A New PSS for the ELBE Accelerator Facility

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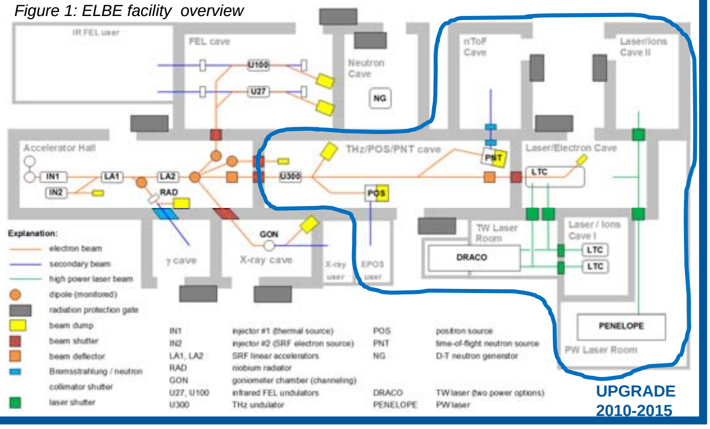
Receiving a larger facility upgrade since 2011 [1], ELBE will soon combine its 40 MeV c.w. electron LINAC (upgraded to 1.6 mA) with two high intensity laser facilities DRACO and PENELOPE [2] for laser driven particle acceleration and electron-laser beam interaction [3]. Due to Building expansion and new laser & radiation safety requirements, a complete redesign of the existing PSS was necessary:

- replacement of the aged out S5 based PSS in 2011
- extension for new or redesigned electron beam targets in 2012
- complete implementation for new laser target sites by end of 2013

The general building concept is to separate the accelerator or lasers from the target sites (fig. 1). Electron beam transport is possible through shutters in combination with dipole structures. Laser beams have to pass a subsurface chicane that is closed by shutters. The radiation protection caves are entered through shielding gates. Closing a room requires following a well-defined search procedure. Dose rate is measured in all monitored or controlled areas.

Figure 1: ELBE facility overview



Hazards and Risks Assessment

A detailed hazards and risks assessment was carried out following IEC 61508 [4], where the safety functions were formulated and their safety implementation level (SIL) was derived taking into account organizational measures (see table 1):

- Most safety functions for the electron accelerator demand SIL1 or SIL2.
- Laser related safety functions require no specific safety technology as the group of staff is small and radiation levels are comparably low with respect to the electron accelerator.

Table 1: hazards & risks , safety functions and SIL requirements

	dangerous event: health damage to person(s)...	safety reqirement	safety function
1	… left in restricted area through direct radiation by electron beam or RF field emission	SIL 1	search room for person(s), inhibit closing gate emergency stop button inhibit accelerator
2	… working in controlled area through direct radiation by misguided electron beam	SIL 2	monitor beam shutter (closed) and dipole (off) / deflector (in) inhibit accelerator
3	… in monitored area through direct radiation by electron beam or RF field emission inside cave while gate is open	SIL 2	monitor gate (closed) inhibit accelerator
4	… in monitored area through radiation by insufficient wall shielding	SIL 2	monitor dose rate outside cave emergency stop button inhibit accelerator
5	… in controlled area through radiation by insufficient wall shielding, shutter irradiation or open shutter	SIL 1	monitor dose rate inside cave, monitor beam shutter (closed) and dipole (off) / deflector (in) emergency stop button inhibit accelerator
6	… outside the caves through activated air	no specific requirements	monitor low-pressure inside caves, inhibit accelerator
7	… entering the cave after experiments through activated air	no requirements	air exchange purging inhibit opening gate
8	… left in restricted area through direct radiation by laser particle acceleration	no specific requirements	personal access control switch laser to alignment mode inhibit opening shutters
9	… in laser rooms/caves through direct laser light exposure (eyesight damage)	no specific requirements	personal access control switch laser to alignment mode inhibit opening shutters

Hardware Implementation

The new PSS is based on two Simatic S7-317F PLCs [4] connected by failsafe communication (fig. 2). Peripheral units are:

- key panel for basic operational modes
- GUI panels for service, operation and alarms (WinCC flexible [4])
- SCADA interface (WinCC [4]) for operation, data logs, alarms
- PLC system (standard technology) for dose rate data acquisition

Safety related I/O signals use binary failsafe channels with redundancy according to the SIL requirements in closed-circuit technology. These channels are subject to monitoring for wire break, short or discrepancies.

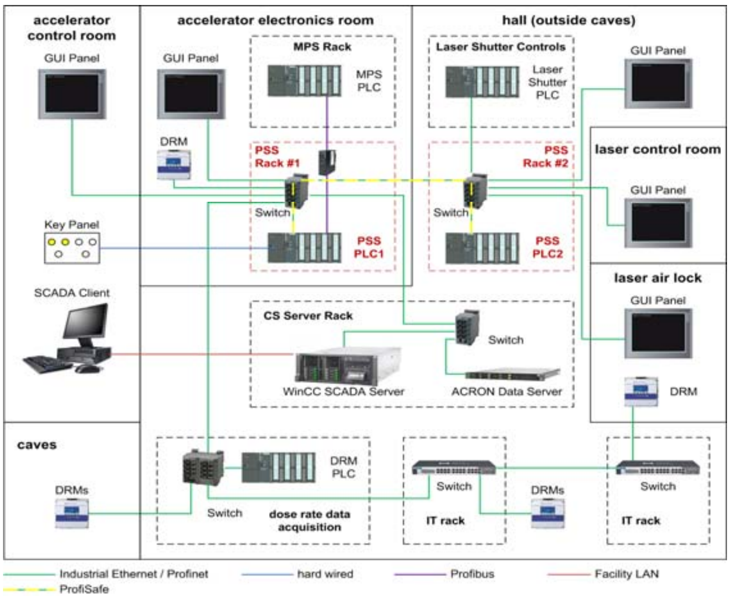


Figure 2: PSS hardware and connections (DRM = dose rate monitor)

PSS Software Implementation

The safety PLCs are configured and programmed using Step7 V5.5 [5]. Safety and standard program are separated by different code arrays. The safety code is executed in fixed cycle (100 ms) and is monitored for data falsification during execution. It includes all safety functions (see table 2). Unauthorized software or configuration changes will cause a CRC change and lead to loss of the approval of operation.

Table 2: PSS software main tasks

Safety Program	Standard Program
PSS operational modes	ventilation system monitoring
room search and status	oxygen monitoring
enable opening / closing doors	GUI / SCADA commands
enable accelerator & laser	alarm handling
interlocks detection	standard communication (MPS)
purge mode handling	
failsafe communication	
hardware monitoring	

References

[1] M. Kuntzsch et. al., *"Electron Bunch Diagnostic at the Upgraded ELBE Accelerator: Status and Challenges"*, Proceedings of IBIC 2013, Oxford, UK

[2] U. Schramm et. al., *"Harnessing laser plasma accelerators for radiation therapy - Lab status and recent results from Dresden"*, Proceedings of LPAW 2013, to appear in print

[3] A. Jochmann et. al., *"Operation of a picosecond narrow-bandwidth Laser-Thomson-backscattering X-ray source"*, NIM B 309(2013), 214-217

[4] *Functional safety of electrical/electronic/programmable electronic safety-related systems*, IEC 61508 (ed. 2) 2010

[5] www.automation.siemens.com, Siemens AG, 2013

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