



Supplementary Information

Presentation from TRIUMF Accelerators Inc.

In the Matter of the

TRIUMF Accelerators Inc.

Application by TRIUMF Accelerators Inc.
for renewal of operating licence for its
particle accelerator facilities

Commission Public Hearing

March 23, 2022

Renseignements supplémentaires

Présentation de TRIUMF Accelerators Inc.

À l'égard de

TRIUMF Accelerators Inc.

Demande de TRIUMF Accelerators Inc. pour le
renouvellement de son permis d'exploitation
pour ses installations dotées d'un accélérateur
de particules

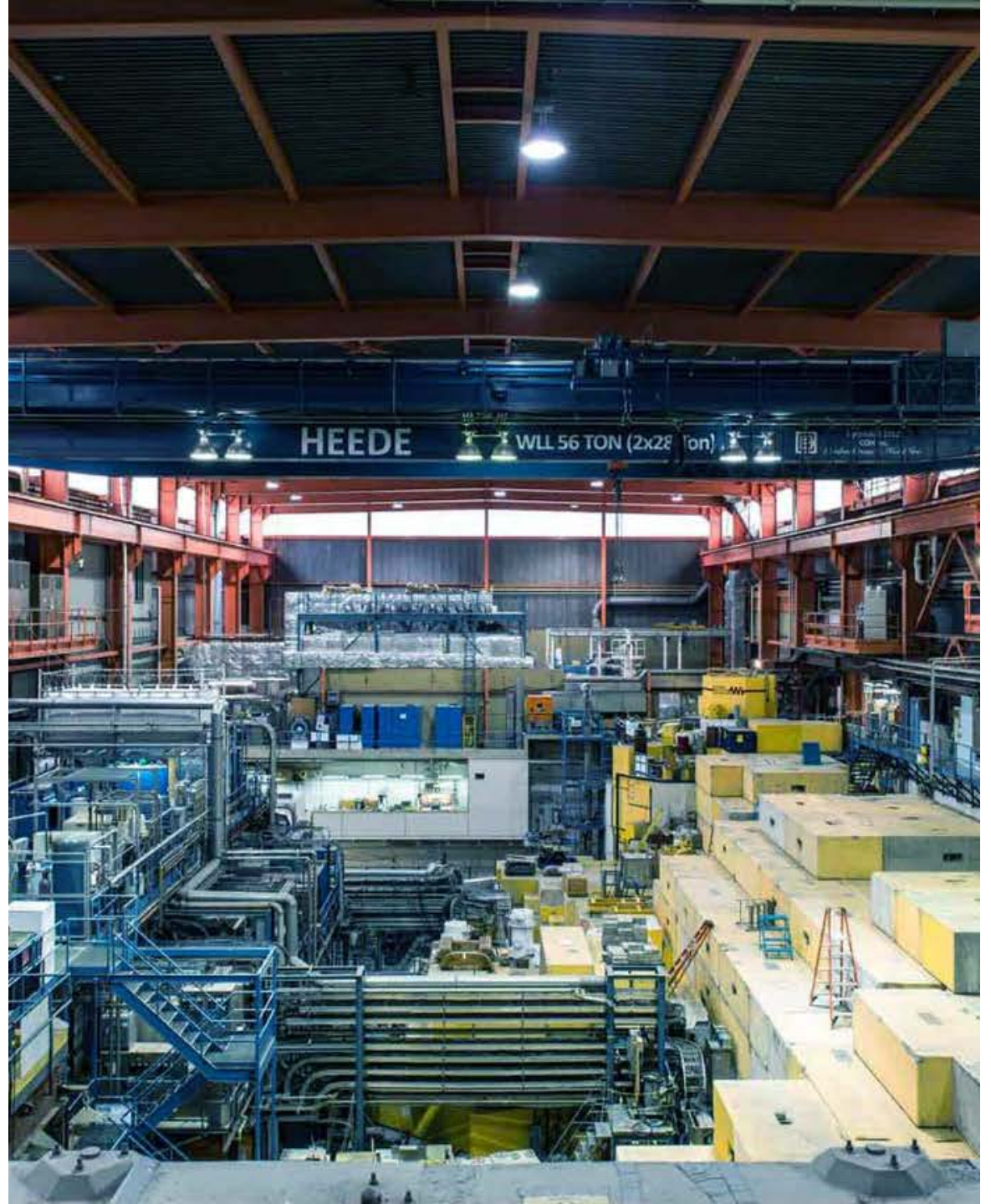
Audience publique de la Commission

23 mars 2022

TRIUMF Accelerators Inc. (TRIUMF)

CNSC License Renewal

March 23, 2022



What is TRIUMF?

TRIUMF is Canada's particle accelerator centre. **We are a world-class hub of research, education, and innovation that is home to ~550 staff and students**

Founded in 1968 by the University of British Columbia, Simon Fraser University, and the University of Victoria, TRIUMF has evolved into a multidisciplinary facility owned and operated by a consortium of Canadian universities from coast to coast



Members

Our multidisciplinary community uses its world-class accelerator infrastructure to drive leading-edge research that delivers impact in **science, medicine, and industry**

Member Universities

University of Alberta
University of British Columbia
Carleton University
University of Calgary
University of Guelph
University of Manitoba
McMaster University

Université de Montréal
Queen's University
University of Regina
Simon Fraser University
University of Toronto
University of Victoria
York University



TRIUMF's Core Values

Safety & 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 of our systems
- We embrace transparency and authenticity, and hold ourselves and each other accountable

Excellence & 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

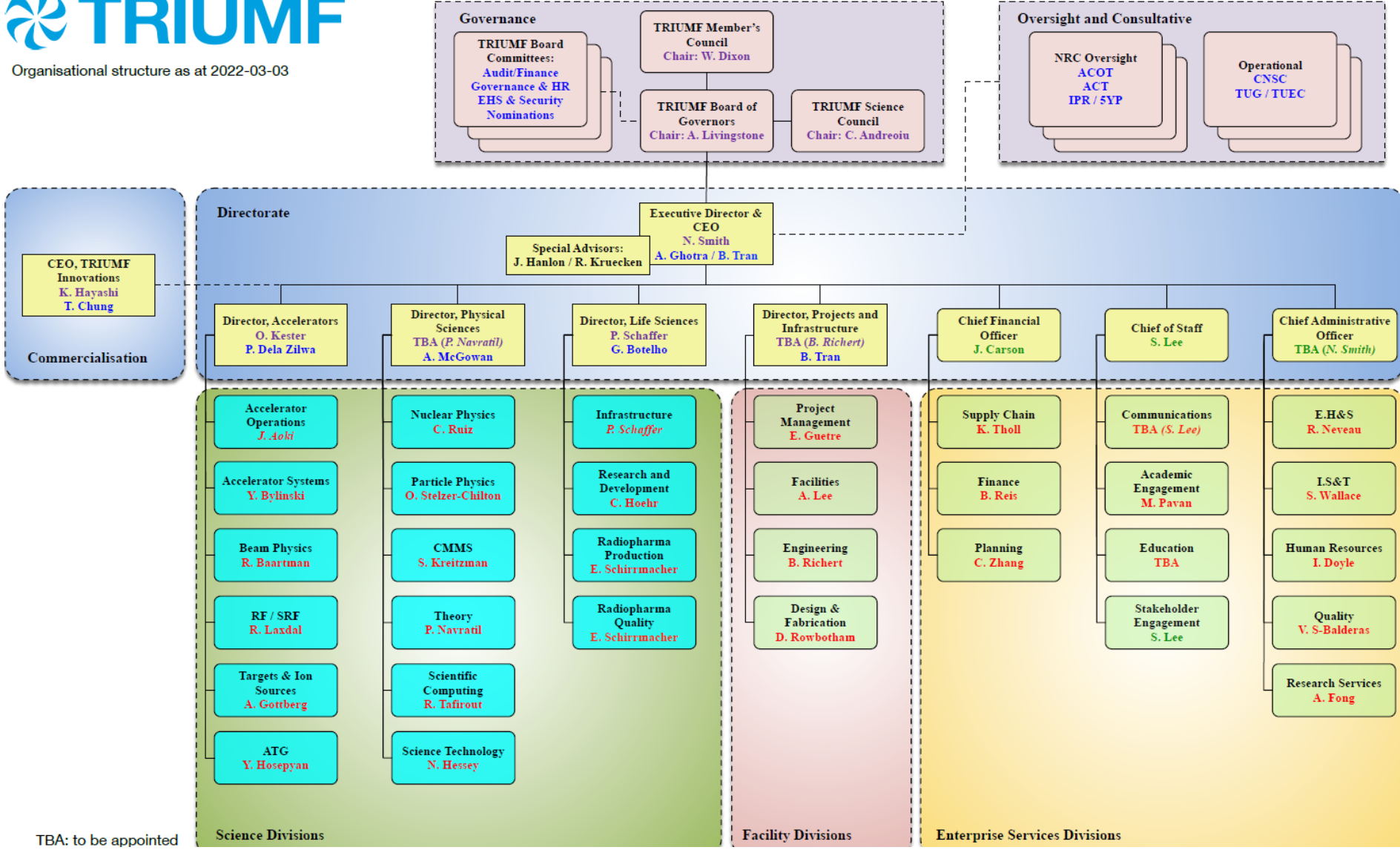
Equity & Inclusion

- 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

Governance and Management



Organisational structure as at 2022-03-03

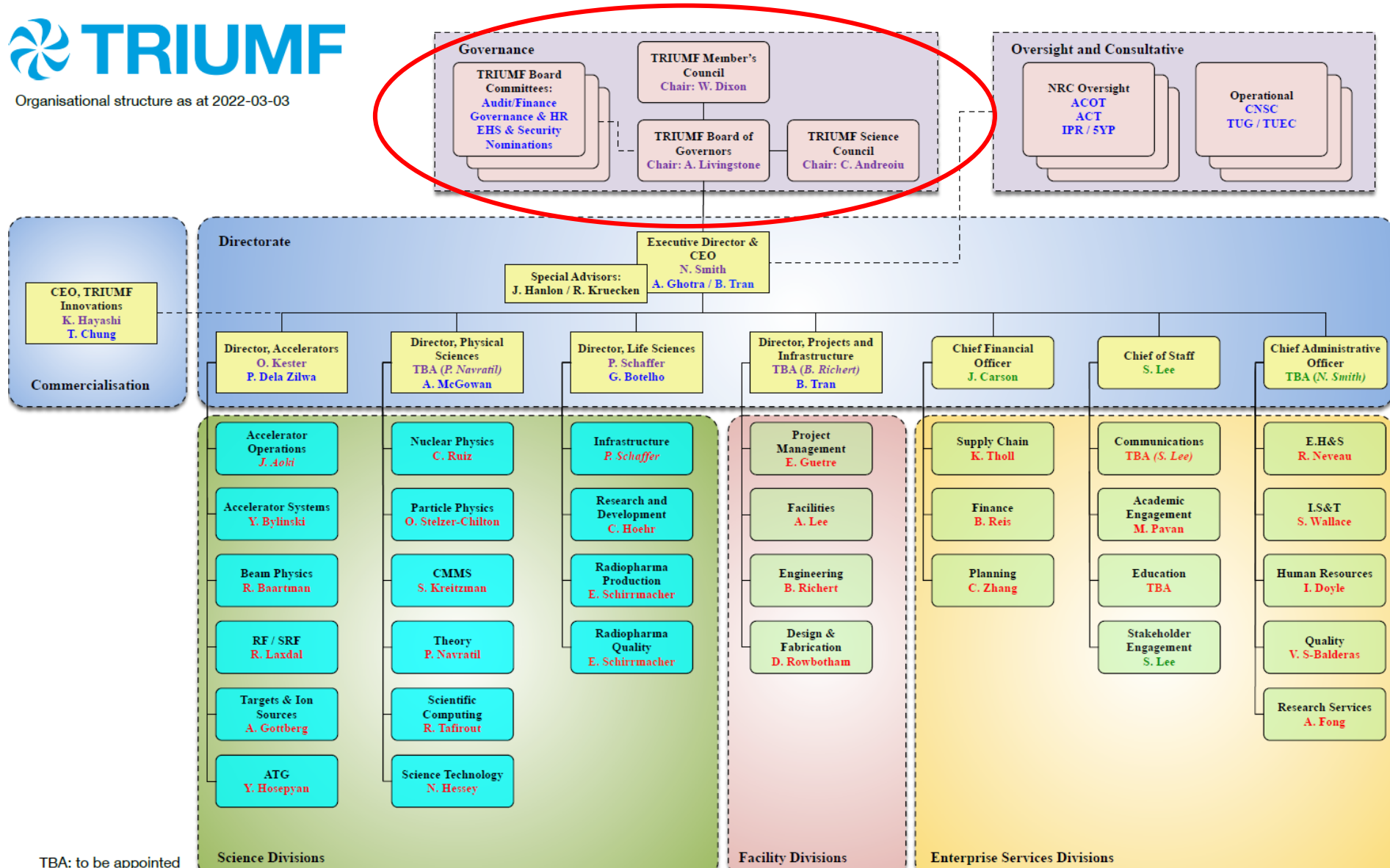


TBA: to be appointed

Governance



Organisational structure as at 2022-03-03



TBA: to be appointed

Governance

Over a period of three years, TRIUMF completed a review of its governance framework with a goal of implementing new structures, policies, processes, and practices to help position TRIUMF for future success in its strategic endeavors

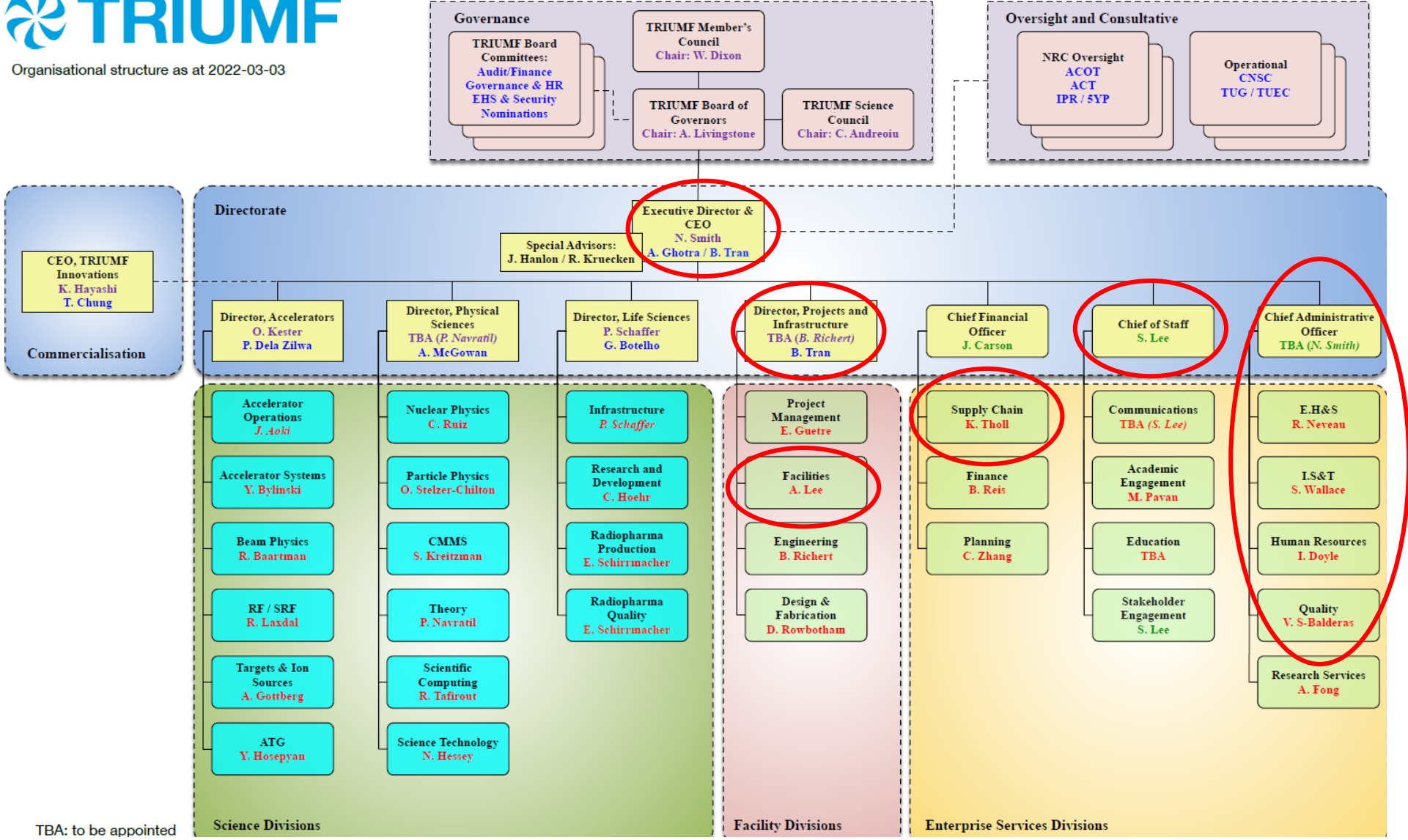
- A smaller, skills-based Board of Governors, composed of 11 members that is consistent with modern best practices for governance
- The Governors have the skills and experience required to oversee strategic priorities and performance management
- The new structure establishes a clear division of responsibility between the Member Universities, the Board, and TRIUMF Management

Pending successful licence renewal and with awareness of CNSC staff, TRIUMF INC. will amalgamate with the current licence holder, TRIUMF Accelerators Inc., during the licence transfer.

Leadership and Management



Organisational structure as at 2022-03-03



TBA: to be appointed

Leadership and Management

- TRIUMF's leadership and management structure supports accountability and clear responsibilities related to license activities
- Several additions and changes over the last year will enhance focus on safety, quality, and facility-wide core services:
 - Executive Director (new appointee in 2021)
 - Chief Administrative Officer – accountable for management system (new position in 2022; Executive Director taking interim role)
 - Chief Safety Officer (new appointee in 2021)
 - Director, Quality (new appointee in 2019)
 - Director, HR (new appointee in 2019)
 - Chief Information Officer (new appointee in 2021)
 - Chief of Staff – accountable for engagement and communications (new position in 2022)
 - Director, Projects & Infrastructure – accountable for site operations & systems (new position in 2022)
 - Director, Facilities (new position in 2020)
 - Chief Financial Officer – accountable for financial services (new appointee in 2019)
 - Director, Supply Chain (new position in 2021)

Research Scope

Our work is both fundamental and applied:



Expanding the boundaries of human knowledge



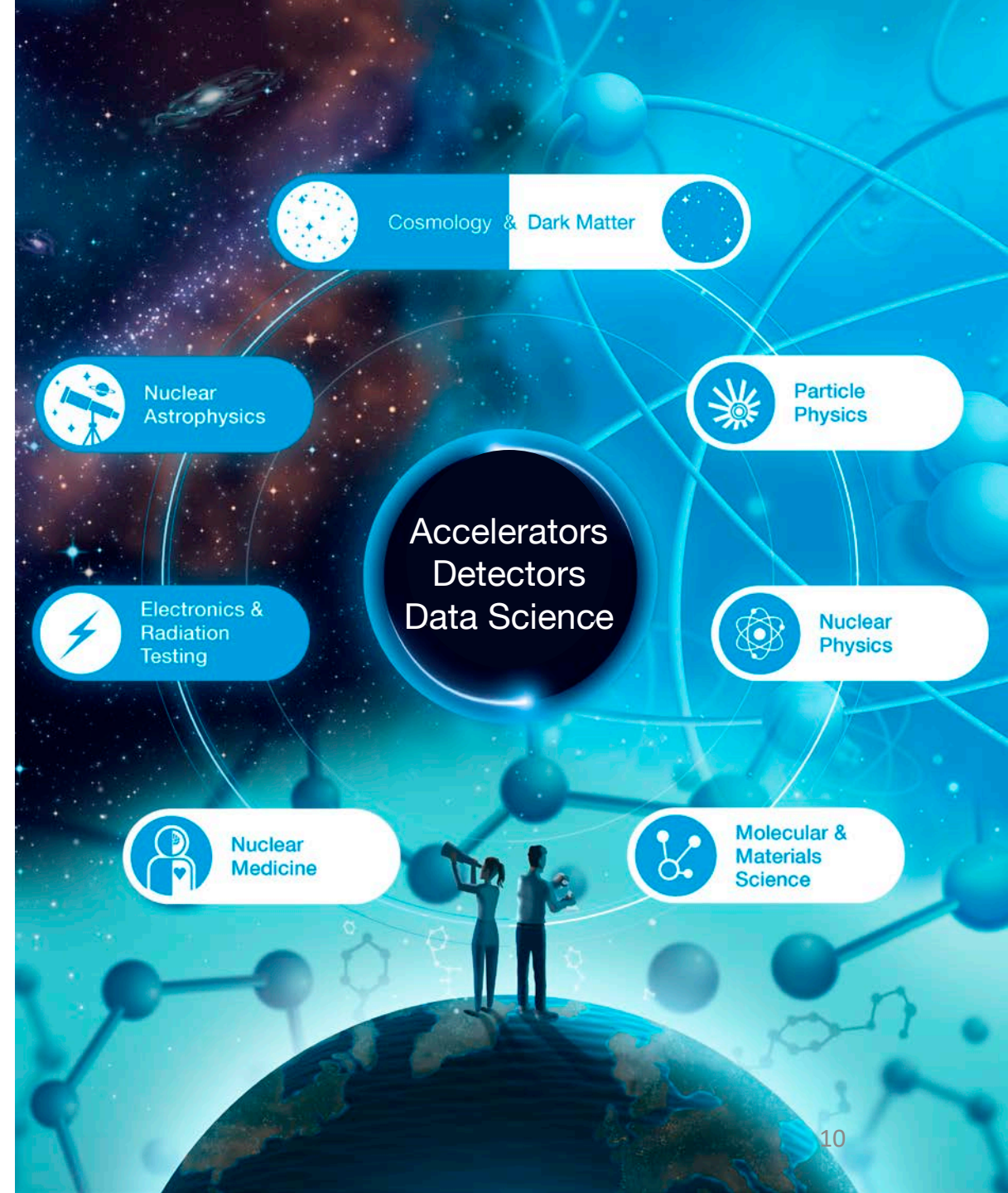
Advancing the treatment of critical diseases



Developing new technologies and innovations



Deepening our understanding of the natural world



Scale of Operations

HIGHLY QUALIFIED PERSONNEL

> 550 staff¹
> 200 students & postdoctoral researchers²
1000+ scientist & researcher visits per year



KNOWLEDGE

~80% of Canada's subatomic physics research involves TRIUMF



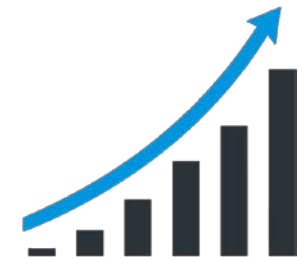
INTERNATIONAL ENGAGEMENT

75+ international agreements & partnerships



BUSINESS

Over \$1.1B in gross economic output since 2012, and >\$600M in GDP attributable to TRIUMF from 2012-2018³



1 – Total across funding sources
2 – Includes external students and post-docs
3 – Timeline of the last economic impact assessment conducted for NRC

Facilities – Accelerators

Main Accelerator Building Facilities

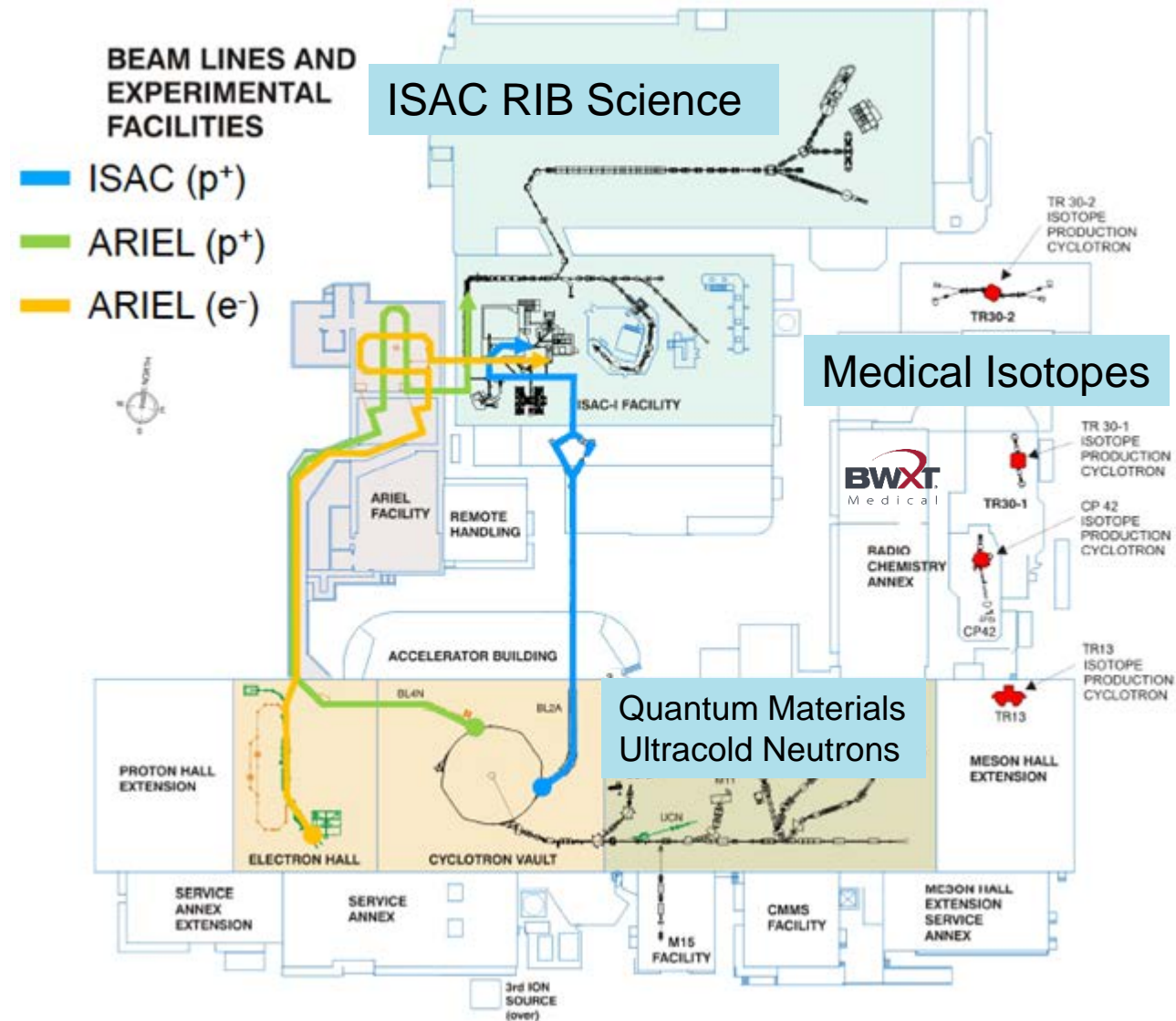
- 520 MeV Cyclotron (Class IB)
- Materials science; isotope production; irradiation facilities, Ultracold Neutrons (under construction)

ISAC & ARIEL Facilities

- ISAC-II (superconducting rare-isotope beam (RIB) accelerator; under Class IB licence)
- ARIEL
 - E-linac (Class II; commissioning)
 - RIB delivery from ISAC (operational)
 - Driver beamlines, targets, and hot cells (under construction)

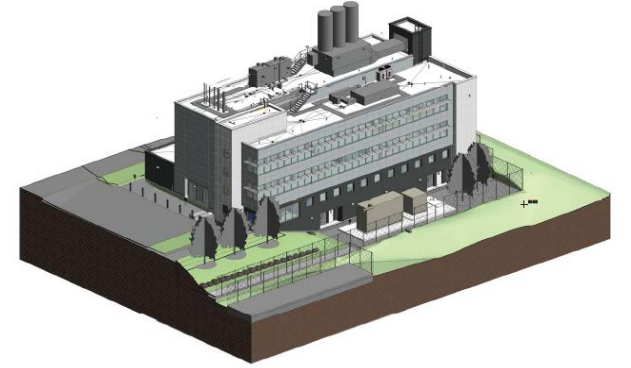
Medical Isotope Production Accelerators

- BWXT Medical – TR30-1; TR30-2; CP42 (Class IB)
- UBC PET program – TR13 (Class IB)
- IAMI – TR24 (Class II; construction)



Facilities – Institute for Advanced Medical Isotopes

- IAMI is a >\$50M facility supported by the Government of Canada, the Province of British Columbia, BC Cancer, and UBC
- Home to a TR24 medical cyclotron and a GMP hot-cell complex, IAMI will serve as a global centre for medical research and radiopharmaceutical development
- Funding was announced by PM Justin Trudeau on November 1, 2018
- Construction under way with completion expected in summer 2022



Highlights & Research Excellence

TRIUMF is a leader in scientific excellence

- TRIUMF elevates Canadian excellence in TRIUMF's fields of research with more than 1,500 publications over five years
- TRIUMF-connected scientists have won numerous prizes, including the Nobel and Breakthrough Prizes, the NSERC Brockhouse and Polanyi Prizes, the APS Pipkin Prize, RSC Rutherford Medal
- TRIUMF-connected scientists have earned major leadership roles on large international experiments, including ALPHA, ATLAS, and T2K
- Since 2015, TRIUMF CFI-related projects received \$108M in funds via the CFI Innovation Fund with a success rate over twice the national average



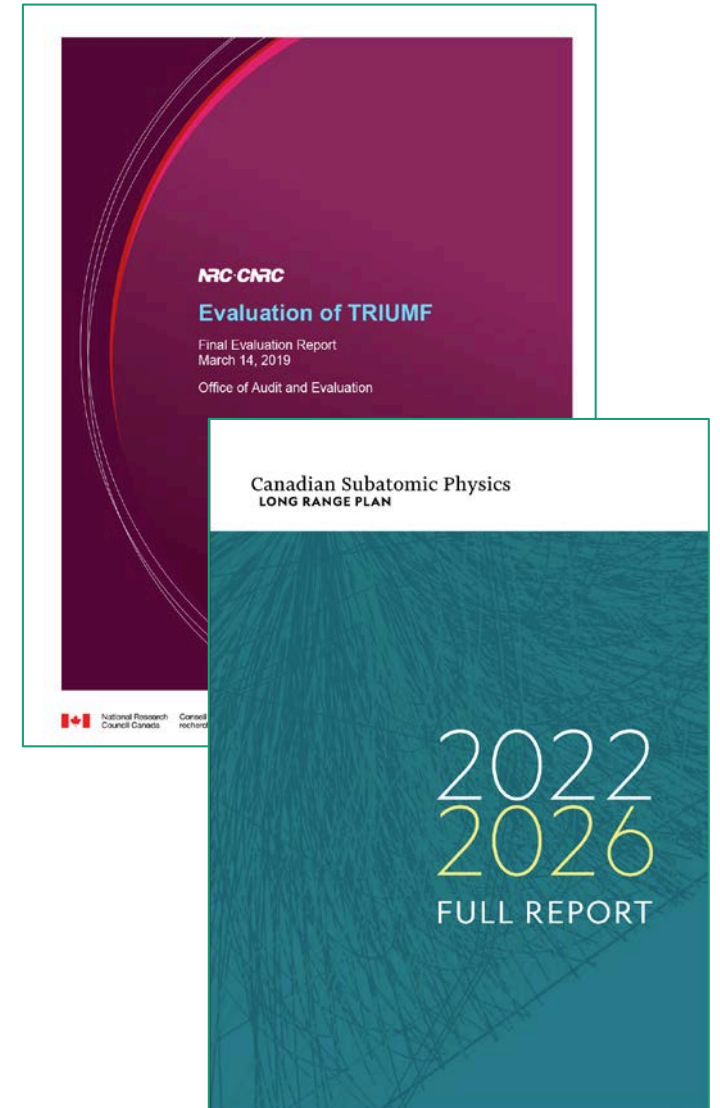
Highlights & Research Excellence

TRIUMF connects Canada to the world

- 58% of TRIUMF's users travel to Canada from 39 foreign countries
- Over 200 Canadian scientists are engaged in international projects via TRIUMF, at CERN (Switzerland), J-PARC/KEK (Japan), VECC (India), JLab and Fermilab (US), Helmholtz Association (Germany), and others
- TRIUMF's infrastructure and expertise have positioned Canada as a world leader in nuclear medicine; TRIUMF Innovations Inc. translates our research into commercial opportunities
- Around 1000 users and visitors per year do research at TRIUMF; ~400 Canadian users from 33 universities in 8 provinces
- Over 100 undergraduates each year spend a work term at TRIUMF, making the laboratory one of the largest such employers in Canada
- Over the last five years, 116 global companies and space agencies used TRIUMF's Irradiation Facilities to qualify electronic components

Highlights & Research Excellence

- The 2018 International Peer Review stated that TRIUMF is a unique facility that is invaluable to the Canadian scientific enterprise
- The 2018 NRC Evaluation found that *“TRIUMF addresses the needs of a growing research community, in particular by providing necessary equipment and facilities, which are not available elsewhere in Canada”*
- The Canadian Subatomic Physics Long Range Plan 2022-2026 recognizes that *“TRIUMF, Canada’s particle accelerator centre, is a unique world-class laboratory hosting its own successful domestic physics program and supporting Canada’s participation in subatomic physics on the international stage.”*



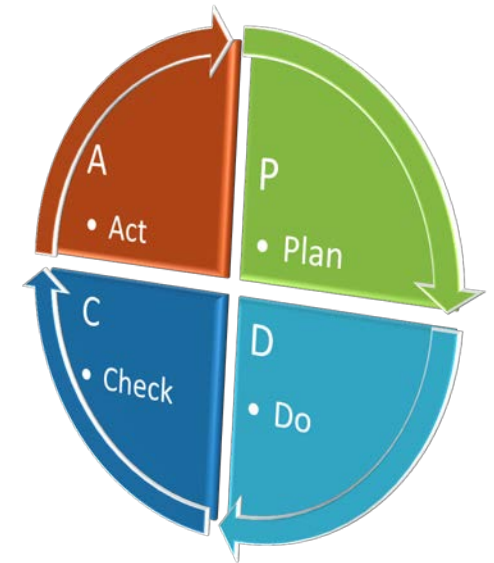
Safety and Control Areas

- TRIUMF's safety and regulatory program covers all Safety and Control Areas (SCAs).
- While each SCA is important, those bolded will be specifically highlighted in this presentation.

Safety and Control Area	CNSC Staff Rating
Management Systems	BE
Human Performance Management	SA
Operating Performance; Fitness for Service	SA
Safety Analysis and Physical Design	SA
Radiation Protection	SA
Conventional Health and Safety	SA
Environmental Protection	SA
Emergency Management and Fire Protection	SA
Waste Management	SA
Security	SA
Safeguards and Non-Proliferation	SA
Packaging and Transport	SA
Site Specific (including Indigenous Engagement, and Public Disclosure and Outreach)	

SCA: Management System

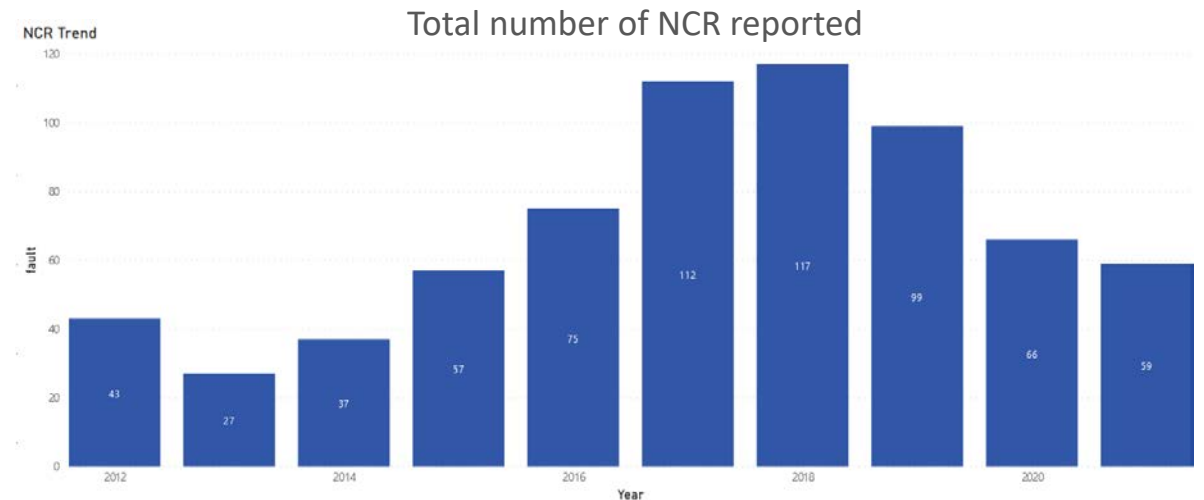
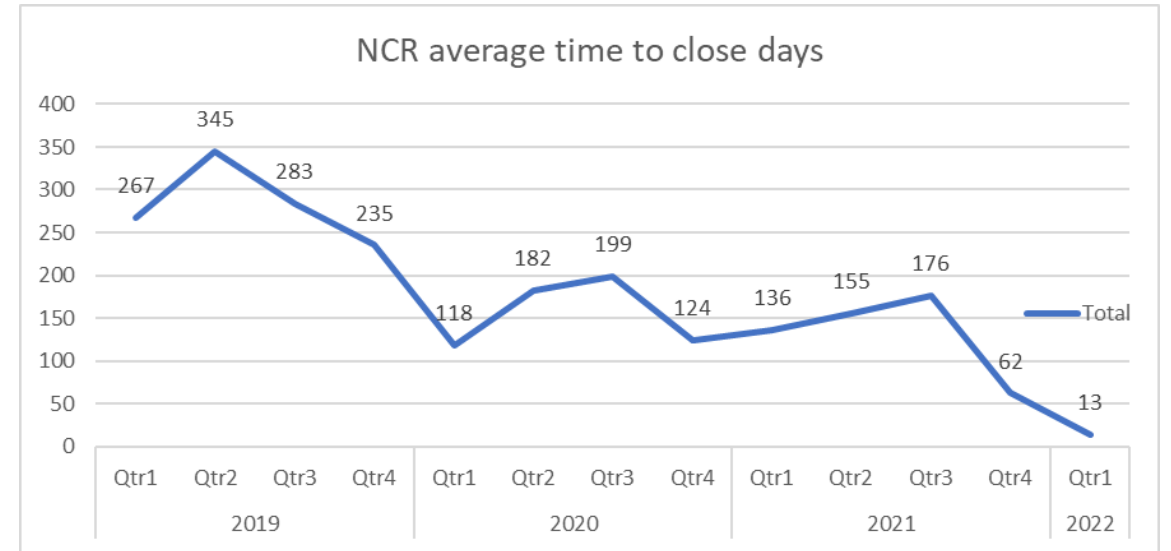
- TRIUMF is committed to implementing and maintaining an effective management system compliant to the Management Systems Requirements for Nuclear Facilities (CSA N286-12)
- There have been challenges and delays in being able to demonstrate full compliance, renewed focus introduced with changes to organisation over the last three years
- A new gap analysis was done in early 2020 which resulted in a revised Quality Manual in compliance to CSA N286-12, approved and released in June 2020
- Several key high-level TRIUMF Standard Operating Procedures (TSOPs) were also revised in response to the gap analysis
- In February 2021, the CNSC performed a Management System Inspection
 - 20 NNC issued - all NNC responded and accepted
 - As of March 16, 2022 – 16 closed; 4 underway/open
- Several actions were implemented, with oversight by our Quality Council, to address the findings from the inspection. These included:
 - Developing an Action Plan as part of the formal response
 - Creating a Work Management Task Force & Work Management Policy
 - Restructuring the Supply Chain group headed by a new Director, Supply Chain



SCA: Management System

Some key highlights from 2020-2022:

- Problem reporting and resolution process improvements focusing on oversight and timeliness for corrective actions (NCR-CA)
- Development of reporting tools and dashboards for key management system processes (trends and monitoring) to track improvements:
 - Nonconformity Reports (NCR)
 - Corrective Actions (linked to NCR)
 - Faults (equipment)
 - Equipment Calibration and Inspections
- Improvements to the documentation management process to enhance the security (Document security policy)



SCA: Management System

Commitment to continuous improvement and N286-12 compliance:

- Management and Ownership
 - Centralization and coordination of all accountable program areas under a single vertical that reports directly to the CAO (presently the Executive Director)
 - The Quality Council (to replace the previous QMS Core) was established in early February 2021 to oversee the day-to-day effective implementation of the Management System
- Accountability and Awareness
 - The closure of the NNCs has resulted in TRIUMF adopting new systems and processes that will keep us on track moving forward
 - The substantial work done to bring TRIUMF in compliance with N286-12 has raised organizational awareness of, and thereby the continued adherence to, the standard
- Continuous Improvement
 - Independent assessments against CSA N286-12 (QM) started in 2021
 - The quarterly Safety and Quality Management Review Meeting performs the assessment of the effectiveness of the safety and quality programs at TRIUMF and discusses strategic deployment of resources and improvement initiatives

SCA: Human Performance Management

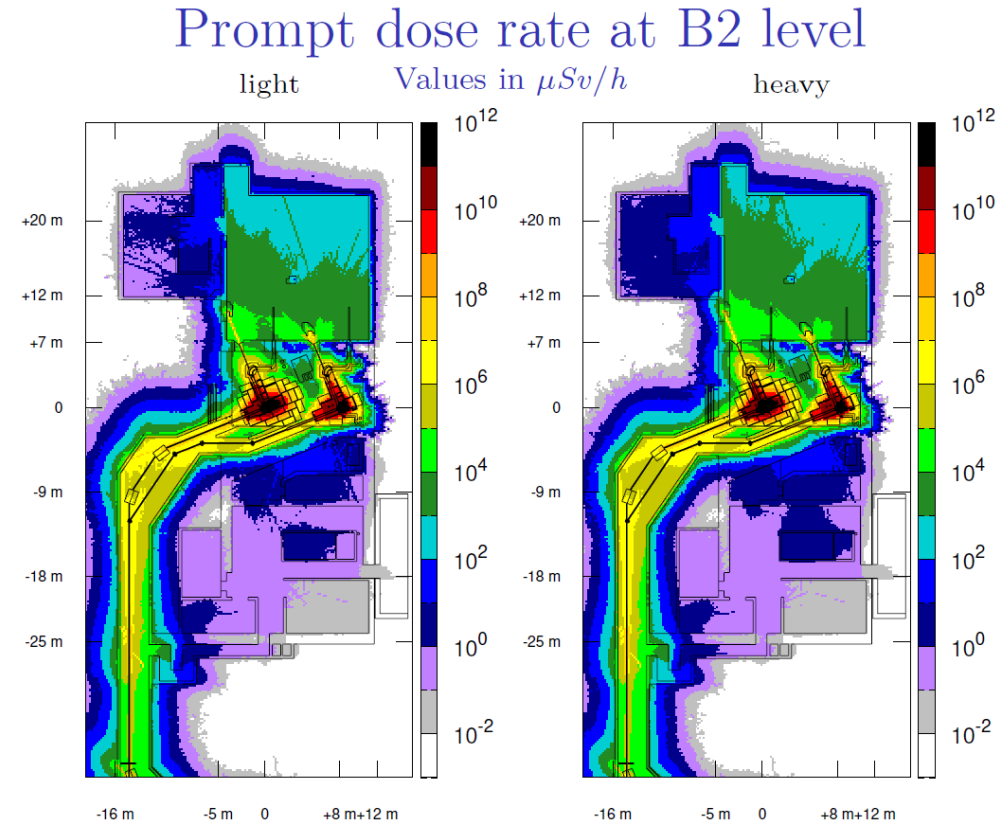
- Training Implementation Panel introduced in 2011; TRIUMF has a mature training program in place
 - Chaired by Training Manager; includes representatives from all Divisions
 - Oversees development of training programs using the "Systematic Approach to Training" for all groups.
 - Mandate includes:
 - Oversight, guidance, and review of all training plans
 - Regular audits of all training plans; risk-based audit frequency of 3-5 years
- Radiation Protection Training
 - Everyone: Basic Radiation Protection Training required for unescorted entry to secure areas
 - NEWs: Advanced Radiation Protection Training; instructor-led course; hands-on section; 5-year refresh
 - Specialized programs:
 - Radiation surveying and decontamination procedures for Operators
 - Contamination monitoring and control for radioisotope lab personnel working with open sources
 - Use and handling of radioactive calibration sources
- Conventional Health and Safety hazards: full suite of training programs for all relevant hazards. Recent additions include:
 - Confined space entry
 - Cryogenic safety

SCA: Operating Performance and Fitness for Service

- Servicing, repair, and inspection of equipment for licensed activities
 - TSOP-08 – Calibration, Inspection and Recurring Maintenance
 - TSOP-11 – Accelerator Operations Management
- Faults and nonconformities (TSOP-02) are tracked, trended, and reported at quarterly Safety & Quality Management Review meetings
- 27 reportable occurrences (2012 – March 2021). Two significant incidents over the licensing period:
 - e-Hall Lock-up incident: Worker missed in pre-lock-up search of electron hall (2014)
 - Worker responded to audible and visible start-up alarms and exited safely; no dose incurred
 - Root Cause Analysis resulted in 11 short-term Corrective Actions (CAs) specific to the Access Control System (ACS) and training, all completed before restarting e-linac. Five longer-term CAs addressed the design and validation of ACSs site-wide and training for people performing lock-ups and working in exclusion areas.
 - Non-NEW dose Action Level exceeded (2015; see “SCA: Radiation Protection” slide)
- Incidents involving unplanned releases of radioactivity:
 - Sources: 8 from radioisotope production targets (Kr-79; Xe-123); 7 from radioisotope lab processing (C-11)
 - Maximum dose to a member of the public for any of these was ~100 nSv; most were much less
 - From 2019, all reportable releases declared publicly on our web pages

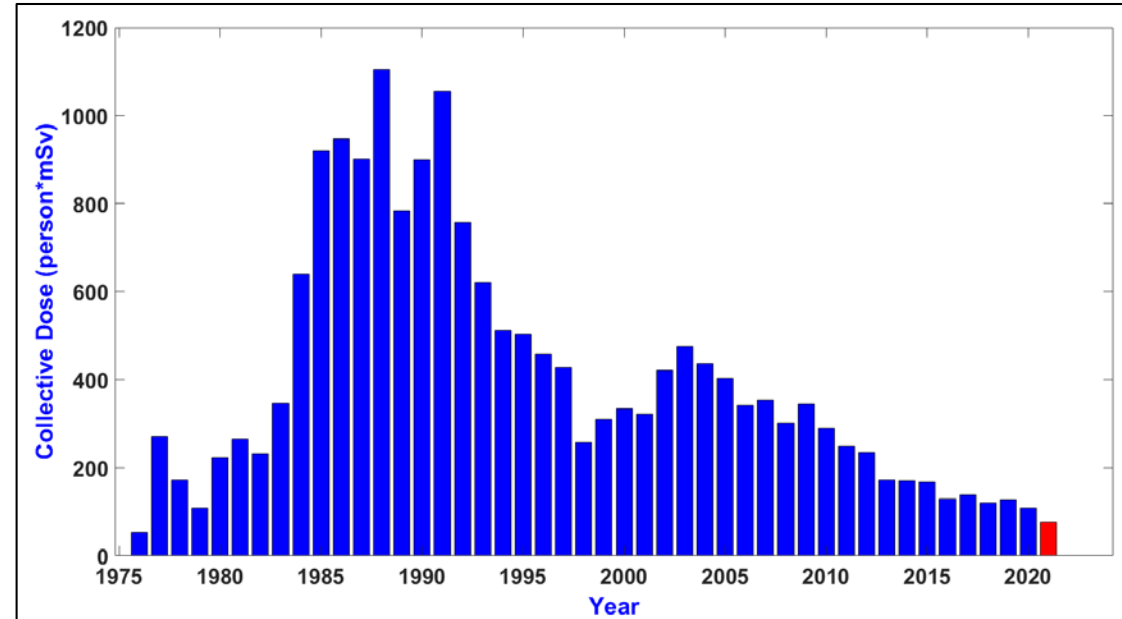
SCA: Safety Analysis and Physical Design

- All facilities have Safety Analysis Reports (SARs)
 - Prompt radiation from accelerated beams is the most significant hazard
 - Shielding, Access Control, and Radiation Monitoring Systems mitigate this hazard
 - Design, engineering, and manufacture of these systems and the ongoing testing and maintenance follow TRIUMF QMS standards
- Hazard analyses include:
 - Expected dose to TRIUMF staff and members of the public from normal operations
 - Analysis of worst-case scenarios for beam losses and releases of radioactive substances, including on-site and off-site doses
 - Consideration of potential to affect decommissioning plan



SCA: Radiation Protection

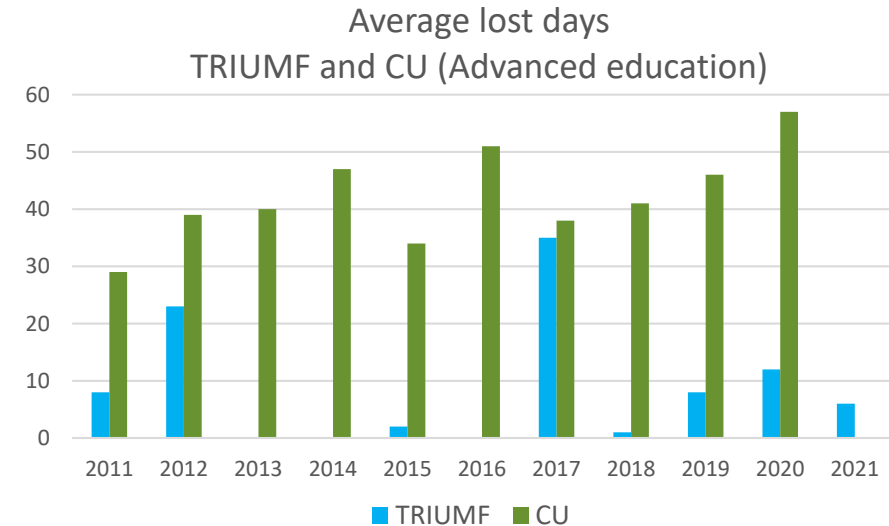
- Collective dose continues downward trend over licensing period
- Average annual doses, 2011-2020:
 - NEW: 0.47 - 0.77 mSv
 - Non-NEW: 0.004 - 0.02 mSv
- One Action Level exceedance (2015):
 - non-NEW quarterly whole body dose quarterly Action Level of 0.5 mSv was exceeded (0.67 mSv)
 - Incident was investigated and several corrective actions implemented, including:
 - Non-NEWs prohibited from high radiation areas without explicit consent of RPG Head (immediate)
 - Introduction of “Basic Radiation Protection Training” course, required for independent access inside TRIUMF security fence.



2020	# Persons monitored	Dose (mSv)				
		0-0.20	0.21-1.00	1.01-5.00	5.01-20.00	≥20.01
NEWs	405	319	53	32	1	0
non-NEWs	701	701	0	0	0	0

SCA: Conventional Health & Safety

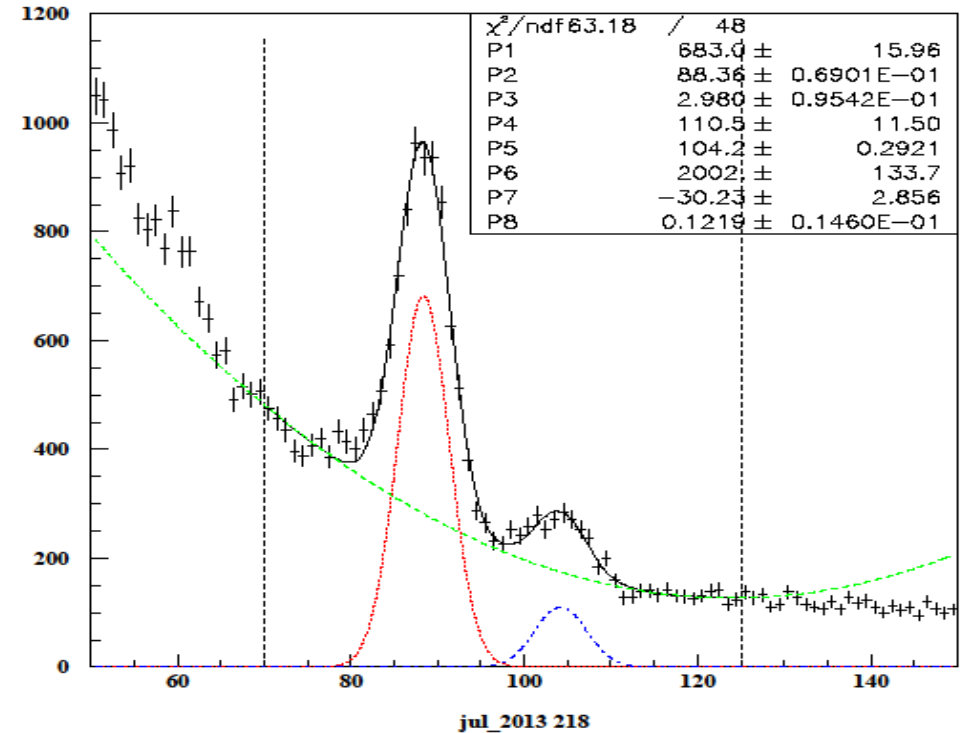
- All CHS hazards included in facility Safety Analysis Reports
- Lost Time Injury (LTI) rate and total / average lost time all lower on average than WorkSafe BC Comparative Unit
 - 2020/21: Rolled out 12 “Safe work procedures” for power tools
- Proactively developing new processes: recently introduced site-wide programs for cryogenic safety and confined space entry
- Mandatory twice-yearly Supervisor Safety Training
- Hosted 2017 “International Technical Safety Forum” (ITSF: CHS at accelerator labs)
- Addressing emergent issues in CHS:
 - Lead dust remediation:
 - Slightly elevated surface levels (unpainted bricks; pulverized paint from concrete shielding blocks); no airborne hazard
 - Remove / paint bare lead bricks; provide training and PPE
 - Acceptable levels verified via 3rd-party testing
 - COVID-19 response:
 - Task Force formed to manage pandemic safety (no outbreaks on-site)
 - Detailed response procedures and community resources for workers and supervisors
 - “Safe work procedures” for close-proximity work
 - “Work from home” used extensively



SCA: Environmental Protection

- Mature emissions and environmental monitoring programs in place to ensure public dose is maintained well below regulatory limits
- Dose to public (Derived Release Limit, CSA N288.1-14): $\sim 6 \mu\text{Sv/y}$
- Radioactive releases dominated by gaseous airborne emissions associated with operation of 520 MeV cyclotron
- Principal emissions: β^+ emitters (C-11; N-13; O-15) ; Ar-41
- Downstream monitoring via Health Canada detector: public dose conservative by a factor of at least $\sim 2-3$ (corrected value: ~ 5)
- Dose from waterborne effluent lower by 5-6 orders of magnitude
- Other environmental monitoring:
 - Twice-yearly vegetation sampling at 11 nearby off-site points; cross-checks with distant sites to baseline cosmogenic Be-7
 - Storm sewers
 - Subsurface sumps (ground water)
- Unplanned releases:
 - Gaseous products from isotope production targets (Kr-79; Xe-123) and radioisotope labs (C-11)
 - Maximum doses to public (c. 100 nSv) predicted via DRL model

Example gamma spectrum from Health Canada detector



SCA: Waste Management / Decommissioning

Waste Management

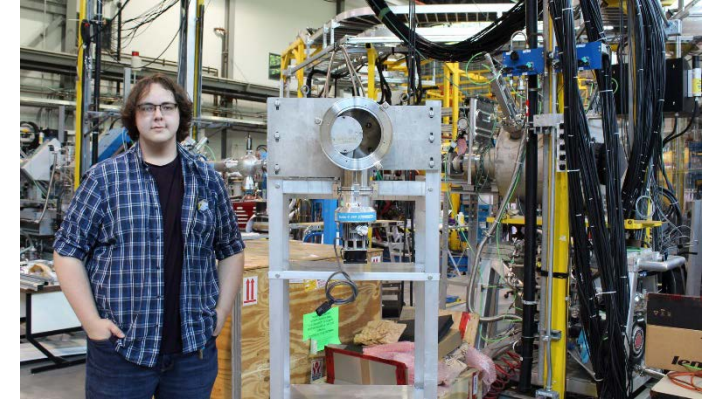
- Radioactive waste, low-level: Well-established program based on NSRDR clearance levels
 - Compactable; ion-exchange resin; HEPA filters: Store until concentration below clearance level; dispose to landfill
 - Oil: Store until concentration below clearance level; dispose as non-radioactive hazardous waste
 - Metal: Store until concentration below clearance level; dispose via local metal recyclers
 - Concrete (under study): Develop “field” characterization methods; dispose as road building material following clearance
- Radioactive waste, high-level:
 - ISAC targets: Store on-site until shippable in Type A flasks; disposal to Canadian Nuclear Labs, Chalk River
 - Decommissioned infrastructure (magnets; beamlines; etc.): Store on site until shippable
- Future: Radioactive Waste Management Task Force Report Phase 1 (2020) Infrastructure Plan for future WM needs
 - Challenges: BL1A refurbishment; Ac-225 production; IAMI; ARIEL

Decommissioning

- Preliminary Decommissioning Plan (PDP) updated in 2013, 2019, 2020
- 2020 update on Financial Guarantees:
 - PDP incorporates CNSC review comments and five-year forecast for decommissioning fund
 - Includes contingency (Phase 1: 15%; Phase 2,3: 30%); Total cost estimated ~\$70 M (costing in 2022 dollars)
 - Present decommissioning fund value: \$12.214 M (March 31, 2022)
- Planned 2023 update to include IAMI decommissioning (estimate in IAMI construction licence application)

Indigenous Engagement

- TRIUMF is a long-term leaseholder on the campus of UBC; this land is on the traditional, ancestral, and unceded territory of the Musqueam ($x^w m \theta k^w \text{əy} \text{əm}$) people
- TRIUMF works closely with UBC to engage the Musqueam, providing key updates through Campus and Community Planning on key developments such as the construction of Institute for Advanced Medical Isotopes (IAMI). TRIUMF and UBC reached out in summer 2021 to provide an update on laboratory activities, leadership changes, and the upcoming relicensing – as well as possible avenues to participate in the process
- Further to this engagement, TRIUMF has taken other small steps to building a deeper connection with indigenous communities
 - Promoting awareness of indigenous issues by embedding these topics into key meetings, newsletters, site-wide messages, and more
 - Building new partnerships with local leaders in indigenous engagement, including UVic and BCIT
 - Targeted recruitment via participation in indigenous career fairs
 - Hosting summer work experience placements for grade 10 – 11 students as part the Emerging Indigenous Scholars Summer Camp



“Finding out that I could potentially work at TRIUMF as my actual job when I’m an adult has made me reconsider the paths I’m taking now and what they’ll lead me to. I’ve always wanted to be a scientist or an engineer, and my experience at TRIUMF reinforced my interests and passions.”

Myles Olson, 2019 Emerging Indigenous Scholar

Public Disclosure & Outreach

- TRIUMF maintains a Public Disclosure Program (as per license conditions) that communicates timely information related to health, safety, and security of persons and the environment to the general public
- In addition to this program, TRIUMF also has a long history of engagement and openness with the public:
 - Since 2012, TRIUMF has hosted more than 33,000 visitors for in-person tours of the lab
 - From 2012 – 2022, TRIUMF has enabled over 120,000 informal science experiences to the public, including at local community festivals, science fairs and STEM-advocacy events, public talks, etc.
 - TRIUMF's social media outreach routinely reaches over 500,000 users per year
 - A single collaboration with a YouTube creator generated over 900,000 views as of March 2022



Dr. Beatrice Franke, Research Scientist, leading a tour group through the laboratory



Thank You
Merci

www.triumf.ca

@TRIUMFLab

