Day 1 in a Nutshell - **What did we hear** that can help shape the elements of a **national neutron strategy for Canada** – what lessons, what issues could do with more discussion?

- Before I begin, on behalf of all of the participants, the Event organizing committee, and the CNI Working Group - I would first of all like to thank all of our invited speakers that presented yesterday – and those of you who will be sharing your knowledge, experience and perspectives today – and commend you for your top-notch, informative and insightful presentations. The level of commitment, thought and care that you put into your talks shone through and are very much appreciated. Thank you!

- We started the day with a warm welcome from Dr. Karen Chad – VP Research University of Saskatchewan and Chair of the Canadian Neutron Initiative Working Group – who encouraged us to gather feedback on the key elements of the strategy, including a challenge to think about the 'what' and the 'how' of the Canadian Neutron Strategy. Karen welcomed our invited speakers from across Canada and abroad and asked us to think about partnerships and to glean and learn from the experiences of others, both domestic experiences as well as from the experiences of foreign neutron sources, and to think about multiple time scales – what is needed to advance a national neutron strategy for Canada in the short, medium and long-terms. Karen encouraged us - stakeholders and the Canadian community of neutron-beam users, to speak up and provide your ideas and perspectives so that the CNI Working Group can be fully informed to forge ahead with "Neutrons Canada" and an inclusive, made-in-Canada national neutron strategy.

- Building on Karen's welcome and introduction, John Root and Daniel Banks helped to set the stage and provided the context for the need for an inclusive, clear national neutron strategy that builds on existing national and international resources and experiences, recognizing that neutron beam facilities are critical tools for materials research and technology development in areas such as clean energy, clean transportation, security

and safety, health, and food security. We learned further that Neutron beams are also vital to a host of scientific challenges including in discovery, as well as applied research. This is why many countries have been re-investing to secure access to neutron sources for the next decades. The versatility and irreplaceability of neutron beams was a major reason that Brockhouse was honored by the 1994 Noble Prize in Physics. More recently, the 2016 Nobel Prize was for the prediction of topological quantum materials – materials that were confirmed to exist through experiments using neutron beams. Neutron beams continue to be vital to the study of these materials that could lead to technology breakthroughs, one example being in computing.

- John and Daniel challenged us to think about how do we define our national strategy and program – what is its scope – probing materials and objects from nanoscale to living systems – broad and inclusive – anything that needs beams from a bright source; used in particle physics – artifacts, treating brain cancer via neutron beams – we have a common occasion to unite around common needs and opportunities so we need a new strategy for the future – we have common needs for critical infrastructure; we need a clear and coordinated roadmap, consisting of a set of guiding principles or rules, that defines the actions of a focused and dedicated team of professionals in the business of neutron beams should take (and not take,) and the things they should prioritize (and not prioritize) to achieve desired goals and objectives. Over the course of the two days. we are here to discuss how to put the meat on bones of what we are going to do and how are we going to do it? To define what needs to be done and what will be achieved; how will it be achieved, how should it be resourced, how will we accomplish the building of a pan-Canadian program for materials research with neutron beams, infrastructures and programs, address the training needs and skills, be inclusive of the diverse needs of different users – experienced expert users and new users – uses from academia, industry and from government labs and institutions – and the needs of our community of domestic users and foreign users? As part of the stakeholder communities, you have an opportunity to shape and guide this direction through these discussions.

In Session 2, we focused on some of the near-term priorities of forging partnerships with high-brightness neutron sources in other countries since we do not currently have a fully operational domestic source.

- Thad Harroun provided us with a glimpse into the current challenges faced by academic users to access foreign facilities. Based on the August 2020 survey of Canadian academic users who use neutron beams, there is a very clear and consistent story about the difficulty's users are having accessing neutron beam facilities since the CNBC closed, and how a national program could relieve the difficulties. It is evidenced in multiple ways through the results. Neutron beams are important for research across a wide variety of fields. We learned that the closure of NRU has had a significant impact in scientific output, even halting the growth in foreign collaborations. The neutron gap (the lack of ready access to neutron beams) is already being seen in fewer users and publications overall. The neutron user community*, as identified by publications, is shrinking. Foreign facility access is slowing the decrease of the expert community*, but less beam time overall erodes the number of publications. The survey of users identified that access and support would most effectively restore Canadian researcher's scientific impact with neutron beams for materials research. Resource planning is critical to provide access to the instruments and support that users need. Neutrons Canada can fill that role. Neutron beams are a national and global resource – neutron beams are important across a wide variety of fields and neutron scattering is important to their field of research regardless where located in Canada and goes beyond material science and physics.

- Ron Rogge provided us with a detailed overview of the impacts of materials research with neutron beams in the nuclear industry and helped us appreciate what industry users need. Ron outlined the scope of materials challenges the nuclear industry faces that ranges from in-core components to fuels to ex-core components to performance to failure analysis to nuclear waste disposal and so on. He presented some examples of the practical applications of problem identification and solution path development using neutron beams materials research. Ron provided a

picture of what industrial access looks like noting that most industrial clients rarely have in-house neutron experts and are occasional users that need immediate access to typically mitigate financial loss due to immediate problems that require quick solutions. Service contracts are preferred over collaborative research agreements as rapid turn-around requires nimble contracting and legal processes to be developed, available and put into place. There may be proprietary information or content exclusive to industrial sector to be considered. Projects are often smaller in nature <$50,000 so they require cost-effective, simple agreement templates. Clients can be industrial, government, or military – so may have national security/sovereignty implications. As a result, there is a need for a national neutron strategy and program to be designed to enable flexible multi-organization partnerships with considerations of a mix of public domain and proprietary data and a need for Neutrons Canada as an organization to have professional staff to serve as knowledgeable liaisons between industry and neutron beam facilities.

- As the Chair of the League of advanced European Neutron Sources (LENS), Helmet Schober provided us with insight into some of the Partnership opportunities at European neutron sources. He noted the similarities in the role of LENS and Neutrons Canada –share opportunities to promote neutrons together; reach out to funders – from national govts and some from EU Commission; room for common developments – around technology, instrumentation, and both being science driven. He described LENS as being open to any neutron provider in Europe running an open international user programme for the majority of the beam time provided and adhering to LENS' principles. Fully Imbedded into the international environment, there are two distinctly different business models for collaboration:
    - The European facilities ILL and ESS rely on a membership model that is open to international partners. Beam time is allocated based on excellence but then adjusted within a frame that is set by the financial contributions.

    - The national facilities welcome international partners via collaboration agreements that may include access to beam time and the operation of specific beam lines.
- He noted that there is a need to act across timelines – that in order to' stay fit for the future' as lead times are long, we have to think and plan beyond the next decade. What is the business case for Compact Accelerator driven Neutron Sources (CANS)? When is there a need to build new powerful national neutron sources complementing, in the case of Europe, the ESS? Should we concentrate on accelerator driven sources or is there a strategic need for reactor sources?
- As an organization that runs a national program, Helmut remarked that access to a service goes way beyond beam time provision. It includes such activities as:
    - Building the community via PhD and Post Doc programmes – including the running of summer camps and educational programs
    - Developing scientific, technical and methodological skills within the member country
    - Training of both expert and non-expert users on the job or via dedicated visitor programmes
    - Possibility to detach staff or get them employed by ILL
    - Possibility to operate CRG instruments
    - Participation in ILL upgrade projects
    - Access to ILL's technological know how
    - Outreach to the member country's industry as a client and supplier.
- And he advised on some of the key questions to consider when seeking partnerships:
    - What do we expect from the partnership or collaboration in the context of our national strategy?
    - What kind of access do we need (type of instruments, volume of use, modality) and where can it be found?
    - Over what period?
    - Can we build on existing collaborations?
    - Can we build up a critical mass?
    - Is distance really an issue in times where experiments can be done remotely?

- Rob Dimeo followed Helmut and provided us with some insights into Partnership opportunities in neutron scattering at US facilities - SNS and HFIR. He provided a high-level overview of the facilities in Maryland and Oak Ridge and their planned upgrades. He identified general opportunities to collaborate around research infrastructure – sample environment, instrument upgrades and data analysis. In his NIST overview, Rob identified the form that Partnership Opportunities can take - **Instrument Ownership** (Facility-owned or Partnership-owned (participating research team) including interagency partnerships (e.g. NSF/NIST CHRNS), consortium-owned (e.g. nSoft, iPRIME/ExxonMobil) options **and Instrument Access** (General user access (competitive proposal-based) or Collaborative access (merit based via instrument "owner") or Consortium-based access and Partnership-based access or Proprietary access. Rob outlined what this could look like for Canada… As part of a national strategy and a pan-Canadian program, the professional staff at Neutrons Canada could coordinate or organize such services as Travel, Staff at partner facilities, Administration of contracts, agreements, business practices/processes, Instrument development, Proposal management systems, etc. A national organization could also develop Facility Partnerships – which could include negotiation and establishment of:
    - Shared operation of instruments and equipment (many possible ways of doing this)
    - Shared development of instrument and upgrades (many more ways of doing this)
    - Appropriate representation on advisory committees
    - Beam time allocation dependent on investment

In Session 3, we delved into some examples of how a pan-Canadian program for materials research with neutron beams that relies on foreign neutron sources could operate by exploring the lessons learned from other experiences.

- Thomas Bruckel provided us with insights into the German experience in operating a virtual institute for neutron scattering through the eyes of the

Foundation of the Jülich Centre for Neutron Science - a user facility without its own neutron source - the Phoenix: that is Reinventing itself. The success of the Jülich Centre is through the development and implementation of a clear and focused strategy – a focussed mission and program – they were recognized for their know-how in METHOD AND INSTRUMENT DEVELOPMENT AND CONSTRUCTION - building instruments – so the strategy adopted was to build the "best instruments at best sources" to maintain their relevance and to get even more experience and build capacity in how to build the best instruments. Know-how makes you attractive for neutron source operators. And in doing so, it provides hands-on education of the next generation of skilled neutron scientists - an important aspect for a user facility!

- Some of the LESSONS LEARNED: WHAT WORKED FOR JCNS include:
    - Success through a clear strategy - "best instruments at best sources"
    - a distributed facility is less vulnerable to "black outs"; but someone else has the say in source operation
    - expertise in neutron methods and instruments is crucial: makes one attractive to source operators, allows one to use instruments at its best
    - own instruments as "in-kind contribution"
    - a main "hub" is needed for user recruitment, education and cooperation with industry – a central organization to perform functions to retain, leverage, and plan for succession of its scientific and technical expertise in neutron beam instrumentation and methods, in planning and shepherding major initiatives through decision-making processes
    - with a team on site, one can make best usage of the partner facility
    - one needs clear measures to keep strong connections to these teams
    - one has to balance scientific integration of this team at the facility, while keeping scientific contact to the home base
    - one has to work much harder to make one's scientific breakthroughs acknowledged with shrinking supply of neutrons and others following the JCNS model (Geesthacht, LLB, IET Norway) the possibilities of partnerships become very limited. New sources are needed.
    - in the long run, it is important to strive to get an "own" facility "to be in the driver seat"– can make the rules.

- Luc Simard provided insight into Herzberg Astronomy & Astrophysics Research Centre's and NRC's roles in facilitating participation in international telescopes. He remarked that he was struck by the parallels between telescopes and neutron sources – just switch beamlines with telescopes and neutrons for astronomy. The Herzberg Centre leverages global investments in excess of $2B to provide Canadian astronomers access to world-leading observatories solely on the basis of the scientific merit of their proposed research as judged by unbiased peer review. The Mandate includes all phases: pre-construction, construction, operations and decommissioning. In order to meet the challenges of the research community, the Centre has leading scientists and engineers on staff and they have integrated labs on unique national sites. The field is a big data generator and user - The Canadian Astronomy Data Centre – provides world-leading astronomy data services with big overlap in ocean sciences and other fields – use Compute Canada, CANARIE and now the New Digital Research Infrastructure Organisation (NDRIO).
- As a national Centre, there is a strong linkage with over 20 Canadian universities (ACURA, CASCA) and industry networks. Extensive international presence (e.g., project leadership, science and technical steering committees) and reputation for delivering on commitments has also been established through the centre. As part of the International Astronomical Observatories Program (IAOP), the NRC Hertzberg Centre, in collaboration with other international bodies, provides financial contributions to support the management and operations of offshore ground-based observatories and their related facilities. NRC participates in the oversight and direction of these facilities and their research capabilities and through NRC's financial and in-kind contributions, the Canadian astronomy community is provided merit-based access to these facilities with appropriate financial and technical support. NRC is the steward of Canadian telescope access. Canada supports international partners in maintaining the facilities at competitive levels and, in doing so, seeks to address the technical problems in a way that allows Canadian industrial partners to capture the innovation inherent in new astronomical facilities and instruments for the benefit of their commercial interests and of Canada. Luc indicated the many benefits and deliverables arising from such a centrally coordinated international program over multiple timescales of the short, intermediate and long-terms.

- The experiences of TRIUMF in operating a pan-Canadian program in nuclear physics combining both domestic and foreign facilities were outlined by Jonathan Bagger. As Canada's particle accelerator centre, TRIUMF has grown from 3 to 21 members and 6 provinces – into a national organization/members and reach which makes it more cost effective to operate and serve the Canadian community. There are marked contrasts between the particle physics and the neutrons physics communities. Based on the experience at TRIUMF, Jonathan noted some observations and Lessons for Canadian Neutron Community:
    - Need smaller scale facilities here in Canada – for research, training purposes
    - Need access to large scale facilities abroad – no need for fear. All facilities are under funded, so all will welcome help.
    - Contribute staff not money – retains expertise in Canada and is easier to sell to government (not shipping Canadian taxpayer dollars abroad, but rather gaining know-how and expertise to apply in Canada)
    - Speak with one voice to CFI, to Government, to funders, to partners, to … - community alignment is essential - Particle physics learned this the hard way over a period of years.
    - Don't fear top-down – need both top-down and bottom-up. And a coordinating, implementing mechanism in between. Sustainability requires partnership with government. Trust. Stewardship…which is famously lacking in Canada.
    - Recognize great benefits of international collaboration. Helps provide access to more facilities. Note: IP flows in both directions and Canada gets as much as it gives.
    - Remember the entire ecosystem – not just neutrons – muons, photons, even isotopes. All probes. Join with partners across Canada to craft a coherent approach to materials science.
    - TRIUMF stands ready to help!

- Throughout our discussions several ccommon themes and common lessons among the speakers were noted … it also became clear that there are many possible ways of approaching or doing certain activities -

- In-house expertise is common to all the models – need domestic strength to access foreign sources - is essential to possibility to getting a new neutron source to replace the one lost 15 years ago - similar time scale in Canada – 15 years to a new neutron source here… if at all
- Lots of projects and opportunities that we can work on with foreign partnerships
- Several roles of national strategy, national organization, and national facility – Success through a clear strategy – or roadmap with a main "hub" is needed for user recruitment, education and cooperation with industry – a central organization to perform functions to retain, leverage, and plan for succession of its scientific and technical expertise in neutron beam instrumentation and methods, in planning and shepherding major initiatives through decision-making processes and implementing major neutron initiatives, in governing and managing a national program for access to neutron beam facilities, both domestic and foreign, in negotiating with foreign facilities, in maintaining the continuity of expertise needed to support both the operations of neutron facilities, and the implementation of capital projects, and to engage industry and contribute to science outreach to the next generation of scientists and communication and awareness of the general public
- Need both top-down and bottom-up approach. And a coordinating, implementing broker mechanism in between. Sustainability requires partnership with government. Trust. Stewardship
- Need to be inclusive of all aspects of the ecosystem; for a national neutron strategy and program to be designed to enable flexible multi-organization partnerships with considerations of a mix of public domain and proprietary access and needs to be accommodated and a need for Neutrons Canada as an organization to have professional staff to serve as knowledgeable liaisons between academia, industry, and neutron beam facilities.

- As we continue today, I encourage you to think of the what's and the how's – what is our national neutron strategy going to do and how are we going to do it – be definitive in your inputs and responses – think about the

questions from both yesterdays and todays sessions - help to put the meat on bones of what we are going to do and how are we going to do it? This is your opportunity to help define what needs to be done and what will be achieved; how it will be achieved, how it should be resourced, how we build a pan-Canadian program for materials research with neutron beams, infrastructures and programs for decades to come. It is also an opportunity to identify what is missing? What are the gaps and issues in our national neutron strategy? What are the lessons and issues that could do with more discussion?

- So with this in mind, please enter your ideas and suggestions in the chat function to Fiona so that we can have lively discussions in Session 6.

Thank you!