Report on Outcomes of the CNI-CIFAR Roundtable on a National Neutron Strategy

December 15-16, 2020

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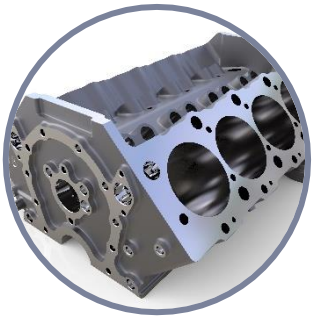
INTRODUCTION

Canada's social, environmental, and economic challenges require a complete twenty-first century scientific toolkit for research and innovation in materials. Engineers and scientists apply many types of probes to advance knowledge and improve materials. Key among these investigative techniques are neutron beams, which are versatile and irreplaceable tools for materials research. Canadians have led in this field for over 70 years, applying neutron beams to make major socio-economic impacts, such as those described at cins.ca/discover. The importance of neutron beams for research is recognized globally, and other nations are currently investing in multibillion-dollar neutron sources.

Neutron beams were vital to explain, and prevent downtime from, leaks at Canada's fleet of nuclear power reactors.



Neutron beams were critical to ensuring reliability of light-weight engine parts manufactured with innovative methods.

Neutron beams were critical to explain cracking in aging pipelines and develop standard practices to ensure reliability.

Neutron beams revealed workings of medical technology now being pursued for early detection of ovarian cancer.

A new strategy for Canadian research with neutron beams is urgently needed due to the shutdown of Canada's primary neutron source, the NRU Reactor in Chalk River, in 2018. Further adding to the urgency is the recent expiry of Canada's only agreement with a foreign neutron source and the restructuring of the federal agencies that previously managed neutron-beam infrastructure for access by the scientific community. Canadian researchers now face severe reductions in access to neutrons, and the foreseeable decline in Canadian publications arising from neutron beams is evident.[1] Further,

[1] Summary of Results from the CINS-CNI 2020 Survey. October 2020. https://fedorukcentre.ca/documents/resources/cni/cins-cni-survey-2020-report.pdf

the global neutron supply is shrinking, which exacerbates Canadian access and requires us to plan for the long term as well as for the immediate challenge of sustaining a national program.

Canadian universities are leading the way to address these challenges through the Canadian Neutron Initiative (CNI). On December 15 and 16, 2020, the CNI Working Group and CIFAR convened a cross-section of stakeholders in a virtual roundtable to shape a national neutron strategy for rebuilding Canadian capacity for materials research with neutron beams. The 88 participants included 40 leading scientists from universities and industry; 20 Vice-Presidents of Research and their designates from 13 Canadian universities; representatives of the U15 Group of Canadian Research Universities, government agencies, and international neutron facilities; and other Canadian research leaders.

PRIOR CONSULTATIONS

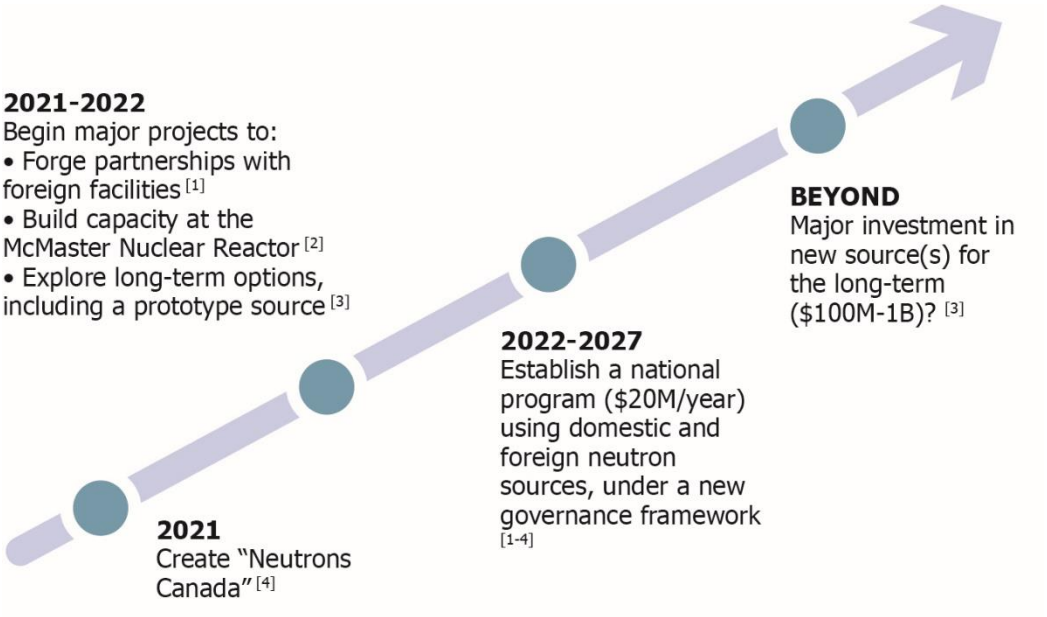
This roundtable was a culmination of several consultations that have taken place since 2015, when the final closure date of the NRU Reactor was announced. An earlier roundtable was held in January 2020 with Vice-Presidents of Research and Associate Vice-Presidents from 16 universities across Canada. The January 2020 roundtable produced a consensus to establish “Neutrons Canada”, a new entity with universities as institutional members. The purpose of Neutrons Canada will be to manage all strategic activities as part of a unified national program.[2] Specifically, Neutrons Canada will negotiate foreign partnership agreements on behalf of the Canadian neutron beam community, support user access to foreign outstations, operate the neutron beam lab at the McMaster Nuclear Reactor (MNR) as a national user facility, develop neutron instruments and technology for a new neutron source, conduct science outreach, engage industry in technology development, and to generally manage the program.

[2] Canadian Neutron Initiative. Canadian Leadership in Materials Research with Neutron Beams: Report on a Roundtable Meeting towards the establishment of “Neutrons Canada”. https://fedorukcentre.ca/documents/resources/cni/neutrons-canada-roundtable-2020-jan-29---full-report.pdf

TOWARDS A NEW STRATEGY

The December 2020 roundtable was framed through an extensive discussion paper[3] representing the work of the CNI Working Group over the past five years to establish a new, pan-Canadian, university-led framework for the stewardship of Canada's capabilities using neutron beams. The discussion paper explores the value of neutron beams to meet Canada's social, environmental, and health challenges, and also describes the present and historical context for materials research with neutron beams. Additionally, it explores the four strategic objectives outlined below.

1. ***Forge partnerships*** *with high-brightness neutron sources in other countries.*
2. ***Build on domestic capabilities,*** *including full exploitation of the McMaster Nuclear Reactor, a medium-brightness neutron source.*
3. ***Explore and invest in developing new neutron sources*** *for the long term.*
4. ***Create a new, national governance and management framework*** *for these activities.*



[3] Canadian Neutron Initiative. "A National Strategy for Materials Research with Neutron Beams." Dec. 12, 2020. The consultation draft is available from http://neutrons.ca.

At the December 2020 roundtable, ideas and feedback were invited regarding key elements of the strategy, including the needed infrastructure and associated programs (both domestic and foreign) on multiple time scales. Speakers shared relevant experiences with international neutron facilities and with various Major Research Facilities in Canada.

The potential role of Neutrons Canada in enabling each of the elements of the strategy was frequently discussed in each session.

OPTIMISM AND GENERAL AGREEMENT ON THE STRATEGY

The tone of the discussion reflected optimism about the future as envisioned in the strategy, despite setbacks such as the closure of the NRU reactor. The neutron beam community perceives appealing prospects for new, innovative neutron sources in Canada. Likewise, it perceives a variety of excellent opportunities for partnerships in both the short and long term with facilities in the U.S. and Europe that are planning investments in traditional reactors, compact accelerator-based neutron sources, and world-leading high-brightness spallation neutron sources.

In addition, McMaster University led the community to develop a strong case, supported by 17 universities, to the Canada Foundation for Innovation 2020 Innovation Fund for a major investment to establish two foreign partnerships and to build the neutron beamlines that are prerequisite for the full exploitation of the McMaster Nuclear Reactor. Operated as a national user facility, the McMaster Nuclear Reactor could provide access to certain high-demand 'workhorse' techniques for which broad-band, continuous neutron intensities are appropriate. (Experiments requiring pulsed or cold neutrons or a high neutron brightness, especially neutron spectroscopy, would be conducted elsewhere.) Over $10M has already been invested, including $2M from the university itself, in the development of the neutron beam lab at the McMaster Nuclear Reactor. Progress

The McMaster Nuclear Reactor is the source of neutrons for a neutron beam lab under development there.

includes the recently completed neutron beam hall and two neutron beamlines: an alignment diffractometer operating since 2009, and a Small-angle Neutron Scattering (SANS) instrument expected to be operating in 2021. These activities have been bolstered by recent NSERC awards for sample environments and other ancillary equipment.

Also lending optimism to the roundtable discussion was the fact that Canada has been reasonably successful at retaining neutron beam professionals as well as users of neutrons, providing a solid base of domestic expertise on which to build a national user program. Today, the Fedoruk Centre is inviting Saskatchewan universities to consider establishing a cluster of faculty members who apply neutron beams for materials research; in addition, it is funding materials research projects that use nuclear tools, including neutron beams. There is also optimism about how a national user program would offer various means to promote equity, diversity, and inclusion (EDI) in the materials research community.

Key areas of agreement and common themes of the December 2020 roundtable discussion included the following points:

- *There is a **strong scientific and socio-economic case** for Canada to continue its leadership in research that requires neutron beams.*
- *There are **useful lessons and models from which we can learn** from other countries who have lost their domestic neutron sources, and from other scientific communities that require access to major research infrastructure located in other countries, such as telescopes and synchrotron light sources or other major particle accelerators.*
- *There is **broad support for the proposed national neutron strategy and for the creation of a national coordinating organization, Neutrons Canada**.*
- ***A national organization is best suited to manage all the strategic activities as a coherent program** according to best practices of governance and management of Major Research Facilities in Canada. Neutrons Canada will be needed to secure capital and operating funds for major research infrastructure, and to operate the resulting programs and infrastructure and on behalf of the national user community.*

- ***A national organization is best suited to build and maintain alignment with a national strategy*** *by integrating the bottom-up activities of the broad user community with the top-down interests of science policy and funding bodies. Specifically, such an organization is needed to create the processes and structures for consensus building and long-range planning, to act as the primary point of contact with the government for this scientific field, and enable stakeholders of this scientific field to speak with one voice.*
- ***A national organization can best promote Canadian objectives****, including advancing EDI within the materials research community, integrating Canadian industry into instrument development opportunities, fostering a science and innovation culture through outreach and communications, and stimulating research that addresses Canadian and global challenges such as climate change, clean energy, health, and food security.*
- ***Access to foreign neutron facilities is an urgent priority to address the present neutron beam shortage****, and will continue to be essential even after the McMaster Nuclear Reactor is fully optimized.*
- ***Canada should be a serious contributor to, not a free rider on, the global supply of neutron beams.*** *Partnerships offer access to world-leading capabilities for science and the ability to shape these capabilities according to Canadian needs. They offer highly inspiring educational opportunities for students, and opportunities for Canadian industry to benefit from developing cutting-edge technology for neutron sources and instruments. In contrast, attempts to 'free-ride' at a time when other countries are investing heavily to mitigate shrinking supply would hinder Canada's reputation as a scientific partner.*
- ***Domestic capabilities are essential for Canada's effective participation in this global arena****. We must be able to contribute expertise and equipment to partnerships, rather than rely solely on cash contributions to leverage access to beam time.*
- ***Domestic neutron facilities are essential for several 'anchoring' functions****: (1) fostering Canadian expertise, including outreach to new users, engagement with industry, and the training of professionals and students; (2) developing technology for neutron instrumentation in response to Canadian needs; (3) enabling 'workhorse' or exploratory experiments that don't*

require the high-brightness or leading capabilities of a foreign facility; (4) enabling experiments for which safety and security requirements limit international mobility (e.g., soils, military vehicle components, or radioactive fuels for nuclear power); and (5) contributing to the global supply of neutrons and welcoming foreign scientists to Canada, which in turn fosters international scientific collaborations and exchanges of ideas.

CONCLUSION

The Canadian neutron beam community is aligning around an emerging national neutron strategy. This strategy constitutes a roadmap for Canada to follow as it pursues the infrastructure and governance framework required for Canadian materials researchers to apply neutron beams for innovation in areas such as clean energy, health, and food security, as well as to make fundamental discoveries.

Key actions toward implementation of the strategy include establishing Neutrons Canada and securing funding to advance key objectives of the strategy, notably, to establish partnerships with foreign neutron sources, to ramp up operations of the neutron beam lab at the McMaster Nuclear Reactor, and explore new neutron sources for the long term.

Clean energy storage: Canadian scientists use neutrons to study the structures of new materials for batteries, fuel cells, hydrogen storage, and other technologies to get our cars off fossil fuels and extend the use of clean energy in the electricity grid: http://cins.ca/tag/clean-energy-technology+energy-storage.