A SMALL BUT EFFICIENT COLLABORATION FOR THE SPIRAL2 CONTROL SYSTEM DEVELOPMENT

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Abstract

The Spiral2 radioactive ion beam facility is built at Ganil (Caen) within international collaborations, as the commissioning of the first phase of the project is planned mid of 2014. Collaborative work also concerns the control system development shared by three laboratories: Ganil has to coordinate the control and automated systems work packages, CEA/IRFU is in charge of the “injector” (sources and low energy beam lines) and the LLRF, CNRS/IPHC provides the emittancemeters and a beam diagnostics platform. Sharing the Epics based technology, this collaboration, although being handled with a few people, nevertheless requires an appropriate and tight organization to reach the objectives given by the project. This contribution describes how, started in 2006, the collaboration for controls has been managed both from the technological point of view and the organizational one, taking into account not only the previous experience, technical background or skill of each partner, but also their existing working practices and “cultural” approaches. A first feedback comes from successful beam tests carried out at Saclay and Grenoble; a next challenge is the migration to operation, Ganil having to run Spiral2 as the other members are moving to new projects.

THE SPIRAL2 PROJECT

Overview

Approved in May 2005, the Spiral2 project is a radioactive ion beam facility under construction at Ganil (Caen) and is planned within two phases.

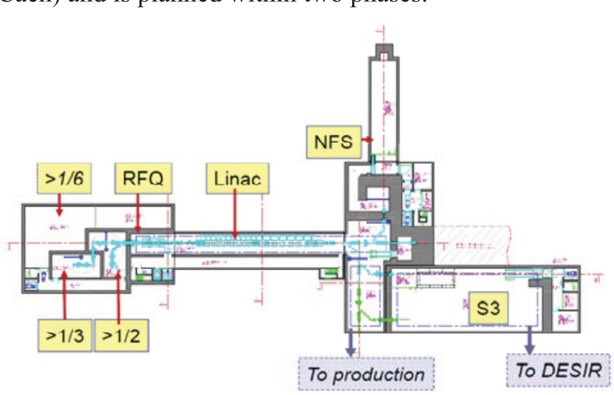

Figure 1: The Spiral2 accelerator phase.

The first phase is an accelerator complex consisting of a RFQ (0.75 MeV/A energy output) for pre acceleration followed by a superconducting Linac (running at 88.0525 MHz) to reach the objectives recalled in the following table [1]. This first part of the new facility also includes two new experimental halls: the Super Separator Spectrometer (S3) and Neutrons for Science (NFS) ones.

Table 1: Beam Specifications

Beam	P^+	D^+	Ions	Ions
Q/A	1	1/2	1/3	1/6
Max. I (mA)	5	5	1	1
Max E (MeV/A)	33	20	14.5	8
Beam power (kW)	≤ 165	≤ 200	≤ 44	≤ 48

Then a second step will be the rare ion production phase to get beams able therefore to be either sent to the new DESIR experimental area or the existing Ganil post acceleration CIME cyclotron and then the current experimental switchyard.

Accelerator Schedule with Controls Incidences

The planning objective is to have the accelerator installed and tested so that the first experiments could start with NFS and S3 in 2014-2015, as the expected building turnover is planned by mid 2014, having nevertheless started the process installation this year as soon as the first rooms become available.

Quite early along the project, to anticipate the commissioning phase, it was decided to test the first part of the machine, the so-called “injector” part consisting of the ions (q/a>1/3), deuterons ECR sources with their associated low energy beam transfer lines (LEBT). So the ions source and the LEBT1 line were mounted and tested at LPSC/Grenoble while the deuterons source and LEBT2 line was in parallel set at IRFU/Saclay from 2009 to 2012. Besides the beam production tests by themselves, this also offered the opportunity to test the first components of the control system within an operational environment, although not being the definitive architecture.

A specific phase during the commissioning will be the use of an Injector Test Bench (“BTI”) platform consisting of many beam diagnostics. This platform will be installed temporarily to qualify the beam at the RFQ output before being able to send it into the Linac ; a dedicated control environment has also to be provided for its operation.

CONTROL SYSTEM CHOICES

When the Spiral2 preliminary phase design was studied in 2001, Epics was one of the technical options envisioned for the control system. Then several

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frameworks were evaluated; in parallel, communication tests between the legacy Ganil control system and an Epics based one were performed. So, in 2006, the project adopted Epics as the control system framework.

Specifications for the control system design were quite classical, having to handle around 2000 pieces of equipment with all common functionalities for such a machine. More specific are the needs for high level tuning applications, and the integration of some beam diagnostics or RF systems. Furthermore, for midterm, gateways have to be provided with the existing Ganil control system, being a homemade system developed by the end of the 80s followed by technical evolutions since that time: now Ada programming above TCP-IP sockets with Motif GUIs on Linux boxes, equipment being addressed with VME/VxWorks crates and Siemens PLCs, with an extensive use of the Ingres relational database.

The most significant technical choices concerning the Spiral2 control system are [2], [3]:

- Epics with IOCs either on VME/VxWorks chassis or Linux PCs,
- For GUIs, use of supervision tools (EDM then CSS/BOY for latest developments) or Java programming within an open-Xal derived environment adapted for Spiral2 because of some specificities (beams acceleration at multiple energies and intensities , devices integration, database links),
- Siemens PLCs for specific subsystems or for security controls,
- Modbus-TCP to be considered as a field bus (power supplies, specific devices or diagnostics, PLCs),
- Use of relational databases (Ingres, Mysql) to manage equipment and hardware configuration, machine lattice for tunings and settings.

COLLABORATIONS FOR THE CONTROL SYSTEM DEVELOPMENT

Along with technical issues, it was decided right from the preliminary design phase to set the control system according to collaborations to be set and organized [4]. Three laboratories are involved within this schema: CEA/IRFU (Saclay), CNRS/IPHC (Strasbourg) and Ganil (Caen) being the site hosting the facility. Presently, the global amount of work for the whole control system development is evaluated to be more than 50 man-years.

Irfu Background

Technically, Irfu has been working since 1993 within the Epics environment, so when the collaboration started, Irfu had already a large Epics experience and was used to interacting with the community. People already got a common practice of Epics environment, distribution and tools (VME/VxWorks, soft IOCs), also with PLC supervision and programming. There was no experience for high level applications programming or use of relational databases.

From an organizational point of view, everyone has the skill to provide an entire Epics application from the bottom equipment interface layer to the top GUI. Given that Irfu is involved in numerous collaborations, people are used to working in collaborations, sometimes in a very structured environment (ESO).

Prior to Spiral2, people were more involved in physics experiments and worked on smaller Epics projects and Spiral2 was the first of such a size.

IPHC Background

The IPHC team involved in Spiral2 controls and PLCs was used to working on collaborative projects or experiments of various sizes with very different technologies (C, VME, Java, LynxOs, LabView ….).

At the beginning of the project, there was no previous experience with Epics. People are also involved into other domains than the controls themselves (mechanical design, electronics, vacuum …).

Ganil Background

The Ganil control group has been used for more than 30 years to providing the control system for the facility (~4000 pieces of equipment) and to daily support the operation, so having a good knowledge and feedback for controlling a machine of this size.

As mentioned above, technologies used for the legacy control system are specific within the accelerators community. So, there were no habits in collaborations and software sharing and no previous experience with Epics. Therefore, as Ganil operation goes on with the existing control system, the controls group has to cope with two different technologies to maintain and evolve the Ganil control system as well as to develop the Spiral2 one.

The internal working organization for the Ganil control separates activities according to people skills: 1) databases, 2) real time and equipment controls, 3) high level applications and GUIs. Therefore, each development requires the collaborative work of people from each of these three software domains. The Ganil control group consists of 9.5 people, among which 5 equivalent full time people are considered for Spiral2 controls. PLC programming is achieved by 2 equivalent full time people from another group.

Organization

Once the technical choice of Epics made, the collaboration for the Spiral2 control system was set, having to take benefit of the prior Irfu experience.

A first step consisted of organizing for Ganil and IPHC people an Epics training held at Ganil in September 2006.

Then, the collaboration was defined as being managed and coordinated by Ganil with a specific position for Irfu according to the "injector" beam tests to be performed at Grenoble and Saclay [5]. Due to these particular intermediate phases, Irfu was in charge of coordinating the control system development of these beam production tests. On-site integration will be done by the three labs.

System infrastructure and network are under responsibility of the Ganil computing infrastructure group.

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Control System Work Packages Affectation

According to that organization, the work packages were defined as follows*:

Table 2: Work Packages Distribution

Ganil	Organization	Global controls coordination
	Developments	Power supplies
		RF amplifiers
		Beam profilers
		Beam losses monitors
		Beam extension monitors
		Magnetic field probes
		Equipment configuration
		Machine lattice description
		High level applications
		Beam settings management
		RF controls
		Central services (alarms, archiving, databases …)
		RF PLC
		Machine protection PLCs
		MEBT, Linac, HEBT vacuum PLCs
		Access and radiation controls (sub-contracted)
	Transverse platforms	CSS/BOY distribution for operation and development
		Xal based Spiral2 framework
	Beam tests	On site commissioning
Irfu	Organization	Coordination for "injector" control system
	Developments	Faraday cups
		Slits
		DCCT & ACCT
		Time Of Flight
		Fast Currrent Transformer
		Beam Position Monitors
		Ions source
		Deuterons source
		Low Level RF
		LEBT 1/2/C vacuum PLCs
		Ion source PLC
		Injector Interlock PLC
		RFQ water cooling PLC
		Modelization and simulation
	Transverse platforms	topSp2 repository
		Epics distribution validation
		VME drivers (ADC, DAC, binary I/Os, fast ADC)
		Agilent oscilloscope interface
	Beam tests	Ions + LBE1 (Grenoble) and Deuterons + LBE2/C (Saclay)
IPHC	Developments	Transverse emittance system
		"BTI" Beam dump
		"BTI" PLC
		Emittancemeters PLC
	Beam tests	"BTI" qualification

(*) PLCs programming for cryogenics is managed by IPNO (Orsay).

SOFTWARE SHARING

Settlements

In the earlier phase, conventions and codification rules for equipment naming were established. A major contribution for the collaboration was then to provide an environment for the Epics deployment for Spiral2, with the so-called "topSp2" repository. This environment also provides system accounts for managing the Epics distribution, the VxWorks platform as well as deployment and operation contexts. It integrates rules for files naming and organization; these conventions were defined not only for standardization but also for software settings (planned tool for equipment configuration, now under test).

As technology evolved, specifications for providing GUI synoptics, first in EDM are now for developing within CSS/BOY. CSS distributions one dedicated to development and the other to operation are now available for sharing. Also, GUI conventions both for CSS/BOY and Java-Xal applications were edited in coherence with the definition of a standardized software layer between IOCs databases and GUIs [6].

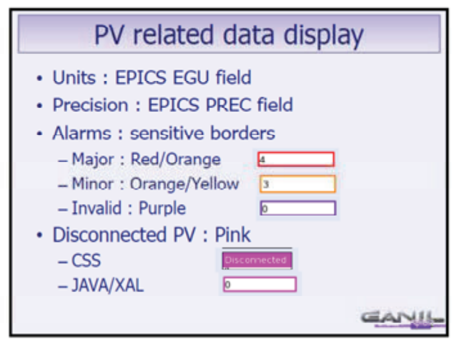

Figure 2: Some conventions from the Spiral2 graphical chart.

To ease software development and sharing, a SVN server located at Ganil is accessible to the collaboration.

Shared Developments

First shared developments are the deuterons source control (EDM) and Xal based Java applications such as the optimization one (successfully tested during the Saclay beam tests) or the general purpose Hook program. All of these handle different types of equipment like Faraday Cups, power supplies, beam profilers, PLC driven devices; the developments induced integration of module interfaces coming from the different labs.

An other type of collaboration concerns the software gateway between the TraceWin modelisation program (Irfu) and the Xal based environment (Ganil).

The transverse emittance measurement system is quite a complex one, with specific devices to be interfaced and a CSS/BOY GUI. It makes an intensive use of the VME based fast acquisition software module so implying a tight integration of developments between IPHC and Irfu.

Other developments illustrating the collaborative work are still in progress: an example is the PLC integration where PVs and Epics files generation from equipment

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database at Ganil are envisioned to be used by Irfu for the LBE1 vacuum supervision or the frequency tuning system. In the same context, Irfu adapts its developments to be coherent with the Ganil specifications for generating PVs and Epics files from equipment database.

Lastly, the "BTI" control by IPHC will integrate interfaces for beam diagnostics (Irfu), beam profilers (Ganil) and a specific Xal based high level application for longitudinal emittance measurement and calculation.

FEEDBACK ON THE COLLABORATION

Global Management

Even being a small collaboration as compared to others within the accelerator controls community, this one is nevertheless a true one from which a first return of experience can be got, with the "injector" beam tests feedback and the current progress of developments.

Besides technical but classical problems, organizational difficulties had to be faced. A first one was the difference of knowledge of the technologies used, so that understanding each other and managing the project were sometimes not as easy. Also cultural approaches and working habits of each lab, resulting from history and context, had to been taken into account.

Decision Making Process

So, many orientations had to be adopted for the control system, resulting from both technical and contextual considerations. They are sometimes issued from compromises and debates, some of them being listed here:

- The "topSp2" repository managed by Irfu was designed from a lot of interactions between the three labs and is at the base of the collaboration.
- Considering Modbus/TCP as a field bus to link PLCs, power supplies, beam diagnostics, RF amplifiers is a Ganil option, then shared and implemented within the collaboration.
- Ganil orientations for providing a global tool for equipment management and a software standardized layer between IOCs and high level applications bring some add-ons and complexity to the developments. So, this type of approach had to be explained and the collaboration to be convinced, with indeed some delay between the specifications coming late and the developments already started.
- Decision to build the supervision GUIs on CSS/BOY is a collegial one, although Irfu and IPHC already had several EDM applications operational when the decision was taken. As distributions suited for Spiral2 are available since only a few time from now, some work still has to be done for update.
- IPHC always followed the main orientations, even when the first developments were still there, such as the change from s7Plc to Modbus/TCP protocol for the Siemens PLC communication or the decision to adopt CSS/BOY so rewriting the EDM and Java existing GUIs.
- As being specific to Ganil, the development of high level applications and the use of databases were never directly considered within the collaboration, only having to take into account the impacts for the global developments.
- For a better formalization, the UML modeling language starts to be progressively introduced along the software development cycle. For future, such an approach in an extensive way should improve the quality of developments and the collaborative work.

Perspectives

Thanks to everyone willingness and through regular general meetings, the pieces of the puzzle started to fit together. With the objective of the on-site installation, tests and then the beam commissioning, the next step is to prepare the software installation while also checking compliances with the specifications and conventions.

An organization for this period then later operation concerning remote support with local assistance is under consideration. While Irfu and IPHC are moving to other projects, Ganil will have to 1) run Ganil operated by the legacy control system, 2) start the Spiral2 machine with the control system including the developments coming from this collaboration 3) provide the whole Spiral2 facility controls with the Linac and the beam lines towards the experimental areas. This is now the main organizational point to deal with.

CONCLUSION

The last and most important chapter still has to be written with the installation and commissioning phases of the facility driven by the Epics based control system.

The difficulties, related to the various environments, are expected to be solved, thanks to the strong involvement of the different teams. The next challenging but promising periods, in the near future, will be a key point of the control system collaboration.

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