TRIUMF

ANNUAL REPORT
SCIENTIFIC ACTIVITIES
2005

ISSN 1492-417X

CANADA'S NATIONAL LABORATORY
FOR PARTICLE AND NUCLEAR PHYSICS

OPERATED AS A JOINT VENTURE

MEMBERS:

THE UNIVERSITY OF ALBERTA
THE UNIVERSITY OF BRITISH COLUMBIA
CARLETON UNIVERSITY
SIMON FRASER UNIVERSITY
THE UNIVERSITY OF TORONTO
THE UNIVERSITY OF VICTORIA

ASSOCIATE MEMBERS:

THE UNIVERSITY OF GUELPH
THE UNIVERSITY OF MANITOBA
McMASTER UNIVERSITY
L'UNIVERSITÉ DE MONTRÉAL
QUEEN'S UNIVERSITY
THE UNIVERSITY OF REGINA
SAINT MARY'S UNIVERSITY

UNDER A CONTRIBUTION FROM THE
NATIONAL RESEARCH COUNCIL OF CANADA

DECEMBER 2006

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.

SCIENCE DIVISION

INTRODUCTION AND OVERVIEW

We started 2005 with great expectations that our Five-Year Plan funding would recognize both the enormous strides TRIUMF has made to become the pride of Canadian science and the exciting future scientific potential of the laboratory. In February, the announcement of a $222M funding for the next five years ($50M short of the recommendation of the international review committee set up by the NRC) did not convey that message, and a considerable damper was placed on our aspirations. Nevertheless, our staff responded by once again accepting that we will have to do more with less. As this report illustrates, the science continued to flow, albeit with major delays and some cancellation of programs.

More and more, ISAC is becoming the reference facility for nuclear physics with exotic beams. The investments made at TRIUMF in world-class facilities, together with the recognition by the Natural Sciences and Engineering Council of Canada (NSERC) which funded world-class instruments required to exploit the laboratory's potential, are now bearing fruit.

The highlight for 2005 at ISAC was the first acceleration of a ^{11}Li beam, which paves the way for a comprehensive program of study of this halo nucleus using nuclear techniques that are well established with stable beam reactions. Combined with exciting new progress in laser ionization from the TRILIS group, ISAC is delivering very attractive high intensity beams unique in the world.

The nuclear astrophysics program, based on ISAC-I accelerated intense beams and on the DRAGON facility, produced a first definitive measurement of the strength of resonance at 188 keV in the ^{26g}Al(p,γ) reaction which controls the destruction of the ^{26}Al in novae. This was a *tour de force* experiment, which placed ISAC at the forefront of nuclear astrophysics. The DRAGON facility was also used to measure a key reaction for the production of ^{44}Ti via the ^{40}Ca(α,γ) reaction. Several other programs contributed to nuclear astrophysics studies with stable beams from OLIS. In preparation for future experiments in that vein, three ^{22}Na targets were made and will be used at the University of Washington to measure the ^{22}Na(p,γ) capture cross section. This is a reaction which is part of the network controlling the destruction of ^{22}Na in novae and will add to the earlier determination of the production of ^{22}Na via ^{21}Na(p,γ). This nuclear astrophysics program is waiting for a high efficiency Febiad ion source to explore Ne reactions, and in preparation for the TUDA ^{18}Ne(α,p) measurement, ^{10}B(α,p) was studied successfully (see Expt. 870).

The second focus of the ISAC science portfolio is our fundamental symmetry program. The TRINAT facility produced new results in 2005, setting limits on scalar, right-handed vector and on tensor interactions. A considerable investment in atomic techniques, trapping and polarization methods is paying off. In parallel, the study of vector transitions to extract the V_{ud} element of the quark mixing matrix got a boost in 2005 from the new ^{62}Ga beam developed by the TRILIS group. Both accurate lifetime and branching ratio measurements were obtained using the 8π spectrometer and the GPS station. The accurate Q value for the decay will be determined with TITAN. Other cases (^{34}Ar) are awaiting operation of the Febiad ion source.

The third plank of the ISAC science portfolio is nuclear structure, where the workhorse is the 8π spectrometer augmented with conversion electron detectors and a plastic counter array. Detailed spectroscopic studies that solved a level assignment for the 2.29 s isomeric decay scheme of ^{174}Tm (Expt. 921); a search for evidence of coexistence of deformed and spherical shapes in neutron rich ^{32}Mg (Expt. 955); and a search for shape coexistence in the N = 90 region are reported. This program not only relies on the superb performance of the 8π system, but also on high production of very neutron-rich nuclei for which an actinide production target will be essential. The second aspect of the nuclear structure program focused on detailed studies of ^{11}Li, which aim at understanding the neutron pairing process involved in this classical halo nucleus. Transfer reactions at ISAC-II will be used next year to resolve this issue with the MAYA detector on loan from GANIL.

Significant progress was made in getting the new NSERC-funded instruments operational. Several modules for the TIGRESS array were tested and accepted, while installations of the TITAN platform proceeded. A revised proposal for the EMMA spectrometer was submitted in October.

TRIUMF also supports the Canadian particle physics program, both locally and at international facilities.

A critical effort was needed to recover from the lack of support in the Five-Year Plan funding for the Tier-1 computing centre for the LHC ATLAS experiment. An approach to the Canadian Foundation for Innovation was initiated and is seen as a way to attract enough resources to establish the centre at TRIUMF, albeit with significant delay. TRIUMF undertook to invest in key personnel to mitigate this delay and hit the ground running. In the meantime, TRIUMF provided expertise for assembling and installing the major components of the ATLAS detector built in Canada, as well as for the commissioning of the accelerator components produced at TRIUMF. The ATLAS-Canada community is getting ready for data-taking in 2007, and the Tier-1 data centre is a critical part of exploiting the Canadian investments in LHC physics.

During 2005, the US National Science Foundation decided to abandon the RSVP project and not support the KOPIO experiment. The considerable resources devoted to the research and development for KOPIO at TRIUMF were redirected to the neutrino program, the T2K experiment and also to a new study of the pion decay branching ratio. Canada has taken a pre-eminent role in the next generation of neutrino oscillation experiments based on the J-PARC neutrino facility in Japan and the Super Kamiokande detector. The T2K experiment regroups a large Canadian contingent, which is proposing to build the most critical elements of the near detector (ND280). Using technologies developed for the Linear Collider detector and for the KOPIO experiment, the group has been assigned the responsibility of providing the tracker detector system: three large TPCs and two fine-grain scintillator assemblies. A prototype of the TPC system was built and operated successfully in time for the NSERC site review, which evaluated the request for such capital funding. In parallel, negotiations with J-PARC have started to identify where TRIUMF could collaborate for the accelerator/beam line systems needed for the T2K program.

Locally, the main event was the publication of the first two physics papers from the TWIST collaboration, a high precision study of polarized muon decay at rest. After 15 years of effort, significant new measurements for two of the so-called Michel parameters characterizing the distribution of the decayed positron were published, and three Ph.D. theses awarded. A very sophisticated data analysis was developed to produce unbiased results, and the experiment will now continue to push for the ultimate anticipated precision. This experiment produces constraints on possible extensions of the standard model, which compliments information obtained at the TEVATRON.

A new effort to trap anti-hydrogen was funded by NSERC, and this new CERN-based experiment is led in Canada by a TRIUMF researcher. A multi-discipline team has been assembled for this effort.

Our condensed matter program benefited from excellent beam delivery in 2005. The focus of the muon program remains on the studies of magnetism and superconductivity in many interesting materials. Studies of spin dynamics of interacting electrons are ideally suited to the μSR techniques. A new facet is emerging with the use of polarized light ions and the exploitation of the β-NMR technique, giving access to the study of thin films or composite nanostructures as opposed to bulk material studies via muon spin rotation. Our β-NMR facility is unique in the world and is now producing physics results. During the year, a second experimental station was commissioned for low magnetic field studies.

Our muon beams are also used for semi-conductor studies (with hydrogen-like muonium impurities). Closer to practical applications, several groups are now studying materials for use in the automobile industry (lithium batteries, thermoelectric oxides, etc.) or for combining data processing and data storage on a chip (spintronics), while the chemistry program is focusing on the studies of free radicals in hydrothermal conditions of potentially "green" solvants.

In the life sciences, the major achievement in 2005 was the establishment of an ^{18}F production facility to provide the BC Cancer Agency with FDG tracers for their new tomography. More than 1000 patients received tracers produced at TRIUMF. More good news came with the funding by the Canadian Institute for Health Research (CIHR) of the neurodegenerative disorder centre at UBC. This team grant provides stable funding for this leading international group which relies on TRIUMF for its tracers and for operating their three PET cameras. The life sciences program also provides tracers for botany, industrial chemistry and earth and ocean faculty members.

TRIUMF's nuclear and particle physics program is also supported by a dynamic Theory group, composed of four permanent staff members and seven postdoctoral fellows and students. A search for a fifth permanent staff member was successful, and the new person will join the group in 2006. This appointment will bring a major change in moving the dynamics of the group more towards the ISAC science program. Already the focus of the research undertaken by the Theory group is moving towards nuclear astrophysics, nuclear structure relevant to ISAC as indicated by the contributions made in 2005 in this Annual Report. Strong participation in the world effort in QCD studies on the lattice is continuing with collaboration with western university faculty members. The particle physics effort is centred about CP violation models, in particular, higher dimensional theories. With the start of the data-taking at the LHC, our effort will have to come to symbiosis with the strong experimental team that is being assembled around TRIUMF to extract the new information from the high energy frontier experiments like ATLAS.

In closing, the laboratory is striving to remain a world-class science environment for the benefit of students, universities and the Canadian public at large. I must acknowledge the indefatigable commitment of our staff, which relies on the recognition of their peers to motivate them!