CERIC

Central European
Research Infrastructure
Consortium

Report

2021

ERIC established by the European
Commision Implementing Decision
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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 all fields of materials, biomaterials and nanotechnology. Located in 8 countries in Europe (Austria, Croatia, Czech Republic, Hungary, Italy, Poland, Romania and Slovenia), it is open to researchers from all over the world. It offers a single access point to world class facilities and techniques based on the use of electrons, ions, neutrons and photons. Each Member Country contributes to CERIC a high-quality Partner Facility (PF), which is available to researchers on the basis of a positive review from the International Scientific and Technical Advisory Committee (ISTAC) of CERIC.

Jana Kolar
CERIC Executive Director

Dear Reader,

I am pleased to introduce CERIC's annual report for 2021. The past year was another one marked by the largest health emergency in modern times. Like many other analytical facilities, which host users, we had to adapt to the new working conditions in order to deliver our services and support to users. Our efforts were rewarded by the users. The number of allocated proposals was at a record high, and our scientists and the CERIC staff were awarded a close to perfect score by the users, for the quality of their support.

Support for scientific discoveries is at the heart of our activities. Read about new perovskite-type superlattices with potential application in optical quantum computing, powerful fuel cells with rare earth metals, to insights into the formation propensity of a novel class of unusual DNA structures, named pseudocircular G-hairpins. And much more.

Next to supporting scientific discoveries, significant efforts of CERIC went into training. In 2021, nearly 70 young researchers and 84 high-school pupils took part in our virtual training events, which extended over several weeks. We were also funding 16 PhD students, who are performing their work across CERIC's facilities.

In 2021, we have completed the EC's funded project ACCELERATE, which aimed at increasing the quality of operations of CERIC. In its final evaluation, the EC's reviewers highlighted '*the progress of CERIC, which was a RI established without any preparatory phase and strong governmental support, which is to be congratulated and a best-practice that should be observed elsewhere. Also, and even more important, one may say, is its scientific excellence and the service that it provides to the scientific community.*'

The expertise of CERIC was also recognised beyond its science, particularly when it comes to delivering the European Research Area (ERA). Carlo Rizzuto, the Chair of our Assembly, led the work of the EC's Expert Group on the ERIC Regulation, which produced an influential report on ERICs' contribution to the ERA.The deputy executive director, Ornela De Giacomo, co-chaired the group writing the charter and is an active member of the task force on financial sustainability within the EOSC Association, and I was elected chair of ESFRI.

These are just a few of the highlights of the past year and I invite you to read the report and find out more about the many contributions that CERIC made to science and various fields, such as UN's Sustainable Development Goals, and ERA.

The functioning of CERIC is made possible by the considerable support from the Italian government and the in-kind contributions of our Member Countries, which pool resources to support CERIC's operations. Furthermore, our activities were supported by several of the Member Countries, the European Commission, and European Structural and Investment Funds, demonstrating how such funds can be used in synergy in the activities performed by CERIC.

My last words go to my colleagues at CERIC, our partner facilities across eight countries, and our bodies – General Assembly, Board of Directors and International Scientific and Technical Advisory Committee, which made the last year's achievements possible. Thank you.

Executive Summary

The year 2021 was marked by the COVID-19 pandemic, which affected the operations of analytical facilities across the globe. Under the changed working conditions, CERIC received only marginally fewer proposals than in the previous year, while participation in policy-related activities was significantly decreased, primarily due to the smaller number of events (Table 1).

Headline Indicators	2018	2019	2020	2021	% Change 2021-2020
Proposals received	234	279	270	298	10
Number of papers	55	88	113	109	-3,5
Projects' funding (CERIC)	509,041.99	694,316.91	699,279.20	796.171,00	13.8
Invited participations in policy-related activities	14	17	12	34	183
Share of papers among 10% top cited*	-	14%		10,5%	

Table 1 Headline indicators for 2018-2021 and changes in the last reported year.

Excellent Science

In 2021, CERIC continued to provide access to its research infrastructure (RI) and contribute to the advancement of science. Its calls for open access attracted 298 proposals, requesting the use of 408 instruments. Proposals came from 37 countries and five continents.

Due to the ongoing COVID-19 pandemic, which has affected the operations of the analytical facilities, as well as the possibility to travel across countries, CERIC kept on accepting sample mailing, thus allowing the performance of experiments, also via remote access.

Whereas the number of publications has slightly decreased (-3,5%) since 2020, the average Impact Factor (IF), at 6.93, was nearly 15% higher than in 2020. However, IF is a poor proxy for scientific excellence. Therefore, also in 2021, CERIC collected the information about the impact of scientific publications, according to the adopted ESFRI methodology[1]. Such impact is expressed as the percentage of publications that are among the 10% top-cited. 10,5 percent of CERIC scientific articles published in 2019-2020 are among the top 10% cited publications[2].

A core activity of CERIC is also to promote the integration of its Partner Facilities (PFs) through internal research projects, RI investments and funding of PhD students, bringing together at least two CERIC facilities. The activities also contribute to increasing the capabilities of CERIC, and to pooling resources across EU countries towards the same objectives.

In addition to its services supporting the characterisation and modification of a large range of materials, the CERIC's multi-annual Science and RI development strategy foresees a stronger focus on the fields of Energy Materials and Life Sciences. In particular, to increase the capabilities of CERIC in the domain of fuel cells, CERIC appointed an external scientific advisory group of distinguished experts (Benedetto Bozzini, Sara Cavaliere, Jakub Drnec, Moniek Tromp). Their report, published in 2021, identifies the potential of CERIC infrastructure in this domain, proposing specific upgrades better to serve this community. The ISTAC found the report excellent and valuable, as did the General Assembly, which adopted the proposed Action Plan, aimed at implementation of the proposed recommendations.

Monitoring the quality of CERIC's infrastructure and services continued in 2021, with a periodic evaluation of the Italian and Slovenian PFs.

Training, Industrial Liaison, Communication, Projects

Training and up-skilling at all levels is strongly prioritised by CERIC. The PaGES6 project enabled 84 pupils from the Italian Region Friuli Venezia Giulia to access a wide programme of lectures on project management, communication and scientific topics. Due to the pandemic, the 2020/2021 edition took a fully virtual shape, also in connection with the scientists in the labs at the CERIC synchrotron facility in Trieste (Italy).

*According to the ESFRI methodology, the percentage of CERIC papers among top 10% most cited ones is reported biannually, with rolling publication dates: for 2019 (publications 2017-2018), for 2021 (publications 2019- 2020).
[1]https://www.esfri.eu/sites/default/files/ESFRI_WG_Monitoring_Report.pdf
[2]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.

The scientific opportunities available in the Consortium, as well as scientific use cases of the techniques available, were presented at scientific events organized by CERIC, its partners, as well as in the frame of the ACCELERATE project, such as the Hercules Specialised Course, and the CERIC-CEI Open Access Training on Materials Characterisation for the Green Deal. For such events, the first set of videos were released to showcase the instruments and techniques available at the CERIC PFs and to get early-stage researchers acquainted with the opportunities for research available in the Consortium.

Activities also progressed to carry out the CERIC-funded PhD programme, which aims to further the integration of the partner facilities and contribute to excellent science. In addition to the fourteen PhDs activated in 2020, a new scholarship was granted in 2021, in the field of battery research, in collaboration with the Polytechnic of Milan.

In 2021, CERIC also continued its capacity building activity for industrial liaison and technology transfer (IL/TT) staff of its PFs and other RIs, through an online webinar carried out by an international expert and focused on setting up a spin-out. Moreover, four online Research to Business events took place to address various aspects related to the usage of Research Infrastructures (RIs) for industrial innovation. All the actions carried out led to the start of negotiations with two companies to provide analytical services and to the definition of possible collaborations with the industry for two spin-outs of one of the CERIC's Representing Entities (REs).

In relation to industrial usage of the CERIC PFs via open access in 2021, 5% of total accesses – according to the users – were projects connected with industrial interest. In terms of publications, 11% of the articles released in 2021 were related to the industry.

In the communication domain, in addition to the regular promotion of the CERIC calls for proposals, the fast-track access for COVID-related research, and of all activities, opportunities and results achieved by the Consortium, also in the frame of its projects, a video on the services offered for the industry was released. CERIC also took part in science dissemination events, such as Trieste Next 2021 and the European Researchers' Night, with booths, conferences and pitches by the scientists for the lay public.

In addition to ordinary funding, CERIC also received funding for European projects, in a total amount oF 796.171 EUR, which is an 13,8% increase over 2020. H2020 projects whose implementation continued from previous years are ACCELERATE, ERIC Forum and PaNOSC.

CERIC Institutional Advances and Contribution to Policies

In relation to institutional development, particular attention was devoted to further implementing the CERIC science strategy. To this aim, CERIC infrastructural development has been complemented with investment in research on the battery topic by supporting different PhD projects in the field, whereas a report was published by the expert group on fuel cells, which identifies the bottlenecks and needs for upgrades of the CERIC infrastructure in this domain.

Moreover, in 2021 CERIC published a paper on the State of Open Access Procedures at Research Infrastructures (RIs), which showcases the various procedures adopted by RIs for open access, as well as the services implemented by facilities to face the COVID-19 outbreak.

CERIC also released its sustainability plan in June 2021, to align with the purpose of its five-year strategy, to deliver on the objectives and secure financial sustainability. The document presents the vision and mission of the institution, places it in the European landscape of RIs, and, based on this, derives its value proposition.

CERIC's contribution to UN Sustainable Development Goals and to the ERA has continued in 2021.

Contribution to the EOSC has been quite consistent as well, throughout 2021, in particular via the H2020 PaNOSC project, through which a FAIR Research Data policy was developed and adopted, as well as a Data Management Plan template. In this respect, CERIC has been dedicating resources to designing and implementing what is needed as part of the quality management system of the RI. Also, an IT strategy was developed and approved by the General Assembly of CERIC and, in January 2021, CERIC was selected among the few RIs receiving funding for the adoption of commercial cloud solutions in the frame of the H2020 OCRE project.

Finally, CERIC's performance monitoring has been continuous throughout the year, through the collection of the data related to all KPIs proposed by the ESFRI working group on Monitoring of RIs Performance. An assessment of the applicability of the KPIs proposed by ESFRI has also been made.

Operations and Finance

The final section of this report presents the financial and economic situation of the Consortium for the year 2021, outlined through statements presented under the accrual basis of accounting according to International Public Sector Accounting Standards.

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Excellent Science

Main Achievements

1. **Implementation of 2 calls for free open access**
to which 298 proposals, requesting the use of 408 instruments, were received.

2. **Proposals came from 37 countries and 5 continents**

3. **Continuous fast-track access for feasibility studies and for COVID-related research**

4. **Positive evaluation of the Italian and Slovenian CERIC Partner Facilities**
by the international team of experts led by CERIC's International Scientific and Technical Advisory Committee (ISTAC).

5. **Positive evaluation of the progress of four CERIC internal research projects**

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 2021, CERIC launched two calls for proposals for the use of the Consortium's research instruments: 298 proposals were received (Figure 1). Given their multi-technique character, this corresponds to 408 single instrument proposals. There has been a 10% increase in the number of applications compared to the previous year. Moreover, 2021 has been the year with the highest number of received applications since the set-up of the Consortium.

There were 186 proposals selected for the use of 227 allocated instruments (Figure 2). In 2021, despite the COVID-19 emergency, nearly 22406 hours of operation were used to perform measurements. In addition to physical access (58%) to the CERIC facilities, some of them continued to offer the possibility of performing measurements remotely through sample mailing. Among the submitted proposals, 26% requested access to multiple facilities.

Figure 1
Number of proposals and requested methods

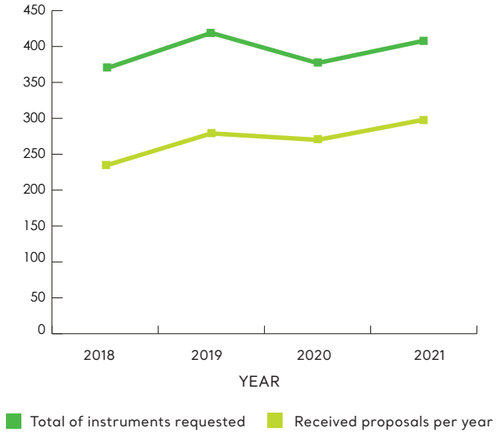
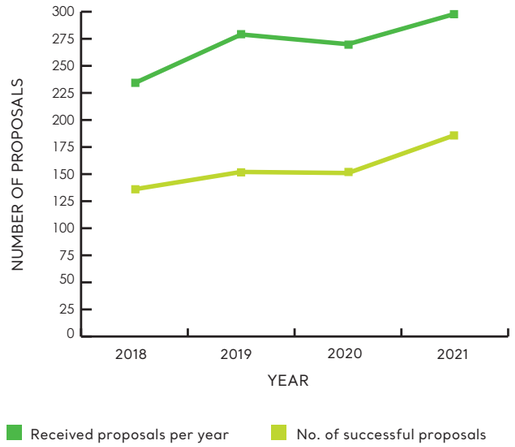
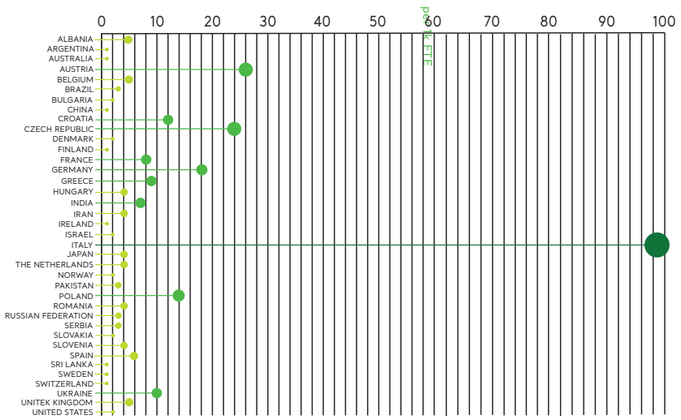


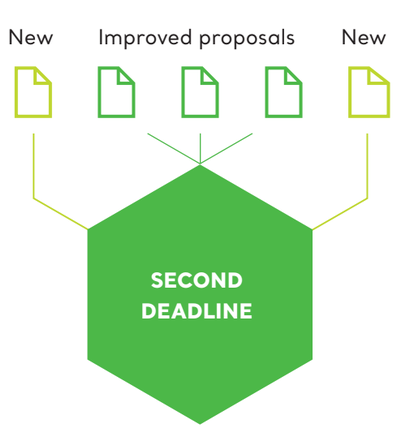
Figure 2
Number of received and successful proposals per year



CERIC remains a highly internationalised research infrastructure, with principal investigators from 37 countries and five continents in 2021 (Figure 3). Most proposals received came from the European Member States, while 46% of proposals came from non-EU countries.

Figure 3
No. of proposals by country

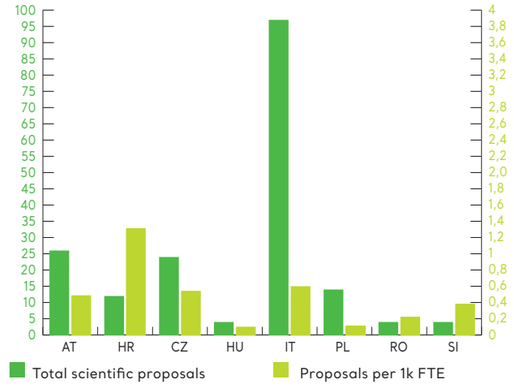




The majority (62%) of submitted proposals also came from CERIC Member Countries in 2021, as in the previous year. The most active users, in relation to the fulltime employees in Research & Development in a country, are from Croatia, followed by Italy and the Czech Republic.

- **2 calls for proposals**
- **298 proposals received**
- **Research groups from 37 countries**
- **227 allocated requests**

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



In 2021, 41% of the principal investigators and 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 2021, the number of publications released from measurements taken at the CERIC facilities slightly decreased (-3,5%), though this may be given by the fact that the CERIC database hasn't been promptly updated by the users. On the other hand, the average Impact Factor (IF, 6.93) increased by nearly 11% in comparison to the previous year. However, IF is a poor measure of the quality of the output. Therefore, also in 2021, CERIC collected data on the most cited publications, expressed as the share of CERIC's publications among the top 10% most frequently cited ones (top10%). The data of the top10% indicator is presented in Figure 6. More than one-third (37%) of the top 10% papers were in the field of life sciences, followed by 17% in the field of energy, supporting the rationale to further focus on these two domains.

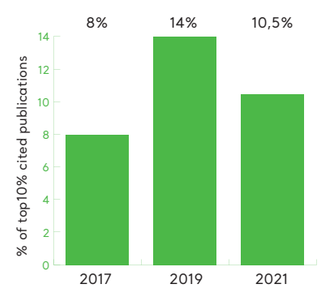


Figure 6
Percentage of CERIC papers among top10% most cited ones. According to the ESFRI methodology, the data is reported biannually, with rolling publication dates: for 2017 (publications 2015-2016), for 2019 (publications 2017-2018) and for 2021 (publications 2019-2020).

International Scientific and Technical Advisory Committee - ISTAC

The purpose of the International Scientific and Technical Advisory Committee (ISTAC) of CERIC is to provide the General Assembly (GA) with recommendations on scientific and technical issues that bear on the full and effective utilization of CERIC as a state-of-the-art research infrastructure and on developments required to maintain its scientific productivity at the highest possible level and ensure its relevance to the international scientific community. In particular, the ISTAC evaluates proposals for new partner facilities, and the operation of existing ones, advising the General Assembly on acceptance and continuation.
The periodic evaluation of the Italian and Slovenian Partner Facility (PF) was held in October 2021, (read more on page 32), with sites visits by the members of the ISTAC, at the synchrotron in Trieste and at the Slovenian NMR in Ljubljana. In the same year, the membership of Karsten Horn in the ISTAC was reconfirmed.

COVID-19 Fast Track Access

Also, in 2021, CERIC continued offering a dedicated Fast Track Access to a selected number of instruments in order to facilitate research on COVID-19.
The dedicated Fast Track Access stayed open throughout the whole year, allowing access to a set of relevant instruments for research related to COVID-19 without the necessity to undergo the regular evaluation procedure and to be scheduled within one month from the submission of the proposal, based on an evaluation performed by the facility. During the year, four proposals have been received for this access mode.
A wide number of techniques at the Austrian, Italian, Polish and Slovenian facilities have been devoted to the purpose, as well as the Italian Network for Micro and Nano Fabrication.
As a pilot of open access of the H2020 ACCELERATE project, all scientific information generated (i.e., peer-reviewed scientific research articles and research data) have been made available and reusable through online access that is free of charge to the end-user.

New instruments available via open access

A new instrument was added in 2021 to the CERIC open access offer: the PHELIX beamline at the Polish PF, SOLARIS. The PHELIX end-station enables a wide range of spectroscopic and absorption studies characterised by different surface sensitivity.

[1]ESFRI, Monitoring of Research Infrastructure Performance, Annex 5, https://www.esfri.eu/sites/default/files/ESFRI_WG_Monitoring_Report.pdf

Scientific Publications

One hundred and nine (109) articles were published in 2021, with a cumulative impact factor of 727,.9 (versus 675.3 in 2020) and an average impact factor of 6,93 (versus 5.6 in 2020):

(1) *Hot-carrier and optical-phonon ultrafast dynamics in the topological insulator Bi_2Te_3 upon iron deposition on its surface,* Weis M., Balin K., Wilk B., Sobol T., Ciavardini A., Vaudel G., Juvé V., Arnaud B., Ressel B., Stupar M., Prince K. C., De Ninno G., Ruello P., & Szade J., Physical Review B, 2021

(2) *Virus pH-Dependent Interactions with Cationically Modified Cellulose and Their Application in Water Filtration,* Watts S., Maniura-Weber K., Siqueira G., & Salentinig S., 2021

(3) *Lipid polymorphism of the subchloroplast—granum and stroma thylakoid membrane—particles. I. 31P-NMR spectroscopy,* Dlouhý O., Javornik U., Zsiros O., Šket P., Karlický V., Špunda V., Plavec J. & Garab G., Cells, 2021

(4) *Local Surface Plasmonic Resonance, Surface-Enhanced Raman Scattering, Photoluminescence, and Photocatalytic Activity of Hydrothermal Titanate Nanotubes Coated with Ag Nanoparticles,* Thuy P. T., Minh V. C., Mai V. Q., Tri Tuan T. T., Tuan P. V., Cuong H. B., Sang N. X., Journal of Nanomaterials, 2021

(5) *Stable aqueous dispersions of bare and double layer functionalized superparamagnetic iron oxide nanoparticles for biomedical applications,* Markhulia J., Kekutia S., Mikelashvili V., Almásy L., Saneblidze L., Tsertsvadze T., Maisuradze N., Leladze N. & Kriechbaum M., Materials Science-Poland, 2021, DOI

(6) *Catalytic hydrogenation of substituted quinolines on Co-graphene composites,* Asaula V. M., Buryanov V. V., Solod B. Y., Tryus D. M., Pariiska O. O., Kotenko I. E., Volovenko Y. M., Volochnyuk D. M., Ryabukhin S. V., & Kolotilov S., European Journal of Organic Chemistry, 2021

(7) *Successive Vapor-Phase Guerbet Condensation of Ethanol and 1-Butanol to 2-Ethyl-1-hexanol over Hydroxyapatite Catalysts in a Flow Reactor,* Zikrata O. V., Larina O. V., Valihura K. V., Kyriienko P. I., Balakin D. Y., Khalakhan I., Veltruská K., Krajnc A., Mali G., Soloviev S.O., & Orlyk S. M. ACS Sustainable Chemistry & Engineering, 2021

(8) *Ferroelectric properties of ZrO2 films deposited on ITO-coated glass,* Silva J. P. B., Sekhar K. C., Negrea R. F., Ghica C., Dastan D., & Gomes M. J. M., Ceramics International, 2021

(9) *Human Antimicrobial Peptide Triggered Colloidal Transformations in Bacteria Membrane Lipopolysaccharides,* Hong L., Gontsarik M., Amenitsch H., & Salentinig S., Small, 2104211, 2021

(10) *Wake-up Free Ferroelectric Rhombohedral Phase in Epitaxially Strained ZrO2 Thin Films,* Silva J. P., Negrea R. F., Istrate M. C., Dutta S., Aramberri H., Íñiguez J., Figueiras F. G., Ghica C., Sekhar K., & Kholkin A. L., ACS Applied Materials & Interfaces, 2021

(11) *Influence of Copper and Silver on Catalytic Performance of MgO–SiO2 System for 1, 3-Butadiene Production from Aqueous Ethanol* Kyriienko, P. I., Larina, O. V., Balakin, D. Y., Soloviev, S. O., & Orlyk, S. M., Catalysis Letters, 1-10, 2021, DOI

(12) *Experimental Analysis on the Influence of Operating Profiles on High Temperature Polymer Electrolyte Membrane Fuel Cells* Chinese T., Ustolin F., Marmiroli B., Amenitsch H., & Taccani R., Energies, 14(20), 6737, 2021, DOI

(13) *Microfluidic Formulation of DNA-Loaded Multicomponent Lipid Nanoparticles for Gene Delivery,* Quagliarini E., Renzi S., Digiacomo L., Giulimondi F., Sartori B., Amenitsch H., Tassinari V., Masuelli L., Bei R., Cui L., Wang J., Amici A., Marchini C., Pozzi D., & Caracciolo G., Pharmaceutics, 13(8), 1292, 2021

(14) *Detection of Pancreatic Ductal Adenocarcinoma by Ex Vivo Magnetic Levitation of Plasma Protein-Coated Nanoparticles,* Digiacomo L., Quagliarini E., La Vaccara V., Coppola A., Coppola R., Caputo D., Amenitsch H., Sartori B., Caracciolo G., & Pozzi D., Cancers, 13(20), 5155, 2021

(15) *Plastics,(bio) polymers and their apparent biogeochemical cycle: An infrared spectroscopy study on foraminifera,* Birarda G., Buosi C., Caridi F., Casu M. A., De Giudici G., Di Bella L., Medas D., Meneghini C., Pierdomenico M., Sabbatini A., Surowka A., & Vaccari L., Environmental Pollution, 279, 116912, 2021

(16) *Pioneer settlement of the cold-water coral Desmophyllum dianthus (Esper, 1794) on plastic,* Bergami E., Caroselli E., Vaccari L., Corsi I., Semenov A., & Macali A., Coral Reefs, 1-6, 2021

(17) *Cubic and Hexagonal Mesophases for Protein Encapsulation: Structural Effects of Insulin Confinement,* Astolfi P., Giorgini E., Perinelli D. R., Vita F., Adamo F. C., Logrippo S., Parlapiano M., Bonacucina G., Pucciarelli S., Francescangeli O., Vaccari L., & Pisani M., Langmuir, 37(33), 10166-10176, 2021

(18) *Controllable magnetic anisotropy and spin orientation of a prototypical easy-plane antiferromagnet on a ferromagnetic support,* Ślęzak M., Nayyef H., Dróżdż P., Janus W., Kozioł-Rachwał A., Szpytma M., Zając M., Menteş T. O., Genuzio F., Locatelli A., & Ślęzak T., Physical Review B, 104(13), 134434, 2021

(19) *Benzohydroxamic Acid on Rutile TiO2 (110)-(1× 1)–A Comparison of Ultrahigh-Vacuum Evaporation with Deposition from Solution,* Köbl J., Fernández C. C., Augustin L. M., Kataev E. Y., Franchi S., Tsud N., Pistonesi C., Pronsato M.E., Jux R., Lytken O., Williams F.J., & Steinrück H. P., Surface Science, 121955, 2021

(20) *Biocompatible Silver Nanoparticles: Study of the Chemical and Molecular Structure, and the Ability to Interact with Cadmium and Arsenic in Water and Biological Properties,* Bertelà F., Marsotto M., Meneghini C., Burratti L., Maraloiu V. A., Iucci G., Venditti I., Prosposito P., D'Ezio V., Persichini T., & Battocchio C., Nanomaterials, 11(10), 2540, 2021

(21) *Thiolate end-group regulates ligand arrangement, hydration and affinity for small compounds in monolayer-protected gold nanoparticles,* Pellizzoni E., Şologan M., Daka M., Pengo P., Marson D., Posel Z., Franchi S., Bignardi L., Franchi P., Lucarini M., Posocco P., & Pasquato L., Journal of Colloid and Interface Science, 2021

(22) *Ethanol Inactivation of Enveloped Viruses: Structural and Surface Chemistry Insights into Phi6,* Watts S., Ramstedt M., & Salentinig S. (2021). The Journal of Physical Chemistry Letters, 12, 9557-9563, 2021

(23) *Novel Christmas Branched Like NiO/NiWO4/WO3 (p–p–n) Nanowire Heterostructures for Chemical Sensing,* Kaur N., Zappa D., Maraloiu V. A., & Comini E., Advanced Functional Materials, 31(38), 2104416, 2021

(24) *Effect of large graphene particle size on structure, optical property and photocatalytic activity of graphene-titanate nanotube composites,* Minh V.C., Dat P. T., Thuy P. T., Sang N. X., Tuan N. T., Tung T. T., Losic D., Optical Materials, 2021

(25) *Addressable Graphene Encapsulation of Wet Specimens on a Chip for Optical, Electron, Infrared, and X-ray based Spectromicroscopy Studies,* Arble C., Guo H., Matruglio A., Gianoncelli A., Vaccari L., Birarda G., & Kolmakov A., Lab on a Chip, 2021

(26) *Correlation of Thermoelectric Performance, Domain Morphology and Doping Level in PEDOT: PSS Thin Films Post-Treated with Ionic Liquids,* Oechsle A. L., Heger J. E., Li N., Yin S., Bernstorff S., Müller-Buschbaum P., Macromolecular Rapid Communications, 2100397, 2021

(27) *Mechanisms of surface nanostructuring of Al2O3 and MgO by grazing incidence irradiation with swift heavy ions* Karlušić M., Rymzhanov R. A., O'Connell J. H., Bröckers L., Luketić K. T., Siketić Z., Fazinić S., Dubček P., Jakšić M., Provatas G., Medvedev N., Volkov A.E., Schleberger M., Surfaces and Interfaces, 101508, 2021

(28) *An N-terminal half fragment of the histidine phosphocarrier protein, HPr, is disordered but binds to HPr partners and shows antibacterial properties,* Neira J. L., Palomino-Schätzlein M., Hurtado-Gómez E., Ortore M. G., & Falcó A., Biochimica et Biophysica Acta (BBA)-General Subjects, 130015, 2021

(29) *Investigation of Ion Irradiation Effects in Silicon and Graphite Produced by 23 MeV I Beam,* Tomić Luketić K., Karlušić M., Gajović A., Fazinić S., O'Connell J. H., Pielić B., Radatović B. & Kralj M., Materials, 14(8), 1904, 2021

(30) *Revisiting the Chemical Stability of Germanium Selenide (GeSe) and the Origin of its Photocatalytic Efficiency,* Boukhvalov D.W., Nappini S., Vorokhta M., Menteş T.O., Piliai L., Panahi M., Genuzio F., De Santis J., Kuo C-N, Lue C.S., Paolucci V., Locatelli A., Bondino F., Politano A., Advanced Functional Materials, 2021

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Scientific Highlights

Scientists develop new perovskite-type superlattices with potential application in optical quantum computing[1]

Perovskite is a calcium titanium oxide mineral composed of calcium titanate (CaTiO3) and characterized by a particular crystal structure. Nowadays, any compound sharing the same perovskite structure with calcium titanate is called perovskite and its properties may vary depending on which elements are used to build the structure. The features of materials based on lead halide perovskites are of relevant interest in several fields of technology, especially in correlation with how light interacts with perovskites. For instance, they have a remarkable efficiency in absorbing photons and therefore are a promising material for next-generation solar cells characterised by higher efficiency and lower costs. Another field of application is quantum dots, a technology applied in next-generation televisions and monitors.

Prof. Maksym Kovalenko
PhD student Ihor Cherniukh
Dr. Maryna Bodnarchuk

Ihor Cherniukh, **Dr. Maryna Bodnarchuk** and **Prof. Maksym Kovalenko**, from ETH Zurich and EMPA- Swiss Federal Laboratories for Materials Sciences and Technologies reported in a Nature publication, together with colleagues, the co-assembly of perovskite-type superlattices from lead halide perovskite nanocubes and Fe3O4 nanospheres. In this study, cubic and spherical nanocrystals were co-assembled into a superlattice, demonstrating that these structures exhibit superfluorescence characterised by emission pulses with ultrafast radiative decay (22 picoseconds). Grazing Incidence Small-Angle X-ray Scattering (GISAXS), available at the Austrian CERIC Partner Facility of the Graz University of Technology at the Elettra synchrotron in Trieste, is among the analytical techniques that allowed to gather fundamental structural insights on the sample study.

"Lead halide perovskites nanocrystals are promising materials for classical and quantum light sources".

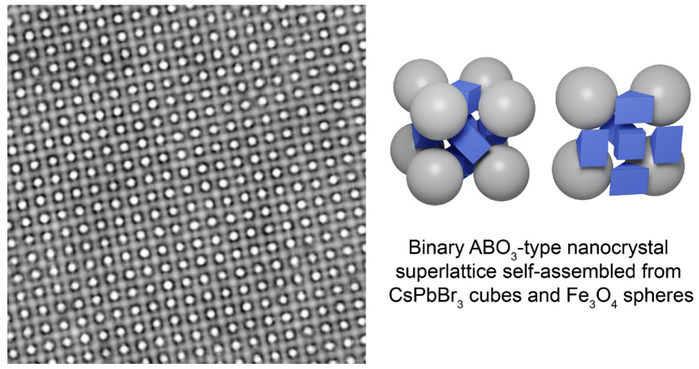


Figure 7
High-angle annular dark-field scanning transmission electron microscopy image of a binary ABO3-type superlattice obtained from cubic 8.6-nm CsPbBr3 and spherical 14.5-nm Fe3O4 nanocrystals; ABO3 unit cell and half of the unit cell showing the relative orientations of nanocubes in the structure.

This scientific work provided relevant insights about perovskite-based materials, such as quantum light sources. Further engineering of perovskite superlattices at the mesoscale and the microscale could have relevant optical quantum computing and quantum imaging applications.

[2] *Perovskite-type superlattices from lead halide perovskite nanocubes,* Cherniukh I., Rainò G., Stöferle T., Burian M., Travesset A., Naumenko D., Amenitsch H., Erni R., Mahrt R.F., Bodnarchuk M.I., & Kovalenko M. V., Nature, 2021, DOI: https://doi.org/10.1038/s41586-021-03492-5

International collaboration provides new insights into an unusual DNA structural family[6]

After almost seventy years from the discovery of the double-helical structure of DNA, this carrier of genetic information keeps amazing us. DNA can, in addition to classical duplex assembled through Watson-Crick base pairs, adopt various structures, including hairpins, triplexes, and quadruplexes. Sequences that are able to form these non-canonical DNA structures are enriched within regions associated with gene regulation and at the ends of the chromosomes (telomeres), where they play an important role in cellular ageing.

A research work by **Dr. Martina Lenarčič Živković** (Masaryk University, Slovenian NMR Centre), **Martin Gajarský** (Masaryk University), **Prof. Janez Plavec** (Slovenian NMR Centre), **Dr. Lukáš Trantírek** (Masaryk University), and colleagues, provided relevant insights into the formation propensity of a novel class of unusual DNA structures, named pseudocircular G-hairpins (PGHs). In 2017, the same authors reported on the first atomic-resolution structure of a PGH formed by a short telomeric sequence of *Saccharomyces cerevisiae*, a yeast employed for millennia in baking and winemaking. In this work, the authors thoroughly investigated sequential requirements leading to the formation of PGHs. Their results reveal that despite the 'circular' nature these structures can form even in the context of extended sequences. Although the PGH-forming sequences are short (from 11 to 14 nucleotides), they form stable structures with amazingly complex topology (Figure 1).

"Detailed structural characterization and insights into formation propensity of PGHs expand our knowledge on complex folding possibilities of biologically relevant DNA regions and offer novel ideas for genetic engineering, and DNA-based nanotechnology".

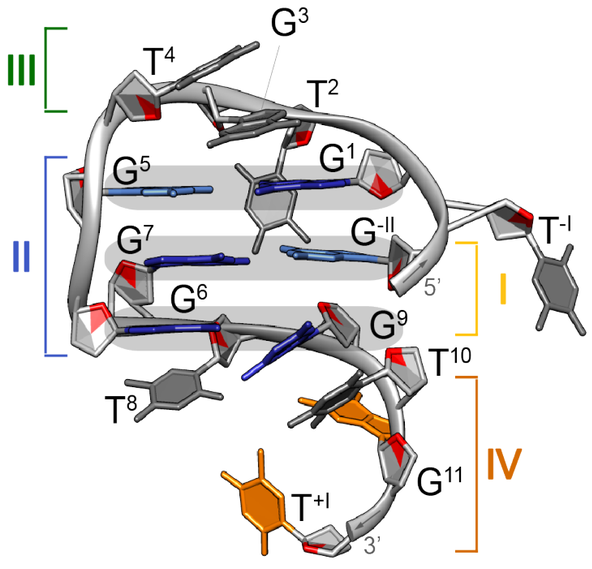


Figure 8
Representative member of a pseudocircular G-hairpin (PGH) structural family. The core of the PGH structure is comprised of three dynamic G:G base pairs (grey ellipses) and characterized by a rather complex topology, which includes (I) stacking of terminal guanines (leading to 'circular' nature of PGH) and (II) chain reversal between residues from the GGG tract. The G:G core is surrounded by stacked loop residues (III) and a flexible 3'-tail (IV).

Bioinformatic analysis revealed that potential PGH-forming sequences are abundant and non-randomly distributed in the evolutionary-conserved regions of the human genome, implicating their functionally important biological role(s). Unique structural properties of PGHs suggest they could be relevant for drug development or DNA-based nanotechnology. Results of this fruitful collaboration between Slovenian and Czech researchers were partially acquired at the Slovenian CERIC Partner Facility at the National Institute of Chemistry in Ljubljana.

[6] *Insight into formation propensity of pseudocircular G-hairpins*, Lenarčič Živković M., Gajarsky M., Bekova K., Stadlbauer P., Vicherek L., Petrova M., Fiala R., Rosenberg I., Sponer J., Plavec J. and L. Trantirek L., Nucleic Acids Research, 2021, DOI: https://doi.org/10.1093/nar/gkab029

Stable and powerful fuel cells with rare earth metals alloy catalysts[3]

In the path toward a climate-neutral European Union, to be achieved by 2050, the development and the large-scale deployment of energy technologies are fundamental. Next to batteries, fuel cells are an important asset to achieve this result. Thanks to their properties, Proton Exchange Membrane Fuel Cells (PEMFC) have a great potential to become part of our daily life. Among their advantages, high power density and low operational temperatures make them a suitable energy source for transportation, from cars to public buses. However, the aspect preventing this technology's diffusion is the catalyst material, mostly a rare metal such as platinum. Substituting or reducing the amount of platinum would make this technology more affordable and thus closer to a large-scale application.

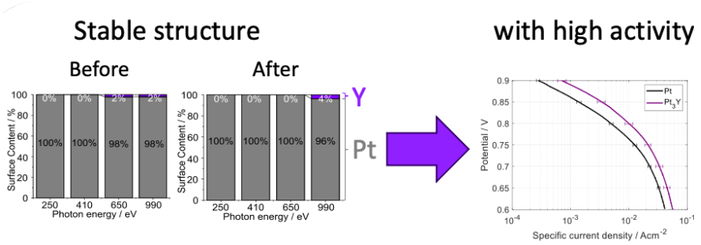


Figure 9
Summary of SRXPS and electrochemical results showing that after electrochemical testing no significant changes in the surface Pt to Y ratio were detected allowing for a high oxygen reduction activity.

In this regard, an example is given by the use of platinum alloys with rare earth metals (REM), such as yttrium (Y), gadolinium (Gd), and terbium (Tb). A collaboration among scientists from the KTH Royal Institute of Technology (Sweden), Chalmers University of Technology (Sweden) and the Charles University of Prague (Czech Republic) resulted in a publication by **Dr. Björn Eriksson** (KTH) and colleagues that reports interesting performances by PtREM alloy catalysts under operational conditions.

Synchrotron Radiation Photoelectron Spectroscopy (SRXPS) measurements, made at the Materials Science Beamline (MSB), available at the CERIC Austrian Partner Facility (Charles University Prague) at Elettra Sincrotrone Trieste, allowed the study of the surface composition of different PtREM alloys tested in this research work. These experiments showed that Pt3Y alloy had no significant change in the surface composition during operations, suggesting that this alloy is the most stable. Experiments also highlighted that Pt3Y and Pt5Gd have a specific activity that is 2.5 times higher than pure platinum. The combination of increased activities and low changes in surface composition, achieved in an operating fuel cell, shows that PtREM catalysts are a promising cathode material for PEMFC.

"Rare earth metals alloy catalysts may help reduce the amount of platinum required in fuel cells catalysts, thus allowing for a large-scale application of a fundamental technology to fight climate change".

[3] *Enhanced oxygen reduction activity with rare earth metal alloy catalysts in proton exchange membrane fuel cells*, Eriksson B., Montserrat-Sisó G., Brown R., Skála T., Lindström R. W., Lindbergh G., Wickman B., & Lagergren C., Electrochimica Acta, 387, 138454, 2021, DOI: https://doi.org/10.1016/j.electacta.2021.138454

Multianalytical characterisation and the drug release profile of silica-based gels[4]

Xerogels can be described as dried gels that retain their porous structure after the drying procedure. They're characterised by mesoporosity and a peculiar structure that can easily be controlled during the synthesis procedure. Silica-based xerogels are exciting materials in different applications sectors such as gas storage and separation, biocatalysis, corrosion protection, and adsorption of organic solvents. Drug delivery is also a relevant field of applications for silica xerogels because of their biocompatibility, high loading efficiency, and low processing temperature.
In the framework of national and international cooperation, the group led by **Dr. Zoltán Dudás** (Centre for Energy Research, Budapest) headed a scientific work characterised by a multi analytical study of silica xerogels prepared at different pH and with varying ratios of precursors. Numerous CERIC techniques were employed to analyse the gels, such as Small-Angle Neutron Scattering (SANS), lab Small-Angle X-ray Scattering (SAXS), High-Resolution Transmission Electron Microscopy (HRTEM), and solid-state Nuclear Magnetic Resonance (NMR), giving fundamental insights into the structure, composition, and synthesis of the silica xerogel. These techniques are available respectively at the Hungarian, Austrian, Romanian, and Slovenian CERIC partner facilities. Following the characterisation, xerogels were tested for the uptake and release of Captopril, a well-known molecule employed in the treatment of hypertension and some types of heart failure.

Zoltán Dudás

"Silica-based Xerogels have exciting potential applications in several fields, including drug delivery thanks to their biocompatibility and high loading efficiency".

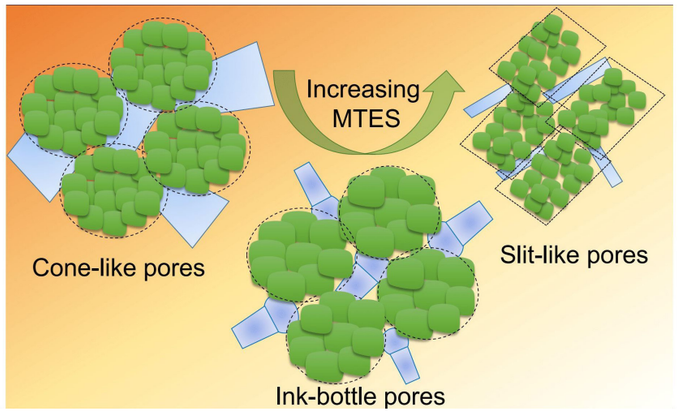


Figure 10
The quantity of methyl functionalization modifies the primary particles size and the shape and size of the pores.

This study allowed to gain essential information about the structural and physicochemical characteristics of silica xerogels and how the pH and the precursors ratios impact the final structure. The loading and release experiment revealed that the synthesis procedure could affect the release profile of the drug, being connected with the apparent surface area.
This study gave essential information for developing technologies in several fields, including drug release, with a relevant impact on future medical treatments.

[4] *Physicochemical Characterization and Drug Release Properties of Methyl-Substituted Silica Xerogels Made Using Sol–Gel Process,* Len A., Paladini G., Románszki L., Putz A-M, Almásy L., László K., Bálint S., Krajnc A., Kriechbaum M., Kuncser A., Kalmár J. & Dudás Z., International Journal of Molecular Sciences, 2021, DOI: https://doi.org/10.3390/ijms22179197

Discovered the technical fingerprint of the traditional Cremonese violin makers[5]

Cremonese traditional luthiery is one of the most renowned artisanal legacies in the world. Between the XVI and the XVIII century families like the Guarneri and the Stradivari built instruments that became legendary, recognised now, centuries later, among the most valuable instruments in the world. The value of traditional violin craftsmanship in Cremona was also declared an intangible cultural heritage by UNESCO in 2012, and several scientific studies focused their attention on these instruments. The intent of these research works is to understand what makes these pieces unique and to discover secrets that could have been lost over the centuries.

Giacomo Fiocco

Giacomo Fiocco, a CERIC user from the University of Turin and the Arvedi laboratory of non-invasive diagnostics at the University of Pavia, and his colleagues, recently published an article about their analyses of traditional Cremonese violins. Among the items that the scientists analysed, there are "Toscano", manufactured by Antonio Stradivari in 1690, and "Bracco", created by Lorenzo Storioni in 1793.

Marco Malagodi

The study, in which also **Dr. Monica Gulmini** (University of Turin) and Prof. **Marco Malagodi** (University of Pavia) were involved, highlighted the technical fingerprint of the two Cremonese masters, which appeared different. Storioni's violins, for example, appear to be characterised by a 10-micrometre ground coat covered by a 60-90 micrometres varnishing layer, while for Stradivari's, the varnishing layer was 10-15 micrometres thick. No ground coat was detected in this last case, but it probably penetrated in the wood pores.

The analysis was carried out on micrometric samples detached from the violin employing synchrotron infrared radiation at SISSI beamline at the Italian CERIC partner facility.

"Non-destructive techniques are perfect candidates for the study of cultural heritage, allowing researchers and other stakeholders (i.e. violin makers, curators, restorers) to improve the knowledge of materials and better approach unique pieces of art and craftsmanship such as violins.".

Figure 11
Harmonic table of Toscano- Stradivari, 1690

Non-destructive techniques, such as the ones available at CERIC's partner facilities, are of fundamental importance for the study of cultural heritage items and allow, at the same time, to improve our knowledge of ancient techniques and preserve unique pieces of art and craftsmanship.

[5] *Reflection FTIR spectroscopy for the study of historical bowed string instruments: Invasive and non-invasive approaches,* Fiocco G., Invernizzi C., Grassi S., Davit P., Albano M., Rovetta T., Stani C., Vaccari L., Malagodi M., Licchelli M., Gulmini M., Spectrochimica Acta – Part A: Molecular and Biomolecular Spectroscopy, 245, 2021, DOI: https://doi.org/10.1016/j.saa.2020.118926

New insights into how grazing incident swift heavy ions interact with different materials[6]

Swift Heavy Ions (SHI) are a special form of high-mass particle radiation. In many solids, incident swift heavy ion beams release sufficient energy to generate long, nanometer-sized damage trails called ion tracks. Swift heavy ions, and ion tracks, have established applications in numerous industrial sectors, including microfabrication of nanomembranes, hadron therapy, radiation hardness testing (including nuclear waste vitrification studies) and fission track dating.

Dr. Marko Karlušić (Ruđer Bošković Institute), and colleagues, discovered that aluminium oxide (Al2O3) and magnesium oxide (MgO) exhibit well-pronounced nanometric modification on the surface when irradiated under a grazing incidence SHI beam. In contrast, the same ion beam with normal incidence leaves no damage. The ERDA beamline, available at the Croatian CERIC Partner Facility at the Ruđer Bošković Institute, allowed for the irradiation of samples. At the same time, Rutherford Backscattering Spectrometry (RBS), available at the same CERIC Partner Facility, was employed to investigate the formation of ion tracks below the surface of the materials. These and other experiments also allowed to characterise the morphology of the ion tracks on the two materials, which appear different. The irradiation of aluminium oxide generated extended hillocks, while magnesium oxide showed a grove-like extended structure surrounded by droplets of ejected material.


Marko Karlušić

"A deeper understanding of surface nanostructuring by grazing incident swift heavy allows for relevant industrial applications spanning from microelectronics to the energy sector.".

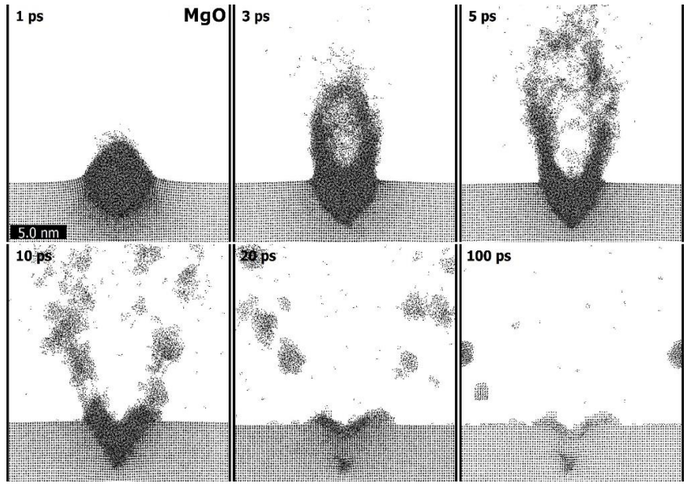


Figure 12
Kinetics of surface rift formation in MGO at different times after 23 MeV ion passage at the depth of 1 nm parallel to the surface.

This research allowed insights into how grazing incident swift heavy ions interact with different materials providing a deeper understanding of the fundamental processes of surface nanostructuring. The application of such a process could allow for the controlled production of periodic surface nanopatterns useful for thin-film template-based synthesis or by tuning the physical properties of 2D materials via strain - when placed over nanostructured substrates.

[6] *Mechanisms of surface nanostructuring of Al2O3 and MgO by grazing incidence irradiation with swift heavy ions* Karlušić M., Rymzhanov R. A., O'Connell J. H., Bröckers L., Luketić K. T., Siketić Z., Fazinić S., Dubček P., Jakšić M., Provatas G., Medvedev N., Volkov A.E., Schleberger M., Surfaces and Interfaces, 2021, DOI: https://doi.org/10.1016/j.surfin.2021.101508

A new hypothesis on the curious features of europium-based multiferroic material[7]

Thanks to their peculiar properties, there's a growing interest in the last decade around multiferroic materials. In particular, their magnetic properties can be tuned by an electric field and vice versa. These features make them an exciting playground for studying new physics and chemistry. Furthermore, they could be a platform for developing new technologies in areas like nano-electronics, spintronics, and more recently, solar cells and photocatalysis. In this regard, a specific multiferroic material, $EuTiO_3$ (ETO), has raised the scientific community's interest.

Dr. Panagiotis Pappas (National Technical University of Athens) and colleagues analysed ETO samples with several analytical techniques encountering puzzling results. They found that around 282 K (8,85 °C), a morphological phase transition from cubic to tetragonal is revealed by X-ray diffraction (XRD), but curiously, no Raman modes were found contrary to the homologous $SrTiO_3$ (STO). Experiments were performed at the XRD1, MCX, and IUVS beamlines, available at the Italian CERIC Partner Facility at the Elettra synchrotron and at the XAS beamline at the Polish CERIC Partner Facility at the Solaris synchrotron. During such tests, the authors also discovered that some Raman modes in ETO samples could be activated by applying hydrostatic pressure or an external magnetic field.


Panagiotis Pappas

"The study of multiferroics could expand our understanding on the underlying physical mechanisms behind the correlation between ferroelectricity and magnetism, as well as lead to novel technologies in strategic sectors such as spintronics".

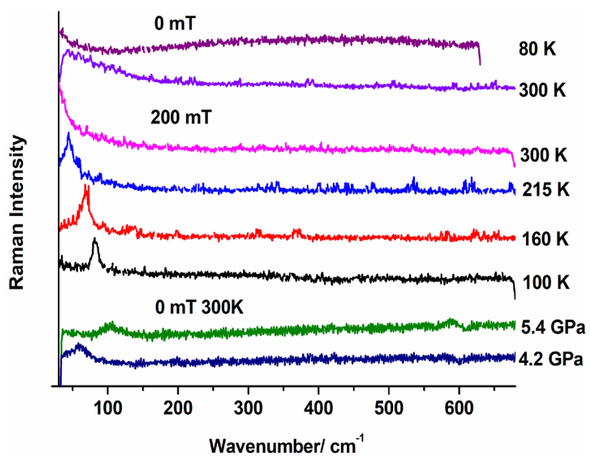


Figure 13
Raman spectra of $EuTiO_3$ under 200 mT DC magnetic field reveal the activation of a mode indicative of the structural phase transition in remarkable agreement with theoretical predictions. Also hydrostatic pressure above 4.1 GPa activates the same mode.

These results suggest that a possible explanation for the puzzling absence of Raman modes could be related to the magnetic europium (Eu) ions. Such a hypothesis would explain the lack of Raman modes as well as their activation following external perturbations. Further investigations on this and other multiferroic materials could allow the discovery of new chemistry/physics with potential applications in strategic technological sectors.

[7] *Magnetic interactions and the puzzling absence of any Raman mode in $EuTiO_3$,* Pappas P., Liarokapis E., Calamiotou M., Bussmann-Holder A., Journal of Raman spectroscopy, 2021, DOI: https://doi.org/10.1002/jrs.6075

New insights into how small extracellular vesicles fuse with a model cellular membrane[8]

Extracellular vesicles (EVs) are nanosized cell-derived compartments with cargo functions. They can transport a wide range of molecules such as proteins, DNA, RNA, metabolites, and nutrients from cell to cell and throughout the body. EVs are an important player in several biological processes and, thanks to features like biocompatibility and small size, have a relevant therapeutic potential. These systems have been widely studied through the years, although various aspects of their physiology remain debated. Gaining insight into how EVs interact with cell membranes would substantially impact the biomedical sector.


Loredana Casalis


Pietro Parisse

Researchers from several European institutions, led by **Dr. Valeria Rondelli** from University of Milan, **Dr. Pietro Parisse** from IOM- CNR and **Dr. Loredana Casalis** from Elettra Sincrotrone Trieste, employed various techniques to gain essential information on the fusion mechanism of small extracellular vesicles (sEVs) with a model plasma membrane. The employment of an artificial lipid bilayer allowed the investigation of different fusion mechanisms that are difficult to examine in a complex cellular environment.

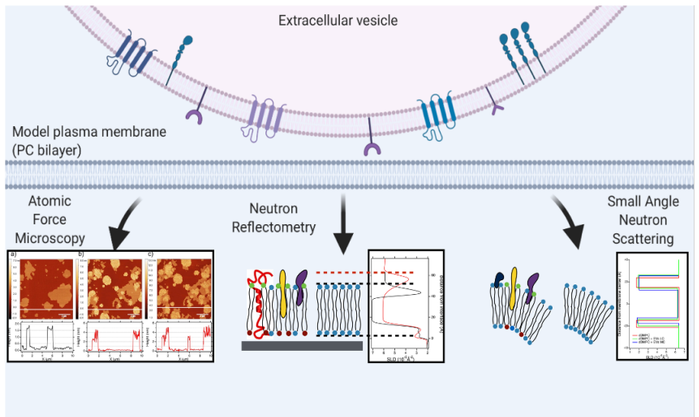


Figure 14
Scheme of the experiment: Extracellular vesicles interaction with artificial model membranes in the form of small unilamellar vesicles and supported lipid bilayers is followed through AFM imaging in liquid, Neutron Reflectometry and Small Angle Neutron Scattering.

This research work took advantage of a set of complementary techniques such as small-angle X-ray scattering (SAXS), small-angle neutron scattering (SANS) and neutron reflectometry (NR) to determine the interaction between sEVs and the model plasma membrane. SAXS is available at the Austrian CERIC Partner Facility at Elettra Sincrotrone Trieste, while neutron-based methods, SANS and NR, are available at the Hungarian CERIC Partner Facility at the Centre for Energy Research in Budapest.

Through this approach, the research group gave a molecular description of the interaction of small extracellular vesicles with a model plasma membrane, demonstrating that sEVs interact with the borders of specific domains of the membrane. Moreover, the biomolecules carried by the vesicle are diffused in a process different from the simple fusion. These results could lead to advancements in numerous biomedical sectors, including immune therapy, vaccination, regenerative medicine, and drug delivery.

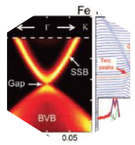
"Improving the knowledge on how extracellular vesicles interact with cell membranes can have a profound impact on several biomedical sectors such as immune therapy, vaccinations, regenerative medicine, and drug delivery".

[7] *Structural insights into fusion mechanisms of small extracellular vesicles with model plasma membranes*, Perissinotto F., Rondelli V., Senigagliesi B., Brocca P., Almásy L., Bottyán L., Merkel D.G., Amenitsch H., Sartori B., Pachler K., Mayr M., Gimona M., Rohde E., Casalis L. & Parisse P., Nanoscale, 2021, DOI: https://doi.org/10.1039/D0NR09075A

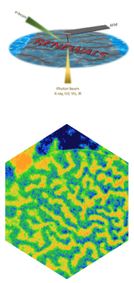
Internal Research Projects

Following the completion of the CEROP project in 2020, the other three projects selected within the frame of the 2016 Call for Research Grants and kicked-off in 2017, were completed in 2021. MAG-ALCHEMI and RENEWALS were positively assessed by the ISTAC of CERIC in October 2021, whereas Dyna Chiro will be evaluated in the first half of 2022. Funding has been allocated by CERIC each fiscal year starting 2017, subject to a positive outcome of the yearly progress evaluation made by ISTAC. The overall contribution of MIUR for the abovementioned projects amounts to € 1,750,530. The partners contributed in-kind a total amount of € 5,659,474.

The goal of these projects was to foster the integration of national multidisciplinary facilities into a unique EU-level distributed research infrastructure. They also aimed to contribute to the scientific excellence of the staff, increase CERIC capabilities and pool resources across EU countries towards the same objectives. The following projects were funded in 2021:



Dyna Chiro (Spectroscopy and Dynamics of Chiral Systems) focuses on the development and construction of special synchrotron-suitable instrumentation to investigate the chiral and dynamic properties of matter. The results of this investigation have a wide range of applications, from a synthesis of new polymers to drug design.



RENEWALS (Graphene for Water in Life Sciences) addresses the growing issue of possible toxic and physiological effects of nanoparticles. The basis of the project is the development of graphene-based liquid cells for multi-technique analysis of hydrated cellular samples and their interactions with nanoparticles.

MAG-ALCHEMI (Magnetic Anisotropy Grafting by Means of Atomic Level Chemical Engineering at Film Interfaces) focuses on magnetic materials and aims at developing tools to control thin magnetism via interfacial engineering.
The main goal is to devise novel means of tuning the magnetic state of matter by appropriately modifying the interface chemistry towards further developments in the architecture and performance of various devices.

Another CERIC internal research project is "**Nanoanalytics for Pharmaceutics**", with Dr. **Aden Hodzic** as principal investigator. In the project, various nano-analytical techniques were used to develop drug formulations and release them in solid, liquid-crystal and liquid states, enclosed in active pharmaceutical ingredients (APIs). The work implemented a methodology based on nano-analytics, which predicts the dissolution and structural properties of tested drugs in a time range of minutes. Once applied, the research will impact the therapeutic performance of nano-systems.

Finally, the CERIC internal project **INTEGRA** (with Heinz Amenitsch as principal investigator), which was kicked off in 2020, will run until April 2022. Its goal is to reinforce, enlarge and better integrate the offer of CERIC's PFs in the field of Life Sciences, covering a wide range of biological targets, from molecules to tissues and organisms.
This undertaking will extend CERIC's offer in the life sciences domain, also in view of the set-up of an integrated Cryo-electron microscopy (Cryo-EM) platform in the region, which will include entry/medium level instruments in Ljubljana, as well as a top-of-the-range microscope at SOLARIS (Krakow).

Scientists gather insights into degradation processes of platinum-nickel alloy catalysts[9]

Proton-exchange membrane fuel cells (PEMFC) are among the most promising candidates for leading the transition from fossil fuels to green energy. However, the large-scale deployment of PEMFCs is hindered by issues like the high cost of the platinum catalyst and its stability. One of the most promising strategies to increase catalyst cost-efficiency is to employ platinum alloys with cheaper transitions metals, such as nickel. The problem, however, remains with durability because of the higher susceptibility of the alloy to corrosion and deactivation. A clear picture of the phenomena occurring during catalyst degradation would help develop corresponding mitigation strategies leading to a more robust catalyst.


Ivan Khalakhan

"We used a combination of powerful in situ techniques for accurate discrimination of different degradation mechanisms of Pt-Ni alloy catalyst under a simulated fuel cell environment".

Dr. Marco Bogar (CERIC-ERIC), **Prof. Heinz Amenitsch** (TU Graz), **Dr. Ivan Khalakhan** (Charles University), and colleagues realised a comprehensive study on time-resolved degradation of platinum-nickel catalysts during potentiodynamic cycling as a function of the alloy composition (nickel content from 0 to 75%) and PEMFC operation (upper potential 1.0 and 1.3 VRHE). Among the techniques employed in this study, in situ Grazing Incidence Small-Angle X-ray Scattering (GISAXS) provided in-depth mean morphological variations, and ex-situ Scanning Electron Microscopy (SEM) helped to observe the formation of the cracks in the structure of the catalyst. The two techniques are available at the Austrian CERIC Partner Facility at Elettra Sincrotrone Trieste and the Czech CERIC Partner Facility at Charles University, respectively.

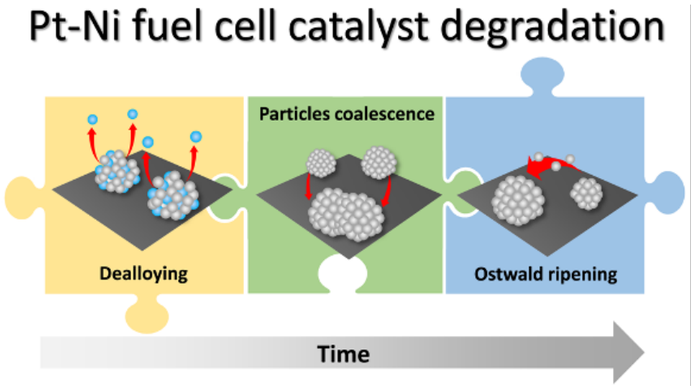


Figure 15
Schematic illustration of the PNi alloy catalyst degradation sequence.

This study was performed in the framework of the internal CERIC research project CEROP. By recording statistically meaningful parameters at the nm scale, scientists developed a methodology to distinguish between different phenomena causing catalyst degradation (dealloying, particle coalescence, and Ostwald ripening) and thus were able to realise time-dependent degradation maps to highlight the timeframe in which the specific phenomenon is prevailing. The results of this research and acquired experimental capabilities represent an important asset for future work that will address catalyst deterioration in diverse applied systems.

[9] *Interplay Among Dealloying, Ostwald Ripening, and Coalescence in PtXNi100–X Bimetallic Alloys under Fuel-Cell-Related Conditions,* Bogar M., Yakovlev Y., Sandbeck D.J.S., Cherevko S., Matolínová I., Amenitsch H., & Khalakhan I., ACS Catalysis, 2021, DOI: https://doi.org/10.1021/acscatal.1c01111

A new study on magnetic properties of materials impacting the information technology sector[10]

The atomic-scale engineering of magnetic properties of selected materials is key to information technology. Advancements in this field could lead to significant progress in the architecture and performance of electronic devices capable of higher storage density, faster access and lower power consumption. Magnetic and non-magnetic materials can be layered to build devices such as spin valves, an essential element for magnetic sensors, including modern hard disk drives. In this regard, the CERIC internal research project MAG-ALCHEMI (led by Dr. Andrea Locatelli, Elettra-Sincrotrone Trieste) aims at developing tools to control thin-film magnetism via interfacial engineering.


Michał Ślęzak

"Antiferromagnets, due to their large potential for downscaling and low power consumption, are a promising candidate for next generation spintronic devices".

In a study that stemmed from the MAG-ALCHEMI project, **Dr. Michał Ślęzak** (AGH University), **Dr. Francesca Genuzio** (CERIC-ERIC) and colleagues reported a study on the magnetic properties of an antiferromagnetic film grown on top of a ferromagnetic material. Ferromagnetic materials, beyond being a subject of fascination, have been of great practical value for thousands of years. In these materials, the magnetic moments are aligned so that they all point in the same direction. On the other hand, antiferromagnets are materials in which the magnetic moments of neighbouring atoms point in opposite directions (they are antiparallel). In the mentioned study, a prototypical antiferromagnetic material, nickel oxide (NiO) was put in contact with ferromagnetic iron (Fe). The authors obtained spectroscopic data through X-ray Absorption Spectroscopy (XAS), while microscopy studies were performed using Spectroscopic Photoemission and Low Energy Electron Microscope (SPELEEM). The two experiments were realised at the Polish and Italian CERIC Partner Facilities at the SOLARIS synchrotron (Krakow) and Elettra synchrotron (Trieste), respectively.


Andrea Locatelli
Francesca Genuzio
Tevfik Onur Mentes

The authors found that the magnetic state of the antiferromagnetic nickel oxide can be controlled by tuning the thickness of the iron layer, changing the temperature, or applying a small external magnetic field. Further advancements in this field and potential applications in the so-called Heat Assisted Magnetic Recording (HAMR) can have a relevant impact in forefront technological sectors, such as spintronics. The publication has been chosen by the editors of Physical Review B journal as highlight in the Editors' Suggestion.

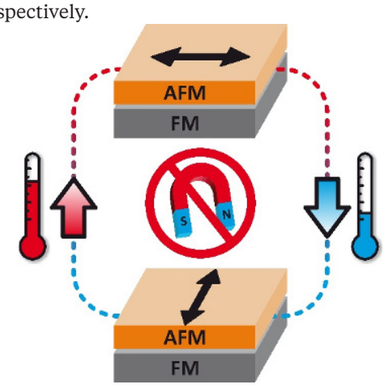


Figure 16
Scheme illustrating the concept of field-free, temperature-controlled switching of antiferromagnetic spins.

[10] *Controllable magnetic anisotropy and spin orientation of a prototypical easy-plane antiferromagnet on a ferromagnetic support,* Ślęzak M., Nayyef H., Dróżdż P., Janus W., Kozioł-Rachwał A., Szpytma M., Zając M., Menteş T. O., Genuzio F., Locatelli A., & Ślęzak T., Physical Review B, 2021, DOI: https://doi.org/10.1103/PhysRevB.104.134434

Scientists provide relevant insights on topological insulators[11]


Pascal Ruello


Jacek Szade

Topological insulators are materials that behave as insulators in their interior but conduct on their surface, meaning that electrons can only flow along the surfaces. They are promising materials for future spintronic-based devices capable of ultrafast data processing. Other potential applications include quantum computing, magnetoelectronic, and optoelectronic. At the moment, the study of topological insulators has entered the stage of finding the best possible systems to harness their unique properties.

In research stemmed from the CERIC internal project Dyna Chiro, **Prof. Pascal Ruello** (University of Le Mans), **Prof. Jacek Szade** (University of Silesia and synchrotron SOLARIS), and colleagues, evaluated the properties of a material based on Bi2Te3 influenced by the proximity of an ultrathin layer of a magnetic metal (iron), or a magnetic insulator (iron oxide). Among the experimental techniques employed in this study, there is Angle-Resolved Photoelectron Spectroscopy (ARPES), performed at the Polish CERIC Partner Facility at synchrotron SOLARIS in Krakow. The time-resolved measurements that provided insights on carrier ultrafast dynamics were performed in le Mans, France and in Nova Gorica, Slovenia.

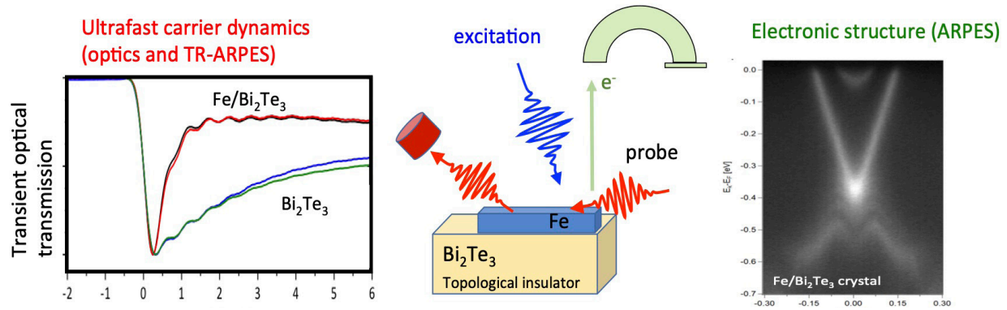


Figure 17
Graphical abstract of the study

The results of this research work provide relevant information about the quantum dynamics at the interface of magnetic and topological insulators layers to guide the realisation of hybrid nanostructures for spintronic devices. Advancements in this field could lead to disruptive applications in vanguard technological sectors that will become prominent in the near future.

" Topological insulators are promising materials for future spintronic-based devices capable of ultrafast data processing", but please, feel free to modify my proposal or propose a new one of approximately the same length".

[11] *Hot-carrier and optical-phonon ultrafast dynamics in the topological insulator Bi_2Te_3 upon iron deposition on its surface,* Weis M., Balin K., Wilk B., Sobol T., Ciavardini A., Vaudel G., Juvé V., Arnaud B., Ressel B., Stupar M., Prince K. C., De Ninno G., Ruello P., & Szade J., Physical Review B, 2021, DOI: https://doi.org/10.1103/PhysRevB.104.245110

New technology opens a whole new set of investigations of biological wet samples[12]

Characterisation of the hydrated specimen using advanced spectroscopic and microscopic methods is a crucial step in understanding biological processes occurring under natural physiological conditions. However, many of these powerful techniques, such as electron microscopy, photoelectron, soft X-ray, and infrared spectromicroscopy, are incompatible with aqueous media due to vacuum requirements or very strong absorption of the infrared light by water molecules. The CERIC internal research project RENEWALS, led by Maya Kiskinova and Lisa Vaccari (Elettra Sincrotrone Trieste), has overcome the limitations of studying hydrated biological specimens by the development of Graphene Liquid Cells (GLCs), using photon and electron transparent and water-impermeable graphene membranes.


Andrei Kolmakov

Most recently, a group from NIST (National Institute of Standards and Technology), led by **Dr. Andrei Kolmakov**, that included **Christopher Arble** (NIST), **Dr. Alessia Matruglio** (NIST guest researcher from CERIC-ERIC), and other collaborators from Elettra Sincrotrone Trieste co-authored a study reporting the most recent advances in fabrication and performance of a graphene encapsulation liquid cells, suitable for in-situ studies of hydrated biological samples with a broad array of analytical methods. They demonstrated successful characterization of a variety of specimens, including mammalian and yeast cells, using multiple techniques, including SEM, fluorescence microscopy, X-ray fluorescence and Fourier Transform Infrared Spectromicroscopy at the TwinMic and the SISSI beamlines at the Italian CERIC Partner Facility at the Elettra synchrotron in Trieste.

" Photons and electrons' based analysis of wet biological samples can be challenging, but Graphene Liquid Cells (GLCs) represent a valuable solution for the implementation of such experimental techniques.".

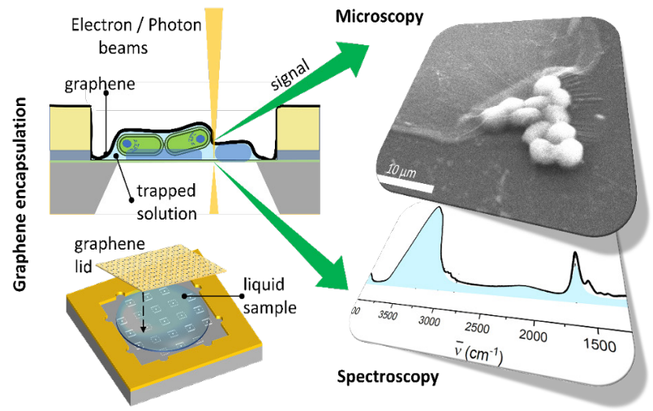


Figure 18
A microchip for correlative spectromicroscopy of biological material in a hydrated state employs a few layers of thin graphene membrane to separate wet samples from a vacuum environment. Enhancement of water retention time has been achieved by lithographically adding hydrogel co-encapsulated microstructures

Trieste.

The new platform has allowed retaining the hydrated state of the sample long enough to enable X-ray fluorescence experiments, which typically take a few hours for a single-cell map and require high-vacuum conditions. These achievements are opening the road to a new type of measurements with different samples in a liquid environment.

[12] *Addressable Graphene Encapsulation of Wet Specimens on a Chip for Optical, Electron, Infrared, and X-ray based Spectromicroscopy Studies,* Arble C., Guo H., Matruglio A., Gianoncelli A., Vaccari L., Birarda G., & Kolmakov A., Lab on a Chip, 2021, DOI: https://doi.org/10.1039/D1LC00440A

A new and promising scaffold nanomaterial for orofacial surgery[13]

Extensive oral bone defects may result from traumas, tumours, infections, or congenital musculoskeletal disorders. Nowadays, reconstruction procedures are based on bone grafts to achieve the full recovery of the subject. The employed materials need to have specific features, such as being biocompatible, capable of inducing the formation of bone-related structures, and bioresorbable. Furthermore, it is desirable that the employed material is easy to handle and cost-effective. Currently, commercial inorganic bovine bone xenografts are largely employed in oral surgery. However, there is a wide availability of healthy extracted teeth discarded every day, and since they carry a valuable source of stem cells in their pulp, they could effectively serve as permanent teeth grafts.


Dragica Bulajic


Branislav Baikin

In a study authored by **Dr. Dragica Bulajic** (University of Novi Sad), **Prof. Branislav Bajkin** (University of Novi Sad), and colleagues, with the support of **Dr. Aden Hodzic** (CERIC-ERIC), scientists were able to produce and characterise a multifunctional nanoparticle scaffold material based on silica and hydroxyapatite. Moreover, scientists evaluated viability on human dental pulp stem cells from healthy deciduous teeth (SHED). Small- and Wide-Angle X-ray Scattering, available at the Austrian CERIC Partner Facility at the Elettra synchrotron in Trieste, was applied to characterise the nanomaterial structure, which displayed excellent biocompatibility performances on SHEDs.

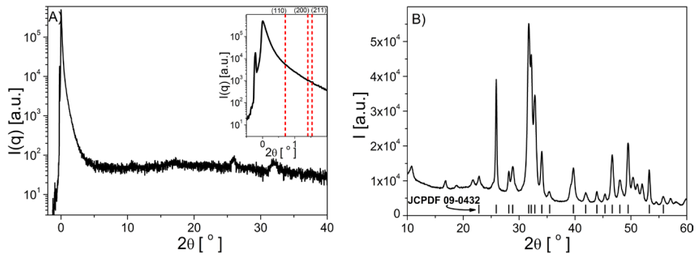


Figure 19
SBA-16/HA nanocomposite; A) SWAXS pattern collected up to 40o (2q) (inset shows the part of SAXS pattern up to 2o (2q), and B) XRD pattern recorded in the 10 to 60o 2q range.

The research was realised in collaboration with the internal CERIC research project Nano-Pharma, led by Dr. Aden Hodzic. Results indicate that using a scaffold nanomaterial based on silica and hydroxyapatite is a viable and promising strategy, paving the way for future biomedical applications, including orofacial surgery.

"Both a multifunctional nanoparticle based on silica and hydroxyapatite, and dental particles, seem to be promising materials for use in biomedical applications. These results pave the way to the future application of this material in the field of oral surgery."

[13] *Biocompatibility of mesoporous SBA- 16/hydroxyapatite nanocomposite and dentin demineralized particles on human dental pulp stem cells*, Bulajić D. V., Drljača J., Čapo I., Savić S. M., Vojisavljević K., Hodžić A., Sekulić S., & Bajkin B. V., Microscopy research and technique, 2021, DOI: https://doi.org/10.1002/jemt.24017

Infrastructure Evaluation and Upgrade

ISTAC's evaluation of CERIC's Italian and Slovenian PFs

On October 5th, 2021, the members of the ISTAC of CERIC performed the periodical evaluation of the Italian and Slovenian partner facilities (PFs) of the Consortium.

At the Italian PF at Elettra Sincrotrone Trieste, **Karsten Horn**, **Christoph Quitmann**, **Paolo Olivero** and **Luis Fonseca**[13] considered very good the scientific output, as witnessed by the quality of publications, including high-impact journals. Between 2017 and 2020, the PF produced 89 scientific articles deriving from CERIC scientific transnational-access activities. They were published in peer-reviewed, ISI listed journals, with an average Impact Factor of 5,4. Moreover, users from 33 countries chose Elettra over other international competitors.
The prompt response to the pandemic was also positively noted: operation and experiments continued via remote access, and COVID fast-track access proposals have already led to significant results.
In their evaluation report, the Committee of Evaluators (CoE) recognised that Elettra is consistently making the most out of CERIC actions. Specific examples are the success in the PhD programme and the internal research grants.
More generally, the Italian PF has been profiting from CERIC initiatives in strategic areas such as battery research, including contributions from other countries, enabling instrumentation and techniques to be developed, and boosting collaboration across facilities and with leading groups. These activities will strengthen Elettra in general and, with it, the impact of the science it enables.
Several upgrades made possible by CERIC were mentioned, and the first effects (new partnerships, data and even publications) are apparent. One important example is the participation in the PANOSC project, which is limited to pan-European RIs, and which will make the power of the EOSC available to CERIC. However, the CoE recommended further progress in providing FAIR data.

At the Slovenian PF, the Slovenian NMR Centre at the National Institute of Chemistry in Ljubljana, the CoE composed of **Andrew Harrison**, **Michel Van der Rest**, **Annalisa Pastore**, **Guy Schoehn**[14] has been highly impressed by the achievements of the PF so far, as well as by the quality and commitment of the staff, as also shown by the outcomes of the periodical surveys on users' satisfaction, whereas the quality of the outputs has been assessed as scientifically excellent.
The impact of participation in CERIC is evidenced by the following:

- The high number and quality of publications by the users (34 scientific articles in peer-reviewed, ISI listed journals, with an average Impact Factor of 7,11), mostly involving the PF's staff as co-authors, which demonstrates the high level of engagement and scientific support to the users.
- The participation in proposals to the Framework Programme through CERIC.
- The fact that the number of papers per unit usage time has doubled, demonstrating the benefits of the open-access programme for the productivity of the PF.
- The increase in the share of instrument time, which has almost tripled since 2017, demonstrates that the PF appreciates the value-added brought by the open access scheme through CERIC.

It was noted that past recommendations had been mostly taken up. These include: the increase of personnel dedicated to CERIC; infrastructure investments, which have been accomplished with the addition of three new NMR spectrometers to the offer, and with the upgrade of the existing ones; the further development of the life sciences and materials sciences domain.

[13] Karsten Horn (Fritz Haber Institute of the Max Planck Society in Berlin, Germany), Christoph Quitmann (Director / Head of Division Project LightHouse, RI Research Instruments GmbH), Paolo Olivero (Associate Professor in Physics at the University of Torino), Luis Fonseca (CSIC in Barcelona (nanoscience and nanomaterials).
[14] Andrew Harrison (CEO at Diamond Light Source), Michel van der Rest (former director of synchrotron SOLEIL), Annalisa Pastore (MRC-UK), Guy Schoehn (IBS, Institute de Biologie Structurale in Grenoble).

2

Training, Industrial Liaison, Communication, Projects

Main Achievements

1 **Educational projects**
Successful implementation of the 6th edition of the training programme for five scientific high schools (PaGES 6).

2 **16 PhD grants co-funded**
in collaboration with 10 universities in Europe. Three new PhD projects started in 2021.

3 **Organization of events**
to increase awareness of CERIC's mission, offer and services among both scientific and industrial communities, as well as lay publics.

4 **Transnational cooperation**
in three EU-funded projects.

Training Activities

Education and skills development is a core activity of CERIC. The promotion of training activities was supported in 2021 through the organization of webinars, lectures and workshops. Due to the pandemic, all events were held in virtual format. The CERIC PhD programme started in 2020 also continued in 2021, in collaboration with 8 European universities. Some of the implemented actions are presented below.

Training high-school pupils. The PaGES 6 project

PaGES 6 is an educational project targeting pupils from scientific high schools in the Italian region Friuli Venezia Giulia, aimed at acquainting them with the basic tools to plan, manage, execute and evaluate a research project, and disseminate its results. Due to the pandemic, the 2020/2021 edition of the project took a fully remote form, with lectures held by the CERIC staff on project management and communication and by scientists connected directly from their laboratories at the CERIC synchrotron facility in Trieste, who introduced pupils to COVID-related research using synchrotron techniques, such as the Synchrotron Infrared Source for Spectroscopy and Imaging (SISSI-Bio), Synchrotron Radiation for Medical Physics (SYRMEP), and Atomic Force Microscopy (AFM), with which a variety of scientific experiments on SARS-CoV-2 have been performed. To extend the offer on scientific topics, a virtual tour at CERN has also been organised and opened to any pupil in the schools who are partners in the project.
The virtual programme had the overall aim to empower pupils to make more conscious choices for their future careers. Eighty-four pupils took part in the project, as well as ten schoolteachers, two experts on the topic of non-scientific training, and a total of eight people, including expert scientists, PhD students and post-doc researchers. At the end of the project, pupils presented the results of the experiments in public online events organised by each school, open to schoolmates, teachers, school managers and local authorities. Outreach activities in the frame of PaGES6 involved nearly five hundred people.

Training PhD students and young researchers

One of the aims of CERIC is the training of young researchers, to spread knowledge and attract new users to its facilities. In this respect, in 2021, two main virtual events - the 8-day long HERCULES Specialised Course and the CERIC-CEI Open Access Training on Materials Characterisation for the Green Deal were organised to promote international scientific cooperation and initiatives and support science diplomacy. The trainings brought together PhD students, young researchers, post-docs and professors, to expand their scientific knowledge about large-scale Research Infrastructures. Nearly 70 participants had the opportunity to get acquainted with the different techniques offered by CERIC's PFs, along with their applications, through theoretical lectures and practical exercises and demos. Moreover, in the CERIC-CEI event, attendants could broaden their scientific knowledge on how CERIC actively supports the EU Green Deal by focusing on the development of dedicated services in the field of energy. From the feedback collected, it resulted that the participants appreciated the wide variety of techniques presented and their use in different scientific fields, and declared that the training allowed gaining insights about new areas in which the discussed methods can be applied.
In 2021, activities continued, also to carry out the CERIC-funded PhD programme, which aims to further the integration of the partner facilities and to contribute to excellent science. In addition to the PhDs activated in 2020, a new PhD scholarship was granted in 2021, in the field of battery research, in collaboration with the Polytechnic of Milan. Moreover, two agreements with the Graz University of Technology (TUG) have been signed during the year, for one project on battery research and another in the life sciences domain. Both projects will start in 2022.
For the ISTAC of CERIC to follow the progress of the PhDs, aid in their integration into CERIC, and create a community of students, it has been agreed that PhDs actively take part in the SCIENCE@CERIC events. The ISTAC would decide which sessions to follow, and enable the creation of a yearly report. Two ISTAC members would act as rapporteurs in each session to allow ISTAC to directly interact with the students during the meeting and share the rapporteurs' feedback at the following ISTAC meeting. ISTAC rapporteurs would also select one presentation from each of the sessions to report to the general ISTAC session.

Human capital development at CERIC and beyond

CERIC has been making continuous efforts towards training and capacity building its staff and managers, adopting a lifelong learning approach. In 2021, in the frame of the ACCELERATE project, CERIC continued its capacity-building activity for PFs related to industrial liaison and technology transfer via an interactive webinar held by an international expert and focused on the setting up of a spin-out. The event was held in April and reached 20 participants.

Industrial Liaison Activities

During the year, CERIC continued contributing to strengthening the whole innovation ecosystem of European stakeholders, both public and private, and enlarging its network through various initiatives aimed at the business sector.
The industrial liaison activity of the Partner Facilities (PFs) was supported by presenting to the industrial environment the advantages of their analytical scientific services. CERIC has also supported the transfer of technologies and knowledge of its Representing Entities (REs), mainly in Croatia, Slovenia, and Poland, that put at the disposal of CERIC the information related to their innovations´ portfolio. Due to the pandemic, most of the activities were held online.

Specifically, the Industrial Liaison Office (ILO) of CERIC kept working on direct commercial activities, and backed the organisation of four online Research to Business (R2B) events, addressing different aspects related to the improvement of the relationship with, and of the usage of, Research Infrastructures (RIs) for industrial innovation. Moreover, the Consortium, the capabilities of its PFs and the type of access for the industry were presented.
In particular, the event RIs - Energy Industry Meeting: improving industry usage of RIs, held in April 2021, focused on the relationship between companies from the energy sector and RIs. Contributions by representatives of CERIC and the companies stimulated the discussion on the opportunities to improve access for the industry.
Both small and large entities attended as panellists during the event, with the goal of identifying the different needs of companies of different sizes. In addition, CERIC performed a series of interviews, to better understand whether and how access to RIs may be further improved, and to tackle the main weaknesses in the relationship between RIs and industry.

A technology transfer online event was also carried out in November 2021, with a focus on the solutions available for energy efficiency and sustainability. A number of innovations resulting from research conducted at the REs and PFs of CERIC were showcased to selected companies with the goal of supporting the transfer of their innovations to the market.

Furthermore, CERIC participated, as a sponsor, in the first European edition of Techconnect (https://events.techconnect.org/Europe/), a technology transfer event showcasing CERIC's capabilities in a dedicated booth at the Innovation Expo. Meanwhile, some of the technologies developed by CERIC REs and its PFs' owners were selected to be presented at the Innovation Spotlight Pitches' section to a panel of industry and investors experts.

All the actions carried out led to the start of negotiations with two companies for providing analytical services and to the definition of possible collaborations with the industry for two spin-outs of one of the CERIC's REs.

In relation to industrial usage of the CERIC PFs via open access in 2021, 5% of total accesses – according to the users – were related to projects connected with the industry. Regarding publications, 11% of the articles released in 2021 were related to the industry. Such data consider publications that include authors affiliated with a company and those that come from proposals connected to the industry.

Communication and Dissemination

Communication about CERIC operations and scientific results during the pandemic

Also, in 2021, the CERIC communication team has supported the user office to widely promote the opportunities open to researchers worldwide, to access and conduct research at the CERIC infrastructure.
Moreover, throughout the year, CERIC communication officers also continued to manage the work packages devoted to the communication and dissemination of the results of three European projects: ACCELERATE, PaNOSC and ERIC Forum, within which a number of events, such as annual project meetings, symposia and webinars, were organized and promoted. Newsletters, video interviews, position papers and publications have been continuously released and distributed to the community of CERIC and its project stakeholders.
In May 2021, on the occasion of the Hercules Specialised Course organised within the ACCELERATE project, a number of promotional videos were released on more than ten of the instruments and techniques at the CERIC partner facilities to get early-stage researchers acquainted with the opportunities for research available in the Consortium. Such pilot action will be continued in the upcoming years to cover most of the CERIC techniques in the open-access offer.
Another video focused on the services that CERIC makes available to the industry was released during the summer for further promotion through the website of the Consortium and its social media channels, as well as at the science fair Trieste Next, where CERIC's contribution to the solution of global societal challenges was showcased.
In addition to CERIC's presence at the booth set up by its Italian representing entity, Elettra Sincrotrone, in the main square of Trieste, two different events addressing the lay public have been organised together with Elettra: a conference on energy research, which involved as panellists, two members of the CERIC's expert group on batteries, and the dissemination event "Sciencespotting" as part of the European Researchers' Night, where four scientists gave brief pitches to showcase how the synchrotron works and what its applications are.
Considering the increasing contribution of the Consortium to battery research, a new website section with detailed information about the analytical techniques available to the scientific community for research in this domain has been designed and will be made available in 2022.

Outreach Events

To increase awareness among the scientific community worldwide about the research opportunities that it offers, CERIC was present at a number of events, including:

Science@CERIC 2021
Online, 28-29 January 2021

Tech for Social Good: How NMR & Ion Beams can help industry solve UN SDGs
Online, 20 May 2021

Hercules Specialised Course 2021
Online, 31 May - 9 June 2021

Trieste Next 2021
Trieste - Italy, 24-26 September 2021

European Researchers' Night
Trieste - Italy, 24 September 2021

14th Central European Training School (CETS 2021) on Neutron Techniques
Budapest - Hungary, 4-28 October 2021

BNC webinar series
Online, January-November 2021

CERIC-CEI OpeN ACces Training – "Materials characterisation for the Green Deal"
Online, 13-15 December 2021

Transnational Cooperation

Transnational cooperation has also been implemented through CERIC's transnational projects. The ReMade@ARI proposal was submitted to Horizon Europe in 2021 and favorably evaluated, and the following EC-funded projects have been implemented:

Horizon 2020 ACCELERATE project

From January 2017 to June 2021, CERIC coordinated the ACCELERATE H2020 project, which aimed at supporting the long-term sustainability of large-scale research infrastructures (RIs) in general, and CERIC in particular. Its implementation period came to an end in June 2021, after four and a half years of impactful activities and achievements.

The project's assessment was finalised in September 2021.
Evaluators highlighted that "*the project has delivered exceptional results with significant immediate or potential impact*".
ACCELERATE aimed at supporting CERIC in its implementation phase, following its set-up as an ERIC in June 2014. This includes all aspects related to operations, visibility, scientific offer and sustainability. Within the project, CERIC also made a SWOT analysis (strengths, weaknesses, opportunities, and threats) and defined specific future actions on that basis.
According to the project's reviewers: "*Building an ERIC is a marathon, not a fast-paced race and CERIC has achieved record times in maturing many of its core dimensions as an ERIC, in the first few phases of the race*". Of particular highlight are: "*the progress of CERIC, which was a RI established without any preparatory phase and strong governmental support, which is to be congratulated and a best-practice that should be observed elsewhere. Also, and even more important, one may say, is its scientific excellence and the service that it provides to the scientific community (with a particular focus in Eastern Europe)*".

The project had a crucial role in supporting CERIC's development. Its major expected outcome has been the development of the sustainability plan of CERIC, which was supported by four main focus areas:

- Ensuring CERIC is at the forefront of excellent science;
- Ensuring effective governance and management of CERIC;
- Stimulating industrial use of CERIC;
- CERIC's financial sustainability.

ACCELERATE contributed, not only to increasing CERIC's sustainability, but also to strengthening its scientific development by implementing various open access pilots, and fostering its visibility among scientific, industrial, and Research Infrastructures communities.
It also largely supported CERIC in bridging the research and innovation gap with the Western Balkan research community, setting opportunities for constructive dialogue across national and cultural borders and differences, and speaking the language of science as a universal tool.
Finally, the project also fostered the positioning of CERIC towards the industry as a regional innovation hub for potential industrial collaboration. Moreover, the scientific development achieved through ACCELERATE has allowed CERIC to increase its contribution to the European Research Area.

Throughout the period of implementation of the project, sixty events have been organised, specifically:

- Twelve scientific events, reaching more than 390 early-stage and experienced researchers from +40 different institutes and universities.
- Six managerial workshops, reaching +437 participants from +94 different organizations (RIs/ERICs, policymakers, NGOs, Industry, universities)
- Forty-two industrial events, reaching +1400 participants from companies, RIs, and researchers in academia and Industry.

All deliverables released in the frame of the project can be browsed and downloaded from the dedicated webpage on the CERIC website: https://www.ceric-eric.eu/project/accelerate/

Horizon 2020 PaNOSC
Photon and Neutron Open Science Cloud

The Photon and Neutron Open Science Cloud (PaNOSC) project is an EU funded project aiming to provide common policies, strategies and solutions for enabling Open Science through the adoption of FAIR principles across European photon and neutron facilities.
A major outcome of PaNOSC is to have ensured that 5 RIs on the ESFRI roadmap and an ERIC make their data open and available to the EOSC.
Although two of the RIs (ESS and ELI) are still in the process of construction and ramping up to user mode, respectively, they are ready to publish Open Data from the beginning of User Mode, thanks to their Open Data policies based on the PaNOSC policy framework and the implementation of data catalogues.
PaNOSC has also allowed the partners to offer data analysis services by developing an Open-Source data analysis portal, VISA, which is ready to be deployed as a generic service at an e-infrastructure and/or other RIs and made available via the EOSC. It offers remote control, data analysis and simulation services of experiments, and experimental set-ups, but also allows analysis of data available in the data portals.

PaNOSC has onboarded the following services in the EOSC Portal:

- **PaNOSC Software Catalogue**: giving access to over a hundred standard software tools used for analysing data from PaN RIs;
- **Pan-learning.org**: giving access to e-learning materials for PaN students and researchers, and which is in the progress of integration with the training catalogue developed by ExPaNDS. Both services will be accessible in 2022 through a single platform, pan-training.eu.
- **Human Organ Atlas**: an open data portal of 3D scans of human organs with micron resolution for different pathologies, including COVID-19.

A number of other services, including the 6 data portals of the PaNSOC partners and the search API service are in the process of being registered.
Finally, PaNOSC, together with GÉANT, has put in operation a standard Authorisation and Authentication Infrastructure (AAI) common to all PaNOSC RIs and EOSC contributors to facilitate access to the different services.

Horizon 2020 ERIC Forum implementation project

The ERIC community has been expanding in the last ten years, and until now, it counts 22 established ERICs and 10 European Research Infrastructures aspiring to become an ERIC. The variety and diversity of ERICs make them important players in European Science excellence that respond to various societal challenges, supporting science diplomacy and creating bridges between research communities within Europe and worldwide.

The ERIC Forum, which was formed in 2017, brings together the ERIC community with the aim of strengthening its coordination, advancing ERICs' operations, collectively responding to common challenges, and effectively interacting with the European Commission and key stakeholders. The Forum also strategically contributes to the development of ERIC related policies, making it one of the leading science policy voices in Europe.

The ERIC Forum implementation project has been supporting the Forum's activities since its launch in January 2019. In 2021, the ERIC Forum developed several reports and organized a set of events providing guidance and best practices on key areas of interest for the Research Infrastructures and ERIC communities, including: sustainability, Key Performance Indicators, quality management and reproducibility, human resources, accounting principles, VAT exemption, contracting, insurance intellectual property. The ERIC Forum has also contributed to the EGERIC (Expert Group on the ERIC Regulation) report assessing the implementation of the ERIC regulation.
In addition to that, the ERIC Forum supported fostering ERICs' visibility through targeted promotional campaigns, videos interviews, and events (such as the United Nations Science Summit, the Stakeholders' Workshop on ERICs, and the new ERA Conference). Through these activities, the ERIC Forum showcases ERICs' added value, scientific achievements, and contribution to the COVID-19 pandemic and the UN SDGs (Sustainable Development Goals).

3

CERIC's Institutional Advances and Contribution to Policies

Main Achievements

1. **CERIC pilot action on batteries**
2. **Released the report on fuel cell**
3. **CERIC paper on the state of Open Access procedures at RIs**
4. **Publication of the CERIC sustainability plan**
5. **Contribution to UN SDGs and to the ERA**
6. **Contribution to the construction of the EOSC**
7. **Updates on CERIC's performance monitoring base on ESFRI KPIs**

CERIC's contribution to research on batteries

A rapidly increasing energy demand, driven by factors like population growth and industrial development, is having severe consequences on the global climate. One of the most important societal challenges is to achieve a paradigm shift towards renewable energy in a short time frame and to increase the energy efficiency of the current systems. However, the intermittent nature of most renewable energy sources deployed so far is a significant limiting factor that needs solutions for large-scale implementation, such as batteries. Achieving a better performance, longer lifetime and diversification of materials is crucial to decrease the impact on the environment.

Several battery technologies are being developed for both stationary and mobile applications. Thanks to CERIC's advanced analytical techniques based on photons, neutrons, ions, NMR, and more, scientists from everywhere in the world can realise a wide range of experiments. Among them, time and space resolved studies, ex-situ, in-situ, operando experiments, and more, to provide a greener future for European citizens.

To position CERIC as a state-of-the-art RI for research in this domain, and on the basis of the recommendations highlighted in the report on batteries[1] - published in 2020 by the members of the CERIC Expert Group on Batteries (**Benedetto Bozzini**, **Antonella Iadecola** and **Lorenzo Stievano**), and positively evaluated by the ISTAC - the Consortium has started implementing its Research and Infrastructure Roadmap, which foresees upgrades of the CERIC infrastructure for research on the batteries of the future.

The PFs have been consulted to collect their requirements and the costs for the purchase of the instrumentation recommended by the Expert Group, for in-situ and operando measurements, sample preparation, materials' characterisation and data analysis, to then proceed with the implementation of the plan for the upgrade of the infrastructure.

Among the recent additions is the extension of the existing HRTEM infrastructure at the Romanian PF at the National Institute of Materials Physics in Magurele, enabling in-situ and operando experiments. This upgrade allows TEM observations while heating or applying an electrical field on the observed sample, allowing experiments on battery materials in real operation conditions.

A second upgrade is the installation of a new automatic tuning/matching static single-channel in-situ 400 MHz NB probe for electrochemistry measurements at the Slovenian CERIC Partner Facility at the National Institute of Chemistry in Ljubljana. This probe is a crucial part of the equipment used for training a PhD student in the CERIC PhD programme. The instrument will also be available to researchers working on new CERIC projects requiring in-situ NMR measurements on batteries and powders.

CERIC infrastructural development is complemented with investment in research on the battery topic by supporting different PhD projects in the field. Below are the ongoing PhD projects in this field:

- Recovery and characterisation of layered oxides materials from spent batteries: a step forward towards sustainability (University of Bologna)
- Morpho-chemical and structural changes of electrodes and electrolytes in all-ceramic solid-state lithium batteries (Polytechnic University of Milan)
- Unravelling the electrochemical mechanisms of battery degradation by operando NMR and X-ray absorption spectroscopy (University of Ljubljana)
- Linking chemistry and phase evolution in metal-O2/S batteries via in-situ SAXS and XAS (Graz University of Technology)

In 2021, four papers were published in the domain of battery research, with an average IF of 6,85. To increase the awareness among the CERIC user community and the research community worldwide about the opportunities for research on batteries at the infrastructures available in the Consortium, a new section on the CERIC website was drafted, showcasing all the analytical techniques offered by CERIC, and which are relevant for battery research. In 2022, these will be accessible also through calls specifically dedicated to research in this domain.

[1] B. Bozzini, A. Iadecola, L. Stievano, *Report on CERIC's Expert Group on Batteries*, 2020, https://doi.org/10.5281/zenodo.3891479

CERIC's contribution to research on fuel cells

One of the greatest challenges of our time is to mitigate the global climate change caused by anthropogenic emissions of greenhouse gases, mainly generated by the use of fossil fuels. A critical part of the solution is to substitute energy generation based on fossil fuels with the more renewable energy sources (solar, wind, geothermal power and others), and one of the main issues is to provide efficient energy storage for a large subset of intermittent energy sources. This can be achieved by various means, such as physical storage (e.g., pump hydro storage, flywheels, compressed air, etc.) and/or chemical conversion (e.g., batteries, hydrogen and ammonia generation and storage, artificial carbon-based fuels). The second family of energy storage solutions is close to maturity for commercial deployment; therefore, research and development proceed at a fast pace and enjoys significant investments at all levels.
For this reason, and following the recommendation by the ISTAC of CERIC, in 2019, to follow up the pilot on batteries[2] with a pilot on fuel cells, in November 2021, an external scientific advisory group of appointed distinguished experts (**Benedetto Bozzini, Sara Cavaliere, Jakub Drnec, Moniek Tromp**) produced a report on fuel cells (FC)[3], which identifies the bottlenecks and needs for upgrades of the CERIC infrastructure in this domain, on the basis of the CERIC Science and RI development strategy, towards the production of the CERIC Research and Infrastructure Roadmap.
The report starts with an introduction about the importance and relevance of research on fuel cells to tackle the challenges given by climate change. Following an overview of the currently available fuel cell technologies (Alkali fuel cells, Molten Carbonate Fuel Cells, Proton Exchange Membrane Fuel Cells, Anion Exchange Membrane Fuel Cells, Phosphoric Acid Fuel Cells and Solid Oxide Fuel Cells), as well as the various available membranes and electrocatalysts, the report showcases the main fuel cell durability issues, which depend on a number of internal and external aspects, such as degradation of materials, impurities or contaminants, flow-field design and assembly, operating conditions.
Considering the technological challenges still to be faced and the relevance and potential of such technologies to tackle climate change, the EU is strongly investing in this domain, and several funding schemes have been activated. The document lists and describes the main initiatives currently in place for this aim.
The report continues with the assessment of CERIC's activities in the field of electrochemical energy conversion by various types of fuel cells by highlighting the current state of the studies in this field at each facility and summarizing the main inputs provided by CERIC PFs, on their interest and possible exploitation of each facility in prospective fuel cell/electrolysis studies.
In 2021, CERIC users released seven publications related to research on fuel cells, with an average IF of 5,97. To increase the number of users in this research domain, the report also includes a set of recommendations to enhance CERIC's role in the fuel cell community. Among them are also science communication actions to foster fuel cell activities within the Consortium, such as the creation of a webpage dedicated to the work on fuel cells, the organization of virtual workshops, and the provision of a list, and presentations, of relevant papers on studies based on the use of the CERIC facilities.
The authors of the report conclude that the suite of CERIC's instruments already offers an outstanding opportunity for FC research and that, "*both in its present setting and a fortiori after expansion of the technique portfolio, CERIC can substantially contribute to the targets set by European Commission for clean transportation and energy transition. Appropriate exploitation would require coordination of PFs and the best use of the CERIC's multimethod access scheme. Communication will be instrumental to exploitation*".
Finally, along the lines of the report published by the expert group on batteries, it was recommended to also further implement the internal funding scheme aimed at supporting PhD projects to accelerate the development of FC technologies.

[2] *Ibidem*
[3] B. Bozzini, S. Cavaliere, J. Drnec, M. Tromp, *CERIC-ERIC Expert Group on Fuel Cells*, 2021, https://doi.org/10.5281/zenodo.5720332

State of Open Access Procedures at Research Infrastructures

Open Access (OA) procedures are crucial for the scientific excellence of a research facility and, therefore, its sustainability. A lot of progress has been made in terms of harmonisation and standardisation of access procedures in Research Infrastructures (RIs), though further improvement may still be achieved.
Following the collection of information, in the frame of the ACCELERATE project, through surveys sent to RIs in Europe, interviews, emails and policies, in 2021, CERIC published the paper *State of Open Access Procedures at Research Infrastructures*[4], which showcases the various procedures adopted by RIs for open access, as well as the services implemented by facilities to face the COVID-19 outbreak.
The publication is the result of the information collected and processed through surveys to RIs, interviews, emails and policies.
It firstly gives an overview of the main actions listed in the European Charter for Access to Research Infrastructures (in the following Charter) related to access and access procedures for RIs to remain at the forefront of scientific excellence. It highlights the efforts made throughout the years toward harmonisation and standardisation of such procedures in RIs. It also presents an overview of the access policies of the RIs, with reference to proposals' submission, evaluation procedures, time dedicated to open calls, additional access channels, such as fast-track access, and remote access, also with reference to open access under emergency conditions, to then focus on the specific practices adopted at CERIC.
As a conclusion to the research conducted in this study, the authors state that, although the European Charter on access was an important milestone towards standardisation of access procedures to benefit users' communities and a better use of resources, there are real obstacles to the harmonisation deriving from the priorities of every RI and the need to respond to societal challenges in the most effective way. The Charter could play a more prominent role if updated in its definitions, principles and guidelines, to make it more specific and at the same time, comprehensive of the existing and required access practices to address societal challenges more efficiently, such as during the COVID-19 outbreak.
In fact, the COVID-19 emergency has challenged facilities in an unprecedented way, affecting their operations, performance and procedures. RIs were forced to speed up and apply remote access extensively, raising a series of issues partly due to the lack of technologies and dedicated funds to support it.
CERIC in particular, like the majority of the other RIs in Europe, decided to adapt its access policies setting up a new Fast-Track open access dedicated to COVID-related studies, and extending the "remotisation" process with a reallocation of the internal resources, as well as from the PaNOSC project. In order to maintain its level of operation and to accommodate external researchers' demand to perform their experiments remotely, the Consortium developed dedicated procedures for remote access with specific tools facilitating samples shipment, such as automatic dedicated solutions for the front-end forms for the logistic organisation of the shipments, and virtual connections to allow a real-time interaction of researchers with the personnel and instruments of the facilities during the measurements, and later for the analysis of the data acquired.
However, as stated in the paper, *although remote access seems to be the most efficient tool to maintain operations, there are a series of issues related to it. The World Health Organization monitors yearly and produces a list of the most dangerous pathogens in terms of their capacity to generate a pandemic. If, as stated by specialists, pandemics will be more frequent in the future, RIs need to do their best to be prepared. Remote access could offer a good solution in case of an emergency; however, to be more widely applied, consistent funding should be invested in it.*

CERIC's approach to sustainability

Research Infrastructures (RIs) are considered one of the success stories of the European Research Area (ERA) and have transformed the way science is done as they facilitate access to large-scale facilities to perform excellent and ground-breaking research.
The continuum of the value of RIs, as innovation hubs and pillars of the science system, is based on their long-term sustainability, which represents a crucial, important and challenging aspect, not only for the infrastructure but also for policymakers and funders.

[4] O. De Giacomo, J. Kolar, D. Brzosko, *State of open access procedures at research infrastructures*, 2021, Zenodo: https://doi.org/10.5281/

To address the topic from different angles, a workshop Planning for Sustainability of Research Infrastructures was held in May 2021, in the framework of the ACCELERATE and ERIC Forum H2020 projects.
The event brought together more than 155 participants from the RIs/ERIC communities, policymakers, funding agencies, NGOs and industry. The event highlighted the views on sustainability of science policy stakeholders, such as the European Commission, ESFRI, OECD and more, as well as some potential directions that could be taken to demonstrate the RIs' socio-economic impact. Moreover, the need to adapt existing business and sustainability planning instruments emerged to meet the varied expectations, requirements and approaches in planning for the medium to the long-term sustainability of the specific environment of the European RIs.
The approach toward sustainability planning varies according to the objectives, domain and development stages of a Research Infrastructure.

As far as CERIC is concerned, the purpose of its five-year strategy is to deliver on the objectives and secure financial sustainability. To achieve these aims, a sustainability plan was released in June 2021. The document presents the vision and mission of the institution, places it in the European landscape of RIs, and, based on this, derives its value proposition.
Based on the current landscape of pan-European research infrastructures, suitability of the existing techniques, the scientific domains of existing users, user surveys regarding future upgrades, upgrade plans of the Partner Facilities and the future societal challenges, CERIC has opted to prioritise the domains of energy materials and life sciences, while retaining its general-purpose character in the broad field of material characterisation.

Following the placement of CERIC in the ERA, the users and the services are described. While the main service is merit-based, free open access to the instruments, the services also address industrial cooperation, dissemination and training, open access to data and data management, as well as dedicated services to CERIC's partner facilities. These aim to increase the quality and support the instrumental development of the instrumentation and contribute to better functioning of CERIC.
The sustainability plan then reviews the weaknesses and opportunities of CERIC and identifies priority activities, which should contribute to CERIC's sustainability within the next five years. This is complemented by the five-year plan, which involves further development of the user base and the services, monitoring and evaluation of CERIC, and changes to CERIC's business model. The latter, in particular, is deemed as of high risk, since the operations are only funded through the host country's contribution. Thus, the plan proposes the introduction of membership fees, which are expected to be implemented in 2022, or 2023, and will significantly increase the financial sustainability of CERIC.
The sustainability plan concludes with the financial analysis and projections for the five-year period.

CERIC's contribution to UN Sustainable Development Goals

CERIC, together with the other 21 established ERICs and the other ten European RIs aspiring to become an ERIC, has been significantly contributing to the UN Sustainable Development Goals (SDGs) and to tackling grand societal challenges. In particular, the Consortium has been increasingly focusing on the development of services in the fields of energy and life sciences, providing ground-breaking discoveries that largely contribute to different SDGs, such as SDG3 - Good Health and Well-being, SDG 7 - Affordable and Clean Energy, SDG 12 - Responsible Consumption and

Production, and SDG 15 - Life on Land.
In the frame of a presentation given by representatives of the ERIC Forum at the Science Summit of the 76th UN General Assembly (UNGA76) held in September 2021, some of the research projects led by CERIC users, which clearly show such contribution, were showcased, to raise awareness about RIs' role and contribution to the attainment of the UN SDGs.

In particular, the CERIC projects highlighted relate to the following:

- The production of artificial photosynthetic system with increased efficiency, close to natural ones, that could be applied for environmentally-friendlier hydrogen production (SDGs 7, 15);
- The discovery of microplastics in small invertebrates in Antarctica, highlighting the widespread pollution of the water and raising concern about its impact on the fragile Antarctic terrestrial ecosystem (SDGs 12, 15);
- The set-up of a dedicated fast track open access to a selected number of instruments, with the aim of facilitating research on the COVID-19 (SDGs 3).

ERICs' contribution to the European Research Area (ERA)

ERICs are a major pillar for the success of the European Research Area (ERA). An instrument to make the best of their contribution to the development of the ERA is the ERIC Regulation.
After the setup of the European Commission's EGERIC expert group aimed to assess the implementation of the ERIC Regulation, and on the basis of the collection of data and evidence from a large set of stakeholders, the EGERIC report and recommendations were released in 2021, including the following:

- The assessment of the implementation of the ERIC Regulation;
- The identification of good practices concerning VAT exemption for in-kind contributions (IKC), and the participation of third countries and international organisations in ERICs, as well as financial sustainability of ERICs and of national investments;
- Outlook on future perspectives concerning the implementation of the ERIC Regulation and its expected impacts.

The document highlights that the impact of the ERIC system can be fostered by strengthening ERICs' interconnection with national research facilities and Nodes, with other ERICs and RIs. The synergies that could potentially support this further integration cover strategic, managerial and operational aspects.

The main findings of the EGERIC assessment include:

- The effectiveness of the ERIC Regulation in empowering the establishment and operational start-up of 23 new research organisations towards the definition of an 'ERICs/RIs' system'.
- Most ERIC statutes commit to translating results into economy and society, developing synergies between research and education, as well as value creation. Further synergies are developed between national, EU and regional funding programmes by involving research resources from countries and regions with lower research performance.
- ERICs address the challenges connected to data production and use, and are directly involved in the development of the EOSC.
- Several ERICs are part of global initiatives where the pooling of resources achieves competitiveness at the world level.
- At the governance level, evaluation of the implementation of the Regulation has been limited mainly to the setting-up phases of the ERICs. Lack of overview and governance has delayed appropriate policies to stimulate the direct involvement of the ERICs in the challenges and partnerships now structuring the new R&D agenda.
- Setting up a governance of the 'RIs/ERICs' system' is needed to empower the ERA with the capacity to effectively respond to challenges, missions and global requirements, by rapidly focusing on large national R&I resources. Effective governance should overcome persisting issues such as the VAT exemptions on IKC and the less favourable employment conditions in comparison with other European and international entities.

The document finally includes EGERIC recommendations that can be summarised below:

- Governance of the 'RIs/ERICs' system' implementing evidence-based guidance must be set up within the overall ERA Governance to meet the overarching ERA policy objectives, ensuring at the same time compliance with the

Regulation.
- Governance should improve sustainability also through focused projects funded in synergy between national, regional and EC resources.
- The basic operation of the ERICs should be supported by the long-term commitments of their members.

The system of ERICs and RIs should be stimulated, also by involving the ERIC Forum, to develop Pan-European multidisciplinary services, responding to the need to narrow the gap between research and innovation.

ACCELERATE project's added value for the partners

Impact assessment and monitoring are fundamental elements for the long-term sustainability of RIs. These aspects were tackled in ACCELERATE through the development of a societal impact protocol approach, which served as a tool for project partners to apply the methodology for their respective RIs and therefore develop their social return reports. The project partners (European Spallation Source, ELI, HZG and FRMII) also had the opportunity to present and discuss with other RIs and policymakers in ACCELERATE events the results of the exercise, the main impact pathways and areas identified throughout the assessment process.
Moreover, project partners had the opportunity to share and exchange expertise, common issues, and best practices to contribute to RIs' development and operations.
Several topics have been tackled through events, trainings and workshops targeting RIs' personnel, including human resources, VAT and tax exemption, in-kind contributions, industrial liaison and networking, and more. Such events brought together participants from more than 94 different organizations (research infrastructures/ERICs, policymakers, NGOs, Industry, universities), contributing to enlarging CERIC and ACCELERATE partners' networks. They also set the path for potential collaboration opportunities and supported increasing all partners' visibility.
Additionally, during the COVID-19 pandemic, a set of questionnaires were conducted in the frame of the ACCELERATE project to assess analytical facilities' operations. The reports provided project partners with an overview of open access procedures and best practices supporting RIs' progress and evolution during a pandemic.

CERIC's contribution to the EOSC

Since the seminal publication by Wilkinson, et al. in 2016[5], FAIR (Findable, Accessible, Interoperable, Reusable) data handling principles have been adopted by the European Commission (EC) and extended into the framework of the European Open Science Cloud (EOSC). Data management conforming to FAIR principles will be mandatory for all the work funded by the upcoming Horizon Europe research framework. In order to prepare specific communities for FAIR uptake and EOSC adoption, several pilot projects have been launched by the EC.
One such project is the Photon and Neutron Open Science Cloud (PaNOSC), in which CERIC is a partner, encompassing two synchrotrons (photon sources) and a nuclear reactor (neutron source) as members. The project's total value is around €12 Mn, spread among seven large-scale facilities, of which CERIC has a bit less than €2 Mn share. The main goals of the project are addressing the FAIR principles in the workflows of the said large-scale facilities, equipping them with all the necessary tools, including software development and unification, as well as the required legal and administrative frameworks preparation (e.g., data policy adoption). Despite the project being aimed at photon and neutron sources, other CERIC PFs will also benefit from it, as the backbone infrastructure (data policy, data transfers, catalogues, DOIs, landing pages, etc.) is going to be put in place by the completion of the project in November 2022. It will allow the PFs to implement FAIR data handling principles with relative ease. Furthermore, as CERIC has been a member of EOSC Association since October 2020, the infrastructure is being designed with future integration into the EOSC in mind, starting as soon as PaNOSC ends.
Thanks to the OCRE funding for a pilot in the use of commercial cloud resources, CERIC has also been setting up a mini-EOSC supporting all its partner facilities in developing their own FAIR enabled workflow, processing it, and making it available after embargo via the respective commercial cloud platform's infrastructure.

The following paragraphs present the main milestones and outcomes achieved in 2021 towards increased adoption of FAIR data practices at CERIC and its facilities.

FAIR Research Data Policy Framework

There are many reasons and benefits for PaN facilities to adopt a Research FAIR data policy. These range from the need to make science reproducible and replicable by adopting an Open Science approach - following the recommendations of international bodies, such as the OECD, ISC, IUCr, implementing the FAIR principles to enable the re-use of data, providing scientists with new data services, archiving of important datasets, to improving the quality of scientific data.
In particular, CERIC considers as necessary to also be compliant with H2020 funding rules. The firm belief of the Consortium in this respect is that open data will benefit researchers and institutions, increasing their visibility, enhancing collaborations and allowing better use of resources in general.
In June 2019, the General Assembly of CERIC approved the new CERIC Research Data Policy (RDP). The updated policy is based on the Research Data Policy Framework released in the frame of PaNOSC and on the PaN-data guidelines, which have been used as initial reference. In addition, other elements have been incorporated from other existing policies (e.g., of ALBA synchrotron, Elettra Sincrotrone Trieste, EuXFEL, ESS, ESRF and ILL).
The RDP covers and is applied to scientific research data and metadata. Data can be raw data, processed data, auxiliary data or results. All CERIC partner facilities agreed to use the HDF5 as the standard file format for the curation of the data generated and collected, ensuring that these are understood by the whole community.
The embargo period (i.e., the period during which the data generated by experiments performed will remain private) has been set to three years, which may be extended upon request, and on the basis of legitimate grounds.
The CERIC data policy is considered a living document. Thus, reviews may take place when necessary, taking into account the evolving norms and guidelines for research (FAIR) data.
In particular, specific services may be further specified in the CERIC RDP, with reference to:
- Persistent identifiers, e.g., DOI generation;
- Data and metadata catalogues;
- Access to and storage of raw, processed and auxiliary data;
- Long-term data archiving service (10 years for data and undefined for metadata);
- Automatic metadata ingestion (through e-logbook if available).

Data Management Plan

In November 2021, the deliverable "Data Management Template for facility users" was released in the frame of the PaNOSC project, with contributions from all project partners, including CERIC.
The document is meant to define a template for data management plans for experiments performed at PaNOSC RIs. CERIC considers the preparation of a Data Management Plan (DMP) as a critical aspect of the infrastructure, and has been dedicating resources to designing and implementing what is needed as part of the quality management system of the RI. DMP involves users, beamline scientists, researchers, administration, legal expertise, and an adequate IT infrastructure. Thus, CERIC has been designing surveys for the specific stakeholders in order to collect their respective views in the field and to further develop a DMP template in the future for each instrument offered to the community. In this respect, it has to be taken into account that an experiment involving different instruments will require a dynamic combination of each instrument-specific DMP. The generated DMP will be presented to the PI as part of the proposal submission in order to make him/her aware of how data will be collected, managed and curated. The resulting DMP, especially if machine-readable and in aggregated form, will be useful to plan the required IT infrastructure.
The DMP template proposed in the frame of PaNOSC takes into consideration best practices developed from the Research Data Management Organiser (RDMO), and aims to help users produce a DMP in an easier fashion by populating the vast majority of fields in an automated manner.
Such fields are meant to collect information about the science to be conducted, with reference to:
- The related datasets, to the expected volume of data, the software used and the dates of data collection
- Data stewardship (who handles and accesses the data and its backup), data sharing and security, with the indications of the associated personnel costs associated with these tasks;
- Metadata and how they are collected, and PIDs;

[5]Wilkinson, M. D. et al. *The FAIR Guiding Principles for scientific data management and stewardship*, Sci. Data 3:160018, DOI: 10.1038/sdata.2016.18

- Legal issues;
- Criteria for archiving, and duration and accessibility to archived data.

Towards a CERIC EOSC ecosystem

In June 2021, the CERIC IT strategy was presented and approved by the General Assembly of the Consortium.
The proposed roadmap is based on the Memorandum of Understanding (MoU) for the Co-programmed European Partnership on the EOSC document that has been signed by all the EOSC members, including CERIC. In a nutshell, the roadmap directly addresses and specifies activities in all general objectives set by the MOU:

- **Ensure that Open Science practices and skills are rewarded and taught, becoming the "new normal".**
  To spread and increase open science practices adoption, the CERIC IT will be building on achievements and experience gained in PaNOSC work package (WP) on training and connect with other CERIC units, while collaborating within the CERIC community to boost awareness of open access. Moreover, to increase the amount of FAIR-by-design research data produced by publicly funded research in Europe, a data steward will be appointed in the team.
- **Enable the definition of standards, and the development of tools and services to allow researchers to find, access, reuse and combine results:**
  The efforts of PaNOSC WP on data catalogues will be extended to all the specific domains outside photon and neutron techniques of CERIC PFs by 2023, enabling them to significantly increase the percentage of open research data. Furthermore, several software tools will be provided, achieving easy and repeatable online pre-processing and data analysis and reduction, and further unification of raw data formats, archiving, data analysis and simulations for specific domains of CERIC PFs. Remote access capabilities will also be deployed at PFs.
  Moreover, the Consortium's IT team will make a significant contribution to the co-development of a minimum metadata framework, and provide a standard search and access mechanism to EOSC resources across the EOSC federation by 2025.
- **Establish a sustainable and federated infrastructure enabling open sharing of scientific results:**
  By PaNOSC completion in November 2022, three online services for data analysis and simulation will be developed and incorporated into a demo data portal. Specific attention will be dedicated to ensuring that CERIC repository(ies) are certified (30% by 2025) and to monitoring the uptake of FAIR usage within CERIC.

OCRE funding for CERIC's mini-EOSC implementation

In January 2021, CERIC was selected among the few research infrastructures receiving funding for the adoption of commercial cloud solutions in the frame of the H2020 OCRE project.
Thanks to the OCRE funding, CERIC will set up a "mini-EOSC", supporting all Consortium members in developing their own FAIR (Findable, Accessible, Interoperable, and Reusable) enabled workflow.
One of the CERIC's main challenges is to find ways to provide open access to data collected at their geographically and scientifically heterogeneous partner facilities. This will be done through the development and maintenance of a distributed IT infrastructure enabling open sharing and reusability of scientific results. This implies the set-up of a FAIR ecosystem for data management, data handling and analysis services. The first step will be the deployment of a common data catalogue with automatic ingestion pipelines (data uploaders, metadata harvesters) for heterogeneous (meta)data types and formats, as collected by the diverse techniques available at the CERIC partner facilities.
To this aim, and following the procurement procedure to identify and select a commercial cloud-based platform for the implementation of the CERIC mini-EOSC, Rackspace/AWS has been selected as the provider of commercial cloud resources to the Consortium and its partners for a period of 12 months.
In the frame of the pilot, a set of scientific use cases for HPC (high-performance computing) cloud applications have been identified at different PFs, to be set up in the SaaS (Software-as-a-Service) model. Their usage (number of users) and scientific output will be monitored throughout the grant duration. Experiences gained from the OCRE pilot grant will serve as a base for developing a novel data analysis user service, which will be of particular interest to highly interdisciplinary experiments (i.e., combining several of CERIC's techniques in one proposal). Such service will further strengthen CERIC's competence and visibility in the key areas of energy storage and life science research.

CERIC's performance monitoring based on ESFRI KPIs

Starting 2020, CERIC has been collecting data related to all KPIs proposed by the ESFRI working group on Monitoring of Research Infrastructures Performance[6], and an assessment of the applicability of the KPIs proposed by ESFRI has been made, in particular to verify whether they meet the RACER criteria (relevance, acceptability, clarity, easiness, robustness). The outcomes have been published in a report including the opinion by the CERIC staff involved in the data collection.
In the area of "**enabling scientific excellence**", most relevant KPIs meeting all RACER criteria are the "number of user requests for access", "number of users served" and the "percentage of top (10%) cited publications". Such data is periodically monitored and presented in the CERIC annual report, where the change over the last three years is also showcased. The "number of publications" is also monitored over time, though a number of them may not be visible, due to the fact that CERIC users do not always promptly update the CERIC database.
In the area of "**education and training**", both indicators used ("No. of master and PhD students using the RI", and "Training of people who are not RI staff") are not very robust, nor easy to monitor. However, the related data are considered relevant, accepted and credible enough to continue its collection.
For what concerns the capacity to "**enhance transnational collaboration in Europe**", the "number of members of the RI from ESFRI countries" is reported, though its change over the years may be quite limited. Moreover, whereas the "share of users per ESFRI member country" is quite straightforward to monitor, it is more laborious to do so for the "share of publications per ESFRI member countries", mainly due to the lack of a dedicated tool to collect such data, which may be adopted in the future.
The "share of users associated with industry" and the "number of publications with industry" are monitored to measure CERIC's performance in "**facilitating economic activities**". Both of them are not considered robust enough. In the first case, data is collected from the proposal submission system, where the applicants tick a box whether the proposal is associated with industry. Reliability of such declaration is an issue, as the answer may be affected by whether the user thinks this will be looked upon positively or negatively during the application. In the second case, the data may not always be reliable, as some publicly-funded institutions are considered as companies even when economic activities represent only a minor part of their mission. Another KPI monitored in this area is the "income from commercial activities and number of entities paying for services", which is not easy to interpret, as contracts for proprietary research are usually concluded with single partner facilities, and not the ERIC.
CERIC also monitors "**outreach to the public**" by measuring the "engagement achieved by direct contact" to high-school pupils, general public and policy makers. In all cases, the exact number of people reached is not always easy to monitor, and the values reported are often not fully reflecting the real results of outreach activities implemented.
"Outreach through media" is a more credible KPI in this domain, though many articles are not tracked due to the lack of a dedicated tool for the purpose. On the other hand, CERIC has started to use Altmetric to collect data about mentions of scientific publications (through DOIs) in press articles, blogs and social media. "Outreach via the RI's own web and social media" is also monitored, though robustness and hence relevance may be questioned, as the engagement may increase by, e.g., publishing posts on trending topics not necessarily linked to science-related topics, or to the Consortium's activity.
"**Provision of scientific advice**" is monitored by collecting data on the "number of publicly available data sets used externally", "Participation by RIs in policy-related activities" and "citations in policy related publications". Among them, only the last one is not easy to monitor, as no automatic tracking is currently available, which may affect the final result.
The most relevant KPI to measure "**facilitation of international cooperation**" is the "number of members of the RI from non-ESFRI member countries", whereas "**optimisation of management**" is monitored by measuring "revenues" and the "extent of resources made available", which both fully meet the RACER criteria.
All such KPIs are collected on a yearly basis to monitor performance in the various areas, whereas only headline indicators are publicly released as part of the CERIC annual report.

[6]Report of the ESFRI Working Group on Monitoring of Research Infrastructures Performance, December 2019, https://www.esfri.eu/sites/default/files/ESFRI_WG_Monitoring_Report.pdf

4

Operations and Finance

Main Achievements

1. **Election of CERIC's Executive Director and of the Chair and Vice-Chair of the General Assembly**
2. **Fruitful discussions towards a new CERIC's business model**
3. **Udated procedure to join CERIC**
   As a Member or Observer, or as Associated Facility.
4. **IKCs, VAT, Excise Exemptions and employment policies**
   Progress and updates.
5. **Financial and in-kind annual account**
   for 2021 and estimate of the auditable values to be included in the Annual CERIC Account.

Election of the CERIC Executive Director and of the Chair and Vice-Chair of the General Assembly

On the 26th of November, 2021, the 19th meeting of the General Assembly (GA) of CERIC-ERIC took place, with the participation of the delegates from the Ministries for Science and Research from CERIC member countries.
The GA reconfirmed **Prof. Carlo Rizzuto** as its Chair for the next three years and elected **Prof. Vladimír Matolín** – who also serves as the Vice-Chair of the consortium's Board of Directors – as the new Vice-Chair.
The GA also reassigned the role of Executive Director of the Consortium to **Dr. Jana Kolar** for the next three years.
In an interview released on the website dedicated to large research infrastructures, supported by the Ministry of Education, Youth and Sports of the Czech Republic, Prof. Matolín declared his will "*to be even more active in the expansion of internal research within CERIC-ERIC* [...] *to ensure that the Consortium not only has the character of an institution providing open access for users to excellent research facilities in Central and Eastern Europe through a single-entry point*", but also that it has *"its own research lines and internal grants with a high degree of joint involvement of its partner institutions. The aim is to fully exploit the high potential of the whole Consortium to achieve excellence in the search for innovative solutions to the societal challenges of today's world*".

Advancements in the adoption of a new business model towards the introduction of fees

Following the discussions started in 2019 at the level of the General Assembly (GA) of CERIC on the proposal to modify the business model of the Consortium, towards a transition from the sole use of in-kind contributions, to monetary contributions by the Members, further exchanges towards a possible amendment of the Statutes of CERIC in this direction took place during the GA meeting in November 2021.

The proposed modifications will be further discussed in 2022 and are based on the following:

- The Host premium of the country hosting the seat is maintained at 5,5 MEUR to strengthen the CERIC integrated operations, including training, technology transfer, and communication.
- The overall additional monetary contribution is set at ca. 1 MEUR. This is roughly 10% of the annual cost of the operation of CERIC, including the Partner Facilities.
- Fixed contribution, the same for all.
- Variable contributions by the Member States based on their percentage of total GDP of all EU Member States.
- The annual contribution by each member should be devoted mainly to improving and integrating its facilities.

The GA of CERIC will further discuss the topic in June 2022 to agree on the formula to calculate the members' yearly cash contribution.

In the meantime, a few changes to the Statutes of CERIC have been agreed upon via written consultation. Approved amendments imply that all contributions of the Members, including the agreed value of in-kind contributions and other revenues, shall be included in the annual accounts, to be approved within six months after the end of the financial year. Moreover, the GA will have the right to further renovate the mandate to the members of the Independent Audit Expert Committee, differently from the past, when their 3-year appointment was not renewable.

Updated procedure to join CERIC

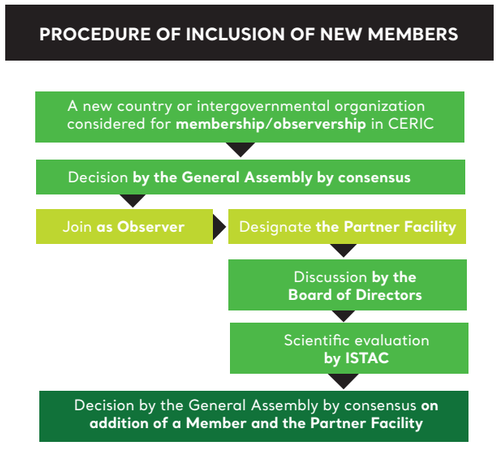
Join CERIC as a Member or Observer

Membership in CERIC is open to the interested Member States with the possible participation of qualified associated countries in the Community framework programme for research, technological development and demonstration (hereinafter referred to as 'associated states'), third countries and specialised intergovernmental organisations. Membership is not limited to a certain geographical region. Each Member may appoint one Representing Entity, which shall be an Institution that can support the scientific/technical operation of CERIC, including the provision of access to one facility (Partner Facility) of which it has ownership.

Member States of the European Union, third countries and intergovernmental organisations may become Observers in CERIC through specific agreements in the following cases:

- When they intend to apply for full membership while still developing appropriate Partner Facilities;
- When they are involved in joint projects with specific scope and time perspective.

Each Observer may appoint one representative to attend the CERIC General Assembly without voting rights.

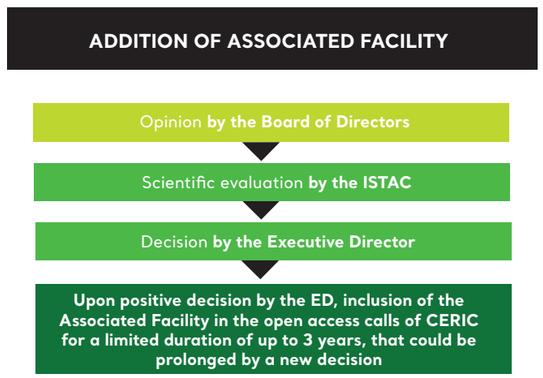


Join CERIC as an Associated Facility

The Associated Facilities collaborate with CERIC but are not formally part of the Consortium. Therefore, minor derogations may apply to CERIC rules and procedures. They may take part in CERIC calls on a trial basis for a limited duration of up to 3 years, which ISTAC can prolong. They offer access on the same (free) basis as the other CERIC Facilities. The addition of these facilities is based on the opinion of ISTAC, while the General Assembly is informed during the annual reporting.

The ISTAC of CERIC will evaluate the facility following these criteria:

1. Must be a user facility with:
   a. dedicated staff for supporting external and potentially inexperienced users,
   b. infrastructure like a data Policy, guest house, travel Office, etc.
2. The equipment offered must be unique. A collection of good commercial Instruments does not qualify.
3. There must be a pan-European perspective adding value to users in other countries and strengthening collaborations across Europe.



A facility (which is not a PF of CERIC) may become an Associated facility to:

- Temporarily expand the offer due to a certain project or a particular topic, and
- Build mutual trust and understanding between CERIC and a facility in order to explore/develop a relationship with a potential new Member.

IKCs, VAT and Excise Exemptions, and employment practices

The full implementation of the ERICs' scopes in terms of integration, mainly depends on the proper use of fiscal exemptions granted to international organizations, on the implementation of simplified procedures agreed with the national fiscal authorities, and on the implementation of national labour rules.
The relevance of fiscal exemption issues at European level is described in a report from the Commission to the European Parliament and the Council on the Application of Council Regulation – (EC) No 723/2009 dated 14.07.2014, within a chapter dedicated to "pending issues and next steps". In this document, it was clearly stated that "*There are also questions to clarify as concerns in-kind contributions to an ERIC by its members, in particular as to whether these contributions could benefit from the VAT and excise duty exemption and, if so, under what conditions*".
The VAT and excise exemptions issues, as well as the implementation of a methodology for managing the IKCs provided by the Member States to the ERICs, have been outlined in two deliverables within the ACCELERATE project – (in WP1 led by CERIC, D1.6 – VAT/excise duty exemption progress report, and D1.8 Comprehensive methodology for IKC accounting), as well as in a specific deliverable within the ERIC FORUM project (in WP3 led by EATRIS, D3.2 Procurement rules, VAT exemptions practices and economic activities).
During 2021, a study was carried out by CERIC, with the support of all other ERICs involved in the ERIC forum project, to provide a better understanding on how the ERICs have implemented, or plan to implement, the VAT exemption benefits, both in the case of exemption on direct procurement and in the case of indirect (in-kind) procurement.
With reference to HR issues, the main challenges that ERICs will face in their future are related to attracting and retaining talent, granting equal opportunity, facilitating international mobility, adopting recruitment and remuneration policies based on a common ground, and implementing the contracting rules outside the country's legal seat.
In addition to these aspects, a common remuneration system and fringe benefit policies, taking into-account the different living costs within EU, could facilitate the integration of the facilities that are part of the ERICs.
Within the ERIC Forum project, in a dedicated project deliverable – WP3, D3.2 Best practices guidelines in employment and secondment for ERICs - the contribution of CERIC focused on pointing out the challenges faced with secondment issues and practices referred to the personnel contributed in-kind, detailing the areas for which the Consortium has already adopted appropriate procedures: hiring and selecting personnel in Italy and abroad, and employing and managing personnel.
During 2021, the initiatives undertaken to simplify the VAT exemption procedures referred to the intra Community acquisition of goods and services continued, addressing a specific consultation to the Italian tax and economical authorities. These initiatives intended to ask for the exemption from the certificate laid down in Annex II of the Reg. 282/2011/EU, within the meaning of Art. 51 paragraph 2, according to which "*(…) if the goods or services are intended for official use, Member States may dispense the recipient from the requirement to have the certificate stamped under such conditions as they may lay down.*" In the case of ERICs, this exemption is related to the purchases made directly by the Italian ERICs for their exclusive use, as well as within their institutional activity of scientific character.
Moving to IKCs issues, the main outcomes of the ACCELEREATE project focused on defining the limits and the subjective/objective conditions for the Members, to benefit from VAT/duty exemptions for in-kind contributions provided to the ERICs through their Representing Entities, by also making reference to the current position of the Commission Tax Services with reference to these operations.
The same topic has been addressed within the ERIC FORUM project, with reference to the IKCs referred to the human resources (personnel seconded and / or committed to ERICs' activities).

Financial Statements 2021

Balance Sheet - Assets and Liabilities		
	2021	**2020**
ASSETS	**7,773,568.77**	**7,354,431.45**
Non-current Assets	**1,613,618.00**	**961,803.73**
Plant, property and equipment	1,559,914.69	923,575.62
Intangible assets	53,703.31	38,228.11
Investments in associates	-	-
Current Assets	**6,159,950.77**	**6,392,627.72**
Inventories	-	47,826.09
Long-term credits	-	-
Short-term credits	100,461.51	64,198.94
Other current credits and receivables	-	-
Cash and cash equivalents	5,528,436.50	5,823,139.02
Prepayments and accrued income	531,052.76	457,463.67
EQUITY AND LIABILITIES	**7,773,568.77**	**7,354,431.45**
Equity	**-**	**-**
Equity	-	-
Capital and other permanent contributions from Members	-	-
Reserves	-	-
Accumulated profits	-	-
Non-current Liabilities	**191,586.78**	**1,070,855.93**
Long-term financial debts and loans	-	-
Other long-term debts and liabilities	-	-
Advance payments for externally funded projects	-	923,644.46
Pensions funds and other benefits for compensation employment	191,586.78	147,211.47
Long-term provisions	-	-
Current Liabilities	**7,581,981,99**	**6,283,575.52**
Short-term financial debts	-	-
Other short-term debts and liabilities	422,623.13	547,447.58
Advance payments for externally funded projects	207,845.41	-
Other current payables	281,682.08	301,315.42
Contingent liabilities	40,783.62	40,783.62
Deferred income and accrued expenses	6,629,047.75	5,394,028.90

Profit and loss account			
		2021	**2020**
Revenues		**2,593,690.94**	**2,167,630.01**
	National and international grants and contributions	2,593,091.99	2,167,475.62
	Contributions in-kind	-	-
Other revenues	Other revenues	598.95	154.39
Operating costs		**2,248,918.89**	**1,998,034.75**
	Costs for raw materials, supplies and goods	30,934.14	47,677.44
	Costs for services	807,520.69	505,978.82
	Resources committed in-kind to CERIC from contributors	-	-
	Staff costs	1,399,038.84	1,441,178.17
	Costs of rents, concessions and royalties for trademarks	-	-
Other operating costs	Costs for institutional activities	11,425.22	3,200.32
Ebitda (Earnings before Interest, Taxes, Depreciations and Amortizations)		**344,772.05**	**169,595.26**
Depreciation		307,963.82	137,883.03
Write-downs for impairment of tangible and intangible assets		-	-
Ebit (Earnings before interest and taxes)		**36,808.23**	**31,712.23**
Financial income and expenses		**-1,719.23**	**-314.23**
	Financial income	482.52	413.21
	Financial charges	2,201.75	-727.44
Income from investments		-	-
Value adjustments to financial assets		-	-
Result before tax		35,089.00	31,398.00
Taxes		35,089.00	31,398.00
Result for the year		**-**	**-**

Notes to the Financial Statements as at December 31, 2021

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. For this purpose, it is relevant to recall the “Report from the Commission to the Council and the European Parliament towards implementing harmonised public sector accounting standards in Member States. The suitability of IPSAS for the Member States”, published in March 2013.
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). The aforementioned EU Directive states that “by 14 December 2018 the Commission shall make public a review of the sustainability of the Directive (see art.16).
CERIC-ERIC is set up as an international organization 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 nations;
- 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.
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.

It has been compiled taking into account international accounting standards for the public sector (IPSAS), 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 analysing 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
- Statement of cash flow
- Trend of the net financial position (NFP)

Evaluation Criteria

TThe 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 realizable 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 recognized as non-current liabilities.

Deferred Incomes and Accrual Expenses

This item includes the amount of funds received up to December 2021 and not yet fully used by 31.12.2021 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 2021.

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", under the conditions specified therein and only as a result of auditing carried out by local auditors, which will be comparable with that of CERIC auditors.

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.

In-kind Contributions

In-kind non-monetary contributions will be distinguished (when realized) 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).

Assets

Non-current Assets

Tangible Assets

Balance as at 31/12/2020	Balance as at 31/12/2021	Variation
923,575.62	1,559,914.69	636,339.07

Most of the represented increase refers to purchases linked to the running of internal research projects; a 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 31/12/2020	**-**	**622,689.24**	**24,912.04**	**21,189.73**	**1,374.80**	**253,409.81**	**923,575.62**
Acquisitions during the year	-	800,153.08	15,112.46	-	501.01	107,003.64	922,770.19
Increases during the year	-	291,404.35	-	-	-	-	291,404.35
Decreases during the year	-	-	-	-	-	-291,404.35	-291,404.35
Depreciation for the year	-	-270,606.03	-10,000.27	-5,305.75	-519.07	-	-286,431.12
Balance as at 31/12/2021	**-**	**1,443,640.64**	**30,024.23**	**15,883.98**	**1,356.74**	**69,009.10**	**1,559,914.69**

The balance sheet items “Decreases during the year” is referred to the completion in 2021 of the supply of scientific instruments; its value is included in under the acquisition made during the year.

Intangible Assets

Balance as at 31/12/2020	Balance as at 31/12/2021	Difference
38,228.11	53,703.31	15,475.20

Historical costs at 31/12/2021 are as follows:

Description	Balance as at 31/12/2020	Operating increments	Operating decreases	Depreciation for the year	Value on 31/12/2021
Concessions, licenses, trademarks	38,228.11	37,007.90	-	-21,532.70	53,703.31
Intangible assets in progress	-	-	-	-	-
Total	**38,228.11**	**37,007.90**	**-**	**-21,532.70**	**53,703.31**

95% of the increments (€ 35,190.90) refers to intangible assets (software) related to the realization of the INTEGRA project.

Current Assets

Inventories

Balance as at 31/12/2020	Balance as at 31/12/2021	Variation
47,826.09	-	-47,826.09

The negative variation in the item "Inventories" (to be referred to on-going commercial activities started in 2020) follows the completion of a commercial contract signed with the Italian representing entity, with a duration of over a year.

Short-term Credits

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

Balance as at 31/12/2020	Balance as at 31/12/2021	Variation
64,198.94	100,461.51	36,292.57

The composition of the amount as at 31/12/2021 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	501.51	-	-	501.51
Tax advances	31,960.00	-	-	31,960.00
Receivables from customers	20,000.00	-	-	20,000.00
Total	**100,461.51**	**-**	**-**	**100,461.51**

- The balance sheet 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 2022.
- The balance sheet item “Other receivables” mainly refers to reimbursement to be received in relation to collaborators travels.
- The balance sheet item “Tax advances” refers to advance payments made in June and November 2021. These advance payments have been calculated on the basis of the fiscal charge for the previous year.
- The balance sheet item “Receivables from customers” refers to limited commercial activities completed in December 2021.

Cash and Cash Equivalents

The balance represents cash at the bank at the end of the financial year. It represents liquid assets and cash equivalents at the end of the year.

Cash deposited at the bank Unicredit Banca Spa:

Description	Balance as at 31/12/2020	Balance as at 31/12/2021	Variation
Bank deposits	5,823,139.02	5,528,436.50	-294,702.52

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 October 2021, 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 May 2021, CERIC received from the EU an amount of € 31,694.80, as final payment for the E-RIHS project. In November 2021, CERIC received from the EU an amount of € 456,182.98, as final payment for the ACCELERATE project. Part of this amount has been transferred to the project partners (€ 383,576.49).

Prepayments and Accrued Income

Balance as at 31/12/2020	Balance as at 31/12/2021	Variation
457,463.57	531,052.76	65,589.19

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 (€523,943.61) represents prepaid expenses related to costs for three-years PHDs program referring to the period 2022-2024. The objective of this activity is to further the integration of the partner facilities and to contribute to excellent science.
The remaining part (€7,109.15 refers to prepaid expenses related to general costs of the Consortium).

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

Description	Balance as at 31/12/2020	Balance as at 31/12/2021	Variation
Long-term advances	923,644.46	-	-923,644.46

The amount of 923,644.46 was partially used in relation to the conclusion of the project ACCELERATE (€ 201,886.61), as well as of the progress report of the PaNOSC (€458,185.89) and ERIC-FORUM projects (€55,726.55).
The residual amount (€ 207,845.41) is included in the short-term debts, as detailed in the following.

Pensions Fund and Other Benefits for Compensation Employment

Severance indemnities for employees.

Description	Balance as at 31/12/2020	Balance as at 31/12/2021	Variation
Severance indemnities for employees	147,211.47	191,586.78	44,375.31

The item is made up as follows:

Description	Initial value 31/12/2020	Plan balance 2021	Substitutive tax	Contribution to national funds for employees (FPLD)	Severances paid during the year	End value 31/12/2021
Severance indemnities for employees	147,211.47	53,578.67	-1,055.75	-3,397.34	-4,750.27	191,586.78

The severance set aside figure represents the actual debt of the Consortium at 31/12/2021, 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 to the expiration of two fixed-term contracts during 2021.
As at 31/12/2021, advances have not been required by employees.

Current Liabilities

Other Short-term Debts and Liabilities

Debts

The composition of the aforementioned amounts is as follows:

Description	31/12/2020	31/12/2021	Variation
Debts to providers	382,023.30	298,520.28	-83,503.02
Tax liabilities	119,673.90	76,672.54	-43,001.36
Payables to social security institutions	45,750.38	47,430.31	1,679.93
Total	**547,447.58**	**422,623.13**	**-124,824.15**

Debts are valued at their nominal value.

The item “Debts to providers” (€ 298,520.28) 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 € 41,222.62, together with € 360,92 of VAT to be paid in 2021, and taxes due by the Consortium (€ 35,089.00). With reference to this last item, an advance payment was made in 2021 to a total amount of € 31,960.00.

“Payables due to social security institutions" includes the amount of social security contributions relating to employees, accrued but not paid as at 31 December 2021, amounting to € 47,430.31

Description	31/12/2020	31/12/2021	Variation
Other payables	301,315.42	281,682.08	-19,633.34

"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 31/12/2021 was as follows:

Description	31/12/2021
Payables to employees (holidays and leave not taken)	81,332.83
Payables to bodies	4,166.67
Other debts of a different nature	196,182.58
Total	**281,682.08**

The item “Payables to bodies” relates to the fee due by the Consortium to an internal auditor.

Debts are evaluated at their nominal value.

The final value as at at 31.12.2021 refers mainly to the following expenses:

- Costs for the spaces charged by Elettra for hosting the statutory seat in 2021 (€ 49,607.27)
- Costs for seconded personnel charged by Elettra, within the H2020 project PaNOSC (€ 56,034.07)
- Access costs related to beamline LISA located at ESRF and managed by CNR. (€ 80,680.72)

Advance Payments received for externally funded projects

Description	31/12/2020	31/12/2021	Variation
Short-term advances	-	207,845.41	207,845.41

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

Description	ACCELERATE	PaNOSC	ERIC Forum	Total
Balance as at 31/12/2020	**201,886.61**	**656,074.65**	**65,683.20**	**923,644.46**
Advance payment received from the EU during the year	456,182.98	-	-	456,182.98
Transfer of funds to project partners	-383,576.49	-	-	-383,576.49
Accrual progress report for the year 2021	-274,493.10	-463,131.89	-58,546.55	-796,171.54
Depreciation costs related to investments made in 2020	-	4,946.00	2,820.00	7.766,00
Balance as at 31/12/2020	**-**	**197,888.76**	**9,956.65**	**207,845.41**

The advance payments received relate to the implementation of the activities described in the project, and it must be returned only if CERIC does not carry out the project, or if it does not comply with the contractual obligations towards the EU. The final amount at 31/12/2021 has been calculated on the basis of the progress reports of the projects PaNOSC and ERIC Forum, with reference to the incurred costs for the period January - December 2021 (€ 513,912.44).

In view of the fact that PaNOSC project will finish in November 2022 and ERIC-FORUM project will finish in December 2022 the total amount of this balance sheet item is represented within the current parts).

Contingent liabilities

Description	Balance as at 31/12/2020	Balance as at 31/12/2021	Variation
Contingent liabilities	40,783.62	40,783.62	-

The final value as at 31.12.2021 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 31/12/2020	Balance as at 31/12/2021	Variation
5,394,028.90	6,629,047.75	1,235,018.85

The item breaks down as follows:

Description	Amount
Deferred income	6,599,618.19
Accrued expenses	29,429.56

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 € 6,599,618.19 is derived as follows:

Category	Deferred incomes as at 31.12.2020	Italian Contribution for 2021	Consortium general expenses for 2021 covered by FOE	Consortium general expenses for 2021 covered by FOE 2019/2020	Depreciation quotes to be covered by external projects	Deferred incomes as at 31.12.2021
Deferred income	5,394,028.90	2,955,392.73	1,329,338.34	412,699.10	-7,766.00	6,599,618.19

The Italian contribution for 2021 (€ 3,005,000.00) initially defined in the collaboration framework agreement signed by CERIC and its Italian Representing Entity for the period2020-2022, was recalculated taking into account the additional activities performed by Elettra-Sincrotrone Trieste S.c.p.A. (€49,607.27) for spaces rented to CERIC.

The amount of the carry-over for 2021 is composed as follows:

Description	Amount
Resources committed to cover the depreciation quotes covered by FOE starting from 2022	259,505.30
Orders issued as at 31.12.2021 but not closed at the end of the year	110,949.58
Resources committed to cover the depreciation costs for orders 2020 completed as at 31.12.2021	5,473.80
Resources committed to the project INTEGRA	2,212,859.07
Resources committed to cover the depreciation costs to investment made within the internal research project MAG ALCHEMI	200,655.13
Carry over 2021 committed to ordinary activities (FOE)	1,626,054.39
Free carry over from the previous years (2019-2020) (FOE)	2,081,185.85
Resources committed to cover the investments made within the Battery Plan Programme	95,169.07
Residual amount of the depreciation quotes covered by projects externally funded in the next financial years	7,766.00
Total deferred income as at 31.12.2020	**6,599,618.19**

During 2021, the residual amount of the free carry-over resulting from 2019-2020 was used for the following activities:

- Coverage of the investments referred to the internal project MAG-ALCHEMI (€ 5,176.85);
- Coverage of the depreciation costs of the investments made in 2021 covered by FOE funds (€ 107,620.97);
- Coverage of the order issued in 2021 but not completed within the end of the fiscal year (€ 110,949.58);
- Coverage of the depreciation costs for the investments made in the previous year, covered by FOE funds (€ 98,157.67).

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 programs 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 2021 (€3,005,000.00), recalculated considering the additional activities performed by Elettra-Sincrotrone Trieste S.c.p.A. (€49,607.27) for the spaces used by CERIC for its statutory seat, corresponds to €2,955,392.73. The portion of the FOE 2021 spent in the current financial year corresponds to €1,329,338.34. The remaining part of the general expenses has been covered by FOE funds 2019 for € 412,699.10.

Balance as at 31/12/2020	Balance as at 31/12/2021	Variation
2,757,731.48	2,955,392.73	197,661.25

The composition of the amount at 31.12.2021 is as shown in the following tables:

Category	31/12/2020	31/12/2021	Variation
MIUR ordinary contribution	2,757,731.48	2,955,392.73	197,661.25
FOE funds 2018/2019 spent	245.691,68	412,699.10	167,007.42
FOE funds 2019 to be spent in the following years	-1,598,802,83	-1,626,054.39	-27,251.56
Total	**1,404,620.33**	**1,742,037.44**	**337,417.11**

Category	31/12/2020	31/12/2021	Variation
H2020 ACCELERATE Project	222,079.58	274,493.10	52,413.52
H2020 ERIC Forum Project	47,635.95	58,546.55	10,910.60
H2020 E-RIHS Project	15,260.88	-	-15,260.88
H2020 PaNOSC Project	414,302.79	463,131.89	48,829.10
Commercial services	15,750.00	102,709.10	86,959.10
Changes in inventories	47,826.09	-47,826.09	95,652.18
Other incomes	154.39	598.95	444.56
Total other incomes	**763,009.68**	**851,653.50**	**88,643.82**

Contributions for Operating Expenses

The amount of the Italian contribution 2021 for the activities of the statutory seat of the Consortium is € 1,329,338.34. This amount will be reported to the Italian Ministry according to the FOE reporting rules. This amount covered 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. The increase in the year is a direct result of the increased activities of CERIC, in particular with reference to internal research grants.

Category	Balance as at 31/12/2020	Balance as at 31/12/2021	Variation
Costs for raw materials, supplies, consumables and goods	47,677.44	30,934.14	-16,743.30

Most of the total value for 2021 refers to costs incurred to support internal research grants.

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	31/12/2020	31/12/2021	Variation
External services related to the commercial activity	13,500.00	0.00	-13,500.00
Legal, fiscal and administrative consultancy	33,589.89	13,476.91	-20,112.98
Technical consultancies	1,330.14	5,351.94	4,021.80
Administrative collaborators	-	22,540.00	22,540.00
Scientific and technical collaborators	146,682.03	105,080.00	-41,602.03
Social security contributions of collaborators	36,262.17	38,967.98	2,705.81
Health contribution for collaborators	700.38	468.00	-232.38
ISTAC remunerations	8,464.26	17,857.11	9,392.85
Travel costs for employees, collaborators, and bodies	22,334.87	23,516.19	1,181.32
Travel costs for users	10,231.10	18,967.43	8,736.33
Expenses for corporate meetings	-	-	-
Insurances	10,812.33	10,995.20	182.87
Representation costs	770.90	3,091.38	2,320.48
Consulting and salaries processing	14,025.65	30,719.18	16,693.53
Mobile phones	8,859.39	8,614.20	-245.19
Annual software licenses	2,640.22	2,300.88	-339.34
Workshops, seminars and publications	6,726.99	12,104.10	5,377.11
Canteen expenses	23,895.30	22,568.35	-1,326.95
Bank charges	1,879.83	1,715.59	-164.24
Postal charges	2,081.75	1,977.00	-104.75
Agreement with Universities to support PHDs	49,072.01	278,687.86	229,615.85
Maintenances	94,237.89	2,654.81	-91,583.08
Training costs	3,434.00	619.60	-2,814.40
Transportation services	1,380.00	1,000.00	-380.00
Other costs	13,067.72	184,246.98	171,179.26
Total	**505,978.82**	**807,520.69**	**290,546.67**

The item "Other costs" includes mainly costs related to the following activities:

- Realisation of promotional videos of 10 CERIC-ERIC instruments (€80,600.00);
- Collaboration agreement between CNR and CERIC-ERIC, concerning the access of CERIC users to the user mode beamtime of LISA at ESRF (€80,680.72);
- Other minor costs related to the transportation services, proofreading services.

Personnel Costs

Personnel expenses: breakdown

Category	31/12/2020	31/12/2021	Variation
Wages and salaries	708,827.00	659,356.59	-52,470.41
Social security charges	218,972.86	194,860.08	-24,112.78
Seconded personnel (IKCs against payment)	25,238.91	61,090.04	35,851.13
Severance indemnities	52,845.95	56,010.89	3,164.94
Allowances to be paid	75,029.07	81,332.83	6,303.76
Fellowships	10,999.98	-	-10,999.98
Director	175,747.99	175,871.97	123.98
Social security charges of bodies	23,516.41	23,516.44	0.03
Auditors and IAEC	150,000.00	150,000.00	0.00
Total	**1,441,178.17**	**1,399,038.84**	**290,546.67**

The item "Auditors and IAEC" is referred to 6 appointments.

Use of Third-Party Materials or Property

No values are entered for these items

Other Operating costs

Other operating costs: breakdown

Category	31/12/2020	31/12/2021	Variation
Membership fees	-	10,000.00	10,000.00
Rounding	244.18	156.08	-88.10
Other taxes	209.44	225.46	16.02
Other expenditures	359.10	1,043.68	684.58
Donations	2,387.60	-	-2,387.60
Total	**3,200.32**	**11,425.22**	**8,224.90**

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%	21,532.70
Total amortisation of intangible assets		**21,532.70**

Tangible Assets

Description	Depreciation Rate	Amount
Office machinery	20%	10,000.27
Equipment	20%	270,606.03
Telephony and mobile telephony	20%	519.07
Office furniture	15%	5,305.75
Total amortisation of fixed assets		**5,305.75**

Total amount (intangible and tangible)	**307,963.82**

Taxation

Current tax	Balance as at 31/12/2020	Balance as at 31/12/2021	Variation
IRAP	31,398.00	35,089.00	3,691.00
Total	**31,398.00**	**35,089.00**	**3,691.00**

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 zero.

The Consortium, in the context of purchases realized, and within the limits following from the Statute, may use VAT exemptions granted on the basis of Article 143(1)(g) and Article 151(1)(b) of Council Directive 2006/112/EC, and in accordance with Articles 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 31.12.2021.

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	31/12/2020	31/12/2021	Variation
Interest on current account	413.21	482.52	69.40
Exchange rate costs	-727.44	-2,201.75	-1,474.31
Total	**-314.23**	**-1,719.23**	**-1,404.91**

Report of the commercial activities

The limited commercial activities of the Consortium have been managed through a separate account. In 2021, one commercial contract started in 2020 was concluded for the value of € 100,000.00. Other minor revenues are referred to the fee credited for the organization of a workshop. (€ 2,709.10).

Revenues	
Commercial services	100,000.00
Revenues for workshop organization	2,709.10
Changes in inventories (work in progress 2020)	-47,826.09
Costs	
Collaboration contracts related to the commercial activity	44,216.40
General costs*	14,674.78
Final balance	-4,008.17

*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 (€54,883.01) compared to the total amount of the revenues accounted for 2021 (€ 2,593,690.94). The ratio corresponds to 2.12%

The resulting percentage has been applied to the amount of € 693,508.51, corresponding to the following general cost categories, common to both institutional and commercial activities and not reported within project externally funded.

General costs	Amount
Executive Director	149,836.23
Auditors	87,500.00
General services	3,961.14
Fiscal, legal and labor consultancies	44,196.09
Insurances	10,995.20
Utilities	8,614.20
Seat staff	338,405.65
Total	**693,508.51**

Events after the reporting date

Following IPSAS 14, this paragraph reports about events that occurred between the reporting date (31.12.2021) and the date when these Financial Statements were approved by the General Assembly.
The only relevant event that occurred relates to the worldwide emergency caused by the COVID-19 pandemic. It is relevant to state that this event continues to be classified among the "non-adjusting events after the reporting date" and that it does not influence the assessment of the appropriate assumption of the ongoing concern of CERIC.
The temporary consequence connected to the aforementioned event can continue to be identified in some potential slight delays in performing the activities related to the externally funded projects, for which appropriate requests of extensions could be submitted to the funding agencies.
The COVID-19 emergency might delay the organization of splanned meetings and cooperation initiatives, thus affecting the use of the budget allocated to support these activities creating the necessity to postpone some expenditures. There are no valid reasons to believe that the aforementioned event could influence the Italian cash contribution from FOE, or the in-kind contributions by the Italian Representing Entity and by the other International Organisations involved in CERIC activities..

Management Report

Comparison between Final Budget and Annual Accounts

Starting from the budget for 2021 approved by the GA in November 2020, some changes were necessary as the result of the following:

EXPENDITURE COMMITMENTS, COSTS and INVESTMENTS:

1. The postponement of the activities related to the Management project system.
2. The additional funds related to the calculation of the actual carry over from the previous years;
3. The carry-over of the funds related to the project INTEGRA, not spent within the closure of the financial year 2020.
4. The remodulation of the expenses within the project externally funded.

REVENUES

1. The calculation of the actual carry-over for 2020. The 2021 budget was approved in November 2020 by the GA taking in to account an estimate of the carry-over for the year at closing.
2. The recalculation of the revenues related to projects externally funded.
3. The resources committed to the hosting costs claimed by the Italian Representing Entity;

Incurred and planned expenses

EXPENSES FOR 2021					
Description	**Initial budget**	**Changes**	**Final budget**	**Total expenses**	**% of expenditure**
Dyna Chiro	85,000.00	-	85,000.00	61,864.98	72.78
RENEWALS	70,000.00	-	70,000.00	69,082.25	98.69
MAG-ALCHEMI	50,000.00	-	50,000.00	34,060.77	68.12
Training Projects	24,000.00	10,000.00	34,000.00	33,162.30	97.54
Collaboration Agreement IT PF and CERIC	2,525,000.00	-2,525,000.00	-	-	n.a.
INTEGRA	-	1,489,534.92	1,489,534.92	399,170.15	22.77
Management project system	125,000.00	-125,000.00	-	-	0.00
Bodies Remuneration	349,000.00	7,000	356,000.00	355,209.78	99.78
Remuneration for Employees	525,500.00	38,000.00	563,500.00	510,433.20	90.58
Communication	36,000.00	-	36,000.00	4,370.17	12.14
Travel Expenses	140,000.00	-	140,000.00	20,223.65	14.45
External Services, Consultants, Consumables	382,500.00	-17,000.00	365,500.00	249,115.59	68.16
Access costs (users)	160,000.00	-	160,000.00	20,569.51	12.86
Fixed Assets	35,000.00	-	35,000.00	20,435.64	58.39
Taxes	50,000.00	-	50,000.00	36,411.80	72.82
Batteries, Fuel Cells and Remotisation	1,450,000.00	-	1,450,000.00	86,168.20	5.94
PhD Programme	960,000.00	-	960,000.00	275,000.00	28.65
PaGES6	10,000.00	-9,000.00	1,000.00	56.73	5.67
Commercial Activity	45,000.00	-	45,000.00	44,216.40	98.26
ACCELERATE (EU)	140,000.00	116,000.00	256,000.00	255,004.98	99.61
CEI Hercules School	-	2,000.00	2,000.00	1,743.77	87,19
ERIC Forum (EU)	38,000.00	8,000.00	46,000.00	44,017.24	95.69
PaNOSC (EU)	390,000.00	-30,000.00	360,000.00	359,424.08	99.84
SUBTOTAL	**7,590,000.00**	**-2.525.000,00**	**5,065,000.00**	**2,480,571.04**	**48.97**
INTEGRA (resourced from 2020)	-	1,489,534.92	1,489,534.92	339,170.15	22.77
Additional resources: carry over from previous years	-	1,089,097.72	1,089,097.72	-	99.84
TOTAL	**7,590,000.00**	**53,632.64**	**7.643,632.64**	**2,819,741.19**	**36.89**

Revenues

Description	Initial Budget	Implemented Changes	Final Budget	Accrued Revenues	%
Carry over from previous years	-	236,821.76	236,821.76	236,821.76	100.00
Commercial activities	50,000.00	2,173.91	52,173.91	52,173.91	100.00
FOE 2021	5,530,000.00	-	5,530,000.00	5,530,000.00	100.00
Carry over for 2022	-	-1,626,054.39	-1,626,054.39	-1,626,054.39	100.00
Funds transferred to the Italian RE	-	-2.574.607,27	-2.574.607,27	-2.574.607,27	100.00
PaNOSC project	487,500.00	-	487,500.00	463,131.89	95.00
ACCELERATE project	175,000.00	-	175,000.00	274,493.10	156.85
ERIC Forum project	47,500.00	-	47,500.00	58,546.55	123.26
Carry over INTEGRA spent	-	175,877.34	175,877.34	175,877.34	100.00
Other incomes	-	3,790.57	3,790.57	3,790.57	100.00
SUBTOTAL	**6,290,000.00**	**-3,781,998.08**	**2,508,001.92**	**2,594,173.46**	**100.96**
Carry over from previous years	1.300.000,00	1.089.097,72	2.389.097.72	-	-
Carry over committed to INTEGRA	-	1,489,534.92	1,489,534.92	-	-
TOTAL	**7,590,000.00**	**-1,203,365.44**	**6,386,634.56**	**-**	**-**

SUMMARY TABLE	
Description	**Amount**
TOTAL REVENUES 2021	2.594.173,46
TOTAL Expenses (contracts signed, incurred costs and investments)	2,819,741.19
Difference resulting from the budget 2021	225,567.73

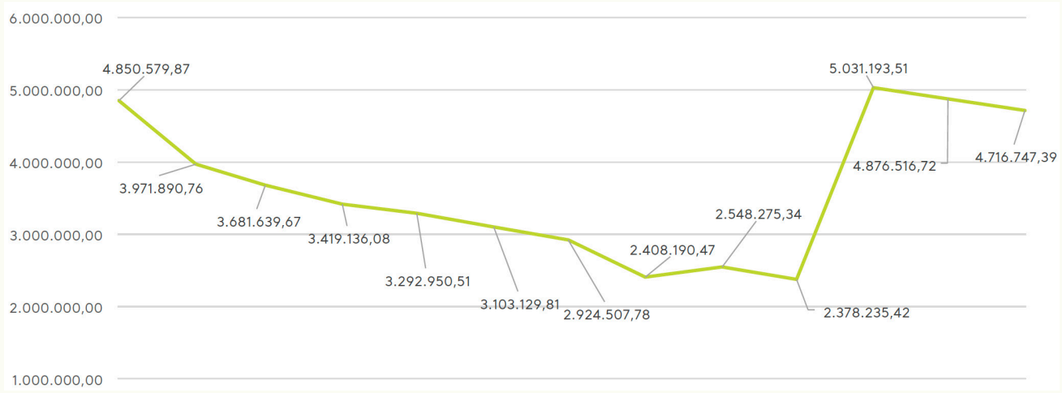
The exceeding amount of € 225,567.73.is widely covered by the amount of the balance sheet item "Deferred income" not committed to specific activities. This item measures the portion of the annual contribution funded by the Italian MIUR for the activities of the CERIC statutory seat deferred to the following years.

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	2021	2020
Cash flows from operating activities		
Receipts		
CERIC externally funded projects	487,877.78.	791,652.67
Commercial activities	40,000.00	66,800.00
Contribution from the host country	3,005,000.00	2,804,535.00
Interest received	357.06	305.77
Other receipts	9,544.19	18,169.19
Payments		
Payments to staff	-746,877.49	-1,286,798.85
Suppliers	-1,933,862.36	-1,182,280.71
Payments to project partners	-383,576.49	-134,057.95
Net Cash from Operating Activities	**478,462.69**	**1,078,325.12**
Cash flows from investment activities		
Purchase of plant and equipment	-773,165.21	-352,440.66
Sale of plant and equipment	-	-
Other	-	-
Net Cash Flow from Investment Activities	**-773,165.21**	**-352,440.66**
Cash flows from financing activities		
Proceeds from borrowings	-	-
Repayment of borrowings	-	-
Other	-	-
Net Cash Flow from Financing Activities	-	-
NET INCREASE/(DECREASE) IN CASH	**-294,702.52**	**725,884.46**
CASH, BEGINNING OF THE YEAR	**5,823,139.02**	**5,097,254.56**
CASH, END OF THE YEAR	**5,528,436,50**	**5,823,139.02**

Net Financial Position - Trend for the period Jan-Dec 2021



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 credits
- - short-term 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 2021 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 2021.

Value of the PFs and in-kind contribution. Consolidated data (2021)

Total costs of the ordinary scientific/technical activities of the Partner Facilities in 2021 - COMMITTED IN-KIND									
	Recurrent costs								
PF	**Personnel costs**	**Travel & accom-moda-tion and similar**	**Consuma-bles**	**Services**	**Utilities**	**Overheads**	**Technical devaluation & maintenance, lease/rent costs of equipment & spaces**	**Cost of access committed to CERIC**	**Total**
AT	400,289.64	647.64	32,776.45	-	-	-	-	-	**433,713.73**
HR	-	-	-	-	-	-	-	27,514.21	**27,514.21**
CZ	264,725.00	3,921.00	253,883.00	78,431.00		150,240.00	-	6,821.35	**758,020.35**
HU	-	-	-	-	-	-	-	149,003.26	**149,003.26**
IT	330,521.65	813.97	72,277.89	32,790.86	-	-	-	2,649,322.52	**3,085,726.89**
PL	-	-	-	-	-	-	-	112,756.20	**112,756.20**
RO	-	-	-	-	-	-	-	76,383.52	**76,383.52**
SRB	-	-	-	-	-	-	-	-	**-**
SI	-	-	-	-	-	-	-	525,696.56	**525,696.56**
Tot.	**995,535.29**	**5,382.61**	**358,937.34**	**111,221.86**	**-**	**150,240.00**	**-**	**3,547,497.62**	**5,168,814.72**

5

CERIC Overview

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 50 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

Polish Ministry of Science and Higher Education

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.

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

X-ray and Light scattering at the TU Graz and Elettra
Graz and Trieste
www.tugraz.at

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

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

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

Synchrotron and laser light at Elettra
Trieste
www.elettra.eu

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

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

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

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