Science & Technology Facilities Council

www.stfc.ac.uk

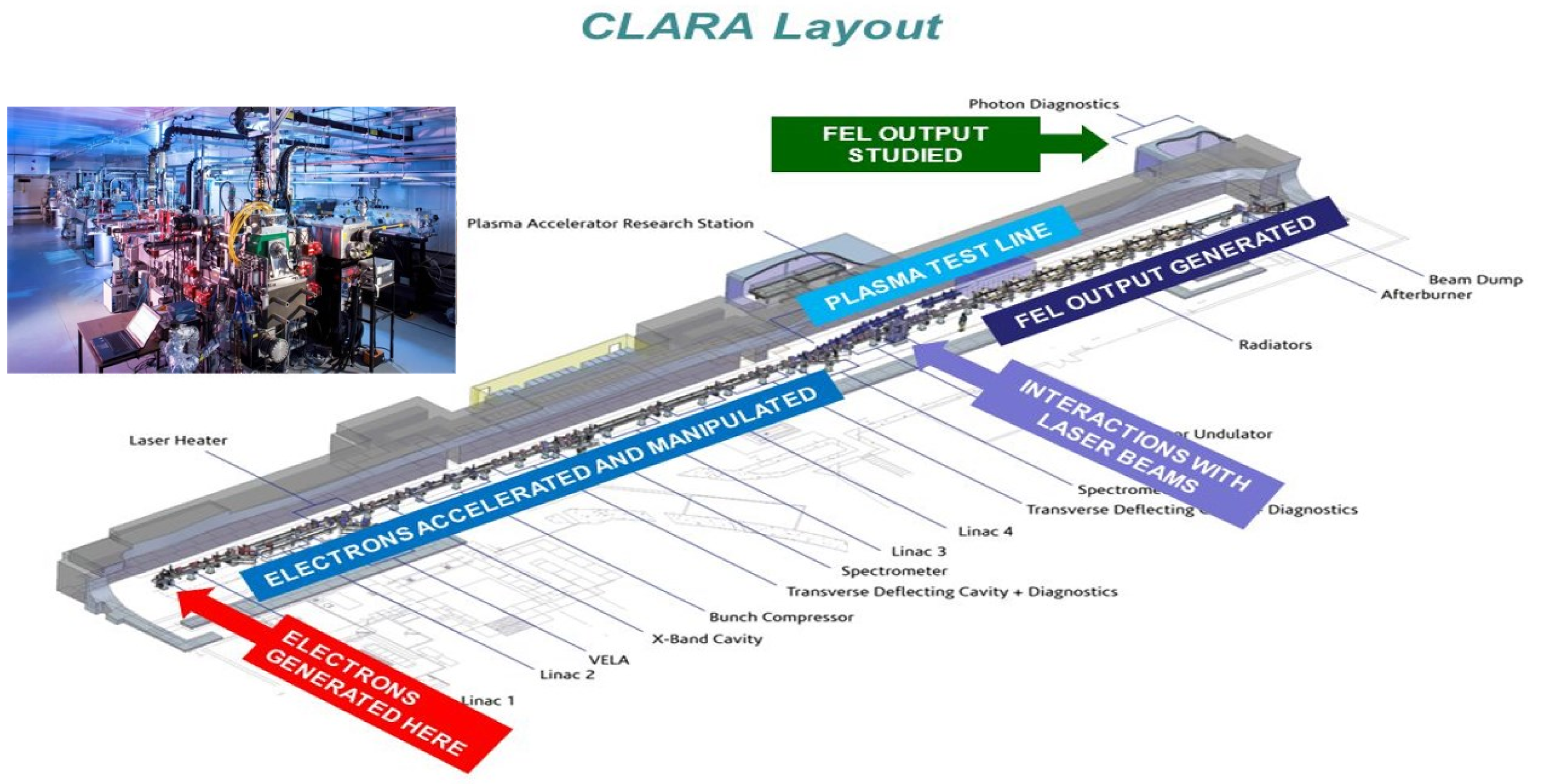
CLARA Virtual Accelerator

R.F.Clarke, G.Cox, D.M.Hancock, P.W.Heath, B.G.Martlew, A.Oates, P.H.Owens, W.Smith, J.T.G.Wilson, STFC Daresbury Laboratory, Warrington, UK
With thanks to T.Price , D.J.Scott, ASTeC, STFC Daresbury Laboratory

STFC Daresbury Laboratory is developing 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. To aid in the development of high level physics software, EPICS, a distributed controls framework, and ASTRA, a particle tracking code have been combined to simulate the facility as a virtual accelerator.

CLARA Free Electron Laser

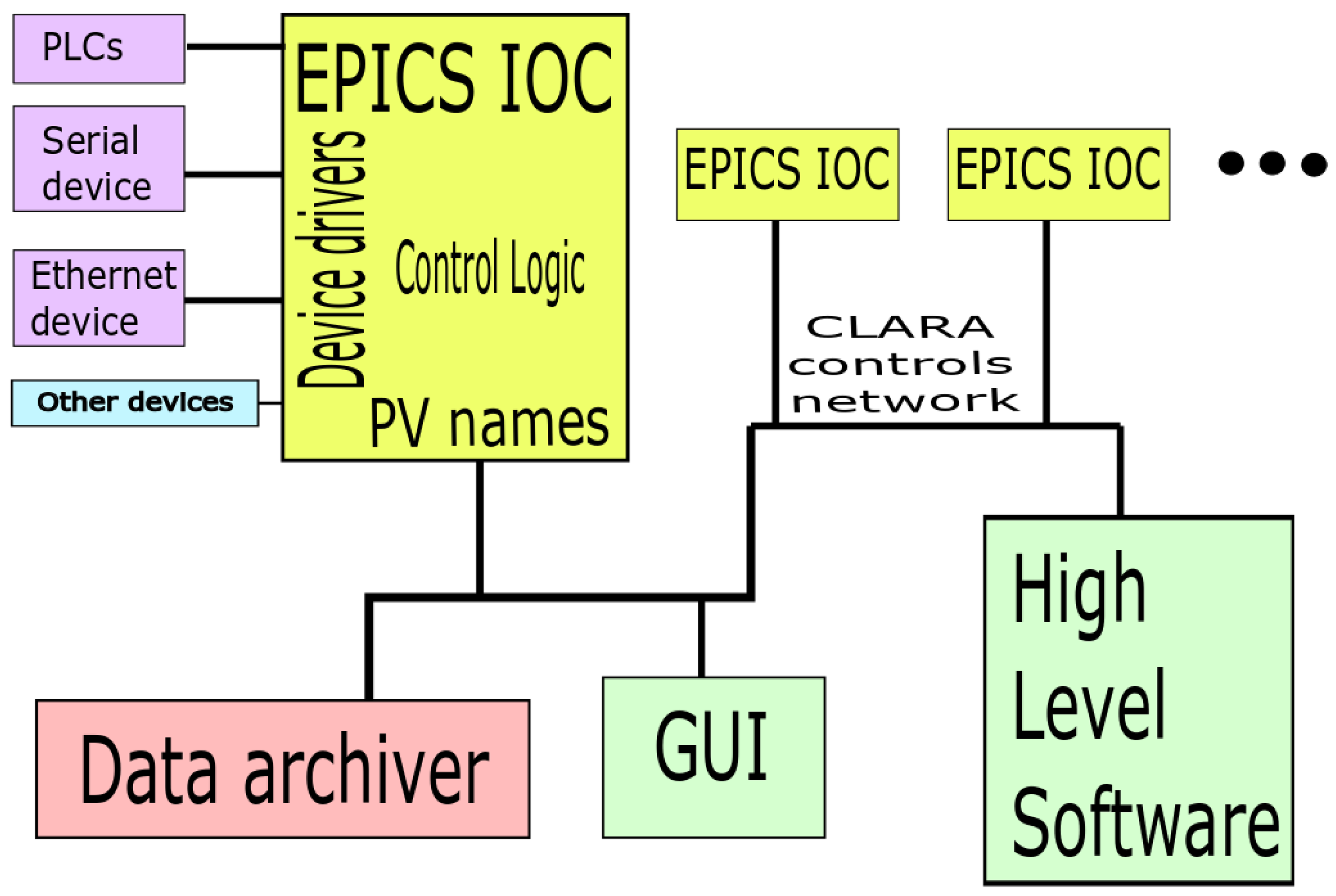
A beam of relativistic electrons are "wiggled" by passing them through a periodic magnetic field called an undulator. This transverse acceleration creates monochromatic but uncorrelated synchrotron radiation



By adding a laser, the transverse field of the radiation will interact with the electron beam causing micro-bunching of the electrons. The micro-bunching causes the free electron laser, FEL, to generate short, highly stable, coherent radiation pulses that are several orders of magnitude greater than the undulator..

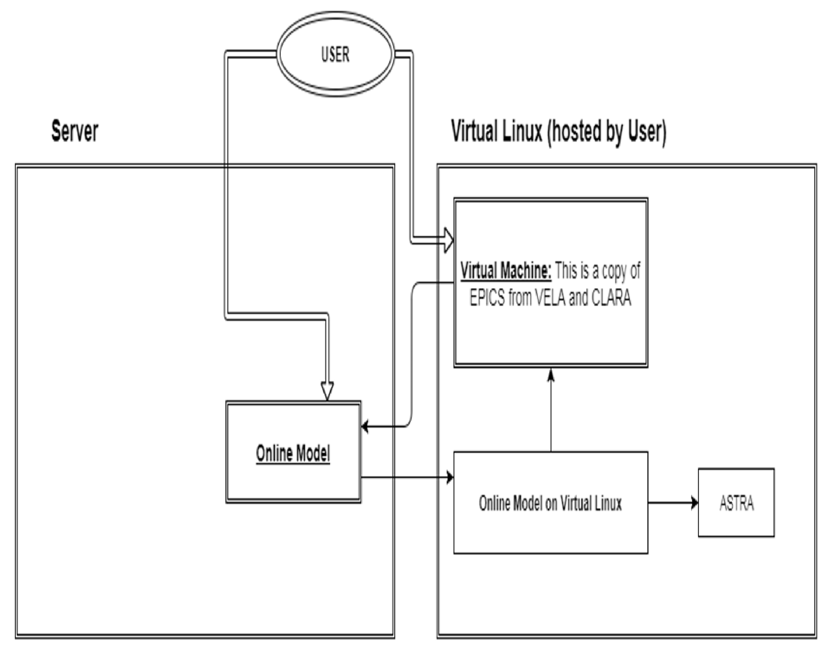
The EPICS Virtual Accelerator

A virtual accelerator allows offline development of high level applications needed for the CLARA FEL to operate, these applications can be developed in parallel while CLARA is under construction and commissioning.



The CLARA technical sub-systems are managed within a distributed control system implemented with the EPICS software toolkit. The core of EPICS are IOCs that provide common controls over a network via Process Variables. A virtual accelerator has been made that simulates CLARA subsystems. The virtual PVs can be used without any particle tracking, providing simple functionality. In the case of magnets; current and interlocks. This mode has been used in the development of GUIs and State Machines.

Beamline Simulation: The Online Model

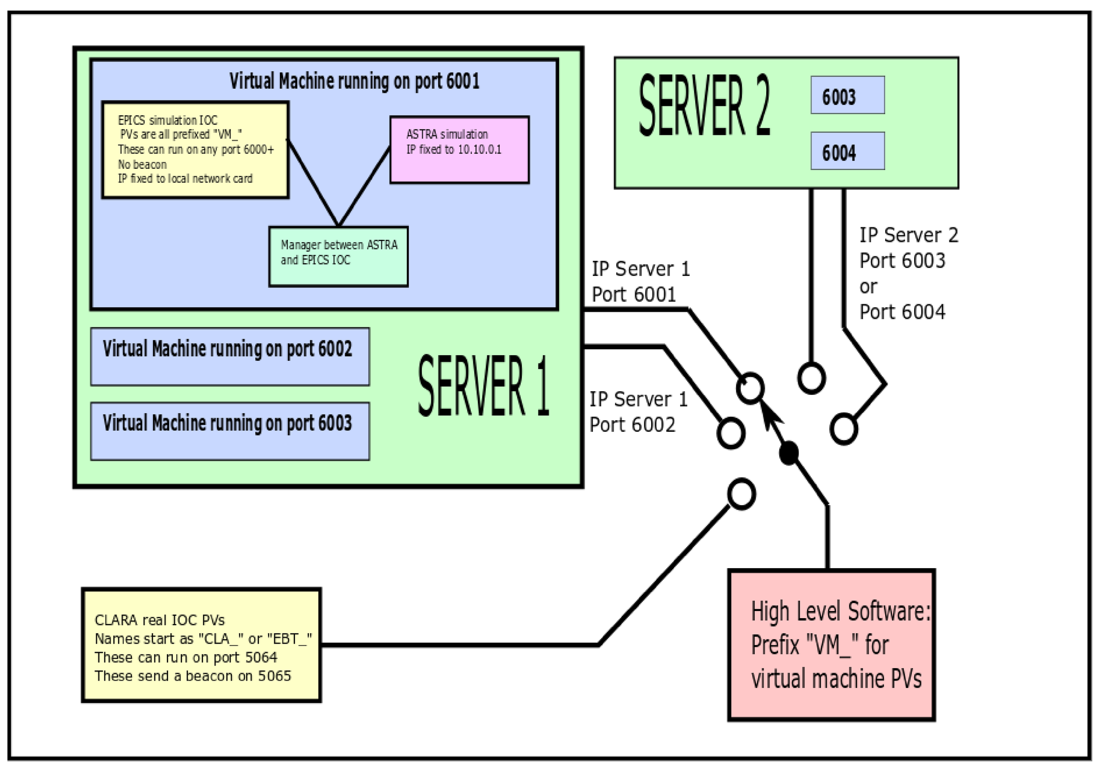


The virtual accelerator also contains a particle tracking framework built around ASTRA. This is called the Online Model and is use to model the transport of electrons through the accelerator. Settings from PVs for the low level RF and magnets are sent to the online model and electron bunches simulated. Beam position results are fed to the BPM and camera PVs . An example where this can be used is in particle orbit calculations. On a standard PC bunches of about 250pC take about 10 seconds to model.

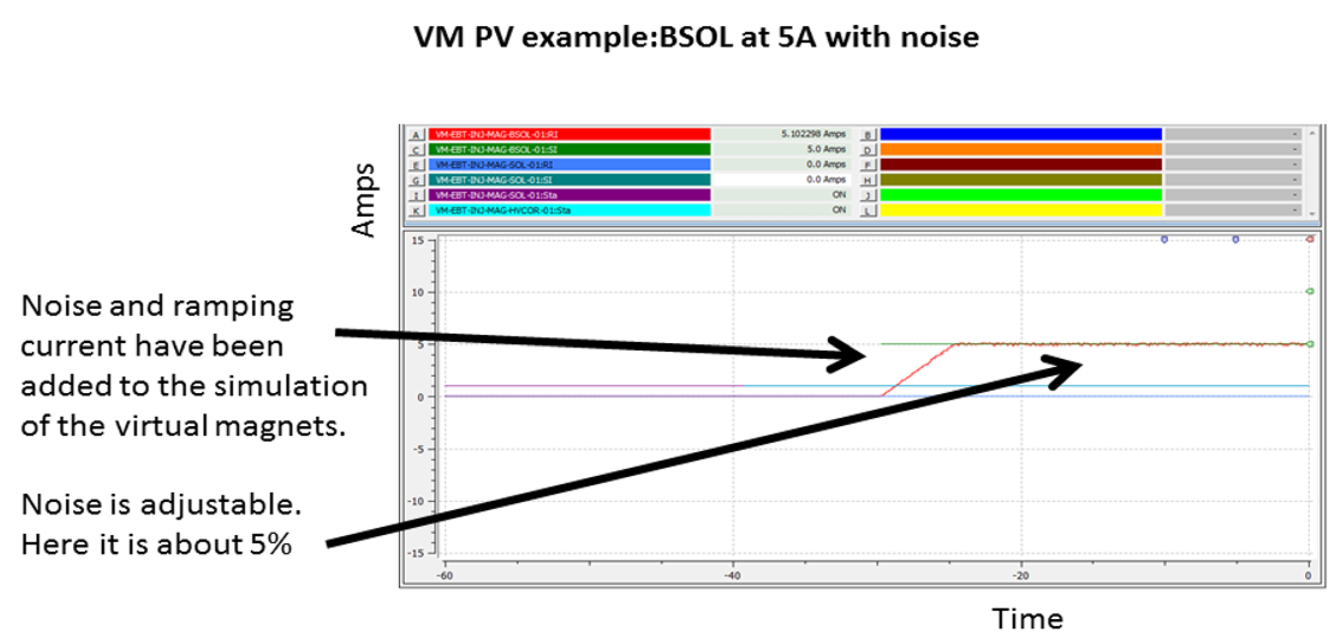
Networking, Cloning and Distribution

To use the virtual accelerator, a virtual machine is downloaded and installed on a local PC. It automatically starts all IOCs and network configurations in the background on startup. In previous versions, the virtual IOCs were simply restricted to a virtual machine with no network access outside the host. To improve functionality in later versions network access had to be granted in such a way that virtual PVs could not interfere with the CLARA PVs and multiple instances of the virtual accelerator could run concurrently. Port numbers are remapped for each virtual IOC and each virtual IOC is denied access to the CLARA controls network IP range, a feature found in EPICS versions greater than 3.15.

The virtual accelerator is now upgraded from a local GitHub repository. The networking features added to this version allow the virtual accelerator to run multiple instances and will allow ASTRA and the online simulations to run on separate servers. These upgrades will allow more powerful simulations to run with future versions of the online model run on dedicated servers



Example of Virtual Magnet



This is an example of a virtual magnet used to test a new Qt GUI striptool running under EPICSQt. The full online model is not needed here and just a basic set of magnet parameters are being simulated. Here the magnet current ramping, interlocks and noise are being generated in the virtual IOC. This tests was useful for rapid application development for CLARA GUIs

Science & Technology Facilities Council
10 Years of Impact and Inspiration

ICALEPCS2017