APPEL A PROJETS LABEX/ CALL FOR PROPOSALS

2010

P2IO

DOCUMENT SCIENTIFIQUE B / SCIENTIFIC SUBMISSION FORM B

Acronyme du projet/ Acronym of the project	**P2IO**
Titre du projet en français	Physique des 2 Infinis et des Origines
Project title in English	Physics of the 2 infinities and of the Origins
Coordinateur du projet/Coordinator of the project	Nom / Name : Guy Wormser Etablissement / Institution : CNRS-IN2P3 Laboratoire / Laboratory : Laboratoire de l'Accélérateur Linéaire Numéro d'unité/Unit number : UMR8607
Aide demandée/ Requested funding	**Budget Total demandé : 20,8 M€**
Champs disciplinaires (SNRI) / Disciplinary field	□ Santé, bien-être, alimentation et biotechnologies / Health, well-being, nutrition and biotechnologies □ Urgence environnementale et écotechnologies / Environnemental urgency, ecotechnologies □ Information, communication et nanotechnologies / Information, communication and nantechnologies □ Sciences humaines et sociales / Social sciences X Autre champ disciplinaire / Other disciplinary scope
Domaines scientifiques/ scientific areas	Particle Physics, Nuclear Physics, Astroparticle physics, Astrophysique, Accelerators science, Interfaces with Health and Energy
Participation à un ou plusieurs projet(s) « Initiatives d'excellence » (IDEX) / Participation in an « Initiatives d'excellence » project	X oui ☐ non

Affiliation(s) du partenaire coordinateur de projet/ Organisation of the coordinating partner

Laboratoire(s)/Etablissement(s) Laboratory/Institution(s)	Numéro(s) d'unité/ Unit number	Tutelle(s) /Research Organis reference
Fondation de Coopération Scientifique du Campus Paris Saclay		
Laboratoire de l'Accélérateur Linéaire	UMR8607	CNRS-IN2P3/Univ. Paris Sud

Affiliations des partenaires au projet/Organization of the partner(s)

Laboratoire(s)/Etablissement(s) Laboratory/Institution(s)	Numéro(s) d'unité/ Unit number	Tutelle(s)/Research Organisation reference
Centre de Physique Théorique	UMR7644	CNRS-INP/Ecole Polytechnique
Centre de Spectrométrie Nucléaire et de Spectrométrie de masse	UMR8609	CNRS-IN2P3/Univ. Paris Sud
Institut d'Astrophysique Spatiale	UMR8617	CNRS-INSU/Univ. Paris Sud
Imagerie Modélisation en Neurobiologie et Cancérologie	UMR8165	CNRS-IN2P3/Univ. Paris Sud/ Univ Paris Diderot
Institut de Physique Théorique	URA2306	CEA/DSM- CNRS/INP
Institut de Physique Nucléaire	UMR8608	CNRS-IN2P3/Univ. Paris Sud
Institut de Recherche Fondamentale et des lois de l'Univers		CEA/DSM
Ingénierie, Radioprotection, Sûreté et Démantèlement	UPS3364	CNRS-INP
Laboratoire Leprince-Ringuet	UMR7638	CNRS-IN2P3/Ecole Polytechnique
Laboratoire de Physique Théorique	UMR8627	CNRS-INP/Univ. Paris Sud
Service d'Etudes des Réacteurs et de Mathématiques Appliquées		CEA-DEN

1. RÉSUME / SUMMARY

The goal of the P2IO LabEx is

- to create a dynamics of interdisciplinary pioneering researches on the hottest issues in theoretical and experimental physics of the infinitely small and infinitely large aspects of our Universe, pushing the associated questions about the Origins up to the conditions for the appearance of life
- to strengthen this dynamics by common researches and developments for innovative instruments to produce, detect and analyse radiations; these new technologies will allow to access new frontiers in probing and observing the Universe
- to increase the impact of these sciences and technologies on society by stimulating common applications to nuclear medicine and nuclear energy.

The P2IO LABEX is taking advantage of the unique concentration on Paris-Saclay Campus of world leading laboratories covering a broad disciplinary spectrum ranging from particle physics, astroparticle and nuclear physics to astrophysics, experiment and theory, accelerator science, instrumentation and associated interfaces. All the actors in these fields on the Campus are joining their forces in this challenging LABEX project: 9 laboratories and 3 teams from 3 other labs. P2IO partners represent a very large fraction of the national effort in this field ranging from around 25% in origins physics, 40% in subatomic physics and 90% in accelerator science. 489 permanent researchers form P2IO workforce, together with a similar contingent of PhD students and postdocs and of high level engineers. More important than the numbers, the quality and the international recognition of the various labs and teams joining their forces in P2IO is the asset for this interdisciplinary project. For example, P2IO concentrates 13 ERC grants, numerous recipients of prestigious awards and medals and many principal investigators, spokes persons and leaders of space missions and international collaborations. P2IO will create a world leading actor and attractor for these sciences and technologies and the associated interdisciplinary researches.

The scientific goals of P2IO labs are to answer fundamental questions about our Universe: what are its structure and evolution, what are dark matter and dark energy, what are the elementary components of our Universe and the laws and symmetries at play, what is the behaviour of nuclear matter in cosmic conditions, how are formed galaxies, stars and planets, and can we identify conditions favourable for the apparition of life elsewhere in the universe,... To address these issues, the strategy is to develop state-of-art instrumentation for space observatories and subatomic physics and for the most advanced particle accelerators. These scientific and technological developments will open creative interdisciplinary applications in biology and medicine, nuclear energy for the future, computing, chemistry, etc.

Given the very broad scientific spectrum of the P2IO members, the LABEX will have the unique opportunity to address coherently the hottest questions which are at the interfaces between the various fields and technologies of expertise of the different teams collaborating in P2IO : the Universe as a laboratory for the elementary structure of matter and forces, the impact of astroparticle, particle and nuclear physics on the

understanding of the Universe origin and dynamics, the experimental and theoretical challenges concerning the mystery of the dark Universe, the emergence of the conditions for life from the nuclear origin of elements to the creation of solar systems, planets and associated soil, water, atmospheres, climate, ...
P2IO members are also developing applications of their science and technologies. The LabEx will foster new collaborations, a deeper sharing of knowledge and know-how, converting laboratory-only based developments into an ambitious collective program. The Paris-Saclay campus will also be a great opportunity to open applications to new partners using interLabex collaborations or with industrial partners. The developments of new technologies, the construction of innovative instrumentation and the strengthening of applications and interfaces will provide new opportunities of co-development and transfer to the industry. Both the cutting-edge scientific research and the nengineering development offered by the P2IO project will benefit to the formation offer and attractiveness to the Paris Saclay Campus students and from abroad.

P2IO research project is based on three pillars : Explore, Transform, Structure.

Explore will be performed through strong support for innovative interdisciplinary initiatives and new collaborations in the most promising topics in P2IO scientific objectives. Four exciting research have been selected: symmetries in the subatomic world, dark components of the Universe, strongly coupled nuclear matter, formation of stellar systems and conditions for the emergence of life. 3 technology-oriented themes have also been identified as the most promising collective developments: innovations in accelerator science and their related spinoffs, advanced sensors and spinoffs, data mining and simulation. Finally, 2 interdisciplinary topics: nuclear energy for the future; health, new methods in imagery and therapies. The P2IO international scientific panel will review these choices after an initial period of 3 years. P2IO support will mainly take three forms: new human resources at the PhD, post-doc and senior levels, targeted upstream R&D, and operating support for the relevant P2IO technological platforms.

Transform will be performed through a new vision of the collaboration between P2IO members. Up to now, all P2IO units rely upon a very strong vertically integrated structure. Each P2IO unit is able to define to a large extent its own scientific policy and to carry it out using its own resources. This model has led to the very high degree of international recognition of P2IO laboratories in the national and international scenes, where they play a leading role in most of the experiments in which they participate. This model is therefore a clear asset but stronger horizontal collaboration across the P2IO partners would bring along a large added value. Joining forces between P2IO labs to create common technological platforms will foster new world-class facilities, boosting P2IO research to unprecedented levels. The P2IO Labex, in prefiguration of the P2IO pole of the new Plateau de Saclay campus, will favour the emergence of one of the five largest subatomic centers in the world with one of the highest degree of excellence and recognition. The tools for this transformation action will be the targeted action towards common technological platforms and a new user policy, and the LABEX governance.

Structure will stem from the integrated governance and its role as a contact point for internal and external collaborations. Within the Plateau de Saclay IDEX, P2IO will be the natural partner of other LABEX with which there are strong scientific interactions. For example, coordinating at P2IO level the various “Physics and medicine” partnerships will bring a strong added value to the IdEx. At the international level, such as EU calls, proposals supported by the P2IO LAbex will have a greater impact than individual responses.

In a similar manner, the formation and training project of P2IO will be quite ambitious, so as to best exploit the remarkable human and technological potential of the P2IO partners. 2/3 of P2IO labs are already integrated within Paris XI University and in the Ecole Polytechnique. All P2IO labs host a large number of PhD students and post-docs. The creation of the P2IO LabEx will be an opportunity to further involve researchers and engineers in existing formations, to transform the action of each of the labs into a global training program and to develop new teaching structures and training opportunities building on the thematic evolution of P2IO fields. Undergraduate, doctoral and post-doctoral training will strengthen new developments and applications. New contacts will be made to take into account the arrival on the Plateau de Saclay of several large engineering schools to which P2IO stat-of-the-art technological platforms can bring many benefits and oportunities. One of the EquipEx proposed in the framework of P2IO is already directly involving one of the "Instituts Universitaires de Technologie" of PXI. The P2IO Labex will offer grants at the M2 level to increase its international attractiveness.

P2IO laboratories are developing new tools and technologies that are well suited to technology transfer. P2IO, in close relationship with the relevant structures at higher levels (FCS, operators), will target the difficult transition between a technical development and its patenting or marketing. P2IO will dedicate the human and financial resources to convert the most promising research prototypes into an industrial product. P2IO will then rely on the IDEX valorization service. P2IO will in addition develop privileged relationships with a selected set of industrial partners through joint R&D programs. It should be noted that P2IO partners are already strongly involved in the development and construction of large scale infrastructures and space experiments in collaboration with the industry (LHC, ISEULT, XFEL, ESS, Planck/HFI…). Acting collectively in the P2IO context will be a way to strengthen the links with industry during the preparation and construction of large scale facilities based on innovative technologies mastered only in our laboratories.
All publications based on work specifically funded by P2IO grants will contain mention of P2IO support in the acknowledgments. A comprehensive record of P2IO publication will be accurately maintained.

P2IO is proposing an integrated governance scheme based on a steering committee constituted by the directors of the partner laboratories. This steering committee will nominate a bureau of 4 members including the P2IO director which will prepare the work and the agenda for the steering committee. In close coordination with the "Fondation de Coopération Scientifique" (FCS) managing the Plateau de Saclay IDEX, the steering committee will form an international scientific council. Once a year, this council will meet so as to formulate recommendations on the scientific strategy of P2IO to be implemented by the steering committee. Partner Labex-s on the Plateau de Saclay may be invited to sit on this Council so as to foster consistency . The P2IO steering committee will also form pluridisciplinary selection board(s) in charge of choosing the best projects proposed by P2IO members in answer to P2IO calls for proposals; These selection boards will be mostly formed by a panel of P2IO members with some national and international membership. P2IO director will regularly report to the IDEX Council on P2IO budget, actions and orientations.

P2IO will be fully integrated in the Plateau de Saclay strategy. Thanks to the very strong international character of P2IO programs and the level of recognition and excellence of P2IO teams, it will be a leading

actor in promoting international visibility of the Plateau de Saclay. P2IO will serve as a unique interface for the many interLABEX collaborations involving P2IO teams. Optimized access to P2IO technological platforms will be offered to other Plateau de Saclay members. Considering the high level technologies developed by P2IO and their broad use in many field of sciences, P2IO capabilities, tools and knowledge are an asset for different field within the IdEx project. Formation strategy will also consolidated at the IDEX level since many LABEX intervene in the various Physics and engineering cursus of interest to P2IO. The strong mixing between science and technologies will be an opportunity to connect various teaching and training activities of physicist and engineers. Finally, the strong instrumental aspects and the associated innovations, the large panel of technologies pushed to the highest level of specifications, the unique R&D platform, the direct links with industry, will be a strength in industrial strategy of the Campus of Paris-Saclay.

2. CANDIDATURE AUX ACTIONS DU PROGRAMME INVESTISSEMENTS D'AVENIR/APPLICATION TO THE ACTIONS OF THE PROGRAMME « INVESTISSEMENTS D'AVENIR »

In this section, are listed the proposals submitted by the FCS Paris Saclay with which the P2IO Labex will build a close relationship including 7 other LABEX, 6 EQUIPEX (including 2 submitted by P2IO (THOMX and COGIS) and one with a very strong P2IO involvement CILEX) , as well as the IRT and SATT structures. In addition, P2IO proposed 6 other EQUIPEX with support from its stakeholders.

Nom de l'action	Acronyme du projet (préciser si le projet est déposé ou envisagé)	Nom du coordinateur	Consortium /partenariat impliqué
IDEX : Campus Paris Saclay		Paul Vialle	FCS, AgroParisTech-CNRS-CEA- Ecole Centrale Paris- Ecole Polytechnique-ENS Cachan- ENSAE ParisTech- ENSTA Paristech - HEC-IHES - INRA-INRIA-Institut Telecom- IOGS ParisTech- Mines ParisTech - ONERA- Pres Paristech - Pres UniverSud Paris -Supélec- System@tic Paris Région - Université Paris-Sud 11 – Université Versailles-Saint -Quentin
LABEX : Interface Physique-Médecine Interface Physics-Medicine		Jacques BITTOUN	CEA - CNRS – FCS – INSERM - Université Paris-Sud 11 - Université Paris-Diderot

LABEX : Institut Pierre Simon Laplace	IPSL	Herve LETREUT	CEA – CNRS – CNES - ENS - Ecole Polytechnique - FCS IRD - Université Pierre et Marie Curie - Université Versailles St. Quentin - Université Paris 12 - Université Paris-Diderot
LABEX : Défis en Sciences et Technologies de l'Information et de la Communication Saclay challenging actions in ICST	Digitex	Maurice ROBIN	CEA – CNRS – ECP - Ecole Polytechnique - ENS Cachan ENSTA – FCS – INRIA - Mines Paristech - Institut Telecom Supelec - Université Paris-Sud 11 - Université Versailles St. Quentin
LABEX : Fondation Mathématique Jacques Hadamard, Campus Paris-Saclay Jacques Hadamard Mathematic Foundation, Paris-Saclay campus	FMJH	Yve LASZLO	CEA - CNRS - Ecole Polytechnique - ENS Cachan - ENSTA ParisTech – FCS -IHES - INRIA - Institut Telecom - Université Paris-Sud 11
LABEX : Physique des deux infinis et des origines Physics of the 2 infinities and of the origins	P2IO	Guy WORMSER	CEA –CNRS - Ecole Polytechnique -FCS - Université Paris-Sud 11
LABEX : Chimie des Architectures des Molécules et des Matériaux Multifonctionnels Chemistry of the Architectures of Multifunctionnal Molecules and Materials	CHARMMM	Jean-Pierre MAHY	FCS, ICMMO/Univ. Paris Sud, ILV/Univ. Versailles Saint Quentin, LHC/Ecole polytechnique, LSO/Ecole Polytechnique, LPICM/Ecole Polytechnique, LPMC/Ecole polytechnique, ICSN/CNRS DR4, LPPSM/Ecole Normale Supérieure de Cachan, SCBM/IBITEC-S/DSV/CEA, LCCEf/SIS2M/IRAMIQS/DSM/CEA, LSPM/Ecole Centrale Paris, LAMBE/Université Evry Val d'Essonne, EPEC/LCP/Univ. Paris Sud,

LABEX : Physique: Atomes, Lumière, Matière Physics : Atoms, Light, Matter	PALM	Marc MEZARD	CNRS – CEA - Ecole Centrale Paris Ecole Polytechnique -ENS Cachan ENSTA –FCS –ONERA -Institut d'Optique - Synchrotron Soleil - Thalès -Université Paris-Sud 11 -Université Pierre et Marie Curie
LABEX : Nano Saclay	Nano Saclay	Claude CHAPPERT	CEA – CNRS - Ecole Centrale Paris -Ecole Polytechnique ENS Cachan -FCS –IOGS – ONERA - INRIA - UVSQ SOLEIL – Thales - Université Paris-Sud 11 – Université Versailles St. Quentin
EQUIPEX : Infrastructure haute performance pour la visualisation interactive et collaborative High performance infrastructure for interactive and collaborative visualization	Digiscope Dossier Soumis	Michel BEAUDOUIN-LAFON	CNRS - INRIA - Ecole Centrale Paris - ENS Cachan – FCS Digiteo-Triangle de la physique - Institut Telecom - Supélec - Université Paris-Sud 11 – Université Versailles St. Quentin
EQUIPEX : Centre Interdisciplinaire Lumière Extrême Interdisciplinary Centre for Extreme Light	CILEX Dossier Soumis	François AMIRANOFF	CEA- CNRS - Ecole Polytechnique - ENSTA ParisTech – IOGS - Université Paris-Sud 11
EQUIPEX : Centre d'Opération des Grands Instruments de recherche de Saclay Large Instrument Operation Center of Saclay	COGIS Dossier Soumis	Jean-Pierre MEYER	CEA - CNRS – Ecole Polytechnique - Université Paris-Sud 11

EQUIPEX : Centre d'Accès Sécurisé Distant aux données confidentielles Development and building of a Secure Remote Access Centre for confidential microdata	CASD Dossier Soumis	Antoine FRACHOT	INSEE- ENS Cachan - Ecole Polytechnique – HEC - GIS Réseau Quetelet
EQUIPEX : Reconstuction et prédiction des dynamiques multi-échelles in toto Reconstruction And Prediction of multi-Scale Overall DYnamics	Rapsody Dossier Soumis	Paul BOURGINE	AgroParistech – CNRS - Ecole Polytechnique - INRA - INRIA
EQUIPEX : Source X monochromatique compacte Monochoromatic compact X-ray Source	THOMX Dossier Soumis	Alessandro VARIOLA	CEA- CNRS – ESRF – SOLEIL – THALES - Université Paris-Sud 11- Université Bordeaux 1
IRT : SYSTEM X	SYSTEM X (Réponse AMI)	Dominique VERNAY	AgroParisTech, CEA, CNRS, Ecole Polytechnique, Ecole Centrale Paris, ENS Cachan, ENSAE ParisTech, ENSTA ParisTech, HEC, IHES, INRA, INRIA, Institut Telecom, IOGS, Mines ParisTech, ONERA, Supélec, Université Paris-Sud 11, Université Versailles Saint-Quentin, Universités Paris 6 et Paris 7
SATT :	Projet	Dominique VERNAY Françoise FABRE	AgroParisTech, CEA, CNRS, Ecole Polytechnique, Ecole Centrale Paris, ENS Cachan, ENSAE ParisTech, ENSTA ParisTech, HEC, IHES, INRA, INRIA, Institut Telecom, IOGS, Mines ParisTech, ONERA, Supélec, Université Paris-Sud 11, Université Versailles Saint-Quentin,

Table of the EQUIPEX projects submitted by P2IO with support from its stakeholders

Nom de l'actio	*Acronyme du projet (préciser si le projet est déposé ou envisagé)*	*Nom du coordinateur*	*Consortium /partenariat impliqué*
EQUIPEX	PH2ELICE-Déposé	R. Cornat	LLR, LAL, IPNO,IRFU, IMNC
EQUIPEX	Cryocube-Déposé	A. Daël	IRFU, IPNO, IUT Orsay
EQUIPEX	Cryomatrix-Déposé	S. Marnieros	CSNSM, IAS, IRFU
EQUIPEX	PAM-Déposé	P. Debu	IRFU, LSI, CSNSM
EQUIPEX	ANDROMEDE-Déposé	S. DellaNegra	IPNO, CSNSM, IRFU
EQUIPEX	XUV-Déposé	A. Chardin	IAS, IRFU
EQUIPEX	Couches minces radioactives envisagé	C.O. Bacri	IPNO,CSNSM

3. ORGANISATION DU PARTENARIAT/MANAGEMENT OF THE PARTNERSHIP

3.1. COMPOSITION DU PARTENARIAT/ COMPOSITION OF THE PARTNERSHIP

Nom du partenaire	*Affiliation*	*Effectifs / Catégorie de personnel (chercheurs, ingénieurs, doctorant …)*
Fondation de Coopération Scientifique Campus de Paris Saclay		
LAL	CNRS-IN2P3/U PSud	C 64 I 82 T 133 D 34 PD 19
CSNSM	CNRS-IN2P3/U PSud	C 36 I 8 T 39 D 12 PD 7
IAS	CNRS-INSU/U PSud	C 42 I 60 D 26 PD 16
IMNC	CNRS-IN2P3/U PSud	C 15 I 2 T 4 D9 PD 7
IPNO	CNRS-IN2P3/U PSud	C74 I 91 T122 D29 PD17
IRFU	CEA/DSM	C 168 I 243 T 210 D 76 PD 75
LLR	CNRS-IN2P3/Ec. Polytechniq	C 28 I 25 T 22 D 12 PD 20
LPT	CNRS-INP/U PSud	C 30 I 2 T 6 D 15 PD 10
CPhT-Equipe	CNRS-INP/Ec. Polytechnique	C 11 I 1 D 5 PD 9
IPhT-Equipe	CEA/DSM	C 21 I 0 D PD
IRSD	CNRS-INP	C0 I 6 D 0 PD 0
SERMA	CEA/DEN	C4 I3 D0 PD 0

3.2. QUALIFICATION DU COORDINATEUR DE PROJET /RELEVANT EXPERIENCE OF THE PROJECT COORDINATOR

Guy Wormser, 54 years old, is one of top senior HEP physicists in France and one of the best known on the international scene. He has since about 10 years, managed (or participated to as French representative) very high level projects and structures and is therefore well qualified to lead the P2IO Labex and has paid during all that period a specific attention to As a Deputy Director of the French Funding Agency IN2P3 from 1999 to 2003, he was deeply involved in the strategic discussions held at that time to propose a joint structure between IN2P3 laboratories and DAPNIA, IRFU predecessor. It is under his leadership that was then created the first joint IN2P3-CEA committee on accelerators, a key component for P2IO. It is also during that period and partly under his responsability that started the intense development of astroparticle physics leading to the founding concept of Physics of the two infinities. From 2005-2010, he directed LAL, the largest CNRS laboratory devoted to particiel physics and cosmology and in this position has to daily confront many issues relevant to P2IO LAbex. He co-founded in 2007 with Jean-Loup Puget, its first director, P2I, a structure similar to P2IO in many respects regrouping all 19 laboratories involved in subatomic physics and cosmology in the greater Paris area and was a member of P2I bureau from 2007 up to now. He has been named to be next P2I director.
G. Wormser is the father of the French Grid effort which he created and lead during ten years. He served as the French representative in the successive grid projects management boards . He founded in 2007 and

directed up to 2010 the CNRS Grid Institute. He founded the GIS France Grilles recently established as the French National Grid Initiative and played similarly a key role in establishing the European Grid Initiative (EGI).
Guy Wormser is or has recently member of many international committees such as ICFA, HEPAP, DESY scientific council, European Strategy group of large laboratory directors, CERN RRBs, OECD Global Forum.
He is therefore quite knowledgeable on all the relevant issues that P2IO LAbex will have to confront.

4. DESCRIPTION DE L'EXISTANT/ DESCRIPTION OF THE EXISTING

4.1. PRESENTATION DES PARTENAIRES

4.1.1 PARTENAIRE 1/ PARTNER 1 : FCS PARIS SACLAY / LAL

The coordinator partner of the P2IO is the "Fondation de Cooperation Scientifique Paris Saclay" which is described in this chapter together with the laboratory of the scientific coordinator, the Laboratory of the Linear Accelerator (LAL), a joint research unit between CNRS-IN2P3 and Paris Sud University, two main founding members of the Fondation.
The Scientific Cooperation Foundation (FCS)1 was created in 2007 to provide two government-approved Advanced Research Thematic Networks (RTRA)2 with a legal personality: one deals with information and communication technologies (DIGITEO), and the other with physics (the so-called "Triangle of Physics"). At that time, these networks involved 9 "founding" establishments and their associated partners. It is in this context that the FCS fosters collaborations, on behalf of these institutions:

- Collaborative research projects and Chairs, which are selected according to a standard method (call for projects and selection by peers). The foundation was thus able to receive funds intended to stimulate scientific cooperation projects in the Plateau de Saclay area, for a yearly expenditure of the order of 8 M€. Its management, which is clearly distinct from scientific governance, is simple: the foundation transfers funds to the beneficiary institutions, but may also hire researchers directly when a fast response is required.
- Coordination of communities. The Digiteo and Triangle of Physics have over time built community networks, which unite researchers who did not necessarily know each other.
- Actions for the exploitation of research results. The Digiteo network funds "technology maturation" actions, which consist in transforming a technology into a final product (market analysis, technological development, canvassing of industries). It is also implied in the European network for "Fostering Interregional Exchange in ICT Technology Transfer" (FITT).

The foundation will soon be involved in a third sector, that of mathematics, through the Jacques Hadamard Foundation of Mathematics on the Paris-Saclay Campus Paris-Saclay.

In 2009, the foundation expanded its field of activities by becoming a promoter for the "project Paris-Saclay Campus", on behalf of twenty-two institutions: research organizations, higher education and research establishments, a competitiveness cluster and two Research and Higher Education Clusters. *It is in this*

[1] Acronym for the French « Fondation de Coopération Scientifique »
[2] Acronym for « Réseau Thématique de Recherche Avancée »

context that the foundation promotes the project of Excellence Initiative for the campus and the associated projects of the Laboratories of Excellence.

These three activities (DIGITEO, Triangle of physics and Campus Project) presently involve twenty persons.
A third step, to take place at the end of 2010, will amend the statutes of the FCS by fully including the additional mission of promoting the Paris-Saclay campus project. Its objective will be to create, over time, an institution with the aim of federating large programmes, which are transverse to the constituent establishments, in terms of training, research, and innovation, organised according to specific themes or subjects selected by mutual agreement. These programmes would be places where the communities thus brought together would coordinate their scientific work, and where sector-specific policies and large programmes would be designed and developed, based on highly innovative projects.

It is in this new framework that the foundation submits an Initiative of Excellence (IDEX3) project, the aim of which is to integrate Laboratories of Excellence which are to be initially selected, and to interconnect these with other possibly selected structures, devoted to the so-called Investments for the Future: University-Hospital Institutes (IHU)4, the Society for the Acceleration of Technology Transfer (SATT5), the Institute of Excellence for Low-Carbon Energies (IEED)6), etc.

4.1.1.1 RECHERCHE ET INNOVATION / RESEARCH AND INNOVATION

Laboratoire de l'Accélérateur Linéaire

The Orsay Laboratory of the Linear Accelerator is the largest CNRS laboratory devoted to particle physics and cosmology. Its total workforce consists 340 people, 120 researchers and 220 engineers and technicians. Its evaluation by AERES end 2008 gave extremely good results: the laboratory is ranked A+ along all criterias and its teams and groups are also all ranked A+, placing LAL among the best ranked laboratories nationwide. LAL has also been ranked first laboratory in physics in France (and 8th overall) according the amount of grants received by the National Research Agency in the period 2005-2008. LAL, together with IRFU, a partner member of 2PIO, is member of the very restricted club of large European laboratories part of the European Strategy group and having an ex-officio seat in ICFA.
LAL has a very large numbers of researchers having or having had in a recent past very large responsibilities' and prizes. The list is given below:

Prize Winners		**Responsabilities**	
A.-M. Lutz, V. Brisson	EPS HEPP Prize 2009 (Gargamelle)	E. Auge	IN2P3 Deputy Director IN2P3 2007-2010

[3] Acronym for Initiative d'Excellence
[4] Acronym for l'Institut Hospitalo-Universitaire
[5] Acronym for Société d'Accélération du Transfert de Technologie
[6] Acronym for Institut d'Excellence dans le Domaine des Energies Décarbonées

E. Augé, D. Fournier, L. Iconomidou-Fayard, A.M. Lutz O. Perdereau, A. Schaffer, L. Serin	EPS HEPP Prize 2005, (NA31 Coll.)	F. Lediberder	IN2P3 Deputy Director IN2P3 2004-2008 BABAR spokeperson 2008-2010
J. Lefrançois	CEA Prize , 1998 Lagarrigue Prize 2006	G. Wormser	IN2P3 Deputy Director 1999-2003
J.F. Grivaz	Joliot Curie Prize 1991	B. D'Almagne	IN2P3 Deputy Director 1997-1999
D. Fournier	CNRS Silver medal 1993	F. Richard	ILC WWS director
D. Zerwas	Thibaud Prize 2008	M. Davier	ILC IDAG chair
M. Davier	French Academy of Science, 1996 Lagarrigue Prize 2010		

• **LAL publication record for the period 2005-2009 is:**
Total number of publications : 1544
In peer-reviews journals : 772
Conférences : 694 (348 with proceedings, 346 without proceedings)
Books : 5
Others (PhD thesis, « HDR » diplomas) : 73
300 publications have been cited more than 10 times (and are listed in Appendix 7.2),
150 more than 20 times and 6 more than 200 times.

LAL research program is composed of three main scientific branches : particle physics, cosmology and accelerator science. In particle physics, it is of course the CERN based large Hadron Collider who dominates the scene presently and the next ten years. LAL teams participate to the ATLAS and LHCB experiments in which they had major responsibilities in their design and construction. The key concept of the ATLAS central piece, the liquid agron calorimeter was invented by the LAL group led by Daniel Fournier, while LHCb trigger relies quite heavily on the pioneering work of the LAL group. The ATLAS and LHCb teams are now fully involved in the data analysis chain and the physics extraction, where they also play a major role. They represent about 50% of the LAL physics workforce. Significant R&D effort is also presently engaged in future upgrades of these experiments, concentrating on new 3D Si design for ATLAS pixel detectors and faster electronics read out for LHCb.
LAL teams are also involved in the D0 experiment at the Tevatron collider where there is now enough data to strongly constraint the Higgs Boson and even maybe to discover it in the coming years, in the final analysis of BABAR and H1 experiments and in the preparation of the SuperB and ILC/CLIC projects.
On the cosmology front, PLANCK is LAL flagship project with many similarities with LHC in term of discovery potential, LAL role in its conception and construction, and implication in the physics analysis. VIRGO and its upgrade, AUGER and its future "view-from-above" version JEM-EUSO, and LSST are the

other LAL projects in this field with a common goal to better understand the dark components of our Universe and its structure.
LAL has a rich program devoted to accelerator science and related R&D, with a mixture of construction activities (responsibility of the delivery of all 640 XFEL power couplers), operation of a local machine (PHIL, LAL photo-injector testbed), participation to advanced R&D platforms (ATF-2 low emittance tests, CTF3 platform to demonstrate two-beam acceleration) and development of new ideas (ThomX compact X-ray source, plasma wakefield acceleration). In addition to its various projects, LAL hosts several important interdisciplinary platforms with national or international participation: PHIL will provide a very high quality low energy electron beam for various users, CALVA is a optical test bed for high finesse Fabry-Perot cavity locking of high interest for the gravitional wave community and beyond, OMEGA a very strong microelectronics inter-laboratory structure designing and providing state-of-the start (and beyond) chips to many customers, GRIF a very active Tier2 node for the European Grid. A new major platform will start being built in 2011 : THOMX, a compact X Ray source based on Compton scattering of unprecedented performances. THOMX should deliver from 2013 onwards 10^{13} monochromatic photons per second in the 50-100 KeV range for medical and cultural heritage applications.

4.1.1.2 VALORISATION / EXPLOITATION OF RESULTS

LAL has an active policy towards all aspects of valorization. From the exploitation of a small but active and developing patent portfolio, to very large contracts to big industrial companies (a recent example being a ~15 M€ contract for XFEL couplers) which has a very beneficial effect in injecting new technologies and stringent requirements in their technologies, LAL uses many different ways to collaborate with industry. LAL performs R&D upon request from some companies, such as in the case of developing new powerful electronics chips for the Siemens company, readout electronics for detectors of the PHOTONIS company, transfers cloud chamber technology to the ACMEL company, hosts for two years a high level THALES engineer part time to develop the THOMX project. Another example is a joint R&D venture with ALCATEL in the framework of the Pole de competitivité SYSTEMATIC where LAL expertise on grids and high speed networks was essential to the success of the CARRIOCAS project.
A LAL engineer D. Breton won in 2005 the Y. Rocard Prize of valorization of French Physical Society for his work on analog memory a patented circuit now heavily used in commercial oscillopes (3 licences).
To conduct its valorization policy, LAL has a "Valorization correspondent" who, in collaboration with the SPV (Service Partenariat et Valorisation) of CNRS, assists LAL physicists and engineers in the building of patenting files, partnerships with Industrial companies and research collaboration with other academic institutes.
LAL policy is to further increase these collaborations and contracts by the flexible and pragmatic use of the various collaborating tools and channels.

4.1.1.3 ENSEIGNEMENT SUPERIEUR / HIGHER EDUCATION

LAL is deeply involved in the higher education program of the Paris Sud University at all levels. LAL professors have the responsibility of the Physics Magistère (M2 level) (P. Puzo), of the M2 NPAC and of the corresponding Ecole Doctorale (A. Stocchi), important responsabilities in the MIPEGE Ecole doctorale (P. Puzo) and of the PolyTech engineering institute (E.Auge, F. Zomer), in the Nuclear Engineering Master (A. Lounis). LAL physicists have served in the University Management Board (P. Puzo) and Scientific

Council (A. Cordier, D. Monnier). They also chaired the local Commission de Spécialistes (A. Cordier) and responsible for the overall PhD supervision (délégué aux thèses) (M. Davier, R. Ansari). LAL impact in the University life is therefore quite strong but is not limited to the role of its professors since in addition, more than 10 LAL high level engineers are also involved in teaching activities at various levels and in various courses. Computing classes, accelerator and electronics courses to several engineering schools are typical examples where LAL unique expertise contribute to higher education in a very effective way.

4.1.1.4 ORGANISATION / ORGANISATION

LAL is a Joint Research Unit (UMR8607) belonging to the CNRS National Institute for Nuclear and Particle Physics (IN2P3) and to the Paris Sud University, located on the Orsay Campus with an occupancy of 17 611 m2 . LAL has a total of 340 employees, 64 researchers out of which 12 have University positions, plus 11 researchers with an emeritus status, and 7 on a temporary contract, 82 high level engineers, 133 technicians, 34 PhD students.
LAL is organized along 14 physics groups, of size ranging from 40 for the ATLAS group to 3 for the smallest, 5 technical services (mechanics, electronics, computing, infrastructure and accelerators), one administrative service covering personnel, finances, travel and technical and scientific information, 4 transverse units : training, quality, technological transfer and engineering computation. The Accelerator Department has been recently created to federate all the work pertaining to accelerators performed in the various groups and services. Finally, LAL hosts a microelectronics pole OMEGA, formed by LAL and serving LAL and several laboratories in the Paris region. The direction team is composed of a director, a deputy director, a administrative director and two technical directors, in charge respectively of strategic and operational issues.
LAL has 3 formal internal instances : the laboratory council (LC), the Scientific Council (SC) and the Health and Safety Committee. LC main task is to approve the annual budget and to give a formal advice for the nomination of the lab director. The leaders of all groups and services meet monthly to discuss all matters of the laboratory day-to-day life. LAL is reviewed every 4 years by a high level international visiting committee, under the aegis of AERES. LAL is one of the leading laboratories of the closely knitted IN2P3 laboratories network and therefore works in close contact with IN2P3 direction. LAL also participates to many University instances on the Orsay Campus.
LAL consolidated annual budget is 22 M€ , on average over the last 5 years, including 15 M€ of manpower. 3 M€ come from various contracts (“resources propres”) with various entities (European Union, National Research Agency, CNES, Ile de France region, CERN, DESY,…). LAL manages all its budget through XLAB, the CNRS middleware which is manually interfaced with the University package SIFAC. All types of resources can therefore be managed by LAL.

4.1.2 PARTENAIRE 2/ PARTNER 2 : CPHT

CPHT-Polytechnique

4.1.2.1 RECHERCHE ET INNOVATION / RESEARCH AND INNOVATION

CPHT - Polytechnique, the Centre de Physique Théorique de l’Ecole Polytechnique, is a Joint Research Unit (UMR7644) belonging to the CNRS National Institute for Physics (INP) and to the Ecole Polytechnique, located on the Palaiseau Campus. The team “Fundamental interactions” has a total of 26 employees, 25

researchers out of which 10 have CNRS positions and 1 has a Polytechnique position, plus 9 researchers on a temporary contract, 1 technician, 5 PhD students.
The research activities of the P2Io team at CPHT follow three main directions:

1. Strong interactions at high and medium energy: this group investigates the partonic structure of the proton in the high-energy limit, and the phenomenology of high-energy proton-proton and nucleus-nucleus collisions.
2. Particle physics beyond the standard model: this group investigates in particular the mechanisms of supersymmetry breaking and the construction of new supersymmetric models, with particular emphasis on the nature of dark matter
3. Progress towards a quantum theory of Gravity, in the framework of String theory and in a new approach within non-commutative field theory.

4.1.2.2 VALORISATION / EXPLOITATION OF RESULTS

Last AERES evaluation (February 2008) concludes on … « un nombre important de percées et de progrès scientifiques particulièrement remarquables. Le comité estime que le laboratoire occupe une place d'excellence sur le plan international. »

Outstanding researchers:
E. Dudas, member of ERC Advanced Grant "MassTeV"
S. Munier, médaille de bronze CNRS, 2009.
In the period 2005-2009, the CPHT P2Io team published around 180 papers in international refereed journals or internation conference proceedings, which represent over 2300 citations (source: SPIRES database). The most significant publications are listed below in 7.2.

4.1.2.3 ENSEIGNEMENT SUPERIEUR / HIGHER EDUCATION

E. Dudas and M. Petropoulos have part-time teaching positions (professeur charge de cours) at Ecole polytechnique and K Kopper has full time teaching position at Ecole polytechnique.

4.1.3 PARTENAIRE 3/ PARTNER 3 : CSNSM

Centre de Spectrométrie Nucléaire et de Spectrométrie de Masse

4.1.3.1 RECHERCHE ET INNOVATION / RESEARCH AND INNOVATION

CSNSM is a joint research unit of Institut National de Physique Nucléaire et de Physique des Particules (IN2P3), an institute of the French National Centre for Scientific Research (CNRS) and Université Paris Sud. CSNSM is rated A+ by AERES and has about 40 permanent researchers and 40 permanent engineers and technicians, and in addition about 25 non permanent personnel (PhD, postdocs, project engineers).
Multidisciplinarity is an essential characteristic of CSNSM. Its research covers a very large range of topics: structure of the nucleus and fundamental interactions, astroparticle physics and astrophysics, solid state physics, irradiation of matter, elementary and isotopic investigation of the components of the Earth and the Universe.

CSNSM is also open to the outside world through several collaborations in France (the laboratories of CNRS, CEA and CNES) and on all continents. The pursuit of a strong interaction with industry (EDF, Alcatel, AREVA...) on both fundamental and applied topics is one of the major axis of orientation of the research programme of CSNSM. Public and private enterprises call upon the skills and facilities of the CSNSM on the road to industrial exploitation.

In fundamental nuclear physics, the CSNSM SNO group (Structure du Noyau) has developed major contributions to the next generation of multi-germanium detector AGATA, and to the SPIRAL-2 program, with contributions to the DESIR and S3 facilities, in particular. The CSNSM nuclear physics team has proposed and led several tens of experiments over the last few years in all the major nuclear physics facilities. It has also developed an important expertise in the development of ion traps, and in mass spectrometry techniques, in particular for unstable short-lived nuclei. The team has also the responsibility of the evaluation of nuclear masses.

The solid state physics group (PS) of CSNSM has developed a first level expertise in systems with correlated electrons in low dimensionality, and in innovative sensors at low temperatures. The group has obtained a key position in the EDELWEISS and the EURECA Dark Matter searches, at the forefront of a very active international competition. This key position has been obtained through the development of innovative cryogenic detectors, of unprecedented sensitivity, energy resolution and particle identification. The group has also developed an important expertise, in collaboration with several other French laboratories (APC-Paris, Néel-Grenoble, IPN Lyon, IEF-Orsay, LPN-Marcoussis, IRFU-Saclay, etc.) in the development and fabrication of matrices of cryogenic detectors. The CSNSM PS group is coordinating the CRYOMATRIX Equipex proposing to establish a national platform of fabrication and testing of cryogenic detectors, essential for the next generation of satellite experiments in the X-ray, CMB and infrared domains.

The AS (Astrophysique du Solide) group in CSNSM has an outstanding experience in micrometeorites and cometology. Its researchers have important responsibilities in the Stardust and the ROSETTA programs. The group has also gathered a unique collection of more than 2000 micro-meteorites, collected in Antarctic near the Concordia station, and studied using the SIMS technique, a technique invented by G. Slodzian, who is an active member of the AS group. The group has recently evidenced a new class of ultracarbonated micrometeorites of cometary origin, of great potential importance for the comprehension of the origin of carbonated life on our planet.

The AN (Nuclear Astrophysics) group of CSNSM is internationally known for its expertise in primordial and stellar nucleosynthesis, essential to the comprehension of nuclear element production and reprocessing in our universe. In collaboration with APC and IRFU, the AN group is involved in the INTEGRAL satellite gamma-ray observatory. In collaboration with the major european expert teams in gamma-ray astronomy (MPE-Munich, APC, IRFU, etc.) the group is developing a new generation of Compton gamma-ray telescope that could allow the observation of galactic sources in the Virgo cluster.

The Semiramis group of CSNSM has an outstanding expertise in ion beam physics. The group has developed the JANNuS-Orsay facility, presently unique in its capabilities to irradiate in a dual ion beam mode with coirradiation by an electron beam of a TEM. JANNuS-Orsay installation allows in situ and real-time observation at the single atom level (0.2 nm resolution) of the structural modification of materials under irradiation. The installation if open by international calls to experiments proposed in the fields of material science (in particular nuclear and fusion materials, and nanostructuration of matter under irradiation).

Semiramis is also a component of the Minerve nanofabrication facility with its FIB (Focused Ion Beam) facility, presently unique in Ile-de-France region for its nanostructuration capabilities. CSNSM has the codirection of the EMIR national platform gathering the French facilities of material irradiation, and ensures the direction of the PACEN interdisciplinary program (Programme sur l'Aval du Cycle et l'Energie Nucléaire). The Semiramis group is also operating the only present electromagnetic isotope separator in Europe, and has expertise in production of isotopically pure targets and of standards of implantation. Two physics groups, PCI and PS2, are benefiting from the Semiramis and JANNuS facilities, and develop important activities in nuclear and fusion materials, with support from european programs such as F-BRIDGE or PERFORM-60, and the EFDA fusion material programs. The main objectives are the study of materials under irradiation, comprising not only the structural changes induced by irradiation under joint nuclear and electronic energy loss regimes by using irradiations with light energy or/and high energy heavy ions and also the behaviour (Migration, agglomeration) of fission products (Cs or rare gases) in some of these materials.
In addition to the Cryomatrix project coordinate by the CSNSM, the CSNSM team participates in four other equipex projects: Cogis, Andromede and PAM.
High level scientists at CSNSM:
Gabriel Chardin, CNRS Silver Medal, 2007
Jean Duprat, Grand prix film de chercheur, Nancy 2008
Hubert Flocard, Director of the PACEN program, national interdisciplinary program of the CNRS
Michel Maurette, Leonard Meteoritical Society Prize, 2007
Grant Raisbeck (for the CSNSM partner), Descartes Prize, 2008 (EPICA project, led by Jean Jouzel)

4.1.3.2 VALORISATION / EXPLOITATION OF RESULTS

CSNSM accelerators (Aramis, Irma and Sidonie) are an important tool in the fields of ion beam assisted synthesis, implantation/irradiation induced modification of materials and characterization of irradiated solids and surfaces. Various contracts have been developed with industry (III V Lab Alcatel Thalès, 3s photonics, CEA …) in these fields.
Since 2009, the JANNuS-Orsay platform installation enlarges these studies to the international scientific community.
Some nanostructuration studies are also performed using the FIB (Focused Ion Beam) facility, presently unique in Ile-de-France.
CSNSM contributes to the organization of various international workshops and conferences such as "IIIrd International Conference REHE, 2009" and "International Conference on Advanced Technologies for Communications, ATC'2008 IEEE".
During the 2005-2009 period, CSNSM team published more than 400 papers in peer review journals and 280 in internationational conference proceedings. They contributed also to 9 books. The most significant publications are listed below in Part 7.2.

4.1.3.3 ENSEIGNEMENT SUPERIEUR / HIGHER EDUCATION

CSNSM is a major player in teaching. Thirty percent of tenured staff scientists hold university positions and are involved in teaching at all levels at the University Paris-Sud 11 mainly in lectures belonging to the 28 and

29 committees of the French CNU (National Committee of Universities). The research and technical staff of CSNSM is strongly involved in masters and at doctorate level courses relevant for fundamental concepts for physics, nuclear physics, modelisation and instrumentation for physics. They hold specialities of three second-year Masters courses (M2). Since 2007, lectures of the "Physique et Environnement" M2 are given in CSNSM .Twenty-one PhD theses and HDR diplomas (Habilitation à diriger des recherches) were defended during the 2005-2009 period.
In addition, CSNSM team is very active in terms of physics diffusion to teachers or juniors: Nepal conferences, associations as "Objectif Science", competition committees for young scientists as "C.Génial" and the 2009 edition of the EUCYS contest in Paris (European Union Contest for Young Scientists).

4.1.3.4 ORGANISATION / ORGANISATION

CSNSM is a joint research unit of Institut National de Physique Nucléaire et de Physique des Particules (IN2P3), an institute of the French National Centre for Scientific Research (CNRS), and Université Paris Sud. The director is nominated by agreement between the two operators after getting the advice of a search committee. He is assisted by a deputy director, an administrator and a technical director, and three formal instances: a laboratory council and a scientific council, which have an advisory role on science and budget issues, and a health and safety committee. The staff is organized in five topical scientific teams and in six technical scientific specialities.

4.1.4 PARTENAIRE 4/ PARTNER 4 : IAS

The Institut d'Astrophysique Spatiale (IAS) focuses on the development and exploitation of science experiments on space mission. It benefits from an excellent international reputation for this type of activities. IAS is involved in all phases of the evolution of an experimental project from the conception and development to testing and calibration, science operations, implementation of the data pipeline leading to data analysis and finally scientific exploitation. This major axis is complemented by experimental activities in the laboratory as well as by modeling activities. Since 2001 IAS is an "Observatoire des Sciences de l'Univers" which provides archiving and data access from space experiments as a service to a large scientific community.

4.1.4.1 RECHERCHE ET INNOVATION / RESEARCH AND INNOVATION

The scientific themes s are structured within three scienceteams ("interstellar matter and cosmology", "solar system and exoplanetary systems", "solar and stellar physics"), complemented by a pluridisciplinary one("astrochemistry and origins") with science goals overlapping that of the first twoteams. These activities have been developing at a fast rate over the last 10 years. The space missions with a scientific involvement of IAS are providing first rate science data, in particular Mars Express (ESA) / MRO (NASA), Corot (CNES), Spitzer (NASA), SOHO (ESA/NASA) / Stereo (NASA), leading to many published papers with high citation rates, including 33 in "Science" and "Nature" since 2004, with 18 as 1st author (see 7.1). The success of the joint launch of Planck and Herschel by ESA in May 2009 has given a new impetus to this trend: IAS has led the large international consortium responsible for the HFI experiment, which maps with unprecedented

accuracy the Cosmic Microwave Background (CMB), and our laboratory is strongly involved in the science exploitation of Herschel (submm observatory, ESA). The first series of articles from HFI is being prepared for presentation at the international conference organized in January 2011. The fly-by of asteroid 21 Lutetia by the ROSETTA mission (ESA) has demonstrated the remarkable capabilities of on-board experiments before the rendez-vous with comet P/Churyumov Gerasimenko in July 2014. IAS has a leading role for science on the comet with the "Philae" lander and is participating in two experiments on board the orbiter.

The next major steps will be the launch of BepiColombo (ESA/JAXA) toward Mercury in August 2014 then that of JWST (NASA/ESA), the next generation space telescope, scheduled for 2015. The instruments developed for major space missions make it possible to be involved in opportunities such as the HECOR rocket flight (solar physics), an experiment on board MSL, the large NASA rover to be deployed on Mars in 2012, or a Russian mission to Phobos, a satellite of Mars. Laboratory experiments dedicated to astrochemistry and detection of dark matter have also obtained excellent results. On this basis, the science activities of IAS were awarded an "A+" ranking by AERES in 2009. The high success rate for new tenured positions (7 in 2009-2010, a 15% increase in 2 years) also testifies to the excellence of research at IAS.

Institut d'Astrophysique Spatiale is very active in the preparation phases for the "Cosmic Vision" program of ESA, which will include two "medium class" missions and one "large class" mission to be launched in 2017-2020. Three experimental contributions are considered for Solar Orbiter, one of the "medium mission" candidates. IAS is a partner in the consortium providing the science payload of Euclid (dark matter / dark energy medium mission candidate). There is also a scientific participation in Plato (exoplanets). Two of these three proposals will be selected in September 2011. IAS is also strongly involved in proposals for the science payload of EJSM/Laplace, a joint ESA/NASA mission to the system of Jupiter which is under consideration as one of the three "large mission" candidates (selection in 2012).

IAS operates two major technical platforms:
- The IAS calibration station is a French national facility supported by CNES, CNRS/INSU and University Paris-Sud XI. It provides state of the art calibration and test capabilities in clean rooms. IAS is leading an "Equipex" proposal ("XUV") which, if successful, would provide a new test facility in 2013 at SOLEIL. The calibration station is the largest platform within a collaboration on test facilities for space instrumentation in the Paris area ("Groupement d'Intérêt Scientifique" MoteSpace) between IAS, IRFU/SAp (a partner in P2IO with IAS) and LESIA (Observatoire de Paris
-The "IAS Data and Operation Center" (IDOC) provides high level tools for managing science operations, data analysis, archiving and access to the data for the French and international science community. IAS is participating in the "COGIS" equipex proposal. If it is selected, "COGIS" will provide new computational and storage capabilities to IDOC.

4.1.4.2 VALORISATION / EXPLOITATION OF RESULTS

Institut d'Astrophysique Spatiale organizes major workshops and conferences such as the International Planck Conference to be held in Paris in January 2011. It is very active in terms of outreach, with 40 to 50 contributions/year in the media and 15 to 20 general interest conferences/year. The "IDOC" center plays an important role in providing data from space experiments to the international scientific community, and

IDOC/MEDOC is being labeled as the French data center for solar physics by CNES. The interaction with industry is strong with collaborations on Research and Development programs and contracts issued by IAS for major developments (e.g. the cryogenic system of Planck/HFI contracted to Air Liquide). As a result, several PhD students are partially supported by industry.

4.1.4.3 ENSEIGNEMENT SUPERIEUR / HIGHER EDUCATION

IAS is a major player in teaching. 55% of tenured staff scientists hold university positions and they are involved in teaching at all levels at the University Paris-Sud XI. The research and technical staff of IAS is strongly involved in masters and at doctorate level courses relevant for astrophysics and space technology (2nd year of Masters, Astrophysics doctorate school). 8 PhD theses supervised by IAS scientists are defended on average each year. IAS hosts each year around 30 students at bachelor and masters levels from scientific and technical curricula.

4.1.4.4 ORGANISATION / ORGANISATION

IAS is an UMR ("Unité Mixte de Recherche") managed jointly by two operators (Université Paris-Sud XI and CNRS). The director is nominated by agreement between the two operators. He is assisted by two deputy directors and a technical director. A laboratory council has an advisory role on science and budget issues. The scientific staff is organized in three topical teams and a pluridisciplinary team. The technical staff is organized with a matrix architecture, by technical specialties and by projects.

High level scientists at IAS (criteria specified by a government decision, "décret", 20/01/2010)

Jean-Pierre Bibring (prix Ernest Deschelles 2007 de l'Académie des Sciences)
François Boulanger (ERC Senior Grant, 2010)
Louis d'Hendecourt (médaille d'Argent du CNRS 2003)
Philippe Lemaire (prix André Lallemand 2007 de l'Académie des Sciences)
Jean-Loup Puget (membre de l'Académie des Sciences)
8 other scientists at IAS have received prizes from international science societies, « bronze medals » from CNRS or positions at "Institut Universitaire de France"

4.1.5 PARTENAIRE 5/ PARTNER 5 : IMNC

LABORATORY Imagerie & Modélisation en Neurobiologie & Cancérologie

4.1.5.1 RECHERCHE ET INNOVATION / RESEARCH AND INNOVATION

Created in 2006, the IMNC laboratory (UMR8165) is jointly supported by IN2P3-CNRS and both Paris Diderot and Paris Sud universities. It incarnates challenging and successful scientific interdisciplinary projects guided by a spirit and a method. We develop mono-disciplinary skills in physics and biology to answer crucial questions of therapeutic issues in cancerology and neurobiology combining latest imaging and modeling approaches. The unit gathers 38 highly skilled collaborators and 5 research teams which mobilize physicists, methodologists, biologists and engineers. The research projects are dveloped along two scientific axis :

• imaging in neurobiology axis focused on the exploration of the cellular basis of the cerebral energy metabolism and brain plasticity (team#1 Métabolisme Imagerie Olfaction: H.Gurden) and the in vivo multimodal neurofonctionnal imaging (radioisotope and optical) on small animals (team#2 Imagerie du petit animal: P.Lanièce)

• imaging and modeling in cancerology axis focused on the development of compact multimodal imagers for the diagnosis and the therapy of tumors (radioguided assistance for the surgery, monitoring response to chemotherapy : team#3 Imagerie Per Opératoire: Y.Charon) and development of associated quantitative methodologies (tomographic reconstruction and estimate of the physiological parameters in PET: team#4 Quantification en Imagerie Moléculaire : I. Buvat). The topic of modeling is focused on the study of process guiding the migration of tumors, in particular high-grade brain tumors (team#5 Modelisation du Vivant et systèmes dynamiques : B. Grammaticos).

These research projects are also based on a broad network of international collaborations (of which some have IMNC's members as speakers such as OpenGate) and is built on two transversal topics of physics. First topic rely on instrumentation and aims at the development of new methods of photo-detection for the imaging (IMNC is partner of the EquipEx project PHE2LICE on silicon PM). The second topic rely on theoretical physics aiming at the study of behavior of dynamic systems that bring new insights into biological complex mechanism such as tumor growth. Thanks to this organization and in order to reinforce impact of its projects, the development strategy of IMNC combines both internal synergies within the UMR (which enhance scientific creativity) and close coupling with upstream physics (IMNC is partner of P2IO LabEx). This double approach is essential for the long term competitiveness of IMNC researches.

Among recent scientific successes of IMNC, one can put forward the key-role of astrocytes in the cerebral energy metabolism and functional neuroimaging thanks to combined optical imaging techniques, the validation of the per-operative imagery for radio-guided surgery of breast cancer (national protocol of 162 patients) and the first very promising results for the modeling of the cerebral tumors at multi-scales levels. The AERES evaluation ranked IMNC A+ in 2009 *(full report available on http://www.aeres-evaluation.fr/Etablissements/UNIVERSITE-PARIS-11)*

• High level researchers : - prizes & distinctions : I. Buvat (bronze medal CNRS) - grant owners : H.Gurden & L.Ménard (ANR young researcher) P.Lanièce (ANR), I. Buvat (ANR & FP7), Y.Charon (PNR INSERM)
• Publications (2006-2009) : 80 peer-reviewed publications, 28 peer-reviewed confderence proceedings, 7 PhD thesis,
• Grants (2006-2009) : 5 ANR programs, 1 FP7 program, 1 ARC program, 1 PNR INSERM
• Available platforms : in vivo small animal multi-modal imaging, rodent housing facility, scientific incubator

4.1.5.2 VALORISATION / EXPLOITATION OF RESULTS

INDUSTRIAL TRANSFER: Since its creation in 2006, the unit has deposited two international patents and signed two license agreements. In addition, many of its current projects are developed in collaboration with companies (in particular within the cluster of competitiveness MEDICEN). Lastly, IMNC also puts forward its engagement of valorization through the success of professional insertion of its PhDs in the industrial business.

4.1.5.3 ENSEIGNEMENT SUPERIEUR / HIGHER EDUCATION

TEACHING AND PhD FORMATION: IMNC is highly involved in teaching. Our manpower gathers a majority of professors and CNRS researchers who intensly participate in training classes in universities.IMNC also host the head of two Masters specialties and until 2008, the director of the principal graduate school leant with P2I. The current average flow of doctoral fellows is about 9 PhDs. IMNC also wants to participate in bridging the gap between science and society: we built a specific program to host students from high schools located around our university.

4.1.5.4 ORGANISATION / ORGANISATION

IMNC mobilizes 38 collaborators including 15 researchers and 2 engineers. It is organized along five research teams. The laboratory is managed using the standard organization of an UMR (namely a scientific council and a laboratory council) and thanks to a steering committee which gathers together weekly, the direction, team leaders and support services. IMNC also implements a structure of scientific incubator which allows to host temporarily teams willing to develop a specific project in areactive way consistent with the lab research.

4.1.6 PARTENAIRE 6/ PARTNER 6 : IPHT SACLAY

Institut de Physique Théorique

4.1.6.1 RECHERCHE ET INNOVATION / RESEARCH AND INNOVATION

The Institute of Theoretical Physics (IPhT) is located at Orme des Merisiers, near Saclay, it hosts approximately 50 faculty members whose research activities cover most areas of contemporary theoretical physics. This P2Io project only includes 19 out of these 50 members, who work in the field of particle physics and cosmology. It is interesting to note that 9 out of these 19 faculty earned their PhD outside France, which reflects the international stature of the team.

The research activities of the P2Io team at IPhT follow five directions:

1. String theory, with emphasis on black hole physics, and the low-energy limit of string theory, which makes contact with the observable world.
2. Precision calculation in gauge theories. This group aims at making predictions for collider experiments, in particular for the LHC at CERN. Precision calculations are also used for testing the AdS/CFT correspondence between string theory and gauge theories.
3. Primordial cosmology: this group investigates the physics of the early universe, as can be probed through the cosmic microwave background, the large scale structure of the universe, non-gaussianities, gravitational lensing, primordial magnetic fields and gravitational waves.
4. Particle physics beyond the standard model: this group investigates in particular the nature of dark matter, the physics of neutrinos, and signatures of cosmological phase transitions. Items 3 and 4 have close links.
5. Strong interactions at high energy: this group investigates the partonic structure of the proton in the high-energy limit, and the phenomenology of high-energy proton-proton and nucleus-nucleus collisions.

The IPhT P2Io team boasts an impressive number of external fundings: 5 of its 19 members have been awarded grants from the prestigious European Research Council (ERC), see list below. To date (Nov. 2, 2010), the Saclay P2Io team coordinates 8 projects funded by the French national research agency ANR: 2 junior excellence chairs, 2 young researcher grants, 4 generic "blanc" projects. Thanks to these external funds, our team has been able to hire a large number of young collaborators: 18 postdocs and 11 PhD students (as of Nov. 2010), so that the total number of young researchers largely exceeds the number of faculty.

Outstanding researchers

- Iosif Bena (CEA), ERC Starting Grant
- Jean-Paul Blaizot (CNRS), Prix Langevin 1995, Prix Ricard 1997, ERC Advanced Grant
- Mariana Grana (CEA), ERC Starting Grant
- David A. Kosower (CEA), ERC Advanced Grant
- Geraldine Servant (CEA), ERC Starting Grant

In the period 2005-2009, the IPhT P2Io team published 364 papers in international refereed journals, which already total over 11000 citations (source: SPIRES database). The most significant publications are listed below in 7.2.

4.1.6.2 ENSEIGNEMENT SUPERIEUR / HIGHER EDUCATION

IPhT organizes series of lectures at the PhD level every Friday. These lectures are part of the doctoral programme of « Ecole doctorale de Physique de la Région Parisienne (ED 107) ». The schedule can be found at the following address
http://ipht.cea.fr/Phocea-SPhT/ast_visu_spht.php?id_ast=572

A total of 11 students are preparing their PhD within the Saclay P2Io team as of Nov. 2010. F. Bernardeau and J.-Y. Ollitrault have part-time teaching positions (professeur charge de cours) at Ecole polytechnique, and F. Gelis teaches at the NPAC Master programme at Orsay.

4.1.6.3 ORGANISATION / ORGANISATION

The Institute of Theoretical Physics (IPhT) at Saclay is an independent institute within DSM (Direction des Sciences de la Matiere) of CEA. It is associated with CNRS (URA2306). The P2Io team contains roughly one third of the faculty of IPhT (8 CNRS, 11 CEA).

4.1.7 PARTENAIRE 7/ PARTNER 7 : IPNO

L'Institut de Physique Nucléaire d'Orsay

4.1.7.1 RECHERCHE ET INNOVATION / RESEARCH AND INNOVATION

The Institute of Nuclear Physics of Orsay (IPNO) is the largest joint research unit of the CNRS/IN2P3 and the University-Paris Sud 11 that pioneered many of the research fields related to nuclear physics and accelerator based research activities in our country. The laboratory is composed of 74 permanent researchers (21 of them are employed by the University), 213 engineers and technicians and about 65 PhD students, post-docs and visitors. The Institute forms students through research and actively contributes to the emergence and development of multidisciplinary activities for which the laboratory has competences. Its evaluation by AERES end 2008 gave extremely good results: the laboratory is ranked A+, placing IPNO among the best ranked laboratories nationwide. The director of IPNO is member of the European NuPECC committee (Nuclear Physics European Coordination Committee) of the ESF (European Science Foundation) for the coordination of the European Strategy in the domain.
IPNO has a very large numbers of researchers having or having had in a recent past very large responsibilities at national and international levels and prizes.

Prize Winners		Responsabilities	
E. Khan	Bronze Medal CNRS 2003	A. C. Mueller	IN2P3 Deputy Director IN2P3 2004-2010
J. L. Biarrotte	Laclare Prize SFP 2008	F. Azaiez	LEA Colliga Italy France Director 2008-2010
S. David	Joliot Curie Prize SFP 2004	A. C. Mueller	I3 EURONS FP6 Scientific Coordinator 2003-2008
Y. Blumenfeld	Joliot Curie Prize SFP 2002	Y. Blumenfeld	EURISOL design Study FP6 Director 2006-2009
D. Guillemaud Muelle	Doctor Honoris causa	E. Simoni	Director of Research

	Chalmers University Göteborg Sweden		Univ Paris-Sud 11
R. Guillaumont	French Academy of Science	F. Azaiez	ECOS European Network, Chairman

IPNO publication record for the period 2005-2009
Total number of publications: 1214
In peer-review journals: 632
Conférences: 410 (338 with peoceedings, 72 without proceedings)
Books: 3
PHD thesis and 'HDR'diplomas: 59
A selection of the 100 most cited publications of IPN is given in Appendix 7.2

The scientific program covers a broad range of topics in nuclear physics, radiochemistry, and astroparticle physics as well as applications of subatomic physics to different multidisciplinary fields. The main research subjects are:

- Nuclear structure far from the valley of beta stability as well as nuclear dynamics
- Structure of the nucleon and hadronic matter studies
- Innovative approaches to nuclear power generation and transmutation of nuclear wastes
- Ultra high energy cosmic ray studies
- Ion-matter interaction experiments and finally
- Theoretical studies of nuclear and hadronic matter

All these activities are carried out within strong national and international collaborations involving high-quality students and post-doctoral researchers. Studies in Cosmic rays, radiochemistry, electronuclear cycle and physics with clusters are the proof of the complete integration of multi disciplinarity in the Institute.

IPNO carries out important R&D activities in accelerators. The Accelerator Division consists of a group of 42 engineers, 49 technicians and 3 physicists. The accelerator Division provides its technical support for the design and construction of European high power accelerators also contributes to the development of major new radioactive beam projects. This division operates also two platforms, the accelerator platform ALTO and the Supratech one.
The two technological poles concentrate the R&D activities which are specially extended in the field of expertise of the cryogenic technology related to the superconducting radio-frequency cavities (pole Supratech) and to the development of radioactive ion beam sources (pole ALTO).These two poles are interfaced with a mechanical design group and a theoretical and computation group. The electronic staff completes this organization. It has in charge the accelerator instrumentation, the high frequency sources and the power supply devices.
The ALTO facility houses two accelerators: the 15 MV Tandem producing stable beams and clusters and the 50 MeV electron linac dedicated to the production of radioactive beams by the isotope separator on line (ISOL) method. This facility offers a unique opportunity to have in the same building, both beams of ions

and electrons delivered to the experimental beam lines for multidisciplinary physics, astrophysics and nuclear
The 50 MeV linac is coupled to the ISOL device PARRNe. Four lines of radioactive ion beams are associated with PARRNe. Three types of ion source operating at high temperature are developed for the production of radioactive beams: a surface ionization ion source, a laser ion source and a hot plasma ion source. A laboratory installed in a nuclear controlled area is dedicated to the development of uranium carbide targets. An off line isotope separator is also available to test ion sources including laser ion sources with a second laser system.
These facilities are part of the new Integrated Infrastructure IA ENSAR in the FP7 and recognized as one of the seven European TNA (Trans National Access) for the running of experiments in nuclear and applied physics.

The SUPRATech platform includes all the equipments necessary to test superconducting radiofrequency cavities (SRF). Many projects of linear accelerators of high intensity protons are based on this new cryogenic technology. This is the case for instance for the steering of future reactors dedicated to the transmutation of nuclear waste (XADS / Eurotrans, Myrrha), for the production of radioactive ion beams (EURISOL) or pulsed protons beams for neutrino sources and spallation neutrons source.
Cryogenic cavities operate at higher gradient, lower AC power, and they offer a great flexibility in beam dynamics and reliability compare to the normal conducting resonators. The long term future of this technology applied to linear colliders or high intensity proton linacs is definitely based on these superconducting radiofrequency systems.
Studies on superconducting cavities continue their progress and can be considered as an alternative for the medium or low energy part of the future SRF Linac machines. In particular excellent performance of the "spoke" cavity, allows extend the use of superconducting cavities to the low energy as well as to the high energy side of the accelerator.

The activities of the Accelerator Division are related to project structure management. Each project has its own organization and follow-up. A general coordination insures to manage the human resources and investments between the different projects.
The more important contributions of the Accelerator Division concern the SPIRAL 2 project aiming at producing radioactive ion beams (RIB) using the ISOL technique and the European programs like CARE and EUCARD (6^{th} and 7^{th} PCRD) for the development of superconducting RF acceleration systems, EURISOL the design study for the future RIB accelerator (fission target, proton accelerator design, super conducting cavity development, coordination task, beta beam studies…) EUROTRANS in the continuity of the PDS-XADS. This program devoted to nuclear waste transmutation consists in the design of a driver accelerator coupled to a sub-critical nuclear reactor. The MYRRHA project in Belgium will be the demonstrator of this new concept.
SLHC PP: Preparatory phase for the future LHC upgrade.
THATEA: Thermoacoustic technology for energy applications

The Accelerator Division has increased its technical potential by massive investments in recent equipments. The Supratech platform has achieved the installation of the chemical etching area. The helium liquefier and the clean room are now fully operational. At ALTO, the off line separator completes the online PARRNE separator for the RIB R&D studies. These entire equipments provide a high level technical center for the development of future accelerators.

The Instrumentation Division objective is to increase the technical organization for better answering the implications of the laboratory in the instrumentation for experimental setups whose size and complexity have largely increased. This trend leads to a request for a diversity of qualifications not only to cope with technological changes in the work done in the laboratory but also to ensure a fruitful dialogue with other laboratories and companies. This evolution leads also to the necessity of long phases of R&D which could imply different knowledge and various technologies. As for example, one can mention the need for simulations not only to evaluate the sensitivity to the physical parameters but also to consider the performances of real detectors with their mechanical and electronic constraints. One can also think of the thermal problems coming from the increase of the number and density of the electronic channels which require compromises between detection, electronics, mechanics and cooling. The regrouping in a same division makes easier the collaboration of personnel of complementary competences and allows taking in charge projects asking for several technical aspects.
The Instrumentation Division includes a Detector Department (19 persons), a Department of Electronics (19 persons) and a Mechanical Construction Department (5 persons). A strong connection is established with the Data Acquisition Group of the Software Department .This allows to strengthen capabilities in detectors, mechanics and electronics. The main works and the future orientations are related to gas detectors and photo detection. The focus is put on the mechanics (feasibility studies, structural analyses, manufacturing drawings, assembly, tests) with integration of the implementation of the electronic circuits. Detector studies (simulation and tests) are also undertaken along with the associated analogical electronics: high voltage bias, preamplifiers, signal processing.
IPNO is also participating in the R&D for calorimeters within new projects like PANDA and EXL in FAIR at GSI. It is also strongly involved in the new set up around SPIRAL2 like the new PARIS calorimeter or the GASPARD device.

Finally, the instrumentation division is an active member of the microelectronics pole OMEGA, hosted by the LAL laboratory. This platform is highly specialized in analog and mixed-signal microelectronics design and ensures the training of young engineers to weave new scientific collaborations and favors the dissemination of new circuits in adjacent fields such as medical imaging.

In the domain of computations, IPNO is also part of the grid GRIF, a joint initiative from 5 CNRS/IN2P3 laboratories and CEA/IRFU all located in Paris region, in order to build a major grid resource. Driven by the needs of LHC experiences, GRIF is largely opened to many other communities like biomed, earth sciences, chemical chemistry, astrophysics...and benefits largely to the different programs carried out by the scientific teams of IPNO

4.1.7.2 VALORISATION / EXPLOITATION OF RESULTS

IPNO is conducted valorisation is different domains. Nevertheless the two main activities are dosimetry and protection against radiation.

The dosimetry service at IPNO is a laboratory approved by the Ministry of Employment for providing individual monitoring of external exposure of workers subjected to ionizing radiation. The laboratory is accredited by the French Accreditation Committee (COFRAC) according to the ISO 17025 (General requirements for the competence of testing and calibration laboratories). The service offers include : the provision of dosimeters on site, analysis of dosimeters, the return of results, advice and technical assistance. The technical platform of the service allows for monitoring of external exposure in mixed radiation fields of gamma-rays, neutrons and/or beta particles using passive dosimeters. The "whole body" surveillance is achieved using radio-photoluminescence dosimeters (RPL). This allows for measurement of the personal dose equivalents down to Hp (10) and Hp (0.07), respectively, for the estimations of the effective dose and the equivalent skin dose. Assessment of risk of neutron exposure is taken into account by associating a solid-state nuclear track detector to the RPL dosimeter. For the extremity dosimetry, additional RPL dosimeters are used for the wrists and Thermoluminescence Dosimeters (TLD) for the fingers. The performance of dosimeters are regularly evaluated through inter comparisons organized by the National Institute of Radiation Protection and Nuclear Safety (IRSN).

Concerning safety against radiation, the service mission is to watch over and contribute to the respect of the ALARA principle.Application of the general principlele of human protection is the main purpose of the Radiation Protection Group RPG, which means to maintain the individual and collective radiation exposures as low as reasonably possible.

Involving the laboratory direction liability and in collaboration with the Health & Security comity, the group is charged to watch for the respect of protection rules concerning workers, public and environment against ionizing radiations risks. Its various tasks are:follow-up of the exposure levels of the different lab rooms, non-contamination controls (checking of absence of undesirable radioactive substances), post analysis of exposed workers, as support for the preventive medical group, solid and liquid sample analysis by gamma spectrometry, information and training about radioprotection of the exposed staff, radiation shielding calculations and simulations. Jointly with the Security, Quality & Environment group, the RPG warrants traceability of production, movement, transfer and loan of radiation sources. The RPG is homologated by the government to proceed to external controls about radiation exposures of any staff according to the public health and work laws. Universities, INRA, CNRS and GDF, among others, benefit of the group abilities.

4.1.7.3 ENSEIGNEMENT SUPERIEUR / HIGHER EDUCATION

IPNO is highly involved in teaching through its professors and assistant professors but also through its CNRS researchers who intensively participate in training classes in universities. IPNO is hosted part of the two Ecoles Doctorales MIPEGE (Modelisation, Instrumentation in Physics, Energy, Geosciences et Environment) and PNC (Particle Nuclei and Cosmology) and sharee the responsibility of the following masters : Physics and Environment, Radiation and Energy, Nuclei, Particles, Astroparticles and Cosmology, Radiochemistry. The international master " Nuclear Energy " was created by B. Berthier physicist at IPNO.

IPNO is also always hosted students from high schools located around our university.

4.1.7.4 ORGANISATION / ORGANISATION

IPNO has 3 formal internal instances: the laboratory council (LC), the Scientific Council (SC) and the Health and Safety Committee. LC main task is to approve the annual budget and to give a formal advice for the nomination of the lab director. The laboratory is divided in four departments: the department of research, the department of instrumentation, the department of R&D on Accelerators and the administrative department. Their directors meet weekly to discuss all matters of the laboratory day-to-day life. IPNO is reviewed every 4 years by a high level international visiting committee, under the aegis of AERES. IPNO is one of the leading laboratories of the closely knitted IN2P3 laboratories network and therefore works in close contact with IN2P3 direction and is also involved in many instances of the Paris-Sud 11 University.
IPNO consolidated annual budget is of the order of 26M€ , on average over the last 5 years, including 20M€ of manpower. 1.6M€ come from various contracts ("ressources propres") with various entities (European Union, National Research Agency, Ile de France region, Essonne regional Council).

4.1.8 PARTENAIRE 8/ PARTNER 8 : IRFU

Institute of Research into the Fundamental laws of the Universe

IRFU is an institute of the Commissariat à l'Energie Atomique operating researches in the fields of astrophysics, nuclear physics and particle physics and driving the construction of instruments for large research infrastructures and Space scientific missions.

4.1.8.1 RECHERCHE ET INNOVATION / RESEARCH AND INNOVATION

The scientific program of IRFU is focused on four fundamentals questions:

- What are the ultimate constituents of matter? To test the standard model and its extension, 60 physicists of IRFU are involved in D0 experiment at Fermi lab and in CMS and ATLAS experiments at CERN. The neutrino physics program consists of participation in the T2K and DOUBLE CHOOZ experiments to measure the parameters of the mixing matrix. IRFU is also playing an important role in experiments devoted to the study of the hadrons structure contributing in both COMPASS and CLAS experiments at CERN and Jefferson Lab.
- What is the energy content of universe? To address this question, IRFU is developing a wide research program which extends from direct dark matter detection to the measure of universe geometry with various probes as CMB, Supernovae, BAO or Weak Lensing. IRFU is collaborating with several laboratories including CSNSM in the EDELWEISS experiment and plays a leading role in the preparation of the EUCLID mission in collaboration with IAS.
- How is the universe structured? The study of the universe structure from big bang to planets is one of the major research themes of IRFU. Violent phenomena in the universe are explored with space missions as FERMI or ground observatories as HESS. IRFU has a leading role in the preparation of the French-China SVOM mission devoted to the detection of Gamma Ray Bursts and has joined the CTA collaboration to prepare the next High Energy Gamma ground observatory. New messengers are also explored with the ANTARES undersea high energy neutrinos observatory. The study of the

formation of Stars and Galaxies is the main part of the program with an important role in HERSCHEL and in the construction of the Mid IR Instrument for the JWST.

- How is nuclear matter organized? The IRFU nuclear physics teams have proposed and led several tens of experiments over the last few years in all the major nuclear physics facilities to study the structure of exotic and super deformed nuclei. IRFU plays an important role in the preparation of the Spiral 2 physics program with a leading role in S3 experiment and a large contribution to AGATA. IRFU is also involved in the study of nuclear matter phase transition with participation in PHENIX and a large contribution to the ALICE experiment at CERN.

To perform its scientific program, IRFU has developed large technological skills in accelerator technology, superconducting magnets, detectors, electronics, Space technology, simulation and data processing. Without being exhaustive, some of the strong technological axes of IRFU are listed below:

- In the field of accelerator technology, IRFU has a research program addressing both intensity and energy frontiers. The institute is developing a research program in high intensity sources with very large responsibilities in SPIRAL 2 injector and IFMIF-EVEDA prototype accelerator. The institute has recently acquired a world class integration platform which allows the fabrication of large cryomodules and which will be used for SPIRAL 2, XFEL and ESS projects. IRFU is also involved in world wide collaborations with other institutions as CERN, DESY, FERMILAB and KEK to develop high field gradient superconducting cavities. Together with LAL, the institute is a member of CLIC and ILC collaborations.
- IRFU is one of the world leading laboratories in the field of superconducting magnets. The institute had very large responsibilities in the construction of LHC magnets for the accelerator (quadrupoles) and for the detectors (Atlas toroide and CMS solenoid) as well. Today, the institute is responsible of the GLAD spectrometer for the R3B collaboration at GSI and has in charge the construction of a large MRI 11.7T solenoid in the frame of the ISEULT project. The institute has also developed large technological platforms for testing superconducting magnets which has been used for the qualification of the Wendelstein W7X stellerator and which are planed to qualify the JT60SA Tokamak magnets in the framework of the broader approach for ITER.
- In the field of space technologies, IRFU has the ability to lead integrations of space instruments and has delivered the flight model of the PACS photometer for HERSCHEL and very recently the Mid IR Imager for the JWST.
- Detectors technology is one of the strong technical axes of IRFU. The concept of Micromegas, one of the most promising micropattern gaseous detectors, has been developed within the institute. Irfu is playing a leading role in this field, participating in AIDA FP7 program and in RD51 collaboration at CERN. A second important axis is the development of spectro-imaging devices for spatial applications. In collaboration with industry, Irfu has developed very innovative concepts for CdTe imagers and leads a R&D program on bolometers in the sub-mm range. All these development take benefit from a strong electronics group which is involved in several active R&D programs as cryogenic electronics supported by an EU FP7 contract and which is based on an outstanding expertise in analog microelectronics.

- In the field of data processing, thanks to the ERC Senior Grant awarded to J.L. Starck, IRFU has created a new lab devoted to the research of new concepts in image and information processing as compressed sensing. IRFU has also a strong involvement in Simulation for Astrophysics which is also supported by 4 ERC starting grants.

IRFU takes benefits from its insertion in Commissariat à l'Energie Atomique which is one of the most important technological research institutions in the world. As an example, a very close collaboration with LETI in Grenoble has led to the development of high tech bolometers which have been used in the frame of the INTEGRAL and HERSCHEL missions. On the other hand, the other divisions of the CEA also benefit of IRFU technologies and several research programs are involving collaborations with the fusion community and the life science division of CEA. IRFU is also linked with local CNRS laboratories in coordination structures as SUPRATECH, with LAL and IPNO, in the field of accelerators and MOTESPACE, with IAS, in the field of Space technologies. IRFU with LAL, IPNO and LLR is also contributing to the GRIF project which aims to build a large grid resource in Paris region. 2PIO "labex" and the related "Equipex" like COGIS, PH2ELICE, CRYOMATRIX, CRYOCUBE and XUV will allow transforming these coordination structures into jointly operated World Class Platforms.

IRFU has been evaluated in 2007 by an international visiting committee and will be evaluated by AERES in 2012-2013 during "vague D".

IRFU is contributing to 14% of CEA publications with a total amount of 550 publications per year. Over the period 2005 to 2009, IRFU researchers have published 14 articles in Nature, 22 in Science and 301 Physical Review Letters [See list of publications].

A large numbers of IRFU's researchers have had in a recent past large responsibilities and prizes. The list of prizes is given below:

Joël Feltesse, Helmholtz-Humboldt Forschungspreis, 2005
Jean Zinn Justin, Prix Pécot du Collège de France, 1974; Prix Langevin de la Société Française de Physique , 1977 ; Prix Ampère de l'Académie des Sciences, 1980 ; Loeb lecturer, Université de Harvard, 1989 ; Prix Gentler-Kastler des sociétés française et allemande de physique, 1996 ; Harris visiting scholar du MIT, 1998 ; Schrödinger Professor Université de Vienne, 2001 ; Prix Humboldt-Gay-Lussac, 2003.
Daniel Denegri, John Hopkins University Society of Scholars, 2006.
Jacques Paul, Prix Cospar Massey, Royal Society, 2002.
David Elbaz, Prix Henri Chrétien, American Astronomical Society, 2000.
Michel Spiro, Prix Joliot Curie, 1983 ; Prix Thibaud, 1985 ; Prix Felix Robin, 1999.
Roy Aleksan, Prix Joliot Curie, 1997.
Christian Cavata, Prix Joliot Curie, 2000.
Gauthier Hamel de Montchenault, Prix Joliot Curie, 2005.
Eric Delagnes, Prix Yves Rocard, 2005.
Robin Ferdinand, Prix Jean-Louis Laclare, 2003.
Philippe Chomaz, Prix Jean Perrin, 2003.
Roland Lehouq, Prix Jean Perrin, 2004.
Ioannis Giomataris, Prix Jaffé, Académie des sciences, 2002
Marc Lachièze-Rey, Prix Moron de l'académie française, 2004.

Vanina Ruhlman Kleider, Médaille d'argent du CNRS, 2003.
Marc Virchaux, Médaille d'Argent CNRS, 1999.
Gabriel Chardin, Médaille d'Argent CNRS, 2007.
Monique Arnaud, Médaille d'Argent CNRS, 2010.
Thierry Lasserre, Médaille de Bronze CNRS, 2010.
Emmanuelle Perez, Médaille de Bronze CNRS, 2002.

Over the three past years, IRFU researchers have obtained important successes in ERC grant programs. Five starting grants and one Senior Grant have been awarded and are listed below:

Jean Luc Starck, ERC Senior Grant, 2007
Alan Sacha Brun, ERC Starting Grant, 2007.
Emmanuel Daddi, ERC Statring Grant, 2007.
Frédéric Bournaud, ERC Starting Grant, 2010
Sébastien Fromang, ERC Starting Grant, 2010.
Alexandre Obertelli, ERC Starting Grant, 2010

Since 2005, 28 ANR and 51 contracts with the EU commission have been signed by IRFU for a total amount of 26M€.

4.1.8.2 VALORISATION / EXPLOITATION OF RESULTS

Owing to the fact that IRFU is part of CEA, the institute has a long and strong tradition of cooperation with industry either by direct subcontracting or by common R&D programs. In a recent past, partnerships have been established with large French or European companies (Siemens, Sagem, Thalès, Air Liquide, Alstom…) and with several SMEs (Pantechnik, CAEN…). The institute has an active technology transfer policy including patenting and licensing. Over the past four years, 4 patent applications have been filed per year for a total portfolio of 32 international active patents.

4.1.8.3 ENSEIGNEMENT SUPERIEUR / HIGHER EDUCATION

The increase of doctoral and post doctoral positions is a priority of the institute which hosts 76 PHD students and 75 postdocs in 2010. More than 75 researchers and engineers are teaching in "M" and "D" level courses relevant for nuclear physics, particle physics, astrophysics and related technologies.

4.1.8.4 ORGANISATION / ORGANISATION

IRFU is located at Saclay and gathers 620 permanent staff people consisting of 168 researchers, 243 engineers and 210 technicians. The institute is organized along 3 physics division (nuclear physics, astrophysics, particle physics) and 3 technical divisions (detectors, electronics and computing, magnets and accelerators, engineering). 2 small additional services are dedicated to the specific activities of IFMIF-EVEDA and to the conception and the decommissioning of nuclear installations.
IRFU director is nominated by the Director of the Physical Science Division of CEA. He is assisted by two deputy directors.
Transverse to this organization, a strong project management allows to focus the technological capabilities of the Institute on common objectives defined at the institute level.

IRFU consolidated annual budget is of the order of 80M€, on average over the last 3 years, including 48M€ of manpower. 17M€ come from contracts ("ressources propres") with several entities (CNES, European Union, National Research Agency, Ile de France region, Essonne Council, ISEULT Project). 7 M€ are devoted to the Broader Approach program (IFMIF EVEDA and JT60SA projects).

4.1.9 PARTENAIRE 9/ PARTNER 9 : IRSD

Ingénierie Radioprotection, Sûreté et Démantèlement

4.1.9.1 RECHERCHE ET INNOVATION / RESEARCH AND INNOVATION

During the exploitation of the LURE facilities from the commissioning in the middle 50's to the dismantling in 2010, we acquired professionals skills in the radioprotection and safety fields. In order to avoid the loss of these competences, the CNRS created a unit (IRSD – Ingénierie Radioprotection, Sûreté et Démantèlement) which regroup the former agent of the LURE who were in charge of safety and radioprotection.
The IRSD, put in the service of the CNRS, will meet the needs of facilities, projects and laboratory in the following fields:

- Studies and assessment in safety and radioprotection
- Preparation and follow-up of operation file for regulatory requirement (Autorité de Sûreté Nucléaire, Agence Nationale des Déchets Radioactifs…)
- Shielding of accelerators, targets and irradiation facilities. We use Monte Carlo code for the modeling and design of accelerator shielding system including electron, proton and ion accelerators, spallation sources and several different type of facilities such as synchrotron radiation, free electron lasers, very hi-intensity laser…

The IRSD will also be in charge of the safety and radioprotection of CLIO (free electron laser) and PHIL (electron accelerator) located in nuclear area of the LURE.

4.1.10 PARTENAIRE 10/ PARTNER 10 : LLR

The « Laboratoire Leprince-Ringuet » (LLR) is a joint research unit of CNRS/IN2P3 and Ecole polytechnique. It is the largest laboratory of the Ecole polytechnique research center, located in Palaiseau. The laboratory is devoted to particle and astroparticle physics, and is ranked A+ by AERES

Prize Winners		Responsibilities	
L. Kluberg	CNRS Silver Medal 1989	Y. Sirois	CMS-France Coordina
B.Degrange	CNRS Silver Medal 1997	H. Videau	ILC-France Coordinat ILE Steering committe
M.Gonin	CNRS Silver Medal 2000	G. Fontaine	IN2P3 Deputy Direct 1992-1999 HESS International Bo

			Chair
O.Drapier	Thibaud Prize 2000	J.C. Brient	CALICE Spokesperso 2002-2008
M. Hagenauer	Prix Valorisation IN2P3 2007		
L.M.Chounet, B.Degrange, M.Hagenauer, L.Kluberg	EPS HEP Prize 2009 (Gargamelle)		

4.1.10.1 RECHERCHE ET INNOVATION / RESEARCH AND INNOVATION

The largest research group of the laboratory is working on CMS at CERN LHC, for which the LLR has developped and installed the ECAL front-end and « trigger concentrator » cards for both the barrel and the end caps. The carbon fiber structure of the ECAL has also been designed and built at LLR. The CMS team mainly studies electron reconstruction and particle flow analysis in proton-proton collisions. It also plays a leading role in the study of heavy ion collisions, continuing the researches performed precedently in the laboratory within the PHENIX experiment at RHIC. Among the responsibilities taken by group members, Y. Sirois is the manager of CMS-France, P . Paganini has been coordinator for the ECAL trigger (and A. Zabi took over in 2010), and R. Granier de Cassagnac is co-convener for heavy ion physics, and recently received an ERC « starting grant » for this activity. B. Wyslouch (Professor at M.I.T., presently visitor at LLR for one year) is responsible for CMS operation with heavy ion beams.

The T2K (Tokai to Kamiokande) group works on neutrino oscillations. For this experiment, the laboratory has designed the « INGRID » detector and built its mechanical structures. This 14x10 ton detector aims at measuring the position and angle of the muon neutrino beam produced at JPARC, before the neutrinos can oscillate and be measured as electron neutrinos in the Super-Kamiokande detector, located 295 km dowstream.

The ILC/ILD team works on future developments for the International Linear Collider. Among the different topics involved, research and development are performed for a new calorimeter concept, based on fine granularity detectors interleaved with heavy converter. A prototype of Si-W calorimeter has been designed and built, within a collaboration (CALICE) initiated by LLR. The team also studies the integration and cost estimate of ILD, future detector for the ILC. These developpments have received financial support from the FP6 EUDET and from ANR. LLR is now taking part in the FP7 AIDA program. The software group of LLR has developed a tool for simulation, used for detector concept as well as prototype in test beam. It is now used worldwide in the LC community.

Gamma-ray astronomy is another important field of research at LLR, with groups participating in HESS, CTA and FERMI experiments. Hess consists of 5 Cherenov telescopes located in Namibia, in which LLR has been responsible for the design and construction of the mechanical structures of the multi-PMT (1024 to 2048) cameras. The next step in this field is the preparation of the large international CTA (Cherenkov Telescope Array) collaboration. Two LLR researchers (M. De Naurois and B. Khelifi) are convenors for work packages in this project. The team is also involved in the FERMI space telecope experiment, the calorimeter

mechanical structure of which has been designed and built at LLR. This satellite has collected more than 1400 gamma-ray sources in one year data taking, and the second year catalog is in preparation.
LLR also studies a novel technique for particle acceleration, based on laser induced plasma waves. A spectrometer has been developped and built for this experiment, performed in collaboration with other laboratories at Ecole polytechnique. Very encouraging results have been obtained, showing electron acceleration around 200 MeV with a very small energy dispersion. This research has been financially supported by the EUROLEAP project.
All the programs described above have benefitted from the expertise developped by LLR in mechanics for carbon fiber composite structures and quality standards needed for satellite experiments, and in electronics for large bandwidth signal processing and data transmission. In addition to these, the computing group successfully operates GRIF_LLR, a node of the « GRIF » (« Grille de Recherche d'Ile de France ») computing grid. This facility serves as a « T2 » for CMS and comprises about 100 (16-core) worker nodes and 600 Tb of disk storage.

4.1.10.2 VALORISATION / EXPLOITATION OF RESULTS

LLR has recently developped a new concept for beam counters dedicated to hadrontherapy. These beam profilers, designed, built and tested in the laboratory, now equip the «Centro Nazionale di Adroterapia Oncologica » located in Pavia (Italy). The team involved in this developpment received the « Prix de la valorisation IN2P3 » in 2007.

4.1.10.3 ENSEIGNEMENT SUPERIEUR / HIGHER EDUCATION

Members of LLR are involved in higher education at many levels, in particular at Ecole polytechnique : G. Fontaine is the director of the selection and admission process, M. Gonin is professor, and many researchers have part-time teaching positions either at Ecole polytechnique (V. Boudry, M. De Naurois, B. Giebbels, A. Specka), at « Ecole Centrale Paris » (R. Granier de Cassagnac) or at « Ecole des Mines de Paris » (P. Miné, O. Drapier).

4.1.11 PARTENAIRE 11/ PARTNER 11 : LPT

Laboratoire de Physique Théorique (UMR8627)

4.1.11.1 RECHERCHE ET INNOVATION / RESEARCH AND INNOVATION

The Orsay Laboratory of Theoretical Physics (LPT) is a joint unit of CNRS and Université Paris-Sud. It provides a multidisciplinary framework for research in Particle Physics, Cosmology, Mathematical Physics and Statistical Physics. The largest part of its activity is at the heart of the P2IO themes « Dark components of the Universe » and « Symmetries in the subatomic world », deeply interwined with the experimental progress, and will benefit from a closer exchange between experimental and theoretical laboratories involved in this LABEX project.

Particle physicists at LPT develop two main lines of research closely connected with existing and future collider facilities and non-collider experiments. First, they are oriented towards an accurate description of the strong and electroweak sector of the Standard Model, as an object of study in itself as well as a background for New Physics. Second, they build models and explore different possibilities beyond Standard Model (supersymmetry, supergravity, extra-dimensions ...) including their impact in cosmology and astroparticles (dark matter, neutrinos, matter-antimatter asymmetry of the Universe, cosmic background, ...). The competences of the group will be crucial for the interpretation of forthcoming results of experiments at colliders (LHC, Tevatron), astroparticle (FERMI, XENON) and neutrino (Double-Chooz, SuperNEMO). The research activities of the members of the cosmology group also combine theoretical and observational aspects. On the theoretical side they study cosmology in theories with extra dimensions, non-Gaussianities and quantum effects in inflation theories, and black holes. On the observational side they are involved in the Planck space mission and in a proposal for a follow-up mission. The Mathematical Physics group investigates more formal aspects of fundamental interactions linked with the structure and symmetries of space-time (group field theory, quantization of gravity, non-commutative geometry).
The laboratory hosts 36 researchers, 15 PhD students, 1 engineer, 6 administrative staff members and a number of visitors. It has been ranked at the highest level (A+) by the evaluation agency (AERES) and the quality of its projects has also been recognized by the french national funding agency for research (ANR) : 9 grants were attributed in the period 2005-2008, 6 more then. Moreover two International "Blaise Pascal" Chairs have been granted to the lab (Gabriele Veneziano, Mikhail Shifman). In recent past members of LPT have received important prizes:

- DJOUADI Abdelhak, Medaille d'argent CNRS, 2007; Humboldt Prize (2007).
- HILHORST Henk, Grand Prix Aniuta Winter-Klein de l'Academie des Sciences, 2006

In the period 2004-2008 the laboratory has produced 371 publications in peer-reviewed journals. For the P2IO themes, more recent publications in peer-reviewed journal are given in appendix. Software tools have also been developped and made available to the Particle Physics community in the domains of strong interaction, higgs physics and supersymmetric models.

4.1.11.2 VALORISATION / EXPLOITATION OF RESULTS

Since LPT is a laboratory mainly dedicated to theoretical aspects of particle physics and cosmology, its research have only limited interactions with industry. However, some of the research led in the laboratory require massively parallel data processing. This situation led LPT to become an active partner in the ANR PetaQCD project. It gathers two industrial partners (CAPS-Entreprise, Kerlabs) as well as seven laboratories, among which LAL and Irfu.

4.1.11.3 ENSEIGNEMENT SUPERIEUR / HIGHER EDUCATION

Members of the laboratory, professors and CNRS staff, are involved in Higher Education at all levels in the curriculum. In particular they participate to the master2 "Noyaux, Particules, Astroparticules et Cosmologie" and "Concepts Fondamentaux de la Physique" and to the doctoral schools ED107 and ED517.
In the period 2004-2010 28 PhD and 7 habilitations thesis have been defended. Currently 15 post-graduate students are preparing their PhD in the laboratory.

4.1.11.4 ORGANISATION / ORGANISATION

The organisation of the LPT is a standard one for a CNRS-University UMR with a director, a deputy director, a laboratory council and a scientific council. According to the AERES procedures, it is reviewed every 4 years by an international visiting committee.

4.1.12 PARTENAIRE 12/ PARTNER 12 : SERMA

Reactors Studies and Applied Mathematics Section

4.1.12.1 RECHERCHE ET INNOVATION / RESEARCH AND INNOVATION

Research & Innovation areas: *The Reactors Studies and Applied Mathematics Section* **(SERMA)** is in charge of particle transport and depletion/generation method, modelling and code development devoted to nuclear reactor and fuel cycle facilities. In addition, the SERMA activity in advanced studies and **benchmarking calculation/analysis** is crucial. SERMA R&D is characterized by both deterministic and stochastic approaches which led to produce several codes as Apollo2 and Apollo3 deterministic transport codes and Tripoli-4, a general purpose Monte Carlo transport code (neutrons, photons, electrons). These codes are validated for applications in the fieds of core physics, radiation shielding, dismantling and criticality/safety. A part of the future research works is focused on the couplings between the Monte Carlo 3D particle transport and a deterministic solver as the generalized Bateman equations to deal with the nuclide depletion/generation in nuclear devices. Several scientific and technical challenges can be pointed out related to the large dimensions of the facilities of interest (PWR, BWR, ITER, …) which address several topics namely: variance reduction techniques, parallelization of applications, uncertainty propagation calculation, ….).

International collaborations: *Europe* (member of several expert working groups of the OCDE/Nuclear Energy Agency, European Commission NURISP Project, ITER Project, …), *Japan* (JAEA, Tsukuba University, Tokyo University, Tokyo technological institute, USA (LANL, ORNL, Penn State University, …).

Publications in international journals: Due to the relatively limited neutronics community and to the industrial partnership our number of open publications can be appeared low comparing to other disciplines. About 50 papers are listed in appendix 2, being published in about ten level international reviews since 2002 up to now. Several searchers of SERMA are international journal reviewers and Richard Sanchez is an advisory editor of *Annals of Nuclear Energy*. Searchers of SERMA participate to international conferences steadily and some of them as main co-organizers too.

Recent Awards: *2009 American Nuclear Society Pomraning Memorial Award (Richard Sanchez), Grand Prix SFEN 2009* (Stéphane Bourganel *et al.)*

Technology transfer: This transfer to our industrial partners (AREVA, EDF, ANDRA, IRSN) has taken place for many years in areas such as expert analysis and support, calculation scheme recommendations, computer code transfer (Apollo2, Tripoli-4, …), validation and training. Fruitful collaborations/exchanges with

academic and research institutions must be highlighted too: INRIA, CNRS, PACS / IPN: Paris Sud 11 University, Paris 6 University, Lille University, Versailles Saint Quentin University.

4.1.12.2 ENSEIGNEMENT SUPERIEUR / HIGHER EDUCATION

Higher education programs and courses: SERMA participates strongly to program content definition, teachings/trainings in High Engineering Schools (ENSTA, ECP, X, …), Universities (Paris Sud 11, Paris 6), INSTN and also in an international frame : *International Master of Sciences Nuclear Energy, International School in Nuclear Engineering, Neutronics for Light Water Reactors, INRIA/EDF/CEA Summer School* (SERMA co-organizer in 2009). In other respects, students are welcomed in SERMA for their internships or PhD thesis preparation. Postdoctoral subjects are also proposed.

4.1.12.3 ORGANISATION / ORGANISATION

The SERMA is a multidisciplinary section of about 80 searchers. The SERMA belongs to the *Structure and System Modelling Department* (DM2S) offering a miltidisciplinary environment. The head structure *is the Nuclear Energy Division* (DEN) of CEA. SERMA is located in the CEA/Saclay Center. Both industrial and scientific oriented programs are carried out according to the *DEN Program Managements*.

APPENDIX 1: PERSONS INVOLVED in SERMA

International level experts working in laboratory:

First Name	Last Name	Employer	Rank	Activities
Richard	Sanchez	CEA	Research Director	Transport theory, Transport in stochastic media, Nuclear reactor physics
Cheikh	Diop	CEA	Research Director	Radiation shielding, Monte Carlo method , Nuclear reactor physics
Fausto	Malvagi	CEA	Senior Expert	Particle transport with Monte-Carlo method, Nuclear reactor physics
Eric	Dumonteil	CEA	Searcher	Monte-Carlo method, Uncertainty propagation, Parallel applications
Alain	Mazzolo	CEA	Searcher	Transport theory, Transport in stochastic media
Mireille	Coste-Delclaux	CEA	Senior Expert	Nuclear data processing,, Self-shielding modelling
Christophe	Calvin	CEA	Senior Expert	High performance computing, Reactor physics

4.2. COLLABORATIONS EXISTANTES / EXISTING COLLABORATIONS

Nuclear physics, particle physics, astroparticles and cosmology, astrophysics and exobiology need very large scale infrastructures, from accelerator based labs to satellites, which require a high level of international

collaborations. Collaborations are therefore organized at diferent levels from individual actions to global coordinations:

- International, European and National coordinations
- European organization and large scale infrastructures
- International collaborations
- International and National networking

High level of international coordination and integration

At the international level the coordination of the P2IO fields is/was done under the auspices of OECD or ad-hoc committees. This is for example recently the case for astroparticle for which an OCDE working group recently concluded on the need for global coordination. The European coordination is performed through European organizations such as ESA for space observatories, ESO for ground observatories and CERN for particle physics or through specific committees (eg APEC for astroparticle or NuPECC for nuclear physics) now reinforced by the ERANET FP7 initiative (eg ASTRONET for astrophysics, ASPERA for astroparticle and NUPNET for nuclear physics). At the national level a coordination committee (CCT PNHE) is in charge of the nuclear and particle physics while for space activities the CNES is animating an inter-organism committee (CIO CNES). Those committees discuss international and national collaborations and future projects and associated roadmaps. Irfu is directly represented in all these committees while the other P2IO labs are represented either by IN2P3 or INSU. Acting coherently is an opportunity for P2IO to influence the orientations of its fields of interest at the highest international level.

Critical role of international organizations and large scale infrastructures

The experimental progresses on P2IO fundamental questions require large scale infrastructures. P2IO partners are directly collaborating both scientifically, defining and developing the physics cases, and technically, designing and procuring high-tech pieces of equipment, with the main actors at the world level.

For particle physics, with the recent start of the LHC, the center of gravity has now shifted to Europe around the complex of CERN accelerator at the expense of FERMILAB and SLAC Chicago. For neutrino physics, Japan is taking the pole position, with the Tokai complex (JAEA and KEK). Whereas the United States, in particular NASA, remains the major player in space experiments, European structuring around ESA provides an important counterweight and new players like Japan and China have emerged more recently. As far as ground astrophysics is concerned, ESO is a strong actor with the Chile observatories and the future ELT (Extremely Large Telescope). Nuclear physics provides a balance between the three major geographic regions with SPIRAL2 GANIL and GSI-FAIR in Europe, Jefferson Lab and Michigan State University in the United States and Riken in Japan. China invests heavily in particle physics and astroparticle with IHEP in Beiijing and nuclear physics with the IMP in Lanzhou. Finally within the ESFRI framework new large infrastructures are under discussion/construction.

P2IO partners are directly collaborating with all these organizations and infrastructures. For example IPNO, Irfu and LAL are working for the CERN accelerator complex, for SPIRAL2, for FAIR, ESS and XFEL. It

should be noticed that LAL and Irfu are 2 out of 7 members of the committee of large laboratories working with CERN. For example, ATLAS and CMS superconducting magnets, which are the largest and the more powerful magnets ever built, have been designed by Irfu for CERN. Irfu and IAS are working for ESO, ESA and NASA and are collaborating with Japan and China. As part of CEA's participation in the Broader Approach around ITER, IRFU is constructing and coordinating parts of IFMIF / EVEDA and JT-60SA. Different P2IO Labs are participating in large projects and European preparatory phases such as Auger, Virgo, CTA, KM3… Two French infrastructures should be stressed here: the reactor neutrino laboratory Double Chooz and the underground Modane Laboratory. Irfu is directly involved in the Financing boards or steering committees of those large scales infrastructures while the other P2IO labs are represented through IN2P3 or INSU. The creation of P2IO will be a great opportunity to act as a single partner of all those international organizations, increasing the visibility, the role and the influence of P2IO and France.

Large international collaborations and strong involvement into FP7 program

Large scale infrastructures and space program need large international collaborations to define the physics case, specify the performances, contribute to the design and construction and finally to scientifically exploit the experiment. P2IO teams are major actors of key experiments in P2IO disciplines. Irfu, LAL, LLR and IPNO have strongly contributed to the 3 large LHC experiments: ATLAS, CMS and ALICE. P2IO partners are constructing part of the detectors needed for FAIR, SPIRAL2, JLAb, … Irfu and IAS members are PI (principal investigators) on major ESA missions of interest for P2IO objectives : Mars Express (conditions for the apparition of life), PLANCK (cosmological microwave background), Herschel (sub-mm astrophysics), ROSETTA (in-situ studies of a cometary nucleus), JWST (next generation space telescope),, ExoMars (exobiology), EUCLID (dark energy).

P2IO partners are also strongly involved in the FP7 programs of all kind. A large number of them are coordinated by members of one of the labs forming P2IO. Because of their involvement in large scale infrastructure, P2IO members are involved in Design Studies (DS) and the preparatory phase (PP) of ESFRI infrastructure (EURISOL, KM3NeT, CTA-PP, TIARA, SPIRAL2, ...). Researchers of various partners are also heavily involved in the Integrated Initiatives (I3) (AIDA, EURON, HP, HP2, ENSAR, ...).
IPhT, Irfu, IAS and LLR have been very successful in the recent excellence program of the European Research Council, with 5, 6, 1 and 1 ERC grants received in 2 years.

The creation of the P2IO Labex will be a way to increase the impact of the partners through new synergies and better use of the coordination potential. Being member of a common structure will give access to a broad ensemble of collaborations and results to P2IO scientist, strongly increasing the scientific return of large experimental investment and allowing innovative combinations of results.

International and national networking at various scales

Exchanges of researchers are primarily motivated by the quest for scientific excellence, even if other concerns such as preparing for the future, are also important. By the reception of foreign researchers at post doctoral or senior level, the P2IO partners are committed to strengthening their scientific impact and to establish international links especially with emerging countries. The P2IO partners have actively participated in the creation of several international laboratories with Asia (Japan, China, India, Vietnam) or Eastern Europe (Poland, Russia). Acting as a group of laboratories will strengthen the position of P2IO in the international networks and the critical mass effect may allow initiating new international networks.

At the national level, the P2IO labs are also strongly involved in collaborations with funding agencies such as ANR or CNES. They are also participating in many networks and collaborations such as the P2I, Supratech and Motespace and national program such as the national program of cosmology. In the future we can imagine creating networks between various Labex focused on similar scientific issues.

The partner laboratories of P2IO are involved in a huge number of collaborations at the individual or team level. Those are the essence of the research activity in the fields of interest for P2IO. This ensemble of links might be a basis to develop more formal relations at the P2IO level when may collaborations are involving the same partner.

Moreover the strong mixing of theory and experiment within the P2IO project might be a way to create new collaborations between experiment and theory at the international level. These new connections are new assets for the increase of the scientific impact of P2IO over the medium and long term.

Interdisciplinary collaboration

The different members of P2IO are widely open to other fields and have strong collaborations on interdisciplinary subjects with other labs and institutes. These collaborations range from research with lasers on plasma for astrophysics and new accelerator technologies, to technological development on nuclear magnetic resonance for medicine and condensed mater studies, from the construction of high field magnets for fundamental research to innovative accelerators for material investigations and new light and neutrons sources. These collaborations are often performed on the basis of local initiatives from the various teams or labs forming P2IO. The creation of P2IO will introduce coherence between the various actions leading to an increase of the impact of P2IO on interdisciplinary researches. This is particularly true for the technological researches presented in the P2IO project and for the 2 fields of applications put in first priority: therapy and diagnostic in medicine and nuclear energy with both fusion and fission.
The creation of P2IO will also benefit to other field of interdisciplinary researches, P2IO being a good framework for individual expertise's and ideas to cluster by joining forces into a structured research project.
Moreover, the P2IO Labex will be a new partner at the campus level and on the national and international scene able to initiate new prospective studies and discussions with other fields.

In particular, it is foressen to implement close ties between this LABEX initiative and other proposed LABEX structures such as PALM, with strong emphasis on laser and plasma physics and PIM, at the physics and medicine interface.
P2IO will be a new structure open to new collaborations and new interdisciplinary researches. It will have the critical mass to bring its knowledge and technologies to other fields and to initiate common activities.

5. DESCRIPTION SCIENTIFIQUE ET TECHNIQUE DU PROJET / TECHNICAL AND SCIENTIFIC DESCRIPTION OF THE PROJECT

5.1. ETAT DE L'ART / STATE OF THE ART

P2IO laboratories cover a large interdisciplinary spectrum with nuclear physics, particle physics, astrophysics and astroparticles studies. They encompass all aspects of these fields from theory to technology going through experiments. They are involved in all major experiments for these fields of all type: using accelerators and cosmic rays with observatories on the ground, underground, under the sea or in space. This clustering of sciences and technology is unique in France and has rare equivalents around the world. Joining the research forces from so different point of views will allow addressing the most challenging problems of the infinitely large and the infinitely small Universe, from the very first time of the Big-Bang to the future of the Cosmos, from the origin of matter to the conditions for the emergence of life. Moreover, all P2IO partners are already involved in the development of the applications of their knowledge's and know-how's. P2IO will be the opportunity to strengthen this opening to other fields and societal issues by acting collectively and gathering expertise from various labs. Among this very rich scientific portfolio, P2IO has selected a small number of themes which contains the most promising scientific potential for discovery and which will benefit most of the collaboration with P2IO members. P2IO international scientific panel will review these choices after an initial period of 3 years, and reassess the situation regarding the emerging P2IO interdisciplinary themes.
P2IO program is focused 4 hot scientific questions: symmetries in the subatomic world, dark components of the Universe, strongly coupled nuclear matter, formation of stellar systems and conditions of the emergence of life. To be able to address these issues in the present and new generations of experiments 3 technology-oriented themes have also been identified: innovative developments in new accelerator science and their related spinoffs, advanced sensors and spinoffs, data mining and simulation. Finally, both the science and the technology mastered and developed by the P2IO partners will be applied to two interdisciplinary topics with direct connection with the French national priorities (SNRI): nuclear energy for the future, health: new methods in imagery and therapies.
A set of general references for each of the P2IO Labex thematics is given in section 7.1.

5.1.1 S1 SYMMETRIES IN THE SUBATOMIC WORLD

Symmetries are the most powerful tools at our disposal to build theories describing the structure and the dynamics of the subatomic world. The major achievement of the Standard Model, built in the 60-70s, thoroughly tested during the LEP era and still under close scrutiny at Tevatron, exemplifies the fruitfulness of this approach. The Standard Model passed an impressive amount of precision tests. No discrepancy has

been found so far. The only piece which is still missing in this frame is the Higgs particle. It has not yet been detected although experimental bounds from LEP and Tevatron have restricted the allowed region for its mass to a rather narrow window. The hunt for the Higgs will be a major task for the LHC. P2IO partner laboratories are forefront players in these activities.

Nevertheless we know the Standard Model cannot be satisfactory: for example it is unable to explain the observed matter/anti-matter asymmetry, it has no dark matter candidates, no description of neutrino masses, no link to gravitation. A lot of alternatives have been proposed by theoreticians to go beyond the Standard Model. These proposals are using different extra symmetry structures (Grand-Unification, supersymmetry, extra-dimensions, ...). Although the constraints coming from the high precision tests of the Standard Model are already very stringent, experimental inputs are clearly needed to restrict the speculations and to help the realization of the next breakthrough.

Another realm with symmetry at its heart is the study of CP violation. An enormous effort, both from the experimental and the theoretical sides, has been devoted to this important topic. Investigated from high precision tests in kaon physics, to the study of the B mesons at B-factories (BaBar, Belle) and still active at Tevatron, this field will be pursued and extended at LHCb.

The searches for supersymmetry and CP violation, which are in the foreground in the subatomic world, are also of relevance for the large scale in the Universe. Supersymmetry can provide candidates for the Dark Matter and CP violation is a key ingredient for the matter/anti-matter asymmetry. P2IO partner laboratories have expertise on these topics on both scales.

To reveal New Physics or to analyze in detail CP violations from experiments, a sufficiently good control of the strong interaction is required. Besides, the strong interaction sector has a very rich dynamics by itself, due to its gauge SU(3) symmetry, and a full understanding of confinement, as well as the behaviour of high energy cross-section, are among the oldest problems of particle physics which are still open. P2IO laboratories are involved in various aspects of the strong interaction (QCD plasma, diffractive physics, …). Analytical tools, massive numerical simulations or approach based on new (conformal) symmetry are mastered by teams within P2IO, at the highest international level.

Concerning nuclear physics, one of the key questions is: *What are the origins of simple patterns in complex nuclei?* One fundamental goal of nuclear structure physics is to evidence regularities and simple features of nuclear spectra, providing a comprehensive understanding of the origin of such regularities in the complex nuclear many-body systems. These features are known to be associated with the so-called dynamical symmetries, which include both symmetries of the mean field and symmetries of the residual interactions among the particles, and which are characterized by definite underlying algebraic structures.

5.1.2 S2 DARK COMPONENTS OF THE UNIVERSE

Astroparticle physics is an interdisciplinary scientific field that appeared at the end of the seventies. Together with cosmology, which entered about ten years ago in a mature phase characterized by the first precision cosmological measurements, this field is today expanding rapidly, with exciting discoveries on Dark Matter and Dark Energy, which represent more than 95% of the universe energy density. Important results have been obtained recently on the physics of the primordial Universe using in particular the cosmological background radiation, on the geometry and expansion of the Universe using supernovae as standard candles

and baryonic acoustic oscillation (BAO) correlations and on violent events in our Universe with the development of gamma-ray, neutrino and ultra-high energy cosmic ray astronomies.
The impressive vitality of this field is related to a new generation of experiments in strong relation with phenomenological and theoretical analysis. This is particularly true of astroparticle physics and cosmology in France, which lies at the forefront of international competition, e.g., with the US (which benefits from much larger human and financial resources) as well as Germany and Japan as leading actors.
Over recent years, the scientific priorities of the astroparticle and cosmology fields have been defined through a series of roadmaps assembled together by the European and US agencies. In Europe, the ASPERA and ASTRONET roadmaps have defined the scientific priorities for Astroparticle physics, with seven top-priority projects. The P2IO laboratories have developed important contributions to several leading projects of the ASPERA roadmap: these include very high energy gamma-ray astronomy with the design study and later construction of CTA (Cerenkov Telescope Array), ultra-high energy cosmic-rays with AUGER, Dark Matter direct detection with EDELWEISS and EURECA (a European project for a 1-ton Dark Matter detector), the determination of the electron neutrino mass and properties with a 1-ton double beta decay experiment, the neutrino telescope ANTARES and the next generation KM3.
The P2IO laboratories also study the role of Dark Energy, which represents 73 % of the energy density of the Universe. The nature and properties of Dark Energy are presently unknown and this question is now central in cosmology, as testified by the presence of ambitious space missions in the Cosmic Vision programme of ESA (EUCLID) and in the US decadal survey. Dark energy can be constrained from the distribution and properties of cosmological structures and galaxies formed in the Universe at redshifts between 1000 and 10.
Pioneering studies of the dark matter distribution have been performed using the gravitational weak lensing effect on elliptical galaxies. These ideas are at the origin of the DUNE/EUCLID mission, which has been proposed by P2IO members.
P2IO partners have developed the formalism and tools to correlate cosmological structures (as observed in the fluctuations of the cosmic background in the microwave but also in the infrared, to include galaxies) to tracers of baryonic matter like IR, X-Ray and Sunyaev-Zeldovich emission of galaxy clusters. Our studies show that these correlations can simultaneously constrain the cosmological parameters and the distribution of dark energy. These methods have been applied by the P2IO partners to the preparation of future space missions (DUNE/EUCLID), e.g. to constrain the sensitivity and wavelength coverage of the instruments.
The study of the dark components of the Universe is among the top priorities defined by both the ASPERA and ASTRONET roadmaps. In the following, we focus on this topic of high scientific priority, where the contributions of the P2IO partners will have the most visible impact and will represent one of the most significant actions of the P2IO LabEx.

5.1.3 S3 STRONGLY COUPLED NUCLEAR MATTER

The strong interaction, which is described mathematically by the theory Quantum Chromo-Dynamics (QCD), is the force which binds protons and neutrons together to form the nucleus of an atom and also, at a smaller and more fundamental scale, the force that holds quarks and gluons together to form the proton, the neutron and the other particles called ``hadrons''. Understanding nuclear and hadron structure and dynamics and all the complex phenomena and dynamics to which QCD gives rise is one of the big challenges of today's research. P2IO aims at conducting experimental programs at the forefront of this research domain covering some of its facets:

Nuclear structure: A real challenge is the understanding of nuclei very far from stability, these nuclei being the precursors in the formation process of the stable nuclei on earth. Nowadays, these nuclei constitute the *terra incognita* and efforts are made to study their properties in order to achieve the ambitious goal of understanding the limit of stability. With the start-up of new Radioactive Ion Beam (RIB) facilities and innovative experimental techniques, nuclear research stands on the verge of a new era, where a much wider range of proton-, neutron-rich and super-heavy nuclei will become accessible. New research challenges and significant investments have led to growing connections between nuclear physics and other fields, particularly nuclear astrophysics. In fact, many nuclear astrophysics problems are intimately connected to nuclear structure and reaction problems:

- The origin of chemical elements and the various paths of nucleosynthesis from the Big-Bang to massive stars explosions
- The study of dense nuclear matter in neutron stars and proto-neutron stars

These phenomena are also studied in P2IO from the astrophysics point of view allowing new possible synergies with observations and simulations.

Nuclear Dynamics: The understanding of excitation properties of nuclei requires the modeling of the dynamics involved in the nuclear excitation process due to the interacting nucleons or nucleons composite systems. Major advances are being made in nuclear theory in this regard. However, there is presently a real need to build a consistent microscopic theoretical framework unifying the description of bulk properties, nuclear excitations and reactions. Light nuclei and nearly bound resonances play a most important role, because their structure and reactions can be modeled using a variety of theoretical approaches, including quantum many-body methods using realistic nucleon-nucleon forces (called "ab initio" calculations). For heavy nuclei this approach is not yet possible. Therefore other methods which are based on effective forces (used to build the so called "nuclear energy-density functional") are becoming increasingly more refined, thanks to theoretical and computational advances. These methods also need stringent experimental tests in order to improve the predictive power of the theory.

Nucleon structure: This domain is vigorously studied through the use of medium energy high luminosity electron, muons or antiproton beams in the USA (Jefferson Laboratory) and in Europe (the CERN/compass experiment and the FAIR/PANDA facility in the near future). One aims in particular at extracting Generalized Parton Distributions (GPDs) and Form Factors in nucleons (and light nuclei) from elementary exclusive reactions on the nucleon. GPDs, whose theoretical formalism has emerged only about 10 years ago, provide a sort of tomography of the nucleon (position vs momentum distributions of quarks inside the nucleon) and describe its quark and gluon structure of the nucleon in an unprecedented way. They also allow in principle to access the contribution of quarks to the orbital momentum of the nucleon which is a fundamental quantity completely unknown today. Form Factors, which are integrals of GPDs, are also essential quantities to be measured: fr instance, they reflect the spatial distribution of electric charge and magnetism in the nucleon due to the quarks and gluons. Form Factors wil be measured with high precision in a largely unexplored kinematical region both at JLab and PANDA in the near future.

Quark Gluon Pasma: The study of QGP, the state of matter that is believed to have existed only a few micro seconds after the Big Bang, will allow us to understand how the elementary components of the matter are confined within the hadronic matter. This physics is now studied at RHIC and LHC at unprecedented high

energies with ultra relativistic heavy ion collisions, providing also a test of the QCD at very high energy density.
Among numerous results from RHIC experiments, it was shown that a state called sQGP for strongly interacting QGP was created. The sQGP has also the particularity to be the lowest viscosity state of the matter never seen. Now the LHC has delivered its first collisions with energy ~15 times higher than the RHIC one. The ALICE experiment has published 6 papers in 2010. These studies may have important consequences on our understanding of matter at very high energy density which can be encountered in the center of neutron stars or during the first microseconds of our Universe.

5.1.4 S4 FORMATION OF THE PLANETARY SYSTEMS AND CONDITIONS FOR THE EMERGENCE OF LIFE

Together with the origin of the universe (cosmology), presented in the preceding section, the origin of the solar system (cosmogony) and the emergence of life have attracted major interest since the dawn of scientific investigations. The last 10-15 years have brought major breakthroughs:

a) Increasingly sophisticated investigations of star formation regions in the near and middle IR have provided new insights on molecular clouds and star formation processes. Improved spatial resolution provided by Hubble and ground-based interferometers, and extension of the observed spectral windows towards millimeter range, have made it possible to monitor all stages of star formation from dense globules to proto-stars then young stars. Spectroscopy detection in the IR, sub-mm and radio wavelength ranges resulted in a drastic increase of the diversity and complexity of molecules observed in astrophysical environments. Gas-grain interactions are now considered to play a major role in the chemical evolution of the matter in galaxies. Laboratory simulations and spectrometry experiments have played a major role in identifying new molecular signatures.
b) The discovery of circumstellar disks then of the first extra-solar planet in 1995, which demonstrated that planetary formation is a common occurrence around other stars. 500 exoplanets are presently known. Even taking into account the observational bias in favor of large planets close to their star, it is already clear that exoplanetary systems can present characteristics which markedly differ from the solar system ("hot Jupiters", elliptical orbits). Our understanding of the photometric and spectral variability of the central star has proven to be a major limiting factor for decreasing the size of discovered planets and obtaining the first spectroscopic characterizations of transiting planets. In parallel, advances in dynamical modelisations of protostellar disks have demonstrated that planets can end up much closer to their stars than their birthplace.
c) The first in-situ investigations of comets (Giotto and Vega in 1986, then Deep Space 1 in 2001, Stardust in 2004 and Deep Impact in 2006 confirmed that comets have primitive characteristics such as the presence of a large complement of water and organic material. The analyses of the grains returned to the Earth in 2006 by Stardust cast a new light on mixing processes within protoplanetary nebulae, as few of these grains could be considered as candidate pre-solar grains having survived the early phases of the condensation process. In parallel, studies of micrometeorites collected in Antarctica demonstrated a broad range of composition, with strong evidence for particles with a cometary origin.
d) European and American missions to Mars have recently demonstrated that liquid water was present on the surface for several hundred million years in the early history of the planet, strengthening the case for the independent emergence of life on another planet than the Earth. The possible discovery of fossil life

on Mars is a question of fundamental scientific and philosophical importance, as it would demonstrate that the emergence of life is likely on any planet in the universe with similar favourable conditions.

These discoveries have set the stage for a worldwide pluridisciplinary effort addressing the formation of stars and planetary systems as well as the development of conditions favorable for the emergence of life (liquid water, complex organic molecules). P2IO partner laboratories have played a major role, as demonstrated by the list of references in annex 7.1. IRFU/SAp and IAS have been strongly involved in the first space IR observatory, ISO (ESA, launched in 1995) then in the exploitation of data from Spitzer (NASA, launched in 2003) and very recently in the preparation and first operations of two major ESA missions at sub-mm wavelengths : Planck and Herschel. Exoplanetary research is very active at IAS, with a strong involvement in the Corot mission (CNES-ESA, detection by transit, launched in 2006) and IRFU/SAp has made it a priority for development in the perpective of JWST, the next generation space telescope. IAS has played a major role in cometary exploration from Giotto and Vega to Stardust then the Rosetta mission which will be discussed in section 5.2. CSNSM is involved in Stardust and Rosetta, and it is a leading laboratory for research on micrometeorites. IAS and IRFU/SAp have strong programs of laboratory experiments, laboratory simulations and numerical simulations which aim at interpreting the results of on-going programs and at preparing the next steps, and other partner laboratories such as IPN have developed powerful relevant analytical techniques. IAS has played a leading role in Mars exploration, with the responsibility of IR imaging spectrometers which have provided breakthrough results on the history of the planet, and IRFU/SAp is also very active in planetary science.
P2IO partner laboratories have developed top level capabilities and they have secured high level science responsibilities on missions constituting the next major steps in this research area. They are therefore ideally placed to undertake the science program which will be described in section 5.2

5.1.5 T1 INNOVATIVE DEVELOPMENTS IN ACCELERATOR SCIENCE AND RELATED SPINOFFS

The state-of-the art of the present accelerators for research is based on the superconducting technology. Although progress remains to be made in that field as the physical limits have not been reached, it is felt that elements such as size of the accelerator, its cost… will limit the final performances. To go beyond, new ideas have to be developed and one of them is the plasma wake field acceleration. Electric field developed in the plasma can reach values orders of magnitude higher than those possible in conventional or superconducting cavities. That would reduce dramatically the size of the accelerator. Two ways are possible: generation of the plasma by a laser (LWFA, Laser Wake Field Acceleration) or PWFA (Plasma Wake Field Acceleration) where the plasma is induced by an electron bunch). The idea was proposed in 1979 and the proof of principle arrived a few years later. Since then, tremendous progresses have been made. If in the beginning, the produced beams had characteristics too far from a possible use, nowadays several groups focus on the improvements on the beam properties and very significant results are available. Among these research groups, some are in the Plateau de Saclay vicinity and are at the forefront of the race.
Laser proton acceleration has also been demonstrated and has also a great potential, in particular in medicine with protontherapy, the Curie Institute Protontherapy facility being on Orsay Campus, synergies are possible.
However, a vigorous R&D is necessary before this new technique can replace the present technology. This new field needs to put together specialists of different domains: accelerator, laser specialists…

Opportunities are widely open for applications: physics, medicine, material analysis… Potentialities are very large and putting together specialists of different fields leads to new very promising concepts, such as ThomX, based of interaction between accelerated electrons and laser, to produce very unique photon beams, the energy of these photons can be adapted to the use: antique objects analysis; medicine or nuclear physics.

5.1.6 T2 ADVANCED SENSORS AND RELATED SPINOFFS

Radiation detectors are essential parts of astrophysics, nuclear and particle physics experiments. In return, these scientific fields are very active in the quest of new sensors with increasing performance in terms of sensitivity and precision. The mastering of the physical basis and of the technology of detectors appears as a key asset in international competition which guarantees a high visibility inside physics collaboration and allows building instruments with the best scientific performance. The challenge doesn't lay only in the performance of sensors but consists also in its integration in very complex environments with severe requirements regarding mass, thermal dissipation, integration density, radiation hardness or cost.
The developments, performed in the frame of physics experiments, offer large opportunities for other scientific fields like biology or medicine. As an illustrative example, the PET scan technique can directly benefit from the discovery of new scintillating materials and of new data acquisition concepts.

Partner laboratories of P2IO have a significant potential in detector technologies dedicated to space instruments, ground observatories or accelerator experiments. More than 120 [check this number] researchers and engineers are directly involved in innovative instrumental developments and have already reached a high international visibility in bolometer techniques, gaseous micro pattern detectors, silicon based calorimeters, X/Gamma ray spectro-imagers or high performance front end electronics. P2IO researchers and engineers are largely involved in several ANR and FP7 programs dedicated to instrumental research for future experiments. 20 [check this number] programs are coordinated by P2IO members e.g. CESAR, GET, NECTAR, VITESSE, PMM2 [list to be completed]. The P2IO research teams have already developed several collaborations with high level European technological platforms like IMEC, LETI, MINERVE [list to be completed] and intend to take benefit from the creation of DIGITEO and NANOINNOV platforms.

Although partner laboratories have already reached a high level of national and international recognition, the synergies between the laboratories and the cross-fertilizations between the various scientific fields are not yet fully exploited. For example, cryogenics electronics developed for space applications can largely benefit to dark matter underground experiments and vice versa. 3D or deep submicron microelectronics technologies studied for the next generation of particle physics experiments can find new applications in space detectors. In this spirit, partner laboratories of P2IO have proposed to build new technological platforms as CRYOMATRIX and PH2ELICE in the frame of the EQUIPEX call for proposals. Other EQUIPEX proposed by P2IO as XUV or CRYOCUBE are also directly linked to the sensor field. These projects will reinforce and share the potential of partner labs in the field of cryogenic sensors, silicon based detectors and photodetectors.

5.1.7 T3 DATA MINING AND SIMULATION

The large experiments in Astrophysics, Nuclear Physics or Particle Physics have the common feature of providing an avalanche of data from which information has to be dug out. Extracting information from these data require: 1) a deep understanding of the experiments, acquired from extensive detector simulations,

laboratory tests and calibration, 2) sophisticated data analysis tools calling for advanced applied mathematics methods and 3) large computing and storage facilities and associated human resources.
The various communities have organized themselves to face the challenges of data reduction and have developed data centers. For example, particle physicists have largely developed grid computing for the LHC. Developing a data center represents an effort of the same order as the effort needed to develop a spectro-imager for a space telescope or a detector for an accelerator.
The P2IO partners have been strongly involved in various data centers for space missions (SOHO, XMM, INTEGRAL, FERMI, HERSCHEL, PLANCK...), large ground-based telescopes (CFHT/MEGACAM, VLT/VISIR, HESS...), nuclear physics or particle physics experiments (AGATA, ALICE, Babar, D0, ATLAS, CMS…).
High performance computing is now considered as the third pillar of modern science, together with theory and experimentation/observation. The importance of high performance computing has been fully recognized and important investments are made in France in the frame work of GENCI ("*Grand Equipement National de Calcul Intensif*") and at the European level in the framework of the Partnership for Advanced Computing in Europe (PRACE). High performance computing is playing a major role in astrophysics, with growing importance over the last decade. P2IO partners have pioneered the field and organized the French community, for example in the framework of the Horizon project to simulate the so-called "structuration of the Universe".

5.1.8 I1 ENERGY : NUCLEAR ENERGY FOR THE FUTURE

From the beginning and all along its history, fundamental knowledge and technological developments in Nuclear Physics have stimulated and fertilized research and applications in a variety of other fields. The growing interest of these interdisciplinary research areas is boosted either by the relevance of the domain itself, or by new possibilities offered by recent developments of nuclear techniques and tools. The coming century may see the end of standard fossil fuels, coal, gas and oil, which represent today 80% of the world energy production. Moreover, their use contributes to the emission of the greenhouse gas CO2. In this context, nuclear power appears as an important energy source available today, able to respond significantly to the growing world energy demand. Some scenarios consider a nuclear energy production of around 5 GTOE/y in 2050, which would represent 20% of the total produced energy. But a large and significant production of nuclear energy requires the development of innovative systems, minimizing the need of natural resources, the production of waste, and increasing the safety and resistance to proliferation.

Research in nuclear energy concerns the simulation of the neutronics and safety of different innovative systems and associated scenarios, as well as experimental measurements of nuclear data and reactor physics. Another aspect is the use of nuclear technologies developed for fundamental research that can be applied in the exploitation of reactors or for safeguard purposes. Different reactors or fuel cycle are presently explored in terms of breeding capacities, waste production and safety constraints: fast critical reactors (sodium, lead, gas), hybrid systems dedicated to minor actinide transmutation, thorium cycle (water moderated reactors, fast reactors, liquid fuels, and others.), fusion reactors with the development of high field superconducting magnets and the development of new materials resistant to the high neutron flux. New methods of simulation, based on deterministic or stochastic codes must be improved in order to ameliorate the accuracy of calculations concerning fuel evolution, power distribution, material activation and damages, and

sensitivity to nuclear data. Safety aspects require the coupling of three-dimensional neutronics and thermal hydraulics codes, as well as fuel modeling in nominal or accidental conditions.

Nuclear data activities are nowadays organized along several schemes, on a national level through entities like GEDEPEON, on a European level in the JEFF project and through the EC framework programmes, and on a worldwide scale through the OECD-NEA and the UNO-IAEA. The most important cross-sections to be measured or re-evaluated have been listed by several expert committees (OECD-NEA). The European Commission has also guaranteed its continuing support to these activities through the recently started FP7 project ANDES. P2IO has teams and experts involved in all these activities, and is in a unique position to bridge the gap beween nuclear physics research and nuclear engineering.

5.1.9 I2 HEALTH CARE : INSTRUMENTS AND METHODS FOR THERAPY

Throughout of its history, nuclear physics has always deal with interdisciplinary repercussions, often turned towards Biology and Health. These contributions has led to development of instruments, methods and facilities which, besides giving access to a better understanding of biological processes, have a large impact on health-care systems. Despite this success story based on « spontaneous » exchanges, this collaboration process is not suited to the current growth of Life Sciences anymore. Life Sciences research currently deals with instruments and quantitive methods even more and more specific and powerful as well. Therefore, connexion between physicists and biologists or physicians has to be much more proactive today. Facing these issues, the scientific and technical potential of P2I researchs remains widely underexploited, especially in France. That is the reason P2I community decided to bring at a higher priority level the Health/Life Science (HLS) interface with respect to knowledge breakthrough and societal missions as well. This strategy is growing up worldwide (US DOE and NIH are jointly working on that topic) and French IN2P3-CNRS recently decides to include the HLS interface among its other scientific axis by creating and funding IMNC laboratory (one of its 20 labs France-wide network). IN2P3 also hosts today an open national network “nuclear tools and methods for the cancer therapy”. Irfu has an important activity in the application of nuclear science and technologies to biology and medicine. Using its expertise on the superconducting magnets and on radio frequency Irfu is involve in different innovative NMR systems including the flagship of the 11.7 Tesla full body ISEULT magnet. Another axis of involvement concerns fundamental biology for which instruments and methods for small animal in vivo imaging have also been developed by P2I teams, especially for neurosciences research. The development of an innovative TeP is also done at Irfu. Thanks to unique intrinsic sensitivity and promizing developments of new high specificity radio-tracers, molecular and functionnal imaging remains a powerfull tool for clinical diagnoses and for therapy monitoring purposes. Current trends in HLS interface with nuclear physics put forward integrated and compact multi-modal imaging systems, innovative and compact accelerators for radiotherapy and development of accurate quantitative methodologies ensuring the best efficiency of these instruments with respect to the patient. In order to address these issues successfully and when compared to others sites worldwide, P2IO potentially combine an unique concentration of high-level skills in physics and technology and efficient structures of interface with HLS as well. Because this last point is a crucial issue, it also constitutes a major factor of originality and competitiveness of our P2IO project.

5.2. OBJECTIFS DU PROJET PAR RAPPORT À L'ÉTAT DE L'ART ET LIENS AVEC LA SNRI/ OBJECTIVES OF THE PROJECT COMPARED TO THE STATE OF THE ART AND IN RELATION TO THE SNRI

5.2.1 Présentation scientifique du projet de recherche/ Scientific programme

As mentioned above, the P2IO project is focused on the most important questions about the Universe at the smallest and the largest scale and about the associated key issue of the origin of the world up to the creation of the condition for the emergence of life. This quest can be broken down into 4 hot scientific questions:
(S1) symmetries in the subatomic world, (S2) Dark components of the Universe, (S3) Strongly coupled nuclear matter and (S4) Formation of the stellar systems and conditions for the emergence of life. P2IO will also focus on 3 key Technological developments (T1) Innovative developments in accelerator science and related spinoffs, (T2) Advanced sensors and related spinoffs and (T3) Data mining and simulation

The interdisciplinary applications of P2IO are directly related with the fact that all the fields of P2IO are using radiation to probe and/or observe the Universe structure at small and large scale. Together with the fact that one essential source of energy at small and large scale is the nuclear energy, P2IO can have a strong impact on two fields of applications with direct connection with the French national priorities (SNRI): (I1) Energy : nuclear energy for the future and (I2) Health : new developments of imaging and therapy.
These 9 items offer promising and novel research opportunities with the P2IO labex thanks to the complementarities and synergy between experimental approaches developed in different laboratories often associated with a hich level of leadership, between the different disciplines and in particular between subatomic physics and astrophysics and last but not least between experiment and theory.
The bulk of the P2IO budget will be invested in two calls for proposals to support these very exciting themes. These calls will focus on the very upstream (preliminary and very exploratory R&D) or very downstream (data exploitation and valorization) segments of the various projects since only the core of the projects is really well covered by P2IO funding agencies. This is why we expect a strong scientific impact of this LABEX initiative even it represents an overall small fraction of the total P2IO projects funding. A first call , with a budget of 500 k€ par year, will be based on human resources (HR call) at the post-doc, PhD and senior levels will support critical analysis projects around the questions mentioned above. The second call with 1,09 M€ annual budget will address targeted upstream R&D (RD call), and operating support to the relevant P2IO common technological platforms. The main selection criteria will be the potential of innovation and the impact of the projects on the technological and scientific competitiveness of P2IO.
The P2IO Labex added value, in addition to the supplementary funding in critical issues described above, will stem out of the new dimension of inter-laboratory and interdisciplinary collaborations brought by the P2IO structure.
A very intense scientific animation will be organized in P2IO Labex with support from the various partners and hopefully at the IDEX level and is not described in detail in this document.
P2IO Labex education actions are innovative and will result in a much stronger collaboration between P2IO partners. They address all levels of education from L1 to PhDs.

- *S1 Symmetries in the subatomic world*

P2IO Labex will focus its efforts on two of the most crucial symmetries and their violation in particle physics: the electroweak symmetry and the matter-antimatter symmetry. As mentioned in section 5.1, the quest for

the Higgs boson and the corresponding detailed understanding of the electroweak symmetry breaking will be at the heart of the program of this next decade. The search for new symmetries such as super-symmetry, a hypothesized symmetry between bosons and fermions will be central in that respect since the Stand Model does not explain the stability of the Higgs boson mass with regard to radiative corrections which is on the contrary implicit in these models. Since the strength of the P2IO LABEX lies in its composition which mixes theory and experimental teams at the highest international level, P2IO actions in this field will take the form of joint proposals to explore further the impact of the results that will be coming from the LHC and Tevatron colliders. P2IO teams will further improve through targeted calls the combining tools they have already offered to the community such as CKMfitter, UTfit, or Sfitter. Improved constraints for Standard model Higgs boson , supersymmetric Higgs, or Higgsless models will result from these detailed phenomenological work which will include both the searches for new particles and the precise measurements of the properties of the W boson and top quark masses, all topics in which P2IO teams play a leading role in ATLAS, CMS and D0 experiments. P2IO calls will reinforce the experimental and theoretical workforce and enable to "embed" young theorists in experimental groups so they make optimum use of the existing expertise.

Towards the second end of the decade, the calls will also cover in a similar way the role and impact of a future linear collider which will become much more concrete by then. A few very high potential R&D projects covering both LHC detector upgrades and LC detectors will also be eligible.

On the matter anti-matter front, the experimental situation is more complex since, as explained above, many new projects with a strong P2IO participation and leadership will attack this front in the quark sector (SuperB factories, LHCb upgrade, rare K decays experiments) as well in the lepton sector (rare muon decays, accelerator based neutrino experiments, double beta decay experiments,…). P2IO actions will therefore be more project oriented with dedicated support to the most innovative R&D ideas and projects and will support promising emerging international collaborations in parallel with the same phenomenology-oriented calls described above. The unique experimental expertise gathered by P2IO teams in all these projects will enable a very fruitful dialogue with present and new theorists. In addition, for both groups, the constraints coming from the "infinitely large" scheme and from QCD and lattice QCD results will be integrated in the best possible way thanks to the presence within P2IO teams of the expertise in all these fields. As an example, neutrino mass constraints from analysis of the PLANCK satellite results should be very stringent and therefore will require in-depth analysis. P2IO LABEX will organize workshops and dedicated actions on these topics.

- *S2 Dark Components of our Universe*

The P2IO partners propose to focus on the question of the nature and properties of the dark components of the Universe, Dark Energy and Dark Matter. As indicated in 5.1, this scientific question has been placed in top priority by both the ASPERA and ASTRONET roadmaps and we expect the contributions of the P2IO partners in this field to be important and of high scientific visibility.

Concerning Dark Matter, the proposed support program will have two main axes: the first axis will be direct detection, with emphasis on the prototyping and, in a second stage, the construction of the next generation of dark matter experiments, the present main contenders being EURECA and XENON-1ton. P2IO partners CSNSM, IAS and IRFU have leading contributions in experiments that should reach in a near future the required sensitivity to test models of supersymmetric particles with detectable signatures. Both the European and the US agencies are expected to take a decision on future large scale dark matter experiments around

2013 and the support of the P2IO LabEx will greatly benefit to the development program of the P2IO partners on this question. P2IO partners also have the potential to develop ambitious R&D programs in order to increase the sensitivity for the next generation of detectors. In particular, the CRYOMATRIX and the PH2ELICE platforms proposed in the context of the 2010 EquipEx call will structure the activities of innovative developments in cryogenic detectors and photodetectors (see the T2 section below).
In parallel, new synergies will be developed within P2IO between particle physics studies and Universe observations. Indeed, to search for supersymmetric particles an intense experimental and theoretical activity is developing around the LHC program, with key contributions from IRFU, LAL, LLR, IPhT, CPT and LPT. On the other hand, the FERMI/LAT mission and the HESS-2 experiment (and its successor CTA, presently in the design study phase) will provide indirect detections of dark matter that should constrain the nature of supersymmetric candidate particles. Additional constraints may be obtained from the Antares project, to which the IRFU partner brings an important contribution.The creation of P2IO will strengthen our contribution to the above projects and attract new researchers. Support from the P2IO LabEx will also strengthen the leadership of the P2IO partners in the ambitious KM3 project, where P2IO contributions obtained through the HR and RD calls will be critical to support the design study phase, and aiming at a kilometer cube underwater detector for dark matter, which also has strong links with environmental studies.
P2IO will also benefit from strong theory groups (CPT, IPhT, LPT), which will work on optimizing the analysis tools and the detection strategy of dark matter particle candidates.
The added values of P2IO will be both

- to foster a coherent program throughthe HR and RD calls including all the ways to constrain dark matter, in order to provide a global picture about this key issue
- to initiate new synergies between the various detection strategies and between experiment and theory

Concerning Dark Energy, the role of P2IO will be similar. P2IO partners will focus on the development of ambitious and complete observation programs through stronger and broader collaborations and through the combination of information coming from various experiments, taking advantage of the important role of P2IO partners in different programs and of the COGIS facility. The first asset of P2IO is the important contribution and role of P2IO partners in the Planck mission. Full expoitation of Planck invaluable data set wil be greatly enhanced thanks to the P2IO support via the HR call. The creation of P2IO will reinforce the collaboration and impact of P2IO partners on the physics of the cosmic microwave background, an essential observable to constrain the geometry and cosmological parameters of the Universe. The P2IO group also has the potential to strongly contribute to the study of Baryon Acoustic Oscillations (BAO), a powerful tool to constrain dark energy, with BOSS and new generation projects such as BAO-radio or BigBOSS projects,. The same dynamics also applies to the ambitious US program LSST (Large Synoptic Survey Telescope) project. Moreover, P2IO will allow the sharing and transfer of the knowledge and expertise in the various fields and will put together researchers from different generations of experiments as, for example, on the supernovae studies. For the future, the EUCLID satellite mission is the most important European dark Universe program. IRFU and IAS have a leading role, at the PI level, in this mission, which focus both on weak lensing effects and BAO. The creation of P2IO will open this collaboration to all partners.

This ensemble of experiments will collect unprecedented amounts of data with very complex observables. Data treatment and data mining will be key issues, a key topic addressed by the COGIS EQUIPEX program proposed by P2IO. The analysis of this data will involve a strong link between P2IO experimental and theory groups, a high priority of the HR call.

In this respect, P2IO also has the ambition to be a first player in simulations. This activity is already strongly developed and recognized, as demonstrated by the ensemble of ERC grants received for this type of activities. To strengthen the data analysis, P2IO will make this expertise available to all experiments.

Combining the various experiments with the theoretical developments and simulations, P2IO will have a direct impact on the extraction of the cosmological information and on the control of systematic errors.

The S2 domain relies very heavily on novel sensor technologies, the main goal of the P2IO T2 RD call, described in the relevant section.

- *S3 Strongly coupled nuclear matter*

Future activities of P2IO will be concentrated along the three major axis of research outlined earlier (see section 5.1.3)

i) Nuclear Structure and dynamics

Significant efforts are being taken to make inroads into the unchartered territory of exotic nuclei by developing new techniques and accelerator facilities to produce beams of unstable isotopes, so-called rare isotope or radioactive beams (RIBs, e.g. at SPIRAL2, FAIR and on the more distant horizon at the proposed EURISOL facility). In this connection, nuclear reactions play a major role and therefore further developments of reaction theory and connections with nuclear structure, possibly microscopic and *ab initio*, should be an important aspect for future investigations.

The realisation of this program requires the availability of both RIB and stable-ion beam (SIB) facilities, along with the development of new experimental techniques and instrumentation. New dedicated facilities delivering high intensity heavy ion beams are needed for the synthesis of new super-heavy elements and to investigate their properties. Several smaller accelerator facilities are also essential for specific experiments requiring long beam times or for developing and testing of new instruments. This will ensure that experiments are carried out on many fronts by a large user community, and, very importantly, will provide training to the next-generation researchers. This is particularly the case for P2IO with the availability at IPNO of the ALTO radioactive beam facility and the tandem accelerator. For instance one of the projects, the ANDROMEDE EQUIPEX proposal, which emerged within the LABEX P2IO is building a dedicated state of the art high intensity nano-particle and heavy ions accelerator.

ii) Nucleon Structure:

The perturbative treatment of the interaction interaction processes, starts to fail when the distance between quarks becomes comparable to the size of the nucleon. In this case, the interaction becomes so strong that very complex phenomena emerge, which are and will be investigated in electron/positron/muon-scattering experiments on nucleons at MAMI in Mainz, ELSA in Bonn, HERMES at DESY, COMPASS at CERN and Jefferson Lab (JLab) in the US. From such experiments, one can obtain 'snapshots' of the internal structure. Depending on the energy of the projectile, such snapshots provide position or momentum distributions of the quarks inside a hadron. However, a consistent description of hadron properties, such as their spin, has still to be achieved from the measured photon or particle distributions. This will be studied in future experiments at the upgraded COMPASS and Jefferson Lab facilities, or new lepton scattering research

infrastructures such as the proposed Electron-Nucleon-Collider, ENC, at FAIR or the Electron-Ion-Collider, EIC, at either Brookhaven National Laboratory, BNL, or JLab. Whilst the large set of excited hadrons discovered in spectroscopy experiments is clear evidence for quark degrees of freedom, unexpected spectroscopic results at e.g. BELLE have recently challenged the picture of hadrons being composed of quark-antiquarks or three quarks only. They indicate a much more complex structure of perhaps multiquark or quark molecule character. One of the most promising experiments to search for these exotic hadrons in the future will be PANDA at FAIR.

iii) Quark-Gluon Plasma

Research at the LHC, using the large dedicated detector ALICE for the study of energetic nucleus-nucleus collisions will push our experimental understanding of the QGP back to about a nanosecond (one billionth of a second) after the Big Bang. Central questions are connected to understanding the symmetry breaking mechanisms that determine the properties of various phases, for example the masses of quarks and the masses of hadrons, via chiral symmetry breaking. Symmetry breaking is central to a wide class of problems in all areas of physics. The experimental program with ALICE at the LHC has just started and it is a central priority that the long-term continuity of the program is assured with a variety of beams and detector upgrades to provide unique new fundamental physics information over the next decade or longer.

- *S4 Formation of stellar systems and the conditions for the emergence of life*

The observation of molecular clouds, star formation regions and protoplanetary disks benefits from the opening of the sub-mm wavelength range with the Herschel space telescope (ESA). They will be complemented in 2012 by interferometric observations with ALMA, which will provide a resolution of a few μrad in the mm-wavelength domain. The JWST space observatory, a joint NASA-ESA program, will be launched in 2015. It will improve on performances of the Hubble space telescope in the visible and near-IR, expanding these capabilities to the middle IR with a focal plane instrument under European responsibility, MIRI. The high spatial resolution and spectrometric capabilities of Herschel, ALMA and JWST will make it possible to closely monitor the role of gas-dust interactions in star formation regions and circum-stellar environments. The P2IO laboratories, in particular IRFU and IAS, are involved at a high level of responsibility in Herschel and JWST. The ongoing laboratory simulation programs will be critical for interpreting new spectral signatures from the near-IR to the sub-mm wavelength ranges. The 2010-2020 time frame will also be critical for developing the required technologies for the post-2020 programs, such as new detectors with lower noise and higher quantum efficiency.

These new observatories will for the first time provide direct information on planetary formation processes at scales relevant for the rapidly expanding field of exoplanet detection and characterization. The COROT and Kepler space observatories (transit) and ground-based observations (radial velocities, astrometry, μ-lensing) are daily increasing the number and diversity of exoplanetary systems, exoplanets being discovered with sizes ever closer to that of the Earth. The next step for transit detection is Plato, a major mission proposed for a launch in 2018. A major limiting factor on the detection capability of transit methods is our understanding of the brightness and spectral variability of central stars. There is therefore a rapidly developing relationship of exoplanetary research with solar and stellar physics (asteroseismology and coronal physics, IAS). This relationship is becoming even more critical for the spectral characterization of exoplanets, which is required for detecting planetary atmospheres, hence the potential habitability of exoplanets. Numerical modeling efforts in P2IO laboratories will further improve our understanding of the

formation and early evolution of planetary systems. The 2010-2020 time frame will also be critical in preparing the post-2020 interferometric programs which will make it possible to obtain direct spectral information on non-transiting exoplanets.

Missions to primitive solar system bodies, comets and asteroids, provide information on planetesimals which have survived the final stages of the formation of the solar system. After the successful fly-by of asteroid 21 Lutetia in July 2010, the ROSETTA mission of ESA will rendez-vous with a comet in August 2014. Several P2IO laboratories are involved in this major mission. IAS has a major science responsibility on the Philae lander which will investigate in-situ the cometary nucleus, with a panoramic camera system and a VIS-NIR microscope for studying cometary samples. It will be possible to directly compare the in-situ and remote sensing results on cometary material with the grains collected by the Stardust space mission during its high velocity fly-by of comet Wild-2 and with micrometeorites collected in Antarctica which include dust particles of cometary origin. The CSNSM Antarctic meteorite collection will be upgraded as a curatorial facility with P2IO support so as to open it to the international community. The interpretation of the results obtained on laboratory samples and with in situ instruments will greatly benefit from the expertise in these analytical methods developed in P2IO laboratories. Shortly after 2020, the BepiColombo orbiter mission to Mercury will provide new insights on planetary formation processes near the central star.

In-situ analyses of cometary material and comparisons with laboratory analogs as well as carbon- and volatile-rich micrometeorites will provide strong constraints on the possible role of extraterrestrial matter in the origin of life on Earth and possibly on Mars. The rapidly developing research field dedicated to the conditions for the apparition of life will strongly benefit from two Mars rover programs launched in 2011 and 2018. The most promising landing sites for these two missions are those where liquid water was present in the early stages of the history of Mars (see 5.1). The next major step will be a Mars sample return program, likely to be scheduled in the 2025 time frame. While it lies beyond the time frame of the Labex, this perspective fully justifies the initiation of upstream research and development programs for developing the sophisticated analytical capabilities required for detecting possible evidence for fossil life. Several P2IO laboratories have expertise which can be exploited in non-destructive and destructive analytical methods. The first developments could be tested on extraterrestrial samples available in the laboratory (e.g. micrometeorites), or samples brought back in 2013 by the Phobos-Grunt Russian mission.

The P2IO Labex will strongly benefit these major science goals by developing the collaborations between partner laboratories, providing opportunities for visiting senior scientists, post-docs and PhD students (HR call), and supporting up-stream research and development programs which are essential in this research domain (RD call). It has a strong appeal for students, which together with the technology aspects will be a major asset for education programs with P2IO participation.

- *T1 Innovative developments in accelerator science and related spinoffs*

To address key P2IO scientific issues, three frontiers have to be overcome: the high intensity frontier, the high luminosity frontier and the high energy frontier.

P2IO will provide new opportunities to perform collective research and development on the various frontiers of particle accelerators. Sharing technological platforms is a key issue for the development of this technology. This high-tech activity provides opportunities to transfer technology to the industry and to

perform common R&D. Accelerator technology has many applications to other basic research field (eg neutron and light sources) and to nuclear energy and nuclear medicine.
A common key point is beam dynamics which should focus both experimental and theoretical effort. The intensity frontier requires also innovations in accelerating structures and in the beam production (sources) of stable or exotic particles as well as antiparticles such as positrons. The high luminosity frontier calls for new cavities and magnets such as high Tc superconducting magnets.
As far as the high energy frontier is concerned, the state-of-the art of the present accelerators for research is based on the superconducting technology. Progress remains to be made in that field as the physical limits have not been reached. Joining forces and expertises within P2IO will be a way to address the bottleneck of this technology and perform innovative R&D. Alternative technologies to access high field gradients should be investigated. To go beyond present limitations, new ideas have to be developed and one of them is the plasma wake field acceleration. Electric field developed in the plasma can reach values orders of magnitude higher than those possible in conventional or superconducting cavities. That would reduce dramatically the size of the accelerator. Two ways are possible: generation of the plasma by a laser (LWFA, Laser Wake Field Acceleration) or PWFA (Plasma Wake Field Acceleration) where the plasma is induced by an electron bunch). P2IO partners and other laboratories on the Saclay plateau are at the forefront of the race. A R&D platform (CILEX equipex proposal) including a laser and an electron accelerator will enable to study both LWFA and PWFA.
Opportunities are widely open for applications which will benefit from the collaboration between specialists in different fields in the P2IO framework. Laser proton acceleration has a great potential in medicine with protontherapy (Curie Institute Protontherapy facility in Orsay). Irfu is already involved in hadron therapy with the IBA company working on a project for developing new gantry technologies. The ThomX Equipex proposal explores the production of X-rays through Compton interactions between accelerated electrons and lasers (see I2). P2IO RD calls will be highly beneficial for the development of these new techniques.

- *T2 Advanced sensors and related spinoffs*

The development of advanced detectors is critical for P2IO research fields. Projects supported through the RD call will focus on upstream developments with the aim of preparing CNES R&T programs or ANR proposals. Some topics can already be identified as short term goals:

- Cryogenic detectors offer a wide field of applications ranging from direct dark matter search to CMB probes. This theme can give rise to innovative projects in active cryogenic devices, detector techniques (bolometers, Transition Edge Sensors) and related ultra-low temperature Front End Electronics with very low thermal dissipation.
- Bi-phase noble gaz detectors using electron amplifiers in the gaz phase and scintillation detection in the liquid are a promising emerging low cost technology for large mass dark matter experiments.
- 3D microelectronics technologies which are still in development at an industrial level offer new opportunities for highly integrated tracking devices or large space sensors combining semiconductor sensors with low noise and low dissipation electronics.
- New scintillators coupled with fast pulse shape analysis offer very promising applications in nuclear spectroscopy and can find direct applications in nuclear medicine.

- Devices operating with picosecond precision range are required for the future particle physics experiments as High Luminosity, High Energy LHC or Super B. This includes Micro Channel Plate phototubes as well as related microelectronics.
- Specific developments will be required for miniaturized photon detection devices on planetary landers or rovers.

By focusing R&T programs on some promising topics and by creating inter-laboratories teams with a critical mass, P2IO Labex will offer new opportunities to answer jointly to CNES, ANR or EU calls for proposals. This criterion together with the number of common publications or patents will be one of the most pertinent indicators to evaluate the impact of P2IO initiative

- *T3 Data mining and simulation*

The strong involvement of P2IO partners in large space-based instruments, in large ground-based observatories, large project in nuclear physics experiments and in particle physics experiments makes them well prepared to face the challenges on short- and mid- terms scales. In addition the fact of pooling resources and expertise, as proposed, for example, in the framework of the COGIS EQUIPEX, will strengthen the possibility of involvement in future projects and allows ambitious goals at the international level.
In order to take up these challenges, new computing infrastructures like grid computing have been put in place and evolution of such infrastructures like cloud computing have to be developed. Thanks to important investment at French and European level, we will have access to the next generation of supercomputers, which will reach the Exascale in floating point operations. The supercomputers will be increasingly complex to use and we will have to face great technical challenges to be able to port our current applications on such machines. Beyond the necessary algorithmic developments, we will have to face many paradigm shifts in the hardware, with the advent of heterogeneous architectures (multi-core nodes, GPGPU) with a small mean time to failure. This will require the necessity to implement new techniques in code optimization, taking advantage of various fault tolerant strategies. Simulations will generate a large amount of data which will be analyzed in conjunction with various observational dataset, requiring a joint effort in data mining and storage. These topics will be the central themes of the P2IO grants in the T3 domain.
To exploit fully the data, sophisticated methods of data analysis are needed, such as methods to detect very faint events embedded in noise, to analyze time series from irregularly spaced observations, to analyze spatially clustering processes, to treat censoring and truncation, heteroscedastic measurement errors. Advanced statistical methodology serves many research communities and is constantly enriching its methodology and capabilities. Astrostatistics today is a growing cross-disciplinary enterprise. It exists officially in few universities in US and England; P2IO has the ambition to further develop this thematic in France through the HR calls.
The EQUIPEX COGIS platform project will provide the network infrastructures needed and will be a place to gather expertise and insure an international visibility. Data mining and numerical simulations which are critical for the scientific fields developed by P2IO will have important applications to other domains, such as image processing in medicine.

- *I1 Energy : nuclear energy for the future*

The next decade will be crucial for the future of nuclear energy systems. Key questions where P2IO will contribute on this topic fundamental to the ANCRE Alliance (National Alliance for the Coordination of Energy Research) are the sustainability and acceptability of nuclear energy generation. In particular, P2IO efforts will be focused on the following issues: accurate nuclear data for the design of new generation reactors, study and modeling of nuclear reactions involved in transmutation processes or new fuel cycles, modern Nuclear Physics tools (accelerators, detectors, modeling techniques, etc.) applied to the design and construction of next generation fission/fusion reactors and incineration factories and material design and testing for the next generation of nuclear reactors and for the confinement of nuclear waste, through their behavior under irradiation (JANNuS facility and EMIR platform). More accurate data on (epi-)thermal neutron-induced reactions, in particular for major actinides, will help increasing the fuel burn-up and the life time of present reactors. The investigation of neutron-induced capture and fission reactions on actinides will be intensified for designing next-generation fast fission reactors. In addition, data on fission yields and delayed neutron production, and in general a better understanding of the fission mechanism, are also closely related to the safe operation of novel reactors. The characterization of high-energy reactions, such as spallation processes, involved in accelerator-driven systems should also be accomplished. New data on the thorium-fuel cycle will similarly be fundamental to develop innovative options based on fission. P2IO will contribute to the elaboration, characterization and validation of new materials (ceramics and metals) for fission reactors of the next generation and fusion reactors. Recognized and supported by the F-BRIDGE, GETMAT and PERFORM-60 European programs, P2IO activities in this field will involve an experimental approach with versatile irradiation tools allowing parametric investigation and comparison with simulations. The JANNuS irradiation platform, at present unique in Europe, will be upgraded to meet challenges in material science for nuclear and fusion energy development. One of the major contributions of Nuclear Physics to nuclear energy generation is the human capital trained in basic Nuclear Physics techniques that is then transferred to nuclear industry or to governmental bodies linked to nuclear energy generation. High-level teaching in Nuclear Physics is required to develop advanced nuclear energy options. P2IO is strongly involved in the NPAC and the Nuclear Energy M2 Masters, attracting high-level students and now recruiting a large fraction of their students internationally. This effort will be developed.

I2 Health Care : instruments and methods for therapy

Facing the current rise of Life Sciences, one of the most exciting challenges of P2IO LabEx is to address the following question : how to stimulate the huge scientific and technical potential of P2IO research for medicine and biology applications ? While including this interface among the scientific priorities of the LabEx, first level of answer of P2IO is to bring Biology and Health issues as close as possible to physics. This strong connexion to the downstream Life Sciences needs will ensure quick developments of accurate tools. The inclusion of the interdisciplinary laboratory IMNC to P2IO is a key element of this strategy. Second level of answer is the decision of P2IO to focus its projects on a selection of a few well identified medical topics based on instruments and methods for diagnosis and therapy.
The « Health » scientific axis of P2IO will address two major fields of Life Sciences: first, cancerology which federates a majority of current and coming P2IO's projects, second, neurosciences, thanks to strong local synergies, in particular around Neurospin facility. Thus, framework of LabEx research is based on a 3 x 3

matrix crossing health care stages (pre-clinical, diagnosis and therapy) and P2IO skills in physics (detectors, accelerators and methodologies). P2IO will therefore mobilize complementary high level instrumental research for multi-modal biomedical imaging systems (SPEC, PET, optics and MRI scans).
In addition to the development of functional imaging systems, bridging the gap between detected signal, spatial mapping of radioactivity and actual metabolic parameters is a key issue for making the most of these imagers. P2IO will also be competitive in that crucial interface area as well. Working closely with physicians and thanks to both simulation tools (GATE platform) and statistical approaches, IMNC develops accurate quantitative methods for image reconstruction and for a reliable estimation of physiological parameters from SPECT or PET scans.
In this context, the P2IO LABEX offers an outstanding add-value by federating and combining these talents in order to address efficiently issues in cancerology and neurosciences. As far as cancer treatment is concerned two top priority axes can be identify:
a) Molecular radio-imaging systems for diagnosis and therapy response monitoring: in addition to their value in initial diagnosing tumour tissue, quantitative data delivered by PET scan allow to assess the response of tumour tissue to treatment. Corresponding scientific challenges are spatial resolution and sensitivity enhancement (CALIPSO project), compactness for portable and low-cost imaging systems (MONIPET project), set-up of multi-modal approaches (optics, MRI) and accurate methodologies for quantization of functional processes. Expected results are focused on new strategies for early therapy monitoring and aim at predictive strategy for therapeutic response.
b) The THOMX Equipex proposal (development of a very compact hard X-ray source) has important potential applications for radiotherapy and in-beam dose control and will be the P2IO leading project for these interdisciplinary objectives. P2IO will also focus on radiotherapy through the development of hadrontherapy in collaboration with IBA (Gantry project) and of in-beam dosimetry techniques for protontherapy. This project will be developed in close collaboration with Institut Curie's facility located in Orsay. Both these two axes will be supported by strong relationship with industrial partners (Thales…).

5.2.2 VALORISATION, TRANSFERT ET EXPERTISE/ EXPLOITATION OF RESULTS, TRANSFER AND EXPERTISE

These activities will be performed in close collaboration between the pan-LABEX structures that will put in place by the FCS IDEX initiative, by a dedicated P2IO LABEX program and the continued strong support from all the laboratory partners of P2IO.
a) Scientific Communication on the LABEX projects
The Scientific Cooperation Foundation7, which is the coordinating partner, will act in support of the project and will provide its communication tools, which will have been developed for its website:

1. On the www.campus-paris-saclay.fr website, web pages will be created, which are specific to each LABEX project (with a portion in English). These will present the LABEX (objectives, members, etc.) publications, salient features, agendas of organised events, while also providing information about the proposed curricula and the competences to which they lead. Particular attention will be devoted to the disclosure of research results to the media and general public.
2. Support to the organisation of national or international events ("open house days", colloquia, etc.). When appropriate, the FCS will organise events common to several LABEX projects.

[7] Acronym for Fondation de coopération scientifique

3. The Foundation will also be an entry point for press relations (calls to journalists, assistance with the preparation of press kits and press bulletins, guided tours, etc.).
4. Creation of communication tools such as descriptive leaflets.

These actions will be implemented in connection with the communication officers of each of the concerned institutions, in order to optimise their synergies.

b) General Intellectual properties policy

When a new common project is initiated, the conditions for granting intellectual property and exploitation rights will be governed by the following principles:

- Each of the parties will preserve the property of the "prior knowledge" (information, technical data, whether patented or not, etc.) it has accumulated, prior to the project or independently from the work being carried out on the project.
- The results obtained and produced by a single party within the project (own results) will remain this party's property.
- The results obtained and produced jointly by several parties within the project (common results) will be the common property of said parties. They will be subject to co-ownership rules specifying the division of property, and its exploitation. Any exploitation by any one of the co-owner parties will be subject to payment to the other co-owner parties.
- If, in order to exploit its own results, one party needs the own results of another party, the latter will grant said former party a non-exclusive license subject to provisions which must be agreed upon between the involved parties.
- If, in order to exploit its own results, one party needs prior knowledge compiled by another party, the latter party will, subject to its previous commitments, grant said former party a non-exclusive license, subject to provisions which must be agreed upon between the involved parties.

c) P2IO LABEX specific actions

Technology transfer coming from research projects pursued in the laboratories participating in this LABEX has been an important activity for years. Presently, in each laboratory there is a person in charge of conducting this work in conjunction with the corresponding technology transfer unit at CEA or IN2P3, the SPV of the CNRS and FIST SA. Several actions are already part of routine work: patenting [more than 40 active patents], technology transfer through licensing [currently 9 licenses are signed or in negotiation], supply of services including technical assistance (non-exhausted list of implied companies: Canberra Semiconducteur NV, Pyrocontrole, Gaz de France, Snadec, Irelec, Thalès Electron Devices, INEL, CPO) and industrial research contracts like (non-exhausted list of partners: Siemens, Photonis, EADS Astrium, Thales, EDF, Rhodia, Hekyom, Philips, Dosisoft, Biospace Lab, IBA, Guerbet), and even creation of start-ups [a total of 3 within the last years, 2 are still alive].

As a result, our technology transfer efforts can be considered significant; however there is still room for improvements. Indeed, current as well as future technology transfer actions of P2IO are based on an enormous potential in creating new components (e.g. electronics, accelerator physics), innovative prototypes (in particular for the live science sector), sophisticated high tech instrumentation for unique platforms (p.e. cryogenics, irradiation, material characterization and implementations) and software.

The exploitation of this potential suffers from several limits. While platforms are internal developments that attract relatively easily the industrial partners, industrial research collaborations deserve an improved industrial network. But clearly the most critical situation to succeed in technology transfer has to be challenged with innovative prototypes: especially an intermediate structure for semi industrial prototyping is missing. Several measures, an engineer for specification and certification, areas for testing and specific founding are foreseen to overcome this limit. P2IO will thus head for definitively incorporating technology transfer actions as an obligatory part of its scientific work.

To give at least a few concrete examples of future technology transfers: a new platform will be added to the already existing ones, ThomX. This project aims at providing a fully operational hard X-ray CBS source, with a performance between one and two orders of magnitude higher than that of the existing one, ready to be operated in a non-expert environment. The ThomX source will provide industrial partners and the academic community with an open access facility for medical and cultural heritage applications (works of art dating and attribution, primitive sketches detection and underlying drawings non-destructive analysis). Also, the experimental areas of the Supratech platform (including a clean room, chemistry and cryogenic facilities) will become accessible to industrial partners. In collaboration with the National Institute of Meteorology (INM-CNAM), the accreditation COFRAC-LNE of the cryogenic thermometer calibration facility should be operational in 2012. This equipment allows for the calibration of up to seventy thermometers in a single run and thus to disseminate the temperature unit within both the laboratories and the industry.

Concerning licensing, several medical prototypes (TReCam, TRIOP and MONITEP) already developed or under development will be transferred in the coming years, one of which, a handheld gamma camera for surgical cancer treatment already in 2011. In the area of electronics, a new family of high performance data acquisition boards based on ultra-fast analog memories should also be commercialized under license very soon. They should set new references in the domain, especially in the picosecond time measurement with low power and high number of channels. Another concrete licensing action is foreseen in the field of accelerator physics: it concerns downloading of software dealing with accelerator beam simulations.

A new tight network between P2IO and industrial partners will be created. It's somehow the heart of P2IO's technology transfer strategy as explained in detail in section 5.4. In addition, the existing structures will be redefined and new means will be added:

- At the P2IO level, a Steering Committee composed of the persons in charge of technology transfer will monitor the different LABEX valorization projects. Their work will rely on the IDEX IP department and on the other above mentioned entities (SPV, FIST, SAIC and IN2P3/CEA technology transfer cells). During routine meetings, the committee will share experiences, networks and industry contacts. In particular, priorities in the use of the common means are defined here.
- In the laboratories, the persons in charge of industrial transfer will continue the previous work. In addition, they will systematically evaluate together with the scientific project managers all Intellectual Property aspects (patent applications, publication schedule, industrial collaborations, NDAs, etc.) right from the beginning and in the course of the project.
- An attractive web site will describe the technology transfer actions, the technological offers of the P2IO laboratories and the "Industrial Partners Club" called PIGES (see 5.4)
- As completely new means dedicated to industrial transfer actions, P2IO will dispose of engineers, areas for short term public-private collaborations and specific budgets, (see 6.1.3).

- Concerning the technological platforms and the P2IO's unique testing facilities (non-exhaustive list: PHIL, IRFU Tests Facilities (partial) …), our industrial partners will have prioritary access (though limited and not free).
- Different services like design study, manufacturing, technical training will also be proposed to industrial partners.

The laboratories will specify the rules regarding confidentiality, intellectual property rights, dissemination and exploitation of the results originating from the LABEX projects through an agreement at the consortium level. Regarding expertise, several laboratories have strong implications in the assistance to projects in the frame of design, decommissioning and exploitation of nuclear installations. Skills and know-how of physicists and engineers teams have shown they could be favourably applied to simulation calculations, radioprotection, safety and waste management studies, together with other societal concerns.

5.2.3 ENSEIGNEMENT SUPÉRIEUR, INSERTION / HIGHER EDUCATION, INTEGRATION INTO THE WORKPLACE

As shown above (4.1.1.3.), each of the P2IO partners is strongly implied in teaching and training, from Master to PhD. These trainings are naturally mainly supported by the "Université de Paris Sud 11" and the "Ecole Polytechnique". Thanks to the LMD institution, over the last years, most of the classes dealing with P2IO topics have been modernized. This concerns the « L3 and M1 de Physique Fondamentale de l'Université de Paris 11 » and the following 9 M2: « Noyaux, Particules, Astrophysique et Cosmologie », « Astronomie, Astrophysique et Ingénierie Spatiale », « Concepts Fondamentaux de la Physique », « Physique et Ingénierie de l'énergie », « Accélérateurs de Particules et Interactions avec la Matière », « Physique et Environnement », « Physique et Systèmes Biologiques ». « Physique des Hautes Energies (Ecole Polytechnique) », « Radiochimie ».

These subjects, which attract more than 300 students each year, have acquired an excellent national and international visibility; they bring PhD students to many laboratories not only those belonging to P2IO. Most of the M2 quoted above are « co-habilités » by High Schools located in Paris, implicated in the P2I group: a good synergy is therefore guaranteed in the Paris area. Nevertheless, we have to underline that P2IO members are strongly involved in energization and management of these subjects, together with the related "Ecoles Doctorales": Particules Noyaux et Cosmos, Astronomie et Astrophysique d'Ile de France , Modélisation et Instrumentation en Physique, Energies, Géosciences et Environnement , Physique de la Région Parisienne, Ecole Doctorale de l'Ecole Polytechnique.

The P2IO Labex will first of all allow to coordinate the practical organisation (and/or funding) of educational projects coming under several partners (CEA-INSTN, CNRS, Université Paris 11, Ecole Polytechnique,..). Emphasis is put on the need for an attractive Master (and the associated M2), in a first step, and, in a second step, attractive Ecoles Doctorales. The principles of this strategy are the following:

- Projects that need a recurrent funding or a funding which lasts several years.
- Concrete actions suggested by or discussed with the managers for the Masters or Ecoles Doctorales quoted above.
- Annual evaluation of the performance of our actions.

We propose to fund 5 recurrent targeted actions and one more ambitious long term project:

- Recurrent projects: (150 k€ per year)

- Provide a laptop, in conjunction with Univertsity and other implied LABEX, to an important part of the students joining the Physique Fondamentale subject. The pedagogical project will focus on four items: data analysis, access to digital libraries, e-learning, interactive teaching
- A summer School, each year, on the scientific items covered by the P2IO, for L3 students. Located in the Paris-Saclay campus, this School would be a very good way to bring young students to our laboratories, stimulate their liking for physics in general, and eventually help them in their future specialization.
- Give grants for M2 students and grants for students during their training periods in our laboratories following thr good example of Fondation X (remuneration is mandatory).
- Pedagogical travels for M2 students so they can discover top level research or nuclear sites such as La Hague, Bure (M2P&E PIE and R), CERN and Ganil (M2 APIM, M2 HEP-X)
- Students Workshops for L1 and above

- The P2IO long term project (500 k€ over 10 years)

Most of the M2 quoted in this document is made of high level practical works (so called TP), settled in our laboratories. These practical works need advanced, ultramodern material, regularly updated. Part of this material will be shared with M1 trainings. We foresee to bring up to date part of these TPs, create new TPs, and make sure that they will be well maintained over all the laboratories.
The complete funding of the 5 recurrent actions and of the long term project is 200 k€/year and is detailed in section 6 below.

5.2.4 GOUVERNANCE DU LABEX/ GOVERNANCE

- ***1° Organisation of governance on the campus***

The campus will be coordinated through the Scientific Cooperation Foundation[8], the new statutes of which provide for:

- ✓ A governance system, which must be centred, on one hand, on *a general assembly* in charge of bringing together the founding institutions, staff representatives, and various qualified personalities and, on the other hand, on the *Administrative Board*, itself comprised of a dozen members who will closely and efficiently scrutinise the system. Furthermore, the foundation will obtain support from a *Committee for the Scientific and Innovation Strategy*.
- ✓ Departments. The foundation will create between five and ten Departments specialising in major domains (societal implications, disciplines) in which it wishes to become a major driving force of transformation. The departments will be designed as structures providing guidance and coordination and will "host" different projects, including LABEX projects.

The inter-department coordination will be provided by a Board of Department Directors, which will be the place where transverse coordination will occur in order to inspire new synergies and provide dynamics for excellence.

The foundation's role as regards the LABEX projects includes:

- The management of subsidies distributed to the LABEX members, once a project has been accepted by the LABEX Scientific Committee. As regards human resources, the Foundation may recruit people

[8] Fondation de Coopération Scientifique

directly when a high speed of response is required. The Foundation, which manages an annual budget of the order of 8 M€ (see section 4.1.1), is accustomed to this type of practice.

- Monitoring and management control of the LABEX project. Indicators and objectives set out by the LABEX need to be monitored, and corrective actions should be prompted by the "Steering Committee",
- Providing support for specific subjects, in particular as regards to communication, to define an overall image of the campus,
- Ensuring optimal integration of the LABEX project within the campus, links with the other LABEX projects, other planned means, such as the "Society for the Acceleration of Technological Transfers", or good practice exchanges,

- The initiative for excellence

This new project is part of the Initiative for Excellence project of the Paris-Saclay campus, which will comprise three components, all linked to the present LABEX project.
A collective coordination: Its goal is to foster, through the intermingling of different scientific communities, the emergence of imaginative ideas, to promote new and transdisciplinary collaborations, to reinforce the site's capacity to exploit and convey new knowledge, and to link upstream with downstream work. This action will be "multiscale". It will involve:

- The departmental level, with vast communities (sometimes a thousand researchers or teaching researchers), involved in programmes that are a link with society-related challenges or with large communities working in different disciplines,
- The LABEX projects. These appear to have the right scale for the interfacing of various communities with the campus, as an entry point into the knowledge generated here, and also into ongoing reflections, on one hand, and as a knowledge disseminator, on the other hand. P2IO LABEX is already in close contact with two other FCS LABex : PALM (atomic, and laser physics) and PIM (Physics and medicine interface) and has a potential to liaise with many other.
- Transverse projects. The campus participants would like act in such a way as to generalise project operation, with flexible, collective and often time-restricted projects. These include scientific projects: funding of emerging ideas, teaching projects related to the dissemination of new knowledge, technological maturation projects. These projects will be assessed according to procedures of the same kind as those used for the LABEX projects (independent experts, separate scientific and management decisions). In this respect, the LABEX may be considered as "pre-funded project package" pertaining to subjects in which the campus participants have decided to invest.

Common transverse structures should be organised in a professional and permanent manner. The Initiative of Excellence project includes

- LABEX support "cells" on issues such as: training (general aspects), international relations, equal opportunities, etc.
- Other “instruments" of general interest concerning in particular the EQUIPEX projects. Special mention should be made of innovation, which is organized at the campus scale: the project for an Institute of Technological Research will be the ideal place for the campus to interface with industry. Also, the SATT project will be responsible for actions relating to the maturation of new technologies.

One of the roles of the aforementioned scientific collective coordination will be to create a link between the LABEX projects and these objects.

2° Governance of the P2IO Labex

The governance of P2IO is based on an overview board formed the P2IO stakeholders representatives, an executive structure and an International Scientific Council. In the following, it is assumed that P2IO will be part of a successful "Initiative d'excellence" (IDEX) in the framework of the Paris-Saclay Campus.

The executive structure (steering committee) is constituted of a chairman, (named by the overview board) which represents the Labex at the "Initiative d'excellence" level, and the directors of the partner laboratories. A small staff (executive secretary, webmaster…) provides support to Labex operations similarly to the RTRA mode of operations. Three topical committees will provide guidance to the steering committee:

- Science projects (visiting scientists, post-doc and doctorate positions, transverse proposals)
- Research and technology, relationship with industry
- Education (support by P2IO of science and technical curricula) and outreach

These committees are constituted by representatives from the P2IO partners and will have to evaluate the responses to calls for proposals defined at the Science Council and Steering committee level. The support decisions are taken by the steering committee of the basis of these evaluations. An evaluation report is prepared as part of the annual report for supporting the annual evaluation of P2IO procedures by the International Science Council.

The International Scientific Council (ISC) meets at least once per year. It is constituted of international experts in the science and technology fields relevant for P2IO. While not a member, the chairman of the P2IO steering committee is invited to all ISC meetings. The ISC exerts a posteriori control on the internal management of the P2IO and on the selectivity of its selection processes. It proposes to the executive new themes or evolutions for the calls for proposals relevant to the following year on the basis of the annual report, which will include an evaluation of the responses to the previous calls.

P2IO will monitor its selected Equipex projects through an annual report and will provide guidelines for future activities.

One of the main goals of P2IO is to improve synergies between technical activities of its partner laboratories. This priority is structured around 5 technical networks (Virtual data, Captinnov, Spacetech, Acceltech, Radiomatter). The technical networks will be strongly involved in providing R&D and industry partnership proposals to the relevant topical committee. They will interact with the Education and Outreach committee in developing training courses for relevant technical and science curricula, and promoting the participation of P2IO engineers to these curricula.

P2IO success criteria after 5 and 10 years are listed in the table below.

Success criteria	2015	2020
1. Academic Excellence		
Number of international scientists attracted to France by P2IO	2	8
Number of national and international contracts awarded to P2IO	5	10
2. "Explore" Activity		
Number of publications after P2IO sponsporship	25	60
Number of colloquia organised by P2IO	5	10
Number of technological breakthroughs	3	8
3. "Transforme" Activity		

Number of shared platforms	4	8
Number of P2IO common bids	3	8
4. "Structure" Activity		
Number of partnership with other LABEX	3	5
Number of interdisciplinary partnerships	2	5
Number of industrial partnerships	2	5

5.2.5 ATTRACTIVITÉ/ATTRACTION

P2IO's main asset to attract first class researchers and students relies of course on its international reputation of world class laboratories where top notch research is performed. P2IO strategy can be declined along three axis: make the original P2IO concept very widely known in the P2IO various communities, very large diffusion of P2IO calls for proposals and building upon the Plan Campus "Plateau de Saclay"
P2IO members will present in a series of seminars the Plateau de Saclay operation in the major international centers of our fields, with its scientific and practical aspects. A P2IO electronics newsletter will be published regularly and widely circulated.
P2IO Calls for proposals will explicitly insist of the excellence criteria needed to postulate for a position. The international composition of our selection juries will be a important tool in that respect.
We will build upon collective effects within the P2IO recrutees by encouraging them to regurlay meet to confront their experience and make it known worldwide through blogs. P2IO will organize internal seminars where they can present their work to a large audience.
Concerning the everyday life of our students, P2IO will rely on existing structures in the Plateau de Saclay to facilitate their social integration. All P2IO laboratories have a very large experience of welcoming foreign students and they will work in close interaction with the overall "Plateau de Saclay" structures that will accompany the Plan Campus buloding up. The Plateau de Saclay IDEX will be very active in that area and the presence on the Plateau of so many engineering schools will guarantee that all aspects of a student's life will be dealt with in the best possible way.

5.3. STRATEGIE DES ETABLISSEMENTS TUTELLES/ STRATEGY OF THE SUPERVISING INSTITUTION

1) Introduction regarding the Mathematics-Physics-Chemistry department

The Paris - Saclay cluster is a site, which over half a century has become a major centre for physics and mathematics. The challenges faced are to improve the structure of this large community, and to even further increase its international visibility. Present in most of Paris-Saclay's institutions, physics now involves approximately 4000 persons of all categories, that is, more than 20% of the national staff. The initial central core has constantly grown and now forms an internationally recognised physics hub, which continuously attracts new partners and has received outstanding recognition. The centre for "physics of the two infinities" (subatomic physics, physics of the origins (astrophysics), and their associated technologies) represents 25% of the national research effort in astrophysics, 40% of that in sub-atomic physics, and 90% of that in particle accelerator physics. It strongly contributes to most of the large European projects. The physics department of the Paris-Sud University, which is only one fragment of the entire cluster, is itself ranked 19th in the world, 4th in Europe and 1st in France, according to the Shanghai ranking.

The strategic goals pursued by the institutions are to develop world-class research, to foster scientific excellence, through collective coordination tools to favour crossbreeding, and to support projects intended to boost the emergence of new fields of research, benefit from the enhanced international visbility to attract the best international talents. The LABEX projects, MATH, PALM , PIIO, CHARMM, and the Jacques Hadamard foundation are the best-suited tools for this purpose.
In addition to their own dynamics, these disciplines contribute significantly to large programmes addressing societal challenges. Mathematics, physics and chemistry are at the heart of these challenges, because of their conceptual contribution, the new instruments they develop, and the evolution of modelling. The organization of the future campus will have a matrix structure to favour interactions between the disciplines related to these major challenges, in particular through multi-disciplinary education, research and innovation programmes.
The synergies between the approaches pursued by researchers and engineers, in public and private research institutions, must be boosted by favouring exchanges between the major scientific and thematic domains of socioeconomic interest through interactions between the academic and industrial worlds on certain teaching curricula, since students are in effect the privileged players of such exchanges, and through partnership research projects, and platforms open to the industry. Optimal use should be made of the structures that are planned at the campus level (Institute for Technological Research and the Society for Accelerating Technology Transfers), and by developing training through research in universities and colleges.
The real estate operations that must be carried out in the mean term, in particular within the Paris-Sud 11 University, according to the Campus Plan, will bring the teams together in common buildings or "thematic" neighbourhoods. These operations will include:

- Bringing the Paris-Sud 11 University, CNRS and CEA closer together, thus forming one of the first world-class clusters in the field of physics “of the two infinites and of its origins”, and will also be advantageous for the pooling of major facilities.
- The physics Neighbourhood will offer physicists working at scales ranging "from the atom to condensed matter" a place to live, with the primary objective of promoting scientific exchanges, where research and teaching will combine with the installation of shared structures,
- Creating a biology-heath-chemistry cluster will generate strong synergetic effects between chemists from Paris-Sud 11, those from CNRS Gif, and the Pharmacy UFR9.
- Education

The reputation of research is a key feature in the construction of a campus image. It is necessary to capitalise on this reputation and the excellence of the associated curricula in order to develop the site, in particular at an international level. The planned actions include:

- Boosting interconnections between the course offering and cutting-edge research. Developing the campus' excellence in PhD courses, and improving its attractiveness by creating new Master's Degrees targeting international exchanges in particular, whilst keeping in mind their link with the Bachelor's Degrees.
- Developing opportunities and mechanisms to assist students with their integration into the industrial workplace, in particular for those trained through research.
- Creating bridges between the curricula offered in the various institutions.

[9] Acronym for 'Unité de Formation et de Recherche : Training and Research Unit'

2) Stakeholder specifc position concerning P2IO Labex

P2IO Labex has 4 stakeholders, CNRS with 3 participating CNRS institutes IN2P3, INSU and INP, CEA, Paris Sud University and Ecole Polytechnique. In the attached letters of support, the stakeholders confirm that P2IO Labex objectives are fully in line with the generic goals stated above.

P2IO Labex plays in addition a special role because of its very high international standing. It regroups the flagship units in its field. For instance, in particle physics, the only two laboratories represented in international bodies such as ICFA (International Committee for Future Accelerators) or the CERN Council European Strategy group are IRFU and LAL which are key players in P2IO. The same situation is found in nuclear physics with IPNO and IRFU, in space with IAS, etc… By strengthening the ties between these units thanks to P2IO labex, the stakeholders are looking forward an even better French international visibility and influence. This is a strategic asset for the ambitious goals of the stakeholders to be in a postion to host future major international facilities on the Plateau de Saclay. The stakeholders will pay special attention to promote the collaboration between the several LABEX that will be selected nationwide in this thematic. The emergence of a few LABEX structures is to be viewed as a positive addition to the vitally needed national coordination and to the close network between all French laboratories of the field.

The stakeholders are also all obviously very strongly engaged in the "Plateau de Saclay" operation of which they represent the main driving force. The importance of having a pole in the future Plateau de Saclay of the strength, excellence and visibility of P2IO can not be underestimated. The role of P2IO labex in this context is to gradually transform a close collaboration between many strongly integrated vertical structures into a much more powerful network including several top notch horizontal platforms.

It is however quite important for the stakeholders that the role and identity of their laboratories is preserved during that transition phase. P2IO Labex governance must therefore be organized around an executive and operational body formed by the P2IO laboratories directors and an overview body formed by the four stakeholders representatives. The stakeholders also assign to the P2IO LABEX the mission to significantly boost the interdisciplinary and spin-offfs actions presently taking place in their laboratories through specific actions supported on the LABEX budget.

In order to help the PI2O labex to accomplish these tasks, the stakeholders will continue to support P2IO members with high priority. Every effort will be made to maintain the huge manpower annual investment (around 200 M€) at the present 2010 level. The laboratories operating budget representing around 10 M€ will also be preserved on the best effort basis. Major equipments already present in P2IO laboratories will be operated, maintained and upgraded while many new facilities are planned, with the help of the EQUIPEX programs. Targeted actions such the as Groupement d'Intérêt Scientifique P2I will be continued in the period 2011 in order to boost scientific activities in the Paris region with P2IO partners as main actors and beneficiaries of these funds.

5.4. RELATION AVEC LE MONDE SOCIO-ECONOMIQUE/ CONNECTIONS TO THE SOCIO-ECONOMIC WORLD

Technology transfer coming from research projects pursued in the laboratories participating in this LABEX has been an important activity for years. Presently, in each laboratory there is a person in charge of conducting this work in conjunction with the corresponding technology transfer unit at CEA or IN2P3, the

SPV of the CNRS and FIST SA. Several actions are already part of routine work: patenting [more than 40 active patents], technology transfer through licensing [currently 9 licenses are signed or in negotiation], supply of services including technical assistance (non-exhausted list of implied companies: Canberra Semiconducteur NV, Pyrocontrole, Gaz de France, Snadec, Irelec, Thalès Electron Devices, INEL, CPO) and industrial research contracts like (non-exhausted list of partners: Siemens, Photonis, EADS Astrium, Thales, EDF, Rhodia, Hekyom, Philips, Dosisoft, Biospace Lab, IBA, Guerbet), and even creation of start-ups [a total of 3 within the last years, 2 are still alive].

As a result, our technology transfer efforts can be considered significant; however there is still room for improvements. Indeed, current as well as future technology transfer actions of P2IO are based on an enormous potential in creating new components (e.g. electronics, accelerator physics), innovative prototypes (in particular for the live science sector), sophisticated high tech instrumentation for unique platforms (p.e. cryogenics, irradiation, material characterization and implementations) and software.

The exploitation of this potential suffers from several limits. While platforms are internal developments that attract relatively easily the industrial partners, industrial research collaborations deserve an improved industrial network. But clearly the most critical situation to succeed in technology transfer has to be challenged with innovative prototypes: especially an intermediate structure for semi industrial prototyping is missing. Several measures, an engineer for specification and certification, areas for testing and specific founding are foreseen to overcome this limit. P2IO will thus head for definitively incorporating technology transfer actions as an obligatory part of its scientific work.

To give at least a few concrete examples of future technology transfers: a new platform will be added to the already existing ones, ThomX. This project aims at providing a fully operational hard X-ray CBS source, with a performance between one and two orders of magnitude higher than that of the existing one, ready to be operated in a non-expert environment. The ThomX source will provide industrial partners and the academic community with an open access facility for medical and cultural heritage applications (works of art dating and attribution, primitive sketches detection and underlying drawings non-destructive analysis). Also, the experimental areas of the Supratech platform (including a clean room, chemistry and cryogenic facilities) will become accessible to industrial partners. In collaboration with the National Institute of Meteorology (INM-CNAM), the accreditation COFRAC-LNE of the cryogenic thermometer calibration facility should be operational in 2012. This equipment allows for the calibration of up to seventy thermometers in a single run and thus to disseminate the temperature unit within both the laboratories and the industry.

Concerning licensing, several medical prototypes (TReCam, TRIOP and MONITEP) already developed or under development will be transferred in the coming years, one of which, a handheld gamma camera for surgical cancer treatment already in 2011. In the area of electronics, a new family of high performance data acquisition boards based on ultra-fast analog memories should also be commercialized under license very soon. They should set new references in the domain, especially in the picosecond time measurement with low power and high number of channels. Another concrete licensing action is foreseen in the field of accelerator physics: it concerns downloading of software dealing with accelerator beam simulations (Toutatis, TraceWin, PlotWin, etc.).

A new tight network between P2IO and industrial partners will be created. It's somehow the heart of P2IO's technology transfer strategy as explained in detail in section 5.4. In addition, the existing structures will be redefined and new means will be added:

- At the P2IO level, a Steering Committee composed of the persons in charge of technology transfer will monitor the different LABEX valorization projects. Their work will rely on the IDEX IP department and on the other above mentioned entities (SPV, FIST, SAIC and IN2P3/CEA technology transfer cells). During routine meetings, the committee will share experiences, networks and industry contacts. In particular, priorities in the use of the common means are defined here.
- In the laboratories, the persons in charge of industrial transfer will systematically evaluate together with the scientific project managers all Intellectual Property aspects (patent applications, publication schedule, industrial collaborations, NDAs, etc.) right from the beginning
- An attractive web site will describe the technology transfer actions, the technological offers of the P2IO laboratories and the "Industrial Partners Club" called PIGES
- As completely new means dedicated to industrial transfer actions, P2IO will dispose of engineers, areas for short term public-private collaborations and specific budgets, (see 6.1.3).
- Access to P2IO technological platforms and unique testing facilities, as well as different services like design study, manufacturing, technical training will be proposed to our close industrial partners, on a pay-per-use basis.

The laboratories will specify the rules regarding confidentiality, intellectual property rights, dissemination and exploitation of the results originating from the LABEX projects through an agreement at the consortium level. Regarding expertise, several laboratories have strong implications in the assistance to projects in the frame of design, decommissioning and exploitation of nuclear installations. Skills and know-how of physicists and engineers teams have shown they could be favourably applied to simulation calculations, radioprotection, safety and waste management studies, together with other societal concerns.

5.5. EFFET D'ENTRAINEMENT POTENTIEL/ PULL EFFECT

The P2IO pull effect will develop along five axes: international, national, regional, interdisciplinary and industrial. Internationally, it is expected that because of the greater visibility and increased integration of P2IO partner technical potential, P2IO will be able to attract on its premises large international platforms or projects and increase its participation to major international space missions. One such example is plasma-wake acceleration, where partnerships with CERN, SLAC in the US and KEK in Japan could materialize around the APOLLON laser and the accelerator facilities and instrumentation which will be built by P2IO, as proposed in the CILEX EQUIPEX project in collaboration with the PALM Labex. P2IO LABEX will be a driving force in promoting such collaborations with major international partners.

At the national level, P2IO will implement a strong collaborative structure between CEA, CNRS and Université Paris-Sud 11. P2IO will constitute a major science and technology cluster. Given the existing collaborations with other laboratories, the regional and national structuring effects of P2IO will be important for the scientific community involved in P2IO themes. P2IO will be a natural partner for other LABEX being proposed (Paris, Grenoble, Lyon,..) with science themes related to that of P2IO. One of the instruments foreseen for this coordination at the regional level is the GIS P2I which will be directed in the key period 2011-2013 by the P2IO coordinator. Coordination is also considered with the "ESEP" Labex (Observatoire de Paris) on "origins" science themes, building on the on-going joint activities between IAS, IRFU (P2IO) and LESIA (ESEP) in the framework of the GIS MoteSpace.

Enhanced interdisciplinary actions with many regional/local structures both inside the Plateau de Saclay and outside it will result in P2IO creation because of its position as the very visible entry point to all P2IO partners. Strong partnerships have already been discussed with the Physics and Medicine interface and PALM Labex projects on the Plateau de Saclay. It is expected that these actions will irrigate in a few years significantly beyond P2IO usual partners which will relay P2IO actions in their respective fields. This will be very proactively promoted through preferential access to P2IO platforms. Industrial contacts with large companies and SMEs involved in P2IO themes will be greatly facilitated through enhanced visibility and specific actions carried out at P2IO level, such as P2IO industrial open days. It is important to notice that 3 large industrial companies, Air Liquide, SDMS and Thalès, as well as the PIGES association regrouping many other companies involved in large scientific equipments have expressed a strong explicit support to P2IO labex through a support letter sent together with this application.
Quantitative indicators relative to P2IO pull effects are integral parts of P2IO success criteria explicated in section 5.2.1

6. JUSTIFICATION SCIENTIFIQUE ET FINANCIERE DES MOYENS DEMANDES / FINANCIAL AND SCIENTIFIC JUSTIFICATION FOR THE MOBILISATION OF THE RESOURCES

6.1. JUSTIFICATION DES MOYENS DEMANDES (SUR 10 ANS) / JUSTIFICATION FOR THE MOBILISATION OF THE RESOURCES

The annual P2IO budget (in k€) is presented in the following table :

	Human ressources	Equipment	Operations	Total
Research	500			500
Teaching/Training	30	50	120	200
Valorisation	100		50	150
Governance	20		20	40
Relations with society			20	20
R&D-Platforms	300	700	90	1090
Management overhead			80	
Total	1050	650	380	2080

The large priority given by P2IO to its R&D and platforms can be readily seen since it corresponds to more than 50% of the budget. The large budget items (Human resources for research and for R&D, equipment for R&D and platforms) will correspond to calls for proposals that will be organize following the best international standards and practices for the evaluation.

6.1.1 PROJET DE RECHERCHE/ RESEARCH PROJECT

Research oriented funds in P2IO will be distributed almost exclusively through two types of calls for proposals :

- A call "RP" oriented towards temporary research positions to get the best scientific return out of the high priority P2IO scientific themes (S1 to S4)
- A call "RD" oriented towards platforms and R&D support.

The RP budget will be 500 k€ per year and will aim to recruit around 10 postdoc positions at a yearly cost of 50 k€ per year. The length of the proposed contracts will be two years, not renewable and therefore P2IO will issue a RP call every other year. Some flexibility will be possible in the RP call to get instead of a postdoctoral position either a PhD position (3 years at 35 k€ per year, therefore financially neutral wrt to a postdoc position) or an invitation to a senior physicist for a shorter term (typically 1 year at 100 k€). P2IO partners have agreed to cover from their own budget the travel and indirect costs attached to these positions. Our experience with similar calls issued by the GIS P2I shows that the pressure within P2IO teams to get a position will be at least 5, high enough to ensure that only top quality projects are selected.

The RD budget will be of 1 M€ per year, mostly devoted to equipment money (70%), with the remainder used to hire support technical staff. It is foreseen to grant this R&D money to 2 projects only per year, giving each project 350 k€ over 3 years. Based on our experience within similar calls granted by ANR or by the GIS P2I, this amount is important enough to make significant advances on R&D oriented projects or to provide key complementary equipments to P2IO platforms. Manpower of various types (engineer, applied physicist, physicist with competence in another field) will be authorized in the call, on a basis of 1 position per project for 3 years at an average cost of 50 k€.

It is expected that scientific animation costs will be borne by the Plateau de Saclay IDEX initiative if approved or by P2IO partners internal budget if not. Note that in the period 2011-2013, the GIS P2I, a consortium of the 19 laboratories in the whole Paris region, will also contribute to this animation.

P2IO will also allocate 90 k€ per year as its contribution to the operation of the various platforms that will support the projects having received the RP grants.

6.1.2 PROJET PÉDAGOGIQUE/ EDUCATIONAL PROJECT

We present here in details the large scale project and the five recurrent actions of our program presented in 5.2.3. The following table summarizes the annual budget.

A. Labwork Project	500 k€ over 10 years (50 k€ per year)
A1 Preparation of the new lab	115
A2 Computing equipments	150
A3 Modernization	200
A4 Working costs and maintenance	35
B. recurrent actions	150 k€ per year
B1 Computing learning project	45

B2 Two Infinities' Summer School	35
B3 M2 Grants and work experience contracts for students	30
B4 Pedagogical travels	10
B5 Federal workshops and communication	30

To meet the needs in experimental and numerical teaching of the different Masters2 concerned with P2IO, we propose to finance new lab-works, computing equipment for calculus, modernization and maintenance of existing and new lab-works.
A. Among the new lab-works, we selected
- In-beam measurements of nuclear properties
- Si-pad detectors and their use in particle and nuclear physics
- New lab-works for Energy production technologies
B. Secondly, we propose to develop teaching facility for large-scale computation, establishing a small computing centre for Master students to allow them to reach a high level of expertise in numerical computation for data reduction or simulations or equation solving. Initial equipment for around 90 students, may consist in 3 computing rooms with 15 terminals. Buying software licenses and renewal of machines and storage after 5 years will follow.
C. Modernization of existing lab-works organized by the M2 NPAC and HEP-X needs also investment.
D. Finally, we propose to financially support five recurrent actions :
- Computing learning project.
- 'Two Infinities' Summer School (two weeks long) with the aim of transmitting to L3 students knowledge and know-how on PI2O research activities.
- M2 Grants and work experience contracts for students.
- Pedagogical travels to allow students to discover powerful accelerators and detectors in nuclear and particle physics (CERN and GANIL).
- Federal workshops and communication dedicated to PhD students presentations.

6.1.3 VALORISATION/ EXPLOITATION OF RESULTS

Valorisation funds are aimed at providing, through a call for proposal, 2 engineering positions to help P2IO teams to transform promising research prototypes into industrial products. These positions, funded at 50 k€ per year will be two years positions. The call will be therefore issued every other year. A small amount (50 k€/year) will be reserved to support these projects with operating money. It is expected that all administrative valorization actions , including patents process, will be supported by the IDEX appropriate structure (SATT) if approved or by our laboratories and stakeholders if not. It is foreseen to increase, probably double, the valorization budget after 4 years since there is a strong expectation that the creation of the P2IO Labex will strongly enhance the valorization potential and therefore generate a corresponding income. In more details, the asymptotic budget is listed below, with the expectation that 50% will come from P2IO budget and 50% from the revenue of the valorization actions.

- Budget for travelling (conferences, visits of industrial partners in Europe, USA and Asia) : 20 k€/year

- 2 engineer positions: one for administrative/secretariat tasks (website, documents drafting, "club" and alumni association secretariat), the other one for the establishment of the technical files (specifications, CE certification action, ..) : 150 k€/year

- 3 equipped areas (desks, computers and network) for the work in collaboration with industrial partners: 60 k€ for renovation of existing rooms in laboratories, 15 k€ for the installation of card access systems, 15 k€ for equipment.

- Budget for market and/or legal surveys (as a complement to industrial partner efforts), club et alumni association (connection actions): 30 k€ / year;

- Budget for prototype development and purchase of components related to industrial transfer (as a complement to industrial partner efforts): 100 k€/year (e.g.: microelectronics development: 30 k€/run, prototype (beta test) realization: 25 k€, mechanical model machining: 25 k€)

6.1.4 GOUVERNANCE/ GOVERNANCE

The money set aside for governance is separated in two parts : one managing assistant will be hired half-time, at the cost of 20 k€ per year and 20 k€ will be used to fund the travel of the international experts sitting on the various P2IO boards.

6.2. AUTRES RESSOURCES / OTHERS RESOURCES

P2IO Labex teams will proceed soon after P2IO creation to propose joint proposals under the P2IO banner to various calls for proposals, such as the ones coming from the European Union, the French ANR or the Ile de France regional calls. It is difficult to foresee the exact sums that will be gained in this way but they should be quite significant. The Ile de France calls, SESAME, have usually two "slot" reserved for P2IO themes and although there will obviously competition especially from the Paris intramuros laboratories, one could expect P2IO to win a call every other year. Since the usual amount of money awarded is 1.5 M€ for 3 years, the Paris Region contribution can be rather prudently estimated to 0, 25 M€ per year on average.
P2IO teams usually are awarded 5 to 10 ANR grants every year, with an average amount 500 k€ over 4 years. One can not assume that all these proposals will be made under the LABEX banner since they often imply small activities that can be outside P2IO priorities but one can safely count on 2 ANR grants with a P2IO label per year representing 250 k€ per year from ANR.
European projects are often larger but coming every 3 or 4 years with larger fluctuations but one can assume 0,5 M€ per year for projects launched under P2IO banner after 2 or 3 years of P2IO operation.
The extra resources for P2IO activities can asymptotically therefore reach 1 M€ per year, ie 50 % of the P2IO budget. This large fraction allows to be reasonably confident of the possibility to continue to fund P2IO in ten years from now just on these resources, since by that time, valorization resources coming from industrial contracts not mentioned above should be rather significant.

7. ANNEXES / APPENDICES

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7.2.3 IPHT PUBLICATIONS

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Flux compactifications in string theory: A Comprehensive review,
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Marco Cirelli, Mario Kadastik, Martti Raidal, Alessandro Strumia,
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Romuald A. Janik and Robert B. Peschanski,
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7.2.12 IRSD PUBLICATIONS

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7.3. DEVIS/ESTIMATE