

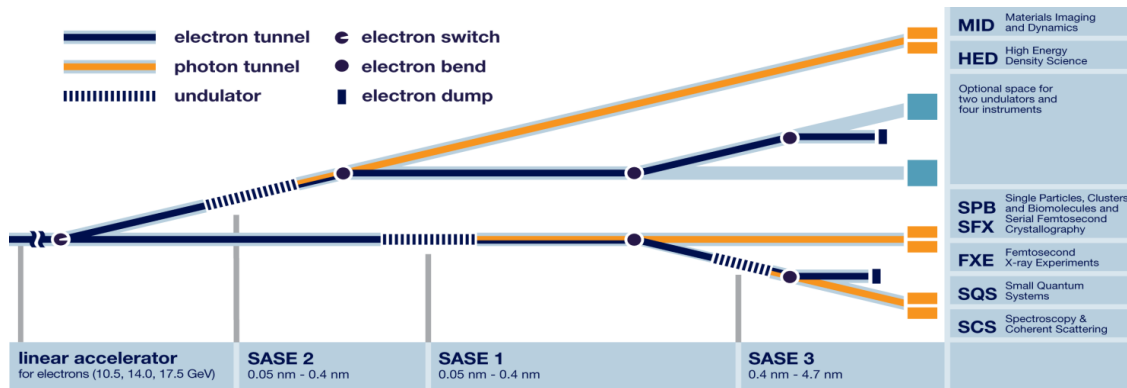
Overview, experience and first results of MTCA applications at European XFEL Experiments

Bruno Fernandes
Advanced Electronics

Hamburg, 6 December 2018



XFEL Overview



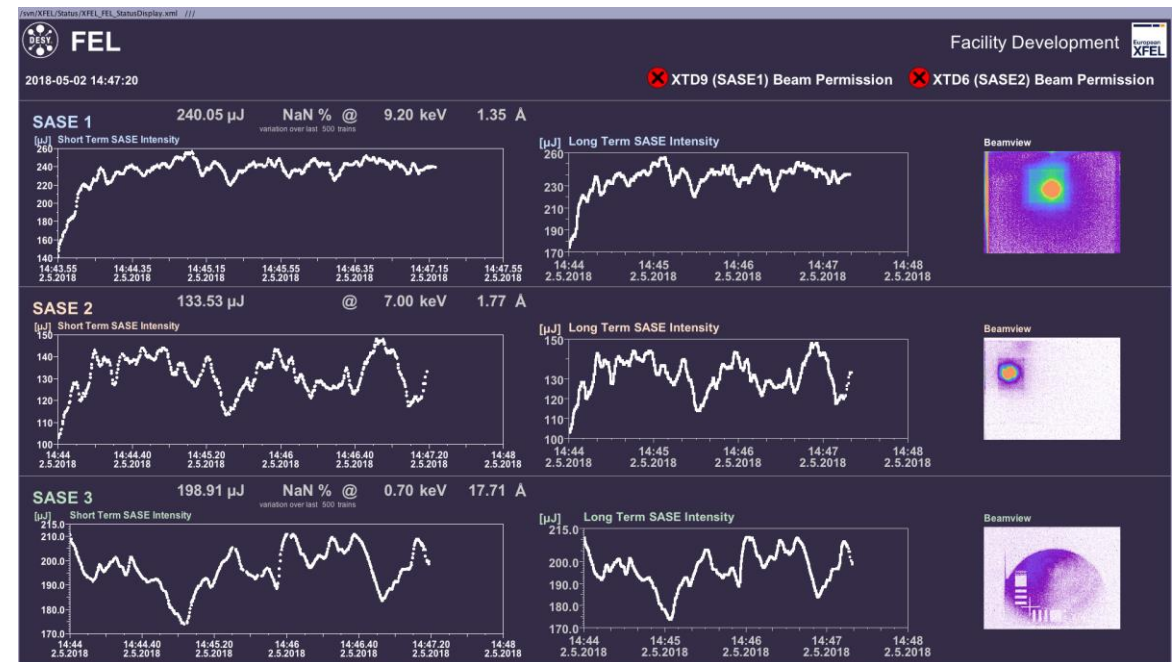
■ The European XFEL generates up to 2700 X-Ray pulses

■ Inter pulse separation of 220 ns

■ Train repetition of 10 Hz

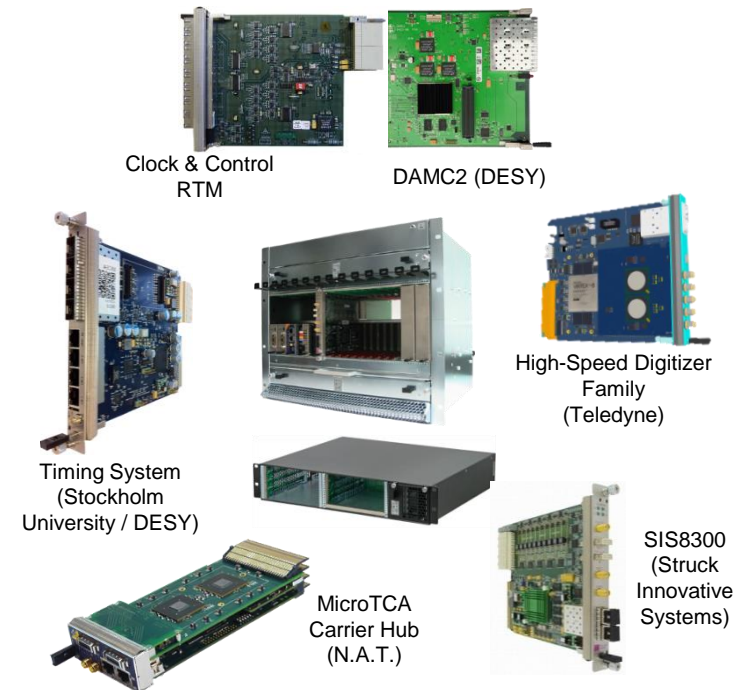
■ First user operation started in September 2017

Lasing in all three Undulators simultaneously



Installation went smoothly

- At photon beam lines, experiments and related laboratories at XFEL are **34 MicroTCA crates**
 - A lot of challenges had to be overcome and we are still learning
- MicroTCA platform is **the key component** for
 - Timing distribution (both in and outside the crate)
 - Digitizer raw and process data
 - Detector triggering and synchronization
- As such we must have
 - Workflows for installation, monitoring and diagnostics
 - Tools that allow us to quickly identify and solve problems
 - and also show that “**MicroTCA is not the issue**”



MCH Boards



- MCHs use configuration files uploaded via browser interface
- Most common options are covered by this procedure
- Remote access via ssh, telnet and browser

NAT-MCH by N.A.T.

Setup

[Base Configuration](#)
[JSM](#)

Switch: BASE 1GbE

[Age Time](#)
[Port on/off](#)
[Port VLAN](#)
[802.1Q VLAN](#)
[802.1X](#)
[802.1p](#)
[Port Mirroring](#)
[Jumbo Frame](#)
[Link Aggregation](#)
[Rapid Spanning Tree](#)
[Serdes/SGMII](#)
[Link Status](#)
[BCM5396 counters](#)

[Switch PCIe x48](#)
[PCIe Virtual Switches](#)
[Error Counters](#)
[Link Status](#)

Maintenance

[Script Management](#)
[Board Information](#)
[System Information](#)
[Reboot NAT-MCH](#)
[Update MCH](#)
[Change Password](#)
[N.A.T. Webpage](#)
[Home](#)

NAT-MCH Script Management

Download Configurations

Startup Configuration : [nat_mch_startup_cfg.txt](#) ⓘ

Running Configuration: [nat_mch_running_cfg.txt](#) ⓘ

Load/Delete Configurations

Startup Configuration : Load ⓘ

Startup Configuration : Delete ⓘ

Upload Configuration

1. Select local file: Browse... No file selected. ⓘ

2. Select upload option: ☒ Overwrite Startup configuration ⓘ

3. Submit upload: Upload

Verify Configuration

Select local file: Browse...

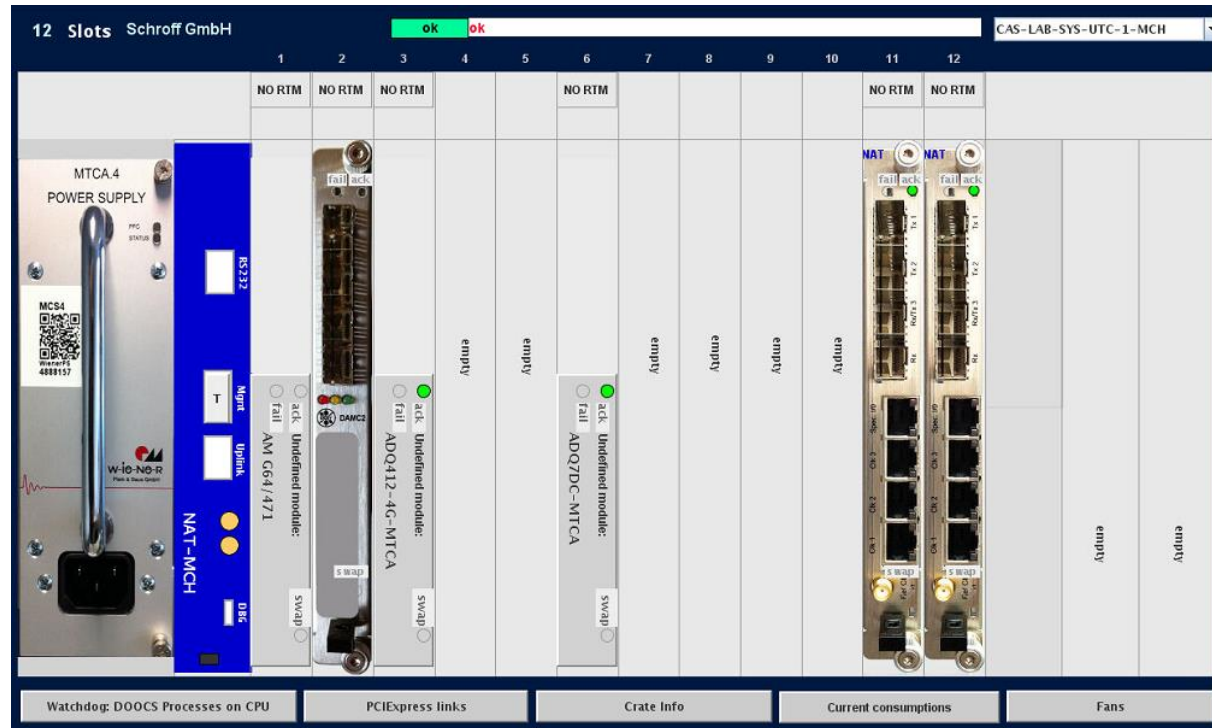
Verify

```
fernands@exflwgs06: ~
show_fru

FRU Information:
=====
FRU  Device  State  Name
=====
0    MCH      M4     NMCH-CM
3    mcmc1    M4     NAT-MCH-MCMC
5    AMC1     M4     CCT AM 902/411
7    AMC3     M4     X2TIMER
8    AMC4     M4     X2TIMER
9    AMC5     M1     DAMC2V3
10   AMC6     M4     DAMC2V3
40   CU1      M4     Schroff uTCA CU
50   FM1      M4     NAT-FM-AC600D
60   Clock1   M4     MCH-Clock
61   HubMod1  M4     MCH-PCIe
93   AMC4-RTM M4     X2TIMERRTM
94   AMC5-RTM M1     DAMC2RTM
95   AMC6-RTM M4     DAMC2RTM
=====

nat>
```

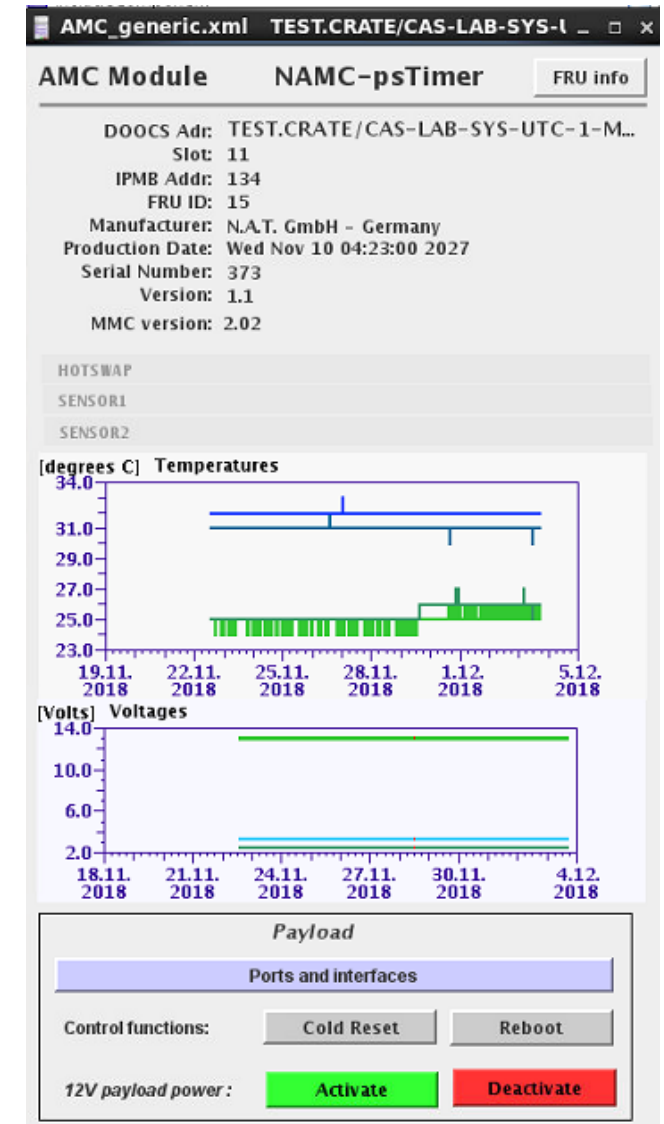
Remote crate management



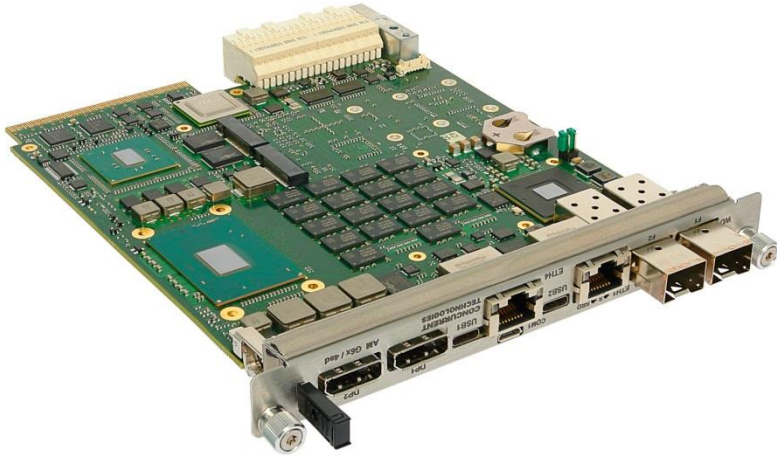
■ jDDD Panels to quickly verify content of crate and board sensors

■ Quick access to certain functions

■ Control Fans, reboot boards, control payload power...



CPU installation with Foreman and Puppet



- OS installation + Puppet **via network**
- New CPU shows up on Network
 - ▶ Foreman install OS and configures target Puppet Manifest
- Monitor Host resources

- Software, drivers, repositories, users, groups, permissions, network, etc.
- Different system types – tunnel, laboratories, rack room, development, instruments....



Nagios monitoring

Automatically send emails for the following situations:

- CPU/MCH down
- CPU Temperature/Sensors at critical level
- Hard disk almost full /Temperature
- NTP service running
- SSH service running

- SMS sent to On call Duty phones
- Immediate reaction to problems

Nagios

General

Home

Documentation

Current Status

Tactical Overview Map (Legacy)

Hosts

Services

Host Groups

Summary

Grid

Service Groups

Summary

Grid

Problems

Services (Unhandled)

Hosts (Unhandled)

Network Outages

Quick Search:

Reports

Availability

Trends (Legacy)

Alerts

History

Summary

Histogram (Legacy)

Notifications

Event Log

System

Comments

Downtime

Process Info

Performance Info

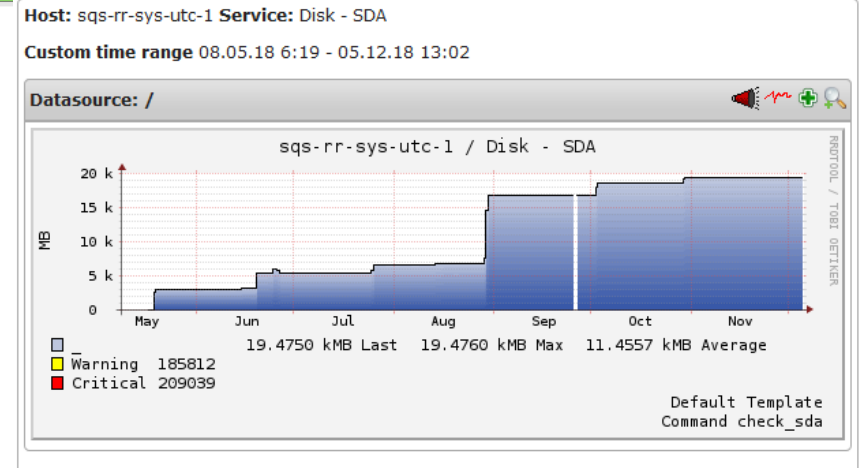
Scheduling Queue

Configuration

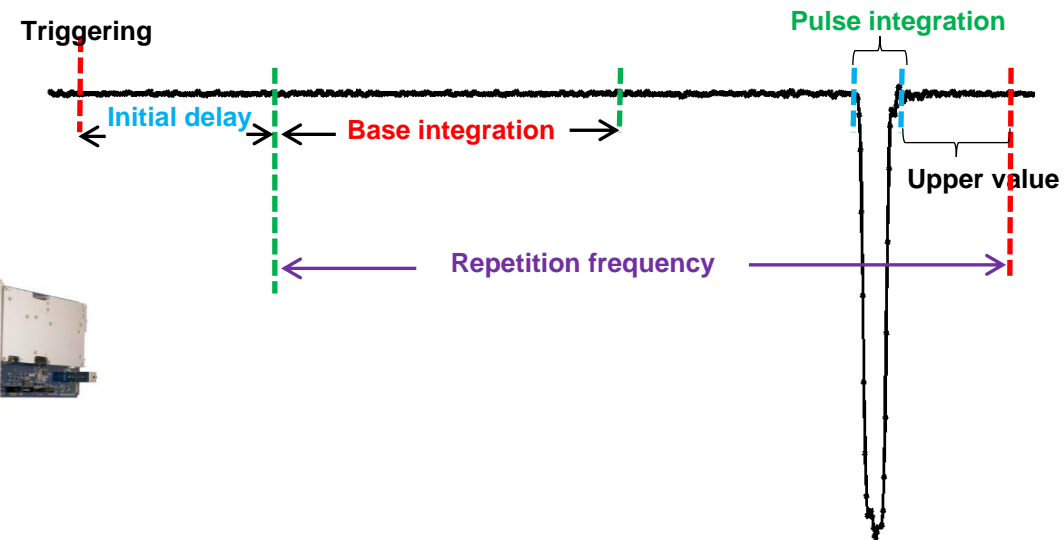
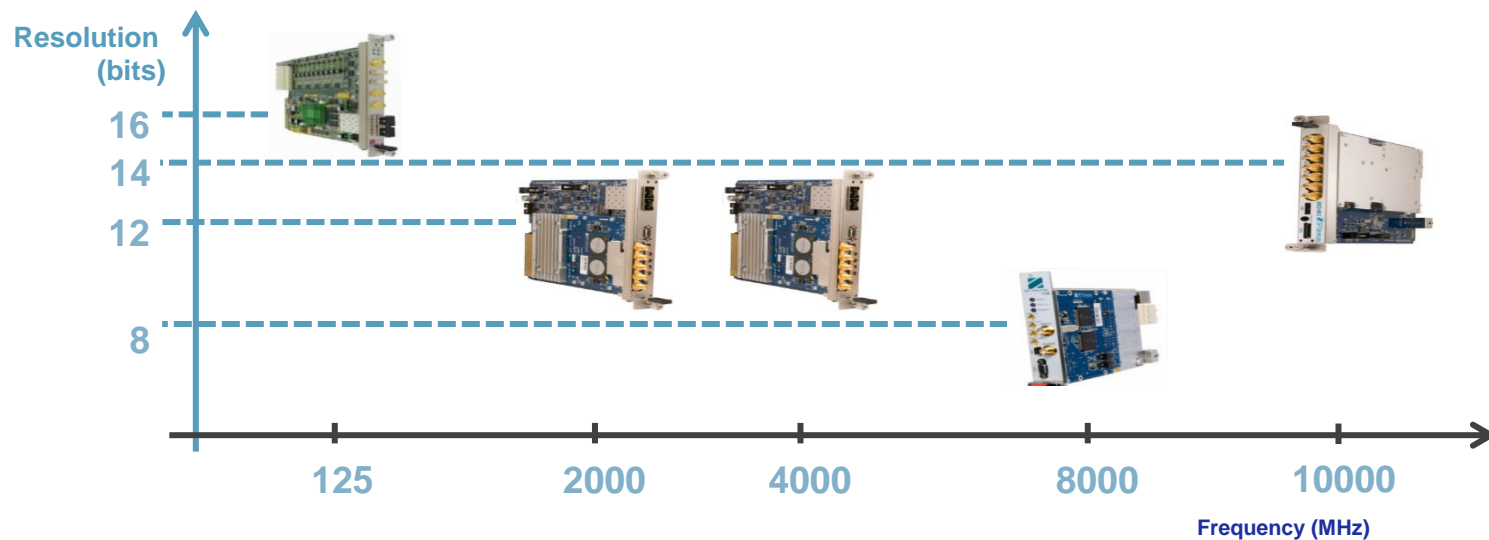
Status Grid For All Host Groups

UTC in XHEXP (utca-control)

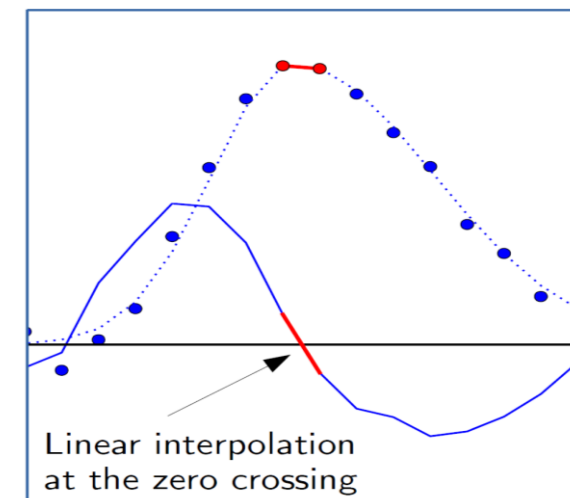
Host	Services	Actions
fxe-rr-sys-utc-1	CPU Temp, Disk - SDA, HDDTEMP, Load, NTP, SMART, SSH Service, Temperature	
fxe-rr-sys-utc-2	CPU Temp, Disk - SDA, HDDTEMP, Load, NTP, SMART, SSH Service, Temperature	
hed-opt-sys-utc-1	CPU Temp, Disk - SDA, HDDTEMP, Load, NTP, SMART, SSH Service, Temperature	
mid-rr-sys-utc-1	CPU Temp, Disk - SDA, HDDTEMP, Load, NTP, SMART, SSH Service, Temperature	
sa1-br-sys-utc-r7	CPU Temp, Disk - SDA, HDDTEMP, Load, NTP, SMART, SSH Service, Temperature	
sa1-xtd2-sys-utc-r12	CPU Temp, Disk - SDA, HDDTEMP, Load, NTP, SMART, SSH Service, Temperature	
sa1-xtd2-sys-utc-r17	CPU Temp, Disk - SDA, HDDTEMP, Load, NTP, SMART, SSH Service, Temperature	
sa1-xtd9-sys-utc-r114	CPU Temp, Disk - SDA, HDDTEMP, Load, NTP, SMART, SSH Service, Temperature	
sa1-xtd9-sys-utc-r19	CPU Temp, Disk - SDA, HDDTEMP, Load, NTP, SMART, SSH Service, Temperature	
sa2-br-sys-utc-r8	CPU Temp, Disk - SDA, HDDTEMP, Load, NTP, SMART, SSH Service, Temperature	
sa2-xtd1-sys-utc-r21	CPU Temp, Disk - SDA, HDDTEMP, Load, NTP, SMART, SSH Service, Temperature	
sa2-xtd6-sys-utc-r219	CPU Temp, Disk - SDA, HDDTEMP, Load, NTP, SMART, SSH Service, Temperature	
sa2-xtd6-sys-utc-r27	CPU Temp, Disk - SDA, HDDTEMP, Load, NTP, SMART, SSH Service, Temperature	
sa2-xtd6-sys-utc-r29	CPU Temp, Disk - SDA, HDDTEMP, Load, NTP, SMART, SSH Service, Temperature	
sa3-br-sys-utc-r8	CPU Temp, Disk - SDA, HDDTEMP, Load, NTP, SMART, SSH Service, Temperature	
sa3-xtd10-sys-utc-r313	CPU Temp, Disk - SDA, HDDTEMP, Load, NTP, SMART, SSH Service, Temperature	
sa3-xtd10-sys-utc-r32	CPU Temp, Disk - SDA, HDDTEMP, Load, NTP, SMART, SSH Service, Temperature	
sa3-xtd10-sys-utc-r34	CPU Temp, Disk - SDA, HDDTEMP, Load, NTP, SMART, SSH Service, Temperature	
sa3-xtd10-sys-utc-r37	CPU Temp, Disk - SDA, HDDTEMP, Load, NTP, SMART, SSH Service, Temperature	
sca-rr-sys-utc-1	CPU Temp, Disk - SDA, HDDTEMP, Load, NTP, SMART, SSH Service, Temperature	
spb-exp-sys-utc-01	CPU Temp, Disk - SDA, HDDTEMP, Load, NTP, SMART, SSH Service, Temperature	
spb-rr-sys-utc-1	CPU Temp, Disk - SDA, HDDTEMP, Load, NTP, SMART, SSH Service, Temperature	
spb-rr-sys-utc-2	CPU Temp, Disk - SDA, HDDTEMP, Load, NTP, SMART, SSH Service, Temperature	
sqs-exp-sys-utc-1	CPU Temp, Disk - SDA, HDDTEMP, Load, NTP, SMART, SSH Service, Temperature	
sqs-rr-sys-utc-1	CPU Temp, Disk - SDA, HDDTEMP, Load, NTP, SMART, SSH Service, Temperature	



FPGA Digitizers

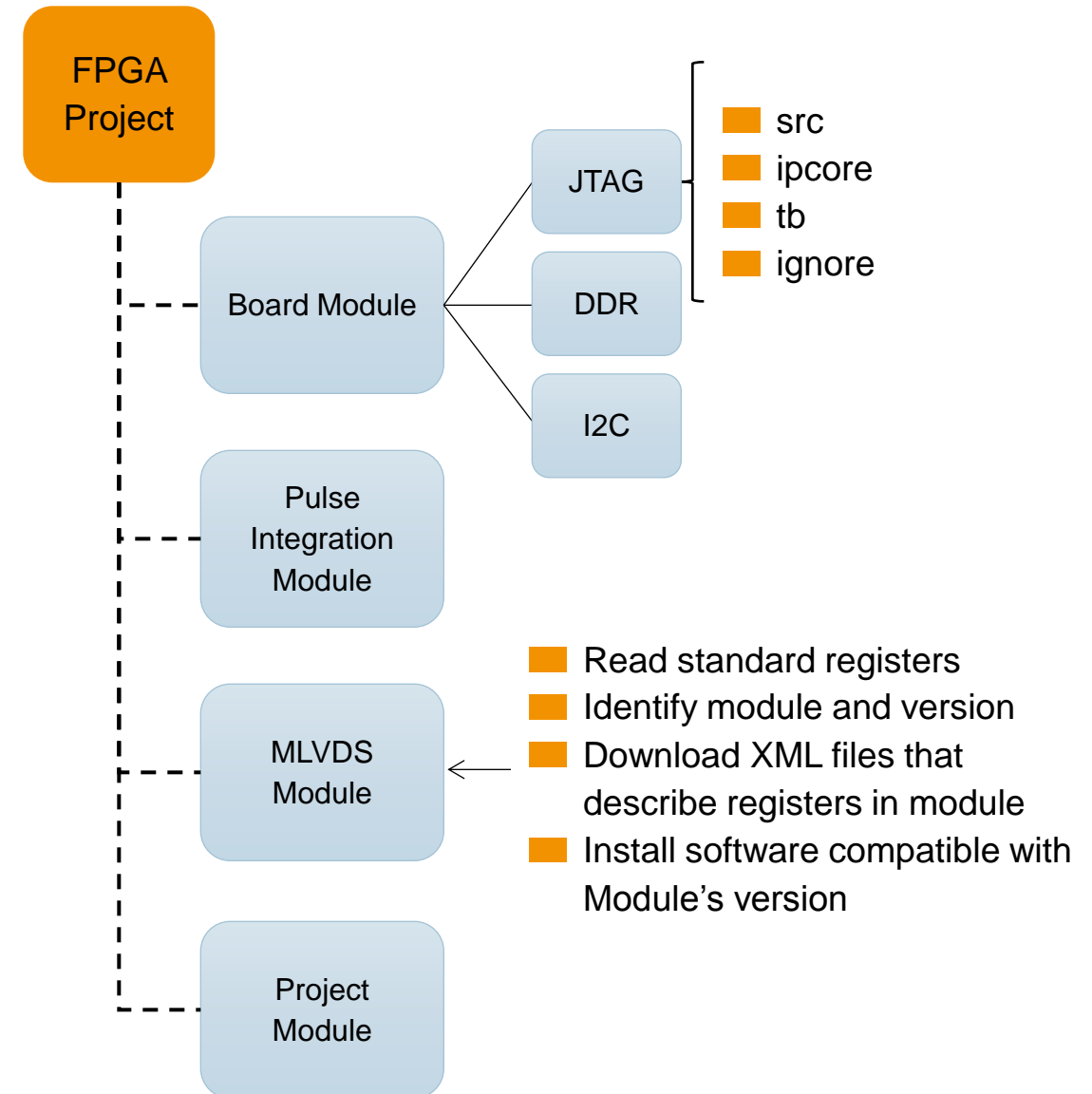


- Hardware Signal Processing
- Most colleagues are right now interested in the **raw data**
- Peak Integration, Peak Detection**, Zero Suppression



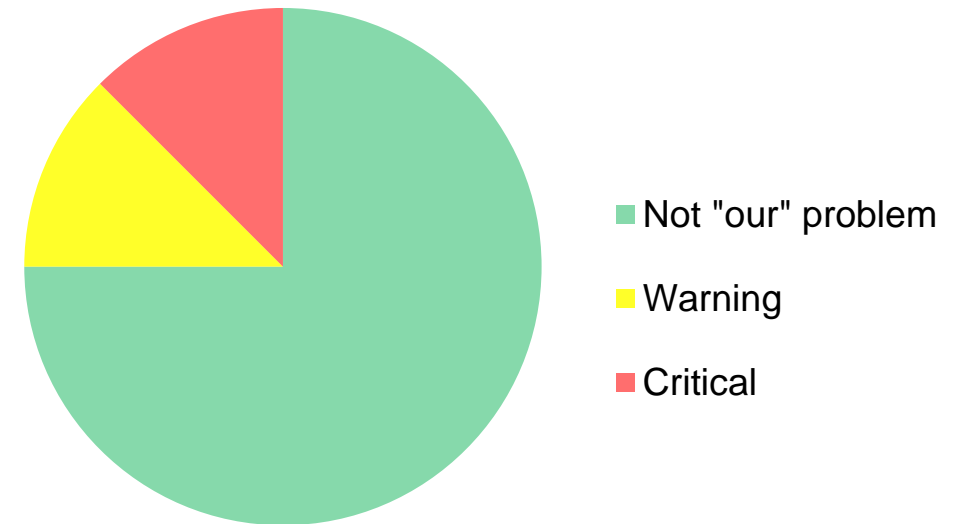
FPGA Development

- FPGA development will increase in the near future as colleagues get more and more familiar with the data
 - Specialized FPGA projects per instrument group/experience
- Process of migration to GIT
 - Standard folder structure for both Modules and Board projects
 - ▶ Scripts to automatize generation of FPGA configuration files depending on requirements
 - Use of GIT submodules for FPGA modules
- Standard Structure of FPGA projects
 - Automatic installation of software devices to communicate with the hardware and its modules



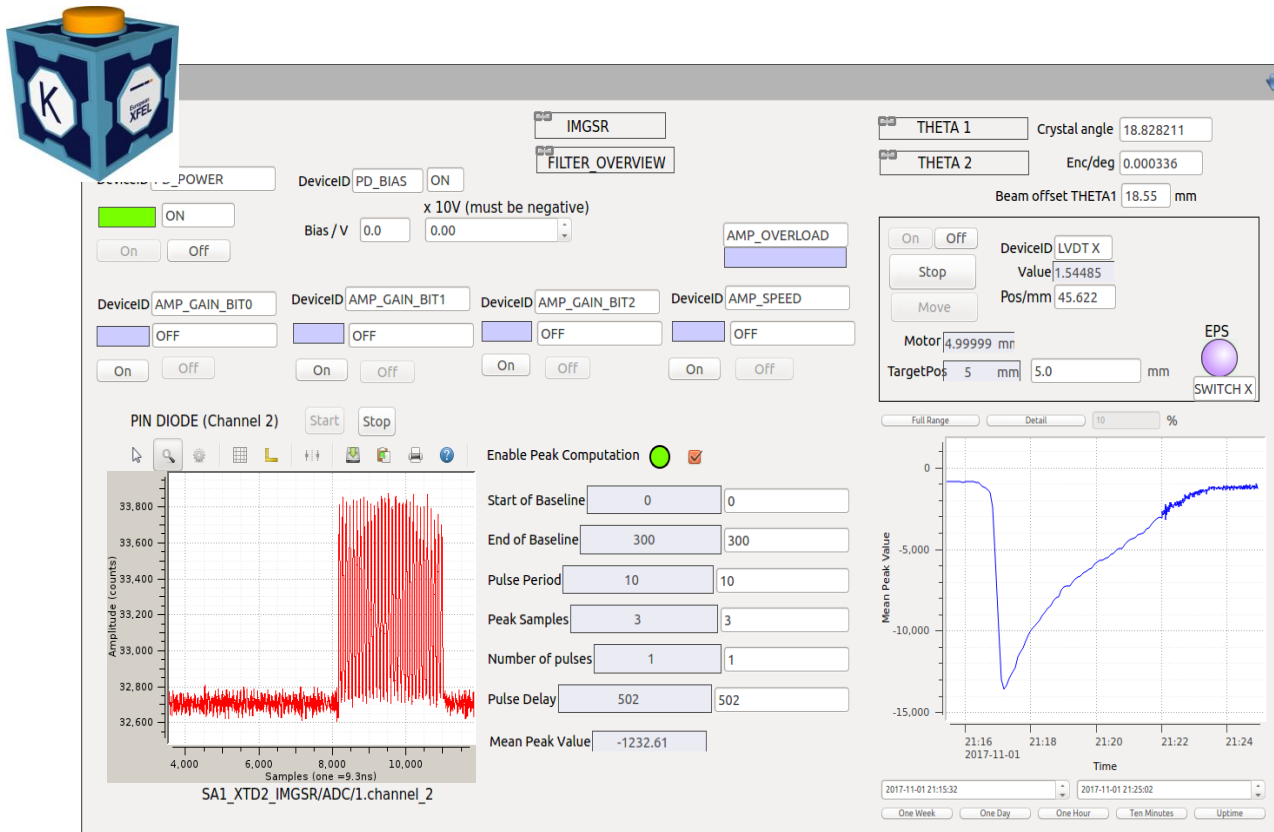
One year in operation

- The MicroTCA On Call duty has significant **low activity** when compared to other XFEL groups
- In total there were **8 calls** made to our group first year of operation
- Stability of MicroTCA and XFEL's FPGA solutions



XFEL Applications

Karabo integration

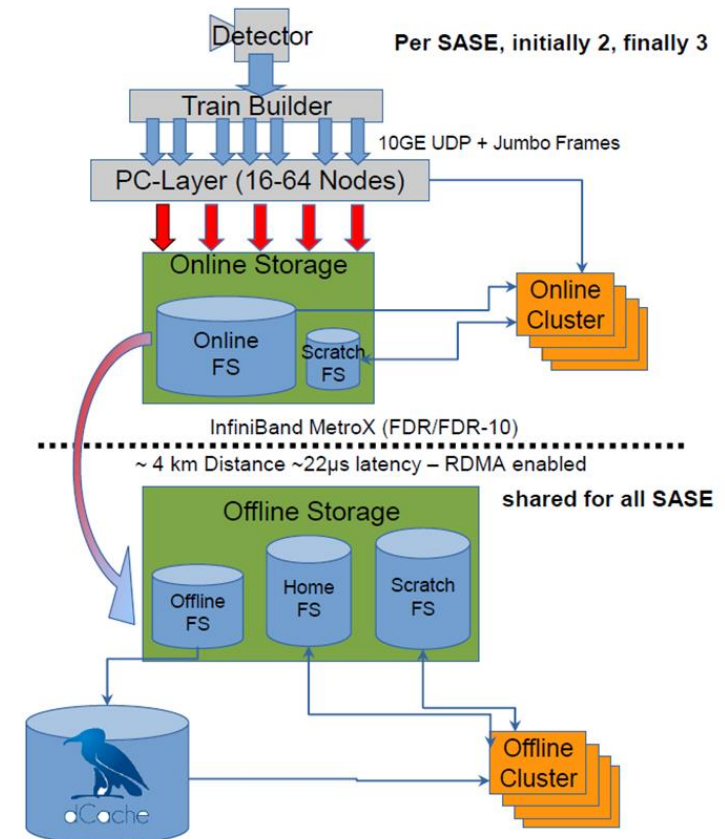


Data storage via XFEL DAQ System

Digitizer data from SQS group

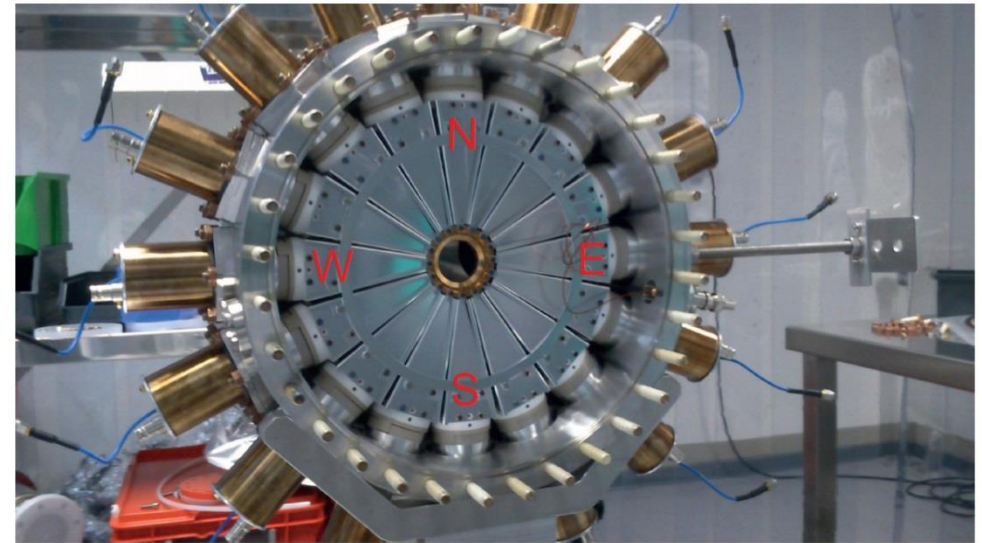
Commissioning: **8020.78 GB** (few months)

First user beam time: **5139.58 GB** (5 shifts)



Diagnostics Group - PES

- Photo-Electron Spectrometer (PES): Pulse resolve information
 - Spectral distribution and (Horizontal) Polarization
 - On each Dirfftube (N, NNE, NE, E...) a voltage is applied
 - Target gas is injected, an X-Ray pulse ionizes it and photo electrons are ejected anisotropically
 - ▶ Small fraction are register by the detectors
 - Based on time of flight, time difference between ionization to detection – related kinetic energy of particle



Diagnostics Group - PES

Polarimetry

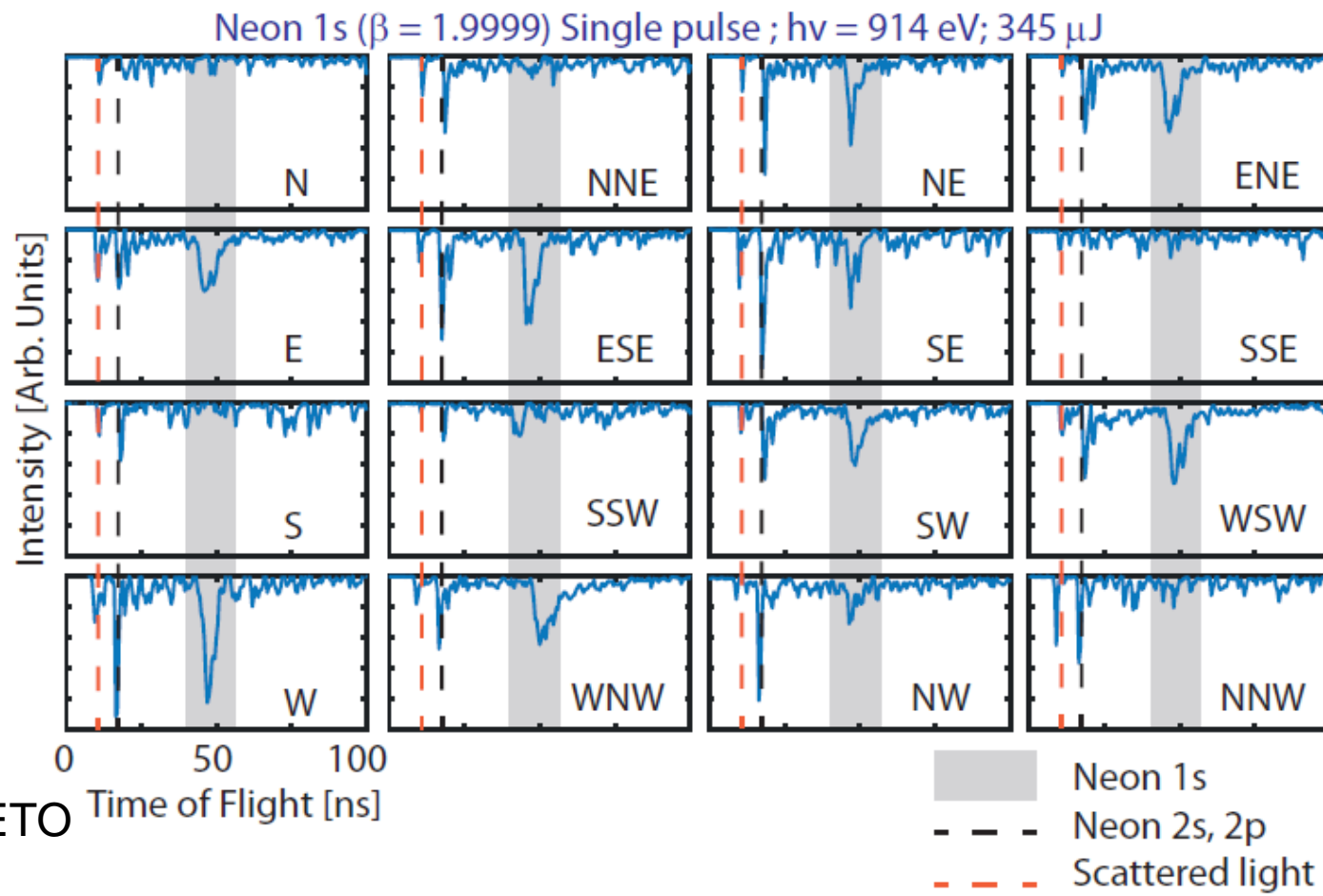
- Accomplish with Auger Lines
- Data collected from single bunch mode
- Polarization P is given by

$$P(\theta) = 1 + \frac{\beta}{4}(1 + 3P_{Lin} \cos(2(\theta - \psi))).$$

Perfect horizontal :

$$P_{Lin} = 1 \text{ and } \Psi = 0$$

- Integral after background subtraction of Neon 1s is marked in a polar plot
- This information could also be use for VETO systems



Diagnostics Group - PES

■ Polarimetry

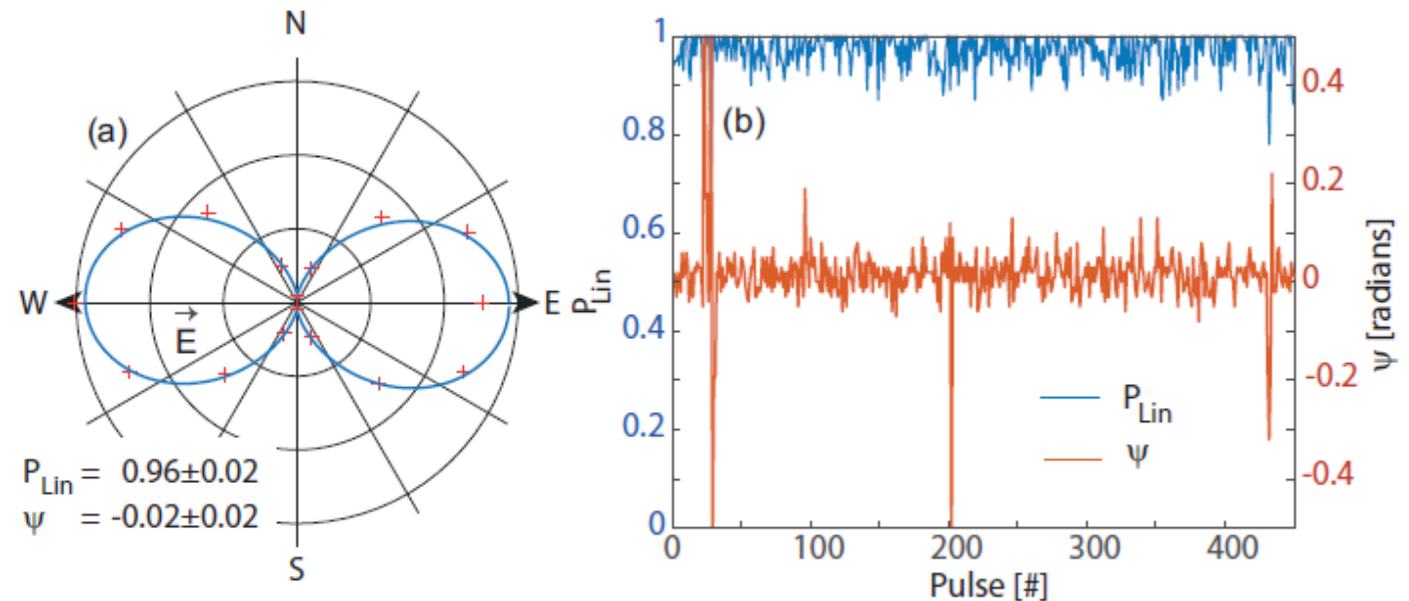
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Thanks for the attention

bruno.fernandes@xfel.eu



Schroff®

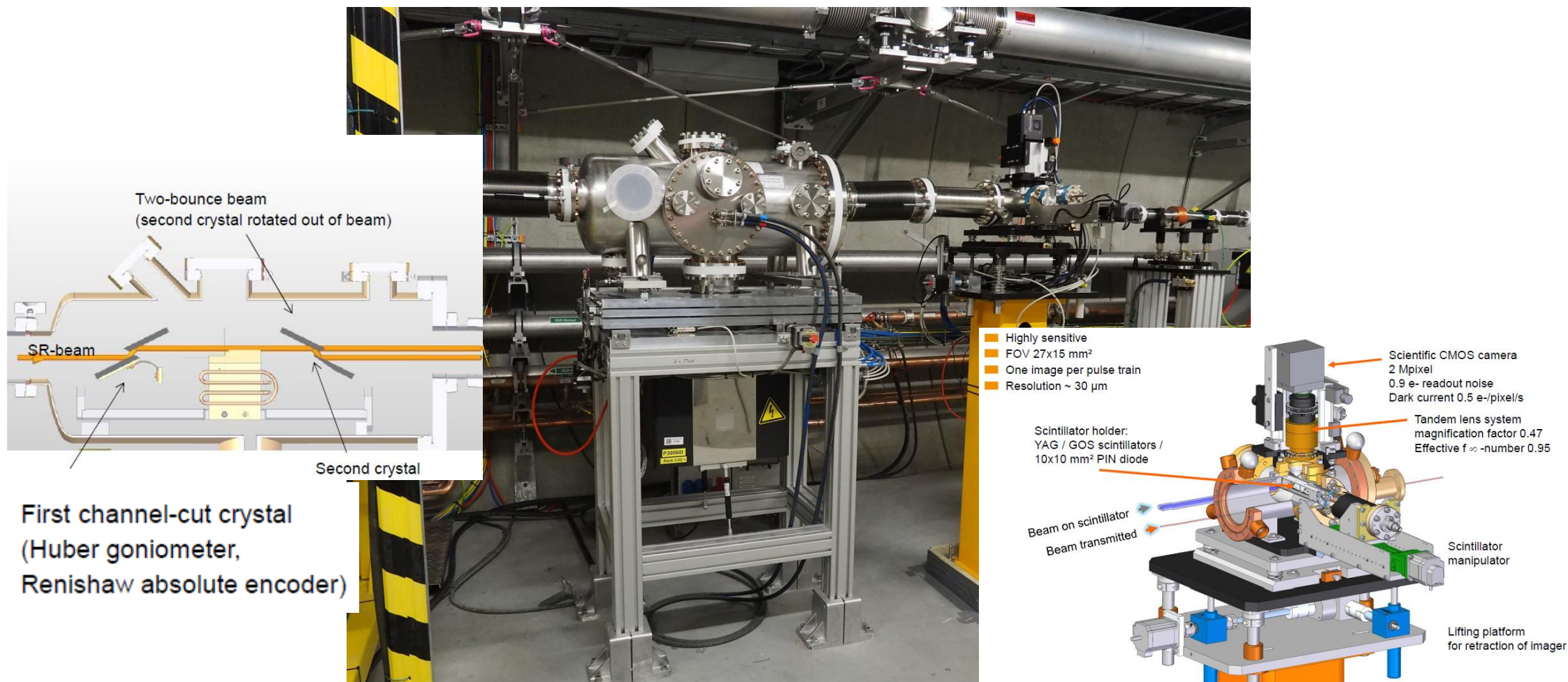
struck innovative
systeme

CONCURRENT
TECHNOLOGIES

The logo icon for Concurrent Technologies consists of a network of blue and red circles connected by lines, forming a stylized molecular or circuit structure.

The logo icon for Teledyne SP Devices is a blue stylized arrow pointing upwards and to the right.
TELEDYNE SP DEVICES
Everywhere you look™

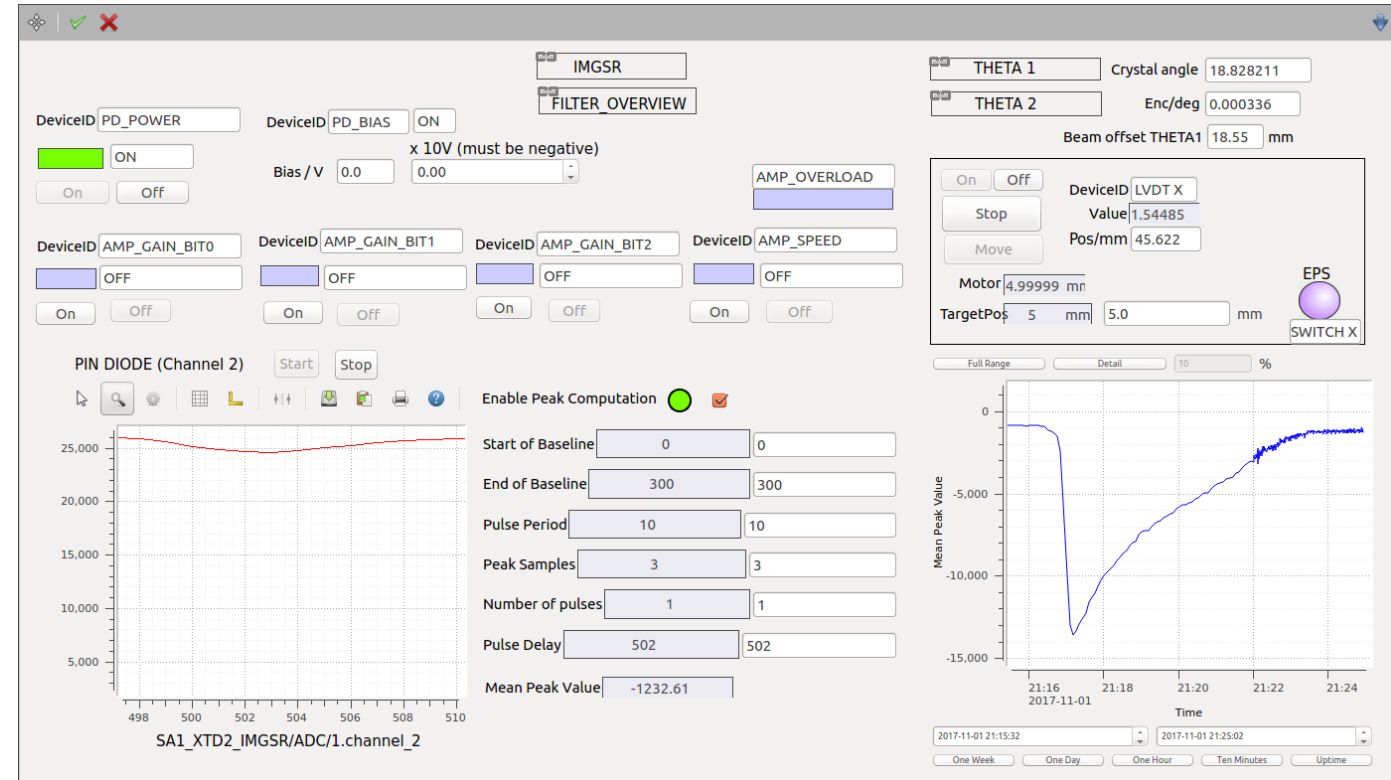
Diagnostics Group – K-Monochromator



Diagnostics Group – K-Monochromator

Gap tuning method or the relative adjustment of undulator segments: measure photon energy of spontaneous radiation **of each undulator segment**, to calculate and adjust the K-parameters within an accuracy required for FEL operation

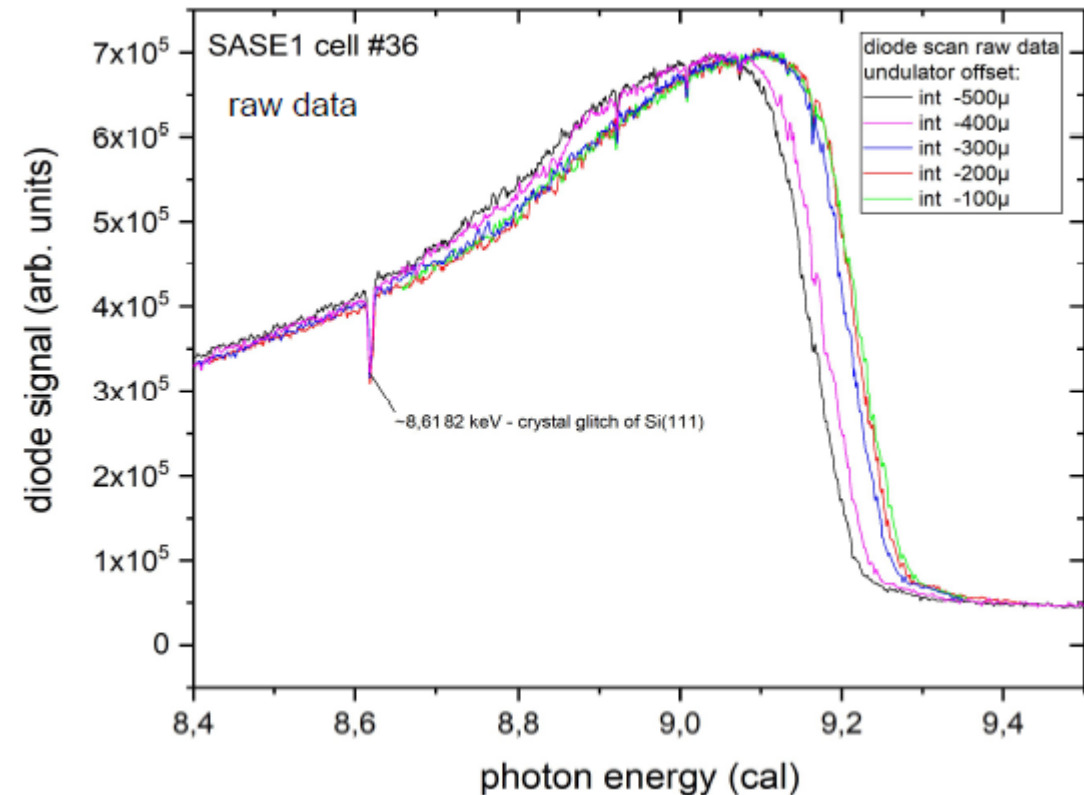
- Monochromatized beam detection
- Scan perform “on the fly”: goniometer is moving continuously
 - For each pulse Train, data is stored
- Spectral Shape → information about the homogeneity of magnetic structure



Diagnostics Group – K-Monochromator

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Optical Laser Group – Timing drift/jitter compensation

■ Balanced Cross-Correlation

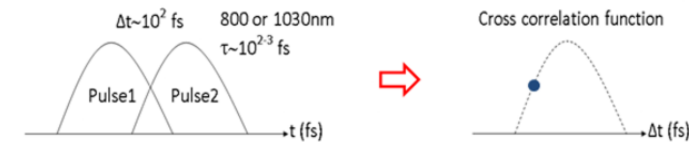
- two cross correlators (CCs), with the same configuration
- Used for compensation of Timing drift/jitter

■ In both CCs, the temporal delays, and the amplitudes of signals are adjusted equally.

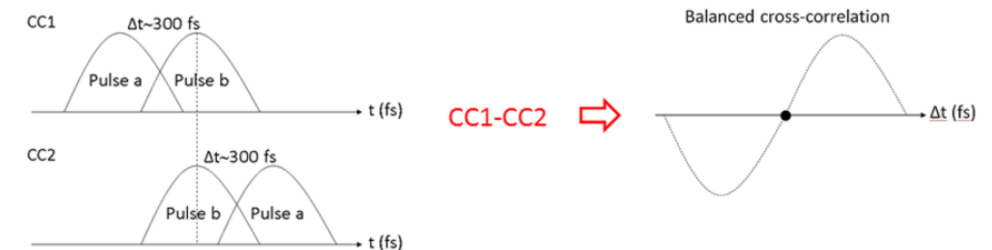
■ The **timing error signal** is the subtraction of the signals from CC1 and CC2.

■ The **error signal** is proportional to the timing drift.

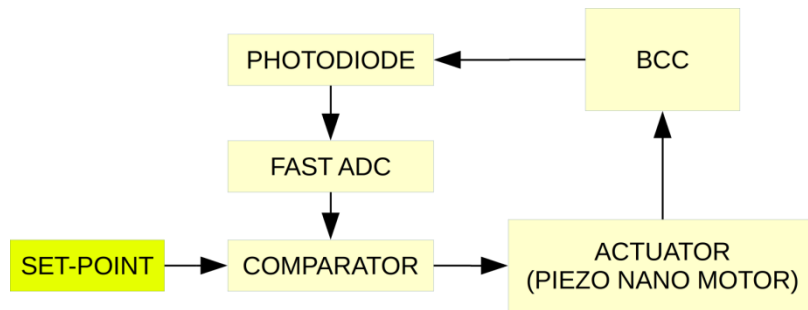
■ Cross-correlation



■ Balanced cross-correlation

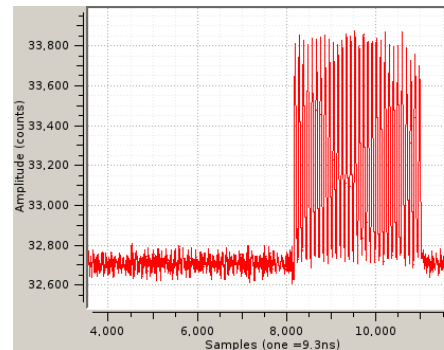


Optical Laser Laboratory

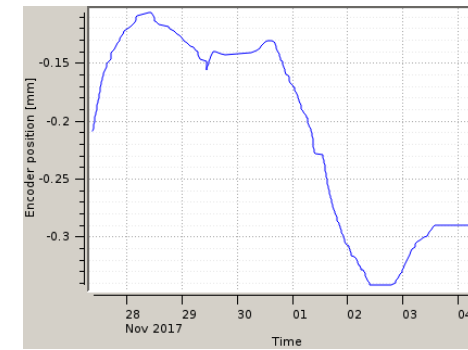


Input parameters to the (DM) BCC at SASE 1:

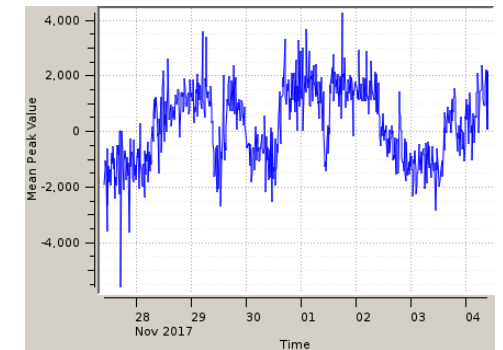
- XF1: 10Hz, 27us, 1.1MHz, ~ 900fs, 7nJ/p;
- XF2: 20Hz, 5.94ms, 4.5MHz, ~ 300fs, 1nJ/p.



Error signal from the DM-BCC



Mean peak value of error signal

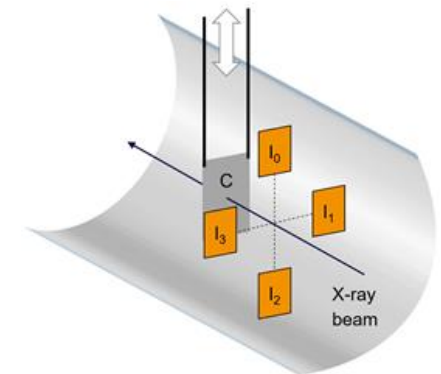
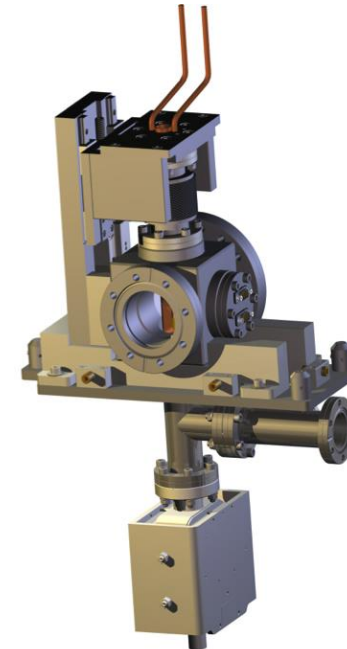


Encoder position of comp.stage

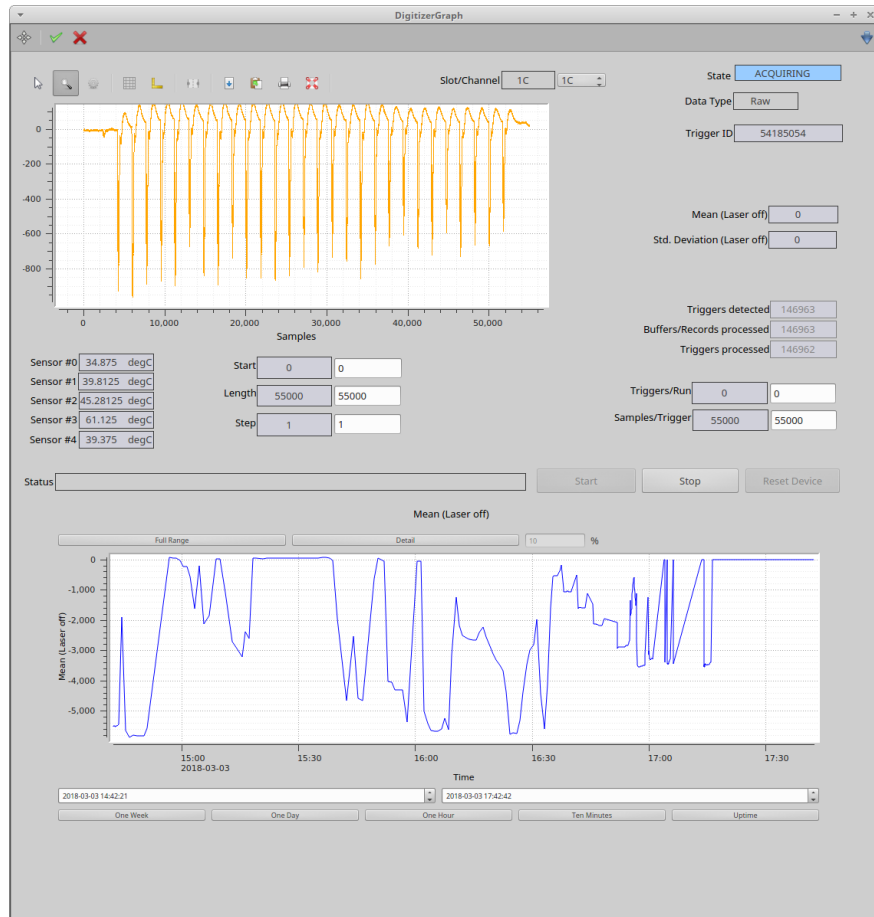
- The pump probe laser in SASE1 is already equipped with one CM- and two DM-BCCs. The operation was successful.
- Slow timing drifts are well measured and compensated, like thermal expansion, humidity change, etc. with **an accuracy of ~ fs**

FXE Group – Intensity Monitor (IPM)

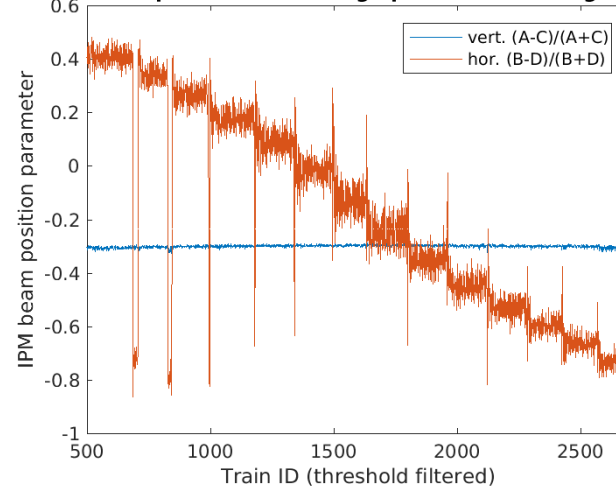
- Measurement of **integrated intensity** of the beam and the corresponding **centre of mass position**
 - relies on the efficient detection of backscattered X-ray photons from a very thin foil of CVD diamond material
 - the detection of the backscattered X-ray photons is realized using 4 photodiodes (PD)
 - All four PDs collect the backscattered radiation from the foil and yield the integrated incident intensity by integrating the output current from the detectors
 - comparing the difference of the individual signals from each diode, one can obtain the position of the beam in the plane perpendicular to the beam direction
- Measurements use ADQ412 from SP Devices



FXE Group – Intensity Monitor (IPM)



Each data point is the average position for a single train



the vertical position does not change, while the beam is moved horizontally with M3 pitch, giving a continuously decreasing value on the IPM. Spikes in the horizontal position are due to the backlash correction.

train-to-train beam position comparison **of each pulse within the train**. It is clear to see that the first few pulses are much more jittering than the later ones

