TRIUMF

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SCIENTIFIC ACTIVITIES
1997

CANADA'S NATIONAL MESON FACILITY
OPERATED AS A JOINT VENTURE BY:

UNIVERSITY OF ALBERTA
SIMON FRASER UNIVERSITY
UNIVERSITY OF VICTORIA
UNIVERSITY OF BRITISH COLUMBIA

ASSOCIATE MEMBERS:

UNIVERSITY OF MANITOBA
UNIVERSITÉ DE MONTRÉAL
UNIVERSITY OF REGINA
UNIVERSITY OF TORONTO

UNDER A CONTRIBUTION FROM THE
NATIONAL RESEARCH COUNCIL OF CANADA

APRIL 1998

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.

ACCELERATOR TECHNOLOGY DIVISION

INTRODUCTION

The ISAC project continued to be the largest user of engineering, design and fabrication effort during the year. This is reflected in the REAs (requests for engineering assistance) submitted during the year, with 61 for ISAC-related projects and only 18 for other activities. The ISAC work is described later in this section, and in more detail in the ISAC section.

The CERN-LHC collaboration work kept an average of one designer busy, first with completion of magnet designs, then the rf dampers, details of the resonant charging supply and the fast blade scanner. Infrastructure support of ATLAS, BaBar and SNO used some engineering, design and electronics effort during the year. The University of Victoria group produced the designs and assisted in the assembly of the prototype module 0 of the hadronic endcap calorimeter. Engineering assistance was also provided for the design of the forward calorimeter. The BaBar drift chamber stringing stand was fabricated in the Machine Shop and then installed in the enlarged clean room. Some Design Office and Machine Shop time was used for SNO work, and very welcome assistance was provided by the Electronics Services group in the testing of the SNO readout electronics. Assistance was also provided to the internal program, particularly parity, TISOL and μSR.

The increased work load has been handled by bringing in design help from other divisions, by contracting some work to outside consultants, and with coop students. The junior designer hired last year resigned in November to take up a higher paying job elsewhere. The assistance of the Remote Handling group in designing the ISAC target and hot cell areas has continued and been very crucial in meeting schedules. The Planning group produced many PERTs and manpower estimates, and provided contract administration for some ISAC magnet contracts.

The Machine Shop was heavily loaded throughout the year, making it necessary to sub-contract more than $800,000 worth of work to local machine shops. The building department was kept busy providing support and monitoring activities on the new ISAC building, as well as assisting in the design of the proposed radiochemistry laboratory.

The Electronics Services group provided a wide range of support to experimental and other groups, including complex electronics designs, equipment repairs, microprocessor and PC support, and installation of new site communication links. Highlights included the support of the SNO work and the rubidium infusion system for PET imaging at the Ottawa Heart Institute. The Electronics Development group were mainly involved in developing the EPIC based ISAC control system, but also found time to support CDS work, development of the CERN timing surveillance module, and the controls and interlock system for the CERN 66 kV resonant charging supply.

MAGNETS

This has been a busy and productive year for magnet design, procurement and field measurement. Some additional help in design by an external consultant, and in contract supervision by the Planning group, was needed to complete the work as scheduled. The magnet work carried out as part of the CERN collaboration (BI quadrupoles, BT quadrupoles, DVT dipoles, BV1 benders, and BV2 bender and MQW twin aperture quadrupole) is reported in the CERN Collaboration section.

Magnets for ISAC

The 4 in. aperture quadrupoles for use in beam line 2A and other ISAC applications were completed, and the quantity needed for 2A installation field mapped. The steel assemblies were manufactured by Sunrise Engineering (BC), and the coils by Everson Electric (USA). The magnets were assembled by the TRIUMF Machine Shop.

The design and specifications for the two 15° 2A dipoles were prepared by an outside consultant. The contract was awarded to Elma Engineering (USA) with the magnets delivered in September. Both these magnets have been field mapped and are ready for installation.

The design of the 27.5° B1 and B2 dipoles for the vault section of beam line 2A was completed. After tendering, the contract to build the 2 magnets was awarded to Sunrise Engineering (BC). Sunrise delivered the magnets in October, and they were field mapped in December. The fields matched the predictions made [see TRI-DN-96-24] and the magnets are ready for installation.

The design of the ISAC pre-separator magnet was completed and documented in a design note, "Concept Design of the ISAC Pre-Separator Magnet" [TRI-DN-97-13]. It is planned to use Krempel Trivolterm GKG insulation for the coils to improve their radiation resistance. Steel was purchased for the magnet, and the drawings completed. The magnet is out to tender with a closing date of January 12, 1998.

Magnet measurements

A total of 52 magnets were surveyed during the year – 18 for CERN and 34 for ISAC (see Table XII).

Table XII. Details of surveyed magnets.

Quantity	Project	Description
1	ISAC	Test stand dipole
1	ISAC	2A combination magnet
13	ISAC	4Q8.5/8.5 quads
1	ISAC	Prague 90° dipole
3	ISAC	4Q14/8 quads
2	ISAC	15° dipoles
10	ISAC	Steering magnets
2	ISAC	27.5° dipoles
1	ISAC	Off-line ion source analyzing dipole
1	CERN	SMIT BT quad from CERN
7	CERN	BT quads (2 doubles, 3 singles)
7	CERN	DV dipoles – shimming required
2	CERN	BV1 dipoles – shimming required
1	CERN	BV2 dipole – shimming required

MECHANICAL ENGINEERING

ISAC

The major effort in Mechanical Engineering was the support of the ISAC project. Basic strategies and philosophies had been established the previous year, producing general conceptual design layouts of most areas of ISAC. During the year these were turned into final design layouts, and detail drawings approved for manufacture. In order to reach the approval stage, a design review process was established, whereby detail design could not commence until approved by a review committee at a formal design review. This allowed all aspects of the project to receive visibility by the project team. Other changes were made to the system to ensure that detail drawings were revised and kept up to date. That was the introduction of the Engineering Change Request and Engineering Change Order, which formalized a needed change to a drawing. This became especially necessary since much of the manufacturing was tendered off-site. Descriptions of some of the major milestones achieved during the year are as follows:

- Beam line 2A – all of the engineering work for the components in beam line 2A was completed, allowing for the completion of the vault upgrade, and much of the 2A tunnel. The engineering input involved the analysis and design of magnet stands and vacuum vessels, and procedures required to install them, particularly the large bender magnets in the 2A tunnel which has an 8 ft. ceiling.

- Target hall – this work was accomplished with considerable assistance from the Remote Handling group. It involved the complete design of the interior of the target hall. Particular attention was necessary in the region of the two target stations due to the complexity of components, the high radiation levels resulting in complex shielding problems, the strict ventilation requirements, the multitude of services necessary throughout the region, and the remote handling issues involved in manipulating all of these large modules and shield plugs. The design work was completed and detail layouts delivered to the consultant at various schedule milestones during the year. About 60% of the actual target hall construction work was completed by the end of the year. The 20 T crane was installed, although the control package will not be available until the new year.

  A major accomplishment was the detail design of the 5 modules and vacuum tank that make up a target station (see Fig. 124). Drawings for all components were released in the second half of the year and tendered for manufacture. The two vacuum tanks were received at the end of the year, and module components will arrive early in 1998.

  An assembly area was established in the ISAC experimental hall for the assembly of the modules. Special assembly fixtures and jigs were designed, manufactured and installed during the latter part of the year.

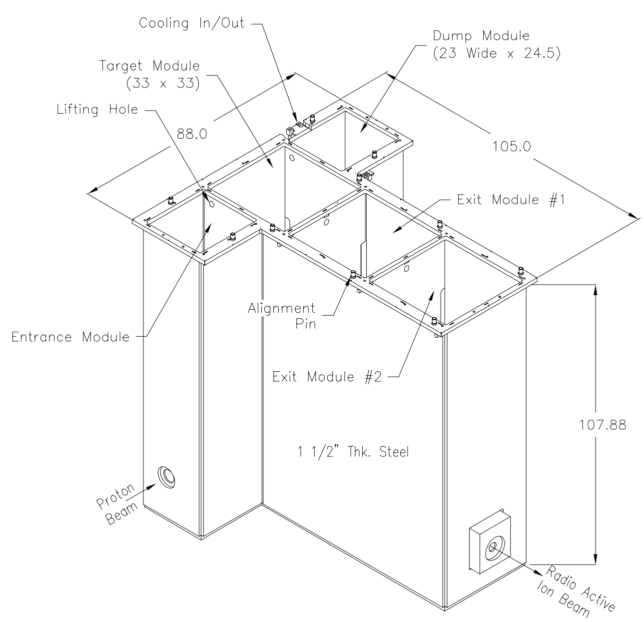

Fig. 124. ISAC target station vacuum box showing five module arrangement. Total weight of tank is 23,000 lbs.

- Mass separator – engineering work commenced later in the year, and mainly involved coordinating the definition of the beam line from the target tank to the vertical section by identifying the necessary components and their location. The major task here from an engineering point of view was the coordination of the design of diagnostics in this region.

- Accelerators – based on the successful tests of a 3-ring prototype, work commenced on the design of the 19-ring RFQ accelerator. The rings themselves remain dimensionally unchanged, with the major effort in the direction of improved manufacturing techniques and simplification (i.e., the electrode support became a solid block of copper drilled for cooling rather than the complex shell with soldered tubes used in the prototype). The accuracy in electrode positioning necessitated a novel approach to the final machining operation, which was done as a ring assembly. Special jigs were made to support the ring, and the electrode monitoring face and locating ridge were electrically discharge machined, such that deflections due to tool contact were eliminated. An unconventional 8 m long vacuum tank, having a square section, was designed with the help of an external consultant. This allowed for a diagonal split line providing a sturdy back wall (1.5 in. thick) for mounting services (i.e., vacuum pumps), and an open front-side for easy accessibility. Construction began mid-year and 7 rings had been installed by year end. Digital electronic theodolytes were used for alignment, and early measurements indicate that tolerance goals will be achieved.

  The DTL accelerator schedule was delayed due to manpower. However, the tank 1 design was completed. Detail design of the tank, the ridge, and the stems, was completed by year end; the specification written and the tank tendered for manufacture. Many configurations were examined during this process based on achieving an effective but simple tank cooling system, a simplified ridge design with drilled water passageways, and a method of attaching the ridge to the tank that allows for accurate machining of the tank and ridge in order to provide accurate stem placement. Manufacture and assembly will commence in 1998.

- Diagnostics – engineering assistance was provided in the coordination and design of the RIB diagnostics, all the way from exit module 1 to and through the RFQ. This involved a review of available designs for wire scanning, harps, faraday cup, and emittance rigs. In many cases new designs were required.

ISAC – University of Victoria

In consultation with Mechanical Engineering, Remote Handling and other TRIUMF groups, the design and detailed drawings for manufacture of the ISAC target station vacuum vessels were completed. The vessels have been manufactured and delivered to TRIUMF where, after some vacuum leaks were sealed, they were internally copper plated, the cooling lines attached, and painted externally with radiation-resistant paint. The first top flange for the tanks was made incorrectly and is being re-manufactured. The design and drawings for the ISAC target station beam dump module were completed. The water-cooled copper plate beam dump under construction at the University of Victoria is 70% complete.

Finite element analysis of the first proposed ISAC target has prompted some changes to the current carrying connections to the target, and will aid future development of the target ionizer, mechanical/electrical connections, and containment box. Figure 125 shows the geometry of the target used in the ANSYS calculation.

Engineering – other

BaBar

Stress analysis was conducted for the fixed tower of the BaBar drift chamber stringing stand. This tower is used to raise the stringing stand into a vertical position to replace bad wires. Modifications were proposed based on this analysis.

ATLAS – TRIUMF

Stress analysis of the forward liquid argon calorimeter (FCAL) end plate was conducted to quantify stresses near the end plate holes. ANSYS was used to model the end plate. A course model identified high stress regions. A detailed sub-model of this high stress region was then analyzed to see more accurate stress concentrations.

Heat flow studies were conducted to determine temperature distribution in FCAL2. FCAL consists of a large number of sintered tungston slugs with copper tubes and tungston rods arranged in a matrix form. A two-dimensional FEA model of the basic building block of the matrix was analyzed to find effective thermal conductivity of the matrix. This gives a means to determine temperature distribution in the entire FCAL. Thermal studies are continuing.

ATLAS – University of Victoria

Design of the production modules for the ATLAS detector hadronic calorimeter endcaps was completed,

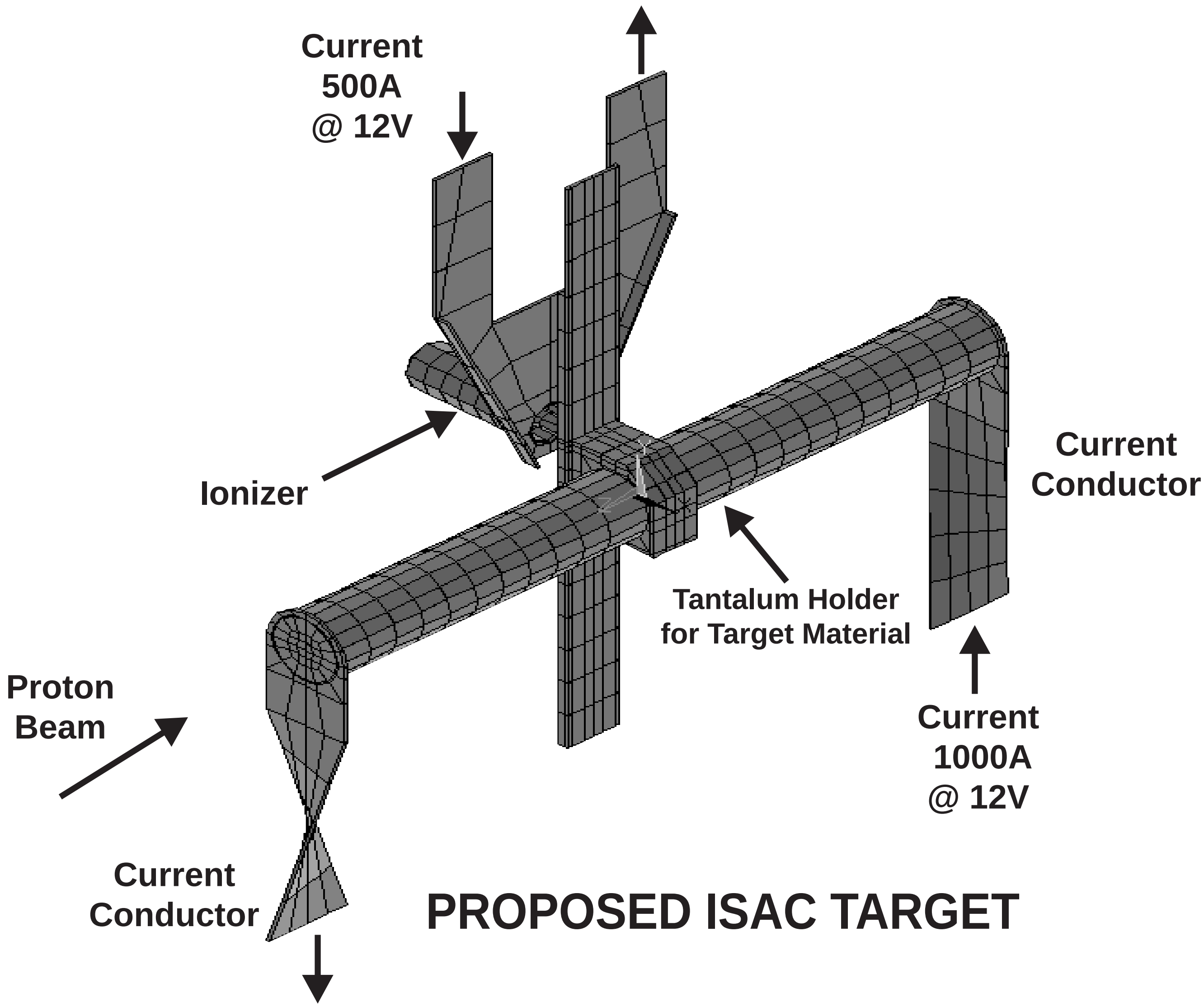

Fig. 125. Target geometry used in ANSYS calculation to produce a uniform temperature of 2200–2400°C in the target and ionizer.

and the final engineering drawings will be finished early in 1998. Work continues on design of tooling and techniques to build the modules into their final "wheel" structures, prior to insertion into the endcap cryostats.

Refinement of the mechanical design of the ATLAS signal feedthroughs has continued in collaboration with Brookhaven National Laboratory. Distortion and vacuum leaks produced when welding the signal pin carriers into the vacuum flanges have been overcome, using carefully designed weld preparations. The design was verified by FEA and two versions tested for ease of welding and vacuum integrity. Work continues on the final details of the mechanical structure (bellows, transition piece, etc.) to prepare for the production phase. The design of the test station for ambient and liquid nitrogen temperature vacuum testing of the production feedthroughs is 90% complete, and most components have been ordered and received. FEA on the striplines, which carry the signals through the feedthrough vacuum space, has shown that the copper trace thickness and width must be doubled to safely carry the current supplies for the cold electronics. Heat leakage, via the signal traces from the liquid argon end of the striplines to the ambient temperature vacuum flanges was modelled in an FEA, to verify the power and positioning of heater resistors required to offset the cooling effect.

TISOL support

During the spring shutdown: the ECR system was repaired and refurbished; "glass ovens" (quartz) were used on-line for our first beam runs after the shutdown. This provides an inexpensive oven shell which is inert to some target material. The runs showed that glass oven shells are workable but required improvements; the desired heat of 1100° C was not achieved during the runs so a new heater for the glass ovens is being made; target change was longer than expected (requiring 3 min. dose 12 mR/man) which hopefully will be faster with the new design; and installation of an inexpensive active drain. This will be used for disposal of potentially radioactive water inside the TISOL boot box area and outside the confinement room (BL 4A/3).

During the fall shutdown: the surface source device was refurbished (new target box and improvements to extraction electrode mounting for easier replacement without the need of realignment), and switched from ECR to surface source system. Routine repairs were made to the ion beam line during switch over.

Parity

A fixed target remote insertion system PPM1 and 2 was designed, built, installed and successfully commissioned for the Parity group. Further, software development to the PPM 1 and 2 PC motion control system has now enabled each of the two PPM's to be independently positioned with respect to their parked positions, to an accuracy of about ±0.036° in addition to their normal operating mode.

PLANNING

This year the Planning group was mainly involved in preparing and updating PERTs, as well as planning and coordinating activities for two scheduled shutdowns – one in spring, and a mini shutdown in September. Considerable effort was spent in planning, coordinating and expediting activities related to the ISAC project, the CERN collaboration and contract administration for ISAC magnets.

The progress on PERTed projects is described elsewhere in this report, under the principal group involved. However, following is a list of projects which required a large part of the Planning group's effort, along with major milestones achieved and planned for next year.

2A extraction probe and beam line 2A

Installed and tested 2A extraction probe and front-end of beam line up to the combination magnet, with a temporary dump at 1–10 nA and at energy of up to 510 MeV, during the spring shutdown.

Installed the 36 ft. long beam-pipe through the vault wall to the entrance of 2A tunnel along with some stands for vault components in the September shutdown. The goal is to start commissioning 2A after April 22, 1998, and commission with proton beam to the dump module by June, 1998.

Target area

Most modules were designed and fabrication of components continued through the year. Both vacuum tanks were received in December. The plan is to install the entrance and dump modules by May, 1998, target and exit modules by June, 1998, with an aim to get a stable beam out of the exit module by July, 1998.

RFQ

The RFQ tank was designed and procured in September, and then installed on a concrete pad in the ISAC building in October/November. After installing and aligning the platens, 7 rings were installed and aligned in the tank in November/December. Most of the design for all 19 rings, and fabrication of some components, were completed during the year. A 150 kW amplifier was designed and built for the 19 ring RFQ system.

Off-line ion source (OLIS) and LEBT

The installation of off-line source was delayed to September, due to delays in building construction. However, about 80% of components for commissioning the source were installed in October.

Mass separator

After extensive negotiations, a mass separator system was finally received from Chalk River in August, and prepared for field mapping in December. The pre-separator magnet was designed in October, and ordered for delivery in May, 1998. The design for pre-separator diagnostics and services started in October.

Drift tube linac (DTL)

The detail design for the first tank, including stems, ridges and end plates was completed and sent out for bids in December. The design and fabrication of a DTL buncher was sub-contracted to Troisk, with an expected delivery date in April, 1998.

Other ISAC PERTs prepared and updated include MEBT and HEBT; and experimental facilities (TRINAT, DRAGON, Spectrometer, LTNO).

The Planning group also prepared and updated the PERT for a 66 kV resonator power supply for the CERN collaboration.

Manpower estimates for all sub-projects were compiled, which showed very high peaks of manpower requirements, both for the current year and in early 1998. Priorities were evaluated, and highest priority was assigned to meet the goal of delivering radioactive beam to TRINAT by November, 1998.

Shutdown activities

Spring shutdown (March 21–May 21)

Major jobs completed in this shutdown include: Cyclotron and vault – installation and testing of 2A extraction probe and front-end of 2A (a combination magnet, a quad, doublet, a rad hard valve and services), overhaul of 2C extraction probe, MRO work on LE1, 2C STF, shine blocker and MRO work on electrical distribution system and cooling systems; Meson hall and proton hall – repair of 1AT2 area vacuum leaks, T2 water package modifications and beam lines MRO. The total man dose incurred in this shutdown was 126.5 mSv distributed among 110 people.

September mini-shutdown

This shutdown was scheduled for extended maintenance from September 20–27, but prolonged to about 3 weeks. When the lid was raised to align a sagging 4U3 resonator, a spontaneous leak from the bellows on the water coolant circuit for resonator 2L1 extended it into an emergency shutdown, causing a 2 week delay to the beam schedule.

Many additional devices had to be removed to 2L1 for repairs, and some problems were encountered in making a tight seal. There were problems in raising the cyclotron lid for resonator jobs. Also the M20Q1/1AT2 vacuum leak was repaired again. The 36 ft. long beampipe was installed through the vault wall to the entrance of the 2A tunnel, along with some stands for 2A vault components. Approximately 35 mSv of total dose was incurred in repairing the resonator bellows, and another 5 mSv was incurred for repairing M20Q1/1AT2 vacuum leaks.

Contract administration

In addition to planning and expediting critical components, the Planning group administered the contract for twenty-two 4Q 8.5/8.5 quadrupole magnets for ISAC. 14 quadrupoles were assembled and field mapped by October. The Planning group also supervised the contract for two 15° dipole magnets for 2A. Both dipoles were received in September, field mapped by November, and prepared for installation.

DESIGN OFFICE

This has been a very busy year for the Design Office, and many TRIUMF individuals have helped with their continued support and cooperation. The volume of work created by the ISAC project has required the Design Office to develop new ways of doing business, and to be as efficient as possible.

The ISAC project received 83.4% of available hours during the year, or the equivalent of 10 designers working full-time. In addition, there was significant support from the University of Victoria group and from TRIUMF groups – remote handling, rf, cryo-targets, and 3 months of contract design. Effort was concentrated on the 2A beam line components, the target station modules and services, LEBT, RFQ, DTL, pre-separator, mass separator, LEBT, remote handling, and preliminary layout of the experimental facility.

By comparison, the CERN collaboration received 8.7%, primarily detailing the high voltage power supply components and the fast blade scanner. The remaining 7.9% of the time was used to detail and document projects for experimental facilities; 2C extraction; 2C STF alignment; parity heat exchanger; T2 cooling; 1A triplet etc., and in support of external projects; BaBar drift chamber; SNO D2O sampling mechanism; CDS phase II.

MACHINE SHOP

The TRIUMF Machine Shop produced approximately $116,000 worth of fabricated and machined components for the various on-site groups each month, during this year. The past eleven months was an exceptional period for sub-contracting work from the TRIUMF Machine Shop to local industry. Over $800,000 worth of work was sub-contracted, most of it in small packages, none above $25,000.

As shown in Table XIII, ISAC was by far the major user of our services, manufacturing magnets, magnet stands, vacuum chambers, beam lines prototype targets and RFQ components, including the first seven RFQ rings. We were able to manufacture these complicated ring assemblies very cost efficiently while still maintaining the very high accuracy required.

Table XIII. Machine shop utilization.

ISAC	65.33%
Science	16.53%
CERN	6.45%
Cyclotron	5.84%
Nordion	2.11%
NSERC	1.55%
Affiliated Institutions	1.52%
Administration	0.13%
Accelerator	0.04%

BUILDING PROGRAM

The construction work on the new ISAC experimental facilities presented a significant load on the building department. Throughout the year a dominating function was the monitoring of the various building trades for compliance with the construction documents. Other ISAC involvements were the design and preparation of construction drawings for the RFQ foundation in the experimental hall, as well as design of reinforced concrete shielding blocks and target storage silos for the new target hall. TRIUMF inventory drawings required updating, reflecting the addition of the new ISAC facilities and alterations to the various underground building services.

Design work continued on the proposed radiochemistry laboratory in the meson hall service annex. Changing requirements necessitated redesign of development drawings and preparation of new cost estimates. The project is now awaiting funding.

Reinforced concrete shielding blocks were designed, drawn and tendered by the Building group for the TR13 cyclotron located in the meson hall extension. This additional shielding is required for the cyclotron to operate at higher beam intensity.

Throughout the year maintenance work was carried out on the TRIUMF site and its aging buildings, ranging from minor repairs and over painting, to roof replacements.

ELECTRONICS SERVICES

The Electronics Services group continued its support of numerous groups and experiments on site during the year. The work ranged all the way from complex electronic designs and software systems, right down to basic repairs and cable assemblies. The groups and experiments supported included ISAC, CERN, CDS, TRINAT, ATLAS, μSR, Proton Therapy, Brookhaven, SNO, Controls, Probes, Diagnostics, PET, Parity, CHAOS and Vacuum, just to name a few. The efforts of the Electronics Services group are outlined below.

Experimental and target technical support

Target support was involved in the general maintenance of 1AT1 and 1AT2 targets, followed by assistance in the design and assembly of a new control system. For ISAC, the design of the cooling system controls for the high active cooling water of the targets was worked on. Other ISAC work included assembling controls for the extraction probes. For proton therapy, modifications to the fast shutter controls were done, as well as the design of a specialized patient flasher.

A high voltage test chamber was built for ATLAS, as well as a specialized high voltage switch module, to ensure the safety of personnel involved in testing of the chambers. Support is now being given to assembly of various components for the CERN 66 kV kicker.

Electronics Shop

The best customer this year was the ISAC project: cables were manufactured and new versions of BIAS supplies and QSX modules were assembled and tested. Surface mount boards were made up for TRINAT. SNO requested cables, and repair and modification of PC boards. Smaller requests for cables and panels came from the CERN, CDS project and the controls and diagnostics groups.

Electronics Repair Shop

Besides providing the traditional experimental and facilities support for TRIUMF, the Electronics Repair Shop made significant contributions to SNO, mostly in the form of equipment loans, and to E787 at Brookhaven. For TRIUMF, a total of 218 electronic devices received service through the Electronics Repair Shop, including: 6 terminals, 47 monitors, 44 SCSI and LAN devices, 65 power supplies and miscellaneous units, 20 Nucleonics devices, 12 items of test equipment and 24 other pieces of electronic equipment. In addition, a total of 109 items of detector electronics were repaired and/or modified and tested for the Brookhaven 787 experiment.

Microprocessor support

The year was substantially consumed with the completion of the CERN magnet survey portable data acquisition project. The project was completed and project objectives were eventually accomplished, despite the numerous technical obstacles that were identified, analyzed and overcome, mainly relating to mechanical encoding components. A major theft of the computer and acquisition components for this project resulted in a delay of a number of weeks. A paper on this project [Rotating coil and data acquisition system for measuring CERN beam transfer line quadrupole magnets] was presented at the 10th International Magnet Measurement Workshop.

Ongoing problems over the last few years with the BL4 twister readout were resolved after an exhaustive period of troubleshooting. Some difficulties with netware server backups were encountered, and considerable effort was expended to correct these. Overall system reliability for the trailer Gg network was very high this year, although not as stellar as previous years. Some initial work was done in EPICS with the intention of assisting in the ISAC controls area.

High level software support

The most significant project was the Rb82 infusion system, built for the Ottawa Heart Institute (see Fig. 126). This is an automated radiochemical direct infusion system for PET imaging of cardiac infarcts. All aspects of the project, other than Machine Shop work, were completed by this group. Contributions to ISAC include the BL2A extraction probe controls, the specification and procurement of VME enclosures, and the packaging of a new commercially made motor driver for general use. One outcome of the extraction probe controls was a paper submitted to ICALEPCS'97.

Fig. 126. Rb82 infusion system, built for the Ottawa Heart Institute.

The polarized proton target control system required continued additions and changes, and the final run of the target took place in December. A fair amount of work was spent on interfacing an HP 3458A DVM via GPIB to the system, to improve quality of data taken for the NMR measurements. During the summer, a small acquisition system was assembled, based on the PPT system for Expt. 785. There were some changes to the automated carbon-11 gas phase synthesis system for PET.

PC support

New Pentium II systems and many Pentiums were purchased on site, replacing older 486 systems, which are still being passed on to others. There are still systems running Windows 3.X, but they are strongly encouraged to upgrade to newer operating systems. Many more PCs are running or upgrading to Windows95, and a few to NT. Most PCs are networking with TCP/IP, Microsoft network and/or Netware network. PC support attends CFAT meetings in order to get information and have some input into site computing and networking.

This department now has a Web site, in order to provide information to TRIUMF PC users. At present, it has little more than the hardware standards list and some outside company links. It is successful so far, in that people seem to be accessing the site and not calling on PC support, as frequently, for information. A software and hardware upgrade was made to the Design Office Netware server (TRI_S01). Ongoing problems with trailer Gg's server were resolved and repaired. PCs are much more complex than they used to be. Servicing them takes a great deal more time, and sometimes research, to accomplish than it did in the past so users' requests are becoming increasingly difficult to support with the available effort.

Site communications

Some 110 cable runs for data communications at ISAC were planned out, and some cable was ordered to allow progress on cabling. For temporary measure, a bridged Ethernet link was installed to ISAC. Lightning storms on July 5 and August 6 damaged 7 thick Ethernet transceivers in various locations around the site, 2 ports on a thin repeater connected to the basement of remote handling building, and all the NIC cards (some 15 plus) in remote handling.

For the site Ethernet, three 10 base-T repeaters were installed, along with cabling to stores, shipping area, accounting office, buyers offices, the microelectronics lab, safety trailer, and the TR30 control room. A number of 10base-2 thin Ethernet segments were added around site. To document the cabling and equipment for the site Ethernet properly, a standardized set of some 40 drawings was created on AutoCAD.

Technical support

Technical support completed assembly and testing of the "Russian Coil Driver" high speed high current switches for TRINAT, and the fluxgate magnetometers for μSR. For the new facilities at ISAC, some modifications to the main tank vacuum system digital TRIMAC software were implemented. Support for PIF saw the designing and construction of a four channel pre-scaler. Other modules included some 16 channel V/F modules for parity, a CAMAC universal digi module, plus a new CAMAC power monitor and diagnostic module for controls. Some board assembly for SNO, and a PC board layout for ATLAS were also worked on.

ELECTRONICS DEVELOPMENT

The Electronics Development group had another extremely busy year. Even the addition of another technician for one year made it very difficult to keep up with the project load. Major efforts went into the ISAC control system, support of several CERN projects, and again, more than expected, into the CDS. Two BCIT coop students were supervised between February and the end of August.

ISAC

For the ISAC control system, major effort went into the conceptual design of the overall system, as well as the detailed design, implementation and commissioning of the off-line ion source and low energy beam transport sections. This project is described in detail in the ISAC section of this Annual Report.

ISAC power supply controllers

The power supply controller modules of the ISAC test stand were upgraded. During the previous year, the tight schedule had only allowed the implementation of an RS485 based master-slave communications protocol for the controller network. Early this year the modules were converted to CAN-bus. A multi-master communications protocol was developed and integrated into the test stand EPICS system, using EPICS device and driver support software layers from the Royal Greenwich Observatory, Cambridge. In order to facilitate testing and commissioning, CAN-bus monitoring software was developed on a PC. Based on the experience with 30 modules on the ISAC test stand, a new revision of the power supply controller cards was developed.

The controller is adapted to different types of power supplies with a supply specific transition card. This card connects to the supply's control connector and adapts to the supply's geometrical dimensions. The card contains a 48-bit serial number chip with non-volatile RAM for storage of configuration parameters. Additional power supply specific digital I/O which exceeds the basic capabilities of the controller card is implemented on this card by using the I^2C serial bus from the controller card connector. Power to the controllers (+24 V) is supplied in the same cable which carries the CAN-bus via small eight-channel hubs. In order to meet the ISAC requirements during 1998, a first batch of 250 controllers was produced.

CERN projects

The VME timing surveillance module (TSM) passed CERN acceptance tests just before the end of the 1996. A first production batch of 15 modules was manufactured, tested and sent to CERN on schedule. During operation at CERN, it was detected that some modules in a heavily loaded VME crate produced phantom empty events, in addition to the real time events. The conditions for this happening are not well described and the problem is being investigated before a second production batch is made in the summer of 1998.

For the Kicker group, a controls and interlock unit for the 66 kV resonant charging power supply was designed, as well as the wiring system, and the interface between components of the power supply. Schematics and PCB layouts for the needed components were produced, and mechanical components for the supply were designed. All necessary components were acquired, and assembly of the components was supervised.

For ATLAS, a 32 channel track and hold motherboard was designed for the FEC group at the University of Arizona. Board construction is on hold pending parts deliveries.

CDS

Final testing of the high voltage power supply (HVPS) and the sub-systems was completed and the tandem shipped to Northrop Grumman Corp. (NGC) in Bethpage, NY. Two members from the group spent most of February installing and commissioning the tandem accelerator at the NGC facility. Telephone support and regular PLC updates rounded out the first quarter activities.

Failures of the low voltage transformer (LVT) plagued the project for most of the second quarter. The LVT was delivered as part of the high voltage power supply system from ERDL. Its design consisted of 20 laminated steel cores, each separated by four sheets of mylar. The mylar insulation is equivalent to air gaps in the core, making the transformer extremely leaky. A compensation network consisting of capacitors in parallel with a secondary winding is used to keep the flux within the transformer core. High voltage punch through of the mylar causes a short between two stages of the HVPS, rendering it unusable. During the summer, three trips to Bethpage, NY, were required to assist NGC personnel in repairing the HVPS, which had been damaged as a result of a high voltage breakdown.

A complete HVPS set-up was required, consisting of a dc power supply, inverter, HVPS stack, and a LVT stack. This allowed development of a new HVPS at TRIUMF, while still allowing NGC to continue with the proof of principle. PSpice modelling of the high and low voltage power supply transformers was done to understand the current design and improve it. Measurements on prototype transformers were made to verify the models.

The inverter currently in use was one of only three prototype units from Varian (Canada). The other two units are in use at the University of Waterloo. Several weeks were spent in an attempt to find a supplier for the inverter. With no productive result, it was decided that we would develop the inverters required. Because of the good success of the HVPS with regards to operation, a similar approach was used for the LVT. Running the LVT at a higher frequency allows the use of ferrite for the core, reducing the values of the components in the compensation network, therefore reducing the size and voltage requirements of components. An operating frequency of 30 kHz was chosen for the LVT. This is well within state of the art technology for switching power supplies, and far enough from 100 kHz to prevent cross-talk with the HVPS.

As an added benefit, both the HVPS and the LVT will be built utilizing the same PCB. For the LVT section, a 30 kHz inverter is required to drive the primary, as well as a rectifier and 60 Hz inverter for the secondary. The new PCB design was completed and four prototype boards were tested. Finally, 100 boards were manufactured. A FET bridge was bread-boarded and successfully tested at both 30 and 100 kHz, in both driven and self resonant modes.

The HVPS/LVT stack was assembled and a high power inverter consisting of 4 paralleled FET bridges was constructed. The HVPS transformer was measured, using a network analyzer, to determine operating characteristics and verify the models. Initial testing of the system was successful with the results closely matching the predicted values from the simulations.

The 30 kHz 3 kW and 60 Hz 3 kW inverters are under construction. The system will undergo final testing at TRIUMF in January and February, 1998, and then be shipped to NGC in Bethpage, NY, to replace the existing HVPS/LVT.

Beam line 1A targets

At the request of the Operations group, the target control system was modified to make it independent of a host processor and network at start-up.

The VXworks real-time kernel is now stored with the flash memory of the VME bus embedded processor. A section of battery backed, non-volatile RAM is configured as a RAM-disk in which the application software is stored. At reboot or power-on, the VXworks kernel is loaded into RAM from flash memory and the control software is loaded from the RAM-disk. The network can still be used for downloading upgrades, but it is not required operationally.

EPICS support

One new SUN Sparcstation 5 was purchased which serves as a development node for the ISAC control system. The TRIUMF Physica package was installed and made available on all ISAC SUN work stations. The upgrade package for VXworks 5.3 Tornado was received, and installation and initial tests carried out.

Miscellaneous projects

A high speed summing amplifier for phototube signals was designed. A pre-amp and shaping circuit for Si strip detectors was designed, and a 24 channel version built for the TRINAT group.

For Ebco Technologies, a bias supply box, two signal conditioning modules for target pressure transducers, a cryopump interface box, and a variable constant current/voltage source were built.