

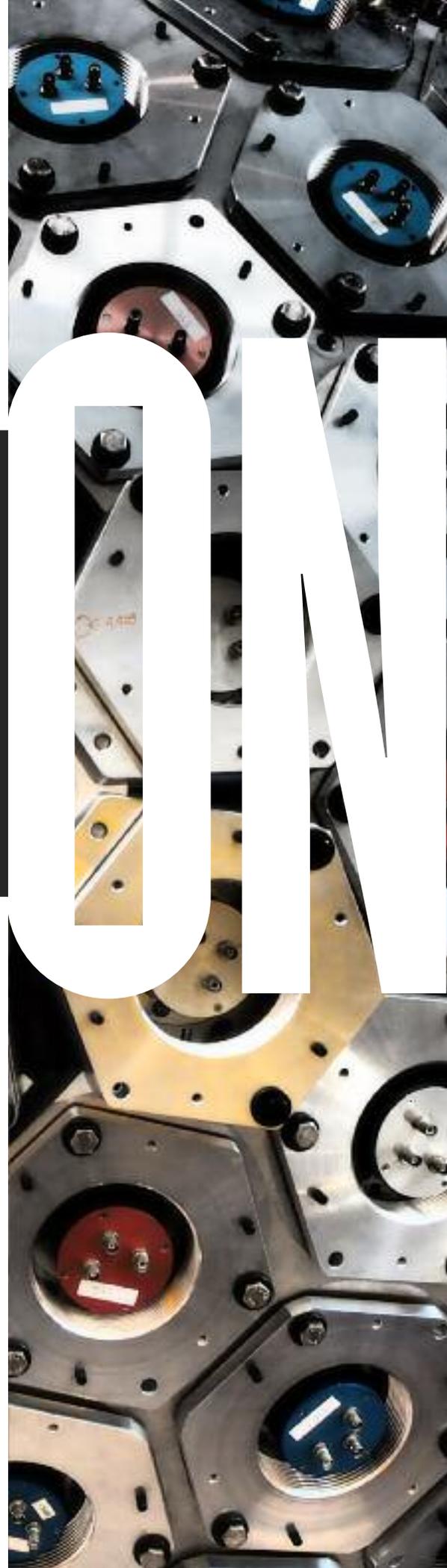
CANADA'S NATIONAL LABORATORY  
FOR PARTICLE AND NUCLEAR PHYSICS

ANNUAL ADMINISTRATIVE  
AND FINANCIAL REPORT 2014 – 2015

# BEAM ON



ACCELERATING SCIENCE FOR CANADA



# delivering on the promise

## BEAM ON

**TRIUMF has completed the fifth and final year of Five-Year Plan 2010–2015.**

This year's report not only captures major milestones during the last fiscal year, it also highlights the importance of driving and delivering on the promise.

**TRIUMF is one of the world's leading subatomic physics laboratories.** TRIUMF brings together dedicated physicists and interdisciplinary talent, sophisticated technical resources, and commercial partners in a way that has established the laboratory as a global model of success.





## MISSION

**To make discoveries** that address the most compelling questions in particle physics, nuclear physics, nuclear medicine, and materials science;

**To act as Canada's steward** for the advancement of particle accelerators and detection technologies; and

**To transfer knowledge**, train highly skilled personnel, and commercialize research for the economic, social, environmental, and health benefit of all Canadians.

## VISION

**Lead in Science:** The world sees TRIUMF as Canada's leader in probing the structure and origins of matter and in advancing isotopes for science and medicine.

**Leverage University Research:** The Canadian university research community views TRIUMF as a way to strengthen and expand their research programs.

**Connect Canada to the World:** International subatomic physics laboratories look to TRIUMF when partnering with Canada and its research community.

**Create Social and Economic Growth:** The global scientific community sees TRIUMF as a bridge between academia and the private sector and as a model for commercialization and social impact.

## VALUES

**Excellence** and Impact

**Collaboration** and Teamwork

**Honesty** and Transparency

**Innovation** and Relevance

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## MESSAGE FROM THE CHAIR OF THE BOARD



Let me begin by expressing my gratitude to the Government of Canada for their commitment to TRIUMF in Budget 2015 and supporting the laboratory's vision for 2015–2020. This is marvelous news – not just for TRIUMF – but for all the communities that connect with the lab, from member

universities, collaborators and partners driving world-class research, to trainees who benefit from outstanding mentors, facilities and infrastructure, to physicians and their patients requiring the use of medical isotopes, to businesses who benefit from technological innovation, and the broader public.

This issue of Beam On, the concluding report for Five-Year Plan 2010–2015, offers a peek at TRIUMF's talented and empowered staff, its ambitious research and projects, and the leadership that drives the lab's successes. We continue to build upon growing pan-Canadian and international collaborations, and laying the path for a compelling, innovative and outstanding scientific program.

Recent years have marked a period of evolution at TRIUMF as the laboratory prepared for the future. Of course, we were fortunate to welcome a new Director, Dr. Jonathan Bagger, who recently completed his first year at TRIUMF. The realization of ARIEL from a mere idea to a full-fledged, world-class facility has been a remarkable achievement! TRIUMF successfully completed the \$62.9M ARIEL-I project. Underway since 2010, ARIEL-I included civil construction for the new facility, as well as the design, manufacture, and deployment of a state-of-the-art superconducting electron linear accelerator. The e-linac successfully

produced first beam in September. In November, we celebrated this milestone with researchers, provincial and federal politicians, and media.

Moreover, ARIEL-II was a uniting project, drawing unprecedented support from all 19 TRIUMF member universities for further funding to support the next phases (2015–2020) of new scientific capabilities and technical development; the proposal received funding from the Canada Foundation for Innovation and included requests to five provincial governments (Alberta, British Columbia, Manitoba, Ontario, and Quebec) for matching support.

A national laboratory owned and operated by a consortium of Canadian universities, TRIUMF has a unique relationship with its member universities, pulling together their strengths and capabilities. This consortium too has evolved in recent years. We've grown from 13 member universities in 2010 to 19, and we expect to continue growing. TRIUMF is also supporting a number of joint faculty appointments in order to increase engagement with the university research community.

As we look to Five-Year Plan 2015–2020, TRIUMF is sure to move forward by continuing to build on achievements like ARIEL and the laboratory's longer standing legacy of success that goes back many years. It is in this spirit that I invite you to explore this issue of Beam On.

Sincerely,

**Steven N. Liss** | Chair, TRIUMF Board of Management | Vice-Principal (Research), Queen's University





## MESSAGE FROM THE DIRECTOR



Scientific excellence has always been at the core of TRIUMF. The wonderful thing about fundamental research is that it drives innovation for society—for the benefit of all Canadians. The scientific questions we pursue demand that we design new experiments, better instruments, and use

resources more efficiently and effectively. Our experiments and instruments are beyond state-of-the-art. The tools we invent have applications ranging from medicine to materials. As director, my job is to fuel the spirit of innovation and support the TRIUMF team to realize benefits from our research.

So, why should Canada invest in Big Science facilities like TRIUMF? It's simple. Sustained investment in large-scale research facilities drives innovation. TRIUMF enables research on a scale that no one university could do alone. A place like TRIUMF brings teams together, it brings facilities together, and it brings solutions to real-life problems. As science advances, society advances and vice versa; they are two sides of the same coin.

All Canadians have a stake in TRIUMF. We are a multidisciplinary laboratory, deeply integrated into the research community, working in support of Canada's Science and Technology strategy. Our research is driven by our users – a third of whom come from across Canada – as well as our 19 member universities.

Our reach extends far beyond our physical infrastructure. We're embedded into the global science and technology community through partnerships with major international projects, connecting Canada to the world. We inspire and train the next generation. We provide opportunities for curious minds to experience the wonder and excitement of science through direct research experiences and informal science education. TRIUMF transfers science to society. We are at the forefront of scientific innovation and discovery and we are committed to transferring advanced technical developments and skills to the commercial sector.

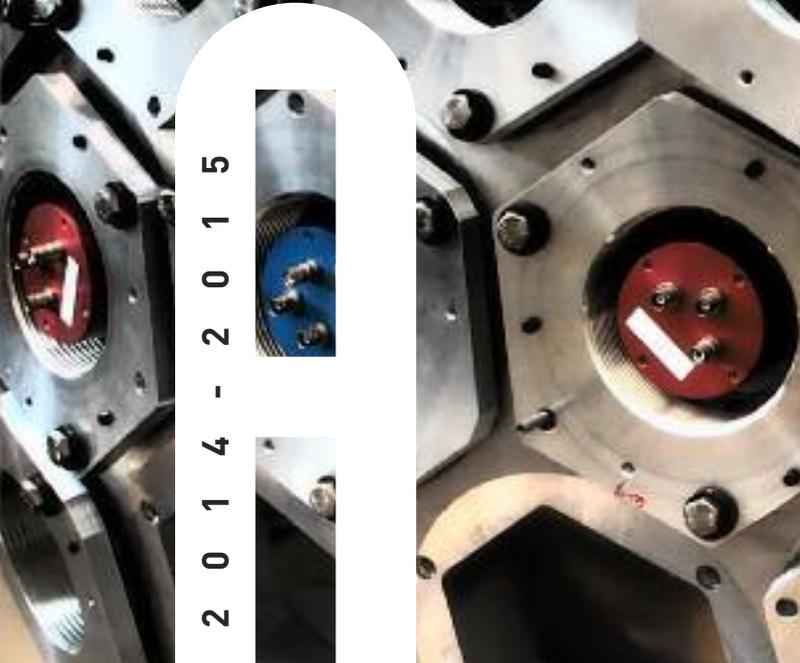
As we conclude the final year of TRIUMF's Five-Year Plan 2010–2015 and approach the next, I'm proud of our achievements. TRIUMF is Canada's national laboratory for particle and nuclear physics. We've diversified in the past years, increasing our relevance for both science and society. We have new facilities, like ARIEL and our nuclear medicine labs; we have expanded our isotope capabilities; and, we have diversified our world-class staff and talent pool.

I invite you to read through this year's report and get a sense of the breadth of TRIUMF's research and its broader impacts.

Sincerely,

**Jonathan A. Bagger** | Director, TRIUMF





## ACCOMPLISHMENTS

THIS IS THE FINAL YEAR OF TRIUMF'S FIVE-YEAR PLAN 2010–2015. THE LABORATORY CONTINUES TO OPERATE WITH HIGH EFFICACY, BUILD INTERNATIONAL REPUTATION, AND FOCUS ON HIGH IMPACT ACCOMPLISHMENTS. GUIDED BY ITS MISSION, PROGRESS ON THE PLANS AND PROMISES DECLARED IN LAST YEAR'S REPORT ARE DISCUSSED.

### LEGEND

- Complete
  In progress

### ARIEL (ADVANCED RARE ISOTOPE LABORATORY)

- Complete the CFI-funded ARIEL e-linac project and demonstrate first beam tests.
- Identify pathway and advance plans for isotope production capability in ARIEL.
- Utilize ARIEL as a platform for student and professional training.

TRIUMF successfully completed the \$62.9M ARIEL-I project. Underway since 2010, this phase of ARIEL included civil construction for the new facility, as well as the design, manufacture, and deployment of a state-of-the-art superconducting electron linear accelerator. The e-linac successfully produced first beam in September 2014.

TRIUMF hosted a celebration to recognize completion of the ARIEL-I project. The event was hosted in the new building and featured representatives from the BC Provincial Government and CFI.

An application for the \$33.89M ARIEL-II project was submitted to CFI. With unprecedented support from all 19 TRIUMF member universities, the proposal requested \$13.556M from CFI, with the remainder requested from five provincial governments (Alberta, British Columbia, Manitoba, Ontario, and Quebec).

Collaboration continued under the MOU between TRIUMF and the Variable Energy Cyclotron Centre in Kolkata, India. Progress was made on the development and testing of two injector cryomodules (ICM). The first ICM has been successfully built and tested. The second ICM is under final assembly; delivery to VECC is expected in 2015.

TRIUMF continued collaborating with PAVAC Industries Inc. of Richmond, BC on the manufacturing of superconducting cavities for US, China, and India, and on the high-tech cryomodules technology transferred from TRIUMF through AAPS.

The CANREB infrastructure layout was established and requirements specifications released. The HRS magnet design has started and the EBIS is under construction by MPI Heidelberg.

A successful first test of thorium target irradiation opened new possibilities for the production of heavy and neutron-rich isotopes.

The TRIUMF accelerator physics course was taught to UBC and University of Victoria students for the fifth year. This is the only course of its type offered in Canada.

**“The completion of this remarkable project couldn't have happened without the cooperation of the scientific and engineering communities along with the input of governments and the private sector.”**

**Dr. Gilles Patry, President & CEO,  
Canada Foundation for Innovation**



**“ARIEL will push the frontiers of knowledge and have profound impacts in many areas of research, including the health sciences, materials science and environmental remediation.”**

Prof. Jamie Cassels, President, University of Victoria

## ADDRESS THE MOST COMPELLING QUESTIONS

- ✔ Continue installation and development of the UCN facility in pursuit of world-leading science.
- ✔ Preserve the pace of scientific results from ISAC experiments and data from ATLAS, T2K, ALPHA2, as well as M20/M15 for top-notch science.

ATLAS published numerous studies on the properties of the Higgs boson and the search for new particles. Work on the New Small Wheel and Liquid Argonne Calorimeter upgrade projects was initiated. Two TRIUMF scientists are serving as the conveners for the ATLAS Higgs and Physics Upgrade groups.



The ALPHA team commissioned the new ALPHA-2 experiment, used to carry out laser spectroscopy on antihydrogen.

The T2K Collaboration published the most precise measurements to date of neutrino mixing properties and established first indications for a non-zero CP violating phase.

The CFI-funded GRIFFIN gamma-ray spectrometer for decay studies was installed and the first experiments were carried out.

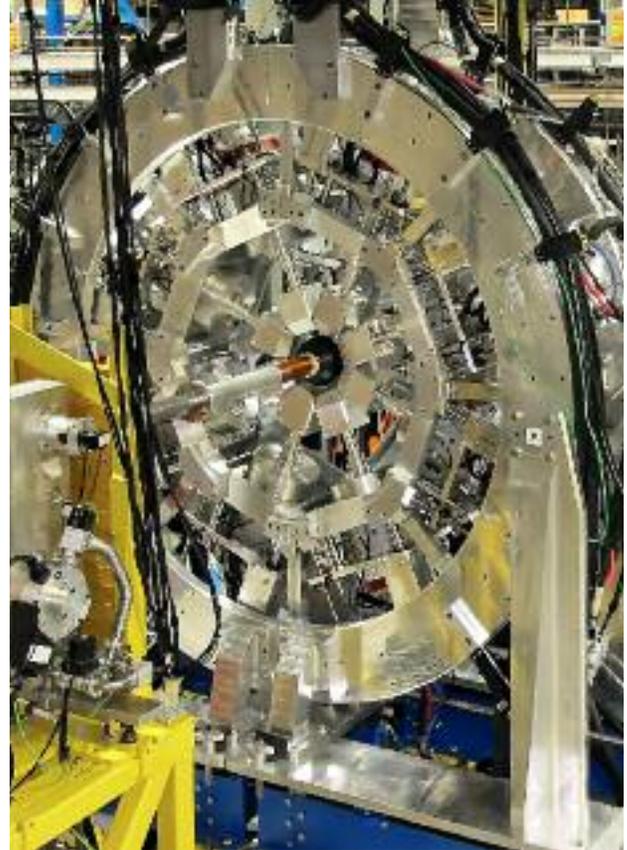
Important reaction studies on light-mass halo nuclei were carried out with the TIGRESS gamma-ray spectrometer and the new CFI-funded solid hydrogen target facility, IRIS. TIGRESS continued its successful transfer reaction program on heavy neutron-rich strontium isotopes using charge-bred beams from ISAC-II.

The TITAN facility, enabled by the new Ion-Guide Laser Ion Source that suppressed contaminants, made a first mass measurement of Mg-20 to test the isobaric multiplet mass equation.

The Francium Trapping Facility for fundamental symmetry tests was successfully commissioned and the first hyperfine spectroscopy experiments on francium were carried out.

Measurements at TRIUMF's betaNMR facility shed light on the lithium ion transport in thin films of pure and lithium-salt-doped polyethylene oxide – a material relevant for lithium-ion batteries.

MuSR experiments resulted in high impact publications on magnetic frustration, ferromagnetic ordering,



as well as the use of supercritical carbon dioxide in chemical reactions.

The TRIUMF-led NRCan ITAP consortium set a new world record for the cyclotron-based production of Tc-99m. Over a six-hour run, the TRIUMF team was able to produce 34 Ci of Tc-99m – enough to satisfy the daily demand for a population the size of BC.

For their outstanding teamwork in realizing a solution for safe and reliable isotope production for hospitals in Canada, the TRIUMF-led interdisciplinary team received the NSERC Brockhouse Canada Prize for Interdisciplinary Research in Science and Engineering.



## GRANT MINOR

Nuclear engineer by day. New wave singer and bassist by night. And no, this is not the tag line to Hollywood's latest blockbuster. It is the life of TRIUMF Remote Handling Group Leader Grant Minor, who also performs live music.

**Your two passions, engineering and performing, seem counter-intuitive. How do you see them fitting together?**

"The way that scientists and engineers communicate science can get dry and boring. Effective communication can help solve problems and spread knowledge. I like the popular science orators like Neil deGrass Tyson and Bill Nye. It's always been a goal of mine to be able to speak like them on science, physics and engineering."



**“The NSERC Brockhouse award is about collaboration, and the TRIUMF-led project is an excellent example of how Canadian researchers from many disciplines work together to solve important challenges.”** Honourable Greg Rickford, Minister of Natural Resources

The award was presented by the His Excellency the Right Honourable David Johnston, Governor General of Canada, at a ceremony in Ottawa (pictured above). Supported by the CIHR Open Operating Grant Program, TRIUMF scientists began investigating the role of oxidative stress in ‘triple negative’ breast cancer. This research will result in the development of a novel radiotracer to image oxidative stress in tissue as a function of disease progression or response to therapy. A publication from this work was recognized as one of the top three Basic Science manuscripts from 2014 in the *Journal of Nuclear Medicine*.

With funding from the Canadian Cancer Society, TRIUMF obtained the first At-209 single-photon computed tomography (SPECT) images using the VECTor SPECT/PET/CT scanner located in the UBC Centre for Comparative Medicine and labeled its first set of targeting peptides with both At-209 and At-211.

This will enable scientists to move novel isotopes produced at TRIUMF from concept into practice, realizing novel innovations in molecular imaging and targeted radiotherapy.

Using tracers produced at TRIUMF, the Pacific Parkinson’s Research Centre is exploring the role of tau protein buildup in the progression of Parkinson’s disease. Feasibility studies have led to the awarding of a large, multi-year grant from the Weston Foundation.

Targeted alpha therapy has long been a promising yet unrealized science for treating cancer. TRIUMF maintains a unique suite of accelerators that can be used to isolate experimental to full production quantities of isotopes that are difficult to obtain. The ISAC facility has been used to successfully isolate At-209 (via Fr-213), At-211 (via Rb-211), and Ac-225 (via Ra-225), and is one of only a few places worldwide capable of doing so.



## FIONA HOLNESS

If you try to catch Fiona Holness in her office, try again. Fiona is a Radiation Protection Technician/Surveyor. As a technician, she is responsible for ensuring that the TRIUMF site is safe for everyone. Armed with Geiger counters, dosimeters, and radiation protection, Fiona can be found all around the laboratory making sure that it is safe for both the hundreds of people who work at TRIUMF as well as the thousands of visitors who come to tour the facilities.

### ADVANCE PARTICLE ACCELERATOR AND DETECTION TECHNOLOGIES

- ✓ Revitalize the main cyclotron to deliver optimal operation and availability.
- ✓ Enhance isotope capabilities and production at ISAC.
- ✓ Pursue world leading accelerator research, including SRF research and development.
- ✓ Refurbish and enhance beamlines to enhance capabilities for materials science.
- ✓ Complete construction of detectors for GRIFFIN and EMMA at ISAC, DEAP and SNO+ and SNOLAB.
- ✓ Contribute to international particle physics projects, specifically for ATLAS upgrades, T2K/Hyper-K, and UCN/nEDM.

The main cyclotron ran for 5181.9 hours in 2014, providing 92.4% of the scheduled beam. High uptime across the beamlines led to a record year of availability with 12,973 hours of beam delivered.

Measurements with laser trackers have been carried out during the shutdown to characterize the misalignment between the front-end of the M9 meson channel relative to target T2 in beamline BL1A. Also a mock-up of the positioning system of this area has been produced that will aid the design of a new front-end for the M9 channel.

The installation of the new beamline for the Ultra-Cold Neutron (UCN) facility has progressed on schedule with most of the beamline installation and the lowest layer of the shielding pyramid for the UCN source in place. Preparations are underway to move the UCN source from Japan to TRIUMF.

The GRIFFIN spectrometer was completed in the summer of 2014 and first experiments were carried out in September 2014. In the four experiments carried out so far the array has successfully demonstrated its much larger detection efficiency over the 8pi spectrometer it replaced.

**“The cyclotron has matured over the years but is not an old car that one polishes regularly and showcases from time to time but more like a Stradivarius violin which is handed to the best artists and is used to perform at top venues.”**

Jean-Michel Poutissou, TRIUMF Emeritus

The installation of EMMA has progressed with the completion of the installation of all major components. Delays in the timeline towards commissioning the system have resulted from deficiencies in the manufacturing at the vendor of the electric dipole components.

The installation of the DEAP-3600 experiment at SNOLAB has been completed and commissioning of electronics and DAQ system has successfully been carried out. The detector will be filled with Argonne later in 2015 and start its physics program. The installation of the SNO+ detector and its auxiliary systems are progressing.

ATLAS detector upgrades have progressed well for the new trigger readout electronics for the Liquid Argonne Calorimeter and the new muon small wheel. For the latter a spray machine has been installed and commissioned for the graphite spraying and cathode production for the thin gap chambers.

The new Photosensor Test facility, which will be used for T2K and Hyper-K R&D has been commissioned and first test have been carried out on large 8" photodetectors.

**“[TRIUMF is] on the cusp of absolute world-class stuff and they do it cheaper than anyone else who has that same technology and they fight for funding all the time.”**

Col. Chris Hadfield, former Canadian astronaut and commander of the International Space Station



## RUEDIGER PICKER

For most of the lab, the annual cyclotron shutdown marks a pause in beam time for the experimental season. But for Ruediger Picker, a researcher in the particle physics department, and the team behind the Ultra-Cold Neutron project, it is the opportune time to install equipment and instruments into the existing Meson Hall for the new experiment. The project includes international collaboration and is on track to be in operation by Spring 2017.

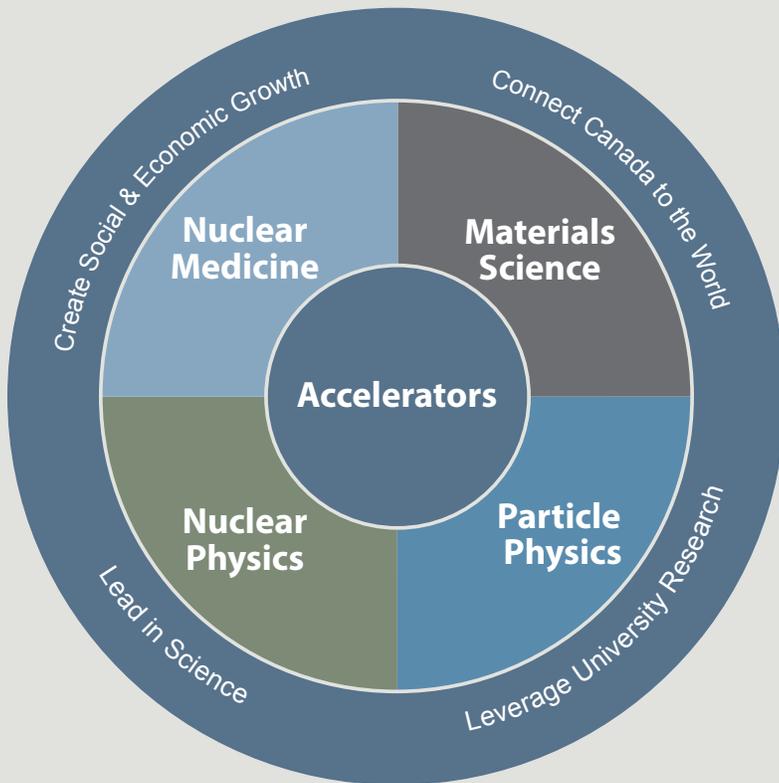
Ruediger describes what it is like to build and install a new experiment.

“Building a scientific apparatus is 1) a lot of real work, 2) heavy lifting, 3) still a little bit like playing with LEGO and 4) a shame that we have to cover all the nice equipment back up after each shutdown.”



# BY THE NUMBERS

FISCAL YEAR 2014-2015 AT A GLANCE



TRIUMF is one of the world's leading subatomic physics laboratories. It brings together dedicated physicists and interdisciplinary talent, sophisticated technical resources, and commercial partners in a way that has established the laboratory as a global model of success. Its large user community is composed of international teams of scientists, postdoctoral fellows, and graduate and undergraduate students.

## Advancing Knowledge

Hosted **460+ visiting scientists** from **19 countries**

Invited to **present 39 lectures** on ATLAS and ISAC research topics, **84** for subatomic physics **overall**

Authored or co-authored **236 scientific peer-reviewed publications**

Operated the main cyclotron for **5,182 hours** (94.2% of scheduled performance)

Supported **27 scientific experiments for subatomic physics, 58 for molecular and materials science, and 15 for life sciences**

Delivered **4,273 hours of radioactive-isotope beams to experiments and for beam developments and 4,505 hours of stable-isotope beams to scientific experiments in its ISAC facility**

High uptime across the beamlines led to a record year of availability with **12,973 hours of beam delivered**

Used the TR13 cyclotron to produce **858 runs of medical isotopes delivered to hospitals** for research including **15 runs for medical isotopes to the BC Cancer Agency for the diagnosis of cancer patients**



# Creating Leaders



Shared the laboratory on over **630 public tours**, for over **4,683 visitors**, 11 VIP visitors, including Col. Chris Hadfield

Provided direct experiences for **5 high school**, **71 undergraduate**, and **30 graduate students**, as well as **40 postdoctoral fellows**

**Established the Society of Graduate Students and Postdocs**, with monthly programming offering professional and academic development opportunities

**Awarded TRIUMF's inaugural Patron of Science Award** to Dr. Emanuele Fiore, Scientific Attaché of the Embassy of Italy, for his selfless contributions to the organization

**Provided expert advice:** Dr. Lia Meringa serves on U.S. P5, the Particle Physics Project Prioritization Panel; Dr. Tom Ruth served as Vice-Chair of a U.S. National Academy of Science committee examining the state of Mo-99 production, and; Dr. Reiner Kruecken served on the Writing Group for the Long Range Plan of the U.S. Nuclear Science Advisory Committee

Received recognition for achievements: **TRIUMF-led team was awarded the 2015 NSERC Brockhouse Prize** for developing a cyclotron-based solution for the production of Tc-99m; **Dr. Pierre Savard was awarded the 2015 CAP-TRIUMF Vogt Medal for Contributions to Subatomic Physics;** **ARIEL engineers received the 2014 Vancouver Regional**

**Construction Association Silver Award of Excellence**, and; **Dr. Jens Dilling was awarded the Membership Award of the GSI Exotic Nuclei Community** in Darmstadt, Germany



# Driving Growth

**Hosted the second Innovations and Industrial Partnerships Workshop** for knowledge mobilization among the member universities and beyond

**Generated nearly \$3M in commercial revenue**, including ~\$0.6M from **60 companies in North America and Europe** for access to the PIF & NIF irradiation facilities

**Produced up to 1.7 million patient doses** (in partnership with Nordion Inc.) of **medical isotopes for commercial sale** and provided secondary, back-up supply of F-18 isotope to BCCA

**Treated 7 cancer patients using proton therapy** in cooperation with the BC Cancer Agency

TRIUMF and its innovation partner Advanced Applied Physics Solutions Inc. were **approved and registered under the Controlled Goods Program**

**Received over \$2M in fees and royalties** from Nordion—the largest payment in the history of the 36-year relationship



## FOR THE BENEFIT OF ALL CANADIANS

- ✔ Launch the IsoSiM program to train young researchers in the application of nuclear isotopes to a broad range of fields.
- ✔ Promote BC expertise in accelerator science as applied to isotope production at the national and international scale, by leveraging a local network of institutions with accelerator-based science, technology, innovation, and commercialization expertise.

The TR13 cyclotron produced 858 runs of medical isotopes delivered to hospitals for research, including 15 runs for medical isotopes to the BC Cancer Agency for the diagnosis of cancer patients. Seven cancer patients were treated using proton therapy in

cooperation with the BCCA. In partnership with Nordion Inc., TRIUMF produced up to 1.7 million patient doses of medical isotopes for commercial sale.

TRIUMF and UBC jointly initiated an NSERC CREATE program on Isotopes for Science and Medicine (IsoSiM) that will provide training in the production, preparation, and application of nuclear isotopes for science and medicine. This program helps students develop the unique skills required for employment in isotope-related fields, helps develop new radioisotopes, and promotes the use of isotopes in new applications.

With experience in irradiation testing for electronics, TRIUMF has taken on an advisory role to UBC Orbit, a 60-student satellite design team participating in a nation-wide challenge to design and build fully operational research satellites for the Canadian Satellite Design Challenge. TRIUMF signed a Memorandum of Understanding with UBC Orbit to provide support and resources to the team, as well as facilities for possible radiation testing.



Western University joined the TRIUMF consortium as an associate member, reinforcing networks in nuclear medicine and materials science.

TRIUMF participated in a number of local community events, including UBC Alumni Weekend. TRIUMF hosted a photowalk event for local photographers, plus a subsequent competition with judges from

**“TRIUMF is a valuable resource for nuclear medicine research. We look forward to many years of collaboration to help keep Canada at the forefront of nuclear medicine.”**

Dr. Frank Prato, Lawson Health Research Institute

## IRIS DILLMAN

Iris Dillman made the switch from chemistry to nuclear astrophysics 15 years ago. Since then, she has aimed to understand from where the elements originated, rather than how they interact.

### What sparked your interest in nuclear astrophysics?

“Originally, the moon. It’s not really nuclear astrophysics, but I always wanted to be an astronaut and fly to the moon. Later, observing the stars furthered my interest. I had studied chemistry first, so I was focusing on the chemical elements. Then I turned to nuclear astrophysics, which is the more physical part of chemistry. I got to ask the question, “Where are all the elements that we are made of coming from?”

For the last two years, Iris has been working at TRIUMF studying the processes that create heavy elements with the DESCANT and GRIFFIN detectors.





## CARLEE POLESCHUK

TRIUMF offers direct research experiences to many undergraduate co-op students from across Canada. Carlee Poleschuk (middle) of Thompsons Rivers University is one of them.

Carlee works with the Nuclear Medicine team and the BC Cancer Agency to use new isotopes to image triple negative breast cancer, a notoriously challenging disease to diagnose and treat.

### What sets this disease apart from others?

"Within the cell of most breast cancers, there are receptors that can be used to determine which kind of treatments can be done. With the breast cancer we're looking at, it doesn't have any of those receptors. That's why it's very aggressive – there's essentially no way to bring the treatment into the cell."

### How do you move forward then?

"There is a tracer that is very similar to a molecule that already enters the cell. So if the cell can't distinguish between the natural molecule and the molecule we've made, it'll take it up anyway."

### If this works, what would it mean for treating triple negative breast cancer?

"If you can image it, you can try different kinds of therapies. After each treatment, you image it again. If the tumor is smaller, you know it's working; if it doesn't change, you try something else. Imaging is vital for personalized medicine, for adjusting the treatment plan for each patient because each patient is unique."

Emily Carr University of Art & Design, Science World, UNA, and UBC. The winning images were on exhibit at Science World and printed in symmetry magazine.

TRIUMF welcomed Emily Carr University of Art + Design studio-based art class, entitled "Quantum Entanglements: Manifestations in Practice" as part of the Artists in Residence program. TRIUMF researchers visited their class to lecture on quantum mechanics, then the class visited the lab. The artistic results of their interactions with TRIUMF were exhibit at Science World for six weeks.

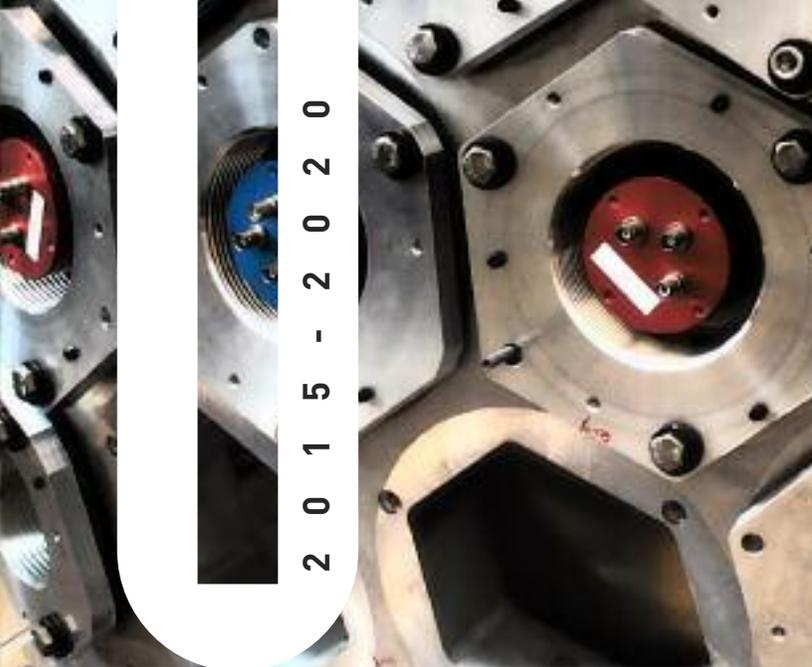
TRIUMF continued the tradition of hosting a number of free events for the community, including 13 Saturday Morning Lectures at TRIUMF and UBC, four public lectures as part of the Richmond Public Library's "Science, Technology and Innovation Speaker Series," and two "Unveiling the Universe" lectures at the TELUS World of Science.

TRIUMF and AAPS welcomed Canadian leaders to its second Innovations and Industrial Partnerships Workshop. The workshop engaged colleagues from TRIUMF's member universities and beyond to discuss innovation practices, explore opportunities for leveraging the federal government's investment in Canadian organizations, and to translate fundamental research into the marketplace.

## AND FINALLY

- ✔ Welcome incoming director  
Dr. Jonathan A. Bagger to the TRIUMF team!





## UPCOMING PRIORITIES

TRIUMF'S ACTIVITIES OVER THE NEXT FIVE YEARS WILL BE FOCUSED IN THE FOLLOWING PRIORITY AREAS.

### 1. ARIEL

The Advanced Rare Isotope Laboratory (ARIEL) will be TRIUMF's highest priority project over the next five years. ARIEL brings together all of TRIUMF's 19 member universities and elevates Canadian science on the global stage.

### 2. NUCLEAR AND PARTICLE PHYSICS

TRIUMF will serve the Canadian and international communities as Canada's national laboratory for particle and nuclear physics. High-level goals include: Reinforcing TRIUMF's world leading ISOL RIB facility (the only one in North America); supporting Canadian participation in international particle physics experiments, including ATLAS, T2K and ALPHA; and completing the Ultra-Cold Neutron facility.

### 3. NUCLEAR MEDICINE

In addition to furthering the award-winning Tc-99m project, TRIUMF will support the Canadian and international communities in developing new technologies, new medical isotopes, and new applications in nuclear medicine, molecular imaging, and radionuclide therapy. In parallel, TRIUMF will launch the Institute for Advanced Medical Isotopes.

### 4. MATERIALS SCIENCE

TRIUMF will support the scientific community with world-class infrastructure, techniques, and expertise. In particular, TRIUMF expects to make the M9 muon channel operational and expand the beta-NMR program with beams from the ARIEL e-linac. TRIUMF will work to build a strong beta-NMR user program and maintain a world-class MuSR facility.

### 5. COMMERCIALIZATION

By December 2015, Advanced Applied Physics Solutions (AAPS) Inc. will graduate from the National Centres of Excellence - Centre of Excellence for Commercialization and Research program. AAPS will join the TRIUMF enterprise and become responsible for the laboratory's commercialization activities, including sales of products and services, licensing and technology transfer, and the incubation of start-up companies.

### 6. SAFE AND EFFECTIVE OPERATIONS

Safety is and will be TRIUMF's highest priority. TRIUMF will continuously assess and improve its performance along these critical axes.

## FINANCIAL POSITION

The end of Fiscal Year 2014-15 brings formal closure to TRIUMF's Five-Year Plan (2010-15). Since 2010, TRIUMF has generated \$386M of scientific and commercial activities, anchored by \$222M in base operating funds provided by the Government of Canada via a contribution through the National Research Council. This funding enabled \$164M of additional revenue to be leveraged for sponsored research, building state-of-the-art infrastructure and equipment for science, private sector sponsored activities, and commercial revenue.



For the operating year, total funding reached \$69M, a decline of \$12M from the prior year's funding. The decrease is mainly attributed to a reduction in recoveries from member institutions for Canada Foundation for Innovation projects (most notably \$9M for the ARIEL project which completed as per schedule) and for Western Economic Diversification (\$5M contribution towards the purchase of nuclear medicine equipment, including a new medical cyclotron). Despite this decline in funding, revenue increased across various activities, such as commercial revenue, which doubled to \$2.9M, reaching new highs in response to increased market demand for TRIUMF's products and services.

TRIUMF expenditures totalled \$67M for the year, a decrease of \$15M from the prior year. Consistent with the revenue flow, decreases in expenditures are mostly accounted for with the completion of the ARIEL project completion and purchase of Nuclear Medicine equipment funded by Western Economic Diversification.

In its 2014-15 budget announcement, the Government of Canada renewed its commitment to TRIUMF with a \$222M funding base for operations for the five years beginning April 2015 (Five Year Plan 2015-20). As part of its Economic Plan 2015-16, the Government of Canada made an additional five-year funding supplement to TRIUMF of \$45M, a significant endorsement of TRIUMF's program.

Looking ahead, we have set robust targets in our next Five-Year Plan that will continue to earn the trust of our funding agencies, research collaborators, and commercial partners. Our team has worked diligently to create value and we remain committed to delivering on our goals and commitments as contained in our next Five-Year Plan.

Henry Chen | Chief Financial Officer

## INDEPENDENT AUDITOR'S REPORT ON THE SUMMARY FINANCIAL STATEMENTS

### To the Joint Venturers of TRIUMF

The accompanying summary financial statements, which comprise the summary statement of financial position as at March 31, 2015 and the summary statement of combined funding/income and expenditures and changes in fund balances for the year then ended, and related notes, are derived from the audited financial statements of TRIUMF for the year ended March 31, 2015. We expressed an unmodified audit opinion on those financial statements in our report dated July 6, 2015. Those financial statements, and the summary financial statements, do not reflect the effects of events that occurred subsequent to the date of our report on those financial statements.

The summary financial statements do not contain all of the disclosures required by section 11b of the TRIUMF joint venture agreement, and are prepared using the basis of accounting referred to in Note 2 of the accompanying summary financial statements. Reading the summary financial statements, therefore, is not a substitute for reading the audited financial statements of TRIUMF.

### Management's responsibility for the summary financial statements

Management is responsible for the preparation of a summary of the audited financial statements on the basis described in Note 2 of the summary financial statements.

### Auditor's responsibility

Our responsibility is to express an opinion on the summary financial statements based on our procedures, which were conducted in accordance with Canadian Auditing Standard (CAS) 810, "Engagements to Report on Summary Financial Statements."

### Opinion

In our opinion, the summary financial statements derived from the audited financial statements of TRIUMF for the year ended March 31, 2015 are a fair summary of those financial statements, on the basis described in Note 2 of the summary financial statements.

signed "PricewaterhouseCoopers LLP"

**Chartered Professional Accountants**

## SUMMARY STATEMENT OF FINANCIAL POSITION

As at March 31, 2015

	2015	2014
	\$	\$
<b>Assets</b>		
Cash and cash equivalents	6,979,272	416,275
Investments	7,076,065	10,044,373
Restricted cash and investments	10,750,766	10,565,669
Due from Joint Venturers	348,289	2,836,706
Funding receivable	1,214,098	1,637,852
	<u>26,368,490</u>	<u>25,500,875</u>
<b>Liabilities</b>		
Accounts payable and accrued liabilities	2,892,334	4,496,995
Funds received in advance	3,364,431	3,371,497
	<u>6,256,765</u>	<u>7,868,492</u>
<b>Fund Balances</b>		
Externally restricted		
Natural Sciences and Engineering Research Council Fund	2,126,198	2,344,975
NORDION Inc. Fund	100,000	100,000
Decommissioning Fund	10,750,766	10,565,669
	<u>12,976,964</u>	<u>13,010,644</u>
<b>Internally designated</b>		
Commercial Revenue Fund	3,865,021	1,827,270
Intramural Accounts Fund	2,758,798	2,268,912
	<u>6,623,819</u>	<u>4,096,182</u>
<b>Unrestricted</b>		
General Fund	510,942	525,557
	<u>20,111,725</u>	<u>17,632,383</u>
Total liabilities and fund balances	<u>26,368,490</u>	<u>25,500,875</u>

The accompanying notes are an integral part of these summary financial statements.

## SUMMARY STATEMENT OF COMBINED FUNDING/INCOME AND EXPENDITURES AND CHANGES IN FUND BALANCES

For the year ended March 31, 2015

	2015	2014
	\$	\$
<b>Funding/income</b>		
National Research Council Fund	45,000,000	44,300,000
Natural Sciences and Engineering Research Council Fund	6,672,462	6,135,227
Canada Foundation for Innovation (including Provincial Contribution)	4,642,134	13,219,278
Western Economic Diversification Fund	-	5,081,099
Natural Resources Canada	699,919	1,065,965
NORDION Inc. Fund	4,254,275	3,826,459
Advanced Applied Physics Solutions Inc. Fund	1,276,291	1,644,857
Decommissioning Fund	185,097	199,430
Affiliated Institutions Fund	1,792,060	2,622,178
Commercial Revenue Fund	2,928,289	1,412,019
Intramural Accounts Fund	1,429,002	1,245,288
General Fund	253,782	280,610
	<b>69,133,311</b>	<b>81,032,410</b>
<b>Expenditures</b>		
Buildings and improvements	658,787	4,443,782
Computer	1,273,950	1,475,398
Consulting	1,115,182	1,245,532
Equipment	5,448,862	17,204,828
Power	3,889,433	3,437,920
Salaries and benefits	42,112,423	40,569,928
Supplies and other expenses	10,343,174	12,004,827
Telecommunications	198,790	196,037
Travel	1,613,368	1,617,064
	<b>66,653,969</b>	<b>82,195,316</b>
<b>Surplus (deficit) of funding over expenditures for the year</b>	<b>2,479,342</b>	<b>(1,162,906)</b>
<b>Fund balances - Beginning of year</b>	<b>17,632,383</b>	<b>18,795,289</b>
<b>Fund balances - End of year</b>	<b>20,111,725</b>	<b>17,632,383</b>

The accompanying notes are an integral part of these summary financial statements.

## NOTES TO SUMMARY FINANCIAL STATEMENTS

### 1. Nature of operations

TRIUMF is Canada's national laboratory for particle and nuclear physics. It is owned and operated as a joint venture by a consortium of Canadian universities via a contribution through the National Research Council of Canada (NRC). As a registered charity, TRIUMF is not subject to income tax.

The members of the joint venture are the University of Alberta, University of Calgary, Carleton University, the University of Guelph, Queen's University, the University of Manitoba, the University of Victoria, Simon Fraser University, the University of British Columbia, l'Université de Montréal, the University of Toronto and York University. During fiscal year 2014-15, University of Calgary transitioned from associate member to member.

At March 31, 2015, each university owned an undivided 8.33% interest in all the assets and liabilities of TRIUMF, except for the land and buildings occupied by TRIUMF, which are owned by the University of British Columbia.

These financial statements include only the assets, liabilities, funding and expenditures of the activities carried on under the control of TRIUMF and do not include the assets, liabilities, revenues and expenditures of the individual joint venture members.

Sources of funding include grants and contributions from the National Research Council, the Natural Sciences and Engineering Research Council, Canada Foundation for Innovation, Western Economic Diversification, Natural Resources Canada, advances and reimbursements from other sources; commercial revenues; and investment income. TRIUMF has established a number of separate funds to account for the various funding sources.

The sources and purposes of these funds are:

#### National Research Council Fund (NRC)

Funding of operations, improvements and development; expansion of technical facilities (buildings excluded); and general support for experiments.

#### Natural Sciences and Engineering Research Council Fund (NSERC)

Funding to grantees for experiments related to TRIUMF activities. These funds are administered by TRIUMF on behalf of the grantees.

#### Canada Foundation for Innovation (CFI)

Funding to Canadian universities for capital projects related to TRIUMF activities and temporary operating funds for newly built infrastructure. These funds are administered by the universities and TRIUMF is reimbursed for expenditures undertaken in accordance with the terms of the grant. The funding that is reported under CFI includes any provincial matching funds (usually from British Columbia Knowledge Development Fund (BCKDF)) required by the grant.

#### Western Economic Diversification (WD)

Funding for projects related to TRIUMF activities that enhance and strengthen the economy of Western Canada.

#### Natural Resources Canada (NRCan)

Funding for projects related to TRIUMF activities that create a sustainable resource advantage for Canada.

#### NORDION Inc. Fund

Advances and reimbursements from NORDION Inc. for expenditures incurred at TRIUMF.

#### Advanced Applied Physics Solutions Inc. (AAPS)

Advances and reimbursements from AAPS for expenditures incurred at TRIUMF.

#### Decommissioning Fund

While there is no intention of decommissioning the TRIUMF facilities, the TRIUMF joint venture members have complied with federal legislation by putting in place a decommissioning plan, including a funding plan, in the event TRIUMF is decommissioned. The decommissioning plan is updated regularly in compliance with TRIUMF's licensing requirements.

Consistent with TRIUMF's accounting policies (note 2), all decommissioning costs will be expensed in the period in which the costs are incurred.

At March 31, 2015, the balance in the fund, \$ 10.8 million, is held in an escrow account to fund decommissioning costs. The majority of the holdings are invested in cash and mutual funds of \$10.3 - million (2014 - \$10.3 million), and a small holding in equity investments of \$0.5 million (2014 - \$0.2 million). The funds are managed by an appointed escrow agent, Royal Trust Corporation of Canada, as agreed to by the Canadian Nuclear Safety Commission (CNSC), a joint venture of each member university and TRIUMF Accelerators Inc. (holder of TRIUMF's operating license). Each Member University has entered into an agreement confirming they will share the cost of any funding shortfall in the event decommissioning costs exceed funding available for decommissioning.

#### Affiliated Institutions Fund

Advances and reimbursements for expenditures undertaken on behalf of various Canadian and International institutions for scientific projects and experiments carried out at TRIUMF.

#### Commercial Revenue Fund

Royalties, revenues and expenditures relating to commercial activities and technology transfer.

#### Intramural Accounts Fund

Net recoveries generated by internal projects and services. The recoveries of expenditures are charged to the appropriate TRIUMF funding source by Intramural Accounts.

#### General Fund

Investment income generated is used for non-qualifying discretionary expenditures incurred by TRIUMF.

### 2. Significant accounting policies

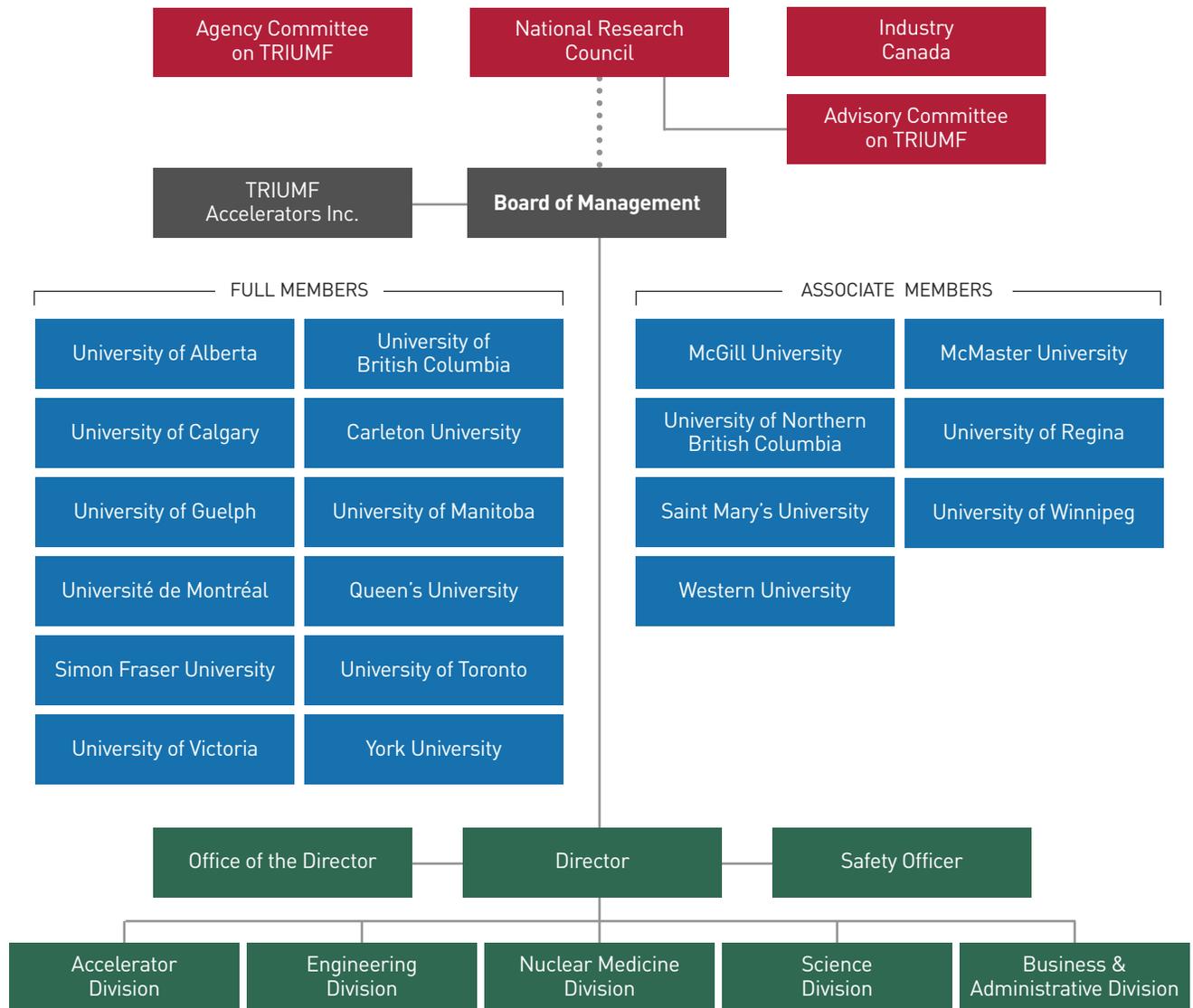
#### Basis of presentation

These financial statements have been prepared in accordance with section 11(b) of the TRIUMF joint venture agreement. TRIUMF has elected to follow Canadian Public Sector Accounting Standards (PSAS), including accounting standards that apply to government not-for-profit organizations, except that all property, plant and equipment purchased or constructed for use at TRIUMF and related decommissioning costs (if any) are expensed in the period in which the costs are incurred.

These financial statements do not include the accounts of TRIUMF Accelerators Inc. (TAI), a not-for-profit federal corporation incorporated in 2006 and controlled by TRIUMF. The only asset held by TAI is the operating license issued by the Canadian Nuclear Safety Commission, which was recorded at the exchange value of \$nil. Since inception, TAI has not incurred any expenses or liabilities and has not recognized any revenue.

## GOVERNANCE STRUCTURE

TRIUMF is Canada's national laboratory for particle and nuclear physics. It is owned and operated as a joint venture by a consortium of Canadian universities via a contribution through the National Research Council Canada with building capital funds provided by the Government of British Columbia. Situated on 13 acres on the south campus of UBC in Vancouver and founded more than 40 years ago, TRIUMF presently employs about 450 staff and students.



## ACKNOWLEDGEMENTS

TRIUMF's activities are largely supported by contributions from the following organizations:

- Canada Foundation for Innovation
- Canadian Institutes of Health Research
- Genome BC
- Government of British Columbia
- Government of Canada
- Government of Manitoba
- Government of Nova Scotia
- Industry Canada
- National Research Council Canada
- Natural Resources Canada
- Natural Sciences and Engineering Research Council
- Networks of Centres of Excellence of Canada
- Western Economic Diversification Canada

## SELECTED PARTNERS

TRIUMF works with many individuals, organizations, educational institutions, and private companies to fulfill its mission. Without listing the large network of universities, these include:

### Canada

Advanced Applied Physics Solutions Inc.  
Advanced Cyclotron Systems Inc.  
Atomic Energy of Canada Limited  
ARTMS Products Inc.  
BC Cancer Agency  
BC Innovation Council  
BC Technology Industry Association  
Burnaby Board of Trade  
Canadian Association of Physicists  
Canadian Institute for Nuclear Physics  
Canadian Light Source Inc.  
Canadian Space Agency  
CANARIE Inc.  
Centre for Probe Development and Commercialization  
Dehnel Particle Accelerator Components & Engineering Inc. (D-Pace Inc.)  
Firnau-Radiochemical Consulting Inc.  
General Electric  
Institute of Particle Physics  
Lawson Health Research Institute  
LifeSciences BC  
Nordion Inc.  
Pacific Parkinson's Research Centre  
PAVAC Industries Inc.  
Perimeter Institute for Theoretical Physics  
Positron Emission Tomography Imaging at UBC  
Royal Society of Canada  
Science World  
British Columbia  
Selkirk College  
Shad Valley  
SNOLAB  
Vancouver Board of Trade  
Virtual Researcher on Call

### International

Argonne National Laboratory, Argonne, USA  
Brookhaven National Laboratory, Upton, USA  
China Institute of Atomic Energy, China  
Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany  
CERN, Geneva, Switzerland  
Fermi National Accelerator Laboratory (Fermilab), Batavia, USA  
GANIL, Caen, France  
Gesellschaft für Schwerionenforschung mbH (GSI), Darmstadt, Germany  
High Energy Research Organization (KEK), Tsukuba, Japan  
Institut des Sciences Nucléaires (ISN), Grenoble, France  
Institute for Basic Science of the Republic of Korea, Korea  
Institute for High-Energy Physics (IHEP), Beijing, China  
Institute of Modern Physics (IMP) of the Chinese Academy of Sciences (CAS), China  
Institute for Nuclear Research (INR), Russia  
Istituto Nazionale di Fisica Nucleare (INFN), Italy  
International Atomic Energy Agency (IAEA), Austria  
Japan Atomic Energy Agency (JAEA), Tokai, Japan  
Japan Proton Accelerator Research Complex (J-PARC), Tokai, Japan  
The Joint Institute for Nuclear Astrophysics Center for the Evolution of the Elements at Michigan State University, USA  
Justus-Liebig-Universität Gießen, Germany  
Kavli Institute for the Physics and Mathematics of the Universe (Kavli-IPMU), Japan  
Lawrence Berkeley National Laboratory (LBL), Berkeley, USA

Lawrence Livermore National Laboratory (LLNL), Livermore, USA  
Lebedev Physics Institute, Russia  
Los Alamos National Laboratory (LANL), Los Alamos, USA  
Max-Planck Institut für Kernphysik (MPIK), Germany  
Ministry of Education, Science, and Technology (MEST), Seoul, Korea  
The National Research Nuclear University (MEPhI), Moscow, Russian Federation  
National Superconducting Cyclotron Laboratory (NSCL), East Lansing, USA  
Oak Ridge National Laboratory (ORNL), Oak Ridge, USA  
Osaka University, Japan  
Paul Scherrer Institut (PSI), Switzerland  
RIKEN Nishina Centre for Accelerator-Based Science, Wako, Japan  
Soreq Nuclear Research Centre, Israel  
SLAC National Accelerator Laboratory, Menlo Park, USA  
TESLA Technology Collaboration, USA  
Thomas Jefferson National Accelerator Facility, Newport News, USA  
Toyota Central R&D Labs Inc.  
The University of Tokyo, Japan  
UT-Batelle, LLC, USA  
Variable Energy Cyclotron Centre, Kolkata, India



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