ALOHA@CHARA in the L band: 2020-2021 progress and perspectives

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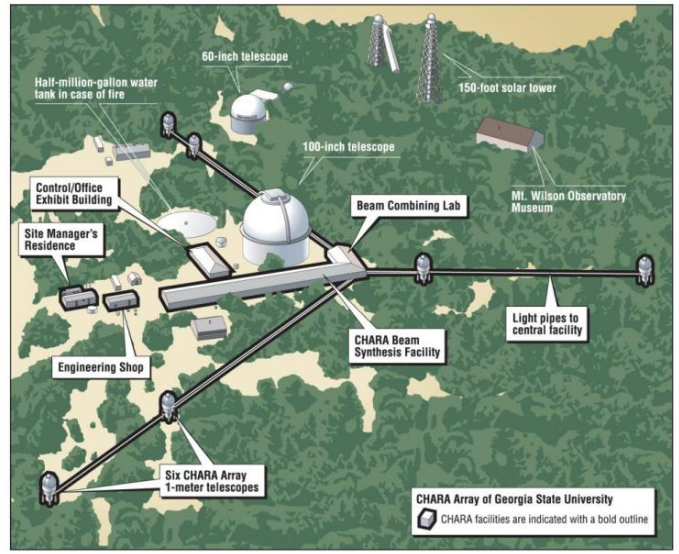
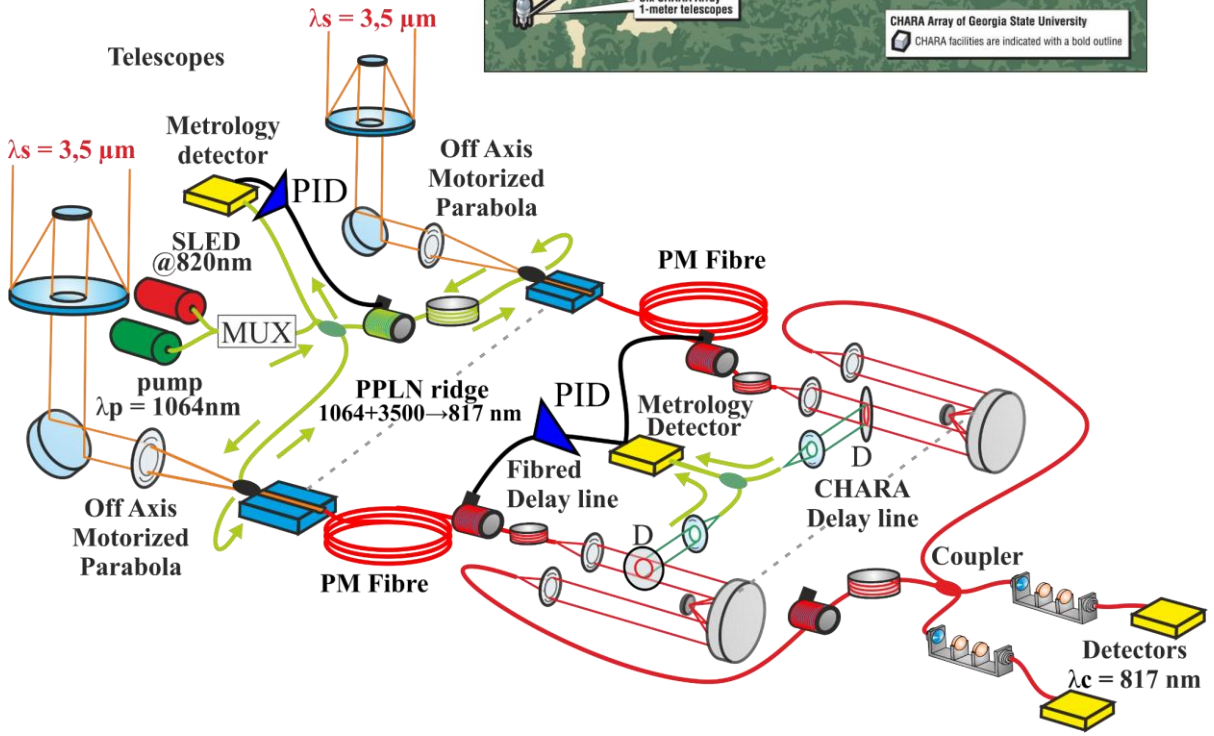
Introduction: ALOHA strategy

	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	* Noise investigation * **Multi channel spectral mode**	* Noise investigation * New crystals * **Fringes with a blackbody source**
On sky tests	* Sensitivity 2014 • Fringes 2015	*Sensitivity 2018 C2PU Preliminary result Lmag = 2.8 *Fringes….

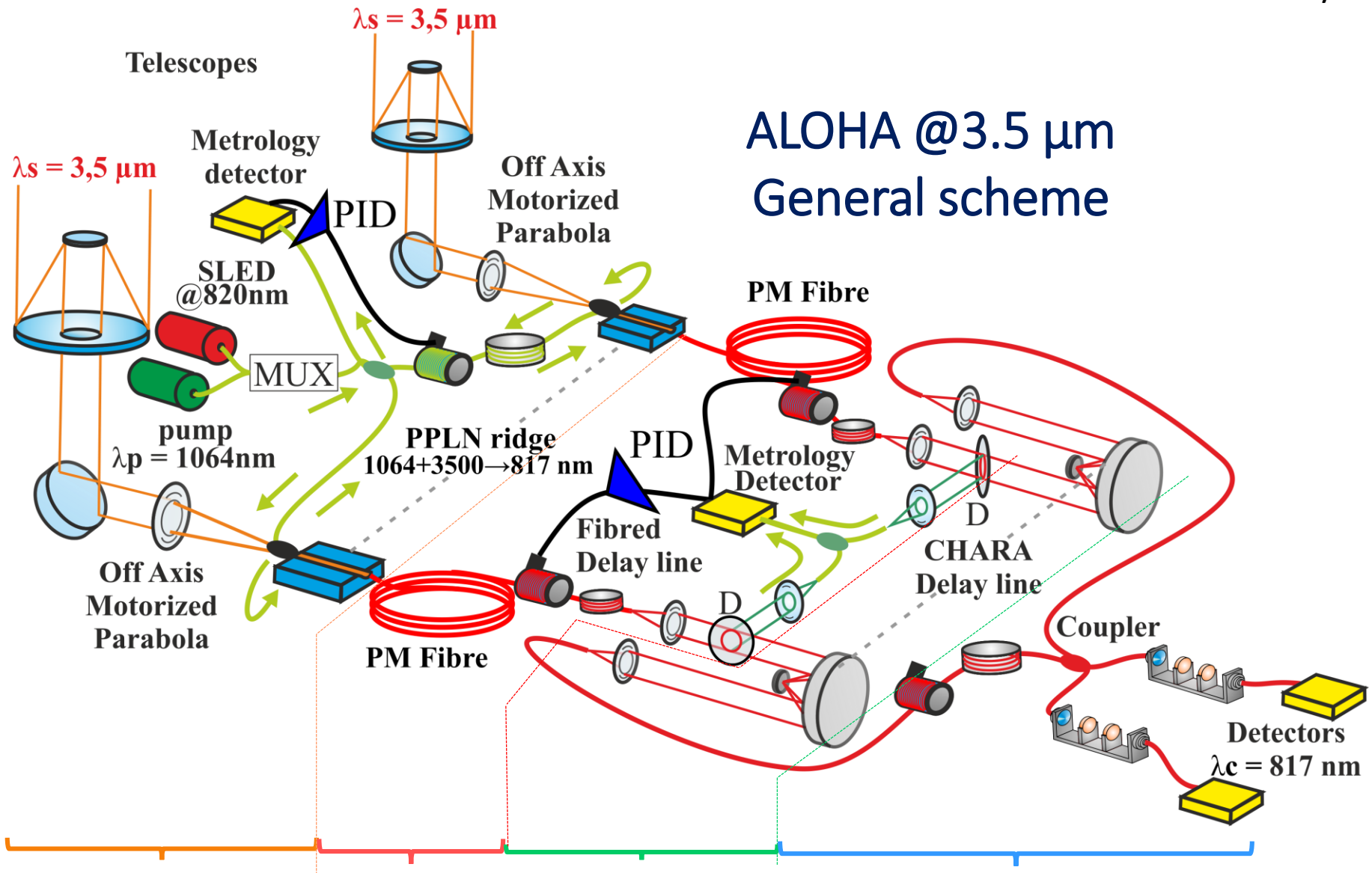




PPLN: Periodically Poled Lithium Niobate

1) Hardware

PPLN: Periodically Poled Lithium Niobate



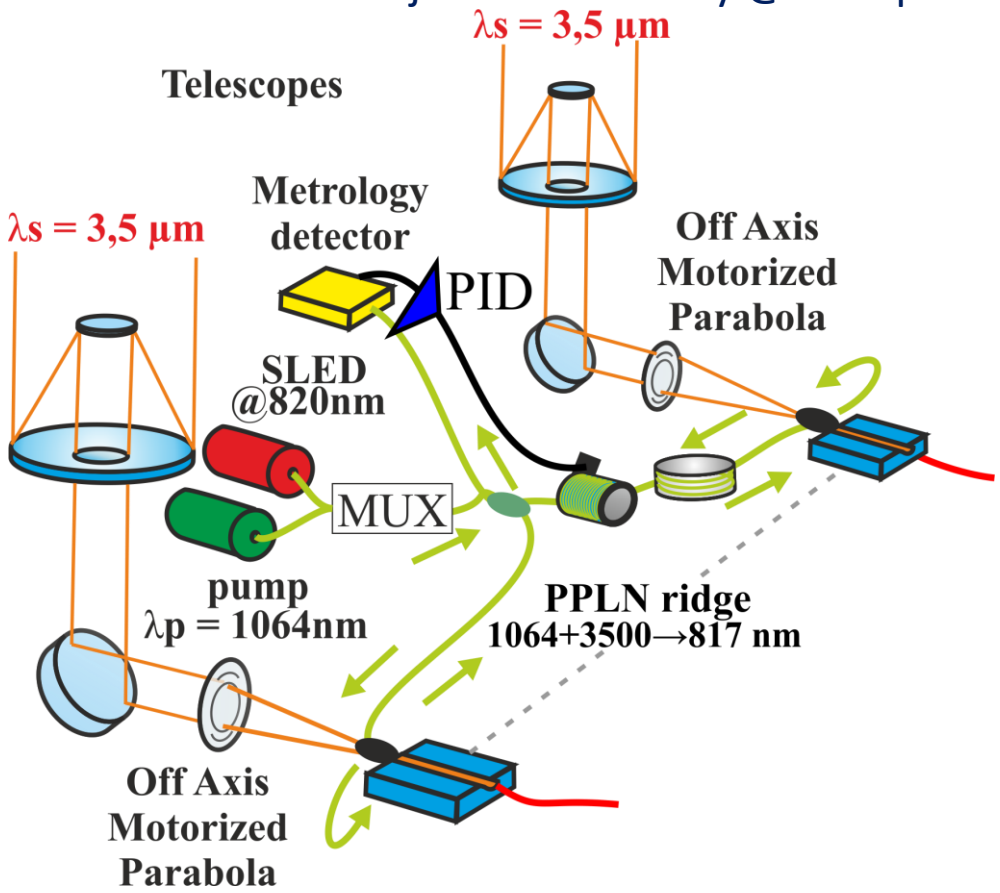
ALOHA @3.5 µm General scheme

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 ▪ Fibred delay line ▪ Filters + Photon detectors

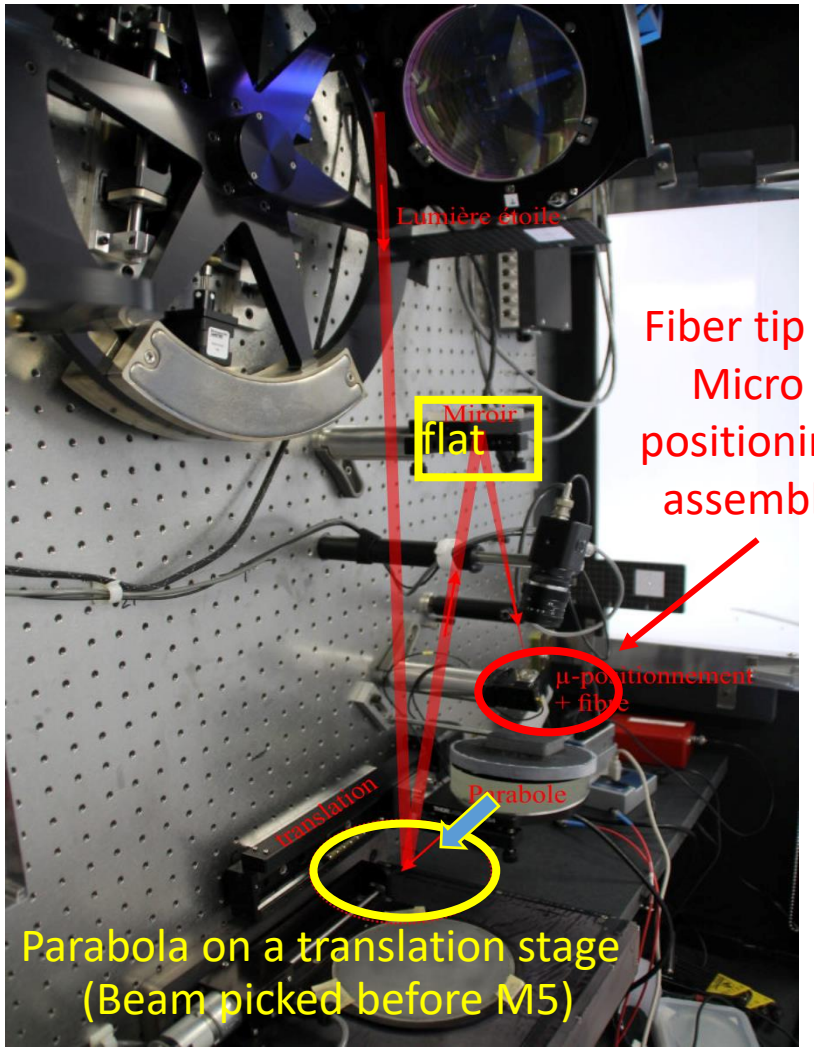
Telescope stage

Status:

- Tip tilt + AO >> available at CHARA
- Injection / conversion stage under development @XLIM
- 2017: test of the thermal disturbance of the PPLN + thermal regulation
- 2018: test of the injection assembly @ 1.5 µm H band
- 2019: test of the injection assembly @ 0.82 µm I band (I mag 9.9)

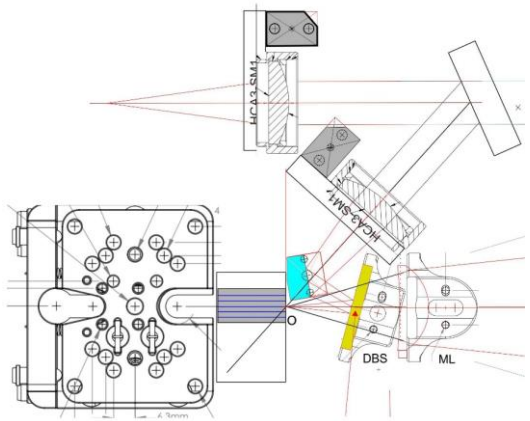


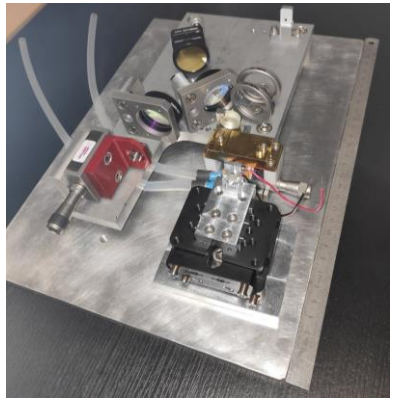
M4

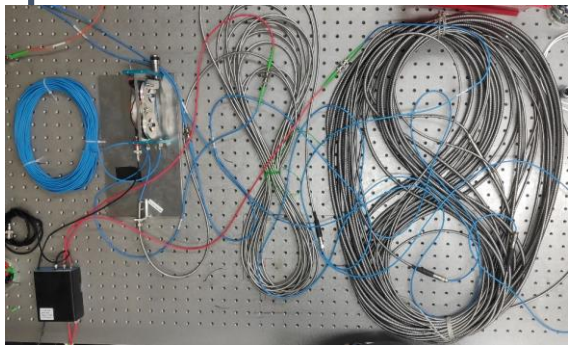


M5

Telescope stage







S1

Level 2

T1 → Off Axis Motorized Parabola → ZABER → Camera + Folding mirror

Thermal source

Motorized stage

Pc1 com 1 com 2 com 3 com 4 com 5 com 6 com 7 com 8

Dichroic, PPLN, MIR shutter, Lab, T°C control, Obj. mic, pump shutter

CHARA Network

Level 1

Cable wrap

MUX, Pump, Driver Pump, SLED, Driver SLED

Delay Line + φ-modulator

Coupler

Metrology detector, Photodiode, PID → HT

ALOHA@CHARA

S2

Level 2

T2 → Off Axis Motorized Parabola → ZABER → Camera + Folding mirror

Thermal source

Motorized stage

Pc2 com 1 com 2 com 3 com 4 com 5 com 6

Dichroic, PPLN, MIR shutter, Lab, T°C control, Obj. mic, pump shutter

CHARA Network

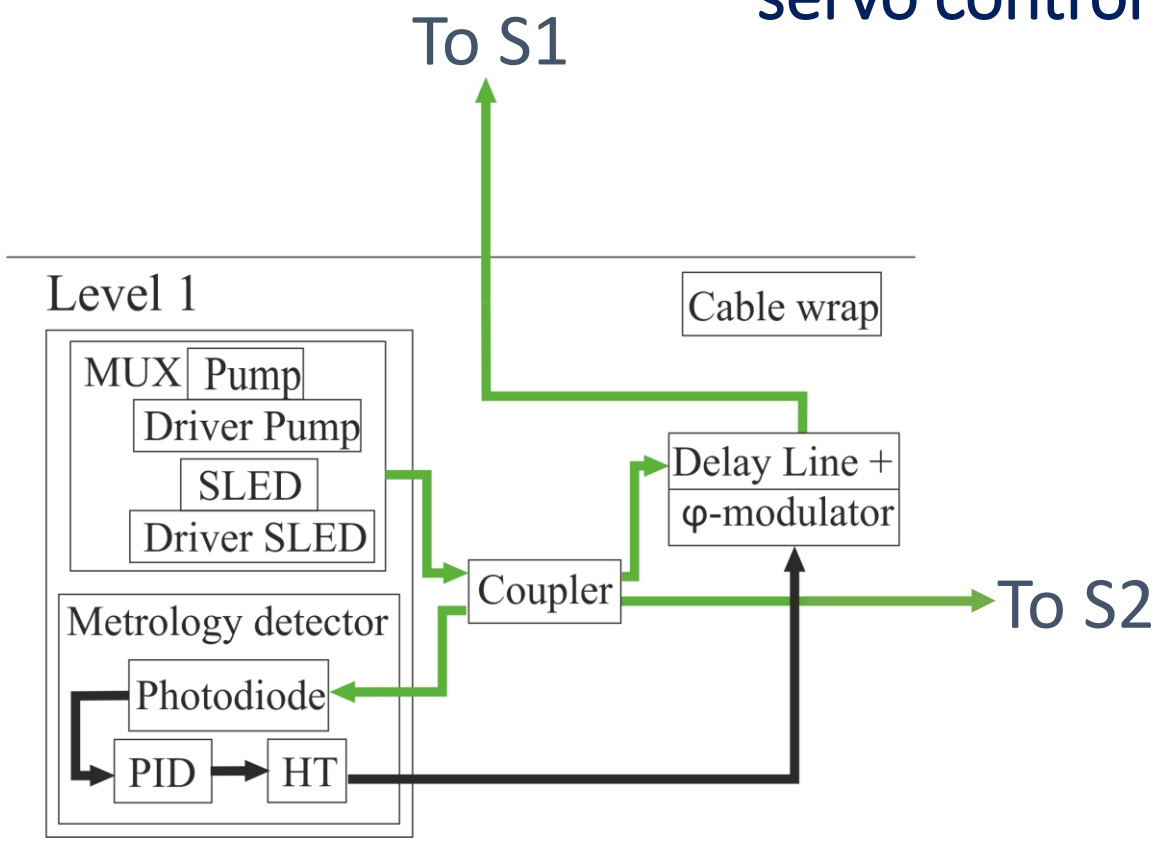
Level 1

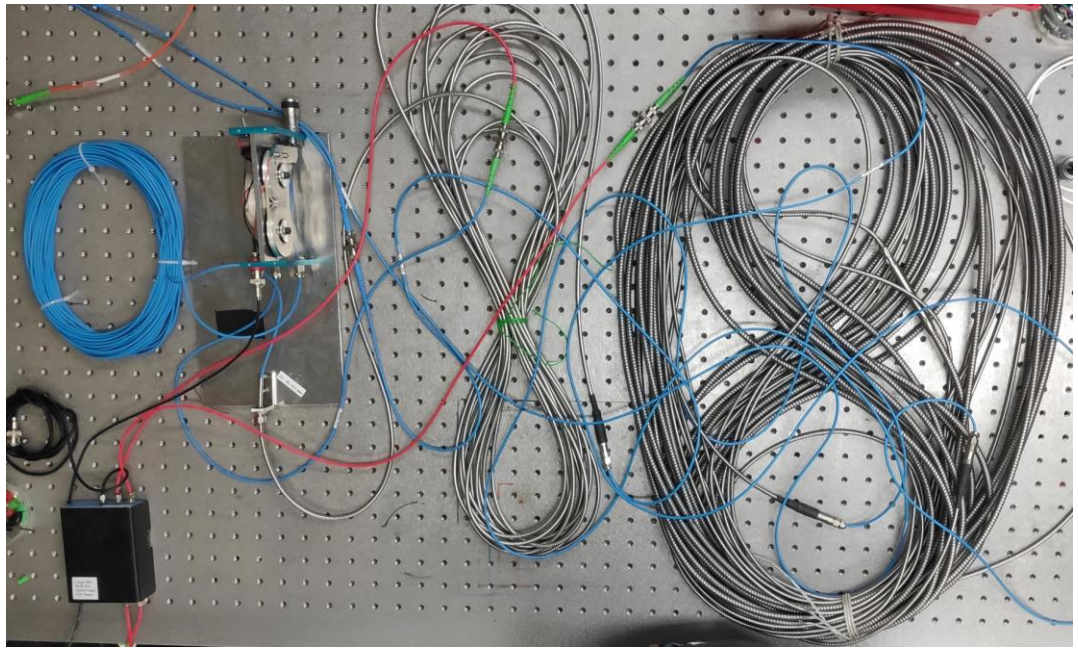
Cable wrap

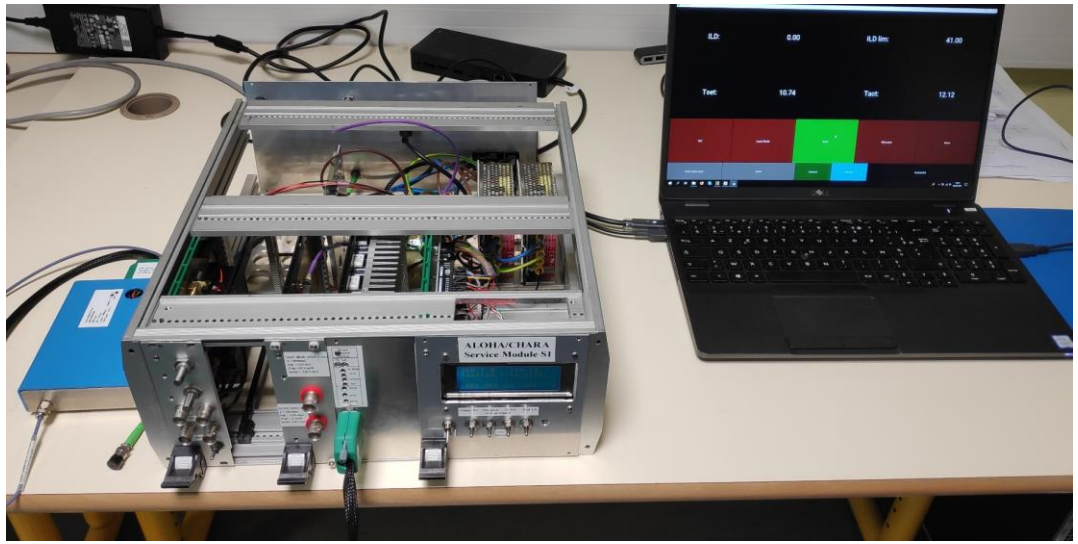
Synoptic scheme

Telescope stage

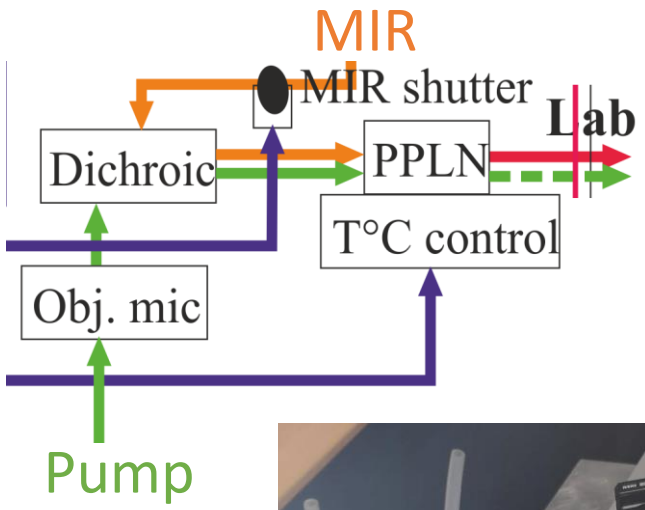
Pump Laser servo control



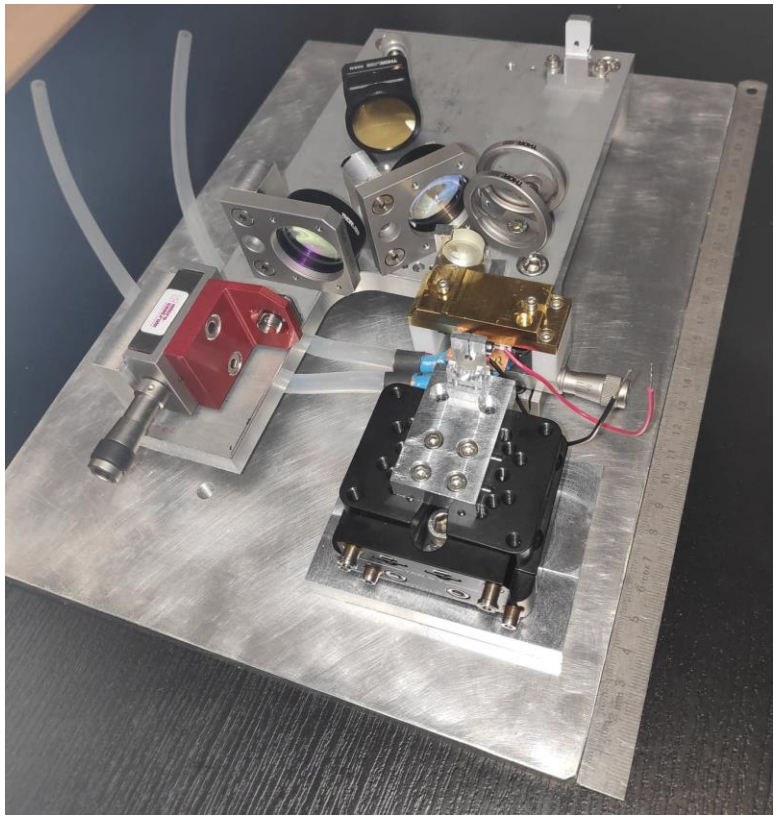




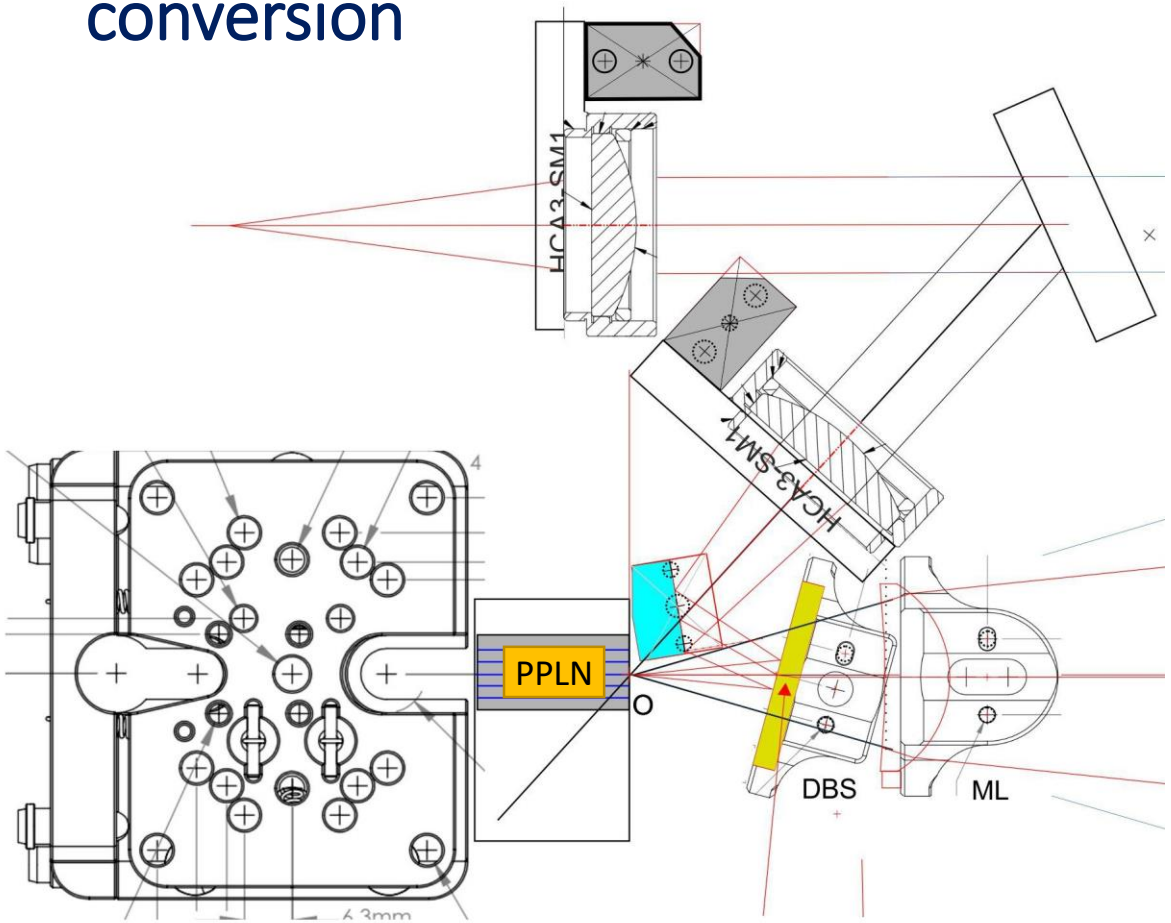
Telescope stage



Converted light



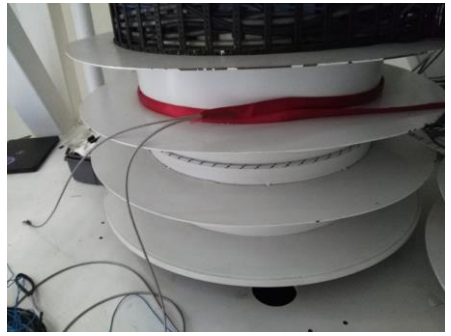
Injection and conversion

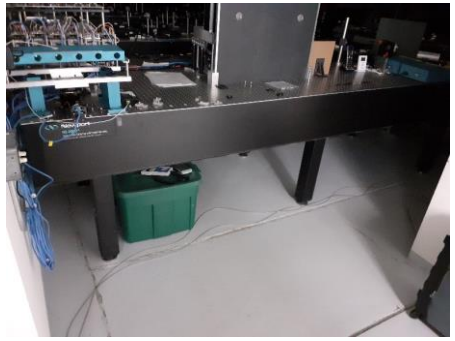


Fiber Link

Status:

- 2017: First test and stabilization of the OPD with the OHANA fibers @ 1.55 µm
- 2018: First propagation of star light from S1 to the lab with the OHANA fibers @ 1.55 µm (flux detection up to Hmag = 6)
- 2019: 820 nm PM fiber laying + first injection tests (flux detection up to Imag =9.98)



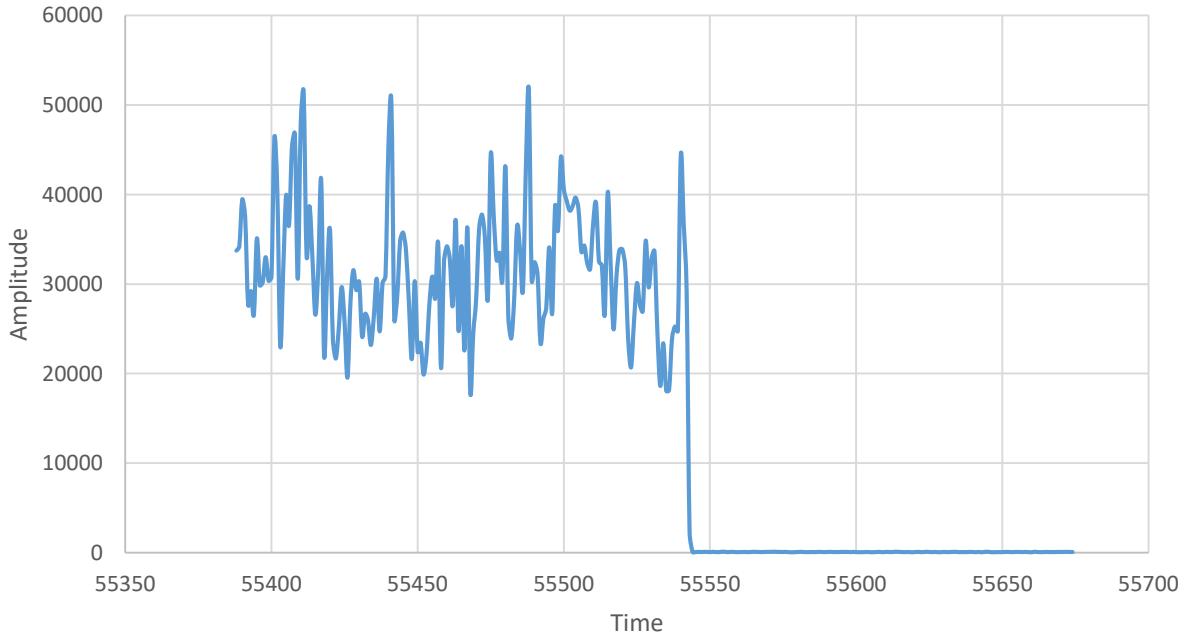


Fiber Link

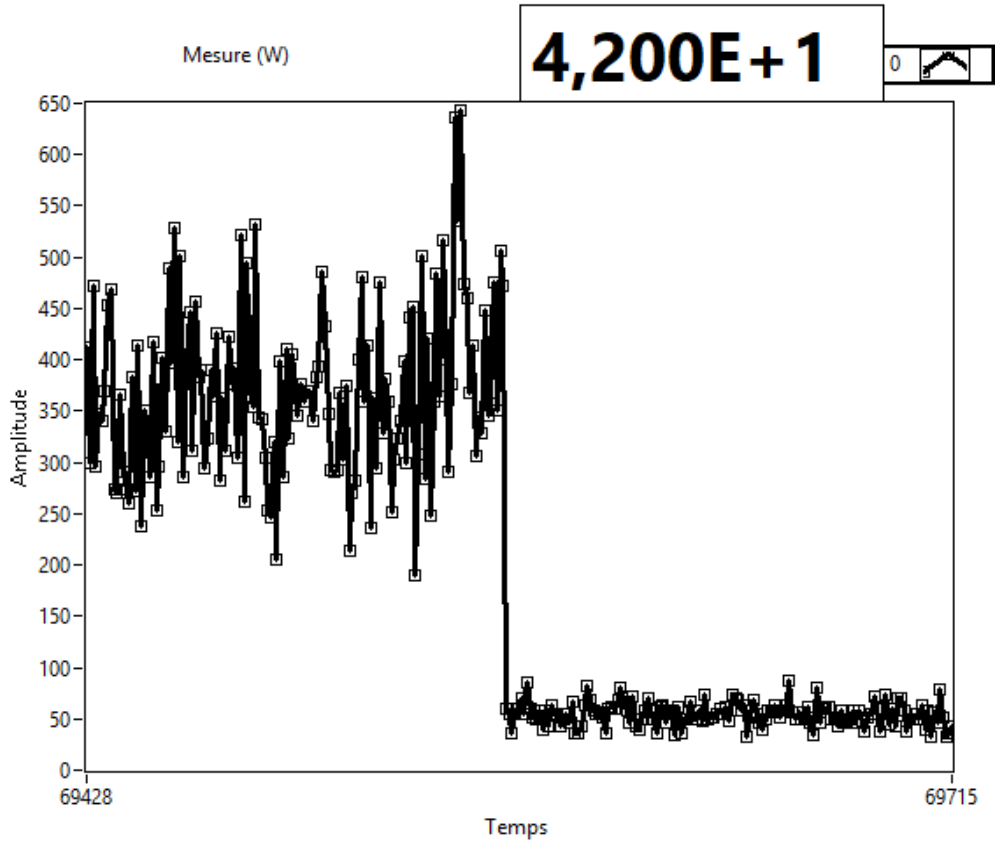
Flux detection with all the Si APD detector bandwidth (around 820nm) Without Adaptative Optics - Night 10/22/19

Imag= 5.19 / HD 214680

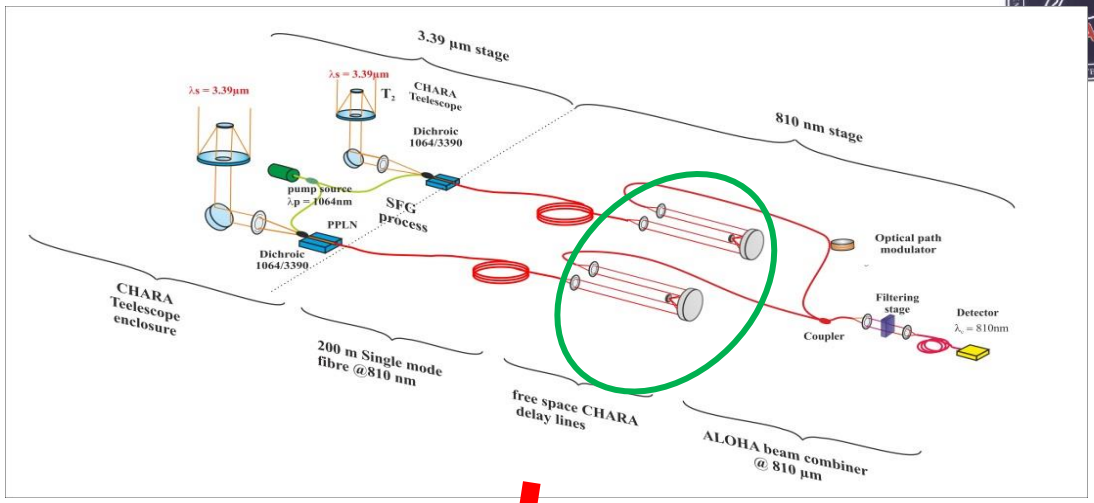
On the star **Off the star**

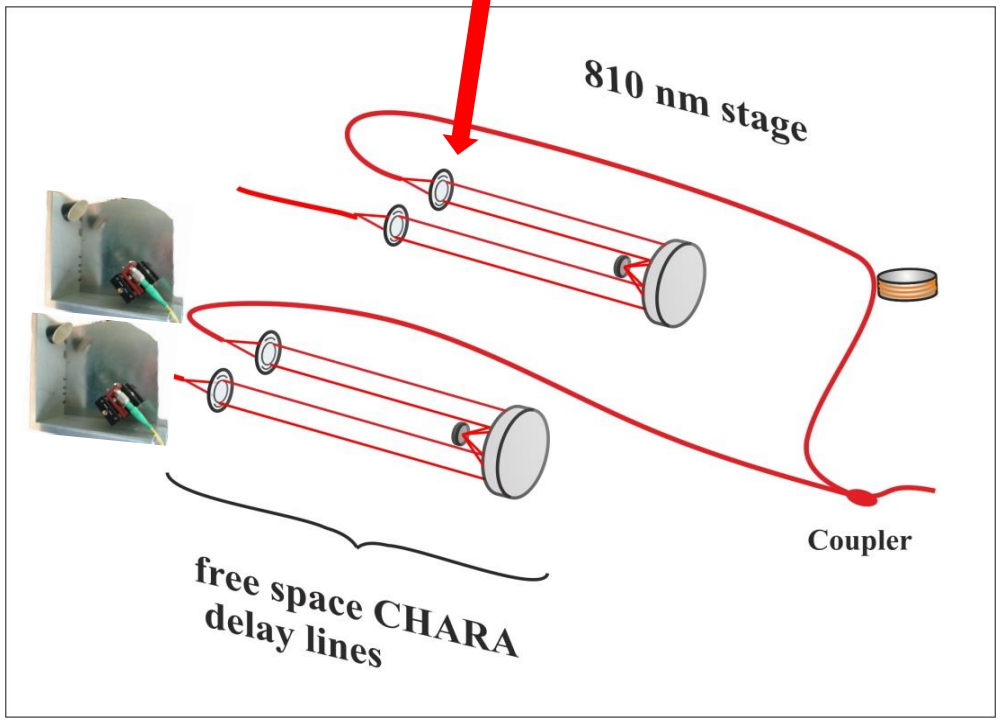


Imag= 9.92 / BD+38 4955



Delay lines





Status:

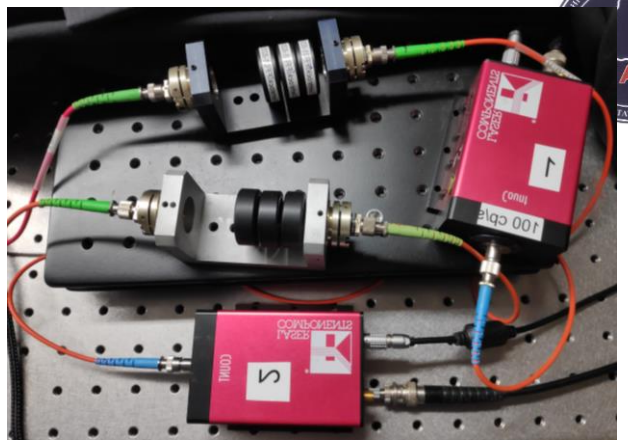
- Use of the CHARA delay lines
- Collimation and injection prototype tested in 2018
- Beam diameter 1-2 ” (Lf >> 100m !!!)
- Collimator and injection stage final version
- Mechanical mounting on the Delay Line at CHARA
- Test at CHARA (Stability of the coupling with an internal source and on the sky)

To be achieved:

- Duplication in progress
- Integration of the OPD servo loop using the pump light

Beam combiner / detection

Combining Lab



From S1

240 m PM Fibre

From S2

240 m PM Fibre

Free space delay line

Dichroic

Obj. mic

Motor

Delay Line

φ-modulator

Servo control

Photodiode

HT

PID

Coupler

Schäfter

Det 1

Det 2

Free space delay line

Pc3

com 1

com 2

com 3

com 4

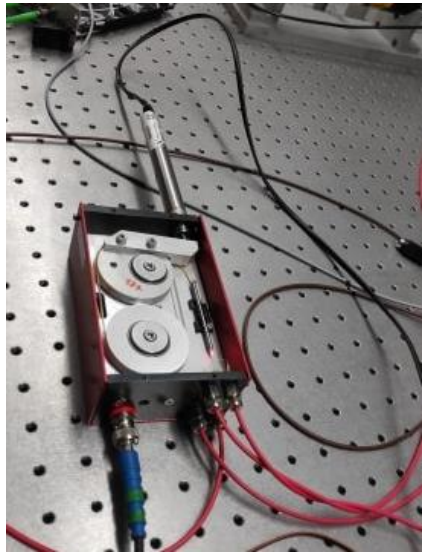
DaqMx

AO 0

Ai 0

Ai 1

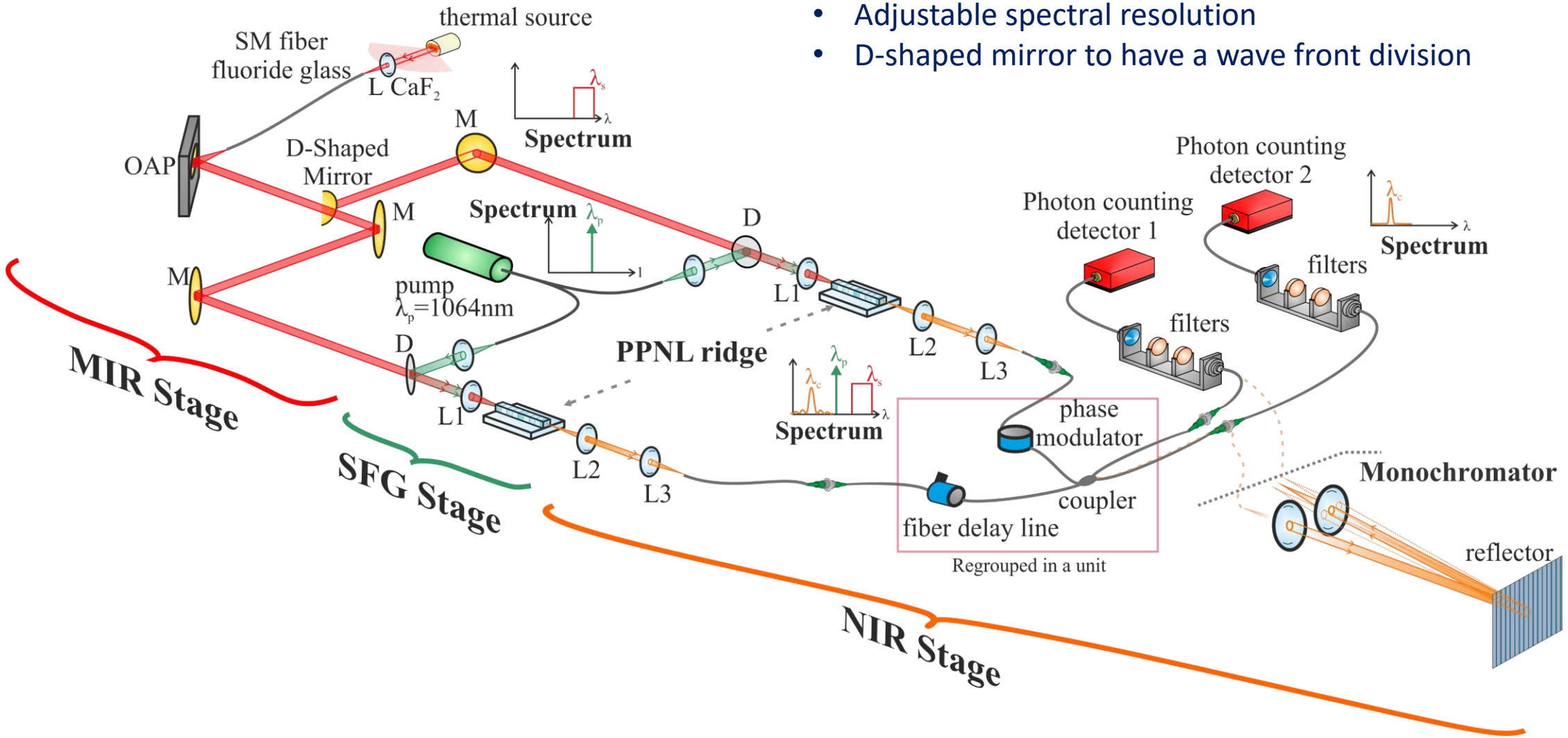
Monostable

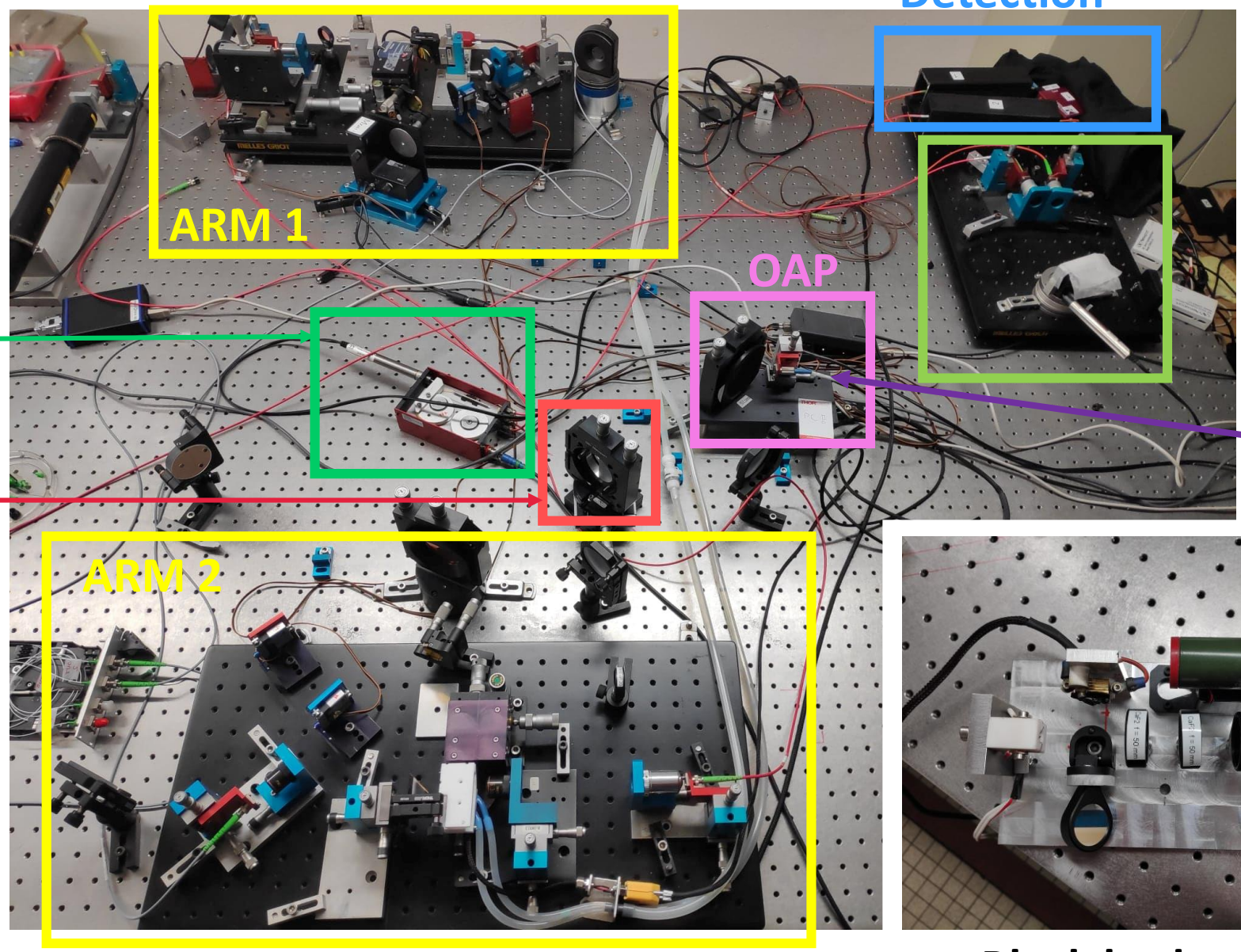


2) XLIM lab tests

Test at XLIM in the L band

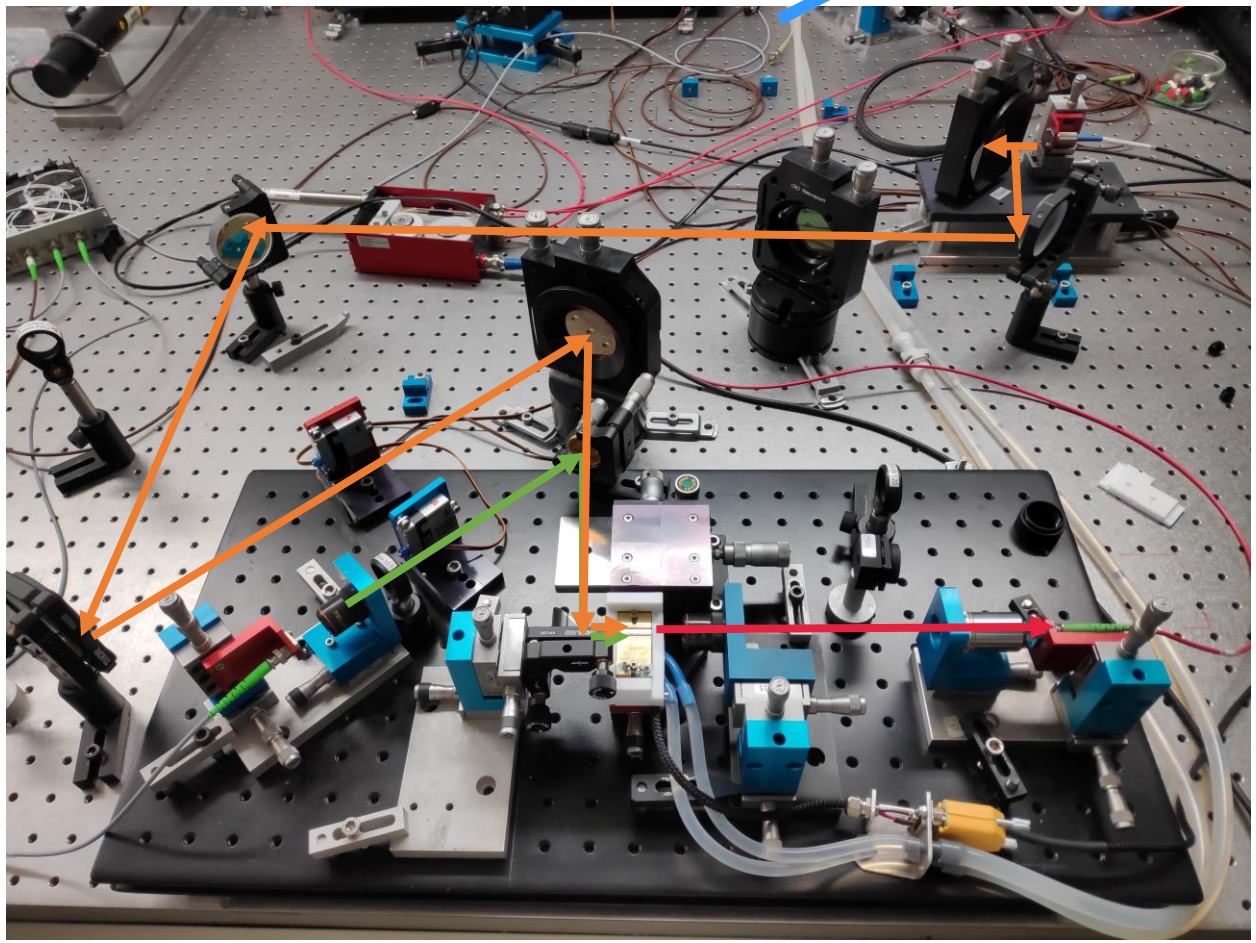
- Black body source
- Fluoride optical fiber >> unresolved object
- Adjustable spectral resolution
- D-shaped mirror to have a wave front division

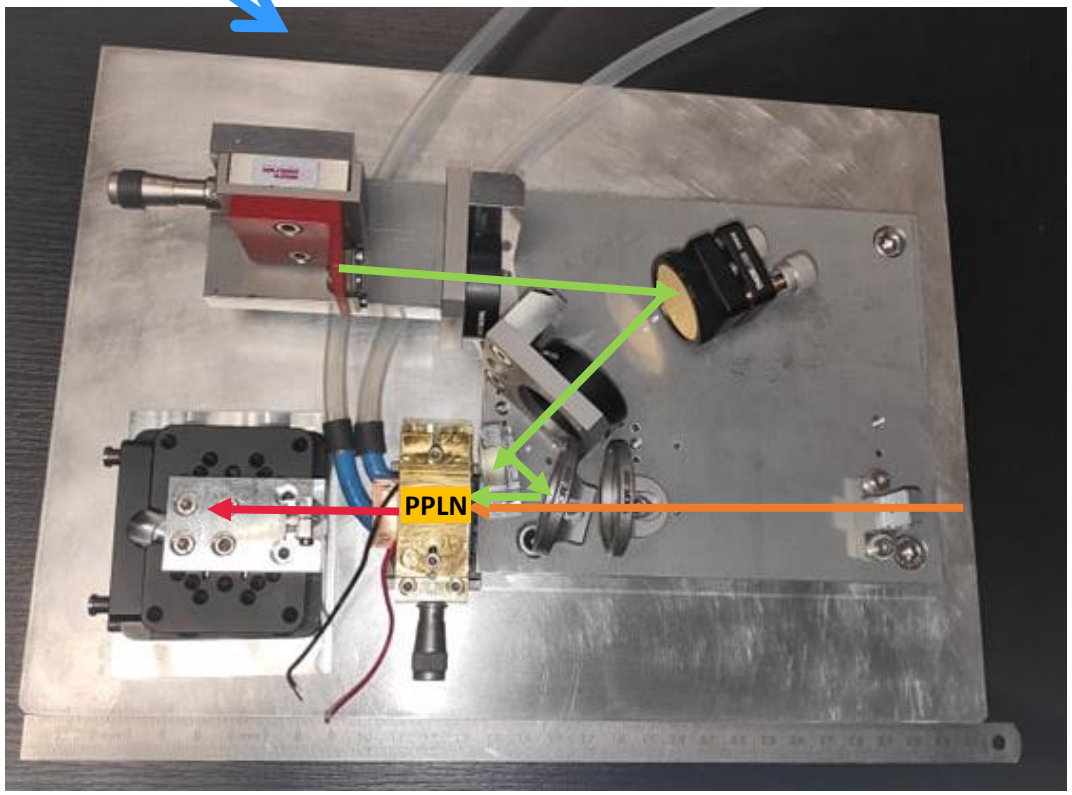




Black body + L CaF2

Miniaturisation and adaptation for CHARA



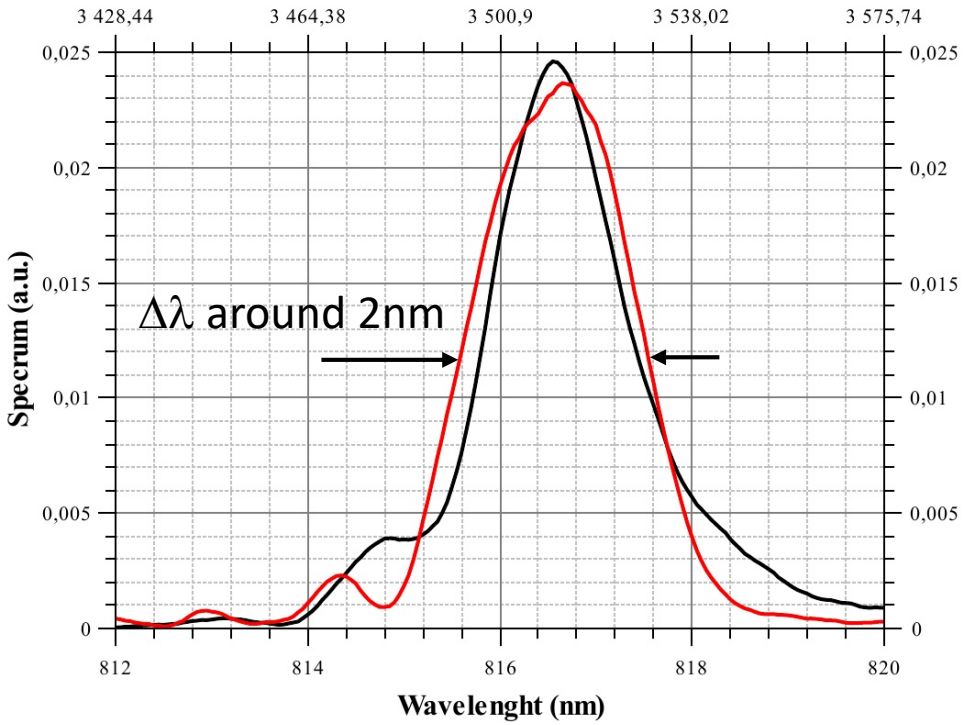


Work in progress

1064 nm 3500 nm 820 nm

Results at XLIM in L band

- Full ALOHA instrumental contrast = 88% with high flux
- Black body source at 25.7°C → equivalent Lmag = 3.88 (ideal 1m telescopes – average over 1200 x 0.2 s acquisitions)
- Taking losses into account → we should detect fringes on stars with **Lmag = 2.0**



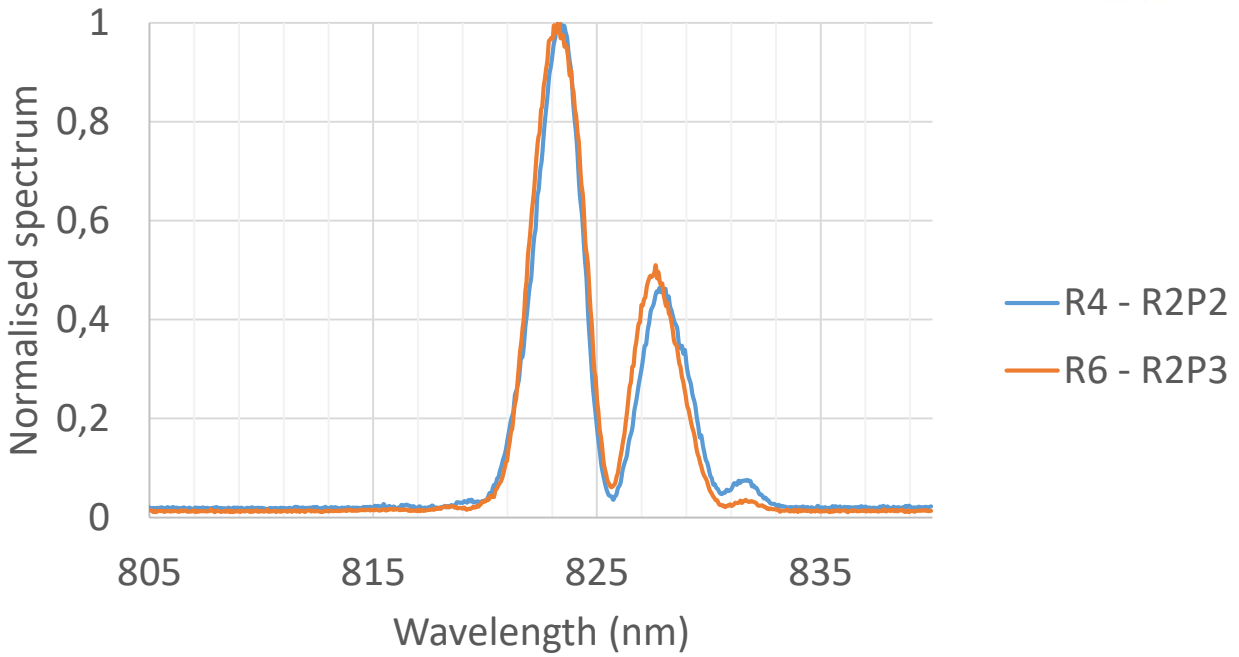
Δλconverted around 2nm @817 nm
>> Δλsignal around 40nm @ 3.5 µm

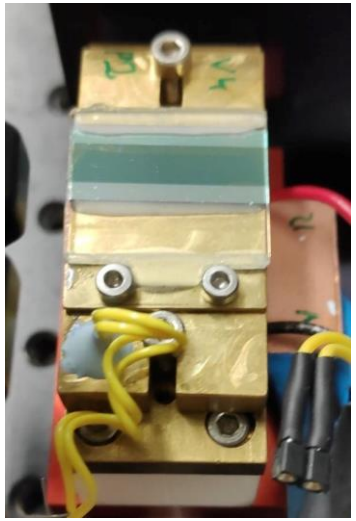
"Influence of the input-stage architecture on the in-laboratory test of a mid-infrared interferometer: application to the ALOHA up-conversion interferometer in the L band",
J.Magri et al., MNRAS, Vol 501, Feb 2021, pp 531–540, doi.org/10.1093/mnras/staa3283

New PPLN ridges (non linear crystals)

PPLN: Periodically Poled Lithium Niobate

- Upgraded conversion efficiency
- Two waveguides compatibles for fringes
- Double lobe due to waveguide geometry/ dispersion
- New encapsulation design (reliability enhanced)





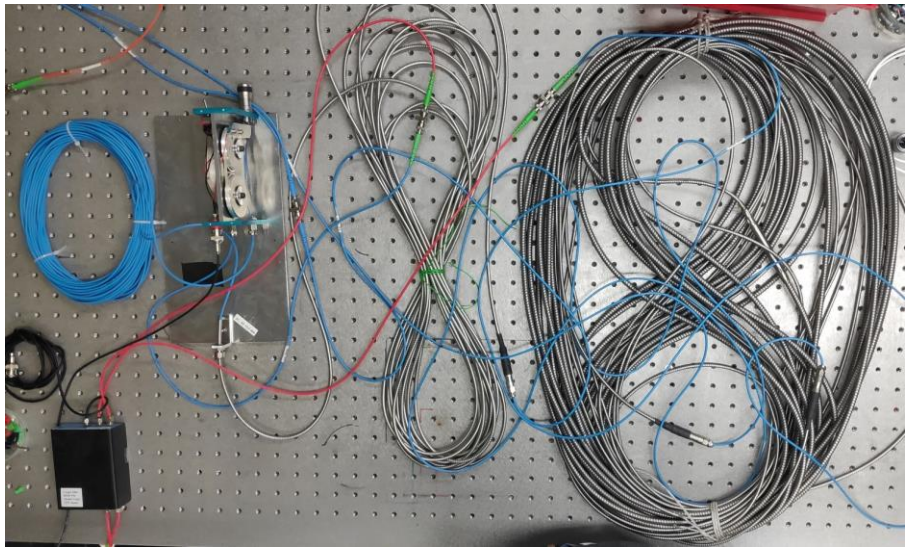
More PPLN ridges are going to be delivered and tested soon…

4) Next steps at CHARA…

1 mission in October 2021

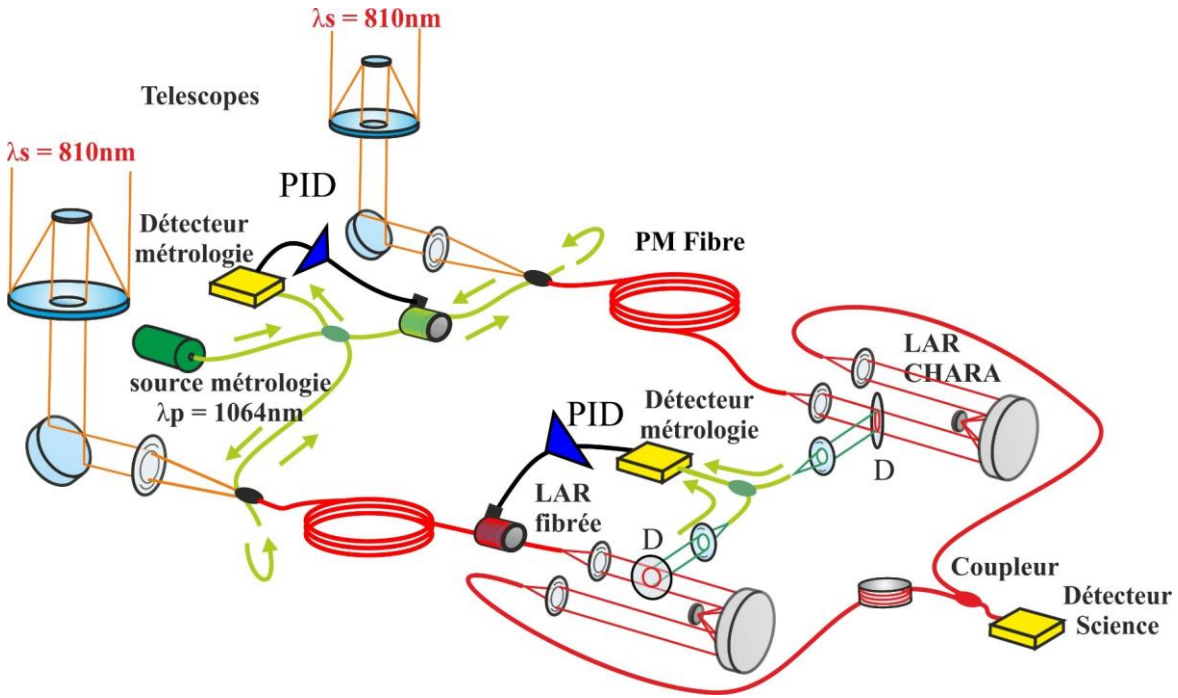
Step 1: Find the OPD on the sky at 820 nm (Precursor tests for the future fiber CHARA project/without conversion)

Step 2: Up-conversion on 1 telescope with the new conversion module and waveguides



Reminder:

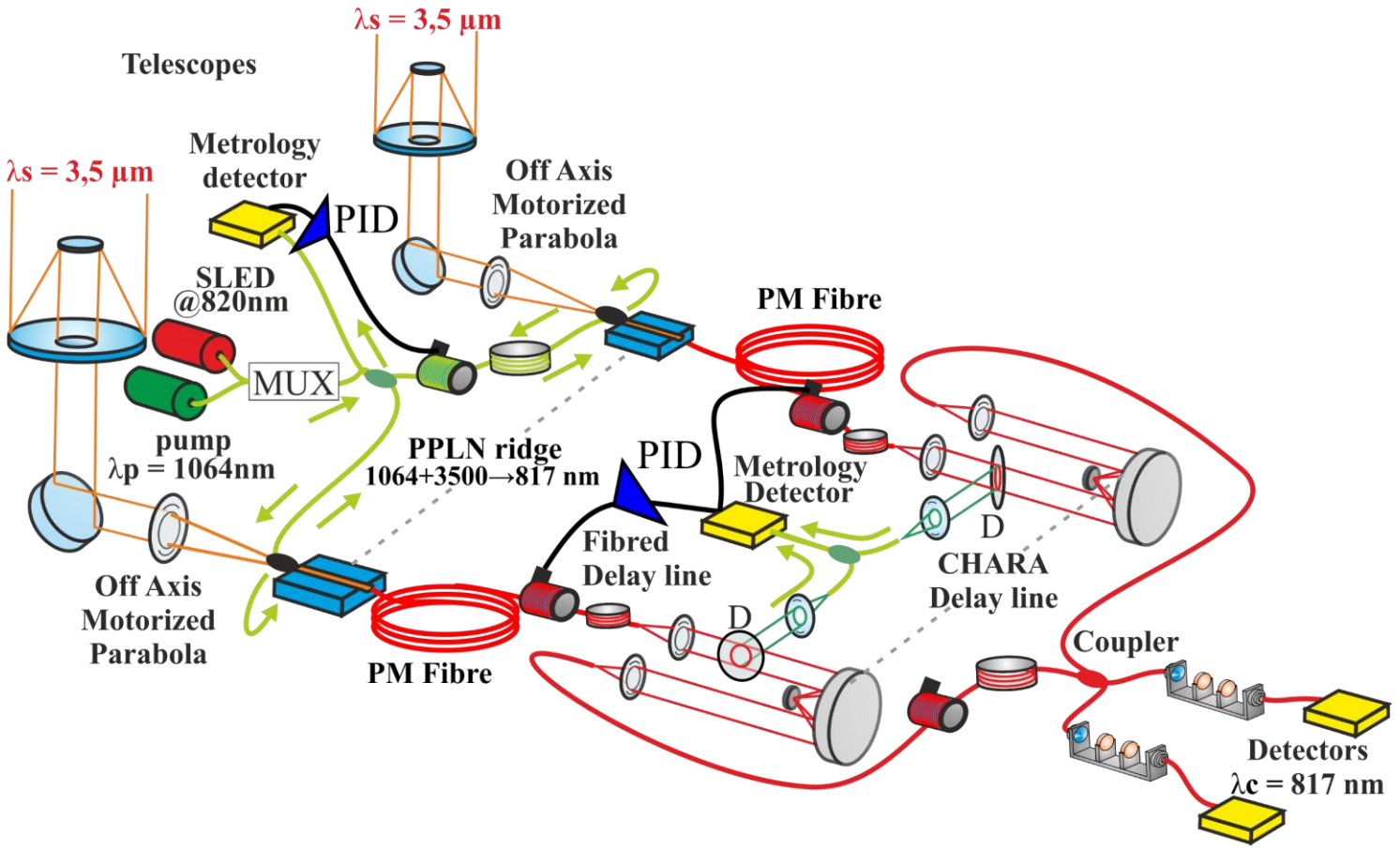
- The conversion takes place in S1 and S2 (AO tables)
- Need of :
  - The CHARA free space delay lines
  - The CHARA pointing facilities
  - The CHARA Adaptative Optics



Pump OPD stabilisation + fiber length stability
Fringes at 820 nm as a precursor for the future CHARA Array

2 missions in 2022

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



Thank you for you attention

Study and PhD grant funded by

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ThalesAlenia Space
a Thales / Leonardo company

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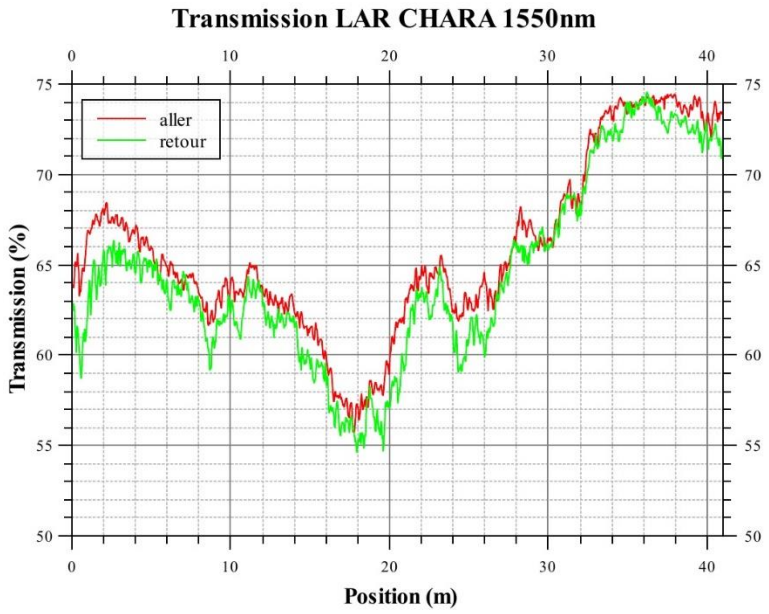
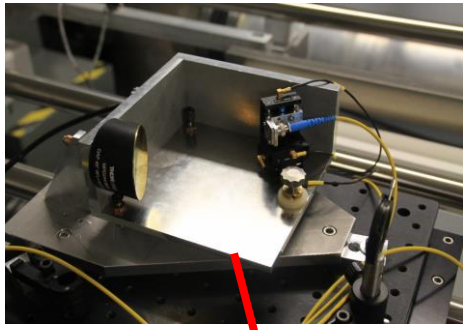
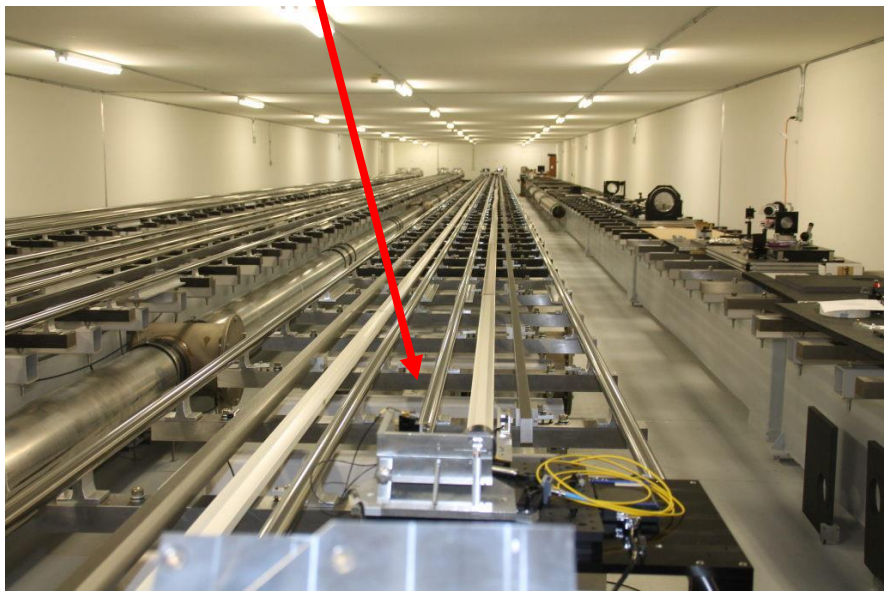
Observer & comprendre

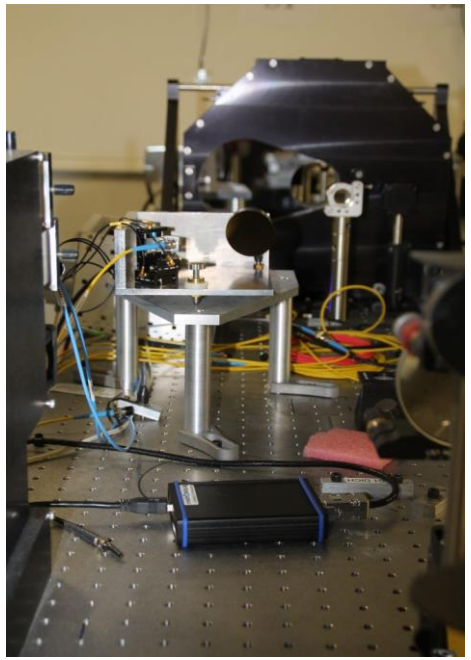
Delay lines

- Tests on the transmission in H band
- All along the stroke 55% ≤T≤ 75%
- Internal source



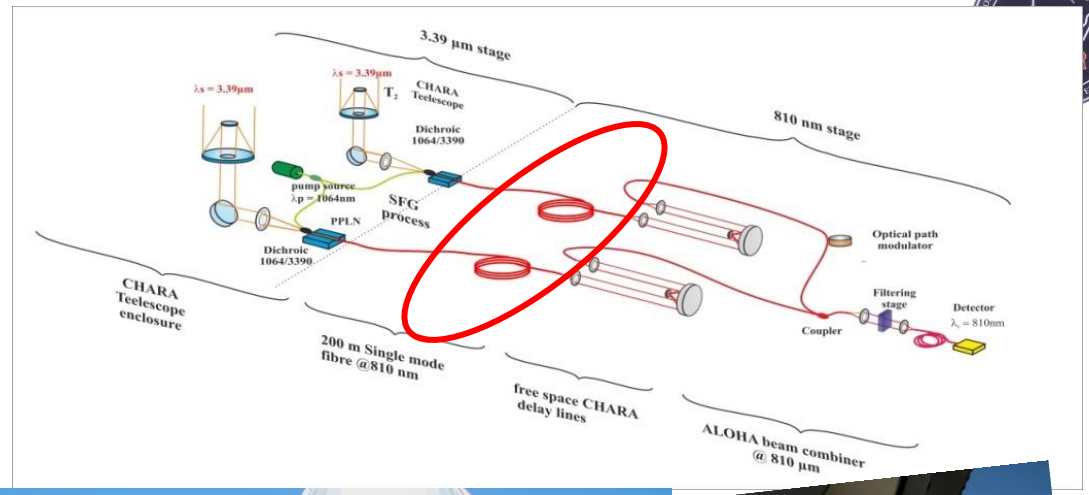






Beam selection table

Fiber Link

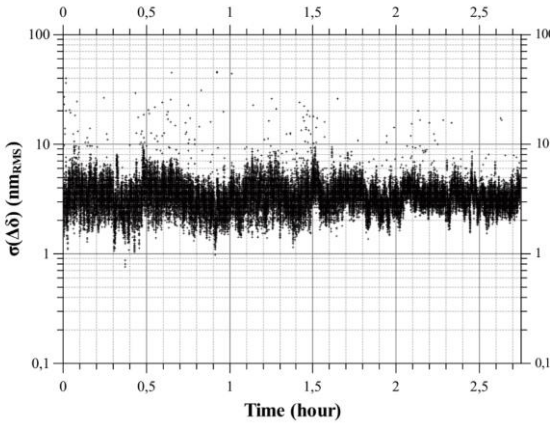


Status:

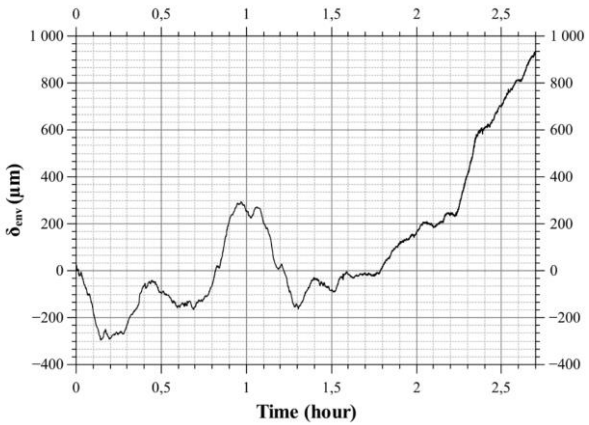
In 2017

First test and stabilization with the OHANA fibers @ 1.55 µm achieved last year is now accepted for publication in

Experimental Astronomy



OPD stability



OPD correction

*« **Environmental characterisation and stabilisation of a 2×200-meter outdoor fibre interferometer at the CHARA Array** » ;* Lucien Lehmann · Laurent Delage ·Ludovic Grossard · Francois Reynaud · Steve Golden · Craig Woods · Larry Webster · Judit Sturmann · Theo ten Brummelaar ·