Frascati National Laboratory
by A. Antonelli (Research Division Head)

1 Introduction

The LNF is the largest (for number of employees) and the first built of the INFN national laboratories. INFN was funded, in the fifties of last century, to give Italy its first particle accelerator and the site to locate this infrastructure was chosen to be Frascati. Since these early days, the LNF has always been involved in two main activities: building and operating particle accelerators, designing and constructing particle detectors.
The LNF site stands on a surface of 135.178 m^2, 25.000 of which are indoor and include offices, laboratories, and workshops.
At LNF are hosted the following facilities:

- DAΦNE, an e^+e^- collider operating at the Φ energy (1020 MeV), able to deliver instantaneous luminosities $2x10^{32}cm^{-2}s^{-1}$, a world record at this energy.
- a synchrotron radiation facility (DAFNE Light) with lines in the X, UV, and infrared regions, extracted in parasitic or dedicated mode, from the intense photon emission of DAΦNE.
- a Beam Test Facility (BTF), with two beam lines providing electron/positron or photon beams mainly for detector calibration purposes.
  SPARC_LAB, a facility that combines a linear accelerator (SPARC) and a 200 TW laser (FLAME). This is an infrastructure for R&D in the field of new technologies for particle acceleration like FEL, PWFA and Terahertz radiation. SPARC_LAB is the seed for the new infrastructure EUPRAXIA.
- SCF LAB, a laboratory equipped for Space Simulation. It characterizes devices that are to be sent in space missions.
- 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 physic experiments.
- COLD (CryOgenic Laboratory for Detectors), the site where research is conducted on super-conductors, magnetic materials and related systems using magnetic and electric transport tools with cryogenic equipment's able to study the dynamic behavior of these materials under conditions of extreme temperature and magnetic field.
- NEXT (Nanoscience EXperiments for Technologies), a laboratory that synthetizes and studies nanostructured carbon materials.
- assembling halls, mechanical workshops, a Computer Center, and an Electronics Laboratory suited for complex and challenging enterprises in many fields of fundamental research.
- eight clean rooms (class ISO 6 8), three connected to DAFNE Light, SPARC_LAB and SCF_LAB, and the others equipped for the construction of different kind of particle detectors, for a total area of 400 m^2.

Year 2023 has been rich of success for many activities carried out both at LNF and in other research centers. We describe the most relevant ones in the following.
The DAFNE collider and the SIDDHARTA-2 experiment started in spring 2023 a new data taking phase, dedicated to measurements of kaonic atoms, in particular to the first measurement in the world of kaonic deuterium.
This measurement is much more difficult than that of kaonic neon, as the transitions on the fundamental level are hundreds of times less probable. The data taking was smooth and the machine performed in excellent way delivering about 8 pb^{-1}/day. In 2023 SIDDHARTA-2 collected about 450 pb^{-1}, the luminosity required by the experiment to perform the measurement being 800 pb^{-1}.
BTF was fully operational, providing beam about 250 beam days to over 150 users. Among the many experiments, it is worth mentioning that in the framework of a scientific collaboration with INFN-LNF, researchers from the Rutherford Appleton Laboratory and ENEA explored a novel approach to produce Tc-99m radiopharmaceutical, a crucial diagnostic tool in medical imaging, without relying on nuclear reactors. The team has successfully used a dedicated high energy electrons beam from BTF (E=504 MeV) on a specially target designed by RAL, to investigate the feasibility of direct electronuclear production. The recent results obtained in BTF could have the potentiality of a critical development for modern medical imaging for a worldwide benefit.
The COLD Lab group started the process to submit a new proposal for the search of light Axion like particles, FLASH. The project involves the incorporation of a cryogenic antenna inside a magnet to observe signals related to axions, hypothetical particles that could constitute the Dark Matter in our galaxy. FLASH will reuse the magnet that had been previously used by the FINUDA experiment at DAFNE; the entire process of refurbishing the various parts of the magnet and adapting the cryogenic system will be completed by 2024 and involve specialized personnel from LNF.
In addition, our staff participate with leading role to many experiments all around the world.

Regarding multidisciplinary research it is worth mentioning the ARTEMISIA (ARTificial intelligence Extended-Multispectral Imaging Scanner for In-situ Artwork analysis) project. ARTEMISIA is a project aimed at developing an experimental technology, called BR-RIS (Broad Spectral Range Reflectance Imaging Spectroscopy), for the in-situ identification of pictorial materials. The project's objective is to enhance imaging diagnostics by extending the spectral analysis range and developing dedicated artificial intelligence algorithms for both automatic recognition and monitoring of the degradation status of the materials constituting artworks. The conclusive results of ARTEMISIA, cofounded by Regione Lazio, were discussed and presented at Museo Carlo Bilotti Aranciera di Villa Borghese di Roma. The successful application of ARTEMISIA's cutting-edge methodologies underlines the transformative potential of integrating artificial intelligence with multispectral imaging for the analysis and conservation of artworks.

Important progress has been achieved in the field of new acceleration techniques.
The SPARC_LAB research team has recently demonstrated that the plasma-based acceleration technique allows one to obtain a high-quality particle beam, comparable to those produced by traditional accelerators. Already in previous years, the electron bunches injected in a plasma contained in a 3 cm long capillary have been accelerated with a gradient of ~ 1.2 GV/m, and have generated coherent light pulses in the infrared range. Recent experiments have shown that such plasma structures can also be used to focus high-energy particle beams (a technique called *Active Plasma Lenses* (APLs)), using the high magnetic field gradients produced, in the kT/m scale, by the intense ionization currents of neutral gas. The result is to focus high-energy beams over distances of a few centimeters, to be compared to the meters required by conventional techniques based on permanent magnets or electromagnets. In the tested module, a single plasma channel having a diameter of 2 mm was created, where each of the three elements, all 30 mm in length, is bounded by a pair of electrodes. This plasma accelerator module, entirely designed at LNF, represents the first prototype of a plasma device capable of integrating the use of focusing and accelerating elements built within the same structure.
This important result also represents a milestone towards the realization of the EUPRAXIA infrastructure, the first research infrastructure addressed to users, based on plasma acceleration capable to reach a beam energy of 1.1 GeV.

LNF is also very active in seeking for fund from external agency, European Commission, Regione Lazio and so on, and participated to many projects funded by the Italian Ministry of Research (MUR) in the PNRR scheme.
In addition, we organized and hosted 30 scientific conferences and many events for public and students.

2 Organization

The LNF personnel, at the end of 2023, consisted of 330 units of personal, 49 of which have a fixed term contract, 56 fellows plus about 300 associate members. Among the latter, there are university and PhD students, young post-Docs and employees from universities or other research institutions. Associate members work alongside staff members and likewise take part in the laboratory's activities. Tab. 1 shows the distribution of the LNF personnel among the different profiles.

	Staff	Temp.	Tot.
Researcher	70	0	70
Engineer	75	19	94

Administrative Technician	38 98	7 23	45 121
Tot.	281	49	330

Table 1: Snapshot of the LNF personnel at Dec. 2023.

Fig. 1 shows the organization chart of the laboratory. The structure consists of services that respond directly to the Director, and three divisions (Research division, Accelerator division and Technical division) that also consist of different services. The laboratory also has a Scientific Committee composed by eminent international scientists that help the Director in shaping the research program. They meet twice a year and deliver recommendations regarding the scientific activities of the laboratory.

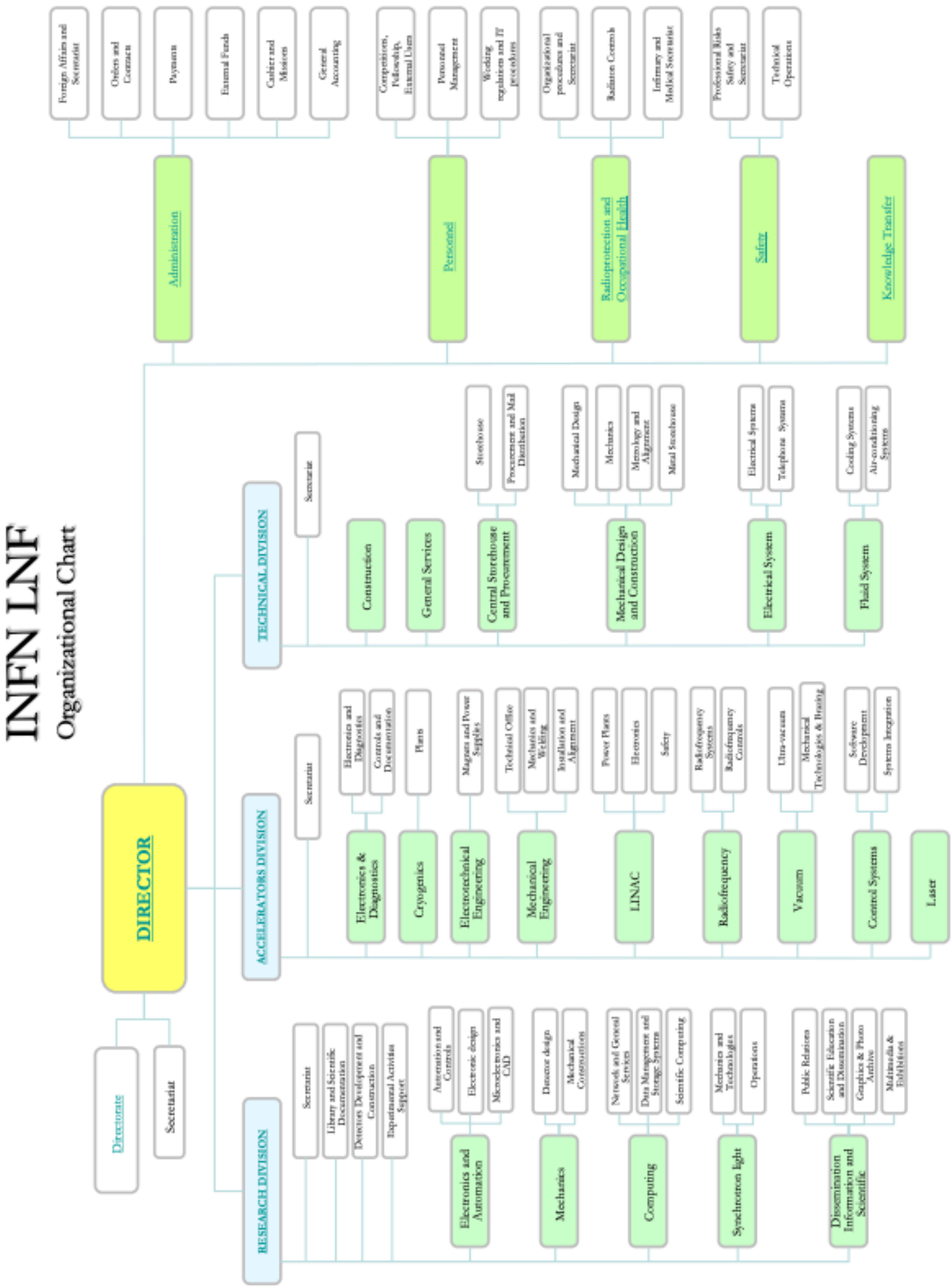

Fig. 1 Organization chart of the laboratory