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FLASHForward: DOOCS CONTROL SYSTEM FOR A BEAM-DRIVEN PLASMA-WAKEFIELD ACCELERATION EXPERIMENT

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Abstract

The FLASHForward project at DESY is an innovative beam-driven plasma-wakefield acceleration experiment integrated in the FLASH facility, aiming to accelerate electron beams to GeV energies over a few centimeters of ionised gas. These accelerated beams are tested for their capability to demonstrate exponential free-electron laser gain; achievable only through rigorous analysis of both the driver and witness beam's phase space.

The thematic priority covered in here the control system part of FLASHForward.

To be able to control, read out and save data from the diagnostics into DAQ, the DOOCS control system has been integrated into FLASH Forward. Laser beam control, over 70 cameras, ADCs, timing system and motorised stages are combined into the one DOOCS control system as well as vacuum and magnet controls. Micro TCA for Physics (MTCA.4) is the solid basic computing system, supported from high power workstations for camera readout and normal Linux computers.

FLASH

FLASH [1], a soft X-ray free-electron laser, is available to the photon science user community for experiments since 2005. Ultra-short X-ray pulses, shorter than 30 femtoseconds, are produced using the SASE process. The FLASH facility operates two SASE beamlines in parallel: FLASH1 & FLASH2 and as third beamline FLASHForward (see Fig. 1). Pulses of FLASH come in bursts of several hundred pulses with a repetition rate of 10 Hz.

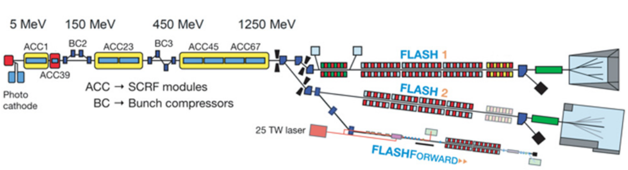

Figure 1: FLASH layout.

DOOCS INSIDE FLASHFORWARD

As FLASHForward is part of FLASH, it is obvious to us also the FLASH control system infrastructure DOOCS. The whole server architecture as existing hardware and software is a big advantage to integrate the needed detector hardware for FLASHForward.

As most of the FLASHForward part is a laser system, diagnostic is slightly different as in FLASH. Laser alignment can be detected with chip cameras. Hence the amount of cameras is increasing easily to more than 70. Other components, like the timing system must be adapted in FLASHForward to get a synchronization to FLASH, which is necessary for all data taking.

In the following chapters a short description of the most important components and systems are made.

DOOCS CONTROL SYSTEM

DOOCS, the Distributed Object Oriented Control System [2] was designed for FLASH. Currently it is extended to control the European XFEL accelerator (see Fig. 2). Recent developments for the client side applications are written in JAVA to allow them to be used on many computer platforms. This object oriented abstraction model helps for clean programming interfaces and in the overall system design including the hardware for a machine and is a significant step forward in the goal to improve software productivity and quality.

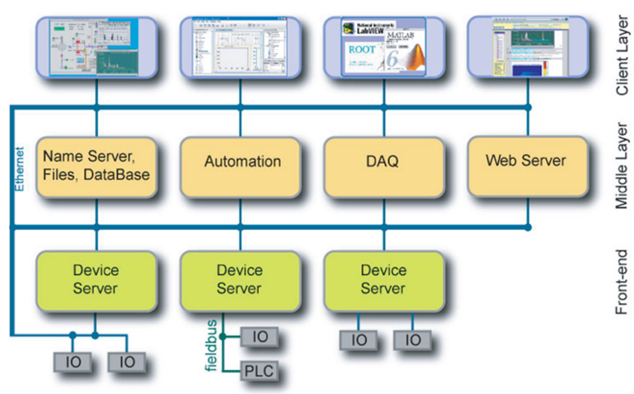

Figure 2: DOOCS structure.

COMPUTING HARDWARE

MicroTCA.4, is a new standard form the PICMG to extend the applications of the existing µTCA crate system. This extension was developed in an international collaboration of High Energy Physics laboratories and many industrial partners within the PICMG organization. It is fully

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compatible with the µTCA crate standard and adds Rear Transition Modules as well as timing and synchronization support. Using this standard makes operation easier, especially in maintenance, reliability and speed. New components like ADCs or Timing systems are working faster and more reliable as in other, older systems like VME.

For reading out cameras from FLASHForward new and powerful DELL Power Edge R330 have been installed and also equipped with the DOOCS environment for better maintenance.

Standard PCs are used for less powerful tasks and to decrease costs if possible.

Several Apple Macintosh computers are completing the user interfaces in the control rooms. As they are also remote maintainable, updates of the operating system is fast and easy to do.

Raspberry Pis are used newly as cheap and good alternative to normal PCs. Detector components like spectrometer are connected here directly via USB and read out with installed DOOCS hardware servers.

OPERATING SYSTEMS

A single operating system can hardly support all necessary needs of a complex control system. Hence a good interaction of OSx, Windows and several Linux operating systems is mandatory. As each system has its benefits, it is helpful not to use only a single one, even it could have a simpler maintenance support.

COMPUTING SOFTWARE

A wide spread of different programming languages are supported at DOOCS and FLASHForward to give users a good and fast opportunity to realize their tasks within a given environment. C++, Python, Matlab or Labview are mentioned here as only a few available software packages. Drivers for integrating hardware or software interfaces from all languages into DOOCS are available or easy to design

CONTROLLED DEVICES

Numerous devices like vacuum components, magnets, optical mirrors, gas (Plasma), shutters, motors and cameras are necessary to drive, support and use a complex project like FLASHForward. To combine all components in one control system, DOOCS is here a good choice as more as system crossing more controls from FLASH are necessary to use within one GUI.

FLASH TIMING SYSTEM

The FLASH timing system [3] is necessary for all events and bunch pattern inside FLASH (see Fig. 3). All systems located in FLASH are depended from this information to work properly. The timing system is based on a new MicroTCA development which is also used in XFEL. The complex architecture guarantees a stable, reliable and ultra-low jitter functionality.

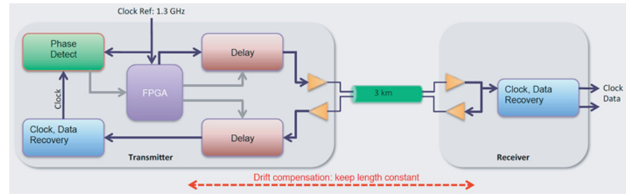

Figure 3: Timing System.

SYNCHRONISATION

FLASHForward is developed with an independent laser system made by Amplitude. To be able to produce plasma in FLASHForward and accelerate electrons from FLASH it is imperative that the same timing events are existing in FLASH and FLASHForward. Hence a complex synchronisation, as shown in Fig. 4 had to be installed, to fulfill the needs.

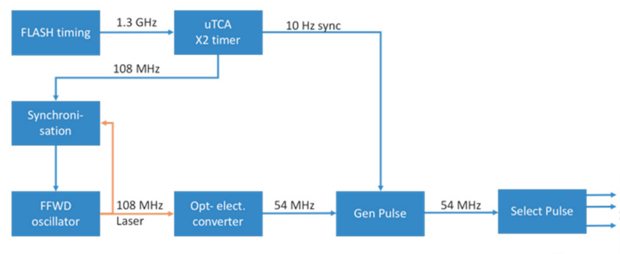

Figure 4: Synchronisation.

DATA ACQUISITION

A central DAQ server (Fig. 5) [4] records and stores the data of more than 900 channels with 1MHz up to 2GHz sampling and several images from the photon science experiments with a typical frame rate of 5Hz.

On this server all data is synchronized on a bunch basis which makes this the perfect location to attach e.g. high level feedbacks and calculations. An overview of the architecture of the DAQ system and its interconnections within the complex of the FLASH facility together with the status of the DAQ system and possible future extensions/applications will be given.

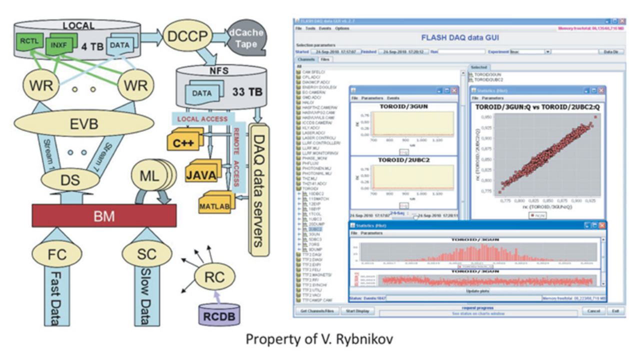

Figure 5: DAQ - Data Acquisition.

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DETECTORS

The main detectors of a laser system are networking pixel detector cameras. Cameras producing a big amount of data, which are used to do analysis of the laser beam itself. Inside FLASHForward are more than 70 cameras installed and their number is growing. To ensure a smooth and reliable dataflow from cameras into the control system, a quite big effort is necessary to distribute all cameras inside the control and network system to reduce the network traffic. Fig. 6 shows the general camera infrastructure.

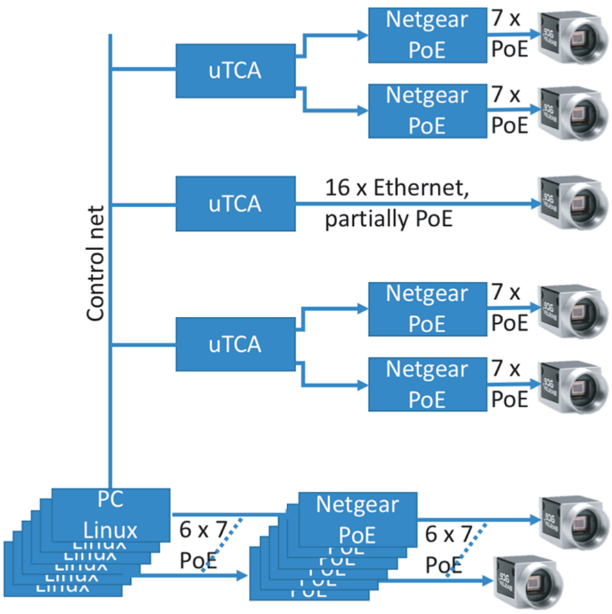

Figure 6: Camera infrastructure.

In addition Silicon Free-Space Amplified Photodetectors, like those shown in Fig. 7, are used as they are sensitive to light in the UV to the NIR wavelength range. The Photodetectors are connected to fast MicroTCA ADCs. Their data are stored not only locally, but also inside the DAQ system.

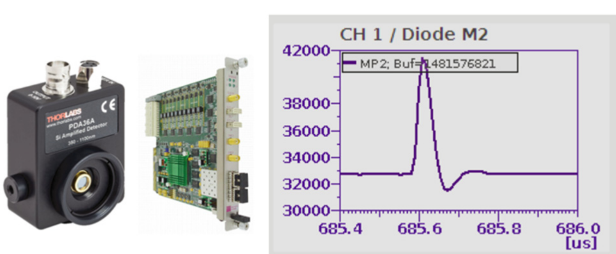

Figure 7: SI amplified photodetector with ADC.

MOVEMENT

Laser controlling is mostly possible with mirrors and lenses. By moving this equipment the laser can be tuned. The movement is done with several types of and stages motors (as shown in Fig. 8). Piezo motors are used as well as stepping motors. A high end solution is the operation of a 6 axis hexapod system which must have its own complex controller. All systems are integrated in DOOCS.

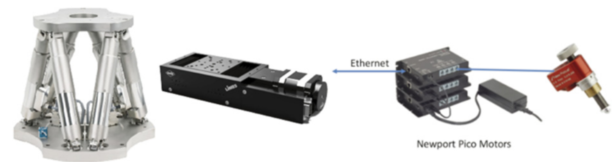

Figure 8: Motor systems (Hexapod, Stepper, Piezo).

GUI – GRAPHICAL USER INTERFACES

Last but not least a GUI interface is a must have. jDDD is part of the DOOCS control system to design GUIs. Panels can be create for every single property inside the DOOCS and allows simple, medium and complex displays of the whole system. An example is shown in Fig. 9.

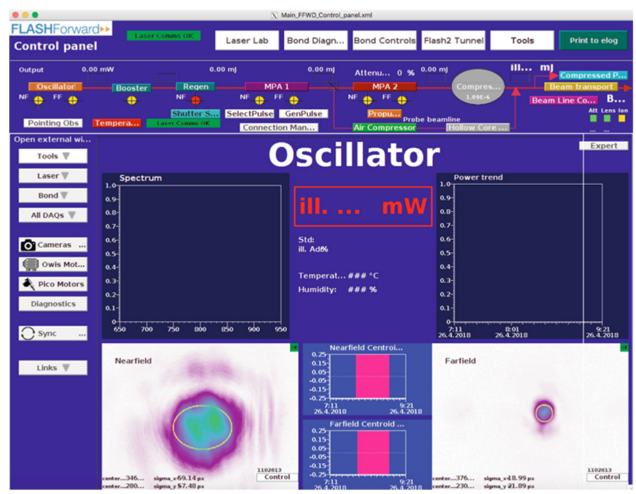

Figure 9: GUI example of a camera.

REFERENCES

[1] Free Electron Laser in Hamburg - FLASH introduction http://flash.desy.de

[2] DOOCS Architecture http://tesla.desy.de/doocs/doocs.html

[3] A. Aghababyan, C. Bohm, P. Gessler, A. Hidvégi, H. Kay, G. Petrosyan, L. Petrosyan, V. Petrosyan, K. Rehlich, "XFEL timing system", http://ttfinfo2.desy.de/doocs/Timing/CDRv2.2short.pdf

[4] V. Rybnikov *et. al.*, "The data acquisition system (DAQ) of the FLASH facility", RPPA25, in *Proceedings of ICALEPCS07*, Knoxville, Tennessee, USA, October 2007, paper RPPA25.