Council for Science and Instrumentation (CSI) of the Laboratoire Léon Brillouin

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Executive Summary

Firstly the committee would like to reiterate the sentiments expressed in our previous report:

- *The committee was impressed by the motivation of the LLB staff, and their clear commitment to achieve the three fold mission of the facility – science, neutron instrumentation, and teaching – often with somewhat limited resources.*

- *Over 20 years, LLB has developed into a highly integrated Center of Excellence that interconnects science and instrumentation across the French research community. LLB is the hub for neutron scattering in France connecting researchers, instrument developers, industry, and other scientific facilities in the region.*

The three major topics covered in this report - cross–disciplinary training of Ph.D students, instrument upgrades, and instrumentation for the ESS - are in fact intimately entwined in the crucial role of LLB as a French National neutron center. Detailed comments on these three areas can be found in the body of the report but summarized here:

- The LLB-Soleil joint Ph.D program is doing an excellent job of training young researchers to use both neutron and x-ray capabilities in a complementary manner to carry out a wide range of research. The program is clearly achieving its goals and should certainly be continued.

- The instrument upgrade program is being carried out effectively and the new capabilities are certainly strategically aimed at providing new capability to the French research community. The IMAGINE instrument provides huge opportunities in multiple fields; in particular we predict that that the capability for in-bulk examination of parts will be a critical analysis tool for the additive manufacturing community. Given the number of imaging instruments available at other facilities we expect that most of the users of IMAGINE would be found within the French community and focus should be on industrial applications.

- The involvement in ESS instrumentation is a recent mandate for LLB. This is appropriate given the role of LLB as the national facility representing the French community and the expertise is certainly there. The manpower required to participate in these projects will be considerable. Involvement in 3 instruments is unrealistic given the level of resources currently available, so certainly this must involve extra staff. The argument has been made that LLB is undertaking instrument projects at ESS where staff have the specific the necessary experience. However it is completely clear that the LLB experts are fully engaged now in running a user program, managing their instruments, doing research and teaching, and are already overloaded. They have no spare time! The only way they can contribute to the design of ESS instruments is if they stop doing something they are doing now. However, these very experts are supporting a vibrant French research community that will de facto become the users of the instrument types they are designing for ESS. The committee is concerned that LLB will be compelled to reduce operations or shut down instruments in order to free up the time of these critical staff members

to work on ESS instruments. This would be highly unproductive to say the least! The long term effect would be to diminish and penalize the very user community for which you are building the ESS. The only thing that makes scientific sense is if the money coming from Sweden can be used in some way to provide people to do some of the tasks now undertaken by the "experts" so that some of their time is freed up to work on ESS instruments.

It was not clear to us that an overarching strategy has been articulated for the construction and potential operation of instruments at ESS. If the goal is to provide capability to French scientists, it must be coupled with something else in France, i.e. some sort of national facility. In this respect, and thinking of the future of LLB, a build-and-operate model for France at ESS seems attractive. However, this is probably not the best solution for ESS.

Clearly the degree of involvement in ESS instrumentation is tied to the future strategy for neutrons in France and in Europe. Given the likelihood of a complete shutdown of Orphée in 2020, and the potential of an ILL shutdown in the same time frame, the ESS, in the absence of a supporting national facility, will be the only major neutron capability available to the French research community. This will almost certainly lead to the demise of the community and expertise in France. The consequence is that France would have invested significantly in the construction of the ESS and would presumably contribute operating costs for a capability that would only be used by a few researchers.

This is not a sensible outcome. In our overview of the Ph.D students we saw clearly the excellent science that was being carried out by young researchers who can use multiple techniques as needed for their research. The French research community needs access to neutrons, but this has to be supported by a national facility that ensures the training and maintains the expertise of the French neutron scattering community. This is not the role of facilities such as ESS.

A long term strategy for the French neutron capacity that merges with the European landscape must be articulated. LLB can continue its role as an interdisciplinary center for the use of neutrons, assembling all instrumental, methodological and scientific expertise for the successful use of the ESS and other major sources, serving as a resource in neutron based science for the whole community. This can be done in a variety of ways, e.g. an ESS outpost of some sort, but we firmly believe that, within Europe, a network of smaller, national facilities that support the flagship ESS is necessary. LLB is the natural choice to maintain the French component of this network. Hence we suggest:

- In the short term, it would be useful to organize a workshop in order to increase the awareness of the French community for accelerator based sources and discuss future challenges.
- On the longer term, we suggest that LLB take the lead for the French community to develop ideas for a small accelerator based source using existing local expertise. France has a top class accelerator community and already has an infrastructure at CEA that would enable development activities. It is critical that these activities be linked to, and coordinated within, a larger European network.

- Use this activity as a possible springboard for a future medium scale national source.

Introduction

The CSI was asked by the Conseil d'Administration du Laboratoire Léon Brillouin to assess, in their 2014 report, the effectiveness of building joint research programs with synchrotron facilities. To do this we focused on the joint LLB-Soleil Ph.D program and talked to students, university mentors and facility mentors.

The committee also followed up the second recommendation from the 2013 report and considered the potential role of LLB in the future European neutron scattering landscape. We assessed the present instrument upgrades, the LLB-ESS instrumentation program and the role of national sources in support of ESS as a flagship European facility.

Given the specific focus of assessment the three additional members were asked to participate on the committee:

Claude Lecomte, Emeritus Professor, Université de Lorraine

Jean Daillant, Directeur Général Synchrotron Soleil, FR

Robert McGreevy, Director ISIS, UK

Roger Pynn, Professor of Physics, Indiana University, US

Claude Berthier resigned from the committee for health reasons. The committee members for 2014 are listed in Appendix 1.

The background information that allowed the committee to develop their report was gathered in two ways:

1. Offline documentation (annual reports, research directions, publications, etc.) were provided on an external web site.
2. The committee spent a day at LLB (November 27) talking with staff, students and their advisors.

This report has been compiled and approved by all committee members and verified for factual accuracy by LLB management.

General Comments

Once again the committee was very impressed with the quality, dedication to mission and achievements of LLB staff. We had a very good overview of the three major foci of the LLB: the science and training mission, as judged this time through the LLB-Soleil Ph.D program, is excellent; and the instrument upgrades which have been managed effectively according to an upgrade strategy which meets the

science needs of the French research community. More recently the LLB has taken on the additional role of interface to the ESS for the French neutron scattering community through the design and construction of instrumentation. This is an appropriate role for LLB and they have chosen instrument projects where they have the skills and knowledge base. LLB has many excellent scientists who understand instrumentation, and who COULD contribute to ESS instruments. However, these people cannot do everything — ESS instruments plus complete their own upgrades plus run a science program on those instruments plus train the next generation of researchers to be able to use neutron capabilities. As we have expressed previously, the LLB has insufficient manpower/resources to accomplish all these related but different activities. Moreover LLB and indeed the supporting agencies (CEA/CNRS /Ministere de l'enseignement superieur et de la recherche) need to define the long term strategy for engagement in ESS and the role of LLB in fulfilling this strategy.

The Future of LLB

The committee had an extensive discussion about the future of LLB. Timelines about the Orphée shutdown, ESS instruments construction, and number of neutron instruments available for the French community were provided by LLB as a basis for the committee discussions.

- The future of the Orphée reactor seems uncertain after 2019/20. Even if this can be extended to 2025, it is imperative to start planning for the future now. The planning must be based on the unique opportunities offered by the existing capabilities and future development of the Saclay campus (Soleil, accelerator expertise, potential laser facilities, training role at Saclay university).

- A 'build and operate' model would make sense for LLB participation in ESS instruments, as a way of retaining (even attracting) skills. However, this may not the best model for ESS as a European facility.

- Using a high brightness, pulsed neutron source like the ESS is also different in many respects from using a reactor source like the LLB. Nevertheless LLB, as a national facility, is critical in the preparation of the French neutron community for the use of the ESS.

- It must be stressed that the existing expertise in neutron scattering at LLB is rare on a global scale. It makes strategic sense to retain this – once lost, France will not get it back. France cannot rely on ILL as their national center on a longer timescale.

- If no action is taken, there is a similar risk that the French neutron community would diminish to a small number of experts, and that a broad expertise within the community will be irretrievably lost.

- Education of the next generation of French neutron experts is thus a major issue.

- One solution could be that LLB becomes an interdisciplinary center for the use of neutrons, assembling all instrumental, methodological and scientific expertise for the successful use of the ESS and other major sources, serving as a resource in neutron based science for the whole community. We do not believe this can be a long term solution in the absence of a local source of neutrons where researchers can practice their skills.

- In the short term, it would be useful to organize a workshop in order to increase the awareness of the French community for accelerator based sources and discuss future challenges.

- On the longer term, we suggest that LLB take the lead for the French community to develop ideas for a small accelerator based source using existing local expertise (France is good at accelerators!) and some existing infrastructure (if feasible). Link to related activities such as the UCANS community, the ISIS Front End Test Stand, particularly as regards targets/moderators. Use this activity as a possible springboard for a future medium scale national source.

- Also use this as a platform to build expertise and technology for participation in ESS operation.

Instrument Upgrades

- The instrument upgrade program at LLB has been well defined as an integral part of the strategic plan of the laboratory and exceptional well executed at impressively low cost.
- We applaud the instrument teams on their effectiveness in accessing external funding to enable the upgrade program
- The success of the upgrade program can be largely credited to the fact that instrument scientists at LLB are top notch researchers who carry out leading research programs on these instruments and are thus fully aware of the upgrades that are required to meet today's scientific challenges and opportunities.
- The committee is always concerned about the low staffing levels at LLB, in particular as far as project management and technical support is concerned. Hence it is remarkable that upgrades were carried out successfully by instrument teams who have multiple additional responsibilities.
- The same staffing concerns are also relevant as upgraded instruments are brought on line. Even upgraded instruments that are replacements of their predecessors can increase the load on scientific and technical staff. New instruments which add to the existing instrument suite require additional staff if they are to be fully effective.
- The new cold, high resolution diffractometer G4.4, is a replacement of the G4.2 Gatchina-LLB instrument which operated successfully from 1995 to 2004, and completes the existing suite of diffractometers with a high-performance, high-resolution, long-wavelength machine. The instrument has been completed at exceptionally low cost (<55 keuros) by using some components from G4.2 and was supported by ANR funds. The instrument fills a gap in the existing LLB capability, providing access to high-resolution studies of large unit cells, and will address a wide ranging science program. The instrument entered the user program this year and

is operating very successfully. We congratulate the team on their success but note the concern that this is essentially a new instrument in the group and does not come with additional staff.

- The PA20 instrument is essentially a replacement of PAXE but with a superior performance. Compared to PAXE, PA20 will have an extended Q range, improved detector resolution and efficiency, and an overall intensity gain of a factor of close to 10. It will also provide new capability in polarized neutrons and GISANS. The instrument, when complete, will be world class. The instrument is nearing completion and we look forward eagerly to see it go through its commissioning. The ability to carry out experiments with polarized neutrons and to implement GISANS will give LLB the opportunity to take a lead internationally in advanced applications of neutron scattering.
- IMAGINE is a new imaging instrument that effectively replaced the old EROS reflectometer on G3bis. Building this instrument and providing access to neutron imaging for a wide range of users was an excellent move by the laboratory. The instrument effectively extends the region of real space that can be measured at the facility and will attract a large range of industrial users provided its capabilities can be widely advertised (again, this takes manpower, which may not be available). This will be good for the laboratory as industrial users will be important ambassadors. The instrument has been open to friendly users since April 2014 and is beginning to deliver interesting results. Although the initial science driver for building the instrument was agro-food applications we firmly believe that the industrial user base is much broader and should be actively pursued (meaning that this should be a primary responsibility for one staff member). There are huge opportunities in multiple fields; in particular we predict that that the capability for in-bulk examination of parts will be a critical analysis tool for the additive manufacturing community. Given the number of imaging instruments available at other facilities we expect that most of the users of IMAGINE would be found within the French community and focus should be on industrial applications. We note that the instrument is operating in a basic configuration with planned upgrades of numerous components (detector size and resolution, time of flight capability, polarized neutrons, etc.). Although all these upgrades are desirable and well thought out, we believe the team should set priorities for these upgrades based on the potential, strategic, user base. With limited man-power you cannot do everything. Given the above comments on potential users we suggest that the team should focus their efforts on detector resolution and size. TOF measurement providing the capability for Bragg edge imaging will have multiple industrial applications as well and would be a good second priority. Although we understand that adding the polarization capability is supported by the FP7 program we do not see it as a highest priority on the instrument.

ESS Instruments

- The manpower required to participate in these projects will be considerable. Involvement in 3 instruments is unrealistic given the level of resources currently available, so certainly this must involve extra staff. If you are going to argue that you are doing particular projects because you

have the necessary experience, you are implying that you are going to use your experts for this project. In that case they will not be available to work more than a few hours per week at LLB

- €34M seems a realistic budget for the work proposed; though the ESS cost book value will not be this high.
- Decide why you are doing this. If it is to provide capability to French scientists, it must be coupled with something else in France, i.e. some sort of national facility. In this respect, and thinking of the future of LLB, a build-and-operate model for France at ESS seems attractive. However, this is probably not the best solution for ESS.
- As with all ESS instruments, thought must be given to exactly how an instrument might be built, how staff and responsibilities might transition from LLB to ESS during the build/construction/commissioning.
- Recognize that doing a project at a distance in an international team is going to be challenging and is likely to take longer, cost more and miss scope. These could be liabilities depending on how the contract is written. LLB, with its very constrained budget, simply cannot afford to accept the level of potential financial liability in the ESS in-kind agreement. You need to be very careful about what you sign up to.
- If some instruments are not approved, would you consider partnerships in other instruments?
- You are designing instruments for an LPSS, having never done so. That will be challenging.
- Be wary of designing instruments on the basis of headline flux increases. These are almost never realised, and can lead to design choices that deliver the flux but not the science.

LLB-Soleil joint PhD program

In an effort to prepare future generations of French researchers in the use of multiple tools for research, and at the same time to increase the collaboration between LLB and Soleil the two facilities launched a joint program of PhD on selected subjects. This highly successful program grants two or three PhD theses each year. While initially the PhD grants were fully funded by the two, the model was recently changed such that the projects should include a third partner, typically a university research group, who is expected to provide half of the required PhD funding. Such a process favors external collaborations and provides visibility/awareness of both LLB and Soleil. It should be noted that the project selection is scheduled several months before the opening of most of the PhD grant calls and the project acceptance is known very soon. This makes it easier for the third partner to find the additional funding and a very good and motivated candidate.

The LLB-Soleil PHD program was a major focus of the CSI evaluation; the committee heard overview presentations of their thesis work from students and had the opportunity to meet with students, university advisers and facility scientists to talk about their experience with the program.

- All CSI members agreed on the excellent quality of the science as evidenced by the very clear and lively presentations across a large variety of scientific domains. In order to solve their scientific problems, the PhD students were expected to carry out both neutron and synchrotron experiments, and hence become familiar with these techniques in addition to the usual laboratory methods. The committee was indeed impressed as to how the students had in most cases mastered the relevant techniques for the research programs they were working on, and were able to take advantage of the complementarity offered by neutron and x-ray capabilities.

- The excellent presentations on these selected thesis projects clearly demonstrated the complementarity of neutrons and X-rays for elucidating very complex problems. Although we were all convinced by this complementarity through the many examples known to us, it is always a great pleasure to learn from such clear demonstrations. The council also really appreciated that the projects have been selected not only to evidence the X-ray and neutron complementarity but more to answer actual scientific problems using this complementarity. It was clear that the program is achieving its goals; the committee commends both facility directors for instigating the program and highly recommends its continuation.

- The open discussion with the students and their advisors, in the absence of Soleil and LLB facility management, showed very clearly that all participants were benefiting immensely from this program and were generally happy with the way it was set up. We are convinced that if major problems had existed these students and/or their advisors would have brought them to our attention. The only recurrent issue that arose was the apparent difficulty to access beam time through the Soleil selection committees. In some cases formal proposals in support of the thesis have been rejected by the selection committees, and the access to beamlines for which the student's adviser is not responsible seems to be more difficult. Furthermore some students mentioned that they were allocated beam time at short notice and/or at weekends or evenings. While we understand that it is sometimes difficult to predict when beam time will become available, especially for non-scheduled experiments, it is clear that it is difficult to perform good measurements in this manner especially if samples need timely preparation or are unstable. The problem really did seem to be related to access to instruments for which the thesis co-adviser was not responsible.
  The committee had the opportunity to discuss these difficulties with the head of Soleil (J. Daillant) who was clearly aware of the issues. The committee is of the opinion that when a PhD joint program is selected necessary beam time should be allocated – in some way the strength of the science has already been evaluated. However, from own experience with similar experiment review processes, we can understand the Soleil viewpoint:

    1. it is not possible for Soleil to give beam time a priori to PhD students in common with partners since one of the goals is to multiply the number of such partnerships

2. the selection should not interfere with in-house beam time allocation

3. it is of the responsibility of Soleil PhD advisors to insure beam time allocation either through the selection committees or in-house research time

The fruitful discussion with J. Daillant led to some suggestions for potential improvements of the procedure which the committee believes will be effective:

1. Directly involve the beamline scientist who has direct access to in-house research beam time.

2. Involve at the beginning of the process the other beamlines that can be concerned with the project.

Appendix 1 Committee Members

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