A Vision for TRIUMF 2010-2015

Discoveries at TRIUMF in the next decade will be the feedstock for translational research that will impact and advance all of Canada. These advances will enhance the health and quality of life of millions of Canadians, seed new high-tech companies, create new high specificity drugs, help us to understand the environment, advance computer GRID technology, enable the development of new materials, and spur the imaginations of our children who want to know their place in the universe. This vision is ambitious but within reach if we fully exploit the present moment.

With over a thousand users, comprised of international teams of scientists, postdoctoral fellows, graduate and undergraduate students, working along side their Canadian counter parts, TRIUMF brings together human talent and sophisticated technical resources. Together, the TRIUMF community participates in theoretical and experimental tests of materials, develops radiotracers and couple them to biologically specific molecules, studies the details of exploding stars, and probes nature's deepest secrets of unstable nuclei.

TRIUMF is one of the world's leading laboratories for studying rare nuclei. Accelerator scientists at TRIUMF are able to reproduce the conditions of supernovae explosions—the deaths of super massive stars—in the laboratory. This environment allows researchers to explore the origin of the chemical elements heavier than iron such as gold, silver, and uranium. Investment world-wide in this area of research will exceed $2B in the next decade. These discoveries will feed into the knowledge base for next-generation nuclear reactors and will help us understand the behaviour of advanced materials under extreme conditions. By connecting researchers in subatomic physics with others, TRIUMF develops and contributes to research in materials (bulk and surface effects in extreme conditions) and to a world-renowned life-sciences program that utilizes medical isotopes combined with positron emission tomography (PET) detectors.

The 21st century promises a revolution even more exciting in terms of our gains in fundamental knowledge of atomic matter, energy, space-time, and our understanding of the universe than all previous centuries combined. We now know that visible matter—the nuclei of our sun, the stars of the galaxies, the planets, the oceans, and even life itself—represents just 5% of the matter in the universe. In the last century, Einstein introduced us to the equivalence of mass and energy and the concept of space-time. Today, TRIUMF and Canadian scientists are working hand-in-hand with researchers from around the world at the Large Hadron Collider (LHC) at CERN, the largest accelerator and most ambitious scientific project undertaken by humanity. This team is poised to answer age-old mind bending questions: What is mass? Are there observable extra dimensions of space, hidden now from our view? Can this mysterious "dark matter" of the universe be produced in the laboratory? Simultaneously an international team located here in Canada, including TRIUMF scientists, is planning and designing experiments to search for this missing matter at SNOLAB, the new underground laboratory in Sudbury Ontario.

In order to seed discoveries and maintain one of the highest standards of living in the world, Canada must be aggressive in investing in fundamental and translational research. TRIUMF has a proven track record in both these areas. TRIUMF is known around the world for its unique relationship with MDS Nordion, a global health and life-science company. Through the spin-off of TRIUMF's medical-isotope technology to MDS Nordion, Canada has established a leadership position in the export of accelerator-generated longer-lived medical isotopes. The value to the Canadian economy over the last 20 years is worth over a billion dollars in today's market. TRIUMF has won the NSERC Synergy award twice for its partnerships with start-up companies. Another recent success is the formation of the company Advanced Applied Physics Solutions (AAPS), which is expected to identify and commercialize industrial applications in medical accelerator technologies, the mining industry, and new materials. Simultaneously, TRIUMF is launching new initiatives with the BC Cancer Agency and MDS Nordion in radiotracer development.

The proposal outlined here requests about 8% growth per year over 5 years. This growth will help keep Canadian researchers competitive with new U.S. initiatives in the physical sciences (doubling of the federal budget over a decade) as well as those elsewhere around the world. This plan charts a path from discovery in subatomic physics, accelerator technology, detector development, materials, and radiotracer development through to knowledge transfer, training, and product development. This proposal builds and expands upon TRIUMF's growing collaborations with Asia and other world-wide partners and the existing highly sophisticated detector and accelerator infrastructure and expertise at TRIUMF to achieve these goals. The following initiatives capitalize on TRIUMF's strengths and significantly enhance its ability to provide tools and resources to the Canadian community.

- We propose a new, world-class, megawatt electron linear accelerator (e-linac) using the latest superconducting radiofrequency (SRF) technologies to complement the existing proton cyclotron accelerator. TRIUMF uniquely houses Canada's state-of-the-art accelerator infrastructure and resources that are capable of designing, building, and commissioning a new world-class machine. This project will also bring together a diverse group of world-leading scientists in particle physics, nuclear physics, condensed-matter physics, and life science as well as members of the Canadian Light Source accelerator community. The new accelerator will allow the creation of neutron-rich nuclear states never produced before. The e-linac will produce new isotopes for research in medical imaging and therapy, and will generate unprecedented quantities of an isotope needed for the study of magnetic properties of nano-material surface interfaces. The SRF technology has applications for the International Linear Collider (ILC), the upgrade to the LHC injector complex at CERN, and numerous other SRF projects around the world including "compact light sources", and 4th generation energy-recovery light sources. The core SRF technology of this accelerator will lead to spin-

off applications for Canadian industry. It will connect Canadian scientists and industry to the latest opportunities using accelerators around the world.

- We propose an initiative in radiotracer development that more than doubles the TRIUMF life-sciences program by expanding from neurodegenerative diseases into cancer imaging and therapy. This initiative involves bringing together a national collaboration of universities, health institutes, and health industry partners focused on molecular imaging using novel radioisotopes and designer molecules with high specificity. Expansions are planned for highly qualified personnel in nuclear medicine imaging, radio-chemistry, and biochemistry.

- We propose a major new thrust in interdisciplinary physics, utilizing laser technology and rare isotope beams to advance the quest to discover the violation of fundamental symmetries. The ultimate goal is an understanding of the behavior of antimatter. This program will require new high-power target technology not available anywhere else in the world that utilizes high currents of protons impinging on uranium-carbide targets. The combination of this initiative and the e-linac will more than triple TRIUMF's ability to provide the Canadian and international communities with the tools needed to advance their research programs in nuclear physics and selected materials-physics techniques.

- We propose to develop an ultracold-neutron facility in a major new collaboration with several Japanese laboratories and universities. There is great interest world-wide in very cold (slowly moving) neutrons. TRIUMF has the required high-current proton beams to leverage the success of the UCN "cryogenic" technique developed in Japan. The science program would initially search for violations of fundamental symmetry. This work would complement and enhance Canada's reputation in this important expanding field of physics. The ultracold neutrons will also be used for precision tests of gravity and to search for extra dimensions of space. Bringing the ultracold neutrons into collision with rare-isotope beams generated by the e-linac is also being investigated as a unique facility in the world.

- We propose to continue our pursuit of the universe's secrets by studying physics phenomena at the highest energies available. Discoveries at the LHC will shed light on this quest in 2009-2010. The world community will be ready to select the next steps, such as a major new initiative called the International Linear Collider (ILC) or whether the LHC accelerator and detectors will be upgraded to enhance their sensitivitiy. Canadian scientists are leaders in the international design effort for the ILC. The ILC is an ambitious project, initiated by all three regions of the world and Canadian scientists and industry are well positioned to contribute to the SRF-based linear accelerator and detectors.

- We propose a major engineering and detector development program aimed at SNOLAB. Canada has already invested substantial funds to build this world-class underground laboratory. TRIUMF is uniquely positioned to assist the university partners to develop and build novel detectors, and develop ultra-low radioactive laboratories for SNOLAB.

TRIUMF is internationally recognized as a unique world-class accelerator physics laboratory in Canada. It represents an investment by Canadian citizens of over $1 billion if built today. TRIUMF provides advanced research opportunities for graduate and undergraduate university students from all across the nation, from St. Mary's in Halifax to the University of Victoria. TRIUMF provides the needed high-tech infrastructure and design resources not available at Canadian universities because of the large and complex scale of the experiments. These resources enable research opportunities for hundreds of Canada's best scientists at the vanguard of their fields of study. Primarily because of its reputation as one of the premier rare-isotope beam facilities in the world, TRIUMF attracts over 500 researchers, postdoctoral fellows, and students from outside Canada each year to its facility to collaborate with Canadian scientists in research. Over two thousand visitors come to TRIUMF each year to visit and tour the facility.

This vision offers distinct advantages to Canada in the following areas.

- Entrepreneurial Advantage
  - Quadruple the economic impact from technology transfer and commercialization via AAPS
  - Forge new industrial partnerships related to our world recognized leadership in medical cyclotron design
  - Establish a major new partnership with India in accelerator science
- Knowledge Advantage
  - Act as the hub for the nuclear medicine revolution in Canada
  - Establish major research initiatives in radiotracers
  - Connect radiotracer know-how with "big pharma"
  - Explore new accelerator methods for producing medical isotopes
  - Expand TRIUMF's world recognized position in GRID information technology
  - Double number of publications and citations
- People Advantage
  - Double the number of international scientists and students
  - Double the number of Asian scientists working at TRIUMF
  - Triple the number of graduate student opportunities
  - Double undergraduate student research opportunities
  - Launch a new initiative in Aboriginal recruiting for coop students
  - Engage all major Canadian Universities across the 5-regions

The requested increased investment in research, when combined with Canada's commitment to higher education, expanded national technical infrastructures such as the Canarie network, and broad support for further growth in the high-tech industrial base,

will enable Canada to seize the economic and social benefits about to emerge in the next decades from breakthrough science discoveries. Canada and its workforce must be amongst the global leaders in subatomic physics in order it to keep pace with the fast changing world of high-tech and to be able to bridge interdisciplinary programs in materials research, molecular imaging, and new cancer therapy techniques. The benefits to present and future Canadian society will be well worth the investment.