



CANADIAN SUBATOMIC PHYSICS LONG RANGE PLAN

Gemini's take on what the LRPC is :-)

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For the LRPC

Joint IPP+CINP Session, CAP, Ottawa, June 2026



LRPC Committee

Voting Members

- Torben Ferber
- Alfredo Galindo-Uribarri
- **Paul Garrett**
- Darren Grant
- David Hornidge
- **Alison Lister**
- Katelin Schutz
- Hirohisa Tanaka
- Nicole Vassh
- Simon Viel

Non-Voting Members

- IPP/CINP
 - Garth Huber
 - Carsten Krauss
- SAPES co-chairs
 - María Chamizo-Llatas
 - Rituparna Kanungo

- Funding agencies
 - Olivier Gagnon
 - Kevin Lapointe
 - Mark Lagace
 - Sarah Overington

Ex-Officio

- Marcela Carena
- Jodi Cooley
- Tony Noble
- Nigel Smith
-



LRPC Mandate

- The Committee is asked to identify subatomic physics scientific ventures and **priorities** that should be pursued by the community on a 7 – 14-year horizon and that would ensure Canadian global scientific leadership, considering
 - The optimization of the human and financial resources of the Canadian subatomic physics community in terms of research excellence and impact
 - The alignment of research endeavors with the established expertise and strengths of the Canadian community
 - The need to coordinate large projects and collaborations with Canada's international partners in a manner that maximizes scientific excellence and impact
 - The concurrent requirement to maintain and further develop world-class domestic research programs and infrastructure
- **Budgetary estimates**, both for new capital investments and for operations, must be provided, including funding ranges for prioritized endeavours
 - These ranges should include funding levels that would allow for a restrained, yet efficient, contribution to the ventures, as well as levels that would enable a more extensive contribution
- The scenarios also need to address the **intellectual capacity** available in the community
- The overarching goal needs to be to facilitate **coalescence** around the most impactful projects

Final output: 2 Documents

- 'Growing the pie'
 - Flashy document (2p)
 - Target audience: Analysts within government, ministers, university administration
 - Highlights of goals, benefits to Canadians, what we bring to Canadian society
- Main document
 - Longer document
 - Target audience: SAP community, CFI expert committees, NSERC SAPES committees, university departments
- Today: focus only on project prioritization and other recommendations
 - Rest of the text will follow over the summer
- Plan: 7 years with outlook to 2041
 - Possibility to revisit mid-term as needed to reflect any major changes in landscapes

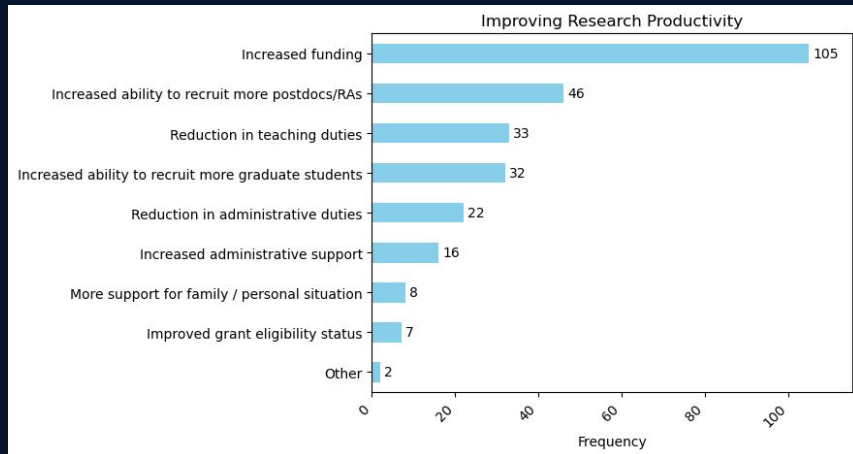
LRPC Inputs & Organisation

Inputs

- IPP and CINP briefs
- Community Survey
 - 323 'good quality' responses
 - 50/50 split senior/HQP
- 9 LRP town-halls
- Reach out to individual PIs as needed
- Small computing (The Alliance) survey

Organisation

- Meetings 3 x week since January
 - All together
 - Particle & Astroparticle
 - Nuclear
 - 'Impact'
- 2 day in person meeting at TRIUMF



Deliberations focus

- Project prioritisation
- Needs for 'growing the pie'
 - NSERC
 - CFI
 - Additional funding needs
- Other recommendations

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References

A Description of Experiments

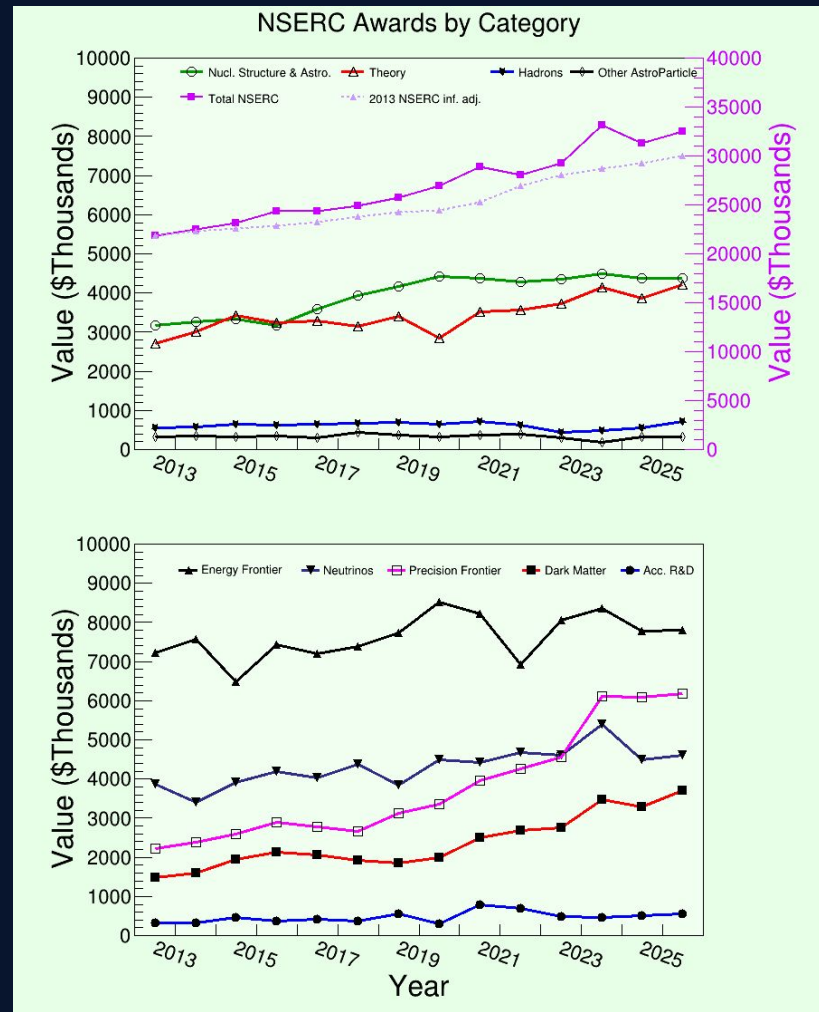
Where we are now

Significant growth: Precision Frontier, Dark Matter

Moderate growth: Nuclear Structure & Astrophysics (flat since 2019), Neutrino

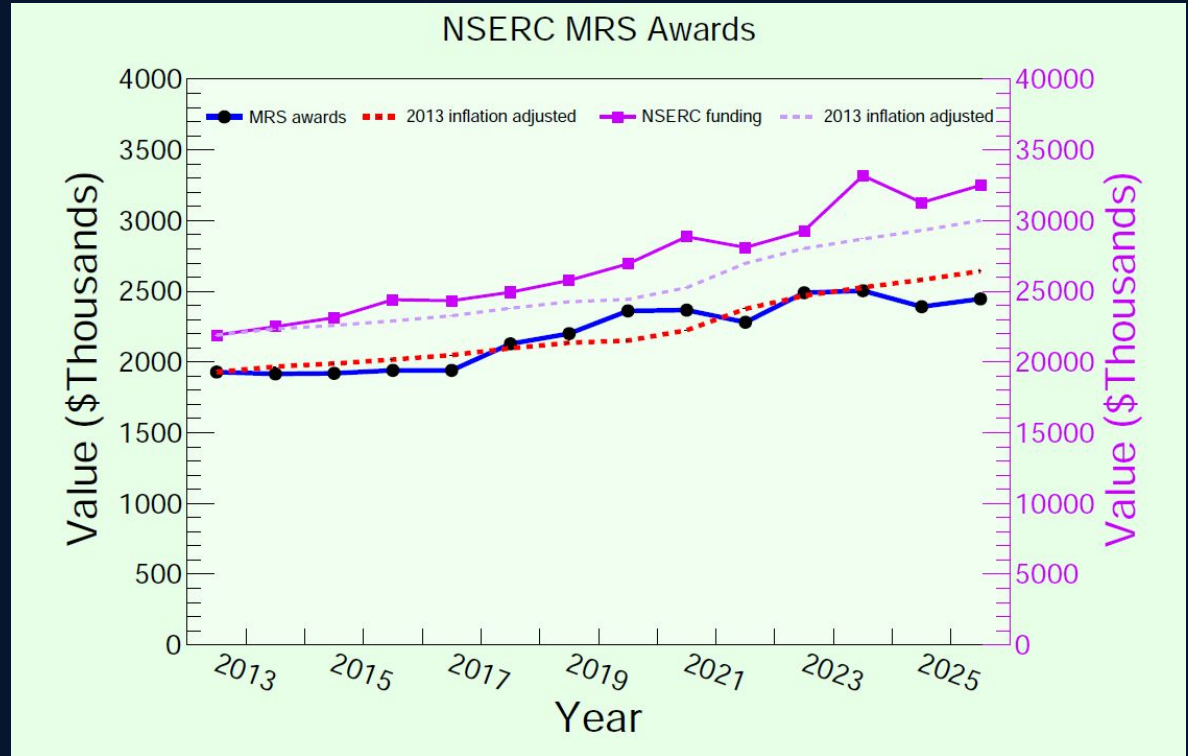
Flat: High-Energy Frontier, Accelerator R&D, Hadronic program

SAP envelope has received injections slightly above inflation (using 2013 as benchmark)....



Where we are now

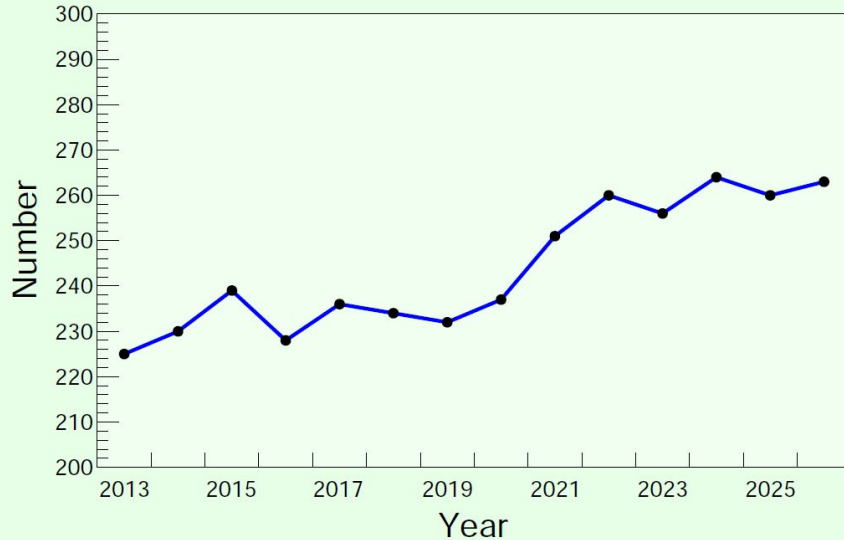
MRS awards have in the past few years fallen below inflation – they are driven largely by salaries in the awards, so this causes an uncomfortable pressure



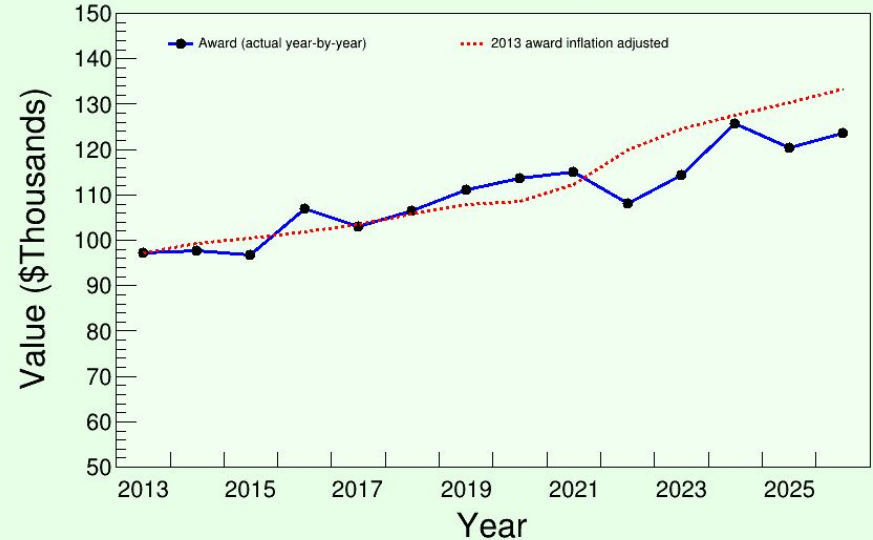
Where we are now

...but the number of investigators has increased such that funding per investigator hasn't kept up with inflation

Number of NSERC Investigators



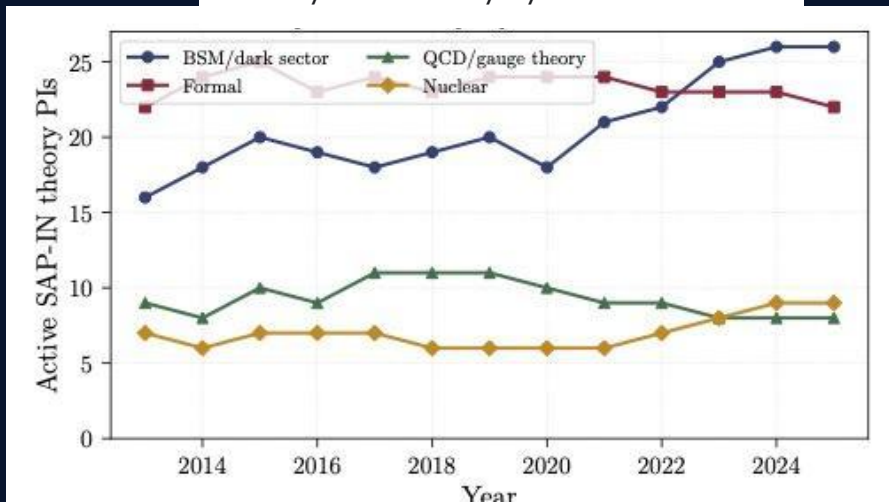
NSERC Award per Investigator



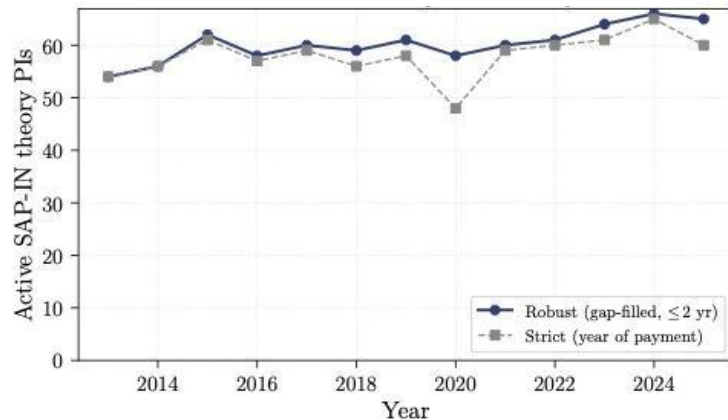
Theory

- Theory community growing slightly
 - Growth mostly in BSM/Dark Sector
- Grant size/PI not keeping up with inflation
- NSERC aims to keep theory fraction to ~13% of envelope

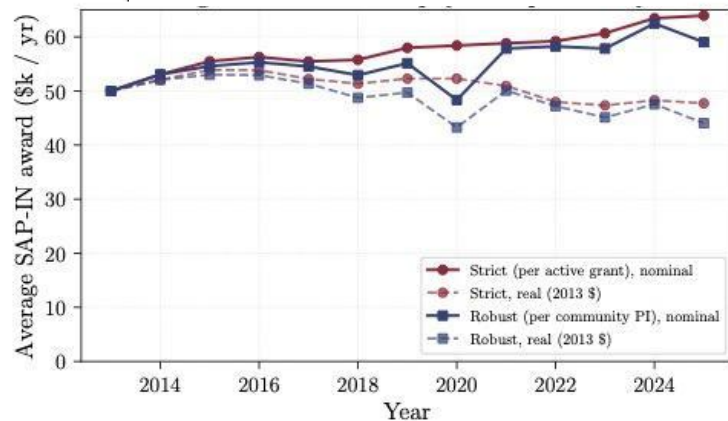
Theory community by subfield



Theory community size



Average annual funding per theory PI



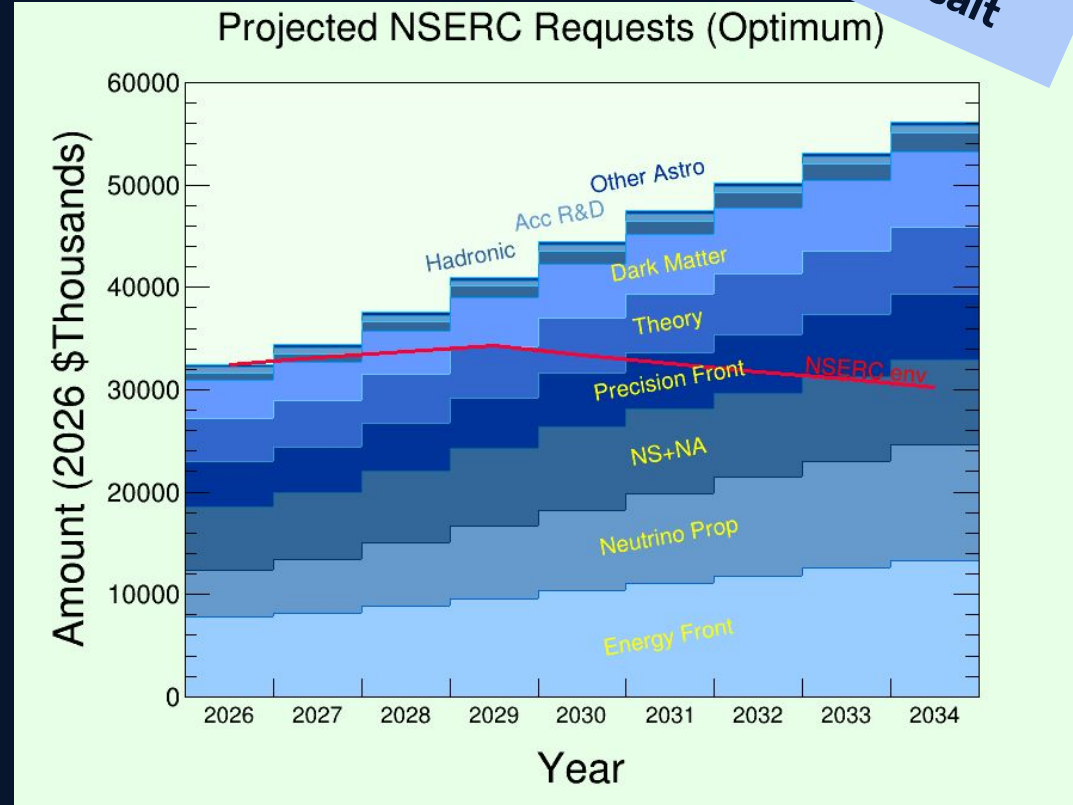
Prioritisation Process

- Initially considered separately IPP and CINP projects then merged
- Categorized and rated projects based on a number of different factors including
 - Current and projected (2034) FTE in Canada,
 - Total FTE on project relative to the FTE needed to be successful (overall for whole project)
 - Science reach and breadth
 - Most exciting science, discovery potential
 - Breadth: measurement sensitivity and range of discovery potential
 - Complementarity with other projects
 - Competition with other projects (globally) and if they are favourably competitive
 - Community support (from survey)
 - Impact of Canadian contribution, leadership
 - Balance of onshore vs offshore
 - History of Canadian investment
 - Future investment needs
 - Any areas of concern
- Lengthy discussions to ensure agreement across the whole LRPC

Prioritisation Need

- Expressed in 2026 \$
- 2026: current allocated funds
- 2034: ideal funding scenario (using best guesses where no information provided) assuming a linear model to achieve it
- Includes projections of EIC, FCC, XLZD – and increases of current portfolio
- Optimum ask in 2029: \$41M
- **Red: Expected total envelope**
 - 2029: \$37M (2026\$ \$34.3M)
 - Envelope line assumes flat budget and 2.5% inflation rate,

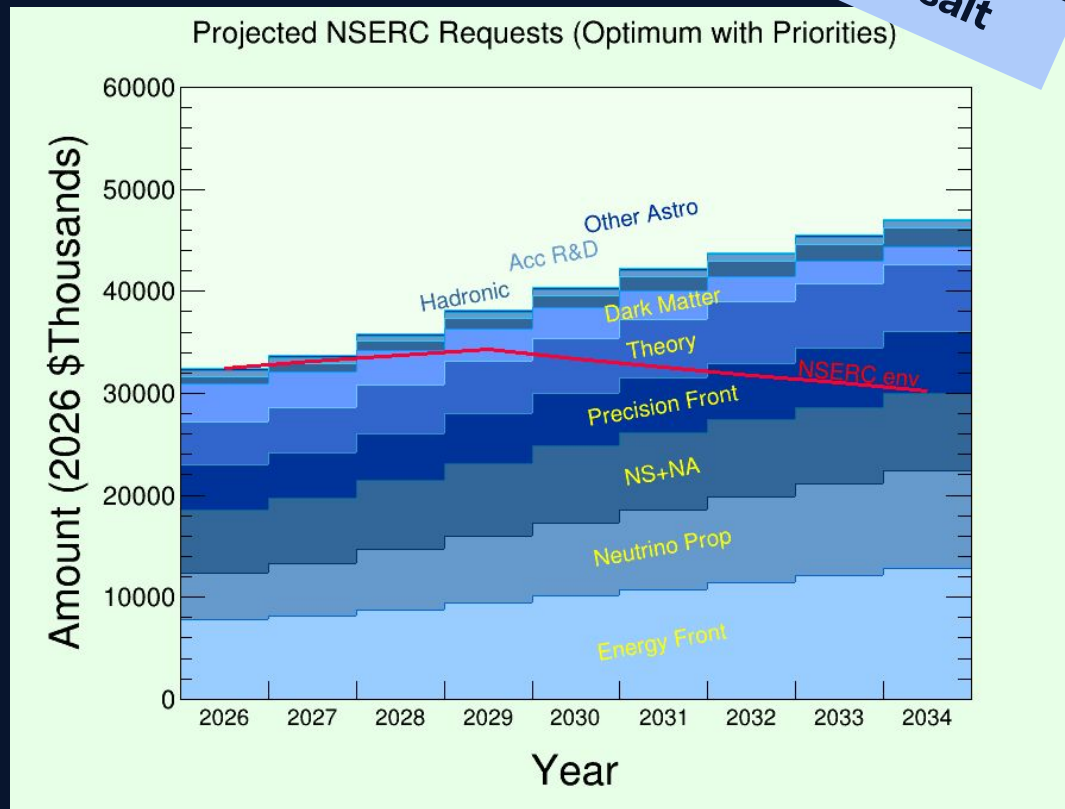
XLZD placed in Neutrino Properties category
NS+NA – Nuclear Structure and Nuclear Astrophysics
Precision Frontier includes projects ranging from Belle-II through TRINAT



After Prioritisation

- 2026: current allocated funds
- 2034: ideal funding scenario **taking into account recommended priorities**
- Optimum with prioritisation
 - Ask in 2029: \$38.1M

XLZD placed in Neutrino Properties category
NS+NA – Nuclear Structure and Nuclear Astrophysics
Precision Frontier includes projects ranging from Belle-II through TRINAT



Prioritisation Categories



Let's go through these one at a time

Prioritisation Categories: Future Projects

- **Highest Priority Future Flagship Projects**
 - Broad and very strong community support
 - Considered by the Committee to have the greatest potential scientific return on investment
 - Substantial involvement in those projects will reaffirm Canada's continuation as a global leader in scientific research
 - Resources to be allocated to reach the optimal impact of the Canadian Community
- **Strong recommendation**
 - Projects are recognized by the Committee as highly impactful in addressing the important questions and also garner broad support of the community
 - These projects are identified for growth that will achieve the main goals of a focused program
- **Limited support**
 - Motivation to devote significant resources is insufficient at this time
 - Community focus on higher-priority experiments is encouraged
 - Some support through R&D efforts for some projects (see later)

Within a given category, projects are listed alphabetically

Prioritisation Categories: Current Projects

- **Highest Priority Current Flagship Projects**
 - See previous slide
- **Strong Recommendation**
 - See previous slide
- **Program Breadth**
 - Identifies experiments with unique scientific objectives that are complementary to the projects in the above categories
 - Strong Recommendation
 - See previous slide
 - Important Projects
 - Where possible maintain current resource levels
 - In a constrained budget scenario, however, major upgrades to the capacity of these projects are ranked with a lower priority compared to realizing the programs of the Highest Priority and Strongly Recommended projects

Prioritisation Categories: Current projects (cont.)

- **Small-scale programs**
 - High-value endeavours with targeted scope and limited financial resource needs
 - We recommend continued support for these projects at modest levels
- **Concluding projects**
 - Important projects for which no further CFI requests are foreseen, or where further CFI requests would not be recommended
 - NSERC support remains important as these projects conclude over the next few years.
 - Concluding these projects will enable the community to coalesce to higher-priority projects
- **Research and development in instrumentation for rare-event searches**
 - Recommended, as technological progress is the driver of future research opportunities
 - Community is encouraged to seek common ground towards more unified national programs in R&D efforts
 - We recommend to fund these activities to ensure future vibrancy of the program



Highest Priority Future Project

Broad and very strong community support

Considered by the Committee as future projects with the greatest potential scientific return on investment

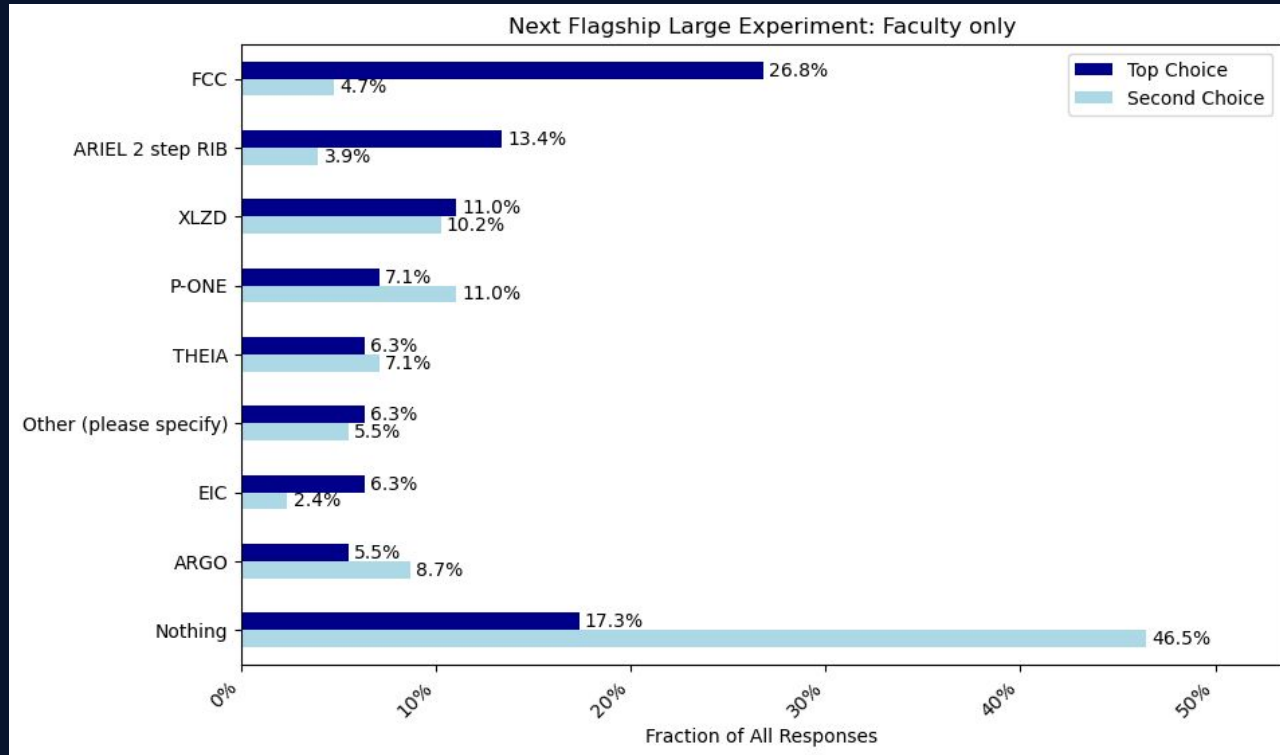
Substantial involvement in those projects will confirm Canada's position as a global leader in scientific research

Resources to be allocated to reach the optimal impact of the Canadian Community

Projects

- EIC
 - Uniquely address profound questions about nucleons and probe how the nucleon-nucleon interaction arises from the QCD regime within the hadrons
 - Allow precision studies of the 3D structure of hadrons, gluon saturation, and the dynamics of quark-gluon interactions across a wide kinematic range
- FCC
 - Largest breadth of program
 - In line with European strategy and CERN council
- XLZD@SNOLAB
 - Potentially transformative opportunity to host at SNOLAB
 - Would establish Canada as the global centre for next-generation direct dark matter detection and the search for neutrinoless double beta decay

Highest Priority New Future Project: LRP Survey



Note: ARIEL 2-step RIB mentioned later in accelerator recommendation



Future: Strong Recommendation

Projects are recognized by the Committee as highly impactful in addressing the important questions and also garner broad support of the community.

These projects are identified for growth that will achieve the main goals of a focused program

Projects

- Chiral Belle (Addition of polarized electron beams)
 - Significantly expand the physics reach of the existing program by enabling uniquely sensitive probes of electroweak couplings, lepton flavour universality, tau lepton physics, and searches for physics beyond the Standard Model
 - Precision measurements complementary to those pursued at the energy frontier
- P-ONE
 - Unique opportunity for Canada to establish international leadership in neutrino astronomy and multi-messenger astrophysics
 - Leveraging national strengths in ocean sciences, particle astrophysics, instrumentation, and large-scale scientific infrastructure

Future: Limited Support



Motivation to devote significant resources is insufficient at this time

Community focus on higher-priority experiments is encouraged

Some support through R&D efforts for some projects (see later)

Projects

- ARGO
 - Based on community input this effort is projected flat over the coming years but would need substantial growth
 - Prioritize instead the successful delivery and operation of DarkSide-20k
- DUNE
 - Limited Canadian contribution, should not be grown
- MAPP-2
 - Limited Canadian contribution and interest
- MATHUSLA
 - Investments not justified by size of Canadian effort
- SNO+ Upgrade
 - Upgrade not justified in comparison with higher-priority projects
 - Future developments of tellurium-loading technology considered in context of national R&D program
- THEIA
 - Amount of funding would require significantly higher support and commitment by the community

Highest Priority Current Flagship Projects



Broad and very strong community support

Considered by the Committee to have the greatest potential scientific return on the investment

Substantial involvement in those projects will confirm Canada's position as a global leader in scientific research

Resources to be allocated to reach the optimal impact of the Canadian Community

Projects

- ARIEL/ISAC: Nuclear structure & Nuclear Astrophysics
 - Tripling of the available beam-delivery time
 - Impacts highly leveraged by taking advantage of targeted experiments at other offshore facilities
- ATLAS
 - Established a sustained and visible leadership role at LHC
 - Fully realize the scientific potential of the LHC and HL-LHC program
- Belle-II
 - Maximize scientific return from long-standing Canadian investments in flavor physics, precision measurements and BSM
- Hyper-K
 - Natural continuation and expansion of neutrino effort in Canada
 - Offering exceptional opportunities for discovery and precision measurements over the coming decade

Current Projects: Strong recommendation



Projects are recognized by the Committee as highly impactful in addressing the important questions and also garner broad support of the community.

These projects are identified for growth that will achieve the main goals of a focused program

Projects

- Darkside-20k
 - Canadian institutions contribute critically to the detector
 - Has expected sensitivity to dark matter and neutrino physics that is complementary to liquid xenon targets
 - An important part of the astroparticle physics portfolio internationally
- RadMol
 - Establish a dedicated laboratory for radioactive molecules and fundamental physics at TRIUMF
 - Provide a timely and strategically important foundation for unifying emerging capabilities, enabling precision measurement and quantum control of molecules containing unstable nuclei
- SuperCDMS
 - Canada plays a central role in SuperCDMS at SNOLAB
 - World-leading experiment should be fully supported to complete its current phase of operations
- TUCAN
 - Measure the neutron EDM with world-leading precision
 - Will also be used to provide neutrons for measurements of the neutron lifetime (PENeLOPE)

Current Projects: Program breadth



*Identifies experiments with unique scientific objectives that are complementary to the projects in the above categories
Projects are recognized by the Committee as highly impactful in addressing the important questions and also garner broad support of the community.*

We recommend the funding required to carry out these experiments

Strong Recommendation



- BeEST&SALER@TRIUMF
 - Probe BSM physics through weak decays of Be or other short-lived atoms embedded in quantum sensors.
 - Identified as a growth area taking advantage of increased beamtime enabled with ARIEL
- JLab Hall C&D including SoLID
 - Canada has played a significant and leading role in JLab programs
 - Hall C&D programs seek hybrid mesons (GlueX) and pion form factor studies. Future SoLID program will measure generalized parton distributions
 - Highly complementary to EIC
- PICO-500
 - Provides sensitivity to the spin-dependent dark matter interactions in unique region of parameter space
 - Program should be supported through its natural conclusion

Current Projects: Program breadth



Identifies experiments with unique scientific objectives that are complementary to the projects in the above categories

Where possible maintain current resource levels.

In a constrained budget scenario, however, major upgrades to the capacity of these projects are ranked with a lower priority compared to realizing the programs of the Highest Priority and Strongly Recommended projects.



Important Projects

- ALPHA
 - Canada plays an important role in the ALPHA project, a world-leading experiment testing anti-hydrogen
 - Support should be maintained at current level
- IceCube
 - Modest investments have realized significant leadership
 - Science program should continue to receive support through transition to P-ONE

Current Projects: Small-scale, impactful programs

High-value endeavours with targeted scope and limited financial resource needs

We recommend continued support for these projects at modest levels

- EDM³
 - eEDM measurements of polar molecules in solid rare-gas matrices
 - Promising and complementary technique to other approaches
- Fr APV
 - Fr atoms projected to have significant enhanced APV effect vs. Cs atoms
 - Recommended to seek synergies with RadMol community
- HALO
 - Participating in the Supernova Early Warning System through neutrino detection
 - Low-cost and well-justified
- MoEDAL/ MoEDAL-MAPP
 - Expand on LHC's sensitivity to new physics via specialized detectors seeking highly-ionizing particles
 - Searches for monopoles, milli-charged particles, and other BSM physics
- PIONEER
 - PSI-based experiment measuring pion decays sensitive to BSM physics between MeV and PeV scales
 - Building and commissioning through 2035 with physics run following
- TRINAT
 - High-precision measurements of K atoms at TRIUMF complementing other searches for BSM physics





Current Projects: Concluding projects

Important projects for which no further CFI requests are foreseen, or where further CFI requests would not be recommended

NSERC support remains important as these projects conclude over the next few years

Concluding these projects will enable the community to coalesce within higher-priority projects

Projects

- DARKLIGHT
 - Search for dark photons using eLINAC beams at TRIUMF. Primary objective requires 50 MeV e
- DEAP-3600
 - New physics run anticipated to end in 2028 with extended sensitivity to DM and neutrino interactions
- MOLLER
 - Under construction at JLab, with data collection 2026-2030. Program should receive strong support until its conclusion
- Nab & pNAB
 - Measurements of neutron decay correlation parameters , expected completion in 2031
- NEWS-G
 - Searching for low-mass DM, currently characterizing ^{210}Pb contamination in Cu. Electroplating of Cu should become part of national R&D program

Current Projects: Concluding projects (cont.)



- SBC
 - Low-mass DM search, currently demonstrating technique through 2028
 - Scintillating detector technology should become part of national R&D program
- SNO+
 - Current $0\nu\beta\beta$ decay search experimental program operating with 0.16% Te loading, with increased loading to 0.5% between 2028-2030
 - Given the projected timelines and within a rapidly evolving $0\nu\beta\beta$ global experimental program, regular evaluation of the science deliverables of the program is recommended to realize an efficient conclusion of the data taking
- T2K
 - Conclusion of operations in 2027/28 with transition to HyperK
- VERITAS
 - Decommissioning planned to begin in 2027

Research and development in instrumentation for rare-event searches

- *Recommended, as technological progress is the driver of future research opportunities*
- *We recommend to fund these activities to ensure future vibrancy of the program*

Recommendation

- The community should prioritise efforts in research and development (R&D)
 - In particular those that align with impactful societal outcomes
- We recommend targeted investments in instrumentation R&D, including
 - Furthering noble liquid detector
 - Semiconductor detector technologies
 - Development of ultra-low radioactivity materials for rare-event searches
 - Research into the long-term future of $0\nu\beta\beta$ decay experiments
- Coordinated national R&D programs could accelerate innovation by maximizing synergies between the participating institutions



Theory

- Critical part of research portfolio
- Current envelope fraction ~constant at 13%

Recommendations

- Maintain the commitment to theory, grow to 15%
- Establish a national theory postdoctoral fellowship program
 - Allow alignment between theory and highest priority experiments
 - ~10 fellows total, 3-4/year
 - Total cost <\$1M

General Funding Recommendations

Split into 3 categories

- NSERC envelope increase
- CFI-IF upcoming requests
 - The \$ on the previous summary figure
- Additional funding needs
 - Things that cannot come from SAPES envelope or traditional CFI-IF competitions

NSERC Envelope Increase

- **Bring all funded HQP up to a liveable stipend**
 - The highest priority need, with broad community support at all levels
 - Net need to increase funding for both graduate students and postdoctoral scholar
 - In order to not compromise on the science and societal benefits goals achieved
 - While needs vary due to cost of living differences: ensure this standard of living threshold is met across the country
- **Permit high priority experiments to realize their full potential**
 - This involves both the operation of the experimental facilities with the critical number of HQP required for program success, and to fulfil the commitments to major international experiments.
 - Recommend bringing the number of supported HQP for the high priority projects up to optimal level required to deliver the program scope (see backup)
- **Enable Canadian leadership in future major projects**
 - New and significant support is needed to enable major leadership and capitalization within those new large collaborations
- **Further enable opportunities for training in transformative technologies (AI, Quantum Science,...)**

Additional External Funding Needs

- **Support ARIEL/ISAC experimental facilities**
 - Ongoing maintenance and operation of the ARIEL/ISAC experimental infrastructure is critical for the success of its science programmes
 - Requires highly-specialized technical support, current demand already outpaces supply
- **Enable full Canadian participation in the FCC**
 - 2025: Canada signed a statement of intent with CERN
 - Recently, CERN Council “invited CERN Management to initiate discussions with the relevant authorities and entities in [. . .] non-Member States [. . .], with a view to obtaining pledges of additional cash and/or in-kind contributions to the cost of constructing and operating the FCC-ee”
- **Explore CERN Associate Membership**
 - We strongly encourage the Canadian government’s continued exploration towards CERN Associate Member State status
 - Opens not only opportunities for Canadian physicists to further contribute to one of the leading global scientific endeavours, but also provide opportunities for Canadian industry to compete for CERN contracts and access knowledge and technology transfer

Additional External Funding Needs

- **Host XLZD in Canada**
 - Attracting XLZD to SNOLAB would be a major achievement, with clear benefits for Canadian science and industry
 - A project of this scale would require dedicated federal and provincial infrastructure investments, laboratory operational support, and potentially new national funding mechanisms developed specifically for large-scale international research infrastructure
- **Find a permanent funding model for the McDonald Institute**
 - Enable the outstanding Canadian expertise and leadership in astroparticle physics to keep flourishing

Other Recommendations

Support R&D in Accelerator and Beam Physics

- We recommend continued strong support for basic accelerator research and encourage the full utilization of Canadian expertise in accelerator development
- Strongly support TRIUMF as being a base of accelerator physics in Canada, leveraging its current expertise
- Targeted research programs in accelerator R&D that support Canada's involvement in the FCC and EIC form an important Canadian contribution
- The community is encouraged to take advantage of synergies between these complimentary development efforts
- **2-step radioactive-ion-beam (RIB) production scheme for TRIUMF**
 - To ensure long-term facility development, there is broad and strong community support for design studies
 - Such a project would be very ambitious, and can only proceed after a significant R&D effort
- **Storage ring for TRIUMF, TRISR**
 - Design efforts initiated
 - TRISR would be a unique facility with the coupling with a neutron source for direct n-capture measurements
 - TRIUMF is in a unique position internationally to build such a facility, which will have significant impact upon the design of other facilities that may be developed abroad

Other Recommendations

Explore a mechanism for funding for conceptual R&D efforts

- Critical need for funding pathways for the development of conceptual designs of experimental infrastructure in order to develop full CFI proposals
- As with any R&D effort, As R&D efforts can be of a high-risk, high-reward nature, often universities are not willing are not willing to 'sacrifice' CFI institutional envelope before projects are mature and guaranteed to succeed
- While the RTI mechanism does exist within the NSERC SAP envelope, such conceptual design projects suffer from the extreme competition for funding
- NSERC and CFI should explore the best mechanism to fund conceptual R&D in a way which is sustainable

Other Recommendations

Improve availability and reliability of computing resources

- Recommend that high-level discussions take place between the leadership of Digital Research Alliance of Canada and that of IPP and CINP
- The subatomic physics community has a long-standing history of being one of the major drivers of computing needs within Canada, often driving innovation in large computing infrastructure with significant storage needs and distributed access
- Community needs are not being met:
 - Grid-accessible storage and computing cluster size and uptime (99% uptime should be considered a minimum)
 - No plans in place for the regular replacement of ageing infrastructures through regular calls, as was initially expected
 - The reputational risks of not delivering 'pledges' to international collaborators are very significant
- Many R&D efforts in computing, including in AI, require reliable, high-availability resources for a modest amount of time. The organisation, minimal access quota, and timelines of RAC competitions, and unpredictability of resources accessed via default allocation or Rapid Access Service prevents those avenues for practical R&D utilisation for individual research groups
- The Alliance does not provide access to Quantum Computing (QC) resources and, in general access to QC resources relies on individual funding and establishing individual relationships with QC providers, impacting Canadian researchers' ability to advance applications for R&D in the QC space

Other Recommendations

Strongly support our national facilities: SNOLAB, TRIUMF

- Sustainable and predictable funding
- Enable many of the highest priorities of the community

Establish the Major Research Facility (MRF) framework

- Building a national strategy to support this infrastructure is critical to ensuring long-term success for Canada
- Strongly advocates that the Government of Canada capitalise on the opportunity of the MRFs by delivering a mission-driven framework that both enables the long-term success of existing facilities, and provides a pathway for the creation of new infrastructure as needs require

Other Recommendations

Create a mechanism to support large projects across their full lifecycle

- Exploring funding models that provide coherent, long-term support spanning the entire project lifecycle, from conceptual design, through construction, commissioning, operations, to final data analysis, knowledge preservation, and eventual decommissioning
- This “cradle-to-grave” approach would improve strategic planning, reduce funding discontinuities, and enable more effective stewardship of major national investments.
- Current fragmentation of funding and oversight across different project phases can lead to gaps in accountability and long-term planning (Supported by community input)

Improve the CFI program

- Thanks to CFI-IF for more regular and predictable competitions
- Would encourage further efforts to stabilise the budgets for each competition
- There are nonetheless a number of limitations to be overcome:
 - The current Innovation Fund structure does not scale well for major projects that require significant investment and coordination across multiple institutions, most often also involving many international partners
 - The timescale over which funds must be utilised does not match the timescale of those large projects from prototyping to final installation
 - The envelope structure imposed on institutions also imposes limitations, and projects selected for submission to CFI are subject to internal institution review often with limited reviewer expertise and reticence to take risks in proposing innovative projects.
 - Managing and applying for multiple provincial matching mechanisms for large projects is difficult

Other Recommendations

Strengthen interaction and communication between CFI and NSERC on major projects.

- Since the previous long-range plan, there has been a substantial and welcome increase in the interactions between CFI and NSERC on particle and nuclear physics project applications
- This level of interaction should be maintained and further strengthened to evolve as driven by the scope and timeline of the projects

Increase coordination between NSERC and the McDonald Institute

- We recommend that the McDonald Institute and NSERC explore pathways for increased communication and coordination of supported programs to ensure fair and equitable distribution of funds within the community

Support for the IPP scientist program

- The continuation of the program is recognized as a community priority, in particular as new projects are launched at the national scale
- Funding for the program has fallen behind the rate of inflation, introducing increasing pressure on its sustainability
- It is recommended that an evaluation of the program model be conducted to ensure it may be maintained to address the community's identified highest priority needs

Consider extending NSERC project grant durations and re-establishing expert review committees for large projects

Q&A

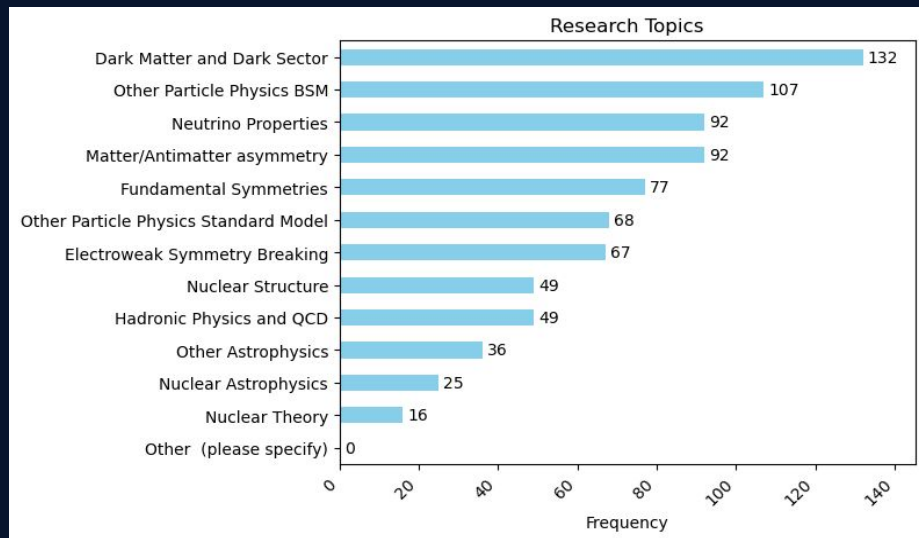
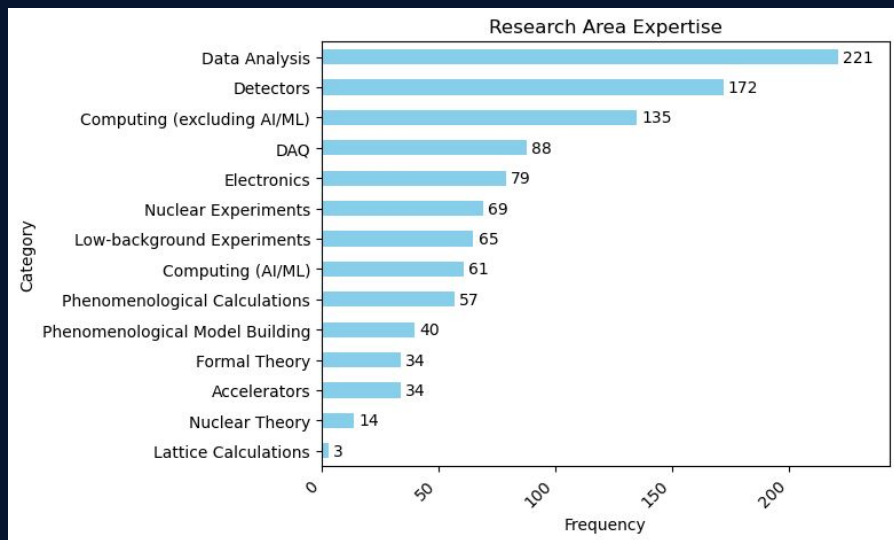
**That's all folks....
The floor is yours**

Backup

LRP Survey

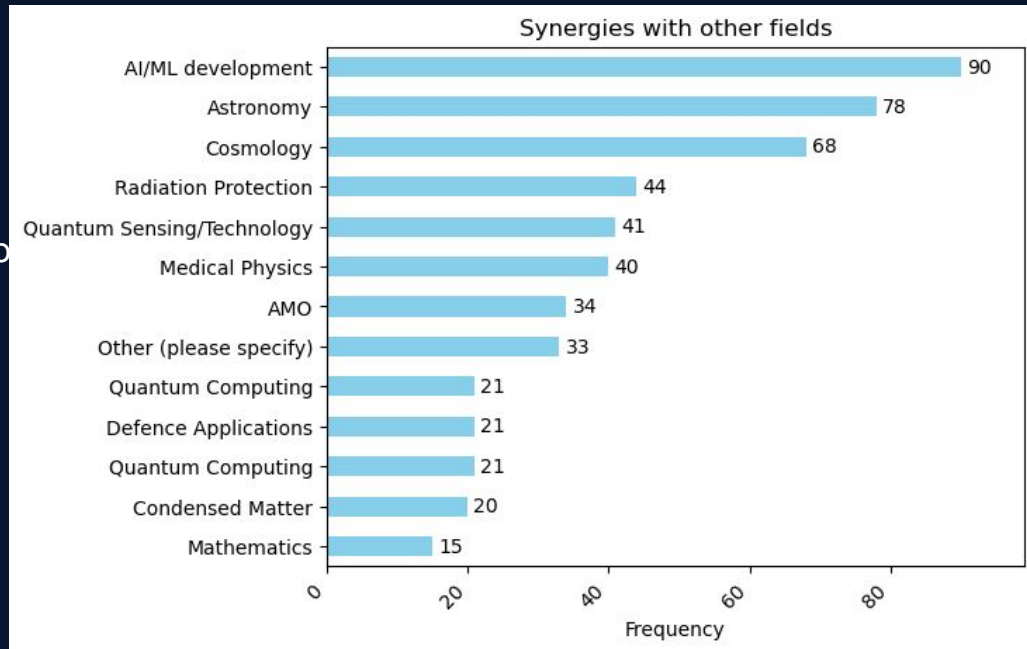
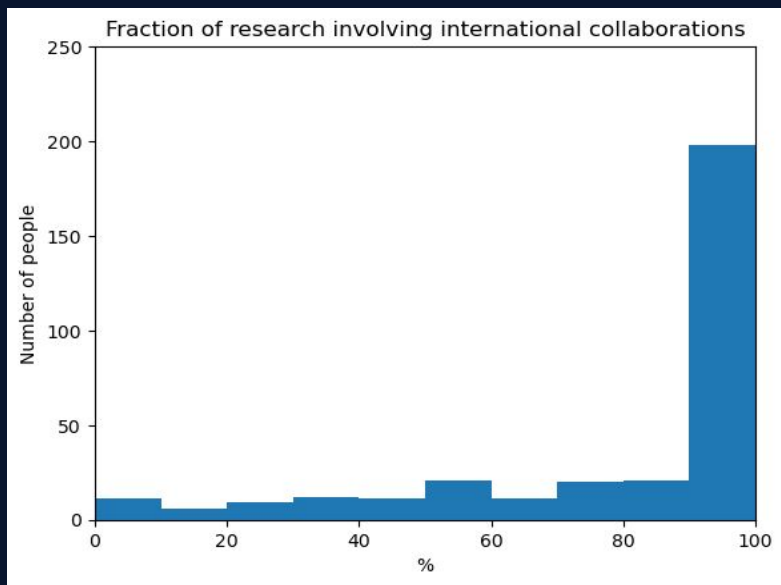
LRP Survey

- 323 'good quality' responses
- Responses: ~50/50 Faculty (or equivalent) / HQP
- Reasonable representation of whole community



LRP Survey

90% of community works >50% of time in international

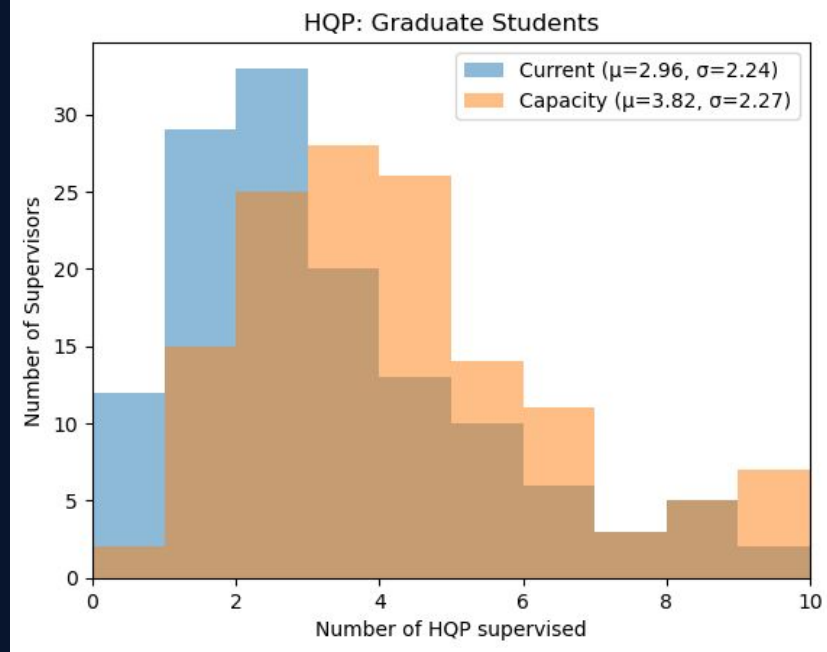
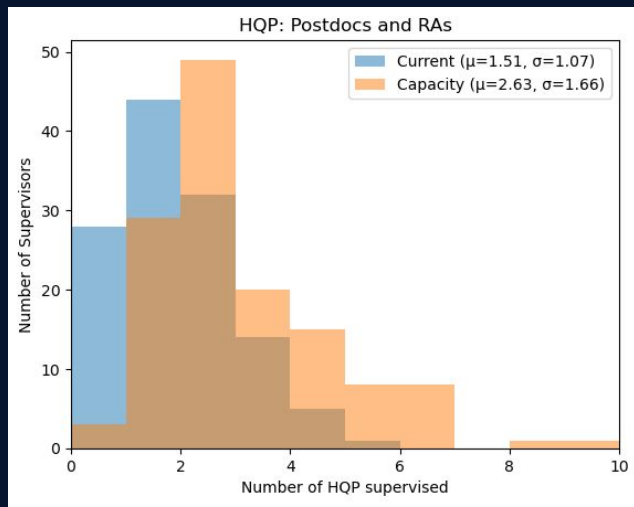


HQP from Survey

Current vs Capacity

Wide spread within surveyed people

- PIs typically would like
 - 0.8 more GS (3.8 vs 3.0)
 - 0.6 more UG (2.6 vs 2.0)
 - 0.9 more PDF/RA (2.6 vs 1.5)
- Theorists bit lower
 - Average 2.4 GS (3.5 capacity)

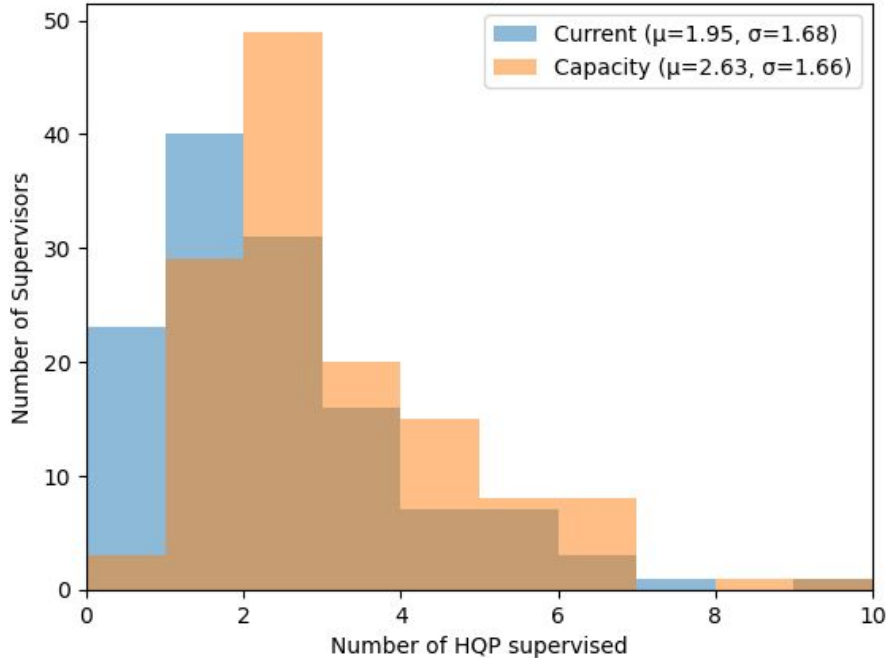


Domestic vs International

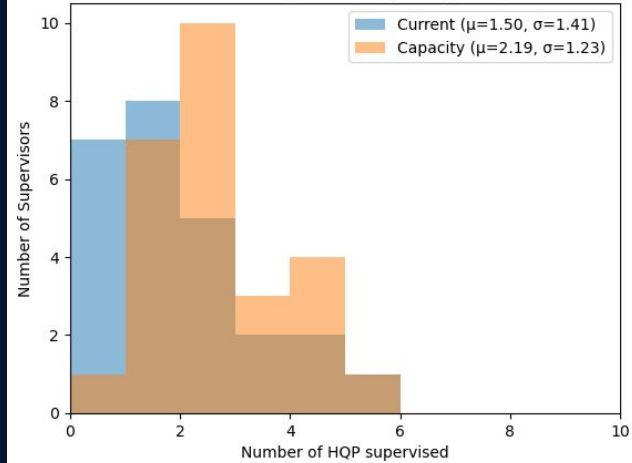
- 56% of GS are domestic
- 38% of PDFs are domestic

HQP: Current and Capacity

HQP: Undergraduates



HQP: Undergraduates (Theory Only)



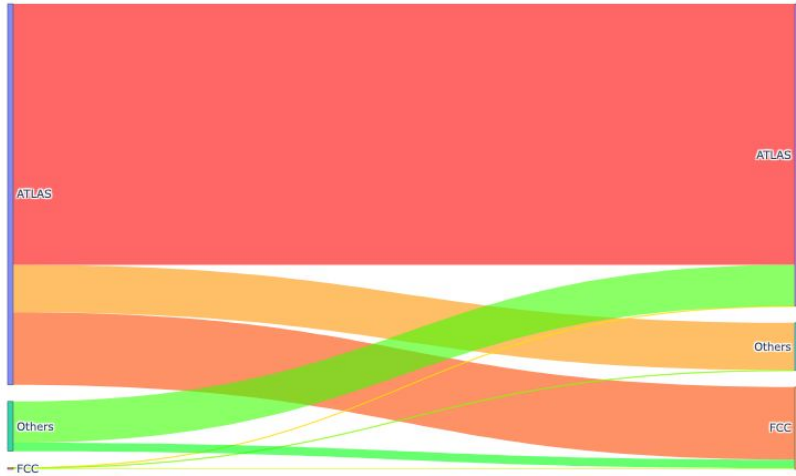
Mobility: Experiment now vs 2034 (fac only)

56% of respondents said would be involved, 8% said no, 36% didn't know

HEP

DM

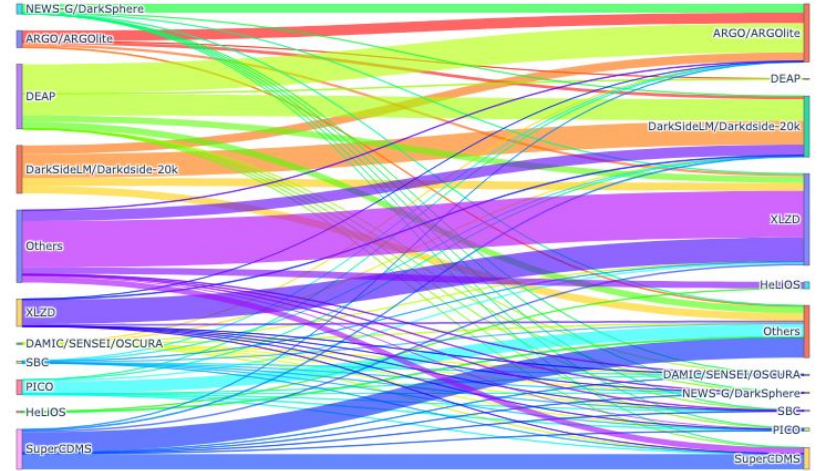
Sankey Diagram of experimental contribution now to experimental contribution in 2034



Now

2034

Sankey Diagram of experimental contribution now to experimental contribution in 2034

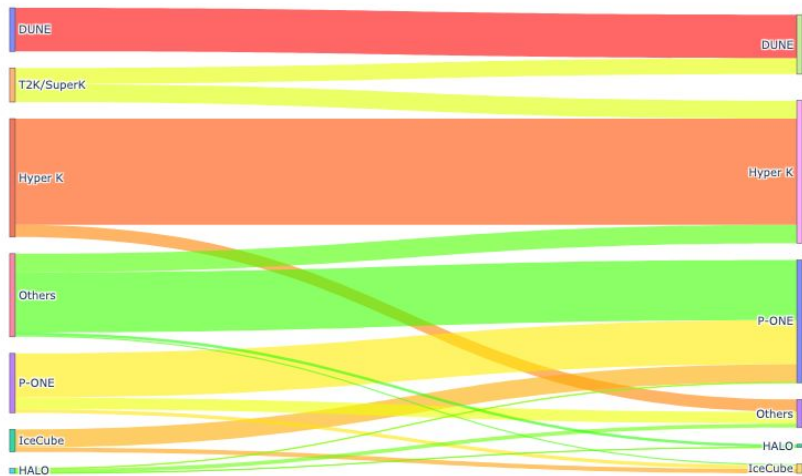


Now

2034

Neutrinos

Sankey Diagram of experimental contribution now to experimental contribution in 2034

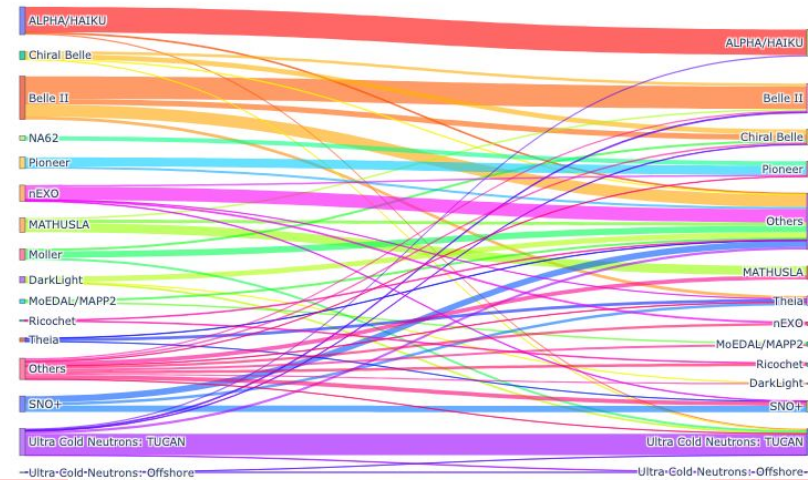


Now

2034

Precision

Sankey Diagram of experimental contribution now to experimental contribution in 2034

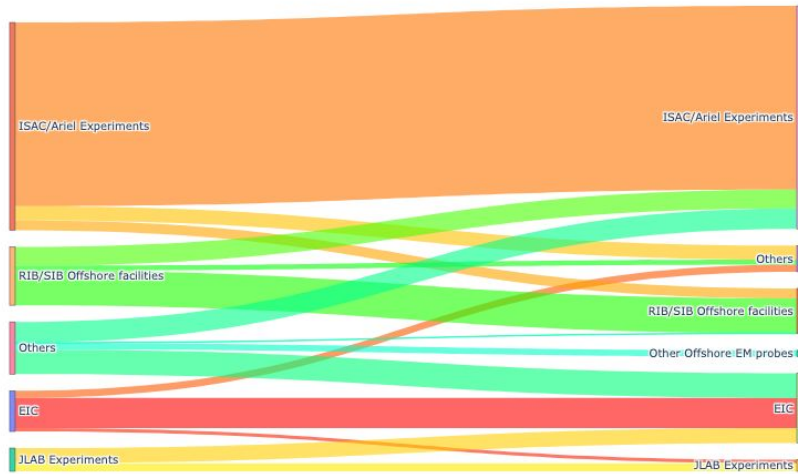


Now

2034

Nuclear

Sankey Diagram of experimental contribution now to experimental contribution in 2034

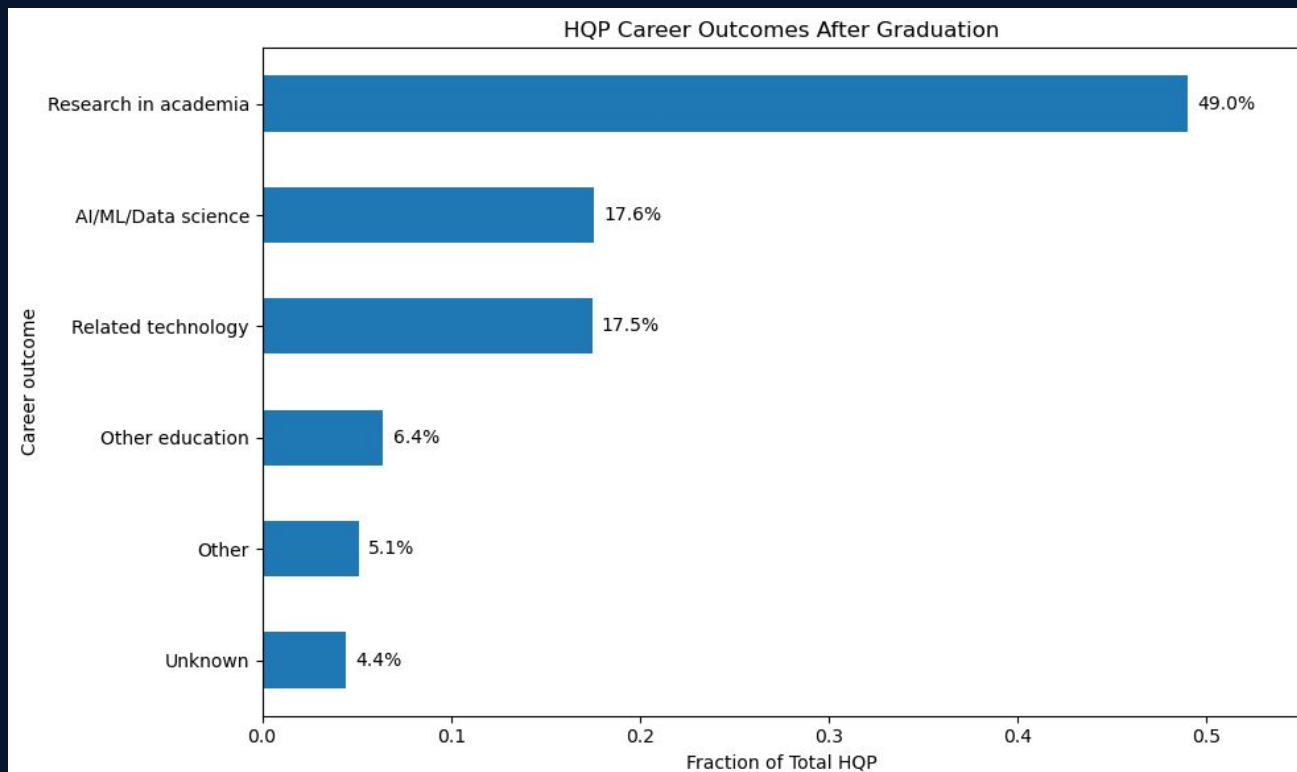


Now

2034

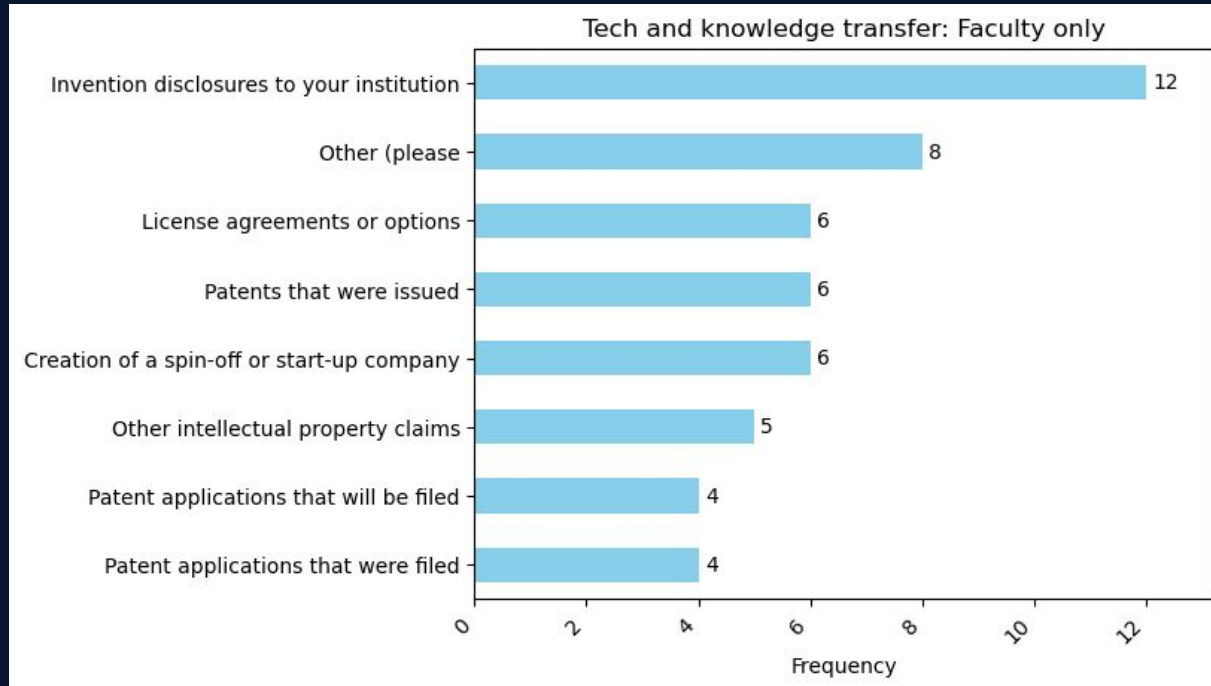
HQP career outcomes

Asked PIs to look at all students over past 5 years



Tech and Knowledge Transfer

- 25% of 'faculty' answered yes to some form of tech transfer and knowledge transfer (using future NSERC categorisation)



LRP Townhalls

LRP Town-halls

- Over 2 weeks in early March
 - Open-ended pre-written questions (circulated to the community ahead of time except for first couple)
- 9 town-halls
 - CERN membership
 - Supporting SAP: Computing, accelerators and Detector R&D
 - Benefits to Canada
 - HQP (for HQP only)
 - Dark Matter /Dark Sector
 - Neutrinos (accelerator, non-accelerator and astrophysical)
 - Collider Physics
 - Nuclear: QCD+ symmetries (incl EIC)
 - Nuclear: Astro + structure

Supporting SAP: Computing, accelerators and Detector R&D

- Challenges in Long-Term R&D and seed funding
 - Need for better support for long-term R&D, particularly in detector development
 - Particularly challenging for DM and FCC type of longer-scale R&D efforts
 - No clear mechanism to get ‘Seed funding’ to prepare larger CFI proposals
 - Also no seed funding for innovative projects [NSERC RTI?]
- Need for better access to pan-Canadian resources like MRS and the McDonald Institute funded resources
- Importance of maintaining technical expertise in Canada
- Computing and Alliance (major sticking point)
 - Concerns about the lack of coordination and the Alliance’s handling of computing resources
 - Concerns about access to discussions with leaders within Alliance
 - Need for more intermediate-scale resources and faster allocation review processes ‘just in time’
- Need for a more efficient and equitable allocation of resources, including computing and funding for students and postdocs.
- Result of community survey: value of DA computing resources used in 2025 > \$2.5M

Benefits to Canada

- Direct Technology Impact
 - Highlighting accelerator technology for medical isotope production and general applications
 - ATLAS use of CVMFS for distributing complex software stacks, which had a significant impact on compute Canada, many people using it now
 - Importance of collecting and systematically documenting various examples of technological impacts
- Potential Opportunities Around Defence Spending
 - Potential of isotope ratios for predicting lung cancer and other applications, but lack of current competitive technologies.
 - Dual-use nature of nuclear data evaluation, lack of Canadian investment in this area
 - Concerns expressed about the ethical implications
 - Need for a clear pathway for funding and hiring personnel for defence applications
- Promoting Diversification of Technologies in Industry
 - Support for idea of helping Canadian industry develop products for research use, citing the Alliance programme as a potential vehicle
 - Need better information sharing and contacts with local industries to facilitate procurement and collaboration
 - Discussed potential for reducing reliance on foreign suppliers for key technologies like scintillators and magnets
- HQP Training and Preparation for Industry
 - Suggest a centralised hub for HQP to find opportunities outside of academia
 - Create a database of HQP and their current positions? Useful for grant requests

HQP (for HQP only)

- **Key Opportunities and Skills Development**
 - Discussion on the need for better exposure to industry opportunities for physics graduates
 - Emphasis on skills like grant writing and leadership experience in experimental setups
 - Importance of international collaborations and hands-on experiences
 - Acknowledgment of the challenges faced by postdocs in learning essential skills for future positions
 - Desire for more formal training in project management and funding applications
 - Concerns about the pressure on early-career researchers regarding publication metrics versus skill development
- **Concerns about Funding and Equity**
 - Funding disparities affect career progression and opportunities
 - Variation in salaries and benefits across institutions impacts motivation and retention
 - Lack of standardized funding for graduate students across disciplines
 - The necessity for equitable funding and resources to support diversity in the physics community
 - Suggestions for integrating EDI principles into all academic processes rather than treating them as separate initiatives

Dark Matter /Dark Sector

- Extensive discussion around large-scale (e.g., XLZD) vs. smaller scale experiments – no clear consensus emerged if community should focus on a large-scale effort, or continue to push smaller scale experiments
 - Part of the issue is the lack of clear leadership roles in larger-scale projects, so many early career faculty/scientists work on smaller-scale projects that they can lead
 - Difficulty of knowing where to look so many smaller scale projects cover larger portion of parameter spaces
 - Concern expressed that a single large-scale experiment could “suck up all the oxygen”
 - To attract large-scale experiment, need to community to coalesce
 - Small or mid-size experiments consumes resources and dilutes focus
- XLZD is highly dynamic, and currently driving future prospects at SNOLAB
- Lack of a clear mechanism for funding of large-scale projects
- Large-scale projects need major international partnerships, but unclear what direction DOE will take in current environment
 - Impression that DOE decisions are strongly influenced by issues with DUNE

Neutrinos

(accelerator, non-accelerator and astrophysical)

- Extensive discussions about XLZD as future DM and neutrinoless double-beta decay experiment
 - Possibility of hosting in Canada @SNOLAB
 - Fast-moving (LRPC getting updates every month or so from community)
- Funding
 - Don't have a clear path how to get \$100M-scale without going CFI after CFI
 - Need to get guidance from Canadian government to say what we need to get there
 - Need to look outside of current funding model: NSERC SAPES + CFI
 - Need to think about better system for building and operating over lifetime of large experiments
- Guidance from government would be helpful on collaborating with China
 - Some technologies are dual use, e.g., tech for P-ONE can have military applications
- Discussed importance of theorists collaborating with experiments in this area
 - E.g. nuclear matrix element calculations
 - Some TRIUMF theorists involved but not much traction outside of that

Collider physics

- How do we ensure maximal exploitation of HL-LHC upgrades and data while finishing Run 3?
 - Funding for HQP to exploit the investment we made in the ATLAS detector, upgrades, machine, etc. Funding agencies (NSERC+CFI) have Spent >\$200M on the whole ATLAS project up to now
 - Scope for improvements for how we collaborate across institutes within Canada
- Towards FCC
 - Emphasis that Canada needs to be part of R&D for future detector systems
 - 2028 CERN commits to FCC: sets timeline to create an official FCC-Canada effort
 - CERN's movement will happen soon, need to move with the other players
 - Now: Small funding portfolio towards R&D, forming collaborations
 - Need to build FCC community within Canada: experiments and accelerator
 - Contribute to 1 experiment and 1-2 detector components: allows to maximise impact (been the case since 1970s)
- 'Don't want to sacrifice the present for the future'
- Who should 'speak for Canada' when pitching for large projects?
 - IPP director
 - TRIUMF director should play a leading role
- Again: cradle to grave funding mechanism missing in Canada
 - Maybe FCC should be a 'major research facility' (like a lab) vs funding within NSERC+CFI IF?

CERN Associate Membership

- Hosted by Salvatore Mele
 - Senior Advisor for International Relations
- LRPC had already had a session with Salvatore covering in depth many similar questions
- Look at national and international context
- Goal is to maximise our impact of SAP in Canada
- Increased access to CERN
 - Industry bids open up to Canadian companies
 - For Associate Member states: ‘ceiling’ to personnel and industrial returns equal to the yearly contribution
 - Procurement report from 2024:
<https://indico.cern.ch/event/1490125/contributions/6281068/attachments/3036835/5364703/IL0%20forum%20Procurement%20report.pdf>
 - Technical and scientific staff eligible for fixed term (≤ 5 year) positions to develop skills then bring back to Canada
 - Get to sit in on CERN council meetings and speak (not vote)
- Associate Membership cost would be 12M CHF/year (~\$21M CAD)
 - Based on Net National Income
 - 10% of cost of full membership
 - Clearly must come from outside of science, e.g. international affairs



2024 IN NUMBERS

32 000
Suppliers



26 500
Orders placed



31 700
Orders placed
in the CERN stores



300
Contracts signed



53
R&D collaborations



129
Price enquiries
above 50 kCHF



118
Invitations to tender



IMPACT SURVEY

47% developed new
products by working with CERN



52% found or opened new
markets by working with CERN



1 out of 4 suppliers hired
new personnel through their
collaboration with CERN



71% enjoyed a positive
impact on their sales
through their collaboration
with CERN



84% of IT suppliers improved
their products by working with
CERN

compared to the overall average of **65%**

76% of Electronics Suppliers
improved Technical Knowledge
by working with CERN

compared to the overall average of **70%**



Nuclear: QCD+ symmetries (incl EIC)

- Historically strong Canadian detector role
 - Lots of people in Canada who are detector experts
 - Lean on TRIUMF detector experts.
 - Synergies between detector development for EIC and FCC, so a strong leverage can be taken advantage of
- Same with theory: EIC questions already strong theory motivation but ways to grow people's interest.
 - Hope: natural shift from experiments that are ending (e.g. Moller) over to EIC
- Some concern from small-scale projects they feel like risk getting squeezed out
 - Emphasis need for balanced portfolio of large and small experiments
- HQP
 - Need more funding for students -> need increased funds just to keep same output
 - More opportunities for students to stay in Canada after graduating.
 - Lack of positions in medium energy scale
- Discussion about how 'twist people's arm' to get more hires at universities
 - TRIUMF joint-hires are very helpful particularly at smaller-scale universities!

Nuclear: Astro + structure

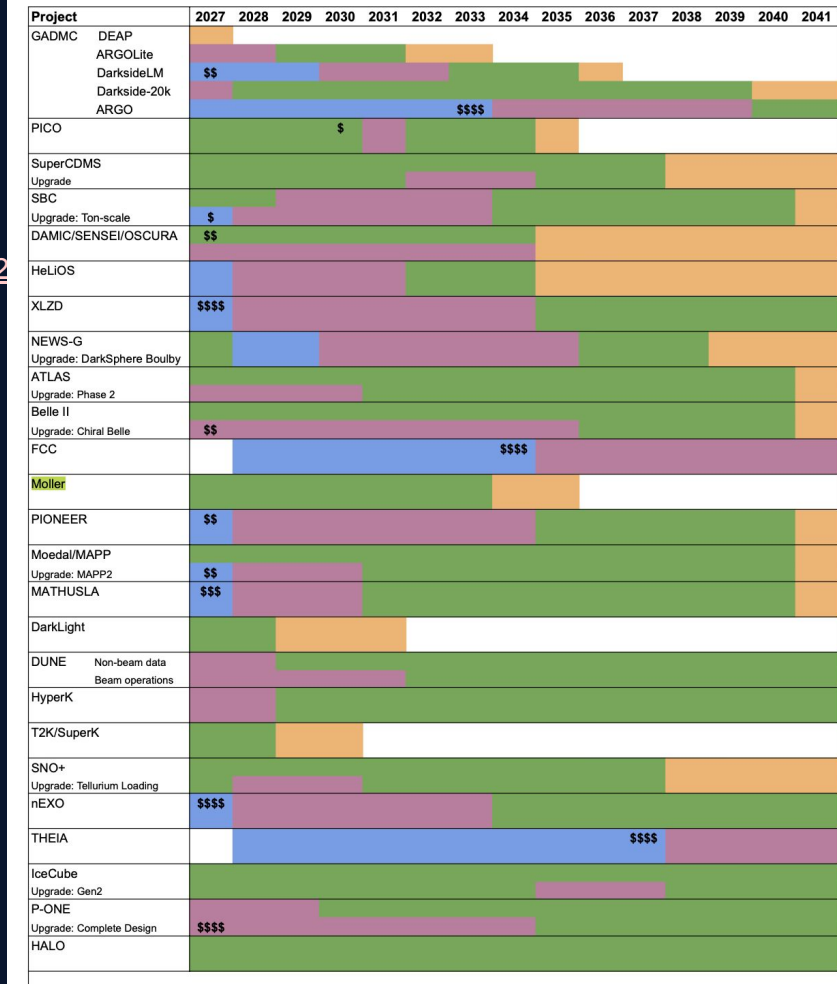
- ARIEL: Tripling amount of beam over 3 years
 - Desire to increase funding of groups involved in ARIEL
 - Hard to recruit enough HQP
 - Need for more on-site support at TRIUMF (brought up many times)
 - Delivering beams but also running experiments will need expanded support
 - Need expert personnel who are there throughout.
 - Students+postdocs come in waves, only there for a couple of years so cannot be only model.
 - Need for having support for on-site people for operating experiments i.e. increase to TRIUMF staff!
 - Take some of ARIEL time to look at things that might have been 'too risky' before
- Again mention TRIUMF bridge positions / joint hires as incentives to build community
- Countering image problem of nuclear being 'rusty'
 - World-wide investment in radioactive beams is \$9B
 - Interdisciplinary work with astrophysicists
 - Most direct connection to society: Energy, health, defence, industry, material testing
 - How much outreach and how much science communication do we do?

IPP & CINP BRIEFS

IPP Brief

https://particlephysics.ca/wp/wp-content/uploads/IPP_Brief_to_the_2025_2

- Put together by IPP Science Council: M. Danninger, R. Gornea, C. Krauss, M. Swiatlowski, R. Teuscher, A. Vincent, Y. Zhang



CINP Brief

- Put together by: Corina Andreoiu, Svetlana Barkanova, Greg Christian, Sandapen
- Initial drafts contained some prioritisation of projects but after community consultation
- Set of recommendations was provided: NSERC Funding, Increased support
 - “A better mechanism is needed for large-scale, long-term projects”

4. The vital roles of TRIUMF:

- TRIUMF's infrastructure role.* TRIUMF has an important role in supporting Canada's international physics program, and it is vital that TRIUMF be provided adequate resources for to act in this capacity, including detector and accelerator development.
- Potential TRIUMF upgrades should be supported in a staged approach:*
 - TRIUMF Storage Ring (TRISR)* would be a unique facility, leveraging the connection to the existing ISAC.
 - Two-step RIB* would be an ambitious but important project, building directly upon ARIEL after the latter is fully implemented.

	Questions addressed				Years																
	Hadrons/QCD	Nuclear Structure	Nucl Astrophysics	Fund Symmetries	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
Nuclear Theory	X	X	X	X																	
Electron-Ion Collider	X			x																	
JLab: SoLID	X			x																	
Duke: hadrons	X																				
JLab: GlueX/JEF/HallC	X																				
Mainz: hadrons	X																				
ARIEL: 2 RIBs		X	X	X																	
ARIEL: 3 RIBs		X	X	X																	
ARIEL: 9khr RIB/yr		X	X	X																	
ARIEL: full intensity		X	X	X																	
ARIEL: photo-fission		X	X	X																	
Offshore: accel RIB		X	X																		
TRIUMF: γ Ray Spec		X	X	X																	
TRIUMF: TITAN		X	X	X																	
TRIUMF: TRINAT		x		X																	
ARIEL: CANREB		X	X																		
CERN: PUMA		X																			
GSI: exotic decays		X	X																		
GSI: FAIR 1,2		X	X																		
Offshore: in-flight RIB		X	X																		
SFU: NSL		X																			
TRIUMF: Astro-4		x	X																		
TRIUMF: EMMA		X	X																		
TRIUMF: EXACT TPC		X	x																		
TRIUMF: IRIS		X	X																		
TRIUMF+Offshore: OGS		x	X																		
CERN: ALPHA-NG/g				X																	
JLab: MOLLER				X																	
ORNL: Nab				X																	
ORNL: pNAB				X																	
PSI: PIONEER				X																	
SNOLAB: nEXO 2.0				X																	
TRIUMF: BeEST/SALER			x	X																	
TRIUMF: Fr PNC				X																	
TRIUMF/CERN: HAICU				X																	
TRIUMF: PENeLOPE				X																	
TRIUMF: Rad Mol				X																	
TRIUMF: TUCAN				X																	
York: EDMcubed				X																	
TRIUMF: Accel Dev		X	X	X																	
TRIUMF: Storage Ring		x	X																		
TRIUMF: 2-step RIB		X	X	X																	

The committee

Meaning Of Roles

- Voting Members
 - Present at as many discussions as possible
 - Voting if there are any items we need to build consensus on
 - Actively engaged in data collection/survey building or other tasks as needed
 - Writing of final documents
- Non-voting members
 - Present at most discussions
 - Free to engage in all discussions and give their thoughts/ideas
 - Not expected to do any writing of the documents
 - In cases of votes of major decisions, their voice can be heard but not counted when deciding on 'consensus' among the LRPC
- Ex-officio members
 - There mostly to listen and to answer questions if the LRPC has any questions from them
 - Can provide context in how what is being discussed fits in or not with priorities of the labs/institute they represent
 - Again they don't vote
 - They aren't usually part of the main discussions other than providing context

Pre-LRPC Timeline

IPP

- 16 May: Submission of inputs to IPP
- Summer: IPP Science council prepares briefs
- 23rd Oct: IPP brief draft circulated to community
- 30th Oct: IPP townhall
- Council updates briefs

LRCP

- March 2025: Chairs found
- June 2025: Full committee formed

• June 2025: Announcement of process kick-off at CAP

CINP

- May 14: Submissions of briefs to CINP
- 13th June: CINP Townhall (Hybrid at CAP Congress)
- 25th Sept: Townhall presentation of draft brief
- 5 Oct: Feedback from community on draft
- End Oct: Revisioned draft to community.
- Nov: 2nd Town Hall.

CINP+IPP Briefs to LRCP

- 30th November 2025

LRPC Timeline

- 14 Oct 2025: Kick-off meeting
- 1st Dec: receive briefs from IPP and CINP
- Throughout: Request data from funding agencies and IPP/CINP
- Dec-June: Regular meetings of LRPC (3x/week since Jan)
 - Particle & Astroparticle sub-committee
 - Nuclear sub-committee
 - 'Impact' sub-committee
 - Joint committee meetings
- Feb 2026: LRCP survey go out to the community
- Mar 2026 Townhall meetings
- April 206: Update with SAP-ES results
- 16+17 April 2026: In person LRPC meeting @ TRIUMF
 - Project Prioritisation
 - Recommendations
- May-June 2026: Drafting of document
- June 2026: CAP 2026 presentation of draft to community
- End Sept 2026: Final LRP documents released

Meet our Voting Members



Alison Lister
alison.lister@ubc.ca

Exp: High Energy
Collider (ATLAS)

SAPES co-chair
LRPC non-voting 2022



Paul Garrett
pgarrett@physics.uoquelpq.ca

Exp: Low E Nuclear
structure

SAPES



Torben Ferber
torben.ferber@kit.edu

Exp: Dark Matter, LLP,
dark sector, flavour
physics (Belle II, LUXE,
SHiP and the DELight),
real-time AI on FPGA



Alfredo
Galindo-Uribarri
uribarri@ornl.gov

Exp: Low E nuclear, now
Neutrino (PROSPECT,
COHERENT, LEGEND)

Chair TRIUMF exp eval
committee
NSF program director
Nucl Phys



Darren Grant
darren_grant@sfu.ca

Exp: Astroparticle, High
energy Neutrino
(IceCube, P-One)

NSF program director

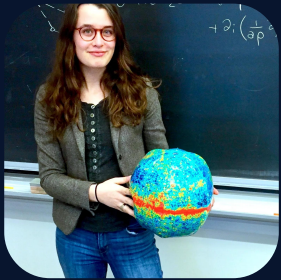


David Hornidge
dhornidge@mta.ca

Exp: Low-Medium
Nuclear (A2 Mainz,
Glu-X, EIC Canada)

SAPES co-chair

Meet our Voting Members



Katelin Schutz

katelin.schutz@mcgill.ca

Theory: Astroparticle
BSM:
particle-astro-cosmo



Hirohisa Tanaka

hatanaka@stanford.edu

Exp: Long
Baseline/accelerator
Neutrino (Dune Near,
ICARUS)

CERN, Fermilab,
SNOLAB advisory
committees



Nicole Vassh

nvassh@triumf.ca

Theory: Nuclear
astrophysics (heavy
element
nucleosynthesis)



Simon Viel

SimonViel@cunet.carleton.ca

Exp: Astroparticle, DM
(DEAP, DarkSide, Argo,
nEXO)
(PhD, postdoc in High
Energy collider)

Meet our Non-Voting Members



Carsten Krauss

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IPP Director



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CINP Exec Director



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SAPES Co-chair

Meet our Ex-Officio Members



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SNOLAB Director



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Director