CANADA'S NATIONAL LABORATORY
FOR PARTICLE AND NUCLEAR PHYSICS

**ANNUAL ADMINISTRATIVE
AND FINANCIAL REPORT 2012 – 2013**

BEAM ON

TRIUMF

ACCELERATING SCIENCE FOR CANADA

BEAM ON

TRIUMF HAS COMPLETED THE THIRD YEAR OF FIVE-YEAR PLAN 2010-2015 AND IT MARKS AN IMPORTANT MID-POINT.

Not only is the laboratory "in the groove" as milestones are reached and the pace of progress becomes the norm, but it is also time to start thinking about the next five years: 2015-2020. Early initiatives are transitioning to completion and moving into operations and the ARIEL flagship project is over halfway completed. This point is important for TRIUMF as it considers the road travelled and the path ahead.

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.

stretch &

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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.

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.

values

Excellence and Impact
Collaboration and Teamwork
Honesty and Transparency
Innovation and Relevance

MESSAGE FROM THE **CHAIR OF THE BOARD**

IN BUSINESS, ONE OFTEN HEARS THE PHRASE "CONSOLIDATE EARNINGS" OR "SOLIDIFY GAINS." THIS TERM REFERS TO THE SOMETIMES CYCLICAL NATURE OF AN ORGANIZATION'S YEAR-TO-YEAR EVOLUTION: STRETCH AND EXPAND, ADJUST AND STABILIZE, AND THEN STRETCH AND EXPAND AGAIN.

As Canada's national laboratory for particle and nuclear physics, TRIUMF is no different. Five-Year Plan 2010-2015 laid out a decadal vision that started with an ambitious "stretch and expand": the Advanced Rare IsotopE Laboratory (ARIEL) that will lead to tripling of Canadian capacity to advance isotopes for science and medicine. As this report will confirm, the civil construction and conventional facilities are nearly complete. The next tasks involve building and commissioning the next-generation electron linear accelerator. Meanwhile, the laboratory is detailing the second chapter of the decadal vision with the development of Five-Year Plan 2015-2020 that will feature completion of the ARIEL facility by funding, building, and installing the isotope-production systems. This effort has required a serious stretch on the part of TRIUMF, its university owners, and the set of federal and provincial government stakeholders.

People are working hard and the effort is paying off. TRIUMF is regularly committing 50-60 FTEs per month on ARIEL and this effort is expected to continue: flagships require attention! In a period of tight fiscal constraints, the laboratory has trimmed activities in other areas to accommodate this priority and innovative approaches to everything from cash flow, recycling liquid helium, and international collaboration have been necessary to maintain the pace of progress.

When will "stretch and expand" turn into "adjust and stabilize"? Completing ARIEL is obviously one of the highest priorities alongside TRIUMF's leadership of the national effort to develop and deploy alternative production methods for key medical isotopes such as technetium-99m. When the tower cranes disappear from the TRIUMF site, when the frenzy of Gantt charts and hard hats is replaced by the enthusiasm of scientists and students giving talks and gesturing at blackboards and computer displays, and when the annual number of scientific publications ticks upward again, we'll know that TRIUMF is entering the new era of operations and unprecedented productivity. I am confident that we'll reach this objective in the next five-year plan and Canada will be recognized as a world leader in the research and development of isotopes for science and medicine.

I am proud to say that, near the end of this fiscal year, McGill University requested and was approved by the Board of Management to become an associate member of the TRIUMF consortium. This expansion of the TRIUMF family is a testament to the national character of the laboratory as well as recognition of the laboratory's track record for success. We look forward to working more closely with our McGill colleagues in the next chapters of TRIUMF's future.

Sincerely,

R. Paul Young | Chair, TRIUMF Board of Management | Vice-President, Research, University of Toronto

NIGEL LOCKYER TO BE NEXT FERMILAB DIRECTOR
20 June 2013

In his capacity as Chairman of the Board of Directors of Fermi Research Alliance, LLC, University of Chicago President Robert J. Zimmer announced that TRIUMF's director Nigel S. Lockyer has been selected to become the next director of the U.S. Department of Energy's Fermi National Accelerator Laboratory, located outside Chicago. Lockyer is expected to complete his work at TRIUMF this summer and begin at Fermilab by Labour Day.

Paul Young, Chair of TRIUMF's Board of Management and Vice President of Research and Innovation at the University of Toronto said, "Nigel was selected from a truly outstanding set of international candidates for this challenging and important position. Although it will be a short-term loss, this development is a clear recognition of Nigel's vision and passion for science and the international leadership taken by TRIUMF and Canada in subatomic physics. On behalf of the entire TRIUMF Board, we wish Nigel, TRIUMF, and Fermilab every success in the future."

IN MY VIEW, THE MOST IMPORTANT SCIENTIFIC EVENT OF THIS PAST YEAR WAS THE DISCOVERY OF A HIGGS BOSON BY THE ATLAS AND CMS COLLABORATIONS AT CERN'S LARGE HADRON COLLIDER.

Canada, through TRIUMF, played a pivotal role in key elements such as the injection kickers that insert the beams of protons into the LHC itself, the energy-measuring detectors called the hadronic endcap calorimeter, and of course the data storage and computing power in the ATLAS Tier-1 Data Centre at TRIUMF. Perhaps most personally satisfying is that TRIUMF researchers and Canadian scientists led critical parts of the analysis that led to the discovery itself.

But why is this so important? For three reasons.

Advancing Science. The Higgs particle is part of humanity's quest to understand the very origins and fundamental nature of our universe, the very reality that surrounds us. A handful of talented physicists in the 1960s had the insight to posit the existence of this mysterious, pervasive field that "gives mass" to elementary particles. This is a discovery, it is a vindication, and it is a revelation. [NOTE: The theory and the discovery of the Higgs particle was awarded the Nobel Prize in Physics in October 2013.]

Inspiring and Attracting the Next Generation of Leaders. Searching for the Higgs has been a multi-decade journey. I joined the effort as soon as I could after graduate school. Think of the hundreds—no, literally tens of thousands—of people who have been involved in this quest. Students of all ages, members of the science-interested public, and scientists from all disciplines have been inspired by this search. Great discoveries come from compelling science that can alter the lives of young people as they get interested in technology or even in becoming a scientist themselves. About a third of the Canadian students who graduated after working on ATLAS are now in the private sector, leading industrial teams or heading up new businesses.

Creating Societal and Economic Impact. What is the Higgs good for? We won't know how to harness the Higgs itself for personal or economic gain for a long time, perhaps a very long time. But we do know that the quest to *find* the Higgs has stretched technology and fostered innovation and growth where it may not have happened otherwise. The Worldwide LHC Computing Grid developed a global standard for shared computing resources that is secure, reliable, and resilient. This system "saved" all the Higgs data that was produced, and it inspired aspects of cloud computing. Elsewhere, the detector systems of ATLAS pushed the capabilities of low-power, ultra-fast electronics. Perhaps most importantly, however, has been the societal impact of this truly global effort: researchers from over 100 countries around the world have all come together to work on the shared scientific quest. I find this profound: the key questions that particle physics seeks to answer can bring us all together, in peace and to work in harmony.

The Higgs breakthrough is something that should be celebrated around the world and by all peoples. It is truly a great achievement. And I am proud that Canada and TRIUMF are part of it. Congratulations!

Finally, on a more somber note, this column is my last as director of TRIUMF. As we each move from opportunity to challenge and back again, I am headed to Fermilab this Labour Day as the new director of the U.S. flagship for high-energy particle physics. I am grateful to have had the opportunity and the privilege of serving TRIUMF: it is a wonderful laboratory and is possessed of a truly excellent staff and larger community. It has been a complete honour to work with you all.

Sincerely,

Nigel S. Lockyer | Director

Accelerators

Lia Merminga | Head, Accelerator Division

Accelerators are at the heart of TRIUMF's research program. With eight different accelerators on site and engagement in another dozen major accelerators around the world, TRIUMF is Canada's national accelerator laboratory. And particle accelerators are at the heart of activities everywhere. Around the world, accelerators influence industries worth $500 billion each year.

Particle accelerators are a vital mechanism in generating scientific, economic and societal impact. One scientific journal[1] declares that the fundamental changes in "the way we live, think, and work" over the past 50 years is a direct result of the evolution of the particle accelerator.

Accelerators use a combination of electrical fields and magnetic fields to add energy to a collection of charged particles and to steer and shape them into pencil-like beams. These beams can be directed to impinge on other materials or even be brought into collision with each other to explore fundamental structure and interactions of elementary particles. Accelerators drive scientific discovery, generate leading-edge technologies and derivative products, and inspire new generations of scientists and engineers.

At TRIUMF, accelerator expertise is concentrated in the Accelerator Division, with a mission:

- To ensure the highest availability of the laboratory's accelerator complex for maximum scientific productivity;
- To build new accelerator facilities using leading edge technology;
- To bring accelerator technologies to private sector for commercialization and societal benefit; and
- To educate the next generation of accelerator scientists.

As the TRIUMF community begins preparing the next five-year strategic plan for the laboratory, what does the future hold for accelerators at TRIUMF? Writ large, the primary goal for accelerator research and development is to "do more with less;" that is, to accelerate using smaller devices and less energy while providing greater intensities and greater energies. No small feat! Consider, however, that over the past 75 years since the invention of the first modern accelerator, the highest-energy accelerator has increased by a factor of 175,000,000 while the geometrical size has increased by a factor 70,000.

Looking a decade ahead from the perspective of accelerators, we envision a future for Canada where TRIUMF will be:

- The leading isotope-production facility in the world using ISOL technology at ISAC and ARIEL;
- Known globally for high-performance operation of existing accelerators at the laboratory as well as pioneering selected next-generation accelerator technologies; and
- The hub for a world-class education in accelerator physics & engineering in partnership with multiple Canadian universities.

How will we get there?

With a set of strategic action plans focused on six objectives that build on TRIUMF's strengths.

Becoming the leading ISOL facility in the world over the next decade is ambitious. (ISOL technology refers to the way isotopes are produced using accelerated lighter-mass particles striking a heavier target and then extracting the isotopes in real-time from the target material.) To work toward this objective, TRIUMF will expand the range of isotopes it can produce by marshalling the combined tools of proton and electron-based production. Completing ARIEL is central to achieving this goal. Together with ISAC, ARIEL provides opportunities for development, proton and neutron-rich isotope production free of isobaric contamination, more beam to beta-NMR, and tripling the rare-isotope beam (RIB) availability to users. Advances in isotope-beam purification will be driven

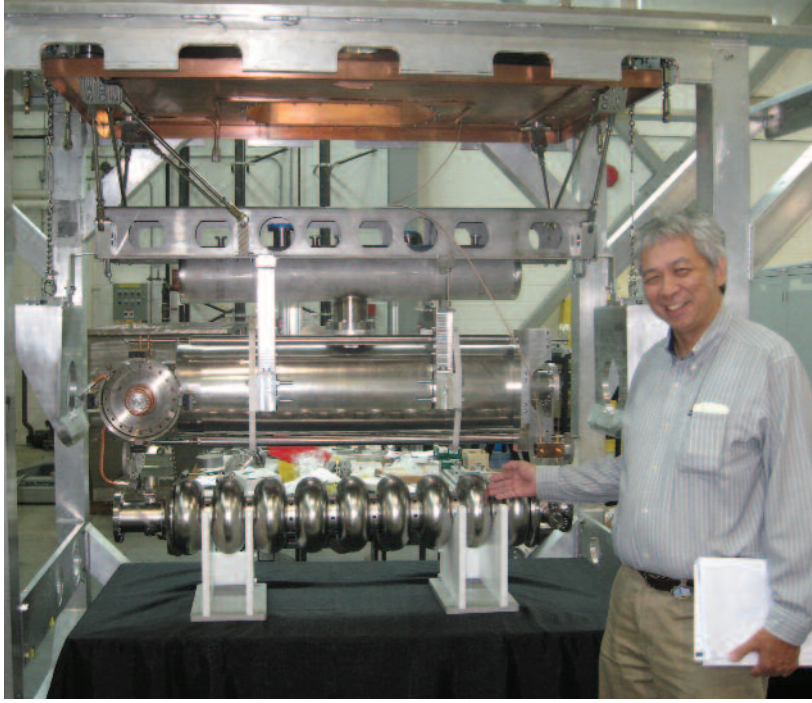
[1] worldscientific.com/worldscinet/rast, Volume 1, 2008; Volume 2, 2009.

by precision magnet technologies. The reliability of the post-production accelerators will be enhanced with a strategic roadmap that targets critical systems such as cryogenics. To further increase reliability, availability, and turn-around time, TRIUMF will improve the design of its target modules and target-exchange facilities and complete a staging area known as the North Hot Cell. Perfecting a rastering technique to slowly move the proton beam across the surface of the target material will lead to improved yields. Finally, completion of new proton beam line from the main cyclotron as part of ARIEL will capstone the initiative and position TRIUMF at the forefronts.

In this era of continuous improvement, TRIUMF will continue to upgrade its day-to-day operations with a series of initiatives designed to streamline control systems, enhance diagnostics and service infrastructure, and integrate performance monitoring and feedback systems. These changes could include a new accelerator control centre as well as automation improvements.

TRIUMF will maintain its world-leading expertise in the physics and engineering of cyclotrons and hadron accelerators. To achieve this objective, the laboratory will develop a test-bed for high-intensity ion sources and diagnostics tools with Canadian partners, including our industrial collaborators. One project would be an upgrade of the main cyclotron's ion source to improve reliability and capacity for increased intensity in the ARIEL era. The conceptual design for a second accelerator leg for ARIEL would be developed to include a RIB storage ring.

The success of the e-linac project at TRIUMF will provide a platform upon which Canada can build broad expertise in high-intensity, continuous-wave accelerators and their applications. As ARIEL is completed, opportunities for developing energy-recovery linac and even free-electron laser capabilities would be explored along with applications to flue-gas remediation and medical-isotope production.



Superconducting radio-frequency (SRF) accelerators are the technology of choice for modern machines and TRIUMF has an opportunity to secure a world-leading position for Canada in this area. With a combination of pioneering research into the fundamental physics of superconducting cavities using TRIUMF's unique materials-science facilities and enhancements to the core infrastructure at the laboratory, TRIUMF would become a global centre of excellence for designing and commercializing novel SRF cavity technologies.

To create a world-class education and training program in accelerator physics and engineering will require attracting students, building a test facility for research projects, engaging in non-programmatic advanced research activities, and working with universities and colleges to develop tenured faculty positions in accelerator physics as well as apprenticeship, Engineer-in-Training, and Professional Engineer certification modules.

Accelerators drive TRIUMF's research and they drive the future. As the laboratory enhances its core competencies in accelerators and develops new partnerships, Canada will benefit from new technologies, applications, and discoveries.

"The beams produced by today's particle accelerators address many of the challenges confronting our nation in the 21st century: energy, the environment, good jobs and economic security, health care, national defense, ..."

Accelerators for America's Future, U.S. Department of Energy

2012 - 2013

ACCOMPLISHMENTS

THIS IS THE THIRD YEAR OF TRIUMF'S FIVE-YEAR PLAN AND THE LABORATORY CONTINUES TO OPERATE WITH HIGH EFFICACY, PROGRESSING IN TERMS OF ITS INTERNATIONAL REPUTATION, AND FOCUSING ON HIGH IMPACT ACCOMPLISHMENTS IN A COMPETITIVE SCIENCE ENVIRONMENT.

USING THE LABORATORY'S MISSION STATEMENT AS A GUIDE, PROGRESS ON THE PLANS AND PROMISES DECLARED IN LAST YEAR'S REPORT ARE DISCUSSED IN THIS SECTION.

MOST NOTABLY, A 2012 REPORT OF THE COUNCIL OF CANADIAN ACADEMIES ENTITLED *THE STATE OF SCIENCE AND TECHNOLOGY IN CANADA* RECOGNIZED CANADA'S GLOBAL EXCELLENCE IN PHYSICS AND ASTRONOMY AND IDENTIFIED "PARTICLE AND NUCLEAR PHYSICS" AS ONE OF THE KEY DRIVERS. THIS RESULT GIVES TRIUMF NEW PURPOSE: NOT ONLY TO MAINTAIN THIS EXCELLENCE BUT ALSO TO CONVERT ACADEMIC PROWESS INTO INDUSTRIAL AND ECONOMIC SUCCESS.

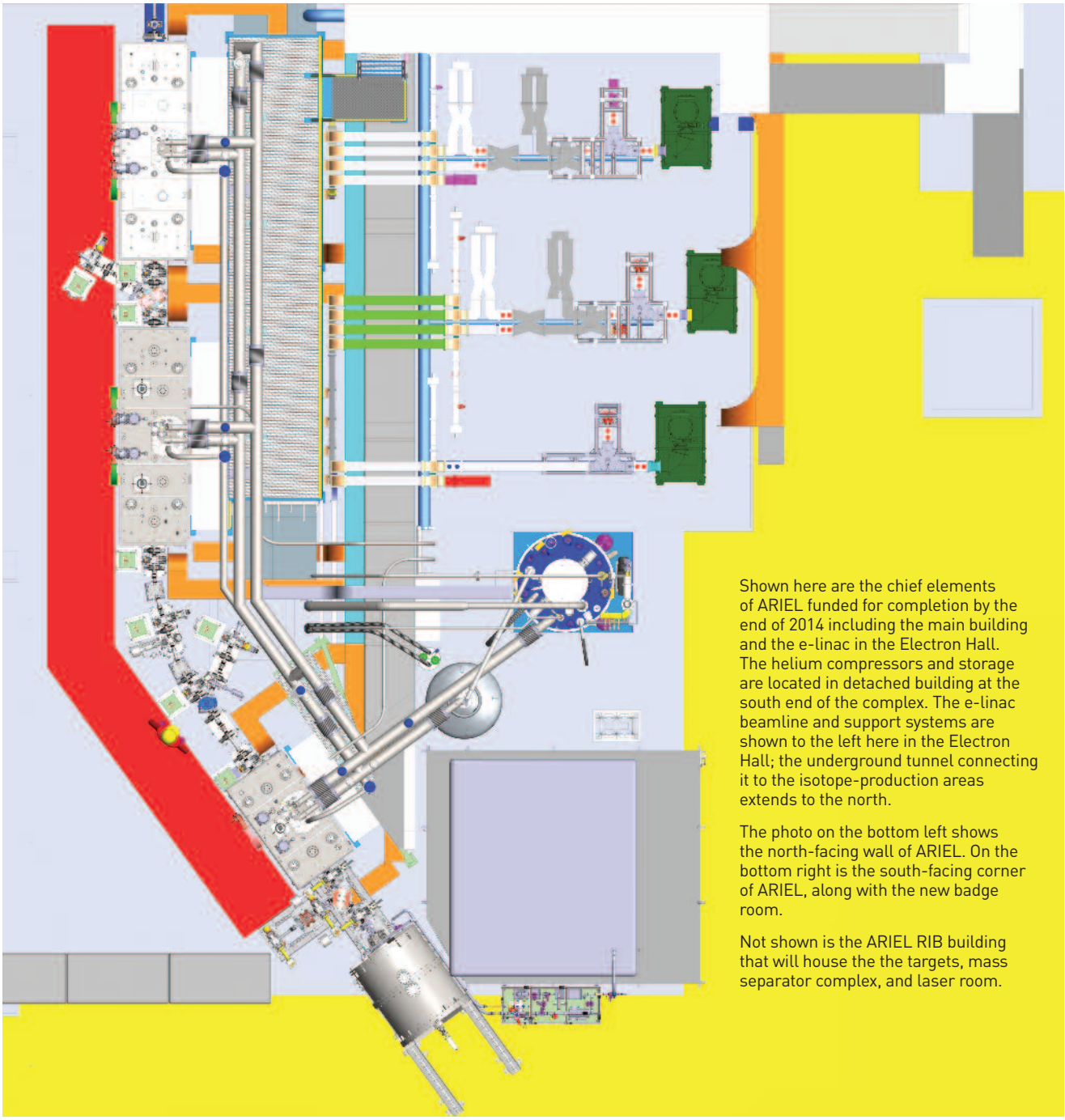
ARIEL

- ☑ Steady progress on the ARIEL project on schedule and on budget, with substantive completion of the ARIEL building construction and services ready for staged use.
- ☑ Maintain e-linac schedule and funding profile.
- ☑ Authorize and launch third phase of partnership with India's VECC laboratory to jointly explore and develop target-module technologies for ARIEL in Canada and ANURIB in India.

The new flagship at TRIUMF, the ARIEL laboratory, has kept pace. From a hole in the ground a year ago to a five-storey concrete and metal structure, the civil construction has proceeded aggressively and successfully in the face of wind, rain, and changing ground conditions. Substantial completion has been secured; correction of deficiencies and building commissioning will be completed by autumn 2013.

Design, fabrication, and procurement of the key components for the e-linac at the heart of ARIEL are moving forward. The injector cryomodule design is now complete and components are in fabrication or are complete. The first nine-cell cavity is nearing completion at PAVAC Industries, Inc. with anticipated delivery by May 15, 2013. The low-temperature cryo-insert was tested at cryogenic temperatures and performance at two degrees above absolute zero was achieved. The vacuum tank, lid, cold mass support unit, liquid-nitrogen thermal shield and cold mu-metal magnetic shield are all complete. Top assembly of the cryomodules is in progress. The cold scissor jack tuner mockup and its controller were tested and the tuner is now in fabrication. Two fundamental power couplers are installed and conditioning of the couplers continues. The design of the accelerating cryomodules is well advanced.

Formal agreement to the next phase of the partnership with India's VECC laboratory has taken longer than anticipated. Canada's High Commissioner to India paid a visit to the VECC laboratory in January to support the project.



Shown here are the chief elements of ARIEL funded for completion by the end of 2014 including the main building and the e-linac in the Electron Hall. The helium compressors and storage are located in detached building at the south end of the complex. The e-linac beamline and support systems are shown to the left here in the Electron Hall; the underground tunnel connecting it to the isotope-production areas extends to the north.

The photo on the bottom left shows the north-facing wall of ARIEL. On the bottom right is the south-facing corner of ARIEL, along with the new badge room.

Not shown is the ARIEL RIB building that will house the the targets, mass separator complex, and laser room.

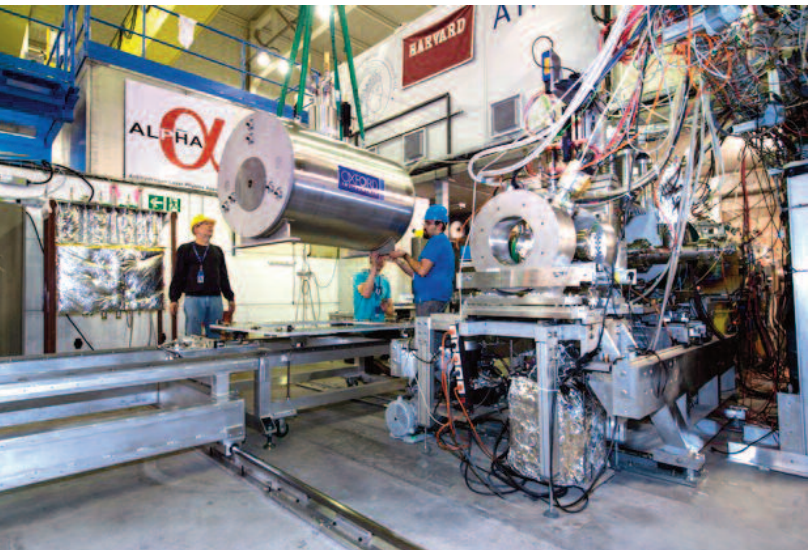
ADDRESS THE MOST COMPELLING QUESTIONS...

- ☑ Advance breakthroughs in particle and nuclear physics to generate at least one science-journal cover story featuring TRIUMF and Canadian scientific contribution.
- ☑ Pursue the Higgs boson and other new physics beyond the Standard Model with the ATLAS experiment at CERN and the T2K experiment in Japan.
- ☑ Complete data-taking and move into final data-analysis for ground-breaking PiENu experiment.
- ☑ Complete and commission new beam lines (M-9 and M-20) for molecular and materials science while simultaneously formulating a new strategic plan for these capabilities that positions Canada among the world leaders.

Through TRIUMF, Canada was not only featured in multiple science-journal cover stories this past year (Nature Physics and the European Journal of Physics A), but also the covers of mainstream newspapers and journals (Maclean's, Time Magazine) with the spectacular discovery of the Higgs boson announced on July 4, 2012. The search for the Higgs boson has been a 15-year long quest for Canadians, along with world partners at CERN. The joint announcement by both experiments at CERN's Large Hadron Collider was a huge success for physics. CBC Radio awarded Pierre Savard, a University of Toronto professor and TRIUMF research scientist with the title "Scientist of the Year" for his role in making this all happen. TRIUMF served as the portal for Canadian involvement through its efforts to design and build the accelerator, build and commission a portion of the ATLAS detector, and store and analyze 10% of the world data via the Canadian ATLAS Tier-1 Data Centre.

Trapping of antihydrogen and the subsequent measurement of the atomic energy levels in antihydrogen is a specialty of Canadian scientists. Fully 1/3 of the collaboration called ALPHA, working at CERN, is Canadian. This program is led by a TRIUMF scientist, Makoto Fujiwara, who shared in the 2012 John Dawson Prize from the American Physical Society for his work. Their upcoming goal, using a newly built detector, much of which has been designed and built at TRIUMF, is to be the first experiment to ever measure antimatter "falling" in a gravitational field (beginning in late 2014).

The T2K neutrino experiment in Japan confirmed its first evidence that neutrinos oscillate between an electron-like neutrino and a tau-like neutrino. Canada is one of the largest participating teams outside of Japan and the collaboration has received numerous awards; in November 2012, the team received an award from "La Recherche" magazine in France, as shown in the photograph on page 10.



Through TRIUMF, Canada was not only featured in multiple science-journal cover stories this past year, but also the covers of mainstream newspapers and journals with the spectacular discovery of the Higgs boson.

Advancing Knowledge

Hosted more than **560** external visiting scientists from over **20** countries

Authored or co-authored **336** scientific peer-reviewed publications and gave **86** invited lectures on ATLAS and ISAC research topics

Supported **24** scientific experiments at ISAC in nuclear physics, **36** experiments at CMMS in molecular and materials science, and **14** experimental programs for life sciences and nuclear medicine

Designed and fabricated more than **685** technical and engineering systems in support of the Canadian research community

Operated the main cyclotron for **5,299** hours or just more than **90.6%** of scheduled performance

Delivered **2,745** hours of radioactive-isotope beams and **1,527** hours of stable-isotope beams to scientific experiments in the ISAC facility

Used the TR-13 cyclotron to produce **754** runs of medical isotopes delivered to hospitals for research including **59** runs for medical isotopes to the BC Cancer Agency for the diagnosis of cancer patients

Creating Leaders

Shared the laboratory with **2,830** people for public tours including about **750** students

Hosted **9** VIP visits including His Excellency Werner Wnendt, the Ambassador of Germany to Canada

Provided educational and/or research work experiences for **6** high-school, **61** undergraduate, and **35** graduate students, as well as nearly **50** post-doctoral fellows

Received high recognition for our staff: Nigel S. Lockyer and Rob McPherson ranked among the Top 45 Over 45 by Zoomer Magazine, the ATLAS and T2K experiments won international prizes, TRIUMF/Toronto physicist Pierre Savard was named Radio Canada "Scientist of the Year," Jens Dilling and Don Fleming were named Fellows of the American Physical Society, and Makoto Fujiwara, awarded the 2012 John Dawson Prize from the American Physical Society

Had **405,500** visits to our website and was followed by **3,251** people across social-media platforms (e.g., Twitter, Facebook, etc.)

Driving Growth

SOCIETAL & ECONOMIC

Launched the spin-off company CRM Geotomography Technologies, Inc. via AAPS, Inc.

Hosted the inaugural AAPS Innovation and Industrial Partnerships Workshop that brought together TRIUMF's member universities to discuss, engage, and collaborate

Generated **$1,127,465** of commercial revenue; including **$276,650** from **43** companies in North America and Europe for access to the PIF & NIF irradiation facilities

Treated **9** cancer patients using proton therapy in cooperation with the BC Cancer Agency

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 vital F-18 isotopes to BC Cancer Agency during periods when their cyclotron was offline for maintenance

In rare-isotope science, TRIUMF made the first direct mass-measurement of the two-neutron halo nucleus He-6 together with a more precise measurement of the mass for the four-neutron halo He-8 as well as the heavy isotopes of calcium. Measurements were performed using the TITAN Penning trap mass spectrometer, supported by NSERC. This work has led to new theoretical work that includes the three-body force in nuclear-theory calculations. Furthermore, results from the TITAN team's precision studies of the rubidium-74 nucleus were published in Physical Review Letters and selected as an Editor's Choice. In the past year, TITAN has published a dozen high-impact journal articles for Canada. TRIUMF's Jens Dilling leads the TITAN project and was invited to attend the 152nd Nobel Symposium in Sweden and the published proceedings are now available. Dilling was recently elected a Fellow of the American Physical Society (roughly 0.5% of the 50,000 members achieve fellowship status). [NOTE: In June 2013, Dilling received the CAP-TRIUMF Vogt Medal for Outstanding Contributions to Subatomic Physics.]

The laser spectroscopy group at TRIUMF succeeded in measuring the atomic spectra of the three lightest francium isotopes for the first time; this project demonstrates the capability to test for the existence of new forces in nature. With support from the U.S. DOE, the facility for laser trapping and measurement of francium isotopes was commissioned. Radioactive francium isotopes, which are only available at TRIUMF in sufficient intensity, combine a large number of protons (Z=87) with a very simple atomic structure (noble gas + 1 electron), making it uniquely suitable for such precision tests of physics.

The new capability of irradiating uranium targets has reached a first milestone in producing very neutron-rich rubidium and strontium isotopes that play roles in the astrophysical r-process that is responsible for the production of half the chemical elements heavier than iron and is likely to happen in supernova explosions or neutron-star mergers.

Finally, the PiENu experiment has been completed. The detector apparatus is being disassembled while the final data is being analyzed. Results are expected in 2014.

Together with Perimeter Institute and SNOLAB, TRIUMF is launching the TRISEP international summer school in particle physics. The inaugural school will be held at TRIUMF, and then each year it will rotate amongst the three labs. At least 50% of the students will be international.

In materials science, TRIUMF has advanced the M-9A beam line. The major infrastructure, including controls, electrical, safety, pneumatic, and water services, have all been installed. Beam commissioning requires the strategic repair of a critical vacuum issue (at the T2-M9 interface, see BL1A below) to proceed. The vacuum leak is due to ageing infrastructure and the shift of a supporting monument; repair work will be quite invasive and an overall plan is still being formulated. The M20 muon beam line is complete with the exception of the fast electrostatic beam kicker.

The Accelerator Division **has set new records for uptime of the cyclotron** as well as the provision of rare-isotope beams to visiting scientists and their experiments. The cyclotron ran for 1,017 hours or 94.4% of the 1,077 hours scheduled.

The manufacturer of this device is continuing to resolve performance issues with the fast high voltage switch technology and has achieved successful bipolar operation in a test setup. M20 nonetheless successfully delivered beam to three muSR experiments in chemistry and materials physics, one experiment conducted by users from industry performing muon irradiation tests, and for tests of new solid-state detector technology in support of muSR spectrometer development.

Using the unique beta-NMR facility at TRIUMF, Canadian scientists have characterized the magnetism developed at the interface between LaAl2O3 and SrTi2O3 - two ordinarily non-magnetic and insulating ceramics. The system exhibits a remarkable change from insulating to metallic and, at sufficiently low temperatures, to superconducting in the interface region, depending on the thicknesses of the layers of each material. This is a beautiful example of the drastic change in materials properties that can be produced with subtle changes in electronic structure at interfaces.

In the realm of nuclear medicine, The MHESA chemistry hot cell lab is now complete. Built jointly with Nordion, work is about to begin on a number of isotopes of interest for commercialization, including work on the Tc-99m extraction and purification task. CIHR funded a new project to develop so-called "salty" targets for isotope production using radiometals.

The team has enhanced its capabilities in isotope production and radiotracer development. In the brain, there are three main monoamine neurotransmitter systems: dopamine, norepinephrine, and serotonin. The three systems work in tandem, but are often studied in isolation. As a result, there is only a partial understanding of the story. With support via a CIHR grant led by Professor Vesna Sossi at UBC, the TRIUMF team is expanding the Parkinson's program beyond studies of the dopamine system to now investigate serotonin using newly developed radiotracers by Dr. Yu-Shin Ding (NYU), who had a sabbatical leave at TRIUMF last year.

ADVANCE PARTICLE ACCELERATOR AND DETECTION TECHNOLOGIES...

- ✓ Complete upgrades to isotope-production target module infrastructure.
- ✓ Examine and begin structured approach to reducing and reusing liquid-helium through a planned future helium-liquefier plant.
- ✓ Develop preliminary elements of e-linac to begin accelerator research and development program.
- ✓ Assess and develop management plan for ageing Beam Line 1A.

TRIUMF AND INDIA'S VECC JOIN FORCES ON ISOTOPES
08 August 2013

At a formal ceremony at TRIUMF, laboratory directors Dr. Nigel Lockyer and Dr. Dinesh Srivastava of the Variable Energy Cyclotron Centre (VECC) of Kolkata inked a new partnership agreement valued at $10.4 million for the advancement of isotopes and accelerators in front of respective leadership teams, researchers and government officials. The agreement, which builds on an earlier Memorandum of Understanding signed between the two institutions, will see resources as well as manpower exchanged as both facilities work to complete their respective next-generation rare-isotope facilities–ARIEL at TRIUMF and ANURIB at VECC. The agreement involves the two laboratories and a number of Canadian companies. Richmond's PAVAC Industries, Inc. will be manufacturing the high-tech cryomodules using technology transferred from TRIUMF through AAPS, Inc., TRIUMF's non-profit commercialization partner.

The target modules used in the ISAC facility for isotope production are ageing and TRIUMF took the next steps in its refurbishment program by focusing work on Target Module #3. The targets group also commissioned a conditioning station that allows pre-testing of devices before installed online. TRIUMF, for the first time, has implemented a systematic approach to the annual three-month long shutdown using established project-management techniques. Over 600 tasks were included in the resource-loaded schedule. The approach proved to be a big success, as it allowed management to reallocate resources to high-priority tasks and fulfill a number of challenging commitments in a tight schedule. This approach to the shutdown will continue in future years.

During the past year, the Accelerator Division has set new records for uptime of the cyclotron as well as the provision of rare-isotope beams to visiting scientists and their experiments. The cyclotron ran for 1,017 hours or 94.4% of the 1,077 hours scheduled. For the main cyclotron, the final phase of the energy-saving trim and harmonic coils power-supply upgrade project was completed.

Led by the Science Division, the project to install liquid-helium recycling (collection, purification, and liquefaction) capability got underway. A seasoned project manager working for AAPS, Inc. is directing the effort, and collection of helium is schedule to start in October 2013.

With support via Infrastructure Operating Funds from the Canada Foundation for Innovation, initial research using the front-end of the e-linac has begun. Students from the University of Victoria assisted with several research projects including beam optics and beam-profile monitors and an SRF separator cavity.

The ageing infrastructure of Beam Line 1A continues to be a challenge. A measurement and monitoring program has begun, and the cause of changing relative position of the T2 target and the vacuum pipe is now roughly understood. However, a complete strategy to mitigate the leak and stabilize the situation until a formal re-build can be planned requires substantial effort.

In February 2013, TRUMF played host to the directors of the world's premier particle physics laboratories from all three regions of the globe. At the meeting, the new "Linear Collider" (LC) organization was announced. Canada has a seat on the newly formed LC Board because of its accomplishments via TRIUMF in SRF accelerator technology. The new Americas steering committee associated with the LC (ALCSC) identifies Fermilab and TRIUMF as the only two laboratories in the Americas with permanent seats.

FOR THE BENEFIT OF ALL CANADIANS...

- ☑ Advance neighbourhood district-energy system project with local UBC community including technical engineering feasibility study.
- ☑ Provide proton-therapy treatment for ocular melanomas and serve as secondary supplier for BC Cancer Agency's medical-isotope needs.
- ☑ Identify and advance major knowledge-transfer project with AAPS, Inc., and third-party commercial partners.
- ☑ Map out and launch national community-based plan to develop and deploy Tc-99m production capacity using existing medical cyclotrons across Canada.
- ☑ Demonstrate performance of safety, assurance, quality-management, and other systems to secure renewed operating license from Canadian Nuclear Safety Commission.
- ☑ Provide cultural activities for local community that advance appreciation of science, technology, and art.

In consultation with TRIUMF and other partners, the UBC Office of Sustainability has chosen Richmond-based CORIX Utilities in an international, competitive bid process based on their established expertise and track record in successful community partnerships in energy and utility systems. In Phase 1 of the neighbourhood district energy system (NDES) project CORIX will be conducting a feasibility study. If a decision is made after Phase 1 to proceed with the NDES Project, CORIX will design, construct, own, and operate the system, with oversight by UBC and the BC Utilities Commission (BCUC). The BCUC regulates all energy utilities in BC, and approves rate structures and customer billing models to ensure transparency.

Over the year, TRIUMF continued to provide proton therapy treatments for ocular melanoma using its main cyclotron. Using its TR-13 cyclotron, the lab served as a regular backup supplier of isotopes for the BC Cancer Agency in its clinical care activities.

In early 2013, the Isotope Technology Acceleration Program (ITAP) of Natural Resources Canada announced a $7M investment in a four-institution team led by TRIUMF for the development and deployment of the team's cyclotron-based technology for the production of the key medical isotope technetium-99m (Tc-99m). This investment is a follow-on to the team's

CANADIAN SOLUTION FOR TC-99M PRODUCTION
09 June 2013

Each year, tens of millions of medical procedures are conducted around the world with Tc-99m, an isotope used in radiopharmaceuticals for imaging disease in the heart, bones, and elsewhere in the body. In February 2012, the TRIUMF-led team demonstrated that the production of Tc-99m was possible on existing medical cyclotrons based in BC and Ontario. After a year of scaling up performance and making engineering improvements to target fabrication, control, and purification procedures, the team has achieved its next milestone: the production of enough Tc-99m in a six-hour overnight shift at the BC Cancer Agency Vancouver Centre to regularly supply the demands of a metropolitan area the size of Vancouver (roughly equivalent to 10 Curies)! This achievement eliminates the need for nuclear reactors to produce isotopes, especially those that use weapons-grade uranium, which has been the traditional approach. In addition to TRIUMF, the team includes experts at the BC Cancer Agency, the Centre for Probe Development and Commercialization (CPDC), and Lawson Health Research Institute.

success with the Non-reactor-based Isotope Supply Contribution Program (NISP) two years earlier. In FY 2012-2013, the TRIUMF team submitted applied for a provisional patent on the target technology and is ramping up for full-power tests in mid-2013 that will demonstrate the scalability of the technology. This program has received and continues to receive worldwide attention and recognition.

TRIUMF reorganized to create a Business & Administration Division, and AAPS has been recognized to fall under this new division. The head of the Business & Administration Division is now the President and CEO of AAPS. The new structure brings TRIUMF's commercial activities together under one roof and allows greater flexibility in pursuing new opportunities.

Within the AAPS sphere, IKOMED Technologies, Inc. has developed its smart-shutter system for reducing X-ray radiation to the physician and patient during minimally-invasive procedures that involve fluoroscopy. IKOMED is in the midst of contract negotiations with GE for OEM sales and distribution that would begin late 2014.

TRIUMF also modified its financial and administrative policies and procedures during this fiscal year to further position the laboratory for success. Procurement policies have been updated to facilitate greater value for money while lowering overhead activities. The cash-flow scheduling for ther NRC Contribution Agreement has been adjusted to maintain overall accountability while giving TRIUMF the ability to advance procurement when discounted pricing warrants.

In other news, two TRIUMF physicists (Lockyer and McPherson) received Zoomer Magazine's "Top 45 Over 45" citation for their work on the Higgs boson. TRIUMF hosted a visit by the Ambassador of Germany to Canada as well as last year's Nobel Physics Prize winner David Wineland (who is interested in atom and ion trapping). Perhaps last but not least, a TRIUMF undergraduate co-op student placed second in CBC's "Canada's Smartest Person" contest.

TRIUMF has partnered with Vancouver's TELUS Science World to to generate a free lecture series, called "Unveiling the Universe" to bring high-profile international scientists in Vancouver on TRIUMF business to the general public. The 400-seat auditorium sells out within 48 hours and is filled with enthusiastic families and students. TRIUMF sponsored three such lectures this year featuring Rolf Heuer, Gino Segré, and Lyn Evans. Similarly, TRIUMF assisted three artists from Emily Carr University and the Berlin University of the Arts to secure Goethe Institut funding for the first phase of a science and arts cultural exchange that resulted in an oversold show at Granville Island and invitations for a keynote address at Wesleyan University.

In summary, this year has been active, engaged, and focused on the twin goals of advancing ARIEL while producing compelling results from the ongoing research programs.

This year has been active, engaged, and focused on the twin goals of advancing ARIEL while producing compelling results from the ongoing research programs.

ARIEL...

- ☐ **Finalize** ARIEL civil construction and begin installation of beam line elements
- ☐ **Complete** procurement for the electron linear accelerator (e-linac)
- ☐ **Demonstrate** capability to provide 25 MeV, 100 kW electron beams with the e-linac, marking the completion of the ARIEL-I project
- ☐ **Advance** designs and implementation plans for completing ARIEL with additional funding

ADDRESS THE MOST COMPELLING QUESTIONS...

- ☐ **Exploit** actinide targets to produce isotopes for studying three-body forces in nuclei and for delineating the astrophysical r-process
- ☐ **Test** *ab initio* theoretical models using light isotopes produced and studied at ISAC
- ☐ **Pursue** particles beyond the Higgs boson with ATLAS at the LHC
- ☐ **Develop** Canadian efforts in neutrinos and neutrons
- ☐ **Support** projects destined for SNOLAB
- ☐ **Explore** development of novel magnetic and electrical properties in thinly layered materials
- ☐ **Pursue** development of novel radiotracers for oxidative stress, genetic markers, and non-dopaminergic neurotransmitters
- ☐ **Pioneer** develop of alpha-emitting isotopes for medicine using ISAC facilities

ADVANCE PARTICLE ACCELERATOR AND DETECTION TECHNOLOGIES...

- ☐ **Deliver** 3,000 hours of rare-isotope beams and maintain cyclotron uptime > 90%
- ☐ **Refurbish** isotope-production target modules for ISAC and test novel ion-guide laser-ion source technology
- ☐ **Develop** novel SRF cavity designs and test equipment to facilitate fundamental research and external collaborations
- ☐ **Secure** partnership with Germany to launch isotope-beam separator and purifier project led by Saint Mary's University
- ☐ **Complete** installation and commissioning of helium recycling facility
- ☐ **Pioneer** delivery of purified, heavy-mass isotope beams to ISAC-II
- ☐ **Expand** fundamental research program in advanced accelerator techniques

FOR THE BENEFIT OF ALL CANADIANS...

- ☐ **Partner** with AAPS, Inc. to launch a new product line or spin-off company deploying TRIUMF technology related to Tc-99m production on cyclotrons
- ☐ **Organize** and host Community Open House for more than 1,000 visitors
- ☐ **Develop** market opportunities for expanded medical-isotope production
- ☐ **Enhance** TRIUMF's approach to safety, quality assurance, human-resource management, and enterprise integration

AND FINALLY,

- ☐ **Develop** a compelling Five-Year Plan for 2015-2020 and share with the community, government, and international stakeholders.

FINANCIAL POSITION

For TRIUMF, Fiscal Year 2012-2013 was an outstanding year in which we made significant progress on the completion of our flag ship project ARIEL and continued to earn Canada's confidence with a new round of funding to develop Tc-99m production alternatives, all while maintaining normal operating levels in support of our core science programs.

The financial statements presented herein reflect the implementation of Public Sector Accounting Standards (PSAS) and the transition has impacted its presentation and disclosure.

During the year, TRIUMF generated funding growth of thirteen per cent to $87.9 million, the highest annual funding level in TRIUMF's history. This reflects the $10.7 million increase in contributions from the Canada Foundation for Innovation (including provincial match) and the British Columbia Knowledge Development Fund toward the completion of ARIEL's civil construction and e-linac equipment requirements.

It is worth noting that $0.9 million was received from Natural Resources Canada representing TRIUMF's first year share of Canada's new four-year $7 million support for the continued development of producing Tc-99m medical isotope using cyclotron-based technology. This national collaboration is headed by TRIUMF and includes Lawson Health Research Institute, the Centre for Probe Development and Commercialization, and BC Cancer Agency.

Operationally, our 2013 financial results continue to reflect the austerity plan started in 2010 (the beginning of the present Five Year Plan 2010-2015) and illustrates our strong focus on cost efficiency. Our annual operational funding channeled through the National Research Council has remained essentially at the same level since 2005. Despite rising costs driven by inflation, provincially imposed increases to electricity rates and modest salary adjustments, TRIUMF continues to deliver on its commitments while managing the spending and the associated trade-offs in order to operate within its budget envelope.

Looking ahead, this time is definitely exciting for TRIUMF as we work towards realizing the benefits of Canada's investment in our new infrastructure and science programs. Our attention to value and disciplined adherence to our financial policies will continue to position us well for the future.

Henry Chen | Chief Financial Officer

INDEPENDENT AUDITOR'S REPORT

To the Joint Venturers of TRIUMF

The accompanying summary financial statements, which comprise the summary statements of financial position as at March 31, 2013, March 31, 2012 and April 1, 2011 and the summary statements of combined funding/income and expenditures and changes in fund balances for the years ended March 31, 2013 and March 31, 2012, and related notes, are derived from the audited financial statements of TRIUMF for the years ended March 31, 2013 and March 31, 2012. We expressed an unmodified audit opinion on those financial statements in our report dated June 28, 2013. 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 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 in accordance with the basis of accounting 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 years ended March 31, 2013 and March 31, 2012 are a fair summary of those financial statements, in accordance with the basis of accounting described in note 2 of the summary financial statements.

PricewaterhouseCoopers LLP

Chartered Accountants | Vancouver, B.C. | July 10, 2013

SUMMARY STATEMENTS OF FINANCIAL POSITION

	March 31 2013	March 31 2012	March 31 2011
	$	$	$
Assets			
Cash and cash equivalents	3,536,396	10,878,148	11,634,530
Investments	10,111,842	-	-
Restricted cash and cash equivalents	10,366,239	10,194,410	10,069,448
Due from Joint Venturers	2,318,758	4,748,402	2,079,449
Funding receivable	2,267,569	2,249,000	1,406,038
	28,600,804	28,069,960	25,189,465
Liabilities			
Accounts payable and accrued liabilities	6,735,661	5,006,537	3,036,060
Funds received in advance	3,069,854	3,974,310	4,085,972
	9,805,515	8,980,847	7,122,032
Fund Balances			
Externally restricted			
Natural Sciences and Engineering Research Council Fund	3,104,601	4,216,445	4,665,908
NORDION Inc. Fund	100,000	100,000	100,000
Natural Resources Canada	-	-	(103,326)
Decommissioning Fund	10,366,239	10,194,410	10,069,448
	13,570,840	14,510,855	14,732,030
Internally designated			
Commercial Revenue Fund	2,991,467	2,056,579	1,434,198
Intramural Accounts Fund	1,863,735	2,272,483	1,768,572
	4,855,202	4,329,062	3,202,770
Unrestricted			
General Fund	369,247	249,196	132,633
	18,795,289	19,089,113	18,067,433
Total liabilities and fund balances	28,600,804	28,069,960	25,189,465

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

For the years ended March 31, 2013 and 2012

	2013	2012
	$	$
Funding/income		
National Research Council Fund	44,000,000	44,000,000
Natural Sciences and Engineering Research Council Fund	6,578,602	6,316,503
British Columbia Knowledge Development Fund	5,419,328	4,877,723
Canada Foundation for Innovation	20,361,685	10,196,335
Natural Resources Canada	853,827	1,043,988
NORDION Inc. Fund	3,892,558	4,190,636
Advanced Applied Physics Solutions Inc. Fund	1,512,691	1,806,141
Decommissioning Fund	171,829	124,962
Affiliated Institutions Fund	2,664,758	2,207,629
Commercial Revenue Fund	1,127,465	1,441,927
Intramural Accounts Fund	1,039,663	1,116,365
General Fund	233,737	200,258
	87,856,143	77,522,467
Expenditures		
Buildings and improvements	16,750,364	6,387,794
Computer	1,277,465	1,241,276
Consulting	1,759,592	3,374,520
Equipment	10,097,681	6,272,932
Power	3,092,094	2,724,992
Salaries and benefits	40,434,297	40,978,020
Supplies and other expenses	12,817,742	13,355,698
Telecommunications	142,329	216,387
Travel	1,778,403	1,949,168
	88,149,967	76,500,787
(Deficit) surplus of funding over expenditures for the year	(293,824)	1,021,680
Fund balances - Beginning of year	19,089,113	18,067,433
Fund balances - End of year	18,795,289	19,089,113

NOTES TO 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, 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. There were no changes to the membership during fiscal year 2012-13.

At March 31, 2013, each university owned an undivided 9.09% 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 summary 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 NRC, the Natural Sciences and Engineering Research Council, Canada Foundation for Innovation, British Columbia Knowledge Development Fund, 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.

British Columbia Knowledge Development Fund (BCKDF)
Funding provided for the civil construction of buildings. These funds are provided by the Province of British Columbia through the university members of the TRIUMF joint venture.

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.

Natural Resources Canada (NRCan)
Funding for approved capital projects related to TRIUMF activities.

Canada Foundation for Innovation (CFI)
Funding to Canadian universities for capital projects related to TRIUMF activities. 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 BCKDF) required by the grant.

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.

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

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.

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.

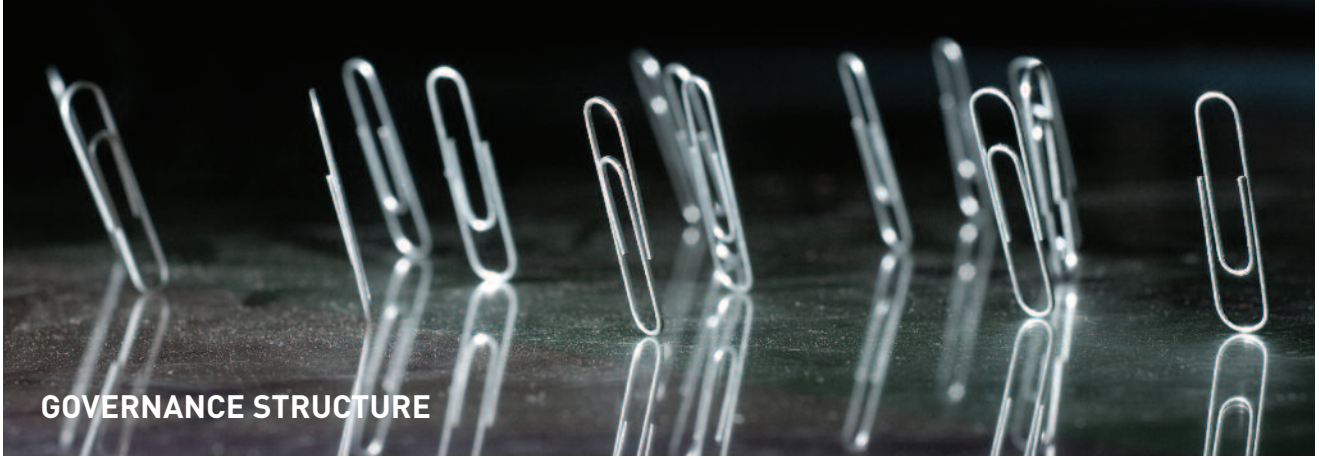
Consistent with TRIUMF's accounting policies (note 2), all decommissioning costs will be expensed in the period in which the costs are incurred.

At March 31, 2013, the balance in the fund, $10.4 million, has been set aside in an escrow account to fund decommissioning costs. The funds are managed by an appointed escrow agent as agreed to by the Canadian Nuclear Safety Commission (CNSC), Royal Trust Corporation of Canada, and each Member University of the joint venture. 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.

2 | Significant accounting policies

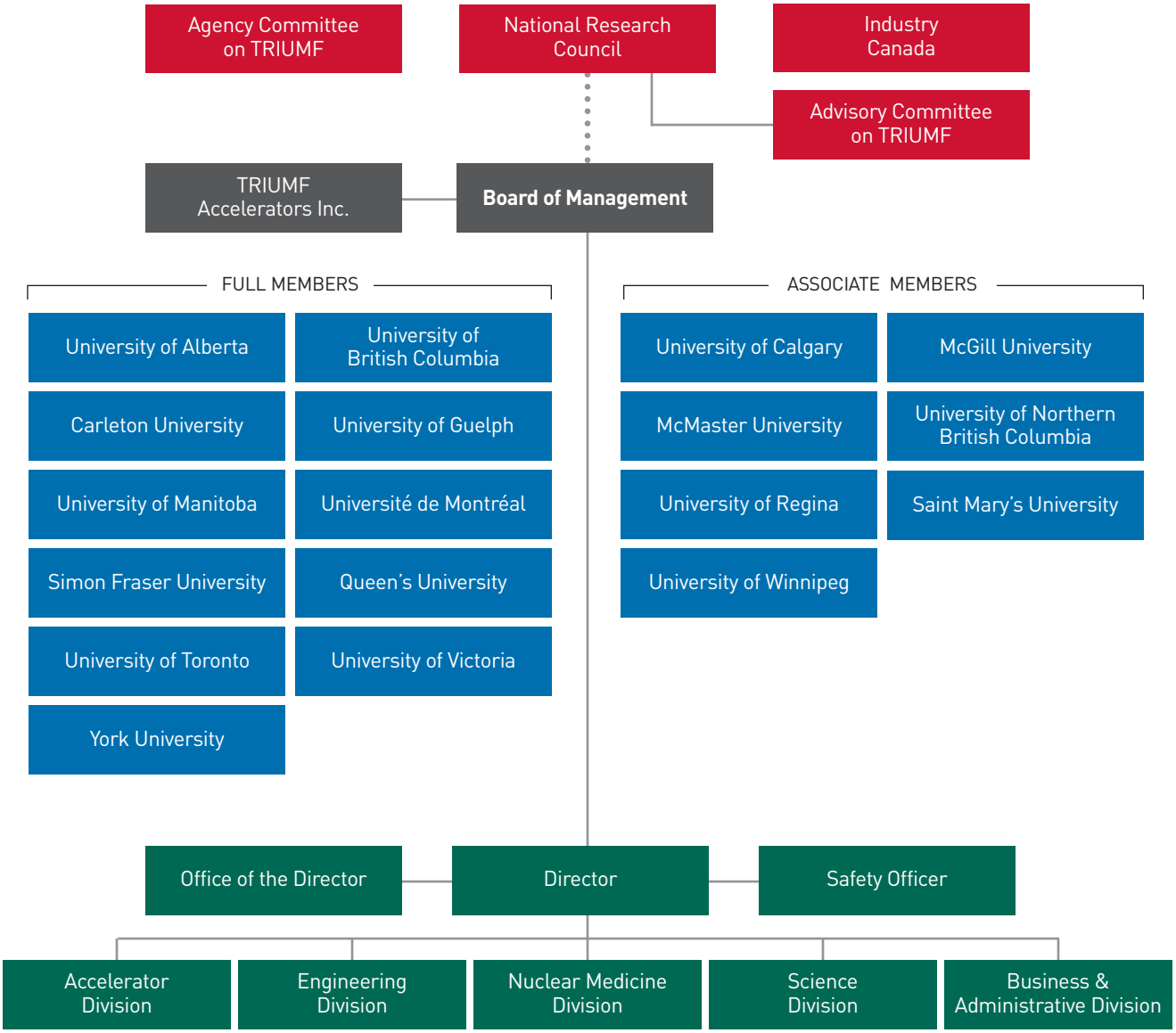
Basis of presentation
These summary financial statements have been prepared in accordance with section 11b of the TRIUMF joint venture agreement. TRIUMF has elected to follow Canadian Public Sector Accounting Standards (PSAS), including accounting standards that apply to government not-for-profit organizations, 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, and they do not include all the disclosures as required by Canadian PSAS.

These summary 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 12.5 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. These include:

Canada

Advanced Applied Physics Solutions, Inc.
Advanced Cyclotron Systems, Inc.
AECL, Inc.
BC Cancer Agency
British Columbia Innovation Council
Burnaby Board of Trade
Canadian Association of Physicists
Canadian Institute for Nuclear Physics
Canadian Light Source, Inc.
Canadian Space Agency
CANARIE
Centre for Probe Research and Development
D-Pace, Inc.
General Electric
Institute of Particle Physics
Jubilant-Draximage, Inc.
Lawson Health Research Institute
LifeSciences BC
Nordion, Inc.
Ottawa Heart Institute
Pacific Parkinson's Research Centre
PAVAC Industries, Inc.
Perimeter Institute
Positron Emission Tomography Imaging at UBC
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, 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 High-Energy Physics (IHEP), Beijing, China
Institute for Nuclear Research (INR), Russia
Istituto Nazionale di Fisica Nucleare (INFN), Italy
Japan Atomic Energy Agency (JAEA), Tokai, Japan
Japan Proton Accelerator Research Complex (J-PARC), Tokai, Japan
Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany
Lawrence Berkeley National Laboratory (LBL), Berkeley, USA
Lawrence Livermore National Laboratory (LLNL), Livermore, USA
Los Alamos National Laboratory (LANL), Los Alamos, USA
Manhattan Isotope Technology, LLC, Lubbock, USA
Ministry of Education, Science, and Technology (MEST), Seoul, Korea
National Superconducting Cyclotron Laboratory (NSCL), East Lansing, USA
Oak Ridge National Laboratory (ORNL), Oak Ridge, USA
Paul Scherrer Institut (PSI), Switzerland
Rutherford Appleton Laboratory (RAL), UK
RIKEN Nishina Centre for Accelerator-Based Science, Wako, Japan
SLAC National Accelerator Laboratory, Menlo Park, USA
Thomas Jefferson National Accelerator Facility, Newport News, USA
Toyota Central R&D Labs, Inc.
UT-Batelle, LLC, USA
Variable Energy Cyclotron Centre, Kolkata, India

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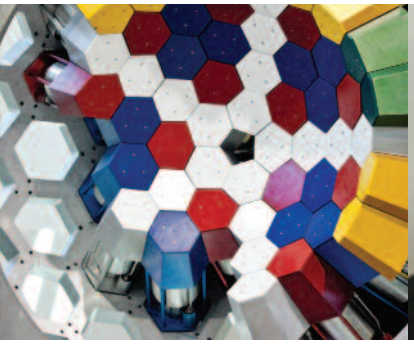
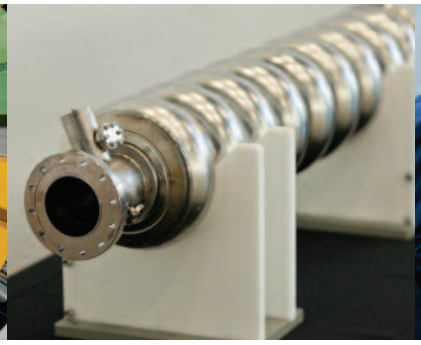

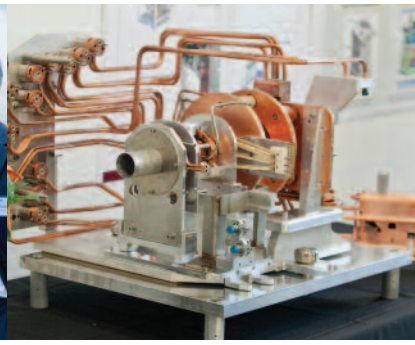

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