



CTPLC Group

PLC-based systems at Alba Synchrotron

ICALEPCS 2021: PLC-based control system Workshop
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- About Alba Synchrotron
- PLC-based systems at Alba:
 - Personnel Safety System (PSS)
 - Equipment Protection System (EPS)
- What about Alba II?

An aerial photograph of the ALBA Synchrotron, showing its large, circular, metallic structure with several small white buildings on top. A semi-transparent yellow box is overlaid on the image, containing the title text.

About ALBA Synchrotron

[HOME](#) / [ABOUT US](#) / [WELCOME TO ALBA](#)

About ALBA Synchrotron

- **3rd generation Synchrotron Light**
- **complex of electron accelerators** to produce synchrotron light
- **3 GeV (LINAC + BOOSTER + STORAGE RING)**
- **eight operational beamlines** comprising soft and hard X-rays
- devoted mainly to **biosciences, condensed matter** (magnetic and electronic properties, nanoscience) and **materials science**
- four beamlines are in construction

About ALBA Synchrotron

- more than **6.000 hours of beam time per year**
- available for **the academic and the industrial sector**,
- serving more than **2.000 researchers every year**.
- Managed by the Consortium for the Construction, Equipping and Exploitation of the Synchrotron Light Source (**CELLS**), it is funded in equal parts by the **Spanish and the Catalanian Administration**, in particular by the [Ministry of Science and Innovation](#) and the [Secretary of Universities and Research](#)

PLC-based systems at Alba

• Personnel Safety System (PSS)

- Radiological risk
- IEC 61508 / IEC 61511
- Specified by Alba and implemented by sub-contractors
- 15 CPU + 40 Remote I/O
- ≈1.500 signals



• Equipment Protection System (EPS)

- Equipment damage, specially temperature and vacuum
- Also Monitoring/Diagnostics (e.g. Building Facilities) and Control Applications (e.g. BL22 Gas control)
- Fully developed by Alba
- 75 CPU + 175 Remote I/O
- ≈10.000 signals

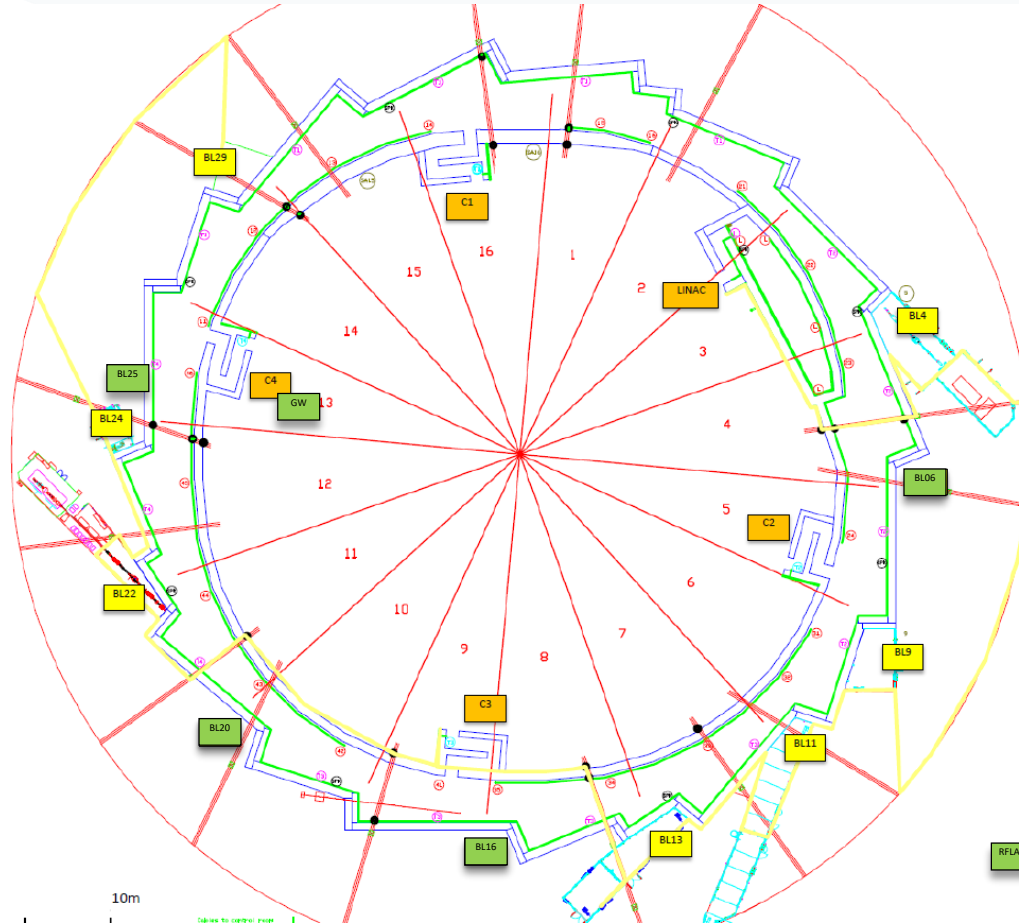
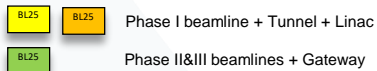
• Personnel Protection System (PPS)

- Conventional risks
- WiP

PSS

Review of PSS key implementations:

- **2006:** First PSS RFLAB Implementation at Universitat Autònoma de Barcelona.
- **2009:** Certification of PSS Tunnel and Linac
- **2012:** Certification of PSS Beamlines (Phase I)
- **2017:** Migration of PSS RFLAB from PSS3000/SafetyBus to PSS4000/SafetyNet; and addition of External RF Plant.
- **2018:** Implementation of PSS Gateway to enable the PSS to interface with new Beamlines
- **2018:** Implementation of PSS LOREA
- **2019:** Implementation of PSS NOTOS
- **2020:** Implementation of PSS XAIRA
- **2020:** Implementation of PSS SCADA
- **2021:** Implementation of PSS MINERVA

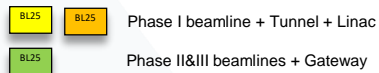
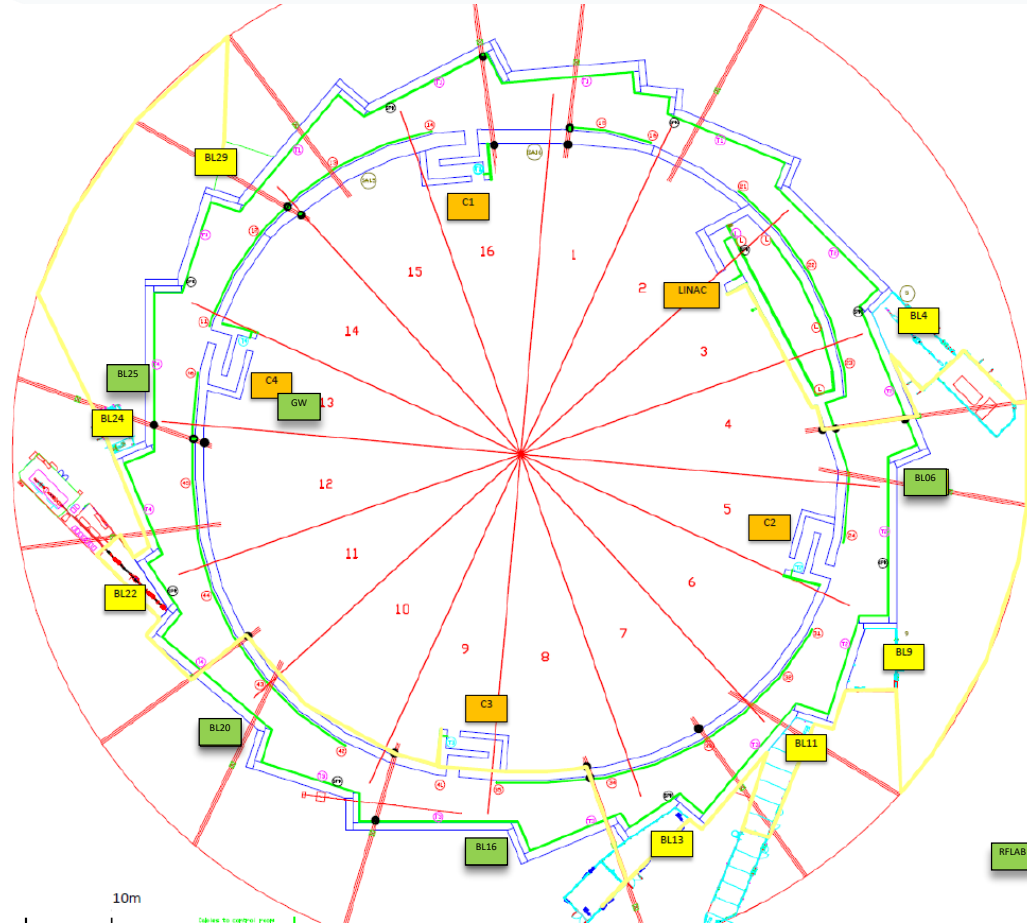


Updates/bugfix:

- **2013-2019:** Several updates (Restricted Procedure, Beam Killer feedback, BL11 Search Procedure, Linac LTB Bending Magnet position, Electrical supply, BL22 and BL04 Chicane Key Procedure, BL29 CPU failure...)

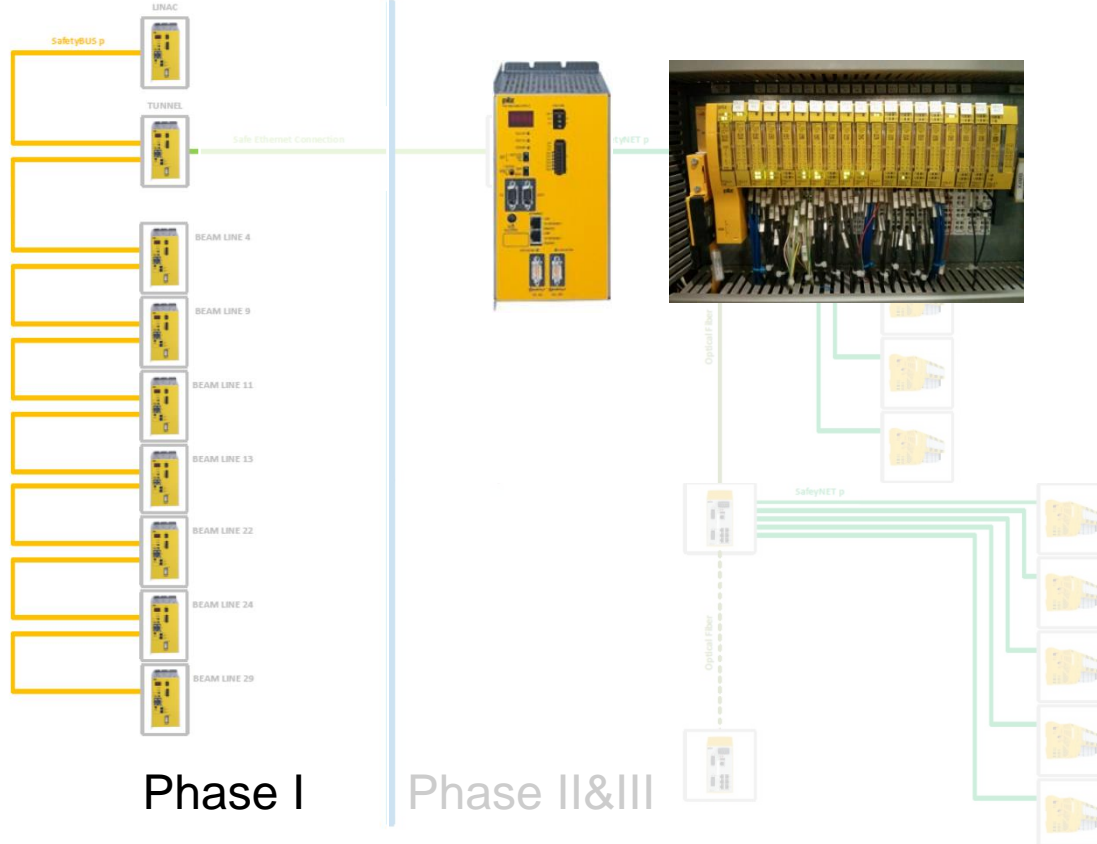
Foreseen:

- **2021-Q4:** PSS Ethernet network update
- **2022:** Implementation of PSS FAXTOR
- **2022:** Update of PSS Gateway. Current implementation is limited to 5 beamlines.



Dealing with PLC obsolescence

PSS



- Pilz PSS3000 series + SafetyBus (Discontinued 2017)
- The I/O modules are not discontinued, but the Remote I/O header is.
- No problem with the field equipment (emergency mushrooms, limit switches, door locks...)

- **OPTION 1: Maintain TUNNEL and LINAC as it is + PSS4000 Gateway**

- New Beamlines are added using PSS4000
- New PSS4000 Beamlines are interfaced with the PSS3000 Tunnel through the PSS4000 Gateway
- Old PSS3000 Beamlines are gradually migrated to PSS4000
- Last PSS3000 to be migrated are PSS3000 TUNNEL and LINAC
- *This is the current strategy.*



- **OPTION 2.A: Migrate PSS3000 TUNNEL and LINAC + PSS3000 Gateway**

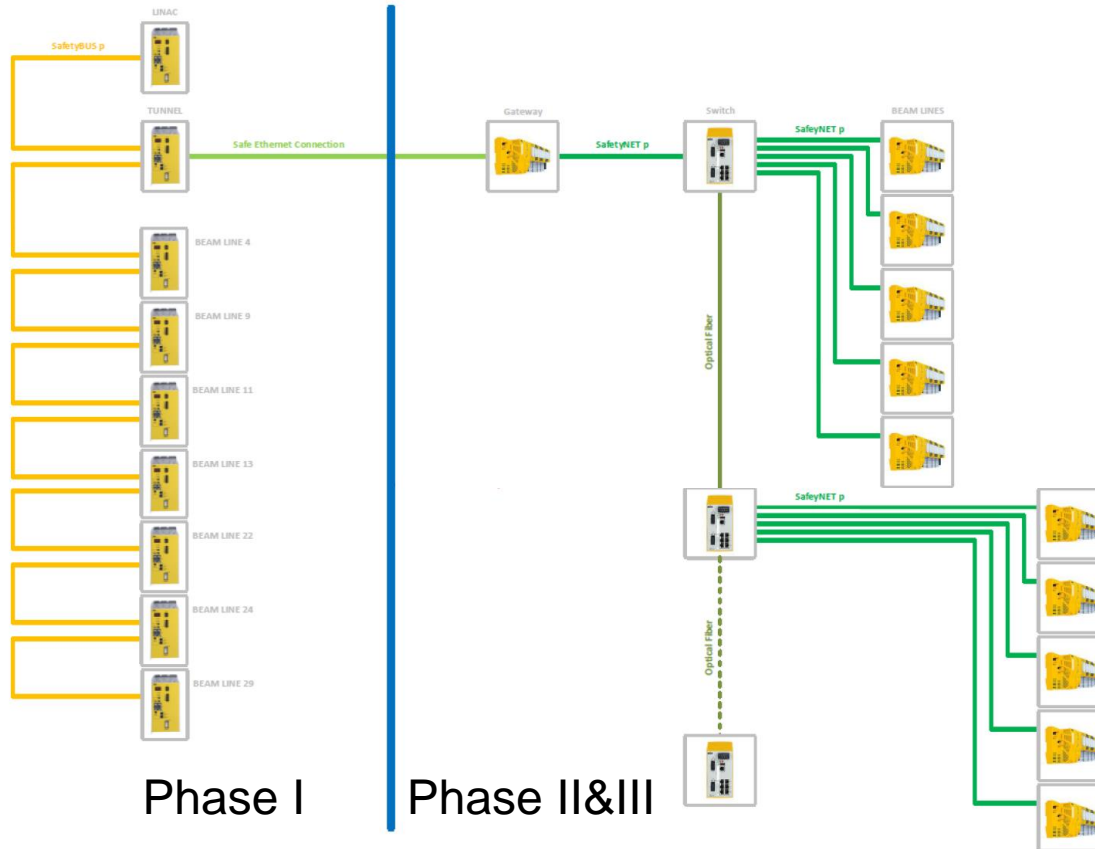
- Develop a PSS3000 Gateway to interface PSS3000 Beamlines with the new PSS4000 Tunnel
- *This strategy was dismissed basically due to the huge impact of migrating the Tunnel and the Linac.*

- **OPTION 2.B: Migrate PSS3000 TUNNEL and LINAC + SafeEthernet**

- Migrate TUNNEL and LINAC
- Modify all PSS3000 Beamlines to interface with the new PSS4000 Tunnel using SafeEthernet point-to-point protocol
- *The use of this protocol to interface many PLCs was discouraged by Pilz and feasibility yet to be confirmed.*

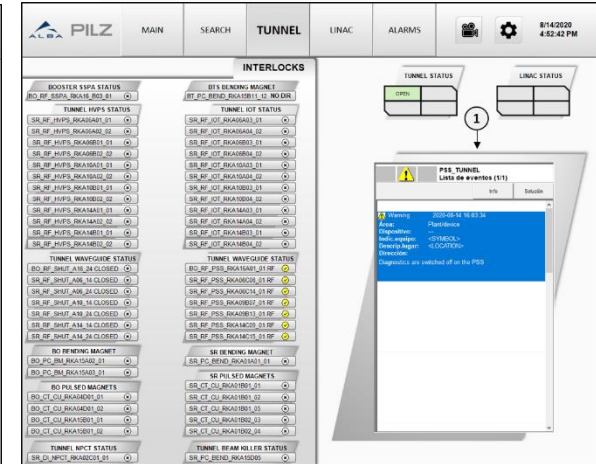
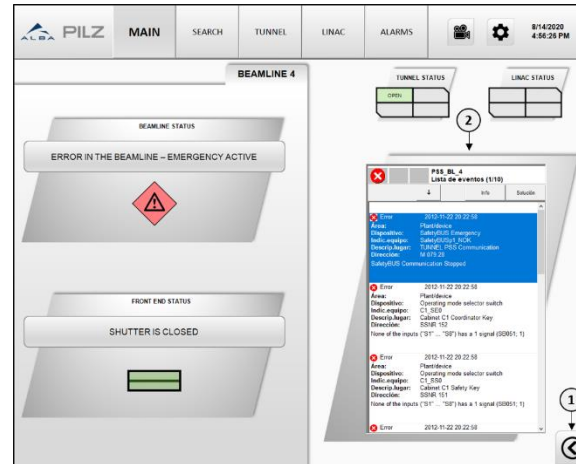
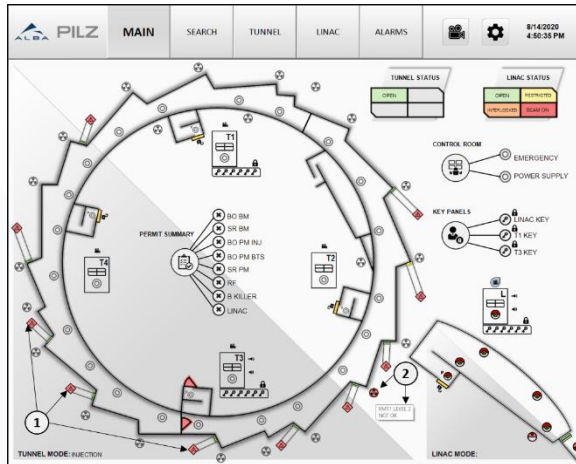
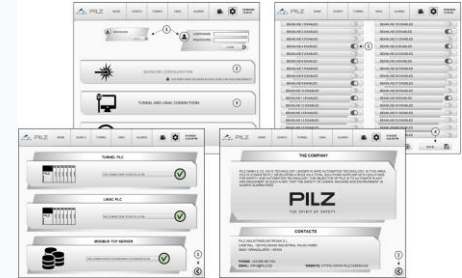
Dealing with PLC obsolescence

PSS

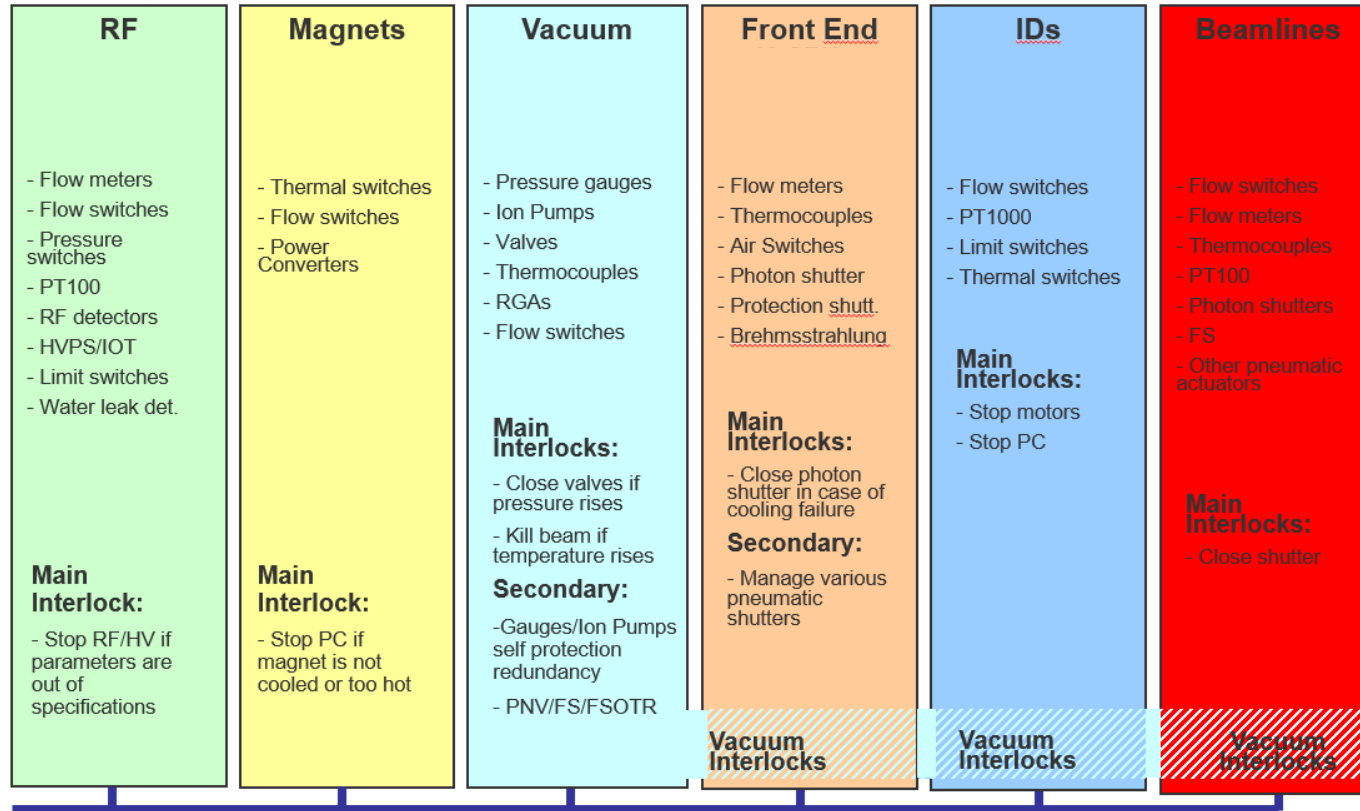


- Pilz PSS4000 series
- SafeEthernet between PSS3000 TUNNEL and PSS4000 GATEWAY
- SafetyNet between PSS4000 GATEWAY and new BEAMLINES
- PSS3000 stock increased to cover until Alba II

- Previous SCADA = Visual Basic 6 (Obsolete)
- New SCADA = Wonderware InTouch

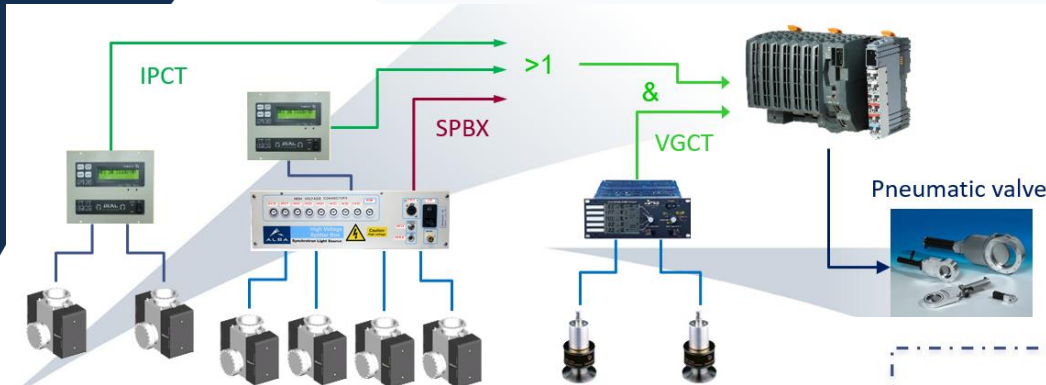


EPS

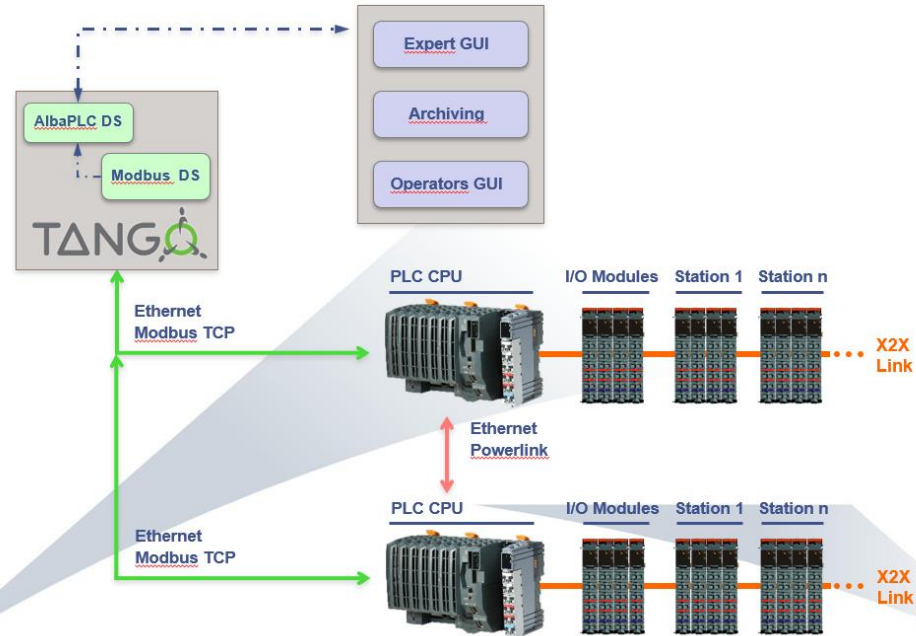


Ethernet Powerlink:
Interactions between subsystems

Interactions with other systems:
Timing, Liberas (BPM)



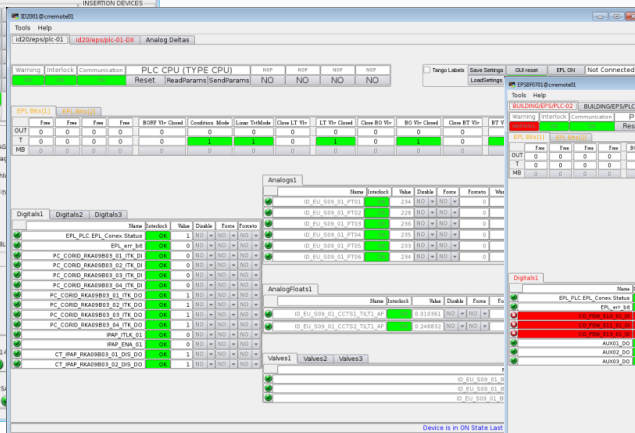
- Manuf.:
 - B&R
- CPU ref.:
 - X20CP1584
 - X20CP1484 (Obsolete)
- Field bus:
 - Ethernet Powerlink v2 between Accelerators CPUs
 - X2X between CPUs and Remote I/O
 - 24VDC signals between Accelerator and Beamlines CPUs



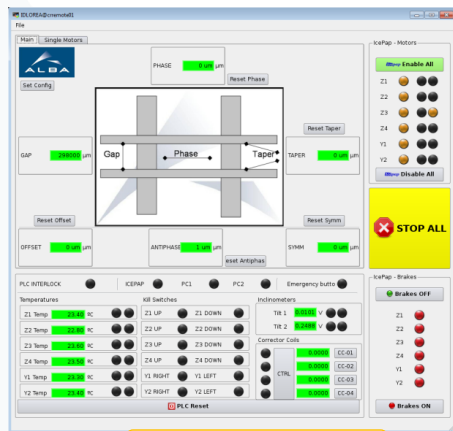
Expert GUI



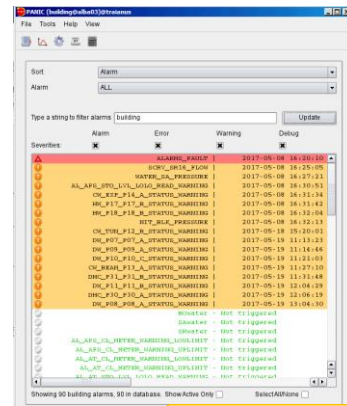
The Operator GUI displays a comprehensive overview of the system's operational status. It includes sections for 'ALBA EQUIPMENT PROTECTION SYSTEM', 'ALBA accelerators EPS Communications', and 'Front-Ends'. Key indicators include 'ST. RING' status, 'MICROFREQUENCY PLANTS OPERATION CONFIGURATION', 'VACUUM VALVES OPEN', 'FRONT-END VALVES OPEN', 'SR BEAM ORBIT INTERLOCK', 'TEMPERATURES - ABSORBES INTERLOCK', and 'WATER DETECTORS'. Each section contains a grid of green and red status lights and buttons for manual intervention.



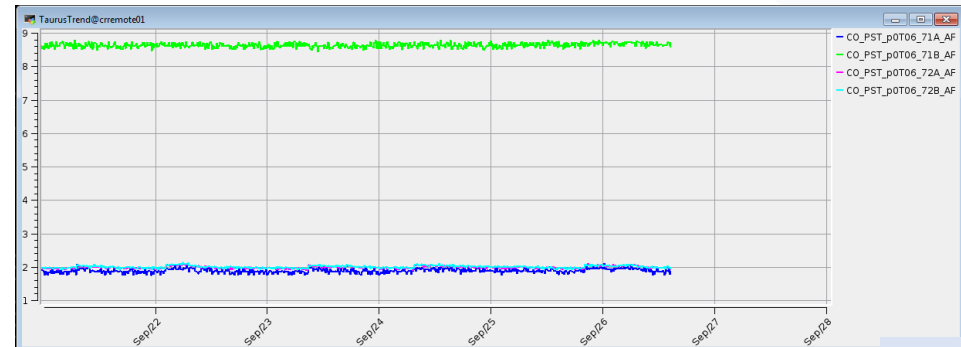
The Panic GUI provides a detailed view of the system's internal parameters and alarms. It includes a 'PLC CPU (TYPE CPU)' section with status indicators for 'RUN', 'STOP', and 'ERROR'. Below this, there are multiple tables for 'Digital' and 'Analog' inputs/outputs, showing values, status, and trends. A 'Values1' section at the bottom displays specific numerical data points.



This Operator GUI screenshot shows a detailed view of the system's internal parameters and alarms. It includes a 'PLC INTERLOCK' section with status indicators for 'ICEPAP', 'PCI', 'PC2', and 'Emergency button'. Below this, there are multiple tables for 'Digital' and 'Analog' inputs/outputs, showing values, status, and trends. A 'Values1' section at the bottom displays specific numerical data points.



The Panic GUI provides a detailed view of the system's internal parameters and alarms. It includes a 'PLC CPU (TYPE CPU)' section with status indicators for 'RUN', 'STOP', and 'ERROR'. Below this, there are multiple tables for 'Digital' and 'Analog' inputs/outputs, showing values, status, and trends. A 'Values1' section at the bottom displays specific numerical data points.



Operator GUI

ICALL

Panic

Control system Workshop

Archiving

EPS

- New Front-ends, Insertion Devices and Beamlines
 - BL01-MIRAS (2016)
 - BL20-LOREA, BL16-NOTOS, BL06-XAIRA (WiP)
 - BL25-FAXTOR (2022)
- Last Process upgrades
 - Powerlink v2 (now Open source)
 - EPS_LIB 3.0 (DeltaT,...)
 - BL22 EPS expansion in EH (due to amount of signals)
 - MPS extended (Fast Interlock signals from/to EPS)
 - RF Plant BO from HVPS/IOT to SSRF (Solid State Amplifier)
 - RF Plant SR Protection Logic refactoring
 - ...
- Working on Tools:
 - Variable and Code Autogenerator, linked to the CableDB
 - UserGUI
 - ...

- B&R X20 X20CP1484 was discontinued and replaced by CPX20CP1584
 - No major issue as the hardware is compatible and the software can be easily migrated
 - We keep stock of X20CP1484
 - Progressively migrating all CPUs
- B&R Powerlink V1 obsolete
 - New EPL library developed to use Powerlink V2
 - V1 and V2 could not coexist. Consequently we were forced to migrate all the Accelerator CPUs at the same time (Summer Shutdown 2015, \approx 50 CPU).
 - The Beamlines and Laboratories CPUs could be migrated one by one.

What about Alba II?

More
questions than
answers, right
now...

- Safety Life Cycle (IEC 61508/61511)
 - What is your experience with the SRS? Have you faced the specification of a complex safety system?
 - At Alba: Top-up/Decay Operation Modes, RF Plant operation modes, Open/Interlocked/Secured/Restricted hutch status, exceptions on what permits are triggered on each case, sequences...

- Technological aspects
 - Interface with Sub-systems. Use of not off-the-shelf equipment in Safety Functions.
 - Use of Ethernet networks in Safety applications. Safety VS Availability.
 - Architectures
 - Development tools
 - Code auto-generation
 - Prototyping and test systems
 - Simulation platforms
 - Formal methods for code testing
 - Methodologies and tests (FAT, SAT)
 - Diagnostics and Monitoring for Safety systems
 - Precision, synchronisation and time stamping among different controllers
 - ...

- Technological aspects
 - EPS Architecture review. E.g: Single controller in an Industrial PC with Remote I/Os? Wifi solutions - IIoT?
 - Use of sensors with field-bus interface – smart sensors?
- New functionalities
 - Fast reaction time in the range of micro-seconds?
 - Safety signals for Conventional Risks integrated in the same EPS PLC? Any experience?
 - Process Control applications in the same EPS PLC?



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Thanks!