FIRST RESULTS OF CW-DIAGNOSTICS FOR FUTURE ACCELERATOR.

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HELMHOLTZ

DESY.

My FLASH / XFEL 10Hz history.

- 10 Hz operation
- Clock from timer
- 1 to 3 ms Sampling time
- More then 95% idle time to do readout and data processing
- Very easy

But CW-operation is coming.
(CW == Continuous Wave)

- Well… PETRA III has always been CW
- KALDERA 100 TW Laser running with 1 KHz
- Ts4i SuperConducting RF-GUN test-stand for XFEL with CW
- PETRA IV got first approval
- XFEL is planning for 1 MHz operation, calling it **H**igh**D**uty**C**ycle

Our first steps are done at KALDERA with:

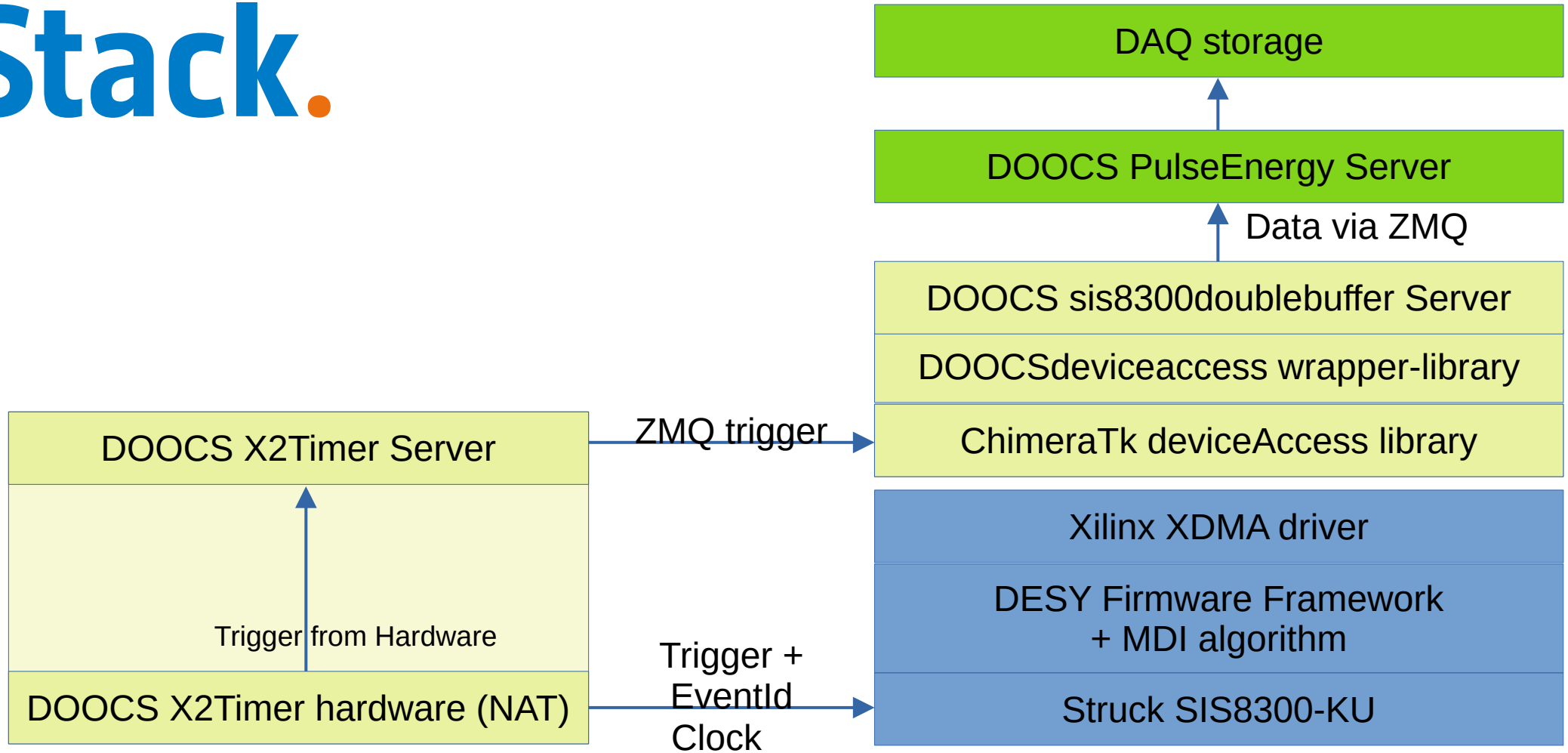
- 1 KHz pulse repetition rate
- 100 Hz external trigger
- 125 MHz sampling
- Using Struck SIS8300-KU

The DoubleBuffer approach.

- One possible option, others may Streaming
  - DoubleBuffer allows to tag the data with a (Run,Event)-Number

- Uses two memory areas
  - One is storing data
  - One is idle for reading
- Swapped by external trigger with 100 Hz
- Every area is tagged with a running number from the timer (EventId)

Hard-, Firm-, Software Stack.



The doublebuffer.

Sampling buffer

Switching with 100Hz

Readout buffer

```
DAQBUF.MEM_MULTIPLEXED_DAQ_CTRL_BUF0    32768  0x80000000    131072  13  32  0  0  RO
```

```
DAQBUF.MEM_MULTIPLEXED_DAQ_CTRL_BUF1    32768  0x80020000    131072  13  32  0  0  RO
```

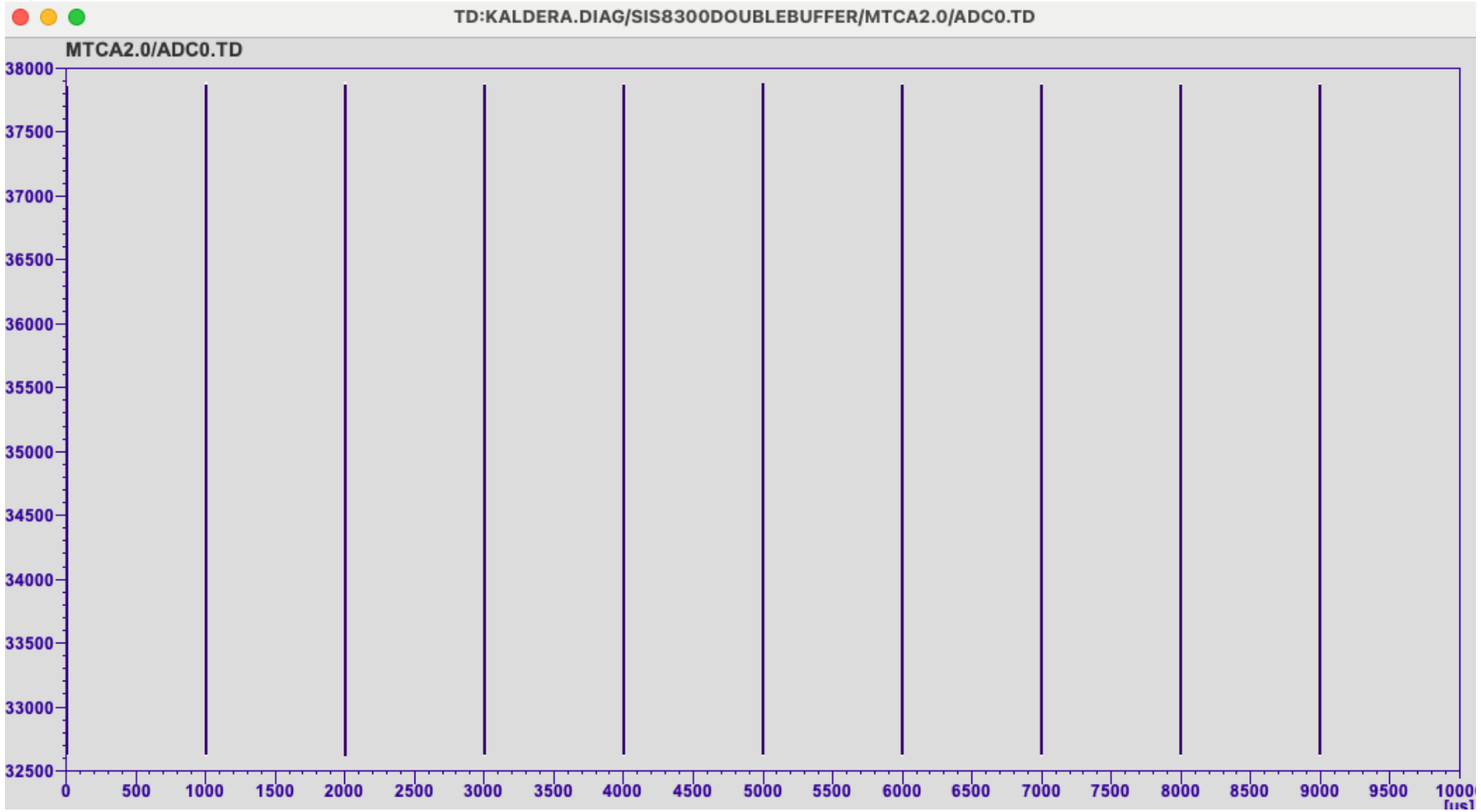
DOOCS properties

APP.CW_NUM_SAMPLES number of samples per pulse	128
APP.CW_TRG_COUNT number of pulses	10
APP.CW_TRG_PERIOD number of samples between pulses	124740

=> in DMA only 10 x 128samples == 2560bytes

The Pulse train.

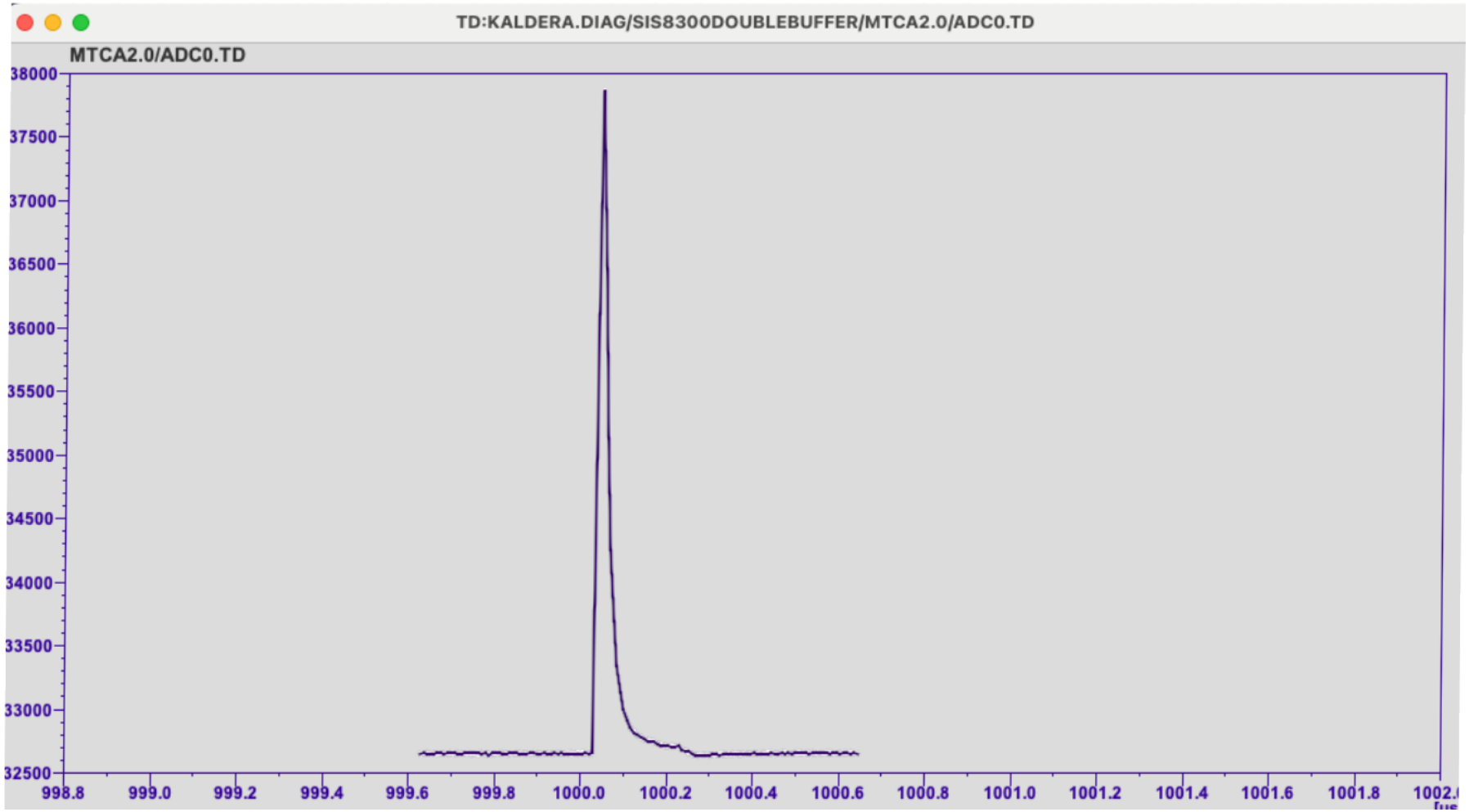
10 pulses in 10ms == 1KHz



- 10 pulses in 10000µs

The Pulse.

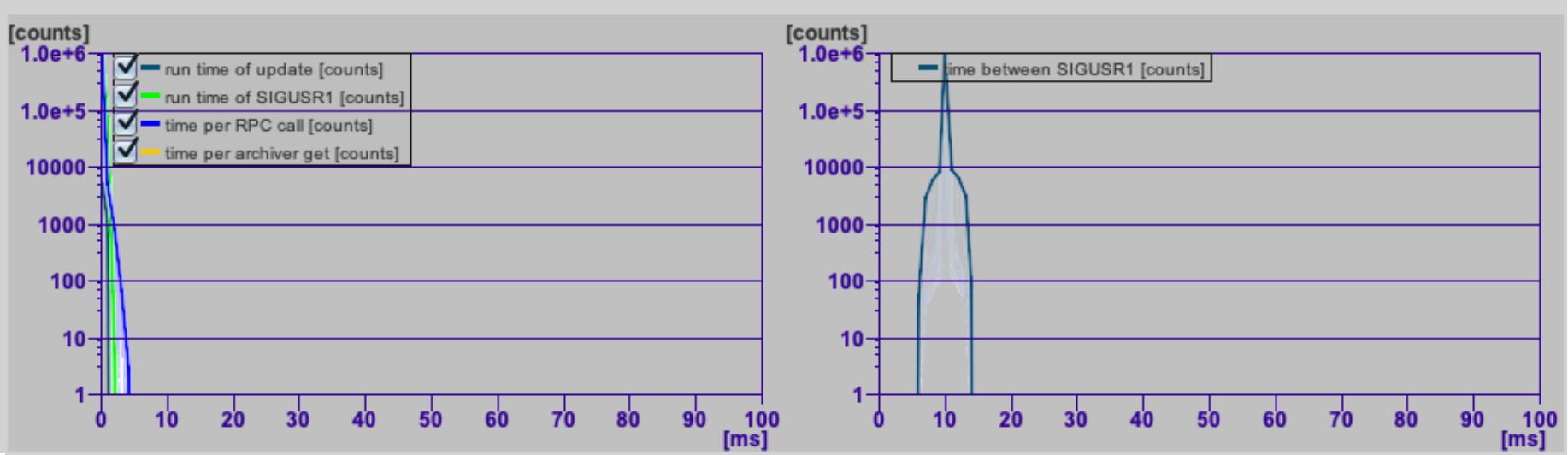
Zoomed into one pulse



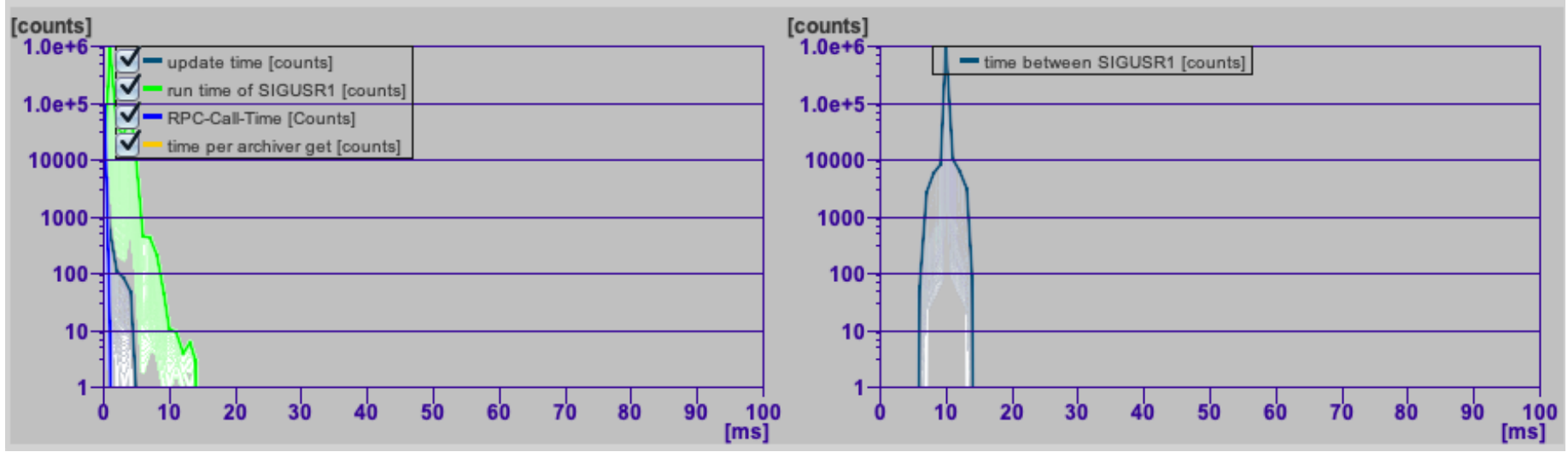
1µs pulse

- 125 MHz sampling clock
- 128 samples

Performance.



Timer Server



SIS8300 DoubleBuffer

DOOCSdeviceaccess library.

DESY Firmware Framework FWK is “quasi” standard at DESY now

Used by MSK, MDI

https://proceedings.jacow.org/ibic2024/pdf/WEAI1_talk.pdf

https://gitlab.desy.de/fpgafw/projects/example/sis8300ku_example_design.git

XDMA Linux driver by Xilinx

Used by this FWK, OpenSource software from Xilinx

https://deepwiki.com/Xilinx/dma_ip_drivers/3-xdma-driver-overview

DOOCSdeviceaccess library.

Properties in DOOCS (Distributed Object-Oriented Control System Framework)

- A DOOCS Server holds its data in so called properties to be exposed to the network
- The C++ base class **‘D_fct’** is the software instance of a property
  - Examples: D_int, D_float, D_hist(History), D_array …
  - Maybe around 50-100 different types derived
  - The Server developer chooses from this list
- https://doocs.desy.de
  - Controlling FLASH, XFEL and foreseen for PETRA IV machine controls

DOOCSdeviceaccess library.

Good software support for FWK/XDMA by MSK

Called: **ChimeraTK-DeviceAccess library**

Provides:

- Scalar 32Bit register access
  - May convert the data to int32, uint32, float, double, long… as defined in the .map file
- DMA read/write
  - 1D and 2D arrays
- Support of the FWK mapping file
- DoubleBuffering (important for CW operation firmware)

https://chimeratk.github.io/ChimeraTK-DeviceAccess/head/html/index.html

DOOCSdeviceaccess library.

Good software support for FWK/XDMA by MSK

Advantage for us:

- Get good modern software
- Well tested by Unit-tests
- Used by many projects already
  - “Rapid hardware integration with the ChimeraTK software framework”, M. Hierholzer
- We don’t need to bother the DESY-MSK firmware guys...

DOOCSdeviceaccess library.

But: Don’t want to work with ChimeraTK in every DOOCS server directly

=> DOOCSdeviceaccess library was developed

- A so called wrapper library
  - So no logic by itself
  - But is doing ChimeraTk calls in DOOCS style
- Its a C++ template library mainly
- Almost header only
- Support D_devicescalar types
  - Like: D_device_short, D_device_int, D_device_float...
- D_devicearray
  - Like: D_device_shortarray, D_device_int, D_device_floatarray...
- D_device2D_array
  - Like: D_device2D_shortarray, D_device2D_uintarray, D_device2D_floatarray...
- Has (some) tests

https://mcs-gitlab.desy.de/doocs/hw/DOOCSdeviceaccess.git

DOOCSdeviceaccess library.

DOOCS server done already

- FaradayCup for FALCO
  - https://mcs-gitlab.desy.de/controls-and-operation/particle-beam-diagnostics/charge-measurement/faradaycup.git
- SIS800doublebuffer server (the one presented here)
  - https://mcs-gitlab.desy.de/doocs/hws/sis8300doublebuffer.git
- Fast Trigger card for FLASHfwd, SIS8172 Board
  - 1 MHz variable trigger train, allowing sub-nanosecond fine delay for individual bunches
  - https://mcs-gitlab.desy.de/doocs/hws/mhztrigger_server.git

DOOCS server to be done (now)

- BLM frontend (BeamLossMonitor), SIS8172 Board – under development
- X3timer Server – planned, when hardware available

Conclusion.

- Works nicely already
  - Data is taken by KALDERA
- Needs much more testing like:
  - 100Hz, 50Hz, 20Hz memory swapping ?
  - How many samples per pulse ?
  - What is the best rate for the DAQ storage
- Get the software/server trigger from hardware directly

- Need to agree what the CW readout schema will be

Thanks to.

- Timmy Lensch for this nice Firmware and many discussions
- Martin Hierholzer for explaining ChimeraTk to me

Thank you.

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