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FOR PARTICLE AND NUCLEAR PHYSICS

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.

SCIENCE DIVISION

INTRODUCTION AND OVERVIEW

In 2004, TRIUMF produced some very exciting new results exploiting past investments in major facilities at ISAC, in the base program, and supporting a carefully selected set of experiments at other high energy laboratories, meanwhile defending its future five-year plan at the government level. It has been a very satisfying year by all accounts, and this Annual Report attempts to capture the highlights of the scientific program.

In ISAC science, a major effort was devoted to the exploitation of the world's most intense ^{11}Li beams, derived from operating Ta foil production targets with up to 60 μA of proton beam intensity. Experiment 991 used a technology developed by the GSI group to determine the charge radius of the typical halo nucleus of ^{11}Li. This *tour de force* experiment was commissioned on a new dedicated beam line in June, and data-taking on all Li isotopes took place in September and October. By measuring the isotope shift of 2S $\rightarrow$ 3S transitions in this series of isotopes, one hopes to follow the redistribution of the 3 protons in the nucleus as more neutrons are added. The 8π group studied the decay of ^{11}Li into ^{10}Be via β-neutron emission. Neutron energy information is obtained by measuring the Doppler-broadened γ-ray lines in the de-excitation of ^{10}Be. This technique has been developed at ISAC and is used to assess the survival probability of the halo neutrons in the decay sequence. This effort provides new information on the nature of the 8.81 MeV state in ^{11}Be leading to a possible excited halo state in ^{10}Be. This information complements the nuclear structure studies undertaken on polarized ^{11}Li by the Osaka group, which also published their spin and parity assignment for several ^{10}Be levels.

The 8π detector proved its versatility in studies of γ-ray spectroscopy of $N = 90$ nuclei searching for coexisting collective phases in ^{156}Ho and also finding new K-isomers in ^{174}Tm. It was also used to get a more precise lifetime measurement of ^{18}Ne, one of the superallowed Fermi decays used to test the conserved vector current hypothesis and extract a value for V_{ud}, the first element of the quark mixing matrix. This program will study several other such transitions in heavier nuclei, and a new branching ratio measurement was made in December on ^{62}Ga using, for the first time, the laser resonant ion source, TRILIS, on-line. This new tool, developed in record time by J. Lassen and his team, will be the main source of radioactive beam at ISAC in the future, providing versatility and selectivity for many isotopes. For the nuclear astrophysics program, a commissioning run of a ^{26}Al beam took place in July and showed that, with further improvement in yield and ionization efficiency, DRAGON could directly measure the strength of an important but weak resonance in ^{26}Al(p, γ) which controls the destruction of ^{26}Al. This came right in time to be showcased at the Nuclei in the Cosmos conference hosted by TRIUMF in Vancouver in July.

Two publications in Physical Review Letters were generated by the β-NMR group. The facility is now well understood and has matured in producing high quality data on their thin samples or their layered structures. A complementary facility for low magnetic field measurements of nuclear quadrupole resonances (β-NQR) is being developed.

In the base program, the highlight has been the announcement of the first results from the TWIST collaboration. Culminating a 12-year effort of attempting the high precision measurement of the Michel parameters governing the decay spectrum from polarized positive muons at rest, the sophisticated blind analysis revealed a factor 3 improvement in the determination of ρ and δ, respectively the first new such measurements in 40 and 20 years. These results help constrain possible modifications of the standard model of weak interactions and every indication is that the ultimate precision envisaged for the experiment is within reach in the next few years. Two Ph.D. theses will be based on these first results.

The rest of the muon program is devoted to muon spin resonance studies (μSR) of material and molecular species. The main theme of the program is to elucidate the interplay between magnetism and superconductivity in many types of high temperature superconductors, either electron or hole doped. Other studies are searching for correlations between magnetism and thermoelectric charge transport properties, linkages between magnetic order and superconductivity under external pressure, magnetic fluctuations and metal to insulator transition, etc. The studies of semi-conductors and the role of hydrogen-like impurities continue using muonium, while the chemistry program is focusing on the studies of muoniated radicals in carbenes and carbene analogues.

In the life sciences, the year was devoted to bringing on-line the two new cameras funded through CFI. A large demand is developing for the microPET animal camera, bringing new user demand for radiotracers. The human program is delayed by the commissioning of the new high resolution camera (which is proving very demanding) and by a delay in the acceptance test of the patient bed.

Major progress is also reported in the studies of marine phytoplankton related to the regulation of CO_2 in the marine atmosphere interface with the delivery of radiocopper to the UBC group.

For our infrastructure support component of the program, 2004 has seen the completion of major construction commitments towards the ATLAS experiment at CERN, with the effort shifting to installation and commissioning at CERN. Beam tests were also conducted for evaluation of the performance and calibration procedure for the combined end cap calorimeters. Coupled with a major shift towards software support at TRIUMF, this represents a new phase in the program. In anticipation of the development of a major data analysis centre at TRIUMF to support the ATLAS-Canada collaboration in accessing the physics of ATLAS, two new hires were made. This is the start of a major commitment, which will be the centrepiece of the next Five-Year Plan program in Canada.

The T2K experiment moved quickly after the announcement of approval by Japan in December, 2003, and the Canadian team grew to encompass 20 physicists from across Canada. The Canadian contribution to the near detector is being formulated and will likely involve building a TPC type tracker and a water-based fine grain detector.

The KOPIO experiment is still in the R&D phase, pending approval of funding in the US. New technologies are being tested for scintillator manufacturing, and fibre and wire chamber readouts, which have already impacted other experimental programs at TRIUMF – most notably in ISAC (TIGRESS readout electronics, TACTIC detector, etc.).

HERMES is producing beautiful results on the spin structure of the nucleon and will take data until 2006. The small, but very visible, Canadian team is at the centre of the data analysis effort.

Two experiments at the TJNAF facility in Newport News, VA have benefited from TRIUMF's infrastructure support. The $G\emptyset$ backward configuration Čerenkov detectors were produced at TRIUMF and delivered to TJNAF after extensive testing at TRIUMF. The first data-taking run in that mode is scheduled for the end of 2005. In the meantime, data from the first phase of the $G\emptyset$ experiment is being analyzed. The new Q_{weak} experiment relies on TRIUMF to produce the coil of the sector toroidal magnet, and TRIUMF is managing that contract for the collaboration.

Our theory group consists of 4 permanent staff members and 7 research associates. The focus of the group is shifted towards nuclear astrophysics with good interaction with some of the experimentalists. The nuclear structure component is still embryonic and will be further developed with the search for a new staff member approved during the fall. The group also covers QCD studies and physics beyond the standard model to match some of the experimental program as well.

Overall, this was a very satisfying year, and the results presented here support our ambitious plans forwarded to the government for the next five years. This Annual Report helps demonstrate the high quality of our staff and the commitment of our scientists to operate and contribute at the forefront of research in their respective fields. We only hope that our funding masters will agree with this observation.