# CONTROL ROOM LAY-OUT

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## 1. TRIUMF-UBC

### *1.1 General information*

TRIUMF is Canada's national laboratory for particle and nuclear physics. It is a member of the international subatomic physics community and strives to play an important role in the global quest for a clearer understanding of the subatomic particles and fundamental forces that determine every aspect of our universe.
TRIUMF was established in 1968 as a laboratory operated and to be used jointly by the University of Alberta, Simon Fraser University, the University of Victoria and the University of British Columbia. The initial consortium has been expanded to include the University of Manitoba, Université de Montréal, the University of Regina and the University of Toronto as associate members. The facility is also open to other Canadian, as well as, foreign users.
TRIUMF is an acronym, standing for TRI-UNIVERSITY MESON FACILITY.
That is because initially, there was a group of three universities that started the programme.

### *1.2 TRIUMF Accelerators:*

Our accelerators are located on UBC campus. It's a beautiful setting, surrounded by forests, in the proximity of the ocean.
There are 6 accelerators at TRIUMF:
500 MeV
42 MeV
30 MeV x 2
13 MeV
1.2 MeV
The first 5 are cyclotrons, the last one, the 1.2 MeV is a LINAC.
There are 3 Control Rooms in TRIUMF, each of them with their own layout.
The Main Control Room serves the big cyclotron, the 500 MeV, and the adjacent experiments.
The 42 MeV and the two 30 MeV ones are production dedicated. These cyclotrons belong to a private company, NORDION, but are operated by TRIUMF staff, from another Control Room: ATG (Applied Technology Group) Control Room.
The last but not the least, is ISAC Control Room, from which the LINAC is controlled.

### *1.3 The world's largest cyclotron*

**T**he giant 500 MeV TRIUMF cyclotron accelerates negatively charged hydrogen ions to 75% of the speed of light.
Inside a vacuum chamber (between the poles of the magnet), a radio frequency electric field "kicks" (accelerates) the ions twice in each orbit. This increases both their energy and the radius of their orbit. At the outer edge of the cyclotron the electrons are removed from the ions, resulting in high-speed protons emerging from the cyclotron.

### *1.4* Research Areas:

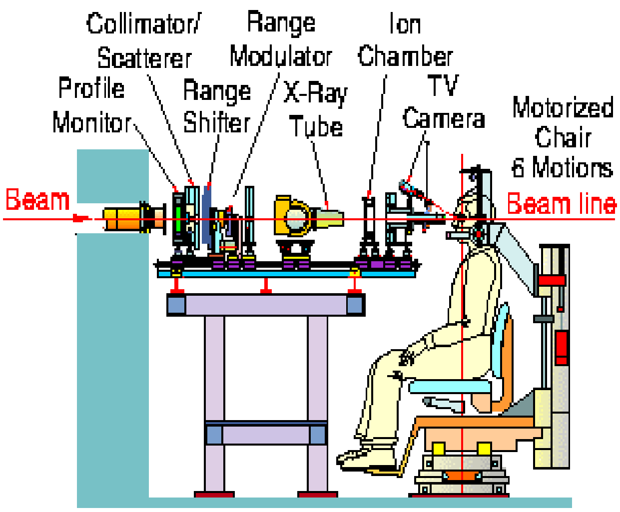
Theoretical:
- The Significance of Spin
- The Standard Model (SM)

Pure:
- ISAC: Astrophysics
- ISAC: Experiments with TRINAT
- Particle Physics: Refinement Through Rarities
- Polarized Source Development (OPPIS)
- Superconductor Research

Applied:
- Contraband Detection System (CDS)
- New Radioisotopes for Medical Diagnosis
- Positron Emission Tomography (PET)
- Proton Irradiation Facility (PIF)
- Proton Therapy for Eye Tumours
- Small Cyclotrons for Medical Radioisotopes
- Smokestack Emission Control
- Super fast Microchips

### *1.4.1 Proton Therapy*

To illustrate some of the applied areas of our accelerators, we present the Proton Treatment Facility, dedicated to treating a cancerous growth on the back of the eye, called choroidal melanomas.



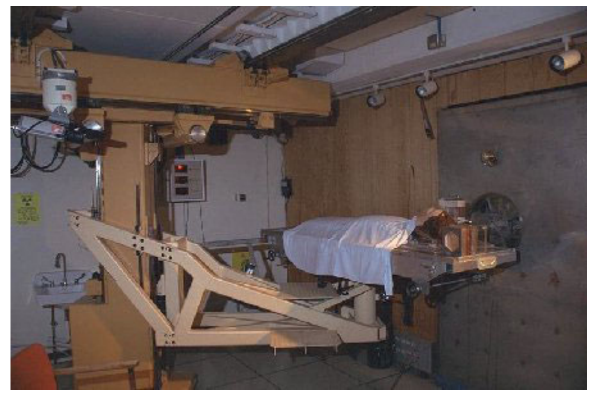

Past Research Areas:

- Pion Therapy Cancer Treatment
- Muon Catalyzed Hydrogen Fusion

### *1.4.2 Pion Therapy*

By shooting a proton beam into various metallic target materials, a subatomic research lab like TRIUMF can, every second, produce billions of unusual subatomic particles called pions. Some are electrically neutral, others carry a negative or a positive charge. They are all classed as "mesons".
The Batho Biomedical Facility was used for the research of pion therapy as a treatment for deep-seated, inoperable brain tumours and for advanced cases of prostate cancer. This is the control room for the pion therapy beam line, which has been decommissioned.

To focus the pion beam accurately into the tumour, TRIUMF personnel constructed a special treatment couch. Pions were used because of their very short (26 billionths of a second) lifespan. While moving, the pion does little damage to the material through which it passes, but at the last instant of its "life", a pion can destroy living cells.
Pion therapy has not been performed at TRIUMF for several years.
The clinical trials are over and the results are being analyzed.



## 2. CONTROL ROOMS IN TRIUMF

### *2.1 500MeV Control Room aka Main Control Room*

In the early '70s, as the 500 MeV was being completed, the first Control Room was built in the main accelerator building.


The TRIUMF Main Control Room has 780 square feet filled with over 40 CRT's, 24 racks, dozens of knobs, levers, wheels, switches, pushbuttons, cables, jacks, meters etc
It really didn't change much from the early days.

The plan view of the consoles resembles a hexagon with two opposing corners open.
This facilitates transition from one end of the room to the other.

There are over 30 cooling fans, which are necessary for cooling the racks.
The result is a permanent, unpleasant humming.
To reduce the noise, Sonex foam was applied to wall surfaces, acoustic foam to rack sides and doors, and the ceiling is covered with fiberglass tiles.
The staff at TRIUMF generally works a 37.5 hours week. The rest of the time, Main Control Room is responsible for the entire ten acre site.
The Main Control Room has people on site at all times, in a rotating shift pattern.
The Shift Supervisor is in charge and has full support of management in regard to any decision he/she makes.
Operators are free to call on any of the experts for assistance whenever required.

### 2.1.1 *What are the operator's duties?*

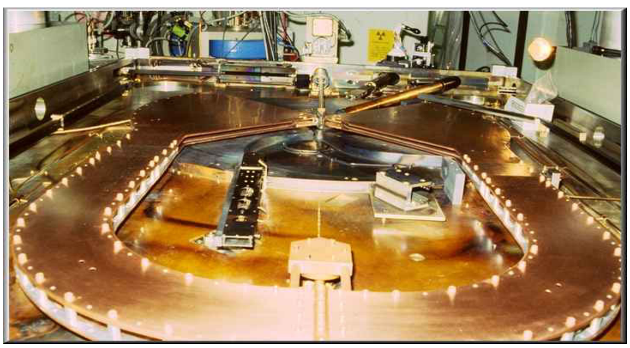
There are thousands of devices, which need to be turned on or adjusted and a large number of parameters to be monitored, in order to get the cyclotron up and running.
The various systems Operators control comprise :
-Ion source and Injection systems
-R.F. - numerous Radio Frequency amplifiers including the 2 Mega watt main accelerating system
-Vacuum - various pumps (mechanical and cryogenic) and valves
-Magnets - 17,000 amps main magnet, trim coils, beamline quadrupoles and steering elements etc.
**-Controls** - VAX based displays, CAMAC based controls
-Targets - beam position & shape, temperatures,
-Diagnostics - beam position and quality monitors, temperatures, pressures etc.
-Plant facilities - heating, ventilating, air conditioning, electrical power, plumbing, compressed air, and anything else required to operate and tune the cyclotron and proton beamlines
The operator is also responsible for:
-Safety - search and lockups for the numerous areas Radiation Safety (surveys and dosimeter control)
-Industrial Safety - for example key control access to hazardous areas such as Chemical shed
-First Aid
-Fire Alarm System - Response to Alarms and the system operations
-Site Security - access, gate control, deliveries etc. as well as :
-Switchboard - answering incoming calls during all "non-business" hours
-Paging - via more than 200 horns and speakers, driven by 700 watts of power
-Information center - for TRIUMF visitors and others who "just want to know about/if..."
-Response to all other conditions and alarms such as the ATG operator alarm and as always, fixing *anything* that breaks !

Tuning the cyclotron and beam lines involves adjusting some or all devices in order to have the beam travel through the system with minimal losses.
Even if no device fails, the cyclotron tune can drift from optimum because of the number variables involved, such as water temperature, crane electro-magnetic interferences, ambient air temperature.
Since the operators are on site all the time, they are responsible for the entire TRIUMF site during off hours.


They keep the keys, maintain security, answer the phones etc.
To keep track of all activities, from beam tuning to troubleshooting, Main Control Room Operators stick to what they began with in 1974: pen and paper, aka the Log Book.
The Log Book is a legal document, and a source of mementos.

Among other purposes, the Main Control Room serves as movie settings too.

### *2.2 CP42 and TR30 Control Room*



The CP42 cyclotron was produced by TCC (The Cyclotron Corporation).

Its installation started in 1979 and was commissioned by 1982.

The first commercial runs commenced in 1983.

The criterion of the design was a negative ion machine capable of output of 200 uA of proton beam at 42 MeV.

This places CP42 cyclotron in the category of "2nd generation" cyclotrons, which are negative ion cyclotrons with external targetry

One intended use of the CP42 machine was for neutron cancer treatment. However the requirements changed and now, several products are created from this cyclotron and associated chemistry.

Experimental irradiations are also conducted for the TRIUMF/UBC PET (Positron Emission Tomography) Program.

The CP42 control console is pretty much what it looked like, back, in the early ‘80s. The two screens provide the operator feedback on magnet, RF, ion source, beam current, and safety values. The operator can control the cyclotron and beamline components by inputting a value on the keyboard or adjusting the knobs on either side of the keyboard.

This console is connected to a DEC PDP11 computer. Although this computer has far less power than one might expect to see in this application, it is surprisingly effective.

At the present time, some of the controls were transferred to a PC, the plan being to switch over completely within the near future.

The TR30 cyclotron is capable of having extracted beam currents of more than 1mA at energy of 29 MeV. It is typically run in a dual beam mode so two targets can be irradiated at one time.

The energy of the beam can be varied by moving the extractors in or out. The machine operates 24 hours a day unless maintenance is being performed. This machine has proven to be very reliable.

This is the TR30 console. The two monitors in the center give a graphical representation of particular groups of components, i.e.: beamline magnets,

injection line, RF, vacuum, etc. By selecting a device on either of these screens we can vary the values and hence steer or focus the beam. This software communicates with PLCs, which communicate directly with the hardware such as power supplies. The two monochrome monitors on the right side display the beamline and target currents and show the vacuum levels throughout the system. The black center panel containing the meters allows us to monitor the relative current on whichever device is selected, i.e.: extractor current. Two LCD modules on this panel count the dose delivered to the targets.
The ATG, as the PET operators, differ from the other groups in the sense that their main area of activity is not research.
The ATG, ensures the proper functioning and maintenance of the CP42 and the TR30 compact commercial cyclotrons, associated targetry systems and a 500 MeV isotope production facility. These services are supplied to an on-site commercial company, MDS Nordion.
Last year, NORDION acquired a second TR30.
The new cyclotron is still in commissioning mode.
The number of operators doubled, there are more computers, more screens, and as a result a new Control Room was necessary.

Unlike the old one, this Control Room is very bright.
New computers and flat screens enhance the high tech appearance of the room.

## 2.3 TR13

The first model of the TR13, a small, new, TRIUMF-designed production cyclotron, was commissioned in 1995. This machine yields a proton beam at 13 MeV, suitable for producing most of the positron- emitting isotopes needed for PET scans. In tests it provided more than 60 µA of beam current simultaneously to each of two targets, exceeding its design parameters.
The machine is owned by the University of British Columbia and resides at the TRIUMF site where it produces radioisotopes for the Imaging Center of the UBC Health Sciences Center Hospital. Operated by TRIUMF staff, the TR13 is used in the research and production of radioisotopes for medical purposes.

What you see here, are both the cyclotron and the Control Room.
Because the energy level is relatively low, there is no need of a lot of shielding.
As a result, the PET operators can literally keep an eye on the machine as they operate.

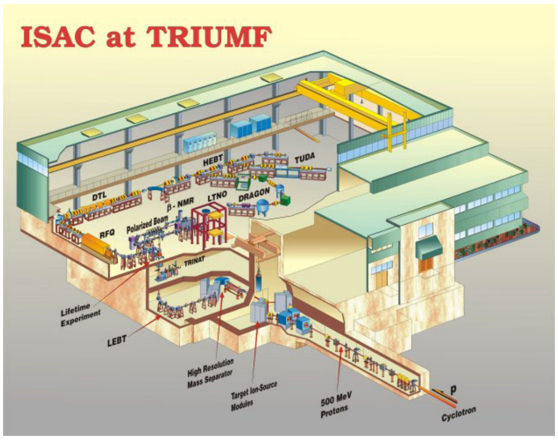
There are two tomographs in operation at the PET Center in the University Hospital. The PETTVI (Washington University design) was built at TRIUMF in 1982 and is still in operation for follow up studies on patients exposed to MPTP over 10 years ago.
The ECAT 953B was installed in 1991. This tomograph has full 3D acquisition capability enabling multiple studies with minimal radiation exposure to the subjects.
The PETTVI operates on a VMS system with two VAX stations while the ECAT is networked to SUN Workstations.

## 2.4 ISAC CONTROL ROOM

### 2.4.1 General Information

ISAC started as an off shoot of TISOL (TRIUMF isotope separator on-line) in the main accelerator building.
As the working theories were proven, design work started on the ISAC (Isotope Acceleration and Separation) facility.
It became reality in April 2000, when the facility was officially opened.
ISAC uses proton beam delivered from the 500 MeV cyclotron.
The beam hits one of two targets, producing radioactive beam.

A set of pre-separator and separator magnets select the isotope of interest, to be delivered to the experiment.

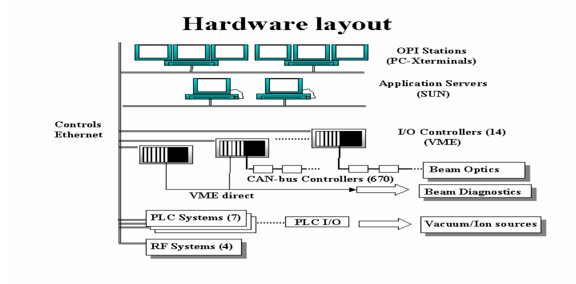



A primary objective of our ISAC Hall facility is the study of subatomic reactions occurring within stars, during the final stages of their life cycle.
Currently, reactions using beams of stable nuclei have revealed a large variety of phenomena involving strong and electro weak interactions, and have allowed scientists to create many new nuclei at, or near the limit of particle stability. The accelerated radioactive beams of unstable nuclei, produced in the ISAC facility, provide a major new tool for studying the formation of elements. In nature, elements with nuclei heavier than lithium are formed in the intense heat and pressure of stellar interiors and are then ejected into space in explosive events such as supernovae.

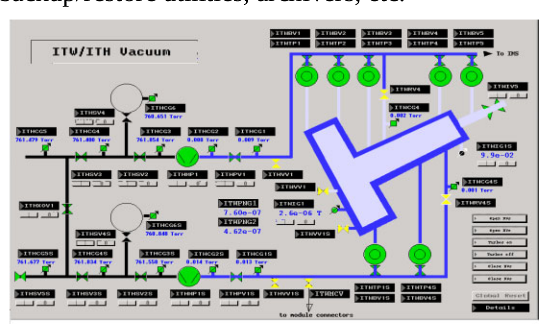
### *2.4.2 ISAC Control System*

ISAC control system controls all aspects of radioactive beam production of the ISAC facility.
It interfaces to the TRIUMF Central Control System, which controls the proton beam.
At the present time, the ISAC control system controls more than 2000 devices with 4200 digital hardware channels, 2500 analog hardware control channels and more than 40 motors. The control system is implemented using the EPICS (**E**xperimental **P**hysics and **I**ndustrial **C**ontrol **S**ystem).
As shown in the diagram, the system consists of Ethernet nodes:

1. Application Servers (SUN Workstations)
2. Operator Interface Stations (PCs running LINUX or Windows98 with X-terminal servers)
3. EPICS IOCs (Input / Output Controllers)
4. Independent control systems (supervised by EPICS):
    a. Vacuum control systems
    b. Ion source control systems
    c. RF control systems



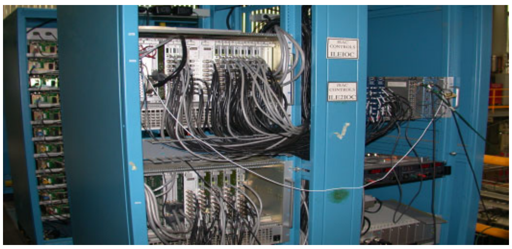

a. **Vacuum system** control is implemented using PLCs ("**P**rogrammable **L**ogic **C**ontrollers"), more specifically a MODICON Quantum Series PLC.
Each section contains several I/O crates, one master crate and several slave crates, which are connected using Modicon's Modbus+ network (1 Mbit/sec).
The master crate contains the CPU (PLC), a network module (NOE), a backplane power supply and different I/O modules. The network module is connected to the controls ethernet and communicates with the supervisory system using the TCP/IP protocol.
Each slave crate contains a Modbus+ network adapter and different I/O modules.
b. Both the **target ion sources and the off-line ion sources** are controlled as semi-autonomous sub-systems. Control is implemented on the same PLCs, which control the vacuum systems. EPICS provide operator interface and monitoring for these systems. This implementation guarantees very high availability for the ion source systems and reliable interlocking. It also decouples running and protection of the ion sources from software development on EPICS.
c. **RF control system** is implemented and maintained by a dedicated team within the RF controls group.
In the EPICS framework, application servers run tool applications, such as display managers (dm), backup/restore utilities, archivers, etc.




dm: vacuum display

The tools read process variable values from the IOCs (**I**nput-**O**utput-**C**ontrollers) via Ethernet using the EPICS Channel Access (CA) protocol.

Application Servers and IOCs communicate via Ethernet using the TCP/IP and UDP based EPICS Channel Access (CA) protocol, which implements a client-server model.
IOCs are CA-servers for the data they "own", they may also be CA-clients for data located in other IOCs.
Programs running on the application servers are CA-clients.

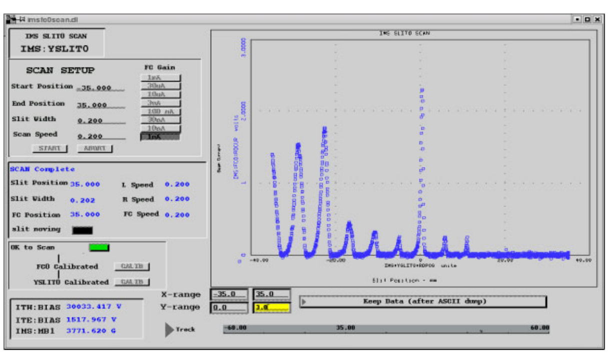


EPICS interfaces to devices through **I**nput-**O**utput-**C**ontrollers (IOCs).
At ISAC, an IOC consists of a VME crate with a CPU (Motorola MV162) and hardware I/O modules. The CPU is connected to the ISAC controls ethernet.

For the ISAC control system, workstations from SUN Microsystems are used as application servers.

### *2.4.3 ISAC Control Room*

ISAC operators use PCs as operator interface stations to the ISAC control system. The PCs are mainly used as X-terminals to connect to the application servers, although some native PC applications are also used.
In the control room, the main operator console contains four PCs. Each PC is connected to several monitors, using the multiple-monitor capabilities of the Linux Operating system.
Operator displays are constructed with the EPICS edit tool and displayed with the dm tool.




To tune and monitor the beam, operators use diagnostic tools like harp monitors, Faraday cups, RPMs (Rotating Profile Monitor), slits, etc.
What you see here is a mass scan display.
This is used both to assure the right isotope is selected and that the beam is centered.

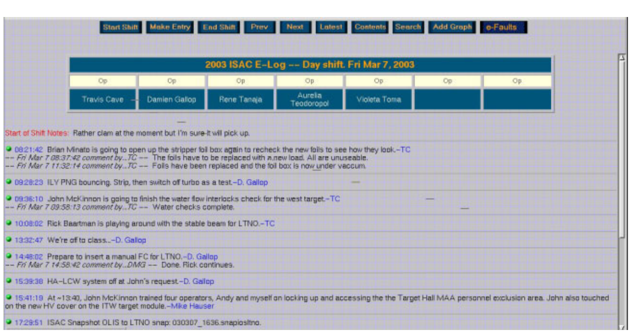
The very first ISAC Control Room is now a secondary beam control room.
We use it mainly to keep the experimenters out of our way.
That is, we give them access control in this room, for their development time.
The consoles are also used for training, an on-going programme run by one of our senior operators.
In the old Control Room we still have the controls for the ISAC building systems.

This is the present, aka new ISAC Control Room, before the face-lift operation.
Initially, it was put together out of left-over desks.
We were lucky though: they matched.
We didn't have a lot of screen space.
At any rate, not enough for what we needed.
Next step was to have custom made consoles.

The purpose was to be able to accommodate more screens.
This is definitely an improvement from where we started.
Unfortunately, as a second target station came on line, our new setting is once more, not enough.
ISAC Control Room doesn't have a TV or stereo. We play music on MP3 and watch the ever increasing deer herd, one of the operators continuously makes out of tea bags.

Here he is at work!
Multitasking: operating, answering the phone and origamiing.

ISAC Operations started by copying the Main Control Room as far as the Log Book is concerned.
That is, we used a pen and paper data acquisition system.
From this, we graduated to an electronic Log Book.




ISAC Ops is trying hard, and, up to now, successfully to adhere to a paperless environment.
We have not only e-log, but also e-fault, e-work permit, e-shift schedule, e-beam schedule, etc, and don't worry, we still function during power outages, as all these are on UPS.

Adjacent to the Experimental Hall where the ISAC Control Room is, there is the ISAC office.
It is a large room, with natural light, shared by 14 people: operators, scientists, visitors, etc.
Each of the operators has a workspace here to work on projects during non-running periods.

This used to be the future at TRIUMF.
As we speak, it is turning into the present.
It is ISAC II, the second stage of the LINAC that extends the reach of ISAC I, both in energy and mass.
It will allow to increase the beam energy to 6.5 MeV/u, for A=150.
This is an energy sufficient to overcome Coulomb barrier for all possible target nuclei.
Within the year, ISAC Control Room will move to its new location, in the ISAC II building.
This Control Room is significantly larger, as it will accommodate the controls for both ISAC I and ISAC II accelerators.

For the time being, both the Control Room and the office area are pretty bleak.
They are coming along though.

## *3. Closing*

Due to the nature of an operator’s job, the Control Room layout is pretty important.
This is true for any work environment, but when working shifts it becomes essential.
Lots of time and effort, not to mention money, were spent to figure out the optimum configuration.
It seems to me that the key factor in the CR layout is versatility, and this is because it has to keep happy a group of people with different inclinations, which have a tendency to become quite moody after the second night shift.
No matter what, there will still be unhappy people, but we are trying our best.

## 3. References


Welcome to TRIUMF
Operator's Duties
The 500 MeV Control Room
Applied Technology Group
ISAC Cotrol System Itroduction
ISAC II