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OPERATED AS A JOINT VENTURE

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UNDER A CONTRIBUTION FROM THE
NATIONAL RESEARCH COUNCIL OF CANADA

OCTOBER 2005

The contributions on individual experiments in this report are outlines intended to demonstrate the extent of scientific activity at TRIUMF during the past year. The outlines are not publications and often contain preliminary results not intended, or not yet ready, for publication. Material from these reports should not be reproduced or quoted without permission from the authors.

INTRODUCTION

This has been an exciting year for TRIUMF. Groundbreaking results are emerging from the scientific program and new facilities are coming on line. In addition, during the year the University of Toronto joined TRIUMF's consortia of universities as a full member and Saint Mary's University joined as an associate member. TRIUMF now has six full member universities and seven associate member universities, representing every region of Canada.

At the core of the ISAC scientific program is the production of intense beams of radioactive nuclei. At ISAC unstable nuclei are produced by nuclear reactions initiated by a 500 MeV proton beam on a thick target. After production, atoms of the unstable nuclei diffuse from the target where they are then directed through an ionizer; the radioactive ions are controlled by electric and magnetic fields. A surface ionizer can produce alkali ions with high efficiency. In particular there is considerable scientific interest in the production of unstable lithium isotopes. ^{11}Li is an isotope that is of considerable interest to many people around the world and since ISAC has developed the most advanced ^{11}Li beam, various international teams are exploiting this capability. For example, during the year this beam has been used to probe the electrical charge distribution of this very exotic nucleus. The Canadian-German scientific team undertaking this work has produced groundbreaking results concerning the fundamental structure of ^{11}Li.

Another unstable isotope, ^{8}Li, is proving to be an excellent probe to study nanostructures of materials. In collaboration with scientists from BC universities, TRIUMF has developed a special technique, β-NMR, using an intense beam of ^{8}Li to undertake such investigations. During the year, important new results demonstrated the tremendous power of this technique which will undoubtedly contribute very significantly to the development of this new field of nanostructures.

A surface ionizer produces intense beams of alkali atoms, but to extend the range of species of isotopes other ionizing methods are needed. A particularly good method for producing isotopes, but technically very challenging, is to use high-powered lasers to selectively ionize the short-lived isotopes once they have been produced in the target. During the year, experimenters at TRIUMF used the first laser-ionized, pure isotopic beam. The laser ionization project is over a year ahead of schedule and shows great promise to be the method of choice to produce such beams in the future.

During the year, significant milestones were reached and passed in the construction of the new ISAC-II accelerator. Reaching and passing these milestones is particularly significant because a new type of technology, involving superconducting accelerating cavities, had to be mastered by the TRIUMF Accelerator Division. It is immensely pleasing that during the year a section of the accelerator was completed and shown to accelerate alpha particles successfully from a radioactive source. The challenge ahead for TRIUMF is to build all the necessary sections required to complete the full ISAC-II accelerator.

Along with facility enhancements, excellent progress has been made in the development of two important ISAC experimental facilities: TIGRESS and TITAN. Both these instruments, when completed, will be world leading so it is perhaps no surprise that large international collaborations are building around them.

The 500 MeV cyclotron has worked well during the year with an actual beam delivery of over 90% of the scheduled delivery. The cyclotron proton beams are not only used to produce isotopes for ISAC, but also to produce intense beams of muons for various experimental purposes. The TWIST experiment to study the decay properties of the muon to high precision had a successful year with the completion of the first phase of the experiment, the results of which are now published. The muon beams are also used for a wide variety of experiments within the molecular and materials science area. The muon spin rotation technique is an excellent method to probe the magnetic nature of materials. A particular highlight of this method is its use in the investigation of the physical parameters that determine the magnetic vortex size in type-II superconductors.

A vital part of TRIUMF's mission is not only to provide support for the subatomic physics program within Canada, but also to support the subatomic physics program based at facilities outside Canada. During the year, TRIUMF provided continued support for the CERN program, the HERMES experiment at DESY, the $G\emptyset$ and Q_{weak} programs at the Jefferson Laboratory, and the rare kaon decay experiment at Brookhaven National Laboratory.

Canada's contribution to CERN has been substantial over the last 10 years. For the LHC accelerator complex, TRIUMF has been involved in various projects. The largest of these projects has been the design, manufacture, and testing of 52 twin aperture quadrupoles. During the year, the final shipment of the magnets occurred and so now the whole project has been successfully completed. TRIUMF is also responsible for two of the LHC injector kicker magnet systems, and during the year about half of the components needed for this were shipped to CERN. On the detector side, Canada is making substantial contributions to the ATLAS detector; in particular, the hadronic end-cap calorimeters. Of particular note is the successful in-beam tests of components of this calorimeter system.

During the year, TRIUMF established a collaboration with the Japanese accelerator facility J-PARC to undertake an experiment that will help explain the enigmatic nature of one of the most populous particles in the universe, the neutrino. This experiment follows on from the successful work carried out at the Canadian Sudbury Neutrino Observatory (SNO) – work that TRIUMF has supported for many years.

One of TRIUMF's main successes in the area of technology transfer is the long-standing collaboration with MDS Nordion. Using TRIUMF-run cyclotrons, MDS Nordion produces medical isotopes, which are distributed across North America and internationally. These isotopes are used for medical therapy and diagnostic purposes. Currently, over two and a half million patient procedures are carried out each year with isotopes produced at TRIUMF. The Natural Sciences and Engineering Research Council (NSERC) recognized this unique collaboration and its achievements by awarding the 2004 University-Commercial Synergy Award to TRIUMF and MDS Nordion. TRIUMF will use the financial portion of the prize to award scholarships to life sciences students involved in TRIUMF-based life sciences research.

Students, undergraduates and postgraduates are our future. As in previous years, TRIUMF was host to many student groups during the year. In particular, a successful Summer Institute was hosted by TRIUMF for young scientists fascinated by the nuclear processes that drive the dynamics of stars. The summer school was planned to coincide with a TRIUMF-hosted international conference on astrophysics, the same subject the students were studying.

TRIUMF has had a very successful year. That TRIUMF is attracting young students and scientists is particularly pleasing to all of us at TRIUMF; our success is their future.

Alan Shotter

A. Shotter,
Director