



LABORATÓRIO DE INSTRUMENTAÇÃO  
E FÍSICA EXPERIMENTAL DE PARTÍCULAS  
*partículas e tecnologia*

# Advanced and Distributed Computing





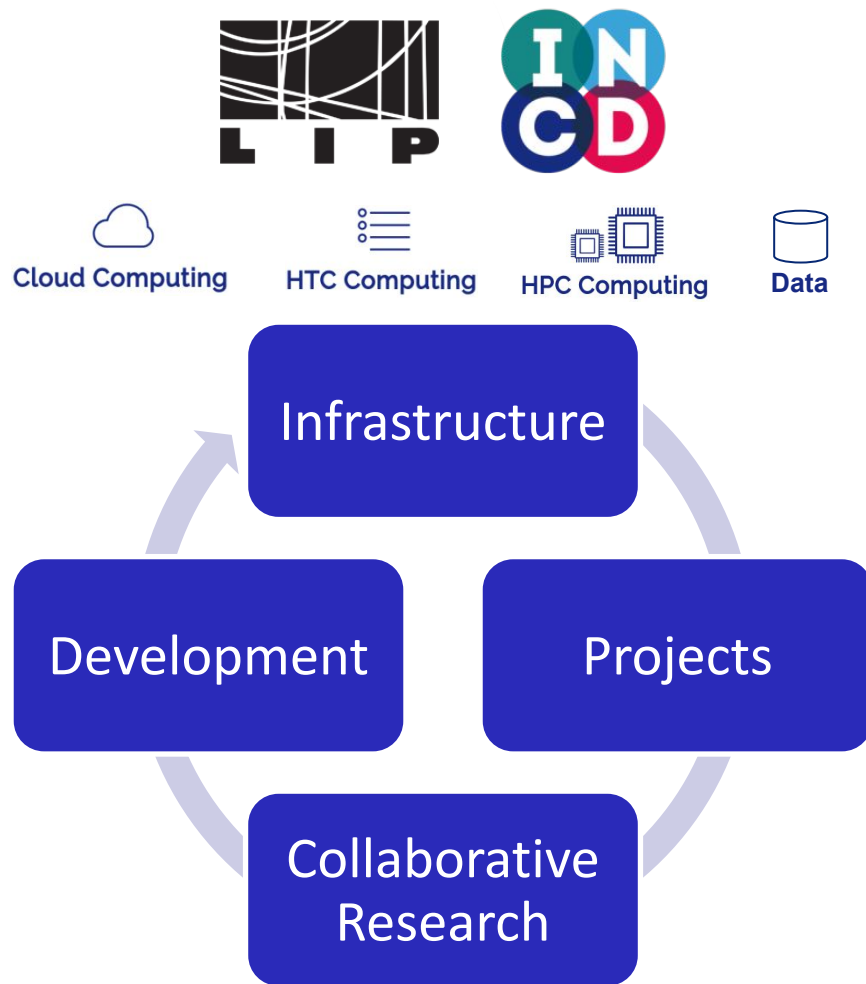
# Delivering IT services Computing and data

## For LIP

1. **Delivering internal IT services to LIP**
  - Supporting research, innovation, education, outreach and administrative activities at LIP.
2. **Participation in national and international projects, initiatives and digital infrastructures**
  - Performing Innovation and Research

## Via INCD

3. **Provide compute and data oriented services to Portuguese academic and research community**
  - INCD is a spinoff from the LIP participation in projects on computing and digital infrastructures.
  - Is the basis for the LIP computing services.
  - INCD itself is a legal entity, private non-profit association that joins LIP, FCT and LNEC.
  - Research infrastructure in the FCT roadmap of research infrastructures (until 2022).

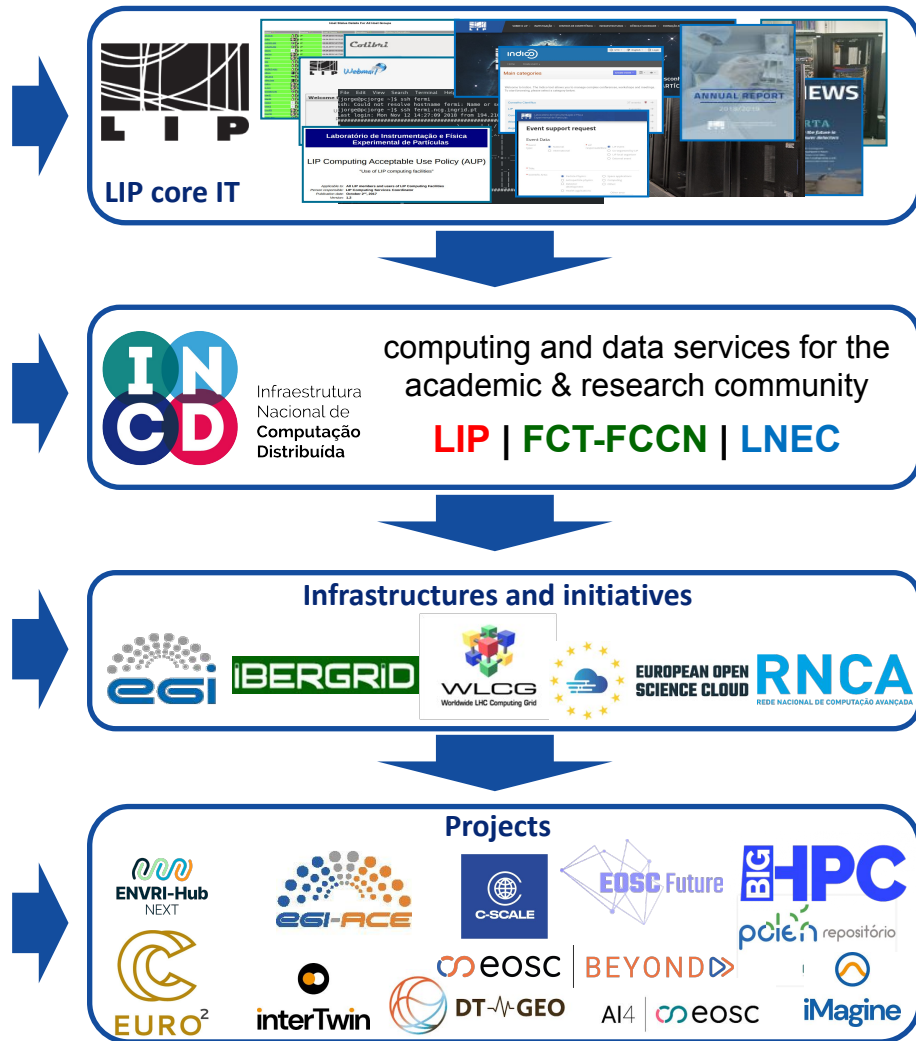




# Competences Projects & Initiatives

The group has participation in projects, infrastructures and initiatives in areas such as:

- Digital infrastructures
- High Performance Computing
- High Throughput Computing
- Cloud Computing
- Federated/distributed computing
- Software Quality Assurance
- Software management
- Linux containers
- Data repositories





LIP staff

Lígia Melo	Communication	LIP Lisboa - Communication, dissemination, outreach for computing & LIP (NEW)
Davi Parma	Technician	LIP Lisboa - Web development for internal and administrative services
Carlos Manuel	Technician	LIP Lisboa - Design, web development, events, multimedia, communication
Hugo Gomes	Technician	LIP Lisboa - Web development, IT support, events, multimedia, communication
João Martins	Researcher	LIP Lisboa - Fabric mgmt, storage, computing, HPC, grid, virtualization, support
João Pina	Researcher	LIP Lisboa - WLCG Tier-2, software management, user support, grid
Jorge Gomes	Researcher	LIP Lisboa - Projects mgmt, network mgmt, computing, sw development, security
Mário David	Researcher	LIP Lisboa - Cloud computing, containers, sw quality assurance, development
Nuno Dias	Researcher	LIP Lisboa - Security, data protection, network services, desktops, laptops
José Aparício	Engineer	LIP Lisboa - Datacenter, networks, notebooks, desktops, hw maintenance, support
Miguel Viana	Engineer	LIP Minho - Cloud, containers, software integration and validation, monitoring
Samuel Bernardo	Engineer	LIP Lisboa - Development, sw quality, AAI, computing, cloud, containers, DevOps
Zacarias Benta	Engineer	LIP Minho - HPC, fabric mgmt, computing, virtualization, support, sw development

Communication

Core Computing Services

INCD +  
Collaborators

Catarina Ortigão	Administration	INCD - Administrative and managerial support
César Ferreira	Engineer	INCD - HPC/HTC, fabric mgmt, computing, virtualization, containers, support
João Machado	Researcher	INCD - Data repositories, open science, data services, software development
António Esteves	Researcher	University of Minho - Application of machine/deep learning techniques
António Pina	Researcher	University of Minho - Application performance analysis, parallel programming
José Rufino	Researcher	Polytechnic Institute of Bragança - Parallelization strategies for GPU algorithms

INCD

LIP



# Human resources

- **LIP staff**
- **INCD staff**
- **Collaborators**



- **7x PhDs**
  - 2x LIP staff
  - 2x INCD staff
  - 3x Collaborators
- **8x Engineers**
  - 7x LIP staff
  - 1x INCD staff
- **3x Technicians**
  - 3x LIP staff



- |                                    | Staff salaries |
|------------------------------------|----------------|
| • LIP (computing <b>projects</b> ) | <b>88%</b>     |
| • LIP (own funds)                  | 2%             |
| • INCD ( <b>projects</b> and RNCA) | 10%            |

- **High sustainability risk**
- **Services on best effort**



# LIP Projects and funding in 2023 and ongoing

LIP Computing Projects	Source	Start	End	Funding
BigHPC	FCT	2020	2023	249 561€
EGI-ACE	EU	2021	2023	196 238€
Contract FCT for catchall research data repository	FCT	2022	2023/2024	19 999€
EOSC-Future	EU	2022	2024	160 375€
Support for the Tier-2 WLCG (FCT CERN fund)	FCT	2022	2024	29 999€
iImagine	EU	2022	2025	222 125€
DT-Geo	EU	2022	2025	542 875€
AI4EOSC	EU	2022	2025	350 250€
interTwin	EU	2022	2025	342 812€
EuroCC 2	EU/FCT	2023	2025	146 000€
EOSC-beyond	EU	2024	2027	182 750€
ENVRI-Hub NEXT	EU	2024	2027	225 302€



# Projects and activities

- **DT-GEO**
  - Digital Twin of geophysical extremes dealing with geohazards earthquakes, volcanoes, and tsunamis
  - Software and Service Quality assessment
  - udocker integration with workflow managers in HPC
  - Application containerisation
- **InterTwin**
  - Common approach to the implementation of DTs applicable across scientific disciplines
  - Software release and management
  - Quality and validation for applications and services
- **iImagine**
  - Imaging data and services for aquatic science
  - Federated computing infrastructure
  - Supporting the DEEP AI platform service
- **EGI-ACE**
  - Advanced computing for EGI
  - Quality assurance for the EGI middleware distributions
  - Integration and supporting of thematic services
  - Integration of HPC resources in EGI
- **BigHPC**
  - Simplify management of High Performance Computing infrastructures for BigData and parallel applications.
  - SQA, DevOps, monitoring and containerisation.
- **AI4EOSC**
  - Advanced services for AI, ML and DL models and applications.
  - Software quality, data FAIRness
  - Integration of udocker for serverless computing
- **EuroCC 2**
  - Awareness and communication
  - Training and skills
  - Interaction with academia and public sector
- **Contract with FCT - data repositories**
  - Pilot for a national research data repository
  - Integration and service provisioning
- **EOSC Beyond**
  - Release management and Software Quality Assurance
  - Process, CI/CD tools and support for QA
- **ENVRI-Hub NEXT**
  - CI/CD integration, including agile software development
  - Release process, automated QA, environment for integration
- **c-Scale**
  - Federate European EO infrastructure services
  - Integrating and supporting EO use cases
- **EOSC-Future**
  - IT Service management for EOSC services





# INCD operations centres in 2023



Cloud Computing  
cloud computing



HTC Computing  
high throughput  
computing (GRID)



HPC Computing  
high performance  
computing



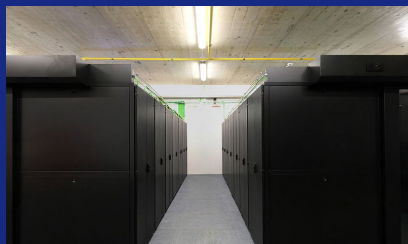
**INCD-A @ LNEC in Lisbon**  
HPC / HTC / Cloud / Federation  
6000 CPU cores  
5 Petabytes online raw  
100 Gbps + **100 Gbps LHCONE**  
**Includes the WLCG Tier-2**



**INCD-B @ REN in Riba-de-Ave**  
**(partially moved to Lisbon)**  
HPC / HTC  
2600 CPU cores (640 cores)  
384 Terabytes raw  
1 Gbps



**INCD-L @ LIP in Lisbon**  
Tape storage  
1 Petabyte backups  
10 Gbps



**INCD-D @ UTAD in Vila Real**  
HPC / HTC / Cloud / Federation  
5000 CPU cores + IB HDR200  
4 Petabytes online raw  
10 Gbps + 10Gbps



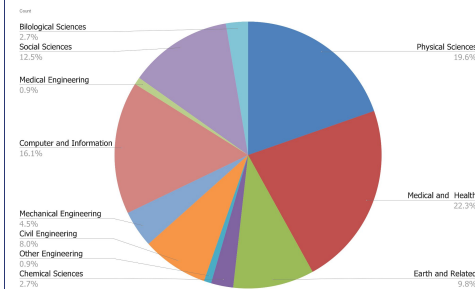
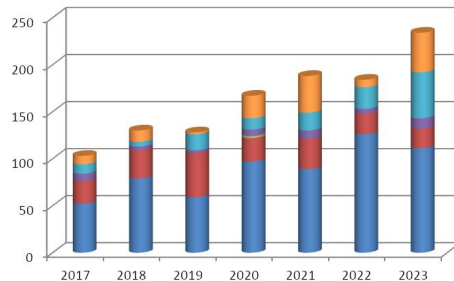
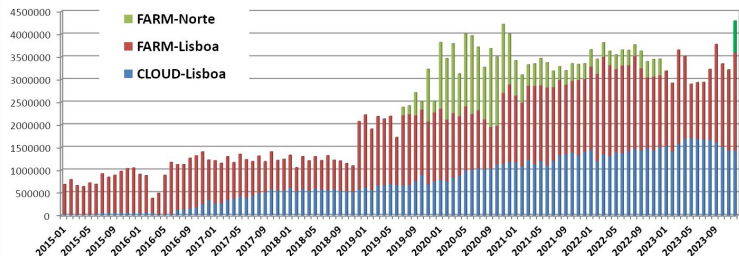
**INCD-C @ UC in Coimbra**  
**(BEING IMPROVED)**  
Tape storage expansion  
20 Petabytes  
10 Gbps





# INCD outcomes 2017 - 2023

Processing Time (hours)



	2017	2018	2019	2020	2021	2022	2023	Total
Publications in journals	52	79	59	97	89	126	111	613
Publications in proceedings	24	30	47	25	32	22	21	201
Books	0	0	0	2	0	0	0	2
PhD Thesis	8	4	3	7	9	5	11	47
MSc Thesis	10	5	17	12	19	23	49	135
Posters	9	12	2	24	39	8	42	136
Patents					2	1	0	3
Datasets and software				1	2	19	11	33
Total	103	130	128	168	192	204	245	1170





## INCD Projects and funding in 2023 and ongoing

INCD Projects	Source	Start	End	Funding
EGI-ACE	EU	2021	2023	78 029€
C-Scale	EU	2021	2023	75 227€
iImagine	EU	2022	2025	50 414€

INCD Protocols	Source	Start	End	Funding
RNCA protocol 2023	FCT	2023	2023	80 000€
RNCA protocol 2023 - datacenter housing Lisbon+UTAD	FCT	2023	2023	243 000€
Institutional scientific employment position	FCT	2023	2029	285 000€

The LIP computing and data intensive resources are largely owned and/or operated and housed by INCD.  
The INCD housing costs including the LIP WLCG Tier-2 are supported by FCT via the RNCA protocol renewed yearly.





## INCD P2020 project - 01/SAICT/2016 nº 22153

The project funded by the roadmap of **research infrastructures finished in December 2022**, the results from the evaluation of the project were announced by FCT in 2023.

*The planned scientific objectives were fully achieved. The results show great scientific quality, namely in terms of publications in international refereed journals. The project contributed to the training of young researchers and to the international projection of the team involved.*





# Advanced Computing Network - RNCA

## RNCA

REDE NACIONAL DE COMPUTAÇÃO AVANÇADA



Infraestrutura  
Nacional de  
Computação  
Distribuída



LCA  
Laboratory for  
Advanced Computing



UNIVERSIDADE  
DE ÉVORA

FCCN

Tecnologia para o Conhecimento

## RNCA Protocol

### PROTOCOLO DE ADESAO DO CENTRO OPERACIONAL INCD - Infraestrutura Nacional de Computação Distribuída - À REDE NACIONAL DE COMPUTAÇÃO AVANÇADA

Considerando que:

A FUNDAÇÃO PARA A CIÊNCIA E A TECNOLOGIA – FCT, I. P. tem entre as suas atribuições instalar, manter e gerir meios computacionais avançados disponíveis em rede e promover a sua acessibilidade às diferentes entidades do Sistema Educativo e do Sistema Científico e Tecnológico Nacional, independentemente da sua natureza pública ou privada; promover a transferência de conhecimento a nível nacional e internacional, designadamente através da concessão de subsídios a projetos, programas ou eventos de interesse científico e tecnológico; e promover a participação da comunidade científica, tecnológica e de inovação nacional, ou ser parceira, em projetos nacionais ou internacionais relevantes, designadamente na criação, absorção e difusão de conhecimento e tecnologia, no acesso a equipamentos científicos altamente sofisticados ou na área da computação científica.

A FCT, I. P. gere a Rede Nacional de Computação Avançada cujo desenvolvimento foi enquadrado pela Resolução do Conselho de Ministros n.º 26/2018 no Eixo 5 da «Iniciativa Nacional Competências Digitais e 2030, Portugal INCoDe.2030».

O Despacho n.º 4157/2019<sup>1</sup> do Ministro da Ciência, Tecnologia e Ensino Superior introduziu a RNCA no Roteiro Nacional das Infraestruturas de Investigação de Interesse Estratégico.

A FCT, I. P. adotou o Regulamento para a RNCA - Rede Nacional de Computação Avançada (Regulamento n.º 1049/2020, de 25 de novembro 2020)<sup>2</sup>, bem como Regulamento anexo n.º 470/2021<sup>3</sup>, cujo número II<sup>4</sup>, determina que os Centros Operacionais (CO) da RNCA estejam integrados no Roteiro Nacional de Infraestruturas de Investigação de Interesse Estratégico (RIIE).

O RIIE<sup>5</sup> inclui a Infraestrutura Nacional de Computação Distribuída (INCD), sendo uma infraestrutura de investigação de interesse estratégico, que sustenta avanços científicos e tecnológicos e reforça a capacidade da comunidade de I&D em Portugal, por forma a fomentar a sua participação ativa em projetos europeus e internacionais.

O ponto 7 do Anexo A do Regulamento n.º 1049/2020<sup>6</sup> estipula que a adesão de Centros Operacionais ou Centros de Competências à RNCA deve fazer-se através da assinatura de um "Protocolo de Adesão".

<sup>1</sup> <https://dre.pt/home/-/dre/122109189/details/maximized>

<sup>2</sup> <https://dre.pt/application/conteudo/149532837>

<sup>3</sup> <https://dre.pt/application/conteudo/163697378>

<sup>4</sup> <https://dre.pt/web/guest/pesquisa/-/search/163697378/details/normal?q=regulamento+470%2F2021>

<sup>5</sup> [https://www.fct.pt/media/docs/Portuguese\\_Roadmap\\_Infrastructures2020.pdf](https://www.fct.pt/media/docs/Portuguese_Roadmap_Infrastructures2020.pdf)

<sup>6</sup> <https://dre.pt/home/-/dre/149532837/details/maximized>

FCT  
Fundação para a Ciência e a Tecnologia

## INCD yearly addendum to the protocol

- Advanced computing resources for applications approved in the FCT Advanced Computing Projects Calls;
- Development and operation of a research data repository;
- **Computing resources that satisfy the computational processing commitments assumed with CERN, or support scientific research and technological development projects associated with official scientific collaborations or recognized by CERN, as well as technology-based projects in the field of applied sciences in collaboration with activities supported by the same laboratory;**
- Computing resources that satisfy the national participation in the international EGI, EUDAT and IBERGRID infrastructures, as well as the participation in the EOSC initiative;
- Computational resources that support the **research and development activities of LIP** and LNEC;



# LIP in IBERGRID and EGI

## LIP responsibilities and activities:

- IBERGRID and EGI provide the backbone for WLCG
- Infrastructure operations coordination at Iberian level and interface with EGI operations
- Software management for the EGI and IBERGRID federations
- National technical contact point
- Security contact for Portugal
- Support to user communities
- Developing and operating core services e.g. software repositories for the EGI federation
- Integration of thematic and/or user services

## IBERGRID Iberian conferences since 2007



36  
EU funded  
projects

1790<sup>+</sup>  
Enabled  
articles

7.1B  
HTC CPU hours  
consumed

29  
EGI Gridnet  
participants

407M  
Computational  
jobs

84.000  
Users

70M  
Cloud CPU hours  
consumed

Federating compute  
and storage from  
hundreds of data  
centres including  
WLCG

cloud+grid+data





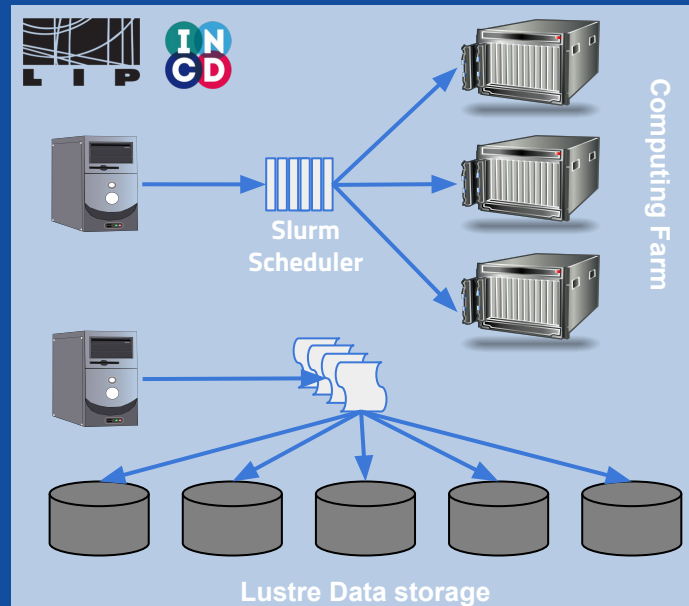
# Portuguese Tier-2 ATLAS and CMS

The **Tier-2 / Tier-3** uses the INCD infrastructure and is **operated by the LIP** computing team.

- Based at INCD using the Lisbon site
- Shares the site Slurm and Lustre systems

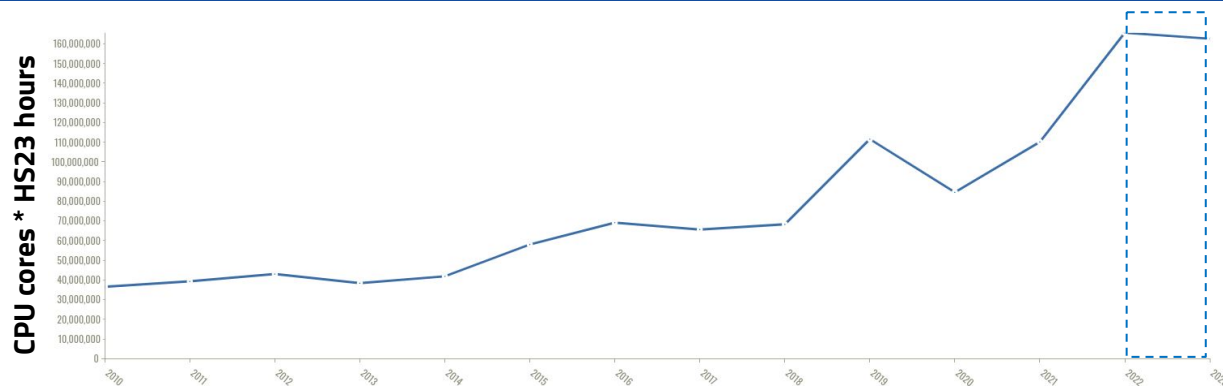
ARC-CE  
with  
Slurm as  
scheduler

XRootd  
Webdav  
StoRM SRM  
with  
Lustre as  
Underlying  
Storage



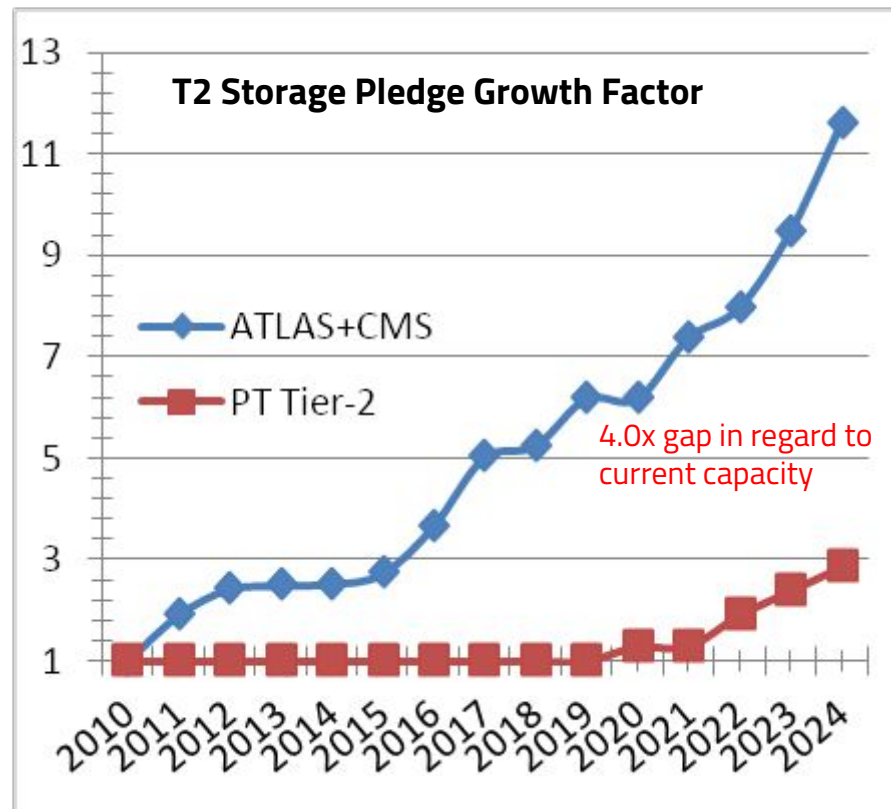
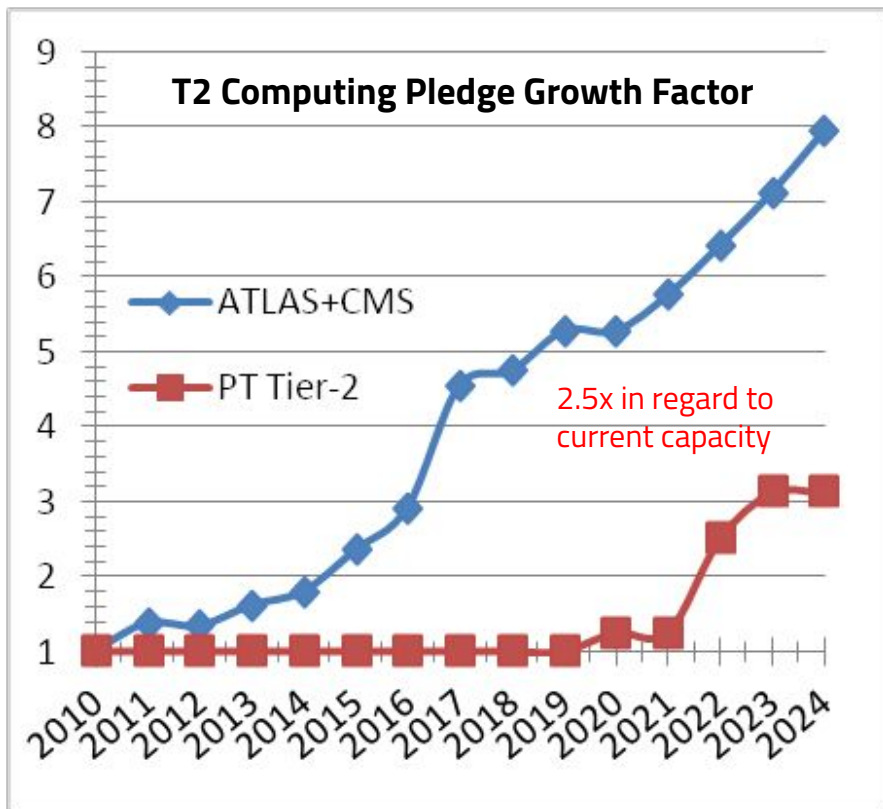
## In 2023:

- 741,737 jobs
- 162,641,224 HS23 hours
- 51.6% ATLAS / 48.4% CMS
- Many sw upgrades
- Many hw replacements



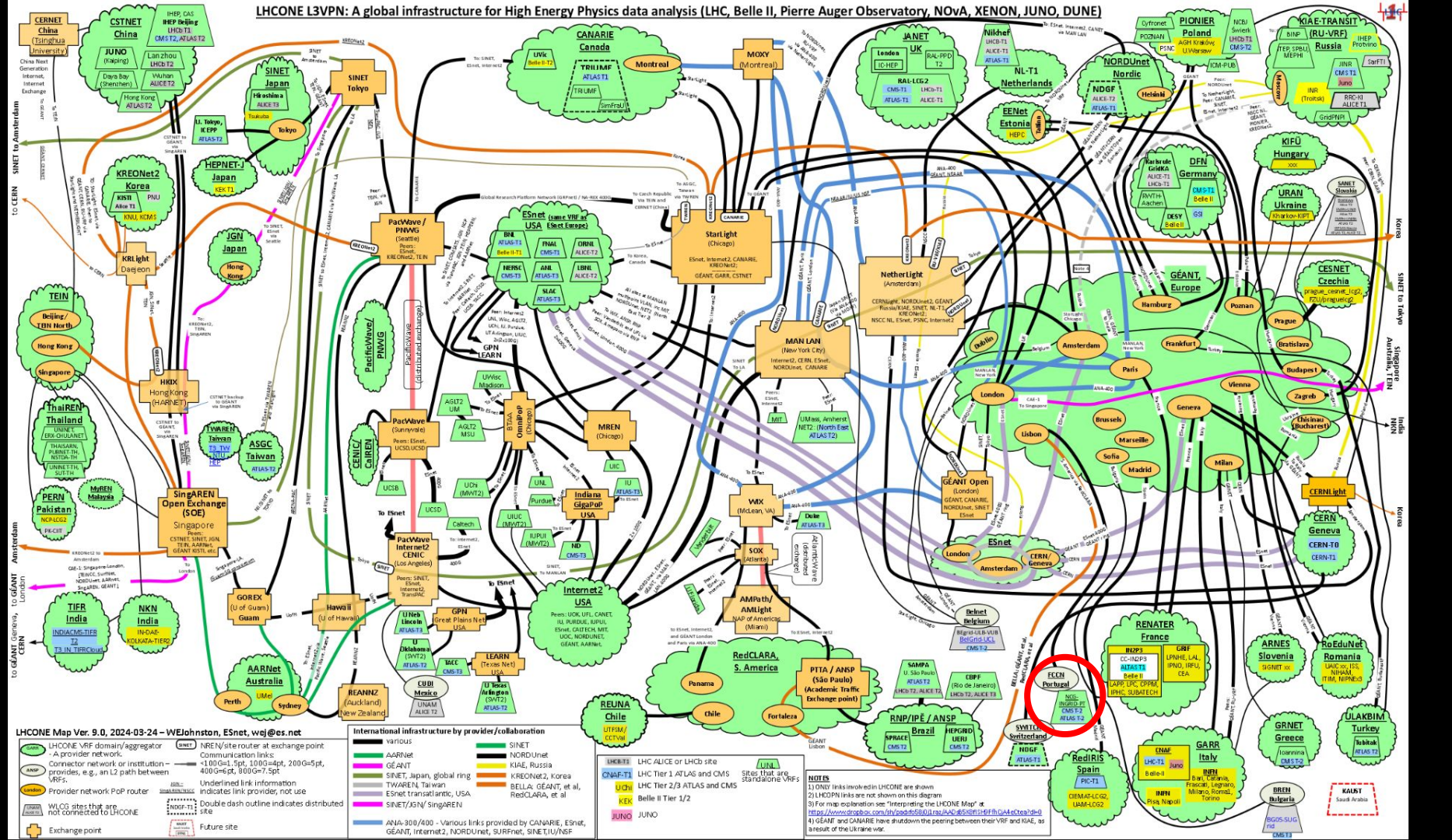


# CERN / WLCG - Portuguese Tier-2 pledge since 2010





# LHCONE L3VPN: A global infrastructure for High Energy Physics data analysis (LHC, Belle II, Pierre Auger Observatory, NOVA, XENON, JUNO, DUNE)





# SWOT

## Strengths

- Expertise in scientific computing, software integration, management and quality assurance, etc.
- Participation in international research e-infrastructures and initiatives (WLCG, EGI, IBERGRID and EOSC).
- Operating the Portuguese WLCG Tier-2 under the CERN LHC computing MoU.
- Participation in European projects.
- Founding member of INCD and key technological partner.
- Partnership with FCT-FCCN and LNEC and collaboration with other organisations via INCD.
- Previous participation in the FCT roadmap of research infrastructures of strategic interest through INCD.
- Participation in the Portuguese Advanced Computing Network (RNCA).

## Weaknesses

- Lack of compute and storage resources to address user needs.
- Capacity wise becoming irrelevant at national level.
- Lack of sustainability with many activities being supported on a voluntary and/or best effort basis.
- Highly overworked team.
- Very large dependency on projects to pay IT staff salaries.
- Heavy administrative burden compromising the effective use of the human resources.
- End of the FCT infrastructures roadmap.
- Uncertain path and role in the national computing landscape.
- No perspectives for real funding beyond participation in EU projects.

## Opportunities

- Participation in activities related to High Performance Computing.
- Participation in open data and digital repositories related activities.
- Potential for public sector applications.
- Possible evolution of the RNCA model.

## Threats

- Lack of proper hardware capacity for ATLAS, CMS and other experiments.
- Competitive market makes difficult contract and retain IT personnel.
- Lack of sustainable funding for human resources.
- Exacerbated focus on supercomputing at national and European level.
- Increasingly higher competition in projects, funding and infrastructure.
- Sustainability and future uncertain.





LABORATÓRIO DE INSTRUMENTAÇÃO  
E FÍSICA EXPERIMENTAL DE PARTÍCULAS  
*partículas e tecnologia*

# Thanks!

**Discovery  
through  
science**

**Innovation  
through  
technology**

**Sharing  
with People**



# Goals and strategy

- **Participate in R&I projects, mainly EU**
  - To develop new competences and service functionalities
  - To obtain funding to sustain the IT personnel
  - To establish a good reputation and links at international level
  - To have interesting activities to help retain the IT personnel
- **Participate in e-infrastructure initiatives at international level (EGI, WLCG, IBERGRID)**
  - To federate, operate and maintain the compute and data intensive services
  - To support LIP users and other research communities and bring added value to these activities
  - To establish and develop international networking and long term collaborations
- **Participate in e-infrastructure initiatives at national level (research infrastructures, RNCA, CPCA, CNCA ...)**
  - To support the operational costs and improvement of the computing and data infrastructure
  - To support other research communities hence further justifying the need of funding for OPEX and CAPEX
  - To establish LIP as a relevant stakeholder in the area



# Software from LIP

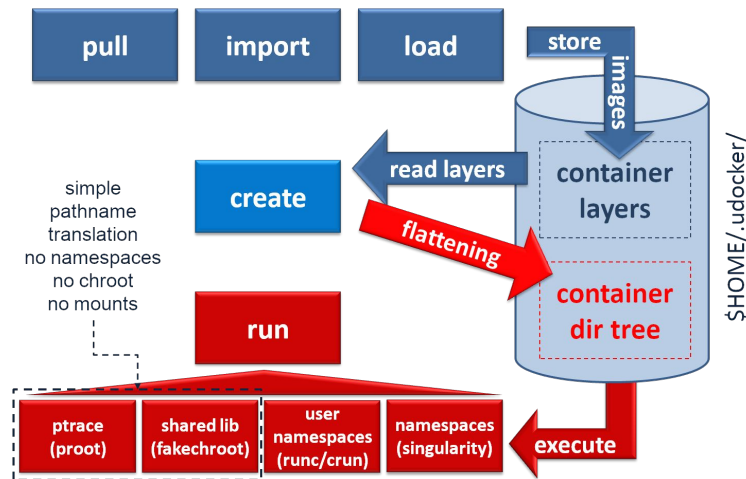
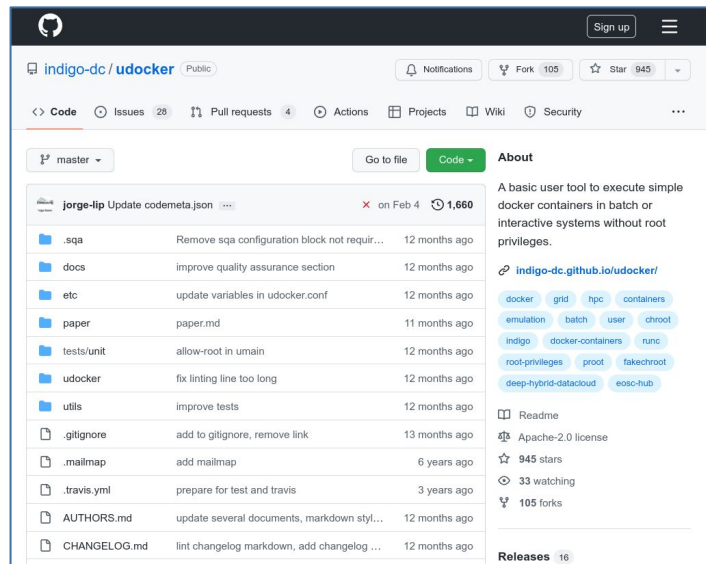
## udocker



User tool to execute docker containers in user space. Developed at LIP:

- Fully user space.
- No root privileges required to use or install.
- Does not require compilation.
- Download and execution of docker containers by non-privileged users.
- Suitable for Linux batch systems and interactive clusters managed by other entities such as grid infrastructures.
- Does not require Linux namespaces.

<https://github.com/indigo-dc/udocker>



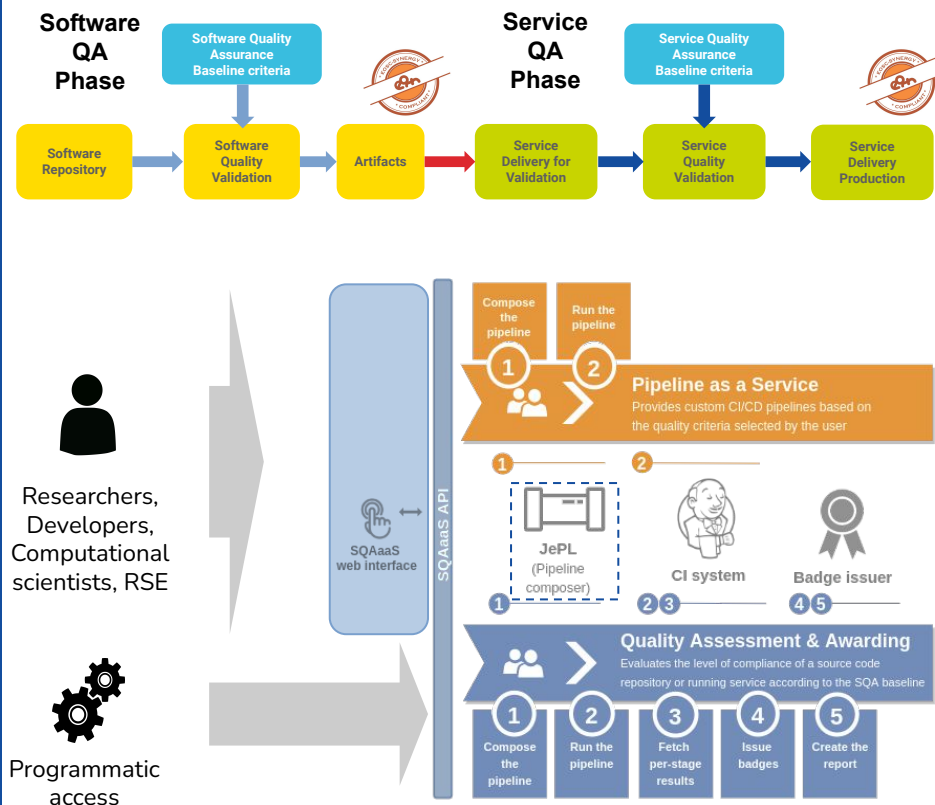


# Software from LIP SQAaaS

## Quality Assurance as-a-Service platform (SQAaaS)

- Enables the on-demand creation of CI/CD pipelines making quality verification and validation easily accessible to developers.
  - The **Pipeline as a Service** building block allows you to compose and test customized CI/CD pipelines in accordance with reference criteria.
  - The **Quality Assessment & Awarding** building block analyses, the level of compliance to the quality baselines.
- Integrates a wide range of quality verification tools that are made easily available through a friendly web interface.

<https://sqaas.eosc-synergy.eu>



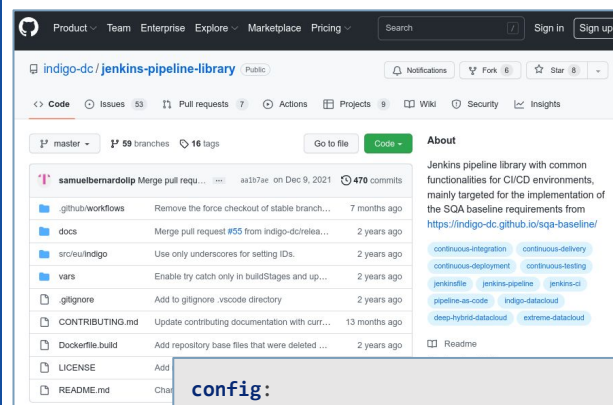
SQA baseline dynamic stages	Environment Setup	qc_style o3api	qc_coverage o3api	qc_functional o3api	qc_security o3api	qc_doc o3api	Push Images to Docker Registry	Docker Compose cleanup
14s	5s	1min 43s	23s	1min 50s	10s	1min 14s	7s	5s
14s	5s	1min 43s	23s	1min 50s	10s	1min 14s	7s	5s



# Software from LIP JePL

## Jenkins Pipeline Library (JePL)

- The library that powers the SQAaaS platform.
- Especially suitable for complex setups, you can use directly the JePL instead of the SQAaaS.
- Tech-savvy users tend to favor code over a graphical interface for the task of managing their CI/CD pipelines.
- JePL uses pipeline descriptions written in YAML.
- Just add JePL to your software repository and build your software or service quality assurance using YAML descriptions to benefit from the full set of features.
- JePL implements the software and service baselines maintained by EOSC-Synergy.



```

config:
project_repos:
  myrepo:
    repo: 'https://github.com/myorg/myrepo'

sqa_criteria:
  qc_style:
    repos:
      myrepo:
        container: myrepo-testing
        tox:
          tox_file: /myrepo-testing/tox.ini
          testenv: stylecheck
  
```

**config.yml**

```

|-- .sqa
|   |-- config.yml
|   |-- docker-compose.yml
|-- Jenkinsfile
  
```

```

services:
  myrepo-testing:
    image:
      "indigodatacloud/ci-images:python3.6"
    hostname: "myrepo-testing-host"
    volumes:
      - type: bind
        source: ./myrepo
        target: /myrepo-testing
  
```

**docker-compose.yml**

<https://github.com/indigo-dc/jenkins-pipeline-library>





## LIP strategy for INCD

- INCD as the main provider for compute and data intensive services for LIP
- Consolidate INCD as a reference organisation with sustainability
- Promote INCD in the scope of the creation of a national advanced computing center
- Seek for a common umbrella for distributed computing, HPC, cloud and data infrastructures with support at national level
- Expand the LIP capabilities through a tight collaboration between the INCD and LIP teams
- Collaborate with other research and academic organisations in the scope of INCD
- Collaborated with the funding agencies in the scope of INCD
- Support other communities and make visible the LIP value and the resulting impact



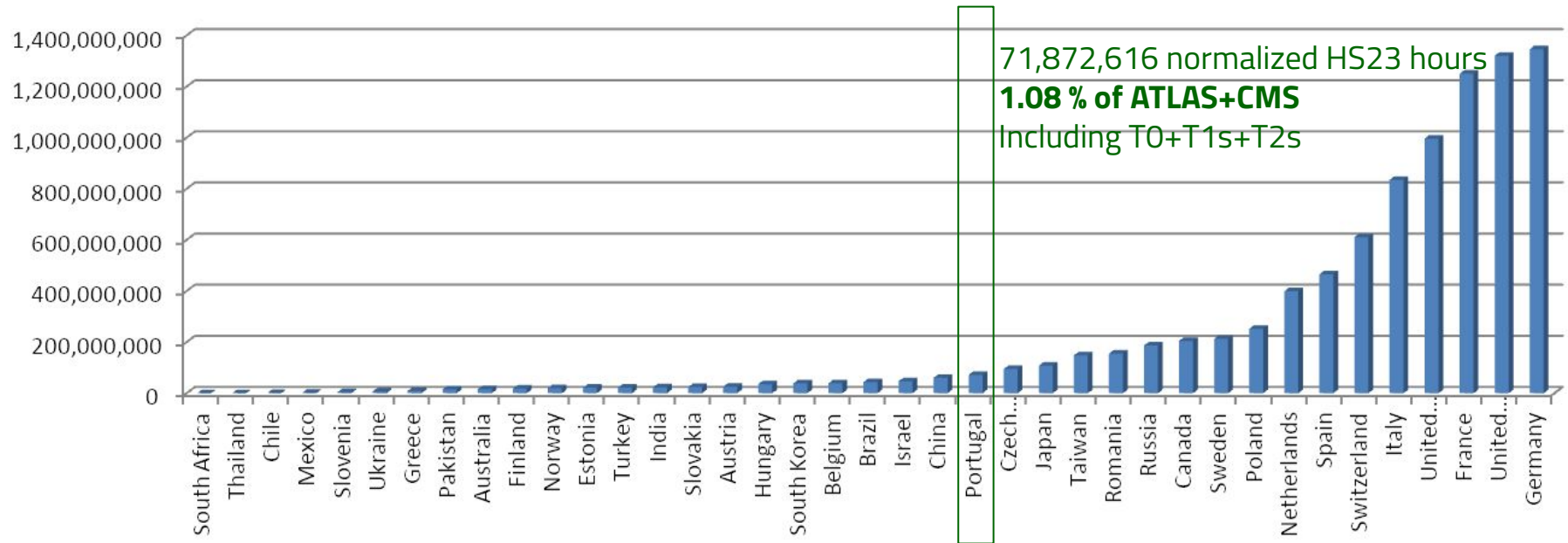
# WLCG strategy

- Follow computing CERN/WLCG activities towards the HL-LHC
- Enlarge the Tier-2 capacity according to the pledges closing the gap as much as possible
- Consolidate INCD as a reference infrastructure with ensured sustainability
- Having the Tier-2 as a flagship service provided by INCD
- Promote distributed computing as an essential service
- Collaborate with other research and academic organisations
- Seek for opportunistic computing capacity from other origins like CLOUD and HPC
- Align our actions with the funding authorities strategy to facilitate access to funding
- Collaborate with FCT and with FCT-FCCN in delivering computing and data services



# CERN / WLCG - Portuguese Tier-2 accounting (in 2011)

## Wallclock normalized (cores \* HS23 hours) in 2011



The Portuguese Tier-2 started in 2009 with a capacity of 90% of a nominal Tier-2



# CERN / WLCG - Portuguese Tier-2 accounting (in 2022)

## Wallclock normalized (cores \* HS23 hours) in 2022

