

Infraestrutura
Nacional de
Computação
Distribuída

CNCA

Centro Nacional
de Computação Avançada

2024 Activities Report

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EXECUTIVE SUMMARY

In 2024, INCD continued to support a wide range of scientific users from multiple research domains fulfilling its mission of supporting advanced computing for research and innovation at national and international level. Since 2022, the infrastructure has been operating as a formal member of the National Advanced Computing Network (RNCA) of the Portuguese Foundation for Science and Technology (FCT). In this regard, in 2024, INCD supported computational projects from the third and fourth editions of the calls for advanced computing projects (CPCA) organised by FCT, by providing processing time, data storage and user support for high performance computing and cloud computing applications. In addition, INCD also supported a range of other projects, communities and services of national and international relevance.

In June, a new computational infrastructure was added: the Deucalion supercomputer. During 2024 Deucalion delivered more than 1,266,567 node hours of computing, which correspond to 125,073,616 processing hours of CPU and additionally 130,104 processing hours of GPU. In this period 264 users were added to the system and 91 projects started in scientific areas such as: Computer Science and Informatics (29), Condensed Matter Physics (9), Fundamental Constituents of Matter (9),Products and Processes Engineering (8), Universe Sciences (8), Molecular and Structural Biology and Biochemistry (5), Genetics, Genomics, Bioinformatics and Systems Biology (4), Diagnostic Tools, Therapies and Public Health (3), Mathematics (3),Physical and Analytical Chemical Sciences (3), Individuals, Institutions and Markets (2), Synthetic Chemistry and Materials (2), Applied life Sciences and Non-Medical Biotechnology (1), Earth System Science (1), Environment, Space and Population (1), Evolutionary, Population and Environmental Biology (1), Immunity and Infection (1), Systems and Communication Engineering (1)

Overall, in 2024, INCD delivered more than 55,746,000 processing hours to the research community supporting 147 projects that produced 120 articles. In addition, the capacity delivered by the infrastructure enabled the support to 76 PhD students and 100 MSc students including both ongoing and finished thesis.

The collaboration in international distributed computing infrastructures continued with participation at international level in EGI, IBERGRID and supporting the Portuguese participation in the CERN LHC experiments through the participation in the Worldwide LHC Computing Grid (WLCG). In the context of these international federated computing infrastructures, INCD delivered 33,328,000 processing hours supporting both cloud computing and high throughput computing applications.

Regarding European projects, the project iMagine continued in 2024, with the INCD participation focused on the provisioning of cloud capacity for image processing in marine and freshwater science. A joint project with Google for the redistribution of cloud capacity continued in the framework of European open Science Cloud (EOSC). Also in the framework of EOSC a new European project was successfully submitted and approved to start in 2025 focused on climate. The activities related to agriculture data were reinforced with the approval of a new FCT project to develop a demonstrator.

Finally, in December of 2024 under the recovery and resiliency plan (PRR) measure RE-C05-i08 "*Ciência Mais Digital*", the INCD legal name and statutes were changed to assume the mission of National Advanced Computing Centre (CNCA). With this major change the organization has now the mission of managing and operationalizing advanced computing infrastructures, supporting scientific research activities, technological development, transfer and valorization of knowledge, qualification of human resources and provision of services, including specialized consultancy, in the scientific-technological areas recognized as constituents of advanced computing, as well as research data. CNCA will encompass the resources from INCD and from Deucalion complemented by 5% of the capacity of Mare Nostrum 5 at BSC. Under this new scope the reinforcement of the technical staff has started.

1. FEEDBACK FROM THE INTERNATIONAL ADVISORY COMMITTEE

The INCD Board of Directors handed over to the members of the AC the Activities Report of 2024 on September 12th 2025, in preparation for the annual meeting on October 22nd. The committee would like to thank the INCD management for the excellent preparation of the report and presentation. Being informed about the activities of the last year, the focus of the meeting was to provide feedback and advice on the future plans and evolution of the infrastructure.

In 2024, INCD focused on several strategic initiatives to strengthen its infrastructure, services, and organizational capacity. Key efforts included maintaining and upgrading its infrastructure in Vila Real and Lisbon, restructuring the internal organization at both managerial and technical levels, and initiating recruitment to reinforce teams. INCD expanded its service offerings, particularly in open science and research data, in partnership with FCT and LIP. INCD actively participated in national and international collaborations such as RNCA, IBERGRID, EGI, and EuroHPC AI Fabric at BSC. It also contributed to European projects like CLIMATE-ADAPT4EOSC and iMagine, and supported various national initiatives including the FCT catchall data repository, EuroCC 2, and agriculture data partnerships.

Efforts were made to establish a Centre for Research Data Management with LIP and ICS, enhance geospatial and Kubernetes-based services, and distribute Google Cloud Platform services. CNCA also emphasized outreach by engaging new user communities, organizing events, and improving its internal accounting and reporting systems. Looking ahead, it is preparing for EuroCC 3 and exploring further opportunities to enhance its infrastructure and services.

A key strategic development took place by December 2024, when INCD legal name and statutes were changed to assume the mission of National Advanced Computing Centre (CNCA). Its new mission includes managing advanced computing infrastructures, supporting scientific research and technology development, promoting knowledge transfer, training human resources, and providing specialized consultancy in advanced computing and research data, in a much broader context.

The new CNCA is therefore on the way to crystallizing in a multi-tiered infrastructure ranging from medium size linux clusters up to large scale HPC systems. More interesting than the infrastructure size by itself, is the fact that the service provision models are covering a large spectrum of needs, from grid computing, to cloud services, and classical batch jobs. This has been a distinctive feature of INCD / CNCA that the new organizational vision should strive to maintain.

The Advisory Board has reflected on this new challenges and wishes to propose the following recommendations:

- *Keep CNCA user-centric* - with CNCA in place the organization is expected to grow in constituency and membership, which reveals on the one hand the success of the infrastructure, but also poses the obvious challenges related to growing. A new governance model is to be put in place, which has many more actors than INCD had. In this respect we would like to recommend that a clear feedback loop from users (the user forum) to decision-makers (directors, technical coordinators of the different areas) is established as early as possible.

- *R&D applied to business innovation* - Interestingly, CNCA has applied to develop new infrastructure in Northern Portugal to support Supercomputing and Artificial Intelligence, aimed at providing advanced computing capabilities to start-ups and tech companies, with a focus on business innovation. The Board encourages CNCA staff to step out of their traditional area of expertise (namely, scientific usage)and engage more directly with the needs of the industrial ecosystem, which operates with its own expectations and priorities. For industry, the ability to access resources on-demand, in a flexible and customizable manner, is often more critical than the ability to use large volumes of resources over extended periods, as is typical in scientific contexts.

- *Consolidation of a Portuguese based Technological Infrastructure* - *The Board commends CNCA for the plans of the new data center, located in Guimaraes, and encourages reporting about the progress of its construction in the years to come.* Construction will be funded as well using PRR funds. We consider this data center a fundamental asset for CNCA, and overall for Portugal as a country to have a stable infrastructure to provide first-line, autonomous, and strategic support to key initiatives in the country.

- *Supporting the public sector* - A range of ongoing initiatives highlight successful collaboration with the Direção-Geral do Território (DGT) and the European Partnership for Agriculture of Data. The Board encourages CNCA to actively participate in similar efforts to help shape long-term strategies for public digital infrastructure. Without such engagement, there is a risk that initiatives will either fail or result in fragmented solutions that lack

integration. The Board recommends CNCA to continue to play a pivotal role to ensure, with its expertise and experience, that these efforts succeed and deliver lasting values.

- *Define and implement a sustainability plan for personnel* - We appreciate that excellent progress was made in increasing the personnel in 2025 to support the new CNCA mission and activities. Given also the difficulty in finding skilled human resources for these tasks and/or training them, we believe it is essential that continued support for the new hires is planned, possibly in the form of a coordinated, multi-year sustainability plan.

- *Support technological innovation areas for novel hardware and software domains* - We believe that providing innovative resources like ARM-based clusters, as it was done with a Deucalion partition, is an excellent idea. This is even more true considering that these architectures can operate at relatively low power consumption levels, thereby decreasing the OpEx costs, compared to traditional, more power-hungry architectures. However, we note that so far the adoption rate of these architectures has been slower than expected. We recommend sustaining these or similar initiatives with proper communication, training and support programs for end users. This will make it possible to smooth the transition of their codes to the new environments and promote their adoption, thereby effectively utilizing them and reaping their benefits to the maximum possible extent.

- *Continue and expand the liaison with international activities* - The connections between Portuguese and international computing initiatives, especially now that CNCA has been created, is very important and should be emphasized and increased. For instance, we noted with great interest the planned connection with European AI Factories. CNCA has the potential to be much more than the sum of its constituents, and give Portugal a strong role at the European level for what regards both technology and policies. We therefore recommend to continue supporting and expanding the connections and cooperation with initiatives similar to CNCA in Europe, as well as with funding programs, such as those promoted by EuroHPC and Horizon Europe.

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2. INTRODUCTION

Infraestrutura Nacional de Computação Distribuída (INCD) was established in 2015 as private non-profit association to develop and operate the INCD digital research infrastructure in the framework of the Portuguese Science and Technology Foundation (FCT)[1] Roadmap of Research Infrastructures of Strategic Interest. Since then, INCD has been providing state-of-the-art advanced computing and data-oriented services to the Portuguese research and academic community.

INCD has been supporting research across all scientific and technological domains. Internationalisation has been a key aspect of the INCD activities both through the participation in European projects, and by linking with international digital infrastructures and initiatives such as EGI[2], IBERGRID[3], WLCG[4] and EOSC[5],EUROHPC.

Since 2022, the infrastructure has been operating in the framework of the National Advanced Computing Network (RNCA)[6], a Portuguese collaborative network that joins computing centres and expertise in high performance computing, high throughput computing and cloud computing for research and innovation. RNCA is coordinated by FCT that manages the access to the computing resources through the national calls for advanced computing projects (CPCA)[7]. INCD has been a provider of High Performance Computing (HPC) and cloud computing resources in these calls.

In 2024, the INCD associates, following a request by FCT, decided to work towards the evolution of the association towards the future National Advanced Computing Centre, with a wider scope and structure of associates. This activity was performed under the recovery and resiliency plan (PRR) measure RE-C05-i08 "*Ciência Mais Digital*". A working group to propose the governance model and the required changes in the INCD bylaws was established. In this regard, the national commitment to advanced computing is understood comprehensively in its various models present and future, as an essential condition for the scientific and economic development of the country, providing the development of new academic and scientific activities and the promotion of training and encouragement of technology-based business activities.

With an already existing autonomous entity, in the form of the INCD Association, supported by FCT and integrated into the national science and technology infrastructure roadmap, dedicated to the operation and development of distributed computing infrastructures, it was decided to promote the expansion of the INCD's scope of action by changing its name and statutes, in order to assume the mission of the National Advanced Computing Centre.

The change of name and statutes of the INCD association took place on 13th December 2024. INCD henceforth named CNCA - National Advanced Computing Centre, has now

[1] https://www.fct.pt/en/
[2] https://www.egi.eu/
[3] https://www.ibergrid.eu/
[4] https://wlcg.web.cern.ch/
[5] https://open-science-cloud.ec.europa.eu/
[6] https://rnca.fccn.pt/en/
[7] https://rnca.fccn.pt/en/projetos/

the mission of managing and operationalizing advanced computing infrastructures, supporting scientific research activities, technological development, transfer and valorization of knowledge, qualification of human resources and provision of services, including specialized consultancy, in the scientific-technological areas recognized as constituents of advanced computing, as well as research data.

During 2024, the infrastructure operated under the INCD branding and structure. This report concerns these activities as INCD. Nevertheless the activities and changes concerning the evolution towards CNCA are of strategic importance for the future of the infrastructure and thus are also highlighted in the document.

3. ORGANISATIONAL STRUCTURE AND MISSION

The INCD organisational structure in place until December 2024 is depicted in Figure 1. With the evolution from INCD to CNCA, this organisational structure will be revised. The main bodies are legally required and will remain largely the same. The general assembly represents the member organisations. During 2024 the member organisations were: *Laboratório Nacional de Engenharia Civil* (LNEC)[8], *Laboratório de Instrumentação e Física Experimental de Partículas* (LIP)[9] and *Fundação para a Ciência e a Tecnologia* (FCT). The new statutes approved in December 2024 foresee the enlargement of the member organisations in a process that will start in 2025. The directorate is responsible for the management of the association and is composed of three to five directors appointed by the general assembly. In 2024, the directorate had three directors nominated by each member organisation. The audit committee oversees the financial reporting, related internal controls and compliance. The advisory board provides strategic advice, critical thinking and analysis of the activities and plans. Security is transversal and is represented as an intermediate element of the organisational structure by the security officer. A users forum complements the new structure. The technical coordinator managed the daily technical activities including the development and operation of the infrastructure. Under CNCA the new structure will include different technical coordinators for specific areas to be defined.

[8] https://www.lnec.pt/en/
[9] https://www.lip.pt/?lang=en

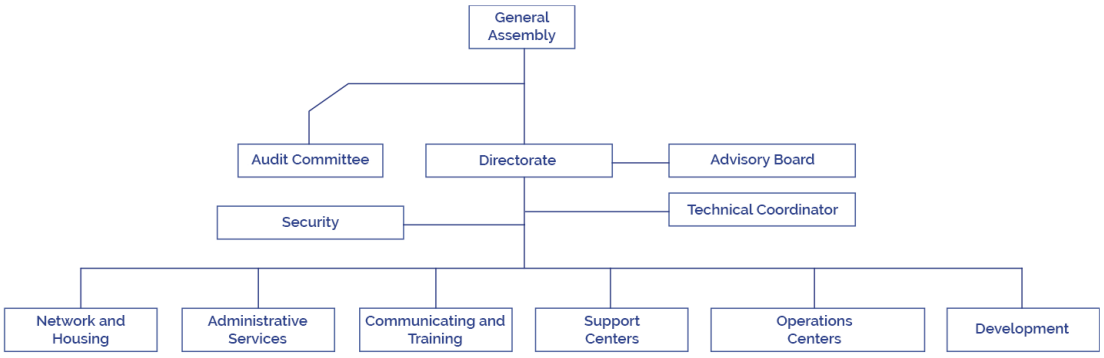

Figure 1: organisational structure of INCD until December 2024.

Under the new statutes, the association has a wider mission of managing and operationalizing advanced computing infrastructures, supporting scientific research activities, technological development, transfer and valorization of knowledge, qualification of human resources and provision of services, including specialized consultancy, in the scientific-technological areas recognized as constituents of advanced computing, as well as research data. This new mission and organisational structure began to be prepared in 2024 and will be implemented in 2025.

4. HUMAN RESOURCES

The human resources have been constituted by a mixed team of staff from the member organisations (LIP, LNEC and FCT-FCCN[10]), from INESCTEC and UMinho, complemented by staff contracted directly by the association.

In 2024, the INCD infrastructure was backed by a technical team that included twelve LIP researchers, engineers, technicians and communications personnel, complemented by one engineer, one auxiliary researcher and one administration assistant hired by the association. The auxiliary researcher hired by the association was contracted in the framework of a PhD position funded by FCT under the programme for Institutional Scientific Employment Stimulus[11]. This team was further complemented with contributions from staff of FCT-FCCN and LNEC.

In 2024, the coordination of the technical activities and related personnel was performed by a technical coordinator from LIP, which is also the coordinator of the LIP computing group that provided most of the operations and development effort. In 2024, the association submitted a set of applications together with its member organisations and partnering with universities, to contract researchers under the FCT tenure programme[12]. This effort aims at reinforcing the human resources for research

[10] https://www.fccn.pt/en
[11] https://www.fct.pt/en/financiamento/programas-de-financiamento/emprego-cientifico/emprego-cientifico-institucional/
[12] https://www.fct.pt/en/concursos/fct-tenure-1-edicao

and innovation as well as strengthening the collaboration with universities. Two applications were successful and the corresponding hiring tenders are ongoing.

As part of the process of becoming the National Advanced Computing Centre, a protocol was established with FCT to enable the hiring of additional technical personnel to support the management and usage of the infrastructure services. These positions are being filled-in with a particular focus on the EuroHPC resources Deucalion[13] and MareNostrum 5[14] co-funded by FCT. These human resources will complement the INESC-TEC[15] team in CNCA, which will continue being responsible for Deucalion. In addition, a proposal with BSC and FCT for an AI Factory was submitted and finally approved already in 2025, the project includes human resources to be hired by CNCA to support those activities, whose hiring process will start in 2025.

5. THE INFRASTRUCTURE SERVICES AND ARCHITECTURE

The infrastructure comprises operational centres across the country in different regions. These centres host the hardware from which the services are delivered. They also provide redundancy, enable exploitation of existing resources and promote partnerships with research and education organisations at the several locations.

The housing in datacenters and the network connectivity provide the foundation layers upon which the architecture of the infrastructure is built. The hosting of the operational centres and the delivery of the network connectivity is performed in close collaboration with the Portuguese National Research and Education Network (RCTS)[16] managed by FCT-FCCN. In particular leveraging the RCTS housing[17] service and RCTS Plus[18] private network services.

Figure 2 provides an overview of the architecture. The primary services delivered by the infrastructure encompass high performance computing (HPC), high throughput computing (HTC) and cloud computing complemented by data oriented services. The primary services sit immediately above the housing and network layers. Each of these primary services can be used either directly by the end-users or indirectly through other higher level services meant to provide additional capabilities.

[13] https://rnca.fccn.pt/deucalion/
[14] https://www.bsc.es/marenostrum/marenostrum-5
[15] https://www.inesctec.pt/en
[16] https://www.fccn.pt/a-fccn/rede-rcts-rede-ciencia-tecnologia-e-sociedade/
[17] https://www.fccn.pt/en/areas-tecnologicas/computacao/rcts-housing/
[18] https://www.fccn.pt/en/areas-tecnologicas/conectividade/rcts-plus/

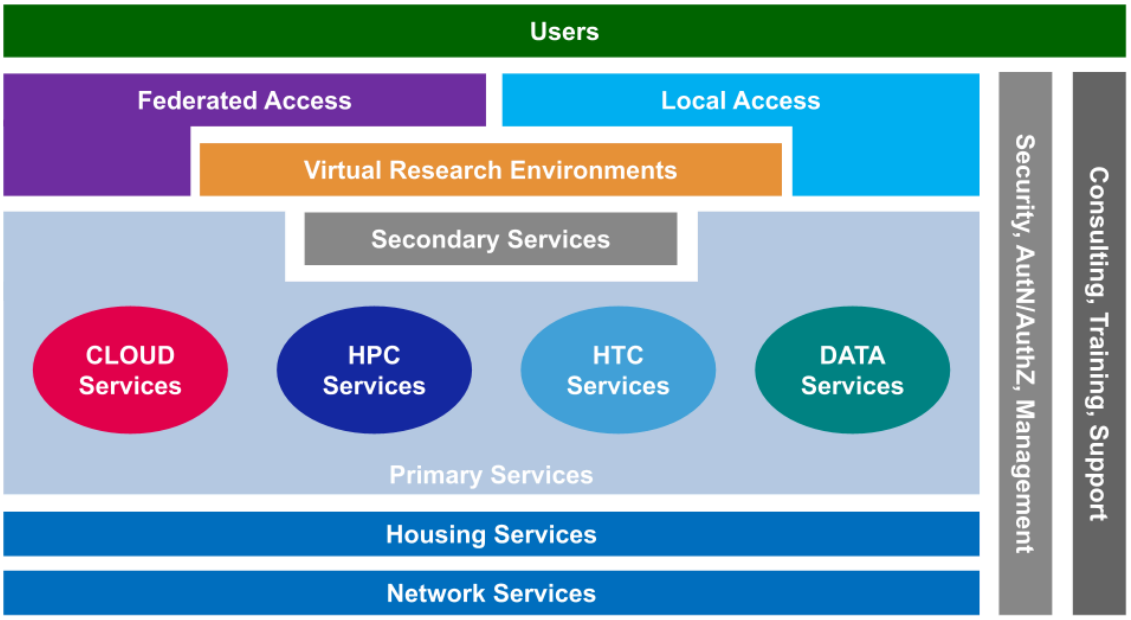

Figure 2: high level view of the architecture.

The hierarchy of services also includes federated access to the computing and data resources, integration in international computing infrastructures, added-value services for computing and data processing, and virtual research environments for specific disciplines or communities.

Thanks to this architecture, the users can choose which services and which layers of access are the most suitable for them. The transversal activities such as security, training, interoperability, support, collaboration, innovation and development are common to all layers. These transversal activities are designed to assist the users in selecting, co-developing and exploiting the infrastructure capabilities.

6. OPERATIONAL CENTRES

The centre in Lisbon (centre-A) was established in the context of the former National Grid Initiative in 2009 and is housed at the Sala-Grid datacenter in the campus of the National Civil Engineering Laboratory (LNEC) in Lisbon. The datacenter was built in 2009 in a partnership that joined FCCN, LNEC and LIP with funding from FCT. The datacenter is managed by FCT-FCCN, while the computing equipment and services are managed mainly by LIP technical staff. This centre is complemented by tape based storage for data protection housed at the LIP datacenter in Lisbon (centre-L).

The centre in the north (centre-D) was established in the North region in cooperation with the University of Trás-os-montes e Alto Douro (UTAD) in Vila Real and became operational in 2023. The centre is managed by staff from LIP with the support of personnel from the association, while the hosting is supervised by FCT-FCCN.

The centre in Coimbra (centre-C) is managed by LIP and was established in the context of the former National Grid Initiative, and is located at the Physics department of the University of Coimbra. This centre provides tape based storage for data protection.

Since 2023, the infrastructure has been exploiting and using additional capacity provided by the Google cloud via an EOSC grant established under the OCRE agreements. Although these resources do not constitute a centre they complement the capacity and capabilities of the cloud computing services in Lisbon and Vila Real.

Most of the services in these centres are federated in the IBERGRID and EGI pan-European computing infrastructures, and via these federations are also usable in other international initiatives such as EOSC. The IBERGRID and EGI federations enable sharing of computing resources across Europe to support research and innovation projects and a diversity of user communities including ESFRIs.

With the evolution of INCD to CNCA, the list of centres has been expanded to include Deucalion, the EuroHPC machine deployed in the north region. Deucalion is hosted at a datacentre specifically set up for this machine at the University of Minho in Guimarães. A partition of 5% of the MareNostrum 5 machine at BSC, which has been co-funded by FCT, will be also included in the CNCA resources. In addition a joint proposal with BSC for an AI Factory was submitted and finally approved already in 2025 reinforcing the share of national resources at BSC.

The construction of a new FCT datacentre is also expected in the north of the country in Guimarães. This new facility will also provide hosting for future CNCA services and is expected to provide additional capacity and redundancy, and enable a better consolidation of the infrastructure services.

7. INFRASTRUCTURE UPGRADES

The cloud computing services including both the Ceph storage and the Openstack IaaS were completely redeployed with upgraded versions of the cloud and data storage frameworks. The Openstack network infrastructure was migrated from OVS[19] to OVN[20]. New object storage services based on MinIO were deployed in Lisbon and Vila Real exploiting existing hardware capacity. These services are meant to support end-user services and to provide fast data backup capabilities.

The development of a newly improved Kubernetes service on bare metal for end-users supporting multi-tenancy continued. A pilot is available and the production service is expected to become available in 2025.

The transition from CentOS to AlmaLinux and in certain cases Ubuntu or Rocky Linux continued inline with the CentOS 7 end-of-life which happened in June of 2024. New equipment and upgrades are now targeting AlmaLinux 9 for the HTC and AlmaLinux 8 for HPC. The migration of HPC to AlmaLinux 9 has also started. For Lustre the target

[19] https://docs.openstack.org/neutron/latest/admin/deploy-ovs-selfservice.html
[20] https://docs.openstack.org/charm-guide/latest/admin/networking/ovn/index.html

became AlmaLinux 8 for storage servers and AlmaLinux 9 or 8 for clients such as the HTC and HPC computing nodes. Correspondingly a large effort continued in creating and optimising the HPC and HTC software environments for AlmaLinux. The Openstack, Ceph, Kubernetes and MinIO based services were reinstalled with Ubuntu LTS 22.04 or 24.04.

8. INFRASTRUCTURE NETWORK

The interconnection between the several centres of the infrastructure is implemented via a private wide area network built on top of the advanced network services provided by FCT-FCCN. The network topology used in 2024 is depicted in Figure 3.

The centres are interconnected via an Ethernet Layer 2 network, which is built upon the RCTS Plus service provided by FCT-FCCN and is connected to the backbone of the national academic network RCTS also operated by FCT-FCCN. All centres have 10 Gbps links with the exception of the centre in Lisbon at the LNEC campus, which is connected both at 100 Gbps for production and 10 Gbps for backup.

A second connection of 100 Gbps in Lisbon for the Large Hadron Collider Open Network Environment (LHCONE) became operational in 2024. The LHCONE is a private network that provides optimised connectivity for computing centres in the Worldwide LHC Computing Grid (WLCG) such as the Portuguese WLCG Tier-2 operated in partnership with LIP. Later in the year, the LHCONE coordination requested the implementation of a new route prefix capability aimed at facilitating traffic filtering from different international research projects. This capability was implemented in coordination with LHCONE and FCT-FCCN.

The IPv6 connectivity was previously restricted to Internet facing services. In 2024, it was extended to the compute nodes in the High Throughput Computing partitions of the computing cluster in Lisbon. This enables IPv6 direct connectivity between tasks running in this computing service and outside services, particularly remote storage systems. This connectivity is becoming particularly important for distributed computing.

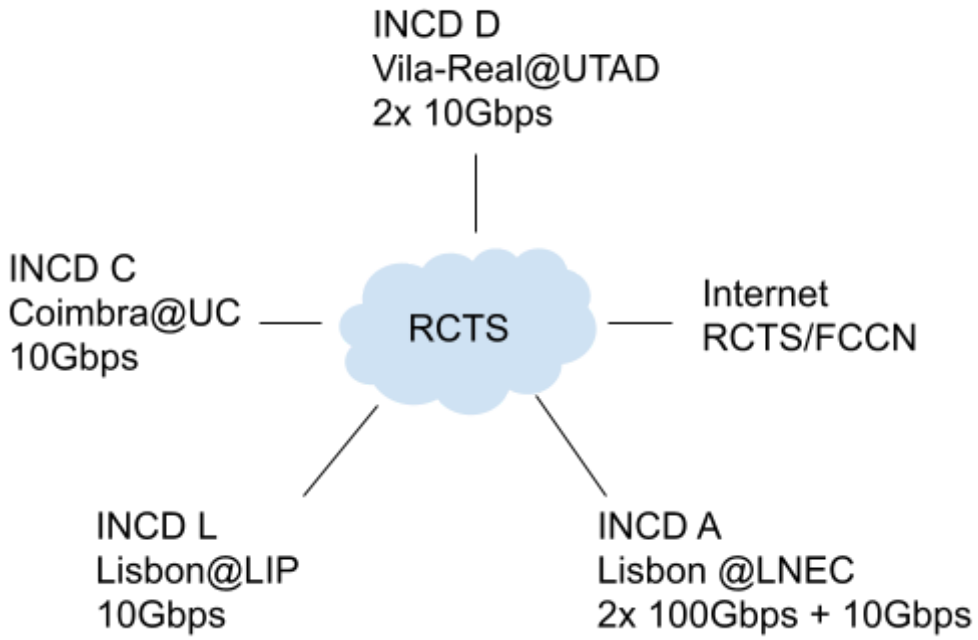

Figure 3: network connectivity in 2024.

9. INFRASTRUCTURE SERVICES CATALOGUE

The catalogue of the services provided in 2024 is summarised in Table 1. The catalogue contains three areas (Computing, Data and Knowledge). Each area is subdivided into a set of primary services. The primary services are the generic building blocks that constitute the core of the infrastructure. The primary services can be used directly or via the secondary services. To this end, each primary service is further subdivided into a set of secondary services. The secondary services include specific services that are largely built upon the primary services but which provide specific capabilities that must be handled separately or whose relevance needs to be highlighted.

Areas	Primary services	Secondary services
Computing	High Performance Computing	Large memory servers Accelerated computing Federated cloud computing Federated HTC/HPC Containerised computing Scientific portals and gateways Value-added services
	High Throughput Computing	
	Cloud Computing	
Data	Cloud Storage	Data repositories Long term storage Data protection Distributed RO filesystem Federated file storage
	File Storage	
	Tape Storage	
Knowledge	Software development	Integration of software & services Software quality assurance Physical resources Virtual resources Training and consultancy Online documentation
	Managed services	
	Support and Documentation	

Table 1: services catalogue

9.1. PRIMARY COMPUTING SERVICES

The primary services encompass the main computing services namely High Performance Computing, High Throughput Computing and Cloud Computing. These services are further described in the following subsections.

Cloud Computing

The cloud computing service (named *Stratus*) is an infrastructure-as-a-service (IaaS) cloud that enables access to virtual machines on-demand. The cloud service is built-on the Openstack cloud management framework, while the virtualisation uses the Kernel-based Virtual Machine (KVM)[21] hypervisor. The cloud computing service is complemented by the cloud storage service that provides block and object storage to the Openstack cloud. In 2024, the cloud computing service was provided by the *Stratus-A* and *Stratus-D* services hosted at the operational centres in Lisbon and Vila Real. In 2024 the service delivered 22,738,000 vCPU hours of processing time. The Openstack installation at the Vila Real operational centre became operational in 2024. This new installation will improve the resilience and capacity of the cloud computing

[21] https://linux-kvm.org/

service. The cloud computing service was also complemented with capacity delivered by the Google cloud via a grant established under the OCRE agreements.

High Throughput Computing

This service is optimised for the execution of large numbers of individual tasks either single threaded or multi-threaded, targeting massively computational and data intensive applications. Differently from the HPC workloads where the running processes need to communicate with low latency, the HTC computing processes are individual tasks that can be executed separately. For higher efficiency, the HTC and HPC services share the same Slurm batch systems. In 2024 the HTC service delivered 15,164,607 hours of processing time, mainly supported by partitions of the *Cirrus-A*[22] cluster in Lisbon. The service is composed of heterogeneous nodes both Intel Xeon and AMD Epyc interconnected via a high performance Ethernet network. The service relies on a file storage service optimised for high-throughput workloads based on the Lustre[23] parallel distributed file-system.

High Performance Computing

This service is optimised for the execution of parallel computing workloads that require inter-process communication across computing nodes with low latency. This service is particularly suitable for MPI applications. In 2024, the service delivered 17,843,225 hours of processing time, backed by the *Cirrus-A* cluster in Lisbon and *Cirrus-D* cluster in Vila Real. These clusters feature computing nodes equipped with AMD Epyc processors and have become operational in 2022 and 2023 respectively. The clusters are equipped with Infiniband networks. The file storage service is also based on Lustre, which in this case has been optimised for parallel workloads.

9.2. PRIMARY DATA SERVICES

The primary data services encompass the main data storage services namely Cloud Storage, File Storage and Tape Storage, upon which other secondary data services are provided.

Cloud Storage

This service provides access to object and block storage. The service is oriented to provide robust scalable storage for cloud applications. The storage service is closely related to the cloud computing service and is based on the Ceph[24] and MinIO[25] data

[22] cirrus.a.incd.pt
[23] https://www.lustre.org/
[24] https://ceph.com
[25] https://www.min.io/

storage systems. The block storage service is based on Ceph and provides volumes for the cloud virtual machines, while the object storage services are based both on Ceph and MinIO and enable data to be stored as objects, therefore providing higher horizontal scalability than conventional data storage on file-systems. The object storage component of the service can also be used independently from the cloud computing service. Through its application programming interface (API), that includes support for S3[26] on Ceph and MinIO and SWIFT[27] on Ceph, the object storage can be easily and safely accessed remotely. In 2024, the cloud storage service was provided by the centres in Lisbon and Vila Real. Complementary storage was also provided in the Google cloud to support virtual machines and containers deployed in Google Cloud Engine and Google Kubernetes Engine.

File Storage

This service provides access to POSIX read-write file systems that are mainly based on Lustre. This service is used in conjunction with the HPC and HTC services. In special cases the service can also be provided using other technical solutions such as NFS. The file storage service can also be used independently from the HPC and HTC services via secondary services such as the federated storage. This service is meant to support applications that rely on conventional file systems and is especially suited for storage and processing of large files. The file storage service provides the data storage backend for the HPC and HTC services with different storage pools adapted to these computing requirements. In 2024, the file storage service was provided by the centres in Lisbon and Vila Real.

Tape Storage

Contrary to other services in the catalogue, the tape storage is an internal service not directly accessible to end-users. This service provides the backbone for data protection and also long-term storage, through the provisioning of reliable yet cost-effective storage capacity for infrequently accessed data. The service is based on LTO tape libraries at LIP in Lisbon and in Coimbra.

9.3. PRIMARY KNOWLEDGE SERVICES

The primary knowledge services category includes three areas namely the software development, the managed services and the support. These services leverage the experience and competences of the technical team to enable knowledge transfer and provide assistance to the users. These services are mainly meant to support the exploitation of the computing and data infrastructure but can also be used separately.

[26] https://docs.aws.amazon.com/AmazonS3/latest/API/Welcome.html
[27] https://wiki.openstack.org/wiki/Swift

Software Development

Performs development of software to expand the services offering includes development of new tools and services, or co-development of specific software solutions in partnership with user communities. The service includes both development of new services and software as well as porting of software to be used in the infrastructure. The service is often provided in the framework of projects in partnership with user communities, or as part of the support provided to new projects and user communities. In 2024, included in this service performed software developments and customisations for several of its services. A particularly intensive activity is the preparation of the software environments for computational projects, including the maintenance of applications and libraries compiled for different architectures and purposes. These software environments are then distributed across the centres using the CVMFS service.

Managed Services

This support service is oriented to the management of virtual or physical resources integrated in the infrastructure. The virtual resources can be virtual machines, containers or other types of resources that can be instantiated using the infrastructure services, and whose management can be fully or partially delegated to the technical team. The physical resources can include private hardware housed under agreed conditions. A key condition for the physical resources is that they are integrated and shared via the primary services (e.g. cloud, HPC, HTC or data storage services). This allows the users to become free of the burden of managing hardware resources, while simultaneously benefiting from the combined capacity of these resources together with the infrastructure capacity, capabilities, scalability and connectivity. Examples of this service in 2024 include the management of hardware integrated in the cloud for the GBIF national node, the management of VMs for many different projects and user communities and the management of the Portuguese Tier-2 in the Worldwide LHC Computing Grid, among others.

Support and Documentation

This service aims at supporting the usage of the services through documentation and user support. Most of the documentation is provided online and is continuously improved and enlarged based on the perceived user difficulties and feedback from the helpdesk. Direct support is provided through the helpdesk via email, complemented with remote conferencing. The implementation of a new trouble ticket system based on Zammad[28] was completed and replaced the current RT system. In 2024, the helpdesk received more than 1000 user support requests via the trouble ticketing system.

[28] https://zammad.com

9.4. SECONDARY SERVICES

The secondary services category includes a wide range of services that are built upon the primary computing, data and knowledge services complementing them with additional capabilities.

Large memory computing

This service is aimed at computational tasks with large memory requirements. The service takes advantage of the HPC, HTC and cloud services, and provides access to a set of compute nodes with larger RAM capacity that can be accessed through batch partitions associated with the HPC and HTC services or via the cloud service. The maximum RAM capacity is limited to 1TB. This service targets multithreaded shared memory applications with large memory requirements such as genome data processing and other *big data* applications.

Accelerated computing

This service provides access to compute nodes equipped with specialised hardware e.g. GPUs. The service is suitable for machine learning, artificial intelligence applications and other GPU enabled applications. The accelerated computing service is supported in Lisbon via the *Cirrus-A* cluster (HPC and HTC) and *Stratus-A* cloud. The range of supported GPUs includes NVIDIA L40S, A100, V100 and T4 for production and older NVIDIA GPUs mainly for development and educational purposes. Access to GPUs in the Google cloud was also provided to support computational projects.

Federated cloud computing

This service provides access to cloud computing resources federated in the EGI and IBERGRID infrastructures interconnecting cloud computing services and cloud data storage at international level. The cloud service itself is federated into the EGI and IBERGRID international infrastructures. Through the federated cloud service, users can access capacity from the Stratus-A and Stratus-D services in Lisbon and Vila Real, and can also access additional cloud capacity integrated in the EGI and IBERGRID federations in the framework of international collaborations. This service is mainly oriented at supporting international research activities that benefit from the access to shared computing resources at international level for added capacity and resiliency.

Federated HTC and HPC

This service provides access to the EGI, IBERGRID and WLCG distributed computing infrastructures, interconnecting computing clusters at international level. The main computing services HTC and HPC are federated in the EGI and IBERGRID international infrastructures. Through the federated computing service, users can access both the HPC and HTC services and access additional cloud capacity integrated in the EGI and IBERGRID federations in the framework of international collaborations. This service is mainly oriented at supporting research activities that benefit from the access to shared computing at international level.

Containerised computing

This service provides support for execution and orchestration of Linux containers for services and applications. The service enables portability, reproducibility and preservation of applications together with their computing environments. The service is meant to support execution of simple or complex containerised services and applications. This service relies on the HPC, HTC and cloud services enabling execution of Linux containers using different types of container execution runtimes. Some of the supported tools include udocker, Docker, Singularity/Apptainer and orchestrators like Docker Swarm and Kubernetes among others.

Scientific portals and gateways

This service supports the deployment, operation and access to scientific gateways and portals. These are community oriented services delivered on top of the cloud service and/or in combination with other data or compute services. Examples of such services include R-Studio, Jupyter notebooks, Galaxy portals and domain specific solutions for simulation and data analysis. These services are deployed on-demand for each community that requires them.

Value-added services

Provisioning of a wide range of generic services mainly delivered through the cloud primary service that target specific yet common requirements of the research and academic community both at the organisation and team level. Examples of such services include Sync & Share services, databases, agenda & meeting organisation, web servers, load balancers, proxies, among others. The range of services is flexible and is managed according to the demand.

Data repositories

Collaboration with FCT-FCCN and LIP continued towards the development and piloting of a catchall data repository tailored to the Portuguese research community. The data repositories service is oriented to support open science requirements concerning open access to research data by supporting digital data repositories for specific communities. The service is based on the Dataverse open source research data repository software. The effort was mainly focused on benchmarking and improving the performance and resiliency of the service. The piloting phase of the service performed in cooperation with selected user communities is ongoing.

In 2024 the participation in activities related to the European partnership of *Agriculture of Data* continued. Collaboration with several public entities is ongoing aiming at piloting different use cases exploiting data from multiple origins with a particular focus on satellite images from Copernicus Sentinel-1 and Sentinel-2. A new project funded by FCT was approved to start in 2025. This activity aims to establish the basis for a future data space dedicated to agriculture.

Long-term storage

This service is aimed at long-term data storage of infrequently accessed data. The service is mainly delivered using tape library based storage, but can also be provided via on-line data storage depending on the nature, size and data access patterns. This service is supported via the LIP managed datacenters in Lisbon and Coimbra.

Data protection

This service is aimed at data backups to protect against data loss and support data recovery. The service is delivered using tape library based storage. This service is supported via the LIP managed datacenters in Lisbon and Coimbra.

Distributed read-only filesystem

This service is meant to share immutable files across the infrastructure centres regardless of their geographic location. The service can be used to make software environments available across the infrastructure centres and services. The service is based on the CernVM-FS (CVMFS)[29], a scalable POSIX read-only file system. The service is mainly meant for sharing of software and smaller read only files in a reliable way enabling an homogeneous computing environment across the centres. The service features a stratum 0 and 1 in Lisbon and stratum 2 at the other centres.

[29] https://cernvm.cern.ch

Federated file storage

This service enables remote access to the File Storage service. It is based on several middleware services that provide high performance secure access to the Lustre file system. The middleware services include mainly StoRM-WebDAV and XRootD. The federated file storage service is integrated with the EGI, IBERGRID and WLCG international infrastructures.

Training and consultancy

This service complements the core support and documentation activities, by providing different types of training either generic such as onboarding and assistance to new users, or specific to address advanced usage topics and target specific communities. Consultancy and technology transfer are also part of these activities.

Integration of software and services

This is a support service aimed at facilitating the integration of generic, thematic or community specific software to take advantage of the infrastructure services. This is a human resources intensive service that is subjected to the availability of experts that work closely with the users providing guidance and accelerating the process of software co-development and integration. This service is oriented both to cloud services to be hosted in the infrastructure and to the integration of HTC and HPC applications. This service also includes the integration at the federation level in order to take advantage of international infrastructures and initiatives like EGI, IBERGRID and EOSC to provide higher capacity, scalability and enable sharing of software, data and computing resources. In 2024, this activity was developed mainly in the context of supporting CPCA projects and also in the context of European projects.

Software quality assurance

This service aims to support software development and the adoption of software quality best practices. The service builds upon the SQAaaS platform developed by IBERGRID in the EOSC-Synergy project to enable on-demand creation of CI/CD pipelines making quality verification and validation easily accessible to researchers and software developers. Besides the SQAaaS other services such as CI/CD and software source code repositories are also provided. A GitLab service for the infrastructure users is also available as part of the software development and quality assurance framework.

As part of this service, the EGI software repositories for the EGI Unified Middleware Distribution (UMD), Cloud Middleware Distribution (CMD) and IGTF trust anchors are hosted in Lisbon. Hence providing a key service for the international distributed computing community. These repositories are also a key component of the EGI quality

assurance process for the UMD and CMD distributions provided by Portugal and Spain in the context of IBERGRID.

10.INFRASTRUCTURE MANAGEMENT AND OPERATIONS

The infrastructure management and operations was split mainly across the centres in regions of Lisbon and Minho that worked closely in the development and management of the infrastructure, user support and in national and international projects.

Preparations for a new coordination structure under CNCA have started. Effort was placed in improving the separation of services and removing dependencies to increase the autonomy in terms of infrastructure operations and management. The separation between user facing services and internal infrastructure support services was improved. Services that were housed or operated as shared services with the associates were duplicated and separated. In particular, the upgrade of the helpdesk ticketing system was completed with the migration of all tickets from the old Request Tracker (RT) system at LIP to a new Zammad based system hosted at INCD/CNCA.

11.FEDERATION ACTIVITIES IN EGI, IBERGRID AND WLCG

The participation as a provider in the international digital infrastructures IBERGRID (ibergrid.eu) and EGI (egi.eu) continued as a key aspect of the strategy to support international projects and research communities. The three main computing services (cloud, HTC and HPC) are integrated in IBERGRID, and through the Iberian infrastructure they are also integrated in the wider federations, therefore enabling the sharing of compute and data resources to support international research. The high energy physics collaborations, such as the ATLAS and CMS experiments at the CERN Large Hadron Collider (LHC), are examples of research communities supported through this approach. Other examples include: the Portuguese node of the Global Biodiversity Information Facility (GBIF), thematic services developed by LNEC in the scope of EOSC such as OPENCoastS and Worsica, among others. In 2024, the infrastructure delivered more than 10,589,000 HTC/HPC federated computing hours and 6,815,000 federated cloud computing hours supporting research projects and communities in the scope of the IBERGRID and EGI federations.

The infrastructure provided the computing and data storage capacity for the Portuguese Tier-2 facility, supporting the national participation in the ATLAS and CMS experiments at the CERN LHC. The Tier-2 is operated under the MoU for the Collaboration in the Deployment and Exploitation of the Worldwide LHC Computing Grid (WLCG) signed between CERN and the Portuguese government. Under this MoU, Portugal contributes to its share of the LHC computing costs through the delivery of computing and data capacity to the CERN experiments, supporting both global simulation and data processing for the experiments, and data analysis by Portuguese researchers. The WLCG is the world's largest thematic distributed computing infrastructure. The WLCG sits on top of the computing and storage capacity delivered by the computing facilities such as the Portuguese Tier-2 that are federated in either

EGI (European Grid Infrastructure), OSG (Open Science Grid), or NeIC (Nordic e-Infrastructure Collaboration).

In 2024, the process to connect the Tier-2 to the LHCONE private network was finalised, and the IPv6 connectivity for internal WLCG virtual networks including computing nodes was set up. A complete restructuring of the data storage spaces for the Tier-2 and Tier-3 facilities also took place. The distributed computing middleware for the grid services was redeployed with new versions on AlmaLinux 9, particularly StoRM-WebDAV and XRootD for storage gateways and ARC-CE for job submissions. A small increase of capacity of the HTC service for grid computing took place using equipment donated by CERN. Several improvements at the level of the grid storage gateways were implemented aimed at stability and increased performance. Finally, the authentication and authorization for the grid services moved from X.509 to tokens.

In 2024, the WLCG Tier-2 consumed 169,392,970 HEPSCORE23 normalised hours fulfilling the yearly pledged capacity. However, the Tier-2 capacity is largely below the necessity and the participation in the upcoming High Luminosity LHC with its huge computing and data requirements will be unfeasible without major upgrades.

In partnership with LIP, the infrastructure is hosting the new EGI software repositories for the Unified Middleware Distribution (UMD), Cloud Middleware Distribution (CMD) and Certification Authorities for the International Grid Trust Federation (IGTF). These repositories support the distribution at global level of all middleware for the EGI federation and related digital infrastructures including the Worldwide LHC Computing Grid. This activity is conducted in the context of a tender for the EGI software management awarded to IBERGRID. The new repositories are part of a complete reorganisation of the EGI software management and quality assurance process, and are now in production.

Also in the scope of the IBERGRID collaboration, INCD together with LIP and CSIC organised the 13th edition of the IBERGRID conference[30]. The IBERGRID 2024 conference took place at the *Faculty of Medicine of the University of Porto* in October of 2024 and was focused on topics related with the development, integration, quality and adoption of services, applications and digital twins to support cutting-edge research.

12.EUROPEAN OPEN SCIENCE CLOUD and EUROPEAN PROJECTS

Bridging with the IBERGRID and EGI activities, the infrastructure participated in several activities related to the European Open Science Cloud (EOSC), both through participation in projects and by supporting thematic services in the framework of EOSC. Among others the infrastructure supported in EOSC the coastal modelling service OPENCoastS[31] and the water detection service WorSiCa[32]. These thematic services were

[30] https://www.ibergrid.eu/2023-ibergrid-benasque/
[31] https://opencoasts.ncg.ingrid.pt
[32] http://worsica.lnec.pt

developed by LNEC in collaboration with INCD and LIP and are housed in the cloud service. Cloud capacity is also provided for the Software Quality Assurance as a Service platform (SQAaaS)[33] that was developed in the EOSC-Synergy[34] project by LIP, IFCA/CSIC and UPV. This service exploits cloud resources at the Lisbon centre and at the Google cloud.

The participation in the iMagine project continued in 2024. The project provides a selection of image datasets, AI-empowered high-performance image analysis tools to enable processing and analysis in marine and freshwater science. A new European project named CLIMATE-ADAPT4EOSC was submitted in partnership with LNEC aimed at assist researchers in various disciplines to better address climate change in their research by providing an EOSC-centred collaborative research environment that is equipped with existing EOSC data and services and extended with new data and innovative services. The project was approved to start in 2025.

Also in the context of the EOSC activities, INCD continued to redistribute Google cloud capacity to support research activities under the OCRE agreements. The development of an architecture to enable movement of projects between the Google cloud and the INCD cloud service continued with a particular focus on Kubernetes applications.

13.RNCA AND ADVANCED COMPUTING ACTIVITIES

Within the scope of the national advanced computing network (RNCA), the infrastructure participated in the support to the FCT calls for advanced computing projects, through which FCT grants computing time for research projects. Namely, INCD participated in the fourth CPCA as an operations centre supporting computing projects in several scientific domains including HPC, cloud and accelerated computing. The collaboration extended to the preparation of the fifth CPCA call and also to the technical evaluation of projects whose actual execution is meant to start in 2025.

Under the RNCA protocol, INCD has the responsibility of supporting research activities of strategic interest related with CERN and high energy physics while simultaneously supporting research projects in the context of FCT calls. In return, FCT is also contributing to the operational costs of the infrastructure under conditions that are agreed annually. The yearly conditions for 2025 were therefore agreed and signed.

The infrastructure is supporting the activities of the Portuguese National High Performance Computing Competence Center (NCC) in the framework of the EuroCC2[35] project that started in January of 2023. In this regard has been collaborating with the LIP and FCT associates that are partners in the EuroCC project to support the dissemination, training and engagement of new users. At the technical level, it is also providing the housing to support the Portuguese NCC web presence and access to resources to promote the adoption of HPC in the public sector.

[33] https://sqaaas.eosc-synergy.eu/#/
[34] https://www.eosc-synergy.eu/technical-areas/quality/
[35] https://eurocc.fccn.pt/en/

The preparation of a consortium to apply to an infrastructure reinforcement project under the NORTE2030 has started. The project to be submitted in 2025 will be focused on "Supercomputing and Artificial Intelligence" aiming at providing the Northern region with an infrastructure capable of accelerating the digital transition, industrial innovation, applied research, and specialized human resource training.

14.OPEN SCIENCE AND RESEARCH DATA

In the open science and research data domain the cooperation with FCT-FCCN and LIP continued aiming at creating a national catchall data repository based on the Harvard Dataverse[36] software. This service coordinated by FCT aims at making research data openly available according to the open science values and FAIR principles. In 2024, this activity continued at an increased pace as part of a collaboration protocol with FCT-FCCN. The infrastructure is housing development and piloting instances of the data repository for FCT-FCCN, and is assisting in the adaptation and deployment of the software to the national requirements. Experimentation with several user communities has started. The production service is scheduled to become widely available in 2025. This collaboration has been extended to study a future architecture for the delivery of research data services by FCT using the future CNCA infrastructure.

In collaboration with LIP and ICS, a new project for the creation of a center for research data management has been submitted and approved to start in 2025. The project will create thematic data repositories customized to the requirements of specific domains. The repositories will be aligned with the catchall data repository of reference developed for FCT, therefore, contributing to the growth of an interoperable network of data repositories. The repositories will be housed at INCD using its infrastructure services.

Under the third CPCA call several entities related to the *agriculture of data partnership* have conducted a project to start exploring the sharing of data and services using the INCD cloud. Three different use cases provide the basis for this work covering soil evapo-transpiration, identification of crops and cultivated areas, and sharing of different types of data. These activities have been reinforced with a research project approved by FCT that will start in 2025. In addition, steps towards establishing protocols with public administration entities have started aimed at sharing and processing of geospatial data.

15.USAGE METRICS

Overall in 2024 about 55,746,000 hours of processing time were delivered across all infrastructure services. Figure 4 shows the combined usage in processing hours of the infrastructure since 2017. The usage includes the high performance computing, high throughput computing and cloud computing services, upon which other services are also built and delivered.

[36] https://dataverse.org/

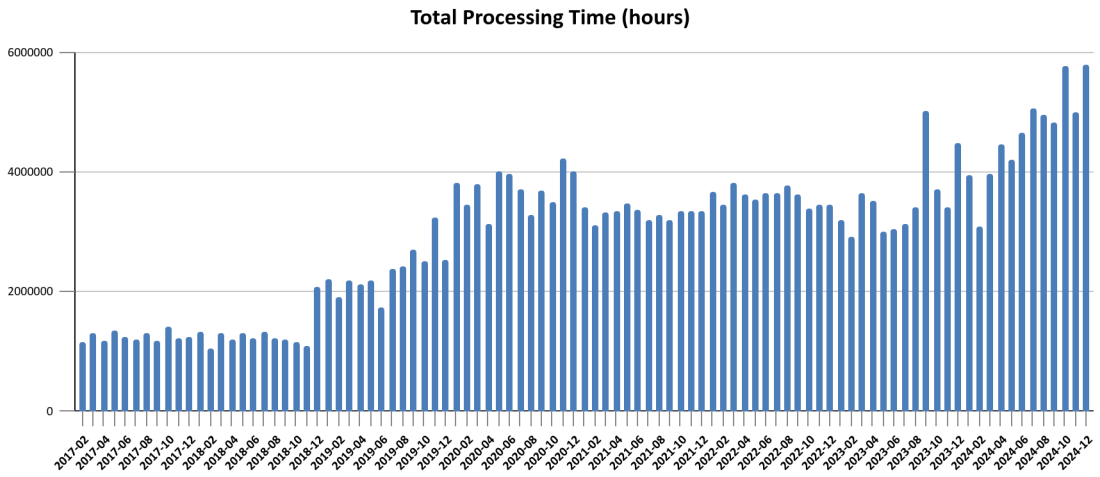

Figure 4: combined usage of all INCD services from January of 2018 to December of 2024.

Figure 5 shows the usage of the main services since 2017 per infrastructure centre and service. The figure shows the batch services supporting HPC and HTC both in Lisbon and in Vila Real, and the cloud computing services in Lisbon, Vila Real and also at the Google cloud. The number of hours delivered in 2024 was the highest since 2017.

The HPC and HTC capacity delivered by the Lisbon centre amounted to 24,337,103 hours. In the north the HPC and HTC capacity delivered amounted to 8,670,729 hours.

Figure 6 shows the usage of the cloud computing services since 2017. In 2024, the overall usage of cloud computing services amounted to 22,738,418 hours, and the cloud services were used by 53 projects from 27 research units and organisations. Through a grant awarded in the framework of an European Open Science Cloud (EOSC), more than 3,329,395 processing hours were delivered using google cloud resources including both VMs via the google cloud engine (GCE) and containers via the google kubernetes engine (GKE).

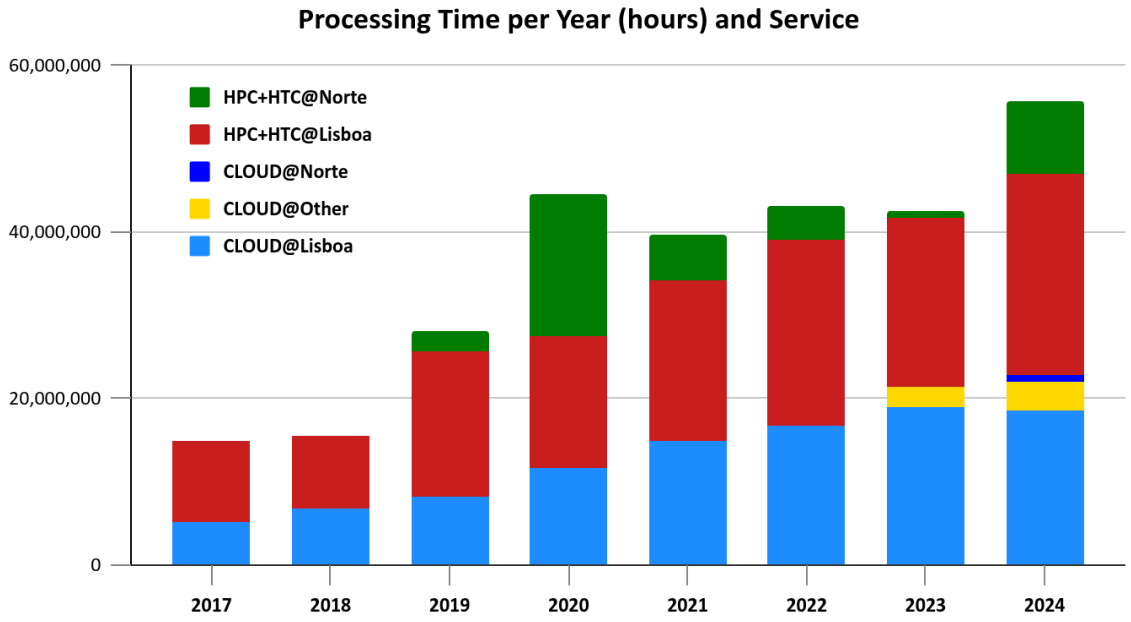

Figure 5: usage in hours of the INCD services from 2017 to 2024.

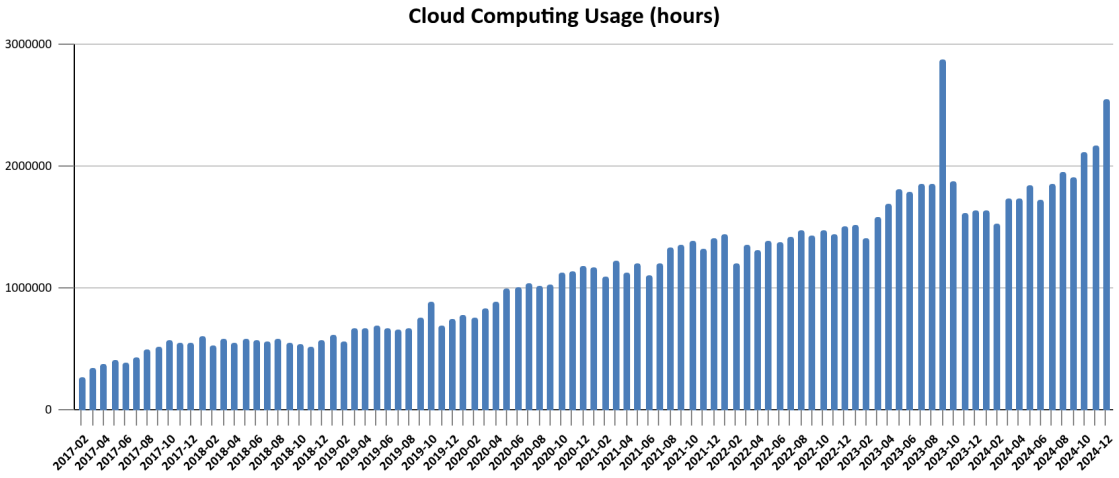

Figure 6: usage of the INCD cloud computing service from 2017 to 2024.

Overall the infrastructure supported 86 computing projects from the CPCA calls organised by FCT. These projects were both from the calls of 2023 whose execution finished already in 2024 and new projects from the calls of 2024 that started later in the year. The infrastructure continued to support the Portuguese participation in CERN related activities such as the ATLAS and CMS experiments at the CERN Large Hadron Collider (LHC). The Portuguese Tier-2 in the Worldwide LHC Computing Grid (WLCG)

executed 579,797 processing jobs and delivered 10,590,573 processing hours. Table 2 shows the usage of the primary computing services in 2024.

Services	Hours	Percentage
Cloud	**22,738,418**	**41 %**
HPC	**17,843,225**	**32 %**
HTC	**15,164,607**	**27 %**
Total	**55,746,250**	**100 %**

Table 2: summary of the INCD services usage in 2024.

16.USERS AND PROJECTS

Table 3 shows the number of projects supported by the INCD infrastructure per year since 2017. In 2024, INCD supported a total of 147 research projects of which 86 were CPCA computing projects, 3 were research infrastructures in the FCT roadmap and 58 were other research projects identified by the users, many of which benefited from the computing time provided by CPCA computational projects.

Projects supported yearly	2017	2018	2019	2020	2021	2022	2023	2024
Number of projects	61	57	65	122	123	114	133	147

Table 3: Projects supported by INCD yearly

The infrastructure continued to support users from research units, departments of universities and research infrastructures from multiple scientific domains and geographic areas. Table 4 shows the list of the 65 different organisations, centres, infrastructures and research units that used the infrastructure services in 2024.

Agência Nacional de Inovação (ANI)
Agência Regional para o Desenvolvimento da Investigação Tecnologia e Inovação (ARDITI)
Associação Laboratório Colaborativo em Transformação Digital (DTx CoLab)

BioData.pt (Associação BIP4DAB)

Centro de Ciências e Tecnologias Mecânicas e Aeroespaciais (C-MAST / UBI)

Centro de Astrofísica (U.Porto)

Centro de Biologia Molecular e Ambiental (CBMA / U.Minho)

Centro de Ciências do Mar (CCMAR / U.Algarve)

Centro de Ciências e Tecnologias Nucleares (C2TN / IST / U.Lisboa)

Centro de Ecologia, Evolução e Alterações Ambientais (cE3c / U.Lisboa)

Centro de Engenharia Biológica (CEB / U.Minho)

Centro de Engenharia e Tecnologia Naval e Oceânica (CENTEC / IST / U.Lisboa)

Centro de Física das Universidades do Minho e do Porto (CF-UM-IP)

Centro de Física da Universidade de Coimbra (FCTUC / U.Coimbra)

Centro de Imagem Biomédica e Investigação Translacional (CIBIT)

Centro de Investigação em Engenharia dos Processos Químicos e dos Produtos da Floresta (CIEPQPF / FCTUC / U.Coimbra)

Centro de Investigação em Serviços Digitais (CISeD / P.Viseu)

Centro de Investigação em Tecnologias e Serviços de Saúde (CINTESIS)

Centro de Neurociências e Biologia Celular (CNC-UC / U.Coimbra)

Centro Interdisciplinar de Investigação Marinha e Ambiental (CIIMAR / U.Porto)

Direcção-Geral do Livro, dos Arquivos e das Bibliotecas (DGLAB)

Faculdade de Ciências da Universidade de Lisboa (FCUL / U.Lisboa)

Faculdade de Ciências Exatas e da Engenharia (FCEE / U.Madeira)

Faculdade de Ciências Sociais e Humanas (FCSH / U.Lisboa)

Faculdade de Medicina da Universidade de Lisboa (U.Lisboa)

Fundação para a Ciência e a Tecnologia (FCT)

Institute for Bioengineering and Biosciences (IBB / IST / U.Lisboa)

Instituto de Astrofísica e Ciências do Espaço (IA / U.Lisboa)

Instituto de Biosistemas & Ciências Integrativas (BioISI / FCUL / U.Lisboa)

Instituto de Ciências Sociais da Universidade de Lisboa (ICS / U.Lisboa)

Instituto de Engenharia de Sistemas e Computadores (INESC-ID)

Instituto de Financiamento da Agricultura e Pescas, I.P. (IFAP)

Instituto de Física de Materiais Avançados, Nanotecnologia e Fotónica (IFIMUP / U.Porto)

Instituto de Materiais de Aveiro (CICECO / U.Aveiro)

Instituto de Medicina Molecular (IMM / U.Lisboa)

Instituto de Nanoestruturas, Nanomodelação e Nanofabricação (i3N/ U.Aveiro)

Instituto de Plasmas e Fusão Nuclear (IPFN / IST / U.Lisboa)
Instituto de Telecomunicações (IT)
Instituto Dom Luiz (IDL / U.Lisboa)
Instituto Nacional de Investigação Agrária e Veterinária (INIAV)
Instituto Nacional de Saúde Dr. Ricardo Jorge (INSA)
Instituto Politécnico da Guarda (P.Guarda)
Instituto Superior de Engenharia de Lisboa (ISEL / P.Lisboa)
Instituto Superior de Engenharia do Porto (ISEP / P.Porto)
Instituto Universitário de Lisboa (ISCTE-IUL)
Laboratório Associado para a Química Verde (LAQV REQUIMTE)
Laboratório de Física para Materiais e Tecnologias Emergentes (LaPMET)
Laboratório de Instrumentação e Física Experimental de Partículas (LIP)
Laboratório de Processos de Separação e Reacção - Laboratório de Catálise e Materiais (LSRE-LCM / FEUP / U.Porto)
NOVA Laboratory for Computer Science and Informatics (NOVA LINCS / UNL)
NOVA Medical School (NMS / UNL)
Portuguese Coastal Monitoring Network (CoastNET / MARE)
Portuguese node of the Global Biodiversity Network (GBIF / ISA)
Rede de Investigação em Biodiversidade e Biologia Evolutiva (Associação BIOPOLIS)
Sociedade Portuguesa de Botânica (SP BOTÂNICA)
Unidade de Ciências Biomoleculares Aplicadas (UCIBIO / UNL)
Universidade Aberta (U.Aberta)
Universidade da Beira Interior
Universidade de Coimbra (U.Coimbra)
Universidade de Évora (U.Evora)
Universidade de Trás-os-Montes e Alto Douro (UBI)
Universidade do Algarve (UALG)
Universidade do Minho (U.Minho)
Laboratório Nacional de Engenharia Civil (LNEC)
Pattern Institute

Table 4: entities and units that used the INCD infrastructure in 2024

17.PUBLICATIONS AND OTHER RESULTS

As a measure of the relevance and impact of INCD the figure 8 shows the evolution of the number of scientific results already published or approved for publication that benefited from the usage of the infrastructure services in 2024. The figures 8 and 9 contain the sum of most results including publications with peer review, publications in conference proceedings, conference posters, books, PhD thesis (finished and ongoing), MSc thesis (finished and ongoing), patents, published datasets and published software. The breakdown of the results per type is shown on Figure 9. The complete list of publications is provided in the appendix I.

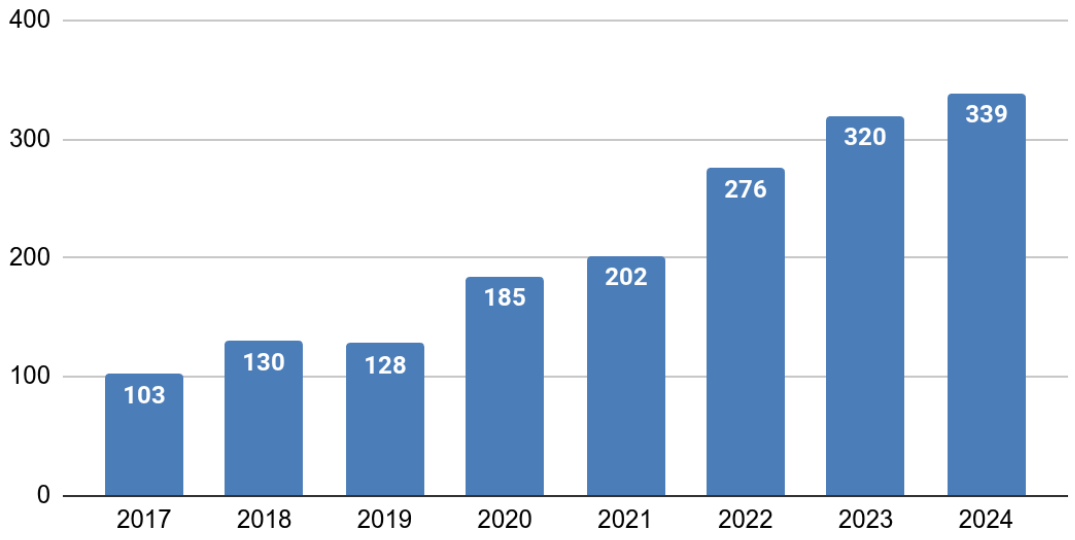

Figure 8: key results made possible by using INCD from 2017 to 2024.

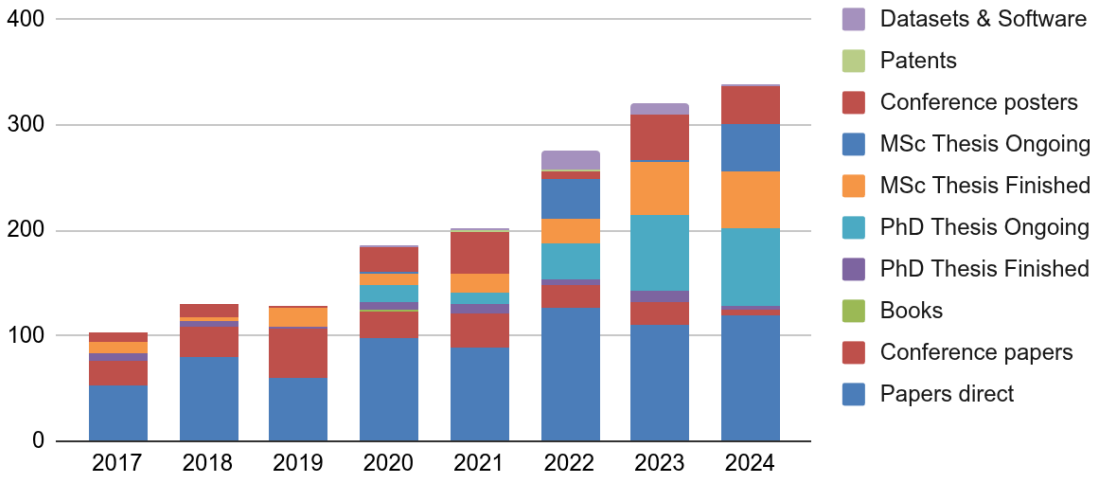

Figure 9: key results made possible by using INCD per type from 2017 to 2024

Regarding the support to PhD and MSc thesis, 3 PhD and 53 MSc thesis were produced by supported projects. In addition to these, the infrastructure supported 73 PhD theses that are ongoing and 46 MSc thesis also ongoing. The number of papers with direct contributions amounted to 120 and was the second highest since 2017. The number of proceedings decreased although the number of oral presentations reported was 46. The table 5 shows the publications made possible by the infrastructure since 2017. Detailed information is available in the wiki under the institutional information section[37].

	2017	2018	2019	2020	2021	2022	2023	2024	Total
Papers direct	52	79	59	97	89	126	111	120	733
Proceedings	24	30	47	25	32	22	21	5	206
Books	0	0	0	2	0	0	0	0	2
PhD Thesis	8	4	3	7	9	5	11	3	50
MSc Thesis	10	5	17	12	19	23	49	54	189
Posters	9	12	2	24	39	8	42	35	171
Patents					2	1	0	0	3
Datasets & software				1	2	19	11	3	36

Table 5: publications made possible by using INCD per type from 2017 to 2024

[37] https://wiki.incd.pt/shelves/incd-institutional-information

ANNEX I - PUBLICATIONS AND OTHER RESULTS

Publications produced with the support of INCD/CNCA in 2024

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- Molecular Dynamics Simulations of Lysinated Multiwalled Carbon Nanotubes for Enhanced Delivery of Doxorubicin in Cancer Therapy Fábio G. Martins; Sérgio F. Sousa – 6th Meeting on Medicinal Biotechnology 17.05.2024 (Porto, Portugal)
- Optimizing Doxorubicin Delivery in Cancer Treatment with Lysinated Multiwalled Carbon Nanotubes: A Molecular Dynamics Study Fábio G. Martins, Sérgio F. Sousa – Encontro Ciência 2024 03.07.2024 (Porto, Portugal)
- Modeling HIV-1 Intasome-Nucleosome Interactions: A Molecular Perspective Fábio G. Martins, Sérgio F. Sousa – 7th Meeting on Medicinal Biotechnology 30.05.2025 (Porto, Portugal)
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- Development of biocidal formulations for effective biofouling control Student: Susana Maria da Fonseca Fernandes (Supervisor Principal: Manuel Simões; Outros Supervisores: Sérgio Sousa e Fernanda Borges) Doutoramento: Programa Doutoral em Engenharia Química e Biológica (PhD) Universidade do Porto Faculdade de Engenharia, Portugal Fevereiro de 2024
- Paroxysmal Nocturnal Hemoglobinuria: Unraveling Epidemiological Patterns, Molecular Mechanisms, And Biotechnological Advances Student: Vanda Patrícia Pinto Peixoto (Supervisor Principal: Mónica Vieira, ESS; Co-supervisor: Sérgio F. Sousa) Doutoramento: PhD Program in Advanced Biotechnology (PhD) Universidade de Vigo, Spain Junho 2024
- New Drugs Against Biofilm Formation and Development: a Computational and Experimental Approach Student: Cláudia Tatiana Vieira (Supervisor Principal: Sérgio F. Sousa; Outros Supervisores: Manuel Simões e Sérgio F. Sousa) Doutoramento: Programa Doutoral em Biomedicina (PhD) Universidade do Porto Faculdade de Medicina, Portugal Julho de 2024

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- Vasco Neto – MSc, “Probing the Anti-Sickling Power of Distinct Drugs in Sickle Cell Disease”, scientific advisor, Biochemistry and Biomedicine MSc, FCUL
- Inês Gomes – MSc, “Probing the Stability of Biomolecules in Deep Eutectic Solvents”, scientific advisor, Biochemistry and Biomedicine MSc, FCUL
- Catarina Nascimento – MSc, “Molecular Mechanisms of Amyloid Aggregation in Neurodegenerative Diseases”, scientific advisor, Biochemistry and Biomedicine MSc, FCUL
- 11/2024, Computational Modeling of Biopharmaceuticals Purification Systems, Jéssica Rodrigues, Master in Computational Biology and Bioinformatics, FCT UNL.

- Designing Optimal 3D Enzyme Computational Models for Efficient Plastic Degradation Student: Mariana Gomes Fernandes (Supervisor Principal: João Carneiro; Co-Supervisor: Sérgio F. Sousa e Diogo Pratas) Mestrado: Bioinformatics and Computational Biology Faculdade de Ciências da Universidade do Porto, Portugal Dezembro de 2024
- Machine Learning Enhanced Optimization of Plastic-Degrading Enzymes for Sustainable Ocean Cleanup Student: Ana Clara Cerqueira (Supervisor Principal: João Carneiro; Co-Supervisor: Sérgio F. Sousa e Diogo Pratas) Mestrado: Bioinformatics and Computational Biology Faculdade de Ciências da Universidade do Porto, Portugal Dezembro de 2024
- Discovery of New Molecules for the Treatment of Machado-Joseph Disease Student: Filipe Rocha Mestrado: Medicinal Chemistry (Supervisor Principal: Sérgio F. Sousa; Co-Supervisor: Fernanda Proença) Universidade do Minho, Portugal Dezembro de 2024
- Designing In-Silico Aptamers for Potential Use in Marine Bioremediation Student: Rafael Vieira Mestrado: Bioinformatics and Computational Biology (Supervisor Principal: Sérgio F. Sousa; Co-Supervisor: João Carneiro e Diogo Pratas) Faculdade de Ciências da Universidade do Porto, Portugal Novembro 2024
- Desenvolvimento de nanomateriais hidrofílicos de carbono com propriedades biomiméticas de enzimas antioxidantes Student: Andreia Daniela Rosa Veloso (Supervisor Principal: Maria C. Oliveira; Co-Supervisors: Nuno Cerqueira e Romeu Videira) Doutoramento: Doutoramento em Ciências Químicas e Biológicas (PhD) Universidade de Trás-os-Montes e Alto Douro, Portugal Novembro de 2024
- Evaluation of acute hepatic toxicity and inflammation induced by nitrosamines in Mus musculus and Danio rerio Student: Isabelly Annunciato (Supervisor Principal: Marcos Hikari Toyama; Co-Supervisor: Sérgio Sousa) Mestrado: Biodiversity in Coastal Environments Institute of Biosciences, Paulista State University, Brazil Agosto de 2024
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- In-medium Gluon Radiation in General Kinematics Afonso Guerreiro Orientador: Guilherme Milhano 2024-12-03 IST
- Multichannel study of cosmic ray variability over different temporal scales http://fisgeo.unipg.it/pacetti/3-LM-Margherita-Fioroni.pdf Margherita Fioroni Orientador: Nicola Tomassetti 2024-04-18 UniPerugia
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Datasets produced with the support of INCD/CNCA in 2024

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Software created and maintained with the support of INCD/CNCA in 2024

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- Development of SQAaaS https://sqaaas.eosc-synergy.eu/#/