Canadian Institute for Neutron Scattering (CINS)
Minutes of the Annual General Meeting (AGM)
2014 October 14 & 15
University of Toronto

The Annual General Meeting of the Canadian Institute for Neutron Scattering was open to all CINS members, guests and interested parties.

Present at the 2014 meeting were CINS Board members John Root and Bruce Gaulin. Participating by phone was Niki Schrie (Secretary-Treasurer). In addition, a quorum of the Science Council members, Institutional representatives and general membership, including professors, students and other science professionals was present.

Friday, October 14, 2014

The 2014 CINS AGM registration and opening session convened at 4:00 PM. Opening remarks were made by Young-June Kim from the University of Toronto.

The keynote speaker was Dr. Olivier Delaire from Oak Ridge National Lab, who spoke on "Phonon Scattering Mechanisms in Thermoelectrics".

Saturday, October 15, 2014

Two guest speakers presented as follows, prior to the CINS business portion of the meeting:

Dr. John Dutcher from the University of Guelph, who spoke on "Monodisperse dendrimeric polysaccharide nanoparticles in water: an ideal hard sphere colloidal dispersion system?"

Dr. Edwin Kermarrec from McMaster University, who spoke on "Exotic magnetism on the frustrated FCC lattice of 5d double perovskites".

1. CINS Business I

The business meeting was convened at 11:00 AM.

A. Election of New President

Written notice had been sent to all CINS members by Dominic Ryan, in advance of the AGM, indicating he would be stepping down from his role as President of CINS. President Dominic Ryan was unable to attend the AGM; therefore, John Root opened the meeting with the election of a new President.

Standing for election were Professor Chris Wiebe and Professor Thad Harroun. After a brief word from each candidate, paper ballots were distributed and collected by John Root.

Professors Young-June Kim and Bruce Gaulin counted the ballots.
Results: 13 votes for Chris Wiebe, 12 for Thad Harroun and 1 ballot left blank.

Chris Wiebe began his term immediately, and chaired the remainder of the CINS business meeting.

B. Approval of the Agenda

Motioned by Bruce Gaulin, seconded by Carl Adams and unanimously carried – that the printed agenda be approved.

C. Approval of AGM Minutes (2013)

Motioned by Carl Adams, seconded by Young-June Kim and unanimously carried - that CINS approve the 2013 Minutes from the AGM.

D. Review Actions Arising from Minutes (2013)

The sole action was for the founding Board to begin the process of identifying new members of stature to help lead the development of CINS as a professional organization with good governance, accountability and engagement with funding agencies, government and university executives. This action is ongoing.

E. Yearly Update on CNBC Performance (Daniel Banks)

Daniel Banks gave an update on the performance of the NRU and Canadian Neutron Beam Centre (CNBC) over the past year.

Daniel Banks' slide deck can be found in Appendix A.

F. Treasurer's Report (Carl Adams/Niki Schrie)

Due to an oversight, the treasurer's report was missing from the printed agenda.

Motioned by Carl Adams, seconded by Young-June Kim and unanimously carried that - CINS add the Treasurer's report to agenda at this point.

Carl reported that the Secretary-Treasurer duties were transferred to Niki Schrie at the CNBC during the 2014 calendar year, and that a bank account had been established locally.

Requests for payment of institute membership dues for FY 2014 and 2015 are late being sent out. Total dues requests will be $1400, to cover both years.

Action: Niki Schrie – to issue letters to institutions, signed by Chris Wiebe, as soon as possible after the next board meeting.

Carl Adams' written report can be found in the Appendix B.

The business meeting was adjourned at this point at 12:02 PM for lunch.

A meeting of the Institutional Member Representatives was held in-camera from 12:45-1:15 PM.

2. CINS Business II

The business meeting was reconvened at 3:30 PM, following a talk by Dr. Neil Alexander of The Sylvia Fedoruk Canadian Centre for Nuclear Innovation who spoke on "How a research reactor could appear on Saskatchewan's roadmap for nuclear research, development and training".

G. Future Business Framework for Access to CNBC (John Root)

As part of his report on the conversion of AECL to CNL, John Root also spoke to some possible future scenarios for access to CNBC, now that the NSERC Major Resource Support program has been terminated and CINS has no oversight role.

John Root's slide deck can be found in Appendix C.

H. University Consortium Initiative & Progress Update (Daniel Banks)

Daniel spoke to the effective replacement of the NSERC MRS program with CFI's new "Major Science Initiatives" program, which might be applicable to covering part of the CNBC operation in the future, except CFI can only fund facilities owned by universities. Daniel conveyed feedback Dominic Ryan had received from his Dean at McGill University, unsupportive of leading any new initiatives for the neutron scattering community, and suggesting that CINS might consider the Institute for Particle Physics as a model for organizing our approach to funding agencies.

Bruce Gaulin reported that he had followed Dominic's attempt by proposing discussion with McMaster's Vice-president of Research. Bruce noted that McMaster is part of one consortium bidding for a role as contract-operator of Chalk River, so now is not a good time to press McMaster to consider leading a university consortium to engage with CNL about how to secure a contribution to the operation of the NRU reactor and the CNBC.

I. CINS Long Range Plan Update, Discussion & Q&A (Zahra Yamani/Zin Tun)

Zahra Yamani and Zin Tun gave a presentation on reasons for and progress on, the updates to the 2008 CINS Long Range Plan. There were no issues surrounding the scientific program parts of the document, including the instruments and methods.

Motioned by Daniel Banks, seconded by John Greedan and unanimously carried – that CINS endorse the proposed changes to portions of the Long Range Plan about scientific programs and requirements.

Zin Tun then led a discussion on the topic of new neutron sources. He identified five possibilities that should be explored by a CINS sub-committee, whose research and recommendations would be presented to the community by May 2015.

Motioned by Bruce Gaulin, seconded by Thad Harroun and unanimously carried – that the Science Council leave the neutron source section of the long range plan as a simple statement of intention to analyze options, and print the document as early as possible. The plan will then be made available for anyone interested in the future of CNL, a new research reactor in Canada, or the possible federal nuclear innovation agenda.

Motioned by Bruce Gaulin, seconded by Jamie Noel and unanimously carried – that CINS appoint a subcommittee with the task of exploring the cost and benefits of the neutron sources identified by Zin, and report back in the new year, with recommendations for including in the next edition of the long range plan.

It was unanimously agreed - That this subcommittee should be comprised of the Science Council with power to add to their number as needed and Zin Tun to chair.

Zahra Yamani slide deck can be found in Appendix D.
Zin Tun's discussion document can be found in Appendix E.

J. Announce New Board Members and Nominees for Science Council Membership

It was unanimously agreed – that the CINS membership adopt the recommendation of the institutional member representatives and that Thad Harroun be named to the Board of Directors to replace outgoing director, Dean Chapman.

Thad Harroun therefore resigned from his position on the Science Council. Noting that terms of duty had expired for two other council members, there were three vacancies on the Science Council.

Motioned by Bruce Gaulin – that Zahra Yamani and Maikel Rheinstadter be re-nominated to the Science Council to provide continuity in the process of the Long Range Plan update. Bruce recommended that Jamie Noel be appointed as a new Science Council member. There being no other suggestions, and after some discussion, Chris Wiebe acclaimed the three nominees to the Science Council.

K. Thank you the outgoing President (Chris Wiebe)

Comments of appreciation were made from the floor for the longstanding service of Dominic Ryan as President of CINS, carrying responsibility for oversight of the NSERC Major Resource Support grant for 11 years before the program was ended in 2012, and building a presence for

CINS in public fora as never before achieved, in federal government committees, print media, radio and television.

L. Next CINS AGM Location

Some discussion was had around location of the 2015 AGM.

Action: Carl Adams to explore venues.

Annual Status Update to the Canadian Institute for Neutron Scattering

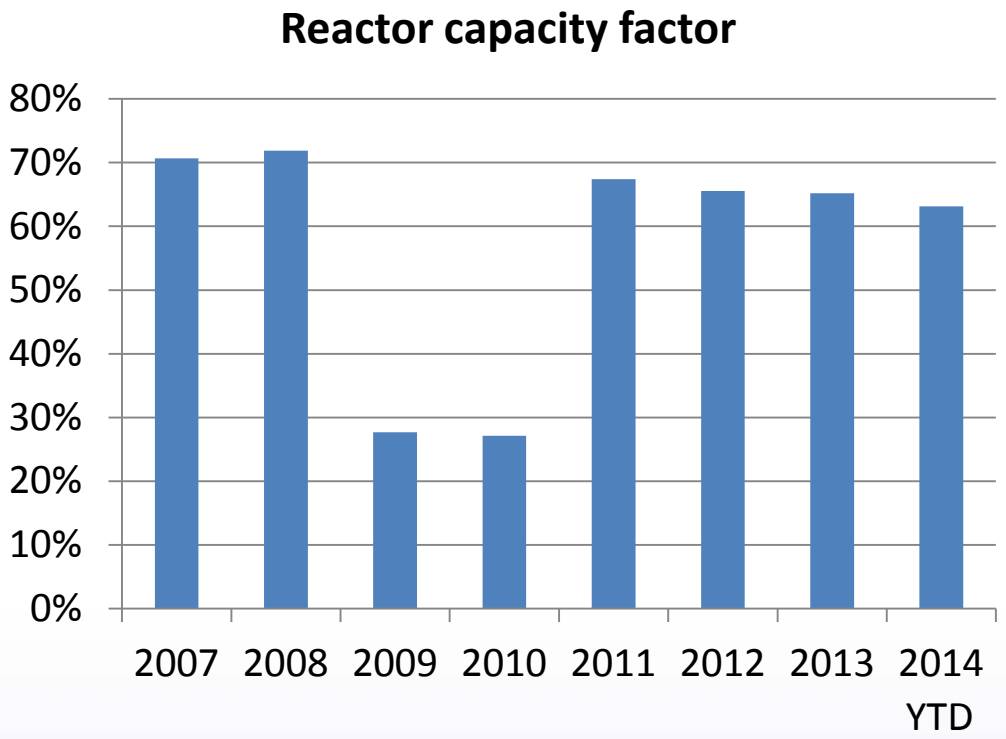
Daniel Banks

CINS Annual General Meeting

University of Toronto

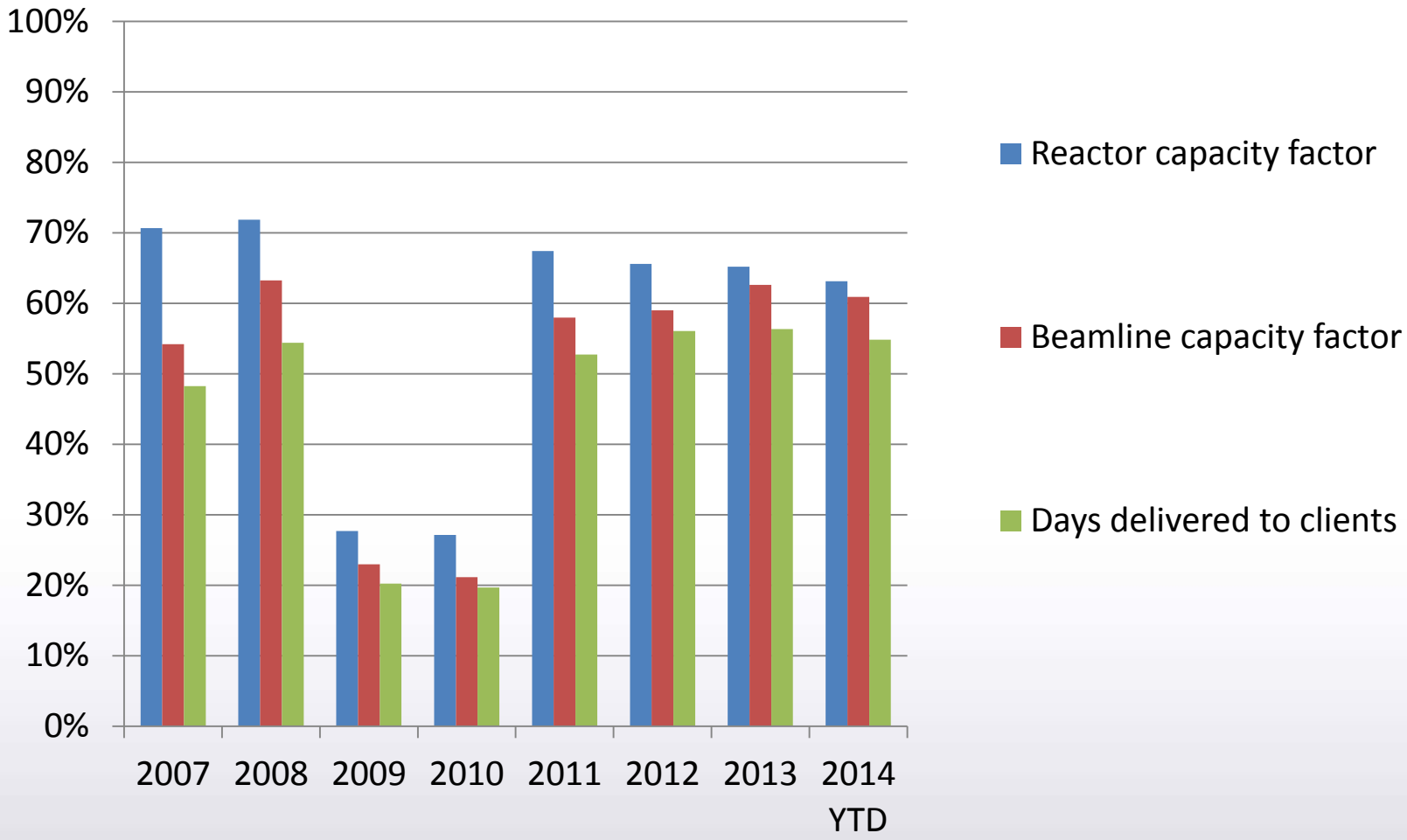
2014 November 15

Neutron Source

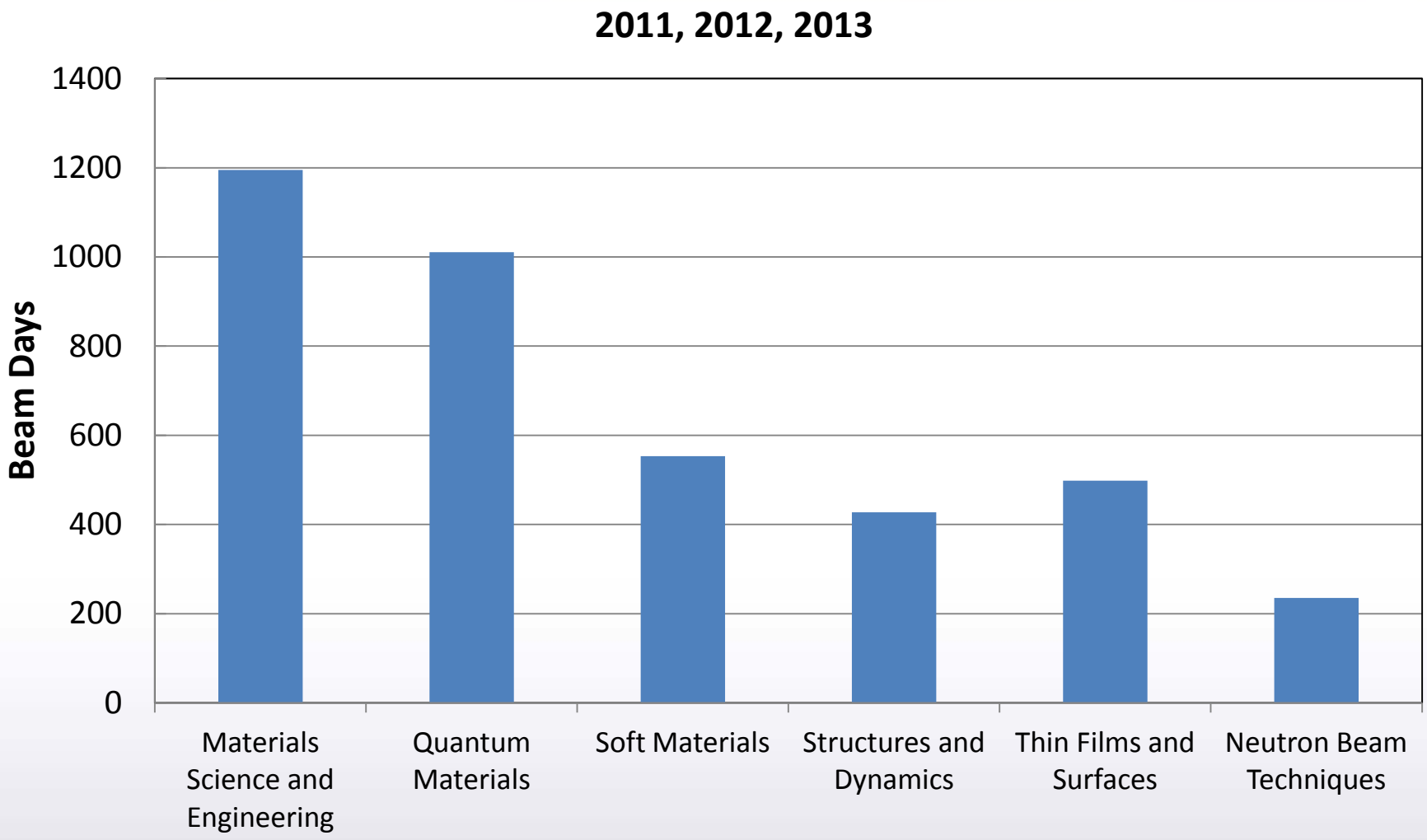


- Current operating license expires Oct 2016.
- CNL planning assumes operation to 2021.
- Annual month-long outage in the spring since the 2009-2010 shutdown

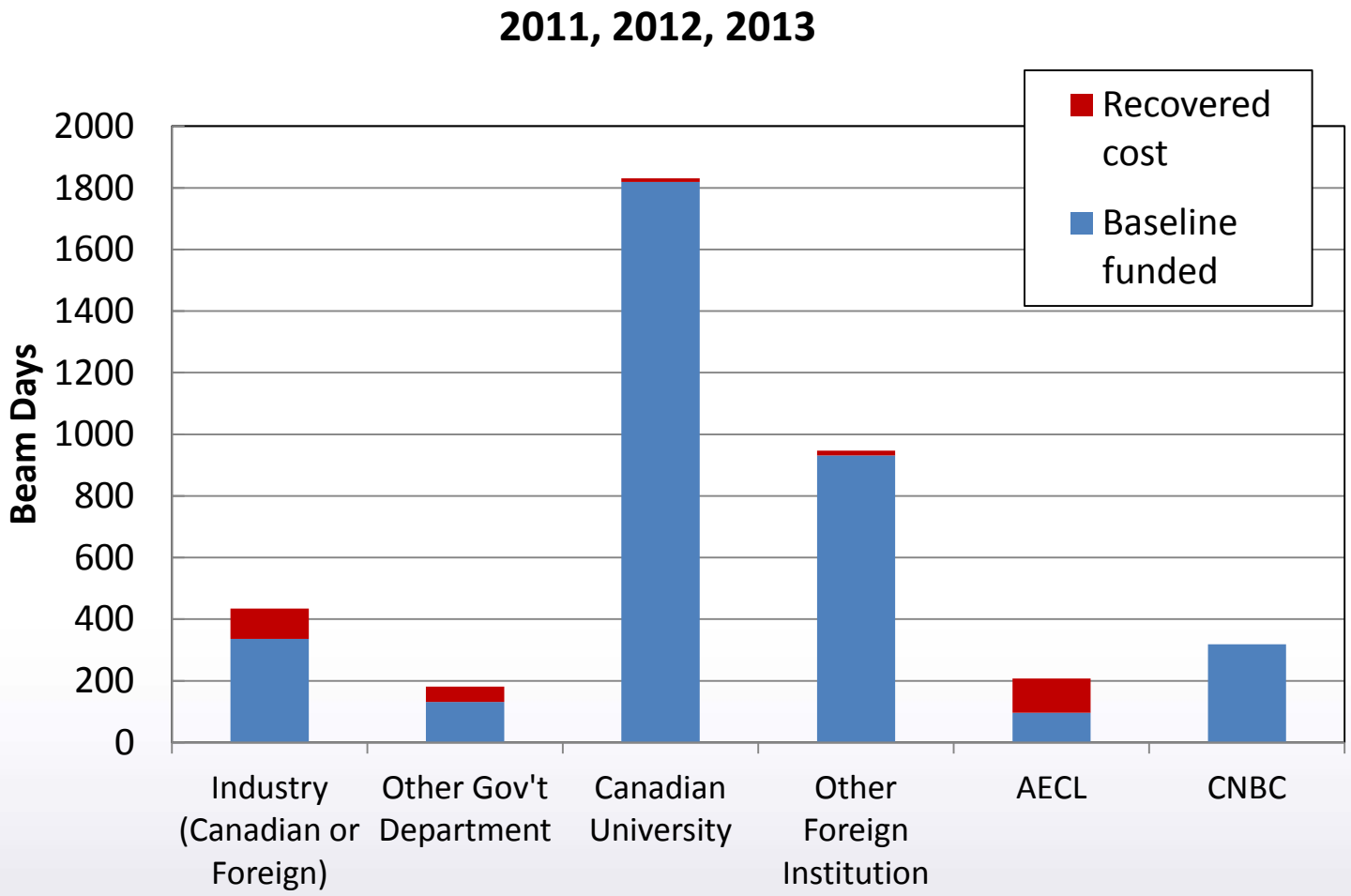
Facility Indicators



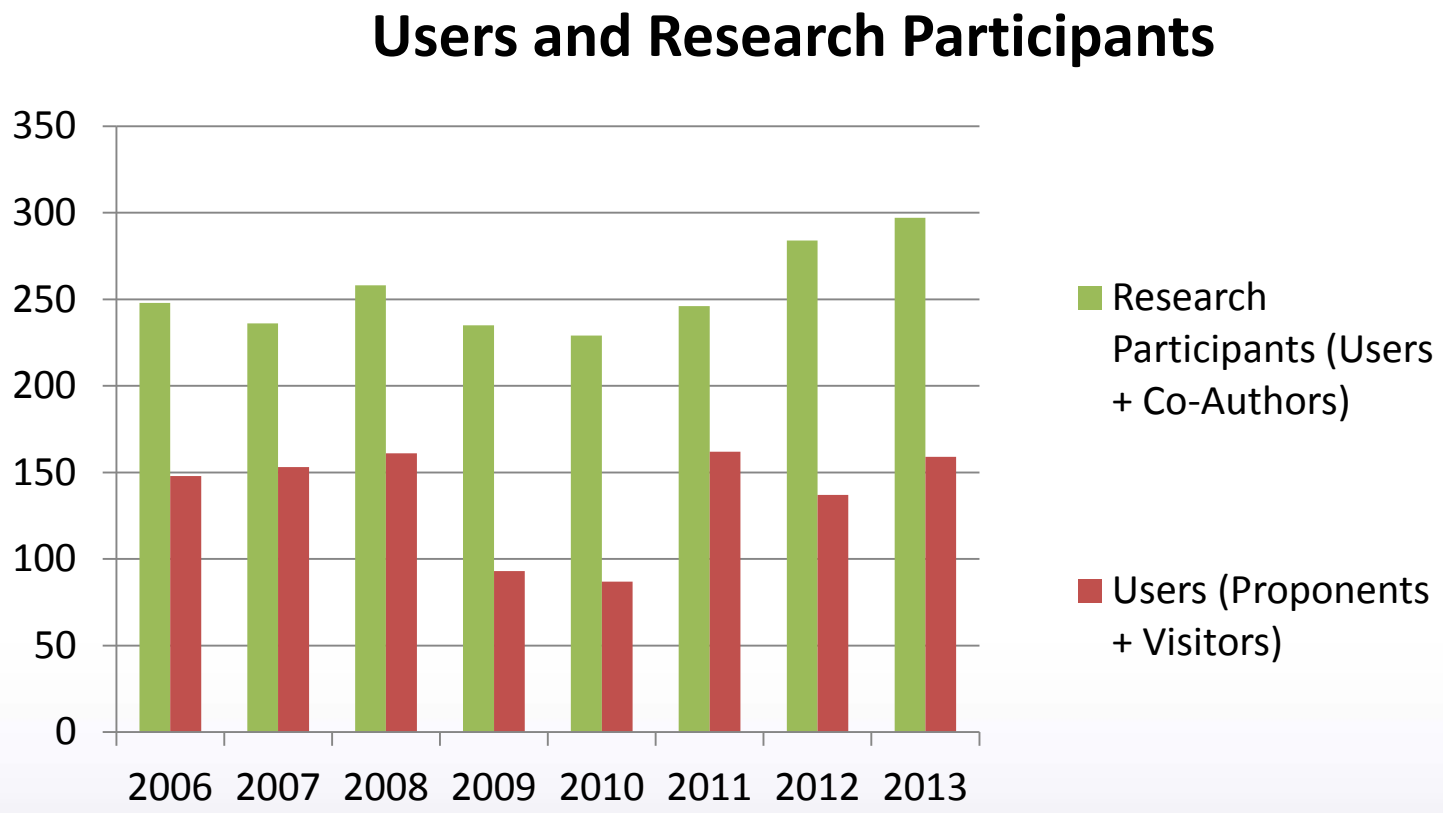
Beam Time by Subject Area



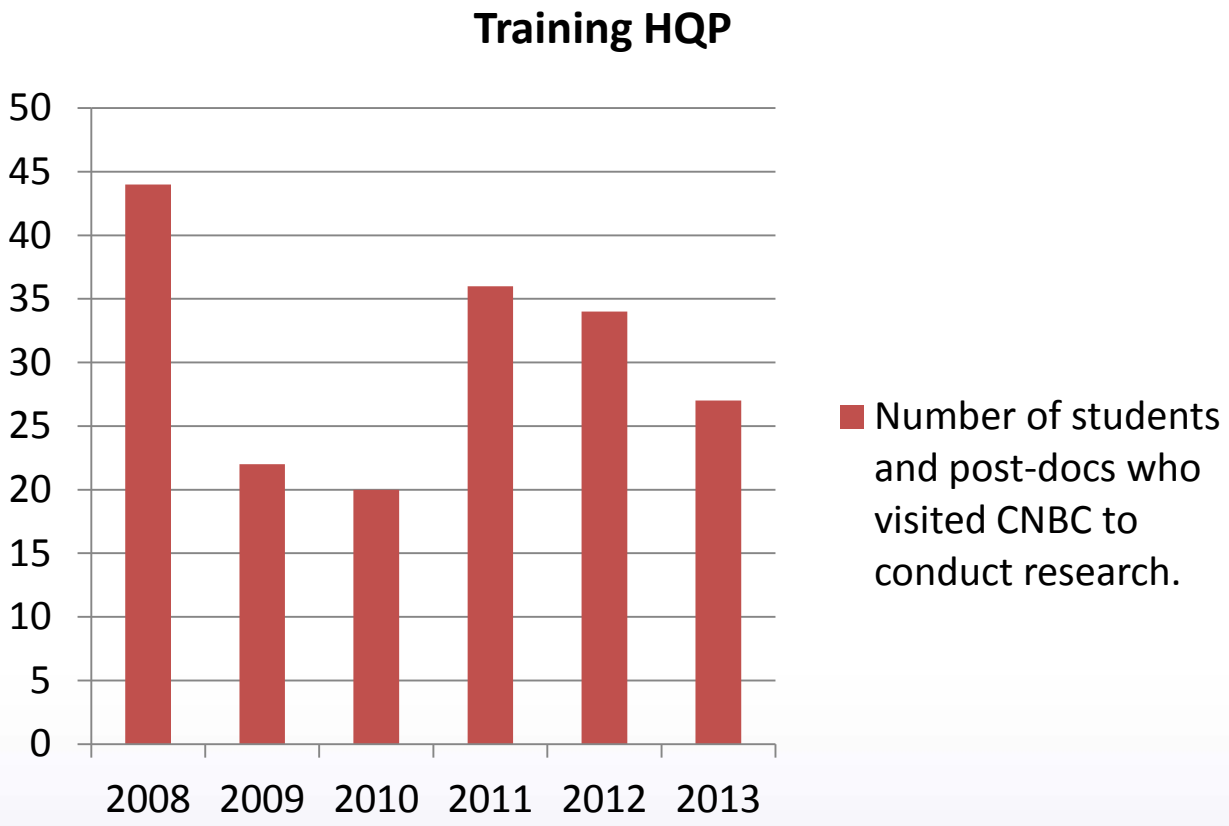
Beam Time by Client Type



Community Indicators



Community Indicators



Challenges

Staffing

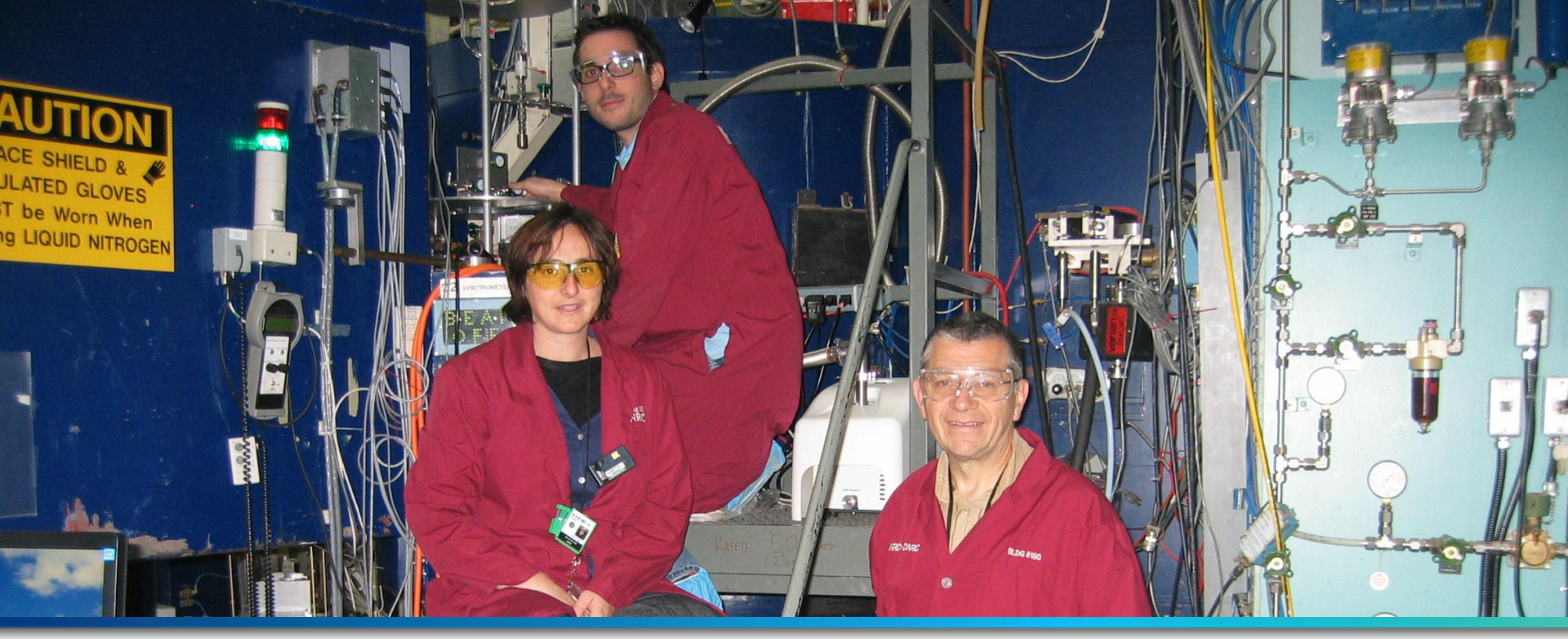
- 21 staff in 2014 (vs. 25 in 2009) or 3.5 per beamline
- North American benchmark for staffing is 5-6 people per beamline
- 1 post-doc newly hired; hiring of 2-3 more underway
- Efforts toward hiring of 2-3 full time positions are underway

Canadian Institute for Neutron Scattering Board of Trustees
June 30, 2014

Outgoing Treasurer's Report

1. **Bank Account/Net Worth:** At the direction of the President (Dominic Ryan) we have closed the CINS bank accounts at Scotiabank in Antigonish ($10500) and the GIC that was held in Kingston ($1070). Effective date June 16, 2014.
2. **Membership/Dues in Arrears:**
    a. Dropped member: Mary Wells confirmed that Waterloo is no longer a member.
    b. This leaves 14 active members. From East to West: St. Francis Xavier, Dalhousie (Institute for Research in Materials), McGill, NRC, AECL, RMC, Toronto, Brock, McMaster, Guelph, Waterloo, Western, Winnipeg, Saskatchewan, and UBC.
    c. I have just contacted Winnipeg, RMC, AECL, and NRC trustees since they still own YE12 and YE 13 dues.
    d. I have not sent a request for the YE14 or YE 15 dues.
3. The new Treasurer/Secretary is Ms. Nicole Schrie at the CNBC. Congratulations, Niki!
4. **2013 AGM at McMaster:** Mikhael Rheinstader and Bruce Gaulin must have had used some other sources for funds because the only bill I had for the AGM was $150 prize to Kemp Plumb.
5. **Incoming Bills:** there will be some upcoming charges for financial services and I am also owed some money for the Trustees Teleconferences.
6. **Proposed Budget**
    a. I of course have no control over the budget except as an Institutional Rep from St. FX but thought I would suggest a reasonable starting point.
    b. I assume that the funding structure is the same and that we would be successful with a two-year call for dues. (Saskatchewan has already paid their YE14 dues.)
    c. I have had some contact with the 4 institutions in arrears so I am hoping that money will still come in.
    d. I can only assume that McMaster/ Brockhouse Institute/Bruce Gaulin covered a lot of the AGM bills (including travel for Mark Lumsden). You might consider waiving YE14 dues for McMaster. I have put the AGM budget item back up.

Carl Adams
Outgoing CINS Treasurer



FUTURE BUSINESS FRAMEWORK

Access to the Canadian Neutron Beam Centre

John Root

2014 Nov 15 –Annual General Meeting of the Canadian Institute for Neutron Scattering

Framework is under construction

AECL restructuring is underway

- Site-operating company Canadian Nuclear Laboratories (CNL) started Nov 3, 2014
- GoCo to be established ~ fall 2015
  https://buyandsell.gc.ca/procurement-data/tender-notice/PW-14-00614229
- Three missions:
  i. manage radioactive waste and decommissioning responsibilities;
  ii. perform S&T projects to meet core federal responsibilities; and
  iii. support Canada's nuclear industry through access to S&T facilities and expertise on a commercial basis.
- Business framework shifting to project proposal-delivery-payment - **No 'Baseline'**

Framework is under construction

Federal Nuclear Innovation Agenda is a separate consideration

- Nuclear Leadership Forum
  https://oci-aic.org/files/file/nlf-vision-and-action-plan-final.pdf

- NLF Action Team 3: “To support a strong Canadian nuclear science, technology and innovation agenda.”

- Includes “Materials science: nuclear tools for better Canadian products”

- Includes consideration of NRU continued operation, NRU replacement, a neutron gap, CNBC continued operation, academia, non-nuclear industries, etc

Framework is under construction

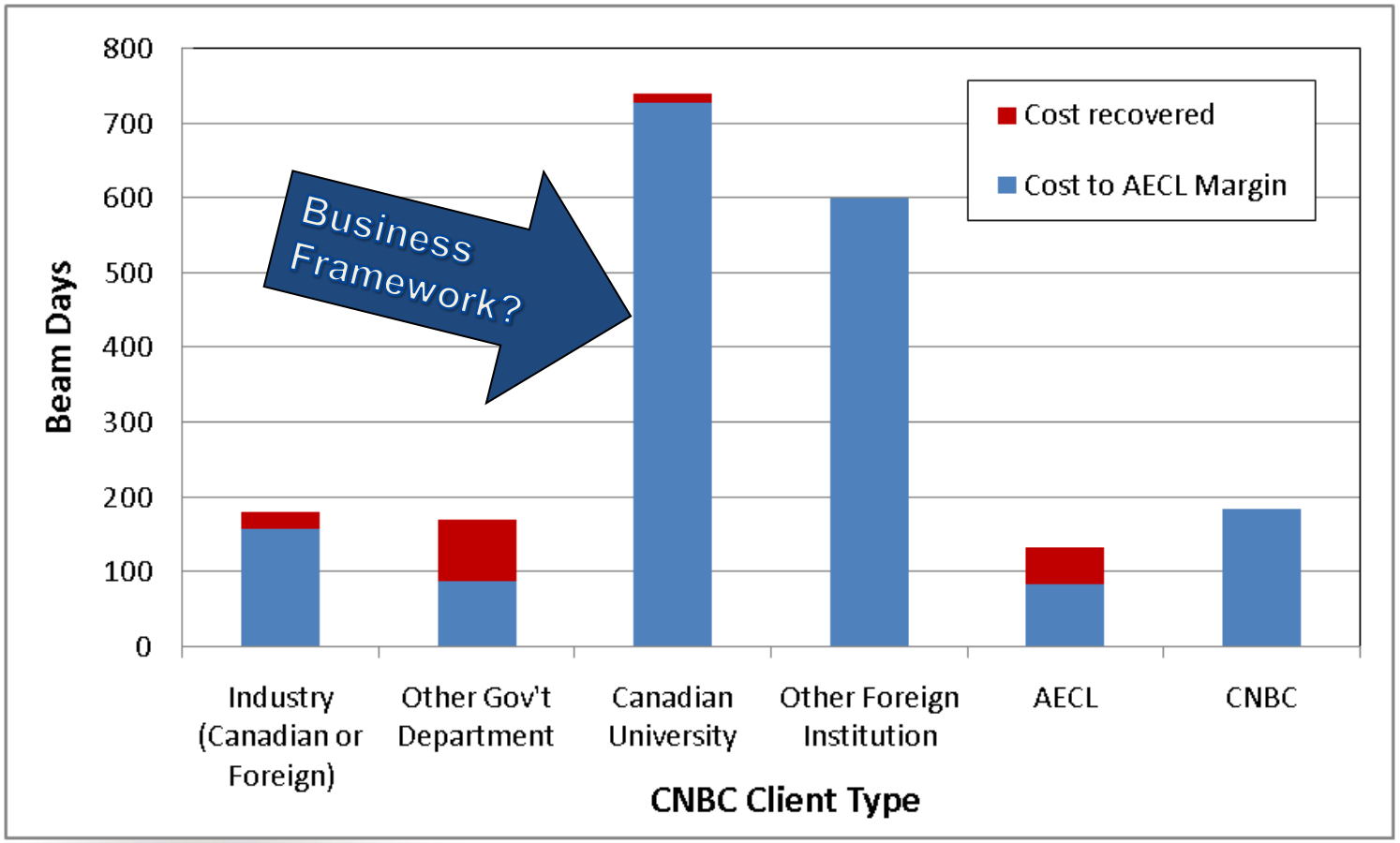
Canadian Neutron Beam Centre is owned by NRC, operated by CNL.

- Corporate plan of AECL migrates to CNL

  http://www.cnl.ca/site/media/Parent/CPS_2014-15_Eng.pdf

- Defines the CNBC as "…responds to the Federal S&T mission… operates a user-access program enabling more than 200 scientists, engineers, and students from universities, government laboratories, and industry to participate in research using the facility's six neutron beam lines…"
- Financial Objectives for 2014-2019 include "Continue to manage and operate the CNBC, with NRC staff seconded into AECL [CNL] as per secondment agreement between AECL and NRC."
- "Increase the use of NRU facilities (including CNBC) by third-parties, in particular, private industry."

CNBC facility access since Apr 2013



AECL contributions since April 2013

Canadian University	Cost of CNBC facility access
McGill University	$ 853 K
McMaster University	$ 584 K
University of Alberta	$ 384 K
Queen's University	$ 369 K
Brock University	$ 341 K
University of Toronto	$ 263 K
University of British Columbia	$ 253 K
Ryerson University	$ 221 K
Dalhousie University	$ 198 K
Université du Québec à Trois Rivières	$ 98 K

+ $3.5M for access from foreign institutions … all covered from AECL's margin on commercial work – **There is no "Baseline support for CNBC"**

CNBC current business framework

EITHER

Knowledge belongs to client, who pays commercial rates for CNBC staff, facility and neutrons from NRU reactor

OR

Knowledge resides in the public domain and principal researchers pay no direct fee for access because costs were covered (until 2012) by:

NRC – acting as a steward of national scientific facilities (50%)

+ NSERC – ensuring unique national facilities are maintained in a state of readiness for access by Canadian academic researchers (40%)

Public-domain access is granted after internal review of feasibility and safety, and external review of scientific merit of a proposal for beam time. Process is owned and overseen by an external organization (CINS) representing the user community.

Consider a future business framework

EITHER

User sets the research direction and CNL provides staff and facilities. User fees are charged* whether the research is proprietary (commercial) or in the public domain.

OR

User and CNL collaborate, sharing costs and outcomes.

* Consider a block fee to CNL for access by a user group.

FEEDBACK WELCOME

John.Root@cnl.ca
(613) 584 8297

Consider a future business framework

Business defined by two agreements made in advance

1. [CNL (Business Office) + User] - to identify and quantify contributions to the project by CNL and the user, then set appropriate user fee.
    - includes Scope and Evaluation (safety, feasibility, alignment, …) made in consultation with CNBC Local Contact

2. [CNL + Institution/Company of each user] – inter-organizational context

Process is owned by CNL, and overseen by (?)

FEEDBACK WELCOME

John.Root@cnl.ca
(613) 584 8297

Timeline

- Consulted with CNBC Science Group — **Aug – Sept**
- Consulted with CNL Line and committee on national / international relations — **Sept - Oct**
- Presenting to Annual General Meeting of CINS, Nov 15 at University of Toronto — **Nov**
- Develop messages, agreements and process to implement in FY 2015-2016 — **Dec - Mar**

FEEDBACK WELCOME

John.Root@cnl.ca
(613) 584 8297

CINS Long-Range Plan Document Update

CINS AGM

Nov 15, 2014

University of Toronto

CINS Science Council

- **Prof. Thad Harroun**
  Department of Physics, Brock University
- **Prof. Maikel Rheinstadter**
  Physics and Astronomy, McMaster University
- **Harlyn Silverstein**
  Department of Chemistry, University of Manitoba
- **Dr. Zahra Yamani**
  Canadian Neutron Beam Centre, Chalk River Laboratories

Background

- CINS LRP was produced in 2008 (http://www.cins.ca/docs/CINSweb_2008.pdf) following CINS AGM in 2006 and 2007.

- The document is now more than six years old:
  - **New and exciting scientific developments** need to be included.
  - landscape of future of neutron scattering in Canada is significantly changing: **Neutron Source?**

Background

- Announcement by the government to stop production of molybdenum-99 at NRU in 2016.
- Ongoing major re-structuring of the Chalk River Labs: Still unclear whether the future lab will have a mandate to operate a research reactor.
- Saskatchewan proposal to build a research reactor, mainly for neutron scattering in 2009.
- Instrument developments at the McMaster Nuclear Reactor: MAD commissioned in 2010 and MacSANS currently in design stage.

CINS LRP Update

- Prof. Dominic Ryan, the President of CINS, asked the CINS Science Council to undertake the task of updating the LRP: "to reflect and plan for the changing environment and demonstrate that the community still sees a future for neutron scattering in Canada" in June 2014.

- Scientific Programs
- Neutron Beam Instruments and Methods
- Neutron Source

Science Council led the efforts in updating the documents asking several community members for help and their expertise when needed.

CINS LRP Update

- Scientific Programs, Beam Instruments & Methods:
  - Community members: John Greedan, Roxana Flacau, Helmut Fritzsche, Zin Tun, Ron Rogge, Daniel Banks, Mark Vigder
  - Science Council: Thad Harroun, Maikel Rheinstadter, Harlyn Silverstein, Zahra Yamani
- Neutron Source:
  - Zin Tun

CINS LRP Update

- Updates of the Scientific Programs, Beam Instruments & Methods were sent to all CINS members seeking feedback on Oct 31.
  - No comments received via email
  - Floor is open for feedback
  - Vote of endorsement

- Neutron Source discussion paper was also sent on Oct 31 seeking feedback.

Source options

- Multipurpose Research Reactor Replacing NRU
- Research Reactor for Neutron Scattering:
  - Saskatchewan
  - Chalk River
  - Green-site
- McMaster Reactor Upgrade
- Spallation Source

Source options

- Comments Received
- Floor open for comments
- Straw vote to get a ranked list (which options are most compelling for further investigation)
- A subcommittee to investigate options in vote-ranked order and report to Science Council by March 2015 with well-researched considerations and conclusions (feasibility, effectiveness, cost, location, timing)
- Vote a motion for a subcommittee to be established
- Hear a slate of nominees for the subcommittee
- Vote to approve membership of the subcommittee

Possible Neutron Sources for Canada beyond NRU Reactor*: A Review prepared for Discussion at CINS AGM 2014*

Dr. Zin Tun
Principal Research Officer
Canadian Neutron Beam Centre, Chalk River Labs

CINS Science Council is undertaking an update of the CINS Long-Range Plan (LRP), a document produced in 2008 based on discussions at CINS AGMs in 2006 and 2007. Since 2008 a number of significant changes or developments have occurred that may have important implications on the kind of neutron source Canada could be operating beyond the lifetime of NRU. As part of the update, Science Council feels that CINS community should engage in a discussion about Canada's needs of a future neutron source. This document was prepared at the request of the Science Council, to be used as a guide for discussion at the 2014 AGM.

1. Introduction

Canada has benefited considerably for more than 70 years from multi-purpose nuclear reactors, initially the ZEEP Reactor and later NRX and NRU. In particular, the NRU Reactor has served the needs of Canadian science and engineering throughout its operation, from 1957 to present. This unique situation is due to Canada's 3-fold need for a neutron source that can provide sufficiently high flux both in the core and in the extracted neutron beams. The activities associated with the needs are:

1. Testing of materials in-core: Canada has successfully developed and maintained a home-grown nuclear power industry that requires continuing technical support.

2. Production of isotopes: Canada is world leader in synthesising and supplying radio isotopes for medical and industrial use.

3. Neutron Scattering: Canada has a community of academic and industrial users who rely on neutron beams to carry out basic science and R&D projects.

CINS community's requirements are encompassed in the third activity #3. The first two represent the needs of the CANDU power industry and the commercial isotope business.

The CINS community believes that, provided all three needs continue into the foreseeable future, a multi-purpose reactor, a modern replacement for the NRU, is the best option for Canada. Served by a single centralized facility, this option is likely to be the lowest in cost in meeting all the national requirements. It also has the advantage that all parties involved are already accustomed to working at a shared facility. Guided by this principle, the neutron source the

CINS community envisioned in the 2008 LRP (Section 4.1) was a multi-purpose research reactor to replace NRU, with the thermal spectrum extended at both ends by a cold-source and a hot-source. However there have been a number of policy developments that could alter the kind of neutron source that Canada might choose to build beyond the lifetime of NRU. These include:

- The announcement by the Government of Canada to stop production of medical isotopes by means of the NRU reactor in 2016 [1].

- The ongoing AECL restructuring [2], and the uncertainty whether the future mandate for the Chalk River site will require a research reactor [3].

- Proposal by the Province of Saskatchewan made in 2009, to build a research reactor, mainly for neutron scattering [4].

- Instrument developments at the McMaster Nuclear Reactor. MAD commissioned in 2010 [5] and MacSANS with secured funding from CFI and the partners and currently in design stage.

The changing landscape makes it prudent to fully consider and evaluate other possible neutron sources for Canada at this critical time.

2. Multipurpose vs. dedicated neutron source for neutron scattering

These two types of reactor are fundamentally different. A multi-purpose reactor typically requires a large core whereas the core of a reactor for producing neutron beams (more specifically for neutron scattering) is very compact. In terms of power density (power/unit volume) the latter is higher, but the larger size of a multipurpose core leads to a higher thermal power output. A comparison between NRU and the ILL reactor is striking: thermal power of NRU is ~100 MW while the ILL runs at ~60 MW. Yet, due to the compact core, ILL core flux is 4-5 times higher than at NRU.

In making a decision to recommend the best and most-cost effective neutron source for Canada, the following factors must be considered and discussed.

2.1. Cost

A multipurpose reactor is larger, more complex and more expensive at all stages (design, construction, operation) than a single-purpose neutron source. A dedicated neutron source is less expensive, probably by a factor of two. However, a National Research Council study in 2005 [6] estimated that three separate facilities, each for the three activities of NRU, in total will be significantly more expensive than one multipurpose facility, especially considering the duplication of operating costs over the long term. Therefore, from Canada's perspective, a multipurpose reactor is more cost effective if all three activities currently supported by NRU will continue in the future.

2.2. Location

A multipurpose reactor requires a lot of supporting infrastructure (hot-cells, isotope separation and handling, etc.). Chalk River Laboratories (CRL) is just about the only existing location with sufficient supporting infrastructure already in place. Locating the facility elsewhere would have significant impact on cost and time required to build it.

A dedicated neutron source can be located at many locations across Canada. Including Chalk River, other existing research facilities are prime candidates (McMaster campus, TRIUMF, next to CLS). If it is a reactor source, it could also be at another site licensed for nuclear operations, such as the Bruce, Darlington or Pickering generating stations.

2.3. Proposal Process

A multipurpose facility requires unanimous and unwavering support from all partners, and must include significant financial support from the industries that will rely on it. The level of commitment displayed by others is, of course, beyond the control of CINS and its members.

Due to the above requirement, the proposal process for a multipurpose facility is far more complex. Strong leadership and cooperation of all parties will be crucial.

2.4. Management structure

A multipurpose facility must be managed by a body that respects the views and requirements of all the partners. All parties must have an adequate representation in the decisions about its governance, missions, funding, and operational priorities, not just at the time of the capital investment, but over the 40-50 operating lifetime of the facility. The risk of changes in priorities and governance over the lifetime of the facility is greater for a multipurpose reactor. However, a transparent funding structure where all partners must contribute to the ongoing operating cost can mitigate the risk.

The management structure of a dedicated neutron source is simpler and is more likely to remain focused on its mission. On the down side, over its lifetime, a single-purpose facility is harder to justify. It may constantly live under the threat of losing the operating budget.

2.5. Potential for future growth

A multipurpose facility is more flexible and more likely to be able to meet the needs of future technologies (i.e. those not foreseeable at the present). A prime example is the medical isotope production that was not part of the original intended use of NRU. Because of its size, the NRU core could be configured for efficient production of ^{99}Mo without affecting the parts that supply neutrons to the beams. A compact core of a dedicated reactor would not be so easily adaptable.

3. Possible Options for a dedicated source for neutron scattering

If the need is only to supply neutron beams without any in-core irradiation sites, the source could be a reactor or a proton-to-neutron spallation source. Herein, we describe both of these source options in terms of three models.

3.1. A dedicated reactor: Saskatchewan Proposal

In 2010, a proposal was made [4] jointly by the Government of Saskatchewan and the University of Saskatchewan to build a reactor in Saskatchewan. It calls for the construction of research reactor similar to the OPAL Reactor at ANSTO, which actually is a dual-purpose facility (for neutron scattering and production of ^{99}Mo radioisotope). A facility dedicated for neutron scattering at or near University of Saskatchewan is attractive due to its proximity to the Canadian Light Source (CLS). The OPAL-type reactor is actually a dual-purpose facility for neutron scattering and production of ^{99}Mo radioisotope. Called the Canadian Neutron Source (CNS), the following extract from the proposal summarizes how the construction and operating cost is to be shared between Saskatchewan and Canada [Ref. 4, Sec 1.3 of the linked pdf document]:

> "Initial cost estimates for the CNS have been benchmarked against facilities around the world, including the Australian research reactor OPAL—a proven technology that has been recently implemented and that can be used for both neutron scattering and medical isotope production. Based on this analysis, we estimate total project development and construction cost of $500M to $750M and an operating cost $45M to $70M annually in 2009 Canadian dollars.
>
> We estimate project development costs at 10% of total project costs, or $50M to $75M. We propose the Government of Canada provide 50 per cent ($25M to $37.5M) of project development funding with the remaining 50 per cent ($25M to $37.55M) provided by the Province of Saskatchewan.
>
> We propose that the Government of Canada provide 75 per cent ($337.5M to $506.25M) of the construction cost for the CNS, with the remaining 25 per cent ($112.5M to $168.75M) funded by the Province of Saskatchewan.
>
> We propose that the Government of Canada provide 60 per cent ($27M to $42M) of annual operating costs, with the Province of Saskatchewan funding 25 per cent ($11M to $18M) and industry funding the remaining 15 per cent ($7M to $11M) via isotope sales and industrial science."

Our discussion above uses Saskatchewan as a model because of the existing proposal, not to preclude other locations. We note here that a reactor dedicated for neutron scattering can be built at many locations in Canada (see section 2.2 above).

3.2. Upgraded McMaster Nuclear Reactor

Given the recent and ongoing instrument developments at the McMaster Nuclear Reactor (MNR), it is appropriate to revisit the upgrade proposal made by the university in 1990's [7]. The proposal described three possible upgrades, two minor and one major. If the major upgrade

is fully implemented MNR may be able to meet most of the CINS community's requirements. In 1993 dollars "... the major upgrade would cost $75M or $95M, depending on whether an equipped guide hall is included", the Executive Summary of the proposal stated. Using the Bank of Canada inflation calculator, 1993 $95M translates to about $140M in 2014 dollars (http://www.bankofcanada.ca/rates/related/inflation-calculator/).

The MNR as exists today is an example of a facility too low in flux to meet the requirements of CINS. The reactor is licensed to operate at 5 MW which would provide a peak thermal flux of 1×10^{14} n/cm^2/sec. However, it routinely operates only at 2.5 – 3 MW range at the present. CINS would ideally like to see MNR upgraded at least to 15 MW, so that its thermal flux increase to ~3×10^{14} n/cm^2/sec. For instrumentation, CINS recommends having one each of the followings ready for operation at the start-up: triple-axis spectrometer on cold-source, single-crystal diffractometer that can function as reflectometer (2.37 Å), powder diffractometer, and SANS.

CINS community has discussed MNR upgrade a number of times in the past. The discussion in 1992 called for replacing the current reactor core with a MAPLE core, install a cold source, and upgrade the rest of the infrastructure to 10 – 20 MW of reactor power. AECL in early 1990s was building a research reactor of MAPLE design for South Korea, which went critical in 1995. Now named HANARO, this reactor can be taken as a model for this option.

HANARO is designed for 30 MW but routinely operates at 26 MW. Open-tank-in-pool design enables easy access to the core, which consists of a light water cooled and moderated inner core, and a light and heavy water moderated outer core. A cold source was installed in 2009. According to the presentation to IAEA by KAERI in 2013, maximum thermal flux (at 30 MW) is 4×10^{14} n/cm^2/sec and the "typical flux at port nose" is 2×10^{14} n/cm^2/sec.

One essential point to consider is whether a Canadian vendor would be capable or willing to provide a MAPLE core. Note, however, that KAERI markets the "HANARO technology" on their own (i.e. no AECL's involvement). According to World Nuclear News, 26 Jan 2010 [8]:

> "Korea is gearing up to try to take a share of up to 50 orders anticipated for new research reactors worldwide over the next 15 years. Current speculation in the Korean press suggests that the country will be renewing an attempt to secure a contract to build the Netherlands' Pallas reactor."

3.3. A Spallation Neutron Source

This type of source is driven by a proton accelerator operating at a relatively high energy, typically in the range 0.5 – 1 GeV.

Given the existing (ISIS, SNS) and future (ESS) major spallation facilities, it does not make sense for CINS to propose a high flux spallation source. However, there may be sufficient reason for Canada to build a medium-flux source, following the example of SINQ. The Swiss Spallation Neutron Source (SINQ) facility at the Paul Scherrer Institute is a 1 MW continuous spallation source [9]. It employs a cyclotron operating in a continuous mode to provide a 1.8 mA beam of 590 MeV protons that strike a lead target. Surrounding the target is a heavy

water moderator tank with beam tubes for experiments. SINQ produces a thermal neutron flux of 1×10^{14} n/cm^2/sec, equivalent to a medium flux reactor (source flux stated by the PSI website).

An interesting question here is how well we will do if we simply use the most intense proton beam currently supplied by the TRIUMF facility [10] to drive a continuous spallation source. The answer is not very well: the maximum power available from TRIUMF is 75 kW, ~1/10 of SINQ. This comparison shows that a major accelerator development will be required if TRIUMF (or part of TRIUMF) is to become a viable neutron source.

A proposal authored by Shapiro, Ruggiero, Ludewig [11] called for construction of a SINQ-type neutron source in the US. Stating that "instruments whose performance depends on the time-averaged flux are best located at continuous sources", the proposed facility would be ten times more powerful than SINQ (10 MW proton beam energy). Its neutron output would also be ten times higher, 1×10^{15} n/cm^2/sec, putting it on par with HFIR or ILL. The time-averaged 1 MW power is a challenge for the design of the SNS target, but a continuous 10 MW power will not be a problem since it does not create shock waves, Shapiro et al. noted. The proposal does not give any cost estimate for the construction of the facility. Such a facility, if built, would be unique in the world, and Canada may wish to boldly go where no one has gone before.

4. References

1. http://www.nrcan.gc.ca/energy/uranium-nuclear/7795; http://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/pdf/eneene/sources/uranuc/pdf/isotopes-gc-re-eng.pdf.
2. http://www.nrcan.gc.ca/media-room/news-release/2014/15661.
3. http://www.aecl.ca/site/media/Parent/2014_AFR_Eng.pdf, page 26.
4. http://www.gov.sk.ca/news?newsId=0cc63a53-5c73-4e6b-aed6-cc45293c24b5; http://www.gov.sk.ca/adx/aspx/adxGetMedia.aspx?mediaId=883&PN=Shared.
5. http://www.physics.mcmaster.ca/files/Current_Events/Department_Newsletter/_miscfiles/P&Anewsletter_Winter2010.pdf, page 4.
6. "Summary and Analysis of Research Reactor Options for Canada" by Alastair McIvor, NPMR-2005-1.
7. "A Proposal to Upgrade McMaster Nuclear Reactor", October 8, 1993, available at http://cins.ca/docs/MNR_1993.pdf.
8. http://www.world-nuclear-news.org/C-Korean_research_reactors_home_and_away-2601107.html.
9. W.E. Fischer, SINQ — The spallation neutron source, a new research facility at PSI, Physica B: Condensed Matter Volumes 234–236 (1997), Pages 1202–1208.
10. http://www.triumf.info/wiki/exp-prog/index.php/ISAC_(Isotope_Separator_and_Accelerator).
11. S.M. Shapiro, A.G. Ruggiero, H. Ludewig: Accelerator Based Continuous Neutron Source: BNL-71184-2003) found at: www.bnl.gov/isd/documents/25113.pdf.