CERIC

Central European
Research Infrastructure
Consortium

Report

2023

ERIC established by the European
Commision Implementing Decision
392/2014/EU

Open for Science

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Providing Open Access to Excellent Researchers

CERIC-ERIC is an integrated multidisciplinary research infrastructure for basic and applied research in materials and biomaterials sciences and nanotechnology.
It operates through a Partner Facility in each of its 8 member countries (Austria, Croatia, Czech Republic, Hungary, Italy, Poland, Romania and Slovenia) which contribute through these facilites. CERIC allow open access to the best researchers from all over the world through a single entry point and international evaluation of the proposed research.
The Partner Facilities, which are periodically evaluated by the International Scientific and Technical Advisory Committee (ISTAC), are strongly complementary to each other. They allow the integrated use of analytical and synthesis techniques based on different microscopic probes for nano-level science and technology. Available methods include the use of photons, electrons, ions, neutrons in X-ray spectroscopy, light scattering, ion beam analysis, high-resolution electron microscopy and neutron spectroscopy.

Jana Kolar
CERIC Executive Director

Dear Partners, Colleagues, and Friends,

Reflecting on 2023, I am pleased to present the CERIC Annual Report, which highlights our resilience and strategic growth amid global challenges.

This report highlights the activities and achievements of CERIC, marking nearly a decade since its establishment by a group of Central European Ministers, hosted by their Austrian colleague. Recognising the critical shortage of relevant European research infrastructures in this region, these leaders proposed the creation of CERIC and offered their top facilities as their countries' contributions. This bold and farsighted initiative is bearing fruit. Over the years, CERIC has evolved into a significant European research infrastructure with global reach, becoming highly important for the research communities of its Member Countries.

As we began to recover from the COVID-19 crisis, new challenges emerged. Russian aggression in Ukraine has led to increased energy prices, affecting access time at some facilities. However, the dedication and resourcefulness of the staff have mitigated the severe impacts of this crisis. The minor decrease in the number of user experiments attests to CERIC's resilience during these turbulent times.

I invite you to explore the breadth of CERIC's undertakings and achievements over the past year – from support for user research, advancements in the EC funded and internal research projects, talent development, and integration into the EU ecosystem, to name just a few topics.

I extend my deepest gratitude to our team, collaborators, bodies and stakeholders for their unwavering support and commitment. Your tireless efforts, innovative contributions, and dedication have been instrumental in achieving our goals. Thank you for your continuous support and for being an integral part of CERIC's success.

Dr. Jana Kolar
Executive Director

2023 Key Achievements

Advancing Scientific Discovery

- Open Access attracted 333 proposals from 35 countries and five continents, requesting the use of 470 instruments.
- 109 peer-reviewed articles published.
- 12.2% of CERIC's total scientific output ranked within the top 10% of most cited papers in their respective fields.
- Over 4 million EUR competitively assigned to twenty proposals to strengthen internal research.
- Five of the 19 CERIC-funded PhD completed by mid-2024.

Improving the Quality of Services

- ISTAC's positive evaluation of the Croatian Partner Facility (PF).
- New instruments and labs added to the CERIC open access offer: the Hydrogen Technology Centre at the Czech PF. Two facilities of the EC's JRC and the Bio Open Lab in Italy, which joined CERIC as Associated Facilities.
- Further promotion of the CERIC's techniques via informative videos.
- Development of the CERIC's own Proposal Management System.
- Continuous performance assessment.

Nurturing Talent

- Lifelong learning: 1500 hours of training for the continuous professional development of CERIC staff and managers.
- Staff exchanges with other RIs and professional coaching.
- Contribution to capacity building of staff from other RIs.
- Training of pupils through the PaGES project.
- Promotion of talent circulation within the ERA via the ERA Shuttle project.
- Publication of a position paper on key challenges related to human resources of EU-level public/private research institutions.

Cultivating Innovation and Industry Cooperation

- CERIC's partnership with the European Innovation Council (EIC).
- Ongoing discussions for future partnerships with several industry players.
- 11% of the articles from open access research related to industry.

Other EU Priorities and impact

- Continuous implementation of the recommendations of expert groups in battery and fuel cell research, significantly contributing to supporting the transition to renewable energy.
- Participation in the ERIC Forum 2 Horizon Europe project.
- Three EC-published reports in 2023 showcasing successful strategies for managing and enhancing RIs, cite CERIC and underline its role as a model in the sector.

Policy, Operations and Finance

- Implementation of a new CERIC funding model based on annual contribution fees from its members.
- Advancements in the implementation of CERIC's Data Management Plan through the introduction of the Data Stewardship Wizard platform.
- Financial transparency is showcased in the financial statements of the Consortium for the year 2023.

Executive Summary

In 2023, the Central European Research Infrastructure Consortium (CERIC-ERIC) continued to excel across its strategic areas, encompassing scientific excellence, innovation, industry liaison, and policy development. With respect to open access, the number of proposals received remained stable (Table 1), while the instrument offering continued expanding with the addition of new facilities and techniques.

Headline Indicators	2020	2021	2022	2023	% Change 2023-2022
Proposals received	270	298	343	333	-3
Number of papers	113	109	120	109	-9
Share of papers among 10% top cited		5,1%	9,9%	12,2%	+23,2

Table 1 Headline indicators for 2020-2023 and changes in the last reported year.

Advancing Scientific Discovery

In 2023, CERIC continued to provide access to its research infrastructure (RI) significantly advancing the global scientific landscape. Its calls for open access attracted 333 proposals from 35 countries and five continents, requesting the use of 470 instruments. CERIC continued to facilitate experiments via remote access, underscoring its commitment to inclusivity, sustainability and innovation in research methodologies.
One hundred nine articles have been published in peer-reviewed scientific journals, with twenty of these articles being featured in the first chapter of this report.
Although there was a decline of 9.17% in total publications compared to the previous year, the quality of research, as evidenced by the average Impact Factor, significantly increased by 29.3% to 8.43. Recognising that the Impact Factor alone does not suitably capture scientific excellence, CERIC continued its practice of evaluating the broader impact of its research. This included an analysis of how many of its publications ranked within the top 10% of most cited papers in their respective fields. In 2023, 12.2% of CERIC's total scientific output achieved this distinction, highlighting the substantial influence and relevance of CERIC's research on the global scientific community[1].
A core activity of CERIC is also to promote the integration of its Partner Facilities (PFs) through internal research projects, strategic investments in RIs, and the provision of funding for PhD projects that encourage collaboration across at least two CERIC facilities. These activities also contribute to CERIC's enhanced capabilities and to the pooling of resources across EU countries towards shared objectives.
In 2023, a significant advancement was achieved under the CERIC 2022 Call for Interest for Research Infrastructure Development and Human Resources (HR). Twenty-six proposals were submitted, and twenty were successfully selected by the General Assembly, representing an investment exceeding 4 million euros. This funding underscores CERIC's commitment to fostering substantial growth and innovation within its network.
Furthering its commitment to education and training, CERIC's PhD scholarship programme, initiated in 2020, has enabled 19 PhD candidates to engage in doctoral programmes that bridge thirty institutions across CERIC PFs and associated facilities, universities, and research institutes throughout Italy and Europe. Five of them achieved their doctoral degrees by the time of the release of this report.
Additionally, the internal research project INTEGRA, which is dedicated to enhancing and expanding the life sciences capabilities within CERIC PFs, received continued support and extension in 2023. This project plays a crucial role not only advancing life sciences research but also in ensuring that CERIC's offer remains at the cutting edge of scientific and technological development.

[1]Percentage of publications based on research performed using facilities/resources of the RI that, compared with the publications in the same field and in the same year, belong to the top 10% most frequently cited.

Improving the Quality of Services

In 2023, CERIC continued its commitment to monitoring and enhancing the quality of its infrastructure and services. A routine evaluation of the Croatian PF was conducted to ensure compliance with the highest standards and further improve it.
Also, the Consortium kept expanding its open access offer with new instruments and laboratories to better serve the scientific community. In this respect, two facilities of the Joint Research Centre of the European Commission and the Bio Open Lab in Italy joined CERIC as Associated Facilities, while the Czech PF was enhanced by the inclusion of the Hydrogen Technology Centre.
To facilitate researchers' engagement, CERIC continued to produce informative videos. These feature interviews with instrument scientists who explain the available techniques, their functions, and uses, and address frequently asked questions. This initiative aims to provide clearer insights to potential applicants about the practical aspects of CERIC's offer.
In the IT domain, CERIC has initiated the development of its own Proposal Management System. This system is being designed to streamline experiment administration, enhancing efficiency and user experience across CERIC's operations.
CERIC continuously strives to improve its operational effectiveness and service quality. This is achieved through regular performance evaluations, guided by the key performance indicators (KPIs) established by the ESFRI working group on Monitoring of RIs' Performance. Such assessments are crucial not only for internal management but also for demonstrating CERIC's value to external stakeholders, including funders, policymakers, and the broader research community. In line with this, an internal impact assessment was initiated in 2023, the results of which will be published in 2024, underscoring CERIC's ongoing commitment to excellence and accountability in its operations.

Nurturing Talent

CERIC is committed to the training and professional development of its staff and managers, adopting a philosophy of lifelong learning that permeates its organizational culture. In 2023, the CERIC central team dedicated over 1,500 hours to training sessions aimed at enhancing a broad spectrum of skills.
HR development has also been promoted through staff exchanges with other RIs and professional coaching to refine the management team's leadership abilities.
Additionally, CERIC staff contributed to the capacity building of staff from other RIs, with training modules in the frame of a master programme of the University Milano Bicocca addressing specifically RI managers.
This engagement underscores CERIC's important role in shaping management practices within the community.
In 2023, the eighth edition of the PaGES project, supported by funding from the Friuli Venezia Giulia regional authority, engaged four scientific high schools and 78 students, enhancing their understanding of scientific processes and the various synchrotron techniques available at CERIC.
Through its partnership in the ERA Shuttle HE project, CERIC has been instrumental in coordinating joint training efforts for scientific and technical personnel, as well as young researchers. This collaboration is part of a broader strategy to promote talent circulation within the European Research Area (ERA).
Additionally, a position paper was developed following a conference co-organised by CERIC in Rome in December 2023, involving the Italian ERIC Forum. The conference, titled "Work at Public/Private Research Institutions," aimed to address and identify the key challenges these institutions encounter in attracting, retaining and managing HR at the European level. This event provided valuable insights into HR management within the scientific sector, contributing to policy development and strategic planning in HR across Europe.

Cultivating Innovation and Industry Cooperation

In 2023, CERIC's partnership with the European Innovation Council (EIC) marked a significant step towards enhancing its service offer to a targeted community that includes entrepreneurial researchers, start-ups, and high-tech small and medium-sized enterprises (SMEs). This collaboration has allowed CERIC to more effectively showcase its capabilities and resources, tailored to the needs of these dynamic sectors. By aligning its advanced technological services and research opportunities with the ambitions of innovators and industry pioneers, CERIC is strategically positioned to contribute more significantly to the development of cutting-edge, disruptive technologies.
Additionally, CERIC deepened its collaborative ties by engaging in substantive discussions for future partnerships with several industry players. These interactions underscore CERIC's commitment to fostering long-term relationships that can lead to significant deep-tech advancements across various sectors.
On the publication front, 5% of the research carried out in 2023 through CERIC's open access demonstrated an industrial interest, reflecting the Consortium's effective bridging of scientific research and practical application in industry settings.

Other EU priorities and impact

CERIC is committed to aligning its operations with the European Union's policy objectives, including the twin transition to a green and digital Europe, strengthening the European Research Area (ERA), and bridging the research and innovation gap across member states. These objectives are crucial for ensuring that CERIC's contributions have a broad and impactful reach within the EU's strategic framework.
Since 2020, CERIC has made strategic use of its resources and capabilities to establish itself as a premier research infrastructure (RI) for cutting-edge energy research. The Consortium has actively implemented the recommendations of expert groups in battery and fuel cell research, significantly contributing to supporting the transition to renewable energy. This includes offering specialized access for research in these fields and expanding the use of advanced analytical techniques. These efforts are designed to support a wide range of experiments, specifically those focused on developing next-generation battery technologies, fuel cells and electrolysers.
The Second Implementation Project for the ERIC Forum commenced in September 2023. As the leader of the work package titled "Strategy on European Employment Contract", CERIC is playing a crucial role in improving and implementing the ERIC Regulation.
The EU-wide relevance of CERIC was demonstrated by references to it in three EC-published reports in 2023, showcasing successful strategies for managing and enhancing RIs, and underlining CERIC's role as a model in the sector.

Policy, Operations and Finance

In 2023, CERIC's statutes underwent significant modifications after thorough discussions and subsequent approval by the General Assembly. These changes laid the groundwork for collecting annual contribution fees from its members, ensuring a more resilient financial framework for the consortium.
With respect to user access operations, CERIC made notable advancements by implementing its Data Management Plan (DMP), through the introduction of the Data Stewardship Wizard platform, which serves as a central tool for collecting the DMP filled in by the PIs during the proposal submission process. More actions are planned to develop harmonised data operations and meticulously document aspects related to data handling, archiving procedures, dataset construction, and storage methodologies.
The final section of this report provides a comprehensive overview of the financial and economic status of the Consortium for the year 2023. This overview is presented in accordance with the International Public Sector Accounting Standards (IPSAS) under the accrual basis of accounting. This financial reporting ensures transparency and provides a clear picture of CERIC's financial health to stakeholders and members alike.

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Advancing Scientific Discovery

The objectives of CERIC, as described in the Statutes, are to:

- Contribute to European top-level research and technological development and demonstration programs and projects, thus representing an added value for the development of the European Research Area (ERA) and its innovation potential while stimulating a beneficial impact on the scientific, industrial and economic development.'
- To further the integration of national Facilities operating mainly in the Central European Area, into a unique, EU-level Distributed Research Infrastructure, open to researchers at world level;
- To make optimum use of resources and know-how by coordinating research and development of relevant technologies, by promoting and coordinating joint training of scientific and technical personnel and young researchers, and by collaborating with neighbouring communities and industry.

Main Achievements

1. **Implementation of 2 calls for free open access to which 333 proposals requesting the use of 470 instruments, were received.**
2. **Submitted proposals from 35 countries and all continents**
3. **Continuous fast-track access for feasibility studies, and possibility to perform experiments via remote access**
4. **Positive evaluation of the progress of CERIC internal transnational research projects**
5. **Positive evaluation of the Croatian PF by the international team of experts led by CERIC's ISTAC**
6. **7 new techniques added to the open access offer**
7. **Participation in externally funded projects: IMPRESS, ReMade@ARI, INTEGRA, OPVStability**

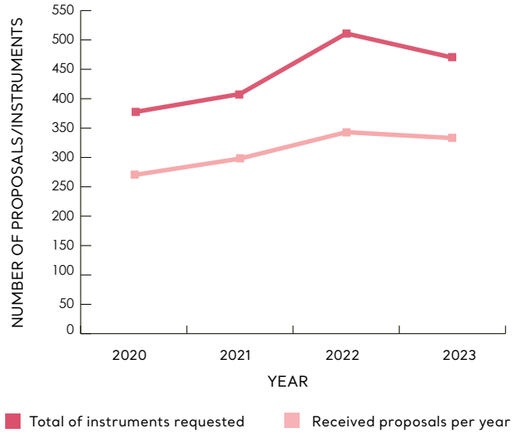
Open Access

CERIC's main aim is to enable excellent science, both as an in-house activity and as a service to international users. This is achieved mainly by providing merit-based open access to its research facilities and promoting internal research.

In 2023, CERIC launched two calls for proposals to use the Consortium's research instruments: 333 proposals were received (Figure 1). Given their multi-technique character, this corresponds to 470 single-instrument proposals. The number of received applications slightly decreased (-2,9 %) when compared to the previous year.

181 proposals, equivalent to 230 single-instrument proposals, were selected (Figure 2) for the use of the over 60 techniques available in the CERIC open access offer, to perform experiments for a total of 22693 hours. In addition to physical access to the CERIC facilities, all facilities continued to offer the possibility of performing measurements remotely through sample mailing. In 2023, 18% of experiments were conducted in this modality.

Figure 1
Number of proposals and requested methods



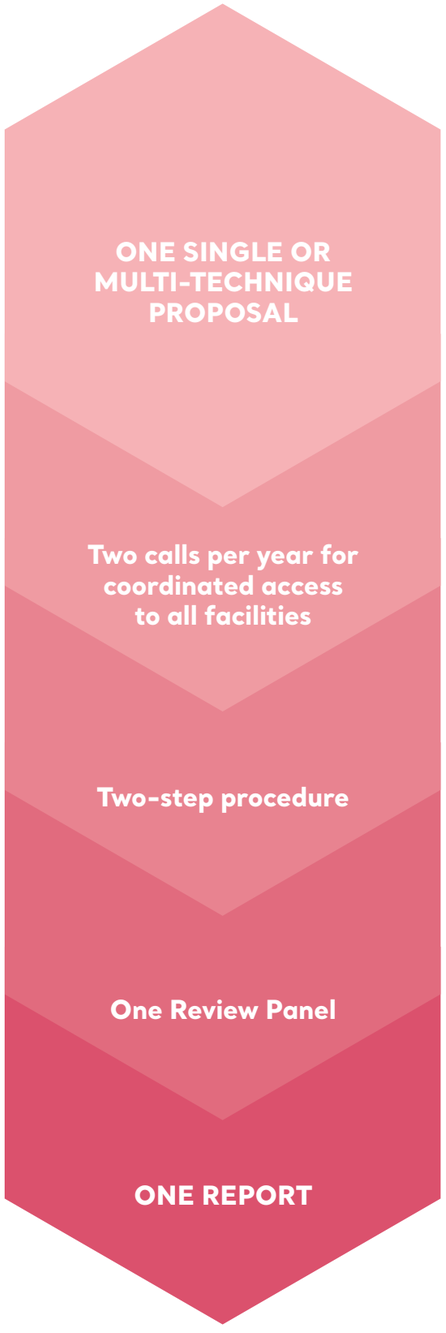
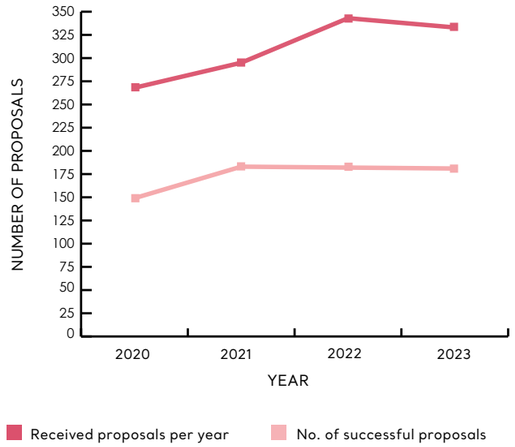
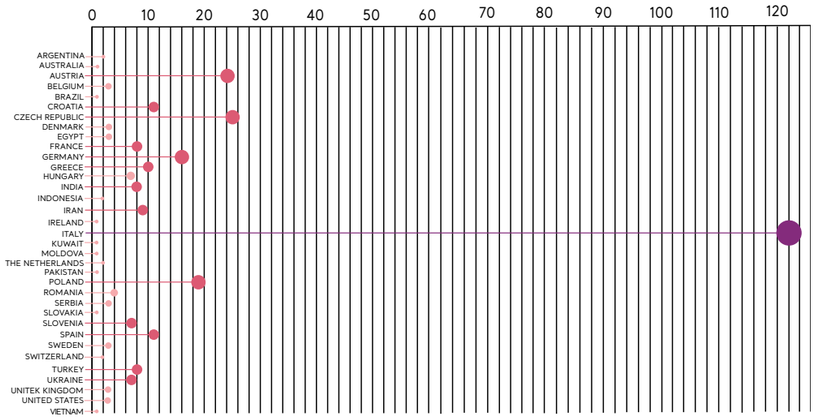


Figure 2
Number of received and successful proposals per year

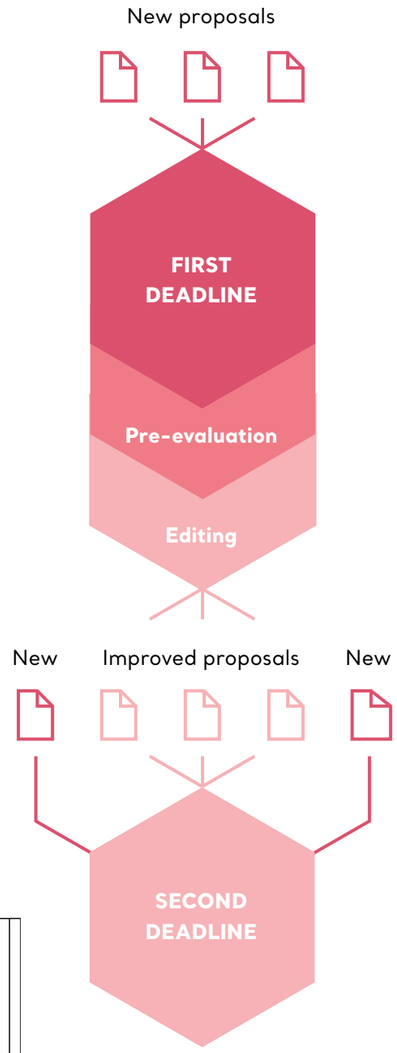


CERIC remains a highly internationalised research infrastructure, with principal investigators from all continents in 2023 (Figure 3). Proposals came from 35 countries, of which 49% are non-EU countries.

Figure 3
No. of proposals by country

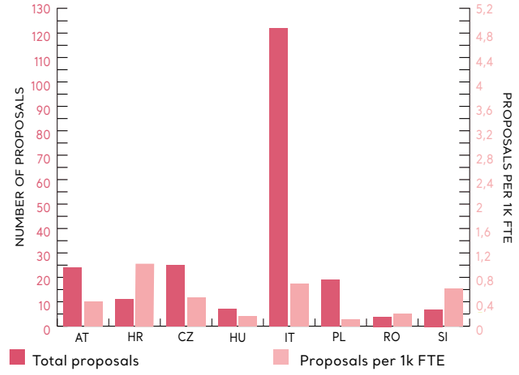


- **2 calls for proposals**
- **333 proposals received**
- **Research groups from 35 countries**
- **230 allocated requests**



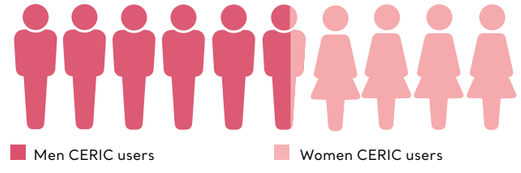
The majority (66%) of submitted proposals in 2023 came from CERIC Member Countries, as in the previous year. The most active researchers, in relation to the fulltime employees in Research & Development in a country, are from Croatia, followed by Italy and Czech Republic (Figure 4).

Figure 4
Submited proposals per 1K full-time employees (FTE) in R&D in Member Countries



In 2023, 40% of the principal investigators (proposers) and 43% of the researchers who performed the measurements at the facilities were women (Figure 5).

Figure 5
Gender distribution of CERIC users



Quantity and quality of the output

In 2023, the total number of publications issued from data gathered at CERIC's facilities experienced a minor decrease (-9%) compared to the preceding year. Contrastingly, there was an improvement in average Impact Factor (IF), which rose by 29.30%, compared to 2022, with a value of 8.43. However, it is important to note that IF is not an ideal indicator of output quality. Thus, also in 2023, CERIC collected data on the most cited publications, expressed as the share of CERIC's papers among the top 10% (figure 6) and top 20% most frequently cited ones. In the last two years, this indicator (which was lower in 2020 and 2021, likely due to the effects of the pandemic) returned to optimal levels, with ~12% of papers in the top 10% of most cited studies in the related fields.

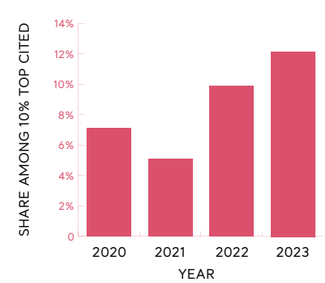


Figure 6
Share of publications, based on the research performed using facilities/resources of RIs, in top 10% most cited papers among a comparable field in the latest 4 years. All the publications tied at the threshold of top10% are taken in consideration.

International Scientific and Technical Advisory Committee - ISTAC

The primary role of the ISTAC within CERIC is to offer guidance to the General Assembly (GA) regarding scientific and technological matters that significantly influence the optimal use of CERIC as a cutting-edge research infrastructure. Specifically, ISTAC assesses proposals for potential new partner facilities and oversees the functioning of existing ones, making recommendations to the GA concerning acceptability and continuation in CERIC's open access service. The periodic evaluation of the Croatian Partner Facility (PF) was held in May 2023 (read more on page 44), with a site visit by the members of the ISTAC at the Ruđer Bošković Institute in Zagreb.

Fast Track Access

Fast Track Access stayed open throughout the whole year 2023, allowing access to a set of relevant instruments for research and testing to be scheduled within one month from the submission of the proposal, based on an evaluation performed by the PF. During the year, 21 proposals were received for this access mode. A wide number of techniques at the Austrian, Czech, Italian, and Slovenian PFs have been devoted to the purpose.

New instruments available via open access

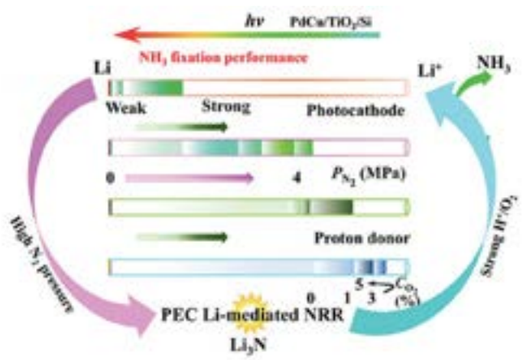
In 2023, new instruments and techniques have been added to the CERIC open access offer, through both the new CERIC associated facilities and the Czech PF. Such instruments include the following: HoloTEM at the University of Salento, Mass Spectrometry at the Universities of Salerno and Salento, LAGE at AREA Science Park, three laboratories (Nanobiotechology Laboratory, Fuel Cell and Electrolyser Testing, Battery Energy Storage Testing Laboratory) at the Joint Research Centre (JRC) in Ispra (Italy) and Petten (the Netherlands), and the Hydrogen Technology Centre as part of the CERIC Czech partner facility.

Scientific Highlights

Characterising a cleaner way to produce ammonia[1]

Ammonia (NH_3), a widely used chemical, is also a critical substance in the production of nitrogenous fertilizers. It is estimated that the current Haber-Bosch synthesis of ammonia is responsible for about 2% of the world's energy consumption and 1.8% of total global CO_2 emissions. Scientists are therefore looking for new solutions to overcome the energy and environmental challenges. Photoelectrochemical nitrogen reduction reaction (PEC NRR) is an alternative route to synthesize ammonia in a solar-powered, green and sustainable way.

A promising strategy is electrochemical Lithium (Li)-mediated NRR, a process that could reduce the amount of external energy required. However, this process is poorly studied and there is no fundamental understanding of its catalytic mechanism, making its improvement challenging. **Xiaoran Zhang** (Hunan University, China), **Nataliya Tsud** (Charles University, Prague, Czech Republic) and colleagues have shown that the Li-mediated PEC NRR by using silicon (Si)-based hierarchically structured $PdCu/TiO_2$ photocathodes in a lithium perchlorate-propylene carbonate solution can achieve a high NH_3 yield rate and excellent faradaic efficiency.



Lithium perchlorate was used as the electrolyte component due to its high stability, safety, and free labile N-containing group. PEC measurements reveal that the chosen photocathode under N_2 pressure facilitates the formation of lithium nitride (Li3N), which reacts with the active protons to produce NH3 while releasing the Li+ to restart the NRR cycle. The process can be further enhanced by introducing small amounts of O_2 or CO_2 under pressure.
In addition, the researchers used field emission scanning electron microscopy (FESEM) to reveal the morphology of the Si-based photocathode, and performed synchrotron radiation X-ray photoelectron spectroscopy at the Materials Science Beamline (MSB), Czech beamline at Elettra Sincrotrone Trieste, to study changes in the chemical state and electron structure of the photocathode surface in the dark and under illumination.
For the first time, through comprehensive operando characterization, the research group obtained a detailed description of the Li-mediated PEC NRR process using a Si-based photocathode, providing a novel approach for fast, cost-effective, and efficient green conversion of N2 to NH3. This work provides a new and systematic strategy for the rational design and development of Li-mediated PEC NRR systems for NH3 synthesis.

"Using state-of-the-art analytical techniques, we have been able to describe in detail a novel, more ecological way to synthesise ammonia, a worldwide used chemical".

Figure 7
Schematic representation of the completely enhanced mechanism of Li-mediated PEC NRR system by optimizing the process of Li cycle [from Advanced Materials, Volume: 35, Issue: 21, First published: 11 March 2023, DOI: 10.1002/adma.202211894]

[1] *Photoelectrochemical N2-to-NH3 Fixation with High Efficiency and Rates via Optimized Si-Based System at Positive Potential versus $Li^{0/+}$* Zhang X., Lyu Y., Zhou H., Zheng J., Huang A., Ding J., Xie C., De Marco R., Tsud N., Kalinovych V., Jiang S.P., Dai L., Wang S., Advanced Materials, 2023, DOI: https://doi.org/10.1002/adma.202211894

A new tool to predict RNA/DNA duplexes stability in cells[2]

RNA/DNA hybrid duplexes formation is a crucial step of important biological processes, such as the initiation of replication, transcription elongation, and reverse transcription, and it is used as base for genetic therapy approaches, such as CRISPR-Cas9 and ASO gene silencing. However, if the stability of hybrid duplexes has been fully studied in vitro, these findings can hardly be applied to living cells, characterized by a heterogeneous distribution of biomolecules and cellular organelles that causes molecular crowding.

Dipanwita Banerjee (FIBER-Frontier Institute for Biomolecular Engineering Research –Konan University, Japan), **Maria Toplishek** (National Institute of Chemistry – Ljubljana, Slovenia) and colleagues studied the effects of these conditions on the thermodynamics and structures of the RNA/DNA hybrid duplexes, adding synthetic cosolutes and analysing the solution with thermodynamic and Nuclear magnetic resonance (NMR) structural techniques available at the Slovenian CERIC PF in Ljubljana. Researchers then found that duplex stability is reduced under crowding conditions, and that this reduction varied significantly depending on the conformation of the hybrid duplex. They could then develop a set of parameters that predict the stability of hybrid duplexes with conformational dissimilarities under diverse crowding conditions in living cells.

"The prediction parameters for hybrid duplex stability can estimate efficiency of transcriptional inhibition, gene editing, and silencing techniques in cells, helping to develop new treatments for lethal diseases".

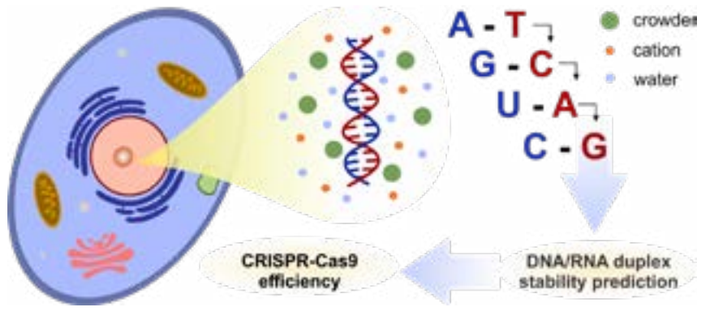


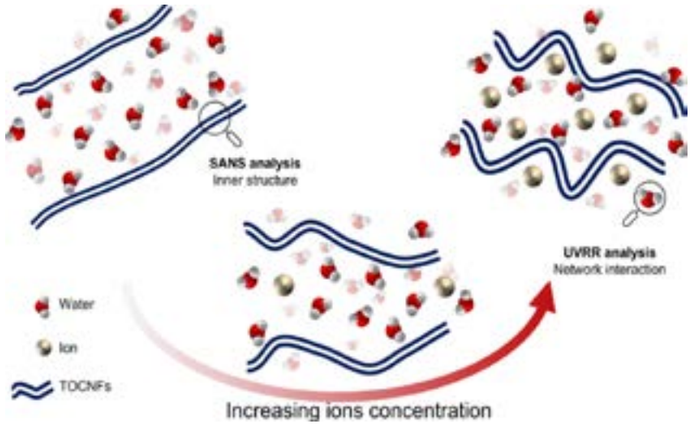
Figure 8
Studying the effects of molecular crowding on RNA/DNA duplexes allows to predict their stability in living cells, and to estimate genetic therapy approaches efficiency.

These results allow to apply the predicted duplex stability to explain the biological processes in a living cell, and they could permit to successfully estimate the efficiency of the CRISPR-Cas9 and ASO techniques, helping to develop novel drug design methods and enhancing therapeutic options for cancer, neurological disorders and other diseases linked to RNA/DNA duplexes stability.

[2] *In-Cell Stability Prediction of RNA/DNA Hybrid Duplexes for Designing Oligonucleotides Aimed at Therapeutics*, Banerjee D., Tateishi-Karimata H., Toplishek M., Ohyama T., Ghosh S., Takahashi S., Trajkovski M., Plavec J., Sugimoto N., . Am. Chem. Soc. 2023, 145, 43, 23503–23518, DOI, https://doi.org/10.1021/jacs.3c06706

A multi-technique analysis to study the structure of cellulose nanofibrils-based hydrogels[3]

Hydrogels are solid–liquid systems formed by a variety of water-soluble polymers, which in the latest years gained an increasing importance in the development of biomedical applications, due to their high biocompatibility and ease of modulation. Among the polymers that can be used to design hydrogels, cellulose - especially in the form of nanofibrils (CNFs) - is particularly suitable for the production of biocompatible products.



Andrea Fiorati

Figure 9
Insight into structure modifications of TOCNF hydrogels in a multi-technique and multi-scale study.
Reprinted with permission under Creative Commons Attribution 4.0 International License from Rossetti, A., Paciaroni, A., Rossi, B. et al. TEMPO-oxidized cellulose nanofibril/polyvalent cations hydrogels: a multifaceted view of network interactions and inner structure. Cellulose 30, 2023

To produce nanofibrils, cellulose often undergoes to a process of oxidation catalysed by TEMPO (2,2,6,6-tetramethylpiperidine 1-oxyl). But how do these nanofibrils, and the derived hydrogels, behave in the cellular environment?

To understand it, **Arianna Rossetti**, **Andrea Fiorati** (Politecnico di Milano) and colleagues investigated their inner structure as a function of both nanofibrils and ions (Ca^{2+} and Mg^{2+}) concentration, at three different pH values. Analyses were conducted using a combination of small-angle neutron scattering (SANS) and UV Resonant Raman scattering techniques, available respectively at the Hungarian and Italian CERIC PFs.

These two complementary techniques allowed researchers to perform a comprehensive structural analysis of TEMPO-oxidized cellulose nanofibrils hydrogels at a nano and molecular scale, in different conditions: this step crucial to understand how these systems interact when they are immersed in a cellular environment, paving the way for the future development of biomedical applications.

Arianna Rossetti

"Our research, which elucidates the behaviour of hydrogels at nano and molecular levels, offers crucial insights for further understanding the intricate interactions between these systems and proteins or other macromolecules".

[3] *TEMPO-oxidized cellulose nanofibril/polyvalent cations hydrogels: a multifaceted view of network interactions and inner structure,* Rossetti A., Paciaroni A., Rossi B., Bottari C., Comez L., Corezzi S., Melone L., Almásy L., Punta C., Fiorati A., Cellulose, 2023
DOI: https://doi.org/10.1007/s10570-023-05058-2

New insights on the formation of secondary nucleic acid structures adopted by cytosine-rich DNA[4]

i-Motifs (iMs) are tetra-helical secondary structures, generated by the folding of DNA sequences containing at least four runs of repetitive cytosines, that could have important therapeutical applications (due to their activity as gene promoters and oncogene regulators) and support technologically innovative approaches (such as bio-sensing and drug delivery). However, until recent days there was a poor understanding of which were the conditions needed for DNA sequences to fold, and there wasn't any algorithm able to predict iM folding from the primary nucleotide sequence.

Claudia Sissi

Then, **Michele Ghezzo** and **Claudia Sissi** (University of Padua), together with **Marko Trajkovski** and **Janez Plavec** (Slovenian NMR Centre, National Institute of Chemistry), developed a novel pipeline for the systematic screening of iM-forming model sequences, in order to provide a description of this process at the molecular level and understand what is the minimal length of the loops required for formation of an intra-molecular iM. At each step of this protocol, the folding of the selected sequence into a 3 CC+ base-paired intra-molecular iM was assessed by nuclear magnetic resonance spectroscopy (600 and 800 MHz NMR spectrometers, available at the Slovenian CERIC PF at the National Institute of Chemistry in Ljubljana), and other techniques.

Marko Trajkovski

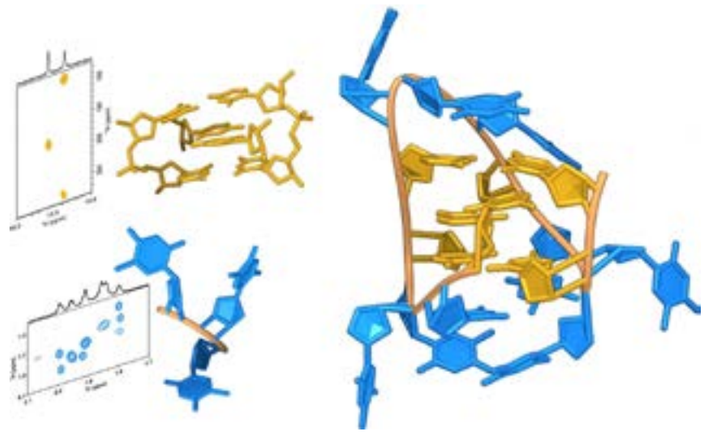


Figure 10
15N- and 13C-edited NMR spectra (left) as the crucial subsets of the spectroscopic data used for characterization of DNA i-motif structures (right) exhibiting core and loops comprised of cytosine (gold) and thymine (blue) residues, respectively.

Scientists discovered that two and three nucleotides are required to connect the strands through the minor and major grooves of the iM, respectively, and that there is an asymmetric behavior according to the distribution of the cytosines. Hopefully, these results could be helpful to develop prediction tools for the identification of biologically functional iMs, and to create technologically innovative devices based on these secondary structures.

"The integration of the different expertise of two research groups made possible to see a very small *knot* on DNA and to understand how it form. This knowledge will help to create new technological devices and drugs".

[4] *A Screening Protocol for Exploring Loop Length Requirements for the Formation of a Three Cytosine-Cytosine+ Base-Paired i-Motif,* Ghezzo M., Trajkovski M., Plavec J., Sissi C., Angew. Chem. Int. Ed., 2023, DOI: https://doi.org/10.1002/anie.202309327

Switch on, switch off: modulating magnetic properties of nanolayers[5]


Michał Slezak

Magnetic anisotropy, which is the directional dependence of the magnetic properties of a certain material, is a key parameter in the development of nanoscale applications, since it determines the long-range magnetic order in thin films and nanostructures. But is it possible to actively modify it?

Exchange bias (or exchange anisotropy) is a phenomenon that is observed in multilayered magnetic materials, where the magnetically “hard” antiferromagnetic thin film causes a shift in the magnetization curve of a ferromagnetic layer.

Michał Slezak and colleagues of the AGH University of Krakow exploit this effect to mediate the interaction between ferromagnetic and antiferromagnetic sublayers (respectively, iron and cobalt monoxide), inserting between them a nonmagnetic gold spacer. Using X-ray absorption spectroscopy instruments available at the PIRX beamline of the CERIC Polish PF, at the National Synchrotron Radiation Centre SOLARIS, scientists were able to observe how magnetic anisotropy could be precisely tuned, stabilising a variety of magnetic moments orientations in both ferromagnetic and antiferromagnetic sublayers. Moreover, they observed that reorientations between particular magnetic configurations can also be triggered either by changing the iron or gold thickness, or temperature.

"We show that the interaction between ferromagnetic and antiferromagnetic sublayers can be mediated and precisely tuned by a nonmagnetic spacer. Further advancements in this field and potential applications in magnetic recording techniques can impact modern spintronics."

These findings will be crucial in the development of future materials and “nano-applications”, as they demonstrate how certain magnetic properties can be modified.

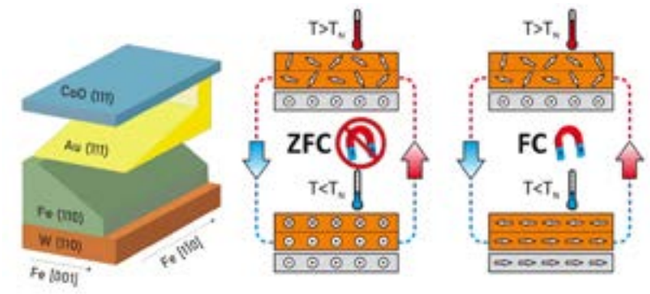


Figure 11
Interaction between ferromagnetic Fe(110) and antiferromagnetic CoO(111) sublayers can be mediated and precisely tuned by a nonmagnetic Au spacer. The choice of particular magnetic state of Fe sublayer, as the system is passing Neel temperature of CoO (~290 K), determines both the axis and direction of interfacial antiferromagnetic spins after the sample is cooled and allows for imprinting their ±90° and 0/180° alignment within the sample plane.

[5]*Tunable interplay between exchange coupling and uniaxial magnetic anisotropy in epitaxial CoO/Au/Fe trilayers,* Nayyef H., Świerkosz E., Janus W., Klimeczek A., Szpytma M., Zając M., Dróżdż P., Kozioł-Rachwał A., Ślęzak T., Ślęzak M., Scientific reports, 2023, DOI: https://doi.org/10.1038/s41598-023-38098-6

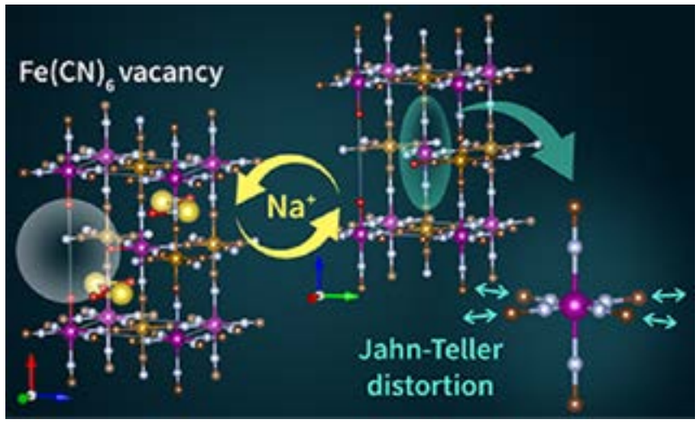
Na-ion batteries: understanding molecular structure to explain performance[6]


Min Li


Marco Giorgetti

Metal hexacyanoferrates, such as the ones realized with manganese (MnHCF), are promising positive electrode materials for organic rechargeable batteries, including Na-ion ones, because of their large specific capacity, high discharge potential and sustainability.
When developing these new devices, however, it is important to understand in detail the influence that various factors can have on the molecular structure of the used materials, and thus on performance.

Min Li, **Mariam Maisuradze**, **Marco Giorgetti** and colleagues of the University of Bologna synthesized two MnHCF materials with the same phase, similar particle size, but different [Fe(CN)6]4− vacancy content (respectively 4 % and 11 %), and tested them as cathode material in organic Na-ion battery. They first demonstrated that the material with the lower vacancies exhibits higher capacity retention (71.1 % vs. 39.4 %) after 100 cycles. Moreover, applying X-ray absorption spectroscopy (XAS) and ex situ X-ray diffraction (XRD) testing, both available at the CERIC Italian PF at Elettra Sincrotrone Trieste, researchers analysed the samples structures: they discovered that both samples displayed a cooperative Jahn-Teller-distortion effect (which reduces symmetry and energy in such systems), but also that the sample with the lower vacancies shows a more stable structural change and weaker distortion effect on the Mn sites during the cycling.



"In a set of experiments, we evidenced the interplay between the local structure and the extended structure of a Na-ion battery material".

Figure 12
A weaker cooperative JT-distortion and relatively smaller crystal structure modification occurs for the sample with lower Fe(CN)6]4− vacancies, which explains the better electrochemical perfor-mance in cycled electrodes.

Scientists could then explain the better electrochemical performance of the electrode realized with the material with lower vacancy, because the weak Jahn-Teller -distortion effect results in a stable crystal structure during Na+ release and insertion. These findings could lead, in the future, to the development of more stable and performing Na-ion batteries.

[6]*Influence of Vacancies in Manganese Hexacyanoferrate Cathode for Organic Na-ion Batteries: A Structural Perspective,* Li M., Gaboardi M., Mullaliu A., Maisuradze M., Xue X., Aquilanti G., Plaisier J.R., Passerini S., Giorgetti M., ChemSusChem, 2023, DOI: https://doi.org/10.1002/cssc.202300201

Control shape and properties of gold nanoparticles[8]

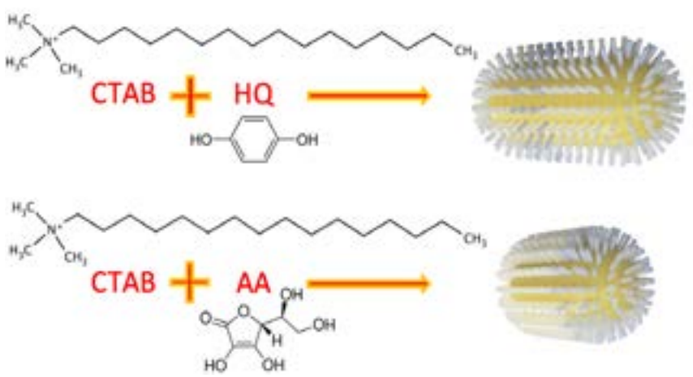
Due to their maximized surface-to-volume ratio, noble metal non-spherical nanoparticles, such as gold nanorods, have physicochemical properties that make them suitable for application in the field of therapeutic and imaging. Every ingredient/parameter used in the synthesis procedure of these nanomaterials plays a critical role in determining their shape, and consequently their chemical and physical properties. It is then fundamental to understand this process in detail.

Chiara Battocchio

In this context, **Chiara Battocchio**, **Simone Amatori** (Università Roma Tre) and colleagues investigated the molecular, electronic and chemical structure of gold nanorods which were stabilized by binary ligand mixtures of cetyltrimethylammonium bromide (CTAB, primary ligand) and ascorbic acid (AA) or hydroquinone (HQ) (secondary ligands). To do so, they combined microscopy studies as Scanning Electron Microscopy (SEM, available at the CERIC Czech PF Charles University in Prague), with a series of complementary analyses, performed with several instruments and techniques, including X-ray photoelectron spectroscopy, (available at the CERIC Italian PF at Elettra Sincrotrone Trieste, on the beamlines SupeESCA), and X-ray absorption spectroscopy (available at beamline XAFS at Elettra and at the LISA beamline of CNR at ESRF, CERIC associated facility).

Simone Amatori

Scientists could then demonstrate that nanorods stabilized by different secondary ligands differ in the plasmon band position, morphology and aspect ratio, due to the influence of the different secondary ligands on the anisotropic growth process.



"We demonstrated how factors used in the synthesis of nanomaterials, such as ingredients and parameters, influence their shape and size, and consequently their chemical and physical properties".

Figure 13
Schematic representation of the influence of the secondary surfactant (HQ = hydroquinone or AA = ascorbic acid) on the shape and size of gold nanorods

The possibility to finely control the shape and dimension of nanorods by selecting the secondary ligands opens new perspectives in the design and synthesis of these important class of nanoparticles, and in their application in novel diagnostic and therapeutical approaches.

[8] *Gold nanorods derivatized with CTAB and hydroquinone or ascorbic acid: spectroscopic investigation of anisotropic nanoparticles of different shapes and sizes,* Amatori S., Lopez A., Meneghini C., Calcabrini A., Colone M., Stringaro A., Migani S., Khalakhan I., Iucci G., Venditti I., Battocchio C., Nanoscale Advances, 2023, 5, 3924-3933, , DOI: https://doi.org/10.1039/D3NA00356F

Different conditions, different composition: investigation on a bimetallic alloy surface[9]

Besides being cheaper, platinum alloys with 3d transition metals show superior activities in many catalytic reactions when compared to pure platinum, due to their modified electronic structure. However, as complex multi-component systems, bimetallic catalysts suffer from surface structural reorganization under operating conditions (such as gas pressure, temperature and the nature of reaction), that may affect their performance.

Ivan Khalakhan

In this framework, **Ivan Khalakhan** and colleagues of the Nanomaterials group (Charles University of Prague) have performed a combined in situ electrochemical and spectroscopic study of surface structural changes in platinum-nickel catalyst during altering oxidation and reduction cycles, carried out at different conditions: electrified liquid and gaseous environments. To monitor possible restructuring of the alloy surface, scientists used cyclic voltammetry and Near Ambient Pressure X-ray Photoelectron Spectroscopy (NAP-XPS) available at the Czech CERIC PF at the Charles University in Prague.

"We used a combination of powerful *in situ* techniques for accurate analysis of PtNi alloy catalyst surface compositional changes under conditions simulating their operational environment".

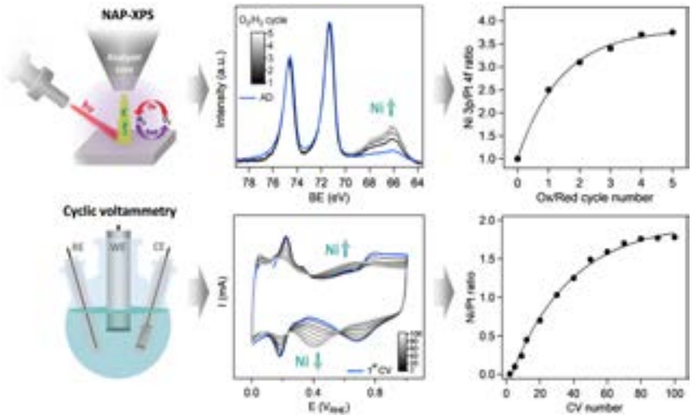


Figure 14
Irreversible changes in PtNi surface composition as a result of a series of oxidation and reduc-tion, cycles monitored in a gaseous environment via NAP-XPS (upper row) and an electrified liquid environment using cycling voltammetry (bottom row).

Scientists discovered that, regardless of the operational environment, the platinum-nickel bimetallic alloy undergoes a significant change in its compositional profile as a result of altering oxidation and reduction cycles. Specifically, this change is manifested in nickel enrichment, that may lead to catalyst deactivation. These finding can have an impact on the development of active and stable catalysts for many reactions by its compositional engineering.

[9] *Surface compositional dynamics in a PtNi bimetallic alloy under simulated operational conditions: Electrochemical and NAP-XPS Study,* Xie X., Mohandas Sandhya A. L., Piliai L., Vorokhta M., Matolínová I., Khalakhan I., Applied Catalysis B: Environmental, 2023, DOI: https://doi.org/10.1016/j.apcatb.2022.122328

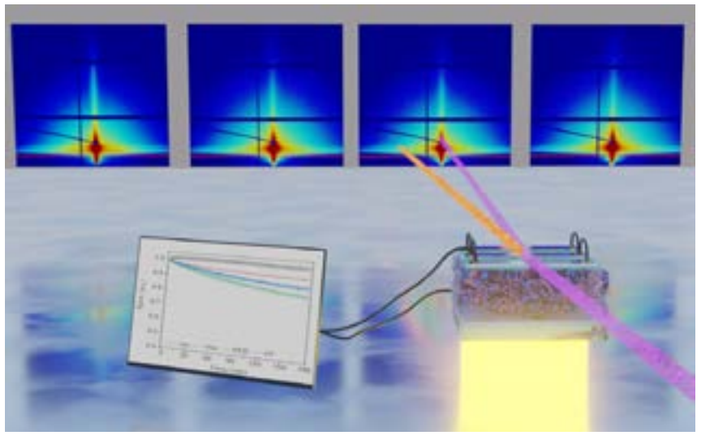
Understanding organic solar cells degradation process[9]

Due to their light weight, low cost and easy processability, organic solar cells (OSCs) are among the most promising photovoltaic technologies in terms of performance and possible application. However, their poor stability, especially attribute to intrinsic degradation processes, remains a significant limitation factor for their usage.


Xinyu Jiang


Peter Müller-Busschbaum

To address this, **Xinyu Jiang**, **Peter Müller-Buschbaum** and colleagues of the Technical University of Munich conducted a series of operando experiments at the Small Angle X-ray Scattering (SAXS) beamline at the CERIC Austrian PF located at Elettra Sincrotrone Trieste. The focus was on analyzing the temporal evolution of the morphology of different OSCs active layers, which contain four different acceptors blended with a conjugated polymer donor that differ in the degree of π–π stacking (attractive, noncovalent orbital overlap between the pi bonds of adjacent aromatic rings) in crystallinity. Researchers discovered that, following the operation of the device, the active layer for all types of devices undergoes a transformation, and develops a finer structure with more isolated domains. Moreover, the morphology of the middle-sized domains shows stronger changes during the initial operating stage of OSCs that have layers with relatively poor π–π stacking. This results in a more pronounced performance decay of these devices. Notable, the stability of the active layer morphology was more affected in well-intermixed donor–acceptor systems with notable face-on crystallinity compared to slightly de-mixed donor–acceptor systems with good π–π stacking.



"By utilising X-ray scattering analysis, we explored how OSC performance correlates with temporal morphology influenced by different degrees of orbital overlap in crystallinity".

Figure 15
A real time study of the active layer morphology evolution with different acceptors during the OSC operation.

These outcomes will help to develop stronger and more effective organic solar cells by acting on the structure of their active layers, enabling applications in both the sustainable energy and aerospace sectors.

[9] *Operando study of the influence of small molecule acceptors on the morphology induced device degradation of organic solar cells with different degrees of π-π stacking,* Jiang X., Gillett A.J., Zheng T., Song X., Heger J.E., Sun K., Spanier L.V., Guo R., Liang S., Bernstorff S., Müller-Buschbaum P., Energy & Environmental Science, 2023, DOI: https://doi.org/10.1039/D3EE02527F

Fabrication of fluorescent MOF micropatterns[10]

Metal-organic frameworks (MOFs) are a class of extended, typically porous, modular materials that have numerous promising applications including catalysis, separation, sensing, and optics. By selecting the building blocks (metal ions and organic linkers) that compose these so-called MOFs, it is possible to customize their chemical and physical properties. This makes MOFs, especially in the form of oriented polycrystalline films, an attractive platform material for miniaturized devices such as chemical sensors, microelectronic components, and photonic devices.


Paolo Falcaro


Mercedes Linares-Moreau

However, to further progress this field, it is necessary to develop positioning protocols that confine portions of the MOF films into predefined areas (i.e. micropatterning). In this context, **Paolo Falcaro**, **Mercedes Linares-Moreau**, **Miriam de J. Velásquez-Hernández** and colleagues from TU Graz, the University of Adelaide and KU Leuven - among others - created oriented MOF patterns from aligned Cu(OH)2 nanobelt films by using a resist-free photolithographic approach. Using different instruments, including the ones available at the DXRL beamline of the Austrian CERIC PF at Elettra Sincrotrone Trieste, the scientists exposed the MOF system to X-ray radiation through a lithography mask. This procedure led to chemical and structural changes in the unmasked regions. The subsequent immersion of the samples in a developer solution caused the selective dissolution of the MOF in the X-ray-exposed regions, revealing localized MOF patterns. The obtained patterns were then characterized using a series of techniques, including X-ray diffraction, FT-IR spectroscopy, scanning electron microscopy and Raman spectroscopy. Finally, the researchers incorporated fluorescent dye molecules within the oriented pore channels of the MOF patterns. The resulting material showed directional photoluminescent response.

"Using X-ray synchrotron radiation lithography, for the first time, we fabricated oriented nanoporous micropatterns with anisotropic optical properties".

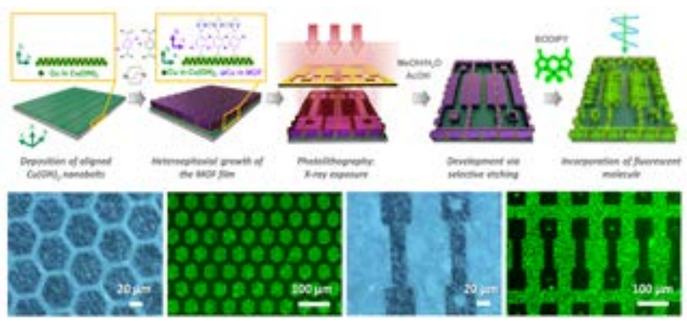


Figure 16
Schematic of the fabrication process to obtain oriented MOF micropatterns (top) and exemplary optical and fluorescence microscopy images of different MOF patterns (bottom).

The developed protocol, which combines precisely oriented MOF films with micropatterning techniques, could be used in the future to integrate MOF components with specific functional properties, such as fluorescence, into miniaturized and photonic devices.

[10] *Fabrication of 3D Oriented MOF Micropatterns with Anisotropic Fluorescent Properties,* Advanced Materials, Velásquez-Hernández M.D.J., Linares-Moreau M., Brandner L.A., Marmiroli B., Barella M., Acuna G.P., Zilio S.D., Verstreken M.F.K., Kravchenko D.E., Linder-Patton O.M., Evans J.D., Wiltsche H., Carraro F., Wolinski H., Ameloot R., Doonan C., Falcaro P., 2023, DOI: https://doi.org/10.1002/adma.202211478

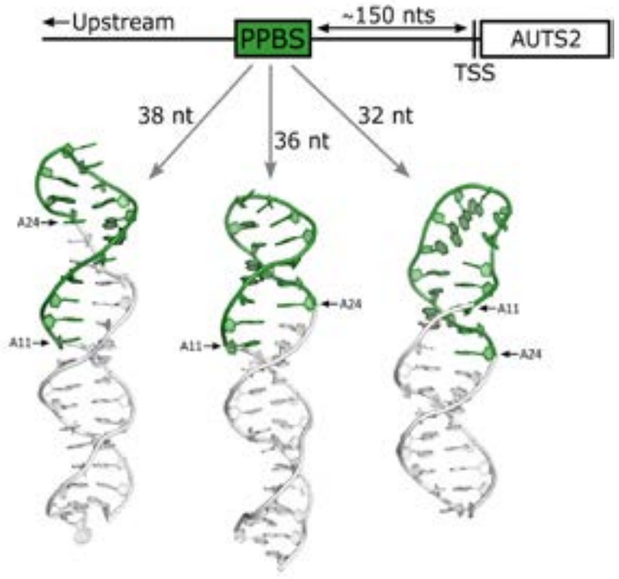
Molecular mechanism potentially involved in gene regulation crucial for brain development revealed[11]

Several diseases are associated with the expansion of short nucleotide repeats, in the form of non-canonical structures (such as hairpins, i-motifs or G-quadruplexes) dispersed across genes. In this context, a CGAG-rich region present in the Autism Susceptibility 2 (AUTS2) promoter gene appears to be involved in the switch between two isoforms (full-length and C-terminal) of the encoded protein, which plays an important role in brain development and neuronal differentiation.


Aleš Novotny


Vojč Kocman

To better understand the molecular mechanism responsible for this switch, **Aleš Novotný**, **Janez Plavec** and **Vojč Kocman** of the Slovenian NMR Centre (Ljubljana) studied a 60 nt long CGAG-rich region of the AUTS2 gene, that can adopt a variety of non-canonical secondary structures. However, due to the flexibility and polymorphism expressed by this region, it was hard to structurally characterise it. Hence, using the Nuclear Magnetic Resonance Spectrometers DAVID and LARA of the CERIC Slovenian PF at the National Institute of Chemistry, researchers focused on three shorter oligonucleotides containing CGAG repeats, which surround the putative protein binding site for transcription regulatory proteins (located in the loop of the CGAG-region). Scientists then discovered that these short sequences adopt thermally stable



"Formation of hairpins by CGAG-rich oligonucleotides derived from the promoter of a gene involved in susceptibility to autism could affect its expression, and consequently brain development".

Figure 17
CGAG-rich region of the promoter comprises putative protein binding site (PPBS) found 150 nucleotides upstream from the transcription start site (TSS) of AUTS2 gene. The oligonucleotides derived from the CGAG-rich promoter form different hairpin structures depending on oligonucleotide length.

non-canonical hairpin structures stabilized by repeating structural motifs called CGAG blocks. These motifs are formed consecutively, in a way that exploits a shift in register to have the maximum of consecutive G:C and G:A base pairs. The differences in CGAG repeat shifting affect the structure of the loop region, leading to different folds in the CGAG-rich region, change in the protein binding site accessibility, and potentially causing the switch between the full-length and C-terminal AUTS2 isoforms.

[11] *Structural polymorphism driven by a register shift in a CGAG-rich region found in the promoter of the neurodevelopmental regulator AUTS2 gene*
Novotný A., Plavec P., Kocman V., Nucleic Acids Research, 2023, DOI: https://doi.org/10.1093/nar/gkad117

A new generation of hydrogen sensors[12]

Monitoring hydrogen levels, an operation which is commonly performed with gas chromatographs and mass spectrometers, can be crucial in several fields: to prevent explosions at storage sites, for environmental monitoring, assisting the diagnosis of gastrointestinal illnesses. It is therefore highly desirable to develop new monitoring systems, based on simpler instrumentation and less expensive materials.


Elisabetta Comini

Elisabetta Comini, **Chathuranga Kumarage** and colleagues of the University of Brescia synthesized at low temperature nanowires made of cobalt oxide (Co3O4, one of the most stable and promising materials for developing gas sensors). Thanks to high resolution transmission electron microscopy (HRTEM) instruments available within the Romanian CERIC PF at the National Institute of Materials Physics (NIMP, Bucharest), researchers observed that nanowires had a diameter between 6 and 50 nm and lengths of 1–5 µm. Moreover, utilising electron paramagnetic resonance (EPR) characterization at the CERIC Partner Facility at NIMP, the research team identified a ferromagnetic phase within Co3O4, linked to the incomplete oxidation of cobalt. Notably, this phase vanished after subjecting the material to 8 hours of thermal aging at 400 °C. Scientists also tested the applicability of the fabricated Co3O4 sensor for hydrogen sensing in high-humidity conditions: in this test, they observed that a higher nanowire density leads to a more pronounced hydrogen-sensing response, and they report an abnormal, yet interesting, conductive behavior at high temperature (<300 °C).


Chathuranga Kumarage

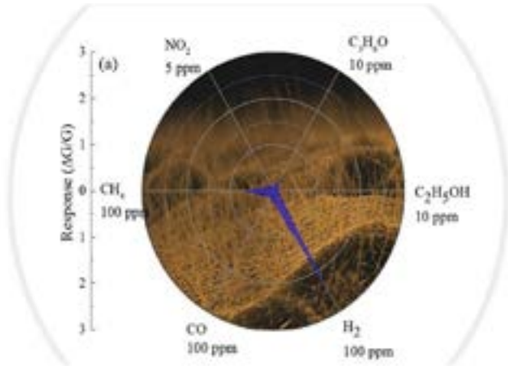


Figure 18
An exceedingly sensitive hydrogen gas sensor is presented, employing Co3O4 nanowires that ex-hibit outstanding response capabilities even within environments characterized by 90% humidity. This advancement contributes to the development of dependable hydrogen detection technologies across diverse industries.

The high conductance baseline that the nanowires sensors express even under high humidity (90%), that could be attributed to the catalytic activity and elevated operating temperature, could represents a major achievement in the development of a new generation of hydrogen sensing devices.

"We have been able to synthesise cobalt (II,III) oxide nanowires at low temperatures, exhibiting outstanding hydrogen gas sensing capabilities, even in environments with 90% relative humidity".

[12] *Revolutionizing n-type Co3O4 Nanowire for Hydrogen Gas Sensing,* Kumarage G.W.C., Zappa D., Mihalcea C.G., Maraloiu V.-A., Stefan M., Comini E., Advanced Energy & Sustainability Research, 2023, DOI: https://doi.org/10.1002/aesr.202300067

How to synthesize stable and strongly confined perovskite quantum dots[13]

The 2023 Nobel Prize in Chemistry was awarded for the discovery and development of quantum dots (QDs) - semiconductor nanoparticles so tiny that their size, due to quantum-mechanical effects, determines their optical and electronic properties. Lead-halide perovskite QDs are the latest and increasingly important generation of QDs. However, applications of perovskite QDs in the strong confinement regime, i.e., with a size smaller than about 7 nm, are still limited due to the insufficient chemical stability and size monodispersity of such tiny QDs.

Simon Böhme

To overcome this limitation, **Simon Böhme**, **Maryna Bodnarchuk**, **Maksym Kovalenko**, and colleagues of the Swiss Federal Institute of Technology (ETH Zurich), devised a postsynthetic QD surface treatment employing didodecyldimethylammonium bromide (DDAB) ligand shells to 5 nm colloidal perovskite QDs. They then achieved chemically stable and strongly confined QDs, with high size monodispersity (7.5% ± 2.0%) and shape uniformity. This enabled them, in collaboration with partners across Europe, to study the structure and fundamental optical properties of these QDs using several techniques, including small-angle X-ray scattering (SAXS) available at the CERIC Austrian PF located at Elettra Sincrotrone Trieste.

Maryna Bodnarchuk

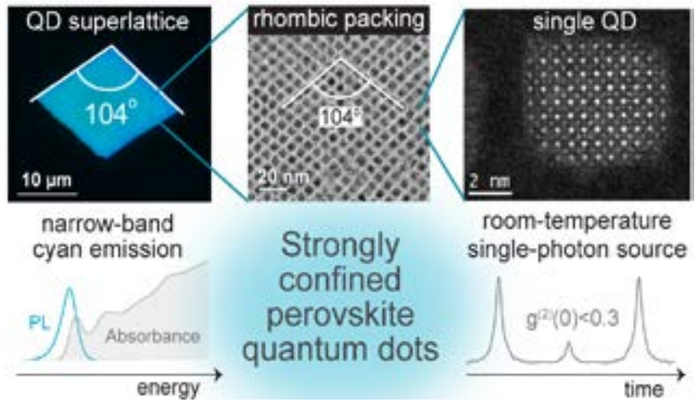
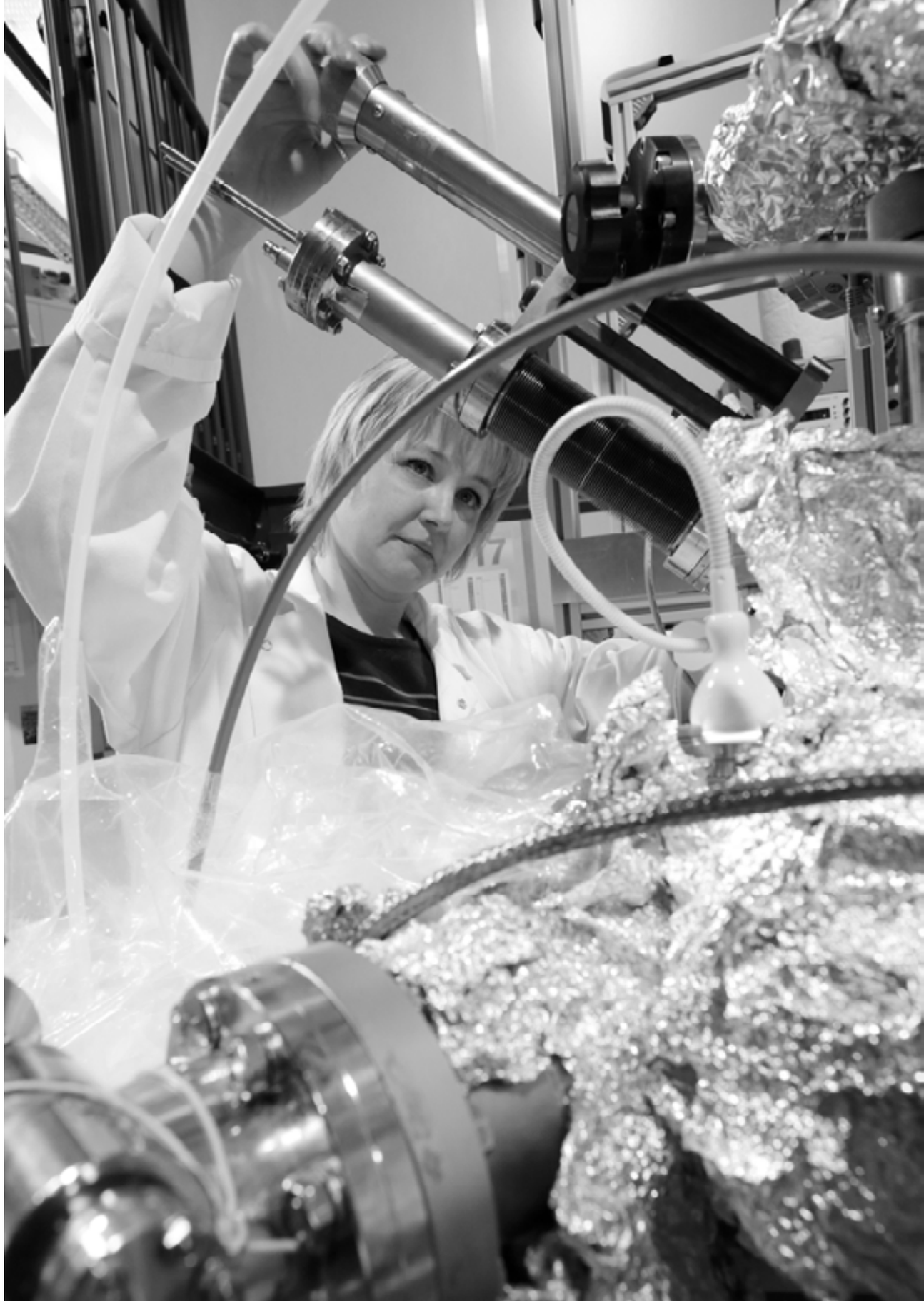


Figure 19
Tiny 5 nm colloidal CsPbBr3 perovskite QDs (upper right) are bright and narrow-band cyan emitters (lower left). Single QDs make for good solution-processable and room-temperature operable single-photon sources, advantageous for quantum applications (lower right). A high size and shape uniformity enables their self-assembly into highly ordered QD superlattices of rhombic macroscopy shape (upper left).

Finally, scientists discovered that these tiny QDs can, thanks to their achieved unique chemical and structural features, self-assemble into QD superlattices with exceptional long-range order, uniform thickness, and rhombic macroscopic shape. Together with the new handle of size control in the strong confinement regime, these exciting features may enable novel devices such as wavelength-tunable and solution-processable quantum light sources operating at room temperature. The future has just become even brighter and more colorful.

"Strongly binding surface ligands enable the synthesis of 5nm-sized perovskite quantum dots, a *strong quantum confinement* that could lead to solution-processable and wavelength-tunable quantum light sources".

[13] *Strongly Confined CsPbBr3 Quantum Dots as Quantum Emitters and Building Blocks for Rhombic Superlattices,* Boehme S.C., Bodnarchuk M.I., Burian M., Bertolotti F., Cherniukh I., Bernasconi C., Zhu C., Erni R., Amenitsch H., Naumenko D., Andrusiv H., Semkiv N., John R.A., Baldwin A., Galkowski K., Masciocchi N., Stranks S.D., Rainò G., Guagliardi A., Kovalenko M.V., ACS Nano, 2023, DOI: https://doi.org/10.1021/acsnano.2c07677



Internal Research Projects

In accordance with CERIC's strategic goal to enhance the collaboration of multidisciplinary analytical, synthesis, and sample preparation capabilities of national PFs primarily situated in the Central European Region into a unique EU-level distributed Research Infrastructure open to researchers on a global scale, ISTAC evaluated proposals submitted by CERIC PFs in response to the 2022 Call for Expression of Interest. Consequently, twenty projects out of the twenty-six submitted were granted Research Grants and Infrastructure Development funds, amounting to a total worth of 4,029,000.00 EUR. Seven contracts have already been signed in 2023-2024 with the PFs and institutions partner in the projects, having the goal to:

- Contribute to the quality and competitiveness of both CERIC internal research and its offer to external users.
- Promote the further attraction and integration of the national resources in the CERIC PFs. Or in CERIC's activities and offer to external users for external invited institutions.

In the following, the projects selected for Research Infrastructure Development, their objectives, and the leading institutions, are presented. Ten additional projects were selected for Human Resources (read more on pages 52-53):

600 SSNMRCERIC, 600 MHz NMR spectrometer for measuring solid samples - Slovenian PF
The aim of the project is the purchase of a new narrow bore 600 MHz NMR spectrometer that will replace the existing old Varian 600 MHz NMR spectrometer called Magic, for measurements of solid samples. Solid-state NMR studies are important for research of inorganic materials used in fields spanning batteries and fuel cells, semiconductors, optical materials, MOFs, catalysts, and glasses. In the life sciences domain, such equipment can be used for the determination of the microscopic structure of solid materials for the needs of pharmacy.

t.next@ill, Thermal Neutron and X-ray Tomograph - Hungarian PF at BNC, and Institute Laue-Langevin - ILL, France
The objective of this project is to establish a top-tier thermal neutron tomography instrument, which will complement the existing neutron tomography capabilities and capacity offered by BNC and enhance the open access opportunities for energy research investigations focused on determining the structural aspects of materials and devices, as well as their temporal evolution.

APEM WE, FC testing laboratory upgrade - PEM/AEM-Water Electrolyser test Stations (PEM-WE, 1 kW) - Czech PF
A Water Electrolyser testing system composed of two stations for testing single cells and stacks of PEMWE and AEMWE simultaneously, will be purchased to enhance CERIC's open access capacity in the field of sustainable energy.

FAI TH, Flexible Apparatus for Imaging and Tomography - Italian and Hungarian PFs
The project foresees the upgrade of the microtomography (microCT) off-line instrument in the SYRMEP laboratory at Elettra Sincrotrone Trieste to support users in data analysis.

STEAM, multiscale TErAhertz iMaging - Italian PF
STEAM will implement a new offline instrument allowing to perform both far-field and near-field THz hyperspectral imaging, from the mm to the nmscale, to address many scientific and societal problems in fields as diverse as biomedicine, cultural heritage, semiconductors, pharmaceutics, agriculture, biochemistry and security.

ARTEMIS, Atomic resolution analytical TEM/STEM facility for correlative microstructural and functional in situ and operando investigations - Romanian PF
ARTEMIS aims to upgrade the existing HRTEM RI at NIMP, to facilitate the approach of in situ and operando analytical TEM/STEM on functional materials for energy and semiconductor industry.

EXIT, Beamline for External Ion microbeam Techniques - Croatian PF
The project proposes to construct a state-of-the-art system based on the scanning microbeam with smallest possible spatial resolution in air and highest possible solid angle detectors for PIXE and PIGE analysis techniques, for analysis of cultural heritage objects, characterisation of complex detectors and electronics, *in operando* analysis of components in energy storage and energy conversion devices and also in the analysis biomaterials, including irradiation of leaving cells.

HF-SAXS 2.0, Upgrade of the Austrian SAXS beamline for Elettra 2.0 - Austrian and Italian PFs
The project focuses on the reinstallation and refurbishment of the new SAXS "high flux beamline" in the frame of the ELETTRA 2.0 upgrade foreseen in 2025.

ESBY, Electron microscopy for Structural BiologY at CERIC-ERIC - Italian PF and CNR-IOM, Italy
The project aims to optimise the cryo-EM station to be built for both structural biology and cellular tissue biology, in the frame of the project "Pathogen Readiness Platform for CERIC-ERIC Upgrade" (PRP@CERIC). The cryo-EM laboratory will also be better equipped for optimal sample preparation and storage.

Triple I / 3I, 200kV Ion Implanter Instrumentation - Croatian PF
To extend the ion energy range of the tandem accelerators (1 MV Tandetron and 6 MV Tandem Van de Graaff) at RBI, to less than 200 keV, the project will upgrade the recently installed 200 keV RBI's implanter/accelerator. This implies the installation of a new ion source, an analysis chamber/end station, and a stable power supply for the analysing magnet.

CERIC co-funded PhD Scholarships

To advance the integration of PFs and foster excellence in scientific research, CERIC has been co-funding nineteen PhD projects (read more on pages 51) in energy research, life sciences, cultural heritage and more, starting from the year 2020. In a show of solidarity towards the Ukrainian population, CERIC launched a **call for Ukrainian postdoctoral researchers** in 2022 to enable them to carry on with their research activities at CERIC's PFs. This call was maintained open throughout 2023, with the intent of attracting collaborative proposals that involve one or more PFs and non-CERIC institutions. In this context, the project initiated in 2022 under the leadership of **Dr. Anatolii Nagornyi** aims to advance the methodologies established during the previous CERIC internal project, CEROP, by exploring innovative fuel cell materials for their development and subsequent testing on model systems. This objective will be achieved through the integration of synchrotron beamlines, specifically Small Angle X-ray Scattering (SAXS) and X-ray Absorption Fine Structure (XAFS), from Elettra Sincrotrone Trieste, as well as neutron imaging and Small Angle Neutron Scattering (SANS) from the Budapest Neutron Centre.
Valuable research outputs have been produced and released in scientific journals in 2023 in the frame of the PhD projects co-funded by CERIC, and PhD students also had the opportunity to participate and present their work both in national and international workshops and events.

Project INTEGRA

The CERIC internal research project **INTEGRA**, which started in 2020 with Heinz Amenitsch as principal investigator, was extended and continued in 2023. Its goal is to reinforce, enlarge and better integrate the offer of CERIC's PFs in the Life Sciences, covering a wide range of biological targets, from molecules, to tissues and organisms.

Some of the results published in 2023 in the frame of both INTEGRA and the CERIC-funded PhD projects are presented in the following pages.

CERIC internal research - Scientific highlights

A multi-technique approach to study Palaeolithic residues[14]

Residue analysis for the study of Palaeolithic represents a powerful discipline to understand how stone tools were used by past human populations, based on the chemical analysis of the organic and inorganic substances that remained trapped on their surface during ancient human activities. However, this type of analysis is far from trivial when dealing with artefacts - and residues - that are tens of thousands of years old.

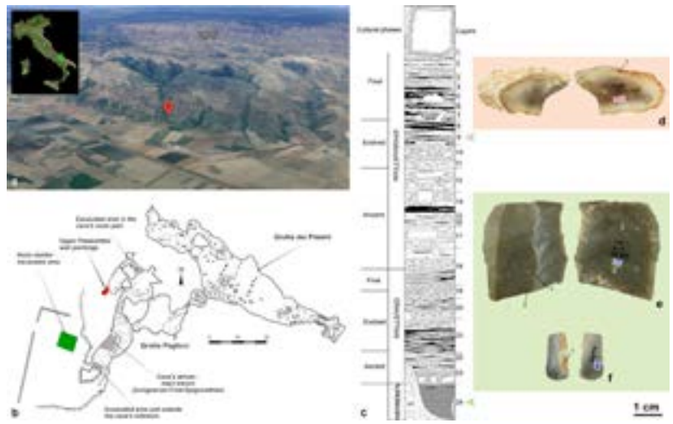


Figure 20
Localisation (a), cave plan (b) and Upper Palaeolithic stratigraphic sequence (c) of Grotta Paglicci (Apulia, Italy), from which the artefacts encompassed by the study were retrieved. Dorsal and ven-tral view of three artefacts (d, e, f), with the indication of the sampling sites.

To address this issue, **Clarissa Dominici**, **Chiaramaria Stani** and **Alessandra Gianoncelli** (respectively CERIC PhD student at the University of Siena, CERIC post-doc researcher and Head of TwinMic beamline at Elettra Sincrotrone Trieste) developed, together with other colleagues from the Elettra Synchrotron, the Ruđer Bošković Institute and the University of Siena, a new methodological protocol that exploits advanced material analysis and characterisation techniques.

In particular, they took advantage of the SISSI-Bio and TwinMic beamlines at the Italian CERIC PF at Elettra Sincrotrone Trieste, and of the PIXE technique available in the Laboratory for Ion Beam Interactions of the Croatian CERIC PF at the Ruđer Bošković Institute in Zagreb, to study lithic artefacts retrieved from the Upper Palaeolithic (40,000–13,000 years ago) stratigraphic sequence of Grotta Paglicci (Apulia, Italy).

Through the use of complementary spectroscopic techniques, namely infrared, X-ray fluorescence and particle induced X-ray emission microscopies, they were able to map the same regions of each sample to obtain a spatial correlation between its molecular and elemental composition to the micro-scale, allowing the identification of three different iron-rich compounds. This study paves the way for the development of new analytical protocols for residue analysis in the field of Palaeolithic studies, to allow the reconstruction of the ways of life of our ancestors, as well as to get pivotal information on their technology, behaviour, and adaptation to the environment.


Clarissa Dominici


Chiaramaria Stani

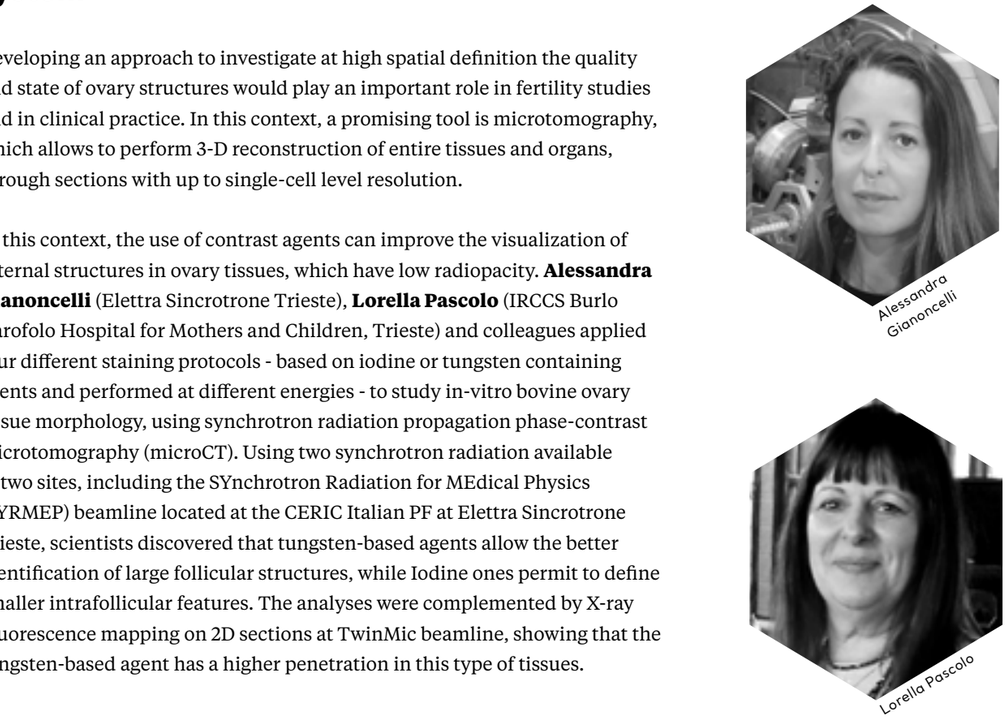
"This is the first time that three high-resolution complementary techniques are combined to gain insights into Palaeolithic residues and their meaning for the reconstruction of past human activities, thanks to the use of synchrotron radiation and ion beam analysis".

[14] *Combining SR-FTIR, SR-LEXRF and PIXE microscopies for residue analysis on Palaeolithic stone artefacts*, Dominici C., Stani C., Bonanni V., Rossini M., Božičević Mihalić I., Provatas G., Fazinić S., Boschin F., Gianoncelli A., Vaccari L., DOI: https://doi.org/10.1140/epjp/s13360-023-04320-7

Synchrotron radiation-based X-ray imaging to improve knowledge about female reproductive system[15]

Developing an approach to investigate at high spatial definition the quality and state of ovary structures would play an important role in fertility studies and in clinical practice. In this context, a promising tool is microtomography, which allows to perform 3-D reconstruction of entire tissues and organs, through sections with up to single-cell level resolution.

In this context, the use of contrast agents can improve the visualization of internal structures in ovary tissues, which have low radiopacity. **Alessandra Gianoncelli** (Elettra Sincrotrone Trieste), **Lorella Pascolo** (IRCCS Burlo Garofolo Hospital for Mothers and Children, Trieste) and colleagues applied four different staining protocols - based on iodine or tungsten containing agents and performed at different energies - to study in-vitro bovine ovary tissue morphology, using synchrotron radiation propagation phase-contrast microtomography (microCT). Using two synchrotron radiation available at two sites, including the SYnchrotron Radiation for MEdical Physics (SYRMEP) beamline located at the CERIC Italian PF at Elettra Sincrotrone Trieste, scientists discovered that tungsten-based agents allow the better identification of large follicular structures, while Iodine ones permit to define smaller intrafollicular features. The analyses were complemented by X-ray Fluorescence mapping on 2D sections at TwinMic beamline, showing that the tungsten-based agent has a higher penetration in this type of tissues.


Alessandra Gianoncelli

Lorella Pascolo

"X-ray Imaging reveals ovarian structures in bovine model by means of a multidisci-plinary study combining morphology and chemistry".

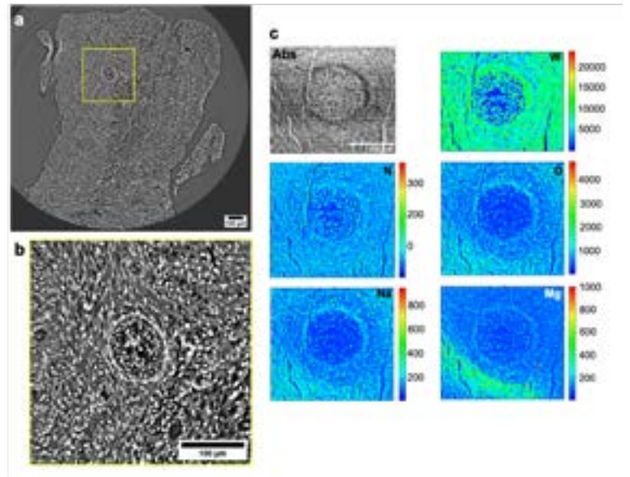


Figure 21
(a) Slice extracted from the microtomography reconstruction, measured at 27 keV at SYRMEP beamline with 0.9 µm spatial resolution, from the PTA stained tissue. (b) zoom of the follicle region. In (c) µXRF and X-ray microscopy of PTA stained bovine ovarian tissue at the TwinMic beamline.

These analyses, which have the advantage of not damaging the tested samples, could be a powerful fool to enhance our knowledge of the folliculogenesis process, having a profound impact on reproductive medicine, specifically concerning fertility preservation options for prepubertal girls with malignant tumours.

[15] *Morphological and Chemical Investigation of Ovarian Structures in a Bovine Model by Contrast-Enhanced X-ray Imaging and Microscopy*, Gianoncelli A., Sena Souza G., Kourousias G., Pascotto E., Tafforeau P., Longo E., Barroso R.C., Salomé M., Stebel M. Zingaro F., Calligaro C., Ricci G., Pascolo L., International Journal of Molecular Sciences, 2023, DOI: https://doi.org/10.3390/ijms24043545

Scientists reveal how osteoporosis and Covid-19 affect bones structure[16]

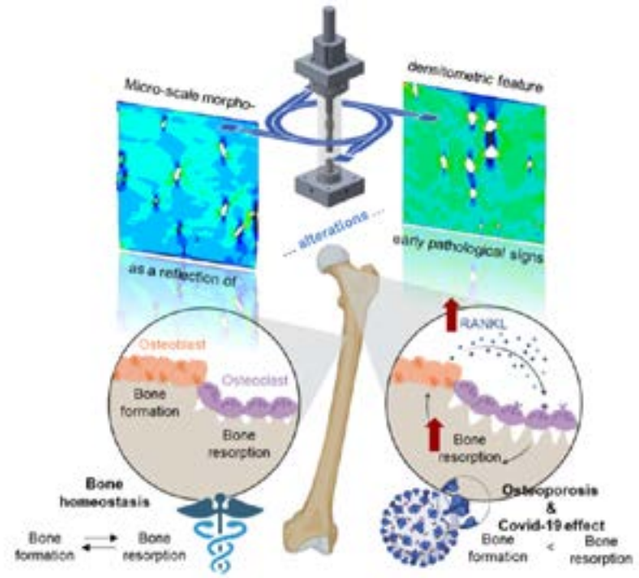
The evolution of micro-scale bone damages into critical fracture is still not a fully understood process. Several data seem to confirm the hypothesis that a key role is played by the so-called lacunae, micron-sized ellipsoidal pores that contain osteocytes cell bodies. However, the characterization of the lacunar system and the detection of early signs of bone alteration aren't trivial operations to perform.


Federica Buccino

Moreover, the application of various advanced investigation techniques (such as 3D imaging) is hampered by the low number of osteocyte lacunae that can be studied per sample. To overcome this barrier, **Federica Buccino** (Politecnico di Milano), CERIC PhD fellow **Lorenzo D'Amico** and colleagues, including research coordinator **Laura Maria Vergani** (Politecnico di Milano), applied novel artificial intelligence (AI)-based approach for automatic large-scale osteocyte lacunar detection and investigation with synchrotron image-guided failure assessment.


Lorenzo D'Amico

This procedure can also be particularly useful in assessing the long-term damage induced by the Covid-19 pandemic, since a slowdown in the bone formation processes is hypothesized as a direct outcome of the virus infection. Using instruments available at the Synchrotron Radiation for Medical Physics (SYRMEP) at the CERIC Italian PF at Elettra Sincrotrone Trieste, researchers studied the femoral head to demonstrate four clinical hypotheses. They could then demonstrate that micro-scale bone alterations and adaptations to external mechanical loadings could result as an early sign of pathology, both in case of osteoporosis and Covid-19 induced changes.



These outcomes help to more accurately describe the transition from micro to macro fractures, and could then be applied to improve already existing clinical and diagnostic tools.

"In the last decades the possibility to access synchrotron facilities has allowed to study and better understand many biomedical problems that otherwise would be still unresolved".

Figure 22
Morpho-densitometric alteration of lacunar characteristics in presence of osteoporotic disease and Covid-19 pathology.

[16] *Osteoporosis and Covid-19: Detected similarities in bone lacunar-level alterations via combined AI and advanced synchrotron testing,* Buccino F., Zagra L., Longo E., D'Amico L., Banfi G., Berto F., Tromba G., Vergani L.M., Materials and Design, 2023, DOI: https://doi.org/10.1016/j.matdes.2023.112087

The effects of nanoplastics on macrophages unraveled by Synchrotron high-resolution spectro-microscopies[17]

Nanoplastics (NPs) can easily interact with cells, therefore their presence in the environment poses a significant concern for human health. However, mechanisms of toxicity are still unknown, and only a few studies focused on model NPs–immune system interaction.


Federica Zingaro

The CERIC PhD fellow **Federica Zingaro**, **Alessandra Gianoncelli** and **Giovanni Birarda** (Elettra Sincrotrone Trieste), **Lorella Pascolo** (IRCCS Burlo Garofolo Hospital for Mothers and Children, Trieste), and colleagues focused on the possible effects of NPs on macrophages, an important class of phagocytotic innate immune cells which are involved in several physiological and pathological processes, such as inflammation and infection (with particular regard to M1 phenotype, which plays an important role in primary immune response against exogenous agents).


Giovanni Birarda

To study in vitro M1 phenotype macrophages, scientists exploited a combination of techniques available at the CERIC Italian PF at Elettra Sincrotrone, including Scanning transmission X-ray microscopy (STXM) and low-energy X-ray fluorescence (LEXRF), both performed at the TwinMic beamline, and Fourier Transform Infrared (FTIR) spectro-microscopy measurements, carried out at the Chemical and Life Science branch of the SISSI-Bio beamline.

Researchers could then demonstrate that M1 phenotype macrophages undergo substantial alterations both in morphology and lipids metabolism when exposed to polypropylene and polyvinyl chloride NPs at the appropriate experimental concentrations and incubation time.

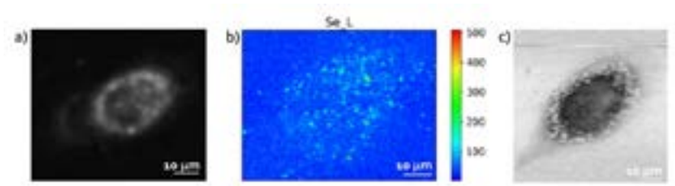


Figure 23
a) Fluorescence image of a M1 macrophage exposed to model polypropylene NPs labelled with cadmium selenide quantum dots (CdSe-QDs; b) Selenium (L Line) chemical map of the same cell of panel a; c) absorption image of the cell acquired with 300 nm spatial resolution.

Although experimental data do not show any alteration of cell viability, these outcomes prove that nanoplastics can cause an evident impairment in lipids metabolism of immune system cells, a hallmark of activation of phagocytosis and oxidative stress.

"The use of advanced spectro-microscopies unravelled the cellular morphological changes in NPs-exposed macrophages M1, suggesting the impairment of lipid metabolism as a toxicological response".

[17] *Morphological and lipid metabolism alterations in macrophages exposed to model environmental nanoplastics traced by high-resolution synchrotron techniques,* Zingaro F., Gianoncelli A., Ceccone G., Birarda G., Cassano D., La Spina R., Agostinis C., Bonanni V., Ricci G., Pascolo L., Frontiers in Immunology, 2023, DOI: https://doi.org/10.3389/fimmu.2023.1247747

Asbestos fibers and cell membranes: interaction revealed[18]

The serious effects of asbestos on lung tissues are, unfortunately, dramatically known. However, the molecular mechanisms of action by which the fibers cross the cell membrane, reaching the DNA and interfering with transcription activity, are not yet completely understood.

To shed light on this process, **Annalisa Bernareggi** (University of Trieste), CERIC PhD fellow **Martina Zangari**, **Giuliano Zabucchi** (University of Trieste) and colleagues investigated the enhancement of chloride conductance induced, in Xenopus oocyte cell membranes, by exposure to asbestos fibers. In particular, they studied the modulation of a calcium-activated chloride channel protein, TMEM16A. Using different investigation techniques, including voltage clamp, calcium imaging and Western Blot, researchers have shown that treatment with asbestos reduced the cell membrane resistance, and that this change is mediated by TMEM16A channels.

Annalisa Bernareggi

Martina Zangari

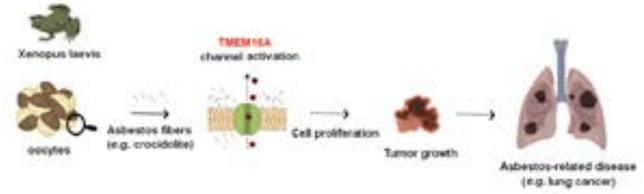


Figure 24
Asbestos fibers (e.g. crocidolite) alter the electrical membrane properties of Xenopus oocytes by stimulating the TMEM16A channel activity. The TMEM16A protein is known to control the cell proliferation, and it is critical for the tumor growth in lung cancer.

Given that the alteration of calcium homeostasis is a distinctive sign of lung cancer, and that TMEM16A is highly expressed in many types of tumors, including some of the ones induced by asbestos, these results suggest that these channels can be considered possible early targets of asbestos-mediated tumorigenic effects on cell membranes.

"By using an electrophysiological approach, we found the cell membrane TMEM16A channel activation an early effect of asbestos, indicating the TMEM16A protein as therapeutic target for asbestos-related diseases".

[18] *Asbestos Fibers Enhance the TMEM16A Channel Activity in Xenopus Oocytes*, Bernareggi A., Zangari M., Constanti A., Zacchi P., Borelli V., Mangogna A., Lorenzon P., Zabucchi G., Membranes, 2023, DOI: https://doi.org/10.3390/membranes13020180

Modifying the structure of platinum-based fuel cells catalysts[19]

Platinum is a promising catalyst material for fuel cells development. However, it is rare and expensive, and its catalytic activity degrades over time. Sputtering deposition via a magnetron (a high-vacuum tube containing a cathode and an anode) is a simple and fast method for the production of catalyst layers, which allows to modify the deposit morphology by variation of certain parameters.

CERIC PhD fellow Athira Lekshmi and colleagues applied this feature by varying the sputtering deposition pressure, with the aim of getting platinum deposited as one monolayer of nanoparticles assembly. They then investigated the morphology and structure of deposited layers with different characterization techniques available at the CERIC Czech PF at Charles University (Prague), including scanning electron microscopy, transmission electron microscopy, grazing incidence small angle X-ray scattering and X-ray diffraction. Scientist then discovered that, due to the increase of pressure, the platinum layer morphology evolves from a thin-film-like layer of tightly packed platinum nanoparticles to a deposit composed of dispersed particles of 5-7 nm in size.

Athira Lekshmi

"Through precise pressure control and comprehensive characterisation we have been able to unveil electrochemical performance enhancements of sputter-deposited platinum".

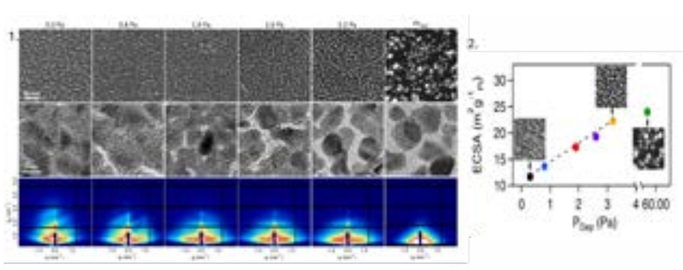


Figure 25
Fig. 1 SEM (upper row), TEM (middle row) images and GISAXS scattering patterns (bottom row) of platinum sputtered at varying deposition pressure and Fig. 2 showing its evolution of ECSA

These results proved the advantage of magnetron sputter deposition for the fast and scalable preparation of fuel cells electrodes, contributing to a conversion to clean energy, which is needed to cut greenhouse gas emissions.

[19] *Tuning the morphology of sputter-deposited platinum catalyst: From compact layers to dispersed nanoparticles,* Sandhya A.L.M., Pleskunov P., Bogar M., Xie X., Wieser P.A., Orság M., Dinhová T.N., Dopita M., Taccani R., Amenitsch H., Choukourov A., Matolínová I., Khalakhan I., Surfaces and Interfaces, 2023, DOI: https://doi.org/10.1016/j.surfin.2023.103079

Mapping light-reflecting protein structures in squid skin cells[20]

Squids and other cephalopods have evolved skin cells, called iridophores and leucophores. These cells contain a high refractive index material, the reflectin protein, which allows them to reflect and scatter light. Despite their potential for the development of novel optical materials, the study and characterisation of these biomaterial-based structures across multiple different environments is challenging.

Atrouli Chatterjee

Preeta Pratakshya

Atrouli Chatterjee, **Preeta Pratakshya**, **Alon A. Gorodetsky** (University of California), **Sigrid Bernstorff** (Elettra Sincrotrone Trieste) and colleagues used a combination of experimental and computational methodologies to map, both in vivo and in vitro, the three-dimensional refractive index distributions and self-assembly of reflectin-based structures. To do so, they have exploited, among several investigation techniques, Small Angle X-Ray Scattering (SAXS) at the Austrian partner facility, located at the Elettra Sincrotrone Trieste. The authors are also continuing to explore these structures with NMR at the Slovenian PF at the National Institute of Chemistry in Ljubljana.

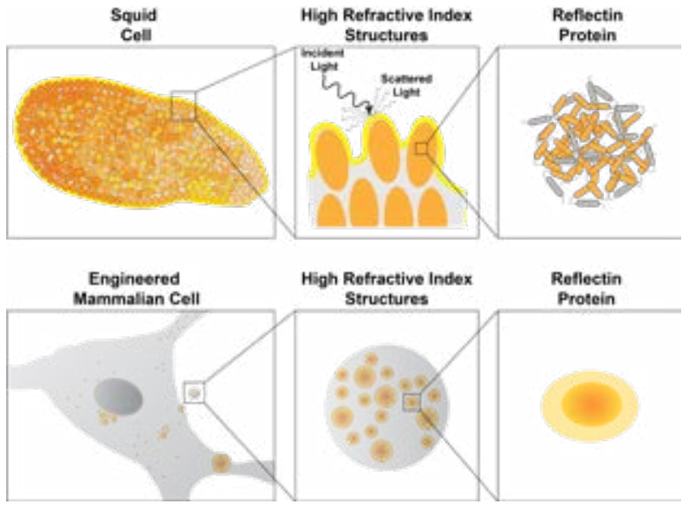


Figure 26
(Top) An illustration of a squid cell (left) which contains broadband-scattering compo-site-like arrangements (middle) composed of the structural protein reflectin (right). (Bottom) An illustration of a mammalian cell (left) which contains high refractive in-dex intracellular structures (middle) composed of the structural protein reflectin (right).

In addition to improving our knowledge on the functionality of these very special squid skin cells, these results emphasize the importance of a multi-faceted approach for characterizing protein-based optical materials.

"By utilizing a synergistic combination of experimental and computational methodologies, we systematically mapped the 3D refractive index distributions of self-assembled reflectin-based structures, *in vivo* and *in vitro*".

[20] *Squid Skin Cell-Inspired Refractive Index Mapping of Cells, Vesicles, and Nanostructures,* Chatterjee A., Pratakshya P., Kwansa A.L., Kaimal N., Cannon A.H., Sartori B., Marmiroli B., Orins H., Feng Z., Drake S., Couvrette J., Le L., Bernstorff S., Yingling Y.G., Gorodetsky A.A., ACS Biomaterials Science and Engineering, *2023,* DOI: https://doi.org/10.1021/acsbiomaterials.2c00088

Externally-funded scientific projects

In 2023, CERIC has been involved in transnational science projects. One EU funded project (IMPRESS) kicked off. The Horizon Europe project ReMade@ARI and the Marie Skłodowska-Curie Action project OPVStability continued to be implemented following the kick-off in 2022.

Horizon Europe project - IMPRESS Interoperable electron Microscopy Platform for advanced RESearch and Services

IMPRESS is a European-funded project bringing together 19 partners from 11 European countries, comprising scientists, companies, experts in the field of electron microscopy and RIs.
The project, which was kicked off in Trieste (Italy) in February 2023, aims to design and deliver Transmission Electron Microscopy (TEM) instrumentation conceived at the highest level of open standards and interoperability.
At the core of IMPRESS is the development of an interoperable platform based on a modular and standardised cartridge concept, which allows for flexibility and adaptability to different microscopes and instrumentation, and which will facilitate a wide range of multimodal experiments, correlative workflows and methodological options, which are currently not available on commercially available electron microscopes. Its architecture is based on interchangeable components that can be readily customised by scientists and further adjusted, taking into account the needs of users from different scientific disciplines. Furthermore, the project will focus on the co-development of new electron sources, techniques based on adaptive optics and event-driven detectors, application-relevant *in situ/ operando* sample environments, as well as software for the simulation of experiments and remote access based on artificial intelligence, while training a new generation of TEM users.
CERIC's role in the project is to provide training, and support the activities aimed to raise awareness about IMPRESS and its potential among different target audiences, as well as the dissemination of the results among the community of TEM users.

Horizon Europe project - ReMade@ARI REcyclable MAterials DEvelopment at Analytical Research Infrastructures

ReMade@ARI is a Horizon Europe project co-funded by UK Research and Innovation (UKRI) and by the Swiss State Secretariat for Education, Research and Innovation.
The project commits to supporting the development of innovative, sustainable materials for key components in the most diverse sectors (such as electronics, batteries, vehicles, construction, packaging, plastics, textiles and food) on an unprecedented level, adopting a circular economy approach.

To reach this goal, the project provides scientists with open access to analytical tools, instrumentation, methods and know-how, to explore the properties and structure of materials right down to atomic resolution. CERIC is among the over 50 analytical research infrastructures in the project offering access to its facilities for this scope, through the involvement of its Czech, Polish, Romanian and Slovenian PFs.
In the frame of the project, an electronic access management system, a user selection panel and a central point for users' travel reimbursement were established, while extensive communication and expertise exchange are promoted across the diverse network of facilities.
By offering effective access routes to RIs for industrial companies of all sizes, the project has been boosting innovation for the Circular Economy, and will set up a Smart Science Cluster to help unexperienced users carry out their research.

MSCA project - OPVStability Understanding, Predicting and Enhancing the Stability of Organic Photovoltaics

The OPVStability Marie Skłodowska-Curie Actions Doctoral Network (MSCA-DN) is an interdisciplinary research training network of ten beneficiary universities from seven countries. Funded under the *Excellent Science* cluster of the Horizon Europe programme, the project aims to develop the Doctoral Candidate's scientific expertise to produce excellent research, and to stimulate interdisciplinary collaboration among scientists from different fields spanning Physics, Chemistry, Materials Science and Data Science.

In the frame of the project, CERIC has hired a PhD student to conduct research with the staff at the Austrian PF on the influence of environmental conditions on absorber layer morphology and interfacial regions in collaboration with the Graz University of Technology.

Expansion of CERIC's offer

Expansion of CERIC's offer

Following the positive evaluation by the CERIC's ISTAC, two Energy storage facilities of the European Commission's Joint Research Centre (JRC) in Petten (the Netherlands), the **Hydrogen Technology Centre (HTC)** in the Czech Republic, and the Bio Open Lab in Italy, have joined CERIC as Associated Facilities in 2023, adding state-of-the-art techniques to the CERIC open access offer, in the fields of fuel cells, batteries research and life sciences, .

FCTEST

The **Fuel Cell and Electrolyser Testing facility (FCTEST)** supports the validation of testing procedures and measurement methodologies for the performance assessment of fuel cells. It is also used in the Clean Hydrogen Partnership for Europe for pre-normative research and harmonization of fuel cells and electrolyser test protocols and testing methodologies and their experimental validation.
The facility allows testing of low and high-temperature polymer electrolyte membrane (PEM) fuel cell and electrolysis test stations in single cell and stack. Solid oxide fuel cells and electrolysis test stations can be characterised in single cell and stack configurations, and there is also the possibility of testing under simulated environmental conditions, including temperature, relative ambient humidity, vibrations, and shocks.

BESTEST

The **Battery Energy Storage Testing Laboratory (BESTEST)** features state-of-the-art equipped facilities for analysing the performance of battery materials and devices by cycling them under controlled environmental conditions (temperature and relative humidity). It also provides integrated thermal and gas analysis systems for battery components testing – used for Simultaneous Thermal Analysis (STA) of battery components and subsequent analysis of the emitted gases. This combination of analytical techniques gives a meaningful analysis of the battery components' thermal degradation under controlled conditions (temperature, heating rate, gas environment, etc.). BESTEST also allows performing *in-situ* thermal imaging, electrochemical measurements, cell preparation, pre-and post-test battery cell tear-down and post-mortem diagnosis.

As stated by CERIC's Executive Director, Jana Kolar:

"By incorporating two testing laboratories for fuel cells and batteries into our offer, users can make significant discoveries and test their prototypes through a single application process, providing them with groundbreaking advancements in these areas".

For testing and analysis of user-provided catalysts and cell components for water electrolysers and fuel cells, the techniques and tools available at the **Hydrogen Technology Centre (HTC)** facilities at the Charles University in Prague have also been included in CERIC's open access offer in 2023.

A new set of facilities gathered under the umbrella of **Bio Open Lab (BOL)** have further enriched the CERIC open access offer for the life sciences. BOL is a collection of facilities, distributed across universities and institutes at three centres in Italy – in Salento, Salerno and Trieste – that aims to provide an integrated system of research equipment and instruments dedicated to investigations in the field of biological and biomedical research.

CERIC setup ~25 techniques in 7 Countries

2014
Synchrotron and laser light at Elettra
X-ray and light scattering at Elettra and TU Graz (AT PF)
Surface science at Charles University Prague (CZ PF)
HRTEM at NIMP (RO PF)
Ion beams at RBI (HR PF)
NMR at Slovenian NMR Centre (SI PF)
Neutrons at the Budapest Neutron Centre (HU PF)

2015
Synchrotron light source at SOLARIS (PL PF)

Awards for high quality publications and conference presentations

2016

2017

Fast Track Access for feasibility studies

2018
Vinča Institute of Nuclear Sciences (RS) - until 2019

Promotional Open Access

2019

COVID-19 Fast Track Access

2020
Ultraviolet Laser Facility at ULF-FORTH (GR AF)
XAS beamline LISA of CNR @ESRF

2021
Soft X-ray Beamline PHELIX@SOLARIS (PL PF)

Fast Track Access for commissioning

2022
5 new beamlines at SOLARIS - URANOS, ASTRA, PIRX DEMETER, PHELIX (PL PF)
Near Ambient Pressure Electron Spectroscopy - EnviroESCA@Charles University Prague (CZ PF)
JRC Nanobiotechnology Lab (EC AF)

Over 60 techniques in 11 Countries

2023
Hydrogen Technology Centre (CZ PF)
JRC BESTEST - Battery Energy Storage Testing Lab (EC AF)
JRC FCTEST - Fuel Cell and Electrolyser Testing facility (EC AF)
Bio Open Lab at AREA Science Park (IT PF)

Evaluation of Partner Facilities

ISTAC's evaluation of CERIC's Croatian PF

On May 31st, 2023, the members of the CERIC's ISTAC performed the periodical evaluation of the Consortium Croatian PF, hosted by the Ruđer Bošković Institute.

The purpose was to evaluate the performance of the PF in terms of the quality of its scientific activities and its contribution to the common strategic objectives and access capabilities of CERIC, as well as the added value for the PF and CERIC of the inclusion in the Consortium. The evaluation was conducted by an international Committee of Evaluators (CoE) composed by **Andrew Harrison** (ISTAC Chair), **Paolo Olivero** (ISTAC member) and **Maria Dolores Ynsa Alcala** (External evaluator)[24].

During the visit at the Croatian PF, the committee was impressed by the high quality of the scientific and technical work carried out, which puts the PF at the top of the European level in key areas of applied ion beam science. Moreover, the CoE highlighted the versatility and management skills of the staff, as well as the declared intention to move towards open data access, a move that aligns with global research trends and promotes scientific transparency and collaboration. The great support offered by the Croatian PF staff to its users has also been very positively evaluated.

Tandetron accelerator at RBI

Tandem Van de Graaff accelerator at RBI

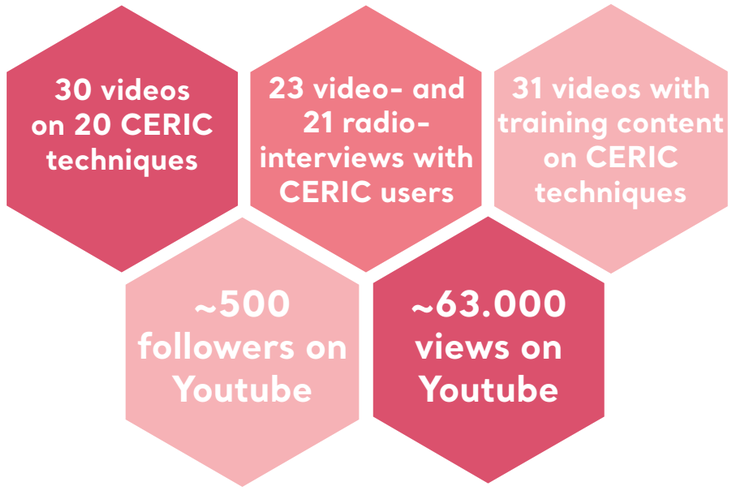
The experts were also positively impressed by the increased quality of the scientific publications emerging from collaborations within CERIC and from the involvement of the PF in CERIC activities, also in the field of battery research, which is one of Consortium strategic priority areas. This is a strong testament to the value of participation in CERIC, underscoring the benefits of collaborative, cross-institutional research efforts.

As with previous evaluations (and those carried out at other facilities), the ISTAC committee also provided a set of recommendations and suggestions to further enhance the efficiency of the Croatian PF, with a view to continuous improvement of CERIC's scientific open access offer.

[24] Andrew Harrison (Extreme Light Infrastructure ERIC), Paolo Olivero (University of Torino), Maria Dolores Ynsa Alcala (Universidad Autónoma de Madrid)

Showcasing the use of CERIC techniques

Since its setup, CERIC has produced and released quite a wide amount and variety of multimedia content spanning video and radio interviews, video recordings from science dissemination and training events, thematic videos on specific research fields, and videos on the use and application of the techniques available in the CERIC open access offer.



In 2023, CERIC continued the work started in 2021 to showcase the techniques available in its open access offer in a series of videos targeting the user community and early-stage researchers, for them to get acquainted with the instruments available for research in all fields of materials science and nanotechnology.
With the involvement of CERIC's beamline and instrument scientists from all the PFs, a total of thirty videos has been produced and released. Each of them explains what the technique is and what it is used for, and provides a guide for researchers on the types of samples they can characterise and for which scientific and technological applications.
The last five videos were realised in 2023 and focused on the ion beam techniques available at the Ruđer Bošković Institute. They have been published in both the CERIC Youtube channels and in the webpages dedicated to each single technique on the CERIC website.
The aim is to present CERIC's services and their quality, to provide useful tools for training purposes, and to support the job of beamline scientists, by reducing their effort in replying to the many questions sent by the applicants to the CERIC calls for proposals. Moreover, the videos have been useful material for the wider online promotion of CERIC and its offer.
Such action will continue in the following years, to possibly highlight all the techniques and instruments offered to the scientific community to enable their research and discoveries.

CERIC's support to the strengthening of its capabilities

Over the past decade since its establishment, CERIC has been committed to supporting the continuous integration of national multidisciplinary PFs into a unique EU-level distributed RI. This integration is vital as it enables the sharing of resources, expertise, and data across borders, enhancing the efficiency and impact of research. Following directives from its General Assembly, CERIC has actively supported joint research projects and the professional growth of young researchers and postdocs. It has also made significant investments in infrastructure enhancements.
In 2023, such activities (including PhDs, internal research projects and projects funded through the 2022 Call for Expression of Interest, batteries' plan, and the support to the Italian PF), have been funded in the amount of 4,441,413.90 EUR.
These initiatives were organised through internal calls proposed by the ED in consultation with the BoD, managed by the ISTAC, with the outcomes approved by CERIC's General Assembly. This structured approach ensures that the activities align with CERIC's strategic objectives and meet the highest standards of excellence and relevance. Below, a summary of the main activities is provided illustrating the specific contribution for each member country.

AUSTRIA

Since CERIC's establishment, it has supported its Austrian PF located in TU Graz (Austria) and in Elettra Sincrotrone Trieste (Italy). The activities encompassed two CERIC-supported PhD students in the fields of battery research and life sciences, two post-doc researchers from Ukraine in the energy research domain and a post-doc researcher in the domain of energy storage. The investment in the upgrade of the Austrian SAXS beamline for Elettra 2.0 has also been approved.
CEROP (energy research) and RENEWALS (life sciences) are two internal research projects in which the Austrian PF took a leading role. Moreover, INTEGRA, (life sciences) which started in 2020, is part of a CERIC investment aimed at enhancing CERIC's life science capabilities.

CROATIA

In addition to continuously offering the ion beamlines located at the Ruđer Bošković Institute in Zagreb, the Croatian PF successfully proposed two projects for Human Resources in response to the CERIC Call launched in 2022. In the frame of the same call, two more new projects have been selected for RI Development.

CZECH REPUBLIC

Since 2014, the Czech PF has operated in at the Charles University in Prague and at the synchrotron in Trieste including open access to the community of CERIC users. CERIC has supported the activities by co-funding three PhD scholarships. Two CERIC internal projects, CEROP and RENEWALS, which ended in 2020, also significantly benefited the Czech PF.

HUNGARY

The Hungarian PF operates its neutron-based techniques at the Budapest Neutron Centre. It benefitted from CERIC's support activities such as internal projects INTEGRA (life sciences, in collaboration with the Austrian PF), CEROP (energy research), and RENEWALS (life sciences), in collaboration with the Austrian, Czech, Italian, and Romanian PFs.
In the frame of the CERIC Call in 2022, the project InNeuRam4Sos was selected, for the creation of a geographically-distributed and scientifically integrated platform for the CERIC users interested in investigating associated liquids and their structural and intermolecular properties.

ITALY

The Italian PF has participated in most research projects funded by CERIC and has a wide variety of synchrotron beamlines, which have been offered to the user community worldwide since the CERIC setup.
CERIC has supported twelve PhD students hosted at the beamlines, which are part of the CERIC offer at Elettra Sincrotrone Trieste. Two additional PhD scholarships have been granted by the Italian PF to work on two projects (BatERIC and CH-ERIC) selected in the frame of the CERIC Call in 2022, which add to three more projects (FAITH, STEAM, ESBY) selected for RI Development (read more on pages 30-31) .
The CERIC internal research projects, INTEGRA, CEROP, RENEWALS, MAG-ALCHEMI and Dyna Chiro, which have been supported by CERIC.

POLAND

The Polish PF at SOLARIS has received support by CERIC for its beamlines, which have been included in the CERIC open access offer since 2015, and their development is continuous.
The PF has been supported also through the internal research projects, MAG-ALCHEMI and Dyna Chiro, which came to an end in 2020.
Similarly to the other CERIC PFs, also the Polish one applied to the CERIC Call for Expression of Interest in 2022, through which one project was funded (CECOMEC), which includes one PhD student in Fuel Cell research.

ROMANIA

The National Institute of Materials Physics in Magurele has been developing research and offering open access to advanced instruments for Electron Paramagnetic Resonance and High-Resolution Transmission Electron Microscopy (HRTEM).
An upgrade of the HRTEM RI is foreseen in the frame of the ARTEMIS project proposed in response to the CERIC Call in 2022. This project aims to facilitate the approach of in situ and operando analytical TEM/STEM on functional materials for the energy and semiconductor industries.
The Romanian PF also collaborated with the Austrian, Czech, Hungarian and Italian PFs in the frame of the CERIC internal research project RENEWALS. Furthermore, two PhD projects co-funded by CERIC were completed in 2023, after three years of implementation.

SLOVENIA

In addition to the two CERIC-funded PhD scholarships, which are expected to be completed by the end of 2024 for projects to be carried out at the Slovenian NMR Centre, the Slovenian PF has successfully applied to the CERIC Call in 2022. In this frame, the DNANANOCERIC project has been funded, to strengthen CERIC research activities in the field of DNA nanotechnology that exploits the predictable self-assembly of DNA oligonucleotides to design and assemble innovative and highly discrete nanostructures.
Another project (600SSNMRCERIC, read more on page 30), has been funded for RI Development in the frame of the same call.
The Slovenian PF has also been actively contributing to the INTEGRA in the life sciences domain, which is expected to be completed in 2024.

2

Nurturing Talent

CERIC is dedicated to advancing scientific excellence by providing comprehensive training and professional development for scientific and technical personnel.
This chapter highlights CERIC's commitment to nurturing talent, enhancing collaborative training efforts, and inspiring the next generation of STEM students through various initiatives and partnerships. These efforts include training programs, staff exchanges, PhD scholarships, and educational projects, all designed to enhance skills, build competencies, and support the professional growth of researchers and technical and support staff.

Main Achievements

1. **Continuous HR development of CERIC staff operating at the Seat**
2. **Contribution to the capacity building of staff of research infrastructures**
3. **Training pupils and early-stage researchers**
4. **Promotion of talent circulation via the ERA Shuttle HE project**
5. **Supporting HR development at the CERIC PFs**

Upskilling staff at CERIC and beyond

HR development of the CERIC staff operating at the Seat

CERIC has consistently focused on the training and professional development of its staff and managers, embracing a philosophy of lifelong learning. In 2023, the CERIC team invested over 1,500 hours - a significant 400% increase from the previous year - in training sessions designed to enhance their skills across a variety of areas, including project management, team leadership, data stewardship, graphic design, workplace safety, FAIR data and methodologies, Trusted Research Environments, and more.
With the growing relevance of AI in content production, review, and throughout the data lifecycle, AI training is scheduled for all staff members in 2024.
Staff exchanges with other Research Infrastructures (RIs) are viewed as valuable for skill enhancement. For example, CERIC's Deputy Director, Ornela de Giacomo, was seconded for a year to EPOS ERIC as a member of its Executive Coordination Office.

To ensure that management practices within the Consortium remain contemporary and meet the highest standards, CERIC managers Ornela de Giacomo and Andrea Santelli (Chief Administrative Officer) participated in team leadership course at the renowned SDA Bocconi School of Management in Milan. Furthermore, CERIC engaged a professional coach to refine the leadership abilities of its management team.

Overall, CERIC employees have collectively engaged in approximately 3,800 hours of training over the past five years, significantly enhancing their skills and competencies. The chart below illustrates the annual distribution of training hours among CERIC staff from 2019 to 2023.

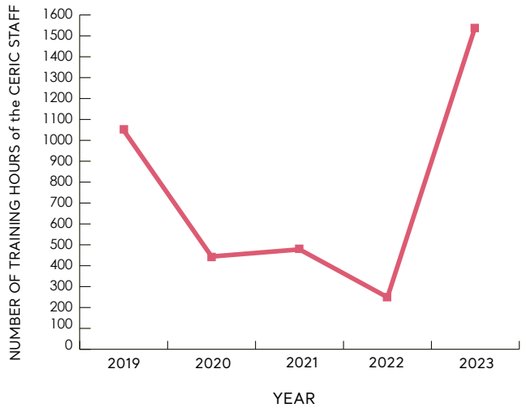


Figure 27
Number training hours of the CERIC staff per year (from 2019 to 2023).

Capacity building of staff at Research Infrastructures

The investments in the staff training results in very high competencies of CERIC's staff, which are recognised Europe-wide. CERIC's Chief Administrative Officer, Andrea Santelli, and Senior Communication Officer, Nicoletta Carboni, were invited by the University Milano Bicocca to train the participants in the Executive Masters in Management of Research Infrastructures in the modules on "Financial Management" and "Raising awareness of RIs", respectively.

Training pupils and early-stage researchers

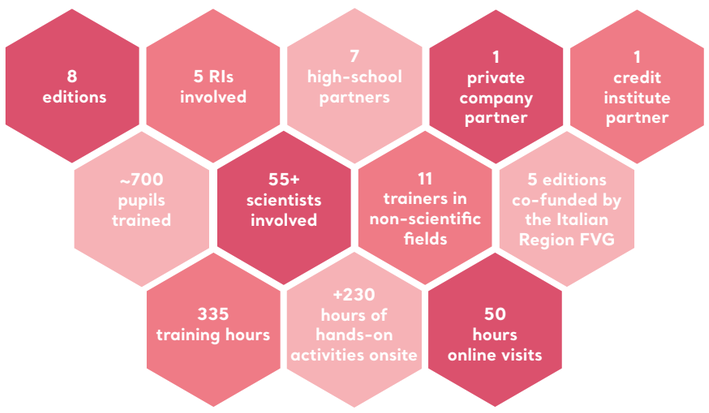
Training high-school pupils. The PaGES 8 project

Education is a key strategic element of CERIC's corporate, science communications, and outreach efforts. A prime example is the PaGES educational project, which has been conducted annually since 2015 in the Italian region of Friuli Venezia Giulia. The primary aim of PaGES is to familiarise young students with the essential skills needed to design, manage, execute, and disseminate the findings of a research project. The programme combines lectures, virtual tours, and hands-on sessions in a research setting, enabling students to make informed decisions about their future studies and careers. This approach bridges educational phases, fostering lifelong guidance and partnership with the corporate sector.

In 2023, the project's eighth edition received funding from the Friuli Venezia Giulia regional authority. This edition involved four scientific high schools and 78 students, enhancing their understanding of various synchrotron techniques available at CERIC, such as lithography and Raman and infrared spectroscopy.

PaGES exemplifies the successful, long-term collaboration among RIs, local institutions, private entities, and public high schools, serving as a model for similar initiatives across Europe. Over its eight editions, five funded by the regional authority, PaGES has engaged seven high schools, five RIs, one private company, and one credit institute. The project has trained nearly 700 students with the support of around sixty scientists and eleven non-scientific trainers, totaling 335 training hours, over 230 hours of hands-on activities at CERIC facilities, and fifty hours of online visits.

PaGES IN NUMBERS 2015-2023

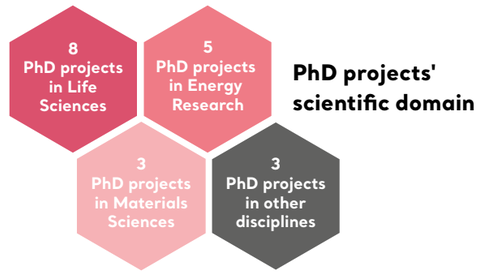


Training PhD students

Following the CERIC's call for PhD scholarships launched in 2020, 19 PhD students have enrolled in doctoral programmes in collaboration with thirty institutions: eight CERIC PFs and two Associated facilities, and twenty universities and RIs in Italy and around Europe.

Eight of the PhD projects are in the Life Sciences domain, five in Energy Research, three in Materials Sciences, and three in other disciplines.

In early 2024, five researchers completed their doctoral programme, whereas all the others are expected to defend their PhD thesis between the second half of 2024 and 2025.



PhD projects' scientific domain

Since the start of the PhD programme, students have had the opportunity to present their research in over ninety national and international workshops and events targeting either the scientific community, or the general public. Moreover, twenty-two papers have been published so far in peer-reviewed scientific journals, and more are expected to come in the following years.

Promoting talent circulation in the ERA

Horizon Europe project ERAShuttle - Accelerating ERA by Sharing Unique Talents for healThy Life and Environment

Aligned with its mission to promote and coordinate the joint training of scientific and technical personnel and young researchers, CERIC has partnered in the Horizon Europe ERAShuttle project.
The project's primary goal is to assess the strengths and weaknesses of Research Infrastructures, enhance research conditions, and attract and retain leading research and innovation talent in the participating Widening countries. This is achieved by bolstering their capacity and skills, thereby fostering research excellence, knowledge valorisation, and cross-sectoral collaboration..
The project facilitates talent mobility between academic and non-academic, aiming to significantly advance collaboration between academia and industry.
CERIC plays a crucial role in fostering synergies among partners by developing a roadmap to optimise the use of available R&I resources. This involves mapping and analysing the R&I capabilities of partners for cross-sectoral collaboration, which is essential for defining synergies and matching partners' R&I resources, ultimately leading to more effective utilisation of these resources. Additionally, CERIC is in charge of monitoring and evaluating the project's activities and outcomes, and identifying best practices for cross-sectoral talent circulation. Starting in 2024, the Consortium plans to host support research staff at its Italian premises, as well as research staff at its Slovenian and Romanian PFs.

Strengthening research capabilities across CERIC

Ten projects specifically focused on human resources, involving PhDs or post-docs, have been approved by the CERIC General Assembly within the framework of the 2022 CERIC Call for Expression of Interest, which aimed at enhancing the capabilities of the PFs and selected associated facilities in Research Infrastructure Development (read more on pages 30-31) and Human Resources (HR).

ENERGY AND ENERGY STORAGE

LEMIS, Analysis and imaging of Light Elements in Materials of Importance to energy Storage using ion beams - Croatian and Italian PFs
A PhD candidate will work on refining existing ion beam analysis techniques for their most effective application in examining materials critical to energy storage. A specific focus of this research is the analysis of light elements.

AEMWE, Investigation of sputtered thin-layer oxygen evolution electrocatalysts in alkaline media and the effect of structural and electronic properties on the catalytical performance - Czech and Austrian PFs
The project will focus on investigating sputtered thin-layer oxygen evolution electrocatalysts in alkaline media. The project aims to build on promising findings from the SPL-HTC RI, specifically in the development of novel catalysts for the oxygen evolution reaction. Researchers will explore magnetron sputtered thin-film catalysts, typically consisting of a Ni, Co, Fe composition with a porous sublayer, examining how their stability and activity are influenced by their morphology and defect density

CECOMEC, Tuning CE-ria-based COMpounds as effective catalyst for Electrochemical Cells - Polish PF / Italian Associated Facility of CNR at ESRF France / Gdansk University of Technology, Poland
The aim of the project is to investigate the influence of double doping on the electrochemical activity of ceria-based compounds that can act as catalysts for fuel electrodes in Solid Oxide Fuel Cells (SOFC) / Solid Oxide Electrolysis Cells (SOEC).
The studies will be based on structural characterisation techniques at the microscopic scale (XAS, XRD) and chemical characterisations coupled to *operando* data collection. The electrodes will be prepared and characterised from an electrochemical point of view in Gdansk, whereas the structural characterisations will be carried out at ESRF and SOLARIS synchrotrons.

BatERIC, CERIC-ERIC for Battery Research - Italian and Austrian PFs
The proposal seeks to appoint a researcher to oversee the newly established Battery laboratory funded by CERIC. This researcher will be instrumental in organizing the laboratory, offering support to users, and spearheading an advanced in-house research program focused on battery technology. The expertise developed through this project will be accessible to academic researchers from universities and research centres, as well as to industrial and high-tech companies, facilitating research and technology transfer activities in the field.

INCITE, probing dyNamiCs In sTructures for Energy-storage - Austrian, Italian and Slovenian PFs
The post-doc researcher will focus on solid-state systems within energy-related applications, analysing their performance over timescales from picoseconds to seconds. The project aims to enhance and integrate the existing research capabilities of x-ray scattering and infrared spectroscopy available at CERIC. The planned research activities will involve optical pump and x-ray/infrared probe experiments, which will be conducted at Elettra and collaborating institutions, including TUG.

HEALTH

PathChip@CERIC, Advanced bio-inspired multiplexing platform for host-pathogen interaction screening - Italian PF / Associated Facility - Joint Research Centre of the EC
The goal of the project is to join the techniques and expertise available at the CERIC facilities of the Elettra laboratories (NanoInnovation and SISSIBio) and the JRC Nanobiotechnology laboratory, to develop an advanced platform to study host pathogens interactions.

DNANANOCERIC, CERIC-ERIC for research in DNA nanotechnology - Austrian, Italian and Slovenian PFs
The project aims to strengthen CERIC research activities in the field of DNA nanotechnology that exploits the predictable self-assembly of DNA oligonucleotides to design and assemble innovative and highly discrete nanostructures. The hired HR will be connecting the existing equipment of various CERIC PFs, to explore their potentials for such research. NMR spectroscopy, Infrared spectroscopy and UVRR spectroscopy in liquid will be used to explore structural features of DNA G-quadruplexes, while atomic force microscopy in liquid and in solid, as well as dynamic light scattering will be used to access information regarding G-wires properties such as height and length. In addition, IR nanoscopy will be exploited for locally probe the vibrational pattern of G-wires at their natural length-scale.

CULTURAL HERITAGE

CH-ERIC, CERIC-ERIC for Cultural Heritage Platform - Croatian, Hungarian, Italian and Slovenian PFs
CH-ERIC is designed to enhance CERIC's research activities in the field of Cultural Heritage (CH). A dedicated researcher, primarily stationed at the Italian PF, will play a key role in promoting and facilitating user research in this area, serving as a liaison between the scientific and humanistic communities. This initiative will be executed through hands-on training across various PF laboratories and by promoting specialised in-house research programmes. Additionally, the researcher will support users throughout the entire research process, and will engage in targeted dissemination efforts aimed at both specialists and the broader public.

TECHNIQUE DEVELOPMENT

InNeuRam4Sos, Integrated Neutron and UV Raman platform for Solvation Science - Hungarian and Italian PFs
The project aims to establish a geographically-distributed, scientifically-integrated platform for CERIC users focused on studying associated liquids and their structural and intermolecular properties. The objective is to develop a station equipped with structure-sensitive probes and experimental expertise alongside innovative data analysis methodologies to cater to the needs of both academic and industrial users in Solvation Science. HR activities will focus on enhancing collaborative research across facilities by integrating complementary techniques such as neutron and UV Resonance Raman scattering. The capabilities of this new interconnected experimental station will be demonstrated through the study of miscible aqueous solutions of model ionic liquids.

SENSORS

DiMiNe, Response of Diamond radiation detectors in the Mixed field of Neutrons and gammas studies by ion microbeam induced sources of neutrons - Croatian and Hungarian PFs
The PhD project is focused on enhancing the understanding and performance of carbon-based semiconductor detectors in mixed radiation environments, particularly improving their capability in neutron-gamma discrimination. The candidate will concentrate on two main areas: developing new detector configurations and extending the methods for investigating and testing these detectors using the Ion Beam Induced Charge technique. This involves creating a new experimental setup that will integrate with the RBI microprobe end-station to produce collimated neutron sources through focused ions. To assess the detectors' performance under pure neutron radiation, further measurements will be conducted at the BNC.

3 Cultivating Innovation and Industry Cooperation

Among CERIC's objectives is economic activity through the collaboration of its facilities with industry. To this end, an industrial liaison has been set up (ILO).
The long-term goal is to contribute to Europe's innovation potential, whereby CERIC positions itself as an important resource in the field of advanced materials, which, as a key enabling technology, affects the performance of various sectors.
The rationale behind the objective is the economic prosperity of Europe, to which also RIs, albeit primarily established to enable scientific research, should contribute by:

- Developing innovative solutions and technology transfer;
- Raising awareness among the industry about RI's potential and solutions;
- Enabling excellent research through access to the excellent facilities usually not available for industry;
- Creating and stimulating industry innovation potential and increasing its performance, providing state-of-the-art knowledge to the industry.
- Aligning the knowledge and potential of RIs with innovation needs from the industry by collecting and mapping its innovation needs.

Main Achievements

1. **Partnership with the European Innovation Council (EIC)**
2. **Membership in the Hydrogen Europe Research**
3. **Updated webpage with use cases on CERIC's techniques for industrial applications**
4. **New collaborations with industry**
5. **Continuous collaboration with an investment fund for start-up creation**

Industrial Liaison Activities

CERIC is an innovation ecosystem offering high-level instruments and expertise for structural, molecular and atomic investigations on materials, biomaterials and nanomaterials, to meet critical safety and performance requirements and assess their capabilities and limitations, even in extreme conditions.
Services for the industry span access to state-of-the-art instruments and techniques for structural and dynamic characterisation of materials, contract research, joint application in projects, as well as training, and spin-off and start-up support.

The Consortium supports the development of key enabling technologies in several sectors:

A retrospective

Starting in 2017, CERIC has been developing its industrial economic activities with the clear objective of contributing to the innovation ecosystem.
It firstly identified the services and solutions offered to the industry, defined the operational procedures to allow and optimise commercial access, and drafted a marketing strategy with the goal of raising awareness of the potential benefits for the industrial sector of working with the Consortium.
Meanwhile, CERIC has dedicated resources to creating and fostering a network between the European RI environment and the entire innovation ecosystem, aligning the knowledge and capabilities of RIs with current innovation needs. The industrial outreach and technology transfer (TT) capacities of its PFs and REs have been continuously fostered to create a proper internal network and collaboration.

Raising awareness of RIs' capabilities

While developing its role as a reference innovation partner in the field of advanced materials, CERIC has faced one of the main obstacles to increasing its innovation impact: the industry's lack of knowledge of the capabilities and potential contribution to boosting industrial innovation that RIs can offer.
To directly engage with industry, CERIC organised five events on different strategic sectors, such as energy, pharmaceuticals and cultural heritage, and attended twelve industry-related events, and a number of Research to Business events, with the goal of targeting industry and gathering its needs.

Industry-related events attended and organised since CERIC's setup

- 5 events organised in strategic domains
- 12 industry-related events attended
- Participation in a wide no. of Research-to-Business events

More recently, in 2023, CERIC took part in the Lisbon Energy Summit and Exhibition, which brought together key stakeholders in the solar, wind, green hydrogen, green ammonia and storage solutions. Several meetings with companies took place to showcase CERIC's key capabilities. The Consortium also set up a booth at the European Hydrogen Week and presented the innovation support that it can provide to different stakeholders.

Also, a new webpage has been released on the CERIC's website, with a selection of case studies showcasing some of the techniques available to tackle specific industry challenges, with the aim of presenting real cases and applications to the needs of industry.

Aligning the knowledge owned by RIs with industry needs and stimulating the innovation ecosystem

To align the capabilities of the RIs with the expectations of the industry, CERIC has continuously dedicated resources to capacity building in industrial liaison (IL) and TT for its PFs and REs, involving companies and key institutions in the research and innovation (R&I) field at various events, to share experiences, best practices and knowledge. For the scope, starting in 2018, CERIC has organised two training workshops and a series of fourteen webinars.

In 2020, selected companies in the energy sector were interviewed to understand how to improve access mechanisms to RIs for the industry.

Industry-related training events and webinars organised since CERIC's setup

with companies and key institutions in R&I

Keeping in mind the importance of adapting and customising communication messages and tools according to the specificities of each industrial sector, CERIC has defined the types of services and solutions offered at each facility in each sector, which has been a useful step to then design and release a dedicated website and brochure for each sector.

In addition to fostering individual projects and collaborations with industry, CERIC has been a proactive player in stimulating the innovation potential of industry and increasing its performance towards a strengthened European innovation ecosystem. To this aim, it has strived to improve the networking with European RIs. A first partnership within EARIV - European Analytical RIs Village, aimed at promoting opportunities offered to industry by large European Analytical RIs (ARIs). Although the network is no longer active, its members have come together in the ReMade@ARI project, where specific activities are dedicated to fostering relationships and stimulating industrial innovation with the support of RIs' capabilities.

Strategic partnership for innovation – CERIC and the EIC

In 2023, to further strengthen the whole innovation ecosystem among both public and private European stakeholders, CERIC presented its full-service profile to the European Innovation Council (EIC), for possible inclusion in its Business Acceleration Services, through which the EIC provides its community with access to coaching, mentoring, training, expertise and business partner.
CERIC succeeded in becoming an EIC partner to provide specific services to companies and projects that gain access to the EIC programmes. This collaboration has allowed CERIC to access a pool of highly innovative entrepreneurs and companies and to support entrepreneurial researchers, start-ups, high-tech SMEs, and more, contributing to the development of highly innovative and disruptive technologies that might solve current key European innovation problems, and eventually create new markets.

Contribution to transferring innovative solutions to the industrial ecosystem

CERIC has continuously supported its Representing Entities and PFs in strengthening their relationships with industrial stakeholders, not only through IL activities, but also through the transfer of innovative solutions, such as the innovations stemming from the research carried out independently by the REs. As an example, CERIC signed an agreement with some of its REs to promote partnerships with the industry and investment opportunities.
CERIC also collaborated with an investment fund dedicated to the creation of start-ups based on technologies developed by universities, technology centres and RIs. Furthermore, the Consortium supported the participation of its REs and PFs in major international events, such as TechConnect, or the Big Science Business Forum, to present high-level innovations to potential investors or industrial acquirers.

Providing access to excellent science for industrial innovation

Thanks to the awareness-raising activities carried out in 2023, CERIC entered into deeper discussions for future collaboration with two companies contacted during the Lisbon Energy Summit, as well as with a large energy company participating in the EU Hydrogen week. Furthermore, thanks to the advantages companies have in accessing several techniques through one single entry point, BASF US benefited from the analytical services provided by CERIC through its commercial access scheme, and a new NDA was signed with a company, to start feasibility tests involving four PFs.
On the other hand, on the basis of applicants' declarations, 5% of investigations carried out in 2023 via CERIC's open access have an industrial interest, keeping the same trend as in the last five years, whereas 11% of the overall 2023 publications of CERIC users is related to industry (publications that derive from a proposal declared to be of industrial interest by the user, or which have as co-author someone affiliated with a company), showing a positive trend since 2018, when this indicator has started to be calculated (Figure 28).
In addition, patent citations of CERIC articles published since 2015 were taken into account as an indicator of the innovation potential of CERIC research: 118 CERIC articles were cited directly (first-degree citations), or were cited by the publications cited in the patents (second-degree citations), which corresponds to 17% of CERIC´s articles.

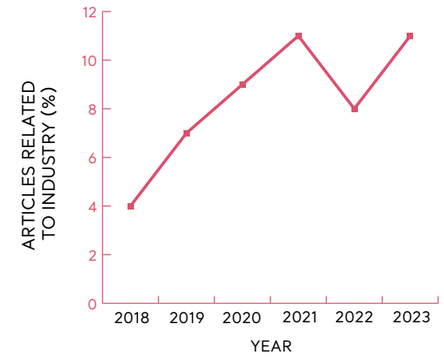
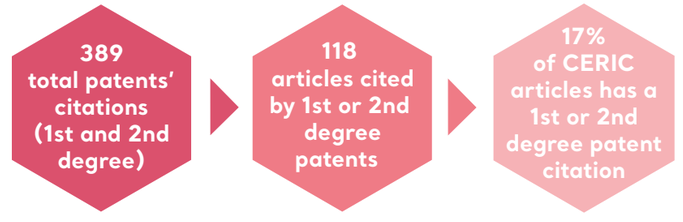


Figure 28 Percentage of articles related to industry per year (from 2018 to 2023).

Results on patent citations' analysis of CERIC's articles since its setup



4

Other EU Priorities and Impact

As an entity established by the European Commission, CERIC should contribute to the European Union's objectives by contributing to the policy priorities. Prominent among these are:

- Contribution to the twin transition
- Decrease of research and innovation gap within EU and EU's neighbourhood, and
- Development of the European Research Area.

CERIC's contribution to these priorities is presented in this chapter.

Main Achievements

1. **Increased support for Battery and Energy research priorities**
2. **Established collaborations in the frame of Hydrogen Research Europe and European Innovation Council**
3. **Development of the ERIC framework**
4. **Improving and implementing the ERIC Regulation**
5. **Continuous efforts in decreasing the R&I gap in the ERA**
6. **~1500 attendees to CERIC's science dissemination activities**
7. **Continuous contribution to policy development**

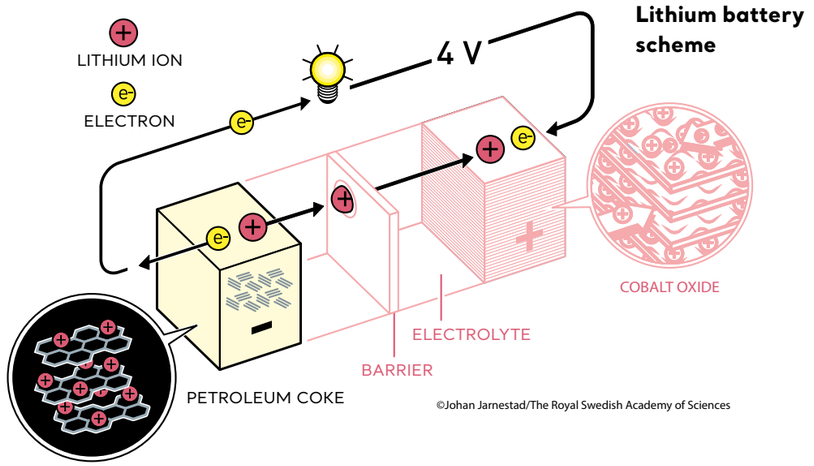
Supporting Battery and Hydrogen Research

Development of dedicated access for hydrogen and batteries

Starting in 2020, CERIC has increasingly dedicated and upgraded its resources to position itself as a cutting-edge RI for energy research. It has implemented the recommendations of the expert groups on Battery[1] and Fuel Cell[2] research, to boost its role in fostering a transition towards renewable energy. The Consortium has progressively enhanced its capabilities by developing specialised access for hydrogen and battery research. It has also broadened its array of advanced analytical techniques, which now support a diverse range of experiments aimed at developing next-generation batteries. These improvements focus on enhancing performance, extending lifetimes, and utilising various materials. Additionally, the Consortium is advancing more efficient energy storage solutions, such as fuel cells, to meet emerging energy demands.

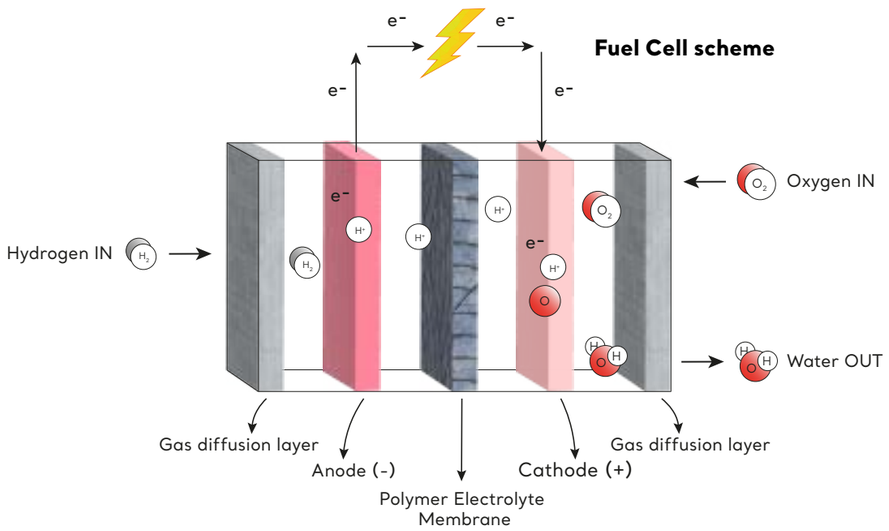
Among the extended offer of CERIC is the Battery Energy Storage Testing Laboratory (BESTEST) of the European Commission's Joint Research Centre (JRC) located in Petten, in the Netherlands, for analysing the performance of battery materials and devices by cycling them under controlled environmental conditions, such as different temperature and relative humidity, and which provides integrated thermal analysis and gas analysis systems for battery components testing.
Another JRC laboratory in Petten, added to CERIC's offer in 2023, is the Fuel Cell and Electrolyser Testing facility (FCTEST), which allows for the validation of testing procedures and measurement methodologies for the performance assessment of fuel cells.

The techniques and tools available at the Hydrogen Technology Centre (HTC) facilities located at Charles University in Prague have also been included in CERIC's open access offer in 2023. These allow for testing and analysis of user-provided catalysts and cell components for water electrolysers and fuel cells through different techniques.



[1] B. Bozzini, A. Iadecola, L. Stievano, *Report of CERIC's Expert Group on Batteries*, 2020, https://doi.org/10.5281/zenodo.3891479
[2] B. Bozzini, S. Cavaliere, J. Drnec, M. Tromp, *CERIC-ERIC Report of the Expert Group on Fuel Cells*, 2021, https://doi.org/10.5281/zenodo.5720332

These new techniques complement the purchase, in the previous years, of new instruments at the Czech, Romanian, and Slovenian PFs, for advanced analysis of batteries and battery stacks (CZ), for enabling *in-situ* and *operando* experiments (RO) and for electrochemistry measurements (SLO).

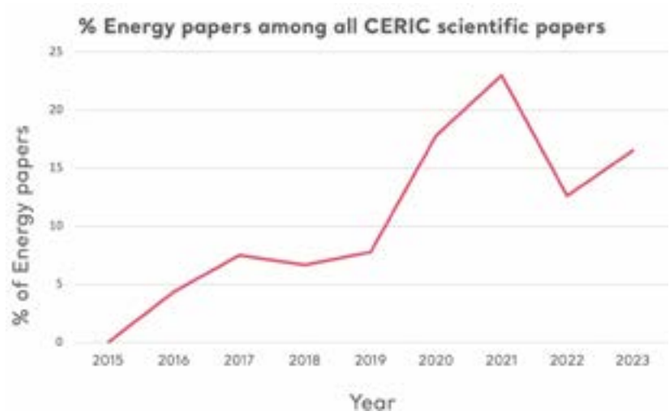


Publications in the domain of Energy Research

In 2023, eighteen peer-reviewed papers were published in the domain of energy research. These equal 16.5% of the overall number of scientific publications published by CERIC users in the same year, which is well above the average of articles published per year in this domain (10.7%) since CERIC's setup.

As shown in Figure 29, starting the implementation of the recommendations by the expert groups on batteries and fuel cells appointed by CERIC, the number of energy papers has nearly doubled in the last 3-year period, and the cumulative IF has also increased by 53%, if compared to the period 2018-2020.

Figure 29
Number of energy papers released in the periods 2018-2020 and 2021-2023



Reaching out to target communities

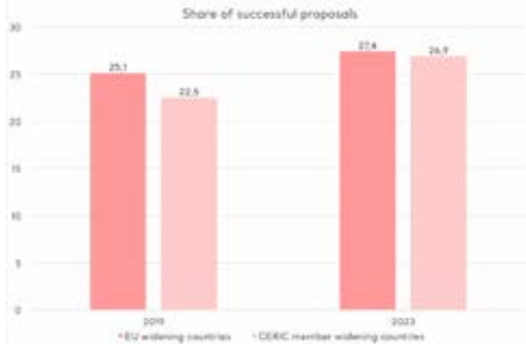
Starting in 2023, CERIC has become a member of Hydrogen Europe Research (HER)* to contribute to addressing research bottlenecks and strive for the development of a hydrogen economy, which would achieve the EU's sustainability and climate objectives.
HER, as a member of the Clean Hydrogen Joint Undertaking strives to accelerate the development and deployment of a European value chain for clean hydrogen technologies, whereas a dedicated Policy working group including all HER members meets monthly to regularly discuss policy developments at the European level that could impact the research community. Another working group has been set up to discuss skills needs in the hydrogen sector and how to address them, involving stakeholders spanning universities, research centres, industry, regions and national associations.

As new ecosystem partner of the European Innovation Council (EIC) since the end of 2023, CERIC has also started to offer a portfolio of tailored services to EIC beneficiaries, to help both industry and RIs to boost R&D activities related to the characterisation and modification of materials in the fields of energy, health, food, cultural heritage and more.

Decreasing the R&I gap in the ERA

Reducing disparities in research and innovation (R&I) performance by sharing knowledge and expertise across the EU is an important objective of the European Union. This effort aims to assist countries and regions that are trailing in R&I performance, including the EU's outermost regions, in order to secure a competitive stance in global value chains.
CERIC contributed to these Community objectives by enabling access to its facilities and support, usually not available in these countries, thus enabling excellent research, and supporting circulation of researchers, rather than brain drain, enabling professional development of scientists from less R&D intensive regions.
Over the last five years, the share of successful proposals from widening countries increased (Figure 30). This is primarily due to an increased share of successful proposals from the widening countries, where CERIC has a PF, or associated facility, demonstrating CERIC's contribution to the decreased R&I gap in Europe.

Figure 30
% of successful proposals from widening countries



*Hydrogen Europe Research is an international, non-profit association composed of more than 150 Universities and Research & Technology Organisations (RTO) from 29 countries all over Europe and beyond. Its members are active within the European hydrogen and fuel cells sector.

Public image of Science

Science communication activities with pupils and lay publics

In 2023, CERIC staff, users and PhD students contributed to a number of science communication events, in which they showcased their studies to a heterogeneous audience, mainly made up of local school students and science enthusiasts, reaching out to a total of nearly 1500 participants.

Our PhD student **Lorenzo D'Amico** explained his research on fibrosis at the event *Waiting for the European Researchers' Nigh*t in the frame of the Maker Faire Trieste.
Moreover, the research group of the Austrian SAXS beamline (**Sumea Klokic, Benedetta Marmiroli, Christian Morello, Barbara Sartori** and **Philipp Aldo Wieser**) proposed the activity *And there was light! Lasers, microscopes and X-rays to analyse matter* at Trieste Next, the Festival of scientific research held in Trieste on 22-24 September 2023. Among microscopes, lasers, tools for creating a vacuum and software for reconstructing the conformation of objects and molecules, school pupils have been involved in hands-on activities to shed light on the structure of matter.

On 26 September 2023, as part of the project *A night with the researcher*, another CERIC PhD student, **Martina Zangari**, proposed a seminar addressing high-school pupils, to explain how asbestos fibres interact with certain proteins, causing their misfolding and altering their functionality.

CERIC researchers also participated in the European Researchers' Night—SHARPER, held in Trieste at the end of September 2023, with two events at the Immaginario Scientifico Science Centre. Martina Zangari and Lorenzo D'Amico presented their studies using complementary techniques, such as spectroscopy, microscopy, imaging, and histology, in a panel focused on health.

CERIC researcher, **Chiaramaria Stani**, participated in a talk/concert entitled *Stradivari and his violins: the secrets of a unique sound*, together with two students at the Tartini Music Conservatory, **Vittorio Chalvien** and **Maharita Shakunova**, to showcase the work carried out at CERIC on Stradivari violins and, more generally, in the field of Cultural Heritage.

The same topic was addressed in November 2023 by Dr. Stani and CERIC user, **Giacomo Fiocco**, at the conference entitled *Searching Antonio Stradivari's signature*" at the Genoa Science Festival.

Contributions to policy development

Improving the functioning of ERICs

All ERICs are members of the European ERIC Forum. A second Implementation Project for the ERIC Forum officially started in September 2023. The project brings together the ERIC community to further reinforce the cooperation between the ERICs, and to support their implementation, shaping their community identity and consolidating their integration within the ERA.
The overall strategic approach of the ERIC Forum will contribute to addressing critical challenges, developing best practices, and framing the necessary knowledge to support ERICs-to-be in aspects spanning sustainability, performance monitoring, quality management and reproducibility, HR management, accounting, VAT exemption, contracting, insurance and intellectual property.
Thus, the project has further contributed to the implementation of the ERIC Regulation by identifying challenges and possible approaches to improving it and investigating HR management solutions to foster ERIC integration.

CERIC, as leader of the work package "Strategy on European Employment contract", led the background research and preparation of a survey for studying and analysing the legal treatment, at the European level, of personnel working for the ERICs, for future development of a common core of rules for the ERICs' HR management in compliance with the European Countries' national legal systems.
One of the project's aims is to build the identity of ERICs as essential bodies and stakeholders, and to ensure that ERICs have an adequate representation at the European level, as well as a unified voice to speak with, and to build stronger links with the society. In this respect, CERIC has been continuously addressing the project's key target audiences through tailored communication actions.

In 2019, an Italian ERIC Forum was established to maintain collaboration among ERICs of which Italy is, or will become a member. Activities have continued throughout the years.
The Italian ERIC Forum serves as a platform for sharing insights and experiences related to managerial, legal, tax, finance, HR, administrative, and other matters at both the national and EU levels. The Forum also seeks to pinpoint shared challenges and best practices that influence ERICs' operations in Italy, develop a coordinated approach with Italian and EU authorities where beneficial, and enhance the visibility, impact, and sustainability of ERICs' activities within Italy.

With particular respect to HR management and contract framework, in December 2023, CERIC organised a conference in Rome on the work at public/private research institutions, aimed at identifying the strongest hurdles which these institutions face in attracting and managing HR at the European level, due to the lack of a coordinated treatment and professional recognition of the personnel working for those Institutions. A position paper has been adopted as the conference's outcome, with the shared participants' commitment in setting up a working group to establish a regular dialogue on these topics.

Review of the CERIC legal framework

The CERIC legal framework review process also started in 2023, seeking greater consistency among the legal documents ruling CERIC activities and operations.
The initiation of national funding for CERIC activities and the enhancement of operations at its PFs provide an opportunity to advance through stronger collaborations between the PFs. Although the current Internal Regulations consider these aspects, they have not been fully implemented yet.

Considering the new contribution model adopted by the GA, the GA approved the setting-up of a Working Group composed of the ministerial delegates of the Member Countries who choose to take part, the Chair of the Board of Directors and the Executive Director, with the task to review, update, improve and complete the Consortium internal rules and regulations to allow for a better integration of CERIC's activities and make the related implementation proposals to the GA.

Furthermore, after the adoption, in 2022, of the GEP and of the Code of Conduct against mobbing, harassment or discriminatory acts, CERIC has further developed its competencies in gender equality tools and monitoring system through participation in the related ERIC Forum 2 work package "Capacity-building programme for ERICs personnel upskilling".

CERIC highlighted in three EC reports

Three EC reports published in 2023 provide a focused analysis on the effectiveness and strategic importance of CERIC as an example of ERIC, exemplifying successful strategies in managing and enhancing RIs.
Moreover, two governments that are members of CERIC (Czech Republic and Croatia) have updated their Reseach Infrastructure roadmaps referring to CERIC as a relevant RI.
A case study published by the European Commission[1] in 2023 focuses on the external coherence of funding for RIs in Europe, particularly those with a European Research Infrastructure Consortia (ERIC) status. It explores how over EUR 20 billion has been allocated across the EU since 2000 to develop over 50 RIs, including 23 ERICs.

The report highlights several good examples and successful strategies employed by CERIC, which include:

- **Synergistic Funding Approaches:** CERIC and its facilities have effectively combined funding from various sources, including national contributions, European Structural and Investment Funds, Horizon 2020, and other EU funding streams. This approach has increased the sustainability of its distributed infrastructure.
- **Strategic Use of In-Kind Contributions:** CERIC, with the agreement of the GA, has introduced membership fees, which provide a more flexible and sustainable funding structure allowing stronger integration.
- **Digitalisation and European Open Science Cloud (EOSC) Involvement:** CERIC has played an important role in Open Science initiatives, notably by participating in and leading Horizon 2020-funded projects like ACCELERATE and PaNOSC. This involvement supports the EOSC, aligning with the broader strategic goals of the European Research Area.
- **Addressing Training and Capacity Building:** Despite initial challenges in accessing training networks due to diverse research interests, CERIC has developed internal projects that foster collaboration and could potentially lead to creating training networks around these projects. This approach helps in building scientific capacity across its network.

[1]European Commission, Directorate-General for Research and Innovation, Evaluation study on the external coherence and synergies of Horizon 2020 within the European research and innovation support system – Case study report, Publications Office of the European Union, 2023, https://data.europa.eu/doi/10.2777/054469

The conclusions and recommendations stress the necessity of combining various funding sources to address regional, national, and international needs and emphasize the creation of synergies between Horizon 2020, European Structural and Investment Funds, and other funding mechanisms to sustain and expand research infrastructures effectively.
Following the Case study report, the Final report refers to CERIC's review of the possible funding synergies for a distributed RI CERIC, emphasizing a highly complementary picture among various funding streams. The document highlights CERIC's table on synergies of funding sources, developed within the frame of the EC funded project ACCELERATE.

The table below showcases an example of funding sources per type of RI activity by CERIC, as published in the EC's report[2].

ACTIVITY	POSSIBLE FUNDING SOURCES
Development of infrastructure	ERDF, EIB, national funding
Ensuring open access to facilities	National funding, Framework Programme (mainly for pilot activities)
Training of scientific and technical personnel	National funding, Framework Programme, ERDF, Territorial Cooperation
Strategy and policy development	Framework Programme, Territorial Cooperation
Operational and coordination costs	National funding
Joint R&D activities	Framework Programme, Territorial Cooperation, ERDF, national funding

In addition to the two EC's reports, CERIC was also highlighted in the outcome of the Policy Support Facility Country - Moldova exercise (2020-2022)[3], in which the Director of Slovenia's PF Janez Plavec was an expert. The report includes an overview and assessment of the Moldovan R&I system, the overarching challenges facing it, a critical review of strategic and policy recommendations, and operational steps for each of the three specific R&I areas of interest. The report stresses that participation of the Slovenian NMR (nuclear magnetic resonance) Centre in CERIC is an example of how even a small country can invest in larger RIs through in-kind contributions as part of an international consortium. Noteworthy, opening up a given RI (i.e., NMR Centre) to all researchers across the world based on the merits of their submitted proposals contributes to the quality and continuity of the facility. It also helps to build capacity (equipment and personnel) within the RI, and improve its overall contribution to R&I in the country and informs future research priorities and investments aimed at addressing societal challenges. The study recommends that the Moldovian government develop a framework for access to research infrastructures. This will lead to better and wider participation by Moldovan researchers in the existing pan-European RIs, such as CERIC-ERIC and EMPHASIS ERIC. Consequently, it can boost the quality of Moldovan academic and industrial research at a relatively low cost, the study concludes.

These observations from the three EC reports affirm CERIC's role as a model in the effective management and operational enhancement of research infrastructures, illustrating a template that could guide the development and expansion of similar entities across Europe.

[2]European Commission, Directorate-General for Research and Innovation, Evaluation study on the external coherence and synergies of Horizon 2020 within the European research and innovation support system – Final report, Publications Office of the European Union, 2023, https://data.europa.eu/doi/10.2777/90147
[3]European Commission, Directorate-General for Research and Innovation, Curaj, A., Angelis, J., Galan-Muros, V. et al., With ambition for transformation – Revisiting research funding, research infrastructures and science-industry links in the Republic of Moldova – Final report – PSF country, Publications Office of the European Union, 2023, https://data.europa.eu/doi/10.2777/138215

5

What is CERIC

The mission and main purpose of CERIC, in line with the ERIC Regulation (EC No 723/2009), is to establish and operate a multidisciplinary distributed research infrastructure on a non-economic basis.

Mission

CERIC is a research infrastructure integrating and providing open access to some of the best facilities in Europe, to help science and industry advance in all fields of materials, biomaterials and nanotechnology. It enables the delivery of innovative solutions to societal challenges in the fields of energy, health, food, cultural heritage and more.

Vision

CERIC co-creates the European Research Area by enabling the best global researchers to realize their ideas in a multicultural research environment with a worldwide reach. By expanding insight into materials on the nano-scale, CERIC contributes to solving contemporary societal challenges.

CERIC is an integrated multidisciplinary research infrastructure for basic and applied research in the fields of materials, biomaterials and nanotechnology. It integrates leading national research institutes into a unique international infrastructure, having its statutory seat in Trieste – Italy, and its nodes distributed in Austria, Croatia, Czech Republic, Hungary, Poland, Romania and Slovenia (Serbia is currently pending full membership). In each country, a Partner Facility (PF) ensures access and outreach to all national scientific communities and to users from all over the world, who compete for free access to over 60 techniques available through a single-entry point and based on the use of electrons, ions, neutrons and photons for the analysis and synthesis of materials. This service is also open to commercial users on market-based conditions.

The governing structure involves ministerial representatives of the Member Countries, as well as the directors of the Partner Facilities. CERIC management and research activities are distributed in the participating countries and cover administration, communication, technology transfer and project management. A common support system allows the distributed staff to operate in an integrated way for transnational and cooperative projects and joint ventures.

Each Member Country contributes to CERIC by making available and supporting a high-quality PF, which is continuously improved by being exposed to international users competing for access through peer-review evaluation and selection of their proposals, based on excellence. The PFs are strongly complementary to each other and act as a whole as an international agency providing support to the best researchers and research projects, contributing access to advanced analytical and synthesis facilities.

CERIC's international, pan-European approach, in line with ERIC Regulation EC No 723/2009, avoids duplication and fragmentation in the research system, and increases the integration and competitiveness of the European Research Area (ERA), speeding up East-West alignment in the ERA.

CERIC Partner Facilities, Instruments and Techniques

AUSTRIA

Graz University of Technology

is dedicated to the structural characterisation of nanosystems with scattering techniques covering topics such as advanced materials, (bio-)polymers, proteins in solids, surfaces, liquids and in the gas phase. The facility provides access to its light and X-ray scattering laboratories, as well as to the Austrian SAXS beamline and Deep X-ray Lithography beamline, both at Elettra.

CROATIA

Ruđer Bošković Institute

develops and allows access to ion beam techniques for materials' modification and characterization, such as PIXE and RBS, as well as a heavy ion microprobe, dual beam irradiation chamber with RBS/channeling, and TOF ERDA spectrometer.

CZECH REPUBLIC

Charles University Prague

has expertise in surface analysis, thin film growth and studies of the reaction mechanism on catalyst surfaces. It offers Photoelectron Spectroscopy (XPS, XPD, ARUPS) with Low Energy Ion Scattering Spectroscopy and LEED, Field Emission Gun Scanning Electron Microscope, Near Ambient Pressure XPS and access to the Materials Science Beamline at synchrotron Elettra dedicated to soft X-ray photoelectron spectroscopy and NEXAFS.

HUNGARY

Budapest Neutron Centre

performs and offers R&D in nuclear science and technology, studying the interaction of radiation with matter and doing isotope and nuclear chemistry, radiography and radiation chemistry, surface chemistry and catalysis (PGAA, NAA, RAD). Neutron scattering instruments allow investigation of the microscopic properties of solids, liquids, soft materials, biological objects and condensed matter (PSD, SANS, TOF, GINA, MTEST, BIO, TAST).

ITALY

Elettra Sincrotrone Trieste

covers a wide range of experimental techniques and scientific fields, including photoemission, spectromicroscopy, crystallography, dichroic absorption spectroscopy, x-ray imaging, etc.

POLAND

National Synchrotron Radiation Centre SOLARIS

offers techniques based on synchrotron radiation: the PEEM/XAS beamline (200-2000 eV photon energy range) is equipped with PEEM - Photoemission Electron Microscopy - and XAS, devoted to spectroscopy studies by absorption of soft X-rays. The UARPES undulator beamline (8-100 eV photon energy range) is equipped with an ARPES end-station, allowing precise studies on the structure of energy bands of solids and their surfaces. The new cryo transmission electron microscope FEI Titan Krios 3Gi enables researchers to look at the macromolecules almost in their natural environment.

ROMANIA

National Institute of Materials Physics

offers access to HRTEM and EPR laboratories for research in solid state physics and materials science, including the synthesis and characterisation of advanced materials for applications in microelectronics, catalysis, energy industry and ICT.

SLOVENIA

National Institute of Chemistry

offers NMR spectroscopy for chemical analysis and identification, for determining 3D structures and studying the dynamics of small and larger bio-macro-molecules, for tracking chemical reactions in analytical and bioanalytical procedures, for studying polycrystallinity and identifying metabolites and various amorphous forms.

Associated Facilities

EUROPEAN COMMISSION

European Commission's Joint Research Centre (JRC) Nanobiotechnology Laboratory in Ispra
allowing interdisciplinary studies with a special emphasis on the characterisation of nanomaterials, nanomedicines, advanced materials and micro(nano)plastics.

European Commission's Joint Research Centre (JRC) Fuel Cell and Electrolyser Testing Facility (FCTEST)
which allows testing of low and high-temperature PEM fuel cell and electrolysis test stations in single cell and stack.

European Commission's Joint Research Centre (JRC) Battery Energy Storage Testing Laboratory (BESTEST)
allowing to analyse the performance of battery materials and devices by cycling them under controlled environmental conditions.

GREECE

Ultraviolet Laser Facility of the Foundation for Research and Technology (ULF-FORTH)
a multi-disciplinary scientific laboratory dedicated to laser-based science, supporting high quality basic and technological research.

ITALY

Bio Open Lab (BOL) in Salento, Salerno and Trieste
providing an integrated system of research equipment and instruments dedicated to investigations in the field of biological and biomedical research.

ITALY / FRANCE

X-ray absorption spectroscopy beamline of CNR @ESRF

6

Operations and Finance

Main Achievements

1. **Adoption of the new CERIC business model introducing Members' fees**
2. **Discussion towards a further integration of CERIC's PFs**
3. **Advancements on the adoption of GDPR**
4. **Update and adoption of the Data Management Plan**
5. **Financial and in-kind annual account**

CERIC's new funding model

In 2023, the General Assembly (GA) of CERIC approved an amendment of the CERIC Statutes, which modifies the business model of the Consortium. Over the past years, a cash contribution was contributed only by the host country, Italy, while all members' contributions were in kind. The Statutes of CERIC are modified, allowing for annual fees by all Members.

The new model, applicable from the financial year 2024, foresees that the total annual contribution of the country presently hosting the Statutory Seat will be maintained at 5,5 M EUR and includes its Member contribution and the Host premium. Furthermore, the decision of the GA states that as long as the contribution by the Host Member State of CERIC allows covering the statutory operations fully, 90% of the Members annual contributions are dedicated, on average over 5-year period, to supporting actions integrating the capabilities of the Members' PFs, such as PhDs, post-docs, joint research projects, infrastructure investments and promotion of CERIC PFs research offer. The remaining 10% will be used for ordinary activities, including the operation of the statutory seat.

The annual monetary contribution by each Member consists of a fixed contribution of 30.000 EUR plus a variable contribution proportional to its GDP calculated according to a formula annexed to the CERIC Statutes.

GDPR and Data Management – activities and next steps

Data Management Plan – activities and next steps

The Data Management Plan (DMP) is a comprehensive document that guides the handling of scientific data throughout and beyond a research project's lifespan. Initiated during the Scientific Proposal Management Submission, the DMP is initially crafted by the Principal Investigator, who furnishes essential initial information regarding the scientific data lifecycle—from pre-experiment stages to post-experiment data management requirements.

In the ongoing efforts to implement the DMP within CERIC, significant progress has been made through the introduction of the Data Stewardship Wizard platform. The platform serves as a central tool for collecting the DMP filled in by the PIs during the proposal submission process. However, considering the multi-stage nature of the DMP process, we are now transitioning to the second stage, which demands a comprehensive approach to ensure full integration and validation of data treatment specified by the PIs. To achieve this, a set of support activities has been structured and prepared. These activities aim to develop harmonised data operations and meticulously document aspects related to data handling, archiving procedures, dataset construction, and storage methodologies.

As a pivotal component of these support activities, the establishment of a Technology Experts Group is vital to developing, training, and promoting the data standards across all PFs. The group will contribute to the review process of the Scientific Data Policy and work towards achieving compliance with CERIC's Scientific Data Policy and with all domain-relevant rules and regulations governing scientific data management.

Being GDPR compliant in a distributed RI

To streamline the transition towards the implementation phase of CERIC's scientific data management policies in compliance with national and EU laws and regulations governing access to and management of CERIC's scientific experimental data, the development of specific agreements is necessary. At the same time, it is equally important to have protocols to help us achieve compliance with the internal policies and regulations of each PF to facilitate CERIC operations.

The first step in this process implies the improvement of the application of GDPR and Data Exchange Agreements in collaboration with the Italian Representing Entity, Elettra-Sincrotrone Trieste S.C.p.A. Subsequently, efforts will be directed toward defining the processes and protocols involving handling of personal data generated during joint projects between CERIC and its partners and collaborators. This includes the formulation of an effective internal framework for managing such data, with implementation on the horizon.

By leveraging these pilot initiatives, the Consortium staff, with the support of the PFs, will conduct in-depth research and strive to ensure compliance with the prevailing data practices and regulations in all PFs.

Following the preparatory work conducted in 2023, it will be possible to formulate comprehensive legal and administrative arrangements, essential for implementing CERIC's IT policies in line with the laws and regulations specific to each PF.

Financial Statements 2023

The financial statements give the details of the additional expenditure for the organisation, coordination and governance activities of the Consortium, which contribute to increase the effectiveness of the much larger in-kind contributions by the CERIC's member countries through the PFs.

The financial statements are compiled in conformity with the IPSAS - International Public Sector Accounting Standards issued by the International Public Sector Accounting Standard Board (IPSASB).

Balance Sheet - Assets and Liabilities		
	2023	**2022**
ASSETS	**8,584,072.52**	**8,116,872.46**
Non-current Assets	**1,417,294.87**	**1,467,891.79**
Plant, property and equipment	1,397,566.25	1,434,146.36
Intangible assets	19,728.62	33,745.43
Investments in associates	-	-
Current Assets	**7,166,777.65**	**6,648,980.67**
Inventories	-	-
Long-term credits	-	-
Short-term credits	135,987.35	201,782.42
Other current credits and receivables	-	-
Cash and cash equivalents	6,875,385.68	6,090,060.82
Prepayments and accrued income	155,404.62	357,137.43
EQUITY AND LIABILITIES	**8,584,072.52**	**8,116,872.46**
Equity	**-**	**-**
Equity	-	-
Capital and other permanent contributions from Members	-	-
Reserves	-	-
Accumulated profits	-	-
Non-current Liabilities	**516,633.99**	**259,132.09**
Long-term financial debts and loans	-	-
Other long-term debts and liabilities	-	-
Advance payments for externally funded projects	294,293.43	44.469.05
Pensions funds and other benefits for compensation employment	222,340.56	214,663.04
Long-term provisions	-	-
Current Liabilities	**8,067,438.53**	**7,857,740.37**
Short-term financial debts	-	-
Other short-term debts and liabilities	295,478.72	347,584.03
Advance payments for externally funded projects	254,789.52	53,343.75
Other current payables	274,684.21	336,741.75
Contingent liabilities	40,783.62	40,783.62
Deferred income and accrued expenses	7,201,702.46	7,079,287.22

Profit and loss account			
		2023	**2022**
Revenues		**2,927,480.77**	**3,050,142.07**
	National and international grants and contributions	2,922,363.29	3,044,978.65
	Contributions in-kind	-	-
Other revenues	Other revenues	5,117.48	5,163.42
Operating costs		**2,423,102.14**	**2,579,533.96**
	Costs for raw materials, supplies and goods	3,437.71	14,138.10
	Costs for services	956,158.83	988,795.22
	Resources committed in-kind to CERIC from contributors	-	-
	Staff costs	1,446,405.27	1,557,763.98
	Costs of rents, concessions and royalties for trademarks	-	-
Other operating costs	Costs for institutional activities	17,100.33	18,836.66
Ebitda (Earnings before Interest, Taxes, Depreciations and Amortizations)		**504,378.63**	**470,608.11**
Depreciation		474,413.51	433,704.18
Write-downs for impairment of tangible and intangible assets		-	-
Ebit (Earnings before interest and taxes)		**29,965.12**	**36,903.93**
Financial income and expenses		**7,212.88**	**401.07**
	Financial income	7,485.10	569.4
	Financial charges	272.22	-168.33
Income from investments		-	-
Value adjustments to financial assets		-	-
Result before tax		37,178.00	37,305.00
Taxes		37,178.00	37,305.00
Result for the year		**-**	**-**

Additional information is provided in Annex 1 (Notes to the Financial Statements as at December 31, 2023) in order to explain the assumptions used to prepare the numbers in the financial statements, as well as to better understand the company's financial position.

Annex 1

Notes to the Financial Statment as at December 2023

Accounting Criteria

These annual Financial Statements have been compiled in conformity with the IPSAS (International Public Sector Accounting Standards) international accounting standards issued by the International Public Sector Accounting Standard Board (IPSASB), and in process of being adopted by the European Commission within the meaning of Council Directive No 2011/85/EU of 8 November 2011, on requirements for budgetary frameworks of the Member States.
The decision voluntarily to adopt an accounting system that can be connected to international principles is consistent with the process of harmonization started some time ago by the EU Commission, but not yet completed.
The IPSAS can in general function as a basis for a harmonised accrual-basis accounting standard passing through its transformation into EPSAS (European Public Sector Accounting Standards).
CERIC-ERIC is set up as an international organisation with scopes of general interest typical of an entity referable to the public sector. CERIC-ERIC should therefore be able to relate to its Members in different countries in a common language. This should be adopted in all matters and at all levels, and thus also in the model of presentation of economic-financial topics that support annual accounts and budgets.
The use of international accounting standards referable to the public sector, taking-into account the specific character and scopes of CERIC-ERIC, adequately conforming to the legal characteristics of the entity and to its functions and scope, allows the development of well-defined best practices, the impact of which on the financial aspects is measurable and effective. The use of international accounting standards, in fact, allows information on the financial statements to be presented in a common way for users/stakeholders of different nationalities.

It is possible in this way to ensure that:

- The information is relevant, reliable, comparable and understandable;
- The terminology used is common, appropriate and explanatory among Members and for similar international organisations outside Europe;
- The financial statements are auditable by the International Standard of Audit by auditors from different countries;
- A host country change - and thus any site change - is not relevant for the comparability of information and models, books and records of the accounting system;
- The accounting system is able to present the in-kind contribution model, and to provide analytical accounting for projects and separate accounting for economic activities.

The aim of the annual financial statements is to provide information on the assets and liabilities, the profit or loss and changes in the financial structure of the Consortium, useful to a wide range of users. The financial statements are prepared within a general-purpose framework.

It has been compiled taking-into account international accounting standards for the public sector (IPSAS), where applicable, and integrated in order to be consistent with the legal and effective structure of CERIC.
Of the various options allowed by IPSAS 1, the Consortium has chosen to present the layout of the balance sheet distinguishing between current and non-current items, and the layout of the profit and loss account classifying the expenses by nature.

In its drawing-up, the following principles have been observed:

- The items have been evaluated prudently, taking into account the perspective of the continuity of the activities, as well as the economic function of an asset or liability;
- Only incomes and expenditures related to the financial year have been accounted, independently on the day of encashment or payment;
- The risks and losses related to the financial year have been accounted for, even if known after the end of the financial year.

These Notes have been compiled with the aim of clarifying, completing and detailing the information contained in the balance sheet and in the profit and loss account, in addition to providing information on the applied evaluation criteria, on movements that have taken place, and changes in various assets and liabilities.
The explanatory notes are an integral part of the following documents, to present these financial statements and provide descriptive and schematic information, with particular reference to property aspects, as well as economic and financial aspects of the overall management.

The financial statements comprise the following parts:

- Balance sheet
- Profit and loss account
- Explanatory notes
- Management report
- Reconciliation between final budget and Annual Accounts
- Statement of cash flow
- Trend of the net financial position (NFP)

Assessment Criteria

The financial statements have been compiled in accordance with the principles of clarity and transparency and provide a correct and exhaustive framework of information on property relations, as well as economic and financial relations implemented by the Consortium in carrying out its activities. They have been compiled taking into account international accounting standards for the public sector (IPSAS), where applicable.

Balance Sheet

Items in the balance sheet are classified into/distinguished as current/non-current.

Assets

Assets have been classified as current assets when:

- They have been realised during the normal operating cycle of the institution;
- They are cash or equivalent complement not restricted in its use.

Assets realisable within the operating cycle have been classified as current, regardless of whether they have actually been realised within 12 months from the balance sheet date.Non-current assets include tangible assets, intangible assets (licenses and in general all assets not related to the operating cycle and realizable after 12 months from the balance sheet date).

Liabilities

Liabilities have been considered current liabilities when:

a) They are extinct in the course of the normal operating cycle of the institution;
b) Extinction is due within 12 months from the balance sheet date.

Other liabilities, i.e., those not related to the operating cycle and all other institutional liabilities, are classified as current if their extinction is due within 12 months from the balance sheet date.
Otherwise, they are recognised as non-current liabilities.

Deferred Incomes and Accrual Expenses

This item includes the amount of funds received up to December 2023 and not yet fully used by 31.12.2023 for the purposes for which they were intended. They will therefore continue to provide utility in coming years, for the same purposes. This item represents the carry-over for balances of the subsequent year to that under review. In this regard, the Consortium is obliged to operate in future years in fulfilment of the mandate required by the Italian Ministry of Education, University and Scientific Research, who assigned the financial funds (FOE) under which CERIC activities were carried out in 2023.

In-kind Contributions

Contributions in-kind will be included in the financial statements on the basis of the details contained in the document entitled "Methodology for Defining the Values Involved in CERIC-ERIC Activities, and to Detail In-kind Contributions".

In-kind non-monetary contributions will be distinguished (when realised) between:

1) Those strictly related to the cost of the production factors (exhausting their utilities during the ordinary cycle).
2) Those strictly related to covering investments (in intangible and tangible assets).

Profit and Loss Account

The drawing-up of the profit and loss account is regulated by the IPSAS, integrated and conformed to be consistent with the characteristics and scopes of CERIC-ERIC.

Incomes

Incomes are increases of benefits connected to the administrative year.

Costs/Expenses

Costs/expenses are decreases of economic benefits of the administrative year. The analysis of costs has been explained in the overview of profit and loss account using a classification based on their nature.

Assets

Non-current Assets

Tangible Assets

Balance as at 31/12/2022	Balance as at 31/12/2023	Variation
1,434,146.36	1,580,574.49	146,428.13

Most of the acquisitions completed during the year refer to purchases linked to the research project INTEGRA and to the investments related to the BATTERIES PLAN; the residual part refers to supplies for the central seat.

The following flow chart shows the change in individual items summarised in the present note.

Description	Property	Technical furniture	Electronic office machines	Office furniture	Mobile phone	Equipment in progress	Total
Balance as at 31/12/2022	**-**	**1,282,436.27**	**24,955.84**	**10,578.23**	**1,690.00**	**114,486.02**	**1,434,146.36**
Acquisitions during the year	-	211,871.18	4,885.00	-	769.00	204,582.29	422,107.47
Increases during the year	-	181,623.84	-	-	-	-	181,623.84
Decreases during the year	-	-	-	-	-	-181,623.84	-181,623.84
Depreciation for the year	-	-442,427.38	-10,262.25	-5,305.75	-692.20	-	-458,687.58
Balance as at 31/12/2023	**-**	**1,233,503.91**	**19,578.59**	**5,272.48**	**1,766.80**	**137,444.47**	**1,397,566.25**

The balance sheet items “Decreases during the year” is referred to the completion in 2023 of the supply of scientific instruments. Its value is included in under the acquisition made during the year.

Intangible Assets

Balance as at 31/12/2022	Balance as at 31/12/2023	Difference
33,745.43	19,728.62	-14,016.81

Historical costs at 31/12/2023 are as follows:

Description	Balance as at 31/12/2022	Operating increments	Operating decreases	Depreciation for the year	Value on 31/12/2023
Concessions, licenses, trademarks	33,745.43	1,709.12	-	15,725.93	19,728.62
Intangible assets in progress	-	-	-	-	-
Total	**33,745.43**	**1,709.12**	**-**	**-15,725.93**	**19,728.62**

Current Assets

Short-term Credits

The balance is divided according to the deadlines of the credits:

Balance as at 31/12/2022	Balance as at 31/12/2023	Variation
201,782.42	135,987.35	-65,795.07

The composition of the amount as at 31/12/2023 is as follows:

Description	Within 12 months	Over 12 months	Over 5 years	Total
Advances to Universities	48,000.00	-	-	48,000.00
Other receivables	8,920.79	-	-	8,920.79
Tax advances	40,062.56	-	-	40,062.56
Advances to suppliers	19,000.00	-	-	19,000.00
Receivables from customers	20,004.00	-	-	20,004.00
Total	**135,987.35**	**-**	**-**	**135,987.35**

- The item "Advances to Universities" represents the part of the expenses paid to Universities for activities that will be implemented in relation to the PHD programmes in the period 2023-2025.
- The item “Other receivables” mainly refers to payments made in relation to the destination of the severance indemnity of an employee to supplementary pension funds (€ 5,312.92). The remaining part is referred to VAT credits (€ 2,156.00) related to purchases linked to the commercial activity of the Consortium, credit notes to be received (€ 1,072.82), other credits of different nature (€ 370.15)
- The item “Tax advances” mainly refers to advance payments made in June and November 2023. (€ 37,410.00). These advance payments have been calculated on the basis of the fiscal charge for the previous year. The remaining part (€ 2,652.46) refers to tax advances related to the severance indemnities calculated for 2023.
- The item “Receivables from customers” refers the completion of a commercial contract (€ 2,557.00) and to the advance invoicing of commercial services that are supposed to be completed within December 2024 (€ 17,447.00).

Inventories

No values are entered for this item.

Cash and Cash Equivalents

The balance item Cash and Cash Equivalents represents the following financial positions:

- Cash at the bank at the end of the financial year. It represents liquid assets and cash equivalents at the end of the year.
- Term deposit at the bank at the end of the financial year. It represents short term liquidity deposit at the end of the year.

Cash deposited and fixed term deposit at the bank Unicredit Banca Spa:

Balance as at 31/12/2022	Balance as at 31/12/2023	Variation
6,090,060.82	6,875,385.68	785,324.86

In this context, the Consortium is in a credit position towards the Institute Unicredit, Agency of Trieste, where it has opened a current account for financial management. In July 2023, a sum of € 3,005,000.00 was delivered to this account by the Ministry of Education, University and Scientific
Research through AREA di Ricerca of Trieste, to support the Consortium’s activities for the year reviewed, according to the Collaboration Framework Agreement signed with Elettra-Sincrotrone Trieste S.c.p.A.
In March 2023, CERIC received from the EU an amount of € 63,765.64, as advance payment for the IMPRESS project funded by the EU. In September 2023, CERIC received from the EU an amount of € 276,417.19, as advance payment for the ERA SHUTTLE project and an amount of 150,517.74 for the ERIC FORUM 2 project, both funded by the EU.

Description	Balance as at 31/12/2022	Balance as at 31/12/2023	Variation
Bank deposits	6,090,060.82	2,875,385.68	-3,214,675.14
Fixed term deposits	-	4,000,000.00	4,000,000.00
Total	**6,090,060.82**	**6,875,385.68**	**785,324.86**

Prepayments and Accrued Income

Balance as at 31/12/2022	Balance as at 31/12/2023	Variation
357,137.43	155,404.62	-201,732.81

This item measures income and expenses whose competence is delayed or advanced with respect to cash or documentary; they disregard the date of payment or collection of related income and expenses common to two or more years and distributable on time. The main part of this amount (€144,488.57) represents prepaid expenses related to costs for three-years PHDs program referring, on an accrual basis, to the period 2023- 2025. The objective of this activity is to further the integration of the partner facilities and to contribute to excellent science.
The remaining part refers to prepaid expenses related to the general costs of the Consortium (€5,818.28) and to accrued incomes for 2023 related to the term deposit interests (€5,097.77)

Reserves

No values are entered for these items.

Accumulated Profits

No values are entered for these items.

Non-current Liabilities

Other Long-term Debts and Liabilities

Long-term advance Payments received for externally funded projects

Description	ReMade	IMPRESS	ERIC Forum 2	ERA SHUTTLE	TOTAL
Balance as at 31/12/2022	-	-	-	-	-
Advance payment received from the EU during the year	-	63,765.64	150,517.74	276,417.19	490,700.57
Accrual progress report for the year 2023	-	-5,277.56	-	-5,277.56	-10,633.52
Funds claimable within December 2024	-	-19.166.67	-66.943.88	-99.663.07	-185,773.62
Balance as at 31/12/2023	**0.00**	**39,321.41**	**83,573.86**	**171,398.16**	**294,293.43**

Pensions Fund and Other Benefits for Compensation Employment

Severance indemnities for employees.

Description	Balance as at 31/12/2022	Balance as at 31/12/2023	Variation
Severance indemnities for employees	214,663.04	222,340.56	7,677.52

The item is made up as follows:

Description	Initial value 31/12/2022	Plan balance 2023	Substitutive tax	Contribution to national funds for employees (FPLD)	Severances paid during the year	End value 31/12/2023
Severance indemnities for employees	212,556.06	51,122.80	590.13	3,775.49	41,006.60	218,326.64
Severance indemnities transferred to complementary social security funds	2,106.98	1,906.94	-	-	-	4,013.92
Total	**214,663.04**	**53,029.74**	**590.13**	**3,775.49**	**41,006.60**	**222,340.56**

The severance set aside figure represents the actual debt of the Consortium at 31/12/2023, to employees in force at that date.
The contribution to FPLD refers to the sum withheld from the severance indemnities of employees in favour of national social security institutions as a contribution to general social security purposes.
The amount of the severance indemnities paid refers for to the conclusion of three fixed terms employment contracts during 2023 for € 41,006.60. These contracts were linked to the PANOSC project ended in February 2023.

Current Liabilities

Other Short-term Debts and Liabilities

Debts

Balance as at 31/12/2022	Balance as at 31/12/2023	Variation
347,584.03	293,937.72	-53.646.31

Debts are valued at their nominal value.

The composition of the aforementioned amounts is as follows:

Description	31/12/2022	31/12/2023	Variation
Debts to providers	207,655.34	150,408.16	-57,247.18
Tax liabilities	89,644.25	98,955.23	9,310.98
Payables to social security institutions	50,284.44	46,115.33	-4,169.11
Total	**347,584.03**	**295,478.72**	**-52,105.31**

- “Debts to providers” are stated net of possible trade discounts.
- The item “Debts to providers” (€ 150,408.16) includes debts to third parties, mainly relating to services purchased on credit. This item appears on the entity's balance sheet as a current liability, since the expectation is that the liability will be met in less than a year.
- The item "Tax payables" includes liabilities for specific taxes, and is composed of withheld taxes for employees, associates and collaborators amounting to € 47,143.04, together with € 14,634,19 of VAT to be paid in 2024, and taxes due by the Consortium (€ 37,178.00). With reference to this last item, two advance payments were made in 2023 for a total amount of € 37,410.00 included in the short term credits.
- “Payables due to social security institutions" includes the amount of social security contributions relating to employees, accrued but not paid as at 31 December 2023, amounting to € 46,115.33.
- "Other payables" includes remaining debts, which by nature cannot be described above, including amounts due by CERIC to staff for all liabilities accrued to them, in accordance with current legislation and Personnel Regulations, including the value of accrued vacation paid at the time of reporting. This account at 31/12/2023 was as follows:

Description	31/12/2022	31/12/2023	Variation
Other payables	336,741.75	274.684,21	-62.057,54

Description	31/12/2023
Payables to employees (holidays and leave not taken)	107,000.16
Advances related to commercial services	17,447.00
Payables to bodies	35,875.00
Other debts of a different nature	114,362.05
Total	**274,684.21**

The item “Payables to bodies” relates to the fee due by the Consortium to a member of the IAEC and to an internal auditor.

Debts are evaluated at their nominal value.

The final value as at at 31.12.2023 refers mainly to the following expenses:
- Costs for the spaces charged by Elettra for hosting the statutory seat in 2023 (€ 39,302.33)
- Access costs related to beamline LISA located at ESRF and managed by CNR (€ 60,000.00)
- Users' travel costs to be reimbursed in 2024 (€ 6,250.69)

Short-term advance Payments received for externally funded projects

The item "Advance payments for externally funded projects" includes the amounts listed in the table referring to the following running projects:

Description	ReMade	IMPRESS	ERIC Forum 2	ERA SHUTTLE	TOTAL
Balance as at 31/12/2022	97,812.80-	-	-		**97,812.80**
Advance payment received from the EU during the year	-	63,765.64	150,517.74	276,417.19	490,700.57
Accrual progress report for the year 2023	-28,796.90	-5,277.56	-	-5,355.96	-39,430.42
Funds to be reported after December 2023	-	-39,321.41	-83,573.86	-171,398.16	-294,293.43
Balance as at 31/12/2023	**69,015.90**	**19,166.67**	**66,943.88**	**99,663.07**	**254,789.52**

Contingent liabilities

Description	Balance as at 31/12/2022	Balance as at 31/12/2023	Variation
Contingent liabilities	40,783.62	40,783.62	-

The final value as at 31.12.2023 refers to the potential credit claimed by a fiscal consultancy firm. At the end of the financial year, the definition of the actual debt is not yet completed.

Deferred Income and Accrued Expenses

For accounting the contribution provided by Italy, the indirect method has been chosen and the stated amount is representative of the portion attributable to future financial years.

Balance as at 31/12/2022	Balance as at 31/12/2023	Variation
7,079,287.22	7.201.702,46	122.415,24

The item breaks down as follows:

Description	31/12/2023
Deferred income	7.166.922,46
Accrued expenses	34,780.00

The balance sheet item "Deferred income" measures the portion of the contribution funded by the Italian MIUR for the activities of the CERIC statutory seat, deferred to the following years.
The amount of € 7,166,922.46 is derived as follows:

Category	Deferred incomes as at 31.12.2022	Italian Contribution for 2023	Consortium general expenses for 2023 covered by FOE	Consortium investments made in 2023 covered by FOE ante 2023	Deferred incomes as at 31.12.2023
Deferred income	7,061,598.66	2,965,697.67	-2,285,686.10	-574,687.77	7,166,922.46

The Italian contribution for 2023 (€ 3,005,000.00) initially defined in the collaboration framework agreement signed by CERIC and its Italian Representing Entity for the period 2021-2023, was recalculated taking into account the additional activities performed by Elettra-Sincrotrone TriesteS.C.p.A. (€ 39,302.33) for spaces rented to CERIC.

The amount of the carry-over for 2023 is composed as follows:

Description	Amount
Resources committed to cover the depreci-ation quotes covered by FOE starting from 2024	95,666.72
Orders issued as at 31.12.2023 but not closed at the end of the year	18,046.96
Resources committed to cover the depreciation costs for orders 2022 completed as at 31.12.2023	3,354.90
Resources committed to the project INTEGRA	1,474,612.54
Resources committed to cover the depreciation costs to investment made within the internal research project MAG ALCHEMI	111,475.07
Free carry over from the previous years committed to EoI investment plan (FOE)	4,608,715.22
Resources committed to cover the investments made within the Battery Plan Programme	315,569.81
Carry over from 2023	539,481.24
Total deferred income as at 31.12.2023	**7,166,922.46**

The carry over free from 2022 is used to increase the funds for the implementation of the project CERIC EoI. The residual amount of the completed WPs of the INTEGRA project will be used to increase the funds available for the implementation of the project CERIC EoI.
The balance sheet item "Accrued expenses" measures the expenses that are recognized on the books before they have been paid. These expenses are recorded in the accounting period in which they are incurred. In particular they referred to the costs arising from the activities foreseen within the PHDs programmes agreed with the Universities.

Income Statement

Financial Revenues

Revenue items primarily identify the portion of the contribution for the financial year allocated by Italy for the Consortium's activities through the public company Area di Ricerca, to cover the expenses of management, as well as the revenues related to projects externally funded.
The Italian contribution for 2023 (€3,005,000.00), recalculated considering the additional activities performed by Elettra-Sincrotrone Trieste S.c.p.A. (€39,302.33) for the spaces used by CERIC for its statutory seat, corresponds to € 2,965,697.67. The portion of the FOE 2023 spent in the current financial year corresponds to € 2,285,686.10. This amount maily covers the operational costs of the Consortium (staff costs, general services, consumables for the seat). Part of the general costs in 2023 were covered by the accumulated revenues related to the projects funded by the EU (€ 3,989.68) The mayor part of the depreciation costs are related to CERIC investment plans (Battery plan, INTEGRA project, EoI project). These costs were covered mainly by FOE funds of the previous years.

Balance as at 31/12/2022	Balance as at 31/12/2023	Variation
2,955,672.24	2,927,480.77	-28,191.47

The composition of the amount at 31.12.2023 is as shown in the following tables:

Category	31/12/2022	31/12/2023	Variation
MIUR ordinary contribution	3,005,000.00	3,005,000.00	0
Cost charged by the Italia RE for the spaces used by CERIC for the statutory seat	-49,327.76	-39,302.33	10,025.43
FOE funds 2022 used to cover Battery Plan investment to be completed in the following years	-76,673.22	0.00	76,673.22
FOE funds 2023 used to cover Battery Plan investment to be completed in the following years	0.00	-134,074.46	134,074.46
FOE funds 2022 used to cover the depreciation costs related to investments made in 2022	-9,042.48	0.00	9,042.48
FOE funds 2023 used to cover the depreciation costs related to invest-ments made in 2023	0.00	-6,455.87	-6,455.87
FOE funds of the current financial year to be spent in the following years	-826,487.04	-539,481.24	287,005.80
Subtotal	**2,043,469.50**	**2,285,686.10**	**242,216.60**
Use of the carry over from previous years	442,456.27	574,687.77	132,231.50
Subtotal	**2,485,925.77**	**2,860,373.87**	**374,448.10**

The balance item Use of the carry-over from previous years refers to the financial coverage of following activities:

- INTEGRA investment: EUR 298.996,66
- BATTERIES investment: EUR 45.849.64
- EOI employment contract: EUR 100,412.06
- Other investment not covered by specific resources: EUR 129.429,41

Category	31/12/2022	31/12/2023	Variation
H2020 ERIC Forum Project	68,371.44	0.00	-68,371.44
H2020 PaNOSC Project	438,622.72	0.00	-438,622.72
Commercial services	45,000.00	22,559.00	-22,441.00
CEI HCS Project	4,615.15	0.00	-4,615.15
H2020 RE-Made Project	2,443.57	28,796.90	26,353.33
H2020 ERA SHUTTLE Project	0.00	5,355.96	5,355.96
H2020 IMPRESS Project	0.00	5,277.56	5,277.56
Changes in inventories	0.00	0.00	0.00
Other incomes	5,163.42	5,117.48	-45.94
Total other incomes	**564,216.30**	**67,106.90**	**-497,109.40**

Contributions for Operating Expenses

The amount of the Italian contribution 2023 for the activities of the statutory seat of the Consortium is € 2,285,686.10. This amount will be reported to the Italian Ministry according to the FOE reporting rules. This amount covered part of the costs for personnel, bodies, consultancies, and other costs of the seat not covered by specific externally funded projects.

Contributions In-Kind

No values are entered for these items.

Costs

Operating Costs

Costs for Raw materials, Supplies, Consumables and Goods

This category includes costs incurred for the supply of consumables.

Category	Balance as at 31/12/2022	Balance as at 31/12/2023	Variation
Costs for raw materials, supplies, consumables and goods	14,138.10	3,437.71	-10,700.39

Most of the total value for 2023 refers to costs incurred to support the internal research project INTEGRA.

Services Costs

It has been decided to divide the item service costs, to facilitate the clarity of the budget, into the following categories of expenses:

Category	31/12/2022	31/12/2023	Variation
Services for commercial activities	-	19,110.00	19,110.00
Legal, fiscal and administrative consultancy	16,809.85	20,839.84	4,029.99
Technical consultancies	1,352.00	6,564.78	5,212.78
Administrative collaborators	30,648.00	5,580.62	25,067.38
Scientific and technical collaborators	100,914.27	104,057.15	3,142.88
Social security contributions of collaborators	43,927.91	41,879.02V	-2,048.89
Health contribution for collaborators	472.64	468.05	-4.59
ISTAC remunerations	20,505.83	16,428.58	-4,077.25
Travel costs for employees, collaborators, and bodies	95,819.20	89,516.54	-6.302.66
Travel costs for users	69,782.37	107,144.99	37,362.62
Insurances	11,503.02	11,168.18	-334.84
Representation costs	3,940.51	3,731.91	-208.60
Consulting and salaries processing	28,977.88	29,763.02	785.14
Mobile phones	7,762.64	8,947.52	1,184.88
Annual software licenses	603.59	341.36	-262.23
Workshops, seminars and publications	35,619.42	10,072.33	-25,547.09
Canteen expenses	22,475.95	17,107.65	-5,368.30
Bank charges	1,485.45	1,559.66	74.21
Postal charges	1,196.78	876.82	-319.96
Agreement with Universities to support PHDs	383,924.06	355,696.80	-28,227.26
Maintenances	4,521.70	2,367.57	-2,154.13
Training costs	328.79	17,598.79	17,270.00
Transportation services	1,003.00	1,564.30	561.30
Other costs	78,620.36	83,421.23	4,800.87
Technical services	26,600.00	352.12	-26,247.88
Total	**988,795.22**	**956,158.83**	**-32,636.39**

The item “Other costs” includes mainly costs related to the access costs to external research infrastructures (€ 60,000.00), and other minor costs.

Personnel Costs

Personnel expenses: breakdown

Category	31/12/2022	31/12/2023	Variation
Wages and salaries	744,116.03	690,897.58	-53,218.45
Social security charges	213,489.97	203,665.58	-9,824.39
Seconded personnel (IKCs against payment)	82,695.17	0.00	-82,695.17
Severance indemnities	69,838.46	51,122.80	-18,715.66
Allowances to be paid	85,010.34	107,000.16	21,989.82
Director	175,878.39	184,087.04	8,208.65
Social security charges of bodies	23,516.44	26,510.63	2,994.19
Auditors and IAEC	163,219.18	175,000.00	11,780.82
Fellowships	0.00	8,121.48	8,121.48
Total	**1,557,763.98**	**1,446,405.27**	**-111,358.71**

Use of Third-Party Materials or Property

No values are entered for these items

Other Operating costs

Other operating costs: breakdown

Category	31/12/2022	31/12/2023	Variation
Membership fees	10,000.00	12,917.00	2,917.00
Rounding	180.65	134.95	-45.7
Other taxes	248.05	2,139.66	1,891.61
Other expenditures	3,407.96	1,908.72	-1,499.24
Donations	5,000.00	-	-5,000.00
Total	**18,836.66**	**17,100.33**	**-1,736.33**

Depreciation of Tangible and Intangible Assets

Depreciation is calculated on the basis of the useful life of the asset and its use in production. For the first year of use, the percentages applied have been reduced by half.

Intangible Assets

Description	Depreciation Rate	Amount
Concessions and licenses	20%	15,725.93
Total amortisation of intangible assets		**15,725.93**

Tangible Assets

Description	Depreciation Rate	Amount
Office machinery	20%	10,262.25
Equipment	20%	442,427.38
Telephony and mobile telephony	20%	692.20
Office furniture	15%	5,305.75
Total amortisation of fixed assets		**458,687.58**

Taxation

Current tax	Balance as at 31/12/2022	Balance as at 31/12/2023	Variation
IRAP	37,305.00	37,178.00	-127,00
Total	**37,305.00**	**37,178.00**	**-127.00**

The annual tax related to institutional activity (IRAP) is calculated on the amount of salaries paid to employees, the amount of fees paid to collaborators and the costs of contracts for temporary employment, with the exception of remunerations paid for researchers. The fiscal charge related to the commercial activity is equal to 137.00 EUR. The Consortium, in the context of purchases realised, and within the limits following from the Statute, may use VAT exemptions granted on the basis of Art. 143(1)(g) and 151(1)(b) of Council Directive 2006/112/EC, and in accordance with Art. 50 and 51 of Implementing Regulation (EU) No. 282/2011 of the Council, and on the basis of Article 12 of Directive 2008/118 /EC.

Financial Costs and Revenues

Under “Financial management”, accrued interest income on the bank account of the Consortium is stated as of 31.12.2023.

Interest on Current Account, Rounding and Exchange Rate Costs

The item represents remuneration on deposits of the Consortium on current account N. 000103334723 opened at Unicredit Banca.

Category	31/12/2022	31/12/2023	Variation
Interest on current account	569.4	7,485.10	6915.7
Exchange rate costs	-168.33	- 272.22	-103.89
Total	**401.07**	**7,212.88**	**6,811.81**

Report of the commercial activities

The limited commercial activities of the Consortium have been managed through a separate account. In 2023, one commercial contract was concluded for the value of € 22,559.00.

Revenues	
Commercial services	22,559.00

Costs	
Collaboration contracts related to the commercial activity	19,110.00
General costs*	591.01
Final balance	2,857.99

*General costs have been calculated according to the Italian fiscal rules for commercial activities performed by non-commercial entities.
In particular, the calculation refers to the incidence of the commercial activities (€22.559,00) compared to the total amount of the revenues accounted for 2023 ((€ 2.927.480,77). The ratio corresponds to 0.77 %
The resulting percentage has been applied to the amount of € 76,754.77, corresponding to the following general cost categories, common to both institutional and commercial activities and not reported within project externally funded.

Category	31/12/2023	%
Legal, fiscal and administrative consultancy	20,839.84	160.47
Insurances	11,168.18	85.99
Consulting and salaries processing	29,763.02	229.18
Mobile phones	8,947.52	68.90
Bank charges	1,559.66	12.01
Stationery	870.96	6.71
Connectivity services - GARR	2,728.77	21.01
Postal charges	876.82	6.75
Total	**76,754.77**	**591.01**

Events after the reporting date

Following IPSAS 14, this paragraph reports about events that occur between the reporting date (31.12.2023) and the date when these Financial Statements were approved by the General Assembly.
In this context it is noted that no relevant event occurred.

Management Report
Comparison between Final Budget and Annual Accounts

1. Starting from the budget for 2023 approved by the GA in November 2022, some changes were necessary as the result of the following:

EXPENDITURE COMMITMENTS, COSTS and INVESTMENTS:

2. The additional funds assigned to the Eoi programme during 2023 due to the recalculation of the final carry over for 2023.
3. The redistribution of the resources available from the WPs completed of the project INTEGRA, to the EoI plan.
4. The allocation of the funds related to the EU funded project. The allocation of the funds related to a new commercial contract.

REVENUES

1. The calculation of the actual carry-over for 2023. The 2023 budget was approved in November 2022 by the GA taking in to account an estimate of the carry-over for the year at closing.
2. The calculation of the revenues related to externally funded projects.
3. The acquisition of a new commercial contract.

Incurred and planned expenses

EXPENSES FOR 2023					
Description	**Initial budget**	**Changes**	**Final budget**	**Total expenses**	**% expenditure**
Collaboration Agreement IT PF and CERIC	2,525,000.00	-	2,525,000.00	2,525,000.00	100.00
Bodies - Remuneration	244,000.00	-	244,000.00	207,928.58	85.22
Remuneration for Employees	1,403,550.00	-	1,403,550.00	1,226,388.10	87.38
Communication	15,000.00	-	15,000.00	12,955.18	86.37
Travel Expenses Bodies	110,000.00	-10,000.00	100,000.00	43,071.15	43.07
Travel Expenses Employees and Collaborators	45,000.00	10,000.00	55,000.00	38,207.68	69.47
External Services, Consultants, Consumables	423,000.00	-11,000.00	412,000.00	285,722.80	69.35
Fixed Assets	15,000.00	-	15,000.00	6,291.56	41.94
Taxes	35,000.00	7,000.00	42,000.00	40,368.29	96.11
Services and Spaces Provided by the IT RE	60,000.00	-	60,000.00	-	-
Access Costs	140,000.00	-	140,000.00	107,879.69	77.06
PhD Programme	348,000.00	16,602.58	364,602.58	363,849.45	99.79
Battery, Fuel Cells, Remotisation	326,450.00	-	326,450.00	134,074.47	41.07
Commercial Activity	-	25,000.00	25,000.00	19,110.00	76.44
EoI Projects Not Started	4,395,643.33	-338,672.72	4,056,970.61	-	-
EoI ESBY	-	536,800.00	536,800.00	536,800.00	100.00
EoI HR CH-ERIC	52,000.00	-	52,000.00	38,274.48	73.60
EoI HR INCITE	52,356.67	11,000.00	63,356.67	62,137.58	98.08
REMADE@ARI Horizon Europe	50,000.00	-35,700.00	14,300.00	6,423.95	44.92
ERA SHUTTLE	-	24,000.00	24,000.00	4,284.76	17.85
IMPRESS INFRA-2022	-	5,200.00	5,200.00	4,222.04	81.19
ERIC Forum 2 - INFRA 2023	-	5,000.00	5,000.00	-	-
OPV Stability MSCA 2022	-	1,500.00	1,500.00	-	-
TOTAL BUDGET	**10,240,000.00**	**246,729.86**	**10,486,729.86**	**5,662,989.76**	**54.00**
INTEGRA	915,399.04	-175,400.00	739,999.04	393,719.74	53.21
TOTAL BUDGET + INTEGRA	**11,155,399.04**	**71,329.86**	**11,226,728.90**	**6,056,709.50**	**53.95**

Revenues

Description	**Initial Budget**	**Implemented Changes**	**Final Budget**	**Accrued Revenues**	**%**
Use of the carry over from previous years committed to EOI project	-	-	-	100,412.06	n.a.
Commercial activities	-	25,000.00	25,000.00	22,559.00	90.24
Contribution from the Hosting Country to CERIC	5,530,000.00	-	5,530,000.00	5,530,000.00	100
Carry over from 2022	950,000.00	950,000.00	-	-	n.a.
Other minor incomes	-	5,117.48	5,117.48	5,117.48	100
Bank interests	-	7,485.10	7,485.10	7,485.10	100
EU projects	53,000.00	35,700.00	88,700.00	39,430.42	44.45
Use of the FOE contribution of the previous years to cover INTEGRA investment	-	-	-	298,996.66	n.a.
Use of the FOE contribution of the previous years to cover other investments	-	-	-	129,429.41	n.a.
Use of the FOE contribution of the previous years to cover battery plan investments	-	-	-	45,849.64	n.a.
Use of the contribution from the hosting Country to CERIC	-	-	-	-719,313.90	n.a.
TOTAL BUDGET 2024	**6,533,000.00**	**-876,697.42**	**5,656,302.58**	**5,459,965.87**	**96.53**
Carry over from previous years committed to EoI project	3,707,000.00	1,159,127.28	4,866,127.28	4,866,127.28	100
Carry over from 2023	-	539,618.24	539,618.24	539,481.24	100
TOTAL BUDGET 2024	**10,240,000.00**	**822,048.10**	**11,062,048.10**	**10,865,574.39**	**98.22**
TOTAL BUDGET + CARRY OVER COMMITTED TO INTEGRA	**11,155,399.04**	**646,648.10**	**11,802,047.14**	**11,259,157.13**	**95.40**

The following table include an explanation of the difference between the actual carry-over resulting from the Financial Statements 2023 and the balance resulting from the final budget 2023.

RECONCILIATION between BUDGET and FINANCIAL STATEMENTS – COSTS	
Description	**Amount**
TOTAL Expenses (Contracts signed, incurred costs and investments)	6,056,709.50
(-) FOE FUNDS TRANSFERRED TO THE ITALIAN PF	-2,525,000.00
(-) INVESTMENTS	-423,816.59
(-) Contracts signed but not completed as at 31.12.2023	-791,921.09
(+) DEPRECIATION	474,413.51
Contracts signed in 2022 and completed within Dec 2023	144,580.54
Total costs (as indicated in the profit and loss account)	**2,934,965.87**

RECONCILIATION between BUDGET and FINANCIAL STATEMENTS - REVENUES	
Description	**Amount**
Total Revenues	11,259,157.13
(-) FOE FUNDS TRANSFERRED TO THE ITALIAN PF	-2,525,000.00
(-) CARRY OVER FROM 2023	-539,481.24
(-) CARRY OVER from previous years committed to EOI project	-4,866,127.28
(-) Funds used to cover INTEGRA project	-393,719.74
Total revenues (as indicated in the profit and loss account)	**2,934,965.87**

Statement of Cash Flow

The cash flow statement identifies the sources of cash inflows, the items on which cash was expended during the year and the cash balance as at the end of the year.
Inflows and outflows are classified on the basis of their (operating or investment) nature.
In the following table is included information about the historical changes in cash (and cash equivalent) referring to operating, investing and financing activities.

Statement of cash flows for the years	2023	2022
CERIC externally funded projects		
Receipts		
CERIC projects funded by third parties	557,783.87	329,170.98
Commercial activities	38,002.00	47,000.00
Contribution from the host country	3,005,000.00	3,005,000.00
Interest received	441.19	421.35
Other receipts	854.83	2,515.25
Other operating payments		
Payments to Staff	- 878,826.29	- 827,985.80
Other operating payments	-1,505,128.77	-1,597,620.90
Payments to project partners	-	-
Net Cash from Operating Activities	**1,218,126.83**	**958,500.88**
Cash flows from investment activities		
Purchase of plant and equipment	-432,801.97	-397,100.08
Sale of plant and equipment	-	223.52
Other	-	-
Net Cash Flow from Investment Activities	**- 432,801.97**	**- 396,876.56**
Cash flows from financing activities		
Proceeds from borrowings	-	-
Repayment of borrowings	-	-
Other	-	-
Net Cash Flow from Financing Activities	-	-
NET INCREASE/(DECREASE) IN CASH	**785,324.86**	**561,624.32**
CASH, BEGINNING OF THE YEAR	**6,090,060.82**	**5,528,436.50**
CASH, END OF THE YEAR	**6,875,385.68**	**6,090,060.82**

Net Financial Position - Trend for the period Jan-Dec 2023

The Net Financial Position represents the net debt position of the Consortium during the year, through comparison of the following balance items: + cash and cash equivalent | + short-term monetary credits | - short-term monetary debts

Additional disclosures on in-kind resources (with reference to Directive 2013/34/EU)

In relation to in-kind contributions, which statutorily constitute a particularly significant element in terms of the resources and organization that can be used by the Consortium, it should be noted that it was not possible to acquire all the accounting values for 2023 according to the principles of consistency and auditability on the basis of the revised "Methodology for Defining the Values Involved in the CERIC-ERIC Activities, and to Detail In-kind Contributions" approved by the General Assembly in June 2018.
However, it needs to be highlighted that, even before the set-up of the Consortium, some of the concerned PFs manifested themselves through this particular mode of contribution, which then allowed the immediate and consistent start of activities.
These values were quantified, albeit with the limitations set forth above, by the various PFs and are shown in the tables below in order to provide supplementary information, which enables a better understanding of the relevance of the total resources used by CERIC in the whole financial year 2023.

Value of the PFs and in-kind contribution. Consolidated data (2023)

Total costs of the ordinary scientific/technical activities of the Partner Facilities in 2023 - COMMITTED IN-KIND									
	Recurrent costs								
PF	**Personnel costs**	**Travel & accommo-dation and similar**	**Consumables**	**Services**	**Utilities**	**Overheads**	**Technical devaluation & maintenance, lease/rent costs of equipment & spaces**	**Cost of access committed to CERIC**	**Total**
AT	-	-	-	-	-	-	-	483,196.09	**483,196.09**
HR	-	-	-	-	-	-	-	-	**-**
CZ	377,283.55	13,661.51	149,512.08	64,261.12	-	175,151.75	-	8,513.64	**788,383.65**
HU	-	-	-	-	-	-	-	-	**-**
IT	-	-	-	-	-	-	-	3,715,916.88	**3,715,916.88**
PL	-	-	-	-	-	-	-	361,549.46	**361,549.46**
RO	43,315.00	1,347.00	8,336.70	17,325.25	-	-	-	132,062.61	**202,386.56**
SI	-	-	-	-	-	-	-	274,109.33	**274,109.33**
Tot.	**420,598.55**	**15,008.51**	**157,848.78**	**81,586.37**	**-**	**175,151.75**	**-**	**4,492,151.92**	**5,825,541.97**

Annex 2

Scientific Publications by CERIC Users

Ninety (90) articles were published in 2023, with a cumulative impact factor of 902 (versus 762 in 2022) and an average impact factor of 8,43 (versus 6.52 in 2022):

(1) *Vibrational spectroscopy methods for investigation of the animal models of glioblastoma multiforme,* Olbrich K., Setkowicz Z., Kawon K., Czyzycki M., Janik-Olchawa N., Carlomagno I., Aquilanti G., Chwiej J., Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, 2023

(2) *Lipid nanoparticles with erythrocyte cell-membrane proteins,* Bóta A., Fehér B., Wacha A., Juhász T., Szabó D., Turiák L., Gaál A., Varga Z., Amenitsch H., & Mihály J., Journal of Molecular Liquids, 2023

(3) *Mechanism of magnesium phosphate cement retardation by citric acid,* Viani A., Mácová P., Ševčík R., & Zárybnická L., Ceramics International., 2023

(4) *Formation of calcium phosphate nanoparticles in the presence of carboxylate molecules: a time- resolved in situ synchrotron SAXS and WAXS study,* Siliqi D., Adamiano A., Ladisa M., Giannini C., Iafisco M., Degli Esposti L., CrystEngComm, 2023

(5) *Design of Magnetic Fe3O4/CeO2 "Core/Shell"-Like Nanocomposites with Pronounced Antiamyloidogenic and Antioxidant Bioactivity,* Shlapa Y., Siposova K., Veltruska K., Maraloiu V.-A., Garcarova I., Rajnak M., Musatov A., Belous A., ACS Appl. Mater. Interfaces, 2023

(6) *Polaronic and Mott insulating phase of layered magnetic vanadium trihalide VCl3,* Mastrippolito D., Camerano L., Świątek H., Šmíd B., Klimczuk T., Ottaviano L., Profeta G., Physical Review B, 2023

(7) *Hematite α-Fe2O3(0001) in Top and Side View: Resolving Long-Standing Controversies about Its Surface Structure,* Redondo J., Michalička J., Kraushofer F., Franceschi G., Šmid B., Kumar N., Man O., Blatnik M., Wrana D., Mallada B., Švec M., Parkinson G.S., Setvin M., Riva M., Diebold U., Čechal J., Advanced Materials Interfaces, 2023

(8) *Solution-processed In2Se3 nanosheets for ultrasensitive and highly selective NO2 gas sensors,* D'Olimpio G., Galstyan V., Ghica C., Vorokhta M., Istrate M.C., Kuo C.-N., Lue C.S., Boukhvalov D.W., Comini E., Politano A., Journal of Materials Chemistry A, 2023

(9) *Highly-doped YAG:Sm3+ transparent ceramics: Effect of Sm3+ ions concentration,* Timoshenko A.D., Matvienko O.O., Doroshenko A.G., Parkhomenko S.V.,Vorona I.O., Kryzhanovska O.S., Safronova N.A.,Vovk O.O., Tolmachev A. V., Baumer V. N., Matolínová I., Hau S., Gheorghe C., Yavetskiy R. P., Ceramics International, 2023

(10) *Protein-induced modifications in crystal morphology of a hydrogen-bonded organic framework,* Flint K.L., Evans J.D., Carraro F., Renner S., Linder-Patton O.M., Amenitsch H., Falconer R.J., White N.G., Sumby C.J., Falcaro P., Doonan C.J., Journal of Materials Chemistry A, 2023

(11) *Fabrication of 3D Oriented MOF Micropatterns with Anisotropic Fluorescent Properties,* Velásquez-Hernández M.D.J., Linares-Moreau M., Brandner L.A., Marmiroli B., Barella M., Acuna G.P., Zilio S.D., Verstreken M.F.K., Kravchenko D.E., Linder-Patton O.M., Evans J.D., Wiltsche H., Carraro F., Wolinski H., Ameloot R., Doonan C., Falcaro P., Advanced Materials, 2023

(12) *Structure of the Hexadecane Rotator Phase: Combination of X-ray Spectra and Molecular Dynamics Simulation,* S.A. Burrows, E.E. Lin, D. Cholakova, S. Richardson, S.K. Smoukov, J. Phys. Chem. B, 2023

(13) *Structure of Rotator Phases Formed in C13-C21 Alkanes and Their Mixtures: In Bulk and in Emulsion Drops,* Cholakova D., Pantov M., Tcholakova S., Denkov N., Cryst. Growth Des., 2023

(14) *DNA Quadruplex Structure with a Unique Cation Dependency,* Gajarsky. M, Stadlbauer P., Sponer J., Cucchiarini A., Dobrovolna M., Brazda V., Mergny J.-L., Trantirek L., Lenarcic Zivkovic M., Angewandte Chemie, 2023

(15) *Mechanism of complexation of toxic arsenate, selenate, and molybdate with hydrotalcites,* Gomez M.A., Ma X., Chen Y., Wang S., Pollastri S., Aquilanti G., Cui Y., Yao S., Xiao T., Environmental Chemistry Letters, 2023

(16) *Unidirectional Nano-modulated Binding and Electron Scattering in Epitaxial Borophene,* Kamal S., Seo I., Bampoulis P., Jugovac M., Brondin C.A., Menteş T.O., Šarić Janković I., Matetskiy A., Moras P., Sheverdyaeva P., Michely T., Locatelli A., Gohda Y., Kralj M., Petrović M., ACS Appl. Mater. Interfaces, 2023

(17) *Revolutionizing n-type Co3O4 Nanowire for Hydrogen Gas Sensing,* Kumarage G.W.C., Zappa D., Mihalcea C.G., Maraloiu V.-A., Stefan M., Comini E., Advanced Energy & Sustainability Research, 2023

(18) *Operando study of the influence of small molecule acceptors on the morphology induced device degradation of organic solar cells with different degrees of π-π stacking,* Jiang X., Gillett A.J., Zheng T., Song X., Heger J.E., Sun K., Spanier L.V., Guo R., Liang S., Bernstorff S., Müller-Buschbaum P., Energy & Environmental Science, 2023

(19) *In-situ/operando characterization of FeOx-based chemiresistive sensor of acetone vapours by X-ray absorption spectroscopy,* Ivančo J., Pollastri S., Hofbauerová M., Thin Solid Films, 2023

(20) *Monitoring of Pore Orientation by in Operando Grazing Incidence Small-Angle X-ray Scattering during Templated Electrodeposition of Mesoporous Pt Films,* Wieser P.A., Moser D., Gollas B., Amenitsch H., ACS Appl. Mater. Interfaces, 2023

(21) *Water sensitivity of heteroepitaxial Cu-MOF films: dissolution and re-crystallization of 3D-oriented MOF superstructures,* Brandner L.A., Linares-Moreau M., Zhou G., Dal Zilio S., Huang Z., Doonan C., Amenitsch H.W., Falcaro P., Chemical Science, 2023

(22) *PNIPAM-stabilized cubosomes as fusogenic delivery nanovectors for anticancer applications,* Balestri A., Gibot L., Amenitsch H., Cervelli L., Montis C., Lonetti B., Berti D., Colloids and Surfaces B: Biointerfaces, 2023

(23) *Unraveling the Morphology-Function Correlation of Mesoporous ZnO Films upon Water Exposure,* Tian T., Tu S., Xu A., Yin S., Oechsle A.L., Xiao T., Vagias A., Eichhorn J., Suo J., Yang Z., Bernstorff S., Müller-Buschbaum P., Advanced Functional Materials, 2023

(24) *Modulation of electronic and ionic conduction in mixed polymer conductors via additive engineering: Towards targeted applications under varying humidity,* Tu S., Tian T., Vagias A., Huber L.F., Liu L., Liang S., Fischer R.A., Bernstorff S., Müller-Buschbaum P., Chemical Engineering Journal, 2023

(25) *Resolving the pharmacological redox-sensitivity of SARS-CoV-2 PLpro in drug repurposing screening enabled identification of the competitive GRL-0617 binding site inhibitor CPI-169,* Kuzikov M., Morasso S., Reinshagen J., Wolf M.,

Monaco V., Cozzolino F., Golič Grdadolnik S., Šket P., Plavec J., Iaconis D., Summa V., Esposito F., Tramontano E., Monti M., Beccari A.R., Windshügel B., Gribbon P., Storici P., Zaliani A., bioRxiv, 2023

(26) *In-Cell Stability Prediction of RNA/DNA Hybrid Duplexes for Designing Oligonucleotides Aimed at Therapeutics,* Banerjee D., Tateishi-Karimata H., Toplishek M., Ohyama T., Ghosh S., Takahashi S., Trajkovski M., Plavec J., Sugimoto N., J. Am. Chem. Soc., 2023

(27) *Microstructure, chemical composition, and dielectric response of CaCu3Ti4O12 ceramics doped with F, Al, and Mg ions,* Yanchevskii O.Z., V'yunov O.I., Plutenko T.O., Belous A.G., Trachevskii V.V., Matolínová I., Veltruská K., Kalinovych V., Lobko Y., Heliyon, 2023

(28) *States of Pt/CeO2 catalysts for CO oxidation below room temperature,* Slavinskaya E.M., Stadnichenko A.I., Quinlivan Domínguez J.E., Stonkus O.A., Vorokhta M., Šmíd B., Castro-Latorre P., Bruix A., Neyman K.M., Boronin A.I., Journal of Catalysis, 2023

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Abbreviations

BoD	Board of Directors
CERIC	Central European Research Infrastructure Consortium
ED	Executive Director
EGERIC	Commission expert group to assess the implementation of the ERIC Regulation
ERA	European Research Area
EOSC	European Open Science Cloud
ERIC	European Research Infrastructure Consortium, a legal framework created by the European Commission to allow the operation of Research Infrastructures of pan-European interest.
FOE	Fondo Ordinario per il finanziamento degli Enti e istituzioni di ricerca (Ordinary Fund for the Financing of Research Entities and Institutions)
GA	General Assembly
IF	Impact Factor
IL&TT	Industrial Liaison and Technology Transfer
IR	Internal Regulations
ISTAC	International Scientific and Technical Evaluation Committee
MIUR	Italian Ministry of Education, University and Research
OA	Open Access
PaN	Photon and Neutron
PI	Principal Investigator
PF	Partner Facility
RE	Representing Entity
RI	Research Infrastructure
R&D	Research & Development
S&T	Science & Technology
TBAB	Technical Bettery Advisory Board

Austrian PF: X-ray and Light scattering at the Graz University of Technology (TUG) and Elettra
Graz and Trieste
www.tugraz.at

Croatian PF: Ion beams at the Ruđer Bošković Institute
Zagreb
www.irb.hr

Czech PF: Surface science at the Charles University
Prague and Trieste
http://spl-msb.mff.cuni.cz/

Hungarian PF: Neutrons at the Budapest Neutron Centre of the Centre for Energy Research (EK)
Budapest
www.bnc.hu

Italian PF: Synchrotron and laser light at Elettra Sincrotrone Trieste
Trieste
www.elettra.eu

Polish PF: Synchrotron light and Cryo electron microscopy at Solaris
Krakow
www.synchrotron.uj.edu.pl

Romanian PF: Electron microscopy and EPR at the National Institute of Materials Physics
Magurele
http://lab50.infim.ro

Slovenian PF: NMR at the National Institute of Chemistry
Ljubljana
www.nmr.ki.si

CERIC-ERIC
S.S. 14 - km 163,5 in AREA Science Park 34149
Basovizza, Trieste - Italy
info@ceric-eric.eu
www.ceric-eric.eu

LinkedIn: www.linkedin.com/company/ceric-eric
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