# SPARC CONTROL SYSTEM

M. Bellaveglia, G. Di Pirro, D. Filippetto, A. Stecchi, INFN-LNF, 00044 Frascati (Italy)
L. Catani, A. Cianchi, E. Gabrielli, INFN-RM2, 00133 Rome (Italy).

*Abstract*

We describe the control system for the new injector project in construction at the Laboratori Nazionali di Frascati INFN (SPARC). The control system must be operative in the 2006 for this reason we have made some choice in the system development.

PCI based industrial PC as standard front-end processors give us the access to a big quantity of different hardware solution.

Small form factor PC as console to have a possibility to tune the number and performance.

Linux PC as general purpose server.

Ethernet Gigabit LAN as data transfer channel give all band necessary to any kind of data exchange.

Labview as control system environment give us the possibility to find a ready to use data acquisition system and reuse some part of software already written to DAFNE control system

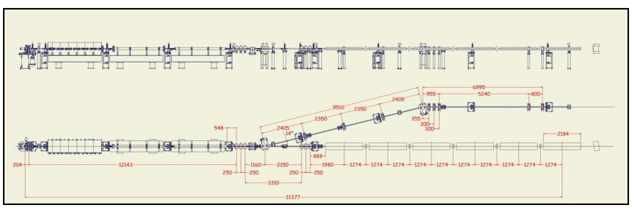

Figure 1: SPARC Layout.

## SPARC

The *SPARC* (Sorgente Pulsata e Amplificata di Radiazione Coerente, Self-Amplified Pulsed Coherent Radiation Source) (fig.1) project is to promote an R&D activity oriented to the development of a high brightness photo injector to drive SASE-FEL experiments at 500 nm and higher harmonics generation. Proposed by the research institutions ENEA, INFN, CNR with collaboration of Universita` di Roma Tor Vergata and INFM-ST, it has been funded in 2003 by the Italian Government with a 3 year time schedule. The machine will be installed at LNF, inside an existing underground bunker. It is comprised of an rf gun driven by a Ti:Sa laser to produce 10-ps flat top pulses on the photocathode, injecting into three SLAC accelerating. The installation of first part of the machine starts at autumn 2005.

## SYSTEM CHOISE

The SPARC Control System is in charge of managing not a large amount of devices (Tab. 1) distributed over an accelerator area (fig. 2). Having a short time and a few people involved in the job we decided to use commercial technologies as much as possible in order to optimize the development time. A commercial product is characterized by a broad distribution, which means a lot of feedback from the users and, consequently, deep debugging. Furthermore the wider is the distribution of a product the more reliable is its support from the producer

Another criterion was to privilege "easy development and maintenance".

We decided to use:

• LabVIEW[1] as development environment for all the software;

• industrial Personal Computer with PCI bus to house the front-end hardware

Table 1: Elements

| Device | Quantity | Interface |
|---|---|---|
| Magnet Power Supplies | 30 | serial |
| Vacuum pump | 23 | Fieldpoint |
| Vacuumete | 6 | serial |
| Modulator | 2 | Ethernet |
| RF | 2 | Ethernet, Digitizer, … |
| Camera | 12 | IEEE1394 |
| Flag | 12 | Serial, CAN |
| Beam Currrent Monitor | 2 | Multimeter |
| Beam Position Monitor | 12 | Ethernet |

## SYSTEM DESCRIPTION

The main operation in an accelerator control system is data taking, display of information, analysis, command execution and expandability. To reach this goal we need to use of well defined system structure. We chose a simple but efficient three level architecture. The main operations of the tasks are:

- Console level implementing the human interface. Several equipollent consoles, built on small personal computers with Linux Terminal Project as operating system;
- Service level is the second and central level of the system. It essentially contains a CPU that acts as a general concentrator and coordinator of messages throughout the system. We logging automatically the command, the machine status and the error. A second processor is used at this level to execute an automatic data acquisition to store information from the front end processors;
- Front-end level is constituted by some (about 8) industrial Personal Computer, distributed around the machines. Each PC performs control and readout of

the related elements in the accelerator. The information can be read by the console on request.

### *Hardware*

In the realization of a control system in this short time bound us to choice a simple system in the feature of the front end acquisition processor. First of all we decide that each one of the distributed cpu control only a kind of element. These simplify the number and kind of acquisition board assigned to the front-end processor. We decide to use standard industrial personal computer with PCI bus as hardware system at the third level. This choice instead of VME and CPci as acquisition bus is due by the diffusion of PCI bus with a large amount of hardware availabe in the world. These give us the possibility to find the right hardware in reason of cost and performance. The window operating system is used at this level to reduce the time in the development of specific driver for the acquisition board.

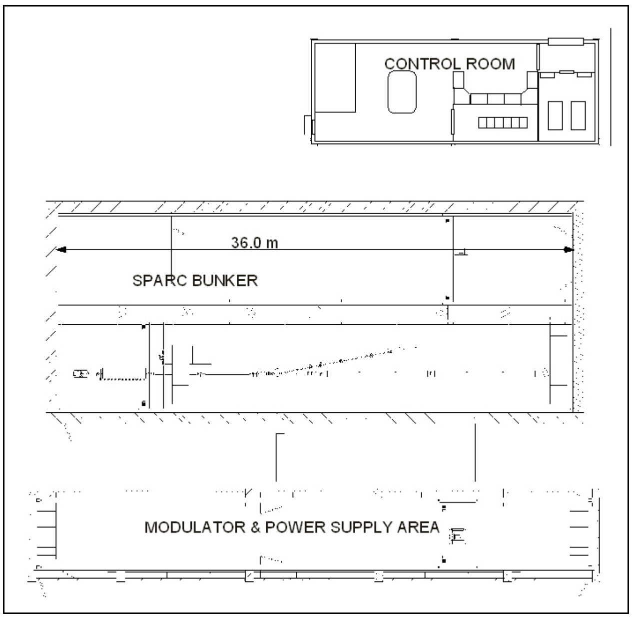


Figure 2: SPARC Area.

At the Console we need us the maximum flexibility in the number of screen and the possibility of a remote connection. Also at this level standard we plan to use PC. In this case we use LINUX as operating system to guarantee us the maximum possibility in the future exaction in the number of console. In this moment we plan to use 5 consoles with 2 monitor.

We have also a server as storage for the software and data of whole the system.

### *Bus interconnect*

In a distributed system the interconnection bus between the different CPU is important to allow maximum performance. First of all we don't want to have any evident bottleneck in the data transfer the second is the reliability and affordability of the bus system. Today in every personal computer the Ethernet connection is a standard this mean that can be it is a robust channel of communication. We use the Gigabit Ethernet to allow us the necessary bandwidth in the data transfer trough the different part of the system.

The realization of a switched LAN gives us the possibility to use the network also as fildbus infrastructure to reduce the maximum the interconnection between the device and the acquisition system. In the table 1 we can see the kind of acquisition system some of them can be directly connected in Ethernet some other fildbus can easily connoted with it.

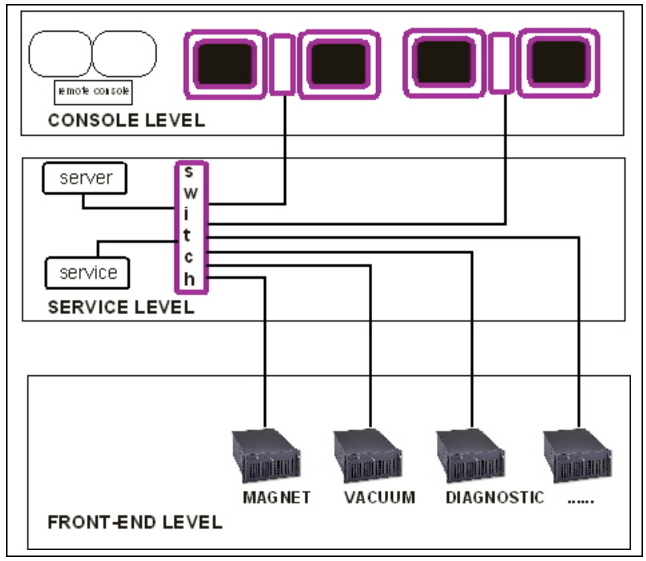


Figure 3: Control System Structure.

## SOFTWARE

In order to reduce the time of development of the control system of SPARC and to have it operating, in all its members, demands to us uses it of software very known. In our case Labview became the natural choice for the following reasons:

- in the LNF the use of National Instrument software is diffused we can say it is a "standard";
- Labview is used as development software in the DAFNE control system. This choice allows us to re-use, when possible, the software;
- Labview is considered as reference software by a lot of hardware manufacturers and write the interface diver directly to it.

### *Porting Software*

The DAFNE control system is working in the last 10 year and now is a well defined a debugged. This concurs to us of being able to re-use beyond to the software also the definition of the elements from a point of view of the control.

Analyzing the two systems we have find two main differences the first we use PCI bus instead of VME for the acquisition board and the second one in the system of communication between the various levels therefore the writing of some members software is necessary.

We have begun the porting of the software beginning from the communication mechanisms in DAΦNE the shipment of the commands happens using of the mailbox written on one shared memory. In the SPARC control we do not have shared memory but a LAN therefore realized a server program that it runs in parallel with the acquisition program that receives the commands and makes available them to the program through a global variable. The DAFNE control system a second communication channel is present that allows reading the state and the variations of the single elements under control, also this communication happens through shared memory. In our case we have realized a second server that bundle the information and it sends them upon request to the console. A first mechanism of bundle in raw data without any type of codifies now we start to develop a new version based on XML.

Use PCI bus instead of VME, in the front-end CPU, demands to replace driver relative to the acquisition board. In some cases this is not necessary because the acquisition happens through a secondary fieldbus (Tab.1) this allows simpler re-use of the software to that element.

### *Magnet*

The control of magnets is the control of the power supply. This affirmation means that the software written for DAFNE can be used if the interface between the control and the power supply satisfies following requirement:

- The interface type with the control program is a serial connection (RS232 or RS245);
- The manufactory must be the same.

In the SPARC control system we match these statements. We have realized a version of magnets control in the industrial PC the only change that we made is to use not a PCI serial interface but an Ethernet converter. In this we reduce the number of to connect to the CPU.

### *Vacuum pump*

The Vacuum pump system in another class of elements that if we using the same hardware it is easy to change software between the different systems. In our case we are using the same kind of vacuum pump but the control board in not more availed. We find a new hardware based on Fieldpoint[3] from National Instrument that means that if we want to reuse the previous software we need to rewrite the acquisition subroutine. In this way we have reuse completely the same data structure of the DAFNE control. The software is completely developed and debugged.

### *Camera*

Some of machine parameter like emittance, bunch length and energy in SPARC is misused with the image. The use of a versatile camera system is a strategic in the realization of this diagnostic. The rapid evolutions in the image acquisition system allow us to choose the camera and it own interface between wide varieties of product. One of this the IEEE1394 interface gives us the possibility to interface different camera with different specification without change the software. Our experience on the TTF2 [5] gives us the confidence that this solution can be implemented on our systems. In this case we cannot reuse completely the software but we can import system idea from TTF. The cameras are acquired by different distributed personal computer and send data trough a TCP/IP channel. In our system we well define the data transfer structure to full integrate the camera inside the control the system is under test.

## SERVICE PROGRAM

The SAPRC collaboration involves different research institution national and international. Some service is necessary to allow all people to have the information available on the status of the machine and the progress on the work. The old system based on a logbook where the operator write the data and glues picture on it can be useful but cannot be available from remote researcher. An electronic logbook is a solution to this problem we start the study of different kind of it to easily integrate in our control system.

The injector project is an experimental machine the possibility to have an automatic saving mechanism can be useful in an offline analysis. We are studding a system based on reflective memory board. This board are under development and when is ready can give us a secondary powerful channel in the data transfer. In the mean time we want implement an Ethernet version of the acquisition mechanism.

## STATUS

The main structure of the control system software is completely defined. The network infrastructure is under construction and it is completed at the end of April 2005. In the third quarter of this year we schedule to install a complete system to start a debug during the first phase of machine commissioning [4].

## ACKNOWLEDGEMETS

We want to thank F.Anelli for its contribution in the software development.

We are also grateful to all the SPARC staff for their continuous suggestions and encouragement for making a good and useful job.

## REFERENCES

[1] SPARC Project Team, Sparc Injector TDR http://www.lnf.infn.it/acceleratori/sparc/

[2] G. Di Pirro et al. "DANTE: Control System for DAFNE based on Macintosh and LabView", Nuclear Instrument and Methods in Physics Research A 352 (1994) 455-475.

[3] LabVIEW, National Instruments Corporation, 11500 N Mopac Expwy, Austin, TX 78759-3504 USA (http://www.ni.com)

[4] A. Cianchi, et alt : "Design Study of a Movable Emittance Meter Device for the SPARC Photoinjector", Proceedings of EPAC2004, 5-7 July, 2004 Lucerne, Switzerland;

[5] L. Catani et alt**.,** A Distribuited Digital Camera System for Accelerator Optical Diagnostic, PcaPAC2005,22-25 March 2005, Hayama Japan, WEP04