

# INFN-LNGS Computing and Networking service: an overview


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**on behalf of INFN-LNGS Computing & Networking Service**


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# INFN-LNGS Computing and Networking staff

The Computing and Networking service manages and gives support to the scientific community for different topics:

- ✓ Cybersecurity and personal data protection
- ✓ Cloud services
- ✓ Mail and mailing list service
- ✓ Collaboration and communication systems (videoconference/streaming)
- ✓ Website creation
- ✓ Research data management and FAIR data repository
- ✓ Psychological support to the users! 😉



# Not only physicists @ LNGS…

Physicists play a key role in scientific research, but many other professionals are essential to achieve results.

They are working behind the scenes, and no one will win a Nobel Prize, but  they are nonetheless critical to the success of every experiments!

Engineers, chemists, network managers, experts in electronics and computer scientists are all key players in the research process!

**Together is the way forward.**

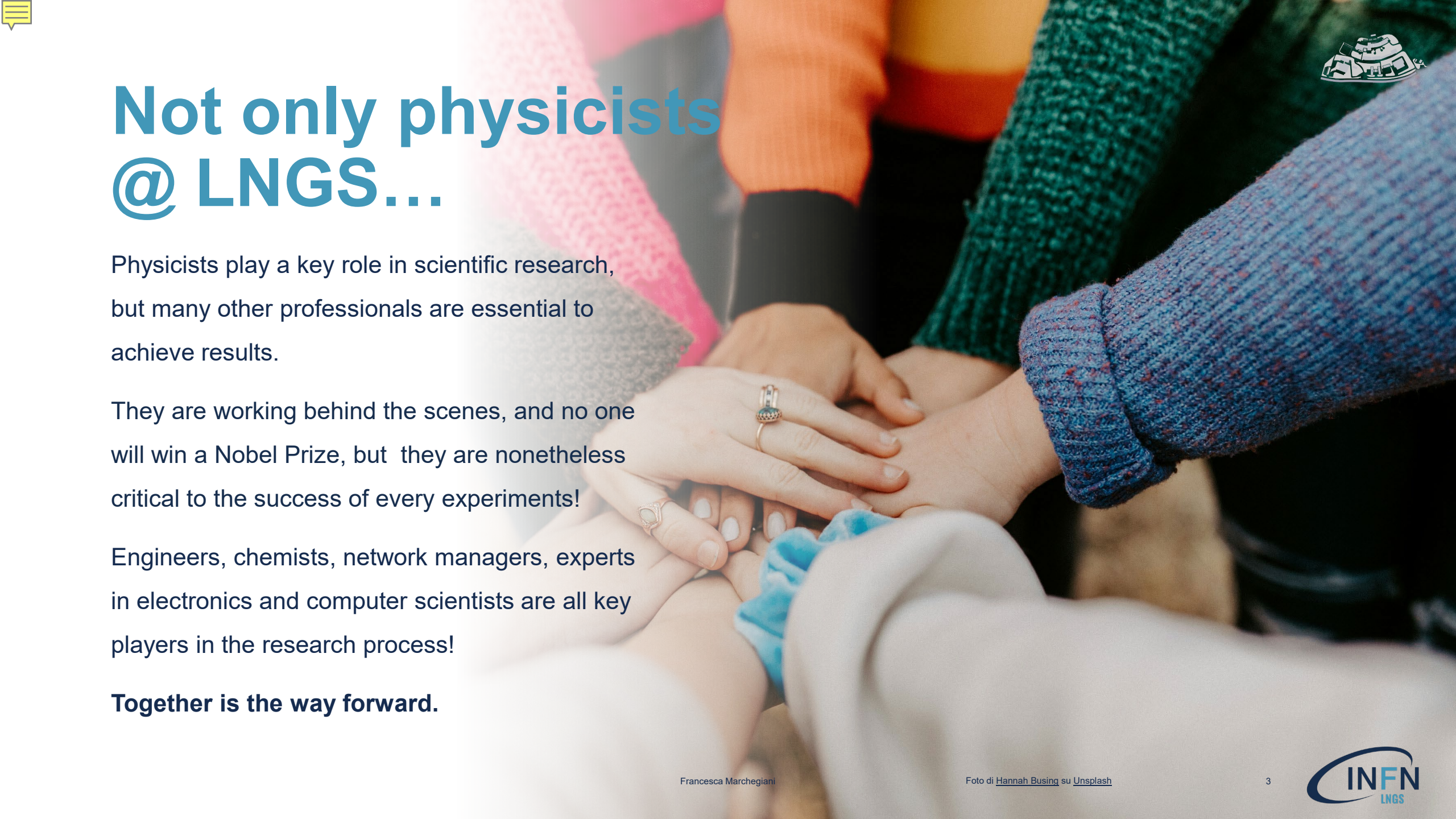


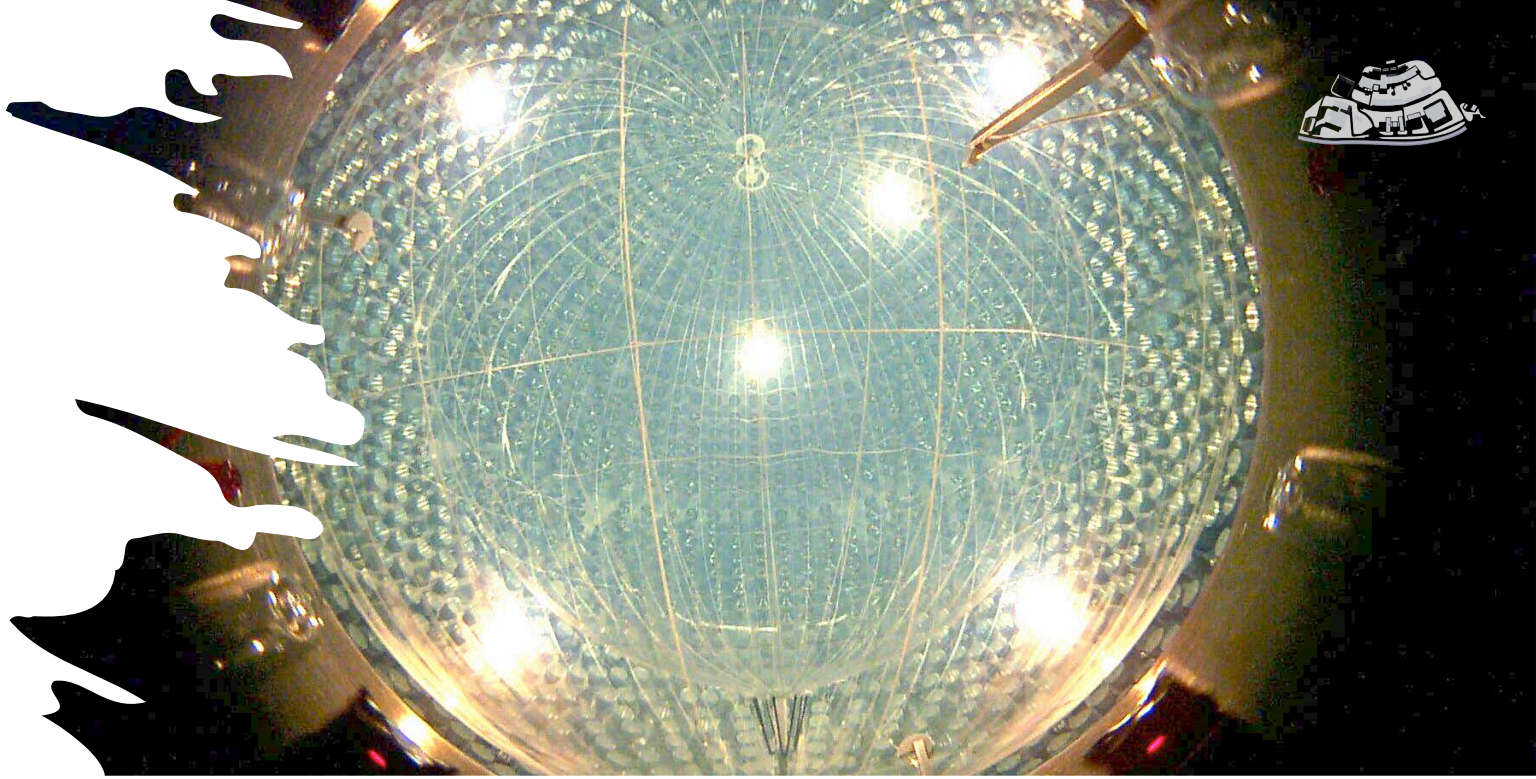


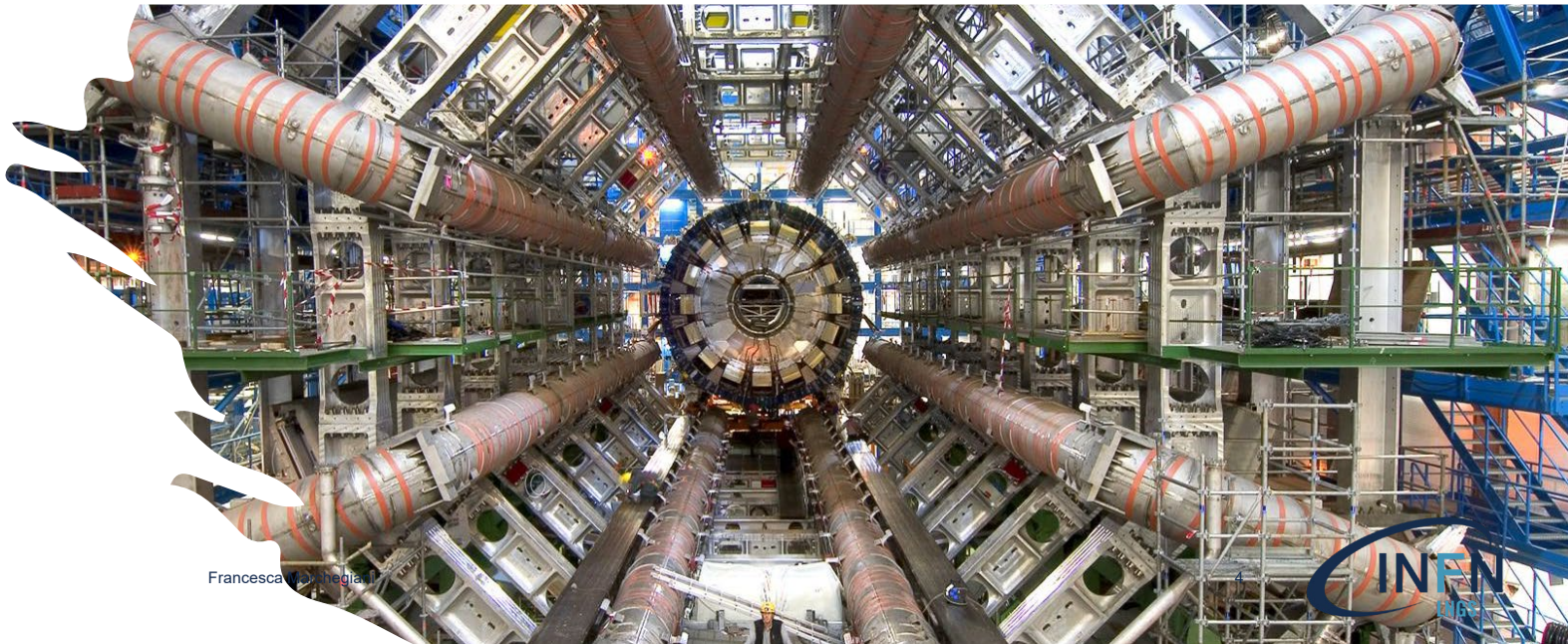
Foto di Hannah Busing su Unsplash

# Computing is important too!

Computers and Information Technology play a crucial role throughout the entire lifecycle of a scientific experiment:

- ✓ Developing and testing new theoretical models
- ✓ Designing new detectors
- ✓ Simulating particle interactions within the detector
- ✓ Acquiring data from the detector
- ✓ Analysing the collected data
- ✓ Sharing data, software, and scientific results..





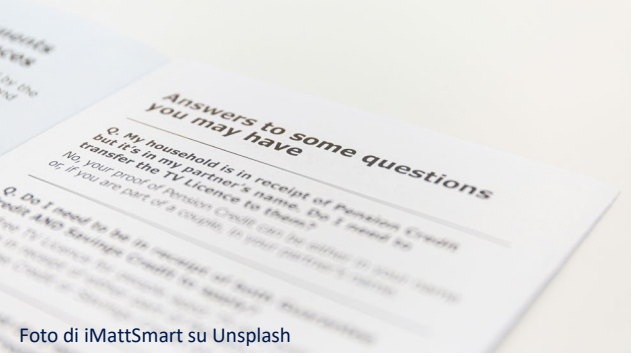


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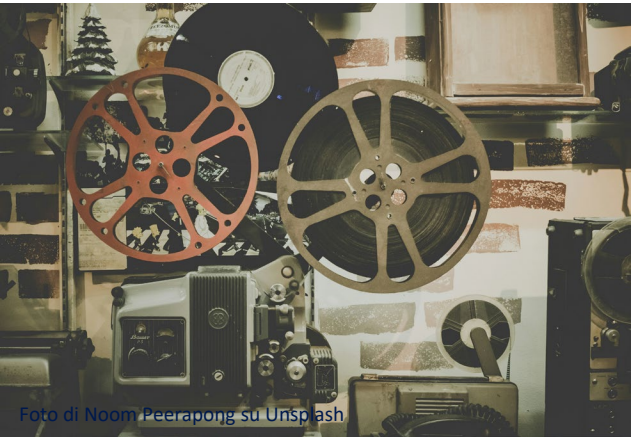
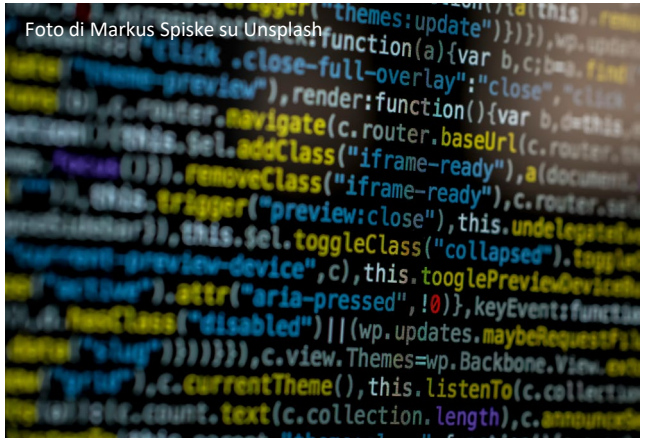

Foto di Noom Peerapong su Unsplash


Foto di Glenn Carstens-Peters su Unsplash



Foto di Markus Spiske su Unsplash

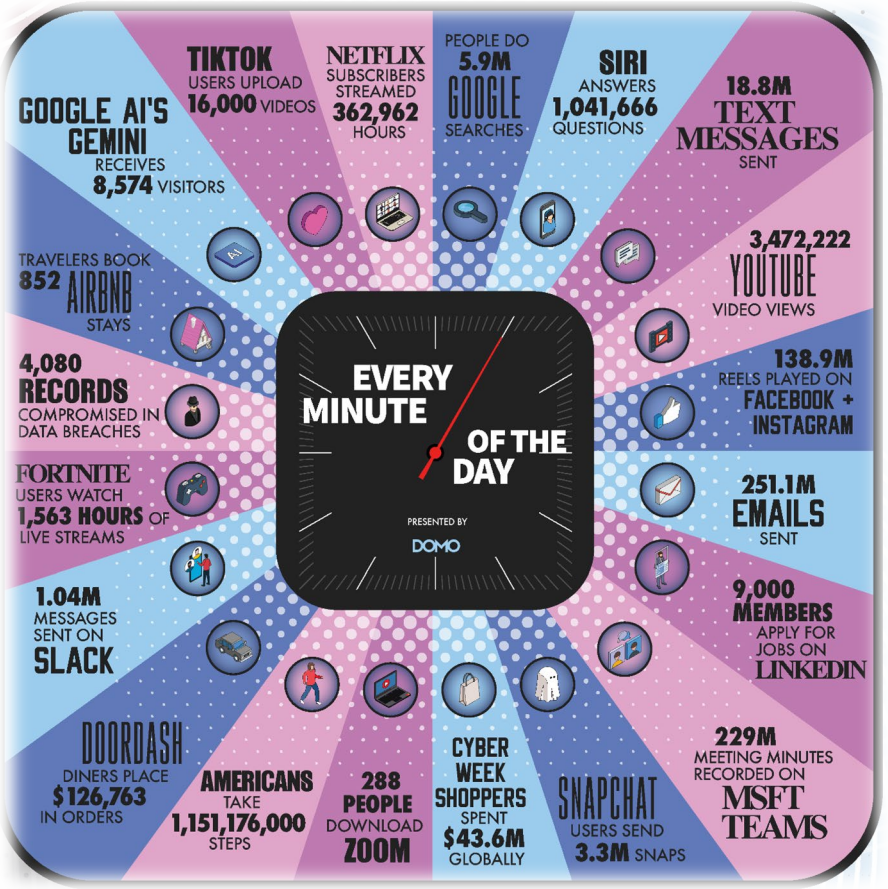

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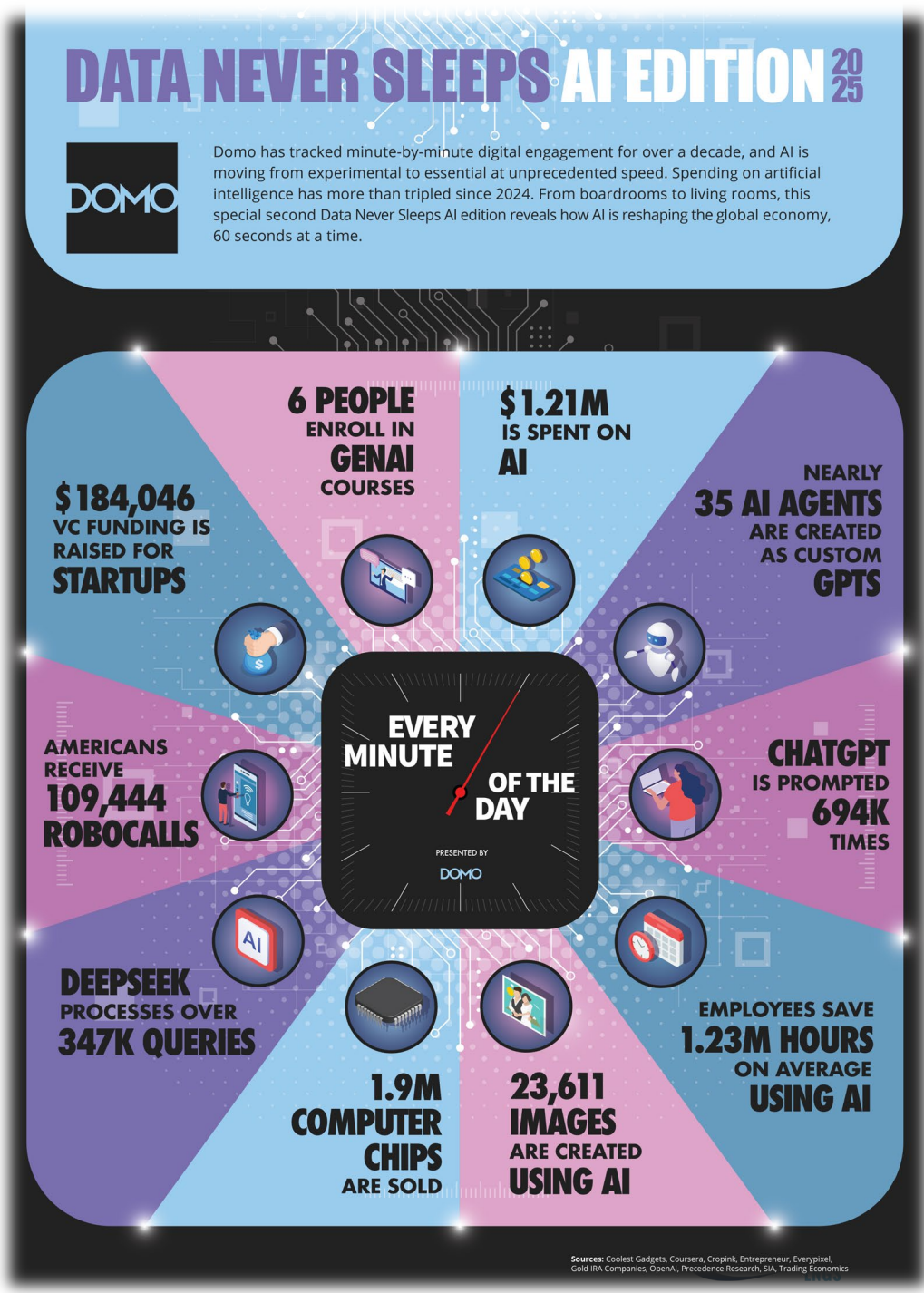
# What is data?

Any **information** or material that is collected, observed, generated, or used during the research process.

All **information** required **to support, validate, or reproduce the results of a research project**, included contextual details and secondary data.

# Big data



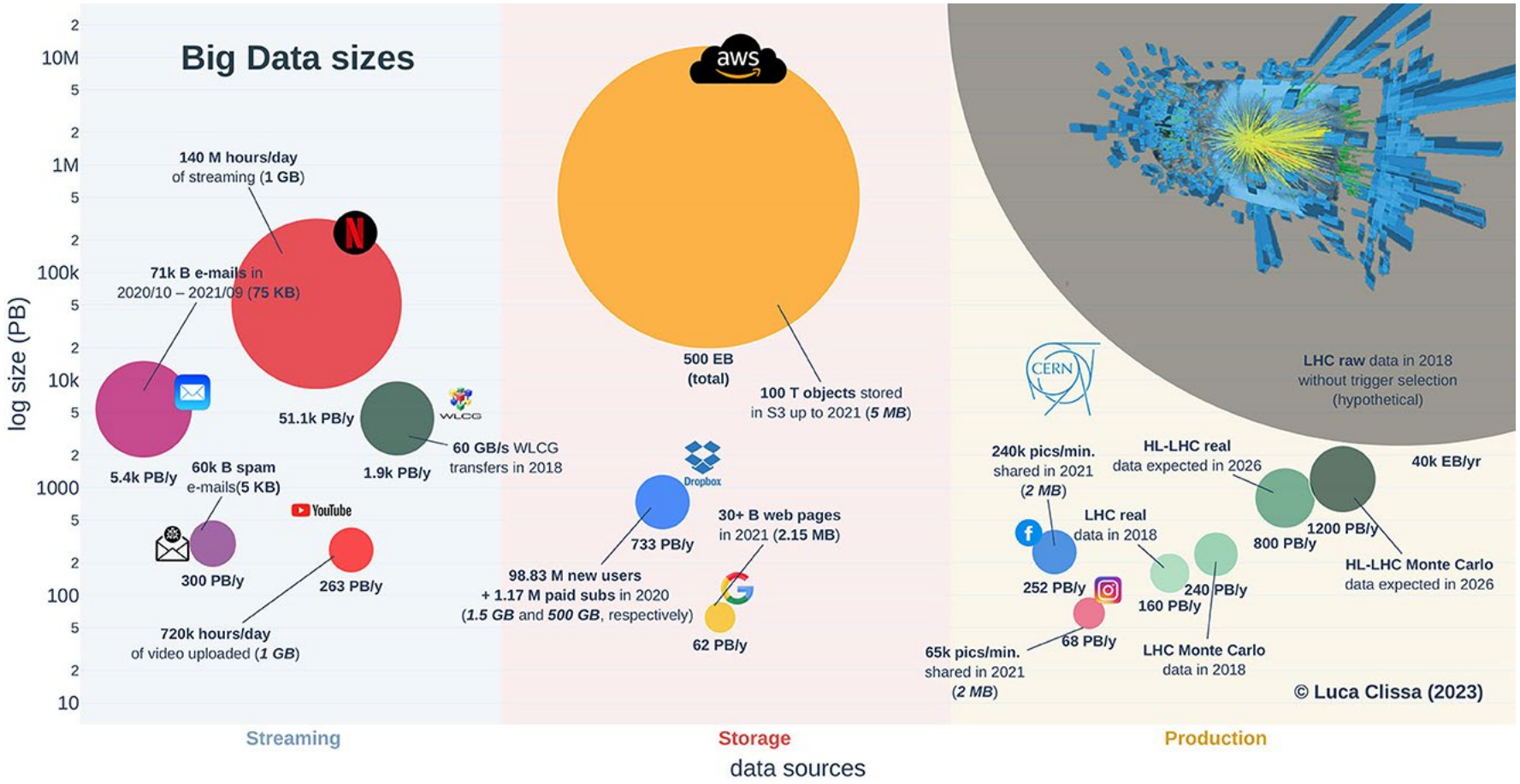

What happens in an Internet minute?

How big is “Big Data”?

Do you have any idea about the size of Big Data?

# Big data

Everyday life vs physics experiment



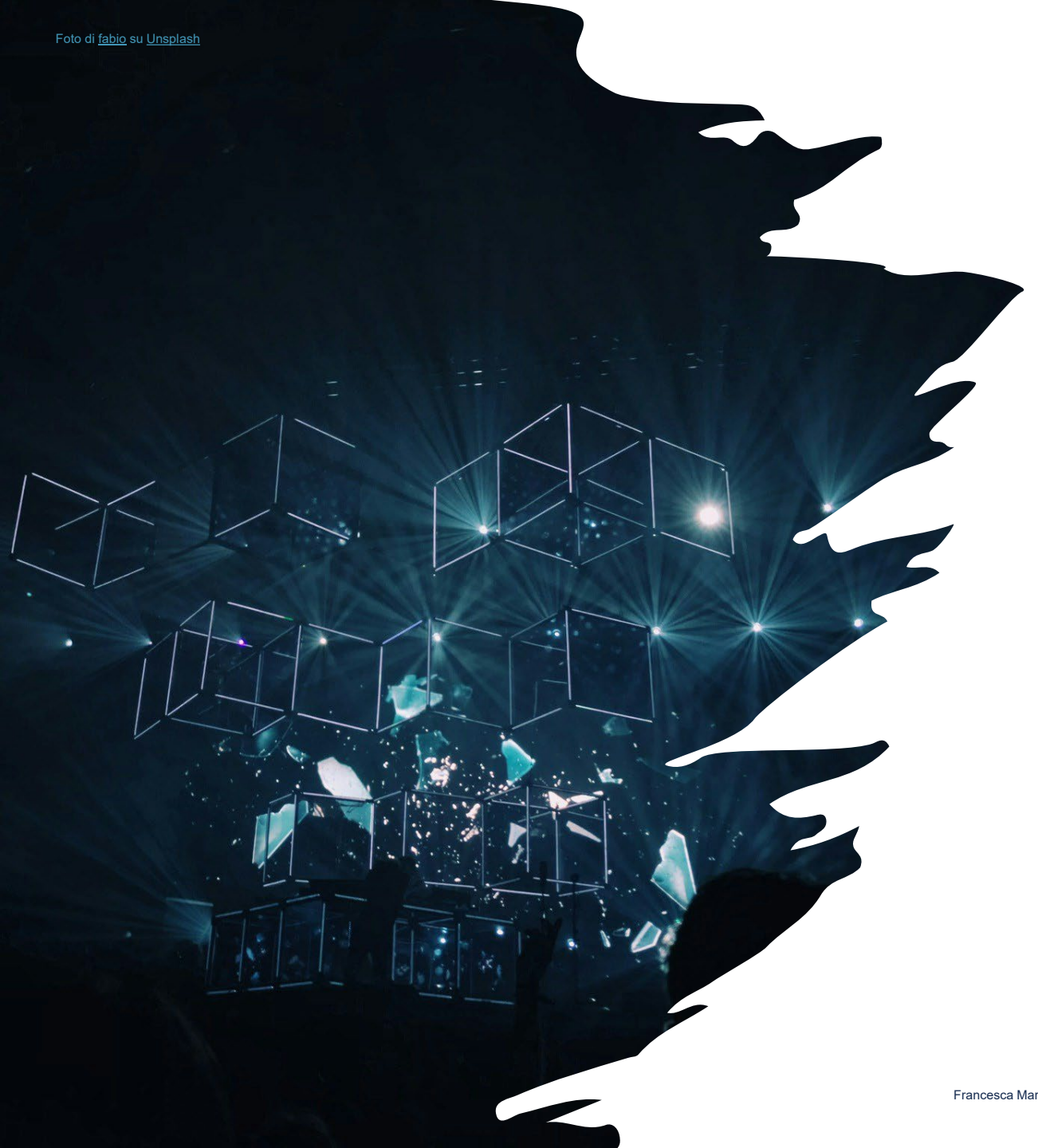


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# Big data @ LNGS

What happens in the context of a physics experiment?

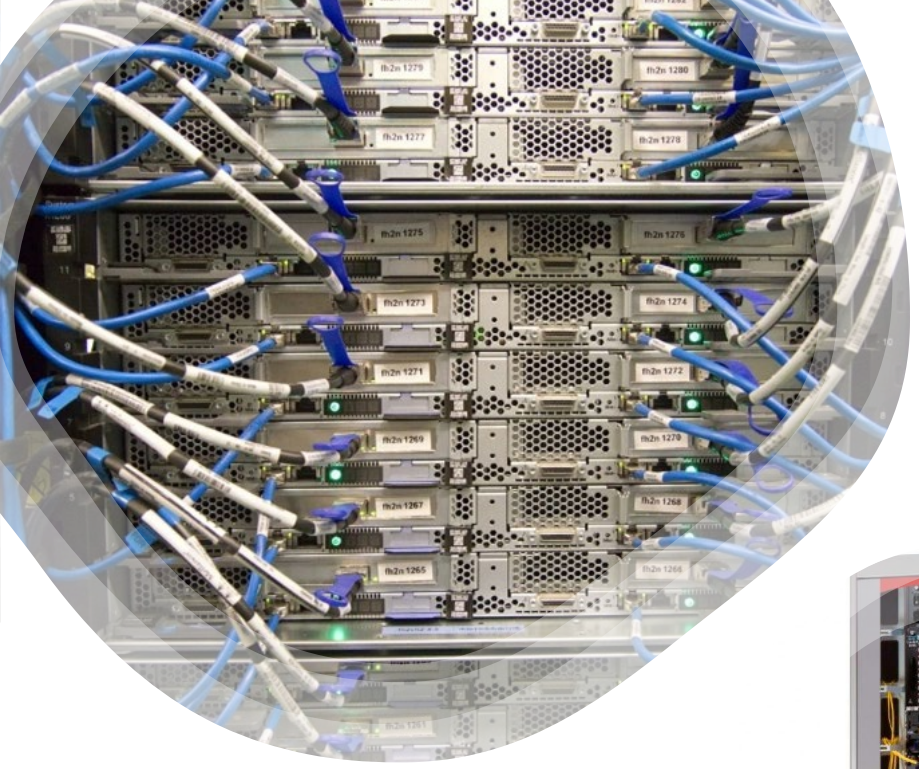
Large-scale experiments with many and complex detectors generate a huge amount of data!

Just to give you an idea:

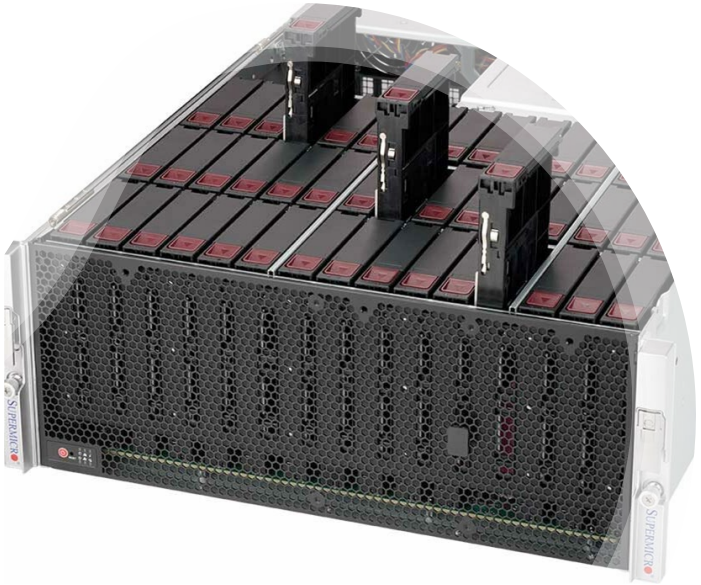
- ✓ Xenon ~1000TB/y
- ✓ Darkside-20K will produce more than 2PB/y

All this data needs to be stored on disks, and at the same time it's necessary to set up robust backup strategies and replicas!

These data are precious, so it's crucial to protect their integrity and availability.







# Data storage and computing power

Experimental data are stored in specialized high-capacity storage systems (hundreds of TB) with fast access speed (around 30Gbit/s).

Once stored, the data must be processed and analysed to select and extract meaningful scientific information.

Analysing such large volumes of data requires a huge computing power: rack full of servers!

# Data center

Usually rack full of storage and servers are hosted in “Data center”.

Data center requires **dedicated power supplies** to ensure equipment runs without interruptions!

Servers operate 24/7!

Equipments produce heat, so a data center needs **efficient cooling systems** to maintain optimal temperatures.

Modern green data centers use renewable energy sources and implement heat recovery systems to minimize environmental impact!






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# A network of data centre

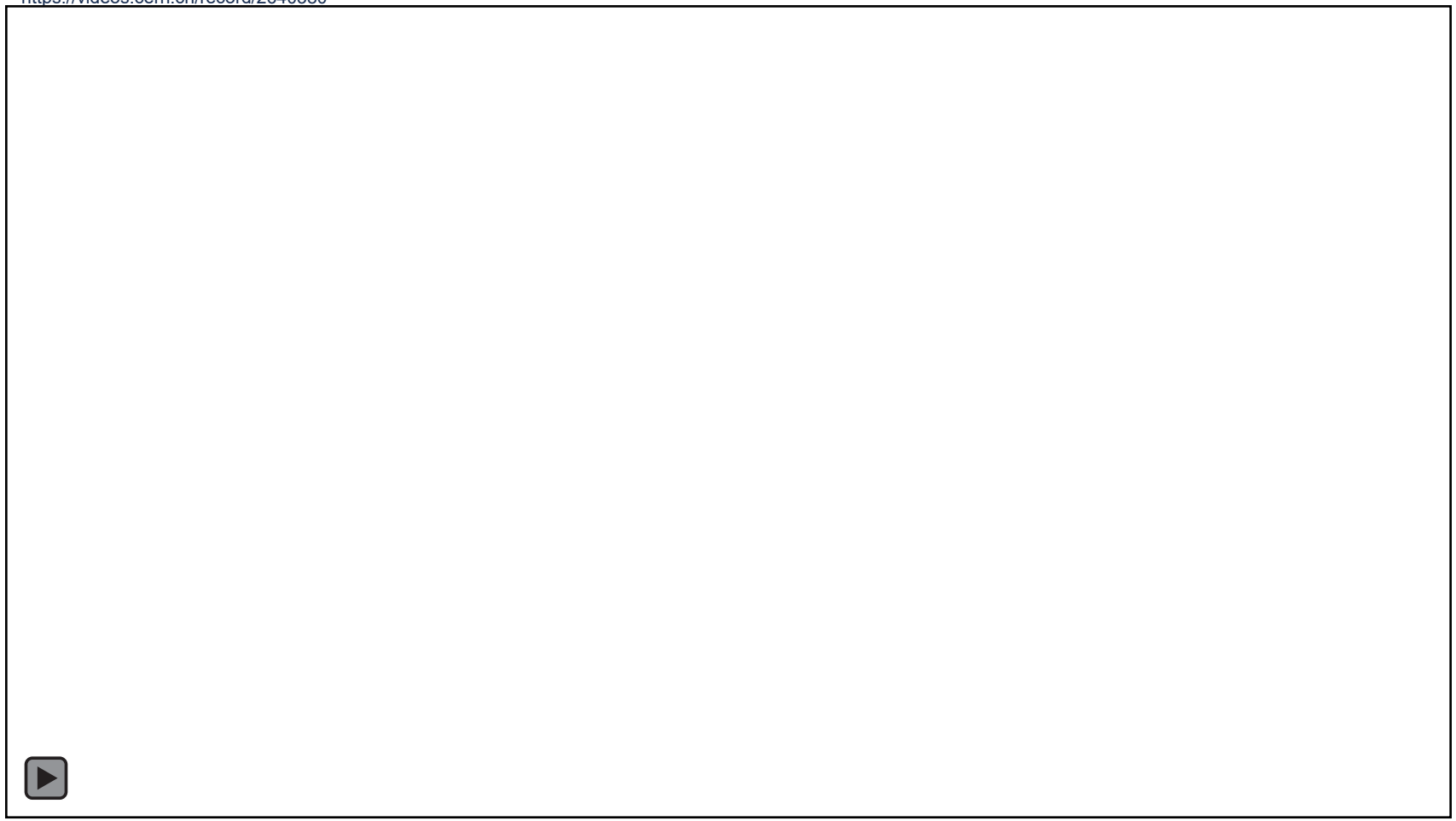
A single data centre often doesn't have enough computing power to analyse data produced by large-scale experiments.

Many data centres around the world, interconnected by high-speed networks, work together as a single huge computer.

It is the so-called computational **GRID**: a hardware and software infrastructure that provides access to distributed **computational** resources.

In recent years, distributed computing model has been evolving from GRID to CLOUD environments.

https://videos.cern.ch/record/2640380



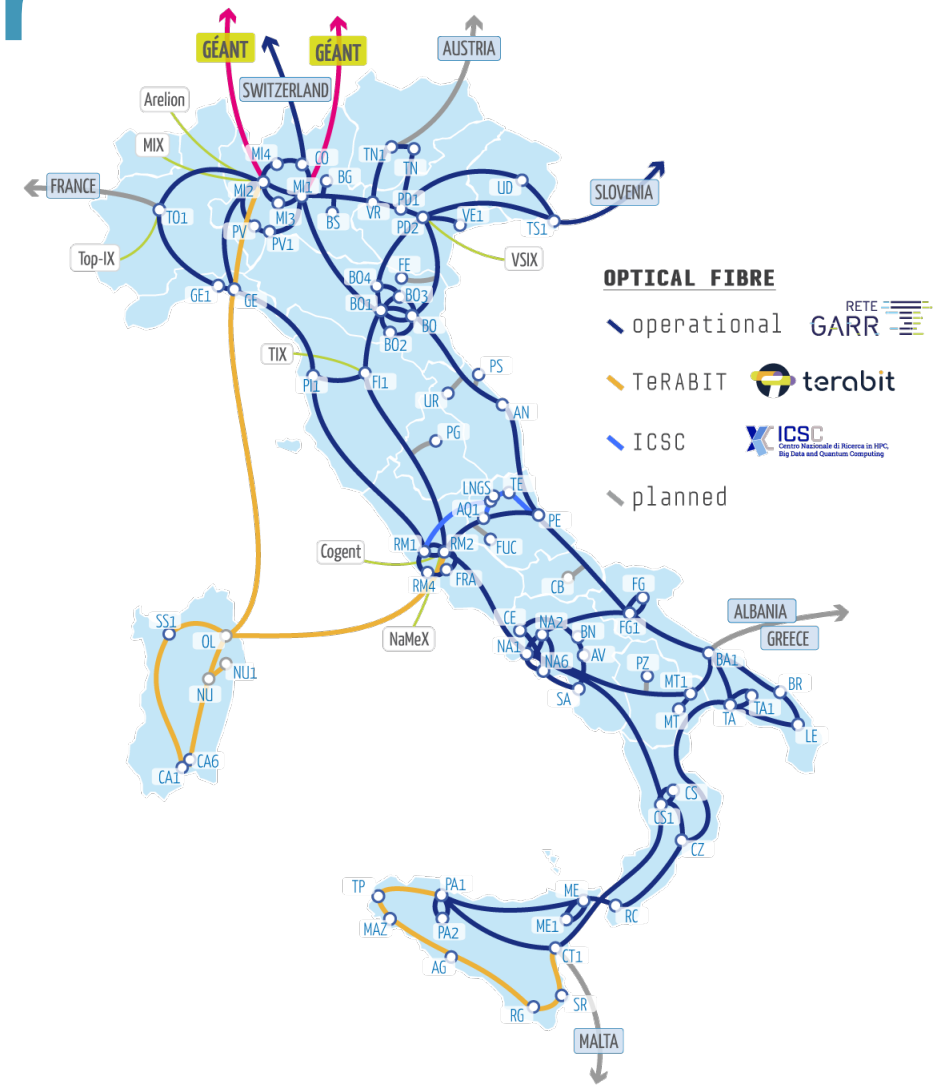
# A dedicated network for scientific data

High-speed network connections are essential to execute jobs on the GRID.

The **GARR network** interconnects universities, research centres, libraries, museums, schools and other institutions involved in education, science, culture and innovation across the country at very high speed.

This network (fibre-optic infrastructure) is used to transfer and share the large volumes of data produced by experiments.

Currently, LNGS is connected to the GARR network at **100Gb/s**.



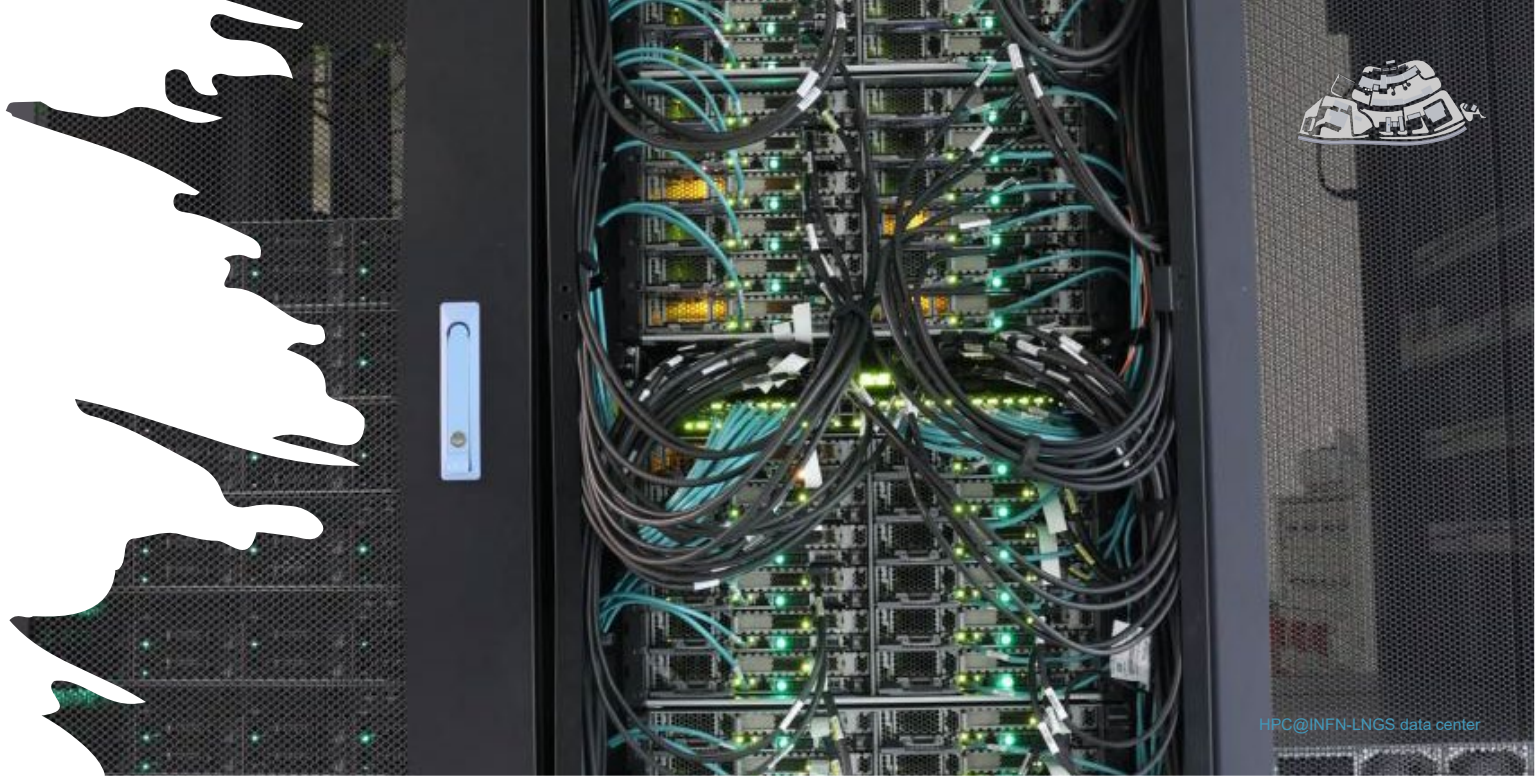

Source: https://www.garr.it/it/infrastrutture/rete-nazionale/rete-garr-t

# New technologies

High energy physics is a field where many new technologies have originated.

Today, emerging technologies are supporting physics research:

- ✓ **Machine Learning**, a subset of Artificial Intelligence, is used to extract useful information from scientific data (for instance, recognising particle tracks inside a detector to identify particle types) replacing traditional analytic procedures.
- ✓ **High Performance Computing (HPC)** and parallel computing are essential to simulate or analyse complex data structures.



HPC@INFN-LNGS data center



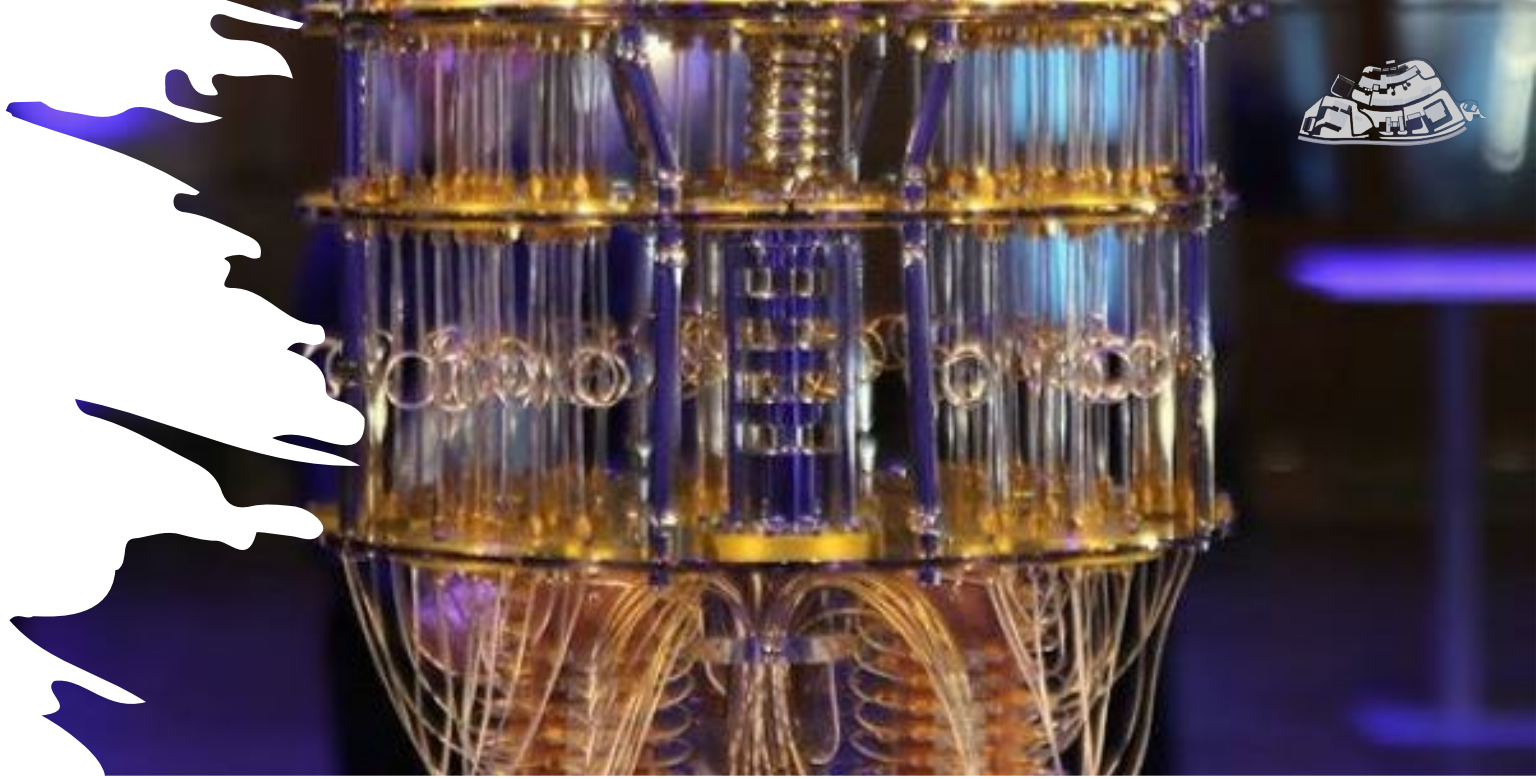
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# New technologies

Quantum Computing is a challenge!

Future Quantum Computing represent a new technology designed to solve computational problems that are too complex for classical computers.

Interestingly, the structure of quantum computers closely resembles the cryogenic experiments hosted at the LNGS underground laboratory





# LNGS Computing and Networking facilities

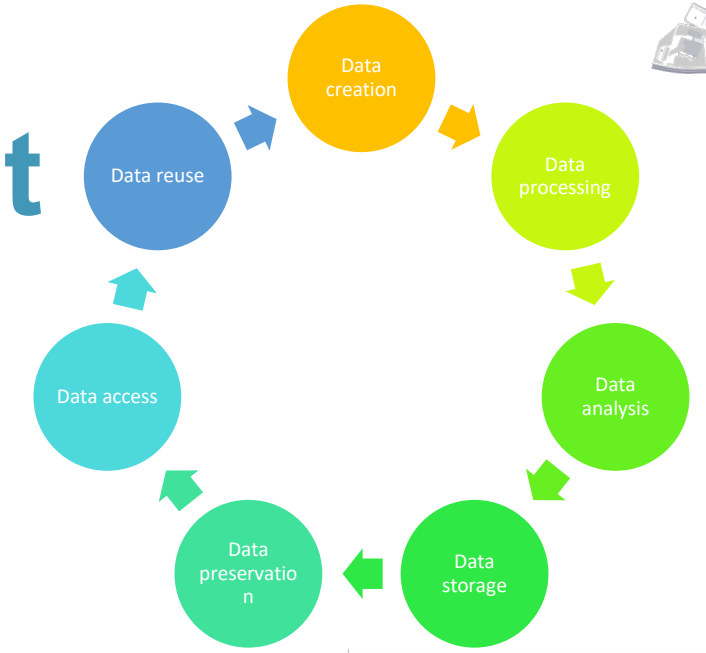
The **LNGS data centre** hosts servers, storage and backup systems to manage data coming from physics experiments hosted in the underground laboratory

A **dedicated optical fibre cable**, running throughout the motorway tunnel, transfers the data from the experimental site to the data centre located in the external laboratories.

The LNGS data centre is part of the **global research network**, and scientific data are transferred to other data centres across Italy and Europe.



# At the end of an experiment




Data are the primary outcome of scientific activity: they represent the heritage of a scientific research, and are often valuable, expensive and unique!

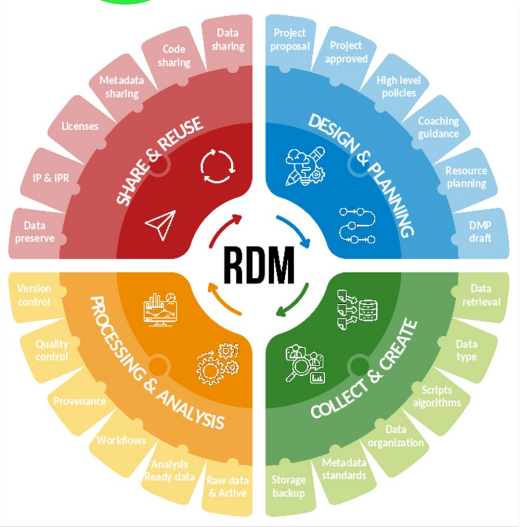
Even after a research project ends and the results are published, data remain precious and relevant.

They must be **preserved for the long-term** and remain **accessible, clear and comprehensive** to the broader scientific community.

Therefore, it's essential to preserve not only the data themselves, but also the virtualization environment, code, software, metadata, README files with accurate details to ensure data can be reusable.

**This requires a responsible and ethical planning and management of research data throughout their entire lifecycle.**





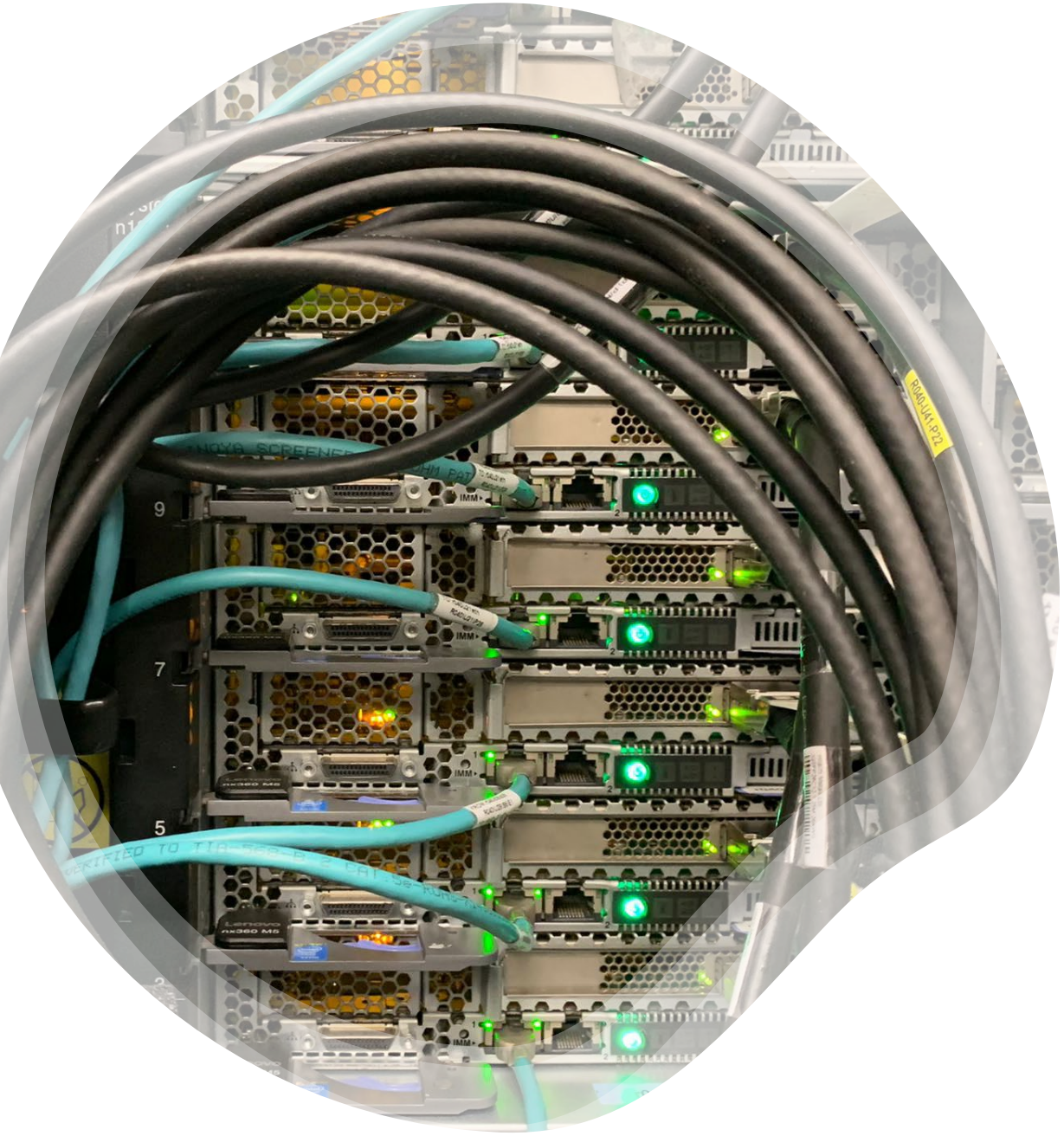


# Data lifecycle and research data management

The **integrity** and **availability** of data over time must be **ensured** through proper data management, starting **from data acquisition** all the way **to long-term storage**.

All aspects of the data lifecycle must be evaluated to ensure the responsible and **ethical management of research data**.

Foto di Rafael Rex Felisilda su Unsplash



# HPC @ INFN-LNGS

A **Lenovo Nextscale** computing infrastructure

A cluster of **400 High Performance Computing nodes** has been recently acquired by LNGS.

These servers have multicore processors Intel Xeon E5-2697 v4 (Broadwell) and are interconnected by a high-speed network, Intel Omni-Path, at **100Gb/s**.

The total computing power is half million billion of operations per second!

A **storage system of 5PB** and a **backup system of 5PB** will be added in the next months.

# Why HPC @ INFN-LNGS?

To increase the computing power available to the LNGS experiments

To create a centre of expertise for reducing risks related to disasters caused by natural and human-made phenomena, equipped with a high-performance computing technological infrastructure, which will be integrated into the national innovation ecosystem.

e.g. This infrastructure will provide computing resources to Universities and Research Institutions to increase, through computational methods and data analysis, the **resilience to natural disasters**, providing citizens and public institutions with reliable scenarios and simulations.

A big improvement of LNGS computational power!



# ICSC - Italian center for Super Computing




The **Italian Center for Supercomputing (ICSC)** has provided LNGS with 5 million euros in funding.

- Upgrade of the LNGS Data Centre to create a modern HPC (High-Performance Computing) cluster capable of hosting 15 computing racks, with a power capacity of approximately 400 kW.
- Acquisition of additional HPC computing resources (GPU-equipped compute servers).
- High-speed (400 Gb/s) interconnection network for the servers.

# Thank you!





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