

CANADA'S NATIONAL LABORATORY  
FOR PARTICLE AND NUCLEAR PHYSICS

BUSINESS DEVELOPMENT  
REPORT 2012 – 2013

# TEAM UP

ACCELERATING SCIENCE  
FOR CANADA





# TEAM UP

The public at large, via taxes and support for the government, invests in scientific research. Around the world, the level of public investment in science continuously exceeds that of the arts and traditional cultural expression. The implicit assertion is that science generates an additional stream of benefits that merit these additional resources beyond the intrinsic cultural and aesthetic appreciation of knowledge. Traditionally, we associate this additional level of impact with the societal and economic growth that arises from the practice of science: both in terms of trained and motivated personnel and short- and long-term economic impact.



**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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There is a creative tension between the desire to build on existing success and the desire to improve the “weakest” links. This tension is healthy and facilitates a dynamic balance that nourishes an entire system. It’s no different in the realm of innovation and industrial partnerships.

Consider the July 2012 report of the Council of Canadian Academies entitled, *The State of Science and Technology in Canada*. This report is the second landmark assessment on this topic by the Council and updates and expands on their 2006 findings. The Council found that, as a country, Canada is among the world leaders in six research fields including physics and astronomy. Perhaps more importantly, the Council found that this pattern of excellence was driven by nine sub-fields where Canada leads the world in science impact (as measured by bibliometrics); the research area of particle and nuclear physics was on this list and Canada’s trio of high-performing subatomic-physics institutes (TRIUMF, SNOLAB, and the Perimeter Institute for Theoretical Physics) were recognized as key contributors (as reported by international surveys).

As a member of TRIUMF’s Board of Management, I was not surprised by these findings: a day at TRIUMF will convince most anyone that Canada is among the world leaders in subatomic physics, be it developing new isotopes for medicine or helping to discover the Higgs boson.

But these findings also point to an opportunity to address one of Canada’s long-standing challenges. Canada must continue to focus attention on fundamental research and research excellence and particularly leverage areas of research strength to address the growing “innovation gap” — the perception that the country is missing out on creating societal and economic growth from basic research, undermining Canada’s competitiveness in the global knowledge

economy. So the question at hand is how to connect Canadian research excellence to business relevance.

TRIUMF has considered this issue at some length and as Jim Hanlon explains, the Board has approved a number of structural changes at the laboratory to seize the opportunity. One of the crucial developments is the recognition that Advanced Applied Physics Solutions (AAPS), Inc. should focus on this gap: capitalizing on TRIUMF’s research strengths in particle and nuclear physics to drive innovation and industrial partnerships that fuel the Canadian economy. This strategy allows the laboratory and AAPS to each focus on their strengths while providing a common framework with overarching objectives.

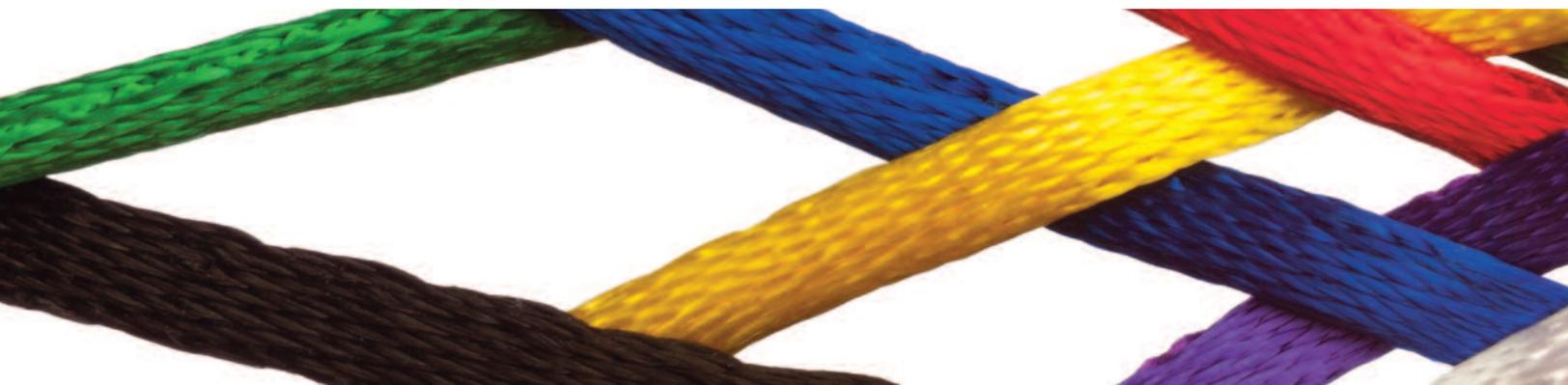
One outcome of this strategic focus for AAPS is a modified leadership team. With the support of the TRIUMF Board of Management and the approval of the AAPS Board of Directors, I am pleased to say that Jim has been named as the President and CEO of AAPS, Inc., providing a common, direct link between the commercial activities and research programs in the larger TRIUMF enterprise.

As we move through this transition and seize new opportunities for innovation and industrial partnership, I trust you’ll agree that TRIUMF and AAPS are well-positioned to assist Canada in realizing its innovation agenda.

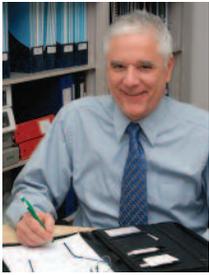
Sincerely,

A handwritten signature in blue ink, appearing to read 'S. Liss', written over a white background.

**Steven N. Liss** | Chair, TRIUMF Board of Management Innovation and Industrial Partnerships Committee | Director, Board of Advanced Applied Physics Solutions, Inc. | Vice-Principal (Research), Queens University



## MESSAGE FROM THE HEAD OF TRIUMF'S BUSINESS AND ADMINISTRATION DIVISION



The 2012-2013 fiscal year has been pivotal for TRIUMF not only in terms of reaching the midpoint of its five-year strategic plan but also in terms of renewing the foundation upon which the lab's business-development activities are built.

One might first ask why TRIUMF pursues business development or even ask what we mean by this term. As a publicly-funded laboratory and as community, TRIUMF affirms that the pursuit of basic research generates a triple impact for the country: advancing knowledge (e.g., scientific discoveries), creating leaders (e.g., training and inspiring students), and driving societal and economic growth (e.g., industrial partnerships and commercialization). Our business-development activities support and enhance this third element of overall value.

**So what has changed this year?** TRIUMF has made some internal adjustments to support a more flexible and responsive approach.

Under the guidance of TRIUMF's director Nigel S. Lockyer and the support of the TRIUMF Board of Management, the laboratory's internal organization was restructured in mid-2012 to create the Business and Administration Division. This change fulfilled on two goals: **(1)** To pool administrative talents and resources across the organization and move the day-to-day management off the desk of the TRIUMF director, and more importantly, **(2)** To combine and enhance TRIUMF's focus on innovation and industrial partnerships. The different revenue-generating activities at TRIUMF are now housed under a common roof and these activities have a combined voice at the senior-executive table on both a tactical and strategic basis.

The second substantive adjustment involves decisions about the future of AAPS, Inc. and a commitment to enhanced synergy with TRIUMF's core programs.

Whereas we might have said last year that there was a firewall between the two organizations, there is now simply a soft veil. One driver of this change was the completion of an invited proposal in autumn 2012 to the Government of Canada's Centres of Excellence for Commercialization and Research (CECR) program to compete for new public funds to support new activities at AAPS. With a portion of the original 2008 investment still in the bank, the selection committee judged that AAPS was likely able to achieve self-sufficiency with its current program of work and without new funds. AAPS was awarded an extension to its original performance period and we now expect that the organization will become sustainable and transition out of the CECR program in fiscal year 2015-2016. These outcomes provided an opportunity to re-examine the relationship between TRIUMF and AAPS. While the two organizations still manage independent and separate resources, there is a clear understanding that new revenue-generating ventures will be steered through AAPS to leverage TRIUMF's capabilities and capture the best value for Canada. This report's feature article outlines the new framework.

These adjustments combined with a set of new opportunities across the board give me renewed confidence that TRIUMF will enjoy a new level of success in business development within the next few years.

Sincerely,

**Jim Hanton** | Head, Business and Administration,  
TRIUMF | President and CEO, AAPS Inc





## FEATURE:

# A STRATEGIC APPROACH TO INNOVATION & INDUSTRIAL PARTNERSHIPS

The third element of TRIUMF's mission highlights the opportunity "To transfer knowledge... and commercialize research for the economic, social, environmental, and health benefit of all Canadians." The vision for TRIUMF echoes this objective with the aspiration of the laboratory to "create societal and economic growth" for Canada. These expectations are in line with what the Canadian taxpayer expects from investments in basic research, namely: discoveries that advance human knowledge, training experiences that create tomorrow's leaders, and technologies that drive societal and economic growth.

Over the past few years, TRIUMF has revised its strategy for realizing this basic value proposition.

## VALUE PROPOSITION

To date, there is no full understanding of the mechanism by which science is correlated with societal and economic progress outcomes. The **fundamental value proposition** is therefore an assertion: basic research fuels innovation and progress (a) by producing breakthroughs that directly create new technological capabilities or (b) by inspiring and motivating the "stretch" of existing technologies' performance limits and constraints.

For instance, in the first category, the discovery of radioactive isotopes that decay by the emission of alpha particles has led to the development of "targeted alpha therapies" where these isotopes are injected into patients to directly manage the course of disease. In contrast, an example in the second category would be TRIUMF's development of a more sophisticated scintillation counter and electronic-readout system for particle physics that now has applications to natural-resource exploration using cosmic-ray muons.

## TRIUMF'S RELATIVE POSITION

TRIUMF is intrinsically engaged and well suited to deliver on this value proposition for three reasons. **(1)** The laboratory has a skilled workforce and uncommon infrastructure that give it a unique perspective. **(2)** Some research topics at TRIUMF

can lead directly to inventions with broader relevance (e.g., functionalized materials with carefully controlled magnetic properties) and other research efforts seek to overcome technical challenges that drive broader innovations (e.g., enhancements in particle-detection efficiency for a precision physics experiment could be applied to security-screening applications by using low-level background radiation sources such as cosmic rays). **(3)** TRIUMF regularly works closely with businesses in its supply chain to enhance and improve product performance and capability

## Unique Resources

TRIUMF has developed a significant portfolio of specialized equipment and expertise through its cutting-edge research in particle physics, nuclear physics, nuclear medicine, materials science, and accelerator physics and through its interactions with Canadian universities and international researchers. The knowledge, skills, and abilities and the facilities and infrastructure at TRIUMF are uncommon in the private sector. These assets give TRIUMF a distinct, creative perspective on technology challenges and opportunities. As shown on the last pages of this report, TRIUMF also has a large network of intentional partnerships, each governed by a specific written agreement with terms and conditions. Partners such as CERN or Fermilab provide technical depth and expertise, and partners such as Nordion, Inc. or General Electric, Inc. provide market expertise and business experience.

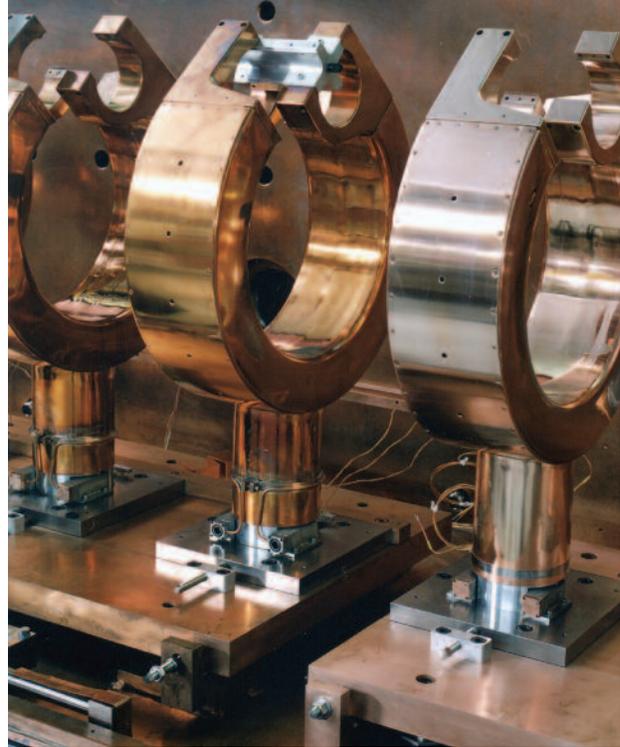
## Innovation and Invention-Relevant Research Topics

Occasionally, a scientific discovery leads directly to a new invention such as the novel control of a material's electrical properties via magnetic fields known as giant magnetoresistance (awarded the 2007 Nobel Prize in Physics) that led to breakthroughs in hard-disk drive size and performance. TRIUMF's research with isotopes for medicine and functionalized materials are candidate areas where inspiration might lead directly to invention.

As an experimental-physics laboratory, TRIUMF wrestles with technical hurdles and solutions in its everyday work. Advances in basic research are almost always driven by developments in sensitivity, efficiency, speed, or some other performance characteristic of a basic system (typically sensors, electronics, computing, chemistries, or the like). That is, subatomic physics is usually seeking to "get closer" to a natural phenomenon and thereby better understand its workings. Basic research in subatomic physics, therefore, usually seeks a level of device performance that is not yet commercially available.

## Upstream Engagement

Wherever possible and appropriate, TRIUMF seeks to obtain competitively priced goods and services from Canadian-based suppliers, providing the foundation for "upstream engagement" opportunities. TRIUMF has a track record for working with external partners (often in the private sector) to develop and deliver systems with performance enhancements. The laboratory may be involved in a technical consulting role to assist an external partner with a challenge they encounter in produce development or qualification (e.g., providing simulation and modelling of irradiation effects in materials for Cisco Systems, Inc.). TRIUMF may also partner with a business to directly explore and develop potential products (e.g., TRIUMF and Nordion co-funded a nuclear-medicine chemistry laboratory with support from NSERC to explore chelate chemistries for application in novel metal-based radiotracers and radiopharmaceuticals). Finally, TRIUMF may also directly engage an industrial supplier to transfer technology and develop a product that is needed for the laboratory's research program (e.g., TRIUMF worked with electron-beam welding company PAVAC, Inc. to nurture private-sector-based manufacturing of superconducting radio-frequency



accelerator cavities needed for the ISAC-II isotope accelerator; PAVAC now has a product line based on this technology that has been successfully marketed to customers in the U.S., China, Korea, and India).

## A NEW PARTNER AND A JOINT STRATEGY

In academic arenas, TRIUMF freely shares its know-how in collaborations intended for mutual benefit, as time and energy allow. In some cases, this expertise has potential relevance to industry or even has commercial value and should be shared in a more structured fashion. The challenge is to discriminate wisely between academic relevance and business relevance while maintaining integrity, using public funds responsibly, and encouraging Canadian success. On the one hand, the laboratory cannot operate "keeping everything to itself" and be effective at sharing ideas, inventions, and innovations, and on the other hand, it cannot respond to every opportunity.

Given these observations, TRIUMF's role as a basic-research laboratory, and the increasing emphasis on innovation and industrial partnerships, it is clear that TRIUMF needed an interface partner. Scientists, technicians, and engineers are not best suited to business management, product development, or market analysis. They have valuable input, of course, but it is unrealistic to expect the laboratory to unilaterally take all good ideas to market on its own. Furthermore, the responsible use of public funds by TRIUMF for its programs requires the laboratory to largely limit its "contract research" or "work for others"

activities to those that directly advance its mission. In other terms, the TRIUMF Board of Management has indicated that resources expended on commercialization efforts should not exceed about 10% of the laboratory's overall resources; crossing this threshold would signal a shift in the character, purpose, or effectiveness of the laboratory in carrying out its mission. The Board of Management has constituted an Innovation and Industrial Partnerships Committee to oversee and guide these activities at the laboratory.

TRIUMF seized an opportunity in 2007-2008 to address this gap. With founding support from Networks of Centres of Excellence Canada through the Centres of Excellence for Commercialization and Research program in 2008, TRIUMF launched a wholly-owned, stand-alone, non-profit company dedicated to advancing the Canadian economic impact of TRIUMF's research, technologies, and partnerships: Advanced Applied Physics Solutions, Inc. (AAPS). Under the TRIUMF umbrella and with a clear product-development and commercialization mission, AAPS substantially expands TRIUMF's options and opportunities for innovation and industrial partnership.

The diagram here illustrates how TRIUMF and AAPS work together seamlessly for technology transfer, product development, and commercialization with the private sector. In a simplified model, TRIUMF and/or its research partners develop generalized technologies in support of the basic-science mission. Through conversations guided by a business-development management team at TRIUMF working with AAPS and the marketplace, some of these technologies are identified as "platforms" (i.e., Technology Readiness Level (TRL) 1-4 or sometimes 5). AAPS then identifies specific opportunities in the market where the platform can be applied to develop a specific product that addresses a tangible market need. AAPS stewards the product-development process (i.e., TRL 5-8) by recruiting industrial partners to join forces and provide expertise, market-specific experience, and resources. At the commercialization step (i.e., TRL 9), the outcome of these efforts would normally be a spin-off venture that takes the product to market.

TRIUMF has an exclusive and inclusive relationship with AAPS for all of its interactions with the private sector. AAPS is consistently involved, consulted,

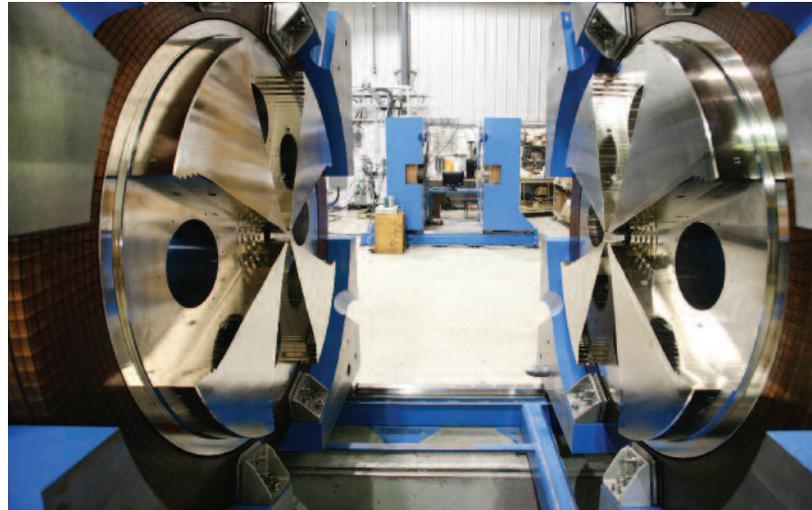
**Under the TRIUMF umbrella, AAPS substantially expands TRIUMF's options and opportunities for innovation and industrial partnership.**



and available for these interactions. In the larger picture, AAPS manages industry access to — and compensation for — TRIUMF technology and know-how for new products or commercial activities.. Moreover, TRIUMF’s partners are encouraged to consider AAPS as a partner or vehicle for fulfilling their industrial-partnership or commercialization objectives, especially when the opportunities are related to TRIUMF.

In return, AAPS provides needed value to TRIUMF by:

- Accumulating talent, expertise, and relationships (relevant to industry & commercialization) that support commercialization as a core competency;
- Making in-kind hardware or labour contributions to projects that provide value to TRIUMF’s research activities (e.g., HRS magnet for CANREB, project management for the liquid-helium recycling project);
- Making cash contributions to TRIUMF’s commercial-revenue stream (the inaugural transfer is expected when AAPS graduates from the CECR program to full self-sufficiency); and
- Shielding members of the TRIUMF joint venture from the potential risks and liabilities of commercialization.

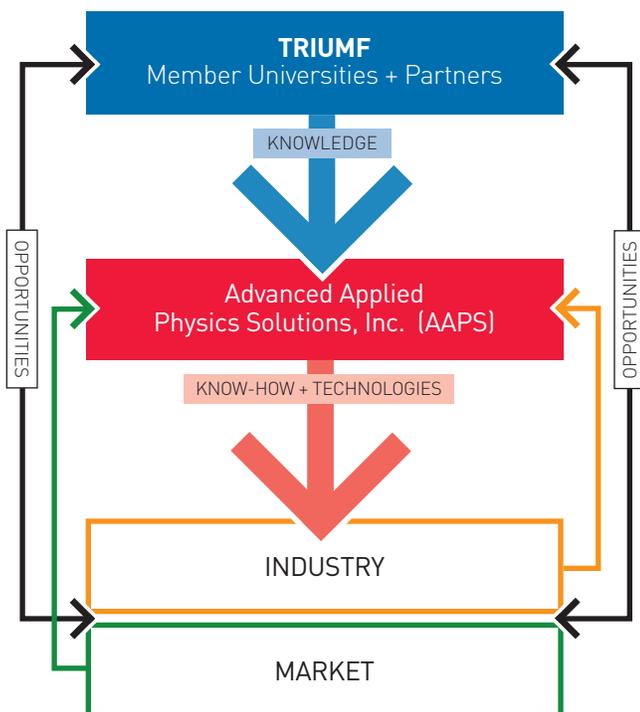


## OUTLOOK

Although the partnership between TRIUMF and AAPS began in 2008, it has taken time to fully define and mature the relationship. At the five-year anniversary in spring 2013, an evolution in governance reflects the bright future. TRIUMF’s Head of Business and Administration is serving as the President and CEO of AAPS to ensure alignment and transparency between both organizations while maintaining a healthy distinction between objectives. The AAPS Board of Directors is becoming more closely connected with the TRIUMF Board of Management with joint appointments and the expectation of a combination of the AAPS Board with the TRIUMF Board’s Committee on Innovation and Industrial Partnerships.

TRIUMF’s four existing business-development areas will continue and help provide the platform for subsequent success. New opportunities in each area will be driven by engagements via AAPS with new management structures emerging as they become.

In summary, TRIUMF is committed to creating societal and economic growth for Canada as part of its mission. Progress in science is unequivocally linked to progress in quality of life and standards of living. TRIUMF has adopted a set of strategies that identify, develop, and exploit these opportunities. The creation of AAPS, Inc. as a stand-alone vehicle specializing in the commercialization route is a critical new tool for TRIUMF and will substantially enhance the laboratory’s contributions in the long term.





## BUSINESS LINE: **IRRADIATION SERVICES**

For decades, research scientists and engineers have been seeking to understand how to mitigate errors caused in electronic devices by naturally-occurring ionizing radiation. Such radiation can lead to a degradation of expected performance, the loss of information or control, and even the failure or destruction of an electronic device.

TRIUMF has several beam lines that provide low-intensity, energetic proton and neutron beams to simulate natural-radiation exposures either in 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 so that accelerated testing for errors in electronics can be carried out. Since 1995, TRIUMF has become recognized as a premier test site for space-radiation effects using protons and neutrons.

### **CORE CAPABILITY**

TRIUMF's Proton Irradiation Facility and Neutron Irradiation Facility, also known as PIF & 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 unique for both its broad range of energy and intensity. Intense neutron irradiations can be done at the TRIUMF Neutron Facility location at the end of BL1A, where neutrons yield 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. As well, irradiations of microelectronics are conducted using electrons from M11 and, more recently, muons from M20.

### **GLOBAL POSITION**

PIF & NIF offers a competitive option for computing, networking, and aerospace companies seeking irradiation testing for equipment. TRIUMF is ideally situated 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 neutron facility, 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. During its operating period, TRIUMF runs "24/7" allowing larger testing companies to efficiently test devices in bulk around the clock; many customers comment on the level of service and the service facilities that TRIUMF has available.

The importance of BL1B 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 many customers come to TRIUMF because of this facility. Over the past few years, many PIF & NIF customers have requested more and regular access to our high-energy facility BL1B because, while the peak of the energy distribution of protons in space is at roughly 100 MeV, the distribution does extend as high as 500 MeV. Current alternatives to TRIUMF's facilities include Los Alamos in the U.S. for neutron tests and TSL in Sweden for protons and neutrons.

### **PERFORMANCE**

Companies pay TRIUMF for the right of access to beam and technical staff time and leave with enhanced understanding of their products, or even with certification of their products to operate in a radiation environment. The past fiscal year was on track with expectations, bringing in some \$0.4 million of revenue. Forty-three companies from Canada, US and Europe made commercial use of the irradiation facilities,

including several new customers along with the core group of repeat users. Cisco Systems remained the 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.

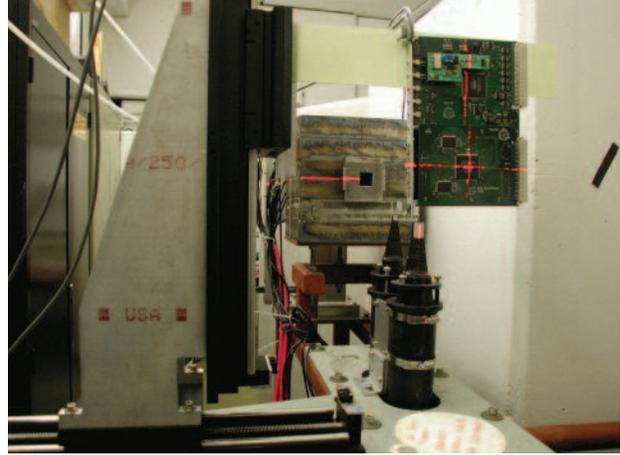
In addition to commercial uses, fundamental research is also performed using PIF & NIF. Regular visiting researchers from several different institutes, laboratories, and universities make use of the facilities and services offered at TRIUMF. In total 240 hours of beam time, awarded by the TRIUMF Experiment Evaluation Committee, was used for research in this fiscal year. The data collected are used in student theses, presented at international conferences, and are published in peer-reviewed journals and much of the research has won awards from the community both at the student and professional level.

## OUTLOOK AND UPGRADES

TRIUMF's reputation for 8-9 months per year of reliable beam delivery remains a strong selling point to our customers and we advocate for activities that maintain this reliability. In 2012, a partnership was arranged by AAPS Inc. between TRIUMF and Cisco Systems, Inc. to explore the feasibility of upgrading the BL1B facility to provide a higher intensity of neutrons and to have this beam line available for commercial testing several times a year. TRIUMF management agreed to proceed, and the upgrade began in 2012 with Cisco Systems investing \$150,000.

Development continues using the Monte Carlo simulation package FLUKA to model the different beam lines to help guide any upgrades and allows for the training of students as HQPs. A successful student project was used to create a model of the low-energy BL2C facility that was then enhanced in 2012 to design a double-scattering system. From the FLUKA modeling, this new device was able to be quickly built and implemented and allows a larger, homogenous area of electronics or materials to be irradiated at a higher rate. It has increased PIF & NIF capabilities and has already been used by several commercial customers.

The collaboration with both academic and industry partners to perform the irradiation testing of electronic components with muons in 2012 was successful and we plan to offer commercial testing with muons to

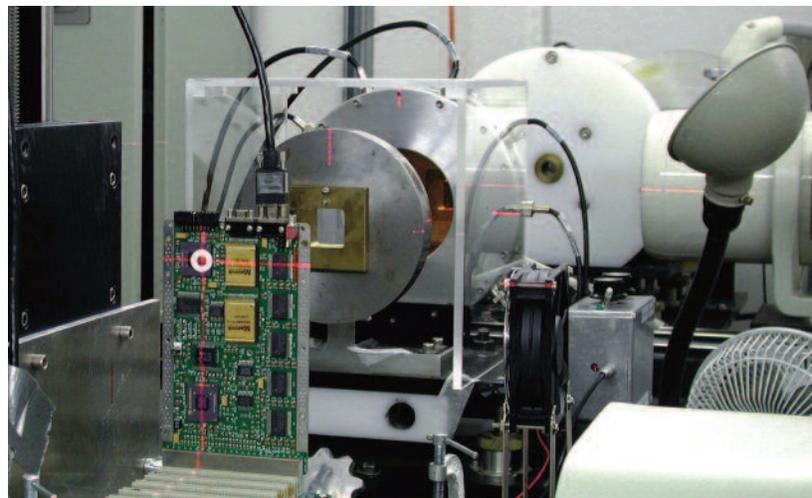


industry in 2013. In addition, TRIUMF may collaborate further with these partners to help better understand the low-energy terrestrial muon spectrum and their relevant effects to upcoming electronics as the radiation-effects community has become increasingly concerned with this potential threat.

With the high reliability of equipment becoming ever more important, this work will have relevance to the design of data servers, medical equipment, and aerospace technology. All of this research, enabled by PIF & NIF at TRIUMF, is allowing scientists and engineers to solve existing and minimize future problems, benefitting society with the training of highly qualified personnel and by developing more reliable, better performing, more efficient and cleaner products.

## PIF & NIF Commercial Use

	Number of Companies	Beam time
2008	42 companies	737 hours
2009	39 companies	610 hours
2010	39 companies	711 hours
2011	36 companies	589 hours
2012	43 companies	667 hours





## 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 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 now serves as a secondary, back-up supplier of fluorine medical isotopes to the BC Cancer Agency.

A year after TRIUMF's announcement of successful production of the workhorse technetium-99m on two different makes of cyclotrons in two Canadian provinces, the Government of Canada announced a new \$7 million investment in TRIUMF's team via the Isotope Technology Acceleration Program (ITAP) of Natural Resources Canada. The objective of this next phase of work is to demonstrate regular commercial-scale production and to further enhance deployment of the core technology across Canada. The TRIUMF team includes partners at the BC Cancer Agency, Lawson Health Research Institute, and the Centre for Probe Development and Commercialization. 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. Greater than 78% recovery efficiency of <sup>99m</sup>Tc-pertechnetate was achieved and 3 types of "kits" (Sestamibi, HMPAO, MDP) were

**TRIUMF has a network of biological and medical partners that pioneer the application of radiotracers for understanding disease and developing new treatment approaches.**

radiolabeled successfully and all passed standard quality controls. The final step of the proposed cycle, recovery and recycling of the molybdenum-100 target material, was demonstrated with greater than 85% yield.

With guidance and support from the international trade counselors of British Columbia and the Government of Canada, TRIUMF continued discussions in the Delhi region of India about piloting a domestic isotope-production facility using Canadian technologies. A partner hospital expressed interest in the proposed combined mission of research and business. At present, however, market conditions are being driven by price wars on other conventional isotopes straining the business case. A lack of startup capital also limits the opportunity.

TRIUMF operates Canada's two oldest medical cyclotrons. The TR13 device and its supporting infrastructure are aging and productivity this fiscal year was hampered by several component failures and unplanned maintenance issues. However, the team of experts worked quickly and deliverables to external partners were maintained as much as possible.

With a team including the BC Cancer Agency and a private company, TRIUMF is developing so-called "salty target" technology with support from the Canadian Institutes for Health Research. This technology, when mature, could allow the production of radio-isotopes by irradiating metals in solution to mimic the irradiation of solid materials. In another effort, the TRIUMF nuclear-medicine team is partnering with experts in the Accelerator Division to pioneer the path for producing therapeutic isotopes at ISAC using the main cyclotron and ISAC infrastructure. This effort is exploratory and could lead to the supply to At-211 or Ac-225 isotopes for clinical development as targeted-alpha therapies.

A collaboration with the BC Cancer Agency and GE has yielded breakthrough results: TRIUMF's most recent development of a specific-purpose radiotracer, this one to be used for labeling oxidative stress in cells, specifically helpful for certain types of breast-cancer tumours.

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; irregularities in usage and shelf life caused the manufacturer to cease production for a period. As a result, the demand for strontium from TRIUMF dramatically decreased for about a year. The issue appears to have been resolved and the demand for TRIUMF's Sr-82 material is returning.

## OUTLOOK

TRIUMF will be working with AAPS to identify the most appropriate strategy for monetizing the cyclotron-based Tc-99m technology. TRIUMF will continue to develop isotopes and radio-tracers for preclinical research; a new underground transport line will connect TRIUMF facilities with the Centre for Comparative Medicine at UBC and its new imaging suite that includes a novel tri-modal scanner.





## BUSINESS LINE: **TECHNICAL CONSULTING**

TRIUMF's capabilities in physics, engineering, and design are often tapped in the form of short-term technical consulting arrangements. TRIUMF staff might contribute to troubleshooting a private company's product line or provide advice in developing needed high-tech infrastructure. TRIUMF's contributions to the success of AAPS, Inc. initiatives fall into this category.

### **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 technical competency is not globally unique, but the concentration of accelerator expertise adjacent to isotope production embedded in an environment where university collaboration and industrial consulting are equally encouraged is rare.

With the emergence of AAPS, Inc. as a broker for private-sector access to TRIUMF expertise, the laboratory is expecting more involvement with interested, needs-focused industrial clients.

### **PERFORMANCE**

TRIUMF participated in some technical consulting with a Vancouver-based startup company on cryogenic technologies for dealing with liquefied and high-pressure natural gas in high-performance engines. Elsewhere, TRIUMF is opening discussions with a local quantum-computing company to determine whether its cryogenic expertise is appropriate for aspects of the technology implementation they are addressing.

Through AAPS, Inc. TRIUMF has also provided consulting services for cyclotron-based isotope production to B.C.-based Advanced Cyclotron Systems, Inc. (ACSI), to assist in installation and commissioning of several ACSI machines in Taiwan and Japan.

### **OUTLOOK**

As AAPS, Inc. becomes a broker in industrial access to TRIUMF's know-how and expertise, this business line is expected to grow and become more targeted.

**The concentration of accelerator expertise adjacent to isotope production embedded in an environment where university collaboration and industrial consulting are equally encouraged is rare.**



## BUSINESS LINE: **PROFESSIONAL TRAINING**

As a national locus for effort, TRIUMF continues to be in demand as an organizer and host to prestigious scientific conferences and training opportunities related to advancing isotopes for science and medicine and probing the structure and origins of matter.

### **CORE CAPABILITY**

Experts appreciate regular interactions with other experts to stay abreast of new development, forge new collaborations, and challenge existing conceptions about the field. Through its fundamental research programs, TRIUMF has experts in nuclear physics, particle physics, nuclear medicine, materials science, and accelerator physics. The calibre of these individuals adds to the reputation of TRIUMF and leads to the hosting of national and international workshops. Not only does this lead to opportunities for training and sharing, but it also has a positive impact on the Vancouver tourism economy by attracting conference delegates to the region on a short-term visiting basis.

### **GLOBAL POSITION**

Although TRIUMF is one of the smaller world laboratories in subatomic physics, its accomplishments speak for itself.

### **PERFORMANCE**

In FY2012-2013, TRIUMF was confirmed as the host of the International Particle Accelerators Conference 2018 (IPAC 2018), an international honour that will bring 1,500+ delegates to Vancouver in a few years to discuss trends in accelerator physics and trends in new machine design.

TRIUMF hosted the February 2013 meeting of the International Committee on Future Accelerators (ICFA) that included the leaders of two dozen international particle-physics laboratories including the U.S., Europe, China, Japan, India, and Korea. This special

occasion was marked by an international press conference announcing global plans for collaborative development of the next high-energy particle accelerator to study the recently discovered Higgs boson.

The laboratory also caused some extra-national professional training. In cooperation with the Council of Canadian Academies and the Department of Foreign Affairs and International Trade Canada, TRIUMF organized a special symposium at the annual meeting of the American Association for the Advancement of Science (AAAS) in Boston on February 15, 2013, to share stories of Canadian excellence with impact with about 150 delegates. The session featured Dr. Elliott Philipson, former president of the Canada Foundation for Innovation, Dr. Chad Gaffield, president of the Social Sciences and Humanities Research Council, and Dr. T.I. Meyer, Head of Strategic Planning and Communication at TRIUMF.

In July 2012, AAPS, Inc. hosted its inaugural Innovation and Industrial Partnerships Workshop (IIPW) with TRIUMF member universities. A dozen different organizations participated in the two-day event and discussed their approaches to innovation and the common fabric of industrial partnerships.

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

### **OUTLOOK**

The conferences agenda for FY2012-2013 notably features the IEEE Conference on Cyclotrons and their Applications and the future holds the prestigious IPAC 2018 conference in Vancouver. Although the TRIUMF conference-organization staff has been reduced in force to accommodate budget restrictions, the demand for TRIUMF to be involved will not let up.



## BY THE NUMBERS

The following table describes the financial activity at TRIUMF over the past two fiscal years.

		Fiscal Year 2012-2013		Fiscal Year 2011-2012
Sponsored Canadian Conferences	\$	<b>1,788,000</b>	\$	<b>952,850</b>
Dollar Value of Sponsored Research				
NSERC, CIHR	\$	6,578,602	\$	6,316,503
NRCan	\$	853,827	\$	1,043,988
	\$	<b>7,432,429</b>	\$	<b>7,360,491</b>
Value of TRIUMF Purchase Orders Issued in Canada				
Inside Canada	\$	30,547,277	\$	19,423,787
Outside Canada	\$	7,902,540	\$	6,193,450
<b>Total</b>	\$	<b>38,449,817</b>	\$	<b>25,617,237</b>
Commercial Revenues	\$	<b>1,127,465</b>	\$	<b>1,441,927</b>
Collaborative Research				
Affiliated Institutions	\$	<b>2,614,920</b>	\$	<b>2,092,381</b>

## CONFERENCES BETWEEN APRIL 2012 TO MARCH 2013

Conference Title	Location	Dates	Delegates	Person Days
Intersection of Particle and Nuclear Physics	St. Petersburg, Florida	May 29 - Jun 3, 2012	485	2,910*
Physics in LHC	Vancouver, BC	Jun 4-10, 2012	195	1,365
IIPW	Vancouver, BC	Jul 16-17, 2012	18	36
Q_weak Collaboration Meeting	TRIUMF, Vancouver, BC	Aug 1-3, 2012	50	150
TRIUMF Summer Institute	TRIUMF, Vancouver, BC	Aug 6-17, 2012	40	480
International Symposium on Radiohalogens	Whistler, BC	Sep 15-19, 2012	75	375
FLUKA Course and Workshop	Vancouver, BC	Sept 15-20, 2012	40	240
Winter Nuclear and Particle Physics Conference	Banff, AB	Feb 15-17, 2013	73	219
SUBTOTAL				5,775
<b>TOTAL</b>				<b>(\$425/person-day) \$1,788,000</b>

\* 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.



## OUTLOOK

At end of FY2012-2013, AAPS has continued to maintain strong relationships with 23 partners this year and initiated new relationships. NDAs were signed with 6 companies to facilitate discussions on potential collaborations. Six MOU / Collaboration agreements were signed, 3 of which generate revenue.

### **IKOMED TECHNOLOGIES, INC.**

IKOMED Technologies, Inc. was launched as a start-up company in 2010, using a loan from AAPS, Inc., and floor space in the AAPS wing of TRIUMF's main building. Following successful demonstration of IKOMED's patented technology with commercial fluoroscopy imaging equipment, the start-up finalized its second round of financing with several million dollars of new investment. Led by a group of Canadian private investors, this round will enable IKOMED to expand its product offering and build manufacturing capability for its X-ray radiation reduction system.

IKOMED has recently signed a terms sheet with GE Healthcare and will become a preferred provider of their proprietary dose-reducing shutter systems that integrate with existing fluoroscopy machines as well as new ones. Discussions with other fluoroscopy-system manufacturers are in progress.

### **CRM GEOTOMOGRAPHY TECHNOLOGIES, INC.**

In 2013, AAPS spun off a wholly owned for-profit company to commercialize intellectual property developed at AAPS with a TRIUMF/UBC inventor. The technology uses cosmic-ray muons, particle detectors underground, and proprietary electronics and software to deduce what ore bodies lie underground between the surface and the detectors. CRM is expected to be transferred to a third party for remuneration.

### **ADVANCED CYCLOTRON SYSTEMS, INC. HIGH-RESOLUTION SEPARATOR**

A key element of TRIUMF's future success in rare-isotope physics is the ability to select and separate out rare isotopes from a milieu of products generated in a target. One tool of the trade is a high-resolution magnetic separator (HRS). TRIUMF built one of these devices as part of the ARIEL project.

Recognizing the global, niche market, AAPS put together a business framework that proposed the transfer of HRS technology from TRIUMF to a Canadian company and will make future sales to laboratories in Switzerland, France, Germany, Japan, and India. Advanced Cyclotron Systems, Inc. (ACSI) of Richmond, BC, expressed serious interest in the core technology and the future business opportunity.

### **PAVAC INDUSTRIES, INC.**

When PAVAC indicated an interest to move from manufacturing and selling SRF cavities valued at a few hundred thousand dollars to manufacturing and selling the full cryomodule system valued at a few million dollars, AAPS proposed a structure for developing and licensing this know-how and intellectual property to PAVAC in a way that was transparent and offered downstream revenues. The first cryomodule manufactured by PAVAC will be sold to India. The company is presently negotiating contracts with Korea as well.

### **LOOKING AHEAD**

AAPS provides needed value to TRIUMF and will continue as a wholly-owned, stand-alone non-profit organization. Self-sufficiency is within reach, and combining governance with the TRIUMF Board will help secure the future of both organizations. Within the next five years, it is projected that AAPS will begin making contributions such that TRIUMF's commercial-revenue will move toward 5% of its operating budget. As AAPS matures, this value will grow towards 10%.



## 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

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**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, McGill University, McMaster University, University of Northern British Columbia, University of Regina, Saint Mary's University, and University of Winnipeg

### BOM Innovation and Industrial Partnerships Committee

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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

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Jim Hanlon (Chair)

Ewart Blackmore

Yuri Bylinsky

Henry Chen

Nigel Lockyer

Neil McLean

Tim Meyer

Jozef Orzechowski

Michael Trinczek

### Private-Sector Advisory Committee

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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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- 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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