STATUS OF THE FUTURE SPIRAL2 CONTROL SYSTEM

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Abstract

For the study of fundamental nuclear physics, the SPIRAL2 facility, a driver accelerator followed by a rare ion production process, will be coupled with the existing GANIL machine to provide light and heavy exotic nuclei at extremely high intensities. To ease the collaboration with several institutes on the control system design, EPICS has been chosen as the basic framework and a specific care has been taken concerning the software organization and management. While first operational interfaces for power supplies, faraday cups or beam slits are already operational, a triggered fast acquisition system for beam diagnostics, a radiofrequency control system, and an admittance measurement system are going to be achieved. First EDM supervision screens and high level tuning applications based on EPICS/XAL framework have been designed. The use of relational databases, on the one hand for the design of an environment to generate the EPICS databases, on the other hand to manage, set and archive meaningful values of the new facility, is under investigation. From the beginning of last year, two sources followed by their first beam line sections have been tested. Promising results are presented.

THE SPIRAL2 PROJECT

Overview

Following the recommendations of international committees and to fulfil the growing demand of the international physiscists community, in May 2005 the French Research Minister decided to build the new SPIRAL2 facility at GANIL laboratory (CNRS-CEA) in Caen (France) [1]. The project aims to enlarge multi-beam production using Isotope Separation On Line (ISOL) method. A superconducting LINear ACcelerator (LINAC) for light and heavy ions preceded by a radio frequency quadrupole (RFQ) will deliver up to 40MeV/A for 5mA deuteron, respectively 14.5MeV/A for 1mA heavy ion continuous wave (CW) beams [2]. These beams can be used for the production of intense Radioactive Ion Beams (RIB) involving the fusion, fission, transfer reaction mechanisms. More specifically, production of RIB with intense neutron-rich nuclei will be based on the fission of uranium targets bombarded either by neutrons produced by a first impact of the deuteron beam on a carbon converter, or by the direct deuteron or heavy ion beam impact. The RIB post-acceleration will be performed by the existing CIME cyclotron, which is perfectly suited to the separation and acceleration in the energy range up to 10MeV/A for the atomic masses between 100 and 150. SPIRAL2 beams after CIME can be reused in present experimental areas of GANIL (see fig 1).

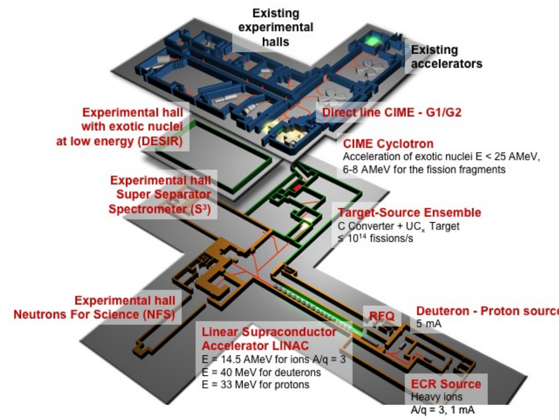

Figure 1: The SPIRAL2 and GANIL facilities.

Milestones

The first primary beams are expected in spring 2012 (phase 1) while the production process is planned more or less one year later (phase 2).

Some parts of the accelerator have been tested: the ion source and its low energy beam line have been in test at CNRS-LPSC (Grenoble) since 2008 and the deuteron source and its coupled beam line are progressively tested at CEA-IRFU (Saclay) since the beginning of this year[3].

Collaboration organisation

In order to build a large machine as SPIRAL2, an international collaborative effort has been made to establish the grounds for the design. A large team composed of people from CNRS, CEA, and international institutes is involved in the scheme. This is also the case as far as the command control system is concerned. The following three French laboratories, GANIL (Caen), IPHC (Strasbourg) and IRFU (Saclay) are currently designing and developing respectively the whole hardware and software command control system phase 1 architecture. For the phase 2, collaboration with the following three laboratories, LPSC (Grenoble), CENBG (Bordeaux), and LPC (Caen) is presently under consideration.

CONTROL SYSTEM

Main choices

The main choice of EPICS [4] as a common framework was early decided to ease pieces of software development and integration efficiency. A set of drivers already

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developed inside this community has been picked to control the majority of equipment. Mainly remote terminal units are VME VxWorks crates with MVME 5500 CPUs and Red Hat Enterprise Linux PCs hosting EPICS Input Output Controllers (IOCs). On the other side, Siemens S7 programmable logic controllers (PLC) are mainly dedicated to slow material protection systems needed for radio frequency, cryogenic, vacuum, or interlock systems[5].

Tuning applications read and write values via the EPICS Channel Access protocol. These values are hosted in EPICS IOCs accessing equipment directly with ADAS VME I/O cards, or Modbus/TCP field bus networks.

Software development

To ease software sharing a unique EPICS SPIRAL2 working environment, an equipment naming convention, and operational rules for interfaces have been specified. The use of SVN server, a versioning control software system, hosting specifics SPIRAL2 EPICS and JAVA directory skeletons, was decided to centralize all the pieces of software [6]. To tune a large facility as SPIRAL2, supervision screens developed with EPICS Extensible Display Manager (EDM), with the same template files and more sophisticated JAVA high level applications derived from the XAL [7],[8] framework, are under way. In order to investigate new EPICS innovative tools, an evaluation of the relatively new Control System Studio (CSS) integrated development environment has begun this year.

EQUIPMENT INTERFACES

Power supplies

To transport or control the beam along the facility, a set of 600 magnetic or high voltage pieces of equipment with specific power supplies driven through the MODBUS/TCP network protocol are needed [9]. Although different kind of power supplies have been already selected, for most of them a common mapping interface will be enforced between IOC and power supplies and a special care was taken about status feedback and tuning application interface. A first EPICS IOC database interface has already been developed and enhanced with an EPICS/GENSUB record.

Faraday cups

Faraday cup, a beam interceptive diagnostic [10], aims to measure through a VME/IOC beam intensity for either pulsed or continuous beam. Specific EPICS drivers were written for the fast acquisition boards ADAS ICV108/178 [11]. Last development improvements allow to set on the fly acquisition rate from 100K to 1.2M samples/s and dynamically select the piece of equipment to acquire. This system is being validated during beam tests.

Beam profilers

Profile monitors measure and visualize the beam dynamics. The EPICS IOC database and JAVA visualisation interfaces of secondary emission profiler have been recently developed. This development has particularly confirmed the necessity of the interface rules decided at the beginning of the project because of the special work induced by the mapping of complex data between IOCs and high level applications.

Emittance measurement system

Emittance measurement characterizes the horizontal and vertical transverse optical behaviour of the beam. The system is built over two scanner pods [12] that are controlled with brushless motors connected to an Oregon MaxV 4000S card. These pods require high voltage power supplies controlled with an ISEG VHQ202 M board or an ADAS ICV714 board. Even though an ADAS ICV150 board presently acquires values inside the faraday cups, the fast acquisition solution described above will be used for nominal performances. A state machine piece of software inside the IOC with a specific algorithm controls the scanner pods in order to build a whole emittance measurement.

Radiofrequency control system

Radiofrequency equipment such as choppers, bunchers, RFQ and LINAC cavities work at 88.0525MHz. They are independently powered by amplifiers controlled via the MODBUS/TCP protocol. IRFU laboratory has developed SPIRAL2 specific VME64x Low Level Radio Frequency (LLRF) boards which integrate, Field Programmable Gate Array (FPGA) to regulate the amplitude-phase of each cavity. An EPICS device/driver has been developed for this card, along with a new type of record. This record also implements an acquisition mode needed for commissioning any piece of software, electronic development or cavities [13]. The prototype of the VME board and RF card and the principle of the Proportional-Integral-Derivative (PID) digital control of phase and amplitude have been validated.

DATABASE ORGANISATION

Equipment characterization

Considering 4000 new pieces of equipment expected to control the facility which will be mainly managed by non EPICS users, led the team to consider a specific equipment INGRES database associated to a friendly JAVA user interface. Each type of equipment should be driven by generic EPICS development which consists of database files with macro substitution. A specific IOC generator will produce start-up IOC files filled with each equipment characterization. This organization was successfully tested with a power supply generic development.

Beam parameters

The SPIRAL2 facility will produce and accelerate a range of beams including deuterons and heavy ions, with different optics, and trajectories. In order to tune this facility efficiently, a beam management process as the one already existing at GANIL is now foreseen [14]. A first application based on the XAL framework described below and based on an Ingres database has been successfully tested this year.

Archives

The first evaluation of the EPICS CSS archiving system based on a MySQL 5.5.1 database has shown a need of disk space of about 10To to store continuous activity 7d/7, 24h/24 during 8 weeks run for 400 significant machine parameter values having 10Hz change rate. To keep performances compatible with the CSS data browser, a study on MySQL is underway for partitioning tables and tuning servers.

HIGH LEVEL APPLICATIONS

Simulations

Very extensive calculations using TOUTATIS and TRACEWIN [15] codes developed by the IRFU laboratory have been performed to simulate beam behaviour and losses, especially in RFQ and LINAC section. These codes could generate equipment theoretical values that could be inserted in the beam parameter database described above. The software gateway between TRACEWIN and the parameters database has been validated last year.

Common frameworks

The whole XAL software could not be reused as is, due to SPIRAL2 specificities such as multi ion species accelerated. The evaluation of this framework has shown that it could increase significantly development efficiency. First applications developed with this graphical interface or reusing some code or pieces of software, such as accelerator configuration, profiler display, beam adaptation or optimisation, are underway.

BEAM TESTS

Beam line section LEBT1 tests performed at LPSC as shown in fig. 2 were an important step to validate the associated control command.

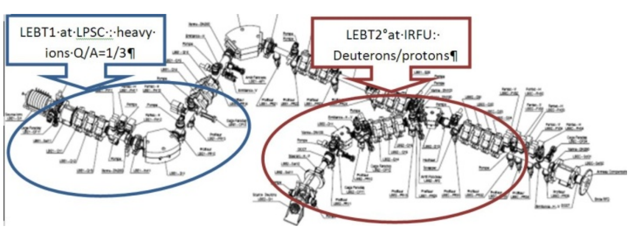

Figure 2: LPSC and IRFU beam tests.

A Labview PC controlling the heavy ion source and a set of EPICS Linux/PCs and VxWorks/VME crates controlling the line equipment communicate through a Labview / EPICS gateway supplied by National Instruments. For EPICS front end part, power supplies and Faraday cups interfaces, the fast data acquisition system, dialogue with the PLCs, emittance measurements have been integrated. Tuning applications such as the correlation of all parameters and analysis of the heavy ion source have been validated. In order to study the beam characteristics, a special use of TRACEWIN connected to a Faraday cup and a legacy profiler diagnostics, and controlling power supplies has successfully optimized the beam transmitted. In the same state of mind, and in order to control the deuteron source with a fully EPICS control system, the beam line section LEBT2 is being tested at IRFU.

ACKNOWLEDGMENTS

As the control system is the core interface with many pieces of equipment, special thanks for the contribution of many people at IRFU, IPHC, LPSC and GANIL laboratories, without whom the SPIRAL2 control command could come out.

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