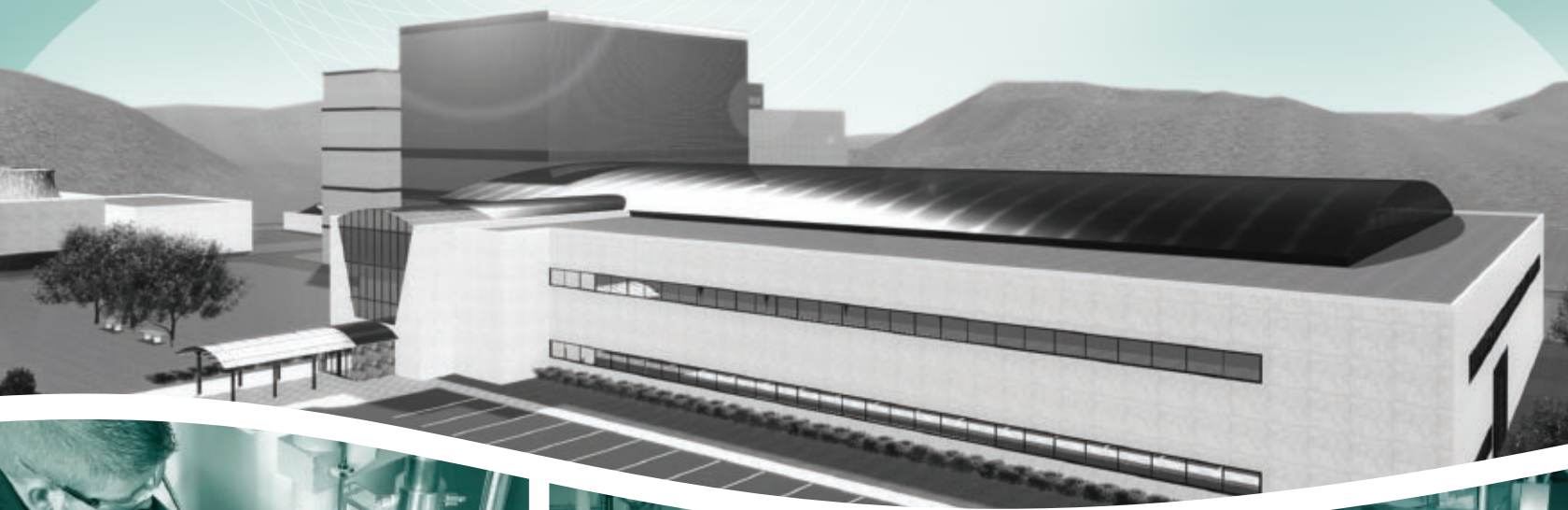
CINS

CANADIAN INSTITUTE FOR NEUTRON SCATTERING

Planning to 2050 for Materials Research with Neutron Beams in Canada

SUMMARY



www.cins.ca

About The Canadian Institute For Neutron Scattering:

The Canadian scientific community of neutron beam users is organized within the Canadian Institute for Neutron Scattering (CINS). CINS promotes scientific research with neutron beams. Incorporated in 1989, CINS now has more than 400 members, including about 300 Canadian academics, with other members from industry, government laboratories and foreign institutions. Canadian neutron scattering researchers and students are found in over 50 university departments, which are distributed among more than 20 universities spread across every province of the country. There are currently 15 institutional members who pay fees that are applied to encourage scientific research using neutron beams, and to ensure access for the Canadian neutron scattering community to competitive research facilities.

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Cover Image: artist's conception of a new Canadian Neutron Centre

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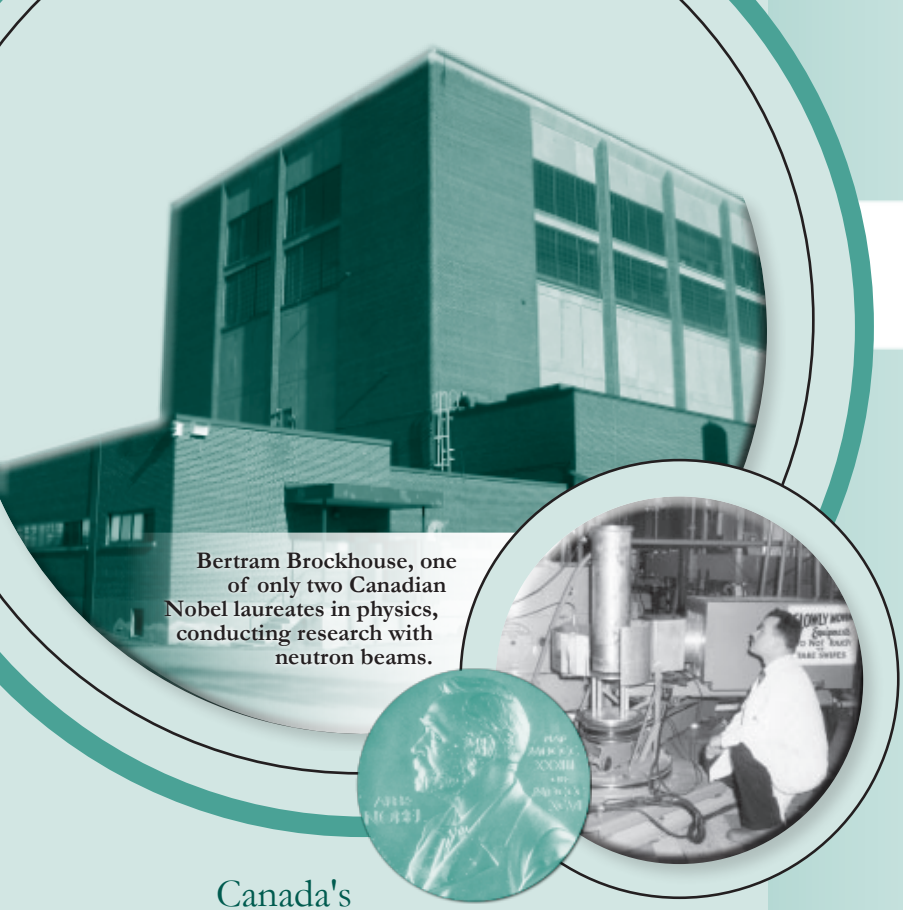
Summary

This document is the summary of the long range plan, Planning to 2050*, and is intended to be an accessible introduction for all interested parties. The full version of the plan is available at www.cins.ca*

Overview

In *Planning to 2050*, Canadian scientists describe materials research with neutron beams and recommend how to maximize its future value to Canada. The centrepiece of the plan is the construction of the Canadian Neutron Centre (CNC), a reactor-based neutron source with associated laboratories and infrastructure. This world-class laboratory will surpass the aging NRU reactor in Chalk River, Ontario, in each of its functions, namely (1) the production of medical isotopes, (2) nuclear energy R&D, and (3) the production of neutrons for materials research. As an important aspect of Canada's infrastructure for science and industry, the CNC will serve broad scientific, technological and health needs of Canadians for the coming decades. The full plan lays out the requirements and priorities of the scientific community for Canada's new neutron source from the perspective of materials research using neutron beams. This plan is the result of a consultative democratic process and is the culmination of the work of CINS members since the early 1990s.



Bertram Brockhouse, one of only two Canadian Nobel laureates in physics, conducting research with neutron beams.

Canada's NEUTRON SOURCE

Canada's neutron source is the National Research Universal (NRU) Reactor at Chalk River Laboratories. This multipurpose facility is owned and operated by Atomic Energy of Canada Ltd. (AECL). The NRU reactor supports science and industry in three distinct areas: (1) it is the largest global producer of isotopes for applications in medicine and industry; (2) its core provides a test environment for fuels and components for nuclear power technologies such as the CANDU® reactor; (3) it supplies neutrons for the Canadian Neutron Beam Centre (CNBC) for materials research across a host of scientific disciplines.

CANDU® (Canada Deuterium Uranium) is a registered trademark of AECL

Canadian Research with Neutron Beams

Canada's neutron source is a highly valuable element of Canada's infrastructure for science and industry. The need to replace and augment its capabilities has been recognised for over 15 years.

Importance of Neutron Beams

Neutron beams are versatile and irreplaceable tools for materials research. They enable fundamental scientific exploration and education, and can be applied in many sectors, including aerospace, automotive and manufacturing, as well as in Canada's four priority areas: energy, environment, health, and communications. Everything around us, even our own bodies, is made of materials whose behaviour needs to be understood. By improving our understanding of the way that materials work, we can have positive impacts on every aspect of our lives.

Research using neutron beams in Canada is carried out at a large centralized facility, but consists of many individual projects driven by research groups from universities, industry and government laboratories across Canada and all over the world.

Canada's Place in the International Community

Canada's neutron source is the National Research Universal (NRU) Reactor at Chalk River Laboratories. The Canadian Neutron Beam Centre (CNBC) operates six neutron beam instruments surrounding the NRU reactor. These instruments direct neutrons from the reactor onto materials of interest. The CNBC is part of the National Research Council of Canada (NRC).

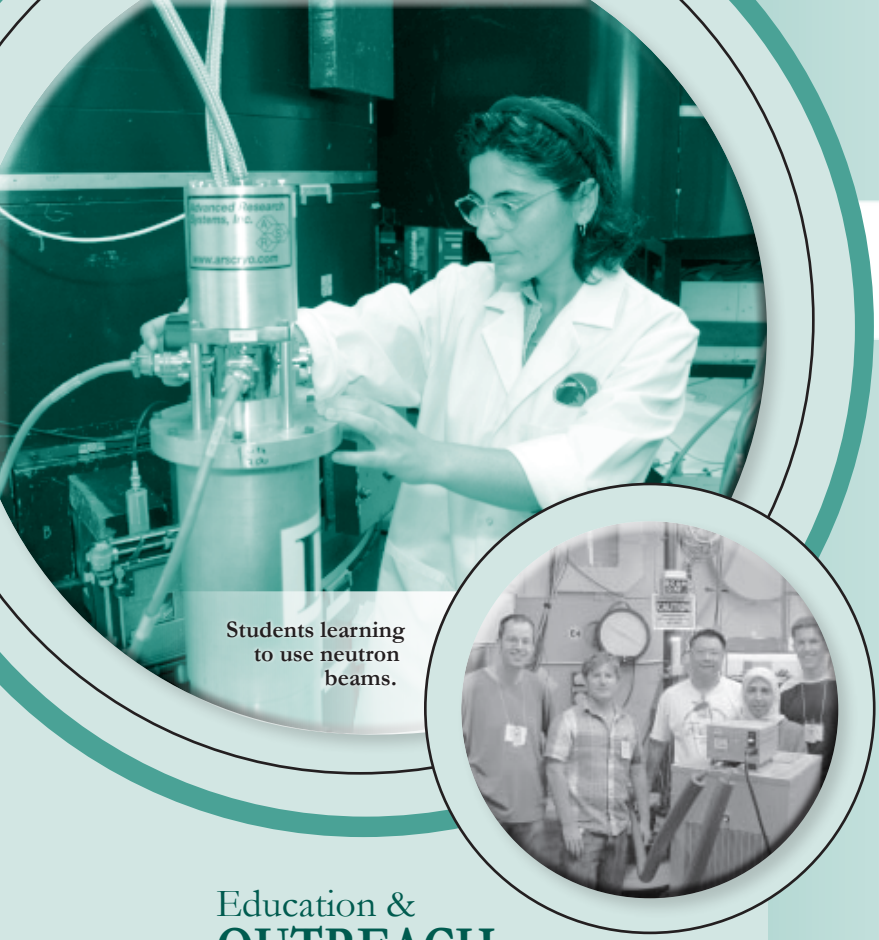
Canada enjoys a strong history in research with neutron beams, starting with the Nobel Prize-winning work of Bertram Brockhouse in the 1960s and continuing today. Innovative neutron instruments developed in Canada have been replicated at every major neutron beam centre worldwide. These include both the Neutron Stress Scanner developed by scientists at Chalk River in the 1980s and Dr. Brockhouse's Triple-Axis Spectrometer.

The Canadian community of researchers who employ neutron beams maintains an international reputation for innovation and for direct engagement of industry clients. The quality and impact of the community is indicated by citation rates of publications in high-quality journals and by the fact that Canadian-trained neutron scattering scientists have gone on to become the leaders of international facilities. The CNBC has an excellent record of training highly qualified people and helps to connect Canadian scientists to a global network of neutron laboratories, fostering collaborations with scientists from over 100 institutions in 19 countries. Recently, international experts rated the CNBC the highest of eleven different elements of the federal S&T infrastructure and regulatory system that are an advantage to Canada. In a recent competition with 75 other facilities, the Canadian academic community committed more than 25% of the funds in the NSERC Major Resource Support program to the CNBC. This decision indicates the priority of Canadian researchers to ensure access to a competitive, national neutron beam facility to advance their research programs.

Canada's Need for a New Neutron Source

Canada's NRU reactor has been operating for over 50 years. The need to replace and augment the aging NRU reactor has been recognised for over 15 years. Although the NRU reactor was the world's best research reactor when it was built, Canada's capabilities have fallen behind in some areas, most notably in its lack of a source of cold neutrons, which are in the highest demand because they are especially useful for nanotechnologies and for health and life sciences.

Canada is not alone. Many foreign neutron facilities are also approaching the end of their life span. The total capacity of neutron sources in OECD countries will decrease over the next ten years, even though the global demand for neutron facilities is growing and several new foreign facilities are being built. Given the costs required to maintain the aging NRU reactor and that eight to ten years may be required to design, build and license a new facility, a decision is urgent.



Students learning to use neutron beams.

Education & OUTREACH

One benefit of a national centre for research using neutron beams that can accommodate visiting groups of scientists, professors and students, is the role it plays in the education and training of highly qualified people. The CNBC hosts regular summer schools. The presence of a national centre with a strong mandate for education and outreach encourages the development of a lively scientific community in Canada, in a way that access to foreign neutron sources does not.

Our Vision for a New Canadian Neutron Centre (CNC)

We envision a new Canadian Neutron Centre to be a world-class, multi-purpose facility for three missions: (1) production of medical isotopes, (2) nuclear energy research, and (3) materials research using neutron beams.

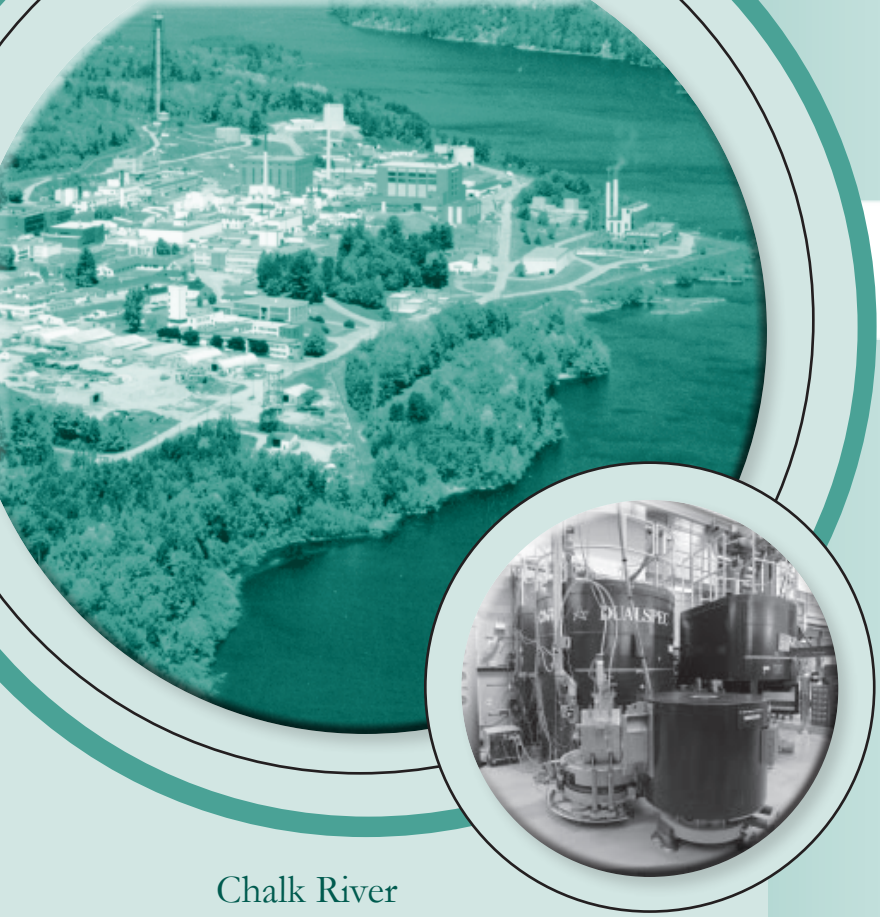
The centrepiece of Canadian neutron research for the next 50 years must be a new Canadian neutron source. The proposed CNC would be a vital part of Canada's infrastructure for science and industry. All of the missions of the CNC are knowledge-intensive endeavours that will enhance Canadian innovation and the competitiveness of Canadian industry. Canada's rich experience with the NRU reactor shows us that a single, multipurpose reactor can perform each of these missions. Instead of building three facilities, one dedicated to each mission, Canada will achieve maximum value through a single, world-class, multipurpose facility, that is, the Canadian Neutron Centre. The CNC will fully surpass the aging NRU reactor.

The materials research capabilities of the CNC will:

- reassert Canada's international leadership in research using neutron beams by enhancing areas in which Canada is strong and in which it currently lags, such as the application of neutron beams to the study of nanotechnologies and life sciences;
- retain and expand Canada's national hub that fosters innovation in the application of neutron beams to respond to Canada's research priorities, while evolving according to national goals and policies;
- educate and develop skills for thousands of highly qualified people, while attracting highly qualified people to Canada;
- sustain and increase proprietary neutron research by Canadian industries to develop new industrial materials and products and to access wider markets;
- support tens of thousands of individual science projects over its lifetime; and
- foster scientific exchange in the global research community as part of a worldwide network of facilities for materials research.

The CNC will provide other major benefits to Canadians:

- The isotope production capabilities will supply medical isotopes for the diagnosis and treatment of tens of millions of patients each year in Canada and around the world.
- The nuclear energy R&D capabilities will be a crucial support for the international fleet of CANDU reactors, as well as Canada's own nuclear industry, which has an estimated economic impact of over $6 B per year, by enabling the testing of fuel and components under conditions representing a power reactor. These capabilities will also enable Canada to develop more advanced nuclear power technologies and to effectively participate in the Generation IV International Forum.
- The construction of the CNC will generate about 9,000 person-years of employment, including 2,500 person-years for highly qualified people, and over $190 M of equipment and materials provided mainly by Canadian small- and medium-sized enterprises, which will be challenged to grow and improve to address stringent specifications.



Chalk River
LABORATORIES

The Chalk River site on the Ottawa River was established as a national laboratory for the nuclear sciences in the 1940s by NRC. The lab was centred around two of the world's most intense neutron sources, the NRX and NRU reactors, enabling a wealth of research and knowledge generation that has launched industries and helped Canada play a prominent role in science internationally. Through the presence of a true national centre for neutron scattering, scientists in universities and industries across Canada have had access to the very best scientific tools. Today, Canada has an historic opportunity to once again establish a world-class national laboratory that supersedes the aging facilities at Chalk River.

An Environment for Science at the CNC

Science is a human endeavour. It is not just about facts, tools and facilities. Science thrives on curiosity about nature and the free exchange of ideas between individuals.

We will create an environment that attracts highly qualified people, that strongly contributes to their education and that facilitates the needs of their research. It will foster exchange of ideas and knowledge between staff and visiting scientists who will continuously flow through the centre. To accommodate scientists who travel from across Canada and from all over the world to participate in experiments, the CNC will operate at full power on a reliable schedule. As a multipurpose facility, the CNC will need a governance arrangement that respects the needs of each user community.

The Neutron Source.

The CNC must include a neutron source delivering world-class neutron flux into many beam lines. A major advance will be a source of cold neutrons, which are in high demand worldwide for the study of life sciences, soft materials and

nanotechnology. A flexible design will allow the addition of beam lines in the future.

Neutron Beam Halls and Instruments.
To perform many simultaneous experiments, a suite of neutron beam instruments will be housed in neutron beam halls. The reactor hall will be adjacent to the reactor, to allow maximum neutron flux by being near the source. One or more guide halls in nearby buildings will increase the number of instruments by being further from the source but a high neutron flux to each instrument will be achieved using state-of-the-art neutron guiding technology. The planned suite of instruments will offer world-class performance and introduce capabilities that are currently unavailable in Canada.

Attached Facilities.
The CNC complex will include much more than the reactor and instruments. There will be office spaces and meetings rooms to enhance scientific collaboration; laboratories for on-site preparation of specimens by visiting scientists; workshops and working areas for design, construction, testing, maintenance and repair of specialised equipment; and a modern data acquisition, networking and control centre that is able to adapt to future technologies.

Recommendations

1. CINS recommends the creation of a steering group, led by a federal agency, to reflect the vision for the CNC as national infrastructure for science and industry.

2. CINS recommends that this steering group be provided with a strong, funded mandate to develop a complete proposal for the CNC as soon as possible.

3. To ensure maximum value to Canada, CINS recommends implementation of the requirements of the neutron beam community for the CNC as presented in the full plan, *Planning to 2050 for Materials Research with Neutron Beams.*

Final Word

Canadians contribute significantly to the world's knowledge of materials and Canada receives much knowledge in return. Industry, academia and government each contribute and Canada reaps wide-ranging benefits, from health to wealth and well-being. As our domestic neutron source, the new CNC will be a versatile and irreplaceable part of the future of materials research in Canada. The CNC will yield high value to Canada by planning for the human side of science, as well as by providing world-class scientific instruments. It will be an environment designed to generate ideas and promote exchange of information. On behalf of the Canadian neutron beam user community, *Planning to 2050* outlines ways to maximise the new CNC as a world-class facility for materials research, delivering impacts across the spectrum from discovery to innovation.

Artist's conception - entrance to a new Canadian Neutron Centre