

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

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Introduction

The Council for Science and Instrumentation (CSI) was given the mandate by the Conseil d'Administration du Laboratoire Léon Brillouin in their December 2014 meeting to advise LLB management on the medium and long term strategy for the French neutron scattering activities within the future European neutron scattering landscape.

Given the specific focus of assessment the following experts were asked to participate on the committee:

Kurt Clausen, Head of the Neutron and Muon Department, PSI, CH

Robert McGreevy, Director ISIS, UK

Ferenc Mezei, European Spallation Source, Sweden

Roger Pynn, Professor of Physics, Indiana University, US

Sebastian Schmidt, Board of Directors, Jülich Research Center, Germany

The committee participated in an LLB organized workshop “New Opportunities in Neutron Scattering: Small to Medium Sources and their Applications”, on May 18 – 19, and then met with LLB management and key personnel on May 20, 2015.

This report has been compiled and approved by all committee members and verified for factual accuracy by LLB management. We have not reiterated the impact of neutron scattering on national science initiatives and industrial development but rather accepted the need for the capability and focused on making it available in a meaningful way to the French research community in the future.

Context

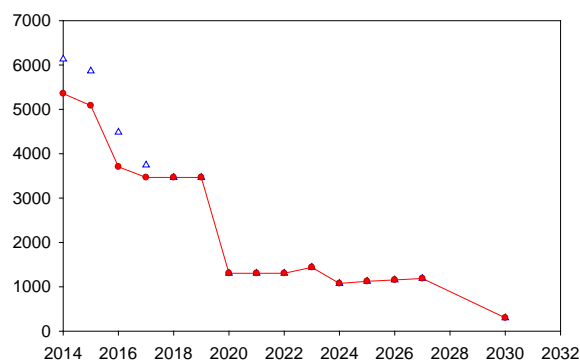
Over 20 years, LLB has developed into a highly integrated Center of Excellence that interconnects neutron science and instrumentation across the French research community. Using the Orphée reactor as its principle resource, LLB is the hub for neutron scattering in France connecting researchers, instrument developers, industry, and other scientific facilities in the region. LLB plays a critical role in preserving and developing the French know-how in neutron based research. This includes training new users, providing critical access to neutrons for established users, and developing a cohort of French researchers and engineers who know how to build and develop instrumentation. LLB/Orphée covers 60% of the neutron scattering needs of the French research community.

In May 2015, faced with the uncertainty in the supply of highly enriched uranium, and the rising cost of fabrication of fuel elements for the Orphée reactor, the CEA and CNRS management announced that the Orphée reactor would operate at a reduced level of 120 days (full power equivalent) until a definitive shut down at the end of 2019.

The Europe Spallation Source ESS plans to put up to 8 instruments into a user program in 2023 but will not reach its full scientific capability/capacity until at least 2030. (This means that the instrument suite is more or less complete and each instrument is mature in capability and user base).

A number of other national/international neutron facilities are either planned for shutdown or, in the case of reactors, in serious threat. Even the future of ILL, the 'de facto' world leading neutron scattering facility, is not clear. CERCA, the company that fabricates the fuel elements for ILL is faced with significant refurbishment costs. Even if the budget for refurbishing the fabrication lines is found the cost of the fabrication is likely to increase. Furthermore the inter-government agreement for operating ILL expires at the time those same countries will need to find budget to contribute to the operating costs of ESS.

Hence over the next few years French (and in fact European) neutron users will see a significant decrease in the availability of neutron instrumentation and beam time. It is also important to note the difference between the **capacity** - the number of experiments and size of user community that can be supported, and the **capability** – the ability to do particular experiments. It is clear that ESS will add significant capability, but will not add sizeable capacity to the neutron landscape. In fact, ESS alone can only provide 16% of the capacity presently available in Europe. The figure shows an estimate (after C. Alba- Simionesco) of the number of instrument days that would be available to French users under the following, realistic scenario: reduction of Orphée operation in 2016, closure of Orphée in 2019, ESS ramp up between 2024-8 and ILL closure in 2030. The blue points represent additional days that would be available from operating CRG's at ILL.



Within an 'ESS only' scenario we estimate that a French user community (the number of French scientists using neutron techniques as part of their research program during a year) of the order of only 100 or so researchers could be supported, compared to of order 1000 at present. This clearly represents a significant loss of scientific capability. The associated cost of maintaining such a small user base is likely unjustifiable and without a national support facility to provide the necessary training and access for underpinning experiments, even the research programs of this small community cannot be sustained. Furthermore an even bleaker outcome of the 'ESS only' scenario is that the lack of a continued knowledge base within national facilities ultimately means that the capability to effectively exploit ESS will be lost.

Hence, if Europe (and France) wishes to maintain access to neutron capabilities for a realistically sized research community then a suite of, cost effective, complementary sources must be available. Since it is very unlikely that any new research reactors will be built in Europe, new sources will be accelerator based. Such sources need to cost <€300M to be affordable by individual countries and energy costs need to be minimized whilst science production needs to be maximized.

Recommendations

France should plan, in the long term and when economically viable, to build and operate a national neutron facility. Such a facility will almost definitely be accelerator based, and should be encompassed in a national center which provides access to French researchers to neutron capabilities, maintains the French knowledge base in neutron technologies traditionally associated with reactors, and provides a training ground for researchers in the use of neutrons in support of national programs. The planning for such a facility needs to start now and be integrated with other European plans including ILL, ESS and the ESFRI roadmap. Early activities to build expertise would also be highly recommended (France has highly developed capabilities in accelerators, but not in their application to neutron sources).

It is very much up to the French community to decide on the role of the national center – whether as a supporter of a broader user community (capacity driven), or a dominated by a national science program (grand challenge), or both. It will also be important to define a unique selling point in science, methodology or technology for the center. Whatever the decision, it seems unavoidable that the size of the French user community will decrease in the (very) near future.

As a basis to developing a roadmap for the future, it is important to consider different sizes of the future community and the models/costs for supporting them, whether through ESS + small national facility/shared inter-country facility/contributions to other facilities.

Given that any new source will inevitably be accelerator based, development of a national programme of relevant development is critical. But this is a problem facing European (world) neutron facilities in general, so there is a strong case for a broad international technical collaboration. Building experience within LLB/France of the effective scientific exploitation of accelerator neutron sources would also be advisable, as this seems to be quite weak at present.

In the medium term it is essential that the French research community maintains access to neutron instrumentation. There are various options that can and should be pursued after the shutdown of Orphée. In the short/medium term, transfer of instruments to other facilities or preferential access to instrumentation at other sources can be considered. Within Europe, both ISIS and SINQ are likely to have capacity. Both these options would give French researchers experience with spallation sources, both pulsed and continuous. The potential transfer of instruments to other sources is attractive in the sense that the associated technical and scientific personnel would gain valuable experience with accelerator based sources, however even in the best cases there is still significant additional investment required for the refit. In the longer term a build and operate role in ESS instruments would seem advisable. But for this to be at a meaningful scale it is somewhat dependent on the ESS instrument selection process. We note that this 'out-station' model has precedence for working very successfully: the Jülich Centre for Neutron Science has embedded staff who operate instruments at several sources but retain their Jülich identity; the J-PARC instruments are operated by at least four different organizations with different funding sources (JAEA, KEK, CROSS, Ibaraki prefecture).

It is essential to define and communicate a roadmap that establishes what the French and European user community can rely on in the forthcoming 10 - 20 years for both science and instrument development. Once this roadmap is established a corresponding recruitment and staffing strategy to meet the short/medium/long term plans should be developed.

In summary the essential elements that must be addressed in the implementation of the road map are:

- It is essential to maintain the 'roles' that LLB has played to date – education, expertise, access, science.
- In order to maintain these roles it also essential to maintain a French neutron scattering identity through some sort of national center (LLB or similar).
- There will be different phases in reaching the longer term goals – each phase will have a different set of associated actions though these actions need to be coherent and in line with other European plans including ILL, ESS and the ESFRI roadmap.
- It is imperative to provide the French user community with access to neutrons during all phases.
- It is also essential to maintain the French 'know-how' for instrumentation through the different phases.
- Given that new neutron sources are likely to be accelerator based it would wise to deliberately enable the transition from the 'reactor based' know-how to spallation (pulsed) source know-how.
- Engagement in ESS instruments, as part of the long term plan, is essential. ESS will be the flagship facility in Europe and must be supported by a network of smaller facilities. It is essential for French researchers to have access to both.

Timeline for Implementation

Short term: (now – 2020, Orphée operating)

- Stretch the number of available beam days at LLB as much and as long as possible, until the final deadline for nuclear operation. Running at 60 - 65 % reactor power still will not make a huge difference for the majority of the studies.
- Put in place mechanisms to enable the French community to get beam time at other facilities, including transfer of instruments and sample environment to other facilities where viable. Transferring instruments will necessarily take time and an associated loss in available beam time can be expected. In particular aim at enabling access to pulsed neutron sources so that the community can gain experience at such sources.
- Establish a funding scheme that: 1) ensures users who compete and get beam time at other facilities receive the necessary travel and operating budget, and 2) makes it attractive for universities and other research labs to carry out "world class" , science using neutrons.
- Aim for an out-station like arrangement with ESS for those 2 -3 instruments for which LLB is the leading laboratory for construction.
- Start considerations/studies for an accelerator driven source at Saclay, taking into account the available experience and existing hardware in accelerator/neutron instrumentation and buildings as available assets at Saclay. Get other relevant communities involved (accelerator isotopes, etc.), communicate this decision broadly and invite European partners to join the discussion.

Medium term (2020- ~2030, no national facility in France, ESS ramping up):

- Maintain a user base and presence with a number of the best LLB instruments installed at other facilities in Europe.
- Develop out-station operation at the ESS instruments built and operated by LLB (or successor).
- Maintain a funding scheme that ensures users who compete and get beam time at other facilities to receive the necessary travel and operating budget.
- Take part in international collaborations for the development of compact sources. Take advantage of available hardware and capabilities at LLB and IRFU to construct and test prototypes, while developing the necessary expertise in target, moderator and instrument technologies.

- Transition the concept of an accelerator based source in France to a design and construction project.

Long term (~2030 onwards, new source on the Saclay site, ESS operating):

- Maintain and develop the out-station at ESS and fully support access to other European facilities.
- Construct a new accelerator based source on the Saclay site.
- Build fully fledged instruments at the new Saclay compact source, using LLB technology/hardware as much as possible.
- Rebuild the user program at Saclay, establishing strong science and instrumentation development programs. Integrate the facility into the complement of science capability available to faculty and students in the new university campus being developed at Saclay.
- Develop NON neutron scattering usage of the accelerator complex where feasible.

Appendix 1 Extract from the CSI report of November 2014

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 be 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.

Appendix 2 Committee Members

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