Submission of the Canadian Subatomic Physics Community to the European Particle Physics Strategy Update 2026 Process

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26 May 2025

This document presents Canada's national input to the 2026 European Particle Physics Strategy Update (EPPSU) process. It summarizes Canadian interests relevant to the EPPSU 2026 process and outlines how the European particle physics community can leverage Canadian human and other resources for our mutual benefit.

1 Subatomic Physics in Canada

The Canadian subatomic physics community is actively involved in a wide range of scientific programs, including **collider physics**, **medium-energy experiments**, **underground/low background experiments**, a**ccelerator physics** and **nuclear physics**. It is engaged in current and future research endeavours having substantial overlap with those of the European particle physics community. The subatomic physics community in Canada is fully engaged in a number of detector development activities for both accelerator and non-accelerator experiments in Europe, North America and Japan.

The community, which includes accelerator physicists, is also involved in high energy accelerator research that includes collider technology development such as superconductive cavities, high intensity beams, automatic beam tuning and beam instrumentation for colliders located at CERN, KEK and BNL, as well as R&D work for other accelerator technologies with applications for nuclear and neutrino physics with facilities at CERN, TRIUMF, FNAL, BNL, and KEK/J-PARC. TRIUMF is also collaborating with DESY and HZDR on electron accelerator technologies and with GSI on heavy ion accelerator systems and beam physics.

Canada is well-positioned to play a major role in the future development of the field, hosting the Perimeter Institute for Theoretical Physics in Waterloo, Ontario, and two world-class experimental facilities: SNOLAB deep underground laboratory in Sudbury, Ontario, and TRIUMF, Canada's particle accelerator centre in Vancouver, British Columbia. The Canadian community pursues projects at these domestic facilities while also making strategic investments in international laboratories that provide world-leading and complementary infrastructure.

The Canadian particle physics community consists of approximately 180 investigators, of which approximately 34% are theorists [1]. The research profile of the Canadian community has evolved over the past two decades to reflect progress and opportunities in the field. The changing research trends within the community over the past 20 years—such as an increased focus on neutrino properties and searches for dark matter—align with global trends and leverage the presence of SNOLAB in Canada. Approximately 30% of members of the community have a significant fraction of their research focus on experimental collider physics.

1.1 Community Consultation Process

The Canadian subatomic physics community establishes its scientific and funding priorities through five-year Long-Range Plans. These plans advise the research community and relevant stakeholders on priorities for current and future endeavours. The current plan covers the period from 2022 to 2026, with an outlook to 2036, and is available at [1]. The process for developing the next Long-Range Plan for the period from 2027 to 2034 will be launched in June 2025.

For the explicit preparation of this Canadian submission to the EPPSU, a separate consultative process was undertaken by the Canadian Institute of Particle Physics, following the European Committee for Future Accelerators (ECFA) guidelines [2] for the collection of national inputs. The consultative process consisted of a community-wide virtual Town Hall held on March 25, 2025, followed by a community-wide survey specifically focused on addressing questions suggested by ECFA. A draft version of this document was reviewed by the community prior to its submission.

A total of 46 investigators responded to the survey, corresponding to approximately 70% of members of the community whose primary research interest is related to collider physics. It should be noted that as there were 53 total respondents, the survey responses are dominated by investigators, with only a small contribution from early career personnel.

2 The Next Collider at CERN

Executive summary: A plurality of Canadians prefer the integrated FCC-ee and FCC-hh option for CERN's next collider project. As alternatives, a direct to FCC-hh option and the linear collider option are significant. A majority (60%) chose the integrated FCC-ee+hh option as one of their top two choices. The most exciting options are perceived to be the FCC-ee+hh option, and the FCC-hh directly along with the muon collider. Physics potential is the main motivation for collider selection, with long-term perspective, and confidence in R&D playing important roles as well.

The following section summarizes the answers from the community poll in more detail.

2.1 Primary and Alternate Choice for Collider Projects

The community was polled for their primary and alternative preferences amongst the following options:

- FCC-ee then FCC-hh [3, 4, 5]
- FCC-hh immediately [6]
- Linear cc collider with upgrade path [7]
- Muon collider [8]
- LHeC [9]
- LEP3 [10]
- Other, or unsure

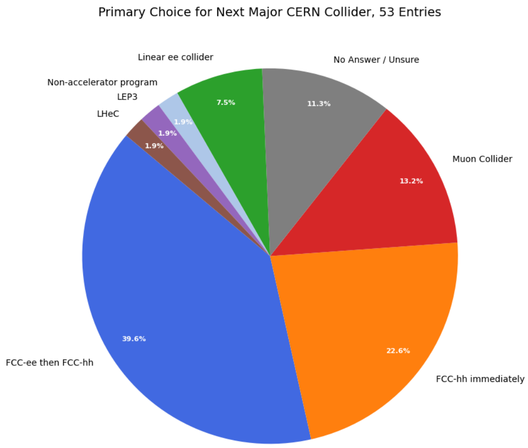
The results are shown in Figure 1. The strongest option is the integrated FCC-ee + FCC-hh option at 40%, followed by support for pursuing FCC-hh immediately at 22%. The alternative choices once again strongly features the integrated FCC-ee + FCC-hh option (as most who chose FCC-hh immediately considered this as their alternative), while those who chose the integrated FCC option saw a linear collider or the FCC-hh immediate options as the preferred alternate collider. These conclusions are consistent when sub-divided into any available statistically significant subgroup, with a slightly stronger preference for the integrated FCC-ee + FCC-hh scenario among currently practicing collider physicists.

The community was also polled for their excitement level on a score of 1-5 for each of the above collider options. The results are shown in Figure 2. The highest level of excitement is generally seen for the FCC-ee+hh option, followed by the Muon Collider and FCC-hh immediate option.

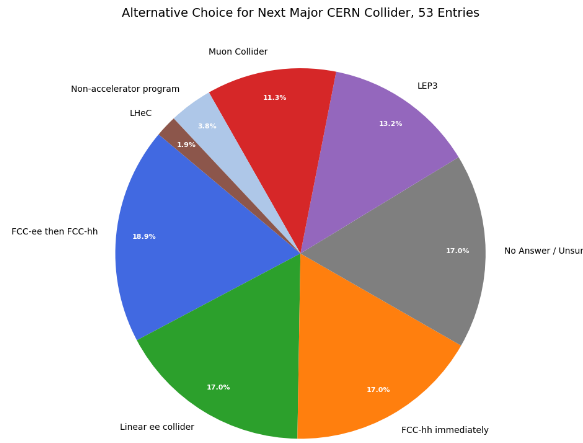
2.2 Reasons for Selecting Colliders

Following ECFA's suggestions [2], a number of questions were posed to the community to understand the motivations for the selection of the primary and alternative collider.

The respondents' selection is shown in Figure 3. The dominant motivating factor expressed by the community is the physics potential, long-term perspective, and confidence in R&D converging. The motivation for the alternative collider choice was largely similar.



(a) Primary choice for collider



(b) Alternate choice for collider

Figure 1: Choices of collider options from the Canadian subatomic physics community.

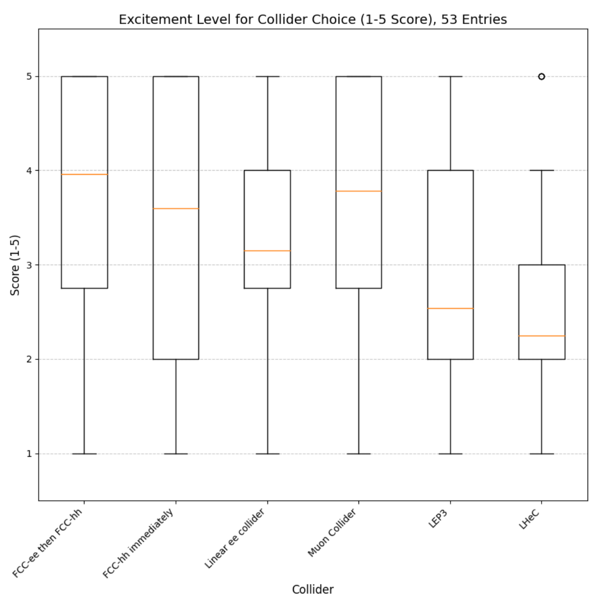


Figure 2: A summary of the excitement level (based on a 1-5 score) for the various proposed collider facilities, presented as a box-plot. The interpolated median value is shown in red, and the 25/75% quartiles as boxes, and the furthest data-point within 1.5x of the IQR as whiskers. Outliers are shown as single points.

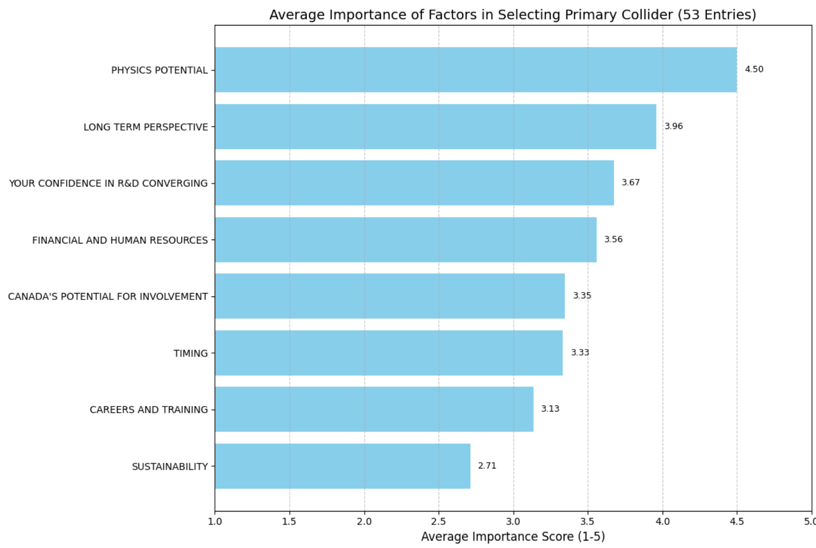


Figure 3: Average score for each question on the motivation for primary choice of the next collider at CERN.

It should be noted that those who chose alternatives to the FCC-ee+hh program were more motivated by timing and financial/human resource considerations.

2.3 Response to Scenarios

The community was asked for whether their primary choice of next collider at CERN should be considered under a number of scenarios:

- If Japan pursues the ILC?
- If China pursues the CEPC?
- If the US pursues the Muon Collider?
- If new physics is discovered?

For all questions, the majority ($> 60\%$) responded either 'Yes' or 'Definitely yes'. Notably, several respondents clarified that if major new results were obtained, the response would depend on the nature of the results.

2.4 Expanding CERN's Program

The community was also asked about whether CERN's participation in Nuclear physics, Astroparticle physics, and Other areas of physics should be "Increased", "Stay at Current Levels", or be "Reduced". The results are summarized in Figure 4. In short, most respondents seemed to believe that CERN's commitment in these areas should be largely the same, but there is a notable component that believed that astroparticle physics and other areas of physics should be increased. It should also be noted that while the collider community was very well represented in this survey, the responses do not accurately represent the low-energy, astroparticle or medical physics communities in Canada, and a wider-reaching survey beyond CERN's traditional user-base might return a different answer.

Our survey also asked what areas of work should CERN pursue in parallel to the next flagship facility. The most common answer was the support of the DRD detector development collaborations, to which Canada is already participating. Other notable responses included support for the neutrino platform, which is being widely used by Canadian groups, and general support for accelerator R&D, such as support for the Super-KEKb accelerator which can also serve as a testing-ground for FCC-ee technologies. Canadians also pointed out the strong existing contributions and continued excitement

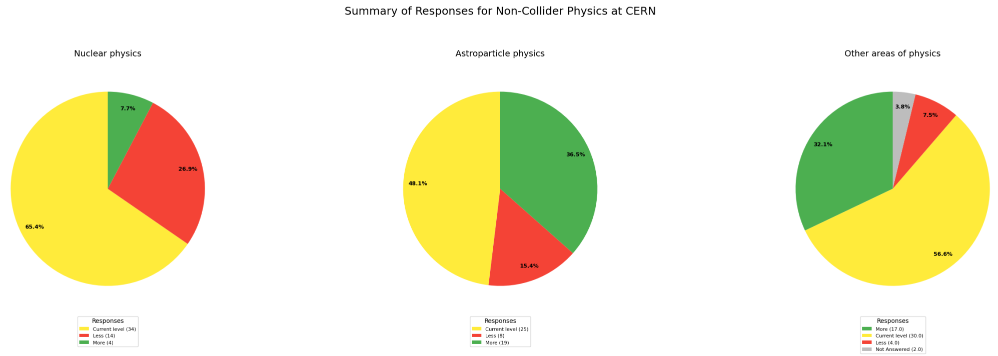


Figure 4: Summary of questions on whether changes should be pursued to CERN's non-collider physics portfolio.

in antimatter research at the Antiproton Decelerator, and opportunities in smaller-scale experiments such as MoEdDAL, FASER, Mathusula, etc.

Finally, our survey asked which accelerator technologies CERN should continue to develop in parallel with its next flagship facility. Advanced magnet technologies emerged as the most frequent response, likely because many proposed future colliders depend on advancements in this area. Novel acceleration techniques, such as plasma wakefields, ERLs, and muon cooling and acceleration were also highlighted. Developments in superconducting RF cavities were also considered important for many future facilities.

3 Canada and CERN Relation

Canada has a long and distinguished history in subatomic physics [11] and has contributed to CERN for decades. Canadian researchers first joined the OPAL experiment at CERN's Large Electron Positron (LEP) collider in 1982, playing a key role in both construction and physics exploitation of the experiment for over 20 years.

Canadians were founding members of the ATLAS Collaboration in 1992. Canada invested CAD 42M from 1996-2004 through TRIUMF into CERN infrastructure, along with substantial personnel contributions. This investment enabled Canadian scientists to build key detector components for the ATLAS experiment, and assume leadership roles within the collaboration. Canada has for many years and continues to support CERN's computing infrastructure through a Tier-1 centre, hosted in a state-of-the-art facility at Simon Fraser University, as part of the Worldwide LHC Computing Grid (WLCG). More recently, a new agreement with CERN cemented a Canadian in-kind contribution to the HL-LHC in the form of the delivery of five crab cavity cryomodules, funded by CAD 10M from the Government of Canada and CAD 2M from TRIUMF. Beyond these infrastructure contributions, Canadian scientists are also making substantial contributions to ATLAS detector upgrade projects with funding from the Canadian Foundation for Innovation (CFI) and the Natural Sciences and Engineering Research Council of Canada (NSERC).

Canadian involvement with CERN has expanded beyond the LHC. In 2017, the Canadian Light Source (CLS) joined the CLIC/CTF3 Collaboration, while in 2018 both the CLS and the University of Saskatchewan joined the Future Circular Collider (FCC) initiative [12]. Canada also participates in several non-LHC experiments including ALPHA, AWAKE, CAST, ISOLDE, NA62, NA64, the CERN DRD program and the Neutrino Platform, and maintains strong engagement with CERN's theory department. Collaboration is also intensifying with SNOLAB in developing liquid argon detectors for dark-matter experiments. Currently, Canada has over 300 researchers (including postdocs and students) from 25 institutes participating in 35 different experiments at CERN [13].

On March 25th, 2025, Canada and CERN signed a Statement of Intent covering general partnership aspects and specifically addressing FCC collaboration [14]. This agreement emphasizes their mutual intention to enhance collaboration in planning future projects, to continue and expand cooperation on innovative detector, accelerator, and computing technologies, to strengthen collaboration on FCC studies, and to promote joint efforts in developing advanced techniques and tools.

Canada has proven itself as a trusted partner with an excellent track record of fulfilling commitments, creating mutual benefits through collaboration with CERN. Moving forward, the Canadian scientific community is expressing strong interest in formalizing the Canada-CERN relationship. Future CERN projects stand to benefit from Canadian excellence in accelerators, detector development, and information technologies, while a stronger partnership can foster international opportunities advantageous to both parties. **The Canadian subatomic physics community eagerly seeks to engage with CERN to explore formalization of their relationship for mutual benefit, potentially through mechanisms such as Observer status.**

4 Potential Future Canadian Contributions

Canadian contributions to a future CERN collider would build upon the successful legacy of contributions to the LHC and HL-LHC infrastructure and detectors. Our survey identified several areas where Canada could provide valuable expertise and resources.

In the area of detector technologies, survey respondents expressed strong interest in hardware contributions, particularly in tracking detectors (especially silicon-based systems employing radiation-hard technologies, such as the ATLAS ITk), calorimeters (both hadronic and electromagnetic), and muon detection systems. Canadian expertise in electronics for data acquisition (DAQ) systems was also highlighted, along with valuable experience in the ongoing operation and maintenance of detector systems.

Regarding physics and computing capabilities, respondents indicated strong interest in physics analysis and motivation studies. The survey also noted Canadian expertise in software development for computing frameworks and capabilities in high-performance computing (HPC) operations.

For accelerator and industrial contributions, approximately half of respondents highlighted TRIUMF's capabilities for contributing to the FCC accelerator complex. Of particular strategic importance is Canada's resource potential: the Niobec mine in Quebec is one of only three primary niobium producers globally [15]. Niobium is a key mineral for superconducting magnet and RF cavity construction, representing a potential major industrial contribution to CERN.

These responses should be considered only a starting point for potential contributions. Additional input is being gathered as part of the ongoing planning process for the next Canadian Subatomic Physics Long Range Plan 2027-2034.

References

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