TRIUMF

ANNUAL REPORT
SCIENTIFIC ACTIVITIES
1998

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

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UNDER A CONTRIBUTION FROM THE
NATIONAL RESEARCH COUNCIL OF CANADA

APRIL 1999

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

As for the past two years, the ISAC project continued to be the largest user of engineering, design and fabrication effort during 1998. This is reflected in the REAs (requests for engineering assistance) submitted during the year, with 48 for ISAC-related projects and 15 for other activities. The main activities for ISAC involved completion of beam line 2A, the target stations and modules, the mass separator system and low energy beam transport (LEBT), the RFQ accelerator, and the first tank of the DTL. An increasing amount of ISAC work is now moving on to the experimental program, with engineering effort put into the TRINAT experiment relocation, DRAGON spectrometer, and the first experiments using low energy radioactive ion beams.

Design work for the CERN-LHC collaboration included the cabinet for the 66 kV resonant charging power supply, the fast blade scanner and a start on the fast wire scanner. The ATLAS collaboration received some engineering assistance in thermal calculations for the forward calorimeter, and the University of Victoria group produced final designs for series production of the hadronic endcap calorimeter and concepts for the wheel assembly. Work was also carried out on the signal feedthrough project.

Assistance was also provided to the internal program, particularly Expt. 614 where an engineer assisted in testing and shipping of the 2 T superconducting solenoid, the μSR program where some detector stands were modified, and the CHAOS experiment, where an improved cryogenic target was designed.

The Design Office and Machine Shop were heavily loaded and outside assistance was used to cope with the demand. The Building department carried out a number of tasks related to completion of the ISAC building and target areas, the largest being the design and contracting of concrete shields for the top of the ISAC target area and separator areas. Design work has started on the completion of the second floor of the ISAC annex to house the occupants of trailer S (Design Office trailer).

The Electronics Service group was fully occupied in producing control and interlock modules for ISAC, cabling manufacture and installation of the data communications cabling. The Electronics Development group provided working ISAC controls as systems came along, and developed VME and other modules for the system. The groups found some time to support the CERN-LHC work in three instrumentation projects and the resonant charging supply project. Some other activities, notably BNL Expt. 787, μSR, and the CDS power supply also received help.

MAGNETS

The magnet work carried out as part of the CERN collaboration is reported in the CERN Collaboration section. The main project was production of the prototype twin aperture quadrupole magnet and subsequent developments towards series production.

The ISAC pre-separator magnet, built by Sunrise Engineering (BC), arrived on site in June, was field mapped and installed in location in September.

Figure 148 shows a photograph of the lower half of this magnet with the vacuum chamber installed. Radioactive ion beams from either of the two target stations are bent into a common exit beam line using this magnet.

The design of the ISAC MEBT 45° dipoles was documented in "Concept design of the ISAC MEBT 45° dipole magnet" [TRI-DN-98-03]. The contract was awarded to Talvan Machine Shop (BC), to make two of these small dipoles. Delivery is expected in April, 1999. The design of two dipoles for the ISAC DRAGON separator was documented in "Concept design of the DRAGON separator MD1 dipole magnet" [TRI-DN-98-12], and "Concept design of the DRAGON separator MD2 dipole magnet" [TRI-DN-98-10]. TRIUMF

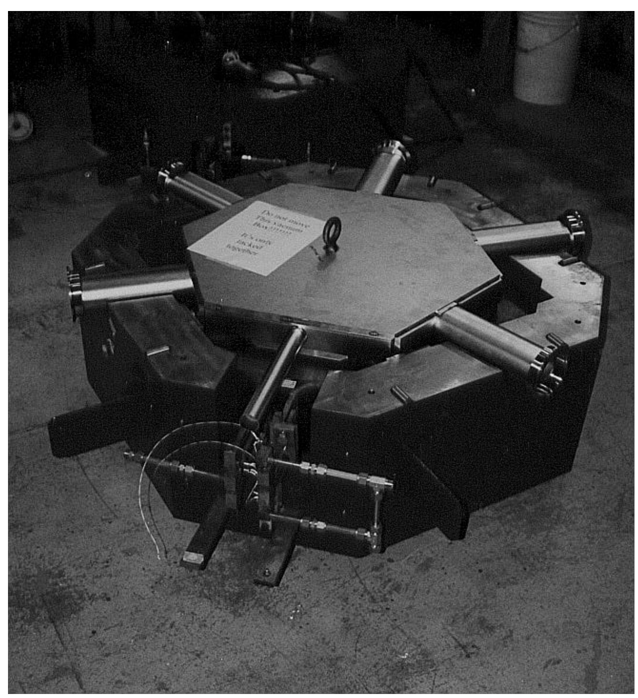

Fig. 148. Photograph of the lower half of the pre-separator magnet with the vacuum chamber in place.

went to tender for these two magnets in December, and a contract is expected to be let in January, 1999.

The design of one of the types of quadrupoles for the ISAC DRAGON separator was documented in "Smit-Elma quads for the DRAGON separator" [TRI-DN-98-17]. This magnet uses a steel core recycled from the CERN PS transfer line and the coil design made by TRIUMF for the CERN BT quads. The Beam Lines group started to assemble two of these quadrupoles in December.

A large superconducting solenoid is required for TRIUMF Expt. 614. A TRIUMF engineer supervised the pre-purchase testing of a used MRI magnet at Cryomag Services (New Jersey), and a decision was made to purchase this magnet. Tests were performed at 2 T at the site and the magnet was field mapped when it arrived at TRIUMF at 0.2 T to check that it survived the trip. The magnet requires a steel shield to contain the return flux and a cost estimate was made for various possible shield arrangements, resulting in a decision to proceed with the design of a rectangular shield.

Magnet Measurements

A total of 10 magnets listed in Table XXII were field mapped during the year. The Chalk River separator dipole, which is a curved magnet with 135° bending angle, was surveyed from both ends, at 4 different current levels and with 4 different combinations of trim coils settings. The ISAC pre-separator magnet was surveyed from the exit and two entrances, at three different current levels.

Two commercial Gaussmeter systems were calibrated and installed in the separator and pre-separator magnets.

Table XXII. Details of surveyed magnets.

Quantity	Project	Description
1	ISAC	Chalk River separator dipole
1	ISAC	Chalk River double steering magnet
1	ISAC	Pre-separator dipole
6	ISAC	4Q8.5/8.5 quadrupoles
1	E614	Superconducting solenoid

MECHANICAL ENGINEERING

ISAC

A considerable amount of engineering effort was expended in support of the ISAC project by all members of the group in various capacities; from project management to specific project engineering participation. Highlights of this work are briefly described below. As well, detail designing and checking continued well into the year necessitating design reviews and engineering participation. This centered around components required for completion of the target hall, pre-separator, mass separator, beam transport, diagnostics and accelerators.

Beam line 2A

The majority of work on beam line 2A and on the vault upgrade was accomplished in the previous year. However, the completion of the vault upgrade could not be achieved until the February shutdown when the remaining magnets, diagnostics and transport elements were installed. The 2A beam line in the tunnel was also completed at that time and beam was successfully run into a temporary dump at the end of the tunnel in late April. This left the remaining beam line from the large bender magnet to the west target station to be completed and this was done later in the year once the west target vacuum tank was installed.

Target hall

The majority of engineering work was completed in the previous year. During 1998, the actual construction of the 2 target stations required a great deal of consultation and supervision due to the complexity of these stations. The creation of each target station involved the placement of 10 ton steel shield blocks in an accurate pre-arranged pattern based on shielding calculations. These were then encased in concrete along with the required penetrations for services such as electrical conduit, vacuum exhaust piping, high voltage chases, etc. This was accomplished in 7 steps starting at level 264 ft. up to the completion level of 284 ft. and involved 525 tons of concrete and 1000 tons of steel. Accurate forming was required in order to minimize gaps around the vacuum tanks and to ensure that covering shield blocks fit properly. The west tank was installed into its cavity in May, and the quality of work was such that its placement was within 0.050 in. requiring only a minor adjustment.

In-parallel work continued on the 5 modules that were to be installed in the west target station (see Fig. 149). These were being assembled in the east end of the experimental hall and involved consultation and supervision from the engineering group along with considerable assistance from the Remote Handling group.

A major effort during this report period was the design manufacture and assembly of all components contained at the bottom of the modules, i.e., target/ion source extraction elements, electrostatic quads, steerers and diagnostics. These elements had to be mounted in such a way as to be remotely handleable in future and their alignment with respect to each other can be adjusted and easily checked. This was achieved by

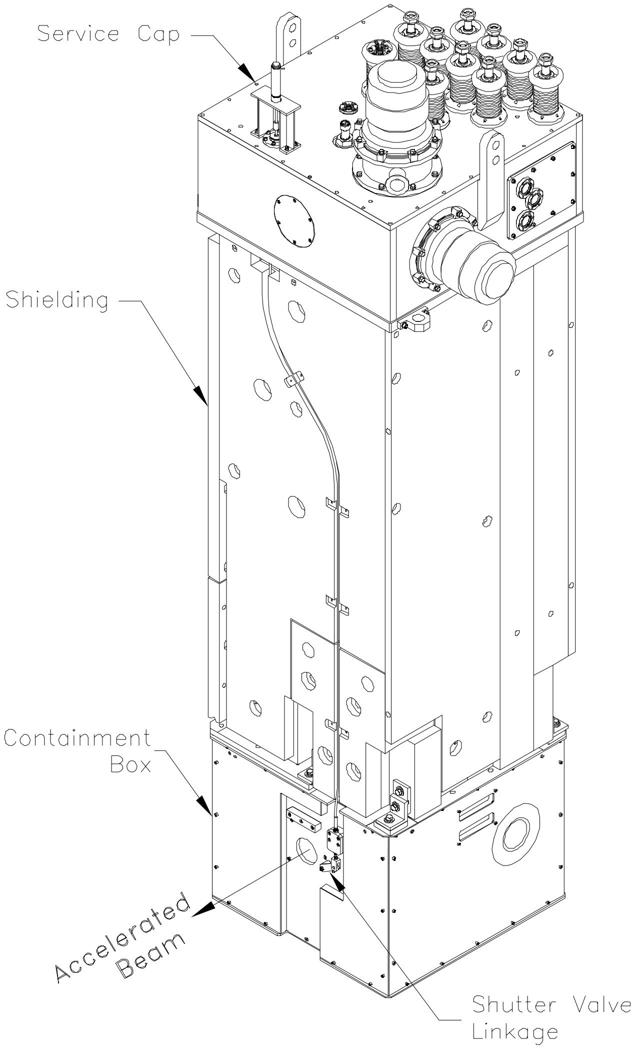

Fig. 149. The ISAC target station module which houses the target/ion source in the containment box. All services enter at the top of the module which is shielded from the target below.

mounting all the elements, in each module, on a removable tray. A special alignment tray is then used to allow adjustment with respect to the module and once this is set the component tray can be placed in situ accurately and repeatedly. Similarly, a master fixture was built to accept any of the modules and this along with a transfer fixture allowed accurate alignment of the modules with respect to the vacuum tank.

As a result of this work all the modules were installed into the west target tank (see Fig. 150) and stable beam was extracted in October, followed by radioactive beam extraction to the mass separator in November, and to TRINAT in December.

TRINAT

This facility has been successfully operating on TISOL in the proton hall extension and was moved to

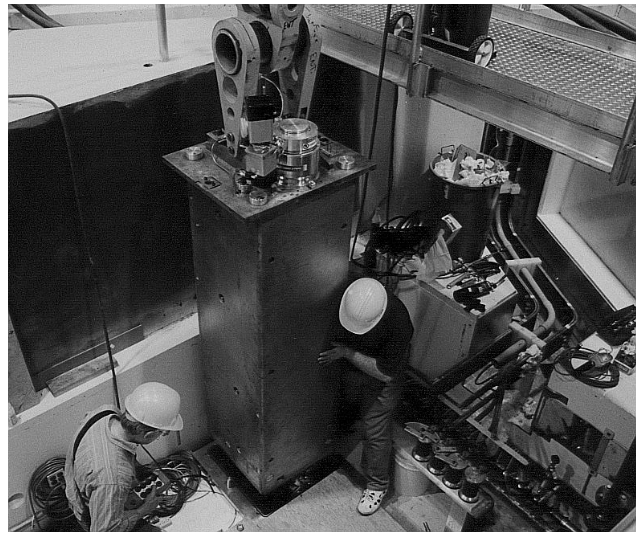

Fig. 150. Photograph of one of the 5 modules, the beam entrance module, being lowered into the west target station.

a new location on the floor above the mass separator in the ISAC building. This required a considerable amount of engineering support in the form of design layout, component design, supervision and scheduling in order to be available by late November, to meet the schedule for radioactive beam delivery. This work was accomplished successfully. At the same time the TISOL facility had to be supported since its operational schedule to other experiments was not interrupted.

Accelerators

Work continued on the installation of the 7 rings into the RFQ vacuum tank. Once the platens had been aligned via a digital theodolite interception procedure, the vanes were installed and services hooked up resulting in the commencement of rf signal level testing in the spring. All this work involved engineering support on a day-to-day basis. Subsequent RFQ tests using the off-line source have indicated operational characteristics exactly as predicted, which also indicate that the design and alignment philosophy and implementation were successful. Work paralleled the above in completing the remaining 12 rings plus 3 spares that will require completion and installation in 1999.

At the same time design work was nearing completion of the drift tube linac (DTL). The detailed drawings were released and components for tank #1 were manufactured during this report period. In order to achieve a high quality rf surface on the inside of the tank, it was plated with copper by the acid bath process which was a procedure new to TRIUMF. This process produced a beautiful surface finish, even filling in machine marks, but did cause some problems due to build up on edges and corners requiring post machining. Assembly of the DTL tank #1 began late in the year and will be completed and rf tests begin early in 1999.

DRAGON

Project engineering assistance has been started on the DRAGON project. The main focus is on the design of 2 electrostatic dipoles (ED's). These ED's will be similar to those installed at the ATLAS facility at Argonne National Laboratory. A great deal of time and effort has been spent to understand these systems. The mean bend radius of ED1 is 2 meters with the bend angle of 20°, while the bend radius for ED2 is 2.5 meters with the bend angle of 35°. The electrodes are held at ±200 kV with a 10 cm separation. The electrodes for both the ED's have been designed and detailed drawings are in progress. Design of the support and alignment system for electrodes is progressing. It is desired to maintain these titanium anodes and cathodes parallel to each other within 100 μm under electrostatic forces in vacuum. The surface of the Ti anodes and cathodes opposing each other must have a mirror finish.

The design and assembly issues of the compact 300 kV Cockroft-Walton high voltage multiplier stacks are being looked into. It is proposed to buy a 10 kV power supply from Glassman and build a 30 stage full wave Crockroft-Walton multiplier stack in-house with assistance from ANL.

Progress is under way to design different diagnostics components including charge and mass slits. Support stands and vacuum vessels for the DRAGON beam line are also being designed.

Some engineering and design assistance was given to the windowless gas target project for DRAGON which is being carried out at the University of Alberta.

Analysis

Engineering of ISAC structures and components has involved the need for structural analysis in many cases. An example is the design of a module which involves 12 tons of steel and must be supported not only in the vacuum tank but in the various assembly jigs and alignment fixtures during assembly. All this equipment required analysis to ensure structural integrity. This involves actual recognition of the requirement during a design review, the analysis accompanied by a brief report, and a signature on the drawing by the analyzer. Complex analyses may require the use of finite element analysis which is available at TRIUMF in the 2 codes ANSYS and ALGOR. These codes are also used for other complex forms of analysis (see ATLAS section in this report).

ISAC – University of Victoria

Construction of the water-cooled, copper plate, beam dump was completed. A static pressure test at 1.5 times the maximum operating pressure was carried out, and water flow versus pressure drop measurements made. The dump is now in service. The design has been documented and distributed as a Victoria Physics Note [VPN-98-1]. Technical support was provided to assist with commissioning the beam dump, assembly of the exit modules and installation of exit module, beam optic elements.

Engineering – Other

ATLAS – TRIUMF

Heat transfer studies continued for the forward liquid argon calorimeter (FCAL). The study considered the heat transport from the FCAL module to the outer support tube through the liquid argon (LARG) gap. A computational fluid dynamics (CFD) model was created using a CFD program FLOTRAN within ANSYS. Due to symmetry in the problem, a 2D model of half of the FCAL support tube and half of the outer support tube was created.

This analysis predicted convective loops in the top section of the LARG gap which promote heat transfer to the outer tube, hence increasing heat transfer and reducing the temperature rise in the LARG gap.

ATLAS – University of Victoria

Hadronic endcap (HEC)

Final drawings for the HEC module series production and subsequent detector wheel assembly were completed. The design was presented before a production readiness review committee at CERN and was approved for manufacture by the collaborating institutes; Dubna, Protvino, Lebedev, MPI-Munich, and TRIUMF. The complete drawing series was converted to CERN compatible files and transferred via interactive Web pages to the CERN drawing directory. Conceptual design work commenced for the HEC detector wheel assembly table, wheel rotation device, and cryostat interface tooling (see Fig. 151). Module support frames and shipping containers were manufactured for transportation of test beam pre-production modules to CERN. In addition, an overhead crane to facilitate module assembly was designed for installation within the existing clean-room facility at TRIUMF.

Signal feedthrough project

Laboratory space for assembly and testing of the ATLAS detector signal feedthroughs has been prepared and the various, vacuum, leak checking, welding and electrical test equipment has been installed. Preliminary tests are under way and suitability of the two technologies available to construct the signal pin carriers is expected to be confirmed in time for the production readiness review scheduled for January, 1999.

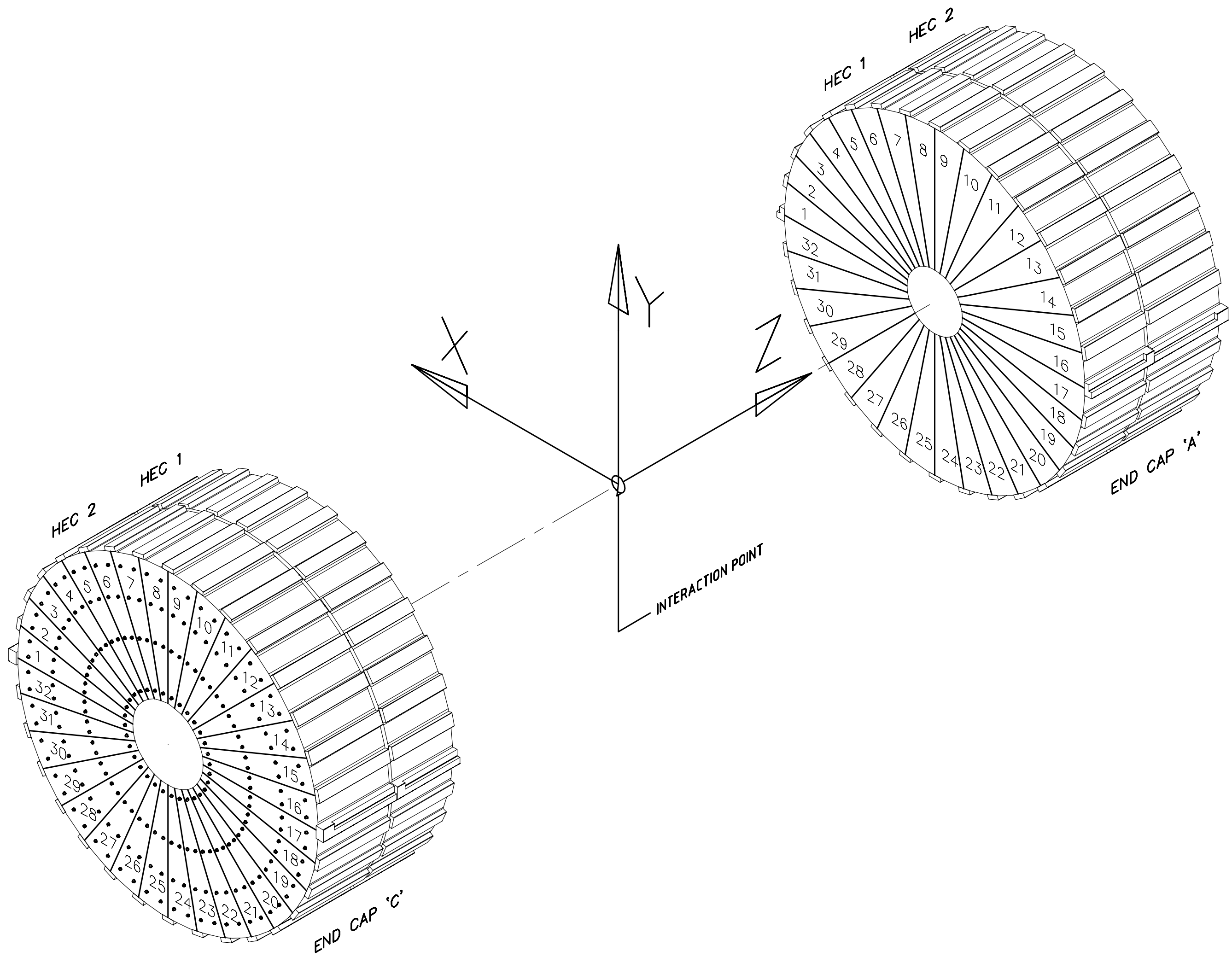

Fig. 151. Thirty two of the ATLAS HEC modules, each weighing 3000 kg, will be assembled as shown into a wheel which is 4 m in diameter, and installed in a cryostat.

Welding tests, with post-weld metallographic examinations, have been done to prepare for the weld and welder qualification processes demanded for these devices under the pressure vessel code.

PLANNING

This year the Planning group was involved in planning, scheduling, coordinating and expediting several sub-projects for ISAC; planning and coordinating activities for two scheduled shutdowns (January 20–May 6, and August 22–November 4); and planning some of the CERN collaboration projects (fast blade scanner, resonant charging power supplies and pulse forming networks).

Various plans and PERTs were prepared, manpower estimated and analyzed and updated regularly. ISAC priorities were evaluated and the highest priority was assigned to produce the first radioactive ion beam (RIB) by the end of November. The resource leveling was done, activities were expedited, and the above goal was achieved on November 30.

The progress on PERTed projects is described elsewhere in this report under the respective principal group. However, following is a summary of projects along with the major milestones achieved:

Beam line 2A

Components were installed in the vault and tunnel in the January shutdown. 2A was commissioned with proton beam to temporary dump (in the tunnel) on April 29, and to the dump module at the west target station on May 25.

Target areas

This work included fabrication, assembly, installation, and alignment of 2 vacuum tanks; fabrication and assembly of 5 target modules for the west target station (entrance, dump, target and 2 exit modules); target hall crane; guard rails, walkways and refinishing of target hall concrete walls by surface parging and painting; shielding (up to 525 tons of concrete poured in several steps and 1000 tons of steel shielding); high voltage system (cage, interlocks and HV lines); services (electrical, water, air); vacuum system, target station (module access area, services, cabling); machine protect system (interlocks, thermocouples, etc.).

Several problems were encountered in the fabrication and assembly of the vacuum tanks and many target module components due to poor copper plating, design and manufacturing errors. The milestone of commissioning stable beam out of the target ion source was achieved on September 24.

RFQ

After signal and power level tests, full voltage on the 7-ring RFQ electrodes was achieved on July 13. First accelerated beam was extracted through the RFQ at full power in September. The remaining 12 rings were designed, fabricated and assembled by December, with the aim to complete installation of all rings by July, 1999.

Separator system

The mass separator, high voltage platform, diagnostics, vacuum system, controls and LEBT (from DB11 to TRINAT) were installed and tested by October. The commissioning sequence involved getting first stable beam through the pre-separator on October 23, first high resolution beam at the separator image slit on November 3, followed by a stable beam to TRINAT on November 19, and RIB on November 30.

Drift tube linac (DTL)

Overall progress on the DTL project was slow due to a relatively higher priority placed (in terms of manpower and other resources) on getting the RIB to TRINAT by the end of November.

The first tank (including stems, ridges and end plates) was fabricated and copper plated by September. The DTL buncher was designed and fabricated at INR-Troisk, received at TRIUMF in August, and tested to full voltage by October. Also, the DTL quadrupole triplet was specified and design started with an aim to order the triplets by April, 1999.

Other

A work breakdown structure (WBS) for the DRAGON project was developed and a detailed PERT was prepared. Major milestones include gas target designed and fabricated at University of Alberta with an aim to test at TRIUMF in May, 1999; 2 magnetic dipoles (MD1, MD2) designed and will be ordered in January, 1999; design of 2 electrostatic dipoles (including electrodes, HV power supplies, support and alignment structure) started.

Also, the Planning group was actively involved in planning, scheduling and expediting activities for the GPS experiment, TRINAT move to ISAC building, LEBT (to TRINAT and GPS), yield station, MEBT layout, LTNO (for beam in July, 1999), and β-NMR (for beam in November, 1999).

In addition to ISAC, the Planning group was involved in planning and scheduling the activities for CERN work; fast blade scanner, fast wire scanner, five 66 kV resonant charging power supplies (RCPS), and nine pulse forming networks (PFN's).

Shutdown Activities

The main purpose of the first shutdown (January 20–May 6) was to complete beam line 2A and all related activities in the vault and tunnel. The cyclotron lid stayed down for the first 5 weeks and then the lid came up for 4–5 weeks. Major jobs completed in this shutdown include: 2A (finish installation in the vault and tunnel), cyclotron probe MRO, vacuum (MRO, rebuilding of cryo pumps 3 and 5), rf (MRO, resonator leveling adjustments), MRO on beam line monitors, tank inflector inspection, correction plate tests, repair trim coil junction box, adjustments to the elevating system controls electronics, CM1 and 1VQ3 (worn hoses) water leak repairs, 1VQ1 damaged cable, T-1 water package, stand modifications to resolve alignment problems of 4AQ4/5 and other beam lines MRO work in the vault, meson and proton areas. The total man dose incurred in this shutdown was 82.6 mSv distributed among 90 workers.

The main purpose of the fall (August 22–November 4) shutdown was to work on beam line 2C and complete ISAC activities to deliver beam to TRINAT. Since the cyclotron lid was not raised, most of the work was done only in the vault and experimental areas. The major jobs completed in this shutdown include: 2C work (solid target facility, cesium target, shine blockers and rubidium target), repair both B20's, replace UPS, rf (MRO and wasterload #3), investigate and repair water and vacuum leaks at T2 and TNF, M13 (triplet and short separator), 4BQ7 magnet coil repair and MRO work in the vault, meson hall and proton hall. The man dose incurred in this shutdown was 21.2 mSv distributed among 41 workers. Beam line 2A was tested at approximately 1 μA on November 16 and 17. Many start-up problems were encountered which caused a significant downtime and those included – aluminum ALCW pump (October 26–November 2), TNF vacuum leak (decided to run with helium), main magnet power supply pre-driver (November 18–20), and

TNF water leak. The main magnet was turned off on December 20 (instead of December 22) due to water in the rf room as the reheating coil burst.

DESIGN OFFICE

The ISAC project received 89% of available hours during the year. This has kept 10 designers, often in teams of two or three, very busy preparing detailed designs for different aspects of the project, specifically and in order of weight: pre- and mass separator sections; target and exit modules; DRAGON experiment including the gas target design; remote handling hot cell, particularly the roof structure containing the elevator turntable device for servicing the target modules; MEBT beam line; low energy experimental yield station, lifetime and β-NMR experiments; RFQ diagnostic station for the 7-ring test and the drift tube linac tank #1.

The CERN contribution accounted for 9.2% of available hours with most effort concerned with the 66 kV resonant power supply and the fast blade profile monitor. Because of the concentration of effort required for ISAC, the only other significant TRIUMF project undertaken was the CHAOS LH2 target design. Continued assistance from the University of Victoria, TRIUMF remote handling personnel, and from students, joining us as part of their mechanical technology program at Camosun College in Victoria, has helped us cope with the heavy workload.

The demand for graphic art services continues to increase in support of seminars, conferences and publications. The addition of digital photography and the increasing use of Web sites for communication has enhanced these services.

MACHINE SHOP

The TRIUMF Machine Shop produced approximately $133,000 worth of fabricated and machined components for the various on-site groups each month. During the year we sub-contracted work from the TRIUMF Machine Shop to local industry worth over $536,000, all in small packages and none above $25,000.

As shown in Table XXIII, ISAC was by far the major user of our services again this year manufacturing the last 15 RFQ ring assemblies and associated components, vacuum chambers, beam lines, tantalum targets and DTL components.

Table XXIII. Machine Shop utilization.

ISAC	8.3%
Science	6.9%
CERN	5.8%
Cyclotron	2.2%
Affiliated institutions	1.5%
NSERC	0.5%
Accelerator	0.1%

A new fume and dust extraction system was installed in the welding and grinding areas which is proving to be a huge improvement in the air quality.

BUILDING PROGRAM

The Building department was presented with a variety of challenges, foremost being the upkeep of the TRIUMF site and buildings. Contracts were let for a wide range of maintenance and repair work such as blacktop repair, parking lot restoration after the departure of the ISAC contractors, repairs to buildings and reroofing of office trailer complexes as well as interior and exterior repainting of various facilities.

With the primary ISAC structure completed, the Building department was called upon to attend to second stage finishing work and also to identify and monitor the correction of architectural and structural deficiencies by outside consultants engaged in the ISAC project.

A major effort was required for the design and contracting of approximately 12 ft. high, cast in place, concrete shielding with channels for the target vacuum tanks, and modular steel shielding blocks in the ISAC target hall. Other work in the target hall was the design and casting of several large movable reinforced concrete shielding blocks to be located over the preseparator magnet. Further, the construction of a set of steel stairs into the 14 ft. deep target module storage pit, as well as contracting cement parging and subsequent painting of the very roughly cast concrete walls and roof of the target hall.

An 11 ft. high and 3 ft. wide angular shielding wall consisting of stacked masonry blocks was designed and built in the mass separator room.

Other projects were the design and contracting of the TRINAT clean room on floor level 278.0 ft. below the experimental hall, and the building of the high voltage room in the ISAC service annex.

ELECTRONICS SERVICES

Overview

This year was a definite challenge to the Electronics Services group. The demands of fast-tracked ISAC installations as well as supporting the cyclotron program put personnel in high pressure situations at times. The group showed great dedication and abilities by interactively supporting areas that required assistance both inside our own group and for numerous groups on site.

Technical Support

Technical support had a large number of projects covering all facets of electronics this year. Support for ISAC included a major circuit design to allow remote control of the Power Ten power supplies used in the new beam line. Also for ISAC, the TRIMAC based ISAC west target protect system was designed, programmed and commissioned. When the Electronics Shop was overloaded, technical support assisted in the assembly of bias supplies, QSX modules, and numerous cables. For BNL Expt. 787 a schematic and PCB layout for the UTC system was worked on. Ongoing software maintenance was carried out for the BL2C safety and TRIM TRIMAC systems. CERN work included a control system and packaging of the fast blade scanner. Background work included continuing work on the CAMAC power and diagnostic module for the Controls group.

Experimental and Target Support

The major effort of experimental and target support was directed towards ISAC. These jobs include: installing cables for the high active cooling system and wiring them into the west target PLC control system; installing all the signal cables for the west target cooling manifold, and design of the west target/dump protect system. A prototype motor control box was built to support the mass spectrometer and help was also given in wiring up the Faraday cup. Ongoing maintenance of the existing systems included 1AT1, 1AT2 and the parity twisters. Experimental support was also involved with the building and wiring of the CERN 66 kV control system.

Electronics Shop

This was a most productive year, with 80% of shop time spent on ISAC requests for cables and modules: QSX, flow-switch, bias supplies, fiducial units and digi modules. Due to many last minute requests for ISAC cables, the shop was severely overloaded on a number of occasions. Shop personnel handled the demand very well with additional help from other members of the Electronics Services group. For CERN, a prototype 200 MHz calibrator filter 0917/1 module was assembled and all requisitions for parts for 250 more of these modules were processed and tracked.

Electronics Repair Shop

This was a busy year for the Electronics Repair Shop, with infrastructure support for the TRIUMF cyclotron and experimental program requiring most of the repair effort. Towards that end, a total of 253 items of electronic equipment were serviced, including: 18 terminals, 59 colour and monochrome monitors, 26 SCSI and LAN devices such as tape drives and hard disks, 60 power supplies for NIM, CAMAC, high-voltage and miscellaneous units, 17 Nucleonics NIM or CAMAC devices, 22 items of test equipment such as oscilloscopes, and 51 other electronic devices mostly related to controlling or measuring the vacuum systems. In addition, 19 detector electronics devices were repaired in support of Expt. 787 at Brookhaven.

Microprocessor Support

The majority of the effort spent related to learning and working on ISAC control system software, specifically EPICS. The RFQ vacuum control system was the first live installation, followed by beam optics for all sections of the mass separator (IMT), and low energy beam transport (ILT), and beam optics to experimental areas ILZ and ILG. UNIX scripting languages were used to create automated systems for creation of EPICS display manager screens, and EPICS databases.

Ongoing consulting services to TRIUMF staff were provided as usual, in areas such as networking, PC support, and miscellaneous software support issues. Programming services provided include low-level drivers written for the Controls Hardware group's development of PCI to CAMAC interface hardware.

High level software support

During the year work was done on several ISAC components. Principally motor drives and controls were built, tested and installed for the diagnostics in the ISAC beam lines. A large shipment of defective rad-hard limit switches was identified in stores and procedures were created to disassemble, clean and reassemble the switches. Changes to the BL2A extraction probe control system were started. Work for CERN involved porting a signal analysis program from BASIC to C++.

Infrastructure work included changes to the CAMP (control and monitoring of peripherals) slow controls software for the Data Acquisition group for μSR experiments. Changes were made to several TRIMAC based control systems. These included addition of a level sensor unit in the TNF target monitor system, and ongoing changes to the thermocouple monitoring program for the CCS.

A new Sun workstation was purchased and some of the software development for VxWorks real-time applications currently run on an obsolete DECStation was transferred to this computer.

PC support

Many tasks were completed throughout the year by PC support such as: distribution of Norton Anti-Virus about site, building new Pentium II PCs, refurbishing old 486s and providing them for users of older systems, and upgrading most of the Design Office workstation hardware and operating systems. This year saw the demand for PC storage and memory capacity increase as applications continue to grow and images play a larger role in computer communications. This has led to many requests for hard disk installations and memory upgrades. There are a large variety of PC problems due to many variations in hardware, operating systems and installed applications. Much effort is being dedicated to reducing these problems by maintaining the site PC standard and detailing it on the PC support Web site. Support of the site's 400+ PC based computers logged 600+ repair calls.

Site communications

The data communications cabling for ISAC was a major project this year. In January, as the as-built drawings were not accurate, all conduits were traced, confirmed and mapped to AutoCAD drawings. February to June involved the twisted cable pulling, terminations, jumpers and commissioning. This was followed by fibre optics cable pulls, plus coordinating an external contractor for terminations and testing. Some of the ISAC work involved isolated systems due to the special grounding requirements in ISAC. Altogether, 124 twisted cables, and 3 pieces of fibre optics cables were installed. There are 212 data connections available, with a fibre optics backbone that connects to the site and the Internet. A Web page was set up and some 40 updated drawings for Ethernet cabling were published in the PDF format for easy access on site. Planning and estimating commenced for upgrading to 100base-T for both the chemistry annex and the main office building.

ELECTRONICS DEVELOPMENT

This year, the majority of the group's effort went to support of the ISAC control system design and installation. In addition, the CERN and CDS projects continued.

ISAC Support

The CAN-bus power supply controllers received minor upgrades and bug-fixes based on the initial operating experience. Especially, the power-up surge current was reduced. By November, 250 of these controllers were tested, installed and commissioned on the ISAC beam lines. Production of 100 additional units was organized towards the end of the year.

The Chalk River Danfysik current supplies were modified to be controllable via CAN-bus. New controller and adapter cards with modified embedded software were developed. These supplies are used to power the ISAC pre-separator and mass separator dipole magnets.

For the ISAC control system several VME modules were developed:

- An 8-channel, variable gain beam current amplifier with transient digitizing capability was designed as a replacement for the TRIUMF 4-channel NIM QSX module. By combining the functionality of a current amplifier, an ADC and a transient digitizer into a single-width 6U VME module, significant savings were obtained in overall module cost, rack space requirements as well as installation and documentation effort. The module has eight gain ranges between 1 nA and 1 mA. For transient digitizing, storage is provided for 4 k samples per channel. Digitizing frequency is programmable up to 100 kHz. Binary output signals for driving 0518 harp monitor readout modules are provided. All module functions are programmable through VME registers. A first batch of 8 modules was produced, tested, and commissioned for ISAC.
- A 32-channel optically isolated digital I/O module was developed. Four groups of 8 channels each can be configured as input or output. 7 modules were produced, tested, and commissioned for ISAC.
- Design work was started for an 8-channel VME-based bias supply for beam current monitors which is programmable for 100 to 300 V output.
- For the ISAC ^{8}Li polarizer, design work on fibre-optics signal transmitters was started.
- A new version of a VME-based SDLC memory link was developed for connecting the TRIUMF central control system to the beam line 2A PLC. It was implemented in software using a Motorola MV162 CPU with an SDLC capable industry pack.

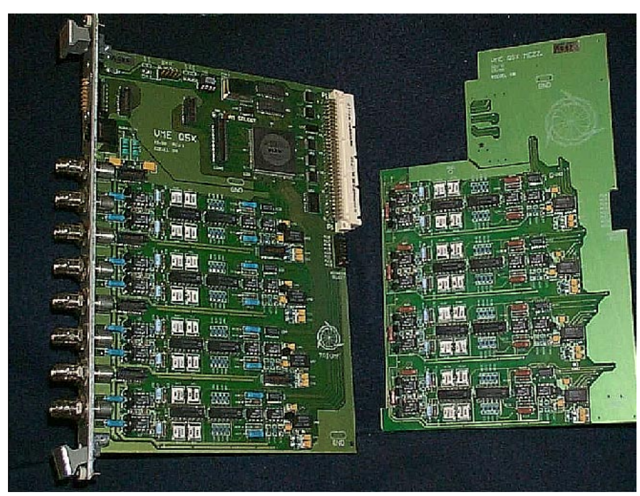

Fig. 152. The VQSX module, an 8-channel VME based beam current amplifier and transient digitizer.

CERN Support

Early in the year, 5 more timing surveillance VME modules (TSM) were built, tested and shipped to CERN. The empty events problem, which was reported in the previous year, was investigated and found to be caused by distortion of the external clock in some VME crates at CERN. Circuitry enhancements to overcome this problem were designed and tested. Another batch of 8 TSMs was built in November.

Support was given to the fast blade scanner project. Software was written under the VxWorks real-time operating system for several VME devices. This included basic driver support and a program file loader for the Galil 1380 motor controller, control and data acquisition drivers for the CERN DPM memory module, and control and data acquisition drivers for the INCAA VD71 transient digitizer. In order to simplify the development work on the blade scanner, a graphical user interface was developed by interfacing these drivers to EPICS.

Support of the Kicker group continued with modifications to the control unit and assembly of the 66 kV resonant charging power supply. Before shipment to CERN all changes were consolidated and a couple of PCBs were redesigned.

CDS

The controllers for the 30 kHz low voltage and 100 kHz high voltage power supply inverters were tested. The high voltage transformer was driven and the stack voltage profile measured to verify that the compensation design was acceptable. The transformer was tested in SF6 to 860 kV output but suffered from sparking at higher voltages.

Work continued on the 100 kHz inverter to improve its operation and power handling capability. The low voltage core was tested to 3 kW into a resistive load.

Nordion TR30

Minor improvements and repairs were carried out on the TR30 rf controller as part of maintenance work on the rf system. After the maintenance work was completed data were collected on the new operating conditions in order to better understand the operation and to provide reference data for the future.