First on-the-sky fringes at 810 nm using fibre links at CHARA

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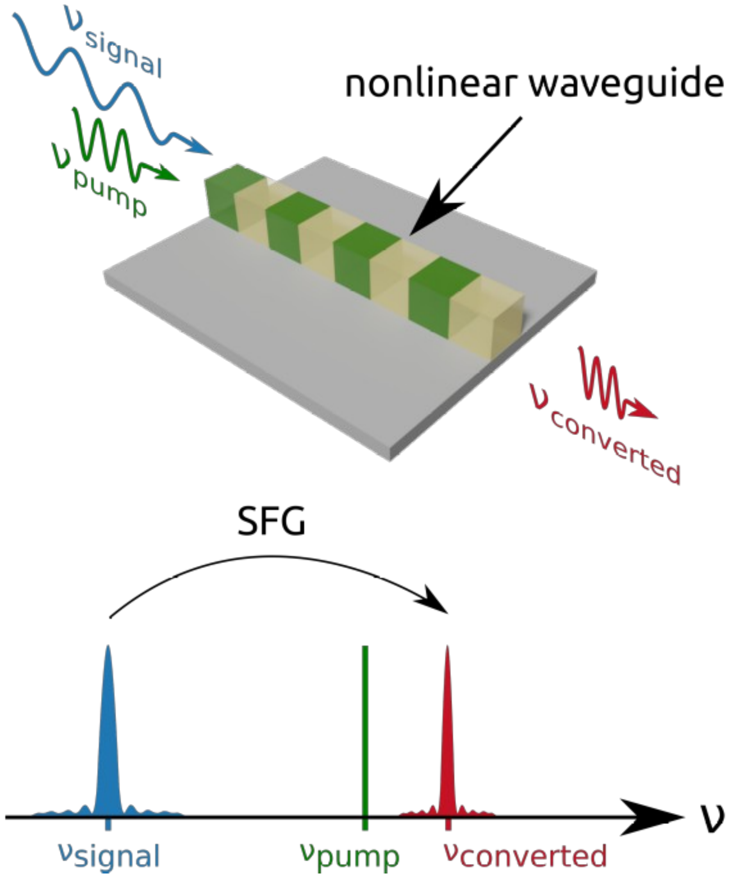
The ALOHA@CHARA project

Astronomical Light Optical Hybrid Analysis

- Aims to implement an innovative **up-conversion fibered interferometer at 3.5µm** (L-band) at **CHARA** (CA,USA).
- The **light collected** by the telescopes at 3.5µm is **converted** at 820 nm thanks to a **nonlinear process** powered by a **1064 nm pump laser** (Sum Frequency Generation process (χ^2)).
- The interferometer is linked by **servo controlled** optical fibers in order to have a **stabilized Optical Path Difference** (OPD).
- In previous studies the ALOHA project succeeded in the **H-band on the sky** at CHARA and in the **L-band in laboratory**.
- We are under progress to perform a demonstration in the **L-band on the sky** at CHARA.



ALOHA strategy

ALOHA @1.5 µm
1.5 µm + 1.06 µm → 630 nm

ALOHA @3.5 µm
3.5 µm + 1.06 µm → 817 nm

In lab tests

ALOHA @1.5 µm:
* Noise investigation
* Multi channel spectral mode

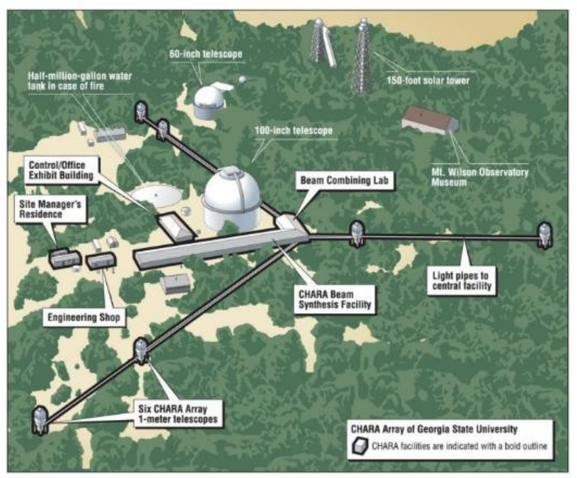
ALOHA @3.5 µm:
* Noise investigation
* New crystals
* Fringes with a blackbody source

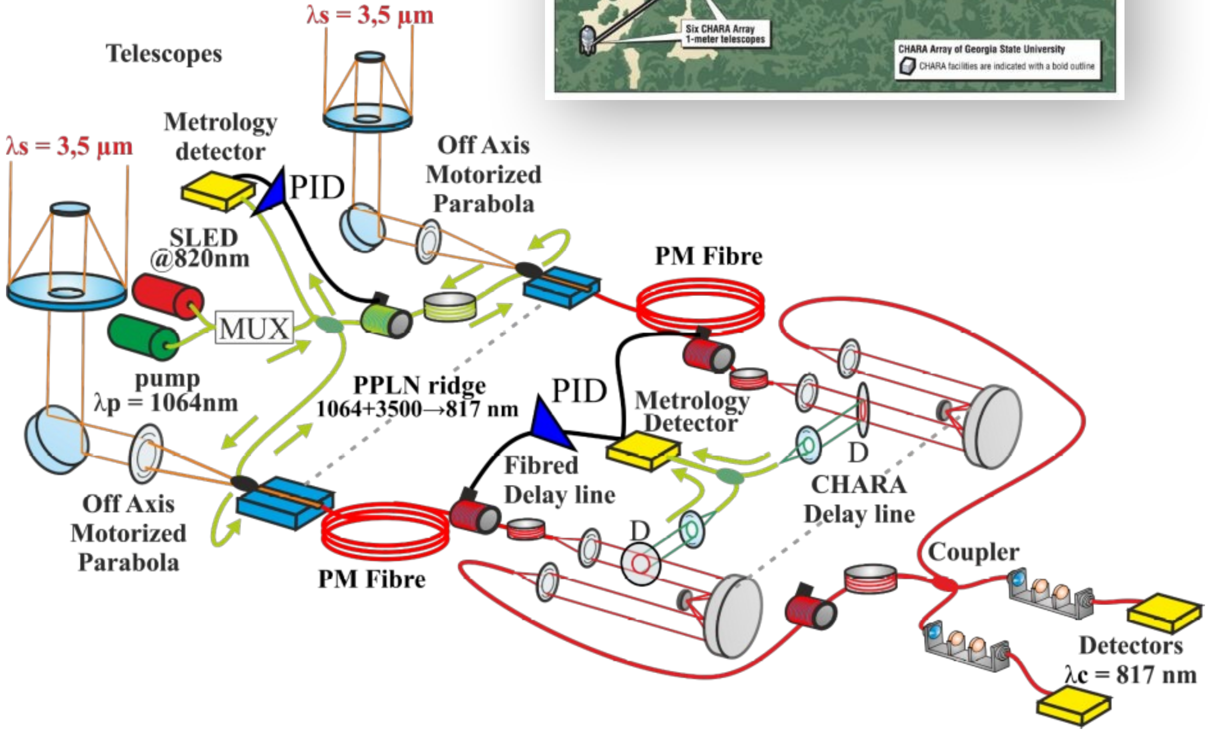
On sky tests

ALOHA @1.5 µm:
* Sensitivity 2014
* Fringes 2015

ALOHA @3.5 µm:
* Sensitivity 2018 C2PU
Preliminary result
Lmag = 2.8

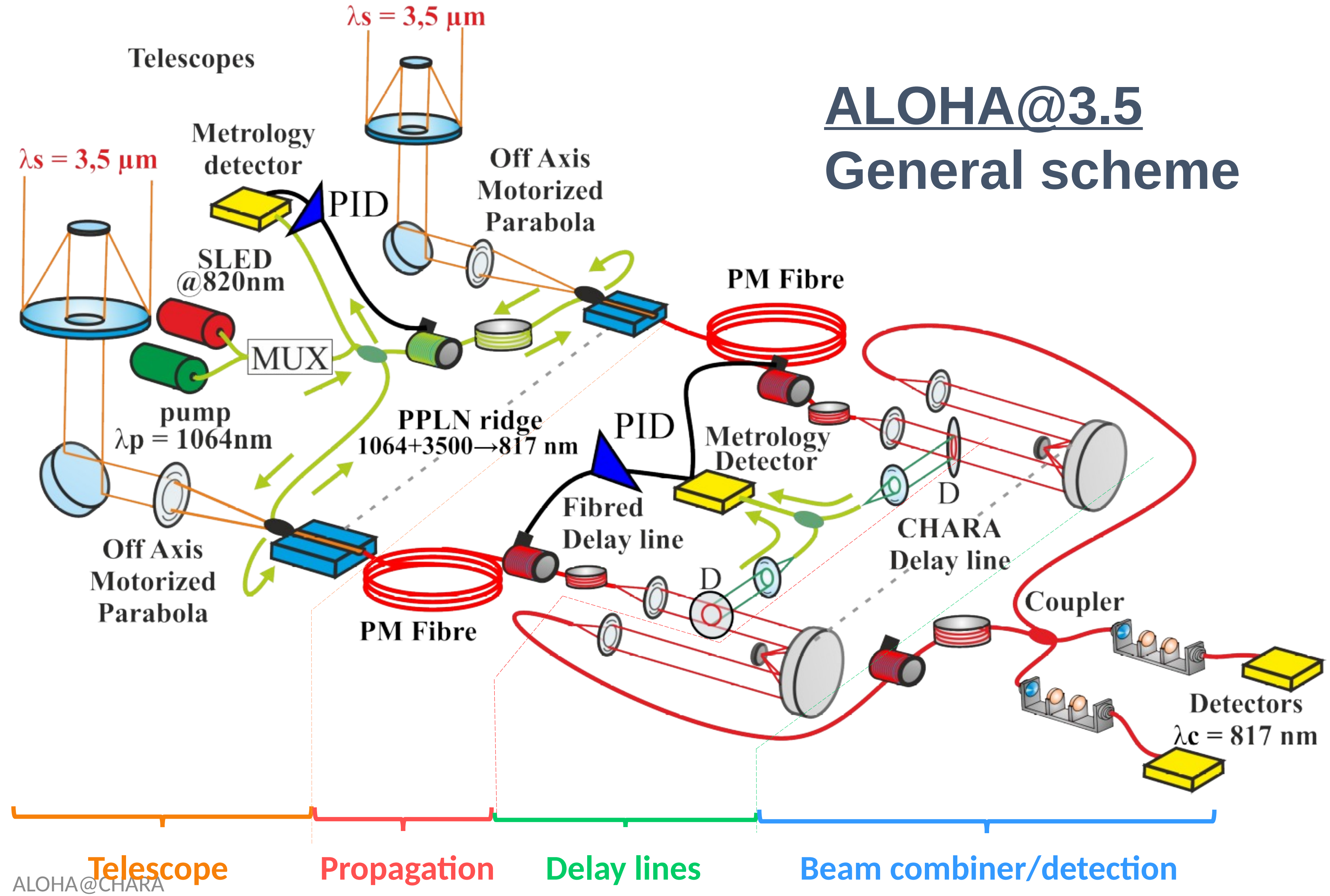
* **2022 : fiber link stabilization**
* 2023
Fringes ?





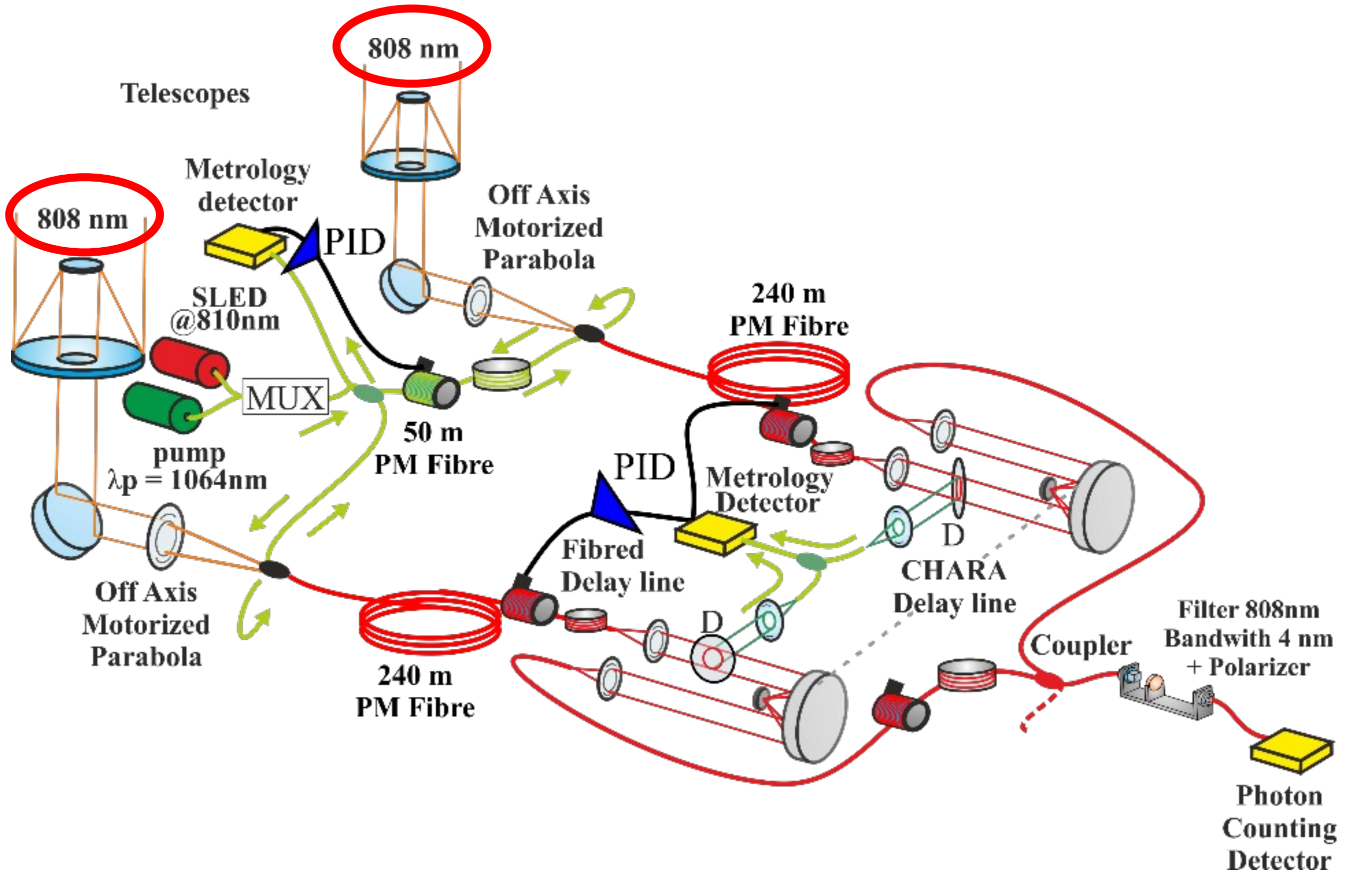
PPLN: Periodically Poled Lithium Niobate

ALOHA@3.5
General scheme



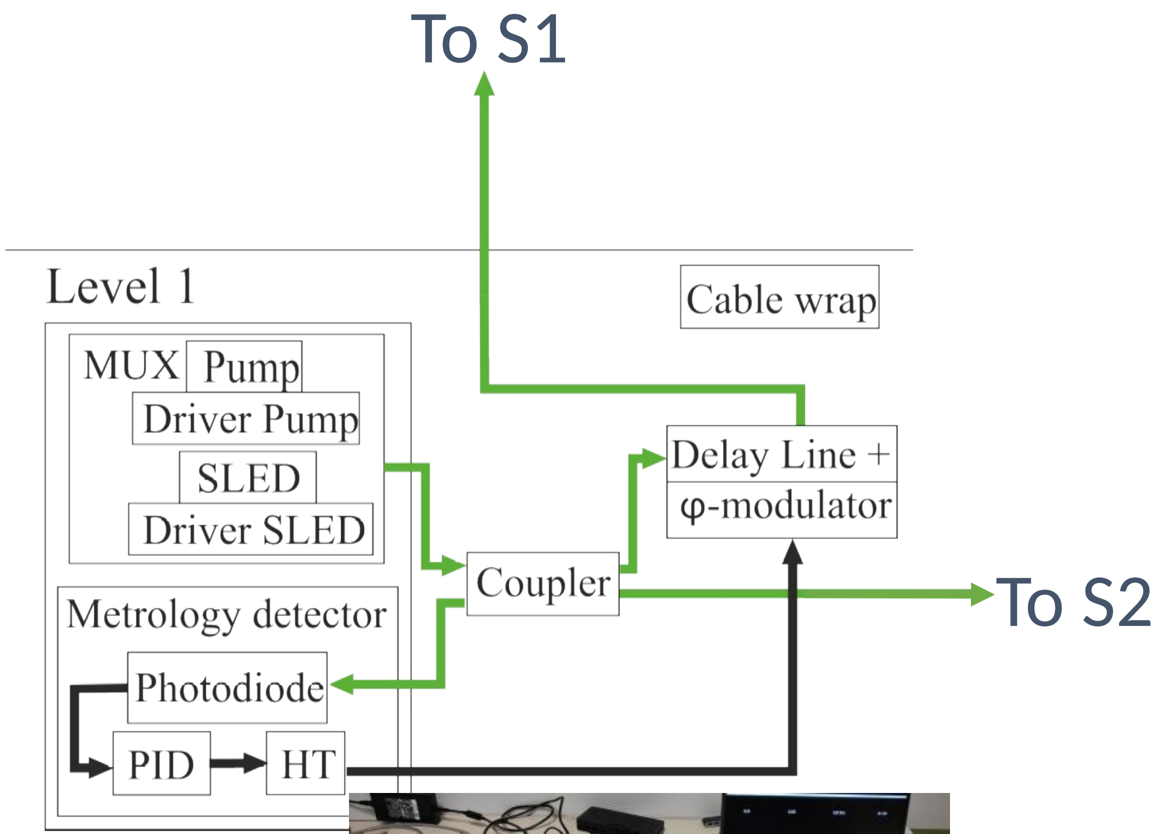
Telescope stage
▪ MIR Injection ▪ Pump sharing ▪ 3.5 to 0.82 µm conversion
Coherent propagation stage
▪ 240 m PM 820nm fibers ▪ OPD stabilization
Delay Line stage
▪ CHARA delay lines ▪ Interfaces
Beam combiner stage
▪ OPD modulation by PZT stroke ▪ Filters + Photon detectors

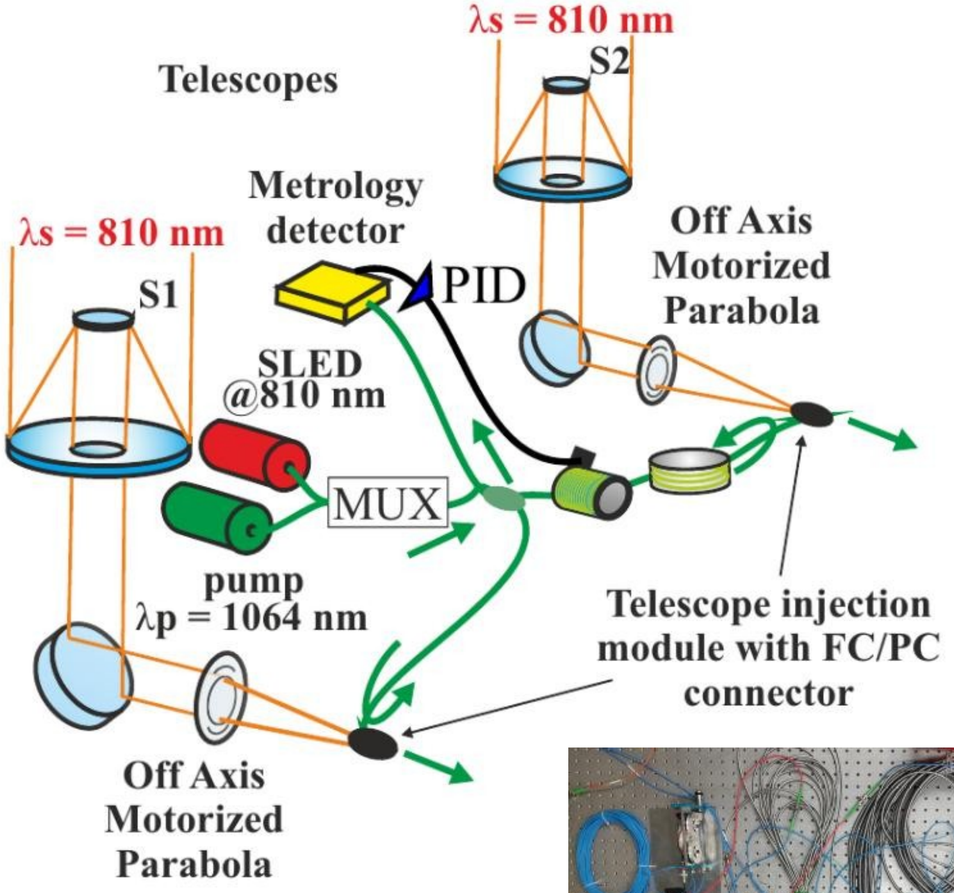
On-sky fringes @808nm without the up-conversion stage

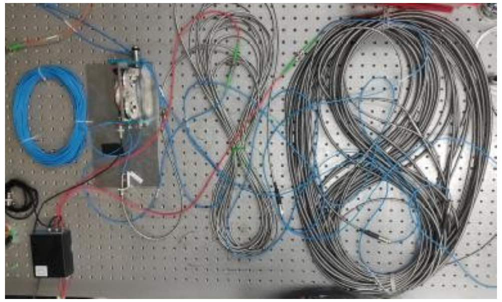


- The first step of the ALOHA project is to find the position of the zero OPD when on-sky **without the up-conversion stages**.
- The keys point is a two-stage **stabilization** of the optical path difference.
- We first used an **internal source** (SLED) **before going on-sky** using the CHARA free space delay lines to get internal fringes.

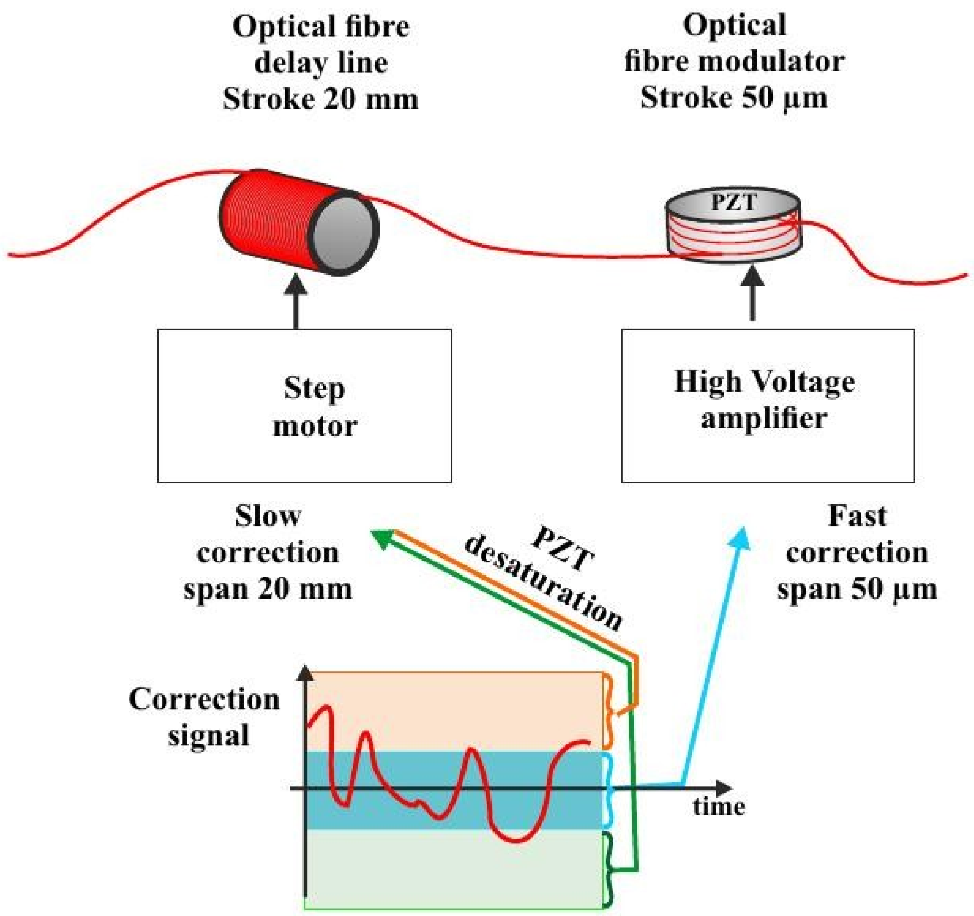
Michelson stage of the servo control system



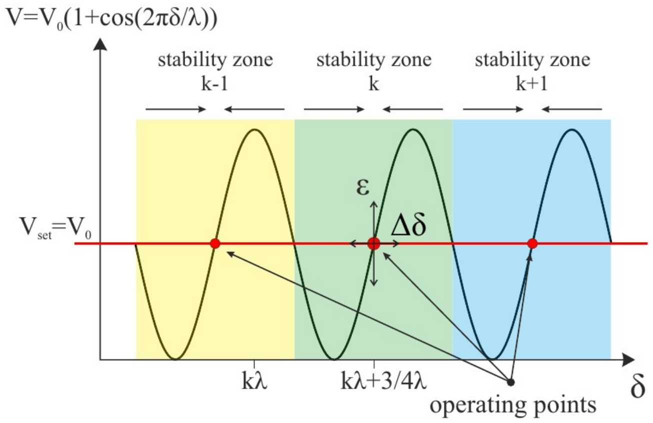




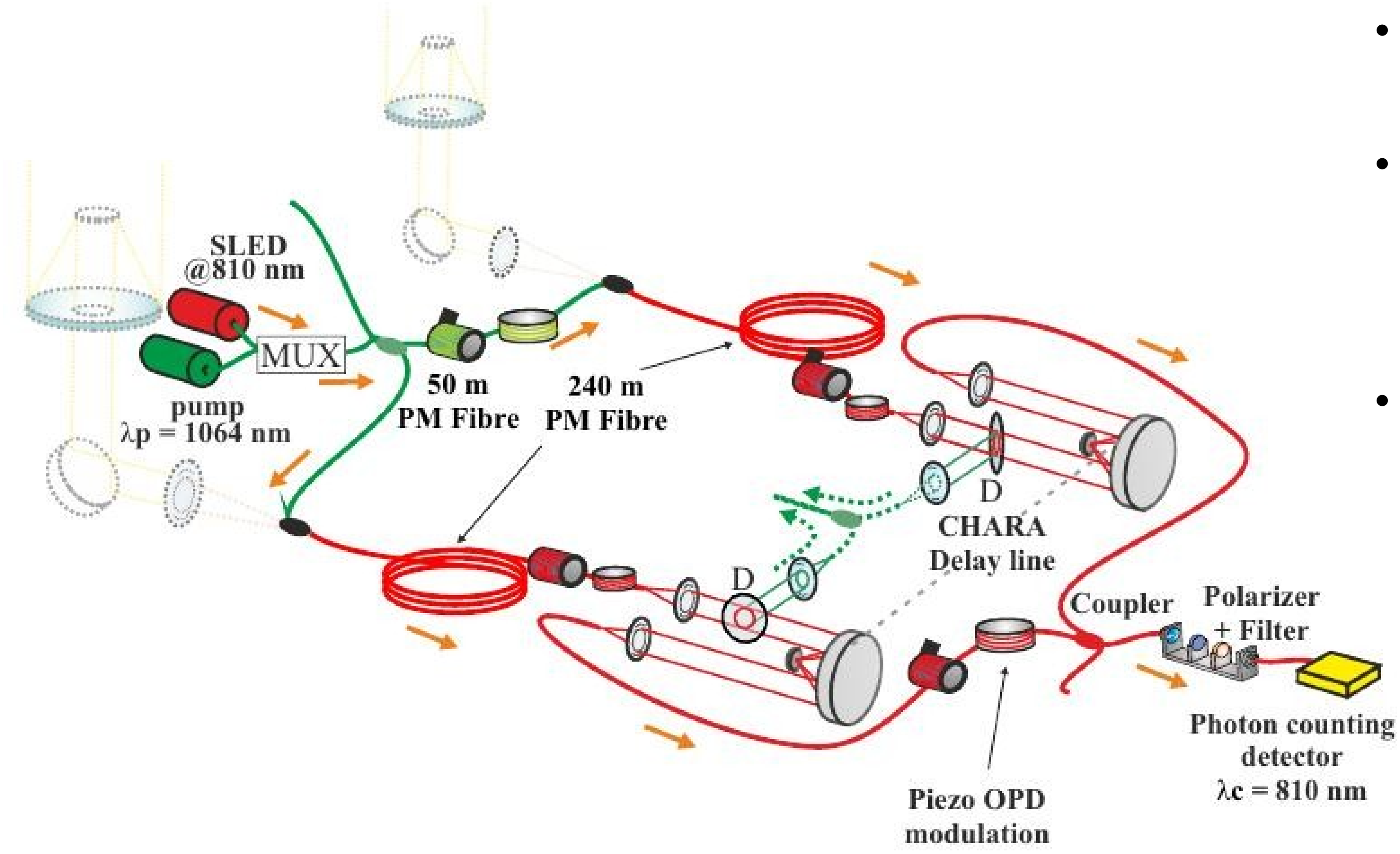
Details of the servo control system



- 2-stage servo control system
- Fast correction with small 50 µm span
- Response time : 0.2 ms
- Slow correction with large 20 mm span
- RMS fluctuation of the OPD around 3 nm (λ/300@1064nm)



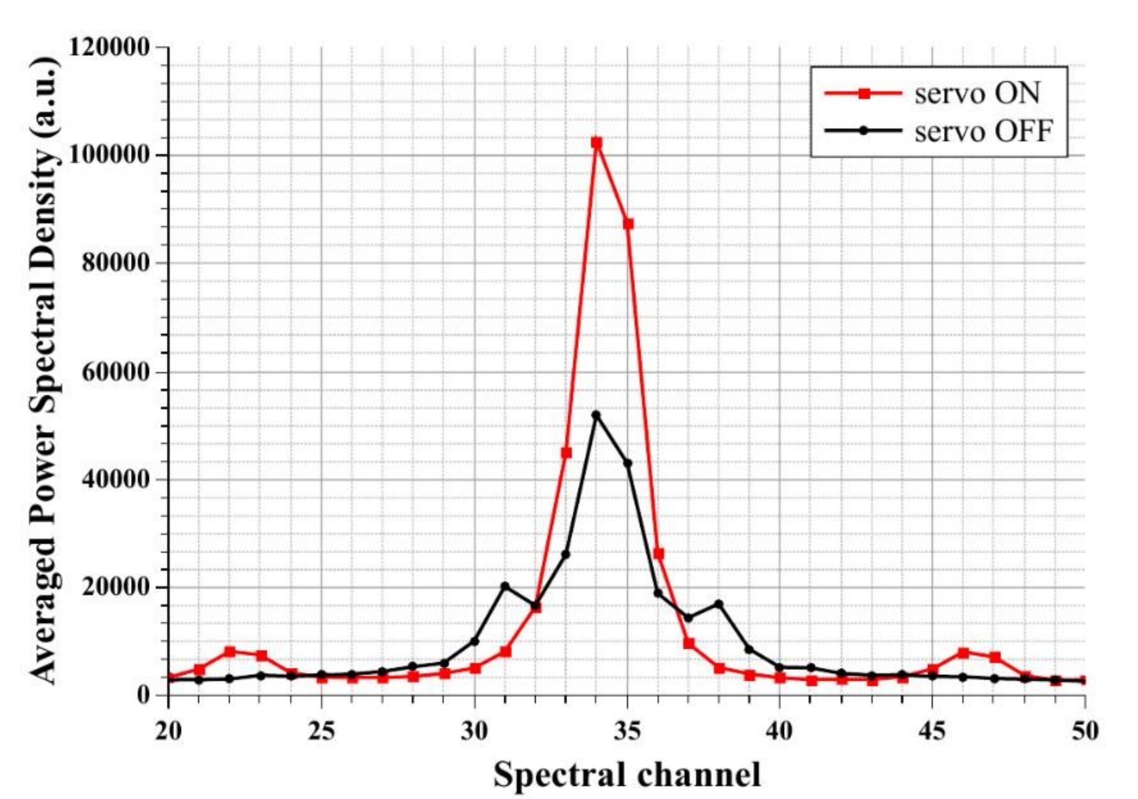
Mach-Zehnder stage of the servo control system



- 240m Mach-Zehnder interferometer
- The metrology signal @1064nm is taken at the inputs of the CHARA delay lines
- same type of 2-stage servo control system, with same characteristics

Internal fringes: Calibration of the optical path difference

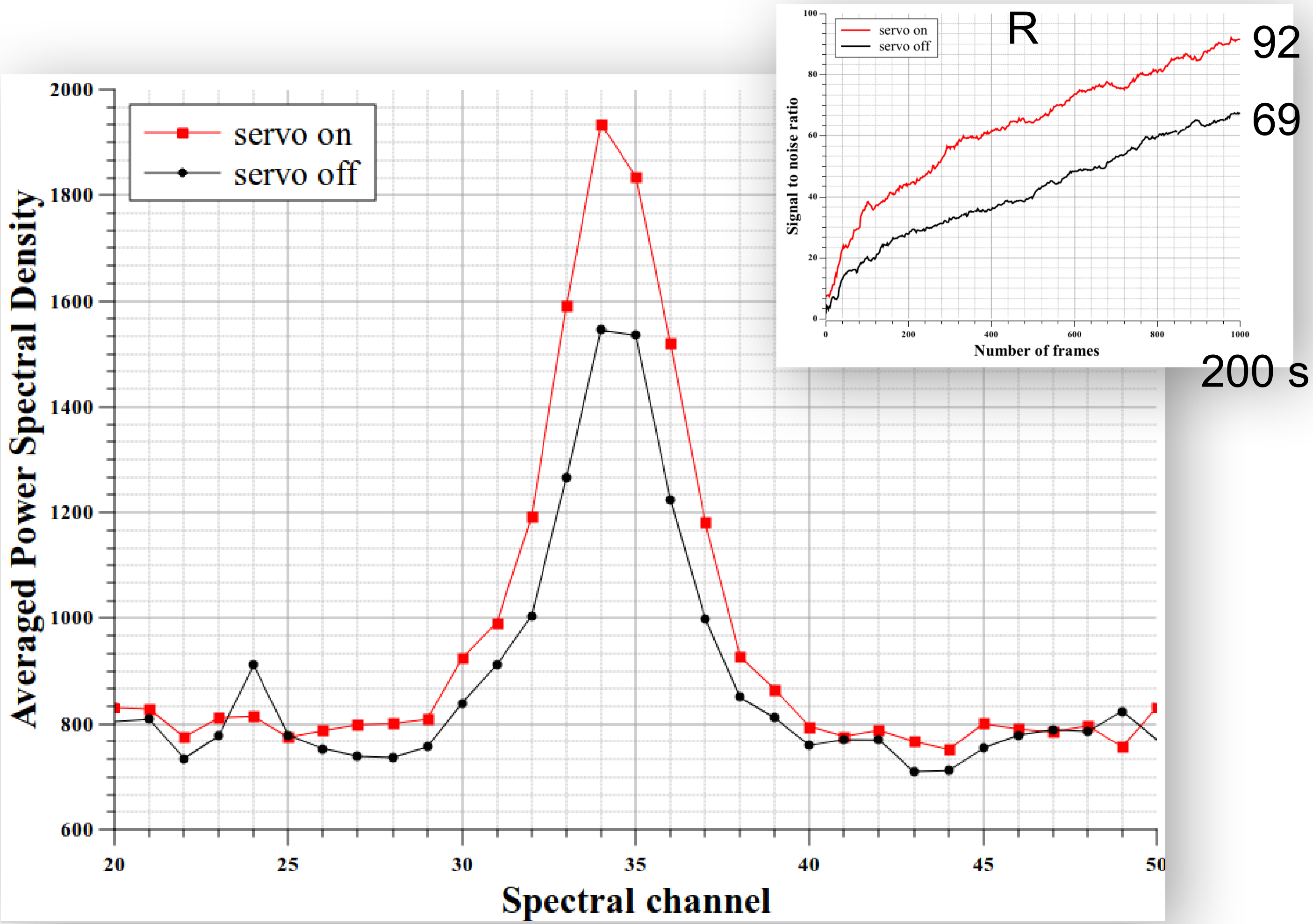
- broadband source (SLED) around 810 nm
- Step1 : internal fringes around the expected zero OPD by scanning over ±5 mm using the CHARA delay lines
- Step2 : fringes measurement with and without servo control
- Instrumental contrast : 68 %
- Demonstration of the efficiency of the two fibre-length control systems



500 frame integration with 0.2 s duration per frame, temporal fringe modulation frequency set to 175 Hz (35 fringes per temporal frame)

On-sky measured fringes using the star VEGA

- Observation dates : 03/26/2022 and 03/27/2022
- adaptive optics (AO) on each telescope
- Temporal fringe modulation frequency set to 175 Hz (35 fringes per temporal frame)
- Integration over 200 s (1000 frames of 0.2 s each)
- → fringe contrast and SNR improvement when the servo is on
- huge impact of atmospheric turbulence at 810 nm

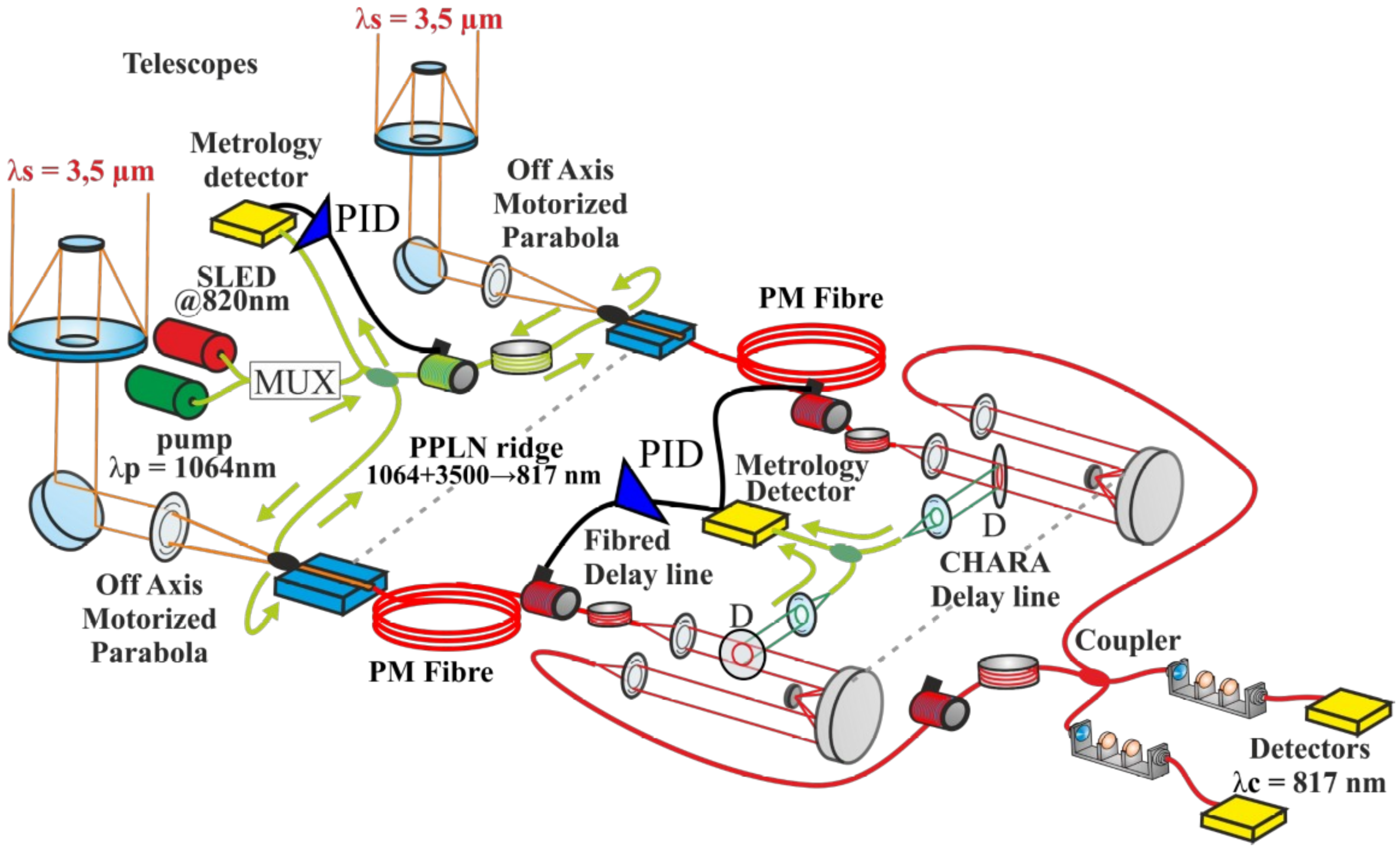


Conclusion and future prospects

- We have implemented a servo controlled hectometric outdoor 240 m fibre link interferometer
- We were able to find the fringes on Vega during two consecutive nights.
- OPD change < 2 mm from one night to the next…
- …and compensated with the internal fringe procedure.
- On-the-sky, fringe position repeatability better than 0.2 mm.
- The efficiency of the servo control systems has been demonstrated
- These results are very promising for the future use of fibre link at the CHARA Array and more generally for very long baseline interferometers

1 mission in june 2023

On the sky tests of the up-conversion interferometer at 3.5 µm



Thank you for you attention

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