



Durham
University

Centre for Advanced
Instrumentation

Durham Adaptive Optics (DAO) real time controller

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RTC4AO

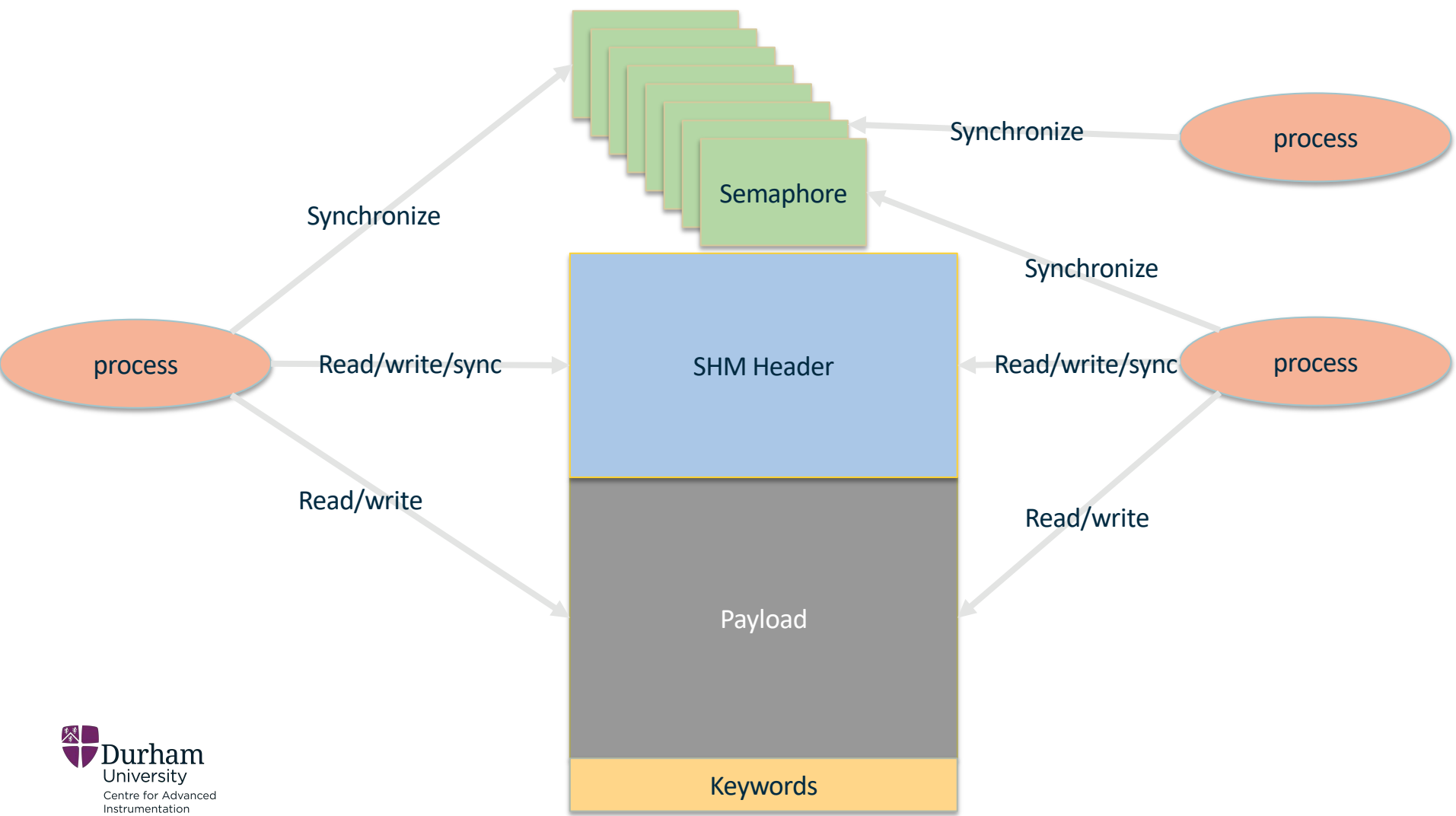
Munich 07/11/2023



Why another RTC solution?

- Not new!
- Inspire by CACAO (Guyon et al.) and still compatible with it
- Based on lessons learned from Keck and LAO
- Still compatible with old system thanks to the shared memory data standard
- Simple to use: our goal is that it can be used by AO scientist or expert RTC software engineer
- Focus on AO and let the non-AO challenges aside like how do I get the pixels from this camera, how do I move actuators, etc.
- Already interfaced with all standard AO hardware (Cameras, Mirrors)
- Telemetry
- Logging system
- CPU/GPU ready
- UNIX based system

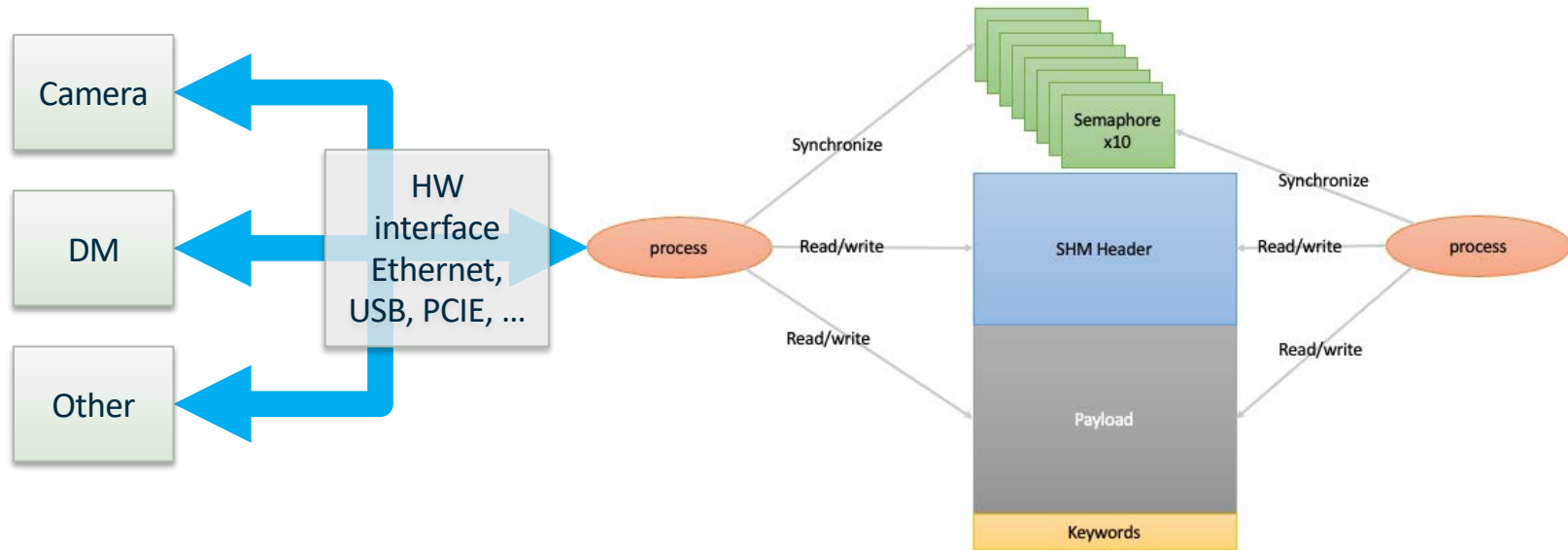




Pro

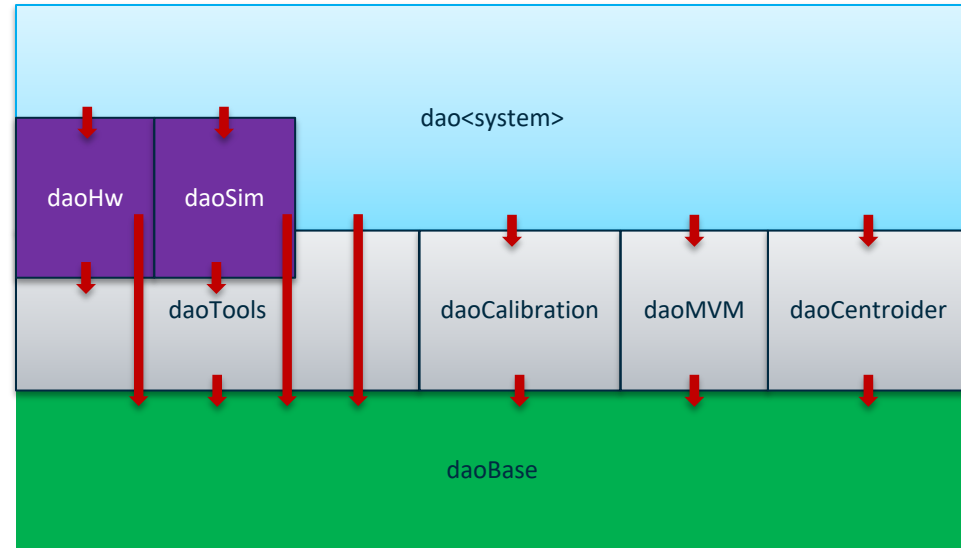
- Processes are completely independent
- Data are all shared with the same format, any new process can get access to everything always the same way
- Fast and simple read write access
- Easy to synchronize
- C/C++/Python and more to come (Matlab)
- GPU/CPU compatible
- Distributed (scalable)
- Biggest advantage of DAO is its flexibility and easy to use approach
- All the data are available at all time, from any language
- Timing information and synchronization tools available

Hardware interface



Module structure

- **Core:** base functionalities, SHM interface, logging, Numa, event handler, state machine, db interface
- **Tools:** collection of well know AO functionalities, centroiders, image calibration, MVM, GUI
- **Hybrid:** both tools and application, simulation, HW interface
- **Applications:** system specific code, where we gather the functionalities, we need to create the final AO system

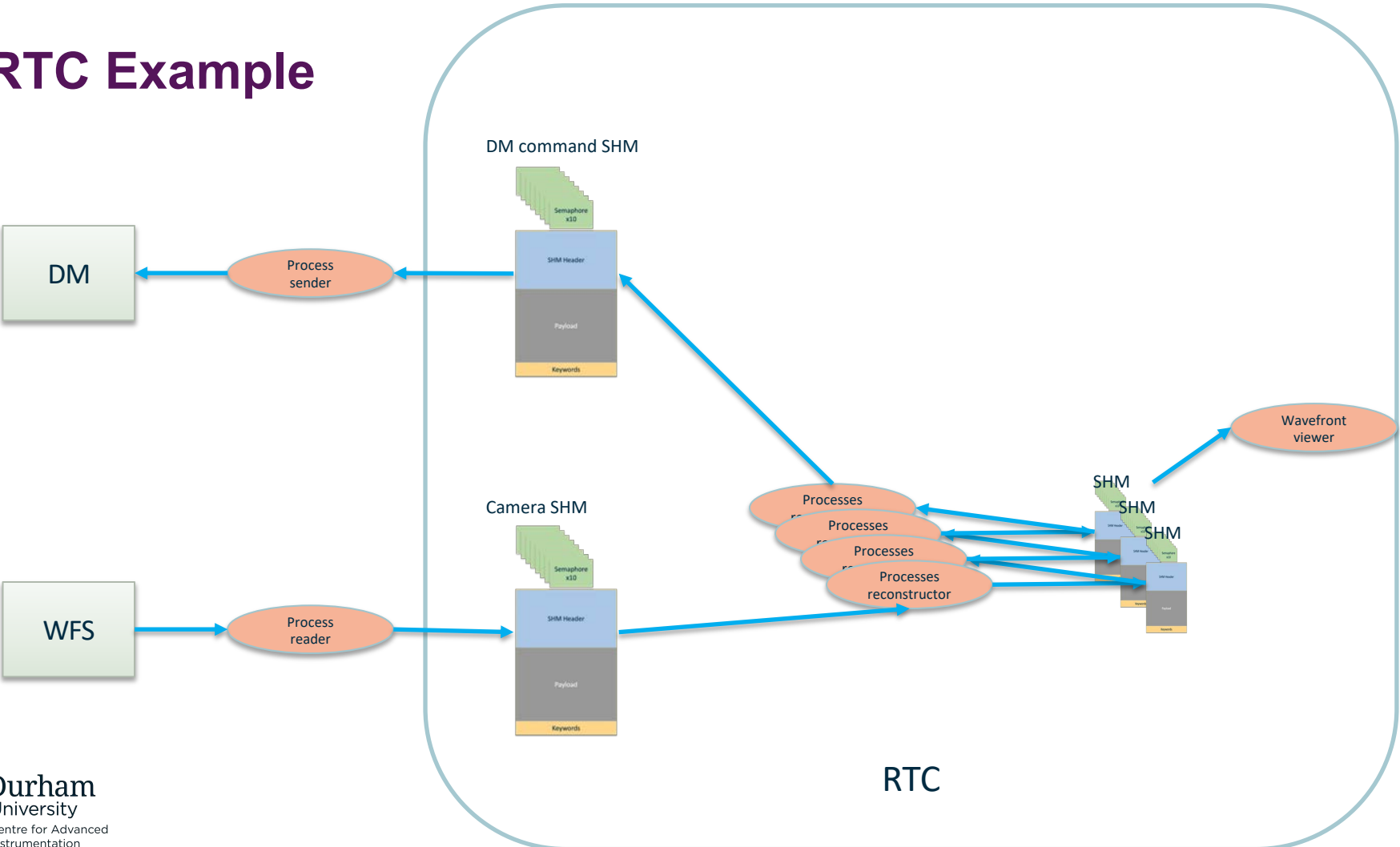


Pushing down functionalities to share as much as possible with the community

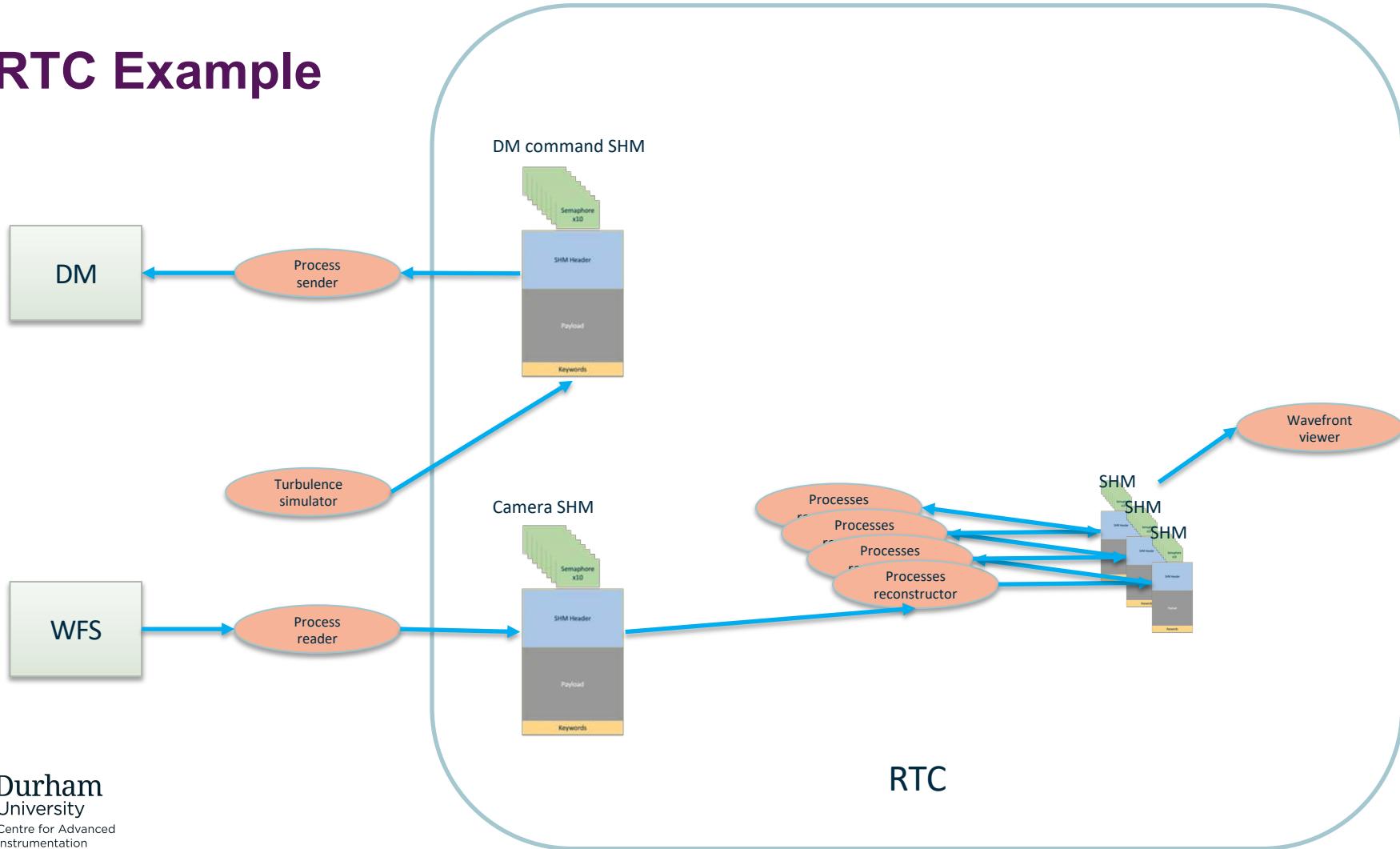
What is included

- Pyramid WFS (slopes/intensities algorithm)
- Shack-Hartmann WFS
- Classical Integrator
 - Leaky
 - Servo filter
- Predictive control (Guyon et al., Jensen-Clem et al.)
- Inter node communication for distributed system
- Lot of AO hardware interfaces
- Growing community... Hopefully lot of collaboration

RTC Example

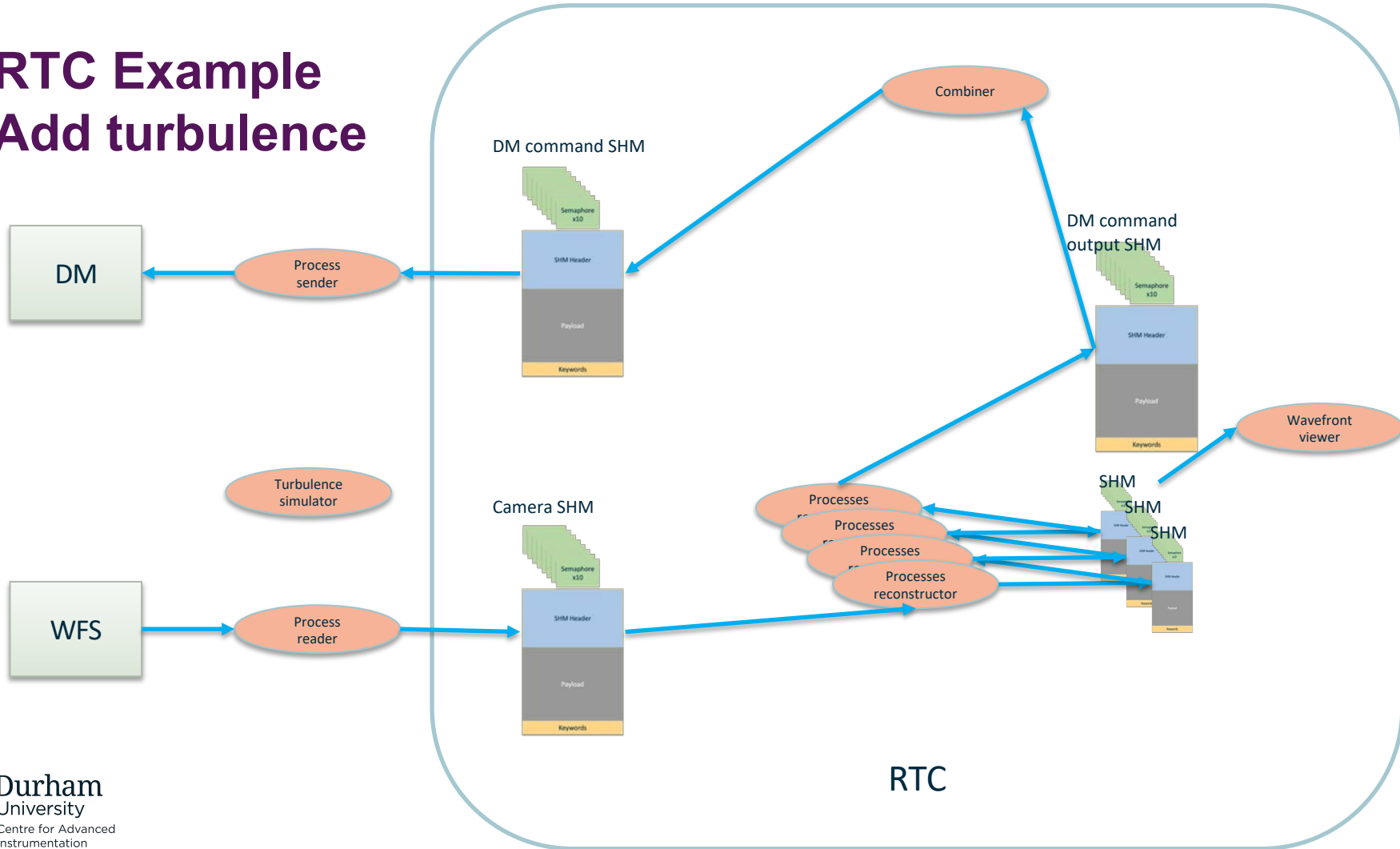


RTC Example

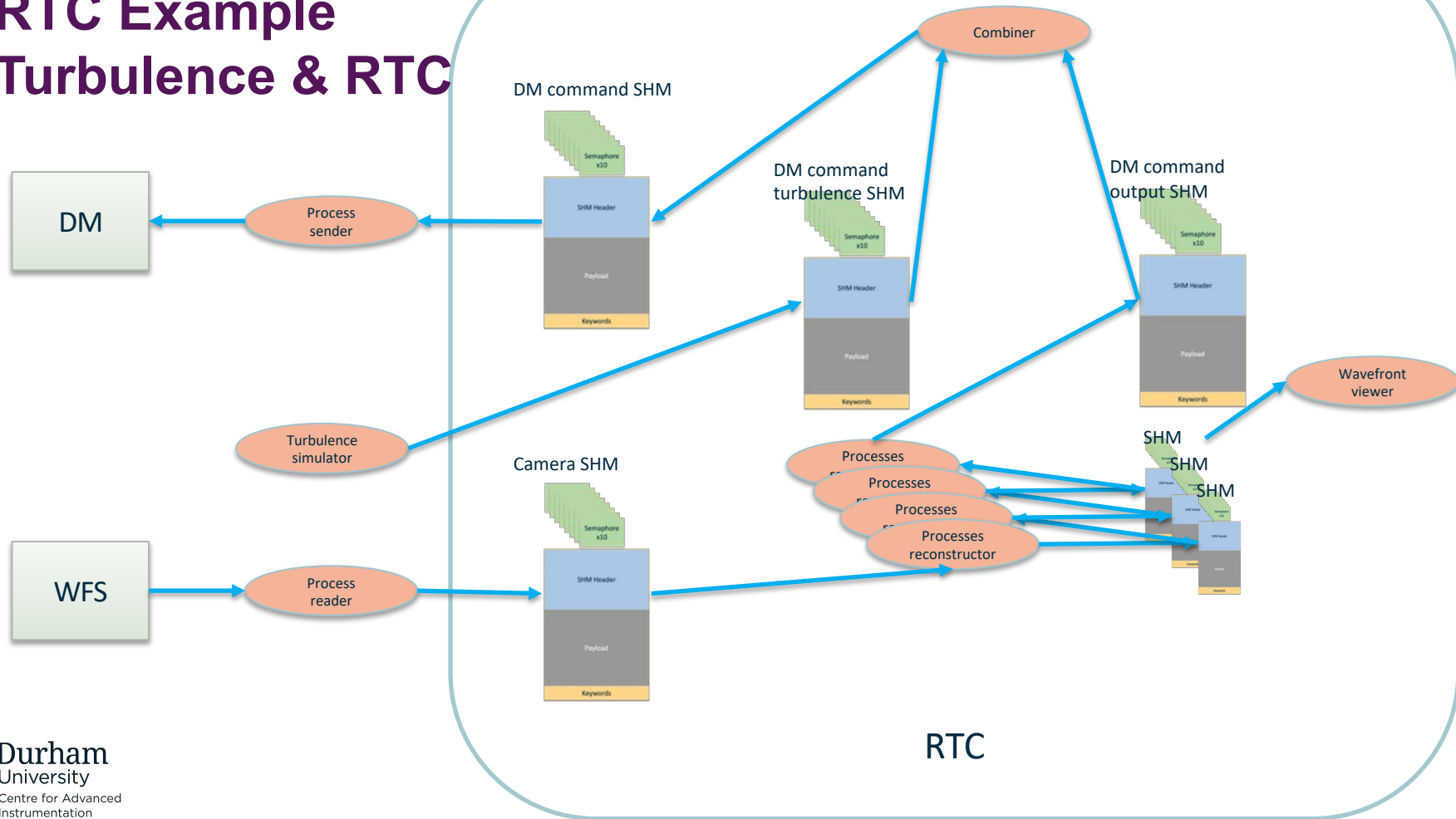


RTC Example

Add turbulence

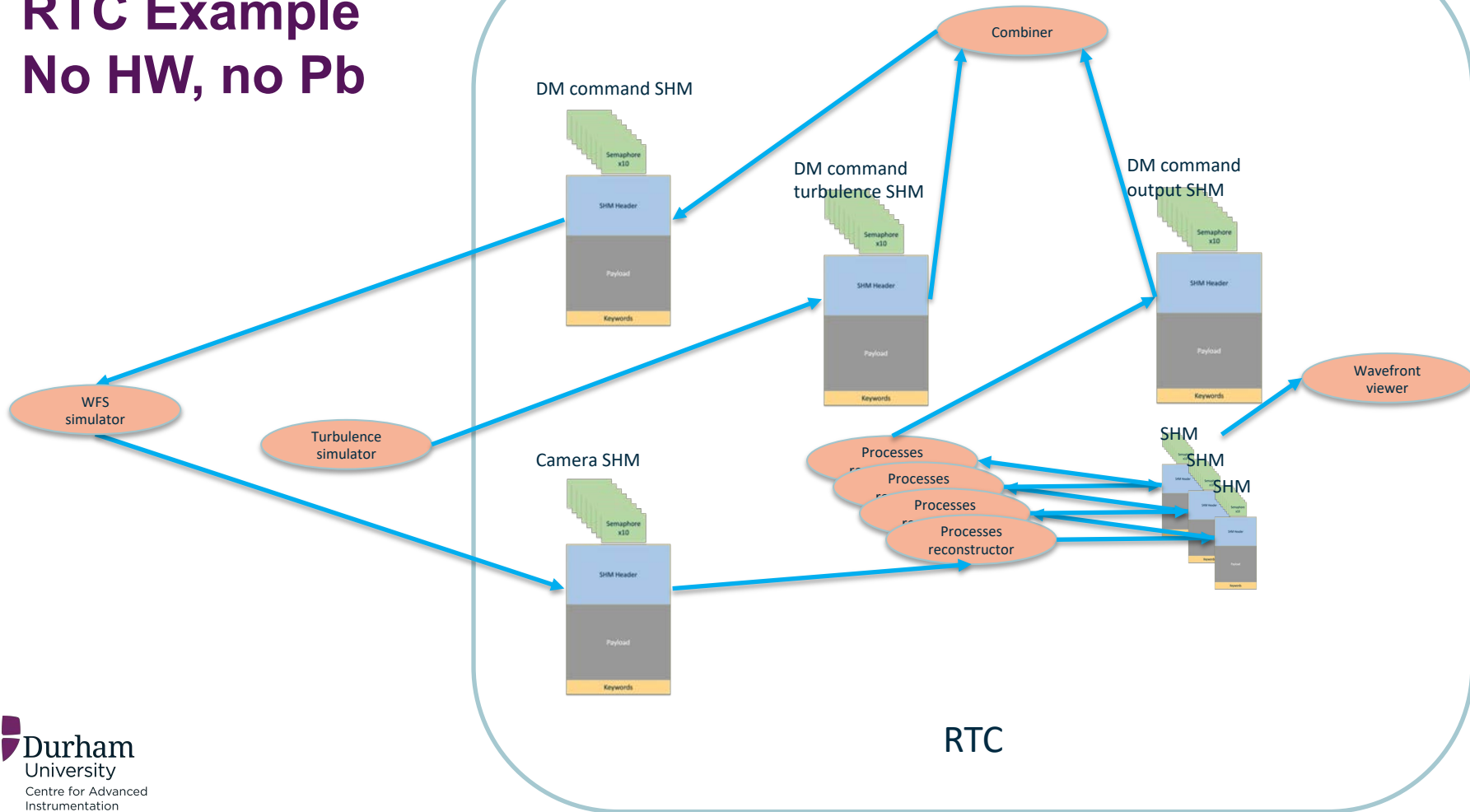


RTC Example Turbulence & RTC



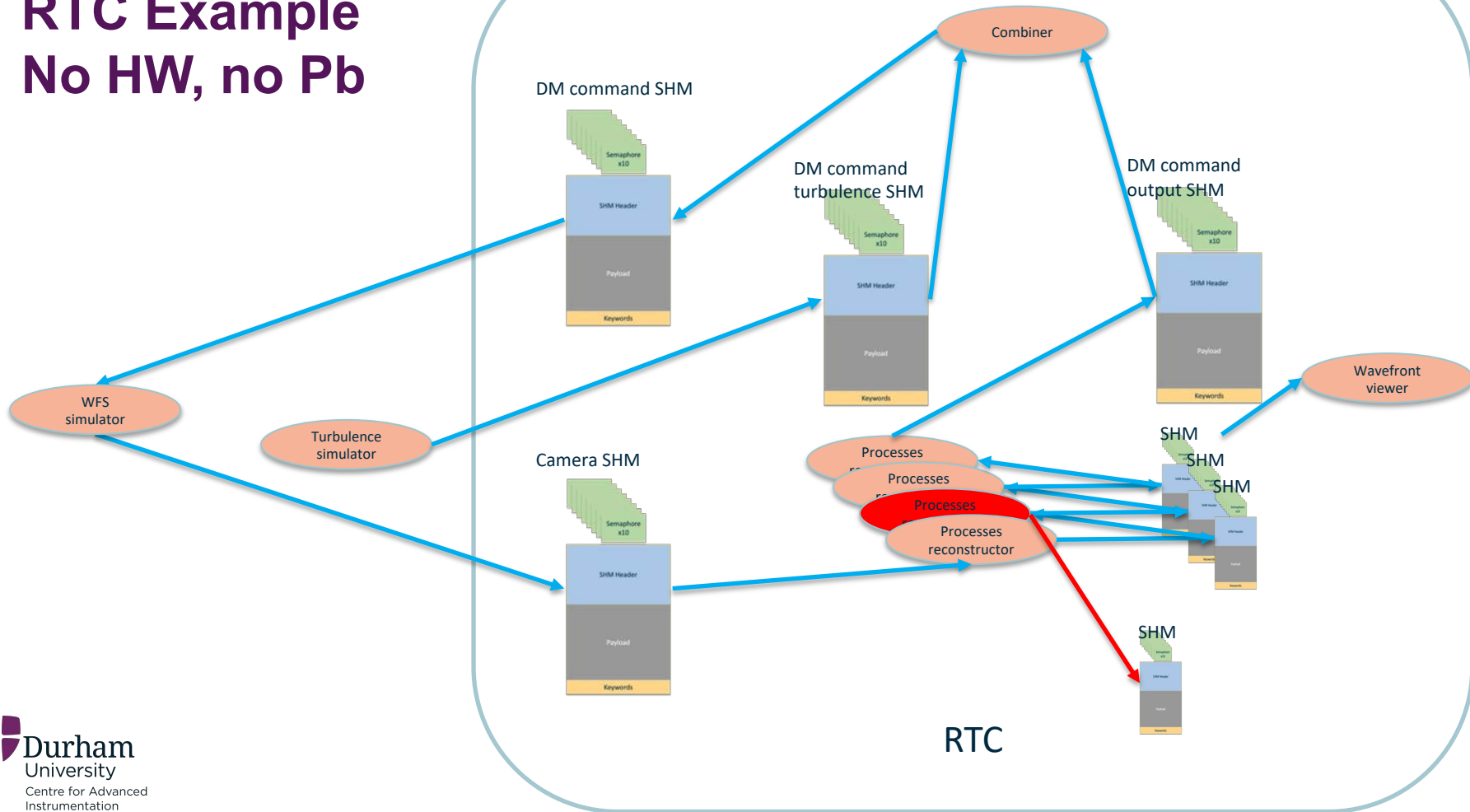
RTC Example

No HW, no Pb



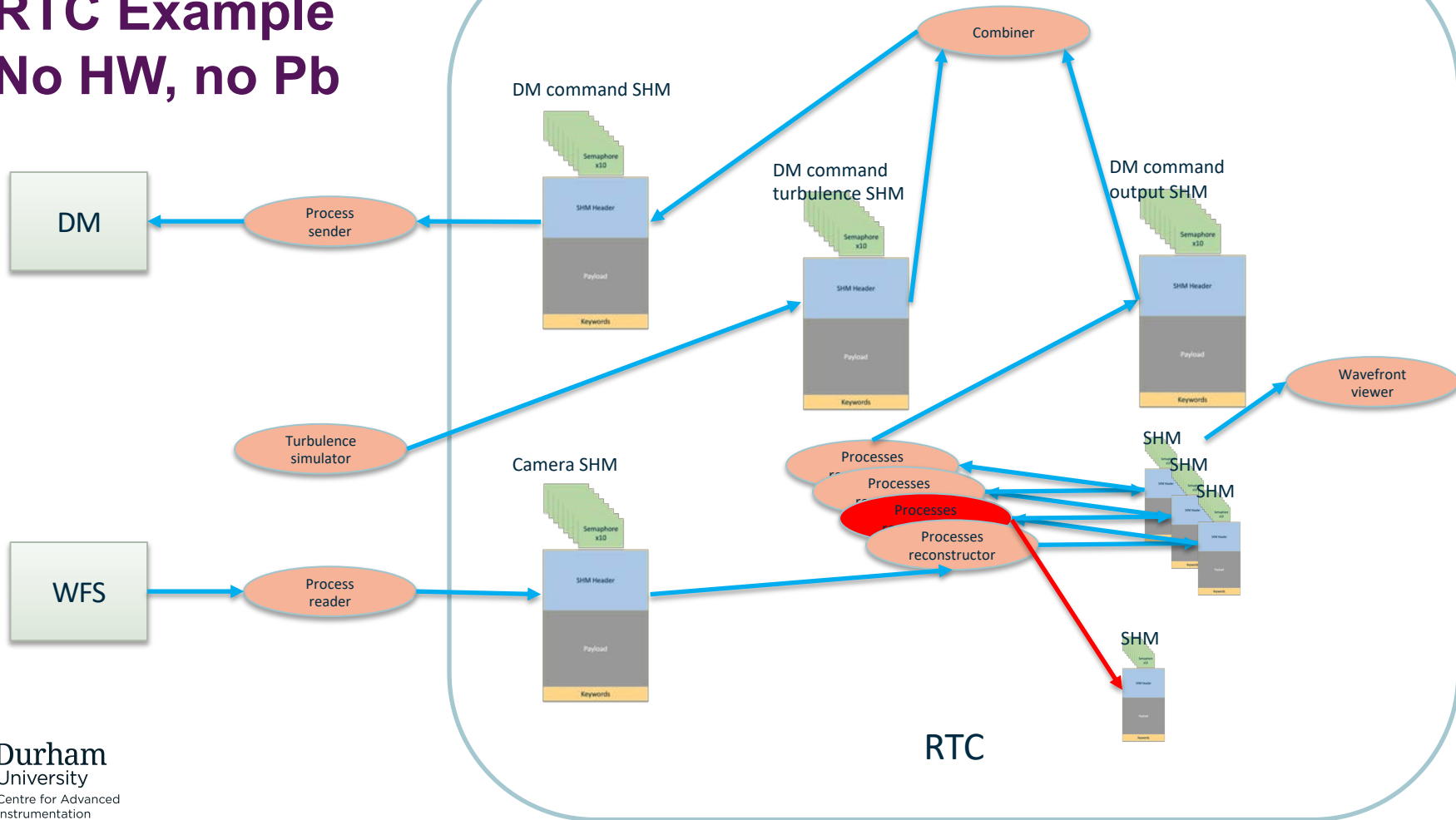
RTC Example

No HW, no Pb



RTC Example

No HW, no Pb

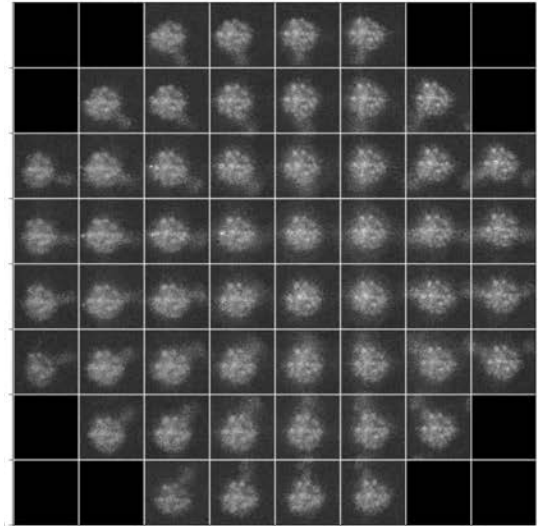


Current and future projects using DAO

- HARMONI
- WIVERN Laser bench
- MCAO bench in collaboration with Padova
- PAPHOS on the OHP
- SHIMM (Turbulence monitor with VIASAT)
- DKIST solar turbulence profiler*
- MKID prototyping*
- EST RTC*

And more in the future...

Wide-field correlating WFS
(similar to Solar AO)

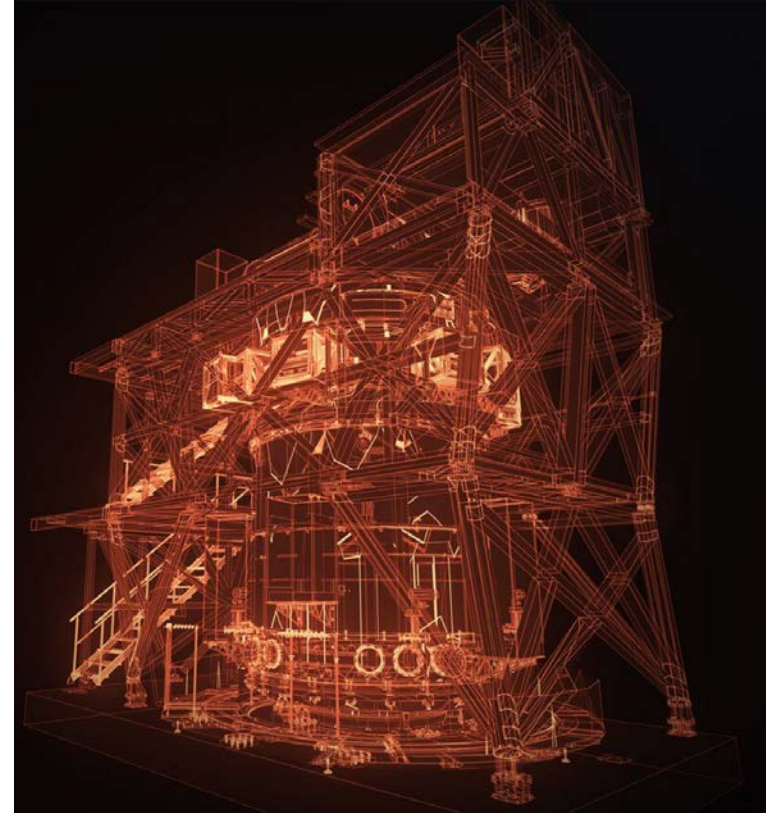


Engineering real-time display
Python QT based

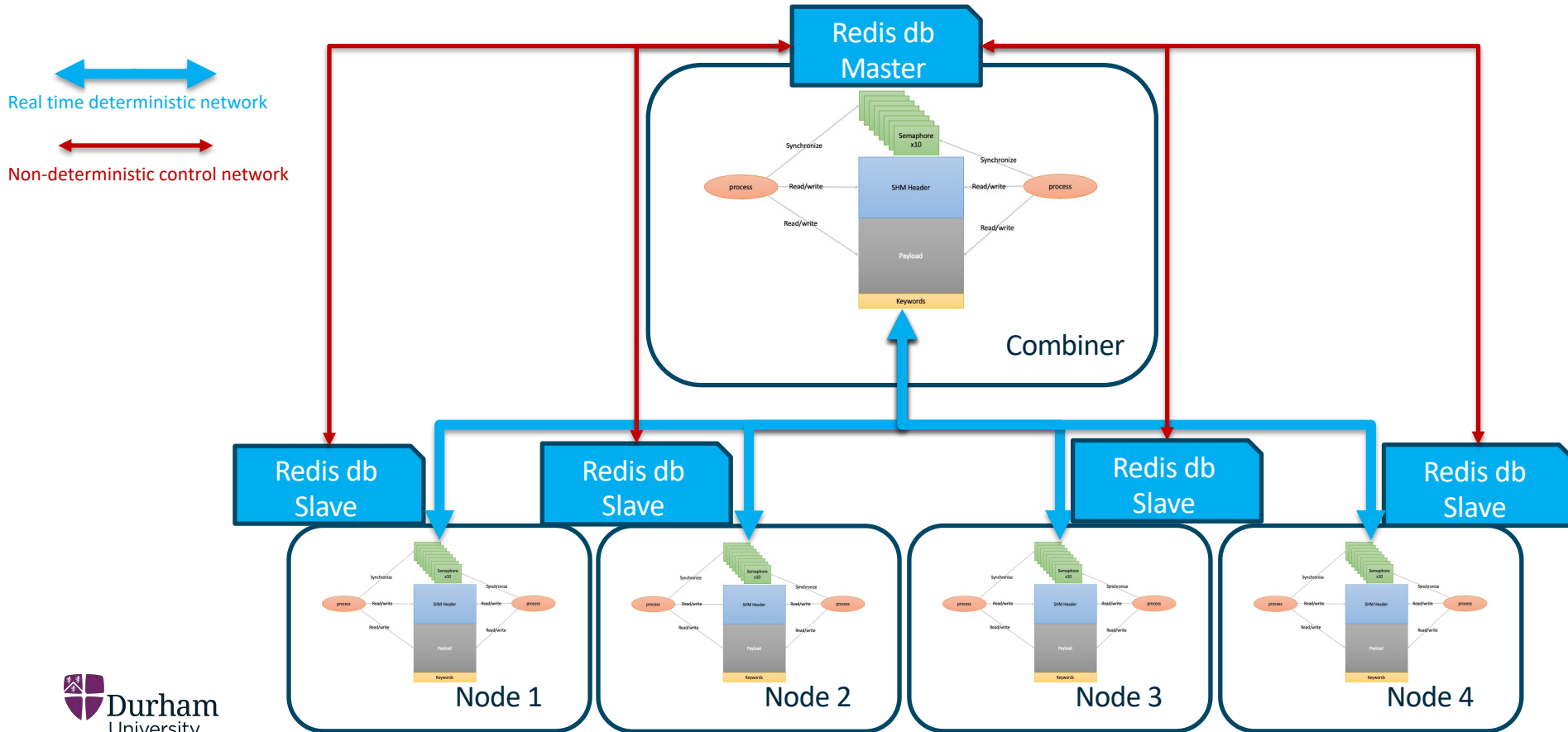
DAO and HARMONI

Advanced system

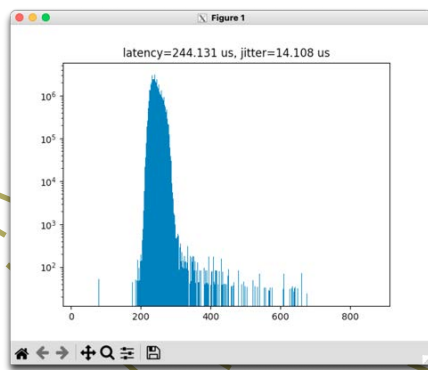
- See David Barr talk about HARMONI RTC
- SCAO (3 nodes)
 - 1x 240x240 u16
 - Multicast to all the nodes
 - 1kHz
 - Reconstructor 29472x4358
 - Node 29472x1453
- LTAO (6 nodes)
 - 6x1092x1092 u16
 - Node input: 1x1092x1092
 - 500 Hz
 - 6x reconstructors 9200x4358 (size if we use 6 nodes)



CPU distributed system on network for big system



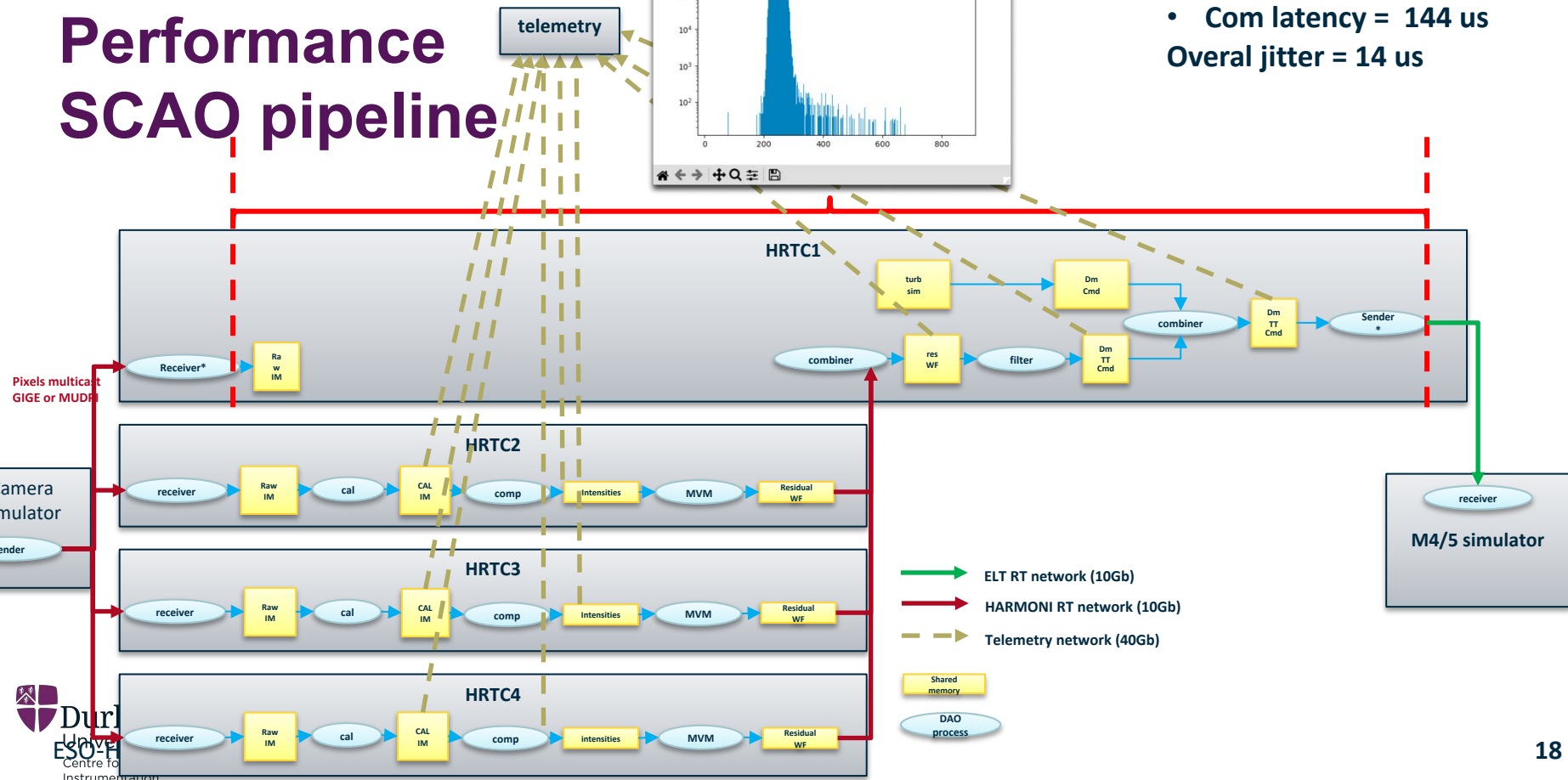
HARMONI Performance SCAO pipeline



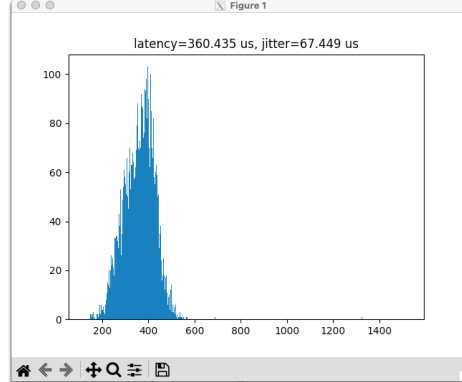
Overall latency = 244 us

- Node latency = 100 us
- Com latency = 144 us

Overall jitter = 14 us



HARMONI Performance LTAO pipeline

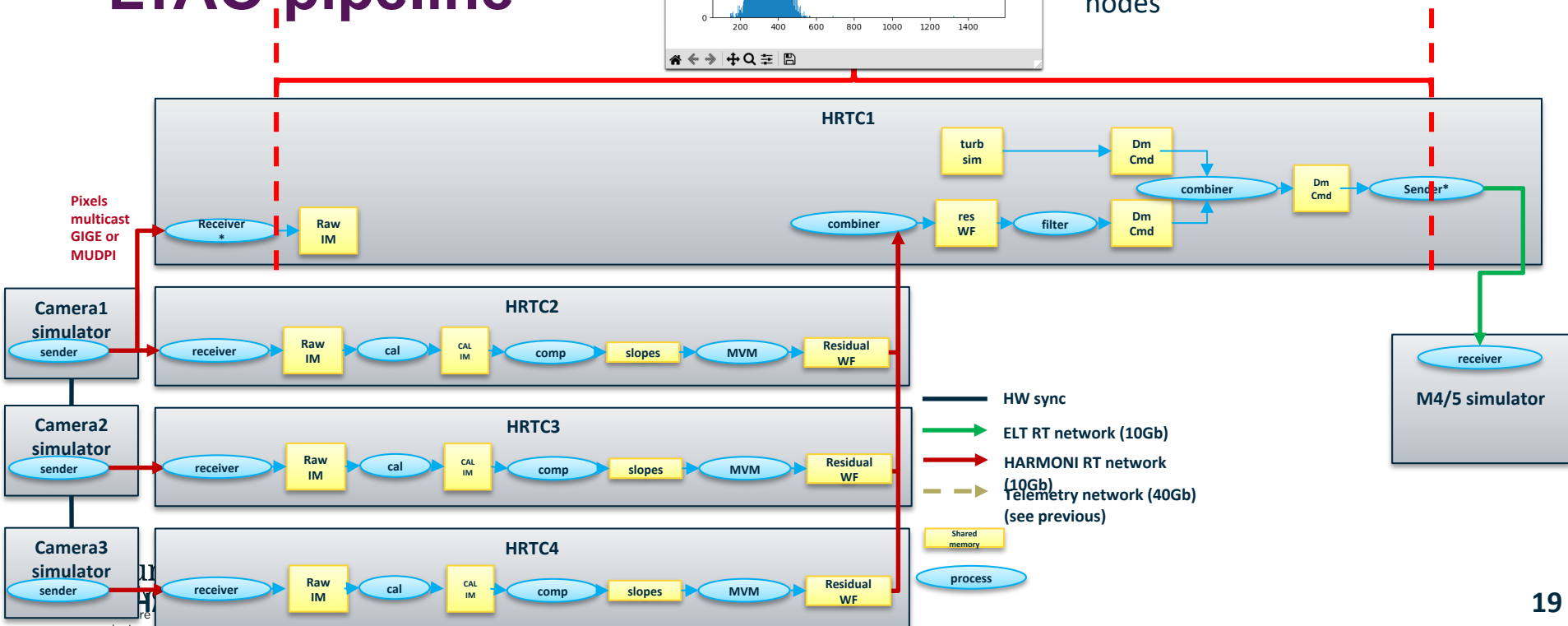


Overall latency = 360 us

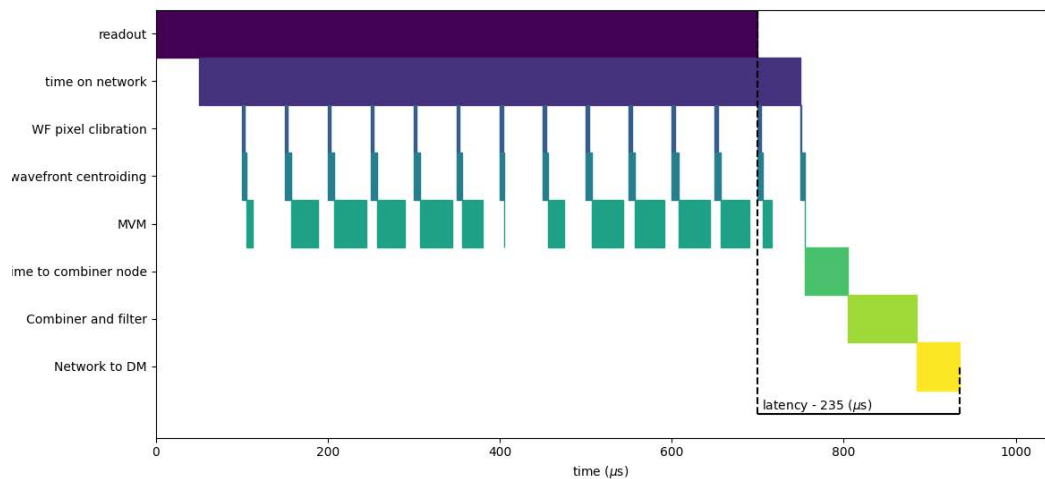
- Node latency = 260 us
- Com latency = 100 us

Overall jitter = 67 us

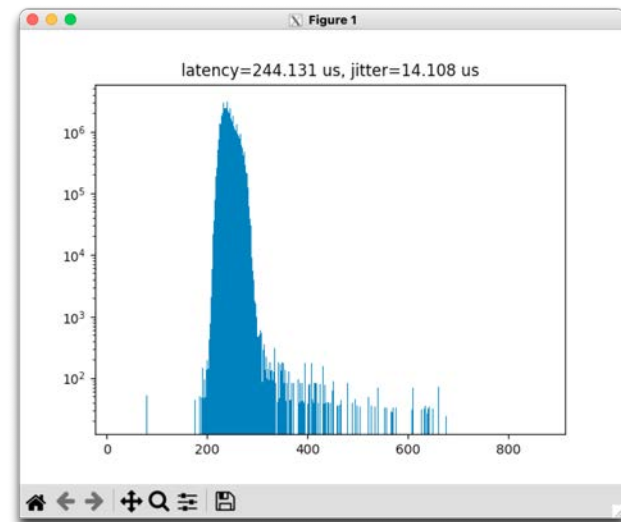
Latency independent of the # of nodes



HARMONI



Prediction



Results

Public release and export control

- Soon to have a public release on Github.
 - Get in touch if you want access now.
- Camera control and reconstruction algorithms
 - Not rated under UK Export law.
- Software (including source code) used for the real time control of deformable mirrors as part of an adaptive optics system - **rated 6D001**
 - **Have to sign an end user certificate before we can distribute the code.**

Conclusion

- DAO is reusing the existing CACAO SHM solution make it compatible with previous code
- Super easy to use, can build a basic RTC for AO bench in few days
- Easy to optimize and to implement more advance code if needed
- Well suited for ELT scale AO system
- Will improve with technology development
- No PU preference, easy to adapt to constraints and budget

Thanks for listening



CFAI Recruitment.

Current/closed

- Postdoc MKID + AO (deadline 5th)
- Assistant Optical Engineer (deadline 10th)

Upcoming

- post docs in AO focuses on RTC
- graduate software engineer roles.

Website, talk or email us for more information

<https://www.durham.ac.uk/job-vacancies/>
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sylvain.cetre@durham.ac.uk



Credit :Durham University