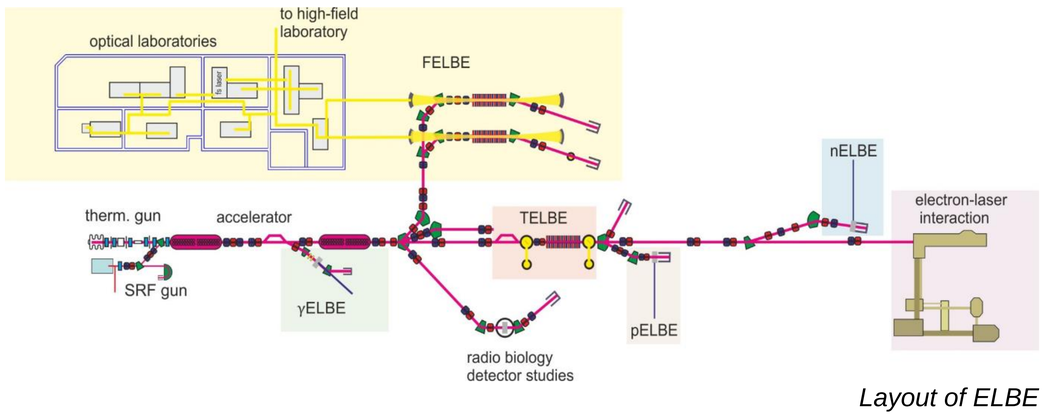
Machine Protection System Upgrade for a new Timing System at ELBE

M. Justus, M. Kuntzsch, A. Schwarz, K. Zenker (Helmholtz-Zentrum Dresden-Rossendorf)
Z. Oven, L. Perusko, L. Krmpotic, U. Legat, U. Rojec (Cosylab)

The ELBE Accelerator Facility and MPS



Layout of ELBE

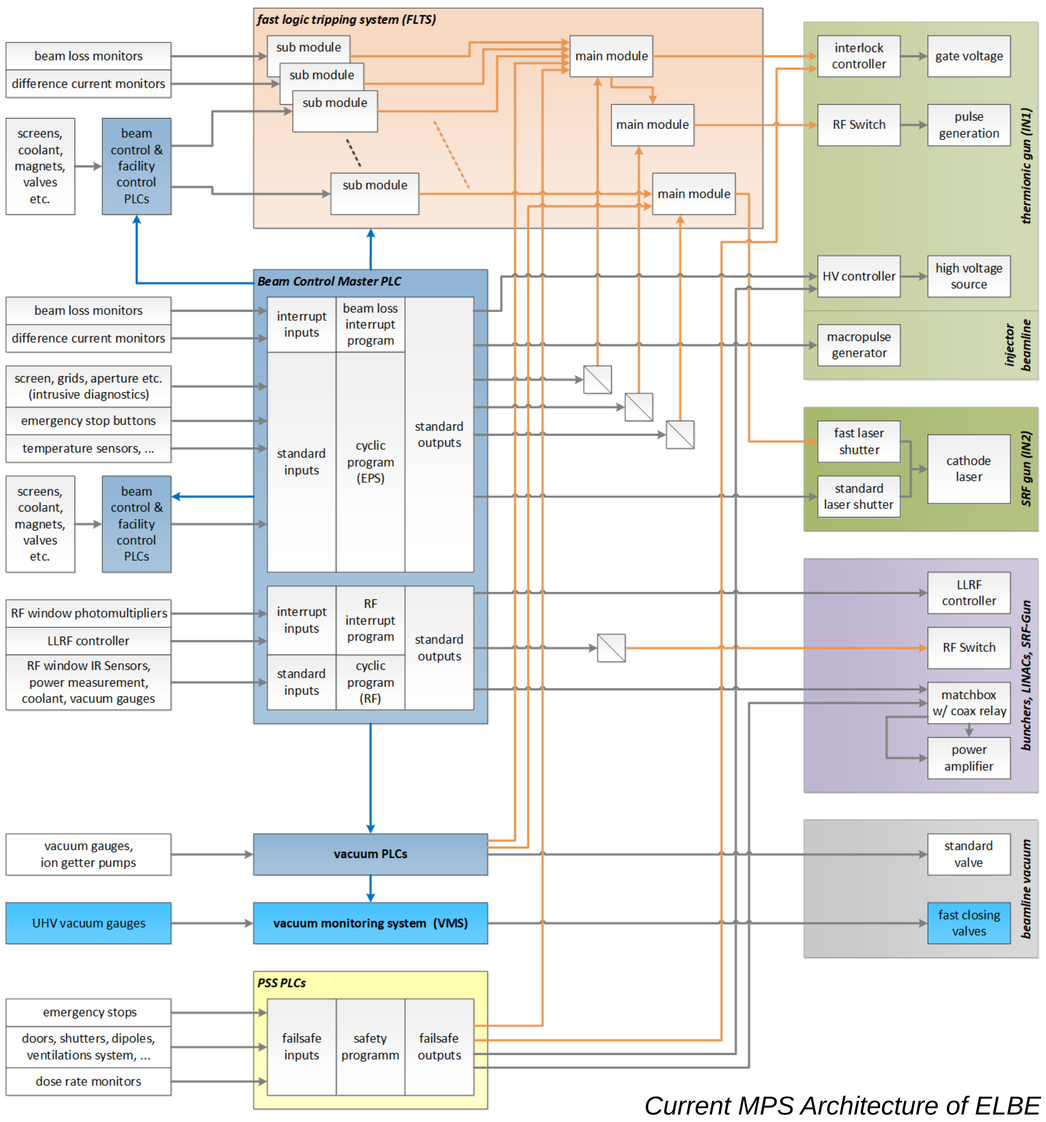
ELBE [1] has provided beamtime as a user facility for more than two decades. Its unique feature is a **1 mA 35 MeV c.w. mode electron beam**. Sources of secondary radiation are

- infrared FELs (FELBE) and THz sources (TELBE)
- Bremsstrahlung facility (γELBE)
- neutron source (nELBE) and positron sources (pELBE)
- electron irradiation site

Over the past five years the **ELBE SRF gun** has become the standard electron source for THz and neutron beams [2] with energies up to 40 MeV and higher brightness beams. **Parallel operation modes were rarely used** in the past.

The core MPS component has been a **superior beam control PLC** that holds the **central beam mode information**, and distributes this information to the subsystems.

Sum interlocks from fast detection systems as well as from standards controls are **collected by the FLTS** or handled by PLC interrupts to shut off the appropriate electron or RF source.

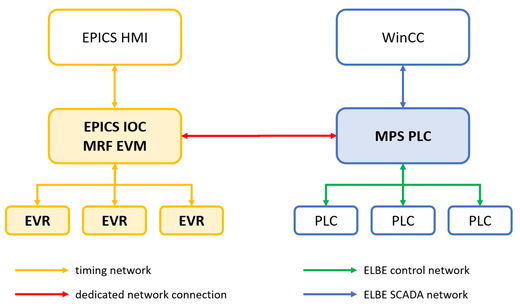


Current MPS Architecture of ELBE

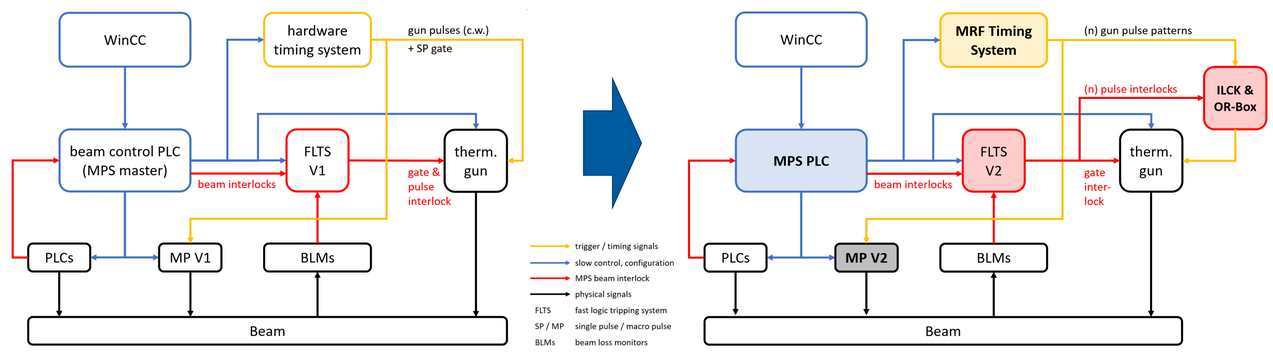
A New Timing System requires a new MPS PLC

To overcome beam mode limitations and hardware legacy, a **new timing system for ELBE** [3,4] has been developed – with demanding consequences for the existing ELBE MPS [5]. A **new MPS PLC** will replace the existing Master PLC to

- administrate beam modes, parameters and thresholds for two electron sources and about ten beam destinations
- configure the fast tripping system and subordinate PLCs
- control of beam sources and i.e. macro pulse generator
- translate GUI representation of gun pulse or beam parameters to the timing system
- check the timing system configuration parameters against beam parameter thresholds (set & effective values)
- ensure safe beam mode changeover



network diagram of the new timing System and ELBE MPS PLC



network diagram of the new timing System and ELBE MPS PLC

The **timing system operation modes** are:

- EPICS mode as expert mode for testing and parameter setup
- WinCC mode for regular operation.

The **data flow** for WinCC control mode:

(1) depending on the type of parameter, a value change will be possible during beam operation or only in beam off state

(2) set parameters are checked against certain thresholds for beam current and power

(3) valid settings will result in an OK signal to the timing system

(4) parameters pass the timing system parameter check for plausibility

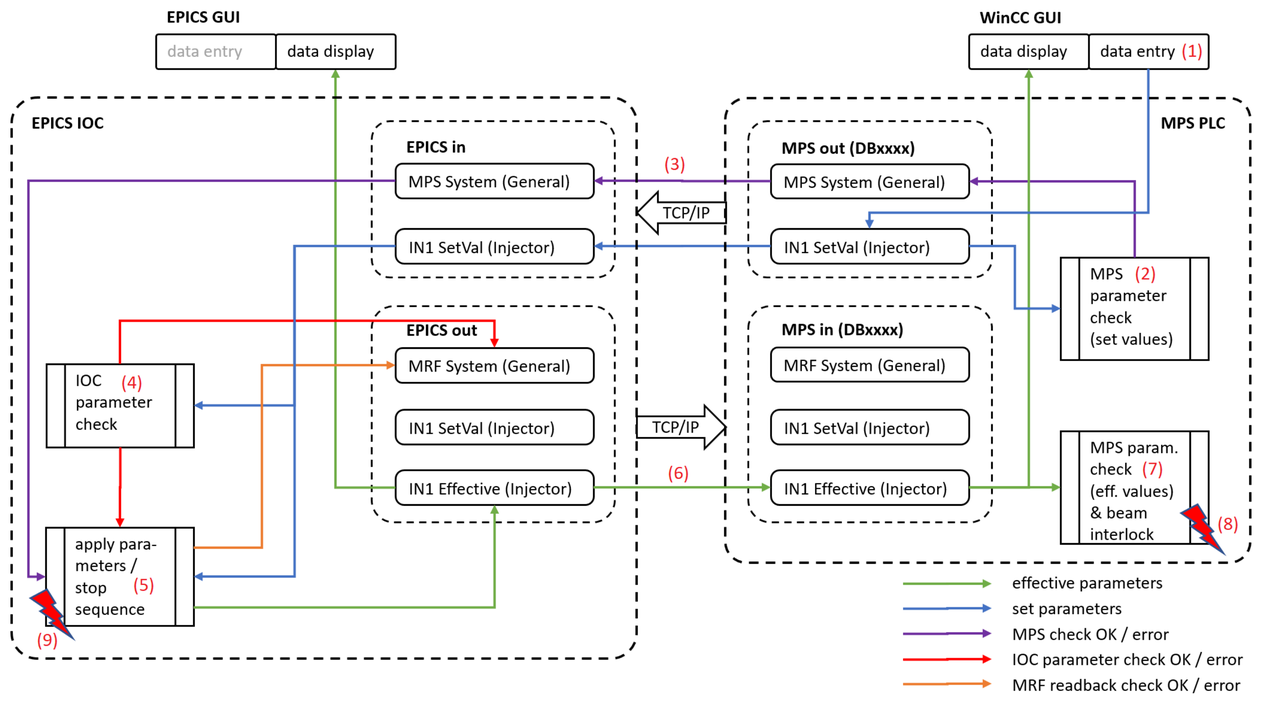
(5) parameters are applied to the MRF system

(6) effective timing parameters are sent back to MPS PLC

(7) …and checked by the MPS PLC

(8) threshold violations and communication failure will trigger an interlock to the FLTS system

(9) …and stop emission by the timing system software



Data flow for MPS related timing parameter check in WinCC control mode

Project Track

- development of the timing system is in the final test bench phase
- in 2023 MPS PLC logic tests with actual ELBE instrumentation were performed (the MPS PLC acts as an interface between the existing MPS hardware and the timing system)
- injector 1 timing parameter checks and interlocks were successfully tested
- FLTS redesign and the new macro pulse generator are work in progress
- with their commissioning, the MPS PLC is to take over beam mode management and serve as the main MPS controller for guns, FLTS and subordinate PLCs
- this will allow parallel beam modes in a broader variety of beam options than ever before

project phase	steps	milestone / outcome
system design	define systems architecture and data interfaces to MRF system, WinCC and existing MPS (PLCs, FLTS)	MPS part of timing system specification
MPSPLC data modeling	define data model of timing parameters, guns, beams, beamlines and operation modes	data model & PLC configuration
MPS PLC implementation	define parameter ranges and validity check logics implement provisional interfaces to existing MPS code MPS PLC timing part for injector 1 test interfaces and logics for current beam options develop WinCC GUI and interface implement new macro pulse generator to MPS PLC test with injector 1 and new macro pulse generator code MPS PLC timing part for injector 2 test with injector 2	 proof of principle pilot operation IN1 pilot operation IN2
FLTS redesign	design, build and test FLTS V2 modules design, build and test ILCK&OR-Box implement FLTS V2 drivers to MPS PLC replace FLTS	MPS ready for parallel beam options
MPS revision	implement gun, kicker and FLTS controls to MPS PLC revise PLC intercommunication implement beam mode state machine to MPS PLC revise beam diagnostics test parallel user options test parallel gun options	 parallel user beams parallel gun operation

References

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HZDR · Institute of Radiation Physics · ELBE Center for High-Power Radiation Sources
Matthias Justus · m.justus@hzdr.de · www.hzdr.de