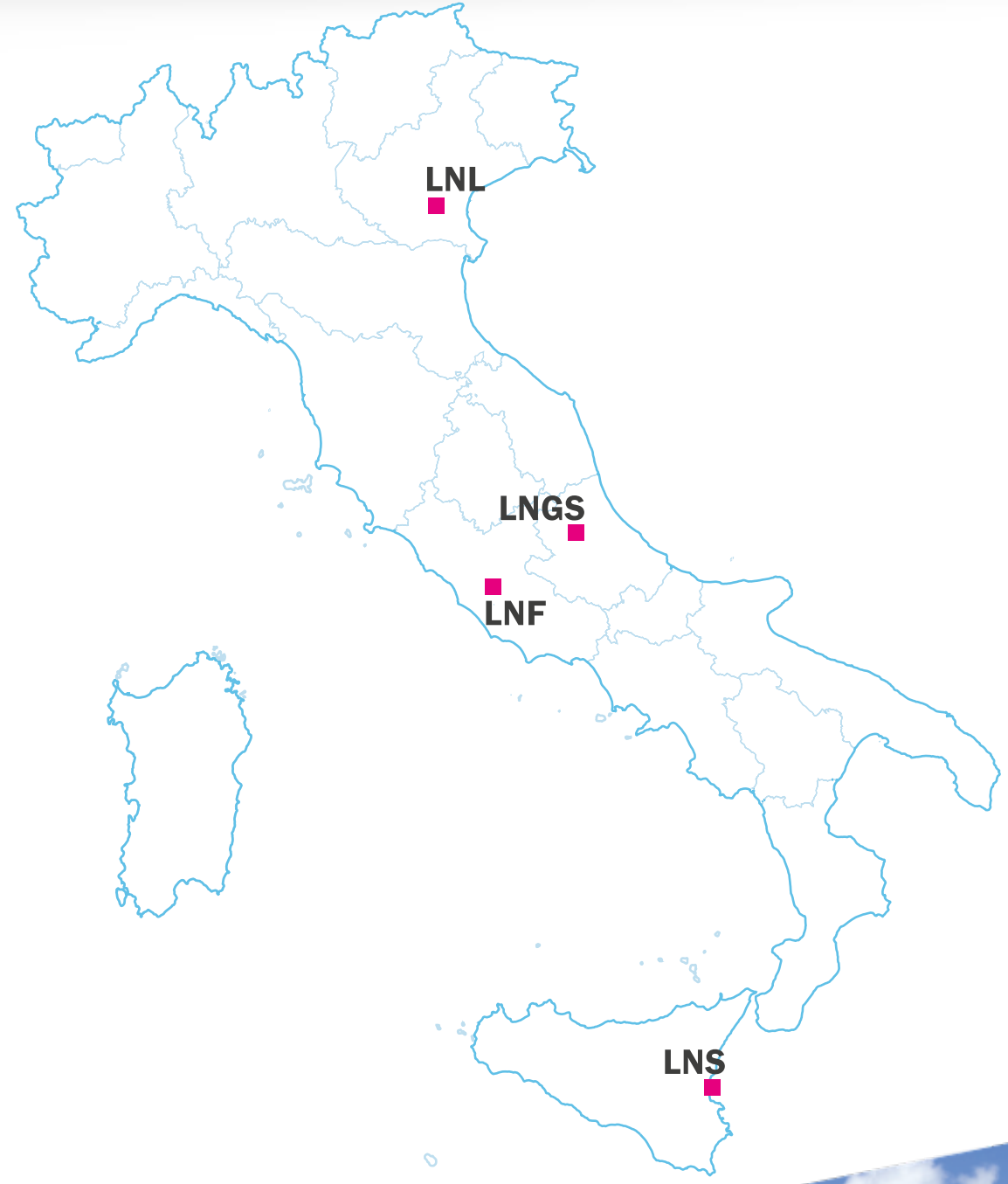




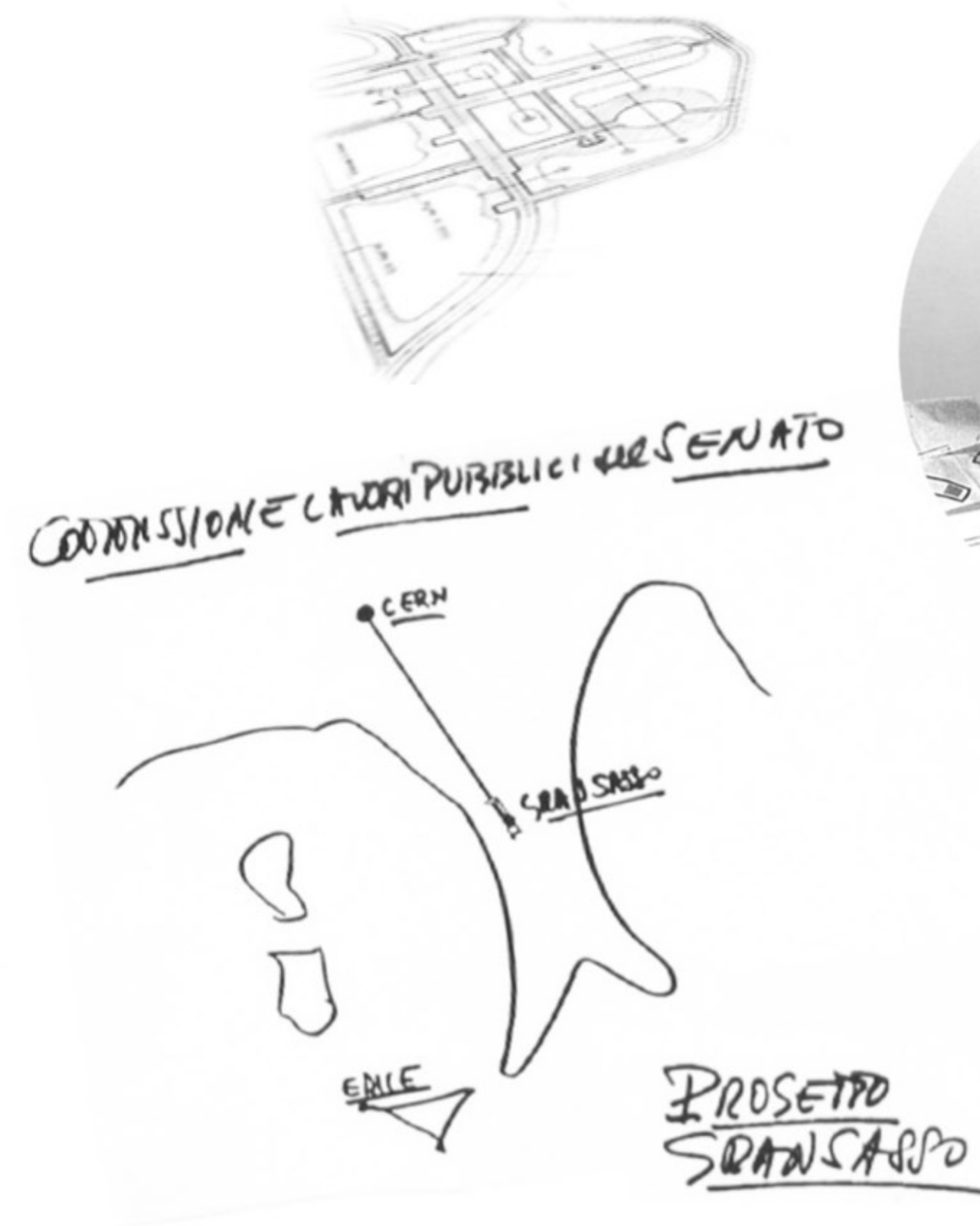
# LNGS laboratories

Carlo Bucci

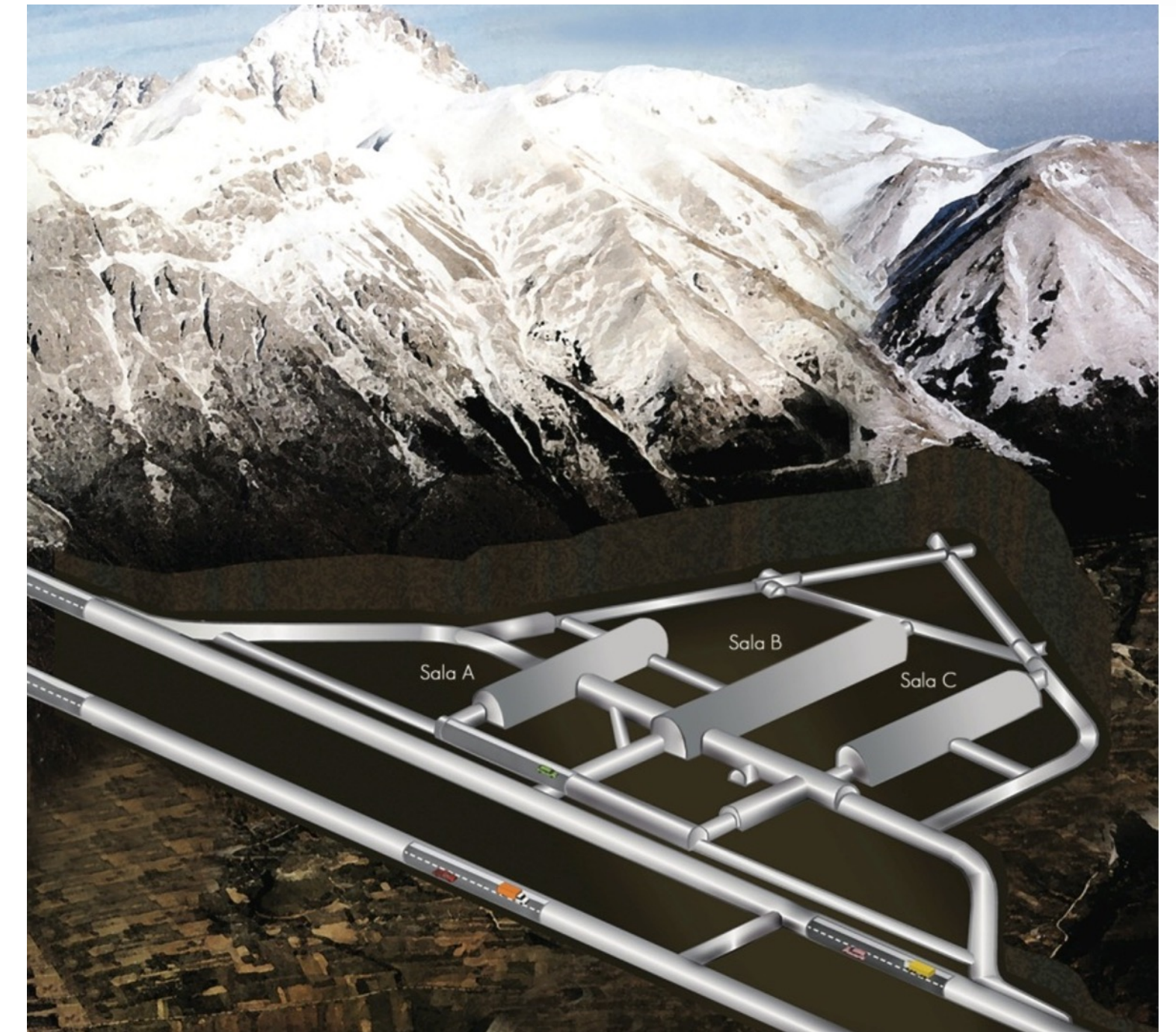
# INFN national laboratories



- 1979 → proposal to the Italian Parliament of a project for a large underground laboratory inside the Gran Sasso highway tunnel (under construction at that time).
- 1982 → approval by Parliament.
- 1987 → construction is completed.
- 1989 → 1<sup>st</sup> experiment, MACRO, begins data taking



- Shielded by 1400 m of rock (3800 m.w.e.)
- Muons flux reduction  $\sim 10^6$
- Surface: 17 800 m<sup>2</sup>
- Volume: 180 000 m<sup>3</sup>
- 3 main experimental Halls (approx. 100 m length, 20 m width, 18 m height)
- Air ventilation: 1 volume / 3 hours
- Easy access directly through the A24 highway
- Long history and experience
- Wide variety of support services for the experimental researches



## Neutrino astrophysics

- Solar neutrinos
- Geo-neutrinos
- Supernova neutrinos

## Neutrino properties

- Neutrinoless Double Beta Decay
- Relic neutrinos

## Dark Matter

- WIMPs direct searches

## Nuclear Astrophysics

- Astrophysical nuclear reactions

## Tests on quantum mechanics

- Electron decay
- Violation of Pauli principle

## Radiobiology

- Biological effects from low radioactivity environments

## Geophysics

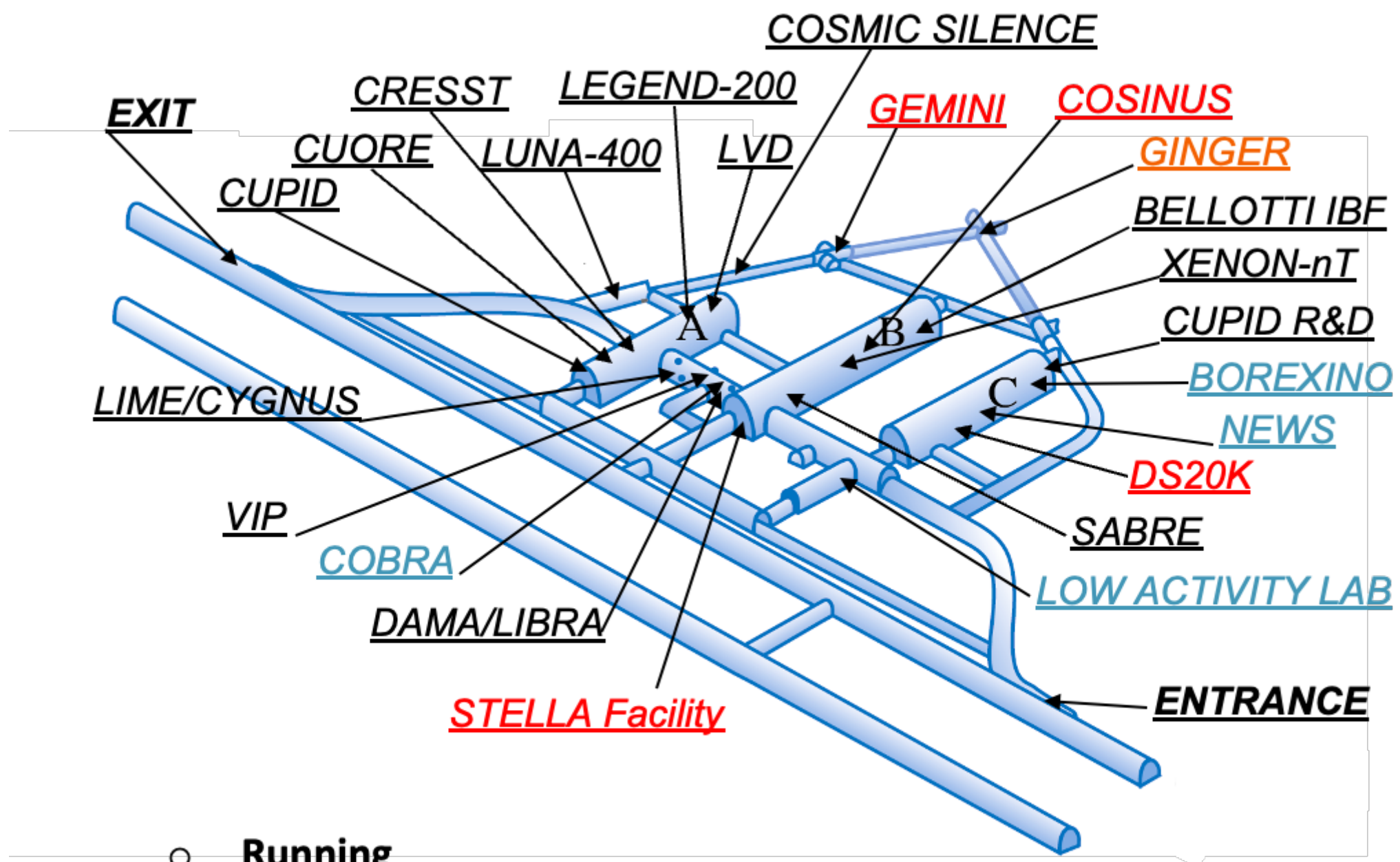
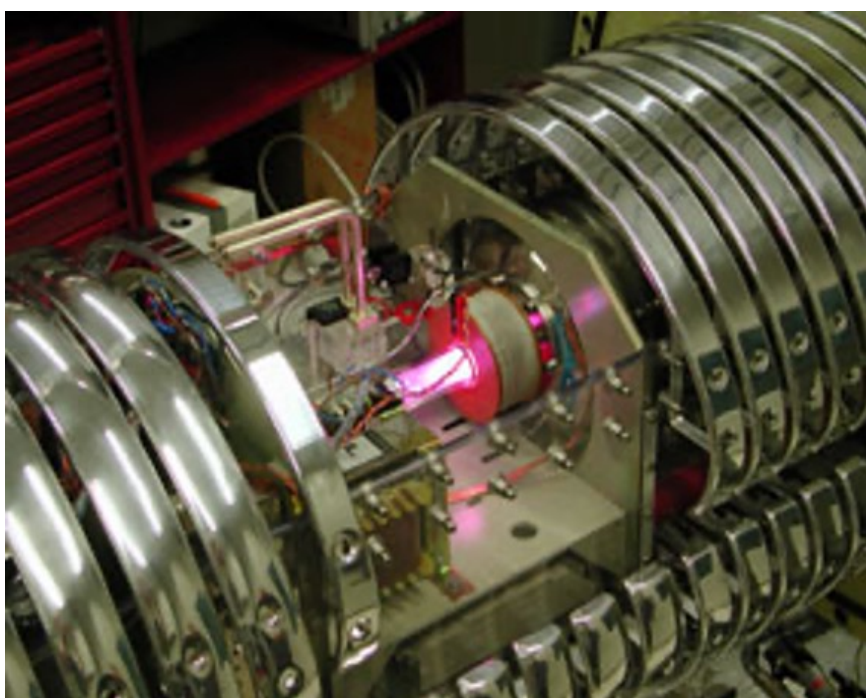
- Earthquakes monitoring and study
- Analysis of water resources

## Ultra-pure materials

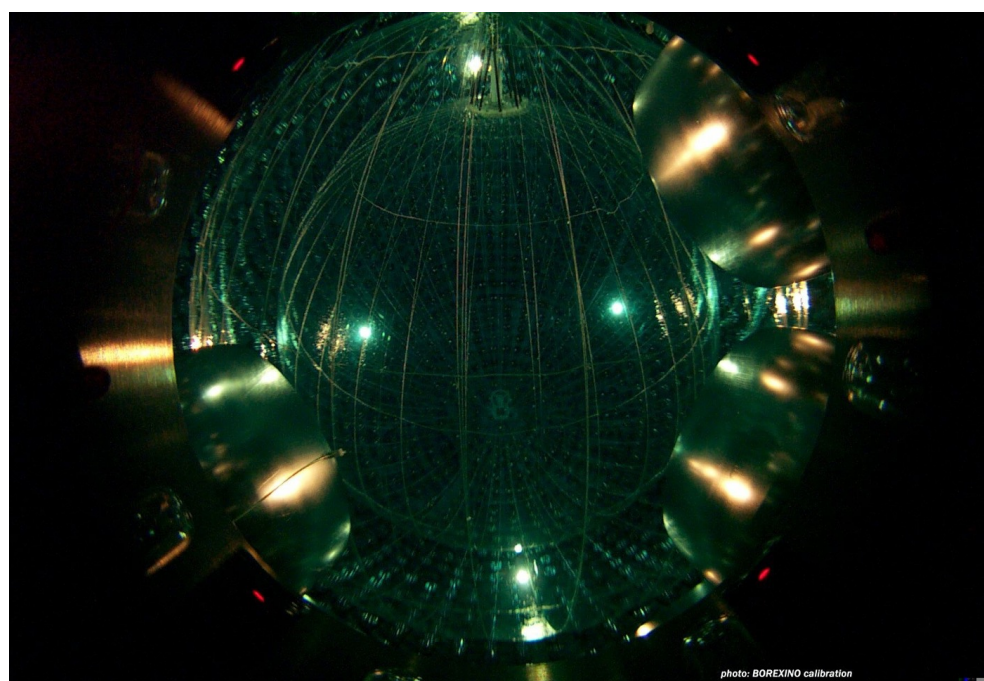
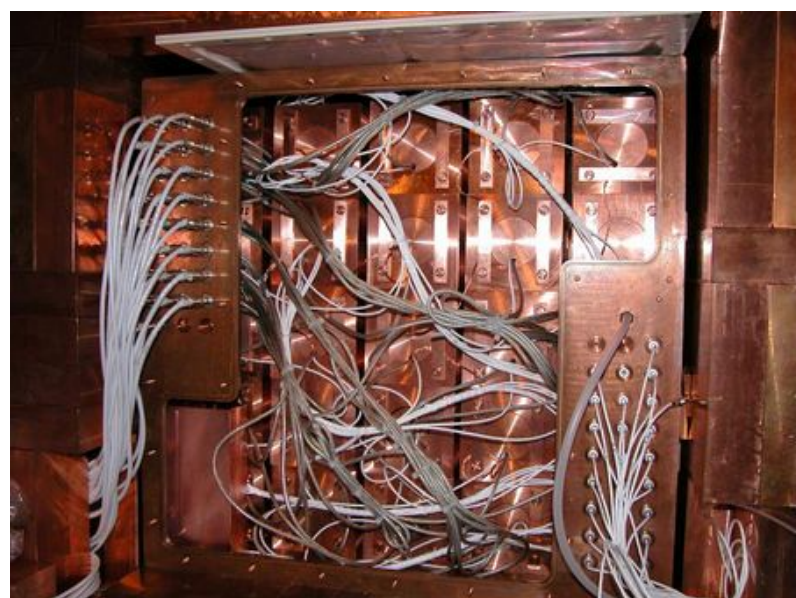
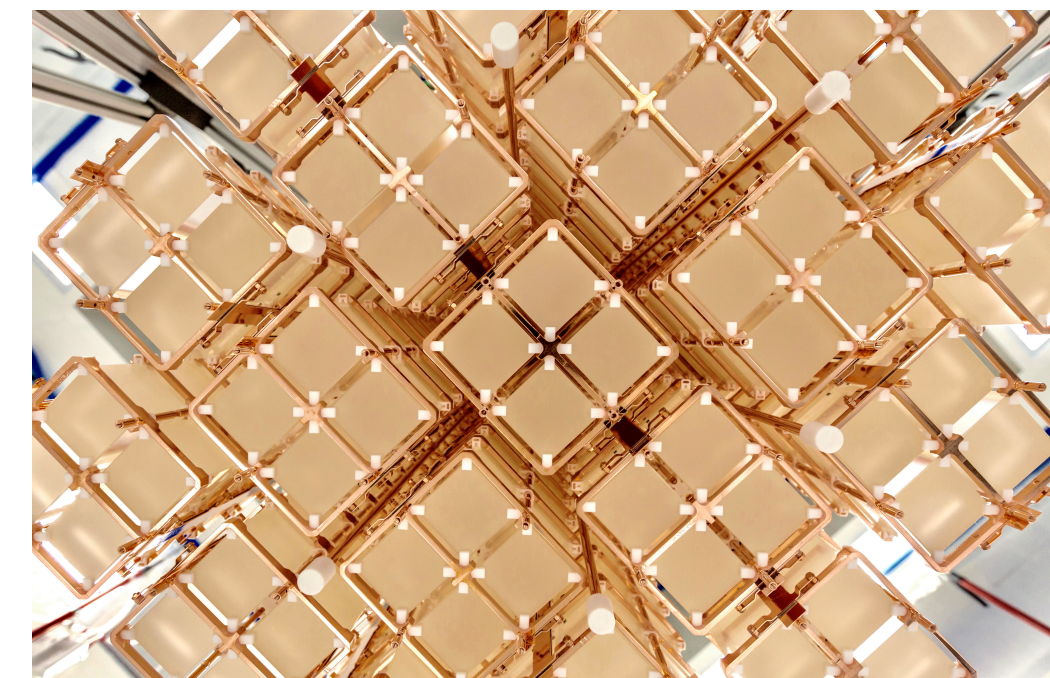
- Low-radioactivity material screening
- Cultural heritage samples analysis
- Additive manufacturing

# Experiments

Presently 22 experiments in data taking or under construction



- Running
- Construction/Commissioning
- Decommissioning



## LNGS Users in 2023

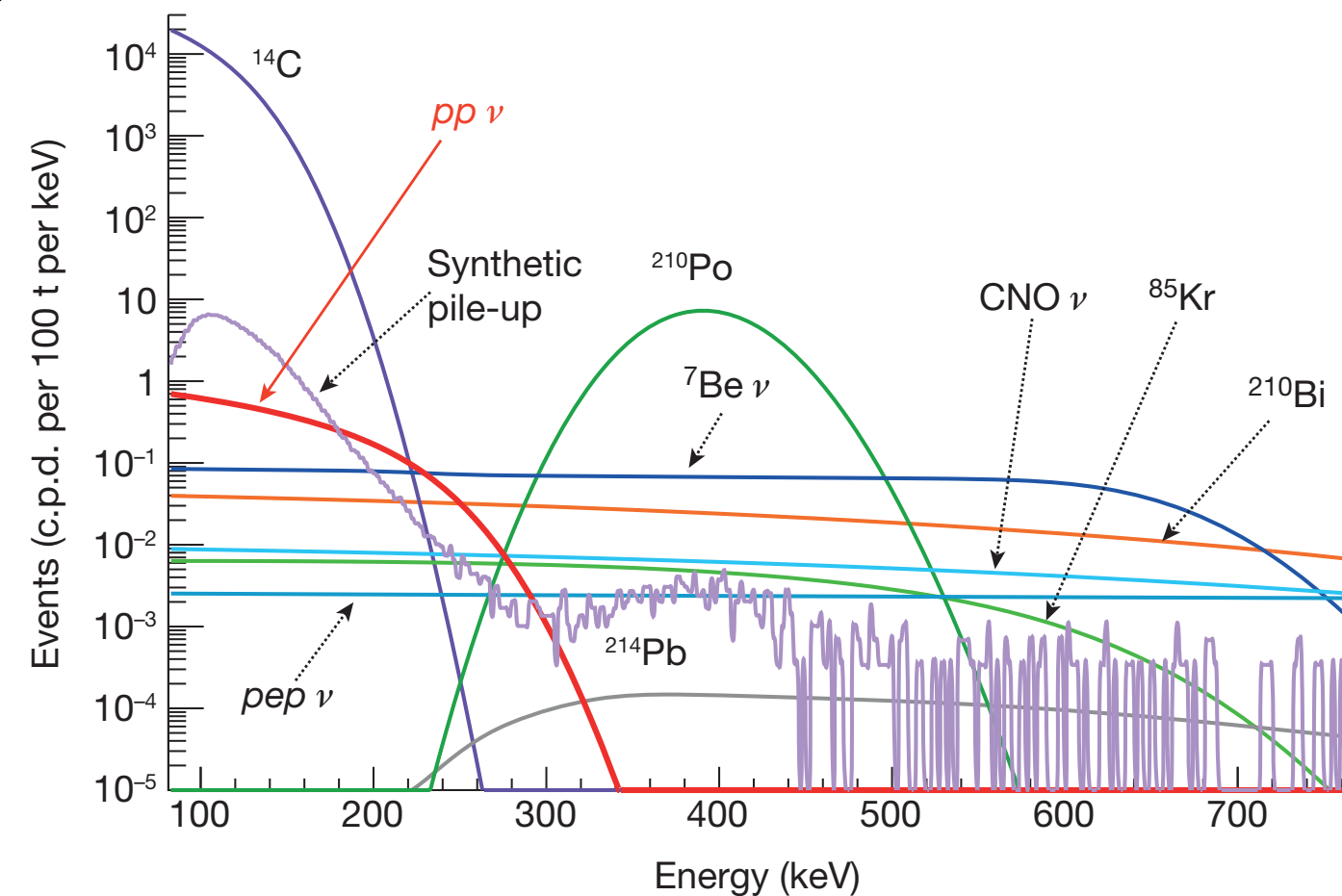
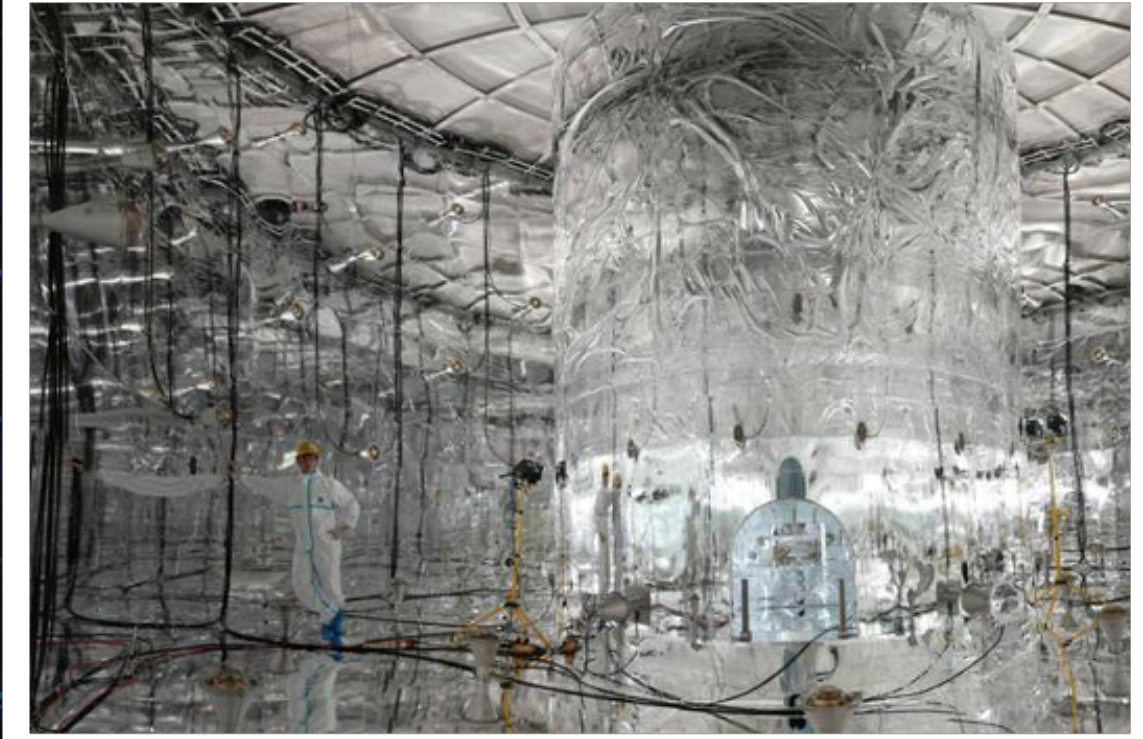
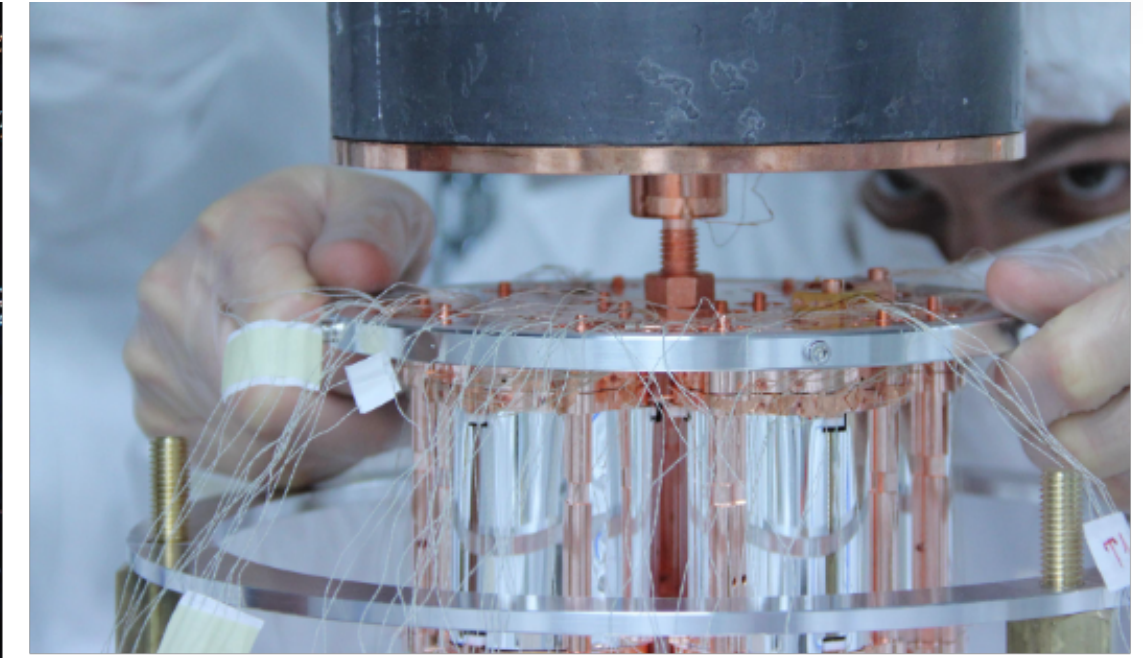
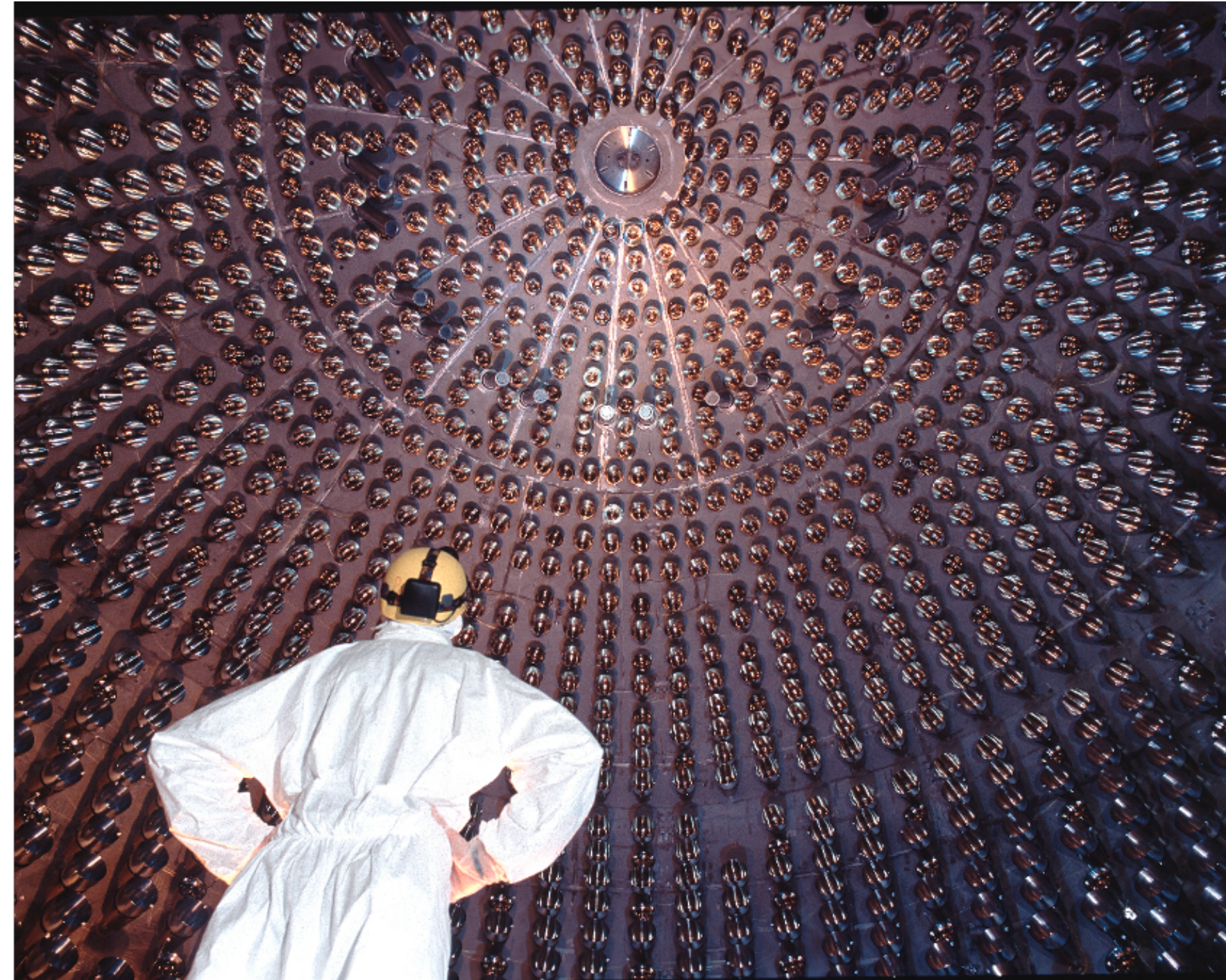
- Italians 354 (~ 600\*)
- Foreigners 256 (~700\*)
- Total 610 (~ 1300\*)

\*members of experimental collaborations



Many of the leading experiments in neutrino astrophysics and neutrinoless double beta decay

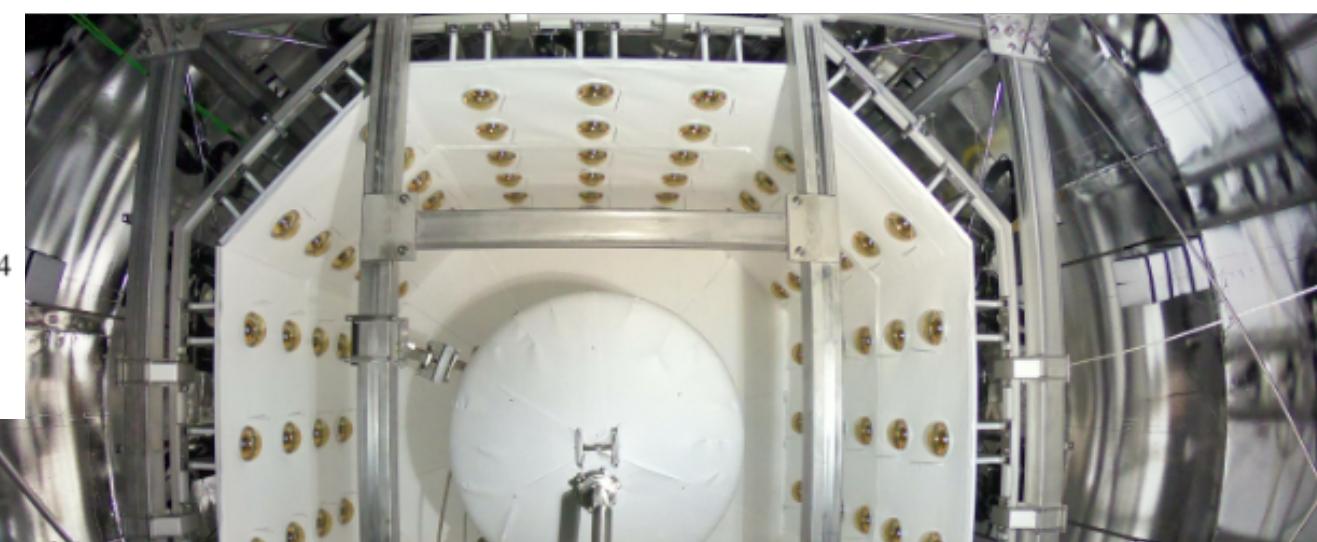
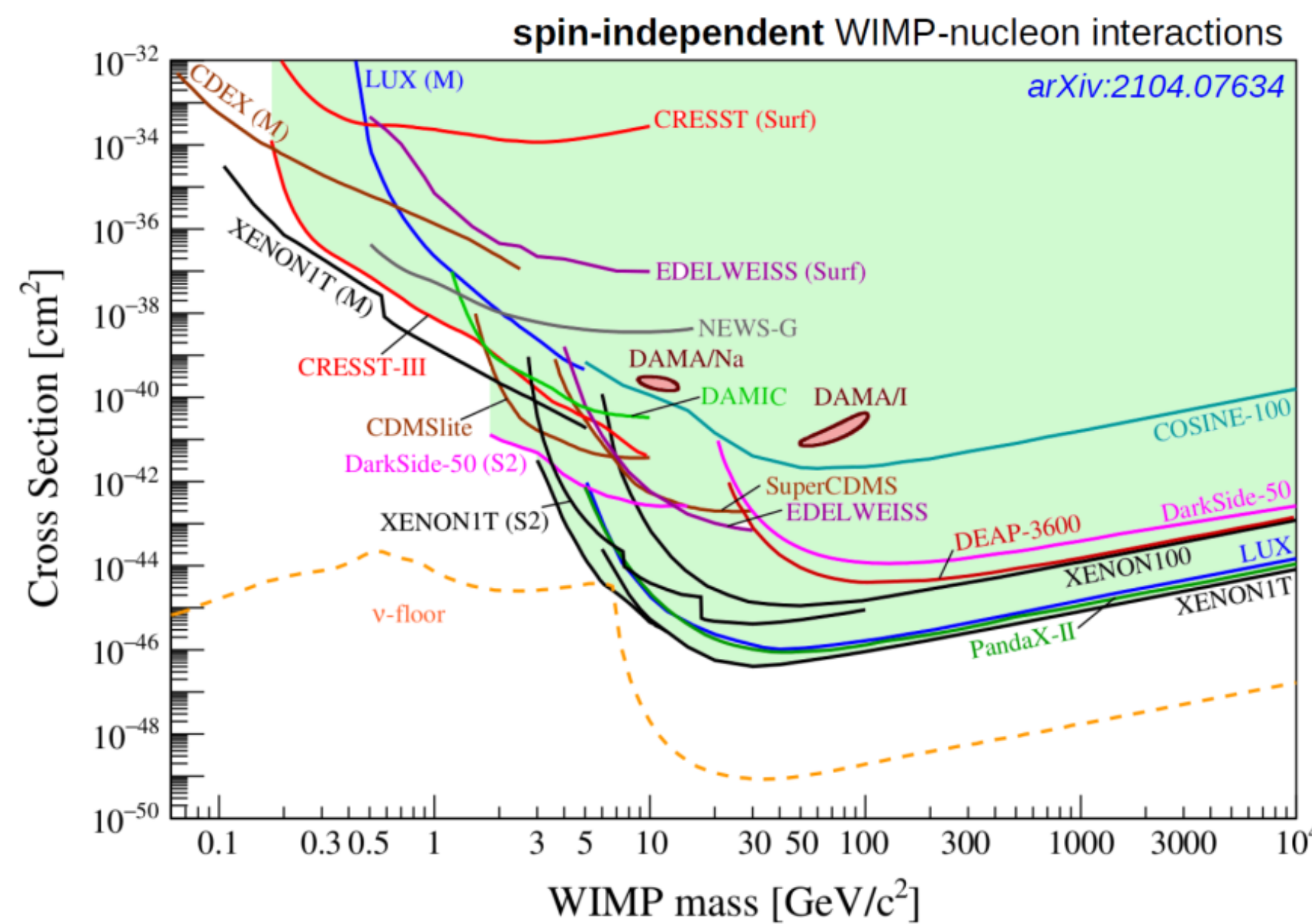
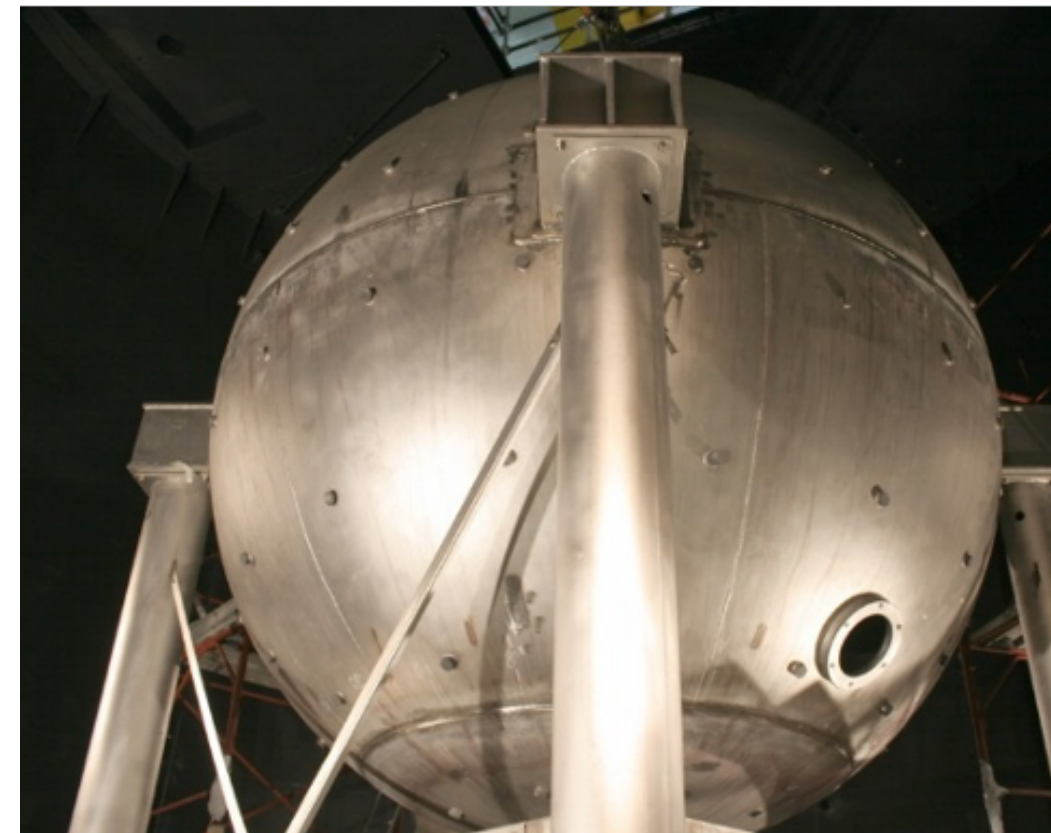
- BOREXINO
- CUORE
- GERDA
- LVD
- CUPID
- LEGEND





Many of the leading experiments in direct Dark Matter search

- XENONnT
- DAMA
- CRESST
- DarkSide 20k
- COSINUS
- SABRE
- LIME/CYGNO



The LNGS are universally recognized as the world's leading laboratory in Astroparticle Physics

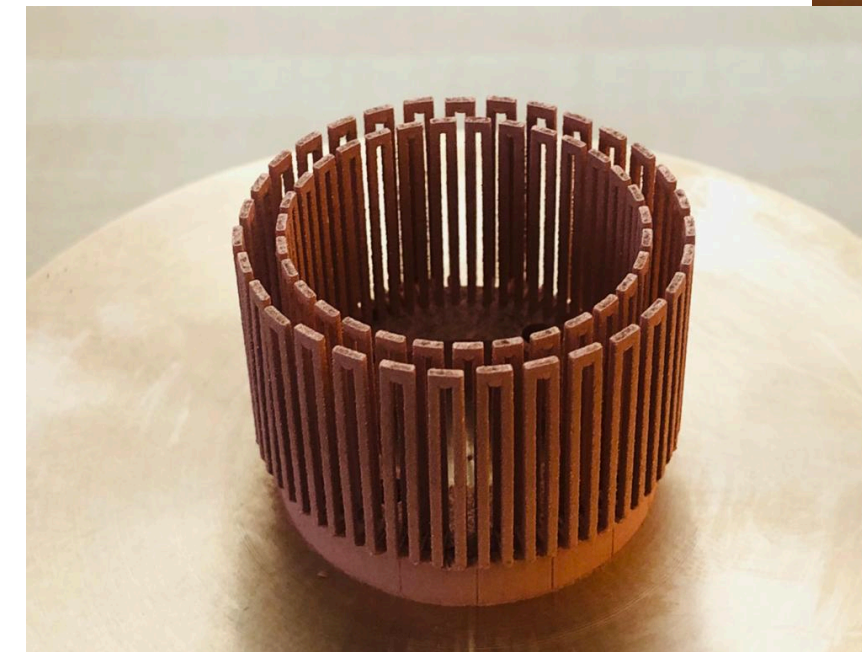
- dimensions
  - easy of access
  - geografic location
  - quality of support to the experiments
- 
- The LNGS lab is ~35 years old: needs modernisations in various parts
- 
- We are working on several upgrades and renovations with the aim of maintaining a high-level support

# External labs

- Directorate
- Offices and meeting rooms
- Cafeteria and canteen
- Administration
- Technical Division
- Assembly and test Halls for large equipments
- Mechanical workshop
- Chemistry service
- Computing service
- Cryogenic service
- Electronics workshop



- Computing
- Design and Mechanical Workshop
- Additive Manufacturing
- Cryogenics and Vacuum
- Chemistry (ICPMS)
- Electronics
- Special Techniques (HPGe)



## STELLA (SubTErranean Low Level Assay)

15 HPGe detectors

- 11 p-type coaxial detectors, all LB or ULB
- 1 ULB well-type detector
- 1 BEGe ULB detector
- 1 multiple p-type crystal ULB detector
- 1 n-type LB detector

Alpha spectrometers

Liquid scintillator counters

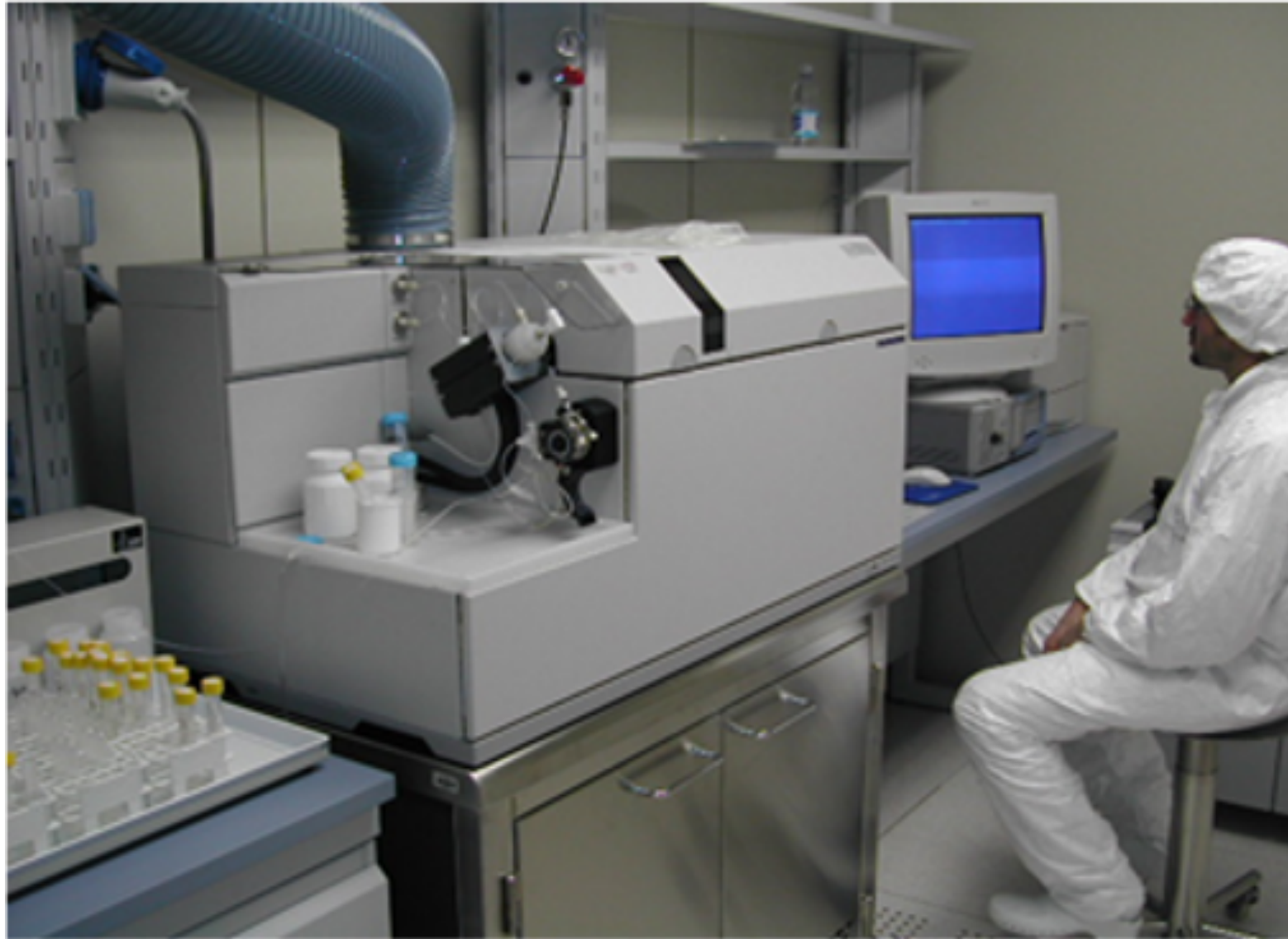
### Sensitivity (Th/U)

- commercial LB detectors  $O(\text{mBq/kg})$
- commercial ULB detector  $O(0.5 \text{ mBq/kg})$
- custom ULB detector  $O(10\text{-}50 \mu\text{Bq/kg})$



## Activities

- material screening for LNGS experiments
- small fundamental physics research projects
- meteorite measurements
- environmental radioactivity
- CELLAR (Collaboration of European Low-level underground LABoratories)



Chemical labs for Ultra-Trace Analysis equipped with

- Clean Room ISO6
- Chemical equipment for treatments and preparation of samples
- Magnetic Sector ICP-MS
- TIMS for isotopic measurements
- New ICP-MS quadrupole
- New Laser Ablation ICP-MS (Agreement between INFN-LNGS and BMBF)

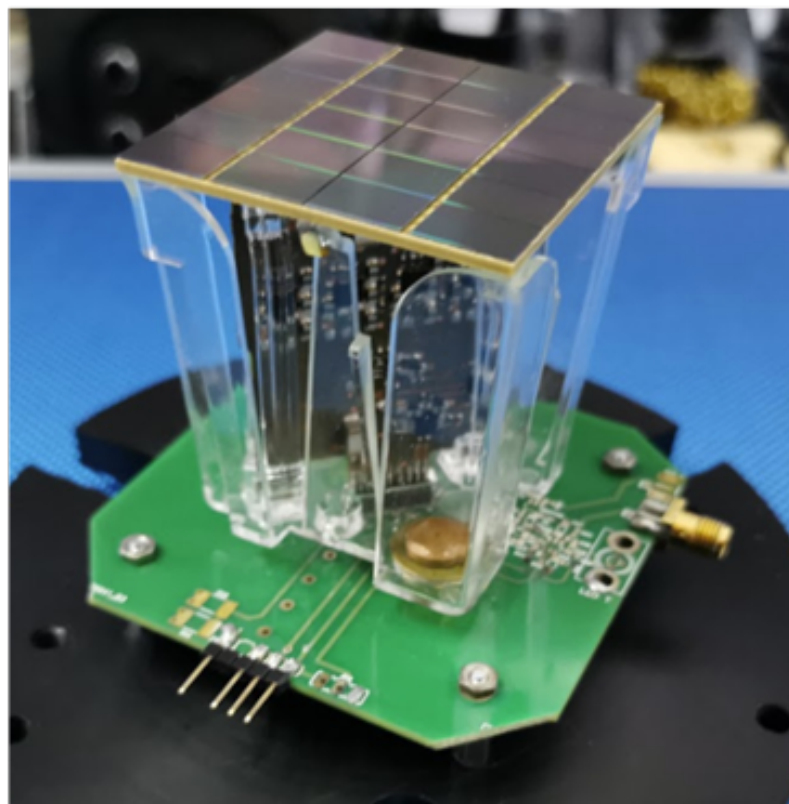


Sensitivity (Th/U)

- few  $\mu\text{Bq/kg}$

## NOA (Nuova Officina Assergi)

- Large (450 m<sup>2</sup>) Clean Room suitable for Radon-free operation
- Equipped for photodetector assembly
  - Cryo-probe
  - Dicing
  - Flip-chip
  - Wire bonding



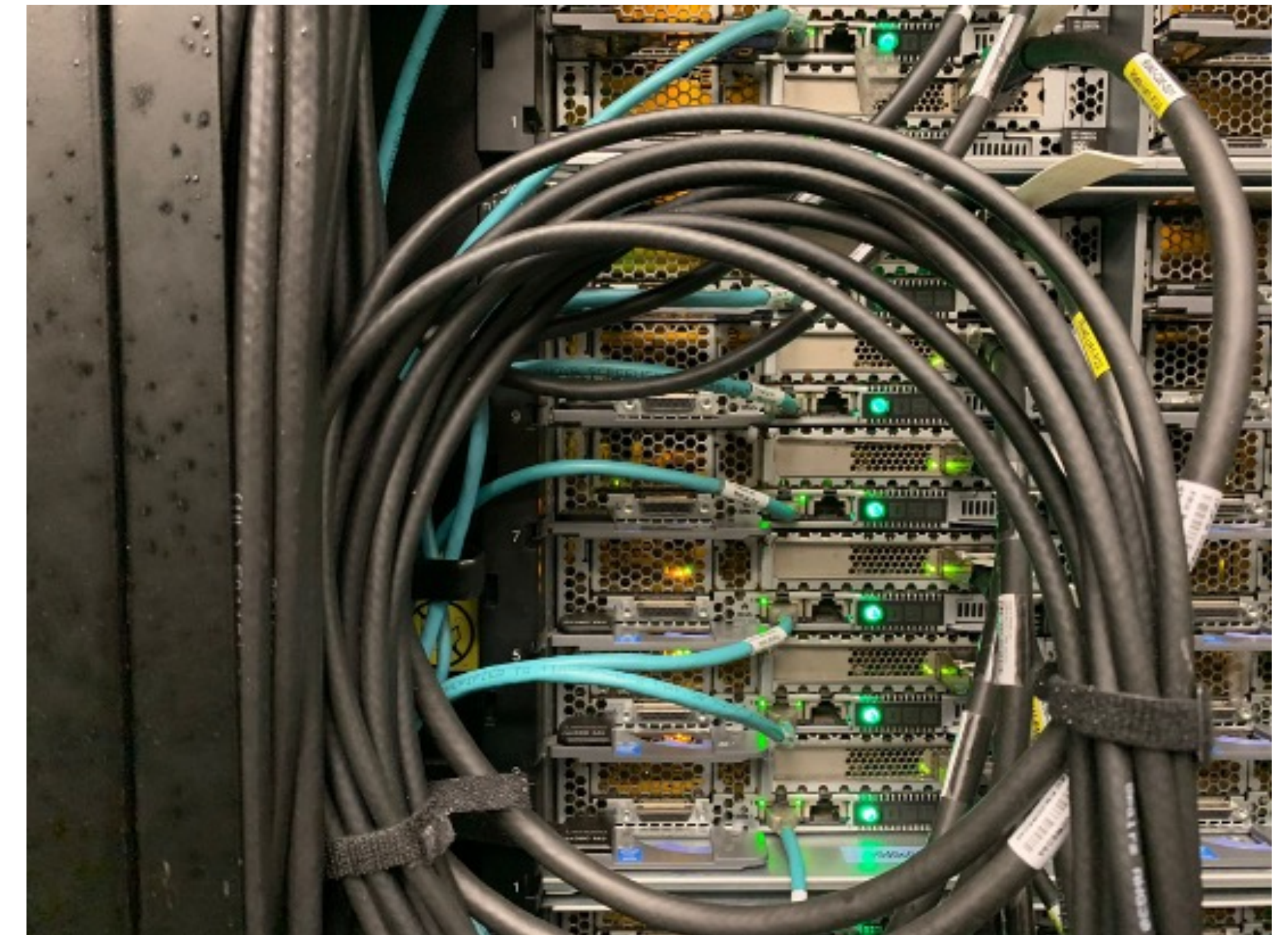
## HPC4DR (High Performance Computing for Disaster Resilience)

A cluster of 400 servers has been recently installed

- multicore processors Intel Xeon E5-2697 v4 (Broadwell)
- Interconnection via a high speed network at 100Gb/s
- high computing power

### Goals

- provide computing resources to Universities and Research Institutions of Abruzzo, Marche e Molise, in order to increase, through computational methods and data analysis, the resilience of local systems to natural disasters
- improve the computing power for LNGS experiments





A new cryogenic setup conceived to perform measurements of detectors and devices at mK temperature

- dry  $^3\text{He}/^4\text{He}$  dilution refrigerators
- Large experimental space:  $\varnothing$  50 cm, h 75 cm
- Base temperature  $< 10$  mK
- Low radioactivity & low vibration environment
- Funded by LNGS-FUTURE, BMBF and SQMS

Useful for low-background tests of

- Cryogenic detectors equipped with TES, NTD, ...
- Qubits

The Cryo-Platform facility access procedures will be regulated by a PAC



In the last few years there is an increasing interest and numerous R&D addressed at Quantum Computing

- There are evidences that cosmic rays and radioactivity have some impact on the coherence time of superconducting qubits
- Low temperature detectors groups at LNGS have the same expertise (low temperature, low vibration, low noise, ...)
- Can LNGS become a reference center for quantum computer development?
- INFN is the only non-US partner of the SQMS (Superconducting Quantum Materials and Systems Center) project
- Some measurements are already going on in a small dilution fridge at LNGS
- In the future we plan to test large qubit arrays in the Cryo-platform

