CESGA

High Performance and Disruptive Computing

High Performance and Disruptive Computing in Remote Sensing School,
CiTIUS, Santiago de Compostela, 4-7 June 2024

CESGA
GALICIA SUPERCOMPUTING CENTER

June 4th, 2024

Galicia Supercomputing Center (CESGA)

- Founded in **1993**
- Placed in **Santiago de Compostela, Galicia, Spain**
- Board of Trustees composed of members from **Xunta de Galicia (Regional Goberment)** e **CSIC (the Spanish National Research Council)**
- **Mision**: contribute to the advance of science and technology via research and application of high performance computing and comunications
- CESGA offered supercomputing services to more than **1000 researchers** in 2023
- CESGA colaborates in research projects with other institutions
    - Participated in more than **200 projects (mostly European!) since the beginnig**

CESGA Staff

- **Around 50 people** in total (and **growing**!)
- **Technical staff**: Physicists, Computer Scientists, Telecomunicaction engineers, Matematicians, etc.
- Most departments **do research** and/or **support researchers**

Spanish Supercomputing Network

- CESGA belongs to the Spanish Supercomputing Network **(RES)**
- RES is a Unique Science and Technology Infrastructure **(ICTS)**
- CESGA is the second largest Supercomputing node in RES
- Provides **HPC services to the national and International research Communities**

Culture

- **CESGA usually work in collaboration with other institutions**
- Main goal is **to advance science and research** that eventually might have a **positive impact on society**
    - CESGA has its **own research groups and projects**
    - CESGA **collaborates** with other research groups
    - CESGA provides **HPC resources and supports researchers from other institutions**

Who can use CESGA Infraestructure?

- **Galician Universities (Coruña, Santiago and Vigo)**
- **Spanish National Research Council (CSIC)**
- **Other Research Institutions from Galicia**
- **Collaborators**
- **Users from Spanish Supercomputing Network (RES)**

CESGA
GALICIA SUPERCOMPUTING CENTER

Classical Infraestructures

HPC for Researchers since 1993

Aspecto do VP2400 de Fujitsu o 22 de xaneiro de 1993, no inicio da instalación na sede do CESGA, na imaxe da esquerda. Na outra imaxe, Juan Casares, segundo pola esquerda, observa os axustes que realizan os técnicos que participaron no proceso de instalación e posta en marcha do supercomputador o 25 de xaneiro de 1993. Fotos: Cortesía Manuel Millares

O SUPERCOMPUTADOR MÁIS POTENTE QUE ESTABA INSTALADO EN ESPAÑA EN 1993

History of CESGA's Supercomputers

Finisterrae III: Datasheet

714 processors of 32 cores each (**22.848 cores in** total)

157 GPU accelerators A100

126 TB of agregated memory

359 TB of storage in high performance SSD disks

Infiniband HDR 100 network

30 qubits simulator of a quantum computer

Peak performance: **4,36 PetaFLOPS**

Storage Systems

- NAS NetApp Cabinet: **1.3PB**
- High Performance Lustre-based Storage system: **1PB**
- High Capacity Lustre-based Storage system: **3PB**
- Tape Library: **25 PB**
- CEPH: **3PB**
- **Aggregated Storage: >33 PB !!**

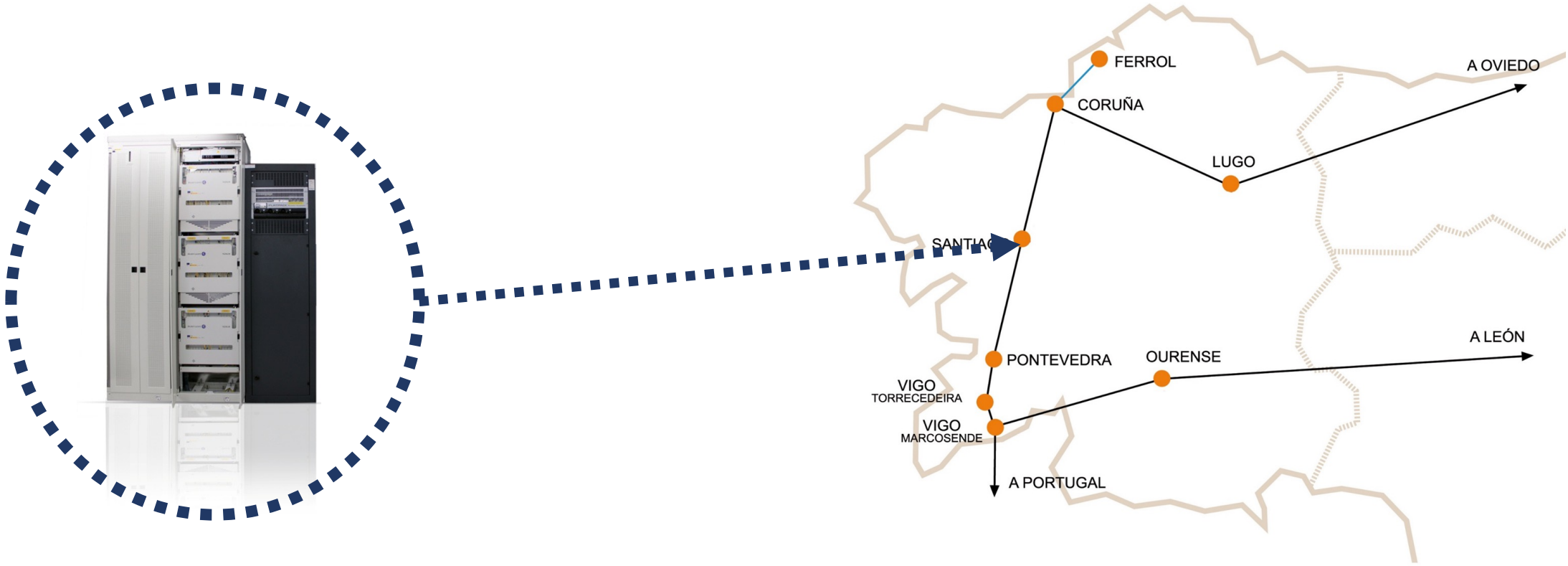
Hardware Resources

The cloud infrastructure is growing a lot!

	Cloud 1	Cloud 2	Cloud 3
Year	2009	2013	2021
Cores	1.200	1.464	>10.000
Memory	2,4 TB	3,5 TB	24 TB
Storage	5,6 TB	63 TB	3.000 TB
Platform	Opennebula 1	OpenNebula 5	OpenStack Xena

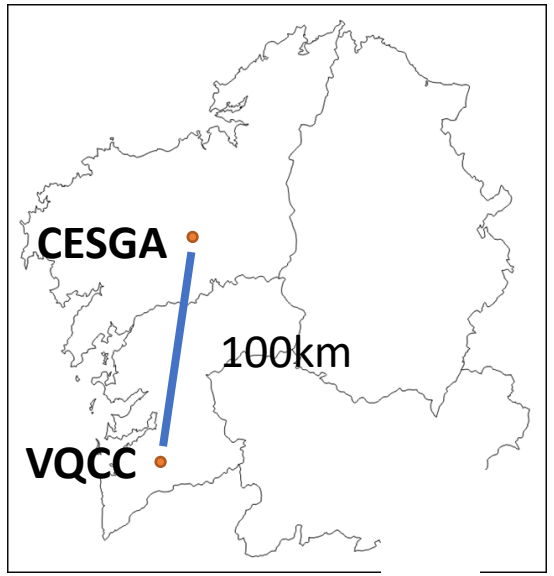


Galicia Science and Technology Network (RECETGA)



Quantum Communications Technology

- **Quantum Link (QKD) between CESGA and VQCC (Vigo) – Coming Soon!!**
- **Quantum Comunication Lab – Continuous Variable QKD**



What about Future Infrastructures?

New CESGA Infraestructures for 2026

- Budget: **47,4 M€ (+taxes)**

- Deadline: **June 2026**

- **4 Projects:**
  - **Classical Supercomputer: 15,5 M€**
  - **Quantum computer: 15 M€**
  - **Storage: 6,5 M€**
  - **Datacenter: 10,4 M€**

- **The projects include budget for hiring people**

CESGA
GALICIA SUPERCOMPUTING CENTER

2

Quantum Infraestructures

Quantum Technologies

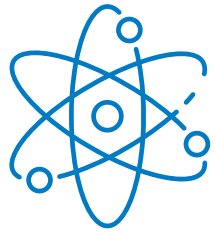
What is the potential of these technologies?

A new Internet with **unbreakable security**

Solving problems that are intractable with **classical computing**

Solving very challenging problems with **low energy consumption**

Sensors with extraordinary accuracy

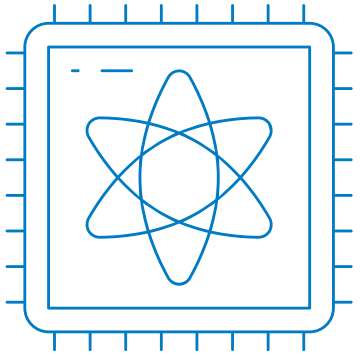


Understanding **complex quantum systems**

Galicia Quantum Technology Hub

- Lead by CESGA
- **Collaborative effort**
- Strategic plan includes an investment of **154M Euros (more than 30M already invested)**
- Quantum Computing, Quantum Communications and Quantum Sensing

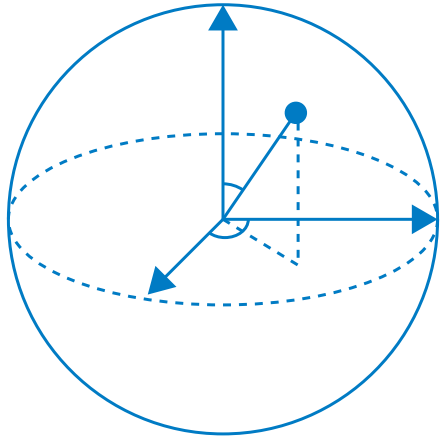
Quantum Computer Simulators



- Quantum Learning Machine (**QLM) de 30 qubits** (ATOS)
  - CESGA researcher reach **38 qubit simulations**
- **Fujitsu Quantum Emulator**: FX700 + MPI QULACS
- **Other simulators** (Qiskit aer, projectQ, YAO, etc.)

CESGA
GALICIA SUPERCOMPUTING CENTER

Quantum Random Number Generator (QRNG)

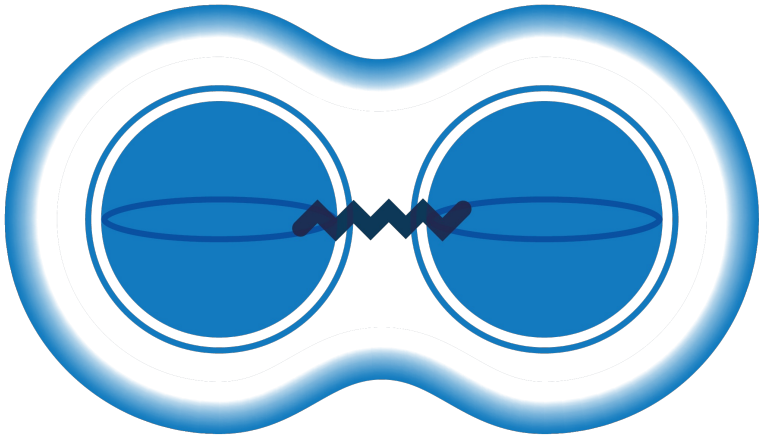


- **Quantum Random Number Generator (QRNG)** from the company **QUSIDE**
- We are **building a better interface** to give an easier access to the QRNG
- Technology based on a patent from **Marcos Curty** (VQCC)
- **Users can already access it!**

QUSIDE

Quantum Key Distribution (QKD) Link Between Santiago and Vigo

Quantum Key Distribution (**QKD**) link **between Vigo and Santiago de Compostela (100 km)**



We are working on the adquisition of the **fiber and the electronic equipment**

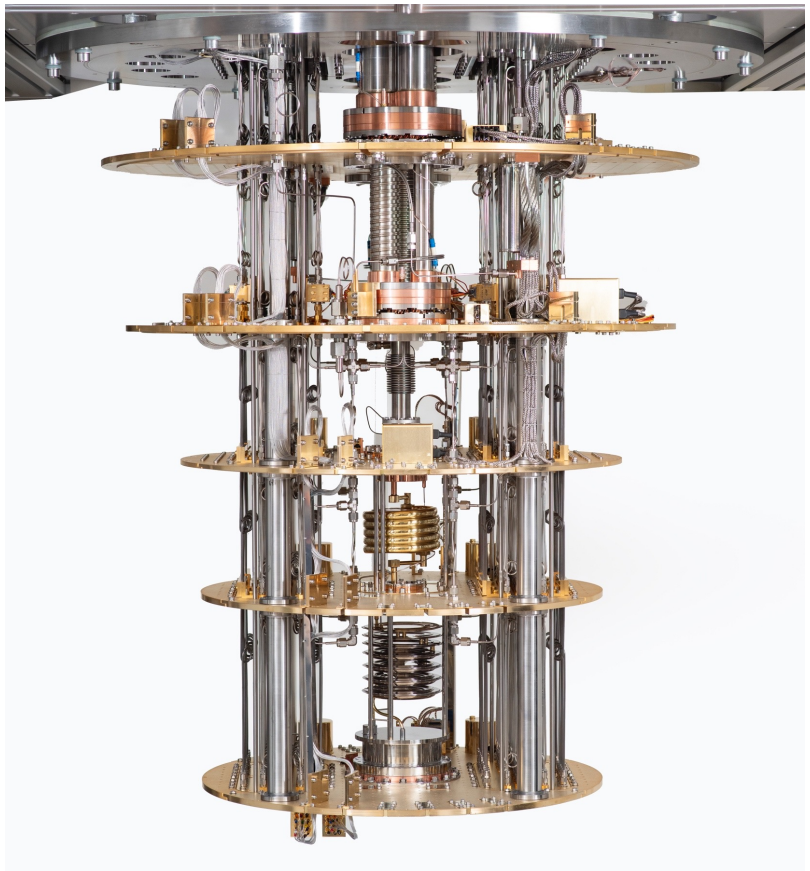
CESGA
GALICIA SUPERCOMPUTING CENTER

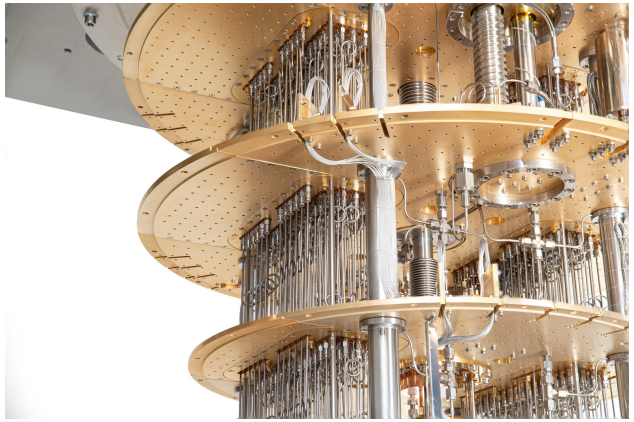
Qmio

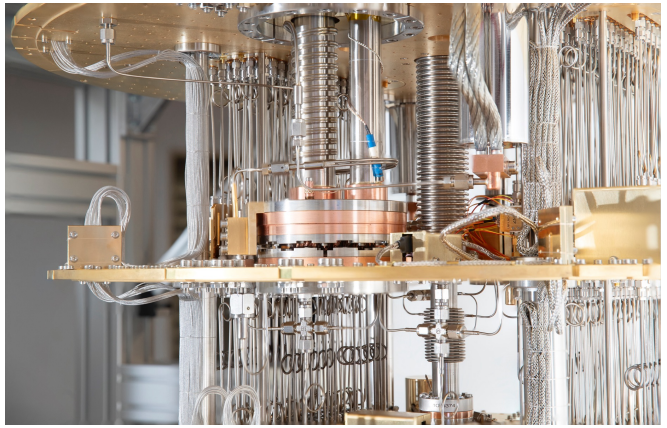
32 Superconducting Qbits

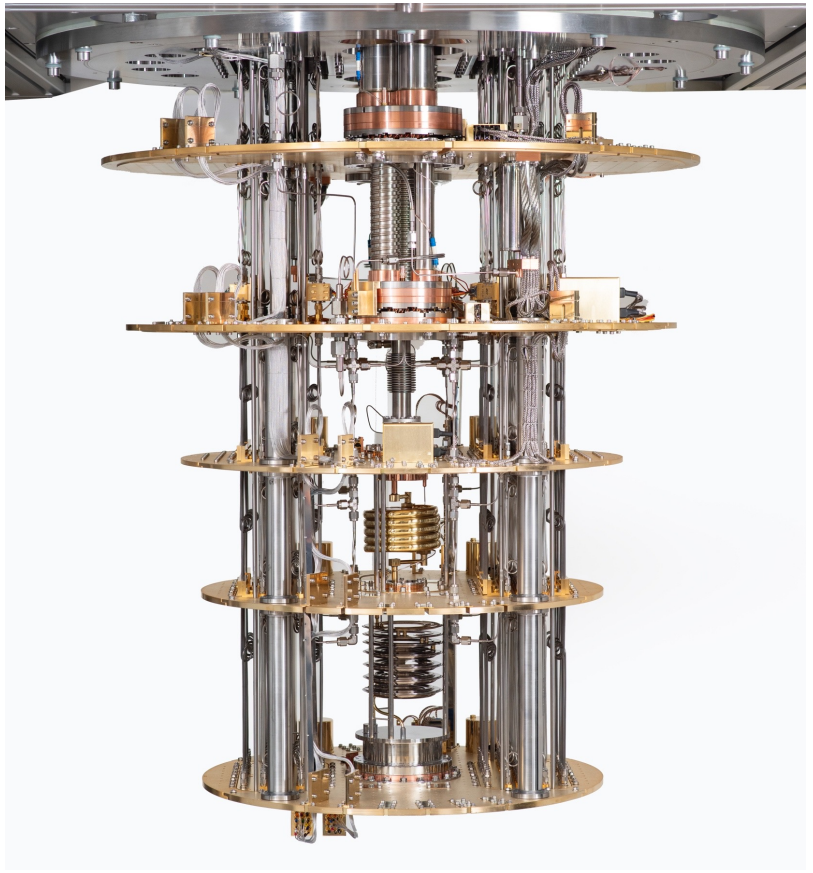
Galicia in the forefront of quantum computing in Europe

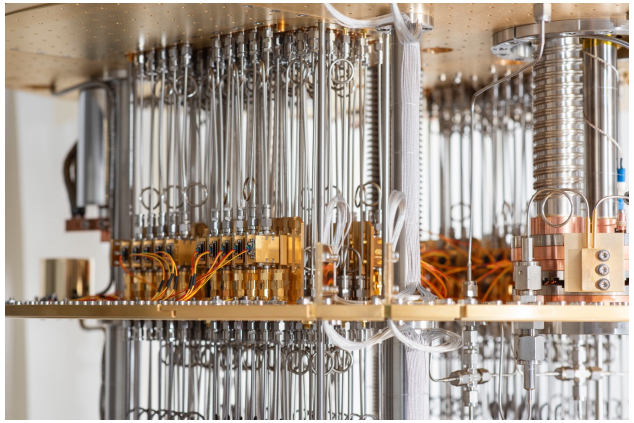
The digital Quantum Computer with more Qbits in an European Public Institution

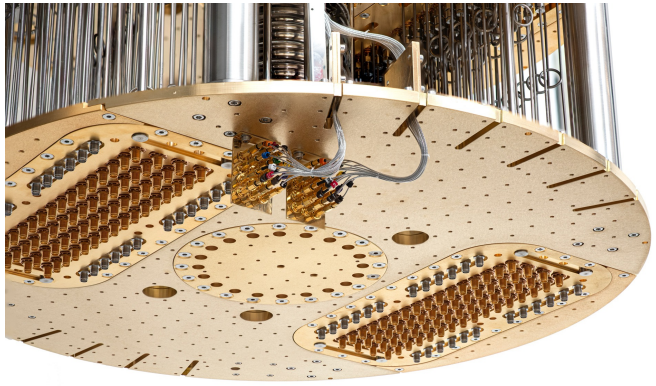












CESGA
GALICIA SUPERCOMPUTING CENTER

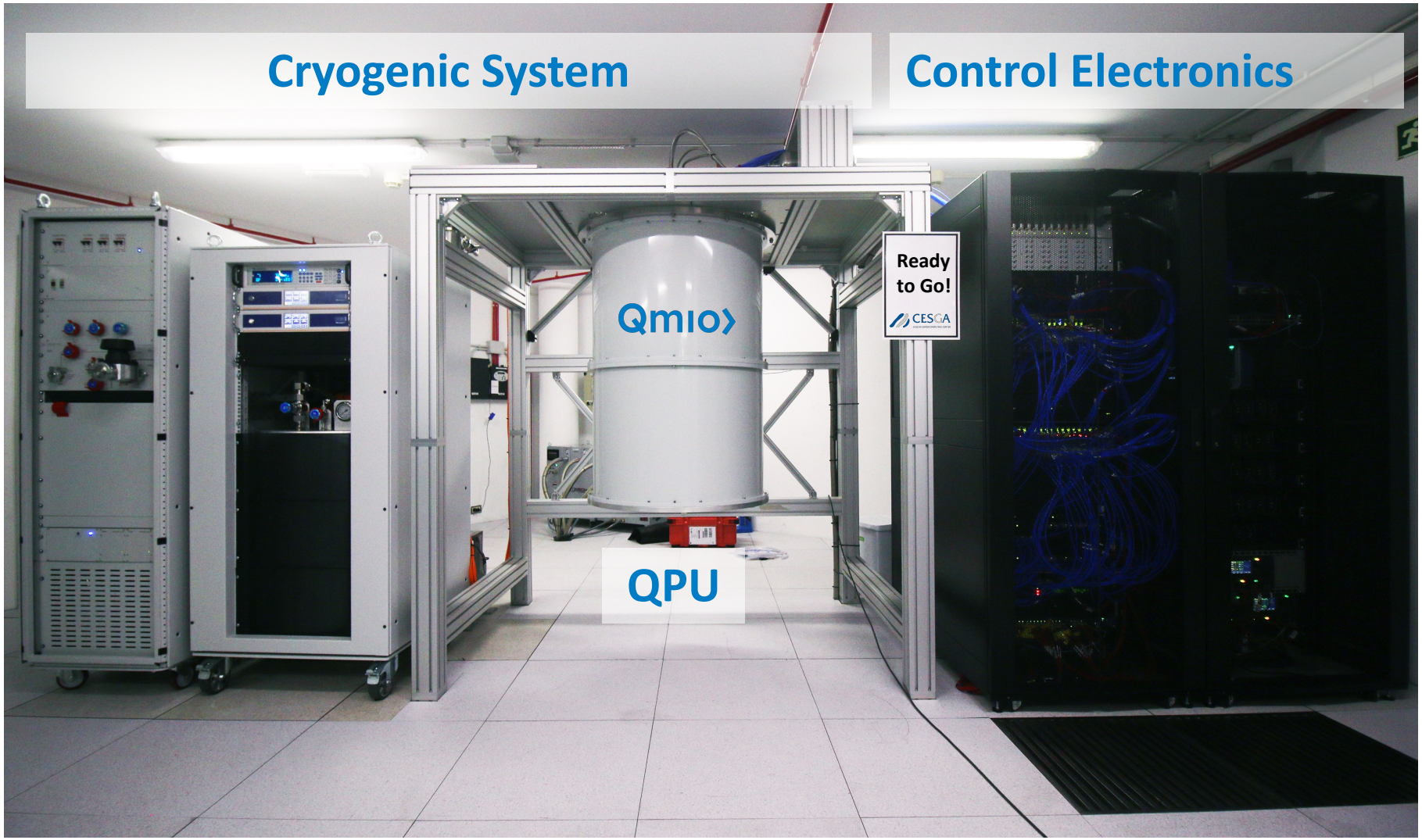
QMIO, the quantum computer with more Qbits of South Europe

- Fujitsu in collaboration with **Oxford Quantum Circuits (OQC)**
- **Call for proposals is open to users**
- **Coaxmon technology, QPU W3X of 32 qbits**
- Funded by Feder REACT UE, throught the Axencia Galega de Innovación

AXENCIA GALEGA DE INNOVACIÓN

UNIÓN EUROPEA

Xacobeo 21·22


Cryogenic System
Control Electronics
Qmio›
Ready
to Go!
CESGA
QPU

CESGA
GALICIA SUPERCOMPUTING CENTER

3

Research and I+D Projects

Research

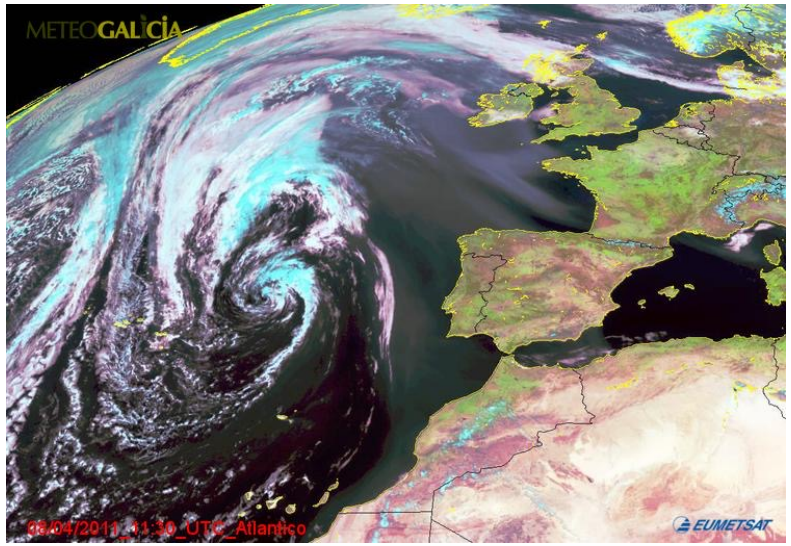
CESGA is also a Research Center

CESGA participates in many **Research Projects** and **Collaborates to advance Science and Technology**

Current Research Lines:

- **High Performance, Secure and efficient Computer Systems**
- **Big Data**
- **Applied Machine Learning**
- **Quantum Computing**
- **Quantum Comunications**
- **Educational Technology**
- **Geografical Information Systems**
- **Earth Sciences**
- **Life Sciences**

Galician Weather Forecasting Service

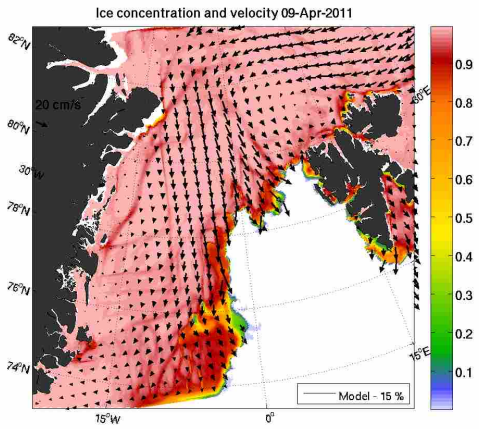


- Weather Forescast: prediction calculated at CESGA twice per day
- Research: Neural Networks applied to Clima and Weather Forecasting

Ocean Forecasting Service

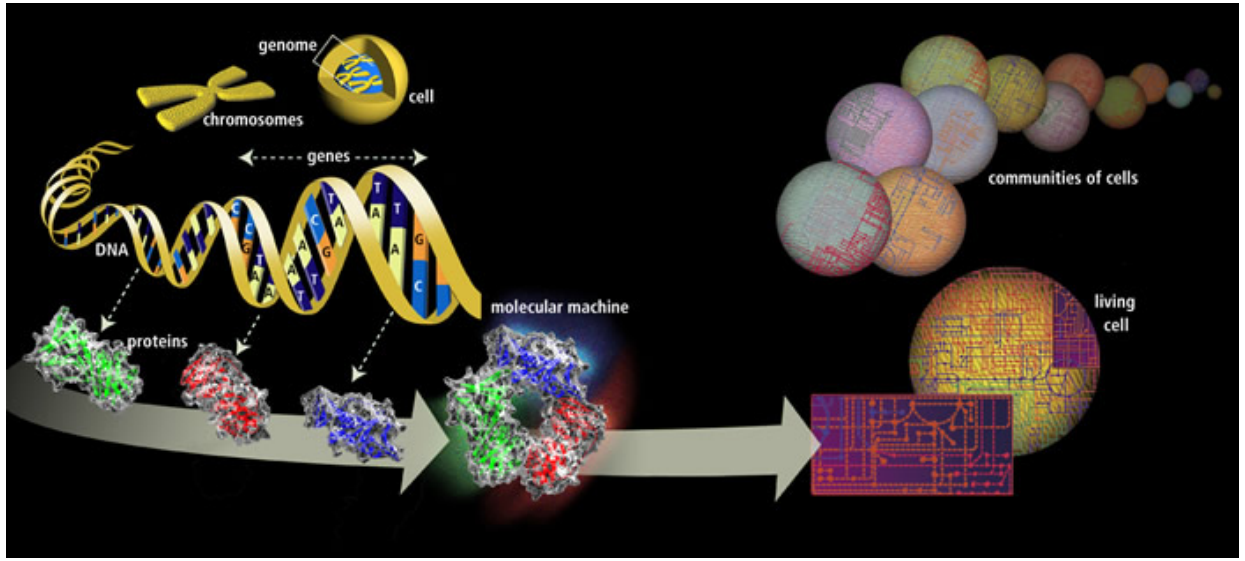
Copernicus (the Earth observation component of the European Union's Space programme)

European IBI (Iberian-Biscay-Ireland) Area



Galician Public Health Administration

- **Fundación Galega de Medicina Xenómica**
- **Genomic analisys** (more than 30K last year)
- **Lead by Ángel Carracedo**



Sinfonia Project

- **Radiation risk evaluation of detrimental effects** from radiation exposure of patients with lymphoma or brain tumour

- **Goals:**
  - Develop Dose estimation tools (computational tools, AI)
  - Research on Individual sensitivity to radiation
  - Develop a novel patient risk evaluation tool
  - Etc.

- **Funded by H2020 program**
- **4 years (2020-2024)**

Galicia Ocean Science Program

- Large Project: **89 research groups involved**

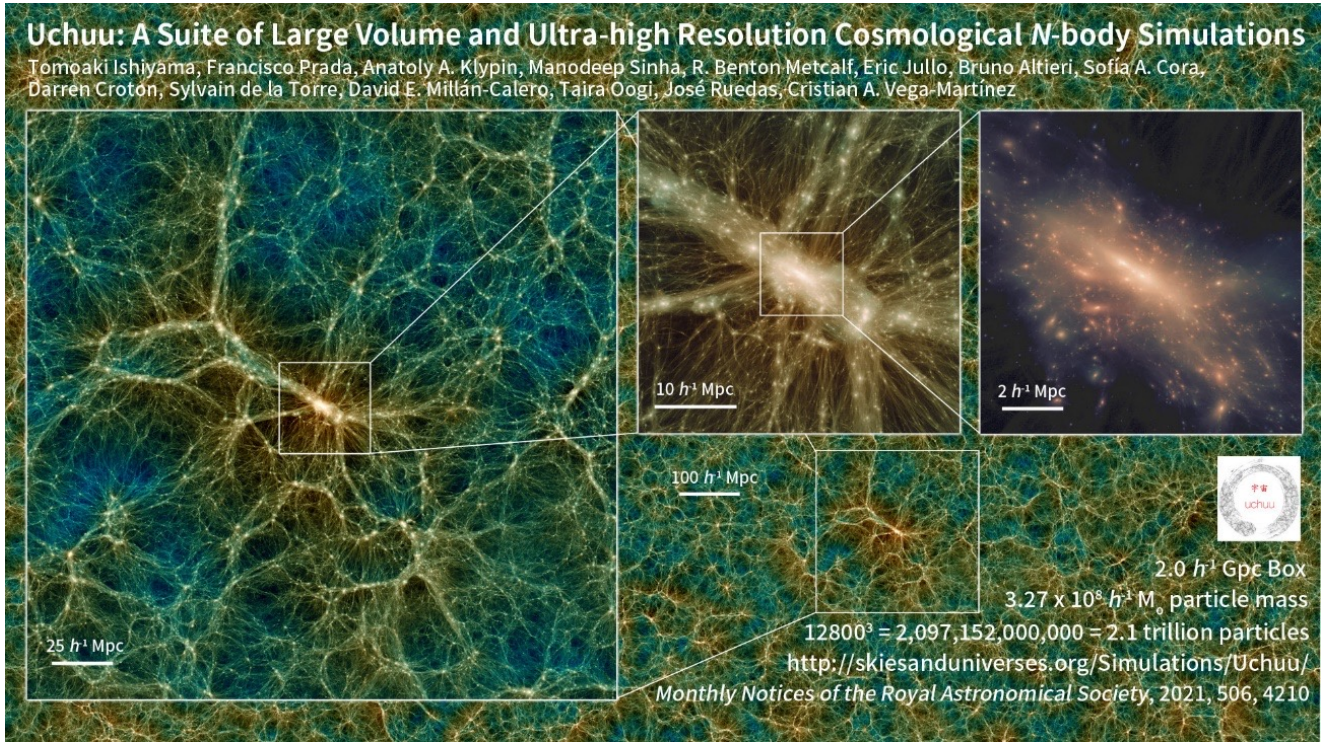
- **Main action lines:**
  - Monitoring the ocean and the coast
  - Sustainable aquaculture
  - Innovation and Oportunities

- **CESGA:**
  - Building the integrated platform of ocean data
  - **2+2 people**

- **Total Budget: 10M**
- **CESGA Budget: 274K**

UCHUU Project

- **The largest simulation of the Universe**
- **CESGA + IAA:** Move the data from Japan, optimization of data, and gave access to researchers (cloud-based infrastructure)
- **N-Body simulation**, 2.1 trillion particles



FINSA

- **FINSA**: Industrial transformation of wood
- **Project:** optimization of the production line using Machine Learning Techniques
- Collaborating with CESGA since **5 years ago**

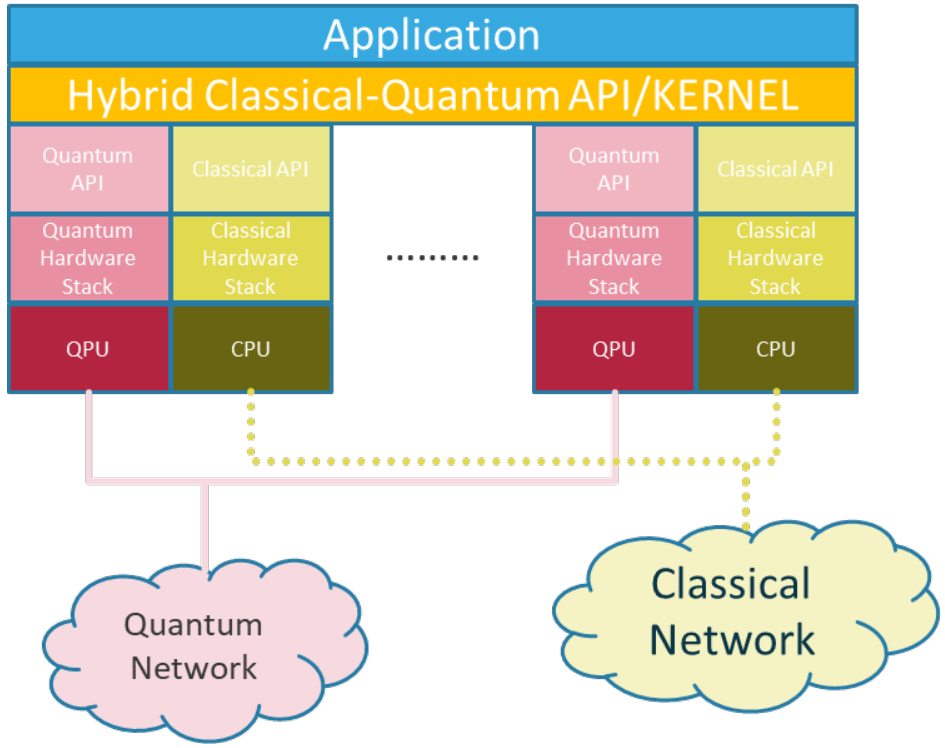
Our Quantum Computing Vision

- **Vision**: quantum computers are going to be **accelerators** of certain kernels (in a similar way as GPUs are accelerators today)

- All quantum algorithms need a **classical part**
  - At least, they need to **initialize** the **qubits**, and **read the results**

- **All algorithms are hybrid**

- **Interests:**
  - HYBRID ALGORTHMS
  - PARALLEL QUANTUM CIRCUITS
  - QUANTUM MACHINE LEARNING
  - BENCHMARKING
  - INTEGRATING QUANTUM COMPUTING IN HPC
  - QUANTUM COMMUNICATION & QKD



CESGA
GALICIA SUPERCOMPUTING CENTER

NEASQC European Project

- Funded by the **European Comision** (Horizon 2020)
- Multidisciplinar consortium composed of **12 companies and research labs**
- **4 years project**
- **Goals**:
  1. Developing **industrial applications**
  2. Develop **open-source libraries**
  3. Create a **strong community around industrial applications** for quantum computers
  4. Develop quantum computing **software stacks and benchmarks**

<NE|AS|QC>

National Project

- Firts quantum computing **ecosystem** of Spain
- Budget: **22M €**
- **Infrastructures**:
  - **One superconducting quantum computer** (BSC)
  - **3 simulators of quantum computers** (**CESGA**, SCAYLE, BSC)
- **Access**:
  - Through the **Spanish Supercomputing Network (RES)**
- **Research**:
  - Universities and Research Centers
- **Training Program** (USC)


CESGA
GALICIA SUPERCOMPUTING CENTER
4
Conclusion

Conclusion

- CESGA is the **second largest Supercomputing Center in Spain**
- CESGA has the **Quantum Computer** with more qubits in the South of Europe
- CESGA **collaborates with other institutions** in research projects
- CESGA provides **HPC services and support to researchers**
- CESGA is involved in many **European Projects**
- CESGA will have **large investements in the next 2 years (mainly infrastruture, but also people)**


CESGA
GALICIA SUPERCOMPUTING CENTER
5
Thanks For Your Attention

CESGA
GALICIA SUPERCOMPUTING CENTER

A iniciativa do Polo de Tecnoloxías Cuánticas de Galicia conta con financiamento de:

Fondos REACT EU

AXENCIA GALEGA DE INNOVACIÓN

UNIÓN EUROPEA

Xacobeo 21·22

CESGA
Centro de Supercomputación de Galicia

Despregamento dunha infraestrutura baseada en tecnoloxías cuánticas da información que permita impulsar a I+D+i en Galicia.

Apoiar a transición cara a unha economía dixital.

Operación financiada pola Unión Europea, a través do FONDO EUROPEO DE DESENVOLVEMENTO REXIONAL (FEDER), como parte da resposta da Unión á pandemia da COVID-19.

PROGRAMA OPERATIVO
FEDER GALICIA
2014-2020

Unha maneira de facer Europa

CESGA
GALICIA SUPERCOMPUTING CENTER

Fondos do Plan de Recuperación, Transformación e Resiliencia

Quantum SPAIN

España | digital 2026

GOBIERNO DE ESPAÑA
VICEPRESIDENCIA PRIMERA DEL GOBIERNO
MINISTERIO DE ASUNTOS ECONÓMICOS Y TRANSFORMACIÓN DIGITAL
SECRETARÍA DE ESTADO DE DIGITALIZACIÓN E INTELIGENCIA ARTIFICIAL

Plan de Recuperación, Transformación y Resiliencia

Financiado por la Unión Europea
NextGenerationEU

RES
RED ESPAÑOLA DE SUPERCOMPUTACIÓN

Apoiado economicamente polo Ministerio de Asuntos Económicos e Transformación Dixital do Goberno de España a través da convocatoria do proxecto QUANTUM ENIA - proxecto Quantum España, e pola Unión Europea a través do Plan de Recuperación, Transformación e Resiliencia – NextGenerationEU no marco da Axenda España Dixital 2025.

CESGA
GALICIA SUPERCOMPUTING CENTER

Plan Complementario de Comunicaciones Cuánticas:

Fondos Next Generation EU (MRR)

This work was supported by MICIN with funding from the European Union NextGenerationEU (PRTR-C17.I1) and with own funding from the Galician Regional Government through the "Planes Complementarios de I+D+I con las Comunidades Autónomas" in Quantum Communication.

Fondos propios da Xunta de Galicia a través da Axencia Galega de Innovación

AXENCIA GALEGA DE INNOVACIÓN

Subvencionado pola Axencia Galega de Innovación.

CESGA
GALICIA SUPERCOMPUTING CENTER

Fondos do Programa Marco de Investigación H2020

Este proxecto recibiu financiamento do programa de investigación e innovación Horizonte 2020 da Unión Europea en virtude do acordo de subvención n.º 951821.