

Detector-DAQ in the Scientific Data Group

Technical Division

MAX IV

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HEPS-MAX IV Meeting 13th August 2025



Status and organisation

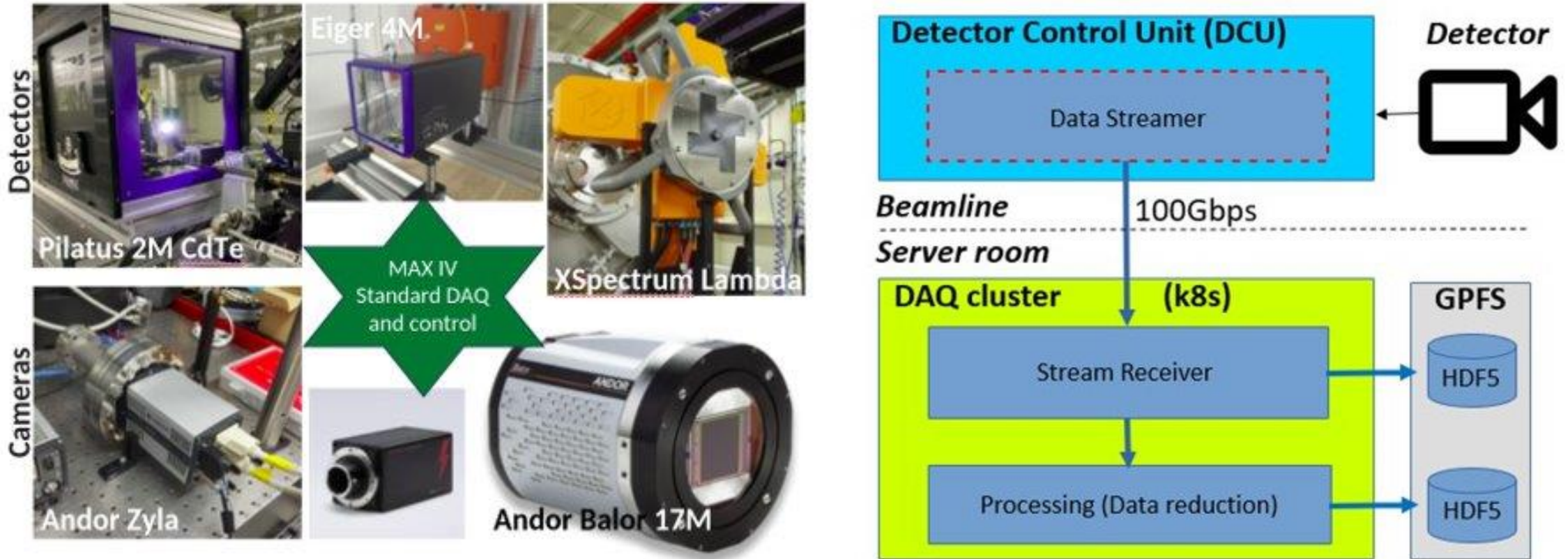
History for detectors

- Detector related activities only started to receive dedicated focus from 2020
- *Scientific Data* group formed 2023 within new Technical Division, to collect together:
 - Detector related activities with a software focus (consolidate this activity in one group)
 - Management of data analysis services - HPC and JupyterHub
 - Scientific Software support to beamlines – data handling and processing with expertise in some scientific areas (SAXS, XRF, imaging...)

Detector responsibilities

- Integration of commercial systems into control and DAQ: getting images to disk with high performance
 - Covering: *Photon counting detectors – CMOS/CCD cameras – pulse processors – delay line detectors*
- Integration of non-commercial systems for tests or user operation
- Detector support to beamlines:
 - Detector operation/trouble shooting
 - SATs and performance/calibration studies (e.g. module alignment, flat fields)
 - Advice around procurements
- Beyond detector first layer DAQ: online data processing & visualisation specific for experiments (-> **DRANSPOSE**)

Integration of detectors/cameras



- Consolidated 30 systems, 10+ unique types into common Kubernetes-managed DAQ cluster (many instances of common data receiver-file writer).

Collaborative & internal development activities

- One MAX IV wish: time resolution for hard and soft X rays
 - To exploit coherence especially in soft X-ray regime and enable techniques such as XPCS
- Interest in LGADs (+ Timepix3)
 - Based on collaboration
 - Have R&D licence for Timepix3: improve in-house knowledge of detector readout and FPGA systems in general



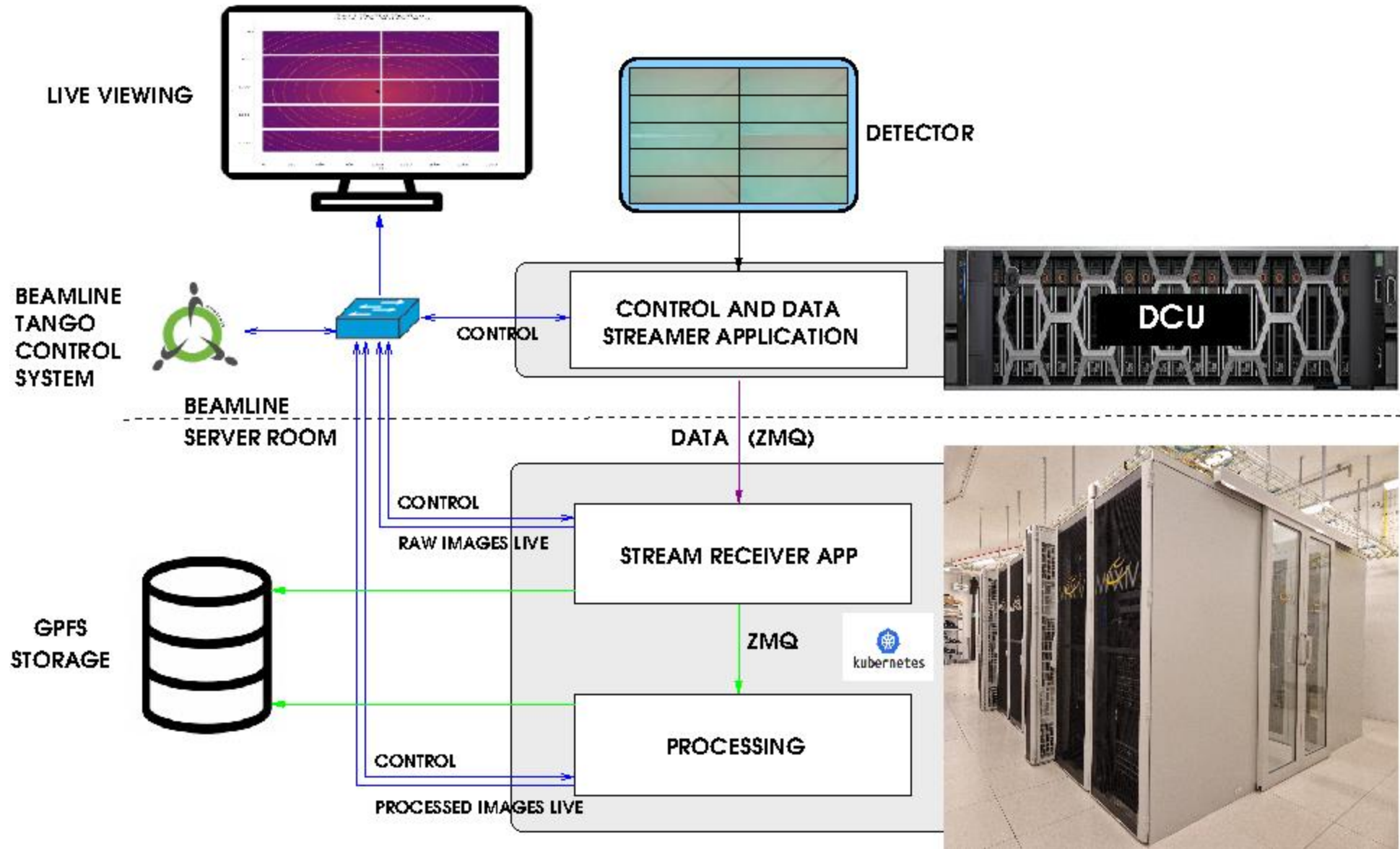
Hardware accelerated data reduction (FPGA)

- For robust real time data processing from next generation detectors
- Testing on Arria10 and Stratix10 boards
- Mainly using Intel OpenCL and more recently oneAPI
- Activities:
 - Azimuthal integration up to 20Gpix/s
 - Bslz4 decompression

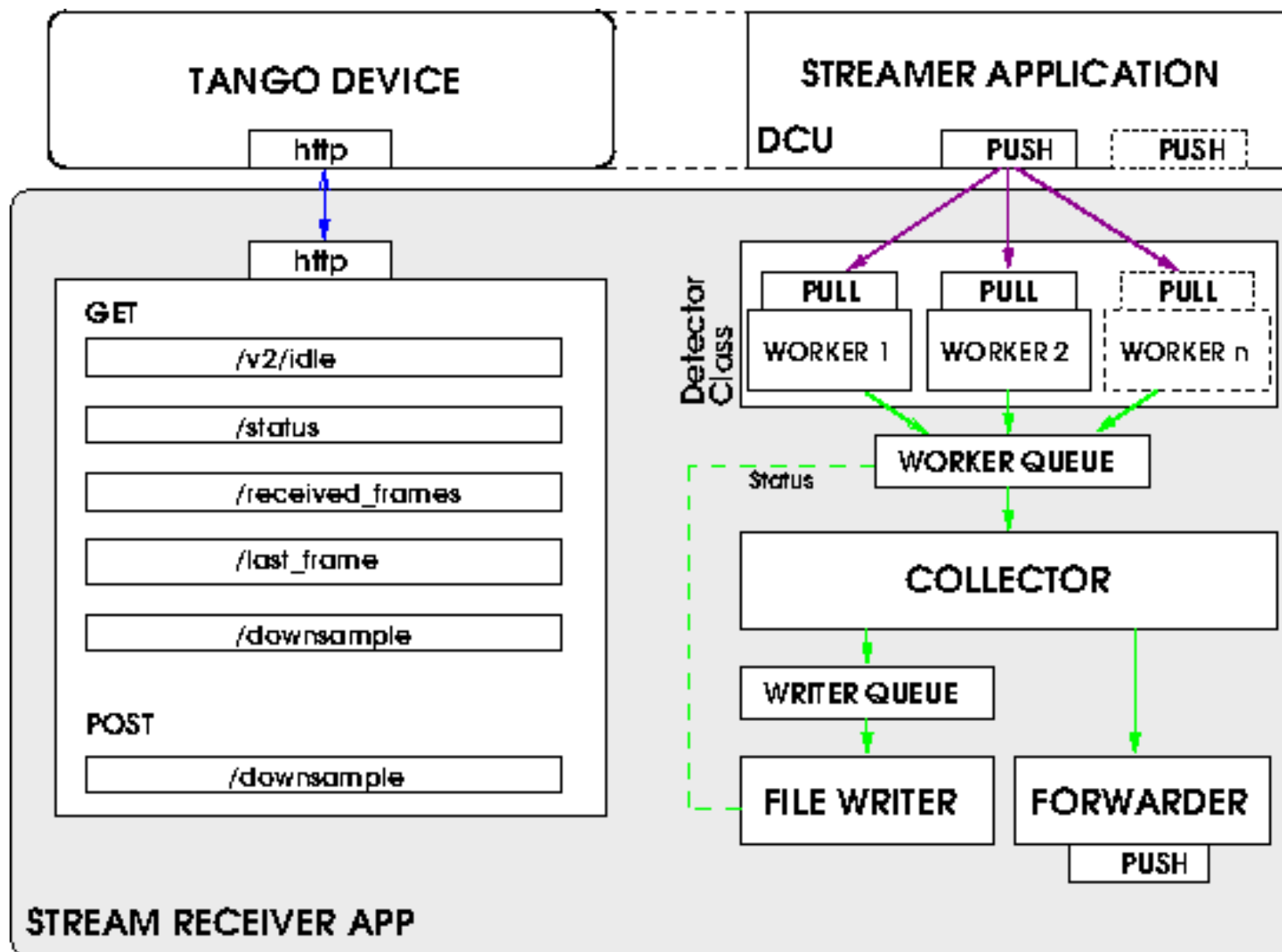
See:

- <https://gitlab.com/MAXIV-SCISW/compute-fpgas>
- <https://indico.desy.de/event/39343/contributions/151774/>

Streaming and Control

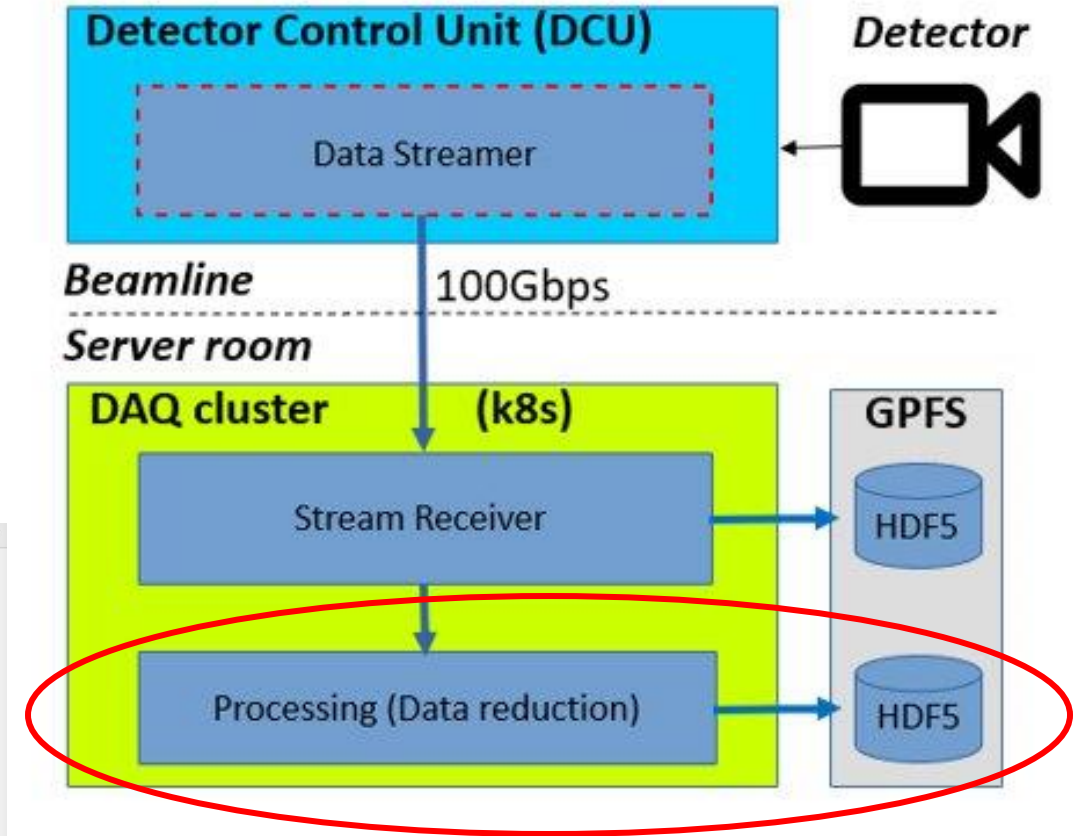
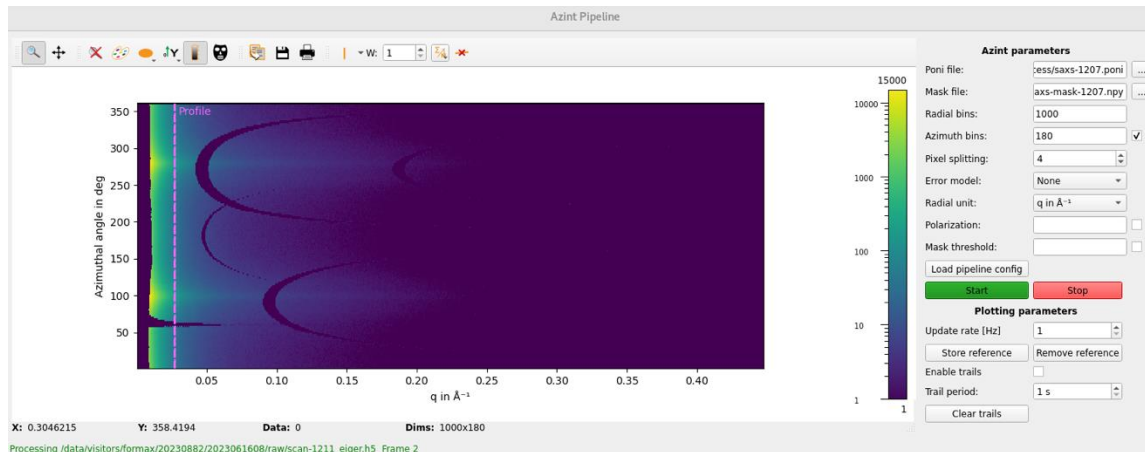


Stream receiver detail



Online data processing and visualisation

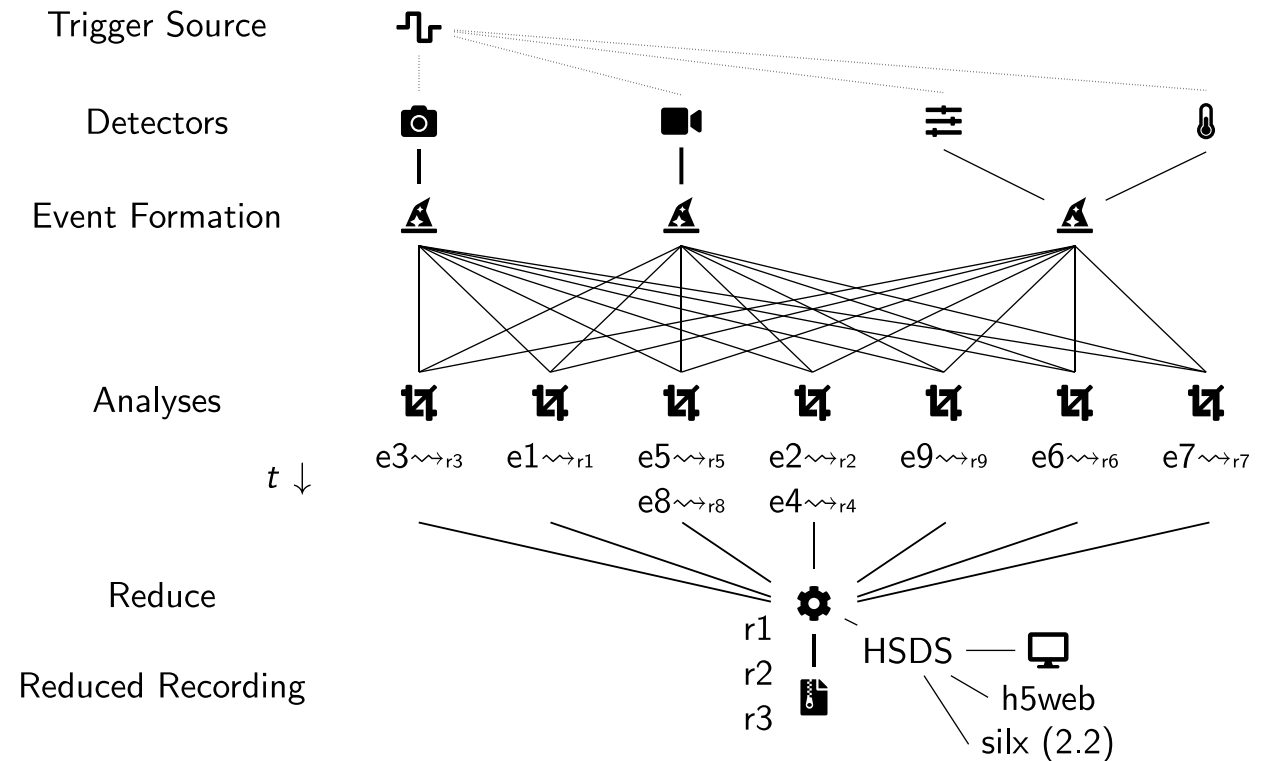
- Data processing steps deployed in same K8s cluster as streaming-receivers with data passed via ZMQ
- Algorithms range from simple operations (frame accumulation, ROI sums...) to real time tomography reconstruction on Nvidia GPUs
- Azimuthal integration common to many beamlines using in-house python implementation "azint" [*]



[*] Very large-scale diffraction investigations enabled by a matrix-multiplication facilitated radial and azimuthal integration algorithm: *MatFRAIA*, J. Synchrotron Rad., 2022. See <https://maxiv-science.github.io/azint/>

DRANSPOSE framework for online processing

- Ad-hoc collection of algorithms now reimplemented into standard framework named DRANSPOSE
- Some documentation and links to posters and conference talks here: <https://dranspo.se/>
- A map-reduce framework to address problems of simple live analysis
 - combining images from different detectors with motor positions, IO...
 - Plug-in any user-defined analysis code
 - Scalable to reach GB/s or kHz throughput
 - Live view results



Summary

- Scientific Data group formed 2023 to consolidate detector activities in one place, but merged with historical scientific software activities
- DAQ software (+ controls integration) is main deliverable of the group, but this naturally expands into online data processing, and builds on scientific expertise of group members
- Hence combination of these activities works well (synergy) though limited resources for "pure" detector work (developments or even optimisation of existing systems)
- Online/on-the-fly processing and visualisation has become essential system we deliver to the beamlines. We are looking for any external interest in DRANSPOSE.

MAXIV

Full list of systems at MAX IV today

In operation - Detectors

- Dectris Eiger and Eiger2 (numerous from 500k to 16M)
- Dectris Pilatus2 and Pilatus3 (several)
- Dectris Mythen2
- XSpectrum Lambda 2M "windmill"
- PSI JungFrau 9M (loan from PSI)
- PSI Eiger (loan from PSI)

At MAX IV but not in regular operation

- Rigaku XSPA1M
- ASI Lynx T3
- QD Merlin Quad

In operation – CMOS and CCD

- Andor Zyla and Balor (numerous)
- Hamamatsu Orca Lightning
- Tucsen Dhyana
- TVIPS TemCam-F216 CMOS
- Teledyne PI-MTE3 CCD
- Photron Nova S16
- AXIS Photonique AXIS-SXR-60 (dev)
- XIMEA MX1510MR-SY-X4G3-FF (dev)

In operation – other systems

- QD XSpres3 pulse processor (numerous)
- Surface Concepts and Roendek DLDs (numerous)

Coming soon

- PSI Mythen 3 (purchase)

Other aspects

Organisational notes

- Hardware support from Beamline Office "Sample Environment and Detectors" group. They maintain pool e.g. for SDDs, perform engineering tasks like the Dhyana rehousing, assist in trouble shooting, but generally not software development.
- SEDS also provide detectors lab which is networked like a beamline, i.e. for Tango control and full rate DAQ data streaming to cluster

Other projects – delay line detectors

- Several DLD8080 and DLD4040 from Surface Concepts (e.g. RIXS beamlines) read out by TDCs
- Project to replace supplied TDCs with Teledyne digitiser cards to capture all pulses and process these into hits in software
- Motivation: reduce artifacts seen in TDC readout