INFN - Laboratori Nazionali di Frascati
Annual Report 2025

Figure 1: *Aerial view of the Frascati laboratory.*

The Frascati National Laboratory (LNF) has been the first among the INFN National Laboratories and is still the largest for number of employees. Since its foundation, in 1957, it has been devoted to two main activities: the development, construction and operation of particle accelerators; the design and construction of forefront detectors for particle, nuclear and astroparticle experiments. With the recent acquisition of a new estate at the north border of the laboratory, the LNF covers an area of about 142300 m^2. Of these, 28500 m^2 are indoor and include offices, laboratories and service areas. The LNF hosts the following research infrastructures:

- DAΦNE, an e^+e^- collider operated at the center of mass energy of the Φ meson (1020 MeV), able to deliver instantaneous luminosities of up to 4.5×10^{32} cm^{-2}s^{-1}. DAΦNE did not operate in 2025; the future of this infrastructure is presently being discussed.
- A synchrotron light laboratory, DAΦNE_ Light, housing seven synchrotron radiation lines in the soft-X rays and infrared range, extracted from the DAΦNE electron ring, when the accelerator is running. The laboratory is also equipped with radiation sources for operation when the extracted beams are not available.

- A Beam Test Facility, BTF, where two beam lines (BTF1, BTF2) are available from the DAΦNE Linac which can provide electrons, positrons and photons of variable intensity and energy up to 700 MeV in the case of electrons. The area is conceived mainly for detector and irradiation tests, as well as beam diagnostic studies, but it can also host small-size fundamental physics experiments.
- SPARC_ LAB, a complex hosting a linear electron accelerator (SPARC) able to drive a FEL, and a laser (FLAME) of 200 TW peak power. The SPARC_ LAB is an infrastructure for R&D on new techniques of particle acceleration and for interdisciplinary studies, including Plasma WakeField Acceleration (PWFA), TeraHertz radiation (SABINA) and the new betatron radiation source (EuAPS).
- SCF_ LAB, a certified laboratory for the design, modelling and characterization of laser ranging equipment. The laboratory procedures are approved by the International Laser Ranging Service.
- COLD_ LAB, a cryogenic laboratory for the development of ultra-sensitive photon detectors equipped with a complete set of cryogenic facilities for measurements down to mK temperatures.
- TEX, an RF test facility for X-band (12 GHz) accelerating structures up to gradients of 100 MV/m. Recently, it has been also equipped for testing C-band (5.7 GHz) components with the installation of an additional power source.
- DDG_ LAB, the infrastructure of the Detector Development Group, that since 1985 has been performing R&D, design, and construction of classical and innovative gas detectors for large high energy physics experiments.
- Large assembly halls with several clean rooms (class ISO 6 and 8 for a total surface of about 480 m^2) equipped with all the necessary tools for designing and building large experimental apparatus.

Furthermore, LNF hosts a mechanical workshop, an electronic service, a plasma laboratory, an advanced UHV laboratory equipped with a brazing facility, a powerful and modern computing center and a medical physics service unique within INFN. Finally, thanks to PNRR funds (Italy's National Recovery and Resilience Plan, a key part of the Next Generation EU), the laboratory will host by summer 2026 a new HPC data center for scientific computing up to a power of ∼1.2 MW.

As of December 2025, the LNF features 285 units of permanent employed personnel and 35 fixed terms, in line (slight decrease) with previous years. Table 1 summarizes the distributions of the different profiles of employees. Besides LNF employees, around 350 collaborators participated to the LNF activities as users during the year. This includes master and PhD students, young postdocs, and employees of other scientific institutions (Universities and other research institutions) from Italy and abroad (10% of the total). Researchers from the Cosenza University involved in INFN activities are also joint to the LNF organization.

1 Progress in the accelerator sector

In the field of particle accelerators, interest is growing in the development of compact accelerating structures capable of overcoming the current limitations of conventional ones based on RF pulses. In this context, research activity is moving toward plasma technology-based devices capable of producing accelerating gradients on the order of tens of GV/m, to be compared with the tens of MV/m achievable by conventional techniques. Thanks to the pioneering work of the

Table 1: *LNF personnel as of December 2025.*

	Permanent Staff	Fixed term Staff	Total
Researcher	66	0	66
Engineer	75	21	96
Administrative	43	3	46
Technician	101	11	112
Total	285	35	320

SPARC_LAB team, the LNF is at the forefront of this research field, and will host in the next years the EuPRAXIA@SPARC_LAB complex. This infrastructure is conceived as the first facility based on plasma accelerated beams providing users with high-brightness Free-Electron Laser (FEL) lines in the soft X-ray regime. Its first user beamline, AQUA, will deliver ultrashort femtosecond soft X-ray pulses within the biologically relevant water window spectrum, enabling real-time imaging, advanced materials development and investigation of chemical processes with unprecedented spatial and temporal resolution. The project will move into the construction phase next year, with the aim of starting operation in the early 2030s.

Crucial milestones have been recently met by the collaboration, *i.e.* the approval of TDR in February 2026 and the launching of the tender for the main building in December 2025, with construction expected to start at the end of 2026. The Italian government already granted 108 MEUR for the construction of this infrastructure. More recently, INFN and Lazio Region have signed an agreement to further support EuPRAXIA with 10 MEUR from regional funds, and further 10 MEUR from INFN, which are made available for the implementation of an additional VUV-FEL beam line, named ARIA, devoted to academic and industrial users. At the same time, the ancillary facilities of the project (EuAPS, TEX, SABINA) are achieving important scientific and technological results, supported by funds provided under the aegis of the PNRR program.

Concerning DAΦNE, which provided valuable data to several experiments in particle and nuclear physics in the past 25 years, did not operate in 2025 and will remain shut down in 2026, except for the Linac and the BTF, that is and will remain a fundamental asset of the laboratory in the future. While a final decision on whether and how to operate the DAΦNE main rings in the future remains under discussion, a new running of the facility as a collider is very unlikely. This is due to the large costs implied by the important maintenance work that a new continuous operation period would require, and to the concurrent commitments taken by the laboratory in the accelerator sector, and primarily in the construction of the EuPRAXIA@SPARC_LAB infrastructure. To help steering the discussion, a task force has been set-up, which made a first report to the LNF Scientific Committee in November 2025. Among the various options, particularly interesting seems the reuse of the DAΦNE damping ring as a pulse stretcher to provide high-charge positron pulses with low average current, to expand the BTF user community.

2 Progress in the research sector

Besides the involvement on EuPRAXIA, a crucial target for the laboratory is to maintain on-site activities in fundamental science of well-recognized scientific interest. Coming to this, in recent years a strong activity started at the COLD lab with the development of resonant cryogenic detectors, the so-called haloscopes. These devices, consisting of microwave cavities cooled down to cryogenic temperatures and placed inside a superconducting magnet, are used for axion dark matter search. In 2024, the COLD lab team, together with three other European institutes, has been awarded by the European Council with a 10 MEUR Synergy Grant, to implement a global network of cryogenic detectors, called GravNet. This network will extend the observational campaign to investigate the uncharted territory of high-frequency gravitational waves. The LNF will contribute the project with two haloscopes. The first is already in operation within the experiment for axion search QUAX@LNF, while the second, FLASH, will be constructed recycling the 3 m bore-magnet of the former FINUDA experiment. In addition, the COLD lab team is developing new superconducting quantum devices to increase the sensitivity of the detectors. Dark matter searches are performed at LNF also by the PADME experiment at the BTF facility. Here, signals of new low-energy particles are looked for in the products of positron, produced by the DAΦNE LINAC, annihilating with the electrons of a very thin diamond target. In 2025, the final result obtained from the analysis of more than 500 billions of annihilation events acquired in 2022 has been published, which shows an intriguing excess of two-prong final states corresponding to the mass reported by the ATOMKI experiment, with a statistical significance of 2σ. During 2025, the BTF running has been almost fully devoted to the experiment, with an expected reduction of the statistical error by a factor two, and including improvements of the detector, too. Data taking for PADME experiment will continue with high priority during 2026, at the very least.

The LNF has always been an important hub for the development of new particle detection techniques, particularly in the fields of gaseous tracking detectors and calorimeters. This expertise allowed the LNF teams to contribute successfully with major parts of the experimental apparatus in many international collaborations all around the world. The participation to experiments at external laboratories is a well-recognized asset for the laboratory and will continue for the next years. At present, the most relevant commitment in detector construction by the LNF is the assembly of the inner tracker for the ATLAS detector at CERN (ITK) for phase 2 upgrade of LHC. For this, a new large clean room has been realised, and the preparation phase for the assembly tooling is now very well advanced.

The successful execution of major detector construction projects is made possible by the extensive multi-year experience of the LNF technical and engineering teams, as well as by the efficient infrastructure and support services. In addition, the BTF serves as a unique resource for testing detector prototypes, continuously attracting new teams and expertise from external institutes. To preserve this powerful research infrastructure for the future, it is necessary to keep on investing in personnel and in the experimental facilities, as well as in R&D in detector technology. Among the new initiatives, a laboratory will be equipped during 2026 for the prototype production of Micro Pattern Gas Detectors (MPGDs), a new generation of gas detectors characterized by sub-millimeter distances between anode and cathode electrodes, which are produced with the lithographic techniques proper of the PCB industry.

You can find all this and much more in the following chapters of the 2025 LNF annual report, which reveal the passion and dedication of all the staff of our laboratory, and which are by far its most important asset.

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