PAUL SCHERRER INSTITUT



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# **Controls & DAQ** (with Science IT) (achievements 2020 & plans 2021)

SwissFEL Performance Workshop (online), 27. Jan. 2021



- Controls EPICS integration and Controls IT
  - -Achievement and plans
  - Impact of other projects on resources
- SwissFEL DAQ
  - General Overview and identified bottlenecks (analysis 2020)
  - -BS sources (scalars and waveforms)
  - Cameras
  - -Image processing (cam\_server)
  - Image buffer/Data buffer
  - Detector Integration and experimental interface
  - Operational stability
  - DAQ Management/coordination



# Controls (EPICS integration & infrastructure)

## Achievements 2020:

- Brought first light to Maloja, Athos machine work, Athos beamline integration, preparations for Furka & Cristallina
- 2020/2021 IT infrastructure & deployment changes (unification of used tools, directory structures, etc...)

## Plans 2021:

- Work on the Archiver appliance (D. Lauk)
- Final RHEL 7 deployment on all consoles, login clusters, VMs
- Further optimization of Controls IT infrastructure and deployment tools consolidation
  - Emphasis on planning, communication and migration efficiency
- Integration work for: Athos machine consolidation, Athos PD, optics, Maloja consolidation, Furka, Aramis
   Cristallina

## **Observed difficulties:**

- HW commissioning of motion systems is time consuming (working on a better workflow)
  - Motion controllers (many faulty and sensitive Power Bricks)
  - Final cabling not ready, so temporary installations are needed to meet given deadlines
  - Introduction of 802.1X network authentication protocol in Athos created some frustration among involved people



**Resources and organizational** 

**SLS 2.0** project already has impact on available people for SwissFEL

- Niko Kivel gave up support of Optic systems in SwissFEL, in order to work on motion system for SLS 2.0) – Thierry Zamofing took over, which might create bottlenecks within Athos Photonics. We will try to cover it with other resources whenever needed (Scott Stubbs, Cosylab). We ask for your understanding.
- Potential limitation of expert group support in the machine on account of SLS 2.0 (EtherCAT motion)

**Controls section reorganization**, planned for mid 2021 – lead Thomas Schilcher.



SwissFEL Beam Synchronous-DAQ (bottleneck analysis 2020)





# Field of Action 1: BS sources – scalars/waveforms



Issues/limitations	Solutions
Some sub-systems not 100 Hz verified yet, some not reaching 100 % success rate (> 95 % )	<ul> <li>system specific optimization on different levels (time consuming)</li> <li>Stability tests ongoing</li> </ul>
High data rate and volume from sub- systems into data buffer	Data buffer input volume optimization if possible (scalars, waveforms) otherwise increase capacity ( $\rightarrow$ increase complexity)

#### Status:

• Does not prevent to run the machine in 100 Hz mode!

#### Plan 2021:

- Final verification of all beam synchronous sources at 100 Hz (resource availability is an issue)
   very specific skill-set needed, suitable resources limited (example BPM)
- Reduction of RF BS data (M. Jurcevic) WIP







# 2.1 - Camera IOCs Achievements & Plans

#### Achievements 2020 (H. Brands):

- Single Camera performance improvements @ 100 Hz (no dropped images)

- Installation of test setup to work on outstanding topics:
  - Tagging problem verified and measured
  - Proof of principle for simultaneous streaming of 2 cameras @ 100 Hz
- OS upgrade on all camera servers (including performance tests and tuning)
- Proof of principle for image processing at the source (later put on hold)

## Plans 2021:

<ul> <li>Solve the mis-tagging issue inside the Camera IOC</li> <li>Simultaneous operation of 2 cameras on 1 server in production (start with end station cameras)</li> <li>upgrade of the development environment (operational aspect)</li> </ul>	<ul> <li>Initial estimate: Q3 2021</li> <li>(most efficient use of our resources is to do everything in a bundle)</li> </ul>
– In addition > 100 new cameras to be commissioned - Athos end stations, Athos PD,	
Athos pump laser, Cristallina, HERO, diagnostics for HERO, new requests for	

- Operations (dual bunch camera operation)
- Define timing events for camera triggering (Tine)
- Usability: new camera user panels for end stations (Tine)

#### 2.1 Camera IOCs

100 Hz performance for PCO.Edge with high resolution (2560x2160) – image dropping

Server 10 Gbit/s limitation - single camera @100 Hz

Wrong pulse ID tagging at 100 Hz & full ROI (+1 offset)



2.2 – Online Image Processing

## Achievements 2020 (A. Gobbo):

- Considerable performance increase due to algorithm <u>parallelization and</u> <u>upgrade to 25 Gbit NIC:</u>
  - Reliable processing of 2 PCO.Edge cameras at 100 Hz with a single server was achieved (2560x2160 + 2048x2048 ROI (Images + processed data))!
  - Only verified for existing processing algorithms (PSEN)!
- Infrastructure: upgrade of existing servers + 2 new servers to cover future needs (A. Dorigo)

# Plans 2021

- Optimization of PSSS processing with background subtraction (under investigation now - currently ca. 95 %) and EPICS usage (challenging with parallelization) – <u>tests planned during the next maintenance window)</u>
   Is EPICS needed? Could BS processed data be used instead?
- user interface improvements

**Online Image Processing** 

Limitations in data transfer between camera server and processing server (limited to 50 Hz at full ROI)

Real time performance of all processing algorithms not verified @ 100 Hz

Server 10 Gbit/s limitation – single camera @ 100 Hz



# 2.3 - Image Buffer (camera requirements @ 100 Hz)

	Presently simultaneously running PCO.Edge (worst case*)	forecast 2022 (5 end stations) (worst case*)	forecast 2022 (5 end stations) (expected**)	comments
Machine	4	6	4-5	Some could run with lower rep rate (DSRM), or limited ROI (DSCR)
Photon diagnostics	3	9	5-7	Request to run diagnostic cameras in different end-stations of the same line simultaneously
Experiments	4	11	4 - 7	Maloja has 5 PCO.Edge cams – but could use data reduction - <b>TBD</b>
Total est.	9	27	14-19	

\* Worst case (bad users): all cameras at all end stations run at 100 Hz

**\*\* Expected (nice users):** Only one end station in each beamline has cameras running

worst case ca. 250 Gbit/s / expected ca. 150 Gbit/s input load to Image buffer servers (No ROI reduction, no compression, RAW images sent) + Basler Cameras ... + Diavolezza + Portos...

## Think about data reduction (super nice users): record only processed data whenever possible!



# 2.3 - Image Buffer & GPFS storage (performance tests and actions)

- Two sets of servers 2 x sf-daq servers (Image buffer servers) + Image buffer GPFS storage.
- 2 Dedicated 100 Hz image buffer testing shifts in 2020:
  - After 1<sup>st</sup> test: image buffer servers upgrade from 25 Gbit/s to 40 Gbit/s per server (2 servers)
  - 2<sup>nd</sup> test showed that we can cope with current data loads
    - Max achieved throughput ca. 9 GB/s (saturation reached (images dropped))
    - ca. 50 % volume reduction due to compression when writing to the Image Buffer GPFS storage (still some reserve with existing 6 GB I/O).
  - Helped us to estimate the requirements for upgrading DAQ infrastructure to meet the final needs
  - in budget for 2021:
    - New Image buffer server
    - New GPFS storage (current one out of warranty July 2021) to be exchanged in Summer SD (A. Dorigo)

# Current 100 Hz camera demands can be supported! But we need to prepare for the future...

**Image Buffer** 

Current Image buffer HW performance cannot cope with final user demands at 100 Hz



# Field of Action 2: BS sources – cameras (status Jan 2021)





# Achievements 2020 (D. Werder)

- New version of data retrieval API (retrieval v2):
  - For image data (from image buffer) in production since mid 2020
  - For scalar and waveform data (from data buffer) currently being tested to be put in production
- 3 x higher performance in terms of retrieve times compared to the previous version
- Can be used by machine as well

## No major development plans for 2021



Field of Action 4: Data Buffer stability (recording)

## Status:

- Data buffer operational (13 servers)
- No showstopper for 100 Hz operation
- However:
  - network and disk IO is high ( $\rightarrow$  field of action 1: IOC data reduction)
  - -Still some stability issues (SW/HW)

# Achievements 2020:

• Improved status overview (collecting metrics, (bad) source diagnostics) and improved operational tools for system maintenance (S. Ebner)

# Plans 2021:

- Focus on Data recording reliability (now that retrieval issues are resolved) (D. Werder)
- Continuous focusing on mid and higher level development to improve operational reliability



# Field of Action 5: Detector integration and experimental interface

### Achievements 2020 (A.Babič, D. Ozerov)

Achievements 2020 (A.Babic, D. Ozerov)		Detector E
Issues/limitations	Solutions	data
<b>Detector data collection</b> : Jungfrau @ 100 Hz	New detector backend system – new receivers	
Experimental interface: up to 7 seconds lost before each run	New experimental interface - broker	Experimental interface
<ol> <li>Data Writers:</li> <li>Writing Jungfrau @ 100 Hz</li> <li>Epics channels writer format (caDump)</li> <li>System stability issues – high maintenance, low flexibility, deployment facilities</li> </ol>	New data writers – detector writer, bsread writer, epics writer (replacing caDump)	



- Conversion and compression JF 16M still not at 100Hz without backlog (I. Usov) ٠
- EPICS data writing missing some PVs (v.2 in progress) ٠

BSREAD

camera

data

image processing Epics

data

Post processing

**BSREAD** 

ioc data

data retrieval

Data writers



SwissFEL Beam Synchronous-DAQ (bottleneck analysis 2020)







SwissFEL DAQ functional layers (excluding BS sources)



We divide the system into 3 functional groups: **Data** 

(everything related to acquisitions)

#### Services

(processing the acquired data)

#### Operations

(running the system)

This groups are further divided into: Low level software (visible mostly to developers) Mid level software (visible to system experts) High level software (visible to end users)



SwissFEL DAQ developments in 2021 (cross-system)

### 1. Data management

- a) Working toward a unified data file for merging all experimental data.
- b) Web interface to view and manage data collected at beamlines.

## 2. Online feedback

- a) Optimized live detector image assembly and conversion.
- b) Specialized online processing framework for live feedback.

## 3. Status overview and automated tools

- a) Provide automated procedures to configure and restart all services.
- b) Implement easy to read metrics in web interface for system health checks.

We are building the daq layer by layer and incorporating into higher layers the knowledge and experience we gained along the way.

Most of the hardest work is behind us! With data safely collected we can now turn our attention on making it accessible and useful to our users.

By providing an easier way to monitor and configure the system we open it to system experts, who will be able to manage parts of it on their own.

	Data	Services	Operations
Low level	Collection and retrieval	Processing and analyzing	Metrics and logging
Mid level	Data management	Online feedback	Status overview and automated tools
High level	Experiment execution and	Generic online processing	Web interface for system





- Very important for us, but not directly visible to the users!
- Focus on:
  - Collecting metrics (Grafana dashboards) DAQ infrastructure, sources, etc...
  - Unified architecture design
  - automated and simplified deployment and configuration
- It needs time but it results in:
  - higher reliability of systems
  - easier problem diagnostics
  - down time prevention or shorter down times
  - Less time for basic troubleshooting →more time for development with limited resources
  - Provision of better DAQ support by Controls Pikett and 1<sup>st</sup> level support





DAQ Management/Coordination

- Close collaboration between Controls, Science IT and users is needed
- **Controls reorganization**: one of the main points is to evaluate and strengthen the interface to the new Science IT department in the new division
  - clear definition of responsibilities, ownership and different roles (technical management and strategy, technical lead, operations management) should be established
- In terms of development we need to carefully evaluate coming requests and align them against our strategy and long term plans in order to efficiently use our resources







- Complex interactive system with many components, people and groups involved.
- Complex HW and SW solutions with specific skill set needed to meet ambitious goals



## We are successfully running 100 Hz experiments for some time already!...

...But with some problems and limitations, and there is still work to do!

Nork in progress



# Wir schaffen Wissen – heute für morgen

Many thanks to the colleagues from Controls and from Science IT for their valuable contributions to the presentation...

...and of course for all their efforts to provide a stable and reliable DAQ system!!!



