# The new INFN Data Center at Bologna Tecnopolo

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# The INFN-CNAF

- INFN-CNAF: the national center of INFN (Italian Institute for Nuclear Physics) dedicated to Research and Development on Information and Communication Technologies
  - https://www.cnaf.infn.it/en
- CNAF hosts the Italian Tier-1 data center for the high-energy physics experiments at the Large Hadron Collider in Geneva
- CNAF is one of the most important centers for distributed computing in Italy
- It is currently located in close to the Bologna city center
  - Co-located with the Physics dept of the Bologna University
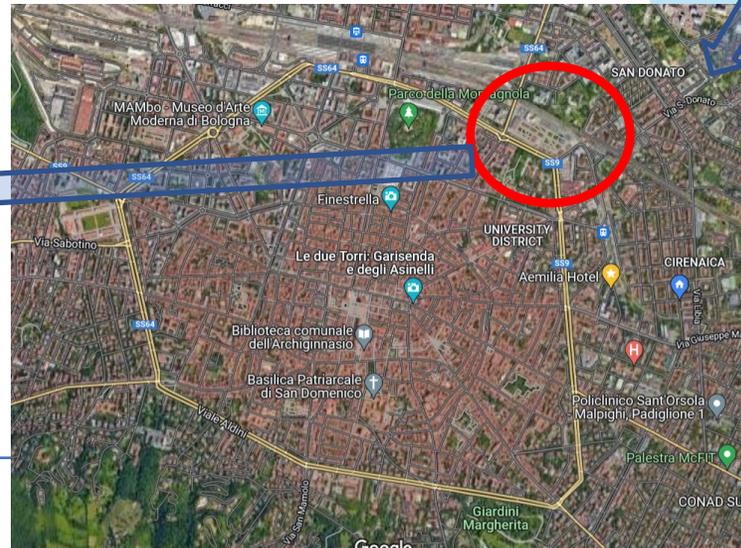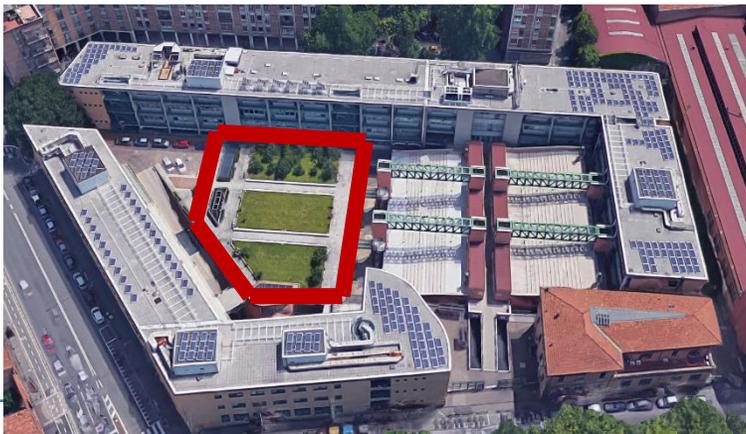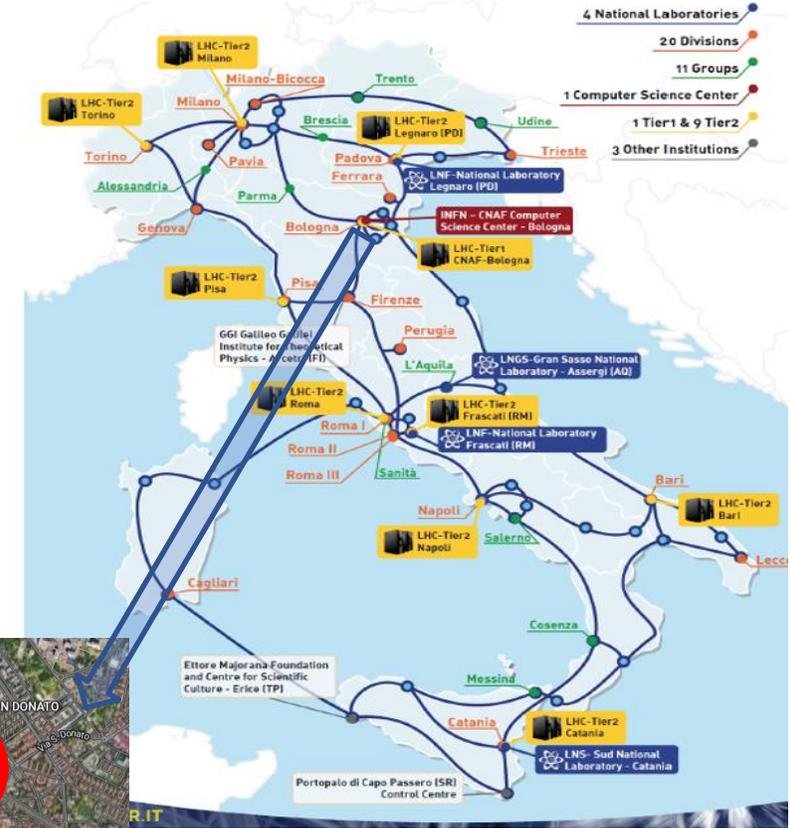
# Scientific motivations

There are three main drivers for the transfer of CNAF resources to a new location:

1) an expected huge increase in IT resources to be installed in the coming years

    - Ready for HI-Luminosity LHC

2) the infrastructural problems at the current site

3) and the opportunity offered by the new location
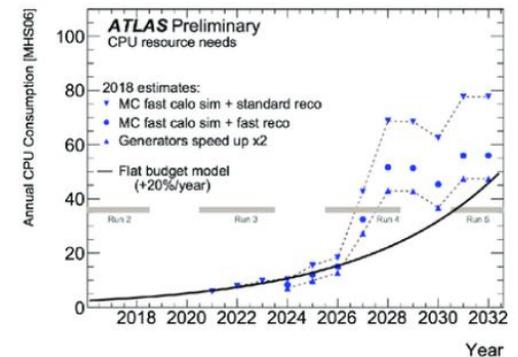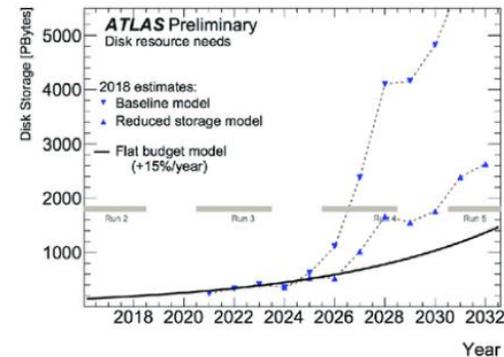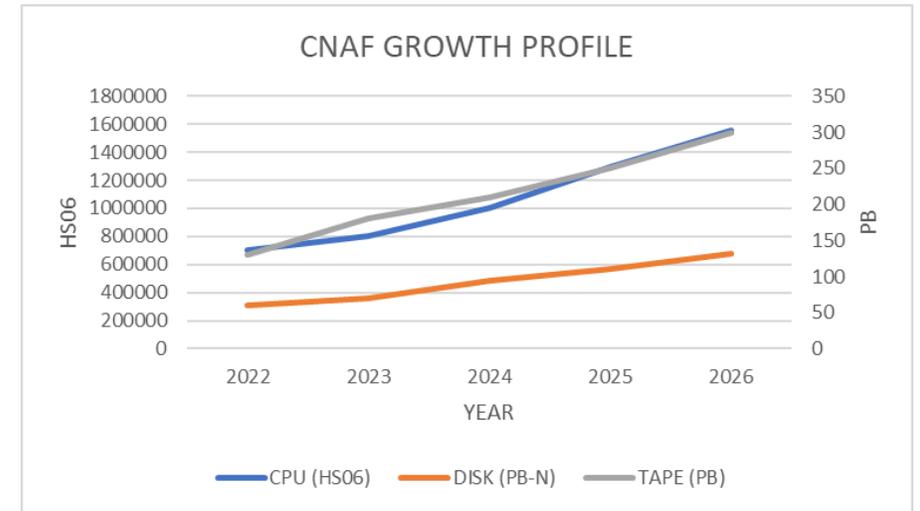
# A brand-new data center for CNAF

- Renew infrastructures to be ready for the HL-LHC era
  - up to ~ 2035 and beyond
- Use more compact computing
  - from today's ~ 20 kW/rack to 80 kW/rack DLC
  - Integration with CINECA-Leonardo Supercomputer
- Lower the PUE (*power usage effectiveness*)
  - Targeting 1.08-1.10
- Extend and expand networking for a future-proof infrastructure

# The opportunities ….

- In **2017**, Bologna won a bid to host the datacenter of the "*European Centre for Medium-Range Weather Forecasts*" - ECMWF

- The Emilia Romagna region decided to repurpose the "*Manifattura Tabacchi*" area to host a technology district, hosting ECMWF <u>and more</u>

**Roughly 250x250 m²**
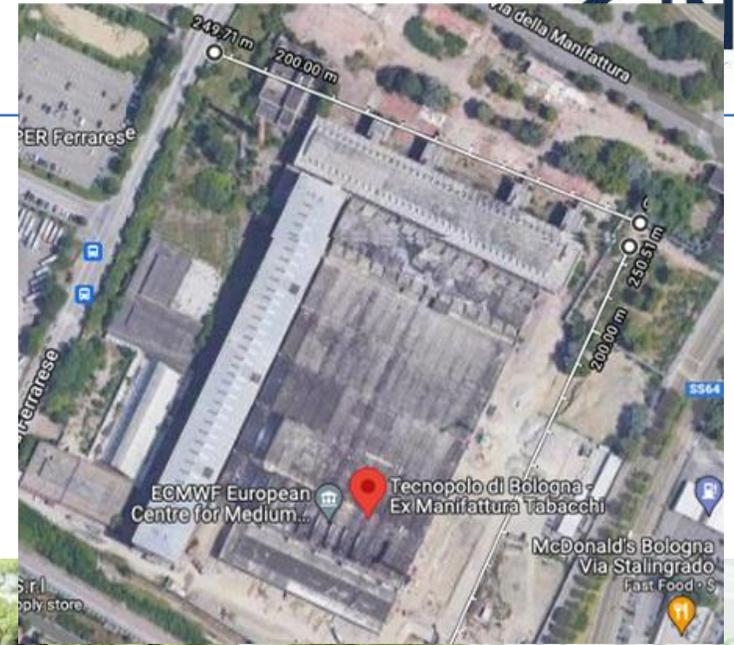
How it will be

# What can the Tecnopolo host?

- Not only research infrastructures and supercomputers

- Areas for
  - Technological institutions
  - university
  - innovation hubs
  - technology transfers
  - Industry 4.0

- Restaurants



Civic Protection and agency for development and innovation

CINECA & INFN Exascale Supercomputing center

ECMWF Data Center

Conference and Education Center

Meteo National Agency

IFAB - International foundation Big Data

University centers

Big Data Association and Foundation

Innovation center

Biobank and Life Science

Enea center

Competence center Industry 4.0
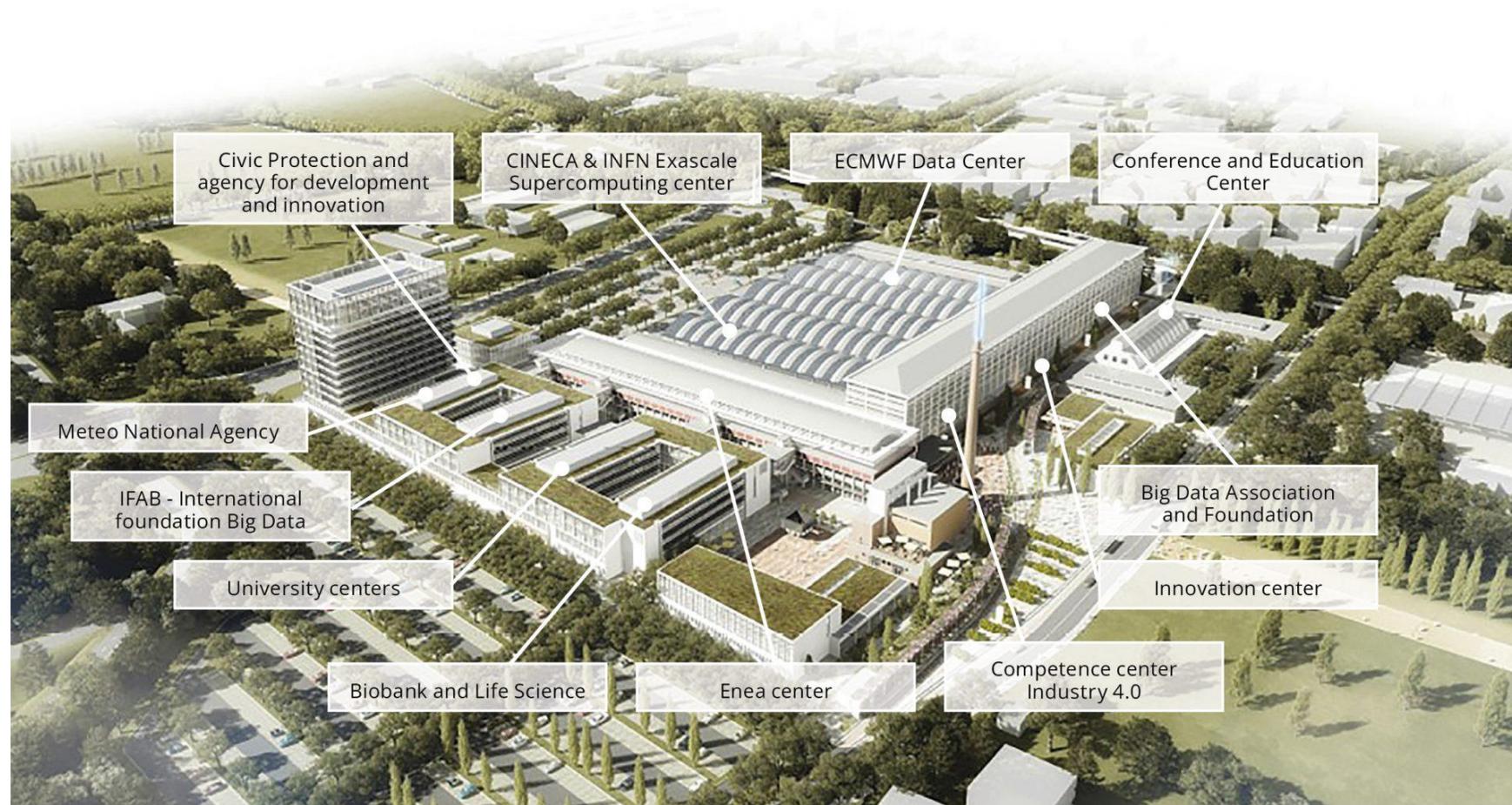
# What can the Tecnopolo host?

## The computing infrastructures
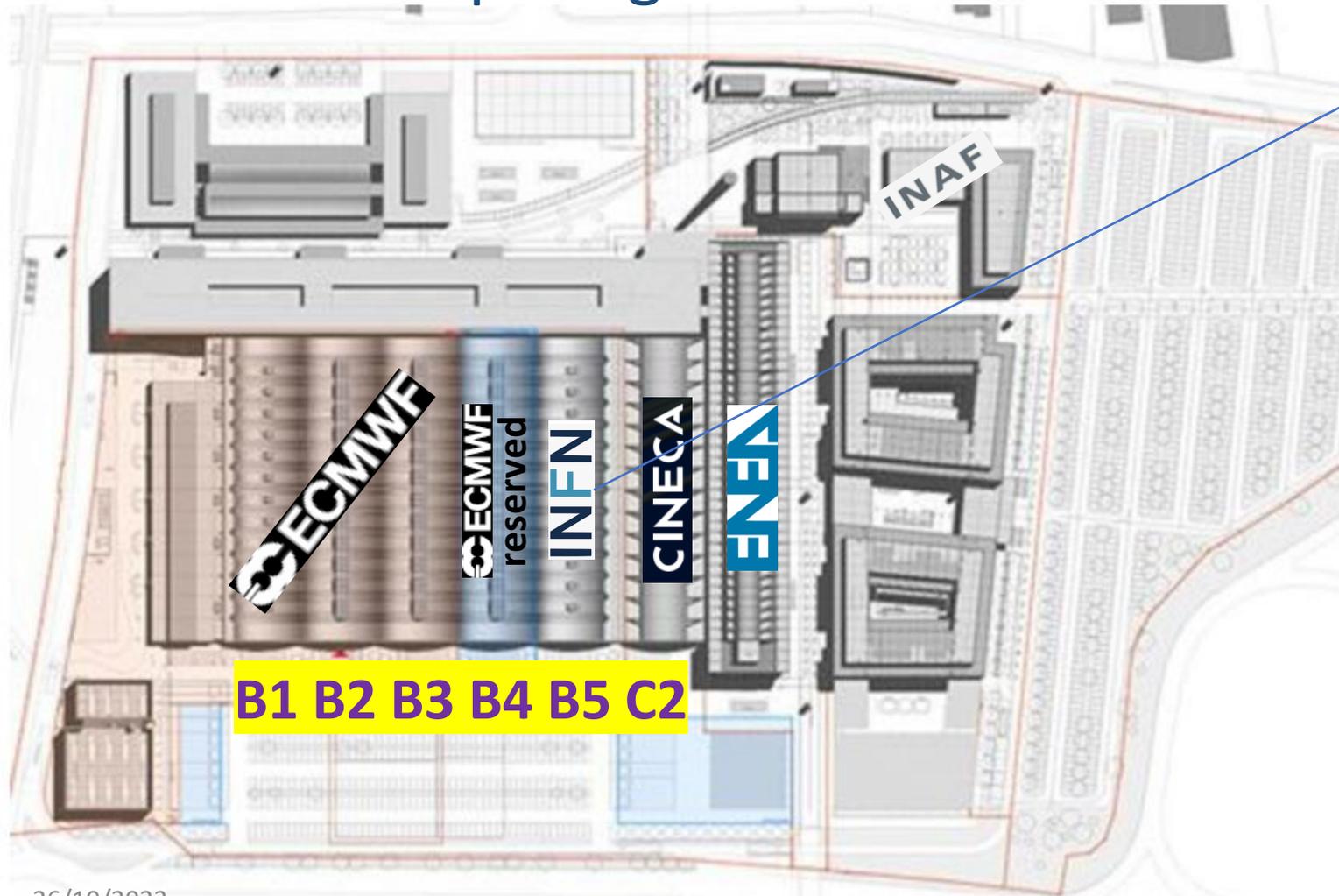




Each of the 6 "botti" (barrels) is ~5000m$^2$ of usable IT space



**Same architect and design of the "Sala Nervi" in the Vatican**
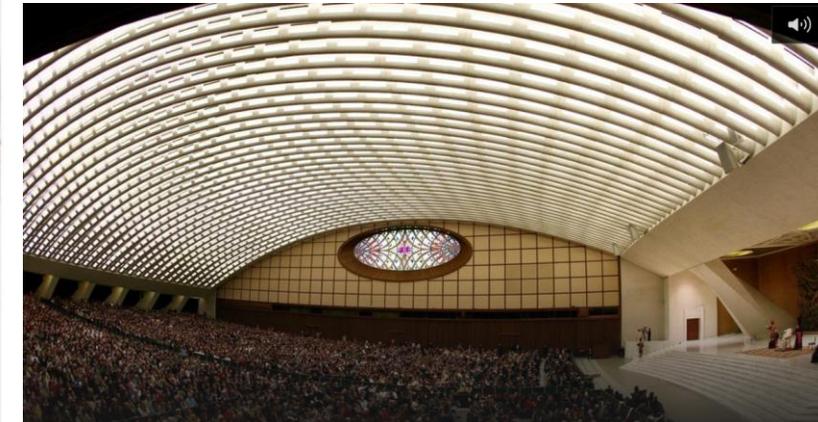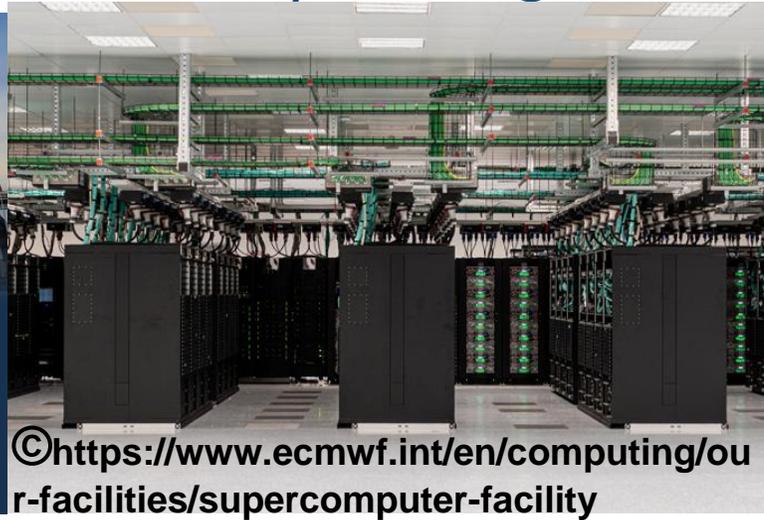
ECMWF

ECMWF reserved

INFN

CINECA

ENEA

INAF

**B1 B2 B3 B4 B5 C2**

# The INFN+CINECA project

- The ECMWF is already running!



14 September 2021: new ECMWF data centre opens in Bologna, Italy

©https://www.ecmwf.int/en/computing/our-facilities/supercomputer-facility

- CNAF "B5" Barrel expected to be ready by mid 2023

- Two phases expected
  - **Phase-1 (2023-2025)**
    - Leonardo + T1-CNAF ➔ 13 MW
  - **Phase-2 (2025+)**
    - infrastructure up to 25 MW ready for post-exascale and for HL_LHC

- CINECA Leonardo is being commissioned in October 2022
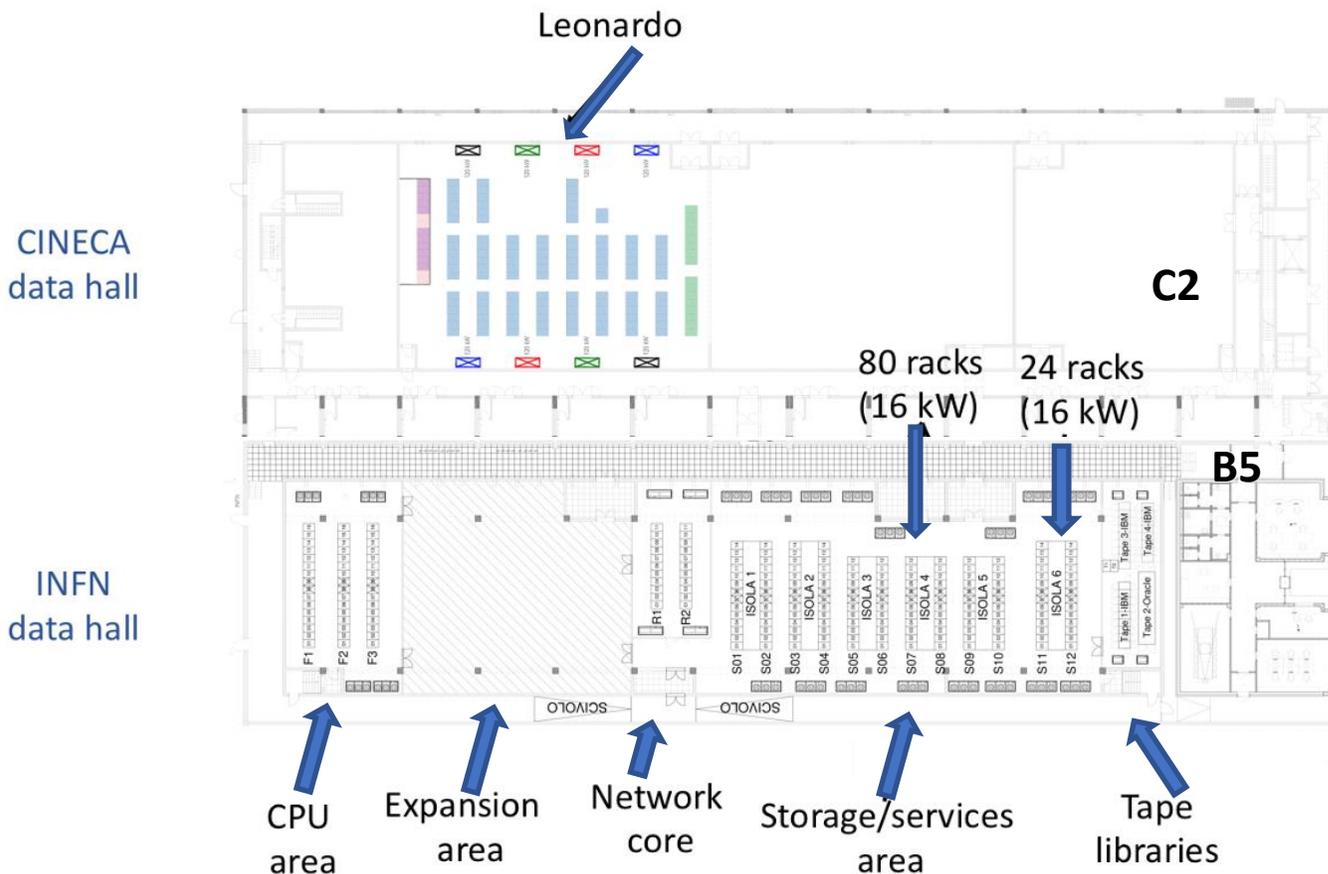
# Current status…..



CNAF Barrel

# Current status…

# CNAF and CINECA data halls



Leonardo

CINECA data hall

C2

80 racks (16 kW)  24 racks (16 kW)

B5

INFN data hall

CPU area   Expansion area   Network core   Storage/services area   Tape libraries

**DLC 80kW**

- The new CNAF Datacenter will feature the following main areas
  - High Density – 2-3 rows for 80kW racks
  - Low density – 80+24 16kW racks
  - Expansion area
  - Tape libraries areas
    - Up to 4 libraries
- The CPU area can host up to 3MW of CPUs via 42 DLC high density racks
- The low-density area will be used to host
  - Storage systems
  - CNAF Cloud Infrastructures
  - ISO certified Cloud racks
- Cooling
  - Air cooled Cold Corridor aisles
  - Direct Liquid in High Density
- 3+1 redundancy in all the infrastructure facilities

# The cooling system and the PUE

- 4 central refrigerator Units
  - 3+1 redundancy

- Chilled water 19-26 °C for the low density air cooled racks
  - 2 MW Chillers
  - Total/partial free cooling is possible

- Warm water 37-47 °C for DLC racks
  - 2,25 MW Chillers

- To be doubled in the second phase

- **High Density CPU Area**
  - 4 CRAH - 200 kW each (3+1)

- **Network Area**
  - 4 CRAH - 75 kW each (3+1)

- **STORAGE Area**
  - 16 CRAH - 200 kW each (12+4)
  - Cold corridor aisles

- **TAPE Area**
  - 4 CRAH - 25 kW each (3+1)
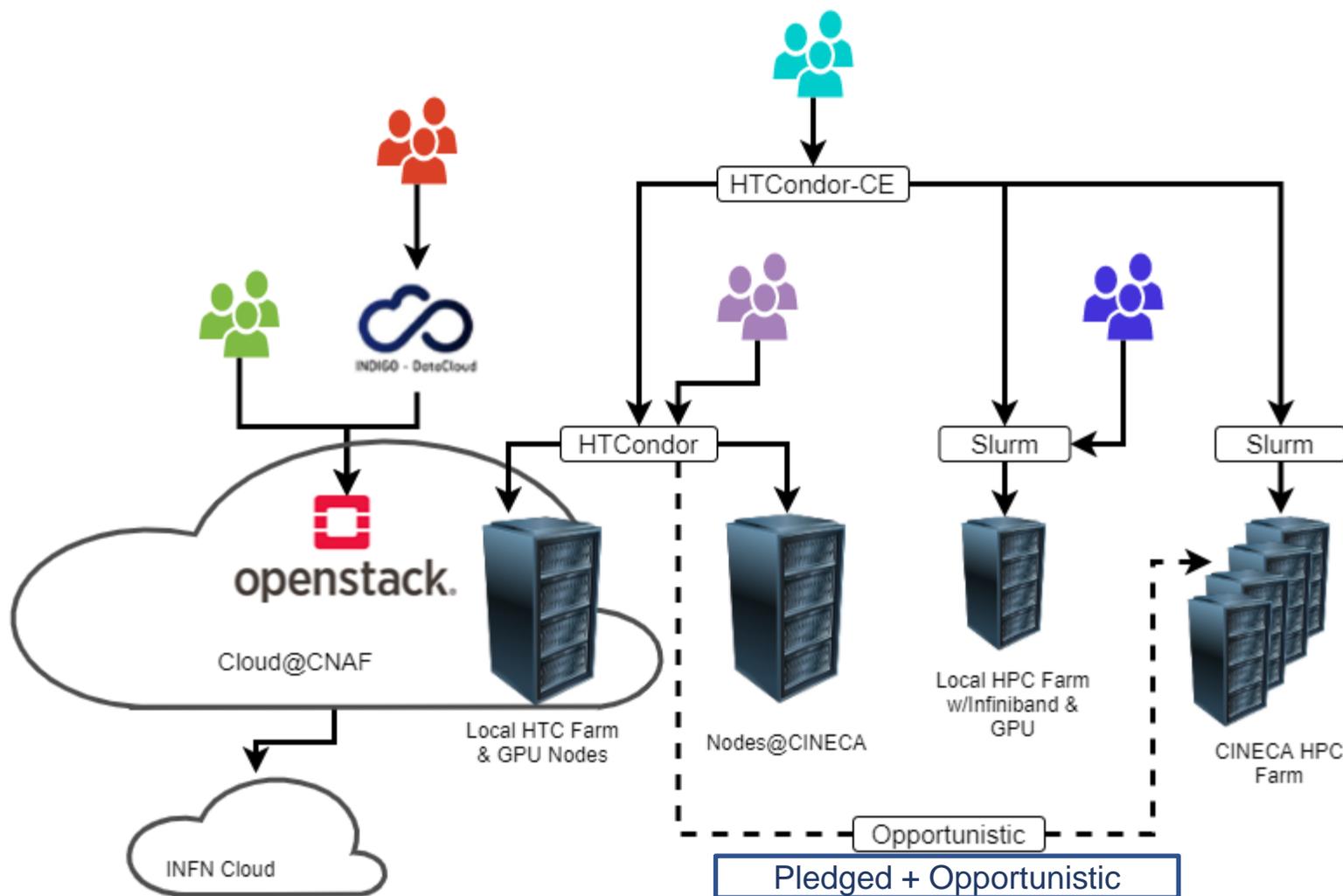
$$PUE_{DLC} \approx 1.08$$

$$PUE_{Tot} \approx 1.2 - 1.3$$

# A "distributed" datacenter
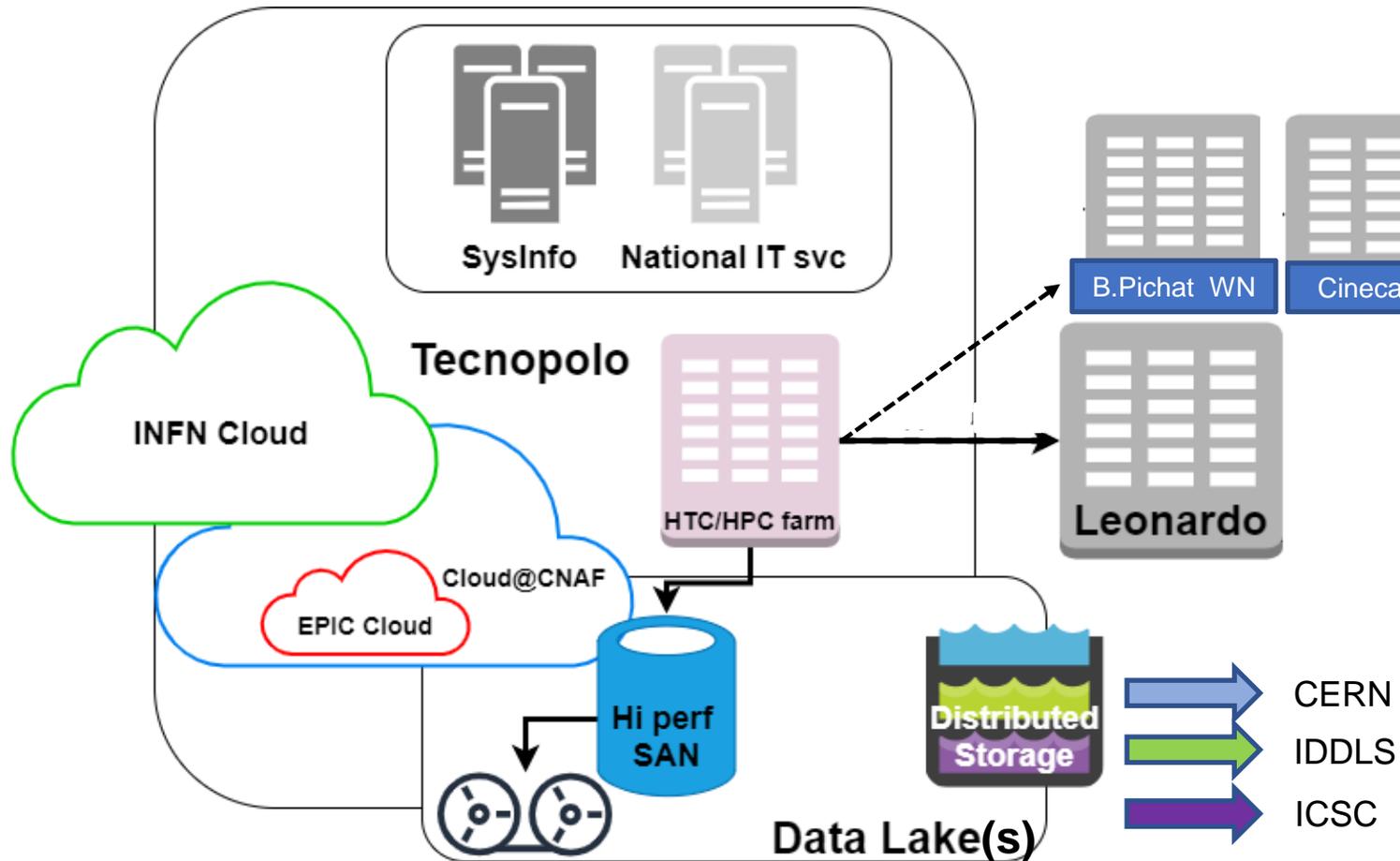


- Multiple "locations"
  - CNAF Technopole
  - CINECA Leonardo CPU access
  - INFN-CLOUD federated cloud
  - Data-lake(s)
    - DCI with INFN sites
    - DCI with CERN
    - New national data lake for the ICSC project
      - The ICSC headquarter will be at the Technopole
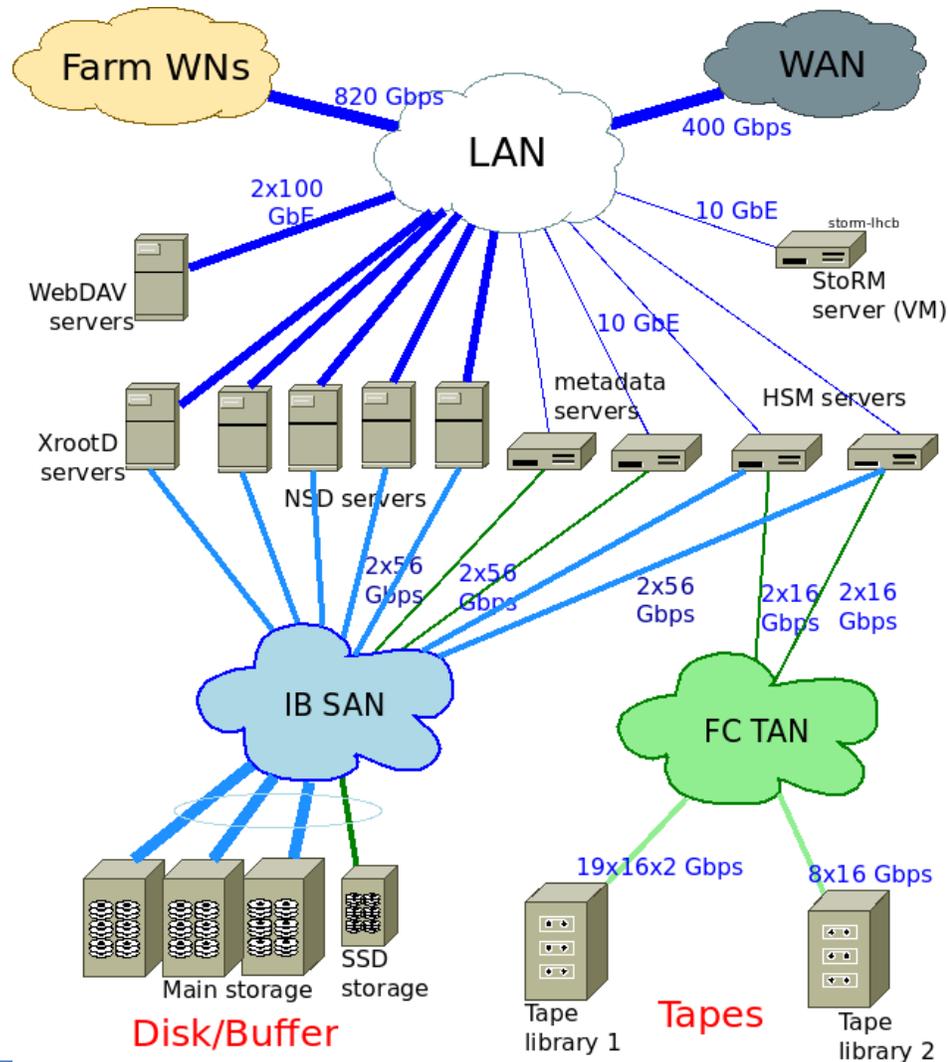
# Farm, Cloud, HPC integration



- Integration of access points for several different infrastructures
  - Cloud@CNAF
  - Cloud@INFN
  - Local HTC farm
  - Local HPC farms
  - CNAF WN@CINECA
  - Leonardo usage

- Based on
  - HTCondor
  - SLURM
  - HTC-SLURM connectors
  - INDIGO PaaS + Openstack

# A Complex Networking Infrastructure
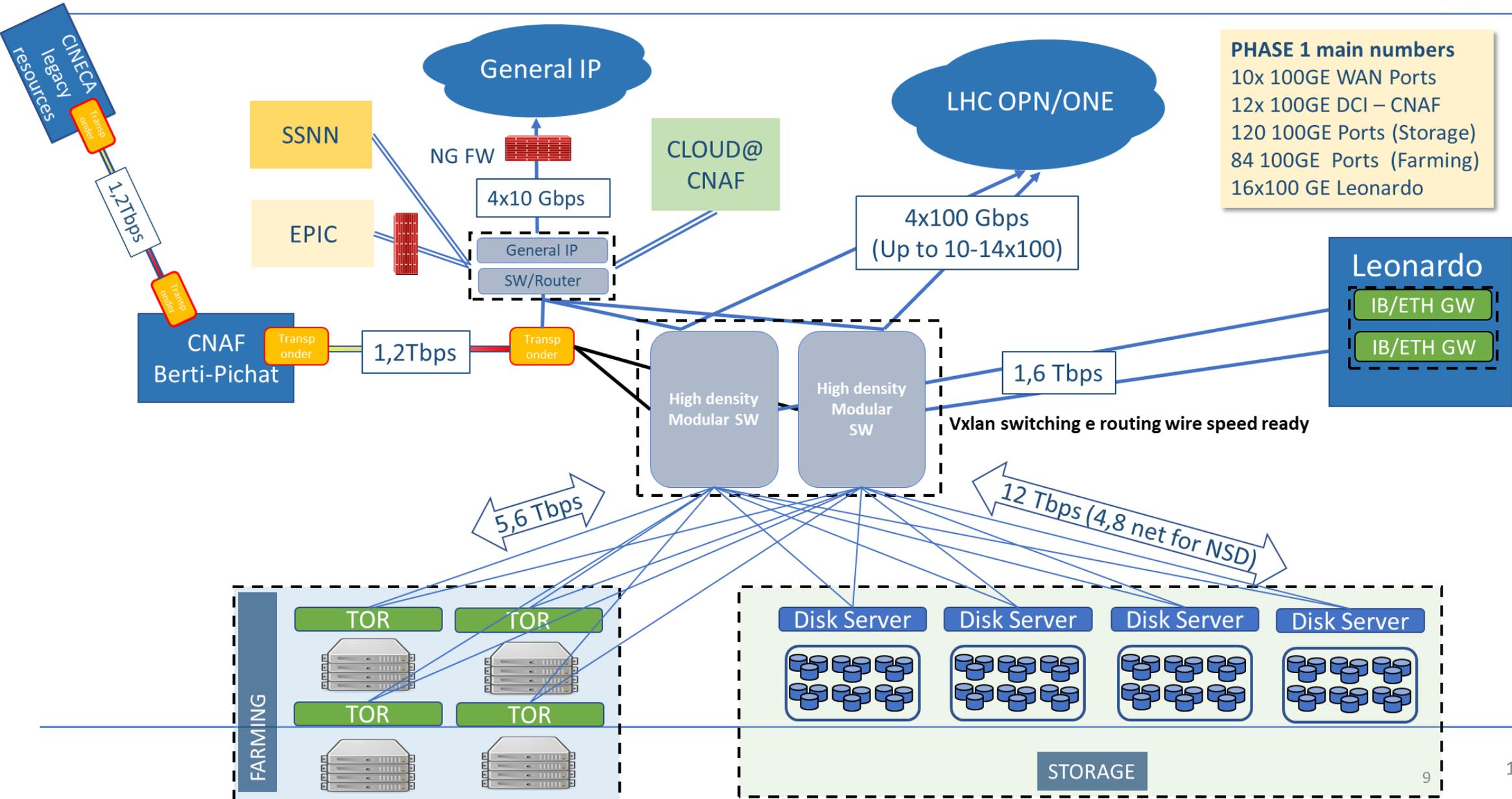
# The storage architecture



Hypothesized network sizing for storage

**STORAGE (DISCO)    120 PB**

- About 60 Disk Servers connected at 2x100 Gbps
- Hypothesized density: 8 PB per Rack
- 15 Rack for the cluster Filesystem
- 3 Rack per Data Transfer R&D e metadata
- TOT 18 Rack
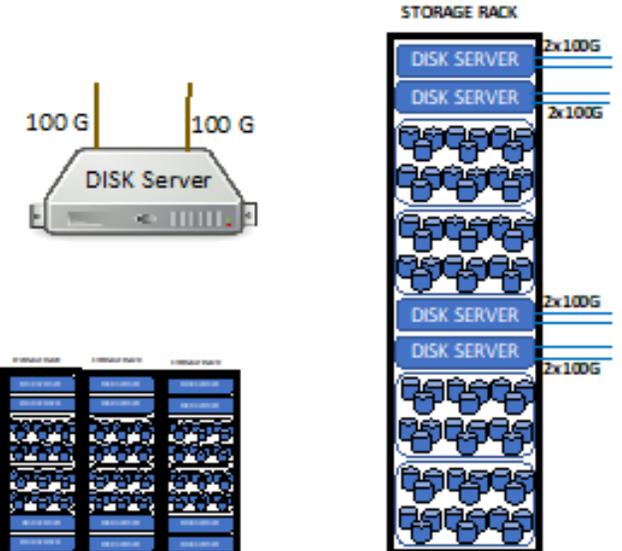
• To maintain 5MB/s for each TB we need to deploy one IO server for every 2PB of usable storage, i.e. 60 IO servers for 120PB of disk storage
• Data Mover servers: 32 ports 2x25Gbs
• Metadata servers 32ports x25Gbs

# Live Relocation Timeline

**Jun 2023 Room Ready**
- Electrical and cooling system available
- Racks installed

**Aug 2023 Network Ready**
- Cabling
- Active core systems
- Management network
- DCI with legacy site

**Sept 2023 Resource Relocation starts**
- New Storage Installed
- Legacy CPU and Storage migration starts

**Apr 2024 Migration Finalized**
- Tape Library migrated
- Site commissioned

- **Live Migration**
  - Legacy site "extended" through a DCI channel 1.2Tbit/s
  - Data moved to a new storage
  - CPUs moved in chunks
- Down only for tape libraries
  - Need dismantle and re-assembling

# Communication



But since I was curious, I asked: what can you actually do with these supercomputers?



They answered: everything you can think of... and other things you can't even imagine.

**Data Valley:**

https://www.youtube.com/watch?v=96TfXHCWxf8

# Conclusion

- CNAF is moving to a new location to cope with the increasing resources demand
  - From HEP communities, but not only
- It will be collocated with supercomputing infrastructure from CINECA and ECMWF
  - Strengthening the long-standing collaboration with CINECA
    - Mainly Theoretical Physics simulations, but increasing usage from WLCG
- A greener datacenter with a much lower PUE
- Targetting a «live» migration
  - With few exceptions, i.e. TAPE libraries