FIRST OPERATION WITH SPARC CONTROL SYSTEM

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Abstract

The SPARC[1] gun and the diagnostic apparatus called emittance meter (e-meter) have been installed in all components. The complete installation of SPARC accelerator is planned for the end of 2006.

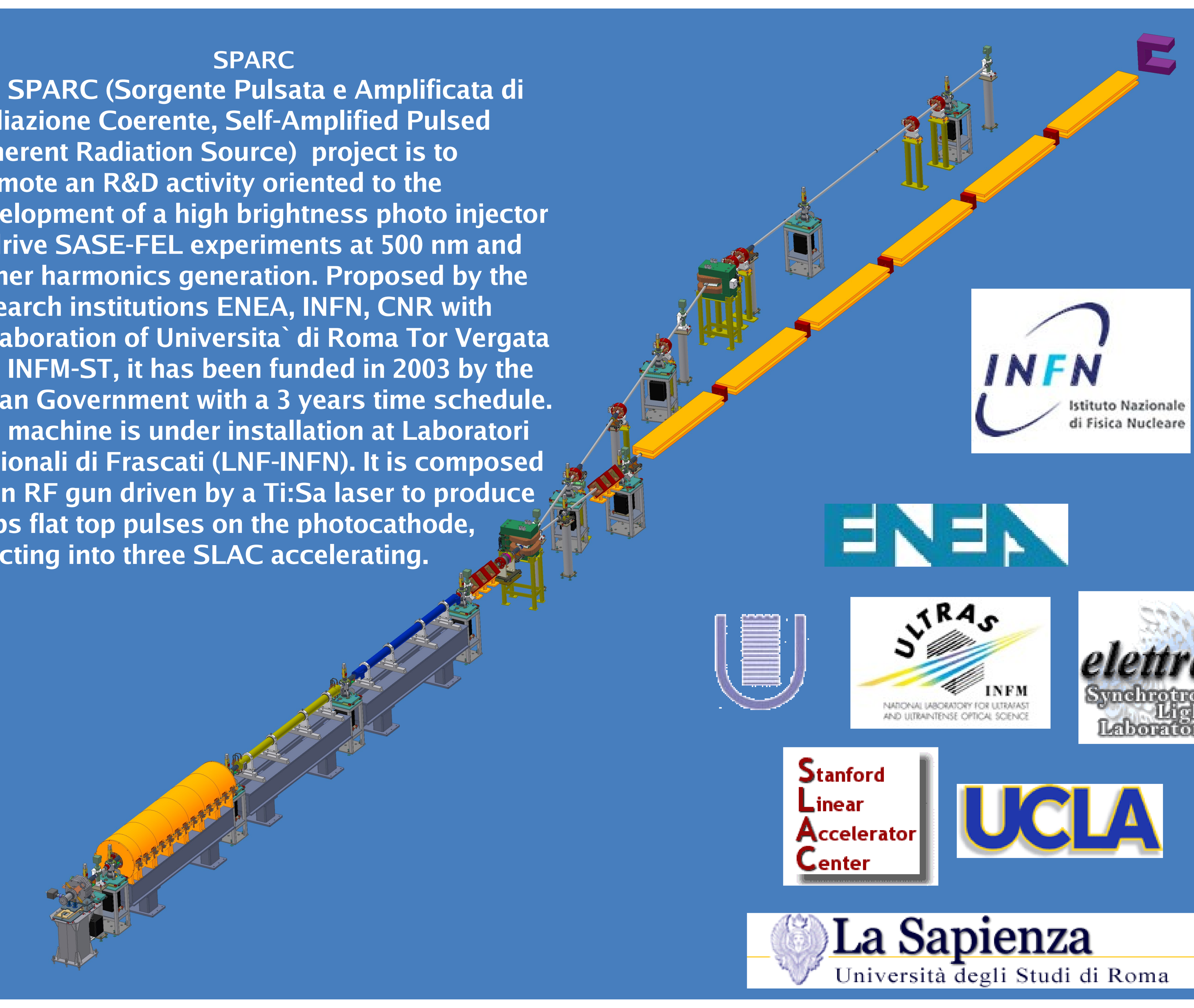
The first part of the installation allows to test the architecture of the control system from the hardware and from the software point of view. Control application for magnetic elements, vacuum equipments, RF cavities and some diagnostics have been developed and debugged on line. In order to improve the machine operations we have included in the system some operation service.

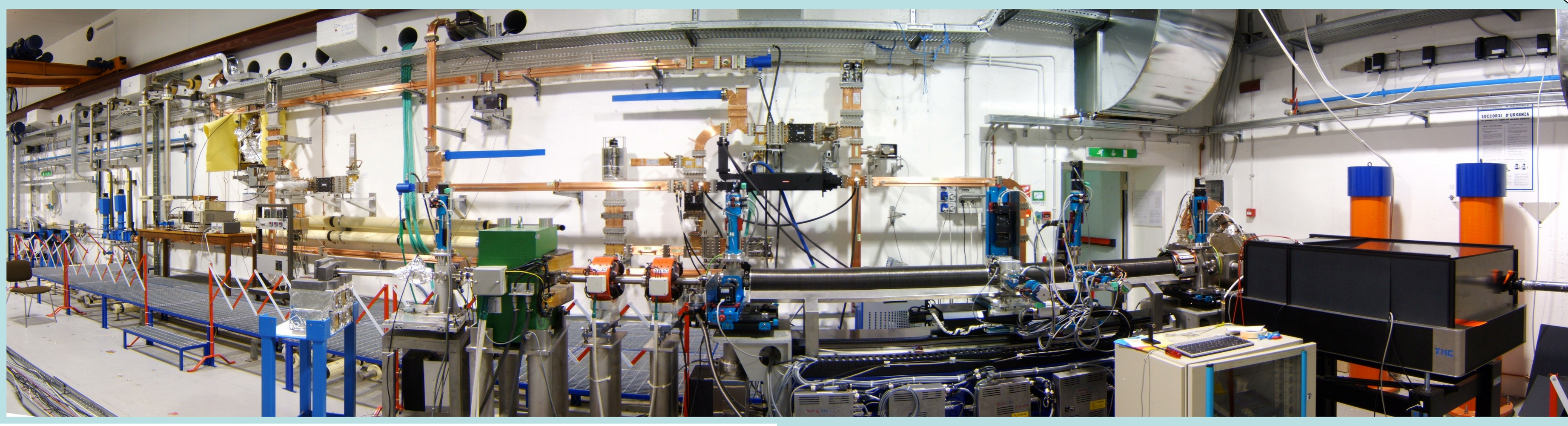
An electronic logbook has been used since the first phase of the operation contributing to share the information between all the members of the collaboration.

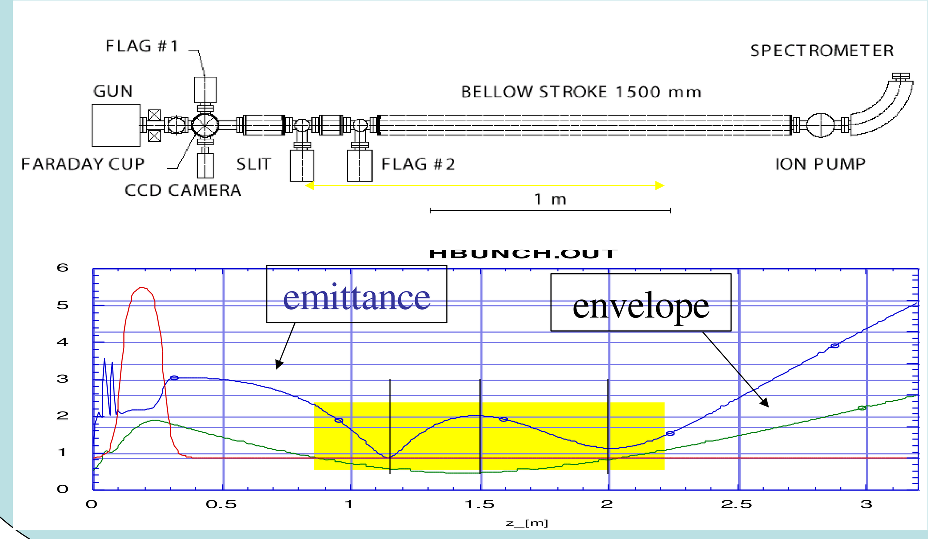
We began to develop an automatic system the accelerator status periodically or when some value changes. This system is based on a PostgreSQL database server.

SPARC

The SPARC (Sorgente Pulsata e Amplificata di Radiazione Coerente, Self-Amplified Pulsed Coherent Radiation Source) 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 years time schedule. The machine is under installation at Laboratori Nazionali di Frascati (LNF-INFN). It is composed 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.

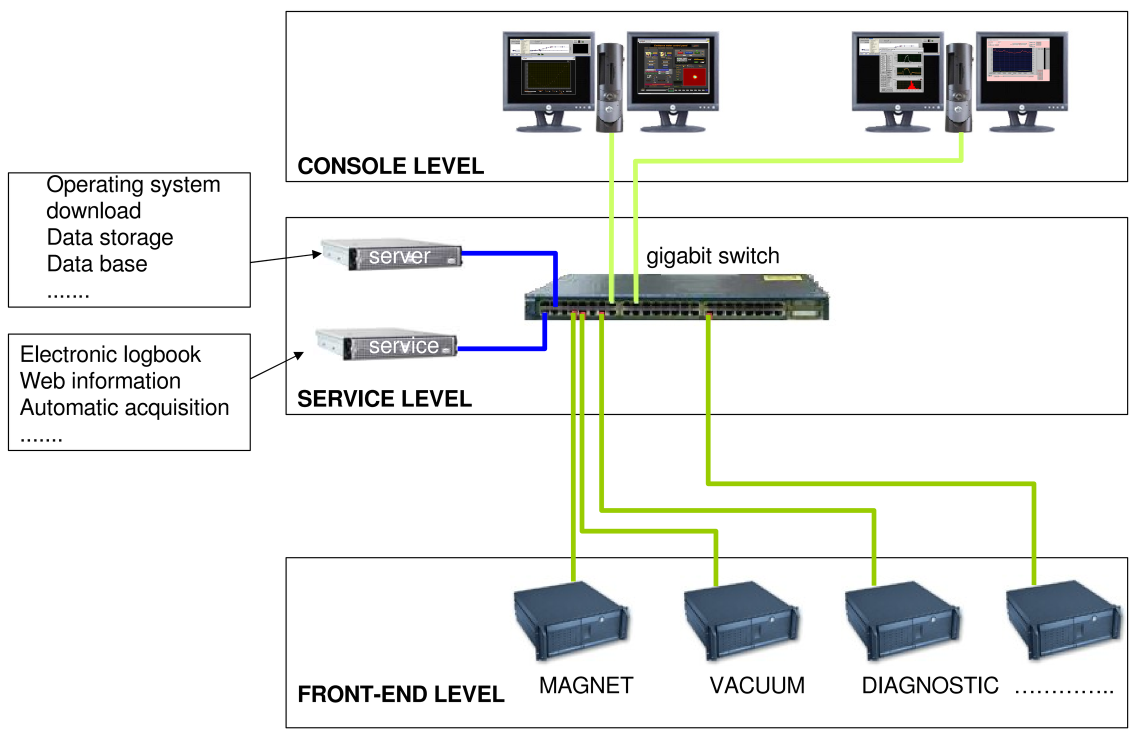






The e-meter

The gun has been installed with a diagnostic apparatus called e-meter . This apparatus allows us to characterize the first 2m of the electron beam. The main component, from the control system point of view, is the emettance measure apparatus composed by a pepper-pot and a YAG target. This part of the e-meter can be moved in any position along a 2 m bellow. At the end is available a spectrometer to measure the energy and a toroid to read the bunch charge.



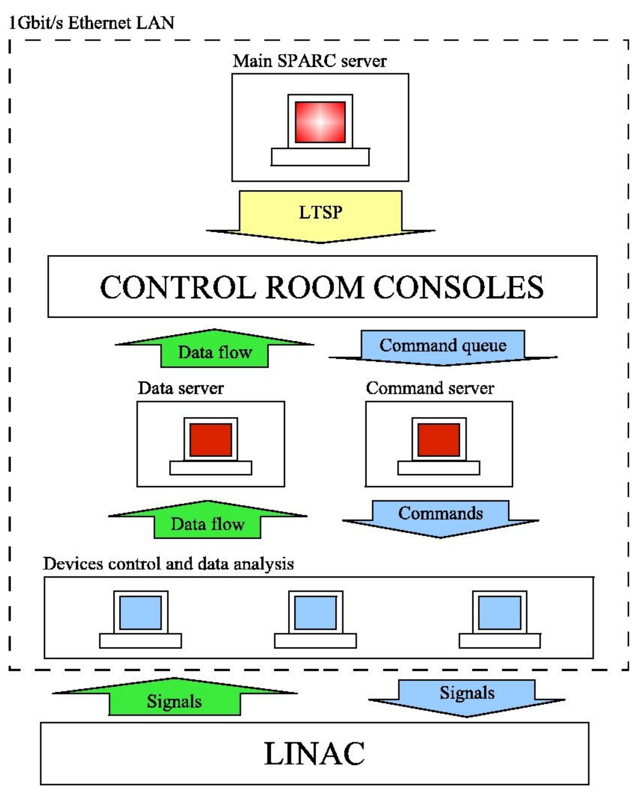
SYSTEM DESCRIPTION

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

Console level it is the human interface. Several equipollent consoles, built on small personal computers with Linux 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 log automatically the command, the machine status and the errors. A second processor is used at this level with an SQL database to store automatically the information from the front end processors;

Front-end level is constituted by some (more than 8) industrial Personal Computer. Each PC performs control and readout of an element of the accelerator. The information can be read by the console on request.



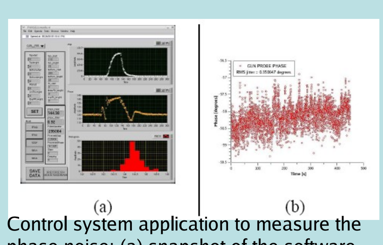
RF

A new acquisition system for radiofrequency (RF) signal monitoring and synchronization is designed as a fundamental part of the SPARC project at LNF and it is currently working with very good performances.

The core of the synchronization system is a demodulation board and digitizer cards in an industrial PC, where data analysis and device control are accomplished. The above apparatus can be seen as a custom multi-channel digital scope, ables to display in the control room all the demodulated signals coming from the RF structures placed along the whole machine. The waveform is digitized using data acquisition (DAQ) cards NI PXI-5105 from National Instruments that are 12bit 60Msamples/s A/D converters. This system allows a real time monitor of amplitude and phase of the RF pulses along the machine.

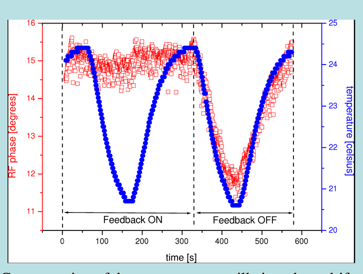
To accomplish the phase noise monitor task, we avoid transmitting the whole acquired waveforms from the tunnel to the control room. To implement a shot to shot monitor at the 10Hz repetition rate of the machine, we analyze data inside the same software application running in the front-end industrial PC. In that way, only a number, representing the phase for each location of interest, can be sent to the control room. Moreover, the control system has been designed to perform a "one-click" phase noise measurement along the whole machine. A snapshot of the console application is shown in (a) and results relative to the RF gun phase noise are shown in (b).

To reduce the phase noise and to enhance the performances of the photo-injector, we implemented also a phase feedback that analyze the acquired values and controls a motorized phase shifter to compensate slow drifts.



(a) (b)

Control system application to measure the phase noise: (a) snapshot of the software window and (b) data taken at the gun internal probe (gun accelerating field is about 120MV/m



Compensation of the temperature oscillation phase drifts

To reduce the phase noise and to enhance the performances of the photo-injector, we implemented also a phase feedback that analyze the acquired values and controls a motorized phase shifter to compensate slow drifts.

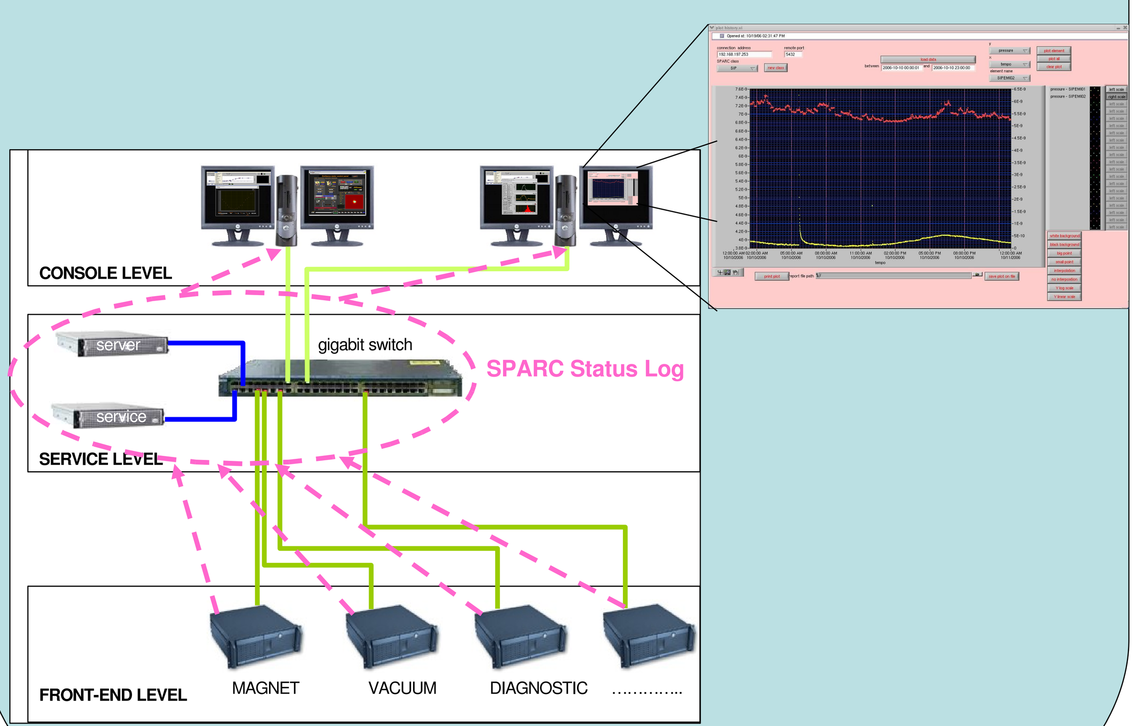
Status log machine

The injector project is an experimental machine the possibility to have an automatic saving mechanism can be useful in offline analysis.

We are studying and developing a data acquisition system based on a database with a possibility to communicate via TCP/IP. We decide to use the PostgreSQL database.

For the moment on each front-end processor a database client program periodically saves the data of the controlled elements. Some interface to plot historical data at console level have been developed.

The system is currently acquiring information by all the elements of the e-meter apparatus. Performance of the system is under test.



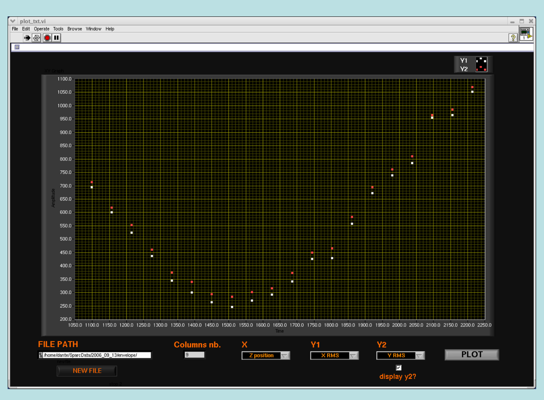
Diagnostic

The main machine parameter emittance, bunch length and energy in SPARC are measured with images. The use of a versatile camera system is strategic in the realization of this diagnostic. The rapid evolution in the image acquisition systems allows us to choose the camera and its own interface in a wide variety of products. The IEEE1394 interface gives us the possibility to interface different camera with different specifications without changing the software.

The cameras are acquired by different distributed personal computers that send data trough a TCP/IP channel. We well defined the data transfer structure to full integrate the cameras inside the control system .

Another important component in the diagnostic is the control of motors to move flags and slits to allow the acquisition of the beam image. Also for the e-meter we need to move position slits and flags.

We have written some useful programs to acquire automatically the position and the dimension of the image of the beam and to save them. The saved images are used by offline beam analysis.



Automatic Envelope

Camera Control