

Detector-DAQ and online processing

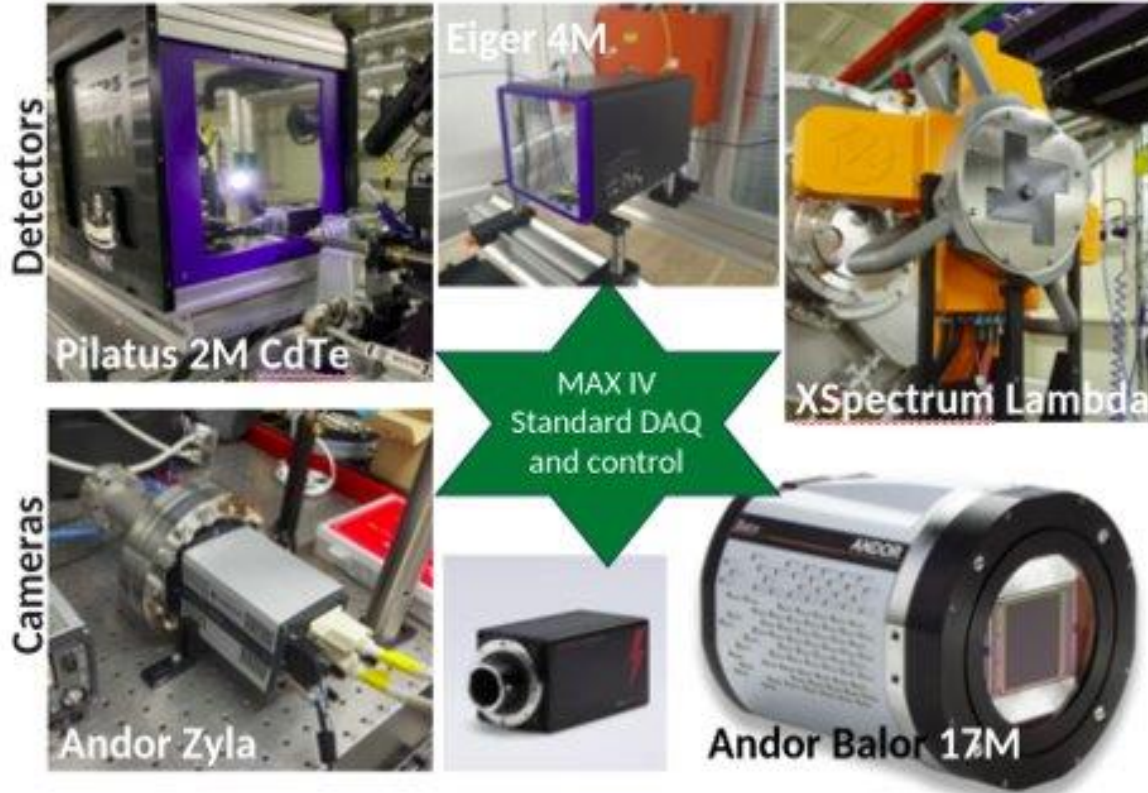
Paul Bell

Scientific Data Group - Technical Division

**Advanced Light Source / MAX IV Bilateral Collaboration Workshop
24th August 2026**



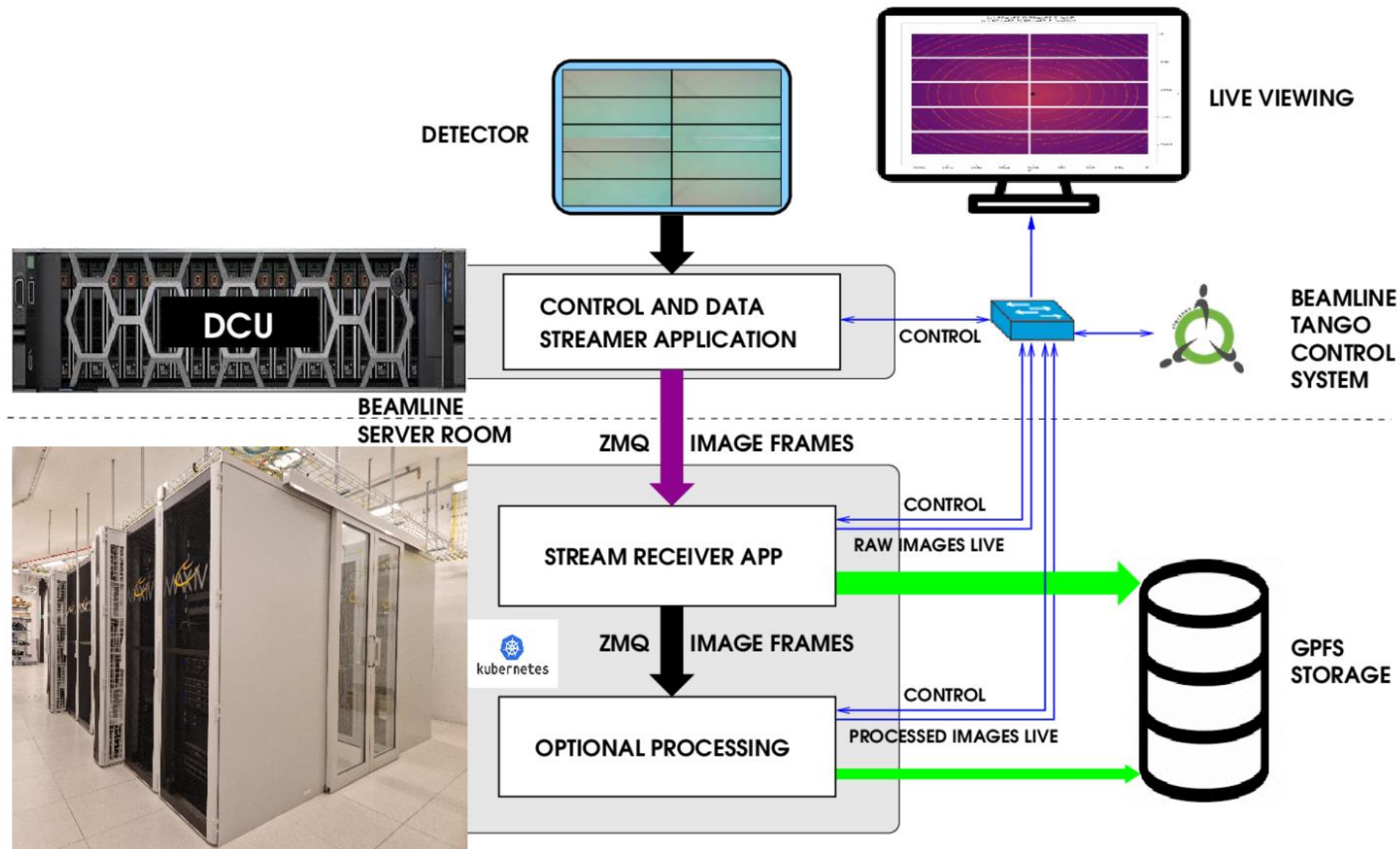
Integration of detectors/cameras



Beamline	Detector make & model	Type	Pixels approx	Frame rate fps	Data rate GB/s
NanoMAX	Dectris Eiger2	PC	500k	100	0.2
	Dectris Eiger2	PC	1M	100	0.4
	Dectris Eiger2	PC	4M	100	1.6
	Dectris Pilatus3	PC	1M	25	0.1
CoSAXS	Dectris Eiger2	PC	4M	500	4.0
	Dectris Pilatus3 "L-shaped"	PC	2M	100	0.8
ForMAX	Dectris Eiger2	PC	4M	500	4.0
	XSpectrum Lambda "windmill"	PC	3M	500	4.5
	Hamamatsu Orca Lightning	sCMOS	12M	120	2.0
DanMAX	Andor Zyla (× 3)	sCMOS	5.5M	100	0.8
	Dectris Pilatus3	PC	2M	250	2.0
	Hamamatsu Orca Lightning	sCMOS	12M	120	2.0
	Andor Zyla	sCMOS	5.5M	100	0.8
	XIMEA MX1510MR-SY-X4G3	sCMOS	150M	6	1.4
Balder	Dectris Eiger (× 2)	PC	1M	500	1.0
SoftiMAX (soft X-rays)	Andor Zyla	sCMOS	5.5M	100	0.8
	Tucsen Dhyana	sCMOS	4M	24	0.2
	Teledyne PI-MTE3	CCD	16M	0.06	0.004
FemtoMAX (SPF)	Dectris Pilatus3 "ToT"	PC	1M	10	0.04
	Andor Zyla (numerous)	sCMOS	5.5M	10	0.08
	Andor Balor	sCMOS	17M	10	0.25

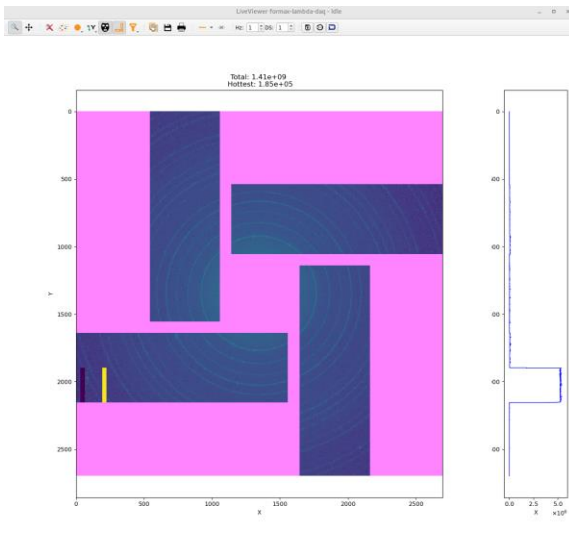
- Consolidated 30+ systems, 10+ unique types into common Kubernetes-managed DAQ cluster
- NB Jungfrau 9M (and 1M) at MicroMAX has custom JungfrauJoch solution from PSI

Streaming (and Control)

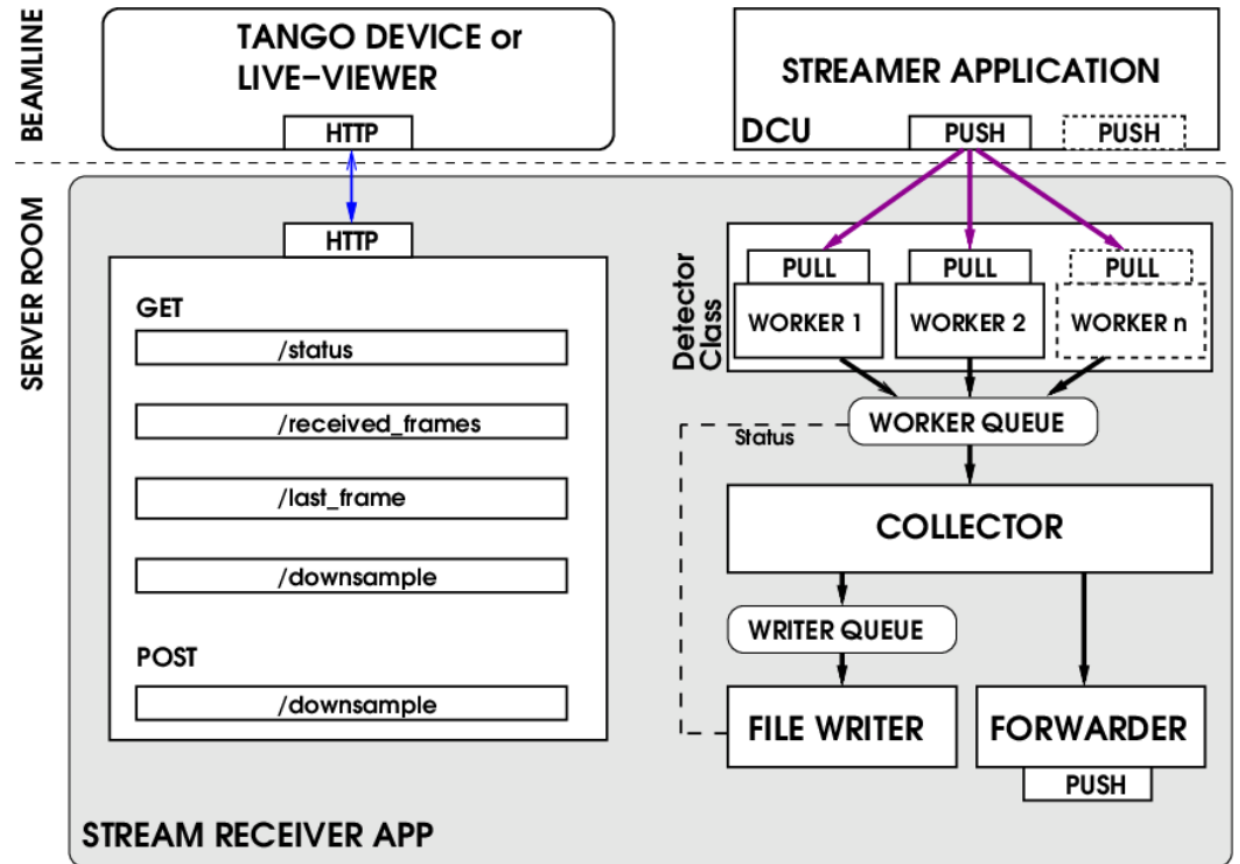


Data streaming and receiving

- Dectris Eiger detectors provide a ZMQ stream from the DCU
- For everything else: A streamer application is created to run on DCU and produce similar ZMQ
- Then in the DAQ cluster (k8s) a receiver is simply deployed for each new detector/camera

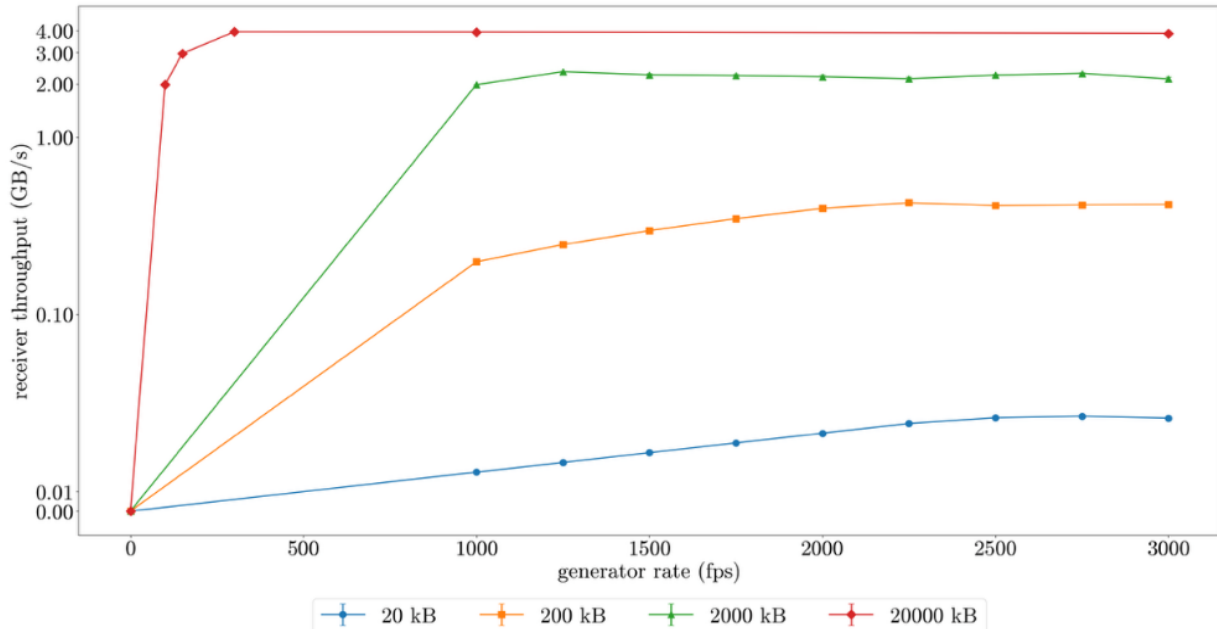
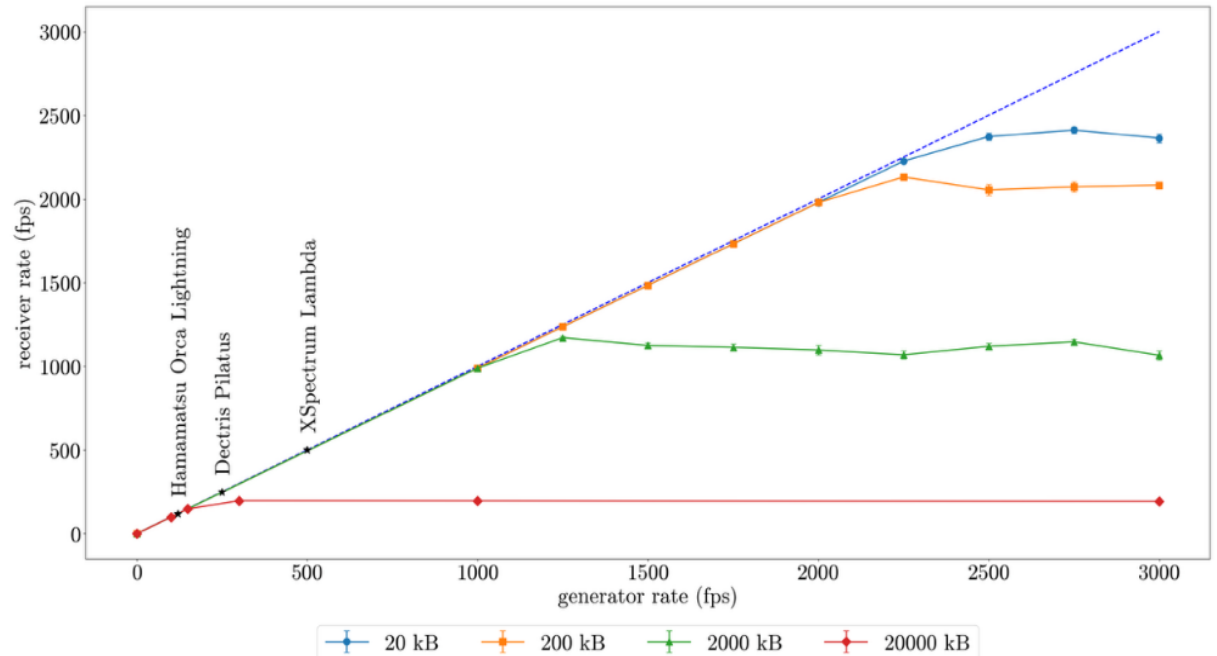


Receiver provides standard interface to simple live-viewer using a SILX widget



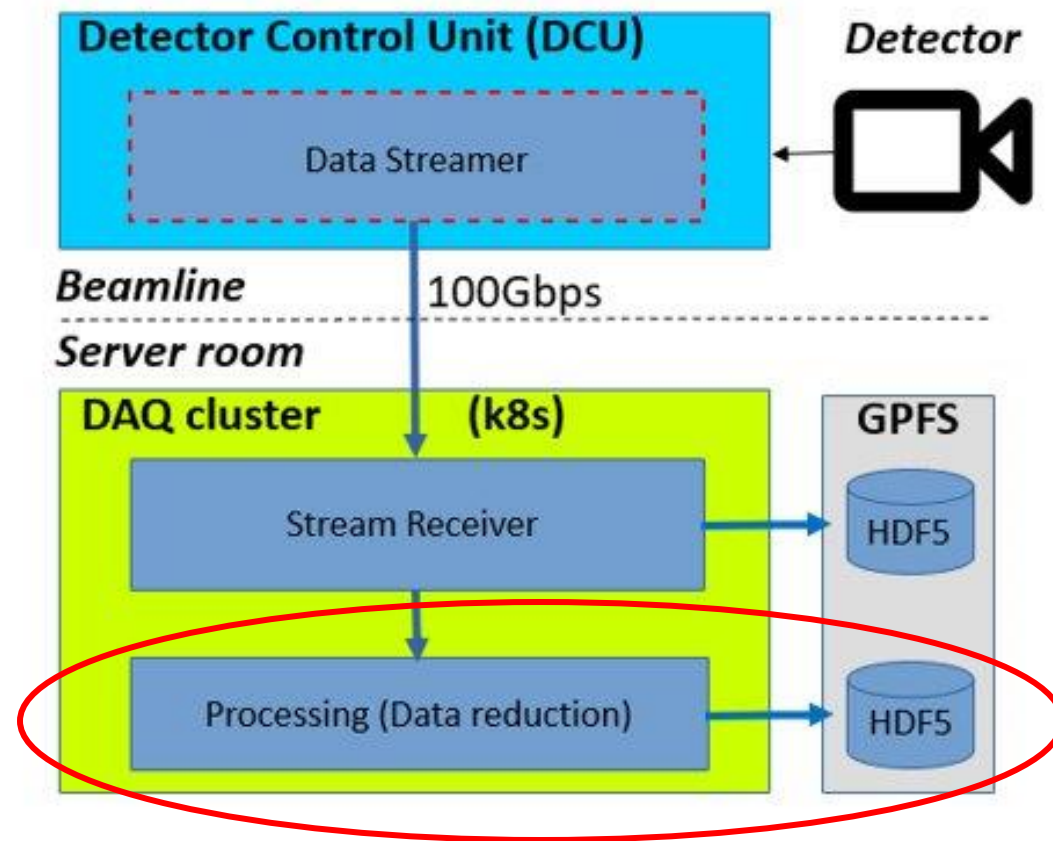
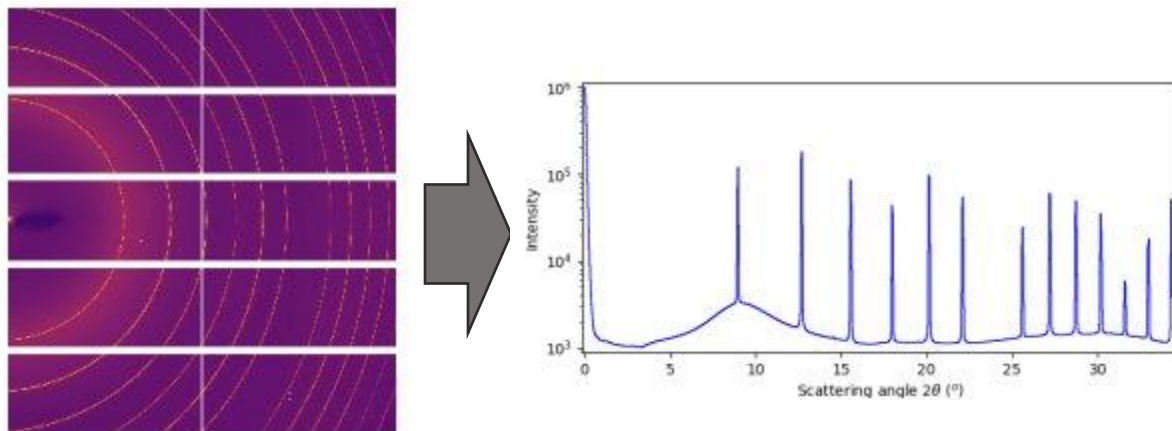
DAQ Performance as is

- highest frame rates attained with smallest frame sizes, e.g. around 2 000 fps for frames of 200 kB
- highest data throughput, 4 GB/s, achieved with largest frame size (20 000 kB) at lower frame rates
- limits are compatible with the current operational needs:
- high frame rate (1000 fps range) photon counting detectors have modest frame sizes due to compression
- lower rate (100 fps range) CMOS cameras deliver high frame sizes due to small pixels and lack of compression.
- Bottle neck is file writing with h5py: without file writing, we reach 4GB/s for all frame sizes
- Then by tuning number of workers and ZMQ context I/O threads, we can reach full 100Gbit/s of the network
- *Current development: to parallelise the file-writing*



Online data processing and visualisation

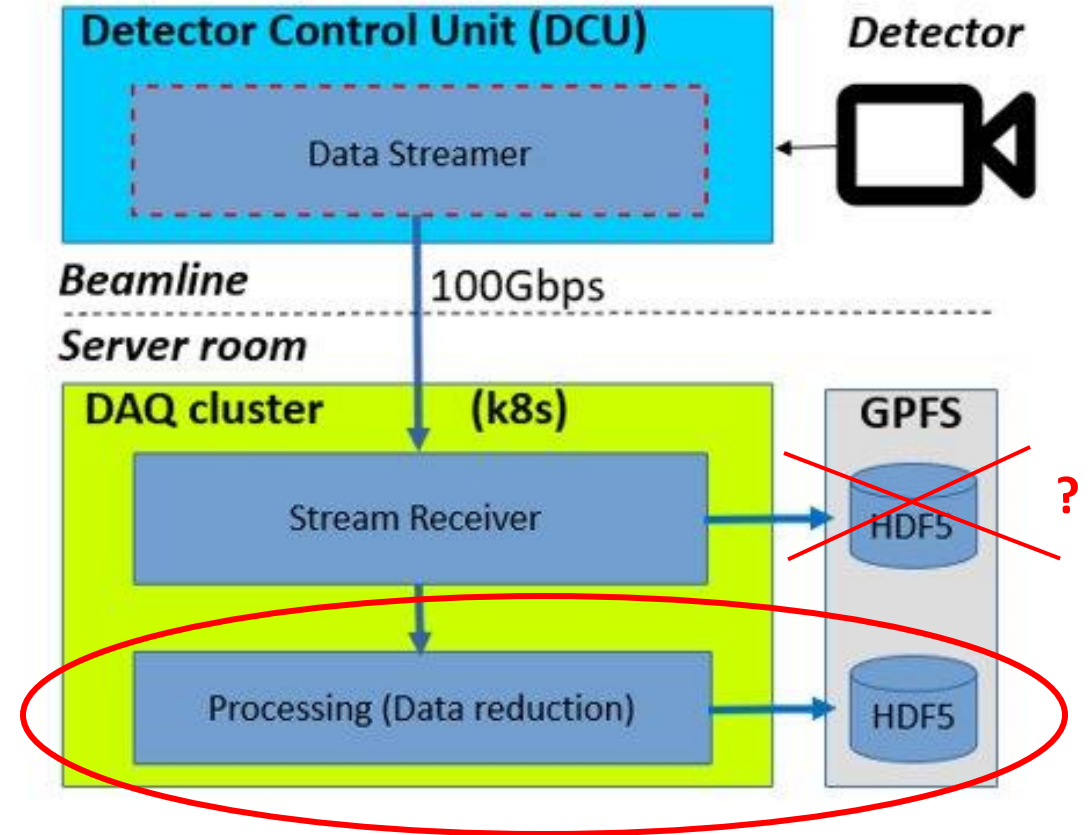
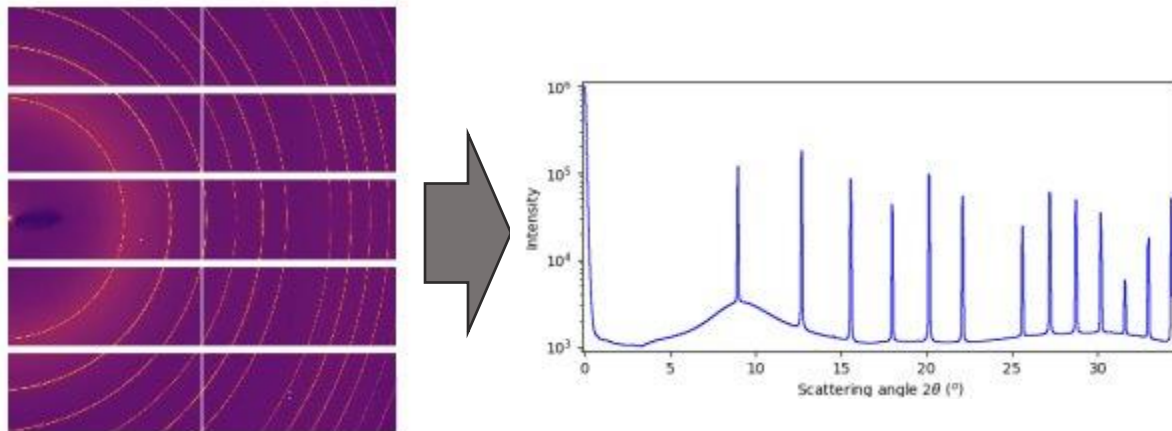
- Data processing steps deployed in same K8s cluster as streaming-receivers with data passed via ZMQ
- Algorithms range from simple operations (frame accumulation, ROI sums...) to real time tomography reconstruction on GPU
- Azimuthal integration common to many beamlines using in-house python implementation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

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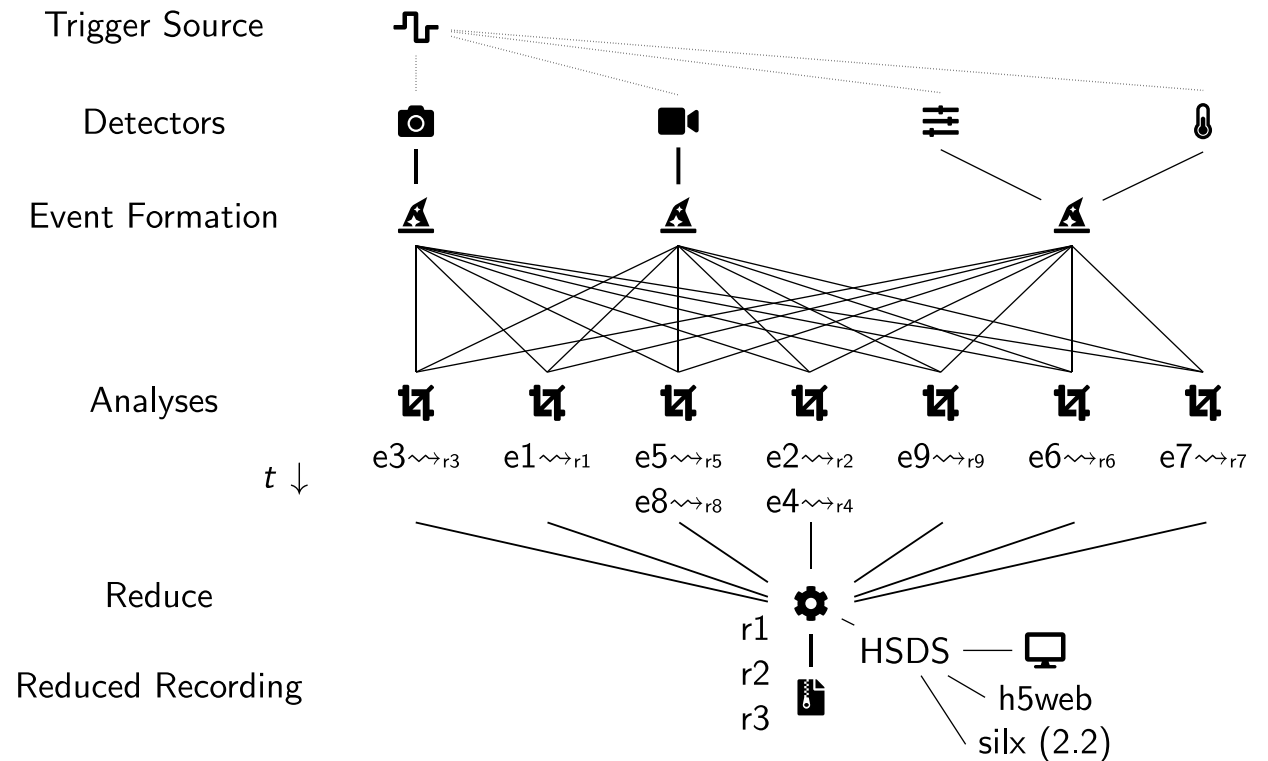
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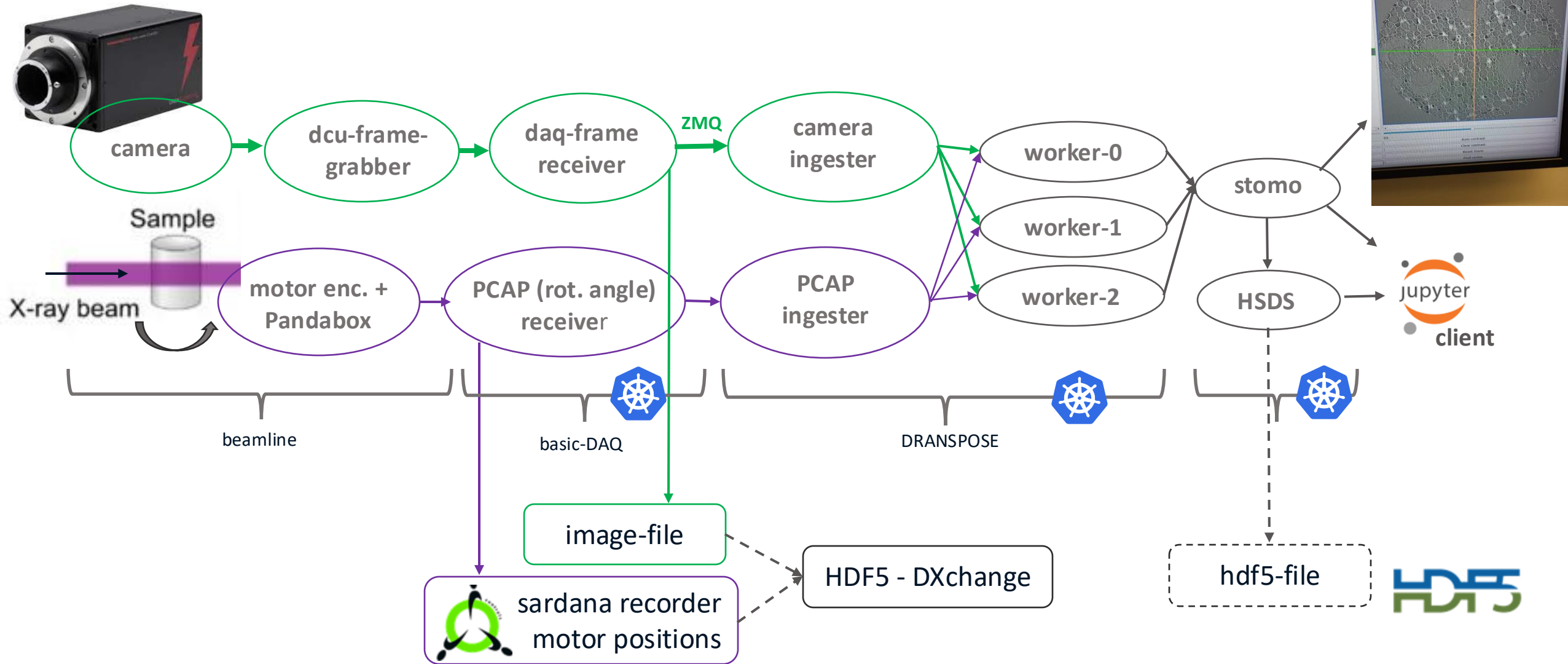
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DRANSPOSE framework for online processing

- 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 constrained 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
- *Can be used for data reduction*

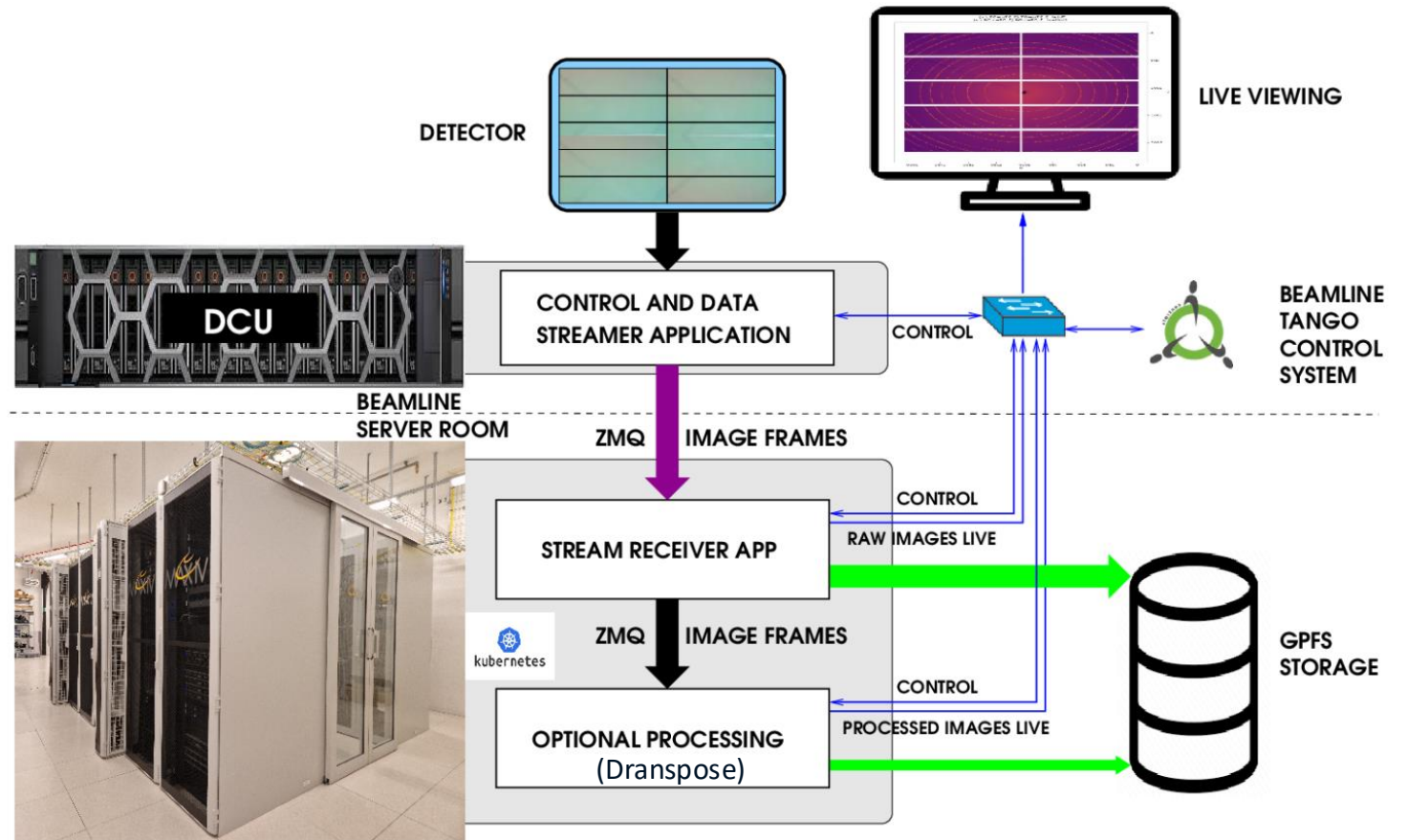


Streaming tomography pipeline



Summary

- Have presented our standard detector-DAQ which servers over 30 systems in k8s
- In same central DAQ cluster, naturally extends into genuine live / on-the-fly processing and visualisation – and in principle data reduction
- "Dranspose" framework is being worked on and we are adding more applications



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