Beamtime

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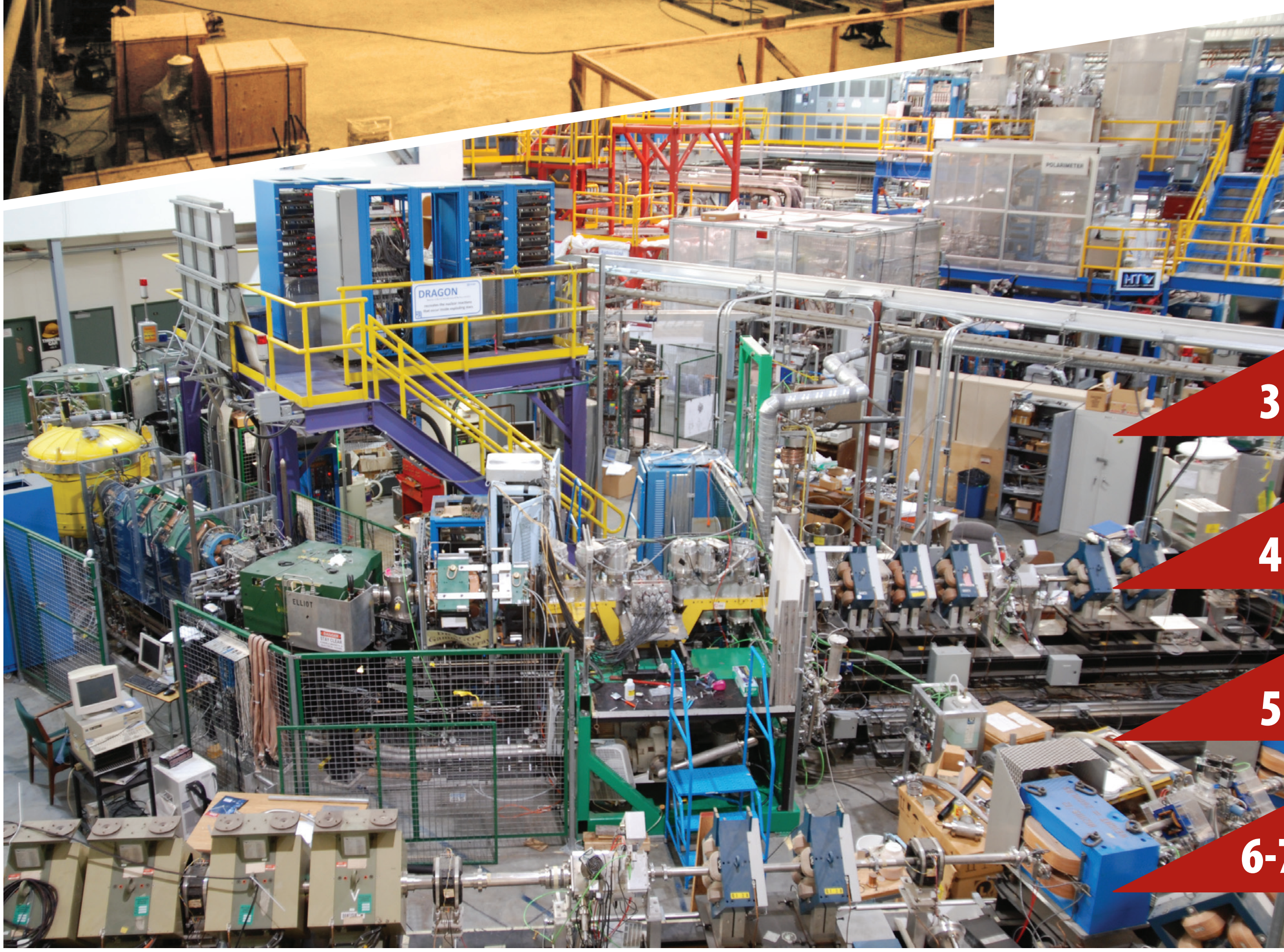
TRIUMF

News from Canada's National Laboratory for Particle and Nuclear Physics

The First Decade of ISAC



Director's Voice

Isotopes Я Us

The decade of isotope research is upon us. Canada and much of the industrialized world has learned a new word that impacts their daily lives - isotope, or perhaps more accurately, isotope shortage. Isotopes are atoms with the same number of protons but different number of neutrons. A good example is C-12 (6 protons 6 neutrons), the most common carbon isotope found in nature, C-14 (6 protons 8 neutrons) another carbon isotope used in geological dating, and C-11 (6 protons 5 neutrons), yet another isotope used in positron emission tomography. These are just three of many isotopes of carbon.

Of course the newspapers have been filled with stories about medical isotopes, and in particular, molybdenum-99, a popular parent isotope used to make technecium-99m, the workhorse isotope of the medical imaging community. Nuclear medicine doctors use the gamma-ray from the decay of Tech-99m to image the inner workings of the body and to allow them to view the metabolism of disease itself.

> "ISAC ... has positioned Canada as a world leader in isotope research"

One future of this research field lies with therapy as opposed to imaging. Isotopes that emit alpha particles rather than gamma-rays can kill nearby cells. Chemists design molecules that travel to a particular location, or to a bio-chemical activity, in your body. When medical isotopes are attached to these molecules, the result can either be an image or cell death, depending on the isotope. Nature has thousands of possible isotopes. TRIUMF scientists produce rare isotopes beams and perform basic research to understand properties of the interesting isotopes relevant for medical research, material science and other applications. The last decade of research and investment in the infrastructure and staff at TRIUMF's ISAC facility has positioned Canada as a world leader in isotope research. TRIUMF and ISAC have done ground-breaking research in the past decade, are well-positioned for important discoveries into the next decade and beyond.

Cover Story

The Birth of ISAC

ISAC project leader looks back

ISAC project team poses with the completed superconducting linear accelerator modules in the ISAC-II vault.

The origins of ISAC at TRIUMF can be traced to a 1984 workshop in Mont Gabriel, QC, where a strong scientific case was seen for a next-generation ISOL (isotope separation on-line) facility and so construction of a test facility was recommended. "The TRIUMF ISOL Facility" proposal was presented to the TRIUMF Board in June 1985 and recommended 1.5 MeV/u radioactive ion beams (RIBs) for nuclear astrophysics experiments. By 1987 the TISOL test facility was built and made successful tests off-line. In October 1993, TRIUMF's five-year funding request included $M67.5 for ISAC, proposing to use 100 μA of 500 MeV protons onto three target stations for accelerated RIBs up to 10 MeV/u.

ISAC (isotope separation/acceleration) was funded in June 1995, far below the $M67.5 request. Consequently, a downsized $M18.1 ISAC facility (plus $M9.7 for civil construction) was proposed in October 1995, accommodating one target station and a 1.5 MeV/u beam. Savings were realized by scavenging accelerator components from the decommissioned TASCC facility at AECL.

The first construction contract was awarded in March 1996 and ISAC was granted its operating licence two years later for currents up to 10 μA. The first proton beam on target followed in May 1998. The first radioactive beam (^{38m}K) from 1 μA of protons on a CaO target was delivered to the TRINAT experiment on November 28, 1998. 10 μA operation began in July 1999, and 100 μA was tested on a high-power molybdenum target in December 1999.

Installation of beam transport (LEBT), accelerator (RFQ) and stable ion-source (OLIS) components began before the occupancy permit was granted in July 1998. OLIS was commissioned in August 1997, LEBT from OLIS to the RFQ in March 1998 and the RFQ commissioned at full power in September 1999. Full-energy stable beam was accelerated through the second-stage accelerator (DTL) on December 21, 2000. The first radioactive beam (^{21}Na) was delivered to the TUDA and DRAGON facilities on March 23 and April 24, 2001, respectively.

The 2000-2005 Five-Year Plan included completion of ISAC (now ISAC-I) and construction of an additional high-energy accelerator utilizing superconducting radio-frequency cavities (ISAC-II). The Canadian Government announced funding in the February 2000 budget. Work on the ISAC-II building design began with $M8.7 of provincial funding released on June 1, 2001, followed by approval to award the construction tender in May 2002. The total allocated funds were insufficient to complete ISAC-II as planned, so work began on the medium-beta accelerator while work on the low and high-beta sections was postponed. A prototype cavity was tested in Legnaro in 2000, followed by further testing and prototyping at a temporary facility at nearby BC Research. Superconducting cavity development moved to ISAC-II when the building was completed in 2004.

Funds to complete the ISAC-II high-beta accelerator section and high-energy experimental beam lines were provided in the 2005-2010 budget. Acceleration of ^{4}He^{2+} through a single medium-beta module was demonstrated in 2005. In April 2006, ^{40}Ca^{10+} was accelerated from OLIS through the ISAC-I DTL and then through all twenty ISAC-II medium-beta superconducting cavities to a final energy of 220 MeV (5.5 MeV/u). The ISAC-II era began when the first radioactive ion beam (^{11}Li) was delivered to the MAYA facility in the ISAC-II experimental hall on January 05, 2007.

The TRIUMF ISAC facilities have conducted world-class experiments using our intense radioactive ion beams. A few of the many physics successes at ISAC are detailed by Jens Dilling elsewhere in this newsletter.

• Paul Schmor

Feature Story

A Decade of ISAC Physics Triumphs

Jens Dilling highlights few of many experimental successes

TRIUMF's ISAC (**I**sotope **S**eparator and **A**ccelerator) facility delivered its first radioactive beam in 1998, and its first post-accelerated beam in 2001, initiating a decade's worth of important nuclear science experiments. ISAC's core mandate is to excel in fundamental nuclear science within Nuclear Astrophysics, Nuclear Structure, and Tests of Fundamental Symmetries. Scientific and technical developments are user-driven, by and large guided by Canadian university groups. ISAC today consists of three experimental areas – the low and medium-energy areas in ISAC-I delivering beams at either 60 keV or between 150 keV/u and 1.8 MeV/u, and the high-energy area in ISAC-II delivering beams up to 16 MeV/u (by spring 2010). Beam post-acceleration plus ISAC's superb production capabilities using its 100μA proton beam results in some of the highest yields available for specific radioactive species.

ISAC physics began strongly with the very first radioactive beam, which was delivered to the TRINAT (**TRI**UMF's **N**eutral **A**tom **T**rap) experiment in 1998. TRINAT's unique double magneto-optical trap coupled to advanced nuclear detectors measured for the first time beta-particle and recoil-ion correlations from radioactive atoms (^{38m}K) decaying in free space (i.e. not embedded in a target). From these correlations the experiment set the best limit on possible scalar interactions, a fundamental symmetry. The first ISAC 'physics' publication was also a fundamental symmetry test, describing a precision half-life measurement of ^{74}Rb decay. Studying so-called "super-allowed" decays leads to a determination of the fundamental quark-mixing matrix element V_{ud}. These studies require the half-life ($t_{1/2}$), the branching ratio (BR), and the Q-value of the decay, all of which can be measured at ISAC. A very successful campaign is still being carried out as shown in Figure 1.

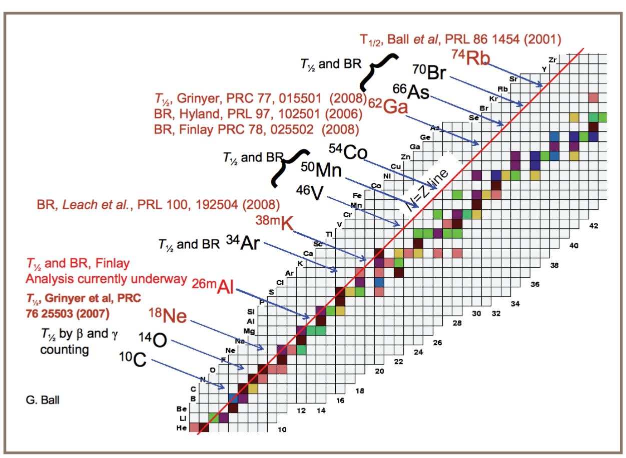


Fig.1. The figure shows super-allowed beta decay isotopes of interest, together with ISAC experiments already completed (red) and those forthcoming (black).

Critical nuclear astrophysics experiments have been performed that shed light on nucleosynthesis in so-called O-Ne novae. The DRAGON (**D**etector of **R**ecoils **a**nd **G**ammas **O**n **N**uclear Reactions) recoil separator has allowed the experimental group to perform three of the only five different direct radiative capture reaction measurements completed over the past 20 years, due to DRAGON's high resolution and ISAC's high beam intensity. One was a highlight experiment in nuclear astrophysics, namely the ^{21}Na(p,γ)^{22}Mg reaction.

Nuclear structure experiments performed at both ISAC-I and ISAC-II benefit from the very high beam intensities available only at those facilities. These intensities have made ISAC the best place to study so-called "halo nuclei" - nuclei with a compact core plus two far-away neutrons in classically-forbidden orbits. These exotic nuclei offer a stringent testing ground for our theory of the strong nuclear force. The GSI-TOPLIS collaboration carried out a charge radius determination of ^{11}Li which gave definitive evidence that it is indeed a two-neutron halo. The TITAN (**TRIUMF**'s **I**on **T**rap for **A**tomic and **N**uclear science) facility measured the short-lived (~8.6ms) ^{11}Li mass precisely for the first time, and from it derived the most precise measurement of the two-neutron separation energy (S_{2n}) (Figure 2). This confirmed the result of the very first experiment carried out at ISAC-II, namely the ^{11}Li(p,t)^{9}Li reaction using the MAYA active target detector. This experiment was only possible by exploiting the yield and the excellent beam quality at ISAC-II.

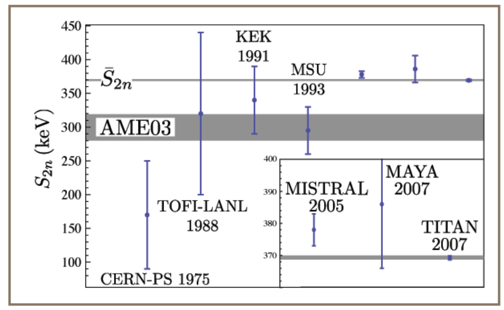


Fig.2. Two-neutron separation energy for Li-11 as derived from the TITAN.

The experiments highlighted here merely touch on ISAC's broad success during its first decade. More groundbreaking science awaits from newly-developed beams and upcoming experimental facilities like TIGRESS, EMMA, or HERACLES. TRIUMF ISAC is certain to continue playing a key role in the international nuclear physics community.

• Jens Dilling

Profile

Robert Laxdal

TRIUMF's Super(conducting) Man

No discussion of the first decade of TRIUMF's Isotope Separation and Acceleration (ISAC) program would be complete without a profile of accelerator physicist Robert Laxdal, who has been instrumental in both the ISAC-I and ISAC-II projects since their inception. Not only has he been a major contributor to the formation and development of the present ISAC accelerator facilities, Laxdal is also leading the initiative to develop superconducting radiofrequency (RF) technology for next-generator accelerators at TRIUMF. This technology will pave the way for the planned electron linear accelerator which will substantially expand the ISAC rare-isotope beam program and cement TRIUMF and Canada's role as leaders in the international accelerator network.

Bob was born and raised in Tisdale, Saskatchewan and completed both his B.Sc. (Honours) and M.Sc. in physics at the University of Saskatchewan (UofS) in Saskatoon. The lone accelerator physics masters student at the UofS, Laxdal was breaking new ground during his time as a graduate student, where he worked at the Saskatchewan Electron Linac, now repurposed as an electron source for the Canadian Light Source Synchrotron. Shortly after completing his graduate studies, Laxdal was lured to the west coast after seeing an advertisement for a position opening at TRIUMF. Although he thought he would always return to Saskatchewan, Bob has lived and worked in Vancouver and with TRIUMF for almost 30 years.

Laxdal joined the TRIUMF cyclotron group in 1980, eventually leading the team developing the 500MeV cyclotron to be used as an injector to the proposed KAON Factory. In 1995, he joined the ISAC project and led a number of design and commissioning teams responsible for the installation of the ISAC-I accelerators and beam lines. In 2000, he began developing superconducting RF technical expertise at TRIUMF with the goal to build and install a heavy ion superconducting linac (SC-linac) as part of the ISAC-II project. The initial phase of the ISAC-II linac was completed in 2006, with the commissioning of the medium-beta section whose accelerating gradients were significantly higher than those available at competing facilities.

> *"Working on ISAC ... was challenging and exciting."*

"The nice thing about the ISAC program was that the projects were smaller, we had a bare hall to work with, and we could design something, build it, and put it on the floor; it was a nice experience," said Laxdal, looking back on the last ten years. "Working on ISAC with one project building on top of another was challenging and exciting."

Laxdal is now collaborating with a local company, PAVAC Industries Inc., in the fabrication of superconducting cavities, a first for Canadian industry. The cavities will be used in the next phase of the SC-linac installation to be completed by the end of 2009. He is currently Deputy Head of the Accelerator Division, Head of the RF Department, and Project Leader for ISAC-II and the VECC Projects. Laxdal has also taught graduate level courses in accelerator physics at UBC and UVic – a recent initiative lead by TRIUMF.

When asked what initially drew him to physics, Laxdal replied, "I was always good at science and math in high school and since physics brought those two disciplines neatly together it seemed like a good fit." But when it really came down to the crucial decision between pursuing physics or chemistry, it was his 8:30am chemistry class in university that eventually sealed his fate as a physicist. Despite what would seem a fluke decision, Laxdal's achievements in and contributions to accelerator science both at TRIUMF and in Canada can testify to the fact that he is right where he belongs. **• Meghan Magee**

In The News

TRIUMF Hosts LHCOPN Meeting

From August 31, TRIUMF played host to a two-day meeting of the Large Hadron Collider Optical Private Network (LHCOPN), the private optical network supporting the four main LHC experiments that links CERN (Tier-0) and the 11 Tier-1 Data Centres around the world. (The TRIUMF Tier 1 centre supports the ATLAS collaboration.) The Tier system was developed to handle the projected 15 petabytes (15 million gigabytes) of data produced by the LHC annually. The single Tier-0, 11 Tier-1, over 150 Tier-2, and numerous Tier-3 Data Centres make up the Worldwide LHC Computing Grid (WLCG), -the data storage and analysis infrastructure for the entire LHC high energy physics community.

The meeting was attended by 20 network administrators from CERN and the Tier-1 centres that operate the LHCOPN, plus regional and national network providers that link the sites. The group discussed the operation, monitoring, and performance of the 10 gigabit/sec network between CERN and the Tier-1 centres, and discussed extending the LHCOPN operations model to include Tier-1-to-Tier-1 and Tier-1-to-Tier-2 data flows. Representatives from various data centres reported on their present and proposed network designs. The LHCOPN was commended for its performance during the first production demonstration in July of all the key WLCG computing elements from data taking to analysis.

This is the first time an LHCOPN meeting was held at a North American Tier-1 Data Centre and TRIUMF was privileged to host the event and showcase its own facilities.

T2K Celebrates Detecting First Neutrinos

As the world's physics gaze was fixed half a world away, a multinational team of scientists at the J-PARC accelerator laboratory in Tokai, Japan celebrated the production and detection of their first neutrino beams. Protons from the 50 GeV synchrotron were directed onto a carbon target to create an intense beam of pions, which subsequently decayed to produce the elusive neutrinos. As expected, at least three of these neutrinos were spotted by a sophisticated detector system 200 metres through the earth. This milestone marks the beginning of the operational phase of the Japanese-led Tokai-to-Kamiokande (T2K) experiment, run by nearly 500 physicists from a dozen nations worldwide,

Canadian spokesperson, TRIUMF Research Scientist Akira Konaka, said, "With the discovery of the phenomena of neutrino oscillations from solar neutrinos at SNO in Sudbury, Canada and from cosmic-ray neutrinos at Super-Kamiokande in Japan, Japan and Canada are taking the lead in the field of neutrino physics. With [confirmation] that we can produce neutrinos and observe them as planned at J-PARC, we are eager to move on to the physics data-taking phase."

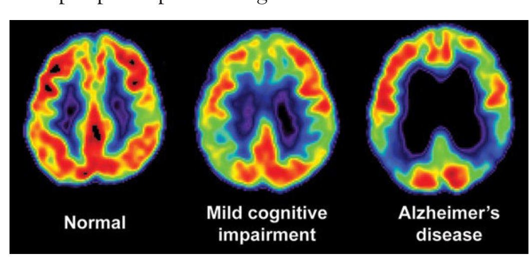
Since its inception, Canadian scientists have been key players in the T2K experiment. Projects include contributions to the off-axis beam design concept, proton beam transport from the accelerator to the carbon target, proton beam monitoring, and remote handling systems for the maintenance of the final focus beam monitors, the target, and the focussing horn.

PET Program Joins Major Alzheimer's Study

The Alzheimer Society of Canada declared that within a generation, up to 1.3 million people could be living with Alzheimer's disease (AD) or related dementias, and today more than 71,000 Canadian dementia sufferers are under the age of 65. These sobering statistics helped spur the University of British Columbia (UBC) and TRIUMF Positron Emission Tomography (PET) groups to play a major role in a ground-breaking study that could significantly advance understanding of these debilitating diseases.

The Alzheimer's Disease Neuroimaging Initiative is being extended by new studies involving 16 North American PET centres, including UBC and TRIUMF. These studies use PET to image the extracellular deposits of protein aggregates in the brain, an AD characteristic which until now could not be definitively diagnosed without an autopsy. New non-invasive PET techniques have been developed for the direct and quantitative assessment of AD in living subjects.

These studies will be conducted in AD, mild cognitive impairment (MCI), and healthy control subjects. MCI is a transition stage between the cognitive decline of normal aging and the more serious effects of Alzheimer's disease. The MCI patient study will asses whether patients progress into AD and will look for markers to use to track the decline. Hopefully these imaging studies will lead to a predictive test or effective treatment of AD, which would be extremely beneficial to people experiencing MCI.



PET scans of normal, mild cognitively impaired, and Alzheimer's diseased patients.

Calendar

February 12-14, 2010 Banff http://wnppc10.phys.uvic.ca/	WNPPC	Winter Nuclear and Particle Physics Conference
March 26, 2010 TRIUMF	BOM	Board Meeting
April 8-9, 2010 TRIUMF	LSPEC	Life Science Program Evaluation Committee
May 14-15, 2010 TRIUMF	ACOT	Advisory Committee on TRIUMF
June 18, 2010 TRIUMF	BOM	Board Meeting
June 21-July 2, 2010 UBC http://nnpss-tsi.triumf.ca/	NNPSS-TSI	TRIUMF Summer Institute with National Nuclear Physics Summer School
July 4-9, 2010 Vancouver http://inpc2010.triumf.ca	INPC2010	International Nuclear Physics Conference

Paul Schaffer Joins Nuclear Medicine Division

On August 4th, TRIUMF welcomed Dr. Paul Schaffer as the new Deputy Head of the Nuclear Medicine Division. Dr. Schaffer brings a wealth of experience and expertise in nuclear medicine imaging and therapy and was most recently Lead Scientist for organic radiochemistry with GE Global Research in New York.

"We're thrilled that Dr. Schaffer has joined our team of leading researchers and scientists," said Dr. Nigel Lockyer, TRIUMF Director. "His extensive knowledge and experience in nuclear medicine and radiochemistry will continue to keep TRIUMF at the forefront of innovation. It's another example of TRIUMF's ability to attract the world's best scientists to conduct research here in Canada."

Dr. Schaffer has a Ph.D. in Chemistry from McMaster University and is recognized as a technical leader for his work related to radiopharmaceutical development, working extensively with medical isotopes such as Technetium-99m and Fluorine-18. Dr. Schaffer also will be responsible for managing the new research and development component of the Nuclear Medicine Division as TRIUMF pursues global-leadership in the field as part of its five-year plan. The position manages a research program aimed at exploiting the lab's science and technology capabilities, emphasizing development and characterization of new radiotracers.

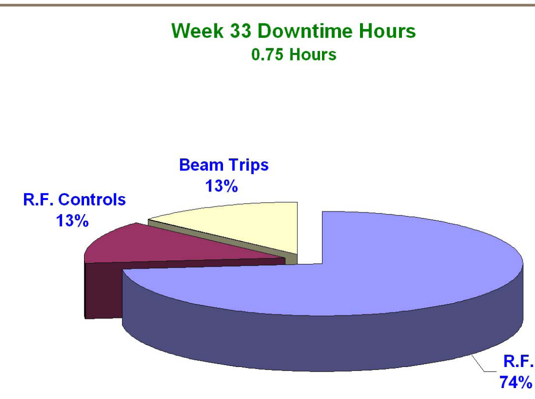
"I'm pleased to be coming home to Canada to join TRIUMF at one of the most pivotal times in the industry," says Dr. Schaffer. "TRIUMF is a long-standing Canadian research institution with world-leading science and technology and I'm excited to be part of the future of this laboratory."

Cyclotron Improving With Age

Like a fine wine, TRIUMF's 500 MeV Cyclotron is getting better with age. During the week of August 10-17, 2009, the main cyclotron broke a beam-delivery record, experiencing only 50 minutes of maintenance, 48 minutes of downtime, and 6 minutes of cyclotron tuning – total beam off of only 2.45 hours! - leaving beam on for a record 165.55 hours. According to Jamie Cessford, Cyclotron Operations Coordinator, this is almost an hour longer than the previous record achieved late November 2008.

The Accelerator Division has introduced new initiatives to monitor and improve beam delivery, including changing the historical maintenance program to better reflect the current experimental rhythm. The once-compulsory 12-hour weekly maintenance has been replaced by "maintenance if required", except in designated weeks to accommodate specific tasks. Also, implementation of new downtime reporting methods and delivery yardsticks has improved beam delivery quality. Weekly and year-to-date statistics on downtime per group and beam availability will be posted around TRIUMF to raise awareness of the different factors contributing to downtime.

The 500 MeV cyclotron is the heart of TRIUMF and reliable beam delivery is essential to the lab's success. As a result of careful monitoring and system upgrades, the cyclotron is keeping fit and youthful through its middle age.



Cyclotron downtime during August 10 - 17, 2009

Back to School

An eager young girl plays with TRIUMF Scientist Peter Gumplinger's magnetism exhibit during TRIUMF's 40th Anniversary Open House. More than 1300 visitors attended the event.

Tim Meyer shows some budding young scientists the tracks left behind by cosmic-rays in TRIUMF's cloud chamber at the 2nd Annual UNA Barn Raising at the UBC Old Barn Community Centre September 12.

Shad Valley students Victoria Loosemore and Teddy Leung pose during a break from their duties. They spent August working in TRIUMF scientist Jens Lassens' laser ionization laboratory.

At the end of their summer work terms, High School Fellowship winners Jeremy Johnson and Anffany Chen (far left and right) , and aboriginal student intern Dylon Martin (in red) , accept their awards from Accelerator Division Head Lia Merminga.

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