TRIUMF 1985-86

Annual Financial and Administrative Report

including summaries of
pure research activities, and of
practical applications of research

TRIUMF

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Canada's national meson facility, managed as a joint venture by:

University of Alberta

University of Victoria

Simon Fraser University

University of British Columbia

Operated under a contribution from the National Research Council of Canada

The Financial & Administrative Annual Report is prepared by the

TRIUMF Information Office.

Editor: Michael La Brooy

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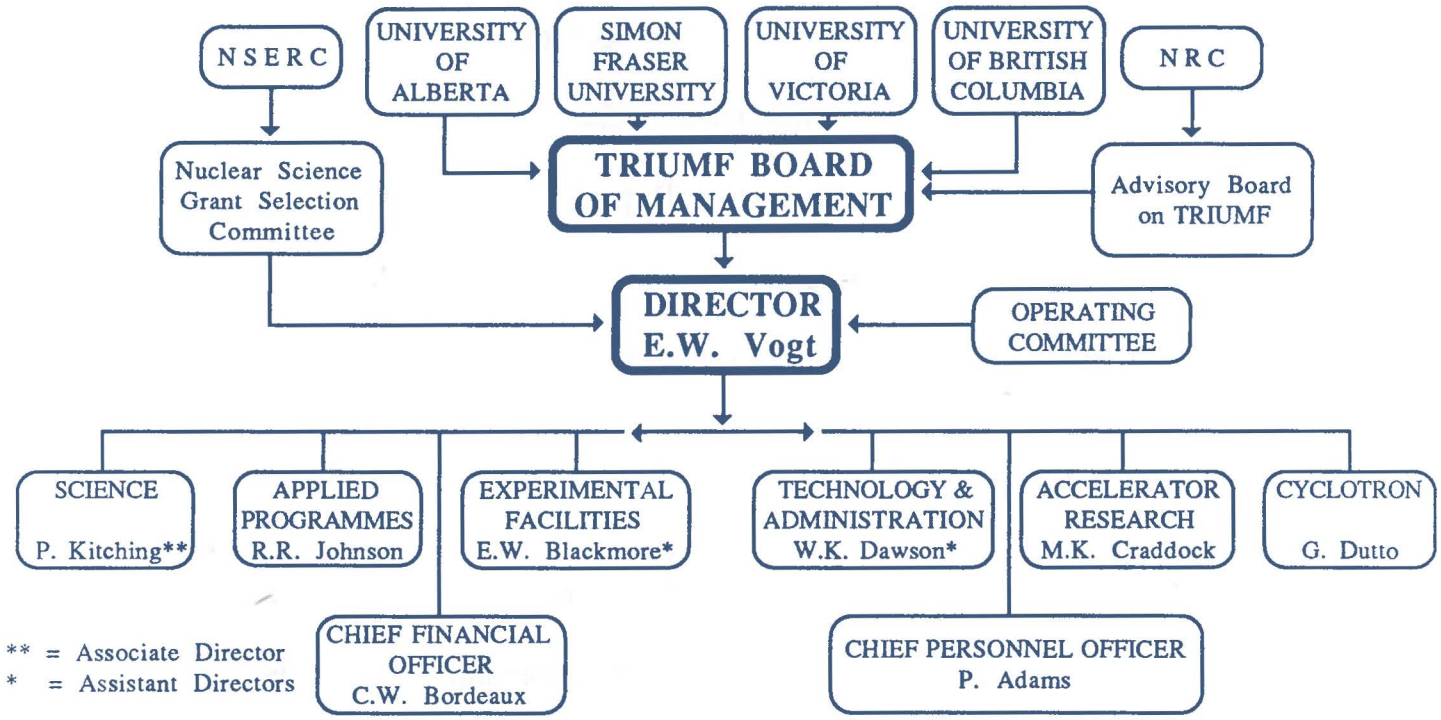


Director's Report

In July 1985 a significant celebration took place at TRIUMF marking the first ten years of beam delivery by the TRIUMF cyclotron. It is a decade from the birth of the project's science to the emergence of its full scientific programme, from the beginning of a regional centre of excellence to a vibrant international laboratory which has put Canada firmly on the world map in fundamental physics.

These annual administrative and financial reports for TRIUMF are always accompanied by some timely vignettes from the programme of pure and applied research of the project. Fuller accounts of that programme are provided in each year's Scientific Annual Report, available separately from TRIUMF.

The 10-year celebration, attended by many of TRIUMF's scientific users and friends from across Canada and abroad, provided them with an opportunity to take a broad overview of the project's scientific accomplishments and their position in a world perspective. Sir Denys Wilkinson, Vice-Chancellor of the University of Sussex in Britain, gave a particularly eloquent overview which is enclosed as a separate insert for those receiving this report. The commendations of TRIUMF delivered at the celebration by the federal Science Minister, the Honourable Thomas Siddon, the provincial Science Minister, the Honourable Patrick McGeer, and by the Presidents of the two federal funding agencies (Dr. Larkin Kerwin of the National Research Council and Dr. Gordon McNabb of the Natural Sciences and Engineering Research Council) augur well for the next decade of TRIUMF.

Whither now? This should be asked in the context of TRIUMF's rapid growth in its initial decade of operation. From its beginning TRIUMF had to make many critical choices among the wealth of science opportunities made possible by the beams of its unique cyclotron. These include the intense primary proton beams and a number of secondary beams: high-energy neutrinos, short-lived bundles of energy called pions, and also their short-lived decay products called muons. The vignettes contained in this report pertain to some of the work with pions and to some of TRIUMF's applied programmes.

The engine driving TRIUMF's science is a whole new framework of ideas concerning the basic building blocks of nature (quarks and leptons) and the unification of nature's fundamental forces. TRIUMF has responded very significantly to these opportunities with the new tools which it made available to the world, and its world reputation has been built by the strength of that response. Especially important, in the past decade, have been experiments relating to the spontaneous break-up of TRIUMF's muons and pions, and to the interaction of high-energy protons and neutrons.

At the beginning of the past decade TRIUMF's experimental facilities were not sufficient for it to compete effectively with the two similar facilities abroad (SIN in Zurich, Switzerland, and LAMPF in Los Alamos, New Mexico). Nurtured splendidly by the attention of its principal funding agency, the National Research Council of Canada, TRIUMF has recently acquired excellent new secondary beam lines and major new large facilities. It is these new facilities which brought about its emergence as a world force in subatomic physics.

This decade of growth, if continued for a few more years, will make TRIUMF a world-leading centre for nuclear physics, using proton, neutron and pion beams to study the dynamics of atomic nuclei.

Even more important, a major new proposal to upgrade TRIUMF emerged in 1985. This compelling proposal will roughly double TRIUMF and its staff. It would see a number of accelerator rings added to the cyclotron. The combination would boost the energy of TRIUMF's primary proton beam sixtyfold and produce intense secondary beams of many new short-lived particles in addition to the present pions and muons. Of especial importance will be the kaons, and hence the name "KAON Factory" for this upgrade. Again, a brochure about this proposal is attached for those receiving this report.

With its compelling KAON Factory, TRIUMF promises to bring world-class science to Canada for several decades. Hand-in-hand with the science come the many economic benefits and technical spin-offs which are so important for high technology. During 1985-86 the KAON Factory proposal began its long route toward funding. In March 1986, it received a very strong endorsement by the prestigious international technical panel which NRC and NSERC jointly established to review the proposal and its science.

Onward to a KAON Factory for Canada!

Erich Vogt

Facilities

We present here some of the highlights of advances in facilities and equipment during the 1985-86 year.

Cyclotron

Several improvements were made in cyclotron operation, most of them involving new ion sources or new methods of extracting the beam after acceleration.

Up to now, TRIUMF has had two sources to provide H^- ions for injection into the cyclotron: one for polarized and the other for high-intensity non-polarized beams. A new cusp ion source was installed and tested during this year in a high-voltage terminal. The stability and brightness of the injected beam are substantially improved, with benefit to the extracted beam's quality, intensity and reliability. This is the first step toward achieving an extracted current of 500 μA, a threefold increase over present operating levels, and five times above the original design value.

An optically pumped polarized H^- source was constructed and tested in the laboratory. Installation of this source into the high-voltage terminal is expected to be completed next year. The polarized beam will be ten times more intense after this change. The new source will also make possible higher-intensity secondary beams of polarized neutrons and/or polarized beams with improved time or energy resolution for more precise experiments. This is the first time that a source of this type has been set up for continuous current injection in a continuous-wave type of accelerator.

The beam inside the cyclotron consists of H^- ions, and it is extracted by converting them into protons. Studies have been made recently of alternative extraction methods, so that a beam of H^- ions can be extracted unchanged. Such a beam can then ease the process of injection in a post-accelerator or allow for special uses in experiments. A prototype dc deflector as well as a newly designed rf deflector have been tested during the past year, and were shown to work with high efficiency.

The structure of the radio frequency used in the cyclotron has been studied and improved. A more stable, reliable and versatile resonating cavity has been designed. Components tested in the cyclotron have so far led to great improvement in the system's performance.

New Facilities

A facility for isotope separation on line (ISOL) has been proposed for installation on beam line 4A, in proton hall. In this facility, rare isotopes of heavier atoms would be created by proton bombardment, and then accelerated and separated for study. Equipment for a small-scale test facility (TISOL) was assembled, and preliminary testing was carried out.

Last year's Report mentioned the new (p,n)(n,p) facility that had just been installed. This facility has been in regular use during 1985-86, and the first important data were collected in the summer, in a (p,n) experiment with a carbon-14 target. [In a (p,n) experiment, an incoming proton causes the ejection of a neutron from the target nucleus.] Both (p,n) and (n,p) reactions were studied in three or four experiments involving international collaborations of physicists. Ours is the only facility in the world for (n,p) experiments in the 200-450 MeV range. Nowhere else are energies above 60 MeV available for such studies.

In the last Report the focal plane polarimeter on the Medium Resolution Spectrometer was mentioned as having been successfully tested. This has also been in regular use during the year, and is now part of the standard facilities available at TRIUMF.

A new switching magnet was installed on the beam line from the small cyclotron (the "CP-42") in AECL's facility for the production of radioisotopes. It allows for the rapid switching of the primary beam to any one of nine beam lines used for the irradiation of gaseous, liquid or solid targets, or for experiments. The cost of the magnet was donated by the Woodward Foundation.

A tensor-polarized deuterium target was put into use in proton hall. The construction of this target was one of the significant achievements by the Cryogenic Targets group this year, and its use permitted a coup for TRIUMF through the completion of an important experiment ahead of other laboratories.

The major new project worked on by Experimental Facilities Division was the provision for a longitudinally polarized beam in proton hall. This will allow for the full utilization of the focal plane polarimeter.

In collaboration with a Japanese group, TRIUMF completed the design work for a new, high-flux, negative-muon channel. The channel will include a six-metre-long superconducting solenoid (valued at $1.1 million) that is being contributed by the Japanese.

Building Programme

The completion of the meson hall extension early in the summer of 1985 allowed the use of this building for the speeches and ceremonies on July 7, when TRIUMF formally celebrated its tenth anniversary of operation.

Applied Programmes

Positron Emission Tomography

This programme revolves around the production of radiopharmaceuticals at TRIUMF, and their use in the TRIUMF-built tomograph at the UBC Health Sciences Centre hospital.

In the former area, a new, improved synthesis method for 6-fluorodopa (bearing a radioactive, positron-emitting fluorine atom) was perfected. The computer-controlled synthesis of 2-FDG (our most frequently used scanning agent), is now routine. As for the tomograph itself, a special study was initiated of a group of people from an area in Guam where there is an abnormally high incidence of brain disease. This is part of the ongoing search for dietary or other factors that may trigger such diseases.

AECL

Atomic Energy of Canada, Ltd. continues to have rapid growth in its worldwide sales of radiopharmaceuticals produced at TRIUMF. During this year a single 24-hour irradiation run produced the largest batch of iodine-123 ever made in the world, and this isotope has a very rapidly growing market. Development work was completed on a regulatory submission for the introduction as a licensed pharmaceutical of hippuran containing iodine-123.

Neutron Activation Analysis

The design was completed and installation began of a new rotating-thimble thermal neutron irradiation facility at the end of the main beam line in meson hall. Novatrack, a private firm, has for many years utilized TRIUMF's facilities to carry out neutron activation analysis of geological samples from all over the world. (This method of ore analysis is extremely rapid and accurate, and is relatively inexpensive compared to old-fashioned chemical methods.) The new facility will be of significant benefit to Novatrack in achieving rapid, uniform irradiation of its samples.

Pion Therapy

We provided treatment for a considerable number of patients with either brain or pelvic tumours, and the total number benefitting from this programme since its inception had risen to 110 by the end of the year. The standard treatment now consists of 15 equal doses of radiation administered over a three- to four-week period. Brain tumours receive 220 to 240 rads each time, and pelvic tumours from 220 to 250 rads. Each treatment lasts from 15 to 60 minutes. Without the intensity of TRIUMF's pion beam (the cyclotron beam output reaches as much as 160 microamperes sometimes) this programme could not continue, as the treatment times would be unacceptably long.

During the year the pion therapy line was also used by researchers from other laboratories for biological experiments. A group from LAMPF (Los Alamos, USA) carried out preliminary experiments involving irradiation of rat spinal cords. They had been unable to carry out the experiment at their own facility (LAMPF is one of the other two "meson factories" in the world) due to hardware failure. Another group, from Japan, carried out experiments to investigate the effects of scanning and variation in irradiation volume, using a mouse gut system.

The M8 beam line, which transports pions to the biomedical facility, has been in use for many years, and some components had gradually moved from their original positions. During the semiannual shutdowns the whole system was realigned, and this has led to an increase in the pion beam intensity.

Electronics

Last year the Electronics Laboratory designed and produced a charge-coupled transient-digitizing circuit component in gallium arsenide. This year, with a new "clean room" facility, they are building more prototypes of advanced CCDs and associated gallium arsenide integrated circuits.

Pure Research

Decay of Pions: A Focus for Experiments

Producing pions (also called pi-mesons) is one of the TRIUMF's specialities. In fact, we produce them so copiously that we are referred to as a "meson factory" – one of only three such facilities in the world. What can we do with all these pions? Many things! In one of TRIUMF's most fascinating and well-known applied programmes, pions are used to destroy certain types of brain tumour, painlessly and efficiently; we study the interaction of pions with nuclear matter; or we allow them to decay, so as to utilize their chief decomposition product, muons, in experiments. We present here yet another area of pion experiments: verifying theoretical predictions of the different ways in which pions themselves may decay.

According to current theory, quarks are the fundamental building blocks of all nuclear matter, and pions are composed of tightly bound quark-antiquark pairs. At TRIUMF energies (that is, up to 520 MeV) only two types of quark are involved: "up" and "down", together with their oppositely-charged antiquark counterparts, "up-bar" and "down-bar". (These are written u, d, $\bar{u}$ and $\bar{d}$.) The fractional electric charges on these quarks mean that three kinds of pions can be formed: the positively charged pion (π^+) is $u\bar{d}$; the negative pion (π^-) is $\bar{u}d$; and either $u\bar{u}$ or $d\bar{d}$ gives a neutral pion (π^0). Studying the decay of these three kinds of pions constitutes a significant part of the fundamental particle physics research at TRIUMF.

Pions exist inside every atomic nucleus and are the mediators of the so-called **Strong** (or Nuclear) force which binds the protons and neutrons of the nucleus together. They can be produced outside the nucleus by bombarding a target of heavy nuclei, such as copper, with a proton beam of more than about 300 MeV energy (the primary proton beam at TRIUMF is 520 MeV). The charged pions can then be processed into the secondary beams used for experiments. The neutral pion cannot be focused into a beam as it does not respond to external electric and magnetic fields. It is generally produced at TRIUMF by a process called "charge exchange": a beam of π^- is stopped in a liquid hydrogen target (positively charged protons), creating neutral pions and neutrons (essentially neutral protons).

Charged pions decay relatively quickly – 26 nanoseconds (billionths of a second) – but they live long enough to travel a few metres – the length of a secondary beam line. They decay by the **Weak** interaction, which is mediated by the W^+, W^- and Z particles, as shown in parts (i) and (ii) of the figure. (W and Z particles are not constituents of matter in the way that quarks and leptons are. They, like the photon and the gluon, belong to a special group called "bosons", which are responsible for carrying one of Nature's four basic forces from one particle to another.) The W and Z particles are very massive – about a thousand times heavier than the pions. They were first isolated three years ago in an historic experiment at the super-high-energy accelerator at CERN, near Geneva. Despite this huge difference in mass, however, it is still possible for the pion briefly to become a W, which quickly decays into an electron or positron (e^- or e^+) or muon (μ^- or μ^+) plus a neutrino (ν). (The Uncertainty Principle allows Nature to be careless with the energy and mass book-keeping over very short time-scales!)

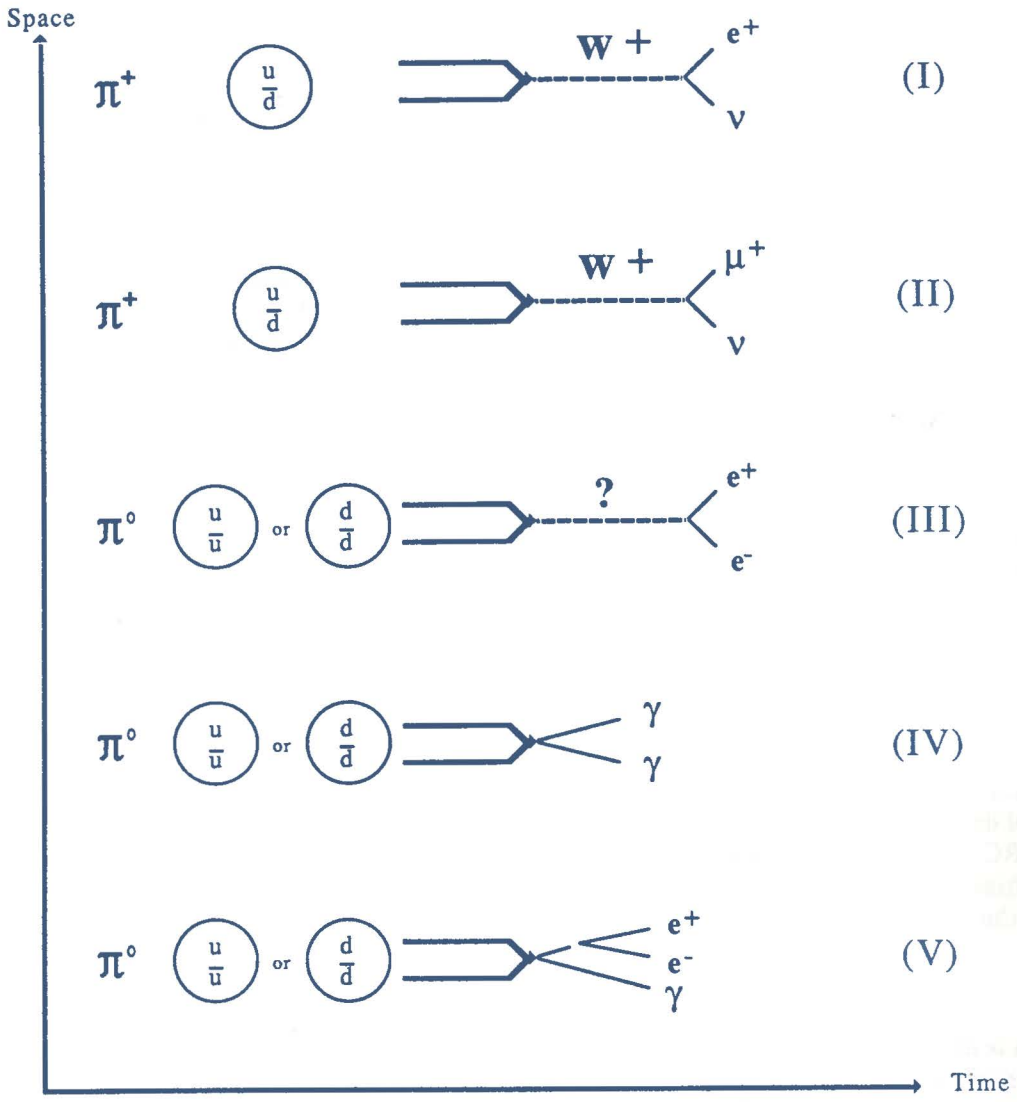
The decays (i) and (ii) provide and excellent means to test a concept called "electron-muon universality" -- the electron and muon appear to be identical particles in all properties except mass (the muon is about 206 times heavier than the electron). This is part of the "generation puzzle" of particle physics: sets of particles appear to be repeated at different mass-levels rather like a set of musical notes – a scale – being repeated an octave higher or lower. Just as the muon resembles a heavy electron, a "tau" is like a heavy muon, but is beyond TRIUMF's energy range. Three "generations" have so far been discovered and it is not known if the replication goes on *ad infinitum*. If the electron and muon are really identical in their interactions, then the charged pion will decay according to schemes (i) and (ii) in a predicted ratio (electron mass/muon mass)^2, or about one in 40,000. This is currently being tested at TRIUMF to an unprecedented accuracy of 0.3%.

If the neutral pion (π^0) decayed in the same manner as its charged counterparts then the decay would be mediated by the massive Z, as in scheme (iii). However, because it is electrically neutral it can decay into two gamma rays via the **Electromagnetic** interaction, as shown in scheme (iv). The **Electromagnetic** interaction is much stronger than the **Weak** Interaction, which means that the lifetime will be much shorter – one 25-millionth of the charged pion's lifetime. The decay $\pi^0 \rightarrow e^+e^-$ should still be be seen, but

(*Swiss Institute for Nuclear Research)

only a tiny fraction of neutral pions are thought to decay this way. Recent experiments at Los Alamos and CERN, however, report seeing the decay at a far greater frequency than expected. This may be due to new and unexpected heavy particles mediating the interaction in the same manner as the Z. To check these controversial results, an experiment is being mounted by a TRIUMF-SIN* collaboration which expects to start taking data in late 1986.

A third decay of the π^0 which has been studied at TRIUMF is its conversion to an electron-positron pair and a gamma ray, as in scheme (v). A TRIUMF/Oregon-State/ Queen's University collaboration has made precise measurements of the momenta of the electrons and positrons in order to test models of how the quarks interact with each other inside the π^0. The analysis of this experiment will be completed late in 1986.



Financial Review

The switch of administrative computer transactions from the University of British Columbia's AMDAHL computer, MTS, to TRIUMF's IBM computer, S.38, went satisfactorily. Some minor transactions remain to be switched over, and this exercise should be completed in fiscal 1986-87. Very few delays were caused, especially in management information systems. The audit by the newly appointed auditors for TRIUMF, Coopers & Lybrand, Chartered Accountants, revealed no significant weaknesses or breakdowns in the system.

National Research Council (NRC) funding increased by 4.67% over last year, but there was a slight decrease in revenue from all other sources. Total funding received therefore increased by less than 1% over last year.

It should be noted that the Natural Sciences and Engineering Research Council (NSERC) supplies additional financial support to TRIUMF by funding TRIUMF-related experiments administered by other institutions, and reported on in the financial statements of those institutions.

Another source of substantial support to TRIUMF, not reported as revenue because the funds are administered elsewhere even though 90% of the work is done at TRIUMF, is the Medical Research Council of Canada. It is fully acknowledged that its support represents a significant contribution to the overall TRIUMF research programme.

- Funding from NRC increased in line with the five-year plan projections, except that, in accordance with the general policy decision by the Federal Government, inflation adjustments were excluded. NRC funds all TRIUMF's operations, maintenance, development and capital expansion. NRC funding this year represented 80.6% of the total funds received. The increase of 3.25% over last year is due primarily to decreased revenue from all other sources of funds.

- The principal financial support for experiments performed under the aegis of TRIUMF is provided by NSERC. The TRIUMF Common Grant, received from NSERC, is administered by TRIUMF on behalf of the grantees in accordance with guidelines received from NSERC. The total funds available, including carry-forward funds from the previous year, increased by 15.24% over last year. The Common Grant awarded decreased by less than 1%.

- Atomic Energy of Canada Limited (AECL) is reported on separately because it is the major commercial user of TRIUMF facilities. Operations are progressing satisfactorily. Its sales of radioisotopes continue to increase considerably each year, and prospects for the coming years are equally promising. The flow of funds through TRIUMF fluctuates because by far most of AECL's transactions are handled by its administration located on the TRIUMF site. Only those services required directly from TRIUMF are reported on here. A decrease in receipts of 15.08% was recorded.

- Through the Universities Council of British Columbia, the Province of British Columbia approved a building programme to keep pace with expansion as reflected in the TRIUMF Five-Year Plan. The total approved amount to date is $7,475,500. Construction of new buildings continued throughout 1985-86, resulting in substantial completion of the total approved building programme.

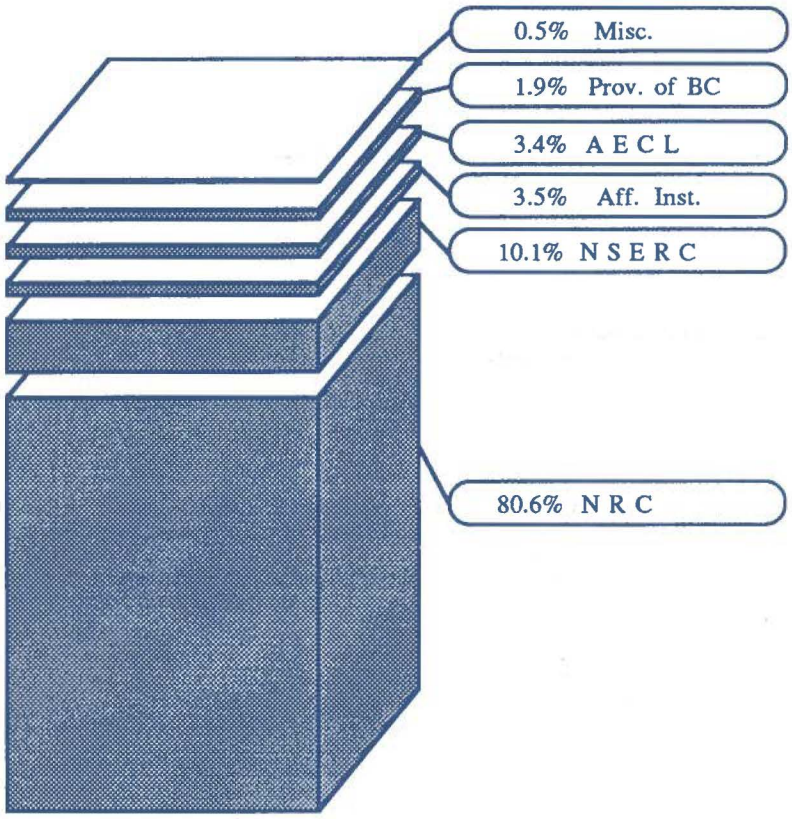
- The number of transactions handled on behalf of affiliated institutions continues to grow. Even though receipts are slightly lower than last year, the number of such institutions has now increased to 69. The receipts consist of imprest funds and reimbursements for expenditures undertaken on behalf of these institutions, from Canada and abroad, for their TRIUMF projects.

Expenditures in the Statement of Combined Funding and Expenditures are within budget. A successful year was experienced in that all major obligations were met and expenses were at acceptable levels. The expectations for next year are that the approved construction funded by the Province of British Columbia will be completed, the institutions using TRIUMF facilities will give us their usual support and the Federal Government will continue to support TRIUMF at a level sufficient to maintain the high international standing TRIUMF has achieved.

Source of Funds (millions of dollars)

National Research Council	26.72	80.60%
Natural Sciences and Engineering Council	3.33	10.05%
Affiliated Institutions	1.16	3.50%
Atomic Energy of Canada Limited	1.12	3.38%
Province of British Columbia	.64	1.93%
Miscellaneous	.18	0.54%
	33.15	100.00%

SOURCE OF FUNDS—— 1985 - 86



Coopers & Lybrand | chartered accountants | a member firm of Coopers & Lybrand (International)

AUDITORS' REPORT TO
THE BOARD OF MANAGEMENT
TRIUMF

We have examined the statement of working capital position of TRIUMF as at March 31, 1986 and the statements of funding and expenditures for the year then ended. 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 working capital position of TRIUMF as at March 31, 1986 and its funding and expenditures for the year then ended in accordance with the accounting policies set out in note 2 to the financial statements, applied on a basis consistent with that of the preceding year.

Coopers & Lybrand

Vancouver, B.C.
June 6, 1986

TRIUMF
STATEMENT OF COMBINED FUNDING AND EXPENDITURES
FOR THE YEAR ENDED MARCH 31, 1986

	1986 $	1985 $
FUNDING		
National Research Council	26,715,000	25,522,000
Natural Sciences & Engineering Research Council	3,331,140	3,369,875
Atomic Energy of Canada Limited	1,118,838	1,317,674
Province of British Columbia	637,661	1,198,600
Affiliated Institutions	1,164,795	1,308,559
Investment income	182,946	229,739
	33,150,380	32,946,447
EXPENDITURES		
Building construction	600,352	1,269,538
Communication	353,445	249,671
Computer	1,330,593	2,571,678
Equipment	2,563,400	2,044,595
Lease payments - Atomic Energy of Canada Limited	538,762	641,095
Power	1,743,371	1,613,071
Salaries and benefits	18,314,043	17,143,897
Supplies and services	7,213,574	6,485,705
	32,657,540	32,019,250
EXCESS OF FUNDING OVER EXPENDITURES	492,840	927,197
FUNDS BALANCE - BEGINNING OF YEAR	817,334	67,301
	1,310,174	994,498
LESS: FUNDS BALANCE - END OF YEAR (note 3)	1,139,027	817,334
SURPLUS FOR THE YEAR	171,147	177,164
SURPLUS (DEFICIT) - BEGINNING OF YEAR	47,044	(130,120)
SURPLUS - END OF YEAR	218,191	47,044

TRIUMF
STATEMENT OF WORKING CAPITAL POSITION
FOR THE YEAR ENDED MARCH 31, 1986

	1986 $	1985 $
A S S E T S		
CASH AND TEMPORARY INVESTMENTS	2,162,215	1,200,034
ACCOUNTS RECEIVABLE	–	51,498
FUNDS RECOVERABLE		
Province of British Columbia	–	195,545
Atomic Energy of Canada Limited	127,040	17,612
	127,040	213,157
DUE FROM UNIVERSITIES		
The University of Victoria	–	3,167
The University of Alberta	–	11,449
	–	14,616
TOTAL ASSETS	2,289,255	1,479,305
L I A B I L I T I E S		
ACCOUNTS PAYABLE	374,493	296,550
DUE TO UNIVERSITIES		
The University of Alberta	21,793	–
The University of Victoria	11,428	–
The University of British Columbia	362,552	84,390
Simon Fraser University	34,731	20,830
	430,504	105,220
FUNDS UNEXPENDED		
National Research Council	2,613	–
Universities Council of British Columbia	3,554	–
Natural Sciences and Engineering Research Council	1,205,856	857,560
Affiliated Institutions	54,044	172,931
	1,266,067	1,030,491
TOTAL LIABILITIES	2,071,064	1,432,261
SURPLUS - END OF YEAR	**218,191**	**47,044**

ENCUMBRANCES AND COMMITMENTS (note 4)

NATIONAL RESEARCH COUNCIL
STATEMENT OF FUNDING AND EXPENDITURES
FOR THE YEAR ENDED MARCH 31, 1986

	1986 $	1985 $
FUNDS UNEXPENDED - BEGINNING OF YEAR	Nil	1,372
Cash contribution	26,715,000	25,520,628
TOTAL APPROVED CONTRIBUTION	26,715,000	25,522,000
EXPENDITURES BY ACTIVITY AREA		
Salaries	15,483,321	14,693,105
Power	1,743,370	1,613,072
Administrative and overhead	1,642,870	1,764,159
Cyclotron and facilities operation	2,522,223	2,525,012
Site services	771,167	495,098
Support services	1,511,117	1,699,661
Major projects	2,402,731	2,381,228
Minor projects and development	902,686	670,967
	26,979,485	25,842,302
Funds recovered -		
Cost centres	267,098	301,666
From TRIUMF funds	–	18,636
	26,712,387	25,522,000
FUNDS UNEXPENDED - END OF YEAR	2,613	Nil
EXPENDITURE BREAKDOWN BY PROGRAM ELEMENT		
Basic support	18,233,314	17,151,135
Facility development	4,766,184	4,804,884
Experimental support	3,712,889	3,565,981
	26,712,387	25,522,000
EXPENDITURE BY OBJECT		
Buildings	139,810	197,755
Communications	325,685	224,033
Computer	1,082,757	981,369
Equipment	2,219,822	1,953,295
Power	1,743,371	1,613,071
Salaries and benefits	15,534,200	14,728,513
Supplies and services	5,666,742	5,823,964
	26,712,387	25,522,000

2. SIGNIFICANT ACCOUNTING POLICIES

As a non-profit organization, TRIUMF follows generally accepted accounting principles as referred to in the CICA Handbook except for:

Capital Assets and Inventories

Expenditures on capital assets an inventories are expensed as incurred.

3. FUNDS BALANCE - END OF YEAR

	1986 $	1985 $
Funds unexpended -		
Province of British Columbia	3,554	–
National Research Council	2,613	–
Natural Sciences and Engineering Research Council	1,205,856	857,560
Affiliated Institutions	54,044	172,931
	1,266,067	1,030,491
Funds overexpended -		
Atomic Energy of Canada Limited	127,040	17,612
Province of British Columbia	–	195,545
	127,040	213,157
Funds balance - end of year	1,139,027	817,334

4. ENCUMBRANCES AND COMMITMENTS

In addition to the accounts payable reflected on the Statement of Working Capital Position, there are outstanding encumbrances representing the estimated costs of unfilled purchase orders and contracts placed as at the fiscal year end.

National Research Council	2,230,000
Natural Sciences and Engineering Research Council	240,000
Atomic Energy of Canada Limited	39,000
Affiliated Institutions	919,000
Universities Council of British Columbia	3,000
	3,431,000

As at March 31, 1986, there were additional lease commitments of $462,000 due in 1987-88.

TRIUMF Users' Group

TRIUMF

R. Abegg
G. Azuelos
J.L. Beveridge
R.F. Blaby
E.W. Blackmore
C.W. Bordeaux
M. Comyn
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