

# The Role of Computing in Particle Physics Research

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# Istituto Nazionale di Fisica Nucleare (INFN)

 The National Institute for Nuclear Physics (INFN) is a public research agency dedicated to the study of the fundamental constituents of matter and the laws governing them



- 4 national laboratories, 20 divisions, 3 centers and schools, 1 consortium
- ~2000 employees, ~3500 associated personnel

- Particle physics (with accelerators)
  - High  $energy \rightarrow discovery of new particles$
  - High  $luminosity \rightarrow$  measurements of rare events













- Astroparticle physics
  - Cosmic rays, neutrinos, gravitational waves, very high energy gamma rays, dark universe

















- Nuclear physics
  - Structure and dynamics of nuclear matter





- Theoretical physics
  - development of hypothesis, models and theories
    - explain already acquired experimental results and to open new scenarios for the physics of the future
  - origin of the mass of elementary particles
  - nature and properties of dark matter
  - asymmetry between matter and antimatter in the universe
  - unification at quantum level of all fundamental interactions, including gravity



- Technological and interdisciplinary research:
  - research and prototype development of new technologies useful to the mission of INFN
  - development of instruments, methods and technologies born within the domain of fundamental physics to be applied in other fields
    - knowledge and technology transfer
    - detectors, electronics, computing





# Centro Nazionale Analisi Fotogrammi (CNAF) Yesterday



# Centro Nazionale Analisi Fotogrammi (CNAF) Today

# All digital

CNAF is the national center of INFN (Italian Institute for Nuclear Physics) dedicated to Research and Development on Information and Communication Technologies //cds.cern.ch/record/1541893

# The Computing Grid

The annual production of *raw data* is around 90 PB

- Besides raw data, there are simulated data, processed data, analysis results...
- · in multiple copies

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Storing and processing such data happens in a coordinated manner in a geographically distributed system comprising 170+computing centers in 42 countries worldwide

World-wide LHC Computing Grid (WLCG)

Based on its size and function, a center is classified as Tier-0 (CERN), Tier-1 or Tier-2

# CNAF in a nutshell

CNAF hosts a WLCG Tier-1

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- It provides support to researchers in using the available computing tools and in software development
- It investigates and develops innovative IT solutions aimed at improving the usability and the efficiency of the computing center and at enabling the use of geographically distributed systems
- It provides IT services of general utility for INFN
- It collaborates with private companies and public administrations to share knowledge and expertise
- We are about 60 people





There are 60+ scientific communities using the data center

- not only LHC and not only from the physics field
- 2000 computing nodes, 40 000+ core
  - managed with a *batch* system

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50 PB of disk space shared among all nodes thanks to a distributed file system (GPFS)

130 PB of tape space

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#### The Tier-1

Power consumption is about 800 kW  $\rightarrow$  7 Gwh/year

• The IT load is ~450 kW, the rest is for cooling, guarantee of power continuity, etc.



• A complex monitoring system is always active to keep under control the entire infrastructure

# WAN@CNAF

CNAF is part of a wide high-performance network

- LHCOPN (LHC Optical Private Network) connects all worldwide TIER-1 with CERN (200Gbps)
- LHCONE (LHC Open Network Environment) all TIER-1 to all TIER-2 (200Gbps)
- 4Links (10Gbps) towards General Internet
- A direct link (1,2 Tbps) with CINECA (one of Europe's best performing computing centre)

(i.e., watching a movie online requires an 8Mbps connection)

#### LHC Optical Private Network

# LHC PN



#### LHCOPN Links summary

#### Network@CNAF



# POP GARR@CNAF



Based on Spine Leaf Architecture (Juniper Routers) and Open Line System (Infinera)

Currently 400G in production

2x400 from Bologna to Milano

Migrating from the old GARR-X 10/100Gbit to New Network GARR-T 400G/Terabit Ready

#### **Future perspectives**



# **Distributed Systems**

- We investigate innovative technological solutions so to evaluate their adoption and integration in the distributed computing system to which the Tier-1 belongs
- · i.e., Cloud systems and virtualization

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- We develop software components to integrate the existing functionalities
- IT security and data management
- often in the context of national or international projects

# **INFN Cloud**

A multi-site, extensible, federated Cloud infrastructure from INFN sites with a customizable portfolio of services targeted to scientific communities.



**Enhanced Privacy and Compliance Cloud (EPIC),** operated at CNAF, is a region of INFN Cloud where we implement a **certified ISO/IEC 27001 27017 27018** Information Security Management Systems to comply with the requirements of health research projects INFN is involved in.

# National services

We deploy and maintain services used by the whole INFN:

- Mailing list, web hosting, calendar and address book
- DNS
- Software repositories, version control systems and collaborative tools for software development
- Documental archival
- Central managements of licenses
- Information System Services: provisioning of interfaces between users and INFN administration
- Multimedia services

# **CNAF Tomorrow: the Data Valley Hub**

Supercomputing facilities of **ECMWF**, **CINECA** and **INFN** 

- The Italian and Emilia-Romagna Region's largest investment in Big Data, Supercomputing and Research Infrastructure
- Hosting 80% of total computing capacity in Italy
- It will host important italian and international research institutes
- The move will begin in spring of 2023



#### ICSC – Centro Nazionale HPC, Big Data e Quantum Computing



#### ICSC – Centro Nazionale HPC, Big Data e Quantum Computing

The ICSC will include ten **thematic Spokes** and one **Infrastructure spoke** 



# Training/Job opportunities

- Stage
- Internships
- Thesis
- Summer students
- Temporary jobs

# **Possible activities**

- Design and management of Cloud-based distributed computing infrastructure for scientific data management
- HW and SW administration to serve users
- Development of SW solutions in science
- Cybersecurity
- Development and management of secure infrastructure for medical and confidential data analysis
- Exploitation of AI solutions for anomaly detection, pattern recognition and predictive maintenance on heterogeneous data