First step towards the new SPIRAL2 project control system

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Abstract

The Spiral2 project at Ganil aims to produce rare ion beams using a Uranium carbide target fission process. The accelerator consists of a RFQ followed by a superconducting cavity linac and is designed to provide high intensity primary beams (deuterons, protons or heavy ions). The accelerator should be commissioned by the end of 2011; then, the first tests aiming to produce exotic beams are planned one year later.

The control system will result of the collaboration between several institutes among which the Saclay Dapnia division yet having a good experience and knowledge with Epics. So and also because of its widely used functionalities, Epics has been chosen as the basic framework for the accelerator control and people from the other laboratories belonging to the collaboration are progressively acquiring a first experience with Epics.

The paper first explains the organisation of the collaboration then it describes the basic hardware and software choices for the project. Some preliminary implementations are therefore given.

As the project is still in its beginning phase, the paper ends by listing some interrogations not yet solved for the control system definition and opened for discussion.

THE SPIRAL2 FACILITY

Spiral2 Overview

The Spiral2 project started in November 2002 and a preliminary phase led to propose a detailed design study by January 2005 so that the project has been approved and financed in May 2005. After a transition phase, the project entered progressively into the construction phase and is planned to be operational in 2012 and will be installed at the Ganil laboratory in Caen.

The project [1] consists of two different parts:

- First, a linac accelerator will produce a primary beam consisting of either a 5mA deuteron beam up to 40 MeV, either a 5mA proton beam up to 33 MeV or a 1mA q/a=1/3 heavy ion beam up to 14.5 MeV/A.
- Then, this primary beam will be able to be sent either to a new specific experimental area or to the second part of the new facility implementing a rare ion beam production process (RIB, still under design study). Two rare ion beams production caves are planned: one of them (the "red" production module cave, highly radioactive zone) first generates neutrons by impinging the primary beam on a converter so that the neutrons therefore produced initiate a fission process on a Uranium carbide target, with a fission rate from 5.10^{13} to 10^{14} fissions/second. The fission products are transferred to an ion source from which they are extracted (1+ beam) and transported to a 1+/N+ charge booster. The second production cave, (a "yellow" production module cave being a medium radioactive zone), mainly dedicated to other types of reactions (ion beams on different targets, fusion-evaporation, transfer reactions) will allow to generate a 1+ rare ions beam also sent to the charge booster. The N+ rare ions are therefore transported either to the new low energy cave named DESIR or to the existing so-called CIME cyclotron post accelerating the beam finally sent to the Ganil experimental area.

This last point clearly shows that the existing Ganil machine will be tightly coupled with the new Spiral2 project and this point has to be taken into account for the control system design and implementation.

The Linac Driver

The principle layout of the accelerator is presented in figure 1 with its main components:

- Two sources, one for the protons and deuterons, the other one for the q/a=1/3 heavy ions.
- A radio frequency quadrupole RFQ designed for the particle listed above (energy output of 0.75 MeV/A).
- Optionally, an upgrade could be added at the injector level, consisting of a q/a=1/6 heavy ions source associated with a second RFQ.
- The accelerator is an independently phased superconducting linac with warm focusing sections equipped with quadrupoles, steerers, beam diagnostics. The whole accelerator frequency (including the RFQ) is 88.05 MHz and the linac consists of two beta quarterwave resonators families: 12 β=0.07 modules equipped with one cavity and 7 β=0.12 modules, each one having two cavities.

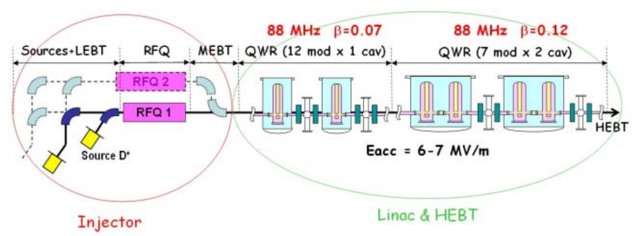

Figure 1: Accelerator layout.

Accelerator Commissioning

The Spiral2 machine to be installed at Ganil results from the collaboration between French, European and international institutions. Among them, Saclay laboratory will have a specific role as the so-called "Injector" (see figure 1) part of the accelerator (deuterons and q/a=1/3 heavy ions sources, RFQ, low and medium energy beam transfer lines –LEBT and MEBT-) will be first installed and commissioned at CEA Saclay (2010) before being moved and definitively installed at Ganil where the whole accelerator (injector and linac) will be commissioned.

THE CONTROL SYSTEM COLLABORATION

As said in the previous paragraph, the Spiral2 project results from a collaboration between institutes and this is also the case as far as the control system is concerned. Laboratories involved into the control system design are:

- Ganil (Caen) which is the installation site having to federate and coordinate the different developments, also in charge of several device interfaces such as the power supplies and the beam profilers.
- CEA Dapnia (Saclay) having yet quite a good experience of Epics that people there used previously in many other projects [2] [3], so first providing the Epics environment (organisation, installation, CPU validation …) and also in charge of subsystems (beam diagnostics, low level RF …).
- IPHC (Strasbourg) in charge of providing the beam emittancemeter measurement systems for the LEBT and MEBT lines. This laboratory is also designing and building a beam test platform to be temporarily installed inside the MEBT line to get the features of the accelerated beam at the RFQ output.

The first point concerning this collaboration is that the three laboratories implied by this design have to adopt a common control system. Furthermore, as mentioned above, the Injector part of the accelerator has to be first tested at Saclay. So, as being nearby, people from CEA Dapnia will be responsible for the Injector control system and they proposed to use Epics. Then, to provide a homogenous control system (for future operation), it has been decided to use of Epics for the whole accelerator.

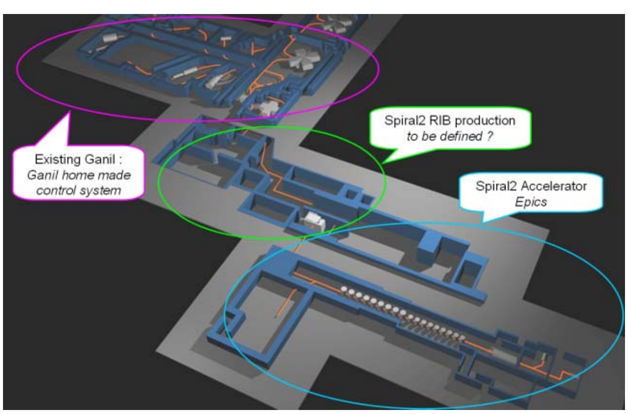

Figure 2: Control systems distribution.

Then, the Spiral2 rare ion beam production will have to be both coupled to the accelerator (beam monitoring, safety) running Epics and to the existing Ganil facility (beam post acceleration and use of the experimental area), within the control of the legacy Ganil control system.

The Ganil control system ("Ganiciel") has been running today for more than 15 years having continuously being upgraded and improved so that now it has reached a high level of reliability and performances for the daily operation [4], using technologies such as the Ada language, Linux operating system (servers and operator consoles), VxWorks (VME crates), Siemens PLCs. It integrates the Ingres relational database management system [5] and is based on a home made protocol over Ethernet TCP/IP sockets.

The next phase for the control system design is to define the RIB control system located between the Spiral2 accelerator control system running Epics and the Ganil machine driven by the existing control system. A first consequence of this statement is that the Ganiciel will have to evolve to integrate this new environment.

EPICS FOR SPIRAL2

Main Options

Table 1: Fundamental choices

Item	Option	Comments
Epics	3.14.8	3.14.9 to be validated
Consoles & servers	PCs / Red Hat Enterprise Linux	Version 4 or 5 to be adopted
IOCs	VME / VxWorks 6.3	
IOC CPUs	MVME 5500	PPC 7457 (1GHz) 512 Mo
GUI	EDM and/or Java	
PLCs	Siemens S7	

It should be noticed that, as possible, most of the options above are common or compatible with the existing Ganiciel environment.

Equipment Interface

Many types of equipment have to be interfaced from the control system and one of the first task has been to specify how each of them will be handled:

- The standard VME I/O will be achieved using ADAS VME boards (ADC : ICV150, DAC : ICV714, binary I/Os : ICV296) previously integrated by Epics drivers written by people from CEA Dapnia within the context of other developments. These boards will be typically used for interfacing beam diagnostics such as Faraday cups, beam current transformers …
- As Siemens S7 PLCs will be in charge of sub-systems or interlocks, the s7plc driver [6] will be used and preliminary tests have been carried out successfully.

- In conjunction with the Ganil power supply group, its has been decided to use Modbus/TCP as the field bus to interconnect all the power supplies so the modbus driver [7] has been downloaded and preliminary tests have been done.
- Beam slits will be controlled by the Ganil stepping motors system reached through the Modbus/RTU protocol, so some tests are planned to use a Modbus/TCP–Modbus/RTU gateway handled from this same Modbus/TCP driver.
- In the same way, RF amplifiers will be addressed using Modbus/RTU and the same Modbus/TCP-Modbus/RTU environment will be set to achieve that purpose.
- The low level RF (LLRF) handling will be under the control of a Saclay specific development implemented on a VME64x board integrating a FPGA component, a dedicated Epics driver has to be written to interface this board.
- The interfaces for the BPMs, the fast Faraday cups (packet length measurement) and for the time of flight acquisition systems have still to be defined.
- The emittance measurement system will make use of Brushless motors driven by an OMS MAXv control board having an Epics driver available; the high voltage ramp will be handled by an ISEG VHQ202M board also under the control of an existing Epics driver.
- The same OMS MAXv motion control board will be used to drive Phytron stepper motors for the linac cavity RF tuning.
- A new generation of beam profilers is under development at Ganil and a prototype has already been interfaced using the Modbus/RTU protocol, within a specific environment based on the use of the Asyn 4.8 driver. Also a specific record type to implement the beam profiler has been derived from the standard GenSub Epics record. An evaluation to design a beam profiler with an embedded IOC server based on RTEMS running on a ColdFire processor is going to be performed in a second phase.

Software Environment

The man machine interface will rely both on EDM screens and Java applications.

Java development will be done under the IDE Eclipse with the integration of graphical libraries (Teechart for the emittancemeter GUI, JFreeChart for the other applications). For the software management, an investigation has to be performed to adopt a versioning system and Subversion is envisioned.

Concerning the Epics software configuration, an organisation has been proposed to provide a common Epics distribution as well as a directory structure associated with specific procedures to manage and archive the Epics environment.

INTERROGATIONS

Epics Database Management ?

Considering the size of the project, we wish to provide tools to manage the Epics database configuration. The Irmis[8] V2.0 package (mainly the pv crawler and Java GUI) has been successfully tested as a first step, being aware that it remains a descriptive approach. At the same time, we are wondering about the possibility to provide a prescriptive approach generating the Epics configuration files from a relational database, so providing final users even not Epics specialists the ability to describe their equipment in a user friendly and safe environment. So, a deeper investigation has to be done to determine if it is feasible in our environment to adopt such an approach.

Use of XAL ?

Tuning the Spiral2 accelerator will need to develop high level application programs (written in Java as previously said). Therefore the question is to decide either to write these programs from scratch or to start (in which extent ?) from the XAL infrastructure developed at SNS [9]. Although some preliminary tests based on XAL packages have been performed successfully, we don’t know yet how realist it would be to follow this approach (to which only one Ganil people could be assigned). A transition way could be to adopt some of the XAL principles but not all the whole software?

CONCLUSION

First, it should be noticed that the collaboration for the Spiral2 control started within a good state of mind and relationship, with an efficient way despite of the different environments of the laboratories and their various knowledge of Epics. Nevertheless, although many options have been decided, a lot of work has still to be performed and the Spiral2 control system design remains still a challenge. A first step is the preliminary Epics based test of the emittancemeter device before the end of this year.

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