

**A game-changing improvement  
for access to high-end  
accelerator-based photon  
sources for European  
researchers and innovators**

A NOVEL BLOCK-GRANT INSTRUMENT

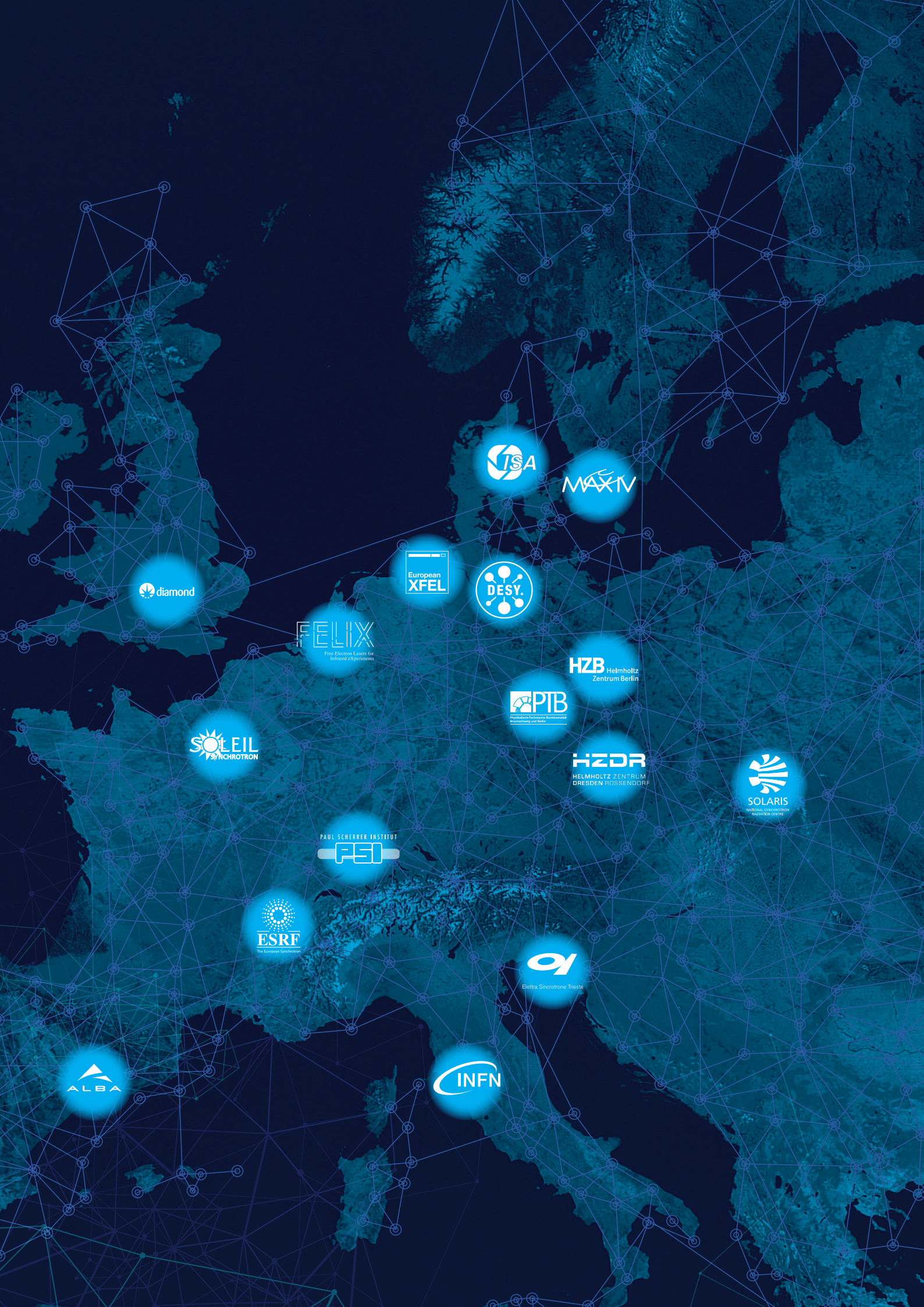


**LEAPS**

League of European  
Accelerator-based  
Photon Sources

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diamond

FELIX  
Free Electron Lasers for  
Infrared Experiments

SOLEIL  
SYNCHROTRON

PSI  
PAUL SCHERRER INSTITUT

ESRF  
The European Synchrotron

ALBA

INFN

TSA

MAXIV

DESY

European  
XFEL

HZB  
Helmholtz  
Zentrum Berlin

PTB  
Physikalisch-Technisches Bundesamt  
Dresden und Berlin

HZDR  
HELMHOLTZ ZENTRUM  
DRESDEN ROSSENDORF

SOLARIS  
NATIONAL SYNCHROTRON  
RACIBÓRZ CENTRE

Elettra Sincrotrone Trieste

The background is a dark blue gradient with a network of thin white lines and dots, and several large, semi-transparent blue circles of varying sizes scattered across the space. The text 'EXECUTIVE SUMMARY' is centered in the lower half of the image.

# EXECUTIVE SUMMARY



**“Large-scale research infrastructures are a backbone of the European Research Area and key to make Europe attractive for the best researchers across the world, contributing to knowledge sharing and innovation.”<sup>1</sup>**

As such, they are key to Europe’s technological sovereignty and to drive innovation in strategic areas like health or quantum and green technologies.

With their unmatched capabilities, the “super-microscopes” of the facilities of the League of European Accelerator-based Photon Sources (LEAPS), gathering all European synchrotrons and free electron lasers, are irreplaceable in unravelling the mysteries of viruses or for the discovery of novel materials and drugs, surpassing traditional methods by many orders of magnitude in sensitivity and resolution. LEAPS constitutes the largest network of analytical infrastructures worldwide, playing a pivotal role in securing Europe’s leadership in a rapidly changing global landscape. By unifying some of Europe’s most advanced analytical capabilities, the creation of LEAPS in 2017 has been a crucial step forward (triggering the establishment of sister organizations).

However, in order to stay competitive on a global stage and to continue providing European researchers with world-class infrastructures, Europe must urgently adapt to the global pace of technological advancements, supported by massive investments in Asia and the US.

LEAPS has taken responsibility by:

- Setting out in 2022 an **integrated European strategy** (ESAPS 2022 [https://leaps-initiative.eu/wp-content/uploads/2022/05/LEAPS-ESAPS-Broschure\\_final-20052022-3.pdf](https://leaps-initiative.eu/wp-content/uploads/2022/05/LEAPS-ESAPS-Broschure_final-20052022-3.pdf)) including a roadmap for technological and scientific development.
- Transforming in 2024 into the **legal entity LEAPS-AISBL** with an even stronger voice in strategic dialogues.
- Advocating in this proposal a **long-term Block Grant approach** that will have the power to unleash the full potential of LEAPS-AISBL, representing billions of investments by Member States.

This will not only fortify LEAPS’s standing but also elevate its role as pivotal component in maintaining Europe’s leading position in science and technology.

Current funding schemes including H2020 and Horizon Europe, have been fundamental in developing collaborations. However, at the current stage of evolution, the size and duration of the projects does not allow the collective strength of the LEAPS facilities, which is to serve multiple application with a common technology, to express its full potential. Fragmentation among multiple projects with a large number of partners inhibits upscaling to joint, road-map based technology developments at the level required to keep pace with the competition and maintain impact. By consolidating these resources, LEAPS will be able to cater more effectively to diverse applications and drive ground-breaking developments.

Our proposal centres on **long-term Block Grant funding** to promote collaboration across Europe. It includes engaging with other networks as needed and aligning with EU Partnerships and Missions. For Europe to maintain its leadership in science, innovation, and technology, commitment to long-term initiatives, typically lasting 7 to 10 years, is essential for developing the required advanced instrumentation. This strategy will not only boost operational efficiency but also foster innovation, guaranteeing growth and competitiveness.

**The immense potential of a united LEAPS initiative can spearhead technology development and synchronize strategic directions, ensuring unparalleled and complementary resources for European innovators.**

This concerted Block Grant approach will enable the realization of joint developments on the following essential main directions:

- **strengthen the technological fundament** of the facilities, also enhancing their sustainability,
- enable the joint development of a new **access roadmap** to our facilities,
- **harness the data generated** by LEAPS facilities, coupled with **AI-based tools**,
- contribute to **education, European cohesion, and science diplomacy.**

**The robust governance structure of LEAPS-AISBL, combined with systematic impact monitoring, guarantees the effective execution of the Block Grant approach.**

**LEAPS-AISBL seeks to engage the European Commission in dialogues, aiming to craft a novel Block Grant instrument that catalyses transformative measures for research infrastructures in science and innovation.**

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<sup>1</sup> COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS entitled “an ERA for research and innovation” 30.9.2020.



# 1

## CONTEXT AND PROBLEM DEFINITION

“Large-scale research infrastructures are a backbone of the ERA and key to make Europe attractive for the best researchers across the world, contributing to knowledge sharing and innovation.”<sup>2</sup>

Europe is facing strong global competition and progressively needs to reduce its reliance on knowledge and production chains beyond its borders, especially for technology areas which are critical for the EU’s economic security. The past few years have shown that, particularly concerning strategically vital technologies as e.g. quantum materials, this poses a significant threat. In addition, European SME and industry need to move into green-tech at an unprecedented speed. This requires keeping Europe at the forefront of the development of new materials and technologies.

**The importance of materials research is clearly emphasized in many European policy initiatives,** notably:

- The European Economic Security Strategy, which prioritizes Advanced Semiconductors Technologies, AI technologies, Quantum technologies and Biotechnologies, all of which benefit strongly from access to high-end analytical facilities.
- The Circular Economy Action Plan, which highlights that Research and Innovation on advanced materials is essential for developing a circular design of products in the transition towards a “Circular economy and a zero-waste programme for Europe”.
- The European Strategy for Plastics in a Circular Economy which specifies the need for plastics design and production fully respecting reuse, repair and recycling requirements.
- The 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals, which emphasizes that technological innovation is the foundation of the efforts undertaken to achieve the environmental and growth objectives, requiring more research and development in high-tech products that dominate the manufacturing productions to increase efficiency (material use, recyclability, energy efficiency).
- The European Commission (EC) communication “A clean planet for all”, which defines a set of seven main strategic priorities considering new and improved materials for buildings, substitution of carbon intensive materials, biogenic materials as well as more efficient and sustainable batteries.
- The EC Communication “A Chips Act for Europe” which stresses the need for equipment manufacturing and

advanced materials, needed to build next-generation production facilities serving all its sectors.

- The EC Communication “A secure and sustainable supply of critical raw materials in support of the twin transition”, which demands more work on advanced materials, including substitution of critical raw materials, to secure Research and Innovation investments levels commensurate with the challenge”. Accelerator-based photon facilities, i.e., high-brilliance synchrotron radiation facilities and free electron lasers, united in LEAPS, are the world’s most powerful microscopes. They provide unique analytical tools for exploration of the atomic and electronic structure and processes in materials and biological systems. Today they serve more than 35,000 academic and industrial researchers with over 1 million hours of access per year across all scientific disciplines ranging from materials, biochemistry, catalysis, geoscience and planetary research to palaeontology and cultural heritage. European industry is both a key user and a key supplier of the 19 LEAPS facilities broadly distributed throughout Europe. By offering fast and customized access for industries, they significantly contribute to critical sectors such as health, energy, aerospace, information technology, quantum technologies, transportation, and consumer/household products.

LEAPS facilities offer open access to national, European and international researchers inviting curiosity-driven research to be carried out as well as challenge-driven projects. Access to the facilities is granted after a successful review process, in which the incoming proposals are rigorously ranked by excellence and relevance. This free-of-charge access to state-of-the-art high-tech infrastructures is heavily over-subscribed, as there is a high demand from a broad spectrum of expert user groups. It is also of high importance for young investigators. The funding for this access is borne primarily by national funding agencies and has in the past also been supported by the European Commission (“transnational access, TNA”). Note that proprietary, i.e., unpublished, industrial research is charged full cost.

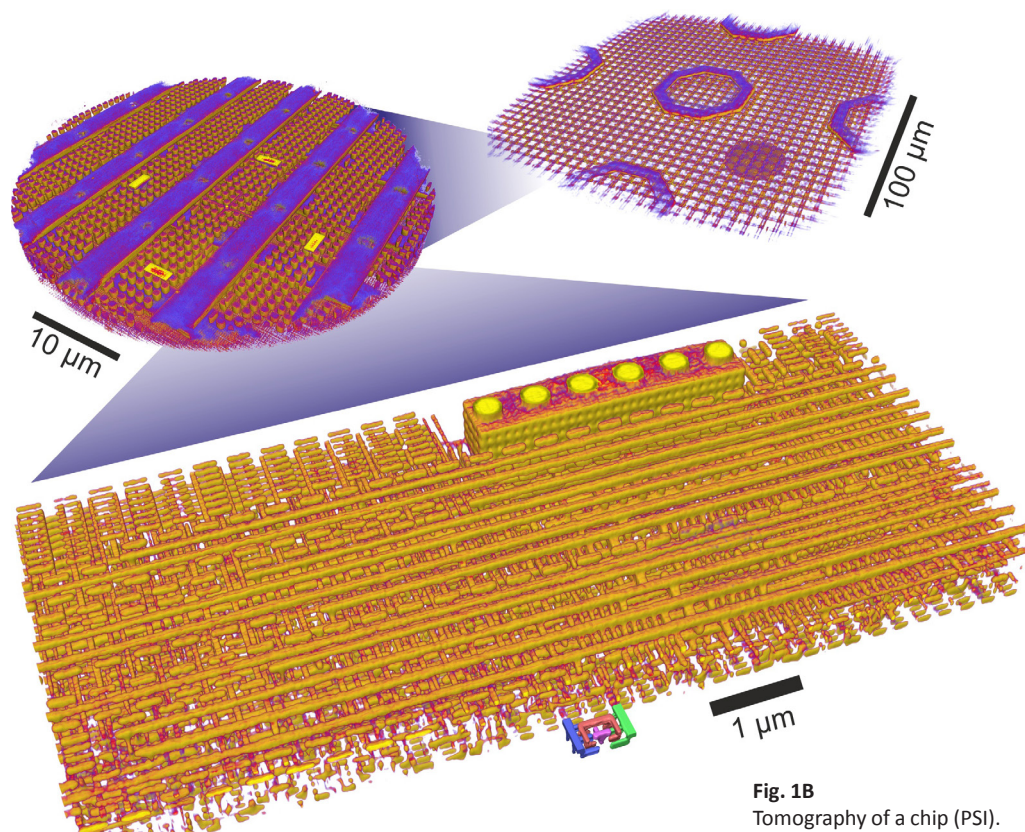
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<sup>2</sup> COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS entitled “an ERA for research and innovation” 30.9.2020.



30 mm

Fig. 1A  
Tomography of a CoViD19 infected lung (ESRF).



**Fig. 1B**  
Tomography of a chip (PSI).

**The problem: In order to respond to the high demand by European researchers and industry and the increasing speed of global competition, a step-change in European collaboration is needed.**

To stay competitive on a global stage and to continue to provide European researchers with world-class infrastructures, Europe needs to keep up with the relentless pace of technological developments that are being implemented worldwide. Massive investments are ongoing e.g. in the USA (<https://www.aps.anl.gov/APS-Upgrade>) and in China (<http://english.ihep.cas.cn/heps/>).

EU Research Infrastructure funding started with a small number of individual co-funded projects in the second Framework Programme FP2 and increased through FP3-FP5 leading to the large Integrated Infrastructure Initiatives (I3) in FP6. Although EU funding was a small percentage of the total, on the order of a percent, the collaboration structures of Research Infrastructures (RIs) that the Integrated Infrastructure Initiatives provided have proven to be extremely effective and laid the groundwork for consortia such as LEAPS. However, through FP6 and FP7 the degree of RI integration enabled by EU programmes has gradually decreased. In Horizon Europe RI activities are spread across many potential projects, each with many partners. This **fragmented participation overlooks the collective strength of LEAPS facilities in pooling**

**resources for the advantage of diverse applications and hinders support for key game-changing developments. For Europe to truly maximize its leadership in science, innovation, and technology, there is a need to revisit the funding structure. This proposal emphasizes the urgent need to introduce a Block Grant funding approach, focused on fortifying European collaborative efforts.**

This document underscores the advantages of a more ambitious approach in achieving European leadership goals in science, innovation, and technology. It emphasizes the importance of fostering European sovereignty, enhancing cohesion, influencing the education and training of upcoming generations of scientists and engineers, and advancing science diplomacy. Concrete actions are proposed, most notably a more strategic and long-term co-funding via a Block Grant. It builds on the success of the H2020 LEAPS-INNOV project (<https://www.leaps-innov.eu/>) and would be a pilot for a wider project as a basis for European analytical research infrastructures.

**The immense potential of a united LEAPS initiative can spearhead technology developments and synchronize strategic directions, ensuring unparalleled and complementary resources for European innovators.**

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2

NOVEL APPROACH

The novel approach is needed to bring together research infrastructures, industry, academia, and the European Commission with the objective to provide European researchers and innovators with the means to boost materials and drug development in Europe by

- massively increasing the speed of technology development of the facilities and
- partnering with strategic initiatives as e.g. partnerships and missions in order to take up their needs.

This will allow

- pooling efforts, resources, and investments to generate a long-term positive impact,
- enabling European SME to enter new markets, both as a supplier and as a user of LEAPS facilities,
- boosting European competitiveness and technological sovereignty,
- creating jobs and growth, and putting Europe in a world-leading position.

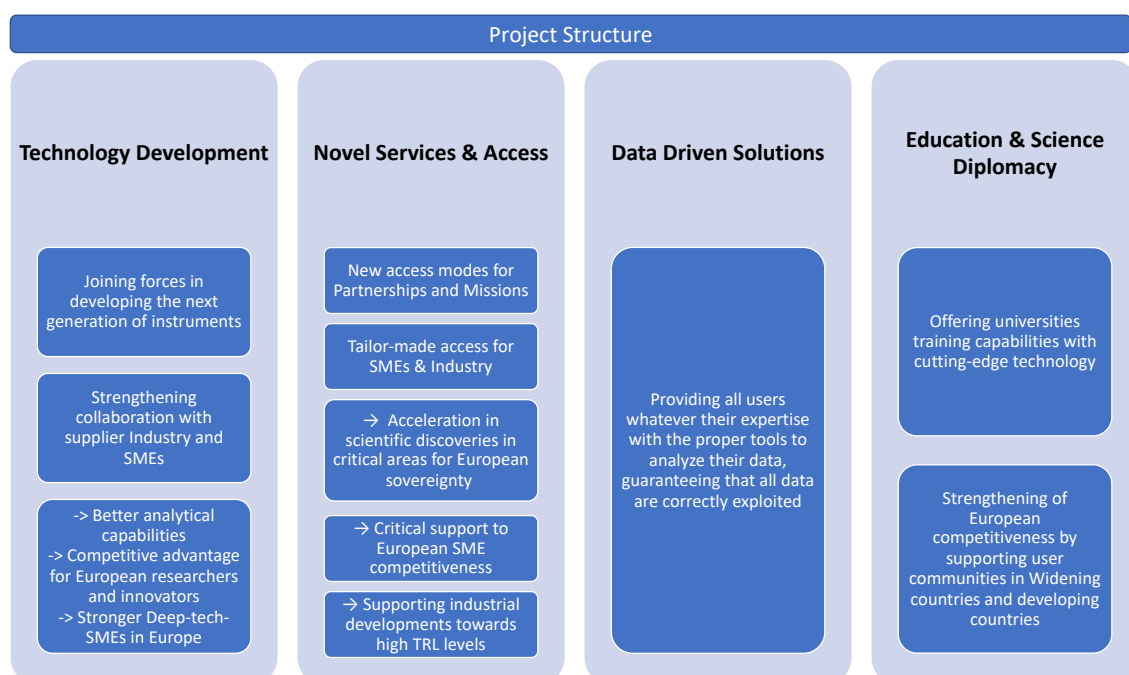
## Structure needed

These objectives require a **long-term** collaboration structure for at least 7 years, going beyond the present situation of individual 3-4-year-projects. Bringing together large national labs into a meaningful collaboration requires a time frame adapted to the development cycles of these large complex facilities. This can be implemented as a Block Grant.

Based on existing structures, ideally the structure of a Research and Innovation Action (RIA) in Horizon Europe, the Block Grant would have an **extended duration, e.g. for 5 years with the option to extend 2 more years** (in order to fit to the EU framework programme duration), and a correspondingly **significant budget allowing to truly make an impact on the challenges faced**. It would have LEAPS facilities as partners, but Industry and other analytical infrastructures would be asked to join specific activities in order to maximise the impact.

**Its main deliverable will be accelerated technology development for Europe in key strategic areas.** European researchers, innovators and Industry will gain more targeted access to the high-end facilities they need to develop novel materials. This will provide a strong competition advantage in key strategic areas, notably Hydrogen, Quantum technology and in key societal challenges, e.g. replacing plastics and rare earths.

The focus is on a **roadmap-process at European level to jointly develop the technologies and a new interaction mode with Industry and users**, most notably with partnerships and missions, and it is not planned to finance the operational costs of the facilities via this grant. More than 95% of the significant costs of operating and upgrading the facilities are covered by their national funding. Efforts also comprise maximizing the contribution of LEAPS facilities to the training of the next generations of scientists and engineers and to strengthen its activities on science diplomacy.



**Fig. 2**  
Summary of the Programme structure and outputs.

Substantial funding to address the challenges described above in a meaningful way is indispensable to ensure true impact. All of the activities described are only possible because of the existing national funding.

At European level, a true difference could already be made by allocating 120-150 Mio. € over 7 years. The majority of these funds will be needed for ambitious technology development to stay ahead of global competition. A second pillar of the programme needs to focus on Novel Access and Services, opening up the facilities to new strategic initiatives, e.g. European Partnerships, and industry users. Improved Data Services will be essential to serve the user needs, and the high potential of the LEAPS facilities to contribute to Education and Science Diplomacy can be better harnessed.

Such a Block Grant could be implemented by a call asking specifically for sustainable measures to ensure joint roadmap-based technology development for elements required for the next generations of synchrotrons and lasers in Europe. The proposal to be submitted would have to show that it comprises a large set of the European large scale facilities in this field, has a solid approach to prioritize the areas in which technology development is most urgently needed to stay ahead of global competition, to respond to the demands of users and the strategic relevance of the subject areas, and produce a sound roadmap. Also, suitable measures have to be established to involve relevant European industry, SME and facilities beyond the initial consortium in the activities as appropriate, e.g. via cascading calls.

A mid-term review by independent experts selected by the EC would ensure that all activities are well on track, allowing an informed decision on prolonging the funding for the full envisaged duration (5+2 years).

This programme will ensure optimization of resources and avoid duplication of developments. Most importantly, it will enable developments which are impossible for individual facilities, since industry has already shown to be more willing to collaborate with a critical mass of several facilities instead of just one or two. Trust and procedures are in place within LEAPS, prioritization in technological developments with co-development being now the rule. Calls will ensure optimal participation of the user community and industry.

## Elements of the novel Block Grant approach

### A. Technology developments

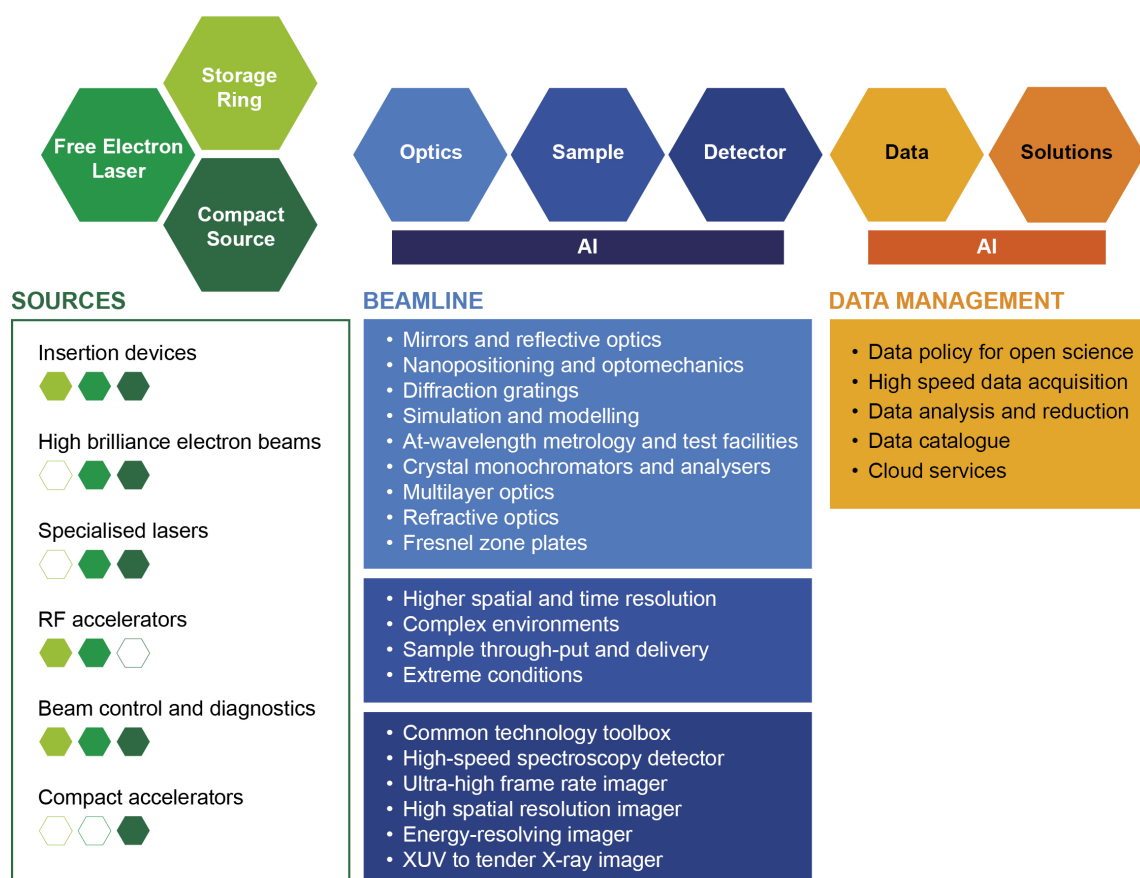
Joint technology developments at the LEAPS facilities and their partners in industry, SME and other analytical facilities is essential for the global competitiveness of European facilities. Some of the potential outputs are described below.

#### Main impacts

- European industrial ecosystem for permanent magnet recycling for LEAPS use  
→ more sustainable and greener operational facilities
- Prototyping of technology for multiple experiment FELs  
→ making FELs accessible to a broader community by increasing the number of simultaneous experiments resulting in more access to the scientific user community and increasing scientific output
- Full scale detector prototypes
- Optical components for full wavefront control
- Fully automated beamline prototype (remotely controlled) - high throughput:  
→ Better analytical capabilities  
→ capability for high throughput feeding databases for AI.
- Call for co-creation of instruments and sample environment with users:  
→ Experiments better suited to most timely user needs,  
→ Experiments allowing LEAPS to fulfil the needs for higher TRL-related experiments.

#### Sustainability

Sustainability is a pivotal ingredient of the LEAPS strategy, one of the key aspects being energy efficiency. The facilities have undergone continuous advances in accelerator technologies, light optics, detectors and sample end stations resulting in significantly improving their energy efficiency and allowing to reduce their environmental impact and this is a priority in the technology development proposed here. In addition, LEAPS prioritizes sustainability through their important role in finding solutions for better batteries, sustainable materials to replace plastics and other contributions which are critical to reducing the human impact on the climate, acting as research hubs for materials science, chemistry, and environmental science, among others. This collaborative model not only fosters innovation but also helps optimize resource utilization,



**Fig. 3**  
Technologies involved in LEAPS facilities.

making light sources a sustainable and indispensable stakeholder.

### Technology roadmap

As indicated above and explained in more detail in the following, current scientific challenges require more precise, faster, multimodal characterization of systems under real conditions which can only be offered by LEAPS facilities. This necessitates ambitious, long-term developments that are only possible with a joint approach.

Europe is at the forefront of light source technology, hosting an unrivalled portfolio of facilities globally and several deep-tech SME developing the high-end components for these facilities<sup>3</sup>. Yet, as the rest of the world rapidly advances, Europe must take decisive action to preserve the innovative edge of its accelerator-based photon sources.

Light sources are already a central pillar in driving forward drug discovery with all major pharma and many biotechs

sending tens of thousands of samples to be analysed routinely at the atomic scale via automated robotic systems to provide protein structural data for drug design. This speeds up drug discovery, has direct societal impact and provides commercial income to the facilities. But industry is now more broadly requiring high precision data for production and product development. Prominent examples are quantum technologies and solid-state batteries, which operate on a scale where individual atoms or atomic structures dictate functionality.

Recent developments in fields like battery research underscore the impact of European funding in sparking innovative, high-capacity services tailored for industry (delivering what industry needs in terms of sample throughput, with reliable and routine access). If possible, at all, lab-based X-ray techniques would require many weeks to test such high sample volumes, whereas with the synchrotrons it takes hours – making experiments required for innovation possible at the speed needed.

<sup>4</sup> See figure 3 for an overview of technologies involved in LEAPS facilities.

LEAPS facilities have capitalized on one of the final Horizon 2020 grants to launch a pilot project called LEAPS-INNOV (<https://www.leaps-innov.eu/>). This project effectively demonstrates the benefits of collaborative technological advancements. By pooling resources and leveraging each facility's strengths, they co-fund the grant for the collective benefit of the entire community. As individual LEAPS members team up based on their unique strengths, it leads to smart specialization. All proposed developments have been identified in the "LEAPS Strategy 2030" [https://leaps-initiative.eu/wp-content/uploads/2019/11/LEAPS\\_Strategy2030\\_June2018.pdf](https://leaps-initiative.eu/wp-content/uploads/2019/11/LEAPS_Strategy2030_June2018.pdf).

### Accelerator technology

Meeting the challenges at stake requires faster, better resolved, automated experiments for which key technological developments are needed for the entire power train, i.e. from photon sources to beamlines using them for experiments. The recent development of 4th generation storage rings, born in Europe and exported to the rest of the world, allows a dramatic increase of photon beam brilliance and coherence. In this novel technology, the wide use of permanent magnets (which do not need electricity, contrary to the previously used electromagnets) already largely reduced the energy consumption for the new generation facilities. **A major challenge ahead of us is now to make this approach systematic to further decrease their environmental footprint and make the operation even more sustainable.** Permanent magnet manufacturing relies on critical materials mainly provided by China and for which recycling is a must in terms of sustainability and sovereignty.

Free Electron Lasers (FELs) offer unparalleled light for dynamic studies of matter, boosting top-tier temporal resolution. Europe proudly holds the most extensive collection of FELs, encompassing a full spectrum of photon energies and techniques. Currently, those facilities are still only used by experts. Further developments allowing a better control of beam properties are needed to make them accessible to broader user communities. Furthermore, Europe is leading in the design of the next generation of compact FELs based on laser plasma acceleration with the ambition to make some of the capabilities of the current RIs available for industrial applications, hospitals, and smaller laboratory environments. Building a laser plasma acceleration demonstrator is the objective of the EUPRAXIA ESFRI project and not part of this programme <https://www.eupraxia-project.eu/home.html>. However, schemes for compact FEL sources need to be studied as well. Therefore, investments in technologies that will allow multiple experiments served by the same facility in parallel, as for example arrays of FEL radiation sources made by superconducting undulators, are an essential step in the technology development of accelerator tech-

nology. For instance, one crucial aspect is the advancement of High Temperature Superconducting Undulators. This technology offers enhanced performance and lowers operational costs. As a result, more compact beamlines would be enabled and potentially allowing multiple independently tuneable sources within a single compact cryostat. This innovation holds the potential to increase efficiency of FEL radiation sources by more than a factor of 5 compared to current systems.

### Optics

Exploiting the full potential of the new photon sources is presently limited by the availability of advanced X-ray optics. Performance improvements are required across a diverse range of optical devices to reveal ever finer details in complex samples. The LEAPS technology roadmap spans developments across the full TRL scale for reflective, diffractive, and refractive optics. Pilot initiatives for the manufacturing of X-ray mirror/grating substrates and X-ray diffraction gratings are currently running in LEAPS-INNOV. These are providing methodologies to facilitate effective technology transfer to new and established European companies. Amongst the direct benefits of this programme will be the creation of robust European supply chains for optical systems capable of delivering smaller X-ray probe dimensions, higher spectral resolutions, and optimized beams for coherent scattering methods.

### Detectors

Similarly, fully exploiting the potential of the new photon sources requires faster X-ray detectors with better spatial and energy resolution. LEAPS-INNOV has initiated a pilot development for a high throughput X-ray spectroscopy detector system. Building a full scale detector prototype will allow to bring the sensor development to a state that fast, powerful, LGAD sensors are available from several industries and in highest quality. In that way it will become a standard product available for the whole European community of accelerator-based photon sources and will reinforce Europe's standing in sensor development, thus enhancing its independence from overseas producers and opening doors to new markets. Finally, a broader academic and industrial user base will be attracted to LEAPS facilities.

### Instruments

Investing in the sample environment, i.e. the area where the sample is positioned for being measured, under a large variety of experimental conditions, like temperature, pressure, magnetic fields is key for these new classes of experiments. Up to now, sample environments have been developed either by facilities or some user groups; a more coordinated co-construction is needed to meet users' needs and for more standardized methods. Joint developments for novel sample environment instrumen-

tation are needed to enhance capabilities and to foster shared standards. Hence, several projects for different scientific communities and techniques should be performed with sufficient resources to enable a broad participation among facilities, users and industry.

LEAPS-INNOV has already focused on the technology of new nano-positioning and scanning systems for speed and accuracy. At the same time fostering automation will increase productivity and boost industrial usage of the facilities. Especially for high throughput experiments, e.g. in advanced material design or life sciences, it is crucial to build large databases to exploit the new capabilities offered by Artificial Intelligence. By composing the beamline of the future of standardized, self-aligning and self-calibrating components the reliance on human intervention will be reduced, which would increase the accessibility for non-experts as industrial users. Integrating Artificial Intelligence will furthermore allow a swift data evaluation during experiments in real-time. In general, we need to address digital technologies for remote services, to provide enhanced digital platforms for networking and training, to develop more overall resilient facilities.

All these developments exemplify systematic long-term projects, usually spanning 7 to 10 years, thus well beyond the duration of EU projects, i.e. incompatible with current funding schemes. **A new funding scheme is needed to unlock the next level and reach the objectives mentioned above for all components in the value chain.**

This roadmap-based approach is in particular important for industries as they can plan, recruit key staff, invest in machines and technology.

### **A stronger alliance with European industry**

As one of many examples, a recent study for the SOLEIL Synchrotron radiation facility with more than 1000 industrial partners showed that developing products and collaborating with such a facility was instrumental for half of them to access new technologies and a third of them to access new markets. Co-developments that are at least partially funded, can significantly sway companies towards choosing collaborations with these facilities and the benefits clearly extend beyond just financial gains.<sup>4</sup>

Funding co-development can help mitigate the risks associated with highly innovative developments, which can be

challenging for companies to undertake, especially for small and medium-sized enterprises. A European contribution supporting the access of SMEs to the European light source portfolio has demonstrated the impact of funding through de-risking and lowering the barriers for companies to benefit from the remarkable insights which the light sources provide in commercial materials, manufacturing processes and industrial innovation.<sup>5</sup> In these cases, the modest per-project funding available through EU framework programme projects often is what is needed to bring SMEs closer to the research infrastructures.

Furthermore, collaborative development can significantly facilitate the contractual technology transfer process. This goes beyond simple licensing of patents or intellectual property rights, encompassing the exchange of comprehensive associated background IP. These insights are typically unveiled only through ongoing collaboration, emphasizing the unique value of prolonged partnerships. This non-exclusive technology transfer favours dissemination of technological advancements, contributing to European technological sovereignty.

The SME approach is very appropriate for this type of companies however, it is not scalable enough to meet the high-performance material characterization needs of Europe's large-scale industry. This need is acknowledged by battery-, car- or steel-/tooling-manufacturers. Addressing the large-scale clean energy and circular economy transition, these industries face challenges to understand completely new classes of materials on unprecedented short time scales. LEAPS facilities can contribute to the competitive advantage needed to achieve European autonomy in these fields. The existing national and EU funding mechanisms don't enable light sources to meet the demands of multi-billion Euro industries in terms of speed of response and required volumes.

Numerous industrial sectors, including drug discovery, have significant innovation opportunities by utilizing light sources. Therefore, to harness these, strategic large-scale investments are essential. Light sources must provide and adapt to what the industry demands, especially to appeal to non-specialist researchers from industry. The light sources are ready to respond rapidly to existing and emerging strategic industry needs. As an integrated group of light sources, LEAPS is already progressing towards:

<sup>4</sup> The Horizon2020 STREAMLINE project has helped to support a co-developed service with BASF for ultra-high throughput X-ray powder diffraction at the ESRF which is used by BASF to provide thousands of data sets to drive battery development.

<sup>5</sup> The Horizon2020 CALIPSOplus and LEAPS-INNOV projects have supported subsidized SME access for over 50 companies to light source across Europe, helping to drive innovation in areas from food technology to additive manufacturing, fusion power, and drug delivery.

- **Listen to industry needs** – go out to where industry is, teaching industry engineers and technologists about advanced materials characterization and marketing light sources as knowledge centres for industry innovation.
- **Create designer services for strategic and disruptive industry innovation** – put the tools in place for what industry needs and when they need it by co-design hand-in-hand with industry, including smart AI-driven high-throughput sample and data workflows and sample environments for on-site and in-operation characterization.
- **Be like industry** – build standard processes and measurement conditions and adopt quality assurance procedures to re-assure and build trust in light source data repeatability and reliability.
- **Connect better with innovation ecosystem actors** – Research and Technology Organizations, Technology Infrastructures, Contract Research Organizations, scientific service companies and European clusters and partnerships are valued partners for light sources in engaging effectively with industry; closer networking brings more opportunities and added value in both service development and provision.

To realize those steps and meet the industry's needs, opportunities need to be created for the LEAPS facilities to invest in targeted technology development, novel services and accessibility and data driven solutions. By doing this, the investments made in the European accelerator-based photon sources will be better harnessed for industry expectations and supporting and driving a new deal for working with innovative industry on their terms.

## B. Novel services and access

### Main impacts

- Strategic partnership with at least 3 communities and (quantum technologies, batteries & health) including support to non-expert users, co-creation of instrumentation and joint appointment of early-stage researchers.
  - Transformative approach in the access to LEAPS facilities enabling an acceleration in scientific discoveries in critical areas for European sovereignty.
  - Extend the research, diagnostic and treatment capabilities of medical doctors and researchers with dedicated tools and workflows
- Support to SMEs as users of LEAPS facilities
  - Critical support of LEAPS facilities to European SME competitiveness
  - Extending LEAPS contribution to industrial developments towards high TRL levels.

## A new offer of LEAPS to address challenges

In essence, to maximize their contribution to solve the main challenges of the green and digital transitions and health challenges, LEAPS facilities aim to broaden their traditional access model which focuses on excellence-based access and open up to approaches which, while still guaranteeing excellence, emphasize strategic relevance. In order to set this up they are willing to collaborate strategically with relevant European initiatives in the form of formal collaboration agreements targeting Horizon Europe missions and Partnerships.

The goal is twofold:

- to develop or broaden expertise within specific communities about opportunities at LEAPS facilities,
- for LEAPS facilities to better address the community needs.

Strategic partnerships will in particular enable tailor-made access to LEAPS facilities with dedicated access and with specific criteria in the proposal selection process. Co-creation of new instruments or capabilities with academic or industrial users or joint appointment of early-stage researchers will be considered when needed. Quantum technologies, batteries and health are considered as first priority areas to establish such partnerships.

LEAPS will involve complementary facilities within the ARIE-network, as for example e-DREAM (electron microscopes), LENS (neutrons) or Laserlab-Europe whenever appropriate, as currently pioneered in the **ReMade@ARIE** HE project.

## C. Data

### Main impacts

- Definition of meta-data and ontologies for LEAPS facilities enabling re-use of data and AI-based applications accelerating research and materials discovery via workflows including AI tools, data analysis software and workflows
  - providing all users whatever their expertise with the proper tools to analyse their data, guaranteeing that all data are correctly exploited.

### Data science and management

LEAPS and neutron facilities have a rich history of data collaboration, notably through the H2020 European projects PaNOSC (<https://www.panosoc.eu/>) and ExPaNDS (<https://expands.eu/>). These projects led LEAPS to adopt data policies encompassing curation, embargo durations, and eventual open access. With the advancements in syn-

chrotron upgrades and the rapid progress of FEL facilities, there's been a significant boost in photon flux, coherence, and ultra-short timescales, ushering in new scientific possibilities. The rapid development in detector technologies has matched these advancements. Consequently, there's been a surge in the volume and intricacy of data from LEAPS, with individual experiments now regularly producing datasets of several TBs and an annual collective production reaching tens of PBs. This fast evolution has been well documented.<sup>6</sup>

This fast transformation unlocks unprecedented opportunities, allowing scientific communities to establish large data bases that expedite materials design and bolster medical research, among other applications. These opportunities, however, do come with significant challenges:

- the overall availability of data repositories with proper storage capacity,
- heroic efforts in documenting data with all the relevant metadata and building the ontologies allowing their exploitation, and
- the risk of “dark data”, meaning that a considerable fraction of the data produced at facilities may not be fully exploited due to bottlenecks, related to volume and complexity.

The FAIR paradigm (FAIR: Findable, Accessible, Interoperable, Reusable) is not merely a desirable objective, but a crucial element for an efficient exploitation of RIs in terms of impact. These challenges have naturally a global dimension, so that it is crucial to deal with them in a coordinated approach. LEAPS is the natural framework for this.

The traditional approach where users visit a facility, collect measurements, and then take data files home for offline analysis with their tools is no longer viable for many experiments. A “new deal” is undoubtedly required.

LEAPS facilities have started working on data and metadata standardization, flexible catalogues, and search tools; data analysis tools guaranteeing that users may effectively analyse fully their data (and also data reused from experiments by others). A detailed analysis of LEAPS data strategy in the framework of the EOSC has recently been published in <https://doi.org/10.1140/epjp/s13360-023-04189-6>.

Some of these critical issues are best addressed at the facility, in a trans-facility federated way or even supported within the EOSC by data-specialized facilities other than photon sources. This requires joint strategic planning within LEAPS and a strongly coordinated approach, where

some aspects that are LEAPS specific cannot be addressed in generic data projects and require considerable resources.

## D. Education, European cohesion and science diplomacy

### Main impacts

- LEAPS as a European-wide training platform
  - To train the next generation of academic and industrial users
  - Offering universities training capabilities with cutting-edge technology.
- LEAPS as an international research community
  - Strengthening of European competitiveness by expanding LEAPS user community in Widening countries and candidate countries
- LEAPS reaching out to developing countries
  - Developing their user base to the mutual benefit of the local scientific community and ERA

### Approach

The impact of research infrastructures on the broader scientific community hinge significantly on the depth and breadth of their integration into the research and innovation system. It is therefore of utmost importance to extend and widen its user community to the benefit of European leadership in science and innovation. While opening to new communities and disciplines was discussed in a previous section, we discuss here how LEAPS can open up internationally following the successful links with the Middle East SESAME synchrotron in Jordan.

To this end, the ambition of LEAPS is:

- *To train the next generation of academic and industrial users in order to make them capable of using the most advanced techniques for their research with an expected strong impact on European science and innovation.* Such an action implies a good alignment between LEAPS capabilities and the needs of scientific communities which is in particular discussed in the new LEAPS conference series “LEAPS meet ...” (2022 “LEAPS meets Quantum Technology, 2023 “LEAPS Meets Life Science”). Training sessions aligned with LEAPS conferences will offer introductory training in LEAPS techniques. Development of MOOCs (Massive Open Online Courses) and online practical sessions are another training activity that will benefit from a joint approach.

<sup>6</sup> C. Wang, U. Steiner, A. Sepe, Synchrotron big data science. Small (2018). <https://doi.org/10.1002/sml.201802291>

- *To unleash the potential of transferring high-impact job skills in engineering and beyond.*

All LEAPS facilities have strong links with universities and already now play an important role in training the next generation of students - both within the external user groups served by the facility and also in house, supporting hundreds of PhDs. They attract leading experts who subsequently teach at their affiliated universities. They also provide unique training opportunities in instrument design.

The technology and science in the facilities are drivers not only for accelerator technology but also in AI, control systems and optics. Through educational programmes and funding for early university involvement in technology advancements, we can greatly expand this top-tier training. This approach will cultivate a new generation of scientists and engineers equipped with cutting-edge skills for the job market.

- *To strengthen user communities in European countries which are not hosting LEAPS facilities, in particular Widening countries and Candidate countries.*

User proposals from countries which operate their own LEAPS facility tend to be better represented in the number of successful proposals for access. This imbalance does not correspond to the spirit of the European Research Area. The most efficient way to develop user communities, especially in Widening countries or Candidate countries will be by supporting early-stage researchers or young professors strongly using LEAPS facilities to develop their research group. Regardless, within this task, LEAPS would like to evaluate the most effective ways to address disparities in the use of the best research infrastructures across Europe, considering also the potential scenario of implanting large infrastructure by underrepresented regions as catalysts for change.

Special attention will be given to Ukraine where LEAPS is striving to establish strong links through the Light for Ukraine initiative.<sup>7</sup>

- *To reach out to developing countries, in particular in Africa, supporting the development of their user communities to the mutual benefit of local scientific communities and the European Research Area, thus contributing to European science diplomacy, and strengthening global collaboration.*

Here, tools similar to those discussed above we wish to use for Widening countries could be used, but LEAPS proposes to start with development of networks where they are weaker, in particular in Africa. LEAPS proposes to expand existing pilot bilateral training actions and develop remote access to our facilities for African researchers with the aim of developing sustainable partnerships with African research institutions.

Regarding capacity development in synchrotron facilities outside Europe, a most efficient tool are twinning arrangements to partner facilities such as the one we are pioneering with SESAME, Jordan.

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<sup>7</sup> [https://synchrotron.uj.edu.pl/en\\_GB/lightforukraine](https://synchrotron.uj.edu.pl/en_GB/lightforukraine)



3

WHY IS IT IMPORTANT?

## Science, innovation and technology strengthening European sovereignty

Europe is facing increasing global competition and progressively needs to reduce its reliance on knowledge and production chains beyond its borders. The past few years have shown that, particularly concerning strategically vital technologies, this poses a significant threat. Keeping Europe at the forefront of the development of new technologies is vital to secure its position in global markets and its independence. This is impossible without excellent science boosting disruptive innovations and a skilled workforce. For all of the above, LEAPS facilities offer unparalleled state-of-the-art tools.

To stay competitive on a global stage and to continue to provide European researchers with world-class infrastructures, Europe needs to keep up with the relentless pace of technological developments that are being implemented worldwide. Massive investments are ongoing e.g. in USA (<https://www.aps.anl.gov/APS-Upgrade>) and in China (<http://english.ihep.cas.cn/heps/>)<sup>8</sup>. The ESAPS 2022 proposes a roadmap for the LEAPS approach.

Research fields of particular relevance for European competitiveness are Health, the Green Transition and the Digital Revolution where academic and industrial users can provide a unique contribution using LEAPS facilities.

## Health – contribution to life sciences and public health challenges

The challenges in understanding life and thereby contributing to health are complex. Meaningful contributions to enhance knowledge require a concerted approach to make the connection to the physiological function and the biological environment (biomolecules, cell, tissue, organism). Accelerator-based Photon Sources make indispensable contributions to address this fundamental step by determining the 3D structure with the highest resolution, precision, and speed allowing for high throughput. For

example, in their pioneering work leading to the 2009 Nobel Prize in Chemistry, the laureates collected in 5 years in more than 100 sessions about 15000 data sets to uncover the structure and function of the ribosome. Paramount impact in structural biology is demonstrated through the Protein Data Bank (PDB) (RCSB PDB: Homepage) wherein of the daily growing number of structures more than 90% are provided by X-ray techniques with an overwhelming contribution of 95% by Accelerator-based Photon Sources. A trend shows that the European fraction (LEAPS facilities) has grown to 40% and has surpassed the US (30%) and Asia (25%). Importantly, many of the LEAPS facilities are also now equipped with cryo-Electron Microscopes (cryo-EMS) or collaborating with cryo-EM centres, fully exploiting the synergy between cryo-electron microscopy and synchrotron light.

The contribution of macromolecular crystallography at synchrotron light sources over the past 30 years has been so successful that the PDB data base itself enabled the AlphaFold2 protein structure prediction tool from Google DeepMind (see <https://alphafold.ebi.ac.uk>) which is complementing synchrotron structure determination and opening new avenues of research for in silico structural studies and biomedicine.<sup>9</sup> Experimentally derived structural data will be critical in allowing the quality of structure prediction algorithms to be further refined in the future while also offering exciting opportunities in the study of protein structural dynamics using time-resolved methods.

The COVID-19 pandemic highlighted the high relevance of an established network when the LEAPS facilities swiftly joined forces offering their capacities to the life sciences community, from medical doctors to structural biologists. As early as 20 March 2020 scientists using the high-intensity X-ray light from the LEAPS facility BESSY II, decoded the 3D architecture of the main protease of SARS-CoV-2 which plays a central role in the reproduction of the virus.<sup>10 11 12</sup> Strong collaborations between facilities and biotech companies (AstraZeneca and BioNTech) were fun-

<sup>8</sup> China's total R&D expenditures rose 10.4% in 2022 to 3.1 trillion yuan (\$448 billion), with support for basic work up 7.4% to 195.1 billion yuan, the National Bureau of Statistics announced in January. Spending on basic research has doubled in 5 years and accounts for 6.3% of total R&D spending. China has set a goal of raising that ratio to 8% by 2025, says Xuemei Xie, an innovation economics specialist at Tongji University. (source: Science | AAAS)

<sup>9</sup> Borkakoti, N, Thornton, J. M., AlphaFold2 protein structure prediction: Implications for drug discovery., Current Opinion in Structural Biology, Vol. 78, Feb 2023. <https://doi.org/10.1016/j.sbi.2022.102526>

<sup>10</sup> Zhang, L., Lin, D., Sun, X., Curth, U., Drosten, C., Sauerhering, L., Becker, S., Rox, K., and Hilgenfeld, R. Crystal structure of SARS-CoV-2 main protease provides a basis for design of improved  $\alpha$ -ketoamide inhibitors SCIENCE 20 Mar 2020, Vol 368, Issue 6489, pp. 409-412, <http://doi.org/10.1126/science.abb3405>.

<sup>11</sup> Sebastian Günther et al. ,X-ray screening identifies active site and allosteric inhibitors of SARS-CoV-2 main protease.Science372,642-646(2021). <http://doi.org/10.1126/science.abf7945>.

<sup>12</sup> Douangamath, A., Fearon, D., Gehrtz, P. et al. Crystallographic and electrophilic fragment screening of the SARS-CoV-2 main protease. Nat Commun 11, 5047 (2020). <https://doi.org/10.1038/s41467-020-18709-w>.

damental for drug discovery initiatives and in guiding the development of new vaccines.

LEAPS contribution to life sciences is not restricted to public health emergencies, but continuously addresses fundamental research questions as well as major public health challenges such as cancer, neuro-degenerative diseases, resistance to antibiotics, and the emergence of new infectious diseases. LEAPS facilities also contribute to the early diagnoses for example through infrared spectroscopy and microscopy by providing additional means for biomarker discovery, an example being the identification of the biomarker for pyridoxine-dependent epilepsy.<sup>13 14</sup> Early diagnosis and consequently treatment optimizes long-term clinical outcome. Based on experience gained at synchrotrons, a team at PSI has succeeded in refining mammography to produce considerably more reliable results and allows for earlier detection which is key to survival.<sup>15</sup> With a significantly improved image resolution signs of breast tumours could be detected earlier than before, improving the chances of survival for the women concerned. According to experts, this technique could swiftly be applied in clinical settings.

Multi-scale and multi-modal imaging are another important contribution of LEAPS facilities. With the high-brightness facilities in operation (MAX IV and ESRF\_EBS) the achieved speed and spatial resolution now allows imaging of larger volumes (brains, lungs) in reasonable exposure times. The Human Organ Atlas (Human Organ Atlas (esrf.eu)) coordinated by the ESRF is mapping human anatomy at an unprecedented spatial scale.

Ongoing and future developments at the LEAPS facilities will open up completely new paths and possibilities for health research by making substantial progress in:

- capturing images of cells in their natural environment,
- recording images rapidly and in extraordinary detail,
- examining a large number of samples in a standardized manner beyond crystallography,
- offering service provision for non-expert users, thus broadening the applicability of existing and new methods and approaches.

A new strategic approach and additional resources are needed to reinforce cross-facility techniques to:

- develop tools that will help to speed up the development of vaccine and therapeutic approaches,
- respond to needs of health care professionals for new diagnostic tools,
- support early detection of non-communicable diseases,
- contribute to various comprehensive data bases (fundamental research, structure prediction, data for preventative studies, and clinical use),
- intensify collaboration with hospitals with dedicated platforms and procedures,
- contribute to inter-linkage between health and climate change (food supply, plant disease, bio sourced materials ...).

## Green transition - supporting Europe in the development of climate neutral technologies (energy and environment)

Climate change and environmental degradation are an existential threat to Europe and the world. To overcome these challenges, the European Green Deal will transform the EU into a modern, resource-efficient, and competitive economy.<sup>16</sup> Critical strategic investments are needed to develop, research and scale techniques to remove greenhouse gases from the atmosphere, as well as to design new efficient remediation methods.

Both a **deep understanding of environmental processes**, and **efficient methods to accelerate the development of new, environment friendly materials and manufacturing processes** are needed to achieve these goals. The former is essential to develop efficient remediation methods and adapt to climate change, whereas the latter will contribute to the development of materials manufacturing procedures requiring less energy and critical material and enabling recycling by design. To achieve these objectives, LEAPS not only provides, but will increasingly become essential in offering the most advanced tools to European researchers and industries, i.e. making decisive contributions to:

- understanding the (de-)pollution and degradation mechanisms (e.g. microplastics) aiming at healthy oceans, seas, coastal and inland waters,

<sup>13</sup> Engelke U, et al. Untargeted metabolomics and infrared ion spectroscopy identify biomarkers for pyridoxine-dependent epilepsy, *Journal of Clinical Investigation*, 131(15)( 2021). <https://doi.org/10.1172/JCI148272>.

<sup>14</sup> van Outersterp, R. E., Udo F.H., et al. Engelke, Merx, J., Metabolite Identification Using Infrared Ion Spectroscopy - Novel Biomarkers for Pyridoxine-Dependent Epilepsy, *Anal. Chem.* 2021. <http://doi.org/10.1021/acs.analchem.1c02896>.

<sup>15</sup> Rawlik, M et al., Increased dose efficiency of breast CT with grating interferometry *Optica*, 18.07.2023 <http://doi.org/10.1364/OPTICA.487795>.

<sup>16</sup> [https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal\\_en](https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en)

- food security, through identification of trace elements and contamination in soil and food, deepening the understanding of the adaptation of plants to climate change, and development of more resistant species.
- the development of sustainable and recyclable materials supporting the development of a circular economy by the design of products that are more durable, reusable, repairable and recyclable to extend their lifetime and reduce waste (<https://remade-project.eu/>).
- sustainable manufacturing processes using less material for better products.

In view of the urgency, stronger and more strategic interaction with the researchers and innovators tackling these challenges is needed, to make sure they get fast access to the tools they need (ESAPS 2022):

- creating cross-facility / cross-technique platforms (see below [A new offer of LEAPS to address challenges](#)) for the characterization of materials and processes under real working conditions to close the gap between academia and industry. Examples should be [Rational Catalyst Design](#), addressing both chemical and biochemical catalysis, [Clean Hydrogen Technologies](#), covering all stages in the hydrogen value chain from the efficient synthesis of hydrogenated compounds to materials for transport and storage, [Water-based technologies](#) as membranes for separation, purification, and strategic-element harvesting or desalination of sea water,
- advancing services for industry by implementing new and fast access schemes and integrated provisions including digital services, remote access, and automation,
- developing lab-scale reactor demonstrators as starting points for industrial up-scaling.

## Digital Revolution – IT and Quantum technology

LEAPS proposes initiatives in the areas of information technology development and quantum technology directly relevant to the long-term economic strength of Europe.

### Information technology security

With the digital transformation, new application markets for the chip industry are emerging such as highly automated cars, cloud, Internet of Things, device connectivity, space, defense, and supercomputers, including training AI models. All those applications require the development of smaller, faster chips with reduced electricity consumption. Security aspects for components manufactured by companies based outside Europe are a major concern. Through the European Chips Act, the EU aims to tackle semicon-

ductor shortages and bolster Europe's position as a technological leader. LEAPS facilities make it possible to analyse whether a chip has only the components it is supposed to have and have a high potential to contribute to relevant materials design and to the non-destructive 3D characterization of circuits and chips at the single transistor scale.

- Additional support is needed to establish a cross-facility platform for the examination of [microelectronics devices](#) in working conditions addressing their reliability and security, a new approach proposed by LEAPS.

### Quantum technologies

Quantum technology is developing rapidly and has the potential to provide enormous benefit for Europe's society and economy. The Quantum Flagship constitutes a strong European effort to achieve a leadership position in this field, where strong leadership within Europe is of key economic and societal benefit. Synchrotron radiation has up to now mainly been used for the characterization of the electronic properties of quantum materials, sometimes under working conditions, but LEAPS facilities can support quantum technology in many other ways.

In 2022, the "LEAPS meets Quantum Technology" conference helped to identify scientific challenges relevant to the progress in the field of quantum technology that could be solved with synchrotron radiation methods. One prominent challenge is decoherence in solid state quantum Qbits. Here, bulk, surface and interface have to be analysed down to lowest temperatures. The same applies in the field of defect-based quantum sensing and quantum computing, where the detailed understanding of the local atomic structure and local strain around dopants are prerequisite to identify active and inactive dopants. More generally, there is an urgent need to characterize and enhance quantum materials for purer states that can be manipulated, along with extending coherence times.

LEAPS facilities can be important tools for this, but considerable dialogue between the quantum technology community, which is not a traditional user of analytical facilities, and the LEAPS community is needed to identify how to best collaborate, and which instruments are needed. Such dialogue, initiated in the H2020 LEAPS-INNOV project is much more efficiently organized at the level of LEAPS than at the level of each individual facility, and it requires again a long-term strategy and a sufficient time-span to develop and lead to results.

*A small activity within LEAPS-INNOV H2020 project aims at identifying the key scientific and technical issues to be solved in order to serve the needs of the Quantum Technology community. A more long-term strategic partnership with the [Quantum Technology](#) community is needed to generate real impact.*



4

ACTORS

With its 300 experimental stations used by an extended scientific and industrial community, spanning fields ranging from biology and chemistry to physics, from health to food security, from energy to bio-materials, from environment to quantum technologies and cultural heritage, LEAPS plays a central role in a wide-ranging network of actors. Supporting LEAPS will very efficiently impact all of them:

### Academic user communities

LEAPS is used by more than 35 000 users from hundreds of universities and research institutions throughout Europe. The European Synchrotron User Organisation (ESUO <https://www.esuo.eu/>) representing users from 31 countries in Europe is a partner of LEAPS. Being the largest network of research infrastructures worldwide, LEAPS has an enormous impact on the progress of science and technology. Through their strong links with universities, LEAPS facilities also provide training for hundreds of students from European universities and beyond.

### Industrial partners and technology

LEAPS offers thousands of high level scientific and technological jobs, with powerful potential for development in all walks of life. It unlocks the potential for innovation of industry, with special impact on SMEs. LEAPS operation, developments and upgrades represent a market size of the order of 1300M€/y for industry as technology provider, a fantastic opportunity for the development of European industry. LEAPS staff has shown its capacity of already creating 15 spin-off companies with direct impact on the society.

### National governments, European Commission

LEAPS research facilities are an essential part of the scientific strategy of National governments via rigorous road-mapping exercises.

LEAPS national funding agencies are supporting the facilities with the vision of serving the whole European Research Area, including those countries without LEAPS member institutions.

LEAPS strategy has been supported from its inception by the European Commission, also through the successful example of the LEAPS-INNOV project. Mainly composed of national facilities, LEAPS also has a fruitful dialogue with ESFRI, in particular within the stakeholder forum framework.

### Research infrastructures

The LEAPS model has been followed by other analytical facilities, and LEAPS has been actively engaged in setting up the extended network ARIE (<https://arie-eu.org/>), bringing together the different types of analytical facility communities. LEAPS also has strong links with CERN and the accelerator community, in particular via the IFAST project <https://ifast-project.eu/home>.

It is vital for LEAPS to open its activities to more research infrastructures, in particular those in ARIE, on a case-by-case basis wherever mutually beneficial.

### Society

LEAPS facilities, are keen to pursue innovative solutions on a large scale, pooling efforts, resources, and investments to generate long-term positive impact, boost European competitiveness and technological sovereignty together with industry, academia, national funding agencies and the European Commission. In all its activities, it commits to Inclusion, Diversity, Equity and Anti-discrimination (<https://leaps-initiative.eu/leaps-idea/>).

**The enormous leveraging potential of this network places LEAPS in a unique position.**



**Fig. 4**  
LEAPS in the European research ecosystem



# 5

## IMPACT ASSESSMENT

The programme proposed here is focused on some of the key elements of LEAPS RI activities, where injection of additional funds in a cooperative way is expected to best pay off in terms of impact increase, according to the well-studied cases of several LEAPS facilities (as in the examples cited below). The programme will include as an integral part a systematic programme-based impact monitoring. The methodologies to be applied will strongly rely on the previous experience present at LEAPS RI in a very pragmatic way as recommended by OECD and ESFRI but will also incorporate new trends such as real time impact assessment.<sup>17</sup>

In deliberating on which measures would be most impactful, various impact assessment have been taken into account as put forward by ESFRI, OECD and others, using different methodologies developed both in Academia and specialized companies with the aim of measuring different impacts on different stakeholders, both qualitatively and quantitatively. LEAPS facilities have since long considered this dimension of their activity addressing it with different initiatives.

Quantitative methods are for example the “Cost-Benefit” analysis by Florio et al.<sup>18</sup> or the ImpactTer method based on multipliers used by the Vertigo Lab company, both involving full monetization of the impacts. A particular way to apply qualitative methods consists in using the concept of pathways, like in the H2020 RI-Paths project or the “pathways to impact” framework developed by Technopolis (<https://www.diamond.ac.uk/Home/News/LatestNews/2021/26-05-21.html>). The activities performed at the RI generate outcomes, which in turn influence the different actors around the RI creating impacts at different timescales. In a complementary way, BETA developed a semi-quantitative method to measure impact on different stakeholders (cite EVARIO).

Beyond scientific production and contribution to the increase of knowledge benefiting society as a whole, a number of other effects have been studied: knowledge transfer to industry and impact on business opportunities; academic publications leading to industrial developments; student internships, leading to increased experience by the trainees and impact in their subsequent careers;<sup>19</sup> outreach events leading to increased awareness and positive perception about science and a stronger societal support for scientific activities altogether.<sup>20</sup>

Impact assessment studies have been performed by several LEAPS members in the past, either linked to a long period of operations for a facility (ex-post) or related to an upgrade project (ex-ante). Some examples are cited here with the aim of illustrating this. Diamond light source performed an impact assessment study in 2021<sup>21</sup>, evaluating the period 2007-20 and with the motivation of the upgrade plans. A global return on investment factor of 1.5 was calculated, which is considered as a conservative lower bound, partly linked to the fact that many impacts take a longer time to materialize than the frame considered in the study at this stage. LEAPS members in Germany perform periodic impact assessment studies as contemplated in the German Pact on Research and Innovation<sup>22</sup>. The approach followed in these studies may be consulted in the ESFRI policy brief on impact assessment of RIs from June 2023<sup>23</sup>. Specific studies in further detailed have been performed for the PETRA III facility at DESY<sup>24</sup>, focusing on the domains deemed more relevant for the PETRA IV project, along with detailed case studies<sup>25,26</sup>. Return on investment was estimated in the range 1.7-3, confirming the conclusions mentioned above for the case of Diamond light source. ALBA has performed as well several impact assessment studies, the latest of them in 2023, which may be found as part of the ALBA II white paper<sup>27</sup>. Return on investment was evaluated to be above 1.9, consistently with the other examples given herein.

<sup>17</sup> Pierre Benoit Joly, Mireille Matt, Douglas K. R. Robinson. Research Impact Assessment: from ex-post to real-time assessment. *Journal for Research and Technology Policy Evaluation*, 2019. hal-02382425

<sup>18</sup> Florio, M. (2019). *Investing in Science: Social Cost-Benefit Analysis of Research Infrastructures*. MIT Press

<sup>19</sup> Florio, M., Giffoni, F., Giunta, A., & Sirtori, E. (2018). Big science, learning, and innovation: evidence from CERN procurement. *Industrial and Corporate Change*, 27(5), 915-936.

<sup>20</sup> Florio, M. (2019). *Investing in Science: Social Cost-Benefit Analysis of Research Infrastructures*. MIT Press

<sup>21</sup> <https://zenodo.org/records/4769840#YK4j-qhKhaQ>

<sup>22</sup> <https://www.gwk-bonn.de/themen/foerderung-von-ausseruniversitaeren-wissenschaftseinrichtungen/pakt-fuer-forschung-und-innovation>

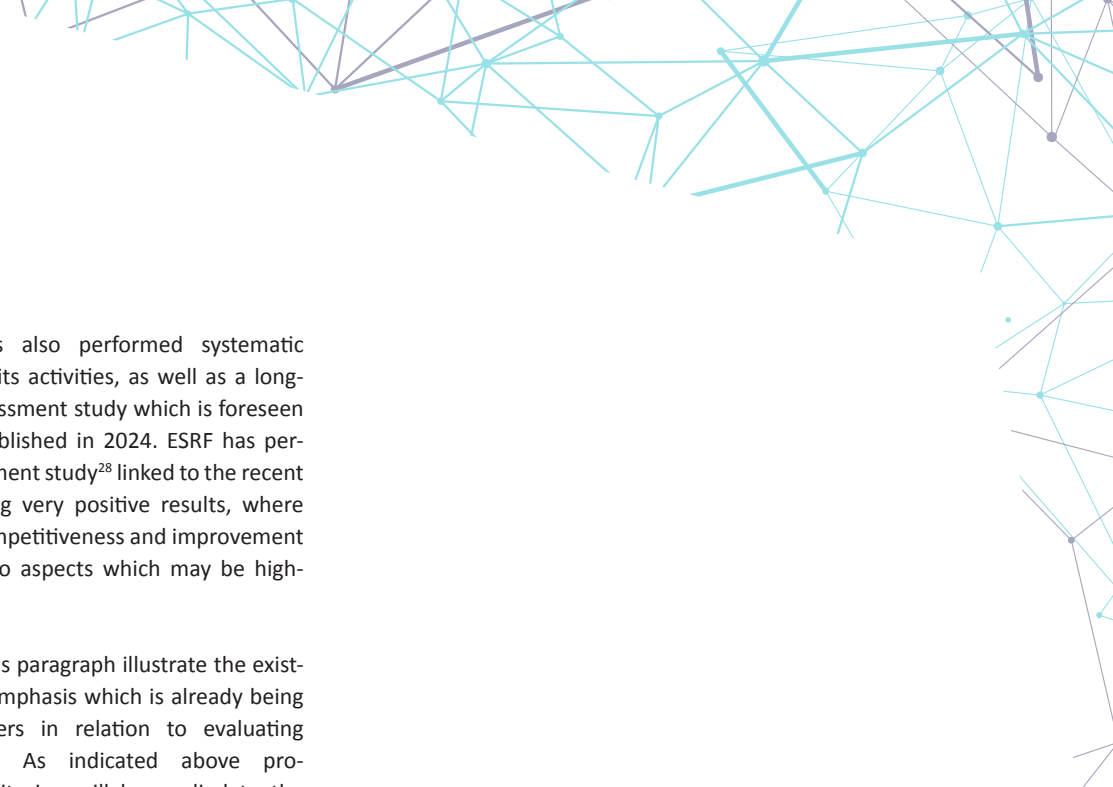
<sup>23</sup> <https://doi.org/10.5281/zenodo.8091632>

<sup>24</sup> <https://www.isi.fraunhofer.de/en/competence-center/innovations-wissensoekonomie/projekte/Impact-DESY.html#3>

<sup>25</sup> Kroll, H. / Hufnagl, M. et al (2020): Pilot Impact Assessment at Photon Science DESY, online: [https://ri-paths.eu/wp-content/uploads/2020/06/T5.2\\_Pilot-IA-project-with-DESY.pdf](https://ri-paths.eu/wp-content/uploads/2020/06/T5.2_Pilot-IA-project-with-DESY.pdf)

<sup>26</sup> Kroll, H., Hansmeier, H., Hufnagl, M.(2022): Productive interactions in basic research an enquiry into impact pathways at the DESY synchrotron, In: *Technology Forecasting and Social Change*, 175, DOI: 10.1016/j.techfore.2021.121408

<sup>27</sup> <https://www.cells.es/en/science-at-alba/alba-ii-upgrade/alba-ii-whitepaper.pdf>



SOLEIL synchrotron has also performed systematic input-output analysis of its activities, as well as a long-term ex-post impact assessment study which is foreseen to be completed and published in 2024. ESRF has performed an impact assessment study<sup>28</sup> linked to the recent EBS upgrade and yielding very positive results, where increasing of industry competitiveness and improvement of human capital are two aspects which may be highlighted.

The examples given in this paragraph illustrate the existing experience and the emphasis which is already being done by LEAPS members in relation to evaluating socio-economic impact. As indicated above program-based impact monitoring will be applied to the Block Grant scheme proposed in this document, based on the very robust and committed starting point where LEAPS stands

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<sup>28</sup> [https://www.esrf.fr/files/live/sites/www/files/about/upgrade/documentation/BROCHURE%20IMPACT%20OF%20ESRF%20AND%20UPGRADE\\_ENGLISH%20VERSION\\_LR.pdf](https://www.esrf.fr/files/live/sites/www/files/about/upgrade/documentation/BROCHURE%20IMPACT%20OF%20ESRF%20AND%20UPGRADE_ENGLISH%20VERSION_LR.pdf)

The background is a dark blue gradient with a network of thin white lines and dots. Some dots are larger and more prominent, while others are smaller. There are also several large, out-of-focus circular bokeh lights in shades of blue and white scattered across the background.

CONCLUSION

The LEAPS initiative plays a pivotal role in ensuring Europe's leadership in the development of critical technologies that are crucial to tackle Europe's challenges in the areas of health, green transformation and the digital revolution.

However, to keep pace with the global advancement in technological development, supported by massive investments in Asia and the US, a novel European funding approach is needed allowing commitment to long-term initiatives to realize joint, road-map based technology developments at the level required to stay competitive and maintain impact in the rapidly changing global landscape.

The LEAPS Block Grant proposal, described in this document, offers an innovative approach to long-term funding, focussing on the realization of joint developments on the following essential main directions:

- **strengthening the technological fundament** of the facilities, with a strong focus on enhancing their sustainability,
- enabling the joint development of a new **access roadmap** to our facilities opening towards new user communities, including enhanced remote-accessibility,

- **harnessing the data generated** by LEAPS facilities, coupled with AI-based tools, increasing the exploitation and accessibility of the data with strong regard of the FAIR principles,
- contributing to **education, European cohesion, and science diplomacy**, including increased focus on widening and developing countries.

LEAPS-AISBL with its proven track-record of collaboration, as exemplified in the LEAPS-INNOV project, and its robust governance structure guarantees the effective execution of the Block Grant approach in a roadmap-based strategic manner and would become a flagship project for a new European funding structure.

With this document, LEAPS-AISBL seeks to engage with the European Commission in a dialogue, aiming to craft this novel Block Grant instrument that catalyses transformative measures for research infrastructures in science and innovation.



# LEAPS and its partners



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## Images

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