SCIENCE DIVISION

INTRODUCTION AND OVERVIEW

April 2006 saw the achievement of a major milestone at TRIUMF, one which will provide a new and very important tool for the nuclear physics community: the operation of the superconducting linear accelerator at ISAC-II. What was most remarkable was that the design specifications were met from the very beginning. R. Laxdal's team is to be congratulated for providing ISAC users with a superb instrument. Work continued during the year to commission the new accelerator, extend the beam delivery system to the experimental hall, and mount the first experiment using the MAYA detector, which was brought to TRIUMF from GANIL in France. After some delays, the Canadian Nuclear Safety Commission (CNSC) granted the licence to run, and the ISAC-II experimental program was officially underway on January 4, 2007.

During 2006, a large number of programs received beam time at ISAC, but the demands from physicists around the world created a large backlog of experiments. Beam development is a main limiting factor having to complete for resources and beam time with the experimental program.

A new FEBIAD ion source was partly commissioned in 2006 and shows a promising outcome. It will allow us to continue our nuclear astrophysics program, which requires very intense beams of low mass isotopes. The nuclear astrophysics program is also making very good use of the off-line source and, during the year, a comprehensive study of the cross section for the ^{40}Ca(α,γ) reaction was completed over the excitation energies from 605 to 1153 keV/u (97 energy steps). This reaction plays a key role in the production of ^{44}Ti, which has been observed by the COMPTEL and Integral emissions. This reaction also demonstrated the capability of DRAGON, the recoil spectrometer developed to study radiative capture reactions at ISAC.

Two other programs benefited from beam delivery in 2006. Radioactive ^{22}Na targets were prepared using a scanning technique to provide a uniform density, and the ^{22}Na(p,γ) reaction will be studied at the University of Washington (this experiment has moved there because of the long-lived activity [2.2 years] of ^{22}Na). An estimate of the α-width of the 4.03 MeV state in ^{19}Ne has been obtained from the measurement of its lifetime. This is key information to establish the strength of the ^{15}O(α,γ) reaction thought to be relevant for the break out from the CNO cycle towards X-ray burst nuclear evolution. Also, the ^{12}C + ^{12}C fusion reaction was revisited. Charged particle exit channels were investigated with the TUDA detector, and strategies to access the astrophysical important region (0.8–1.2 $\times$ 10^9 K) have been evaluated.

The ISAC nuclear structure program focused on the spectroscopy of ^{9}Li, the asymptotic normalization coefficient in ^{8}Li (this ANC method is used to access astrophysical reaction rates but must be tested against direct measurements, for example ^{7}Be(p,γ)), preparation for ^{11}Li(p,t) and (p,d) reactions to extract correlation functions for the $2n$ in ^{11}Li and studies of shape coexistence in the N=90 isotone nuclei region with the 8π detectors. The highlight of this program was the first measurement of Coulomb excitation of ^{20,21}Na using two of the new TIGRESS Ge detectors and associated electronics. This measurement demonstrated the power of the combination of state-of-the-art Ge detectors and the superb beam quality achieved at ISAC.

Finally, a study of neutron-rich Ca isotopes via $^{51-63}$K decays aimed at determining sub-shell closure in the N=34 region was run using $\beta-\gamma$ and $\beta-\gamma\gamma$ coincidences measured with the 8π detector array.

The symmetry program focused on $\beta-\nu$ correlations in ^{38m}K to constrain scalar interactions in semileptonic decays, spin asymmetries in ^{80}Kr recoils from polarized ^{80}Rb decays to constrain tensor interactions in weak decays and development of a technique to search for massive scalar or pseudo-scalar particles, using Rb or Cs isomer decays. An attempt to measure the half-life of ^{34}Ar with high precision was not successful due to the low efficiency of the FEBIAD ion source in its initial configuration.

Several new instruments made good progress during the year. TITAN, the high-precision mass measuring ion trap, is in the final stages of installation; the EBIT section was received from the Max Planck Institute and was mounted on the TITAN platform. The superconducting magnet for the Penning trap was received but had to be returned to the manufacturer to fix a cold vacuum leak. TITAN was set to measure its first masses in 2007.

The EMMA spectrometer is moving ahead to the tendering process and is aimed at being commissioned in late 2009.

The TACTIC detector, a low mass time projection chamber to measure low reaction cross sections is being manufactured at the University of York in the UK while its readout system is provided by the Canadian team.

The last component of the ISAC program uses the β-NMR techniques to study thin films and interfaces in new materials. A second leg of the initial facility is being installed, and this leg will complement the high-field spectrometer (8 T) in the β-NMR section with a low magnetic field spectrometer. As stated elsewhere in this report, physics is emerging from this program: in the type-II superconductor, the evolution of the vortex lattice is followed near the surface of such superconductors as $NbSe_2$, studies of materials exhibiting large magneto-resistances (for example, $LaCaMnO_3$), studies of molecular mono-layer magnets, etc. The reach of this technique is limited by the amount of beam time that can, at present, be delivered to the user community. This program complements nicely the other leg of our materials science effort using the μSR technique.

As mentioned elsewhere in this report, considerable progress was made this year, in part because of the development of new high-quality instruments like the new high-pressure cell or the high magnetic field spectrometer. The program is still very much focused on magnetism, high-temperature superconductors, semiconductors, as well as studies of the new carbide materials, green solvents like ionic liquids, etc.

For the particle physics program, locally the TWIST experiment has taken high-precision data on the Al and Ag targets and decided that Al was presenting the best opportunity to achieve a 10^{-4} precision in the determination of the Michel parameters of muon decay. The final data set will be taken in 2007, with optimized beam injection into the 2 T solenoid.

The major milestone for TRIUMF was the successful funding award for the ATLAS Tier-1 data analysis centre. Mike Vetterli and Reda Tafirout are to be congratulated for this achievement, which will position TRIUMF as one of the ten ATLAS Tier-1 centres around the world. This is a \$23 M investment, which is bringing state-of-the-art grid computing to Canada and will allow Canadian physicists to exploit the detectors they developed for the ATLAS experiment.

The T2K Canada collaboration is moving quickly forward with the construction of 3 TPC modules and 2 fine grain detectors (FDGs) for which 1200 scintillation bars of very high-quality were produced by a local company. The timetable to construct these detectors calls for an installation at the J-PARC neutrino facility in late 2009. Canada is also responsible for providing a proton beam monitor at the neutrino production target and remote handling equipment for the neutrino facility.

At the Thomas Jefferson National Accelerator Facility, the Canadian group linked to TRIUMF completed the data-taking phase for the $G\emptyset$ experiment and delivered the magnet coils for the Q_{weak} experiment that will follow. $G\emptyset$ is expected to provide new information on the strange form factor of the proton.

In July, 2006, TRIUMF held a very successful International Linear Collider (ILC) workshop, which attracted some 325 physicists. The goal of the workshop was to determine the specifications and possible costs of such a collider.

All these programs benefit from the strong support of our theory group, which was reinforced considerably with the arrival of A. Schwenk in August. He is providing expertise ranging from effective field theories, to nuclear structure and atomic physics, as well as condensed matter. Several workshops are now planned to position TRIUMF as a leader in many-body physics.

The Life Sciences program continues to support a large team at the Neurodegenerative Disorder Centre at UBC, providing isotopes, radiopharmaceuticals and PET camera support, while increasingly supporting the diagnostic imaging of the BC Cancer Agency (BCCA). Several thousand oncology patients have had scans using ^{18}FDG produced at TRIUMF. Further expansion of the collaboration with BCCA is being contemplated.

During the year, TRIUMF continued its strong outreach activities, with more than 60 undergraduates experiencing our research environment for four months, several activities directed at high school teachers (hands-on participation, internship programs, educational videos) as well as public tours.

TRIUMF can only accomplish all of this by relying on the competence and dedication of its devoted staff. The user community is very appreciative of these efforts.