Roadmap of Large Research Infrastructures of the Czech Republic for the years 2023–2026

Ministry of Education, Youth and Sports

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YOUTH AND SPORTS

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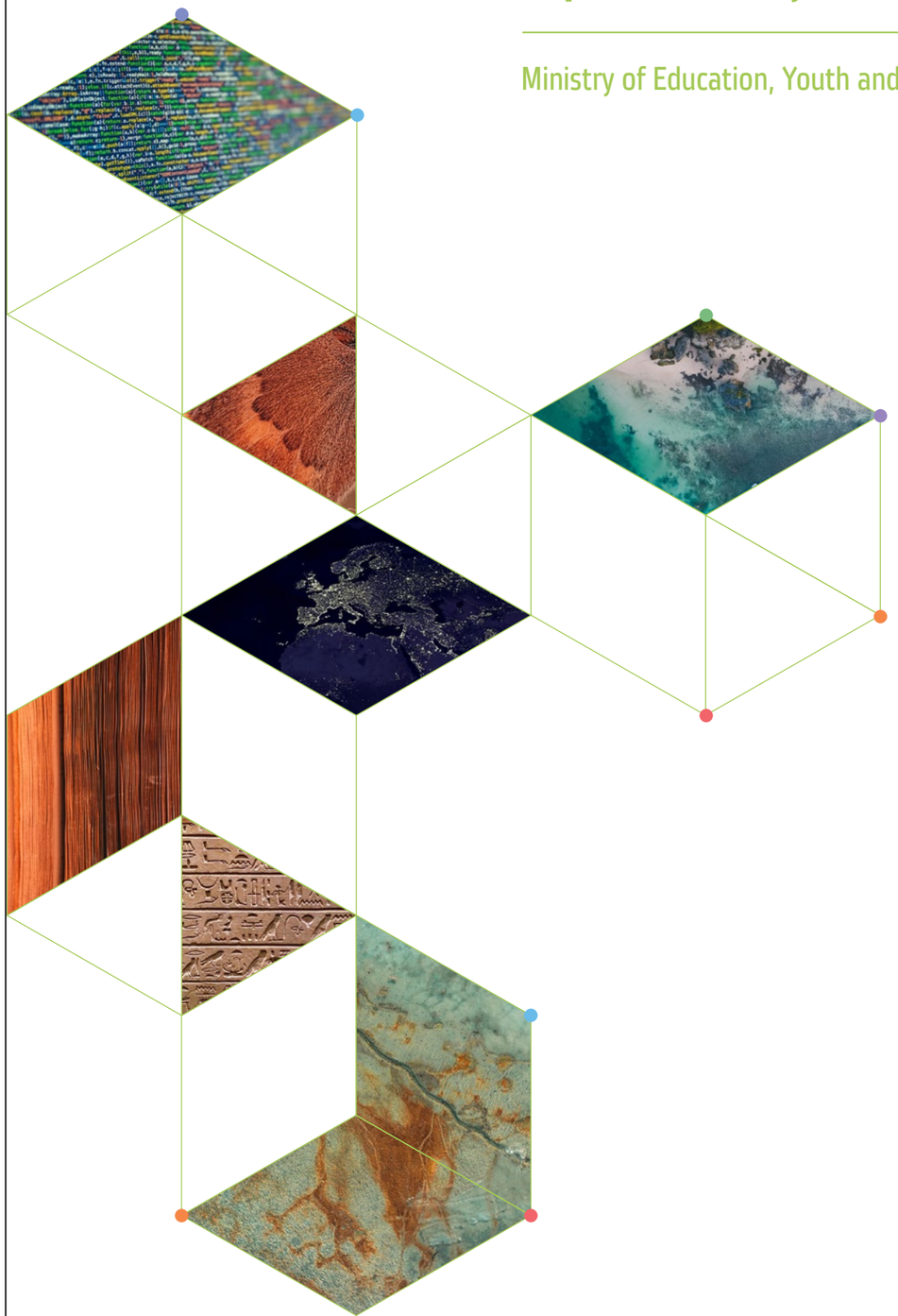

MINISTRY OF EDUCATION,
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Ministry of Education, Youth and Sports
Karmelitska 529/5
118 12 Prague 1
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Foreword

Mikuláš BEK
Minister of Education, Youth and Sports
of the Czech Republic

Jan HRUŠÁK
Special Envoy for Research Infrastructures
Ministry of Education, Youth and Sports
of the Czech Republic

Research infrastructures (RIs) constitute a fundamental pillar of the research and innovation (R&I) ecosystems in the European Union's (EU) Member States and their regions, and the EU as a whole. They are top-class facilities which provide scientists and innovators with unique knowledge and expertise, experimental devices and technical resources, as well as extensive collections of data sets, and related ICT and computing services. In this way, RIs bring together a critical mass of the material, financial and human resources which are necessary to perform cutting-edge fundamental and applied research, extend the frontiers of human knowledge beyond yet known horizons, and develop state-of-the-art technologies, feeding into both incremental, and breakthrough, deep-tech, disruptive innovations.

The open access policies of RIs, making their capacities and capabilities available to their user communities regardless of institutional affiliation or nationality, are a major contribution to the implementation of the open science policy in Europe. Thereby, RIs stimulate knowledge and brain circulation and encourage inter-sectorial, cross-border and international mobility, while attracting the most talented students and early career researchers, as well as the leading senior scientists and highly skilled innovators from all around the world to Europe. Hence, RIs contribute to enhancing the EU's international R&I collaboration, and to reinforcing the EU's R&I competitiveness macro-regionally and globally.

Apart from the benefits they deliver in the sectorial domain of science, public investments into RIs also have considerable impacts on businesses and industries. These are encouraged and incentivised to develop and produce the most advanced technologies when suppling RIs with their experimental devices, spare parts and maintenance services. In addition, businesses and industries may also use RIs as their primary users through proprietary access, contractual R&I and training. Notwithstanding, more frequent is the secondary use of know-how resulting from the research carried out in RIs in subsequent stages of the innovation cycle as businesses and industries, in close cooperation with the primary users of RIs, enter as partners in public-private partnership R&I projects.

RIs are natural meeting places for scientists, technicians, students, innovators, entrepreneurs, policy-makers and funders that integrate a broad range of stakeholders on the knowledge basis, including those outside the areas of R&I. Given the role that RIs, as a role model, play in collecting, processing, storing and providing access to the scientific data in line with the FAIR (*Findable, Accessible, Interoperable and Reusable*) digital data principles, RIs promote multi-disciplinary, cross-sectorial and international cooperation, and facilitate problem-solving and solution-oriented approaches to coping with grand societal challenges. As a result, RIs not only strengthen R&I and economic competitiveness and enhance the prosperity and well-being of the European society, but they also foster the EU's resilience and preparedness to tackle urgent crisis scenarios requiring knowledge-based solutions.

RIs fulfil a large variety of missions that spread far beyond their fundamental roles in the fields of R&I. Against this background, the RIs ecosystem should be considered a key component of the critical infrastructure, in addition to energy, environmental, emergency, healthcare, defence or security infrastructures, since RIs empower scientists and equip innovators to come up with novel solutions to address sudden threats, and increase the immediate response capacity of the European society to deal with acute crises, such as those induced by the SARS-CoV-2 outbreak and Covid-19 pandemic.

Regionally anchored RIs, which are embedded in the Smart Specialisation Strategies of their host countries, trigger and accelerate the societal and economic development of their sites and neighbouring regions through attracting both public and private investments. They offer highly skilled jobs, including managerial, scientific, technical and administrative positions. When cooperating with their contractors, RIs stimulate the development of supply chains. They grow into competence hubs, facilitating the valorisation of their knowledge, and contributing to the re-shaping and creation of new markets. RIs also boost the amplification of civil infrastructure and related services. In consequence, they largely influence the regional economic strategies and, by spreading the principles of knowledge society, induce changes in the cultural attitudes of society.

In a wider and a more general perspective, through creating geographically well-balanced and excellence-based networks of knowledge hubs, RIs bear a great potential to help bridge the research gap and close the innovation divide that still persist between European regions and macro-regions. RIs can increase the competences of communities to resolve their local and regional social, health, environmental and economic challenges. At the same time, they can contribute to responding to grand societal challenges of macro-regional and even global relevance.

All in all, RIs gather capacities and capabilities, which can help harvest and exploit the full potential of the R&I excellence in the European Research Area (ERA). Jointly with technology and data infrastructures, RIs stand at the heart of the ERA Policy Agenda as a cross-cutting element facilitating its implementation. In view of their impacts on the local, regional, national and macro-regional societal and economic development, RIs belong among the key actors in post-pandemic recovery and contributors to the green transition and digital transformation of the European economy and achieving the United Nations Sustainable Development Goals. On the top of that, RIs increase cohesion in the EU and thereby foster the prosperity and well-being of the entire European society.

The R&I community in the Czech Republic gathers a broad portfolio of expertise allowing for the operation a number of top-class national RIs that are densely networked at the European and international levels. Simultaneously, Czech scientists get engaged with numerous projects of leading international facilities based in Europe and in the Americas. The list of RIs financially supported by Czechia covers a large variety of disciplinary domains, ranging from physical sciences, engineering, energy, and environmental, biological and medical sciences to computer sciences, social sciences and humanities, thereby providing a comprehensive knowledge basis to address any current and future R&I, societal or economic need.

It is our great pleasure and true honour to introduce you this update to the Roadmap of Large Research Infrastructures of the Czech Republic, published in 2023, which shows how Czechia responds to challenges and opportunities in the field of RIs. The Roadmap contains a total of 43 large research infrastructure projects implemented across all scientific areas, including projects through which Czech scientists participate in European Research Infrastructure Consortia (ERIC). In addition, the Roadmap overviews the membership of the Czech Republic in international R&I organisations established under international public law. The initiatives behind the Roadmap represents the Czech contribution to building a fully functional and operational RI ecosystem which efficiently integrates regional, national, European and other international RIs of various sizes and legal personalities, all of them being a vital cornerstone in the development of the renewed ERA.

The long-term sustainable development of the RI facilities listed in this Roadmap requires that Czechia continue to foster a stable, reliable and predictable environment for financial planning of the RIs' concept development, design, implementation and construction, operation, upgrade and other capital investment, such as reorientation or even decommissioning and termination, at all times underpinned by long-term strategic evidence-based policy orientations setting out far-sighted goals and objectives and reflecting the possibilities of public budgets.

We highly appreciate the tremendous work of the international assessment committee, which in 2021 monitored the presented large research infrastructure projects of the Czech Republic, as well as the immense contribution by the international evaluation committee, which in the same year reviewed the benefits of Czech memberships in international R&I organisations. With the growing importance of monitoring the impacts of R&I investments on society and the economy, the assessment framework used to evaluate the implementation of RI projects and their performance will further evolve in accordance with good practice examples elaborated by ESFRI.

Last but not least, a special thanks goes to individual research infrastructure teams that through their enormous engagement have made it possible for this Roadmap to be introduced to both professionals and the general public in Czechia, Europe and all around the world.

Mikuláš BEK
Minister of Education,
Youth and Sports of the Czech Republic

Jan HRUŠÁK
Special Envoy for Research Infrastructures
Ministry of Education, Youth and Sports
of the Czech Republic

Research infrastructures in the European Research Area

The genesis of research infrastructure (RI/s) policy-making in the European Union (EU) dates back to the beginning of the current millennium. Since then, the importance of RIs in relation to the advancement of the EU Member States' national and regional research and innovation (R&I) ecosystems, and the European Research Area (ERA) as a whole, has been reflected by the adoption of a number of political decisions and regulatory measures. Their purpose has been to set out a suitable political, strategic, legislative and funding environment for the operation of RIs in the EU with the ultimate goal of strengthening the international competitiveness of ERA and the European economy in the macro-regional and global context.

European Strategy Forum on Research Infrastructures (ESFRI)

In 2002, following a decision taken by the EU Research Ministers at the EU Competitiveness Council, the **European Strategy Forum on Research Infrastructures (ESFRI)** was set-up, bringing together delegates from EU Member States, Associated Countries to the EU R&I Framework Programmes and the European Commission's Directorate General for Research and Innovation, to facilitate their strategic debates on the European RI policy-making.

In 2006, ESFRI prepared the first **ESFRI Roadmap**, which was updated in 2008, 2010, 2016, 2018 and 2021, with the next update foreseen for 2025. The ESFRI Roadmap includes RIs of European nature, importance and impact, and divides them among ESFRI Projects and ESFRI Landmarks. While **ESFRI Projects** are European RIs with an excellent scientific concept showing an advanced stage of preparation, assuming the commencement of their implementation phase within ten years since their inclusion in the ESFRI Roadmap, **ESFRI Landmarks** have either already completed their implementation phase and entered the operations, or have progressed so far in their implementation that they have a clearly defined timetable for completion.

The 2021 update to the ESFRI Roadmap lists a total of 63 European RIs, of which 41 fall under the ESFRI Landmark category and 22 under the ESFRI Project category. **Through the large research infrastructure projects included in this Roadmap, Czechia is currently involved in 25 ESFRI Landmarks and also participates in the implementation of 7 ESFRI Projects, as listed in Annex 7**.

In 2019–2021, Dr Jan Hrušák, the Special Envoy for Research Infrastructures at the Ministry of Education, Youth and Sports (MEYS) of the Czech Republic, and a senior researcher at the J. Heyrovský Institute of Physical Chemistry of the Czech Academy of Sciences, served as the ESFRI Chair. Under his term, ESFRI adopted not only the **2021 ESFRI Roadmap update**, but also the **ESFRI White Paper 2020**: Making Science Happen – A New Ambition for Research Infrastructures in the European Research Area, outlining a strategy for the development of the European RI ecosystem in the 20'.

In 2023, ESFRI entered the third decade of its existence, operating through the Forum Plenary, six Strategic Working Groups on Physical Sciences and Engineering, Energy, Environment, Health and Food, Social and Cultural Innovation, and Data, Computing and Digital RIs, and other standing and ad hoc working groups, including those on the Implementation, Monitoring or Long-Term Sustainability of RIs. ESFRI develops structured dialogue with R&I stakeholders via the ESFRI Stakeholder Forum. Since 2020, it implements the concept of a fully integrated European RI ecosystem, interconnecting and interlinking its building blocks across scientific disciplines, regions and countries throughout Europe and beyond. Owing to its contribution to R&I policy-making in Europe, ESFRI has long been an indispensable and irreplaceable constituent of the ERA governance structure, providing its members and other R&I actors with timely strategic advice on a broad range on RIs, as well as general R&I policy issues, also being a role model for the operation of other ERA strategic and expert bodies.

European Research Infrastructure Consortium (ERIC)

At the legislative level, the increased emphasis placed on RIs of European impact has brought a specific EU legal framework that defines the principles for the governance and management of European RIs. Since 2009, the EU regulation on the **European Research Infrastructure Consortium (ERIC)** has made it possible to adopt flexible models for setting-up European RIs as independent legal entities with their own legal personality.

The original Council Regulation (EC) No 723/2009 of 25th June 2009 on the Community Legal Framework for a European Research Infrastructure Consortium (ERIC) was adopted during the first Czech Presidency of the Council of the EU and amended by Council Regulation (EU) No 1261/2013 of 2 December 2013 during the Lithuanian EU Council Presidency term. Further possible amendments are being considered based on experience during the ERIC regulation implementation over the past decade.

An ERIC consortium is analogous to an international R&I organisation established under the international public law. ERIC consortia are set-up by the European Commission, advised by the ERIC Committee, based on the application presented by at least three founding countries. The main advantage of the regulatory framework is that the establishment of an ERIC is usually procedurally much easier than in the case of an international R&I organisation. ERIC consortia, like international R&I organisations, can, however, also benefit from financial advantages. An ERIC consortium may be exempted from the payment of value added tax or concise tax. ERIC consortia may also adopt their own procurement rules, provided the principles of transparency, proportionality, mutual recognition, equal treatment, competition and non-discrimination are dully respected.

A total of 26 ERIC consortia have already been established in the EU with new applications entering the process every year. The **ERIC Forum** brings together delegates of all operational ERIC consortia to address jointly with the European Commission critical issues related to the implementation of the ERIC regulation. Thus, the ERIC Forum represents ERIC stakeholders, similarly to the **EIRO Forum** (*European Intergovernmental Research Organisation Forum*) and the **ERF** (*Association of European-Level Research Infrastructure Facilities*) associations.

Czechia has already become a Member State of 17 ERIC consortia and is a prospective founding Member of further ones currently in their preparation phase. As part of that, the Czech Republic is the host country of the statutory seat of the ELI ERIC consortium (*Extreme Light Infrastructure European Research Infrastructure Consortium*) based in Dolní Břežany near Prague.

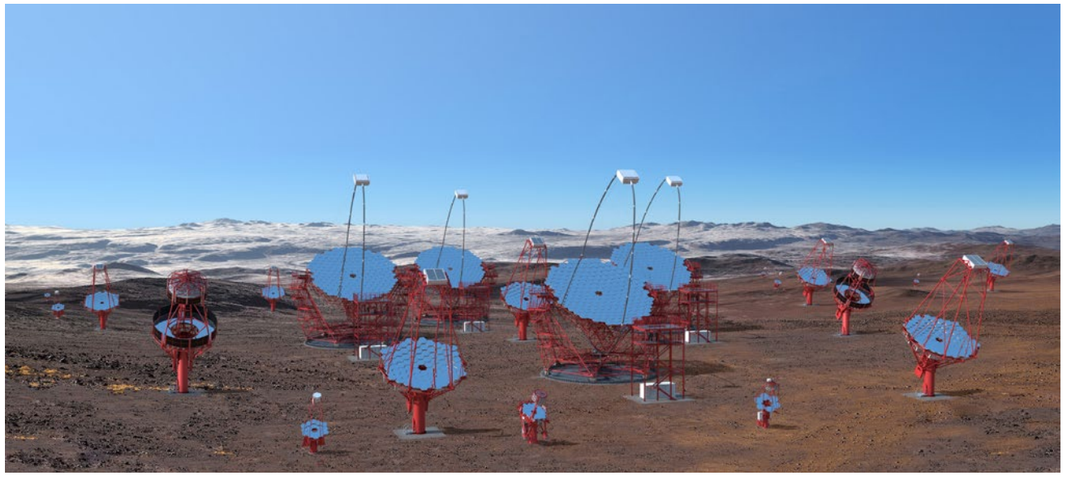
An overview of the Czech memberships in ERIC consortia can be found in Annex 6.

Legislative framework

In 2014, the **Framework for State Aid for Research, Development and Innovation** (2014/C 198/01) and **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**, later both regularly amended, introduced the legislative definition of a research infrastructure:

"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) – see 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)."

The objective of these EU regulations has been to determine the boundary conditions of aid for the construction and upgrade of RIs that mainly addresses market failure, whereas high-quality RIs are increasingly necessary for the ground-breaking research and high up-front investment costs for acquiring state-of-the-art RIs used for early-stage research activities that are predominantly performed by the scientific community usually make it impossible to find the necessary financing on the market.



▼ CTA – Different types of CTA telescopes for the southern CTA site at ESO Paranal

Policy Agenda

As of 2021, Europe develops the concept of the new ERA implemented through the ERA Policy Agenda. The **Council Conclusions of 1 December 2020 on the New European Research Area**, introducing the concept of this new ERA, underline the RI domain as a priority to develop the ERA Policy Agenda and implement the ERA Actions. Furthermore, they outline the need for long-term sustainable investments in the European RI ecosystem to contribute to excellent results in both fundamental and applied sciences, and deliver the comprehensive knowledge needed to address present and future grand societal challenges.

The follow-up **Council Recommendation of 26 November 2021 on a Pact for Research and Innovation in Europe**, determining the ERA Policy Agenda for 2022–2024, encompasses RIs as a priority area for joint action in the EU to further deepen a functioning internal market for knowledge and calls for enhancing integration of the European RI ecosystem to maximise the benefits and impacts of investments in RIs in order to provide knowledge-based solutions to global societal and economic needs.

The first ERA Policy Agenda for 2022–2024 consequently sets out a catalogue of a total of 20 voluntary ERA Actions to promote the new ERA, comprising also ERA Action No 8, specifically addressing the European RI ecosystem and aimed at further strengthening the sustainability, accessibility and resilience of RIs in the ERA. However, RIs are a cross-cutting element of the ERA Policy Agenda and the close engagement with the European RI ecosystem is conditional also for the successful implementation of numerous other ERA Actions, particularly ERA Action No 1 to enable the open sharing of knowledge and the re-use of research outputs, including through the development of the European Open Science Cloud (EOSC), and ERA Action No 12 to accelerate the green transition and digital transformation of Europe's key industrial ecosystems. **Czechia has committed to the implementation of all the ERA Actions and thereby contributes to the further enhancement of the European RI and R&I ecosystem.**

Council Conclusions

After the first ever EU Council Presidency term in the first semester of 2009, when Czechia as the Presidency facilitated the adoption of the ERIC regulation, it picked up RIs as one of the key political priorities again during its second Presidency term in the second semester of 2022. Strategic debates of the R&I stakeholders led to the EU Research Ministers' approval of the **Council Conclusions of 2 December 2022 on Research Infrastructures**, determining the policy orientations for further advancement of the European RI ecosystem until mid-20'.

Among other things, the Council Conclusions stress the essential role of RIs as an instrument for achieving knowledge-based solutions to pressing societal and economic challenges of European and global relevance. They call for building a fully integrated European RI ecosystem and encourage international RI cooperation at macro-regional and global levels. The Council Conclusions also emphasize the importance of establishing adequate conditions for the RIs' long-term sustainable development and advancing their digital services. Further, they underline the need for convergence of the RI policy with the policy-making processes in other sectorial domains. Last but not least, the Council Conclusions invite relevant RI stakeholders to reinforce the operational capacity of ESFRI.

Brno Declaration

Apart from the European RI dimension, the second Czech Presidency of the Council of the EU paid particular attention also to the global RI ecosystem. On the occasion of hosting the 2022 edition of the **International Conference on Research Infrastructures (ICRI)** in Brno, Czechia, in close cooperation with the EU Member States and the European Commission, launched the **Brno Declaration on Fostering a Global Ecosystem of Research Infrastructures**, drafted as a complementary policy document to the Council Conclusions of 2 December 2022 on Research Infrastructures.

The Brno Declaration invites RI stakeholders all around the world to use their processes, such as ESFRI in Europe, to intensify the sharing of experiences and exchange of good practices in the RI domain, including areas such as policy-making, funding, roadmapping, landscape analysis, user strategy, access policy, governance, management, monitoring or assessment. In this way, the Brno Declaration delivers a new impetus promoting and facilitating international cooperation between RIs, underpinning the development of a thriving global RI ecosystem.

EU Framework Programmes for Research and Innovation

European RIs are addressed at various EU policy-making levels and they also belong among the priority target areas of financial support provided through the EU Framework Programmes for R&I. The 9th **Horizon Europe** EU Framework Programme for R&I (2021–2027) is no exception in this regard and focuses on RIs in the first Excellence Science Pillar.

The areas of intervention cover particularly the development of the next generation of scientific instrumentation and digitalisation of European RIs, promoting FAIR (*Findable, Accessible, Interoperable, Reusable*) scientific data management in Europe, consolidating, developing and optimising the landscape of European RIs through their opening and increased networking and integrating, reinforcing European RI policy-making and international RI cooperation, and developing their innovation potential.

EU Framework Programmes are additional sources of European RI funding. They are not meant to cover the basic operation and investment costs of European RIs, which usually fall under the full responsibility of their host countries and national and regional research funding organisations. Nonetheless, EU Framework Programmes constitute an important instrument to advance the European RI ecosystem and provide important resources of seed money for the implementation of European RI projects.

Research infrastructures in the Czech Republic

Over the past more than a decade, Czechia, following good practice examples of ESFRI, has also responded to the increasing importance of RIs for strengthening the R&I ecosystem and its competitiveness in the EU and worldwide. A number of measures towards creating a stable, reliable and predictable environment for the financial planning of RIs, when it comes to their concept development, design, implementation, construction, operation and upgrade, has been taken.

Legislative framework

In 2009, a brand-new legislative instrument to support top-class RIs from the public funds of the Czech Republic was integrated into Act No 130/2002 Coll., on the Support of Research, Experimental Development and Innovation from Public Funds and on the Amendments to Some Related Acts that stipulates conditions for the provision of aid for R&I. **The legislative regulation brings about the concept of the large research infrastructure (LRI/s)**, defining it as:

"a research infrastructure 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."

When using the term "research infrastructure" in the LRI definition, the Act on the Support of Research, Experimental Development and Innovation refers to the RI's definition, as stipulated by the Framework for State Aid for Research, Development and Innovation (2022/C 414/01). In view of this, the Czech legislative framework is directly linked to the EU legal environment.

In practical terms, **an RI becomes an LRI thanks to its top-class expertise and open access mode of operation**. Against this background, an LRI is usually a unique R&I facility, bringing together exceptional knowledge and technological resources, including scientific data archives and ICT resources that are necessary to perform ground-breaking R&I. At the same time, the operator opens an LRI to any relevant scientist or research group regardless of their institutional affiliation. In this way, each and every scientist and innovator has the opportunity to use an LRI's capacities and capabilities, provided their project proposal successfully passes through the LRI's open access arrangements and meets the relevant criteria of admission.

National public authority

Since 2009, **MEYS has been the public authority of the Czech Republic in charge of the policy-making and public funding of LRIs**. Overall, MEYS is the Czech national public office responsible for science policy-making, including at the EU and international levels, and the EU Cohesion Policy in the public R&I sector. MEYS bears the same roles in the area of LRIs.

MEYS is the policy-maker setting out the strategy for the development of the LRI ecosystem in Czechia. It is also the public funding provider for LRIs, using both the state budget and the EU Cohesion Policy Funds, thereby financing the operations and investments of LRI projects. MEYS is also mandated to develop and implement international cooperation in R&I, including membership of the Czech Republic in international R&I organisations and ERIC consortia, and represents Czechia at European and international fora dealing with the R&I and RI policies.

In this capacity, MEYS administers all the responsibilities related to the implementation of the Czech LRI policy, such as LRI policy-making, roadmapping, public funding, monitoring and assessment. MEYS also represents the Czech Republic at the RI European and international platforms, and contributes to

◀ WCZV – Physical Protection laboratory

▲ RECETOX RI – Biobank provides an access to biological material and related data from the CELSPAC population studies

the integration of the Czech LRI landscape into the European and international RI ecosystem.

Council

R&I stakeholders engaged in Czech LRI policy-making are coordinated through two expert advisory bodies. **The first of the coordination platforms is the Council for Large Research Infrastructures, an expert consulting forum established by the Minister of Education, Youth and Sports**. The Council was founded already in 2010 and it participates in all important processes related to the preparation and implementation of LRI policy-making in Czechia.

The Council for Large Research Infrastructures brings together representatives of MEYS, the Research, Development and Innovation Council, the Czech Academy of Sciences, the Czech Rectors Conference, the Council of Higher Education Institutions, and also the most important LRIs operated in individual scientific fields. The Council also includes the Czech delegates to ESFRI, as well as National Contact Points for the support of RIs from the EU R&I Framework Programmes. Since recently, delegates of the Ministry of Industry and Trade, the Ministry of Transport, the Ministry of the Environment, the Ministry of Agriculture, the Ministry of Health, the Ministry of the Interior, and the Ministry of Labour and Social Affairs have also been invited to take part in the Council's deliberations in order to further promote the convergence of LRI policy with other sectorial policies. Representatives of these Ministries have already been involved in the latest Czech LRI landscape analysis to identify possible gaps to be filled by potential new LRI project proposals in 2020.

The other coordination platform engaged in LRI policy-making in the Czech Republic is the Research, Development and Innovation Council in its role of an expert advisory body to the Government of the Czech Republic. The Council acts at the supreme level and gathers representatives of the most important R&I stakeholders from the public research and industrial sectors. Whereas the Council for Large Research Infrastructures provides expertise to the Minister of Education, Youth and Sports, the Council for Research, Development and Innovation advises the Czech Government as a whole.

Roadmap

The Roadmap of Large Research Infrastructures of the Czech Republic is the Czech LRI policy document equivalent to the ESFRI Roadmap, thereby being the Czech national contribution to European and global RI roadmapping. It overviews the genesis and LRI agenda development in Czechia. It describes the typology of LRI projects financially supported by MEYS. It summarises memberships of the Czech Republic in international R&I organisations, ERIC consortia, and other international governmental and non-governmental RIs. Particular attention is paid to the description of the methodology framework for LRI monitoring and assessment, which is regularly carried out by MEYS on an international peer-review basis.

The core part of the Roadmap consists of one-pagers presenting LRI projects implemented in the disciplinary areas of physical sciences and engineering, energy, environmental sciences, biological and medical sciences, social sciences and humanities, and e-infrastructures. Apart from their basic characteristics, the Roadmap places the individual LRI facilities in the landscape and creates a map of unique national RIs based in Czechia and international RIs participated in by the Czech Republic.

MEYS published the Roadmap of Large Research Infrastructures of Czechia for the first time in 2010. Later updates were released in 2011, 2015, 2019 and 2023. The forthcoming update to the Roadmap is planned for 2027, following the adoption of the public funding of LRI projects by the Czech Government in the period 2027+.

Public funding

Since 2009, the importance attributed to LRIs in the Czech Republic has been reinforced by the fact that LRI project proposals are submitted to the Czech Government for approval of their public funding as the only individual R&I projects in Czechia.

Following the act of adoption of the Czech Government's resolution on LRI public funding, **MEYS uses the Czech state budgetary resources on R&I to finance the LRIs' operation costs, while their investment costs are covered in a synergic and complementary way by the EU Cohesion Policy Funds**. As of 2023, the Johannes Amos Comenius Operational Programme (OP JAK), which also falls under the responsibility of MEYS, constitutes the tool through which the LRIs' investment costs are financed in the current EU programming period.

A third of the budgetary resources mobilised by MEYS for RI funding are specific R&I funds dedicated to financing the participation of the Czech Republic in international R&I organisations and ERIC consortia. Per se, these budgetary resources are not used to finance the LRI projects themselves. Nevertheless, they serve to ensure the LRIs' and overall Czech participation in European and other international RIs, and add up to the other two budgetary envelopes.

When it comes to the nominal amount, the budget allocation exceeding EUR 80 million in 2023 is aimed at supporting the LRIs' operation costs. An additional envelope of nearly EUR 160 million, to be raised from the EU Cohesion Policy instruments through the Johannes Amos Comenius Operational Programme, is meant to finance the LRIs' investment costs in 2023–2026. On the top of that, MEYS also contributes to international R&I organisations and ERIC Consortia with an additional budget totalling almost EUR 70 million in 2023. Thereby, the construction, operation, upgrade and access of Czech user communities to top-class national and leading international RIs, including deliveries of Czech in-kind contributions, is facilitated.

The total of 43 LRI projects adopted by the Government of the Czech Republic for public funding in 2023–2026 is listed in Annex 1.

National scientific data infrastructure

Alongside other RI initiatives, the Czech Republic is also closely following the implementation of the European Open Science Cloud (EOSC) initiative to manage digital scientific data in line with the FAIR (*Findable, Accessible, Interoperable and Reusable*) principles.

The Coordination Committee for the Implementation of the EOSC Initiative in the Czech Republic, driven by MEYS, brings together all the leading R&I stakeholders, including the Council for Research, Development and Innovation, the e-INFRA CZ national e-infrastructure, the National Library of Technology, the Czech Rectors Conference, the Czech Academy of Sciences, the Czech Science Foundation and the Technology Agency of the Czech Republic, in order to discuss the policy orientations to develop and build an overarching Czech national scientific data infrastructure.

As of 2021, the work follows a high-level strategy document co-designed and co-created by Czech R&I policy-makers, e-infrastructure operators and R&I actors, linking the national scientific data infrastructure architectural design and implementation plan with relevant funding instruments. Among other things, it brings about the EOSC-CZ Secretariat operated by the e-INFRA CZ national e-infrastructure to coordinate R&I stakeholders. Specific working groups, as inclusive platforms with fluid membership open to interested stakeholders, have also been established to address a broad range of cross-cutting and science-disciplinary features of the Czech national scientific data infrastructure and its individual constituents. The working groups focus on developing the national metadata directory and national repository platform, building individual science-disciplinary repositories, and spreading knowledge and expertise through education and training.

A specific budgetary allocation of about EUR 120 million has been earmarked in the Johannes Amos Comenius Operational Programme (OP JAK) to use the EU Cohesion Policy Funds for developing and building the Czech national scientific data infrastructure and federating it within the pan-European scientific data infrastructure incentivised through the EOSC initiative.

Communication, marketing and public relations

A specialised information portal on Czech LRIs, operated by MEYS in close cooperation with the e-INFRA CZ national e-infrastructure and providing an up-to-date overview of Czech LRI policy-making in the EU context and achievements reached by individual LRIs is available at https://research-infrastructures.cz/en.

Typology of research infrastructures

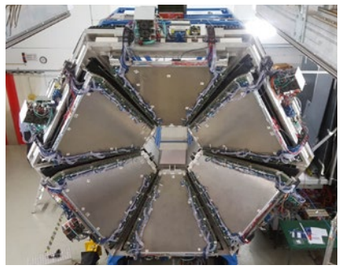
The basic typology divides RIs according to their physical distribution and life-cycle phases.

From the perspective of the life-cycle stages, RIs are usually classified into RI facilities in the phases of their preparation (concept development, design), implementation and construction, operation, upgrade, reorientation, decommissioning and termination.

All of the aforementioned types of RIs are present in the Czech LRI landscape, including LRI projects which were terminated due to their significantly lower performance or outdated technology basis.

Most of the LRI projects listed in the presented Roadmap facilitate the operations of RIs, whose projects have already been successfully implemented and whose location is in the Czech Republic. However, the areas of physical sciences and engineering or energy are rather specific compared to other science-disciplinary fields, and give rise to specific types of the LRI projects.

Especially the area of physical sciences and engineering is characterised by the concentration of available resources through large-scale international installations, whose construction and operation is highly demanding and exceeds not only the capabilities of individual research performing organisations, but also those of entire countries. Against this background, specific LRI projects evolved within the Czech LRI landscape to secure participation and engagement of the Czech R&I community in these large-scale international installations.



▲ FAIR – Electromagnetic calorimeter (ECAL) for the HADES experiment, completed by a Czech team of the FAIR-CZ

International non-governmental research infrastructures

The first specific type of these LRI projects is an LRI project implemented to secure the Czech participation in an international RI located abroad. The purpose of such a project is typically to deliver the Czech share on the construction or upgrade of international RI either in the form of cash contribution or in-kind delivery of scientific equipment, specialised services or manpower. If such an international RI is an international R&I organisation established under the international public law or the ERIC regulation, any other obligations related to the Czech membership, such as the payment of mandatory membership fees, are fulfilled by MEYS in its role of the Czech national public authority exercising membership rights and obligations in international governmental R&I organisations. However, there are international RIs which have neither the ERIC legal form nor the international public law-based framework, but are established according to the national legal framework of their host country. In this case, MEYS, as the Czech national public authority, does not act as the representing entity of the member in such an international non-governmental RI, nor does it exercise the mandatory membership rights and obligations. The respective LRI project acts as the access point of the Czech R&I community to the international non-governmental RI and the LRI project beneficiary deals with the membership rights and obligations on its behalf. Approximately a quarter of the total of 43 LRI projects listed in the presented Roadmap has this primary mission, consisting in securing the participation of the Czech Republic in international RIs located abroad. Nonetheless, most of the other LRI projects facilitate Czech engagement in international non-governmental RIs as well through their international networking and other integrating activities, even though it might not be their primary function, which is operating an RI facility located in the Czech Republic.

International governmental R&I organisations

Beyond this scope, there is another specific type of RIs which are not funded through LRI projects but also constitute a **Czech national R&I initiative to finance RIs. These are the Czech memberships in international governmental R&I organisations that are established and operated under the international public law**. One-pager descriptions of these memberships of the Czech Republic in the CERN (*Conseil Européen pour la Recherche Nucléaire*), EMBC (*European Molecular Biology Conference*), EMBL (*European Molecular Biology Laboratory*), ESA (*European Space Agency*) and ESO (*European Southern Observatory*) international R&I organisations follow in the next chapters. In addition, through its membership in NATO (*North Atlantic Treaty Organisation*), the Czech Republic participates in the VKIFD (*Von Karman Institute for Fluid Dynamics*), whereas Czech membership in EURATOM (*European Atomic Energy Community*) and F4E (*European Joint Undertaking for ITER and the Development of Fusion Energy*) constitutes the legal basis for the engagement of Czechia in the ITER (*International Thermonuclear Experimental Reactor*) international R&I organisation.

International cooperation of research infrastructures

Cross-border and international RI cooperation enables developing an integrated RI ecosystem in Europe and globally. The networking, interconnecting, associating and merging of RIs, including across science-disciplinary areas, facilitates capacity building necessary for bringing together a critical mass of material, financial and human resources that are needed to perform top-notch R&I with societal and economic impacts. It contributes to avoiding overlaps and the duplication of efforts, and thus to the consolidation and optimisation of the RI landscape which, when integrated, pools the limited resources in a more efficient manner.

Cooperation among RIs leads to the sharing of experiences and exchanging of good practices in the areas of governance and management. It helps to shape the RIs' strategies and policies in line with internationally recognised standards and cross-fertilisation. It also opens up RIs in terms of their transnational access and fosters brain circulation. RI cooperation within and across countries and scientific domains results, among other things, in making extensive collections of data sets available to wider user communities, and in consequence to the development of new multidisciplinary approaches to complex scientific, technological and societal phenomena.

Single-sited international research infrastructures

For single-sited international RIs, in particular large-scale RI installations, cooperation is very often the very prerequisite for their existence, since they usually evolve from large international consortia, bringing together a broad range of knowledge and expertise, which a single research performing organisation or country cannot encompass. It can even be said that most single-sited international RIs could have never been built without extensive international cooperation. Even in the most advanced countries, the amount and range of resources is usually not broad enough to build and operate such RIs and fully use their capacities at the national level.

▲ EMBL Imaging Centre

Distributed international research infrastructures

For distributed international RIs, integrating a larger number of standalone national RI nodes, cross-border and international cooperation brings added value due to the sharing of capacities and capabilities, resulting in delivering a wider portfolio of RI services. These integration processes are typical for RIs specialising in the fields of environmental sciences, biological and medical sciences, or social sciences and humanities, but they are not unusual also for particular areas of physical sciences and engineering, such as material sciences.

Engagement of the Czech Republic

For the reasons outlined above, MEYS strongly supports the internationalisation of Czech LRI projects and their integration within ERA and globally. Given that, MEYS enters as a Founding Member into legal entities that govern and manage the work of RIs at the international level in its role of the Czech national public authority responsible for international R&I cooperation.

As a Founding Member, Czechia has joined a total of 17 ERIC consortia, which are listed in Annex 6, and takes part in setting-up further ones that will be applying for the ERIC status in the years to come.

Moreover, the Czech Republic is a Member State of seven international governmental R&I organisations established under the international public law specified in the next chapters of the presented Roadmap and listed in the Annex 5.

In general, all LRI facilities financially supported by MEYS cooperate internationally, while their international cooperation is among the monitoring criteria within assessment exercises organised by MEYS. Czech memberships in ERIC consortia and international governmental R&I organisations constitute good practice examples of Czech LRIs' international cooperation that is developed under various legal frameworks and within different legislative environments.

International peer-review of large research infrastructures

As of 2014, Czech LRI projects have been subject to regular assessment organised on the basis of an international peer-review. The very first evaluation exercise was held by MEYS in 2014, followed by subsequent rounds conducted in 2017 and 2021. Usually, the aim of such a monitoring procedure is to perform an interim assessment of the current state of implementation and R&I performance of the ongoing LRI projects. In parallel, brand-new LRI project proposals, applying to fill in the gaps identified within the Czech LRI landscape, enter the Roadmap and receive public funding, are submitted for their ex-ante evaluation. As a rule, **outcomes of such a monitoring exercise directly feed as an independent expert basis into adopting an informed evidence-based political decision by the Czech Government on the public funding of LRIs in the upcoming multiannual period**. Following the adoption of the Czech Government's resolution on the LRI public funding, LRI projects are included in the update to the Roadmap of Large Research Infrastructures of the Czech Republic and also become eligible to apply for financing their investment costs by the EU Cohesion Policy Funds raised through the respective Operational Programmes, where specific LRI investment calls are launched. The LRI projects adopted by the Czech Government for public funding are also provided with political and financial support to apply for their inclusion in the upcoming update to the ESFRI Roadmap, while participating as a member in European RI consortia.

Methodology framework

Since 2014, MEYS monitors Czech LRI projects according to an international peer-review assessment methodology inspired by the ESFRI's evaluation framework used to monitor European RI projects. Prior to the launch of a call to submit documentation for the evaluation, the methodology framework is always consulted with a large variety of R&I stakeholders represented at the Council for Large Research Infrastructures and the Council for Research, Development and Innovation in a co-design, co-creation and co-implementation spirit. The assessment process is then performed by MEYS, being the relevant Czech national public authority.

Monitoring criteria

When it comes to the monitoring criteria, the evaluation is executed in accordance with a broad range of indicators to assess a large variety of the LRI attributes and features, including the knowledge and technology expertise, governance and management, strategies and policies, R&I performance, societal and economic impacts, or financial planning.

- **Scientific and technological vision and mission**
- **Expertise provided through open access services**
- **Governance, management and human resources development**
- **Relevance, importance and significance nationally and internationally**
- **Cooperation, networking and clustering within R&I and industrial sectors**
- **Societal and economic impacts and addressing grand societal challenges**
- **User strategy and open access policy**
- **e-Infrastructure needs and scientific data management**
- **Feasibility study and SWOT analysis**
- **International benchmarking**
- **Communication, marketing, public relations and outreach**
- **Capacity use and R&I performance**
- **Operation and investment costs**

Review committee

As a rule, the evaluation exercise of Czech LRI projects is conducted by an international assessment committee, including six review panels with 5–7 Members and a Chair, who steers the work of individual review panels, harmonises it and ensures that each of them applies the monitoring criteria to the same extent and with the same relevance. Division of work among the review panels corresponds to the classification of science-disciplinary areas by ESFRI.

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

Members of the international assessment committee who reviewed Czech LRI projects in 2021 are listed in **Annex 2**, including their division into six science-disciplinary review panels.

Assessment procedure

The international assessment committee performs evaluation tasks based on the submitted documentation by LRIs and with the help of outputs from an external international peer-review that usually consists of three individual reviews per each LRI project. Another input to decision-making is a hearing/interview organised with representatives of the LRI project that serves as an opportunity to clarify ambiguous information and data provided in the documentation for the assessment. If a review panel also requests a site-visit to the LRI facility, MEYS may arrange it. **The summary decision of review panels of the international assessment committee is based on a synthesis of all the inputs, which feed into deliberations of the review panels and harmonisation meetings between the review panels' Chairs and the Chair steering the work of the entire international assessment committee.**

Evaluation outcomes

The work of the international assessment committee usually takes approximately six months and leads to a summary decision taken by the review panels. It is elaborated in the form of a consensus report per each LRI project. Consensus reports include a thorough narrative, which justifies the evaluation outcomes, and recommendations for the future, which serve as guidelines to further develop the LRI's strategies and policies. The assessment procedure also results in a score indicating the overall quality of the LRI project on a scale from 5 to 0, where 5 is the highest score and 1 is the lowest. LRI projects that receive 0 are found to be non-compliant with the basic LRI qualitative criteria.

Following the outcomes of the international peer-review of LRI projects that took place in 2021, the Government of the Czech Republic adopted a resolution on the public funding of 44 LRI projects in 2023–2026 and 43 of LRI were funded. Their list is provided in **Annex 1**.

▼ CICRR – Reactor LR 0 – a look to the reactor vessel

International peer-review of memberships in international R&I organisations

Analogically to the international assessment of the Czech LRI projects, MEYS has also been evaluating benefits and impacts of Czech memberships in international governmental R&I organisations established under the international public law. In 2016, MEYS held the very first assessment round of this kind, with the second one following in 2021. Overall, the evaluation enables MEYS to comprehend benefits and impacts of memberships of the Czech Republic in international governmental R&I organisations in terms of involvement in their governance and management structures, and their R&I, educational and training activities.

Methodology framework

The methodology framework to assess the benefits and impacts of Czech memberships in international governmental R&I organisations is largely similar to the framework used to evaluate Czech LRI projects' implementation and R&I performance. Both of these approaches are inspired by ESFRI and jointly form a comprehensive methodology framework to monitor national and international RIs which are operated and participated in by Czechia.

Monitoring criteria

The assessment exercise follows a numerous set of monitoring criteria, focusing on qualitative and quantitative features of the governance and management of the Czech membership in an international governmental R&I organisation, and the **benefits and impacts stemming from such a membership in the areas of science and research, technology development and innovation, knowledge valorisation, business and industrial advancement, education, training and human resources development, and public outreach**.

Review committee

For the purpose of the evaluation, an international assessment committee is appointed, consisting of three review panels per three Members responsible for the assessment of the Czech memberships in each of the three coherent groups of international governmental R&I organisations. A Member of each review panel is appointed the Chair to coordinate the work of the review panel and draft consensus reports, recording the overall evaluation results.

International governmental R&I organisations are grouped in clusters and individual review panels of the international assessment committee focus on coherent clusters encompassing Czech memberships in **CERN** (*Conseil Européen pour la Recherche Nucléaire*), **EMBC** (*European Molecular Biology Conference*), **EMBL** (*European Molecular Biology Laboratory*), **ESA** (*European Space Agency*), **ESO** (*European Southern Observatory*) and **VKI** (*Von Karman Institute for Fluid Dynamics*).

Members of the international assessment committee who reviewed the benefits and impacts of Czech memberships in international governmental R&I organisations in 2021 are listed in **Annex 3**, including their division into three science-disciplinary review panels.

Assessment procedure

The international assessment committee conducts the evaluation based on the information and data collected and provided by MEYS. There is an external international peer-review consisting in providing three individual reviews per each Czech membership in an international governmental R&I organisation as an input to the work of the review panels. Another input to deliberations of the review panels are hearings/interviews with representatives of Czech R&I communities using the capacities of international governmental R&I organisations.

Conclusions by review panels of the international assessment committee are based on a synthesis of all the inputs in the monitoring exercise. Eventually, they are recorded in consensus reports, justifying the overall outcomes and delivering recommendations to enhance Czech memberships in international governmental R&I organisations.

Evaluation outcomes

As a result of the international peer-review, **MEYS is able to better understand the potential and needs of the Czech R&I community to enter optional R&I programmes, projects and other non-mandatory initiatives of international governmental R&I organisations**. MEYS also obtains evidence-based expert recommendations as guiding principles to further enhance Czech memberships in international governmental R&I organisations, and to reinforce their benefits and impacts.

Research infrastructures as a part of the critical infrastructure

Investments in RIs bring multiple societal and economic impacts. Putting aside the immediate benefits in terms of the boom or growth of their sites and neighbouring regions, the development of supply chains or deployment of civil infrastructure, which follow and become noticeable as early as at the beginning of RIs' construction phase, **the primary impacts of RIs, i.e., those stemming from scientific experiments and research data, can usually be expected rather in later stages of the RIs' life-cycle, after entering the initial or steady-state operation phase**.

Despite their benefits for technology development and innovation, the RIs' key portfolio of activities, contrary to the one of technology infrastructures, predominantly lies in fundamental research and the generation of new knowledge. Application of the basic research results in novel goods and services is, generally, a long-term process proceeding through the entire innovation chain, which, at the end, results in the reshaping or creation of new markets.

On the other hand, RIs bring together extensive encyclopaedias of expertise and state-of-the-art technology repertoires available for any ad hoc application, which RIs proved following the SARS-CoV-2 outbreak and during the Covid-19 pandemic.

Research infrastructures and the Covid-19 pandemic

As a result of an immediate call for action by ESFRI, European, as well as national and regional Ris, contributed in a substantial manner to a timely response to the acute crisis evoked by the Covid-19 pandemic. **The RIs' involvement was remarkable, particularly when it came to the development and deployment of detection tools, diagnostics, vaccines, medicines and treatments. The engagement of RI personnel in the crisis management through their membership in expert advisory boards was significant as well.**

In spite of severe containment measures and tough restrictions, RIs adapted to unprecedented conditions of operation and continued to serve their users. They introduced innovative modes of operations, re-baselined their user programmes in line with the pressing societal needs and prioritised user experiments of critical relevance through fast-track and mission-oriented access. Where possible, RIs advanced in mediating the remote/virtual access to their facilities. Last but not least, and most importantly, **RIs integrated their capacities, capabilities and services across scientific disciplines and sectorial domains in a problem-solving and solution-oriented fashion**.

Acknowledgement of research infrastructures by the Council of the EU

Against this background, the Czech Governmental and R&I stakeholders, participating in the conference "Science and Research in the Fight against the SARS-CoV-2 / Covid-19 Pandemic: Research Infrastructure as a part of the Critical Infrastructure of the State", organised by MEYS on 15 July 2020 in Prague, reached the conclusion that RIs and R&I human resources proved their readiness to adapt to a sudden crisis scenario of utmost urgency and act as the key element in reaching knowledge-based solutions to cope with any present or future societal and economic crises.

Two years later, during the Czech Presidency of the Council of the EU, which selected RIs as one the top political priorities for EU policy-making in the second semester of 2022, **the EU Research Ministers adopted the Council Conclusions on Research Infrastructures that acknowledge the European RI ecosystem as a key component of the European critical infrastructure**, which usually includes the defence, security, energy, emergency, healthcare or environment infrastructures. In addition, EU Research Ministers also recognised RIs as an essential instrument for the post-pandemic recovery of Europe, bearing a great potential to strengthen resilience and preparedness of European society.

Summary and outlook

Since 2002, RI policy-making in Europe has made a remarkable advancement, both at the levels of political and financial coordination between the European Commission, EU Member States and Associated Countries, as well as in terms of developing the common EU legislative environment for operating European RIs.

The specific approach to the RI agenda by Czechia dates back to 2009 and the progress has also been noteworthy in the areas of RI legislation, policy-making, roadmapping, landscaping, monitoring, public funding and internationalisation.

In spite of the achievements summarized in the previous chapters of the presented Roadmap, **the EU, European and Czech RI stakeholders have been facing short-, mid- and long-term, as well as urgent needs, to which they have to pay their utmost attention in order to safeguard long-term sustainable development of the RI ecosystem** in Europe, macro-regionally and globally, and to ensure its expected contribution to responding to grand societal challenges of local, regional, macro-regional and worldwide importance and impact.

Research infrastructures at the European level

Success of the RI policy agenda development in the EU, including the EOSC initiative, largely depends on the EU Member States' commitments to the ERA Policy Agenda and the pace of its implementation. Putting the high-level policy orientations set out by the Council Conclusions on Research Infrastructures into practice is also of critical importance.

Jointly, the ERA Policy agenda and the Council Conclusions present policy guidelines for the further advancement of the European RI ecosystem, whose concept has been evolving as of 2020 in line with the ESFRI White Paper's full integration approach principle, allying the RIs' capacities, capabilities and services across regions and countries, and science-disciplinary and sectorial domains, and engaging RIs with a broad range of R&I stakeholders, as well as those outside the areas of R&I.

Among other agendas included in these high-level policy orientations, such as considerations of an amendment to the ERIC Regulation or an update to the European Charter for Access to Research Infrastructures, RI stakeholders must put emphasis, in particular, on the digitalisation of RI services and reducing their environmental footprint in line with the green transition and digital transformation of the European economy, and deepening its circularity, renewability and sustainability features. Adapting to innovative and brand-new modes of operations, induced by sudden challenges and wider EU policy objectives, will set the tone for the future evolvement of the European RI ecosystem.

Research infrastructures at the Czech national level

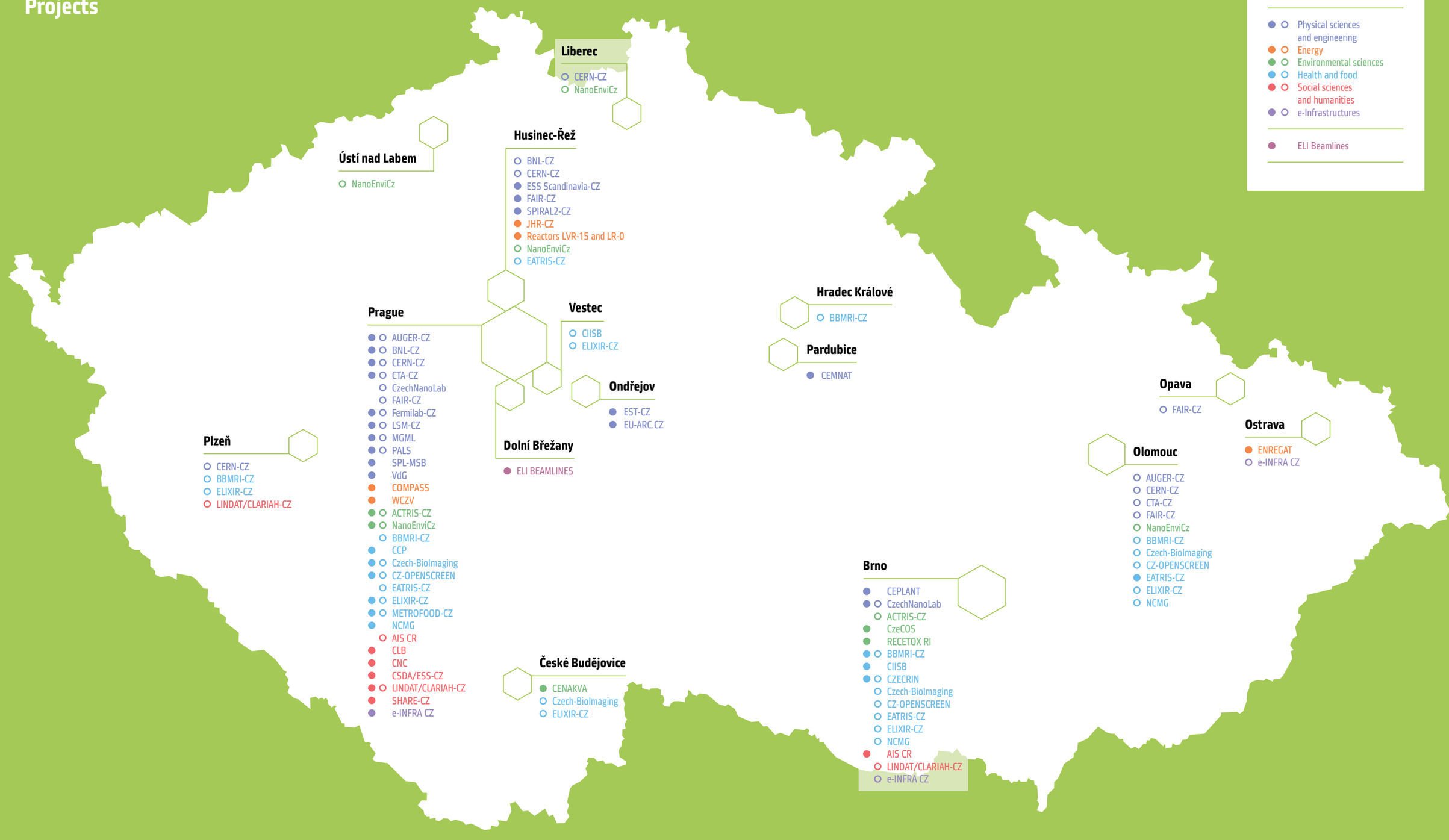
Providing a stable, reliable and predictable legislative, political and financial framework for preparing and implementing the RI projects, and facilitating RIs' operations and their upgrades belong among the top priorities of the Czech RI strategy for the years to come. Serious societal and economic turbulences caused by the SAR-CoV-2 outbreak and Covid-19 pandemic and the energy and economic crises evoked by the Russian military invasion of Ukraine have brought about new challenges to the European, as well as Czech RI landscape, including the skyrocketing of operation costs, in particular of energy-intensive facilities, the disruption and even breakdown of supply chains for critical technologies, the discontinuation of complex and demanding scientific experiments, or major delays in construction affecting the implementation baselines of RI projects.

Against this background, reinforced investments into RIs, enabling the RI stakeholders to cope with urgent threats and persistent crisis scenarios, is an imperative not only to facilitate further enhancement of the RI ecosystem, but to safeguard the qualitative level of the RI landscape achieved so far. Envisaged societal and economic benefits of RI investments call for further development of the RI monitoring framework, lining up the impacts on society and the economy alongside the traditional set of governance, management and R&I performance indicators.

ESFRI has proved its indispensable and irreplaceable role in providing good practice examples for RI policy-making in Europe, pooling expertise, and structuring and harmonising RI policy approaches across European countries. MEYS will continue to follow the ESFRI's guidance and align the Czech national RI strategy accordingly.

◀ ELI ERIC – Experimental Hall E2 dedicated to X-ray sources

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
- ELI Beamlines

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

Dolní Břežany / Czech Republic / ELI

Garching / Germany / ESO

Szeged / Hungary
ELI

Boloňa / Italy
CTA

Darmstadt / Germany
FAIR

* **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

Extreme Light Infrastructure European Research Infrastructure Consortium

Acronym:
ELI ERIC

Hosting institution:
Extreme Light Infrastructure ERIC

Responsible person:
Allen Weeks
allen.weeks@eli-laser.eu

Phase: operational

Character: multi-sited

Website:
eli-laser.eu

Year of inclusion on the Czech Roadmap: 2010
Status on ESFRI Roadmap 2021: landmark

Motto:
The World's Largest and Most Advanced High-Power Laser Research Infrastructure

eli beamlines

Characteristics

ELI (*Extreme Light Infrastructure*) is the world's largest and most advanced high-power laser RI. As an international user facility dedicated to multi-disciplinary science and research applications of ultra-intense and ultra-short laser pulses, ELI provides access to world-class high-power, high-repetition-rate laser systems and enables cutting-edge research in physical, chemical, materials and medical sciences, as well as breakthrough technological innovations. ELI operates through ELI ERIC (*Extreme Light Infrastructure European Research Infrastructure Consortium*) as a single multi-site organisation with two complementary facilities specialised in different fields of research with extreme light, ELI Beamlines in Dolní Břežany, the Czech Republic, and ELI Attosecond Light Pulse Source in Szeged, Hungary. The forthcoming third facility, ELI Nuclear Physics in Măgurele, Romania, is expected to join the ERIC in the future.

As Europe's first large-scale RI located in Central Europe, ELI has been recognised by ESFRI as a strategic priority for Europe and included in the ESFRI Roadmap as an ESFRI Landmark. The mission of ELI ERIC is making the ELI facilities available to the scientific community as a single international organisation, with unified governance and management. The two host countries, the Czech Republic and Hungary, are joined by Italy and Lithuania as Founding Members, while Germany and Bulgaria are Founding Observers. The ELI Facilities are open to scientists, as well as innovators from ERA and all around the world. Access to the ELI Facilities is competitive-based, international and open to users from within and outside the ELI ERIC Member States.

The **ELI Beamlines** facility integrated into ELI ERIC on 1 January 2023. Located in Dolní Břežany near Prague, Czechia, ELI Beamlines focuses on the development of short-pulse secondary sources of radiation and particles, and on their multidisciplinary applications in molecular, biomedical and materials sciences, the physics of dense plasmas, warm dense matter and laboratory astrophysics. In addition, the ELI Beamlines facility will utilise its high-power, high-repetition-rate lasers for high-field physics experiments investigating exotic plasma physics and nonlinear quantum electrodynamic effects. ELI Beamlines operates four ultra-intense laser systems, each with different characteristics and parameters. A total of five experimental halls and an advanced biology laboratory with end stations enable a wide range of research.

Societal and economic impacts

ELI's ultra-high-power ultra-short, pulsed lasers with focused intensities and average powers at the edge of laser technology open new frontiers in fundamental science. As the first RI dedicated to the fundamental study of laser-matter interaction in the ultra-relativistic regime, the scientific research at ELI will challenge the vacuum critical field, as well as provide a new avenue to ultrafast attosecond studies of laser-matter interaction. This will make it possible to study, e.g., the internal structure of molecules and the processes that take place in them, the behaviour of viruses and other microorganisms, the principles of proton therapy, new materials and their properties, the environment in space or the possibilities of accelerating nuclear waste.

ELI will deliver a broad range of societal and economic impacts beyond scientific and technical breakthroughs which will benefit society as a whole. Through the creation of highly-skilled jobs, the development of training and education opportunities, the development of sustainable innovation partnerships and ecosystems with technological and industrial players, ELI will also contribute to the competitiveness of Europe.

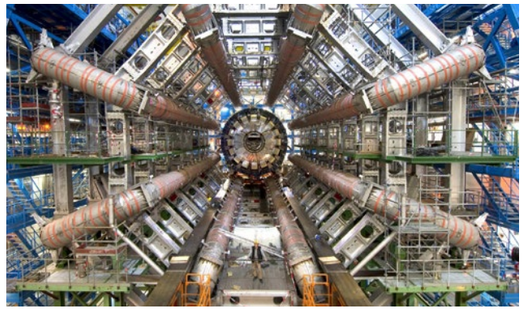
▶ The ELI Beamlines Facility Building in Dolní Břežany

International R&D Organisations

11

page

European Organisation for Nuclear Research (CERN)



CERN (*Conseil Européen pour la Recherche Nucléaire*) is an international R&I organisation based in Geneva, Switzerland, operating the largest laboratory in particle physics globally. CERN's main focus is particle physics and the study of the fundamental constituents of matter, but the physics programme of the laboratory is much broader, ranging from nuclear to high-energy physics or from studies of antimatter to the possible effects of cosmic rays on clouds. Established in 1954, CERN has 23 Member States, including the Czech Republic, and a number of cooperating countries and observers. The annual budget of CERN is approximately CHF 1.4 billion, with the contribution by Czechia amounting to more than CHF 14 million, i.e., 1% of the total CERN budget.

CERN's main RI is LHC (*Large Hadron Collider*), the most powerful accelerator in the world. LHC serves two general purpose detectors that are ATLAS (*A Toroidal LHC Apparatus*) and CMS (*Compact Muon Solenoid*), ALICE (*A Large Ion Collider Experiment*) and LHCb (*Large Hadron Collider beauty*) experiments focused on specific phenomena, and also other smaller experiments, such as FASER (*Forward Search Experiment*), LHCf (*Large Hadron Collider forward*), MoEDAL (*Monopole and Exotics Detector at LHC*) and TOTEM (*Total Elastic and Diffractive Cross Section Measurement*). Fixed-target experiments, antimatter experiments, experimental facilities and the CERN Neutrino Platform also make use of the LHC injector chain.

In CERN, different R&I activities are implemented, which are later used in experiments and other technology development (e.g., magnets, superconductors, detectors, medical applications, etc.). The main planned activity for the upcoming years is the High Luminosity upgrade of CERN's LHC and of its main experiments.

CERN is used by about 13 000 users per year. On the top of that, CERN offers various education and training schemes for graduates, traineeships for students (doctoral, technical, administrative), summer schools or professional development programmes for teachers.

Each year, CERN procures technologies, supplies and other services worth about CHF 550 million. CERN also supports knowledge transfer and the creation of spin-offs, and provides its Member States with the development of business incubators CERN BIC.

Membership of the Czech Republic

Participation of Czechia in CERN is coordinated by MEYS through its expert advisory board, the Committee for Cooperation of the Czech Republic with CERN. Engagement of the Czech scientific community in CERN is facilitated within the framework of CERN-CZ (*Research Infrastructure for Experiments at CERN*).

Approximately 230 Czech users, i.e., nearly 2% of the total CERN users, collaborate with CERN. The main focus of Czech participation in CERN are the ATLAS and ALICE experiments. Czech scientists of CERN are also involved in many other CERN experiments, such as AEgIS (*Antimatter Experiment: Gravity, Interferometry, Spectroscopy*), COMPASS (*Common Muon and Proton Apparatus for Structure and Spectroscopy*), MoEDAL, n_TOF (*Neutron Time-of-Flight Facility*), NA62, OSQAR (*Optical Search for QED Vacuum Bifringence, Axions and Photon Regeneration*) or TOTEM. In addition, they operate the CERN's Worldwide LHC Computing Grid Tier-2 centre in Prague, the Czech Republic.

For years, Czechia has been considered by CERN as a well-balanced Member State in terms of technology supplies. Czech companies are also involved in the CERN knowledge transfer. The successive generations of Medipix and Timepix detectors, developed under Czech leadership in the framework of the Medipix Collaboration, have become a trademark for highly competitive Czech industries. These detectors are used, e.g., in medical research for tomography, general dosimetry and in the space monitoring applications developed by NASA (*National Aeronautics and Space Administration*) and ESA (*European Space Agency*). They have also resulted in start-up enterprises (e.g., the Czech-Finnish Advacam, etc.).

Czech nationals are also represented among the CERN staff and students at Czech universities are successful in the CERN Graduate and Student programmes. Since 2019, a specific programme between CERN and MEYS for the support of Czech students has been increasing Czech participation in student programmes of CERN.EU Framework Programmes are additional sources of European RI funding. They are not meant to cover the basic operation and investment costs of European RIs, which usually fall under the full responsibility of their host countries and national and regional research funding organisations. Nonetheless, EU Framework Programmes constitute an important instrument to advance the European RI ecosystem and provide important resources of seed money for the implementation of European RI projects.

European Molecular Biology Conference (EMBC)

EMBC (*European Molecular Biology Conference*), founded in 1969 with the statutory seat based in Heidelberg, Germany, focuses on providing scientists and researchers grants, internships and training in the field of molecular biology. This international R&I organisation unites 30 Member States, including the Czech Republic. The annual budget of EMBC amounts to EUR 30 million per year, of which approximately EUR 250,000 is a membership contribution by Czechia.

EMBC does not operate an RI. It is basically a funding body to EMBO (*European Molecular Biology Organisation*), a profession organisation of more than 1.900 associated honorary members, who are prominent life scientists. The goals and objectives of EMBO are promoting R&I in life sciences and enabling knowledge exchange between researchers through co-funded fellowships, courses, workshops and conferences. In addition, EMBO publishes scientific journals. EMBO and EMBC are closely interlinked and share the same administration and management. EMBC does not carry out its own activities, but entrusts the execution of the general programme to EMBO and serves as a funding and administrative background provider.

The portfolio of programmes of EMBO includes Postdoctoral Fellowships, Scientific Exchange Grants, Core Facility Fellowships, EMBO Young Investigator grants and EMBO Installation Grants, as well as EMBO Courses and Workshops. The grant competitions are open not only for applicants from EMBC Member States and the key decisive criterion is the scientific excellence of candidates and their proposals. As for the EMBO Courses and Workshops, their mission is to stimulate exchange of the latest scientific knowledge and offer training in new techniques. There are over 90 meetings attracting more than 11,000 participants every year.

Membership of the Czech Republic

The Czech Republic has been a Member State of EMBC since 1994, with MEYS being responsible for participation in the EMBC's activities. Czech researchers are most successful in pursuing short-term fellowships with about five grants per year with a success rate of around 50%. In post-doctoral fellowships, the Czech success rate is about 12% with 1–2 grants obtained per year. In the most prestigious category of young investigator grants, no Czech applicant has succeeded in the last five years.

In 2006, the Czech Republic joined the voluntary programme of EMBO Strategic Development Installation Grants, which provides funding to selected scientists returning to their home country from abroad. The purpose is to facilitate the building of their research team by annual support of EUR 50,000 during the first three-year period, or five-year if extended. EMBO conducts an evaluation of the projects, suggests which of them should be supported, and the participating country decides on the number of grants to be awarded. The country´s co-funding of the programme is not included in the respective EMBC mandatory contribution.

Regarding the Czech EMBO membership basis, there are currently 12 renowned Czech scientists based at Czech research organisations who were invited to become members of the EMBO organisation.

European Molecular Biology Laboratory (EMBL)

EMBL (*European Molecular Biology Laboratory*) was established in 1974 as an international R&I organisation for life sciences with its statutory seat in Heidelberg, Germany. EMBL currently has 28 Member States, including Czechia, and Australia as an Associated Country. The annual budget of EMBL amounts to approximately EUR 260 million, of which about a half are EMBL Members´ contributions; the other half are mostly grants. The Czech contribution to EMBL amounts to about EUR 1.6 million per year.

EMBL performs R&I activities through six sites located in five host countries. The portfolio of services is wide and encompasses most of the life sciences disciplines. **EMBL Heidelberg**, besides housing the headquarters, focuses on cell biology and biophysics, developmental biology, genome biology and structural and computational Biology. Structural biology technology and services are provided at **EMBL Hamburg** and **EMBL Grenoble**. They utilise capacities of DESY (*Deutsches Elektronen-Synchrotron*) and those of ESRF (*European Synchrotron Radiation Facility*), respectively. **EMBL-EBI Hinxton** (*European Bioinformatics Institute*), located in Hinxton, United Kingdom, develops and maintains over 40 databases and tools to help scientists share and analyse global biological data. Its BioImage Archive is developed to serve as the central bioimage data repository for the European scientific community. **EMBL Rome** focuses on epigenetics and neurobiology with major strengths in mouse genetic and viral engineering, gene editing and embryology services. **EMBL Barcelona** is dedicated to biomedical and translational research with a focus on tissue biology and disease modelling.

EMBL has a long history of ground-breaking scientific achievements. Among the most notable are the unravelling of the genetic and molecular mechanisms by which multicellular organisms develop (Nobel Prize awarded); significant contributions to the study of the fundamental units of life, such as the cell and its molecular components; characterisation of the cellular transport machinery; analysis of cytoskeleton organisation; and an understanding of the function and regulation of RNA metabolism. Ground-breaking technologies are also developed at EMBL, for example, the imaging of biological samples using cryo-EM. Other notable inventions include the first functional light-sheet microscope or mass spectrometry-based protein analyses. All of these technologies are widely used today in academia and industry.

EMBL operates according to five-year plans. The current **Molecules to Ecosystems (2022–2026)** is the first one emphasizing the environmental and human health broader context instigated by global climate change, greenhouse gas effects, civilisation diseases and other eminent global challenges. One of the most instrumental facilities for achieving these goals will be the **EMBL Imaging Centre** opened in Heidelberg, Germany, offering access to state-of-the-art imaging technologies and expertise, ranging from light-sheet microscopy, 2-photon imaging, cryo-EM single molecule structure determination, correlated light-EM to cryo-EM tomography.

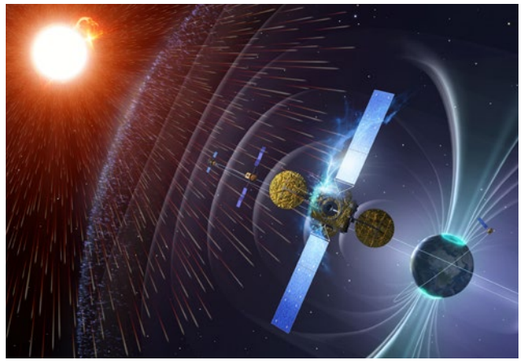
Membership of the Czech Republic

The Czech Republic became a Member of EMBL in 2014, with the participation coordinated by MEYS. The Czech membership enables Czech stakeholders to join their forces with EMBL, a strong and experienced partner, in European grant schemes. Annually, about fifteen projects coordinated by EMBL and participated in by Czech scientists are granted.

In 2012, a Memorandum of Understanding was concluded between EMBL and CEITEC (*Central European Institute of Technology*) in Brno. In 2013, a similar one was concluded between EMBL and BIOCEV (*Biotechnology and Biomedicine Centre of the Academy of Sciences and Charles University in Vestec*) near Prague.

On average, there are about 20 collaborative publications co-published annually by Czech and EMBL scientists. Many more are based using publicly available data stored by EMBL. Thanks to links between EMBL and the Czech life sciences community, a number of Czech Ph.D. students and early career researchers become interns or trainees at EMBL every year.

European Space Agency (ESA)



The main mission of **ESA** (*European Space Agency*) is to provide and promote, for exclusively peaceful purposes, cooperation among European states in space research and technology development, with a view to their use for scientific purposes and operational space application systems. Established in 1975, ESA has 22 Members, including the Czech Republic. The annual budget of ESA is approximately EUR 7 billion with ESA's headquarters located in Paris, France.

ESA operates numerous out-stations all around the world, namely **EAC** (*European Astronauts Centre*) in Cologne, Germany, **ESAC** (*European Space Astronomy Centre*) in Villanueva de la Canada near Madrid, Spain, **ESEC** (*European Space Security and Education Centre*) in Redu, Belgium, **ESOC** (*European Space Operations Centre*) in Darmstadt, Germany, **ESRIN** (*European Space Research Institute*) in Frascati near Rome, Italy, **ESTEC** (*European Space Research and Technology Centre*) in Noordwijk, the Netherlands, and **ECSAT** (*European Centre for Space Applications and Telecommunications*) in Oxfordshire, United Kingdom. **CSG** (*Centre Spatial Guyanais*) in Kourou, French Guiana, as well as the **Columbus** European module at the ISS (*International Space Station*) also fall under ESA.

ESA operates laboratories and experimental facilities on electronics, mechanics, software and material testing. Access is available for ESA project participants and external customers. ESA also supports technology transfer, and in collaboration with Member States establishes business incubation centres with **ESA BIC Prague**, operating as of 2016.

Activities of ESA are classified under mandatory activities (Basic Activities and Science Programme), Guiana Space Centre activities, and optional programme activities in the fields of Commercialisation, Earth Observation, Human Spaceflight, Microgravity and Exploration, Navigation, PRODEX (*Scientific Instruments Development Programme*), Space Safety, Space Transportation, Telecom and Integrated Applications, and Technology Support. The activities of ESA are implemented through contracts with research organisations and companies, and only entities based in ESA Member States and cooperating countries are allowed to enter.

ESA also provides a number of career opportunities, particularly in engineering. The "Young Graduate Trainee" programme is focused on graduates and offers one-year traineeships, whereas the post-docs research fellowship programme offers two-year training in science or engineering.

Membership of the Czech Republic

The leading national managing authority of the Czech Republic in charge of cooperation with ESA is the Ministry of Transport (MT), which is also the national funding authority of the ESA's industry-oriented programmes implemented in the domains of Commercialisation, Copernicus Space Component, Earth Watch, Future Earth Observation, General Support Technology, Human Spaceflight and Exploration, Launchers, Meteorology, Navigation, Space Situational Awareness and Telecommunications. The MT's annual contribution to these programmes is approximately EUR 35 mil. per year. On the top of that, MT is also responsible for the bilateral Czech-ESA Framework Project with an annual contribution of about EUR 8 mil.

On the other hand, MEYS is in charge and finances the ESA's core research and technology development programmes, i.e., Basic Activities, Guiana Space Centre, PRODEX, Science Programme and Space Situational Awareness Programme, with an annual contribution of more than EUR 14 mil.

All the Czech stakeholders, including outside the MT and MEYS, involved in the space activities are coordinated through the Coordination Committee of the Minister of Transport for Space Activities. The Czech PRODEX Committee advises both MEYS and the MT on PRODEX.

As for the ESA's core research and technology development programmes, Czech companies and research organisations are participating in the ESA flagship missions of **ATHENA**, **JUICE** and **LISA**, medium-class missions of **ARIEL**, **EnVision**, **PLATO** and **Solar Orbiter**, and the first fast-class mission of **Comet Interceptor**. In the Space Safety domain, Czech entities are actively engaged in the development of the **Vigil** mission.

European Southern Observatory (ESO)

ESO (*European Southern Observatory, its full name The European Organisation for Astronomical Research in the Southern Hemisphere*) is an international R&I organisation seated in Garching near München, Germany, operating one of the largest state-of-the-art ground-based astronomical infrastructures in the world. ESO was established in 1962, currently unites 16 Member States, including the Czech Republic, and carries out a programme focused on designing, constructing, maintaining and operating large-scale facilities for astronomy and astrophysics in Chile. The annual budget of ESO amounts to approximately EUR 250 million, with a Czech share of about 1.1%.

The very first observatory built and operated by ESO was **La Silla**. It's been equipped with several optical telescopes, of which the leading one is the 3.5-metre NTT (*New Technology Telescope*), the first in the world to have a computer-controlled main mirror. Another, 3.6-metre telescope is the world's foremost extrasolar planet hunter HARPS (High Accuracy Radial Velocity Planet Searcher) that operates a spectrograph with unrivalled precision. Nevertheless, the scientific flagship of ESO is currently the **Paranal Observatory** and VLT (*Very Large Telescope*), the most sophisticated optical ground-based astronomical facility with four 8.2-metre coordinated telescopes supplemented by four additional 1.8-metre moveable auxiliary telescopes. Scientific operations began here in 1999 and have resulted in many extremely successful research programmes, including participation in three Nobel Prize awarded discoveries. The largest ground-based astronomy project in existence is **ALMA** (*Atacama Large Millimetre/Submillimetre Array*), the radio-telescopes array, inaugurated in 2013, located in the Llano de Chajnantor desert, at 5000 metres above sea level. It is comprised of 66 giant 12-metre and 7-metre diameter antennas observing the sky at millimetre and submillimetre wavelengths and ESO holds a 37.5 % share in the project. Other partners are the American NSF (*National Science Foundation*), Japanese NINS (*National Institutes of Natural Sciences*), Canadian NRC (*National Research Council*), Taiwanese NSC (*National Security Council*) and ASIAA (*Academia Sinica Institute of Astronomy and Astrophysics*), and the South Korean KASI (*Korea Astronomy and Space Science Institute*).

Together, ESO facilities constitute the most productive astronomical infrastructure in the world. Observing time is granted on a project-quality basis. Applications are carefully assessed by the Observing Programmes Committee. Each year, more than 1800 research proposals are submitted for the use of ESO telescopes, requesting up to six times more nights than are available. For instance, in 2022 observations at ESO and the provision of ESO data resulted in over 1000 refereed published papers. Data are stored in a permanent Science Archive Facility at the ESO headquarters. The archive currently contains more than 35 million images or spectra with a total volume of about 1 petabytes of data, and it has been made available in open access mode.

Currently, the most ambitious ESO project is **ELT** (*Extremely Large Telescope*) that is being built on the Cerro Armazones mountain, close to Paranal. With its 39-metre primary mirror, it is going to be the largest telescope to have ever existed. The foundations of the construction have already been completed, with the start of operations scheduled for 2028.

Membership of the Czech Republic

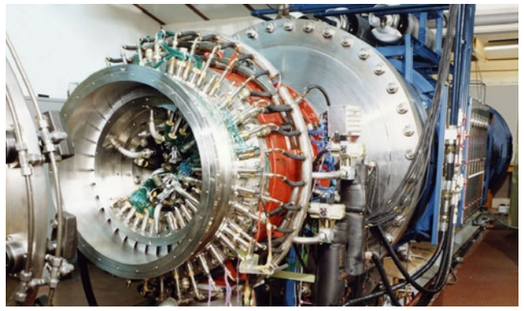
Czechia has been a Member of ESO since 2007. Czech participation in ESO is coordinated by MEYS through the Committee for ESO, an expert advisory board. Membership in ESO offers Czechia privileged access to the world´s most advanced telescopes, the opportunity to contribute to ESO's instrumental development or the possibility to take advantage of ESO's training programmes.

In 2016, Czechia became the host of the **ALMA Regional Centre**, a facility connecting the Central European region with the ALMA observatory in Chile, enabling the remote control of observations. The facility was built at Ondřejov Observatory by the Institute of Astronomy of the Czech Academy of Sciences, and since then, it has been financed by MEYS through **EU-ARC.CZ** (*Atacama Large Millimetre/Submillimetre Array – participation of the Czech Republic*)

A significant contribution to the cooperation between ESO and Czechia is the bilateral agreement on the On-the-Job Training Programme concluded in 2019, providing training positions for Czech students, early career researchers and engineers, whose expenses are covered by MEYS, including allowance for the trainees. Each trainee may stay at ESO for a period of 6–12 months, possibly extended for another term lasting up to 12 months.

A specific example of the Czech engagement in ESO is the Czech-Danish 1.54-metre telescope at La Silla observatory operated mutually by the Niels Bohr Institute and the Institute of Astronomy of the Czech Academy of Sciences. The telescope has been substantially upgraded thanks to Czech funding and is remotely controlled from the Czech Republic and Denmark.

Von Karman Institute for Fluid Dynamics (VKI)



Being a research and educational institute, **VKI** (*von Karman Institute for Fluid Dynamics*) focuses on training specialists from NATO (*North Atlantic Treaty Organisation*) Member States in the field of fluid dynamics. Founded in 1956, VKI is among the leading institutions in the respective scientific field globally. Since 2011, VKI has been serving as an ESA (*European Space Agency*) reference laboratory, and as of 2022, VKI also cooperates with NASA (*National Aeronautics and Space Administration*). Almost 60% of the VKI's income comes from research contracts concluded with the EU, ESA and industries. Approximately 25% comes from Member States' contributions. The total annual budget of VKI amounts to EUR 15 million.

VKI is divided into the **Aeronautics and Aerospace Department**, targeting aviation and space vehicle technologies, the **Turbomachinery and Propulsion Department**, focused on aeroengines, rocket engines, steam turbines, compressors, turbochargers or pumps, and also the **Environmental and Applied Fluid Dynamics Department**, which centres its activities around industrial processes, heat exchangers, pollutant dispersion, hazard mitigation and wind energy.

Almost 150 students participate every year in the VKI's academic programmes. These are **Short Training** (3–6 months), **Research Master** (a one-year postgraduate programme completed by the thesis defence), **Doctoral Programme** (in collaboration with a Belgian or foreign university) and **Post-Doctoral Programme** (advanced-level applied research programme). Moreover, VKI also organizes 8–12 one-week **Lecture Series** each year as short courses on specific topics in various areas of aerodynamics, fluid mechanics and heat transfer with application in aeronautics, space, turbomachinery and industrial fluid dynamics. Lecture Series are attended by 600 participants annually.

Research at VKI covers experimental, theoretical and computing fields. Experimental research is carried out by a unique set of wind tunnels covering all regimes, from low subsonic to hypersonic flow up to the Mach 20 Longshot Hypersonic Gun Tunnel, and other facilities, such as plasma facilities, a water tunnel, turbomachinery facilities, such as CT-3, the biggest compression tube in the world, a ground vehicle facility, wind gallery, water spray, aeroacoustics, solid propulsion facilities, as well as industrial test rigs. The experimental approach is complemented by extensive numerical simulation activities using modern parallel computing platforms.

VKI produces approximately 120 open publications per year, and further publications are based on about 130 R&I projects of proprietary nature both in the civil and defence sectors.

Membership of the Czech Republic

Participation of the Czech Republic in VKI is managed by MEYS with an annual contribution of about EUR 35,000. Approximately 6 Czech students per year participate in the VKI's academic programmes, with a similar number of participants in the Lecture Series. The level of engagement of Czechia in VKI has had an increasing tendency over the last couple of years.

Physical sciences and engineering

12

page

Background and context

R&I in physical sciences and engineering require RIs equipped with state-of-the-art technology that provides opportunities not only to keep pace with groundbreaking research in particle and nuclear physics, but also to perform breakthrough R&I 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 RIs for physics is generally demanding from a financial point of view, and usually exceeds the capacities and capabilities of individual research organisations, as well as those of regions and even countries. One can achieve an effective use of resources only by integration at the international level within the framework of RIs at the service of a wider user community.

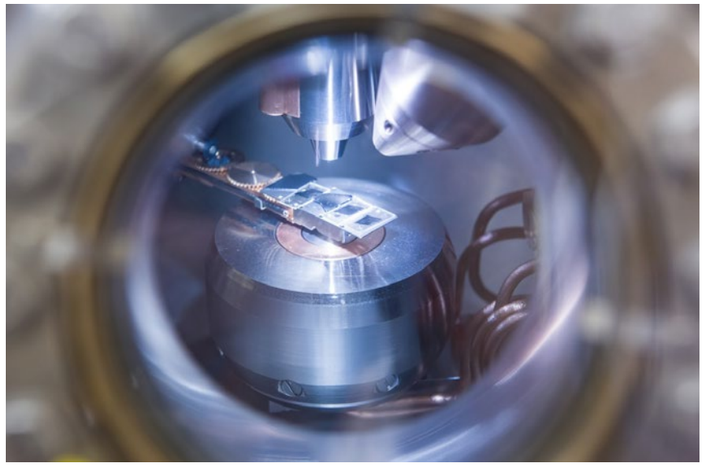
R&I in physical sciences and engineering aims to understand the physical structure of nature and its interactions over an enormous range of distances, energy and time, from the Big Bang until now, and from the subnuclear scales to the entire observable Universe. Therefore, the landscape of physical sciences and engineering RIs contains a large variety of RIs in terms of advanced technologies and services.

Physical sciences and engineering RIs share technologies, tools and practices, which go beyond thematic disciplines and constitute a solid basis for effective cooperation. The integration of large-scale analytical facilities with complementary material synthesis, characterisation and numerical simulation services facilitates close engagement with researchers and innovators across universities, research institutes and industry.

Large experiments of particle and nuclear physics, through their needs for massive data transfer, storage and processing, drive the field of Big Data. Quantum computing, although still far from practical implementation, offers the potential to solve specialised tasks much more effectively than current conventional methods. At analytical physics facilities, the brilliance increase enables higher throughput of samples with higher resolution by employing faster and larger detectors. The use of artificial intelligence, as well as standardisation in hardware and software will aid progress toward fulfilling the needs of RIs to transfer, store and handle Big Data.

▼ ESO (European Southern Observatory) – A cluster of ALMA (Atacama Large Millimeter/ Submillimeter Array) antenas

The front-line technologies required for particle and nuclear physics find their way into numerous applications in areas such as medical imaging and therapy, advanced detection and diagnostic methods, environmental sciences or computing. Particle and nuclear physics methods are closely related both in terms of science and technology, but also have significant overlaps with many other scientific fields in astronomy and astroparticle physics, material science, real-time chemistry and biology. Therefore, closer cross-disciplinary exchanges should be further reinforced. Furthermore, RI services should evolve to cope with the new needs of FAIR data, effective interactive remote access and mission-oriented R&I. The interoperability of physical sciences and engineering RIs is a new frontier, enabling the development of new and overarching R&I programmes. Clustering, powerful in enabling synergies, including the sharing of technologies and best practices, should therefore be promoted.



▲ CEPLANT – Plasma treated glass samples loaded in the XPS analysis chamber

Astronomy and astroparticle physics

Astronomy and astroparticle physics seek to understand the Universe and its components, from its still mysterious beginnings to its growing complexity, with the formation and evolution of galaxies, stars and planetary systems, up until the emergence of life. The level of necessary precision requires high-performing space, ground-based or underground observatories, mostly built and managed through international collaboration and exploited in synergy. Observations extend beyond the historical optical domain to the whole electromagnetic spectrum from radio waves to gamma-rays and new messengers, such as gravitational waves and neutrinos. Multi-messenger astronomy with its multi-wavelength, multi-instrument approach is the new frontier for studying the phenomena of the Universe and their evolution. Underground physics laboratories investigate the rarest phenomena to discover dark matter and the nature of neutrino mass. Gravitational wave astronomy is developing and ongoing observation of gravitational waves is completed by the first identifications of their source through the detection of the electromagnetic and neutrino counterparts.

The study of planets from our Solar System through telescope observations, planetary probes and sample return missions, has built up a multidisciplinary field spanning from astrobiology to geology. With facilities able to probe the atmospheres of planets outside our own Solar System, new directions in comparative climate science could yield new insights about the Earth's climate.

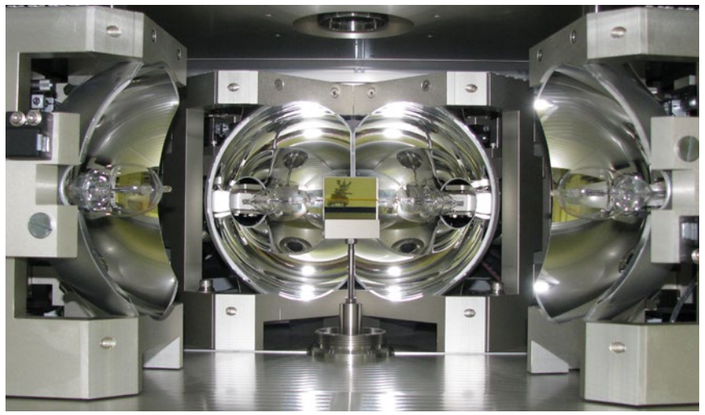
The science drivers of astronomy and astroparticle physics merge with those of particle and nuclear physics, linking physics from the infinitely large to the infinitely small, giving a holistic rationale for overall RI investment in the physical sciences and engineering field. The evolution of astronomy and astroparticle physics projects goes toward internationalisation in the construction and operation of RIs. Furthermore, RIs may work in close cooperation and international networks can be set up to deal with the key subjects. Ground-based observations can play an essential role in the scientific exploitation of space/ observations.

The study of planets from our Solar System and other planetary systems in our galaxy builds up as a multidisciplinary science field, using a variety of techniques, complementary ground and space-based observations. A key topic for the future is the search for early life signs in exoplanet studies, the expansion of astrochemistry to this field, as well as the development of astrobiology.

Particle and nuclear physics

Particle and nuclear physics deal with the smallest building blocks of nature that constitute our present world and the Universe, and the interactions among them. Dedicated accelerator facilities are necessary to probe hadronic and nuclear structure. The research in particle and nuclear physics thus relies on intense international cooperation and pooling of resources on the macro-regional and even global scales.

In particle physics, the recent discovery of the Higgs Boson has completed the Standard Model. Nevertheless, this discovery cannot provide any explanation for Dark Matter and Dark Energy. At the confluence of particle and nuclear physics, the exploration of Quark Gluon Plasma and of the strongly interacting matter gives access to study the properties of matter prevalent in the early Universe after



▲ MGML – Optical furnace for growth by floating zone method

the Big Bang. Nuclear physics contributes with precision measurements to the search for Dark Matter and new physics beyond the Standard Model. Fundamental and applied research in nuclear physics also play an important role in the development of carbon free sources of energy and advanced cancer diagnosis and treatment.

Following the abovementioned, the search for physics beyond the Standard Model will remain the central quest for particle physics. The recent update to the European Strategy for Particle Physics identifies a Higgs factory – linear or circular collider – as the next future accelerator goal for Europe in order to explore in detail the properties of the Higgs particle.

Complementary to the energy frontier, new physics can be probed by experiments searching for extremely rare phenomena. There are proposals targeting feebly interacting particles in the low mass region that could reveal new particles with possible cosmic relevance. They require very intense particle beams or lasers. Dark Matter searches in underground laboratories will require detectors with much larger target mass. In the longer-term, new detector technology capable of directionality will have to be developed.

In accelerator technology, the development of new and compact acceleration schemes, such as laser and electron or proton induced wake fields in static plasmas, are potential game changers. Likewise, developing a muon collider demonstrator in Europe would be a major new element in accelerator technology opening new scientific doorways. Advanced and reliable innovative detectors are a cornerstone of research in the area of particle and nuclear physics, and propagate over time to detection and imaging systems for use in many other areas of science and society. New Quantum sensing devices are under development and will increase the precision of measurements considerably.

Analytical physics

Analytical physics RIs explore the frontiers of science ranging from fundamental physics to applied materials science, using high-brilliance beams of electrons, neutrons, ions, photons or high magnetic fields. They offer a broad range of analytical techniques based on particle and field interactions with matter. They serve academia, industry and society with strong links to other RI facilities, especially in the domains of energy, environment, health and food. They find use in physics, chemistry, materials science and engineering, environmental research, life sciences, in the fields of cultural heritage, as well as in clean energy and climate R&I. High-performances, innovative and state-of-the-art nanotechnologies are also essential to address several of the grand societal challenges. Nanotechnologies are involved in the development of clean energy, combating global climate change and eliminating pollution. However, they also play a key role in cybersecurity, biotechnologies, key digital technologies and computing.

All analytical physics RI facilities boost their technologies to increase beam brilliance and field density to improve characterisation sensitivity, as well as resolution in time and space. Short-pulse, high-power lasers and their secondary sources of particles and radiation aim at highly efficient and high repetition rate laser systems to drive laser-plasma based particle accelerators and x-ray sources. Addressing these new needs in laser technology is becoming a challenging task in order to further enlarge the user community in areas with high industrial and societal impact. Laser physics RIs have a strong impact on particle and nuclear physics through the common development of accelerator technologies. Developments are also needed in novel electron microscopes focused on three-dimensional imaging of materials' functional properties. The future unavailability of neutron sources poses a major threat as older sources are closing down, while existing sources are unable to cope with increasing demands. Therefore, there will be a strong need to continue to support existing national sources. In ion beam facilities, there is a growing interest in the use of radioisotopes in materials research. For high magnetic field RI facilities, coordinated development is needed to develop even higher static and pulsed magnetic fields, improve the required materials and enable a wider portfolio of measurements in the short time scales of pulsed fields.

All in all, significant scientific and technological breakthroughs are expected from analytical physics RIs by exploiting new ways of open cooperation with other fields of physical sciences and engineering and users from different fields of science, new thematic user access modes, as well as the close involvement of industrial R&I.

Current state of play

RIs included in the presented Roadmap operate in the Czech Republic and provide services for R&I in physical and technical sciences. They are supplemented by numerous memberships of Czechia in international RIs based in Europe, the United States of America (USA) and Latin America.

Particle and nuclear physics

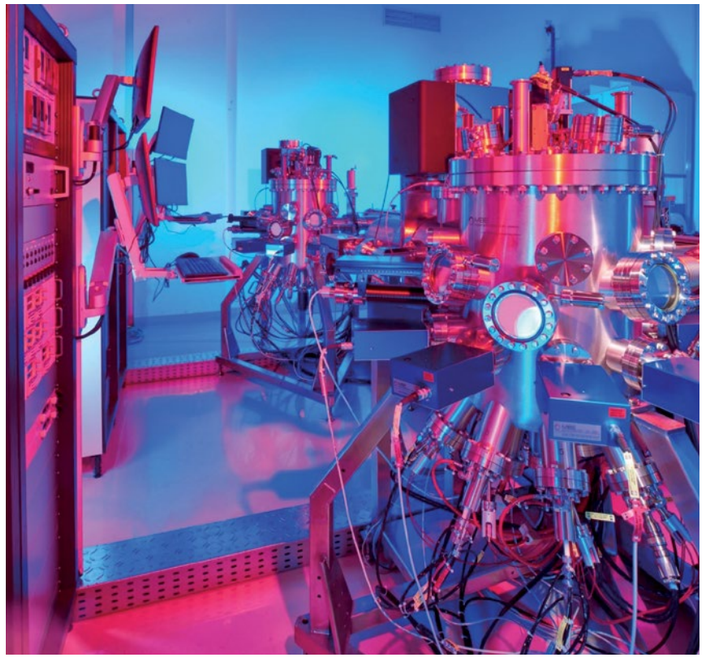
Research in the fields of nuclear and particle physics usually requires large-scale RIs, and it is thus conducted in large international laboratories. Czech researchers have a good reputation in this field, and they participate in leading experiments in Europe, as well as globally.

Since its establishment, Czechia 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*), based in Geneva, Switzerland. The Czech Republic is very active in the CERN scientific programme through experiments such as ATLAS and ALICE, but it is also involved in technology contracts and provides equipment to CERN. **CERN-CZ** (*Research Infrastructure for Experiments at CERN*) organises Czech scientists for their participation in CERN experiments and supports the development, construction and operation of equipment delivered to CERN. In the Czech Republic, it supports the related RI necessary, e.g., for the development and testing of detectors and IT services for CERN.

The Czech research community also participates in experiments performed at Fermilab (*Fermi National Accelerator Laboratory*) in Batavia, Illinois, USA. After the termination of the Tevatron collider in 2011, the laboratory has been devoting its capacities to the preparation of a major neutrino physics experiment. **FERMILAB-CZ** (*Research Infrastructure for Fermilab Experiments*) facilitates Czech engagement in the NOvA experiment and Czech involvement in the construction of DUNE, currently the largest neutrino experiment worldwide. Moreover, it runs a detector laboratory contributing to the design and construction of detectors for Fermilab experiments, and develops 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 possibilities to work with the unique collider based at BNL (*Brookhaven National Laboratory*) in Upton, New York, USA. Related to BNL, based on the same principle as in other cases, **BNL-CZ** (*Brookhaven National Laboratory – participation of the Czech Republic*) supports the participation of Czech scientists in the construction, as well as operation of the latest detection technologies used in BNL to study ultrarelativistic collisions of nuclei.

The LSM (*Laboratoire Souterrain de Modane*) underground RI laboratory situated in Modane, France, covers multidisciplinary fundamental research (e.g., dark matter searches, neutrino properties, radiobiology, etc.) and related applied research fields (e.g., security in nuclear energetics, electronics, etc.), which require an extremely low radiation background. Czechia takes part in the construction of new LSM equipment (e.g.,



▶ CzechNanoLab – Molecular beam epitaxy equipment for growing thin-film monocrystalline materials

in the field of the automated operation of detectors, etc.) and LSM laboratory operations (e.g., laboratory of ultra-sensitive detectors, anti-radon measures, etc.). In this case, Czech activities are supported through **LSM-CZ** (*Laboratoire Souterrain de Modane – participation of the Czech Republic*).

The main goals and objectives of **AUGER-CZ** (*Pierre Auger Observatory – participation of the Czech Republic*) are to contribute to the understanding of the nature, origin and propagation of ultra-high energy cosmic rays in the universe. This is being studied through the Pierre Auger Observatory, the largest detector of cosmic rays in the world, which is based in Malargüe, Mendoza, Argentina. Czech researchers take part in the development and construction of the observatory fluorescence telescopes, atmospheric monitoring and data analysis.

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

Last but not least, Czech scientists are also involved in the construction of FAIR (*Facility for Antiproton and Ion Research in Europe*) in Darmstadt, Germany, through **FAIR-CZ** (*Facility for Antiproton and Ion Research – participation of the Czech Republic*), enabling the participation of Czech scientists in experiments with antiprotons and heavy ion beams.

Beyond the above-mentioned LRI projects, Czechia is also active in other international large-scale RIs for nuclear and particle physics, such as ESRF (*European Synchrotron Radiation Facility*) and ILL (*Institut Laue-Langevin*) in Grenoble, France, and XFEL (*X-ray Free Electron Laser*) in Hamburg, Germany. However, Czech involvement in these facilities is financed through other funds available directly to Czech research organisations, though not depreciating the importance of Czech involvement in the development and operation of relevant RIs.

Radiation-based physics

The radiation of photons, neutrons and charged particles is among the key technologies in R&I in many areas, including materials research and biology. In the Czech Republic, there are several LRIs using such methods. In addition, the Czech research community is involved in many similar international laboratories abroad, thus complementing the opportunities that are provided directly in Czechia.

▼ SPIRAL2-CZ –Time of Flight (TOF) hall for measurements on neutron beams at NFS (Neutrons For Science) laboratory

One of the most developed memberships of Czechia in international RIs is **SPL-HTC** (*Surface Physics Laboratory – Hydrogen Technology Centre*). SPL-HTC provides unique experimental equipment for photoemission spectroscopy, which constitutes a part of CERIC-ERIC (*Central European Research Infrastructure Consortium*). SPL-HTC runs the Material Science Beamline (MSB) at the Elettra Synchrotron in Trieste, Italy. In addition, it operates the Surface Physics Laboratory (SPL) and a hydrogen technology facility (HTC) for the energy storage R&I at Charles University, Prague, Czech Republic. SPL-HTC provides top-class conditions for materials research, surface physics and chemistry, catalysis and the study of organic molecules.

ESS Scandinavia-CZ (*European Spallation Source – participation of the Czech Republic*) is focused 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, the foreseen most intensive neutron pulsed source in the world, currently under construction in Lund, Sweden, with an out-station computing centre in Copenhagen, Denmark.

SPIRAL2 (*Système de Production d'Ions Radioactifs Accélérés en Ligne*) is developed as an important enlargement of the GANIL (*Grand Accélérateur National d'ions Lourds*) laboratory I in Caen, France. The cooperation with this RI is facilitated through **SPIRAL2-CZ** (*Système de Production d'Ions Radioactifs Accélérés en Ligne – participation of the Czech Republic*), which enables Czech researchers to study nuclear reactions that are important for the astrophysical models of nucleosynthesis in red giants, explosions in novae or changes in material properties in neutron fields.

Laser physics

The operation and further development of laser physics facilities situated in the Czech Republic represent a major contribution to the Laserlab-Europe (*Integrated Initiative of European Laser Research Infrastructures*) association of European laser laboratories. Czechia is an important player in the field of laser physics and contributes to general progress in this area both in Europe and worldwide. The expertise gained by Czech scientists in this field led not only to the assignment of PALS to Czechia, but also to the subsequent decision to place ELI Beamlines in the Czech Republic.

PALS (*Prague Asterix Laser System*) is a first-class RI designed to study laser induced plasma and its applications, as well as the interactions of radiation, in particular X-rays, with matter. PALS plays a decisive role in the development of laser sources of multiply charged ions with energies in 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 became the basis for the growth of laser physics in the Czech Republic, which led to the formation of ELI Beamlines and the Czech assignment to ELI.

ELI Beamlines is one of the three pillars of ELI (*Extreme Light Infrastructure*), and it operates a world-class laser facility. It enables to carry out 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, or X-ray optics.

The decision to build one of the pillars of the most powerful laser RIs in the world in Czechia resulted from the wide recognition of the expertise of Czech laser physicists, proved by the successful transfer and operation of PALS (former ASTERIX) and its further development and the introduction of new experiments. Thereby, the Czech Republic gained solid foundations to host excellent researchers and it has become a generally recognized centre of excellent laser science in Europe and globally. The future development of laser RIs situated in Czechia will bring new challenges in the technology development of sophisticated instruments necessary for upcoming fields of R&I. This progress will provide opportunities also for facilities complementary to ELI, such as HiLASE (*High Average Power Pulsed Lasers*).

The significance of ELI as a whole is symbolically emphasized by the fact that it is the very first and only RI from the ESFRI Roadmap that was built entirely in the so-called new EU Member States. The success of operation of the ELI pillars depends on their integration within ELI ERIC (*Extreme Light Infrastructure European Research Infrastructure Consortium*) and their close cooperation with countries with the most important user communities. Wide involvement of the international community of laser physicists in the R&I programmes of ELI Beamlines, PALS and HiLASE, is therefore a key prerequisite for the efficient use of these RIs and an essential condition for their long-term sustainable development.

Materials physics

Progress in R&I performed in the areas of the fabrication, characterisation and use of new materials, nanomaterials, functional materials and nanostructures in Czechia is very intense. In the initial period of worldwide interest in new materials and advances in nanotechnologies, the Czech Republic was set back by the lack of laboratory equipment necessary for these new materials and nano-sciences. The first phase of construction of relevant R&I laboratories was later financed using the EU Cohesion Policy Funds and enabled Czech researchers to gain state-of-the-art equipment. After finishing this phase, the original equipment deficit was eliminated. Nevertheless, the profile of the majority of LRIs operated in Czechia in the field of materials physics is relatively similar. In light of this, it is necessary to achieve a higher specialisation, narrower specification and cooperation based on synergies and complementarities between individual RI laboratories. The following periods of advancement of newly constructed LRIs in the Czech Republic will depend not only on

sustainability, but also on the ability to react rapidly to the new challenges in materials sciences and to the progress made in the instrumentation.

The contribution of Czechia to the pool of European research organisations acting in materials sciences is mainly through **CzechNanoLab** (*CzechNanolab Research Infrastructure*), which provides technologies and services in nanotechnologies and materials sciences through the CEITEC Nano laboratory in Brno and the LNSM Prague Laboratory of Nanostructures and Nanomaterials. These two laboratories together facilitate open access to excellent instruments for the fabrication and analysis of nanostructures, nanomaterials and nanocomponents.

The expertise of CzechNanoLab is further complemented by **CEMNAT** (*Center for Materials and Nanotechnologies*), which contributes to R&I in physics, chemistry and in the field of new materials synthesis and their characterisation.

MGML (*Materials Growth and Measurement Laboratory*) offers open access to the equipment designed for the preparation and characterisation of high-quality materials, monocrystals in particular. MGML also enables taking 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 LRIs operated in Czechia in materials sciences completed by **CEPLANT** (*R&D Centre for Low-Cost Plasma and Nanotechnology Surface Modifications*), aiming to provide services for the R&I of plasma technologies and nanotechnologies, leading to the fabrication of unique advanced materials and the introduction of environmentally friendly manufacturing processes.

Astronomy, astroparticle physics and space activities

The engagement of Czech scientists in the Pierre Auger Observatory and the construction of CTAO (*Cherenkov Telescope Array Observatory*), described above in the context of Czech LRI projects in the fields of nuclear and particle physics, is also highly relevant for research being conducted in astrophysics.

The key partner of the Czech research community in the field of astronomy is ESO (*European Organisation for Astronomic Research in the Southern Hemisphere*) with headquarters based in Garching near München, Germany, and out-stationary observatories in the Atacama Desert in Chile. ESO is participated in by Czechia as a Member State and the Czech membership in ESO guarantees Czech astronomers access to top-class instruments for astronomical observations, including participation in the construction and operation of the largest ground-based telescope – ELT (*Extremely Large Telescope*). ESO, in cooperation with its American and Asian partners, has built and operates, inter alia, the ALMA (*Atacama Large Millimetre / Submillimetre Array*) interferometer. The access of users from Czechia and Central Europe to ALMA is facilitated through **EU-ARC.CZ** (*Atacama Large Millimetre/Submillimetre Array – participation of the Czech Republic*).

EST-CZ (*European Solar Telescope –– participation of the Czech Republic*) supports Czech researchers in their involvement in the design, construction and operation of EST (*European Solar Telescope*), which will be built on one of the Canary Islands, 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.

Czechia is also a Member State of ESA (*European Space Agency*) with headquarters in Paris, France, focusing on space research and the development of space technologies. Based on its membership in ESA, Czechia can use ESA's capacities and capabilities within EAC (*European Astronauts Centre*) in Cologne, Germany, ESAC (*European Space Astronomy Centre*) in Villanueva de la Canada near Madrid, Spain, ESEC (*European Space Security and Education Centre*) in Redu, Belgium, ESOC (*European Space Operations Centre*) in Darmstadt, Germany, ESRIN (*European Space Research Institute*) in Frascati near Rome, Italy, ESTEC (*European Space Research and Technology Centre*) in Noordwijk, the Netherlands, and also ECSAT (*European Centre for Space Applications and Telecommunications*) in Oxfordshire, United Kingdom. The Czech Republic also participates in the operations of CSG (*Centre Spatial Guyanais*) in Kourou, French Guiana, as well as the European module Columbus at the ISS (*International Space Station*).

The specific membership of Czechia in international R&I organisations, covering a wide range of scientific disciplines including aeronautics, is 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 R&I in astronomy, astrophysics and space are fully international. This brings an obvious advantage to smaller and mid-sized countries with rather limited R&I capacities, including the Czech Republic. Thanks to the memberships of Czechia in the international RIs described above, Czech researchers can gain access to excellent facilities, which substantially exceed the capabilities of equipment in their home institutions.

Gaps, challenges, needs and opportunities

The cosmic gravitational waves detection achieved by the U.S.–European consortium LIGO-Virgo, composed of LIGO (Laser Interferometer Gravitational-Wave Observatory), operated by Caltech (California Institute of Technology) and MIT (Massachusetts Institute of Technology), and Virgo, run by EGO (European Gravitational Observatory), leads to rapid development in the respective field and experimental study of yet undiscovered astrophysical processes, including detected objects and phenomena observations by astrophysical and particle physics methods, such as astronomical telescopes and experiments detecting space neutrinos and cosmic radiation. This particular scientific field has emerged with the endorsement of the ESA's LISA (Laser Interferometer Space Antenna) mission and its progress is also closely linked to the emerging Einstein Telescope project to build a next generation underground gravitational wave observatory. Against this background and considering the Czech research community's expertise in physical sciences, it appears appropriate for Czechia to engage with this scientific collaboration through participation in the already existing and future international **gravitational wave observatories**.

▶ **ESO (European Southern Observatory) – The vibrant ripple of the Milky Way above Chile's Chajnantor plateau with several of the Atacama Large Millimeter/submillimeter Array (ALMA) antennas**

Another prospective area for a potential new LRI project to emerge in Czechia is the sectorial domain of engineering, namely **engineering applications for the 21st century**. The economy of the Czech Republic has been largely based on industrial production, with mechanical engineering playing an essential role. One of the major challenges still persisting in Czechia is multidisciplinary R&I covering all Key Enabling Technologies (KETs) or other specialised fields. Whereas rather standard equipment, methods and expertise are widely available in a number of Czech research organisations and companies, highly specialised and unique R&I facilities and functionalities are rare in the Czech Republic. Their integration through an LRI project would benefit both academia, and businesses and industries. Additionally, the **Industry 4.0** concept, based on automatisation, digitalisation and robotisation, also brings a distinctive added value for the manufacturing sector, including the involvement of artificial intelligence in all phases of the product's life-cycle. While providing opportunities to strengthen the complex industrial production chain resilience, it constitutes another field for a possible new LRI project proposal to be submitted in the years to come.

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

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

Phase: operational
Character: distributed

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

Year of inclusion on the Czech Roadmap: 2010

Motto:
International Research Infrastructure to Study the Most Energetic Particles in the Universe

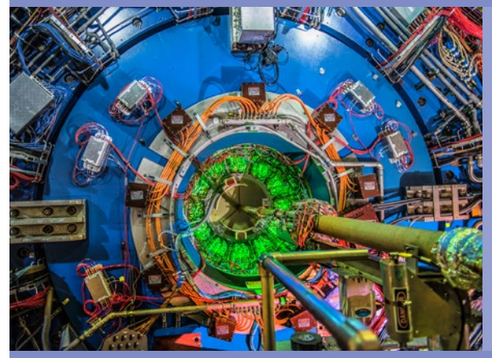
Characteristics

For over a decade, the Czech Republic has been contributing to the construction, operation, maintenance and improvement of equipment at the Pierre Auger Observatory, the largest detector of cosmic rays in the world, covering more than 3,000 square kilometres of the Argentinean pampa. The Observatory is an international RI with 17 Member Countries and uses two techniques to detect cosmic rays – namely fluorescence telescopes and an array of surface detectors. Both systems are targeted at particles of the highest possible energies that arrive to Earth from space. The Czech research community, in collaboration with international partners, contributes to a deeper understanding of the properties of cosmic ray particles; its key role was demonstrated when, for many years, it took over leadership responsibility for the operation of the fluorescence telescope system. Overall, 15 out of the 27 Pierre Auger Observatory telescopes are equipped with glass mirrors of Czech provenance. Another unique contribution by Czechia is the development and construction of devices for atmospheric monitoring. Two Czech robotic telescopes FRAM, which work fully autonomously, measure the aerosol content above the Pierre Auger Observatory and determine if cosmic ray showers seen with an anomalous profile through the fluorescence detectors are affected by the scattering of light in the presence of clouds. The all-sky cameras from the Czech Republic measure the distribution of clouds above the Pierre Auger 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 Czechia carry out tests of brand-new techniques to study cosmic rays. Recently, Czechia has participated in the expansion of the Pierre Auger Observatory with an array of scintillator detectors placed above the existing surface detector stations. The activities of AUGER-CZ have also led to the involvement of the Czech Republic in CTA (*Cherenkov Telescope Array Observatory*). AUGER-CZ has been actively involved in a number of European RI networks, such as the AugerNext, which studies the possibilities offered by new techniques of cosmic ray detection. AUGER-CZ also takes part in strategy building through APPEC (*Astroparticle Physics European Consortium*).

Societal and economic impacts

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, the robotisation of devices to allow them to collect data in autonomous mode, detection of optical and radio-frequency radiation and wireless communications. For Czech glass, optical and mechanical components suppliers, AUGER-CZ presents opportunities for collaboration in the world's largest experiment in the field and significantly increases their international 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

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

Phase: operational
Character: distributed

Website:
bnl.casticova-fyzika.cz

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 Upton, New York, 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 globally unique scientific instruments, such as the BNL's Relativistic Heavy Ion Collider (RHIC), National Synchrotron Light Source II 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 the 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, preparation of the ePIC experiment for the future Electron Ion Collider (EIC) and taking part in the development, construction and operations of leading 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 research programme 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 programme, the construction of the EIC will commence 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 worldwide, such as LBL (*Lawrence Berkeley National Laboratory*) in Berkeley, California, USA, LLNL (*Lawrence Livermore National Laboratory*) in Livermore, California, USA, and ANL (*Argonne National Laboratory*) in Lemont, Illinois, USA. In ERA, Czech researchers are intensively working on the development and testing of new detector technologies with FAIR (*Facility for Antiproton and Ion Research*) in Darmstadt, Germany, and High-Luminosity LHC (*High-Luminosity Large Hadron Collider*) at CERN in Geneva, Switzerland.

Societal and economic impacts

BNL-CZ performs the 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 industrial partners in Czechia. 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 and crystals for calorimeters.

Centre of Materials and Nanotechnologies

Acronym:
CEMNAT

Hosting institution:
University Pardubice

Responsible person:
Prof Dr Tomáš Wágner
tomas.wagner@upce.cz

Phase: operational
Character: single-sited

Website:
fcht.upce.cz/en/fcht/center-of-materials-and-nanotechnologies-cemnat

Year of inclusion on the Czech Roadmap: 2015

Motto:
Research Infrastructure for Basic and Applied Research with Particular Significance in the Field of One- and Two-Dimensional Nanomaterials, Setting New Trends in their Synthesis and Practical Application

Characteristics

CEMNAT is a LRI for basic and applied research with particular significance in the field of chemistry and new materials technologies. In the Czech Republic, it contributes to fulfilling national priorities in terms of the sustainability of energetic and materials resources. R&I at CEMNAT is focused on 0D,1D and 2D nanomaterials (e.g., quantum dots, nanotubes, nanofibers, nano sheets, etc.) and thin films, in particular, on thin functional layers. It advances the latest trends in their synthesis and practical application. CEMNAT owns a whole range of modern scientific instruments that are operated in open access regime. Many of these are unique in Czechia, being intensively utilised by various user groups. Among these instruments, the device for atomic layer deposition is 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 device for fibre synthesis that enables 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 beam 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 visualisation functions and elemental analyses. All prepared or modified materials have various uses. Using the CEMNAT equipment, users can achieve excellent scientific results overcoming challenges in the fields, such as energy conversion and storage, optoelectronics or surface engineering. CEMNAT is a partner of Czech nanotechnological companies that deal with R&I of various types of nanomaterials for various uses. CEMNAT is a part of the NANOPROGRESS cluster connecting companies and research organisations active in R&I and the commercialisation of nanomaterials. CEMNAT also cooperates with RIs in the Czech Republic and abroad that are very significant in materials research. This applies, in particular, to synchrotron units, Elettra Synchrotron in Trieste, Italy, and ESRF (*European Synchrotron Radiation Facility*) in Grenoble, France, and also RIs utilising high energy lasers, ELI ERIC (*Extreme Light Infrastructure*) and HiLASE (*High Average Power Pulsed Lasers*) in Dolní Břežany, Czechia.

Societal and economic impacts

CEMNAT researchers prepare innovative materials with high added value (highly pure amorphous or crystalline inorganic materials) that have excellent performance in catalysis, medicine, batteries, sensors, memories and optoelectronics. Due to their comprehensive experience, excellent know-how and quality of equipment, CEMNAT has successfully developed collaboration with companies dealing with nanomaterials. The most important cooperations include the development of technologies for the production of various inorganic and biopolymeric fibres, inorganic nanoparticles and nanotubes. Based on these partnerships, new patents and verified technologies are being realised 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 Czechia also through the education of students and young researchers who learn to work with excellent technologies.

R&D Centre for Plasma and Nanotechnology Surface Modifications

Acronym:
CEPLANT

Hosting institution:
Masaryk University

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

Phase: operational
Character: single-sited

Website:
ceplant.cz

Year of inclusion on the Czech Roadmap: 2019

Motto:
Environmentally Friendly, Low-Cost Plasma Technologies

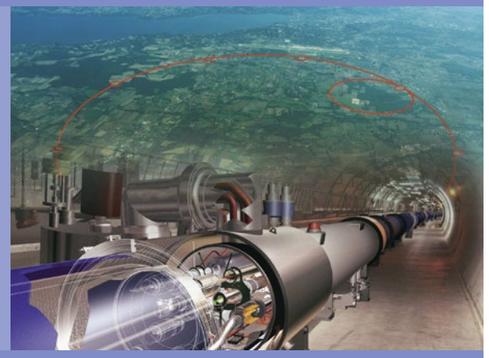
Characteristics

CEPLANT is based on the long-standing tradition of top basic and applied research in the field of plasma nanosurface science with a focus on plasma-enabled scalable nanofabrication. Its activities have 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. R&I in this area help address current socioeconomic 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. The scientific and technological scope of CEPLANT extends along the entire innovation chain, 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 customised plasma technologies developed to test and optimise the different plasma surface treatment approaches of materials according to the user specifications. CEPLANT users are able to carry out research and modelling of fundamental plasma processes and their advanced diagnostics at an international level under one roof. CEPLANT also participates in the teaching and guiding of Bachelor, Master and Ph.D. students, and involves them in their R&I career. CEPLANT is engaged in international networks and associations of research organisations and innovative companies active in the field of plasma technology and cooperates, e.g., with INPLAS (*Network of Competence Industrial Plasma Surface Technology*), BalticNet-PlasmaTec, or the Graphene Council.

Societal and economic impacts

The key feature of CEPLANT is to carry out R&I of unique advanced materials and environmental production processes in engineering, energy, sustainable agriculture and biomedicine. CEPLANT is active in developing advanced plasma technologies potentially applicable in the textile, polymer, glass, paper, wood and food industry. In cooperation with various companies, CEPLANT develops plasma technologies for the environmental cleaning of material surfaces, advanced materials for printed electronics, photovoltaics and wide-scale green energy applications (e.g., manufacturing of graphene materials prepared by the unique plasma-triggered reduction of graphene oxide), plasma sources for biomedicine and agriculture, and the deposition of functional coatings for engineering. Long-term cooperation with companies has already resulted in the inclusion of CEPLANT among European KET centres (*Technology Centres in the field of Key Enabling Technologies*) that cooperate with small and medium-sized enterprises across the EU. CEPLANT is implementing international projects with small and medium-sized enterprises and due 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:
Charles University
Czech Technical University in Prague
Nuclear Physics Institute of the Czech Academy of Sciences
Palacký University Olomouc
Technical University of Liberec
University of West Bohemia

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

Phase: operational
Character: distributed

Website:
particle.cz/infrastructures/CERN-CZ

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2021: landmark

Motto:
Support for the Participation of Czech Researchers and Research Institutions in Experiments at the World's Largest Particle Accelerator and Other Unique CERN Facilities, as well as Engaging Czech Companies in CERN Technology Development

FZU Institute of Physics of the Czech Academy of Sciences

Characteristics

CERN-CZ organises the participation of the Czech research community in CERN (*Conseil Européen pour la Recherche Nucléaire*), located in Geneva, Switzerland. CERN operates the world's largest particle accelerator – Large Hadron Collider (LHC) – and hosts experiments that study particle collisions at the highest energies. CERN coordinates and organises European research in the field and plays a world-leading role in the research of elementary particle physics and the properties of matter under extreme conditions. The aim of CERN-CZ is to support the participation of the Czech Republic in CERN experiments, primarily in the development, construction and operation of these facilities, including the operation of the local Czech RI, which is substantial for the detector R&D and production, as well as computing e-infrastructure for the data processing. CERN-CZ develops new particle detection technologies, including their applications, primarily in the field of calorimetry and semiconductor tracking detectors. The technology scope of CERN-CZ comprises 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 Cooperation of the Czech Republic with CERN, an expert advisory board to the Ministry of Education, Youth and Sports, CERN-CZ also ensures representation and exercises the rights and obligations in CERN governing and advisory bodies, and in CERN experiments. Unique experimental equipment at CERN, constructed and operated with the assistance of CERN-CZ, allows the Czech research community to contribute to the world-class results in nuclear and particle physics produced at these facilities.

Societal and economic impacts

The ambitious CERN research programme and access to the most progressive technologies increase the attractiveness of educational and research institutions. Students and trained experts subsequently use acquired skills outside academia, increasing the innovative potential and competitiveness of companies. Czech companies annually obtain CERN contracts in the range of CZK 30–100 million. These benefits also go beyond the bare financial value, as the construction of technologically demanding devices stimulates innovation and their successful operation brings prestige to the companies and the Czech industrial sector. Czech companies have significantly contributed to the construction of CERN LHC experiments (e.g., silicon detectors, power sources, vacuum and optical components, steel, etc.) and the ongoing HL-LHC (*High-Luminosity Large Hadron Collider*) upgrade provides even further opportunities. Examples of the application of technologies in Czech industry include semiconductor detectors with applications in the cosmic industry, education and medicine, and scintillation detectors employed in electron microscopy and tomography.

cta cherenkov telescope array

Characteristics

CTA (*Cherenkov Telescope Array*) is an international RI dedicated to 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 plays an important role in the preparation of CTA, in particular through the development of optical components and the construction of devices for the characterisation of the atmosphere. The Joint Laboratory of Optics 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 takes place. Czech opticians are developing technologies for the production of optical systems, such as positioning the cameras and long-lived mirror surfaces used, e.g., in CTA LST (*Large Size Telescope*) and MST (*Middle Size Telescope*). Throughout the process, they apply the experience they gained at the Pierre Auger Observatory. Moreover, two telescope prototypes of SST-1M (*Small Size Telescope*) originally developed for CTA are now installed at the Ondřejov Observatory, Czechia. Regarding the monitoring of the atmosphere above the future observatory, 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 with the observations of the main telescopes during FRAM operation. Two FRAM devices are already in operation on the site of the future southern part of the CTA observatory in Chile close to the experimental apparatuses of ESO (*European Organisation for Astronomical Research in the Southern Hemisphere*). A further FRAM device is installed at the site of the future northern part of CTA at La Palma within the Canary Islands archipelago, Spain. The atmospheric monitoring activities are a continuation of previous work regarding the search for optimal locations of CTA sites. CTA-CZ significantly contributed through the development of all-sky cameras and new methods for analysing satellite images. CTA is collaborating with other international RIs such as SKA (*Square Kilometer Array*) and it is in the final phases to establish an ERIC.

Societal and economic impacts

The Czech Republic is contributing to the construction of CTA mainly through the development of optical systems for Cherenkov telescopes and of atmospheric monitoring devices, such as the FRAM telescopes and all-sky cameras. Czech optical detectors are already being widely used at CTA and the development of further devices is underway. Participation in CTA is thus significant in terms of the development of new technologies. CTA presents a unique opportunity for Czech industry to collaborate with a large-scale RI 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 their participation in the largest international experiment in this key scientific field. Thanks to this, their international recognition, as well as their competitiveness, is significantly increasing.

Cherenkov Telescope Array – participation of the Czech Republic

Acronym:
CTA-CZ

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

Partner institutions:
Astronomical Institute of the Czech Academy of Sciences
Charles University
Palacký University Olomouc

Responsible person:
Michael Prouza, Ph.D.
prouza@fzu.cz

Phase: construction
Character: distributed

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

Year of inclusion on the Czech Roadmap: 2015
Status on the ESFRI Roadmap 2021: landmark

Motto:
Research Infrastructure to Study High-Energy Photons – Probes into Extreme Processes in the Universe

CzechNanoLab Research Infrastructure

Acronym:
CzechNanoLab

Hosting institution:
Brno University of Technology

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

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

Phase: operational
Character: distributed

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 its users with multi-disciplinary tools and know-how at the frontier of nanoscience and nanotechnology. It gives scientists and engineers an opportunity to complete the R&I cycle, in which fundamental ideas and experiments fuel tech-transfer activities that in turn provide feedback and inspiration to basic science. CzechNanoLab bridges fundamental academic research and practical industrial applications with training in R&I and entrepreneurship. CzechNanoLab serves an international community of scientists and engineers with ambitions to work on the most attractive and challenging R&I projects in nanoscience and nanotechnology. These projects include new types of quasiparticle interactions, lossless electron transfer, artificial neural networks, nanodevices for medical diagnostics and therapeutics, and many more. CzechNanoLab consists of two sites, CEITEC Nano located in Brno, and the Laboratory of Nanostructures and Nanomaterials (LNSM) based in Prague. These two workplaces provide fast and easy access to cutting-edge equipment and 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 RI. Basic technologies and devices are available at both CzechNanoLab sites, and the sites complement each other in advanced and more demanding equipment.

Societal nad economic impacts

CzechNanoLab offers unique services and expertise in the Czech Republic, which are used by a number of educational institutions, research organisations and high-tech companies. New materials and nanostructures developed in CzechNanoLab laboratories can lead, e.g., to the development of faster and more economical recording media or to a timelier diagnosis of diseases. Unique within Central Europe, open access to CzechNanoLab facilities enables researchers to use most of the technology independently in the 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 high added value products in cooperation with high-tech companies.

European Spallation Source – participation of the Czech Republic

Acronym:
ESS Scandinavia-CZ

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

Responsible person:
Dr Petr Lukáš
lukas@ujf.cas.cz

Phase: construction
Character: single-sited

Website:
ujf.cas.cz/en/research-development/large-research-infrastructures-and-centres/ess-scandinavia-cz

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2021: landmark

Motto:
Providing the Scientific Community with the World's Most Powerful Neutron Source, Enabling Breakthrough Studies in Materials, Energy, Medical, Environmental and Other R&I Fields

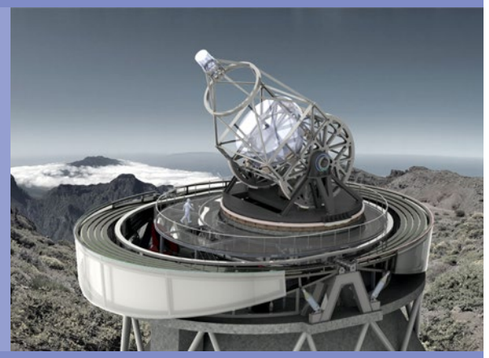
Characteristics

ESS (*European Spallation Source*) is a project of a high-power pulsed neutron source currently under construction in Lund, Sweden. The neutron beams of ESS will help 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 leading in-kind contribution of the Czech Republic to the construction of ESS – the BEER (*Beamline for European Engineering materials Research*) diffractometer– is a scientific instrument on one of the ESS beams. It is designed to provide the 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 other 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 Czechia to the construction of ESS. These contributions will provide researchers from Czechia 2% of the measuring capacities across the whole suite of ESS instruments. The Czech Republic has become a Member State of ESS ERIC (*European Spallation Source ERIC*), and ESS Scandinavia-CZ will provide assistance to the Czech user community to access the ESS instruments after becoming operational. ESS ERIC, as a legal entity, participates in international networks through LENS (*League of Advanced European Neutron Sources*), which brings together key European RIs running neutron sources and ensures their optimal exploitation by users from both the academic and commercial sectors.

Societal and economic impacts

The construction of ESS involves a number of Czech companies, particularly those active in the field of nuclear technologies. Their contributions through the delivery of cutting-edge technologies for the ESS target building and the BEER instrument resulted in their entering the European market and gaining the opportunity to realize further follow-on deliveries for ESS. The Czech membership in ESS ERIC and future access by scientific and industrial users to its unique facilities will bring technological innovations and applications in materials engineering, ICT, energy, chemistry, pharmacy and medicine, and will help address socioeconomic challenges, such as the development of sustainable energy, the introduction of new industrial technologies or the advancement of environment-friendly transport systems.

European Solar Telescope – participation of the Czech Republic



Acronym:
EST-CZ

Hosting institution:
Astronomical Institute of the Czech Academy of Sciences

Responsible person:
Jan Jurčák, Ph.D.
jurcak@asu.cas.cz

Phase: preparatory
Character: single-sited

Website:
asu.cas.cz/est/est-en

Year of inclusion on the Czech Roadmap: 2019
Status on the ESFRI Roadmap 2021: project

Motto:
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 Czechia in the implementation and operation of EST (*European Solar Telescope*). EST will become an RI focused on observations of the Sun, the only star that can be investigated in high resolution and on which life on Earth depends. This four-meter aperture solar telescope will be one of the two largest solar instruments worldwide. It will be located at La Palma, one of the Canary Islands, Spain, where the best observation conditions in Europe are available. EST will provide the most advanced observations, allowing for understanding the complex mechanisms governing the magnetic activity of the Sun and studying fundamental interactions between plasma, magnetic fields and radiation in the stellar atmospheres. The data will enable to understand in greater detail how energetic events taking place in the solar atmosphere influence space weather and affect human technologies. EST is the only planned RI focused primarily on the field of solar physics and unites the interests of solar research community in ERA. The realisation of EST will provide the user community with access to the most advanced instruments designed to observe the Sun. The institutes involved in EST 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 EST will start in 2025 and the device will become operational in 2031. EST cannot be realised by any single European country alone, therefore EAST (*European Association for Solar Telescopes*) was established to coordinate the development, construction and future operation of EST. The European Solar Telescope – Fundación Canaria is being established as the interim legal structure with the main objective to set up the EST-ERIC (*European Solar Telescope – European Research Infrastructure Consortium*) for the construction and operation phase of EST.

Societal and economic impacts

The application potential of EST-CZ will be most relevant in the near future. EST is finishing its preparatory phase and generates incentives for industrial growth through the participation of private companies in civil works, the provision of components, systems and instrumentation, or technological development, etc. It is expected that the percentage of participation of the European industry in EST will be in line with the financial contribution from each individual involved country. Since EST is focused on fundamental research, the development of state-of-the-art technologies is the only direct application potential of EST-CZ. Apart from that, the socioeconomic impact of EST-CZ will be on higher education, in particular the level of Ph.D. students. New knowledge gained via 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.).

Atacama Large Millimetre/ Submillimetre Array – participation of the Czech Republic

Acronym:
EU-ARC.CZ

Hosting institution:
Astronomical Institute of the Czech Academy of Sciences

Responsible person:
Pavel Jáchym, Ph.D.
jachym@ig.cas.cz

Phase: operational
Character: distributed

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 Interferomete

Characteristics

ALMA (*Atacama Large Millimetre/Submillimetre Array*) is an excellent astrophysical facility built and operated through worldwide collaboration in the Atacama Desert in northern Chile, at 5,000 meters of altitude with dry and thin air, to observe the universe at (sub-)millimetre wavelengths. The main partners in the ALMA consortium are ESO (*European Southern Observatory*), the U.S. NRAO (*National Radio Astronomical Observatory*) or the Japanese NAOJ (*National Astronomical Observatory of Japan*). ALMA is the largest existing ground-based astronomical observatory. It comprises 66 high-precision antennas (radio telescopes) that can be configured to achieve baselines of up to 16 km. It is equipped with state-of-the-art receivers covering all the atmospheric windows up to 1 THz. 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 angular resolution that exceeds that of the Hubble Space Telescope. ALMA has opened 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 observation projects, through quality assurance of the acquired data, their calibration and imaging, to assistance with data analysis. EU-ARC.CZ is the only node of the European network that has expertise in solar research with ALMA, but also in galactic and extragalactic astrophysics, stellar physics, 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, it leads European participation 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, institutional affiliation or professional background. EU-ARC.CZ is part of a network of seven nodes of the European ALMA Regional Centre (*ARC*), coordinated by ESO from Garching near Munich, Germany. Thereby, EU-ARC.CZ works closely with other nodes of the European ARC network, ESO and other partners in the ALMA consortium.

Societal and economic impacts

Throughout its existence, ALMA has generated 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, galaxies and organic molecules as building blocks of life in the Universe. Thanks to EU-ARC.CZ, Czechia is the only country in the region of Central and Eastern Europe directly participating in ALMA activities. 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 R&I. 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. In the framework of Czech membership in ESO (*European Southern Observatory*), Czech companies participated in the construction of the ALMA observatory. Activities of EU-ARC.CZ bring the potential for Czech enterprises to participate in the further technological development of this revolutionary instrument in the frame of the ALMA 2030 Development Roadmap. EU-ARC.CZ engages in a number of educational activities to help create opportunities for a new generation of experts in Czechia and contribute to quality education and the development of international cooperation not only in the modern field of observational radio astronomy and astrophysics.

Facility for Antiproton and Ion Research – 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
Palacký University Olomouc
Silesian University in Opava

Responsible person:
Dr Andrej Kugler
kugler@ujf.cas.cz

Phase: construction
Character: distributed

Website:
ujf.cas.cz/en/research-development/large-research-infrastructures-and-centres/fair-cz/

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2021: landmark

Motto:
Research Infrastructure to Study the Universe in a Laboratory Setting by Exploiting Beams of Accelerated Antiprotons and Relativistic Heavy Ions

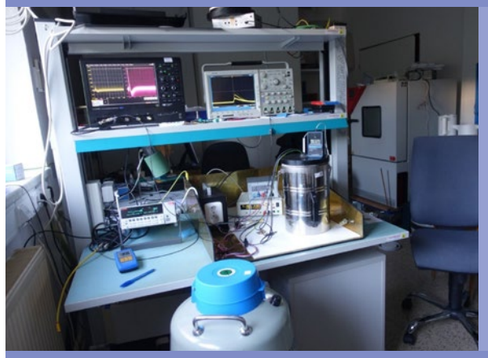
Characteristics

FAIR (*Facility for Antiproton and Ion Research in Europe*) is a European RI for nuclear and hadron physics currently under construction in Darmstadt, Germany, as a part of the capacity of GSI (*Helmholtzzentrum für Schwerionenforschung*). The Czech Republic became an Aspirant Member of FAIR in 2019. The Czech participation in FAIR, organized through 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 key 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 a portfolio of services, such as infrastructure for the development and production of complex scientific devices for conducting FAIR experiments in Czechia, coordinating access to research at FAIR, as well as technologies developed in all four FAIR research pillars. After its completion, FAIR will be a worldwide leading 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 programme 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 are used to describe the fusion of neutron stars assumed to be the source of recently detected gravitational waves.

Societal and economic impacts

FAIR-CZ will contribute to new innovations in oncology by developing micro-dosimetry and studying modifications in absorbed radiation dosages due to implants. In addition, it will contribute to the development of technologies and detectors used in medicine (e.g., PET cameras, diagnostics, etc.), the energy industry (e.g., new materials for fusion, etc.) and machinery. FAIR-CZ also educates students. Czech companies benefit from the involvement of the Czech research community in FAIR by delivering sophisticated scientific instruments for FAIR, thus improving their technological expertise. Specific examples include the massive production of unique PbWO4 scintillators for FAIR worth approximately EUR 20 million and the development of new composite materials for vacuum usage, such as a carbon beam pipe with very thin walls and high tolerance to radiation.

Research Infrastructure for Fermilab Experiments



Acronym:
FERMILAB-CZ

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

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

Responsible person:
Dr Jaroslav Zálešák
zalesak@fzu.cz

Phase: operational
Character: distributed

Website:
particle.cz/infrastructures/fermilab-cz/

Year of inclusion on the Czech Roadmap: 2010

Motto:
Integrated Environment for Efficient Collaboration on Fermilab Experimental Activities 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 Tools

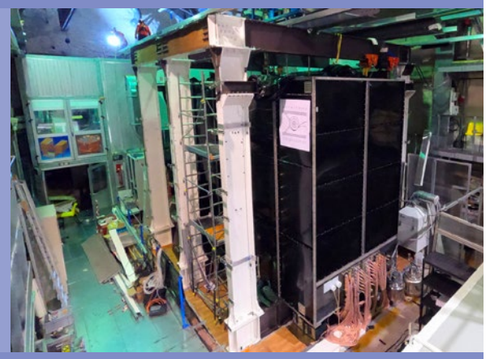
Characteristics

FERMILAB-CZ is devoted to cooperating with Fermilab (*Fermi National Accelerator Laboratory*), the U.S. national laboratory, the primary concern of which is the research of elementary particles. The core of the present Fermilab research programme is neutrino experiments, including the NOvA and DUNE experiments. European laboratories, including CERN (*Conseil Européen pour la Recherche Nucléaire*), are actively involved in these neutrino experiments through strategic collaborations. Main knowledge and expertise of FERMILAB-CZ lies is the detector laboratory, which is engaged in the design and construction of detectors, and the mathematical expert group, which is involved in the development and application of advanced statistical and deep machine-learning artificial intelligence algorithms for data analysis. FERMILAB-CZ also contributes to research activities with its significant computing resources in the field of the distributed processing of experimental data and simulations, and participates in the development of software for data acquisition, operation and control, using the most recent international standards. The FERMILAB-CZ expert group covers a community of around 12,000 researchers who work together to develop detectors, electronics and data analysis methods which are used across many areas of human activity. Through deep involvement in the construction and operation of experiments, FERMILAB-CZ enables Czech researchers to participate in unique physics research. Both Czech scientists and all individual members and research groups of the supported experiments use and benefit from FERMILAB-CZ open access services free of charge.

Societal and economic impacts

FERMILAB-CZ contributes to excellent research aimed at understanding the fundamental laws of elementary particle interactions and their properties. The individual experiments use cutting-edge technologies that lead to the further development and advancement of new technologies with a subsequent transfer to industry. During the construction of the Tevatron accelerator, a new technology for the production of reliable superconducting magnets was developed and enabled the efficient production of superconducting magnets later used in medical magnetic resonance imaging (MMR) applications. The DUNE detector will be the world's largest liquid argon detector, which could stimulate advances in, e.g., cryogenic technologies. Fermilab experiments are carried out with the significant participation of students in international teams. In this way, students not only gain knowledge about new technologies and the scientific content of experiments, but also become familiar with advanced management methods utilised within large-scale experimental collaborations. In addition, they are exposed to the ethical issues of scientific research. Students transfer this valuable experience to their subsequent professional career not only in research, but also in industry or public 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

Responsible person:
Assoc. Prof Ivan Štekl
ivan.stekl@utef.cvut.cz

Phase: operational
Character: single-sited

Website:
lsm.utef.cvut.cz

Year of inclusion on the Czech Roadmap: 2010

Motto:
Unique Multidisciplinary Research Infrastructure for Conducting Fundamental and Applied Research in a Zero-Dose Radiation Environment with Important Impact in Science, Education and Technology Transfer

Characteristics

LSM-CZ organises Czech participation in the underground LSM (*Laboratoire Souterrain de Modane*) laboratory located in Modane, France, and has a significant share in the construction of its new facilities and operation. LSM-CZ also includes complementary RI in Czechia, which strengthens this reciprocal international R&I cooperation. LSM is a multidisciplinary platform for fundamental experiments requiring an extremely ultra-low radioactive background in many areas, such as particle, astroparticle and nuclear physics, biology and medicine. Examples of specialised scientific 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 discharges 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 geo-neutrinos, archaeology in radionuclides dating and climatology to understand climate changes. LSM provides users with unique technologies with significant application potential for industry, including an environment with ultra-low background conditions with the suppression of all types of radioactivity, clean rooms with highly reduced radon concentration, a filtration anti-radon facility suppressing the content of radon by a factor 10000 and ultra-low background HPGe spectroscopy for the detection of radioactivity in the environment. LSM also offers conditions for selecting radio-pure materials and studying ultra-rare nuclear processes, automatic systems for HPGe detectors, an advanced radon emanation screening facility, improved innovative detector technologies for low background conditions, cooling and gas mixture systems for installed experiments, and computer and safety systems. Such conditions or sensitive technologies are impossible to reach outside of the deep underground laboratories. The auxiliary RI in the Czech Republic has a similar structure to LSM, a shielded whole-body counter and HPGe detectors, including an automatic system for samples changing, a spectrometric laboratory for the detection of alpha particles, a radon test chamber, an anti-radon test device, a test clean room, sensitive radon detectors, equipment for measuring emanation and diffusion of radon, a specialized radiobiological laboratory, a calibration laboratory and an electronic laboratory. Research conducted at LSM may have significant application potential in the future for the long-term storage of biological materials to reduce radiation damage by cosmic rays. LSM is involved in international collaboration with other deep underground laboratories in the United Kingdom (*Boulby Underground Laboratory*), Spain (*Canfranc Underground Laboratory*), Italy (*Laboratori Nazionali del Gran Sasso*), the People´s Republic of China (*Jinping Underground Laboratory*) and Canada (*SNOLAB*). Within the EU, the establishment of a distributed platform for deep underground research laboratories and its transformation in an ERIC is under preparation.

Societal and economic impacts

The general impact of LSM-CZ is provided by the education of students and young experts in a broad range of R&I, attracting experts from abroad into the Czech Republic and cooperating with innovative companies. In collaboration with LSM-CZ, numerous Czech companies have been involved, producing automatic systems for HPGe detectors, pixel, radon and scintillating detectors, anti-radon devices or clean rooms with the suppression of radon. The MEXED (*Matrix Elements for Double Beta Decay Experiments*) international conference focused on R&I performed at LSM is regularly organised in the Czech Republic as a platform for exchanging knowledge between experts and the further education of students.

Materials Growth and Measurement Laboratory

Acronym:
MGML

Hosting institution:
Charles University

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

Responsible person:
Dr Jan Prokleska
jan.prokleska@mff.cuni.cz

Phase: operational
Character: single-sited

Website:
mgml.eu

Year of inclusion on the Czech Roadmap: 2010

Motto:
Synthesis and Characterisation of High-Quality Materials for Modern Research and Applications and Measurements of their Physical Properties under Different External Conditions

Characteristics

MGML is an RI providing a research base for advanced materials research. Within its closely cooperating units, the Material Growth and Characterisation Laboratory (MGCL), Structural Analysis Laboratory (SAL) and the Material Properties Measurement Laboratory (MPML), MGML offers open access for external users to utilise 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 multiple different techniques. The unique combination of different crystal growth methods allows its users a great deal of flexibility and the ability to optimise the technology of producing entirely new materials. Modern X-ray diffraction and electron microscopy instruments in SAL allow for the detailed structural and phase characterisation 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 millikelvins up to several hundred degrees Celsius, magnetic and electric fields, and hydrostatic and uniaxial pressures. The possibility of preparing, characterising and measuring uranium materials, for which the host institution has the appropriate license, is also important. Interconnection of this wide range of experimental techniques for the preparation, characterisation and measurement of physical properties makes MGML a unique RI in the Czech Republic, fully comparable with the world's leading laboratories. MGML actively collaborates with major European RIs, such as EMFL (*European 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 RI providing top-notch high-quality sample preparation and characterisation, as well as a broad spectrum of macroscopic experimental techniques.

Societal and economic impacts

MGML equipment contributes to the development of materials research and physics, in particular in the search for functional materials and a better understanding of the physical phenomena that may lead to new emerging technologies. The research of magnetocaloric materials, uranium alloys or radiation-modified superconductors intended for the construction of tokamaks contributes to solving the technological challenges being faced by the field of energy. On the other hand, the investigation of magnetic nanoparticles is significant for medicine. Cooperation with suppliers in developing prototype equipment for the preparation of new materials and 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 early career researchers in MGML contributes to the education of the young generation in R&I.

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

Responsible person:
Miroslav Krůs, Ph.D.
krus@ipp.cas.cz

Phase: operational
Character: single-sited

Website:
pals.cas.cz

Year of inclusion on the Czech Roadmap: 2010

Motto:
Unique Pulsed Iodine Laser with Reliable Operation and Various Diagnostic Equipment Among the Four Largest Laser Systems and Most Demanded Laser User Facilities in Europe

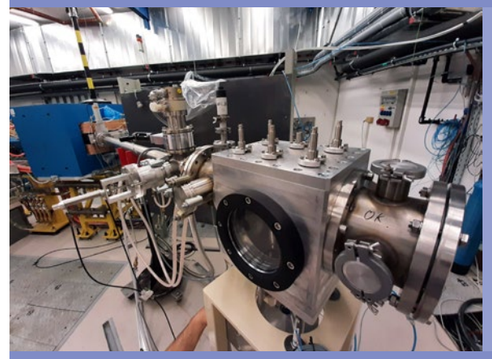
Characteristics

For more than two decades, PALS has belonged to the world's leading laboratories in physics and has provided top-quality high-power lasers with a focus on the interaction between laser radiation and matter. PALS operates a pulsed photodissociation terawatt iodine laser, one of four of the largest lasers in Europe. The laser delivers up to 1 kJ of energy which can be focused on a spot as small as 50 μm, reaching intensities of more than 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 precise synchronisation of the iodine laser with the ultrashort (femtosecond) Titanium-Sapphire laser is completely unique. Synchronised femtosecond pulses are primarily exploited for probing plasma generated by the iodine laser. Such synchronisation 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, astrochemistry and astrobiology studies, and for developing and testing sources of high-energy photons and charged particles. As one of the Founding Members of Laserlab-Europe (*Integrated Initiative of European Laser Research Infrastructures*), PALS offers open access to international users. PALS also serves as a training centre for students and early career researchers from Czechia and abroad, allowing them to obtain experience with cutting-edge technologies. In the framework of international activities, PALS participates in EUROfusion, it devotes a part of the beam-time to the investigation of energy production by means of inertial fusion and it also collaborates with FAIR (*Facility for Antiproton and Ion Research in Europe*) in Darmstadt, Germany. At the national level, PALS cooperates extensively with ELI Beamlines of ELI ERIC (*Extreme Light Infrastructure*) and HiLASE (*High Average Power Pulsed Lasers*).

Societal and economic impacts

The long-term existence of PALS, the first large-scale international laser RI in the Czech Republic, is a remarkable stabilising factor of the Czech laser R&I, ranking Czechia side by side with field-established countries like the United Kingdom, Germany or France. At the national level, it contributes to R&I in the areas of the use of fusion 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 collaboration with the application sector, PALS contributes to the competitiveness of the Czech Republic by educating early career researchers, allowing them obtaining 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

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

Phase: construction
Character: single-sited

Website:
spiral2.cz

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2021: landmark

Motto:
Laboratory Equipped with Stable and Radioactive Ion Beams and Fast Neutrons for Conducting Research in Nuclear Physics and Astrophysics, Construction Materials and Radioisotopes for Medicine

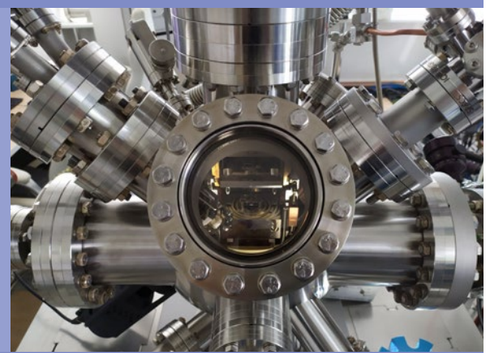
Characteristics

SPIRAL2-CZ facilitates the participation of Czechia in SPIRAL2 (*Système de Production d'Ions Radioactifs Accélérés en Ligne*), which is being built as part of an important upgrade to the existing GANIL (*Grand Accélérateur National d'Ions Lourds*) 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, search for superheavy nuclei, study the activation of construction and target materials by charged particles, and explore changes in materials exposed to neutron fields (for nuclear fission and fusion facilities). Intense ion beams will be used for the investigation of radioisotopes 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 are 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 technology and equipment at SPIRAL2 will allow for previously unfeasible experimental tests. The state-of-art Super Separator Spectrometer (S3) will open a new region of radioactive and superheavy nuclei to research. Due 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 and worldwide.

Societal and economic impacts

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. In the framework of SPIRAL2-CZ, new technological contributions are planned. There are several companies in the Czech Republic with a know-how in clean vacuum materials and vacuum technologies that can participate in the construction of the facility. Different types of high-power targets are in the design phase, automatised detection systems are under development, future possibilities for a regional partner in innovative radioisotopes for medicine are emerging.

Surface Physics Laboratory – Hydrogen Technology Centre



Acronym:
SPL-HTC

Hosting institution:
Charles University

Responsible person:
Prof Dr Iva Matolínová
imatol@mbox.troja.mff.cuni.cz

Phase: construction
Character: distributed

Website:
spl-htc.cz

Year of inclusion on the Czech Roadmap: 2010

Motto:
Our Goal is to Offer Advanced Analytical Techniques to Scientists Worldwide

Characteristics

SPL-HTC was created by the extension of the original SPL-MSB, the Czech Material Science Beamline (MSB) Laboratory at the Elettra Synchrotron in Trieste, Italy, and the Surface Physics Laboratory (SPL) of Charles University at the Centre of Hydrogen Technology (HTC) in 2023. SPL-HTC offers access to its facilities through a single entry point through CERIC-ERIC (*Central European Research Infrastructure Consortium*), which brings together eight European countries and is open to researchers from around the world through periodic calls for proposals with independent peer-review. The excellence of SPL-HTC is based on the 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 (PES), particularly spectroscopy at MSB based on synchrotron radiation (soft X-ray PES, Resonance Photoemission Spectroscopy and NEXAFS). SPL-HTC provides Ion Scattering Spectroscopy, Energy Dispersive X-ray Spectroscopy, Scanning Electron Microscopy and Focussed Ion Beam Microscopy, Scanning Tunnelling Microscopy, Atomic Force Microscopy, which enables electrochemical analysis in liquids, and a Fuel Cell Testing Laboratory and Electrocatalyst Application Laboratory. SPL and HTC provide 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 two near ambient pressure photoelectron spectrometer NAPXPS and fully automated EnviroESCA, photoelectron spectrometer XPS, scanning electron microscope FESEM, focus ion beam scanning electron microscope FIB-SEM and the beamline for materials science MSB at the Elettra Synchrotron in Trieste, Italy. The active involvement of students of the Faculty of Mathematics and Physics of Charles University in SPL-HTC activities plays a significant role in their Ph.D. and Master degree studies. Regular workshops attended by both Charles University and foreign partner institutions students are organised.

Societal and economic impacts

Within CERIC-ERIC, SPL-HTC contributes to the open access by research organisations to cutting-edge research infrastructure, technology transfer and industrial relations. The results of the fundamental research on materials developed, high level of know-how and exchange of expertise between CERIC-ERIC users and SPL-HTC staff in a number of scientific fields lead to the successful implementation of novel technologies in practice. For example, the former SPL-MSB successfully participated in the basis for the applied development of innovative nanocatalysts for hydrogen fuel cell technologies within the promotion of a strategic European portfolio of sustainable energy. These are now protected by a total of seven international patents, and SPL-HTC is preparing their entry into the technology transfer market.

Energy

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page

Background and context

Over the past 30 years, the energy sector in Europe and all around the world has gone through major transformations as a result of intensive R&I investment. Worldwide efforts to mitigate the global climate change by reducing greenhouse gas emissions have been a major driving force for R&I in the field of energy, placing special emphasis on the areas of renewable energy, carbon capture and storage technologies, low-carbon technologies, as well as nuclear power generation. At the same time, some countries have, nevertheless, decided to move away from the use of nuclear energy, and consequently also to decommission their nuclear power plants and research reactors. All this, including the EU's ambition consisting in the green transition and digital transformation of the European economy, has posed new challenges for both R&I stakeholders and the energy sector as a whole.

The Russian-evoked gas shortage in 2021 and the Russian military invasion of Ukraine a year later resulted in the breakdown of complex geopolitical relations and the disruption of traditional supply chains, leading to energy prices skyrocketing and causing severe energy and economic crises. Against this background, Europe's determination to mitigate damaging dependencies on external suppliers of raw materials and technologies has grown and induced the revision of former energy strategies in a number of countries and even macro-regions. The essential role of energy R&I, including RIs, bearing a great potential to bring knowledge-based solutions to energy needs has, therefore, grown in importance.

The ultimate goal of the energy R&I sector is to ensure long-term sustainable, safe, affordable and competitive energy for European citizens, while considering the EU's overall geopolitical, economic and environmental objectives. In order to meet these goals, a number of initiatives have emerged in the EU in the past less than two decades.

In 2007, the European Commission issued the key EU far-sighted energy strategy, SET Plan (*A European Strategic Energy Technology Plan: Towards a Low-Carbon Future*), determining the ambitious goal of reducing the rate of global climate change by reducing greenhouse gas emissions and transforming the energy industry in Europe through the development and introduction of low-carbon technologies. Specific targets were originally set 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 efficiency of use. The SET Plan also identifies a set of R&I actions, addressing the whole energy innovation chain, from research to market uptake, including objectives such as increasing the efficiency of carbon capture and storage technologies, developing and reducing the cost of low-carbon technologies, integrating renewable technologies into energy ecosystems, increasing the energy efficiency of industry, reinforcing the resilience and security of energy ecosystems, strengthening nuclear safety, or fostering competitiveness in the global battery sector and e-mobility. Currently, there is an ongoing process of revamping the SET Plan while reflecting new challenges and opportunities.

In 2014, an EU coordinated approach was proposed as a part of the document titled "Towards an Integrated Roadmap: Research and Innovation Challenges and Needs of the EU Energy System", a SET Plan action plan. Back then, the EU Council approved the goal of reducing greenhouse gas emissions by at least 40% by 2030, compared to 1990, and also set the target of producing at least 27% renewable energy and an indicative energy savings target, both of them also linked to 2030.

Later on, and in view of the European Green Deal initiative, striving for to Europe become the first climate-neutral continent on Earth, the political decision was reached to make the targets even more ambitious, namely for greenhouse gas emissions to be reduced by up to 55% by 2030, compared to 1990.

The implementation plan was then proposed through the so-called Fit-for-55 package to make reaching the EU's climate goal of reducing greenhouse gas emissions by at least 55% by 2030 a legal obligation.

▶ CICRR – Construction of Jules Horowitz Reactor in the South of France

In light of the military invasion of Ukraine by Russia, the European Commission also proposed the so-called REPowerEU (*REPowerEU: A Plan to Rapidly Reduce Dependence on Russian Fossil Fuels and Fast Forward the Green Transition*), an initiative to make Europe independent of Russian fossil fuels well before 2030.

All in all, the energy targets to be achieved through the EU initiatives above constitute major challenges for Europe, as well as the Czech Republic, and the energy R&I sector, using state-of-the-art RIs, should focus on addressing them using both EU and national and regional R&I funding instruments.

When it comes to the critical challenges for energy R&I, these emerge throughout the entire energy R&I ecosystem, including the nuclear (both fusion and fission) energy R&I; renewable energy R&I, which address solar, wind, bio-fuels, geothermal or ocean energy; and efficient energy conversion and use R&I impacting, particularly, the industry and building (construction) sector. Last but not least, the evolution of the energy infrastructure in line with the current policy goals and objectives is also largely dependent on an enhanced energy systems integration.

The nuclear energy R&I sectorial domain is centred around developing the next generation of fission reactors based on more efficient fuel use with less waste production; implementation of the fusion reactor concepts of ITER (*International Thermonuclear Experimental Reactor*) and DEMO (*Demonstration Power Plant*); nuclear safety aspects related to the operation of nuclear power plants; nuclear fuel and radioactive waste management and disposal issues; and needs linked to the decommissioning of aging nuclear power plants and research reactors. Materials studies and HPC (*High Performance Computing*) also play a prominent role in the nuclear energy R&I and likewise belong to areas of paramount importance.

The renewable energy R&I sector has undergone dynamic development lately. The science and technology advancement, resulting in new and more efficient concepts of renewable energy harvesting and exploitation, in particular solar and wind, has led to a considerable drop in renewable energy costs and massive market deployment. Further progress, going beyond the scope of incremental innovation of the currently used technologies, bears a great potential for further renewable energy cost reduction and increase in deployment. This applies not only to solar (both photovoltaic and concentrated solar power) and wind energy, but also to bio-fuels, geothermal and ocean energy. The recent increase in intermittent energy production from renewable sources has also given rise to new needs in terms of efficient energy conversion and use, and the energy systems integration.

The energy efficiency and use R&I domain is largely driven by the challenges the construction (building) sector and the industry sector overall are facing. Among the key priorities are better product quality and lifetime achieved with an improved energy and materials efficiency, and with reduced greenhouse gas emissions and waste production, including through advanced carbon dioxide capture, storage and utilisation techniques.

The rapid increase in intermittent energy production from renewable sources has placed even greater emphasis on the energy storage R&I. As batteries are an unlikely solution to the energy storage needs – due to limited volumes of storage achievable based on the current lead and lithium technologies – an alternative form of chemical storage of surplus electrical energy (to be reconverted to electricity when necessary), e.g., in the form of hydrogen, is necessary.

An efficient energy system requires an efficient integration of all components and constituents of the energy infrastructure, especially as Europe transitions from the traditionally centralised system of energy generation to a much more diverse, as well as distributed energy generation portfolio. Therefore, solutions for efficient energy storage and efficient low emission energy transport underpin such an energy transformation of the EU. The ultimate success depends to a large extend on the successful implementation of the concept of the so-called smart cities and communities, with a design based on the "smart grid", i.e., an electricity network intelligently integrating the actions of all its users (i.e., generators, energy storage facilities and consumers) in order to efficiently deliver sustainable, economic, secure and safe electricity supply.

The scope and focus of R&I programmes with a potential to promote the energy R&I that are implemented at the EU level is very broad, reflecting on the diverse possibilities and policy orientations of the EU Member States. The energy R&I is covered, in particular, by the Cluster 5 – Climate, Energy and Mobility – of the Horizon Europe Framework Programme for R&I. The nuclear part is concentrated under the Euratom Research and Training Programme, which complements Horizon Europe and focuses on nuclear fusion and nuclear fission. Overall, the key strategic orientation of the EU is making Europe the first digitally enabled circular, climate-neutral and sustainable economy through the transformation of its mobility, energy, construction and production systems. This general approach of Horizon Europe is put into practice through work programmes which focus on cross-sectorial solutions for climate transition, including dealing with the European battery value chain; sustainable, secure and competitive energy supply through renewable energy; energy systems, grids and storage, and carbon capture, utilisation and storage; and efficient, sustainable and inclusive energy use in the European building stock and industry. European R&I Partnerships also play an important role. Among the institutionalised partnerships, the most relevant is Clean Hydrogen. Regarding the co-financed partnerships, the Czech Republic is involved in CET (*Clean Energy Transition*) and DUT (*Driving Urban Transitions to a Sustainable Future*). Finally, EU Missions, namely the Climate-Neutral and Smart Cities, also contribute significantly.

Current state of play

Some areas of the energy R&I have relatively limited importance for the Czech Republic, such as energy conversion using tidal effects. On the other hand, other areas of the energy R&I are traditional for Czechia and therefore deserve utmost attention, such as nuclear fission and fusion, the use of biomasses, fossil fuels (with limitations due to greenhouse gas emissions or the gradual extraction of coal reserves), energy storage and accumulation, co-generation, heat storage, or energy efficiency improvement and advanced materials.[1]

Nuclear energy has played a key role in the Czech energy supply for many years. In order to provide the means for R&I of advanced nuclear energy technologies, appropriate LRIs have to be operated.

Since the latest Roadmap update from 2019, Reactors LVR-15 and LR-0 (Nuclear Research Reactors LVR-15 and LR-0) and JHR-CZ (*Jules Horowitz Reactor – participation of the Czech Republic*) have merged into **CICRR** (*Czech International Centre of Research Reactors*), and have also been complemented by an ecosystem of supporting R&I laboratories, hot cells, loops and other analytical facilities developed under SUSEN (*Sustainable Energy*). The LVR-15 and LR-0 Nuclear Research Reactors are the basis for the neutron physics applications in nuclear research, including 2nd, 3rd and 4th generation reactors and nuclear fusion. Their potential, however, lies also in materials research and, thus, in covering a broad range of R&I beyond the energy sector. Among other things, CICRR also facilitates the participation of Czechia in the Jules Horowitz Reactor, the most advanced European test reactor, which is currently under construction in Cadarache, France, and which will provide the intense flux of fast neutrons $5x10^{14}$ cm^2s^{-1} for conducting materials tests.

WCZV (*VR-1 Nuclear Experimental Hub*) currently provides access to a training reactor as an experimental facility for the education of the Czech and foreign university students. The VR-1 reactor is also used for R&I in the areas of nuclear safety, reactor and neutron physics, nuclear fuel cycles, and as a source of neutrons for experimental tests. The facility will be enlarged by the VR-2 subcritical reactor, which is planned to start operating in 2023.

In general, with a considerable share of electricity generation, nuclear energy is a significant component of low-carbon electricity production in the EU, and it is expected to remain an important part of EU energy production also in the future. Nevertheless, further investments are necessary to provide both short- and long-term safety and security, a more efficient operation of nuclear powerplants, and the development of innovative nuclear reactor concepts, sustainable solutions for radioactive waste management and the decommissioning of nuclear reactors. Since the Fukushima accident (2011), nuclear reactor technologies have been placing emphasis on safety and security. Security studies are, therefore, included not only in nuclear-oriented R&I programmes, but also in multidisciplinary ones, such as **EURAMET** (*European Association of National Metrology Institutes*), which aims, e.g., to develop advanced detection technologies for the new generation of nuclear powerplants.

Regarding nuclear fusion, the contribution of the Czech Republic to the development of thermonuclear fusion energy in the frame of ITER (International Thermonuclear Experimental Reactor), through EUROfusion (*European Consortium for Development of Fusion Energy*), is represented by **COMPASS** (*Tokamak for Thermonuclear Fusion Research*).

The list of LRIs in the Czech Republic in the energy sector is completed by **ENREGAT** (*Energy Waste Recovery and Gas Treatment*), operating capacities for waste treatment, minimizing the emissions of gaseous pollutants, and enabling data transfer from the laboratory to the pilot scale.

1/ The energy mix of the Czech Republic is still predominantly, by around 2/3, based on fossil fuels. However, the share of low-carbon resources, mainly of renewable energy resources and nuclear energy, has been growing. The share of low-carbon resources is comparably higher in the electricity generation mix, and they are responsible for approximately 50% of all generated electricity. More than 20% of heat is also generated from low-carbon resources, mainly bioenergy. Nevertheless, centralised generation is still predominantly based on fossil fuels, mainly coal. The transition towards different resources has been ongoing. The level of total energy consumption has been fairly stable over the last decade, and it indicates that economic growth is not necessarily linked to further increase in energy consumption, although differences between the sectorial domains exist. Households, industry and transport sectors are the main consumers of energy, and each of these sectors has approximately a 30% share of the total energy consumption.

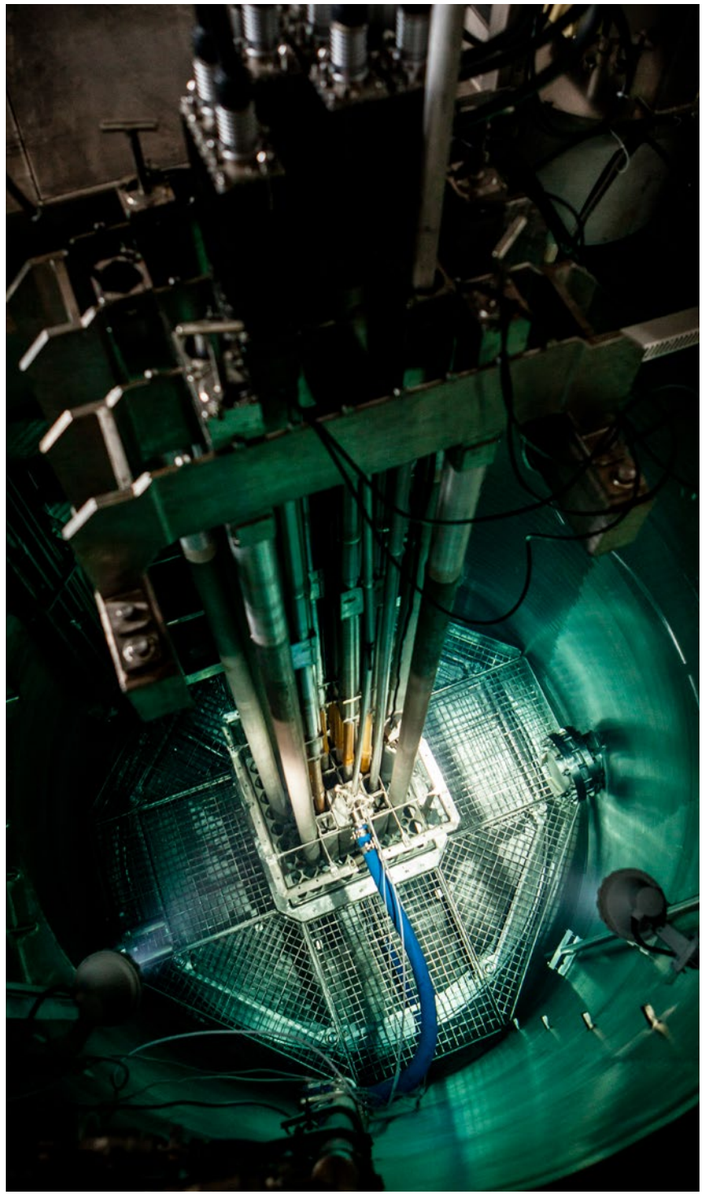
Gaps, challenges, needs and opportunities

This brief overview shows that LRIs in Czechia are focused particularly on nuclear fission and nuclear fusion, and the efficient use of energy and biofuels. From the point of view of ESFRI, the following topics do not have their counterpart in the ecosystem of energy-oriented LRIs in the Czech Republic, but can be identified as highly strategic.

The first one, **smart cities and smart grids**, largely involves smart components in buildings combining several elements – from smart sensors and measuring instruments to innovative heating and integration of energy generation, such as photovoltaics and materials developed in order to reduce energy consumption. In this respect, a LRI in the form of experimental buildings, where users could examine such components, is highly conceivable.

The second topic, **energy storage**, covers a large variety of possibilities, such as battery systems, or the storage of energy in hydrogen or in a rock massif, etc. A solution for an economically available accumulation of (electric) energy with sufficient capacity is a requirement to further reduce greenhouse gas emissions.

One of the possible approaches to fill in these gaps in the area of energy LRIs of Czechia could be closer cooperation with already existing or newly planned European RIs, while taking into account the key aspects of the state energy strategy of the Czech Republic.



▶ WCZV – Training Reactor VR-1

Czech International Centre of Research Reactors

Acronym:
CICRR

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

Responsible person:
Ján Milčák
jan.milcak@cvrez.cz

Phase: operational
Character: single-sited

Website:
cvrez.cz

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

Motto:
Material Test Reactors for the Development of Ionizing Radiation Applications, Conducting Research on Materials for Nuclear Technology, Educating Nuclear Experts and the Production of Radionuclides

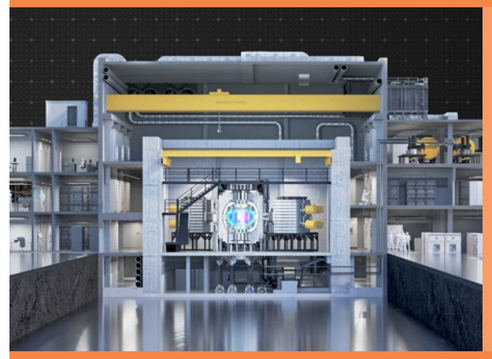
Characteristics

CICRR manages two existing LRI projects long listed on the Czech Roadmap – Reactors LVR-15 and LR-0 (*Nuclear Research Reactors LVR-15 and LR-0*), and JHR-CZ (*Jules Horowitz Reactor – participation of the Czech Republic*). In addition, these are newly supported by a system of laboratories, hot cells, loops, and other analytical and R&I facilities developed in the framework of the recently commissioned SUSEN (*Sustainable Energy*) capacity, which is also operated by Research Centre Řež s.r.o. The main goal of the LVR-15 and LR-0 experimental nuclear reactors is to provide technological and experimental background for users in the field of the R&I of 2nd, 3rd and 4th generation nuclear technology and fusion. The LVR-15 reactor is a multi-purpose research reactor producing 10MW of thermal power. It provides a high-density neutron field comparable to energy reactors suitable, e.g., for researching neutron properties, producing radionuclides for medical purposes, and for the research of radiation resistance of construction materials in related experimental devices that simulate the operational conditions of different types of energy reactors. The LR-0 reactor is an experimental zero-power nuclear reactor, which allows for taking 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 that are often developed in collaboration with leading nuclear instrumentation suppliers directly inside of 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 for simulating other reactor technologies, especially selected types of 4th generation reactors. The combination of experimental flexibility, as well as large field versatility, makes the LR-0 reactor unique in the world. Finally, JHR-CZ allows for Czech participation in JHR (*Jules Horowitz Reactor*), a material testing reactor for the research, development and qualification of materials and nuclear fuel. It 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. 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 or materials studies. The portfolio of provided expertise and services will also include nuclear waste management and medical applications. The overall mission of CICRR is to provide an integral set of facilities for cutting-edge R&I in the fields of nuclear and material sciences, able to accommodate both current and emerging trends and needs, leveraging on the unique ability to provide investigations of the combined effects of extreme environments and radiation on a large variety of components and systems for a wide range of applications.

Societal and economic impacts

CICRR will facilitate the production highly valuable data for the nuclear community in different sectors, such as nuclear fuel (e.g., in-pile studies of claddings and fuels of new ATF concepts, etc.), structural materials (e.g., qualification of current and new structural materials for plan lifetime extension, etc.), radioisotopes (e.g., production of radioisotopes, development and testing of regular production of new isotopes for medical applications, etc.), and nuclear data validation and verification (e.g., specific reactor experiments to verify the suitability of nuclear models, computational algorithms and data, etc.), thereby significantly contributing to implementing the national energy strategy in the Czech Republic, as well as the broader energy objectives of the EU. Among other things, CICRR also brings possibilities for education in terms of supporting early career researchers under different types of collaborations based on using the experimental capacity of CICRR.

COMPASS – Tokamak for Thermonuclear Fusion Research



Acronym:
COMPASS

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

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

Phase: re-construction
Character: single-sited

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

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

COMPASS consists of a 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 EUROfusion (*European Consortium for Development of Fusion Energy*). Research at COMPASS focuses on those areas where it can deliver unique results due to its parameters, diagnostic equipment and capabilities. After 11 years of operation, COMPASS has currently been in the upgrade phase since 2021, to be completed in 2025, during which the development and installation of the new COMPASS-U tokamak and its auxiliary systems are underway. The new COMPASS-U tokamak operating with a high magnetic field (5 T) and a high plasma current (2 MA) represents a unique device globally. It will allow for addressing the key challenges of the ITER (*International Thermonuclear Experimental Reactor*) future exploitation, which stands out as one of the key missions in the EUROfusion strategy – European Research Roadmap to the Realisation of Fusion Energy. In addition, the upgraded RI will serve for the development, investigation and tests of innovative plasma and divertor configurations focusing on the energy and plasma exhaust from the reactor, and thus contribute to solving one of the key challenges on the road towards the future European DEMO fusion reactor. COMPASS will provide open access to a wide user community and enhance education in the field of high-temperature magnetized plasma physics. Furthermore, it will facilitate deep expertise in the development of the individual tokamak systems, plasma control and data acquisition systems and advanced diagnostics. It has established extensive collaboration with Czech and world-leading research organisations. At the European level, COMPASS is used mainly for the tasks of EUROfusion and ITER. In addition, a strong collaboration with the U.S. Department of Energy and U.S. national laboratories has also been established.

Societal and economic impacts

Securing the ever-increasing worldwide energy consumption without any negative effects is a key socio-economic challenge to which COMPASS is significantly contributing. The research being conducted at COMPASS brings new results and knowledge in the field of magnetized plasma physics, which significantly overlaps into other fields, such as nuclear physics and materials research. The tokamak construction, as well as the diagnostic and operating systems of COMPASS represent cutting-edge technologies. The development and production of these systems has a direct impact on new innovations and skills, increased technological levels and know-how of the participating companies. COMPASS also represents an ideal tool for training and educating the young generation of scientists, who will be ready to address both present and future societal and economic challenges. In addition, by intensively participating in the research activities of EUROfusion, as well as ITER, 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

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

Phase: operational
Character: single-sited

Website:
ceet.vsb.cz/iet/en/enregat/

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

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, e.g., 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. ENREGAT 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, ammonia, organic substances, etc.) through laboratory tests up to pilot scale verification in a waste incinerator. The aim of ENREGAT is to provide services to the research community that in open access mode support the development of innovation through cooperation with industry. ENREGAT is involved in a large number of national R&I projects, and is collaborating with a number of foreign partners, as well as with the private sector. At the national level, ENREGAT cooperates with biogas plants and companies dealing with the development of units for the thermal degradation of waste and catalytic technologies for NOx reduction, VOC degradation and the emissions elimination by advanced oxidation processes. The Jagiellonian University of Krakow (Poland), the University of Oulu (Finland), the National Taiwan University (Taiwan), the University of Crete (Greece), the National University of Littoral (Argentina) and the National University of Tumbes (Peru) are among the key foreign partners.

Societal and economic impacts

ENREGAT allows for interdisciplinary research and the acquisition of new knowledge in the field of the energy recovery of waste (mixed municipal and hazardous waste, biowaste, solid alternative fuels) and helps 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 accordance with the emission limits under EU legislation. Examples of the collaboration of ENREGAT users with the application sphere in collaborative and contractual 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 in Czechia.

VR-1 – Training Reactor for Research Activities

Acronym:
WCZV

Hosting institution:
Czech Technical University in Prague

Responsible person:
Assoc. Prof Ľubomír Sklenka, Ph.D.
lubomir.sklenka@fjfi.cvut.cz

Phase: operational
Character: single-sited

Website:
reaktor-vr1.cz/en

Year of inclusion on the Czech Roadmap: 2011

Motto:
Easily Accessible, Highly Flexible and Excellently Equipped Place for Your Research

Characteristics

The VR-1 Nuclear Experimental Hub is a cluster of experimental nuclear facilities and nuclear laboratories consisting of training reactor VR-1, subcritical reactor VR-2, an internet reactor laboratory, neutron activation analysis laboratory, neutron interactions laboratory, nuclear security laboratory, radiation protection laboratory, reactor I&C laboratory, external neutron sources and neutron detectors. The hub was systematically built step-by-step during the last decade to maximise synergy utilisation effects between various parts of the hub and to optimise its operational costs. The VR-1 reactor is state-of-the-art experimental instrumentation for the education of Bachelor, Master and Ph.D. students in the field of nuclear engineering from the Czech Republic and abroad. The VR-1 reactor has been in operation since 1990. The VR-2 subcritical reactor is a nuclear reactor that cannot reach criticality or supercriticality. It requires an external source of neutrons to keep the steady-state chain reaction. The VR-2 reactor has been in operation since 2023. The internet reactor laboratory offers the opportunity to add real remote reactor experiments to the academic curriculum, particularly in nuclear engineering and reactor physics, where students' access to an operating research reactor is not feasible. The neutron activation analysis laboratory contains two HPGe detectors in a lead shield, several gamma spectrometric systems and multichannel analysers. The devices allow for performing the qualitative and quantitative analysis of monitored samples from various fields of science (e.g., historical samples, soil samples, etc.). The neutron interactions laboratory consists of three principal experimental instrumentations, a graphite prism, water bath and manganese bath. The main purpose of the nuclear security laboratory is to understand, model and evaluate physical security systems at nuclear installations (reactors). The laboratory is designed for the facility characterisation, target identification, threat definition and basic principles of a physical protection system design (detection, delay, response). R&I activities at the VR-1 hub mainly focus on current challenges in nuclear energy development. Apart from traditional nuclear technology, the hub is also active in using neutron applications in R&I, thus enabling various multidisciplinary R&I that combines nuclear technology and natural sciences, social sciences or humanities.

Societal and economic benefits

The main socioeconomic benefits of the VR-1 hub for national and regional development impact education, employment, public services, the attracting of investments and cybersecurity, the development of social policies and environmental protection. R&I activities at the hub allow users to develop new technologies that can 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 industrial partners, is taking place. Besides R&I, the VR-1 hub provides state-of-the-art experimental education in nuclear engineering and neutron applications. The VR-1 hub is closely connected with the peaceful use of nuclear energy in a wide range of applications, from nuclear education through nuclear training to nuclear analytical techniques and neutron applications. All these applications are predominantly connected with nuclear power in the Czech Republic. The development of nuclear power programmes or electricity generation from nuclear power plants is closely connected with the United Nations Sustainable Development Goals and the Paris Agreement on Climate Change. In addition, the VR-1 hub also carries out multidisciplinary R&I activities in neutron applications, such as neutron activation analysis. This multidisciplinary R&I carried out at the hub brings unique collaboration between nuclear technology and natural sciences, social sciences or humanities, and impacts, e.g., cultural heritage preservation.

Environmental sciences

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Background and context

Environmental RIs play a central role in environmental observation and monitoring, providing fundamental data, methodologies and technologies that facilitate a better understanding of the systemic processes of Planet Earth, ongoing at various spatial and temporal scales, and ranging from sub-second and sub-micron scales to the decadal global scale, exceeding the human lifetime. Global changes in the environment thereby require complex solutions at various levels.

Environmental RIs enable scientists and innovators to carry out a broad range of R&I to combat and adapt to global climate change, mitigate its damaging impacts on the environment and society, preserve scarce natural resources and biodiversity, secure human health, ensure food and water production, and safeguard sustainable use of marine water, freshwater and soils.

In addition, environmental RIs are also indispensable for policy-makers in promoting and supporting evidence-based policy-making, i.e., the design, development, implementation and evaluation of regulations that aim to fulfil policy objectives of the EU and the Sustainable Development Goals of the United Nations.

Overall, environmental sciences are not limited to ecology, which assesses the relationship between the environment and living organisms. They also include the so-called geo-sciences, striving to comprehend complex functions of energetic metabolism and the biogeochemical cycles on Planet Earth. Environmental research also focuses on interactions between the environment, individuals and society as a whole, including the assessment of regulatory pathways. All these aspects are of utmost important since, according to the "one-health" concept, Planet Earth's environment determines the existence of life and the survival of humankind as such, as well as its nutrition, health and wellbeing. The environment provides natural and ecosystem services, which are necessary to support the existence of life, and even though we tend to take them for granted, human activities can seriously threaten their future availability.

▼ CzeCOS – Experimental Facility of Plant Ecophysiology "Domanínek"

Methodologically, environmental sciences are traditionally divided into four interdependent and closely interconnected domains focused on studying the geosphere, atmosphere, hydrosphere and biosphere, which jointly feed into a holistic interdisciplinary approach to the environmental phenomena, requiring a high degree of integration and interoperability of environmental RIs, particularly when it comes to the alignment and harmonisation of data management approaches.

The solid Earth sciences concentrate on solid Earth dynamics and the interface of physical, chemical and biological processes, in particular on plate tectonics, natural hazards (e.g., earthquakes, volcanic eruptions, rock falls, landslides, soil liquefaction, tsunamis, avalanches, etc.), man-caused hazards (e.g., wildfires, forest fires, landslides, groundwater depletion, etc.) and natural resources in terms of geo-resources and minerals. The call for strengthening the solid Earth scientific base in Europe is induced not only by requirements in the natural and man-caused hazards management field, but also due to the necessity of achieving the energy and raw materials strategic autonomy of Europe, including through implementing the concept of a green and circular economy.

Atmospheric research is a largely multidisciplinary scientific domain, encompassing atmospheric chemistry, physics, dynamics, and radiation, since the atmosphere contains a broad range of trace species, and the identification and quantification of their properties, and their atmospheric transport, transformation processes and life-cycles require highly interdisciplinary approaches. In this regard, it is important to study not just the components of the atmospheric system, but to apply a synergistic approach, including the use of surface observations, together with columnar and vertical profiles, aircraft and satellite observations, as well as laboratory and model studies to understand the atmospheric composition, linkages and processes in a comprehensive manner. An emerging field requiring particular attention is the study of persistent organic pollutants, i.e., chemicals with potential for long-range transport, persistence in the environment and an ability to bio-magnify and bio-accumulate in ecosystems, that are of rising global concern due to their significant negative effects on human health and the environment.

The hydrosphere scientific domain focuses on studying water ecosystems and the effects of human activities on water reservoirs, be it the salt water in oceans and seas, or the fresh water in icecaps, glaciers, groundwater, rivers, lakes or swamps. Water is essential for human life and it also plays an irreplaceable role in most natural processes, which is why the availability of water is an issue of utmost importance, and the preservation of water ecosystems poses a critical challenge for humankind. Sustainable water resources management is dependent on and must be underpinned by freshwater monitoring and analysis RIs providing, among other things, also platforms for experimenting, modelling and simulating possible water ecosystem development scenarios, mostly affected by global climate change impacts and the impacts of industry and agriculture. The same applies to the seas and oceans research, where special emphasis needs to be placed on coastal preservation, management and planning.

Biosphere sciences focus on studying biodiversity, i.e., the diversity of biological systems at all levels, including genes, species and ecosystems, with the objective to expand knowledge on terrestrial, marine and freshwater ecosystems, their structural components, as well as their mutual interaction. Biosphere research therefore focuses, e.g., on unknown species and their potential benefits in terms of food, medicine or ecosystem services; too close, unhealthy interactions between humankind and wildlife; intensive agriculture based on extensive use of fertilisers and pesticides, leading to habitat destruction and invasions of alien species; or the effects of microplastics on the food chain. Given that, there is an urgent need to strengthen the monitoring of biodiversity and ecosystem changes and environmental contamination.

All in all, environmental sciences, supported by a large variety of environmental RIs operated in the fields of the geosphere, atmosphere, hydrosphere and biosphere, enable placing increased value on natural ecosystems and the sustainable use of natural resources. Their research priorities are expected to centre around the mitigation of ecological degradation and global climate change, and their impacts on human health; the elimination of environmental exposure to chemicals, waste or biological agents harmful to human health; improving the health impact assessment of environmental factors; the promotion of healthy lives in sustainable societies; and promotion of intervention R&I.

Current state of play

A number of research institutions are participating in environmental research in the Czech Republic. The structure of the LRIs that they are hosting adequately reflects the importance of environmental challenges, as well as current trends in each given research field. Regarding geographic distribution, the majority of LRIs operated in Czechia within the environmental context is focused on the European region and linked to European networks reflecting the geopolitical position of the Czech Republic. The LRIs listed below support a broad range of R&I activities of their users, provide them with technology, expertise and data that are hard to obtain elsewhere, as well as with the opportunity to collaborate on 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. **ACTRIS-CZ** (*ACTRIS – participation of the Czech Republic*), participating in ACTRIS ERIC (*Aerosol, Clouds and Trace Gases Research Infrastructure*) is focused on the long-term monitoring of air quality and research addressing the 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 necessary for predicting and mitigating global climate change and other environmental, societal, and health impact challenges related to air quality.

Global climate change is closely linked to biogeochemical cycles, especially the carbon cycle. A detailed assessment of the links between the climate and terrestrial ecosystems is necessary to improve our understanding of the mechanisms of global climate change and, at the same time, to allow us to plan adaptations and mitigation activities. **CzeCOS** (*Czech Carbon Observation System*) offers a unique platform supporting complex research of the global impacts of climate change on terrestrial ecosystems. CzeCOS also represents a Czech national node to AnaEE-ERIC (*Analysis and Experimentations on Ecosystems*), DANUBIUS-RI (*International Centre for Advanced Studies on River-Sea Systems*), eLTER RI (*Long-Term Research on Ecosystems, Critical Zones and Socio-Ecological Systems*), EUFAR (*European Facility for Airborne Research*) and ICOS ERIC (*Integrated Carbon Observation System*). CzeCOS provides 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 gas fluxes 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 **RECETOX RI** (*RECETOX Research Infrastructure*). The existing and newly built core facilities of this LRI offer their users a wide range of expertise necessary for making an assessment of the impacts of environmental exposures on humans and populations and open access to environmental monitoring networks, population studies, the capacities of chemical, toxicological and microbiological laboratories, and extensive databases. RECETOX RI coordinates EIRENE (*Environmental Exposure Assessment Research Infrastructure*) and closely collaborates with other European RIs, be it those monitoring degradation of the natural environment and its impact on society (ACTRIS ERIC), as well as those which are active in various fields of biological and medical sciences, such as BBMRI-ERIC (*Biobanks and Biomolecular Resources Research Infrastructure Consortium*) and ELIXIR (*European Life-Science Infrastructure for Biological Information*). RECETOX RI 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 evaluation of their advantages and potential risks. **NanoEnviCz** (*Nanomaterials and Nanotechnologies for Environment Protection and Sustainable Future*) provides a platform for conducting research on nanomaterials and nanocomposites applicable in environmental protection and other related fields, such as chemical synthesis, chemical, structural and morphological characterisation, the optimisation of nanomaterial functional properties, and the development of tools for assessing their application potential and potential harmful effects.

The goals and objectives of **CENAKVA** (*South Bohemian Research Centre of Aquaculture and Biodiversity of Hydrocenoses*) are 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 LRI 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 areas related to landscaping for water conservation, drinking water and wastewater management, as well as aquaculture.

Gaps, challenges, needs and opportunities

LRIs in the Czech Republic operating in the field of environmental sciences cover an extensive portfolio of current trends in the environmental sciences. They are mainly focused on global climate change with respect to the general meaning of the phrase (ACTRIS-CZ, CzeCOS), the challenges related to the chemical pollution and degradation of the natural environment, and subsequent environmental and human health risks (CENAKVA, NanoEnviCz, RECETOX RI).

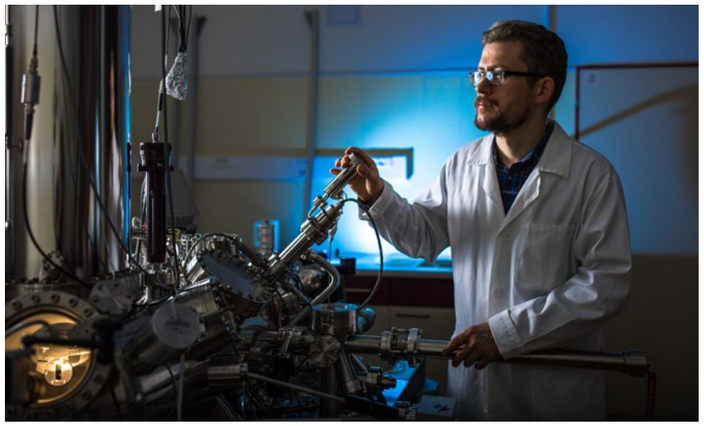
LRIs not only strive to explain the mechanisms driving key environmental processes, but also develop new applications and technologies for mitigating the adverse impacts of human activities, such as decontamination technologies, tools for the adaptation and mitigation of global climate change, biodiversity conservation and ecosystem restoration (CENAKVA, CzeCOS, NanoEnviCz, RECETOX RI).

Future challenges include further integration of LRIs to support the development of the **one-health concept**, embracing interactions between the individual environmental compartments and biological systems, including the human population, and the social aspects of interactions. Bridging environmental LRIs with those operating in the fields of biological, medical and social sciences and humanities will be even more important in the future. It will allow for the characterisation of the human exposome, and for exploring new approaches to changing the behaviour of human society, the long-term sustainable exploitation of natural resources and the preservation of the Earth's natural environment, health and wellbeing of the human population.

Besides the cross-disciplinary challenges of environmental LRIs described above, the already existing Czech landscape neither sufficiently reflects the key **link of the environment to the agriculture sector** nor the productive function of the countryside. Therefore, there is an urgent need to focus on the scientific areas which can ensure the long-term ecological and biological integrity of the environment. Attention should also be paid to the sustainable management of natural resources, particularly in terms of water retention in the landscape and soil quality, including the geological environment and mineral resources. Other areas also link the environment to the agriculture sector, such as the wildlife ecology of both plants and animals.

An important field with the potential to bring relevant knowledge for agricultural production is the breeding of new varieties of plants able to adapt to global climate change, and the breeding of plants that are resistant to harmful organisms. Therefore, one of the expanding fields is **plant phenotyping** to measure structural and functional plant characteristics. The involvement of the Czech Republic in EMPHASIS (*European Infrastructure for Multi-scale Plant Phenomics and Simulation*) constitutes a solution to fill the gap in the Czech LRIs landscape.

The area of environmental sciences should also have much stronger focus on the industry's long-term sustainability by reducing its negative impacts on the environment. In the framework of the sustainable management of natural resources, the concept of **circular economy** should be advanced. The building industry, from the perspective of the introduction of new processes and materials aimed at the BIM concept (*Building Information Modelling*), which works with the entire lifetime of constructions from the preparation of the project to its (ecological) demolition, can also be identified as a relevant topic.



◀ NanoEnviCz – The Ultra-High Vacuum Low Temperature Scanning Probe Microscope (UHV LT-SPM)

ACTRIS – participation of the Czech Republic

Acronym:
ACTRIS-CZ

Hosting institution:
Czech Hydrometeorological Institute

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

Responsible person:
Adéla Holubová Šmejkalová, Ph.D.
adela.holubova@chmi.cz

Phase: operational
Character: distributed

Website:
actris.cz/web/

Year of inclusion on the Czech Roadmap: 2015
Status on the ESFRI Roadmap 2021: landmark

Motto:
Unique Platform for Long-Term Background Air Quality Monitoring and Research Closely Related to Climate, Environmental and Health Issues Qualified as Societal Challenges

Characteristics

ACTRIS-CZ provides expertise in the field of atmospheric sciences, in particular the research of atmospheric aerosols, clouds and trace gases. Activities of ACTRIS-CZ are performed at the National Atmospheric Observatory Košetice (NAOK), and Suchdol, Lom and Milešovka Observatory. A new very important facility is the Prague Aerosol Calibration Centre (PACC). The central station is NAOK as the station with the most extensive measurement programme and facilities designed for research internships, small workshops and conferences. The exclusivity of ACTRIS-CZ lies in the set of measured parameters, where the selected measurements are unique not only in the Czech Republic, but also in the Central European region. Owing to high-quality research, ACTRIS-CZ possesses up to 30 years of homogeneous data on air quality and meteorological parameters, a unique time series measuring the size distribution of aerosol particles and information on the impact of pollution on other components of the environment. The atmospheric tower with a height of 250 m expands the possibilities of ground research by measurement in a vertical profile and monitoring of long-range transport. ACTRIS-CZ provides open access to equipment, data sets and other products. ACTRIS-CZ represents the Czech national node to ACTRIS (*Aerosol, Clouds and Trace Gases Research Infrastructure*). ACTRIS-CZ is also linked to ICOS ERIC (*Integrated Carbon Observation System*) and EIRENE (*Environmental Exposure Assessment Research Infrastructure*).

Societal and economic impacts

The results of ACTRIS-CZ research are used in practical applications, such as improving weather forecast and climate models, especially in extreme events (e.g., floods, storms, drought, etc.). ACTRIS-CZ outcomes also contribute to preventing emergencies. The data has been repeatedly used for the development of utility models for new sampling devices. The tall atmospheric tower is suitable for the steel construction sector, in the area of the dynamics and statics of tall slender constructions. Benefits from this special construction are used for testing new devices for monitoring air quality and measuring meteorological parameters towards their sensitivity to extreme conditions. Capacities of PACC provide opportunities for aerosol instrument calibrations open to customers both from Czechia and abroad.

South Bohemian Research Centre of Aquaculture and Biodiversity of Hydrocenoses

Acronym:
CENAKVA

Hosting institution:
University of South Bohemia in České Budějovice

Responsible person:
Assoc. Prof Vladimír Žlábek, Ph.D.
vzlabek@frov.jcu.cz

Phase: operational
Character: single-sited

Website:
frov.jcu.cz/en/faculty/faculty-parts/south-bohemian-research-centre-for-aquaculture-and-biodiversity-of-hydrocenoses-cenakva

Year of inclusion on the Czech Roadmap: 2019

Motto:
Sustainable Fisheries and Water Quality Based on Research and Education

Characteristics

CENAKVA serves as an RI and a unique centre of knowledge, science, services and education in fisheries and water protection. CENAKVA aims to understand the ongoing processes in freshwater ecosystems and their importance in biodiversity conservation, water environment protection, and water resources for life and human activities. The unique facilities and expertise offer the capacity needed for various users who dare to comprehensively investigate emerging issues of aquaculture and biological processes in changing conditions of freshwater ecosystems. CENAKVA has fishpond facilities encompassing 40 hectares and many closed recirculation and aquaponic systems unique in Europe. It has expertise in the assisted reproduction and breeding of nearly 30 species of freshwater fish and crustaceans and manages the largest sturgeon gene bank in the world. The biological, chemical and toxicological laboratories with state-of-the-art equipment allow for investigation of the global processes in freshwater ecosystems and the cycling of substances in water, including monitoring new environmental pollutants. The unique ponds, experimental facilities and scientific background of CENAKVA empower close ties with the aquaculture community and stakeholders in the Czech Republic, Europe and worldwide. CENAKVA participates in a consortium of 22 RIs from 13 European countries involved in AQUAEXCEL3.0 (*Aquaculture Infrastructures for Excellence in European Fish Research*), enabling access to its excellent RI. These connections allow for planning and verifying modifications to actual pond management within the context of ongoing global climate change, promoting sustainable aquaculture in the long-term with minimal water consumption, together with minimum discharges of waste substances and greenhouse gases into the environment. CENAKVA has become an integral part of DANUBIUS-RI (*International Centre for Advanced Studies on River-Sea Systems*) and is associated with the Czech national nodes to eLTER (*European Long-Term Ecosystem Research*) and ELIXIR (*European Life-Science Infrastructure for Biological Information*). It also cooperates with EMBRC-ERIC (*European Marine Biological Resource Centre*) and contributes to the implementation and progress of PARC (*European Partnership for the Assessment of Risks from Chemicals*). CENAKVA also organizes professional conferences, training courses, workshops, and lectures for scientists, students, industrial enterprises, regional and public authorities, international organisations and the public.

Societal and economic impacts

CENAKVA allows for studying the impacts of global climate change on aquatic ecosystems, which has a significant application for the practical life of mankind. CENAKVA is prepared to lead the expansion of sustainable aquaculture for environmentally friendly fish production in the Czech Republic and Europe to maintain good water quality. The CENAKVA aquaculture practices minimal water and energy consumption, minimal adverse environmental impacts and minimal waste production. It collects information on the effect of pollutants in Central European waters under conditions of natural ecosystems. This information is used in strategic planning in water conservation, wastewater management and drinking water treatment. The outputs of CENAKVA are used by both Czech, foreign and international institutions, such as WAS (*World Aquaculture Society*), EAS (*European Aquaculture Society*), WSCS (*World Sturgeon Conservation Society*), FAO (Food and Agriculture Organisation of the United Nations) and EFSA (European Food Safety Authority). At the Czech national level, CENAKVA cooperates with the Ministry of Agriculture, the Ministry of the Environment and the Czech Fish Farmers Association.

Czech Carbon Observation System

Acronym:
CzeCOS

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

Responsible person:
Prof Michal V. Marek, Dr, dr. h. c
marek.mv@czechglobe.cz

Phase: operational
Character: distributed

Website:
czecos.cz/en.html

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2021: landmark, project

Motto:
Unique Platform for Undertaking Comprehensive International Interdisciplinary Research on Global Changes and their Impacts on Ecosystems

Characteristics

CzeCOS is a distributed environmental RI focused on global change research in the atmosphere and the most important ecosystems in the Central Europe, such as forests, agroecosystems, meadows and pastures or wetlands. CzeCOS provides to a wide range of users unique RI, 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 study greenhouse gas and energy flows in terrestrial ecosystems, including assessing the effects of changing environmental conditions. The atmospheric station allows for the 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 a higher spatial scale. Linking these elements 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 national and regional levels, as well as for companies whose business is affected by global 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 climate change. CzeCOS is the Czech national node to ICOS ERIC (*Integrated Carbon Observation System*), AnaEE-ERIC (*Analysis and Experimentation on Ecosystems*), DANUBIUS-RI (*International Centre for Advanced Studies on River-Sea Systems*), eLTER RI (*Long-Term Research on Ecosystems, Critical Zones and Socio-Ecological Systems*) and EUFAR (*European Facility for Airborne Research*).

Societal and economic impacts

CzeCOS tackles the impacts of global climate change, especially drought, e.g., within the Intersucho long-term programme. 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, e.g., 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 engaged in the field of operational forecasting in energy, the calibration of satellite imaging and biowaste processing. The complex of the interconnection of individual elements of CzeCOS allows to create and improve models of future long-term impacts of global climate change on ecosystems.

Nanomaterials and Nanotechnologies for Environment Protection and Sustainable Future

Acronym:
NanoEnviCz

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

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

Responsible person:
Martin Kalbáč, Ph.D.
martin.kalbac@jh-inst.cas.cz

Phase: operational
Character: distributed

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 Safety

Characteristics

NanoEnviCz integrates capacities of leading national academic institutions to create an expert multidisciplinary platform providing domestic and foreign academia and industries with both scientific expertise in the development of nanomaterials and nanotechnologies for environmental remediation and highly advanced experimental techniques. NanoEnviCz covers a wide range of fields spanning from the application of nanomaterials and nanotechnologies in biomedicine and environmental protection to novel environmentally friendly production. Specifically, the consortium provides services including the development of nanomaterials and their complete characterisation, process analysis and optimization, health and environmental impact assessment and the development of their applications in advanced nanotechnologies. This complex approach enables the application of the modern safe-by-design strategy for the effective development of new functional and safe nanomaterials.

Societal and economic impacts

The main benefit of NanoEnviCz is the creation of a scientific platform for the development of novel technologies in the field of environmental and health protection and sustainable production, which substantially supports the long-term competitiveness of the Czech economy. Activities of NanoEnviCz help not only strengthen national cooperation, but also help develop regions with economic and social problems. The highly progressive multidisciplinary character of NanoEnviCz enables to combine expertise in a number of scientific fields, which is vitally important for the successful implementation of novel technologies in practice. In cooperation with industrial partners, new materials, such as nanofibrous membranes for wound dressings, nanomaterials for air antimicrobial filtration, photocatalytic nanocomposites with high pollutant degradation efficiency and perovskite catalysts for the highly effective degradation of nitrogen oxides in industrial waste gases, were developed and successfully introduced into industrial production. Besides the public sphere, NanoEnviCz cooperates closely with military institutions in the development of reactive sorbents for the disposal of chemical warfare agents. Finally, NanoEnviCz provides systematic training not only for its own personnel, but also for that of users' institutions, which is important for the wide implementation of progressive technologies in practice and their general acceptance.

RECETOX Research Infrastructure

Acronym:
RECETOX RI

Hosting institution:
Masaryk University

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

Phase: implementation
Character: single-sited

Website:
recetox.muni.cz/en/services/recetox-ri

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2021: project

Motto:
Science for a Healthy Future

MUNI | RECETOX
Research infrastructure

Characteristics

RECETOX RI is the European coordinator of EIRENE (*Environmental Exposure Assessment Research Infrastructure*), enabling human exposome research advancement. It brings together advanced technologies and multidisciplinary expertise necessary to address grand challenges related to chemical exposures and their impacts on population health. The existing and newly built RECETOX RI core facilities offer a wide range of services to a large variety of users from both the academic and private sectors. They provide access to accredited analytical facilities for target and non-target screening of biomarkers of exposure and effect in environmental matrices and human tissues, toxicological laboratories and omics technologies, environmental monitoring networks (MONET – *Monitoring Networks*) and population studies (CELSPAC – *Central European Longitudinal Studies of Parents and Children*), including sample and data collections and biobanking capacities. They also support the European open science policy approach by developing an open-access information platform (GENASIS – *Global Environmental Assessment and Information System*) and coordinate efforts at the global level (GOS4POPs – *Global Observation System for Persistent Organic Pollutants*). Capacities for data analysis, interpretation and modelling are also available at RECETOX RI, including advanced biostatics and bioinformatics, and data processing pipelines for functional exposomics developed in collaboration with ELIXIR (*European Life-Science Infrastructure for Biological Information*). The advanced infrastructure enables the development of innovative methods, technologies, products, building capacities and transferring of technology and know-how. The education activities of RECETOX RI improve the quality and professional readiness of graduates at all levels of higher education. The training courses, workshops and international summer schools are organised 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 national nodes to ACTRIS (*Aerosol, Clouds and Trace Gases Research Infrastructure*) and BBMRI-ERIC (*Biobanks and Biomolecular Resources Research Infrastructure Consortium*).

Societal and economic impacts

The R&I results and data generated by RECETOX RI have an application potential and are transferable to innovative technologies, products and services for environmental and medical practice and informed policies. They help identify toxic mixtures in environmental and food samples and human tissues, the sources of these mixtures and their health effects; establish causal links between chemical exposures and chronic diseases, and the mechanisms of such interactions; explore associations between environmental exposures and socio-economic factors; and allow for the identification of vulnerable populations and better targeting of the relevant legislation. They contribute to the better management of toxic chemicals, safe food production and waste processing, better health protection, preventive measures and the sustainability of healthcare. RECETOX RI capacities and services contribute to addressing grand societal challenges and sustainable development goals. They are instrumental in the implementation of various European strategies (Chemical Strategy for Sustainability, Zero Pollution, Safe-by-Design Concepts of the Green Deal) and EU Missions (Water, Soil and Food, Cities, Cancer). In 2009, RECETOX RI was endorsed by the United Nations Environment Programme (UNEP) as the regional centre for capacity building and technology transfer in Central and Eastern Europe. Through the development of international monitoring networks and information portals, it contributes to the implementation and effective evaluation of global conventions protecting human health from the negative impacts of toxic chemicals. In 2023, it was also endorsed as the WHO (*World Health Organisation*) collaboration centre providing capacities to the countries lacking appropriate expertise in the risk assessment of endocrine-disrupting chemicals to reinforce the regulation. At the Czech national level, RECETOX RI, as the National Centre for Toxic Compounds, supports the Ministry of Environment and other relevant ministries in developing and implementing chemical management and safety policies.

Biological and medical sciences

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page

Background and context

Biological and medical RIs play a key role in human efforts to facilitate healthy population living in a balanced environment. They are essential to understanding complex biological processes on Planet Earth through which they contribute to conserving biodiversity and preserving ecosystem services, and help to cope with phenomena such as global climate change. They are fundamental to promoting human health and healthy ageing as they empower to fight against infectious and contagious pathogenic diseases, and to addressing civilisation disorders such as cancer, neurodegenerative diseases, diabetes and obesity. Last but not least, against the background of the growing world's population and the increasing life-expectancy, they also underlie the human struggle to ensure safe, healthy and sustainable food production without compromising the environment.

In all these missions, biological and medical RIs stand on the interface with environmental as well as social sciences, and aim at a multidisciplinary approach to address grand health, food, environmental, societal and economic challenges, which no science-disciplinary domain or sub-domain can comprehensively resolve alone. In light of this, the intra-domain integration of biological and medical RI services, as well as their inter-domain clustering with RIs across diverse R&I areas, is a major challenge in terms of further consolidation and future development of the health and food RI landscape in Europe and globally.

In this way, including through the cross-fertilisation of R&I methods and techniques, biological and medical RIs may strengthen their capacities and capabilities to fully respond to the needs above, efficiently using their expertise throughout a broad range of specialisations, such as chemical, structure and systems biology; bioimaging, bioscreening, phenotyping, biobanking, clinical research and transnational medicine; exposomes (i.e., environmental determinants of human health); or food and nutrition, all of them underpinned and supported by bioinformatics.

When it comes to critical thematic challenges for the health sub-domain, these encompass, in particular, responding to pandemics through a rapid development of diagnostics, vaccines, cures and treatments; tackling antimicrobial resistance; developing platforms to address aging, neurodegenerative diseases, cancer, rare diseases or exposomes; promoting the tools of precision medicine and implementing the concept of personalised healthcare; and designing robust prevention programmes.

In terms of emerging areas with the potential to enrich the biological and medical R&I field through new technological approaches, these include, in particular, synthetic biology, gene-therapy, biomedical engineering and electronics, biotechnologies, environmental medicine, or the use of artificial intelligence to process biomedical data.

Regarding the food sub-domain, animal and plant health belongs among the prerequisites to contributing to the production of safe, healthy and sustainable food. The scientific disciplines focused on food and nutrition metrology and animal and plant phenotyping and breeding therefore grow in importance, as well as studying the potential of biological resources, such as plant, algae, fungi, marine life or micro-organisms, for the production of materials, chemicals and energy.

Overall, a better understanding of food consumption patterns is instrumental to measuring their impacts on the environment, agriculture and human health, and to developing a sustainable food production ecosystem with a reduced environmental and climate footprint.

▼ Czech-BioImaging – Light Microscopy Core Facility of the Institute of Molecular Genetics of the Czech Academy of Sciences, equipped with a wide range of high-end microscopy technologies and image processing tools

Current state of play

The biological and medical sciences part of the 2023 update to the Roadmap describes the area of biomedicine, food and nourishment, which is equivalent to the Health and Food area in the ESFRI Roadmap. The LRIs mentioned below cover a wide range 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 domain of food and nourishment covers a vast array of agro-food sector challenges ranging from the agricultural production of raw materials through technological manufacturing to analysing food safety and authenticity, as well as nutritional value, hygienic, technological and sensory quality. Here, the food area is also linked to LRIs 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.

The recent dynamic development of the Czech biomedical LRI landscape has followed the traditional course of Czech R&I. Establishing new and modernising existing biomedical LRIs in the Czech Republic required the use of the EU Cohesion Policy Funds in 2007–2015. The availability and use of the funds substantially and successfully aided in the establishment and modernisation of biomedical LRIs in Czechia. The investments in technology development have also continued in subsequent periods of the EU Cohesion Policy.

The presented Roadmap is a comprehensive network of complementary biomedical facilities that equally contribute their resources and expertise to achieve service integration and facility unification, allowing for excellent R&I. The LRIs listed below demonstrate synergistic efforts and biomedical expertise unprecedented in Czechia. The integration of Czech biomedical LRIs into European RIs further enhances their level of expertise and efficiency, while also indicating their relevance and importance within ERA and globally.

CCP (*Czech Centre for Phenogenomics*) is the national node of Czechia to INFRAFRONTIER (*European Research Infrastructure for the Generation, Phenotyping, Archiving and Distribution of Mouse Models of Human Diseases*) and aims to identify the functions of genes and provide the animal models necessary to test hypotheses before entering the human testing phase.

Two LRIs operate at the level of early-stage drug discovery. The first one is **CZ-OPENSCREEN** (*National Infrastructure for Chemical Biology*), representing the Czech national constituent of 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 national node to Instruct-ERIC (*Integrated Structural Biology European Research Infrastructure Consortium*). Both of these LRIs 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 national constituent of EATRIS ERIC (*European Advanced Translational Research Infrastructure in Medicine*), operates a translational, non-clinical and pre-clinical RI facility. **CZECRIN** (*Czech National Node to the European Clinical Research Infrastructure Network*), the Czech national node to ECRIN-ERIC (*European Clinical Research Infrastructure Network*), provides services for clinical research to optimise diagnostic and therapeutic procedures, as well as to conduct clinical trials of drugs and devices on patients in hospitals and clinics, while **BBMRI.cz** (*Network of Czech Biobanks*), the Czech national constituent of BBMRI-ERIC (*Biobanks and Biomolecular Resources Research Infrastructure Consortium*), facilitates the clinical aspect of biomedical R&I through collecting and analysing biological samples and corresponding data required for the development of new drugs or diagnostic assays.

As of the worldwide SARS-CoV-2 outbreak, EU-AMRI (*European Alliance of Medical Research Infrastructures*) has facilitated the clustering of BBMRI-ERIC, EATRIS-ERIC and ECRIN-ERIC to enhance sharing and access to European medical RI resources and services and, thereby, to accelerate the development of diagnostics, vaccines, medicines and treatments against the Covid-19 disease.

NCMG (*National Centre for Medical Genomics*), the newest member of the biomedical LRIs cluster in the Czech Republic, offers services and expertise in medical genomics.

From the environmental perspective, **RECETOX RI** (*RECETOX Research Infrastructure*) that coordinates EIRENE (*Environmental Exposure Assessment Research Infrastructure*) adds to the list of biomedical LRIs. Its long-term population studies, samples and data offer tools for monitoring the health impacts of selected factors and enables the linking of the population and clinical studies.

The following group of biomedical LRIs provides integrative services. **Czech-BioImaging** (*National Research Infrastructure for Biological and Medical Imaging*), the Czech national node to Euro-BioImaging ERIC (*European Research Infrastructure for Imaging Technologies in Biological and Biomedical Sciences*), covers the needs in biological and medical imaging at multiple levels, from the imaging of live animals, tissues and cells, including in vitro dynamics of cell behaviour, all the way down to the imaging of cell organelles, transport and biomolecules, as well as their interactions in health and disease.

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

The memberships of the Czech Republic in EMBC (*European Molecular Biology Conference*) and EMBL (*European Molecular Biology Laboratory*), both with their statutory seats hosted in Heidelberg, Germany, are a significant contribution to the development of biomedical RIs in Europe and complement the portfolio of LRIs operated in the Czech Republic in the area of biological and medical sciences.

As described above, the most advanced Czech biomedical LRIs are connected with excellent international partners, which results in (1) providing open access to cutting-edge technology platforms for academia and industry; (2) standardising R&I output and reducing fragmentation; (3) promoting interdisciplinary R&I in biological and medical sciences; (4) facilitating the translation of findings from basic research to applications in medicine; (5) strengthening competitiveness of academic research with outreach to industry; (6) providing training and education to future professionals in life sciences; and (7) attracting world-leading scientists to the Czech Republic.

The recently established **METROFOOD-CZ** (*Infrastructure for Promoting Metrology in Food and Nutrition in the Czech Republic*) is the Czech national node to METROFOOD-RI (*Infrastructure for Promoting Metrology in Food and Nutrition*). Its main goals and objectives are to promote interdisciplinary R&I 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 the development of new reference materials for making a quality assurance analysis of food and natural products. Through its open access, METROFOOD-CZ offers its unique experimental and instrumental capacities for both the research and application sectors in the form of expert analyses, use of unique analytical instrumentation, possibility of developing new products and testing of the hygienic-toxicological, nutritional and sensory quality of food.

◀ EATRIS – Evaluation of pharmacokinetics and distribution of candidate radiopharmaceutic in experimental animals using positron emission and computer tomography

Gaps, challenges, needs and opportunities

The Czech biomedical LRIs are complementary to each other and as such, contribute to R&I in many fields. Nevertheless, if comprehensively compared, the landscape shows certain gaps.

The field of **nanobiotechnology**, i.e., nanomaterials for biomedical sciences, focuses on the research of high-resolution artificial structures and targets the interface between life sciences and nanomaterials. Nanobiotechnology largely supports the development of new therapeutics, diagnostics, imaging and regenerative medicine. It also provides considerable benefits for all areas of disease, including cardiovascular diseases, diabetes or cancer, and has substantial potential to become one of the main instruments utilised in personalised, targeted and regenerative medicine.

Other scientific approaches combine results from plant research with environmental sciences. Plants, providing 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 for understanding ongoing molecular processes. Such knowledge is critical to improving plant tolerance under adverse environmental conditions to ensure food quality and yield. **Plant phenotyping thus** helps define strategies to improve the yield, stability and quality of globally important crops, and to develop new resilient crops. Collections of plant genetic resources, plant germplasm, wild plant relatives and native seeds, accompanied by corresponding specialised metadata provided on the basis of open access, are of growing importance for conducting plant-biology R&I. Establishing the Czech national node to EMPHASIS (*European Infrastructure for Multi-scale Plant Phenomics and Simulation*) as a long-term LRI project might be a solution to the identified gap.

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 as such is highly multidisciplinary and technically demanding, requiring complex research facilities. Its impact is significant within R&I in a socioeconomic 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 LRIs would establish a united front in the pursuit of a common goal that is understanding the mechanisms behind clinical symptoms and disease progression. Pooling resources and expertise would successfully extend the frontiers of our knowledge and facilitate (bio-) pharmaceutical manufacturing and (pre-) clinical trials, which lead to the discovery of personalised medicine and improved healthcare. Establishing a network of multidisciplinary LRIs has the ability to augment the contributions of any single RI to provide an integrated and multi-faceted understanding of disease development. Moreover, a multidisciplinary platform enhances the complementarity and establishes a mutual support base between participating members in the Czech Republic. The advancement of biomedical R&I calls for closer collaboration among LRIs in order to provide a full pipeline of expertise and services. Depending on the specific needs of certain R&I projects, LRIs should enable open-access services at the (macro-) regional and international level. Therefore, providing support to the interoperability of biomedical research facilities is of utmost importance, as it will improve overall work efficacy. The resulting synergies will lead to the efficient use of available resources and increase efficiency of LRIs' operations. Such a development would immensely benefit the cross-sectorial R&I carried out not only in the fields of biological and medical sciences, but also in material and environmental sciences.

Each of the established biomedical LRIs 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 their scientific and technological base to increase international competitiveness and, together with their European partners, address the grand challenges in biomedical R&I.

▲ CZ-OPENSCREEN – High-throughput screening robotic platform

Network of Czech Biobanks

Akronym:
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 Olomouc
Institute of Hematology and Blood Transfusion in Prague
Institute of Rheumatology in Prague
Masaryk University

Responsible person:
Assoc. Prof Roman Hrstka, Ph.D., M.Sc.
hrstka@mou.cz

Phase: operational
Character: distributed

Website:
bbmri.cz

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2021: 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 since they are not routinely preserved in health care institutions. 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 "sample/data 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 healthcare institutions. BBMRI.cz also has a unique set of technologies and knowledge for conducting translational research, and for transferring clinical applications from translational research to academic clinical trials. The user community utilises 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 the Czech national node to BBMRI-ERIC (*Biobanks and Biomolecular Resources Research Infrastructure Consortium*) and the Czech Republic is its Founding Member. BBMRI.cz, as a part of BBMRI-ERIC, is currently a central medical RI 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. BBMRI.cz fundamentally participates in the development and gradual improvement of web tools, such as the BBMRI-ERIC Directory or the BBMRI-ERIC Negotiator freely available to the European research community. The BBMRI-ERIC Directory is a horizontal cataloguing tool that provides concise, sufficiently clear information about European biobanks involved in BBMRI-ERIC. This tool supports finding a suitable partner biobank for researchers interested in specific clinical sample/data sets. The BBMRI-ERIC Negotiator tool enables specific communication between the applicant (research, development) and the provider (the institution managing the biobank).

Societal and economic impacts

The societal and economic benefits of BBMRI.cz lie in activities defining the key documents of healthcare policy in the Czech Republic, such as clinical practice guidelines with a direct impact on clinical medicine related to, e.g., the use of predictive laboratory tests in oncology and guidelines for determining targeted treatments, where the respective molecular therapeutic targets are studied and identified in the target tissue. The impacts of BBMRI.cz concentrate on research for disease biomarkers that will be discovered and characterised using human biological material collections linked to clinical data and subsequently tested in clinical trials. The search for appropriate biomarkers specific to a relevant disease using archived collections is thus an important factor in the design of innovative therapeutic products and procedures in many human diseases.

Czech Centre for Phenogenomics

Akronym:
CCP

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

Responsible person:
PD Dr rer. nat. habil. Radislav Sedláček
radislav.sedlacek@img.cas.cz

Phase: operational
Character: single-sited

Website:
phenogenomics.cz

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2021: landmark

Motto:
Centre for the Research of Comprehensive Functions of Mammalian Genes

Characteristics

CCP is the largest non-distributed biomedical RI in the Czech Republic with international impact, providing a unique and complex service portfolio which, on this scale, can only be found in just a few places around the world. CCP activities in excellent research and user service focus on four main areas. The first is genome editing, which is currently performed primarily using the programmable nuclease. CCP belongs to the best centres in the world in this area and offers numerous services to researchers, thus facilitating the development of animal models to study human diseases. Second, CCP focuses on phenotyping, i.e., the comprehensive characterisation of genetically modified models to describe the functions of studied genes with informative mutations. CCP can investigate all the 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 standardised, hence improving result reproducibility. Third, CCP develops not only new technologies for genome editing and for the characterisation of physiological functions, but also provides services in preclinical development, including pharmacokinetics, dynamics and toxicology, thus contributing to the development of new medicines for both the academic and commercial sectors. This also includes PDX technology (*Patient-Derived Tumor Xenograft*), which investigates the development of human tumors engrafted into mouse models and the possibilities of their treatment using a personalised therapeutic approach. The fourth and newest area is studying infection using mouse models, for which CCP has recently opened a state-of-the-art BSL-3 facility to investigate dangerous infections. Altogether, CCP proceeds to develop further and to expand from disciplines such as genetics, molecular biology and physiology to preclinical activities aiming at innovation in the design of new treatment approaches to human diseases. CCP is a member of INFRAFRONTIER (*European Research Infrastructure for the Generation, Phenotyping, Archiving and Distribution of Mouse Models of Human Diseases*) and due to the comprehensive portfolio of its expertise, ranging from the generation of mutant models to its knowledge and experience with analysing the functions of genes and their mutations, it has also become a member of IMPC (*International Mouse Phenotyping Consortium*). CCP works together with IMPC members on a very ambitious goal, which is the description of the functions of all mammalian genes. CCP is finalising its entry into EurOPDX European RI.

Societal and economic benefits

In both the Czech Republic and Europe, CCP is working on projects striving to tackle a few socioeconomic challenges, including ageing, metabolic disorders, oncologic and neurologic diseases, and recently also infection and the preclinical development of therapies for human diseases, which result in innovative solutions for biomedical industry as CCP has strengthened its contract research activities. CCP effectively supports the scientific community in studying the function of genes in physiological processes and during the development of human diseases and their treatments, and provides the Czech research community with excellent know-how and service, offering a standardised environment in which they can test new therapeutics and publish their results in high-quality international journals. CCP also increases the profile of science in Czechia through its international cooperation and by performing R&I projects with commercial partners, including preclinical research to develop new therapeutics through the development of new technologies to study metabolism, artificial intelligence solutions for imaging and other phenotyping technologies. In 2022, CCP established the first Czech platform for gene therapy and precise medicine, aiming to provide proof-of-concept studies of gene therapies for specific diseases in vitro and in vivo models and to develop new tools for gene/drug delivery.

Czech Infrastructure for Integrative Structural Biology

Akronym:
CIISB

Hosting institution:
Masaryk University

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

Responsible person:
Assoc. Prof Pavel Plevka
pavel.plevka@ceitec.muni.cz

Phase: operational
Character: distributed

Website:
ciisb.org

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2021: landmark

Motto:
Expertise and State-of-the-Art Technologies Enabling the Characterisation of Living Cells and their Components at Atomic Resolution

Characteristics

CIISB is operated through CEITEC (*Central European Institute of Technology*) and BIOCEV (*Biotechnology and Biomedicine Centre of the Czech Academy of Sciences and Charles University in Vestec*). It provides expertise and access to technologies for integrative structural analyses of cells and their biologically important macromolecular components with atomic-level resolution. CIISB consists of a total of 10 core facilities and central laboratories of national and international importance. CIISB provides expertise and access to state-of-the-art technologies for the preparation of samples, determination of their spatial structure and characterisation of their dynamics over a time scale ranging from 10-9 to 103 s. Excellent CIISB technologies used for NMR spectroscopy, cryo-electron microscopy and tomography, X-ray diffraction and Bio-SAXS measurements, nanobiotechnologies, the biophysical characterisation of bio(macro)molecules and mass spectrometry are at a level of quality that compares favourably with large European RIs. The combination of modern high-end equipment and scientific expertise, unrivalled at the national level, enables the acquisition and interpretation of data obtained from instruments covering more than 20 key technologies and 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 top-class equipment for cryo-electron microscopy and tomography, high-field NMR spectroscopy and high-resolution structural mass spectrometry. CIISB is the Czech national node to Instruct-ERIC (*Integrated Structural Biology European Research Infrastructure Consortium*), 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 provides key services to the international research community.

Societal and economic impacts

CIISB encourages national and transnational collaboration across mathematics, physics, chemistry, biology and medicine in academia and the industrial sector. While CIISB primarily serves basic research, innovation and technology transfer are among the strategic priorities of host institutions. CIISB supports developments in scientific areas such as molecular biology, biochemistry, biomedicine and biotechnology by providing the best 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, the application sphere and industrial partners is reflected in developing new technologies and key experimental techniques, primarily in the fields of NMR, cryo-electron microscopy, X-ray diffraction and structural mass spectrometry.

Czech National Node to the European Clinical Research Infrastructure Network

Akronym:
CZECRIN

Hosting institution:
Masaryk University

Partner institutions:
St. Anne's University Hospital Brno

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

Phase: operational
Character: distributed

Website:
czecrin.cz/en/home

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2021: landmark

Motto:
Medical Research in our Application is Always About the Patient – CZECRIN: Towards Patient-Oriented Medicine

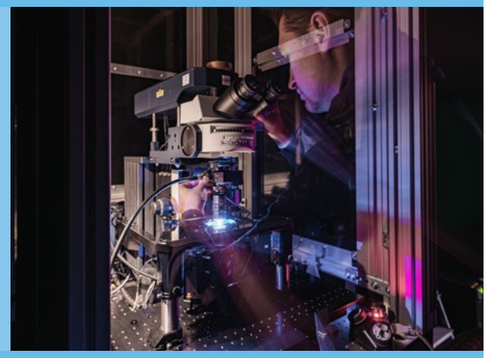
Characteristics

CZECRIN is a distributed nationwide RI providing a stratified portfolio of services and research capacities for innovative clinical research and drug development primarily through non-commercial clinical trials and advanced education. Since 2020, CZECRIN's comprehensive research and service strategy has been based on the vision towards patient-oriented medicine, in which the results of clinical studies help optimise the healthcare of patients, access to innovative medicinal products and medical devices. CZECRIN currently brings together nine large university hospitals and three specialized medical centres for oncology, psychiatric and haematology care, with a vision of possible expansion in the years 2023–2026. Priority areas of clinical research in medicine are implemented through branch-oriented networks, the so-called Disease-Oriented Networks. CZECRIN has expertise and technological capacities covering all stages of the drug/medical device life-cycle. In the medicines and medical devices R&I, it offers comprehensive services and expertise, including regulatory knowledge for the translation of preclinical experiments into the clinical part of development, for the area of clinical studies protocol writing, regulatory support, pharmacovigilance, the provision of complex biometrics through data management and biostatistical analyses, for the area of health technology assessment, expertise in the field of pharmacoeconomic and other professional analyses. CZECRIN has technological capacities in the Good Manufacturing Practice (GMP) regime for R&I and the production of somatic cell medicinal products with the application potential of treating patients through non-commercially initiated clinical trials. CZECRIN is the Czech national node to ECRIN-ERIC (*European Clinical Research Infrastructure Network*), which is a distributed RI, a non-profit organisation connecting scientific partners and national RI networks across Europe, facilitating transnational clinical research and supporting the conduct of international clinical trials in Europe. ECRIN-ERIC is a part of EU-AMRI (*European Alliance of Medical Research Infrastructures*) together with BBMRI-ERIC (*Biobanks and Biomolecular Resources Research Infrastructure Consortium*) and EATRIS ERIC (*European Advanced Translational Research Infrastructure in Medicine*). EU-AMRI was established in the wake of the Covid-19 pandemic with the aim of establishing closer cooperation between EU Member States and facilitate researchers' access to the resources and services of individual RIs to accelerate the development of diagnostics, vaccines and treatments.

Societal and economic impacts

CZECRIN strategically focuses on and supports national and international cooperation in the areas of clinical research, the results of which have a direct impact on the treatment of patients or its availability and economy through the optimisation of treatment procedures, medical recommendation or innovative therapies, always for the benefit of patients, citizens and healthcare. In the areas of clinical research, CZECRIN focuses primarily on patients with rare diseases and cancer, with priority in the paediatric population. An example of successful R&I and the production of medicinal products is the MyDendrix somatic cell vaccine for paediatric oncology patients with a high risk of recurrence and FlyCellyx for paediatric patients with the butterfly children disease. Other priority areas of CZECRIN support are focused on areas of clinical research in neurology, cardiology, infectious diseases, psychiatry and pneumology, which also contribute to the optimisation of the pharmacotherapy of patients. In all the above cases, these are areas that are not in the priority interest of the R&I of large pharmaceutical companies. Owing to the sharing of its capacities on an open access basis, CZECRIN enables effective and high-quality implementation of clinical trials throughout the Czech Republic, and in addition to new benefits for the treatment of patients, it also brings cost savings. In recent years, CZECRIN has also been developing cooperation with smaller biotechnological small- and medium-sized enterprises, which do not have a comprehensive portfolio of activities in the framework of drug development, and the missing parts of which can be supplemented by CZECRIN on the basis of contractual cooperation.

National Research Infrastructure for Biological and Medical Imaging



Akronym: Czech-BioImaging

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

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

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

Phase: operational
Character: distributed

Website: czech-bioimaging.cz

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2021: landmark

Motto:
National Research Infrastructure for Biological and Medical Imaging Providing Open Access to Cutting--Edge Imaging Technologies and Methodologies

Characteristics

Innovative imaging technologies allow for studying hidden biological processes in cells, tissues and whole organisms. Imaging has become one of the most critical elements of research in biological and medical fields. Czech-BioImaging was designed as a distributed RI of imaging research institutions in the Czech Republic. It provides open access to a wide portfolio of imaging technologies and methodologies, thus allowing for the extraction of completely new scientific data, particularly 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 programmes. 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 broad 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 R&I, 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 contributes to the development of biomedical sciences through publication, educational, and methodological activities. Czech-BioImaging represents the Czech Republic through three national nodes in Euro-BioImaging ERIC (*European Research Infrastructure for Imaging Technologies in Biological and Biomedical Sciences*), of which Czechia is a Founding Member.

Societal and economic impacts

The technological and methodological foundation of Czech-BioImaging significantly improves biomedical R&I due to the top imaging technologies made accessible to users and the professional expertise of the Czech national nodes to Euro-BioImaging. 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 its personnel and intensive involvement in international R&I cooperation. Czech-BioImaging supports the development of biological, biomedical and medical sciences. It carries out measurements for various types of R&I projects and provides feedback, suggests new ideas for making improvements and other technological development propositions to manufacturers. Thanks to its own methodological research, Czech-BioImaging has become a partner of manufacturers in the development, implementing and testing of new instruments. As a result, Czech-BioImaging is also involved in the education of the staff of supplier companies, and plays an important role in the education of users in cooperation with instrumentation manufacturers.

National Infrastructure for Chemical Biology

Akronym: 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

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

Phase: operational
Character: distributed

Website: openscreen.cz

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2021: landmark

Motto:
Providing Access to State-of-the-Art Technologies and High-Quality Services in the Field of Chemical Biology, Systematically Building a Library of Chemical Compounds, Identifying New Molecular Probes and 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 RI for basic and applied research in the fields of chemical biology and genetics in the Czech Republic, and provides open access to external users. It supports 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 the identification of new molecular probes and the development of 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 users from the biological and chemical community, CZ-OPENSCREEN offers standard biological and biochemical assays, consultancy and the development of new assays, high-throughput screening (HTS), profiling of chemical compounds on a panel of cell lines and medicinal chemistry optimisation of newly identified biologically active compounds. CZ-OPENSCREEN is systematically building a library of commercial chemical compounds, as well as compounds synthesised in Czechia, while providing access to this unique library to external users. An integral part of the services facilitated by CZ-OPENSCREEN is cheminformatics support, such as data analysis and storage and the development of new analytical tools and database systems. CZ-OPENSCREEN is equipped with state-of-the-art technologies for the high-throughput screening of chemical compounds, such as integrated robotic HTS stations, robotic stations for performing automatic microscopic analyses and label-free technology, and integrated robotics systems for compound storage and sample preparation. The long-term international collaboration of CZ-OPENSCREEN with other European partners has contributed to the establishment of EU-OPENSCREEN ERIC (*European Infrastructure of Open Screening Platforms for Chemical Biology*), of which the Czech Republic is a Founding Member. CZ-OPENSCREEN constitutes its Czech national node and hosts the European Chemical Biology Database (ECBD), where all data generated by EU-OPENSCREEN ERIC partners are stored.

Societal and economic impacts

Research in the field of chemical biology has an immediate impact on translational research for the identification and validation on the new activities of known drugs, ex-vivo therapeutics and targeted experimental therapy. The excellent equipment and chemical biology expertise of CZ-OPENSCREEN strengthen the Czech Republic's position in the biomedical field in the EU and globally. CZ-OPENSCREEN develops new technological approaches to identifying novel inhibitors for advanced therapies in oncology, inherited and metabolic diseases, as well as neurodegenerative and neglected diseases. The results of CZ-OPENSCREEN research have high translational and application potential for the pharmaceutical, biotechnology and agrochemical industries. CZ-OPENSCREEN collaborates with a number of Czech and foreign innovative companies active in the development of specific tumour growth inhibitors.

Czech National Node to the European Infrastructure for Translational Medicine

Akronym: EATRIS-CZ

Hosting institution: Palacký University Olomouc

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

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

Phase: operational
Character: distributed

Website: eatris.cz

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2021: landmark

Motto:
Infrastructure for Translation Medicine Providing Users with Access to Technology and Knowledge for the Research and Development of Personalised Medicine Products – from Validation of Molecular Targets to Proof-of-Concept Clinical Trials

Characteristics

EATRIS-CZ is one of the largest distributed RIs in the Czech Republic, incorporating important centres of biomedical R&I. EATRIS-CZ provides cutting-edge RI and expertise along the entire translational value chain. Through interrelated product platforms, EATRIS-CZ enables the development of innovative therapeutics, vaccines, imaging agents and biomarkers to reach first-in-human application and clinical proof-of-concept verification. EATRIS-CZ provides capacities for multidisciplinary R&I in genomics, proteomics, metabolomics, high-capacity testing, complete drug development pipeline, molecular imaging and radiopharmaceuticals, the R&I of biomarkers, early phase clinical trials and regulatory expertise. EATRIS-CZ also offers a wide range of services, models, datasets, patient cohorts, interactions with leading experts in R&I, industry and regulation. The EATRIS-CZ network includes accredited centres with the possibility of producing and testing medical products in good manufacturing practice (GMP) and good laboratory practice (GLP), or under ISO certification guidelines (ISO 17025, ISO 15189 and ISO 27001). EATRIS-CZ outcomes have led to numerous national and international projects, scientific publications, patents, clinical trials, the development of software tools and databases for clinical and preclinical data stewardship, cooperation with industrial partners and the development of specialised molecular diagnostics allowing for the practical implementation of personalized medicine in the Czech Republic. EATRIS-CZ provided support to the Czech Government during the Covid-19 pandemic (preventive and diagnostic testing, self-reporting, contact tracking, reporting of testing results to citizens). In the upcoming period of operation, EATRIS-CZ expects to further consolidate and integrate the network of EATRIS-CZ centres. EATRIS-CZ is the Czech national node to EATRIS ERIC (*European Advanced Translational Research Infrastructure in Medicine*). EATRIS-CZ also actively cooperates with other RIs in both Czech and international relations. Namely, collaboration with INFRAFRONTIER (*European Research Infrastructure for the Generation, Phenotyping, Archiving and Distribution of Mouse Models of Human Diseases*) 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 BBMRI-ERIC (*Biobanks and Biomolecular Resources Research Infrastructure Consortium*) or ECRIN-ERIC (*European Clinical Research Infrastructure Network*) was established to implement discovery and validation projects in the field of biomarkers, rare diseases and advanced clinical testing.

Societal and economic impacts

EATRIS-CZ contributes to healthcare by increasing the number of innovative products, which address unmet medical needs in the Czech Republic and abroad, as well as by training a new generation of researchers, and healthcare and pharma industry professionals. EATRIS-CZ maximises its return on investment in basic research, advances candidate products from academia and increases their chance to be licensed by industry. EATRIS-CZ institutions work closely with the industrial sector, and they are also involved in medical competence centres. EATRIS-CZ cooperates with the Czech Government, health insurance companies and the Institute of Health Information and Statistics of the Czech Republic to develop guidelines and strategic documents in health. EATRIS-CZ contributes to the solution of major public health challenges, such as the recent Covid-19 pandemic or cancer control via innovations in pathogen/cancer screening programmes. EATRIS-CZ institutions are actively involved in the preparation and implementation of key national projects targeting cancer, infectious and neurological disorders. Strategic cooperation with a major cancer research charity, the Cancer Research Czech Republic, enables direct access to patients, dissemination of information and services to clients. EATRIS-CZ also collaborates with national regulatory bodies to foster regulatory sciences, expertise and knowledge.

Czech National Infrastructure for Biological Data

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

Responsible person:
Prof Dr Jiří Vondrášek
jiri.vondrasek@uochb.cas.cz

Phase: operational
Character: distributed

Website: elixir-czech.cz

Year of inclusion on the Czech Roadmap: 2011
Status on the ESFRI Roadmap 2021: landmark

Motto:
National Research Infrastructure for Storing, Processing and Analysing Life Science Data

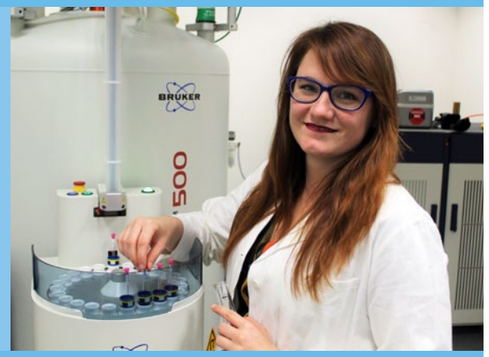
Characteristics

ELIXIR CZ is a distributed RI for bioinformatics that emerged from an advanced computational environment. It is dedicated to the management, organisation, storage, sharing and facilitation of the interoperability of life-science data for further processing and analysis. ELIXIR CZ offers the use of its specialised databases and unique tools free-of-charge to the national and international life science research community. The mission of ELIXIR CZ is to provide solutions to the real problems related to the exponential increase of biological research experimental data. Life science research around the world faces the challenge of not only how to store data safely and accessibly, but also how to secure the interoperability of heterogeneous datasets. ELIXIR CZ tackled these challenges by introducing and sharing standards and best practices. Moreover, in both independent and collaborative efforts, ELIXIR CZ continues to develop and refine advanced tools and services for powerful, efficient and easy-to-use data analysis. Beyond the Czech Republic, ELIXIR CZ is the Czech national node to ELIXIR (*European Life-Science Infrastructure for Biological Information*), coordinating and developing life science resources across Europe. Nationally, ELIXIR CZ collaborates closely with LRIs on curating research data and bridging life science disciplines in a synergic fashion. Collaboration has been developed with BBMRI.cz (*Network of Czech Biobanks*), CIISB (*Czech Infrastructure for Integrative Structural Biology*), CZ-OPENSCREEN (*National Infrastructure for Chemical Biology*), Czech-BioImaging (*National Infrastructure for Biological and Medical Imaging*), CZECRIN (*Czech National Node to the European Clinical Research Infrastructure Network*), EATRIS-CZ (*Czech National Node to the European Infrastructure for Translational Medicine*), METROFOOD-CZ (*Infrastructure for Promoting Metrology in Food and Nutrition in the Czech Republic*) and RECETOX RI (*RECETOX Research Infrastructure*).

Societal and economic impacts

ELIXIR CZ plays an essential role in the development of biological and medical sciences in the Czech Republic by contributing to solving challenges in the field of personalised medicine and safe access to biological and medical data. ELIXIR CZ enables users to implement brand new methods and technologies and provides users with the necessary expertise. Progress in the field of bioinformatics brings new approaches and solutions with significant impact on the pharmaceutical, medical, agricultural and biotechnology industries. ELIXIR CZ cooperates with the commercial sector in NGS data processing, drug design, protein engineering and software development. ELIXIR CZ is also the initiator of the application of unified data management in projects funded by the Government of the Czech Republic with the aim of ensuring the availability and sustainability of these data even after the end of project funding.

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



Akronym:
METROFOOD-CZ

Hosting institution:
Czech University of Life Sciences Prague

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

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

Phase: operational
Character: distributed

Website:
metrofood.cz

Year of inclusion on the Czech Roadmap: 2019
Status on the ESFRI Roadmap 2021: project

Motto:
Improvement of Food Quality and Safety Through Metrology Techniques within Unique European Research Infrastructure

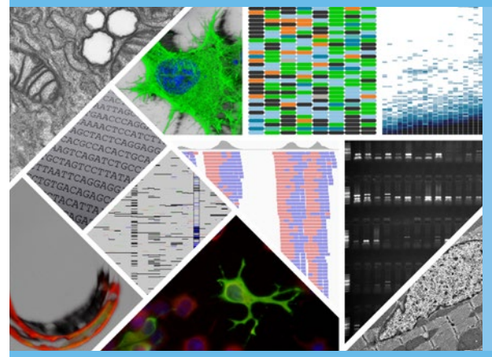
Characteristics

METROFOOD-CZ is the only Czech RI in the health and food realm that focuses on foodstuffs and nutrition. Its main objective is to carry out and support new interdisciplinary R&I in areas covering primary agricultural production, food processing and technology, quality, authenticity, safety and traceability of food, raw materials, products or dietary supplements. METROFOOD-CZ provides world-class equipment and facilities for the analysis of agricultural products and food, offers potential for experiments on trial fields and stables, as well as developing new food products and testing innovative technologies. METROFOOD-CZ personnel are the leading experts in the agrifood sector and metrology. METROFOOD-CZ focuses on the development and validation of analytical methods for evaluation of the quality, safety and authenticity of food, feed and raw materials, and preparation of new reference materials to ensure quality in the field of food and natural product analyses. As a part of open access, METROFOOD-CZ offers its unique experimental and instrumental capacities to the research and application sectors in the form of expert analyses, the use of unique analytical instrumentation, the potential for developing new products and the testing of the hygienic-toxicological, nutritional and sensory quality of food. METROFOOD-CZ is vital for public and private research laboratories operating in various fields (e.g., food metrology, food chemistry and analysis, food composition, nutrition, food quality and safety, etc.), as well as for commercial food producers, consumers, public institutions, inspection authorities and services. In addition, METROFOOD-CZ also provides educational services to experts, as well as the public, access to food composition databases and libraries of spectra from analytical methods, and contacts to international experts working in the field of food quality and nutrition. METROFOOD-CZ has been the Czech national node to METROFOOD-RI (*Infrastructure for Promoting Metrology in Food and Nutrition*), aiming for an ERIC legal form.

Societal and economic impacts

METROFOOD-CZ offers an excellent RI 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 the Czech and international markets. METROFOOD-CZ closely cooperates with agri-food companies, the Chamber of Commerce, inspection authorities and research institutes. The benefits of such cooperation include, e.g., 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 small- and medium-sized enterprises in scientific projects and the participation of experts in evaluation committees.

National Centre for Medical Genomics



Akronym:
NCMG

Hosting institution:
Charles University

Partner institutions:
University Hospital Brno
Masaryk University
Palacký University Olomouc

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

Phase: operational
Character: distributed

Website:
ncmg.cz/en

Year of inclusion on the Czech Roadmap: 2011

Motto:
Helping to Understand Genetic and Molecular Bases of Human Health and Disease

Characteristics

Medical genomics is a dynamically evolving scientific discipline which 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 created a LRI that allows for the rapid implementation of novel genomic technologies and enables their rational utilisation in the characterisation of genetic underpinnings of human health and disease in the Czech Republic. As in other countries, Czechia also has a unique population with genetic variants, which 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 Czechia. NCMG possesses state-of-the-art instrumentation and provides the expertise 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 facilitates basic bioinformatic and statistical support for a number of projects targeting various rare diseases, cancers and complex phenotypes. NCMG was conceived as a distributed multi-centred, nation-wide LRI of top genomic laboratories operating in leading Czech national institutions of medical education and biomedical research. Localisation and, at the same time, dissimilar specialisations of individual nodes guarantee territorial and occupational development, and the application of genomics in the Czech Republic in accordance with worldwide trends. Within this setting, NCMG develops its technological and methodological background in a coordinated and complementary manner, maintains and provides state-of-the-art analytical expertise to investigators having access to well-defined cohorts of patients, control individuals and various clinical materials. Jointly with continued technological advances in instrumentation, data analysis and data storage, NCMG builds a reference database of genetic variations in the Czech population based on exome, and later, whole genome sequencing data. The hosting institutions of NCMG are members of BBMRI-ERIC (*Biobanking and Biomolecular Resources Research Infrastructure Consortium*), EATRIS ERIC (*European Advanced Translational Research Infrastructure in Medicine*), 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 Czechia is a Member State.

Societal and economic impacts

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

Social sciences and humanities

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Background and context

RIs operated in the area of social sciences and humanities usually bring together data about different phenomena, across countries and over a long period of time to support research of the historical, social, economic, political, cultural and other contexts of the development of society. Besides their primary objectives to address various cultural and societal challenges, they also help understand the historical, social and political processes – currently such as the mitigation of global climate change, or the green transition and digital transformation of the economy – so that these may be perceived correctly by the broad public and the perception is always based on relevant evidence.

The key starting points for social sciences and humanities are linked to the preservation of cultural and historical heritage, and the study of the evolution of society, which is also why continuity in the collection of data and the conduct of continuous long-term investigations is of paramount importance. Any damage caused by the interruption of the data archiving and the loss of digital data may be irreversible. The long-term sustainability and systematisation of archival activities is therefore an essential prerequisite for the success of the current and, especially, future social sciences- and humanities-based research, with the solution being to concentrate such digital data in the archives of long-term sustainable RIs.

Recent developments in the field of social sciences and humanities and their growing ability to contribute to addressing the grand societal challenges are closely linked to the dramatic increase in the production and use of digital data. In addition to traditional resources, such as galleries, libraries, archives

▼ Czech Literary Bibliography – Materials on Karel Hynek Mácha, Biographical Archive Fund

and museums (i.e., the GLAM sector), new specialised RIs of the digital age have become critical for efficiency and international competitiveness in the area of social sciences and humanities.

The goals of such RIs are to acquire data, integrate them in large-scale databases and corpora; make them available through open access; systematise and interlink different data resources; promote data comparability internationally and over time; support the development of empirical data research methods; develop and implement innovative technologies for data collecting, sharing, disseminating, processing and analysing; promote new ways of multidisciplinary R&I cooperation; create backgrounds for coordinating the data digitalisation processes; create new forms of research outputs; and provide information to help researchers work with digital content, tools and methods, including training and providing technical and methodological support.

Regarding the actual focus of the social sciences and humanities RIs, one of the well-advanced trends supported by them is comparative research based on data that are collected and made available to allow for understanding various cultural and societal processes in comparison, and for detecting wider trends over different instances, events and countries, and over time. Such longitudinal social science data collections focus on a large variety of aspects of human life, including attitudes, behaviour, beliefs, health, socioeconomic status, family or social networks, as well as life-course trajectories and patterns across diverse populations, which are usually examined through interviews and opinion surveys. Apart from bringing the social science data together and making them available, relevant RIs also focus on opening up the social science archives in Europe and internationally in order to promote the results of social science research and support international collaboration.

The cultural part of humanities aims to preserve primary material for cultural research, leading to the acquisition of knowledge, understanding and interpretation of the past, as well as of cultures, their diversity and common traits. The overall aim is to document, safeguard and promote cultural heritage, and RIs operated in the field play a central role in this endeavour. Their focus covers a very broad range of R&I areas, including arts (both performing and visual), archaeology, history, languages, literature, philosophy or religion. In spite of recent remarkable progress, enormous amounts of both historical and contemporary cultural data have not been digitised yet, while some of the already digitised data could not be incorporated in RIs since they were not annotated and curated appropriately. This poses a huge challenge for cultural humanities in the years to come. Another one is enlarging the current portfolio of technologies used to analyse and preserve cultural heritage objects. The adoption of new technologies from the areas of materials sciences, physical sciences and chemistry is a way forward in this regard.

In addition, there are also further important elements factoring in the future development of social sciences and humanities. The first one is the exponential growth in the amount of data, which is usually called the Big Data phenomenon, i.e., assemblages of data files, datasets, databases and a data stream which, in terms of their volume, variety and velocity of creation, pose severe challenges for conventional analytical and computational methods, and call for new environments to access, process and analyse such data, including the use of tools of artificial intelligence and machine learning.

RIs operated in social sciences and humanities are also subject to challenges in the form of New Data. With advanced and advancing digitalisation, individuals, organisations and state administrations produce enormous amounts of digital data that document human behaviour, attitudes, and the social structure and its dynamics. Such digital data resources have the potential to enrich social sciences- and humanities-based research and 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 such data, therefore, requires the development of innovative methodology, technological tools and organisational environments for research, the concentration of efforts across scientific disciplines, as well as the introduction of legislative instruments to provide solutions for ethics and privacy issues.

The envisaged development of close cooperation between the social sciences and humanities on one hand, and other scientific disciplines on the other offers great potential for further advancement and for increasing the efficiency of RIs operating in social sciences and humanities. A number of activities are aimed at studying interactions between society and nature, and run along the boundaries of social and environmental sciences where data used to study social and environmental phenomena are linked to each other by their geographical location and offer unique opportunities to study relationships between society and the natural environment.

Similar to this, research on the boundaries of social sciences on one hand, and biological and medical sciences on the other is a challenging and potentially very effective field opening up new areas of research. In this regard, several household surveys are already underway and could gain new momentum by including biological data collection in the sociodemographic and socioeconomic surveys being conducted. While biosocial data-driven research must confront ethical, conceptual, and technical challenges, it holds great promise for the future.

Current state of play

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 Czechia 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.

Social sciences- and humanities-based research focuses on topical themes as well as long-term trends in 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 policy-making. Research in social sciences and humanities also supports the development of the knowledge economy of Czechia and has a clear impact on strengthening international competitiveness and developing the quality of life in the Czech Republic.

The implementation of LRI projects included in the presented Roadmap brings significant improvements and systematic development in several social sciences and humanities areas. 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. LRIs in social sciences and humanities have also proven to be an important player when facing global crisis scenarios, providing crucial data during the Covid-19 pandemic or offering language tools and thus alleviating interaction with Ukrainian refugees during the Russian military invasion of Ukraine.

Czech involvement in high-profile research programmes in social sciences and humanities realised through ERA and the Czech participation in European RIs, 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 Czechia. Czech participation is expected also in the emerging EHRI (*European Holocaust Research Infrastructure*), facilitating the collection of widespread and fragmented archival material across Europe and beyond, and the Holocaust historiography.

The presented Roadmap, as updated in 2023, includes the following LRIs 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/ESS-CZ**, consisting of the **CSDA** (*Czech Social Science Data Archive*) and **ESS-CZ** (*Czech National Node to the European Social Survey*) nodes, **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 LRI projects included in the previous versions of the Roadmap has helped to substantially improve their mutual coordination and overcome the initial state of fragmentation within the Czech social sciences and humanities LRI landscape. The trend of tightening cooperation between RIs can also be observed in this latest update to the Roadmap. Having a common hosting institution, CSDA and ESS-CZ have merged into a single LRI project. LINDAT/CLARIAH-CZ has newly integrated the Czech national node for holocaust studies. The foundation for social sciences- and humanities-based research in Czechia thus successfully develops and deepens its position within the framework of ERA.

◀ LINDAT/CLARIAH-CZ – Digitising national treasures in the National Film Archive

Gaps, challenges, needs and opportunities

With the ever increasing need for FAIR (*Findable, Accessible, Interoperable and Reusable*) scientific data, correctly digitalised and stored resources are required for excellent research in many areas of social sciences and humanities.

Recently, demand has been directed towards coordinating the digitalisation and implementing technologically advanced research tools and methods further enhancing **cultural heritage** preservation practices, facilitating open access to data and promoting their use. The starting points for research efficiency are usually the deployment of innovative digital technologies, the interconnection of digital material resources from institutions that focus on preserving such national memory, such as archives, museums and libraries, and coordinated efforts to develop tools and techniques to use the data. E-RIHS (*European Research Infrastructure for Heritage Science*) constitutes a multidisciplinary RI, integrating archives of heritage science information, virtual platforms for data access, as well as accelerators, synchrotrons, neutron sources and other analytical instruments to study and protect cultural heritage. If the Czech Republic also develops a comprehensive Czech national node to E-RIHS, it will have a positive impact on the competitiveness of many fields of humanities and Czech cultural heritage protection.

Longitudinal research surveys, particularly in the form of international and centrally managed programmes, are resources of vital importance for social science-based research. SHARE and ESS have already been fully implemented in the Czech Republic, which brings considerable benefits to both the Czech and international research communities. However, several other already running survey projects with similar potential have not yet taken the form of long-term sustainable programmes in Czechia. In particular, the study of family life, strategies, attitudes and peoples' behaviour towards family-planning, parenthood, childcare, care for the elderly, housing, ageing or behaviour on the labour market may bring solutions to the challenges modern societies face in the field of **population development and changes in the labour market**. GGP (*Generations and Gender Programme*) supports studies in these areas continually by data which are unique in terms of the panel survey design and the number of participating countries. GGP thereby offers an exceptional opportunity to study the course of life and family dynamics in an international and historical comparison. The participation of Czechia through an LRI project would provide continuity to the previous Czech participation in GGP in 2005–2010 and allow for continuous Czech involvement in the programme.

The Czech LRIs Roadmap, updated in 2023, provides a very good starting point for ensuring the long-term sustainable development of LRIs operated in the field of social sciences and humanities and for further integration of Czech social sciences- and humanities-based research in ERA. At the same time, it also indicates the areas that should receive appropriate attention in the upcoming period, taking into consideration the current and foreseeable future developments of social sciences- and humanities-oriented RIs in Europe and globally.

▲ AIS CR – Aerial photo of the archaeological excavation beneath what is today the water park

Archaeological Information System of the Czech Republic

Akronym:
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

Responsible person:
Olga Lečbychová
lecbychova@arub.cz

Phase: operational
Character: virtual

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

Characteristics

AIS CR functions as a central public service providing a secure repository of archaeological data at the Czech national level and advocating its dissemination, synergistic use and accessibility for scientific and lay purposes. AIS CR integrates the components of the information collection and distribution process in archaeology, handles the legal agenda for archaeological fieldwork, supports education, collects preserves, and makes available the primary source of data for research. These data are the only existing record of archaeological contexts, which for the most part have been irreversibly destroyed by construction activity. AIS CR creates an umbrella platform for tools and services which record and manage archaeological fieldwork (Archaeological Map of the Czech Republic; Map of Archaeological Organisations); enable the publication of data and documents related to fieldwork (Digital Archive of the AMCR; 3D Library); systematically publish structured information of a synoptic nature and data on selected topics (Archaeological Atlas of the Czech Republic; Prague-Archaeological; THANADOS); provide a formal framework for the operation and recording of results of citizen science (Portal of Amateur Collaborators and Register of Individual Finds of the Archaeological Map of the Czech Republic); and support education, data sharing and the promotion of good practices in the discipline (TEATER, AMCR API, Archaeology Online). Basic information about all prepared, ongoing and completed fieldwork in the territory of the Czech Republic and its results is currently entered into AIS CR. In order to improve and expand the spectrum of information, older information concerning archaeological heritage is also being saved and systematised to prevent its irretrievable loss. Within AIS CR, a team of data experts was formed to advocate for several substantial changes in the approach to archaeological research and the management of the archaeological archives, and which fundamentally contributed to the greater openness of Czech archaeological data made available in the open access regime. AIS CR enriches the portfolio of available digital services and partnerships at the level of international research projects and initiatives, enabling data integration, sharing standards, removing barriers to international data use and the dissemination of good practices in the field of archaeological data archiving based on FAIR digital data principles.

Societal and economic impacts

AIS CR is a unique set of services and information that can be utilised for research, the teaching of historical fields and for heritage care. It provides access to cultural heritage for conservation and tourism purposes, is an aid in land-use planning while reducing the costs of construction and industrial terrain interventions, and develops technologies in the field of digital humanities. It provides users with linked and accessible information regarding archaeological heritage and the historical landscape, thereby contributing to the formation of the Czech national cultural identity. AIS CR centrally collects and offers information on archaeological projects, fieldworks and sites (e.g., project documentation, fieldwork reports, photographs, maps, plans, expert reports, etc.), thereby providing public administration bodies and professional archaeologists with the tools necessary to meet their obligations under the State Heritage Care Act. Development companies and investors can use AIS CR to assess risks in areas of interest and to communicate their plans.

Czech Literary Bibliography

Akronym:
CLB

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

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

Phase: operational
Character: virtual

Website:
clb.ucl.cas.cz/en

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

Characteristics

CLB is the key RI for Czech literature, literary culture and related disciplines. Established over 75 years ago, its main task is the processing and continuous development of a set of bibliographic databases mapping Czech (and, selectively, world) literature, as well as its reception in the Czech lands. The excerption scope of CLB ranges from articles in daily newspapers and specialist press, conference proceedings and other types of published works to book volumes and, more recently, online documents and samizdat production. The bibliographic databases of CLB cover the entire period of modern Czech literature, from its origins in the last third of the 18th century to the most recent era, and include approximately 2.3 million records. They are supplemented by a set of smaller knowledge databases on Czech literature and culture (e.g., covering literary figures and literary prizes, etc.). CLB data curation follows best methodological practices and standardised international formats designed to facilitate integration into national and international networks for the exchange of scientific information (e.g., literarybibliography.eu, knihovny.cz, etc.). In terms of quality, quantity and expertise, CLB is a leading institution in the European context and beyond. All CLB data is available to users on an open access and free licence basis. The CLB portfolio, furthermore, includes a number of additional activities for users and partners spanning over a wide range of disciplines and geographical boundaries. CLB is committed to international scholarly communication in conjunction with its co-stewardship of the Bibliographical Data Working Group of DARIAH ERIC (*Digital Research Infrastructure for the Arts and Humanities*) and the Consortium for Czech Literary Studies. CLB actively helps develop and customise software for the presentation and analysis of bibliographical data (VuFind discovery system), as well as quantitative data analysis using advanced computational processing methods (Bibliographical Data Science). While CLB aims to offer resources and expertise beneficial to all, its users are primarily scholars and researchers from adjacent fields (scholarship on a variety of artistic disciplines, including literary and theatre studies, cultural history, philosophy, and national philologies), media professionals and specialists from creative industries, as well as publishing, cultural and education professionals from the Czech Republic and abroad. CLB reaches out to its broad user community via social networks and public engagement lectures. It regularly organises educational courses for university students, including the Hands-On Czech Literary Studies School, and professional conferences and workshops for both national and international audiences. It publishes the Czech Literary Studies newsletter with distribution to both the scholarly and lay public.

Societal and economic impacts

CLB contributes to solving challenges in society related to the understanding and mapping of Czech literature as one of the constitutive elements of the Czech national identity. It facilitates the dissemination and promotion of Czech literature and culture abroad (e.g., through mapping the international circulation of translations, etc.). A significant share of its users is based abroad; these include translators, students and scholars of Czech Studies, and cultural and promotional staff of Czech Centres, whose work helps promote the good name of Czechia internationally. Several dozen books are published each year with the use of CLB data, including scholarly monographs and critical editions of Czech literature. A wide range of domestic and foreign cultural heritage institutions and Government bodies depend on the expertise and know-how that CLB offers for all manner of inquiry into the practical and methodological issues of bibliographical culture.

Czech National Corpus

Akronym:
CNC

Hosting institution:
Charles University

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

Phase: operational
Character: virtual

Website:
korpus.cz

Year of inclusion on the Czech Roadmap: 2010

Motto:
National Infrastructure for Mapping the Czech language and Facilitating its Empirical Analysis with Specialized Tools

Characteristics

The mission of CNC is to continuously map the Czech language by building electronic language corpora and providing user access to them. For this purpose, CNC collects, processes and annotates large quantities of language data to produce corpora of Czech in many genres and varieties, including written, spoken, as well as internet Czech. Given their large scope, diverse and balanced design, high processing standard, reliable metadata and high-quality linguistic annotation, CNC language corpora can compete with similar resources for major world languages. The key feature here is the systematic and continuous nature of data collection that enables researchers to carry out longitudinal studies of the language development, as well as to study public discourse changes over time. CNC is used mainly in linguistics, in a wide range of other social sciences and humanities, such as literary studies, translation studies, history or sociology, as well as in natural language processing. As the only LRI of its kind, CNC fulfils a function similar to that of the National Library or the National Archives in preserving the national verbal heritage. The CNC corpora are supplemented by specialised analytical tools in the form of web-based user applications that enable effective and user-friendly work with the corpora. The central access point to all the applications and multi-faceted user support (e.g., documentation, knowledge base, online helpdesk, etc.) is the CNC research portal at korpus.cz. CNC is fully committed to the open access policy in all its activities, and its services are provided free of charge. CNC actively cooperates with CLARIN ERIC (*Common Language Resources and Technology Infrastructure*) and its Czech national node, LINDAT/CLARIAH-CZ (*Digital Research Infrastructure for Language Technologies, Arts and Humanities*). CNC is an associated member of the CLARIN-CZ consortium with K-centre status and maintains active contacts with many foreign research institutions with a similar focus.

Societal and economic impacts

With more than 8,000 registered active users and approximately 4,000 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 it is also a guarantee of stable and representative source data, which ultimately leads to 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 100 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 modernisation of language education in the Czech Republic.

Czech Social Science Data Archive / European Social Survey – participation of the Czech Republic

Akronym:
CSDA/ESS-CZ

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

Responsible person:
Jana Leontijeva, Ph.D.
yana.leontiyeva@soc.cas.cz

Phase: operational
Character: virtual

Website:
archiv.soc.cas.cz
ess.soc.cas.cz

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2021: landmark

Motto:
International Comparative Research Data and Open Science Data Services for Social Sciences in the Czech Republic and Europe

Characteristics

CSDA/ESS-CZ was created by integrating two existing LRIs, the Czech Social Science Data Archive (CSDA) and the Czech National Node to the European Social Survey (ESS-CZ). 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 secondary analysis in scientific research and training at universities. At the same time, CSDA serves as the Czech national node to CESSDA ERIC (*Consortium of European Social Science Data Archives*), and it is the CESSDA Service Provider in the Czech Republic. CESSDA has developed a comprehensive and integrated European system of data services in social sciences by connecting existing national data services. ESS-CZ is the Czech national node to ESS ERIC (*European Social Survey*). ESS ERIC undertakes a longitudinal programme of cross-national quantitative bi-annual 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). Both CESSDA ERIC and ESS ERIC are landmarks of the ESFRI Roadmap and are at the forefront of the efforts to build open science in the field of social sciences and humanities data in Europe. The archival and information system ensures the long-term preservation and availability of data for re-use in compliance with international standards. The data files are available to researchers and students via online systems allowing for the searching, browsing, analysing, visualising and downloading of data. The opportunities to combine data from different research projects, as well as to analyse academically rigorous cross-national data on European societies, are the starting points for many social science studies and make Czech social research internationally competitive. The use of archived data for international comparisons, longitudinal studies of social dynamics and other comparisons in time radically increases the ability of social sciences to address contemporary societal challenges. CSDA/ESS-CZ is also a resource of research instruments verified in previous research, thereby creating an important background for the implementation of new surveys. A strong emphasis is placed on communication with researchers, including the dissemination of knowledge and tools and provision of training in data management and social data analysis. Moreover, CSDA/ESS-CZ integrates Czech social sciences into international cooperation in the development of new technologies, standards, best practices, and methodologies in the domains of survey research, data sharing and data analysis.

Societal and economic impacts

The availability of relevant social science data, integrating national data resources into international research, creating conditions for cross-national comparisons, and extending access to international data sources are critical preconditions 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 disseminated by CSDA/ESS-CZ serve as the basis for many analyses conducted for public administration. They are also employed by institutions of applied research 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, the International Labour Organisation, Eurostat and many others.

Digital Research Infrastructure for Language Technologies, Arts and Humanities

Akronym:
LINDAT/CLARIAH-CZ

Hosting institution: Charles University

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

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

Phase: operational
Character: distributed

Website: **lindat.cz**

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2021: landmark, project

Motto:
Open Access to Language Resources and Other Data and Services for the Support of Research in Digital Language Technology, Arts, Humanities and Social Sciences

Characteristics

LINDAT/CLARIAH-CZ joins together three RI pillars – LINDAT/CLARIN, DARIAH-CZ and EHRI-CZ. It is a unique RI that provides language and other digital data and software tools and services to researchers and other users in the area of language technology, humanities and arts. LINDAT/CLARIAH-CZ is the Czech national node to CLARIN ERIC (*Common Language Resources and Technology Infrastructure*), DARIAH ERIC (*Digital Research Infrastructure for the Arts and Humanities*) and EHRI (*European Holocaust Research Infrastructure*). It consists of 15 top research organisations that are active in the domain of humanities and arts in the Czech Republic – in linguistics, history (including oral history), historical bibliography, culture and cultural research, 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, including students both in Czechia and in the EU and worldwide and, at the same time, obtaining access to similar resources available in CLARIN, DARIAH and EHRI. LINDAT/CLARIAH-CZ takes part in international cooperation between RIs of a similar type, as well as directly between the relevant research institutions in all branches of humanities. It puts emphasis on digital and interdisciplinary processing methods, including modern methods of machine learning and artificial intelligence. An integral part of LINDAT/CLARIAH-CZ is an analysis of relevant legal aspects of the use of its resources, such as copyright and other intellectual property laws, in order to minimise the impact of their restrictions on research activities. LINDAT/CLARIAH-CZ also offers know-how and provides software tools for the processing of language resources and other digital data. It also develops basic language technologies for use in industrial, as well as public services sectors.

Societal and economic impacts

Language, culture, arts and humanities together form an important component of the national identity and are crucial for education at 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. The efforts result in the expanded involvement of Czech teams in international research activities, presenting the Czech Republic as a culturally rich and technologically-oriented country that is able to make its language, history and heritage accessible by modern methods. In the domain of language and multimodal technologies and artificial intelligence, the data and services of LINDAT/CLARIAH-CZ represent fundamental support for the upcoming, artificial intelligence-based digitisation of economy and society in Europe. The language technology itself also helps to overcome present-day language barriers. LINDAT/CLARIAH-CZ offers the opportunity for industry and public institutions to collaborate with research institutions by obtaining access to knowledge and resources in the domains served in order to build applications for businesses, public and government services, as well as for all citizens.

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

Akronym:
SHARE-CZ

Hosting institution:
Economics Institute of the Czech Academy of Sciences

Responsible person:
Radim Boháček, Ph.D.
radim.bohacek@cerge-ei.cz

Phase: operational
Character: distributed

Website:
share.cerge-ei.cz

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2021: landmark

Motto:
Research Infrastructure for Studying the Effects of Health, Social, Economic and Environmental Policies over the Life-Course of European citizens

Characteristics:

SHARE-CZ is the Czech national node to SHARE-ERIC (*Survey of Health, Ageing and Retirement in Europe*). Since 2004, SHARE has collected 530,000 interviews with 140,000 respondents aged 50+ from 28 European countries and Israel. SHARE is the largest pan-European social sciences panel study providing internationally comparable longitudinal micro-data, which allow for insights in the fields of public health and socioeconomic conditions of European population. SHARE has global impact since it covers not only EU Member States, but also countries in a network of longitudinal ageing studies all over the world. SHARE is built on the following five principles. It is designed by researchers for researchers. Research excellence is paramount to all consideration and the close integration of survey design and substantive research is essential. SHARE is supranational since its data reflect cross-country differences in welfare policies to identify their impacts. This requires strict ex-ante harmonisation of the survey instrument and methods across time and countries. SHARE is multidisciplinary and provides research capacity to study interactions between biomedical factors on one hand and socioeconomic factors on the other. SHARE is longitudinal in order to understand the ageing process and changing environment over time. This is especially important in times of accelerated technological advances and medical innovations, changes in healthcare and social policies, as well as during crises, such as the Covid-19 pandemic or global climate change. The result is a free, open access, unique data collection that provides information about the state, history and future of both Czech and European society. SHARE-ERIC cooperates with other European research consortia, such as CESSDA ERIC (*Consortium of European Social Science Data Archives*), ESS ERIC (*European Social Survey*) and CLARIN ERIC (*Common Language Resources and Technology Infrastructure*). Innovation plans of SHARE-CZ include the collection of biomarkers together with EIRENE (*Environmental Exposure Assessment Research Infrastructure*), links to administrative data, or flexible and new interview modes and questionnaire modules.

Societal and economic impacts:

The sustainability of the welfare state due to the socioeconomic and health effects of population ageing belongs to one of the main challenges of the 21st century. SHARE open access data serve as the empirical foundation for addressing this challenge by policies based on scientific evidence. In the Czech Republic, the project offers external researchers an opportunity to place their own questions into a national questionnaire added to each wave of data collection. This initiative allows Czech researchers to conduct their own research with data merged with the only internationally comparable longitudinal database in demographics, economics, health, social care or epidemiology. By the end of 2020, more than 16,000 registered users had produced 3,800 scientific publications based on SHARE data. In Czechia, LRI cooperates with the Ministry of Labour and Social Affairs and with more than 20 academic and policy research institutes. Due to the strict protection of private data, any commercial use of SHARE data is not allowed. However, SHARE data inform on the needs and opportunities related to healthy ageing, gender inequality, health and long-term care, poverty or retirement decisions. SHARE serves as the foundation for empirical research on ageing and has become an essential tool for evidence-based policy-making in Europe.

e-Infrastructures

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Background and context

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

The key objective of an 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 scientific teams can fully focus on their R&I without having to address issues related to the processing, storage or transfer of scientific data. Such a type of e-infrastructure, which is based on technologies for the exchange, processing, storage and archiving of scientific data and interconnects geographically distributed scientific teams, their equipment and RIs, is a pre-requisite for interdisciplinary cooperation.

The benefits of an e-infrastructure are not restricted merely to ensuring sufficient capacity. E-infrastructure also acts as an equivalent partner to those scientific 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 maintain e-infrastructure at the cutting edge of current knowledge, while ensuring continuous development of the services provided and their world-class quality. In addition, the certification requirements for data storage facilities to fulfil the FAIR (*Findable, Accessible, Interoperable, Reusable*) principles in respect of (meta) data have been added, posing increased requirements on e-infrastructures, as well as on data producers and their users.

The envisioned green transition and digital transformation of the European economy amplifies the need for European sovereignty in the areas of data, computing and digital RIs, shortly e-infrastructures, and managing digital scientific data across countries and R&I disciplinary domains through a virtual environment with pre-defined parameters.

The EOSC (*European Open Science Cloud*) initiative concentrates on federating national data infrastructures in Europe and providing researchers and innovators opportunities to manage digital scientific data in accordance with FAIR principles. The foundation of the EOSC international non-profit association in 2020 and the subsequent launch of the EOSC European Partnership introduced a new impetus for the development of a federated pan-European data infrastructure to process, store, share and reuse digital scientific data through an open and trusted environment, and turn the EOSC open science concept into a working ecosystem.

The rapid increase in the amount of FAIR scientific data also calls for efficient instruments for their processing, based on fast connectivity, high capacity and supercomputing capability. While HTC (*High Throughput Computing*) systems enable the running of numerous independent tasks that require a large amount of computing power and are optimised for large data processing tasks, the HPC (*High Performance Computing*) systems, i.e., the supercomputers, facilitate the processing of data in parallel and are optimised for a maximum number of computing operations per second. Further and continuous advancement in both of these e-infrastructure domains is a key to sustain the ability to handle the increasing volumes of the digital scientific data.

Other progressive e-infrastructure trends include the cloud and edge computing to provide the research community a fully controllable and programmable virtualized digital infrastructure test platform, or big data and social data mining, the aim of which is to facilitate large-scale social data mining experiments, including the use of artificial intelligence tools.

Lastly, full integration and interoperability of the "primary" data, computing and digital RIs with the thematic e-infrastructures of large-scale RIs, such as those of CERN (*Conseil Européen pour la Recherche Nucléaire*), ESA (*European Space Agency*) or ESO (*European Southern Observatory*), managing large amounts of the digital scientific data they produce, is another challenge for the e-infrastructure domain.

Current state of play

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

Individual components of the Czech national e-infrastructure include the **CESNET3** National Research and Education Network (NREN), the **MetaCentrum** National Grid Infrastructure, the **IT4Innovations National Supercomputing Centre** and a high-capacity **data storage infrastructure**. The key authentication and authorisation infrastructure governing access to the infrastructure is the Czech academic identity federation **eduID.cz**, interconnecting the identity providers (entities from which the users originate) and the service providers, and is a member of the European **eduGAIN** inter-federation. The e-infrastructure's security is provided for by the internationally accredited **CESNET-CERTS** security team in close 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 to European and global e-infrastructures, such as the **GÉANT** European communication infrastructure, **EGI** (*European Grid Infrastructure*) and **PRACE** (*Partnership for Advanced Computing in Europe*). They are also linked to European e-infrastructure initiatives, such as **BDVA** (*Big Data Value Association*), **ETP4HPC** (*European Technology Platform for High Performance Computing*) and **EUDAT CDI** (*Collaborative Data Infrastructure*), and play a key role in connecting the Czech Republic to **EOSC** (*European Open Science Cloud*) and **EuroHPC** (*European High-Performance Computing Joint technology Initiative*), including **LUMI** (*Large Unified Modern Infrastructure*).

◀ e-INFRA CZ – Flagship supercomputer Karolina

Against this background, the Czech national e-infrastructure facilitates the interconnection of Czechia and ERA, providing other Czech RIs and scientific teams access to unique RIs located abroad.

Being fully integrated in the European e-infrastructure, the Czech national e-infrastructure not only provides the Czech research community with 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 individual abilities of the e-infrastructure facilities. Thus, considerably larger ICT resources, which individual research organisations and RIs could not possibly afford, may be acquired and exploited. At the same time, this approach has a positive impact on the efficiency of the Czech national e-infrastructure operation, not only by reducing operation costs, but also by minimising their impact on the environment.

Thanks to its distributed nature, the Czech national e-infrastructure also contributes significantly towards the widespread availability of top-class ICT services with the same parameters across all the regions of the Czech Republic. This has become a necessary precondition to maintain and further deepen the level of competitiveness of R&I in Czechia, and consequently also the competitiveness of the Czech economy.

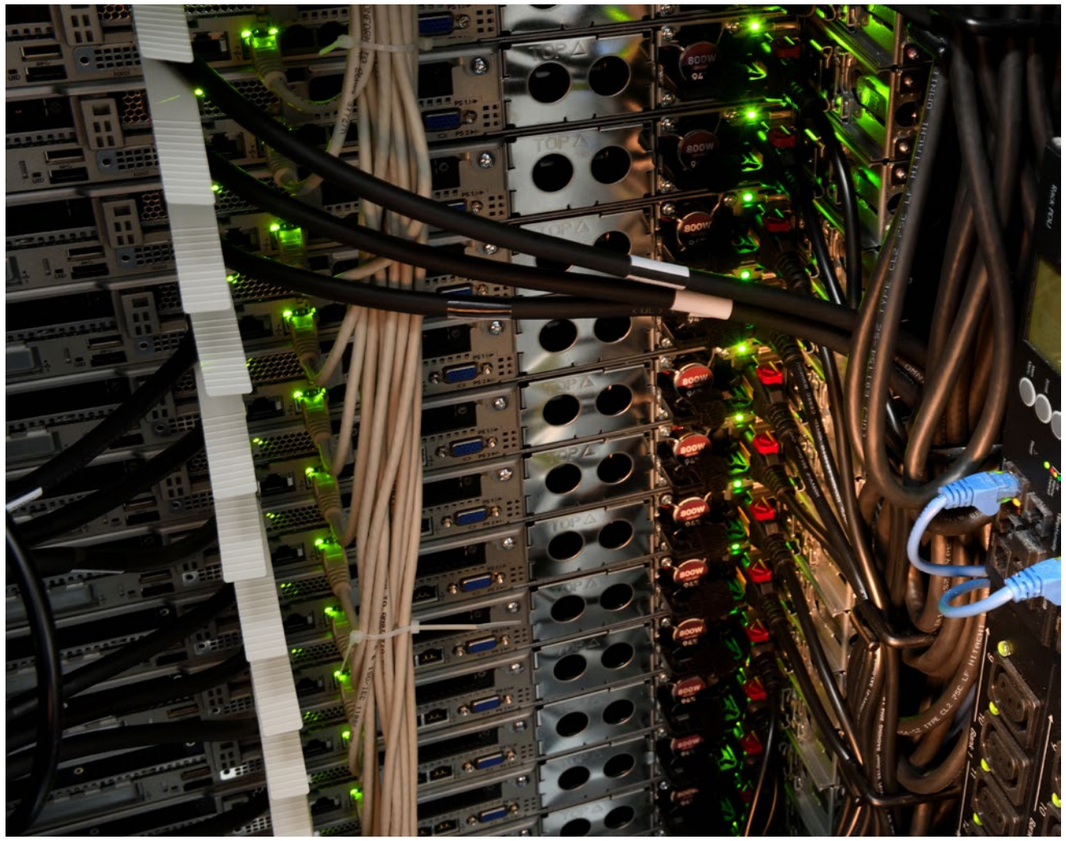
Apart from providing services for R&I, the Czech national e-infrastructure also establishes a unique environment for experimenting and testing new technologies necessary for its own operation, mostly modern data transfer systems, computing and storage technologies, or data analysis systems and environments. Moreover, the Czech national

e-infrastructure accelerates ICT development in all areas and plays a major role in building 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 R&I have also been confirmed in the international monitoring of LRIs organised by MEYS in 2014, 2017 and 2021. In consensus reports, the international assessment committee recommended that all entities involved in the e-infrastructure ecosystem in the Czech Republic closely collaborate to ensure their long-term funding and the streamlining of all three e-infrastructures into a single national e-infrastructure of the Czech Republic. All three e-infrastructures have been closely cooperating to coordinate their activities and their closer collaboration in building up a common Czech national e-infrastructure has already enabled the exploitation of the synergic effects, thereby 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 European and worldwide e-infrastructures.

In relation to this 2023 update to the Roadmap, the e-infrastructures of Czechia continue their operations under the **e-INFRA CZ** (*e-Infrastructure of the Czech Republic*) consortium, jointly responsible for the Czech national e-infrastructure. Also in the upcoming period, the task of this single Czech national e-infrastructure is to further develop the Czech national environment of R&I excellence and to enlarge and enhance the incorporation of e-INFRA CZ 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 Czech research entities access to EOSC and enable them to exploit the resources and data of this e-infrastructure, but also to adapt architecture, internal processes and horizontal relations so that its ICT resources, devices and data can be exploited by other entities within the EOSC European framework.

▼ e-INFRA CZ – Computing cluster



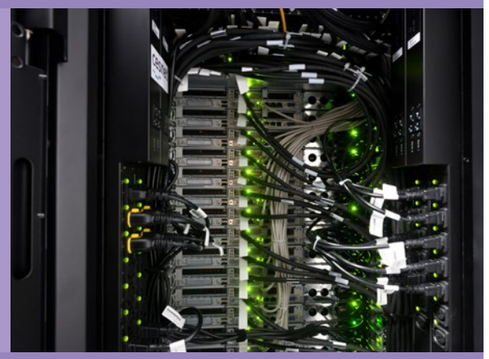
Gaps, challenges, needs and opportunities

All in all, high-quality and highly functional communication e-infrastructure implemented within GÉANT, the most advanced computing systems operated in collaboration with EuroHPC and PRACE, distributed computing and storage capacities and services operated in the framework of EOSC, the development of principles for handling heterogeneous and big data with extensive use of artificial intelligence tools, and a focus on new technology areas, such as the application of quantum technologies, are among the key areas of interest for e-INFRA CZ in the years to come. At the same time, it is perceived as a goal to open a debate on the possibilities of how to use e-INFRA CZ for public sector R&I needs, and how to use e-INFRA CZ to help with the Government's large-scale data processing and computing.

The Roadmap of Large Research Infrastructures of the Czech Republic places emphasis on the sustainability and further development of the Czech national e-infrastructure's components and related ICT 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 Czechia in Europe and globally. Nevertheless, it is necessary to ensure the development of e-INFRA CZ in all crucial directions, thus accommodating new user needs and new emerging challenges.

▲ e-INFRA CZ – Data storage facility

e-Infrastructure of the Czech Republic



Akronym:
e-INFRA CZ

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

Partner institutions:
Masaryk University
VŠB – Technical University of Ostrava

Responsible person:
Jakub Papírník
jakub.papirnik@cesnet.cz

Phase: operational
Character: distributed

Website:
e-infra.cz/en

Year of inclusion on the Czech Roadmap: 2010
Status on the ESFRI Roadmap 2021: landmark

Motto:
Excellent ICT Environment, Capacity and Services for Research, Development, Innovation and Education

Characteristics

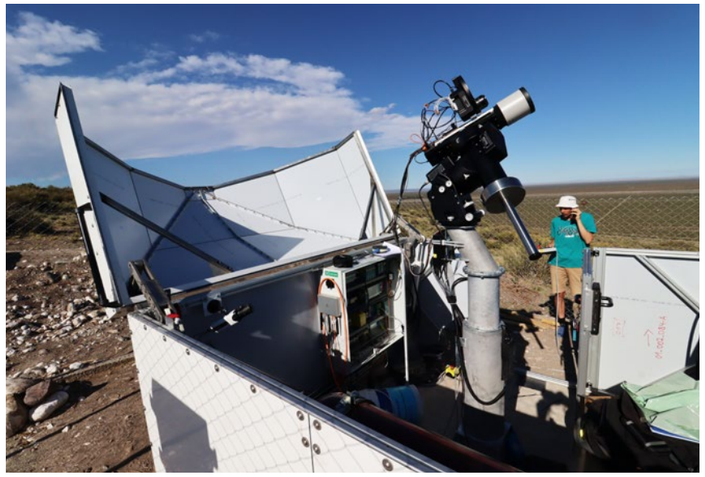
e-INFRA CZ provides unique e-infrastructure for R&I and education in the Czech Republic. It offers a fully transparent environment with a comprehensive portfolio of ICT services essential for performing modern R&I and education, and ensuring extensive capacities and resources for the transferring, storing and processing of scientific data for all entities engaged in R&I and education. e-INFRA CZ directly contributes to the e-infrastructure foundations of ERA, while serving as the Czech national node to European, as well as worldwide RIs and e-infrastructure initiatives, such as (in alphabetical order) BDVA (*Big Data Value Association*), EGI (*European Grid Infrastructure*), EOSC (*European Open Science Cloud*), EUDAT CDI (*Collaborative Data Infrastructure*), ETP4HPC (*European Technology Platform for High Performance Computing*), EuroHPC (*European High-Performance Computing Joint Technology Initiative*), GÉANT European communication infrastructure, LUMI (*Large Unified Modern Infrastructure*) or PRACE (*Partnership for Advanced Computing in Europe*). The basis of the e-infrastructure is a high quality, high throughput and low latency internationally interconnected communication backbone network. e-INFRA CZ offers many well-advanced functions and features, including dedicated transport channels and non-IP services (transmission of precise time and stable frequency or distribution of quantum keys). e-INFRA CZ provides extensive computing capacities of IT4Innovations (*IT4Innovations National Supercomputing Centre*) and the MetaCentrum National Grid Infrastructure. IT4Innovations operates the largest and unique Czech supercomputers, including the European Karolina peta-scale HPC system. Furthermore, IT4Innovations also participates in operating the European LUMI (*Large Unified Modern Infrastructure*) pre-exa-scale HPC system in Kajaani, Finland, which is one of the world's most powerful and energy efficient supercomputers. MetaCentrum is a distributed system of heterogeneous clusters with different ownership under joint operation and management provided by standard tools and technologies. Another integral component of e-INFRA CZ is its high-capacity distributed data storage infrastructure. Storage is accessible through various file system and object storage protocols. Advanced applications include the FileSender file depository and data synchronization and sharing systems. Access to the e-infrastructure is provided by authentication and authorization infrastructure built on the Czech national federation of identities eduID.cz, which is a part of the European eduGAIN inter-federation and is managed by the Perun Identity and Access Management system, which was developed by e-INFRA CZ. The internationally accredited security team CESNET-CERTS provides the security of e-infrastructure in cooperation with similar teams of other members of e-INFRA CZ. e-INFRA CZ also coordinates the implementation of EOSC in Czechia, the setting up of the EOSC-CZ Secretariat, and is directly responsible for the key components of the National Repository Platform and its services.

Societal and economic impacts

ICT is the key component of all fundamental and applied research in developed countries, with e-infrastructures materializing the implementation of needed ICT tools, services and capacities. e-Infrastructures reduce regional disparities, making the most advanced ICT environments available and accessible. The supported high productivity and competitiveness in R&I positively impacts the industry and economy. Access to well-advanced and high-quality services contributes to the competitiveness of the national industry on a European and global scale. Collaboration with public authorities is also essential, ranging from service provisioning to participation in the establishment of specific infrastructures. Contribution to the defence of the national cyberspace, in close collaboration with responsible national institutions, is also crucial. e-INFRA CZ is active in all of the above-mentioned areas where society benefits from advanced e-infrastructures. e-INFRA CZ also contributes to the training and awareness-raising of the ICT potential across all scientific disciplines, as well as industrial and public areas. e-INFRA CZ is directly involved in joint R&I activities with industry, provides contractual research services and shares licenses to the results of its R&I activities. It is also active in the network of European Digital Innovation Hubs. e-INFRA CZ is a crucial driver for the implementation of Open Science and FAIR digital scientific data principles at the Czech national level.

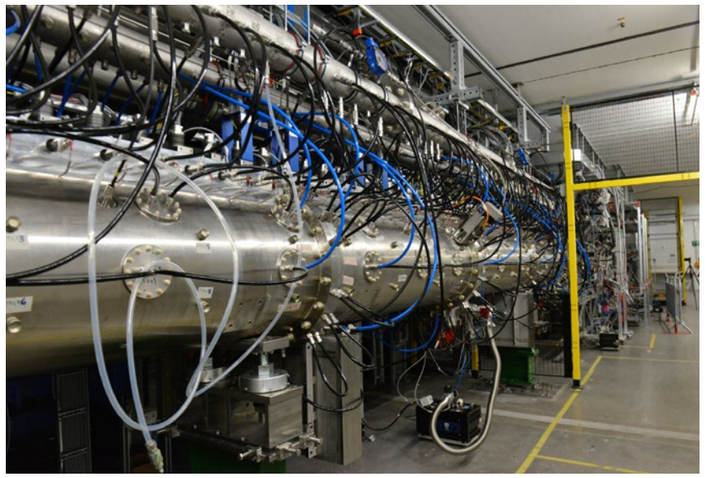
Annex 1: Large research infrastructures approved by the Government of the Czech Republic for public funding in 2023–2026

Science-disciplinary domain	Acronym	Large research infrastructure (LRI) project	Hosting institution (coordinator) / Partner institution	Location	Life-cycle phase	LRI project character	Year of inclusion of LRI on the Czech Roadmap	Status on the ESFRI Roadmap 2021
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 Czech Republic	operational	distributed	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 Czech Republic	operational	distributed	2015	–
	CEMNAT	**Centre of Materials and Nanotechnologies**	University Pardubice	Czech Republic	operational	single-sited	2015	–
	CEPLANT	**R&D Centre for 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) Charles University Czech Technical University in Prague Nuclear Physics Institute of the Czech Academy of Sciences Palacký University Olomouc Technical University of Liberec University of West Bohemia	Switzerland Czech Republic	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) Astronomical Institute of the Czech Academy of Sciences Charles University Palacký University Olomouc	Chile, Spain Czech Republic	construction	distributed	2015	ESFRI Landmark
	CzechNanoLab	**CzechNanoLab Research Infrastructure**	Brno University of Technology (coordinator) Charles University Institute of Physics of the Czech Academy of Sciences Masaryk University	Czech Republic	operational	distributed	2010	–



▶ AUGER-CZ – Telescope FRAM used to monitor atmospheric conditions at Pierre Auger Observatory in Argentina which detects the highest energy cosmic rays coming from the Universe

Science-disciplinary domain	Acronym	Large research infrastructure (LRI) project	Hosting institution (coordinator) / Partner institution	Location	Life-cycle phase	LRI project character	Year of inclusion of LRI on the Czech Roadmap	Status on the ESFRI Roadmap 2021
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 Czech Republic	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 Czech Republic	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 Czech Republic	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) Charles University Czech Technical University in Prague Palacký University Olomouc Silesian University in Opava	Germany Czech Republic	construction	distributed	2010	ESFRI Landmark
	FERMILAB-CZ	**Research Infrastructure for Fermilab Experiments**	Institute of Physics of the Czech Academy of Sciences (coordinator) Charles University Czech Technical University in Prague Institute of Computer Science of the Czech Academy of Sciences	USA Czech Republic	operational	distributed	2010	–
	LSM-CZ	**Laboratoire Souterrain de Modane – participation of the Czech Republic**	Czech Technical University in Prague (coordinator) National Radiation Protection Institute	France Czech Republic	operational	distributed	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 (coordinator) 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 Czech Republic	construction	single-sited	2010	ESFRI Landmark
	SPL-HTC	**Surface Physics Laboratory – Hydrogen Technology Centre**	Charles University	Italy Czech Republic	operational	distributed	2010	–



▶ ESS – Proton accelerator installation

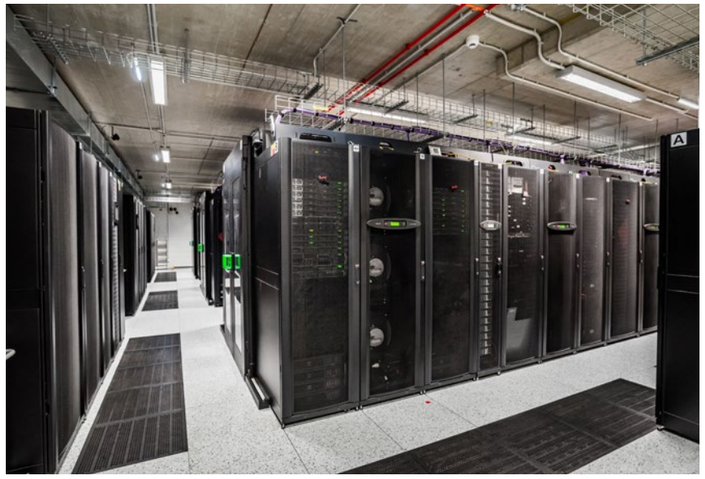
Science-disciplinary domain	Acronym	Large research infrastructure (LRI) project	Hosting institution (coordinator) / Partner institution	Location	Life-cycle phase	LRI project character	Year of inclusion of LRI on the Czech Roadmap	Status on the ESFRI Roadmap 2021
Energy	**CICRR**	**Czech International Centre of Research Reactors**	Research Centre Řež s r.o.	Czech Republic France	operational	multi-sited	2010	ESFRI Landmark
	COMPASS	**COMPASS – Tokamak for Thermonuclear Fusion Research**	Institute of Plasma Physics of the Czech Academy of Sciences	Czech Republic	major upgrade	single-sited	2010	–
	ENREGAT	**Energy Waste Recovery and Gas Treatment**	VŠB – Technical University of Ostrava	Czech Republic	operational	single-sited	2019	–
	WCZV	**VR-1 Nuclear Experimental Hub**	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) Global Change Research Institute of the Czech Academy of Sciences Institute of Atmospheric Physics of the Czech Academy of Sciences Institute of Chemical Process Fundamentals of the Czech Academy of Sciences Masaryk University	Czech Republic	operational	distributed	2015	ESFRI Landmark
	CENAKVA	**South Bohemian Research Centre of Aquaculture and Biodiversity of Hydrocenoses**	University of South Bohemia in České Budějovice	Czech Republic	operational	single-sited	2019	ESFRI Project
	CzeCOS	**Czech Carbon Observation System**	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) Institute of Experimental Medicine of the Czech Academy of Sciences Institute of Inorganic Chemistry of the Czech Academy of Sciences Palacký University Olomouc Technical University of Liberec University of J. E. Purkyně in Ústí nad Labem	Czech Republic	operational	distributed	2015	–
	RECETOX RI	**RECETOX Research Infrastructure**	Masaryk University	Czech Republic	implementation	single-sited	2010	ESFRI Project

▼ CENAKVA – Genetic reserves of the critically endangered star sturgeon (*Acipenser stellatus*)

Science-disciplinary domain	Acronym	Large research infrastructure (LRI) project	Hosting institution (coordinator) / Partner institution	Location	Life-cycle phase	LRI project character	Year of inclusion of LRI on the Czech Roadmap	Status on the ESFRI Roadmap 2021
Biological and medical sciences	**BBMRI.cz**	**Network of Czech Biobanks**	Masaryk Memorial Cancer Institute (coordinator) Faculty of Medicine of Charles University in Hradec Kralové Faculty of Medicine of Charles University in Pilsen Faculty of Medicine of Palacký University Olomouc First Faculty of Medicine of Charles University in Prague Institute of Hematology and Blood Transfusion in Prague Institute of Rheumatology in Prague Masaryk University	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 Brno University of Technology Charles University Institute of Experimental Botany of the Czech Academy of Sciences Institute of Experimental Medicine of the Czech Academy of Sciences Institute of Physiology of the Czech Academy of Sciences Institute of Scientific Instruments of the Czech Academy of Sciences Masaryk University Palacký University Olomouc	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

▶ CCP – A cutting-edge animal biosafety level 3 laboratory, providing a secure environment to study infectious diseases and their treatments for public health using rodent models

Science-disciplinary domain	Acronym	Large research infrastructure (LRI) project	Hosting institution (coordinator) / Partner institution	Location	Life-cycle phase	LRI project character	Year of inclusion of LRI on the Czech Roadmap	Status on the ESFRI Roadmap 2021
Biological and medical sciences	**EATRIS-CZ**	**Czech National Node to the European Infrastructure for Translational Medicine**	Palacký University Olomouc (coordinator) Charles University Institute of Experimental Medicine of the Czech Academy of Sciences Institute of Macromolecular Chemistry of the Czech Academy of Sciences Institute of Microbiology of the Czech Academy of Sciences Institute of Organic Chemistry and Biochemistry of the Czech Academy of Sciences Masaryk University Nuclear Physics Institute of the Czech Academy of Sciences St. Anne's University Hospital in Brno 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 CESNET, z. s. p. o. Charles University Czech Technical University in Prague Institute of Biotechnology of the Czech Academy of Sciences Institute of Microbiology of the Czech Academy of Sciences Institute of Molecular Genetics of the Czech Academy of Sciences Masaryk University Palacký University Olomouc St. Anne's University Hospital in Brno University of Chemistry and Technology Prague University of South Bohemia in České Budějovice 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) Food Research Institute Prague University of Chemistry and Technology Prague	Czech Republic	operational	distributed	2019	ESFRI Project
	NCMG	**National Centre for Medical Genomic**	Charles University (coordinator) Masaryk University Palacký University Olomouc University Hospital Brno	Czech Republic	operational	distributed	2011	–



▶ ELIXIR CZ – Supercomputers as an integral part for tackling highly intricate and data-intensive challenges in the field of life science research

Science-disciplinary domain	Acronym	Large research infrastructure (LRI) project	Hosting institution (coordinator) / Partner institution	Location	Life-cycle phase	LRI project character	Year of inclusion of LRI on the Czech Roadmap	Status on the ESFRI Roadmap 2021
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/ESS-CZ	**Czech Social Science Data Archive / European Social Survey – participation of the Czech Republic**	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 Czech Language of the Czech Academy of Sciences Institute of History of the Czech Academy of Sciences Institute of Philosophy of the Czech Academy of Sciences Library of the Czech Academy of Sciences Masaryk Institute and Archives of the Czech Academy of Sciences Masaryk University Moravian Library National Archives National Film Archive National Gallery in Prague National Library Terezín Initiative Institute Terezín Memorial University of West Bohemia	Czech Republic	operational	distributed	2010	ESFRI Landmark ESFRI Project
	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 of the Czech Republic**	CESNET, z. s. p. o. (coordinator) Masaryk University VŠB – Technical University of Ostrava	Czech Republic	operational	distributed	2010	ESFRI Landmark

▶ Czech Literary Bibliography – Card Catalogue of the Retrospective Bibliography of Czech Literature

Annex 2: International asssessment committee evaluating large research infrastructures of the Czech Republic in 2021

Chair

Giorgio ROSSI (IT)	University of Milano / Institute of Materials of the Italian National Research Council	

Physical sciences and engineering

Eckhard ELSEN (DE)	Deutsches Elektronen-Synchrotron DESY / University of Hamburg	*Chair*
Ulrike DIEBOLD (AT)	Vienna University of Technology	*Member*
Michel de LABACHELERIE (FR)	Centre National de la Recherche Scientifique / FEMTO-ST Institute	*Member*
Gerd LEUCHS (DE)	Max Planck Institute for the Science of Light	*Member*
Michèle PÉRON (FR)	European Organisation for Astronomical Research in the Southern Hemisphere	*Member*
Mario PIMENTA (PT)	Laboratory of Instrumentation and Experimental Particle Physics	*Member*
Jeroen van BEECK (NL)	von Karman Institute for Fluid Dynamics	*Member*

Energy

Bent LAURITZEN (DK)	Technical University of Denmark	*Chair*
Lothar FICKERT (AT)	Graz University of Technology	*Member*
Kathryn McCARTHY (US)	Oak Ridge National Laboratory	*Member*
Thomas SCHULENBERG (DE)	Karlsruher Institute of Technology – Institute for Thermal Energy Technology and Safety	*Member*
Gražyna ZAKRZEWSKA-KOŁTUNIEWICZ (PL)	Institute of Nuclear Chemistry and Technology	*Member*

Environmental sciences

Jozef PACYNA (PL)	AGH University of Science and Technology	*Chair*
Aoife BRAIDEN (IR)	Geological Survey of Ireland	*Member*
Rui FIGUEIRA (PT)	University of Lisbon	*Member*
Magnus FRIBERG (SE)	Swedish Research Council	*Member*
Milena HORVAT (SI)	Jožef Stefan Institute	*Member*

Biological and medical sciences

Marialuisa LAVITRANO (IT)	University of Milano-Bicocca	*Chair*
Gregor ANDERLUH (SI)	National Institute of Chemistry	*Member*
Mads Hartvig CLAUSEN (DK)	Technical University of Denmark	*Member*
Hanne Chritine BERTRAM (DK)	Aarhus University	*Member*
Serge PEREZ (FR)	Centre National de la Recherche Scientifique	*Member*

Social sciences and humanities

Lorna HUGHES (UK)	University of Glasgow	*Chair*
Patrick DEBOOSERE (BE)	Vrije Universiteit Brussel / Université Libre de Bruxelles	*Member*
Christofer EDING (SE)	Lund University	*Member*
Hanna SNELLMAN (FI)	University of Helsinki	*Member*
Sonia STEFANIZZI (IT)	University of Milano-Bicocca	*Member*

e-Infrastructures

Ana PROYKOVA (BG)	University of Sofia / Sofia Tech Park	*Chair*
Andreas DUDLER (CH)	SWITCH	*Member*
Kimmo KOSKI (FI)	CSC – IT Center for Science Ltd.	*Member*
Dieter KRANZLMÜLLER (DE)	Ludwig Maximilian University of Munich / Leibniz Supercomputing Centre of the Bavarian Academy of Sciences and Humanities	*Member*
Kristina LILLEMETS (EE)	University of Tartu	*Member*

Annex 3: International assessment committee evaluating benefits and impacts of the Czech memberships in international R&I organisations in 2021

CERN, JINR

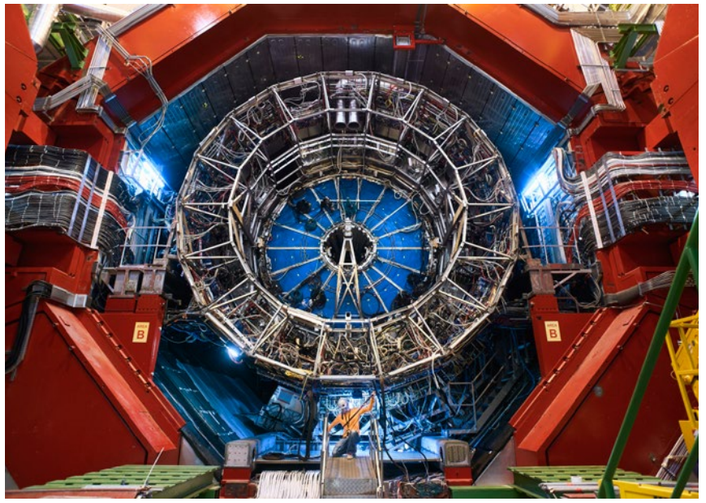
Eckhard ELSEN (DE)	Deutsches Elektronen-Synrotron DESY / University of Hamburg
Agnieszka ZALEWSKA (PL)	H. Niewodniczański Institute of Nuclear Physics of the Polish Academy of Sciences
Peter JENNI (CH)	Albert-Ludwigs-University of Freiburg

ESO, ESA, VKIFD

Volker GASS (CH)	École Polytechnique Fédérale de Lausanne
John ZARNECKI (UK)	Open University
Tim de ZEEUW (NL)	Leiden University

EMBC, EMBL

Poul NISSEN (DK)	Aarhus University
Susan GASSER (CH)	Friedrich Miescher Institute for Biomedical Research
Maria CARMO-FONSECA (PT)	University of Lisbon



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

Annex 4: Task force for the preparation of the 2023 update to the Roadmap of Large Research Infrastructures of the Czech Republic

Lukáš LEVÁK	Director of the Department for Research and Development; Ministry of Education, Youth and Sports
Jan HRUŠÁK	Special Envoy for Research Infrastructures; Ministry of Education, Youth and Sports
Marek VYŠINKA	Head of the Unit for Research Infrastructures; Ministry of Education, Youth and Sports
Jan BURIÁNEK	Unit for Research Infrastructures; Ministry of Education, Youth and Sports
Petra NICHTBURGEROVÁ	Unit for Research Infrastructures; Ministry of Education, Youth and Sports
Ondřej NOVÁK	Unit for Research Infrastructures; Ministry of Education, Youth and Sports
Magda PEKTOROVÁ	Unit for Research Infrastructures; Ministry of Education, Youth and Sports
Jan ŠVEHLA	Unit for Research Infrastructures; Ministry of Education, Youth and Sports
Marta VANDROVCOVÁ	Unit for Research Infrastructures; Ministry of Education, Youth and Sports
Naďa VAVEROVÁ	Unit for Research Infrastructures; Ministry of Education, Youth and Sports

Annex 5: Membership of the Czech Republic in international R&I 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
ITER	International Thermonuclear Experimental Reactor *through memberships of the Czech Republic in EURATOM (European Atomic Energy Community) and F4E (European Joint Undertaking for ITER and the Development of Fusion Energy)*
VKIFD	von Karman Institute for Fluid Dynamics *through membership of the Czech Republic in NATO (North Atlantic Treaty Organisation)*

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

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

European Research Infrastructure Consortium (ERIC)	ERIC acronym			LRI project acronym	Large research infrastructure project (LRI)	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**			**CSDA/ESS-CZ**	Czech Social Science Data Archive / European Social Survey – participation of the Czech Republic	2013
Biobanks and Biomolecular Resources Research Infrastructure Consortium ERIC	**BBMRI-ERIC**			**BBMRI.cz**	Network of Czech Biobanks	2013
Central European Research Infrastructure Consortium ERIC	**CERIC-ERIC**			**SPL-HTC**	Surface Physics Laboratory – Hydrogen Technology Centre	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**	Czech Carbon Observation System	2017
Consortium of European Social Science Data Archives ERIC	**CESSDA ERIC**			**CSDA/ESS-CZ**	Czech Social Science Data Archive / European Social Survey – participation of the Czech Republic	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
Extreme Light Infrastructure ERIC	**ELI ERIC**			**ELI Beamlines**	Extreme Light Infrastructure – ELI Beamlines	2021
Infrastructure for Analysis and Experimentation on Ecosystems ERIC	**AnaEE-ERIC**			**CzeCOS**	Czech Carbon Observation System	2022
Aerosol, Clouds and Trace Gases Research Infrastructure ERIC	**ACTRIS ERIC**			**ACTRIS-CZ**	ACTRIS – participation of the Czech Republic	2023
Cherenkov Telescope Array Observatory ERIC	**CTAO ERIC**			**CTA-CZ**	Cherenkov Telescope Array – participation of the Czech Republic	*2023
European Research Infrastructure for the Generation, Phenotyping, Archiving and Distribution of Mouse Models of Human Diseases ERIC	**INFRAFRONTIER ERIC**			**CCP**	Czech Centre for Phenogenomics	*2023
International Centre for Advanced Studies on River-Sea Systems	**DANUBIUS-ERIC**			**CzeCOS** **CENAKVA**	Czech Carbon Observation System South Bohemian Research Centre of Aquaculture and Biodiversity of Hydrocenoses	*2023

* Following the submission of the step 2 application to the European Commission, the ERIC consortium is expected to be set-up in 2023 with the Czech Republic as a Founding Member.

Annex 7: Participation of the Czech Republic in European research infrastructures listed in the 2021 update to the Roadmap of European Strategy Forum on Research Infrastructures (ESFRI)

Science-disciplinary domain	European research infrastructure	Acronym		Status	Acronym	Large research infrastructure project - national node of the Czech Republic
Physical sciences and engineering	Cherenkov Telescope Array Observatory	**CTAO**		ESFRI Landmark	**CTA-CZ**	Cherenkov Telescope Array – participation of the Czech Republic
	Extreme Light Infrastructure	**ELI**		ESFRI Landmark	*The Czech Republic participates in ELI through ELI Beamlines, a pillar of ELI ERIC.*	
	Extremely Large Telescope	**ELT**		ESFRI Landmark	*The Czech Republic participates in ELT through its membership in ESO.*	
	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 Plasma Research Accelerator with Excellence in Applications	**EuPRAXIA**		ESFRI Project	*The Czech Republic participates in EuPRAXIA through ELI Beamlines, a pillar of ELI ERIC.*	
	European Solar Telescope	**EST**		ESFRI Project	**EST-CZ**	European Solar Telescope – participation of the Czech Republic
Energy	Jules Horowitz Reactor	**JHR**		ESFRI Landmark	**CICRR**	Czech International Centre of Research Reactors
Environmental sciences	Aerosols, Clouds and Trace Gases Research Infrastructure	**ACTRIS ERIC**		ESFRI Landmark	**ACTRIS-CZ**	ACTRIS – participation of the Czech Republic
	Infrastructure for Analysis and Experimentation on Ecosystems	**AnaEE ERIC**		ESFRI Landmark	**CzeCOS**	Czech Carbon Observation System
	Integrated Carbon Observation System ERIC	**ICOS ERIC**		ESFRI Landmark	**CzeCOS**	Czech Carbon Observation System
	International Centre for Advanced Studies on River-Sea Systems	**DANUBIUS-RI**		ESFRI Project	**CzeCOS** **CENAKVA**	Czech Carbon Observation System South Bohemian Research Centre of Aquaculture and Biodiversity of Hydrocenoses
	Environmental Exposure Assessment Research Infrastructure	**EIRENE RI**		ESFRI Project	**RECETOX RI**	RECETOX Research Infrastructure
	Integrated European Long-Term Ecosystem, Critical Zone and Socio-Ecological System Research Infrastructure	**eLTER RI**		ESFRI Project	**CzeCOS**	Czech Carbon Observation System
Biological and medical sciences	Biobanks and Biomolecular Resources Research Infrastructure Consortium ERIC	**BBMRI-ERIC**		ESFRI Landmark	**BBMRI.cz**	Network of Czech Biobanks
	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 Mouse Models of Human Diseases	**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/ESS-CZ**	Czech Social Science Data Archive / European Social Survey – participation of the Czech Republic
	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	**CSDA/ESS-CZ**	Czech Social Science Data Archive / European Social Survey – participation of the Czech Republic
	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
	European Holocaust Research Infrastructure	**EHRI**		ESFRI Project	**LINDAT/CLARIAH-CZ**	Digital Research Infrastructure for Language Technologies, Arts and Humanities
e-Infrastructures	Partnership for Advanced Computing in Europe	**PRACE**		ESFRI Landmark	**e-INFRA CZ**	e-Infrastructure of the Czech Republic

List of abbreviations

A.SPIRE	Processes4Planet Co-Programmed Partnership
ACS	American Chemical Society
ACTRIS	Aerosol, Clouds and Trace Gases Research Infrastructure
ACTRIS ERIC	Aerosol, Clouds and Trace Gases Research Infrastructure – European Research Infrastructure Consortium
ACTRIS-CZ	ACTRIS – participation of the Czech Republic
AEgIS	Antimatter Experiment: Gravity, Interferometry, Spectroscopy
AF	ÅF-CONSULT Ltd.
AIS CR	Archaeological Information System of the Czech Republic
ALICE	A Large Ion Collider Experiment
ALMA	Atacama Large Millimetre / Submillimetre Array
AMCR API	Archeological Map of the Czech Republic Application Programming Interface
AnaEE-ERIC	Analysis and Experimentation on Ecosystems – European Research Infrastructure Consortium
ANL	Argonne National Laboratory
API	Application Programming Interface
AQUAEXCEL3.0	Aquaculture Infrastructures for Excellence in European Fish Research
ARC	ALMA Regional Centre
ASIAA	Academia Sinica Institute of Astronomy and Astrophysics
ATLAS	A Toroidal LHC Apparatus
AUGER-CZ	Pierre Auger Observatory – participation of the Czech Republic
BBMRI.cz	Network of Czech Biobanks
BBMRI-ERIC	Biobanks and Biomolecular Resources Research Infrastructure Consortium – European Research Infrastructure Consortium
BDVA	Big Data Value Association
BEER	Beamline for European Engineering Materials Research
BIC	Bio-based Industries Consortium
BIM	Building Information Modelling
BIOCEV	Biotechnology and Biomedicine Centre of the Czech Academy of Sciences and Charles University in Vestec
Bio-SAXS	Biological Small-angle X-ray Scattering
BNL	Brookhaven National Laboratory
BNL-CZ	Brookhaven National Laboratory – participation of the Czech Republic
Caltech	California Institute of Technology
CBM	Compressed Baryonic Matter
CCP	Czech Centre for Phenogenomics
CEITEC	Central European Institute of Technology
CEMNAT	Center for Materials and Nanotechnologies
CENAKVA	South Bohemian Research Centre of Aquaculture and Biodiversity of Hydrocenoses
CEPLANT	R&D Centre for Low-Cost Plasma and Nanotechnology Surface Modifications
CERIC-ERIC	Central European Research Infrastructure Consortium – European Research Infrastructure Consortium
CERIT-SC	CERIT Scientific Cloud
CERN	Conseil Européen pour la Recherche Nucléaire
CERN BIC	CERN Business Incubation Centre
CERN-CZ	Research Infrastructure for Experiments at CERN
CESNET	CESNET e-infrastructure
CESSDA ERIC	Consortium of European Social Science Data Archives – European Research Infrastructure Consortium
CET	Clean Energy Transition
CICRR	Czech International Centre of Research Reactors
CIEMAT	Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas
CIISB	Czech Infrastructure for Integrative Structural Biology
CLARIN ERIC	Common Language Resources and Technology Infrastructure
CLB	Czech Literary Bibliography
CMS	Compact Muon Solenoid
CNC	Czech National Corpus
COMPASS	Common Muon and Proton Apparatus for Structure and Spectroscopy
COMPASS	Tokamak for Thermonuclear Fusion Research
CSDA	Czech Social Science Data Archive
CSDA/ESS-CZ	Czech Social Science Data Archive / European Social Survey – participation of the Czech Republic
CSG	Centre Spatial Guyanais
CTAO	Cherenkov Telescope Array Observatory
CTA-CZ	Cherenkov Telescope Array – participation of the Czech Republic
CzeCOS	Czech Carbon Observation System
CZECRIN	Czech National Node to the European Clinical Research Infrastructure Network
Czech-BioImaging	National Research Infrastructure for Biological and Medical Imaging
CzechNanoLab	CzechNanolab Research Infrastructure
CZ-OPENSCREEN	National Infrastructure for Chemical Biology
DANUBIUS-RI	International Centre for Advanced Studies on River-Sea Systems
DARIAH ERIC	Digital Research Infrastructure for the Arts and Humanities – European Research Infrastructure Consortium
DEMO	Demonstration Power Plant
DESY	Deutsches Elektronen-Synchrotron
DLR	German Aerospace Centre
DUT	Driving Urban Transitions to a Sustainable Future
EAC	European Astronauts Centre
EAS	European Aquaculture Society
EAST	European Association for Solar Telescopes
EATRIS ERIC	European Advanced Translational Research Infrastructure in Medicine – European Research Infrastructure Consortium
EATRIS-CZ	Czech National Node to the European Infrastructure for Translational Medicine
ECBD	European Chemical Biology Database
ECRIN-ERIC	European Clinical Research Infrastructure Network – European Research Infrastructure Consortium
ECSAT	European Centre for Space Applications and Telecommunications
eduID.cz	Part of the European eduGAIN interfederation
EFSA	European Food Safety Authority
EGI	European Grid Infrastructure
EGO	European Gravitational Observatory
EHRI	European Holocaust Research Infrastructure
EIC	Electron Ion Collider
e-INFRA CZ	e-Infrastructure of the Czech Republic
EIRENE	Environmental Exposure Assessment Research Infrastructure
EIRO Forum	European Intergovernmental Research Organisation Forum
ELI	Extreme Light Infrastructure
ELI ERIC	Extreme Light Infrastructure – European Research Infrastructure Consortium
ELIXIR	European Life-Science Infrastructure for Biological Information
ELIXIR CZ	Czech National Infrastructure for Biological Data
ELT	Extremely Large Telescope
eLTER	European Long-Term Ecosystem Research
eLTER RI	Long-Term Research on Ecosystems, Critical Zones and Socio-Ecological Systems
EMBC	European Molecular Biology Conference
EMBL	European Molecular Biology Laboratory
EMBL-EBI	EMBL European Bioinformatics Institute

EMBO	European Molecular Biology Organisation
EMBRC-ERIC	European Marine Biological Resource Centre – European Research Infrastructure Consortium
EMFL	European Magnetic Field Laboratory
EMPHASIS	European Infrastructure for Multi-scale Plant Phenomics and Simulation
ENREGAT	Energy Waste Recovery and Gas Treatment
EOSC	European Open Science Cloud
ERA	European Research Area
ERF	Association of European-Level Research Infrastructure Facilities
ERIC	European Research Infrastructure Consortium
E-RIHS	European Research Infrastructure for Heritage Science
ESA	European Space Agency
ESA BIC	European Space Agency´s Business Incubation Centre
ESAC	European Space Astronomy Centre
ESEC	European Space Security and Education Centre
ESFRI	European Strategy Forum on Research Infrastructures
ESO	European Southern Observatory / European Organisation for Astronomic Research in the Southern Hemisphere
ESOC	European Space Operations Centre
ESRF	European Synchrotron Radiation Facility
ESRIN	European Space Research Institute
ESS	European Social Survey
ESS	European Spallation Source
ESS ERIC	European Social Survey – European Research Infrastructure Consortium
ESS Scandinavia-CZ	European Spallation Source – participation of the Czech Republic
ESS-CZ	Czech National Node to the European Social Survey
EST	European Solar Telescope
EST-CZ	European Solar Telescope – participation of the Czech Republic
ESTEC	European Space Research and Technology Centre
EST-ERIC	European Solar Telescope – European Research Infrastructure Consortium
ETP4HPC	European Technology Platform for High Performance Computing
EU	European Union
EU-AMRI	European Alliance of Medical Research Infrastructures
EU-ARC.CZ	Atacama Large Millimetre / Submillimetre Array – participation of the Czech Republic
EUDAT	Collaborative Data Infrastructure
EUFAR	European Facility for Airborne Research
EU-OPENSCREEN ERIC	European Infrastructure of Open Screening Platforms for Chemical Biology – European Research Infrastructure Consortium
EURAMET	European Association of National Metrology Institutes
EURATOM	European Atomic Energy Community
Euro-BioImaging ERIC	European Research Infrastructure for Imaging Technologies in Biological and Biomedical Sciences – European Research Infrastructure Consortium
EUROfusion	European Consortium for Development of Fusion Energy
EuroHPC	European High-Performance Computing Joint Technology Initiative
F4E	European Joint Undertaking for ITER and the Development of Fusion Energy (Fusion for Energy)
FAIR	Findable, Accessible, Interoperable and Reusable
FAIR	Facility for Antiproton and Ion Research in Europe
FAIR-APPA	Atomic, Plasma Physics and Applications
FAIR-CZ	Facility for Antiproton and Ion Research – participation of the Czech Republic
FAO	Food and Argiculture Organisation of the United Nations
FASER	Forward Search Experiment
FERMILAB	Fermi National Accelerator Laboratory
FERMILAB-CZ	Research Infrastructure for Fermilab Experiments

FRAM	F/Photometric Robotic Atmospheric Monitor
GANIL	Grand Accélérateur National d'ions Lourds
GÉANT	European Communication Infrastructure
GGP	Generations and Gender Programme
GKN	Sinter Metals Filters GmbH Radevormwald
GLAM	Galleries, Libraries, Archives, Museums
GLP	Good Laboratory Practice
GMK	Deutsche Wissenschaftliche Gesellschaft für Erdöl, Erdgas und Kohle
GMP	Good Manufacturing Practice
GSI	Helmholtzzentrum für Schwerionenforschung
HAPRS	High Accuracy Radial Velocity Planet Searcher
HiLASE	High Average Power Pulsed Laser
HL-LHC	High-Luminosity Large Hadron Collider
HPC	High Performance Computing
HTC	Centre of Hydrogen Technology
HTC	High Throughput Computing
HTS	High-Throughput Screening
HVAC	Heating, Ventilation, Air Conditioning
ICOS ERIC	Integrated Carbon Observation System – European Research Infrastructure Consortium
ICRI	International Conference on Research Infrastructures
ICT	Information and Communication Technologies
ILL	Institut Laue-Langevin
IMPC	International Mouse Phenotyping Consortium
INERATEC	Innovative Chemical Reactor Technologies
INFRAFRONTIER	European Research Infrastructure for the Generation, Phenotyping, Archiving and Distribution of Mouse Models of Human Diseases
INPLAS	Network of Competence Industrial Plasma Surface Technology
Instruct-ERIC	Integrated Structural Biology – European Research Infrastructure Consortium
ISO	International Organization for Standardization
ISS	International Space Station
IT4Innovations	IT4Innovations National Supercomputing Centre
ITER	International Thermonuclear Experimental Reactor
JHR	Jules Horowitz Reactor
JHR-CZ	Jules Horowitz Reactor – participation of the Czech Republic
KASI	Korea Astronomy and Space Science Institute
K-centre	CLARIN Knowledge Centres
KET centre	Technology Centres in the field of Key Enabling Technologies
KETs	Key Enabling Technologies
Laserlab-Europe	Integrated Initiative of European Laser Research Infrastructures
LENS	League of Advanced European Neutron Sources
LHC	Large Hadron Collider
LHCb	Large Hadron Collider beauty
LHCf	Large Hadron Collider forward
LIGO	Laser Interferometer Gravitational-Wave Observatory
LINDAT/CLARIAH-CZ	Digital Research Infrastructure for Language Technologies, Arts and Humanities
LISA	Laser Interferometer Space Antenna
LLNL	Lawrence Livermore National Laboratory
LNEG	Laboratório Nacional de Energia e Geologia
LNSM	Laboratory of Nanostructures and Nanomaterials
LRI/s	Large Research Infrastructure/s
LSM	Laboratoire Souterrain de Modane
LSM-CZ	Laboratoire Souterrain de Modane – participation of the Czech Republic

LST	Large Size Telescope
LUMI	Large Unified Modern Infrastructure
MEDEX	Matrix Elements for the Double Beta Decay Experiments
METROFOOD-CZ	Infrastructure for Promoting Metrology in Food and Nutrition in the Czech Republic
METROFOOD-RI	Infrastructure for Promoting Metrology in Food and Nutrition
MEYS	Ministry of Education, Youth and Sports
MGCL	Material Growth and Characterization Laboratory
MGML	Materials Growth and Measurement Laboratory
MIT	Massachusetts Institute of Technology
MoEDAL	Monopole and Exotics Detector at LHC
MPML	Material Properties Measurement Laboratory
MSB	Material Science Beamline
MST	Middle Size Telescope
MT	Ministry of Transport
n_TOF	Neutron Time-of-Flight Facility
NanoEnviCz	Nanomaterials and Nanotechnologies for Environment Protection and Sustainable Future
NAOJ	National Astronomical Observatory of Japan
NAOK	National Atmospheric Observatory Košetice
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organisation
NCMB	National Centre for Medical Genomics
NCMG	National Centre for Medical Genomics
NINS	National Institutes of Natural Sciences
NMR spectroscopy	Nuclear Magnetic Resonance spectroscopy
NRAO	National Radio Astronomical Observatory
NRC	National Research Council
NREN	National Research and Education Network
NSF	National Science Foundation
NSC	National Security Council
NTT	New Technology Telescope
NuSTAR	Nuclear Structure, Astrophysics and Reactions
OP JAK	Johannes Amos Comenius Operational Programme
OSQAR	Optical Search for QED Vacuum Bifringence, Axions and Photon Regeneration
PACC	Prague Aerosol Calibration Centre
PALS	Prague Asterix Laser System
PANDA	Anti-Proton Annihilation at Darmstadt
PARC	European Partnership for the Assessment of Risks from Chemicals
PCR analysis	The Polymerase Chain Reaction
PES	PhotoElectron Spectroscopies
PIC	ePIC experiment
PRACE	Partnership for Advanced Computing in Europe
PRODEX	Scientific Instruments Development Programme
R&I	Research and Innovation
Reactors LVR-15 and LR-0	Nuclear Research Reactors LVR-15 and LR-0
RECETOX RI	RECETOX Research Infrastructure
REPowerEU	A Plan to Rapidly Reduce Dependence on Russian Fossil Fuels and Fast Forward the Green Transition
RHIC	BNL's Relativistic Heavy Ion Collider
RI	Research Infrastructure
RILEM	Réunion Internationale des Laboratoires et Experts des Matériaux, Systèmes de Construction et Ouvrages
SAL	Structural Analysis Laboratory
SET Plan	A European Strategic Energy Technology Plan: Towards a Low-Carbon Future
SHARE-CZ	Survey of Health, Ageing and Retirement in Europe – participation of the Czech Republic
SHARE-ERIC	Survey of Health, Ageing and Retirement in Europe – European Research Infrastructure Consortium
SKA	Square Kilometer Array
SPIRAL2	Système de Production d'Ions Radioactifs Accélérés en Ligne
SPIRAL2-CZ	Système de Production d'Ions Radioactifs Accélérés en Ligne – participation of the Czech Republic
SPL	Surface Physics Laboratory
SPL-HTC	Surface Physics Laboratory – Hydrogen Technology Centre
SST-1M	Small Size Telescope – 1M
SUSEN	Sustainable Energy
TEATER	Thesaurus of Archaeological Terminology
THANADOS	Anthropological and Archaeological Database of Sepultures
TOTEM	Total Elastic and Diffractive Cross Section Measurement
UNOTT	University of Nottingham
VKI	Von Karman Institute for Fluid Dynamics
VLT	Very Large Telescope
VTT	Technical Research Centre of Finland Ltd.
WAS	World Aquaculture Society
WCZV	VR-1 Nuclear Experimental Hub
WSCS	World Sturgeon Conservation Society
XFEL	X-ray Free Electron Laser

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