SUBATECH - Laboratoire de physique subatomique et des technologies associées

Rapport Hcéres

HCERES

High Council for the Evaluation of Research
and Higher Education

Research units

HCERES report on research unit:

Laboratory of Subatomic Physics and Associated Technologies

SUBATECH

Under the supervision of the following institutions and research bodies:

École des Mines de Nantes

Centre National de la Recherche Scientifique – CNRS

Université de Nantes

Evaluation Campaign 2015-2016 (Group B)

HCERES

High Council for the Evaluation of Research and Higher Education

Research units

In the name of HCERES,[1]

Michel Cosnard, president

In the name of the experts committee,[2]

Jens Jørgen Gaardhøje, chairman of the committee

Under the decree N°.2014-1365 dated 14 november 2014,

[1] The president of HCERES "countersigns the evaluation reports set up by the experts committees and signed by their chairman." (Article 8, paragraph 5)

[2] The evaluation reports "are signed by the chairman of the expert committee". (Article 11, paragraph 2)

Evaluation report

This report is the sole result of evaluation by the expert committee, the composition of which is specified below.

The assessments contained herein are the expression of an independent and collegial reviewing by the committee.

Unit name:	Laboratory of Subatomic Physics and Associated Technologies
Unit acronym:	SUBATECH
Label requested:	UMR
Current number:	UMR 6457
Name of Director (2015-2016):	Mr Bernd GRAMBOW
Name of Project Leader (2017-2021):	Mr Bernd GRAMBOW

Expert committee members

Chair: Mr Jens Jørgen GAARDHØJE, Niels Bohr Institute, Copenhagen, Denmark

Experts:

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Mr Jean-Paul BLAIZOT, CEA/DRF/IPhT, Saclay

Mr Horst GECKEIS, KIT/INE, Karlsruhe, Germany

Mr Michel GUIDAL, CNRS/IN2P3/IPNO, Orsay (representative of CoNRS)

Mr Ulli KOESTER, ILL, Grenoble

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Ms Clarisse DAVID, CNRS

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Mr Olivier LABOUX, Université de Nantes

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Representative of Doctoral School:

Mr Pol Bernard GOSSIAUX, Doctoral School n° 500, Matières, Molécules, Matériaux en Pays de la Loire (3MPL)

1 • Introduction

History and geographical location of the unit

SUBATECH is a 'Unité Mixte de Recherche' (UMR) in the region Pays-de-la-Loire and a 'laboratory for subatomic physics and associated technologies´. SUBATECH operates under 3 trustees (tutelles) : Mines Nantes, IN2P3/CNRS and the University of Nantes. SUBATECH is located on the Campus of Mines Nantes.

SUBATECH was established in 1994 with the ambition of becoming a center of excellence for research and education combined with functioning as an interdisciplinary hub for researchers working at CERN in Geneva and researchers working on applications for society.

The research unit stands today with a broad portfolio of activities in fundamental and applied nuclear science and related areas with a strong component of industrial contracts. The unit was last reviewed, by AERES, in 2011.

Management team

The management team of the SUBATECH laboratory, as defined since October 2010, is presently constituted by the following:

- Mr Bernd GRAMBOW, director of SUBATECH;
- Mr Thierry GOUSSET, scientific representative for physics;
- Ms Catherine LANDESMAN, technical staff expert;
- Mr Jean-Luc BENEY, technical director;
- Ms Sophie GIRAULT, administrative director.

HCERES nomenclature

Domaine scientifique principal: ST – ST2 – Physique.

Domaines applicatifs :

- P : Santé humaine et animale;
- S : Environnement;
- S : Énergie nucléaire.

Scientific domains

The activities of SUBATECH span three major axes:

1. The Universe at High Energy;
2. Nuclear Environmental Science, Radioactive Waste Management and Society;
3. Nuclear Science and Health;

and comprise seven research teams, a radioactivity analysis & metrology service and five internal technical and administrative sections.

The seven research teams are listed below with a brief description of their main activities:

- ASTRO adresses the field of astroparticles, notably the study of ultra-energetic Cosmic Rays (UHECR) presently at CODALEMA at Nançay and AERA at the Pierre AUGER observatory, Argentina, connecting particle physics with astrophysics and cosmology. The team is involved in understanding the properties of the electromagnetic shower and its radio signal in the magnetic field of the Earth and searching for sources of UHECR;

- ERDRE is concerned with problems related to neutrino physics and nuclear reactors (neutrino mixing angle, antineutrino detection and sensitivity to fuel composition), notably at the Double-Chooz reactors, on neutrino oscillations at BR2-Mol, and on improving nuclear data related to beta-decay and antineutrino spectra. In addition, the team works on issues related to electronuclear power production of societal relevance;

- PLASMA studies the Quark Gluon Plasma, a deconfined state of matter consisting of the fundamental constituents of matter, the quarks, and their force carriers, the gluons. The team participates in the large international ALICE experiment at CERN's Large Hadron Collider (LHC), and performs experiments at the highest collision energies available in the world today. The team is centrally involved in the development and construction of new detectors for that experiment;

- PRISMA is engaged in fundamental research and the development of applications around the interaction of radiation and matter, notably in the production of new radionuclides for medical applications using the ARRONAX high-current cyclotron, and non-destructive monitoring using nuclear methods (i.e. PIXE) and X-ray tomography;

- RADIOCHEMISTRY focuses on the chemistry of radionuclides in solution, their interaction at mineral/water interfaces, and radiation induced chemical reactions (radiolysis), in close partnership with industrial and public sectors. The topics have a clear fundamental and applied science character. The issues related to disposal of nuclear waste, nuclear decommissionning and the development of radionuclides for cancer therapy and diagnostics have a strong societal impact;

- THEORY carries out fundamental research mainly in nuclear and particle physics. This includes the modeling of heavy-ion collisions over a broad energy range, the study of hard processes in Quantum Chromo-Dynamics, as well as more formal developments in Quantum Field Theory. A particular strength of the group, responsible in part for its international visibility, is its expertise in numerical simulations together with its intensive collaborations with experimental groups;

- XENON constitutes the French hub for Dark Matter searches using the Xenon100 detector located in the Gran Sasso tunnel in Italy, and its upgrade to Xenon1T that will soon become operational. The team is responsible for data analysis, background simulations and for the Xenon storage system. The team is also engaged in developing a new PET camera (XEMIS) using 3-photon Compton scattering imaging and liquid-Xenon detector technology. A startup company Ai4R for development of medical imaging has been formed;

In addition, SMART is a metrology and trace element analysis service that provides measurements of radioactivity to local communities and companies on a commercial basis. SMART is accredited by the French national accreditation agency (COFRAC).

Unit workforce

Unit workforce	Number on 30/06/2015	Number on 01/01/2017
N1: Permanent professors and similar positions	19	20
N2: Permanent researchers from Institutions and similar positions	34	36
N3: Other permanent staff (technicians and administrative personnel)	69	69
N4: Other professors (Emeritus Professor, on-contract Professor, etc.)		
N5: Other researchers from Institutions (Emeritus Research Director, Postdoctoral students, visitors, etc.)	19	
N6: Other contractual staff (technicians and administrative personnel)	6	
N7: PhD students	31	
TOTAL N1 to N7	**178**	
Qualified research supervisors (HDR) or similar positions	24	

Unit record	From 01/01/2010 to 30/06/2015
PhD theses defended	50
Postdoctoral scientists having spent at least 12 months in the unit	36
Number of Research Supervisor Qualifications (HDR) obtained during the period	4

2 • Overall assessment of the unit

Introduction

The field of activity of SUBATECH is, in a broad sense, nuclear physics and nuclear (radio) chemistry and their applications and derived technologies. The activities range from studies of the strong interaction and the state of matter in the early Universe, the Quark Gluon Plasma, in both experiment and theory, over the search for Dark Matter and the understanding of the characteristics and sources of high energy cosmic rays from the Universe, to a broad spectrum of applications of nuclear techniques and methods within the areas of radiochemistry, radioactive waste management, nuclear decommissioning, development of radioisotopes assays for diagnostics, medical imaging, detector development and diagnostics for reactors and the nuclear industry.

A strong element underpinning the laboratories success is the interplay of fundamental research and applied science, of experiment and theory and of the technical services with the research groups. The portfolio of activities appears well balanced and relies on the strengths that have been developed over the years in various areas but, at the same time, evolving in line with international developments and national needs.

With respect to the status at the time of the last evaluation report (in 2011) the experts committee notes in general, very positive developments, some of which are briefly mentioned below.

The ASTRO team has developed its activities in high-energy cosmic ray detection, contributing to better understanding of cosmic ray showers and their radio signals in magnetic fields and developing modular antennas and amplifying equipment. An interesting avenue has been the participation in the Pierre AUGER experiment in Argentina that, however, will be terminated in 2016.

The ERDRE team has developed its involvement in reactor related activities, notably neutrino studies at the fundamental level, aiming at determining backgrounds impacting the determination of the neutrino mixing angles at Double-Chooz, and determination of antineutrino spectra for the monitoring of the fuel composition and collection of better nuclear data using total absorption techniques. In addition, an activity targets the development of electronuclear scenarios.

The PLASMA team continues to play an important and very visible role in the ALICE experiment at LHC/CERN. It has played an important role in the extention of the ALICE calorimeters and is now developing new detectors (MFT, muon-trigger) for the major upgrade of ALICE to be implemented in 2018-19. The team has contributed to the notable scientific output from LHC Run1 and is now involved in analysis of the first Run2 data at top LHC energy.

The PRISMA team has taken new steps in developing new radionuclides for medical applications in particular in view of higher production rates of, for example, ^{82}Sr, ^{44}Sc or ^{44m}Sc and developing high-energy proton-induced X-ray or gamma emission (PIXE/PIGE) methods unique in France using the ARRONAX cyclotron and other non-destructive diagnostic tools. PRISMA has developped particularly important collaborations with regional and national industry.

The RADIOCHEMISTRY team has extended its expertise into quantum chemistry and molecular dynamics simulations and thus strengthened the linking of basic and applied research. Work has been ongoing addressing geo/chemistry issues related to nuclear waste disposal, and the development of new radionuclide assays for nuclear medicine. Fundamental studies related to the clay mineral/water interface chemistry and to the chemical properties of ^{211}At are of high relevance for nuclear waste repository safety considerations and the innovative development of targeted radionuclide cancer therapy methods, respectively. The team develops in a very dynamic way interactions with socio-economic research groups.

The THEORY team has enacted in 2013 a merger of the high-energy and lower energy activities as recommended by the 2010 evaluation panel, and later by the scientific council. Visible efforts have been made to place the various activities of the group into a coherent scientific framework, and to strengthen the discussions leading to decisions on issues of common interest. The overall scientific production of the group during the period is remarkable, with many new results that have contributed to reinforce the international visibility of SUBATECH.

The XENON team is acquiring a very visible role in the upgrade of the most sensitive experiment for direct Dark Matter and axion searches, Xenon1T at Gran-Sasso. This experiment is currently being commissioned and is expected to provide 100 times improved sensitivity by 2017 with a significant discovery potential. It is also constructing the XEMIS2 detector, which will demonstrate proof of concept for 3-photon imaging of small rodents. Future plans involve developments aiming at the clinic for humans.

The SMART service has continued to reinforce its high level of expertise. It is the largest team of the 'Réseau Becquerel', the CNRS network for measurements of radioactivity in the environment. It was called to respond to analyses in the wake of the Fukushima accident. The service has acquired financial autonomy in a challenging competitive market environment.

Global assessment of the unit

SUBATECH has developed into an excellent laboratory that combines in a noteworthy way front-line fundamental research in nuclear, high-energy physics, neutrino physics, and astroparticle physics with a broad spectrum of applications within the fields of nuclear physics, radiochemistry, radiation detection and nuclear medicine, of significant societal importance.

The research teams have overall achieved significant visibility and impact within their areas, both at the national level and at the international level, in some cases being at the absolute international forefront. An important element in this success is the strong fundament provided by the technical services (electronics, IT, mechanical, etc.), and the strong involvement role of theory in many of the laboratory research activities.

SUBATECH achieves a excellent impact within its field of activities and has managed to bring its competencies to the service of the industrial sector and of society in a very fruitful fashion. This is also exemplified by the large

income generated by such services that, in turn, contributes to enlarging the laboratory's possibilities for development.

Strengths and opportunities in the context

- SUBATECH operates several excellent fundamental and applied research programs of high international profile, of which some are outstanding and compete on the world level. These include the activities in XENON1T, in ALICE@LHC and in Theory;
- the activities of SUBATECH have, overall, significant visibility at the regional, national and international levels;
- the unit is involved in a number of high-profile experiments and activities, of which some are unique in France;
- SUBATECH has been able to achieve a fruitful interaction between theory and experiment;
- at the research-unit level, SUBATECH demonstrates a strong complementarity between fundamental and applied research. This is also true for several of the individual research teams;
- SUBATECH has developed a research platform involved in strongly interdisciplinary science fields, e.g. between fundamental physics and nuclear chemistry and nuclear medicine;
- SUBATECH has a strong component of applied research of relevance for industry and society, connected with nuclear energy and the medical sector;
- the research unit has been able to acquire significant external funding from industrial contracts;
- several teams are 'young' leading, potentially, to a dynamical environment.

Weaknesses and threats in the context

- the age profile of the highly successful theory team will entail several retirements in the near future. This will require a targeted effort to assure future continuity at a comparable high level;
- there is a shortage of postdoc and PhD funding in some areas, when comparing to the international standards and also taking into account the specific French job structure;
- the termination of the Pierre AUGER activities may endanger the 'capitalization' of the successful and unique development of methodology around radio signals from atmospheric ultra high energy showers. This will require a careful repositioning of the ASTRO team;
- the low number of HDR (Habilitation à Diriger des Recherches) qualifications acquired over the review period, may constitute a threat to the laboratory's possibilities to maintain a strong PhD student training component and attract the necessary scholarships;
- an adequate technical service that can provide the fundament for the strong role of SUBATECH in both experimental fundamental research and applied and contract based activities could be difficult to maintain;
- there appears to be a tendency of fragmentation in certain areas/teams which may led to sub-criticality and consequently lowered impact;
- the SMART service development may be affected by the increasing business competition in the sector. At the practical level, the SMART service appears to have reached the limit of expansion in the present locales;
- the potential synergy between RADIOCHIMIE, PRISMA and SMART could be better exploited, e.g around the interdisciplinary cooperation and education of young scientists.

Recommendations

- the age profile of the highly successful theory team, which must foresee several retirements among its world-class researchers, will require a targeted effort to assure future continuity at a comparable high level. Top-level recruitment (international call) must take place well ahead of retirements to assure a smooth and

efficient transition. This must be negotiated with the trustees. A targeted call (laboratory and field) should be negotiated to avoid random effects that may leave this activity stranded;

- some of the experimental involvements of SUBATECH are world-class and have well defined plans and significant discovery potential, e.g. XENON1T and ALICE. At the same time, these activities involve significant technology development. The evaluation committee recommends that these activities be given the resources necessary to achieve their (realistic) goals in a timely manner. Likewise the RADIOCHIMIE and PRISMA teams have demonstrated an impressive and very positive development and the level of support should be maintained;

- the termination of the Pierre AUGER activities in the field of Astroparticles will require a careful future repositioning of the ASTRO team. The termination of this activity is regrettable considering the important contributions of the team to the understanding and development of radio signal detection. A new scientific strategy of sufficient scope must be formulated in order to assure a new coherent and strong future program involving all team resources;

- the ERDRE team drives a number of successful activities of importance for nuclear reactor and energy considerations, including neutrino measurements and the development of electronuclear scenarios. The evaluation committee has noticed a lack of cohesion/synergy between the various activities of the group and recommends that efforts be made to develop a coherent and joint program and avoiding fragmentation of efforts. In the case that the group decides to move its activities to fundamental neutrino physics, the EC strongly recommends that a critical mass of scientists with expertise in the domain be assembled before embarking on a new venture;

- maintaining an adequate and well functioning technical service that can provide the fundament for the strong role of SUBATECH in experimental fundamental research, applied and contract based activities, appears paramount for the future program. The evaluation committee notes the excellent level of the technical services that underpin both the fundamental and applied science programs and recommends that these facilities and capabilities be maintained, not least to make it possible for SUBATECH, in the future, to embark with confidence in new experimental and technological projects of significant scope. In this context the balance between 'in-house' and of 'out-sourced' capabilities and functions should be carefully evaluated;

- the evaluation committee supports the plan to extend the instrumental portfolio of SUBATECH by an Accelerator Mass Spectrometer (AMS) with extremely sensitive analysis capabilities. In the frame of environmental analysis of actinides (e.g. Pu), fission products (e.g. 129I) or activation products (e.g. 14C). AMS offers unprecedented detection power and thus would perfectly support the environmental radionuclide chemistry and analytical activities not only of the RADIOCHIMIE group but also of SMART. A suitable choice of this machine would moreover enable PRISMA to develop non-destructive testing methods perfectly complementing the capabilities of ARRONAX;

- the low number of HDR (Habilitation à Diriger des Recherches) qualifications may constitute a threat to the laboratory's possibilities of maintaining a strong PhD student-training component and acquire the necessary scholarships. The laboratory and its management should undertake a campaign to motivate researchers to acquire this qualification;

- the evaluation committee encourages the laboratory management to undertake a discussion, involving all relevant actors, of a longer-term strategy for the laboratory development including an assessment of the most promising directions for the research teams. From experience, the evaluation committee recommends that such a discussion be undertaken in broad fora at the laboratory, since this may be beneficial in several ways, i.a., by 1) developing a common understanding of the challenges facing the laboratory and; 2) contributing to a better understanding of how the individual groups can contribute to and benefit from the fulfillment of common laboratory strategies.