TRIUMF

ANNUAL REPORT
SCIENTIFIC ACTIVITIES
2000

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 VICTORIA

ASSOCIATE MEMBERS:

THE UNIVERSITY OF MANITOBA
L'UNIVERSITÉ DE MONTRÉAL
QUEEN'S UNIVERSITY
THE UNIVERSITY OF REGINA
THE UNIVERSITY OF TORONTO

UNDER A CONTRIBUTION FROM THE
NATIONAL RESEARCH COUNCIL OF CANADA

OCTOBER 2001

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.

CONFERENCES, WORKSHOPS AND MEETINGS

MUON SOURCE MINI-WORKSHOP

On March 24–25, TRIUMF was host to a workshop with about 40 invited participants, organized jointly by TRIUMF (D. Bryman) and KEK (Y. Kuno), to discuss various aspects of future intense sources of muons. Its principal motivation was to investigate the creation of ultra-high intensity (10^{11} – 10^{12} s^{-1}) cooled muon beams for lepton flavour violation (LFV) experiments such as $\mu \rightarrow e\gamma$ and $\mu \rightarrow e$ conversion, as well as other applications.

About a dozen presentations outlined various aspects of the techniques and technologies that will be required to collect copious muons from pion decay, cool, and eventually accelerate them. One focus of these discussions was a scheme called PRISM (phase rotation intense slow muons) which uses the rf structure in a fixed field alternating gradient (FFAG) synchrotron to cool a muon beam injected with a large momentum acceptance to a narrow $\sim$1 MeV energy spread. Among the topics discussed were pion production and proton drivers, targetry, muon capture solenoids, injection and dispersion matching, as well as aspects of the rf systems involved. Several design and prototype studies ongoing at KEK were described.

To complement these sessions, a number of presentations were made and discussions were held relating to the physics possibilities. There were talks on the LFV experiments as well as on the prospects to exploit these facilities for μSR studies.

An important goal of the workshop was met in identifying several key issues for research and development and in exploring the possibilities for collaboration, particularly between TRIUMF and KEK.

ASTBURY SYMPOSIUM

A reception and a symposium to mark the occasion of TRIUMF Director Alan Astbury's 65th birthday were held on April 15 and 16. The Vancouver Maritime Museum was the venue for a reception, attended by 150 friends and colleagues, while the scientific symposium at TRIUMF attracted 120 physicists who listened to speakers covering the many achievements of Dr. Astbury, most notably the discovery of the massive Z and W particles, and also the promising avenues for future advancements of the science he loves.

The speakers included two Nobel prize laureates, R. Taylor (SLAC) and C. Rubbia (CERN), former colleagues J. Deutsch (Louvain la Neuve) and W. Scott (RAL), University of Victoria faculty colleagues R. Keeler, M. Lefebvre and R. Sobie, and TRIUMF scientists R. Kiefl and J.-M. Poutissou. Dr. W.J. Macdonald (University of Alberta) gave the TRIUMF Board of Management greetings and read some of the numerous telegrams received on this occasion.

The most gracious Vancouver weather set the tone for a joyful celebration of a most productive career.

SUMMER NUCLEAR INSTITUTE AT TRIUMF

The 2000 Summer Nuclear Institute at TRIUMF was held July 10–21. The general theme of the Institute was Experimental Techniques at ISAC and the specific topics were chosen following a poll of the growing number of graduate students associated with this facility. The lecturers and their subjects are given below:

- G. Savard, Argonne National Lab, *Gross Properties of Nuclei and their Determination*
- L. Buchmann, TRIUMF, *Low Energy Nuclear Scattering*
- A. Shotter, University of Edinburgh, *Nuclear Astrophysics Studies with Radioactive Ion Beams*
- J. Wood, Georgia Tech., *Gamma-Ray Spectroscopy and Nuclear Structure*
- K. Krane, Oregon State University, *Angular Distributions and Correlations*
- R. Baartman, TRIUMF, *The Mechanics of Particle Beam Transport*

As in previous years, the general format involved three lectures each morning with an informal problem solving and discussion session in the afternoon. There were 19 registrants including 6 undergraduate students working at ISAC. The Institute was organized by J.-M. Poutissou, K.P. Jackson and G.C. Ball.

FOURTH INTERNATIONAL SYMPOSIUM ON RADIOHALOGENS (4ISR)

The Fourth International Symposium on Radiohalogens (4ISR) was held September 9–13 at Whistler.

Radiohalogens are unique among the radioactive elements of interest to diagnostic and therapeutic nuclear medicine because of their broad range of chemical, biological and nuclear properties. The radiochemistry of ^{18}F has been tamed so that radiofluorination of metabolic substrates is almost routine, and ^{18}F-labelled products are readily available for onsite "molecular" positron emission tomography (PET). The radioiodines in mainstream medical use include ^{125}I and ^{131}I, the traditional workhorses of biochemistry and radiotherapy, respectively. ^{123}I is commonly used for single photon emission tomography (SPET) imaging, while ^{124}I is the most recent addition to the list of PET radionuclides. Speakers at this symposium focused primarily on these five radionuclides, but also addressed radiobromines (^{74m,75,76,77}Br) and the most esoteric radiohalogen, astatine (^{211}At). Radionuclide production, radio-organic chemistry, medical applications, and commercialization of these radionuclides were discussed.

An ad hoc committee from within the radiopharmaceutical and radiochemical communities again organized the fourth in a series of radiohalogen symposia. As in earlier meetings, this year's committee, which comprised Drs. M. Adam (University of British Columbia), S. Wilbur (University of Washington, Seattle), H. Coenen (Forschungszentrum Jülich) and B. Abeysekera (Nordion International Inc.), created a program that was more of a workshop than a symposium. Invited speakers presented papers to a specialist audience. The small number of papers and the absence of a poster session ensured extensive dialogue and animated discussion throughout the meeting. The program included reviews on radiohalogen production, chemistry and special applications of the radiohalogens including ^{18}F, radioiodines, radiobromines, and ^{211}At. Approximately 130 scientists from North America, Europe and Asia participated.

S.M. Qaim (Forschungszentrum Jülich) opened the proceedings with a review of radiohalogen production. Production of radiohalogens such as ^{123}I, ^{124}I, ^{120g}I, ^{18}F, ^{76}Br, ^{77}Br were discussed in this session.

M. Kilbourn (University of Michigan) reviewed developments in radiofluorination chemistry from the early electrophilic reactions to the predominantly nucleophilic reactions now in use.

B. Mazière (CAE, Paris) reviewed the radiobromines and dismissed all, including ^{77,82}Br but with the exception of ^{74m,75,76}Br ($t_{\frac{1}{2}} = 0.7$, 1.6 and 16.2 h, respectively), as useful for imaging. These positron emitters have been incorporated into nucleosides, nucleotides, monoclonal antibodies and receptor ligands, especially for study of the dopaminergic system.

Evidence of a role for boron intermediates in radiohalogen chemistry was presented by G. Kabalka (University of Tennessee Medical Center). Advantages of these compounds include low toxicity and applicability to compounds that have a broad range of functional groups.

H. Kung (University of Pennsylvania) reported the synthesis of ^{123}I-labelled CNS receptors, with emphasis on destannylation radioiodination of aryl- and vinyl-tributylstannyl precursors, for dopamine receptor imaging.

The generation and biological effectiveness of Auger electrons associated with ^{123,125}I decay were explained by A. Kassis (Harvard Medical School). Situating these atoms directly on, or inserting them into, the nucleic acid chain (e.g., via IUdR) will produce an average of one DNA double-strand break per decay event (21 Auger electrons per decay), resulting in an 8-fold increase in radiotoxicity compared to ^{131}I.

Y. Arano (Chiba University, Japan) presented the only paper on radioiodination of monoclonal antibodies and peptides. This work concentrated on the development of hydrolyzable linkers between the protein and the labelled (^{99m}Tc or ^{125}I) synthons.

R. Counsell (University of Michigan) evaluated a number of iodophenyl-phospholipid ethers as potential tumour imaging agents based on the rationale that tumours exhibit elevated phospholipids. Studies of human tumours in SCID mice that have validated structure-activity models form the basis for phase I studies.

S. Wilbur and D. Hamlin (University of Washington, Seattle) described the applications of ^{211}At in open source radiotherapy. Dr Wilbur reviewed At chemistry and production (there are no stable or long-lived nuclides; ^{209,210,211}At have $t_{\frac{1}{2}}$ values of 5.4, 8.3 and 7.2 h, respectively), and concentrated on ^{211}At which, through a branched decay chain, is essentially a 100% α-emitter.

Of the application themes presented, nucleoside-based radiopharmaceuticals spanned the full range of radiohalogens. L. Wiebe (University of Alberta) provided an introduction to molecular biology and gene therapy, and a review of critical elements of nucleoside and nucleotide biochemistry.

B. Abeysekera (Nordion International Inc.) and J. Lu (University of British Columbia) closed the symposium with presentations on the impact of radionuclide production (nuclear reactions, production chemistry), delivery, and end-user applications on the commercial producers.

One of the symposium highlights was the barbecue banquet on top of Whistler Mountain in the Roundhouse building, thanks in part to the generous financial support from the US DOE, MDS Nordion, Mallinckrodt, Nycomed Amersham, and the BC Information Science and Technology Agency.

ISAC LASER ION SOURCE WORKSHOP

The ISAC Laser Ion Source Workshop was held at TRIUMF from December 4–5. The main themes were:

- To explore the possibility of installation of a resonant laser ion source at ISAC.
- Determine the best technique for producing the laser light.
- Define the infrastructure required.
- Determine the resources required for the operation of such an ion source, and emphasize the new and exciting developments that are imminent in this fast growing field.

Over 30 participants from Europe, Asia and America attended the two day workshop. The meeting started with a presentation of the ISAC facility, followed by the physics to define the need for special isotopes.

One of the main problems of ion sources for on-line mass separators is to obtain a pure ion beam. The usual ion sources used on-line are the thermo-ionic or gas-discharge plasma types. The ionization process in those ion sources is not selective. Hence, the separated ion beams are contaminated by isobars. The process of resonance laser ionization of atoms is non-thermal by nature. The atoms are ionized only when the laser radiation frequency matches the element's atomic transitions. Since each element has its own energy level structure, the laser ionization process can be very selective. Furthermore, the photo-ionization of atoms is very efficient and can lead to very high yields.

Dr. Klaus Wendt gave a very nice description of his system used for trace analysis, developed at the Johannes Gutenberg-Universität, Mainz. The separation he was able to accomplish with his laser system is new, competitive with the AMS technique.

A description of the laser system developed at the Russian Academy of Sciences, Troitsk by Dr. Viatcheslav Mishin showed the usefulness of the on-line laser ionization. It is currently used at several on-line facilities: ISOLDE-CERN, Petersburg Nuclear Institute, etc. This system used powerful copper-vapour lasers that are suitable for producing the laser radiation needed for the ISAC program.

After the workshop a collaboration between TRIUMF and Troitsk was initiated.

TRIUMF USERS' GROUP ANNUAL GENERAL MEETING

The TRIUMF Users' Group Annual General Meeting was held December 6–7, sandwiched between the Materials Science and Subatomic EEC meetings. See http://www.triumf.ca/tug/agm2000 and below for details of the sessions and talks.

J.H. Brewer, the TRIUMF Users' Executive Committee chair for 2000, reported on TUEC business conducted during the year.

TUEC met with each of the candidates for the next TRIUMF Director and conveyed evaluations to the Search Committee, which subsequently considered all input and presented its recommendations to the Board of Management, which then selected Prof. Alan Shotter as the new Director.

Following a mandatory membership renewal during 2000, the TRIUMF Users' Group (TUG) had 235 reconfirmed members from 11 countries. A Web-based survey of User interests and priorities conducted in conjunction with the mandatory membership renewal can be viewed in Appendix C and at http://www.triumf.ca/tug/new/tugstats.php .

TUEC selected two members to represent the Users on the TRIUMF Operating Committee: J. Vincent (TRIUMF) and E. Mathie (U. Regina) with alternates G.M. Marshall (TRIUMF) and G.M. Luke (McMaster U.), respectively. G.M. Marshall replaced J. Vincent in mid-2000 with S Yen (TRIUMF) becoming the alternate.

As a result of the annual ballot, G.M. Luke (McMaster U.) was elected as chair-elect for 2001. G.D. Morris (TRIUMF) and W.D. Ramsay (U. Manitoba) were elected as members for 2001/2002.

TUEC Membership for 2000

J.H. Brewer	UBC	*Chair*
N. Rodning	U. Alberta	*Chair-elect*
J.M. D'Auria	SFU	*Past-chair*
G.M. Marshall	TRIUMF	1999/2000
B. Turrell	UBC	1999/2000
R. Helmer	TRIUMF	2000/2001
A.K. Opper	Ohio U.	2000/2001
M. Comyn	TRIUMF	*Liaison Officer*

Program of the 2000 Annual General Meeting

Wednesday, December 6

Director's Report	A. Astbury
Accelerator Technology/ CERN Collaboration	E. Blackmore
Cyclotron Division	G. Dutto
Science Division	J.-M. Poutissou
KOPIO and TRIUMF	R. Poutissou
Materials Science at ISAC	R. Kiefl
NSERC SAP 5-Year Plan	M. Vetterli
"What Comes After ISAC-II?"	
Neutrino Schemes	A. Konaka
Open Discussion	
Buffet Dinner at TRIUMF	
Evening Session	
NSERC SAP GSC Business	R. Keeler
TUEC Business	J. Brewer

Thursday, December 7

"What to do with ISAC-II?"

ISAC-I Progress, ISAC-II Plans	P. Schmor
Nuclear Structure with TIGRESS	C. Svensson
Studies of Nuclei at the Limits of Stability Using Recoil Separators	J. Batchelder
The HERACLES Array at ISAC-II	Y. Larochelle
Nucleosynthesis in Supernovae — What Can We Learn with ISAC-II?	B. Fulton
Open Discussion	