Personnel Safety System and Equipment Protection System

PLC Based independent Protection systems

D. Fernández-Carreiras. Controls group

Computing Division


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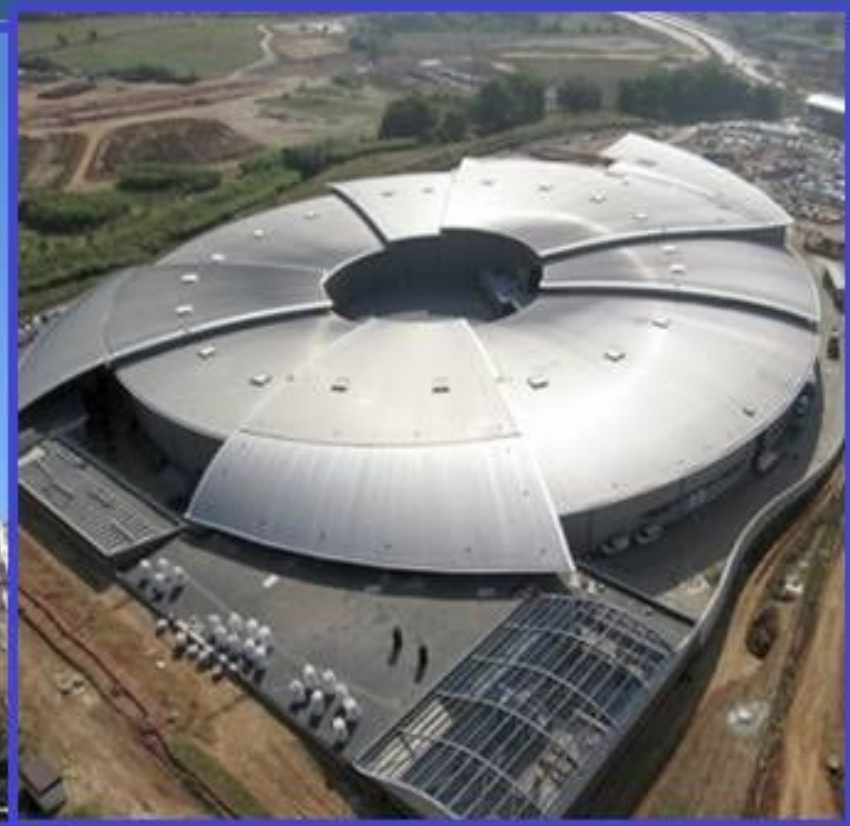


Contents

- PSS vs EPS
- Design and operation
- Deployment
- Machine protection system
- Conclusions

PSS vs EPS: Independent systems

PSS

Based on Safety PLCs, cares of:

- Access Control
- Intrusion
- Radiation levels during operation are in the allowed limits,
  - **0.5 µSv/h assuming 2000 hours per person and year (1 mSv/year).**

It issues Operation Permits

EPS

Based on Conventional PLCs cares about the protection of the components of accelerators and Beamlines.

Independent relays in the power supplies

Temperature monitoring in vacuum chambers

Actuators for shutters, fluorescence screens, etc.

Logic following the severity of the event

PSS: Safety PLC Pilz

PILZ Components.

- SIL3 certified.
  - PSS SB2 3006-3 ETH-2 CPU
  - Safety-Bus. Digital I/O modules, 2 channels.
  - Field elements. Redundancy and diversity
    - PNOZ safety relays. Double channel.

- Redundancy and Diversity

- In case an error is detected, the power is gone, etc, the system goes to safe state. Actuators are released, **permits are revoked** (beam is killed), doors are open after a **safety period**.

- **The PLC functions are certified**
  - Modifications in the code require a new safety check and certification. Check-sum and password protected

PSS implementation and operation

- Search patrol control.
  - Push Buttons
  - Magnetic card reader authentication
- Restricted access permits
  - Holding keys
- Emergency Stops
- Operation permits
  - Safety Relays
- SCADA
- Dedicated Voice and Video

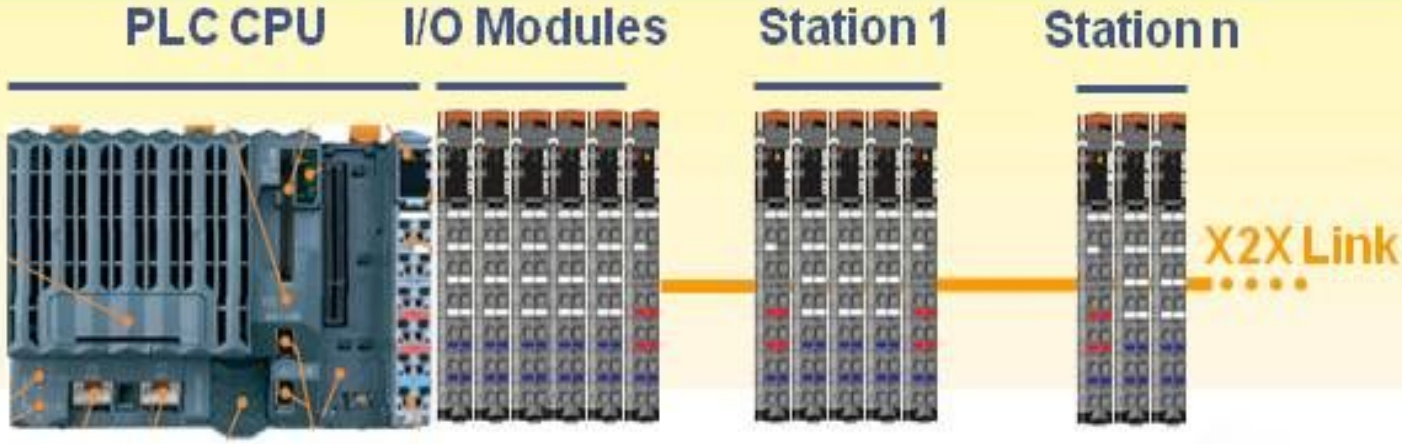
RESTRICTED ACCESS PERMITS, LIN, T1, T3

Power supplies, BO, SR, Pulsed

Tunnel. Operation permit, Boextraction, TOPUP

LINAC. Operation permit, Test, Injection

EPS: B&R Conventional PLC



- Intel Celeron@266MHz
- Automation Runtime
- 1xETH 10/100
- 1xEPL

- AI/AO: -10 ~ 10V, 4..20mA, 12-16 bits
- Temp: Th (J, K, R...), PT100/1000
- DI/DO: NPN – PNP (24V)

- Decentralized backplane
- Up to 253 I/O modules (3000 channels)
- Line topology
- Up to 100m separation between stations
- 100us minimum bus cycle time

CPU TO CPU COMS: **Ethernet Powerlink:**
- Cyclic (4ms)
-Master/slave
-Deterministic: all nodes addressed each cycle

-Covers various **subsystems** Vacuum, RF, Magnets, IDs, Front Ends and Beamlines.
  -More than 6000 signals
  -Sensors: Temperature (PT100/thermocouples), flowmeters, RF detectors, switches/digital signals, etc.
  -Actuators: Switches, digital signals.
-**Distributed**. Extensive use of field buses (making cabling easier).
  -**Mechanical issues**: Installation in tunnel, radiation, size.
    -Lead shielded boxes for periphery installed in the tunnel.

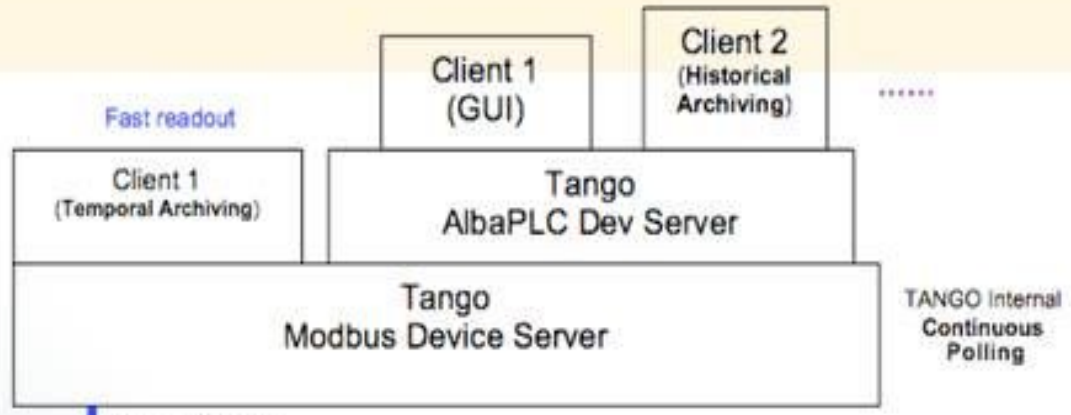
EPS Implementation and operation

-Fully Interfaced with **TANGO**

-Time restrictions: response time <50ms.

-Communication between CPUs: Ethernet **Powerlink**, Deterministic

-Uses the controls network infrastructure. Dedicated **VLAN**

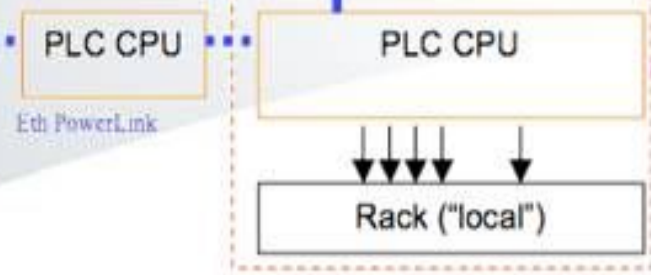


Modbus/TCP

PLC Periphery (in tunnel)

X2X Link

PLC CPU



	Vacuum		Magnets		Radiofrequency		Insertion Devices	Front Ends	Beam lines	Coms. Master CPU
	BO	SR	BO	SR	BO	SR				
CPU cabinet	16		1	1	1	6	6	10	7	1
Periphery cabinet	4	16	23	31	1	6	3	10	7(+)	-

EPS implementation and operation

EPS functionalities by subsystem

RF
7 CPUs
+
7 Periphery
- Flow meters
- Flow switches
- Pressure switches
- PT100
- RF detectors
- HVPS/IOT
- Limit switches
- Water leak det.

Main Interlock:
- Stop RF/HV if parameters are out of specifications

Magnets-PC
2 CPUs
+
54 Periphery
- Thermal switches
- Flow switches
- Power Converters

Main Interlock:
- Stop PC if magnet is not cooled or too hot

Vacuum
16 CPUs
+
20 Periphery
- Pressure gauges
- Ion Pumps
- Valves
- Thermocouples
- RGAs
- Flow switches

Main Interlocks:
- Close valves if pressure rises
- Kill beam if temperature rises

Secondary:
- Gauges/Ion Pumps self protection redundancy
- PNV/FS/FSOTR

Front Ends
10 CPUs
+
10 Periphery
- Flow meters
- Thermocouples
- Air Switches
- Photon shutter
- Protection shutt.
- Brehmsstrahlung

Main Interlocks:
- Close photon shutter in case of cooling failure

Secondary:
- Manage various pneumatic shutters

IDs
6 CPUs
+
3 Periphery
- Flow switches
- PT1000
- Limit switches
- Thermal switches

Main Interlocks:
- Stop motors
- Stop PC

Beamlines
7 CPUs
+
7(+) Periphery
- Flow switches
- Flow meters
- Thermocouples
- PT100
- Photon shutters
- FS
- Other pneumatic actuators

Main Interlocks:
- Close shutter

Vacuum Interlocks

Vacuum Interlocks

Vacuum Interlocks

Ethernet Powerlink:
Interactions between subsystems

Interactions with other systems:
Timing, Liberas (BPM)

Pictures

EPS

PSS

EPS development and deployment

ALBA Equpment and Cabling DB (MySQL)

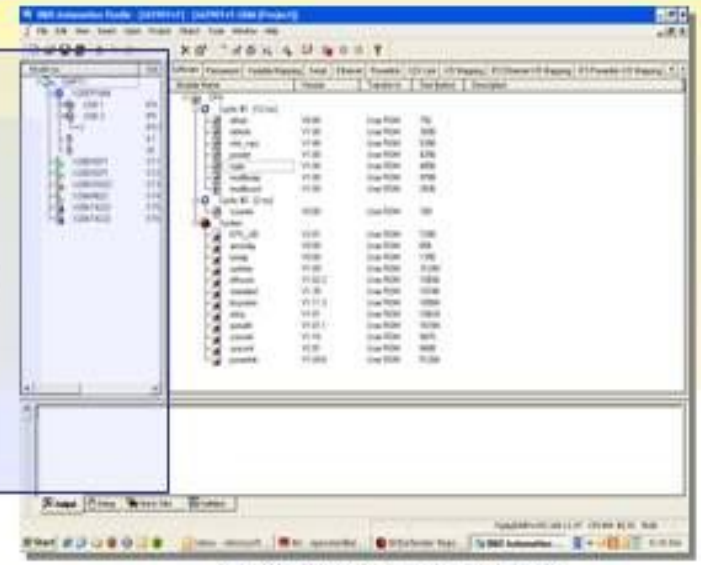
MySQL

WEP009

APJ

APJ file

PLC Common INIT file:
- Coms. Libraries (Modbus, EPL)
- Data structures
- Common variables
- Common SW tasks



PLC Programming SW (B&R Automation Studio)

Modbus/TCP

Programmer Inputs

XLS

XLS files

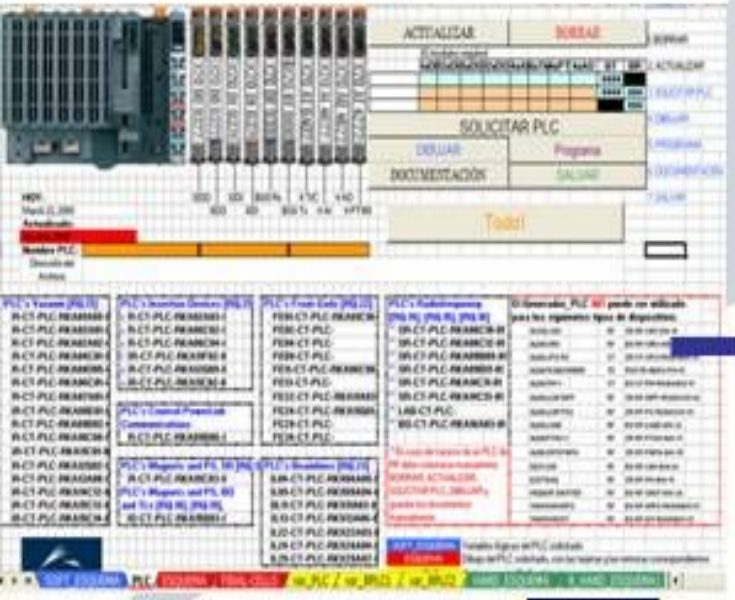
PLC documentation: I/F with devices, I/O channels assignation, etc.

PLC code generation:

PLC variables declaration

PLC modbus mapping and variables allocation.

PLC standard services: disable and force variables, alarm/warning thresholds checking, permanent memory storage, etc.



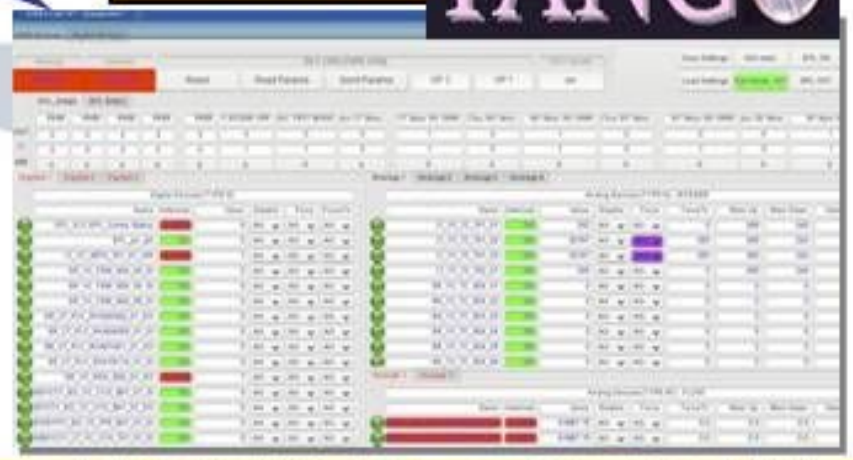
XLS – VBasic script

VBasic

Modbus Device Server

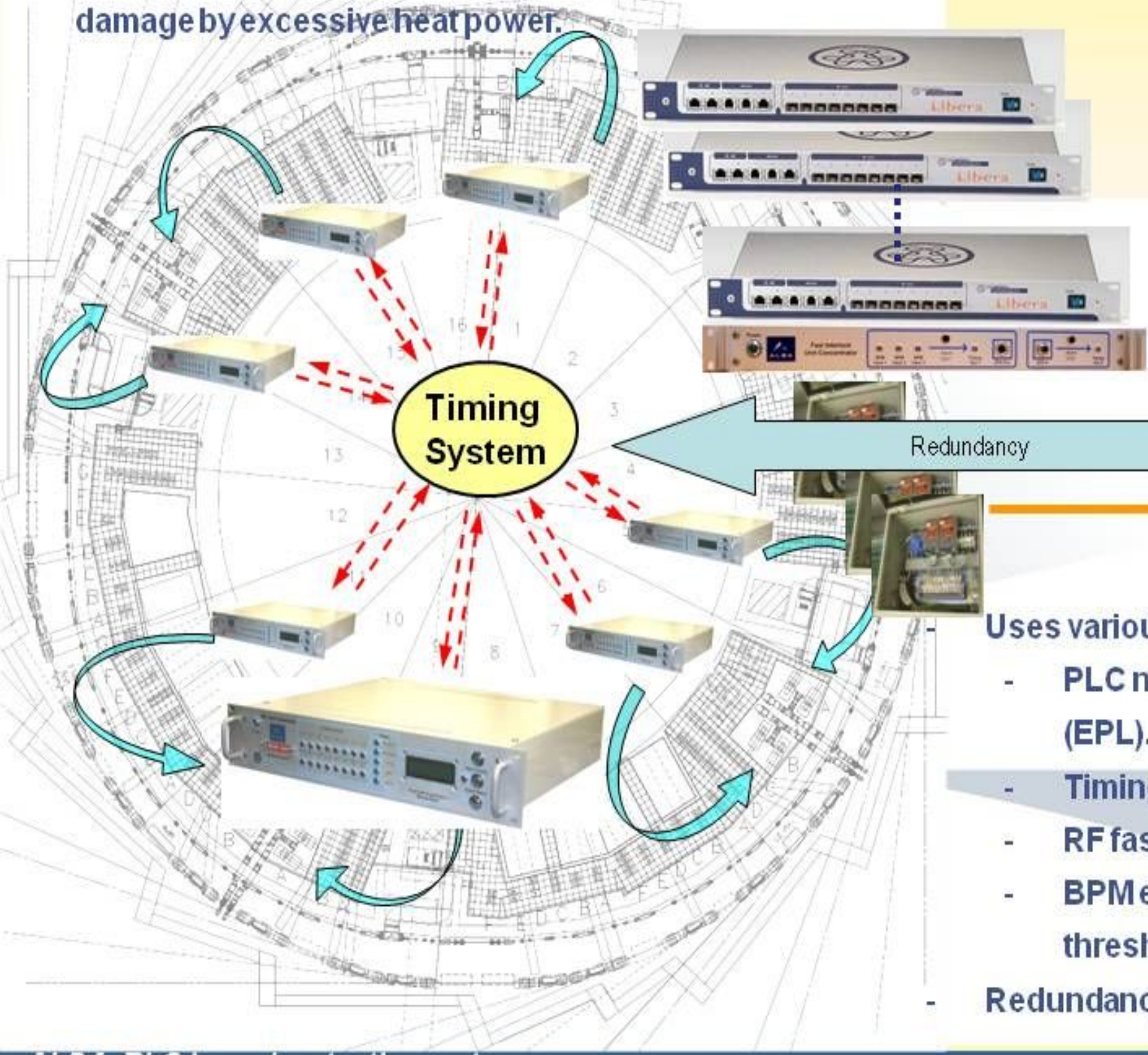
AlbaPLC Device Server

TANGO



Machine protection system

Global interlock system protecting the accelerator components from any missfunction avoiding component damage by excessive heat power.



- Uses various hardware :
  - PLC network (EPS). Ethernet powerlink (EPL). <50 ms
  - Timing system (MRF bidirectional). < 5us
  - RF fast interlock module.
  - BPM electronics. Liberas. Beam orbit thresholds
- Redundancy: PLCs and Timing system.

Conclusions

- **EPS and PSS for the linac and Transfer line have been commissioned**
- **Tunnel is being commissioned at the moment**
  - Tunnel PSS installed and ready for the commissioning of the booster
  - Booster EPS cabling and mechanical installation done.
- **Threats**
  - PSS SIL3 compliance with several elements.
  - EPS. Radiation damage in the electronics in the shielded boxes.
- **PSS and EPS. Pilz and B&R**
  - Fulfills design premises. As Low as Reasonably Achievable
  - Cost-effective

Thank you very much for your attention

¿?

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R. Ranz


A. Rubio


S. Rubio