# TRIUMF

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**CANADA'S NATIONAL LABORATORY**
**FOR PARTICLE AND NUCLEAR PHYSICS**

OPERATED AS A JOINT VENTURE

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NATIONAL RESEARCH COUNCIL OF CANADA

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*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

The millennium year 2000 proved to be appropriately a banner year for TRIUMF. In February, with its "Budget 2000", the federal government announced a funding package of $200M for TRIUMF, to cover the five years 2000–2005. This amount represents a 20% increase over the level which had prevailed for the previous quinquennium. The staff of the laboratory are to be congratulated, since the new figure signifies a solid vote of confidence from the federal government for a facility which has truly become Canada's National Laboratory for Particle and Nuclear Physics. However a word of caution is in order. A 20% increase is always very welcome, but TRIUMF has very ambitious plans, particularly for capital expenditure, and some priority decisions will be required, between ISAC-II – an upgrade of ISAC-I to an energy of 6.5 MeV/u – and a continuation of the contribution on behalf of Canada to the Large Hadron Collider (LHC) at the high level anticipated by CERN. One thing is clear, the main Canadian responsibilities to LHC can be discharged, but no new opportunities can be explored.

The proposal for ISAC-II has now become a reality. Its realization will open up the experimental program with ISAC to nuclear physics with ions of 6.5 MeV/u, an energy comfortably above the Coulomb barrier. The immediate issue became the acquisition from the BC provincial government of the money required for the civil construction associated with ISAC-II. An application was made to the BC Knowledge Development Fund, and December brought the news of an award of $8.7M. TRIUMF now has all the pieces in hand to move forward to the realization of one of the best centres in the world for science with exotic radioactive ion beams. This is a dramatic turnaround from the possibilities which confronted the laboratory in the dark days of February 1994 after the refusal of the KAON proposal.

The program of science using ISAC-I at low energies begins to take shape. The electron-neutrino correlation in the $\beta$-decay of $^{38\mathrm{m}}$K is being studied in the TRIUMF neutral atom trap (TRINAT) as a means of revealing a possible level of a heretofore undetected scalar coupling in the weak interaction. This low energy study will be complementary to the high energy particle searches for $S$=0 leptoquarks in the DØ experiment at Fermilab and at HERA. The historic series of measurements on superallowed Fermi $\beta$-decay transitions can be extended to include $^{74}$Rb, which proves to be an excellent nucleus in which to test theoretical models. The ISAC results have so far yielded the best estimate of the half-life and branching ratio of $^{74}$Rb, two vital ingredients for the determination of the transition rate. In July polarization was achieved in a $^{8}$Li beam, and with the target sample placed at high voltage a "soft landing" was achieved also. The $\beta$-decay of the $^{8}$Li yields a unique probe in condensed matter physics, especially in the study of surface phenomena. Several other experiments are beginning to come online, and the richness of the science with low energy ion beams becomes very evident.

TWIST is the flagship experiment of the subatomic program based on the 500 MeV cyclotron. The decay parameters of the muon are being revisited in a precision test of the theory of the weak interaction. The targeted accuracy is roughly a part in ten thousand, which represents a gain of a factor of ten over previous results. This is a very difficult task, and will in essence represent a tour de force in the understanding of systematic errors. The experiment moved on to the floor late in the year and ambitiously projects a run with all equipment installed within one year.

TRIUMF continues to provide contributions to the LHC in CERN on behalf of Canada. The new funding level permits the provision of the equipment for which TRIUMF had previously assumed technical responsibility. The initial phase of the project, which was dedicated to the upgrading of the CERN PS complex, has been successfully completed, and the PS has operated with a beam of appropriate brightness for injection into the LHC. TRIUMF had a major role in this upgrade. Now the responsibilities move into the LHC itself, where they concentrate on two main components – the injection kicker magnets and warm quadrupoles. The provision of power supplies and pulse forming networks for the injection kickers are well in hand. The warm quadrupoles which will carry the counter rotating proton beams through the LHC cleaning insertions have not yet been realized. The prototype, produced in 1998, indicated that in order to achieve the desired quality of magnetic field, the mechanical tolerances would have to be tightened by about a factor of five to $\sim$100 $\mu$m in the placement of laminations. This requirement makes these quadrupoles the most mechanically precise warm magnets in the project. The company selected for the series production of the magnets is ALSTOM of Montreal. They appear to have the capability to deliver the product, but the successful series production has yet to be established.

A large international community uses the TRIUMF muon beams for experimental work in chemistry and condensed matter using the technique known as $\mu$SR. This year they have been joined by a group from the Rutherford Appleton Laboratory in a project known as MuScat. In the world of high energy physics, some very forward looking proposals aim to employ stored muons as an intense source of neutrinos in complexes which are becoming known as "neutrino factories". In order to make these proposals practical, muons must be produced, trapped, and their phase space cooled before rapid acceleration to the stored energy. An old measurement has cast doubt on the validity of the theory of large angle multiple scattering of muons at low energies. MuScat will provide a practical answer by measuring the scattering process in the laboratory, yielding an important piece of input into the design of a neutrino factory.

TRIUMF is providing infrastructure support to a number of experiments within the Canadian program in subatomic physics in concert with the NSERC Grant Selection Committee. The production in TRIUMF of modules for the ATLAS HEC calorimeter proceeds smoothly and is keeping to its timescales. The laboratory also has significant involvement in the feedthrough project at the University of Victoria, where signal feedthroughs are now in production for the ATLAS HEC calorimeter. At Brookhaven, experiment E787 has been upgraded significantly and has emerged as E949, which will endeavour to collect ~10 decays of $K^+ \to \pi^+ \nu \bar{\nu}$; a very ambitious project working with a branching ratio of $\sim 10^{-10}$. TRIUMF has provided apparatus for the $G\emptyset$ experiment at TJNAF, HERMES at HERA, and SNO. Additionally, a small group in TRIUMF provides ongoing collaborative effort in the global GEANT 4 project.

The PET component of the Life Sciences program achieved an outstanding success in obtaining the funds for a new state-of-the-art PET camera which will be installed at the Neurodegenerative Disorders Centre at the UBC Hospital. The money came from three sources: the Canadian Foundation for Innovation, the Canadian Institutes of Health Research, and the BC provincial government. In addition the TRIUMF/UBC PET group assured renewed funding for a five year term, putting the group on a very solid financial footing.

The Year 2000 ended on a very high note. On December 21, one day before the laboratory closed for Christmas, the ISAC team accelerated alpha particles to 1.5 MeV/u. The milestone had been promised some two years earlier and was gratifyingly passed, albeit in the "nick of time". The outstanding success of accelerated beam means that TRIUMF can anticipate commencing an experimental program in nuclear astrophysics during the year 2001. This will be an exciting period and should place TRIUMF on the world map with a number of unique measurements.

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Director