Emerging Themes

This document presents the themes emerging from the ongoing long range planning process for Canadian subatomic physics. It focuses on how to view the Canadian science described in the CINP and IPP Briefs within a coherent framework, and the resources and support structures that will enable the future success of the Canadian subatomic physics community.

The emerging themes[1] presented in this document were developed utilizing input from the CINP and IPP Briefs to the LRP, the Community-wide Long Range Plan (LRP) survey, and four Topical Townhall Meetings, and highlight ideas under consideration by the LRP Committee for the development of specific recommendations.

Feedback on the content of this document is welcome, and can be provided to the LRP Committee via an anonymous webform or via email to lrpc@subatomicphysics.ca.

1. Subatomic physics landscape

The scientific drivers for future research, and the associated experimental infrastructure and technology, provide the context for the subatomic physics LRP.

- The LRP Committee is considering the value of using visual schematics to anchor the presentation of the plan, linking the subatomic physics science drivers with inter-connected research fields, the enabling infrastructure and technologies, and broader applications.
    - A specific example of such a schematic, with the science drivers identified in the primary interior triangles, plus an exterior band with the enabling infrastructure, is shown in Figure 1.
- The LRP Committee also sees value in retaining NSERC's definition of the scope of subatomic physics, which is reflected in the schematic in Figure 1.
- Beyond the science drivers, the LRP report will also discuss the following components:
    - Canadian research progress since the last LRP report.
    - Research pillars, e.g., enabling technologies, computing.
    - Connections with overlapping and adjacent research fields.

2. Opportunities for Canada

The following opportunities for Canada that are relevant to the development of the LRP have been identified:

- Unique features of the Canadian research ecosystem and infrastructure - TRIUMF, SNOLAB, Perimeter Institute.
- Active community organizational structures.

[1] The order of the themes below does not reflect their relative importance.

- Flexible funding structures to support new scientific initiatives.
- Research potential of emerging technologies.
- Canada's excellent standing as a trusted international partner.
- Capacity of the community to train additional highly qualified personnel (HQP).

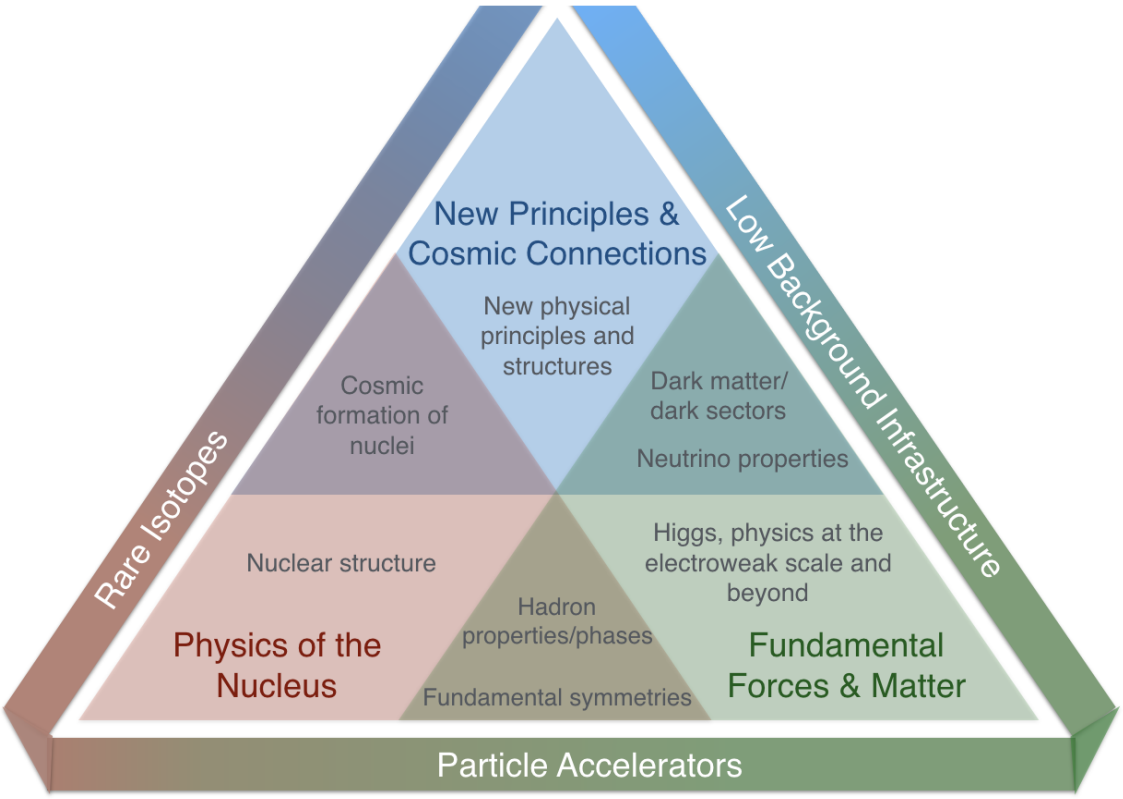

Figure 1 : Science drivers, with discovery potential overlapping all sub-topics.

3. Research plan

In order to maximize Canada's scientific and societal impact, accounting for the opportunities noted above, the following objectives for the subatomic physics research plan have been identified:

- Focus effort on the most relevant research problems.
- Fully exploit Canada's unique facilities, competitive advantages, and past investments.
- Partner in leading international research projects and deliver on commitments.
- Maintain capacity and flexibility, through R&D support, to explore and develop new scientific opportunities.
- Fully engage HQP in all aspects of scientific research to maximize training outcomes.

The CINP and IPP Briefs to the LRP provide a comprehensive summary of the community's current research activities, and priorities going forward in relation to the science drivers (as articulated in Figure 1).

The LRP Committee has discussed the benefits of formulating the research plan as a portfolio of research projects, where an optimum balance among various dimensions would maximize the scientific impact according to the objectives above while minimizing risk. Possible dimensions of the portfolio include:

- Canadian scientific specialization vs breadth.
- Experimental project lifecycle (R&D and new construction vs operation/science output).
- Guaranteed scientific output vs high-risk/high-reward.
- Project timeline.
- Theory vs experiment.

As envisioned, the balanced portfolio would be a bottom-up community-led vision of future subatomic physics priorities and would convey to stakeholders the value and promise of subatomic physics research in Canada. Moreover, it could be used to emphasize new science opportunities and/or the need for additional resources. Based on feedback received to date, the LRP Committee currently views the portfolio concept as potentially having more support than prioritization in specific research areas.

The LRP Committee has also discussed highlighting specific scientific milestones reachable on the timescale of this plan, in addition to identifying promising longer-term forward-looking directions and opportunities for transversal inter-connections between research sub-fields.

4. Resources, supports, and infrastructure

Components of the Canadian research ecosystem that are important for enabling the success of the subatomic physics long-range plan:

- Canada has world-leading centers (TRIUMF, SNOLAB, Perimeter) which require ongoing support to remain at the forefront.
- The NSERC subatomic physics envelope has been successful in enabling Canadian research in this field to have significant global impact, for example, via the following:
    - Providing flexibility to annually optimize the use of available funds.
    - Allowing for annual oversight of a national research portfolio.
    - Providing unique funding programs that are well-adapted to the varying scales and needs of subatomic physics research.

- The existence of community-led shared research support (IPP Research Scientist program, MRS[2] labs, Arthur B. McDonald Institute (MI) technical support) is valuable and allows an efficient use of existing funding.
- The existence of a computing backbone infrastructure with sufficient capacity and technical support is highly valuable in enabling subatomic physics research.
    - Continued subatomic physics community engagement in the ongoing transformation of the Canadian computing research backbone (e.g., NDRIO[3]) is important.

To fully realize the community's ambition, a number of developments would be valuable:

- Growth of the subatomic physics envelope is required to support the full community capacity for HQP training and ensure maximum benefit to Canada from investments in subatomic physics research.
- There is recognition that coordination of the capital and operational funding over the life-cycle of large-scale (~$100M) projects is difficult within the current system, and a new structure (as articulated in the Naylor Report) would be valuable.
- The LRP Committee views the following recommendation from LRP 2017-2021 as still relevant: "*Identify an office in Canadian government responsible for engaging with the international community in moving forward major new science initiatives.*"
- Essential *generic* R&D activities in detector and accelerator technologies are currently not well covered by existing funding programs, and new mechanisms are required to most efficiently fund modest and timely investments in equipment and expertise.

5. Subatomic physics community

The LRP committee has identified a number of aspects impacting the success of the Canadian subatomic physics community:

- Equity, Diversity and Inclusion (EDI)
    - Recognizing the current representation of various equity groups within the subatomic physics community, and the benefits of diversity for the research endeavour, there are opportunities for further sustained actions, including regular data-gathering, and targeted initiatives, for example by the Institutes, to enhance EDI.
    - The LRP committee views the following recommendation from LRP 2017-2021 as still relevant: "*The community should actively promote balanced representation at all levels, including those with high responsibility and visibility, as individuals in high-level positions serve as important role models."*
    - Acknowledging the legacy of colonization in Canada, through for example, the wider use of land acknowledgements throughout subatomic physics research activities.

[2] NSERC Major Resources Support program.

[3] New Digital Research Infrastructure Organization

- Highly qualified personnel (HQP)
  - The subatomic physics community has the capacity for additional HQP training (as identified in the LRP community survey), which presents an opportunity to increase research impact and training outcomes given sufficient funding.
  - To maximize student training outcomes, there are possibilities to further coordinate and share training opportunities across Canada.
  - There is recognition of the value in acquiring broad non-technical skills in subatomic physics graduate training, taking advantage of other Professional Development opportunities, and providing guidance to HQP for their career progression and transitions.

- Early Career Researchers (ECR)
  - It is desirable that the community ensures that ECRs have the opportunity to quickly gain knowledge of the Canadian research support and funding ecosystem, and for ECRs to have opportunities to interact broadly with the community, enhancing their ability to attract high quality HQP (e.g., via colloquium invitations, and direct involvement in community organizations).

- Community organization
  - The existence of the Arthur B. McDonald Institute has added considerable value to the community; its CFREF[4] funding is coming to an end and maintaining continuity of the support and programs provided by the Institute would be valuable.
  - The coordinated effort of various community organizations is desirable for efficient self-organization and to allow the community to effectively speak to other stakeholders.
  - CINP and IPP now meet regularly with agency stakeholders to discuss issues relevant to the community. These interactions are seen as mutually beneficial and there may be value in formalizing them to maintain continuity, e.g., through the establishment of a standing LRP Consultation Committee.

6. Broader impacts of subatomic physics research

This section highlights unique aspects and broader impacts of subatomic physics research activities.

- Distinctive features of subatomic physics research.
  - The scope, size and international nature of collaborative networks through which research is performed.
    - It is important that in an era of growing security concerns, this openly collaborative aspect be maintained.
  - The efficient sharing of global research resources and funding.

[4] Canadian First Research Excellence Fund

    - The breadth and required interplay between different skills and technologies; this enables the research community to quickly pivot and address other priorities (e.g. MVM ventilator project).
    - The depth of technical skills and expertise required (e.g., from theory, complex data analysis, to instrumentation and software development, and system integration).
    - The high level of technological innovation - the community is often required to develop its own unique instrumentation, that can lead to broader applications.
- Synergistic connections with other research fields.
    - Examples include astrophysics and cosmology, AMO[5] and condensed matter physics, etc.
- Broader impacts of subatomic physics research:
    - A highly qualified workforce - training in subatomic physics has value as preparation for specific fields in the knowledge-based economy.
    - Collaboration with industry (with opportunities within the funding ecosystem) - multiple past examples of mutually beneficial collaboration exist which, more generally, can open the door to technology development and commercialization.
    - Cultural benefits - inspiration, public education, encouraging scientific literacy.
        - Environmental impact and sustainability, e.g., the consequences of subatomic physics research and related activities (travel, materials, decommissioning, etc.).

The LRP Committee would like to thank all members of the community for their engagement in this planning process. Feedback on the content of this document is welcome, and can be provided to the LRP Committee via an anonymous webform or via email to lrpc@subatomicphysics.ca.

The 2022 Subatomic Physics Long Range Plan Committee
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[5] Atomic, molecular, and optical physics