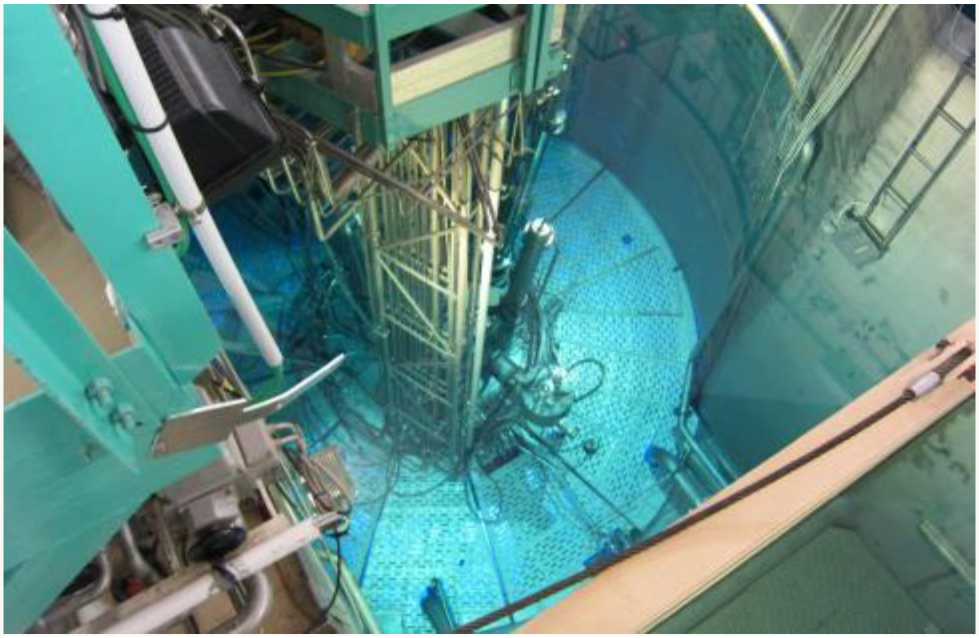
THE VERY FABRIC OF RESEARCH: A VISIT TO THE ILL IN GRENOBLE



The nuclear reactor at ILL. The nuclear fuel is underneath the steel shield. The blue glow of that is partly visible is caused by Cerenkov radiation.

You look down into a clear pool of water. The water has an appealing blue glow to it that makes you want to dive into it. But this isn’t a swimming pool, it is a nuclear reactor. And the soothing blue glow is not due to the blue paint of the pool walls but caused by the Cerenkov radiation, emitted as a result of the electrons created by the fission process that move faster than the speed of light in water.

The electrons that are ejected from the nuclear fuel elements are fast than the speed of light in water (about 75% of the speed of light in vacuum). Similar to the supersonic bang of jets that fly faster than the speed of sound, Cerenkov radiation is emitted by water as the fast electrons pass through it. The blue shimmer of the Cerenkov radiation is visible on the right of the photo, showing the pool containing spent reactor fuel.

The reactor I am visiting is that at the Institut Laue-Languevin (ILL) in Grenoble. As a research reactor it is generating up to 58 megawatts of power, about 25 times less than that of commercial reactors. Still, I am nervous holding my camera directly above the pool to take pictures, afraid I might be dropping it into the running reactor. But there is no need to worry, it is safe to stand there, the water is a perfect shield from the radiation, it absorbs all the neutrons and electrons created by the nuclear reaction. And there is of course plenty of security and radiation monitoring before, during and after my visit. Even if I would drop the camera into the pool, there is a steel construction in the water that would catch larger objects. And stuff that would slip through that grid would probably lie harmlessly at the bottom of the pool until the reactor is decommissioned.

Not many people are allowed inside the reactor and I am lucky enough to be invited to the ILL along with a few British colleagues. It is only the second time I am inside a nuclear reactor. It is an awesome feeling, certainly for a physicist, to see an operating reactor and to admire the technology that keeps the nuclear chain reaction under control. The impressions from my visit not only reinforce what I know about the benefits of neutron research, but the variety of research to me also underlines the dangerous implications of possible recession-related government budget cuts to facilities like ILL.

ILL was founded by France and Germany in 1967, with the UK becoming a third major partner in 1973. Initially, the UK did not join the institute because it wanted to build its own reactor, tells us our tour guide, Andrew Harrison, an Associate Director of ILL. Nowadays it seems almost unbelievable to me that the UK abstains from a European research project because it intends to invest more money into a certain area of research, not less. In any case, today, Germany, France, and the UK still share 75% of ILL's operating budget of 88 million Euros, the rest being distributed amongst its other international partners. Their continuing support has made ILL one of the leading research institutions that uses neutrons for experiments in life sciences (18% share of experiments), environment (11%), materials science (29%) and fundamental sciences (35%).

The many benefits of neutron research

How are the neutrons from the reactor put to use for research? Neutrons are unusual particles. They are electrically neutral, which means they can travel easily through matter. The exception is water, because hydrogen very efficiently slows neutrons. This is why the nuclear reactor is surrounded by water as a protective shield and to control the nuclear chain reaction.

In research, the strong scattering properties of hydrogen are of great benefit, as one can use neutrons to track the hydrogen atoms in fuel cells. This helps towards the design of more efficient fuel cells for cars, or for the development of hydrogen storage materials. Another example of research into hydrogen-containing materials is that of Werner Kuhs from the University of Göttingen in Germany. He studies methane hydrates, cages of water molecules that contain methane. These hydrates form crystals under high pressure, which are detrimental to the operation of oil pipelines, and were one of the reasons the BP leak in the Gulf of Mexico was so difficult to plug.

A look at the experiments at ILL

Because neutrons fly so easily through matter means they can also be used to study the interior of large objects. This is similar to x-rays, but with higher resolution, down to the atomic scale. An example of this technique is the development of new structural materials. An experiment I saw at ILL is looking for cracks in railway tracks. And indeed, car companies, jet engine makers like Rolls Royce, all benefit from research with neutrons.

In the life sciences, the neutron scattering by hydrogen is also extremely useful. Most organic molecules contain hydrogen. And here, researchers make use of the very different neutron scattering properties of hydrogen and deuterium, an isotope of hydrogen that has a neutron as well as a proton in its nucleus. Replacing hydrogen in sections of a protein with deuterium allows the specific study of those areas of a protein, which helps to understand the function of the various parts of a protein.

This way, Fritz Vollrath and colleagues from Oxford University discovered how silk proteins from silkworms get activated once they are diluted with water. This helps silkworms to store larger quantities of concentrated silk proteins in their bodies without turning them into silk. And Adrian Rennie from Uppsala University in Sweden in collaboration with Habauka Kwaambwa from the University of Botswana has discovered how the seeds of the ‘miracle tree’ purify contaminated water by binding to foreign objects in the water and gluing them together.

In the physical sciences, neutrons are important because they have a magnetic moment, which means they react to magnetic fields. This makes neutrons indispensible in studying the structure and magnetic properties of complex magnetic materials, superconductors, multiferroics, and many others.

The future of neutron scattering

All these applications show how crucial neutron research is for many areas of research. The experiments at ILL are two-fold oversubscribed, despite the fact that many neutron reactors are now in operation: Munich, Oak Ridge National Laboratoryand JAERI in Japan to name but a few. In addition, spallation sources like the newESS neutron source are a complementary technology that also deliver neutrons for research.

The construction of neutron scattering facilities like ESS demonstrates the huge demand for this technology. These institutions are not competitors for a small number of high-profile scientific experiments. On the contrary, the demand for such facilities demonstrates that neutron scattering research is increasingly part of a basic experimental infrastructure across all natural sciences.

As for ILL, even though the reactor is 40 years old, the facility continues its attempts to improve. For some of the instruments, detection rates of neutrons have improved by an order of magnitude over the past decade . There are also plans to integrate a neutron beam from ILL with x-ray radiation from the neighbouring ESRF synchrotron. The close vicinity of both institutions could lead to world-wide unique situation where experiments can use x-ray and neutron beams simultaneously.
There are further upgrades planned for ILL. 130 million Euros have been invested so far, and 50 million are still being spent. And there are plans for more. The possibility of measurements in very high magnetic fields is something that is being discussed, as it would benefit many areas of science. Building an experiment where measurements can be done up to the high magnetic fields of 30 T would cost around 40 million Euros estimates Harrison, although the specifics of such projects are still debated within the community.

Funding cuts in the UK

A threat to such successful research could be the broader problem of science funding in Europe. The UK in particular is going to see significant spending cuts in science of 10% or more. I asked Harrison how the ILL could cope if faced with cuts exceeding 10%. He tells me it would be impossible to keep the facility running and to conduct experiments. The same he predicted would be the case for other large-scale facilities. If the UK indeed intents to apply the announced cuts to large facilities, entire institutions may need to be shut down or mothballed. This may mainly be of concern to other institutions; the ILL seems to be relatively safe. Its present 10-year operating contract between France, Germany and the UK ends in 2013 says Harrison. Should the UK decide to pull out of ILL anyway, considerable decommission costs for the nuclear reactor await. There is no way these could lead to a short-reduction of science budget.

The wider question is of course the wisdom of cuts to the science budget more generally. Yes, possibly shutting down facilities or cutting funding for researchers will bring short-term budget relief. But in the long-term it feels almost a platitude emphasizing that any investment in the science and technology base will benefit the economy and therefore government budgets. It is truly sad that options such as shutting down essential institutions like the Diamond Light Source are not off the table in the UK. The latter, like ILL, supports research in all natural sciences and is crucial to UK engineering and pharmaceutical companies.

Institutions such as ILL and Diamond represent the very fabric of fundamental research, not an optional add-on. Cutting science budgets beyond where it hurts the research infrastructure, as planned in the UK, is a rather foolish undertaking. It is still time to reverse the cuts. Otherwise, the foolishness of the cuts sadly will all to quickly become apparent.

Source: http://allthatmatters.heber.org/2010/09/20/the-very-fabric-of-research-a-visit-to-the-ill-in-grenoble/