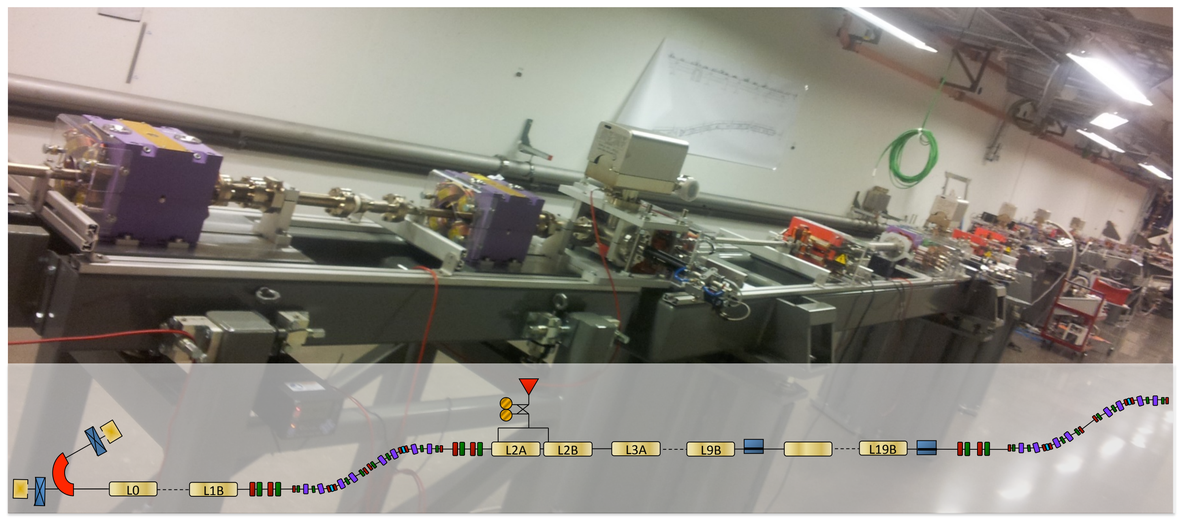
100Hz data acquisition in TANGO at the Max IV linac

Paul Bell, Vincent Hardion and Vincent Michel, Max IV Laboratory, Lund, Sweden

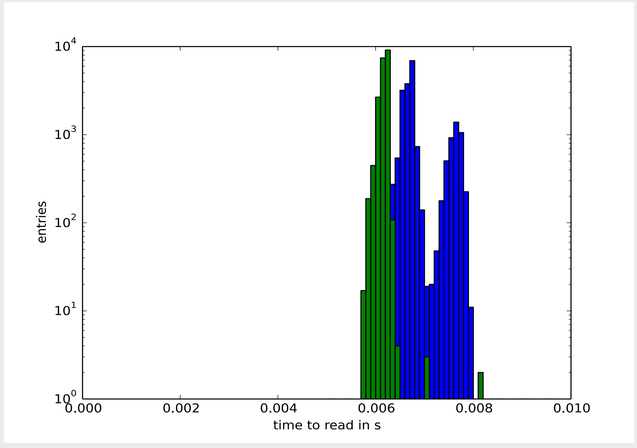
Introduction

The MAX IV synchrotron radiation facility is currently being constructed in Lund, Sweden. The accelerator complex consists of a 3GeV, 250m long full energy linear accelerator (linac), two storage rings of 1.5GeV and 3GeV and a Short Pulse facility (SPF). The repetition rate of the linac is a maximum of 10Hz when serving as the injector for the storage rings and 100Hz when providing pulses for the SPF. The controls system, based on TANGO [1], is required to collect and archive data from several different types of hardware at up to this 100Hz rate. These data are used, for example, in offline beam diagnostics, for which they must be associated with a unique trigger number (electron bunch number). To meet these requirements a Fast Archiving system has been designed, a prototype version of which is currently deployed at the linac.



Timing Studies

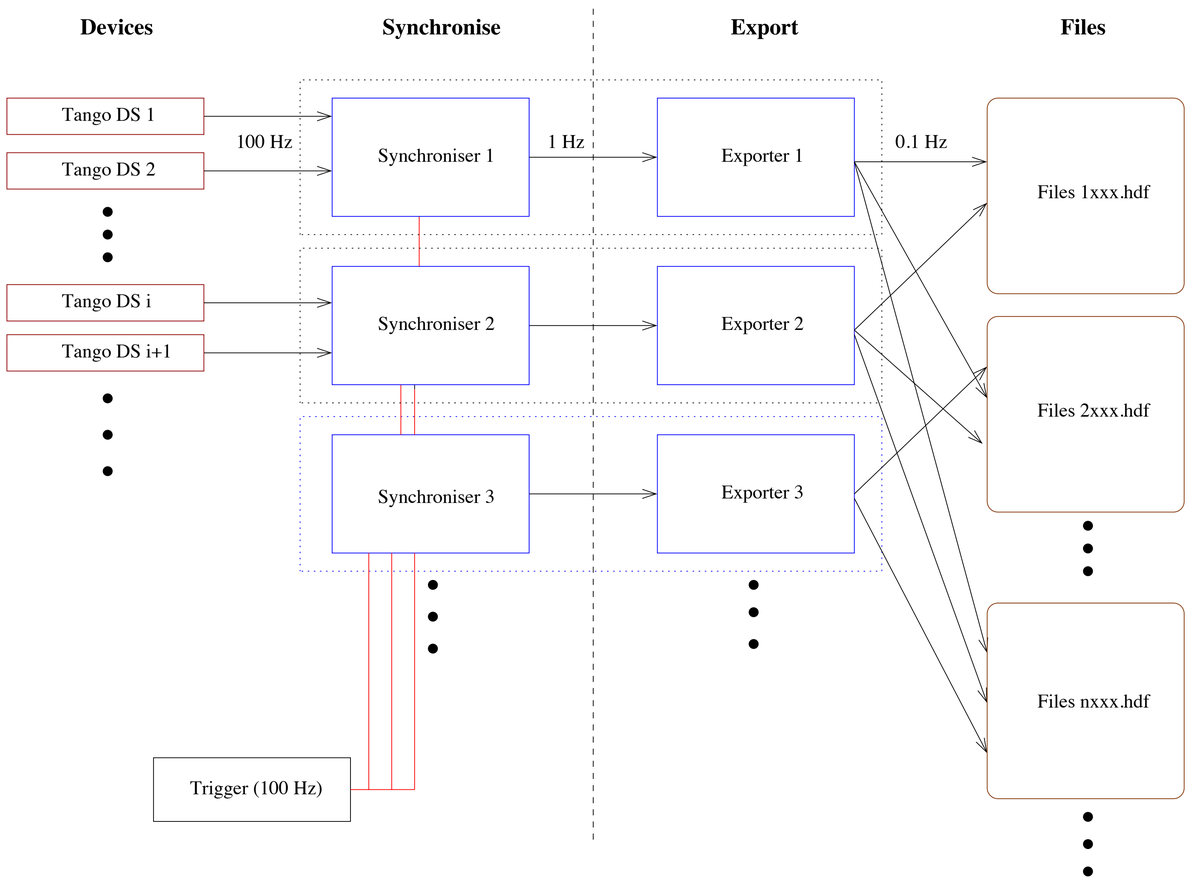
Most equipment is interfaced directly to TANGO via TCP/IP. As a pre-requisite for participating in the Fast Archiving, timing studies are performed on the hardware inside and outside of the TANGO system. Scripts are used to poll attributes many thousands of times and analyse the response time distribution, which must lie within 10ms.



Distribution of time taken to read the current from a power supply over a direct raw socket (green) and via the "Current" attribute in TANGO (blue). The difference gives an indication of the overhead of the control system.

Oscilloscope Integration

Many Rohde & Schwarz RTO oscilloscopes [2] are used to measure the distribution in time of the charge of the passing electron bunches as captured by Current Transformer devices located along the length of the linac. This "Waveform" attribute, which is a spectrum of length up to 10,000, can be read from all channels of an oscilloscope simultaneously in around 3ms, acceptable for 100Hz operation. The oscilloscopes receive an external trigger synchronised with the repetition rate of the linac. Their TANGO devices are configured to wait for the external trigger and block until a new waveform is captured. Each time a new acquisition is made, the device sends a TANGO event containing both the waveform data and its timestamp. This event is guaranteed to correspond to the previous trigger. Tests in the laboratory show that no triggers are missed at 100Hz.

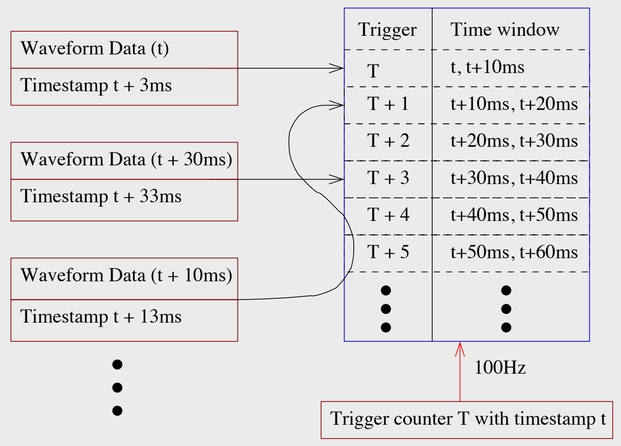


Fast Archiver

The design of the Fast Archiver is shown below left. The only requirement on the individual devices that participate is that they push events at sufficiently high frequency, as previously described for the oscilloscopes.

Synchroniser

The *Synchronisers* subscribe to events from one or more participating devices, and also to events from the Libera [3] timing system, containing the unique trigger number and its timestamp. The *Synchroniser* device then associates the data to be archived with the correct trigger number, irrespective of the event order.



Exporter

After being associated to a trigger number the data are buffered in the *Synchroniser* devices until a separate process, the *Exporter*, requests them. The Exporter writes the data to hdf5 files according to the trigger counter, where one new file is made for each new batch of 1000 events.

Performance

A single Fast Archiver device taking the data from a single oscilloscope device has been successfully tested in the laboratory, using a 100Hz external trigger on the oscilloscope. For the MAX IV linac a Fast Archiver system comprising 18 Synchroniser devices has been deployed. These are currently archiving 152 waveform attributes from 38 oscilloscope devices, though the maximum repetition rate of the linac has so far been 0.50 Hz.

References

[1] The TANGO Control system website: http://www.tango-controls.org
[2] Rohde and Schwarz RT0 1024 Digital Oscilloscope on the R&S website: https://www.scope-of-the-art.com/en/rto/0
[3] Libera Single Pass E, Electron beam position processor for single pass machines http://www.i-tech.si/accelerators-instrumentation/single-pass-e

The MAX IV Laboratory

The MAX IV Laboratory opened for operation in 1987 (under the name MAX-lab) and is a national laboratory operated jointly by the Swedish Research Council and Lund University. The laboratory supports three distinct research areas: Accelerator Physics, Research based on the use of Synchrotron Radiation, and Nuclear Physics using high energy electrons.

At present three synchrotron storage rings are in operation MAX I-III and each year close to 1000 researchers visit the laboratory to perform experiments. The MAX IV laboratory is also responsible for the build up of the MAX IV facility situated in the Brunnshög area just outside of Lund and approximately 2 km from the present facility.