TRIUMF

Financial and Administrative
Annual Report 1981-1982

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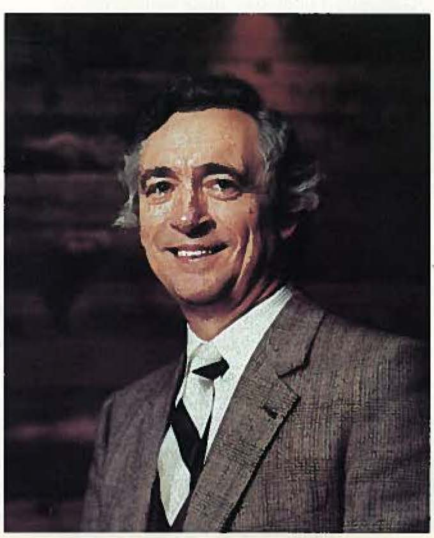


DIRECTOR'S REPORT

This report chronicles the beginning of TRIUMF's fourth administration — the first years of the full scientific program.

TRIUMF's first director, Dr. John B. Warren led the project (1968-1971) through its development from an idea into a construction project. Dr. J.R. Richardson, the second director, not only conceived the idea of TRIUMF (1962) but also headed the project (1971-1976) during its construction period until extracted beams were first achieved and used. The third director, Dr. John T. Sample presided over the five year period (1976-1981) in which full intensity was achieved, the major secondary lines and facilities were built and in which the experimental program developed strongly.

Essentially all of the science program for which TRIUMF was established is now underway. Some important areas of research — such as the full survey of the basic neutron-proton and proton-proton interaction — have been completed. Most of the meson research areas are being strongly pursued and the use of intermediate energy protons in high resolution nuclear spectroscopy is to begin soon.

The organization of TRIUMF was greatly changed with the advent of the new administration. Because of the increasing complexity of the whole establishment and its growing complement of scientists and support staff the former centralized administration has been replaced by one with five divisions under the director. This new structure, described separately in this report, aims at better financial control and better articulation of science priorities.

The TRIUMF building program funded by the province of British Columbia continued through the year. The office building and proton hall extensions were completed and construction of the new remote handling building was begun.

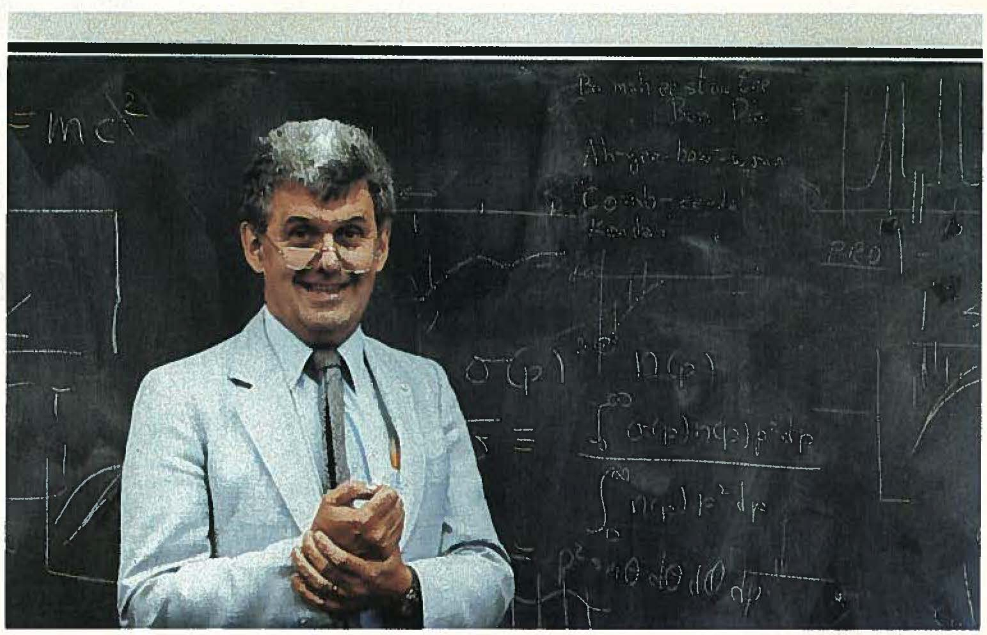
The effort at long range planning by the Users and the administration produced firm plans for a second arm to the Medium Resolution Spectrometer and for a new meson line (M15) to relieve the scientific pressure on the superb lines at TRIUMF for surface muons. Much planning effort was given toward the development of a new proton hall.

The full scientific program will require a decade or more of high intensity running at TRIUMF's main cyclotron. For this purpose cyclotron reliability became the highest priority. Although 1981-1982 produced a little less beam current than planned, the operation in early 1982 was the best ever and augured well for the scientific program to be carried out in the next year.

More than ever at TRIUMF it has been "full steam ahead".

Opposite page:
View from the end of the Meson Experimental Hall.
TRIUMF's 500 MeV cyclotron is behind
the 3 storey high, 5 meter thick yellow concrete shielding.

Erich Vogt,
Director of TRIUMF



FACILITIES

There were many improvements to facilities this past year and inadequate space is available in this report for them all. This represents an indicative sampling of the accomplishments in this area.

Radio Frequency System

One of the unique features of the TRIUMF cyclotron also leads to one of its major problems. Because of the immense size of the machine, approximately 20 meters (60') across, the part of the cyclotron that actually does the accelerating, the radio frequency resonator or "resonator" for short, is very large. The fact that resonators are very sensitive to mechanical misalignment was not fully appreciated when first designed. Each of the 80 resonator segments must be aligned to within two one-hundredths of an inch or the support structure heats up and causes the resonator to sag, which in turn causes further misalignment and sagging. In the past this led to the melting of parts of the resonator. One of the major projects in the Cyclotron Division has been the upgrading of the existing resonator and the designing of a new one which will in time replace the original, troublesome system.

This year a new water-cooled resonator was designed and a prototype built. Instead of aluminum, the new model is in copper with a riveted rather than extruded support system. These improvements mean the resonator is stiffer and less likely to bend. Water cooling will keep the equipment from getting hot and prevent sagging.

Lifting Mechanism

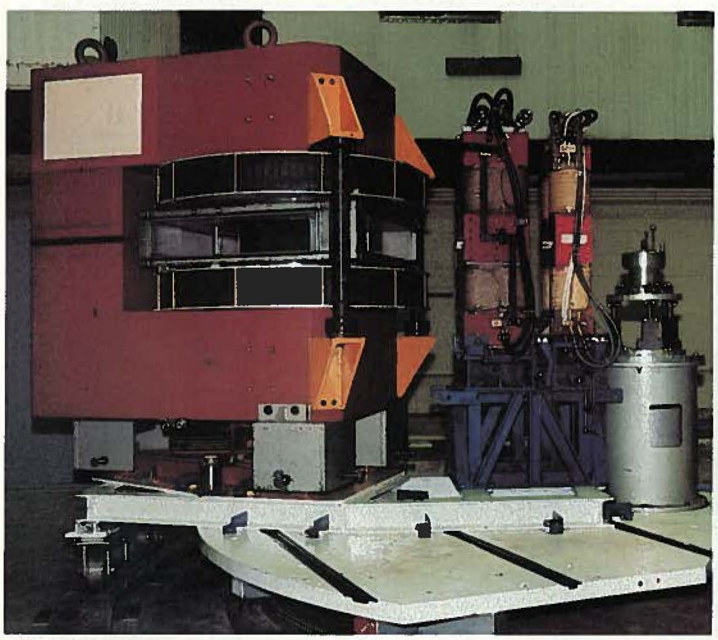
TRIUMF's 500 MeV cyclotron is the largest in the world. The particles being accelerated within the machine are kept in their circular paths by a very stable magnetic field provided by the main magnet. The region of the cyclotron where the particles are accelerated must be opened for maintenance from time to time. Raising the top half of the magnet, which weighs 2,000 tonnes, the required 1.1 meters is accomplished in 35 minutes by 24 screw jacks. In November one of the jacks was found to be faulty. As a manufacturing flaw in the original bearings turned out to be the cause, the lifting system had to be repaired. A variety of qualified members of TRIUMF's maintenance and design staff were able to complete the work in less time than anticipated.

Experimental Facilities

A new secondary beam line, M11 was completed this year. A secondary beam line is one which carries secondary particles generated by running the main proton beam through a target. Experiments are then performed with these particles called mesons..

M11 was one of the first experimental areas planned when TRIUMF was in its conceptual stage but one of the last beam lines built because of design difficulties. M11's completion now gives TRIUMF its full set of secondary channels as originally planned. Magnets are used in the channel to focus charged particles much as glass lenses are used to focus light. A septum magnet steers the stream of mesons from the production target into the M11 beam line. The septum is a very powerful electromagnet which has to be very compact so as to fit closely beside the main proton beam without disturbing it. The reason for this is that the majority of high energy pions come off in the forward direction, i.e. in the same direction as the proton beam. The need for a sufficiently powerful yet compact magnet that wouldn't affect the nearby proton beam was met by using a sophisticated magnet designed and built by the University of Victoria participants in TRIUMF.

QQD Spectrometer with dipole magnet at left, two quadrupoles, right.



Below:
Working on the prototype Radio Frequency resonator.

The first particles came down M11 in April 1981. For test purposes, a small radioactive source was used at the start of the secondary channel to simulate the pions coming from the target. The M11 channel was used for its first experiments in June and July. More trials were done for fine tuning in November and January.

The development of an RF separator for the M9 channel, another secondary channel, was a major achievement this past year. On any secondary channel the beam consists of pions, muons and electrons in varying amounts depending on the production target channel design. For some critical experiments it is important to remove the unwanted particles, in this case, pions and electrons and transport only muons to the experimental apparatus. This has been done at TRIUMF using an electrostatic or DC separator but the RF separator is more effective and provides twice the flux of muons on the M9 channel. This separator relies on the fact that the TRIUMF proton beam is pulsed and this pulse structure is retained by the secondary particles. The pulses of electrons and pions arrive at the RF separator at different times than the muon pulses and therefore can be removed by an appropriately varying voltage on the electrodes of the separator. The separator works at the same frequency as the cyclotron and relies on much of the same technology as the cyclotron RF system.

Another addition to the laboratory is an example of the International flavour and co-operation enjoyed by TRIUMF within the scientific community. The QQD spectrometer is named for the three magnets which are the main components of the device: 2 Quadrupoles, and a Dipole. It was economically and rapidly constructed because the whole system of magnets was provided by scientists from KFA JULICH in West Germany who plan to collaborate in the use of the QQD spectrometer.

The QQD spectrometer will be used to distinguish pions of different energies after they have been scattered from a target. Using a variety of targets such as carbon, oxygen, neon, magnesium, sulphur or calcium scientists will be able to study these different elements' nuclei by hitting them with a stream of pions. There are two kinds of low energy pions, positive and negative, interacting with the nucleus in these experiments. The nuclei of all atoms are made up of protons and neutrons. Neutrons affect negative pions much more than positive ones. It is this difference in effect that is used to give physicists more information on how neutrons are spread around the nucleus of an atom. There seems to be a significant difference among different elements in the distribution of neutrons around the nucleus.

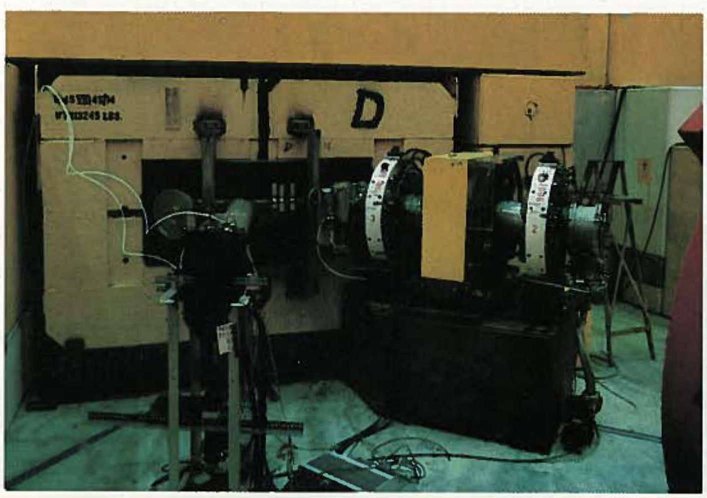
Utilizing the QQD spectrometer to measure the different speeds of the negative and positive pions coming off of the target it is now possible to map out the "location" of neutrons within the nucleus of specific elements.

From the time of the initial TRIUMF QQD spectrometer concept to the finished equipment in March of 1982 less than a year and a half had elapsed which is a short time for a project of this nature. Systems of this complexity routinely take three to four years to complete.

The first experiments using the QQD spectrometer are due in May of 1982 with many more planned to be scheduled for the near future.

Below:
New Secondary beam line, M11.

Right:
Repairing the lifting jacks for the 2000 tonne lid of the 500 MeV cyclotron.



APPLIED PROGRAM

This fiscal year has seen the achievement of numerous goals within the applied science division. The Pion Irradiation Cancer Therapy research project has had promising results with its use of π^- particles to treat tumours. An original radioisotope production area was shut down and a new one installed. Excellent progress has been made towards finding a greater variety of radiopharmaceuticals for medical diagnostics using low radiation dose iodine (I-123) produced at TRIUMF. Work on a number of radiochemicals for use with the PET brain scanner is under way and the long awaited "baby" cyclotron devoted to radioisotope production has arrived.

Cancer Therapy Research

There were three patients treated in this year's experimental pion cancer therapy program. Because of the depth-charge effect they have within the body, pions are being tested as tumour killing agents. They can be aimed to deposit the majority of their radiation energy within a tumour, interfering little with the healthy cells around it, which has been a common problem with conventional cobalt radiotherapy.

The pion irradiation therapy program continued to explore avenues which could lead to further increases in the effectiveness of pion radiotherapy by enhancing cancer cells' susceptibility. For more efficient use of the pion beam it was decided to move the patient in front of a small concentrated stream of pions, about the diameter of a dime, to treat a tumour rather than using one large dilute stream of pions on a stationary patient. For this reason a computerized treatment couch was designed and installed. Patients are now moved in front of the pion beam to irradiate the total area of a tumour, which is usually much larger in size than the pion beam. It is now possible to treat any shape of tumour in a uniform and controlled way.

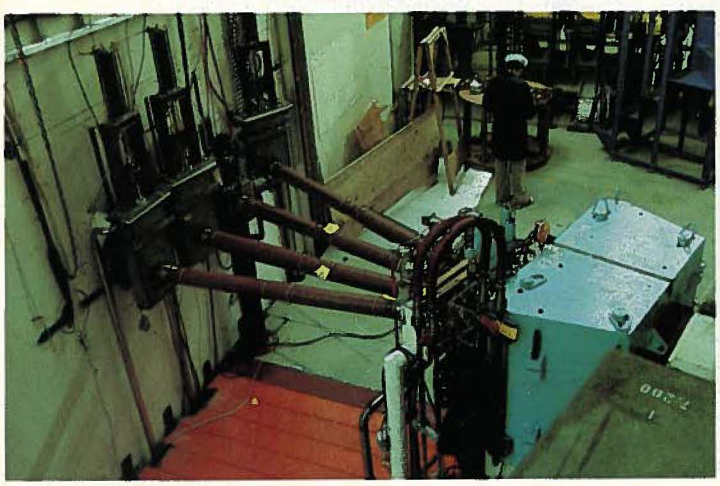
Radioisotopes

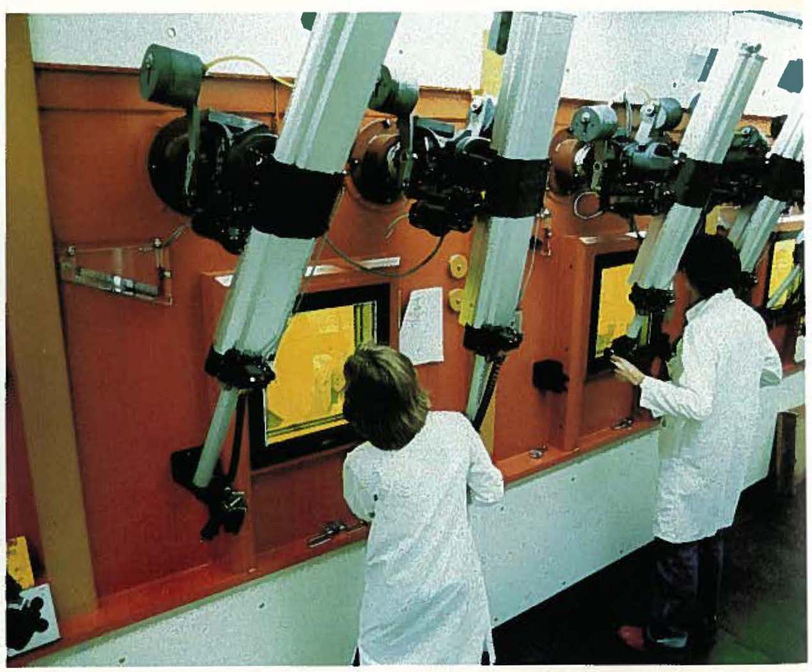
The cesium spallation target of the TRIM (TRIUMF Radioisotopes for Medicine) group, which has been in use since its inception in 1978, had its last run this year. The new facility, beam line 2C (BL2C) and its isotope production targets will continue to add to the more than $1 million worth of medical radioisotopes distributed free of charge by this project to 18 institutions across Canada since 1978. These isotopes have been used in the imaging of heart, kidney and thyroid patients for medical diagnostics and research, as well as at the British Columbia Institute of Technology (BCIT) for the training of medical technicians in the handling of these radiopharmaceuticals The original goal of the TRIM group, to complete a production, delivery and clinical testing program for their radiopharmaceuticals, has been reached. The experience gained has been used in the newer facility, BL2C, which is devoted to the production of specific radioisotopes on a regular, as opposed to developmental, basis. The goals of the TRIM group and those associated with it have matured to encompass physiological research into the reasons *why* these radioisotopes work as they do, as well as using the radioisotopes to learn more about healthy organs. By improving their knowledge of heart muscle function, for example, doctors will in time be better able to treat people who suffer the effects of one of the most common causes of disability and death in North America.

In addition to improvements in the isotope production area, there is ongoing research into developing more radiopharmaceuticals for medical research and diagnostics using radioisotopes produced in this new facility.

Below:
Beam line 2C and its four target areas.

Right:
Atomic Energy of Canada Limited hot cells with workers operating the remote control "hands".





Positron Emission Tomography

The Positron Emission Tomograph (PET) is 80% complete. This new form of brain scanner will allow scientists and doctors to better study, understand and treat the human brain by going beyond the simple X-ray information provided by a CAT scan. In contrast the PET scanner will show the actual functioning of the brain tissue in colour images resembling slices through the brain rather than showing only structure as a CAT scan does. By giving the patient a minute amount of a radioactive chemical and measuring the amounts of radiation coming from each area of the brain with the PET scanner it will be possible to discover a variety of causes of healthy brain responses as well as those for illnesses. A variety of chemicals is being developed at TRIUMF for use with the PET scanner. Each different chemical will be used to show some kind of brain function, such as where the blood flows or how oxygen is used.

The development of production processes for these radioactive chemicals is further complicated by the fact that the radioisotopes being used are short-lived and so must be used within a brief period of time after they are manufactured. The production process, which can number up to ten separate reactions, combines the isotopes with special chemicals designed to carry them to the brain. The reactions must be done quickly by remote handling in a "hot" cell while ensuring a large percentage of the original radioactive product ends up in the radiopharmaceutical and thus the patient. An unusual chemical being combined with a radioactive label is dopa. This substance acts on brain cells and is used to treat Parkinson's Disease. It is hoped dopa can be used with the PET scanner to study movement disorders, in particular Parkinson's Disease.

New Addition

The long awaited 42 MeV or "baby" cyclotron has arrived. It will be used to produce isotopes on a regular basis for both the Atomic Energy of Canada Limited (AECL) radioisotope operation and the PET program's imaging agents. The smaller machine was purchased because the large, 500 MeV cyclotron has been designed for purely experimental work and is not always running in a manner suitable for the production of isotopes. This can be a problem for AECL, especially when producing short-lived radioisotopes which must be used within a brief time of when they are made. It has been difficult and on occasion impossible to co-ordinate running the large cyclotron for isotope production with hospital patient schedules and with the needs of the pure research program. Procedures refined on the large machine will now be put into regular production with the baby cyclotron.

Neutron Activation Analysis

Novatrack Analysts Limited, a subsidiary of a North Vancouver based firm, Chemex Labs Ltd., uses some of the slow moving neutrons, generated by stopping the proton beam in a tub of lead, to analyze geological and environmental samples for heavy metals such as gold and silver. Novatrack broke records for the number of samples they irradiated in March because of the high reliability of the cyclotron in the latter part of the fiscal year.

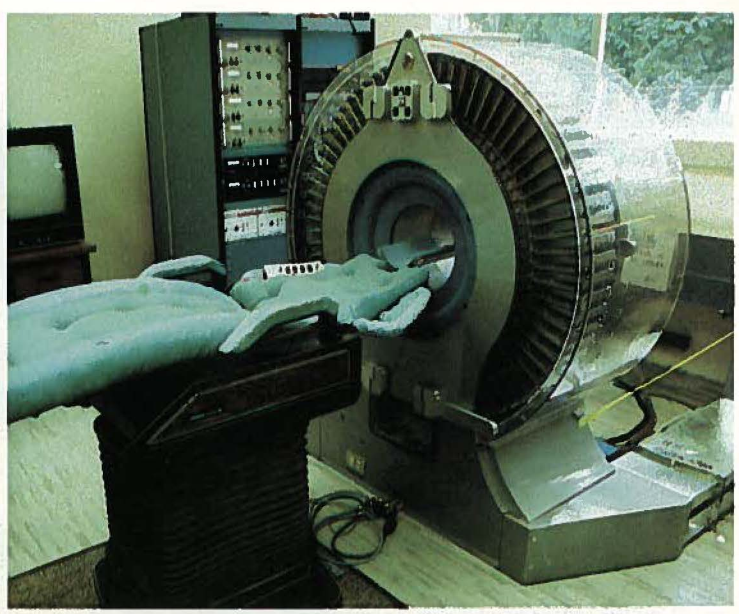
Arrival of the Baby Cyclotron.

Top right:
Lowering the 42 MeV cyclotron into the vault.

Below:
Positioning the cyclotron on its base.

Lower right:
interior of the 42 MeV cyclotron.

PET scanner.



PURE RESEARCH PROGRAM

The "MF" in TRIUMF stands for Meson Facility. π mesons, or pions as they are commonly called, are one of the main tools used to investigate the nucleus of the atom. In this year's report we shall deal mainly with the pion research at TRIUMF.

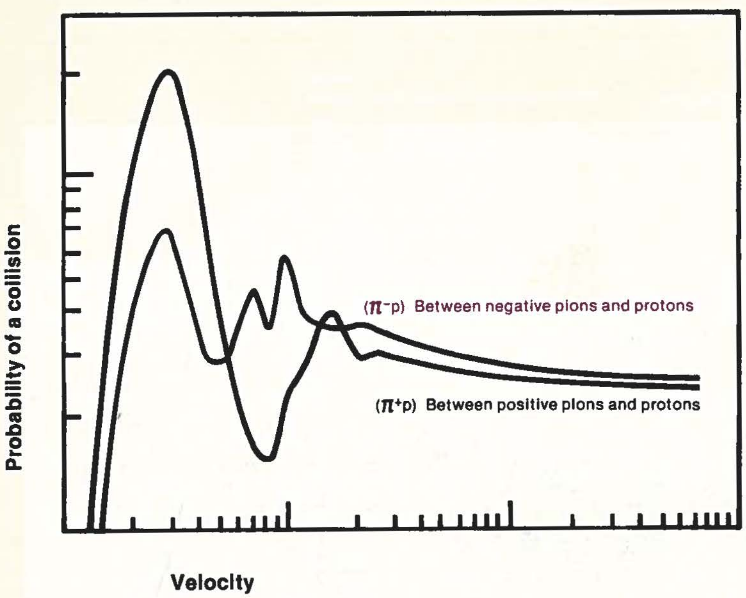
Pions do not occur naturally but are "made" at TRIUMF by bombarding targets of carbon or other heavier elements with the stream of fast moving protons from the cyclotron. (These protons have an energy of 500 MeV which is another way of saying they are travelling about three quarters the speed of light.) Pions come in three varieties — positively charged, negatively charged and uncharged, those having no charge. Pions disintegrate very quickly. In the time it takes light to go 26 feet, 26 billionths of a second, a charged pion's life is over. Since it lasts an even smaller time, the uncharged pion has too short a life to be useful as a probe for physics experiments.

Where do pions go? When a pion disintegrates it normally breaks up into two lighter particles called a muon and a neutrino. Being an elusive particle, the neutrino can be detected only by very large and sophisticated apparatus. On the other hand, the muon is used extensively at TRIUMF for research as is its parent, the pion.

The main proton beam coming out of the cyclotron travels down one of three "primary" beam lines. Pions can be generated at two different locations along one of these primary beam lines. From there they travel down TRIUMF's five "secondary channels". One carries only pions and goes to the Batho Biomedical Annex for pion irradiation cancer therapy. The other four secondary channels can be "tuned" for pions or muons as required by individual experiments. The cyclotron produces a high intensity (100 microamperes) unpolarized proton beam during times when pions are required for experiments. These experiments are thus in competition with those experiments described last year requiring the cyclotron to produce a beam of polarized protons, as it is not possible to mix the two types of proton beams in the cyclotron. Research using pion beams is therefore scheduled for times when the high intensity proton beam is available in the Meson Hall.

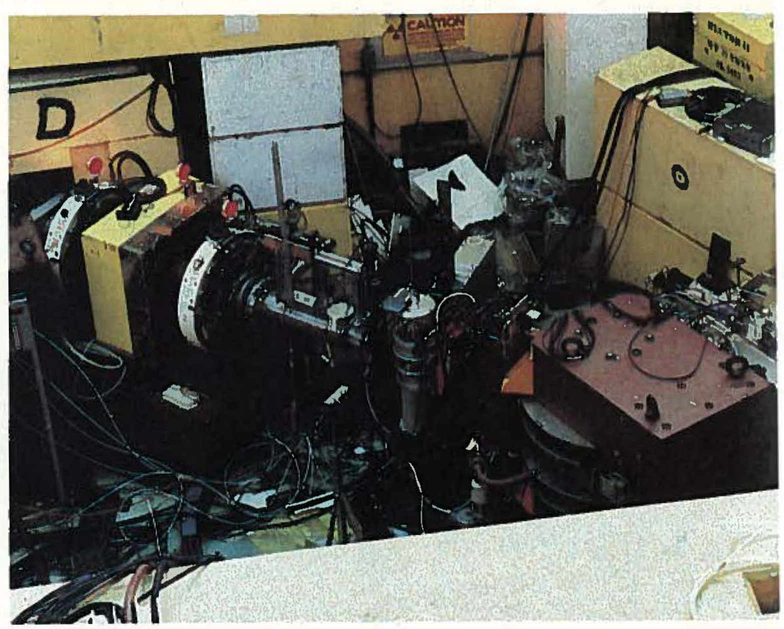
Pion Producing Experiments

On the borderline between research using pion and proton beams are those experiments investigating the production of pions by high energy proton beams. Last year we reported on a UBC/TRIUMF/Manitoba group that examined how pions were produced by polarized proton beams from targets of light elements such as carbon. In addition to this experiment the BASQUE group (U. Vic/London, UK) has been looking at the same problem but using a liquid hydrogen target — a target of pure protons: the lightest nucleus. In the collisions of interest the incoming proton was "shattered" into a neutron and a positive pion, both of which were detected. The experiment measured how often this process occured and whether the outgoing pion appeared to the left or right of the apparatus. Frequently in these collision with hydrogen, along with the pion, the outgoing neutron and the target proton come off joined together as a



The usefulness of the two varieties of pions lies in the way which interact with protons (and neutrons) inside the nucleus of the atom. The large bump means that a beam of positively charged pions is more likely to scatter off protons than a beam of negatively charged pions. A similar strong effect is observed between pions and neutrons.

QQD Spectrometer set up for pion experiment in the M11 beam line.



single particle, called the deuteron. This second reaction was investigated by a UBC/Manitoba/TRIUMF group which was also interested in the basic properties of producing pions in collisions between protons and protons. The results of both these experiments are being used to refine the knowledge of the complex force that is involved in producing pions. A knowledge of this force is needed by theoretical physicists when calculating how protons interact with the nucleus.

Pion Experiments

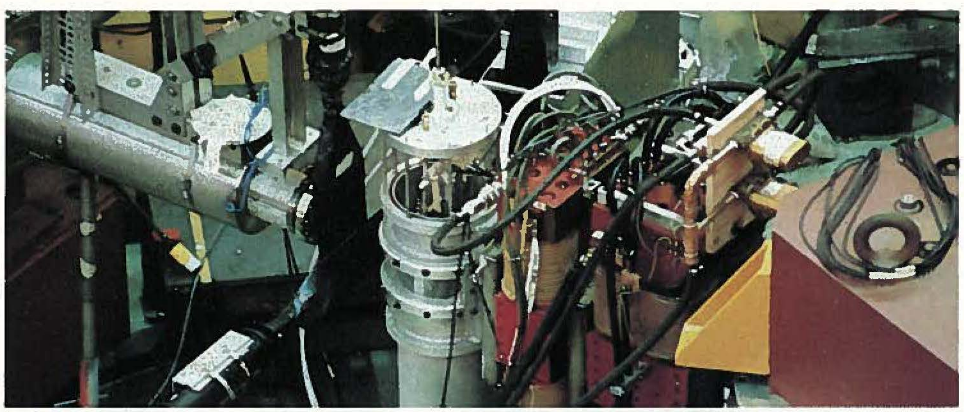
A UBC/TRIUMF/Weizmann Institute group has been using pions to measure the difference in the distribution of neutrons between isotopes of a light element. The worlds' supply of a rare sulphur isotope was brought to TRIUMF for use in one of these experiments and was prepared in the form of very thin targets 1 centimeter in diameter, each weighing less than one fifth of a gram. The measurements indicated a difference of a tenth of a fermi between the radii of the volumes occupied by neutrons in the two nuclei of sulphur. By comparison the proton has a radius of one and a half fermis. An experiment scattering electrons from the same targets will be undertaken to see whether there is a difference in the size of the volume occupied by the protons.

Exotic atoms are formed when negatively charged pions are captured into orbits around a positively charged nucleus. They are called pionic atoms and emit X-rays as the pions are absorbed by the nucleus. A Univ. of Victoria group has been measuring X-rays emitted by pairs of isotopes in an attempt to deduce the distribution of neutrons and protons in the nucleus. These experiments complement the pion scattering experiments described above and vividly illustrate the wide variety of different techniques available to physicists for measuring basic properties of matter.

Rare Decay Modes

Pions are interesting particles in their own right. Sometimes, however, the pion does not break up into a muon and a neutrino. Approximately one in every ten thousand will undergo one of the rare breakups shown in the table. Accurate measurements of how probable these rare breakups are allow physicists to test the contemporary theories of how the pion is constructed from quarks and how the quarks interact among themselves "inside" the pion.

A group of physicists from NRC/UBC/U Vic/Queens Univ. measured the probability of how often the pion breaks up into an electron and the (undetected) neutrino. From the table one can see this occurs once in every ten thousand normal pion breakups. The result agreed with a prediction from a new theory in particle physics that unifies our understanding of the "weak" nuclear force and the electromagnetic force and confirmed the belief that electrons and muons are in fact affected the same by "weak" forces. It is accurate measurements like these, using very slowly moving or stationary pions, that complement experiments performed at the giant accelerator laboratories in the USA and Europe in confirming or refuting contemporary theories of matter.



Enlargement of photo at left.

Table 1 *RARE BREAKUP MODES OF THE PION*

How often	Physicists Write...	But say "The pion decays to..."
1.3 in 10,000	$\pi \rightarrow e\nu$	"...an electron and a neutrino."
1.2 in 10,000	$\mu\nu\gamma$	"...a muon, a neutrino and a gamma ray."
1 in 100,000,000	$e\nu\pi^\circ$	"...an electron, as neutrino and a neutral pion."
5 in 100,000,000	$e\nu\gamma$	"...an electron, a neutrino and a gamma ray".
5 in 1,000,000,000	$e\nu e^+ e^-$	"...an electron, a neutrino, a positron, and an electron".

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J. Tinsley, University of Oregon
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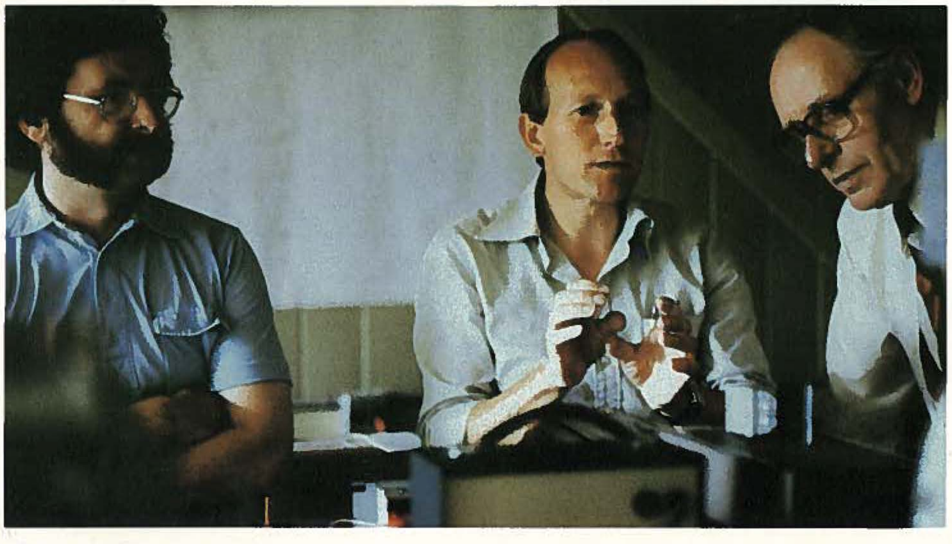

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A.S. Clough, University of Surrey
A.N. James, University of Liverpool
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R. Grynszpan, CNRS Vitry
R. van Dantzig, IKO Amsterdam
J. Niskanen, University of Helsinki
M. Furic, Inst. R. Boskovic
C. Cernigoi, N. Grion, University of Trieste and INFN
J. Alster, Tel-Aviv University
B.K. Jain, Bhabha Atomic Research Centre
R. Hayano, A. Ito, K. Nagamine, K. Sakamoto, T. Yamazaki, University of Tokyo
I.R. Afnan, Flinders University of South Australia

United States

D. Ashery, Argonne National Laboratory
K.W. Jones, Brookhaven National Laboratory
F.P. Brady, University of California, Davis
B.M.K. Nefkens, J.R. Richardson, University of California, Los Angeles
M.P. Epstein, D.J. Margaziotis, California State University
B. Bassalleck, Carnegie-Mellon University
J.J. Kraushaar, T. Masterson, University of Colorado
H.S. Plendl, Florida State University
M.E. Rickey, P. Schwandt, T. Ward, Indiana University
Y.K. Lee, Johns Hopkins University
P. Tandy, Kent State University
C. Clawson, K.M. Crowe, G. Gidal, S. Kaplan, R.H. Pehl, V. Perez-Mendez, S. Rosenblum, H. Steiner, M.W. Strovink, R. Tripp, Lawrence Berkeley Laboratory
J.W. Blue, Lewis Research Center, NASA
L.E. Agnew, H.L. Anderson, R.M. de Vries, C.A. Goulding, C.Y. Huang, R.J. Macek, T. Suzuki, Los Alamos National Laboratory
R.P. Redwine, Massachusetts Institute of Technology
H.B. Willard, National Science Foundation
B. Dieterle, University of New Mexico
J.K. Chen, State University of N.Y. Geneseo
K.K. Seth, Northwestern University
F.E. Bertrand, Oak Ridge National Laboratory
B.C. Clark, Ohio State University
D.K. McDaniels, University of Oregon
K.S. Krane, R. Landau, A.W. Stetz, L.W. Swenson, Oregon State University
R.F. Carlson, University of Redlands
G.S. Mutchler, Rice University
R. Dubois, Stanford Linear Accelerator Center
R. Bryan, R.B. Clark, Texas A & M University
V.G. Lind, R.E. McAdams, O.H. Otteson, Utah State University
M. Blecher, K. Gotow, D. Jenkins, Virginia Polytechnic Institute and State University
I. Halpern, E.M. Henley, P. Wooton, University of Washington
A.S. Rupaal, Western Washington University
W.C. Sperry, Central Washington University
M. Eckhause, R.T. Siegel, College of William and Mary
H. Bichsel
T.C. Sharma

Users Executive Committee

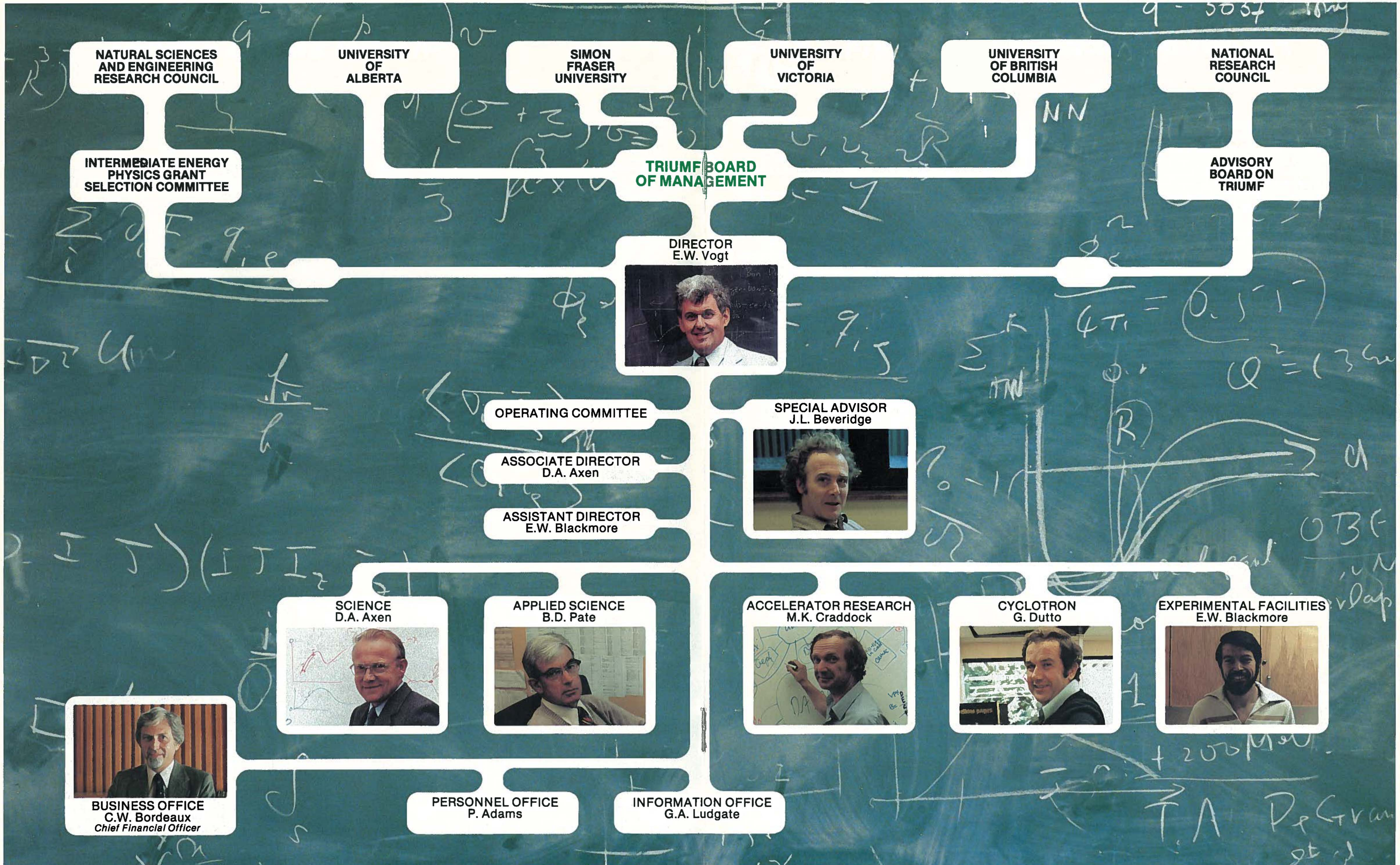
At the Users Annual General Meeting November 12 - 14 the following Executive Committee was elected:

L.G. Greenlaus, *Chairman*	University of Alberta
D. Garner, *Assoc. Chairman*	University of British Columbia
A. Olin	University of Victoria
A.W. Stetz	University of Alberta
G. Roy	University of Alberta

P.W. Schmor TRIUMF Liaison Officer

Long Range Planning Committee

D.F. Measday, *Chairman*	University of British Columbia
J.M. Poutissou, *Secretary*	TRIUMF
D.V. Bugg	Queen Mary College, UK
K.M. Crowe	Lawrence Berkeley Laboratory, USA
D.A. Hutcheon	TRIUMF/University of Alberta
K.P. Jackson	TRIUMF/Simon Fraser University
J.R. Richardson	University of California, Los Angeles, USA
A.W. Thomas	TRIUMF, EEC Chairman
T. Yamazaki	University of Tokyo, Japan


NATURAL SCIENCES AND ENGINEERING RESEARCH COUNCIL
UNIVERSITY OF ALBERTA
SIMON FRASER UNIVERSITY
UNIVERSITY OF VICTORIA
UNIVERSITY OF BRITISH COLUMBIA
NATIONAL RESEARCH COUNCIL
INTERMEDIATE ENERGY PHYSICS GRANT SELECTION COMMITTEE
TRIUMF BOARD OF MANAGEMENT
ADVISORY BOARD ON TRIUMF
DIRECTOR E.W. Vogt
OPERATING COMMITTEE
ASSOCIATE DIRECTOR D.A. Axen
ASSISTANT DIRECTOR E.W. Blackmore
SPECIAL ADVISOR J.L. Beveridge
SCIENCE D.A. Axen
APPLIED SCIENCE B.D. Pate
ACCELERATOR RESEARCH M.K. Craddock
CYCLOTRON G. Dutto
EXPERIMENTAL FACILITIES E.W. Blackmore
BUSINESS OFFICE C.W. Bordeaux *Chief Financial Officer*
PERSONNEL OFFICE P. Adams
INFORMATION OFFICE G.A. Ludgate

FINANCIAL REVIEW

Real growth continued with an overall increase in receipts of 36% over fiscal 1981 (Fig. 1). The extraordinary growth experienced in receipts from Atomic Energy of Canada Limited (AECL) and from Sponsoring Organizations is temporary in that the major transaction undertaken on behalf of AECL, the purchase of a 42 MeV Cyclotron, is nearly complete and the manufacturing of the Positron Emission Tomography (PET) unit, accounted for under Sponsoring Organizations, is nearing completion as well.

The Province of British Columbia, through the Universities Council of British Columbia, has approved Phase II of a building program designed to keep pace with expansion as reflected in the TRIUMF 5-Year Plan. The total amount approved for Phases I and II is $7,475,000. Phase I was completed this year and a start was made on Phase II.

As a result of the 42 MeV Cyclotron and the PET transactions, the apportionment of the total receipts (Fig. 2) shifted so that the National Research Council (NRC) and the Natural Sciences and Engineering Research Council (NSERC) portion is now 80.5%, as opposed to last year's 88.5%, and the other contributors' portion has increased from 11.5% to 19.6%. This is significant in that all funding for operations, maintenance, development and capital expansion of TRIUMF, except for buildings, comes from NRC and that NSERC provides the sole financial support for all experiments performed under the aegis of TRIUMF.

The expenditures in the Summary of Combined Receipts and Expenditures (page 17), reflect the installation of a VAX computer on the TRIUMF site, causing computing costs to be reduced by 20.9%. A longer maintenance period for the cyclotron resulted in slightly reduced power costs. Communication expenditures increased because the new building additions necessitated upgrading the existing systems, including installation and purchase of telephone instruments. Interest expenses increased considerably due to a loan by AECL, which is administered by TRIUMF on their behalf, and therefore fully recoverable by TRIUMF.

The general increase in activities and the needs created by the five-year plan projections led to the hiring of additional staff which is reflected in the increased salary expenditures.

A successful year was experienced in that all major obligations were met and expenses were at acceptable levels. The forecast for next year, fiscal 1983, is continued real growth in receipts from NRC, NSERC and the Government of British Columbia, plus usual support from all institutions using the TRIUMF facilities.

Figure 1
% increases in receipts over previous year

	1982
NRC	24.75%
NSERC	16.77%
AECL	3011.55%
Province of B.C.	35.2%
Sponsoring Organizations	193.1%
Investment Income	5.4%
Total	36.%

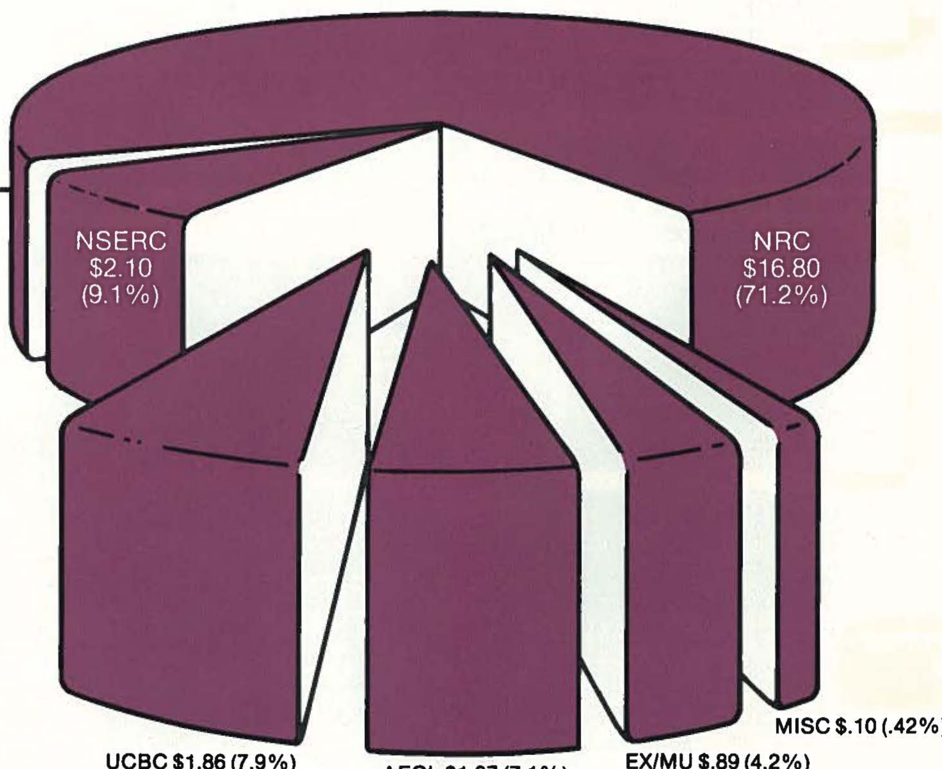
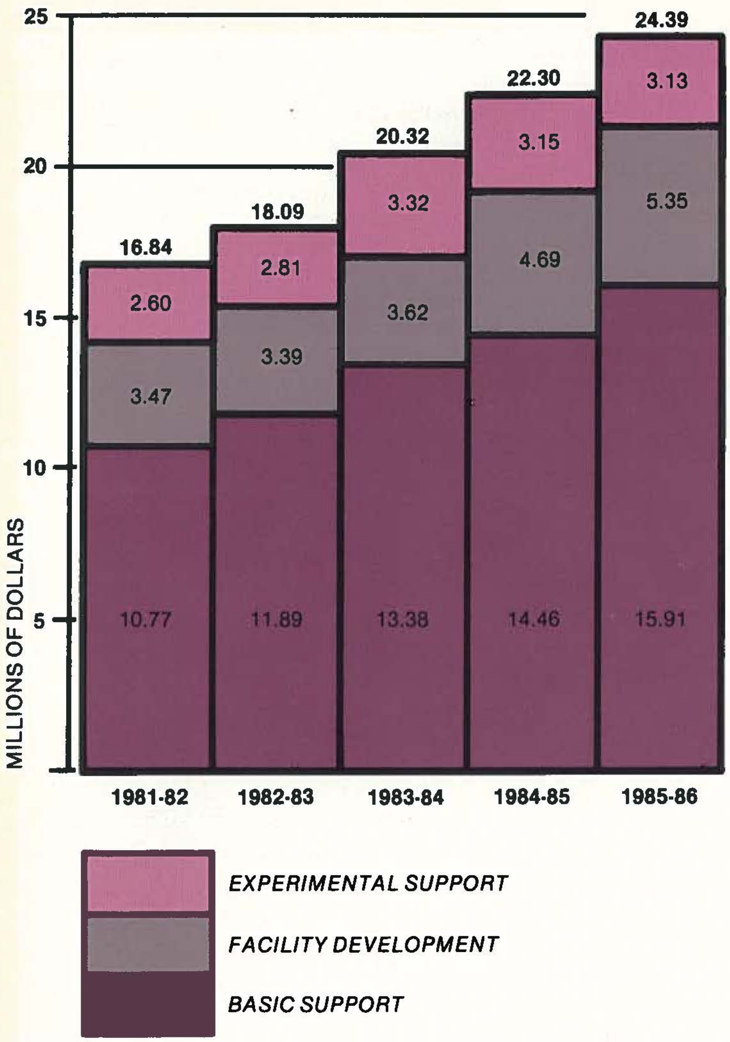


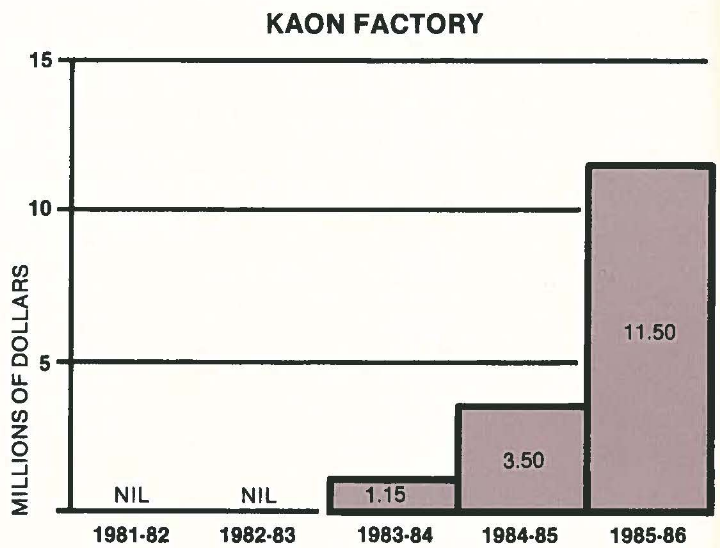
Figure 2
SOURCE OF FUNDS
(in millions of dollars)

NRC: *National Research Council*
NSERC: *Natural Sciences and Engineering Research Council*
AECL: *Atomic Energy of Canada Ltd.*
UCBC: *Universities Council of British Columbia*
EX/MU: *Extra-mural*

FIVE YEAR PLAN



TRIUMF's 5 Year Plan is submitted to the NRC Advisory Board on TRIUMF in the fall of each year. It is a rolling plan intended to forecast TRIUMF's future intentions and the associated financial requirements. Within the plan three broad areas of expenditure are identified, namely: the basic support and operation of the existing facility, the development of new facilities which enhance TRIUMF's capabilities and the support of experiments being performed at TRIUMF. Forecasts of future requirements in each of these areas are centered about the development of major facilities and are based on a model to guide the extension of the 5 Year Plan. This model defines additional financial requirements associated with the general increase in TRIUMF's scope and capabilities implied by the completion of major facilities. A proposed major new addition to TRIUMF, the Kaon Factory, is dealt with as a separate line item within this plan due to the magnitude of the anticipated costs.



TRIUMF 5 YEAR PLAN
(in millions of 1981-82 dollars)

	1981-82	1982-83	1983-84	1984-85	1985-86
Basic Support	10.77	11.89	13.38	14.46	15.91
Facility Development excl. Kaon Factory	3.47	3.39	3.62	4.69	5.35
Experimental Support	2.60	2.81	3.32	3.15	3.13
Subtotal	16.84	18.09	20.32	22.30	24.39
Kaon Factory	—	—	1.15	3.50	11.50
Total	16.84	18.09	21.47	25.80	35.89

AUDITORS' REPORT

To the Board of Management,
TRIUMF:

We have examined the statements of fund transactions of TRIUMF for the year ended March 31, 1982. Our examination was made in accordance with generally accepted auditing standards and accordingly included such tests and other procedures as we considered necessary in the circumstances.

In our opinion these financial statements present fairly the results of fund transactions of TRIUMF for the year ended March 31, 1982 in accordance with the accounting policies set out in Note 1 (page 18) which, except for the changes in policies as described in that Note, have been applied on a basis consistent with that of the preceding year.

Vancouver, Canada
July 16, 1982

MacGillivray & Co.

MacGillivray & Co.
Chartered Accountants

FINANCIAL STATEMENTS

TRIUMF
SUMMARY OF COMBINED RECEIPTS AND EXPENDITURES
FOR THE YEAR ENDED MARCH 31, 1982

	1982	1981
RECEIPTS		
National Research Council Funds	$16,845,000	$13,502,000
Natural Sciences and Engineering Research Council Grant	2,165,420	1,854,340
Atomic Energy of Canada Limited Funds	1,673,770	53,792
British Columbia Development Corporation Loan Proceeds	—	140,000
Province of British Columbia Grant	1,861,128	1,376,488
Sponsoring Organizations	981,539	334,893
Investment Income	105,826	100,384
	23,632,683	17,361,897
EXPENDITURES		
Building Construction	1,801,580	1,390,893
Communication	171,165	72,111
Computer	176,156	222,773
Cyclotron Costs-Atomic Energy of Canada Limited	473,442	—
Equipment	2,333,604	1,509,613
Equipment and Facility Components-Atomic Energy of Canada Limited	13,998	217,317
Facilities in Progress	1,202,609	603,661
Insurance	37,637	11,968
Interest Expense	752,662	484,930
Minor Construction	67,687	116,364
Miscellaneous	4,644	30,067
Power	676,825	742,238
Salaries and Benefits	10,391,489	7,964,389
Sessional and Occasional Staff Costs	470,059	505,959
Supplies and Expenses	4,326,304	4,506,282
	22,899,861	18,378,565
EXCESS OF RECEIPTS OVER EXPENDITURES	732,822	(1,016,668)
ADD FUNDS BALANCE beginning of year (Note 2)	(450,044)	602,010
	282,778	(414,658)
LESS FUNDS BALANCE end of year	225,155	(450,044)
DECREASE IN DEFICIT for the year	57,623	35,386
SURPLUS (DEFICIT) beginning of year	(217,674)	(253,060)
SURPLUS (DEFICIT) end of year	$ (160,051)	$ (217,674)

TRIUMF
NOTES TO THE SUMMARY OF COMBINED RECEIPTS AND EXPENDITURES
FOR THE YEAR ENDED MARCH 31, 1982

NOTE 1: ACCOUNTING POLICIES

The following are the significant accounting policies:

a) Basis of Accounting
All transactions are recorded on an accrual basis. This represents a change in policy from prior years in respect of all funds, other than the National Research Council, which were previously reported on a cash basis. The comparative figures for 1981 have not been restated to reflect this change.

b) Rental Policy Change
The charge for rentals (an internal charge to the various funding organizations and credited to National Research Council) has been discontinued.

c) Atomic Energy of Canada Limited
Only transactions recorded by TRIUMF are included.

NOTE 2: SUMMARY OF END-OF-YEAR FUNDS BALANCE

	1982	1981
FUNDS UNEXPENDED		
National Research Council	$ 16,243	$ —
Natural Sciences and Engineering Research Council Grants	481,660	225,227
Other Administered Funds	—	4,101
	497,903	229,328
FUNDS OVEREXPENDED		
National Research Council	$ —	$280,779
Atomic Energy of Canada Limited	234,038	398,593
Other Administered Funds	38,710	—
	272,748	679,372
FUNDS BALANCE	$225,155	($450,044)

TRIUMF
STATEMENT OF WORKING CAPITAL POSITION
FOR THE YEAR ENDED MARCH 31, 1982

	1982	1981
ASSETS		
FUNDS RECOVERABLE		
Natural Sciences and Engineering Research Council Overexpended Grants	$ 65,400	$138,090
Atomic Energy of Canada Limited Projects	234,038	398,593
Other Administered Overexpended Funds	151,085	82,699
	450,523	619,382
DUE FROM UNIVERSITIES		
University of British Columbia	271,289	(306,363)
Simon Fraser University	12,891	(70,519)
	284,180	(376,882)
TOTAL ASSETS	734,703	242,500
LIABILITIES		
DUE TO NATIONAL RESEARCH COUNCIL	16,243	(280,779)
DUE TO UNIVERSITIES		
University of Victoria	30,064	5,268
University of Alberta	12,337	56,692
	42,401	61,960
ACCOUNTS PAYABLE	176,675	228,876
	219,076	290,836
UNEXPENDED BALANCES		
Natural Sciences and Engineering Research Council Unexpended Grants	547,060	363,317
Other Administered Unexpended Funds	112,375	86,800
	659,435	450,117
TOTAL LIABILITIES	894,754	460,174
WORKING CAPITAL — UNALLOCATED FUNDS	$(160,051)	$(217,674)

TRIUMF
NATIONAL RESEARCH COUNCIL FUNDS
STATEMENT OF RECEIPTS AND EXPENDITURES
FOR THE YEAR ENDED MARCH 31, 1982

	1982	1981
RECEIPTS		
Contribution	$16,845,000	$13,502,000
EXPENDITURES		
Administration	1,749,410	1,679,991
Cyclotron services	5,013,893	4,613,864
General services	4,324,456	3,790,866
Commissioned facilities	1,217,512	1,276,817
Minor projects	101,194	133,386
Major projects	3,143,048	1,501,414
Experimental support	793,072	680,072
Unallocated	205,393	243,045
	16,547,978	13,919,455
EXCESS OF RECEIPTS OVER EXPENDITURES	297,022	(417,455)
FUNDS UNEXPENDED (OVEREXPENDED) beginning of year	(280,779)	136,676
FUNDS UNEXPENDED (OVEREXPENDED) end of year	$ 16,243	$ (280,779)

A breakdown of expenditure by object is as follows:

	1982	1981
Communications	$ 151,212	$ 64,785
Computer	126,729	146,203
Equipment	2,073,929	1,236,281
Facilities in progress	1,202,609	603,661
Insurance	37,637	11,968
Minor construction	67,687	116,364
Rentals	—	(129,912)
Power	676,825	742,238
Salaries and benefits	9,140,479	7,096,985
Sessional and occasional staff costs	330,662	322,175
Supplies and expenses	2,740,209	3,708,707
	$16,547,978	$13,919,455

NOTE 1: COMMITMENTS

Commitments represent the estimated costs of unfilled purchase orders and contracts placed as at the fiscal year end.

1982	1981
$1,533,000	$1,759,000

NOTE 2: RESTATEMENTS

The comparative figures have been restated to reflect reclassifications of salary accounts.

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