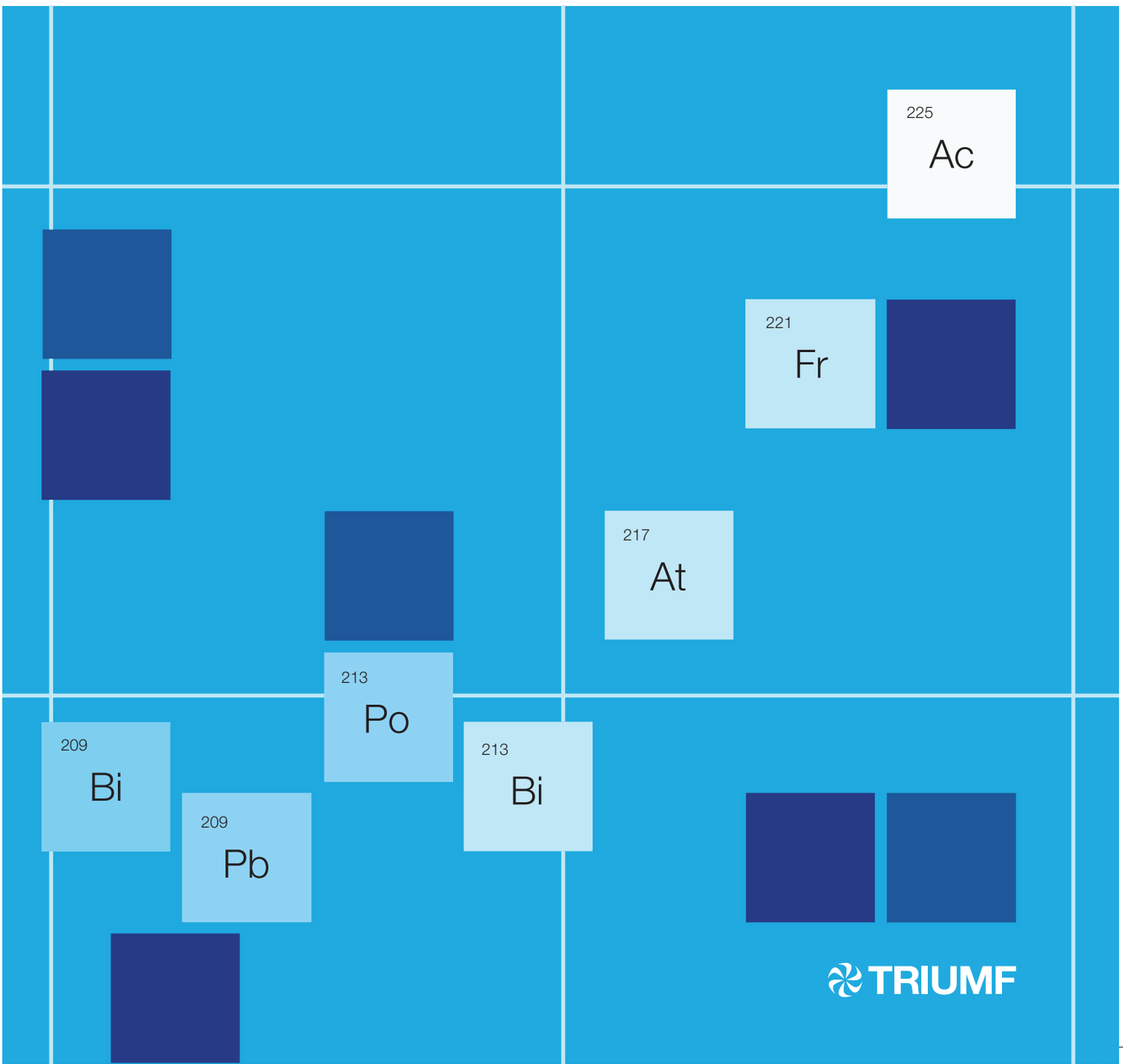
TRIUMF
IMPLEMENTATION PLAN

2025-2030
Realizing Canada's Potential



TRIUMF is located on the traditional, ancestral, and unceded territory of the xʷməθkʷəy̓əm (Musqueam) people, who for millennia have passed on their culture, history, and traditions from one generation to the next on this site. TRIUMF's home has always been a seat of learning, and we are honoured to continue to use these lands as a centre of knowledge and education.

TRIUMF's activities are supported through a combination of public funds, revenues generated from commercial activities, and contributions received through scholarships, awards, and philanthropic donations. Our discoveries and innovations wouldn't be possible without the contributions made by our global network, which includes member universities, partner laboratories, our user community, private sector partners, and community organizations. We are deeply grateful to all those who help us push the frontiers of knowledge and harness its power for the benefit of all. Together, we're unlocking a universe of possibilities for Canada and the world.

VISION, MISSION AND VALUES

Underpinning the delivery of all that we do is the core vision and mission of the facility, coupled to the values that we embrace in our work.

VISION

Our vision is for Canada to lead in science, discovery, and innovation, improving lives and building a better world.

MISSION

TRIUMF's mission is to serve as Canada's particle accelerator centre. We advance isotope science and technology, both fundamental and applied. We collaborate across communities and disciplines, from nuclear and particle physics to the life and material sciences. We discover and innovate, inspire and educate, creating knowledge and opportunity for all.

VALUES

Excellence and Integrity

• We have a passion for excellence in all that we do.
• We are decisive, bold, courageous, and compassionate.
• We take responsibility for our actions, our commitments, and our contributions to the larger community.

Safety and Accountability

• We respect the health and safety of our workers, our visitors, and our neighbours.
• We build quality into our processes and seek continual improvement in all our systems.
• We embrace transparency and authenticity, and hold ourselves and each other accountable.

Equity and Inclusion

• We empower our workforce and foster an inclusive work environment, enriching our science and our community.
• We value teamwork and open communication to ensure that everyone belongs and all voices are heard.
• We respect each other, take care of each other, and support the success of all

EXECUTIVE SUMMARY

TRIUMF is a national asset. From supporting Nobel-prize winning research that elucidates unknown facets of the Universe to creating new, life-saving drugs and devices, we use our particle accelerator complex and highly skilled community for the betterment of society.

This Implementation Plan for the period FY2026 - FY2030 articulates the way in which TRIUMF will fulfil its primary mission over this period, which is to deliver world-class science and socio-economic impact for Canada and the world. This mission has been recognized and endorsed by the Canadian federal government through the allocation of $399.1M for operational support over these five years, a 50% increase in the current baseline support TRIUMF receives. These operational funds will be instrumental in allowing TRIUMF to deliver world-class science, complete and start operating two new world-class infrastructures, train the next generation of leaders and innovators, and maintain Canada's leadership position in major international research collaborations. This funding also secures the added socioeconomic benefits of the TRIUMF science program (medical isotopes, new technologies, and spin-off companies), which are not possible without stable facility operations.

To achieve these outcomes, TRIUMF will enhance core infrastructure systems, with defined core deliverables over this period related to this infrastructure. TRIUMF will also implement core, facility-wide changes expected by our Board and community, namely the alignment of our talent strategy to market levels, the completion of critical deferred maintenance, and the implementation of operational excellence to ensure our systems and processes are fully effective. This will position our team, systems, and processes to deliver outcomes with safe, compliant and modern operations.

TRIUMF is at a pivotal moment in its life cycle as a major research facility; the lab faces a critical point as it balances the demands of aging and essential infrastructure while seeking to complete and operate new world-class facilities. New requirements are being placed on research institutions through research security and geopolitical concerns, yet Canada has an opportunity to provide global leadership due to internal advantages such as unique capabilities for isotope production, and external factors such as coordination with international facilities as they go into shutdown.

This Implementation Plan outlines how TRIUMF will balance these demands and represents the outcome of extended discussions and consultations through Spring and Summer 2024 with a broad range of stakeholders including internal leadership and research teams, external communities, and TRIUMF governance and oversight structures. These deliberations have led to an Implementation Plan that will ensure the completion and initial operations of both ARIEL, the Advanced Rare Isotopes Laboratory, and IAMI, the Institute for Advanced Medical Isotopes. The completion of these infrastructures, which will require an extended shutdown of the main accelerator, will place TRIUMF in a world-leading position that will be fully exploited through subsequent 20-year vision and five-year planning cycles. The consolidation of the major infrastructure at TRIUMF currently under development will form the foundation of the next phase of TRIUMF's scientific journey.

In summary, this Implementation Plan commits TRIUMF to the following core deliverables:

- Delivery of 5000 hours of radioactive isotope beam to ISAC in the 2029 operational year
- Initial operations of the IAMI facility in 2026
- Ensuring ARIEL is ready for Gate-4A in the TRIUMF project management process in 2027
- Replacement of key components of Beamline 1A, supporting material sciences and isotope production, during planned shutdown periods

These deliverables form the basis of this Implementation Plan. In contrast to previous five-year strategic plans, these deliverables have been tensioned against our awarded funding. Oversight on the delivery of these objectives will be through our university governance structure, through the National Research Council as our funding steward, and through community engagement.

The future of TRIUMF and the Canadian communities we support is bright, facilitated through our enhanced operational funding and new oversight and governance structures.

LETTER FROM CHAIR
Of TRIUMF Board of Governors

On behalf of TRIUMF's Board of Governors, I strongly endorse TRIUMF's Implementation Plan for the Period of 2025-2030.

TRIUMF is at a crucial turning point in its 55-year history. With critical infrastructure needs, emerging regulatory requirements, a challenging geo-political environment, and the possibility of a new federal Major Research Facilities Framework coming into place, these next five years will be critical to the lab's future.

TRIUMF's implementation plan includes market-based compensation for employees and students, addressing critical infrastructure requirements; and promotes operational excellence through the Weft & Warp program designed to enhance processes and systems. This will position TRIUMF for success over the next five years in delivering outstanding scientific research, ensuring the completion of ARIEL and IAMI projects, as well as the refurbishment of critical infrastructure. It provides a solid foundation for TRIUMF to achieve its 20-year vision.

TRIUMF's remarkable progress in recent years reflects the hard work of its community and validates the effectiveness of our new governance model established in 2022. We are incredibly proud of TRIUMF's achievements and eagerly anticipate collaborating with members and partners to drive even greater improvements.

In closing, the Board of Governors is incredibly pleased with the efforts made by the organization to secure its future, and we look forward to TRIUMF continuing to lead Canada's efforts in achieving global scientific excellence.

Sincerely,

Angus Livingstone
Chair, TRIUMF Board of Governors

LETTER FROM TRIUMF
Executive Director and CEO

As Executive Director and CEO of TRIUMF, I am delighted to present TRIUMF's 2025-2030 Implementation Plan: Realizing Canada's Potential. This Plan is the apex of our quinquennial cycle to request federal operational funding and follows the development of TRIUMF's first-ever 20-Year Vision, a successful review of TRIUMF science and operations undertaken by the National Research Council of Canada, and the conclusion of our 5-Year Request for Support to the Canadian federal government.

Previously, TRIUMF had combined requests for support with science and implementation strategies. In this cycle, we have sequenced these various elements to provide greater granularity and to allow us to build on each stage. The 20-Year Vision process collated the scientific opportunities and ambition of our community over an 18-month period, the year-long quinquennial review by NRC demonstrated and re-affirmed the excellence of our existing and future science programme, and our operational funding request to the federal government detailed various scenarios for the next five years of TRIUMF research and infrastructure. In developing our funding request, our team was therefore able to focus on emphasizing and describing in detail the overall outcomes, objectives, and benefits that TRIUMF brings to Canada. Although not fully funded, the outcome of that request for support was a historic increase of 50% in operational funding, securing $399.1M over the next five years. This is a truly wonderful outcome, and a testament to the excellence and hard work of the TRIUMF team and our science and innovation portfolio.

This Implementation Plan is therefore able to take the secured operational funding for TRIUMF over the next five years and marry that to the objectives of both our community and the federal government. Additional consultation with our community, our governance and oversight structures, and internally within TRIUMF ensured that this Implementation Plan and the core deliverables contained therein were informed by the most up to date information. In presenting this funded and informed Plan to the community, our Leadership Team is therefore committing to the delivery of the objectives it sets out.

These objectives include the fundamental principles anchoring our strategic approach: to deliver market-based compensation for our staff and students; to address the infrastructure needs of our facilities; and to implement a culture of operational excellence within TRIUMF. These principles will allow TRIUMF to succeed in delivering world-class scientific research and drive novel innovation, with core infrastructure deliverables including the completion and operation of ARIEL, IAMI, and refurbishment of key infrastructure.

In our success, we have proven that TRIUMF represents a unique and highly important national asset for Canada, and that this understanding is shared across government, our academic networks, and around the world. We are extremely grateful to the federal and provincial governments for their strong and continuing support for TRIUMF's mission and its community, and for this tremendous commitment to scientific research in Canada – for today, and the years and decades to come.

Sincerely,

Dr. Nigel Smith
Executive Director & CEO, TRIUMF

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1. OVERVIEW OF TRIUMF AND OUR REQUEST FOR SUPPORT

1.1 INTRODUCTION

TRIUMF is a national asset. From supporting Nobel-prize winning research that elucidates unknown facets of the Universe, to creating new life-saving drugs and devices, we use our particle accelerator complex and highly skilled community for the betterment of society.

Founded in 1968, TRIUMF is host to over $1.5 billion dollars in large-scale scientific and research infrastructure, including recent substantial investments in two new world-leading research platforms. As a research-oriented, university-owned facility, we operate and develop infrastructure too large for any one organization and drive large-scale collaborative research across the country through close interlinks with faculty. TRIUMF acts at the intersection of academia, government, and industry, and contributes to major national priorities, such as training the next generation of innovators, transferring knowledge to industrial and mission-driven purposes, providing capacity to pivot to shifting needs and priorities, and supporting health care resiliency. This mission has been recognized and endorsed by the Canadian federal government through the allocation of $399.1M for operational support over five years, a 50% increase in the current baseline support TRIUMF receives.

As one of the largest research facilities in the country, we support and drive the Canadian university-based research ecosystem, tackling problems too large for individual universities and addressing fundamental questions in contemporary science. TRIUMF enables Canada to collaborate and compete with other major international facilities in the delivery of world-class science and innovation, and the attraction of top global talent. Domestically, TRIUMF connects other major research laboratories in Canada, underpinning their research programs with our capabilities and technological developments. By giving all our members an equal footing, we help support universities from Victoria to Halifax, providing smaller institutes the ability to undertake large-scale science projects they otherwise could not. The laboratory has become the leading component of the Canadian academic “Big Science” ecosystem. The recent pandemic illustrated that national resilience to emergent crises and risks

relies on a bedrock of scientific and research capabilities, as well as the ability to rapidly deploy these to mission-driven challenges. TRIUMF excels at both, with a dynamic governance and leadership structure and a wealth of expertise, capability, and world-leading research facilities.

A recent government evaluation confirmed TRIUMF's exceptional performance, with the laboratory delivering both significant science and socioeconomic benefit to Canada. Furthermore, the international peer review that took place as part of this process reaffirmed that "TRIUMF demonstrated scientific excellence across all of the areas reviewed," with the laboratory commended for "performing high impact research, developing new technologies, building and operating an expanding array of unique experimental capabilities."

TRIUMF pushes the boundaries of knowledge, creates and commercializes innovative solutions, maintains and operates world-class infrastructure, and inspires and educates some of the brightest minds in the world. Our student training program is one of the most competitive in the country, providing unique opportunities for the development of highly qualified personnel. As a globally sought-after collaborator, we project Canadian leadership and innovation onto the international arena, connecting to national and international laboratories around the world, and translating our research into socioeconomic benefits for Canada.

Through the provision of new infrastructure and the exploration of new techniques and technology, we are entering a new era for Canadian science, with TRIUMF applying its excellence in basic science to other research areas, including contemporary mission-driven challenges. Two new major world-class facilities for radioactive ion beams and medical isotopes will come online during the next five-year period, providing a step-change in capability for Canada to explore new research and innovation areas, develop and produce new medical isotopes, and attract global talent to Canada.

TRIUMF is a national asset and a globally recognized symbol of Canadian scientific and technological excellence.

1.2 KEY THEMES THAT WILL BE ENABLED BY THIS PLAN

To support the Canadian program of world-class science that TRIUMF embodies, this Implementation Plan secures a stable operational platform for the facility. There are five key areas that will be realized through the operational support awarded in Budget 2024:

- **Delivering new infrastructure for research and scientific impact:** The next five-year period will see TRIUMF dramatically increase its output of world-leading science following the completion of two major infrastructure projects that have each been in development for over a decade: The Advanced Rare Isotope Laboratory (ARIEL), a transformative facility that will triple the production of rare isotope beams at TRIUMF; and the Institute for Advanced Medical Isotopes (IAMI), a cutting-edge life sciences centre and incubator for new medical isotope development. To ensure these facilities are completed and delivering impact within the next five-year period, TRIUMF will be implementing an extended 16-month main accelerator and beam shutdown to marshal necessary resources. Together, these new large-scale facilities, valued at approximately $250M, ensure Canada remains at the very forefront of this highly competitive branch of global research, with potential outcomes ranging from Nobel-winning fundamental science breakthroughs to the possible curing of a range of terminal illnesses, including several types of untreatable cancer.

- **Ensuring operational excellence:** As a high-profile national asset, it is imperative that TRIUMF maintain compliance and operational excellence across its spectrum of programs. This Implementation Plan aims to ensure TRIUMF fulfils the increasing regulatory compliance and

oversight requirements that the laboratory is subject to, including accounting for geopolitical considerations and actively managing research and cybersecurity.

- **Training the diverse talent of tomorrow:** A major objective of the next five-year Plan is to ensure TRIUMF retains the staff complement to operate the laboratory and new infrastructure effectively and efficiently. The implementation of a market-competitive compensation plan will not only ensure TRIUMF is able to deliver on its infrastructure and science objectives but also enhance the laboratory's ability to develop a pipeline of talent, both for internal requirements and for growing Canada's innovation ecosystem. The objective is to ensure TRIUMF and Canada remain a global attractor for top talent in this sector.

- **Refurbishing legacy facilities:** Commissioned in 1976, many TRIUMF facilities are approaching 50 years in operation. As such, there is a critical need for deferred maintenance beyond regular operations and repairs. This infrastructure is still in active use and is required as drivers for the operation of TRIUMF's newest facilities, such as ARIEL. The awarded funds for the next five years will allow some aspects of this deferred maintenance to be addressed, specifically critical components in a core beamline for material science and radioisotopes, maintenance of the foundational 520 MeV cyclotron, and the replacement of an electrical sub-station that provides power to the laboratory. TRIUMF will aim to complete as much as this work as feasible during the extended shutdown to limit the impact on science once beam delivery resumes in 2027.

- **Evolving TRIUMF's program towards the future and addressing societal challenges:** Alongside the infrastructure and operational improvements targeted for the next five years, TRIUMF will also take the first steps towards achieving the goals in its 20-Year Vision. Complementing the new frontiers of science that will be unlocked with ARIEL and IAMI, we will initiate the first steps towards mission-driven centres of excellence in areas such as quantum, green technologies, detectors, and data/artificial intelligence will be supported through internal redeployment of resources and talent, as possible. These centres will enable Canada to innovate and respond to emergent challenges quickly and effectively. TRIUMF has a legacy of world-leading expertise in discovery science and the development and application of new techniques and technologies, which will be applied to address major contemporary societal challenges.

1.3 HIGHLIGHTS OF ANTICIPATED WORLD–LEADING SCIENCE AND INNOVATION OUTPUTS

Our globally unique infrastructure provides Canada the opportunity to host and deliver world-leading science, with research capabilities that reinforce our status as a sought-after international collaborator and destination of choice. Domestically, this science is primarily supported through tri-council grant-driven research, with 80% of Canadian sub-atomic research involving TRIUMF. As described within this Plan, to achieve the primary goals of completing new infrastructure in ARIEL and IAMI, we will be taking an extended shutdown of the main cyclotron complex in 2026. Nonetheless, we anticipate delivering world-leading science and innovation over the five-year period covered by this Implementation Plan, especially as those infrastructure come on-line.

Key scientific highlights to be delivered by this Plan, many of which are detailed later, include:

- The completion of the ARIEL facility provides two additional targets for rare isotope production, one electron target and an additional proton target. This allows more efficient use of our Isotope Separation Online (ISOL) facility, but also the ability to run longer experiments currently disfavoured due to operational time. These additional capabilities will allow our nuclear astrophysics and nuclear structure programs to evolve substantially, addressing new r- and i-processes for elemental production in stars, and nucleon structure studies.

- The completion of the IAMI facility and startup of operations in both production and research. IAMI, coupled with existing resources and industrial partners new and old, will enable the development of new radiochemical processes and radiopharmaceutical drugs. These include actinium-225-labelled compounds for targeted alpha therapy, leading to new life-saving technologies that will be optimized for safe and efficient clinical translation, transitioned to production scale, and distributed by our commercial partners to deliver innovative treatments to patients in Canada and around the world.

- Testing the limits of the Standard Model of particle physics and shedding light on one of the greatest challenges in physics, the matter-antimatter asymmetry in the universe, by studying the electric dipole moment of the neutron and of radioactive molecules, only possible due to TRIUMF's unique combination of infrastructure and capabilities.

- Leveraging our expertise in superconducting radio frequency acceleration and beam physics to deliver international commitments for new accelerator components and operation in the high luminosity (Hi-Lumi) upgrade of the Large Hadron Collider (LHC) in at CERN in Geneva; and for the new billion-dollar Electron Ion Collider accelerator complex being developed at the Brookhaven National Laboratory in the US.

- Driving and supporting physics exploitation of the ATLAS experiment at CERN, leading the construction of the ATLAS inner tracker upgrade; and maintaining the central CERN Tier-1 data storage and analysis systems, supporting the largest sub-atomic physics research collaboration in Canada.

- Securing Canada as the host of the next-generation neutrino-less double-beta decay detector, continuing the legacy of Canadian leadership in the neutrino sector and illuminating the fundamental nature and properties of these elusive particles.

- Applying our expertise in scientific computing to develop novel applications of machine learning and other techniques, which will optimize the use of our accelerator beams and our science and support the development of a greener facility.

- Exploring new technologies and techniques to develop and improve quantum and green technologies such as materials research, quantum sensors, fusion energy, small modular reactor component testing, accelerator-driven systems to convert nuclear reactor waste into energy, and real-time water quality monitoring for remote communities. These technologies provide opportunity for intellectual property development and commercialization.

Figure 1: TRIUMF's research activities

1.4 CONNECTION TO TRIUMF'S 20–YEAR VISION

Released in October 2022, TRIUMF's 20-Year vision articulates our future potential and that of the various communities we support, as shown in Figure 1. It signals our ability to undertake world-leading research and translate our capabilities for societal benefit and commercial opportunities.

Our 20-Year Vision leverages past investments by government and builds on our strengths to deliver a new level of top-tier science, training, and innovation for Canada. It was developed over an 18-month period in full consultation and collaboration with a broad stakeholder group, including our research community, university members, and national and international research partners. Following a detailed 'bottom-up' process articulating the scientific and innovation ambitions of the research community, this was consolidated into core key themes that position TRIUMF to become:

- **A global leader in discovery science, delivering breakthroughs that unlock the deepest mysteries of the universe:**

  Strengthening Canada's leadership in ground-breaking particle and nuclear physics.

- **A world-class accelerator centre driving use-inspired research – from the life sciences to quantum and green technologies:**

  Leveraging our unique infrastructure to pursue research in Canada that will change the world.

- **An inclusive multidisciplinary talent incubator, attracting and developing the best people from around the world:**

  Producing Canada's future science leaders and innovators.

- **A leader in a flourishing national Big Science ecosystem:**

  Catalyzing the success and growth of Canada's network of major research facilities.

- **A national innovation hub translating discovery science into health and sustainability solutions:**

  Responding nimbly to complex societal challenges for the benefit of Canadians.

This Implementation Plan is the first step in realizing our bold vision, realigned to the awarded operational funding level. As the first stage of delivering the longer-term vision, this five-year Implementation Plan lays the groundwork by completing and operating new world-leading research infrastructure with ARIEL and IAMI, delivering world-class science, and fostering leading talent from around the world. Given our awarded operational funding, we will endeavour to consolidate research themes around green and quantum technologies and enhance our ability to deliver innovative solutions for socioeconomic impact, through internal resource redeployment.

1.5 THE TRIUMF ORGANIZATION

TRIUMF operates as an incorporated not-for-profit owned by a consortium of 21 Canadian member universities who assume ultimate liability for the laboratory's eventual decommissioning. The incorporation of TRIUMF occurred in June 2021, with the new governance structure now embedded in TRIUMF oversight and operations. Leadership of TRIUMF is through an executive Leadership Team led by the Executive Director and CEO, who is accountable to a skill-based Board of Governors, including external governors, providing a broad range of expertise. The Board is supported by appropriate sub-committees which have external subject matter experts appointed. The Board is appointed by representatives of university Members, who collectively form the

Members' Council. Complementing this skills-based governance board, a Science Council – comprised of appointees from the Members and TRIUMF – also support the Board with scientific guidance and direction from TRIUMF's various research communities.

TRIUMF's current funding model is unique within the Canadian system. Predating other funding mechanisms, such as those administered by the Canada Foundation for Innovation, TRIUMF's operational funding comes in five-year tranches via direct allocations in the federal budget which flow through the National Research Council (NRC) via a Contribution Agreement. In the new governance structure, the Executive Director is empowered by the Members to sign the Contribution Agreement on their behalf, thereby reducing administrative overburden. This is the only funding mechanism available to support core operations and the development of central capacity for research, which make up approximately two-thirds of TRIUMF's total revenues of approximately $100M annually. All other public funding sources, both federal and provincial, are fully restricted, typically reserved for research or project activities. As compared to its international peers, TRIUMF also generates a significant proportion of its revenues from engagement with the private sector; however, the majority of these funds are used to cover project or operational costs due to shortfalls in the five-year requests or the ineligibility of certain expenses (e.g., capital construction) under the NRC funding arrangement.

This Implementation Plan details the response of TRIUMF to funding awarded in the 2024 federal budget for the period April 2025 – March 2030. Historic levels of operational support were provided by the federal government following substantial engagement from TRIUMF, our community and stakeholders, totalling $399.1M over the five-year period. The NRC provides significant oversight on the use of the federal government funds as part of its responsibility for managing the Contribution Agreement, through quarterly reports, financial projection and expense reports, a quinquennial major evaluation of TRIUMF, and biannual meetings of the NRC Agency Committee on TRIUMF (ACOT). ACOT also provides recommendation to TRIUMF on the delivery of its program and systems.

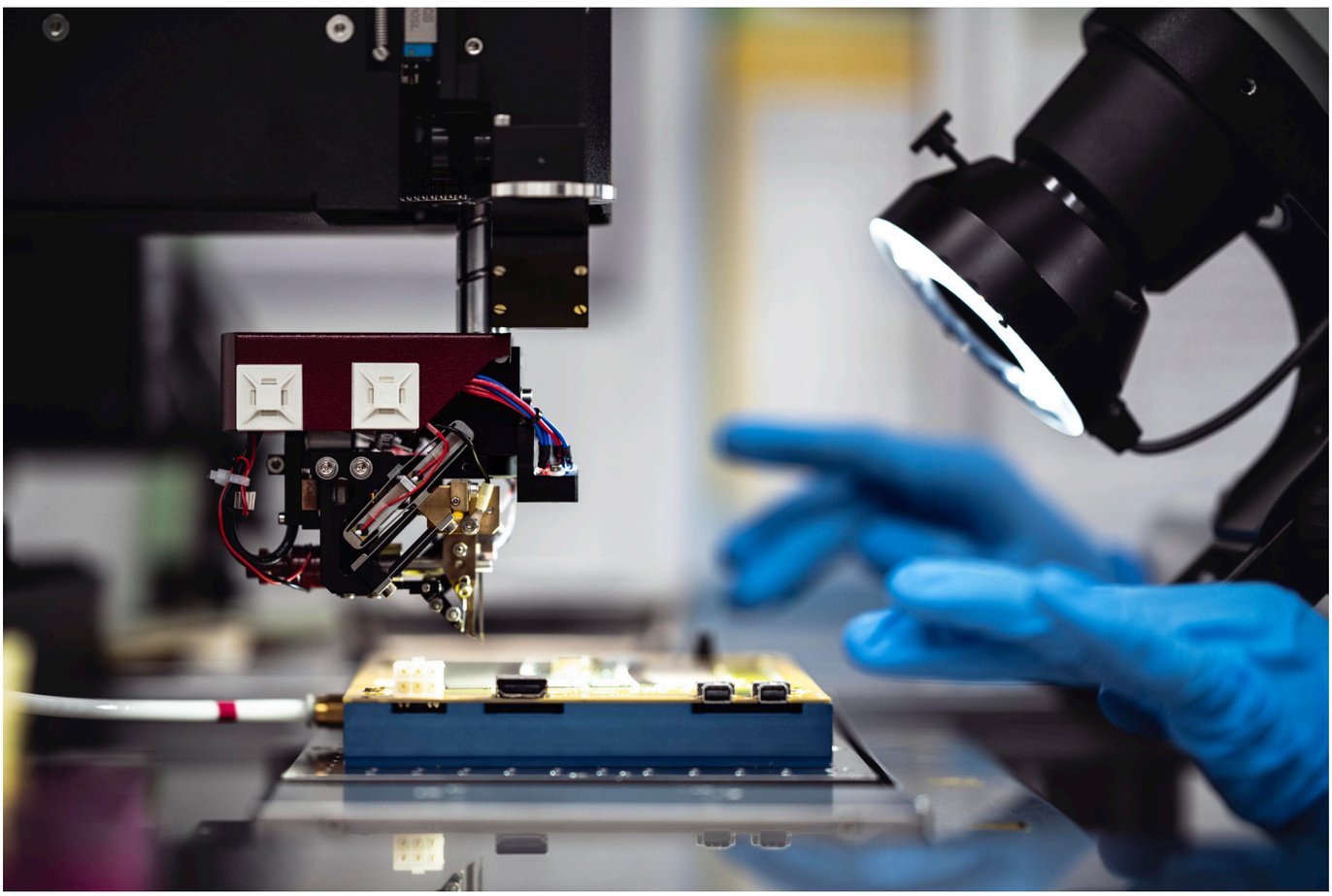
The uniqueness of TRIUMF's funding structures means that it stands alone in the broader ecosystem, with few viable options within the current model to address major challenges. For instance, while TRIUMF has existed as an active concern since its founding over 55 years ago, the current model of a sun-setted project provides limited assurance of long-term sustainability, which does not align with the long timescale and operational commitments associated with the type of research undertaken at the laboratory. Beyond the risk of being precipitously shut down at the end of each five-year cycle, the fact that the lifecycle costs of new facilities, infrastructure renewal, and economic contingencies are not built into operational funding severely and negatively impact TRIUMF's success and the benefits it can deliver to Canada.

However, many challenges faced by TRIUMF are also shared by a series of smaller, but similar facilities across the country. Taking a unified approach to addressing the common challenges faced by Canada's major research facilities – while maintaining sensitivity on the unique nature of each – would create a critical mass around Canada's approach to "Big Science", enhancing coordination, reducing redundancies, and returning added value to the country. This approach has been articulated within the reports of the 2017 Fundamental Science Review (Naylor) and the 2023 Advisory Panel on the Federal Research Support System (Bouchard). As a response to these reviews, the 2024 federal budget provided welcome additional resources to the Canadian research ecosystem, including fellowship and tri-agency funding, and direct allocation to several Canadian major research facilities, in addition to the TRIUMF support detailed above.

1.5.1 OVERSIGHT AND EXECUTION OF THE IMPLEMENTATION PLAN

Following the model described above, oversight of the delivery of this Implementation Plan will be through two primary channels: regular reporting to the Board of Governors, and through regular reporting to NRC and ACOT. The Board of Governors will be supported by the Science Council and will ensure infrastructure deliverables and scientific, commercial and innovation priorities are appropriately managed.

Accountability for the delivery of objectives within the Implementation Plan resides with the Executive Director and the Leadership Team at TRIUMF. Execution of the Plan will be through the Senior Management Group. who will be responsible for managing resources and deliverables. This will be especially important during the first two years of the Plan, as TRIUMF prepares and then executes on the extended shutdown of the main cyclotron and associated systems. The anticipated delivery structures for these key deliverables are articulated further in Section 4.6.



2. TRIUMF AS A NATIONAL ASSET

TRIUMF is Canada's particle accelerator centre and an international hub for discovery and innovation. For over 50 years, we have been advancing fundamental, use-inspired, and interdisciplinary research for science, medicine, and industry. We will continue to address fundamental and emerging challenges in these areas, including health, environment, energy, and green materials. TRIUMF's state-of-the-art accelerator complex – featuring the world's largest cyclotron and the most powerful superconducting electron linear accelerator for the production of radioisotopes – is the foundation upon which our competitive advantage rests. It is a magnet for attracting leading talent to Canada. Further, over 50 years, TRIUMF has developed core expertise in accelerator systems, including the ability to manage high particle beam currents; high power targets for producing intense beams of radioisotopes; particle detector and data acquisition systems; and data management and analysis for the large data sets collected from our experiments.

TRIUMF's current core programs exist in the areas of accelerator science, nuclear physics, particle physics, molecular and materials science, and life sciences – with strategic focus applied to growth in new areas advocated from community discussion, such as quantum and green technologies, as we progress through the laboratory's inaugural 20-Year Vision, which was released in 2022. This growth will be supported by the new infrastructure that will come online during the next five-year period. We are home to more than 600 staff and students, whose broad scope of knowledge and expertise provide us with the capacity to answer fundamental questions beyond the reach of any single academic institution.

Critically, TRIUMF also has strong legacy of excellence that anchors Canada's reputation in many of the fields that the laboratory supports. A comprehensive evaluation conducted by the NRC in 2023 found TRIUMF to be a high-performing and an "agile organization with leadership that keeps a pulse on evolving scientific and technological needs worldwide." This sentiment was further articulated by an international Peer Review Committee (PRC) that found "TRIUMF demonstrated scientific excellence across

all of the areas reviewed and is on a good trajectory to achieve the goals laid out in its twenty-year vision." Our research impact was demonstrated clearly through a bibliometric analysis showing a highly collaborative environment with citation impact greater than twice the global average, amplifying Canadian university research with tremendous effect.

Supported by a modern governance structure and robust oversight mechanism, TRIUMF is well-positioned for the future, with the PRC concluding that "TRIUMF has the capacity, competencies, and facilities to achieve its objectives moving forward."

With world-class talent and "unique infrastructure that enables significant contributions and meets the research needs of the Canadian physics community," the NRC evaluation found TRIUMF to enable and deliver scientific excellence; to drive social and economic impact through research, innovation, and skills training; and to help maintain Canada's relevance in the global science ecosystem.

2.1 DELIVERING IMPACT FOR CANADA

Although located in Vancouver on the campus of the University of British Columbia, TRIUMF is truly a national endeavour operating on the international stage, with the laboratory engaging a network of 21 Canadian universities spanning coast to coast. This broad-based and inclusive structure has produced an environment which enables community-driven, large-scale multidisciplinary research in a manner that is nationally unique. The benefit and value that TRIUMF affords the university sector was clearly reaffirmed when all members rejoined TRIUMF following our recent transition from a joint venture to an incorporated entity. In total, TRIUMF plays host to over 1000 users per year from across the country and around the world, all of whom come to the laboratory to take advantage of the unique collection of infrastructure and talent that has been curated on our site over the last half-century.

TRIUMF contributes to the broader national prosperity in many ways, from driving discovery and innovation to developing talent and skills. We have a history of excellence in fundamental science, supporting core programs in particle and nuclear physics, accelerator-based science, nuclear medicine and isotope science, and materials science. We also translate science into innovations that benefit Canada, from transferring superconducting and radiation detection technology to local industry, to developing novel processes for producing life-saving medical isotopes and new tumour irradiation technologies, as well as new technologies that make mining greener and more cost-efficient. And, over the decades, we have trained generations of discoverers and innovators, equipping them with the skills needed to keep Canada competitive in the global knowledge economy.

Offering world-unique infrastructure and leading talent, TRIUMF is positioned at the nexus of government, academia, and industry – collaborating and providing skills and expertise beyond what any of these groups could do alone. With agility and comparative independence, TRIUMF has proven its ability to rise to challenges and leverage our science for impact. For example, in response to global shortages for a critical medical isotope, technetium-99m, a TRIUMF-led consortium – with support from the federal government – developed an alternative production process, taking this technology all the way from concept to a successful spinoff company, ARTMS Inc, which has recently been bought out by an international company. Today, this technology provides essential supply chain stability for technetium-99m, and novel opportunities to produce new and innovative isotopes for healthcare. Another TRIUMF spinoff company, Ideon Technologies, leads an international collaboration supported by the national Digital

Supercluster, coupling TRIUMF-invented particle detection technology with artificial intelligence to create an “Earth x-ray” to as much as one kilometre below the earth’s surface. The COVID-19 pandemic has also highlighted the requirement of having resilience within the national research and development ecosystem. In this case, TRIUMF – alongside several other Canadian major research labs – worked together to rapidly design, prototype, and move to market a new type of ventilator to assist in the pandemic response, within an unprecedent timeframe of just 6 months. This endeavour would not have been possible without the laboratory’s community of expert scientists, engineers, and technicians, and its major research infrastructure coupled to a dynamic and agile governance and leadership structure.

Through its commercialization arm, TRIUMF Innovations, TRIUMF has played a leading role in the establishment of the new Canadian Medical Isotope Ecosystem (CMIE), supported by the Strategic Innovation Fund program to build new national ecosystems for producing and commercializing medical isotopes. This initiative brings together public and private sector leaders including CNL, Bruce Power, McMaster University, and the Centre for Probe Development and Commercialization to accelerate and advance Canada’s position in the fast-growing medical isotope sector.

Beyond emergent needs, TRIUMF’s programs can also seed upstream research with clear societal benefit that would not be possible without the unique infrastructure and multidisciplinarity inherent in the laboratory’s operation. For instance, leveraging decades of accelerator and life sciences expertise and proven ability to work successfully with industry partners, TRIUMF has been able to make world-leading breakthroughs in the production of novel technologies and radiopharmaceuticals for the treatment of various cancers, dramatically improving health care outcomes for patients across Canada and beyond. TRIUMF has been producing isotopes for patients for over 40 years and currently produces more than 1.5 million doses per year annually, delivered to patients in Canada and around the world. Moving forward, TRIUMF’s 20-Year Vision charts a path whereby the laboratory will leverage its base of expertise to make strategic engagements in sustainability and green technology to help combat the global threat posed by climate change.

The breadth of infrastructure and research at TRIUMF provides a unique training opportunity for Canadian and international talent. This includes the research community itself, which attracts global talent to Vancouver, but also in the technical and administrative areas required to support such an endeavour. This includes the specialized personnel and engineers required to maintain the research and conventional infrastructure, to design and build the unique and often bespoke components required for research, and the management and administrative services needed to deliver the research program. TRIUMF is home to one of the most sought-after co-op student programs in the country, which is oversubscribed by a factor ten and trains more than 150 students per year. Similarly, our technical teams are a key part of a pipeline for Canadian industry, with personnel having the opportunity to gain experience in a world-class, multidisciplinary facility.

Furthermore, TRIUMF’s work can also help address systemic societal challenges, particularly those within Canada’s science, technology, engineering, and math (STEM) research communities and beyond. Taking a leading role in developing the next generation of leaders, TRIUMF is uniquely positioned to foster a culture of equity, diversity, and inclusion across disciplines and programming in Canada, with the objective of creating a laboratory that more accurately reflects the makeup of Canada itself. Steps are also underway to embed a reconciliation framework within both the organization itself and the work we conduct.

2.2 TRANSLATING SCIENTIFIC DISCOVERY INTO COMMERCIAL OPPORTUNITIES

TRIUMF Innovations Inc. is the business interface and commercialization arm of TRIUMF, acting as a portal into TRIUMF and its network for the private sector world of industry partners, customers, and investors. Through TRIUMF Innovations, companies can access the multidisciplinary expertise, world-class infrastructure, and global network at TRIUMF to:

- Create life-saving nuclear medicine technolgies, including new diagnostics and radiotherapeutic treatments.
- Commercialize particle detector technologies for use in sectors ranging from fusion energy, mining, and security to oil and gas.
- Radiation-test new technologies for small modular reactors, computing, communications, and aerospace electronics.
- Develop and validate new technologies in emerging areas like quantum and green technology using TRIUMF's global network of top researchers.

TRIUMF Innovations' business team brings new discoveries to market through industry partnerships, licensing, and start-up companies. TRIUMF Innovations identifies, assesses, develops, incubates, and commercializes technologies in collaboration with partners in industry, academia, and government. To date, six spin-off companies have successfully gone to market, with more in the pipeline. TRIUMF Innovations helps navigate business challenges, including intellectual property management, fundraising, and scale-up.

A Commercialization and Entrepreneurship Training Program is equipping our people with the skills necessary to accelerate innovation. Through a range of courses, workshops, and individual mentoring programs, TRIUMF Innovations provides effective, hands-on business training to Canada's research community.

In addition, TRIUMF Innovations also functions as a hub to connect private sector partners with TRIUMF's national network of top researchers and institutions. For example, the federal Strategic Innovation Fund is supporting the new Canadian Medical Isotope Ecosystem (CMIE), co-led by TRIUMF Innovations and the Centre for Probe Development and Commercialization. This initiative provides matching funding to innovative new medical isotope projects from McMaster, CNL, Bruce Power, as well as from academic researchers and small / medium enterprises from across Canada. Five new Canadian startup companies have received funding from the $5M CMIE Development fund to date.

3. FINANCIAL PLANNING MODEL FOR THE IMPLEMENTATION PLAN

TRIUMF articulated the operational funding requirement for delivering the first five-year phase of the 20-year vision in a Request for Support to the federal government. As with past funding cycles, TRIUMF's operations are supported in five-year tranches via direct allocations in the federal budget that flow through the NRC. This funding stream is the only mechanism available to support core operations and essential components of the laboratory's capacity for research. Beyond federal support, there is no viable alternative funding source to cover TRIUMF's operational needs, as there is neither capacity nor precedence to transfer this responsibility to another source, such as provincial governments or industry partners.

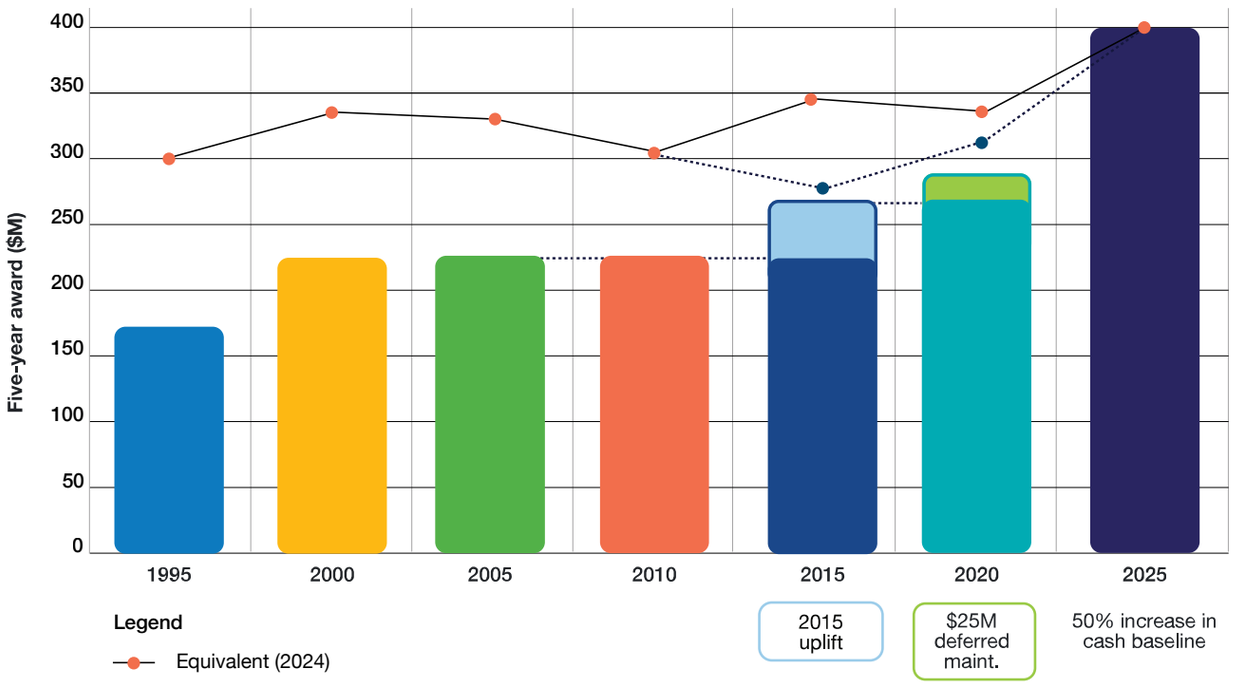
The Request for Support included three non-negotiable principles that were enshrined based on discussions with the Board, which have been carried forward into this Implementation Plan:

- Improving staff and student compensation by developing a market-based compensation philosophy to attract and retain talent
- Addressing major deferred maintenance needs, including accelerator maintenance and core facility infrastructure
- Developing and entrenching "operational excellence" into TRIUMF culture, including regulatory compliance, OH&S, program management, and operational consistency across the organization (see Section 4.5)

The Request for Support was for $450M in operational support over five years and outlined three additional scenarios which included sub-optimal outcomes between $300M and $400M, detailing the impact and implications of not receiving the requested level of support. These implications included loss of staff, loss of opportunity through delayed or deferred infrastructure development (ARIEL and IAMI), loss of science and commercial work, and loss of national and international reputation.

As a response to our Request for Support, the federal government allocated $399.1M over the five-year period April 2025 – March 2030. This is an historic level of operational support and represents a 50% increase in

Figure 2: TRIUMF funding levels (all 5-year awards)



baseline operations and the first significant lift in indexed support since 1995, as shown in Figure 2 below, despite a significantly expanded science and innovation portfolio.

The financial planning model used for the Request for Support took a holistic approach to the revenue and expense streams to ensure there was full visibility of the assumptions within the Plan. This was even though the request itself was for purely operational costs (primarily staff). This model has been carried forward into the Implementation Plan, and the financial model for the next five-year cycle thus utilizes 3 main revenue streams:

- Federal support through the NRC, focused on operations
- Grant funding (primarily tri-agency, CFI, and provincial) which is focused on research and developing capacity for research, including capital development
- Commercial Funds including Intramural and General Funds

The expenditures within this planning model are broken down into Operations, Capacity for Research, and Research.

- **"Operations"** isolates those categories (revenue sources & expenses) specifically required to sustain the laboratory. This includes the bulk of the operational staff compensation costs, power and utilities, insurance, maintenance and repair costs, critical deferred maintenance and repairs. Staff compensation accounts for two-thirds of these costs. This section includes funding revenue from such streams as the NRC line, CFI Infrastructure Operations Fund, Intermural TRIUMF House, and investment returns.
- **"Capacity for Research"** funds infrastructure, the ability to develop new capabilities, and TRIUMF's Board Appointed Employees (BAEs).

Of note, NRC currently funds BAEs and these are purposely not placed under the operations category (to align with anticipated Major Research Fund reporting processes). Other revenue categories include the CFI Infrastructure Fund, provincial funding for specific projects (e.g., IAMI), BWXT cost recoveries, and specific sections from the Commercial Fund which include Royalties, Proton & Neutron Irradiation Facilities (PIF & NIF) and work for others. This ensures that the returns from general commercial work are reinvested in the facility infrastructure and developments to enhance our capacity to do research.

- **"Research"** isolates revenues and expenses associated with actual research projects, whatever the source of funding, and includes commercial and innovation projects. It consists of tri-agency funding, affiliated funding, and any aspirational or new business from TRIUMF Innovations' commercial activity.

Following the announcement of the federal funding award and using this holistic approach to the funding model and forecasts, TRIUMF's Leadership Team developed three scenarios that fit within the overall anticipated financial envelope and incorporated the non-negotiable elements discussed above. These scenarios addressed different high-level objectives for the organization and,

Figure 3: Staffing requirements (FTE years) across the proposal categories. Full award supports 2309 FTE years over the five-year period, representing 66% of the federal award

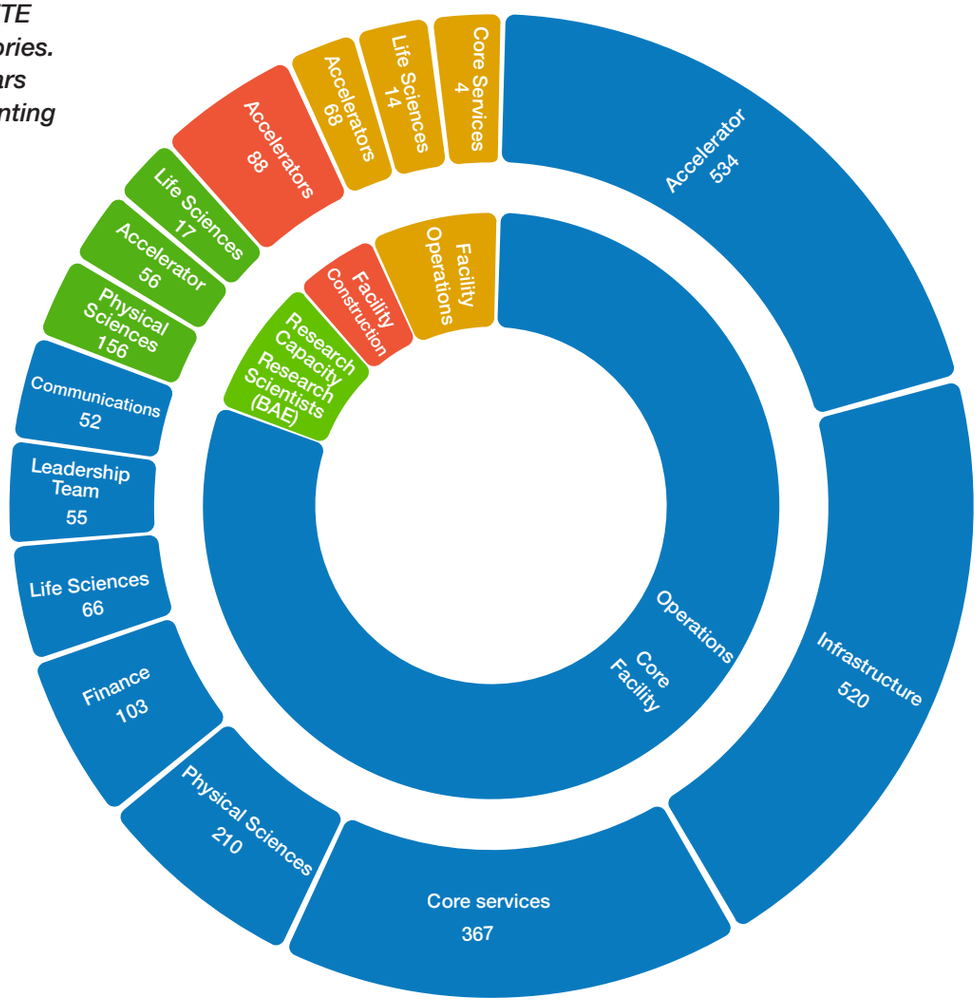
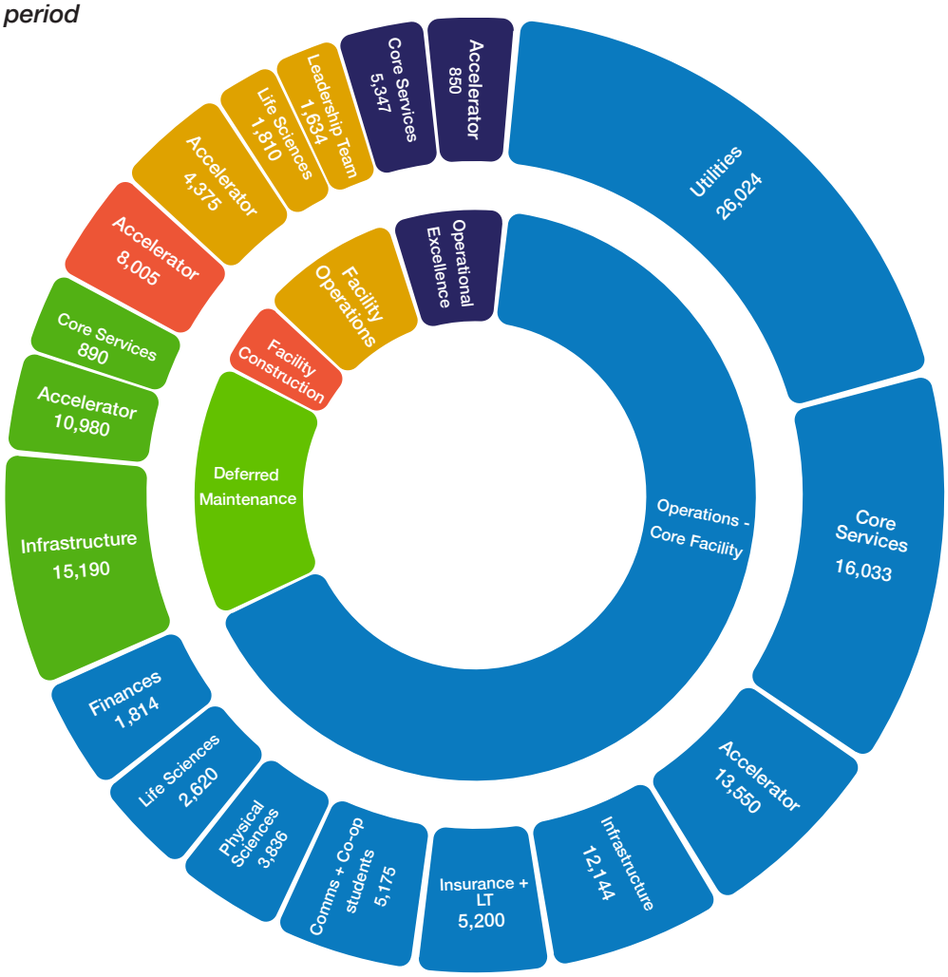


Figure 4: Resource requirements ($M) across the proposal categories. Full award supports $135M over the five-year period



as discussed in greater detail in Section 8, were used for substantial engagement with our community and oversight and governance structures. The outcome of this consultation and deliberations by TRIUMF was the development of the high-level objectives described within this Plan. The delivery of these objectives requires the extended shutdown of the main accelerators to create sufficient resource capacity, given the reduction from the Request for Support and the additional Board requirement that commercial revenue not be applied to Operations.

The output from these deliberations also created a financial model and plan for the five-year period, across all funding and revenue streams. The breakdown of the use of the projected five-year federal support is provided in Figures 3 and 4, for staffing requirements across the organization and resource requirements respectively. These figures show the breakdown within the categories of operations and capacity for research, as no NRC support is targeted directly to research costs.

4. DEVELOPING CAPACITY FOR RESEARCH

During the period from 2025 – 2030, two new major infrastructure investments on the TRIUMF campus will come to fruition. The $250M investment in the ARIEL and IAMI facilities will provide TRIUMF with capabilities that will generate world-leading research for many years to come, and benefit society through newly generated knowledge and upstream innovations. Therefore, this Implementation Plan will ensure the completion of these constructions; commission the infrastructures; and transition to initial science operations.

As our major priority, reaffirmed through discussion with ACOT and our research and governance communities, the ongoing construction of ARIEL has required the de-prioritization and deferral of other science projects through our internal program management processes. The current objective for ARIEL is the transition to the commissioning phase in 2027, delivering the capability to increase TRIUMF's science output by providing three targets for radioactive ion beam production from 2028 onwards, with the delivery of 5000 hours of radioactive ion beam time in 2029. With the budget allocation of $400M, the anticipated additional new staff required to reach this goal cannot be hired directly and hence the workforces must be seconded from TRIUMF staff that are responsible for the operation of the TRIUMF accelerator complex. To first order, the total integrated work effort required to complete the ARIEL program has not changed between the initial estimation at conception and the current projections. The project team is therefore confident that the required resources can be made available in a 16-month long shut down in 2026 and 2027.

This five-year Plan prioritizes activities that can be supported by TRIUMF, given the operational funding awarded. High priorities are assuring the core operation of the TRIUMF accelerator complex, enabling incremental accelerator upgrades for priority performance and reliability enhancements, along with the commissioning and initial operation of the additional ARIEL related facilities. These priorities mitigate operational risks, gain efficiency, and expand the capabilities the new infrastructure will provide. Initiatives will address deferred maintenance of the 520 MeV cyclotron, the proton Beamline 1A (BL1A)

and ISAC, improve the operational performance, and maintain the accelerator systems at their highest performance level. In addition, the increase in efficiency of the accelerator operation using advanced beam instrumentation developed for ARIEL and automatic beam tuning and machine learning will be a hallmark of the ARIEL era, delivering a high return on investment that also produces world-unique science output. However, with the reduction of the operational budget, the ramp-up of beam delivery to the 9000 RIB hours per year anticipated in full ARIEL operations will need to be deferred to the next five-year period.

The first phase of IAMI is currently in final outfitting, with the expectation that the Phase-II projects will be completed during the next five-year period – with the commencement of operations of IAMI in 2026 being one of the core deliverables TRIUMF is aiming to achieve. Phase-I work has provided the building, core infrastructure and services, and the implementation of the TRIUMF TR-24 cyclotron, which will be primarily used for research and development purposes. The Phase-II work includes projects to complete outfitting for the radiochemistry laboratories, and the inclusion of an additional cyclotron from BC Cancer. All projects are interlinked due to shared services within the IAMI facility, driving the desire to complete construction simultaneously across other phases.

Following construction of ARIEL and IAMI, we will transition both facilities to commissioning and operational phases. Operations of the ARIEL's superconducting e-linac, the rare isotope producing target stations, and the new beamlines will require resources beyond the construction level. Efficiencies are planned through the consolidation of the control centres for the accelerators (which will use common control systems), new automatic tuning technologies including the driver accelerators, and the standardization of electronics components for all accelerator systems.

4.1 PROBING FUNDAMENTAL SCIENCE USING A MULTIDISCIPLINARY FLAGSHIP RESEARCH FACILITY— ARIEL

TRIUMF's international reputation for high profile science is driven by its unique rare isotope production capabilities. As evidenced from our experiment selection committees, the demand for beam time from experiments using rare isotopes exceeds the capacity by an order of magnitude. The Advanced Rare Isotope Laboratory (ARIEL) is Canada's answer to the requests from the science communities to provide more beams for leading-edge multidisciplinary research.

Funded by the Canada Foundation for Innovation (CFI), as well as six provinces, and with backing from 21 universities, construction of ARIEL has progressed in two major stages. The first stage (2010-2014) included the construction of the ARIEL outer building envelope, as well as development and construction of a superconducting electron accelerator (e-linac), which produced its first accelerated beam in 2014. The second stage (2017-2027) involves the construction of the two target stations, associated infrastructure in the target hall and laboratories, hot cell infrastructure, as well as the rare isotope beam transport beamlines, mass-separator, and an electron-beam ion source for charge state breeding. Additional beam delivery infrastructure, like the high-resolution mass separator and the charge state breeder, was funded in a separate CFI project (CANREB), which has been commissioned and will operate at full performance in 2027.

ARIEL is one of the world's only purpose-built, multi-user rare isotope facilities, as well as the world's most powerful ISOL complex. ARIEL will enable world-class research on the nature of atomic nuclei, the origin of the heavy chemical elements, the study of quantum materials and biomolecules, as well as the production of medical isotopes for the imaging and treatment of disease. It will greatly expand TRIUMF's rare isotope

program by providing more exotic isotope species with very high intensities and by adding two production targets in parallel to the existing ISAC target station. Together, the planned completion of ARIEL in 2026/27 will allow TRIUMF to fully exploit the numerous existing experimental facilities at a time when CERN's ISOLDE facility, the next leading competitor to TRIUMF, will be shut down for maintenance. This fortuitous timing presents Canada with a unique opportunity to seize global leadership of science and research in this space.

At the heart of ARIEL is a built-in-Canada superconducting e-linac for isotope production via photo-nuclear reactions like photofission, as well as a second proton beamline from TRIUMF's cyclotron for isotope production via proton-induced spallation, fragmentation, and fission. ARIEL employs next-generation target stations and associated infrastructure. The development of these systems was guided by many lessons learned from ISAC at TRIUMF and other major ISOL facilities worldwide. A new advanced rare isotope beam preparation system (the completed CANadian Rare-isotope facility with Electron Beam ion source, CANREB), will in future allow the parallel operation of three rare isotope beams. The ability to run three targets will allow more science experiments to be executed but will also change the nature of the projects that can be undertaken at TRIUMF – especially those experiments that require long run times, which are currently disfavoured as the experiment selection process looks to maximize the science yield from the single ISAC target. Furthermore, the installation of a symbiotic target in the beam dump of the ARIEL proton target station will enable the production of high-value medical isotopes, such as actinium-225 for targeted radionuclide cancer therapy, using unspent energy from particle beams. Although actinium-225 is being produced at the Isotope Production Facility on Beamline 1A (noted below in 4.3), world demand far outstrips current global production capacity, and the addition of this second beam dump production facility will enhance TRIUMF's ability to support these health benefits for society.

4.2 A WORLD-CLASS CENTRE FOR DEVELOPING LIFE-SAVING RADIOISOTOPES — IAMI

Building on TRIUMF's 40-years of experience in nuclear medicine and life sciences, the Institute for Advanced Medical Isotopes (IAMI) will be a major new part of the TRIUMF life sciences program for research into next-generation, life-saving medical isotopes and radiopharmaceuticals.

The IAMI facility, located on the TRIUMF campus, convenes an interdisciplinary community of TRIUMF faculty and students, research partners, government stakeholders, and industry collaborators into a new frontier of medical isotope development for both health research and clinical use. IAMI comprises an integrated series of labs and a TR24 cyclotron, one of the most technologically advanced commercial cyclotrons in the world (the TR refers to a TRIUMF design manufactured by a commercial cyclotron company, ACSI, in Richmond, BC; the 24 refers to the 24 MeV energy of the protons accelerated.) Providing capability for both isotope production and extraction through radiochemistry laboratories and Good Manufacturing Practice (GMP) capable facilities, IAMI will be able to span the full spectrum from medical isotope production through to separation, to labelling of radiopharmaceuticals, to human injectable doses. This capability will facilitate the development of clinical trials, bringing life-saving cancer treatments to Canadians and the world, and open the potential for incubating new companies. Within the context of the expertise and surrounding infrastructure at TRIUMF, IAMI will be one of the most versatile and potent medical isotope and radiopharmaceutical research facilities in the world. In tandem, BC Cancer is installing a second cyclotron in IAMI, an 18 MeV GE machine, to provide additional support for production of radioisotopes used in PET scanning, which will provide additional diagnostic capacity and redundancy for the BC health ecosystem.

IAMI will significantly increase Canada's capacity for the sustainable and reliable production and distribution of medical isotopes currently critical for Canadian health research and clinical use, including technetium-99m, fluorine-18, and novel radio-metals. It will synergize the Vancouver region's diverse nuclear medicine sector, acting as a research hub and centrally managing the production of radioisotopes and radiotracers for clinical research and commerce. In sum, IAMI provides TRIUMF and its partners with centralized access to leading-edge infrastructure and world-class expertise to propel Canada forward in the field of accelerator-based isotope research.

As TRIUMF's first purpose-built life sciences facility in decades, IAMI will enable a broad-based research and development program, providing capacity not available elsewhere in Canada – and, in some respects, especially for therapeutic isotopes, unique in the world. From routine production of critically needed routine isotopes to novel development of next-generation therapies, IAMI will serve as a hub for Canadian excellence in radioisotope innovation. In addition to providing critical capacity to academic and industry partners, including start-up and spin-off companies, the facility will also backstop the local healthcare system and maintain a domestic base of expertise and resilience that can be leveraged in times of national or international need.

4.3 BEAMLINE 1A REFURBISHMENT

Beamline 1A provides beam to a significant fraction of the TRIUMF science and application portfolio. It delivers protons from the 520 MeV cyclotron with intensity ranging from a few nano-Amperes to about 120 μA within an energy range of 180-500 MeV. Although it is the oldest proton beamline system on campus, Beamline 1A has been highly productive due to the simultaneous parallel operation of several independent users sharing a single continuous wave proton beam. The maximum beam intensity the beamline can provide for experiments is limited by the original beam optics design and by the aged and partially obsolete equipment employed.

This high energy proton beam is used to produce a number of rare and exotic isotopes that are finding their way into mainstream medical radioisotope applications, which are developing significant momentum. This application leverages the unique 520 MeV facility at TRIUMF to produce and study known and novel alpha and beta-emitting isotopes with potential application in targeted radionuclide therapy. Research and application of these isotopes is currently limited by their scarce availability, with demand far outstripping global supply; however, TRIUMF's facility stands to dramatically change this situation. Using the 520 MeV cyclotron and Beamline 1A, TRIUMF can irradiate thorium-232 metal targets, producing select actinide radioisotopes such as radium-225 and thorium-228, which are not only potential therapeutic radioisotopes themselves, but also serve as parent isotopes that naturally generate high-value products, including actinium-225, bismuth-212 and bismuth-213, and lead-212. All of these isotopes have noted applications as therapeutic beta and alpha emitters and currently maintain intense community interest.

In addition to medical isotope production, Beamline 1A is essential to produce and provide muons as part of the only North American μSR facility for studies of quantum materials; critical chemistry for fundamental and applied questions such as energy production and storage; and probing of properties of magnetic materials for information processing and retention. This capability is a key component of the TRIUMF user program and supports about 1000 international and domestic academic users and researchers every year. The spectrometers connected to M15, M9a, M9A and M20 have recently been, or are in the process of being, upgraded with support from CFI, NSERC, and TRIUMF on the level of $20M. The experimental program typically supports 50 experiments per year and a corresponding annual number of peer-reviewed publications. Beamline 1A is also supporting the radiation detector tests on M11, the

PIF & NIF facilities, and the new ultracold neutron facility dedicated for neutron EDM experiments.

While it is a critical piece of infrastructure, Beamline 1A increasingly experiences downtime and performance limitations due to aging equipment and infrastructure, including a substantial failure risk due to water absorption in the concrete of the main pedestals. If either the beamline or its supporting infrastructure was to fail, the likelihood of an extended outage is very high. With a number of focused refurbishment activities that mainly address the proton beam optics and diagnostics, reliable beam operation can be restored. In addition, performance can also be gained through tailored improvements to the beam optics system, which is funded in the $400M scenario.

4.4 LEGACY INFRASTRUCTURE AND DEFERRED MAINTENANCE

Where possible, TRIUMF's fifty-year-old accelerator infrastructure has been upgraded with new systems, components, and modern controls. However, due to a lack of viable funding avenues within the current paradigm, major deferred maintenance projects have gone unfunded for decades. Within the sun-setted five-year funding paradigm, delivering long timescale maintenance and refurbishment is challenging. TRIUMF has not had the tradition of long shutdowns to up grade or refurbish systems, unlike other accelerator centres. The importance of accelerator technologies and our existing infrastructure has not declined as new capabilities have become available – this criticality drives the need for continued maintenance and innovation of the machines within TRIUMF's accelerator complex. Many of these accelerator facilities and systems are deeply embedded within the infrastructure plan and will remain crucial to the future operations of the laboratory during the ARIEL era.

To preserve leadership in science and technology and capitalize on historical government investments into TRIUMF's world-leading capabilities, infrastructure maintenance must be a high priority for the lab's aging accelerator complex. Facilities of such scale and impact must have a program of development and improvement projected over extended timescales; inevitably, however, tight operational budgets over successive funding cycles have resulted in significant delay of replacement of major systems like RF, vacuum, and beam instrumentation.

As a facility with a broad range of legacy infrastructure that is still required for operations of a heavily integrated accelerator complex, deferred maintenance is a fact of life. Securing funds for deferred maintenance and refurbishment of critical systems has been challenging through grant-driven request processes, and operational support has been insufficient to address all but the most urgent needs, including through a one-off injection of $25M during the current five-year cycle. An analysis of anticipated deferred maintenance was completed at the divisional level, with critical and high-risk deferred maintenance anticipated through to 2035 included in the funding request. Overall, this totalled some $50M capital over the five-year period, including the refurbishment costs of Beamline 1A detailed in Section 4.3 Within the $400M funding scenario the budget for deferred maintenance had to be reduced to $28M but remains a key area of focus. Additional funding streams will be sought to augment the federal government investment in the deferred maintenance program, including through the CFI Infrastructure Fund calls.

Planned deferred maintenance falls into three main categories: operational excellence, accelerator infrastructure, and conventional service infrastructure. For operational excellence, replacement of aging IT and network infrastructure is required to improve cybersecurity and reliability, and replacement of radiation assay capabilities with modern systems to improve compliance monitoring. For the accelerator systems, deferred maintenance includes work on the main cyclotron control systems, RF systems, target station and target operation infrastructure, remote handling reliability maintenance, beam instrumentation and liquid cryogen systems. Conventional service deferred maintenance primarily revolves around replacement of aging electrical

infrastructure, including transformer and distribution systems and the replacement of our main electrical sub-station, a long-standing item of risk for the organization, valued at over $10M alone. Additional conventional systems include replacing a 45-year-old cooling tower, as well as addressing crane and elevator infrastructure reaching end of life.

4.5 OPERATIONAL EXCELLENCE AND COMPLIANCE

TRIUMF is an internationally high-profile and very visible national asset, and as such is required to ensure operational excellence at all times, including regulatory compliance and adherence to stakeholder expectations.

The TRIUMF site is highly mixed-use workplace, from young students engaged in scientific research, to industrial construction with skilled tradespeople. This requires robust and variable procedures and systems to safely support the different types of workers and work. Furthermore, TRIUMF hosts numerous visitors, from visiting researchers to commercial partners to contractors every year. Thus, TRIUMF operates in a myriad of safety, compliance, and regulatory frameworks. These expectations have become more rigorous as cyber- and research security requirements – compounded by geopolitical implications – have become more stringent. This has led to an increase in compliance and oversight obligations that have strained the laboratory's operational capacity.

TRIUMF has also been working to align to the evolving and tightening requirements from the Canadian Nuclear Safety Commission, Engineers and Geoscientist British Columbia, WorkSafe BC, and other regulatory bodies. This work is representative of the requirement for TRIUMF to further develop operational excellence across all systems, through ensuring enterprise services align with the needs and requirements of both external stakeholders and the laboratory itself. This includes the development of an integrated asset management system, which will improve efficiency of asset maintenance and facilitate compliance requirements for those assets.

The stated objective within the requested five-year budget was to support this capacity building within the enterprise services team, to maintain compliance against all requirements, and ensure operational excellence. The approved funding level precludes an expansion of the FTE count at TRIUMF, and so this required growth will be accomplished through evolution of the staff portfolio under an umbrella program known internally as 'Weft & Warp'. Alluding to the weaving of dynamic threads throughout an anchored framework, Weft & Warp seeks to identify, contextualize, and re-align TRIUMF's operational priorities, work processes, and documentation practices (the dynamic weft) within a matrixed set of requirements as established by regulators, funding bodies, and the standards of operational excellence (the static warp).

4.6 THE PATH TO DELIVERING ARIEL AND IAMI BY 2030

The sections above detail the key infrastructure and capacity for research developments that TRIUMF aims to prioritize over the next five-year period. Taking these priorities as inputs, the TRIUMF leadership team, in concert with all stakeholding groups, has formulated this Implementation Plan. The development process of the Plan is detailed in Section 8, with the high-level outputs described within the section. The core philosophy is to leverage a single extended shutdown of the main cyclotron to complete construction of ARIEL & IAMI, and commission and begin operations within the five-year period.

The primary operating paradigm is to implement an extended shutdown of the main cyclotron in 2026 to complete IAMI and ARIEL construction (as defined by the CFI criteria) and conduct critical

deferred maintenance. The shutdown would cover one full operational cycle of the main cyclotron, (i.e., 12 months) with a standard 'Systematic Approach to Shutdown (SAS)' period to restart the machines. The main cyclotron would therefore be off-line for 16 months in total, from January 2026 through to May 2027. This approach allows total focus on the construction of the IAMI and ARIEL infrastructures as our prime objective during the 12-month shutdown, especially from the operational teams who are drawn into repair and maintenance challenges when the main machine is operating normally. This approach will allow us to commission and initiate operations of both infrastructures during the 2025-2030 timeframe and recover the science that will be deferred from the 2026 shutdown.

In addition to IAMI and ARIEL construction, all efforts will be made to align Beamline 1A (BL1A) refurbishment to the timeline of the 2026 shutdown. At a minimum, the TRIUMF-supported replacement of critical components (a triplet and collimator downstream the T2 meson target) would be targeted for the shutdown period. If additional funds can be secured for more extensive refurbishment, we would aim to overlay, if possible, but the intention overall is to ensure work on BL1A is completed during scheduled shutdowns to minimize additional impact on the user facilities and medical isotope production. The smaller medical cyclotrons operate independently from the main cyclotron and continue to produce a reduced selection of isotopes.

Following the extended shutdown, the intention is to return to 8-month operations with a target of delivering 5000 Rare Isotope Beam (RIB) hours during the 2029 operational period from the ARIEL complex (which includes the ISAC target stations).

4.6.1 RESOURCE, FINANCES AND EXTENDED SHUTDOWN DELIVERY

A trivial requirement of all scenarios assessed in Section 8 is that TRIUMF remains financially secure. The definition of this has evolved since the submission of the request for support, based on discussions with the Board of Governors, with the requirement that revenues from commercial work, including royalties and commercial projects, not be utilized for operational costs. Commercial revenues will instead be directed to develop additional capacity for research or research projects, and to support contingency funds. Sustainable budget forecasts were created for these scenarios, as detailed in Section 3, with the preferred scenario benefitting from cost savings on maintenance and operations during the extended shutdown.

There is an expectation that all groups within TRIUMF view the delivery of ARIEL and IAMI as the highest priority and contribute accordingly. Not all lab resources will be required, but when a resource is required for the core deliverables the expectation is that it is available. The core deliverables are therefore defined as the highest resource priority for the lab as a whole. This may have impact on areas that can get stretched, such as design, safety, remote handling, accelerator physics, engineering and radiation protection, etc., with potential impact on the broader lab research program, including innovation projects. Management of additional resources would be through the standard TRIUMF processes, such as the Quarterly Review of Plans and Priorities (QRPP) which prioritizes and allocates resources on a quarterly basis to science and innovation projects, drawing together the various drivers and requirements of the broader research and innovation program. Figure 5 provides a high-level block diagram of project delivery and operations over the first two years of this Plan.

The project governance and leadership structures for the shutdown period will follow the general principles that have been so effective in delivering the Canadian Nuclear Safety Commission (CNSC) requirements over the last 18 months and are shown in Figure 6. These include leveraging:

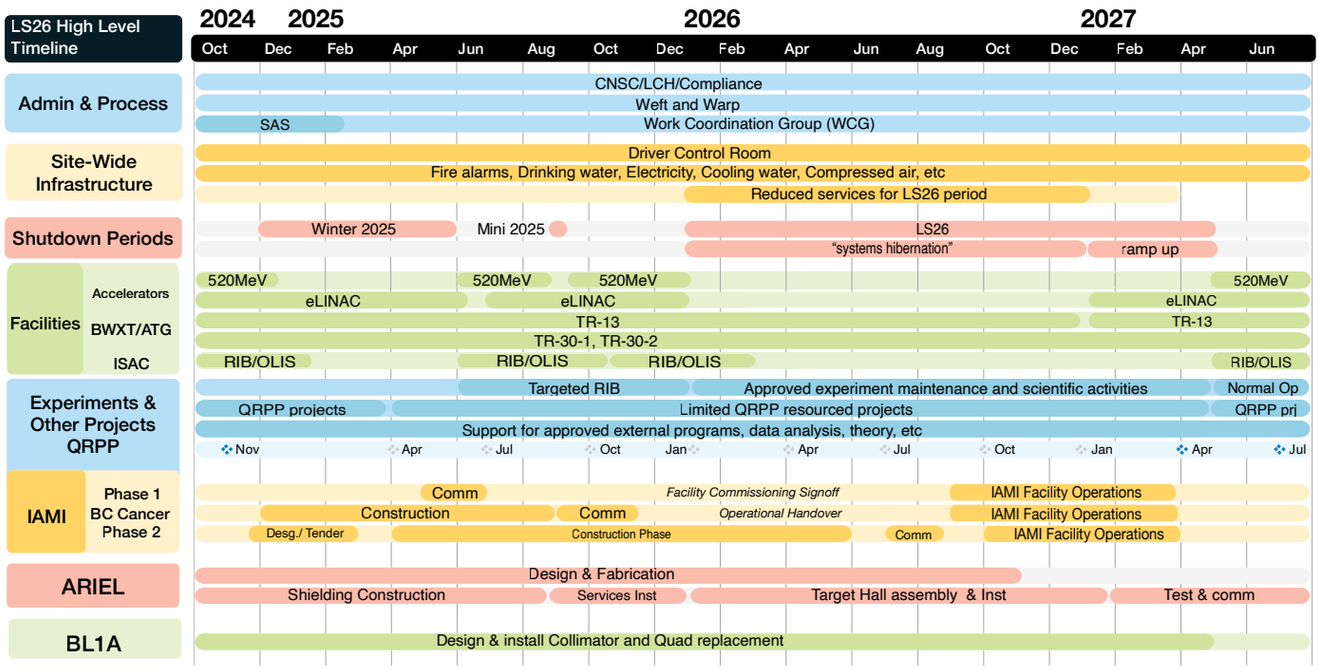


Figure 5: Extended shutdown block project planning

- A Tiger Team (Leadership Team) with overall accountability to ensure strategic decisions are implemented and resources available
- The Senior Management Group acting as resource owners, ensuring a forum for discussion on tactical delivery and resolving any resource collisions
- Project leads having responsibility for ensuring projects are on track through PM resources
- A specialized technical team to coordinate the work at an operational level, similar to TRIUMF's Systematic Approach to Shutdown team. The head of this group will be ex officio a member of the advisory team to the Executive Director and sit at the Leadership Team as appropriate.

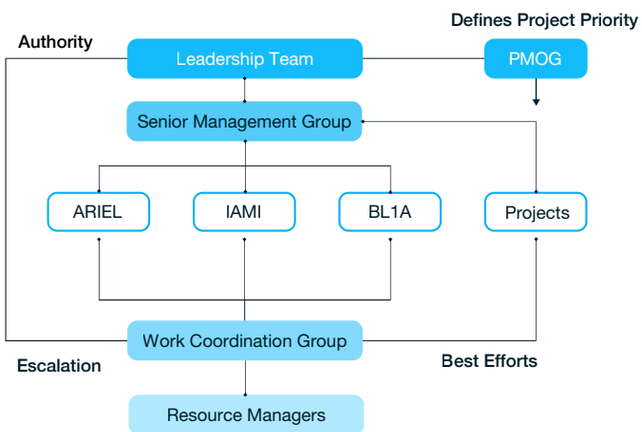


Figure 6: Delivery model for the extended shutdown showing the various components of the accountability and responsibility chain

5. OUR RESEARCH PROGRAM

TRIUMF research covers a broad, multi-disciplinary, program that both develops and exploits research infrastructure at the local site and connects Canada to the world. This section provides a brief overview of the various research areas that TRIUMF and our community are engaged in, demonstrating the world-class nature of the facility, and the international reputation that TRIUMF possesses. This research program is enabled by TRIUMF's core competencies, which include accelerator and detector expertise, data management and analysis, and talented staff with a broad skillset supported by local infrastructure. Accordingly, the research threads are closely interwoven with the capabilities of the laboratory.

It should be noted that the research threads described in this section represent the current research program, with an expectation that these threads will continue based on available resources. Those resources will be defined by the capacity available given the focus on the core deliverables described in Section 4, and so the research program described here may evolve, or be delayed compared to initial plans within the 20-year Vision. Once the core deliverables are concluded in 2027, the expectation is that operational resources again focus on the research and innovation program.

5.1 ACCELERATOR SCIENCE

Our expertise in developing, operating, and maintaining our advanced accelerator technologies and infrastructure is the bedrock of TRIUMF's leadership in cutting-edge research and technology development. TRIUMF excels in building and operating unique, high-performing accelerator systems featuring a wide variety of particle beams, from protons and electrons to rare isotopes, neutrons, and muons. These systems drive our multidisciplinary science and innovation portfolio, from nuclear and particle physics and quantum materials to applications in nuclear medicine, telecommunications, clean power, and aerospace.

Our expertise and infrastructure empower Canada to compete at scale in global "Big Science" and make significant in-kind contributions to many of the world's leading physics experiments, from the frontier of high-energy physics at the LHC to the hunt for dark matter or the characterization of neutrinos. Further, we can realize important domestic projects like a compact accelerator-based neutron source (CANS) or a unique source for intense THz radiation based on TRIUMF's superconducting e-linac. Driving impact both domestically and internationally, our accelerator facilities serve as a training ground for the next generation of accelerator scientists, engineers, technicians, students, and other professionals, significantly enhancing Canada's STEM-based knowledge economy.

TRIUMF's accelerator physics research team ensures that the beams required to satisfy the demands of the TRIUMF science program are delivered, and the accelerator complex operates at optimal performance. This group of scientists provides support for operation of all accelerators and beamlines, as well as their development and extension; develops collaborations with other accelerator-based laboratories; and undertakes research in the three key areas of accelerator science and technology in which TRIUMF excels (superconducting radio frequency (SRF), theoretical and experimental aspects of accelerator beam physics, and secondary particle production techniques).

TRIUMF's accelerator science program is positioned as a critical factor in the development of the next generation of rare isotope production facilities and key technologies for particle accelerators, from TRIUMF's ARIEL to facilities across the globe where our contributions support critical areas of cutting-edge research.

5.2 NUCLEAR ASTROPHYSICS

Nuclear reactions play an important role in astrophysics and cosmology. The lightest elements are synthesized in the early universe during the Big Bang reaction chain. Heavier nuclei, those up to iron, are produced by fusion, transfer, and radiative capture processes in the stars, while still heavier nuclei are produced by the slow, intermediate, or rapid neutron capture (i.e., s-process, i-process, r-process) in neutron-rich environments and by the proton capture in the rp-process.

To understand the abundances of elements in our solar system, in the Milky Way galaxy, and beyond requires knowledge of the rates of the relevant nuclear reactions and various reaction chains, many of which involve radioactive isotopes. TRIUMF's ability to produce many species of radioactive isotopes in substantial amounts positions the laboratory at the forefront of the nuclear astrophysics research. With experimental facilities like DRAGON and TUDA, cross sections of many astrophysics nuclear reactions can be measured. Mass measurements of neutron rich isotopes at TITAN provide important inputs for i- and r-process simulations. The DRAGON collaboration performed the first ever isomeric beam radiative capture measurement of the 26mAl(p, γ)27Si reaction, which is important for the understanding of stellar and galactic evolution.

TRIUMF theorists contribute to these simulations by performing extensive reaction network calculations. TRIUMF theorists are also developing and applying first-principles, or *ab initio* techniques, to calculate cross sections of nuclear reactions relevant for astrophysics. Theoretical investigations become important for reactions that occur in the cosmos at very low energies not accessible to experiments. Theory then provides an extrapolation from the measured cross sections to the astrophysical relevant low energies.

Notable recent investigations comprised a series of decay spectroscopy experiments with the GRIFFIN facility in the neutron-rich N=82 region, important for r-process nucleosynthesis in explosive astrophysical environments. These include the resolution of a controversy regarding the half-life of the "waiting point" nucleus cadmium-130 and studies of the beta and beta–delayed neutron decays of indium isotopes.

With the coupling of the EMMA and TIGRESS facilities, we are now able to directly measure the cross sections of reactions induced by radioactive beams that take place in astrophysical processes such as the p-process at the relevant energies. We have demonstrated that we can study reactions on both hydrogen and helium, utilizing plastic and novel silicon-magnetron sputtered thin film targets, respectively.

The first TIGRESS-EMMA science result was a direct measurement of the $^{83}Rb^{(p,\gamma)84}Sr$ radiative capture cross section at energies relevant to p-process nucleosynthesis in core collapse supernovae using an accelerated radioactive beam, the first such measurement ever reported. The cross-section results confirmed that the abundance of strontium-84 produced in the astrophysical p-process is higher than previously predicted based on statistical model calculations.

The IRIS facility with a solid hydrogen target enables direct measurement of (p,α) reaction cross sections, especially with rare isotopes, that play important role in the vp-process in core collapse supernovae and in X-ray bursts. The first direct measurement of $^{59}Cu^{(p,\alpha)56}Ni$ at IRIS yielded a cross section lower than statistical model predictions. This shows the reaction can win over the competing $^{59}Cu^{(p,\gamma)60}Zn$ reaction only at very high temperatures and therefore might not hinder the production of heavier elements.

5.3 NUCLEAR STRUCTURE AND DYNAMICS

Nucleons, protons, and neutrons, interacting by strong short-range nuclear forces, give rise to the complex properties of atomic nuclei. How the structure of nuclei emerge from nuclear forces is one of the key questions of nuclear physics. TRIUMF nuclear physicists investigate rare isotopes that challenge conventional nuclear structure observed in stable nuclei.

Studying rare isotopes, we observe unexpected exotic features such as extended halo states, the coexistence of spherical and deformed configurations at low excitation energies, the evolution of nuclear shells with the changing numbers of protons and/or neutrons, and even rare processes such as beta decay to continuum. TRIUMF experimental facilities investigate reactions of rare nuclear isotopes on targets to study the arrangement of neutrons and protons in exotic nuclei, excitations of exotic nuclei, and measure masses of short-lived isotopes. These studies discover new features in rare isotopes and feed back into our understanding of the strong nuclear force between nucleons.

Working alongside experimentalists, TRIUMF theorists also develop and apply *ab initio* techniques to calculate properties of atomic nuclei. Theoretical studies help to interpret and inform TRIUMF experiments that then provide feedback on the nuclear force serving as input for the theory, as well as on the adequacy of the applied quantum many-body methods.

A notable recent beta-decay study at ISAC revealed multiple shape coexistence in cadmium isotopes. This was part of a series of measurements in palladium, cadmium, tin, tellurium, and xenon isotopes around magic proton number Z=50, which made significant contributions to the understanding of shape coexistence as a ubiquitous feature of the nuclear many-body system. This work was featured as a Research Highlight in the prestigious journal Nature.

5.4 QUANTUM MATERIALS

Quantum materials are solids with exotic physical properties which arise from the quantum mechanical properties of their constituent electrons. Well-established quantum materials include magnets, semiconductors, unconventional superconductors, and heavy fermion- and multiferroic systems. More recently discovered quantum materials, such as topological insulators, Weyl semi-metals, quantum spin liquids, and spin ices arise from geometrical frustration, spin-orbit coupling and time and crystal symmetry-protected ground states. Many quantum materials derive their properties from reduced dimensionality, in particular from confinement of electrons to two-dimensional sheets. Some of the more esoteric but observable effects displayed by quantum materials include unusual fluctuations, quantum entanglement, quantum coherence, and the dependence of properties on the topology of the quantum mechanical wave functions. Topological insulators, which are materials where electrons on surfaces have a metallic character that is distinct from the electrons in the bulk, have a particular kind of electrically insulating character. The surface electrons could protect electronic charge transport and could form the basis for a new generation of energy-efficient electronics.

Quantum materials have significant applied and/or technological potential, but much fundamental scientific research needs to be done before it may be realized. To advance this research, TRIUMF provides Canadian and international researchers with unique and cutting-edge tools such as muon spin resonance (μSR) and beta-detected nuclear magnetic resonance (βNMR) to characterize quantum materials and better understand the complex interplay between crystalline, magnetic, and electronic structure and properties. By understanding why they behave the way they do, we can design the next generation of materials with optimized properties.

- μSR has been extensively used to characterize magnetic fields inside a material and their associated fluctuations. In addition, the technique is a unique tool to determine magnetic phase diagrams in materials such as superconductors, quantum spin liquids and spin ices. μSR is particularly powerful for studying systems with frustrated magnetic interactions, weak magnetic moments, and disordered magnetism, as well as the coexistence of different phases within a material of interest.

- βNMR has been used to perform depth-resolved measurements on quantum materials to show differences in behaviour near a free surface or an interface. It is possible to perform measurements within a few nanometers of a surface, to study ultra-thin films, and to probe buried interfaces between materials.

5.5 RESEARCH AT THE HIGH-ENERGY FRONTIER

Researchers working at the energy frontier accelerate particles to the highest energies created by humanity and then collide them to produce and study the fundamental constituents of matter and the architecture of the universe – including the Standard Model of particle physics, the leading paradigm explaining particles, fields, and forces. While it is very successful in what it can predict about known particles, the Standard Model is not complete in its description of the universe. Many advanced theoretical models predict additional fundamental particles, beyond those in the Standard Model, that may be produced in very high energy particle collisions.

Working together with colleagues from several Canadian universities, TRIUMF particle experimentalists participate in the ATLAS (A Toroidal LHC ApparatuS) experiment at the Large Hadron Collider (LHC) at CERN, one of the two

main detectors that enabled the discovery of the Higgs boson and subsequent Nobel prize in 2012. Today, researchers on ATLAS continue to search for new discoveries in the head-on collisions of protons at energies as high as 14 trillion electron-volts (TeV). Building on the discovery of the Higgs boson, these additional searches will allow in-depth investigation of the particle's properties and thereby of the origin of mass, as well as will probe new physics at high energy and mass scales. Since 2012, researchers with the ATLAS collaboration have improved understanding of the Higgs boson and found it to agree with all the Standard Model predictions with high precision. For example, they have measured the Higgs coupling to vector bosons to about 5%. Also, they have performed measurements of the Higgs self-interaction – an incredibly rare process to which the detectors are just beginning to develop precision sensitivity.

To analyze the enormous amount of information from LHC experiments, CERN coordinates an international network of large high-performance computing centres that are linked by "grid" tools so that they may act as one global system to study one of the largest data sets in history. On behalf of the Canadian community, TRIUMF computer scientists manage one of the world's ten ATLAS Tier-1 centres, located at the Simon Fraser University.

Providing critical support to many of Canada's contributions to ATLAS, TRIUMF scientists successfully built and installed the Phase 1 upgrades – highlights of which are the Liquid Argon calorimeter readout and the New Small Wheel muon detectors. The liquid argon readout is already having a tremendous impact on the trigger strategy of the detector, enabling a dramatic improvement in the trigger of electrons and photons, while the New Small Wheels are also entering the trigger operations as their commissioning continues.

5.6 PRECISION TESTS OF FUNDAMENTAL INTERACTIONS

In the last 50 years, the Standard Model has been extremely successful in describing fundamental interactions and predicting particles. This work culminated in the discovery of the Higgs boson in 2012. However, there is strong evidence that the Model is not yet complete.

Searches for new particles beyond the Standard Model at the high energy frontier is one avenue to probe this, while precision tests of fundamental interactions at low energies are the other. TRIUMF is well positioned to realize the latter by testing fundamental symmetries, such as the symmetry between matter and antimatter (with the CERN-based Antihydrogen Laser Physics Apparatus, ALPHA), time-reversal symmetry (TUCAN nEDM), or the mirror-symmetry between left and right-handed systems (TRINAT and Francium). TRIUMF is now embarking on a new experimental program utilizing radioactive molecules (RadMol) which has the potential to provide unique sensitivity to electric dipole moments (EDMs) and nuclear anapole moments.

Results of experiments confirming the Standard Model prediction will lead to better constraints of "beyond the Standard Model theories", such as supersymmetry. Reducing the limit for the T-violating neutron electric dipole moment has significantly challenged many particle physics theories. Deviations from Standard Model predictions, such as the muon g-2 experiments, provide smoking guns for its incompleteness. TRIUMF has the unique capability to carry out some of the most precise measurements of the fundamental interactions and symmetries utilizing systems where experiments can have the same precision as Standard Model predictions or where the observable would clearly stand out above Standard Model background. These capabilities are complemented by advanced theoretical support including *ab initio* calculations of symmetry-violating moments and investigations of beyond the Standard Model particle theories.

5.7 MEDICAL RADIOISOTOPE RESEARCH

Throughout its 40-year history, TRIUMF's radioisotope program has been pushing the frontiers of diagnostic and therapeutic radioisotope and radiopharmaceutical production for critical, life-saving isotopes, which in many cases are becoming a standard of care for diagnosing and treating a variety of diseases. In tandem, researchers continue to explore an expanding repertoire of radioisotopes for future generations of radiopharmaceuticals.

From the onset, the TRIUMF program has enabled scientists to examine the molecular nature of neurodegenerative conditions, including Parkinson's Disease, dementia, addiction and mental health, and traumatic brain injury. More recently, the program is working to scale up and remains one of very few centres capable of producing emerging and game-changing alpha-emitting isotopes now in clinical trials for treating late-stage, untreatable, prostate, pancreatic, and blood-based cancers. In addition, the program is also focusing on novel, highly promising Auger emitters for targeted cancer therapy with the potential of superior sparing of healthy bystander tissue. The list of cancers treatable by radiotherapy is growing, and TRIUMF-enabled research will soon include clinical efforts for treating skin, breast, brain, ovarian, colorectal cancers and many more.

Working with TRIUMF's Accelerator Division teams, the Life Sciences Division is innovating high-powered, versatile target solutions to produce a wide array of known and novel isotopes critical to fuel new radiochemistry research and, ultimately, radiopharmaceuticals used for visualizing, diagnosing, and treating diseases. These efforts also encompass leveraging TRIUMF's deep expertise in accelerator-based isotope production to address the recent medical isotope crisis and enabling global cyclotron infrastructure to meet isotope production requirements within hospitals today.

This research builds on TRIUMF's core competencies in accelerator science and a growing suite of dedicated radiochemistry research and radiopharmaceutical production facilities; empowered by our expertise and infrastructure, these capabilities further amplify TRIUMF's impact as an international hub, connecting communities of accelerator and nuclear physicists, chemists, radiation biologists, and health researchers with collaborators and companies that bring the benefits of radioisotope applications from lab bench to bedside.

Built in part on its deep expertise in accelerator science (including high power production targets for radioisotope production), TRIUMF's radioisotope research and production program is globally unique in that it operates further upstream compared to many sector-adjacent institutions and market competitors, creating a unique ecosystem of cross-disciplinary innovation that continues to benefit and advance the field of radioisotope research. This philosophy has allowed TRIUMF's research community and market-facing commercialization experts to enrich partnerships through the application of fundamental science principles, further amplifying the impact of the downstream, real-world solutions.

5.8 APPLIED ION BEAMS

Leveraging over five decades of experience and knowledge gained in the design and implementation of accelerators, targets, and beamlines, TRIUMF produces beams of ions (protons as well as isotopes) to fuel a diverse portfolio of research, applied use, and production.

In TRIUMF's Life Sciences Division, applied ion beams are used for the exploration of new medical isotopes. Discovery efforts into the more exotic radioisotopes of today have tremendous promise to fuel the novel applications of tomorrow. For example, TRIUMF is capable of making certain rare isotopes that are not only difficult to produce but also gaining attention as key building blocks for innovative targeted molecules capable of treating cancers and autoimmune diseases, as well as opening new lines of broad-spectrum antibiotics, antivirals, and antifungal agents to combat increasing resilient infections.

At TRIUMF's unique βNMR (beta-detected Nuclear Magnetic Resonance) facility, scientists are using radioactive isotopes to take inside-out, atomic-level snapshots to guide the way to new materials. Short-lived isotopes of commonly used elements are used to obtain some of the highest-sensitivity NMR measurements on the planet; such sensitivity enables scientists to glean important structural information not possible using conventional analytical techniques.

TRIUMF and collaborators are also investigating the potential of the FLASH radiotherapy technique in both photons and protons, where a specified radiation dose is delivered at ultra-high dose rates over a much shorter period of time than traditional radiation therapy. This technique, first observed in the 1950's, appears to provide comparable impact on tumours while reducing impact on surrounding tissue when compared to multiple lower dose irradiations. In TRIUMF's unique, multidisciplinary environment, teams of experts can design materials, detectors and configure hardware to provide real-time beam delivery analytics that will ultimately enable both the accelerator and healthcare communities with technologies to optimize isotope production and patient treatment regimens.

In another area of applied use, TRIUMF has established the unique Proton & Neutron Irradiation Facility (PIF & NIF), where commercial partners can access ion beams – proton and neutron beams produced using the 520 MeV cyclotron – that simulate the radiation conditions of low-orbit space and provide highly valuable information for materials characterization and design and development for space-bound technologies. These facilities can be used to test the performance of aviation and aerospace components and systems in specific radiation fields and assess any subsequent harmful effects they may be exposed to in use.

5.9 NEXT GENERATION NUCLEAR AND CLIMATE CHANGE SOLUTIONS

TRIUMF is working with collaborators in academia and industry to explore new technology solutions for climate change challenges. This includes photon detector technologies developed in the course of research experiments at TRIUMF may have potential for industrial use in real-time air and water quality monitoring, including for wildfire detection. In FY2023, a funded collaboration agreement was signed with General Fusion to design a custom neutron detector. This collaboration advanced in FY2023/24 with an NSERC Alliance project award, with $800K in funding for TRIUMF over 3 years. Other advanced nuclear energy projects, including other fusion energy developers are interested in accessing TRIUMF expertise and infrastructure related to detectors and radiation test environments utilizing the beamlines at TRIUMF.

5.10 NEUTRINOS AND DARK MATTER

Even though the Standard Model provides excellent descriptions and explanations for an enormous range of experimental data in contemporary particle physics, it cannot be the complete theory of elementary particles and fundamental forces. For instance, the discovery of neutrino masses and dark matter both point towards new physics beyond the Standard Model. The Standard

Model is also unable to explain why there is more matter than antimatter in the universe, or why gravity is so much weaker than all the other known forces. Solving these outstanding questions about the basic building blocks of matter and the architecture of the Universe requires close collaboration between theory and experiment.

TRIUMF convenes a community of physicists, engineers, technicians, and others to contribute to a variety of accelerator-based and deep underground experiments to elucidate the properties of neutrinos and to uncover the nature of dark matter particles.

TRIUMF particle physicists participate in the T2K and Hyper-K neutrino experiments. Located in Japan, the T2K experiment is a long-baseline neutrino experiment intended to measure neutrino oscillation parameters, including the phase that governs CP symmetry breaking. Hyper-K, the successor to T2K, will include a far detector with 8-fold larger active volume and a neutrino beam 2.5 times more intense, and is planned to start operation in 2027. TRIUMF personnel have played a leading role in the analysis of T2K data to measure the CP symmetry parameter, culminating in the publication of a Nature paper in 2020 showing the strongest constraint on the parameter. TRIUMF is leading the development of the Intermediate Water Cherenkov Detector (IWCD), which has been adopted by Hyper-K and its prototype, the Water Cherenkov Test Experiment (WCTE), which has been approved by CERN. TRIUMF has successfully developed essential water Cherenkov detector technologies for WCTE, IWCD, and Hyper-K, including multi-PMT photosensors and photogrammetry calibration devices. TRIUMF has also initiated and led the development of machine learning event reconstruction techniques, which are being applied in the IWCD, WCTE and Hyper-K data analysis frameworks.

As part of the global hunt for dark matter, TRIUMF collaborates on numerous experiments with partners both national (e.g., SNOLAB and the McDonald Institute) and international, providing critical expertise and production facilities for some of the world's most sensitive particle detection apparatus. TRIUMF provides critical expertise and technology around data acquisition systems and photon detection systems, including silicon photo-multiplier devices and ancillary electronics and optical systems. This expertise has been instrumental in the DEAP-3600 and Darkside experiments, two liquid argon dark matter systems, and in SuperCDMS, a germanium-based experiment for low mass dark matter.

There has been much attention recently on a new mediator particle, a new fifth force, that is potentially coupling to dark matter. Following the first reports of a new dark boson of mass ~ 17 MeV, termed as the 'X17', there is a surge of activities in various laboratories to find a confirmation of this new boson with different approaches. TRIUMF is installing a new experiment, DarkLight, partnering with US institutions to search for signals of a new dark boson in electron scattering off a tantalum foil.

TRIUMF theorists also investigate potential candidates for dark matter, theories of neutrino masses, and mechanisms for the creation of matter in the first seconds after the Big Bang. This work is essential for guiding experimental tests and searches. Members of TRIUMF's Theory Department also calculate nuclear matrix elements of the neutrino-less double-beta decay needed for the interpretation of experiments. These calculations are at the leading edge of this field using *ab initio* approaches in determining the matrix elements, illuminating a long-running discrepancy between alternative phenomenological models.

6. DELIVERING RESEARCH AND IMPACT FOR CANADA

Over the next five-year period, the expectation is that TRIUMF progresses the research program described in Section 5, within the constraints of available resources. These resources will be defined by the requirements of delivering the core infrastructure described in Section 4, especially during the first two years of the five-year Plan. TRIUMF will ensure that proposals made to funding agencies are aligned with the broader objectives of the facility, especially in terms of timing of available resources. This is the inevitable trade-off of contracting the overall Program to fit the available budget, and the requirement to complete the core infrastructure. Nonetheless, the expectation is that once those core infrastructures are completed, the available capacity for research is greatly enhanced, leading to an overall increase in science output over the full five years of the Implementation Plan. This section follows the format of our Request for Support and details the impact of the decisions made within the current Plan.

6.1 REALIZING TRIUMF'S SCIENTIFIC POTENTIAL THROUGH RESEARCH CENTRES

Although not funded at the requested level, over the next five years TRIUMF will take the first steps towards achieving the goals set out in its 20-Year Vision. Resources will be directed towards reconfiguring existing program areas to better align with stated national objectives and priority areas. To facilitate the development of mission-focused research threads encapsulated within the 20-Year Vision, TRIUMF initially anticipated the creation of research centres on quantum sensing, precision physics, artificial intelligence and detector development. Given the focus of this Implementation Plan on the core infrastructure deliverables through to 2027, and the operational funding secured from the federal government, the creation of these research centres will be evaluated mid-term. The expectation is now that creation of any of these centres would utilize existing resources, connecting across Divisions to ensure efficient delivery of the research threads and

creating multi-disciplinary teams seeding the development of future programs in the next five-year period.

6.2 OUR FUTURE RESEARCH AND DEVELOPMENT PROGRAM

TRIUMF's extraordinary suite of experimental stations and the availability of extended measurement time with rare isotope beams enabled by ARIEL will empower the pursuit of a new range of major science questions. For instance, one area of focus planned for post-ARIEL operations is further study into how elements are produced in stars and extreme astrophysical environments and subsequently spread across the Universe. Direct measurements of astrophysical reaction rates will be made with DRAGON and TIGRESS-EMMA, and complementary measurements of reaction rates, masses, beta-decay half-lives, beta-delayed neutron branching ratios, and masses will be made with DESCANT, GRIFFIN, IRIS, TIGRESS, TITAN and TUDA. These measurements, combined with in-house modeling and *ab initio* nuclear theory initiatives, will pave the way for: (i) establishing the path of the intermediate neutron capture processes, resulting in a detailed understanding of the abundances of rare earth elements in our solar system; (ii) understanding how heavy chemical elements from iron to uranium are produced in the Universe by the rapid neutron capture process; (iii) understanding how light and medium-mass elements are synthesized in the Big Bang and in the stars.

Experiments with the same suite of experimental stations will allow TRIUMF nuclear physicists to discover new phenomena and properties of rare isotopes and, in collaboration with the in-house *ab initio* nuclear theory team, obtain a deeper understanding of the detailed nature of the nuclear forces and how atomic nuclei emerge from them. With new capabilities such as polarized beams at the GRIFFIN station, and taking advantage of three simultaneous rare isotope beams, TRIUMF nuclear physicists will study exotic nuclei such as lithium-11 whose nuclear radius is as big as lead-208; the coexistence of spherical, deformed, and triaxial shapes across the nuclear chart (drawing parallels to recent work in A~100); the evolution of nuclear shells in isotopic chains with increasing imbalance between numbers of protons and neutrons; and the limits of nuclear stability in isotopes with extreme excesses of protons or neutrons.

The long run times of rare isotope beams enabled by ARIEL, once operational, will also pave the way for sterile neutrino searches at TRIUMF. Sterile neutrinos are well-motivated, natural extensions to the Standard Model that have the ideal characteristics to serve as a warm dark matter candidate. The recently launched BeEST (Beryllium Electron-capture with Superconducting Tunnel junctions) experiment conducts searches for sterile neutrinos in the keV mass range using the nuclear electron capture decay of beryllium-7 implanted into superconducting tunnel junction radiation detectors (STJs). The planned experimental program for the BeEST, which is scaled to multi-pixel STJ arrays with four orders of magnitude higher sensitivity than the current limits, will require months-long run times – a capability that will only become possible in the ARIEL era.

TRIUMF is preparing to develop a new research program on radioactive molecules at ARIEL which is expected to be operational within the five-year period, based on capital support from external funding structures. This project will be hosting a series of unique precision experiments in search of new physics beyond the Standard Model. In the wider context of electric dipole moments, ultracold trapped ^{223}FrAg molecules will have provided the most stringent limit on Charge-Parity (CP)-violating phenomena inside the atomic nucleus. Moreover, radioactive molecules will have been exploited to measure nuclear anapole moments of short-lived

radionuclides. We project an initial sensitivity to fundamental hadronic CP-violating parameters by factors of 1000 or more compared to the best present limits.

Our unique capability to produce radioactive isotopes of francium at ISAC/ARIEL will enable not only the RadMol ^{223}FrAg CP-violation measurement but also probe the electron-quark weak neutral current strength to high accuracy, thereby enabling a competitive search for new physics beyond-the-Standard Model (BSM).

In the next five-year period, TRIUMF will be operating the highest intensity ultra-cold neutron (UCN) source in the world. This will enable a measurement of the neutron electron dipole moment (EDM) with a 10-fold higher sensitivity compared to the best present limits, as well as world's most precise neutron lifetime measurement. The beta-decay lifetime of the free neutron is an important fundamental constant that plays a role in tests of the Standard Model of particle physics and big-bang nucleosynthesis; TRIUMF UCN measurement will resolve a long-standing discrepancy in the neutron lifetime determination. The UCN experiment will make Canada a leader in studies of fundamental symmetries in nature with the world's most intense ultra cold neutron source combined with the high intensity beam from the world's largest cyclotron.

By fielding two world-leading experiments exploring time-reversal and CP-violation, the neutron EDM and the ultra-cold trapped ^{223}FrAg radioactive molecules enabled by ARIEL, TRIUMF will be on the forefront of discoveries shedding light on the matter-antimatter asymmetry in the Universe, which is one of the greatest challenges in physics. If successful, these endeavours would represent Nobel-winning research.

Addressing similar physics questions, TRIUMF participates in and significantly contributes to the Hyper-Kamiokande (Hyper-K) experiment in Japan, which probes the CP symmetry violation in the neutrino oscillations. Hyper-K explores fundamental physics including neutrinos oscillations, nucleon decay searches, dark matter searches and supernova neutrino detection. With a planned start date of 2027, Hyper-K will quickly accumulate accelerator neutrino data and should surpass the sensitivity of currently operating experiments such as T2K and NOvA by 2030. Hyper-K will measure the level of CP violation in neutrino mixing with a high accuracy by 2030.

Additional focus will be brought to bear on physics beyond the Standard Model by the TRIUMF's TRINAT experimental system. TRINAT will achieve a direct measurement of the electron neutrino helicity, to 0.5% accuracy, thereby enabling the measurement of a key Standard Model parameter, the V_{ud} element of the Cabibbo-Kobayashi-Maskawa (CKM) matrix, in the beta-decay of the radioactive isotope potassium-37, at similar accuracy to the most accurate current measurement of 0+ to 0+ beta decays, but in a system with nonzero spin sensitive to other beyond-the-Standard-Model physics. Further, this will enable competitive search for time reversal breaking, isospin breaking, and beyond Standard Model parity-even interactions.

The quantum materials program at TRIUMF will take advantage of the refurbished M15 beamline and the newly commissioned M9A and M9H beamlines. μSR will play an important role in identifying and understanding the effects of disorder on the exotic physical properties of quantum materials, leading to improved synthesis methods. The muon probes will also be applied for sustainable materials and environments. These goals will be accomplished with the advent of the M9H beamline, the first muon decay channel with full transverse polarization spectroscopic functionality, and by the development of new βNMR techniques that take advantage of sophisticated NMR type pulse sequences. For M9H, TRIUMF will pioneer the scope of μSR research by expanding the extreme pressure/temperature/magnet field parameter space available for the muon spectroscopy, applicable over the range of its quantum and sustainable material perspectives. For βNMR, capabilities to selectively detect and measure the electronic environment of near-neighbour nuclei in complex interfaces will yield detailed information on these technologically important quantum structures. These beamlines will, of course, not be operational

during the extended shutdown of the main cyclotron, so there will be an impact on the output of this program during the development of the core infrastructures – however, part of this development is the critical refurbishment of Beamline 1A, thereby overall providing additional security to the operation of this program.

Over the five-year period, TRIUMF particle physicists and accelerator scientists will mount DarkLight, a fixed-target experiment, at the ARIEL e-linac. The experiment will use measurements of electrons and positrons produced in the scattering of the electron beam from a thin foil to search for new light bosons (i.e., BSM particles). Because this measurement probes only leptonic couplings of such a new boson, it provides complementary data to similar searches in the same parameter space which depend in whole or in part on coupling to hadrons. As a secondary motivation for the experiment, the apparatus can also be used for measurements of Standard Model processes such as higher order corrections to scattering processes.

TRIUMF scientists are also exploring global collaborations with academic and industrial partners to develop climate change solutions including next generation nuclear power. Projects of interest include neutron detectors for fusion energy (in collaboration with Canadian company General Fusion), novel neutron sources for the advanced nuclear energy community, and advanced detectors air and water quality monitoring.

The completion of IAMI brings with it powerful new tools in the form of a high-current 24 MeV cyclotron and several radiochemistry labs with research and good manufacturing practices (GMP) laboratories to enable the future of TRIUMF's Life Sciences program. The repertoire of radioisotopes that can be produced on the TR24, coupled with those available from TRIUMF's other drivers, provides unmatched capabilities to produce known and new isotopes that can be used to advance the pillars of TRIUMF's Life Sciences research program. Through IAMI, TRIUMF will support the development of new technologies for advanced, high-power isotope production; and pursue basic and applied radiochemistry transformations and novel radiopharmaceuticals – all while enabling translation into the commercial and clinical realms.

IAMI will enable discovery research to advance the concept of personalized medicine, which in turn will advance our understanding of disease at the molecular level, a capability enabled by tools such as molecular imaging and targeted radionuclide therapy (TRT). Molecular imaging has long been a part of TRIUMF's program, with decades-long work into a number of main-group and transition metal isotopes used for producing radiopharmaceuticals in single photon emission computed tomography (SPECT), and positron emission tomography (PET) studies of the brain and in cancer.

Beyond imaging, alpha-, beta- and Auger-emitting radioisotopes produced at TRIUMF can be used for TRT research, which involves the conjugation and injection of these particle-emitting isotopes as targeted biological vectors that deliver a selective and lethal dose to unwanted tissue. When applied to cancer, the short range and highly cytotoxic nature of alpha-, beta-, and Auger-particles provide a mechanism for destroying small, diffuse, and post-operative residual tumours, while minimizing damage to surrounding healthy tissues. The strength of TRT lies in the diversity and adaptability of the available isotopes, targeting molecules, including monoclonal antibodies, antibody fragments, nanoparticles, and small peptides and molecules. This diversity makes it possible to target an array of diseases by developing an optimal regimen for each application.

TRIUMF's high-intensity 520 MeV cyclotron is capable of large-scale production of numerous known and novel isotopes that hold therapeutic and theragnostic potential. Using thorium-232, TRIUMF produces more than 300 products during high-energy proton-induced spallation, and many are subject to intense global interest for use in certain applications. Isotopes such as terbium-149/155, astatine-211, bismuth-212/213, lead-212, radium-223/224/225, actinium-225,

thorium-227 and uranium-230 can be made available via thorium spallation to support radiopharmaceutical development and emerging clinical trials. During the extended shutdown, the production of these isotopes is clearly not possible, and TRIUMF is working with our partners to mitigate the impact of this period. It should also be noted that upgrading the Irradiation Production Facility is in discussion with BWXT, which will depend on the anticipated demand for these products and the utility of the production facilities available from ARIEL and Beamline 1A.

Many other target materials potentiate the identification and further development of several promising radionuclides that can be incorporated into novel radiopharmaceuticals to treat late-stage, metastatic disease lacking current therapeutic options. Many of these isotopes are the focus of a New Frontiers in Research Fund Transformations six-year grant initiative (Rare Isotopes to transform Cancer Therapy) in which more than a dozen Canadian institutions will utilize radioisotopes produced at TRIUMF to pursue numerous pre-clinical, and ultimately clinical trials for Canadians with currently untreatable disease.

6.3 CANADA AS AN INTERNATIONAL LEADER

The ARIEL and ISAC rare isotope facilities position Canada among the world leaders in rare isotope science, with our domestic research program projecting Canadian science on the international stage. With ARIEL being commissioned in 2027, Canada is also ideally positioned to fill a void in the international landscape following CERN's planned shutdown from 2026 to 2030. If capitalized upon, TRIUMF will be able to step in and become the preeminent international ISOL facility for rare isotope beam research. This will propel TRIUMF into a key leadership position internationally by attracting leading-edge research and talent to the laboratory, thereby elevating Canada's standing within the global "Big Science" ecosystem.

In addition to this, TRIUMF's expertise in accelerator science situates Canada as a strong collaborator in advanced accelerator technology development. Our research excellence in superconducting radio frequency technology, theoretical and experimental aspects of accelerator beam physics, and secondary particle production techniques is essential in providing world-leading technologies, which in turn are leveraged to increase the performance and optimize the operation of our accelerator complex. This allows TRIUMF to add capabilities like ARIEL, but also to provide expert knowledge for international projects such as the High-Luminosity upgrade to the Large Hadron Collider (HL-LHC), the Brookhaven-based Electron-Ion Collider (EIC), and future flag ship facilities for particle physics research such as the International Linear Collider (ILC) or the Future Circular Collider (FCC). Our expertise and status within the sector are recognized internationally; worldwide, several rare isotope facilities under construction have requested design and development specifications, expertise, or direct contributions from TRIUMF.

Our innovations in beam physics research are leading a change in the paradigm of tuning accelerators, beamlines, and high-power secondary particle production facilities in that we are employing beam physics models-assisted beam tuning and machine learning, improving availability of the beams for science, and maximizing efficiency and use of resources. The expertise in accelerator science and technology is also demonstrated by participation in the TESLA Technology Collaboration (TTC) for advanced superconducting accelerator structure, the RADIATE collaboration for exploration of high power targetry and accelerator materials and accelerator science collaborations with CERN, PSI in Switzerland, and SCK-CEN in Belgium.

A key contribution by Canada in particle physics is to the ATLAS experiment at CERN LHC, in which TRIUMF particle physicists play a major active role, providing capabilities and infrastructure that underpin the national contribution. By 2030, the High-Luminosity

phase of the LHC will be starting in earnest. The ATLAS data set will not only contain three times more events than it does today, but they will be higher quality due to the improved triggers and detectors made possible by the recent and ongoing upgrades (a new innermost layer in the inner detector, new muon detectors, and more granular and faster readout of the calorimeters). These contributions – coupled with better analysis techniques, including greater use of artificial intelligence – will dramatically increase researchers' understanding of the Higgs boson. Canada's commitment to ATLAS puts Canadian scientists at the forefront of this knowledge, with TRIUMF playing a critical ongoing role by supporting 10% of the global computing capacity for the project through operating the SFU-hosted Tier-1 computing centre.

TRIUMF particle physicists also play a major role in ALPHA, an international antimatter experiment located at CERN, including substantial collaboration leadership roles. The primary objective of ALPHA is to test fundamental symmetries between hydrogen and antihydrogen with the highest possible precision. Thanks to rapid developments in the past decade, the precision of antihydrogen measurements is approaching that of normal hydrogen. However, to make further progress, we will need to develop entirely new techniques – some of which will be pioneered at TRIUMF. HAICU is a new project at TRIUMF aimed at developing quantum sensing techniques applicable to antimatter. By 2030, we anticipate establishing novel techniques such as the anti-atomic fountain and conducting initial measurements using these techniques.

Strengthening the Canadian contribution substantially, TRIUMF scientists joined the international nEXO collaboration led by the US Lawrence Livermore National Laboratory. The experiment will conduct a search for the neutrino-less double-beta decay in 5 tons of xenon-136 isotope with a beyond 10^{28}-year half-life sensitivity. The experiment will be located 2 km underground at SNOLAB in Ontario. TRIUMF-led *ab initio* nuclear theory is applied to compute nuclear matrix elements required for the analysis. The TRIUMF Executive Director is playing a leading role in coordinating national funding agencies between North America and Europe to deliver an international program in this area.

6.4 DEVELOPING THE LEADERS AND HIGHLY QUALIFIED LEADERS OF TOMORROW

As a unique and major international accelerator centre, TRIUMF provides a compelling and attractive venue to undertake research and develop knowledge. The infrastructure and science programs outlined above provides an illustration of the world-class research that TRIUMF will ultimately enable and deliver over the five-year period between 2025 and 2030. TRIUMF brings together technical, professional, and scientific proponents, ensuring a thriving and stimulating learning environment. The value of TRIUMF as a centre of learning for the university sector is illustrated through the growth of our membership, and additional expressions of interest.

As an attractor for highly qualified people, TRIUMF runs a competitive undergraduate co-op student training program, which is currently substantially over-committed. Through the support and growth of our research community, we develop highly qualified people who have broad skills that are transferrable to many areas of industry and society. These include critical thinking and analytical skills, collaborative and team engagement skills, presentation and communication, as well as the technical and

creative capabilities inherent in undertaking world-class science. These skills are developed directly through working in multi-skilled groups, but also through direct training, workshops, and schools. These highly qualified individuals become the leaders of tomorrow.

Many of the TRIUMF research staff are connected to university departments. We also support temporary joint appointments directly with universities to strengthen research connections between our community and TRIUMF. As such, TRIUMF staff engage in teaching and course development, including undergraduate and graduate courses, and seminar/colloquia. Through these connections we ensure close ties with the research community and enhance the university capabilities around HQP development. Through its commercialization arm, TRIUMF Innovations, TRIUMF provides valuable training through internships and workshops on topics including intellectual property, confidentiality, and technology and market assessment.

The technical requirements of many of the experimental and commercial programs envisaged over the next five-year period require expert technical and engineering support. The stringent requirements of these systems ensure our technical teams are challenged and constantly learning new techniques and capabilities which enhance the technical skill base at TRIUMF, and in many cases provide a pipeline to other opportunities within the local and national areas. TRIUMF contributes directly to the knowledge economy through this training and development.

A continued commitment at TRIUMF is to ensure we support a respectful work environment and fully support the development of equity, diversity, and inclusion. TRIUMF has an EDI Committee and an EDI Special Advisor, and, through the development of an action plan that has near, medium, and long-term objectives, we strive to ensure TRIUMF reflects the full breadth of Canadian culture and maintains a supportive environment for all. As a key value for the organization, this work will continue through iteration of a rolling action plan, incorporating best practice and committing continued investment into this critical area. TRIUMF also supports the national efforts within EDI, with connections to NSERC Chairs and the Dimensions program.

7. DELIVERABLES & RESULTS

The Five-Year Implementation Plan (2025-2030) comes at a critical time in TRIUMF's history, with the laboratory on the precipice of completing several critical facilities, upgrading existing infrastructure, and implementing new systems to ensure operational excellence (including those developed within the Weft & Warp program).

With the laboratory set to celebrate its 60th anniversary in 2028, the projected deliverables and outcomes of this plan seek not only to deliver what is needed at present, but also build the foundation needed to support decades of research to come. Aligned with national priorities and informed by the research communities we serve, this plan will help ensure Canada maintains global competitiveness in science and research, remains at the forefront of innovation, continues to develop world-class talent, and ultimately delivers impact and benefit to Canadians across the country.

7.1 PLAN PRINCIPLES

The Request for Support that was developed to secure funding in Budget 2024 presented a compelling vision for the future of the laboratory that included specific deliverables if TRIUMF was fully funded at the level of $450M over five years. Beyond these specifics, however, the Request also included foundational tenets that were framed as critical to ensuring the long-term success of the organization. Although securing less than requested in operational funding, TRIUMF Leadership – with support from the Board of Governors – has committed to embedding these principles into TRIUMF's Five-Year Implementation Plan (2025-2030).

OVER THE NEXT FIVE YEARS, TRIUMF COMMITS TO:

- Improving staff and student compensation by developing a market-based compensation philosophy to attract and retain talent
- Addressing major deferred maintenance needs, including accelerator maintenance and core facility infrastructure

- Developing and entrenching “operational excellence” into TRIUMF culture, including regulatory compliance, OH&S, program management, and operational consistency across the organization

These principles are foundational to the Plan and help form the conditions required to support the deliverables and outputs targeting from the laboratory from 2025 to 2030.

7.2 CORE DELIVERABLES

The significant financial commitment made by the Government of Canada in Budget 2024 will enable the laboratory to make the investments required to sustain its cutting-edge infrastructure and enable operational excellence. This Plan is centered on core deliverables that will collectively move the organization forward in alignment with its mission and the existing 20-Year Vision.

In the pursuit of enabling world-leading science and research, TRIUMF’s Five-Year Implementation Plan (2025 – 2030) commits to the following operational deliverables:

DELIVER SCIENCE FROM THE ADVANCED RARE ISOTOPE LABORATORY (ARIEL)

- Deliver 5000 hours of radioactive isotope beam to ISAC by the 2029 operational year
- Ensure ARIEL is ready for Gate-4A in the TRIUMF project management process in 2027

COMPLETE AND OPERATE THE INSTITUTE FOR ADVANCED MEDICAL ISOTOPES (IAMI)

- Initial operations of the IAMI facility in 2026

REFURBISH KEY INFRASTRUCTURE AND SYSTEMS

- Replacement of key components of Beamline 1A, supporting material sciences and isotope production, during planned shutdown periods

It is through the delivery of the above items that TRIUMF will position itself, its community, and Canada for success over the course of the Five-Year Plan and beyond. The operational milestones targeted for this plan will help ensure the laboratory is appropriately stewarding its unique facilities and infrastructure, creating new opportunities for world-class science and innovation outputs.

7.3 EXPECTED RESULTS

Over the next five years, extending from the Plan’s principles, as well as both supporting and leveraging the core deliverables, TRIUMF expects to generate significant impact through its programs, infrastructure, and partnerships. As captured in sections 5 and 6 above, TRIUMF’s activities over the period covered by this Implementation Plan are expected to generate significant impact and outputs in several key areas. Though not exhaustive, the following is a high-level summarizes some of the results anticipated by 2030.

ADVANCING WORLD-CLASS SCIENCE AND DISCOVERY ACROSS ON-SITE PROGRAMS

Taken together, the core deliverables of this Plan will strengthen output from TRIUMF’s on-site programs.

As noted previously, ARIEL will triple Canada’s production capacity of rare isotope beams, being the only facility delivering simultaneous multi-port rare isotope beams, thereby boosting capacity across TRIUMF’s science programs. The access to high mass rare isotopes will enable understanding of the astrophysical rapid neutron capture process, the fundamental knowledge on the nuclear force, finding new features in nuclear shells and shape evolution. In conjunction with the refurbishment of existing infrastructure and systems, the resulting increase in beams will not only allow access to new isotopes, but also the isotope availability, opening new possibilities for advancements across the sub-atomic physics and materials science programs. Likewise, the technologies underpinning ARIEL unquestionably position TRIUMF’s accelerator program as one of the global leaders in this space.

Furthermore, the completion of IAMI is also critical to advancing TRIUMF’s life sciences program. The first purpose-built life sciences research, IAMI represents

the cornerstone of the program for decades to come. Providing the team with new capabilities and additional capacity, IAMI will accelerate Canada's leadership in the growing field of medical isotope development and production.

PROJECTED OUTPUTS:

- INCREASED OUTPUT OF ACADEMIC PUBLICATIONS
- INCREASED RESEARCH IMPACT
- INCREASE IN HIGH-PROFILE AWARDS TO CANADIAN RESEARCHERS

STRENGTHENING CANADA'S POSITION IN LARGE-SCALE GLOBAL RESEARCH AND MAJOR FACILITIES

The principles and deliverables underlying the Five-Year Implementation Plan (2025-2030) will help ensure Canada remains at the forefront of several major international experiments and projects across the fields of research that TRIUMF is engaged in. Through the commitment of maintaining world-class facilities on site, as well as attracting and retaining top talent, TRIUMF will deliver outcomes that elevate Canada's standing in large-scale global science and research.

As already noted above, TRIUMF is Canada's lead on a number of major experiments, including upgrades to the ATLAS and ALPHA detectors at CERN, major contributions to the Hyper-K in Japan, and leadership in forthcoming endeavors such as nEXO. In addition, TRIUMF is also well-positioned to be at the forefront of technological contributions to some of the world's most advanced new facilities, with TRIUMF being recruited to provide its expertise to major accelerator projects around the world, including the High-Luminosity upgrade to the Large Hadron Collider at CERN and Electron-Ion Collider at Brookhaven National Laboratory. The value of TRIUMF's leadership in these major initiatives should not be understated, as these projects have been identified by the community (in the 2022–2026 Canadian Subatomic Physics Long Range Plan) as critical priorities and flagship programs.

Furthermore, beyond the important contributions that TRIUMF makes to major offshore initiatives, it must also be noted that core on-site deliverables of the Five-Year Implementation Plan will also help ensure Canada is well-positioned to elevate its standing as a prime destination for sub-atomic physics and related research. The completion and operation of ARIEL and IAMI – along with the refurbishment of other key infrastructure – will make TRIUMF an attractive destination for both talent and experiments. The timing of the update and renewal of key on-site facilities is also highly advantageous, as TRIUMF will be back online and ramping up beam while CERN remain in shutdown, thereby presenting a prime opportunity to attract new science and users to Canada.

PROJECTED OUTPUTS:

- INCREASED GLOBAL PROFILE FOR CANADIAN SCIENCE AND RESEARCHERS
- INCREASED OPPORTUNITIES FOR CANADIAN RESEARCHERS AND STUDENTS TO ENGAGE IN AND LEAD MAJOR INTERNATIONAL PROJECTS
- INCREASE IN THE ATTRACTION AND RETENTION OF TOP INTERNATIONAL TALENT

GROWING CANADA'S TALENT PIPELINE AND BUILDING NATIONAL RESILIENCY

Through the delivery of new facilities and increased operational capacity, the Five-Year Implementation Plan (2025-2030) will enable conditions that will increase the recruitment, training and retention of highly qualified personnel (HQP) in Canada. With state-of-the art infrastructure and new varieties of research possible, TRIUMF will make Canada a destination for leading talent in a range of important fields. From physics and engineering to data science and life sciences, the laboratory will serve as a portal to attract and train the talent that will be critical in driving Canada's knowledge economy forward. Furthermore, with more science possible, TRIUMF will widen Canada's talent pipeline – not only in numbers, but also in breadth and representation, a critical factor in ensuring global competitiveness. Finally, this growth in HQP will not only support the laboratory's research program also position this talent to make important contributions elsewhere in the Canadian ecosystem, either within TRIUMF's large university network or through translating their skills, knowledge, and experience to the private sector.

The additional talent and capacity made possible by the Five-Year Implementation Plan will also serve to bolster national resiliency in areas of strategic importance. With TRIUMF enabling cutting-edge research in areas such as quantum technologies, advanced detectors, superconducting accelerator systems, and novel radioisotope development, there exists significant domestic capacity to support mission-driven research in these and many other critical areas. As evidenced during the COVID-19 pandemic, infrastructure and talent form the backbone of national resiliency, and TRIUMF stands ready to support national strategic priorities as required.

PROJECTED OUTPUTS:

- INCREASED TRAINING OPPORTUNITIES FOR HQP
- INCREASED REPRESENTATION AND TRAINING COMMUNITIES IN STEM
- INCREASED CAPACITY TO SUPPORT MISSION-DRIVEN RESEARCH AND THE BOLSTERING OF NATIONAL RESILIENCY

DELIVERING SOCIOECONOMIC BENEFIT TO CANADIANS

With new facilities, increased capacity, and a thriving talent pool, TRIUMF will be well positioned to deliver increased socioeconomic benefits to Canada. In particular, the operationalization of ARIEL and IAMI – in conjunction with the refurbishment of existing core facilities – will make available new beams and capabilities that will allow for the development of new innovations across TRIUMF's program areas. Furthermore, as one of Canada's leading major research facilities, TRIUMF attracts significant economic activity to British Columbia and Canada at large, delivering tangible impact both locally as well as through indirect and induce effects that flow across our national Member and partner networks.

Of particular note, IAMI will enable academic and industrial partners to develop and produce in-demand medical isotopes and novel radiopharmaceuticals for theranostic (therapy and diagnostic application combined) cancer treatments and play a critical role in the safe and efficient translation into the clinic. With the advent of these highly promising and novel treatments, Canadians and people around the world will have access to therapy for cancers that were previously very difficult or impossible to treat. Treatment

outcomes will be improved in terms of suffered side effects and life expectancies. Apart from the cost saving to our society that an effective treatment will bring, the human impact will be significant, as 50% of Canadians will be impacted by cancer.

Beyond IAMI, other examples of translating TRIUMF's science, technology, and services to benefit Canadians can be seen across the laboratory's major facilities and programs. With the support of TRIUMF Innovations, TRIUMF will seek to identify opportunities to work with industry partners to help develop and scale-up new technologies to address major societal challenges, such as addressing resource scarcity and climate change. Possible contributions include leveraging TRIUMF expertise and infrastructure to develop new quantum sensors, real-time water quality monitoring detectors, and new sustainable materials. There is also significant interest and opportunity in the area of next-generation nuclear energy solutions including fusion energy, small modular reactor component testing, accelerator-driven systems to convert nuclear reactor waste into energy, TRIUMF Innovations will help accelerate the commercialization of these technologies through the creation and fund-raising for spinoff companies, as well as developing industry-partnered collaborations and technology licensing initiatives.

PROJECTED OUTPUTS:

- INCREASED ECONOMIC IMPACT (DIRECT, INDIRECT & INDUCED)
- INCREASE IN THE NUMBER OF PARTNERSHIPS, SPIN-OFF COMPANIES, AND LICENSING ARRANGEMENTS
- INCREASE IN THE NUMBER OF NEW TECHNOLOGIES AND MEDICAL THERAPIES ENABLED BY TRIUMF RESEARCH

8. DEVELOPMENT OF THE IMPLEMENTATION PLAN

Following the award announcement of $399.1M in the 2024 federal budget, over the Spring and Summer of 2024 TRIUMF developed a program that would maximize the impact of this investment, the culmination of which is this Five-Year Implementation Plan.

Although a substantial and extremely welcome uplift in core operational support for TRIUMF, the ultimate operational resources were reduced from the Request for Support by 15%. This has required difficult decisions to be made, which have impact on the science and infrastructure program at TRIUMF. However, this Implementation Plan is designed to balance the needs of the facility and our community while delivering and consolidating core infrastructure and placing us in an enviable and strong position for future operations. NRC has confirmed no restrictions or constraints on the use of the funding, unlike past awards which have had some amounts ring-fenced for specific purposes.

8.1 ANALYSIS OF OPTIONS AND SCENARIOS CONSIDERED

The development of TRIUMF's Five-Year Implementation Plan (2025-2030) was guided by several parameters and requirements that had to be considered in the creation and evaluation of the various operational scenarios, including the approved budget and constraints imposed by the Board of Governors on unrestricted funding. In particular, and already noted in Section 7.1, extending from the principles highlighted in the Request for Support, three non-negotiable elements were embedded into each of the scenarios considered:

- Improving staff and student compensation and retention by developing a market-based compensation philosophy
- Addressing major deferred maintenance needs
- Developing and entrenching "operational excellence" into TRIUMF culture

In addition to these constraints and Plan principles, a number of key objectives were considered in developing and evaluating various possible scenarios; these considerations were driven by several inputs, including community and stakeholder expectations, TRIUMF's 20-year vision, and the reliability of the assumptions built into each scenario. The deliverables and objectives considered in the assessment of various operational scenarios, included:

- Positioning TRIUMF for 2030 and beyond (i.e., the next five-year plan)
- Remaining financially viable throughout the full five-year period
- Maintaining scientific excellence in our domestic research program
- Maintaining scientific excellence in our international research program
- Maximizing talent development
- Completing and operating ARIEL
- Completing and operating IAMI
- Complete refurbishment of Beamline 1A (major deferred maintenance objectives)
- Maintaining medical isotope production
- Managing reputation with users
- Managing reputation with international collaborators
- Managing reputation with government
- Managing reputation with business partners

There are clear interplays between the delivery of many of these objectives; however, following extensive internal analysis, including a pro/con analysis and various consultations detailed below, it became evident that the prioritization of moving ARIEL and IAMI into their operational phases in the next five-year plan would optimally benefit many of the objectives stated above, through the results, outputs. and outcomes made possible by delivering on this infrastructure.

With the constraints considered and the key objectives analyzed, TRIUMF's Leadership Team developed this high-level Implementation Plan around the four key infrastructure deliverables for 2025-2030. A core component of the developed scenario is an extended operational shut down of the main cyclotron in 2026 to devote the necessary resources required for the completion, and subsequent operation of ARIEL and IAMI within the five-year window; the smaller medical isotope cyclotrons would continue operations. Critical refurbishment of the Beamline 1A infrastructure is required during this next five-year period, irrespective of the scenario selected, and will be implemented to minimize disruption to the Beamline 1A user base.

This analysis was also compared against alternative scenarios, which either delayed or deferred ARIEL and IAMI in the pursuit of delivering science using existing facilities; in each of these cases, the short-term benefits of delaying the completion and operation of these major infrastructure were overshadowed by longer-term risks to science output, TRIUMF's reputation, and the laboratory's operational viability beyond 2030. Figure 7 provides a colour heat map showing the impact on the various considerations of the three scenarios assessed, which were:

1. Returning to an eight-month operational cycle for ISAC, delaying operations of IAMI into the next five-year period and effectively deferring ARIEL construction and operations well beyond existing five-year plan.

2. A single extended shutdown of the main accelerator for a year in 2026 to complete ARIEL construction as defined by the CFI criteria. This allows focus on ARIEL during that period without

distraction, yet has impact on ISAC, CMMS, and medical isotope production.

3. The status quo of longer shutdowns over the next four or five years to provide some spare capacity for ARIEL construction. This implies continued six-month shutdowns, which impacts science and medical isotope production.

It should also be noted that a fourth option of securing additional funding to address the $50M gap between request and award was deemed unfeasible, either from federal or provincial budgets, or though commercial or philanthropic means on the required timescale.

	Scenarios		
	1 (Defer ARIEL/IAMI; 8-month cycle)	2 (Extended Shutdown)	3 (Delay ARIEL/IAMI; 6-month cycle)
Non-negotiable elements			
Compensation	✔	✔	✔
Deferred Maintenance	✔	✔	✔
Operational Excellence	✔	✔	✔
Considerations			
Position TRIUMF for next 5YP			
Maintain domestic scientific user-base / excellence			
Maintain international scientific user-base / excellence			
Talent Development (also 'compensation' above)			
Complete and operate ARIEL			
Complete and operate IAMI			
Complete BL1A Refurbishment			
Financially secure - operations & capacity			
Medical isotope production			
Manage reputation with users			
Manage reputation with international collaborators			
Manage reputation with government			
Manage reputation with business partners			

More +ve
Less +ve
Less -ve
More -ve

Figure 7: Heat map analysis of considerations (The subdivisions in scenario 2 represent the pre-, during, and post-cyclotron shutdown periods)

8.1.1 RISK ASSESSMENT AND MITIGATION STRATEGIES

Several risks and issues were identified during the development of this Implementation Plan. These risks and mitigating factors are noted below:

ISSUE/CONCERN	MITIGATING STRATEGY
Impact on HQP and graduation through loss of experiments in 2026	Supervisors to work with HQP to minimize impact (scheduling, alternative projects/ locations, support for transitions); Scheduling of 2025 and 2027 experiments to factor near-term graduations; Communication of plans and feedback
Financial impact from loss of royalties	TRIUMF budget reworked to remove dependence on commercial income for operations; Longer IPF/STF runs in 2025 and 2027; Once complete, production from ARIEL target stations increases overall production capability
Medical isotope production	Continued operation of smaller cyclotrons; Discussions with BWXT on STF/IPF on diversification concluded successfully (BWXT source Sr elsewhere currently, IPF runs in 2025 and 2027, plus diversification of source); Once complete, production from ARIEL target stations increases overall production capability
Loss of commercial partners and clients	Discussions with BWXT on STF/IPF on diversification concluded successfully (BWXT source Sr elsewhere currently, IPF runs in 2025 and 2027, plus diversification of source); Discussions with PIF & NIF customers to be managed – extended runs in 2025/2027
Ability to prioritize resource utilization	Implementation of governance and leadership structures that include full supervisory chain (Leadership Team, Senior Management Group, etc.); Use of Work Coordination Group (WCG) team for delivery; Authority cascade from Executive Director
Impact on science from the main cyclotron	Planning of experiments in 2025 and 2027 to maximize science, including return to eight-month operational cycle; Experience of other facilities that take shutdowns, with returning community and partners; Completion of ARIEL increases science capacity within the five-year period, integrated RIB hours exceeding current status quo capability; Objective of 5000 hours RIB in 2029
Impact on international research community	As above for international community using TRIUMF facility; Completion of ARIEL prior to ISOLDE shutdown allows continuity of access to RIB facilities world-wide
Beamline 1A refurbishment	Dovetail critical refurbishment into 2026 if possible; Secure additional funding for further upgrades (CFI IF25 request being pursued)
Financial viability	Ensure sustainable financial plan in place; As per Board, remove dependency of operations on direct commercial revenue

8.2 CONSULTATION AND APPROVAL PROCESSES

The development of this Plan has interleaved multiple consultation and approval processes. These are shown graphically in Figure 8, with the key approval steps being TRIUMF Members' Council approval of the Contribution Agreement with NRC which incorporates approval of the five-year Implementation Plan. This approval is based on recommendation by the Board of Governors, supported by the TRIUMF Science Council.

Consultation has been through various committees, oversight bodies and forums, including:

• TRIUMF science community through internal discussions with Board Appointed Employees, the TRIUMF User and Early Career Groups, substantial engagement during our annual Science Week, and Science Council. Although risks were identified, there has been universal recognition that the proposed approach optimizes the use of resources and places TRIUMF in the optimal long-term position for science delivery.

• NRC and ACOT, with clear direction from ACOT that the completion of ARIEL and IAMI is essential for the lab's reputation and the long-term success of its science programs. ISED is also aware of our deliberations and preferred path forward, as are CFI and NSERC as the funding agencies that support the bulk of our research.

• TRIUMF's Board of Governors and the TRIUMF Innovations Board.

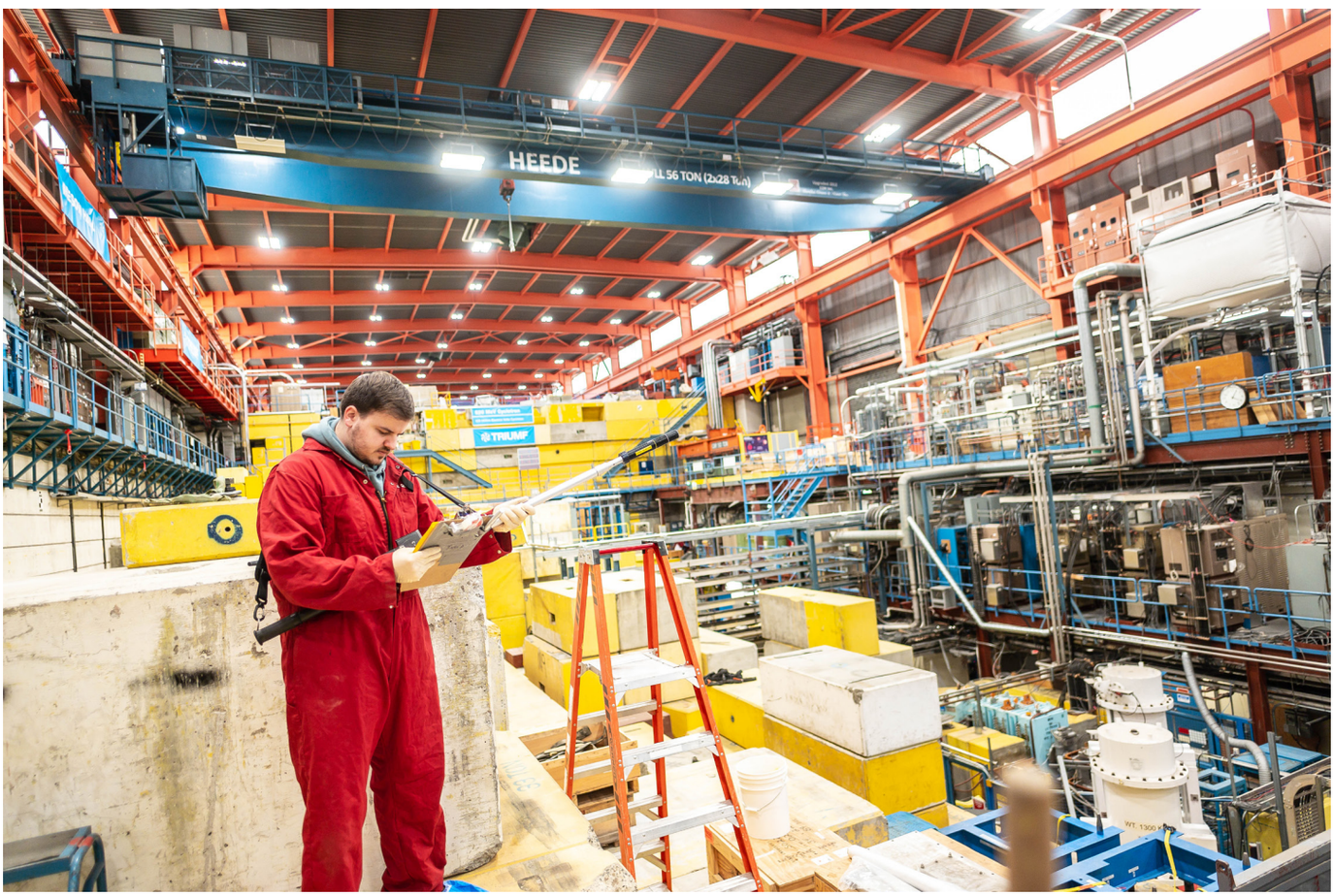
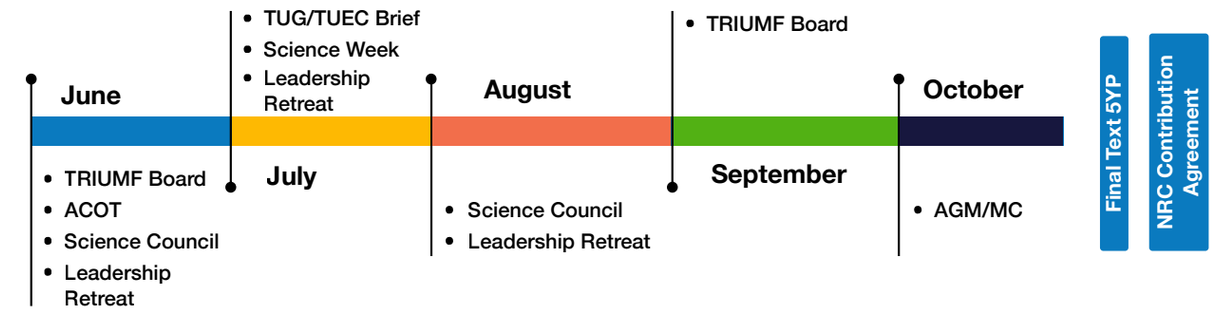


Figure 8: Five-year Implementation Plan approval and construction processes (across 2024)



Outputs:

- NRC TB Initial input
- Summary of 5YP
- Draft 5YP
- Final Draft 5YP

Meeting Details

- Leadership Team Retreat (Plan Development)—May 13
- Leadership Team Retreat (Plan Development)—May 31
- Board of Governors Meeting—June 18
- NRC – Advisory Committee on TRIUMF—June 10–12
- Science Council Meeting—June 27
- TRIUMF User Group Pre-Science Week Briefing—July 5
- Leadership Team Retreat (Plan Development)—June 28
- TRIUMF Science Week—July 22–26
- Science Council Meeting [Unanimous plan endorsement from voting members]—September 17
- Board of Governors Meeting [Unanimous approval to recommend 5YIP deliverables]—September 17
- Members' Council Annual General Meeting [Implementation Plan Approved]—October 28–29
- NRC Contribution Agreement—March 2025

• Commercial partners, specifically PIF & NIF and BWXT, around the implications for actinium production and potential loss of commercial clients.

Also shown in Figure 8 are the various stages of the plan documentation. This is generated primarily from the Request for Support, modified to reflect the extended shutdown of the main cyclotron, as the impact of the loss of the $70M from the initial request. Overall, however, this Implementation Plan provides a simple, measurable, key objective to deliver 5000 hours of RIB beam from the ARIEL complex in our 2029 operational cycle.

APPENDIX: TRIUMF GOVERNANCE AND LEADERSHIP

TRIUMF MEMBERS

- University of Alberta
- University of British Columbia
- University of Calgary
- Carleton University
- University of Guelph
- University of Manitoba
- McGill University
- McMaster University
- Université de Montréal
- University of Northern British Columbia
- Queen's University
- University of Regina
- Saint Mary's University
- Université de Sherbrooke
- Simon Fraser University
- University of Toronto
- University of Victoria
- University of Waterloo
- Western University
- University of Winnipeg
- York University

TRIUMF BOARD OF GOVERNORS

Angus Livingstone

Chair of the TRIUMF Board of Governors

Lisa Kalynchuk

Vice-President, Research & Innovation, University of Victoria

Vice-Chair of the TRIUMF Board of Governors

Amir Asif

Vice President, Research & Innovation, York University

Gail Murphy

Vice-President, Research & Innovation, University of British Columbia

Heather Kleb

Senior Strategist, Isotopes and Site Energy Development, Bruce Power

Jeff Martin

Professor, Canada Research Chair (Tier 1) in Fundamental Symmetries in Subatomic Physics, University of Winnipeg

Chair of the TRIUMF Science Council

Jonathan Saari

Founding Partner, Last40 Ventures

Karamjeet Heer

Associate Vice-President, Finance, Simon Fraser University

Rafik Goubran

Vice-President, Research & International, Carleton University

Rob Thompson

Associate Vice-President of Research & Director of Research Services

Sylvain Lévesque

Chief Financial Officer, DBC Group

Julie Lefebvre

Vice-President, Emerging Technologies, National Research Council Canada

Observer to the TRIUMF Board of Governors

TRIUMF LEADERSHIP

Nigel Smith

Executive Director & CEO

Oliver Kester

Director, Accelerator Division

The Accelerator Division has operational responsibility for all accelerator facilities on site, including those operated for our on-site commercial partner. The Division also has responsibility for the design, construction, and commissioning of future accelerators on-site, and it provides support for external accelerator projects.

Rituparna Kanungo

Director, Physical Sciences

The Physical Sciences Division is responsible for the design, installation, operation, and maintenance of components and systems required for all experimental operations on site, as well as coordination of infrastructure support for external programs.

Cornelia Hoehr

Director, Life Sciences Division (Acting)

The Life Sciences Division is responsible for the support of projects and provides support for collaborations with the University of British Columbia, BC Cancer, BWXT Medical and other university faculties relying on radiotracers from TRIUMF for their research. This Division is also responsible for the design, installation, operation and maintenance of components and systems required for radioisotope production and processing facilities for tracers to be used in research projects both at TRIUMF and at other laboratories. They are also charged with the completion and operations of the new IAMI facility within this five-year period.

Bill Richert

Director, Projects and Infrastructure Division

The Project and Infrastructure Division provides mission-critical operational support for project delivery and infrastructure support. This includes the design and fabrication of parts for on- and off-site experiments, and the operations and maintenance of the core facilities.

Chris Astle

Chief Financial Officer

The Finance and Supply Chain Division provides financial oversight, planning and leadership, in addition to logistical support for the laboratory.

Sean Lee

Chief of Staff

The Communications and Engagement Division provides cross-laboratory support in a number of key areas, including outreach to our international, academic, and user communities, along with the burgeoning educational programming.

Sanjeev Dewett

Chief Administrative Officer

The Core Services Division is responsible for critical enterprise functions across the laboratory, including the responsibility for stewarding key operational elements to ensure a safe, secure, and effective workplace. In addition, they provide contracts and grant support to researchers and the organization.

Kathryn Hayashi

President & CEO of TRIUMF Innovations

While a separate entity, TRIUMF Innovations serves as the interface bridging TRIUMF with the business world. TRIUMF Innovations link cutting-edge science and technology to tangible business opportunities.

James D. Hanlon

Post-Retiree Special Advisor

Doug Preddy

Special Advisor

Directing the Long Shutdown 2026 efforts through the Work Management Group to ensure the main priorities are appropriately resourced.

Grace Wong Sneddon

Equity, Diversity, & Inclusion Special Advisor (Interim)

Leading TRIUMF's efforts to ensure the core values of TRIUMF's are adhered to. At TRIUMF, we are committed to fostering a diverse, equitable, and inclusive community where everyone can work, learn, connect, and discover, with the EDISA leading initiatives to ensure we uphold these values.

TRIUMF

4004 Wesbrook Mall
Vancouver BC V6T 2A3 Canada

t 604.222.1047

www.triumf.ca
@TRIUMFLab