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UNDER A CONTRIBUTION FROM THE
NATIONAL RESEARCH COUNCIL OF CANADA

DECEMBER 2003

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

The year marked a new era in TRIUMF's scientific achievements. This report highlights the very new results coming out in publications from ISAC while the final papers related to experiments that took data in the proton hall before its decommissioning were released. Also, physics analyses of CHAOS data are being finalized.

In ISAC, a major accomplishment is reported by the DRAGON collaboration with the publication of the first direct proton capture measurement of the ^{21}Na(p,γ) reaction. It has demonstrated that the combination of ISAC accelerators and the DRAGON spectrometer has outstanding potential, as we had hoped. DRAGON has met its specifications very quickly. In parallel, the TUDA collaboration studied the level structure of ^{21}Mg and ^{22}Mg.

The refurbishing of the 8π spectrometer has been completed and a large collaboration is now exploiting the unique features of the twenty Compton suppressed germanium detector array. In this report the 8π group reports on a study of ^{11}Li high energy levels, a high precision lifetime measurement with ^{26}Na, a new value for the lifetime of ^{176}Lu, a geochronometer decay of $T_{1/2} = 40.8 \pm 0.3$ billion years, and a study of the long-lived isomer $^{178\mathrm{m}2}$Hf ($T_{1/2}$ = 31 years). The 8π spectrometer is already generating many interesting proposals and will be even more attractive when it is fitted with charged particle detectors next year.

Beautiful new results were obtained by two groups from Osaka University. Using ^{11}Li beams, several spin and parity assignments were made for states in ^{11}Be using a novel technique of β-delayed asymmetry measurements. Studies of aligned ^{20}Na nuclei will test the possible existence of non-standard interactions in the weak decay of ^{20}Na.

The TRINAT group has continued their studies of correlations in the beta decay of ^{37}K and $^{38\mathrm{m}}$K. These beautiful experiments rely on atomic trapping and polarizing techniques to test properties of the weak interaction.

This report demonstrates that science is coming out of our ISAC investments. This development is helping us attract new users and talented young physicists who want to exploit the unique opportunities created at ISAC.

Also, in this report, very important new results are presented linked to data taken some years ago with the CHAOS spectrometer. CHAOS has proven to be a very versatile and unique instrument to study pion physics and, in particular, to test predictions of chiral perturbation theories. New results on the analyzing power measurement of $\pi^{\pm}p$ elastic scattering at low energies are presented. Constraints on the πN coupling constant, the πN scattering length at low energies, and ultimately the πN sigma term were obtained.

The charge symmetry breaking experiment was the last experiment which took data in the proton hall. It used the SASP spectrometer to measure a forward-backward asymmetry in the charge exchange reaction $np \to d\pi^0$ to look for evidence of a charge symmetry breaking term in the strong interaction. This is related to the mass difference between an up and down quark. The TRIUMF result is new and has sent theorists back to their model to try and reproduce the experimental result.

The TWIST experiment was able to take its first complete data set. It is designed to make high precision measurements of the energy and angular distribution of the decay positrons in the decay of polarized muons at rest. This difficult experiment is limited by systematic effects and many data sets were taken in varying conditions to assess the systematic errors and learn ways to control them.

In the support TRIUMF gives to Canadian researchers in high energy physics experiments at facilities abroad, the main event was the delivery of all modules for the hadronic endcap calorimeter to the future ATLAS experiment at the LHC. The TRIUMF team, led by Dr. C. Oram, has delivered on time and on budget an $8 million contribution to the ATLAS experiment. Funds for the hardware were provided by NSERC (Natural Sciences and Engineering Research Council) while TRIUMF invested in infrastructure support and assembly personnel.

Another ATLAS project was brought to conclusion at the University of Victoria with the help of TRIUMF engineers and technicians: 55 feedthrough assemblies were produced and 50 delivered to CERN by year end. Both of these ATLAS project teams will now focus on the assembly and commissioning efforts at CERN in preparation for the completion of the detector by 2007. In a related activity, a demonstration test was carried out to transfer huge data sets (1 Tbyte) from TRIUMF to CERN over commercial networks and using commercial software tools. It established a world record for high speed transmission over long distances (12,000 km).

Other activities at DESY (HERMES experiment), at TJNAF ($G\emptyset$ and Qweak experiments), at BNL (rare kaon decay studies), and at SNO are also reported in this section.

Our condensed matter effort has continued to grow with both polarized muons (μSR) and light ions (β-NMR). In particular, the considerable investments made at ISAC to generate low energy polarized light ion beams are now leading to new physics opportunities in the studies of thin films or multi-layered materials like recording media, superconducting films, etc. The commissioning phase for the beam line, the spectrometer and its data acquisition system is now complete and the physics program can now start in earnest.

The μSR facility is attracting many users (130) and materials developers who want to study the magnetic properties of new materials. This year a new superconductor material MgB_2 was tested at TRIUMF; new organic superconductors, C_{60}, molecular magnets, and new electron-doped superconductors found their way into our muon beams. The studies of muonium as analogue of hydrogen in semiconductors (GaAs, GaP, ZnS, etc.) continued in these industrially very important materials. The SFU chemistry group studied muonium in critical water and critical CO_2, while the UBC chemistry group focused on zeolites.

In the life sciences, TRIUMF plays an important role in delivering novel tracers to a variety of institutions ranging from the UBC Neurodegenerative Disorders Centre to the local hospitals, the Botany and Chemical Engineering departments, etc. The most important event was the funding of two new PET cameras (one for human brain studies, the other for small animal studies) by the Canadian Foundation for Innovation.

These experimental programs are complemented by a strong theoretical effort. The 4 permanent staff members and their 7 research assistants cover a wide range of topics from extra-dimension theories, to chiral perturbation theories, to quantum chromodynamics on the lattice, to standard model tests, to novel nuclear physics models to explore the region of neutron-rich nuclei.

A review of the Theory group activities took place early in the year and recommended a refocusing of the group's activities toward ISAC-related science. A search for a Theory group leader who would accomplish this task was initiated in collaboration with the UBC Physics department.

We continued to treat western Canadian patients with large ocular melanomae, as well as providing irradiation services for the space industries and high energy groups who need to test their detectors for radiation resistance.

Overall, this was a very successful year scientifically and I would be extremely satisfied if it were not for the loss of a very talented experimenter and friend in the person of Nate Rodning, the leader of the TWIST experimental team. He will be missed.