DEVELOPMENT OF THE FUTURE SPIRAL2 CONTROL SYSTEM

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Abstract

The Spiral2 facility aims to provide rare ions beams using the ISOL method. It consists of a driver accelerator followed by the rare ion production process coupled with the existing Ganil machine. From the beginning of this year, one ion source followed by the first beam line section has been in test hence implying the first components of the control system. The whole accelerator should be commissioned in spring 2012 and the first exotic beams are planned one year later. Several institutes are collaborating for the control system design and Epics has been chosen as the basic framework. The architecture will rely on Linux PCs and servers, VME VxWorks IOCs and Siemens PLCs; equipment will be addressed either directly or using a Modbus/TCP field bus network. To ease the collaboration, a specific care has been taken concerning the software organisation and management both for the Epics developments and the Java high level applications. Under investigation are the evaluation of the Xal environment, the development of a triggered acquisition system and the design of an environment to generate the Epics databases from a relational database. Also, the first results obtained are presented.

THE SPIRAL2 PROJECT

Overview

The Spiral2 project [1] at Ganil aims to provide high intensities rare ion beams (RIB), the unstable beams being produced by the "Isotope Separation On-Line Method" via a converter or direct irradiation of a fissile material.

To achieve this goal, the machine consists of two parts:

- First an accelerator driver will accelerate the primary stable beam: protons or deuterons (5 mA), heavy ions (1 mA). It consists of high performances ECR sources, a warm RFQ and the superconducting linac having two resonators families operating at 88.05 MHz. High energy beam transfer lines then distribute the beam to the S3 and NFS stable experimental areas or the RIB production process.

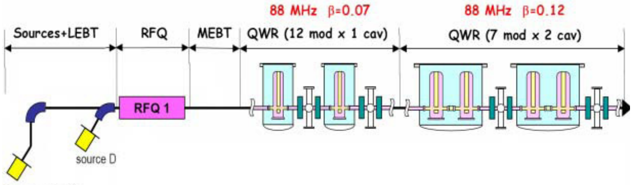

Figure 1: The Spiral2 accelerator schematic layout.

- Then, within the production process, target ions source systems will produce rare ion beams (up to 10^{14} fissions/s on an UCx target). Lastly, the RIB are either sent to a new low energy experimental hall or driven to the existing Ganil facility: CIME cyclotron for post-acceleration, then to the experimental areas.

Milestones

The first primary beams are expected in spring 2012 while the production process is planned one year later.

Some parts of the accelerator will be tested previously: the ion source and its low energy beam line are now in test at CNRS-LPSC (Grenoble) and the deuteron source and its coupled beam line will be progressively tested at CEA-IRFU (Saclay) from the end of next November.

CONTROL SYSTEM STATUS

Collaboration Organisation

The control system is currently being designed by a collaboration between CEA-IRFU (Saclay), CNRS-IPHC (Strasbourg) and Ganil (Caen). Since the preliminary design phase study, it has been decided to build the Spiral2 control system upon the Epics framework [2] and, because of its previous experience running within this environment, IRFU provided the global Epics software architecture to the other collaboration partners. Now the three laboratories share their developments [3] according to the work packages they are in charge of.

Main Options

The current Epics version in use is the 3.14.9 one and the standard IOCs will be either VME crates (running VxWorks 6.5 on MVME 5500 CPUs equipped with a PPC 7457 processor at 1GHz) or Linux PCs (Red Had Enterprise Linux 5). On the server side, the standard Epics tools EDM, Archive Viewer, StripTool etc will be used (may be CSS later); high level applications will be written in Java developed under the Eclipse platform.

Equipment will be addressed either through Siemens S7 PLCs or directly from the VME chassis via VME boards (ADC, DAC or binary I/Os) or field buses..

The Modbus/TCP protocol will be in use to interface the PLCs, the power supplies as well as some beam diagnostics such as the beam profilers. The software interface is based on the driver from Chicago University [4], with some modification to allow to simultaneously accessing several slaves from a single Modbus/TCP node.

First Operational Interfaces

- Considering Ethernet as a field bus led us to adopt the Modbus/TCP protocol to interface the power supplies. So a dedicated mapping was defined so that

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manufacturers provided us equipment featuring a Modbus/TCP server. Also the Ganil "power supplies" group developed a home-made board to integrate within this context off the shelf power supplies. A specific Epics database design [5] was developed, using GenSub records to implement data conversion and to handle the local/remote control modes.

- Siemens PLCs are mainly devoted to the vacuum handling, the cryogenic distribution, the RF securities and the beam interlocks system.
- As three emittance measurement systems are planned to be installed, a first set has been built and was successfully tested with a real beam, integrating a VME IOC and a PLC. The GUI relies on an EDM screen for the equipment configuration and a Java application for the emittance display (addressing the IOC via the CAJ package).
- Faraday cups to get the average beam intensity are addressed using the VME ICV150 Adas boards. The same configuration is used to read the magnetic field using a Hall probe.
- Beam slits are interfaced using the Modbus/TCP protocol addressing a gateway to connect them on a Modbus/RTU serial field network.

FIRST USE AT THE LPSC TEST BENCH

As previously said, the q/a=1/3 ECR ion source and the first part of the coupled low energy beam line have been installed at LPSC to perform the first beam tests for the Spiral2 project. Beside of the obvious objective to start some beam qualification and analysis without waiting for the definitive installation at Ganil, this platform is also the opportunity to install and validate the first basic components of the control system. It therefore constituted the first integration within a shared and common environment of the different developments realized by the members of the control system collaboration.

The Epics platform consists of PCs, 2 VME IOCs and 2 PLCs and allows interfacing 15 power supplies (1 hexapole, 1 dipole, 1 solenoid, 6 quadrupoles, 6 steerers), 2 Faraday cups, 2 beam slits and the PLCs. Even being quite a small installation, it is somewhat representative of the main control system functions to be provided.

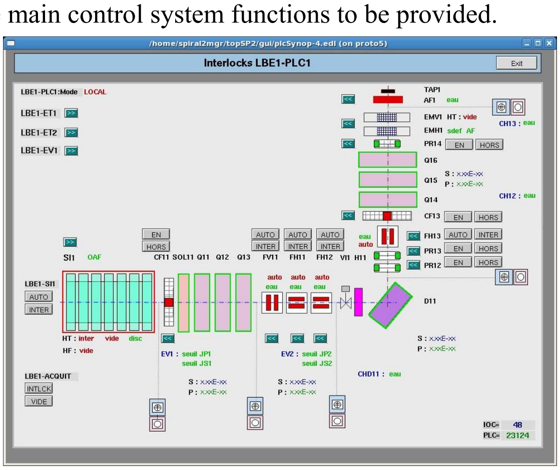

Figure 2: The LPSC beam line interlocks EDM display.

A LabView GUI interfaces the source and accesses the beam line equipment (under the control of Epics IOCs) using the EpicstoLabView.dll. In order to get the beam analysis, a dedicated script allows ramping the magnetic elements so that a first O^{6+} spectrum was obtained using Epics on June, 12. Nevertheless, some work has still to be done in order to improve the resolution and performances obtained, mainly by increasing the scanning frequency.

INVESTIGATIONS IN PROGRESS

Software Development and Sharing

As the software development is jointly performed by three institutes, it turned out quickly that it was mandatory to adopt a strong organisation based upon procedures, conventions and rules helped by the appropriate dedicated software tools [6].

So, first, naming conventions have been adopted for equipment, IOCs, directories and files names. Then the “topSP2” common software platform has been defined and is available from a central server by each developer.

Lastly, a SVN server is available in order to manage both the Epics developments as well as the Java programming environment, the standard client being the Eclipse subclipse plug-in.

Integration of a Fast Triggered Acquisition

Although the Spiral2 accelerator will be a CW process, because of the beam power (up to 200 kW with deuterons), machine tunings will be performed within a pulsed mode at a duty cycle of 10^{-4} (pulses at 1Hz of minimum 100µs width progressively increased by steps). So, specific diagnostics, such as Faraday cups or DC current transformers [7], will have to be interfaced by the control system synchronously with the beam pulse distribution in order to get the peak value.

So, a set of Adas VME boards is now in test: ICV 178 card to perform the 16 bits data acquisition, ICV 108 card to trig the acquisition and store the data buffers to be transferred to the CPU in DMA mode. Following the beam pulse width, the application user can choose a frequency between 200 kSample/s and 1 MSample/s The Epics device drivers have been developed and are currently under test. More details can be found in [8].

High Level Applications and Xal Evaluation

Tuning such a machine will require providing to operators and accelerator engineers high level applications in order to both perform specific tuning phases as well as to manage all the set of machine and beam configurations able to be applied. These high level applications will be written in Java and some investigations have been done, including an evaluation of the Xal environment [9], [10] to know how it could be transposed within our environment (manpower, code size and complexity, multi-beams management). This led us to design applications as platform tests, derived from the Xal framework as shown in Figure 3 and relying on specific Spiral2 .xdxf compliant Xal machine description files.

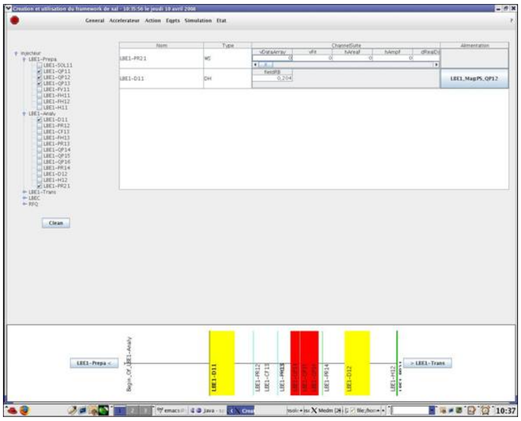

Figure 3: The Spiral2 hierarchy viewer application.

Also based on the Xal framework, an alarm GUI able to process both the Epics alarms (using log4java) as well as the Ganil ones (log4ada based) is under consideration.

Furthermore, a link with the CEA TraceWin simulation code [11] will have to be established both to validate modelisation algorithms and also to provide on-line ways to optimize the machine settings. This is currently under test having integrated within the TraceWin software calls to the Epics Channel Access library.

Database Management

Database management addresses two main objectives:

- First, concerning the Epics database files, we are using Irmis [12] (MySql database filled by the pvCrawler script) to analyze the IOC configuration; Irmis V2 is used at the moment, with the Java based GUI. As we consider that this approach is rather limited to Epics aware people, we are in parallel working on an "equipment database" accessible by end-users; the objective is to provide an environment (GUI and database) where anyone would be able to enter or modify equipment data without any specific Epics knowledge. The concept here is to use VDCT to create the "template" database files with the macro substitution mechanisms and then to generate from the database the appropriate correlated files: substitutions, sequences, starting ".cmd" scripts.

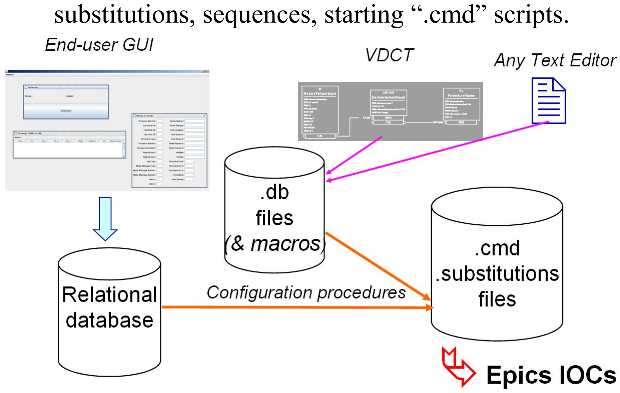

Figure 4: Epics databases generation work flow.

- The second database to be integrated is related to the high level applications as it should constitute a repository for tuning applications and the machine configuration management. Some work is currently under way to define gateways between the TraceWin files, this configuration database and the standard description files as seen from the Xal applications.

CONCLUSION & NEXT STEPS

Thanks to the collaboration, the very first results obtained with the control system during the LPSC tests are promising, but still a lot of work has to be done to get a more robust, flexible and powerful environment, to improve performances and to provide more functionalities. In parallel, other milestone is the starting phase of the deuterons source tests by the end of this year.

Lastly, a lot of work has still to be done concerning the integration of beam diagnostics (losses, position …) and subsystems such as the low level RF handling.

ACKNOWLEDGEMENTS

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PLCs organisation and programming are managed by C. Berthe (Ganil) and R. Touzery (IRFU).

The LPSC platform has been configured by N. Menard (Ganil) with the collaboration of P. Meyrand (LPSC) for the network configuration. Warm thanks also have to be addressed both for the local installation and for the users' feedback to C. Peaucelle (IPNL) and T. Thuillier (LPSC).

TraceWin integration is studied by D. Uriot (IRFU).

REFERENCES

[1] T. Junquera et al. "Status of the Construction of the Spiral2 Accelerator at Ganil" Linac 2008.

[2] E. Lécorché et al. "First steps towards the new Spiral2 project control system" Icalepcs 2007.

[3] E. Lécorché et al. "Preliminary implementations for the new Spiral2 project control system" PCaPAC 2008.

[4] http://cars9.uchicago.edu/software/epics/modbusDoc.html.

[5] D. Touchard, C. Haquin "A Modbus/TCP based power supply interface" PCaPAC 2008.

[6] D. Touchard et al. "The Spiral2 command control software organisation and management", this conference.

[7] C. Jamet et al., "Injector diagnostics overview of Spiral2 accelerator", Dipac 2007.

[8] F. Gougnaud, P. Mattei "The first steps of the beam intensity measurement of the Spiral2 injector", this conference.

[9] J. Galambos, et al, "XAL the SNS application programming infrastructure" Epac 2004.

[10] T. Pelaia II et al. "XAL Status" Icalepcs 2007.

[11] D. Uriot, N. Pichoff "New implement in TraceWin/Partran codes: integration in external field map", PAC2003.

[12] http://www.aps.anl.gov/epics/irmis/index.php.