Beamtime

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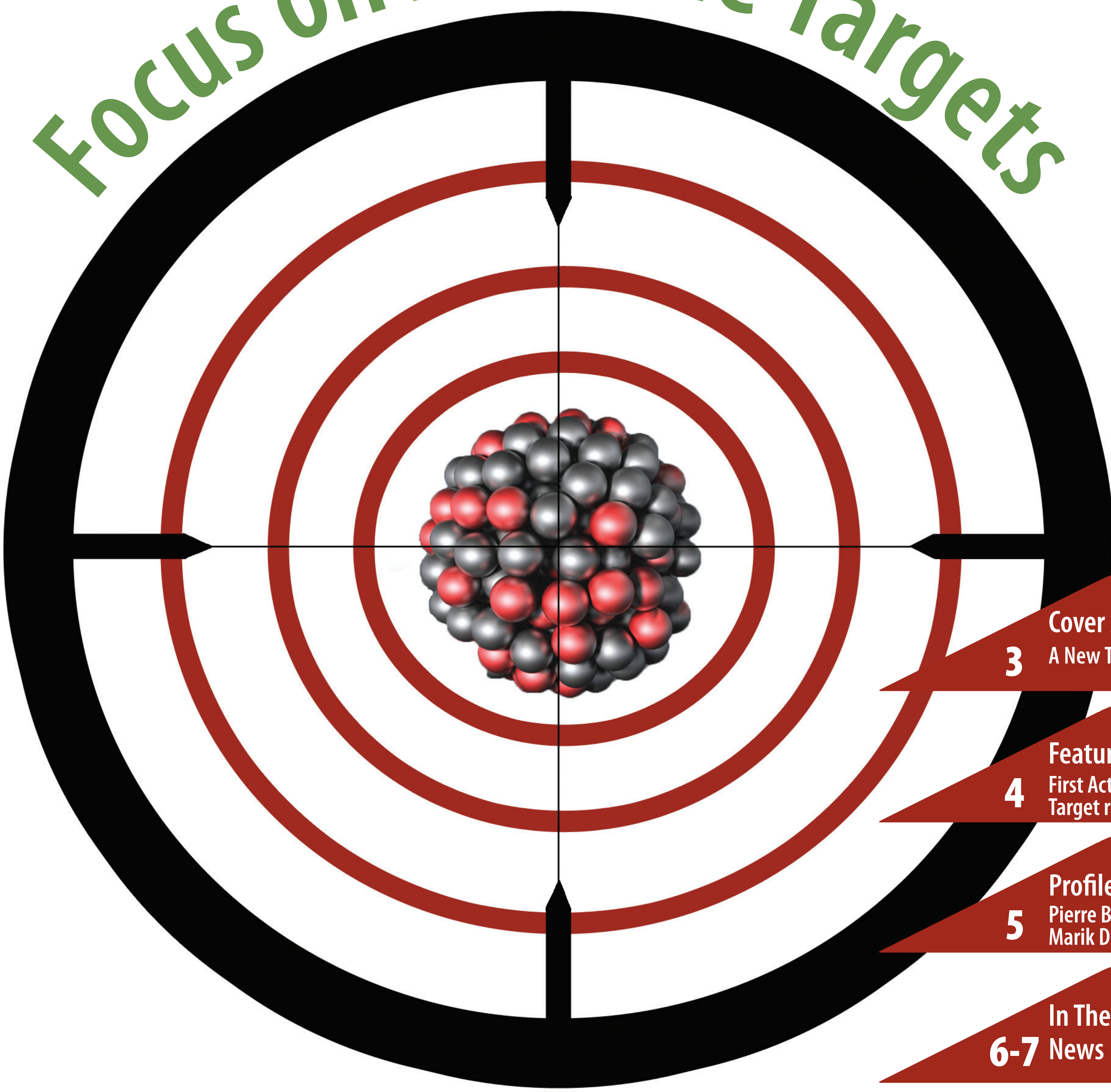
TRIUMF

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

Focus on Actinide Targets



Director's Voice

Putting Canada in the Lead of Isotope Physics Research

Most accelerator laboratories choose a particle and stay loyal to it. TRIUMF has accelerated protons for over 40 years. However, TRIUMF is breaking into new territory. As you will note in Mike Craddock's article on the back page, here we are forty years later and a new TRIUMF team is constructing a "Made in Canada" complementary accelerator to the award-winning 500 MeV cyclotron — and this one will use electrons. When the first phase is completed in early 2015, the e-linac will be a state-of-the-art ~50 MeV high-power 100 kW electron accelerator. Together the cyclotron and e-linac will place Canada in a unique position in the world of rare-isotope beam physics research. These two accelerators together will open a new era of research that can only be described as exciting. The goal is simple but ambitious: understand the origin of the heavy chemical elements such as gold, develop a fundamental theory of the nucleus using measurements made first at TRIUMF, and explore the production and use of new isotopes for medicine. The technical challenges in front of us now are many, but if we follow the footsteps of the cyclotron builders, we will achieve success and the great journey of scientific rewards will follow.

> "TRIUMF is breaking into new territory"

Beyond the journey of scientific discovery, though, this project will again expand TRIUMF's contributions to the Canadian economy. Earlier, Ebco Industries' involvement in the construction of the main 500 MeV cyclotron led to the spin-off of Advanced Cyclotron Systems, Inc., that manufactures TRIUMF-inspired medical cyclotrons for use around the world. The e-linac design and technology bring additional benefits to Canada. Key elements of the technology are now being commercialized by PAVAC Industries, Inc., in Richmond. PAVAC has grown from 10 employees in 2007 to over 40 today. Their industrial floor space has expanded from 3,000 square feet to over 30,000 square feet. This high technology company benefits from TRIUMF but we also benefit by co-developing with PAVAC. Their e-beam welding technology is world-class and the advanced accelerator devices designed for TRIUMF are in turn sold by PAVAC to their growing international customer base. A true team effort. We aim to repeat, and if we're lucky, exceed the tremendous legacy of the original cyclotron and its builders.

Cover Story

A New Era for Isotope Production

Actinide Targets Open Up Unexplored Vistas for TRIUMF Experiments

At ISAC, rare-isotope beam (RIB) production by bombarding targets like silicon or tantalum with 500 MeV protons from the cyclotron has been routine for many years. However, certain radioactive isotopes of great importance for the ISAC scientific program, such as radium, francium, astatine, and radon as well as very neutron-rich isotopes of lighter elements, are simply too heavy or contain too many neutrons to be produced as spallation or fission reaction products from these targets. Only uranium — and a few other actinides — at the very end of the periodic table of stable elements fulfill the necessary preconditions.

The first results of TRIUMF's new actinide target program were obtained in 2008, with test runs using limited proton beam currents to establish operational procedures and safety protocols. In 2011, an operating license was obtained from the Canadian Nuclear Safety Commission to irradiate actinide targets up to 10 μA currents of 500 MeV protons. So far, no other RIB facility in the world can match this integrated beam power.

Uranium dicarbide (UC_2) has the right properties — high thermal conductivity, low vapor pressure — to withstand a 10 μA proton beam. Procedures to manufacture UC_2 by carbothermal reduction ($UO_2 + 4C \rightarrow UC_2 + 2CO_{(g)}$) had to be developed in the ISAC Actinide Target Laboratory. A high vacuum furnace bakes a mixture of UO_2 and graphite at temperatures up to 1750 °C until the reduction process is completed. The final products are D-shaped target discs with approximately 50 mg/cm^2 UC_2 slip-cast on a graphite backing. Up to 400 target disks can be stacked into to a standard target container.

A highlight from the first 10 μA UC_2 run in December 2011 was extracting neutron-rich magnesium isotopes up to ^{35}Mg with resonant laser ionization. The upgraded ISAC yield station data acquisition system was instrumental in gaining new insights into the half-lives of neutron-rich Mg isotopes and in the discovery of previously unknown gamma transitions in ^{33}Mg and ^{34}Mg. The interesting aspect of this run was significant extraction of radium and actinium isotopes two weeks *after* the last proton irradiation ended. These and other successes (see Feature Story), bode well for the future of RIB at TRIUMF.

• Peter Kunz

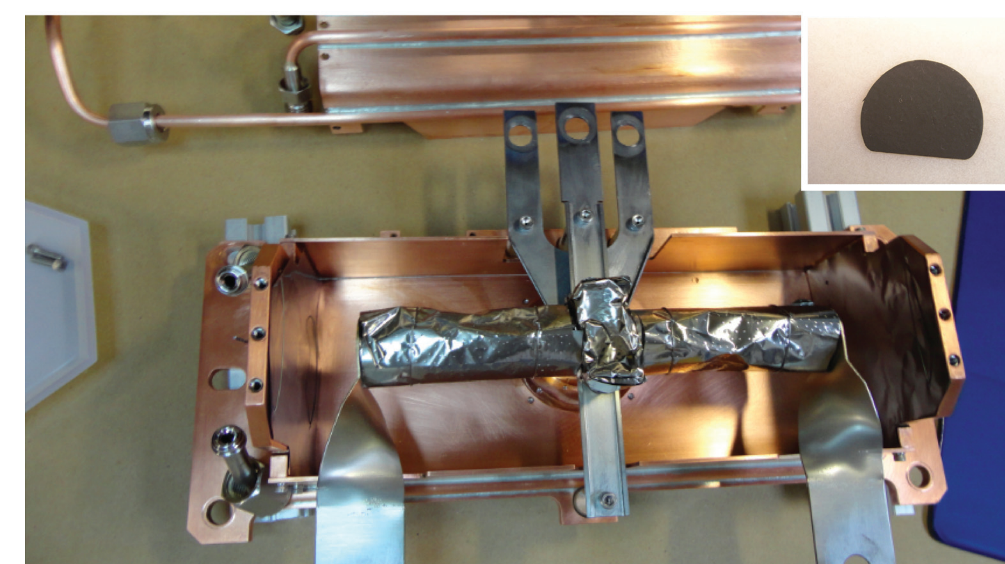


Figure: Uranium carbide target. The tantalum target container, mounted inside a copper heat shield, contains up to 400 thin, D-shaped uranium carbide discs (upper right corner).

First Results of Actinide Target Era

Precision mass cartography of the island of inversion using TITAN

Progress in our understanding of the natural world often coincides with experimental advances enabling new classes of measurements not otherwise possible. This phenomenon is evident with each higher energy accelerator pushing fundamental particle physics, but it is no less significant in nuclear physics, where creating exotic isotopes of sufficient quantity and purity is crucial to advancing nuclear structure research. A great example is the recent development of uranium carbide targets at TRIUMF, which is enabling scientists to make important headway in our understanding of nuclear structure around the theoretically-important "Island of Inversion".

Nuclei with a so called "magic number" of protons or neutrons (Z or N=2, 8, 20, 28, 50 and 82) and neutrons (N=126) are more tightly bound than their neighbours. The "shell model" arose from this fact and led to the Nobel Prize for Goeppert-Mayer and Jensen in 1963. However, the theory's ability to describe nuclear structure diminishes the more unstable the nucleus, spawning ongoing interest on whether nuclear magic numbers exist for nuclei far away from stability. Structural anomalies for very unstable nuclei around the neutron magic number N=20 were first discovered from studying sodium isotopes at CERN, which have been traced to nuclear deformation and the resultant inversion of the standard sd-shell and pf-shell intruder configurations. Thus, the region of neutron-rich nuclei with $10 \le Z \le 12$ and $20 \le N \le 22$ is known as the "Island of Inversion" (see Figure) and its elucidation has been the focus of much recent experimental effort, in particular at TRIUMF ISAC's facility using the TITAN Penning trap mass spectrometer.

Penning traps are the most accurate tools for high-precision mass spectrometry of atomic nuclei. TITAN scientists have performed such measurements on ten short-lived neutron-rich magnesium (Mg), sodium (Na) and aluminum (Al) nuclei around N=20. TITAN is the only facility capable of carrying out such high-precision mass measurements of these nuclei due to the very short half-lives involved, due to advances in ISAC's uranium carbide isotope production target and resonant laser ionization. Several of the masses near the Island of Inversion have been significantly improved with some significant deviation from literature values. The new precise mass values from TITAN now map the vanishing of the shell closure around ^{32}Mg isotope.

• Jens Dilling

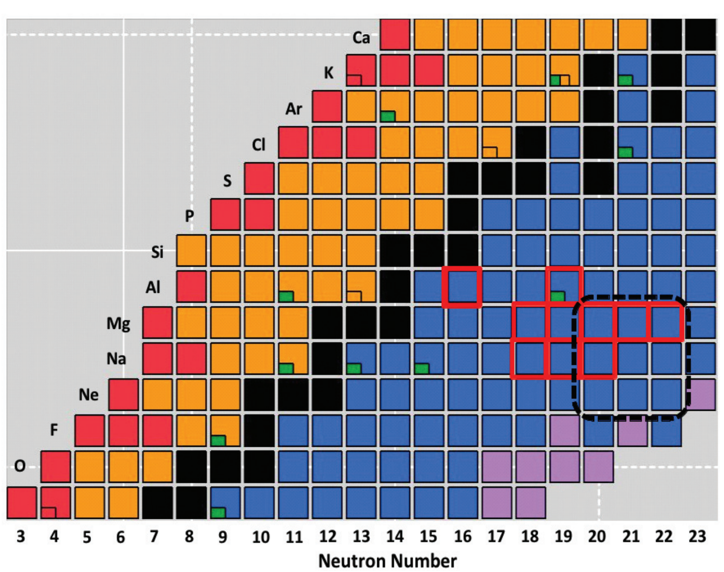


Figure. The position of the island of inversion in the nuclear chart is marked by the dashed rectangle. The masses of the nuclei marked by the red-bordered rectangle were measured at TITAN. The color of the boxes denotes the nuclear decay modes; black: stable nuclide, blue: β^- decay, orange: β^+ decay, red: proton emitter, and violet: neutron emitter.

For more: titan.triumf.ca

Pierre Bricault and Marik Dombsky

On Target With Isotope Beam Development

At the core of every facility at TRIUMF are indispensible people who labour tirelessly to make the lab work as well as it does. Pierre Bricault and Marik Dombsky are the dynamic duo at the launching point of TRIUMF science, namely isotope production at ISAC. Beamtime caught up with these busy scientists to ask them a few questions.

How did you come to work at TRIUMF?

Marik: I did my doctoral thesis here on the TISOL project, and because of that experience, I decided to work on ISAC. I became staff in 1995.

Pierre: I arrived at TRIUMF in March 1993. I was working in France at the GANIL laboratory when I came on a 6-month sabbatical leave. I ended up staying when the ISAC project resurfaced.

What is your role at TRIUMF now?

M: I'm basically the ISAC target scientist, finding a way to produce a particular isotope beam when a scientist requests it.

P: I am the Group Leader of Target/Ion Sources, covering the meson hall targets, the solid target facility for medical isotopes production, and of course the ISAC targets.

What was one of the first experiments you worked on at TRIUMF and what are you working on now?

M: As a graduate student, I was working on proton-induced negative-pion production from bismuth, doing irradiations here and elsewhere to get measurements from 100 to 800 MeV.

Right now, I'm mainly in target development but sometimes take part in experiments with visiting scientists, the latest with an Oregon State group working on Lithium-11 fusion on lead.

> "*TRIUMF is really doing a lot with a little*"

P: When I arrived at TRIUMF I began working on a TISOL upgrade, but then moved to the new ISAC project when KAON wasn't funded. I worked on a brand new resonant circuit, a continuous-mode Split-Ring 4-rod radio-frequency quadrupole (RFQ), which ultimately became the first ISAC accelerator.

Right now I am planning and designing targets for the ARIEL project.

What is the biggest challenge you've faced during your time at TRIUMF?

M: No money, no resources, no time. That's about it.

P: The biggest challenge is the resources. TRIUMF is really doing a lot with a little compared to other laboratories in the field.

Most memorable experience at TRIUMF?

M: Building ISAC–I. TRIUMF, really is a small lab on an international scale, yet we managed to do something beyond what a lab our size should have done. It was very satisfying being part of very hard-working and dedicated team.

P: The coffee, or what they were calling coffee, when I first arrived at TRIUMF.

Seriously, it was to see how ISAC changed the laboratory. People are proud to work at TRIUMF.

• Jordan Pitcher

In The News

Canadian report finds opportunity for PET in clinical care of cancer

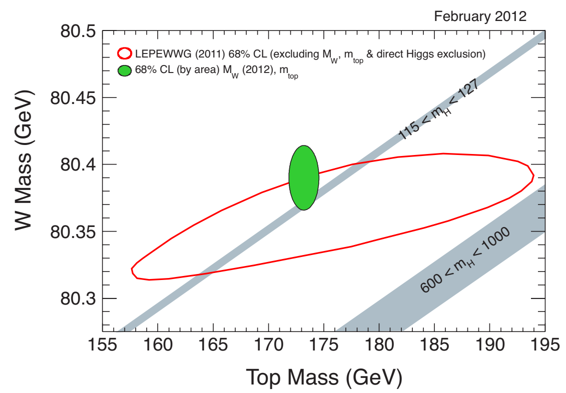
A report by independent medical-research consultant Susan D. Martinuk suggests that utilization of Positron Emission Tomography (PET) for the diagnosis, staging, and monitoring of cancer treatment varies widely across Canada, putting cancer patients in some areas at a distinct disadvantage. "The Use of Positron Emission Tomography (PET) for Cancer Care Across Canada: Time for a National Strategy" was prepared for TRIUMF and AAPS, Inc., documenting how PET imaging is already integral to cancer care in most developed nations, and how increased utilization could provide more clinically and cost-effective treatment for cancer patients in Canada. A nationally coordinated strategy to take up and standardize this technology could bring Canada back to the forefront of global cancer care.

Martinuk compiled the report by interviewing nuclear-medicine leaders in each province and collecting data about the deployment and utilization of PET-based technology for clinical oncology. She concluded that "PET is revolutionizing clinical cancer care in the United States and Europe, yet many Canadian doctors and policy officials continue to see PET as experimental and unproven technology. Cancer patients can suffer because of this reluctance." Studies show that PET is clinically effective, affecting the planned treatment regime of a patient in 36.5% – 50% of cases.

Canadian investigators surround last Higgs hideout

For decades, investigators have been searching for the elusive Higgs boson, never finding it but systematically ruling out places where the enigmatic 'God particle' could be hiding. At long last, they have surrounded the last place where it could be located, and so will soon reveal the Higgs, or discover it never existed at all.

Results released in late 2011/early 2012 by the ATLAS and CMS Collaborations at the Large Hadron Collider (LHC), and the CDF and DZero Collaborations at the (now defunct) Tevatron at Fermi National Accelerator Laboratory (Fermilab), have restricted the mass that the Higgs boson would have to between about 115-127 GeV. The LHC and one Fermilab result arose from searches for direct evidence of the Higgs from data accumulated until 2011. Both showed tantalizing indications, but not proof, that the Higgs boson was indeed detected (~3 sigma significance at LHC, and ~2 sigma at FermiLab). The other Fermilab result restricted the Higgs mass to a range compatible with the direct searches through precision measurements of the W boson and top quark masses (see figure). "Trigger-happy" investigators are busy fine-tuning their analyses since it is expected that by the end of 2012 the LHC will have accumulated enough data to make a definitive statement on the Higgs. The world will then know if the God particle was finally found, or never existed in the first place.



Tim Meyer Recognized as "Top 40 Under 40"

Tim Meyer, Head of Strategic Planning and Communications, was recognized as one of the "Top 40 Under 40" for 2011 by Business in Vancouver. Dr. Don Brooks, a member of TRIUMF's Board of Management, remarked that Tim "is one in a million and we are delighted to have him with us. This is a richly deserved award." Since beginning at TRIUMF, Tim has made great contributions to the lab's communication, outreach, long-term planning, and partnership efforts. From the entire TRIUMF community, congratulations, Tim!

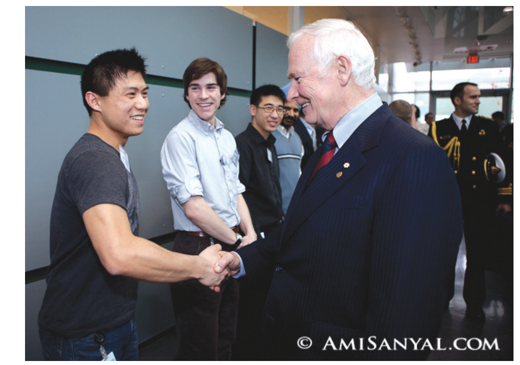
The Business in Vancouver article can be found at:
http://www.biv.com/article/20111227/BIV0208/312279960/-1/BIV0203/tim-meyer

AAAS 2012: A Big Success For TRIUMF and Canada

The 2012 Annual Meeting of the American Association for the Advancement of Science (AAAS 2012) took place in Vancouver from February 16th to 20th. Held in Canada for first time in 30 years, the "world's largest general science conference" attracted a record breaking 12,478 participants, including over 5,300 delegates, 760 journalists and 6,400 members of the general public during Family Science Days. TRIUMF was heavily involved in AAAS 2012, with Tim Meyer serving as chair of the Vancouver Local Organizing Committee and also serving on the Canada National Steering Committee, while the lab was involved in a number of events that showcased TRIUMF and Canadian research on the national and international stage.

TRIUMF and the Canada@AAAS organizing group successfully promoted and bolstered Canada's reputation as a global science and technology leader through a carefully coordinated campaign that garnered much media attention. Among the highlights for TRIUMF were: visits to the lab of high-profile VIPs, in particular His Excellency the Right Honourable David Johnston, Governor General of Canada (see photo); intense public exposure at the Family Science Days and the Big Science kiosk at the Canada Pavillion; high-value networking with international media at several social events; and unprecedented levels of positive national and international media attention to TRIUMF successes announced at the meeting. In particular, there was an announcement by TRIUMF, BC Cancer Agency, Lawson Health Research Institute, and the Centre for Probe Development and Commercialization of the development of a method to produce important medical isotopes that up to now have needed nuclear reactors

Overall, the meeting was a spectacular success, with the AAAS executive calling it "the best ever", and all organizers are to be enthusiastically congratulated on a job very well done.



His Excellency the Right Honourable David Johnston, Governor General of Canada, meets with students at TRIUMF

Calendar

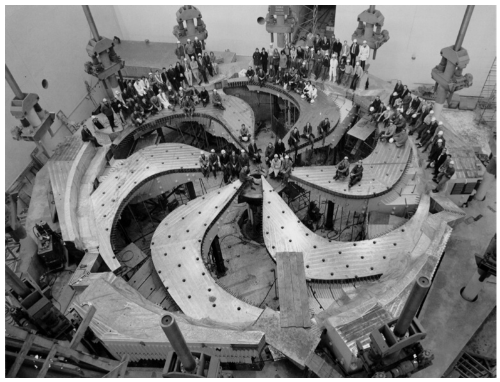
June 4-9, 2012 TRIUMF http://plhc2012.triumf.ca	PLHC2012 Physics of LHC in Vancouver Conference
June 21, 2012 TRIUMF	Scientific Symposium in Honour of Tom Ruth
July 6, 2012 TRIUMF	BOM TRIUMF Board of Management Meeting
July 9, 2012 TRIUMF	TUG AGM TRIUMF Users Group Annual General Meeting
July 10-11 2012 TRIUMF	ARIEL Science Workshop
July 11, 2012 TRIUMF	Scientific Symposium in honour of Gordon Ball
July 12-13, 2012 TRIUMF	SAP-EEC Subatomic Physics Experiments Evaluation Committee
July 16-17, 2012 TRIUMF	IIPW Innovations and Industrial Partnerships Workshop
August 1-4, 2012 UBC http://www.phas.ubc.ca/~wipc2012/	WIPC2012 Women in Physics Canada Conference
August 6-17, 2012 TRIUMF http://tsi2012.triumf.ca/	TSI2012 TRIUMF Summer Institute and 2012 US Summer School on Fundamental Neutron Physics
Feb 21-22, 2013 TRIUMF	ICFA meeting International Committee on Future Accelerators

Looking Back

Forty Years On

July 1971 – May 1972: Cyclotron Construction Begins

With the cyclotron building complete, the major activity over this period was the assembly of the cyclotron magnet and vacuum tank. The first of the six magnet sectors arrived in July 1971, having occupied nine flat cars on the rail journey from Davie Shipbuilding in Quebec. By January all had arrived and the lower sectors had been installed in the vault, allowing the entire staff to pose for a memorable photo. (see top centre)



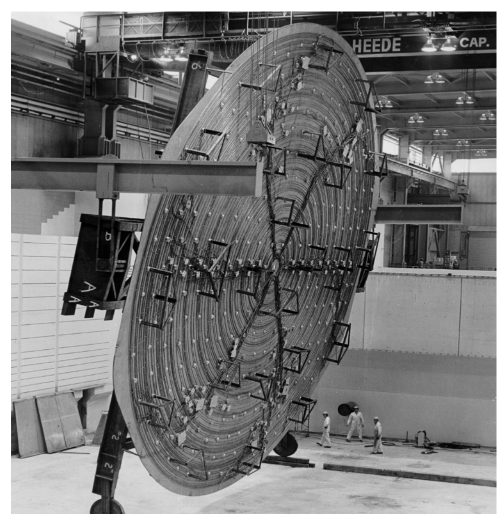
Meanwhile, Ebco had been busy in the Meson Hall assembling the gigantic (15-m diameter) stainless-steel vacuum tank, with its myriad field-adjustment and water-cooling coils. Tests showed that there were no leaks, and indeed a vacuum of 2 x 10^{-7} Torr (one 4-billionth of an atmosphere) was achieved on the first pumpdown – a real tribute to the skill of the welders. In February, the tank and lid were lifted over the vault wall and lowered on to the lower magnet sectors, allowing the upper sectors to be installed in March. The 664 tie rods (to support the 2660-tonne atmospheric load on each face of the tank) were also installed, followed in April by the massive spider-web support structure. Only the welding together of the six upper coil sectors remained to make the magnet complete.

On the Central Region Cyclotron (CRC), tests led to various improvements in the resonator design, the fine tuning mechanism, and the amplifier's control circuitry. For better radial centring of the beam, it was decided to move the injection gap by 36° into line with the dee gap. This required redesign of the spiral inflector, and a prototype was then manufactured using UBC's novel computer-controlled milling machine and successfully tested to full voltage in vacuum. These efforts were crowned by the first successful injection of beam into the CRC on May 12th.

On the personnel side, John Warren completed his term as Director in September 1971, and was succeeded by Reg Richardson from UCLA, the originator of the H$^-$-cyclotron meson-factory concept and a valued consultant since 1965. Other notable new appointments were Peter Bosman, Fritz Choutka, John Cresswell, Dennis Healey, Corrie Kost, Ken Lukas, Gerd Ratzburg, Pat Sparkes, Gary Wait, and Marge Williams.

Another important milestone in September had been the first selection meeting of the Experiments Evaluation Committee, at which no less than 29 proposals were considered. Such an enthusiastic initial response by the user community spoke well for the future!

• Mike Craddock



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