CPHT

The Center of Theoretical Physics (CPhT) at Ecole Polytechnique groups together research scientists active in developing new physical theories in quite varied domains. It is supported both by Centre National de la Recherche Scientifique (CNRS) and by Ecole polytechnique. It is located inside Ecole Polytechnique in Palaiseau. The scientific domains covered by its members range from very fundamental aspects of fundamental interactions to some aspects relevant for applied physics. The physicists are organized in 6 groups: Particle physics, String theory, mathematical physics, Condensed matter, Laser-Plasma interactions, Magnetized plasmas.

CSNSM

The Center for Nuclear Spectrometry and Mass Spectrometry (CSNSM) includes 50 researchers and 42 engineers, technicians and administrative staff. Located in the heart of Campus d'Orsay, it is characterized by its interdisciplinarity.

Strongly involved in a number of French and international scientific collaborations, it also interacts with industry on both basic and applied research through its JANNuS platform of multi-beam irradiation (a member of EMIR national network), its electron microscopes, and its FIB (Focused Ion Beam) facility, integrated in the MINERVE nanotechnology platform.
It also contributes to higher education and participates in the management of two Masters (Environmental Physics, and Applied Physics & Mechanics).

Its research topics are largely connected to the P2IO objectives. In particular:
➢ The dark components of the Universe: bolometric detectors for dark matter search (EDELWEISS, EURECA),
➢ Strongly coupled nuclear matter: study of exotic nuclei and transuranic elements; gamma spectrometry (AGATA multi detector), measurement of atomic masses (ion traps),
➢ Star formation and conditions of the emergence of life: study of nuclear reactions for primordial and stellar nucleosynthesis, gamma radiation spatial detector for INTEGRAL; collection and analysis of meteorites and micro-meteorites,
➢ New generation of sensors: bolometer arrays for astrophysics; material nanostructuration by irradiation,
➢ Nuclear energy of the future: study of nuclear materials properties under ion irradiation (JANNuS).

IAS

« Institut d'Astrophysique Spatiale » (IAS) is a joint laboratory between CNRS and Université Paris Sud (UMR 8617). It is also an « Observatory for Sciences of the Universe », an internal school of the university associated with the « National Institute

of the Sciences of the Universe » (INSU). 170 persons work at IAS : 46 tenured scientists, professors and astronomers, 89 engineers and technicians (28 on contract funding),10 post-docs and 25 PhD students. Research activities are structured within four science teams: astrochemistry and origins, interstellar matter and cosmology, solar and stellar physics, solar system and exoplanetary systems.

IAS has as a main goal the realization and the science exploitation of experiments on board space missions, in particular those of the European Space Agency (Soho, Cassini/Huygens, Mars Express, Rosetta, Herschel, Planck, BepiColombo, ExoMars). Our laboratory is strongly involved in two ESA missions, Solar Orbiter (solar physics) and Euclid (dark matter and energy), which have recently been selected for a launch in the 2017-2020 time frame. Other instrumental contributions have been delivered for CNES missions (Corot) or NASA missions (Stereo, MSL) and collaborations are developed with other space agencies (Japan, Russia, India, China). There are experimental activities in the laboratory dedicated to astrochemistry and to dark matter.
Among the most recent scientific results, one can mention: the discovery of hydrated minerals on Mars (OMEGA/Mars Express) which provide direct evidence for the presence of liquid water early in the history of this planet; the characterization of the internal structure of stars and the discovery of exoplanets (CoRot); the characterization of distant galaxies, of the gas in the interstellar medium and that of shock regions (Spitzer-Herschel); the comprehensive mapping of the Cosmological Microwave Background (Planck/HFI) which makes it possible to access the first stages of the evolution of the universe; the discovery of formation processes which lead to pre-biotic organic molecules by irradiation in astrophysical environments.

Web site of IAS: http:www.ias.u-psud.fr

IMNC

Created in 2006, the IMNC laboratory incarnates challenging scientific interdisciplinary projects guided by a spirit and a method: developing mono-disciplinary skills in physics and biology in order to address questions of fundamental neurosciences and therapeutic issues in cancerology. The laboratory gathers 43 collaborators and 5 research teams which mobilize physicists, methodologists, biologists and engineers along two scientific axis:

- imaging in neurobiology axis focused on the exploration of the cellular basis of the cerebral energy metabolism and the *in vivo* multimodal neurofonctionnal imaging (radioisotope and optical) on small animals.

- imaging and modeling in cancerology axis focused on the development of compact multimodal imagers for the diagnosis and the therapy of tumors and development of associated quantitative methodologies (tomographic reconstruction in PET).

The topic of modeling is focused on the study of process guiding the migration of tumors.

These research projects are also based on a broad network of international collaborations and are built on two transversal topics of physics. First topic rely on instrumentation and aims at the development of new methods of photo-detection for both optical and radio-isotope imaging. The second topic relies on theoretical physics aiming at the study of behavior of dynamic systems that bring new insights into biological complex mechanism such as tumor growth.

IPhT

The team of the IPhT (Institute of Theoretical Physics) works at the CEA campus of Orme des Merisiers, near Saclay. The research topics are purely theoretical and encompass a wide range of fundamental problems in particle physics and cosmology.

- String theory, with emphasis on the microscopic description of black holes, and the low-energy limit of string theory, which provides a link to the observational world.

- Precision calculations in gauge theories: the goal is to make accurate predictions for experiments at the Large Hadron Collider (LHC). Precision calculations are also used to test the conjectured duality between string theory and gauge theories, known as the AdS/CFT correspondence.

- Primordial cosmology, which is the study of the early phases of the Universe through various observations: cosmic microwave background radiation, large-scale structure of the Universe, gravitational lensing, primordial magnetic field and gravitational waves.

- Particle physics beyond the standard model. Activities of this group focus in particular on the nature of dark matter, the physics of neutrinos, and signatures of phase transitions in the early universe.

- Strong interactions at high energy. This group studies the internal structure of the proton at high energy, and the phenomenology of proton-proton and nucleus-nucleus collisions at ultra-relativistic energies.

The team comprises 19 permanent researchers (CEA and CNRS), 17 postdoctoral researchers and 11 doctoral students. It boasts six winners of prestigious European Research Council (ERC) grants. In addition, three members of the team have been awarded "junior excellence chairs" by the French National Research Agency (ANR).

IPN

The « *Institut de Physique Nucléaire »* (IPN) is one of the largest nuclear physics laboratories in Europe whose research is centred on a deeper understanding of matter and its basic constituents. The Institute, which belongs jointly to the « *Centre National de la Recherche Scientifique* » (CNRS) and the « *Université Paris-Sud* », is a leader at both national and international levels in the areas of nuclear and astroparticle physics as well as in the domain of radiochemistry and various, related interdisciplinary fields. It plays an important role at the heart of high-level collaborations performing experiments at major accelerator facilities, most notably in Europe, the USA and Japan.

Organised into four divisions, the IPN, which operates and exploits the accelerators ALTO and the TANDEM, and will shortly host the ANDROMEDE (nanoparticle accelerator) project, comprises more than 350 collaborators, researchers, engineers and technicians. These human resources allow the laboratory to participate in research at a technological forefront whose progress is assured by two technical divisions, the Accelerator division and the *« Instrumentation et Informatique »* division, which study and develop new approaches to associated detection systems. The expertise of the IPN in the conception and construction of superconducting linear accelerators represents a major asset both nationally and internationally.

The IPN also plays a dual role in training and teaching; the laboratory welcomes many foreign visitors each year, as well as running and accommodating two of the university's doctoral schools.

IRFU

IRFU is a CEA fundamental research institute located on the CEA center of Saclay. It almost gathers 800 people: 320 physicists (including 150 PhD students and postdocs) doing research on the fundamental laws of the Universe with 243 engineers and 210 technicians by advancing the technologies needed for instrumentation project management. IRFU includes the three disciplines, astrophysics, nuclear physics and particle physics, and approaches in a complementary way the major questions concerning the fundamental laws of the Universe.

What are the elementary components of the Universe?
IRFU plays a dynamic role in ATLAS and LHC CMS experiments in order to test the Standard Model of particle physics, eventually discover the Higgs boson and explore its extensions. With T2K in Japan and Double Chooz in Europe, IRFU is in the race for neutrinos properties.

What is the energetic content of the Universe?
IRFU is involved in experiments pursuing dark matter in a direct way (EDELWEISS) and indirect way (HESS and CTA) as well as in experiments testing dark energy

using various sensors such as fluctuations in the cosmological background, effects of gravitational lenses, baryon acoustic oscillations and supernovae. It is at the origin of EUCLID project, major mission for black energy research that has just been selected by ESA as M2 mission.

How is the Universe structured?
Study of planets, stars and galaxies formation occupies a substantial part of IRFU astrophysics component with an important role among others in the use of HERSCHEL satellite observations and the construction of average infrared camera for JWST next mission.

What are the origins and structure of particles and nuclei?
Matter under extreme conditions of temperature and density such as they prevailed in the first instants of the Universe is studied thanks to ALICE experiment at LHC; proton internal structure is explored at JLAB and CERN. For the study of superheavy, exotic and deformed nuclei, physicists are involved in several experiments with various accelerators such as GANIL, then soon Spiral2 and FAIR. The institute develops machines allowing to explore the infinitely small such as particle accelerators, and detecting systems of any kind of radiation, and in any conditions (underground, under the sea, with particle colliders and in space).

The institute is also leader in the field of large-scale simulations. It also applies its know-how in the field of fusion, in therapy imaging and, in a general fashion, in the construction of large-scale instruments, in which IRFU masters high technology.

LAL

The «Laboratoire de l'Accélérateur Linéaire» (in English the Linear Accelerator Laboratory, in short the LAL) is a major laboratory in fundamental research which main field is the physics of the two infinities. On the one hand, the study of the tiniest components of matter, the elementary particles; on the other hand, the cosmology which explores the history, the composition and the evolution of the Universe. As implied by its name, the LAL has been tightly coupled to particle accelerators since its creation in 1956, both on the physics side and through the associated technological developments.

The LAL is a joint research unit of the IN2P3 (the "National Institute of Nuclear Physics and Particle Physics", one of the ten institutes of the French "National Center for Scientific Research", in short the CNRS) and of the Paris-Sud University. The lab is deeply involved in teaching activities at all levels and a dozen students start their PhD thesis at LAL every year. In addition to fundamental research, the LAL is sponsoring many outreach activities which target students, teachers and the general audience.

The LAL includes about 120 researchers which work in a dozen of projects. The contributions of its teams range from technical developments to state-of-the-art physics analysis. Its successes are primarily due to its high-quality services, both technical (electronics and instrumentation, mechanics, computing and accelerator services design) and administrative (human resources, finance, travel and infrastructure & logistics), which count in total more than 200 engineers and technicians.

Among the projects in which the LAL is currently involved, one can name: the ATLAS and LHCb CERN experiments; the Planck satellite which is surveying the Cosmic Microwave Background; the Pierre Auger observatory which is studying ultra-high energy cosmic rays; the building and conditioning of the couplers of the new free-electron laser XFEL. Locally, the LAL is completing the construction of a 10 MeV electron accelerator named PHIL. The laboratory is also planning its future with the project of a compact X-ray source named ThomX (and which was recently awarded «Equipement d'Excellence» by the French National Research Agency) and developments in many areas: LHC upgrades, next generation colliders, astrophysics and cosmology projects (gravitational waves, dark matter and dark energy), etc.

LLR

The Leprince-Ringuet laboratory has two domains of research which are sharing not only physical concepts but also technical approaches: very high energy gamma astronomy and particle physics.

The gamma astronomy looks at the sky through photons of energy around the TeV, thousand billions times more energetic than those from the visible light. The quest is twofold: what mechanisms generate such photons, what are their sources. We contributed to build, and we now use an observatory, HESS, sited in Namibia which detects these photons through their interaction in the atmosphere. The laboratory also participates in the observation programme performed by the Fermi Space Telescope, for which we designed and built the mechanical structure of the calorimeter.

Concerning particle physics, we are participating in the search for the «Higgs boson», the missing piece of our understanding of the subatomic world, in proton-proton collisions at the record energy of 7 TeV. This research takes place at the CERN LHC (Large Hadron Collider) in the CMS experiment. Using this same experiment, we also study the formation of a quark-gluon plasma in collisions of lead nuclei at the energy of 2.76 TeV per nucleon. In the future, the detailed study of the Higgs boson will require the study of high energy electron-positron interaction, for which we develop innovative techniques for ultra-granular calorimetry Another important research in particle physics deals with the oscillations between the three neutrino flavors, that

have been observed for several years and are presently studied in the T2K experiment (Japan).

Our physics has a world-wide development and the experimental installations are scattered all around the world. Always at the limit of the existing technologies, our field develops its own technologies which can be applied to many other domains. We develop codes for simulating the interactions of particle with matter, or realize beam profilers for the ions accelerators used in cancer therapy. We also prepare the future by looking at new acceleration techniques by laser-plasma interactions.

LPT

The Laboratoire de Physique Théorique d'Orsay is a joint research unit (UMR 8627) of the Université de Paris-Sud and CNRS. Its research subjects are particle physics, cosmology, mathematical physics and statistical mechanics.

- The research of the particle physics group concerns the fundamental interactions between the elementary building blocks of matter as described within the Standard Model, as well as the physics beyond the Standard Model, both in relation to present and future experimental programs.

- The cosmology group works in particular on gravity in the presence of supplementary dimensions and on the initial conditions in the early universe and their effects on galactic structures.

- The mathematical physics group studies, on the one hand, algebraic and geometric methods in areas ranging from non commutative geometry to quantum field theory, and on the other hand classical and functional analysis in quantum mechanics and field theory.

- The statistical physics group studies both the equilibrium and transport properties of complex physical systems, with applications in areas beyond the traditional boundaries of physics, such as road traffic.

Various research subjects at LPT cover more than one of the themes listed above. The LPT groups collaborate with other laboratories of the Labex P2IO (LAL, IPN, IAS, CPhT, IPhT,...) and also have inter-Labex collaborations on the Orsay Campus, in particular with the Labex Palm.