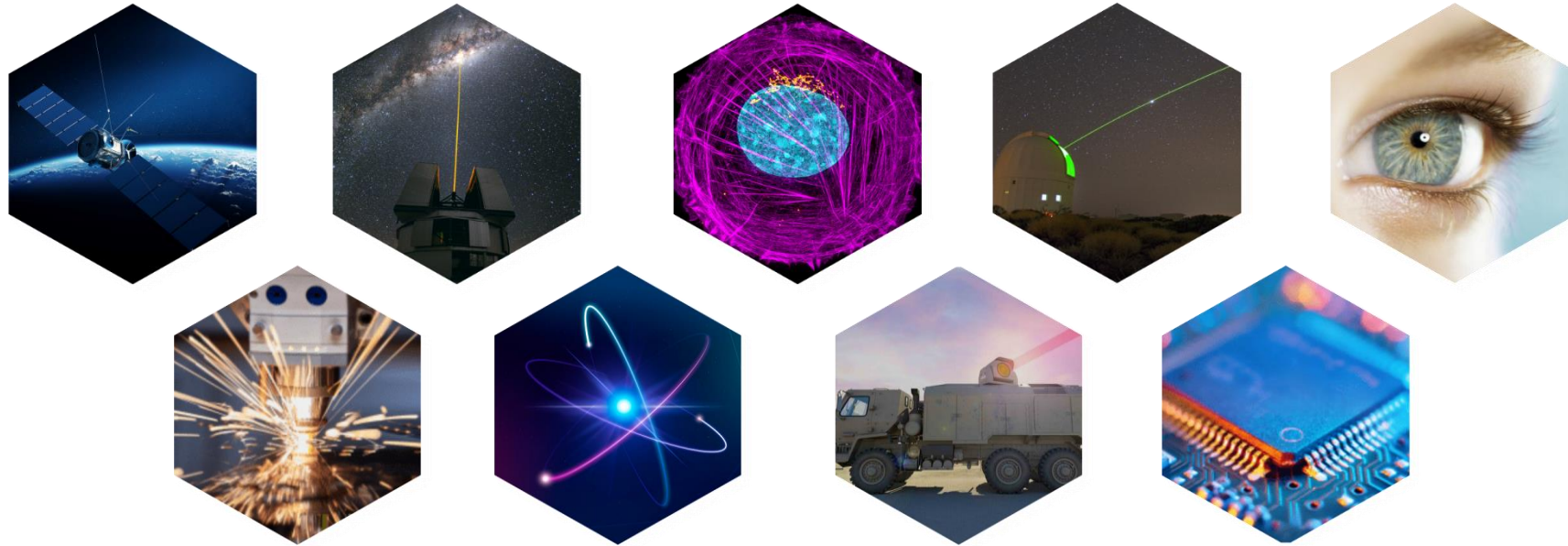


ALPAO RTC



RTC4AO – 06/11/2023 – Bruno Martin

ALPAO and systems



- ALPAO :
 - ▶ Deformable Mirror, Wave Front Sensors and RTC,
 - ▶ 40 employees entirely dedicated to Adaptive Optic,

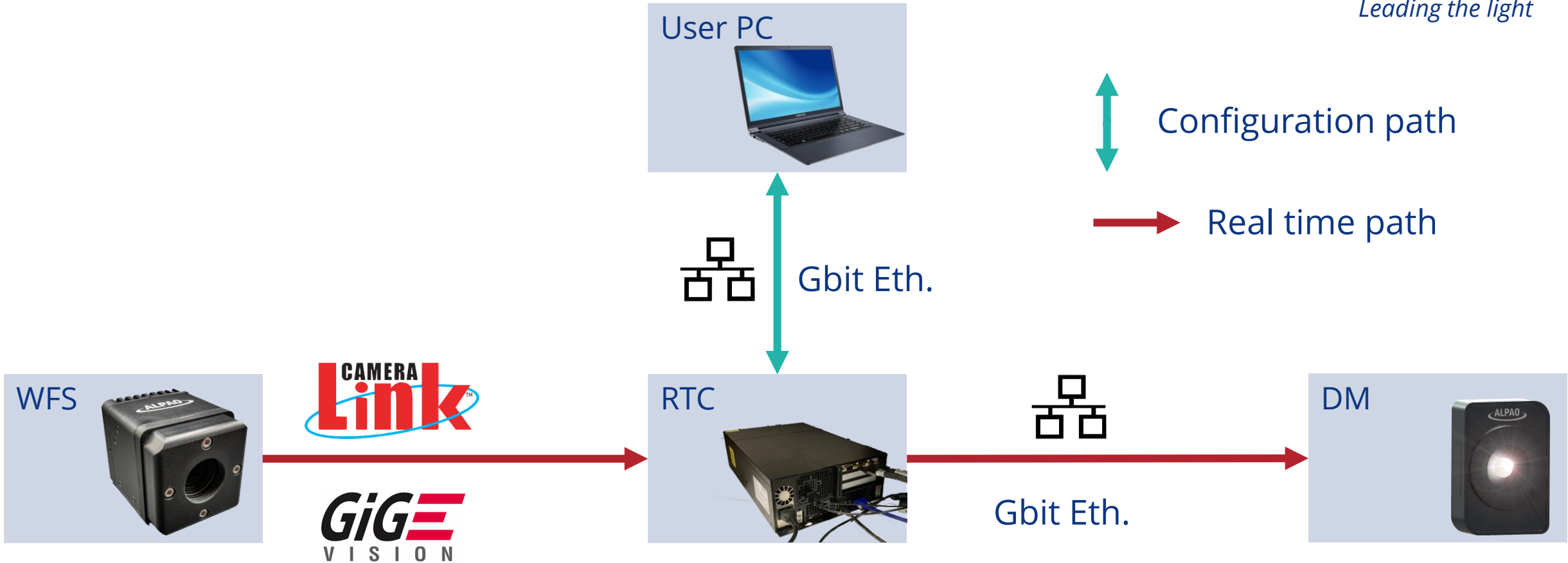
- Our task:
 - ▶ **Provide robust and compact real-time control solutions**
 - ▶ **for astronomy and FSO**
 - ▶ **up to 10kfps and 1k modes.**

Outline

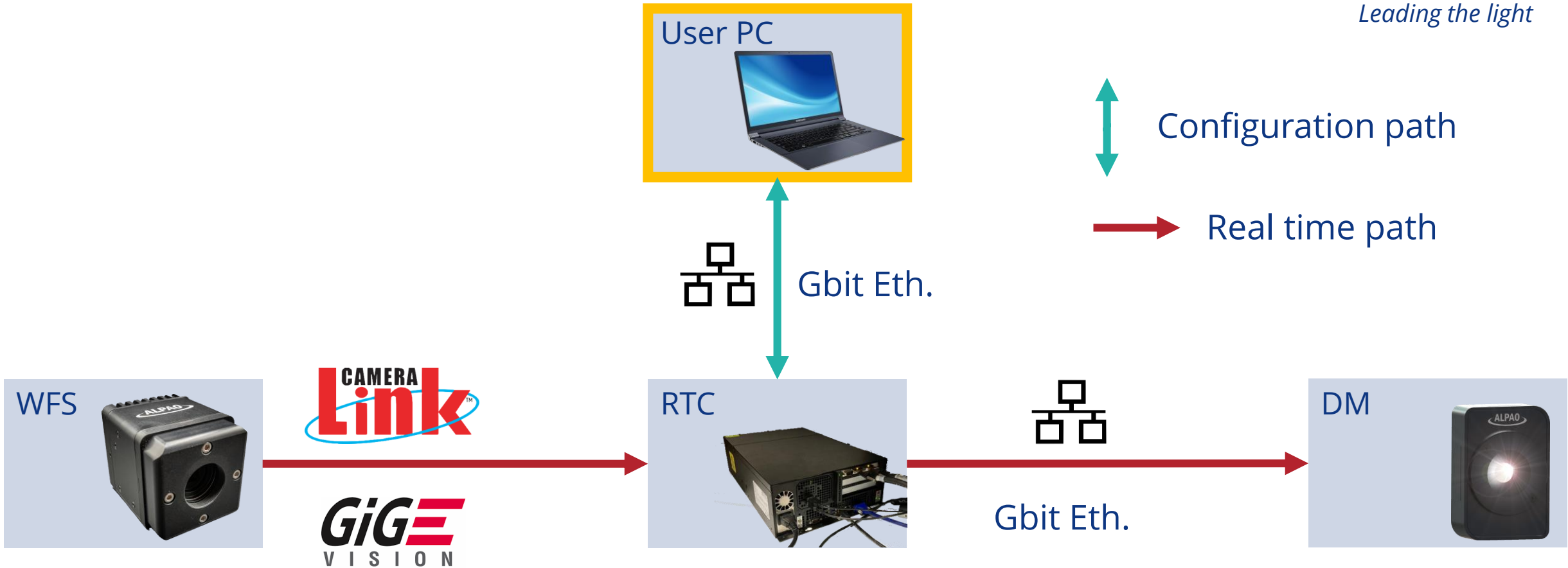


- ALPAO RTC overview,
- RTC interfaces,
- Inside the RTC,
- Test and performances,
- Implementation examples,
- Conclusion and perspectives

ALPAO RTC: Hardware & block Diagram



ALPAO RTC: Hardware & block Diagram



ALPAO RTC: User PC, Software interfaces & workflow



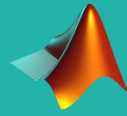
Leading the light

User PC



Matlab ACE Toolbox

- Fast learning / Fast prototyping,
- GUI,
- Large code base.



C/C++ RTC SDK

- Minimal dependencies
- Industrial environment operation



WFS



RTC



Gbit Eth.

DM



ALPAO RTC: User PC, Software interfaces & workflow



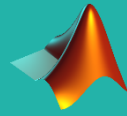
Leading the light

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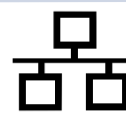


C/C++ RTC SDK

- Minimal dependencies
- Industrial environment operation

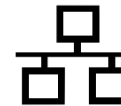


WFS



Gbit Eth.

RTC

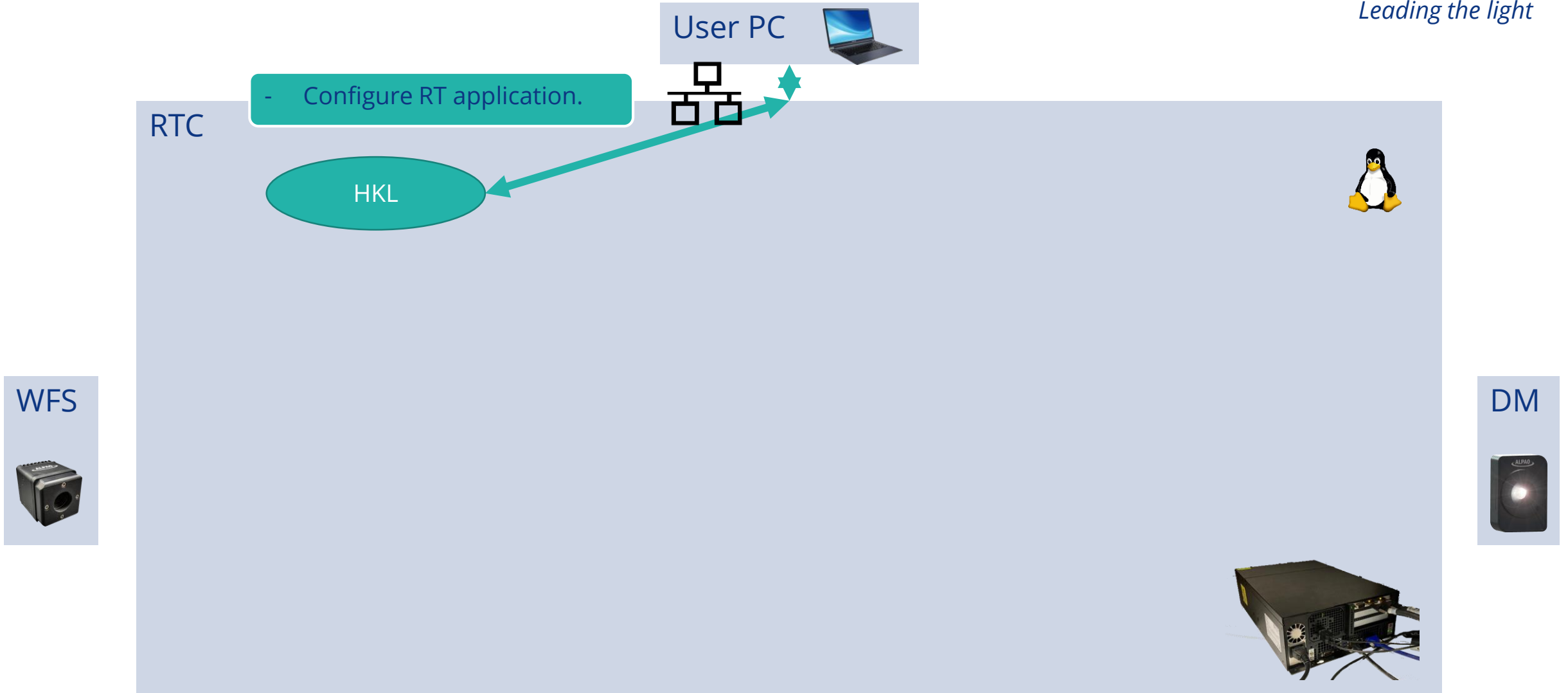


Gbit Eth.

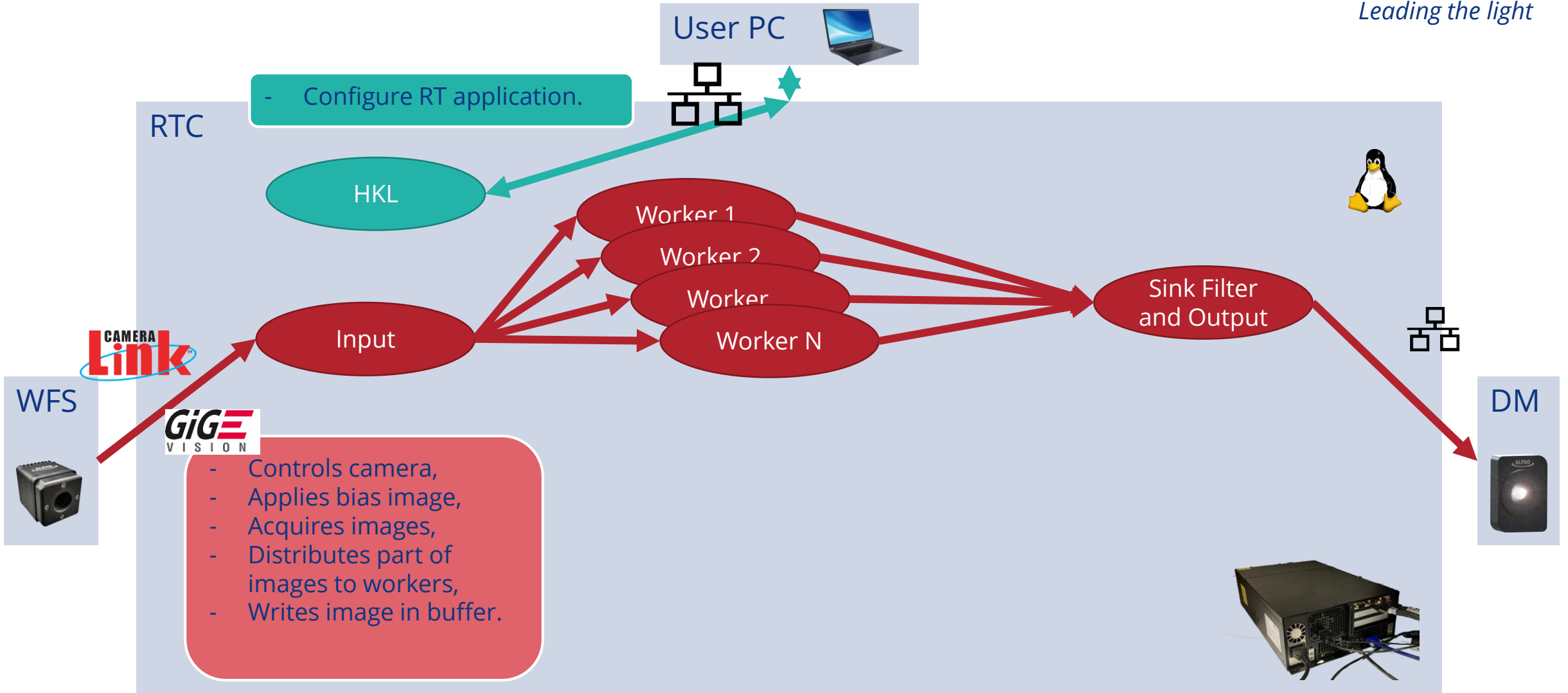
DM



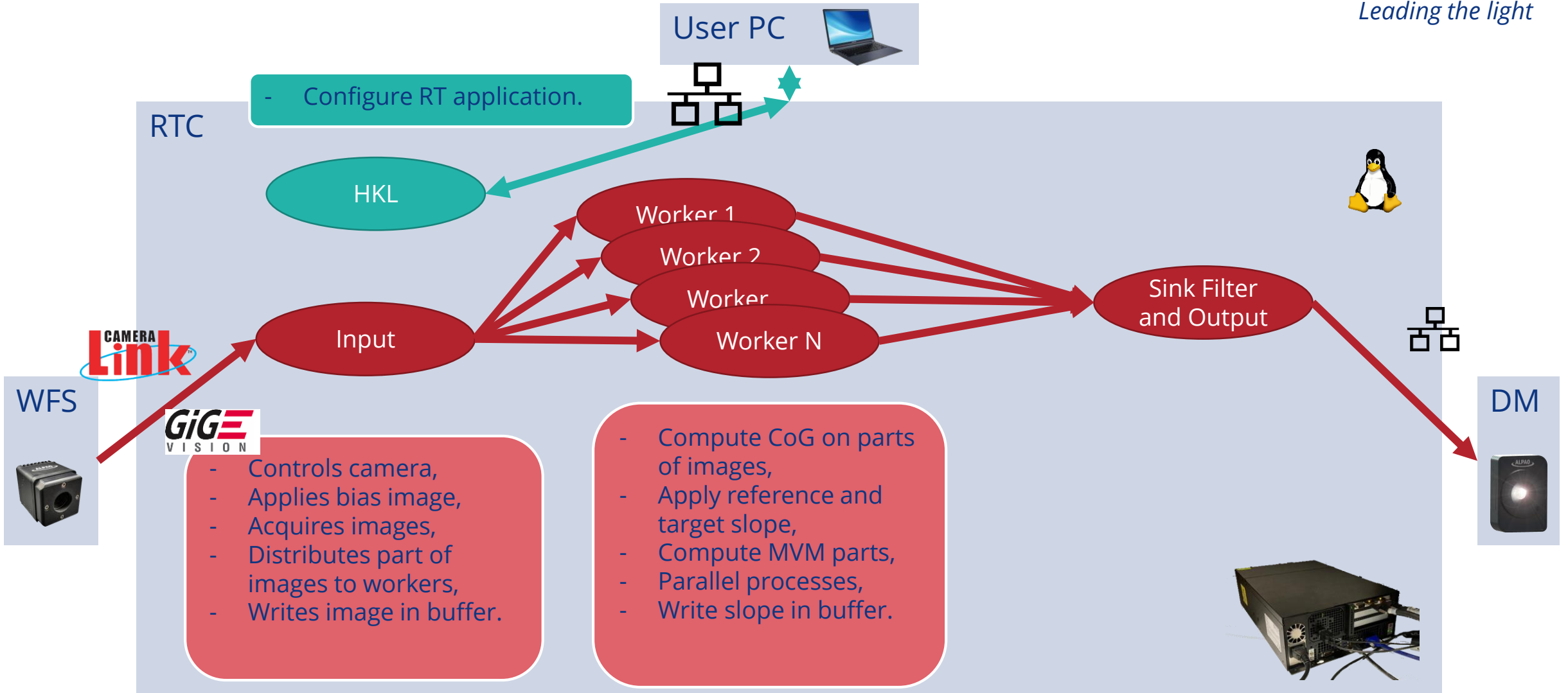
ALPAO RTC: RTC & parallel processes



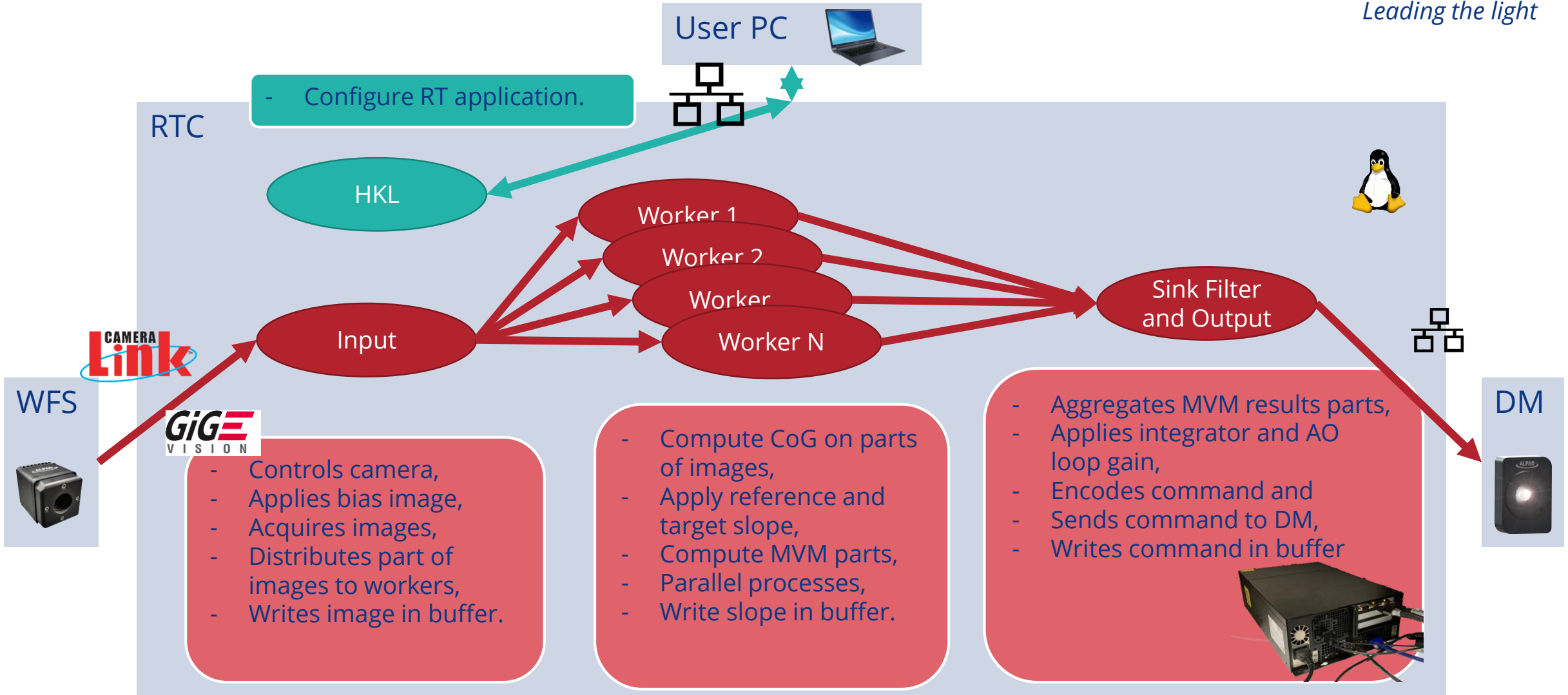
ALPAO RTC: RTC & parallel processes



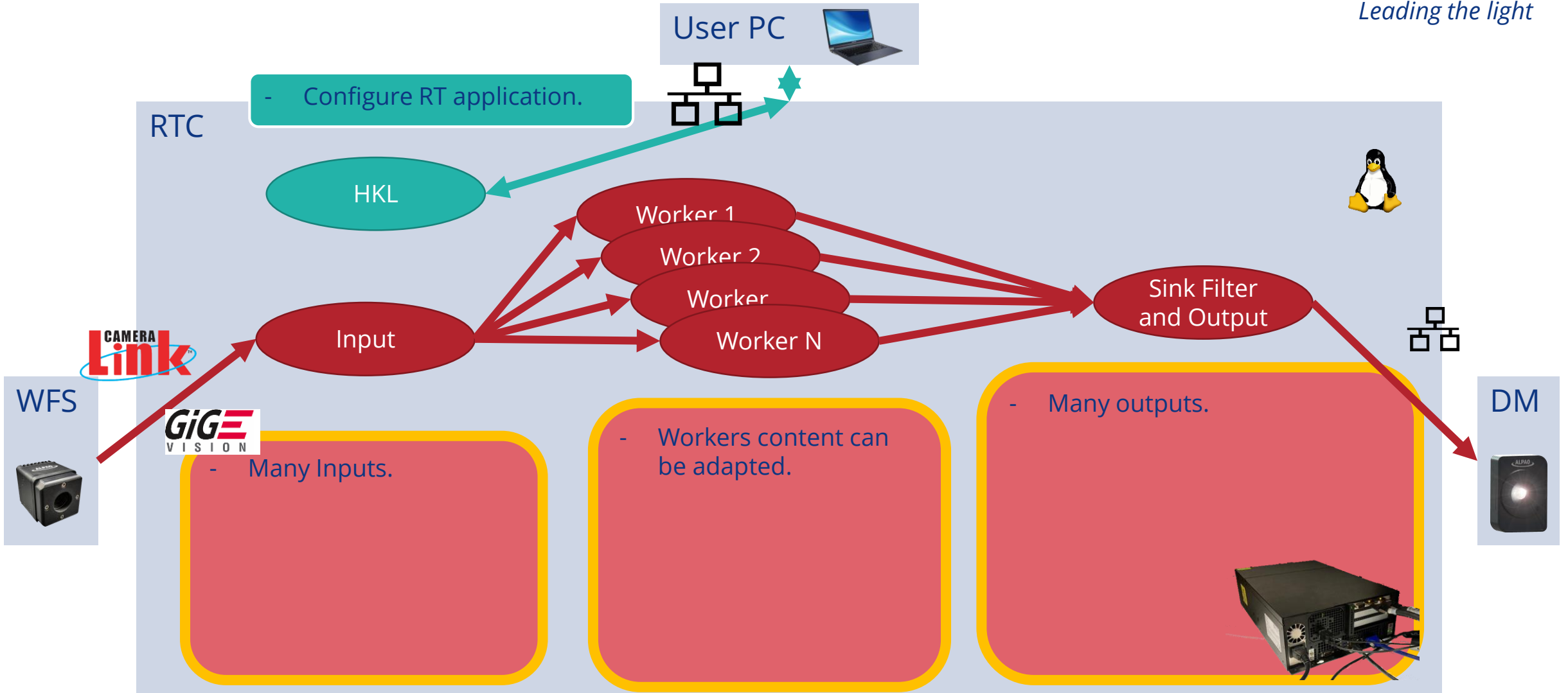
ALPAO RTC: RTC & parallel processes



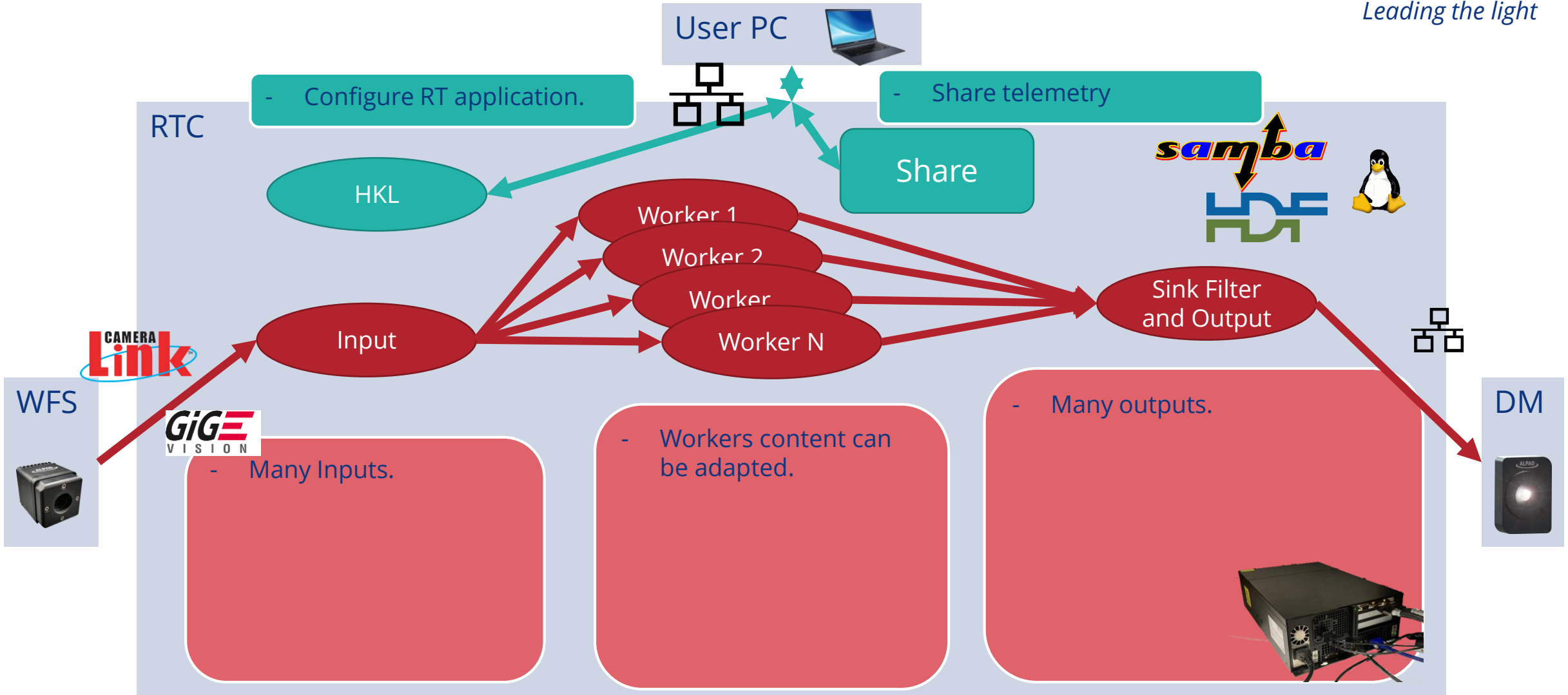
ALPAO RTC: RTC & parallel processes



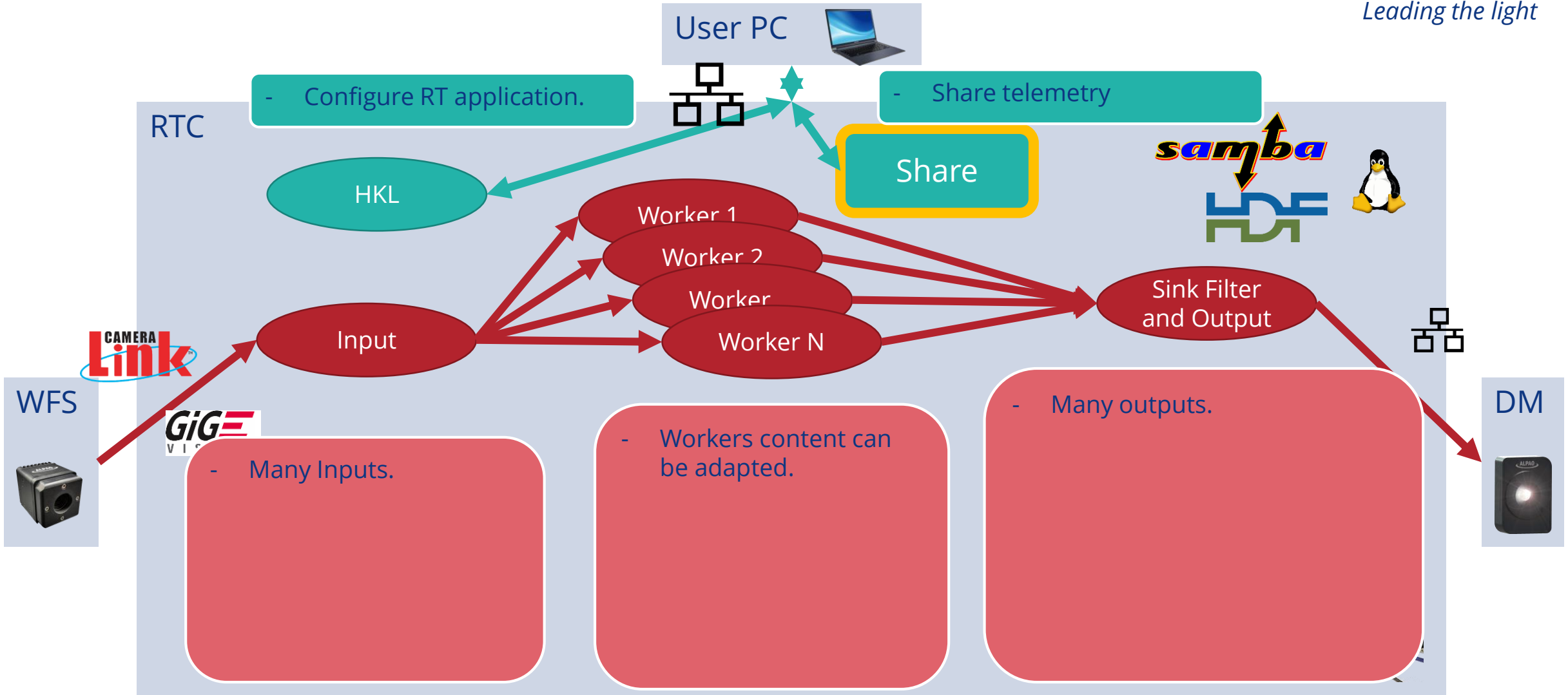
ALPAO RTC: RTC & parallel processes



ALPAO RTC: RTC & parallel processes



ALPAO RTC: RTC & parallel processes



ALPAO RTC: RTC & HDF5 & share



Leading the light



RTC

- Share: HDF5 files for Telemetry data (image, slope and commands),
- Many languages supported (Matlab , C/C++, java, python, ...),
 - Self describing,
 - Each process writes in its circular HDF5 buffer in SWMR mode,
 - `idx_last_write` attribute let a reader know where last data has been written.



Write cursor

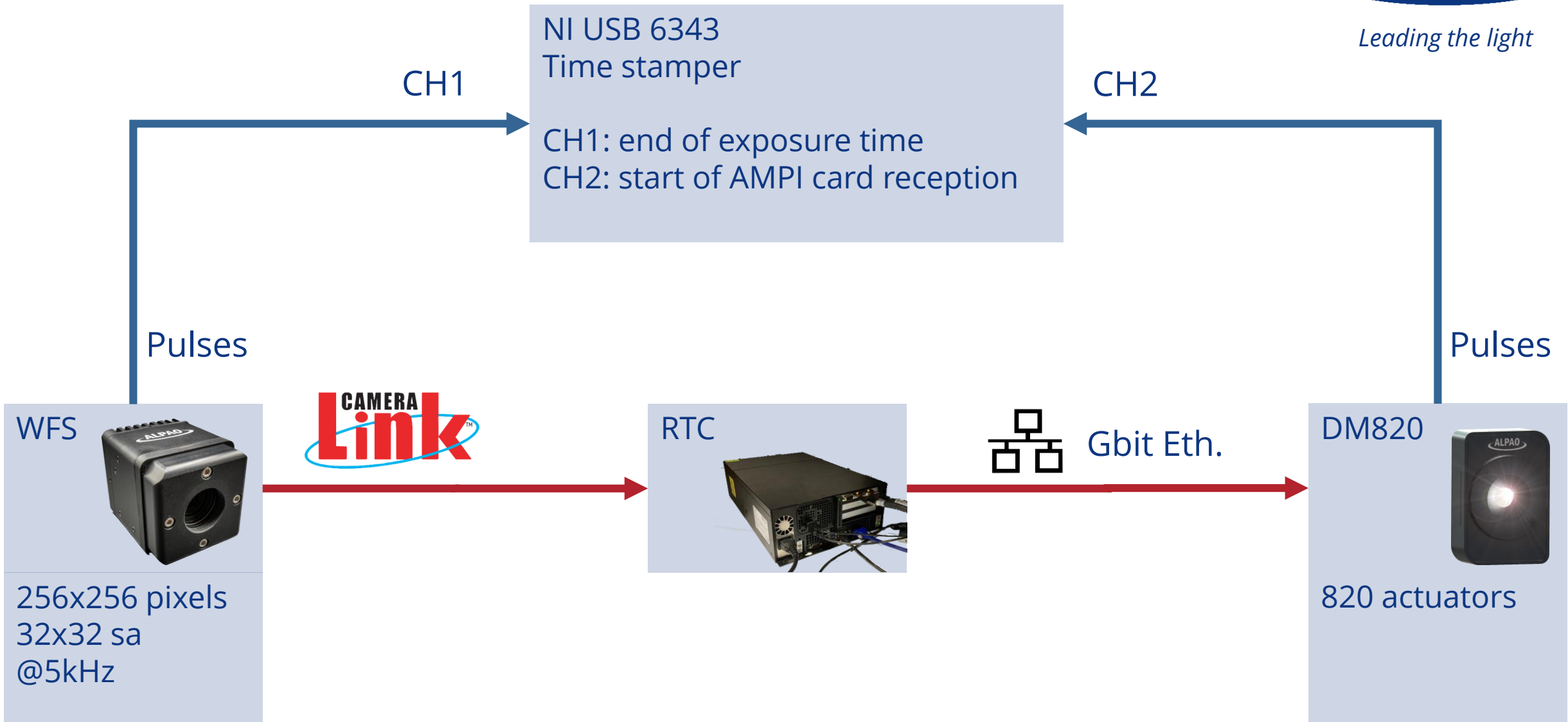
		idx_last_write	10573		
1				1	
2				2	
3				3	
	Frame ids	Timestamps	Raw data		
10572				10572	
10573				10573	
10574				10574	
N				N	

Read cursor

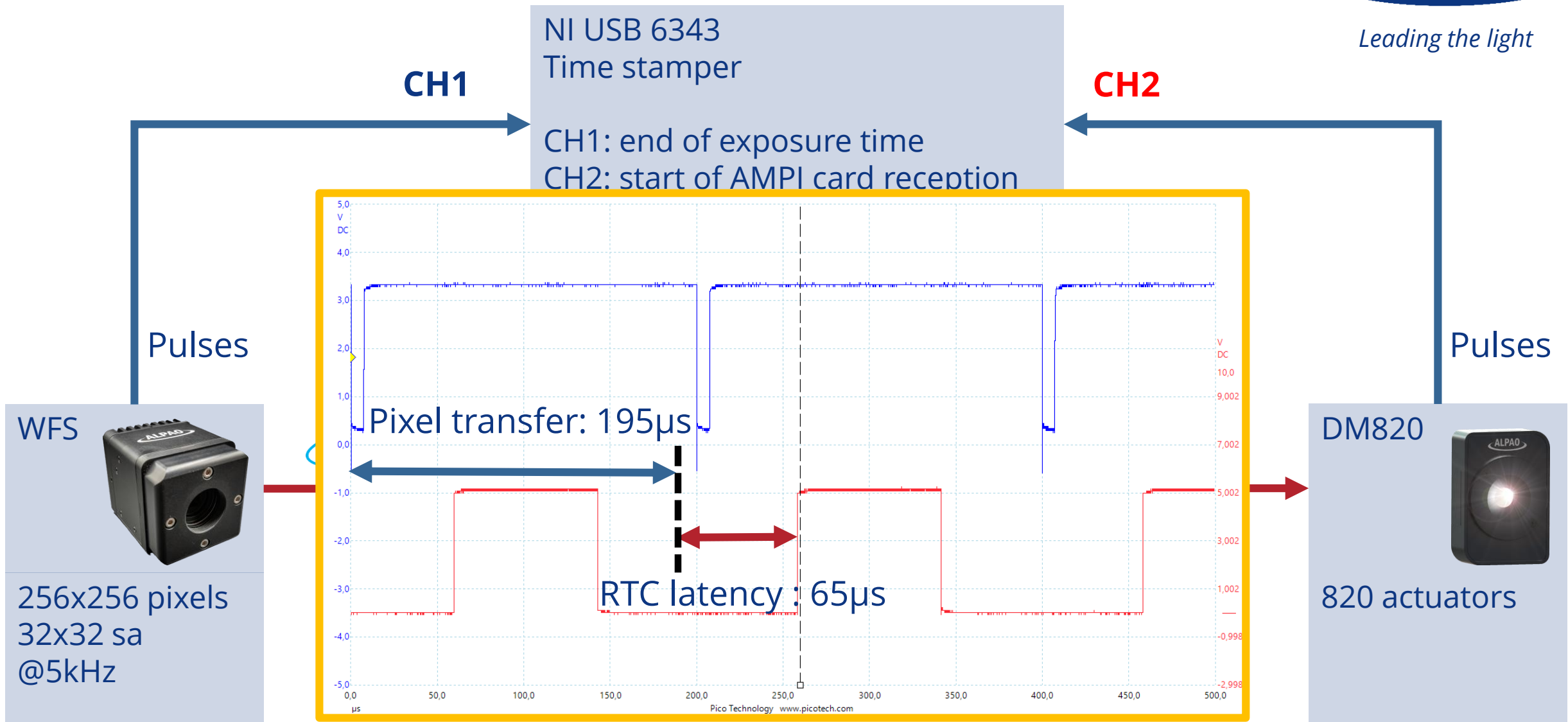
e.g. OCAM2K 16x16 s.a.
+ DM292 @2kHz :
recording @~230MB/s



ALPAO RTC: Performance test setup

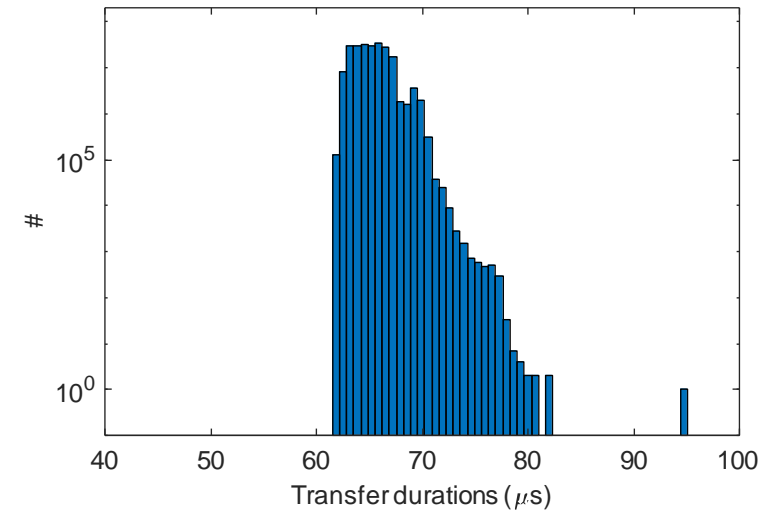
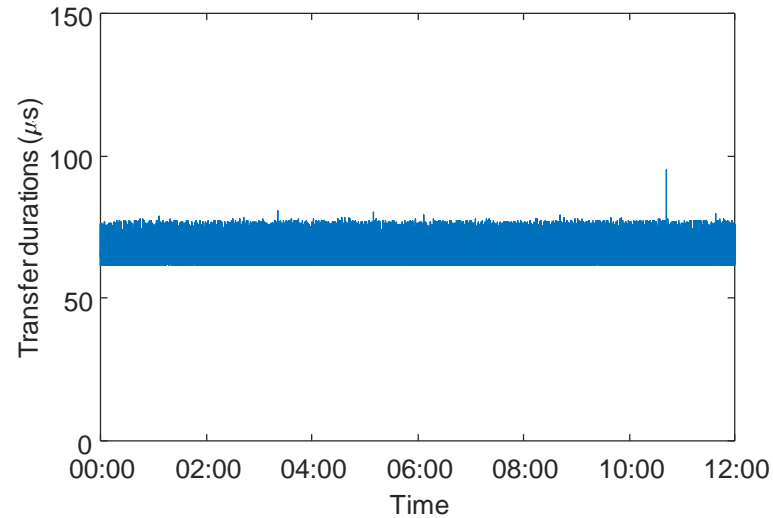


ALPAO RTC: Performance test setup



ALPAO RTC: Performance test results

- Long run : 12h, Real time,
- DM820, 32x32 sa, RTC Latency:
 - ▶ Average: $\sim 65\mu\text{s}$
 - ▶ std. dev.: $\sim 1.5\mu\text{s}$
 - ▶ Max: $\sim 95\mu\text{s}$



ALPAO RTC: Performance test results

- Long run : 12h, Real time,
- DM820, 32x32 sa,
RTC Latency:

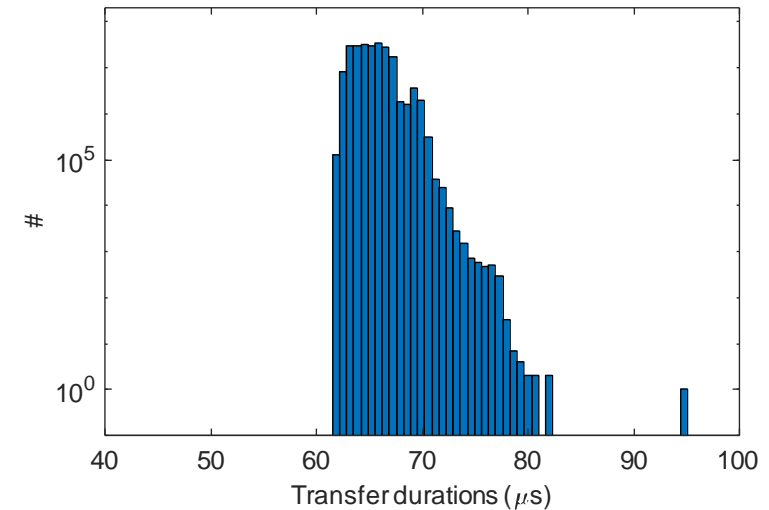
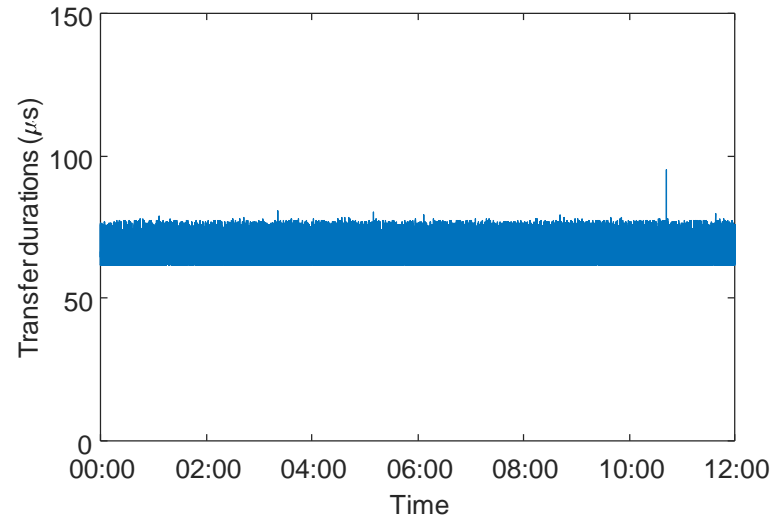
- ▶ Average: $\sim 65\mu\text{s}$
- ▶ std. dev.: $\sim 1.5\mu\text{s}$
- ▶ Max: $\sim 95\mu\text{s}$

- DM468, 24x24 sa:

- ▶ Frame rate: 8kHz
- ▶ RTC Latency: $\sim 40\mu\text{s}$

- DM292, 20x20 sa:

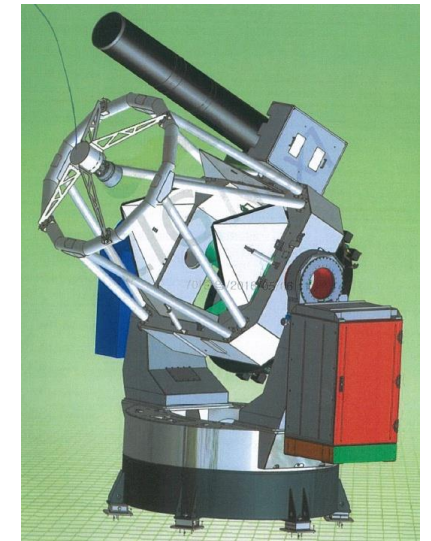
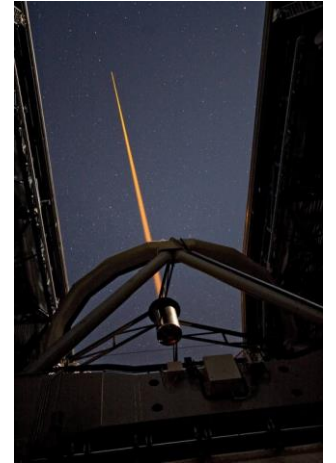
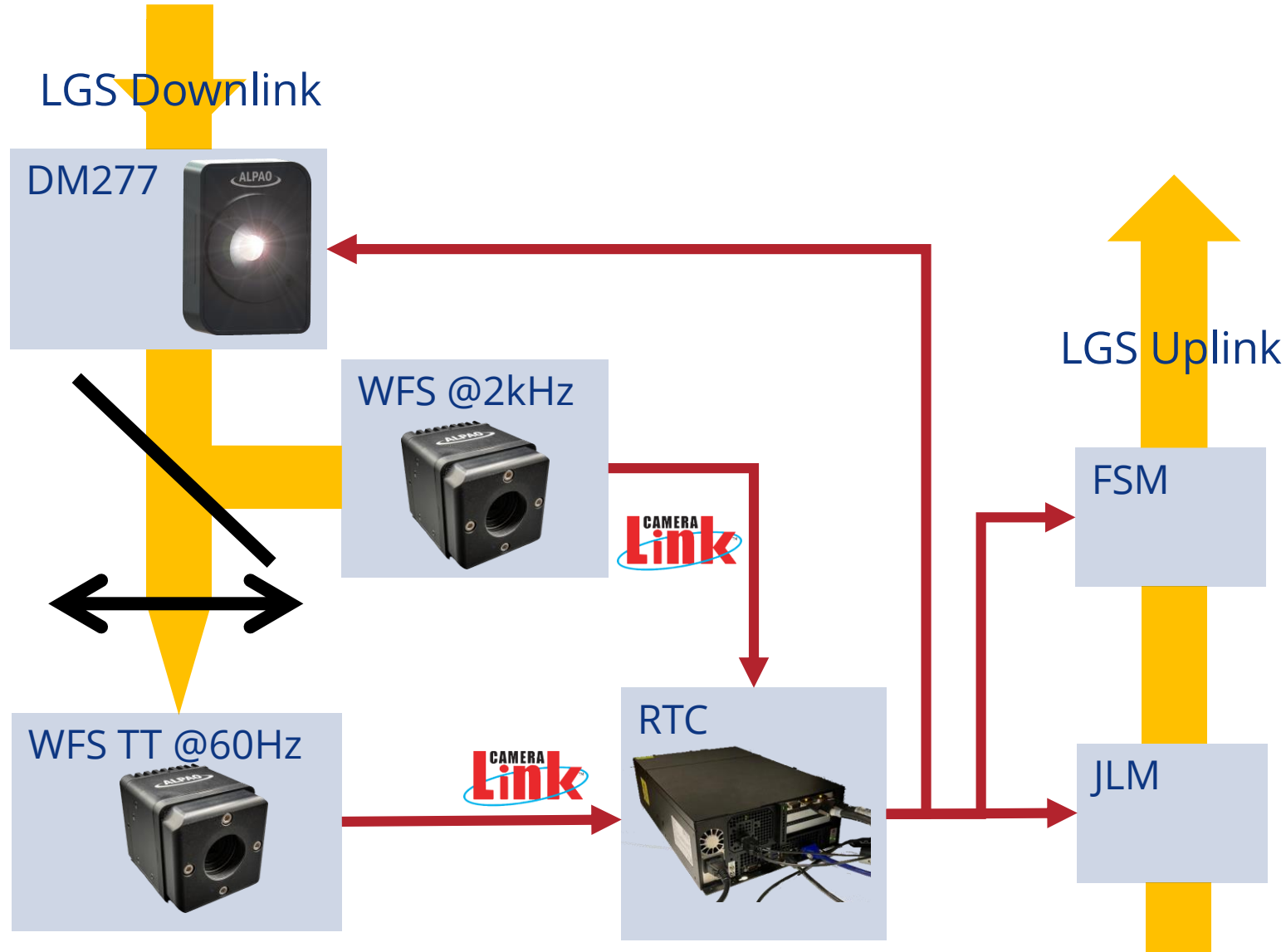
- ▶ Frame rate: 10kHz
- ▶ RTC Latency: $\sim 33\mu\text{s}$



ALPAO RTC implementations: LGS AO System



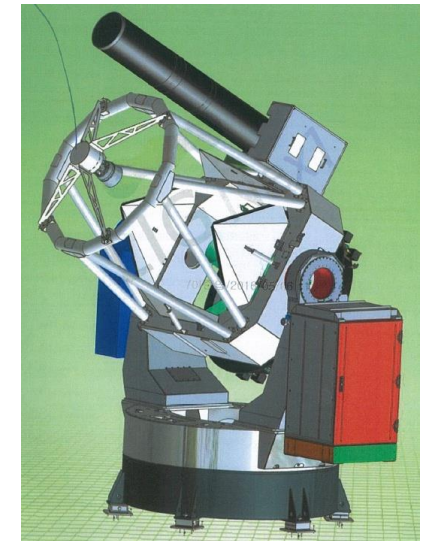
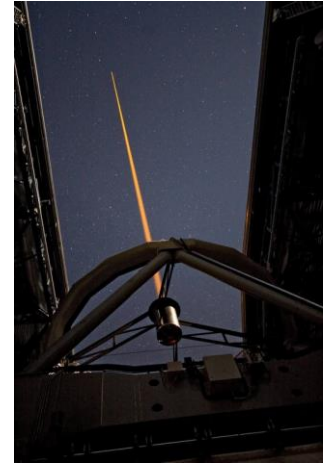
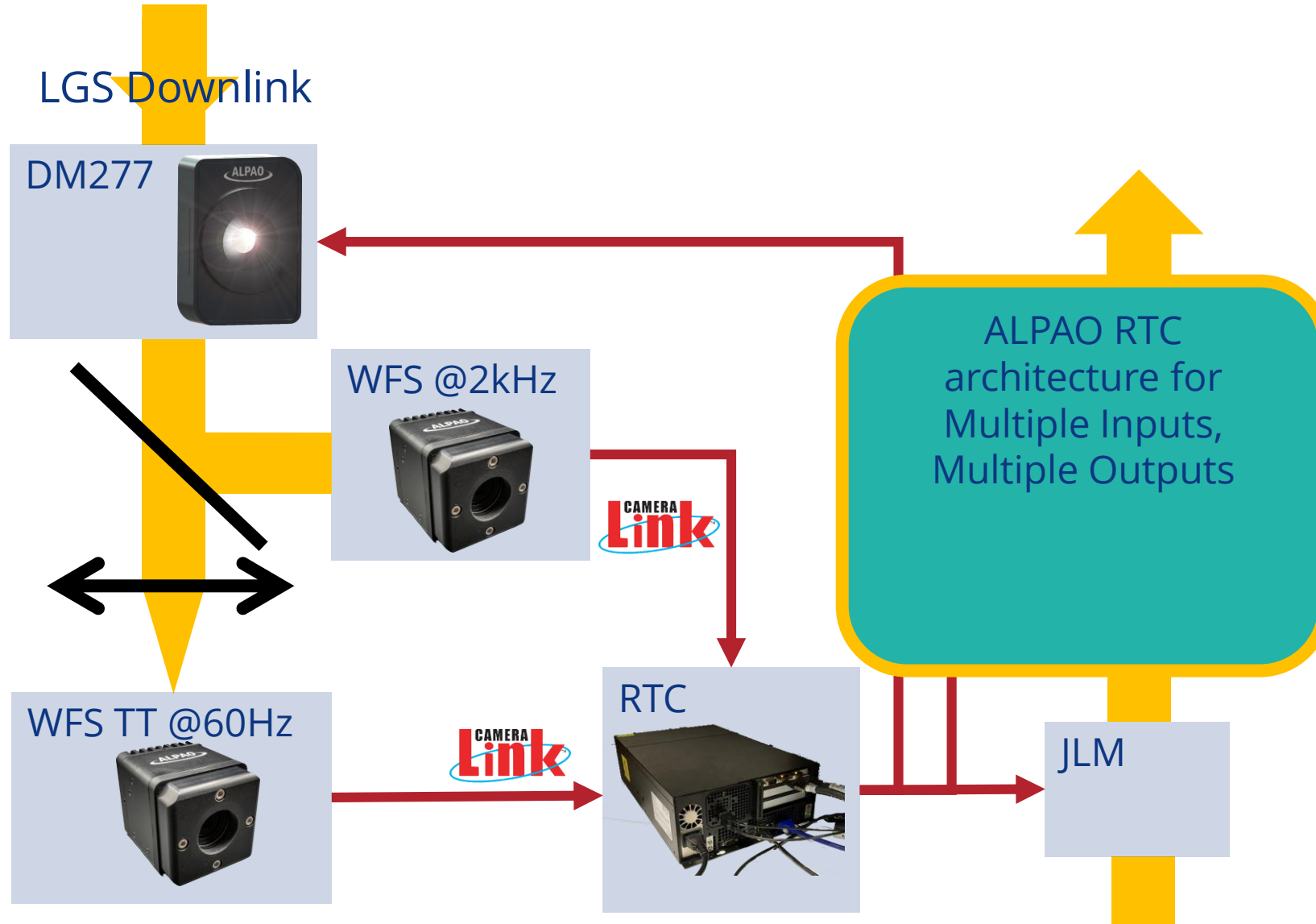
Leading the light



ALPAO RTC implementations: LGS AO System



Leading the light

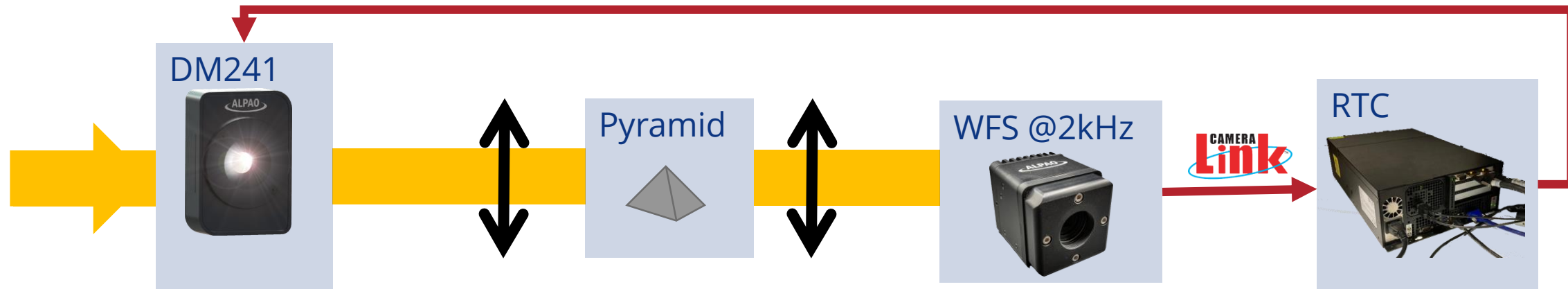


ALPAO RTC implementations : PyWFS on PAPYRUS OHP



Leading the light

- Project in collaboration with LAM team
- 80x80 pixel for Pyramid pupil, DM241,
- Up to 2kHz,
- RTC latency less than 150 μ s.

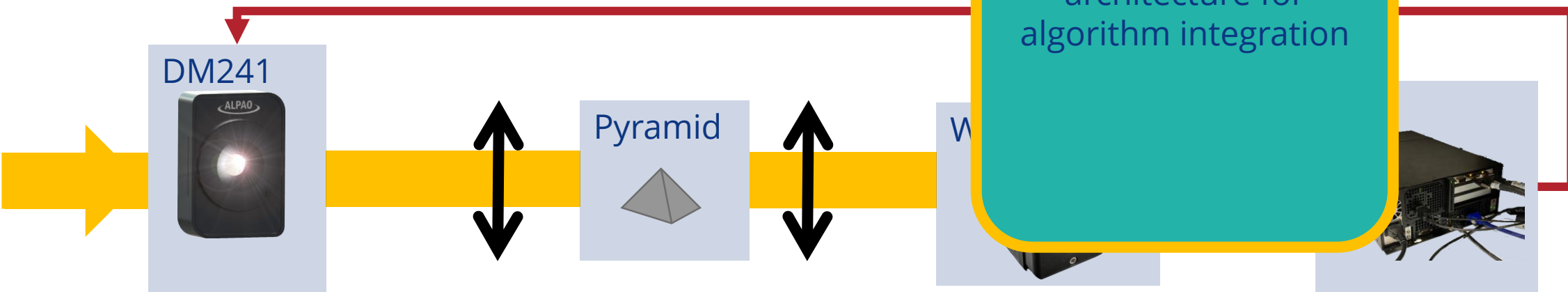
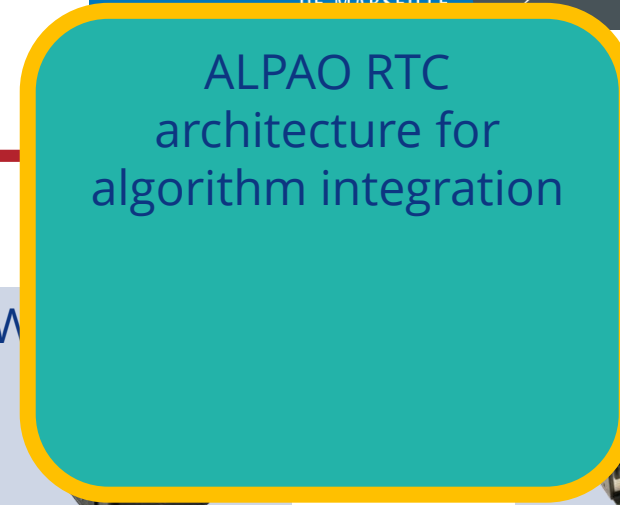


ALPAO RTC implementations : PyWFS on PAPHYRUS OHP



Leading the light

- Project in collaboration with LAM team
- 80x80 pixel for Pyramid pupil, DM241,
- Up to 2kHz,
- RTC latency less than 150 μ s.



Conclusions et perspectives



- Conclusions:
 - ▶ ALPAO RTC architecture and features,
 - ▶ Stability, determinism and performances of the solution,

- Perspectives:
 - ▶ ALPAO is partner in 2 projects: COOP and TeQuants pave the road for industrial FSO-AO,
 - ▶ Fast DM control,
 - ▶ Operational RTC automation,
 - ▶ Telemetry server for fast recording.



Thanks

