

2008-2010 Report

of the Laboratoire Léon Brillouin

The French Neutron Scattering Facility







STRUCTURE OF THE REPORT

THIS DOCUMENT IS THE REPORT OF THE ACTIVITIES OF THE LARGE SCALE FACILITY (TGIR) THE LABORATORY LÉON BRILLOUIN (LLB) ATTACHED AT THE REACTOR ORPHÉE FROM 2008 TO 2010.

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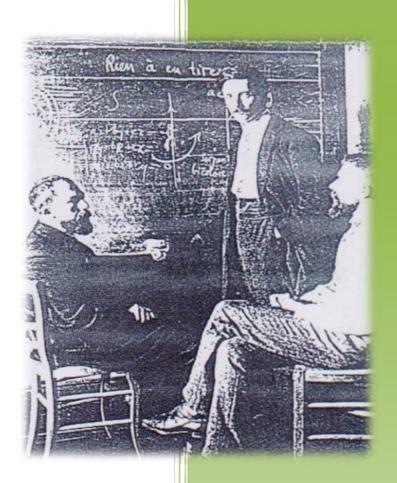
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2008~2010

PART I : OVERALL PRESENTATION OF THE LÉON BRILLOUIN LABORATORY









2008~2010

A- Short Presentation

The Laboratoire Léon Brillouin is a French research infrastructure supported jointly by the Commissariat à l' Energie Atomique et aux Energies Alternatives (CEA) and the Centre National de la Recherche Scientifique (CNRS), so-called UMR 12; it constructs and operates spectrometers around Orphée, a 14MW reactor operated by the CEA since 1980. The three missions of this national large scale facility (called TGIR in French) are proper research, service and development, training and education.

As a service institute the LLB makes its facilities and expertise available to visiting scientists from France and foreign countries, either European or not. Every year, about 500 researchers from France and other countries visit the LLB and perform their experiments on the 21 spectrometers available in 2010. About 450 experiments selected by a scientific review committee are performed annually. The director and deputy director, respectively from the CNRS and the CEA, are reporting yearly to a Steering Committee, and alternatively to a Scientific Council and an International Committee for Instrumentation. The TGIR LLB benefits from the exceptional scientific environment provided by the 'plateau of Saclay', which includes the synchrotron source SOLEIL and many renowned Universities, research centres and engineering schools. It is a leading hub for neutron scattering at the national and European levels, and a part of the European network, thus involved in the NMI3 project under the Seventh Framework Program of the European Union Commission.

In March 2011, the TGIR comprises 111 people, permanent and non-permanent, distributed in six scientific groups defined by their particular expertise in neutron scattering and four technical groups acting on the instrumentation. The scientific activity of the LLB is distributed along three axes: - Strongly Correlated Quantum Materials and Magnetism, - Materials and Nanosciences: Fundamental Studies and Applications - Soft Matter and Biophysics. The scientific results obtained from 2008 to 2010 were the object of 578 publications registered so far, equivalent to 70% of the scientific production of the French Neutron Scattering Community. The 2009 Annual Report summarizes scientific highlights of 2008 and 2009 and the new 2010 Annual Report is in press.

New objectives in research are at the centre of the instrumental development program CAP2015. The goal of this program is the modernization or construction of nearly half of the laboratory's instruments by 2015, accounting for the needs of the scientific community. This will give LLB an excellent quality of instrumentation at the disposal of the French and European communities in the following years. In particular we hope to enhance the cooperation between neutron scattering communities of Sweden and France in the development of various technologies which will support the operation of their neutron user facilities, *i.e.*, the future European Spallation Source at Lund; in the meanwhile it is therefore crucial to get staff expertise and prepare neutron user community to such an unprecedented performance. A very recent French-Swedish cooperation agreement for neutron instrumentation, signed the 13th of December 2010, will be set up presumably at the end of 2011.

The overall activity of the TGIR LLB, in terms of research and as a facility, is regularly reviewed by peer-committees of international experts:

- in 2003 (19th of November): Committee Report known as the "Nozières Report",
- in 2006 (29-30th November): Scientific Council,
- in 2007 (23rd of November) : first Instrumental Committee,
- in 2010 (8th of November): second Instrumental Committee.

At the end of 2011, a single Council for Science and Instrumentation will be created; it will meet yearly and will report both about Research activity and Instrumentation. In addition, the activities of the LLB will be evaluated as a facility and as a research unit by the AERES agency in 2013 for the period extending over the past five years. The current AERES evaluation is a mid-term analysis for the period from 2008 to 2010, before a full examination in 2013.

Historical background

The decision to construct a specialized reactor, optimized for the production of neutron beams for research was made in 1976 and the laboratory was formally created at the same time. The ORPHEE reactor was built between 1976 and 1980 as a, national-based, sister facility of the High Flux Reactor (RHF) of the Laue Langevin Institute (ILL) in Grenoble. The decision to build the reactor stemmed from the continuous expansion of European and international neutron research in the 70's. The ORPHEE design directly benefited from the safety, construction and operation feedback of previous generation reactors like RHF and was contemporary to the development of the PWR equipment program in France. The reactor first went critical on December 19th 1980. The designers' projections purposely resulted into a moderate investment cost - moderate operation cost facility ensuring reliable operation, good safety record and high performances.

Though the first five years of operation were perturbed by technical problems of youth rapidly solved, the compact design of the reactor enabled the construction of very high performance spectrometers. User access on an open basis was already set up in 1983 with the organisation of the first "Round Tables". The construction of the LLB building (563) in 1986 and the first participation to the European programs in early 1993 finalized the way of operation of the LLB-Orphée entity. During the long shutdown of the RHF-ILL in 1990-1993, Orphée operated up to 250 days a year. Up to now, since its first divergence, the reactor has been operated circa 5500 days.

Why do we use neutrons?

Nowadays, neutron and X-ray scattering experiments are unique and in constant development for the study of condensed matter. Both imply large facilities and relatively important investments, however, quickly recovered because of the large demand coming from both academic and industrial environments.

Because of its properties, the neutron is an ideal tool for exploring the structural and dynamical properties of condensed matter, measuring "where the atoms are and what the atoms do". It is relevant for materials science, engineering, soft or hard condensed matter, and increasingly to applications in biology and life sciences, earth sciences and environmental sciences. This is also important for the investigation of materials under extreme conditions such as very low and very high temperatures, high pressures, high magnetic and electric fields, or any combination of these factors. The world record of very high pressure was obtained at the LLB by I. Goncharenko (52GPa) unequalled until now

Among the specific properties of neutrons should be mentioned their very low energy, high penetrating power in matter and the possibility of magnetic polarization. The first two, often contradictory to other probes, have opened up enormous opportunities for the study of biological materials in which the low energy chemical bonds can be easily destroyed or altered. The polarization allows the study of magnetic configurations and magnetic excitations in materials as diverse as alloys, molecular organic materials, high critical temperature superconductors, thin films or nano-magnetic objects. In the case of disordered systems, including biological macromolecules and organic compounds, the possibility of isotopic labeling (usually selective substitution of hydrogen atoms by deuterium atoms) allows discrimination between sites and studies of dynamics at different scales in space and time. The specificity of neutron scattering in the case of biology or chemical physics derives from the strong interaction of neutrons with atoms of hydrogen and deuterium, an essential constituent of all organic molecules. The "contrast variation" based on the fact that the substitution of hydrogen by deuterium through chemical synthesis methods does not modify chemical properties but generates a "contrast" for discriminating isotopes by neutrons. In all cases, the low energy of the incident beam (the equivalent of a few degrees K) does not alter the properties of samples that are naturally fragile. Thanks to these unique properties, neutron scattering experiments are often well enhanced by combining them with complementary methods such as X-ray or light scattering, NMR or computer simulations. There are numerous

examples of crucial challenges where neutron scattering are about to provide decisive answers. It goes from fundamental to applied research, exploring the frontiers of knowledge and learning about the systems of tomorrow for a healthy, sustainable and technological society.

Three missions: research, service and training

The objectives of the LLB large scale infrastructure as defined in the French roadmap are to perform research on its own scientific programs, to promote the use of diffraction and neutron spectroscopy, to welcome and assist experimentalists. One should note that research at the LLB has a dual character as it encompasses both the own research programs carried out by the LLB members as well as the collaborations with visitors associated with the activities of local contacts and with instrument development.

The exceptional properties of neutrons make available information often impossible to obtain by using other techniques and provide a precise picture of where the atoms are and how the atoms move and vibrate. Not surprisingly, the research done at the LLB is multidisciplinary and covers a broad range of domains spanning basic physics, chemistry and biology. For the purpose of this report, we have summarized the research activities along three main axes, - Strongly Correlated Quantum Materials and Magnetism, - Materials and Nanosciences: Fundamental Studies and Applications, - Soft Matter and Biophysics. This distinction follows the obvious specific scientific areas, but it also accounts for the different ways to proceed in terms of collaborations, contracts and publications. In addition, this classification illustrates the strong interactions between researchers beyond their range of expertise in specific neutron scattering techniques.

Organization of Training sessions is a part of the main assignments of the LLB in addition to its own training activity through research programs for PhD students. It consists in Summer schools and lectures, but also implies to offer beam time access to students. The LLB proposes PhD and post-doc training sessions, such as "les FANS du LLB" (Formation à la Neutronique), each year in autumn, and is involved in the annual organization of HERCULES training sessions (Higher European Course for Users of Large Experimental Systems), together with the ILL, ESRF and Soleil Synchrotrons. The purpose is to offer a wide spectrum of the instruments used in a specific scientific domain. These training sessions are validated by all the "Ecoles Doctorales" and allow the students to gain ECTS points. They are completed by practical experience for students at bachelor or Master Levels, or from engineering schools. The LLB also organizes visit tours for everybody interested. Two thirds of the research staff are currently involved in Master 2 lectures and practical works listed and detailed in this report. This illustrates the commitment of the laboratory in this field and shows the implication of its permanent staff.

As a national facility, the LLB must ensure -(i)training and education (including maintaining links with universities); -(ii) access for industrial partners; - (iii) exploratory studies and experiment preparation including development of instrumentation and methodology; -(iv) provision of complementary capabilities, unique instruments and adaptability to new topics. These are enduring and complementary roles aside international centres such as the Institute Laue Langevin or the future European Spallation Source. The TGIR LLB/Orphée provides a fully-supported instrument set enabling visiting national and international teams to exploit neutron techniques. There are two calls for experiment proposals every year. The proposals are reviewed by five peer-committees of international experts. The instruments are distributed among six scientific groups responsible for operating 21 neutron instruments and for providing expertise in data analysis: Triple Axes, Powder and Liquids Diffraction, Single Crystal Diffraction, Small Angle Scattering, Reflectometry, Quasi-elastic Scattering. The experimental support for running experiments and developing instruments is provided by four technical groups: Instrument Development, Sample Environment, Electronics, and Information Technology. Common platforms have been implemented to ensure and support specific research activities. Several years ago, the LLB adopted an ambitious policy for instrumentation

improvements and upgrades never undertaken previously: the first step was done *via* the CAP2010 program ending last year, whose financing was mainly taken without extra funding. It was a modest phase before a more complete renewal with the CAP2015 program, which requires increased funding (as well recurrent subsidies as external contracts) and manpower devoted to this task.

Contents of this report

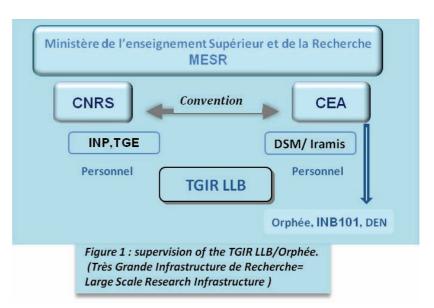
This report is organized as follows. After this short presentation, we present the governance and management, the human resources, the budget and funding, the scientific production, the training and education activities of the infrastructure, and a SWOT self-analysis. Then, the scientific activities of the LLB are presented in Part II, where the scientific results obtained from 2008 to 2010 by the LLB teams are described, together with their scientific projects. Part III focuses on the operation of the facility, pointing out the service activity, the instrument pool at the disposal of the scientific community and the CAP2015 program; statistics and advanced publishing survey which we have undertaken are presented. Finally, lists of documents (Scientific Production, Staff, Contracts, Seminars at the LLB...) are given in the annexes.

B- Governance and management

The convention CEA-CNRS

The LLB is governed by a convention signed between the CEA and the CNRS (see figure 1). This convention is for 5 years with tacit renewal since January 2006, guaranteeing 180 days minimum of operation per year. We are in a period of renegotiation of the convention and a new version will become operational for the end of 2011. It takes into account the administrative and financial arrangements and defines the role of the following organs:

- the Steering Committee (SC); 3 members designated by the CEA administration, 3 members designated by the CNRS administration, the president being one of the members and designated for two years; the heads of the departments involved and the heads of the reactor Orphée are present.
- the Director and deputy Director (extracted from Article 5: Le Directeur assume la direction du LLB dans le cadre des directives du Conseil d' Administration devant lequel il est responsable. Il associe étroitement le Directeur Adjoint auquel il peut déléguer certains actes. 5-3. Le Directeur soumet chaque année au Conseil d' Administration);



The Director is nominated by the Steering Committee with the mutual agreement of the CEA and the CNRS; the head might belong to one of the two institutions alternatively and the deputy head to the other. The deputy head is in charge of the budget of the laboratory and of the human resources. The assistant head is in charge of the relation with the reactor, the instrumental policy and projects. Over the period covering this report, several movements happened: P. Mangin was the Director until the 31th of December 2008, C. Alba-Simionesco was nominated the 1rst of January 2009; S. Gota-Goldmann was deputy-Director until September 2010; J-P Visticot was nominated as deputy-Director in February 2011.

- the Scientific Council (extracted from Article 6: analyser le rôle que joue le LLB en tant que structure d'accueil de la communauté scientifique et des industriels, d'évaluer

la qualité des résultats obtenus par les utilisateurs du LLB, d'évaluer l'instrumentation, d'apprécier l'effort accompli pour la formation dans le domaine de l'utilisation des neutrons, d'évaluer la qualité des résultats obtenus par les chercheurs du LLB et leur place dans la discipline concernée. Le Conseil Scientifique formule ses avis et recommandations au Conseil d'Administration qui les tient à disposition des instances d'évaluation des Parties.). This Council met once in 2006; its mission will be reformulated in the new convention.

Management of human and financial resources

Within every agency, the TGIR is followed for its budget by - an institute at the CNRS, the INP (Institut National de la Physique jointly with an inter-institute advisory committee for large scale infrastructures called TGE) and - a division at the CEA, the DSM (Direction des Sciences de la Matière) under the supervision of the DGRI at the MESR, the French Ministry for Education and Research. The management and the follow-up of the staff are separately carried out by the INP (and, concerning some members from the Institut National de la Chimie or the Institut des Sciences Biologiques) for the CNRS and the IRAMIS (Institut Rayonnement Matière de Saclay, DSM) for the CEA. However the budget of the TGIR depends on a vote of the parliament (the blue print) together with all infrastructures defined in the ministerial roadmap. The LLB (*i.e.* instruments, any equipments, building and staff) is a part of the entity called the INB101 (Installation Nucléaire de Base #101) shared with the reactor Orphée under the governance of another division of the CEA, the DEN (Direction de l'Energie Nucléaire) and managed by M. Delage. The total budget of the LLB includes the expenses of the reactor up to the 26/29 th.

External committees

- The Council for Science and Instrumentation.

Until 2010 the Scientific Council was operating; its action was completed in 2007 by an International Advisory Committee for the Instrumentation. However a Council for Science and Instrumentation (CSI) will be created and report to the Steering Committee every year; the president designated by the SC will be a member of the SC for two years. He will organize yearly meetings of the CSI with the help of Director. Moreover, in the new formulation of the convention, it will also be mentioned that the review of the all activities of the facility TGIR LLB/Orphée will be done after 2010 by the AERES, the Evaluation Agency for Research and Higher Education, every five years (next expected for 2013).

-The Selection Committees.

Selection Committees (SC) are reviewing the proposals written and submitted by the users; they are composed of high level scientists from France and other European Countries and meet twice a year, typically one month after the deadline for submission. Presently five colleges are operational:

THEME 1: CHEMICAL PHYSICS, BIOLOGICAL SYSTEMS

THEME 2: CRYSTALLOGRAPHIC AND MAGNETIC STRUCTURE

THEME 3: MAGNETISM/ SYNGLE-CRYSTAL SYSTEMS AND THIN LAYERS

THEME 4: DISORDERED SYSTEMS, NANOSTRUCTURED MATERIALS AND MATERIAL SCIENCE

THEME 5: EXCITATIONS

The lists of members of each council or committee acting over the last three years are given in the chapter 'Personnel' in the appendix.

Organisation chart

The organization chart of the LLB is governed by the use of the neutron beam provided by the Reactor Orphée and the best operation of the spectrometers.

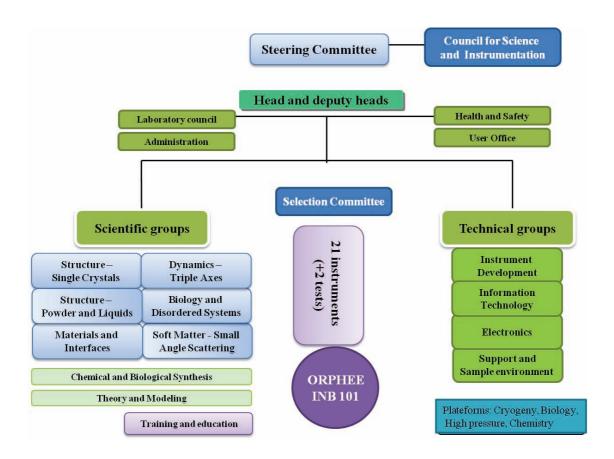
The heads of the laboratory are helped by an *administrative group* which manages the budget, the contracts, human resources, user access... These tasks are performed in close relationship with the corresponding services of the CEA (IRAMIS institute) and the CNRS (Regional Delegation, DR4). It has also in charge communications actions (web site, publications, reports..), and health and safety considerations. The heads are reporting to the 'Conseil de Laboratoire' (CL) about any information related to these tasks and consult it about any strategic decision to take. The CL is made of elected and nominated people representing every profession (researchers, technicians, students, collaborators) for 2 years. The current CL was renewed in September 2009.

All the neutron scattering methods are installed and distributed along the 21 spectrometers (+ 2 for tests), supported by common platforms proposed to the visitors. Their management and functioning are in charge of the *six Scientific Groups* (SG) members, researchers and technicians, in collaboration with the *four Technical Groups* (TG).

The groups are defined according to their scientific and technical expertise, which is described in Part III. The SG members are not only expert in a given neutron scattering method but they are also deeply involved in the national and international scientific community and recognized for their own scientific domain of expertise; they are able to establish a perfect link between inexperienced and professional users. Consequently they attract, help and guide new users from the early stage of writing a proposal to the data analysis and the interpretation of the experiments within numerous scientific domains. This scientific expertise is reinforced by transverse axis dedicated to i) chemical and biological synthesis and sample preparation, and ii) Theory and Modeling.

Recently we have introduced in the organization chart a new group in charge of the training and education activities. Its action is detailed in the Training and Education section of this report. It illustrates the strong consideration of this mission by the LLB.

The distinction of SG and TG was introduced under this form in 2008 by P. Mangin, and the final structure of this chart was approved by the Steering Committee in 2010.



Scientific animation and Communication at the LLB

Regular meetings are organized during the year, preferentially during reactor shutdowns:

- -The 'Conseil de Laboratoire' and the direction meet about 6 times a year; all information about the laboratory is discussed. A report is written by one of the members and spread with the rest of the members of the laboratory. It is available on the website of the lab.
- -The *group leaders* and the direction meet on a monthly basis; these meetings set up the execution of the budget, technical and scientific programs, and requests of the steering committee already discussed with the CL.
 - -The heads of the LLB meet monthly the heads of Orphée Installation.
- -Meetings of members within their group are organized at their convenience and vary from one group to another depending on their size, their actions (from daily to weekly basis) and the urgency. Each spectrometer responsible organizes meeting for the planning of visitors, the maintenance of the instrument with members of other groups.

The scientific animation is marked by several events:

- -Seminars are proposed at the LLB on a regular basis: on Tuesday, for general interest and hard matter (organizer J.-M. Mignot), and on Friday, for more specific topics on soft matter and biophysics (organizer S. Longeville). The titles of the seminars are given in the appendix. However, one should mention here the difficulties to reach the centre and the consequent low participation of external researchers.
- *-PhD defences and HDR vivas*: we have about four PhD and one to two Habilitation (HDR) vivas each year. They represent very good opportunities for the members of the laboratory to meeting and supporting the students and young colleagues. However here again, the problem of access forces us to organize the vivas outside of the laboratory.

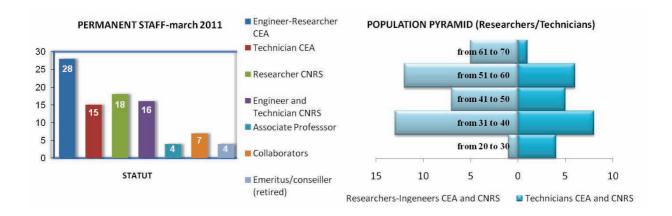
- -'specials days' are organized to encourage the young researchers to present and discuss their results: 'la journée des thésards' is prepared every year in June by the PhD students themselves with the help of the deputy-Director. Recently we have also organized a one-day meeting 'la journée des ANRs' in order to keep informed all the LLB members on new projects that have been accepted and funded by the ANRs.
- We plan to organize a LLB scientific day in autumn to facilitate inter-group communication and to pursue the discussions initiated by the preparation of this report and the implementation of three scientific axes.

C- Human resources

Staff in March 2011

The permanent staff of the LLB consists of people from the CEA and from the CNRS. For the CEA, two categories are considered researchers-engineers and technicians according to the labels of the agency; in the former one, one can find researchers, associated to publications, and engineers building the instruments, not always part of the publications, and technicians. For the CNRS, the labels are slightly different: the researchers on one hand, associated to publications, and, engineers and technicians on the other hand, the engineers being nevertheless often considered as researchers. In both cases, the technicians are assigned to a specific instrument or to a technical (or administrative) group. In the 2008-2010 periods, we have hired engineers and technicians to replace most of those retired; however only one young researcher (CR2 at the CNRS) was hired. Actually there are 46 researchers and engineers and 31 technicians, 4 associate professors and 7 collaborators at part time, and 4 emeritus.

In the figures below are represented the status of the permanent staff on March 2011 and the age pyramid shared between researchers (publishing) and technicians. One should notice that the average age is about 45, but the distribution is among -young members between 30 and 40, which is a good sign for the future, and -people between 50 and 60, near the age of retirement, which departure could be a concern for the perpetuation of neutron scattering expertise.



Evolution

The number of permanent staff remains almost constant; the most important changes in the population come from the Associated **Professors** from different Universities of Paris. closely collaborating with teams, and the increased number of non permanent staff, i.e., students. Post-Docs **Technicians** under contracts. Collaborators include people, from various institutions requesting partial attachment to our unit and Emiritus from CNRS and CEA.

Students, Post-Docs and Vivas Habilitation Vivas(HDR) not completed PhD Vivas Post-Docs

■ PhD Students

However our major concern is

the low number of permanent people acting around the spectrometers (77 all included). As mentioned in the report of the last Instrumental Committee (November 2010, see in Part III), a proper number of 105 people for 21 spectrometers would be required to maintain the LLB at the level of the other centers.

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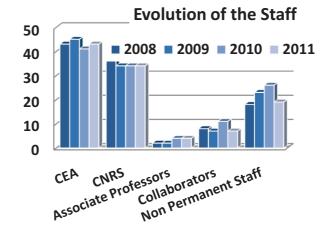
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Another important aspect of the evolution of the LLB members, the increased number of PhD students and PhD vivas; as detailed below the training and education of

students and young researchers is of major importance for the laboratory.

We welcome about 13 PhD students with 4 PhD vivas a year (more are coming in 2011) and less than ten Post-Docs. The financial supports of the PhD students arise from various origins, from the CEA, CNRS, MESR, Industry, Regions, while Post-docs salaries come from ANR or European contracts; the latter number of post-docs is quite low and results from the



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choice in the granted projects in favor of instrumentation rather than manpower. We hope to increase these numbers in the future especially via international cooperation agreements. Moreover with our contribution to Masters degrees, we also hope to convince more widely students to come to make a thesis in our laboratory. One should also keep in mind that the real number of PhD students supervised in their experiences is quite large: 100-120 students are welcomed and helped every year. Finally the number of "Habilitation à Diriger des Recherches" increases to 26 people (about 60% of the population) able to supervision a PhD work, and young researchers are deeply encouraged to defend it before the age of 40, leading to about 2 vivas per year.

Continuing Education of the Personnel

The LLB is particularly attentive to providing Continuing education for the personnel. This is important both for the people and their career and to build a project

management for the Cap2015 program. Over the last three years, the LLB members have participated in 68 training sessions organized by the CNRS and 143 by the CEA, with an

important
demand for
Methods and
Instrumentatio
n, which
correspond to
the needs of

	CNRS	CEA
Security (qualité, sureté environnement)	8%	9%
Methods/Instrumentation (métiers scientifiques)	32%	31%
Schools+ DIF (formation individuelle) 44% 44%		44%
Language/Soft (métiers du support	16%	16%

our facility. A great effort has also been made for training PhD students and post-doc (counting for 22% of the dedicated budget). We note a balanced participation of men and women in training actions: women represent 29% of the participants and 29% of the personnel.

Health and Safety

All equipments and buildings of the LLB and the Orphée reactor are grouped within a single entity called the INB101 (*Installation Nucléaire de Base* #101). The director of the Orphée reactor is responsible for the safety responsible within the whole entity, and the director of the LLB has in charge the safety of the LLB visitors, equipments and buildings. Most of the periodic regulatory controls, such as electricity, lifting equipments, fire detectors, cryogenics systems, are supported by contracts at the CEA/Saclay level. Specific contracts are set for the maintenance of special devices like centrifuges.

At his arrival at the laboratory each individual worker elaborates and signs his risk analysis sheet with the safety engineer. This document describes all risks linked with the work performed at the LLB. Various CEA softwares are also used in order to evaluate the level of classical and chemical risks in all offices and laboratories of the LLB. They have been applied to each individual rooms of the installation during the Summer 2010. This analysis enables to suggest some modifications which are currently underway in order to improve safety in our chemical laboratories. In order to set the radiological safety and protection against radiations the director of the Orphée reactor is helped by an independent radiation protection group advising him how to put in application all the regulations within the entity INB101. Different actions undertaken recently aim to the reduction of the exposure of workers to radiations, chemical and mechanical risks.

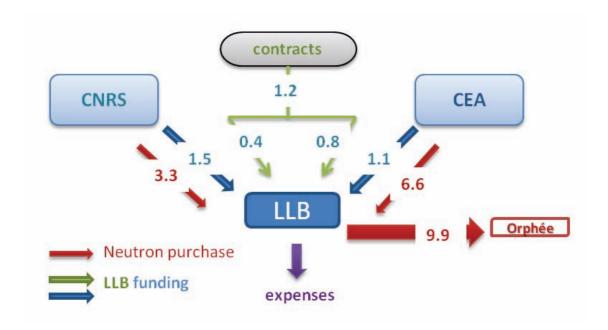
The next short time projects in safety are more dedicated to the improvement of wellness of work. They mainly concern the modification of the access to the experimental hall with a shorter path to blg.563 and the realization of a new cloakroom for all workers of the hall of neutrons guides in blg.541.

More details are given in the second part of this report devoted to the large scale facility.

D- Financial resources

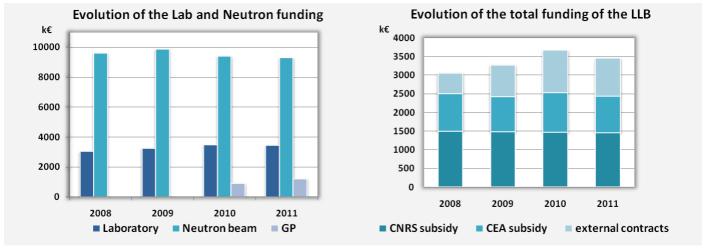
CEA & CNRS Contributions

The convention between the CEA and the CNRS rules the way the budget is shared and distributed to the LLB. A schematic illustration is depicted hereafter (the figure represents the approximate amounts in M \oplus). The budget received by the facility consists of i) the purchase of the neutron beam time from Orphée (9.9M \oplus) which is shared with the key 1/3 coming from CNRS and 2/3 coming from CEA, and ii) the running and functioning of the laboratory (salaries of permanent staff not included) (3.8M \oplus). The latter part includes itself three components: the CNRS subsidy, the CEA subsidy and the external resources obtained by contracts (national or international). Their respective amounts should obey the following equation: CNRS sub.+ 1/3 contracts= CEA sub.+ 2/3 contracts (1/3 of the amount of the contracts is formally attributed to the contribution of the CNRS and the rest 2/3 to the CEA).



Evolution of the total budget

In the following figures, the total budget of the LLB is analyzed: on the left, the evolution of funding for the purchase of neutron beam and for the laboratory is displayed. One can observe: i) a slight decrease of the budget in 2010 and 2011, partly due to 5% of precautionary reserve not reallocated, ii) an extra financing starting in 2010 specially devoted to the maintenance of the reactor Orphée, ii) a slight increase of the total budget



of the laboratory.

For the reactor safety case, on October 23rd 2010, a panel of experts (panel called GP for Groupe Permanent) nominated by the French safety authorities (*Authorité de Sureté Nucléaire ASN*) did publish the evaluation of the status report of Orphée given by the CEA. Though some improvement of safety were asked, the report points out that the initial reactor safety features remain appropriate to up-to-date safety practices; the cost of this improvement was planned in an additional funding and spread over few years. All these maintenance operations will enable us to keep the Orphée reactor in a very good functionning state. With that point and with the amount of fuel that we already have, we are prepared to reach the next safety reassessment in 2020 in good conditions.

The budget of the Laboratory is considered in the figure on the right hand side: an increase of the LLB financing is seen. It is directly related to an increase of external funding (in number and volume), thanks to the success at the various calls for tender, with an average rate of about 25% (1 project accepted for 4 submitted).

External funding

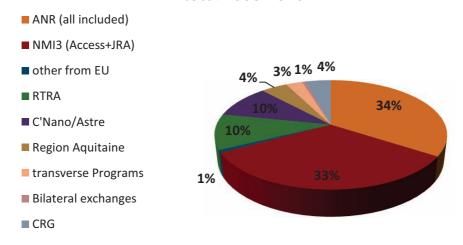
External contracts are of several origins: they correspond to projects selected by different organizations at

- i) *local level* such as RTRA (Réseau Thématique de Recherche Avancée= Advanced Research Cluster) Triangle de la Physique, C' Nano (Nanoscience Competence Centre, leading the lle de France region's Major Research Area), ASTRE (Action de Soutien à la Technologie et à la Recherche en Essonne= support to research and technology in Essonne).
- ii) national level with the ANR (the French National Research Agency), Cooperation Agreement with Regions and French Universities, Industrial program and service offers and transverse programs of CEA and CNRS;
- iii) international level with bilateral projects (ANR or exchange programs between France and another country). The main contribution corresponds to the support by the European Commission under the Framework Program through the 'Research Infrastructure' action (NMI3 = Integrated Infrastructure Initiative for Neutron Scattering and Muon Spectroscopy) in terms of Transnational Access and Joint Research Activities. Moreover, one instrument (1T) is a Collaborative Research Group Instrument (CRG) with the Karlsruhe Institute of Technology (KIT), a German University of the State of Baden-Württemberg and National Laboratory of the Helmholtz Association.

This decomposition of the contracts into three categories reflects the organization of the collaborations. The complete list of ongoing contracts over the period of this report is provided in the annexes.

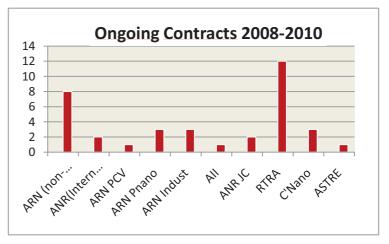
The external funding might be considered in slightly different point of view: national or international, basic research and industrial contributions. In a tentative way to share these funding between the laboratory and the facility activities, a special attention on the NMI3 program, the CRG and the relations with industrial partners will be presented in the Part III of the report. However all these fundings participate in the development of both the own research and the instrumentation, allowing diverse financial plans (see for instance the PA20 project in CAP2015), sample environments (High Pressure or cryogenic equipments), and non-permanent staff salaries (Post-doc or Technicians).

Distribution of fundings from various Contracts total 2008-2010



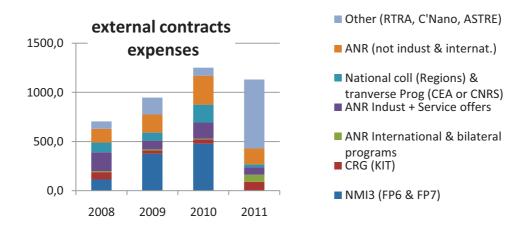
The success encountered over these last year's can be represented in the figure, where we have represented the distribution of funding from various granted projects, 34% of the total amount comes from ANR (all themes included), 34% from the European Union, 27% from Regional and local calls, 5% from international cooperation agreements.

Thanks to its intense recognized activity in fundamental science, the LLB scientists participate to consortiums at the national level successfully obtains **ANR** contracts (non-thematic or thematic). projects represent These a non negligible part of our resources and contribute largely to the instrumental developments. A highly important aspect is that ANR projects (50% are non-thematic ones) allow integration of our scientists in the French research network. In addition, number of projects have been funded

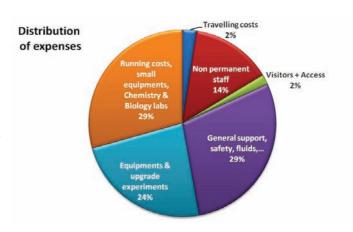


by Foundations and Agencies that support projects at the regional (C Nano IdF, ASTRE) or local level (RTRA Triangle de la Physique). The research associated with these contracts is at the centre of the Scientific Report in Part II.

In terms of societal impact, the financed projects are distributed among various domains; they illustrate once more the multidisciplinary aspects of our work. Some of them belong to the National Strategy of Research and Innovation (SNRI): 22% for Biology and Health, 11% for environmental issues, 11% for energy.



On the above figure, we have plotted the real distribution of expenses originating from the same calls: it increases with time because of the increasing number of granted projects, but essentially it takes into account the long period required to develop instrumental projects of the size of a neutron scattering spectrometer. For instance, it shows that most of the contracts received from local organizations will be spend in 2011: it corresponds to the future SANS spectrometer PA20 expected to be operational in 2014. The main reason



for the decrease in 2011 comes from the fact that the present LLB NMI3-FP7 Access program started on February 2nd 2009 and ended in 2010; a new program was submitted in November 2010, which was successfully received and will start early 2012.

Distribution of expenses

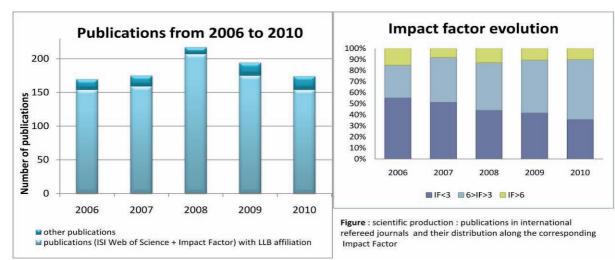
The part of total budget of the LLB without salaries of permanent staff is distributed among major and uncompressible expenses such as all running aspects, general supports, salaries of non-permanents staff, and visitor's access. Most of the travelling costs, salaries and running equipments are spent over the contracts. Only 24% is left for instrumentation and new developments, which is pretty low when compared to other centres and when the cost of spectrometer is kept in mind. A considerable effort was made with the CAP2010 program, restricting strongly the research budget of the LLB teams. But an ambitious policy for instrumentation improvements and upgrades needs more financing and the CAP2015 program requires increased funding both recurrent subsidies and external contracts. However we shall need in the future of a better follow-up of contracts and financial subsidies both towards the CEA and towards the CNRS.

E- Scientific production

To assess the performance of the infrastructure, we have collected all the publications in a list presented in the appendix. This list takes into account the research work performed and/or initiated by the LLB members described in Part II, that of closely collaborating users often associated in specific national or international programs described in Part III, and finally the work of other external users carried out with the help of LLB scientists and technicians. The latter list is the most difficult to complete: for some publications the LLB affiliation appears explicitly, but in many cases it is not, which makes their accounting problematic if the users forgot to send them to LLB after publication. On the basis of the user's feedback that we have explicitly asked for the year 2008, we have estimated that about 10% of the publications are missing for all the years (except for 2008). We have also added in the appendix the list of book chapters or editorial activities. Moreover, a list of all the communications (invited or not, international or national) performed by the LLB members is proposed demonstrating the efforts made to broaden the diffusion of the work performed at the LLB and its recognition at the international level.

A specific study of the LLB Bibliography was performed with the help of Marie-Anne Leriche from the CNIST (Scientific and Technical Information Group) at Saclay. A summary is provided in the following pages.

Publication records 2008-2010



In the present document, we propose two procedures to classify and analyze the scientific production of the LLB. On one hand, we have considered the available list of publications resulting from all works performed at the facility; within this list we have made a distinction between the publications extracted from the citation data base ISI Web of Knowledge and international journals with an impact factor, and, the publications in conference proceedings or journals not listed in ISI Web of Knowledge, so the actual publication records is higher as found in ISI, as illustrated in following Figures. On the other hand, we have classified this list according to the three research axis presented in Part II and a fourth one accounting for the production of research not related to three (external users and other collaboration). The former classification is analyzed in this chapter and will be at the centre of a comparative study between neutron scattering centres; the latter one will help the experts in their analysis of the proper research activities presented in Part II.

Over a larger reporting period from 2006 to 2010 in the right hand side figure, the number of publications according to the ISI Web of Knowledge registered with the LLB affiliation is roughly constant, with a consistent presence in the most prominent journals when their impact factor is considered: about 10-15% of the publications are accepted in highly ranked journals (Nature, Science, Angewandte Chemie, Physical Review Letters, ..). The major change comes from the increasing contribution in medium ranged journals (3< IF< 6): the rate changes from 30% to 54% in 2010, reducing the number of publications in journals with an IF below 3. This is the sign of an increasing community especially in materials sciences, soft matter and biology.

However the real impact of a publication is measured by its number of citations. When the above publications are associated to a citation index, the result shows the quality of the work performed. From the ESI (Essential Science Indicators) base, which

already selects 20% of the most cited publications, an average citation number of 4.02 is found in Physics for publications in 2006-2010; here the average number of citations is 5.7. Furthermore the proportion among the LLB list of the ones ranked among the 10% most cited worldwide is about 21%

LLB	2008	2009	2010
Top 10%	42	41	32
Articles among the 10% most cited worldwide	20%	23%	21%
Top 1%	5	4	2
Articles among the 1% most cited worldwide	2.4%	2.3%	1.3%

while the proportion ranked among the 1% most cited is 2%. Being in the 10% most cited papers of 2008 (in March 2011) means that it should cited at least 10 times (or 5 in 2009, 2 in 2010), for the 1% at least 36 times (or 19 in 2009, 6 in 2010). The number of citations for 2010 might increase slightly with time; effectively the study shows that the number of citations evolves with time slowly in Europe when compared to United-states.

Beyond the statistics it is important to check what topic was mostly cited recently; here is a selection of them over the last three years:

Electronic liquid crystal state in the high-temperature superconductor YBa2Cu3O6.45, Science, 319; 5863, 597-600, (2008) Hinkov, V. Haug, D. Fauque, B. Bourges, P. Sidis, Y. Ivanov, A. Bernhard, C. Lin, C. T. Keimer, B. 94 citations

Electric-field-induced spin flop in BiFeO3 single crystals at room temperature, Physical Review Letters, 100; 22, 4,(2008) Lebeugle, D. Colson, D. Forget, A. Viret, M. Bataille, A. M. Goukassov, A., 72 citations

Magnetic-Field-Enhanced Incommensurate Magnetic Order in the Underdoped High-Temperature Superconductor YBa2Cu3O6.45, Physical Review Letters, 103; 1, 4(2009) Haug, D. Hinkov, V. Suchaneck, A. Inosov, D. S. Christensen, N. B. Niedermayer, Ch. Bourges, P. Sidis, Y. Park, J. T. Ivanov, A. Lin, C. T. Mesot, J. Keimer, B., 41 citations

Polysaccharide-block-polypeptide Copolymer Vesicles: Towards Synthetic Viral Capsids, Angewandte Chemie-International Edition, 48; 14, 2572 (2009), Schatz,

Christophe Louguet, Stephanie Le Meins, Jean-Francois Lecommandoux, Sebastien, 28 citations

Normal-state spin dynamics and temperature-dependent spin-resonance energy in optimally doped BaFe1.85Co0.15As2, Nature Physics, 6; 3, 178-181,(2010) Inosov, D. S. Park, J. T. Bourges, P. Sun, D. L. Sidis, Y. Schneidewind, A. Hradil, K. Haug, D. Lin, C. T. Keimer, B. Hinkov, V., 32 citations

The average publication rate per researcher of the LLB and per year is about 4; it becomes 3 when only own research is considered. To evaluate these numbers one should obviously bear in mind the particular status the facility; however it is quite high when compared to other facilities (and thus normalized by the number of scientists or any other criteria suggested in Part III) or when compared to other laboratories. Moreover one should consider the considerable amount of time dedicated to maintenance development of new instrumentation, and the low number of manpower on each spectrometer as notified by the

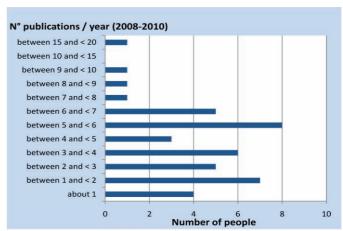
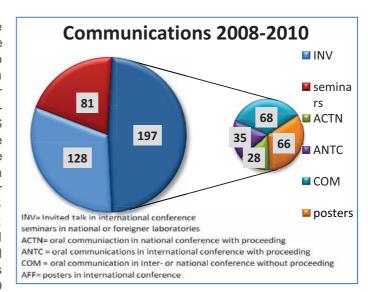


Figure : distribution of the number of publications among the LLB researchers

Instrumental Committee in November 2010. The resulting distribution of publication rate among the members of the facility is shown on the joined figure aside from 1 article per year for 4 people to almost 20 for one of them. When analyzing these numbers, one should also keep in mind the time spent in writing and submitting applications (local, national and international) guarantying a third of the LLB budget.

Communications

As a result of the high publication rate and the high number of citations of the articles, the members are often invited to international conferences and seminars in in various Universities laboratories Institutes. A compilation over the years 2008-2010 is presented according to the AERES classification and a list is added in the appendix. On average, there is more than one invited talk (keynote or lectures) international conference per year and per researcher. It is distributed between 0 and 6 per year depending on the scientist, and it illustrates the recognition of the internal research of the LLB. The high number of oral communications and posters demonstrates the wish to help young scientists, PhD



students and Post-Docs and contribute to their training through research.

Patents

Three patents have been submitted.

"2-D High Resolution Detector for Neutron Scattering" P. Baroni & L. Noirez, $n^{\circ}0502379-$ PCT. Using Light to see Neutrons : a new two-dimensional detector with high resolution.

"Improved method to determine dynamic properties in fluids and liquids" P. Baroni, H. Mendil & L. Noirez, n°0510988 -PCT. The authors have developed a new type of substrate intended to replace the aluminium fixtures traditionally used in rheology.

"Mineral electrolyte membrane for electrochemical devices", J.-M. Zanotti & K. Lagrené, Patent # FR 10/56178. The authors have proposed an original way to significantly increase the ionic conductivity at room temperature of lithium metal batteries by combining nanometric confinement and ionic conduction in one dimension.

Memberships

The staff of the laboratory participates actively in the national and international scientific life; this is noticeable by its multiple contributions in committees for PhD and HDR vivas, in the organization of national and international conferences (local organizing or scientific advisory committees), in various boards of evaluation (AERES, ANR, RTRA, CNRS), in the selection committees of the other facilities (ILL, FRMII, HMI, ESRF..), in various work groups. A non exhaustive list is given in the annexes.

F- Training and education

There is no means to perform neutron scattering in a standard laboratory as neutrons are only available at medium and large scale facility, thus teaching and deepening of knowledge must involve these facilities. Therefore a top mission of the LLB is to educate students, scientists and the general public about both the capabilities of neutron scattering per se and the scientific advances achieved thanks to the use of this probe. To reach these goals, the LLB staff actively participates in the scientific community by taking part on national and international conferences (contributing and coorganising), by presenting the technique at local meetings or at all levels of University courses, by hosting advanced neutron scattering schools and sponsoring workshops, by jointly working with other large scale facilities and in close collaboration with the French Neutron Scattering Society (SFN). Several other ongoing actions are publications, displays, website, books, but a major one is the supervision of PhD students. The coordination of all the actions is ensured by the 'training and education' unit, composed by S. Petit, F. Porcher, A. Menelle, F. Cousin and Y. Sidis, but it involves most of the members of the laboratory, including the technicians who take great care and contribute to their training.

Training through research, PhD students and Post-Docs:

-PhD program at the LLB: Supervision of PhD students is certainly one of the major causes of satisfaction of the researchers at the LLB. Every year about 10-15 PhD subjects are proposed as well as Master degrees; unfortunately the localization of the Laboratory and the difficulties of access are often a cause of refutation of young students.

On average there are 10-15 'in house' PhD students working on the research axes developed in Part II, 13 students in March 2011. Over the period of this report we had 12 PhD vivas, and 7 Habilitation (HDR) vivas, increasing the number of researchers able to supervision their work to 26 (excluding the emeritus), *i.e.*, 60% of the staff, and more are expected in 2011.

-PhD students and Post-Docs visiting the LLB: due to its facility activity, the LLB researchers and technicians are also welcoming and training a lot of external PhD students, often coming alone. The local contacts are particularly aware in helping and teaching them how to conduct the experiments and to treat the data. We estimated the number of 100 to 120 visiting PhD students and about 60 Post-docs per year. Unfortunately non European students often encounter major difficulties to enter, work at the LLB and stay at the guest house.

-PhD and Post-Doc training sessions:

Training session organization is a part of the main assignments of the LLB. It consists in Summer school and lectures, but supposes also favoring beam time access to



students. There are several special training session (or Summer schools) on neutron scattering on which the LLB is deeply involved; Lectures on neutron scattering techniques (70h by 16 scientists), along with practical works (6 days/year) are offered to students.

-The laboratory proposes its own training session, called « les FANS du LLB » (Formation à la Neutronique), each year in Autumn. Web page: http://www-llb.cea.fr/fan. The aim is to provide young French speaking researchers with a first simple contact to real experimental neutron scattering. Students and post-doc working in all scientific areas where neutrons can provide valuable insights will be welcome; those having not yet had any contact with neutrons

scattering will be selected in priority. After a 4 hours introduction to neutron sources and neutron scattering, 10 different subjects, based on various scientific problems that can be addressed by neutron scattering, are proposed to students. Within each subject studied by group of 5, students will discover 2 different neutrons scattering techniques. The main specific feature of our school is that usually, most of the students come with their own samples which are tested during the trainees among our demonstration samples. This ensures a strong and efficient participation of all to the courses.

The usual number of students (nationals/non-nationals) is about 35 in total, 25 French, 10 non French. This training session is validated by all the "Ecoles Doctorales" and allows gaining ECTS points.

Since 10 years, this school is fully supported by the LLB which has in charge the development of the French neutron scattering community. However in the new FP7 call and the under the NMI3 project, support from EU will allow us to open our school to all French speaking European young researchers, and provide them an easier access to neutron scattering.

- The annual organization of HERCULES training session (*Higher European Course for Users of Large Experimental Systems*), together with the ILL, ESRF and Soleil Synchrotron. 16 LLB's researchers participate, for a total of 6 hours lectures along with practical works (3 days/year).

-The LLB is also involved, in collaboration with the Soleil Synchrotron, in the \tt Cristallographie et Grands Equipements » training session. It consists in series of M2 lectures on crystallography, proposed to PhD students and regular scientists, mixing theoretical and experimental approaches.

-other training sessions:

The LLB traditionally participates to the organization and financial support of a number of Summer schools, acknowledged by the CNRS and CEA « continuing education». This activity is part of LLB major assignments. The aim is to encourage new users to use neutron techniques, especially PhD students, post-docs, and professors who would like to become familiar with neutron scattering. For instance, such a Summer school devoted to « l' Apport des Symétries en Matière Condensée » took place in 2009 in the Presqu' î le de Giens.

The laboratory also participates to the Summer schools organized each year by the French Neutron Scattering Society (3 to 6 scientists for about 12 hours' lectures per year since 1998):

- Inelastic neutron scattering studies in condensed matter (May 2008 Albé)
- Neutrons and soft matter (May 2009 La Grande Motte)
- Neutrons and numerical simulations (June 2010 Rémuzat)

Each Summer school mentioned is accompanied by the publication of a special issue. These issues written in French propose a complete corpus of lectures on neutron scattering techniques and of their use in different research fields. They are available at the EDP publishing site EDP (http://www.neutron-sciences.org) and can be the basis for lectures and practical work on neutron scattering.

Teaching and Supervision, bachelor and master degrees

Several researchers are currently involved in M2 lectures and practical works. This accounts for the experience of the laboratory in this field and shows the implication of its permanent staff.

-French neutron scattering society (SFN) itinerant chair: for example a lecture on « Neutrons et Science des Matériaux » done by M-H Mathon at the University of Marseille in 2010

-L3-M1-M2 lectures: for example « Introduction à la Spectroscopie Neutronique » by Y. Sidis for the Master NANOMAT at the University Paris 6. -M2 practical works: for example at the 'Ecole Centrale de Paris' for 2 days a year, « Grands Instruments », « Diffraction magnétique de neutrons », « Mesure de la densité d' aimantation d' un monocristal de Nickel », « Diffraction de neutrons aux petits angles », by A.Bataille, G. André, B. Gillon, J. Jestin.

Scientific popularisation:

The LLB participates each year to the « Fête de la Science ». Aiming at reaching a broad audience, a giant spot devoted to diffraction phenomenon has been designed and built. Special attention is paid to the importance of tuning the wavelength according to the typical dimensions of the objects under study. The LLB researchers are also present to answer questions and help visitors and secondary school pupils.

LLB members are invited to conferences of a broad audience, such as the 'Cyclope conference' where J. Teixeira recently presented a lecture on 'I' eau, cette inconnue'.

Together with the "Orphée Reactor" department (CEA Saclay), the LLB has participated to the writing of a scientific popularization book by Denis Mazzucchetti, entitled *Des Neutrons pour explorer la Matière* (Félix Torres Editor). This book details the research activities using neutron scattering techniques as well as the physics of reactors.

For the future:

Our implication at M1 and M2 levels should allow us to introduce the possibilities of the neutron techniques right from the ground levels. As far as a lot of research fields are concerned (soft matter, biology, nano-materials, thin films, crystalline and magnetic phase transitions, phonons, magnetic fluctuations, strongly correlated electrons ...), neutron techniques federate a broad audience, hence a number of universities degree courses. To this end, we intend to prepare practical works in close collaboration with the M1 and M2 university professors.

At the M1 level, this can be a simple visit. Depending on the main course, a general reactor hall visit can be proposed (condensed matter or nuclear physics), along with dedicated visits, devoted for instance to cryogenics (thermodynamics).

At the M2 level, we may propose a standard practical work (see the list above), but other possibilities could be offered, for instance long projects (typically a few days or a week), where students would have to face more complex problems.

Virtual practical works could also be carried out. To this end, we will need informatics tools to simulate a neutron scattering experiment. This kind of training is already proposed by the FRM-II (Munich) neutron large facility to German students.

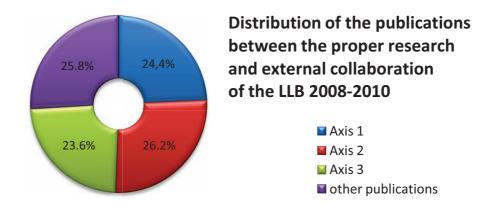
The LLB permanent staff should dedicate part of their time and energy to these activities. These proposals were included in the recently accepted Labex PALM with the University Paris 11, but it could be extended to other Universities and Engineers Schools; this is also clearly registered in the recent NMI3 project.

G- Presentation of the Part II and III

The LLB provides world class facility for neutron investigation of materials across a large range of science disciplines. It is operationally organised in groups as mentioned above around the spectrometers. However its scientific activity is more transversal and distributed among 3 axes illustrating the multidisciplinary use of neutrons although only part of it is reasonably conducted.

Part II of the document reports on the proper research activity of the LLB; it contents at the end the Scientific Projects in each area. Part III focuses on the operation of the facility, pointing out the Service Activity, some highlights of visitors, and the instrument pool at the disposal of the scientific community. The 21 spectrometers are spanned over Triple Axes, Powder and Liquids Diffraction, Single Crystal Diffraction, Small Angle Scattering, Reflectometry, Quasi-elastic Scattering. The program CAP2015 for the renewal of the instrumentation is presented at the end with the Instrumental Advisory Committee report of November 2010.

The selection of works and their synthesis in Part II are the results of very active discussions organized within the laboratory for the preparation of this report. The three axes are: - Strongly Correlated Quantum Materials and Magnetism, - Materials and Nanosciences: Fundamental Studies and Applications - Soft Matter and Biophysics.



The scientific production of each of them has been considered and selected among the general list provided; a color code and a classification per year are defined for the three axis and a fourth one which includes works performed in collaboration but not ranging in these topics and publications where the LLB affiliation was not explicit. The distribution of publications is shown below: about ¾of the publications involve a deep commitment of the LLB members. Here is an abstract of each of them.

Axis 1 Strongly Correlated Quantum Materials and Magnetism

The term "strongly correlated electron systems" (SCES) broadly denotes a class of materials and physical phenomena which cannot be described in terms of the standard theory for a Fermi gas of non-interacting electrons. Such situations mainly occur in compounds containing transition-metal or rare-earth elements, because d and f orbitals have a more pronounced localized character. One common feature in many of these

materials is the coexistence of several degrees of freedom associated with the electron-(charge, spin, orbital) or lattice sub-systems, whose interplay is responsible for a large variety of ground states and excitation spectra. Well-known examples studied at LLB, both experimentally and theoretically, include cuprate or ferropnictide high- $T_{\rm c}$ (HTC) superconductors, "giant magnetoresistance" manganites, compounds with short-range magnetic interactions subject to geometrical frustration (multiferroics, spin-ices, etc.), lanthanide-based heavy-fermion systems and "Kondo insulators", as well as a number of materials in which unconventional orders occurs, such as the "magnetic blue phase" of MnSi, or the multipole-order states found in rare-earth hexaborides. Because neutrons interact with both the atom nuclei and their electron shells, neutron scattering is one of the best tools to study this type of physics involving interplay of lattice and magnetic properties. Polarized neutron beams, implemented on several spectrometers at LLB, further enhance the potential of neutron experiments for studying strong correlation phenomena in condensed matter.

Axis 2 Materials and Nanosciences: Fundamental Studies and Applications

This scientific axis covers the activities related to the research in material sciences and more generally in hetero-systems (interfaces, alloys, composites materials, confined systems). The topics cover the study of the detailed structure of nano-objects, the interactions between nano-objects, and the role of nanostructures in composite materials. In these studies, the length-scales which characterize the properties of the systems range between 1-100nm. The techniques used for these studies range from diffraction to small angle scattering and reflectivity. More specifically the topics which are addressed at the LLB cover the following areas: Magnetic nanostructures (metallic layers, oxide epitaxial layers, nanoparticles) studied by diffraction, SANS and reflectometry; Composite materials (polymer reinforcement by nano-particles, metallurgical composites) whose properties are studied by SANS; Metallurgy (both fundamental and industrial). Textures and Strain heterogeneities are studied by diffraction in various alloys or nuclear materials; Confined systems (microporous materials and organized guest-hosts systems, mesoporous materials and organized guest-hosts systems) in which the dynamics of the confined elements can be studied by inelastic scattering techniques; Amorphous materials (disordered systems – glasses). The local atomic order can be studied by diffraction.

Axis 3: Soft Matter and Biophysics

Flourishing of many new systems, marrying different components, many involving nanoscales (1-100 nm) has become a major current trend in soft mater. At LLB, researchers have developed in similar directions and keeping some of the historical specificities of the lab: involving polymers as one of the components, and with in mind the advantages of neutron scattering, i.e. labelling and contrast matching, while we often marry the reciprocal space (SANS but also SAXS) with other techniques, in real space or at macroscopic scales. The following topics are presently developed: nanoparticles and hybrid systems; organic systems and self- organization; polymer dynamics; electrostatics complexes.

The research at the interface of physics and biology is based on three main topics:

1) Proteins in complex media viewed as model systems for living environments. Experiments are concerned with macro- or supra-molecular scales and their analysis is strongly influenced by our background in polymer physics, statistical physics and phase transition physics; 2) Local dynamics of proteins and hydration water in relation with the dynamical transition of proteins and their enzymatic activity. Neutron scattering techniques, that are very sensitive to protons, are particularly suitable for these studies; 3) Water and its specific properties are fundamentally related to life and to the very peculiar properties of some biological molecules like proteins. Here, water properties are studied in relation with the dynamics of hydrogen bonds network, the notions of hydrophobicity and confinement

H- SWOT analysis

The LLB is rather unique among neutron centers worldwide because it was specified from the outset to operate as both a large facility "TGIR" open to a user's community and a research institute in charge of developing its own research programs. In view of the duality of our missions, weak and strong points of our activity can be considered with respect to other large facilities or to classical laboratories. However it is difficult to separate our actions between the two goals since they are strongly interdependent and the strengths of the one can be the causes of the weaknesses of the other one. As far as there are no elements of comparison, our self-analysis will contain elements of evaluation of one research laboratory as those of a large-scale Infrastructure, but the most singular aspect will be the intimate combination of both. We thus suggest a self-analysis by developing some points linked to LLB specific actions, followed by a table summarizing what we have considered as strength, weakness, opportunity or threat in a more classical way, i.e., with elements common to all centres and laboratories in the French landscape.

As a national facility, we would like to recall that the LLB must ensure —(i)training and education (including maintaining links with universities);—(ii) access for industrial partners;—(iii) exploratory studies and experiment preparation including development of instrumentation and methodology;—(iv) provision of complementary capabilities, unique instruments but still adaptability to new topics. These are enduring and complementary roles aside international centres such as the Institute Laue Langevin or the future European Spallation Source. The TGIR LLB/Orphée provides a fully-supported instrument set enabling visiting national and international teams to exploit neutron techniques; a program for upgrade and construction of world-class instruments started, CAP2015, which should guaranty the excellence of the results for the next 20 years, sustained by the reliability of the Reactor Orphée, but with the threat of lack of financial support.

As a research laboratory, the LLB teams are developing their own research program. Due to the central use of neutron scattering and its multidisciplinary applications for exploring condensed matter, the research is performed among three main axes, covering most of the domains of current interests. Our researchers have a strong international visibility and recognition (number of publications and citations, invitations at international conferences, number of selected projects in national and international calls, awards and prizes). They share their time between i) welcoming and helping users, ii) developing new instrumentation corresponding to their needs, iii) answering to calls to get more funding for the instrumentation and research, iv) being part of national projects, and members of various evaluation committees, and v) ensuring training and education of students and post-docs, all these actions with a rate of staff renewal kept very low, with the threat of loss of expertise and motivation.

STRENGTHS

LLB's dual mission: Being able of managing at once all the aforesaid missions, as well as their outcome and the successes which ensue from it, can be considered as a strength per se. On the long term, this dual mission turned out to be a very wise and long-sighted choice. Despite relatively modest funding on the scale of comparable infrastructures, the LLB can prevail itself of a rich, *multidisciplinary*, *world-class scientific production over the years*, *reflecting a remarkably effective* synergy between external users and local neutron specialists. To the LLB teams, this brings up valuable opportunities to engage into novel fields of research, in cooperation with leading international teams. The user community, on the other hand, benefits from the support of renowned experts in a whole spectrum of neutron scattering techniques, who get personally involved not only in preparing and carrying out the experiments, but also in treating and interpreting the data as well as writing the publications. Numerous examples of such successful collaborations can be found in the fields of high- T_c superconductors, soft Matter, nano magnetic materials, protein dynamics and many others.

Since most of the LLB members have permanent positions, they are able to develop and promote long term projects and new instrumentation directly related to the needs of their collaborators; thus the instrument use is optimized by matching scientific interest to the capability of any specific technique. A side effect of such policy is that high performance, and low cost instruments can be built (TPA is a remarkable example, 7C2 and PA20 are promising..). We are making constant efforts to develop the performance of the instruments; for the most part, this consists in increasing the available flux so that smaller samples can be measured, as well as "regular" ones, with more and more complex sample environments (very high pressure and low temperature and high magnetic field..), or gaining a factor 10 to 30 in Reflectometry by using new neutron optics technique. Sample environment is permanently improved, but also methodology such as processing the single crystal diffraction data acquired by the Position Sensitive Detectors.

The dual character of LLB, however, entails some difficulties which must also be addressed.

STRENGTHS

- -Neutron Scattering. A unique experimental probe for exploring the structural and dynamical properties of condensed matter: selective, non-destructive, highly penetrating, with magnetic moment, polarization.
- -21 spectrometers: flexibility and specialization. Complementarities with the other Centres; very high rate of use of the spectrometers. Renewal program Cap2015.
- -New organization chart: scientific and technical groups in charge of the instruments and transverse research actions; additional tools installed and developed for research
- -Strong involvement of the personnel (technical and scientific experts) into the scientific community: 70 % of the French scientific production in neutron scattering involves the LLB.
- -multidisciplinary aspects of research from Fundamental to Applied Research: thanks to collaboration, ability to anticipate the needs of the community
- -Strong international visibility of researchers (citations rate of the publications and the number of invitations at international conferences, number of projects selected);
- -Increase of the external resources: dynamism of the personnel evidenced by its strong involvement in national and international programs, keeping the scientific consistency around neutron scattering.
- Training and Education: strong increase in the number of non-permanent staff and Insertion in the world of the education- Creation of a unit for training and education
- Reliability of the reactor Orphée source of the neutrons; Functioning guaranteed for the next ten years
- Attractiveness of the international visitor and industrial users.

WEAKNESSES

Because their primary role in external collaborations is that of neutron experts, LLB researchers may tend to overspecialize in their field, which makes it more difficult for them to act as coordinators of large-scale projects based a variety of experimental techniques. In the case of solid-state physics and materials science, one further limitation lies in the fact that the LLB has no in-house material synthesis or crystal-growth facilities. As a result, most internal research projects in this field rely primarily on outer sources for accessing new materials. On the other hand, groups from universities or other research institutes having their own sample preparation capabilities often include experienced neutron users, which can freely apply for beam time at different places. Some of them even operate their own CRG instruments at some of the major European sources. Attracting the best teams to perform their experiments on the LLB spectrometers thus represents a major challenge, and is of vital importance for LLB to remain a first-rank contender in today's scientific competition.

The split of the activity into users welcoming and own researches might slow down the process of personal research which might then appear as inefficient when initiating a new subject. The user-welcoming task might be quite substantial in particular in soft matter and biology, where the average beam time of an experiment is about 3 days. Other weaknesses in that field are directly related to the use of neutron scattering as main experimental techniques: concurrent techniques such as electron microscopy, NMR, X rays, may appear more up-to-date or less heavy; the required sample volume can also be a severe limitation, in particular in sophisticated soft matter systems, deuterated systems and even more in biology, the worst situation corresponding to deuterated biological systems. Thus here again having access to chemical labs are crucial.

Finally the entry level into neutron scattering technique is quite high for external users. The required sample size and sample volume are often limitations which can deter new users. In addition, samples dedicated to neutron scattering experiments are often required. Oftentimes, either an experiment becomes non-feasible because either the sample or the signal is too weak, or the experiment becomes very long \sim 7 days. Measurements on sample surfaces on the order of 25 mm² in reflectometry are feasible but lead to only average quality data, even for long counting times. We are making constant efforts to overcome these limitations.

Most of the spectrometers are run by a single scientist who holds most of the knowledge about the spectrometer, including its settings, optimizations, and shortcomings. The departure of the scientist usually leads to the loss of this

expertise in the laboratory. In order to meet the needs of our external users, the scientific areas covered by our laboratory instrumentation are extremely diverse (e.g., polymers, metallurgy, and magnetism). Each LLB scientist has thus developed a specific expertise in a given field. The counter effect is that for a given research field, the laboratory may lack a critical mass. It might compensated by strong external collaborations, as soon as scientists dedicated to the access to large scale facilities are hired.

WEAKNESSES

- -difficulties to reach the centre by public transportation; only few available accommodations on site (not authorized to the non EU visitors)
- -administrative problem linked to the entry in Saclay campus still unsolved; additional difficulties of access to the INB (regulations CEA, international context): a major limit of our attractiveness to young students, collaborators and users.
- Activity split into users welcoming and own researches, overloading (180days per year, days 7/7, 24 / 24h including weekend)
- Sub-critical teams on instruments
- need of intermediate level to establish stable links between users non physicists (Chemistry, Biology..) and neutron scattering professionals (in particular for relations to industry that is a task not defined in our missions).
- high entry level (in Physics) into neutron scattering technique for external users.
- -weak implication in the world of the education: no associate professors specially affected.
- -Enhancement of the scientific life of the lab; (as soon as the overload of service is reduced)
- -More needs in chemical synthesis and deuteration of samples

OPPORTUNITIES

The dual mission can be achieved only as long as the experimental equipments open to users remain at the forefront of neutron instrumentation. The present situation can be regarded as quite good. Despite the lower neutron flux available at Orphée in comparison with the ILL or FRMII in Munich, a full range of experiments, with the exception of just a few studies specifically requiring the highest possible counting rate, can be performed here under optimal conditions. Evidence for this is given by the large number of world-class results reported in the recent years, some of which could be obtained to date only at LLB. Reasons for this success can be found in the continuous improvements made on the spectrometers, in the emphasis placed on users' requests in designing instrumental evolutions, and in the possibility given to LLB researchers to engage in long-term collaborations with user teams whenever the scientific case requires.

The current reorganization of the French national research system places strong emphasis on the central role of universities. As noted above, the LLB already maintains close connections with teams belonging to many French or European universities. Training courses specialized in neutron scattering (FAN) take place annually at LLB for Ph.D students or post-docs. In the last few years, tutorial sessions have been organized, in connection with several Masters Courses (Paris 6, Bordeaux, Marseille, etc.). They were quite successful and will likely keep growing in the near future. The idea is to make physics students better aware of the potential of neutron scattering in their particular field of research. In this way, the LLB can hope to attract more Ph.D. students from the best universities and, ultimately, to create appropriate conditions for young "Maî tres de Conférence" interested in performing their research in the environment of a large facility to come to the LLB. A special unit dedicated to training and education was organized.

Neutron diffraction experiments have a history of being long and complicated, and of being used primarily to address "exotic physics". Until recently, neutron scattering was not seen as a routine characterization tool. The evolution of the instrument performances and the resulting gain in flux currently allow 2 different experimental routes to be

followed: (i) perform more complicated experiments; (ii) perform very short, but useful characterization measurements, the latter being particularly suitable for nano-objects of all kinds.

In the field of materials sciences there is an existing need to use neutron time to perform routine characterization measurements, as well as some untapped potential for new applications. These possibilities could be developed, provided such measurements are "user friendly" and do not require a major time investment by the users. That is, it should be possible to process the data automatically.

An important point will be our capacity to join into the new outlines of the French research; for it the recent successes in the diverse national and international calls, our participation to European programs, are assets to be preserved and enhanced. In those are added our integration on the Plateau of Saclay through Labex, our future demand of Equipex, our collaboration with Soleil. However it is clear that the major opportunity will be the implementation of the French-Swedish agreement for the instrumental development and our participation to the future European Spallation Source.

OPPORTUNITIES

- -adaptation to the changes of outlines and become integrated into national projects (ANR, labex, RTRA) and international (NMI 3, ESS Lund, MoU with the other centres);
- -Staff deeply involved in diverse committee of evaluation, organization and selection
- -Insertion in the world of the education and the universities: A special unit dedicated to training and education was organized
- -Implementation of a project management for the program CAP2015
- -Enhancement of the scientific life within the lab and Strengthen the transverse axes.
- -Professionalism and experience of the CEA teams for the safety of the installation
- -Vicinity of Soleil and collaborations
- -Development of the Plateau of Saclay (Labex, Nano Innov)
- -needs in the characterization of nano-objects
- -New NMI3 and European integration in the FP7 program
- -The Swedish French agreement of cooperation for the instrumental development

THREATS

Serious concerns arise from the aging of a number of spectrometers and the insufficient support available, both in terms of funding and technical manpower, to carry out necessary upgrades. The LLB has addressed this problem by setting up an engineering team in charge of supporting the development of new instruments, but any effort in this direction is made at the expense of technical support staff on the spectrometers or in other support teams (electronics, computing, detectors, etc.). This represents a serious threat for the reliable operation of future experiments. Obviously, no satisfactory solution can be found unless the technical staff is raised to a level comparable to that of other neutron sources, as pointed out by the Instrumental Committee in November 2010.

Furthermore, the increasingly competitive scientific environment pushes researchers to concentrate on developing ambitious research programs, which implies

struggling for funds, performing experiments in the best available facilities all over Europe, and writing extensive reports and publication. The operation of LLB as a users facility entails further duties related to the access of visitors to the center of Saclay, and various other security issues (transfer of radioactive samples, health physics), which the "local contacts" often have to deal with personally due to the lack of sufficient staff at the users office. As a whole, this leaves only limited time to staff members for conducting large-scale instrumentation projects. At the same time, the scientific profile now requested from young researchers to apply for positions at the major research organizations often turns down the more technically-oriented candidates. There is no doubt that the strength and vitality of neutron research at LLB, like in other comparable facilities, ultimately relies on the commitment of researchers themselves to designing of next generation instruments in close connection with their own projects and those of their external collaborators. It is absolutely prerequisite that this approach should be preserved in the coming years.

In the field of nanomagnetism, we are "suffering" from the external emergence of an array of new technologies, which are attracting users away from LLB because of their novelty (e.g., X-PEEM, linear/circular, electron holography, Resonant X-ray reflectivity). Despite this popularity, it appears that these techniques are neither trivial to use nor interpret. We think that the situation will settle and that these different available techniques will eventually be seen as complementary to traditional methods of analysis. Contacts already exist with the Synchrotron group (SOLEIL), but active collaborations have until now been limited by the availability of the magnetism spectrometers. As a consequence, only very few joint experiments have yet to be performed.

Moreover to not lose the expertise and the strong motivation of the scientific and technical teams, as well as the users and the French neutron scattering community, or looking for the time required to get it and to develop an instrument, a better vision of the future of the facility would be helpful.

THREATS

- Miss vision on the future of the road maps of the TGIR, and decrease of subsidies; short-term contracts not enough for constructions requiring several years.
- -Cost of the upgrade program CAP2015 and, if not, Risk losing the French community when the European Spallation Source will be operational (2025-2030)
- -Demography of permanent staff, it may be difficult to replaces to the expertise of people leaving; critical sizes of teams for maintaining current instruments (Risk of obsolescence of instruments) and developing new ones.
- -Implication in the world of the education and Integration of university staff has to be facilitated.
- -No intermediate level people to welcome non-physicists; No implication of the other CNRS institutes than Physics in the development of the research.
- Risk of loss of motivation (LLB staff and the user community)
- -Risk of hardening of the regulations on the nuclear power in the current context, generating problems for user's samples and access.
- -Societal distrust towards nuclear reactors and nanotechnologies

GLOSSARY			
ANR	Agence Nationale de la Recherche - French National Research Agency		
ASN	Authorité de Sureté Nucléaire - French nuclear safety authorities		
ASTRE	Action de Soutien à la Technologie et à la Recherche en Essonne - support to research and technology in Essonne		
BENSC	Berlin Neutron Scattering Center		
C' Nano	Nanoscience Competence Centre		
CEA	Commissariat à l' Energie Atomique et aux Energies Alternatives		
CNRS	Centre National de la Recherche Scientifique		
CRG	Collaborative Research Group Instrument		
CRISMAT	Laboratoire de Cristallographie et Sciences des Matériaux in Caen		
CRM2	Laboratoire de Cristallographie, Résonance Magnétique et Modélisations in Nancy		
CROPS group of Marseille	Team 'Chimie Radicalaire, Organique et Polymères de Spécialité' of Laboratoire Chimie de Provence in Marseille		
DEN	CEA Direction de l'Energie Nucléaire		
DGRI	MESR direction générale pour la recherche et l'innovation		
DSM	CEA Direction des Sciences de la Matière		
ESRF	European synchrotron radiation facility in Grenoble		
FANS du LLB	Formation à la Neutronique		
FRM-II	Neutron source in Munich		
GDR MCM	Groupement de Recherche 'Magnétisme et Commutation Moléculaires'		
GP	Groupe Permanent		
HdR	Habilitation à Diriger des Recherches		
HERCULES	Higher European Course for Users of Large Experimental Systems		
HMI	Hahn-Meitner Institute, Berlin		
ICMMO	Institut de Chimie Moléculaire et des Matériaux d'Orsay		
IEF	Institut d'Electronique Fondamentale in Orsay		
ILL	Laue Langevin Institute		
INB	Installation Nucléaire de Base		
INP	CNRS Institut National de la Physique		
IRAMIS	Institut Rayonnement Matière de Saclay, CEA/DSM		
IRSN	Institut de Radioprotection et de Sûreté Nucléaire		
ISIS	Spallation Neutron Source in UK		
J-Parc	Spallation Neutron Source in Japan		
KIT	Karlsruhe Institute of Technology		
LEMA	Laboratoire d' électrodynamique des matériaux avancés in Tours		
LLB	Laboratoire d'electrodynamique des materiaux avances in Tours Laboratoire Léon Brillouin		
LMPC (ENSCMu,			
Mulhouse)	Laboratoire de Matériaux à Porosité Contr ô ée, Mulhouse Laboratoire des Propriétés Mécaniques et Thermodynamiques des Matériaux,		
LPMTM	Université Paris XIII		
LRS (Paris VI)	Laboratoire de Réactivité de Surface, Paris		

MAGMaNet	Molecular approach to nanomagnets and multifunctional materials, FP6 Project
MESR	French Ministry for Education and Research
MPI	Max Planck Institute
NMI3	Integrated Infrastructure Initiative for Neutron Scattering and Muon Spectroscopy
PND	Polarised neutron diffraction
RHF	High Flux Reactor of ILL
RTRA	Réseau Thématique de Recherche Avancée - Advanced Research Cluster
SANS	Small Angle Neutron Scattering
SAXS	Small Angle X-ray Scattering
SFN	French Neutron Scattering Society
SINQ	Swiss Spallation Neutron Source
SNRI	National Strategy of Research and Innovation
SNS	Spallation Neutron Source in the United States
SRMA	CEA/DEN
SPAM	IRAMIS Service des Pohtons, Atomes et Molécules
SPEC	IRAMIS Service de l'Etat Condensé
TGIR	Très Grande Infrastructure de Recherche - Large Scale Facility
UMR CNRS-Thalès	Physics laboratory, Mixed unit CNRS/THALES in Palaiseau