Roadmap of Large Infrastructures for Research, Experimental Development and Innovation of the Czech Republic for the years 2016–2022

Ministry of Education, Youth and Sports

MINISTRY OF EDUCATION,
YOUTH AND SPORTS

Roadmap of Large Infrastructures for Research, Experimental Development and Innovation of the Czech Republic for the years 2016–2022

Ministry of Education, Youth and Sports

Roadmap of Large Infrastructures for Research, Experimental Development and Innovation of the Czech Republic for the years 2016–2022

Ministry of Education, Youth and Sports

MINISTRY OF EDUCATION,
YOUTH AND SPORTS

Ministry of Education, Youth and Sports
Karmelitska 7
118 12 Prague 1
Czech Republic
www.msmt.cz

ISBN 978-80-87601-34-1

Foreword

Research infrastructures, including e-infrastructures, represent one of the key pillars of the national research and innovation ecosystems of individual EU Member States, the European Research Area as a whole and other macro-regional and global formations.

Research infrastructures are the principal "backbone" for conducting excellent R&D as the critical mass of material, financial and human resources and technological and knowledge expertise is concentrated within their capacities. Research infrastructures thus enable the achievement of breakthrough ideas in basic or so called "blue-sky" research, "frontier" research in fundamental and applied scientific fields and the development of advanced technologies, which show high knowledge intensity and potential for applications in modern innovative products and services of high added value.

Research infrastructures create favourable environments, where individual segments of the knowledge triangle (education, research and industry) are efficiently interconnected, resulting in intensive interactions. The results achieved by using the research infrastructures thus stimulate private investments in R&D and, consequently, foster the leverage effect. In this way, research infrastructures contribute to the bloom of science & technology parks.

Construction of research infrastructures, development of their technical devices and upgrade of their capacities offers great opportunities for enterprises to take part in tenders for delivery of these facilities. Such tenders stimulate and encourage the firms to produce advanced, state-of-the-art technologies and increase their innovation skills. The private sector benefits from the research infrastructures both from the economic and knowledge point of view as they are stimulated to supply the research infrastructures with high-tech products and services, which increase their economic profits and strengthen their competitiveness in business. At the same time the enterprises use the know-how resulted from R&D carried out in research infrastructures to produce goods widely applicable on the marketplace.

In this way, the investments made in research infrastructures also significantly overlap into a broad range of socio-economic sectors in addition to the results of R&D achieved by using their facilities. Research infrastructures thus contribute to the progressive development of entire economic spheres and (speaking in geographical terms) of urban areas at the level of regions and macro-regions. Since the research infrastructures are as a general rule constructed and operated in direct response to identified R&D and societal challenges and needs, results achieved by using their facilities are of high socio-economic relevance and impact, bringing important multiplier effects.

While being networked at the international level and operated on the basis of open access, research infrastructures enable even more efficient addressing of the macro-regional and global challenges we are facing. Successfully tackling them generally requires knowledge intensive and high-tech solutions. Moreover, networking of facilities and technical devices in internationally shared "single-sited" or "distributed" research infrastructures prevents the hosting institutions from fragmentation and duplication of efforts.

The operation of research infrastructures capacities and capabilities in an integrated (inter-) national area in line with the principles of open access policy allows their users to achieve results that would be barely achievable by individual participants of research and innovation ecosystems by using their own institutional facilities. In this respect, research infrastructures also help to increase the efficiency of public spending on R&D by providing their users with top-class facilities, technical devices, expertise and open access services mediating the most up-to-date and state-of-the-art resources for conducting excellent R&D.

The research community of the Czech Republic gathers a broad portfolio of expertise that enables operation of numerous local research infrastructures with significant international overlaps as well as participation in the most powerful pan-European and worldwide facilities. To secure this positive trend, the Czech Republic will create a favourable environment for the management of individual research infrastructures in line with their specific needs, both in legal and funding terms.

At the same time, the Czech Republic will continue to harmonize its research infrastructure approaches in compliance with good practice examples agreed within the European Strategy Forum on Research Infrastructures. The operation of the Czech research infrastructures will thus contribute to strengthening R&D performance and competitiveness both at the national and pan-European level.

I am very glad to present this Roadmap of Large Infrastructures for Research, Experimental Development and Innovation of the Czech Republic for the years 2016–2022 which demonstrates how the Czech Republic is responding to the challenges and opportunities of engaging in the international research infrastructure sector. I acknowledge the work of the International Evaluation Committee and the staff of the Ministry of Education, Youth and Sports, and the dedication of the individual research infrastructure teams, in enabling this Roadmap to be prepared.

Kateřina Valachová
Minister of Education, Youth and Sports
of the Czech Republic

Table of contents

1|

Research infrastructures in the European Research Area

The growing importance of top-class research infrastructures in relation to strengthening the competitiveness of the ERA (*European Research Area*) and the EU economy in a global context has been reflected by a number of important steps since the beginning of the new millennium.

In 2002 **ESFRI** (*European Strategy Forum on Research Infrastructures*) was established bringing together the EU Member States and defining the priorities for developing excellent research infrastructures of pan-European character and impact. In 2006 the 1st **ESFRI Roadmap** was issued followed by its updates in 2008 and 2010 whilst the further ones are foreseen for 2016 and thereafter at regular intervals. To provide a forum dedicated particularly to the ICT-based pan-European research infrastructures, **e-IRG** (*e-Infrastructures Reflection Group*) was established in 2003.

At the legal level, in 2009 the increased emphasis put on the European multinational research infrastructures resulted in the creation of a new specific EU legal framework for the management of research infrastructures, defining principles of their financial and other operational aspects. The legal entity of **ERIC** (*European Research Infrastructure Consortium*) introduced a completely flexible legal framework for the management of pan-European research infrastructures, in particular the "distributed" ones, including the possibility of exemption of an international research infrastructure operated in the form of ERIC from the payment of value added tax.

Research infrastructures have been included in past EU Framework Programmes supporting R&D, and their importance was confirmed through their inclusion as a key component of the Excellence Pillar of **Horizon 2020** – The Framework Programme for Research and Innovation – when it was launched in 2014.

EU regulations establishing the framework for granting state aid for research, development and innovation from public funds confirmed the definition of a research infrastructure in 2014 and laid down specific principles for their public funding. A **research infrastructure** was defined as *"facilities, resources and related services that are used by the scientific community to conduct research in their respective fields and covers scientific equipment or sets of instruments, knowledge-based resources such as collections, archives or structured scientific information, enabling information and communication technology-based infrastructures such as grid, computing, software and communication, or any other entity of a unique nature essential to conduct research. Such infrastructures may be "single-sited" or "distributed" (an organised network of resources) in accordance with Article 2(a) of Council Regulation (EC) No 723/2009 of 25 June 2009 on the Community legal framework for a European Research Infrastructure Consortium (ERIC)."*

While the importance of research infrastructures grows in line with the need of addressing advanced and demanding R&D and socio-economic challenges that require costly high-tech and expertise solutions, research infrastructures require a more and more specific approach, both in terms of policy coordination and financial commitment at national, macro-regional, pan-European and global level. A suitable legislative framework is needed to create a favourable environment for the operation of individual research infrastructures, enabling them to achieve to the maximum of their specific objectives.

2|

Research infrastructures of the Czech Republic

In recent years, the Czech Republic has also responded to the significantly increasing importance of research infrastructures. Taking into account that research infrastructures are one of the principal components of the Czech national research and innovation ecosystem, a number of steps aiming at providing the Czech research infrastructures with a stable legal and financial environment were made.

In 2009 the "Act No 130/2002 Coll. on the Support of Research, Experimental Development and Innovation from Public Funds and on the Amendment to Some Related Acts" established a specific legal instrument for financing research infrastructures of the Czech Republic. The Ministry of Education, Youth and Sports (MEYS) was entitled to be the national authority for funding the **Large infrastructures for research, experimental development and innovation** within a brand-new legal and funding framework. The Large Infrastructure has been defined as *"a unique research facility, including its acquisition and related investment costs and the costs of ensuring its activities that are essential for comprehensive research and development with heavy financial and technological demands and which is approved by the Government of the Czech Republic and established by one research organisation for the use of other research organisations"*.

In 2010 the 1st **Roadmap of Large Infrastructures of the Czech Republic** was issued following the structure of the ESFRI Roadmap and early afterwards updated in 2011. The significance given to research infrastructures was further emphasised as individual proposals for Large Infrastructures funding were submitted for the final adoption by the Government of the Czech Republic. The MEYS, being the central authority of the Czech state administration responsible for Large Infrastructures, also established an expert advisory board – **Council for Large Infrastructures for Research, Experimental Development and Innovation.**

Over the past years, in view of their prevailing characteristics, **4 coherent groups of research infrastructures** have been distinguished within the Czech research infrastructures landscape:

- A research infrastructure located in the Czech Republic having a significant international impact;
- A research infrastructure located in the Czech Republic representing the Czech national "node" of a pan-European "distributed" research infrastructure;
- A research infrastructure operated in the form of an "access point" of the Czech R&D user community to a research infrastructure located abroad;
- A research infrastructure of the Czech Republic located abroad.

Beyond the given general typology, there is a specific kind of research infrastructure of the Czech Republic, which is primarily characterized by its different legal form – **membership of the Czech Republic in international research organizations** established and operated under the Public International Law. Besides the membership in the UN (*United Nations*), NATO (*North Atlantic Treaty Organization*) and OECD (*Organisation for Economic Cooperation and Development*), which implement their internal R&D programmes, the Czech Republic has been a Member State of:

- **CERN** *(European Organization for Nuclear Research);*
- **EMBC** *(European Molecular Biology Conference);*
- **EMBL** *(European Molecular Biology Laboratory, including ELIXIR);*
- **ESA** *(European Space Agency);*
- **ESO** *(European Southern Observatory, including European Extremely Large Telescope)*
- **JINR** *(Joint Institute of Nuclear Research);*
- **VKIFD** *(Von Karman Institute for Fluid Dynamics).*

3|

Investments in research infrastructures of the Czech Republic made by using the EU structural funds in 2007–2015

While the operational costs of Large Infrastructures of the Czech Republic are covered by the state budget expenditures for R&D, the investment costs for technological development or upgrade of their facilities have been financed in previous years pre-dominantly by using the instruments of EU cohesion policy.

Thus, in the course of the period 2007–2015 the investments were made particularly by the use of ERDF (European Regional Development Fund) mediated via the **Operational Programme Research and Development for Innovation** (OP RDI) and managed by the MEYS. Simultaneously, minor investments were made also via the **Operational Programme Prague – Competitiveness** (OP PC) implemented by the City of Prague. In numerous cases, the investments enabled major upgrades of the technological devices of research infrastructures or the construction of brand-new ones. These research infrastructures have proved to be not only of national impact and importance but also of the macro-regional, pan-European and in a few exceptional cases even of global significance.

The list of R&D facilities that have been built by using the ERDF via the OP RDI and OP PC and contributed to the development of research infrastructures or the construction of brand-new ones is included in the Annexes (No 6). All the mentioned research infrastructures were positively assessed by the International Evaluation Committee as they had reached the sufficient level of maturity to be operated as high-quality research infrastructures that comply with all the relevant standards and criteria.

4|

Comprehensive evaluation of research infrastructures of the Czech Republic

Following on the 1st phase (since 2010) of financing of Large Infrastructures from the state budget expenditures on R&D and investments made by using the ERDF in the period 2007–2015, the MEYS performed a comprehensive evaluation of research infrastructures of the Czech Republic in 2014.

All the research infrastructures, regardless of their previous main funding source (i.e. state budget expenditures on R&D or ERDF) and their current state-of-play (i.e. preparatory, implementation, operational or decommissioning phase) were subject to this assessment.

The evaluation was carried out by an **International Evaluation Committee** according to the research infrastructures evaluation methodology that had been inspired by ESFRI evaluation procedures and prepared within the framework of the Individual National Project named **Effective System of Evaluation and Funding of Research, Development and Innovation** financed by the ERDF. The International Evaluation Committee was composed of a Chairman and 6 Scientific Boards of 3 members specialized on the R&D areas of: (1) Physical Sciences; (2) Energy; (3) Environmental Sciences; (4) Biomedicine; (5) Social Sciences and Humanities; and (6) ICT/e-infrastructures. The International Evaluation Committee members were appointed from a pool of experts with long-term experience with research infrastructures in their roles as users or research infrastructures policy-makers. Each Scientific Board included one evaluator coming from the Czech Republic in order to allow reflecting the knowledge of Czech research and innovation ecosystem and Czech research infrastructures landscape in the evaluation process. The International Evaluation Committee thus consisted of a total of 19 members.

The evaluation itself was carried out in 2 stages and was based on the principles of informed international peer-review combining the methods of panel and peer-review evaluation. To pass the **1st stage** of assessment, all proposals were expected to fulfil the definition of a research infrastructure, which includes particularly (1) operation of unique technological R&D facilities; (2) having at least nation-wide importance and impact in the Czech Republic and potential international overlap; and (3) managing the research infrastructure on the basis of an open access policy consistent with international good practice.

The **2nd stage** of assessment consisted in a detailed evaluation of the quality level of research infrastructures characteristics, which might be grouped as follows:

- **Socio-economic impact** *(The research infrastructures are operated in direct response to socio-economic challenges. Therefore, the research infrastructure must fulfil its role in the research and innovation ecosystem appropriately. As the research infrastructures usually have an overlap into the ERA and other international macro-regional formations, the impact and added value on these formations are assessed too.);*
- **Uniqueness of technological facilities** *(The technological devices operated by a research infrastructure are of a high-tech and knowledge intensity and unique within the research and innovation ecosystem of the Czech Republic.);*
- **Management and sustainable development strategy** *(The research infrastructure has established a governance structure clearly defining the responsibilities of the executive and supervisory bodies; a management strategy; an intellectual property rights strategy; a human resources development strategy; a long-term sustainable development strategy and a public relations and marketing strategy.);*
- **Open access policy** *(The research infrastructure is operated on the basis of an open access policy to its facilities for a broad range of potential users from the R&D community*

and under the transparent conditions consistent with international good practice. The research infrastructure services are provided subject to applications evaluated by experts following the principles of relevance and excellence of the proposals.);

- **R&D strategy** *(The research infrastructure is devoted, unlike the other kinds of research entities, to operate its facilities for the use by individual participants of the research and innovation ecosystem. Therefore, a substantial part of its R&D activities focuses on R&D to improve its services and expertise for the users, further development of technologies and expertise of the research infrastructure, and to a limited extent on the collaborative and contractual R&D.);*

- **Cooperation with other research organisations and research infrastructures operated in the respective scientific field or multidisciplinary R&D area and industrial sector** *(The research infrastructure has established a relevant formal framework determining rules of cooperation developed with partner research organisations and research infrastructures in the Czech Republic and abroad as well as with the industrial sector.);*

- **Quality of R&D results achieved by using the research infrastructure** *(R&D results that are achieved by using the facilities and expertise of a research infrastructure must be of high-quality and adequate from the point of view of "value for money".);*

- **Potential for the development of new technologies** *(The research infrastructures are operated in high-tech and knowledge-intensive areas and used for the development of new advanced technologies.);*

While the 1st stage of research infrastructures evaluation was carried out exclusively by the 6 Scientific Boards, the 2nd stage included also the **international peer-review** (2 or 3 reports per research infrastructure proposal) and interviews with the representatives of research infrastructures management. The principal purpose of the external international peer-review was to obtain additional independent expert opinions beyond the assessment conducted by the respective 6 Scientific Boards of the International Evaluation Committee. The **interview with research infrastructures management** was aimed at enabling Scientific Board members to address questions on the operation of the research infrastructure and the delivery of services to external users.

The overall outcome of the research infrastructures assessment was the identification of **58 positively evaluated research infrastructures** (including 42 research infrastructures of high-priority) recommended by the International Evaluation Committee for public funding and divided into **4 performance-related groups** (A1, A2, A3 and A4) indicating the priority for public funding in direct proportion to the quality-differentiated output of the evaluation.

The outcomes and recommendations made by the International Evaluation Committee will serve to the MEYS and Government of the Czech Republic as an **independent expert basis for the informed policy decision making** concerning:

- **Funding the Large Infrastructures** of the Czech Republic in the course of the forthcoming multiannual financial framework 2016–2022, combining the state budget expenditures of the Czech Republic on R&D with EU cohesion policy instruments (*European Structural and Investment Funds*, ESIF) to be mediated via the Operational Programme Research, Development and Education (OP RDE);

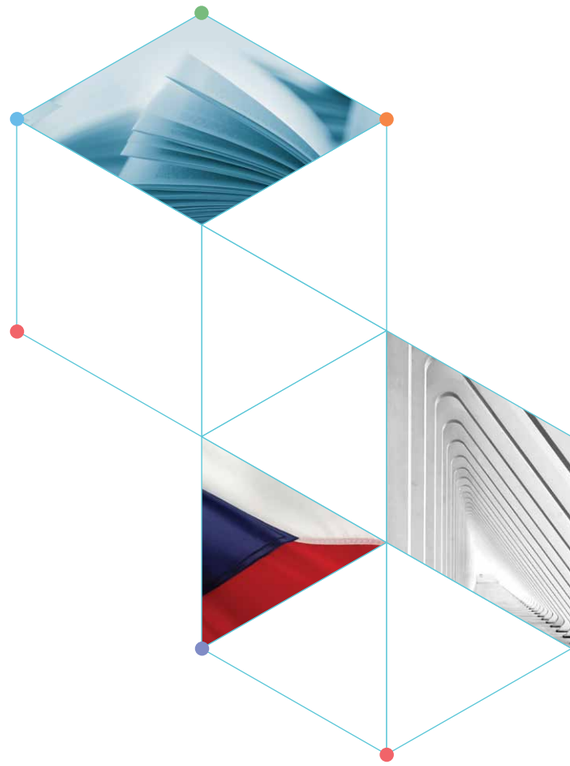
- **Declaring the political and financial commitment of the Czech Republic to the pan-European research infrastructures** with Czech involvement and participation that will be submitted for the future ESFRI Roadmap updates;

- **Joining the emerging ERICs** to be established within the ERA in the years to come.

Multi-source funding of Large Infrastructures of the Czech Republic in 2016–2022

Funding of the operational and development investment costs of Large Infrastructures of the Czech Republic will be of a multi-source nature in the years 2016–2022 and will place the spending of **state budget expenditures on R&D in a full complementarity with the ESIF** mediated through the OP RDE.

While the **operational costs** of Large Infrastructures will be funded by the MEYS mainly (but not exclusively) within the Large Infrastructures financial instrument using the state budget expenditures on R&D, the **investment costs** for further technological development of the facilities will be funded within a special call to be launched as a part of the implementation framework of OP RDE using the ESIF. High efficacy of both the funding resources operated by the MEYS will thus be multiplied.



6|

Interim evaluation of research infrastructures of the Czech Republic

As for the evaluation methodological approach, the comprehensive assessment of research infrastructures of the Czech Republic performed in 2014 is regarded as a pivotal milestone in the management of the agenda of research infrastructures in the Czech Republic.

As mentioned above, the purpose of the evaluation was to asses not only the already long-time operated facilities but also those newly built by using the ERDF within the OP RDI in the course of the period 2007–2015. The evaluation was also for the first time (i.e. since 2009 when the first such an assessment was performed) based at the international level involving an international evaluation committee.

As a result, the 2014 assessment can be viewed and considered a comprehensive **ex-ante evaluation** of the research infrastructures of the Czech Republic before the beginning of the new multiannual financial framework 2016–2022. In the future, the 2014 ex-ante evaluation will be transformed into continuous **interim assessment** of Large Infrastructures, which will be financially supported by the MEYS.

The methodology used for the interim evaluation of Large Infrastructures is planned to be similar to the ex-ante evaluation framework introducing the panel assessment with the involvement of foreign experts. The evaluation will be conducted in multi-year periods and the standard **written reporting** will be completed by **on-site-visits** of Large Infrastructures.

The general intent of the MEYS is to create a stable pool of experts involved in the research infrastructures evaluation over a longer period so that the Scientific Boards are aware of the previous development of Large Infrastructures and thus able to observe how their previous recommendations were reflected in the operation of the facilities.

The interim assessment of Large Infrastructures will be conducted in 2017 and 2019, i.e. after the end of the 1st and 3rd year of the 7-year Large Infrastructures funding framework. Another comprehensive evaluation of the research infrastructures of the Czech Republic is anticipated for 2021 before the launch of the follow-up funding period 2023–2029.

7|

Roadmap of Large Infrastructures of the Czech Republic in the context of ESFRI and ERA

Given that research infrastructures emerge in direct response to R&D and socio-economic demands and are aimed to facilitate solutions to the challenges identified, it can be expected that new research infrastructures will emerge both in the Czech Republic and ERA in the R&D fields where relevant R&D and socio-economic needs are defined in the coming years. For this reason it is absolutely necessary to approach the agenda of research infrastructures as an evolving agenda responding to the changing R&D and socio-economic demands that are (re-)defined over the course of time.

The facilities of research infrastructures that are already operated will be upgraded in order to accommodate the demands for more complex technological and knowledge solutions. After the level of their maximum technological upgrade and development is reached, their facilities will be gradually decommissioned and replaced by the newly constructed research infrastructures enabling the most up-to-date and state-of-the-art solutions.

Therefore, similarly to the ESFRI Roadmap updates, the Roadmap of Large Infrastructures of the Czech Republic is expected to be reviewed periodically and the calls for its updates will be announced. In particular, the research infrastructures concepts viewed promising but not mature enough within the comprehensive 2014 ex-ante evaluation are expected to reapply as well as brand-new research infrastructure concepts that might emerge in direct response to the (re-)defined R&D and socio-economic challenges.

Furthermore, as excellent R&D even more and more consists of multidisciplinary approaches combining different scientific expertise from various R&D fields, research infrastructure clustering or the development of new multidisciplinary research infrastructures is expected to a considerable extent. The interdisciplinary approach has been obvious in all the fields of physical, material, energy, biological, medical, environmental and social sciences and ICT and is expected to be present even more in the future.

The announcement of the 1st follow-up call for the Roadmap of Large Infrastructures of the Czech Republic update is anticipated for 2016/2017 with possible funding granted by the MEYS in 2018 for a 5-year period until 2022.

8|

Conclusions

Starting in 2002 the research infrastructures agenda has developed significantly at the EU level followed by the specific Czech national approach since 2009. The overall level of political, legal and financial coordination has been strengthened within the EU in an extraordinary way (ESFRI, e-IRG, ERIC). The approach to the research infrastructures agenda began to be harmonized across the EU. The pan-European ESFRI Roadmap has been put in place and updated on a regular basis as well as the EU Member States continuously reviewing their National Roadmaps.

Since research infrastructure facilities are usually high-tech demanding, require costly advanced technological and knowledge base and their life-time cycle usually extends over periods of several decades, an increased emphasis needs to be given to a highly strategic approach leading to long-term commitments on research infrastructures which are then reflected in political decisions.

The EU Competitiveness Council have repeatedly called on the Member States to avoid cuts in public spending on R&D, maintain the current level and even increase the spending intensity despite the financial and economic crises. It has been proved that the Member States showing a higher level of public spending on R&D have evinced a higher innovation performance and thus the impact of financial crises on their economies was not so negative. At the same time, the Member States have been encouraged to devote their public expenditures on R&D sectors preferentially to the research infrastructures.

Research infrastructures are the "backbone" for conducting excellent high-tech knowledge-intensive R&D on one hand. On the other one, the major pre-condition for their effective operation is the long-term budgetary stability and predictability. Thus, only the long-term political and financial commitment will enable the research infrastructures to adopt strategy decisions concerning their technological and expertise development, which usually extend beyond a one decade period, to ensure that they are able to maintain high standards of performance.

The Czech Republic will continue in harmonizing its research infrastructure approaches in line with good practice examples agreed at the ESFRI and e-IRG levels.

The process of updating the Roadmap of Large Infrastructures of the Czech Republic will continue to be synchronized with the ESFRI Roadmap updates in order to be able to provide the pan-European research infrastructures applying for the ESFRI Roadmap with involvement and participation of the Czech research infrastructures with both the political and financial commitment.

At the national level, the key emphasis will be put on creating a stable, predictable and long-term funding framework for operation, further technological development and capacities and capabilities building of research infrastructures. The political commitment for funding of Large Infrastructures will extend for the 7-year period as the EU Framework Programmes for R&D and EU cohesion policy instruments do. Only if such an approach is assured, will the research infrastructures be enabled to make long-term strategy decisions on their future development and their involvement in international networks. An increased attention will also be paid to the "interim" evaluation of Large Infrastructures and the analysis of their socio-economic impacts.

The success of a research infrastructures policy is seen in ensuring the quality, reliability and accessibility of technical devices, expertise and data. Generally, it is essential to ensure a user friendly access to all these constituents and easy processing methods. At its best, R&D generated by using research infrastructures benefit research communities, industries, businesses, public administration and the general public.

9|

Structure

The Roadmap of Large Infrastructures for Research, Experimental Development and Innovation of the Czech Republic for the years 2016–2022 contains the outcomes of the 2014 comprehensive ex-ante evaluation of research infrastructures of the Czech Republic. It comprises the total of **58 positively assessed research infrastructures** with the indicated degree of priority for the public funding (A1, A2, A3 and A4) in direct proportion to the quality-differentiated output of the evaluation. The Roadmap is divided into 6 disciplinary areas of:

1) Physical Sciences;
2) Energy;
3) Environmental Sciences;
4) Biomedicine;
5) Social Sciences and Humanities;
6) ICT/e-infrastructures.

Each chapter is introduced by a **landscape analysis** putting individual R&D facilities into the research infrastructures landscape of the Czech Republic and identifying any persistent "gaps", drafting the outlook for future development and presenting the possible scenarios for eventual clustering of research infrastructures (if applicable).

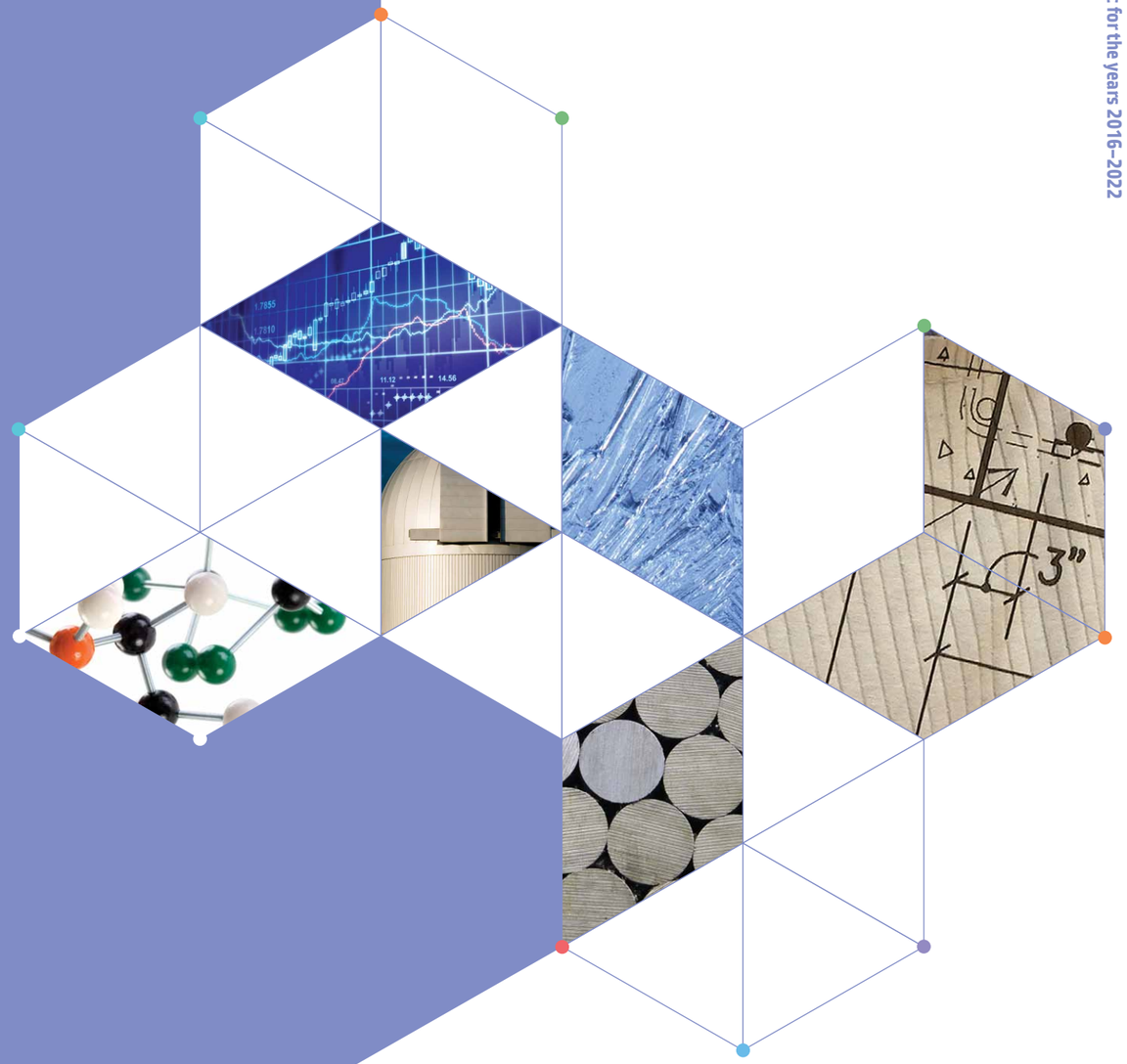
Each research infrastructure included in the Roadmap is described within a **business plan** comprising the background description (genesis, technological devices, knowledge expertise provided and involvement in the ERA), outlook for its future development and information on its socio-economic impacts.

The Roadmap of Large Infrastructures for Research, Experimental Development and Innovation of the Czech Republic for the years 2016–2022 was prepared by the MEYS in a close cooperation with **6 Expert Working Groups** specialized on the 6 respective scientific areas of the Roadmap. After that, the Roadmap was reviewed by the **Council for Large Infrastructures for Research, Experimental Development and Innovation** and **International Peer-Review Committee.**

Physical Sciences

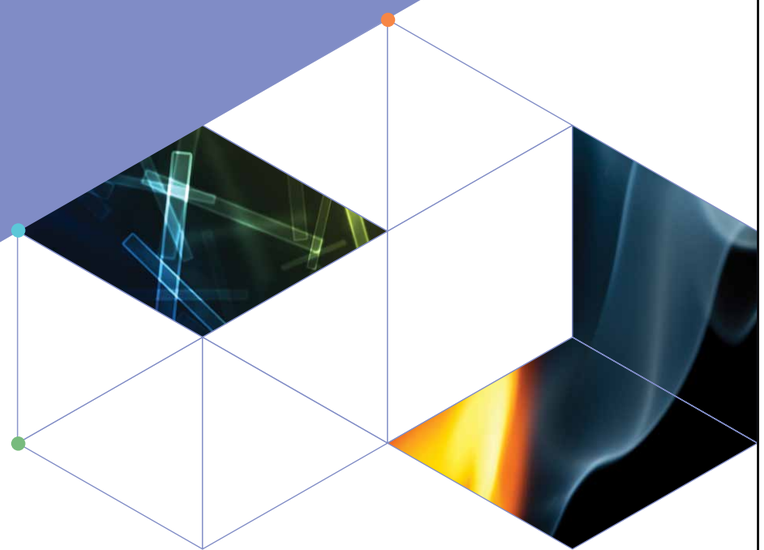
10.1

page



R&D in physics usually require extensive, technologically demanding facilities that allow not only to keep pace with the world-class nuclear and particle physics research, but also to perform excellent material development of structures, compositions and apparatuses for measuring the adequate sets of material parameters using complementary macro-scopic and micro-scopic methods.

The operation and development of unique R&D facilities is very costly and usually exceeds the financial resources of a single research organisation, region, or even a country. Their effective use can be achieved only by integrating these facilities in research infrastructures serving the wider research community. The landscape of research infrastructures of the Czech Republic operated in the field of physical sciences is thus complemented by the participation in a number of international facilities located in Europe or in the United States.



Nuclear and particle physics

Nuclear and particle physics research requires extensive infrastructures and is performed in large international laboratories. Scientists from the Czech Republic have a strong position in the field and participate in the major experiments.

Since its origin the Czech Republic has been a Member State of CERN (*Conseil Européen pour la Recherche Nucléaire*, Switzerland) – the world number one research infrastructure for the fundamental properties of matter – and has actively participated in its activities not only by being involved in experiments such as ATLAS or ALICE, but also by obtaining important contracts for supply of technological equipment. The research infrastructure **CERN-CZ** covers and organizes the participation of Czech research teams in CERN and supports development, construction, maintenance and operation of the research facilities in CERN experiments, including a Czech research infrastructure for development and fabrication of unique facilities as detectors or data processing technologies used in CERN.

The Czech research community participates also in experiments carried out on the Tevatron facility in the **Fermilab** (*Fermi National Accelerator Laboratory*, United States). Although the operation of Tevatron was stopped in 2011, whereas only already obtained data are analysed, nowadays the FERMILAB is concentrated at the "Intensity Frontier" programme presented by neutrino experiment NOvA.

As for the experiments based on high energy heavy-ion collisions, the Czech researchers have unique opportunity to use the accelerator in the **BNL** (*Brookhaven National Laboratory*, United States). The **LSM** (*Laboratoire Souterrain de Modane*, France) covers the research of processes in particle physics such as dark matter or neutrinoless double beta decay that requires measurements of very small signals.

The main goal of the **AUGER-CZ** (*Czech participation in Pierre Auger Observatory*, Argentina) is a contribution to deeper understanding of the properties of production and transportation of cosmic rays of ultra-high energies in the Universe. The **CTA-CZ** ensures involvement of the Czech Republic in design, construction, operation and maintenance of facilities of the world astroparticle physics research infrastructure CTA (*Cherenkov Telescope Array*). It comprises the involvement of Czech teams in the management and expert panels and scientific groups of CTA and allows discoveries of a number of new astrophysical sources of gamma rays. The **FAIR** (*Facility for Antiproton and Ion Research*, Germany) facilitates the Czech research community unique experiments with antiproton and heavy ion beams.

Radiation based sciences

Radiation of photons, neutrons and charged particle beams is a key technology for R&D in many fields such as materials and biological sciences. The Czech Republic hosts a number of national sources and is a member of several international laboratories.

The Czech participation in the **ESRF** (*European Synchrotron Radiation Facility*, France) gives extensive opportunities for experimental use of one of the strongest resources of synchrotron radiation. One of the most traditional and well developed Czech participations in research infrastructures situated abroad is the **Materials Science Beamline at ELETTRA Synchrotron** (Italy), which provides unique experimental equipment for photoemission spectroscopy. The distributed **SPL-MSB** research infrastructure has a user access through a common entry point of CERIC ERIC (*Central European Research Infrastructure Consortium*). The Czech Republic is also a member of **XFEL** (*X-ray Free Electron Laser*, Germany), which is currently under construction and will be the most powerful source of short pulse X-rays.

The long-term Czech membership in the **ILL** (*Max von Laue and Paul Langevin Institute*, France) provides the research community with excellent experimental opportunities offered by the strongest stationary resource of neutrons in the world. The Czech in-kind contribution to the ILL 20/20 programme consisted in successful finalizing of the ThALES project.

The ESS (*European Spallation Source*, Sweden) is currently under construction and will be the world's most powerful source for pulsed beams of cold neutrons. During the construction phase, the **ESS Scandinavia-CZ** consists mainly in the delivery of design and construction of the *Beamline for European Engineering Research* and other technological devices for the ESS.

The **VdG** (*Van de Graaff Proton Accelerator – A Source of Tunable Monoenergetic Neutrons and Light Ions*) is an adjustable monochromatic source of neutrons for the purposes of realisation of the most important projects in neutron physics. One of those will involve also adaptation of the HV2500 accelerator to the so-called "ESA Approved Neutron Facility", which will be used for testing the detectors for space research and associated electronics in view of sensitivity to neutrons and resistance to space radiation.

Cooperation within the **SPIRAL2** (*Système de Production d'Ions Radioactifs en Ligne*, France) ensures worldwide competitiveness via production of primarily radioactive beams by the isotope separation method ISOL.

The Czech research community has a broad portfolio of opportunities to participate in all the most powerful research infrastructures in Europe and in the United States. The involvement is ensured by the Czech partner facilities operated as national research infrastructures on one hand, and serving as access points to these international facilities on the other. These enable not only the researchers to keep pace with peak experimental results, but allow also the high-tech industry to take part in tenders for development and delivery of upgraded and new instrumentation. Apart from these obvious benefits, hi-tech deliveries create the need of innovative solutions and stimulate "in-house" research within the companies.

It is crucial that the Czech Republic continues to be involved in all the above-mentioned facilities as they enable the Czech research community to maintain the current qualitative level of nuclear and particle physics, as well as radiation based sciences. R&D in these fields performed at high quality research infrastructures brings also significant multiplying effects into other physical and material sciences areas.

Laser physics

The Czech researchers form an integral part of the international laser community (LASERLAB EUROPE – *Integrated Initiative of European Laser Research Infrastructures*). This enables not only the use of external laser capacities, but it has led to the placement of PALS into the Czech Republic and resulted in building such internationally recognized expertise of Czech scientists, which further on, could be utilized in the decision to build the world's most powerful laser system – ELI Beamlines – in the Czech Republic.

The **PALS** (*Prague Asterix Laser System*) is a first-class facility for the research and application of laser plasma, interaction of radiation with matter and X-ray lasers and plays a major role in the development of laser sources of highly charged ions with energies in MeV/nucleon. The PALS, which tasks cover also providing the facilities for material properties research under extreme temperatures and pressures and unique research and application projects in the surface modification, gave the basis for construction of the most ambitious laser facility worldwide.

The **ELI Beamlines** (*Extreme Light Infrastructure*) will produce an entirely new generation of secondary sources driven by ultra-intense lasers producing flashes of X-rays and gamma-rays, bunches of accelerated electrons, protons and ions. These will support the research focused on X-ray sources driven by the ultrashort laser pulses, particle acceleration by lasers, applications in molecular, biomedical or material sciences, plasma physics, physics of high energy densities and warm dense matter and exotic and frontier physics. The ELI Beamlines lasers will produce electromagnetic radiation (light) of extreme properties with the radiation intensity many times exceeding the current capacities worldwide and serve as the multiple purpose facility for the fundamental research of interaction of radiation with the matter under the ultrarelativistic regime for testing the materials, development of new diagnostic methods in medicine and advanced radiotherapy methods and for the verification of new methods based on the obtaining energy from the nuclear fusion using inertial confinement with lasers.

The 3rd Czech laser physics research infrastructure, the **HiLASE** (*New Laser for Industry and Research*) will provide the research community with "next generation" laser technologies based on the highly efficient laser emitting diode (LEDs) pumped solid state amplifiers. The diode pumped solid state laser (DPSSL) technology will bring a unique combination of high peak laser power, high average power and high pulse repetition rate.

The decision to develop the world's most powerful pulse laser – ELI Beamlines – in the Czech Republic resulted from the widely recognized high expertise of the Czech laser physicists proved by the assembly, operation and scientific results of PALS. The Czech Republic has currently all the necessary prerequisites to host top-class laser scientists and to become the world's leading centre of laser science excellence. The future development of laser research infrastructures in the Czech Republic will bring also new challenges concerning the high-tech instrumentation required for experiments in different laser R&D fields.

The ELI Beamlines construction phase is supposed to be accomplished by 2018. It forms one of the 3 pillars of pan-European ELI research infrastructure, which scientific importance is empowered by its symbolic value – being the 1st and only ESFRI research infrastructure built entirely in the newer EU Member States (i.e. Czech Republic, Hungary and Romania). Its successful operational phase is subject to the establishment of ELI ERIC in close cooperation with ELI DC AISBL Member States and other interested countries. Major involvement of the worldwide laser physics community in the ELI Beamlines, HiLASE and PALS programmes is then the key prerequisite for efficient use of these facilities and their long-term sustainable development, both in scientific and financial terms.

Material physics

Preparation, characterization and utilization of new (nano-) materials, functional materials and nanostructures emerged in the Czech Republic in recent years. The **CEITEC Nano** (*Central European Institute of Technology*) provides complex equipment, expertise and methods for nanotechnology and advanced materials R&D. The CEITEC Nano facilities for nanofabrication, nanocharacterization and structural analysis and X-ray tomography/LIBS enable to carry out complete fabrication of nanostructures and nanodevices and their characterization down to the sub-nanometre level in an entirely clean environment. The **CEMNAT** (*Centre of Materials and Nanotechnology*) serves for the basic and applied R&D in the fields of physics, chemistry, synthesis of new materials and their characterization while the **IPMINFRA** (*Infrastructure for Study and Application of Advanced Materials*) addresses advanced materials studies. Testing, evaluation and prediction of important material properties such as mechanical (fatigue and creep, their interaction and fracture behaviour), magnetic and thermodynamic properties and their relations to the structure (phase morphology, compositions etc.) of new advanced engineering materials is of crucial importance for their development and applications.

Experimental opportunities arising from methods using the interaction of neutrons with ions and materials at a microstructure level are offered by the **CANAM** (*Centre for Modification and Analysis of Materials with Ions and Neutrons*). The CANAM with its accelerators and equipment provides analytical and radiation services. The cyclotron U-120M is used for the nuclear reactions research and for the preparations of radionuclides for their utilization in radiopharmaceuticals. It serves also as a unique source of fast neutrons. The electrostatic accelerator Tandetron 4130MC is used for the material analysis with ion beams and material modification by ion implantation. Experimental equipment installed on the neutron radiation channels of LVR-15 reactor is intended for structural and elementary analysis of materials with neutrons.

The **LNSM** (*Laboratory for Nanostructures and Nanomaterials*) operates the facilities for semiconductor nanostructures and a laboratory for voluminous nanomaterials while the main mission of **SAFMAT** (*Centre for Analyses of Functional Materials*) is to create conditions for interdisciplinary R&D on crossroads between physics, material sciences, engineering and medicine, particularly in the areas of surface analysis of functional materials, materials for medical and high-tech devices and biomaterials.

A certain gap in laboratory equipment for new material (nano-) science in the Czech Republic derived from the world outburst in the search for new materials and progress in nanotechnology. Now, after the 1st batch of research infrastructures financed by the ERDF is almost finished and state-of-the-art instrumentations purchased, the gap seems to be filled. Nevertheless, profiles of the most individual material physics research infrastructures are relatively close to each other and therefore their narrower specification and specialisation is necessary in the future. The next features of their development will comprise the sustainability phase of apparatuses as well as development of abilities to innovate the instrumentations as quickly as new challenges in the material R&D will arise.

Astronomy, astrophysics and space

The Czech participations in Pierre Auger Observatory (**AUGER-CZ**) and Cherenkov Telescope Array (**CTA-CZ**) described within the particle physics research infrastructures landscape are both closely connected to astrophysics as well.

The **ESO** (*European Southern Observatory*) is currently the most important partner for the Czech Republic, being its Member State, in the astronomy research. The **EU-ARC.CZ** is the cutting-edge observational facility for astrophysics constructed and operated in worldwide cooperation enabling access to ESO, including participation in the ALMA project (*Atacama Large Millimeter/sub-millimeter Array*) and E-ELT (*European Extra Large Telescope*). Its huge potential covers all the areas of modern astronomy and astrophysics.

The Czech Republic also entered the **ESA** (*European Space Agency*), where focus is put on the space R&D and development of cosmic technologies. When participating in particular ESA R&D projects the Czech users may utilize the ESA facilities, including the European spaceport CSG (*Centre Spatial Guyanais*) and European Columbus Module at ISS (*International Space Station*) and 5 ESA R&D centres – EAC (*European Astronauts Centre*); ESAC (*European Space Astronomy Centre*); ESOC (*European Space Operations Centre*); ESRIN (*European Space Research Institute*); and ESTEC (*European Space Research and Technology Centre*).

The major R&D fields of astronomy, astrophysics and space are fully internationalized, which is clearly beneficial for the countries of smaller size and limited opportunities like the Czech Republic. Due to the involvement in international research infrastructures annotated above the Czech research community has at its disposal top-class facilities that significantly surpass possibilities of their home institutions. Therefore the Czech research infrastructure landscape in astronomy, astrophysics and space – being complemented by the membership of the Czech Republic in ESA and ESO – satisfactorily covers the needs of relevant research community.

Pierre Auger Observatory – participation of the Czech Republic

Acronym:
AUGER-CZ

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

Partner institutions:
- Charles University in Prague
- Palacký University in Olomouc

Responsible person:
ŘÍDKÝ Jan
ridky@fzu.cz

Website:
www-hep2.fzu.cz/Auger

Background description

For about a decade the Czech Republic has been contributing to the construction, operation, maintenance and improvement of the detection facilities of the Pierre Auger Observatory – the largest cosmic ray detector in the world located on more than 3000 km^2 in Argentinean pampa. This international research infrastructure has 17 participating Member States and combines 2 detection techniques – fluorescence telescopes and array of surface detector stations. Both these systems study the highest energy cosmic rays coming to the Earth from the Universe. By participation in the Pierre Auger Observatory, the research community of the Czech Republic jointly with international partners contributes to a deeper understanding of the physical properties of cosmic particles. The significant role of Czech involvement in the Pierre Auger Observatory can be demonstrated by the fact that the Czech research group has taken the responsibility for the operation of the fluorescence detector system of the Pierre Auger Observatory for many years. Furthermore, Czech glass mirrors have been installed in 15 out of 27 fluorescence telescopes of the Pierre Auger Observatory. Therefore, one of the main goals of the Czech contribution to Pierre Auger Observatory is to continue in developing technological solutions of optical and other systems for fluorescence telescopes and other devices dedicated to the study of cosmic rays and monitoring of the atmosphere. The Czech experts also test, both in the laboratory and in the Pierre Auger Observatory, new detection techniques and systems for the study of cosmic rays and participate in the upgrade of the Pierre Auger Observatory. Collaborations of the research infrastructure AUGER-CZ at the national level are established in particular with the RCPTM (*Regional Centre of Advanced Technologies and Materials in Olomouc*) and CESNET e-infrastructure, which cooperates on the administration of central computing servers of the Pierre Auger Observatory.

Future development

Being in a successful operational phase for years, the Pierre Auger Observatory is currently undergoing a substantial upgrade of the surface array, which is planned to enhance the capabilities of the Pierre Auger Observatory with the aim to distinguish the types of primary cosmic ray particles, study the particle physics beyond the reach of accelerators and enhance investigation of puzzles of cosmic rays. The Pierre Auger Observatory upgrade consists mainly of the addition of scintillator counters above the existing surface detectors and enhanced operation of the fluorescence detector system.

Socio-economic impact

The participation of the Czech Republic in operation and other activities of the Pierre Auger Observatory is an example of application of Czech skills and long tradition in optical systems development in highly prestigious international research infrastructure. The Pierre Auger Observatory is recognized by the relevant industries as a project with successful application of Czech products and technology. Czech companies involved in production of glass, optical instruments and mechanical devices profit from delivery of their products installed at the Pierre Auger Observatory and in this way they increase their international competitiveness.

Brookhaven National Laboratory – participation of the Czech Republic

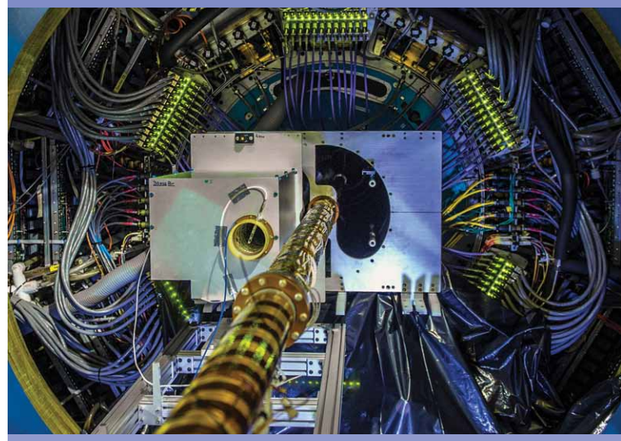
Acronym:
BNL-CZ

Hosting institution:
Czech Technical University in Prague

Partner institutions:
- Charles University in Prague
- Nuclear Physics Institute, Academy of Sciences of the Czech Republic

Responsible person:
BIELČÍK Jaroslav
jaroslav.bielcik@fjfi.cvut.cz

Website:
bnl.phys.cz



Background description

The BNL-CZ facilitates access and supports participation of the Czech research community in the Brookhaven National Laboratory (BNL) in the United States. The BNL is one of the largest multidisciplinary 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. The BNL-CZ provides access to several world unique scientific instruments, the BNL's *Relativistic Heavy Ion Collider* (RHIC), *National Synchrotron Light Source and Brookhaven Linac Isotope Producer*. Significant contributions in experiments at RHIC have been made by the Czech researchers in exploration of nuclear matter, proton spin structure and research and development of new detector technologies. Therefore one of the main goals of the BNL-CZ is to facilitate future access to experimental facilities at RHIC, allowing continuation of Czech participation in the STAR and PHENIX experiments, and taking part in development, construction and operation of cutting edge detectors. The BNL-CZ also grants the access to the "RHIC Computing Facility" – a large-scale computing centre used for analyses of data collected at RHIC. The local part of the BNL-CZ supports development and maintenance of the computing cluster *Sunrise* at the Faculty of Nuclear Sciences and Physical Engineering of the Czech Technical University in Prague. The research programme of the BNL is fully complementary to the research programmes carried by the CERN experiments.

Future development

The experimental programme at the RHIC has perspective for many years ahead. The current and future upgrades of the STAR and PHENIX experiments will further strengthen the scientific goals of the BNL. In the short term the scientific focus will be to fully explore the heavy flavour sector and study properties of Quark Gluon Plasma utilizing the recently upgraded detectors. In addition the phase structure of nuclear matter and critical point search will continue. In the long term the spin programme at RHIC and also more precise measurement of cold nuclear effects and flavour tagged jets will be completed and community will move towards the construction of an *Electron Ion Collider* and studies of QCD with gluons.

Socio-economic impact

The BNL has developed very strong cooperation with the commercial sector. Similarly, the BNL-CZ has a strong potential for commercial applications that is related to the Laboratory for Advanced Detection Technologies located in the Czech Technical University in Prague. The laboratory specializes in development of silicon sensors and read-out chips using deep submicron technology and it has developed very good cooperation with the international community interested in detector R&D.

Center of Accelerators and Nuclear Analytical Methods

Acronym:
CANAM

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

Responsible person:
DOBEŠ Jan
dobes@ujf.cas.cz

Website:
canam.ujf.cas.cz

Background description

The CANAM operates several different types of accelerators and neutron facilities, which are used in a wide range of scientific and technological disciplines. The ions are prepared at the isochronous cyclotron accelerator U-120M and at the electrostatic linear Tandetron 4130M accelerator. The facilities for studies with thermal neutrons are installed at the irradiation channels of the LVR-15 research reactor operated by the Řež Research Center. Fast neutrons are obtained from production targets at the cyclotron U-120M. The possibilities and scope in combination with different techniques using the ion and neutron beams (which can be implemented in synergic combination in the CANAM laboratories) are unique, even at the international level. The production, modification and complex characterization methods of CANAM are offered with employment for basic and applied studies in various R&D fields such as physics, materials sciences, chemistry, biology, biomedicine, energetics, microelectronics, environmental sciences, archaeology, cultural heritage, etc.

Future development

Permanent effort is devoted to developing, upgrading and modernizing the CANAM laboratories. At present, the most important enlargement is the purchase of the new TR-24 cyclotron, which substantially increases the possibilities in the research of radionuclide production, with applications mainly in medicine and life sciences, and in fast neutron studies, with an impact on the development of future fission and fusion technologies. Other significant developmental step is considered, namely the purchase of an Accelerator Mass Spectrometry (AMS) system, presently not available in the Czech Republic.

Socio-economic impact

Both ion and neutron beams are important for their performance in various targeted applications, which are important not only for the scientific community, but also for the commercial sector, as the development of new materials and technologies, nanostructure synthesis, ion beam micromachining, radiation hardness of electronic elements, and nuclear data for fusion and advanced fission systems. Cooperation between CANAM and the commercial sector concentrates not only on solving common R&D projects and tasks, but also on providing services at the CANAM facilities and expertise.

CEITEC Nano

Acronym:
CEITEC Nano

Hosting institution:
Brno University of Technology

Partner institution:
Masaryk University

Responsible person:
ŠKODA David
david.skoda@ceitec.vutbr.cz

Website:
www.ceitec.eu/ri-ceitec-nano

Background description

The CEITEC Nano provides open access to technological equipment for research in the areas of nanotechnologies and nanosciences. The research infrastructure consists of 2 core facilities – *Core Facility Nanofabrication and Nanocharacterization* and *Structural Analysis Laboratory* – which provide complex processes for fabrication and characterization of nano objects up to the sub-nanometre scale in a dustless environment with high cleanliness. Research fields employing the capacity of CEITEC Nano include physics and chemistry of low-dimensional systems (spintronics, nanoelectronics), material sciences, including solidstate physics, chemistry, surface engineering, biochemistry, bioengineering and biomedicine. The portfolio of provided services is focused on the processes of fabrication and analysis using excellent devices, which offer detailed information for the study of surfaces, interfaces, nanostructures and nanomaterials. As a part of fundamental research, CEITEC Nano enables the users to create nano- or micro-structures based on his or her own design from the wafer (silicone substrate), analyse or check the results of the processes step by step, encapsulate the created parts and test them, optimise the technical process using sophisticated analytical techniques, divide almost any large object into samples and analyse those samples up to the atomic resolution, regarding their surface and volume morphology, chemism and crystal composition. The CEITEC Nano further opens the ways to the collaboration between research teams focusing on nanobiology or nanomedicine. Owing to the fabrication and characterization methods, CEITEC Nano users can profit from a unique and complex set of devices and expert background for nanofabrication and nanocharacterization.

Future development

Over the short term, the remaining equipment of the CEITEC Nano purchased by using the ERDF will be installed and tested. Over the medium term, it will be necessary to further increase the level of expertise in the research infrastructure, both in terms of modernization of the gradually obsoleting equipment, and in terms of developing human resources, so that the current high international standards are maintained.

Socio-economic impact

One of the most important characteristics of CEITEC Nano is the open access to technological equipment of the research infrastructure with shared self-service equipment, which enables researchers to control devices without help. Further, together with the sharing of research know-how between the users and the CEITEC Nano staff, enables the research groups to reach high expertise and international level. The positive impact of CEITEC Nano is also the cooperation with high-tech companies on development of products with high technological and knowledge added value.

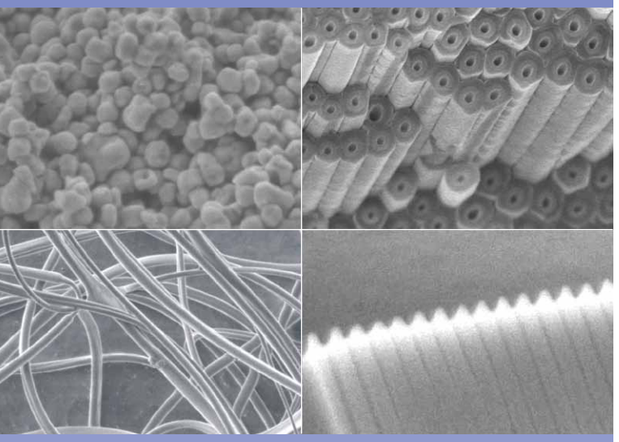
Centre of Materials and Nanotechnologies

Acronym:
CENMAT

Hosting institution:
University of Pardubice

Responsible person:
VLČEK Miroslav
miroslav.vlcek@upce.cz

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



Background description

The CEMNAT enables R&D activities in materials sciences with use in photonics, electronics, photovoltaics and catalysis. Based on its resources the research infrastructure CEMNAT provides synergic opportunities to external users from the research and industrial sectors. The portfolio of expertise in synthesis, characterization and applications of both inorganic and organic materials focuses on applications in photonics (metamaterials, 3D photonic crystals, opals), electronics and electrical engineering (memories, thin conducting layers, RFID antennas), renewable energy resources (1D nanotubes and nanoparticles for solar cells and baterries) and chemically active surfaces (zeolites, silica, alumina as membranes or nanofibers). Services of the CEMNAT include consultancies, syntheses or characterizations of materials. The instrumental equipment of the CEMNAT comprises dual SEM/FIB microscope, SEM+EDX, DSC, TG-GS-MS, ALD, PVD, PLD or flash-evaporation, photo- and electro-chemical work stations, glove boxes, flow box, optical microscopes and spectrophotometers.

Future development

The CEMNAT will focus on research of high performance materials, their characterization and exploitation in applications. The aim will be given to amorphous chalcogenides (bulks, thin films) and nanostructured inorganic oxides (nanotubes, nanofibers, nanoparticles). Applications of these materials will be in electronics, optics, solar cells, energy storage, catalysis.

Socio-economic impact

The instrumental equipment and expertise of the CEMNAT will assure effective technology transfer and development of cooperation of the research infrastructure users with industry. The CEMNAT will also focus on education of qualified young researchers through advanced master and doctoral programmes.

Research Infrastructure for Experiments at CERN

Acronym:
CERN-CZ

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

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

Responsible person:
KUPČO Alexander
kupco@fzu.cz

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

Background description

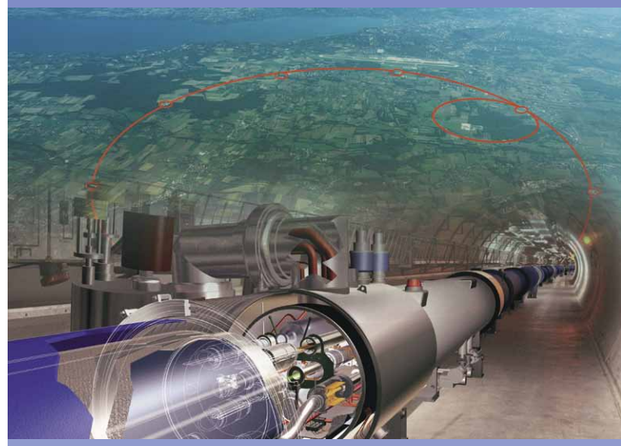
The CERN-CZ organizes and promotes the participation of the Czech research community in the international particle physics laboratory CERN (*Conseil Européen pour la Recherche Nucléaire*) in Geneva. The CERN, with the world's largest collider LHC (*Large Hadron Collider*), plays the leading role in experiments on the energy frontier. Following one of its principal roles, the CERN also organizes the European research in particle physics. The CERN-CZ aims to support the Czech contribution to developing, construction, maintenance and operating of scientific instruments in CERN experiments, including the infrastructure located in the Czech Republic necessary for R&D, detector construction, and for processing data collected by the CERN experiments. The CERN-CZ promotes new technologies for particle physics detectors and their applications and provides the expertise in the area of particle physics instrumentation, in calorimetry, tracking detectors based on semiconductors (including R&D of radiation hard detectors), detector construction, cooling, cryogenics, vacuum, electrical design, mechanical design, and data processing. The portfolio of services covers operating and maintenance of scientific devices, many of them built partially in the Czech Republic; upgrade of existing detectors and construction of new ones; operation of a computer centre, which serves as the national Tier2 centre in the CERN computer network; coordination of CERN projects through the Committee for Cooperation of the Czech Republic with CERN, and representation of the Czech Republic in CERN governing and advisory bodies, Committees and Boards of the CERN Experiments. Unique experimental devices built with the contribution of the Czech research organisations constitute the core of CERN-CZ and they allow the Czech research community to contribute adequately to the world-class results in particle and nuclear physics produced by the CERN experiments.

Future development

Development plans of the CERN-CZ closely follow the plans of the main CERN facilities, in particular the plans for the LHC high luminosity upgrade foreseen for the years 2022–2025, which will lead to a tenfold increase in the frequency of precipitation. The Czech research organisations are involved in 2 major LHC experiments: ATLAS (*A Toroidal LHC Apparatus*) and ALICE (*A Large Ion Collider Experiment*) and several smaller experiments. The LHC experiments have to build new detectors able to operate in the harsh environment of high intensity beams. Significant resources of the CERN-CZ will be devoted to developing and construction of these new detectors. Upgraded LHC and the experiments are foreseen to be in operation until 2035 with the goal to collect luminosity of 3000 fb1.

Socio-economic impact

The CERN-CZ serves as a communication point, which enables know-how and innovation transfer to and out of the Czech research community. The ambitious CERN scientific program together with the opportunity to work with cutting-edge technologies attracts many experts not only from the field of particle physics. The participation in CERN projects increases the visibility and attractiveness of Czech research organisations. Deliveries and successful operation of numerous instruments built in the Czech Republic for CERN present technically demanding contracts for companies, which further stimulate innovation skills.



Cherenkov Telescope Array – participation of the Czech Republic

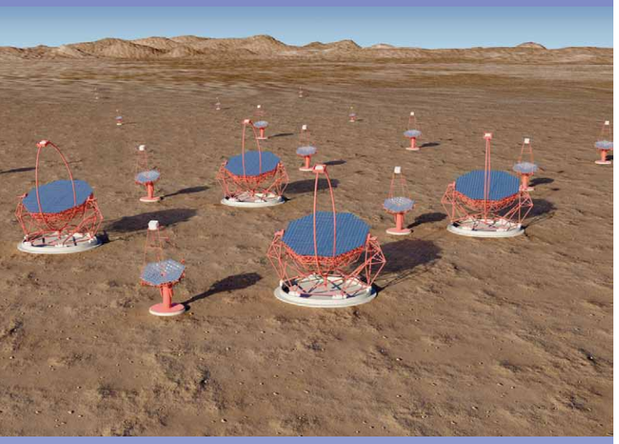
Acronym:
CTA-CZ

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

Partner institutions:
- Charles University in Prague
- Palacký University in Olomouc

Responsible person:
TRÁVNÍČEK Petr
petr.travnicek@fzu.cz

Website:
cta.fzu.cz



Background description

CTA is a European and international research infrastructure in astroparticle physics. It will enable the discovery of a large number of new astrophysical sources of gamma rays and determination of their characteristics. The research community of the Czech Republic is significantly involved in CTA preparation; namely the Czech researchers develop telescope mirrors as well as evaluate candidate sites for CTA location. Their participation in CTA includes involvement in organizational structures, expert panels and CTA scientific groups. The Czech research community developed the all-sky cameras and innovative methods for the analysis of satellite images in order to identify the optimal location for CTA. The research community of the Czech Republic will also continue in monitoring the atmosphere during the CTA operation, when another camera system with robotic telescopes (all provided by the Czech Republic) shall define detailed cloudiness conditions in real time during CTA observation. The CTA mirror prototypes and optical samples are extensively tested in the optical laboratory of the Palacký University in Olomouc and the Institute of Physics, Academy of Sciences of the Czech Republic. Czech opticians develop technology for future production of mirrors for the so-called *Small Size Telescopes* (SST), drawing on the expertise from the Pierre Auger Observatory. With respect to providing computing resources for CTA, the collaboration with CESNET e-infrastructure plays an important role.

Future development

The CTA is currently at the beginning of its construction phase, which is envisaged for 2016–2020. The final design and management decisions concerning the location, exact layout and technical realization should be finalized soon, so that the production of all CTA components can start simultaneously with development of the chosen sites (La Palma – Canary Islands, Paranal in Chile). This encompasses ground work, setting up infrastructure and engineering networks as well as production of experimental components such as telescopes, cameras, mirrors and various auxiliary devices. The Czech research community will continue in its activities, namely it will prepare several systems for the central calibration of CTA, and will participate in the production and deployment of SST mirrors

Socio-economic impact

The Czech Republic has been involved in CTA especially by the production of components for the camera systems used for selection of the CTA final location. The participation of the Czech Republic in CTA is important from the point of view of the long history of development of optical elements in the Czech Republic. Furthermore, the Czech involvement is crucial for ensuring the excellent level of astroparticle physics in the Czech research organizations.

Extreme Light Infrastructure – ELI Beamlines

Acronym:
ELI Beamlines

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

Responsible person:
ŘÍDKÝ Jan
ridky@fzu.cz

Website:
www.eli-beams.eu

Background description

ELI Beamlines is a key pillar of the world's first laser research infrastructure ELI (*Extreme Light Infrastructure*). ELI comprises 3 individual pillars: (1) ELI Beamlines – Dolní Břežany in the Czech Republic; (2) ELI Attosecond – Szeged in Hungary; and (3) ELI Nuclear Physics – Măgurele in Romania. The location of a 4th site – ELI Ultra-High Intensity – is to be determined. ELI Beamlines will develop a new generation of high energy, high repetition rate lasers and secondary sources driven by ultra-intense lasers. The ultra-short pulses of light and particles generated by ELI Beamlines will enable a broad range of R&D projects. In particular, ELI Beamlines will facilitate new R&D in molecular, biomedical and material sciences, physics of plasmas, physics of high energy densities, physics of warm dense matter and frontier physics. ELI Beamlines will host a high harmonic source and plasma source for material sciences and imaging studies and a Betatron source using laser accelerated electrons. ELI Beamlines will provide a platform for ultra-intense laser matter interactions, a platform for studying and providing controlled laser produced ion beams and a platform for laser driven electron acceleration process and collision studies for future extension of LUX to a free electron laser. ELI Beamlines has identified its main user groups, including partners from LASERLAB EUROPE (*Integrated Initiative of European Laser Research Infrastructures*), CRISP (*Cluster of Research Infrastructures for Synergies in Physics*) and HepTech (*High Energy Physics Technology Transfer Network*). ELI Beamlines cooperates with a number of leading research organisations such as DESY (*Deutsches Elektronen-Synchrotron*), LLNL (*Lawrence Livermore National Laboratory*), STFC (*Science and Technology Facilities Council*), Elettra – Sincrotrone in Trieste, INFN *(Istituto Nazionale di Fisica Nucleare*) or SLAC (*SLAC National Accelerator Laboratory*) to develop technologies and R&D programmes. Relevant Czech partner research organisations are members of the ELI-CZ consortium.

Future development

The construction of ELI Beamlines will be completed by commissioning of the major laser and experimental systems in late 2017. Starting in 2018, all pillars will be unified under the legal framework of European Research Infrastructure Consortium ELI ERIC. Following this, from the beginning of 2018 to mid-2019 the performance of all technology systems, and particularly the lasers, will be ramped up to the full specifications, involving the fine-tuning of operational conditions of each system in the context of integrated and complex operation of the whole facility.

Socio-economic impact

ELI Beamlines will host a major international research infrastructure attracting world leading researchers and businesses. The facility will provide more than 2200 researcher days per year yielding an additional local economic impact. By a projected workforce of more than 250 employees, ELI Beamlines will generate high-level long-term career opportunities for researchers, engineers and technicians, primarily those involved in optics and laser sciences, electronics, mechanical engineering, and material sciences. In addition, the Czech optics and photonics industry is expected to take a significant role in developments required for the construction of ELI Beamlines and future maintenance of its facilities.

European Spallation Source – participation of the Czech Republic

Acronym:
ESS Scandinavia-CZ

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

Responsible person:
LUKÁŠ Petr
lukas@ujf.cas.cz

Website:
www.europeanspallationsource.se

Background description

ESS (*European Spallation Source*) is a pan-European research infrastructure currently under construction in Lund, Sweden. It will be based on the world's most powerful spallation neutron source, producing intense neutron beams for a large array of instruments for studies of structure and dynamics of matter over very broad range of size scales and energies. The Czech Republic participates in the design and construction of one of these instruments – *Beamline for European Materials Engineering Research* – addressing the needs of future research of advanced materials for a broad area of applications. The participation in ESS will provide the Czech research community with access to all ESS instruments, allowing researchers to carry out cutting-edge research in various areas, such as condensed matter physics, chemistry, biology, geology or archaeology. ESS will provide experimental capacity to more than 2000 researchers from both academic and industrial areas every year, who will be given access to the advanced neutron scattering and imaging instruments, in many cases complementary to or outperforming the instruments available at the other neutron facilities. In addition, ESS will support users by providing specialized laboratory equipment, data analysis tools and instrument specialists assisting with the neutron experiments.

Future development

Construction of the ESS has started in summer 2014 and will continue until 2025. The design and construction of the main components (the accelerator, target station, neutron scattering systems and supporting facilities) is scheduled for 2016–2020. Production of the first neutrons is expected in 2020. At the same time, the first neutron scattering instruments, including the materials engineering diffractometer built with Czech participation, will enter the hot commissioning phase (2020–2023). The first external users of the facility are expected during this period, while the neutron source will be gradually increasing its power up to the designed 5 MW. As of 2025, ESS is expected to operate at full power with the planned suite of 22 instruments.

Socio-economic impact

Neutron methods can be applied to a broad range of scientific questions, spanning physics, chemistry, geology, biology, medicine, energy, engineering materials, geosciences, archaeology and heritage conservation. Neutron methods are important for development of new computer chips, cosmetics, detergents, textiles, paints, fuels, drugs, batteries and plastics. Industrial drivers – such as fuel cells, superconductors, innovative structural, engineering, climate, transportation and food technologies as well as pharmaceuticals, medical devices and clean energy – are dependent on advances in neutron science. Many products created and improved with the help of material sciences using neutrons are essential for maintaining a high quality of life.

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

Acronym:
EU-ARC.CZ

Hosting institution:
Astronomical Institute,
Academy of Sciences of the Czech Republic

Responsible person:
BÁRTA Miroslav
barta@asu.cas.cz

Website:
www.asu.cas.cz/alma

Background description

ALMA (*Atacama Large Millimeter/Submillimeter Array*) is a cutting-edge observational facility in astrophysics constructed and operated in the worldwide cooperation in Atacama Desert in Chile. The main partners in the ALMA consortium – ESO (*European Southern Observatory*), NRAO (*National Radio Astronomy Observatory*) and NAOJ (*National Astronomical Observatories of Japan*) – decided to form a user-support infrastructure in the form of 3 ALMA Regional Centers (ARCs). The European ARC is formed as a distributed network of 7 nodes centered in ESO and coordinated by the ESO headquarters in Garching near Munich. The Czech node EU-ARC.CZ provides services namely in ALMA research in solar physics, galactic and extragalactic astrophysics, physics of stars and interstellar matter, and laboratory millimeter spectroscopy. In all of these expertise areas the EUARC.CZ serves the ALMA user community in the entire region of Central and Eastern Europe. In the solar research the expertise of the node is unique even at the European scale. The services provided to the ALMA users´ projects range from help with proposal preparation (Phase I), negotiation of technical details of the project with the observatory (Phase II), data reduction and imaging (QA2) up to help with data analysis and interpretation. The EUARC.CZ also contributes to further development of ALMA – at the European scale it leads development and commissioning of the new solar observing mode. In fulfilling these tasks it closely collaborates with the other European ARC nodes and ESO.

Future development

Although the ALMA observatory has been officially inaugurated in 2013, it still operates in the "Early Science" regime and its development continues. New capabilities are introduced in line with the development plan, including the solar observing mode, developed in Europe by the EU-ARC.CZ. After the commissioning in 2016 a strong increase of services provided by the EU-ARC.CZ to the entire European solar physics community is envisaged. The number of proposals is expected to increase also in other areas of the node expertise in connection with the gradual increase of Central and Eastern European ALMA user community and with redistribution of the ALMA engineering time for science observations after 2016. Due to new demands increase of staffing and computer resources is also expected.

Socio-economic impact

ALMA faces high expectations concerning break-through discoveries in space research and fundamental physics. Presence of the EU-ARC.CZ accounts for direct involvement of the Czech research community in utilization and further development of this revolutionary instrument. Involvement of the Czech Republic in R&D with ESO brings chances for Czech high-tech industry companies in development and fabrication of technologies for cutting-edge astronomical instruments. Moreover, ESO is financing the commissioning of Solar ALMA Mode, whose development in Europe was delegated to the EU-ARC.CZ.

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

Acronym:
FAIR-CZ

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

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

Responsible person:
KUGLER Andrej
kugler@ujf.cas.cz

Website:
www.fair.ujf.cas.cz

Background description

Facility for Antiproton and Ion Research (FAIR) is a new European research infrastructure for nuclear and hadron physics under construction at Darmstadt in Germany as a part of the capacity of *GSI Helmholtzzentrum für Schwerionenforschung*. The Czech participation in FAIR, organized within FAIR-CZ, is anticipated to cover not only the 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*) research pillars of FAIR, but also activities in other fields of science such as radiobiology and biophysics developed in APPA (*Atomic, Plasma Physics and Applications*) research pillar of FAIR. Multidisciplinary aspect of FAIR-CZ represents its unique feature, supported by portfolio of services, such as support and infrastructure for development and production of complex scientific devices for FAIR experiments in the Czech Republic, coordinating access to research at FAIR, as well as to technologies developed in all 4 FAIR research pillars and operation of the computer centre in the main FAIR hosting institution, which serves as a national Tier3 centre of GRID computer network. After its completion, FAIR will be leading worldwide facility for hadron and nuclear physics for several decades. FAIR will be unique in areas such as production of highly-compressed plasma exploiting intense heavy-ion beams, with an unparalleled research program with cooled antiproton beam and internal-target storage-ring capabilities for Quantum Chromodynamics studies. The participation of the Czech research community in FAIR could be integrated in a Central European consortium of the Czech Republic, Hungary, Austria and Slovakia, which might become an associate member of FAIR in the future.

Future development

A number of complex detector systems is necessary to perform experiments at FAIR. The development of ECAL (*Electromagnetic Calorimeter*) for experiment HADES@FAIR and PSD (*Projectile Spectator Detector*) for CBM experiment are the main Czech contributions to the CBM pillar of FAIR. The Czech contributions to R&D and production of electromagnetic $PbWO_4$ calorimetry system, silicon tracking detectors or low mass superconducting passive shielding for transversely polarized gas targets in large angular acceptance spectrometer detectors as well as in particle identification system based on Ring Imaging Cherenkov detector technology and in a central Data Acquisition system are also planned in PANDA pillar of FAIR. First experiments exploiting FAIR are expected after 2019.

Socio-economic impact

Czech companies benefit from the involvement of the Czech research community in FAIR by delivering sophisticated research instruments for FAIR and thus improving their technological expertise. Specific examples are development of new silicon sensors with high densities of pads and with high tolerance to radiation, massive production of PbWO4 scintillators, ultra-high vacuum components or the new hardware and software solutions needed for the extremely high data rate.

Research Infrastructure for Fermilab Experiments

Acronym:
Fermilab-CZ

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

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

Responsible person:
LOKAJÍČEK Miloš
lokajicek@fzu.cz

Website:
www.particle.cz/infrastructures/fermilab-cz
www.fnal.gov

Background description

Fermilab-CZ supports and coordinates collaboration of the Czech research organisations in Fermilab (*Fermi National Accelerator Laboratory*), United States premier national laboratory for particle physics, operated by Fermi Research Alliance LLC for the United States Department of Energy. More than 4 200 scientists worldwide use Fermilab for their research. Fermilab-CZ supports the Czech contribution to detector design and construction, running and maintenance of the experiments and their upgrade. The Czech researchers also participate in Fermilab management bodies. Expertise of the Fermilab-CZ covers various areas such as detector design (e.g. silicon photodetectors), detector infrastructure monitoring, running and data acquisition and processing using novel statistical and artificial intelligence methods. It is reflected by provided services – detectors design and construction, their running, monitoring and maintenance, delivery of computing capacities for data processing from the Czech Republic and support of novel statistical and artificial intelligence methods for data analysis. Electromechanical workshops of the Fermilab-CZ in the Czech Republic perform long term detector tests and contribute to their upgrade. For the last 25 years, Fermilab has operated the proton–antiproton particle collider TEVATRON at highest achieved energy and produced world-class results. The operation of TEVATRON was finished in 2011. Nowadays, Fermilab concentrates on the "*Intensity Frontier*" programme with neutrino experiments. The Czech researchers collaborate on its flagship neutrino experiment NOvA.

Future development

The neutrino NOvA experiment should run at least for another 6 years. Fermilab is advancing plans for international long-baseline neutrino experiment, which aims to discover whether neutrinos and antineutrinos interact with matter differently. This experiment would send a neutrino beam from Fermilab to a large neutrino detector located in a mine in South Dakota. The experiment of such an extent requires worldwide contributions including CERN test beam facilities.

Socio-economic impact

The use of particle accelerators to treat cancer and other contributions to the development of medical imaging techniques such as PET scans (*Positron Emission Tomography*) and MRI (*Magnetic Resonance Imaging*) represent examples of particle physics applications. Particle accelerators shrink tumours, improve tires, spot suspicious cargo, clean up dirty drinking water, help design drugs or discover building blocks of matter. In this way, FermilabCZ guarantees access for a broad area of expertise to many physicists, students and technicians and allows them to contribute to newly developed technologies.

HiLASE: New Lasers for Industry and Research

Acronym:
HiLASE

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

Responsible person:
MOCEK Tomáš
mocek@fzu.cz

Website:
www.hilase.cz

Background description

HiLASE represents excellent technological infrastructure in the field of laser research and development at the European level. The "next generation" laser technology is based on highly efficient *Diode Pumped Solid State Laser* (DPSSL) amplifiers. One amplifier concept utilizes a thin-disk on a heatsink as the laser active medium, while in the other one we use a cryogenically cooled multi-slab architecture. In both types of the amplifier design, DPSSL technology brings a unique combination of high average power, high pulse repetition rate and high efficiency. The only way to test durability and long term stability of an optical component is to measure precisely the value of *Laser Induced Damage Threshold* (LIDT) by exposing the same spot on the surface of the material to a large number of high power laser pulses and observing the occurrence of damage. The multi-purpose experimental station for laser-matter interaction at HiLASE will allow experiments relevant to LIDT process in the air or in a vacuum. *Laser Shock Peening* (LSP) is a progressive and very efficient surface enhancement process which is used to increase the resistance of metals to surface-related failures, such as fatigue, fretting fatigue and stress corrosion cracking. The LSP station equipped with a robotic arm will allow surface processing of materials according to industrial standards. Over the last 3 years since the HiLASE project launch, cooperation with more than 10 top foreign research organisations has been started in specific areas relevant to DPSSL's development and its applications.

Future development

In order to significantly extend its application potential HiLASE will focus primarily on development of pulsed multi-kW thin-disk DPSSL systems for industrial and scientific applications, which will lead to efficient generation of THz waves with picosecond pulse length and high average power, and/or compact bright EUV radiation source for metrology, lithography and micro-processing. Further development and optimization of the 100J/10Hz laser system will be accompanied by increasing the repetition rate up to 100 Hz for limited energy output, and with developing a short-pulse laser beam. Development of key technologies related to high repetition rate amplifiers and their applications will include a smart diagnostic system for LIDT station and setup for advanced processing and micro-machining methods.

Socio-economic impact

HiLASE includes a combination of various research fields such as material research or biomedical engineering with laser physics and development of laser technologies. Those linkages of experts with different scientific backgrounds have a great potential to lead to the establishment of completely new scientific fields as well as to extensive applications of laser technologies in industry.

Institut Laue-Langevin – participation of the Czech Republic

Acronym:
ILL-CZ

Hosting institution:
Charles University in Prague

Responsible person:
JAVORSKÝ Pavel
javor@mag.mff.cuni.cz

Website:
www.ill.eu

Background description

ILL-CZ ensures the long-term membership of the Czech Republic in Institut Laue-Langevin (ILL) in Grenoble, which opens for the Czech research community extensive opportunities to perform unique experiments using top instruments installed in ILL as the most intense stationary neutron source in the world. The Czech membership in ILL provides access to ILL facilities and provides the possibility to perform neutron scattering experiments. There are about 40 unique instruments available for users in ILL, covering all fields of neutron scattering as diffraction, large scale structures investigation, dynamics studied by time-of-flight, highresolution and three-axis spectrometers or nuclear and neutron particle physics. The neutron scattering experiments are essential part of research in many areas of physics, materials science, chemistry or biochemistry. Such experiments provide indispensable microscopic information about the studied materials. The access to experimental infrastructure of ILL and related direct involvement in activities of international neutron research community is essential for the Czech neutron research community, which is steadily growing.

Future development

The list of available instruments does not change considerably over time, but the instruments itself are continuously and significantly upgraded or replaced by completely new ones with the same focus. Excellent example represents the ThALES (*Three Axis Instrument for Low Energy Spectrometry*) instrument, which replaces an older spectrometer and which has been constructed and delivered by the Czech Republic in the form of an in-kind contribution.

Socio-economic impact

The experimental results achieved within the framework of the Czech membership in ILL can be directly utilized in the commercial sector. It concerns microstructure of metals and alloys, glasses, ceramics or semiconductors, mechanical stress in industrial components, composites, metals, ceramics, environment and energy, applications in chemistry as phase changes in industrial products or catalysis. It is also important that the Czech membership in ILL entitles Czech companies and research organisations to be considered as potential participants in tenders for ILL instrumentation. The construction of the ThALES instrument is one of the crucial examples of cooperation of the research infrastructure with the commercial sector.

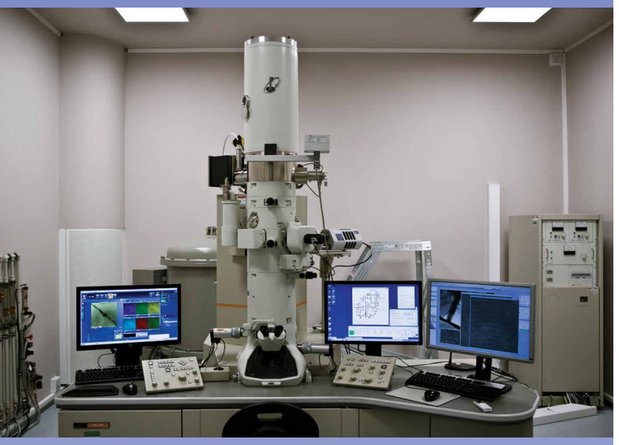
Infrastructure for Study and Application of Advanced Materials

Acronym:
IPMINFRA

Hosting institution:
Institute of Physics of Materials,
Academy of Sciences of the Czech Republic

Responsible person:
NÁHLÍK Luboš
nahlik@ipm.cz

Website:
www.ipminfra.ipm.cz



Background description

IPMINFRA represents a research infrastructure for study and testing of advanced materials used in engineering applications. The research infrastructure covers particularly the area of long-term mechanical tests (fatigue of materials, creep and fatigue/creep interaction and fracture and failure analysis in broad temperature range) and characterisation of material structure and its changes during loading. The laboratory core of IPMINFRA is formed by 35 creep machines with testing range up to 1600ºC, 10 fatigue testing machines with testing range from -180ºC to 950ºC, and 5 electron microscopes. This equipment jointly with a number of other devices (light microscopy, X-ray analysis, electron backscattered diffraction, equipment for measurement of magnetic properties, calorimeters, equipment for mechanical testing, indentation, instrumented impact testers) makes it possible to realize long-term and wide range testing of advanced materials and materials used in new engineering applications. IPMINFRA has the leading position in material research in the area of long-lifetime materials and their mechanical properties in the Czech Republic.

Future development

IPMINFRA development plan is based mainly on improvement of the quality and availability of provided services for scientific and industrial partners. The research infrastructure was recently equipped by most of the necessary devices. Only a few instruments, complementary to the existing ones or replacing older ones, will be acquired in the period of the following 5 years. An acquisition of equipment for 3D metal printing is presently under consideration.

Socio-economic impact

The modern materials are at the heart of technological progress, covering e.g. the equipment for safe and ecological production of electricity, a new generation of high-performance steels for the automotive industry, nanomaterials with unique properties, high-temperature superalloys for aircraft engines, life-saving medical implants and functional materials and composites. Such progress could not be reached without deep understanding of the materials properties and fundamental processes defining those properties. IPMINFRA opens up excellent facilities to external users, offering the research infrastructure for solving R&D projects and industrial problems and increasing the level of cooperation with academic and application sectors.

Laboratory of Nanostructures and Nanomaterials

Acronym:
LNSM

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

Responsible person:
FEJFAR Antonín
fejfar@fzu.cz

Website:
lnsm.fzu.cz

Background description

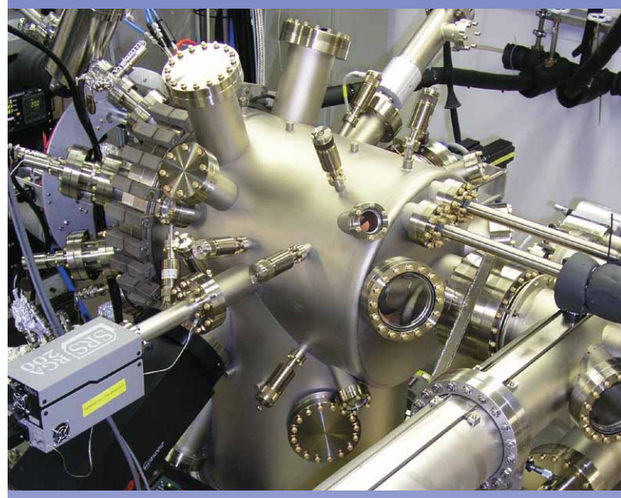
LNSM is focused on enabling research and development of a wide spectrum of inorganic nanomaterials (semiconductors, metals and ceramics) and nanostructures (particles, wires, interfaces, monolayers, thin films, nanostructured bulks). Subjects include microelectronics, microcomponents and MEMS (*Micro-Electro-Mechanical Systems*), nanoelectronics and spintronics, photovoltaics and hydrogen storage, photonic structures, carbon based thin films and nanostructures and materials and functionalised surfaces for applications in medicine (e.g. implants, sensors). LNSM offers thin film depositions, diamond thin films and nanostructures, carbon-based materials such as nanotubes or graphene and composites, bulk nanocrystalline metal-based alloys and composites and metaloxide nanoparticles. It also provides further patterning and device preparation by optical and electron-beam lithographies and by reactive ion etching, ion milling, contact metal deposition, and auxiliary technologies. Samples can be characterized and analysed by state-of-the-art microscopic techniques. LNSM has close links to other research infrastructures hosted by the Institute of Physics, Academy of Sciences of the Czech Republic such as the SAFMAT, HiLASE and ELI Beamlines. In its activities, LNSM closely cooperates with CEITEC Nano and participates in European and worldwide networks such as IUVSTA (*International Union of Vacuum Science and Technologies*) or AVS (*American Vacuum Society*).

Future development

On the long-term horizon it will be necessary to make acquisitions of up-to-date instrumentation in order to maintain the leadership within its core areas. The research infrastructure has already been expanded by UHV atomic force microscopy at low temperature (1.2 K) and high magnetic field (3 T) for atomically resolved scanning probe research. Development of new devices will be enabled by the new MOVPE (*Metal Organic Vapour Phase Epitaxy*) for the preparation of a nitride semiconductor nano-heterostructures used in blue light emitting diodes and ubiquitous in electronic devices. It is also a basis for development of power and high frequency electronics and electronic applications for extreme conditions.

Socio-economic impact

LNSM offers unique services and expertise, which are used by numerous educational and research organizations, as well as companies contributing to the present and future high-tech industry.



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:
ŠTEKL Ivan
ivan.stekl@utef.cvut.cz

Website:
www.lsm.in2p3.fr

Background description

Laboratoire Souterrain de Modane (LSM) is an international underground laboratory, which covers multidisciplinary fundamental research in particle, astroparticle and nuclear physics requiring extremely low radioactivity environments (e.g. search for dark matter, studies of the properties of neutrinos) and broad range of applications such as very sensitive detection of radionuclides (safety, health), microelectronics (tests of chips), radiobiology (investigation of DNA and cells in conditions with an extremely low level of ionizing radiation), geoscience (geoneutrinos), archeology (radionuclides dating) and climatology. LSM provides its users with ultra-low background conditions from a point of view of all types of radioactivity (cosmic rays, gammas, neutrons), including air purification (suppression of radon), ultra-low background HPGe (*High Purity Germanium*) spectroscopy for the selection of radio-pure materials or for the study of rare processes, BiPo detector for measurement of thin foils radioactivity at the level of few μBq/kg in ^{208}Tl and ^{214}Bi, an advanced radon emanation screening facility and an improvement of innovative detector technologies (pixel detectors) for low background conditions. LSM is involved in international cooperation with other deep underground laboratories in United Kingdom, Spain, Italy, People´s Republic of China or Canada. LSM-CZ allows the participation of the Czech research community in LSM research mainly concentrated in neutrinoless double beta decay, detection techniques and development of ultra-low background technologies. LSM-CZ contributes to the operation of the research infrastructure LSM as well as to the supportive research infrastructure in the Czech Republic. R&D performed by the Czech user community of LSM is based on detection of extremely rare signals (e.g. $0\nu\beta\beta$ decay of ^{82}Se with the half-life sensitivity of $2x10^{26}$ years, an application of Si pixel detectors in 2νEC/EC decay, environmental studies, and a selection of radiopure materials). In addition, the construction of the ultra-low background facility as a common activity of the Czech Technical University in Prague, Comenius University in Bratislava and Joint Institute for Nuclear Research (JINR), biological studies of cells and bacteria under "zero" radiation conditions or studies of radioactive traces in environment of a nuclear power plant should be mentioned.

Future development

LSM itself is undergoing continual development of its technological facilities. At present, the project of the LSM laboratory area extension to 14 000 m^3 is being prepared. In a long-term perspective the establishment of a common pan-European platform, involving 4 existing underground laboratories, is planned.

Socio-economic impact

An important impact of the LSM-CZ activities is given by the creation of a complementary national research infrastructure in the Czech Republic, educating the team of Czech experts, including diploma and Ph.D. students in underground science, and establishing a cooperation with innovative industrial partners involved in the development of components for LSM and LSM-CZ (scintillating detectors, sophisticated automatic system for HPGe detectors, facilities for cleaning of air from radon, neutron shielding, low background steel constructions, and stainless steel vessels). An international MEDEX conference dedicated to nuclear matrix elements calculations and double beta decay is regularly organized by LSM-CZ in the Czech Republic.

Prague Asterix Laser System

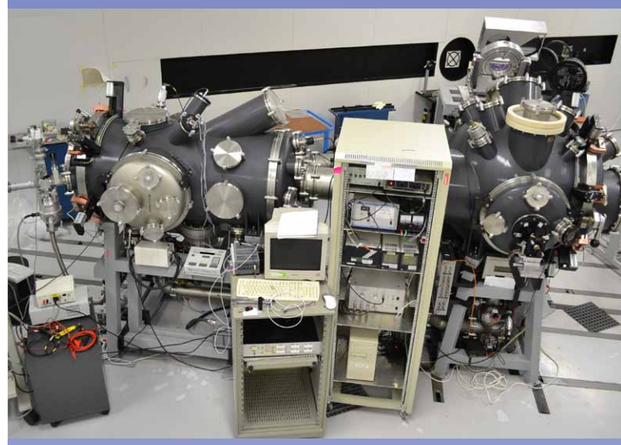
Acronym:
PALS

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

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

Responsible person:
ULLSCHMIED Jiří
ullsch@ipp.cas.cz

Website:
www.pals.cas.cz



Background information

PALS belongs to the founding members of the LASERLAB EUROPE (*Integrated Initiative of European Laser Research Infrastructures*). Its main experimental facility is a pulsed terawatt iodine laser, capable of delivering up to 1 kJ of energy in an infrared subnanosecond pulse with an intensity of up to 30 PW/cm^2. Its relatively high repetition rate, high beam quality, use of red and blue harmonics of the fundamental frequency, additional XUV laser and versatile target chamber with rich diagnostic equipment makes it one of the most in demand lasers for users in Europe. Auxiliary femtosecond beam lines extend its capabilities with tools for femtosecond probing of plasma and double-pulse experiments with synchronized fs and ns beams. PALS helps to cover European demand for kilojoule-class lasers. Its flexible laser systems are well suited for experimental studies of the interaction of intense laser radiation with matter, thermonuclear and laboratory astrophysical experiments and for developing and testing a variety of applications requiring large volumes of hot and dense plasmas. PALS offers experimental background for development of plasma-based accelerators of charged particle and plasma clusters, of high-intensity XUV radiation sources, in particular of plasma lasers, and amplifiers operating in the soft x-ray region. It provides its domestic and foreign users with full scientific, technical and logistical support, including access to data networks and optical testing laboratories. PALS helped develop the expertise necessary for the Czech Republic to participate in the projects of pan-European research infrastructures HiPER (*High Power Laser Energy for Research*) and ELI (*Extreme Light Infrastructure*). Jointly with partners from LASERLAB EUROPE it carries out joint research and serves as a development and testing site and a training centre for young researchers. PALS cooperates closely with laser research infrastructures ELI and HiLASE and in the framework program Horizon 2020 it participates in the research of energy production by means of inertial fusion.

Future development

Technological and structural modernization of PALS assumes replacement of measurement and control systems. PALS future developments will consist of the introduction of new advanced methods of plasma diagnostics with extreme temporal and spatial resolution. Due to the increasing number of days with high humidity, appropriate technical measures to reduce operating humidity in the laser laboratories are also foreseen. With regard to the lifetime of the energy sources these devices will be gradually replaced. An option is also upgrading the main laser using gas-cooled diode-pumped solid-state laser amplifiers. After bringing ELI-Beamlines into operational phase work of PALS will be coordinated with the programme of that research infrastructure.

Socio-economic impact

New laser technologies belong to the key incentives for a variety of innovative applications and products in many areas of life in modern society, such as medicine, science, energy, environment, informatics, and electronic industry. Laser fusion represents an alternative on the way to cheap energy for the next millennia. Laser research infrastructures such as PALS help effectively stimulate the demand for laser, vacuum and instrumentation technologies and electronic systems being developed and supplied by Czech high-tech companies.

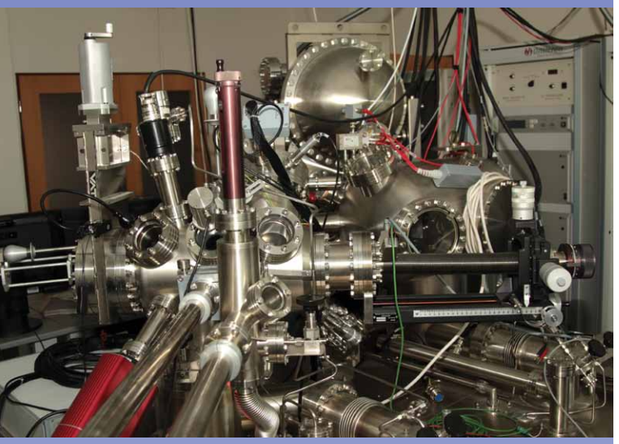
Centre for Analyses of Functional Materials

Acronym:
SAFMAT

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

Responsible person:
LANČOK Ján
lancok@fzu.cz

Website:
www.fzu.cz/en/safmat



Background description

The technological background of the SAFMAT facility is based on modern experimental equipment for surface and bulk analysis. SAFMAT aims at strengthening interdisciplinary research on the crossroads between physics, materials science, engineering and medicine, particularly in the areas of surface and bulk analysis of functional materials, materials for medical devices and biomaterials. The main purpose of SAFMAT is the enhancement of R&D capabilities in the areas of nanotechnologies covering experimental facilities, methods and human resources. SAFMAT services offered to the user community consist of oriented research focused on advanced functional materials for optics, engineering and power engineering as well as materials for medical devices, biomaterials and applications of physics in medicine. Besides development of novel material technologies requested by users, the services cover a variety of characterisation and analysis of materials in various application-relevant environments. SAFMAT develop synergic cooperation with other Czech research infrastructures such as SPL-MSB and LNSM. Due to the strategic focus of SAFMAT on the application of physics in the research of surfaces and (bio)materials, there is a key complementarity with the research to be carried out in the ELI Bealines and HiLASE research infrastructures.

Future development

The SAFMAT laboratories were completed in 2015. Nevertheless, since the state-of-the-art equipment and methods in the field of materials characterisation is evolving very rapidly, further improvements of the facility are envisaged, such as development of the combination of photoelectron spectroscopy and electron microscopy for materials characterisations, enlargement of the electron paramagnetic resonance spectroscopy by nonconventional electrically detected magnetic resonance technique and improvement of using the plasma Xe focused ion beam for electron microscopy.

Socio-economic impact

The uniqueness of SAFMAT consists of the combination of the unique experimental facilities for characterization of materials and biomaterials with world level expertise, which is accessible at the hosting institution. SAFMAT also accelerated the oriented research and cooperation with industrial partners, especially SMEs. Close cooperation of SAFMAT with universities represents an important part of the SAFMAT educational program consisting of lectures of SAFMAT researchers at universities, organizing excursions to laboratories or supervising of Ph.D. and undergraduate student training.

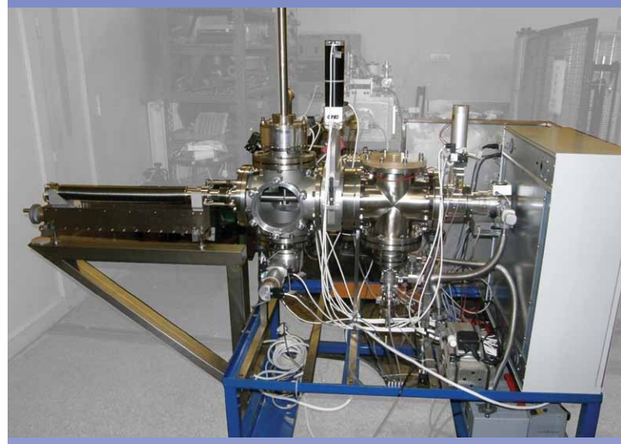
Système de Production d'Ions Radioactifs Accélérés en Ligne – participation of the Czech Republic

Acronym:
SPIRAL2-CZ

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

Responsible person:
MRÁZEK Jaromír
mrazek@ujf.cas.cz

Website:
www.spiral2.cz



Background description

SPIRAL2 is a major upgrade of the existing GANIL facility (*Grand accélérateur national d'ions lourds*) in Caen in France. SPIRAL2 is based on a linear accelerator with high current (up to 5mA) and energies up to 40 MeV for deuterons. The project will allow users to study the questions of nuclear physics, both in the fields of basic and interdisciplinary research. The participation of the Czech Republic has been formally supported since 2011 by the LEA NuAG (*Laboratoire Européen Associé – Nuclear Astrophysics and Grids*), which connects experimental and theoretical physicists and includes collaboration in the field of nuclear astrophysics, activation of construction materials for future power plants and development of fast neutron generators for basic and applied research. In the future, research infrastructure plans to participate on research with radiopharmaceutical background. At the beginning SPIRAL2 will deliver proton and deuteron beams and later beams of heavier ions to experimental areas NFS (*Neutrons for Science*) and S^3 spectrometer (*Super Separator Spectrometer*). The irradiation chamber in NFS with a pneumatic transport system will allow charged-particle irradiation and fast offline analysis. The neutron target will allow for the study of samples by neutron activation and perform experiments with neutron beams by TOF method (*Time of Flight*). The S^3 spectrometer will allow to select and study nuclei at limits of stability and super-heavy nuclei. In later phases, experimental areas DESIR (*Désintégration, excitation et stockage des ions radioactifs*) will be constructed and the future production UCx target will allow for the production of radioactive ion beams by the ISOL method (*Isotope Separation On-line*). Current experimental lines, cyclotrons and spectrometers of GANIL will be interconnected to SPIRAL2 for eventual post-acceleration and experiments there.

Future development

Two parts of SPIRAL2 will start operation in 2016 – the NFS and S^3. The irradiation chamber for SPIRL2/NFS will be installed by the Czech Republic in 2015/2016. The Czech research community will work on target prototypes for radiopharmaceuticals and for production target for radioactive beams R-OBOT (*Řež-Other Beams Other Targets*) – in one specific scenario the intensive ^{3}He beams will generate radioactive isotopes of oxygen to study nuclear reactions with astrophysical interest.

Socio-economic impact

Czech companies with high-tech know-how will deliver the production target R-OBOT for SPIRAL2. The Czech Republic will benefit from the close connection to SPIRAL2 also by means of sharing knowledge in radiopharmaceutical development and by the complementarity of SPIRAL2/NFS and neutron generators of Nuclear Physics Institute, Academy of Sciences of the Czech Republic..

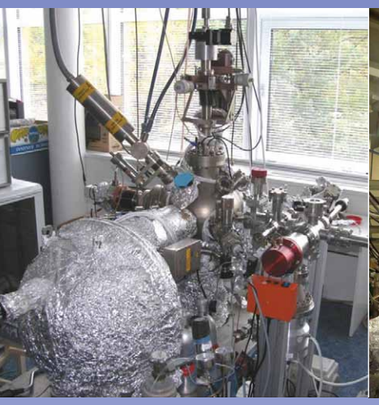
Surface Physics Laboratory – Materials Science Beamline

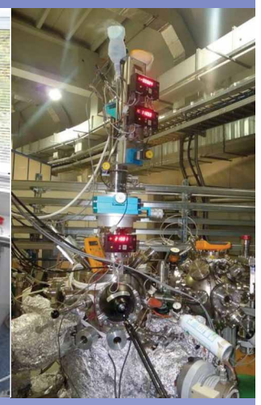
Acronym:
SPL-MSB

Hosting institution:
Charles University in Prague

Responsible person:
MATOLÍN Vladimír
matolin@mbox.troja.mff.cuni.cz

Website:
www.ceric-eric.eu





Background description

The SPL-MSB research infrastructure is the union of the Czech Material Science Beamline (MSB) open-access laboratory at the synchrotron Elettra and its operator, the Surface Science Laboratory (SPL) at the Faculty of Mathematics and Physics, Charles University in Prague. The SPL-MSB research infrastructure offers open user access to its facilities through a common single entry point of CERIC ERIC (*CentralEuropean Research Infrastructure Consortium*), which integrates resources of 9 European countries and is open to researchers from all over the world through competitive peer-review calls. For scientific excellence SPL-MSB draws on the expertise of SPL – the largest surface research oriented centre in the Czech Republic, which operates a number of techniques for materials science, surface physics, catalysis and organic molecules study. These include a variety of photoelectron spectroscopies, where MSB adds the synchrotron-based resonant photoemission and near-edge x-ray absorption fine structure spectroscopy (NEXAFS), ion scattering spectroscopy, electron diffraction, scanning tunnelling microscopy, thermal desorption spectrometry, scanning electron microscopy with dispersive x-ray analysis and focused ion beam nanolithography and atomic force microscopy with electrochemical analysis in liquids option. Opening the SPL to the research community at large gives users the possibility to use advanced surface science equipment and expert support of SPL staff.

Future development

In 2015 a new cutting-edge instrument NAPXPS (*Near Ambient Pressure Photoelectron X-ray Spectroscopy*) will be installed at SPL. It will be immediately made available through CERICERIC user access and simultaneously upgraded with auxiliary modules, such as optional X-ray source, LEED subsystem and a second NAP cell for highly customized user experiments. MSB will be upgraded with a new end-station vacuum chamber. This plan may be extended by constructing a new NAPXPS beamline laboratory at the new Solaris synchrotron in Krakow.

Socio-economic impact

SPL-MSB is strongly involved in catalysis research, which led to the development of novel nanocatalysts for fuel cell technology. They are protected by 6 international patents now and SPL is preparing their commercialisation. Through CERICERIC the SPL-MSB contributes to the development of a common transnational strategy of intellectual property, confidentiality and data policies and technology transfer as well as industry liaison. In combining the scientific expertise with technology drive, SPL-MSB contributes to the strategic portfolio of energy technologies in Europe.

Van de Graaff Accelerator – A Source of Tunable Monoenergetic Neutrons and Light Ions

Acronym:
VdG

Hosting institution:
Czech Technical University in Prague

Responsible person:
GRANJA Carlos
carlos.granja@utef.cvut.cz

Website:
vdg.utef.cvut.cz

Background description

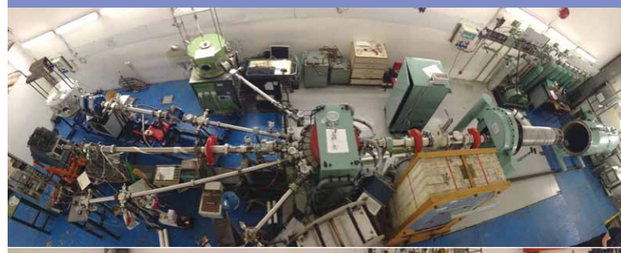
VdG provides light ions and especially tunable monoenergetic neutrons for basic and applied research in subatomic physics, material physics and space research. The facility also provides education and training to students and young researchers. With funding from the European Space Agency (ESA) the VdG facility modernized (upgrade, calibration) its neutron sources and newly built dedicated gamma-ray stations (wide range, discrete energies). As an ESA certified radiation facility, the laboratory provides testing and calibration of radiation sensitive instruments for space. A transportable gamma-ray station was additionally built for the testing of integrated instruments at remote space test centers. Besides additional radionuclide sources (X-ray, alpha, beta, neutron AmBe) the VdG laboratory is equipped with dedicated setups for tagged neutron beam and polarizing beam/polarized target for spin physics experiments, nuclear analytical methods as well as beamline for low-energy nuclear reactions for astrophysics and fusion studies. Experiments at the VdG are carried out in close cooperation with national and international research teams.

Future development

The development of VdG focuses on the modernization of accelerator (new voltage belt, ion beam guides, cooling system reconstruction and replacement of the neutron and radiation monitors) and installed equipment (neutron targets, vacuum chambers) as well as associated experimental setups (nuclear analytical experiments). Dedicated beamlines are being newly opened (new neutron target, beamline for astrophysics and fusion experiments), which include associated equipment such as radiation detector instrumentation. The short-term upgrades include reconstruction of the polarization experiment, design and construction of a high-power neutron target and installation of rare ^{3}He beam and necessary beam reclying system. In the long-term the replacement of the accelerator unit including the implementation of automatic control system is forseen.

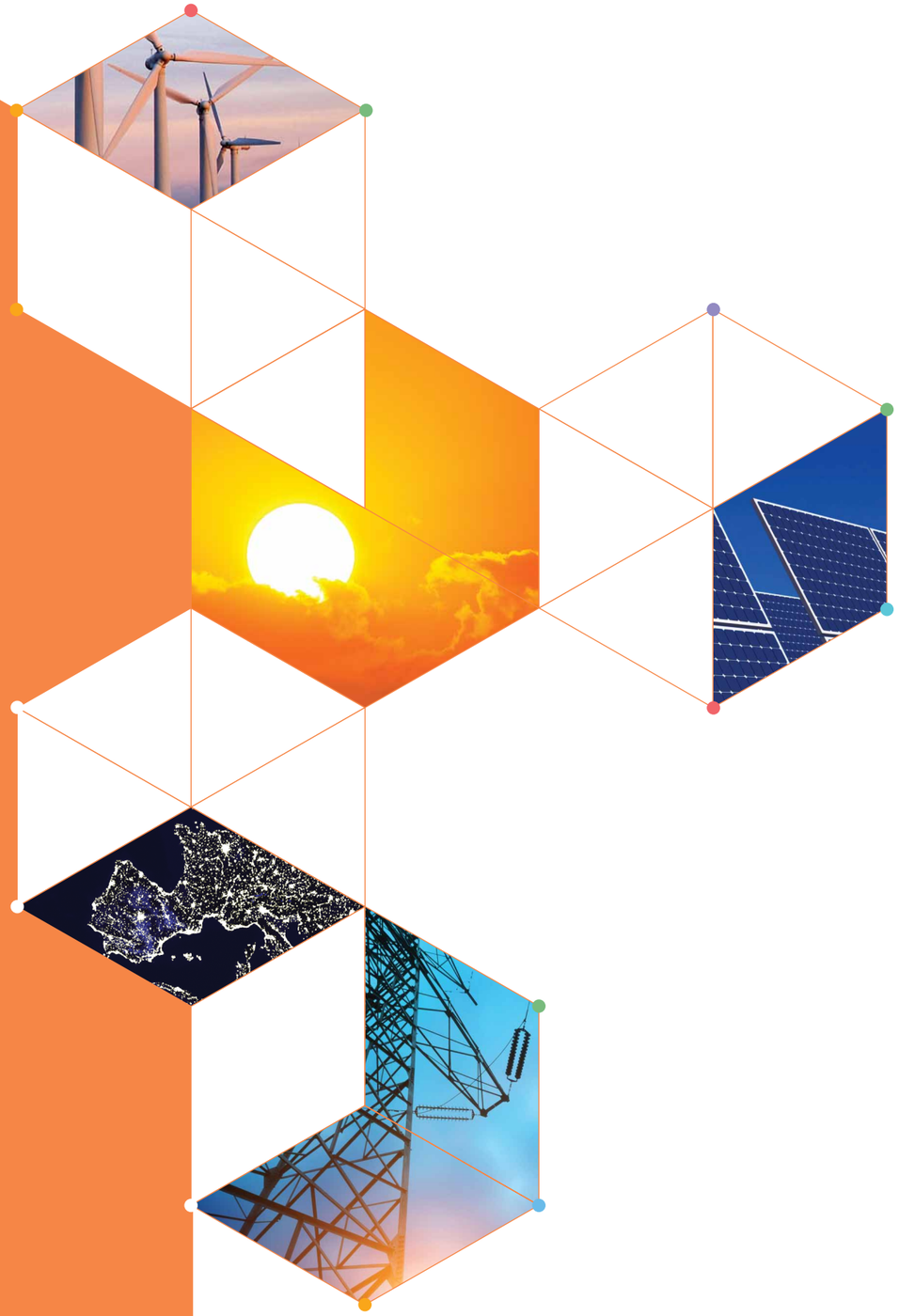
Socioeconomic impact

The users of VdG come mainly from the national and international research organizations as well as from high-tech small and medium-sized enterprises for testing and development of their prototypes. As the sole particle accelerator in the Czech universities VdG provides practical and laboratory education of students and young scientists not only from the Czech Republic. The facility enables researchers to develop and test new methods and their own setups in a local facility. Similarly, the facility provides valuable testing and calibration of scientific instruments and detectors prior installation elsewhere, including laboratories and larger experiments abroad.

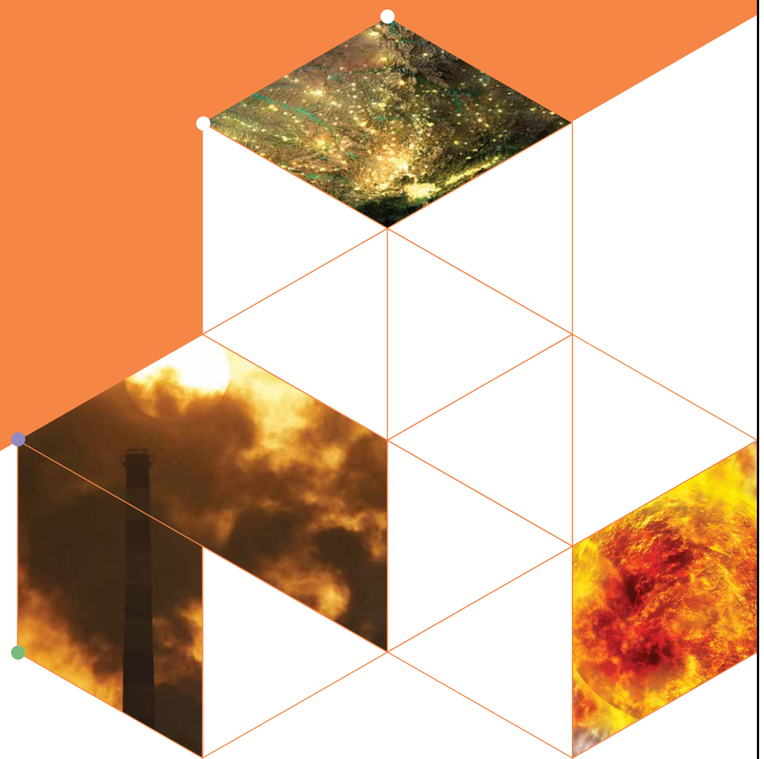


Energy

10.2



The energy sector has been undergoing important technological changes as a result of intensive R&D over the last 20 years. Considerable investments have been devoted to R&D in energy resources in the United States, which has led to an increase in the U.S. production of oil and natural gas from non-conventional resources. In addition to other factors (e.g. economic crisis), this increase caused a decrease in the price of fossil fuels. The global policy to reduce green-house-gas (GHG) emissions is also a driving force for innovations focusing on renewable energy, carbon capture and storage technologies and nuclear power. At the same time, some countries (e.g. Germany) have decided to phase out nuclear energy and gradually close down their nuclear power plants.



10.2 | Roadmap of Large Infrastructures for Research, Experimental Development and Innovation of the Czech Republic for the years 2016–2022

Energy

In 2007 the European Commission published the *Strategic Energy Technology Plan* (SET Plan) emphasizing the energy technology development needed to reach the energy policy goals of 2020 – i.e. a 20% reduction of the GHG emissions, a 20% share of renewable energy sources, and a 20% reduction in the use of primary energy by improving energy efficiency. For 2050 the SET Plan is targeted at limiting climate change to a global temperature rise of no more than 2ºC, particularly through reduction of GHG by 80 – 95%. The objective of SET Plan is also to lower the cost of clean energy and put the EU industry at the forefront of the low-carbon technology sector.

In 2014 a more coordinated approach was proposed by the European Commission within a document developed in close cooperation with the Member States and stakeholders – Towards an Integrated Roadmap: *Research Innovation Challenges and Needs of the EU Energy System*. The European Council agreed on a domestic GHG reduction target of at least 40% by 2030 compared to 1990 and set a target of at least 27% for renewable energy, binding at the EU level, as well as an indicative target of energy savings by 2030, to be reviewed in 2020.

R&D is the pivotal pillar of SET Plan implementation, while the Horizon 2020 – The Framework Programme for Research and Innovation, EURATOM Research and Training Programme, EERA Joint Programmes, Joint Technology Initiatives and national programmes including ESIF are the main financial tools for reaching its goals.

The key objective of European and Czech energy R&D is to provide the citizens with secure, sustainable, competitive and affordable energy. The distribution of primary energy supply in the Czech Republic is 37.2% coal; 18.3% gas; 20.8% oil; 18.6% nuclear fuel; 8.7% renewables; 0.7% other resources. The balance of electricity export / import is - 4.3%. The overall energy consumption is 7.7% coal; 23.8% gas; 29.7% oil; 18.1% electricity; 10.1% heat and 10.6% others. Almost 50% of the primary energy resources is used for electricity production (electricity is produced from 49% coal; 5% gas; 34% nuclear; 5% biofuel; 3% hydro; 1% wind; 2% photovoltaics and 1% others).

The Czech Republic faces significant challenges to meet the 2050 energy policy goals, reduce energy consumption and in increasing demands on the robustness of electrical transmission system. R&D performed by using the most modern research infrastructures should contribute to their successful addressing.

The range of energy-oriented R&D programmes in the EU is very broad and reflects different challenges and opportunities the Member States are confronted with in the various areas of: (1) Renewable energy (photovoltaics, concentrated solar power, geothermal energy, wind energy, ocean energy, hydropower, biofuels); (2) Efficient energy conversion and use in industry and buildings (energy transport and storage, fuel cells and hydrogen, smart cities and communities, smart energy networks); (3) Carbon capture and storage technology to reduce GHG emissions from fossil fuels and biomass sources; (4) Nuclear energy (nuclear fission and fusion); and (5) Cross-sectional energy technologies (simulation and modelling capacities, monitoring and testing facilities, advanced materials). Because of this, a broad range of energy-oriented research infrastructures is needed at the EU and Member States levels.

Some energy R&D areas have only limited or no general importance for the Czech Republic (e.g. ocean energy). Because of the geography and traditions of the Czech Republic, other energy R&D sectors are addressed more intensively when planning the energy mix – nuclear fission and fusion, biomass use, fossil energy (limited by the GHG and declining domestic coal resources), power storage and accumulation, co-generation, accumulation of heat, increase in energy efficiency and advanced materials.

With a share of about 25% in electricity production, nuclear energy now provides a major part of the low-carbon electricity in the EU. In the Energy Roadmap 2050 – *A Roadmap for Moving to a Competitive Low Carbon Economy in 2050* – it is anticipated that nuclear energy will remain for the foreseeable future an important component of the EU power generation mix. Nevertheless, investments are urgently needed to provide both short-term and long-term solutions to ensure safer and more efficient operation of nuclear facilities, the development of innovative nuclear reactor concepts, sustainable solutions for management of radioactive waste and the decommissioning of nuclear reactors. Particularly after the Fukushima nuclear accident in 2011 the focus of nuclear reactor technology has been on safety (*e.g. Identification of Research Areas*

in Response to the Fukushima Accident, 2013). Safety studies are thus included not only within the primarily nuclear-oriented R&D agenda, but also within the agenda of cross-disciplinary initiatives such as EURAMET (*European Association of National Metrology Institutes*), which aims (among other things) to cover the advanced measurement technologies required by the new generation nuclear power plants.

Nuclear energy has been for years one of the most important components of the energy mix of the Czech Republic. As a result, the advanced technologies necessary for addressing the nuclear R&D challenges make up an important element of the Czech energy research infrastructures landscape. The **Reactors LVR-15 and LR-0** (*Nuclear Research Reactors LVR-15 and LR-0*) are essential for neutron-based applications in nuclear R&D, including nuclear power technologies not only for the Generation II, III/III+, but also for Generation IV and nuclear fusion. The **SUSEN** (*Sustainable Energy*) research infrastructure operated by the same entity – Research Centre Řež – has been developed to include four R&D programmes focused on Generation IV, safety of existing facilities and fusion technologies: (1) Technological Experimental Circuits; (2) Structural and System Diagnostics; (3) Nuclear Fuel Cycle; and (4) Material Research. The **JHR-CZ** represents the involvement of the Czech Republic in the *Jules Horowitz Reactor*, the most advanced European materials testing reactor, which is being built at the CEA (*Commissariat à l'énergie atomique et aux énergies alternatives*) Cadarache research centre in France. It will provide a slow neutron flux higher than $5x10^{14}/cm^2s$ for materials R&D. The **WCZV** (*VR-1 – Support for Reactor Operation for Research Activities*) offers a training reactor used as a crucial experimental facility in the education of students from both Czech universities and abroad. The reactor is also used for R&D in safe operation of nuclear installations, reactor and neutron physics, nuclear fuel cycle and fuel management, and as a source of neutrons for dedicated experiments.

The contribution of the Czech Republic to the development of thermonuclear fusion energy covered by the ITER (*International Thermonuclear Experimental Reactor,* France) is presented by the **COMPASS** (*Tokamak for Thermonuclear Fusion Research*). The COMPASS tokamak is, together with the JET (*Joint European Torus, United Kingdom*) and ASDEX Upgrade (Germany) tokamaks, a key component in the European effort to master thermonuclear fusion.

The Czech energy research infrastructures landscape is completed by the CVVOZEPowerLab, CATPRO and RINGEN. The **CVVOZEPowerLab** (*Power Laboratories for Support of Electrical Grids R&D*) facilities consist of a high current laboratory and a shielded high voltage laboratory, aimed at R&D on electrical switching technology and processes, insulation materials, interference and EMC measurements. The **CATPRO** (*Efficient Use of Energy Resources Using Catalytic Processes*) is directed towards the efficient use of carbon energy resources with a special emphasis on the use of biomass for producing liquid fuels and chemicals. The **RINGEN** (*Research Infrastructure for Geothermal Energy*) is based on an existing geothermal site with a 2.1 km deep well and provides specific services and expertise in the area of deep geothermal energy exploitation.

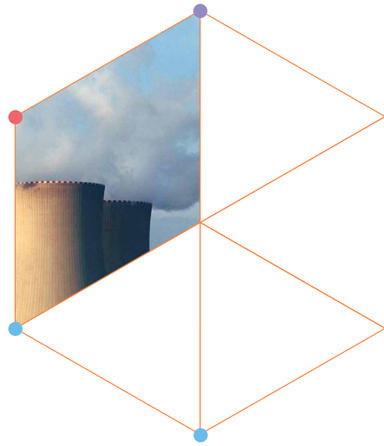
Research infrastructures of the Czech Republic thus focus particularly on the areas of nuclear fission and fusion, energy efficiency, biofuels, geothermal energy and distributed power and energy. Nevertheless, some important R&D areas are less well covered – renewable energy (photovoltaics, concentrated solar power, wind energy, hydropower) and efficient energy conversion and use (smart cities and communities, smart energy networks, energy storage, fuel cells and hydrogen, carbon dioxide capture and storage). There are R&D centres (e.g. *UCEEB – University Centre for Energy Efficient Buildings of the Czech Technical University in Prague; and ERC – Energy Research Centre of the VŠB – Technical University of Ostrava*), which undertake important energy-oriented R&D programs, but have not been operated on the basis of research infrastructure.

The rationale behind some of the energy research infrastructures of the Czech Republic in the period after 2020/2022 need to be discussed in advance, because some of the currently operated facilities are intended to be gradually decommissioned unless they are significantly upgraded (e.g. *Reactors LVR-15 and LR-0*). The needs of the Czech research community would then have to be satisfied through even more intensive participation and involvement in facilities situated abroad (e.g. *Jules Horowitz Reactor*).

One approach to the filling of certain identified gaps in the energy research infrastructure landscape of the Czech Republic might be closer cooperation with existing or newly planned pan-European research infrastructure programmes such as ECCSEL (*European Carbon Dioxide Capture and Storage Laboratory Infrastructure*), EU-SOLARIS (*European Solar Thermal Research Infrastructure for Concentrated Solar Power*) or European WindScanner Facility, taking into account the overall landscape of energy research infrastructures in the EU and the Energy Policy of the Czech Republic.

Energy R&D is now characterized by innovative technologies directed towards the industrial sector; this provides the competitive advantage that comes from financing R&D from public funds. Since the construction and operation of energy research infrastructures is very costly, industrial companies should also participate in the construction or upgrade of energy-oriented research infrastructures in the future.

The energy R&D of the Czech Republic is dispersed among different research organisations that are small compared to their European counterparts. There is a need for Czech research organisations to strengthen their cooperation so that the concentration of efforts can lead to better efficiency (cost sharing) when increasing the capacities and capabilities of joint research infrastructures. The Czech energy R&D sector must further increase participation of foreign researchers and integrate the national energy research infrastructures of the Czech Republic into the ERA. The Czech involvement in the construction of *Jules Horowitz Reactor* and the Czech participation in the EUROfusion consortium established under the EURATOM Research and Training Program can be considered good examples in this respect.



Efficient Use of Energy Resources Using Catalytic Processes

Acronym:
CATPRO

Hosting institution:
Research Institute of Inorganic Chemistry

Responsible person:
SVOBODA František
frantisek.svoboda@vuanch.cz

Website:
www.vuanch.cz

Background description

CATPRO is oriented on the operation of facilities for R&D on efficient use of carbon-energy resources using catalytic processes. One of the greatest challenges in R&D of the transformation of carbon-energy raw materials including the use of biomass for the production of advanced liquid fuels and chemicals is the gap between the laboratory and industrial scales. CATPRO will enable users to perform almost all activities in R&D valuechain that are essential to overcome that gap and for development of heterogeneous catalysts and catalyst processes. CATPRO provides expertise and services covering catalyst synthesis and preparation scale-up, catalyst forming and shaping, catalyst testing and process development in bench scale and analysis and identification of complex organic product mixtures. CATPRO will become an open platform between the academia and industry that will stimulate their collaboration. CATPRO closely cooperate with some of the members of the pan-European research infrastructure BRISK (*Biofuels Research Infrastructure for Sharing Knowledge*).

Future development

Future development of CATPRO will concentrate on reinvestment in the existing research infrastructure, which allows keeping its quality and technological level up-to-date, including automation and safety of operation and modularity of the experimental set-ups. At the same time, CATPRO will focus on the introduction of new services according to the regularly analysed users´ requirements and R&D trends in the field of catalytic processes. In this way, services in the most perspective R&D areas such as biomass-to-chemicals transformations and demonstration of newly developed technologies will be improved.

Socio-economic impact

The CATPRO research infrastructure has a strong potential to establish itself as an important partner for the research community in the field of heterogeneous catalysts and related processes in Europe. The unique research infrastructure of CATPRO will enable to overcome existing deficits in the connection between fundamental and applied research in the field. CATPRO will allow its users to progress to a higher level of technologyreadiness for the processes they are developing. This jointly with the benchscale demonstration of the processes will increase their attractiveness for industry and potential investors and take them closer to implementation of R&D results on the market. CATPRO will strengthen the international competitiveness of the Czech Republic in the field of catalysis and sustainable catalytic processes with associated benefits in the area of environmental protection, sustainable economy and society well-being.

COMPASS – Tokamak for Thermonuclear Fusion Research

Acronym:
COMPASS

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

Responsible person:
PÁNEK Radomír
panek@ipp.cas.cz

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

Background description

The COMPASS research infrastructure consists of the tokamak and auxiliary systems and represents one of the key facilities in a joint European effort to master thermonuclear fusion within the EUROfusion consortium (*European Consortium for Development of Fusion Energy*). COMPASS operates in divertor plasma configuration with ITER-like plasma cross-section to address the key problems in construction and future exploitation of the ITER tokamak (*International Thermonuclear Experimental Reactor*). COMPASS provides open access for a wide user community and enhances education in the field of hightemperature magnetized plasma physics. Furthermore, COMPASS provides expertise in development of plasma control and data acquisition systems and development of advanced diagnostics for edge plasma physics as well as in several aspects of tokamak construction. It has established intensive collaboration with leading Czech research organisations. On the European level, COMPASS is utilized mainly within the EUROfusion consortium and collaborates with ITER.

Future development

Scientific strategy of COMPASS is based on further enhancement of the tokamak, auxiliary systems and services mainly in the field of edge plasma physics, where COMPASS represents an important element of European fusion research. The enhancement will focus on further improvement of the tokamak performance as well as on improvement of diagnostic capabilities. In the long-term, the tokamak will be upgraded by a new central solenoid to prolong significantly the plasma discharge length, new plasma facing materials and enhanced plasma heating capabilities.

Socio-economic impact

Diagnostic and operating systems of COMPASS represent the cutting-edge technologies. Development and production of these systems in collaboration with research infrastructure have, therefore, a direct impact on innovations and increase the skills, technological level and know-how of participating companies. Operation of the research infrastructure has also significant effect on the educational and trainning activities in the field of thermonuclear fusion in the Czech Republic and abroad.

CVVOZE Power Laboratories

Acronym:
CVVOZEPowerLab

Hosting institution:
Brno University of Technology

Responsible person:
TOMAN Petr
toman@feec.vutbr.cz

Website:
www.cvvoze.cz

Background description

The research infrastructure CVVOZEPowerLab consists of 2 special laboratories at Science and Technology Park of Professor List. The technology of the High Current Laboratory enables the generation of alternate currents up to a 150 kA magnitude at a 250 V voltage and direct currents up to a 50 kA magnitude at a 1000 V voltage. The second shielded High Voltage Laboratory enables the generation of a 300 kV AC voltage with a maximum of 1 A current and the DC voltage pulses of both polarities up to 1000 kV with up to 100 kJ energy. The attenuation of the laboratory shielding equals 90 dB in the frequency range 30 MHz to 1 GHz for the electric field and over 60 dB in the frequency range 10 kHz to 30 MHz for the magnetic field. Portfolio of the research infrastructure expertise covers research fields such as electrical switching technology adapted to DC equipment, physics of the electric arc during a switching process, faults in the structure of insulation materials and methodology of EMC measurement and testing. Provided services include power tests, withstand currents, strong magnetic field and magnetization tests, current wave tests and tests of fast energy storage devices, impulse testing and discharge tests. CVVOZEPowerLab is a member of DERlab association (*European Distributed Energy Resources Laboratories e. V.*).

Future development

In the future, the CVVOZEPowerLab research infrastructure will focus on improvement of the accuracy of measuring equipment and extension of the possible measuring conditions. In accordance with this new apparatus is planned, such as DC system for partial discharge measurements, radio interference voltage measurement system, system for measurement of high intensity pulsed fields, diagnostic system for liquid insulation media including a small climate box or encapsulated vessel for experiments with gaseous insulators.

Socio-economic impact

Producers of low and middle voltage network components represent a very important part of industry in the Czech Republic. In the context of smart grid development there are many new challenges and opportunities for development of new network components and the research infrastructure CVVOZEPowerLab is going to play a key role in activities with a vast influence on the position of the Czech producers on the global market. CVVOZEPowerLab brings new possibilities for high quality education and basic and applied research in the electro-energetic areas mentioned above.

Jules Horowitz Reactor – participation of the Czech Republic

Acronym:
JHR-CZ

Hosting institution:
Research Centre Řež

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

Website:
cvrez.cz/vyzkum-a-vyvoj/jhr

Background description

JHR (*Jules Horowitz Reactor*) will represent a material research reactor of 100 MW thermal power output, designed for R&D and material and nuclear fuel qualification. The reactor will make possible material testing under conditions corresponding to power reactors, an acceleration of model degradation and an evaluation of component properties at the end of their lifetime. JHR will serve purposes of a wide range of irradiation experiments, such as fuel studies including fuel selection and characterization, testing and evaluation of fuel exposed to conditions corresponding to reactor normal operation or its transients, as well as to incidental and accidental conditions. Additionally, JHR will enable material studies, including studies of fuel cladding corrosion and effects of high dose rates on the cladding and structural materials. The portfolio of JHR expertise and services provided will include also nuclear waste management and medical applications. Related studies will also contribute to enhancement of safety for both existing and future reactors. JHR is being constructed in Cadarache research centre in France under the coordination authority of CEA (*Commissariat à l'énergie atomique et aux énergies alternatives*) as an international project of research infrastructure with Belgium, Czech Republic, Finland, France, India, Israel, Japan, Spain, Sweden, Great Britain and the European Commission participating. JHR-CZ ensures the contribution of the Czech Republic to JHR by participating at JHR construction with a supply of hot cells. Due to this contribution, the Czech Republic will have an access to 3 % of the JHR research measuring capacity once the reactor will be put into operation. Consequently, JHR-CZ will be in charge of ensuring access of the Czech research community to JHR capacities. At the same time, the LVR-15 research reactor, operated by Research Centre Řež, has a high potential to become a part of the regional research infrastructure associated with JHR. Thus, some of the scheduled experiments could be prepared, on a smaller scale, in LVR-15 reactor, before being conducted in JHR.

Future development

The JHR construction will continue until 2020, while the hot cell unit installation should be completed in 2018. After a civil work completion, an installation of JHR technologies and equipment will proceed. A commencement of JHR operation phase, which is projected at least for 50 years, is scheduled for 2020. After termination of its operation, a phase of JHR decommissioning has been planned for the following 22 years, with the hot cells also to be used during this process. Reliability and safety of the hot cells supplied by the Czech Republic must be ensured, therefore, for the minimum period of 72 years.

Socio-economic impact

Most of the research reactors currently operated in the EU will be gradually removed from operation after the year 2020, due to their obsoleteness. Similarly, a gradual activity diminution of LVR-15 and LR-0 Czech research reactors is envisaged. Thus, after 2030 JHR will become a unique material research reactor in Europe. JHR will be beneficial for sectors of both conventional and nuclear power industry in the areas of material and fuel qualification, as well as for medicine and research of short-term radioisotopes used for diagnostic or therapeutic purposes, and also for advanced methods in the semi-conductor industry, such as Neutron Transmutation Doping. JHR will make possible a cooperation of nuclear regulatory bodies and nuclear facility operators from Bulgaria, Czech Republic, Finland, Hungary, Russia, Slovakia and Ukraine in context of subjects related to VVER type reactors (*WaterWater Energetic Reactor*) and coordination of the optimal use of shared research capacities for VVER community in Central and Eastern Europe. Many industrial companies from the Czech Republic also belong among potential users of the JHR capacity. The Czech participation in JHR brings positive effects on Czech industry even during the time of the JHR construction, due to the cooperation in the design and construction of the hot cells.

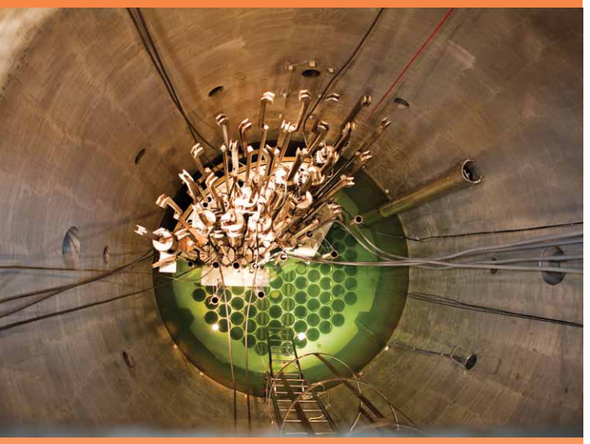
Nuclear Research Reactors LVR-15 and LR-0

Acronym:
Reactors LVR-15 and LR-0

Hosting institution:
Research Centre Řež

Responsible person:
JUŘÍČEK Vlastimil
vlastimil.juricek@cvrez.cz

Website:
www.cvrez.cz



Background description

Nuclear research reactors LVR-15 and LR-0 are a research infrastructure for basic and applied R&D in the field of neutron applications, especially for nuclear power technologies of Generation II, III, IV and fusion. The experimental loops can be used also in conventional power engineering, such as supercritical water or hydrogen technology. The reactors LVR-15 and LR-0 are a unique source of high flux neutrons for material research. The experimental loops provide an environment simulating various power plants of generations II, III and IV. For generation II and III units, the main value lays in prolonging the lifetime of nuclear power plants, increasing safety and the efficiency of power plants. For Generation IV and fusion the reactors provide unique background for R&D of new materials and coolant chemistry. Besides, the LVR-15 reactor produces radionuclides for various industry and health applications. The reactors LVR-15 and LR-0 provide the neutrons for the use by CANAM research infrastructure as well being continuously engaged in EURATOM projects (e.g. ARCADIA – *Assessment of Regional CApabilities for New Reactors Development through an Integrated Approach*, CORONA – *Establishment of a Regional Center of Competence for VVER Technology and Nuclear Applications*).

Future development

Both research reactors LVR-15 and LR-0 have the operating license valid till the end of 2020. To extend this license, it will be necessary to prove the residual lifetime of all important components. This assessment is carried out according to an aging management plan and the its results are used for planning the preventive maintenance with the ultimate goal to ensure the reliable operation of the reactors through their lifetime. For example, this assesment resulted in the refurbishment of LVR-15 instrumentation and control system in 2014. The future plans include neutron detectors and radiation monitoring system. The reactors LVR-15 and LR-0 are expanding further – new experimental loops will be installed by the end of 2016. Besides that, LVR-15 reactor could increase its maximum power (to provide higher neutron flux) by increasing the actual power 10mW by 50%. The decision on this upgrade has a direct impact on the operational costs and has not been justified by users requirements yet.

Socio-economic impact

The main purpose of the research reactors LVR-15 and LR-0 is to support the applied research. Nevertheless, they are also used to some extent for commercial activities, such as radionuclide production for radiodiagnostics and radiotherapy used in the healthcare. Besides the applied research and commercial activities, the research infrastructure focuses on education and training of young researchers as well as on supporting public awareness in the field of nuclear technology. The research infrastructure host regularly technical visits and seminars. To attract university students, a program called "Capacity for Ideas" gives free access to the LR-0 reactor, offering them unique experimental possibilities.

Research Infrastructure for Geothermal Energy

Acronym:
RINGEN

Hosting institution:
Charles University in Prague

Partner institutions:
- Czech Geological Survey
- Czech Technical University in Prague
- Institute of Geonics, Academy of Sciences of the Czech Republic
- Institute of Geophysics, Academy of Sciences of the Czech Republic
- Institute of Rock Structure and Mechanics, Academy of Sciences of the Czech Republic
- Technical University of Liberec

Responsible person:
FISCHER Tomáš
fischer@natur.cuni.cz

Background description

RINGEN will be constructed in already existing geothermal site with a 2.1 km deep testing well. The aim of RINGEN will be the R&D support and offer of services and expertise in deep geothermal energy exploitation and related areas such as underground construction, or oil and gas exploitation. Geothermal research includes a wide range of technical and geoscientific disciplines and testing in real conditions. RINGEN will provide numerical modelling of the heat transport and extraction, hydrogeological and hydrochemical survey, studies of hydrothermal alteration due to hydraulic injections, or assessment of the induced seismicity, its monitoring and analysis.

Future development

RINGEN is intended to act as one of the nodes of the European network of geothermal test sites, which enables verifying new technologies of drilling, technologies of rock permeability stimulation for creating deep-seated heat exchangers or the microseismic monitoring.

Socio-economic impact

RINGEN will contribute to increasing the energy efficiency and security by undertaking its own strategic research and by development of research disciplines needed for better and routine exploitation of widely existing geothermal energy. RINGEN will provide services for public research and commercial institutions to further develop technologies needed for deep geothermal energy utilisation for heating and cooling. This will subsequently allow the reduction of costs for renewable energy, which results in decreasing CO_2 emissions. Approximately 30% of the capacity dedicated to the external users will be offered to the commercial sector. The main contribution of RINGEN consist in further development of geothermal, energy and the building industry.

Sustainable Energy

Acronym:
SUSEN

Hosting institution:
Research Centre Řež

Partner institution:
University of West Bohemia in Pilsen

Responsible person:
RICHTER Jiří
jiri.richter@cvrez.cz

Website:
www.susen2020.cz

Background description

Research infrastructure of SUSEN is focused on energy R&D with an emphasis placed on nuclear research. Within the framework of nuclear research, the research infrastructure will be used to solve problems related both to power production through thermonuclear fusion and fission. An important part of the research infrastructure will also be the laboratory for the development of hydrogen technologies, especially hydrogen production by high-temperature electrolysis of water. SUSEN is built on 4 fundamental pillars represented by the following research programs: (1) Technological Experimental Loops; (2) Structural and System Diagnostics; (3) Nuclear Fuel Cycle; and (4) Material Research. Nuclear and energy research has a strong transnational character. SUSEN will be part of European consortia focusing on R&D for the safe operation of existing nuclear reactors, prolonging their lifetime and also R&D focused on the future generations of nuclear reactors (ALFRED – Advanced Lead Fast Reactor European Demonstrator, or ALLEGRO – *Gas-Cooled Fast Reactor Demonstrator*). SUSEN will also contribute to the development of the fusion reactors ITER (*International Thermonuclear Experimental Reactor*) a DEMO (*DEMOnstration Power Plant*).

Future development

Research infrastructure of the SUSEN centre is currently under construction. Its future development will especially follow the fulfilment of the research goals defined by the National Nuclear Energy Action Plan of the Czech Republic. An important part of considerations on the SUSEN direction is also applying research infrastructure outside the nuclear area, e.g. in fossil energy and renewable energy sources.

Socio-economic impact

International range and uniqueness of SUSEN research infrastructure will contribute to the development of a highly professional competence of researchers, technical personnel and young researchers and students. SUSEN will contribute to the safe operation of power units, both present and future generations of fission and fusion reactors. This will support the energy security of the Czech Republic, reduction of the greenhouse gas emissions and safe operation of current and future nuclear power plants.

VR-1 – Training Reactor for Research Activities

Acronym:
WCZV

Hosting institution:
Czech Technical University in Prague

Responsible person:
SKLENKA Ľubomír
lubomir.sklenka@fjfi.cvut.cz

Website:
www.reaktorvr1.eu

Background description

Training Reactor VR-1 is a key experimental facility for education of bachelor, master and Ph.D. students at Czech and foreign universities. The reactor is predominantly used for R&D in the field of safe operation of nuclear installations, theoretical and experimental reactor and neutron physics, nuclear fuel cycle and fuel management and as a source of neutrons for dedicated experiments. The share of R&D represents approximately 20% of operational time. The reactor is designed particularly for dynamic experiments, which are essential for safe operation of nuclear power plants and research reactor. Research activities carried out by using the reactor are also focused on the development a testing of pyro-electric neutron generators, diamante detectors or detectors based on Cherenkov radiation, study of radiation influence to semiconductor memories or study of deep sub-criticalities of the reactor cores. Training Reactor VR-1 has strong linkages to various national and international research organisations as well as to industry. The reactor collaborates with 18 Czech and 28 foreign research organisations. The reactor is a member of national and international educational and research networks such as EERRI (*Eastern European Research Reactors Initiative*), RROG (*Research Reactors Operators Group*) or ENEN (*European Nuclear Education Network*). The reactor has developed also a wide collaboration with the IAEA (*International Atomic Energy Agency*).

Future development

Training Reactor VR-1 is well established educational and research infrastructure, which has been in the operational phase for almost 25 years. Experimental instrumentation is being upgraded step-by-step and new instrumentation is annually installed, for example under construction is new instrumentation MONTE-1 for advanced testing of detection equipment of monitoring and intervening groups in the case of nuclear accidents and of early detection network equipment or neutron radiography which increases reactor capabilities in neutron activation analysis. In the future it has been planned to build a new subcritical assembly or Cf neutron source, which will significantly increase reactor capabilities in the field of complex testing of new generations of neutron detectors.

Socio-economic impact

Training Reactor VR-1 offers experimental education in nuclear engineering and neutron applications at high level quality to bachelor, master and doctoral study programmes at national and international level. The reactor also offers new and unique experimental instrumentation, methodologies and R&D outputs in nuclear engineering and neutron applications.

Environmental Sciences

10.3

page

The environmental research is closely connected not only with ecology that explores how living organisms interact with the environment but also with earth sciences, trying to understand the complexity of the function of energy metabolism and biogeochemical cycles on our planet. The environmental research is focused also on studying the environmental interactions with human society, including finding the ways how these interactions can be influenced, guided and regulated. The latter aspects are very important as the environment of our planet provides the life support that is essential for the very existence of mankind but also the ecosystem services which are basis for our economy. Although, we tend to take these "services" for granted, human activity may compromise their provisioning.

10.3 | Roadmap of Large Infrastructures for Research, Experimental Development and Innovation of the Czech Republic for the years 2016–2022

Environmental Sciences

Besides the complexity of subjects mentioned above the environmental issues have to deal with a large complexity of spatiotemporal scales. Many of key environmental processes take place on the micro-scale level, but their cumulative effect have global dimension and in the time-scale may exceed the human life span. The global climate change, environmental pollution or eutrophication are examples of the complex problems that require complex solutions at various levels. The science reflects these issues by new methods in combination with large-scale, long-term monitoring networks and new approaches in the data processing. In this respect, urgent need for environmental sciences for implementation of systematic and qualitative data collection and further processing, database formation and data sharing, allowing cumulative post processing of data and synthesis, should be emphasized.

A number of research organizations are involved in the environmental research in the Czech Republic. Research infrastructures listed below are aimed to facilitate this broad field by specific analysis and expertise, by providing and monitoring data that are not available elsewhere and by mediating data storage, exchange and post processing.

The global climate change represents one of the major of current environmental challenges, which are reflected by an intensive scientific effort in this field. The **ACTRIS-CZ** (the Czech node of the *Aerosol, Clouds and Trace Gases Research Infrastructure*) focuses on the long-term background air quality monitoring and research related to the interactions of aerosols, clouds and trace gases and their connection to the biosphere and anthropogenic activities. The ACTRIS-CZ helps and improves the global and macro-regional models of atmosphere that are essential for coping with the climate change and other environmental and health issues qualified as societal challenges.

The global climate change is closely connected also with the biogeochemical cycles, namely the carbon cycle. The interaction of global climate change with the terrestrial ecosystem is essential for better understanding of mechanisms of climate change and adaptation and mitigation effort. The **CzeCOS** thus offers a unique basis for complex research of global change impact on the terrestrial ecosystems and forms the national complement to several pan-European research infrastructures as ICOS (*Integrated Carbon Observation System*); AnaEE (*Analysis and Experimentations on Ecosystems*); and EUFAR (*European Facility for Airborne Research in Environmental and Geo-sciences*). It provides unique facilities for manipulation experiment for the long-term impact studies that investigate effects of environmental factors on plants / ecosystems; array of tools for physiological field observation; facilities for observations and quantification of greenhouse gas fluxes in ecosystems, metabolomics and isotope laboratories and remote sensing laboratory.

The Polar Regions are particularly sensitive to the global climate change and understanding of mechanisms of ecosystem transformation in the Arctic and Antarctic regions is essential for the global understanding of climate change processes. The **CzechPolar2** composed of the CARI (*Czech Antarctic Research Infrastructure*) and CARS (*Czech Arctic Research Station*) is focused on the discoveries made in the polar ecology and geosciences dealing with emerging questions of the climate change and anthropogenic impacts on polar geo- and eco-systems. A strong emphasis is given to the multidisciplinary approaches applied at various temporal and spatial scales.

The global change and population growth have put an increasing strain on the soil and freshwater ecosystems worldwide and, in consequence, on impact ecosystem services. The water supply and nitrogen and phosphorus availability represent major limiting factors for the primary production, which is essential for the food production as well as for mitigation of the climate change. The **SoWa** (*National Infrastructure for Comprehensive Monitoring of Soil and Water Ecosystems in the Context of Sustainable Use of Landscape*) provides the facilities for investigations of complex interactions between the soil and water ecosystems from the micro-scale to the catchment level with a particular emphasis put on the systems under the anthropogenic pressure. It supports research relevant for key ecosystem services provided by the soil water interactions such as the water run-off, water purification, nutrient flow, decomposition or nutrient release.

The assessment of environmental and human exposures to toxic chemicals, related effects and health risks is the focus of the **RECETOX** (*Research Centre for Toxic Compounds in the Environment*). The RECETOX research infrastructure offers facilities and a broad expertise in environmental chemistry,

10.3 | Roadmap of Large Infrastructures for Research, Experimental Development and Innovation of the Czech Republic for the years 2016–2022

Environmental Sciences

biochemistry, biosensors, bio-catalysis, enzymology, microbiology, molecular biology, genetics, toxicology, eco-toxicology, risk assessments, pathophysiology, bio-statistics and data analysis and modeling.

The **CzechGeo/EPOS** is comprehensive system of observations of geophysical fields operated by geo-sciences oriented Czech research organizations, complemented by the data services and repositories. The aim of CzechGeo/EPOS is to integrate, coordinate and support a broad spectrum of areas related to the seismic data collection and processing. The CzechGeo/EPOS is also the Czech national node of the pan-European research infrastructure EPOS (*European Plate Observing System*).

Development of new nanotechnologies will always undergo the objective assessments of not only the benefits but also of the potential risks that are associated with the nanomaterials. The **NanoEnviCz** (*Nanomaterials and Nanotechnologies for Environmental Protection and Sustainable Future*) provides facilities for research of nanomaterials and nanocomposites for environmental and other related applications, including controllable syntheses, chemical, structural, surface and morphological characterization, tuning functional properties, monitoring of potential toxicity and hazard and exploring their application potential.

Research infrastructures of the Czech Republic oriented on the environmental sciences cover most of the fields dealing with major components of the environment, namely atmospheric sciences (ACTRIS-CZ) and solid earth, including soils (SoWa, CzechGeo/EPOS) and water (SoWa) sciences. The particular topic of biodiversity has not been covered by a specialized individual research infrastructure as well as the social aspects of interaction between the environment and human society, but both these topics are included in a degree within the scope of other research infrastructures (CzeCOS, SoWa, CzechPolar2). Major focus of the Czech research infrastructures is put on the global change in a wider sense (CzeCOS, SoWa, ACTRIS-CZ, CzechPolar2), others include the issues of environmental pollution (RECETOX, NanoEnviCz) and environmental aspects dealing with health risks and natural catastrophes such as earthquakes or floods (CzechGeo/EPOS, SoWa). The majority of research infrastructures focus not only on the elucidation of mechanisms of key environmental processes but also on development of responses in the form of mitigation, adaptation and ecosystem restoration decontamination (CzeCOS, SoWa, RECETOX, NanoEnviCz). It reflects quite well the major issues of present environmental research.

From the geographical point of view, most of the facilities focus primarily on the European region and have been already included in the pan-European research infrastructures networks oriented on the environmental fields, which is clearly in line with the general geopolitical status of the Czech Republic. The CzechPolar2 puts its major focus on the activities in Polar Regions, which corresponds with the necessity of dealing efficiently with the global change issues in a complex and complete way.

More comprehensive linking of the behavior of individual components of the environment will probably increase its importance in the future. A new challenge for the environmental research is clearly a closer link with social sciences and humanities and improving approaches how the behavior of human society can be modified in a way ensuring the sustainable use of natural resources, maintaining the functional environment and allowing the well-being of society.

ACTRIS – participation of the Czech Republic

Acronym:
ACTRIS-CZ

Hosting institution:
Czech Hydrometeorological Institute

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

Responsible person:
VÁŇA Milan
milan.vana@chmi.cz

Website:
www.chmi.cz

Background description

ACTRIS-CZ is focused on the background level of air quality issues in the Czech Republic and in Central Europe. The potential of ACTRIS-CZ is formed by Co-located Station Košetice – Křešín by Pacov and by research and operating supplement of institutes implementing their research and monitoring activities. ACTRIS-CZ represents a Czech national node of the pan-European research infrastructure ACTRIS (*Aerosol, Clouds and Trace gases Research Infrastructure*) and moreover, its capacity is integrated into the pan-European research infrastructure ICOS (*Integrated Carbon Observation System*). ACTRIS-CZ comprises unique research infrastructure focused on the long-term background monitoring and research of physical and chemical processes in the atmosphere including long-range transport. Actually the Czech Republic is one of the first European countries, where the ACTRIS and ICOS activities are coordinated at the same site. Moreover, partner institutions of ACTRIS-CZ are included in a wide range of other pan-European and global networks.

Future development

Further development of ACTRIS-CZ is planned in line with the long-term goals of pan-European infrastructure ACTRIS. A significant enhancement is planned in research of the surface-atmosphere exchanges of aerosols. Attention will be paid to the monitoring and research on the aerosol optical properties having influence on climate issues. The long-term development of aerosol measurements within 10 years will continue with on-line monitoring and chemical analysis of aerosol source tracers and precursors of secondary aerosols.

Socio-economic impact

ACTRIS-CZ contributes to the integration of knowledge potential in air quality research, which leads to better usage by strategic decision-making and support of technologies focused on the protection of climate and human health. The data from ACTRIS-CZ has been repeatedly used for development of the utility models of new sampling devices. This research can be also translated into more practical applications as improvement of weather forecast models, especially in extreme events (floods, storms, etc.). The data is also used in the research connected to renewable energies (solar, wind power). The measurements of air pollutants at the height of 230m may provide important data for a warning system regarding long range transport of background pollution. Meteorological measurements at the tall tower also serve the steel construction sector, especially in the area of dynamics and statics of tall slender constructions. In case of new lidar acquisition in the future it may serve as a basis of a warning system for air traffic in cases such as the Eyafjalajökul eruption in 2010.

CzeCOS

Acronym:
CzeCOS

Hosting institution:
Global Change Research Centre,
Academy of Sciences of the Czech Republic

Responsible person:
MAREK Michal V.
marek.mv@czechglobe.cz

Website:
www.czecos.cz

Background description

CzeCOS provides to a wide range of users unique facilities for impact studies on the effects of global change impacts on aquatic and terrestrial ecosystems (bioreactors, growth chambers, open-top chambers and glass domes), observational research (a set of ecosystem stations for measurements of greenhouse gases and energy fluxes), quantification of long-distance fluxes of greenhouse gases and air pollutants (atmospheric station), environmental metabolomics (including stable isotopes) and remote sensing of processes within carbon and other biogeochemical cycles (aircraft and hyperspectral sensors). CzeCOS is the only one research infrastructure of the Czech Republic dealing with the problem of global change impact on ecosystems. CzeCOS is a crucial part of the pan-European research infrastructures such as ICOS (Integrated Carbon Observation System), AnaEE (*Infrastructure for Analysis and Experimentation on Ecosystems*) or EUFAR (*European Facility for Airborne Research in Environmental and Geo-sciences*).

Future development

Developing activities of the CzeCOS in the next years include restoration and maintenance of the existing facilities and follow the technological and scientific development in fluxes measurement including observation of non-CO_2 greenhouse gases and volatile organic compounds emissions using new analysers (laser spectroscopy), replacement of outdoor sensors and measurement systems behind their lifetime to maintain compatibility with foreign research infrastructure partners.

Socio-economic impact

CzeCOS provides research on mitigation and adaptation on the negative global change impacts on ecosystems. It helps to develop the sustainability of energy and food production, water management and prediction of sociological and economic impacts of global change. The complex inter-connection between individual elements of the research infrastructure focused on ecosystem research allows researchers to create and refine models of future impacts on a relatively long timescale with high spatial resolution and thus produce outcomes that are demanded by society, policy makers or the business community. The current CzeCOS results have been already used (e.g.) by UN IPCC (*United Nations – Intergovernmental Panel on Climate Change*).

Distributed System of Permanent Observatory Measurements and Temporary Monitoring of Geophysical Fields

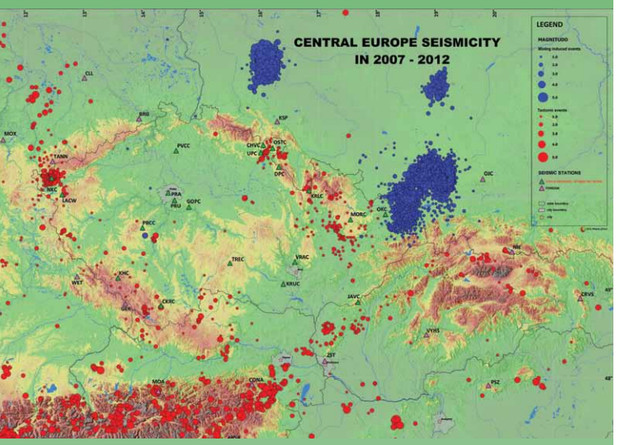
Acronym:
CzechGeo/EPOS

Hosting institution:
Institute of Geophysics, Academy of Sciences of the Czech Republic

Partner institutions:
- Charles University in Prague
- Czech Geological Survey
- Institute of Geonics, Academy of Sciences of the Czech Republic
- Institute of Rock Structure and Mechanics, Academy of Sciences of the Czech Republic
- Masaryk University
- Research Institute of Geodesy, Topography and Cartography

Responsible person:
HEJDA Pavel
ph@ig.cas.cz

Website:
www.czechgeo.cz



Background description

CzechGeo/EPOS is a distributed network of geoscience observations operated by the Czech research organisations. The system consists of permanent observatories (seismic, GNSS, magnetic, gravimetric and geodynamic), usually incorporated into global data networks, local stations or networks in areas significant in the long-term for basic research or applications, and mobile stations, which serve for repeated observations at selected points or for field measurements, usually within the scope of large international projects. CzechGeo/EPOS is closely connected with the pan-European research infrastructure EPOS (*European Plate Observing System*) and its service covers continuous monitoring of geophysical fields on the Czech territory and in selected areas abroad via long uninterrupted series of measurements on fixed sites, which are vital for understanding of Earth's interior processes. CzechGeo/EPOS provides user-friendly data access to global or regional data bases/repositories, including real-time data access whenever possible, transmits access to high-level products (e.g. waveform data, seismological bulletins and regional catalogues, geomagnetic indices) and integrates data in the frame of the Implementation Phase of the EPOS Project. CzechGeo/EPOS involves nearly all observational activities related to the solid Earth carried out by the Czech geoscience institutions. Through participation in more than 20 global or regional networks CzechGeo/EPOS builds up close cooperation with European partners and contributes substantially to better understanding of the processes in the Earth's interior.

Future development

Most of the observatories and networks of CzechGeo/EPOS will require moderate expansions and upgrade of components that are near the end of their working cycle or that have to be innovated in order to respond to the actual demands of the research community and to technological development. In addition to innovation of existing facilities, new components (e.g. *West Bohemia Near Fault Observatory, involving 3 boreholes*) are planned. Cooperation with EPOS will be aimed at contributing to and taking advantage of thematic and integrated core services. According to the strategy of EPOS, geological data will be newly included.

Socio-economic impact

CzechGeo/EPOS contributes through seismic and geothermal monitoring to an effective exploitation of geothermal energy. Exposure to shaking due to local and regional earthquakes is the major threat for safety of critical infrastructures, nuclear power plants in particular. Geophysical data are vital for exploration of sites for nuclear waste repositories as well. The research infrastructure also focuses on monitoring slope stability around the deep open pit brown coal mines in West Bohemia and other areas exposed to slope deformation. CzechGeo/EPOS closely cooperates with public authorities, e.g. *State Office for Nuclear Safety* (SÚJB) and *Radioactive Waste Repository Authority* (SÚRAO), as well as with companies in energetics or the mining industry.

Czech Polar Research Infrastructure

Acronym:
CzechPolar2

Hosting institutions:
- Masaryk University
- University of South Bohemia in České Budějovice

Responsible persons:
- PROŠEK Pavel
  prosek@sci.muni.cz
- ELSTER Josef
  jelster@prf.jcu.cz

Website:
www.czechpolar.eu

Background description

CzechPolar2, consisting of the Czech Antarctic Research Infrastructure (CARI) and the Czech Arctic Research Station (CARS), is a research infrastructure of the Czech Republic specialized in polar research, which offers the platform for Czech and foreign scientists to conduct multidisciplinary research in both areas, which are currently undergoing unprecedented and unparalleled environmental and climatic transformations. The J. G. Mendel Station provides support to field research at James Ross Island and adjacent Antarctica, while the Laboratory of Extreme Environments Life located at Masaryk University (Brno) focuses on research of characteristics of these organisms under the conditions simulating their natural environment. The Czech Arctic J. Svoboda Station consists of a research base in Longyearbyen, field camp in Petuniabukta and a research boat; all these parts support field activities in Svalbard. Centre for Polar Ecology in České Budějovice provides laboratories equipped for biological research. CzechPolar2 is a member of international research bodies and databases: Committee for Environmental Protection of the Antarctic Treaty System (CEP/ATCM), Scientific Committee on Antarctic Research (SCAR), Council of Managers of National Antarctic Programmes (COMNAP) or International Arctic Science Committee (IASC). The research infrastructure CzechPolar2 is also closely connected with the Svalbard Integrated Arctic Earth Observing System (SIOS), Svalbard Science Forum (SSF) or INTERACT project (*International Network for Terrestrial Research and Monitoring in the Artic*).

Future development

CARI will be modernized in the coming years. The J.G. Mendel Station in Antarctica and the Laboratory of Extremophilic Organisms at Masaryk University will be extended by the "Clima-Geo" laboratory and Open Access Data Unit (OADU). Within the framework of CARS it is scheduled commissioning of the laboratories on the J. Svoboda Station on Svalbard and in the Centre for Polar Ecology at University of South Bohemia in České Budejovice, prolonging the research season to whole year, providing open access to databases and integrating the CARS facilities into INTERACT.

Socio-economic impact

CARI issues international journal "*Czech Polar Reports*" and provides scientific background for the Government of the Czech Republic within the Consultative Party Status to the Antarctic Treaty Consultative Meeting. CARI collaborates also with the business sector on testing advanced materials and equipment. Arctic issues are more connected with those of the temperate zone due to the ongoing global change for which CARS offers a research infrastructure for collecting relevant data. Moreover, there is a perspective of the economic potential connected with the opening of the Northwest Passage or extended commercial fishing territories and exploration of resources in the Arctic shelf.

Nanomaterials and Nanotechnologies for Environment Protection and Sustainable Future

Acronym:
NanoEnviCz

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

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

Responsible person:
KALBÁČ Martin
martin.kalbac@jh-inst.cas.cz

Background description

NanoEnviCz integrates the infrastructure facilities of Czech research organisations for complex interdisciplinary research in a broad range of nanomaterial and nanotechnology sciences. The activity of the research infrastructure is focused on research in the field of nanomaterials, surfaces and nanocomposites for environmental and related applications. Services provided by NanoEnviCz include the controllable syntheses, their complex chemical, structural, morphological and surface characterization, tuning their functional properties, monitoring their potential toxicity and hazard and developing their application in advanced technologies. NanoEnviCz forms an efficient multipurpose platform both for partner research organisations as well as for external users from academia, industry and governmental organizations. NanoEnviCz provides centralized access to all the capabilities of the distributed research infrastructure.

Future development

Further development of NanoEnviCz includes improvement of the efficiency of open access services for external users to the advanced instrumentation of the research infrastructure, intensification of the educational and research activities and further extension of the capacity and expertise of the research infrastructure.

Socio-economic impact

NanoEnviCz is designed as a platform providing complete services in R&D in the field of nanomaterials and nanocomposites for environmental and related applications. The research infrastructure thus serves as an example of a progressive trend of multidisciplinary expertise, combining knowledge from various scientific fields, while strengthening its scientific and technological excellence. The research infrastructure also offers regular training of employees from commercial companies focused on advanced R&D of nanotechnology and nanomaterials and their safety.

Research Centre for Toxic Compounds in the Environment

Acronym:
RECETOX

Hosting institution:
Masaryk University

Responsible person:
KLÁNOVÁ Jana
klanova@recetox.muni.cz

Website:
www.recetox.muni.cz

Background description

The RECETOX Research Infrastructure addresses problems related to the Environment and Health. Environmental and human exposures to toxic chemicals, their effects and related risks are assessed as a part of the multidisciplinary research on factors affecting human health. Research capacities of 3 core facilities (trace analytical laboratories, environmental information systems and epidemiological studies) of the RECETOX bring together interdisciplinary expertise on environmental science (chemistry, technology, toxicology, environmental and human exposure, impact and risk assessment and modelling), biomedicine, biostatistics and informatics. These core facilities support their own long-term projects (MONET – *MOnitoring NETworks*, GENASIS – *Global ENvironmental ASsessment and Information System*, and ELSPAC – *European Longitudinal Study on Pregnancy and Childhood*) while offering a rapidly developing portfolio of expertise and services to multiple users. RECETOX is a leading partner of GEOSS (*Global Earth Observation System of Systems*) in the area of health. RECETOX collaborates on a long-term basis with UNEP (*United Nations Environment Programme*) and WHO (*World Health Organisation*).

Future development

The accredited trace analytical laboratories are fully equipped for a wide range of environmental and human exposure studies. A need for enhancement of the laboratory capacities (emerging pollutants, human tissues) is expected in relation to further development of the epidemiological studies. The ELSPAC follow-up projects collecting biological samples will require development of the specimen banking capacity for long-term storage and management of these precious materials. The GENASIS/GMP (*Global Monitoring Plan*) data warehouse completed in response to the need for visualization of the global air monitoring and human biomonitoring data will be transformed into data collection, evaluation and visualization tool for on-going and future regional and global monitoring programmes and linked to GEOSS.

Socio-economic impact

Interdisciplinary expertise of RECETOX offers potential for addressing the most relevant European research priorities and societal challenges. Data on environmental, social, economic, and other health-affecting factors collected over more than two decades and available through open-access to professionals, policy makers as well as the general public provide a valuable source of information on the rapidly changing Central/Eastern European societies. The commercial sector can potentially use the research results created with the help of RECETOX in the process of development of new technologies required for implementation of the circular economy concept (towards improved resource efficiency, waste management and recycling).

National Infrastructure for Comprehensive Monitoring of Soil and Water Ecosystems in the Context of Sustainable Use of the Landscape

Acronym:
SoWa

Hosting institution:
Biology Centre, Academy of Sciences of the Czech Republic

Partner institutions:
- Czech Geological Survey
- Charles University in Prague
- University of South Bohemia in České Budějovice

Responsible person:
FROUZ Jan
frouz@upb.cas.cz

Website:
www.bc.cas.cz

Background description

SoWa will be focused on the investigations of biotic and abiotic processes driving nutrient cycling at the soil-water interface (with emphasis on nitrogen and phosphorus and their biochemical and biological transformations), from micro- to the landscape scale. SoWa aims to facilitate the research of complex interactions between soil and water ecosystems from microscale to the catchment level, with particular emphasis on systems under anthropogenic pressure. The research infrastructure will primarily support research activities aimed at understanding mechanisms and processes responsible for determining key ecosystem processes and services on the catchment level, such as water runoff and purification, nutrient flow in the landscape, decomposition and nutrient release, or key biological processes. SoWa will also assess interactions between ecosystem processes and services following large artificial disturbances. SoWa will provide analyses, methodological background and expert knowledge in the fields of soil biology, hydrobiology, nutrient fluxes and cycling in ecosystems, and the modeling of their interactions. These services will complement other institutions in the Czech Republic involved in both the basic and applied research of processes in soil and water ecosystems.

Future development

The construction phase of the research infrastructure is planned for 2017–2018. During this time the microcosm and mesocosm facilities will be linked to an artificial catchment, which is a unique combination worldwide. These facilities will be combined with long-term data from surrounding experimental plots. The scientific value of proposed devices aimed on ecosystem manipulation, the artificial catchment in particular, will increase with ecosystem development in the catchment and with the known history of this development. This, together with the simplicity and robustness of the design and the fact that most of the state-of-the-art devices can be updated easily, creates a very good perspective for long-term operation of the research infrastructure once it is built.

Socio-economic impact

The anthropogenic pressures on soil and water may disrupt the provision of ecosystem services, which are essential for the functioning of human society. The research activities at SoWa will produce outputs leading to the improvement of ecosystem services, especially in the areas of land restoration, cleanup and decontamination, clean water supply for drinking water production and other uses, flood protection, land use management for sustainable agriculture and forestry, nature conservation and the provision of ecosystem services (including mitigation of global change).

Biomedical Sciences

10.4

page

The Roadmap of Large Infrastructures of the Czech Republic in biological and medical sciences keeps its focus (solely) on biomedicine. The research infrastructures listed below encompass a broad range of scientific disciplines, ranging from basic research with systems biology approaches to translational and clinical research, which accelerates the development of new biotechnical specialisations.

10.4 | Roadmap of Large Infrastructures for Research, Experimental Development and Innovation of the Czech Republic for the years 2016–2022
Biomedical Sciences

The recent dynamic development of the Czech biomedical research infrastructures landscape follows the traditional orientation of Czech R&D and has been powered even more by making use of ERDF in the course of the period 2007–2015, when the construction or major upgrade of most of the biomedical research infrastructures facilities was performed.

The Roadmap of Large Infrastructures of the Czech Republic includes mutually complementary biomedical facilities at different stages of impletmentation, each of those constituting a certain level of service integration, bringing together facilities, technologies, expertise and resources, which all result in a new level of biomedical expertise and synergy. The majority of biomedical research infrastructures are interconnected within the pan-European research infrastructures thus increasing their expertise, efficiency and importance within the ERA.

The **CCP** (*Czech Centre for Phenogenomics*), representing a Czech node of the pan-European INFRAFRONTIER research infrastructure, serves to identify the functions of new genes and provides the animal models to test hypotheses before entering the human testing. At the level of early stage drug discovery, both the **CZ-OPENSCREEN** (*National Infrastructure for Chemical Biology*), being a Czech node of the pan-European EU-OPENSCREEN (*European Infrastructure for Chemical Biology*), and the **CIISB** (*Czech Infrastructure for Integrative Structural Biology*), being a Czech node of the pan-European INSTRUCT (*Integrated Structural Biology*), provide the research community with a platform to identify compound hits, which might be included in target pipelines. The **EATRIS-ERIC-CZ**, representing a Czech node of the EATRIS (*European Infrastructure for Translational Medicine*), operates the translational non-clinical as well as translational early clinical research facility. The **CZECRIN**, being the Czech node of the ECRIN (*European Clinical Research Infrastructure Network*), offers the research infrastructure for clinical research on diagnostic and therapeutic procedures as well as clinical trials of drugs and devices on patients in hospitals and clinics. The clinical part of biomedical R&D is supported by the **BBMRI-CZ**, a Czech node of the BBMRI (*Biobanking and Biomolecular Resources Research Infrastructure*) that collects and analyses biological samples and corresponding data required for the development of new drugs or diagnostic assays. The **NCMG** (*National Centre for Medical Genomics*) is the "youngest" concept of biomedical research infrastructure of the Czech Republic and offers services and expertise in medical genomics.

The following group of biomedical research infrastructures provides integrative services. Thus, the **Czech-BioImaging**, a Czech node of the *Euro-BioImaging* research infrastructure, covers the needs in biological and medical imaging at various levels, from imaging living animals and their tissues and cells, including in vitro dynamics of cell behaviour, down to imaging of cell organelles, transport, biomolecules and their interactions in health and disease. The **ELIXIR-CZ**, a Czech node to ELIXIR – being a special project under the umbrella of EMBL (European Molecular Biology Laboratory) – focuses on establishing a research infrastructure for storage, processing and analysing the life sciences data in response to the growing needs of biomedical research community, which is generating an immense and exponentially increasing data volume. Thus, it is necessary to store the biomedical research data, efficiently extract their key information and make it accessible. The **C4SYS** (*Centre for System Biology*), representing a Czech node of the ISBE (*Infrastructure for Systems Biology – Europe*), is another research infrastructure having a strong role in integrating life sciences technologies, data and services among the research infrastructures and biological and medical sciences research community.

The most advanced Czech biomedical research infrastructures are connected with excellent foreign partners (1) providing open access to cutting-edge technology platforms for academia and industry; (2) standardizing research outputs and reducing fragmentation; (3) promoting interdisciplinary R&D in biological and medical sciences; (4) facilitating translation of findings from fundamental research to new applications in medicine; (5) improving competitiveness of academic research with outreach to industry (e.g. pharmaceutical industry, biotechnology, advanced equipment manufacturers etc.); (6) providing training and education to future professionals in life sciences; and (7) attracting world-leading scientists to the Czech research organizations.

10.4 | Roadmap of Large Infrastructures for Research, Experimental Development and Innovation of the Czech Republic for the years 2016–2022

Biomedical Sciences

All the biomedical research infrastructures listed in the Roadmap of Large Infrastructures of the Czech Republic (except for one) are networked in pan-European research infrastructures. Six of them successfully went through the preparatory and construction phase at the EU level and have begun with their operational phase (BBMRI, EATRIS, ECRIN, ELIXIR, INFRAFRONTIER, INSTRUCT), being followed by the other ones (EU-OPENSCREEN, Euro-BioImaging, ISBE). Some of these research infrastructures have also been already converted into the new legal form of ERIC, while the others are still in the process of transformation or have used other legal form within which they are operated.

The Czech biomedical research infrastructures are complementary and cover a broad range of R&D areas. However, if comparing the landscape with multidisciplinary scientific fields, certain gaps might be identified as the current R&D require more and more cross-sectoral approaches combining different expertise.

The area of *nano-biotechnology* (nanomaterials for biomedical sciences) keeps its focus on the R&D of high-resolution artificial structures and targets the interface between the life sciences and nanomaterials. Nano-biotechnology has significant impact in therapeutics, diagnostics, imaging and regenerative medicine. It brings a considerable benefit also for all disease areas, including cardiovascular diseases, diabetes and cancer, and has a substantial potential to be one of the main instruments utilized in the personalized, targeted and regenerative medicine.

Other cross-sectoral scientific approach combines the plant-biology R&D with environmental sciences. The plants create an indispensable basis for all food and feed, for maintaining a healthy environment, and are employed for renewable bioenergy production. To describe the plant genome and individual gene functions is a pre-condition for understanding the molecular processes, whose knowledge is fundamental for ensuring food quality and yield, biomass for non-food purposes and for enhancing higher tolerance to adverse environmental conditions. The *plant phenotyping* helps to define the strategies to improve the yield, stability and quality of globally important crops and to develop new resilient crops. The collections of plant genetic resources, plant germplasm, wild plant relatives and native seeds accompanied with corresponding specialized (meta-) data and provided on the basis of open access are thus of growing importance for conducting plant-biology R&D.

Synthetic biology applies the principles of engineering to the biosciences trying to design and construct new biological parts and systems. Synthetic biology utilizes the chemical synthesis of DNA and growing knowledge of genomics to facilitate researchers to quickly assemble new or modified DNA aiming at the construction of novel parts of microbial genomes that are inserted into a microbe or a cell. Synthetic biology is highly interdisciplinary and technically demanding R&D area that requires complex research infrastructure facilities. It has significant impacts on many R&D and socio-economic fields by providing novel concepts for regenerative medicine, pharmaceuticals, high-value chemicals, biosensors, biofuels and new biomaterials.

Solving some of the particular tasks that the biomedical research infrastructures have recently been facing might be efficiently facilitated by their *meta-integration and clustering*. Employment of these processes in the development of services for personalized medicine, healthcare, (bio-) pharmaceutical manufacturing and (pre-) clinical trials would lead to increased understanding of disease mechanisms behind the clinical symptoms and disease progression. Building these structures is thus a pre-condition for deepening the complementarity of biomedical research infrastructures and developing of their mutual supporting base.

The complex cross-discipline R&D tasks urge for collaboration among research infrastructures in order to provide a full pipeline of expertise and services. Depending on the specific needs of R&D projects, research infrastructures should enable open access services in collaboration at the (macro-) regional and international level. Therefore the biomedical research infrastructures should be supported in interoperability, clustering and cooperation effort as it will contribute to improve the usage of resources and overall work efficacy. Such a development shall bring huge benefits for the cross-sectoral R&D carried out not only in the fields of biological and medical sciences, but also in material and environmental sciences.

All the Czech biomedical research infrastructures have been either established recently or are still in their construction phase, receiving new buildings and state-of-the-art technologies. Each of them, being an inseparable part of the pan-European effort, should further strengthen its scientific and technological base, increase international competitiveness and together with European partners jointly address the grand challenges in biomedical sciences.

Bank of Clinical Specimens

Acronym:
BBMRI-CZ

Hosting institution:
Masaryk Memorial Cancer Institute

Partner institutions:
- First Medical Faculty, Charles University in Prague
- Medical Faculty, Charles University in Hradec Králové
- Medical Faculty, Charles University in Pilsen
- Medical Faculty, Palacký University in Olomouc

Responsible person:
VALÍK Dalibor
valik@mou.cz

Website:
www.bbmri.cz

Background description

Using standardized procedures BBMRI-CZ collects, processes and stores human-derived biospecimens (such as primary tumor tissues and other relevant specimens) that would be otherwise irreversibly lost. Such biospecimens are of critical importance for either existing or future research projects and for patient benefit as well. In the Czech Republic, BBMRI-CZ organizes not only a dedicated set of cancer-oriented biorepositories but also operates a unique set of technologies and knowledge to perform clinical applications of translational research including clinical trials. The user community may take advantage of the expertise of the BBMRI-CZ qualified staff and resources archived in biorepositories. BBMRI-CZ represents a Czech national node of the pan-European research infrastructure BBMRI (*Biobanking and Biomolecular Resources Research Infrastructure*) and has been a Member State of the BBMRI ERIC since 2013.

Future development

In area of academics, the BBMRI-CZ development plan comprises taking leadership in the field of research-oriented clinical biobanking in the Czech Republic, including setting up a network of regional biobanks to focus on the premorbid period in cancer in the context of regional exposure in the Czech Republic. At the academia-industry interface BBMRI-CZ will increase its role as a leading partner for innovative industrial activities to enhance introduction of new potential medicinal products to better serve patient community in the Czech Republic.

Socio-economic impact

Direct socio-economic impacts of BBMRI-CZ pertain to activities defining key documents of health policies in the Czech Republic such as clinical practice guidelines on the use of clinical laboratory and predictive testing in oncology. Indirect impacts pertain to the medical applications of biomarkers to be discovered and characterized with the use of collected biological material connected to clinical data and tested through a comprehensive system of clinical trials. Search for relevant biomarkers specific for certain disease using archived human tissues is a critical component in the design of innovative medicinal products and diagnostic procedures in human diseases.

Centre for Systems Biology

Acronym:
C4SYS

Hosting institution:
Institute of Microbiology, Academy of Sciences of the Czech Republic

Partner institutions:
- Global Change Research Centre, Academy of Sciences of the Czech Republic
- Masaryk University
- University of South Bohemia in České Budějovice

Responsible person:
ETTRICH Rudiger H.
ettrich@nh.cas.cz

Website:
www.c4sys.cz

Background description

C4SYS concentrates the knowledge potential in the field of systems biology and links diverse systems biology research in the Czech Republic to the pan-European research infrastructure for systems biology ISBE (*Infrastructure for Systems Biology – Europe*). Its portfolio includes a spectrum of approaches to build and exploit predictive maps and models of complex biological systems that range from molecular to whole organism level, the design of experimental approaches to efficiently collect data that are fit for modeling and stewardship of relevant data, models and maps. C4SYS services comprise consulting, support through contract activities, development of standards and teaching and training. Apart from providing the core services expected from each of the ISBE national node, C4SYS contributes complementary expertise on selected organisms (Algae, cyanobacteria, ticks, yeast). C4SYS is involved in international research networks and collaborations with top-ranked institutions worldwide. Agreements to exploit C4SYS's large synergy potential have been signed at the Czech national level with the research infrastructures CIISB, Czech-BioImaging and ELIXIR-CZ.

Future development

Systems biology is a key component in development of biological and biomedical research. C4SYS will trigger the spread of systems biology approaches within the Czech life science community. Users will cover a wide range of different fields within biological and medical sciences as well as in applied fields such as industrial and agricultural biotechnology.

Socio-economic impact

Systems biology is considered to be the key scientific driver towards applicable systems medicine. The notion that understanding and potentially treating complex diseases relies on the ability of taking systemic complexity into account, depends, in turn, on providing the robust systems biology underpinning for the biomedical research field. Facilitating this integrated approach to the study of biological processes will transform our knowledge of the functioning of biological systems at many scales. Exploitation of this knowledge will have immense impacts for applications in bio-medicine, bio-technological industry, agriculture and the environment and will contribute to shaping future healthcare in the Czech Republic.

Czech Centre for Phenogenomics

Acronym:
CCP

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

Responsible person:
SEDLÁČEK Radislav
radislav.sedlacek@img.cas.cz

Website:
www.phenogenomics.cz

Background description

CCP provides expertise and services to the biological and medical research community studying gene function. An understanding of gene function is essential as population-based genetic associations using genome-wide association studies and the complete sequencing of individual patient genomes can only achieve their promise for effective preventative and personalized medical treatment. CCP thus provides a full spectrum of genetic engineering services, including the generation of mouse models of diseases, cryoarchiving and distribution, advanced phenotyping and imaging techniques as well as specific pathogen free animal housing. CCP is a member of both the pan-European research infrastructure INFRAFRONTIER and the world-wide consortium IMPC (*International Mouse Phenotyping Consortium*), whose shared goal is to produce a comprehensive "encyclopaedia" of gene function that will help identify causative factors of human diseases and novel targets for therapeutic intervention.

Future development

CCP's operation is based on a comprehensive portfolio of services and expertise, which are unique in the Czech Republic and competitive worldwide. CCP strives to continuously improve our operational effectiveness and to ensure maximal utilization of capacity and processes. CCP will also continue to keep pace with technological developments and adopt new tests, as agreed by the consortia partners. CCP will further establish bioinformatics and imaging units, units for reproductive biology, antibody production, and/or metabolomics. The goal of CCP is to receive ISO accreditation and to implement good laboratory practice (GLP) quality management controls. Ensuring adherence to internationally recognized standards of practice will not only boost credibility, but will also allow CCP to offer its contract research services to the pharmaceutical industry.

Socio-economic impact

CCP provides the research community with convenient and cost-effective access to a comprehensive portfolio of services, which include transgenic rodent model generation and phenotyping services and thereby serves as an invaluable catalyst for Czech biomedical research and pre-clinical therapeutic development. As an integral contributing partner of respected international consortia (INFRAFRONTIER and IMPC), it contributes to the scientific reputation of the Czech Republic abroad. The expertise of CCP facilitates the earliest stage of the pharmaceutical developmental pipeline, which is becoming increasingly reliant on the type of extensive mechanism of action knowledge provided and facilitated by our services. This is especially relevant as therapies are becoming more personalized, rather than populationtargeted.

Czech Infrastructure for Integrative Structural Biology

Acronym:
CIISB

Hosting institution:
Masaryk University

Partner institution:
Institute of Biotechnology, Academy of Sciences of the Czech Republic

Responsible person:
SKLENÁŘ Vladimír
vladimir.sklenar@ceitec.muni.cz

Website:
www.structuralbiology.eu/update/centres/instruct-cz

Background description

CIISB is a distributed research infrastructure of the core facilities and central laboratories of CEITEC (*Central European Institute of Technology*) and BIOCEV (*Biotechnology and Biomedicine Center of the Academy of Sciences and Charles University in Vestec*). CIISB provides expertise and access to technologies used for integrative approaches to structural analysis of biologically important cellular components and macromolecules at different resolution levels, ranging from atomic to cellular. CIISB consists of 10 core facilities and central laboratories at levels of national and international importance. CIISB provides equipment, expertise and access to the latest technologies of preparation and characterization of samples and their structural analysis. CIISB represents a National Affiliate Centre of the pan-European research infrastructure INSTRUCT (*European Integrated Structural Biology Infrastructure*).

Future development

In the short term, the CIISB cutting-edge technologies for NMR, crystallization of biological macromolecules, X-ray diffraction and Bio-SAXS measurements, cryo-electron microscopy and tomography, nanobiotechnology, biophysical characterization and mass spectrometry equipment for characterization of biomacromolecules already installed and planned until the end of 2015 will require only partial extensions and upgrades. Until 2020, the equipment of CIISB will be maintained and modernized to keep the research infrastructure at the level comparable to similar European research infrastructures. Technologies and methodologies offered by CIISB will trace the development of integrative structural biology in international context and the portfolio of provided expertise and services will be continuously optimized.

Socio-economic impact

CIISB stimulates national and trans-national collaborations across mathematics, physics, chemistry, biology and medicine at academic and industrial levels. CIISB serves mainly basic research. Nevertheless, innovations and technology transfer are among the strategic priorities of the hosting institutions of CIISB. CIISB supports progressive development in biomedicine and biotechnology by providing the best available technological platform for obtaining highresolution structural data for biotechnological applications, drugrelated research, development of new biomarkers, and improvement of food technologies.

Czech National Node to the European Clinical Research Infrastructure Network

Acronym:
CZECRIN

Hosting institution:
Masarykova Univerzita

Partner institution:
Fakultní nemocnice u sv. Anny v Brně

Responsible person:
DEMLOVÁ Regina
demlova@med.muni.cz

Website:
www.czecrin.cz

Background description

CZECRIN provides research, knowledge, methodological and service support for academic clinical trials (*Investigators Initiated Trials – IIT*) and under organizational leadership of Masaryk University in the cooperation with St. Anne's University Hospital in Brno creates an interoperable collaborative network of academic clinical research institutes in the Czech Republic. CZECRIN represents the Czech national node of the pan-European research infrastructure ECRIN (*European Clinical Research Infrastructures Network*), which is aimed at promoting the academic clinical trials at the EU level. The key areas addressed by CZECRIN are: regulatory and knowledge support, including quality assurance within the accreditation procedures and the preparation of complete study documentation for IIT; clinical application support ensuring biometry, monitoring, pharmacovigilance and systematic educational programme comprehensively covering the IIT; and research and development activities, including manufacturing of new advancedtherapy medicinal products (ATMP).

Future development

CZECRIN will develop its activities in order to further expand the research support for the implementation of applied biomedical research through academic clinical trials conducted in the key areas of origin and development of diseases, new diagnostic and therapeutic methods, epidemiology and prevention of the most serious diseases. The CZECRIN will help to maximize the utilization of research potential in the application environment, therefore with direct impact on patient health. Development of CZECRIN as the Czech national node within the ECRIN will allow better linking of Czech clinically-oriented research organisations with a sphere of application at the EU level.

Socio-economic impact

Excellence in clinical trials execution is the critical step in significantly affecting the overall ability to successfully translate research results into practice. CZECRIN, by focusing on the key elements of support for academic clinical trials through research, educational, methodological and regulatory support across the various disciplines of medicine, has major social implications in the translation of biomedical research results into clinically applicable outputs, such as new drugs, medical procedures and practice guidelines. This potential can be exploited by the business community and cooperation with business partners is promoted even on the basis of collaborative contract research in accordance with the policy of the ECRIN. An important part and one of the priorities is the area of advanced therapy medicinal products (ATMP) with the production of unique, individual, cell- and gene-based therapeutics focused on cancer and regenerative medicine.

National Infrastructure for Biological and Medical Imaging

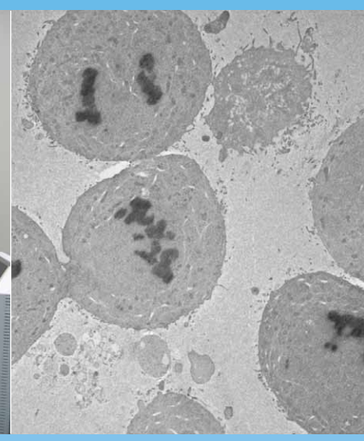
Acronym:
Czech-BioImaging

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

Partner institutions:
- Biology Centre, Academy of Sciences of the Czech Republic
- Brno University of Technology
- Charles University in Prague
- Institute of Experimental Botany, Academy of Sciences of the Czech Republic
- Institute of Physiology, Academy of Sciences of the Czech Republic
- Institute of Scientific Instruments, Academy of Sciences of the Czech Republic
- Masaryk University
- Palacký University in Olomouc

Responsible person:
HOZÁK Pavel
hozak@img.cas.cz

Website:
www.czech-bioimaging.cz



Background description

Thanks to rapid technological development, innovative imaging technologies enable observing previously hidden life processes inside cells, tissues and entire organisms. Therefore, imaging has truly become one of the main drivers of research in biological and medical sciences. CzechBioImaging is built as a distributed research infrastructure of imaging core facilities in the Czech Republic. It will offer open access to a broad portfolio of imaging techniques and expertise for acquiring completely new research data. Additionally, it will enhance the qualification of researchers and students in this area through training programmes. Czech-BioImaging addresses needs in imaging at various levels – from imaging of organisms, tissues and cells, down to imaging of cell organelles, transport, biomolecules and their interactions in health and disease. CzechBioImaging offers access to a broad range of imaging technologies, e.g. advanced light and fluorescence microscopy, super-resolution microscopy, electron microscopy, correlative light and electron microscopy, sample preparation, neuroscience imaging, magnetic resonance, magnetic particle imaging, and image data analysis. Czech-BioImaging is a member of the panEuropean research infrastructure Euro-BioImaging.

Future development

Basic and applied research in biology, medicine and other research areas require in-vivo insight into live organs and tissues as a very important part of a multi-level and multidisciplinary approach. Czech-BioImaging will provide the necessary expertise and guidance starting from designing an experiment to data analysis. It will also conduct its own research aiming to improve existing imaging methods or to develop new methods and data processing strategies for the study of animate as well as inanimate matter, thus establishing a bridge between life and material sciences. Czech-BioImaging multidisciplinary teams will provide the research community with the professional base necessary for the effective solution of newly emerging needs in the area of imaging.

Socio-economic impact

Outcomes of the research utilizing the instrumentation available at Czech-BioImaging will have a positive impact on the quality of life and development of biomedical knowledge of the research community in the Czech Republic. Czech-BioImaging maintains long-term cooperation with abroad and runs joint innovative projects on development of new imaging methods with the world leading imaging manufacturers. Czech-BioImaging may thus help attract foreign investments in the imaging industry in the Czech Republic and boost the establishment of new companies in this industrial sector.

National Infrastructure for Chemical Biology

Acronym:
CZ-OPENSCREEN

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

Partner institutions:
- Institute of Chemical Technology in Prague
- Masaryk University
- Palacký University, Olomouc

Responsible person:
BARTŮNĚK Petr
bartunek@img.cas.cz

Website:
www.openscreen.cz

Background description

The main aim of CZ-OPENSCREEN is to operate state-of-the-art research infrastructure in the fields of chemical biology and genetics and to support a new interdisciplinary research approach by bridging traditional natural sciences such as cell biology, molecular and structural biology, biochemistry, organic chemistry and chem/bioinformatics. The CZ-OPENSREEN mission is to identify new molecular probes/tools for research and proof-of-concept compounds for the development of new potential therapeutics. Unlike commercial platforms, CZOPENSCREEN also focuses on non-validated molecular targets, signalling pathways and neglected diseases. As a part of portfolio of offered services CZOPENSCREEN builds a compound library consisting of diverse, commercially available compounds as well as chemical compounds synthesized originally in the Czech Republic. CZOPENSCREEN represents a Czech national node of the pan-European research infrastructure EU-OPENSCREEN (*European Infrastructure for Chemical Biology*) and closely cooperates with other Czech research infrastructures such as CCP, CIISB, CzechBioImaging, EATRIS-CZ and ELIXIRCZ.

Future development

CZ-OPENSCREEN currently employs a broad portfolio of biochemical and cell-based assays and technologies that will be further developed and strengthened, including several unique platforms focusing on nuclear receptors. It is also planned to establish procedures for transnational open access enabling to provide access and services for researchers beyond the EUOPENSCREEN activities (United States of America, Asia and Australia). The strong chem/bioinformatics platform will be further enhanced by development and implementation of innovative data mining and visualization tools that will allow users to efficiently analyse their data. CZOPENSCREEN plans to primarily support projects from the biomedical field, but is open to other areas of life sciences like veterinary science, agrochemical and environmental sciences.

Socio-economic impact

Chemical biology practiced in academia is focused primarily on basic research and the understanding of molecular mechanisms of normal development and disease. However, it might have immediate impact on translational research, for example, identification and validation of novel activities of known drugs, ex vivo therapeutics and targeted experimental therapy. State-of-the-art equipment and the chemical biology knowledge-base of CZOPENSCREEN strengthen the very competitive position of the Czech Republic in the life sciences. There is a high translational and application potential of research outcomes of CZOPENSCREEN for pharmaceutical, biotechnology and agrochemical industries.

Czech National Node to the European Infrastructure for Translational Medicine

Acronym:
EATRIS-CZ

Hosting institution:
Palacký University in Olomouc

Partner institutions:
- Charles University in Prague
- Institute of Experimental Medicine, Academy of Sciences of the Czech Republic
- Institute of Chemical Technology in Prague
- Institute of Macromolecular Chemistry, Academy of Sciences of the Czech Republic
- Institute of Microbiology, Academy of Sciences of the Czech Republic
- Institute of Organic Chemistry and Biochemistry, Academy of Sciences of the Czech Republic
- Masaryk University – Central European Institute of Technology (CEITEC)
- Nuclear Physics Institute, Academy of Sciences of the Czech Republic

Responsible person:
HAJDÚCH Marián
marian.hajduch@upol.cz

Website:
www.eatris.cz
www.imtm.cz

Background description

The pan-European research infrastructure EATRIS (*European Infrastructure for Translational Medicine*) comprises over 80 leading research organisations across Europe. The Czech national node EATRISCZ was embedded into the Institute of Molecular and Translational Medicine of the Palacký University in Olomouc. EATRIS-CZ provides cutting edge research infrastructure and expertise along the entire translational value chain. It provides the possibilities of "one-stop-shop" access to reach the first-in-human application and clinical proof-of-concept in 5 interrelated product platforms. EATRIS-CZ offers a multidisciplinary development, including key technologies, services, patient cohorts and opinion leader interactions. EATRIS-CZ actively cooperates with other research infrastructures within the Czech and international landscape. Namely, collaboration with INFRAFRONITIER and EU-OPENSCREEN (*European Infrastructure for Chemical Biology*) is being actively developed in the field of identification/validation of new molecular targets and development of innovative therapies. Similarly, the collaboration with BBMRI (*Biobanking and Biomolecular Resources Research Infrastructure*) and ECRIN (*European Clinical Research Infrastructure Network*) is being established for the discovery and validation projects in the field of biomarkers, rare diseases and advanced clinical testing.

Future development

In the following period, EATRIS-CZ will further expand the network of centres and establish mechanisms of cooperation to develop open access strategies and to create by 2016 a national network of translational medicine and biomedical infrastructures working together on joint pilot projects.

Socio-economic impact

EATRIS-CZ contributes to public health by increasing the number of innovative products from preventive, diagnostic and therapeutic disciplines, while focusing on unmet medical needs in the Czech Republic and Europe. EATRIS-CZ improves research culture and improves control of academic community over its own research. It trains a new generation of researchers, health care and pharma industry professionals. EATRIS-CZ maximizes return on investment in basic research, advances candidate products from the academia and increases their chance to be licensed by the industry. EATRIS-CZ re-fills the pipeline of industry by transferring promising candidates to interested companies.

Czech National Infrastructure for Biological Data

Acronym:
ELIXIR-CZ

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

Partner institutions:
- Biology Centre, Academy of Sciences of the Czech Republic
- CESNET, z. s. p. o., Prague
- Charles University in Prague
- Institute of Biotechnology, Academy of Sciences of the Czech Republic
- International Clinical Research Center of St. Anne's University Hospital in Brno
- Institute of Chemical Technology in Prague
- Institute of Microbiology, Academy of Sciences of the Czech Republic
- Institute of Molecular Genetics, Academy of Sciences of the Czech Republic
- Masaryk University
- Palacký University in Olomouc
- University of South Bohemia in České Budějovice

Responsible person:
VONDRÁŠEK Jiří
jiri.vondrasek@uochb.cas.cz

Website:
www.elixir-czech.org

Background description

Life science experiments generate an immense and exponentially increasing volume of data. It is necessary to store the data, make them accessible, interoperable and safe. The major aim is to extract key information and analyse the data effectively. The mission of ELIXIR-CZ is to create a sustainable infrastructure for storing, processing and analysing life science data in the Czech Republic and to provide an access to tools and training to facilitate these activities. ELIXIR-CZ currently provides 9 databases of life science data and 15 instruments and tools for their processing and analysis. Uniqueness of the ELIXIR-CZ lies in the expertise provided by specialized groups at significant Czech life research organisations – members of ELIXIR CZ consortium. Jointly they create a bioinformatics platform offering services for wide research community in the open access regime. The participation of ELIXIR-CZ in the panEuropean research infrastructure ELIXIR is essential and ELIXIR-CZ benefits from this membership. It increases the visibility of ELIXIR-CZ services and tools, enlarges its user community and it catalyses project based cooperation with other ELIXIR national nodes.

Future development

Bioinformatics is a very dynamic area spontaneously reflecting the progress in life sciences. The new technological developments in almost all life science disciplines bring forward new challenges for data usage and their analysis. ELIXIR-CZ in close collaboration with CESNET e-infrastructure will implement cutting edge technology in data processing, storage and accessibility as well as its own strategy of data management. All the services offered by ELIXIR-CZ research infrastructure are meant to be dynamic to reflect current development of the field and to add new functionalities to existing ones and therefore be able to meet the needs of the user community.

Socio-economic impact

Creating ELIXIR-CZ research infrastructure and its integration into the pan-European research infrastructure for biological data ELIXIR, represents a key moment for life science disciplines in the Czech Republic. Its operation will enable Czech users to implement the best European and world-class methodologies and techniques. It is also expected that scientific fields of bioinformatics will expand supporting pharmaceutical, healthcare, agriculture and bioscience industries in development of competitive products with significant multiplication effects.

National Center for Medical Genomic

Acronym:
NCMG

Hosting institution:
Charles University in Prague

Partner institutions:
- General Faculty Hospital in Prague
- Masaryk University
- Palacký University in Olomouc
- University Hospital in Motol
- University Hospital Brno
- University Hospital Pilsen

Responsible person:
KMOCH Stanislav
skmoch@lf1.cuni.cz

Website:
www.ncmg.cz

Background description

Medical genomics is a dynamically evolving scientific discipline that gathers and uses the genomic information of patients, their genetic relatives and even the entire population to identify the genetic, genomic and molecular basis of human health and disease. NCMG creates a research infrastructure that allows rapid implementation of novel genomic technologies and enables their rational utilization in the characterization of genetic underpinnings of human health and disease in the Czech Republic. NCMG currently possesses state-of-the-art instrumentation and provides expertise that is needed for genomic sequencing, transcriptome analysis, epigenetic analysis, cytogenomics, quantitative PCR analysis and high throughput genotyping. NCMG has sufficient computational and data storage capacities and provides basic bioinformatic and statistical support to a number of projects targeting various rare diseases, cancer and complex phenotypes.

Future development

NCMG is conceived as a distributed multi-centered, nation-wide research infrastructure of top genomic laboratories operating at leading national institutions of medical education and biomedical research. Localization and at the same time dissimilar specializations of individual laboratories guarantee the territorial and occupational development and application of genomics in the Czech Republic in accordance with worldwide trends. In this setting, NCMG laboratories will develop its technological and methodological background in a coordinated and complementary manner, maintain and provide state-of-the-art analytical expertise to investigators having access to well-defined cohorts of patients, control individuals and various clinical materials. As in other countries, the Czech Republic has a unique population with genetic variants that may be specific to this population. Understanding genetic variation in the Czech Republic and how it compares to other populations will be an important step in understanding how genetics affects the health of individuals in the Czech Republic. Together with continued technological advances in instrumentation, data analysis and data storage, NCMG will build up a reference database of genetic variation of the Czech population that will be based on exome – and later – whole genome sequencing data.

Socio-economic impact

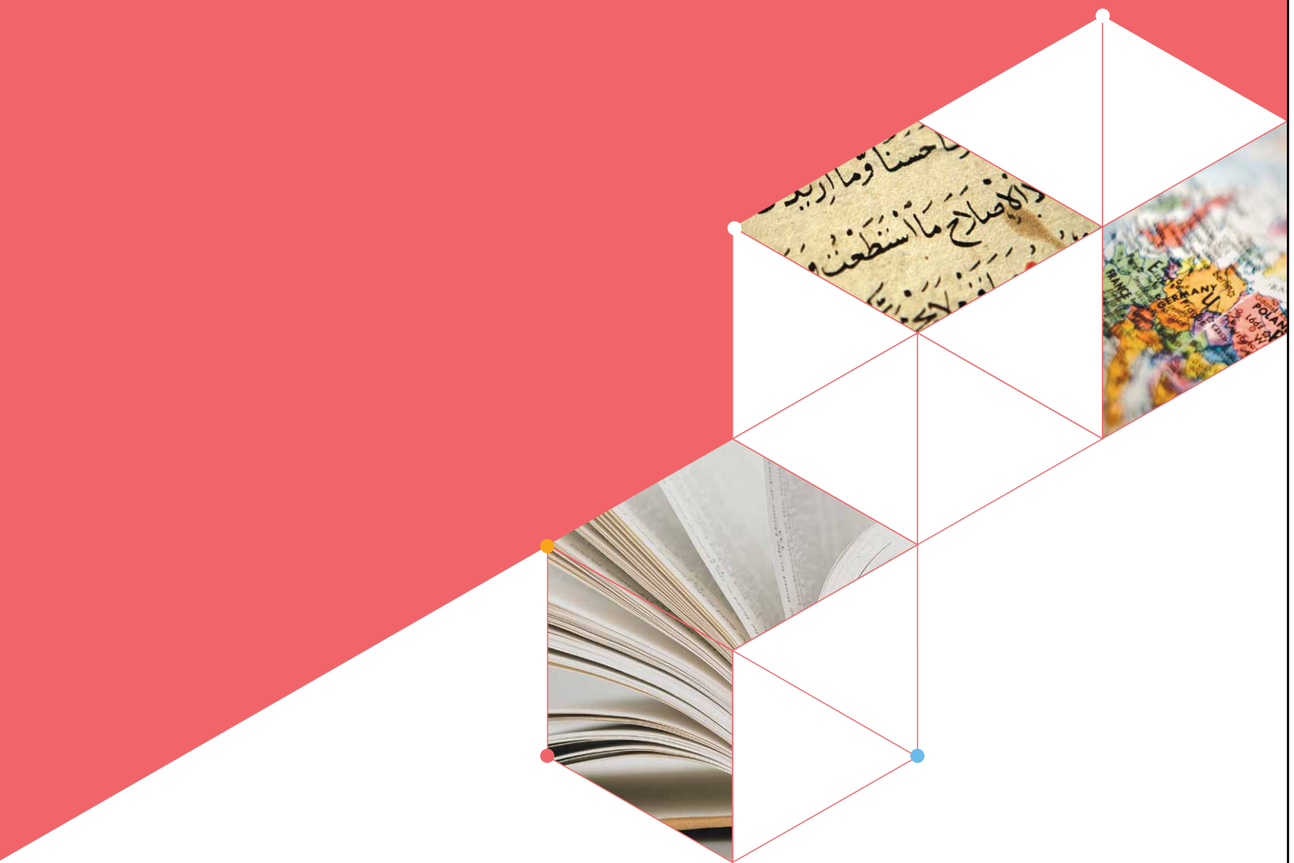
Medical genomics provides new methodologies for biomedical research and alters how we think about the causes of disease. These findings will have an immediate impact on clinical practice. NCMG research infrastructure is therefore essential for education and training of a new generation of researchers,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

Social Sciences And Humanites

10.5

page

Social sciences and humanities (SSH) make an important contribution to our understanding of the historical, social, economic, political and cultural aspects of life in the Czech Republic and helps develop expertise in promoting processes of integration of the Czech Republic into international structures in the EU and globally. Knowledge of cultural heritage, traditions, values and identity promotes social cohesion as well as mutual understanding between Czech and other societies, and between different social groups in the Czech Republic, and thus promotes cooperation and helps to mitigate social conflicts.



10.5 | Roadmap of Large Infrastructures for Research, Experimental Development and Innovation of the Czech Republic for the years 2016–2022

Social Sciences And Humanites

Research addressing current and long-term issues in the SSH areas includes demographic development, migration, social inequalities, ethnic and other diversities, gender inequalities, educational systems, economic development and job creation, welfare systems, health and wellbeing, regional development and many others. This research provide politicians with a platform for efficient evidence-based decision making processes and promotes the development of a knowledge-based economy, with clear implications for promoting competitiveness and quality of life.

Recent developments in SSH research and its ability to contribute to solutions of important societal challenges have been driven by a dramatic increase in the production and utilisation of digital data. In consequence, alongside the traditional sources of materials in libraries, archives, museums and galleries, new specialised research infrastructures of the digital age are a necessary precondition for efficient and internationally competitive SSH research. The activities of these research infrastructures are aimed at (1) collecting and integrating data into large-scale collections and corpora; (2) opening national and international access to data; (3) systematising and linking different data sources; (4) making data comparable across countries and over time; (5) contributing to advances in research methods for data-driven research; (6) development and implementation of technical solutions for data collection, dissemination, sharing, processing and analysis; (7) facilitating new models for collaborative research practices; (8) coordinating and enhancing data digitisation processes; (9) creating new forms of data research outputs; and (10) providing information to help researchers engage with digital content, tools and methods, including training, and technical and methodological assistance.

The key drivers and objectives in SSH include the preservation of cultural and historical heritage, especially as this can contribute to social development at the national level. Thus there is a need for the continual gathering of research materials as well as longitudinal data collections. Irreparable damage to research in SSH would result from an interruption in such processes, or if digitally archived content were to be lost. The long-term durability of these systematic processes is therefore critical to the success of current and future research in SSH. The solution is a concentration of efforts into sustainable SSH research infrastructures.

The implementation of the Roadmap of Large Infrastructures of the Czech Republic has brought significant improvements in the "governance" of several areas of SSH research infrastructures. Substantial upgrades and continuity of activities have been achieved in the development of language research resources and technologies and archiving and dissemination of the social sciences data. The involvement of the Czech Republic in leading social survey programmes implemented within the ERA and the participation in pan-European research infrastructures CESSDA (*Consortium of European Social Science Data Archives*); CLARIN (*Common Language Resources and Technology Infrastructure*); ESS (*European Social Survey*); and SHARE (*Survey of Health, Ageing and Retirement in Europe*) have significantly improved the conditions for SSH research in the Czech Republic.

The updated Roadmap of Large Infrastructures of the Czech Republic thus builds on these achievements whilst the following research infrastructures have been recommended for continuation: **CNC** (*Czech National Corpus*); **CSDA** (*Czech Social Science Data Archive*), including the Czech participation in CESSDA; **LINDAT/CLARIN** (*Centre for Language Research Infrastructure in the Czech Republic*), including the Czech participation in CLARIN; **ESS-CZ** (*Czech participation in European Social Survey*); and **SHARE-CZ** (*Czech participation in Survey of Health, Ageing and Retirement in Europe*). In addition, three SSH research infrastructures based on the systematic development of existing activities have been newly included: **AIS CR** (*Archaeological Information System of the Czech Republic*); **CLB** (*Czech Literary Bibliography*); and **RIDICS** (*Research Infrastructure for Diachronic Czech Studies*).

The previous implementation of the Roadmap of Large Infrastructures of the Czech Republic helped SSH research infrastructures to increase their mutual coordination and overcome initial fragmentation. Nonetheless a large number of resources and services still have limited compatibility and accessibility. On the other hand, even though particular deficiencies have persisted and certain gaps need to be filled in the future in line with current trends in SSH research, the research infrastructures landscape of the Czech Republic recently underwent a substantial positive development, accompanied by further integration into the ERA.

10.5 | Roadmap of Large Infrastructures for Research, Experimental Development and Innovation of the Czech Republic for the years 2016–2022

Social Sciences And Humanites

One of the emerging SSH areas to be addressed more intensively in the future is the *digital humanities*. The research infrastructure projects based on the broader inter-institutional and multidisciplinary cooperation, aimed at interconnection of existing resources devoted to cultural heritage and history research materials, are in demand by the Czech, European and worldwide research community. Coordinated efforts in digitisation and implementation of technologically advanced research tools and methods promote efficiency in preservation activities and make it possible to provide open access to resources and ensure their extensive use. In particular, efforts to apply innovative digital technologies, connecting digital resources from various types of memory institutions (such as archives, museums and libraries) and creating new tools and techniques to use these data, are being developed.

Such efforts are already well underway within the ERA and most importantly represented by the DARIAH ERIC (*Digital Research Infrastructure for the Art and Humanities*). So far, similar achievements have not been reached in the Czech Republic, but individual institutions are active in certain areas (e.g. through creating links to Czech cultural heritage content in *Europeana* – an aggregator of digitised arts and culture in Europe), which is a promising phenomenon for future development. Progress towards explicit cooperation among various humanities-serving research infrastructures – similar to that of Netherlands (where CLARIN and DARIAH merged in 2015) or Germany (where both cooperate closely on technical matters, share a Technical Advisory Board, and cooperate at the user level too) – is also expected.

Other research infrastructure operated in this field, the EHRI (*European Holocaust Research Infrastructure*), entering its 2nd preparatory and construction phase, has collaborated with two Czech research organisations and ongoing Czech involvement will be sought in the future. The situation is similar to the case of the E-RIHS (*European Research Infrastructure for Heritage Science*). The *Excellence Centre for Cultural Heritage Research in Telč* recently developed by the Institute of Theoretical and Applied Mechanics, Academy of Sciences of the Czech Republic, is a promising Czech node of this pan-European research infrastructure, although so far considered not mature enough to be funded as a Large Infrastructure.

Research infrastructures listed in the Roadmap of Large Infrastructures of the Czech Republic have also considerable potential to contribute to the development of digital humanities in the Czech Republic by establishing closer cooperation with existing pan-European research infrastructures, especially between the linguistic research infrastructures and CLARIN by the extension of their collaborative activities within the field, and encouraging connections between humanities and arts research infrastructures with the DARIAH ERIC. For example, there is potential to connect the CLB with other bibliographic initiatives covering other fields of arts and humanities.

The *longitudinal surveys* – most importantly internationally coordinated surveys – represent a crucial resource for SSH. While the SHARE and ESS have been implemented in the Czech Republic to a great benefit of both the national and international research community, several other data gathering activities with great potential are still to be developed into sustainable programmes. These surveys include systematic exploration of values and attitudes, socio-economic panel studies focused on issues of social and economic inequality and mobility, as well as socio-demographic panels and cohort studies revolving around the human sexual and reproductive behaviour, health, partnership formation and dissolution. Some other kinds of data collecting activities (such as longitudinal multi-actor surveys) may arise in the near future as well.

Increasing interactions between SSH and other scientific fields have proved a great potential for further developments and better efficiency.

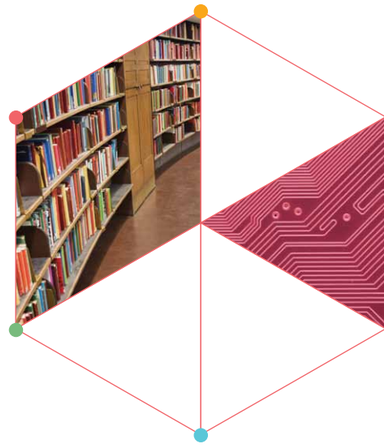
Numerous research activities are carried out on the border between the social sciences and environmental sciences for the purposes of exploring the interactions between society and nature. Data on social and environmental phenomena and processes has a strong geographical component. Therefore, there is a need for an integrated *Spatial Data Infrastructure*, which would enable the linking of the social and natural sciences through *geo-data* (GIS – *Geographic Information Systems*) and offer a unique opportunity for examining the close relationship between society and the natural environment.

Similarly, the interface between social research, on one hand, and biological and medical sciences, on the other, represents challenging yet potentially very productive lines of inquiry. Several multi-purpose household surveys exist, capitalizing on this potential to collect biological data in addition to more familiar socio-demographic and economic data. These data resources have proven informative, spurred significant interdisciplinary communication and opened up new fields of inquiry. Scholars have been able to address new and important issues based on these data resources. While researchers working with biosocial data face several ethical, conceptual and practical challenges, the promise of such interdisciplinary data collections activity is enormous and is likely to attract more attention in the near future.

SSH research infrastructures also face challenges regarding the utilization of *new data*. In the digital age, individuals, organisations and state administrations produce enormous amounts of electronic data that document human behaviour, attitudes, social structures and dynamics. The more extensive digital communication also generates new demands regarding tools for data harvesting, access and analysis. Many of these resources have great potential to enrich SSH research, including the ability to respond to grand societal challenges. The utilisation of these new data requires further development of (1) innovative methods; (2) technological instruments and capacities; (3) concentration of efforts across scientific disciplines; and (4) implementing legal solutions to deal with ethical, confidentiality and privacy issues.

National research infrastructures facilitating access and usage of new data, which promise high operability and economic efficiency, have already been implemented in some of the EU Member States (e.g. ADRN – *Administrative Data Research Network* in the United Kingdom). International collaborative projects and activities aimed at filling current gaps have emerged in the ERA. The Czech Republic should not remain outside these innovative developments and a future strategic political decision concerning the adoption of an effective open access data policy in the Czech Republic represents a part of the complex solution.

The SSH research infrastructures listed in the Roadmap of Large Infrastructures of the Czech Republic provide a solid basis for ensuring continual operation and development of several well established SSH research infrastructures in the Czech Republic with important benefits for SSH research and its integration into the ERA. Therefore, emerging projects and activities aimed at filling the gaps identified above will be stimulated to achieve the appropriate level of maturity in order to be included in the future Roadmap updates. Existing research infrastructures will contribute towards reduction of these identified gaps by extending their collaborative activities on both the national and EU level.



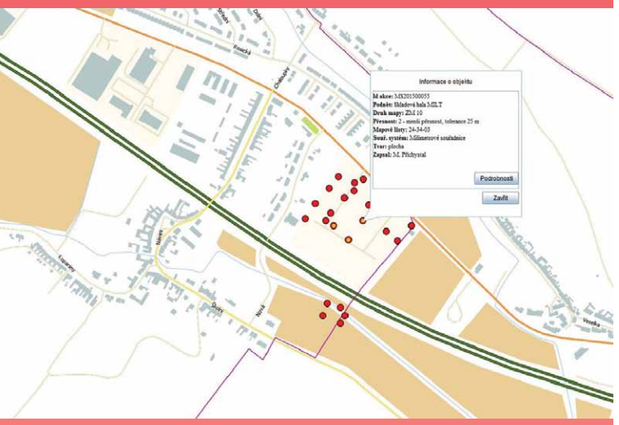
Archaeological Information System of the Czech Republic

Acronym:
AIS CR

Hosting institutions:
- Institute of Archaeology, Academy of Sciences of the Czech Republic, Brno
- Institute of Archaeology, Academy of Sciences of the Czech Republic, Prague

Responsible persons:
- KUNA Martin
  kuna@arup.cas.cz
- LEČBYCHOVÁ Olga
  lecbychova@arub.cz

Website:
www.idav.cz
www.arub.smartgis.cz



Background description

Czech archaeology deals with a large amount of digital data, but lacks sufficient tools for analysing and evaluating them. The main problems result from the lack of interconnection of existing databases, lack of contextual information and often unsatisfactory quality of available sources of information. AIS CR aims to integrate existing comprehensive resources on archaeological heritage, therefore enhancing their accessibility to research community, state administration and the general public. AIS CR focuses on an effective management of the national archaeological heritage and ensures longterm preservation. AIS CR will restructure the existing information systems and databases, integrate currently disconnected databases from Bohemia, Moravia and Silesia, finalise processes of completion of the databases, make them publicly accessible, increase the international compatibility and enhance existing international collaboration. As an infrastructure resource, AIS CR will bring information on archaeological excavations (preliminary reports, excavation reports, photographs, maps, plans) and provide access to information, which is essential for purposes of students´ works and teaching archaeology and history. Moreover, the state administration can draw on information on field activities and resources for spatial planning. Developers and investors can use the expertise of AIS CR for predictions of archaeological situations necessary for planning in the territory of their interest. In addition, AIS CR will introduce international standards, promote international compatibility of the information and services and allow further collaboration on the international level, drawing on the already existing cooperation in projects such as AREA (*Archives of European Archaeology*), ARCHES (*Archaeological Resources in Cultural Heritage: a European Standard*) or ARIADNE (*Digital Infrastructures for Archaeological Research*).

Future development

AIS CR will create an information system with a database containing all available archaeological data, which will be made accessible in an interlinked form, creating a complex Czech research infrastructure for research and education in the area of archaeology. The general public will be able to access necessary archaeological data. State administration will be able to access complete archaeological databases on a national level. Developers and investors will be able to access structured data from excavation reports. A new nationwide archaeological information system enriched with a public web interface will be created and we plan to strengthen partnerships with organizations, which generate their own data and which would contribute to the national database. Partnerships at the international level will be created, which will enable contributions to Europe-wide infrastructures and initiatives.

Socio-economic impact

AIS CR will provide comprehensive, interlinked and easily accessible information concerning archaeological excavations, digital archive, access to maps with excavation visualisations and tutorial module. Apart from the research community it will also serve the governmental and commercial sectors as well as the general public and thus contribute to the formation of cultural and national identity of the Czech Republic.

Czech Literary Bibliography

Acronym:
CLB

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

Responsible person:
MALÍNEK Vojtěch
malinek@ucl.cas.cz

Website:
clb.ucl.cas.cz

Background description

CLB is a primary research infrastructure for Czech literary studies and associated humanities disciplines. CLB carries on the almost 70-year tradition of compiling specialist bibliographies at the Institute of Czech Literature, Academy of Sciences of the Czech Republic, and continues to develop it. Within this framework a set of bibliographical databases is being compiled and supplemented on an ongoing basis, as well as being systematically utilized at a professional level, consistently mapping out literary life in the Czech lands from the first stirrings of the National Revival to the present, along with associated information resources (biographical databases, digital libraries, literary award databases, etc.). CLB resources are used as source material for valued synthetic work (e.g. *the Lexicon of Czech Literature and the Dictionary of Post-1945 Czech Literature*). CLB research infrastructure offers unlimited online access to extensive database corpora that are updated on an ongoing basis in real time. CLB also focuses on the development of ancillary software aids. CLB staff are also preparing personnel and subject bibliographies, which are not infrequently book-sized. Not least, the CLB is engaged in tuition and education, inter alia in the direct involvement of university students in CLB data processing. CLB also have a clear international dimension, particularly for German-Czech and Slavonic research, as well as national philology and associated humanities disciplines.

Future development

In the next few years the activities of CLB will focus in particular on completion of the system integration of their previously heterogeneous database sources on a uniform software platform and the associated editing of converted data. In addition to processing the current output in the field, CLB will also focus on the retrospective mapping of previously neglected data corpora (inter alia a bibliography of Czech samizdat literature, previously unprocessed interwar periodicals, etc.). Increased attention will also be paid to the development of services for CLB users (presentation interface, development and innovation of software applications for working with CLB data, etc.) or activities involving tuition and education.

Socio-economic impact

CLB sources are a primary source for studying literary and more broadly cultural life in the Czech lands in all its historical and linguistic varieties and so fundamentally help to get to know national literature as one of the basic components that make up the Czech national identity. Comparatively, this is one of the most extensive and complex projects of its kind both here and abroad, whose online services are used regularly by a large number of users from the Czech Republic and elsewhere.

Czech National Corpus

Acronym:
CNC

Hosting institution:
Charles University in Prague

Responsible person:
CVRČEK Václav
vaclav.cvrcek@ff.cuni.cz

Website:
www.korpus.cz

CZECH NATIONAL CORPUS

Background description

CNC is continuously mapping the Czech language by building large general-purpose language corpora and providing access to them. The CNC's linguistic data cover a wide range of genres and language varieties, including written, spoken and diachronic Czech. In addition, the InterCorp parallel corpus contains original and translated texts in Czech and more than 30 other languages. The CNC corpora constitute a unique resource of authentic language information for both basic and applied linguistic research as well as for other domains of social sciences and humanities. CNC corpora are widely used thanks to their continuously growing size, varied and well-defined composition, reliable metadata and high quality data processing with state-of-the-art tools. The CNC provides intuitive access to its corpora through efficient, specialized web-based applications and user support featured at the CNC research portal www.korpus.cz that also includes a User Forum (with Q&A, bug reporting, etc.) and a corpus linguistics Wiki. CNC is the only research infrastructure in the Czech Republic focusing systematically on developing the methodology of corpus linguistics. It also provides data packages tailored to specific users' needs. Despite its national character, CNC is widely used by international users and the exceptional range of CNC corpora attracts collaborative corpus-based research in the area of contrastive language study, which requires comparable data in different languages. The CNC closely cooperates with the research infrastructure LINDAT/CLARIN, the Czech national node of the pan-European research infrastructure CLARIN ERIC.

Future development

The development strategy of CNC is based on CNC's own strategic research, current trends in empirical linguistics and user feedback. CNC plans to continually develop operation by systematically building its user community mainly by reaching out to new end-users that are increasingly being recruited from the broader field of social sciences and humanities, enriching the spectrum of data collected with semi-official language used on the internet, semi-formal spoken language or monitor corpus that will cover the period from 1850 to present. CNC also plans to enhance the corpus annotation by including syntactic and semantic levels and broaden the portfolio of user applications through enhancement of existing applications and development of new ones.

Socio-economic impact

The primary orientation of CNC is to provide an open access service for the research community in SSH, as well as for the general public. Currently CNC has more than 4,500 registered active users, who perform more than 1,400 corpus queries per day. CNC linguistic data and related technologies are also a valuable source for applied research in areas of machine translation, speech recognition and natural language processing (NLP) in general.

Czech Social Science Data Archive

Acronym:
CSDA

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

Responsible person:
KREJČÍ Jindřich
jindrich.krejci@soc.cas.cz

Website:
archiv.soc.cas.cz

Background description

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 purposes of secondary analysis in scientific research and training at universities. CSDA is also the Czech national node of the pan-European distributed research infrastructure CESSDA (*Consortium of European Social Science Data Archives*) and the CESSDA Service Provider in the Czech Republic. CESSDA builds a comprehensive and integrated pan-European social data research infrastructure based on collaboration among national data archives. The wide exchange of scientific information is crucial for the development of the European Research Area. In social sciences, efficiency in sharing digital data is maintained by centralised data archives, which provide fundamental background for longitudinal and cross-national comparative analysis and empirically oriented research in general. CSDA has established, maintains and continually develops an extensive library of data collections from different data producers. These data collections are available to researchers and students via an on-line system allowing searching, browsing, analysing, visualising and downloading of data and related study materials. The archival and information system ensures long-term preservation and availability of data. In addition, CSDA provides support for large-scale survey research programmes, e.g. Czech participation in the ISSP (*International Social Survey Programme*) and promotes secondary data analysis also by reviewing data resources, analysing data quality, conducting research in data harmonisation and providing training services.

Future development

CSDA is the only national social science data archive in the Czech Republic. Its development strategy is targeted towards ensuring the long-term provision of data services in social sciences in the Czech Republic in conformity with OECD and EU principles for access to research data along with long-term assurance of integration of Czech national data services into the CESSDA pan-European system. The data library will be systematically expanded taking into consideration its multidisciplinary nature as well as emerging new data sources. Technical development of an enhanced high quality national data service will be based on policies of cooperation within the CESSDA framework. Activities supporting data sharing, use of secondary data analysis and Czech participation in international social research programmes will be further developed and expanded.

Socio-economic impact

Availability of relevant social science data is a critical precondition for the development of evidence based policies with clear implications for national competitiveness and quality of life in the Czech Republic. Data driven social research contributes to conceptual solutions in domains as diverse as demographic development, social inequalities, human capital development and educational systems, migration, labour market, environmentally friendly society, behavioural aspects of health, social aspects of security and many others. The availability of internationally comparable data improves conditions for comparative research vis-à-vis the obligations associated with membership of the Czech Republic in the EU and other international organisations. The availability of data services increases the quality of education at universities by making it possible to use real research data in teaching.

Czech National Node of the ESS (European Social Survey)

Acronym:
ESS-CZ

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

Responsible person:
PLECITÁ Klára
klara.plecita@soc.cas.cz

Website:
www.ess.soc.cas.cz
www.europeansocialsurvey.org

Background description

ESS-CZ is the Czech national node of the pan-European distributed research infrastructure ESS (*European Social Survey*).The European Social Survey (ESS) is an academically driven cross-national survey that has been conducted every 2 years across Europe since 2001. The main aims of the ESS are: (1) to chart stability and change in social structure, conditions and attitudes in Europe and to interpret how Europe's social, political and moral fabric is changing; (2) to achieve and spread higher standards of rigour in crossnational research in the social sciences; (3) to introduce soundly-based indicators of national progress, based on citizens' perceptions and judgements of key aspects of their societies; (4) to undertake and facilitate the training of European social researchers in comparative quantitative measurement and analysis; (5) to improve the visibility and outreach of data on social change among academics, policy makers and the wider public. ESS publishes national and international integrated data files from ESS surveys in open access. In addition, it publishes Key Findings, enables eLearning via ESS EduNet platform, and maintains bibliographic database of publications resulting from research on ESS data.

Future development

ESS has become a key data source for substantive and methodological research. Since 2015, ESS will expand: (1) Networking Activities to extend the influence of National Coordinators in pre-pilot field experiments in order to test rotating modules of questions; (2) Joint Research Activities in the field of international comparative surveys; and (3) Virtual Service Arrangements will be updated and expanded to increase visibility and accessibility of data, metadata, and services. The technological platform of the ESS is located at the *Norwegian Social Science Data Services* and supports a dynamic information system that enables a cumulative growth of empirical data and metadata, plus methodological and analytical advancements.

Socio-economic impact

The social sciences must pay close attention to the social and institutional arrangements that structure human interaction, behaviour and attitudes. Europe's cultural diversity makes it a natural laboratory for the social sciences, which can analyse differences in institutions, structures, behaviours and beliefs across European states and relate these to explanations of human interaction. For these analyses the social sciences require regular cross-national surveys that are conceptually well anchored, conducted according to rigorous methodological standards and are available at little cost to a wide range of social science disciplines such as political science, sociology, social psychology, the study of mass communication and economics. Such data are valuable for researchers, state and local governments, and the general public.

Language Research Infrastructure in the Czech Republic

Acronym:
LINDAT/CLARIN

Hosting institution:
Charles University in Prague

Partner institutions:
- Institute of the Czech Language, Academy of Sciences of the Czech Republic
- Masaryk University
- University of West Bohemia in Pilsen

Responsible person:
HAJIČ Jan
hajic@ufal.mff.cuni.cz

Website:
lindat.cz

Background description

LINDAT/CLARIN is a Czech national node of CLARIN (*Common Language Resources and Technology Infrastructure*), a pan-European research infrastructural network established in 2012, currently consisting of 14 countries. The aim of LINDAT/CLARIN is to provide open and free access to language research data through a certified repository and language technology and services to be used in social sciences and humanities (linguistics and related interdisciplinary research such as formal and computational linguistics, translatology, lexicography, psychology, sociology, history, neurolinguistics, cognitive sciences and artificial intelligence). In addition, LINDAT/CLARIN also serves language technology and application development areas and is compatible with the META-SHARE network by creating linguistically analysed open resources for Czech and other languages. LINDAT/CLARIN connects linguistic resources (data) of various types and structure with language technology for the full range of natural language processing applications important in the Czech language environment. Such data are important for R&D of technologies based on machine learning (natural language processing, speech recognition and synthesis and a combined analysis of text, speech, image and other multimedia). LINDAT/CLARIN also provides space and support for persistent data storage for languagerelated data resulting from projects of external researchers and institutions, allowing long-term preservation, easy citations and metadata transfer to the CLARIN portal. LINDAT/CLARIN closely cooperates with research infrastructures CNC and CESNET at the national level and with several other pan-European research infrastructures, namely DARIAH (*Digital Research Infrastructure for the Arts and Humanities*), EHRI (*European Holocaust Research Infrastructure*), ELRA (*European Language Resources Association*), EUDAT (*European Collaborative Data Infrastructure*) and LDC (*Linguistic Data Consortium*).

Future development

LINDAT/CLARIN has been fully operational since 2014 with the highest CLARIN certification (CLARIN B Centre). Maintenance and further development of the repository is a key for continuous data storage and preservation. Substantial expansion of its web services and tools aimed at all users is planned in the near future. It will further strengthen its international collaboration with other national nodes within CLARIN research infrastructure and other pan-European research infrastructures, primarily in the social sciences and humanities (DARIAH, EHRI, EUDAT and others).

Socio-economic impact

Language technologies are essential for all areas of the European economy, especially for its inherently multilingual market. In turn, LINDAT/CLARIN language resources and services are essential for R&D in this area. In the social sciences and humanities, language is the primary means of communication and information exchange and recording. Text analysis and the analysis of multimedia using language technology will broadly support research in the area of national heritage and cultural identity. Open access to the data and services guarantees uninhibited use in research and education at all levels at the universities as well as in the Academy of Sciences of the Czech Republic. LINDAT/CLARIN is taking part in various initiatives to change the European legal system in the intellectual property rights area to make the use of language resources easier in all areas of research and applications. It will also continue to serve the general public in Czech language-related needs (orthography, grammar, lexicons).

Research Infrastructure for Diachronic Czech Studies

Acronym:
RIDICS

Hosting institution:
Institute of the Czech Language, Academy of Sciences of the Czech Republic

Partner institution:
Czech Technical University in Prague

Responsible person:
LEHEČKA Boris
lehecka@ujc.cas.cz

Website:
vokabular.ujc.cas.cz

Background description

RIDICS will co-create and operate 2 complementary web portals facilitating and inspiring research in the field of diachronic Czech studies (i.e. Czech from the earliest periods up to the late 18th century) and other related fields. The research web portal will provide access to a vast number of miscellaneous scientifically processed and analysed primary and secondary resources, including full texts of Czech writings resources, dictionaries, grammars and bibliographical databases, it will therefore provide researchers with tools appropriate for their research such as metadata, full text search, corpus analysis tools, lemmatisation and morphological annotation and intertextual relations. The community web portal will enable researchers to share their research outputs (store and make works and electronic editions of primary sources accessible), keep up with events in individual fields and discuss scholarly issues. RIDICS will also develop and offer tools for the preparation of primary sources and research, e.g. template for electronic editions or software for computer assisted transcription. These will be available in the form of web services, individual programs or add-ons for programs, with which researchers work on everyday basis (text editors). Cooperation of RIDICS with research infrastructures CNC and LINDAT/CLARIN is expected in terms of data and tools exchange, cooperation in tool development and providing expert opinions. On the international level, RIDICS will be involved in projects concentrating on language resources preparation (DiXiT – *Digital Scholarly Editions Initial Training Network*) or on digital lexicography (eNeL – *European Network of e-Lexicography*).

Future development

RIDICS will focus on preparing and distributing new documents and materials, on refinement of existing primary and secondary resources and on improving developed tools. The research infrastructure will expand its support of individual research projects, in terms of resources and tools for analysis preparation or customization. RIDICS will also integrate existing or new relevant resources from other research projects.

Socio-economic impact

RIDICS will help to improve the preservation of language cultural heritage and knowledge of national language, literature and history. It will provide access to primary and secondary materials and ensure their extensive use. The community web portal will establish a basis for interdisciplinary cooperation and by mutual interlinking of various data sources, the reading comprehension of presented historical materials will be easier for scholars, students and also for the general public.

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

Acronym:
SHARE-CZ

Hosting institution:
Economics Institute, Academy of Sciences of the Czech Republic

Responsible person:
BOHÁČEK Radim
radim.bohacek@cerge-ei.cz

Website:
share.cerge-ei.cz
www.share-project.org

Background description

SHARE-CZ is a Czech national node of the pan-European distributed research infrastructure SHARE (*Survey of Health, Ageing and Retirement in Europe*), which is a multidisciplinary and crossnational longitudinal database of micro-data on health, socio-economic status, social and family networks and other issues collected from more than 85,000 individuals coming from 20 European countries aged 50+ and their partners. The result is a free and unique data collection that provides information about the state, history and the future of Czech and European society. SHARE allows researchers and state administrations to understand the consequences of demographic changes and formulate optimal policies for public finances, labour market, health care or pension systems. Since 2004, SHARE is a longitudinal survey that is repeated every 2 years. The main goals are to create a main questionnaire for 6,000 respondents aged 50+ and their partners in each country, every 2 years collect data on the same individuals and store the collected data and its documentation in a user friendly, free and open access database accessible to all users. SHARE combines 3 unique and innovative strengths. It is ex-ante harmonized across the countries, multi-disciplinary and longitudinal. SHARE also provides publications on the methodology and data and organizes every year international conferences, workshops, user conferences and summer schools at the central level of the SHARE ERIC coordinator and at each SHARE national node. In the Czech Republic, SHARE-CZ cooperates with the Ministry of Labour and Social Affairs, Expert Commission on the Pension Reform of the Government of the Czech Republic and with more than 20 other universities and research organisations.

Future development

Researchers participating in the SHARE-CZ project are actively cooperating with the leading world research projects on population ageing such as HRS (*Health and Retirement Study*), ELSA (*English Longitudinal Study of Ageing*), *RAND Center for the Study of Aging* and with the international research community in order to maintain highest possible quality of research, comparability of data with other surveys, methodology and innovative technology of data collection and dissemination. Future development of SHARE-CZ includes the collection of biomarkers, linkage of data to official statistics, development of new modules (time use questionnaire, life history), user friendly easySHARE database for students, national questionnaires developed by external researchers, new modes of interviewing between the main waves of data collection, evaluation and development of physical and mental health measures, a pension claim data base and European Poverty Module, among others.

Socio-economic impact

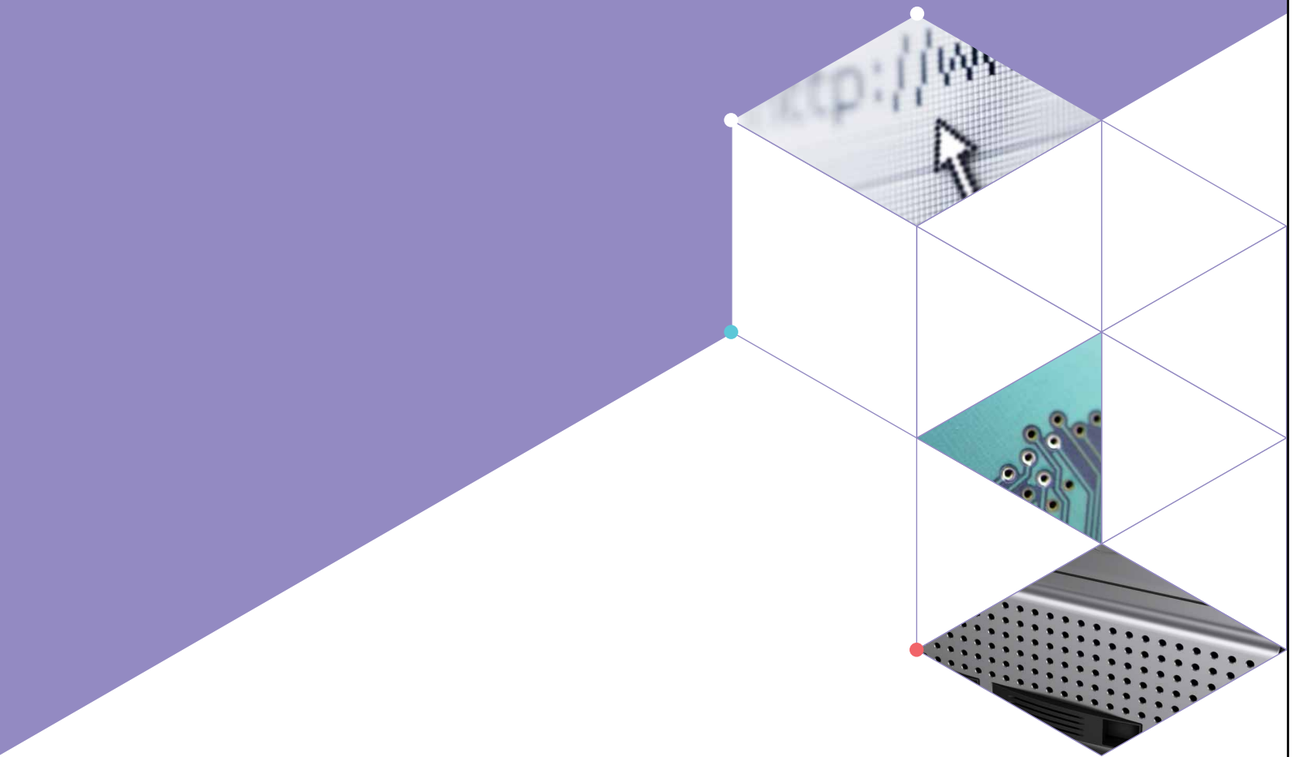
SHARE-CZ is a service for the international and Czech research community as well as to the whole society. SHARE-CZ promotes innovation and research through its freely accessible data used by other researchers at universities and other research organisations. By the end of 2014, SHARE-CZ research infrastructure had over 4,200 registered individual users. The main impact of SHARE is the creation of a truly longitudinal and internationally comparable data collection, which allows researchers to analyse and understand interactions between the dramatically changing demographic development and policy responses in individual countries and the EU as a whole.

ICT/ e-infrastructures

10.6

page

High quality and adequately dimensioned information and communication technologies (ICT) are fundamental for modern R&D. No research team can be expected to carry out excellent R&D without solid ICT support. On the other hand, ICT support has many common elements independent of specific scientific disciplines, which make up an e-infrastructure and require careful development and operation.



10.6 | Roadmap of Large Infrastructures for Research, Experimental Development and Innovation of the Czech Republic for the years 2016–2022

ICT/e-infrastructures

The main aim of an e-infrastructure is to provide the research community with a comprehensive portfolio of ICT services. Transparent availability of these ICT services (with the same and guaranteed parameters) means that the research community has a unified ICT platform at its disposal and individual teams can thus fully concentrate on R&D without the necessity of solving data processing, storage and transmission problems. This kind of an e-infrastructure, based on technologies for exchanging, storing and archiving R&D information and for interconnecting geographically distributed research teams, equipment and infrastructures, is also a key supporter of interdisciplinary cooperation.

The pan-European e-infrastructure, based on the GÉANT backbone, enables remote access also to unique research infrastructures physically located abroad to the Czech research infrastructures and research teams, thus eliminating the need of Czech scientists to leave their country for accessing advanced research infrastructures abroad.

The Czech e-infrastructure, connected to the pan-European e-infrastructure, thus not only provides the research community of the Czech Republic with these advanced ICT services, but also contributes to its sustainability. Moreover, the accumulation and concentration of ICT resources in the e-infrastructure mean elevated efficiency compared to the individual procurement and operation of these ICT resources. By this way, the e-infrastructure can integrate and offer ICT resources of a scope that individual research organisations could otherwise hardly afford. At the same time, such an approach is positively reflected in the energy consumption (both input power and cooling), and this advantage not only results in the reduction of operating costs, but also in the terms of minimising the environmental impacts.

Owing to its distributed character, the Czech e-infrastructure contributes to a significant extent to improving the availability of the best, most advanced ICT services with the same parameters in all of the Czech regions. This is quite essential for maintaining and increasing the competitiveness of the Czech R&D and thus the competitiveness of the Czech economy.

Besides services for R&D, the Czech e-infrastructure provides a unique opportunity for experiments and deployment of new ICT by offering a testbed function on the basis of the availability and operation of the e-infrastructure (above all, up-to-date data transmission systems, as well as computing and storage technologies). Moreover, the e-infrastructure is also an accelerator for overall ICT development and plays a fundamental role in building the information society.

The Czech e-infrastructure is built up by two particular facilities that provide Czech research community with e-services, as well as linking their parts to the relevant pan-European and/or global e-infrastructures.

The **CESNET** e-infrastructure (*Czech Education and Scientific Network*) provides a high transmission rate national communication infrastructure and a national grid infrastructure of the Czech Republic, together with a large capacity data-storage infrastructure and an environment for collaboration between distributed research teams. These components are complemented by horizontal services such as tools and services for e-infrastructure resource access control, and also tools for ensuring secure communication, data protection and effective collaboration. In the international context, the CESNET e-infrastructure represents the *National Research and Education Network* (NREN) and the *National Grid Infrastructure* (NGI). In these roles it is a part of the *GÉANT pan-European Research and Education Network and the EGI pan-European Grid Infrastructure*.

The **IT4Innovations** e-infrastructure (*National Supercomputing Centre*) provides the research community with high-performance computer systems, including the most powerful scientific supercomputer in the Czech Republic. The main objective of the IT4Innovations is to support high performance computing (HPC) at national level, provide training in HPC, strengthen and expand the national HPC community, both in the academic sphere and in the industrial sector, and help link together the international and the national HPC communities. The IT4Innovations e-infrastructure is a component of the pan-European PRACE (*Partnership for Advanced Computing in Europe*) e-infrastructure and of the HiPEAC (*High Performance and Embedded Architecture and Compilation*) networks.

A fundamental element and an essential part of the Czech e-infrastructure is the CESNET's communication network infrastructure. It is conceived as a multilayer system interconnecting at individual layers the research projects and user

networks, the research networks of foreign partners, the pan-European GÉANT network and the GLIF (*Global Lambda Integrated Facility*) experimental infrastructure. The communication infrastructure offers parallel IPv4 and IPv6 protocol support with options of advanced functions and characteristics, provision of reserved services in individual layers of the network, in particular lambda services and remote access to user operated research equipment in real time. In terms of topology and capacities, it is currently adequately dimensioned to cover the data traffic requirements, but in the near future it will be necessary to dynamically respond to demands for new advanced services (e.g. IaaS – *Infrastructure as a Service*).

The ICT services related to security play a key role in the area of horizontal services, both for user identification and access control as well as for protection of data and user privacy, including monitoring and responses to security incidents. Key elements of the Czech e-infrastructure are also eduID.cz (*Czech Academic Identity Federation*) and CESNET-CERTS (*Computer Security Incident Response Team*). These services are critical for all parts of the Czech e-infrastructure.

The Czech computing infrastructure consists of the IT4Innovations Supercomputing facility and the embedding distributed computer environment. Its interconnection in international collaborative research area is provided via the PRACE e-infrastructure in case of the IT4Innovations and via the European EGI initiative in case of the grid environment. The IT4Innovations has a cutting-edge system with 2PFLOPS theoretical peak performance and a smaller system with 94TFLOPS theoretical peak performance. Since the HPC area is developing very rapidly, it is necessary to regularly update the IT4Innovations systems in the coming period. Only in this way can a stable HPC environment be maintained at the national level in order to provide access to sufficient computing capacity to ensure R&D excellence in the Czech Republic in the scope of the ERA and worldwide.

The *National Grid Infrastructure* (NGI) is a part of the CESNET e-infrastructure and inter-connects the computing and storage capacities of various research organisations. Virtualised (cloud) resources are gradually becoming components allowing highly flexible direct administration by the end users. The most important provider of computer resources comparable to the CESNET is the **CERIT-SC** (*Centre for Education, Research and Innovation – Scientific Cloud*), operating an experimental infrastructure for R&D in the area of flexible e-infrastructures. The computing capacities within the NGI are currently fully utilised and therefore it will be necessary to maintain and appropriately expand these computing capacities in the forthcoming period. Since the NGI architecture assumes the inter-connection of capacities available at individual research units, the development and the sustainability of the NGI depends on the abilities of the involved organisations to acquire resources for renewal, development and operation of the nodes operated by them. With the growing significance of ICT in R&D, the NGI will have to respond to specific requirements, such as provision of tailor-made virtual infrastructures or to demands for platforms with an instant environment for specific applications or scientific workflows, as well as to demands in the area of sharing new types of resources such as commercial SW licences, experimental tools, scientific databases and of operating virtual laboratories.

Another part of the CESNET e-infrastructure is a *large capacity data infrastructure* (20 PB) serving the Czech research organisations, other research infrastructures, projects, and teams, by offering long-term storage of scientific data. The data are made accessible by various protocols and the users have the possibility of controlling the access to the stored content with a very distinct granularity. This part of the CESNET e-infrastructure is quite new and, due to the growing importance of scientific data, it is necessary not only to take care of providing adequate capacities, but also to focus conceptually on the issue of big data with a view to the tools required for their organisation and long-term maintenance, by aiming at efficient management and reproducibility of scientific experiments partly or entirely implemented in the virtual electronic laboratory.

As a response to recently emerging requirements, the e-infrastructure will also support open access to data. Formal involvement in the international RDA (*Research Data Alliance*) and EUDAT (*European Data Infrastructure*) activities is crucial too.

The objectives of the Roadmap of Large Infrastructures of the Czech Republic put distinct emphasis on maintaining and further developing the achieved e-infrastructure facilities and related services briefly described above, in order to offer leading edge ICT support for the Czech research community and contribute, by this way, to the economic competitiveness of the Czech Republic.

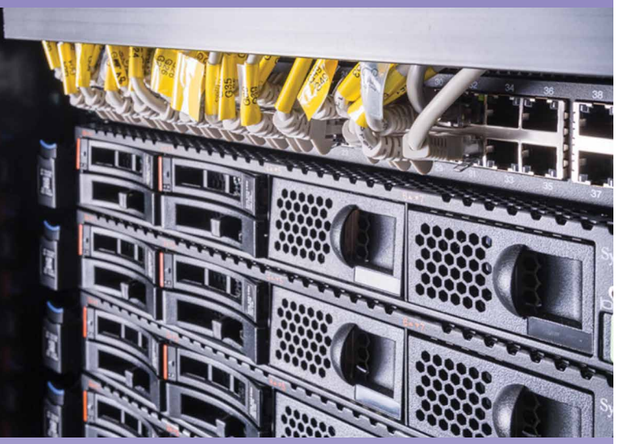
CERIT Scientific Cloud

Acronym:
CERIT-SC

Hosting institution:
Masaryk University

Responsible person:
MATYSKA Luděk
matyska@ics.muni.cz

Website:
www.cerit-sc.cz



Background description

E-infrastructure CERIT-SC emerged from the transformation of the Brno Supercomputing Centre and it is a part of the Masaryk University's Institute of Computer Science. CERIT-SC's primary focus is the flexibility of e-infrastructure services. CERIT-SC is a node of the Czech National Grid Infrastructure. It combines elastic computing and storage capacity with the associated services and know-how, thus complementing production-oriented resources of other components on the Czech national e-infrastructure. CERIT-SC is unique in its experimental approach; its users are encouraged to request unusual configurations or ways of use of the ICT resources while impact on other users is minimized by their thorough virtualization. CERIT-SC is thus systematically participating in research activities of its users and brings into the collaboration the ICT expertize required to carry out excellent competitive R&D in all scientific disciplines. Through efficient use of available ICT resources CERIT-SC contributes substantially to the acceleration of its users' R&D activities and develops expertise and know how complementary to CESNET e-infrastructure.

Future development

CERIT-SC focuses on extending its expertise in innovative use and development of einfrastructures. The collaboration with established and emerging research infrastructures and R&D centres will be strengthened to increase the benefits of flexible and innovative use of einfrastructures to their own research. An integral part is also the support of optimal use of their own ICT capacity and resources. Joint R&D activities with academic and commercial partners will keep CERIT-SC at the knowledge edge. Contemporary technological trends and their linkage to users' needs will be closely followed. Keeping a properly combined portfolio of progressive computing and storage platforms, needed to stay ahead of resources directly available to its partners and being able to actually run in silico experiments, CERITSC will strengthen its close partnership with CESNET e-infrastructure, providing additional expertise on top of combined resources.

Socio-economic impact

Running excellent e-infrastructure in an adaptable mode, even with disruptive changes, unaffordable in commercial environment, opens means to collaborative pre-competitive R&D activities that also involve industrial partners. CERIT-SC expertise is provided as the highest added value in areas directly related to the e-infrastructure construction, operation and use, such as flexible and powerful testbeds, security, scheduling for highly optimized use of einfrastructure, and optimization of applications and algorithms.

E-infrastructure CESNET

Acronym:
CESNET

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

Responsible person:
GRUNTORÁD Jan
jan.gruntorad@cesnet.cz

Website:
www.cesnet.cz

Background description

CESNET is a unique e-infrastructure for R&D in the Czech Republic representing a transparent environment for transfer, storage and processing of scientific data for subjects involved in R&D, regardless of scientific field they are focused on. The main components of CESNET e-infrastructure comprise high throughput national communication infrastructure, National Grid Infrastructure, data storage infrastructure and an environment for collaboration of distributed teams. These main components of CESNET e-infrastructure are complemented with tools and services of e-infrastructure resource access control, tools for ensuring secure communication and data protection. CESNET has nearly 20 years of experience providing high quality, flexible, secure and reliable complex of ICT services for the research community fully comparable with similar foreign e-infrastructures. In international context the CESNET is in a part of GÉANT pan-European Research and Education Network and EGI pan-European Grid Infrastructure.

Future development

The CESNET e-infrastructure development will be based on innovation of e-infrastructure itself and development and experimental operation of its new components. In all of these areas the requirements of user communities and global trends in the ICT with strong respect to users´ security, data privacy as well as to economic efficiency and effectiveness and to environmental impact will be taken into account.

Socio-economic impact

CESNET creates a communication and information base for R&D on both national and international levels and provides an integrated portfolio of ICT services, which modern R&D cannot exist without. CESNET also positively impacts on the reduction of imbalances between different regions in the Czech Republic caused by differing rates of development and availability of new technologies for the research community. Higher productivity in R&D has direct positive impact on business and economy. Beside that CESNET e-infrastructure helps to broaden spectra of knowledge and to increase the level of education in the area of ICT in a general sense.

IT4Innovations National Supercomputing Center

Acronym:
IT4Innovations

Hosting institution:
VŠB – Technical University of Ostrava

Responsible person:
PALKOVIČ Martin
martin.palkovic@vsb.cz

Website:
www.it4i.eu

Background description

IT4Innovations operates nationally unique state-of-the-art supercomputing resources and provides open access to those resources on the basis of scientific excellence. Supercomputing and high-performance computing (HPC) is the 3rd pillar of science, besides theory and experiment. In the last years, this pillar is of utmost importance and often is the only possibility, especially if experiment is not feasible. Computer simulations are often cheaper, faster and safer or environmentally friendlier than experiment. IT4Innovations' portfolio of services is split into core services and added value services. The core services consist of provisioning an optimized HPC environment, in particular core hours of supercomputer time, software license hours and compute-oriented storage capacity. The added value services are based on the expertise accumulated at IT4Innovations and include user and application support, code enabling and optimization, training activities, dedicated HPC research and contact point of international HPC infrastructures. IT4Innovations and CESNET form main pillars of the e-infrastructure in the Czech Republic and serve as the base layer for other research infrastructures in the Czech Republic. Thanks to IT4Innovations, the Czech Republic has access to state-of-the-art HPC infrastructure and expertise. As a member of the prestigious pan-European e-infrastructure PRACE (*Partnership for Advanced Computing in Europe*), IT4Innovations also enables access for Czech researchers to all services provided by this e-infrastructure and opens opportunity for international collaboration. IT4Innovations has a rich international network and actively contributes to the research in HPC related areas.

Future development

IT4Innovations operates supercomputers Anselm (Rpeak 94 TFLOPS) and Salomon (Rpeak 2000 TFLOPS) and runs a state-of-the-art data centre providing ample space and power and unique hot water cooling with recuperation. In 2015, the Salomon supercomputer ranks as the largest Intel(r) Xeon Phi(tm) coprocessor-based cluster in Europe. IT4Innovations actively develops and widens its service portfolio, including its own HPC related research, to access new research areas and user groups. Further development of IT4Innovations presumes regular upgrades of the systems to continue excellent service to the users as well as extension and development of training and visualisation capacities of the centre.

Socio-economic impact

HPC is globally recognized as an important innovation enabler in research as well as industry. Supercomputing simulations are often the only way to understand complex problems and to solve grand scientific challenges. The expertise and capacity of IT4Innovations supports multiple R&D areas having significant socio-economic impact, e.g. in flood prevention, crash tests, drug design, chemical catalysis and personalised medicine.

Annexes

11

Annex No. 1: International Evaluation Committee of Research Infrastructures of the Czech Republic

Head of Evaluation Committee:

FLETCHER Peter, Science and Technology Facilities Council

Physical Sciences:

FRÖJDH Christer, Mid Sweden University (Chair)
SAGHAI Bijan, Atomic Energy and Alternative Energies Commission
POLÁK Jaroslav, Central European Institute of Technology

Energy:

ROZLÍVKA Zdeněk, National Radiation Protection Institute (Chair)
RANDEWICH Andrew, Atomic Weapons Establishment
LAURITZEN Bent, Technical University of Denmark

Environmental Sciences:

IKONEN Eeva, Academy of Finland (Chair)
PACYNA Jozef, Norwegian Institute for Air Research
MOLDAN Bedřich, Charles University in Prague

Biomedicine:

CURTIUS Eckhart, Federal Ministry of Education and Research (Chair)
LUXEN André, University of Liége
ŠEBO Peter, Institute of Microbiology, Academy of Sciences of the Czech Republic

Social Sciences and Humanities:

HUGHES Lorna, School of Advanced Study, University of London (Chair)
MÜLLER Karl H., Steinbeis Transfer Centre New Cybernetics
FRANKL Michal, Jewish Museum in Prague

ICT/e-infrastructures:

BÁLINT Lajos, National Information Infrastructure Development Institute (Chair)
VANDENBROUCKE Rosette, Vrije University Brussels
TVRDÍK Pavel, Czech Technical University in Prague

Annex No. 2: Expert Working Groups on Roadmap of the Czech Republic of Large Infrastructures for Research, Experimental Development and Innovation for the years 2016–2022

Working Group of the Ministry of Education, Youth and Sports:

LEVÁK Lukáš, Director, Department of Research and Development
DLOUHÁ Hana, Head of Unit for Research Infrastructures, Department of Research and Development
VENTLUKA Petr, Department of Research and Development
GERLOVÁ Ivana, Department of Research and Development
HAVLÍČKOVÁ Blanka, Department of Research and Development

Principal Expert Consultant:

HRUŠÁK Jan, Academy of Sciences of the Czech Republic, ESFRI Executive Board Member

Physical Sciences:

KŘENEK Petr, Institute of Plasma Physics, Academy of Sciences of the Czech Republic (Chair)
HNATOWICZ Vladimír, Nuclear Physics Institute, Academy of Sciences of the Czech Republic
CHÝLA Jiří, Institute of Physics, Academy of Sciences of the Czech Republic
KOLÁŘ Jan, Czech Space Office
KRÁSA Josef, Institute of Physics, Academy of Sciences of the Czech Republic
LEJČEK Pavel, Institute of Physics, Academy of Sciences of the Czech Republic
PALOUŠ Jan, Astronomical Institute, Academy of Sciences of the Czech Republic
SECHOVSKÝ Vladimír, Charles University in Prague
SOJKA Jaroslav, VŠB – Technical University of Ostrava

Energy:

ŠTEKL Ivan, Czech Technical University in Prague (Chair)
KOC Josef, National Radiation Protection Institute
MAREŠ Jiří J., Institute of Physics, Academy of Sciences of the Czech Republic
OCHODEK Tadeáš, VŠB – Technical University of Ostrava
TOMAN Petr, Brno University of Technology
WITZANYOVÁ Naděžda, Research Centre Řež

Environmental Sciences:

MAREK Michal V., Czech Global Change Research Centre, Academy of Sciences of the Czech Republic (Chair)
FROUZ Jan, Charles University in Prague
HLADÍK Jiří, Research Institute for Soil and Water Conservation
KIRSCHNER Jan, Institute of Botany, Academy of Sciences of the Czech Republic
MOLDAN Bedřich, Charles University in Prague
ŠARAPATKA Bořivoj, Palacký University Olomouc
TURČÁNI Marek, Czech University of Life Sciences Prague

Biomedicine:

SEDLÁČEK Radislav, Institute of Molecular Genetics, Academy of Sciences of the Czech Republic (Chair)
BARTŮNĚK Petr, Institute of Molecular Genetics, Academy of Sciences of the Czech Republic
HAJDÚCH Marián, Palacký University Olomouc
SKLENÁŘ Vladimír, Masaryk University
VONDRÁŠEK Jiří, Institute of Organic Chemistry and Biochemistry, Academy of Sciences of the Czech Republic

Social Sciences and Humanities:

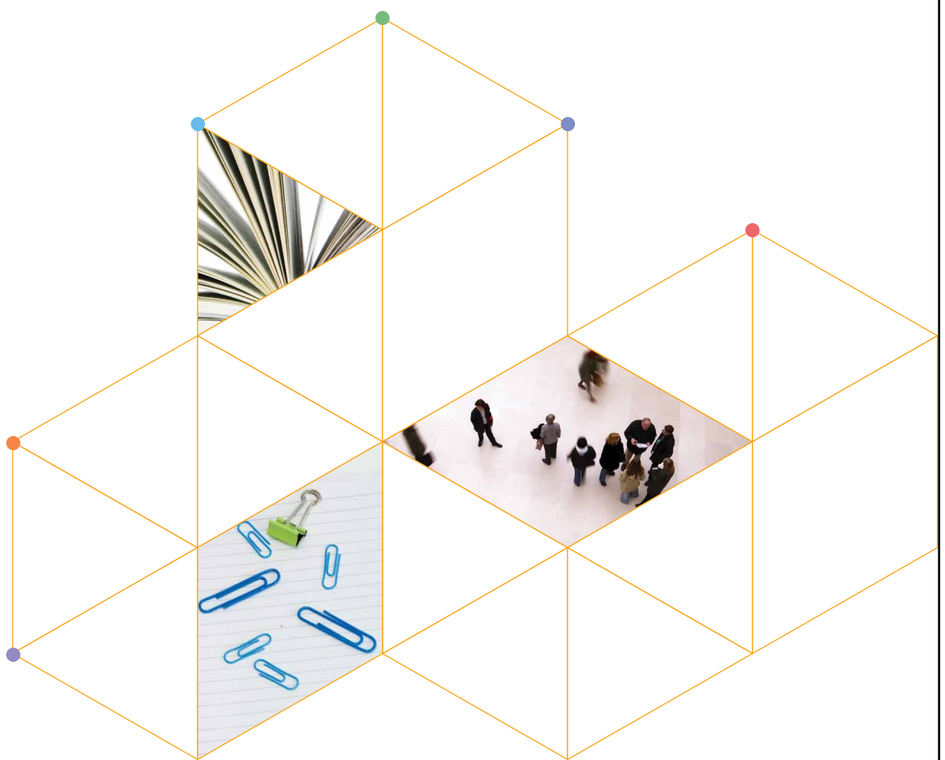
KREJČÍ Jindřich, Institute of Sociology, Academy of Sciences of the Czech Republic (Chair)
DRBOHLAV Dušan, Charles University in Prague
FRANKL Michal, Jewish Museum in Prague
HAJIČOVÁ Eva, Charles University in Prague
KREIDL Martin, Masaryk University
LHOTÁK Martin, Academy of Sciences Library

ICT/e-infrastructures:

GRUNTORÁD Jan, CESNET, z. s. p. o., Prague (Chair)
BITTNAR Zdeněk, Czech Technical University in Prague
KUČERA Antonín, Charles University in Prague
MATYSKA Luděk, Masaryk university
SITERA Jiří, University of West Bohemia
TŮMA Miroslav, Institute of Computer Science, Academy of Sciences of the Czech Republic
TVRDÍK Pavel, Czech Technical University in Prague
VONDRÁK Ivo, VŠB – Technical University of Ostrava

Annex No. 3: International Peer-Review Committee of Roadmap of the Czech Republic of Large Infrastructures for Research, Experimental Development and Innovation for the years 2016–2022

FLETCHER Peter, Science and Technology Facilities Council (Chair)
FRÖJDH Christer, Mid Sweden University (Physical Sciences)
LAURITZEN Bent, Technical University of Denmark (Energy)
IKONEN Eeva, Academy of Finland (Environmental Sciences)
CURTIUS Eckhart, Federal Ministry of Education and Research (Biomedicine)
HUGHES Lorna, School of Advanced Study, University of London (Social Sciences and Humanities)
BÁLINT Lajos, National Information Infrastructure Development Institute (ICT/e-infrastructures)



Annex No. 4: Council for Large Infrastructures for Research, Experimental Development and Innovation

HAJIČOVÁ Eva, Charles University in Prague (Chair)
GRUNTORÁD Jan, CESNET, z. s. p. o.
HRUŠÁK Jan, Academy of Sciences of the Czech Republic, ESFRI Executive Board Member
KOLÁŘ Jan, Czech Space Office
KREJČÍ Jindřich, Institute of Sociology, Academy of Sciences of the Czech Republic
KŘENEK Petr, Institute of Plasma Physics, Academy of Sciences of the Czech Republic
LEVÁK Lukáš, Ministry of Education, Youth and Sports
MAREK Jan, Office of the Government of the Czech Republic
MAREK Michal V., Global Change Research Centre, Academy of Sciences of the Czech Republic
MOLDAN Bedřich, Charles University in Prague
SEDLÁČEK Radislav, Institute of Molecular Genetics, Academy of Sciences of the Czech Republic
ŠTEKL Ivan, Czech Technical University in Prague
TOMAN Petr, Brno University of Technology
VALÍK Dalibor, Masaryk Memorial Cancer Institute
VONDRÁK Ivo, VŠB – Technical University of Ostrava
WITZANYOVÁ Naděžda, Research Centre Řež
ZSAPKOVÁ HARINGOVÁ Dominika, Technology Centre, Academy of Sciences of the Czech Republic
VENTLUKA Petr, Ministry of Education, Youth and Sports (Secretary)

Annex No. 5: Research Infrastructures in Czech Republic

Scientific field	Name	Acronym		Main hosting institution / Coordinator	Location	Priority *	Life-cycle phase (2015)	Previous major funding source
Physical sciences	Pierre Auger Observatory – participation of the Czech Republic	AUGER-CZ		Institute of Physics, Academy of Sciences of the Czech Republic	Argentina	A1	Operational	state budget
	Brookhaven National Laboratory – participation of the Czech Republic	BNL-CZ		Czech Technical University in Prague	United States of America	A2	Operational	state budget
	Center of Accelerators and Nuclear Analytical Methods	CANAM		Nuclear Physics Institute, Academy of Sciences of the Czech Republic	Czech Republic	A2	Operational	state budget
	CEITEC Nano	CEITEC Nano		Brno University of Technology	Czech Republic	A1	Operational	ERDF + state budget
	Center of Materials and Nanotechnologies	CEMNAT		University of Pardubice	Czech Republic	A3	Operational	ERDF + state budget
	Research Infrastructure for Experiments at CERN	CERN-CZ		Institute of Physics, Academy of Sciences of the Czech Republic	Switzerland	A2	Operational	state budget
	Cherenkov Telescope Array – participation of the Czech Republic	CTA-CZ		Institute of Physics, Academy of Sciences of the Czech Republic	Chile, Spain	A1	Implementation	state budget
	Extreme Light Infrastructure – ELI Beamlines	ELI Beamlines		Institute of Physics, Academy of Sciences of the Czech Republic	Czech Republic	A2	Implementation	ERDF + state budget
	European Spallation Source – participation of the Czech Republic	ESS Scandinavia-CZ		Nuclear Physics Institute, Academy of Sciences of the Czech Republic	Sweden	A1	Implementation	state budget
	Atacama Large Millimeter / Submillimeter Array – participation of the Czech Republic	EU-ARC.CZ		Astronomical Institute, Academy of Sciences of the Czech Republic	Germany	A2	Operational	ERDF + state budget
	Facility for Antiproton and Ion Research – participation of the Czech Republic	FAIR-CZ		Nuclear Physics Institute, Academy of Sciences of the Czech Republic	Germany	A1	Implementation	state budget
	Research Infrastructure for Fermilab Experiments	Fermilab-CZ		Institute of Physics, Academy of Sciences of the Czech Republic	United States of America	A2	Operational	state budget
	HiLASE: New Lasers for Industry and Research	HiLASE		Institute of Physics, Academy of Sciences of the Czech Republic	Czech Republic	A4	Operational	ERDF + state budget
	Institut Laue-Langevin – participation of the Czech Republic	ILL-CZ		Charles University in Prague	France	A1	Operational	state budget
	Infrastructure for Study and Application of Advanced Materials	IPMINFRA		Institute of Physics of Materials, Academy of Sciences of the Czech Republic	Czech Republic	A2	Operational	ERDF + state budget
	Laboratory of Nanostructures and Nanomaterials	LNSM		Institute of Physics, Academy of Sciences of the Czech Republic	Czech Republic	A4	Operational	state budget
	Laboratoire Souterrain de Modane – participation of the Czech Republic	LSM-CZ		Czech Technical University in Prague	France	A2	Operational	state budget
	Prague Asterix Laser System	PALS		Institute of Plasma Physics, Academy of Sciences of the Czech Republic	Czech Republic	A3	Operational	state budget
	Centre for Analyses of Functional Materials	SAFMAT		Institute of Physics, Academy of Sciences of the Czech Republic	Czech Republic	A4	Operational	ERDF + state budget
	Système de Production d'Ions Radioactifs Accélérés en Ligne – participation of the Czech Republic	SPIRAL2-CZ		Nuclear Physics Institute, Academy of Sciences of the Czech Republic	France	A2	Operational	state budget
	Surface Physics Laboratory – Materials Science Beamline	SPL-MSB		Charles University in Prague	Italy	A2	Operational	state budget
	Van de Graaff Accelerator – A Source of Tunable Monoenergetic Neutrons and Light Ions	VdG		Czech Technical University in Prague	Czech Republic	A2	Operational	state budget
Energy	Efficient Use of Energy Resources Using Catalytic Processes	CATPRO		Research Institute of Inorganic Chemistry	Czech Republic	A1	Operational	ERDF + state budget
	COMPASS – Tokamak for Thermonuclear Fusion Research	COMPASS		Institute of Plasma Physics, Academy of Sciences of the Czech Republic	Czech Republic	A1	Operational	state budget
	CVVOZE Power Laboratories	CVVOZEPowerLab		VŠB – Technical University of Ostrava	Czech Republic	A4	Operational	ERDF + state budget
	Jules Horowitz Reactor – participation of the Czech Republic	JHR-CZ		Research Centre Řež	France	A2	Implementation	state budget
	Nuclear Research Reactors LVR-15 and LR-0	Reactors LVR-15 and LR-0		Research Centre Řež	Czech Republic	A2	Operational	state budget
	Research Infrastructure for Geothermal Energy	RINGEN		Charles University in Prague	Czech Republic	A3	Implementation	state budget
	Sustainable Energy	SUSEN		Research Centre Řež	Czech Republic	A4	Operational	ERDF + state budget
	VR-1 – Training Reactor for Research Activities	WCZV		Czech Technical University in Prague	Czech Republic	A1	Operational	state budget

* *Indicates the priority for public funding within the "large infrastructures for research, experimental development and innovation" financial tool in direct proportion to the quality-differentiated output of the evaluation.*
***A1** (highest priority), **A2** (high priority), **A3** (middle priority), **A4** (low priority).*

Scientific field	Name	Acronym		Main hosting institution / Coordinator	Location	Priority *	Life-cycle phase (2015)	Previous major funding source
Environmental sciences	ACTRIS – participation of the Czech Republic	ACTRIS-CZ		Czech Hydrometerological Institute	Czech Republic	A1	Operational	state budget
	CzeCOS	CzeCOS		Global Change Research Centre, Academy of Sciences of the Czech Republic	Czech Republic	A2	Operational	ERDF + state budget
	Distributed System of Permanent Observatory Measurements and Temporary Monitoring of Geophysical Fields	CzechGeo/EPOS		Institute of Geophysics, Academy of Sciences of the Czech Republic	Czech Republic	A3	Operational	state budget
	Czech Polar Research Infrastructure	CzechPolar2		Masaryk University – University of South Bohemia in České Budějovice	Arctic, Antarctica	A3	Operational	state budget
	Nanomaterials and Nanotechnologies for Environment Protection and Sustainable Future	NanoEnviCz		J. Heyrovský Institute of Physical Chemistry, Academy of Sciences of the Czech Republic	Czech Republic	A2	Operational	ERDF + state budget
	Research Centre for Toxic Compounds in the Environment	RECETOX		Masaryk University	Czech Republic	A1	Operational	ERDF + state budget
	National Infrastructure SoWa (Soil and Water) for Comprehensive Monitoring of Soil and Water Ecosystems in the Context of Sustainable Use of the Landscape	SoWa		Biology Centre, Academy of Sciences of the Czech Republic	Czech Republic	A2	Implementation	state budget
Biomedicine	Bank of Clinical Specimens	BBMRI-CZ		Masaryk Memorial Cancer Institute	Czech Republic	A4	Operational	ERDF + state budget
	Center for Systems Biology	C4SYS		Institute of Microbiology, Academy of Sciences of the Czech Republic	Czech Republic	A2	Implementation	ERDF + state budget
	Czech Centre for Phenogenomics	CCP		Institute of Molecular Genetics, Academy of Sciences of the Czech Republic	Czech Republic	A1	Operational	ERDF + state budget
	Czech Infrastructure for Integrative Structural Biology	CIISB		Masaryk University	Czech Republic	A1	Operational	ERDF + state budget
	Czech node to the European Clinical Research Infrastructure Network	CZECRIN		Masaryk University	Czech Republic	A4	Operational	ERDF + state budget
	National Infrastructure for Biological and Medical Imaging	Czech-BioImaging		Institute of Molecular Genetics, Academy of Sciences of the Czech Republic	Czech Republic	A2	Operational	ERDF + state budget
	National Infrastructure for Chemical Biology	CZ-OPENSCREEN		Institute of Molecular Genetics, Academy of Sciences of the Czech Republic	Czech Republic	A2	Operational	ERDF + state budget
	Czech National Node to the European Infrastructure for Translational Medicine	EATRIS-CZ		Palacký University Olomouc	Czech Republic	A2	Operational	ERDF + state budget
	Czech National Infrastructure for Biological Data	ELIXIR-CZ		Institute of Organic Chemistry and Biochemistry, Academy of Sciences of the Czech Republic	Czech Republic	A1	Operational	ERDF + state budget
	National Center for Medical Genomic	NCMG		Charles University in Prague	Czech Republic	A4	Operational	ERDF + state budget
Social sciences and humanities	Archaeological Information System of the Czech Republic	AIS CR		Institute of Archaeology of the Academy of Sciences of the Czech Republic, Brno / Institute of Archaeology of the Academy of Sciences of the Czech Republic, Prague	Czech Republic	A3	Implementation	state budget
	Czech Literary Bibliography	CLB		Institute of Czech Literature, Academy of Sciences of the Czech Republic	Czech Republic	A2	Operational	state budget
	Czech National Corpus	CNC		Charles University in Prague	Czech Republic	A1	Operational	state budget
	Czech Social Science Data Archive	CSDA		Institute of Sociology, Academy of Sciences of the Czech Republic	Czech Republic	A2	Operational	state budget
	Czech National Node of ESS (European Social Survey)	ESS-CZ		Institute of Sociology, Academy of Sciences of the Czech Republic	Czech Republic	A2	Implementation	state budget
	Language Research Infrastructure in the Czech Republic	LINDAT/CLARIN		Charles University in Prague	Czech Republic	A2	Operational	state budget
	Research Infrastructure for Diachronic Czech Studies	RIDICS		Institute of the Czech Language, Academy of Sciences of the Czech Republic	Czech Republic	A3	Operational	state budget
	Survey of Health, Ageing and Retirement in Europe – participation of the Czech Republic	SHARE-CZ		Economics Institute, Academy of Sciences of the Czech Republic	Czech Republic	A1	Operational	state budget
ICT	CERIT Scientific Cloud	CERIT-SC		Masaryk University	Czech Republic	A3	Operational	ERDF + state budget
	E-infrastructure CESNET	CESNET		CESNET, z. s. p. o., Prague	Czech Republic	A1	Operational	ERDF + state budget
	IT4Innovations National Supercomputing Center	IT4Innovations		VŠB – Technical University of Ostrava	Czech Republic	A2	Operational	ERDF + state budget

* *Indicates the priority for public funding within the "large infrastructures for research, experimental development and innovation" financial tool in direct proportion to the quality-differentiated output of the evaluation.*
A1 *(highest priority),* ***A2*** *(high priority),* ***A3*** *(middle priority),* ***A4*** *(low priority).*

Annexe No. 6: Projects financed by EU structural funds that contributed to upgrade of already operated or to construction of newly established research infrastructures of the Czech Republic in the years 2007–2015

Acronym	Name	Operational Programme
Algatech	Centre for Algal Biotechnology Třeboň	OP RDI
BIOCEV	Biotechnology and Biomedicine Center of the Academy of Sciences and Charles University in Vestec	OP RDI
BIOMEDREG	Biomedicine for Regional Development and Human Resources	OP RDI
CAPI	Center of Advanced Preclinical Imaging	OP RDI
CEITEC	Central European Institute of Technology	OP RDI
CEMNAT	Center of Materials and Nanotechnologies	OP RDI
CERIT-SC	CERIT Scientific Cloud	OP RDI
CETOCOEN	Research Centre for Toxic Compounds in the Environment	OP RDI
CVVOZE	Centre for Research and Utilization of Renewable Energy Resources	OP RDI
CzechGlobe	Global Change Research Centre of the Academy of Sciences of the Czech Republic	OP RDI
CxI	Institute for Nanomaterials, Advanced Technologies and Innovation	OP RDI
CZ-OPENSCREEN	National Infrastructure for Chemical Biology	OP PC
eIGeR	Extension of the National R&D Information Infrastructure in Regions	OP RDI
ELI Beamlines	Extreme Light Infrastructure	OP RDI
FUNBIO	Centre of Functional Materials for Bioapplications	OP PC
FNUSA-ICRC	University Hospital of Saint Anne in Brno – International Clinical Research Centre	OP RDI
HiLASE	New Lasers for Industry and Research	OP RDI
IT4Innovations	IT4Innovations National Supercomputing Center	OP RDI
RCPTM	Regional Centre of Advanced Technologies and Materials	OP RDI
RECAMO	Regional Centre for Applied Molecular Oncology	OP RDI
SAFMAT	Centre for Analyses of Functional Materials	OP PC
SUSEN	Sustainable Energy	OP RDI
UniCRE	Unipetrol Centre of Research and Education	OP RDI
OP RDI	Operational Programme Research and Development for Innovations	
OP PC	Operational Programme Prague – Competitiveness	

Roadmap of Large Infrastructures for Research, Experimental Development and Innovation of the Czech Republic for the years 2016–2022

First edition
Publisher: Ministry of Education, Youth and Sports, Karmelitska 7, 118 12 Prague 1
Press run: 150 copies
Book design: Hedvika Člupná
Print: POINT CZ, s. r. o.

Prague, October 2015
www.msmt.cz

ISBN 978-80-87601-34-1

Roadmap of Large Infrastructures for Research, Experimental Development and Innovation of the Czech Republic for the years 2016–2022

Ministry of Education, Youth and Sports
Prague 2015
www.msmt.cz

MINISTRY OF EDUCATION,
YOUTH AND SPORTS