ISAC CONTROL SYSTEM UPDATE

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Abstract

At the ISAC radioactive beam facility, the superconducting Linac was commissioned and several experimental beam lines were added. The paper will describe the additions to the EPICS based control system, issues with integration of third party systems as well as integration of accelerator controls with experiment controls.

INTRODUCTION

The TRIUMF/ISAC facility continues to grow. The commissioning of stage A of the superconducting linear accelerator (SC-Linac) was completed. Beam transport to the experimental hall and to two new experiment beam lines was installed and commissioned. Radioactive ion beam was delivered to the first experiment in April of this year. In addition, beam lines for the TITAN (TRIUMF's Ion Trap for Atomic and Nuclear science) experiment facility as well as test stations for a charge state booster and a laser ion source were installed and commissioned. Fig. 1 shows a plan view of the ISAC facility. The highlighted areas are relevant to this paper.

CONTROL SYSTEM SUMMARY

The scope of the ISAC control system includes direct control and machine protection for all beam optics and beam diagnostics systems, vacuum systems, and the distribution systems for liquid Helium and liquid Nitrogen. Supervisory control is provided for all RF control stations and the liquid Helium plant. The ISAC building control system is integrated for monitoring only.

The ISAC control system software is based on the EPICS control system toolkit. A "standard architecture" is implemented with input/output computers (IOCs), PLC systems, SUN file servers, and Linux based operator consoles as peer nodes on the controls Ethernet. A short overview of the input/ouput (I/O) system is given in Table_1, more details can be found in [1].

The installation and commissioning of the new high-energy beam-lines did not present any new, major technical challenges. The existing concepts accommodated the additions without requiring new software developments. One exception was the TITAN experiment, where an RF cooler trap turns the low energy ISAC DC beam into a pulsed beam. This required both

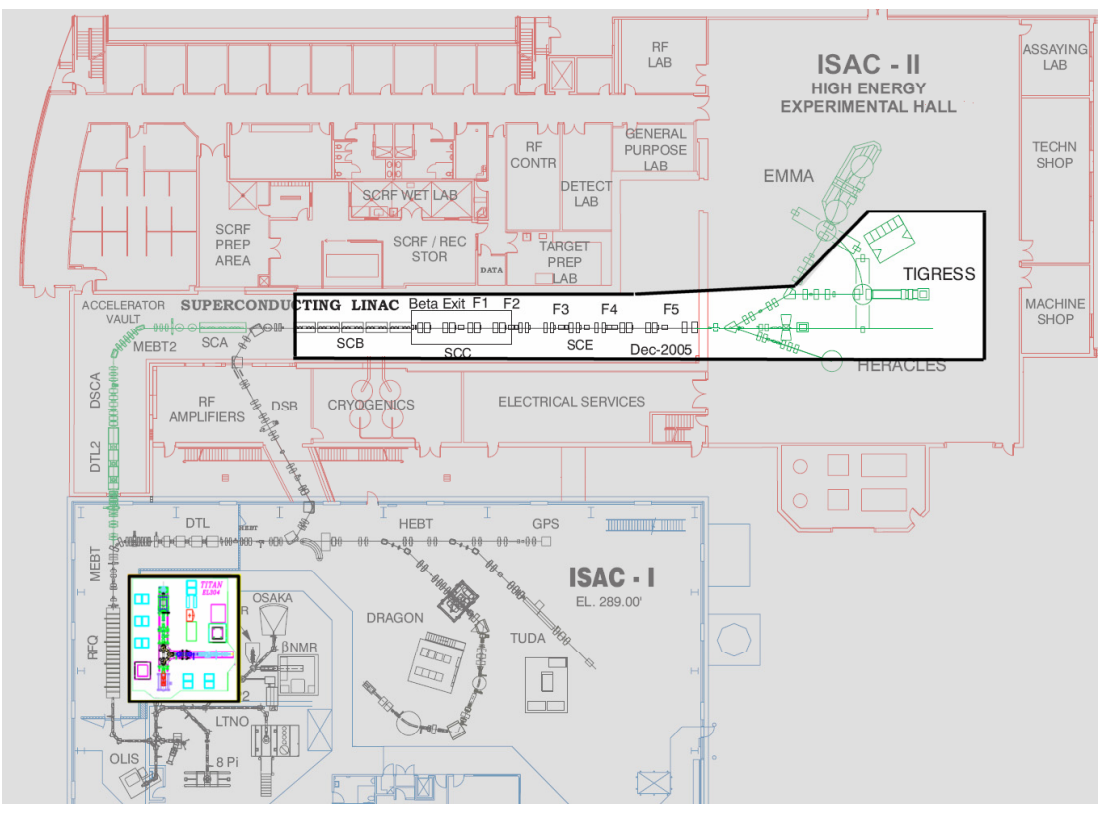

Figure 1: Plan view of the ISAC facility. Areas relevant to this paper are highlighted.

Figure 2: The new ISAC control room.

software and hardware modifications to beam diagnostics elements, such as emittance scanners. More details are given in [2].

Table 1: ISAC I/O Systems.

Subsystem	I/O system	I/O
beam optics	CANbus	microcontroller
beam diagnostics	VME	VME I/O
vacuum, cryo distribution	Modicon PLC	PLC I/O
cryo plant	Siemens PLC	PLC I/O

With the addition of the new sub-systems the number of directly controlled ISAC devices increased to approximately 3700. The control system contains now 33 IOCs and 12 PLCs, which interface to 16000 hardware channels. The EPICS runtime database has grown to a total of 110,000 records.

SYSTEM EVOLUTION

Infrastructure

Initially, all IOCs in the ISAC control system were VME based (Motorola MV162) and used the VxWorks real time operating system. Subsequently the supervision of PLC systems was transferred to Intel x86 IOCS in PC104 form factor and higher powered Pentium-based VME CPUs were introduced to gradually replace the ageing, but very reliable MV162 IOCs. Problems were encountered with frequent (i.e. every few days) IOC crashes on the Intel architectures after a major reorganization of the TRIUMF intra-net. Unfortunately, this reorganization happened during a major shut-down with many configuration changes. Due to operational pressure and lack of man-power the cause of these crashes was never fully understood. More recently, the PC104 IOC exhibiting the most severe problems was replaced with a desktop PC running EPICS release 3.14.8 under Linux. Since that change the IOC has been stable for more than four months. Based on this experience, all PC104/VxWorks IOCs are now being replaced with Linux PCs.

In general, the use of Linux PCs is increasing: as IOCs which control GPIB and HTML devices, Channel Access Gateways, fire-walls and user machines.

NEW DEVELOPMENTS

Beam Sharing

ISAC beam to experiments is in very high demand. The beta-NMR group performs experiments, where targets are irradiated for approximately one second and then observed without beam during the following seconds. The group maintains two experimental stations on neighboring beam-lines where the beam optics contains only electrostatic elements. This made it possible to implement user-controlled beam-switching. Under supervision of an EPICS IOC, a custom made FPGA module controls and synchronizes several device groups:

- HV-switches, which connect pre-tuned HV-supplies to the bending dipole electrodes per schedule requirement
- A fast HV-kicker near the ion source, which keeps beam off during the beam-line switching
- A PLC which controls the beam polarization
- Two data acquisition systems, which determine the length of the beam pulse and request the polarization required for the next beam slice to the respective experiment.

This system has been in operation for more than a year, effectively doubling the beam-time available to the team of experimenters.

Conversion to EDM

A major step forward was the adoption of the EDM display tool with the concurrent phasing out of the edd/dm display editor/manager combination. This involved the conversion of 700 interactively generated display pages and upgrading existing scripts, which generate more than 3500 additional display pages, mostly device face-plates. For the conversion task the SLAC badlfish tool [3] was merged with the EdlBuild [4]

display generator library to overcome some limitations and adapt to specific TRIUMF requirements. Several conversion passes were done to optimize the tool and some final interactive adjustments were required to EDM XY-graph and bar-graph widgets. The existing generator scripts for edd/dm pages were easily adapted to use EdlBuild.

The small-footprint web-browser dillo was integrated with the EDM pages to implement a context-sensitive help system. It provides access to device parameters, trouble-shooting hints, access to channel access logs, alarm logs, etc.

sch2edl

The ISAC controls group designs IOC runtime databases using the Capfast schematics editor [5]. A tool sch2edl was developed for the system designers, which generates EDM pages from Capfast schematics and allows live visualization of the control system functionality. This tool turned out to be a big time-saver during development and is described in more detail in a different contribution to this conference [6].

Cryogenic Systems

The Linde liquid Helium refrigeration plant for the SC-Linac was delivered with a control system based on a Siemens Simatic S400 PLC. That system was initially integrated into the EPICS system for monitoring only. Only minor extensions were required to the TRIUMF modtcp driver, which is used for monitoring and control of the Modicon PLCs. Operation of the Linde system with the touch-panel controls provided by the manufacturer proved to be cumbersome for the system experts and EPICS controls were requested. It would be difficult to achieve this within the existing PLC driver framework. A new project is under way which will be based on a new EPICS modbus module [8]

Several small PLC systems were installed to control the automatic filling of expensive detector systems with liquid Nitrogen. They are supervised by EPICS and integrated with the ISAC alarm system.

Beam Physics and Diagnostics Support

For the beam physics group, a framework was set up which integrates Matlab development with the control system. It allows rapid development work, which is mostly done by students, without impacting on the work load of the controls group [7].

The ISAC beam diagnostics group implements low intensity beam diagnostics systems, which use particle counting techniques. The data acquisition software for these systems is written and maintained by the diagnostics experts. Their Linux-based VME systems were interfaced into the EPICS system by the controls group. An EPICS IOC process on the Linux CPU uses shared-memory to exchange data with the beam diagnostics applications [7,9]. Matlab is used for data visualization and processing.

OPERATIONS SUPPORT

The addition of the SC-Linac and associated beam lines to the ISAC facility required the construction of a new, larger control room in the ISAC-II building (see Fig. 2). As a condition for moving the operating centre to the new control room, the Canadian Nuclear Safety Commission (CNSC), TRIUMF's licensing authority, required a verification and validation of human factors engineering. A detailed verification and validation of the control system operator interface against the NUREG-0700 standard [10] was performed..

The ISAC operations group uses an electronic log-book, fault report system and work permit system. The first phase of a project to integrate these applications was completed, linking the e-Log and e-Fault data.

SUMMARY

With increasing size and maturity of the ISAC control system there is a notable shift of effort. Standard expansion becomes more efficient due to improved development tools and more time is spent on integration of systems provided by third parties, both external and internal. The EPICS tool-kit provides both the flexibility and a clean layer-structure to support this integration. The amount of resources swallowed by the integration tasks depends to a large extent on the quality of specifications by the controls group, good communication lines, and last, but not least, on the willingness of the third party to agree to the requested specifications.

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