

# BEAMTIME



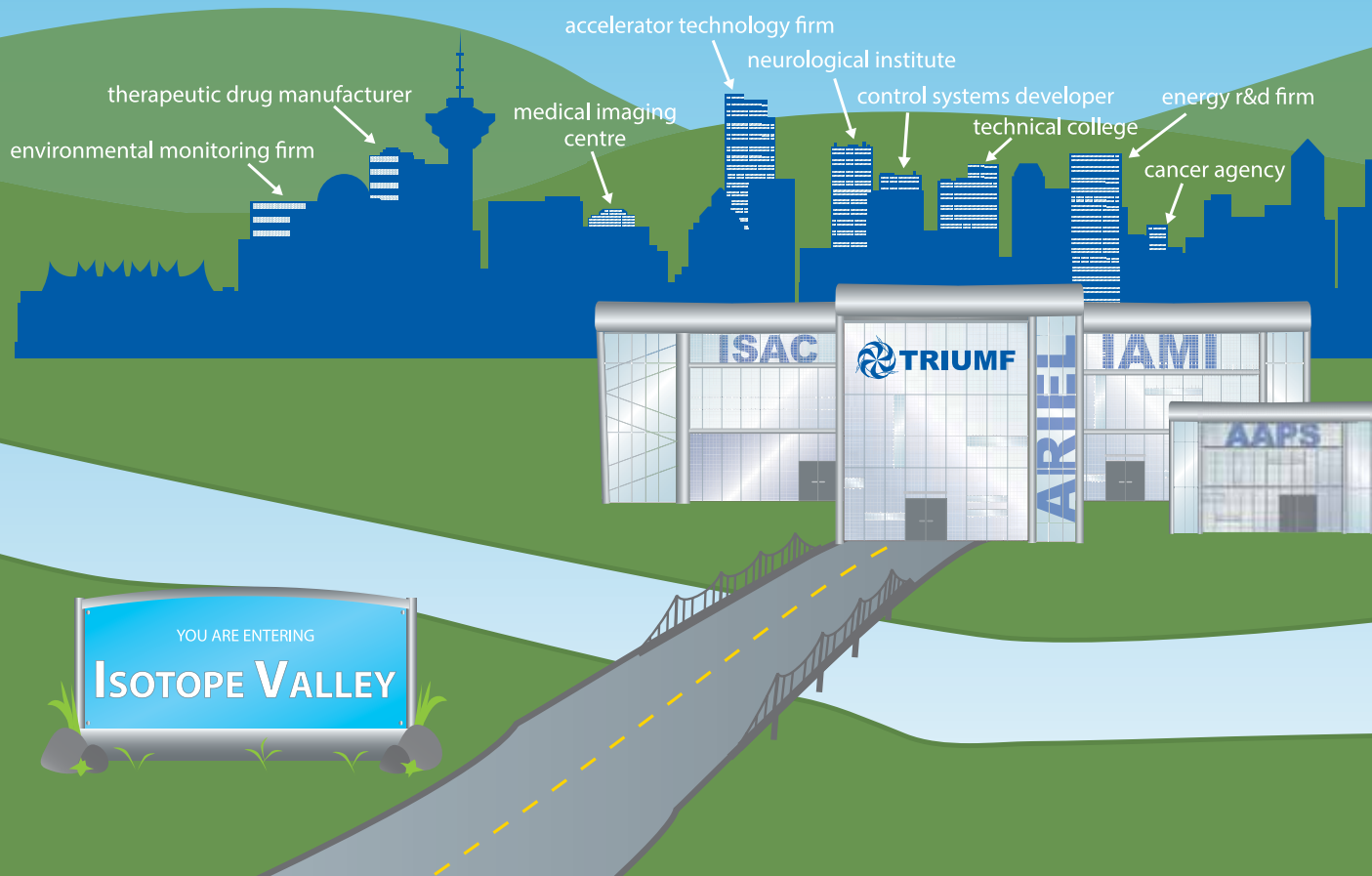
News from Canada's national laboratory for particle and nuclear physics

SPRING 2014 | VOLUME 11 ISSUE 1

## Welcome to Isotope Valley

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Jonathan Bagger



# spring



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## Safety, Science, and Society

It is a pleasure to welcome you to *Beamtime* – and my first issue as Director of TRIUMF!

I have been in Vancouver for just two months, and already the laboratory seems like home. When I arrived, I was fortunate to find the laboratory in great shape, a testament not only to the skill of the leadership team, but also to the dedication of its staff – the people who make TRIUMF the terrific place that it is.

I came to TRIUMF because of the laboratory's great potential, not only in nuclear and particle physics, but more broadly in accelerator science, nuclear medicine and advanced materials. I am delighted that my first issue of *Beamtime* is highlighting one of those areas, nuclear medicine.

In my remarks during the September 5 All Hands Meeting, I stated that I have three priorities for TRIUMF: To have us work safely, do great science, and connect beyond our walls. The priorities flow from our mission and vision, and are true to our most fundamental values.

To my mind, nuclear medicine lies at the intersection of all three priorities. With radioactive isotopes, it is imperative to work safely, and I believe that our team does just that. There is no doubt that the science is at the cutting edge; nuclear medicine thrives at the interface between biology, chemistry and physics. And the applications are manifest, ranging from new diagnostics and therapies to help Canadian patients to new commercial opportunities to grow the Canadian economy.

During the months and years ahead, I look forward to working with Paul Schaffer and the nuclear medicine team, and with our partners in the life sciences – including the University of British Columbia and other member universities, the BC Cancer Agency and other medical institutions, as well as our federal and provincial government sponsors – to ensure that Canada is at the forefront of the global effort to advance health and well-being through nuclear medicine, both here and abroad.

Enjoy your reading – *et bonne lecture!*

“  
...nuclear  
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[of TRIUMF's]  
priorities...  
”

# IAMI

## The Institute for Accelerator-based Medical Isotopes

Future home base for Isotope Valley

by Dr. Paul Schaffer, Head of the TRIUMF Nuclear Medicine Division

TRIUMF houses the ingredients for a regional centre of excellence that could transform the Vancouver area into “Isotope Valley,” a local network of institutions that maintain accelerator-based science, technology, innovation, and commercialization expertise. The Institute for Accelerator-based Medical Isotopes (IAM) aims to synergize diverse nuclear medicine sectors by sharing resources and centrally managing production of isotopes and radiotracers for clinical research and commerce.

The IAM’s mission is to enhance radioisotope and radiopharmaceutical research by bringing together interdisciplinary faculty and students with partners from academia, not-for-profits, government, and industry. It will leverage the facilities, equipment and expertise of TRIUMF via: accelerator research into targets for cyclotrons and electron linacs; isotope production for research; research into nuclear, hot atom, radio-, and

radiopharmaceutical chemistry; and supplementing critical medical-isotope supplies in BC. This will, in turn, foster applications in the physical, biological or medical sciences, interactions between academic and private-sector research, dissemination of research and technology, training of the next generation of interdisciplinary radioisotope scientists, and production of GMP-compliant radiopharmaceuticals.

The IAM’s vision is to be a beacon of excellence and global leadership in accelerator-based radioisotope production and application. It will pursue a core R&D effort that will define the state of the art in the field, while fostering Canadian excellence by bringing together researchers and students across a broad class of universities and disciplines, and nurturing research translation by engaging various stakeholder industries. Moreover, the IAM will produce and distribute isotopes for British Columbia (and potentially Canada and beyond), serving as a non-reactor source of Tc-99m and other isotopes produced via TRIUMF’s TR13 and (upcoming) TR24 cyclotrons, as well as radiotherapeutic isotopes created at ISAC and ARIEL. At the outset the IAM envisions a number of research areas, outlined here below.

### PET Isotopes

One important component of the IAM is the research and development of radioisotopes for in vivo Positron Emission Tomography (PET) imaging. Specifically,

Target module for cyclotron production of the key medical isotope Tc-99m. Developed by a TRIUMF-led team, the module can be retrofitted on common existing hospital cyclotrons (like a TR13 or TR24) to produce enough isotope overnight to serve a metropolitan area.



Artist rendering of the new Djavad Mowafaghian Centre for Brain Health which opened this past year on UBC's main campus. Photo credit: UBC



it will continue to provide regulatory-approved positron-emitting radiopharmaceuticals to serve the PET imaging program at UBC while supporting the clinical and research program at the BC Cancer Agency.

### Neurodegenerative Disease

Brain disease is a staggering societal problem expected to worsen as the population ages. UBC excels in brain research and the new Djavad Mowafaghian Center for Brain Health (DMCBH) will champion an interdisciplinary “bench-to bedside” program. The DMCBH is envisioned to subsume and extend the existing Pacific Parkinson’s Research Centre into an institutional facility open to researchers in most aspects of brain function and disease: Alzheimer’s and dementia, mood disorders, addiction, multiple sclerosis, brain trauma and healthy ageing. An UBC/IAMI partnership will synergize the radiopharmaceutical-development and medical-imaging communities to optimize radiotracer development. Housing a state-of-the-art translational imaging centre, the partnership will create a provincial and national brain illness reference facility which will enable better disease understanding, develop novel therapies, and improve interaction between academia, clinics, and industry.

### The Fight Against Cancer

Isotopes have critical uses for the diagnosis, treatment, and management of both acute and chronic disease affecting many individuals, which draw resources from a system struggling to balance costs with service demands from an aging Canadian population. The IAMI will work

closely with the BC Cancer Agency to extend the use of isotopes for cancer diagnosis and monitoring, while exploring the untapped potential to harvest TRIUMF isotopes to enter the therapeutic arena. There are a number of radiometal isotopes emitting particles ( $\beta^-$ ,  $\alpha$ , or conversion or Auger electrons) very effective in killing cells. These could be delivered selectively to tumours, releasing “therapeutic” radiation doses that spare surrounding healthy tissue. By employing a strategy similar to molecular imaging, therapeutic isotopes can be incorporated into more complex pharmaceuticals for specific, targeted delivery of potent radiation doses. “Radiotherapeutics” remains a largely nascent science to date.

### Facilities

The cornerstone of the IAMI is a TR24 cyclotron recently purchased with funding from Western Economic Diversification (WD) of Canada. It also will maintain state-of-the-art isotope research facilities enabling cyclotron component development, isotope production on the TR24 or (existing) TR13 cyclotrons, product testing, extraction and manipulation of radioisotopes, and GMP-capable facilities producing human-ready radiopharmaceuticals. The DMCBH will house a state-of-the-art hybrid PET/MR scanner in addition to two existing brain scanners and a pre-clinical PET

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**IAMI [...] will form a bedrock foundation for the home of a future Isotope Valley.**

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scanner, as well as dedicated MRI, EEG and (in the longer term) MEG equipment.

The IAMI will bring together academic interests from senior researchers from TRIUMF and its 18 member universities, in particular the UBC Faculties of Medicine, Science, Applied Science, and Pharmaceutical Sciences, and stakeholders at Simon Fraser University. Along with the BC Cancer Agency, it will provide important medical isotopes for British Columbians, like Tc-99m and F-18. Furthermore the IAMI will engage with commercial concerns like Advanced Applied Physics Solutions, the Centre for Probe Development and Commercialization, The Centre for Drug Research and Development, General Electric, Nordion, Advanced Cyclotron Systems Inc., IBA, Best Cyclotron, D-Pace, Enigma Pharmaceuticals, Roche, and others. Together with the IAMI, these organizations will form a bedrock foundation for the home of a future Isotope Valley.

# ISO SiM

## The Isotope for Science and Medicine Training Program

Preparing Young Researchers for Science and Industry

by Reiner Kruecken, Head of the TRIUMF Science Division

NSERC's Collaborative Research and Training Experience (CREATE) Program supports key programs that train young researchers transitioning from academia into the Canadian workforce. The Isotopes for Science and Medicine (IsoSiM) CREATE program at UBC and TRIUMF was recently funded to provide young scientists with enriched training experiences in the production, preparation, and innovative application of isotopes for science and medicine.

IsoSiM has been developed in response to the growing importance of applications of nuclear isotopes in a broad range of fields from environmental science, preclinical medical research, and characterization of new materials, to investigations of the foundations of the universe. The term isotope refers to different forms of the same chemical element that contain equal numbers of protons but different numbers of neutrons in their nuclei. Isotopes of the same element are chemically very similar, but are distinguishable by their masses. Radioactive isotopes (radioisotopes) can be identified by the distinctive properties of their decay radiation, which allows them to be detected and located in trace amounts, e.g. in the medical imaging technique of positron emission tomography (PET).

While their medical use is widely known, isotopes enjoy growing importance in environmental studies to trace flow of nutrients or pollutants in the environment. For example, they are used to understand the influence of micronutrient trace metals on the productivity of marine phytoplankton, which consume large amounts of carbon dioxide, important in the regulation of the global carbon cycle. Isotopes also are used as tracers in environmental assessments for the mining, oil, and gas industry. While today mostly stable isotopes are used, such studies can be carried out faster and more effectively using small quantities of short-lived (days or weeks) isotopes that can be produced by accelerators on demand for the application. IsoSiM will enable the development of new techniques at the frontier of isotope applications.

TRIUMF's Ken Buckley test drives one of the brand new hot cells in the MHESA Lab for nuclear medicine.



The IsoSiM CREATE program involves a set of related research and background development topics:

- Isotopes for environmental science
- Isotopes for molecular imaging of diseases and treatment of cancer
- Isotopes as probes of magnetism at interfaces and surfaces of new functional materials
- Isotopes as laboratories to search for new forces in nature
- Isotopes to determine how and where the heavy elements were produced in the universe
- Isotopes for developing a standard model for nuclear physics
- Accelerator science and technologies for isotope production

Developing new and refined applications of isotopes in various fields requires an understanding of their production techniques and nuclear properties. At the same time, new knowledge about the fundamental physics of atomic nuclei can lead to new opportunities for the application of isotopes. IsoSiM provides an environment which encourages the cross-fertilization of ideas among the diverse research areas using and producing rare isotopes. TRIUMF, with its unique capability to produce designer isotopes, has a central role to play in this enterprise. UBC, with its wide spectrum

**IsoSiM [...] encourages the cross-fertilization of ideas among the diverse research areas**



A trace metal clean rosette for sampling seawater is prepared for deployment. This rosette holds twelve 12L bottles that can be triggered to sample water at specific depths within the water column. The rosette can pick up trace levels of isotopes used in environmental science.

of interests and expertise, is able to exploit these specially developed isotopes in new and exciting ways.

The IsoSiM program involves researchers from TRIUMF and UBC's Department of Physics & Astronomy, Department of Chemistry, Department of Earth, Ocean and Atmospheric Sciences, Department of Radiology as well as the Faculty of Pharmaceutical Sciences. The NSERC funding will support roughly 14 PhD and 19 MSc students with fellowships over its 6-year time span. In addition, about 5 undergraduate research experiences will be supported each year.

The program will train undergraduate students, graduate students, and postdoctoral researchers at UBC and TRIUMF in isotope-related fields in an individually tailored, interdisciplinary curriculum that will build on and complement their academic specialty. Unique in Canada, this program offers

a combination of interdisciplinary isotope-related training ranging from pure to applied sciences, industrial internships, along with mobility with German research institutions having unique large-scale equipment and scientific infrastructures. The IsoSiM program will also provide a variety of professional-development initiatives to help trainees develop essential skills for science and industry.

Within the Vancouver metropolitan area there is emerging a hub of isotope-related research and industries with UBC and TRIUMF working closely with institutions like the BC Cancer Agency and companies like Nordion and Advanced Cyclotron Solutions Inc.. There is a long-term vision to develop the region into an "Isotope Valley", and IsoSiM will be a key component to develop and sustain that vision.

**For further information please visit [isosim.ubc.ca](http://isosim.ubc.ca).**

# News & Announcements

## TRIUMF Undergrads sweep Presentation Awards at CUPC

Three TRIUMF co-operative education students were taken home the top awards for their presentations in the Particle and Nuclear Physics division at the annual Canadian Undergraduate Physics Conference at McMaster University this past October. Sebastien Rettie, Chelsea Dunning and Ben Davis-Purcell (right, left, centre in photo) took the top three prizes for their outstanding presentations based on their TRIUMF research.

Sebastien's presentation on "Searching for Supersymmetry (SUSY) with the Upgraded ATLAS Detector" won first place.



He credits his TRIUMF experience with helping him to decide to pursue graduate studies in experimental particle physics. Ben (CUPC conference co-chair) presented his second-place talk on "Neck Optics Tuning of the SNO+ Experiment". Chelsea's presentation, "TRIUMF's Proton and Neutron Irradiation Facility (PIF & NIF) and the Two-Step Monte Carlo Simulation" earned her the third-place prize. Chelsea worked on three different projects at TRIUMF confirming her interest in pursuing graduate studies in medical physics. She credits TRIUMF's student presentation skills workshop and symposium for giving her the confidence to present in front of an audience. Well done to all!

## International Peer Review vets TRIUMF

Every five years, TRIUMF undergoes a comprehensive review to assess its performance, progress, and future plans. As part of the 2015-20 strategic planning cycle, the NRC Office of Audit and Evaluation conducted the review during 2013, culminating on November 13-15 with the International Peer Review (IPR).

The IPR Committee (IPRC) included nine distinguished scientists and industry leaders from Canada, the U.S., and Europe, with skills in research, science, technology, commercialization, and laboratory management. The IPRC engaged in various activities to gauge the vitality, structure, and impact of the laboratory, including plenary talks, parallel sessions dedicated to TRIUMF's various research areas, student poster sessions, and tours. The IPRC's report to the NRC

provided valuable guidance to federal and provincial governments considering investments in TRIUMF's next five-year plan. The NRC released their final evaluation in May 2014, concluding in part that "... the activities undertaken by TRIUMF represent good value-for-money for NRC and for Canada. The implementation of the recommendations will be important to enable TRIUMF to continue to perform at a very high level, support the needs of the research community in subatomic physics research and Canada's S&T strategy and yield greater impacts from their commercialization related activities."

For more information, visit [http://www.nrc-cnrc.gc.ca/eng/about/planning\\_reporting/evaluation/2013\\_2014/triumf.html](http://www.nrc-cnrc.gc.ca/eng/about/planning_reporting/evaluation/2013_2014/triumf.html)

## Federal Government supports IAMI & TR-24

On May 30, the Honourable Michelle Rempel, Minister of State for Western Economic Diversification, announced \$5.5 million of funding to support TRIUMF in developing the Institute for Accelerator-based Medical Isotopes (IAMIs), and to support significantly procurement of a new TR-24 cyclotron, which will enhance TRIUMF's research capabilities and ability to supply important medical isotopes provincially and beyond.

The TR-24 will be critical for the IAMIs as it strives to become a centre of excellence in isotopes for science and medicine. The IAMIs will bring together researchers, clinicians, entrepreneurs, and technicians to support a vision where new isotopes drive the personalized healthcare revolution



(see article in this issue). The TR-24 will bring Canada closer to meeting its medical isotope needs after the NRU reactor in Chalk River, ON ceases production in 2016. Together, the TR-24 and IAMI will provide a platform for local British Columbia enterprises to study and test drug therapeutics, and to develop highly qualified personnel in nuclear medicine.



## Proton Cancer Therapy treats 175th patient

by **Melissa Baluk**

The Proton Cancer Therapy (PCT) facility at TRIUMF is a one-of-a-kind Canadian cancer treatment centre providing treatment for ocular melanoma since 1995. One of just 42 facilities worldwide with the beams, technical know-how, and coordination with local cancer-care institutions to provide the best possible treatment for this rare disease, the PCT centre treated its 175th patient in late 2013.

Local doctors treat about 40 ocular melanoma cases a year. Patients of all ages come from western Canada, Ontario and Quebec. Annually, TRIUMF treats one quarter of the patients, while the rest are treated with radioactive seeds inserted around the tumour (brachytherapy). TRIUMF receives patients that

brachytherapy can't treat effectively, e.g. the tumour is too large. PCT's astounding efficacy has prompted construction or planning of 41 similar facilities worldwide.

PCT is a collaboration among the BC Cancer Agency, UBC's Eye Care Centre and TRIUMF, coordinated on site by TRIUMF scientists Dr. Cornelia Hoehr, Dr. Michael Trinczek and Dr. Ewart Blackmore.

For more information, visit [www.triumf.ca/proton-therapy](http://www.triumf.ca/proton-therapy)

## Erich W. Vogt 1929-2014

TRIUMF lost a dear member of its family when Erich Vogt, its co-founder, longest-serving Director and visionary leader, passed away peacefully in Vancouver on February 19th 2014. He was 84. Erich and TRIUMF have been inseparable since 1966, when he championed a bold proposal from a western-Canadian university consortium for a 500 MeV cyclotron on the UBC campus. He also served on the TRIUMF Board of Management, and was lab Director from 1981 until his retirement in 1994.

Under Erich's directorship, TRIUMF transitioned from a university lab into an international user facility. Early on he foresaw the importance of broadening the science program beyond nuclear and



particle physics by supporting the material science and chemistry effort using polarized muons, by investing in a radiochemistry program to support medical imaging diagnostics, and by fostering a development program for small cyclotrons producing radiotracers for hospitals. All have since become core TRIUMF competencies. Furthermore, Erich worked tirelessly to bring TRIUMF into the global science big leagues by building strong reciprocal collaborations with scientists and laboratories world wide.

The TRIUMF family continues to build on his legacy of excellence, strength, daring vision, collaborative spirit and above all, friendship, that he instilled in everyone and cultivated as a laboratory policy. He will be sorely missed.

See <http://www.memorial.supporting.ubc.ca/erich-vogt/>

## Calendar

Upcoming Important Events  
(at TRIUMF unless otherwise stated)

October 3, 4 2014	ACOT Meeting
October 15-17, 2014 in Halifax	Canadian Science Policy Conference
October 24, 2014	Teacher Professional Development Day
November 6-7, 2014	Board of Management Meeting
January 21-22, 2015	MMS-EEC
January 2015	SAP-EEC
February 2015 at UBC	Erich Vogt Memorial Scientific Symposium

### TRIUMF Event Calendar

[admin.triumf.ca/d2w-pub/eventsca/display](http://admin.triumf.ca/d2w-pub/eventsca/display)

# profile

## Jonathan Bagger

From Theory into Practice

by Melissa Baluk, Communications Coordinator

Before taking office as TRIUMF's Director, Jonathan Bagger sat down for a candid conversation about his life at home and in physics, why he shifted into leadership roles, and what he'll bring to his new job.

Jonathan Bagger grew up in Westfield, New Jersey with his parents and three siblings in a home that was over 200 years old. The eldest child, Jon spent summers restoring the Revolutionary-era farmhouse. With his adept electrical, carpentry, and plumbing handiwork, he had plans to become an engineer. "At the time, I didn't know there was such a thing as a physicist," he admits.

### Jon spent summers restoring the Revolutionary-era farmhouse

But once at university, Jon discovered theoretical physics. Referencing the film *Particle Fever*, he explains that "in the film, Savas Dimopoulos explains that physics is the search for truth. It asks deep questions, but ultimately, the answers are either yes or no. That resonated with me: I liked the quest for truth. I also liked the mathematics behind the physics. The math raises barriers however, so it is important that we learn how to communicate the importance of what we do."

Regarding theorists, Jon clarifies: "There's a myth that theorists are quiet, solitary people who work in isolation. Not true! The cliché of the theorist standing at the

blackboard misses the physicist beside him, arguing with him and sharing the one piece of chalk. Theoretical physics demands social interaction—theories are not created solely on paper; they come to life through discussion."

After completing his Ph.D. with Edward Witten at Princeton, Jon took positions at Stanford and Harvard before moving to Johns Hopkins University. At Johns Hopkins his career stepped from theoretical physics professor, to department chair, to university vice-provost. "In the provost's office, I had to expand my horizons and learn about areas far removed from physics. I was especially privileged to work with our medical faculty, and to witness their commitment to their mission." Nodding to the TRIUMF Five-Year Plan on his desk, he adds, "TRIUMF has a powerful mission. And mission aligned with community and country makes a compelling combination."

In 2001, Jon co-chaired a strategic planning committee for the future of US particle physics. His committee broadened the definition of particle physics, set a mandate for US involvement in international projects, and developed the precursor of the U.S. Department of Energy particle physics "P5" Report.



The committee's recommendations were distilled from contrasting expert opinions. "You listen to everyone in the room. Working with physicists involves forming a simple concept and then adding complexity layer by layer. Near the end, we locked ourselves in a hotel and kept going for a week, until we achieved support from each committee member. The final report was stronger for the effort."

Jon continues to serve on many committees, saying, "My motivation is to pull the best out of people because that can lead to remarkable results. At Johns Hopkins, I chaired the search committee to hire our next Dean of Engineering. That's a fun job! As Dean, you get to channel creativity and empower people—not to just do their job, but to own their job." Jon leans forward beaming, "Now, doesn't that sound a lot like TRIUMF?"

Visit [www.triumf.ca/leadership-team](http://www.triumf.ca/leadership-team) to read more about Jonathan's background.

“My motivation is to pull the best out of people”

## Forty Years On

May 1972 - April 1974: Two Difficult Years

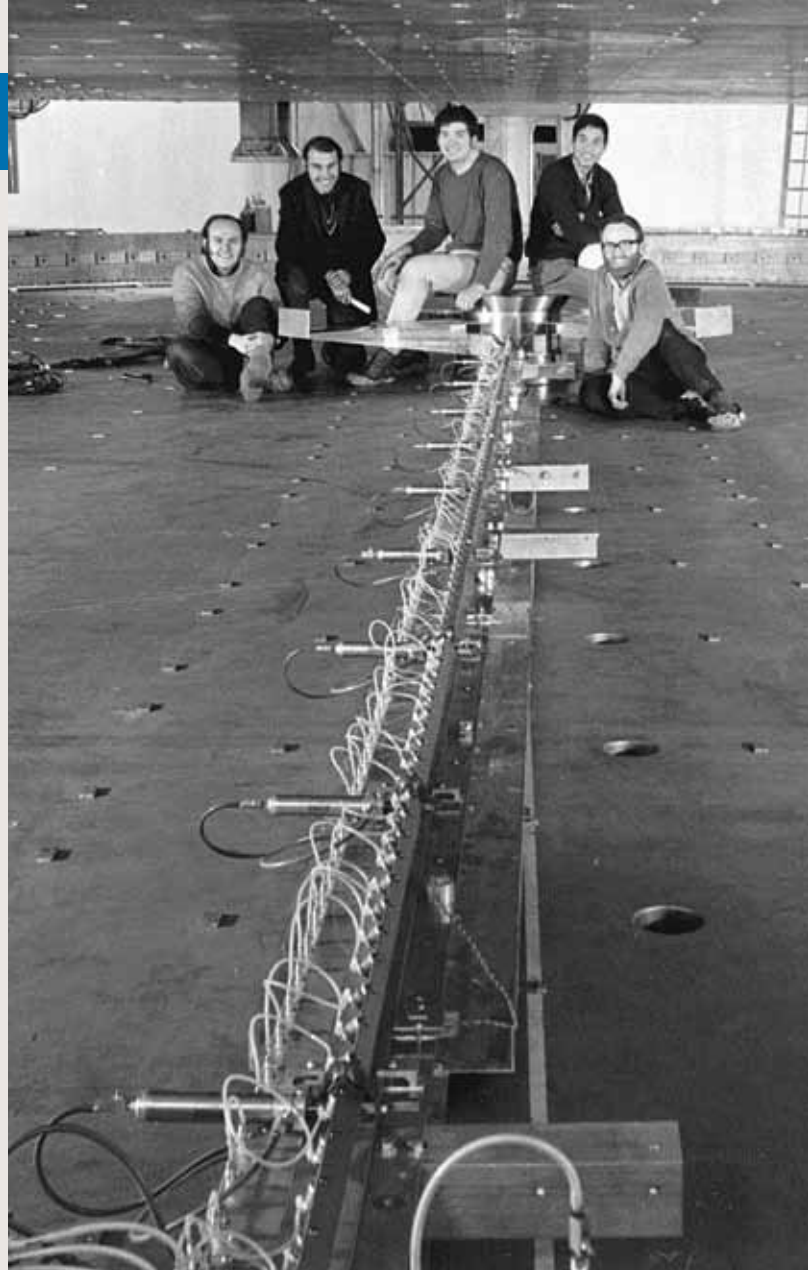
by Mike Craddock

This was a period of great difficulties and delays for the construction of TRIUMF, beginning with a 3-month-long general labour dispute in BC that delayed completion of the main cyclotron's magnet. Consequently the jacking system could not be finished until July 1972, and the six sectors of each magnet coil could not be welded together until August. The 27,000-amp magnet power supply was then commissioned and by mid-December the rotating field survey arm had been installed and was ready to take magnetic field strength data inside the cyclotron (at 105 radii in 1° steps over a full circle). But the first results were alarming! The mean field strength was 3% too high over the inner region and 3% too low at the outside - rather than the  $\pm 0.01\%$  required to keep the ions in synchronism with the fixed-frequency accelerating voltage. Although the 1/10 scale model on which the design was based had been built of plates from the same steel melt as the full-scale magnet, apparently the rolling process had affected the magnetic properties of the surface, lowering the overall permeability more for thin plates than for thick ones. On top of this, in January the isolating transformer was destroyed by fire, delaying further measurements by three months.

Meanwhile the Central Region Cyclotron model was making good progress. The measured orbits agreed with computations and by October 1972 the beam had been coaxed to the full 3 MeV energy, in the process confirming its sensitivity to radiofrequency cavity misalignment and to magnetic field asymmetry across the large 20.8" pole gap. But with central correction electrodes, steel shims and trim coils the beam could be brought sufficiently close to the mid-plane, and by June 1973 the design 100  $\mu$ A beam intensity had been achieved.

It took [...] the volunteer shimming efforts of nearly everyone on site

But drastic surgery was required on the main cyclotron magnet, so over the spring and summer, 100 tons of steel were added to the outer return yokes and 16 tons cut away from the inner ones. This brought the field error down to  $\pm 0.1\%$ , close enough to bring the desired accuracy within reach using just pole shims (thin steel plates located at 6" intervals along the 24 pole edges). But not only the mean field had to be corrected - its azimuthal variation had to be adjusted to ensure vertical focusing and eliminate non-6-fold harmonics, and any field asymmetry between the upper and lower magnets had to be removed. In all there were 15 parameters to be corrected at each of 103 radii by adding or removing shims at up to 666 locations - a massive undertaking.

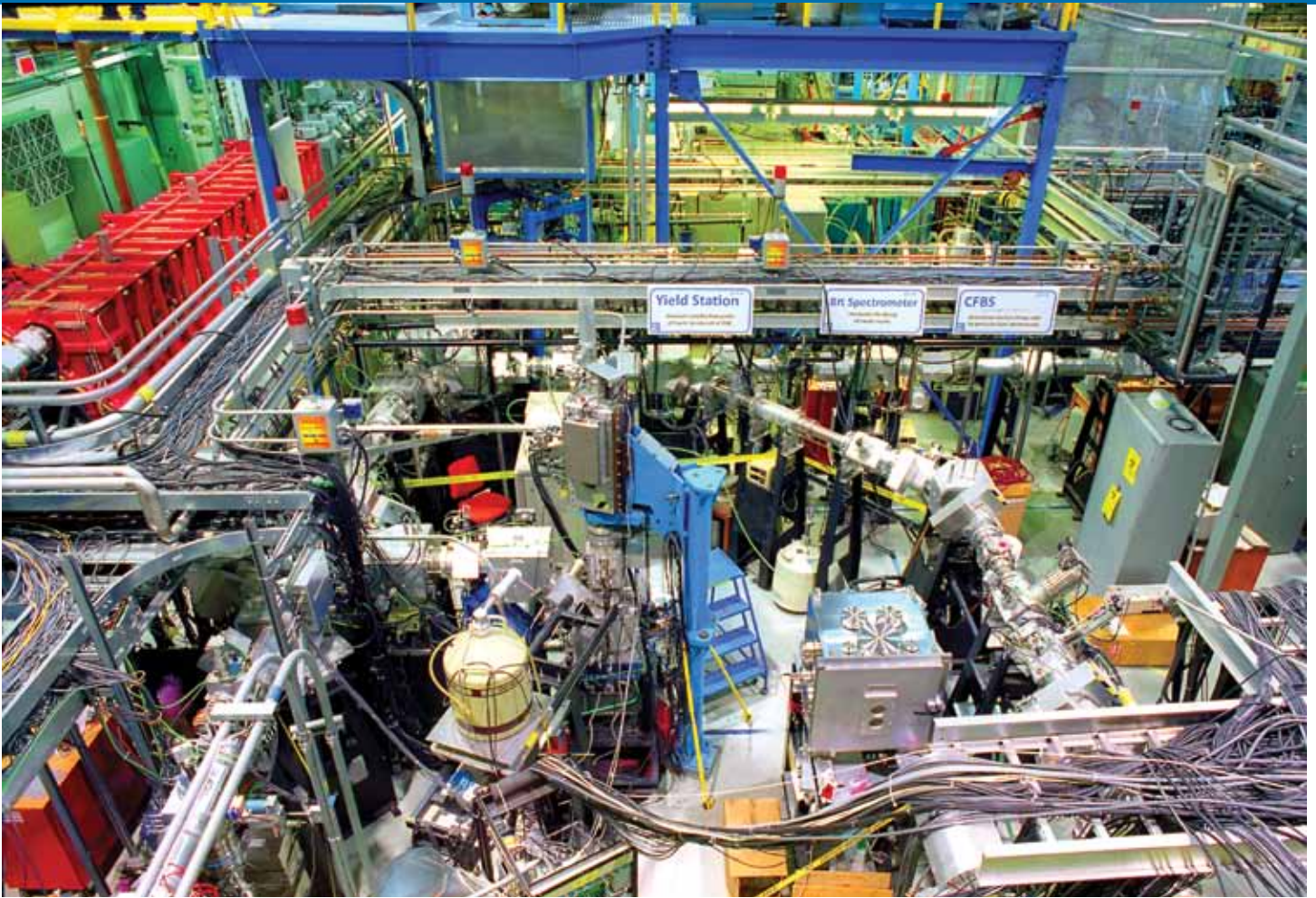


The Magnet Group, led by Ed Auld (R, beard), and the survey arm with 105 flip coils

There were 15 parameters to be corrected at each of 103 radii by adding or removing shims at up to 666 locations

Computer programs were devised to calculate the shim changes required, but the physical changes had to be made by hand.

In that era the only computer available was UBC's mainframe IBM360, and as our codes demanded hours of dedicated running they were only accepted overnight. During the day devoted teams laboured to implement the changes - and very many iterations were needed, as cross-talk between the field parameters meant that improvement was slow. Indeed it took from September until April and the volunteer shimming efforts of nearly everyone on site before the magnetic field was deemed accurate enough to commission the beam with trim coils alone. So after 492 days the survey equipment was removed, and the Radiofrequency, Vacuum and Probes Groups were at last free to complete the cyclotron by installing their devices.



## Isotope Switchyard

A beam of rare isotopes produced using the TRIUMF cyclotron emerges (light blue, centre) vertically into the ISAC-I experimental hall, where it is then directed either to the low-energy area (right and lower right), the TITAN isotope trap (dark blue platform, top), or to the linear accelerator (red tank, upper left) to boost its energy for higher-energy studies. An artful marriage of form and function to TRIUMF scientists, the “isotope switchyard” greets tour guests with an imposing visual cacophony, here brilliantly captured by photographer David Rasmussen.

Image credit: David Rasmussen 2010. (Creative Commons Attribution-NonCommercial-NoDerivs)