

# STATUS OF THE ALBA CONTROL SYSTEM

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## Abstract

Alba [1] is a synchrotron light source under installation located nearby Barcelona. This 3 GeV third generation light source is planned to deliver the first X-rays beam to the users in 2010. This paper describes the progress in the development and installation of the control system for the machine and beamlines. Solutions for interfacing devices, networking, interlocks, diagnostics etc. are presented.

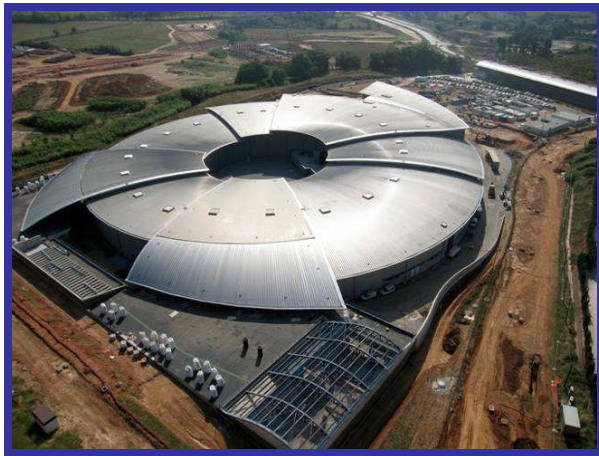


Figure 1: View of the progress of the building. Picture taken on the 10<sup>th</sup> of October 2008.

## INTRODUCTION

The commissioning of the 100 MeV Linac (outsourced to Thales Communication) has finished in September 2008. Booster mechanical installation is planned to start in December 2008, whereas commissioning is scheduled in June 2009. The commissioning of the storage ring and beamlines will take place in 2010.

The architecture of the control system is distributed. Boot servers, Tango [2] databases and archivers run on boxes located in the computing room. Tango servers run in IOCs (Input Output Controllers) most of them diskless running OpenSuse 10.2. Compact PCI crates (around 120 all of them diskless) are used where a timing event receiver is required. Control software for vacuum, insertion devices and front ends run in diskless industrial PCs. Due to their independent operation, industrial PCs with disks are foreseen for the beamline controls. Tango device servers are mostly written in Python and C++. Graphical user interfaces and other clients are mostly based on Python [3] and Qt [4] (TAU, Sardana Device Pool [5]) while most Tango standard tools are written in Java (ATK [2]), so are some custom graphical user interfaces.

## ACCELERATORS

### Architecture

Ethernet is widely used by the control electronics. Power supplies, Libera electronics for control and data acquisition from beam position monitors, CCD cameras for fluorescence screens, oscilloscopes for diagnostics, and of course IOCs are connected by Ethernet. IOCs get a dynamic address by Dynamic Host Configuration Protocol (DHCP). Operator's interfaces communicated by Ethernet with the controls networks are installed in the controls room. No other electronics besides the main cabinet of the personnel safety system (PSS) is foreseen in the control room. Each sector has few Virtual Local Area Networks (VLANs) for the different subsystems as shown in Figure 2. Communication between IOCs and Liberas (8 per sector), power supplies (around 20 per sector), vacuum, etc. is handled by the main controls VLAN of the sector. CCD cameras and oscilloscopes are connected to a separate VLAN. In addition there is one for PLCs intercommunication and one for supervision of the crates and an additional one for safety devices. The Tango main database for the control system and databases for archivers are based on mysql. They run on Linux servers in the computing room whereas fast data loggers for RF store data locally.

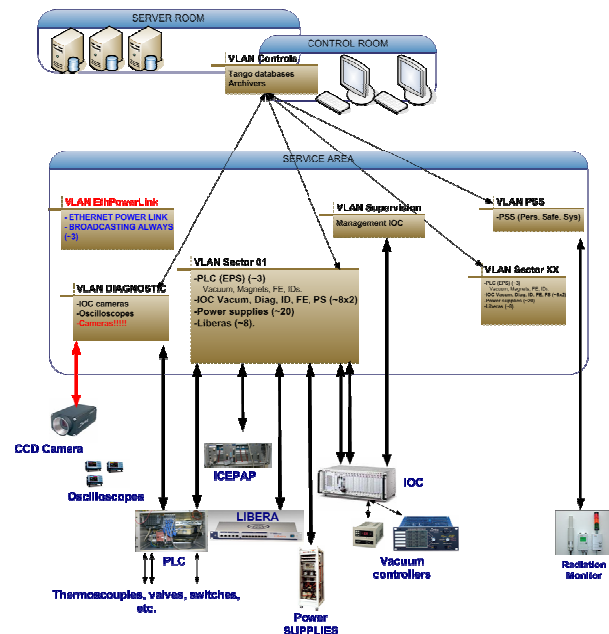


Figure 2: Layout of the different controls VLANs

## Linac

The Linac is delivered as a turnkey system. Controls and data acquisition are handled by five Siemens S300 PLCs. The user interface is developed with LabView. A Tango device server with access to all variables in the PLC has been developed and integrates the Linac into the Alba control system. This allows storing any variable of the Linac in the central archiving facilities. Also generic save/restore procedures can include parts of the Linac. The Linac to Booster Transfer line and the diagnostics Line have been installed and tested prior to the commissioning of the Linac. An entire Tango control system has been installed in the transfer line. It comprises GUIs, archivers, device servers, and implements also the first operational version of the Sardana Device Pool [7]. This system is running since April 2008. A snapshot of the main application including a synoptic is shown in the figure 3. This application is the main directory for opening the different GUIs for particular subsystems. It gives at the same time the overall status of all elements and the physical position of every device. A “help” button is present in every GUI and points to the help pages in the intranet. Also every device has a link to the hardware documentation centralized in the cabling database.



**Figure 3: Main Graphical User Interface for the Linac to booster transfer line.**

## Radio Frequency (RF)

The storage ring has six radio frequency plants with a power of 160 kW (two transmitters of 80 kW each). The booster has an additional 80 kW RF plant. Transmitters comprise High Voltage Power Supplies (HVPS) and Inductive Output Tubes (IOT). They are manufactured by Thomson and are controlled by Siemens Programmable Logic Controllers (PLCs). The Low Level RF system regulates both phase and amplitude (I/Q loops), and the resonance frequency of the cavity. This is actuated by a plunger controlled by an Icepap motor controller. This regulation is achieved by an analogue system for the booster cavity and by a digital system for the 6 cavities of the Storage Ring (SR). The Digital Low Level RF

(DLLRF) is based on a commercial cPCI board with 16 ADCs, 8 DACs and 2 FPGA (Virtex-4) from Lyrtech Ltd [7]. Analogue LLRF is based on “custom made” electronics controlled by ADLINK Digital and Analogue I/O cards. Both analogue and digital systems have been tested in the RF lab together with the whole control system.

## Power Converters

Power converters for the booster and transfer lines are manufactured by Bruker, whereas the ones for quadrupoles, sextupoles and bending magnets of the storage ring are provided by Hazemeyer. Pulsed power supplies are PPT. All of them have an Ethernet interface supporting TCP/IP and an external trigger for synchronization. Communications with the correctors of the storage ring (Ocem) is carried out by the PSI [10] interface for power supplies. It comprises electronics for digital regulation, and a fiber optics link with IOCs. On the IOC, a cPCI carrier with 2 IP modules, and a transition board having the fiber optics transceivers are installed.

## Timing system

The Timing system manufactured by Microresearch Finland is based on events. A new bidirectional link has been added. Consequently, the timing system, besides synchronizing the different elements of the machine, is the base of the fast interlock system. The timing system consists of an event generator, several fiber optics fan-outs, and event receivers. An event can be generated in the event generator (the normal operation for synchronization), or can be the result of an interlock signal that appeared in one of the leaves of the tree and has been transmitted to the generator which sends it back to all leaves. All “fast” interlocks are also monitored by the PLCs and transmitted in a redundant “slow” way over the PLC network.

## Diagnostics and beam dynamics

The storage ring includes 88 Libera BPM electronics [6] and 88 correctors in each plane for orbit correction. Corrector magnets are integrated in the sextupoles as extra coils. Data from the BPMs is passed through the Liberas to the neighbors and up to the cPCI crate. This data transmission, meant to be used for the fast orbit correction uses a dedicated fiber optics link. A tango server for every Libera box runs in the Compact PCI crate and is accessible from the control system for the slow orbit correction, displays, archiving etc... This so called slow control goes over the normal Ethernet link. Furthermore, 30 CCD cameras for fluorescence screens are interfaced using the E-Giga protocol, whereas other signals like Beam Charge Monitors are read by analogue input cards in the cPCI crates. Oscilloscopes are used for Fast Current Transformers, Faraday cups, annular electrodes, among others, and are accessed over VNC or NX connections. Beam Lost Monitors are read through RS485 link by a Tango device server.

## BEAMLINES

Seven beamlines are installed in the first phase. Four of them work with hard X-rays: Non-Crystalline Diffraction, High Resolution Powder Diffraction, X-ray Absorption Spectroscopy and Macromolecular Crystallography. Other three work with Soft X-rays: Photoemission Spectroscopy and Microscopy, Soft X-Ray Microscopy and Magnetic dichroism. Although beamlines are very different one from the other, all of them are controlled by the Sardana Device Pool [5]. Two phase stepper motors are standardized and all of them controlled by the Icepap (developed at the ESRF). In the few cases where the design of a particular component requires a DC motor (like the direct drive Monochromator provided by FMB Oxford), Delta-Tau controllers are used. Data acquisition is very much dependent on the detector, however step scans, continuous scans, sequences, and rapid integration of new hardware for a particular experiment are common requirements shared by all of them. Classic scans and plotting are managed by the Sardana Device Pool [5], whereas data acquisition systems are being developed following particular requirements of the different beamlines. Thus pixel detectors, CCD detectors, special hardware like Time Frame Generators, and bigger systems like a photoemission electron microscope are being interfaced with the controls and data acquisition system. Although encoders are managed by the Icepap motor controller, which can work in both open and closed loop, in some particular cases a special interpolator is needed. This is the case of two grating monochromators, each of them having two RON 905 encoders interfaced with 2 boards IK220 (interpolation factor of 4096). The precision given by the system goes from 0.01 to 0.06 arcsec.

Many data formats are available. Currently Alba uses the ESRF data format for two dimensional images, and the SPEC [12] format for scans. NeXus is being also considered since it is flexible, meets the requirements and the number of institutes that adopted or are migrating to NeXus is getting significant.

## COMMON SYSTEMS

Hardware and software have been chosen to be reusable in the different subsystems. Furthermore, many components of the control system are shared by beamlines and accelerators. This is the case of vacuum device servers, motion controls, DAQ software, archivers, etc. Furthermore, the technology and standards for interlocks, safety systems, etc. is shared by all subsystems.

### Vacuum

MKS gauge controllers and Varian Dual Ion Pump controllers combined with high voltage splitters are the main electronics for vacuum. Both gauges and pumps controllers are interfaced by serial lines. The control software runs on industrial PCs equipped with 16 ports RocketPorts cards. Software comprises serial connections,

Tango servers for the different controllers, and connections with the different PLCs.

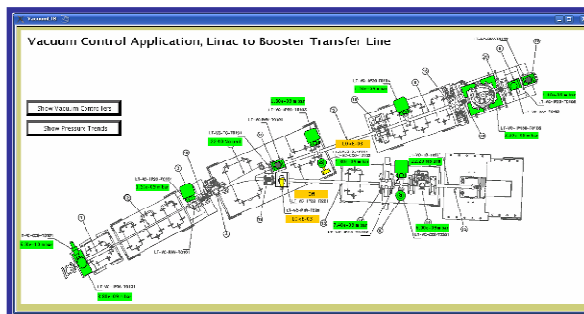


Figure 4: Graphical interface of the vacuum control of the Linac to booster transfer line.

### Archiver

All databases used by the control system, Archiving, Tango, and Cabling databases, have been implemented on MySQL. The archiver system uses the configuration tools and the database design developed at Soleil. Various stress tests have been successfully performed, storing 6000 attributes every 10 seconds in the historical database and every 1 second for the temporal database. Figure 5 shows the graphical interface built on TAU for plotting trending charts from temporal buffers, temporal databases or historical databases.

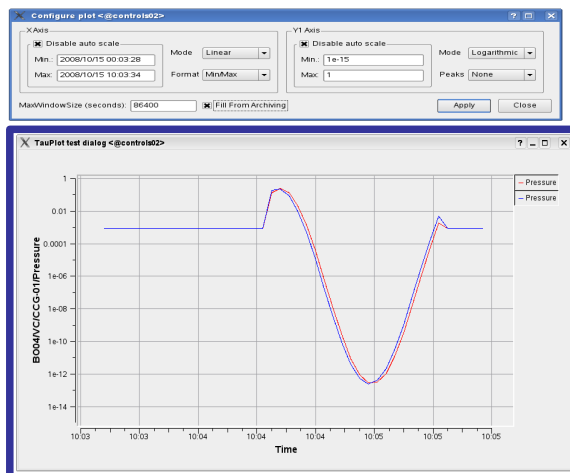


Figure 5: Snapshot of the TAU widgets for plots and trends.

### Pre-installation

IOCs are mounted with the required DAQ cards in a dedicated area. Then, remote booting parameters, drivers and Tango servers are installed and tested. Once the IOCs are ready, they are mounted in the racks with the final equipment.

The racks are then pre-cabled (with the internal cables), and as the last point powered up for the final test. Once those steps are completed, the rack is ready for installation. All tests are recorded in the cabling database. Information and documentation regarding equipment

types, position, channels, cables, and even equipment tests are stored in the database. The cabling database is a “corporative” one for hardware for controls, whereas the Tango database is meant for controls software operation.

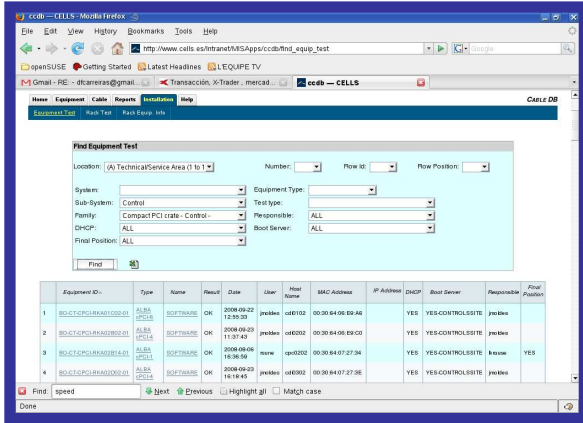


Figure 6: Cable database: View of the interface for logs/reports of preinstallation works.

### Equipment Protection System (EPS)

The equipment protection system manages permits and interlocks avoiding damaging the hardware. It is built on B&R PLCs with CPUs installed in cabinets in the service area and distributed I/O modules installed in shielded boxes inside the tunnel. CPUs and Remote interconnected by the X20 bus. PLCs manage interlocks, temperature readouts, actuators for shutters and fluorescence screens, etc. Vacuum devices, Radiofrequency plants, and power supplies interlocks are also managed by the EPS.

The cabling database has a lot of information concerning not only cables, but equipments, channels, connectors, and even, domain names, boot servers, etc. Variables for the PLC programs, cabling reports, and attribute names are automatically generated from the Cabling database. Furthermore, dynamic declaration of PLC variables and Input/Outputs (attributes of the PyPLC Tango Device, written in python) allows the expert view of our graphical user interfaces (TAU) to be generated automatically from the cabling database.

### Personnel Safety System (PSS)

The PSS ensures that nobody gets irradiated during operation. This comprises access control to bunkers, intrusion and malfunction detection as well as radiation level monitoring. The system is based on Safety PLCs from Pilz, and the system is designed for being SIL3 compliant (IEC/EN 61508), following the golden rule of redundancy and diversity. Twenty three radiation monitors (Thermo) are installed in service area and experimental hall, each of them having two safe connections to the PSS. Those are two alarm levels that have different actions depending on the position in the network. In addition to managing permits, interlocks, emergency stops, and the search process, the PSS system provides other added services like voice messages and video-

surveillance of the access doors. The PSS for the Linac bunker is installed and running. The installation in the tunnel is being carried out at the moment. The whole system will be verified and certified by TÜV Rheinland [11] once the installation is finished.

## CONCLUSION

The control system has proven to work well in the Linac to Booster transfer line (LTB). Prototypes have been tested. The LTB control system comprises vacuum, interlocks, synoptics, power supplies, the Sardana Device Pool, archiving, etc. The control software is installed and tested in the IOCs, prior to be preinstalled in the racks. Motion control, counter devices, scans and basic online data analysis, particularly interesting for beamlines, have also been worked out in the transfer line.

## CONTRIBUTIONS

Many developers are working on this project. We would like to thank all of them. J. Klorá, the director of the computing division and architect of the Sardana Device Pool [5]. The controls group, T. Coutinho (PyTango, TAU, Device Pool), S. Rubio (Vacuum, Archiver, DAQ, PyPLC), G. Cuní (Motion, 1 beamline), S. Blanch (CCDs, diagnostics, 1 beamline), F. Becheri (IDs, GUIs), R. Suñé (RF, DAQ, Timing, Drivers), L. Krause (Power Supplies, Linac), C. Lazar (Counters, 2 Beamlines), J. Moldes (Libera BPMs, 1 beamline), A. Milán (IOCs, Preinstallation, 2 beamlines), M. Niegowski (GUIs), R. Ranz (Equipment Protection, cabling, PLCs), A. Rubio (PLCs), R. Montaña (PLCs). The electronics group, in particular O. Matilla, J.V.Gigante and J. Lidón, who are among other duties responsible for cabling, fast interlock units, vacuum splitters, etc. The system administrators, in particular S. Pusó and the head of the group, J. Metge. The MIS group headed by V. Prat, who developed and maintain the cabling database. We would also like to thank other contributors from different institutions, in particular A. Homs, V. Rey and M. Guijarro from ESRF and N. Leclercq from Soleil. Also special thanks to the Tango collaborators who have written most of the standard Tango Applications and Tools available for the community: ESRF, Soleil, Elettra and DESY.

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