Research evaluation

# EVALUATION REPORT OF THE UNIT

LPNHE - Laboratoire de Physique Nucléaire et de Hautes Énergies

# UNDER THE SUPERVISION OF THE FOLLOWING ESTABLISHMENTS AND ORGANISMS:

Sorbonne Université

Université Paris Cité

Centre national de la recherche scientifique - CNRS

**EVALUATION CAMPAIGN 2023-2024**

GROUP D

Report published on May, 02 2024

High Council for evaluation of research and hgher education

In the name of the expert committee :

Nicolas Alamanos, chairman of the committee

For the Hcéres :

Stéphane Le Bouler, acting president

In accordance with articles R. 114-15 and R. 114-10 of the Research Code, the evaluation reports drawn up by the expert committees are signed by the chairmen of these committees and countersigned by the president of Hcéres.

To make the document easier to read, the names used in this report to designate functions, professions or responsibilities (expert, researcher, teacher-researcher, professor, lecturer, engineer, technician, director, doctoral student, etc.) are used in a generic sense and have a neutral value.

This report is the result of the unit's evaluation by the expert committee, the composition of which is specified below. The appreciations it contains are the expression of the independent and collegial deliberation of this committee. The numbers in this report are the certified exact data extracted from the deposited files by the supervising body on behalf of the unit.

## MEMBERS OF THE EXPERT COMMITTEE

| | |
|---|---|
| **Chairperson:** | Mr Nicolas Alamanos, CEA, Saclay |
| **Experts:** | Ms Corinne Augier, Université Claude Bernard Lyon 1 (representative of CNU) |
| | Mr Tiziano Camporesi, CERN, Switzerland |
| | Mr Alessandro De Angelis, University of Padova, Italy |
| | Ms Stéphanie Escoffier-Martory, CNRS, Marseille (representative of CoNRS) |
| | Mr Fernando Ferroni, Gran Sasso Science Institute, Italy |
| | Mr Patrick Pangaud, CNRS, Marseille (supporting personnel) |

## HCÉRES REPRESENTATIVE

Mr Guy Chanfray
Mr Philippe Moretto

## REPRESENTATIVES OF SUPERVISING INSTITUTIONS AND BODIES

Mr Philippe Agard, Sorbonne Université
Ms Ursula Bassler, CNRS/IN2P3
Ms Nathalie Eisenbaum, Université Paris Cité
Mr Edouard Kierlik, Sorbonne Université
Ms Marjolaine Robillard, CNRS/DR

# CHARACTERISATION OF THE UNIT

- Laboratoire de Physique Nucléaire et de Hautes Énergies
- LPNHE
- UMR 7585
- Composition of the executive team: Mr Marco Zito (directeur) and Mr Tristan Beau (directeur adjoint)

## SCIENTIFIC PANELS OF THE UNIT

ST Sciences et technologies

ST2 Physique

## THEMES OF THE UNIT

The LPNHE is a joint research unit (UMR) of the National Institute of Nuclear Physics and Particle Physics (IN2P3) of the CNRS (main supervisory authority), University of the Sorbonne (SU) (main supervisory authority and host), and Paris Cité University (UPCité) (secondary supervisory authority). The LPNHE carries out cutting-edge research in the field of the physics of the two infinities, from the infinitely large (cosmology, astroparticles) to the infinitely small (physics of elementary particles, fundamental symmetries).

It is organized around research projects, supported by administrative and technical services, and aligned along four axes: i) Cosmology and Dark Energy (COEN), ii) Cosmic Rays and Dark Matter (RCMN), iii) Matter-Anti-Matter Asymmetry (AMA) and iv) Masses and Fundamental Interactions (MIF). The unit's research programmes are conducted within the framework of leading international scientific collaborations that are recognised worldwide.

Cosmology and Dark Energy (COEN). The COEN group participates in a group of experiments that attempt to understand the universe and its evolution: the LSST camera at the Vera Rubin Observatory, intended to carry out a deep sky survey, the high-precision photometric calibration system, called StarDICE, which should make it possible to fully exploit the LSST data, and DESI, a spectrograph which should produce a cosmological survey complementary to that of the LSST. The unit has also begun to take part in the ZTF-II observatory, which could provide additional cosmological constraints through observation of the nearby Universe.

Cosmic Rays and Dark Matter (RCMN). After a series of important discoveries with the H.E.S.S. telescope, a major international collaboration is working on the construction of CTA. The RCMN team fully participates in this theme through the operation of H.E.S.S., its participation in the construction of CTA and the design of GRAND that will probe the most energetic astrophysical neutrinos. Recently, another line of research has been added which concerns direct searches for dark matter. In this context, the RCMN team participates in three experiments dedicated to the search for WIMPs (Weakly Interacting Massive Particles): DAMIC using CCDs, and two experiments using noble liquids, Argon for DarkSide and Xenon for XENON.

Matter Anti Matter Asymmetry (AMA). The AMA group is committed to precision measurements at the LHCb in the field of heavy flavor physics. Part of the team also participates in an experiment in preparation in Japan, COMET. Its objective is to study the conversion of muons of a very intense beam into electrons, which would signify the non-conservation of the lepton number. Recently, the team has become firmly committed to research into artificial intelligence techniques. The AMA group's neutrino team is successfully continuing the study of neutrino oscillations with the T2K experiment. It is also preparing a major makeover of one of the experiment's detectors and is preparing its contribution to the next-generation Hyper-Kamiokande (HK) experiment.

Masses and Fundamental Interactions (MIF). Ongoing measurements with the ATLAS detector continue to refine our knowledge of the Standard Model and its interactions. The team participates in these measurements as well as the major upgrade of the ATLAS detector to prepare it for the new high luminosity phase of the LHC, which is expected to be taking data until the end of the 2030s. In parallel, the team has continued to focus on future colliders. The continuation of CALICE R&D for high-tech detectors is now accompanied by studies on the physics potential of the future CERN collider "Future Circular Collider" (FCC), which should reach 100 km in length and be located on the Franco-Swiss border.

A major strength of the unit is its ability to build-up state-of-the-art detection systems. This is supported by its technical services, which cover three main areas of activity: electronics (16 persons), computing (13 persons) and mechanics (7 persons). They enable the scientific teams to make significant experimental contributions, from preliminary explorations through the construction and acceptance stages of detection systems. Among the achievements of the technical services during the evaluation period, the design and production of electronic boards for CTA and T2K may be mentioned as well as the characterization of CCD sensors for the focal plane of LSST and the development of a very low noise readout chain for DAMIC-M.

## HISTORIC AND GEOGRAPHICAL LOCATION OF THE UNIT

The LPNHE was founded in 1970 by a group of researchers from the "high energy" division of the Institute of Nuclear Physics (IPN) in Orsay, mainly carrying out experiments at CERN. In 1970, these bubble chamber specialists joined the University of Paris VI and a new unit associated with the CNRS was created. The unit has a long history of collaboration with CERN behind it. Today, the unit is still involved in CERN experiments, but its activities have diversified towards astroparticles and cosmology. It is located on the Pierre and Marie Curie campus of the Sorbonne University (SU) in the 5th arrondissement of Paris. The transfer of the LPNHE to the renovated "West sector" of the Jussieu campus took place in 2010. The LPNHE is located in "barres" 12/22 (basement, ground floor, first and 2nd floors), 12/13 (basement, ground floor and first floor), 13/23 (two test rooms on the ground floor) and 22/23 (two archive rooms in the basement). The Charpak amphitheatre and an assembly hall located in patio 22/33 on the ground floor were opened in 2014.

## RESEARCH ENVIRONMENT OF THE UNIT

The unit plays a coordinating role in several major international collaborations, for example at CERN (ATLAS, LHCB, FCC), in cosmology (LSST, DESI), and at Kamiokande(T2K, HK) or (DAMIC, XENON) associated with dark matter research. The unit's physicists are also active in the management of certain associated international units (LIA). For example, one LPNHE physicist from the unit has directed the LIA with China. The unit's members are also active in the "Pierre Binetruy" Centre in Berkeley and in the ILANCE in Tokyo. They maintain close links with the IFJ in Krakow (COPIN), and support the La Conga and Cofecub initiatives, which promote scientific development in Latin American countries.

The LPNHE also collaborates actively with units in the region: this is the case for the "Physique des Infinis" Initiative, coordinated by a member of the unit, which brings together the LPNHE, the IAP, the LPTHE and other astrophysics and plasma physics units. This initiative has enabled the unit to benefit from several doctoral and post-doctoral grants.

The LPNHE is a member of FRIF "Fédération de Recherche en Ile de France", which supports the organisation of scientific events, and of the "Domaine d'Intérêt Majeur Origines de la région Ile de France", which follows on from DIM-ACAV and DIM-ACAV+. These structures fund PhD theses, post-docs and equipment. One example of this type of close collaboration is the Cluster "Parisien ITk" which is a consortium of three units (LPNHE, IJCLab and Irfu) aiming to jointly build a major part of the ATLAS Inner Tracker.

A new stage in these exchanges will be reached with the creation of a platform around semiconductor detectors (CLAP and Tisidet), as well as with the formalisation of the Computing and Storage Platform, which has for a long-time housed computer equipment for other units.

The unit's participation in the network of Ile-de-France units federated around the GRIF and its leading role in the LHCB's Allen/RTA project, developed in close collaboration with the "Laboratoire d'Informatique de Paris 6" and the Sorbonne's artificial intelligence centre, should also be mentioned.

## UNIT WORKFORCE: in physical persons at 31/12/2022

| Catégories de personnel | Effectifs |
|---|---|
| Professeurs et assimilés | 10 |
| Maitres de conférences et assimilés | 12 |
| Directeurs de recherche et assimilés | 13 |
| Chargés de recherche et assimilés | 13 |
| Personnels d'appui à la recherche | 43 |
| **Sous-total personnels permanents en activité** | **91** |
| Enseignants-chercheurs et chercheurs non permanents et assimilés, y compris post-doctorants | 14 |
| Personnels d'appui non permanents | 35 |
| Doctorants | 34 |
| **Sous-total personnels non permanents en activité** | **83** |
| **Total personnels** | **174** |

DISTRIBUTION OF THE UNIT'S PERMANENTS BY EMPLOYER: in physical persons at 31/12/2022. Non-tutorship employers are grouped under the heading "others".

| Nom de l'employeur | EC | C | PAR |
|---|---|---|---|
| CNRS | 0 | 25 | 42 |
| Sorbonne Université | 16 | 0 | 1 |
| Université Paris Cité | 5 | 0 | 0 |
| Autres | 1 | 1 | 0 |
| **Total personnels** | **22** | **26** | **43** |

# GLOBAL ASSESSMENT

During the evaluation period, the unit continued to consolidate its reputation as a first-class unit in its field. Its four scientific research teams have played a central role in international collaborations and have made significant contributions to data analysis and instrumentation. In addition, LPNHE members hold important positions at the national and international levels, contributing to the definition of global roadmaps in their fields of research.

LPNHE also stands out for its important technical developments. Its technical expertise lies in the field of detector instrumentation, the design of electronics boards and programmable components, mechanical design, in particular precision mobile systems and optimised detector structures, computer development for data acquisition or analysis, systems and network administration. To give just one example from the unit's major technical achievements, the LSST filter changing system was delivered to SLAC and successfully tested. This is a mechatronic assembly capable of changing filters in 83 seconds, a key element in LSST's major photometric survey programme. This system has required since 2007 the commitment of a team of around fifteen engineers and technicians from LPNHE. This expertise has made the unit's teams very attractive to students - as shown by the increase in the number of PhD theses during the evaluation period - and has led to major technical contributions to experiments in cosmology, high-energy astrophysics and particle physics. This is all the more commendable given that some of the experimental rooms, located in the basement of the building, do not comply with the working health and safety requirements. Despite this, the excellence of the teams, assuming that the number of staff in the unit does not decrease, should enable LPNHE members to take part in ambitious projects in the future. However, to ensure that the technical group continues to work in the best possible conditions, the unit management must remain vigilant concerning the preservation of the technical group's staff and the technical level of the infrastructures. These must be regularly renewed to ensure they are as efficient as possible.

Furthermore, it must be noted that seven of the unit's researchers, two CNRS and five teacher-researchers, are due to retire in the next few years, and if they are not replaced the unit will have to reconsider its scientific commitments.

A new stage in the unit's development will be reached with the creation of a platform based around semiconductor detectors (CLAP and Tisidet), as well as the formalisation of the Computing and Storage Platform. The CLAP (Capteurs à LA Pointe) project will be open to partner units and companies wishing to use it. The connection to external companies/industry is a new opportunity as well as a challenge for the unit.

During the period of confinement, the unit's administrative team showed great resilience and continued to work remotely using the tools made available to them. They have adapted to the new software for dematerializing expenditure and missions, some of which having increased the complexity of the administrative tasks (ETAMINE). The financial management of expenditure and income for the unit's future platforms, such as CLAP, should also bring additional work for the administrative team. In order to ensure the smooth running of this team it is important to adapt its workforce, possibly by recruiting two new agents.

More details concerning the unit teams' performances are now given.

*COEN:* The team works in the field of physical cosmology, in particular the observational determination of the components of the universe, their evolution and the formation of large-scale structures. The Dark Energy Spectroscopic Instrument (DESI) at Kitt Peak National Observatory in Arizona began its five-year survey in 2021, while the Space and Time Survey (LSST) at the Vera Rubin Observatory in Chile is scheduled for 2025. The team is focusing most of its efforts on these two projects, in which it has been heavily involved since the design and construction phases. Today, the team's priority is to ensure the scientific on these long-term investments, with a view to combine Supernovae plus Baryon Acoustic Oscillation analysis. The results of these two surveys may significantly change the scientific questions that are in the scope of the team's scientific work.

*RCMN:* The team investigates very high-energy phenomena in the Universe through gamma-ray and neutrino astronomy. A second research domain, direct search of dark matter, completes the teams' activities. Concerning the first domain, the team is involved in the operation of H.E.S.S., the construction of CTA and the design and construction of the Giant Radio Array for Neutrino Detection (GRAND). The team is particularly well positioned to take advantage of the "targets of opportunity observations" which are a priority of the H.E.S.S collaboration. However, the number of permanent researchers in this domain – only two - is probably too low to allow them to participate in an optimal way in both the analysis of the CTA data and the construction of GRAND. Another part of the team is involved in the DAMIC, DarkSide and XENON experiments, in the definition of the French contribution to DarkSide-20k, and in the next-generation DARWIN project. The team is well positioned to take advantage of the complementary of the techniques used in the search for the nature of dark matter. Nevertheless, with two permanent researchers working on XENON, one and a half on DAMIC and one on DarkSide, this part of the team is also rather weak in terms of human resources. This is especially true since DAMIC's financial possibilities are presently linked to the ERC DAMIC-M contract and the activity will disappear unless a proper support is programmed in due time. With this in mind, the decision to discontinue the team's contribution to DarkSide's activities for the next few years can only be welcomed.

*AMA:* The team investigates indirect research into physics beyond the Standard Model of particle physics. A second research domain, neutrino oscillation experiments in Japan, T2K, and the preparation of the Hyper-Kamiokande experiment, which should start taking data in 2027, completes the team's activities. Concerning the first domain, the team is involved in the LHCb experiment as well as the COMET experiment (JPARC, Japan). It has six permanent physicists, plus an emeritus professor and has benefited from several external grants, such as the ERC RECEPT (09/2017 - 09/2023), the ANR ReViSal, etc., which have enabled it to recruit since 2017 a significant number of PhD students and post-docs. The part of the team, four physicists, involved in both the operation of T2K-II and in R&D for Hyper-Kamiokande, are relatively few in number, which may lead to human resources difficulties in the years to come. Another concern in this area is the absence of a Memorandum of Understanding between Japan and France that would provide a framework for the participation of the unit's physicists and technical contributions to Hyper-Kamiokande.

*MIF:* The scientific programme of the team is aimed at rigorously testing the Standard Model of particle physics. To this end, the team is concentrating its efforts on the ATLAS experiment, both in terms of analysis and technical implications, while also participating in the preparation of future Higgs factories. Its scientific programme for the next few years is a continuation of what is currently being done, namely to finalise the analyses underway with the data from Run 2 of the LHC and to exploit the new data recorded during Run 3 (2022-2025). The MIF team is highly regarded within major international collaborations, and its scientific output is of exceptional quality.

# DETAILED EVALUATION OF THE UNIT

## A - CONSIDERATION OF THE RECOMMENDATIONS IN THE PREVIOUS REPORT

The previous Hcéres committee provided the unit's management with a set of challenging recommendations aimed at strengthening internal communication, facilitating the circulation of information and standardizing administrative practices in order to improve the functioning of the unit. The unit's management has responded to these recommendations with the implementation of a set of actions that are particularly, but not exclusively, relevant to the internal life of the unit.

The previous Hcéres committee has noted that the unit Council meets only 3 times a year, with a consequently overloaded agenda and without systematic distribution of preparatory documentation.

In addition, the committee noted that the RSE/RSR sometimes bypassed its role, which should be that of the Scientific Council, by approving new projects.

The composition and operation of the Scientific Council was improved with the internal election of a Chair and a secretary. Since then, the ensemble of the unit's new projects are presented to and are discussed by the Scientific Council.

The unit management has clarified the role of each body and the RSE/RSR has evolved towards monthly coordination meetings, one general, the other technical.

Finally, internal communication has improved, with a particular effort to liven up the Friday meeting and make it a forum for discussion open to all staff.

Concerning the threat posed to the unit by the end of the labex "Institut Lagrange de Paris" (ILP), the unit has taken steps to follow up this initiative. This led to the creation of the "Initiative de la Physique des Infinis" (IPI), which has awarded the unit a number of doctoral and post-doctoral grants. However, the creation of an "Institute de Physique Fondamentale de deux Infinis" over the next few years remains a priority of the LPNHE.

With regard to the dispersal of forces in the field of dark matter, as noted by the Hcéres committee, the 'Xenon' group has received the reinforcement of a permanent researcher and two research engineers. It has also obtained funding from IN2P3 for the XeLab R&D platform and an ANR X-ART grant. However, the unit acknowledges that its contribution to DarkSide may be considerably reduced over the next few years.

## B - EVALUATION AREAS

### EVALUATION AREA 1: PROFILE, RESOURCES AND ORGANISATION OF THE UNIT

#### Assessment on the scientific objectives of the unit

The unit plays a coordinating role in several major international collaborations, for example at CERN (ATLAS, LHCb, FCC), in cosmology (LSST, DESI), and at Kamoiokande (T2K, HK) or (DAMIC, XENON) associated with dark matter research. It has made and still makes key contributions to several projects, such as: the design and production of electronics boards for CTA and T2K, the characterisation of CCD sensors for the focal plane of LSST and the development of a very low noise readout chain for DAMIC-M. Its research themes are in line with the research themes of the main international collaborations and funding agencies, as well as with IN2P3's scientific policy. A large proportion of these themes are part of IN2P3's so-called "Mafo" projects, i.e. "projets d'enjeux majeurs et de fort engagement de l'IN2P3".
The research carried out by the unit also has a certain impact on society, since doctoral students are trained in computer science and artificial intelligence, among other fields. These research activities, which benefit from the network of collaborations that the unit has created with other units in the Paris region and with the University, are very closely linked to the needs of industry in terms of skills and open up a wide range of recruitment opportunities to its PhD students from the private sector.

## Assessment on the unit's resources

The unit's resources are largely provided by CNRS, in terms of staff, operations and projects. The Sorbonne university also contributes with a strong team of "research professors" and recurrent doctoral funding. The budget allocated by the supervisory bodies also makes it possible to fund each year new initiatives like XeLab R&D, GRAND or non-project R&D and to strengthen the unit's equipment.
The unit is also capable of mobilising a significant amount of additional resources through contracts and additional doctoral funding (ILP and IPI, CSC, etc.). The excellence of the projects and of the personnel associated with, yields to a very good ratio between the annual recurrent operational budget (allocated by the supervisory authorities) and the funds obtained through contracts with European and state agencies (It should be noted that even without ERC funding, the unit's external sources are already significant).
The present ERC and ANR contracts have made it possible to open up new fields of research, such as: DAMIC for the direct search for low-mass dark matter, RECEPT for software trigger developments in LHCb and many others. In addition, the COVID years have led to significant savings in the mission budget, which have made it possible to renovate or install some new equipment in the unit.

## Assessment on the functioning of the unit

The functioning of the unit complies with regulations on human resources management, safety, environment and protection of scientific heritage.
Several of the unit's bodies, such as the Unit Council (le Conseil d'Unité), the Local Joint Committee (Commission Paritaire Locale) (promotions, bonuses, career development) and the CLHSCT, ensure compliance with standards and good practice in human resources management. In this context, a "Professional Equality" officer was appointed in 2020. In addition, the team of prevention assistants (assistants de prévention) has been strengthened to take better account of the diversity of the unit's professions.
Particular attention is paid to temporary staff, especially doctoral students. A system of mentors (a researcher from outside the group) enables regular checks to be made on how well students are settling in and how their theses are progressing. A welcome booklet is given to all new recruits.
As far as professional equality is concerned, some progress seems to have been made with the recent recruitment of female "Chargées de Recherche" and "Ingénieures–techniciennes".
Computer systems and data are subject to a set of computer security measures that are consistent with those recommended by the CNRS and those applied in other CNRS/IN2P3 units. A charter for users of IT services is included in the welcome booklet and all users agree to respect it.
The COVID requirements imposed several forms of business continuity plan to take account of the very limited access to these premises. In its extreme version (with access limited to only ten authorised personnel), this plan was drawn up taking into account the imperatives linked to the safety of the installations and infrastructure, as well as the need to continue certain priority experimental activities.
The unit recently set up a sustainable development committee, which carried out two greenhouse gas emission assessments for 2019 and 2022. In this context, the unit is considering how to adapt its practices to climate change. This will probably involve a sharp reduction in the number of missions, whenever possible.

### *1/ The unit has set itself relevant scientific objectives.*

#### Strengths and possibilities linked to the context

The unit's scientific programmes cover areas of research relating to studies of the Standard Model, cosmology and dark matter. They form part of the major scientific research programmes in the discipline and are fully recognized as such by the unit's supervisory authorities, IN2P3 and the Sorbonne University.

#### Weaknesses and risks linked to the context

Some research groups, such as those involved in direct searches for dark matter and cosmic rays, are still sub-critical, which raises questions about the role that members of the unit will be able to play in these collaborations in the future. Short-term contracts can only alleviate this situation without solving the underlying problem. The solution may lie in internal redeployment eventually combined with new recruitment.

### *2/ The unit has resources that are suited to its activity profile and research environment and mobilises them.*

#### Strengths and possibilities linked to the context

The unit's resources skills range from instrument design to deployment, analysis, interpretation and theory, enabling it to have a major impact on the experiments in which it participates. This diversity of professions also means that the unit can mobilize a range of skills that are essential for cutting-edge projects, whether they involve major collaborations, R&D projects or small and medium-sized projects, with highly agile, high-performance mixed research-engineering-technician teams.

#### Weaknesses and risks linked to the context

The number of researchers, teacher-researchers (Enseignants-chercheurs or EC) and IT staff has decreased slightly in recent years. Two CNRS and five EC are due also to retire in the next few years. Even if this decrease is offset, depending on the ability of unit members to obtain external funding, by thesis students or post-docs, it may jeopardise some of the unit's research areas. If this decline continues, the unit may be forced to reconsider the scope of its scientific programme.

Another area of concern is the relatively high age pyramid of technical staff (IT). This should lead to a large number of retirements in the coming years, with a possible loss of competitiveness for some technical groups. Furthermore, it seems that the recruitment of IT staff by CNRS in the Paris region is facing real difficulties. On the one hand, the job market is very tight and CNRS salaries are far from attractive. The difficulties specific to the Paris region - high rents, often-inadequate public transport, long and arduous journeys - make this situation even more acute.

### *3/ The unit's practices comply with the rules and directives laid down by its supervisory bodies in terms of human resources management, safety, environment, ethical protocols and protection of data and scientific heritage.*

#### Strengths and possibilities linked to the context

The unit's management complies with national and European regulations. During the evaluation period, the operation of some of the unit's bodies was improved and others were created in order to ensure the smooth running of the unit in the domain of human resources, safety, sustainable development and protection of scientific assets. In particular, computer security measures are in line with those recommended by its supervisory authorities (CNRS) and applied by other CNRS/IN2P3 units.

Furthermore, the unit has set-up a sustainable development committee aiming to adapt its practices to climate change.

#### Weaknesses and risks linked to the context

One of the areas in which management could take incentive actions is the non-compliance by the unit's staff with the teleworking rules (keeping track of their teleworking days, giving priority to face-to-face work, if necessary, use of videoconferencing only if essential, etc.). This situation seems to be causing some disruption to its operations.

## EVALUATION AREA 2: ATTRACTIVENESS

#### Assessment on the attractiveness of the unit

The unit is a high-performance research unit with a worldwide reputation. Its scientific output and impact make it an asset for fundamental research in France. In particular, the unit is attractive because of its scientific and technical contributions to the construction of the European Research Area, where its staff are involved in a number of research bodies and experiments, often taking on major responsibilities. It is also attractive for the quality of its equipment and its technological skills. At the national level, this is reflected in leading coordination roles in various national authorities, such as IN2P3, where five members of the unit are national coordinators. The number and quality of internships at L3-M1-M2 level is another sign of the unit's attractiveness.

*1/ The unit has an attractive scientific reputation and is part of the European research area.*

*2/ The unit is attractive because for the quality of its staff support policy.*

*3/ The unit is attractive through its success in competitive calls for projects.*

*4/ The unit is attractive for the quality of its major equipment and technical skills.*

### Strengths and possibilities linked to the context for the four references above

The unit is attractive due to its scientific influence and contributions to the construction of the European Research Area. Its staff are involved in a number of research bodies and experiments, often taking on major responsibilities.

Here are just a few examples: Two spokespersons for international collaborations (DAMIC, GRAND), six L1/L2 leaders in LHC experiments and two in T2K. Five members of the unit are national coordinators at IN2P3 level (LSST, T2K, XENON, DESI, COMET), for GDRs (Intensity Frontier), for the European Particle Physics Strategy Update EPPSU 2019-2020, for the IPI initiative "Initiative de la Physique des Infinis" (co-lead) and for the UPC "Université Paris Cité" La Conga training-research project (project leader).

Members of the unit have won international prizes : two 'Cristal CNRS' awards for LSST activities, the 'LHCb Early Career Scientist Award' and the 'Lee Grodzins Postdoctoral Award' from MIT, and they have been referees for high-impact journals. Finally, many of them are invited speakers at international conferences (ICHEP, ICRR, etc.) and help to organise them. They have also been awarded two ERCs.

The unit is attractive because of the quality of its policy for welcoming staff. During the evaluation period, it hosted several visitors, including Saul Perlmutter, American astrophysicist and winner of the 2011 Nobel Prize in Physics, Steve Kahn (head of the LSST in the United States), etc. Exchange programmes are in place with Brazil (Cofecub) and Poland (COPIN IN2P3). During the evaluation period, two EC outside the LPNHE's university supervision decided to carry out their research activities in the unit. Finally, the number and quality of internships at the L3-M1-M2 level give another sign of the unit's attractiveness.

The unit is attractive for the quality of its equipment and its technological skills. The LPNHE has a range of cutting-edge equipment and platforms covering its areas of technical expertise: The TisiDet platform, a range of micro-wiring equipment; the CLAP platform, a modern under-tip test machine, which will be open to other units in 2023, and the PCS platform, whose main purpose is to be a GRIF centre, has been approved by SU. It also offers a cloud service.

As far as equipment is concerned, we should mention the multi-material 3D printer, the mechanical workshop (including digital control), the metrology equipment, the assembly hall, the REFIMEVE time reference equipment and GPS antennas, the clean rooms, the liquid nitrogen line, and the XeLab cryogenic system based on liquid nitrogen.

### Weaknesses and risks linked to the context for the four references above

While the unit's geographical location is certainly attractive, it can create difficulties in terms of affordable accommodation. This situation should prompt the unit to look for ways of supporting its visitors so as not to limit its attractiveness. Another area of concern could be the method of funding basic research, which does not seem to be suited to the unit's projects, which are very long-term. The creation of an Institute of Fundamental Physics, with additional funding, could be a partial response to this concern.

## EVALUATION AREA 3: SCIENTIFIC PRODUCTION

### Assessment on the scientific production of the unit

The scientific output of the unit's teams is well balanced and all the teams have an excellent scientific impact at world level. The originality of their work is often based on strong instrumentation skills (in the field of CCDs, new algorithms and new computing architecture, precision calibration …), with a strong synergy between instrumental skills and scientific skills. As regards the quality and integrity of the scientific results published by the unit, it should be noted that most of its researchers are part of major international collaborations that have well-established procedures for verifying experimental results. In purely numerical terms, the 1447 published papers in Journals of a very high scientific reputation like Science or Physical Review Letters, and the important number of conference contributions, are one of the measures of its success over the reference period.

*1/ The scientific production of the unit meets quality criteria.*

*2/ The unit's scientific production is proportionate to its research potential and properly shared out between its personnel.*

*3/ The scientific production of the unit complies with the principles of research integrity, ethics and open science. It complies with the directives applicable in this field.*

## Strengths and possibilities linked to the context for the three references above

The unit conducts research programmes aimed at extending our knowledge of the properties of the Standard Model of particle physics and of the ΛCDM model of cosmology and its researchers participate in experiments aimed at verifying the limits of validity of these two models. Without being exhaustive let us cite:

The ATLAS team is actively involved in studying the properties of the Higgs boson, and its couplings with vector bosons and fermions, in the search for new resonances and new particles, and in searches for long-lived particles decaying within the detector. The LHCB team has also been a leader in studies of the $B^0 \to K^{*0}\,\tau^{\pm}\,\mu^{\mp}$ decay, violating leptonic flavour. All these results are in good agreement with the Standard Model predictions.

Measurements of the neutrino oscillations, in particular the $\nu_\mu \longrightarrow \nu_e$ oscillation, have allowed the parameters of the PMNS matrix to be measured. A non-zero $\theta_{13}$ angle was obtained, the $\theta_{23}$ angle was deduced with a better accuracy inducing constraints on the $\delta_{CP}$ phase were established. The measurement of this phase, linked to a possible CP violation, motivated the new-generation Hyper-Kamiokande and DUNE experiments.

The detection of a TeV emission (H.E.S.S) has demonstrated for the first time the presence of accelerated particles in gamma-ray bursts at extreme energies. This opens up a new observational window on these objects.

In the field of dark matter, analysis of the DarkSide50 data (two PhD theses at the unit) has made it possible to establish the best limits in the world on a light WIMP.

The LPNHE cosmology team has long carried out measurements based on Supernovae as standard candles. It is now preparing to reap the rewards of intense work on the front of a new parametrisation of Supernovae (PhD thesis at the unit), a precise calibration with StarDICE, and new samples at small z (ZTF-2) and large z (HSC). In these last two experiments, the team plays a key role, and the results (in 2023-2024) will be the most binding before the arrival of LSST.

It should be noted that the originality of the teams' work is often based on strong instrumentation skills (in the field of CCDs, new algorithms and new computing architecture, precision calibration), with a strong synergy between instrumental skills and scientific skills. One part of the unit's activities is linked to phenomenology. For example, the crucial recent results on g-2 are based on the study of the hadronic polarisation of the vacuum carried out by a 12 members Lattice QCD collaboration with one of the unit's researchers (Eur. Phys. J. C 80 (2020) 241).

The scientific output of the unit's teams is well balanced and all the teams have an excellent scientific output at world level.

The number and quality of the unit's publications are excellent. However, when teams are part of major international collaborations, as is the case for the LPNHE teams, the number of their publications depends on the collaboration policy and far exceeds the team's responsibility. That said, the number of publications by the unit has remained stable for several years. Here is the number of published papers by team : MIF : 517 papers (mostly ATLAS), AMA : 400 papers (322 LHCB, 78 T2K-HK), RCMN : 198 papers (DAMIC 6, XENON 32, Darkside 11, HESS 59, CTA 38, AUGER 44, GRAND 8), COEN : papers 57. Moreover, at least 33 articles exceed 163 citations. Among them multi-messenger astrophysics articles and articles on searches for direct detection of dark matter are part of this list. LHCB tests of the lepton universalities, where the LPNHE team has provided coordination of the analysis effort, appear as well. The ATLAS collaboration results on the Higgs properties (H→bb) and several detector performance papers, with direct participation by the unit, are also among the highly-cited papers.

The unit has developed a research ethic and for the last twenty years, all publications have been made available on open access platforms such as arXiv. In the field of cosmology and astrophysics, the data format makes it possible that basic data can be made public, and this is starting to happen in accelerator physics too.

As regards the quality and integrity of the scientific results published by the unit, most of its researchers are part of major international collaborations that have well-established procedures for verifying experimental results, such as internal reviews by internal referees, reviews by the entire collaboration, etc., which ultimately ensures excellent quality and traceability of scientific results.

## Weaknesses and risks linked to the context for the three references above

For some teams, the opportunities for PhD theses, provided by the unit's rich programme, are likely to be limited by restricted supervision capacity and the lack of offices to accommodate students.

## EVALUATION AREA 4: CONTRIBUTION OF RESEARCH ACTIVITIES TO SOCIETY

### Assessment on the inclusion of the unit's research in society

The unit's research has a strong societal impact, in particular in the field of fundamental knowledge. It encourages the development of a new understanding of nature and of the Universe, which while based on theory, is confirmed by experiment. However, it is probably in the field of training where the unit's direct impact on the economic world seems to be most significant, with PhD students being recruited as data scientists. A further interesting initiative of the unit, in partnership with the economic world, is the development of video games for teaching science. Finally, the recent creation of two platforms and a technical platform that will eventually be open to the business world is another way in which the unit is opening up to the economic world.

*1/ The unit stands out for the quality and the amount of its interactions with the non-academic world.*

*2/ The unit develops products for the cultural, economic and social world.*

*3/ The unit shares its knowledge with the general public and takes part in debates in society.*

### Strengths and possibilities linked to the context for the three references above

The unit's interactions with the non-academic world are numerous. They cover areas as diverse as interactions with the industrial world, the training of young doctoral students in the management of large databases, the training of young apprentices in the mechanical, electronic and computer professions, the development of video games for higher and secondary education and the general public. Finally, the members of the unit take part in numerous cultural events aimed at the public and in popular science writings. Some explicit examples are given below.

The skills of the unit's members in computer science and instrumentation enable them to interact with the world of industry, particularly in the context of projects linked to the unit's scientific projects. They have interacted on numerous occasions with industry (the FBK foundry in Trento, Italy), which was responsible for producing silicon detectors for the ATLAS Inner Tracker, the design of which had been carried out in the unit. Similarly, the detailed understanding of CCDs by the unit's technical staff has been the subject of numerous exchanges with a manufacturer.

It is probably in the field of training that the unit's direct impact on the economic world is most significant. For example, PhD students have used the data processing skills they acquired during their theses to find jobs as data scientists in industry and the service sector. The unit is also involved in taking on apprentices in mechanics, electronics and IT, as well as trainees and doctoral students in electronics. These internships enable the unit members to train young people in sectors where the job market is under pressure. They also provide a breeding ground for future recruitment to the unit's technical groups. The unit also hosts a PhD student, employed by IBM, who is working on the analysis of ATLAS data using ML (Machine Learning) algorithms.

The unit is also working to develop teaching tools. One of the unit's researchers, a professor at the Sorbonne University, has founded the Ikigai association. Its aim is to develop educational video games for use in higher education in the short term, followed by secondary education and the general public in the long term. A consortium of universities, "grandes écoles", research units, game development studios and the EdTech start-ups supports Ikigai.

The recent creation of two platforms and a technical plateau will enable the unit to share its infrastructure and equipment with the academic and business worlds. Agreements will enable this opening-up to take place, with clear rules on intellectual property, terms of use and the pricing of services.

A patent in the field of health is currently being finalised (TRL 7). During the pandemic, a PhD student contributed to the production of a mechanical respirator for COVID-19 patients (MVM collaboration). Another patent in the field of ionising radiation detection techniques is maturing.

When it comes to integrating research activities into society, the unit is most active in 'outreach'. There are many activities in this area. The Fête de la science is one of the highlights of this activity. Around thirty people from the LPNHE run a stand in the 'Science Village' on campus, and organise visits to the unit for school classes (lycée) and the general public.

During the first confinement period, two members of the unit initiated the PyCoA (Python Covid Analysis) project. PyCoA is a set of PythonTM code that provides simple access to the COVID-19 databases and tools for analysing the data.

Researchers regularly contribute to the writing of books and popularisation articles or are interviewed. The organisation of scientific events for different audiences is a recurring activity of the unit.

### Weaknesses and risks linked to the context for the three references above

The unit's interaction with industry is currently rather limited. An effort should be made, particularly in the context of the unit's new platforms, to increase this interaction.

# ANALYSIS OF THE UNIT'S TRAJECTORY

The unit's trajectory is marked by a deep thematic continuity, dictated by its scientific commitments, some of which spanning of several decades.

After an initial construction phase of new large physics instruments involving the unit's technical services - ATLAS ITk and HGTD, CTA, Hyper-Kamiokande, DAMIC, etc. - and the commissioning of LSST, the time has come for the unit's physicists to participate in the analysis of the scientific results of these experiments and in drafting the corresponding publications. Indeed, the full exploitation of these projects is of primary importance for the scientific community.

In particular, the physicists in the COEN team will take part in the two major cosmological surveys, LSST and DESI, which have the potential to change our present understanding of the evolution of the Universe (validity of general relativity on cosmological scales, validity of the ΛCDM cosmological model, nature of dark energy).

The next few years will also see the deployment of the various telescopes on the two CTA sites. Physicists from the RCMN team will be involved in finalising the construction of CTA and in analysing its first experimental data, which will enable compact objects such as AGNs to be studied with great sensitivity. The next few years will probably also see the development of the GRAND project, a radio antenna array for the detection of very high-energy cosmogenic neutrinos.

Physicists in the AMA team will be involved in the analysis of the LHCB data and in the upgrade of the T2K near detector, which will also serve as the near detector for Hyper-Kamiokande (HK). The trajectory of the team participating in the LHCb experiment will also depend on the choices made by the LHCb collaboration concerning the detector chosen for the phase 2 upgrade and on the national context. Members of the AMA team will also participate in R&D programmes related to the HK detector. Ultimately, the HK detector will become a unique observatory for cosmic neutrinos.

The physicists in the MIF team will also be involved in a number of research areas: ATLAS at the LHC accelerator at CERN, which is currently in operation, the CALICE collaboration and its R&D programme for silicon-tungsten calorimetry, and the programmes for CERN's Future Circular Collider (FCC). Currently, and for the next few years, most of the team members will be taking part in the ATLAS experiment. The scientific programme is a continuation of what is currently being done, i.e., finalising the analyses with the data from Run 2 and exploiting the new data recorded during Run 3 (2022-2025) of the LHC. The team's R&D activities will draw on the skills of the unit's technical services in electromagnetic calorimetry and silicon trajectography.

For the physicists working in the LHCb (AMA) and ATLAS (MIF) teams, the next few years will be particularly exciting as they await the roadmap for the field, which will be defined by the working group on the European strategy for particle physics up to 2025.

Furthermore, the end of the current construction period will free up forces to study and carry out a new generation of projects in which the unit plans to participate. These include a major refurbishment of the LHCb (phase 2 upgrade), which will be installed around 2033, and developments aimed at preparing new detectors for the search of dark matter, such as the DARWIN project, for which the unit has already acquired the XeLab experimental equipment.

The unit's trajectory is consistent with its long-term scientific commitments and the expertise of its technical services. For the long term, it plans to develop new R&D themes, whether in silicon sensors, new CMOS cameras for cosmology, artificial intelligence ever closer to sensors, digital electronics and on-board electronics. This R&D will be based on the unit's platforms and technical facilities, which are constantly expanding and are now open to other units in the area.

The excellence of the planned research and developments for the unit depends on increasing its permanent personnel. Furthermore, external resources provided by the EU and National research programmes will be mandatory. In this respect, the committee supports strongly the request for dedicated staff in the administration team to help in this quest.

Finally, one of the major assets of the unit is its technical equipment and the competence of the technical staff: maintaining and consolidating this sector is a must for the continuing success of the unit.

# RECOMMENDATIONS TO THE UNIT

## Recommendations regarding the Evaluation Area 1: Profile, Resources and Organisation of the Unit

The unit is actively involved in a number of collaborations and has the knowledge and the expertise required to carry out its commitments. However, particular attention must be paid to the DAMIC experiment, for which the ERC, which provided the necessary funding for its realization, particularly in terms of human resources, is ending. The committee strongly supports all the initiatives that the unit's management will undertake to enable this team to participate in the next stage of this experiment, i.e. data taking. Indeed, in the absence of recruitment and/or fixed-term contracts for researchers and theses DAMIC-M activity at the LPNHE will be jeopardised from mid-2024 and any participation in OSCURA will become pointless.

Clearly, the general situation at the unit has improved considerably since the last Hcéres visit, and the unit's members feel that the current management is attentive to their needs. An amendment to the unit's internal regulations has reformed the procedures for setting up and running the scientific council. The Hcéres committee encourages the unit's management to continue the reform of the scientific council by giving it as many external members as internal members.

## Recommendations regarding the Evaluation Area 2: Attractiveness

The competences of the unit are clearly an attractive factor for any project requiring them. However, before committing to a new project, management should carefully assess the long-term benefits for the unit, beyond immediate visibility: in particular, it should evaluate the capacity of the unit (in particular in terms of human resources) to play a visible role in the project.

Furthermore, the committee recommends improving the welcome process for new arrivals, particularly PhD students and postdocs: the committee suggests that new arrivals receive a welcome letter from the unit director or a representative that includes a public link to a "welcome booklet". The welcome booklet, probably to be drawn up in coordination with the relevant university departments, should include practical information on the procedures involved in moving to the Paris region and details of who to contact in the event of personal problems (e.g. harassment).

## Recommendations regarding Evaluation Area 3: Scientific Production

The unit's scientific output is very good. The number of articles published reflects the size of the collaborations in each field as well as the phase of the various experiments (preparation, data analysis, etc.). The committee encourages the unit to maintain or even increase this high scientific level in the coming years.

## Recommendations regarding Evaluation Area 4: Contribution of Research Activities to Society

The unit has launched the construction and eventual accreditation (labelling) of three technical platforms: CLAP (around the newly acquired probe station), TiSiDet (microbonding), and PCS (computing, disk space), open with priority to other labs (SU, IN2P3) but also to the private sector. The committee recommends taking advantage of the presence of these platforms to create links with industry, which could ultimately increase not only the unit's external resources but also enhance technology transfer from the unit to industry and from Industry to the unit.

# TEAM-BY-TEAM OR THEME ASSESSMENT

**Team 1:** Masses and Fundamental Interactions

Name of the coordinator: Mr José Ocariz

## THEMES OF THE TEAM

The main activities of the MIF (Matter, Interactions, and Forces) team have as primary objective to rigorously test the Standard Model (SM) of particle physics. Their researches span a wide range of areas, from the exploration of fundamental particles to the development of advanced detector technology.

The MIF flagship experiment is the ATLAS experiment at the Large Hadron Collider (LHC). They have made significant contributions to past and ongoing physics analyses, as well as in preparations for detector upgrades to accommodate the expected increase in LHC luminosity.

Following their pivotal role in the discovery of the Higgs boson, the MIF team has diversified its physics pursuits in ATLAS, including (a) Investigations into Higgs boson properties, (b) Research in hadronic jet and top quark physics, (c) Exploring physics beyond the Standard Model (SM), (d) Vigilant efforts in assessing detector performance.

The MIF team is actively involved in detector upgrades, with a specific focus on silicon pixel sensors for the inner tracker (ITK). They have been among the initiators of the new high granularity timing detector (HGTD).

The CALICE project focusses the team's R&D efforts on a silicon-tungsten (Si-W) calorimeter within the International Linear Collider (ILC) project.

## CONSIDERATION OF THE RECOMMENDATIONS OF THE PREVIOUS REPORT

Most of the recommendations of the previous report have been followed. Despite the departure of some team members, new arrivals have been correctly integrated and the balance among the research and technical activities maintained. The number of PhD students has remained adequate despite the COVID epidemics and the team internal communication has been consolidated by regular meetings between the members involved in diverse projects. The team is actively involved in the European Strategy through their involvement in the FCC project.

The area which is still lagging behind, is the technology transfer where little progress has been achieved.

## WORKFORCE OF THE TEAM: in physical persons at 31/12/2022

| Catégories de personnel | Effectifs |
|---|---|
| Professeurs et assimilés | 3 |
| Maitres de conférences et assimilés | 3 |
| Directeurs de recherche et assimilés | 6 |
| Chargés de recherche et assimilés | 3 |
| Personnels d'appui à la recherche | 0 |
| **Sous-total personnels permanents en activité** | **13** |
| Enseignants-chercheurs et chercheurs non permanents et assimilés, y compris post-doctorants | 3 |
| Personnels d'appui non permanents | 7 |
| Doctorants | 11 |
| **Sous-total personnels non permanents en activité** | **21** |
| **Total personnels** | **34** |

# EVALUATION

## Overall assessment of the team

The MIF team is highly regarded within major international collaborations, and their scientific output is of exceptional quality. Their involvement in critical research and upgrade initiatives across various experiments demonstrates their significant contribution to the field.
The committee acknowledges that the team is well positioned for its flagship project ATLAS, for the next five years. This strong positioning encompasses both research activities and the upgrade programme, ensuring continued success and impact in the field.
The committee sees potential for the team to engage in more technology transfer activities, offering an opportunity to them to apply their research outcomes in practical applications.
The dedication of team personnel to training young generations is commendable. The significant presence of teaching staff within the team has a substantial impact on student formation. The diversity of the team's research programmes allows them to supervise a large number of students and post-docs, contributing to the development of highly skilled professionals.
The committee recognizes that the team's activities and research excellence not only push ahead fundamental knowledge but also play a pivotal role in maintaining public interest in these subjects. The team actively promotes the understanding of their research efforts, making science more accessible to the broader community.
Overall, the MIF team has demonstrated high level of performance in its scientific work, a commitment to educating next generations, and a strong presence in international collaborations, all of which contribute to their positive reputation and potential for further growth.

## Strengths and possibilities linked to the context

The MIF team exhibits a remarkable array of strengths that firmly establish their prominence and potential within the field of particle physics, particularly in the context of the ATLAS project.

The team's profound understanding of detector performance places them in key analyses in ATLAS. The expertise extends to crucial areas like photon and jet identification, leading to visible roles in the study of Higgs Boson, top quark and the search for Dark matter. Notably, their approach seamlessly integrates standard model (SM) physics with the quest for new physics, reflecting a well-rounded research strategy.

The team's scientific productivity is exemplary, marked by a consistent output of journal publications and international conference presentations annually. The positions held by team members as coordinators of the SM physics group, the jet Et-miss physics object group, and the e/gamma detector performance group within the ATLAS collaboration underscore the team's visibility and influence within this collaborative effort.

The team's choices in research upgrades are both strategic and pertinent. Their strong involvement in the ITK baseline detector and the pHGTD timing detector demonstrates a forward-thinking approach, especially in addressing challenges posed by future Hi-Lumi LHC and the increased collisions pile-up. Their prior expertise in planar pixel sensors uniquely positions them for success in the ITK upgrade.

The team has cultivated significant international connections with various universities, hosting more than ten visiting physicists over the evaluation period. This international network enriches their research efforts and contributes to the global exchange of scientific knowledge.

The team is deeply committed to education, with half of its members holding positions as professors or assistant professors (maitres de conférences). Some team members also lead masters or doctoral schools, emphasizing their role in nurturing the next generation of scientists.

The team actively engages in outreach events, extending their scientific mission to the wider community.

In sum, the MIF team's exceptional strengths encompass a profound understanding of detector performance, a rich publication and presentation record, strategic leadership roles, a forward-thinking approach to upgrades, extensive international collaborations, a strong focus on education and outreach, and pivotal contributions to key initiatives. Their well-rounded and influential presence within the ATLAS collaboration positions them as a prominent force in the field of particle physics.

## Weaknesses and risks linked to the context

The approval of the HGTD, the ongoing involvement in ITK and the engagement in the FCC e-e risk to stress the resources (both human and financial) of the team. The CALICE involvement appears unproductive at present due to unfavourable prospects for the ILC, compounded by an alternative major realization of a Silicon-based calorimeter within the CMS experiment. Despite the major technological developments in HGTD and ITK there is little effort addressing technology transfer.

### Analysis of the team's trajectory

The activities for the team both on the technological and the research sides are well defined: the LHC programme will continue for at least a decade and the team is well placed to play a very visible role both on the upgrade of ATLAS and in its physics programme. The diversity of the competences will also allow the team to engage in any special/new research investigation, which might be steered from the RUN3 results.

## RECOMMENDATIONS TO THE TEAM

The team should manage carefully the human resources and give priority to the deliverables for the approved programmes of ATLAS.

The engagement on the future European HEP roadmap should be further defined after 2025, and, in case of firm decision, the effort on the detector R&D should be steered accordingly.

With respect to possible involvement in calorimetry for future projects, the committee recommends to have a global national approach: calorimetry based on Silicon active layers will be clearly one of the choices and the French units should have a unified approach in this respect and play a central role in proposing this technique.

The committee renews the invitation to explore ways to connect more to the industry and be more proactive in identifying areas of collaboration.

**Team 2:** Matter-Antimatter Asymmetry

Name of the coordinator: Mr Eli Ben-Haïm

## THEMES OF THE TEAM

The team is looking at the fundamental question of the matter-antimatter asymmetry in the Universe.

There are two distinct angles of approach and the team is trying to give an answer looking at both.

One group explores the problem from the neutrino perspective, aiming to measure the CP violating phase that might disclose the road to leptogenesis.

The other group keeps investigating the quark sector trying to find a solution both through refining the precision of the measurement and searching for deviations not permitted in the Standard Model context.

## CONSIDERATION OF THE RECOMMENDATIONS OF THE PREVIOUS REPORT

The team line of research in the LHCb data analysis follows the recommendations made. No specific mention has been made about COMET staffing nor to the strategy so it is not possible at this stage to assess whether the recommendations have been followed. There is no mention to a significant outreach activity neither from the neutrino nor from the LHCb team.

The team did not take part to DUNE but given the team size and composition, it does look a sound choice.

The work on LHCb upgrade is in progress and the group is fully involved.

## WORKFORCE OF THE TEAM: in physical persons at 31/12/2022

| Catégories de personnel | Effectifs |
|---|---|
| Professeurs et assimilés | 2 |
| Maitres de conférences et assimilés | 3 |
| Directeurs de recherche et assimilés | 1 |
| Chargés de recherche et assimilés | 3 |
| Personnels d'appui à la recherche | 0 |
| Sous-total personnels permanents en activité | 9 |
| Enseignants-chercheurs et chercheurs non permanents et assimilés, y compris post-doctorants | 2 |
| Personnels d'appui non permanents | 9 |
| Doctorants | 9 |
| Sous-total personnels non permanents en activité | 20 |
| Total personnels | 29 |

## EVALUATION

### Overall assessment of the team

There are two distinct angles of approach to the fundamental question the team is trying to answer.
One looks at the problem from the neutrino perspective, aiming to measure the CP violating phase that might disclose the road to leptogenesis. The other keeps investigating the quark sector trying to find a solution both through refining the measurement precision and through looking for deviations not permitted in the Standard Model with results opening the possibility of non-vanishing CP violation phase.
The neutrino group is giving a substantial contribution to the upgrade of the T2K experiment in the TPC electronics while participating with clear responsibilities in the HK preparation. A substantial number of students is involved in the group activities.
The second strong group LHCb shows a significant attractiveness for students, PostDocs and staff researchers. Significant results concerning the leptonic universality and leptonic flavour violation have been obtained.

Few group members are in a position of responsibility in the collaboration, more than expected, given the size of the group. The activities span over data analysis, trigger evolution, machine learning and use of artificial intelligence and electronics.

### Strengths and possibilities linked to the context

The search for a possible charge and parity violation (CP) in the lepton sector is one of the fundamental questions in neutrino physics. The possible observation of a CP violation by neutrinos could explain why the Universe is dominated by matter and put into question the Standard Model. In 2020, T2K published the first indications that CP could be violated in the lepton sector. New experiments in search of CP violation will be undertaken during the second phase of the T2K experiment and, later on, with Hyper-Kamiokande.

As far as LHCB is concerned, the group is heavily involved in the physical analyses and technical aspects of the experiment. The physical analyses, aimed at observing anomalies in the quark sector, focus on two axes: the study of universality and violation of the lepton flavour, using mainly semi-leptonic decays of the type $b \rightarrow s\ \ell^+\ \ell^-$ (charged lepton) and $b \rightarrow c\ \ell\ \nu$, and the study of B meson decays in final states without charmed particles. These investigations will continue, with better statistics, in the next phase of the LHCb experiment.

The search for CP violation in the neutrino sector and anomalies in the quark sector are among the most exciting research themes in this domain.

### Weaknesses and risks linked to the context

As for the LHCb group, there is expertise in data analysis and a good engagement in the upgrade programme. There is no specific risk or particular weakness. Everything is linked to the general performance of the entire experiment. One example is the incident to the VELO combined with the LHC magnet failure that have not allowed to take meaningful data this year. In addition, the start of HiLumiis pretty far in the future. The group faces the same problem of all LHC experiments to maintain attractivity for young people.

The neutrino group is small although pretty well embedded in the T2K and the future HK programmes. It is important not to lose people and to be fully recognised in the French strategy for neutrino research given the competition with DUNE.

### Analysis of the team's trajectory

The choices of the neutrino group are wise and there is no specific concern about them. The group is involved in COMET to some extent but this point was not extensively discussed during the visit of the committee.

As for the LHCb group, the most interesting activity is in the implementation of techniques based on the AI both for the data analysis and, more relevant in perspective, at trigger level. However, there is still some confusion about the national strategy for the LHCb Phase2 upgrade, so some definite decision has not been taken for the involvement of the LPNHE team.

## RECOMMENDATIONS TO THE TEAM

There is no specific recommendation for the neutrino group. Their participation to T2K is successful and the preparation for HK is proceeding well. They should just follow the preparation of the MoU, which will frame the IN2P3 participation to HK.

As for the LHCB group, the recommendation is to position it in order to bring out maximum value from its expertise as soon as the national strategy for the next phase of the experiment is clarified.

**Team 3:** Cosmic Rays and Dark Matter

Name of the coordinator: Mr Luca Scotto Lavina

## THEMES OF THE TEAM

The Cosmic Rays and Dark Matter (RCMN) team is involved in research into the origin of cosmic rays and the processes involved in their acceleration in compact objects, as well as investigating the nature of dark matter in the Universe.

Research into the nature of dark matter (DM) is one of the unit's major cross-disciplinary themes, present in all four research teams. RCMN team is involved in three major direct research experiments in underground units, under the main hypothesis of WIMP (weakly interacting massive particles) interacting with detector nuclei, but also searching for dark sector particles interacting with electrons: XENON, which is starting to collect data in its XENON-nT phase; DarkSide, whose detection principle is based on the use of liquid Argon; DAMIC, which specializes in low-mass DM particle search.

The study of cosmic rays (CR) concerns in particular their origin, the nature of particles accelerated, and the propagation of ions and gamma rays, which is a probe into the nature of space-time. LPNHE is involved in four experiments. The Pierre Auger collaboration studies the highest energy cosmic rays, at the EeV level; they are mostly ions. The future GRAND detector will study highest-energy neutrinos through emission of photons in the radio band. The H.E.S.S. large Cherenkov telescope array, which is evolving towards the CTA detector on a global scale, studies very high-energy gamma rays at the TeV level. The study of those TeV gamma rays also offers an independent way of studying DM.

## CONSIDERATION OF THE RECOMMENDATIONS OF THE PREVIOUS REPORT

The previous committee was concerned about the dispersal of forces in the RCMN field.

The Xenon group was reinforced by a permanent researcher and two IRs, and succeeded in obtaining substantial funding from IN2P3 for the XeLab R&D platform, as well as an ANR X-ART. ERC funding for DAMIC-M also enabled the hiring of several non-permanent staff. Finally, the unit has committed itself to a very reduced contribution to DarkSide for the next two-three years, before a possible reassessment.

The main recommendation related to strategy by the previous evaluation committee was to strengthen the transfer of human resources and expertise from H.E.S.S. to CTA. This does not seem to have happened, but several difficulties independent of the good will of the team (the delays of CTA, uncertainties in the governance of the experiments, COVID) have certainly played a role.

## WORKFORCE OF THE TEAM: in physical persons at 31/12/2022

| Catégories de personnel | Effectifs |
|---|---|
| Professeurs et assimilés | 1 |
| Maitres de conférences et assimilés | 1 |
| Directeurs de recherche et assimilés | 1 |
| Chargés de recherche et assimilés | 2 |
| Personnels d'appui à la recherche | 0 |
| Sous-total personnels permanents en activité | 5 |
| Enseignants-chercheurs et chercheurs non permanents et assimilés, y compris post-doctorants | 7 |
| Personnels d'appui non permanents | 6 |
| Doctorants | 6 |
| Sous-total personnels non permanents en activité | 19 |
| Total personnels | 24 |

# EVALUATION

## Overall assessment of the team

With its involvement in three of the major international experiments in the direct search for dark matter, the LPNHE team covers a wide range of particle masses (WIMPs, dark photons, ALPs) accessible with this physics. It also benefits from the complementary nature of the techniques used (silicon skipper CCDs, xenon or argon TPC), and its major expertise in each of them. The team is involved not only in physical analyses, but also in more instrumental and technical achievements. In the field of cosmic rays, high-quality analyses of violations of Lorentz Invariance and a strong technical expertise in electronics acquired thanks to the H.E.S.S. and CTA (NectarCam) cameras give a distinctive character to the LPNHE group, which is however understaffed. GRAND, of which the LPNHE is one of the originators, could represent an interesting long-term opportunity for the research unit.

## Strengths and possibilities linked to the context

A major contribution has been made in the field of the direct search for dark matter, with some outstanding new results. Two PhD theses carried out at the unit as part of the DarkSide-50 experiment have set the world's best limits for a light WIMP. The DAMIC team has succeeded in installing a DAMIC-M prototype (LBC) at LSM which, thanks to the Skipper CCD technique, provides a resolution of 0.2 electrons on the deposited charge, and limits on DM-electron interactions. The Xenon team has placed new constraints on leptophilic dark matter (dark photon and ALP). The team has also embarked on a highly technical and instrumental activity with XeLab, a cryogenic device equipped with a dual-phase TPC containing a few kilograms of xenon to study the problems of new-generation detectors. Finally, the team has just received ANR funding for the X-Art R&D project to study the properties of the xenon-argon mixture, which could have a major impact on future research projects in astroparticles. The committee welcomes the decision to open a position for an assistant professor (maitre de conférences) in the dark matter field in 2024.

In the CR field, for what concerns gamma rays, high-quality analyses of violations of Lorentz Invariance, as well as strong technical expertise in electronics acquired thanks to the H.E.S.S. and CTA (NectarCam) cameras, give a distinctive character to the LPNHE group. GRAND, of which the LPNHE is one of the originators, could represent an interesting long-term opportunity for the LPNHE, but its performance is not yet sufficiently proven. Auger is still a safe bet in the short-to-medium term, even if its discovery potential is decreasing.

## Weaknesses and risks linked to the context

Efforts have been made, but mainly in terms of funding and staff for the XENON group (one permanent researcher and two IRs). The team has been involved in three different projects for the direct detection of dark matter, and despite the decision to stop the participation to DarkSide experiments, the RCMN team is still understaffed, independently of the cosmic ray groups. Although the scientific results and funding achievements of the dark matter groups over the last few years have been very impressive, there is cause for concern for the future, especially since DAMIC's financial possibilities for maintaining non-permanent positions will disappear in mid-2024 at the end of the ERC contract.

On the CR side, the LPHNE gamma-ray group does not currently have the strength to capitalize on the engineering work done for CTA, which is a too complex experiment for a single unit. The H.E.S.S./CTA group is down to two permanent staff, and CTA's 'attractiveness' is not excellent (which doesn't seem to be just a LPNHE problem).

## Analysis of the team's trajectory

The world's best limits on low-mass WIMPs were obtained with DarkSide-50. The group is involved in defining the French contribution to DarkSide-20k, developing the calibration system and taking responsibility for reconstruction by the APC, CPPM and LPNHE groups. However, the need to concentrate forces means that the LPNHE will not be continuing DarkSide activity in the coming years.

The team is involved in DAMIC at SNOLAB and in DAMIC-M at LSM thanks to an ERC grant. The technical developments carried out for DAMIC-M, the installation at LSM of the Low Background Chamber prototype with skipper-CCDs having a charge resolution of 0.2 electrons, and the associated first publications attest to the quality of the achievements. Between 2023 and 2026, the team will focus on installing the DAMIC-M detector, taking data, analysing and publishing the results, if possible, with the support of a researcher and a PhD student. The team is keen to participate in the future OSCURA experiment, thanks to their expertise in MonteCarlo simulation, skipper-CCD characterization and optimization, as well as in the use of DAMIC-M infrastructures (test benches at LPNHE, clean room and LBC infrastructure at LSM).

The XENON team has demonstrated its leadership in the analysis of leptophilic dark matter in XENON1T, and in the first dark matter results from XENONnT. The quality of the publications, including one in Nature, is to be commended. For the XENONnT experiment, the team is in charge of coordinating cryogenics and computing activities, developments to optimize the experiment's computing infrastructure. It is also in charge of continuing work on the simulation of XENONnT electrodes, and analyses on related astroparticle physics topics already underway with three PhD theses (detection of boron-8 solar neutrinos, detection of supernova neutrinos in the Milky Way, improved measurement of the double electron capture of xenon 124). The XENON team is also involved in the XLZD Consortium (XENON-LUX-ZEPLIN-DARWIN), which aims to build a next-generation detector using 50 tonnes of liquid xenon. The team coordinates the DARWIN working group on liquid xenon processing. With developments linked to its XeLab cryogenic platform and the X-Art R&D project to study the properties of the xenon-argon mixture, the team could have a major impact on future research projects in dark matter search, astroparticles and medical physics.

The dark matter team's national and international collaborations, as their numerous responsibilities, are noteworthy.

Ultimately (post 2026), depending on the development of the DAMIC-M and XENON teams, a merger could be envisaged.

Optimistically, the CTA array in the Southern hemisphere will surpass the differential sensitivity of H.E.S.S. only after 2028, and CTA will be superior to MAGIC in the Northern hemisphere after 2026. Taking into account the volume of data collected, only in the decade 2030 CTA will exceed the integral sensitivity achieved by H.E.S.S. on the reference target sources. This situation, which is not favourable to global astrophysics, is nevertheless good for the LPNHE gamma-ray astrophysics group.

The LPNHE H.E.S.S. group is particularly well positioned to take advantage of observations in the multimessenger context. A significant proportion of activities concerns the observational and phenomenological study of the variability of active galactic nuclei, which may be important in the context of studies of Lorentz invariance violation, where the LPHNE group has developed tools that are a reference in the community worldwide.

From the hardware point of view, LPNHE is involved in supplying the Front-End Boards for NectarCAM, in production until the end of 2024. The group will participate in the analysis of test data during the production of the nine NectarCAMs that will be integrated at the CEA/Irfu and then deployed in the medium-size telescopes on the La Palma site, where MAGIC and LST are already taking data, as well as in commissioning and verification on-site.

The work of the GRAND group at the LPNHE will focus on the two main areas developed by the team: the analysis of data from the GRAND@Auger prototype (an array of 10 GRAND antennas deployed on the Pierre Auger Observatory site), and the GRANDProto300 detector, an array of 300 antennas (from 2024) deployed at a selected site in Gansu province. The main aim will be to demonstrate GRAND's detection principle, i.e. to reconstruct the characteristics of cosmic rays with sufficient accuracy for physical analysis.

## RECOMMENDATIONS TO THE TEAM

The committee welcomes the courageous decision to stop DarkSide activities for the next few years for lack of human resources, despite the excellent results achieved.

The committee suggests strengthening both the cosmic rays and dark matter groups to pursue commitments, and not taking on more. The gamma-ray unit should become more involved in CTA; this would require to promote synergies with other groups.

**Team 4:** Cosmology and Dark Energy

Name of the coordinator: Mr Pierre Antilogus

## THEMES OF THE TEAM

The Cosmology and Dark Energy team contributes to the understanding of the Universe and its evolution, by carrying out precision tests of the Standard Model of Cosmology, where ΛCDM describes the dark energy contribution and CDM stands for Cold Dark Matter. The team is focused on investigating the nature of dark energy, through either cosmic expansion and characterization of the dark energy equation of state, or through structure formation and tests of modified gravity. To this end, the team is heavily involved in technical and instrumental contributions on large-scale cosmology programmes such as LSST and DESI, as well as in data analysis and interpretation.

A particular strength of the team lies in its multi-probe and multi-survey approach. For the analysis of Type Ia supernovae used as standard candles, the team is involved in the future major LSST photometric survey at the Rubin Observatory, and has initiated preliminary analyses with data from the Zwicky Transient Factory (ZTF) and Hyper Suprime-Cam (HSC) on Subaru. The team also pursued its commitment to gravitational lensing analyses in LSST. For galaxy clustering analyses, the team is actively involved in spectroscopic projects such as eBOSS and DESI, and in the exploitation of these data. Analyses have focused on measuring the BAO in Lyman-alpha data from eBOSS, and are now focusing on BAO (Baryon Acoustic Oscillation) and RSD (Redshift-space Distortion) analysis in DESI/BGS data.

Finally, an activity is being conducted on the study of the formation of non-linear structures, based on numerical simulations from a theoretical point of view.

## CONSIDERATION OF THE RECOMMENDATIONS OF THE PREVIOUS REPORT

This report recommended that the team should put a strong effort into recruiting postdocs and PhD students. This has now been achieved, with a highly satisfactory number of doctoral and post-doctoral students.

The second concern was about the team's internal scientific animation. Today, the team organizes regular internal meetings. A number of cross-analyses between different cosmological surveys such as LSST and DESI are anticipated by the team, which will eventually enable collaboration between projects.

Another risk was the identified need to recruit young researchers in order to consolidate the team's openness to weak lensing and galaxy clustering. This was taken into account with the hiring of a young CNRS Researcher in 2020 that ensured the team's high visibility in galaxy clustering (GC). Although the team now boasts a wealth of internationally recognized expertise, it will be important to stay alert to future retirements.

As far as theoretical activities on the simulation aspects of large-scale structure formation are concerned, synergy with observational activities remains shy.

## WORKFORCE OF THE TEAM: in physical persons at 31/12/2022

| Catégories de personnel | Effectifs |
|---|---|
| Professeurs et assimilés | 2 |
| Maitres de conférences et assimilés | 3 |
| Directeurs de recherche et assimilés | 3 |
| Chargés de recherche et assimilés | 3 |
| Personnels d'appui à la recherche | 0 |
| Sous-total personnels permanents en activité | 11 |
| Enseignants-chercheurs et chercheurs non permanents et assimilés, y compris post-doctorants | 2 |
| Personnels d'appui non permanents | 7 |
| Doctorants | 8 |
| Sous-total personnels non permanents en activité | 17 |
| Total personnels | 28 |

# EVALUATION

## Overall assessment of the team

The cosmology team is highly recognized internationally. The team was a driving force in the French participation to the American LSST project, being responsible for the filter changer and the camera focal plane. This technical contribution has earned the team several awards, including one collective CNRS Cristal and one individual Cristal. On the instrumental side, the team has developed an expertise in the detailed study and understanding of electronic effects in CCDs. Over the last ten years or so, the team has identified the Brighter-Fatter effect, and is still carrying out studies to characterize CCDs and correct distortions, for example in the context of lensing analyses.
In terms of supernova (SN) data analysis, the team has devoted considerable effort for understanding the systematic uncertainties that will dominate measurements in LSST. To this end, it has influenced the cadence of the LSST photometric survey and is leading the LEMAITRE programme, which aims at producing a new Hubble-Lemaitre diagram with low-redshift ZTF data and high-redshift HSC data, constituting a total sample of 5,000 supernovae. In addition, the team is involved in the instrumental calibration of LSST with StarDICE, and the measurement of atmospheric transmission with LSST's auxiliary telescope AuxTel.
In the DESI project, the team played an active role in validating the optical transmission of spectrographs built at Winlight, based in Pertuis, and in setting up an in-situ calibration system, which earned two team members the status of DESI Builder. The team has also made a major contribution to the analysis of the BAO signal in eBOSS Lyman-alpha data, and since 2021 has been involved in galaxy clustering analyses with DESI data, specifically the Bright Galaxy Sample (BGS).

### Strengths and possibilities linked to the context

The team has for many years demonstrated its leadership in the field, and holds all the necessary cards - i.e. the tools and the data - to continue playing a leading role over the next decade:

The team's involvement in the LEMAITRE programme, which includes ZTF and HSC/HST data, as well as SNLS 5-year data, is highly strategic and, with the publication of the expected major results, will enable the team to boost its visibility and international recognition.

The involvement of the team in galaxy clustering (GC) analyses, strengthened by a recent recruitment in the team, is highly visible and will lead, in the very short term, to first-class cosmological results. The decision to stop working on Lyman-alpha analyses, following the departure of the CEA physicists with whom the collaboration was conducted, is a pertinent (and welcome) move, and ensures critical mass for GC analyses.

Participation in lensing analyses on LSST, and in GC analyses on spectroscopic surveys such as eBOSS and DESI, is an undeniable asset for a multi-probe approach in a highly competitive international context.

### Weaknesses and risks linked to the context

The team promotes a multi-probe approach to cosmological analysis, which will undoubtedly be essential for the cosmological analyses of the next ten years. However, the team masters the tools of analysis in primary probes such as supernovae, lensing and galaxy clustering individually, but has not yet exploited cross-analysis approaches such as the combination of GC and WL (weak lensing), or GC and SN.

A further weakness of the team is that the newly acquired expertise in lensing analysis may not last after the retirement of the physicists involved.

### Analysis of the team's trajectory

The team's trajectory is well defined, with the exploitation of LSST and DESI data, and the ZTF and HSC supernovae sample. In the longer term, the team wants to set up cross-analyses, an ambitious goal within the team's scope.

# RECOMMENDATIONS TO THE TEAM

The results expected from the LEMAITRE programme will represent the state of the art in supernovae analysis before the arrival of LSST data, with a high impact for future analyses over the next few years. The team must ensure that these major results are properly published for the benefit of the community.

The team activities are moving towards multi-probe analysis, which is strategically wise. The committee suggests that the unit's management should ensure that the team's strengths in analysis are secured with students, in order to guarantee scientific feedback with data from the DESI and LSST surveys.

However, the committee recommends that permanent physicists who do not already have their HDR (half the team) take it as soon as possible, to ensure that they can supervise PhD thesis in good conditions.

# CONDUCT OF THE INTERVIEWS

## Dates

**Start:** 03 décembre 2023 à 19h00

**End:** 06 décembre 2023 à 12h00

**Interview conducted: on-site**

## INTERVIEW SCHEDULE

### Dimanche 3 décembre

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|---|---|
| 20h00 | Diner à huis clos du comité |

### Lundi 4 décembre

| | |
|---|---|
| 9h00 - 9h15 | Huis clos : réunion de préparation du comité |
| 9h15 - 10h45 | Session plénière<br>- Présentation des membres du comité (5 min)<br>- Présentation du directeur (50 min)<br>- Questions (35 min) |
| 10h45 - 11h00 | Pause café |
| 11h00 - 12h15 | Équipe Masses et Interactions Fondamentales (MIF)<br>- Présentation (45 min) questions (30 mn)<br>- Présence : membres de l'équipe |

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|---|---|
| 12h15 - 13h45 | Buffet : session posters avec les responsables de services techniques |

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|---|---|
| 14h00 - 15h15 | Équipe Asymétrie Matière Antimatière (AMA)<br>- Présentation (45 min) questions (30 mn)<br>- Présence : membres de l'équipe |
| 15h15 - 15h30 | Pause café |
| 15h30 - 17h00 | Équipe Rayonnement Cosmique et Matière Noire (RCMN)<br>- Présentation (50 min) questions (40 mn)<br>- Présence : membres de l'équipe |
| 17h00 - 18h00 | Session fermée du comité |

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| 19h30 | Diner à huis clos du comité |

### Mardi 5 décembre

| | |
|---|---|
| 8h45 – 10h45 | - Présentation du directeur technique (30 min)<br>- Visite du laboratoire et des aires expérimentales (1h30) |
| 10h45-12h00 | Équipe Cosmologie et Énergie Noire<br>- Présentation (45 min) questions (30 mn)<br>- Présence : membres de l'équipe |

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|---|---|
| 12h00 – 13h30 | Buffet : session poster avec les responsables des équipes de recherche |

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|---|---|
| 13h30– 14h30 | Rencontre avec les chercheurs et enseignants-chercheurs |
| 14h30– 15h30 | Rencontre avec les IT et Biatss |

| | |
|---|---|
| 15h30– 16h30 | Rencontre avec les doctorants et les post-doctorants |
| 16h30 – 17h00 | Pause café |
| 17h00 – 18h00 | Rencontre avec les tutelles : CNRS, Sorbonne Université, Université Paris Cité |
| 18h00 – 19h00 | Rencontre avec le Directeur d'unité et/ou l'équipe de direction |

| | |
|---|---|
| 20h | Diner à huis clos du comité |

## Mercredi 6 décembre

| | |
|---|---|
| 9h – 13 h | Session de travail du comité |

# GENERAL OBSERVATIONS OF THE SUPERVISORS

Marie-Aude Vitrani
Vice-Présidente Vie institutionnelle et démarche participative
Sorbonne Université

à

Monsieur Eric Saint-Aman
Directeur du Département d'évaluation de la recherche
HCERES – Haut conseil de l'évaluation de la recherche et de l'enseignement supérieur
2 rue Albert Einstein
75013 Paris

Paris, le 4 avril 2024

Objet : Rapport d'évaluation LPNHE - Laboratoire physique nucléaire et hautes énergies

Cher Collègue,

Sorbonne Université vous remercie ainsi que tous les membres du comité HCERES pour le travail d'expertise réalisé sur l'unité de recherche « LPNHE ».

Vous trouverez joint à ce courrier, les observations de portée générale apportées par la tutelle Université Paris Cité.

Je vous prie d'agréer, Cher Collègue, l'expression de mes cordiales salutations

**Marie-Aude Vitrani**
Vice-Présidente Vie institutionnelle
et démarche participative

Université Paris Cité

Le Président

**Paris, le 25 mars 2024**

HCERES
2 rue Albert Einstein
75013 Paris

**Objet :** Rapport d'évaluation de l'unité **DER-PUR250024432 - LPNHE - Laboratoire de Physique Nucléaire et de Hautes Énergies.**

Madame, Monsieur,

L'université Paris Cité (UPCité) a pris connaissance du rapport d'évaluation de l'Unité de Recherche LPNHE - Laboratoire de Physique Nucléaire et de Hautes Énergies.

Ce rapport a été lu avec attention par la vice-doyenne Recherche et le doyen de la Faculté des Sciences d'UPCité (cf courrier du Doyen Cazayous), par la vice-présidente Recherche d'UPCité et par moi-même.

Je remercie le comité pour la qualité de son évaluation et vous indique ne pas avoir d'observations d'ordre général à apporter.

Je vous prie d'agréer, Madame, Monsieur, l'expression de ma considération distinguée.

Édouard Kaminski

**Présidence**

**Référence**
Pr/DGDRIVE/2023

**Affaire suivie par**
Christine Debydeal - DGDRIVE

**Adresse**
85 boulevard St-Germain
75006 - Paris

www.u-paris.fr

Sciences
Université Paris Cité

Référence
MC/NE/EB/2024-024

**Faculté des Sciences**
**Université Paris Cité**
5 rue Thomas Mann
75013 Paris

Objet : DER-PUR250024432 - Évaluation HCERES de l'UMR 7585 LPNHE – Retour Tutelle Université Paris Cité

Chères et Chers Collègues,

Nous souhaitons par ce courrier remercier les membres du comité de visite pour le temps qu'ils ont consacré à l'évaluation de LPNHE, ainsi que pour leur écoute et le travail considérable qu'ils ont accompli.

La Faculté des Sciences est fière de compter LPNHE parmi ses unités de recherche et rappelle la grande qualité de la recherche menée par tous les membres du laboratoire.

Après lecture du rapport provisoire d'évaluation de l'UMR 7585 LPNHE, la Faculté des Sciences ne souhaite ajouter ni remarques générales, ni remarques factuelles.

En vous priant, chères et chers collègues, d'accepter nos chaleureuses salutations.

Maximilien CAZAYOUS
Doyen
Faculté des Sciences
Université Paris Cité

Nathalie EISENBAUM
Vice-Doyenne recherche Faculté des Sciences
Université Paris Cité

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