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Status of the CLARA Control System

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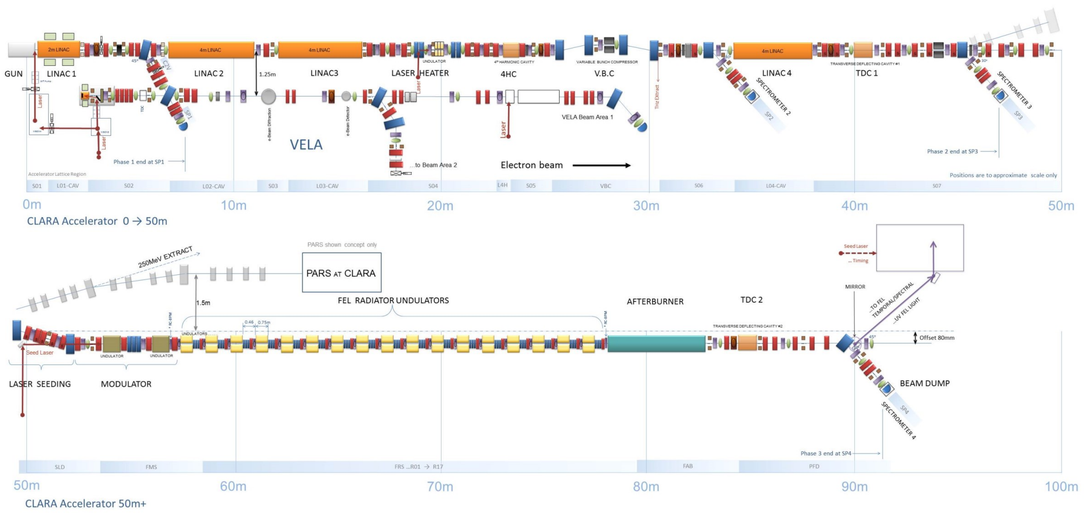
STFC Daresbury Laboratory has recently commissioned Phase 1 of CLARA (Compact Linear Accelerator for Research and Applications), a novel FEL (Free Electron Laser) test facility focussed on the generation of ultra-short photon pulses of coherent light with high levels of stability and synchronisation. The main motivation for CLARA is to test new FEL schemes that can later be implemented on existing and future short wavelength FELs. Particular focus will be on ultra-short pulse generation, pulse stability, and synchronisation with external sources. Knowledge gained from the development and operation of CLARA will inform the aims and design of a future UK-XFEL. The control system for CLARA is a distributed control system based upon the EPICS software framework. The control system builds on experience gained from previous EPICS based facilities at Daresbury including ALICE (formerly ERLP) and VELA.

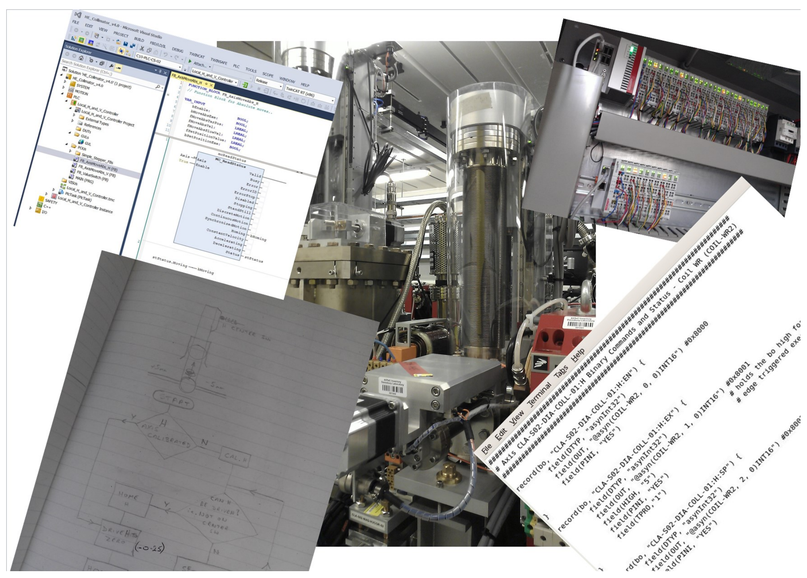
CLARA

CLARA will be primarily an FEL R&D facility and will inform the aims and design of a future UK-XFEL. It is being constructed across three main phases. Phase 1 is the front-end of the facility which has recently been commissioned. It includes the photo-injector and first linac (up to 50 MeV)and has recently been commissioned. Phase 2 will begin installation early in 2019 and includes all of the accelerating sections (up to 250 MeV). Phase 3 is the FEL section and will be installed following commissioning and a short operational period of the accelerator section.

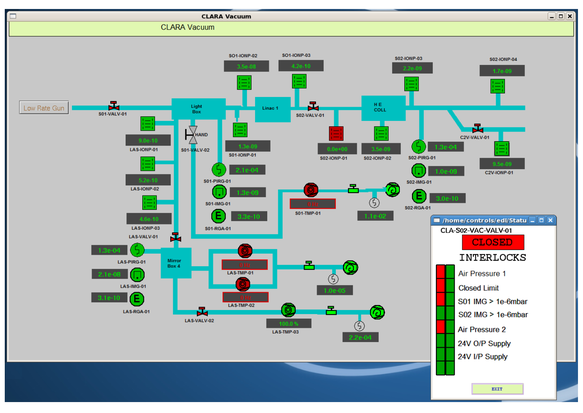


Motion Control

Beckhoff EtherCAT fieldbus motion control systems have been chosen for CLARA. Phase 1 has been implemented using TwinCAT 3 and CX5020 embedded PCs with EtherCAT modular I/O terminals. A virtual PLC running in the PC handles feedback from sensors and controls motors and servos in a closed loop. Integration with EPICS is via Modbus TCP protocol.



Status & Interlocking



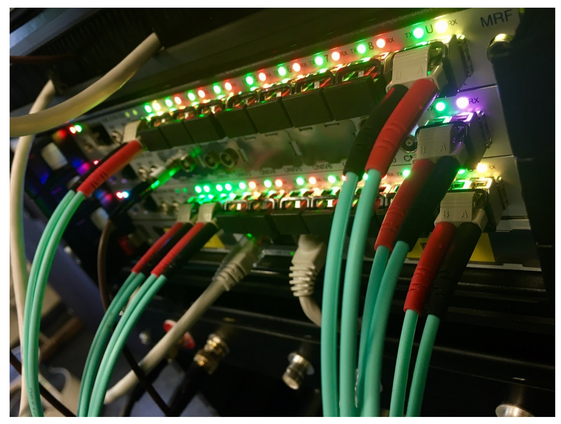
The status & interlocking system is responsible for on/off control and interlocking of hardware on the facility. It provides slow (>10ms) machine protection for technical sub-systems by only allowing operation of devices when predetermined conditions are met. It comprises of Omron CJ2M PLCs with digital I/O modules to marshal signals to and from hardware. ADC modules are also used to allow analog levels to produce interlocks directly within the PLC.

RF Control

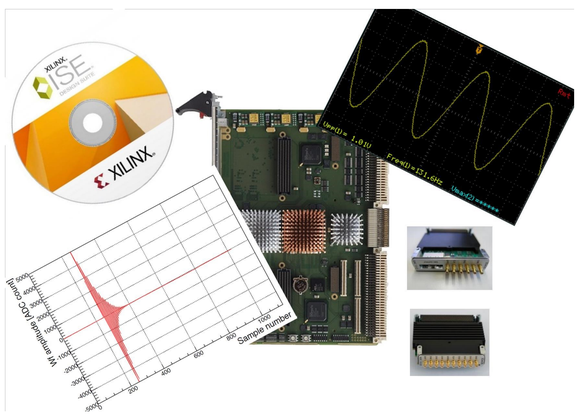
LLRF on CLARA is provided by Instrumentation Technology Libera systems running an EPICS IOC on-board. High power RF to the gun is provided by a ScandiNova modulator and linac 1 by a Diversified Technologies modulator. The modulators are integrated with EPICS via an ASCII protocol and Modbus TCP respectively.

Timing System

A stable and reliable timing system is essential for a pulsed machine. The MRF system chosen for CLARA is fully integrated into the control system. We use the delay compensated MRF 300 series boards in both VME and PCIe form factor. The system is synchronised to the 50Hz AC mains and is used to synchronise various technical sub-systems with high precision and is also crucial for beam synchronous data acquisition.



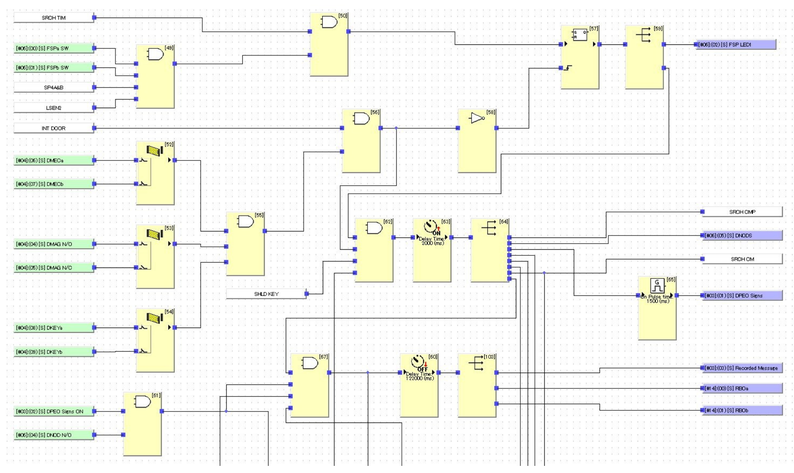
Beam Diagnostics



Stripline BPMs are digitised by a VME based system originally developed for EMMA. The system has been migrated from the MVME5500/vxWorks architecture of EMMA to the IOxOS IFC1210/Linux architecture for compatibility with the timing system. Diagnostic signals from cavity BPMs, bunch charge monitors, laser power meters and beam loss detectors will be sampled via systems using FMC data acquisition cards mounted on VME IFC1210 boards running EPICS.

Personnel Safety System

The PSS controls the generation of ionising radiation by enabling the operation of the electron gun and RF cavities. The gun and RF cavities may only be operated when the appropriate accelerator areas have been searched and interlocked. The PSS uses Omron Safety Network Controllers and DST1 series safety I/O terminals to construct a safety control network, providing safety logic operations and a DeviceNet Safety protocol.



Virtual Accelerator

To allow physicists to rapidly prototype and test applications whilst the facility is under construction an EPICS integrated accelerator model has been developed that will allow rapid test and optimisation of these applications against a simulation before they are commissioned and operate on the real machine. Electron beam transport is modelled using the particle tracking code ASTRA.