



Modular Hardware, Firmware, and Control-System Integration: Lessons from Commissioning the Fast Beam Interlock System at ESS

FBIS at ESS: a distributed FPGA-based machine protection system

- ESS, Lund: most powerful neutron source under construction.
- The FBIS (Fast Beam Interlock System) must stop beam and machine within microseconds.
- It is a distributed system along the 600 meter of the linac that interfaces ~ 250 systems (mostly FPGA systems).

- 32 crates: 7 mTCA and 25 cPCI.
- Zynq Ultrascale MPSoC and Kintex Ultrascale.
- VHDL and 32 parametrized different firmwares.
- Synchronization using MRF timing system.

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One framework, simulation and hardware — **what do YOU use?**

- Simulation: Cocotb + GHDL/Questa.
 - Vunit, OSVVM, UVVM, others ?
- Build system / Package manager.
 - FuseSoC ? HDL make? Others?
- IP core libraries.
 - SURF, PSI cores, PoC (PLC2), Open Logic, General cores, others ?
- AI tools in the workflow.
 - i.e. Claude in VS Code.
- CI/CD.
 - Simulation only? Only reports? Full HIL/FAT ?