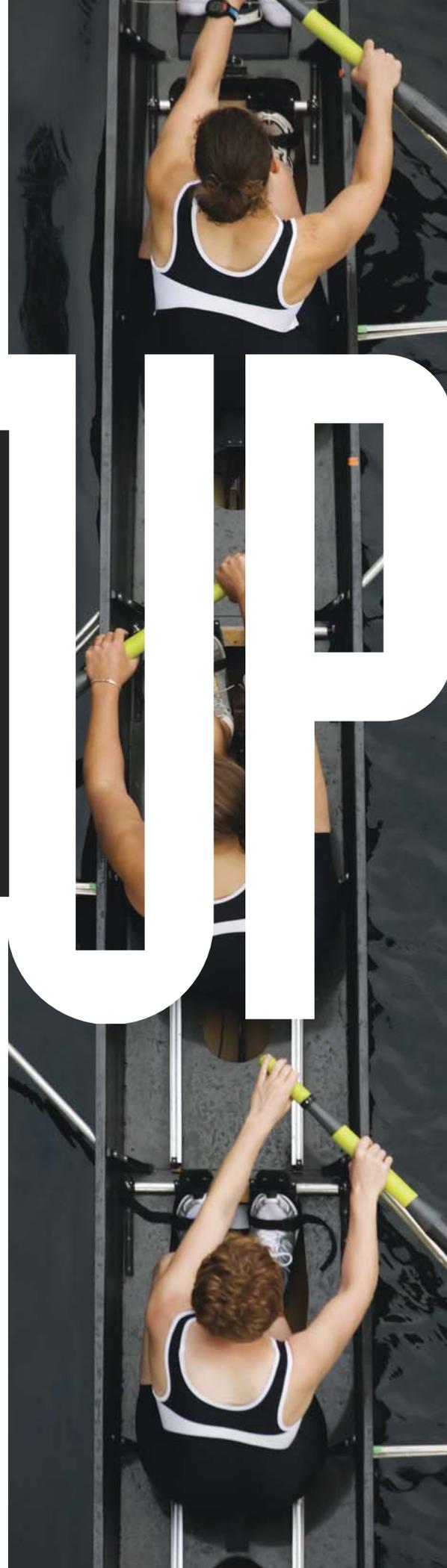


TEAM UP



ACCELERATING SCIENCE FOR CANADA







TEAMUP

Innovations arise at the boundaries between disciplines and at the interfaces between supply and demand, push and pull, creativity and productivity. To foster these types of interactions, TRIUMF has built a network of government, university, and industrial partners. These relationships ultimately enable TRIUMF to “team up” for a win in the race for Canada’s international competitiveness.

**AS A NATIONAL LABORATORY,
TRIUMF CONTRIBUTES TO
CANADA’S COMPETITIVE ADVANTAGE.**

The global scientific community sees TRIUMF as a bridge between academia and the private sector and as a model for transferring knowledge, training highly skilled personnel, and commercializing research for the economic, social, environmental, and health benefit of all Canadians.

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I write this just as the 2012 Summer Olympic Games in London are drawing to a close. Every four years, the world comes together to celebrate and showcase athletic achievement and to push the limits of what is humanly possible—to compete and to win.

At home in Canada, many of us watched favourite events and others checked the daily medal count, keen to know how well our country and its top athletes were faring.

Did we expect to medal in every event? No, of course not. Our colleagues in the statistics, population studies, and economics departments can explain how Olympic success can (almost) be effectively modeled by taking into account both the size of a country's population (influencing the size of the talent pool) and the economic considerations such as GDP and standard of living (influencing access to specialized training and facilities as well as talent-scouting for promising super-athletes). Against some of these models, Canada has already outperformed expectations with 18 medals. (A study by PriceWaterhouseCoopers suggested that Canadians would earn 15 medals total.) Bravo to Team Canada!

But what are the essential ingredients that drove this success? How do we know from where the big performances will come? More importantly, how do we clone these results in other areas? For instance, we all recognize the urgency of securing the economic future of Canada in an increasingly competitive global marketplace. How do we accelerate our participation in the knowledge economy when we know that sometimes life happens and performance falls short? How do we ensure that our "knowledge athletes" are getting everything they need to win the medals and bring home the victories?

In the area of science, technology, and innovation, I am convinced TRIUMF is part of the answer. The laboratory has been operating for more than 40 years and, in a recent event earned a medal (i.e., ranked well in a global statistic): the ratio of annual commercial revenues to operating budget is 3%, equivalent to the same metric for the Massachusetts Institute of

Technology. What drives this success for TRIUMF? The pursuit of research excellence coupled with a sense of business relevance, all made possible through a network of deep partnerships. This laboratory is a joint venture of great Canadian universities—a demonstration of collaboration and teamwork in its very origins.

For instance, it is TRIUMF's three-decade relationship with commercial partner Nordion, Inc., that has made it a leader of a Canadian team that is developing an alternative technology for producing the world's most popular medical isotope without using nuclear reactors or highly-enriched uranium. It is TRIUMF's relationship with AAPS, Inc., and several Vancouver-based entrepreneurs that led to the launch of IKOMED Technologies, Inc., a startup firm with a technology for reducing radiation-dose during fluoroscopic procedures that is nearly ready for initial deployment. And it is TRIUMF's relationship with PAVAC Industries, Inc., that has opened new markets in India and China for the company's next-generation accelerator components. These successes will inspire many more.

As you read this year's report, look for the great relationships, look for the emerging partners, and look for the promise of gold medals. I'm sure you'll agree that TRIUMF will continue to be a critical element of Canada's recipe for global success.

Sincerely,



Steven N. Liss | Chair, TRIUMF Board of Management Innovation and Industrial Partnerships Committee | Vice-Principal (Research), Queens University



Welcome to the second annual Business Development Report for TRIUMF's Five-Year Plan 2010-2015. It's been a good year and our expectations are high for the future. TRIUMF has not only expanded its domestic network but is now also exploring several international opportunities for leveraging Canadian businesses.

Some will notice that we have renamed the business-development functions at TRIUMF from "technology transfer" to "innovation & industrial partnerships." What does this shift represent? Several changes. First, TRIUMF's perspective on how to be effective in the modern era has evolved, and since words create the world, a new title was appropriate. Second, as a joint venture of Canadian universities, the laboratory is declaring its larger commitment to fostering innovation and building long-term, mutually beneficial relationships with industry. Moving a technology out the door is no longer sufficient; in some instances, that might be just the beginning of a valuable long-term relationship. And that relationship holds greater value than any one new product. We are still working on a paradigm that effectively measures and monitors the quality and extent of these types of partnerships, but we recognize them as important.

Looking across TRIUMF's four declared business lines, the role of industrial partnerships in driving innovation and economic benefit is clear.

- **Irradiation services.** TRIUMF provides beams of energetic protons and neutrons, and what attracts industrial customers is the level of consistent partnership and technical assistance.
- **Isotope production and chemistry.** TRIUMF's association with the BC Cancer Agency and Nordion, Inc., to name a few, keep this business line innovative and relevant by connecting directly with the experts in commercial and clinical applications.

- **Technical consulting.** External entities seek out TRIUMF's advice on technical matters and where appropriate, these arrangements are formalized as ongoing partnership interactions with invoiced work packages.
- **Professional training.** TRIUMF is fundamentally a research institution and yet the culture of training for excellence permeates the hallways through the fundamental partnerships with Canadian universities. Thus, TRIUMF often organizes training workshops or scientific conferences in collaboration with other organizations.

TRIUMF continues to reinvigorate its approach to business development. For instance, the lab co-hosted a national workshop with the industry-liaison offices of its member universities in July 2012. This Innovation and Industrial Partnerships Workshop helps establish TRIUMF and its sister organization AAPS, Inc., as national resources for the commercialization of physics and accelerator-based technologies. The workshop is a great beginning to establishing business relationships involving TRIUMF's academic partners and suppliers.

Sincerely,



Jim Hanlon | Chair, TRIUMF
Innovation and Industrial
Partnerships | Head, Human
Resources and Administration





BUSINESS LINE: IRRADIATION SERVICES

Beginning in 1995 TRIUMF has built up several beam lines that provide low-intensity, energetic proton and neutron beams to simulate natural-radiation exposures in either space or terrestrial environments.

Even at low intensity, a few minutes of exposure in these beams can correspond to years of operation in space, air, or ground. This allows for accelerated testing of electronics for errors. Since then, TRIUMF has become recognized as a premier test site for space-radiation effects using protons. By converting these protons into neutrons, testing with neutrons is also possible.

CORE CAPABILITY

TRIUMF's Proton Irradiation Facility (PIF) and Neutron Irradiation Facility (NIF) regularly make use of three beam lines at TRIUMF. Protons and neutrons are available at energies up to 120 MeV via BL2C1, which is shared with TRIUMF's Proton Therapy Centre for the cancer treatment of ocular melanoma. Higher energies, up to 500 MeV, are available with BL1B, a testing facility truly unique to the world for both its broad range of energy and intensity. More intense neutron irradiations can be done with the TRIUMF Neutron Facility (TNF) location at the end of Beam Line 1A. Here, the "leftover" protons from the Meson Hall are converted to neutrons at the beam dump, yielding an energy spectrum well matched to that of atmospheric neutrons, ideal for testing avionics and ground-based electronic systems, such as network and power-distribution servers, or even the latest cell-phone chips.

TRIUMF's expertise in radiation effects in materials is well recognized. This past year, Ewart Blackmore, the chief scientist for PIF & NIF, was asked to provide expert support to a technology assessment initiated by the Canadian Space Agency related to radiation prediction, monitoring and protection technologies for future space missions.

GLOBAL POSITION

PIF & NIF at TRIUMF offer many competitive advantages. As a destination for testing equipment, TRIUMF is ideally situated very close to an international airport making both travel and shipping easy. TRIUMF is also accessible to international customers who may find it difficult to obtain clearance to test at other facilities such as the U.S. DOE laboratories which house national defense-related activities. The TNF neutron facility location, while limited in the size of parts it can test, has roughly 5 times the intensity available elsewhere, making it the preferred choice for many chip makers and third-party testing companies. The fact that TRIUMF runs "24/7" allows larger testing companies to be more efficient with their time and most customers comment on the level of service and the facilities that TRIUMF has available.

The importance of Beam Line 1B cannot be understated. It is the only proton beam line in the world that offers a range of both high energy and variable intensity and is the reason many customers come to TRIUMF. Alternatives to TRIUMF's facilities include Los Alamos in the U.S. for neutron tests and TSL in Sweden for protons and neutrons.

PERFORMANCE

PIF & NIF generated lower revenues than usual this fiscal year because of a longer-than-usual annual winter shutdown and problems with Beam Line 1A infrastructure. To first order, less available beam time translates into less income. Despite initial predictions that PIF & NIF would generate only 60% of its typical annual revenue, extraordinary efforts in the productive season resulted in about \$0.3 million of revenue. The PIF & NIF team was able to generate and develop extra business before year-end. December 2011 became particularly busy and was heavily oversubscribed; more beam time than the 15 available days of the month could have been used!

In typical years about 90 users about 30 companies in Canada, the U.S., and Europe make use of TRIUMF's irradiation facilities. This past year had several new customers including several from Norway and Argentina. Cisco Systems remains our largest customer while a number of Canadian space and avionics companies rely on TRIUMF radiation-effect testing for component selection and to meet contractual requirements. Data taken at PIF & NIF often ends up in student theses, presented at numerous international conferences, and in refereed journals. This publicity frequently leads to new customers.

OUTLOOK

The level of business is expected to remain approximately the same as last year.

The revenues from PIF & NIF are set by the level of main-cyclotron beam time allocated to irradiation services. Thus, the level of business set by scheduling of the beam line and required maintenance of the ageing infrastructure. TRIUMF's reputation for 8 to 9 months per year of reliable beam delivery has always been a strong selling point to our customers. With a slightly longer shutdown in earlier 2012, several customers chose to take their business elsewhere because beam time was not available; the impact is estimated to be around \$50,000.

The core team is examining options for modest enhancements to the capabilities. Modifications, perhaps funded by customers or customer credits, could allow TRIUMF to irradiate larger components, attracting some new business. The business opportunity will be explored in the coming year. TRIUMF is also considering tweaks to its beam-line scheduling to enhance the combined outcomes of science and irradiation-services revenues. Additionally, TRIUMF is evaluating the feasibility of longer-term adjustments to the main cyclotron's ports and/or beam lines to provide additional time and space for irradiation services. Finally, the demand for different particles types (e.g., heavy ions or muons) is emerging and TRIUMF is exploring opportunities to provide these capabilities for radiation-effects testing.

Beyond the physical irradiation services, TRIUMF has become a resource for simulation and modeling across Canada. Monte Carlo simulations have been performed using the FLUKA framework to model both Beam Line 2C1 and the TNF facility which will

allow the evaluation of possible upgrades to PIF & NIF. This timing is favourable as the neutron-testing landscape may be changing in the near future with the possible shutdown of the TSL facility in Sweden and the startup of the new ISIS facility in the UK. Some investment in upgrading the PIF & NIF capabilities could present new opportunities as several customers have been asking us to increase what we can offer. In addition, collaboration with both academic and industry partners will allow the irradiation testing of parts with muons in 2012 which could lead to a new income stream. New capabilities in the irradiation business will require some careful decisions by TRIUMF to rebalance beam-time allocations.





BUSINESS LINE: **ISOTOPE PRODUCTION AND CHEMISTRY**

TRIUMF's core competency in production, processing, and preparation of isotopes for science and medicine has been in demand this fiscal year. From global requests for expanded production of medical isotopes such as strontium-82, to detailed conversations about setting up isotope-production facilities in the Asia-Pacific region, partners are seeking out TRIUMF.

CORE CAPABILITY

TRIUMF is a world expert in the physics and chemistry of isotopes and partners with global leaders in biological applications (e.g., medical diagnosis and treatment). As an accelerator laboratory, TRIUMF has deep expertise in cyclotron design, engineering, and operation. TRIUMF has also developed a variety of novel targets that enable the production of selected isotopes in relatively high yields. The nuclear-medicine team has mastery of the chemistry used to isolate, purify, and combine the isotopes with biologically active target molecules for use by its partners.

GLOBAL POSITION

TRIUMF's nuclear-medicine team is not unique in Canada, let alone the world, nor are any of its facilities and equipment especially unusual. TRIUMF's competitive advantage arises from its combination of knowledge, skills, and abilities. TRIUMF has the expertise and the equipment to design and operate accelerators for production of medical isotopes. And TRIUMF has 30 years of experience doing so with Nordion, Inc., in a competitive business environment. TRIUMF has the tools and talents to identify and then

test new techniques for producing isotopes and can then fashion novel radiotracers using cutting-edge chemistry. Finally, TRIUMF has a network of biological and medical partners that pioneer the application of radiotracers for understanding disease and developing new treatment approaches. It is this "one-stop shop" aspect of TRIUMF's prowess in the physics and chemistry of isotopes that make this business line its strongest.

PERFORMANCE

Existing business relationships with the U.S. Department of Energy for the production of silicon-32 isotopes continued. TRIUMF also now serves as a secondary, back-up supplier of fluorine medical isotopes to the BC Cancer Agency.

Paul Schaffer, Head of the Nuclear Medicine Division, secured a grant from Genome BC's applied research and technology program for a team effort. The research is at the border between discovery science and technology development, focusing on developing radiotracers that would be sensitive to the genetic progenitors of cancer in the body. The result could be a PET scan that reveals aberrant genetic activity, heading off the diagnosis of cancer before the tumour has had a chance to grow and become life-threatening.

Perhaps the most significant outcome this year was the TRIUMF-led national effort to develop a cyclotron-based technology for the production of technetium-99m (Tc-99m), the world's most popular medical isotope. Together with support from Natural Resources Canada and partners at the BC Cancer Agency, Lawson Health Research Institute, and the

It is this "one-stop shop" aspect of TRIUMF's prowess in the physics and chemistry of isotopes that make this business line its strongest.

Centre for Probe Development and Commercialization, TRIUMF announced a breakthrough in February 2012 with the successful demonstration of producing Tc-99m on existing medical cyclotrons without the use of nuclear reactors or highly-enriched uranium. The core technology has been protected with a provisional patent, and TRIUMF is now working with industrial partners to develop the best path toward full commercialization.

TRIUMF is exploring topics of mutual interest with multi-national General Electric (GE). Past efforts have leveraged the synergy between TRIUMF's core competencies in accelerator targetry, radiochemistry, and pre-clinical applications to address unmet needs on several fronts—with a significant potential for commercial impact.

The Nordion-TRIUMF radiochemistry lab known as the MHESA nuclear-medicine laboratory is being completely renovated and four new hot cells have been installed. Control and ventilation systems are being commissioned and the laboratory will be available for joint research projects by the end of 2012.

The synergistic relationship between TRIUMF and Nordion, Inc. for the commercial manufacture and sale of medical isotopes continues to be unique—but perhaps not for long. During 2011, TRIUMF engaged in a serious set of conversations with a region in China and a region in India to start developing a template for “isotope production facilities using cyclotrons” that would exploit Made-in-Canada technologies while giving those regions self-sufficiency in terms of supplying their own medical isotopes. TRIUMF's progress in demonstrating production of technetium-99m on modern medical cyclotrons has dramatically expanded interest in so-called “green field” site approaches.

TRIUMF regularly irradiates a variety of target materials used to extract strontium-82 (Sr-82) for the production of strontium generators that yield rubidium-82 isotopes used in cardiology imaging. Nordion, Inc., procures Sr-82 from TRIUMF for commercial sales and distribution. Downstream, Bracco, Inc., uses the Sr-82 to manufacture the actual generators. In 2011, Bracco experienced a series of setbacks in marketing its generators; irregularities in usage and shelf life caused the manufacturer to cease

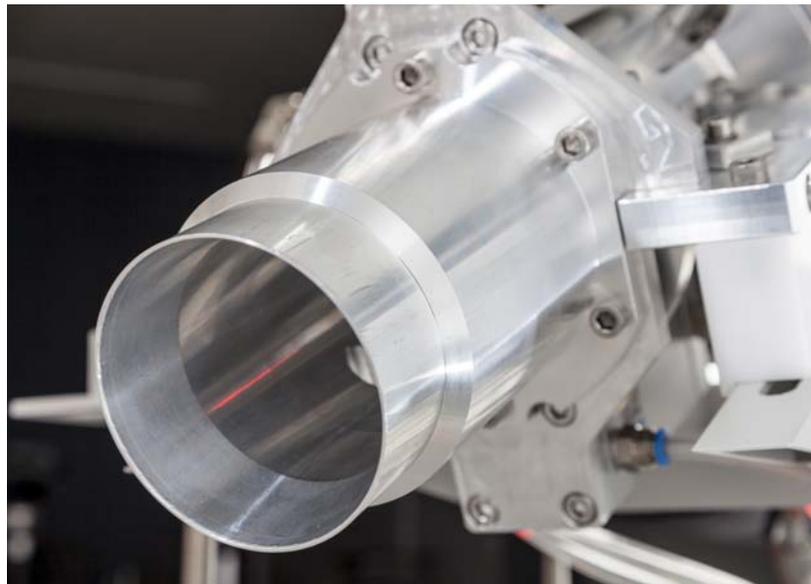
production for six months. As a result, the demand for strontium from TRIUMF dramatically decreased for at least six months. The issue appears to have been resolved and the demand for TRIUMF's Sr-82 material is returning.

OUTLOOK

TRIUMF is exploring several opportunities for expansion in this business line that should generate a modest increase in the near-term and significant growth over the next three years.

One is a supply relationship with a BC-based company that would use the medical isotope fluorine-18 to generate fluorodeoxyglucose for use in PET scans for oncology. This engagement would utilize the capacity of the TR13 cyclotron that became available after the BC Cancer Agency developed its own production capabilities with the acquisition of a TR19 cyclotron.

TRIUMF is engaging an expanded national team to participate in the Isotope Technology Accelerator Program (ITAP) from Natural Resources Canada, to fully develop and then deploy the team's technology for cyclotron production of Tc-99m. The proposal builds on the platform technology that is based on an “upgrade kit” for existing, conventional medical cyclotrons whose demonstrated feasibility was announced in February 2012 at the American Association for the Advancement of Science meeting held in Vancouver. The program would be used to deploy the technology across four different provinces along with full regulatory approvals in the next few years.





BUSINESS LINE: TECHNICAL CONSULTING

The true value of TRIUMF for Canada is in its impressive assembly of technical and engineering knowledge, skills, and abilities. The personnel, the equipment, and the expertise make TRIUMF an unparalleled resource.

Over the course of the past year, TRIUMF developed a formal approach to this line of business. On one hand, the laboratory is not a contract-research organization nor a contract-manufacturing organization (especially as the program of work in the five-year mandate subsumes all the available resources). On the other hand, the laboratory is committed to serving the nation. In general, TRIUMF does not seek “work for others” type business relationships (where external organizations reimburse TRIUMF for addressing their technical concerns on a cost-recovery basis). A key element of TRIUMF’s mission is, however, to drive the development of new technology and its applications. Thus, work with a private-sector partner should advance the scientific agenda of the laboratory; co-developing the technology with a private-sector partner or licensing the technology to a commercial partner is encouraged and would be a natural element of such activities.

CORE CAPABILITY

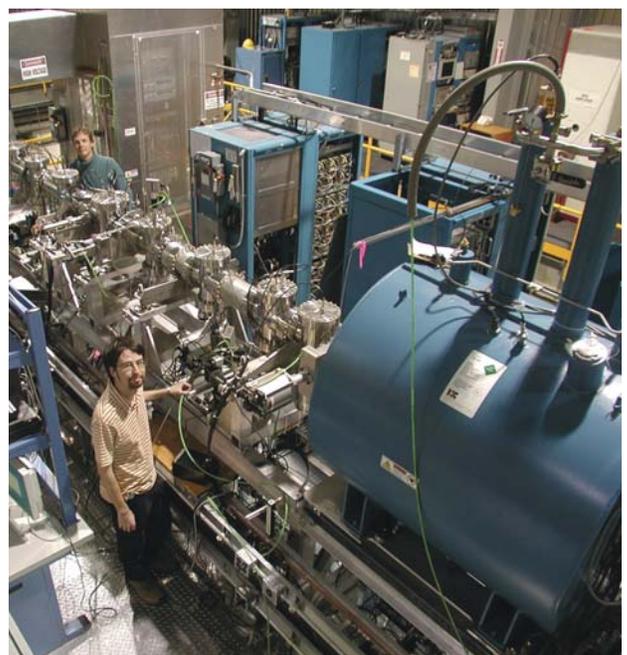
TRIUMF has established technical prowess in the following areas in addition to irradiation of materials and isotope production and chemistry:

- Ion beam dynamics;
- Mechanical design, engineering, and fabrication;
- Advanced electronics: digital and analog;
- Advanced computing for scientific and facility control;

- Particle and radiation detection, modeling, and shielding;
- Radio-frequency (RF) technology including low-level RF and high-power RF;
- Precision magnet design, engineering, and measurement;
- Vacuum technology; and
- Cryogenic technology.

GLOBAL POSITION

TRIUMF’s scientific and technical talent pool has several competitive advantages. Distinct from a traditional university department, TRIUMF offers interdisciplinary expertise that spans multiple academic disciplines. Physicists, chemists, and engineers work alongside each other on challenging technical projects. Other laboratories around the world have equally talented individuals; TRIUMF’s specialization in isotopes for science and medicine is unique, however, and makes the laboratory an in-demand resource for this industry.



PERFORMANCE

TRIUMF has undertaken a larger-than-usual variety of consulting arrangements this past year.

On a pro bono basis, Lia Merminga, head of the TRIUMF Accelerator Division, was invited to serve as an expert member of the U.S. Department of Energy's Task Force on Accelerator Science and Technology. She participated in a series of workshops and helped prepare a report that outlines the future economic opportunities presented by modern accelerator technologies. TRIUMF and Canadian expertise are cited in multiple areas of the report (available online at www.acceleratorsamerica.org/report/accelerator_task_force_report.pdf). TRIUMF's involvement in U.S. discussions about particle accelerators and innovation continued with an invitation to two of TRIUMF's senior management team to visit the U.S. SLAC National Accelerator Laboratory in Menlo Park, California, to lead a two-day workshop on innovation and industrial partnerships.

The demand for small medical cyclotrons continues to escalate around the world. In Canada, the company Advanced Cyclotron Systems, Inc. (ACSI) uses designs inspired from work on TRIUMF's main cyclotron to manufacture and sell modern medical cyclotrons. The company has sold 19 machines in the past 18 months, capturing 20% of global sales. The design and engineering of the shielded vaults to house these cyclotrons is not easy, however; TRIUMF has been consulting on a number of projects this year to assist Canadian universities and research hospitals validate their designs from a safety and shielding perspective as well as for workflow and radiochemistry capabilities.

In the area of accelerator science and technology, TRIUMF has been asked by multiple entities to provide consulting and support. Based on the expanding level of interest and activity in this area, the laboratory may formally develop it as a fifth business line in the coming year. For instance, PAVAC Industries, Inc. (based in Richmond, BC), is in discussions with TRIUMF and AAPS, Inc., to develop a framework for transferring cryomodule technology from the lab to industry. Heretofore, PAVAC has worked with TRIUMF to develop know-how from TRIUMF at a cost-neutral basis for the fabrication of superconducting radio-frequency (SRF) cavities for next-generation particle accelerators. TRIUMF took some of the up-front risk

by serving as the first customer; these cavities are now in use in the ISAC-II facility. PAVAC is now manufacturing SRF cavities and making sales to the U.S., India, and China to name a few. Globally, PAVAC is quite competitive; in a recent international bidding process held by Beijing's Institute for High Energy Physics for the qualification and manufacture of a novel "spoke" SRF cavity, the TRIUMF-PAVAC team was the only group awarded a contract outside of China. PAVAC now sees the business opportunity in moving up the value chain to deliver not just the cavities but the entire superconducting cryomodule that contains about ten times more value. TRIUMF is working with PAVAC to develop the umbrella agreements that would proceed with technology transfer, intellectual property protection, modest royalty payments, and so on.

In a similar example, TRIUMF is finalizing an arrangement with AAPS, Inc. and ACSI, Inc., to develop the world's highest-precision mass-separator magnet system. The device would be used at TRIUMF to separate isotopes online for use in research in science and medicine. The team believes that once demonstrated, the technology would be in demand by other laboratories around the world. A full business plan is under development and the AAPS Board will consider the investment decision at its summer meeting.

TRIUMF has been vigorously engaged in the cosmic-ray geotomography project led by AAPS, Inc. The technology uses advanced detectors inspired from particle physics to monitor the flux of cosmic rays received in mines to draw conclusions about the layers of rock and ore between the detector and the surface. TRIUMF's detector and electronics groups are performing technical contract work for the AAPS initiative to develop an initial suite of detectors that will be used by a spin-off company for the mining industry.

OUTLOOK

As TRIUMF's profile in the engineering and business community increases, more requests for technical assistance can be expected. Following guidelines about work-for-others will be important to keep TRIUMF focused on its primary deliverables while also encouraging the laboratory staff to share their knowledge, skills, and abilities with the private sector on a standard cost-recovery basis.



BUSINESS LINE: PROFESSIONAL TRAINING

With a mission that includes science and innovation alongside professional outreach and training, TRIUMF contributes to Canadian national objectives for attracting, retaining, and enhancing talent. TRIUMF hosts scientific conferences and organizes interactions between the scientific and business communities.

CORE CAPABILITY

TRIUMF has three assets to deploy in service of professional training.

1. Top talent.
2. Convening power.
3. Selected conference & event services.

In response to resource constraints and shifting priorities, TRIUMF has been adjusting its strategy for supporting the organization and execution of scientific conferences.

GLOBAL POSITION

Being asked to host and/or organize a scientific conference is both a privilege and a responsibility. It acknowledges the intellectual leadership of the host to design and convene a compelling cutting-edge conference program as well as the attractiveness and prestige of the host city to entertain and inspire the visiting delegates. TRIUMF is increasingly called upon to organize conferences on topics ranging from accelerator production of medical isotopes to the latest breakthroughs in particle physics revealed at CERN in Geneva, Switzerland.

In the broad area of professional training, TRIUMF continues to provide a unique environment that emphasizes research excellence and business relevance.

PERFORMANCE

The American Association for the Advancement of Science (AAAS) conference took place in Vancouver in February 2012, held outside of the U.S. for the first time in 30 years. TRIUMF played a critical role. TRIUMF's T.I. Meyer chaired the local organizing committee for Canadian participation and sat on the national steering committee. The result was a conference that not only attracted \$20,000 of investment from the Government of British Columbia in partnership with the BC Innovation Council to support the participation of 200 BC high-school students, but also a conference that set the AAAS world record for participation and engagement. As part of the conference events, His Excellency the Right Honourable David Johnston, Governor General of Canada, visited TRIUMF on February 16. Positive outcomes from TRIUMF's involvement ranged from new networking contacts at an international level to breakthroughs in media coverage and a new platform for working as "Team Canada" across the country. TRIUMF was directly involved in four different symposium sessions; one of TRIUMF's speakers (Lia Meringa) was recognized by the Globe & Mail as a "shining light for Canadian science among a galaxy of stars" at the conference.

In FY2011-2012, TRIUMF led the organization and hosting of nine prestigious scientific conferences. This activity level is lower than the previous year primarily because there were no international mega-conferences this year; the number of conferences and workshop is within standard fluctuations from year to year. For instance, TRIUMF is organizing the 350-delegate Physics at the LHC conference during the first week of June 2012.

To estimate the economic impact, TRIUMF uses the conservative multiplier of \$425.00 per day to calculate the economic impact of one conference visitor for one day. The following table lists the conferences hosted by TRIUMF, the number of person days spent at the conference and the net economic impact. The TRIUMF

| Conference Title | Location | Dates | Delegates | Person Days |
|---|-----------------------|----------------------|---------------------------|------------------|
| IAEA Conference on Production of Mo-99/Tc-99m | TRIUMF Vancouver, BC | Apr 16-20, 2011 | 16 | 80 |
| International Conference on Low Energy Antiproton Physics | Vancouver, BC | Apr 27 – May 1, 2011 | 93 | 465 |
| 12th Conference on Muon Spin Rotation | Cancun, Mexico | May 15-20, 2011 | 122 | 732/4 = 183* |
| Summer School on COULEX Techniques | TRIUMF Vancouver, BC | Jun 20-24, 2011 | 30 | 150 |
| ARIEL Science Workshop | TRIUMF, Vancouver, BC | Jul 6, 2011 | 35 | 35 |
| TRIUMF Summer Institute 2011 | TRIUMF, Vancouver, BC | Aug 8-19, 2011 | 42 | 504 |
| 20th High Energy Physics and Computing Conference (HEPiX) | Vancouver, BC | Oct 24-28, 2011 | 99 | 495 |
| 49th Winter Nuclear & Particle Physics Conference | Mount Tremblant, QC | Feb 23-26, 2012 | 57 | 228 |
| KEK/TRIUMF Slow Muons Workshop | Vancouver, BC | Mar 8-10, 2012 | 34 | 102 |
| SUB-TOTAL | | | | 2,242 |
| TOTAL | | | \$425 / person-day | \$952,850 |

* Because this conference was held outside of Canada but heavily involved Canadian vendors, 25% of the spending has been retained to reflect the Canadian proportion of goods and services sourced domestically.

multiplier is a conservative estimate of the contribution because it does not take into account the likelihood of a visitor to Vancouver or other host city spending extra days before and after the conference to visit the city and surrounding areas.

To address an emerging culture of technology and innovation, TRIUMF launched the first phase of its entrepreneurship@TRIUMF initiative. TRIUMF houses significant technical capabilities and expertise that might be the linchpin in a startup company's technology development program, and vice versa, individuals or ideas from TRIUMF might find great resonance in the larger technical and innovation community that intersects with the market outside of the laboratory. The entrepreneurship@TRIUMF program will be developed throughout the coming year to provide tailored training opportunities on topics ranging from IP protection and patenting to fundraising with venture capital to best practices for preparing business plans.

OUTLOOK

The professional-training line of business is expected to remain at roughly the same level.

Using its international reputation, TRIUMF is organizing an international training school in Vancouver for September 2012 on the FLUKA radiation modeling and simulation program. FLUKA is a fully integrated particle physics Monte Carlo simulation package. It has many applications in high energy experimental

physics and engineering, shielding, detector and telescope design, cosmic ray studies, dosimetry, medical physics and radio-biology. Research teams and engineers from across Canada are taking advantage of this opportunity to get trained in some of the best technology for understanding radiation transport.

In the next year, TRIUMF is organizing scientific conferences on early physics results from CERN's Large Hadron Collider in June 2012 and an autumn 2012 conference on radiohalogens for nuclear medicine. In the coming years, TRIUMF will be involved in conferences such as the annual SNM meeting (the premier nuclear medicine and molecular imaging conference in the world) in June 2013 with more than 10,000 delegates and the global IEEE conference on cyclotrons and their applications in autumn 2013. In one example of the forward planning required to make these events successful, TRIUMF was selected to host the International Particle Accelerators Conference for about 1,500 delegates to be held in the year 2018.

TRIUMF and AAPS, Inc. are organizing a formative workshop for July 2012, one that brings together the industry-liaison offices of all of TRIUMF's 17 member universities. The workshop will look at opportunities for synergy between TRIUMF's technical talent and resources and the on-campus efforts of each university as well as examining a common framework for managing the development of intellectual property that involves multiple academics.



BY THE NUMBERS

In fiscal year 2011-12, TRIUMF generated \$1.4 million in commercial revenues. These revenues were derived from Nordion royalty payments, Proton and Neutron Irradiation facilities (PIF & NIF), and other minor contract services.

TRIUMF's royalty income for the year was \$1.0 million and is derived substantially from eight Nordion products. Because of a recall of CardioGen-82 (a cardio PET imaging agent) in July 2011 associated with a downstream manufacturer, Nordion's demand for strontium isotopes declined precipitously. Hence, TRIUMF's royalty revenues from the production of strontium are significantly (\$0.5 million) smaller when compared to the prior year.

At the time of writing, TRIUMF has started production of strontium from one of its two production facilities but it is uncertain when a return to normal strontium production level will occur. Additionally, TRIUMF's solid target facility is being reworked to accommodate a higher-intensity and higher-energy beam that will yield additional strontium production and potentially higher royalty revenues when Nordion's demand for strontium resumes.

The PIF & NIF operations generated \$0.3 million in revenues this past year, a slight decline from the prior year. An extended shutdown in 2011-12 resulting in reduced availability of beam time and therefore

lowered revenues. TRIUMF continues to be oversubscribed in this area. PIF & NIF revenues are derived from the charge-out of the TRIUMF facilities and services to organizations engaged in industrial and technological applications of beams. There is no charge for researchers whose interest is publishable research of radiation effects. Both facilities are designed for simulating space radiation (PIF) and air- and ground-based (NIF) effects on electronic systems.

TRIUMF's commercial supply relationship with BCCA for the production of FDG completed near the end of fiscal year 2010-11. BCCA has purchased their own cyclotron and is producing their own FDG which is used for diagnosis and treatment of cancer patients. In the past, this activity generated about \$0.5 million per year of commercial revenues for TRIUMF.

TRIUMF is reviewing opportunities to derive new streams of commercial revenues and has entered into an agreement to produce silicon-32 (an isotope used in oceanography). In addition, there are on-going discussions with a BC-based firm to whom TRIUMF may supply fluorine-18, an isotope that is used for PET scans.

TRIUMF has started a review of its pricing and costing methodologies to better understand the financial impact of commercialization efforts. The results should provide better guidance for decisions regarding resource deployment.

TRIUMF's royalty income for the year was \$1.0 million and is derived substantially from eight Nordion products.

BY THE NUMBERS

| | Fiscal Year 2011-2012 | Fiscal Year 2010-2011 |
|-----------------------------------|--------------------------|--------------------------|
| Sponsored Canadian Conferences | \$952,850 | \$2,651,575 |

Dollar Value of Sponsored Research

| | | |
|-------------|--------------------|--------------------|
| NSERC, CIHR | \$6,316,503 | \$6,309,557 |
| NRCan | \$1,043,988 | \$700,238 |
| | \$7,360,491 | \$7,009,795 |

Value of TRIUMF Purchase Orders Issued in Canada

| | | |
|----------------|---------------------|---------------------|
| Inside Canada | \$37,237,768 | \$16,778,935 |
| Outside Canada | \$11,205,547 | \$9,130,270 |
| Total | \$48,443,315 | \$25,909,205 |

| | | |
|---------------------|--------------------|--------------------|
| Commercial Revenues | \$1,441,927 | \$2,628,668 |
|---------------------|--------------------|--------------------|

Collaborative Research

| | | |
|-------------------------|--------------------|--------------------|
| Affiliated Institutions | \$2,092,381 | \$1,753,856 |
|-------------------------|--------------------|--------------------|





OUTLOOK

As part of its current Five-Year Plan, TRIUMF seeks to double its commercial revenues; these results will be achieved through a combination of new business lines developed through AAPS, Inc.; strategic choices about sharing time and resources with the private sector to develop and commercialize technologies; and enhanced efficiency on existing business activities.

The firm commitment to business development by the laboratory and its Board is bold, to be sure, but it springs from an intention to fully return the value of public research to the public sector. Consider: It is a fact that scientific research receives more public support in terms of funding than arts and culture. Certainly scientific inquiry and our understanding of the broader universe in which we live have intrinsic cultural value (as evidenced by the number of people who flock to lectures on cosmology, particle physics,

or microbiology). But the prevalent model for public funding of basic research also recognizes:

- Scientific research drives benefits in multiple sectors and at multiple scales; and
- These benefits are of broad and shared value; and
- These benefits take “unusual” time and effort to develop or accrue

Thus, it is good public policy to support science with public funds so that the benefits and impacts are optimally generated for—and captured by—all of society. That is, the chief assertion is that research and development (or science and technology) drive innovation, economic growth, and societal progress by creating:

- New products and new jobs;
- Enhanced health and wellness;
- Increased standard of living; and
- The knowledge-based economy.

Governments and their constituent tax payers want to optimize these “returns” on the public investment into science. TRIUMF’s business strategy makes a chief assertion: that encouraging collaboration between science and industry will accelerate this process. The strength of TRIUMF, then, in forwarding these national objectives is in its ability to convene industrial partners to form long-standing networks and its capacity to provide ongoing value to the commercial sector.

The engine behind TRIUMF’s utility or value to the private sector is, of course, the basic research program. Without the drive for discovery, the talent for technology, TRIUMF would have nothing to add to the challenges and opportunities faced by Canadian industry.



ADVANCED APPLIED PHYSICS SOLUTIONS, INC.

Advanced Applied Physics Solutions (AAPS), Inc. is a federally funded Centre of Excellence for Commercialization and Research, launched in 2008 based on a proposal filed by TRIUMF. The vision for AAPS is:

To be a self-sustaining national and international leader in the successful commercialization of advanced physical-science research emanating from major laboratories across Canada for the benefit of society as a whole.

Leveraging its network of partners including governments, universities, national laboratories, and industry, AAPS fulfills the following mission:

- Identify research outcomes that can be moved rapidly to commercialization in partnership with the private sector to generate profitable income streams within a reasonable time-period;
- Develop and maintain a portfolio of activities that generate revenue sufficient to support operations and selected investments;
- Provide increased opportunities for science, technology, and engineering personnel to work at the R&D interface, helping train the entrepreneurs of tomorrow; and
- Serve as a strategic advisor and resource for innovation and commercialization activities to increase opportunities for Canadian companies in the areas of natural resources, health, environment, and information and communications technologies.

AAPS has developed a refined governance model, mission and vision statements to encompass the lessons learned in the first several years. Initially built on the foundation of the TRIUMF Technology Transfer Division, AAPS has become a standalone company with a strong, fully independent Board of Directors.

The AAPS Board of Directors is composed of primarily business and financial leaders. The AAPS governance model is successful and remains unchanged after nearly five years. The business experience of the Board has been crucial to not only running the company, but also to steering the process towards greater and greater business best practices. The connections of the Board continue to grow to include TRIUMF member universities and key entrepreneurs in the

high-tech physics sector. AAPS has now positioned itself as the lead commercialization resource in Canada for the accelerator-based sciences.

The AAPS business strategy has been honed on the anvil of experience during the last five years. The three commercial spaces in which AAPS is focussing its business development are natural resources (mining exploration), health & life sciences (medical isotopes and imaging radiation), and national security (detection of nuclear materials).

AAPS pursues three independent streams for potential projects: **(1)** IP from TRIUMF, its 17 member universities and its peer institutions across Canada including the Canadian Light Source and SNOLAB; **(2)** Local entrepreneurs bringing IP; **(3)** Building off established private-sector partnerships.

Responding to a recent announcement, AAPS is applying to the CECR program to seek additional program funds between 2013 and 2018 to become fully self-sufficient. As one of the initial cohort of federally supported CECRs in 2008, the five-year mandate for AAPS expires in April 2013.

From Research Excellence to...

TRIUMF

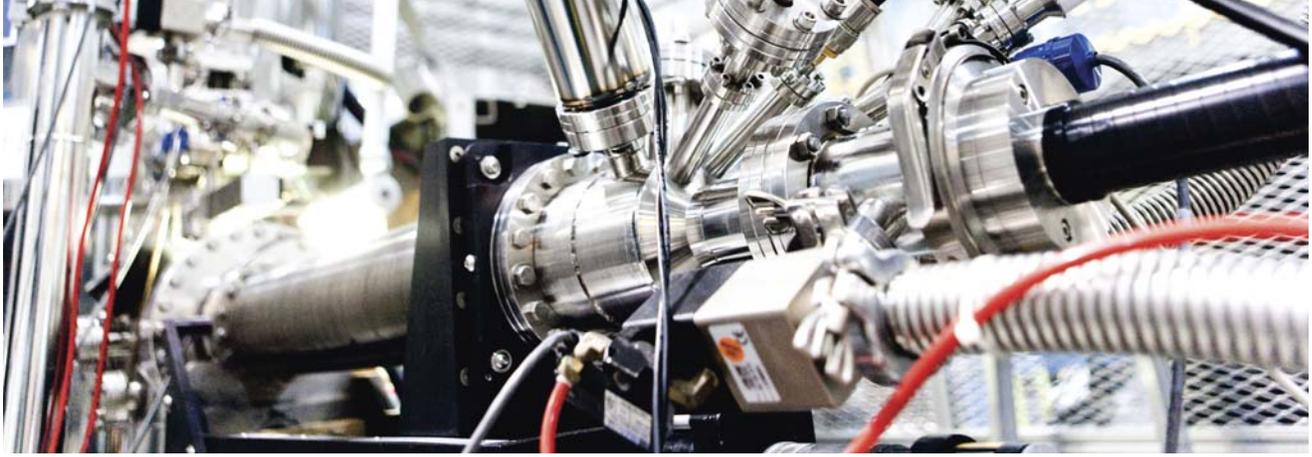
Imagines

AAPS

Delivers

...Business Relevance.

AAPS **ETPP** **TRIUMF**



ORGANIZATION AND GOVERNANCE

TRIUMF's business-development activities are guided by several entities. The Board of Management's Innovation and Industrial Partnerships Committee oversees all of TRIUMF's innovation activities and facilitates interactions with the industrial liaison offices of member universities. TRIUMF's Innovation and Industrial Partnerships Panel manages the week-to-week operations of TRIUMF's industrial partnership activities. Finally, the TRIUMF director receives strategic advice about commercialization and market development through a Private Sector Advisory Committee.

University Consortium

Full Members: University of Alberta, University of British Columbia, Carleton University, University of Guelph, University of Manitoba, Université de Montréal, Simon Fraser University, Queen's University, University of Toronto, University of Victoria, and York University

Associate Members: University of Calgary, McMaster University, University of Northern British Columbia, University of Regina, Saint Mary's University, and University of Winnipeg

BOM Innovation and Industrial Partnerships Committee

Steven Liss (Chair), Vice-Principal (Research), Queen's University

Ewart Blackmore, Senior Research Scientist, TRIUMF

Don Brooks, Professor of Chemistry and Director, Support Programs to Advance Research Capacity, UBC

Jim Hanlon, Head of Human Resources and Administration, TRIUMF

Digvir Jayas, Vice-President (Research & International), University of Manitoba

Neil McLean, President and CEO, AAPS, Inc.

Edward Odishaw, Chair of the Board, AAPS, Inc.

TRIUMF Innovation and Industrial Partnerships Panel

Jim Hanlon (Chair)

Ewart Blackmore

Yuri Bylinsky

Henry Chen

Nigel Lockyer

Neil McLean (AAPS, Inc.)

Tim Meyer

Jozef Orzechowski

Michael Trinczek

Private-Sector Advisory Committee

Jack Scott, Senior Vice President, Allana Potash Corp.

Henri Buijs, Senior Scientist, ABB Bomem

Alan Pelman, retired Vice President, Technology, Weyerhaeuser Canada, Ltd.

Dan Gelbart, co-founder and former president, Creo Products, Inc.

Pierre Coulombe, Chef de Projet, Centre de Recherche Industrielle de Québec

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- Government of British Columbia
- Government of Canada
- 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
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

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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