of 22 partners from 12 European countries involved in AQUEXCEL 2020, as well as in the management and classification of scientific data, and for data sharing within projects of the ELIXIR (*European Life-Science Infrastructure for Biological Information*) and EMBRC-ERIC (*European Marine Biological Resource Centre*) European research infrastructures. CENAKVA is also participating in the research of aquatic ecosystems which are connected to the basin of important European streams through close cooperation with the Academy of Sciences of the Czech Republic and the DANUBIUS-RI (*International Center for Advanced Studies on River-Sea Systems*) European research infrastructure.

Socio-economic benefits

CENAKVA allows for research of the impacts of global changes on aquatic ecosystems which has a strong application for the practical life of humans. CENAKVA is prepared to lead the expansion of sustainable aquaculture for environmentally friendly fish production in the Czech Republic and Europe so as to maintain good water quality. CENAKVA aquaculture practices minimal water and energy consumption, minimal negative environmental impacts and minimal waste production. It collects information on the effect of foreign compounds in Central European waters, under conditions of real ecosystems. This information is used in strategic planning in the areas of water conservation, wastewater management and drinking water treatment. The outputs of CENAKVA are also used by foreign institutions, such as World Aquaculture Society, European Aquaculture Society and World Sturgeon Conservation Society. At the national level, CENAKVA cooperates with the Ministry of Agriculture, the Ministry of the Environment and the Czech Fishing Association.

CzeCOS

Acronym:
CzeCOS

Hosting institution:
Global Change Research Institute of the Czech Academy of Sciences

Phase: operational
Character: distributed

Responsible person:
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marek.mv@czechglobe.cz

Website:
czecos.cz/en.html

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2018: landmark

Motto:
The CzeCOS research infrastructure is a unique platform for undertaking comprehensive international interdisciplinary research on global changes and their impacts on ecosystems.

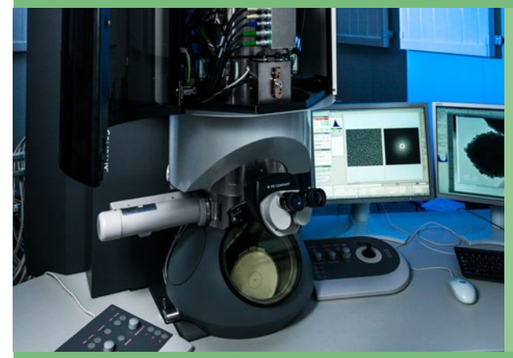
Characteristics

CzeCOS is a distributed environmental research infrastructure focused on global change research in the atmosphere and the most important ecosystems in the Central Europe such as forests, agroecosystems, meadows and pastures, wetlands, etc. CzeCOS provides to a wide range of users unique research infrastructure such as growth chambers, open-top chambers, experimental stations and bioreactors for conducting impact studies of the effects of global changes on terrestrial and aquatic ecosystems. CzeCOS ecosystems research sites are used to measure greenhouse gas emissions and to research greenhouse gas and energy flows in terrestrial ecosystems, including assessing the effects of changing environmental conditions. The atmospheric station allows for research of atmospheric matter fluxes and long-range transport gases and air pollutants. An indispensable part of CzeCOS is also its metabolomics and isotopic laboratory, which analyses the metabolic responses and metabolic processes of acclimation or adaptation of different parts of ecosystems to the effects of global change. For Earth Remote Sensing, a flying laboratory using laser scanning (Lidar) and hyperspectral and thermal sensors can be used to assess the spatial variability of the effects of global change on terrestrial and aquatic ecosystems, and to investigate the carbon cycle and other biogeochemical cycles on the higher spatial scale. Linking these elements of the research infrastructure together with the high potential for interpreting research outputs from different spatial and time series is attractive to research partners and is vitally important for decision-makers at both the national and regional levels, as well as for companies whose business is affected by climate change (e.g. energy, forestry, agriculture, etc.). CzeCOS also assists in fulfilling the international commitments of the Czech Republic in the areas of research, adaptation and mitigation of the impacts of global change. CzeCOS is an integral part of the ICOS ERIC (*Integrated Carbon Observation System*), AnaEE (*Analysis and Experimentation on Ecosystems*), DANUBIUS-RI (*International Centre for Advanced Studies on River-Sea Systems*), and EUFAR (*European Facility for Airborne Research*) European research infrastructures.

Socio-economic benefits

CzeCOS tackles the impacts of global change, especially drought, for example, within the Intersucho long-term program. This strengthens the Czech Republic's competitiveness in agriculture, forestry, water management and energy. CzeCOS is also involved in addressing challenges in the areas of energy and food security, the development of environmental protection and pest management, the enhancement of ecosystem services, land use and technological development, for example in the monitoring of climate change and the development of measuring techniques. The benefits of CzeCOS include, in particular, adaptation and mitigation measures and the development of strategies in the fields of agriculture, forestry and the environment. CzeCOS is also involved in the development of cultivation practices and GIS applications, and is involved in the field of operational forecasting in energy, the calibration of satellite imaging and biowaste processing. The complex of interconnection of individual elements of CzeCOS allows to create and improve models of future long-term impacts of global changes on ecosystems.

Nanomaterials and Nanotechnologies for Environment Protection and Sustainable Future



Acronym:
NanoEnviCz

Hosting institution:
J. Heyrovsky Institute of Physical Chemistry of the Czech Academy of Sciences

Partner institutions:
Technical University of Liberec / University of J. E. Purkyně in Ústí nad Labem / Palacký University Olomouc / Institute of Inorganic Chemistry of the Czech Academy of Sciences / Institute of Experimental Medicine of the Czech Academy of Sciences

Phase: operational
Character: distributed

Responsible person:
Ing. Martin Kalbáč, Ph.D.
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Website:
nanoenvicz.cz/en

Year of inclusion on the Czech Roadmap: 2015

Motto:
Nanomaterials and the environment: from synthesis and characterization to the testing of functional properties and applications.

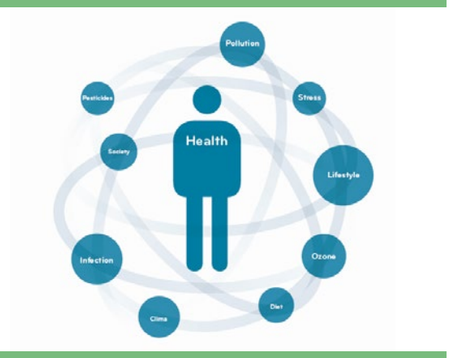
Characteristics

NanoEnviCz integrates the capacities of several research organisations in the Czech Republic in the field of multi-disciplinary research in a wide range of nanomaterials and nanotechnologies. The portfolio of NanoEnviCz equipment and expertise provided by NanoEnviCz covers various research areas of nanomaterials and nanocomposites such as materials for environmental protection and related applications. NanoEnviCz services include the controlled synthesis of nanostructured materials, their complex chemical, structural, morphological and surface characterization, optimization of their functional properties, monitoring of their potential toxicity and environmental hazards and development of their applications for advanced technologies. NanoEnviCz creates an effective multipurpose platform for partner research organisations involved in the structure as well as for external users from the academic community and from the industrial sphere, as well as the state administrative bodies of the Czech Republic. NanoEnviCz provides open, centralized access to all capacities of this distributed research infrastructure for both domestic and international users.

Socio-economic benefits

NanoEnviCz provides comprehensive research infrastructure services and expertise to conduct research and development of nanomaterials and nanocomposites for environmental and related applications. The research infrastructure thus serves as an example of progressive trends in multidisciplinary development combining knowledge from various scientific fields. NanoEnviCz also offers regular training of employers for advanced nanomaterial and nanotechnology research and development and their safety. NanoEnviCz collaborates with industrial partners to develop nanofibrous membranes for wound dressings, nanomaterials for air antimicrobial filtration and photocatalytic nano-composites with increased pollutant degradation efficiency. Another example of collaboration is the development of perovskite structure catalysts for highly effective degradation of nitrogen oxides originating from industrial waste gases. NanoEnviCz works closely with military institutions in the development of reactive sorbents for the disposal of chemicals, including chemical warfare agents.

RECETOX Research Infrastructure



Acronym:
RECETOX RI

Hosting institution:
Masaryk University

Phase: construction
Character: single-sited

Responsible person:
Prof Jana Klánová, Ph.D.
klanova@recetox.muni.cz

Website:
old.recetox.muni.cz/index-en.php

Year of inclusion on the Czech Roadmap: 2010

Motto:
Science for a healthy future.

MUNI | RECETOX
Research infrastructure

Characteristics

RECETOX RI enables research on both environmental and human health risks related to environmental contamination, and supports the safe management of chemicals. The existing and newly built capacities of the RECETOX RI core facilities offer a wide range of expertise needed for making environmental impact assessments for a variety of users. They provide access to analytical, chemical, biological, and toxicological laboratories, the environmental monitoring networks MONET (*Monitoring NETworks*), population studies CELSPAC (*Central European Longitudinal Study of Parents and Children*), and related data sources. They allow for the presentation of external data through the GENASIS (*Global ENvironmental ASsessment and Information System*) information platforms. The capacities for data analysis, interpretation and modelling are also available together with advanced biostatics and bioinformatics offering a portfolio of services to users from both the academic and private sectors in the Czech Republic and abroad. The comprehensive interdisciplinary approach taken by RECETOX RI is unique in the European context. RECETOX RI offers capacities for the assessment of environmental impacts on human health, a platform for the development of innovative methods, know-how and technology transfer, teaching and consulting. The education and training activities of RECETOX RI at all levels of higher education improve the quality and professional readiness of its graduates. The training courses, workshops, and the international summer schools are also organized for attendees from universities, research institutes, health facilities, industrial enterprises, regional and state authorities, ministries, governments and international organisations. RECETOX RI is associated with the Czech nodes of the ACTRIS (*Aerosol, Clouds and Trace Gases Research Infrastructure*), ELIXIR (*European Life-Science Infrastructure for Biological Information*), and BBMRI-ERIC (*Biobanks and Biomolecular Resources Infrastructure*) European research infrastructures. It coordinates the EIRENE (*European Environmental Exposure Assessment Network*) project for the updated ESFRI Roadmap, and the GEO (*Global Earth Observation*) initiative GOS-4POPs (*Global Observation System for Persistent Organic Pollutants*). It also contributes to the implementation and management of joint European programmes such as HBM4EU (*Human Biomonitoing for Europe*) and ERA PLANET (*European Network for Observing our Changing Planet*).

Socio-economic benefits

RECETOX RI develops new approaches to assess the causal links between human exposure to toxic substances and the development of chronic diseases, and improves our understanding of the mechanisms of such interactions. It identifies toxic mixtures in the environmental samples, consumer products and human tissues, as well as sources of such chemical mixtures, their health effects and most vulnerable populations. It explores the links between these environmental exposures and social and economic factors that affect the human health, and allows for the prioritization and better targeting of the relevant legislation. It contributes to the better management of toxic chemicals, the safe production of food and consumer products, and safe waste processing. It enhances the protection of human health, the development of preventive measures, and sustainability of healthcare. It collaborates with UNEP (*United Nations Environment Programme*) and WHO (*World Health Organisation*), and supports the implementation of the concepts of a circular economy and healthy smart cities. It also provides university education and builds international capacities for assessing environmental exposures.

Health and food

10.4

page

The biological and medical sciences part of the 2019 update to the Roadmap of Large Research Infrastructures of the Czech Republic describes the area of biomedicine, food, and nourishment, which is equivalent to the "Health and Food" area within the ESFRI Roadmap. The large research infrastructures mentioned below thus cover a wide spectrum of scientific disciplines from basic research with systematic biological approaches to translational and clinical research that accelerates and supports the creation of new biotechnological specializations. The area of food and nourishment then covers a vast array of agro-food sector challenges ranging from the agricultural production of raw materials over technological manufacturing to analysing food safety and authenticity, as well as nutritional value, hygienic, technological and sensory quality. Here, the food area is also connected to the large research infrastructures focused on environmental and social sciences and humanities to address the health impacts of other factors, such as the environment and its degradation or changes in the socioeconomic environment.

10.4 | Roadmap of Large Research Infrastructures of the Czech Republic for the years 2016-2022
Health and food

The recent dynamic development of the Czech biomedical large research infrastructure landscape has followed the traditional course of Czech research, development, and innovation. Establishing or modernizing existing biomedical large research infrastructures in the Czech Republic required the use of ESIF resources from 2007 to 2015. The availability and use of such resources successfully aided in the establishment and modernization of the biomedical large research infrastructures in the Czech Republic. These investments into technological development have continued in the current period of EU Cohesion Policy.

The Roadmap of Large Research Infrastructures of the Czech Republic is a network of complementary biomedical facilities that equally contributes resources and expertise to achieve service integration and facility unification, which allows for excellent research, development, and innovation. The large research infrastructures listed below demonstrate synergistic efforts and biomedical expertise that is unprecedented in the Czech Republic. The integration of the Czech Republic's biomedical large research infrastructures into European research infrastructures further enhances their level of expertise and efficiency, while also indicating their relevance and importance within the ERA.

The **CCP** (*Czech Centre for Phenogenomics*), representing the Czech node of the European INFRAFRONTIER (*European Research Infrastructure for the Generation, Phenotyping, Archiving and Distribution of Model Mammalian Genomes*) research infrastructure, aims to identify the functions of new genes and to provide the animal models necessary to test hypotheses before entering the human testing phase. Two large research infrastructures operate at the level of early stage drug discovery. The first one is **CZ-OPENSCREEN** (*National Infrastructure for Chemical Biology*), the Czech constituent of the European EU-OPENSCREEN ERIC (*European Infrastructure of Open Screening Platforms for Chemical Biology*), and the second one is **CIISB** (*Czech Infrastructure for Integrative Structural Biology*), the Czech constituent of the European Instruct-ERIC (*Integrated Structural Biology European Research Infrastructure Consortium*). Both of these large research infrastructures provide the research community with platforms for identifying substances and determining their structure to find and comprehensively describe therapeutic targets. **EATRIS-CZ** (*Czech National Node to the European Infrastructure for Translational Medicine*), the Czech constituent of EATRIS ERIC (*European Advanced Translational Research Infrastructure in Medicine*), operates a translational, non-clinical and translational, early clinical research facility. **CZECRIN** (*Czech National Node to the European Clinical Research Infrastructure Network*), the Czech constituent of ECRIN-ERIC (*European Clinical Research Infrastructure Network*), provides clinical research to optimize diagnostic and therapeutic procedures, as well as conducts clinical trials of drugs and devices on patients in hospitals and clinics. **BBMRI-CZ** (*Bank of Clinical Specimens*), the Czech constituent of BBMRI-ERIC (*Biobanks and Biomolecular Resources Research Infrastructure Consortium*) provides the clinical aspect of biomedical research and development by collecting and analysing biological samples and corresponding data required for the development of new drugs or diagnostic assays. The **NCMG** (*National Center for Medical Genomic*), the newest member of the biomedical large research infrastructures of the Czech Republic, offers services and expertise in medical genomics. From the environmental science perspective, **RECETOX RI** (*RECETOX Research Infrastructure*) adds to the list of large research infrastructures. Its long-term population studies, samples and data offer tools for monitoring the health impacts of selected factors and enables linking of the population and clinical studies.

The following group of biomedical large research infrastructures provides integrative services. Thus, **Czech-BioImaging** (*National Infrastructure for Biological and Medical Imaging*), a Czech constituent of the Euro-BioImaging ERIC (*European Research Infrastructure for Imaging Technologies in Biological and Biomedical Sciences*) covers the needs in biological and medical imaging at various levels, from the imaging of live animals, tissues, and cells, including in vitro dynamics of cell behaviour, down to the imaging of cell organelles, transport, biomolecules

▶ CZ-OPENSCREEN (*National Infrastructure for Chemical Biology*)

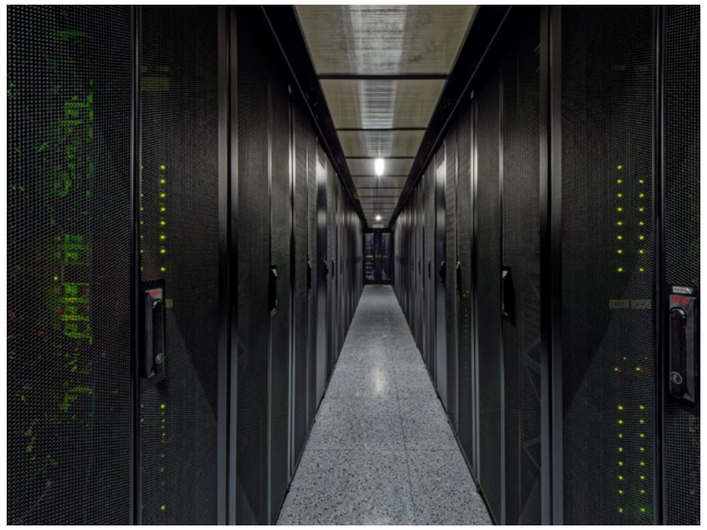
and their interactions in health and disease. **ELIXIR-CZ** (*Czech National Infrastructure for Biological Data*), the Czech constituent of ELIXIR (*European Life-Science Infrastructure for Biological Information*) is a special project under the umbrella of EMBL (*European Molecular Biology Laboratory*). This large research infrastructure deals with the archiving, processing and analysis of life sciences data. This is in response to the growing needs of the biomedical research community, which is generating an immense and exponentially increasing amount of data. Thus, it is necessary to store the biomedical research data, efficiently extract their key information, and make it accessible.

The membership of the Czech Republic in the international organisations EMBC (*European Molecular Biology Conference*) and EMBL (*European Molecular Biology Laboratory*) is a significant contribution to the development of biomedical research infrastructures in Europe and complements the portfolio of large research infrastructures operated in the Czech Republic in the area of biological and medical sciences.

As written above, the most advanced Czech biomedical large research infrastructures are connected with excellent foreign partners, which (1) provides open access to cutting-edge technology platforms for academia and industry users; (2) standardizes research outputs and reduces fragmentation; (3) promotes interdisciplinary research and development in biological and medical sciences; (4) facilitates the translation of findings from fundamental research to new applications in medicine; (5) improves competitiveness of academic research with an outreach to industry (e.g. the pharmaceutical industry, biotechnology, advanced equipment manufacturers, etc.); (6) provides training and education to future professionals in life sciences; and (7) attracts world-leading scientists to the Czech research organisations.

The Czech biomedical large research infrastructures are complementary and as such, contribute to research, development, and innovation within many fields. Nevertheless, if we comprehensively compare the landscape of multidisciplinary scientific fields, certain gaps are identifiable and reliant on both collaborative expertise and integrated innovation to circumvent such issues.

The field of *nano-biotechnology* (nanomaterials for biomedical sciences) focuses on the research of high-resolution artificial structures and targets the interface between the life sciences and nanomaterials. Nano-biotechnology substantially supports the development of therapeutics, diagnostics, imaging, and regenerative medicine. It also provides considerable benefits for all areas of disease, including cardiovascular diseases, diabetes, and cancer, and has a substantial potential to be one of the main instruments utilized in personalized, targeted, regenerative medicine. Other collaborative scientific approaches combine results from plant research with environmental sciences. Plants, which provide an indispensable basis for food production and environmental maintenance, are also employable in renewable bioenergy production. Describing the plant genome and the function of individual genes is a necessary prerequisite to understanding ongoing molecular processes; knowledge that is fundamental to improving plant tolerance under adverse environmental conditions to ensure food quality and yield. *Plant phenotyping* helps to define strategies to improve the yield, stability, and quality of globally important crops and to develop new resilient crops. The collection of plant genetic resources, plant germ plasm, wild plant relatives and native seeds accompanied with corresponding specialized metadata provided on the basis of open access are thus of growing importance for conducting plant-biology research and development.



Synthetic biology applies the principles of engineering to biosciences by trying to design and construct new biological parts and systems. Synthetic biology couples chemical DNA synthesis with the growing knowledge of genomics to allow researchers to assemble new or modified DNA, aimed at constructing novel microbial genome inserts. Synthetic biology is highly interdisciplinary and technically demanding, requiring complex research facilities. Its impact is significant within the research and development field in a socio-economic sense as it provides novel concepts for regenerative medicine, pharmaceuticals, high-value chemicals, biosensors, biofuels, and new biomaterials.

The *meta-integration and clustering* of biomedical large research infrastructures would establish a united front in the pursuit of a common goal: understanding the mechanisms behind clinical symptoms and disease progression. Pooling resources and expertise would successfully extend the frontiers of our knowledge and thus, facilitate (bio-) pharmaceutical manufacturing and (pre-) clinical trials that lead to the discovery of personalized medicine and improved healthcare. Establishing a network of multidisciplinary large research infrastructures has the ability to augment the contributions of any single research facility to provide an integrated and multi-faceted understanding of disease development. Furthermore, a multidisciplinary platform enhances the complementarity and establishes a mutual support base between participating members in the Czech Republic.

◀ ELIXIR-CZ (*Czech National Infrastructure for Biological Data*)

◀ EATRIS-CZ (*Czech National Node to the European Infrastructure for Translational Medicine*)

The advancement of biomedical research and development calls for collaboration among large research infrastructures in order to provide a full pipeline of expertise and services. Depending on the specific needs of certain research and development projects, large research infrastructures should enable open-access services at the (macro-) regional and international level. Therefore, lending support to the interoperability of biomedical research facilities is of utmost importance, as it will improve overall work efficacy. The resulting synergies improve the use of available resources and increase the effectiveness of large research infrastructures' operations. Such a development would be immensely beneficial for the cross-sectorial research and development being carried out, not only in the fields of biological and medical sciences, but also in material and environmental sciences.

Each of the recently established biomedical large research infrastructures in the Czech Republic have proven to be invaluable and inseparable to the pan-European effort. As such, emphasis should be placed on further strengthening its scientific and technological base to increase international competitiveness and together, with its European partners, address the grand challenges in biomedical science research.

Recently established since the last edition of the Roadmap and addressing the "Health and Food" field, **METROFOOD-CZ** (*Infrastructure for Promoting Metrology in Food and Nutrition in the Czech Republic*) is the Czech national constituent of the European Research Infrastructure METROFOOD-RI (*Infrastructure for Promoting Metrology in Food and Nutrition*). Its main objective is to promote new interdisciplinary research in areas ranging from primary agricultural production, food processing, and technology to the quality, authenticity, safety and traceability of food, raw materials, products and dietary supplements. In this respect, METROFOOD-CZ focuses on the development and validation of analytical methods for determining the quality, safety and authenticity of food, feed and raw resources, and on the development of new reference materials for making a quality assurance analysis of food and natural products. Within the open access framework, METROFOOD-CZ offers its unique experimental and instrumental capacities for both the research and application spheres in the form of expert analyses, the usage of unique analytical instrumentation, the possibility of developing new products and the testing of the hygienic-toxicological, nutritional and sensory quality of food.

Bank of Clinical Specimens

Acronym:
BBMRI-CZ

Hosting institution:
Masaryk Memorial Cancer Institute

Partner institutions:
First Faculty of Medicine of Charles University in Prague
Faculty of Medicine of Charles University in Hradec Kralové
Faculty of Medicine of Charles University in Pilsen
Faculty of Medicine of Palacký University in Olomouc

Phase: operational
Character: distributed

Responsible person:
Assoc. Prof Dalibor Valík, Ph.D.
valik@mou.cz

Website:
bbmri.cz

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2018: landmark

Motto:
"Making new treatments possible"…research infrastructure for the design of new treatments.

Characteristics

BBMRI-CZ collects and stores human biological material and associated clinical data. Primary tumour tissues and other samples that would otherwise be irretrievably lost for future research are specifically collected as they are not routinely preserved in health care institutions. The human biological material is catalogued into collections in BBMRI-CZ and these comprehensively characterized collections are a key element for both current and future research projects. The unique units of these collections are no longer denoted as samples, but rather as "data/sample sets" that aggregate clinical data with a specified biological material. BBMRI-CZ is inherently anchored in the backbone institutions of Czech academic medicine, faculty hospitals and specialized health care institutions. BBMRI-CZ has also a unique set of technologies and especially knowledge for conducting translational research and for transferring clinical applications from translational research to academic clinical trials. The user community utilizes the expertise of the skilled staff of BBMRI-CZ, ranging from their consulting and data services to the human biological material stored in BBMRI-CZ biorepositories. BBMRI-CZ is represented as Czech national node in the BBMRI-ERIC European Research Infrastructure Consortium (*Biobanks and Biomolecular Resources Research Infrastructure Consortium*) and the Czech Republic is its founding Member State. BBMRI-CZ, as a part of BBMRI-ERIC, is currently a central medical research infrastructure that is focusing on the problem of the irreproducibility of research results through the implementation of quality control processes into activities related to the long-term archiving of human biological material and its subsequent use for meaningful research purposes. Representatives of BBMRI-CZ are actively working in the European consortium BBMRI-ERIC. New services for communication between biobanks and research teams include the IT tools called BBMRI-ERIC Directory and BBMRI-ERIC Negotiator. BBMRI-CZ fundamentally participates in the development of these IT tools for the European research community. The BBMRI-ERIC Directory is a horizontal cataloguing tool that provides concise, sufficiently clear information about the European biobanks involved in BBMRI-ERIC. This tool supports finding a suitable partner biobank for researchers interested in specific clinical samples. The BBMRI-ERIC Negotiator tool then enables specific communication between the applicant (research, development) and the provider (the institution managing the biobank).

Socio-economic benefits

The socioeconomic benefits of BBMRI-CZ lie in activities defining the key documents of health care policy in the Czech Republic, such as clinical practice guidelines with a direct impact on clinical medicine related to, for example, the use of predictive laboratory tests in oncology, and guidelines for determining targeted treatments where the respective molecular therapeutic goals are studied and identified in the target tissue. The benefits of BBMRI-CZ concentrate on research for disease biomarkers that will be discovered and characterized using human biological material collections linked to clinical data and subsequently tested in clinical trials. The search for appropriate biomarkers specific to a concrete disease using biobanked collections is thus an important factor in the design of innovative therapeutic products and procedures in many human diseases.

Czech Centre for Phenogenomics

Acronym:
CCP

Hosting institution:
Institute of Molecular Genetics of the Czech Academy of Sciences

Phase: operational
Character: single-sited

Responsible person:
Assoc. Prof Radislav Sedláček, Ph.D.
radislav.sedlacek@img.cas.cz

Website:
phenogenomics.cz

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2018: landmark

Motto:
A centre for the research of comprehensive functions of mammalian genes.

Characteristics

CCP is the largest non-distributed biomedical research infrastructure in the Czech Republic with international significance, providing a unique and complex service portfolio, which on this scale, can only be found in just a few places throughout the world. The activity of CCP focuses on three main areas: the first being genome editing (mainly in laboratory rodents), which is currently performed primarily using the programmable nuclease (e.g. CRISPR/Cas9). CCP is among the best centres in the world in this area and offers this service to researchers from around the world, thus facilitating the development of animal models to study human diseases. Secondly, CCP focuses on phenotyping, i.e. comprehensive characterization of genetically modified models in order to describe the functions of studied genes with informative mutations. CCP is able to investigate all main physiological systems and reveal how and where specific genes function. As CCP closely cooperates with partners from international consortia, all procedures and technologies are standardized, which improves result reproducibility. CCP develops not only new technologies for genome editing and for the characterization of physiological functions, but also provides services in pharmacokinetics and toxicology, therefore contributing to the development of new medicines for both the academic and commercial spheres. This preclinical research represents the third area of CCP's activities. PDX technology (Patient-Derived tumour Xenograft), which investigates the development of human tumours engrafted into mouse models and the possibilities of their therapies using a personalized therapeutic approach, is also included in this area. Altogether, CCP's scope is very broad, ranging from genetics and molecular biology to physiological disciplines, and from biochemistry to technology disciplines including mass spectrometry. CCP is a member of the INFRAFRONTIER (*European Research Infrastructure for the Generation, Phenotyping, Archiving and Distribution of Model Mammalian Genomes*) European research infrastructure and due to the comprehensive portfolio of its expertise, from the generation of mutant models to its knowledge of and experience with analysing the functions of genes and their mutations, it has also become a member of the international consortia IMPC (*International Mouse Phenotyping Consortium*). CCP is working together with IMPC members on a very ambitious goal, which is the description of the functions of all mammalian genes. CCP is currently working on its entry into the EurOPDX European research infrastructure.

Socio-economic benefits

In both the Czech Republic and throughout Europe, CCP is working on projects which are striving to tackle a number of socioeconomic challenges, including ageing, metabolic disorders, oncologic and neurologic diseases. CCP effectively aids the scientific community in studying the function of genes in physiological processes and during the development of human diseases and their treatment. CCP provides the research community in the Czech Republic with excellent know-how and service and offers a standardized environment in which to test new therapeutics and to publish their results in high-quality international journals. CCP also increases the profile of science in the Czech Republic via its international cooperation. CCP is working on a number of projects with commercial partners, including preclinical research to develop new therapeutics, the development of new technologies to study metabolism, the digital monitoring of breeding cages for laboratory animals, and it is preparing new models of human disease for both domestic and international users.

Czech Infrastructure for Integrative Structural Biology

Acronym:
CIISB

Hosting institution:
Masaryk University

Partner institutions:
Institute of Biotechnology of the Czech Academy of Sciences

Phase: operational
Character: distributed

Responsible person:
Prof Vladimír Sklenář, Dr
vladimir.sklenar@ceitec.muni.cz

Website:
ciisb.org

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2018: landmark

Motto:
National research infrastructure for integrative structural biology providing expertise and access to unique technologies used for studying cellular molecular systems at atomic resolution.

Characteristics

CIISB is a distributed large research infrastructure of the core facilities and central laboratories operated within the capacities of the research and development centres of CEITEC (*Central European Institute of Technology*) and BIOCEV (*Biotechnology and Biomedicine Centre of the Czech Academy of Sciences and Charles University in Vestec*). CIISB provides expertise and access to technologies used for integrative approaches for conducting structural analyses of biologically important cellular components and macromolecules at different resolution levels, ranging from atomic to cellular. The CIISB research infrastructure consists of 10 core facilities and central laboratories of national and international importance. CIISB provides equipment, expertise and access to the latest technologies for the preparation and characterization of samples, for the determination of their spatial structure at atomic resolution and for mapping the time variability of a three-dimensional arrangement over a wide time scale ranging from 10-9 to 103 s. Excellent CIISB technologies used for NMR spectroscopy, cryo-electron microscopy and tomography, the crystallization of biological macromolecules, X-ray diffraction and Bio-SAXS measurements, nanobiotechnologies, the biophysical characterization of bio(macro)molecules and mass spectrometry for studying bio(macro) molecules are at a level of quality that is comparable to other large European research infrastructures for structural biology. The concentration of up-to-date high-end instrumentation and scientific expertise, unrivalled at the national level, facilitates the acquisition and interpretation of data obtained from instruments covering more than 20 key technologies and enables the development of new methodologies. CIISB facilitates the dissemination of knowledge and stimulates collaboration between centres of fundamental and applied research. At the European level, CIISB stands out due to its high-end equipment for cryo-electron microscopy and tomography, X-ray techniques, high-field NMR spectroscopy and high-resolution structural mass spectrometry. CIISB has become a part of the Instruct-ERIC (*Integrated Structural Biology European Research Infrastructure Consortium*) European research infrastructure, of which the Czech Republic is a founding Member State. CIISB serves domestic, European and overseas users and thus represents not only a principal basis of national biomedical and biotechnological research, but also plays an essential role in the international research community.

Socio-economic benefits

The CIISB research infrastructure stimulates national and transnational collaboration across the fields of mathematics, physics, chemistry, biology and medicine at both the academic and industrial levels. While CIISB mostly serves basic research, innovation and technology transfer are among the strategic priorities of the CIISB hosting institutions. The CIISB large research infrastructure supports progressive developments in many scientific areas (e.g. in molecular biology, biochemistry, biomedicine, and biotechnology) by providing the best available technological platforms for obtaining high resolution structural data for biotechnological applications, drug related research, the development of new biomarkers, and the improvement of food technologies. Collaboration between CIISB and the application sphere and industrial partners is reflected in the development of new technologies and key experimental techniques (primarily in NMR, cryo-electron microscopy, X-ray diffraction, and structural mass spectrometry).

Czech National Node to the European Clinical Research Infrastructure Network

Acronym:
CZECRIN

Hosting institution:
Masaryk University

Partner institutions:
St. Anne's University Hospital in Brno

Phase: operational
Character: distributed

Responsible person:
Assoc. Prof Regina Demlová, Ph.D.
demlova@med.muni.cz

Website:
czecrin.cz

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2018: landmark

Motto:
"When science helps patients" – a distributed network of universities and healthcare facilities for academic research through highly specialised clinical trials.

Characteristics

CZECRIN is a large research infrastructure for clinically oriented biomedical research focused on investigator-initiated clinical trials. Under the supervision of Masaryk University and in collaboration with St. Anne's University Hospital in Brno, CZECRIN has created an expert network of clinical trial centres performing independent clinical research in cooperating university hospitals. The development of innovative personalised somatic-cell therapy for oncology, paediatric medicine, and rare diseases is the priority of this large research infrastructure. CZECRIN has several key fields of activity. Its own research and development activities consist of research in clinical pharmacology, including the development of new advanced therapy medicinal products (ATMP). For collaborating users, CZECRIN offers regulatory and knowledge support for investigator-initiated clinical trials, quality assurance/quality control (QA/QC) for accreditation purposes, and practical clinical support consisting of biometry, monitoring, pharmacovigilance, and systematic educational programmes covering the field of clinical research. In accordance with the research priorities, CZECRIN has constructed a manufacturing cleanroom unit operating within the GMP (good manufacturing practice) regime. This manufacturing facility serves for the development and manufacture of personalised medicines used in clinical trials in children's oncology, children's diabetology and rare diseases. CZECRIN concentrates on the unique know-how of manufacturing technologies and the implementation of clinical trials in the field with highly innovative potential. Through professional support, CZECRIN increases the potential for the commercialisation of innovative biotechnological research. The new European regulation concerning clinical trials represents a critical step in the future development of clinical research. Regulation EU 536/2014 significantly changes the system of clinical trials in the EU and has a significant impact on the Czech Republic. Without a functional research infrastructure ensuring research, knowledge, and methodologic support, it would almost be impossible to perform investigator-initiated clinical trials. The future development of CZECRIN, a national node to the ECRIN-ERIC (*European Clinical Research Infrastructure Network*) European research infrastructure, will facilitate the linking of clinically oriented research infrastructures in the Czech Republic with the application sphere in Europe. On the international level, CZECRIN works very closely with the consortia of BBMRI-ERIC (*Biobanking and Biomolecular Resources Research Infrastructure*) and EATRIS ERIC (*European Infrastructure for Translational Medicine*) European research infrastructures.

Socio-economic benefits

CZECRIN contributes to addressing healthcare challenges associated with the innovative personalised pharmacotherapy of rare diseases and the optimisation of treatment. The strategic creation of a biomedical large research infrastructure for conducting clinical trials is essential for the proper utilisation of resources invested in research excellence, and for maximisation of the use of scientific potential in the application sphere. Both of these aspects are important for the future users of research results – the patients, and for the prestige of Czech clinical research in the European context. CZECRIN participates in the translation of the scientific results into clinically applicable outcomes, including innovative medicines. On the basis of permission issued by the State Institution of Drug Control, CZECRIN develops personalised somatic-cell medicinal products administered to child patients with malignant diseases and to those patients with rare skin disease ("butterfly children") participating in clinical trials. CZECRIN also collaborates with commercial suppliers of GMP technologies for the cleanroom unit and with various biotechnology companies.

National Research Infrastructure for Biological and Medical Imaging

Acronym: Czech-BioImaging

Hosting institution:
Institute of Molecular Genetics of the Czech Academy of Sciences

Partner institutions:
Biology Centre of the Czech Academy of Sciences / Institute of Physiology of the Czech Academy of Sciences / Masaryk University / Charles University / Palacký University Olomouc / Institute of Experimental Botany of the Czech Academy of Sciences / Institute of Scientific Instruments of the Czech Academy of Sciences / Brno University of Technology

Phase: operational
Character: distributed

Responsible person:
Prof Pavel Hozák, Dr
hozak@img.cas.cz

Website: czech-bioimaging.cz

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2018: landmark

Motto:
National research infrastructure for biological and medical imaging providing open access to cutting-edge imaging technologies and methodologies.

Characteristics

DInnovative imaging technologies allow us to study hidden biological processes in cells, tissues, and whole organisms thanks to technological development. Imaging has become one of the most crucial elements of research in biological and medical fields. Czech-BioImaging was designed as a distributed large research infrastructure of imaging institutions in the Czech Republic. It provides open access to a wide spectrum of imaging technologies and methodologies allowing for the extraction of completely new scientific data, especially in cell and molecular biology, genetics, physiology, parasitology, tumour biology, neurosciences, developmental biology, and pathology. It also increases the qualifications of researchers and students in this field through educational programs. Czech-Bioimaging reacts to imaging needs on many levels – from the imaging of organisms, their tissues, and cells to the imaging of cellular organelles, transport, biomolecules and their interactions in health and disease. Czech-BioImaging offers access to a wide range of imaging technologies, such as advanced light and fluorescence microscopy, super-resolution microscopy, electron microscopy, correlative light and electron microscopy, sample preparation, imaging in neurosciences, magnetic resonance, magnetic particle imaging, and imaging data analysis. Czech-BioImaging also performs its own methodological research and development, particularly in the field of the implementation of new imaging methods (multimodal holographic microscopes, new detection systems of multiple markers, new applications for magnetic particle imaging, stereological methods, image processing, analysis methods, and 3D reconstruction including custom software development). Czech-BioImaging provides its users with cutting-edge instruments and methodologies for biomedical imaging and it contributes to the development of biomedical sciences through its publication, educational, and methodological activities. Czech-BioImaging represents a Czech national node within the European research infrastructure for biological and medical imaging, Euro-BioImaging (*European Research Infrastructure for Imaging Technologies in Biological and Biomedical Sciences*). Moreover, the Czech Republic will also become a founding Member State of the Euro-BioImaging ERIC consortium.

Socio-economic benefits

The technological and methodological foundation of Czech-BioImaging significantly improves biomedical research due to the top imaging technologies made accessible to its users and the professional expertise gathered from the national nodes of the Euro-BioImaging European research infrastructure. Czech-BioImaging also contributes by sharing its experience from research projects, developing new methods for the extraction and analysis of image data, providing continual education to large research infrastructure personnel, and its very intensive involvement in international cooperation. Czech-BioImaging supports the development of biological, biomedical, medical, and liberal arts as well. It carries out many measurements for various types of research projects and it provides feedback, suggests new ideas for making improvements, and other technological development propositions to manufacturers. Thanks to its own methodological research and development, Czech-BioImaging can become a direct partner of manufacturers in the development, implementing, and testing of new instruments. As a result, Czech-BioImaging can be also involved in the education of the staff of supplier companies and it plays an important role in the education of users in cooperation with instrumentation manufacturers as well.

National Infrastructure for Chemical Biology

Acronym:
CZ-OPENSCREEN

Hosting institution:
Institute of Molecular Genetics of the Czech Academy of Sciences

Partner institutions:
Masaryk University / Palacký University Olomouc / University of Chemistry and Technology Prague

Phase: operational
Character: distributed

Responsible person:
Dr Petr Bartůněk
bartunek@img.cas.cz

Website: openscreen.cz

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2018: landmark

Motto:
CZ-OPENSCREEN offers access to state-of-the-art technologies and high-quality services in the field of chemical biology; is systematically building a library of chemical compounds; is identifying new molecular probes and is developing new tools for the research of chemical compounds as candidates for the development of new potential therapeutics.

Characteristics

CZ-OPENSCREEN operates the most advanced research infrastructure for basic and applied research in the fields of chemical biology and genetics in the Czech Republic and provides open access to its external users. It supports this new interdisciplinary research by bridging traditional natural sciences such as cell biology, molecular and structural biology, biochemistry, organic chemistry and chem/bioinformatics. The main mission of CZ-OPENSCREEN is to identify new molecular probes and to develop new tools for the research of chemical compounds as candidates for the development of new potential therapeutics. Unlike commercial platforms, CZ-OPENSCREEN also focuses on non-validated molecular targets, signalling pathways and neglected diseases. To those users from the biological and chemical community, CZ-OPENSCREEN offers standard biological and biochemical assays, consultancy and development of new assays, high-throughput screening (HTS), profiling of chemical compounds on a panel of cell lines and medicinal chemistry optimization of newly identified biologically active compounds. CZ-OPENSCREEN is systematically building a library of both commercial chemical compounds as well as compounds synthesized in the Czech Republic. It provides access to this unique library to external users. An integral part of the services is chemiformatics support, such as data analysis and storage, the development of new analytical tools and database systems. CZ-OPENSCREEN is equipped with state-of-the-art technologies for high-throughput screening of chemical compounds such as integrated robotic HTS stations, robotic stations for performing automatic microscopic analyses and label-free technology, integrated robotics systems for compound storage and sample preparation. The long-term international collaboration of CZ-OPENSCREEN with other European partner institutions has contributed to the establishment of the EU-OPENSCREEN ERIC (*European Infrastructure of Open Screening Platforms for Chemical Biology*) European Research Infrastructure Consortium. The Czech Republic is among the founding Member States. CZ-OPENSCREEN is its national node and besides other activities, it will host the European Chemical Biology Database (ECBD), where all the data generated by EU-OPENSCREEN ERIC partner sites will be stored.

Socio-economic benefits

Research in the field of chemical biology has an immediate impact mainly on translational research for the identification and validation on the novel activities of known drugs, ex-vivo therapeutics and targeted experimental therapy. The excellent equipment and chemical biology expertise of CZ-OPENSCREEN strengthen the position of the Czech Republic in the biomedical field. CZ-OPENSCREEN is developing novel technological approaches to identify new inhibitors for advanced therapies in oncology, inherited and metabolic diseases, neurodegenerative and neglected diseases. There is a high translational and application potential of the research outcomes of CZ-OPENSCREEN for the pharmaceutical, biotechnology and agrochemical industries. CZ-OPENSCREEN cooperates with many Czech and foreign innovative companies active in the development of specific inhibitors of tumour growth.

Czech National Node to the European Infrastructure for Translational Medicine

Acronym: EATRIS-CZ

Hosting institution: Palacký University Olomouc

Partner institutions: St. Anne's University Hospital in Brno / Masaryk University / Institute of Microbiology of the Czech Academy of Sciences / Charles University / Institute of Experimental Medicine of the Czech Academy of Sciences / Nuclear Physics Institute of the Czech Academy of Sciences / Institute of Macromolecular Chemistry of the Czech Academy of Sciences / Institute of Organic Chemistry and Biochemistry of the Czech Academy of Sciences / University of Chemistry and Technology Prague

Phase: operational
Character: distributed

Responsible person:
Assoc. Prof Marián Hajdúch, Ph.D.
marian.hajduch@upol.cz

Website: **eatris.cz**

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2018: landmark

Motto:
Infrastructure for translation medicine provides users with access to technology and knowledge for the research and development of personalized therapeutic products – from the validation of targets to early phase clinical trials.

Characteristics

EATRIS-CZ is one of the largest distributed research infrastructures in the Czech Republic and incorporates the most important centres of biomedical research. EATRIS-CZ provides cutting-edge research infrastructure and expertise along the entire translational value chain. Through 5 interrelated product platforms, EATRIS-CZ enables the development of drugs, vaccines and diagnostics to reach "the first-in-human application" and clinical "proof-of-concept" verification. EATRIS-CZ provides capacities for multidisciplinary R&D in key technologies (genomics, proteomics, metabolomics, high-capacity testing, complete drug development, molecular imaging and radiopharmaceuticals, early phase clinical trials and regulatory expertise). EATRIS-CZ offers a wide range of its services, patient cohorts, interactions with key experts in research, industrial development and regulation. The EATRIS-CZ network also includes accredited centres with the possibility of producing and testing products in good manufacturing practice (GMP) and good laboratory practice (GLP), or within ISO certification guidelines. EATRIS-CZ outcomes have led to a number of national and international projects, scientific publications, patents, clinical trials, the development of software tools and databases for clinical and pre-clinical data management, cooperation with industry and the development of specialized molecular diagnostics that allows for the practical implementation of personalized medicine. In the upcoming period of operation, EATRIS-CZ expects to consolidate and integrate the network of centres in order to support cooperation with their clients, to develop open access to their capacity and expertise and to support cooperation on common pilot projects. EATRIS-CZ is a Czech national node of the EATRIS ERIC (*European Advanced Translational Research Infrastructure*). EATRIS-CZ actively cooperates with other research infrastructures within both the Czech and international landscapes. Namely, collaboration with the INFRAFRONTIER (*European Research Infrastructure for Phenotyping, Archiving and Distribution of Model Mammalian Genomes*) and EU-OPENSCREEN ERIC (*European Infrastructure of Open Screening Platforms for Chemical Biology*) is being actively developed in the field of the identification/validation of new molecular targets and the development of innovative therapies. Similarly, collaboration with the BBMRI-ERIC (*Biobanks and Biomolecular Resources Research Infrastructure Consortium*) and ECRIN-ERIC (*European Clinical Research Infrastructure Network*) is being established for discovery and validation projects in the field of biomarkers, rare diseases and advanced clinical testing.

Socio-economic benefits

EATRIS-CZ contributes to public health by increasing the number of innovative products focusing on unmet medical needs in the Czech Republic. EATRIS-CZ improves the research culture and improves control of the academic community over its own research. It is training a new generation of researchers, health care and pharma industry professionals. EATRIS-CZ maximizes its return on investment in basic research, advances candidate products from academia and increases their chance to be licensed by industry. EATRIS-CZ host institutions work closely with the industrial sector and they are also involved in two competence centres (Centre for Development of Original Drugs and Centre of Competence for Molecular Diagnostics and Personalized Medicine). EATRIS-CZ also cooperates with the state administration in the Czech Republic, health insurance companies, and the Institute of Health Information and Statistics of the Czech Republic. Cooperation with the Cancer Research Foundation of the Czech Republic is based on the development of a molecular screening programme for cervical cancer, while collaboration with the State Institute for Drug Control is focused on the regulatory aspects of (pre)clinical trials.

Czech National Infrastructure for Biological Data

Acronym: ELIXIR-CZ

Hosting institution: Institute of Organic Chemistry and Biochemistry of the Czech Academy of Sciences

Partner institutions:
Biology Centre of the Czech Academy of Sciences / Institute of Biotechnology of the Czech Academy of Sciences / CESNET, z. s. p. o. / Czech Technical University in Prague / St. Anne's University Hospital in Brno / University of South Bohemia in České Budějovice / Masaryk University / Institute of Microbiology of the Czech Academy of Sciences / Charles University / Palacký University Olomouc / Institute of Molecular Genetics of the Czech Academy of Sciences / University of Chemistry and Technology Prague / University of West Bohemia

Phase: operational
Character: distributed

Responsible person:
Dr Jiří Vondrášek
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Website: **elixir-czech.cz**

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2018: landmark

Motto:
ELIXIR-CZ – national research infrastructure for storing, processing and analysing life science data.

Characteristics

The current rate of the generation of experimental data in life sciences raises a problem of their exponentially increasing volume and further processing. The issue is not just the safe storage and access to data, but also the creation of tools for making an effective analysis that brings new knowledge. Another serious problem is the lack of data interoperability. ELIXIR-CZ is an open access research infrastructure for organizing, storing, sharing and facilitating the interoperability of data for further processing and analysis. It provides advanced tools and workshops that are related to data usage and provides specialized databases and tools for analysing biological data. The uniqueness of ELIXIR-CZ lies in the distinctive interconnection of expert teams of the consortium members that provide services (tools and databases), as well as e-infrastructure services and technical solutions. This strategy creates a bioinformatics platform for the broad research community. ELIXIR-CZ is a national node contributing to the European research infrastructure for biological data ELIXIR (*European Life-Science Infrastructure for Biological Information*). ELIXIR ensures connections on the highest possible level and integration with other biomedical research infrastructures. ELIXIR-CZ is a complementary and synergic large research infrastructure for most biomedical large research infrastructures operating at the national level, namely CZ-OPENSCREEN (*National Infrastructure for Chemical Biology*), CIISB (*Czech Infrastructure for Integrative Structural Biology*), NCMG (*National Center for Medical Genomics*), EATRIS-CZ (*European infrastructure for translational medicine*), Czech-BioImaging (*National Research Infrastructure for biological and medical imaging*) and BBMRI-CZ (*Biobanking and Biomolecular Resources Research Infrastructure*).

Socio-economic benefits

ELIXIR-CZ plays an essential role in the further development of biological and medical sciences in the Czech Republic and contributes to addressing challenges in this field, such as personalized medicine and safe access to biological and medical data. ELIXIR-CZ enables users to implement new methods and technologies and provides them with expertise. Progress in the field of bioinformatics brings about the development of new approaches and solutions with significant multiplier effects in the pharmaceutical, medical, agricultural and biotechnology industries. ELIXIR-CZ closely cooperates with the commercial sector in NGS data processing, drug design, protein engineering and software development. ELIXIR-CZ is also the initiator of unified data stewardship for data generated in projects funded by the Government of the Czech Republic with the goal of ensuring the availability and sustainability of data after the end of project financing.

Infrastructure for Promoting Metrology in Food and Nutrition in the Czech Republic

Acronym:
METROFOOD-CZ

Hosting institution:
Czech University of Life Sciences Prague

Partner institutions:
University of Chemistry and Technology Prague
Food Research Institute Prague

Phase: operational
Character: distributed

Responsible person:
Assoc. Prof Lenka Kouřimská, Ph.D.
kourimska@af.czu.cz

Website:
metrofood.cz

Year of inclusion on the Czech Roadmap: 2019
Status on the ESFRI Roadmap 2018: project

Motto:
Improvement of food quality and safety through metrology techniques within unique European research infrastructure.

Characteristics

METROFOOD-CZ is a new and unique large research infrastructure in the field of food and nutrition. Its main objective is to operate and promote new interdisciplinary research from primary agricultural production, food processing and technology with respect to the quality, authenticity, safety and traceability of food, raw materials, food products and supplements. METROFOOD-CZ enables not only the use of top instrumentation for agricultural products and food analysis, the possibility of conducting experiments in experimental fields and stables, the development of new food products and the verification of innovative technologies, but also provides experts in the agro-food sector and corresponding metrology. METROFOOD-CZ focuses on the development and validation of analytical methods for determining the quality, safety and authenticity of food, feed and raw materials, and the preparation of new reference materials for quality assurance in the field of food and natural products analysis. Within open access, METROFOOD-CZ offers its unique experimental and instrumental capacities to research and application users in the form of expert analyses, the use of unique analytical instrumentation, the development of new products and the evaluation of hygienic-toxicological, nutritional and sensory food quality. The users of METROFOOD-CZ are public and private research laboratories and research groups active in various fields (e.g. metrology in the food industry, chemistry and food analysis, food composition, nutrition, food quality and safety, etc.) as well as food companies, consumers, public authorities, supervisory bodies and services. In addition, METROFOOD-CZ also offers services in the field of educating experts and the public, provides access to food composition databases and analytical methods, and contacts with international experts working in the field of food and nutrition. METROFOOD-CZ is the Czech national hub of the METROFOOD-RI (*Infrastructure for Promoting Metrology in Food and Nutrition*) European research infrastructure, which aims to achieve ERIC (*European Research Infrastructure Consortium*) status in the future.

Socio-economic benefits

METROFOOD-CZ offers an excellent research infrastructure to support cutting-edge research projects aimed at increasing efficiency and introducing innovation into the agri-food sector. METROFOOD-CZ educates young professionals and promotes legislation through ensuring the quality of data generated by the analysis of food and natural products. METROFOOD-CZ results have an impact on increasing the prestige of Czech science and on the competitiveness of Czech products with high added value in both Czech and international markets. METROFOOD-CZ closely cooperates with agro-food companies, the Chamber of Commerce, the inspection authorities and research organisations. The benefits of such cooperation include, for example, analyses of newly bred crop varieties, the detection of food fraud, the evaluation of new food technologies, the development and validation of analytical methods, providing data on food composition, the involvement of SMEs in scientific projects and the participation of experts in evaluation committees.

National Center for Medical Genomics

Acronym:
NCMG

Hosting institution:
Charles University

Partner institutions:
Masaryk University
Palacký University Olomouc
University Hospital Brno

Phase: operational
Character: distributed

Responsible person:
Prof Stanislav Kmoch, Dr
skmoch@lf1.cuni.cz

Website:
ncmg.cz

Year of inclusion on the Czech Roadmap: 2011

Motto:
Helping to understand to genetic and molecular bases of human health and disease.

Characteristics

Medical genomics is a dynamically evolving scientific discipline that gathers and uses the genomic information of patients, their genetic relatives and even the entire population to identify the genetic, genomic and molecular bases of human health and disease. NCMG creates a large research infrastructure that allows for the rapid implementation of novel genomic technologies and enables their rational utilization in the characterization of genetic underpinnings of human health and disease in the Czech Republic. As in other countries, the Czech Republic has a unique population with genetic variants that may be specific to this population. Understanding genetic variation in the Czech Republic and how it compares to other populations will be an important step in understanding how genetics affects the health of individuals in the Czech Republic. NCMG currently possesses state-of-the-art instrumentation and provides expertise that is needed for genomic sequencing, transcriptome analysis, epigenetic analysis, cytogenomics, quantitative PCR analysis and high throughput genotyping. NCMG has sufficient computational and data storage capacities and provides basic bioinformatic and statistical support to a number of projects targeting various rare diseases, cancers and complex phenotypes. NCMG was conceived as a distributed multi-centered, nation-wide large research infrastructure of top genomic laboratories operating in leading national institutions of medical education and biomedical research. Localization, and, at the same time, dissimilar specializations of individual laboratories guarantee the territorial and occupational development and application of genomics in the Czech Republic in accordance with worldwide trends. Within this setting, NCMG laboratories will develop its technological and methodological background in a coordinated and complementary manner, maintain and provide state-of-the-art analytical expertise to investigators having access to well-defined cohorts of patients, control individuals and various clinical materials. Together with continued technological advances in instrumentation, data analysis and data storage, NCMG will build a reference database of genetic variations in the Czech population that will be based on exome – and later – whole genome sequencing data. The host institutions of NCMG are members of European Research Infrastructures such as BBMRI-ERIC (*Biobanking and Biomolecular Resources Research Infrastructure*), EATRIS ERIC (*European Advanced Translational Research Infrastructure*), ECRIN-ERIC (*European Clinical Research Infrastructure Network*), ELIXIR (*European Life-Science Infrastructure for Biological Information*) and EU-OPENSCREEN ERIC (*European Infrastructure of Open Screening Platforms for Chemical Biology*), of which the Czech Republic is a Member State.

Socio-economic benefits

Medical genomics provides new methodologies for conducting biomedical research and alters how we think about the causes of disease. These findings will have an immediate impact on clinical practice. NCMG is therefore essential for educating and training the new generation of researchers, computer scientists, bioinformaticians, statisticians, instrument operators, clinical geneticists and clinicians. NCMG is also a unique platform for the preparation of expert recommendations and guidelines for various professional and Governmental bodies in the Czech Republic. The expertise available within NCMG's structure can be also used by the commercial sector.

Social sciences and humanities

10.5

page

Social sciences and humanities make an important contribution to our understanding of the historical, social, economic, political and cultural aspects of life in the Czech Republic and provide expertise used in the processes of integrating the Czech Republic into international structures within the EU and in the global perspective. Knowledge of cultural heritage, traditions, values and national identity contributes to the social cohesion of Czech society and its various social groups, as well as to fostering mutual understanding between Czech and foreign societies. This promotes their cooperation and helps to alleviate social conflicts.

10.5 | Roadmap of Large Research Infrastructures of the Czech Republic for the years 2016-2022
Social sciences and humanities

Social sciences- and humanities-based research focuses on topical themes as well as long-term trends in various sectors such as demographic development, migration, social inequalities, ethnic and other kinds of disparities, gender inequalities, education systems, social security systems, economic development, job creation, health and quality of life, regional development and many others, and creates a platform for evidence-based policies. Research in social sciences and humanities also supports the development of the knowledge economy of the Czech Republic and has a clear impact on strengthening the international competitiveness and developing the quality of life in the Czech Republic.

Recent developments in social sciences- and humanities-based research and its ability to contribute to addressing grand societal challenges are closely linked to the dramatic increase in the production and, in turn, the use of digital data. In addition to traditional sources such as libraries, archives, museums and galleries, new specialised research infrastructures of the digital age have become a prerequisite for efficiency and international competitiveness in social sciences and humanities. The objectives of these research infrastructures are (1) to acquire data and integrate them into large databases and corpora; (2) to open national and transnational access to data; (3) to systematise and interlink different data sources; (4) to promote international data comparability and data comparability over time; (5) to support the development of empirical research methods; (6) to develop and implement new technologies for data collection, sharing, dissemination, processing and analysis; (7) to promote new ways of scientific cooperation; (8) to create backgrounds for and coordinating data digitisation processes; (9) to create new forms of research outputs; and (10) to provide information to help researchers work with digital content, tools and methods, including training and providing technical and methodological support.

The key starting points and objectives of the social sciences and humanities are linked to the preservation of cultural and historical heritage and the study of the evolution of society. Continuity in the collection of research materials and the conduct of long-term research investigations is therefore important. Damage caused by any interruption of these processes or the outright loss of archived digital material tends to be irreversible. The long-term sustainability and systematisation of such activities is a precondition for the success of current and future social sciences- and humanities-based research, with the solution being to concentrate them within long-term sustainable research infrastructures.

The implementation of projects of such capacities, included in the Roadmap of Large

▼ CLB (*Czech Literary Bibliography*)

10.5 | Roadmap of Large Research Infrastructures of the Czech Republic for the years 2016-2022
Social sciences and humanities

Research Infrastructures of the Czech Republic, has brought significant improvements and systematic development in several areas of research infrastructures for social sciences and humanities. Substantial improvements and assurances of continuity have been achieved in the Czech Republic in the field of creating resources and tools for conducting linguistic research and the language technologies based thereon, as well as in the field of archiving and opening access to social sciences data. Czech involvement in high-profile research programmes in social sciences and humanities realised through the ERA and Czech participation in European research infrastructures such as CESSDA ERIC (*Consortium of European Social Science Data Archives*), CLARIN ERIC (*Common Language Resources and Technology Infrastructure*), DARIAH ERIC (*Digital Research Infrastructure for the Arts and Humanities*), ESS ERIC (*European Social Survey*), and SHARE-ERIC (*Survey of Health, Ageing and Retirement in Europe*) have greatly improved the conditions for social sciences- and humanities-based research in the Czech Republic.

The presented Roadmap of Large Research Infrastructures of the Czech Republic for the years 2016-2022, as updated in 2019, includes the following large research infrastructures in the field of social sciences and humanities: **AIS CR** (*Archaeological Information System of the Czech Republic*), **CLB** (*Czech Literary Bibliography*), **CNC** (*Czech National Corpus*), **CSDA** (*Czech Social Science Data Archive*), **ESS-CZ** (*Czech National Node of ESS – European Social Survey*), **LINDAT/CLARIAH-CZ** (*Digital Research Infrastructure for Language Technologies, Arts and Humanities*), and **SHARE-CZ** (*Survey of Health, Ageing and Retirement in Europe – participation of the Czech Republic*).

The implementation of large research infrastructure projects, included in the previous version of the Roadmap, has helped to substantially improve their mutual coordination and overcome the initial state of fragmentation within the landscape of the large research infrastructures of the Czech Republic operated in the domain of social sciences and humanities. The foundation for social sciences- and humanities-based research in the Czech Republic has thus recently undergone a significant and positive development, while integration in the ERA has also been deepened. Nevertheless, many of the already existing resources and services provided continue to show relatively limited compatibility and availability. Gaps in the landscape of social sciences- and humanities-based large research infrastructures of the Czech Republic are also identifiable.

The areas requiring increased attention and a search for solutions include the so-called "digital humanities". Over the past period, the Czech, European and global research communities have shown great interest in the implementation of a Czech large research infrastructure project based on extensive inter-institutional and inter-disciplinary cooperation aimed at connecting existing resources from cultural heritage and resources for historical research. Demand has been directed towards coordinating the digitisation activities and implementing technologically advanced research tools and methods, cultural heritage preservation practices, creating open access to data and promoting their intensive use. The starting points for research effectiveness are generally the deployment of innovative digital technologies, the interconnection of digital material resources from institutions that focus on preserving the national memory, such as archives, museums and libraries, and coordinated efforts to develop tools and techniques for using these data.

In the ERA, construction of such research infrastructure has already progressed considerably, in particular through the implementation of the DARIAH project. In the Czech Republic, the new **LINDAT/CLARIAH-CZ** (*Digital Research Infrastructure for Language Technologies, Arts and Humanities*) large research infrastructure will focus on these objectives, bringing together in its scope the capacities of the long-running LINDAT/CLARIN (Language Research Infrastructure in the Czech Republic) large research infrastructure and newly developing the activities of building the Czech national hub of the European research infrastructure DARIAH ERIC.

Longitudinal research surveys, particularly in the form of international centrally managed programmes, are resources of vital importance to social science-based research. The SHARE and ESS programmes have already been fully implemented in the Czech Republic, which bring considerable benefits to both the Czech and international research communities. However, several other running survey projects with similar potential in the Czech Republic have not yet taken the form of long-term sustainable programmes. The

◀ CSDA (*Czech Social Science Data Archive*)

examples include systematic research projects on values and attitudes, socio-economic longitudinal panel studies focusing on social and economic inequality and mobility, and socio-demographic panels and cohort studies on sexual and reproductive behaviours, health and partnership cohabitation, while other similar data collection projects may emerge in the near future.

The development of intensive cooperation between the social sciences and humanities and other scientific disciplines also offers great potential for further developing and increasing the efficiency of large research infrastructures operating in the social sciences and humanities.

A number of research activities are aimed at studying interactions between society and nature, and run along the boundaries of social and environmental sciences. Data used to study social and environmental phenomena are linked to each other by their geographical location. In this context, there is thus a need for an integrated Spatial Data research infrastructure, which would enable social and environmental research to be connected through so-called "geo-data" (GIS) and offer unique opportunities to study the relationships between society and the natural environment.

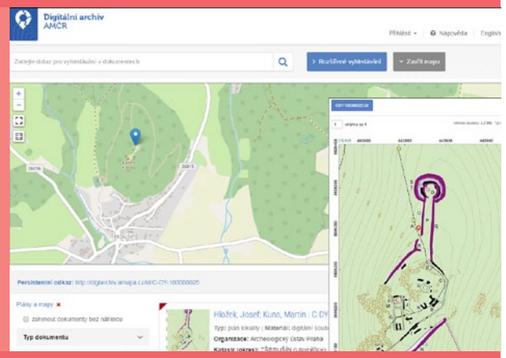
Similarly, research on the boundaries of social sciences, on the one hand, and biological and medical sciences, on the other, is a challenging but potentially very effective field of research. In this context, several household surveys are underway and could gain new momentum by including biological data collection in the socio-demographic and socio-economic surveys being conducted. Similar projects abroad have demonstrated that they can provide useful information, provide input for productive collaboration between scientific disciplines, and thus open up new areas of research. Researchers are then able to raise new research questions solvable using these data sources. While biosocial data-driven research must confront ethical, conceptual, and technical challenges, it holds great promise for the future.

Research infrastructures operated in the social sciences and humanities are also subject to challenges in the form of so-called "new data". With advanced and advancing digitization, individuals, organisations, and state administrations produce enormous amounts of digital data that document human behaviour, attitudes, and social structure and its dynamics. Many such digital data sources have the potential to enrich social sciences- and humanities-based research and to contribute to obtaining answers to grand societal challenges. Large-scale digital communication also creates the need for new tools for data collection and analysis. The use of new data therefore requires the development of an innovative methodology, technological tools and organisational environment for research, the concentration of efforts across scientific disciplines and the introduction of legal instruments to provide solutions for ethics and privacy issues. National research infrastructures have already been set up in some EU Member States to deal with the access to and use of new data and promise to make research operational and more economical. Within the ERA, international projects and activities to address existing gaps are also gradually being developed. The Czech Republic should therefore not stand aside from these developments.

The Czech Republic's Roadmap of Large Research Infrastructures for the years 2016-2022, updated in 2019, provides a very good starting point for ensuring the long-term sustainable development of large research infrastructures operated in the field of social sciences and humanities and for further integration of the Czech social sciences- and humanities-based research within the ERA. At the same time, it also indicates the areas that should receive appropriate attention in the coming period, taking into account the current and foreseeable future developments in the field of social sciences- and humanities-oriented research infrastructures.

▲ ESS-CZ (*Czech National Node of the ESS / European Social Survey*)

Archaeological information system of the Czech Republic



Acronym:
AIS CR

Hosting institution:
Institute of Archaeology of the Czech Academy of Sciences, Brno

Partner institutions:
Institute of Archaeology of the Czech Academy of Sciences, Prague

Phase: operational
Character: virtual

Responsible person:
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Website:
aiscr.cz/en

Year of inclusion on the Czech Roadmap: 2015

Motto:
People and their traces in the landscape – a digital record of the Czech Republic's archaeological heritage.

Archaeological Information System of the Czech Republic

Characteristics

AIS CR is a centrally provided public service that ensures the safe storage of archaeological data while promoting the spread, synergistic use and accessibility of that data for the scientific community and the general public. AIS CR is committed to making sure all components of its system are integrated so that it is able to circulate information, provide an ongoing administrative agenda for archaeological fieldwork, support education, and deliver a primary data source for scientific research. Until recently, Czech archaeology lacked the requisite infrastructure for data analysis and had no management structure to create, store or vouchsafe the quality of data. With the creation of AIS CR, all the nation's archaeological heritage information systems were centralised under a unified platform – the Archaeological Map of the Czech Republic – with further related services subsequently formed, such as the Digital Archive of the AMCR, the Archaeological Atlas of the Czech Republic and the web portal Prague Archaeological. The main mission of AIS CR is to have an integrated administration system for the field of archaeology in place, as well as a database of quality information on archaeological sites and monuments that can be accessed without any restrictions by as many domestic and international users as possible. In order to improve the quality and information potential, AIS CR rescues and protects archaeological data on previous excavations and archived research. Such data would be scattered or irretrievably lost without the existence of an efficient storage system. AIS CR has already brought about important changes in terms of the approach taken towards excavations and the administration of archaeological assemblages. This involves creating a dynamic model of circulation of information to aid archaeological practice, introducing a uniform classification and administration system of archaeological research, sites and documentation, and providing a digital database for professionals and the wider public. Currently, all basic information on upcoming, ongoing and completed archaeological fieldwork in the Czech Republic, together with research results, are stored in AIS CR. The aim is to constantly enhance the collection of available digital services through partnerships on international research projects so that data continue to be integrated. This helps uphold standards with regard to sharing and circulating archived archaeological data based on best practice, taking into account the principles of FAIR data (*Findable, Accessible, Interoperable, and Reusable*). AIS CR uses open data principles and open-source solutions to support the international compatibility and accessibility of the information and services it provides domestically, and fosters continued international collaboration through its involvement in European research infrastructures, such as ARIADNE (*Advanced Research Infrastructure for Archaeological Data Networking in Europe*) and E-RIHS (*European Digital Infrastructure for Heritage Science*).

Socio-economic benefits

AIS CR delivers a unique complex of information services for the purposes of research, education and archaeological heritage management. It ensures that the nation's cultural heritage remains accessible and protected. It is also committed to supporting local tourism and improving spatial planning, reducing the costs of the construction industry while mitigating its impacts on the landscape, and developing digital humanities technologies. By providing its users with up-to-date and accurate information on the nation's archaeological heritage and historical landscape, AIS CR helps to promote the national cultural identity. AIS CR is a central repository for information on archaeological projects, excavations and sites (project documentation, fieldwork reports, photographs, maps, plans, expert opinions) and is equipped with the tools necessary for the performance of the duties expected of it in accordance with the Act on State Heritage Care. Developers, companies and investors can evaluate risks on sites of interest and announce construction projects via AIS CR.

Česká literární bibliografie
Czech Literary Bibliography

Characteristics

CLB is the only large research infrastructure for research into literature and literary culture in the Czech lands with a tradition going back over 70 years. Its activities are based on processing and making ongoing additions to an analytical bibliography of Czech literature which consistently charts the reflections of Czech (and selectively, world) literature and culture in the periodical press and the output of books published in the Czech lands in all historical languages of communication. The CLB databases chronologically cover the period from the end of the 18th century to the recent past and contain a total of more than 2.2 million entries. At the same time, CLB is also involved in compiling associated knowledge databases (e.g. of literary figures and literary prizes). It is only with difficulty that comparisons with CLB can be made at a European level in terms of the number and quality of entries, the length of the period covered, the topicality of the excerption and the methodological standard. CLB data is available in standardized formats that enable it to be efficiently utilized in national and international scientific information exchange networks. All CLB resources are available to users online without any limitations in open-access mode at the CLB website and through other collaborating systems (e.g. at Knihovny.cz). CLB is also active in open source software development and digitization (RETROBI index card digitization software) fields. In addition to providing online tools for working with data, CLB also provides an information service and specialist consultations with researchers from the Czech Republic and abroad, i.e. Bohemists and scholars from associated disciplines (e.g. theatre studies, history, philosophy and other modern philologies). Moreover, CLB services are used by media professionals and specialists in creative fields, as well as publishing, cultural and pedagogical staff. The number of visits to the CLB web interface exceeds 80,000 a year. CLB collaborates closely with higher education institutes, organizing training sessions and workshops for their students and directly taking part in their tuition. It also offers employment for graduates in Czech studies and related disciplines, as well as Ph.D. studies programme participants. In the field of data exchange, it liaises closely with Instytut Badań Literackich at the Polish Academy of Sciences in particular and coordinates the Consortium for the Creation and Communication of World Czech Literary Studies Resources, using it to chart impressions made by Czech literature and culture abroad. CLB partner institutes are active in Europe and North America in particular, but links have also been forged with partner organizations e.g. in South Korea, Japan and China.

Socio-economic benefits

CLB contributes towards the resolution of present-day social challenges involving recognition and preservation of the national identity. It also helps to promote Czech literature and culture abroad, where its users, particularly Slavists, translators and historians, are creating an image of the Czech Republic through their publications and media output. Every year, several dozens of book titles appear as a result of CLB resource usage (e.g. specialist monographs and critical editions), including the prestigous *Česká knižnice* series of classic Czech literature works from the *Host* publishing house. CLB services are used in particular by creative, media and educational specialists, while CLB data is used as material for the development and verification of library software and specialist IT solutions. CLB is currently working closely together with the state in the fields of librarianship and research information, e.g. with regard to data exchange within shared library networks and those of other memory institutions. CLB activities have resulted inter alia in two specialist methodologies for processing article bibliographies, certified by the Ministry of Culture of the Czech Republic.

Czech Literary Bibliography

Acronym:
CLB

Hosting institution:
Institute of Czech Literature of the Czech Academy of Sciences

Phase: operational
Character: virtual

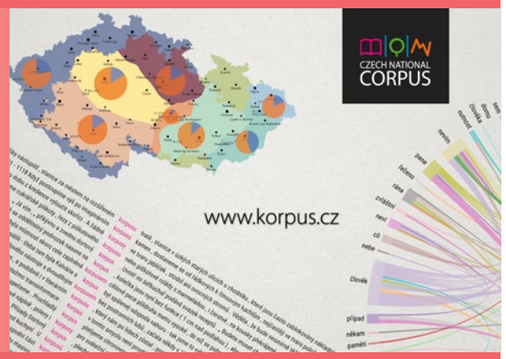
Responsible person:
Vojtěch Malínek, Ph.D.
malinek@ucl.cas.cz

Website:
clb.ucl.cas.cz

Year of inclusion on the Czech Roadmap: 2015

Motto:
Unlimited online access to a database covering 250 years of modern Czech literature and literary culture.

Czech National Corpus



Acronym:
CNC

Hosting institution:
Charles University

Phase: operational
Character: virtual

Responsible person:
Michal Křen, Ph.D.
michal.kren@ff.cuni.cz

Website:
korpus.cz

Year of inclusion on the Czech Roadmap: 2010

Motto:
National infrastructure for a survey of Czech, the empirical research of languages and their analysis with specialized tools.

Characteristics

CNC is continuously mapping the Czech language by building large electronic language corpora and providing access to them. As the only project of this kind, CNC focuses on broad-scale and complex data collection, including contemporary written Czech in all its genres and varieties, spoken Czech (covering the whole area of the Czech Republic), older Czech, as well as translated Czech. Given its large scope, diverse and balanced design, high processing standard, reliable metadata and high-quality linguistic annotation, CNC language data can compete with similar resources for major world languages. What is crucial is the continuity of data collection that enables researchers to carry out longitudinal studies of the language's development, as well as to study changes in language awareness and public discourse in different periods of time. CNC language corpora serve as a primary research material for a wide range of research topics mainly within the social sciences and humanities (linguistics, sociology, translation studies, history, literary science, etc.), but also in natural language processing. CNC provides user access to the corpora through specialized analytical tools in the form of web-based applications, enabling user-friendly, yet effective work with language data. Together with complex user support (an online user forum, documentation and knowledge base for corpus linguistics), these applications are located at the CNC research web portal https://www.korpus.cz. The CNC portal is based on open access. To fully use all the features, free online registration is required; however, many tools and functions are also available to unregistered users. CNC actively cooperates with the CLARIN ERIC (*Common Language Resources and Technology Infrastructure*) European research infrastructure and with its Czech national node, the LINDAT/CLARIAH-CZ (*Digital Research Infrastructure for the Language Technologies, Arts and Humanities*) large research infrastructure. CNC is an associated member of the CLARIN-CZ consortium with the K-centre status and maintains active contacts with many foreign research institutions with similar focus.

Socio-economic benefits

With more than 6,500 active users and 2,500 user queries per day, CNC creates prerequisites for world-class language research without the need to collect data for each research project separately. The centralized provision of all these services is not only economical, but also a guarantee of reliable source data, which ultimately leads to high-quality research outputs. Thanks to many multilingual resources, CNC is also widely used abroad. The CNC language corpora are an indispensable source of data for any modern language research and empirical study of Czech (grammar books, dictionaries and textbooks). More than 150 bachelor's and master's theses based on CNC resources are defended at Czech universities every year. Given that corpora and corpus tools have become an important part in language teaching, CNC plays a vital role in the modernization of language education in the Czech Republic.

Czech Social Science Data Archive

Acronym:
CSDA

Hosting institution:
Institute of Sociology of the Czech Academy of Sciences

Phase: operational
Character: virtual

Responsible person:
Jindřich Krejčí, Ph.D.
jindrich.krejci@soc.cas.cz

Website:
archiv.soc.cas.cz

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2018: landmark

Motto:
Research data and data services for social science research in the Czech Republic and Europe.

Characteristics

CSDA is a national resource centre for social science research, which acquires, processes and archives datasets from social research and makes these data publicly available for the purposes of performing secondary analysis in scientific research and training at universities. Sharing research data is a prerequisite for the development of contemporary research. The opportunity to analyse data from various research projects is the starting point for many social science studies and it makes the research internationally competitive. In academia, efficiency in sharing digital data is ensured by centralized national data archives; in the Czech Republic, CSDA fulfils this mission. CSDA has established, maintains and continually develops an extensive library of data collection from different data producers. These data are available to researchers and students via an on-line system allowing for the searching, browsing, analysing, visualizing and downloading of data. In CSDA, data are professionally processed, classified, documented and contextualized with other data and complementary materials. The archive is also a resource of research instruments verified in previous research, thereby creating essential background for the development of new surveys. The archival and information system ensures the long-term preservation and availability of data in compliance with international standards. CSDA is engaged in methodological research and produces studies of data resources and quality of research data. It also conducts analyses on data harmonization and standardization of indicators and provides instruction in data management and methods of analysis. In addition, CSDA serves as a directory to other data resources and provides technical and organizational background for large-scale survey research programs, e.g. Czech participation in the ISSP (*International Social Survey Programme*). CSDA endorses EU and OECD principles of open access to research data and creates an environment for their implementation in Czech social science. CSDA is a Czech national node of the CESSDA ERIC (*Consortium of European Social Science Data Archives*) European research infrastructure and CESSDA service provider in the Czech Republic. CESSDA is an ESFRI Landmark. It interconnects national data archives and thereby creates an integrated European system of data services in social science. CESSDA is also a platform for international cooperation in the development of technology, standards, best practice and procedures in the domain of archiving and sharing of data.

Socio-economic benefits

The availability of relevant social science data is a critical precondition for the development of evidence-based policies with clear implications for national competitiveness and quality of life. Data driven social research contributes to conceptual solutions in domains as diverse as demographic development, social inequalities, educational systems, migration, the labour market, an environmentally friendly society, behavioural aspects of health, social aspects of security and many others. Data archived by CSDA serve as the basis for analyses conducted for the purposes of public administration. They are also employed by institutions of applied research, e.g. the Czech Statistical Office, and various expert and advisory groups. The availability of internationally comparable data improves conditions for comparative research vis-a-vis the obligations associated with the membership of the Czech Republic in the EU and other international organisations, such as the United Nations, International Labour Organisation, Eurostat, European Regional Development Fund and many others.

Czech National Node of the ESS (European Social Survey)

Acronym:
ESS-CZ

Hosting institution:
Institute of Sociology of the Czech Academy of Sciences

Phase: operational
Character: virtual

Responsible person:
Klára Plecitá, Ph.D.
klara.plecita@soc.cas.cz

Website:
ess.soc.cas.cz

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2018: landmark

Motto:
A cross-national survey to assemble, interpret and disseminate data on social attitudes and behaviours.

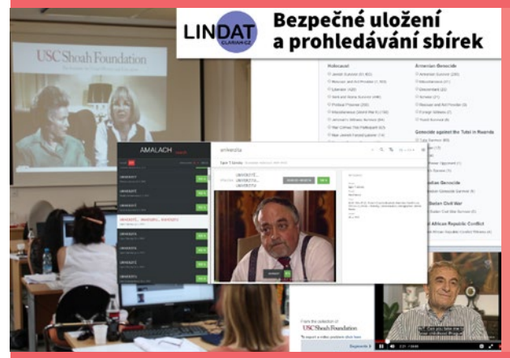
Characteristics

ESS-CZ is the Czech national node of the ESS ERIC (*European Social Survey*) European research infrastructure. ESS ERIC undertakes international quantitative surveys of the socio-demographic characteristics of people living in European countries and their opinions on current social issues (e.g. immigration, climate change, energy, democracy, economic morality, criminal justice, economic justice and social policy). The surveys take place every two years with the view to obtaining comparable data from European countries so that researchers, educators, politicians, journalists, the public administration, local governments and the general public can analyse and understand the similarities and differences between European societies. Open access to the data from ESS ERIC surveys is provided and registered users can download datasets from the online data archive of the Norwegian Social Sciences Data Service or analyse them online in the NESSTAR system. ESS ERIC is one of the leading projects implemented under the European Research Area. In 2005, it was the first social sciences and humanities project with Czech participation to be awarded the European Commission's Descartes Prize. The main goals of ESS ERIC include mapping the stability and dynamics of social structures, maintaining and disseminating high standards of international comparative research in the social sciences and humanities, introducing plausible indicators of European countries' national development as it is perceived and evaluated by their populations, and implementing and supporting professional education of European researchers. ESS ERIC publishes the basic findings of its studies in the form of the ESS Topline Series, facilitates e-learning through its ESS EduNet platform and maintains a bibliographic database, ESS Bibliography. Furthermore, it publishes national and international integrated datasets and provides for comparative analyses of countries in time (2002-2018). In the Czech Republic, ESS-CZ issues press releases and scholarly publications. At the international level, ESS ERIC collaborates with other European research infrastructures and projects, especially with SHARE ERIC (*Survey of Health, Ageing and Retirement in Europe*), CESSDA ERIC (*Consortium of European Social Science Data Archives*), GGP (*Generations and Gender Programme*), EVS (*European Values Study*) and the WageIndicator Survey.

Socio-economic benefits

ESS ERIC data are utilized in a number of scientific disciplines: sociology, psychology, economics, political science, epidemiological and health research, criminology, migration studies and communication studies. ESS-CZ contributes to addressing current issues such as health care and its availability, reconciling work, family and leisure, immigration and its effects on security, economy and culture, income inequalities and social cohesion. ESS-CZ collaborates with market, media and public opinion research companies. The collaboration contributes to introducing new technologies such as CAPI interviewing and online/mobile applications for fieldwork monitoring and data transfer. It also provides the business sector with know-how for reaching high response rates for surveys as a whole as well as individual items within in, interviewer training, fieldwork monitoring, and the detection of incorrect/incomplete interviews or interviewer misconduct.

Digital Research Infrastructure for Language Technologies, Arts and Humanities



Acronym:
LINDAT/CLARIAH-CZ

Hosting institution: Charles University

Partner institutions:
Institute of Philosophy of the Czech Academy of Sciences / Institute of History of the Czech Academy of Sciences / Library of the Czech Academy of Sciences / Masaryk University / Moravian Library / National Film Archive / National Gallery / National Library Prague / Institute of the Czech Language of the Czech Academy of Sciences / University of West Bohemia

Phase: operational
Character: distributed

Responsible person:
Prof Jan Hajič, Dr
hajic@ufal.mff.cuni.cz

Website: **lindat.cz**

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2018: landmark

Motto:
Open access to language resources and other data and services for the support of research in digital humanities and social sciences.

Characteristics

LINDAT/CLARIAH-CZ was established as the unification of two large research infrastructures, LINDAT/CLARIN and DARIAH-CZ. It is a unique research infrastructure which deals primarily with language data, but also with other digital resources and tools for their exploitation, maintenance and enhancement and offers them to the research community, to industry for the development of applications and in specific cases, such as language culture, also directly to the public domain. LINDAT/CLARIAH-CZ is a joint, distributed Czech national node of the pan-European CLARIN ERIC (*Common Language Resources and Technology Infrastructure*) and DARIAH ERIC (*Digital Research Infrastructure for the Arts and Humanities*) networks. It consists of 11 top research organisations that are active in the domain of humanities and arts in the Czech Republic – in linguistics, history and historical bibliography, culture and science on culture, the history of arts, philosophy, film culture, visual arts, musicology and the history of music, ethnology, folklore, archaeology and also in some cross-disciplinary domains. The aim of LINDAT/CLARIAH-CZ is to allow for open access to digitalized data resources of each given discipline for the broad research community and for students both in the Czech Republic and in EU and at the same time to obtain access to similar resources available in the pan-European networks CLARIN and DARIAH. LINDAT/CLARIAH-CZ takes part in international cooperation between research infrastructures of a similar type and also directly between the relevant research institutions in all branches of humanities and places emphasis on digital and interdisciplinary processing methods, including modern methods of machine learning and artificial intelligence. An integral part of LINDAT/CLARIAH-CZ activities also consists in an analysis of the legal aspects of the use of resources from the humanities domain with regard to possible legal restrictions concerning authorship rights and to the minimization of the impact of these restrictions on research work. LINDAT/CLARIAH-CZ also offers know-how and provides software tools for the processing of language resources and other digital data. It is also involved in the development of language technologies serving the needs of industry, and provides services, including those concerned with the exploitation of these services in cultural and creative branches of industry.

Socio-economic benefits

Culture, arts and humanities together form an important component of the national identity and are crucial for education on all levels of the school system. LINDAT/CLARIAH-CZ develops modern digital technologies and offers them to serve both for conducting top research in the humanities as well as for the general public. One of the consequences of these efforts is the larger involvement of Czech teams in international research activities and emphasis on the acknowledgement of the Czech Republic as a culturally rich country, which is able to make its history and heritage accessible by modern methods. In the domain of languages and multimodal technologies and artificial intelligence, the data and services of LINDAT/CLARIAH-CZ represent fundamental support for digital economics and for the broader involvement of the Czech Republic in the European economy thanks to the overcoming of present-day language barriers. LINDAT/CLARIAH-CZ offers the opportunity for industry and public institutions to collaborate with research institutions and to obtain access to knowledge and resources in the domains concerned by means of application projects.

Survey of Health, Ageing and Retirement in Europe – participation of the Czech Republic

Acronym:
SHARE-CZ

Hosting institution:
Economics Institute of the Czech Academy of Sciences

Phase: operational
Character: distributed

Responsible person:
Radim Boháček, Ph.D.
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Website:
share.cerge-ei.cz

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2018: landmark

Motto:
SHARE is a multidisciplinary database of microdata on health, socio-economic status, social and family networks on 120,000 individuals aged 50+ from 27 European countries and Israel.

Characteristics

SSHARE-CZ is the Czech national node of the SHARE-ERIC (*Survey of Health, Ageing and Retirement in Europe*) European distributed research infrastructure, the largest research infrastructure in social sciences in the EU. It is a multidisciplinary, international and longitudinal database of microdata on health, socio-economic status, social and family networks and other issues collected from more than 120,000 individuals aged 50+ from 27 European countries and Israel. The result is a free and unique data collection that provides information about the state, history and the future of both Czech and European society. SHARE allows researchers and state administrations to understand the consequences of demographic changes and formulate optimal policies for public finances, the labour market, health care and pension systems. Since 2004, the goal of the project has been to create a questionnaire for 5,000 respondents aged 50+ and their partners in each country, collect data on the same individuals every 2 years, and store the collected data in a user friendly, free and open access database. SHARE-ERIC also provides publications on the methodology and the data as well as organizes international conferences, workshops, user conferences and summer schools. In the Czech Republic, the project offers Czech researchers the possibility to place their own questions into an additional paper questionnaire. The future development of SHARE-CZ includes the collection of biomarkers, a link to administrative data, new questionnaire modules (time use, cognitive skills, social networks), a user-friendly and easy SHARE database for students, new modes of interviewing between the main waves of data collection, the evaluation and development of measures of poverty, physical and mental health, and a pension claim database. SHARE-ERIC cooperates with other European research consortia such as SERISS (*Synergies for Europe's Research Infrastructures in the Social Sciences*), CESSDA ERIC (Consortium of European Social Science Data Archives), EVS (*European Values Study*), ESS ERIC (*European Social Survey*), CLARIN ERIC (*Common Language Resources and Technology Infrastructure*), and DARIAH ERIC (*Digital Research Infrastructure for the Arts and Humanities*). SHARE-ERIC is coordinated with world leading research projects on ageing in the United States, England, and China and with the European Commission requirements for maintaining the highest possible quality of research, methodology and innovative technologies of data collection and their dissemination.

Socio-economic benefits

Population ageing and the related socio-economic consequences for growth and well-being are among the main challenges of the 21st century. SHARE data serve as the empirical foundation for the formulation of government policies based on scientific evidence. For Czech scientists and students, the SHARE project is the only open access, internationally comparable database for conducting research in demographics, economics, health, social care and epidemiology. The project serves the international and Czech research community with more than 8,500 registered users and 2,230 scientific publications. In the Czech Republic, SHARE cooperates with the Ministry of Labour and Social Affairs and with more than 20 research institutes. Due to the strict protection of private data, the commercial use of SHARE data is not allowed. SHARE data enables the commercial sector to understand the needs and opportunities of the ageing population. For example, the efficient use of social resources or an optimal health care policy is a necessary condition for improving the quality of life and for economic development.

e-Infrastructures

10.6

page

High-quality information and communication technologies (ICT) with sufficient capacities are absolutely crucial for the most modern research, development and innovations. No research team can carry out excellent research, development and innovations without an adequate ICT background system. Irrespective of the particular scientific discipline, this background system has many common features. These common ICT features are the basis for the build-up of shared e-infrastructure, the development and operation of which requires proper care.

10.6 | Roadmap of Large Research Infrastructures of the Czech Republic for the years 2016-2022
e-Infrastructures

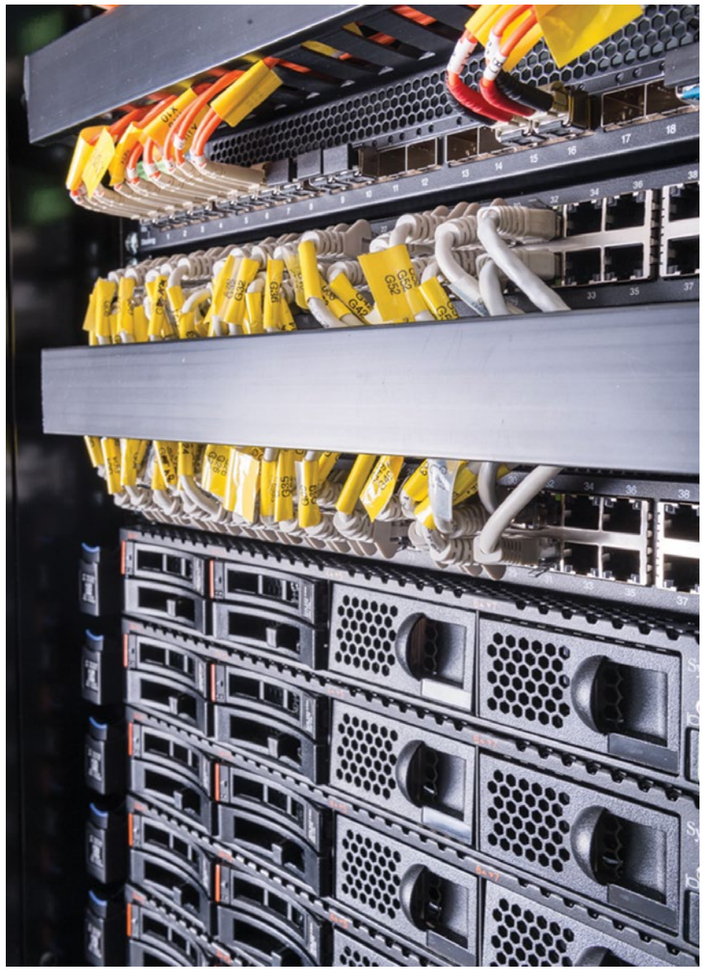
The key objective of e-infrastructure is to provide a comprehensive portfolio of ICT services with both identical and guaranteed parameters. Thus, the research community has a unified ICT platform at hand, and individual research teams can fully focus on their research, development and innovations without having to address issues related to the processing, storage or transfer of data. Such a type of e infrastructure that is based on technologies for the exchange, processing, storage and archiving of research data and interconnects geographically distributed research teams, their equipment and research infrastructures, is a pre-requisite for interdisciplinary cooperation.

The benefits of e-infrastructure are not restricted to only ensuring the sufficient capacity. E-infrastructure also acts as an equivalent partner to those research teams with specific needs and requirements that cannot be fulfilled using a pre-defined portfolio of ICT services. Direct cooperation with the research community helps to maintain e-infrastructure at the cutting edge of current knowledge while ensuring the continuous development of the services provided and their world-class quality. In addition to all the above-mentioned, the certification requirements for data storage facilities to fulfil the "FAIR principles" (*Findable, Accessible, Interoperable, Reusable*) in respect of (meta) data files have been recently added, posing increased requirements on an entity's own e-infrastructures, data producers and their users.

Since 2010, three national e-infrastructures have been developed in the Czech Republic. These include CESNET (*CESNET e-infrastructure*), CERIT-SC (*CERIT Scientific Cloud*) and IT4Innovations (*IT4Innovations National Supercomputing Centre*). Together, these constitute the Czech national e infrastructure for research, development and innovations. Research organisations administering these e-infrastructures rely on over twenty years of experience in providing high-quality, flexible, comprehensive, secure and reliable ICT services for the Czech research community that are cutting-edge and fully comparable to similar foreign e-infrastructures.

Individual components of the national e-infrastructure of the Czech Republic include the National Research and Education Network (NREN) CESNET2, the National Grid Infrastructure MetaCentrum, National Supercomputing Centre (the Salomon supercomputer ranks among the most powerful supercomputers worldwide) and high-capacity data storage infrastructure. The key authentication and authorisation infrastructure governing access to the infrastructure is the Czech academic identity federation eduID.cz. This federation interconnects the identity providers (entities from which the users originate) and the service providers, and is a member of the pan-European inter-federation eduGAIN. The e-infrastructure's security is provided for by the internationally-accredited CESNET-CERTS security team in collaboration with other similar teams from CERIT-SC and IT4Innovations.

The above-listed components of the Czech national e-infrastructure also constitute the Czech national nodes within the European



▶ e-INFRA CZ (*e-infrastructure CZ*)

and global research infrastructures, such as the European communication infrastructure GÉANT, the European Grid Infrastructure EGI, the European HPC e infrastructure PRACE (*Partnership for Advanced Computing in Europe*) and the Global experimental infrastructure GLIF. Thus, Czech e-infrastructure ensures the interconnection of the Czech Republic and ERA, providing the other Czech research infrastructures and research teams access to unique research infrastructures actually located abroad, and mitigates the need for Czech researches to go abroad in order to join similar excellent research infrastructures.

The Czech Republic's e-infrastructure is also linked to other European initiatives, including for instance, the European Technology Platform for High Performance Computing ETP4HPC and the European Network on High Performance and Embedded Architecture and Compilation HiPEAC. Last but not least, they play a major role in connecting the Czech Republic with the European Open Science Cloud EOSC and the European High-Performance Computing Joint Undertaking EuroHPC.

Being fully integrated in the European e-infrastructure, the Czech e-infrastructure not only provides the Czech research community access to advanced ICT services, but also contributes to its long-term sustainability. By cumulating and streamlining the ICT resources within individual e-infrastructure components, significantly higher efficiency can be achieved compared to the individual abilities of these facilities. Thus, considerably larger ICT resources, which individual research institutions and infrastructures could not possibly afford, may be acquired and exploited. At the same time, this approach has a positive impact on efficient e-infrastructure operations, not only by reducing operation costs, but also by minimising their impact on the environment.

Thanks to its distributed structure, the Czech e-infrastructure contributes significantly towards the widespread availability of excellent modern ICT services with the same parameters across all the regions of the Czech Republic. This has recently become a necessary precondition to maintain and deepen the level of competitiveness of research, development and innovations in the Czech Republic, and consequently the competitiveness of the Czech economy.

Besides providing services for research, development and innovations, the e-infrastructure also establishes a unique environment for experimenting and testing new technologies relating to the e infrastructure's own operation (mostly modern data transfer systems, computing and storage technologies and data analysis systems and environment). Moreover, e-infrastructure accelerates ICT development in all areas and plays a major role in building up the Czech information society.

The level of excellence of individual components of the Czech national e-infrastructure, and the importance and indispensability of e-infrastructures for research, development and innovations have also been confirmed in

▶ e-INFRA CZ (*e-infrastructure CZ*)

◀ e-INFRA CZ (*e-infrastructure CZ*)

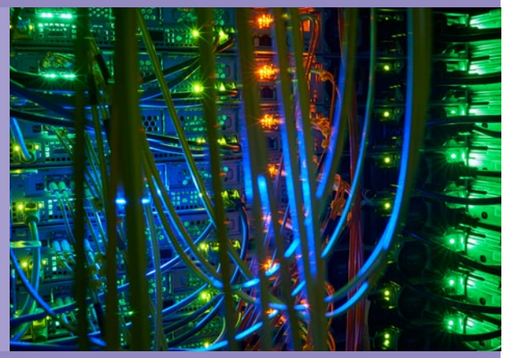
the international evaluation of large research infrastructures organised by the MEYS held in 2017. In the consensus report, the International Assessment Committee recommended that all entities involved in e-infrastructure activities in the Czech Republic closely collaborate to ensure the long-term funding and streamlining of all three e-infrastructures into a single national e-infrastructure. All three e-infrastructures in the Czech Republic have been closely cooperating to coordinate their activities. Closer collaboration in building up a common national e-infrastructure will enable the exploitation of the synergic effects, thus creating a single national environment which, from the point of view of the users, provides barrier-free access to the services provided and is interconnected with the European e-infrastructure.

In relation to the 2019 update to the Roadmap of Large Research Infrastructures of the Czech Republic for the years 2016-2022, the e-infrastructures in the Czech Republic have agreed to establish a consortium jointly responsible for the national e-infrastructure **e-INFRA CZ** (*e-infrastructure CZ*). In the upcoming period, the task of the single national e-infrastructure will be to continue to further develop the national environment of excellence and to enlarge and enhance the incorporation of the Czech e-infrastructure into European and international e-infrastructures such as GÉANT, EGI, PRACE and EuroHPC. At the same time, such an integrated e-infrastructure should not only provide the Czech research entities access to EOSC and enable them to exploit the resources and data of this e infrastructure, but also to adapt its architecture, internal processes and horizontal relations so that its ICT resources, devices and data could be exploited by other entities within the EOSC framework.

The Roadmap of Large Research Infrastructures of the Czech Republic places emphasis on the sustainability and further development of the national e-infrastructure's components and related services briefly described above. The objective is to offer the Czech research community the highest-quality ICT support, thus contributing towards increasing the economic competitiveness of the Czech Republic.

▲ e-INFRA CZ (*e-infrastructure CZ*)

e-Infrastruktura CZ



Akronym:
e-INFRA CZ

Hosting institution:
CESNET, z. s. p. o.

Partner institutions:
Masaryk University
VŠB – Technical University of Ostrava

Phase: operational
Character: distributed

Responsible person:
Dr Jan Gruntorád
jan.gruntorad@cesnet.cz

Website:
e-infra.cz

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2018: landmark

Motto:
An excellent ICT environment, capacity and services for research, development, innovation and education.

Characteristics

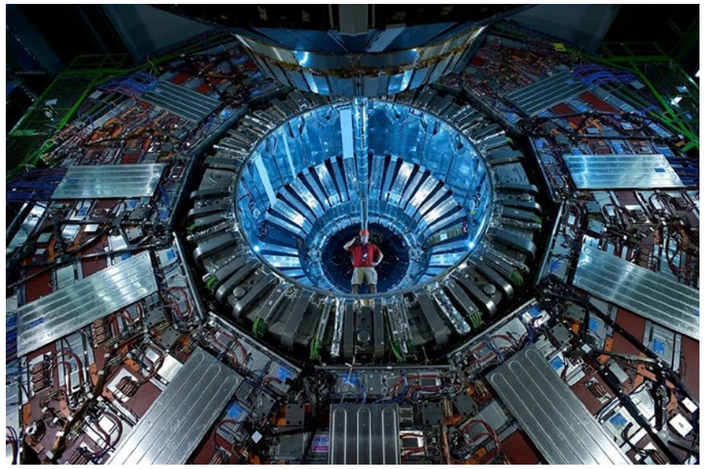
e-INFRA CZ provides unique e-infrastructure for research, development and innovation in the Czech Republic and offers a fully transparent environment ensuring comprehensive capacities and resources for transferring, storing and processing scientific data for all entities engaged in research, development and innovation across various sectors. Thus, it establishes a communication, information, storage and computer platform for research, development and innovation at both the national and international levels and provides an extensive and comprehensive portfolio of ICT services, without which modern research, development and innovation could not be carried out. The e-INFRA CZ consists of (1) a highly efficient national communication infrastructure; (2) a national grid and cloud infrastructure; (3) the most powerful and state-of-art supercomputer systems in the Czech Republic; and (4) high-capacity data storage. Other tools and services, such as ICT resource access management, tools supporting remote collaboration, and tools ensuring secure communication and data protection, which collectively enable an efficient yet manifold application, make up an inherent part of the e-infrastructure while contributing to increased added value. e INFRA CZ interconnects all 3 national e-infrastructures in the Czech Republic – CESNET (*e-infrastructure CESNET*), CERIT-SC (*CERIT Scientific Cloud*) and IT4Innovationss (*IT4Innovationss National Supercomputing Center*), all incorporated in the Roadmap of Large Research Infrastructures of the Czech Republic since 2010, thus taking a joint step towards integrating them more closely. Those research organisations operating e-INFRA CZ can boast of more than 20 years of experience in providing high-quality, flexible, secure and reliable comprehensive ICT services for the research community in the Czech Republic. The services provided are cutting-edge and fully comparable with similar foreign e-infrastructures. The basis of the Czech e-infrastructure is the CESNET2 National Research and Education Network (NREN). This backbone e-infrastructure was designed as a multi-layer system interconnected across individual layers, both by means of research projects and user networks and foreign research networks, the GÉANT pan-European network and the GLIF (*Global Lambda Integrated Facility*) experimental infrastructure. The communication infrastructure offers parallel support of IPv4 and IPv6 protocols with a number of advanced functions and features, and provides selected services in individual network layers, in particular lambda services and remote access to user research equipment in real time. At the same time, e-INFRA CZ provides extensive computing capacities, the basis of which consists of a cluster network and powerful systems interconnected within the National Grid and Cloud Infrastructure – the MetaCentrum. This is a heterogeneous (with regards to various types of computing capacities and owners) and dynamically changing (with regards to hardware and software life cycle) system that is interconnected with common tools and technologies for the administration and management of the entire e-infrastructure's operation and creates a single environment for the provision of services. At present, two large, and on the Czech national level, unique supercomputers, Anselm and Salomon, form the peak of the computational output of e-INFRA CZ, the latter being one of the most powerful supercomputers in the entire world. Another inherent component of e INFRA CZ is its data storage infrastructure. This high-capacity data storage is currently distributed across four geographically independent localities across the Czech Republic. Storage systems are accessible through a number of protocols, including NFSv4, rsync, scp, FTPS, the Globus (formerly Globus Online) application and the dCache system. Sophisticated applications include the FileSender file depository and its own storage cloud. The computing and storage facilities are closely interconnected with the communications network, thus creating a comprehensive environment for the processing of bulk data. The key authentication and authorisation infrastructure governing access to the e-infrastructure is the Czech academic identity federation eduID.cz. This federation interconnects identity providers (entities from which the users originate) and service providers, and is a member of the eduGAIN pan-European inter-federation. e-INFRA CZ also operates the national node of the eduroam worldwide academic roaming. The e-infrastructure's security is provided for by an internationally-accredited CESNET-CERTS security team in collaboration with other similar teams from other e-INFRA CZ members. In order to efficiently take advantage of this unique infrastructure, regular workshops and training sessions are held, both at the national and international levels. All resources in the possession of e INFRA CZ are made available to the entire Czech research community, including university students, through an open access regime. e-INFRA CZ systematically participates in the research activities of its users, bringing powerful resources and ICT expertise necessary to perform research, development and innovation par excellence in every scientific branch. By efficiently utilizing available ICT resources, e-INFRA CZ contributes towards substantially speeding-up research, development and innovation in individual areas of user professional interest. Further e-infrastructure development will include the continuous innovation, development and experimental operation of new components in order for the e-infrastructure to continue to provide excellent services to its users. When developing the e-infrastructure, the greatest emphasis is placed on user needs and modern technology trends, not only from the point of view of capacities provided, but also from the point of view of user security, data protection, economic efficiency and environmental impact. No less emphasis is placed on the development of human resources to ensure a sufficient number of experts necessary to provide comprehensive e-infrastructure services of the highest quality. e-INFRA CZ is a Czech national node of the following European and global research infrastructures: the GÉANT European communication infrastructure, the EGI European Grid Infrastructure, the European HPC PRACE (*Partnership for Advanced Computing in Europe*) e-infrastructure, and the GLIF Global Experimental Infrastructure. e-INFRA CZ is also a member of other European initiatives, such as the EOSC (*European Open Science Cloud*), the EuroHPC (*European High-Performance Computing*), the HiPEAC (*European Network on High Performance and Embedded Architecture and Compilation*) and the ETP4HPC (*European Technology Platform for High Performance Computing*).

Socio-economic benefits

E-infrastructures have an impact on almost all scientific, industrial and social sectors. Their services complement time-consuming and expensive experimental development, and provide a fundamental research and development tool in all developed countries. e-INFRA CZ has a positive impact on reducing the disparities between individual regions of the Czech Republic caused by different speeds of development and the availability of new technologies to the research community. The high quality of services provided ensures the competitiveness of the Czech Republic on both European and global scales. Furthermore, high productivity and competitiveness in research, development and innovation has a positive impact on business and the economy in general. In addition, e-INFRA CZ facilitates enlarging the knowledge base and enhancing ICT awareness in the Czech Republic in the broadest sense. The collaboration between e-INFRA CZ and the industrial sector is carried out on two levels. The first level includes common research activities performed together with businesses. The second level includes the provision of services (e-infrastructure capacities and contractual research) and the provision of licences in respect of the results of its own research. In relation to the output of its own research, several spin-offs (e.g. FlowMon, a.s. and Netcope, a.s.) have been established. The benefits for Czech public authorities lie not only in the actual provision of services to this segment, but also in the participation in the establishment of regional or specific key infrastructures. One essential benefit is the defence of the Czech Republic's cyberspace. In addition, e-INFRA CZ significantly participates in the development of new drugs, personalised medicine, material research and development of nanotechnologies, natural disaster prediction, research in security, environmental care, the development of new energy sources and intelligent transport systems, as well as in implementing the Smart City and Industry 4.0 concepts.

Annex 1: Large research infrastructures approved by the Government of the Czech Republic for financing from the public funds of the Czech Republic until 2022

Scientific field	Acronym	Large research infrastructure	Hosting / Partner institution	Location	Phase	Character	Year of inclusion on the Czech Roadmap	Status on the ESFRI Roadmap 2018
Physical sciences and engineering	**AUGER-CZ**	**Pierre Auger Observatory – participation of the Czech Republic**	Institute of Physics of the Czech Academy of Sciences (coordinator) Charles University Palacký University Olomouc	Argentina	operational	single-sited	2010	–
	BNL-CZ	**Brookhaven National Laboratory – participation of the Czech Republic**	Czech Technical University in Prague (coordinator) Charles University Nuclear Physics Institute of the Czech Academy of Sciences	USA	operational	single-sited	2015	–
	CEMNAT	**Centre of Materials and Nanotechnologies**	University Pardubice	Czech Republic	operational	single-sited	2015	–
	CEPLANT	**R&D Centre for Low-Cost Plasma and Nanotechnology Surface Modifications**	Masaryk University	Czech Republic	operational	single-sited	2019	–
	CERN-CZ	**Research Infrastructure for Experiments at CERN**	Institute of Physics of the Czech Academy of Sciences (coordinator) Czech Technical University in Prague Technical University of Liberec Charles University Palacký University Olomouc Nuclear Physics Institute of the Czech Academy of Sciences University of West Bohemia	Switzerland	operational	distributed	2010	ESFRI Landmark
	CTA-CZ	**Cherenkov Telescope Array – participation of the Czech Republic**	Institute of Physics of the Czech Academy of Sciences (coordinator) Charles University Palacký University Olomouc	Chile, Spain	construction	single-sited	2015	ESFRI Landmark
	CzechNanoLab	**CzechNanoLab Research Infrastructure**	Brno University of Technology (coordinator) Institute of Physics of the Czech Academy of Sciences Masaryk University	Czech Republic	operational	distributed	2010	–
	ELI Beamlines	**Extreme Light Infrastructure – ELI Beamlines**	Institute of Physics of the Czech Academy of Sciences	Czech Republic	operational	single-sited	2010	ESFRI Landmark



▶ CERN (*Conseil Européen pour la Recherche Nucléaire*) – CMS (*Compact Muon Solenoid*)

Scientific field	Acronym	Large research infrastructure	Hosting / Partner institution	Location	Phase	Character	Year of inclusion on the Czech Roadmap	Status on the ESFRI Roadmap 2018
Physical sciences and engineering	**ESS Scandinavia-CZ**	**European Spallation Source – participation of the Czech Republic**	Nuclear Physics Institute of the Czech Academy of Sciences	Sweden	construction	single-sited	2010	ESFRI Landmark
	EST-CZ	**European Solar Telescope – participation of the Czech Republic**	Astronomical Institute of the Czech Academy of Sciences	Spain	preparatory	single-sited	2019	ESFRI Project
	EU-ARC.CZ	**Atacama Large Millimeter / Submillimeter Array – participation of the Czech Republic**	Astronomical Institute of the Czech Academy of Sciences	Chile	operational	distributed	2015	–
	FAIR-CZ	**Facility for Antiproton and Ion Research – participation of the Czech Republic**	Nuclear Physics Institute of the Czech Academy of Sciences (coordinator) Czech Technical University in Prague Charles University Silesian University in Opava	Germany	construction	single-sited	2010	ESFRI Landmark
	Fermilab-CZ	**Research Infrastructure for Fermilab Experiments**	Institute of Physics of the Czech Academy of Sciences (coordinator) Czech Technical University in Prague Charles University Institute of Computer Science of the Czech Academy of Sciences	USA	operational	single-sited	2010	–
	LSM-CZ	**Laboratoire Souterrain de Modane – participation of the Czech Republic**	Czech Technical University in Prague (coordinator) National Radiation Protection Institute	France	operational	single-sited	2010	–
	MGML	**Materials Growth and Measurement Laboratory**	Charles University (coordinator) Institute of Physics of the Czech Academy of Sciences	Czech Republic	operational	single-sited	2010	–
	PALS	**Prague Asterix Laser System**	Institute of Plasma Physics of the Czech Academy of Sciences Institute of Physics of the Czech Academy of Sciences	Czech Republic	operational	single-sited	2010	–
	SPIRAL2-CZ	**Système de Production d'Ions Radioactifs Accélérés en Ligne – participation of the Czech Republic**	Nuclear Physics Institute of the Czech Academy of Sciences	France	construction	single-sited	2010	ESFRI Landmark
	SPL-MSB	**Surface Physics Laboratory – Materials Science Beamline**	Charles University	Italy, Czech Republic	operational	distributed	2010	–
	VdG	**Van de Graaff Accelerator – A Tunable Source of Mono-energetic Neutrons and Light Ions**	Czech Technical University in Prague	Czech Republic	operational	single-sited	2010	–

▶ Pierre Auger Observatory

Scientific field	Acronym	Large research infrastructure	Hosting / Partner institution	Location	Phase	Character	Year of inclusion on the Czech Roadmap	Status on the ESFRI Roadmap 2018
Energy	CATPRO	Efficient Use of Energy Resources Using Catalytic Processes	Unipetrol Centre for Research and Education, a. s.	Czech Republic	operational	single-sited	2015	–
	COMPASS	COMPASS – Tokamak for Thermonuclear Fusion Research	Institute of Plasma Physics of the Czech Academy of Sciences	Czech Republic	operational	single-sited	2010	–
	ENREGAT	Energy Waste Recovery and Gas Treatment	VŠB – Technical University of Ostrava	Czech Republic	operational	single-sited	2019	–
	JHR-CZ	Jules Horowitz Reactor – participation of the Czech Republic	Research Centre Řež s r.o.	France	construction	single-sited	2010	ESFRI Landmark
	Reactors LVR-15 and LR-0	Nuclear Research Reactors LVR-15 and LR-0	Research Centre Řež s.r.o.	Czech Republic	operational	single-sited	2010	–
	WCZV	VR-1 – Training Reactor for Research Activities	Czech Technical University in Prague	Czech Republic	operational	single-sited	2011	–
Environmental sciences	ACTRIS-CZ	ACTRIS – participation of the Czech Republic	Czech Hydrometeorological Institute (coordinator) Masaryk University Institute of Chemical Process Fundamentals of the Czech Academy of Sciences Global Change Research Centre of the Czech Academy of Sciences	Czech Republic	operational	distributed	2015	ESFRI Project
	CENAKVA	South Bohemian Research Centre of Aquaculture and Biodiversity of Hydrocenoses	University of South Bohemia in České Budějovice	Czech Republic	operational	single-sited	2019	–
	CzeCOS	CzeCOS	Global Change Research Institute of the Czech Academy of Sciences	Czech Republic	operational	distributed	2010	ESFRI Landmark ESFRI Project
	NanoEnviCz	Nanomaterials and Nanotechnologies for Environment Protection and Sustainable Future	J. Heyrovsky Institute of Physical Chemistry of the Czech Academy of Sciences (coordinator) Technical University of Liberec University of J. E. Purkyně in Ústí nad Labem Palacký University Olomouc Institute of Inorganic Chemistry of the Czech Academy of Sciences Institute of Experimental Medicine of the Czech Academy of Sciences	Czech Republic	operational	distributed	2015	–
	RECETOX RI	RECETOX Research Infrastructure	Masaryk University	Czech Republic	construction	single-sited	2010	–

▼ CzeCOS

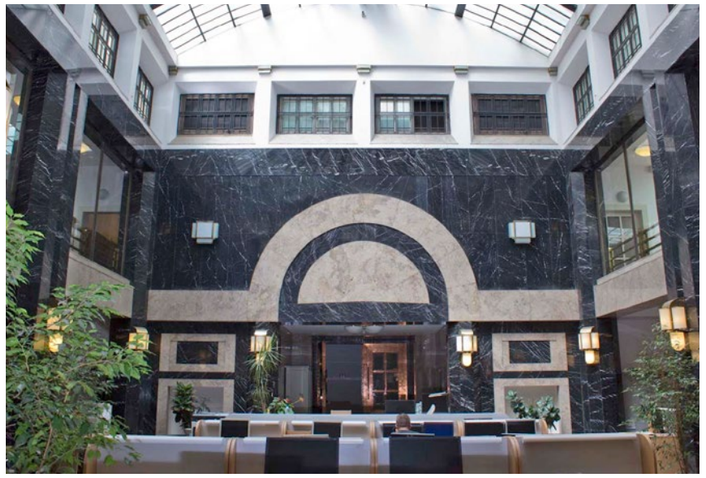
Scientific field	Acronym	Large research infrastructure	Hosting / Partner institution	Location	Phase	Character	Year of inclusion on the Czech Roadmap	Status on the ESFRI Roadmap 2018
Health and food	**BBMRI-CZ**	**Bank of Clinical Specimens**	Masaryk Memorial Cancer Institute (coordinator) First Faculty of Medicine of Charles University in Prague Faculty of Medicine of Charles University in Hradec Kralové Faculty of Medicine of Charles University in Pilsen Faculty of Medicine of the Palacký University in Olomouc	Czech Republic	operational	distributed	2010	ESFRI Landmark
	CCP	**Czech Centre for Phenogenomics**	Institute of Molecular Genetics of the Czech Academy of Sciences	Czech Republic	operational	single-sited	2010	ESFRI Landmark
	CIISB	**Czech Infrastructure for Integrative Structural Biology**	Masaryk University (coordinator) Institute of Biotechnology of the Czech Academy of Sciences	Czech Republic	operational	distributed	2010	ESFRI Landmark
	CZECRIN	**Czech National Node to the European Clinical Research Infrastructure Network**	Masaryk University (coordinator) St. Anne´s University Hospital in Brno	Czech Republic	operational	distributed	2010	ESFRI Landmark
	Czech-BioImaging	**National Research Infrastructure for Biological and Medical Imaging**	Institute of Molecular Genetics of the Czech Academy of Sciences (coordinator) Biology Centre of the Czech Academy of Sciences Institute of Physiology of the Czech Academy of Sciences Masaryk University Charles University Palacký University Olomouc Institute of Experimental Botany of the Czech Academy of Sciences Institute of Scientific Instruments of the Czech Academy of Sciences Brno University of Technology	Czech Republic	operational	distributed	2010	ESFRI Landmark
	CZ-OPENSCREEN	**National Infrastructure for Chemical Biology**	Institute of Molecular Genetics of the Czech Academy of Sciences (coordinator) Masaryk University Palacký University Olomouc University of Chemistry and Technology Prague	Czech Republic	operational	distributed	2010	ESFRI Landmark

▶ EMBL (*European Molecular Biology Laboratory*)

Scientific field	Acronym	Large research infrastructure	Hosting / Partner institution	Location	Phase	Character	Year of inclusion on the Czech Roadmap	Status on the ESFRI Roadmap 2018
Health and food	**EATRIS-CZ**	**Czech National Node to the European Infrastructure for Translational Medicine**	Palacký University Olomouc (coordinator) St. Anne´s University Hospital in Brno Masaryk University Institute of Microbiology of the Czech Academy of Sciences Charles University Institute of Experimental Medicine of the Czech Academy of Sciences Nuclear Physics Institute of the Czech Academy of Sciences Institute of Macromolecular Chemistry of the Czech Academy of Sciences Institute of Organic Chemistry and Biochemistry of the Czech Academy of Sciences University of Chemistry and Technology Prague	Czech Republic	operational	distributed	2010	ESFRI Landmark
	ELIXIR-CZ	**Czech National Infrastructure for Biological Data**	Institute of Organic Chemistry and Biochemistry of the Czech Academy of Sciences (coordinator) Biology Centre of the Czech Academy of Sciences Institute of Biotechnology of the Czech Academy of Sciences CESNET, z. s. p. o. Czech Technical University in Prague St. Anne´s University Hospital in Brno University of South Bohemia in České Budějovice Masaryk University Institute of Microbiology of the Czech Academy of Sciences Charles University Palacký University Olomouc Institute of Molecular Genetics of the Czech Academy of Sciences University of Chemistry and Technology Prague University of West Bohemia	Czech Republic	operational	distributed	2011	ESFRI Landmark
	METROFOOD-CZ	**Infrastructure for Promoting Metrology in Food and Nutrition in the Czech Republic**	Czech University of Life Sciences Prague (coordinator) University of Chemistry and Technology Prague Food Research Institute Prague	Czech Republic	operational	distributed	2019	ESFRI Project
	NCMG	**National Center for Medical Genomic**	Charles University (coordinator) University Hospital Brno Masaryk University Palacký University Olomouc	Czech Republic	operational	distributed	2011	–

▶ EMBL (*European Molecular Biology Laboratory*)

Scientific field	Acronym	Large research infrastructure	Hosting / Partner institution	Location	Phase	Character	Year of inclusion on the Czech Roadmap	Status on the ESFRI Roadmap 2018
Social sciences and humanities	**AIS CR**	**Archaeological Information System of the Czech Republic**	Institute of Archaeology of the Czech Academy of Sciences, Brno (coordinator) Institute of Archaeology of the Czech Academy of Sciences, Prague	Czech Republic	operational	virtual	2015	–
	CLB	**Czech Literary Bibliography**	Institute of Czech Literature of the Czech Academy of Sciences	Czech Republic	operational	virtual	2015	–
	CNC	**Czech National Corpus**	Charles University	Czech Republic	operational	virtual	2010	–
	CSDA	**Czech Social Science Data Archive**	Institute of Sociology of the Czech Academy of Sciences	Czech Republic	operational	virtual	2010	ESFRI Landmark
	ESS-CZ	**Czech National Node of the ESS (European Social Survey)**	Institute of Sociology of the Czech Academy of Sciences	Czech Republic	operational	virtual	2010	ESFRI Landmark
	LINDAT/CLARIAH-CZ	**Digital Research Infrastructure for Language Technologies, Arts and Humanities**	Charles University (coordinator) Institute of Philosophy of the Czech Academy of Sciences Institute of History of the Czech Academy of Sciences Library of the Czech Academy of Sciences Masaryk University Moravian Library National Film Archive National Gallery National Library Prague Institute of the Czech Language of the Czech Academy of Sciences University of West Bohemia	Czech Republic	operational	distributed	2010	ESFRI Landmark
	SHARE-CZ	**Survey of Health, Ageing and Retirement in Europe – participation of the Czech Republic**	Economics Institute of the Czech Academy of Sciences	Czech Republic	operational	distributed	2010	ESFRI Landmark
e-Infrastructures	**e-INFRA CZ**	**e-Infrastructure CZ**	CESNET, z. s. p. o. (coordinator) Masaryk University VŠB – Technical University of Ostrava	Czech Republic	operational	distributed	2010	ESFRI Landmark



▶ LINDAT-CLARIAH/CZ (*Digital Research Infrastructure for Language Technologies, Arts and Humanities*)

Annex 2: International Assessment Committee of Large Research Infrastructures of the Czech Republic in 2017

Chair

Peter FLETCHER (UK) — Science and Technology Facilities Council, United Kingdom

Physical sciences and engineering

Colin CARLILE (UK) — Uppsala Universitet, Sweden / *Chair*
Gerd LEUCHS (DE) — Max-Planck-Institut für die Physik des Lichts, Germany / *Member*
Mario PIMENTA (PT) — Laboratório de Instrumentação e Física Experimental de Partículas, Portugal / *Member*
Bijan SAGHAI (FR) — Commissariat à l'Énergie Atomique et aux Énergies Alternatives, France / *Member*
Martin PUMERA (CZ) — Nanyang Technological University, Singapur / *Member*

Energy

Bent LAURITZEN (DK) — Danmarks Tekniske Universitet, Denmark / *Chair*
Lothar FICKERT (AT) — Technische Universität Graz, Austria / *Member*
Kathryn McCARTHY (US) — United States Nuclear Regulatory Commission, USA; Canadian Nuclear Laboratories, Canada / *Member*
Thomas SCHULENBERG (DE) — Karlsruher Institut für Technologie, Germany / *Member*
Tadeáš OCHODEK (CZ) — VŠB – Technical University of Ostrava, Czech Republic / *Member*

Environmental sciences

Jozef PACYNA (PL) — Norsk Institutt for Luftforskning, Norway / *Chair*
Magnus FRIBERG (SE) — Vetenskapsrådet, Sweden / *Member*
Philippe GARRIGUES (FR) — Université de Bordeaux, France / *Member*
Milena HORVAT (SI) — Institut "Jožef Stefan", Slovenia / *Member*
Pavel JENÍČEK (CZ) — University of Chemistry and Technology Prague, Czech Republic / *Member*

Health and food

Marialuisa LAVITRANO (IT) — Università degli Studi di Milano-Bicocca, Italy / *Chair*
Gregor ANDERLUH (SI) — Kemijski Inštitut, Slovenia / *Member*
Johanna MYLLYHARJU (FI) — Oulun yliopisto, Finland / *Member*
Serge PEREZ (FR) — Centre National de la Recherche Scientifique, France / *Member*
Tomáš BÜCHLER (CZ) — Charles University, Czech Republic / *Member*

Social sciences and humanities

Lorna HUGHES (UK) — University of Glasgow, United Kingdom / *Chair*
Patrick DEBOOSERE (BE) — Vrije Universiteit Brussel, Belgium / *Member*
Karl H. MUELLER (AT) — Steinbeis Transfer Center New Cybernetics, Austria / *Member*
Andreas WITT (DE) — Ruprecht-Karls-Universität Heidelberg, Germany / *Member*
Petr KITZLER (CZ) — Institute of Philosophy of the Czech Academy of Sciences, Czech Republic / *Member*

e-Infrastructures

Lajos BÁLINT (HU) — Nemzeti Információs Infrastruktúra Fejlesztési Intézet, Hungary / *Chair*
Kimmo KOSKI (FI) — CSC – IT Center for Science Ltd., Finland / *Member*
Dieter KRANZLMÜLLER (DE) — Ludwig-Maximilians-Universität München, Germany / *Member*
Kees NEGGERS (NL) — SURFnet, Netherlands / *Member*
Zdeněk STRAKOŠ (CZ) — Charles University, Czech Republic / *Member*

Annex 3: International Assessment Committee evaluating the benefits of Czech memberships in international R&D organisations founded under international public law in 2016

CHAIR

Peter FLETCHER (UK) — Science and Technology Facilities Council, United Kingdom

CERN, ESO, JINR

Agnieszka ZALEWSKA (PL) — Uniwersytet Jagielloński w Krakowie, Poland
Peter JENNI (CH) — Albert-Ludwigs-Universität Freiburg, Germany
Siegfried BETHKE (DE) — Max-Planck-Institut für Physik, Germany

EMBC, EMBL

Anthony HYMAN (UK) — Max-Planck-Institut für molekulare Zellbiologie und Genetik, Germany
Wilhelm ANSORGE (CH) — École Polytechnique Fédérale de Lausanne, Switzerland
Israel PECHT (IL) — Weizmann Institute of Science, Israel

ESA

Xavier BARCONS (ES) — European Organisation for Astronomic Research in the Southern Hemisphere, Germany
Volker GASS (CH) — Swiss Space Center – École Polytechnique Fédérale de Lausanne, Switzerland
John ZARNECKI (UK) — International Space Science Institute, Switzerland

◀ ESA (*European Space Agency*) – Solar Orbiter Artist's Impression

Annex 4: Working Group for the preparation of the 2019 update to the Roadmap of Large Research Infrastructures of the Czech Republic for the years 2016-2022

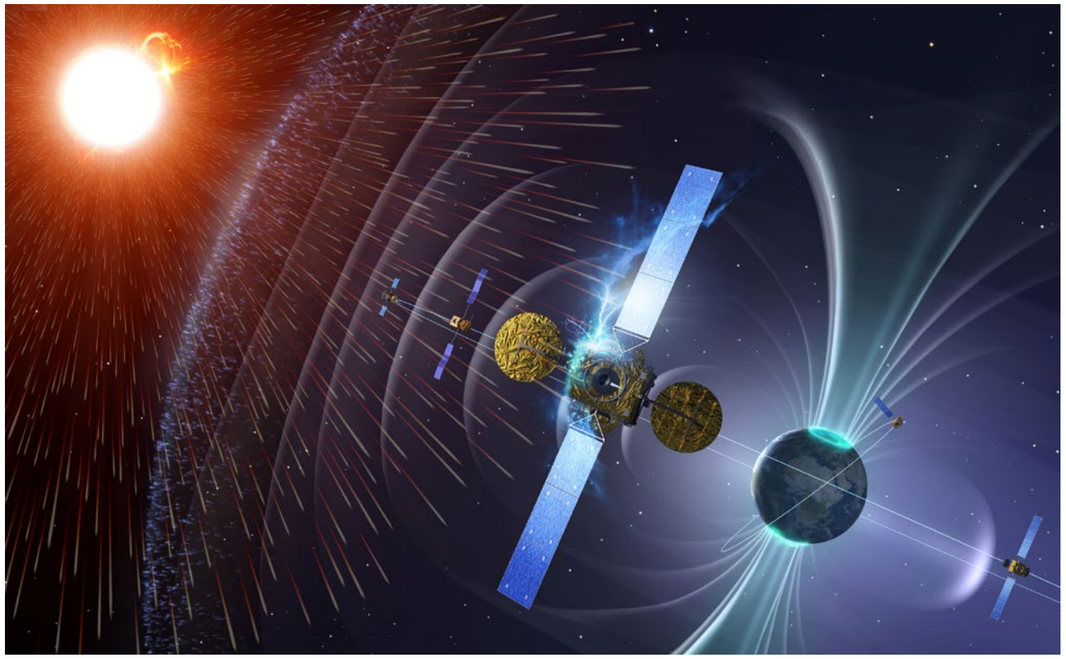
Pavel DOLEČEK / Deputy Minister for Higher Education, Science and Research, Ministry of Education, Youth and Sports
Lukáš LEVÁK / Director of Department for Research and Development; Ministry of Education, Youth and Sports
Jan HRUŠÁK / Special Envoy for Research Infrastructures; Ministry of Education, Youth and Sports
Petr VENTLUKA / Head of Unit for Research Infrastructures; Ministry of Education, Youth and Sports
Lucie NÚÑEZ TAYUPANTA / Head of Unit for European Research Area; Ministry of Education, Youth and Sports
Jan BURIÁNEK / Unit for Research Infrastructures; Ministry of Education, Youth and Sports
Ondřej NOVÁK / Unit for Research Infrastructures; Ministry of Education, Youth and Sports
Marek VYŠINKA / Unit for Research Infrastructures; Ministry of Education, Youth and Sports
Kamila GABRIELOVÁ / Unit for Research Infrastructures; Ministry of Education, Youth and Sports
Renáta CHUDÁČKOVÁ / Unit for Research Infrastructures; Ministry of Education, Youth and Sports
Veronika MACKOVÁ / Unit for Research Infrastructures; Ministry of Education, Youth and Sports
Helena ŘÍMSKÁ / Unit for Research Infrastructures; Ministry of Education, Youth and Sports
Jitka SIGMUNDOVÁ / Unit for European Research Area; Ministry of Education, Youth and Sports

Jan ŘÍDKÝ / Institute of Physics of the Czech Academy of Sciences
Petr LUKÁŠ / Nuclear Physics Institute of the Czech Academy of Sciences
Ivan ŠTEKL / Czech Technical University in Prague
Radomír PÁNEK / Institute of Plasma Physics of the Czech Academy of Sciences
Michal V. MAREK / Global Change Research Institute of the Czech Academy of Sciences
Jana KLÁNOVÁ / Masaryk University
Radislav SEDLÁČEK / Institute of Molecular Genetics of the Czech Academy of Sciences
Dalibor VALÍK / Masaryk Memorial Cancer Institute
Eva HAJIČOVÁ / Charles University
Jan HAJIČ / Charles University
Jindřich KREJČÍ / Institute of Sociology of the Czech Academy of Sciences
Jan GRUNTORÁD / CESNET, z. s. p. o.
Vít VONDRÁK / VŠB – Technical University of Ostrava

Annex 5: Membership of the Czech Republic in international R&D organisations established under international public law

CERN Conseil Européen pour la Recherche Nucléaire
EMBC European Molecular Biology Conference
EMBL European Molecular Biology Laboratory
ESA European Space Agency
ESO European Organisation for Astronomical Research in the Southern Hemisphere
JINR Joint Institute for Nuclear Research

▼ ESA (*European Space Agency*) – Space Weather Visualisation



Annex 6: Membership of the Czech Republic in European Research Infrastructure Consortia (ERIC)

ERIC	ERIC acronym			Large research infrastructure acronym	Large research infrastructure	Year of entry
Survey of Health, Ageing and Retirement in Europe ERIC	**SHARE-ERIC**			**SHARE-CZ**	Survey of Health, Ageing and Retirement in Europe – participation of the Czech Republic	2011
Common Language Resources and Technology Infrastructure ERIC	**CLARIN ERIC**			**LINDAT/CLARIAH-CZ**	Digital Research Infrastructure for Language Technologies, Arts and Humanities	2012
European Advanced Translational Research Infrastructure in Medicine ERIC	**EATRIS ERIC**			**EATRIS-CZ**	Czech National Node to the European Infrastructure for Translational Medicine	2013
European Social Survey ERIC	**ESS ERIC**			**ESS-CZ**	Czech National Node of the ESS (European Social Survey)	2013
Biobanks and Biomolecular Resources Research Infrastructure Consortium ERIC	**BBMRI-ERIC**			**BBMRI-CZ**	Bank of Clinical Specimens	2013
Central European Research Infrastructure Consortium ERIC	**CERIC-ERIC**			**SPL-MSB**	Surface Physics Laboratory – Materials Science Beamline	2014
European Spallation Source ERIC	**European Spallation Source ERIC**			**ESS Scandinavia-CZ**	European Spallation Source – participation of the Czech Republic	2015
Integrated Carbon Observation System ERIC	**ICOS ERIC**			**CzeCOS**	CzeCOS	2017
Consortium of European Social Science Data Archives ERIC	**CESSDA ERIC**			**CSDA**	Czech Social Science Data Archive	2017
Integrated Structural Biology ERIC	**Instruct-ERIC**			**CIISB**	Czech Infrastructure for Integrative Structural Biology	2017
European Clinical Research Infrastructrure Network ERIC	**ECRIN-ERIC**			**CZECRIN**	Czech National Node to the European Clinical Research Infrastructure Network	2018
European Infrastructure of Open Screening Platforms for Chemical Biology ERIC	**EU-OPENSCREEN ERIC**			**CZ-OPENSCREEN**	National Infrastructure for Chemical Biology	2018
Digital Research Infrastructure for the Arts and Humanities ERIC	**DARIAH ERIC**			**LINDAT/CLARIAH-CZ**	Digital Research Infrastructure for Language Technologies, Arts and Humanities	2019
European Research Infrastructure for Imaging Technologies in Biological and Biomedical Sciences ERIC	**Euro-BioImaging ERIC**			**Czech-BioImaging**	National Research Infrastructure for Biological and Medical Imaging	2019

▼ CERIC-ERIC (*Central European Research Infrastructure Consortium ERIC*) – Elettra Sincrotrone Trieste

Annex 7: Involvement of the Czech Republic in research infrastructures listed in the 2018 update to the Roadmap of European Strategy Forum on Research Infrastructures (ESFRI)

Scientific field	European research infrastructure	Acronym		Status	Acronym	Large research infrastructure
Physical sciences and engineering	Cherenkov Telescope Array	**CTA**		ESFRI Landmark	**CTA-CZ**	Cherenkov Telescope Array – participation of the Czech Republic
	Extreme Light Infrastructure	**ELI**		ESFRI Landmark	**ELI Beamlines**	Extreme Light Infrastructure – ELI Beamlines
	Extremely Large Telescope	**ELT**		ESFRI Landmark	*The Czech Republic participates in the ELT project due to its membership in the ESO international organisation.*	
	European Spallation Source ERIC	**European Spallation Source ERIC**		ESFRI Landmark	**ESS Scandinavia-CZ**	European Spallation Source – participation of the Czech Republic
	Facility for Antiproton and Ion Research	**FAIR**		ESFRI Landmark	**FAIR-CZ**	Facility for Antiproton and Ion Research – participation of the Czech Republic
	High-Luminosity Large Hadron Collider	**HL-LHC**		ESFRI Landmark	**CERN-CZ**	Research Infrastructure for Experiments at CERN
	Système de Production d'Ions Radioactifs en Ligne de 2e Génération	**SPIRAL2**		ESFRI Landmark	**SPIRAL2-CZ**	Système de Production d'Ions Radioactifs Accélérés en Ligne – participation of the Czech Republic
	European Solar Telescope	**EST**		ESFRI Project	**EST-CZ**	European Solar Telescope – participation of the Czech Republic
Energy	Jules Horowitz Reactor	**JHR**		ESFRI Landmark	**JHR-CZ**	Jules Horowitz Reactor – participation of the Czech Republic
Environmental sciences	Integrated Carbon Observation System ERIC	**ICOS ERIC**		ESFRI Landmark	**CzeCOS**	CzeCOS
	Aerosols, Clouds and Trace Gases Research Infrastructure	**ACTRIS**		ESFRI Project	**ACTRIS-CZ**	ACTRIS – participation of the Czech Republic
	International Centre for Advanced Studies on River-Sea Systems	**DANUBIUS-RI**		ESFRI Project	**CzeCOS**	CzeCOS
	Infrastructure for Analysis and Experimentation on Ecosystems	**AnaEE**		ESFRI Project	**CzeCOS**	CzeCOS
Health and food	Biobanks and Biomolecular Resources Research Infrastructure Consortium ERIC	**BBMRI-ERIC**		ESFRI Landmark	**BBMRI-CZ**	Bank of Clinical Specimens
	European Advanced Translational Research Infrastructure in Medicine ERIC	**EATRIS ERIC**		ESFRI Landmark	**EATRIS-CZ**	Czech National Node to the European Infrastructure for Translational Medicine
	European Clinical Research Infrastructure Network ERIC	**ECRIN-ERIC**		ESFRI Landmark	**CZECRIN**	Czech National Node to the European Clinical Research Infrastructure Network
	European Life-Science Infrastructure for Biological Information	**ELIXIR**		ESFRI Landmark	**ELIXIR-CZ**	Czech National Infrastructure for Biological Data
	European Infrastructure of Open Screening Platforms for Chemical Biology ERIC	**EU-OPENSCREEN ERIC**		ESFRI Landmark	**CZ-OPENSCREEN**	National Infrastructure for Chemical Biology
	European Research Infrastructure for Imaging Technologies in Biological and Biomedical Sciences	**Euro-BioImaging**		ESFRI Landmark	**Czech-BioImaging**	National Research Infrastructure for Biological and Medical Imaging
	European Research Infrastructure for the Generation, Phenotyping, Archiving and Distribution of Model Mammalian Genomes	**INFRAFRONTIER**		ESFRI Landmark	**CCP**	Czech Centre for Phenogenomics
	Integrated Structural Biology ERIC	**Instruct-ERIC**		ESFRI Landmark	**CIISB**	Czech Infrastructure for Integrative Structural Biology
	Infrastructure for Promoting Metrology in Food and Nutrition	**METROFOOD-RI**		ESFRI Project	**METROFOOD-CZ**	Infrastructure for Promoting Metrology in Food and Nutrition in the Czech Republic
Social sciences and humanities	Consortium of European Social Science Data Archives ERIC	**CESSDA ERIC**		ESFRI Landmark	**CSDA**	Czech Social Science Data Archive
	Common Language Resources and Technology Infrastructure ERIC	**CLARIN ERIC**		ESFRI Landmark	**LINDAT/CLARIAH-CZ**	Digital Research Infrastructure for Language Technologies, Arts and Humanities
	Digital Research Infrastructure for the Arts and Humanities ERIC	**DARIAH ERIC**		ESFRI Landmark	**LINDAT/CLARIAH-CZ**	Digital Research Infrastructure for Language Technologies, Arts and Humanities
	European Social Survey ERIC	**ESS ERIC**		ESFRI Landmark	**ESS-CZ**	Czech National Node of the ESS (European Social Survey)
	Survey of Health, Ageing and Retirement in Europe ERIC	**SHARE-ERIC**		ESFRI Landmark	**SHARE-CZ**	Survey of Health, Ageing and Retirement in Europe – participation of the Czech Republic
e-Infrastructures	Partnership for Advanced Computing in Europe	**PRACE**		ESFRI Landmark	**e-INFRA CZ**	e-Infrastructure CZ

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