COSYLAB

The ELI-NP GBS CS: A Tale of Engineering a Complete EPICS Control System

EXECUTIVE SUMMARY

Extreme Light Infrastructure Nuclear Physics is a Big Science facility being built in Magurele, Romania, and is slated to become the most advanced, highly intense laser and gamma beam facility in the world. Cosylab, as a subcontractor for the EuroGammaS Consortium, assumed the responsibility for defining the scope and the delivery of the complete control system for the Gamma Beam System, based on the industry-standard EPICS framework.

THE CHALLENGE

The ELI-NP (Extreme Light Infrastructure Nuclear Physics) project will focus on the study of the fundamental processes that unfold during light-matter interactions and will be made up of a very high-intensity, 10-petawatt laser and an ultra-brilliant and tunable gamma-ray beam. The ELI-NP facility is being constructed in Magurele, near Bucharest in Romania. Together with sister projects in Hungary and the Czech Republic, ELI-NP is one of the first large research facilities in Central and Eastern Europe that are financed by European Commission structural funds allocated to EU member states.

In 2014, a European Consortium, EuroGammaS, won the tender to build a Gamma Ray Source for fundamental and advanced research at the ELI-NP facility, which is operated by Romania's National Institute for Nuclear Physics and Engineering (IFIN-HH).

The Consortium is led by the Italian Institute of Nuclear Physics (INFN), and counts among its partners the French National

COSYLAB INDUSTRY

Industrial Hi-Tech Applications and Custom Solutions

CUSTOMER

EuroGammaS Consortium;

CUSTOMER'S DOMAIN

European Consortium that won a tender to build a Gamma Ray Source for fundamental and advanced research at the ELI-NP facility.

COSYLAB SERVICES & PROCESSES EMPLOYED

- Requirements elicitation
- Requirements redefinition and optimisation
- Control System Architecture
- Project Planning
- Instrumentation Hardware Selection
- EPICS Device Integration
- Control Room Design

BENEFITS GAINED

- Reduced Integration Time
- Reduced Development Cost
- Realization of demanding requirements
- Good documentation and training that shortens operator learning curve
- Leverage use of established open-source technologies such as EPICS

Centre for Scientific Research (CNRS), the Sapienza University of Rome, and several European companies - ALSYOM (France), A.C.P. Systems (France), COMEB s.r.l. (Italy) and ScandiNova Systems AB (Sweden).

The Consortium is comprised of many stakeholders - partners and subcontractors, ranging from equipment manufacturers to research organisations. In this way, the EuroGammaS Consortium became responsible for the design, manufacture, delivery, installation, testing, commissioning and maintenance of a custom Gamma Beam System (GBS).

One of the main characteristics of the ELI-NP GBS project is its complexity, both from the technical and organizational views. Besides the highly technical requirements of the project, the Consortium also faced a challenging timeline to realize the ELI-NP GBS.

EuroGammaS needed a subcontracting partner that could accelerate the system integration, as well as take on responsibility for a well-defined part of the project. They found and hired Cosylab as the one-stop solution provider and system integrator for the control system of the GBS. The first task for Cosylab was to work on the control-system design, which included defining the scope of the control system. In the next phase, we performed all the engineering work that was needed to fulfill the scope.

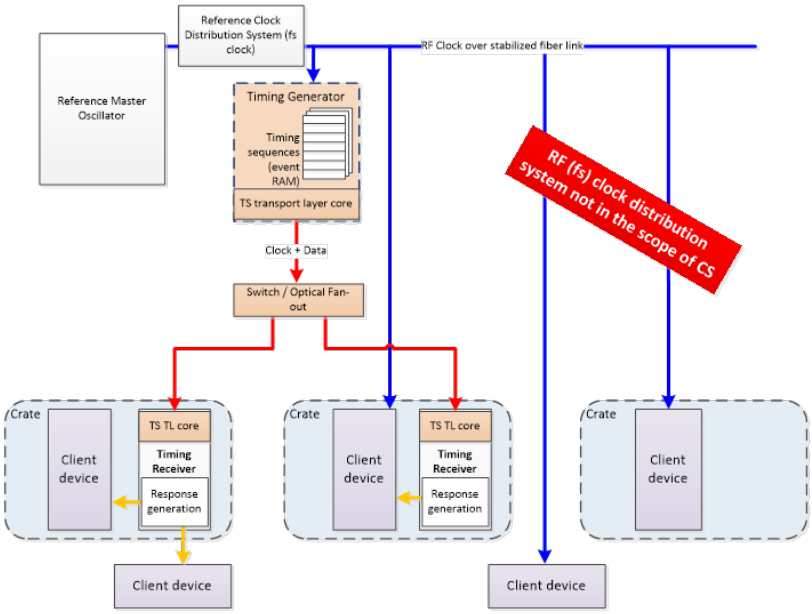
COSYLAB'S SOLUTION

"Given there was not enough time to perform a full Control System study and design using a waterfall model to decide on the scope, we agreed with Cosylab that they prepare various proposals for the Control System work package optimised for different scenarios, based on their experience. That would allow the Consortium greater flexibility to evaluate and decide which of the proposals best matched the constraints of the project. This way of working was well received and proved effective."

Antonio Falone, Deputy Machine Leader, Integration

Since there were many parties responsible for specific subsystems in the ELI-NP GBS, with work spread over eight countries, and given that all subsystems interfaced with the control system, a period of intense work commenced for Cosylab. We had to ensure that all contributors were on the same page as to how to integrate the control system to function as a whole.

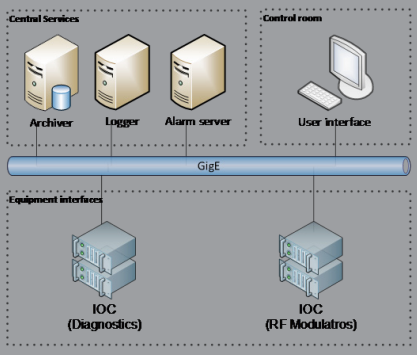
We drew upon our extensive experience with control system integration for projects such as the European Spallation Source and ITER to provide scope, guidelines and control system integration concepts. We used these to proactively involve all the work package owners. In addition to purely technical interfacing, there were many project management aspects to be synchronized with project participants, e.g. definition of the development timeline, scheduling of testing and integration, and specification of the necessary inputs and outputs of each development step. We also made sure that the control system stakeholders had a clear and common understanding of all issues, so that the integration phase would be smoother.



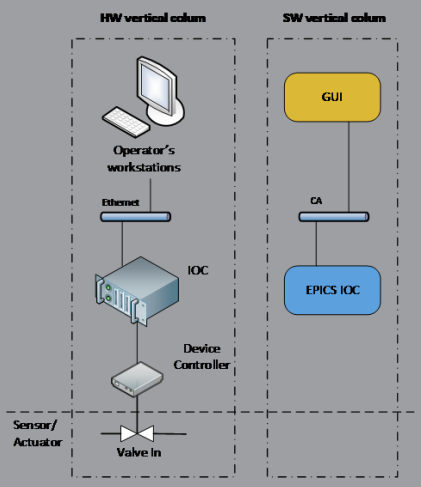
The picosecond timing trigering system diagram

DETAILS OF THE CONTROL SYSTEM

In a complex machine such as the ELI-NP GBS, a central control system manages the whole machine, from the source to the Gamma Beam Characterization System. This means that the control system must be able to concurrently execute commands on all active elements in the machine and control all diagnostic devices, providing the necessary information to the operators. Furthermore, we were convinced that the control system should be based on industry standard open-source software and structured in such a way that made it is easy to upgrade - substituting elements, devices or subsystems with new counterparts. Thus, we proposed the EPICS framework to be used for the ELI-NP GBS control system and this was accepted by the Consortium.



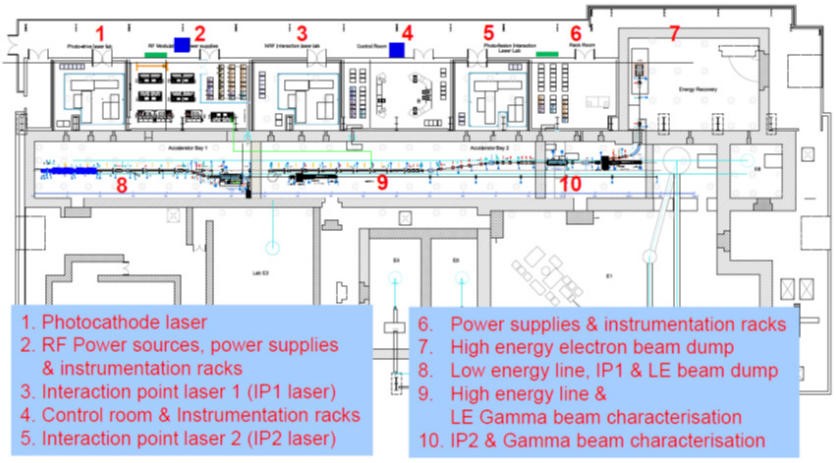
Three-tier architecture of ELI-NP control system



HW and SW columns of device integration

EPICS is an open-source software infrastructure, optimised for building large distributed control systems to operate devices such as particle accelerators, large experiments and major telescopes. EPICS has been collaboratively developed with contributions from a variety of scientific facilities for a long time. This makes EPICS one of the most preferred choices for Big Physics experiments or complex, large scale distributed control system applications, e.g. GSI FAIR, UKAEA CFE, W.M. Keck Observatory, SLAC, ASKAP, LNLS, SNS, FHI FEL, LIGO, ITER, Diamond LS and ESS.

Cosylab's EPICS implementation for the ELI-NP GBS is based on a modular control system design that leverages solutions developed at other similar facilities. Even "out of the box" EPICS, with its set of strict processes and conventions, ensures that any custom and project-specific development can be performed in a standardized and coherent manner.

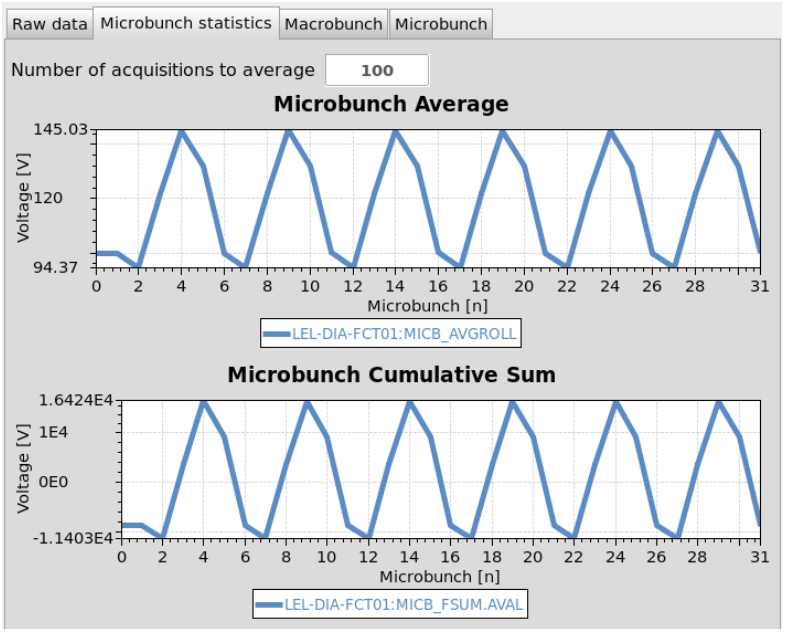


Overview of the system

INTEGRATING A FAST DIGITIZER INTO EPICS FOR BEAM CHARGE MONITORING

An example of Cosylab's proactive approach to control system integration was the case of integrating a Fast Digitizer into EPICS for GBS Beam Charge Monitoring.

For Big-Physics facilities with unique systems requirements, such as the ELI-NP GBS, commercial off-the-shelf technology is rarely good enough. Instead, cutting-edge hardware with custom integration is the only way to go. While any custom device integration has its own individual challenges, an excellent example of a demanding device integration into EPICS for the project at hand was an ADC to digitize the output of the integrating current

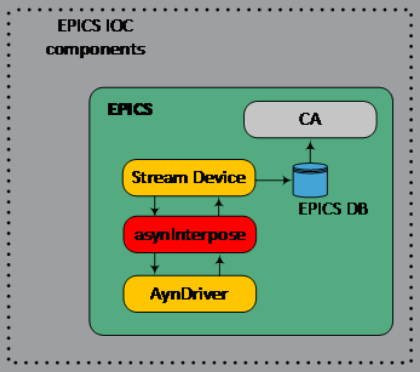


Microbunch statistics display

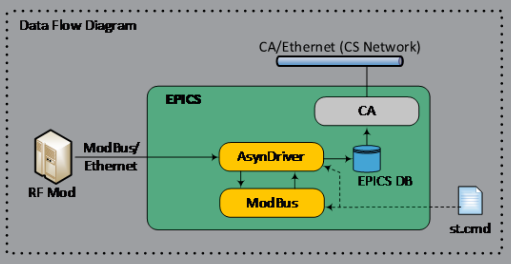
transformer (ICT). An ICT, as opposed to more standard beam charge monitors, was needed because of the nature of the GBS electron beam. The latter has an electron train of 32 micro-bunches at a rate of 100 Hz. Each micro-bunch is 50 ps wide and is 16 ns apart. This meant that an ADC with a sufficiently high sampling rate was needed for accurate measurement.

Cosylab worked with the EuroGammaS team to formalize the requirements for this specific device integration and also advised on the actual hardware that should be used. The Consortium demanded a multi-GS/s sampling rate, a wide input-voltage signal-range of 0-10 V and compatibility with the CompactPCI platform. We chose an Agilent High-Speed Digitizing Scope with a real-time sampling rate of up to 4 GS/s. In addition, the acquisition of the signal was synchronized with the timing signal (100 Hz) with low jitter in the order of magnitude of several picoseconds.

The goal of the integration was to provide a way to operate the Digitizing Scope from EPICS, as part of the overall control system. Therefore, we delivered the necessary EPICS device support to interface between the hardware-specific fields in an EPICS database record and the device drivers/hardware. Specifically, the asyn driver and nominal device support (NDS) were used. In addition, we also delivered operator interface screens (developed in Control System Studio) to support configuring and operating the Digitizing Scope.



EPICS IOC components



EPICS data-flow diagram

For the whole project, Cosylab developed device integration for several types and classes of devices. The agreed acceptance procedure, as is common practice in this type of project, was that all software be signed off after successful factory acceptance testing and that the hardware was correctly calibrated and configured before shipment to the customer.

CONCLUSION

"Cosylab acted like a reliable, proactive subcontracting partner to the Consortium and they delivered on their promise."

Antonio Falone, Deputy Machine Leader, Integration

We put all of our proactive effort into defining the scope and the integration of the control system for the ELI-NP Gamma Beam System, and it paid off. We completed all of our contractual work on the software development for the GBS control system, performed a successful factory acceptance test and delivered all the software components to our direct customer, EuroGammaS, by the end of 2016. Over the course of 2017, we also delivered the hardware and equipment for ELI-NP as specified in the requirements by the EuroGammaS Consortium leader, INFN.

Because of this, Cosylab is proud to have contributed our engineering skills and project management expertise to the construction of the ELI-NP Gamma Beam System as a critical component of a unique Big-Physics Machine, and of having successfully delivered the contractual services and equipment in the agreed time and scope to our customer.

"Given there was not enough time to perform a full Control System study and design using a waterfall model to decide on the scope, we agreed with Cosylab that they prepare various proposals for the Control System work package optimised for different scenarios, based on their experience. That would allow the Consortium greater flexibility to evaluate and decide which of the proposals best matched the constraints of the project. This way of working was well received and proved effective."

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COSYLAB
CONTROL SYSTEM LABORATORY

Founded in 2001, Cosylab provides and integrates state-of-the-art software and electronics for the world's most sophisticated, precise and advanced systems, to enable research organizations to make scientific breakthroughs, hospitals to deliver better cancer treatment and organizations to improve their performance.

The company employs physicists and engineers that can understand the physical operational principles of highly elaborate devices and that can master the software and hardware engineering of large-scale distributed control systems at the same time.

With its headquarters in the EU, Cosylab has a strong international presence and has worked on hundreds of multi-year and multi-people projects all over the world.

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CONTACT US

We're here to answer your questions.

For more information on building the right control system infrastructure for your integration project, send an email to
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