

Low Energy Accelerator-driven Neutron Sources: Closing the Gap and Shaping the Future

The advent of research reactors in the middle of last century opened the opportunity for research with neutrons. Cliff Shull and Bert Brockhouse were awarded the Nobel prize for physics in 1994 for pioneering contributions to the development of neutron scattering techniques for studies of condensed matter. Since then, research with neutrons has emerged as an indispensable technique for materials research and development of functional materials, which is key to the solution of many of the grand challenges of our modern societies. With its broad user community, its hierarchical structure of neutron sources and the Institute Laue-Langevin as the leading neutron facility, Europe has acquired an excellent standing in this field in terms of publication output. In its network of sources, the low flux sources provide the foundation by educating the next generation of neutron users and offer a platform for method development. Medium flux sources having a broader instrumentation also cover similar aspects, but in addition provide capacity and capability, e.g. by specializing on certain aspects like distinctive sample environment or by addressing a specific local or regional user group. Finally, the flag ship facilities are essential for the most demanding flux-hungry experiments.

This well-established European network is threatened by the slow dying of older research reactors, most of which became critical in the middle of last century. Just last year 2019, three important research reactors were permanently shut down in Europe: the Orphée reactor in Saclay, France, the BER II reactor in Berlin, Germany, and the JEEP II reactor in Kjeller, Norway. Already in 2016, a working group of the European Strategy Forum on Research Infrastructures on the neutron landscape in Europe has predicted a dramatic loss of instrument beam days.

The existing and future neutron flag ship facilities in three world-regions are or will be based on spallation sources and Europe is looking forward to the start of operation of the European Spallation Source ESS. However, there is a clear understanding that this future flagship needs to be underpinned by a renewed hierarchical network of small to medium size facilities. Several ongoing European projects clearly demonstrate that neutron sources based on low energy (up to 100 MeV) proton accelerators provide an attractive opportunity to replace the ageing research reactors. There are several clear advantages of these type of sources:

- They are scalable, from small local sources at Universities, healthcare facilities or industrial companies (e.g. the Mirrotron project), via medium size regional sources (e.g. the projects of ESS-Bilbao, IFE and INFN) towards high brilliance facilities (the SONATE and HBS projects of the LLB and JCMS, respectively).
- Invest and operation costs are smaller than comparable reactor-based facilities.
- In general, such sources do not need nuclear licensing.
- Due to the lower security requirements, these facilities can be realized and operated in a very flexible manner

These advantages have been recognized in the US and Asia, where a number of smaller, so-called Compact Accelerator-driven Neutron Sources (CANS) exist, such as LENS in Bloomington, Indiana, USA, or RANS at RIKEN in Japan. Several projects are ongoing in Europe, two of which aim for brilliances comparable to existing middle or high flux research reactors.

With the situation in Europe, several laboratories in Europe have decided to join forces in the promotion of such facilities, providing a place for the discussions on the scientific and technical challenges to tackle. They follow the example in Japan of the Japan Collaboration on Accelerator-driven Neutron Sources JCANS or in China of the China Collaboration on Accelerator-driven Neutron Sources CCANS. On September 10th 2020, the European Low Energy accelerator-based Neutron facility Association, abbreviated as ELENA, has been founded with members from ESS-Bilbao, IFE, INFN, JCNS, LLB and Mirrotron. Its common goal is to close the gap, which is opening in Europe by the ongoing shutdown of research reactors, and to shape the future of research with neutrons by providing novel opportunities urgently needed to solve grand challenges of our modern societies.

In this edition of Neutron News an overview on Low Energy Accelerator-driven Neutron Sources and projects is given, showing experience with existing sources and presenting the potential of ongoing projects.

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